UNIVERSITY OF
BIRMINGHAM

SCHOOL OF CHEMISTRY

Synthesis of azetidines and pyrrolidines:

Towards medicinal chemistry and organocatalysis applications.

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PROJECT SUPERVISOR: Dr J.S.Fossey

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Abbreviations

Bn: benzyl

Cy: cyclohexyl

DIBAL-H: diisobutylaluminium hydride

DIEA: diisopropylethylamine

DIPEA: *N*,*N*-diisopropylethylamine

DMF: *N*,*N*-dimethylformamide

DMPU: *N*,*N′*-dimethylpropylene urea

DMSO: dimethyl sulfoxide

HMDS: Bis(trimethylsilyl)amine

HRMS: high resolution mass spectrometry

LAH: lithium aluminium hydride

LDA: lithium diisopropylamide

MTBE: methyl-*tert*-butyl ether

NBS: *N*-bromosuccinimide

NIS: *N*-iodosuccinimide

PMB: para-methoxy benzyl

PTB: para-tolyl benzyl

Py: pyridine

Pyr: pyrrolidine

rt: room temperature

TBAF: tetrabutylammonium fluoride

TBAI: tetrabutylammonium iodide

TBD: 2-*tert*-butyl-4-[2-(3-*tert*-butyl-4-hydroxyphenyl)propan-2-yl]phenol

Tf: trifluoromethanesulfonyl

TFA: trifluoroacetic acid

THF: tetrahydrofuran

TMS: trimethylsilyl

TMSOTf: trimethylsilyl trifluoromethanesulfonate

Ts: para-toluenesulfonyl

Contents

1 Introduction

1.1 Azetidine

Azetidine is a thermodynamically stable four membered nitrogen containing heterocycle. Azetidines are a very important class of molecules. They have been used as ligands,[1-2] synthetic building blocks[3] and can be found in a range of natural products (Figure 1).[4-5]

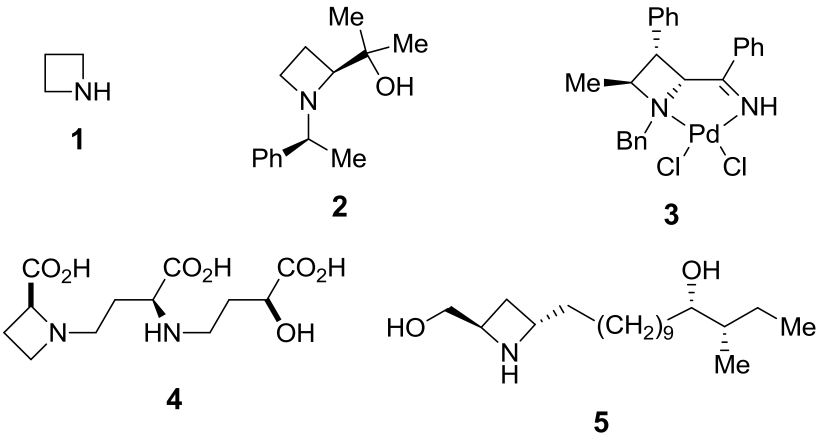
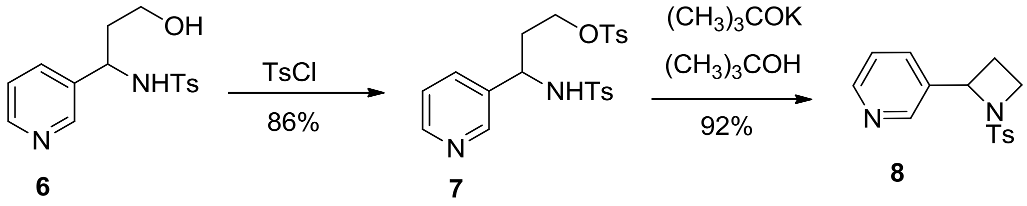


Figure 1. Azetidine containing compounds. **1**, azetidine. **2**, azetidine ligand. **3**, azetidine palladium complex. **4**, 2^{I}-deoxymugineic acid. **5**, penaresidin A.

The antibacterial activity,[6] binding to acetylcholine receptors[7] and psychotropic potency[8] of azetidine derivatives have been studied and contrasted with their five-membered pyrrolidine congeners, revealing them as an intriguing class of compounds. For example it has been shown that ring size variation between pyrrolidine and azetidine increases receptor affinity and psychotropic potency in rat brain membranes for the four-membered ring.[8]

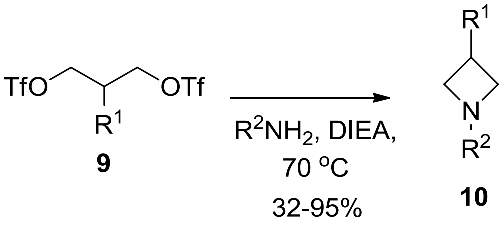
1.1.1 Synthesis of azetidines

Azetidines can be prepared by cyclisation of 1,3-diols with amines; compound **6**, a tosyl protected pyridyl amino alcohol, is tosylated to form compound **7** in 86% yield, which gives azetidine derivative **8** in 92% yield *via* intramolecular displacement of the tosylate by the tosylated nitrogen (Scheme 1).[9]



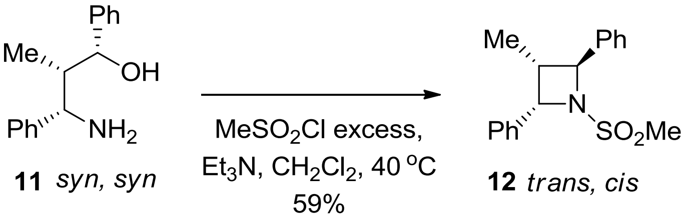
Scheme 1. Cyclisation of 1-3-amino alcohol.

Hillier and co-workers reported a formation of azetidine derivatives in yields between 32% and 95%. Several bis triflated diols were reacted with different primary amines in the presence of diisopropylethylamine at 70 °C (Scheme 2).[10] It was found that the nucleophicility of the amine carries an important role towards the outcome of the reaction. In fact, lower yields were observed when the HCl salt of aminodiphenylmethane or aniline were employed.



Scheme 2. Transformation of bis triflated diols into azetidine derivatives

In 1996, Barluenga and co-workers attempted the synthesis of enantiomerically pure polysubstituted azetidines *via* cyclisation of 1-3 amino alcohols with three stereogenic centres. Such alcohols were previously synthesised by the same group.[11] Compound **11** (*syn, syn*), first reacted at the hydroxyl and amino groups with an excess of methansulfonyl chloride, was then intramolecularly displaced by the sulfonated nitrogen in a 4-*exo*-tet fashion to afford the *trans, cis* multisubstituted azetidine **12** in 59% yield (Scheme 3).[12] Although this methodology does not furnish azetidines in high yield, enantiomerically pure azetidines with three stereogenic centres can be obtained.



Scheme 3. Synthesis of enantiopure azetidines with three stereogenic centres

An electrophilic selenium-induced cyclisation of homoallylic benzylamines to form azetidines was observed for the first time in the 1997 by Berthe and co-workers. Homoallylic amines **13** were reacted with 1.5 equivalents of PhSeCl or PhSeBr in the presence of sodium carbonate. A mixture of azetidines **14** and pyrrolidines **15** was obtained in most of the cases (entry 1,2,4, Table 1), however, the azetidine was the only product observed when R^1 = Et; R^2 = Me (entry 3, Table 1). It was speculated that steric hindrance around the α-carbon favours the formation of the azetidine. It was also observed that formation of halopyrrolidines does not proceed *via* expansion of azetidine.[13-14]

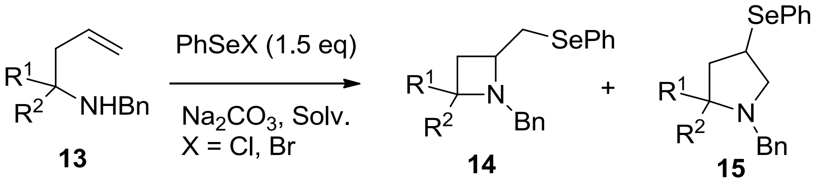
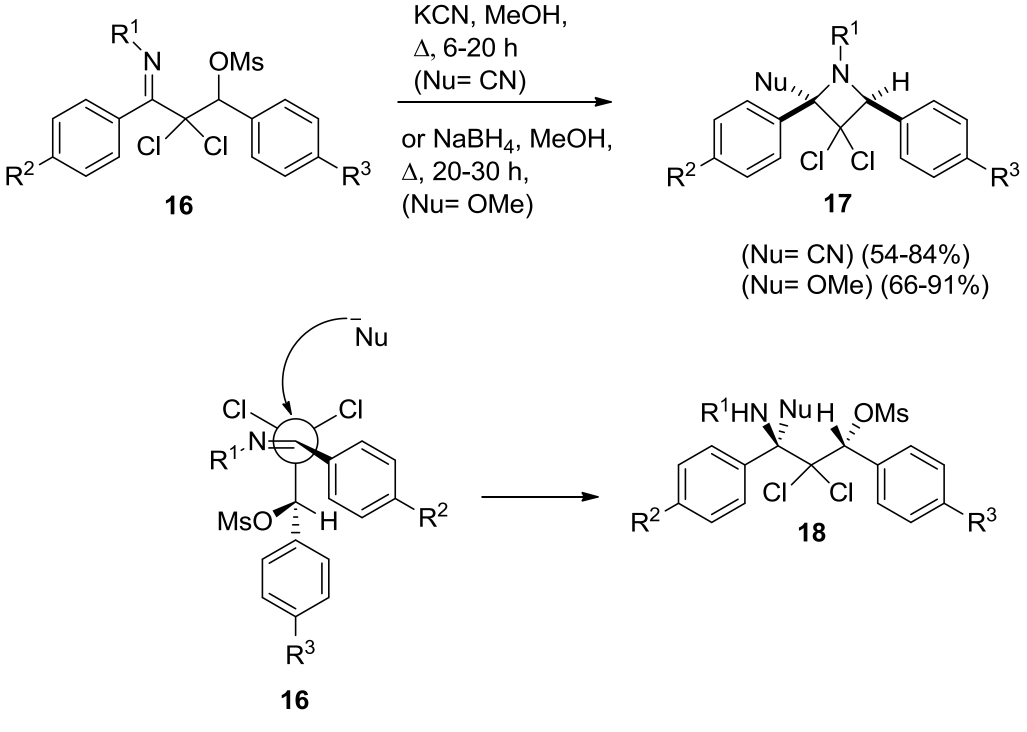


Table 1. Cyclisation of homoallylic amines

entry	R^1	R^2	conversion of **13** (%)	ratio **14**/**15**	yield (%) **14**/**15**
1	Ph	H	95	70/30	62/16
2	Me	Me	70	86/14	50/6
3	Et	Me	77	100/0	55/0
4	Me	H	95	28/72	15/37

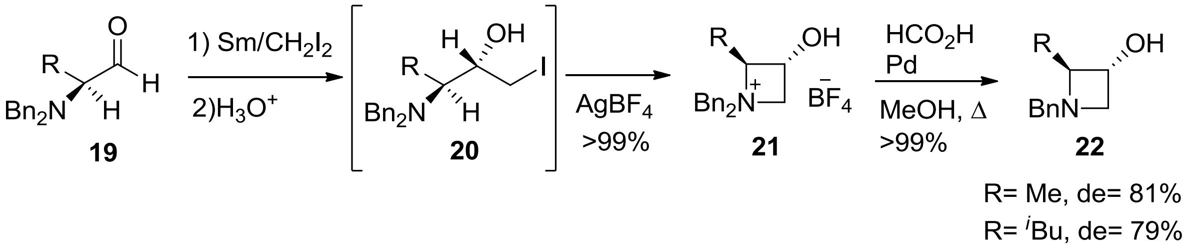
Different substituted aromatic di-chloro imines **16** were directly converted to *cis*-azetidines **17** in 54-91% yield and high diastereoselectivity (*trans*-azetidines were not observed) as reported by Aelterman and De Kimpe in 1998. The asymmetric nucleophilic attack by the metoxide or cyanide group to the imine, produces the intermediate secondary amine **18** which can lead to the product *via* intramolecular S_N2 attack by the nitrogen (Scheme 4).[15]



Scheme 4. Direct conversion of aromatic di-chloro imines into 2,3,4 substituted azetidines

The high diastereoselectivity of the products might be explained by the formation of the more kinetically favoured intermediate **18** where, according to the model proposed by Evans and others,[16-21] less steric congestion is present between the imidoyl carbon substituent (R) and the β- aryl substituents (Scheme 4).

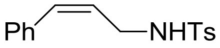
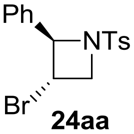
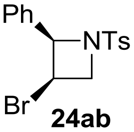
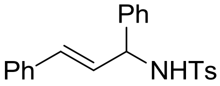
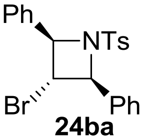
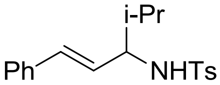
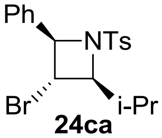
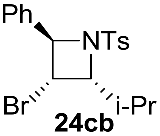
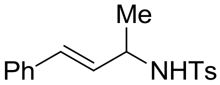
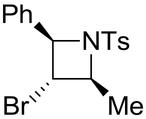
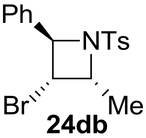
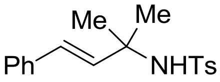
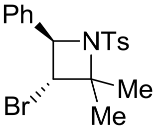
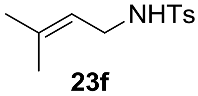
In 1999, Concellòn and co-workers reported the synthesis of azetidines by ring closing of aminoiodohydrins.[22] Enantiopure α-aminoaldehydes **19** were iodomethylated using samarium diiodide to afford aminoiodohydrins **20**, which proved to be not very stable. However, the aminoiodohydrins **20** obtained were reacted with $AgBF_4$ to afford the azetidinium tetrafluoroborate salts **21** which were converted to the azetidines **22** in quantitative yields and good diastereoisomeric excess (R = Me; de = 81%, R = ^{i}Bu; de = 79%) by monodebenzylation *via* hydrogenolysis (Scheme 5).[23] The use of $^-BF_4$ as counterion prevented ring opening of the azetidinium salts **21**. In fact, ring opening of the azetidinium salts **21** was observed when the more nucleophilic iodide was used as counterion.



Scheme 5. Synthesis of azetidines by ring closing of aminoiodohydrins

In 2000, Robin and Rousseau reported the cyclisation of tosylamides to produce azetidines.[24] Bis(collidine)bromonium(I)hexafluorophosphate was used as the cyclisation promoter. Different tosylamides **23a-f** were converted to azetidines **24aa-ea** in 52.5-95% yields and good diastereoselectivities. One must note that only the isomer (2*R*,3*S*,4*S*) **24ba** was formed when phenyl group was used as substituent (entry 2, Table 2), whereas two isomers were obtained when smaller substituents such as *i*-Pr and Me were used (entry 3 & 4, Table 2). It is also noteworthy that the yield was improved to 95% by the presence of a *gem*-dimethyl group (entry 5, Table 2). No reaction occurred when tosylamides **23f** was used (entry 6, Table 2).

Table 2. Synthesis of azetidines *via* cyclisation of tosylamides

entry	substrate	product(s) (yield %)
1	 **23a**	 **24aa** (52.5)  **24ab** (9)
2	 **23b**	 **24ba** (64)
3	 **23c**	 **24ca** (74)  **24cb** (6.5)
4	 **23d**	 **24da** (66.5)  **24db** (6.5)
5	 **23e**	 **24ea** (95)
6	 **23f**	N.R.

A hydrozirconation protocol for the synthesis of chiral azetidines was established starting from Boc protected chiral allylic amines **24a-f**. The formation of an organozirconium species followed by treatment with iodine, diastereoselectively forms the iodocarbamate, which converts to azetidines **25a-f** after addition of sodium hexamethyldisilazane in THF (Table 3). The attack to the *re*-face is considered to be favoured, in fact, the presence of bulky groups in R^1 would make the *si*-face less accessible to the nucleophile (Figure 2). The best diastereomeric ratio 96:4 was obtained when R^1 = Bn, R^2 = Bu (entry b, Table 3).[25]

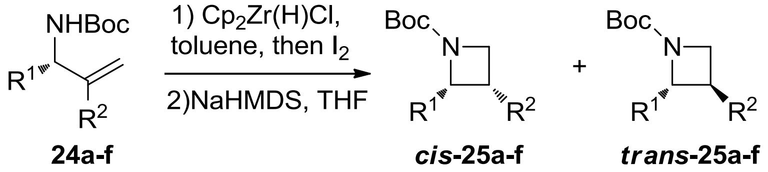


Table 3. Boc-protected chiral allyl amines ring closing

entry	R^1	R^2	dr (*cis*:*trans*)	yield of **25** (%)
a	Me	Me	94:6	65
b	Bn	Bu	96:4	75
c	Bn	Me	95:5	65
d	*i*-Pr	Me	50:50	68
e	Ph	Me	73:27	80
f	CH_2OTBS	Me	92:8	65

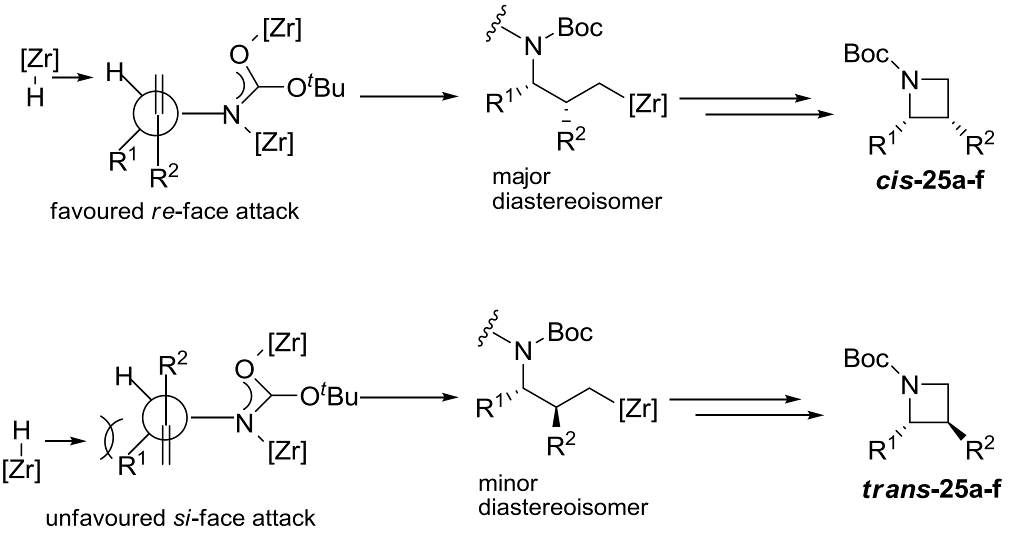
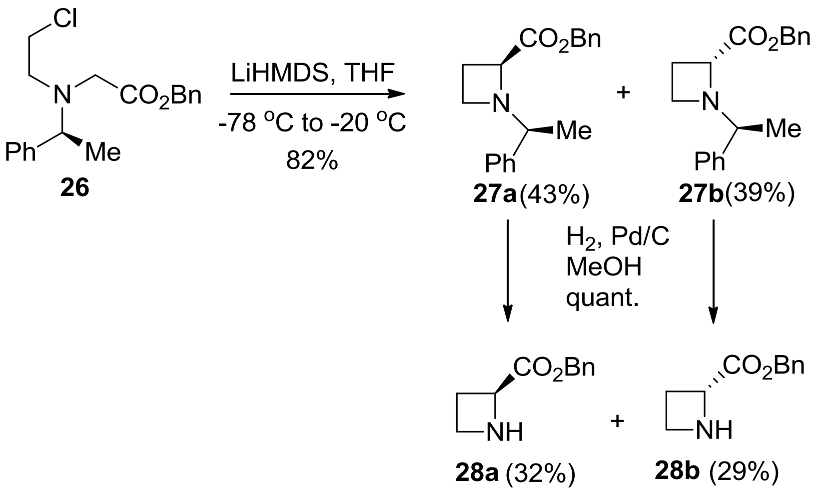


Figure 2. Favoured *re*-face and unfavoured s*i*-face attack

Couty and co-workers reported the synthesis of enantiopure azetidine-2-carboxylic acids using α–methyl benzylamine as chiral auxiliary.[26] An enolate, formed by deprotonation of **26** with LiHMDS, displaced the halogen intramolecularly to furnish a 1.1:0.9 mixture of diastereoisomers **27a** and **27b**, which were converted to the final products by hydrogenolysis with Pd/C. Although relatively poor diastereoselectivity was observed, the two diastereoisomers were easily separated by flash chromatography and the azetidine 2-carboxilic acids **28a** and **28b** were obtained in 32% and 29% yields over two steps (Scheme 6).



Scheme 6. Synthesis of enantiopure azetidine 2-carboxylic acids

In 2006, a synthesis of 3-fluoroazetidines was reported by Van Brandt *et al.*[27] Regiospecific bromofluorination of imino olefins **29** furnished imines **30**. Reduction of the imino group with sodiumborohydride produced the amino group which could then displace the halogen intramolecularly to afford the azetidines products **31** (Table 4). All the azetidines **31** were obtained in good yields (59-70%) and no significant effects of the different substituents were observed (Table 4).

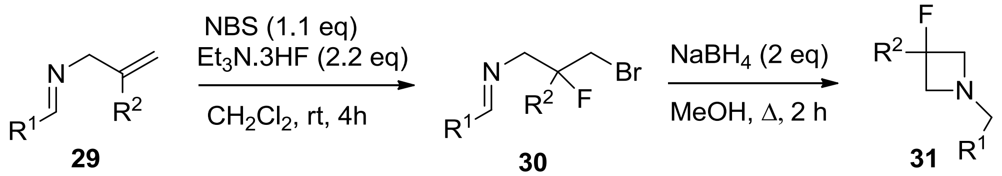


Table 4. Synthesis of 3-fluoroazetidines

entry	R^1	R^2	yield of **30** (%)	yield of **31** (%)
1	C_6H_5	Me	76	70
2	4-MeC_6H_4	Me	78	61
3	4-$MeOC_6H_4$	Me	71	65
4	$CHEt_2$	Me	68	61
5	*t*-Bu	Me	73	59
6	C_6H_5	C_6H_5	77	60

An electrophile-induced intramolecular cyclisation of homoallylic amino vinylsilanes **32** to obtain azetidines was published in 2007 by Banide and co-workers.[28] Compounds **32** were reacted with *N*-bromosuccinimide to produce the bromonium species (Figure 3), which can be attacked by the amino group to produce azetidines **33** and **34** (Table 5). Compounds **33** and **34**, with *cis* configuration, were the only products observed and there was no evidence of *trans*-azetidine formation. It might be speculated that bromine attack would occur in a concerted mechanism producing two diastereoisomers bromonium intermediates a and b which are in equilibrium with the starting material. Bromonium intermediate b would lead to the disfavoured transition state B (TS B) where the bromine, the TMS and the R groups would in fact, experience a pseudo 1,3-diaxial interaction, making the cyclisation difficult to occur. On the other hand, bromonium intermediate a would produce the favoured transition state A (TS A), where the bromine, the TMS and the R groups are in the *pseudo*-equatorial positions (Figure 3).

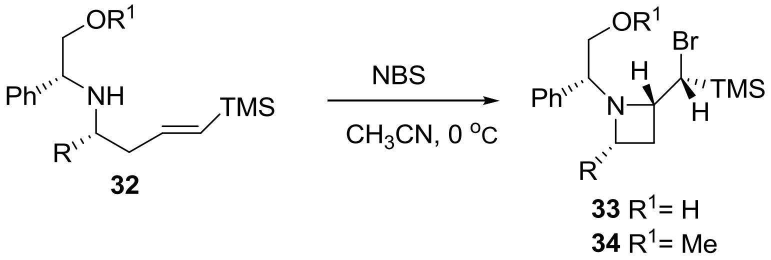


Table 5. Electrophile induced intramolecular cyclisation of amino vinylsilanes

entry	R	yield of **33** (%)	yield of **34** (%)
1	Ph	75	52
2	Pr	70	39
3	*i*Pr	55	43
4	^{t}Bu	53	66

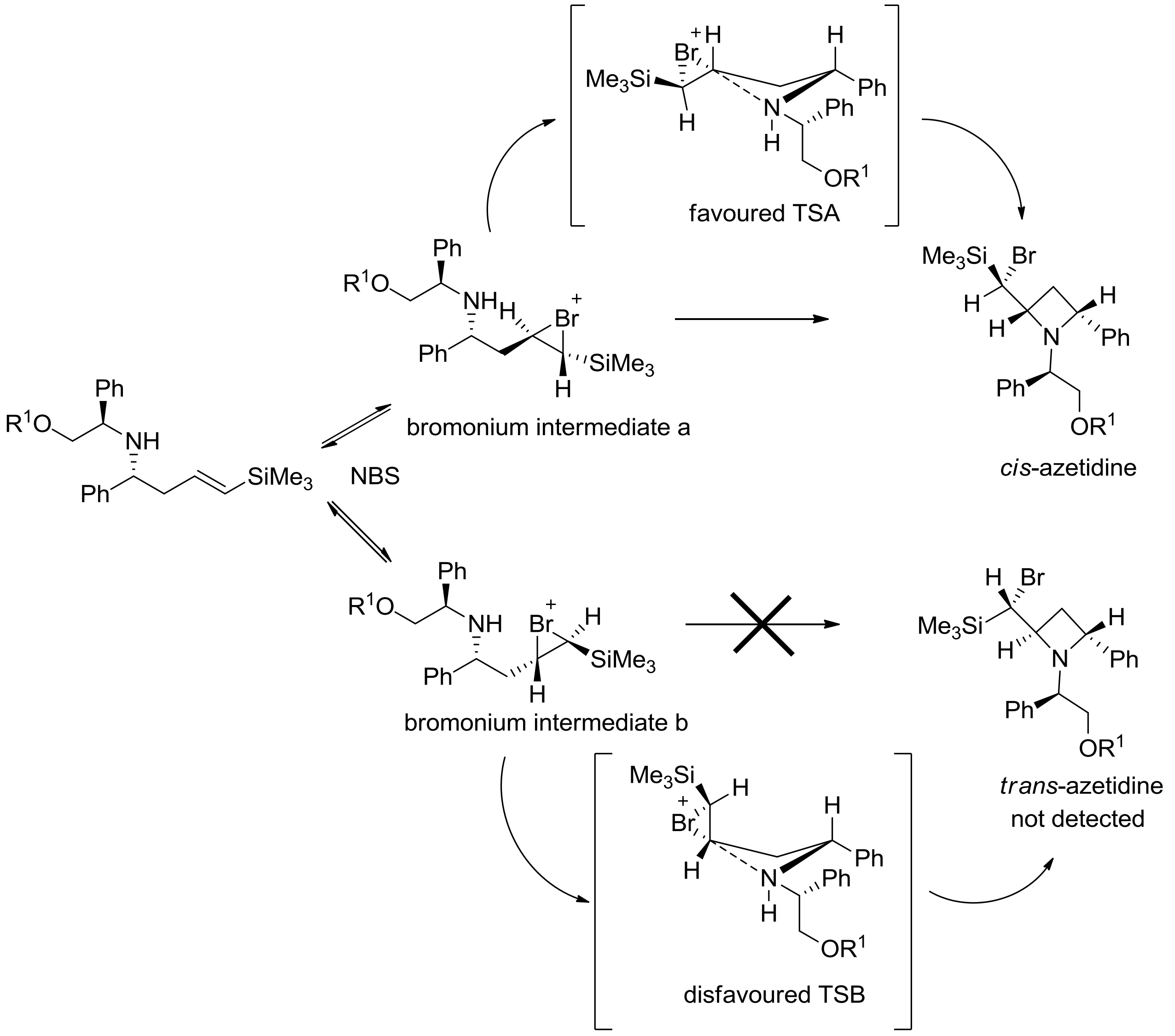


Figure 3. Bromonium intermediates a and b: favoured and unfavoured transition states.

In 2009, Medjahdi and co-workers published a base induced cyclisation, which afforded enantiopure 2-(hydroxymethyl)azetidines.[29] Enantiomerically pure oxiranes **35a-d** were reacted with potassium carbonate at 80 °C for 48 hours to provide enantiomerically pure hydroxymethyl azetidines **36a-d** in good yields (61-89%) (Table 6). The configuration of the azetidines **36a-d** depends on the configuration of the starting oxiranes **35**, considering that the intramolecular reaction between the nitrogen and the epoxide follows a S_N2 mechanism with inversion of stereochemistry.

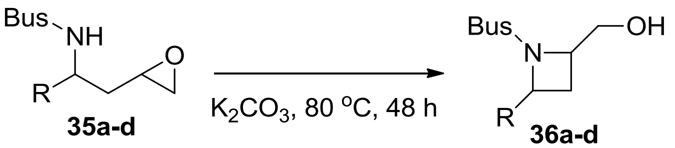
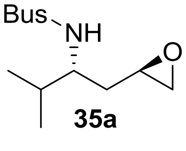
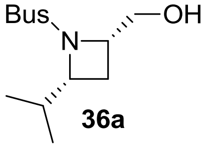
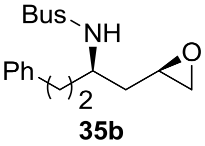
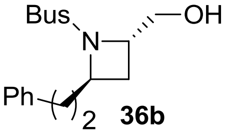
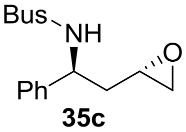
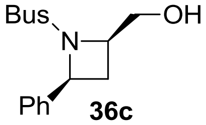
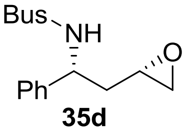
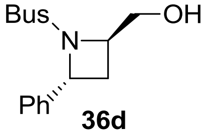
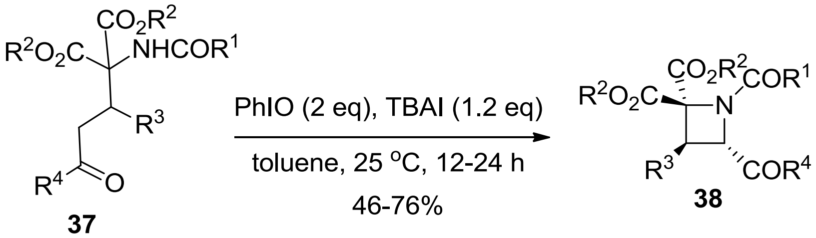


Table 6. Base induced cyclisation of enantiopure oxiranes

entry	oxirane **35**	azetidine **36**	yield of **36** (%)[a]
1	 **35a**	 **36a**	89
2	 **35b**	 **36b**	74
3	 **35c**	 **36c**	64[b]
4	 **35d**	 **36d**	61[b]

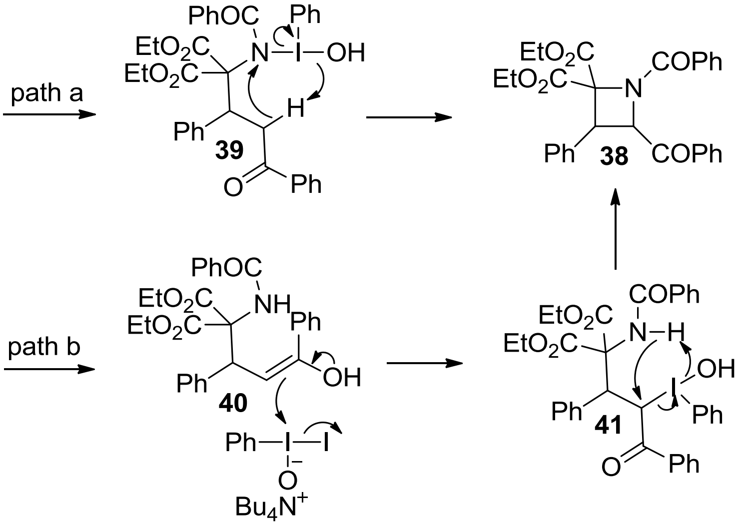
Bus = *t*-BuSO$_2$. [a]isolated yield after column chromatography. [b] pyrrolidines was also isolated as minor component

Multisubstituted azetidines **38** can be prepared in moderate to good yields (46-76%) by oxidative cyclisation of Michael adduct **37** with PhIO and Bu$_4$NI (Scheme 7).[30] Michael addition of functionalised diethyl 2-aminomalonates with chalcone in the presence of a phase transfer catalyst (PhEt$_3$NCl) furnished Michael adduct **37**.



Scheme 7. Synthesis of multisubstituted azetidines *via* PhIO/Bu$_4$NI mediated oxidative cyclisation

Two possible mechanisms (path a or b) for the formation of the azetidines were speculated as shown in (Scheme 8). Compound **37** could react with the iodine(III) species to form the intermediate **39** (path a), which might evolve to azetidine *via* intramolecular reductive elimination. Alternatively, the enol tautomer **40** could access the intermediate **41** (path b) *via* an α hyperiodination of the methylene of the phenyl ketone of compound **37** and the intermediate **41** could finally yield the azetidine **38** with a reductive elimination of PhI.



Scheme 8. Cyclisation proposed mechanism (path a or b)

Enantiopure azetidines **43**, **44** and **45** were synthesised from nitrile containing azetidine derivatives **42** by Leng *et al.* *via* a biocatalytic kinetic resolution protocol using enzyme Rhodococcus erythropolis AJ270. Nitriles **42** were converted to enantioenriched amides (matched) **43**, which were hydrolysed to the carboxylic acid (mismatched) **44**.[31] Excellent yields (42-46%) and *ee* (89.0 up to >99.5 %) were observed in all cases and the nature of the electronic substituents seemed not to be relevant for this transformation (Table 7). It is worth comparing the reaction times when Ar = 4-Br-C_6H_4 (entry 4, Table 7), Ar = 3-Br-C_6H_4 (entry 5, Table 7) and Ar = 3-Br-C_6H_4 (entry 6, Table 7). The reaction took five days to completion when Ar = 2-Br-C_6H_4 was used (entry 6, Table 7). This might be explained by steric interactions between the Br group and the active site of the enzyme where the reaction occurs.

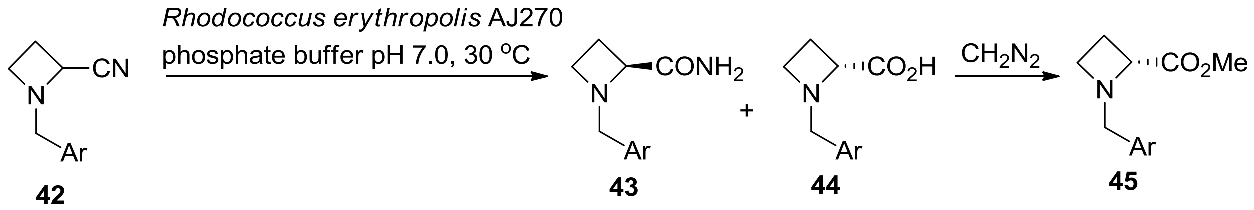


Table 7. Biocatalytic kinetic resolution of nitrile containing azetidine derivatives

entry	Ar	time (h)	yield of **43** (%)	*ee* of **43** (%)	yield of **45** (%)	*ee* of **45** (%)
1	C_6H_5	9.5	46	>99.5	49	>99.5
2	4-Me-C_6H_4	4.7	45	>99.5	39	>99.5
3	4-MeO-C_6H_4	3	45	>99.5	37	90.8
4	4-Br-C_6H_4	4.25	43	>99.5	43	89.0
5	3-Br-C_6H_4	4.75	42	>99.5	42	>99.5
6	2-Br-C_6H_4	5d	42	96.6	45	>99.5

Synthesis of 2,3-substituted azetidines *via* CH activation of picolinamide substrates **46a-f** by palladium acetate was published by Gang He *et al.* in 2011.[32] Several picolinamide substrates were first reacted with 5% mol of $Pd(OAc)_2$ and then with 2.5% mol of $PhI(OAc)_2$ to afford azetidines **47a-f** in 68-91% yields (Table 8). The presence of α and β substituents on the picolinamides seemed to favour the formation of azetidines (entry 1,2,4,5,6, Table 8), whereas the picolinamide substrate, with no β substituent appended, converted mainly to the acetoxylated product **48c** (entry 3, Table 8). It was speculated that a possible reason for the favoured azetidine formation might be the torsional strain imposed by the R^2 substituent, which would kinetically favour the cyclisation.

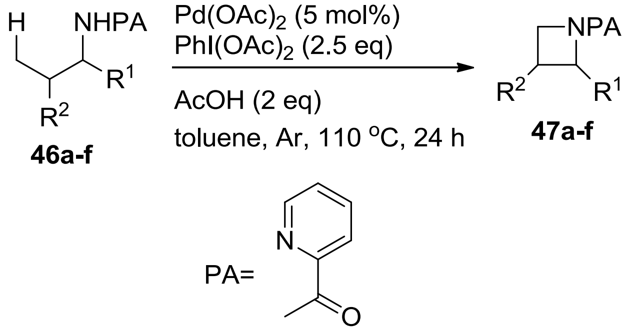
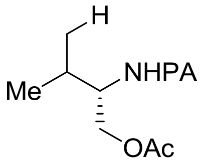
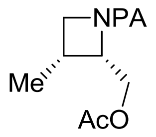
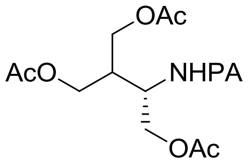
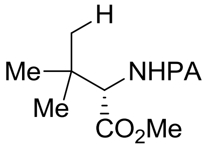
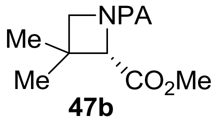
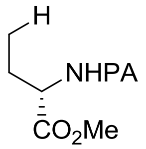
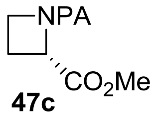
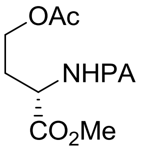
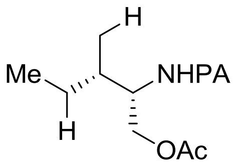
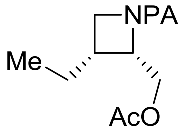
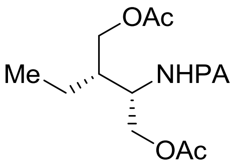
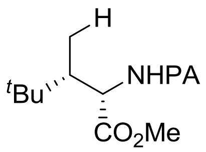
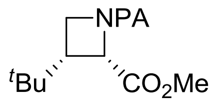
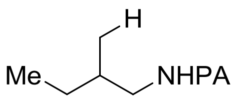
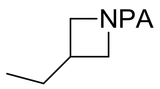
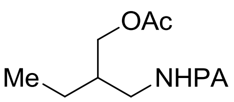


Table 8. Synthesis of 2,3-substituted azetidines *via* CH activation of different picolinamide substrates

entry	substrate	products (isolated yields)
1	 **46a**	 **47a** (82%, dr> 20:1)  **48a** (9%)
2	 **46b**	 **47b** (91%)
3	 **46c**	 **47c** (25%)  **48c** (70%)
4	 **46d**	 **47d** (70%)  **48d** (8%)
5	 **46e**	 **47e** (79%)
6	 **46f**	 **47f** (68%)  **48f** (12%)

It was hypothesised that oxidation by PhI(OAc)$_2$ of the kinetically favoured five membered palladacycle intermediate **49**[33] (Figure 4) followed by a C-N reductive elimination might be the possible mechanism of the reaction.

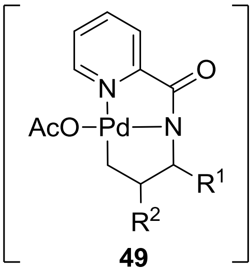
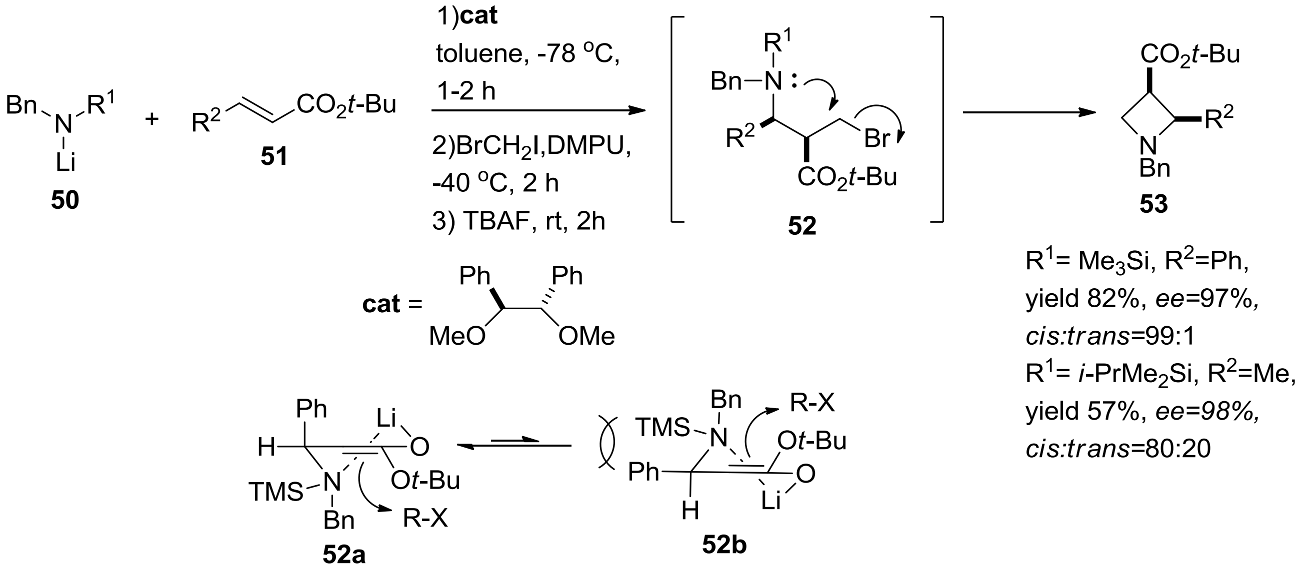


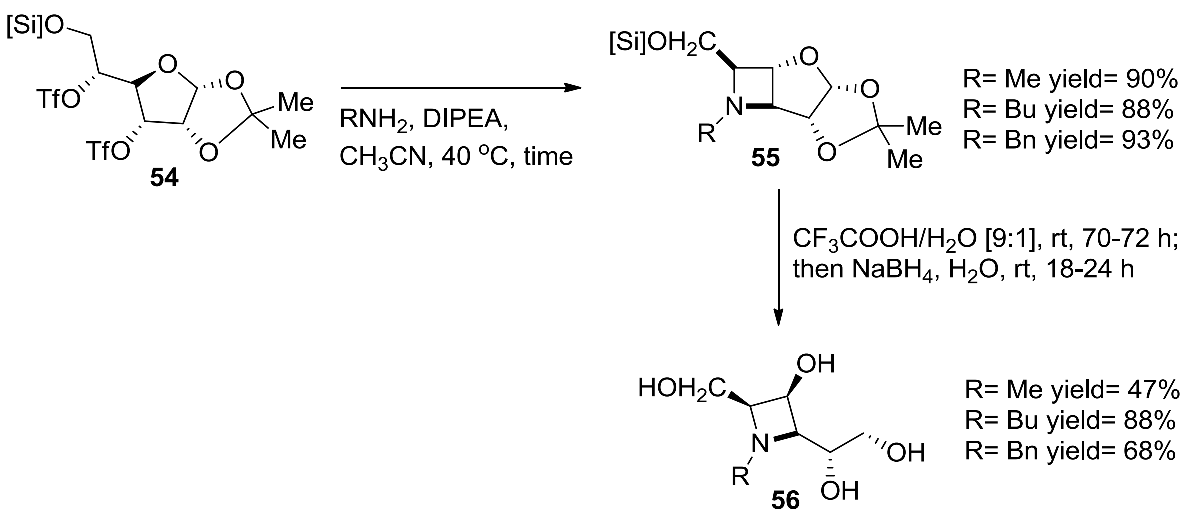
Figure 4. Five membered palladacycle intermediate

The synthesis of enantioenriched 2,3-substituted azetidines was reported by Harada *et al.* in 2012.[34] A one pot [*N*+2+*1*] cyclisation using lithium amides **50**, α-β unsaturated esters **51** and dihaloalkane, furnished 2,3-*cis*-azetidines **53** in good yields (57% and 82%) and excellent *ee* (98% and 97%) (Scheme 9). The intermediates **52** were formed in excellent *ee* with no difference when diverse R^1 and R^2 groups were used. This occurred due to the formation of the most kinetically favoured species **52a**, where the bulky groups are pointing away from one another (Scheme 9). Intramolecular halogen displacement by the nitrogen leads to the formation of the products with the best diastereoselectivity (*cis*:*trans* = 99:1) obtained when R^1 = Me$_3$Si, R^2 = Ph (Scheme 9).



Scheme 9. Synthesis of enantioenriched 2,3-substituted azetidines

Azetidines containing imino sugars analogues were synthesised in 2012 by Lenagh-Snow and co-workers.[35] Ditriflate allose **54** were exposed to a bis-triflate displacement by different amines to furnish the protected azetidines **55**, which were then hydrolysed and reduced to afford the final products **56** in 47-93% yields (Scheme 10).



Scheme 10. Synthesis of azetidine containing imino sugar analogues

Azetidines can also be prepared by a selective transformation of 2-bromomethyl-2-methylaziridines as reported by Stankovic' *et al.* in 2012.[36] Several aziridines **57** were reacted with several nucleophiles such as cyanide, thiocyanide and acetate to obtain 3-substituted azetidines **59** in 92-96% yields (Table 9). A mixture of products **59a** and **59b** was observed when phenate or thiocyanide was used as nucleophile (entry 5 and 6, Table 9). It was speculated that the formation of the azetidinium salt **58** followed by attack of the external nucleophile is the possible mechanism (Table 9).

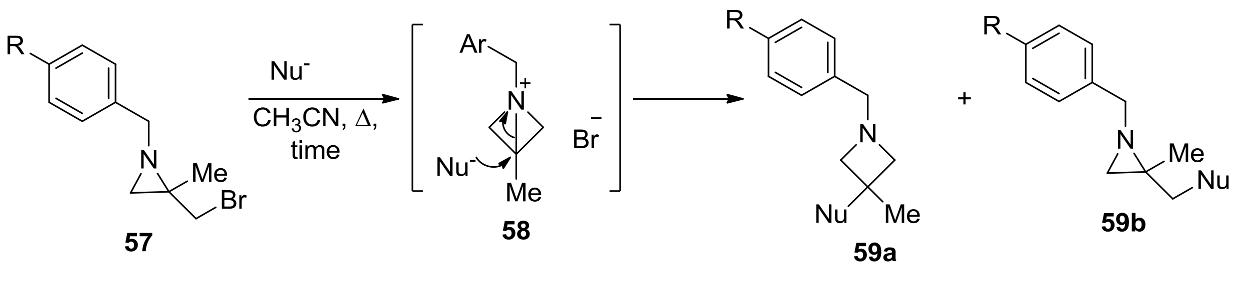
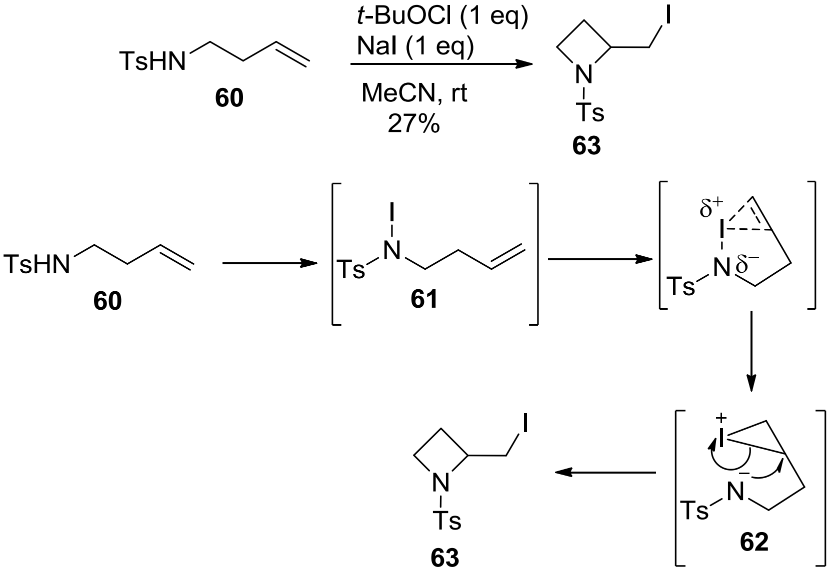


Table 9. Selective transformation of 2-bromomethyl-2-methylaziridines into 3 substituted azetidines

entry	R	Nu	time (h)	ratio **59a**: **59b**	yield of **59a** or **59b** (%)
1	Me	2 eq KCN	26	100:0	**59a** (96)
2	OMe	2 eq KCN	26	100:0	**59a** (95)
3	Me	1.1eq NaOAc	24	100:0	**59a** (95)
4	OMe	1.1eq NaOAc	22	100:0	**59a** (92)
5	Me	1 eq KSCN	4	57:43	**59a** (55)
6	Me	2.2 eq PhOH, 5 eq K_2CO_3	20	57:43	**59a** (47)

2-substituted iodo-azetidine **63** can be prepared by cyclisation of the homoallylic tosylamine **60** with *tert*-butylhypoiodite (Scheme 11). Compound **61** can be produced *via* iodination by *t*-BuOI of the sulfonamide nitrogen of compound **60**. Iodonium ion can be intramolecularly transferred to the olefin to obtain the halonium species **62**, which can be attacked by the nitrogen to afford iodo-azetidine **63** in 27% yield (Scheme 11).[37]

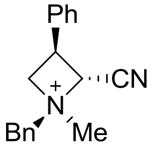
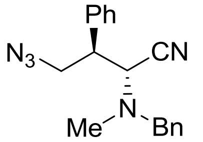
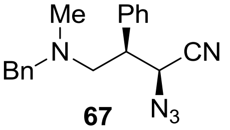
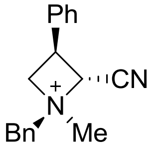
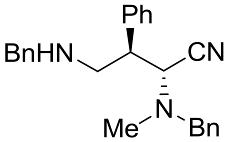
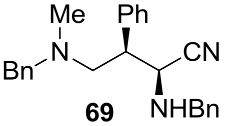
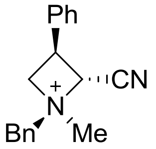
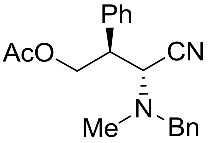
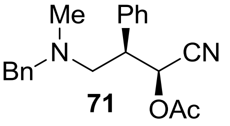
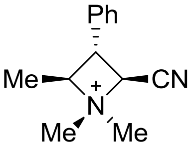
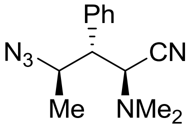
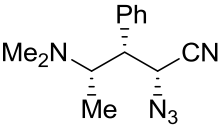
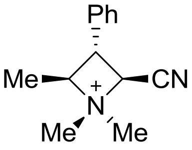
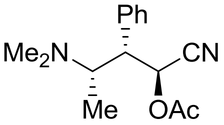
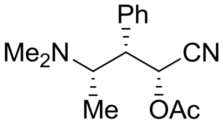


Scheme 11. Synthesis of 2-substituted iodoazetidine

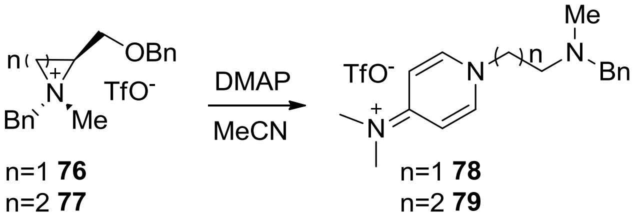
1.1.2 Reactivity of azetidinium ions

In 2006, Couty and co-workers investigated the regioselectivity in nucleophilic ring opening of azetidinium ions.[38] Differently substituted azetidinium salts **64** and **67** were reacted with oxygenated and nitrogenated nucleophiles. Azetidinium salt **64** with substituents in position two and three were mostly attacked on the C4 carbon (entry 1,2,3, Table 10). On the other hand azetidinium salt **65** with an added methyl group in position four was mainly attacked on C2 (entry 4,5, Table 10). An optimised transition state, obtained with computational studies, showed the shielding effect of the methyl group in position four distorts the angle of attack of the nucleophile from the ideal 180° to 167° making the C4-attack more difficult to occur.

Table 10. Regioselectivity in nucleophilic ring opening of azetidinium ions

entry	substrate	nucleophile	Products			yield (%)
			C4-attack		C2-attack	
1	 **64**	NaN_3	 **66**	+ 82:18	 **67**	quant.
2	 **64**	$BnNH_2$	 **68**	+ >98:2	 **69**	89
3	 **64**	AcONa, DMF	 **70**	+ >98:2	 **71**	quant.
4	 **65**	NaN_3	 **72**	+ >2:98	 **73**	27
5	 **65**	AcOCs, DMF	 **74** (78) +  **75** (22)			91

In 2011, De Rycke and co-workers investigated the rates of aziridinium **76** and azetidinium **77** opening.[39] DMAP was chosen as a suitable nucleophile to probe reactions with aziridinium and azetidinium trifuolomethane sulfonates (Scheme 12). The kinetics of nucleophilic opening of the aziridinium salts were followed by UV spectrophotometry, whereas the kinetics of nucleophilic opening of the azetidinium salts, being a much slower process, were followed by NMR spectroscopy. The difference in rates corresponded to a $\Delta\Delta G^{\#}$ of 5.6 Kcal x mol^{-1} at 293 K.



Scheme 12. Aziridinium and azetidinium ring opening by DMAP

A regiospecific ring opening of azetidinium salts was studied by Kenis *et al.* in 2012.[40] 2-trifluoromethyl azetidines **80a-d** were reacted with Me_3OBF_4 to afford the corresponding azetidinium salts **81a-d** in quantitative yields. Compounds **81a-d** were then ring opened by oxygen, nitrogen, carbon and sulphur nucleophiles and in all cases these non activated 2-CF_3 azetidines were opened at C4 affording compounds **82a-d** in 52-88% yields (Table 11).

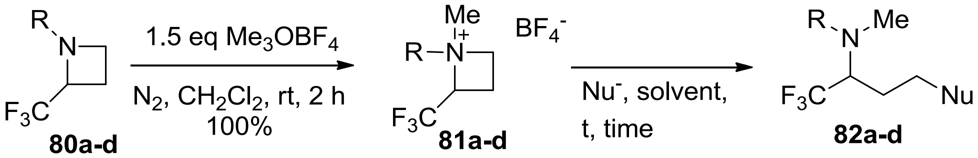
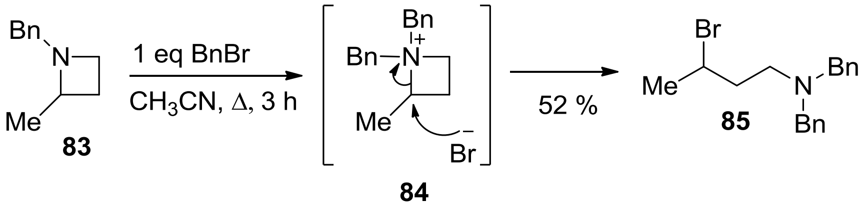


Table 11. 2-trifluoromethyl azetidinium ring opening

entry	R	nucleophile	conditions	yield of **82** (%)
1	4-$MeC_6H_4CH_2$	2 eq NaCN	CH_3CN, Δ, 3 h	74
2	4-$ClC_6H_4CH_2$	2 eq NaCN	CH_3CN, Δ, 3 h	78
3	4-$MeC_6H_4CH_2$	-	H_2O/CH_3CN (1/1), Δ, 24 h	72
4	2-$ClC_6H_4CH_2$	-	H_2O/CH_3CN (1/1), Δ, 24 h	88
5	4-$MeC_6H_4CH_2$	2 eq PhSH	CH_3CN, Δ, 3 h	64
6	2-$ClC_6H_4CH_2$	2 eq PhSH	CH_3CN, Δ, 3 h	63
7	Bn	2 eq $BnNH_2$	CH_3CN, rt, 2 h	56
8	2-$ClC_6H_4CH_2$	2 eq $BnNH_2$	CH_3CN, rt, 2 h	52

A complete switch of the reactivity was observed when the CF_3 substituent was replaced by a methyl group (compound **83**). 2-methyl-azetidine **83** was reacted with one equivalent of benzyl bromide to form the intermediate azetidinium salt **84** which was ring opened by the bromide to furnish compound **85** in 52% yield. Attack of the nucleophile occurred at the C2 under thermodynamic control (Scheme 13) in line with some literature reports regarding 2-substituted aziridinium salts ring opening.[41-42] The strong electrowithdrawing nature of the CF_3 group disfavours the attack at the more substituted carbon, destabilising the required accumulation of positive charge on the carbon in the alpha position.[43]



Scheme 13. 2-methyl azetidinium ring opening

1.1.3 Application of azetidines as ligands in catalysis

In 2001, Hermsen and co-workers studied the addition of diethylzinc to aldehydes **86** using chiral N,O-ligands containing azetidine fragments (Table 12).[44] 1-phenylpropan-1-ol and 1-(4-methoxyphenyl)propan-1-ol **87** were obtained in good yields and *ee* up to >99% when ligand **88** was used (entry 1 and 5, Table 12). Use of ligand **90** improved the *ee* to 95% (entry 3, Table 12), whereas when ligand **89** was employed the *ee* decreased to 35% (entry 2, Table 12) due to a case of match/mismatch. One can see that when pyrrolidine **91** was used the *ee* resulted to be lower (entry 4 & 6, Table 12) than when azetidine analogue **88** was used (entry 1 & 5, Table 12). This shows that the four membered ring allows a more effective chiral environment compared to the five membered ring.

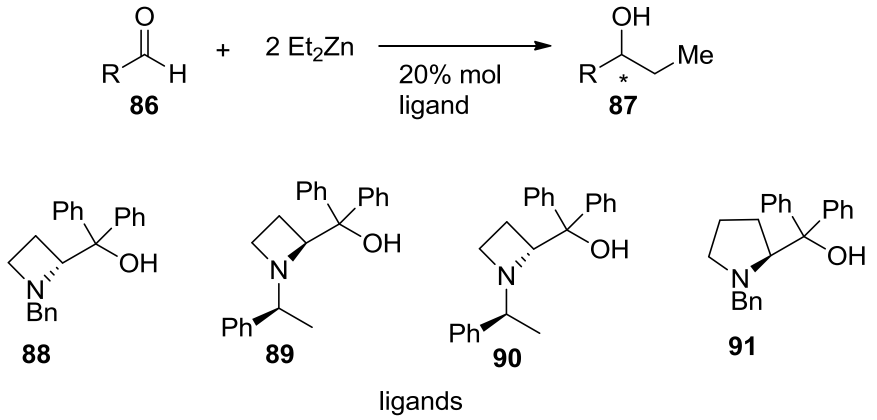
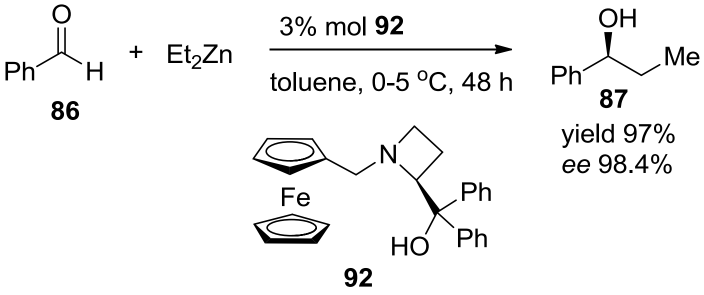


Table 12. Chiral N,O-ligands containing azetidine fragments for the addition of diethylzinc to aldehydes

entry	Aldehyde	ligand	yield of **87** (%)	*ee* of **87** (%)	configuration of **87**
1	Benzaldehyde	**88**	62	88	*R*
2	Benzaldehyde	**89**	75	35	*S*
3	Benzaldehyde	**90**	85	95	*R*
4	Benzaldehyde	**91**	92	72	*S*
5	Anisaldehyde	**88**	91	>99	*R*
6	Anisaldehyde	**91**	94	79	*S*

The ligand **88,** which was found to be the best in terms of *ee* in the addition of diethylzinc to aromatic aldehydes, was also used with aliphatic aldehydes showing good yields and *ee*. In particular when cyclohexanecarboxyaldehyde was used, the corresponding alcohol was obtained in 80% yield and 97% *ee* with (*R*) configuration. In 2008, Wang *et al.* reported a slightly modified version of the Hermsen ligand. A ferrocenylmethyl group was attached to the nitrogen. The yield and the *ee* were improved respectively up to 97% and 98.4% when diethylzinc was added to benzaldehyde **86** in presence of ligand **92**. Ligand load was also decreased to 3% mol against the 20% mol previously used with Hermsen ligand (Scheme 14).[45]



Scheme 14. Chiral N,O-ligands containing ferrocenylmethyl azetidine fragments for the addition of diethylzinc to aldehydes

The same reaction employing a chiral ferrocenyl aziridino alcohol as ligand was already tested by the same group.[46] The improvement in the *ee*, from 92.6%, when the aziridine based catalyst was used, to 98.4% when the azetidine based catalyst was used, was explained by considering the more pronounced steric interactions between the hydrogen and the phenyl group in the smaller 3-membered ring as shown in (Figure 5).

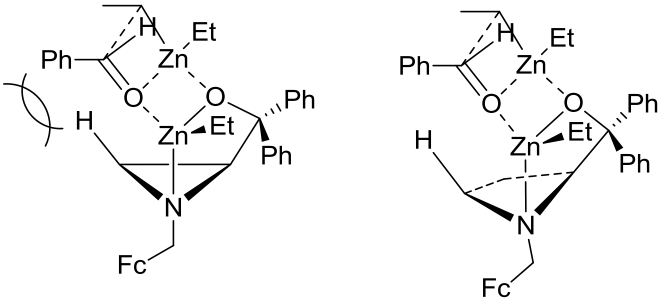


Figure 5. More pronounced steric interactions in the aziridine based catalyst compared to the azetidine based catalyst

2,3-substituted azetidines have been used as catalysts for addition of diethylzinc to benzaldehyde to furnish 1-phenylpropan-1-ol (Henry reaction) in good yield and *ee* (Table 13). Ligand **95** (entry 3, Table 13) produced the best yield 93% with an excellent *ee* = 97%. [47-48] Changing the R group from hydroxyl to amino (ligand **93**) the *ee* drops down to 53% (entry 1, Table 13) and even more (*ee* = 1.4%) with a bulky group on the nitrogen (ligand **94**) (entry 2, Table 13).

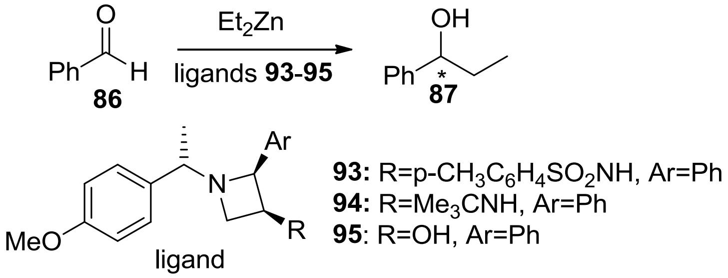
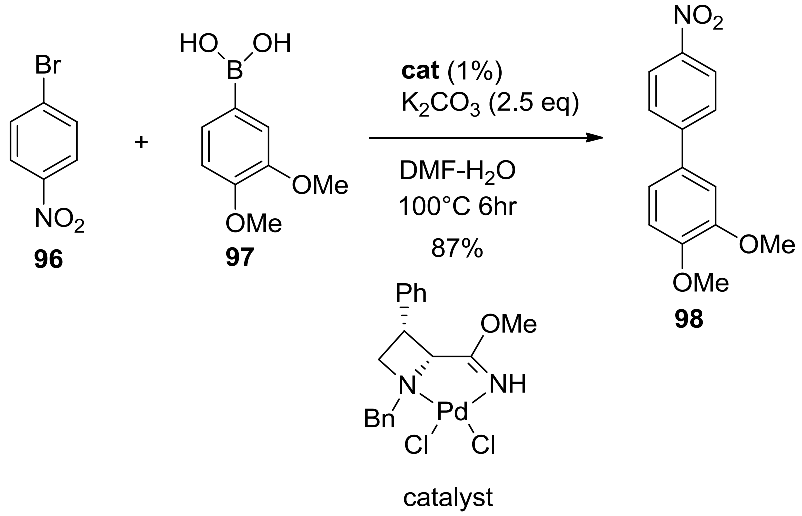


Table 13. Amino azetidines and hydroxyl azetidine as catalyst for Henry reaction

entry	solvent	Ar	ligand	yield of **87** (%)	*ee* of **87** (%) (config)
1	toluene	Ph	**93**	100	53 (*R*)
2	toluene	Ph	**94**	47	1.4 (*S*)
3	toluene	Ph	**95**	93	97 (*R*)

In 2005, Keller and co-workers used azetidines as ligands for the first time in Suzuki cross-coupling reactions. This catalytic system based on palladium and amino azetidine derivative ligands showed good efficiency in aromatic bromide substrates. 1-bromo-4-nitrobenzene **96** and (3,4-dimethoxyphenyl)boronic acid **97** were reacted in the presence of 2.5 equivalents of potassium carbonate and 1% mol of palladium amino-azetidine catalyst to yield the product **98** in 87% yield. It was also found that a very low catalyst loading 0.1% mol still shows a good conversion of 87% (Scheme 15).[49] If one considers that according to the literature the general amount of catalyst loaded in Suzuki cross-coupling reactions is between 0.1 and 1% mol,[50] it is clear that this new palladium amino-azetidine complex catalyst proved to be very suitable for this type of reaction.



Scheme 15. Palladium amino azetidine complex as catalyst for Suzuki cross-coupling reaction

In 2010, Couty and Menguy reported the use of amino-azetidines and amino-pyrrolidines as organocatalysts for a Michael addition reaction.[51] 2,3,4-substituted amino-azetidines **99-106** and 2,3,4,5-substituted amino-pyrrolidines **107-109** (Figure 6) were initially screened to find the best catalyst in terms of yield and *ee* in the addition of diethyl malonate **111** to β-nitrostyrene **110** (Scheme 16).

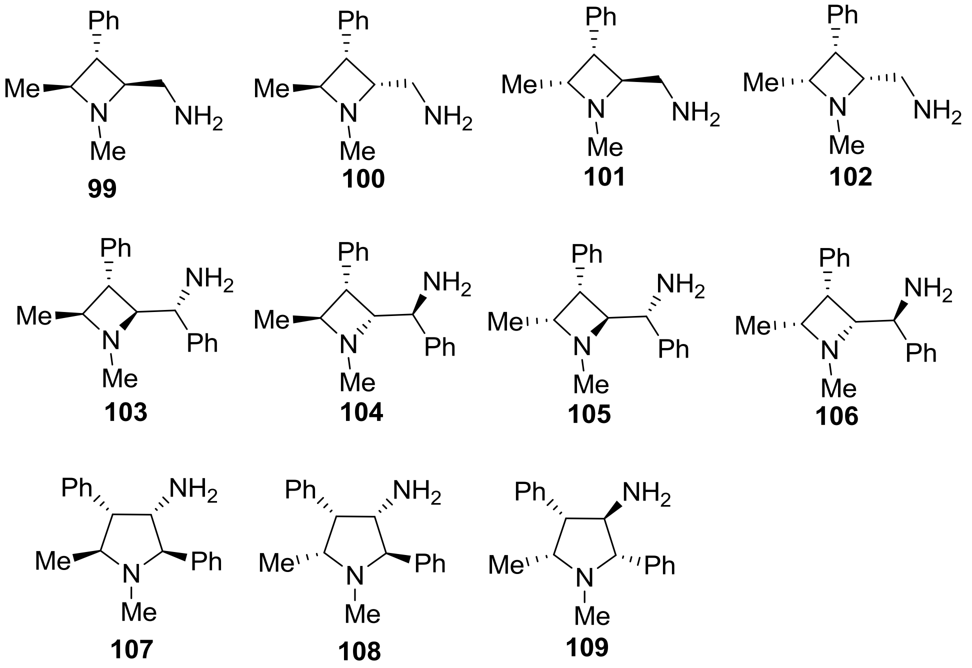
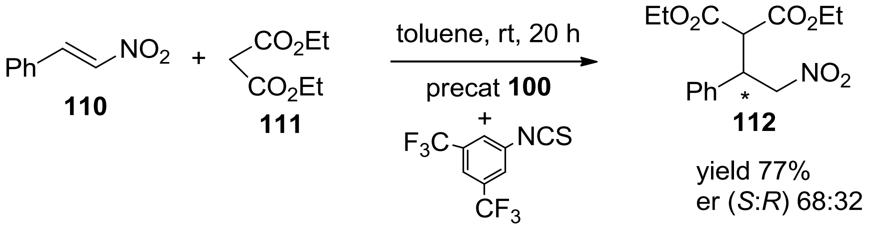


Figure 6. 2,3,4-substituted Amino azetidines and 2,3,4,5-substituted amino pyrrolidines as precatalyst for Michael addition

The catalyst was prepared in *situ* by stirring the corresponding amino-azetidine or amino-pyrrolidine with 3,5-bis trifluoromethyl isothiocyanate in toluene at room temperature for 15 minutes. No formation of the product was observed when amino-pyrrolidines **107-109** were used. The best result was obtained when azetidine **100** was employed yielding the product **112** in 77% yield and 68:32 (*S*:*R*) enantiomeric ratio (er).



Scheme 16. Michael addition of diethyl malonate to β-nitrostyrene

Different nucleophiles such as malononitrile, acetylacetone and Meldrum's acid were added to β-nitrostyrene **110** and the best result was achieved when acetylacetone was used. The product was obtained in 63% yield and 12:88 (S:*R*) er (entry 1, Table 14). The enantiomeric ratio (*S*:*R*) increased to 90:10 (entry 2, Table 14) when (*E*)-1-(2-nitrovinyl)naphthalene was used as Michael acceptor. The presence of ortho-substituted benzene rings in the Michael acceptor also increased the enantiomeric ratio (*S*:*R*) to 8:92 (entry 3, Table 14) and 7:93 (entry 4, Table 14) despite the electronic nature of the substituents. This improvement in the enantiomeric ratio might be explained by considering possible steric interactions caused by the substituent in the ortho position. Such interactions might perhaps disfavour the formation of the (*R*) enantiomer. The presence of para-substituted or meta-substituted benzene rings in the Michael acceptor slightly decreased the enantiomeric ratio (*S*:*R*) to 17:83 (entry 5 and 6, Table 14).

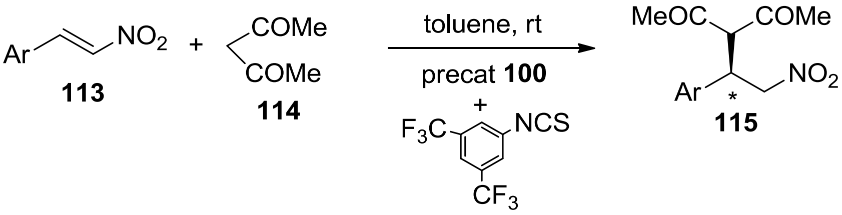
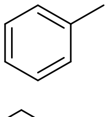
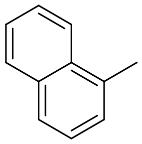
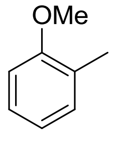
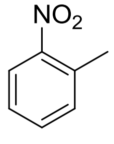
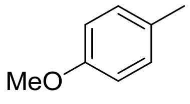
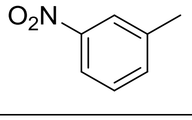
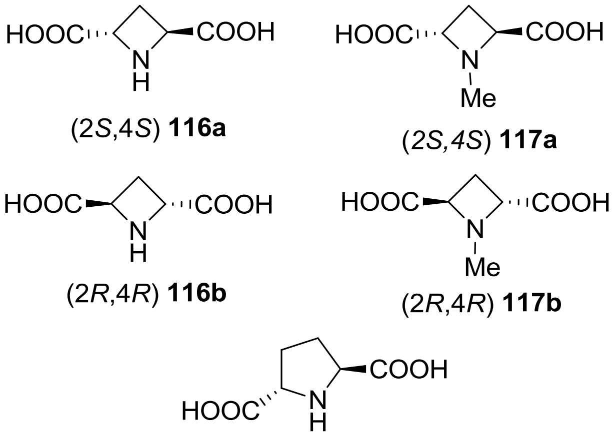


Table 14. Addition of acetylacetone to different nitrostyrenes

entry	Ar	time (h)	yield (%)	er (*S*:*R*)
1		6	63	12:88
2		24	74	10:90
3		24	78	8:92
4		24	67	7:93
5		24	79	17:83
6		24	79	17:83

1.1.4 Azetidines: Biological applications

The azetidine core has played an important role in the design of novel molecules with potential uses in medicinal chemistry. Activation of metabotropic glutamate receptors is responsible for an increase in level of calcium ions in the extracellular area.[52-53] This increase in concentration of calcium ions results in a delayed cell death.[54] In 1993, a study of *trans*-azetidines-2,4-dicarboxylic acid and their *N*-methyl derivatives as activators of metabotropic receptors was reported by Kozikowsky *et al.*[55] Hydrolysis of phosphoinositide (PI), which is activated by glutamate and so related to the glutamate receptors, was measured to investigate the activity of the azetidines. It was found that the (2*S*,4*S*)-*trans* azetidine **116a** produced an increase in phosphoinositide hydrolysis whereas the (2*R*,4*R*)-*trans* isomer **116b** proved to be inactive. The *N*-methyl azetidines derivatives **117a**, **117b** and the racemic *trans*-pyrrolidine-2,5-dicarboxylic acid **118** were inactive (Figure 7).


(2*S*,4*S*) **116a**

(2*S*,4*S*) **117a**

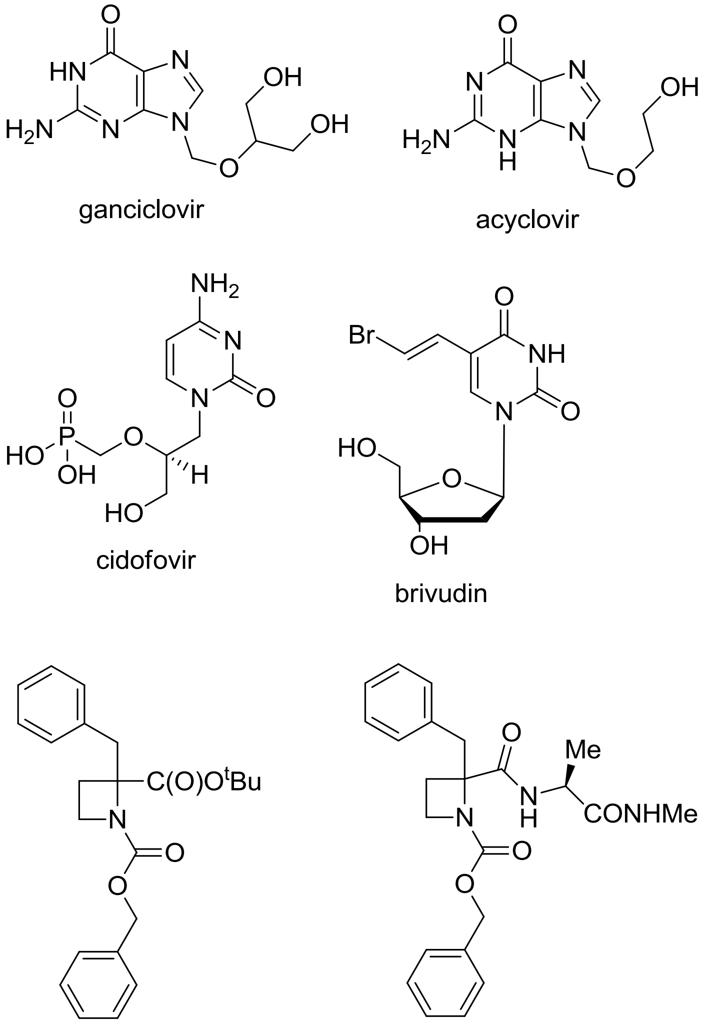
(2*R*,4*R*) **116b**

(2*R*,4*R*) **117b**

118

Figure 7. *trans*-azetidines-2,4-dicarboxylic acid, their *N*-methyl derivatives and *trans*-pyrrolidine-2,5-dicarboxylic acid as activators of metabotropic receptors

In 2005, Navarro *et al.* published the synthesis of 2-azetidinones and 2-substituted azetidines which were screened against human cytomegalovirus (HCMV) protease.[56] HCMV proved to be responsible for birth defects and it was also found that kidney, liver, bone marrow and heart/lung transplant recipients are affected by HCMV hepatitis and pneumonia.[57] To investigate the activity against HCMV, the 2-azetidinones and 2-substituted azetidines were compared to the already licensed compounds ganciclovir, cidofovir, acylclovir, brivudin (Figure 8).[58]



119 **120**

Figure 8. Human cytomegalovirus (HCMV) protease inhibitors

Azetidines showed a better activity than azetidinones which proves non covalent inhibition works successfully. This result was in line with the literature considering that for serine protease inhibitors, it was accepted that non covalent inhibitors are preferred to the covalent ones.[59] Among all the molecules tested, compounds **119** and **120** showed the best activity against HCMV. It was claimed that the presence of the NHMe group instead of NH_2 resulted in an enhancement of the activity, probably due to the increase in the hydrophobic nature of the molecule (Figure 8). Depressive disorder is caused by an insufficiency of monoamine neurotransmitters in the brain and inhibition of the reuptake could maintain the concentration of neurotransmitters at the right level. In 2012, Han and co-workers reported a study of novel 3-substituted azetidine derivatives as triple reuptake inhibitors.[60] All the azetidines synthesised were screened against dopamine, noripenephrine and serotonine transporters (HEK-hDAT, HEK-hNET, HEK-hSERT) and compared to the commercially available fluoxetine, nisoxetine and vanoxerine (GBR12909). The biological screening revealed some important aspects: the bulkiness of the substituent at the oxygen (R^2) and the napthyl as R^1 seemed to have an effective role. In particular it is worth noting that activity increased significantly when $R^1 = C_6H_4(4\text{-Cl})$ was replaced with $R^1 = C_6H_3(3,4\text{-Cl})$ (Figure 9). The azetidine with $R^1 = C_{10}H_7$ and $R^2 = C_6H_5$ exhibited even higher activity than the commercially available inhibitors .

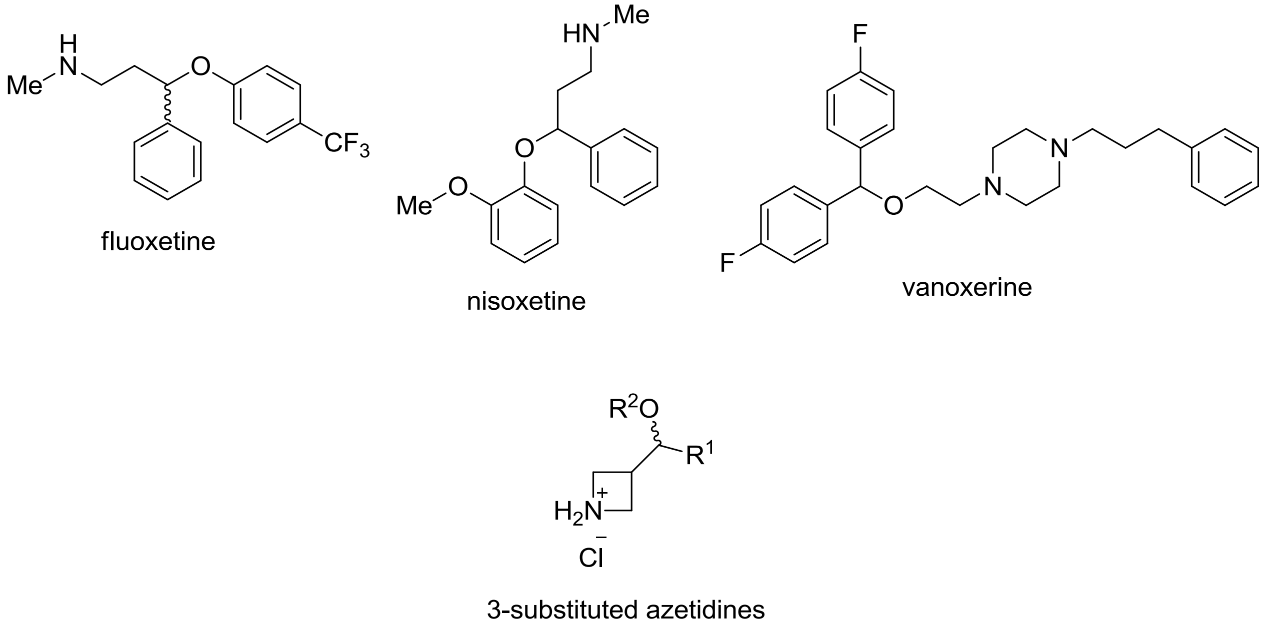
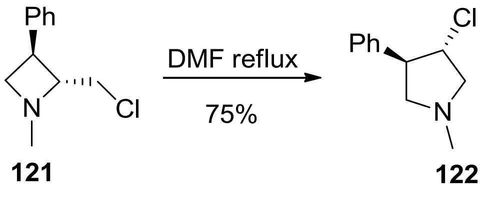


Figure 9. Triple reuptake inhibitors

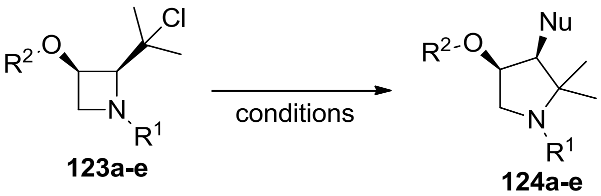
1.1.5 Ring expansion

In 2003 Couty and co-workers showed a stereoselective rearrangement of azetidine into pyrrolidine. Chloro-azetidine **121** was stereoselectively converted into the corresponding chloro-pyrrolidine **122** in 75% yield (Scheme 17).[61]



Scheme 17. Stereoselective ring expansion of iodo-azetidine into iodo-pyrrolidine

A ring transformation from azetidines to pyrrolidines was reported by Van Brabandt *et al.* in 2006.[62] 2,3-substituted chloro-azetidines **123a-e** were converted into the corresponding 2,3,4-substituted pyrrolidines **124a-e** with inversion of stereochemistry in moderate yields (44-52%). Several nucleophiles were used to afford pyrrolidines functionalised in position three with useful groups such as OH, CN, N_3 (Table 15).



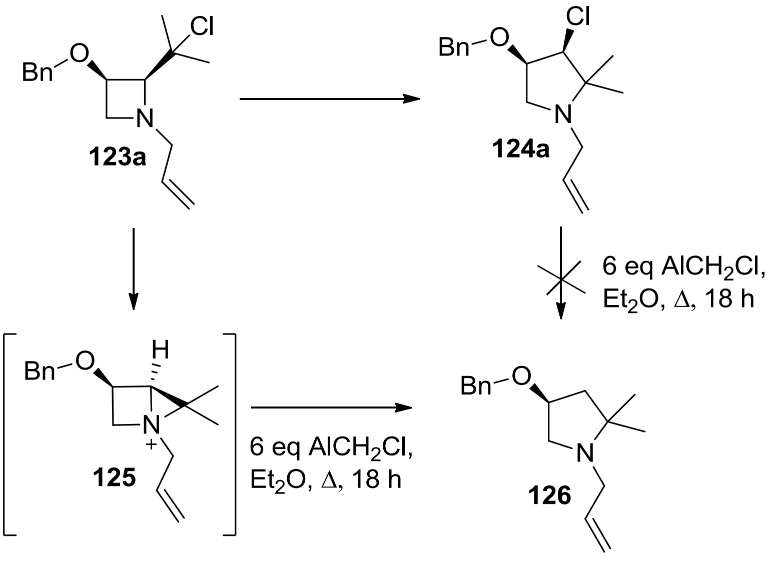
123a-e

124a-e

Table 15. Ring expansion of 2,3-substituted chloro azetidines into 2,3,4-substituted pyrrolidines

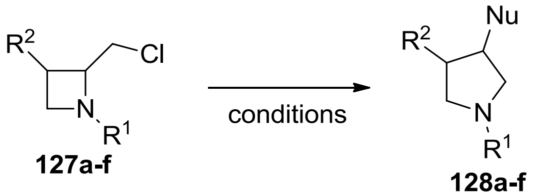
entry	R^1	R^2	conditions	Nu	yield of **124** (%)
a	allyl	Bn	Δ, CH_3CN, 18 h	Cl	46
b	allyl	Me	Δ, CH_3CN, 18 h	Cl	44
c	*t*-Bu	Bn	10 eq. NaOH, 100 °C, 18 h, DMSO	OH	46
d	allyl	Bn	10 eq. KCN, 100 °C, 18 h, DMSO	CN	44
e	allyl	Bn	10 eq. NaN_3, 100 °C, 18 h, DMSO	N_3	52

To understand the mechanism of this transformation, compounds **123a** and **124a** were both reacted with six equivalents of AlH_2Cl in diethyl ether under reflux for 18 hours. Only the chloro-azetidine **123a** yielded the product **126** showing that the formation of an aziridinium intermediate **125** is necessary to allow ring expansion of chloro-azetidines **123a** to produce pyrrolidine **126** (Scheme 18). This experiment suggested that all the transformations of azetidines **123a-e** into pyrrolidines **124a-e** occur *via* the formation of an aziridinium intermediate.



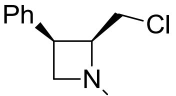
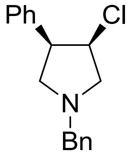
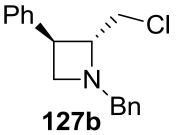
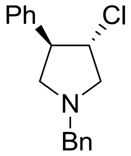
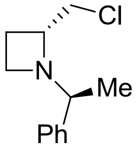
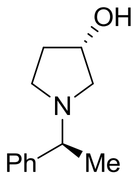
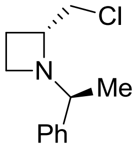
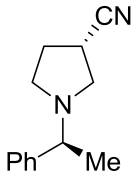
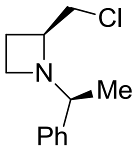
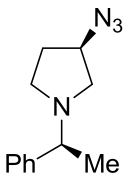
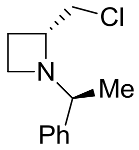
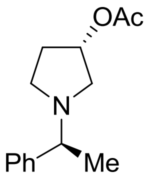
Scheme 18. Conversion of **123a** into **126** via aziridinium intermediate **125**

In 2008 Durrat and co-workers reported a stereoselective ring expansion of 2-(α-chloroalkyl)azetidines **127** into the corresponding chloro-pyrrolidines **128**.[2] *cis*-2,3-azetidines and *trans*-2,3-azetidines were refluxed in DMF for 12 hours to afford *cis*-3,4-pyrrolidine and *trans*-3,4-pyrrolidine in 39% and 75% yields. Ring expansion in the presence of an external nucleophile was also investigated. Hydroxide, cyanide, azide and acetate were added to 2-(α-chloroalkyl)azetidines **127** to afford pyrrolidines **128** in moderate to good yields (39-87%).

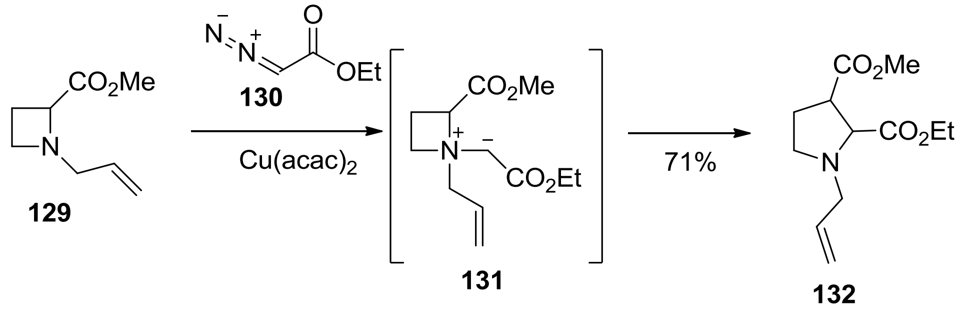


127a-f **128a-f**

Table 16. Stereoselective ring expansion of 2-(a-chloroalkyl)azetidines

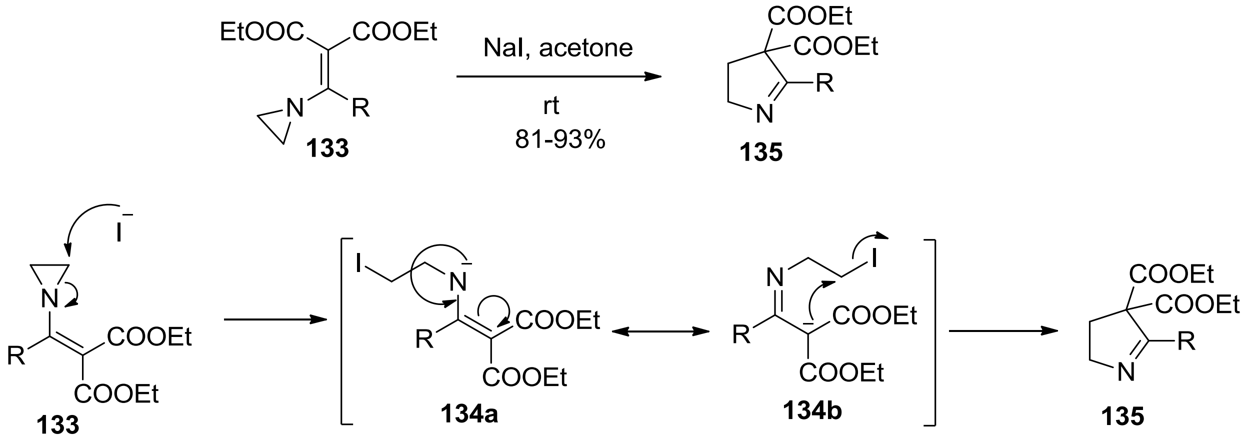
entry	substrate	conditions	product	yield of **128** (%)
1	 **127a**	DMF, reflux, 12 hours	 **128a**	39
2	 **127b**	DMF, reflux, 12 hours	 **128b**	75
3	 **127c**	DMSO KOH 40 °C, 48 h	 **128c**	39
4	 **127d**	DMSO KCN 70 °C, 72 h	 **128d**	77
5	 **127e**	DMSO NaN$_3$ 50 °C, 72 h	 **128e**	87
6	 **127f**	DMSO NaOAc 50 °C, 72 h	 **128f**	68

Another example of azetidine ring expansion was illustrated by Bott and co-workers in 2009.[63] 2-substituted azetidine **129** was reacted with diazocarbonyl compound **130** in the presence of a catalytic amount of $Cu(acac)_2$ to produce the intermediate azetidinium ylide **131** which could rearrange to the pyrrolidine **132** *via* Stevens [1,2]-shift (Scheme 19).[64-66] No stereoselectivity was observed and the product was obtained in 71% yield.



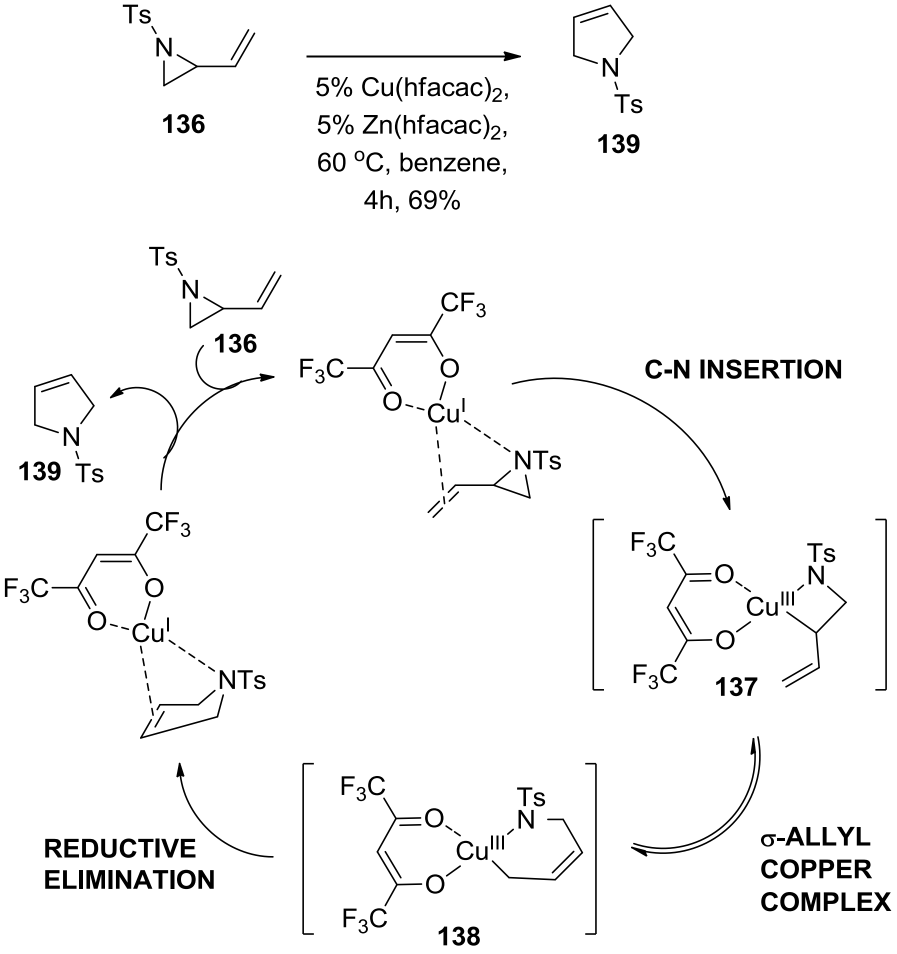
Scheme 19. Azetidine ring expansion via Stevens [1,2]-shift

N-vinyl aziridines **133** can be converted to substituted 3,4-dihydro-2H-pyrrole-4,4-dicarboxylates **135** in very good to excellent yields (81-93%) *via* ring expansion promoted by sodium iodide.[67] Iodide can ring open the aziridine to produce the intermediate **134** which can displace iodine to afford the product **135** (Scheme 20). It was observed that the reaction rate decreased when an aryl group with electrowithdrawing groups was present at the α-carbon (R = Ar) as opposed to an alkyl group. This could be explained by considering that the presence of electrowithdrawing groups might reduce electron density on the methylene carbon of diethyl malonate.



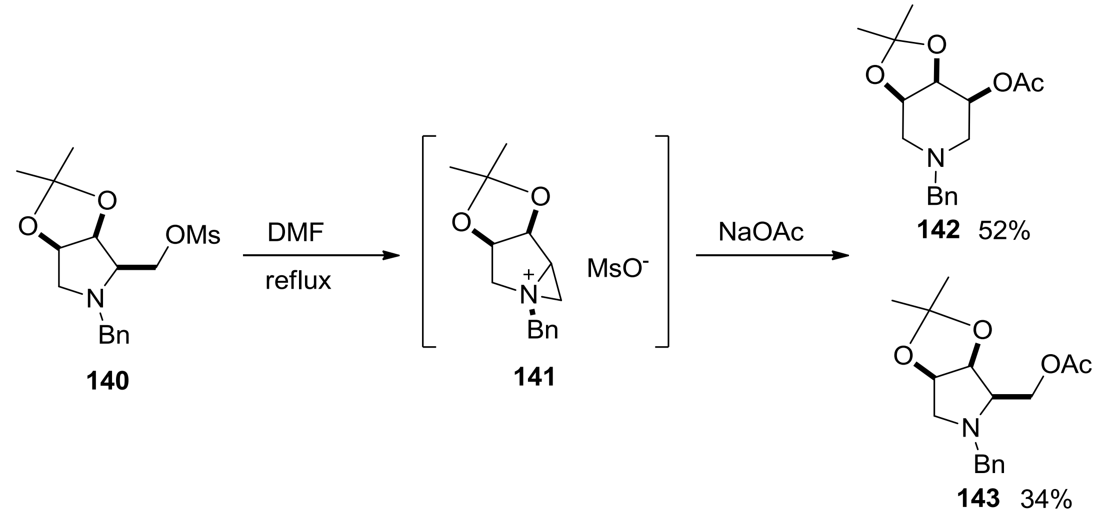
Scheme 20. *N*-vinyl aziridine ring expansion promoted by sodium iodide

A ring expansion of vinyl aziridine was studied by Mack *et al.* in 2012. 1-tosyl-2-vinylaziridine **136** was converted to 1-tosyl-2,5-dihydro-1H-pyrrole **139** in 69% yield using 5% of Cu(hfacac)$_2$ and 5% of Zn(hfacac)$_2$ in benzene at 100 ^{o}C for four hours. It was postulated that the copper is chelated in a tethraedral mode to form an σ-allyl four-membered ring copper(III) metallocyclic intermediate **137** which is able to isomerise to six-membered ring **138** and finally undergo reductive elimination process to produce the product **139** (Scheme 21).[68]



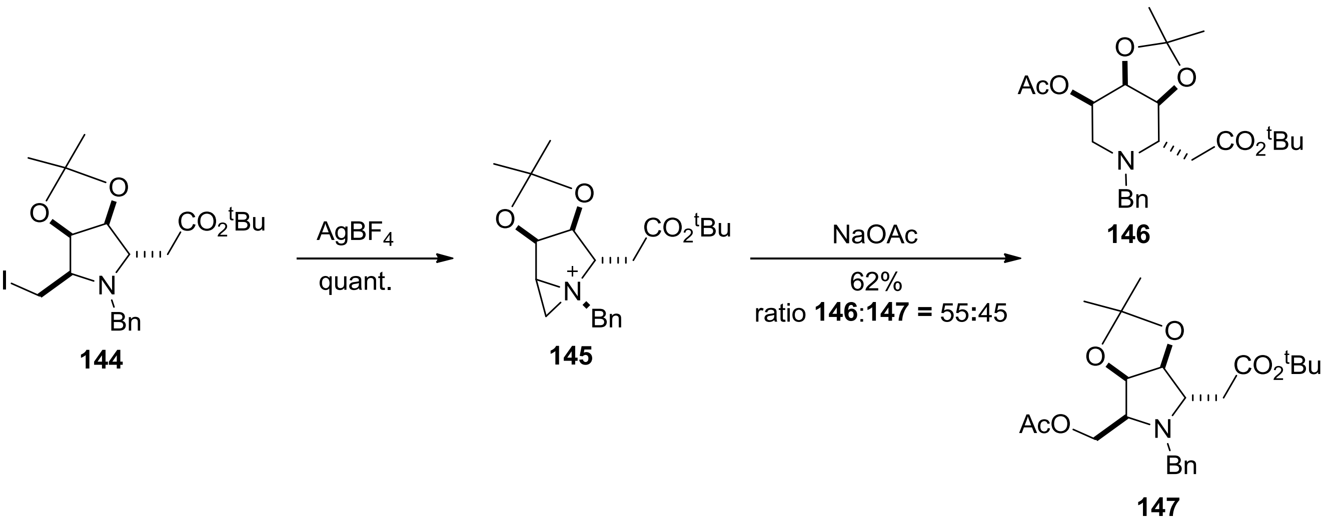
Scheme 21. Ring expansion of 1-tosyl-2-vinylaziridine to 1-tosyl-2,5-dihydro-1H-pyrrole

Ring expansion of pyrrolidine **140** to piperidine **142** was published by Kim and co-workers in 1996. 1-benzyl-2-(methyl-sulfonyloxymethyl)pyrrolidine **140** was refluxed in DMF for 30 minutes in the presence of acetate to afford a mixture of compounds **142** and **143** in 52 and 34% yields, respectively.[69] It was speculated that aziridinium salt **141** might be the possible intermediate which could be ring expanded *via* a S$_N$2-type attack by the acetate (Scheme 22).



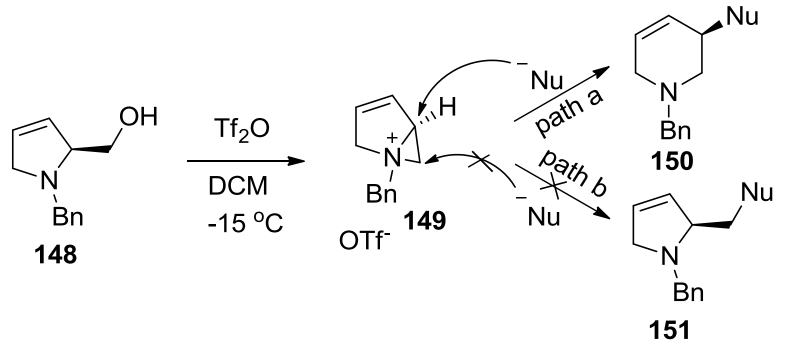
Scheme 22. Ring expansion of through aziridinium formation to piperidine reported by Kim and co-workers

Davies *et al.* reported a five (pyrrolidine) to six (piperidine) membered ring expansion reaction which involves an aziridinium salt formation. Iodo-pyrrolidine **144** was reacted with silver tetrafluoroborate to produce the intermediate **145** which was first isolated and characterised by single crystal X-ray diffraction, and secondly reacted with acetate to give a 55:45 mixture of compounds **146** and **147** (Scheme 23).[70]



Scheme 23. Ring expansion of through aziridinium formation to piperidine reported by Davies *et al.*

Jarvis and co-workers utilised an aziridinium ring expansion to synthesise enantiopure substituted piperidines **150**.[71] Pyrrolinol **148** was reacted with triflic anhydride to produce the aziridinium salt intermediate **149** which could undergo ring expansion *via* nucleophilic attack by different nucleophiles. The piperidine **150** was the only product observed and the possible pyrroline product **151** was not detected. It was theorised that the double bond might be capable of activating the allylic position (path a) reducing the attack at the least hindered position (path b) (Scheme 24).



Scheme 24. Ring expansion of aziridinium salt by selective nucleophilic attack at the homoallylic carbon

1.2 Pyrrolidine

The pyrrolidine core is found naturally in the leaves of tobacco and carrots. The pyrrolidine fragment is also present in many alkaloyds such as nicotine, hygrine and racetam compounds such as piracetam and aniracetam. Pyrrolidine is part of the structure of the amino acid proline and hydroxyproline (Figure 10).

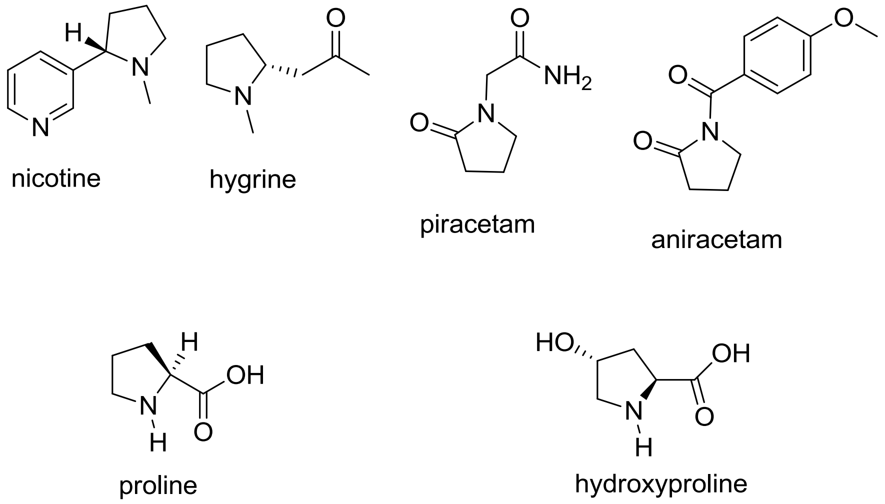
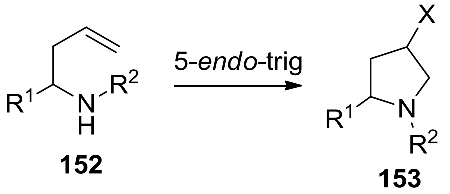


Figure 10. Molecules with pyrrolidine fragment

Nicotine has many pharmacological applications such as pain relief, relief of anxiety and depression; improvement in concentration and performance in those with attention deficit hyperactivity disorders; relief of some of the symptoms of acute schizophrenia; relief of some of the symptoms of Tourette's syndrome; relief of some of the symptoms of Parkinson's disease; and relief of some of the symptoms of Alzheimer's disease. It has been proved that nicotine can enhance cognitive processing when administered to adults.[72-74]

1.2.1 Synthesis of pyrrolidine derivatives

There are many examples in the literature of homoallylic amines **152** as good starting reagents to prepare pyrrolidine derivatives **153**, *via* a 5-*endo*-trig ring cyclisation (Scheme 25).



Scheme 25. Homoallylic amines as starting reagents to synthesise pyrrolidines derivatives

According to Baldwin's rules, the 5-*endo*-trig cyclisation is a geometrically disfavoured process and 4-*exo*-trig is a favourable process.[75-78] However, there are some ways to make this reaction possible such as: nucleophile-driven, electrophile-driven, and radical-initiated cyclisations. In 1998, Lee and co-workers reported a synthesis of pyrrolidine derivatives **155a-h** *via* diastereoselective iodoamidation of 3-acetyloxybut-1-enylamines **154a-h**.[79] The homoallylic amine **154a** was reacted with three equivalents of iodine at room temperature with different solvents such as THF, MeOH, CH_2Cl_2, MeCN. In all cases formation of pyrrolidine **155a** was observed but starting material was still present at the end of the reaction (entry 1,2,3,4, Table 17). Complete conversion to the product **155a** in 92% yield was obtained in three hours when a 2:1:1 mixture of $NaHCO_3$, THF and Et_2O was used (entry 5, Table 17).

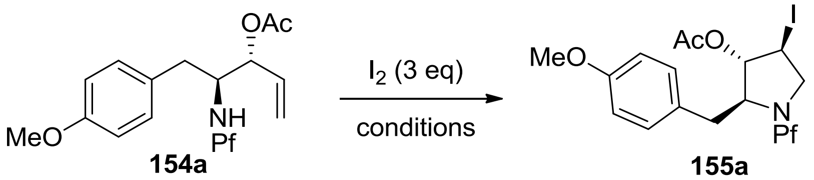


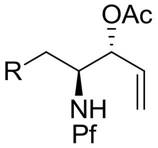
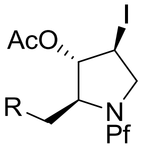
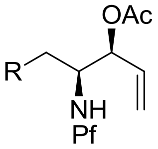
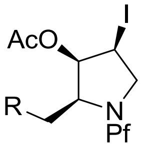
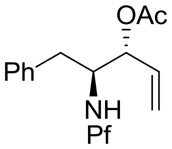
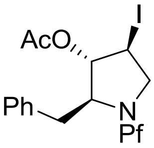
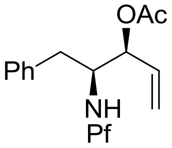
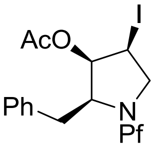
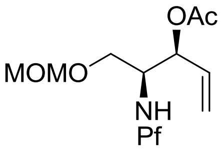
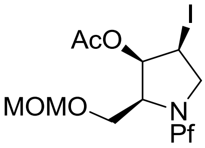
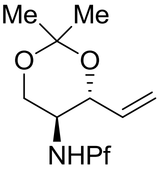
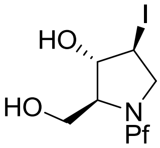
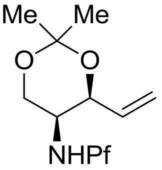
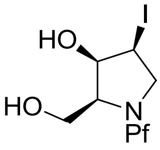
Table 17. Diastereoselective iodoamidation of 3-acetyloxybut-1-enylamines: Solvent screening

entry	solvent	time (h)	yield of **155a** (%)
1	THF	15	48
2	MeOH	18	45
3	CH_2Cl_2	6	50
4	MeCN	6	60
5	Biphase[a]	3	92

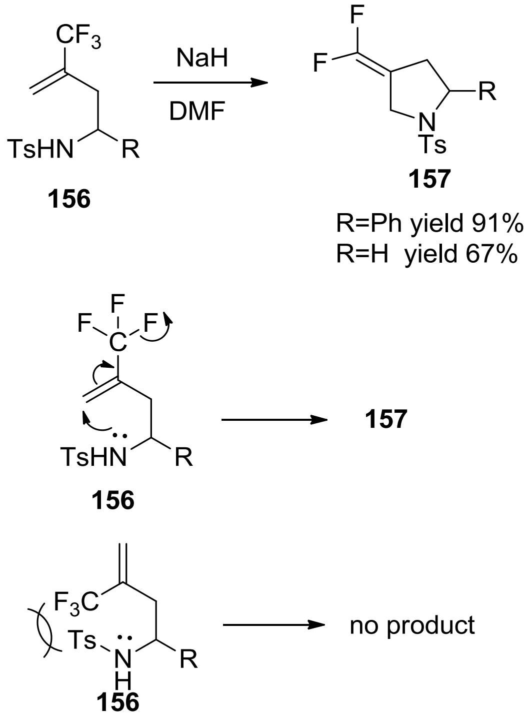
[a] $NaHCO_3$-THF-Et_2O = 2:1:1, Pf = 9-phenyl-fluoren-9-yl

A substrate scope was also investigated and several homoallylic amines **154b-g** were exposed to the iodoamidation reaction, affording the corresponding iodo-pyrrolidines **155b-g** in good yields (66-92%) and good diastereomeric ratios (Table 18). Single diastereoisomers were obtained when substrates **154b** and **154g** were used (entry 1,7, Table 18).

Table 18. Diastereoselective iodoamidation of 3-acetyloxybut-1-enylamines: Substrate scope

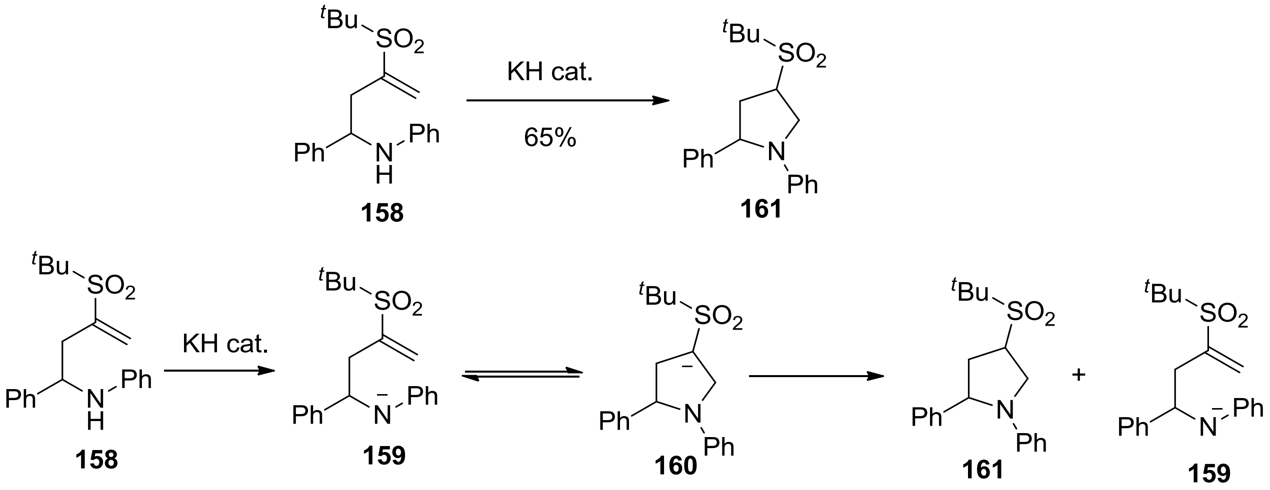
entry	substrate	conditions	product	yield of **155** (%)
1	 **154b** R= *p*-tolyl	I_2, biphase, rt, 3 hours	 **155b**	92 (sole)
2	 **154c** R= *p*-tolyl	I_2, biphase, rt, 3.5 hours	 **155c**	90 (25:1)
3	 **154d**	I_2, biphase, rt, 3 hours	 **155d**	90 (62:1)
4	 **154e**	I_2, biphase, rt, 3 hours	 **155e**	90 (5:1)
5	 **154f**	I_2, biphase, rt, 10 hours	 **155f**	66 (21:1)
6	 **154g**	I_2, THF, rt, 10 hours	 **155g**	92 (20:1)
7	 **154h**	I_2, THF, rt, 10 hours	 **155h**	88 (sole)

In 2007, a 5-*endo*-trig cyclisation of 2-trifluoromethyl-1-alkenes **156** was reported by Ichikawa *et al.*[80] where 4-methylbenzenesulfonamide (tosylamide: TsNH–) was used as a protecting group on the nitrogen. The nitrogen anion attacks the alkene as in a S_N2 reaction, promoting the elimination of a fluoride ion. The trifluoromethyl group activates the double bond allowing a 5-*endo*-trig rather than a 5-*exo*-tet ring closure (Scheme 26). It was claimed that the preference for the 5-*endo*-trig product **157** is due to the reduced steric and electrostatic repulsions between the sulfonamidate and the halogens.



Scheme 26. 5-*endo*-trig cyclisation of 2-trifluoromethyl-1-alkenes

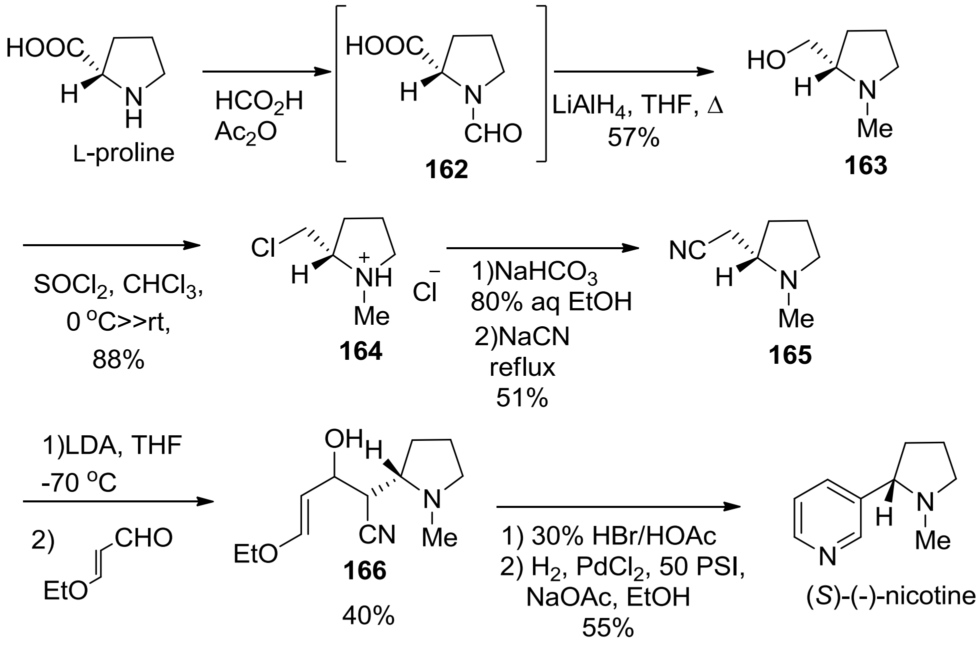
A 5-*endo*-trig ring closure was accomplished treating γ-amino-sulphone **158** with a catalytic amount of potassium hydride yielding the product **161** in 65% yield (Scheme 27). Deprotonation of the NH of compound **158** leads to cyclic carbanion **160**, which after proton exchange with another molecule of **158**, forms the product **161.** The amide **159** formed can attack the double bond again in a new catalytic cycle (Scheme 27).[81]



Scheme 27. 5-*endo*-trig ring closure of a γ-amino-sulphone

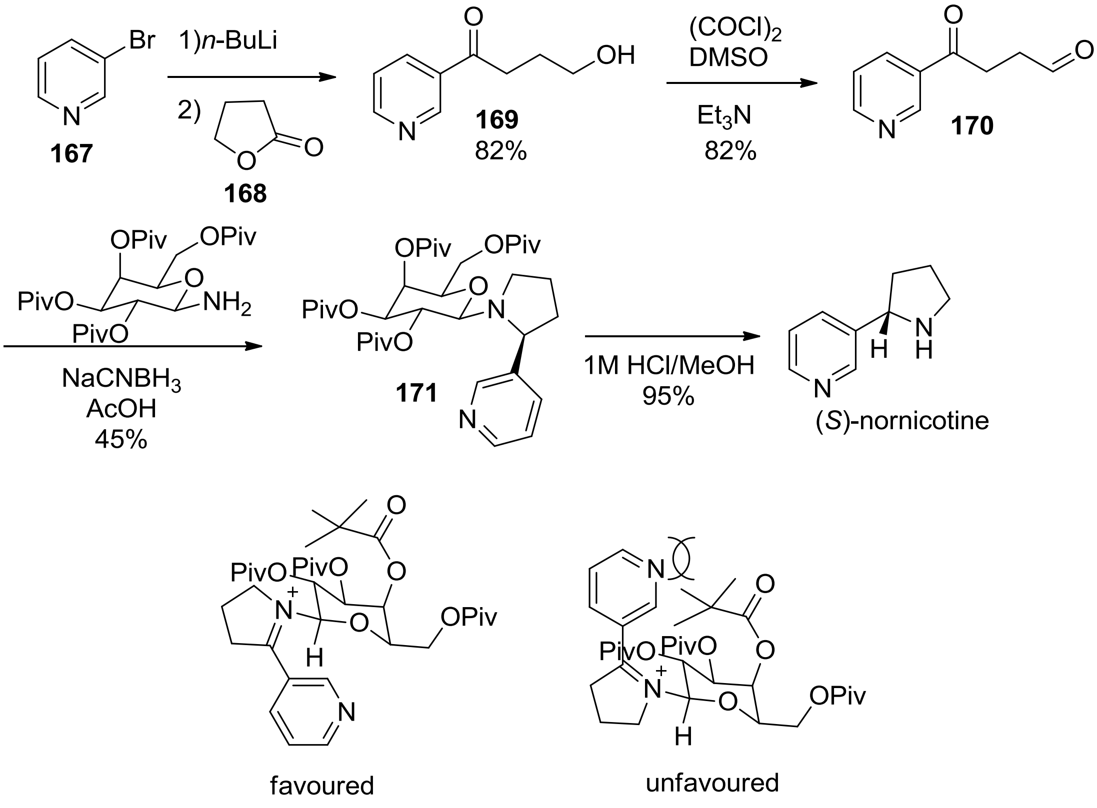
1.2.2 Synthesis of Nicotine and Nornicotine: known methods

Several methods to synthesise nicotine have been developed using different approaches. The pyrrolidine ring of nicotine can be accessed using a chiral catalyst or a chiral ligand. Direct modification of L-proline to make optically active nicotine was reported in 1982 by Chavdarian and co-workers. The *ee* was only 24%. However, this was the first example of synthesis of enantioenriched nicotine (Scheme 28).[82] L-proline was first reacted with formic acid and acetic anhydride to form (-)-1-formylprolyne intermediate **162**, which was reduced with $LiAlH_4$ to afford L-prolinol **163** in 57% yield. Compound **163** was then treated with thionyl chloride in chloroform to produce (-)-1-methyl-2-(chloromethyl)-pyrrolidine hydrochloryde **164** in 88% yield. Neutralisation of compound **164** with aqueous sodium bicarbonate followed by halogen displacement by sodium cyanide afforded (-)-1-methyl-2-(cyanomethyl)-pyrrolidine **165** in 51% yield. Compound **165** was reacted with lithium diisopropylamide in THF at -70 °C after which, 3-ethoxyacrolein was added to afford compound **166** in 40% yield. Compound **166** was finally converted to (*S*)-(-)-nicotine in 55% yield *via* ring closing followed by catalytic dehalogenation (Scheme 28).



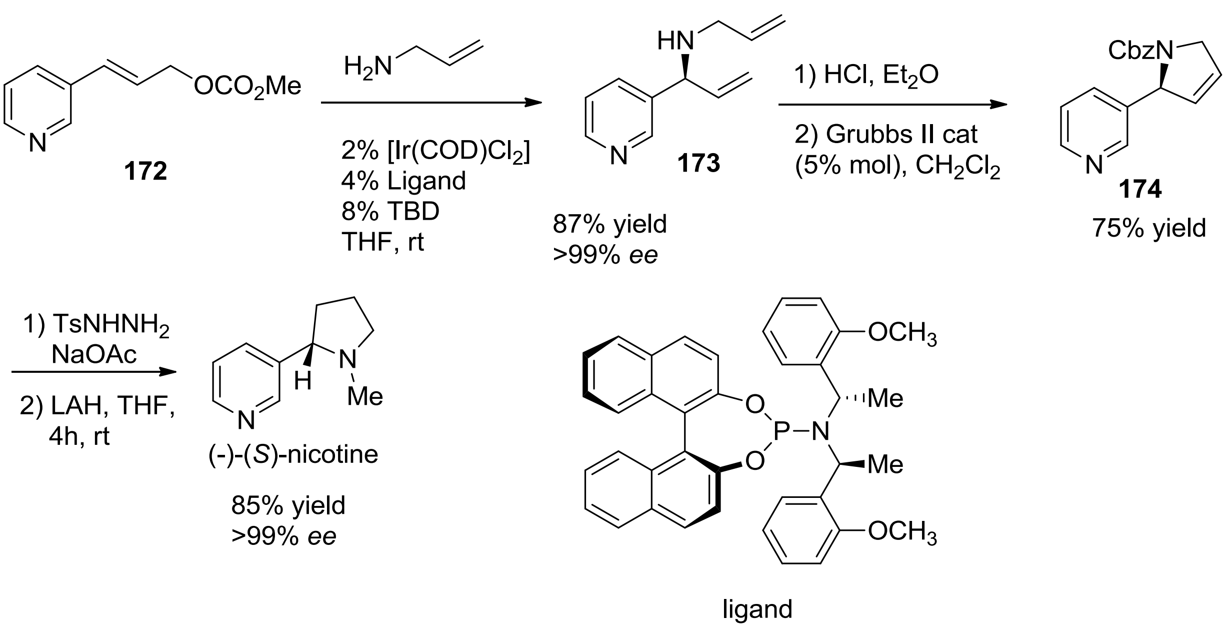
Scheme 28. Synthesis of nicotine *via* direct modification of L-proline

In 1999, Loh and co-workers reported a four-step stereoselective synthesis of (*S*)-nornicotine. Reaction between 3-bromopyridine **167** and lactone **168** in the presence of *n*-BuLi produced the hydroxyketone (82% yield) **169**, which was converted to aldehyde **170** in 82% yield *via* Swern oxidation. Aldehyde **170** was then reacted with 2,3,4,6-tetra-O-pivaloyl-13-D-galactosylamine in the presence of sodiumcyanoborohydride to afford compound **171** diastereoselectively in 45% yield. Hydrolysis of single diastereomer **171** yielded optically pure (*S*)-nornicotine in 95% yield. It was speculated that hydride transfer to the front *re*-face might be the explanation for the high diastereoselectivity. The s*i*-face is, in fact, shielded by the bulky pivaloyl group in the favoured iminium intermediate, where steric interactions between the aromatic group and the pivaloyl group are avoided (Scheme 29).[83]



Scheme 29. Four-step stereoselective synthesis of (S)-nornicotine

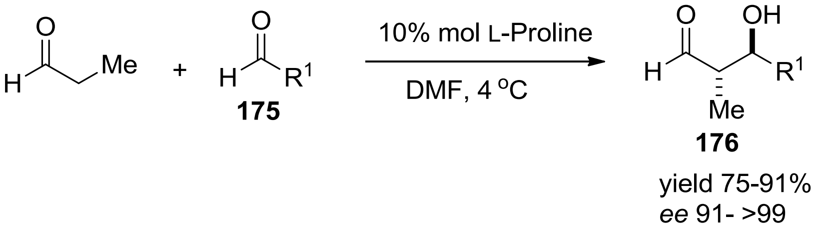
In 2005, Helmchen and co-workers reported the synthesis of nicotine in greater than 99% *ee*. The key steps of this method were an asymmetric iridium-catalysed allylic amination and a ring-closing metathesis.[84] Asymmetric allylic substitution of 3-(3-pyridyl)allyl carbonate **172** afforded *N*-allyl derivative **173** in 87% yield and >99% *ee* when the phosphorus amidite ligand was used. Compound **173** was first protected at the nitrogen with Cbz and then reacted with Grubbs second generation catalyst to furnish compound **174** in 75% yield. A first reduction with $TsNHNH_2$ followed by a second reduction with LAH provided (-)-(S)-nicotine in 85% yield and >99% *ee* (Scheme 30).



Scheme 30. Synthesis of (-)-(*S*)-nicotine *via* iridium-catalysed allylic amination and RCM

1.2.3 Applications of Pyrrolidines

Pyrrolidines have found extensive applications as catalysts for several organic transformations, showing very good yields and enantioselectivities.[85-93] Perhaps one of the most popular pyrrolidine containing organocatalysts is the amino acid L-proline. In 2002, Nirthrup and MacMillan published a direct and enantioselective cross-aldol reaction.[88] Propionaldehyde was added to several non-enolisable aldehydes **175** (aromatic and aliphatic) in the presence of a catalytic amount of proline (10 mol%) to afford *β*-hydroxy aldehydes **176** in very good yield (75-91%) and excellent *ee* (91->99%) (Scheme 31). Addition of propionaldehyde to aldehydes **175** was performed by using a syringe pump to avoid homodimerisation. The best diastereoselectivity (24:1 *anty:syn*) and the best enantioselectivity (*ee* = >99%) were observed when the propionaldehyde was added to isobutyraldehyde.



Scheme 31. Enantioselective cross-aldol reaction using L-proline as catalyst

Diastereoselectivity is controlled by the formation of a six-membered ring in the transition state proposed by List in 2000,[94] where the R[1] and R[2] substituents sit in pseudo-equatorial positions (Figure 11).

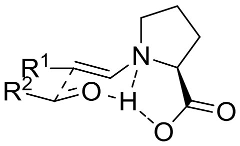
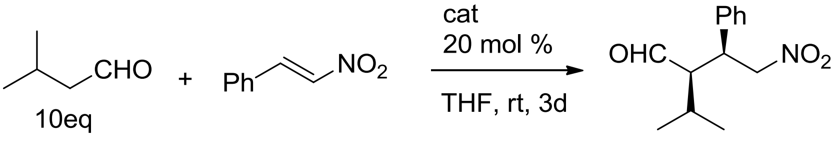


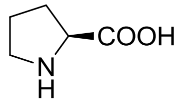
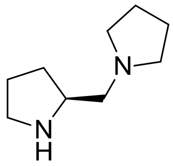
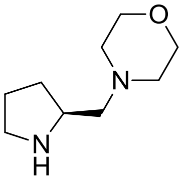
Figure 11. Transition state proposed by List

In 2001, Betancort *et al.* compared L-proline with different 2-substituted amino-pyrrolidines as catalysts for the Michael addition of aldehydes to nitro olefins.[93] Ten equivalent of 3-methylbutanal were added to (*E*)-(2-nitrovinyl)benzene to produce aldehyde **177**. Amino-pyrrolidines **178** and **179** were screened as catalysts (Table 19) and (*S*)-2-(morpholinomethyl)-pyrrolidine **179** gave the second best diastereoselectivity (*syn:anti* 92:8) and good enantioselectivity (*ee* = 72%) (entry 3, Table 19). L-proline deemed to be the best catalyst in terms of diastereoselectivity (*syn:anti* 93:7) but *ee* was only 25% and yield <5% (entry 1, Table 19). The best enantioselectivity (*ee* = 75%) was obtained when (*S*)-1-(pyrrolidin-2-ylmethyl)pyrrolidine **178** was used but diastereoselectivity (*syn:anti* = 80:20) (entry 2, Table 19) was not as good as (*S*)-2-(morpholinomethyl)-pyrrolidine.

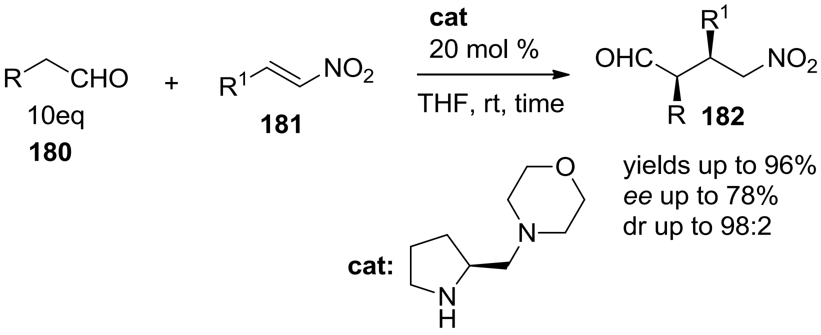


177

Table 19. Michael addition of aldehydes to nitro olefins. Screening of catalysts

entry	cat	yield of **177** (%)	dr (*syn:anti*)	*ee* of **177** (%)
1	 L-proline	<5	93:7	25
2	 **178**	80	80:20	75
3	 **179**	78	92:8	72

To investigate the limitations and scope of the reaction several substituted aldehydes **180** were reacted with several nitro olefins **181** in the presence of 20 mol % of (*S*)-2-(morpholinomethyl)-pyrrolidine **179** (Scheme 32). In general, better enantioselectivity was seen with increasing bulkiness of the substituent on the aldehyde. The best diastereoselectivity (*syn:anti* 98:2) and the best *ee* (78%) were obtained when R = $(CH_3)_2$ and R^1 = 2-CF_3Ph.



Scheme 32. Michael addition of aldehydes to nitro olefins using (*S*)-2-(morpholinomethyl)-pyrrolidine as catalyst

A possible transition state, where favourable electrostatic interactions between the nitro group and the pyrrolidine nitrogen are involved, was proposed. Stereoselectivity could be explained by a less hindered *si*-face approach of the nitro olefin (Figure 12).

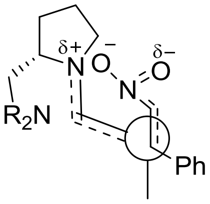
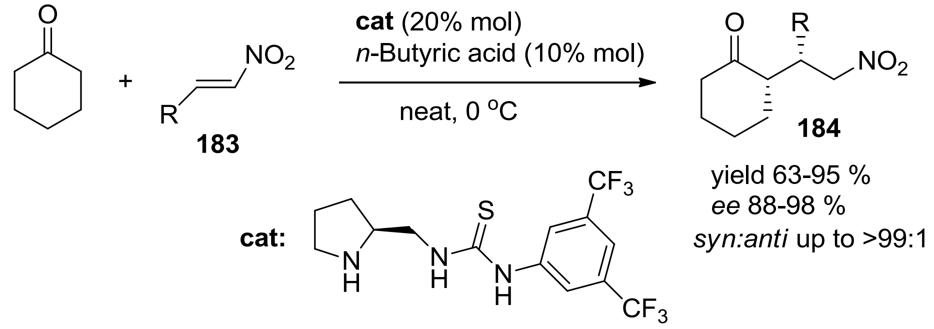


Figure 12. Transition state: favourable electrostatic interactions between the nitro group and the pyrrolidine nitrogen

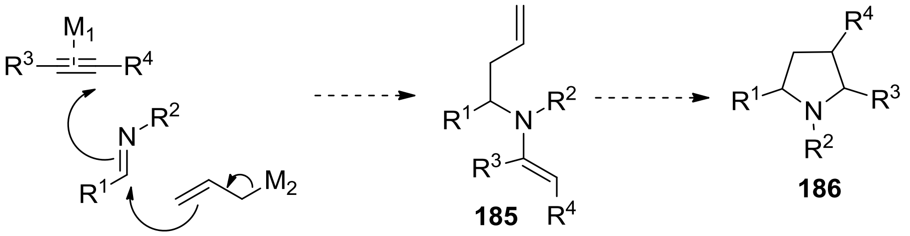
In 2006, Cao and co-workers developed a new pyrrolidine based catalyst, which proved to be very effective in the Michael addition of cyclohexanone to nitroolefines **183**.[92] The products **184** were obtained in moderate to very good yield (63-95%) and the *ee* (88-98%) was very good in all cases (Scheme 33). The diastereoselectivity was also very high and the *syn* diastereoisomer was always the main product. The electronic nature of the substituents on the aromatic ring did not effect the yield, the enantioselectivity and the diastereoselectivity. In fact, only a slight difference was observed when R = 4-OCH_3Ph (yield = 95%, *ee* = 88%, *syn*:*anti* = 97:3) and R = 2-NO_2Ph (yield = 95%, *ee* = 97%, *syn*:*anti* = 96:4).



Scheme 33. Michael addition of cyclohexanone to nitroolefines

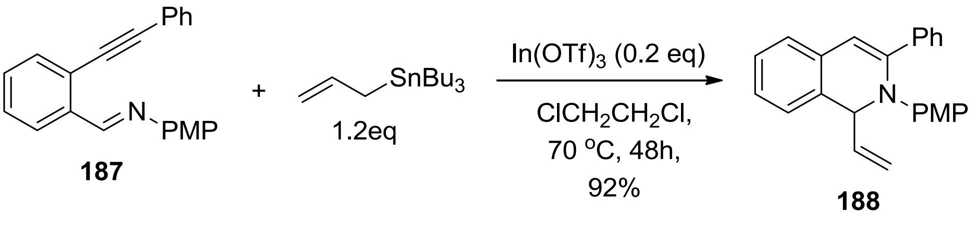
1.3 Aim of the project

The aim of this project is to make multifunctionalised pyrrolidines *via* an alkyne hydroamination cascade to obtain the intermediate enamine **185**, which could then access the desired pyrrolidines **186** with a ring closure metathesis (RCM), followed by reduction of the double bond (Scheme 34).[95-96] Hydroamination of alkyne is a well known reaction in the literature. Several metals such as copper, tantalum, zinc, palladium, iridium, ruthenium, silver, gold and indium have been used to activate the triple bond.[97-104]



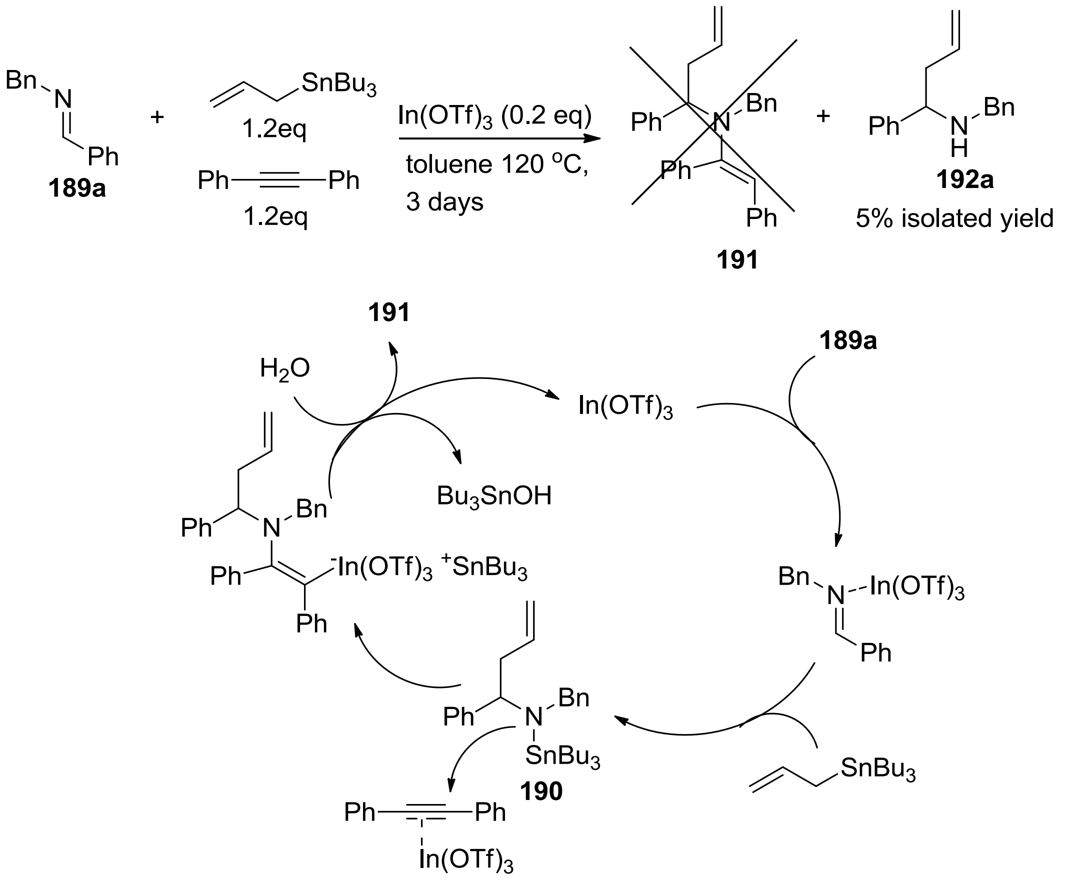
Scheme 34. Alkyne hydroamination cascades and RCM as key steps for the synthesis of multifunctionalised pyrrolidines

We were particularly inspired by an intramolecular alkyne hydroamination cascades involving 2(1-alkynyl)arylaldimine **187** and allyltributylstannane, where indium triflate was chosen to activate both the imine and the triple bond. 1,2-dihydroisoquinoline **188** was obtained in 92% yield when 0.2 equivalents of indium triflate and 1.2 equivalents of allyltributylstannane were used.[105-106]



Scheme 35. Synthesis of 1,2-dihydroisoquinoline from 2(1-Alkynyl)arylaldimine

An intermolecular version of the methodology shown above (Scheme 35) will be attempted for the first time as starting point of the research reported in this thesis. (*E*)-*N*-benzylidene-1-phenylmethanamine **189a** was first obtained in >99% yield by condensation of benzaldehyde and benzylamine and then reacted with 1.2 equivalents of allyltributylstannane, 1.2 equivalents of 1,2-diphenylethyne and 0.2 equivalents of indium triflate in toluene at 120 °C. Activation of the imino group of compound **189a** by indium triflate followed by allylation, would produce the intermediate **190**, which could then attack the triple bond activated by another molecule of indium triflate (Scheme 36). The reaction was monitored by TLC every 30 minutes and after three days starting material was still present. Analysis of the crude ^{1}H NMR spectrum showed no product **191** was formed, however, it was found that homoallylic amine **192a** was obtained in 5% yield after flash chromatography (Scheme 36).



Scheme 36. Hydroamination cascade using (*E*)-*N*-benzylidene-1-phenylmethanamine, allyltributylstannane and 1,2-diphenylethyne

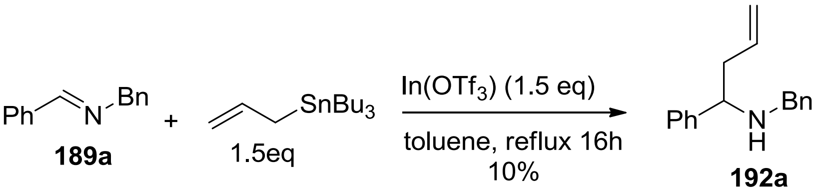
It has been reported in the literature that homoallylic amines are suitable starting materials to make azetidines and pyrrolidines *via* electro-induced cyclisations as it is illustrated in the introduction section. Although the synthesis of compound **191** had failed after many attempts, the possibility to access the homoallylic amine **192a** would still be a good starting point to make pyrrolidines. The new aim of the project is to develop a new methodology for the synthesis of multifunctionalised azetidines and pyrrolidines using homoallylic amines as starting materials. Iodine will be used as cyclisation promoter. All the new molecules synthesised will be used in medicinal chemistry applications. Asymmetric synthesis of azetidines will be also investigated by exploiting asymmetric synthesis of homoallylic amines. The enantioenriched azetidines obtained will be tested as organocatalysts for some organic chemistry reactions.

2 Results and Discussion

2.1 Synthesis of Azetidines

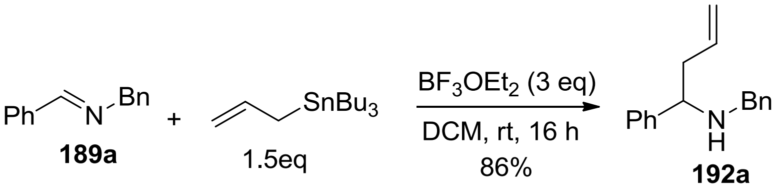
2.1.1 Iodine-mediated Cyclisation of Homoallylic Amines

There are many procedures in the literature regarding allylation of imines. Different Lewis acid such as boron trifluoride, palladium, indium, stannane chloride, magnesium and zinc have been used to activate imines.[107-115] Allylation of imine **189a** with allyltributylstannane was attempted using 1.5 equivalents of In(OTf$_3$) as catalyst (Scheme 37).



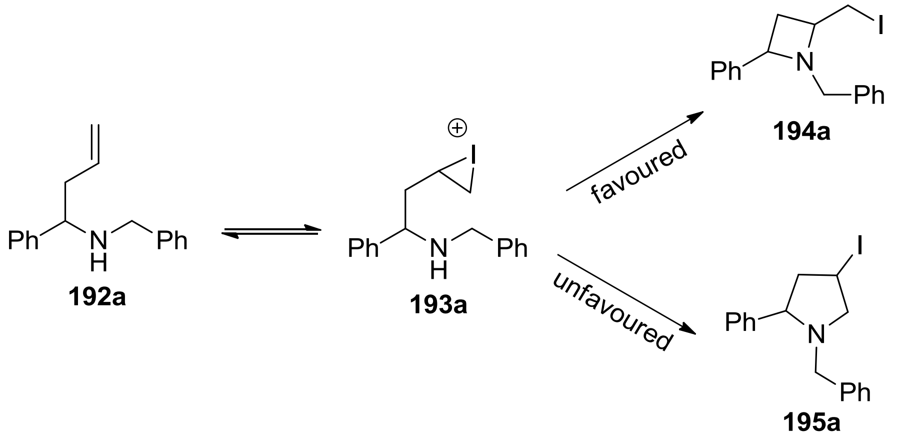
Scheme 37. Allylation of (*E*)-*N*-benzylidene-1-phenylmethanamine with allyltributylstannane and In(OTf)$_3$

The product **192a** was formed in very low yield (10%), however, compound **192a** was obtained in 86% yield when 1.5 equivalents of allyltributylstannane and three equivalents of BF$_3$·Et$_2$O were used in CH$_2$Cl$_2$ at room temperature for 16 hours (Scheme 38).[113]



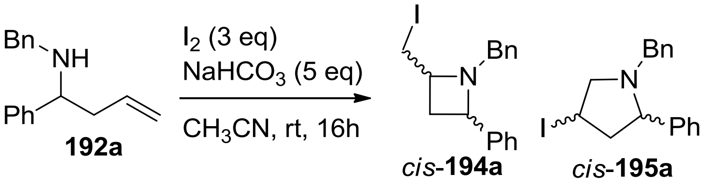
Scheme 38. Allylation of (*E*)-*N*-benzylidene-1-phenylmethanamine with allyltributylstannane and BF$_3$·Et$_2$O

As described above in the introduction section, homoallylic amines have been largely used as starting materials for the synthesis of azetidines and pyrrolidines. Since iodine has already been shown to deliver pyrrolidines in a 5-*exo* fashion,[22] and this sterically encumbered halide could perhaps offer high stereodefinition, it was selected as the cyclisation promoter. Cyclisation of compound **192a** would access azetidine **194a** or pyrrolidine **195a** *via* halonium species intermediate **193a**. According to Baldwin,[75-78] when a three membered ring is opened to form a cyclic structure, the rules lie between those for tetrahedral and trigonal systems, however, *exo* modes are generally preferred. If one considers that 5-*endo*-trig and 5-*endo*-tet are unfavoured processes whereas 4-*exo*-trig and 4-*exo*-tet are favoured processes, it might be expected that azetidine **194a** is the favoured product in the ring closing reaction of **192a** with iodine (Scheme 39).



Scheme 39. Iodine mediated cyclisation: azetidine formation versus pyrrolidine formation

Compound **192a** was treated with three equivalents of molecular iodine at room temperature in acetonitrile for 16 hours. Analysis of the crude ^{1}H NMR spectrum showed only 44% conversion of the starting material. Nonetheless, when a three-fold excess of iodine was used at room temperature in acetonitrile accompanied by a five-fold excess of $NaHCO_3$, only azetidine *cis*-**194a** could be obtained, albeit in 45% isolated yield, but most of the starting amine (**192a**) had been consumed (Scheme 40). Purification of compound **194a** by silica gel flash chromatography proved to be not particularly efficient in terms of yield, in fact, different other fractions were collected and analysed suggesting that a possible decomposition of the product **194a** had occurred.



Scheme 40. Iodine mediated cyclisation of homoallylic amine **192a**

The structure of **194a** was confirmed by 2D-NMR spectroscopy, in particular the HMBC experiment, where a ^3J coupling between carbon one and the CH rather than a CH_2 (Figure 13), showed clearly that the four member ring was formed. The relative stereochemistry of **194a** was confirmed by nOe, irradiating H^3 nOe with H^5 was seen, showing the two protons are on the same side in a *cis* configuration (Figure 13).[116]

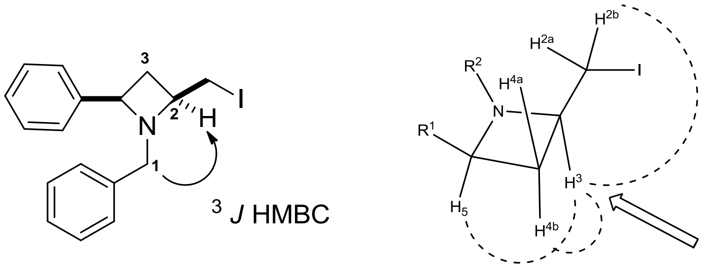


Figure 13. 2D-NMR spectroscopy to assign structure of azetidine *cis*-**194a**: irradiating H3 nOe has been seen with H^5, H^{2a}, H^{2b} ,H^{4b}

The reaction was then studied under different temperatures to probe the best reaction conditions. Homoallylic amine **192a** was stirred with three equivalents of iodine and five equivalents of sodium bicarbonate for 16 hours in acetonitrile affording 2,4-*cis*-azetidine **194a** (entry 1, Table 20) at 20 °C and 3,5-*trans*-pyrrolidine **195a** (entry 2, Table 20) at 50 °C. Post-work-up azetidine and pyrrolidine were obtained in 96% and 82% yield and the ^1H NMR spectra were relatively clean compared to the spectra obtained after further purification by flash chromatography. One can note that further purification of compounds **194a** and **195a** by silica flash chromatography resulted in a dramatic loss in yields 45 and 42% (Table 20).

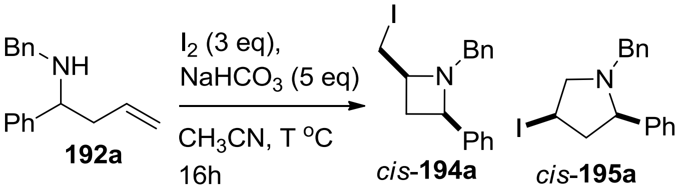


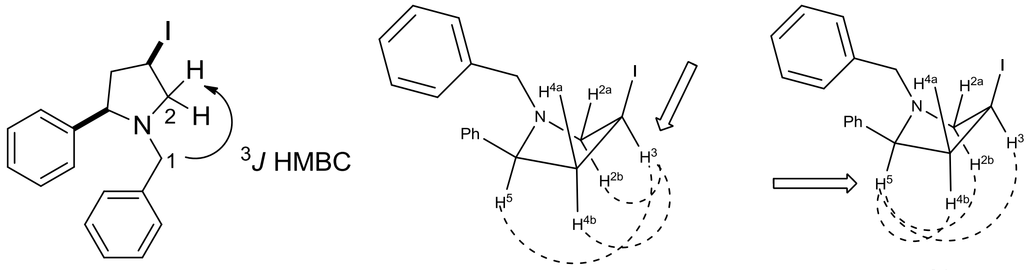
Table 20. Iodine mediated cyclisation of homoallylic amine **192a** under different temperatures

entry	T(C)	conv,%[a]	yield, %[b]	yield, %[c]	**194a:195a**[c]
1	20°	>99:1	96	45	99:1
2	50°	>99:1	82	42	1:99

[a] Conversion to **194a** + **195a** based on consumption of **1** by ^1H NMR spectroscopy.
[b]yield after work up. [c]yield after flash chromatography.
[c] *cis*-(**194a**:**195a**) Ratio obtained by inspection of the ^1H NMR spectrum post aqueous work-up.

The formation of the pyrrolidine core was confirmed by 2D-NMR spectroscopy, in particular a ^3J between carbon one and the CH_2 (2) with the HMBC technique was used to assign the structure of *cis*-**195a**. The relative stereochemistry of *cis*-**195a** was corroborated by nOe studies. Irradiating H^3 a weak nOe with H^5

was detected. However H^3 and H^5 showed both a strong nOe with H^{2b} and H^{4b} as proof they are on the same side (Figure 14).[116]



cis-**195a** *cis*-**195a** *cis*-**195a**

Figure 14. 2D-NMR spectroscopy to assign structure of pyrrolidine *cis*-**195a**: Irradiating H^3 nOe has been seen with H^5, H^{2b}, H^{4b}, irradiating H^5 nOe has been seen with H^3, H^{2b}, H^{4b}

The *cis* configuration was the only one observed, there was no evidence for the formation of the *trans* product. If one considers that the azetidine has a puckered conformation with *pseudo*-axial and *pseudo*-equatorial positions, the formation of the *cis*-azetidine as single product, could be explained by the favoured transition state where the iodine and the phenyl group are in the *pseudo*-equatorial positions. The disfavoured transition state would increase a pseudo 1,3-diaxial interaction (Figure 15).

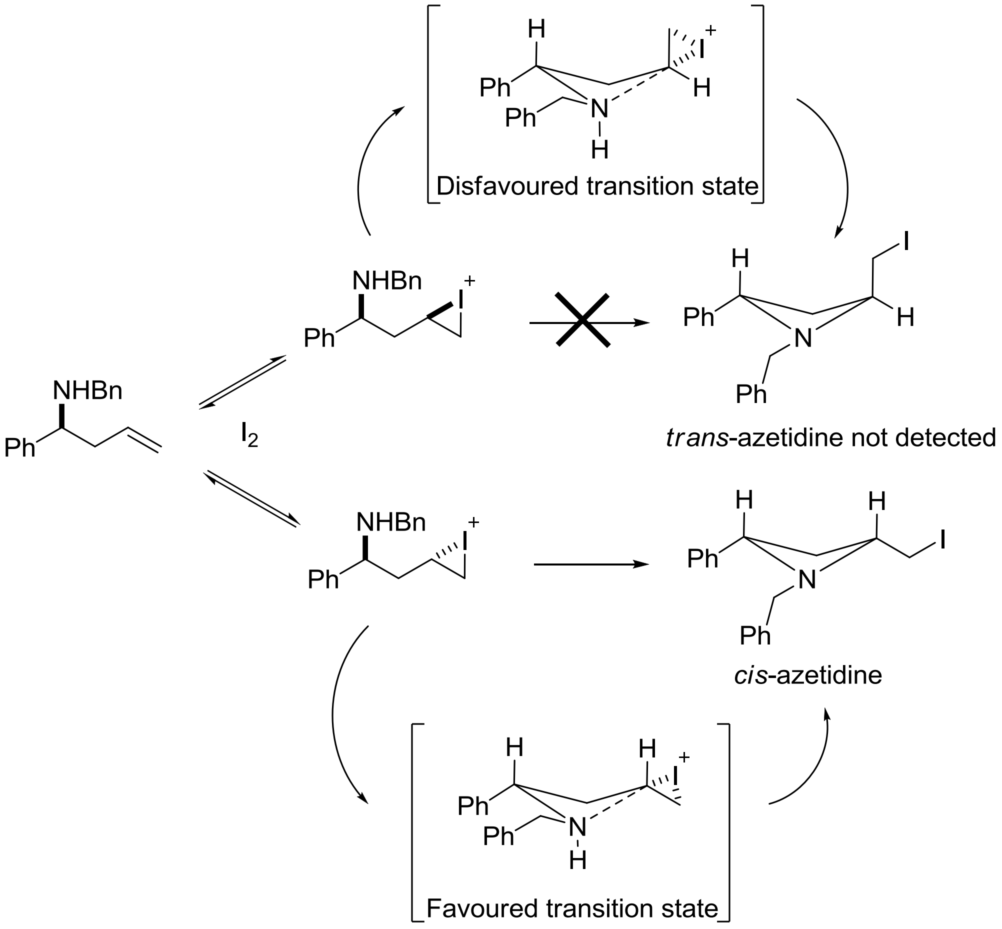


Figure 15. Disfavoured and favoured transition state for the formation of azetidine

A solvent and base screening was tried to find the best conditions for the synthesis of the azetidine **194a**. A control reaction using three equivalents of iodine but no base was attempted. After 16 hours the reaction was worked up and analysis of the crude ^{1}H NMR spectrum showed azetidine and the starting material were in a 44:56 ratio, (entry 1, Table 21). Using sodium bicarbonate as base and acetonitrile as solvent, was found to be the best condition for this reaction. The desired azetidine **194a** was formed as the only product with complete conversion of the starting material (entry 7, Table 21). When three equivalents of iodine and five equivalents of sodium bicarbonate were used it required 16 hours for the reaction to reach completion. The reaction time can, however, be reduced to six hours by using five equivalents of iodine. It is interesting to note that oxidation of homoallylic amine **192a** to the imine **196a** was observed when K_2CO_3, Cs_2CO_3 or KOAc were used as bases with acetonitrile as solvent (entry 4,5,12, Table 21). Formation of compound **196a** was also noted when MeOH and DMSO as solvents and $NaHCO_3$ as base were used (entry 14,17, Table 21).

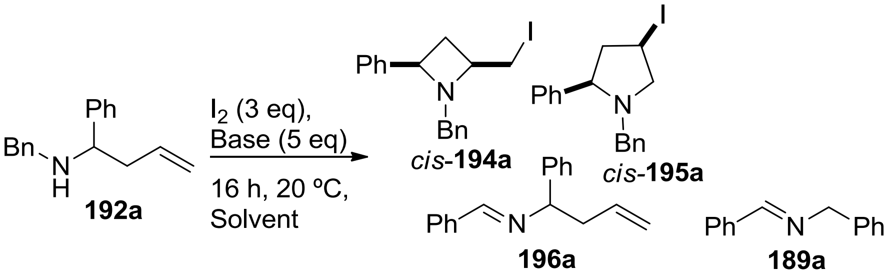
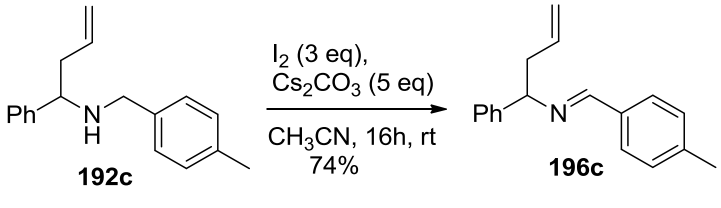


Table 21. Iodine mediated cyclisation: Base and solvent screening

entry	base	solvent	**192a**[a]	**194a**[a]	**195a**[a]	**196a**[a]	**189a**[a]
1	-	CH_3CN	56.0	44.0	-	-	-
2	Li_2CO_3	CH_3CN	25.0	75.0	-	-	-
3	Na_2CO_3	CH_3CN	-	61.0	39.0	-	-
4	K_2CO_3	CH_3CN	-	35.5	-	64.5	-
5	Cs_2CO_3	CH_3CN	-	-	-	82	18
6	LiOH	CH_3CN	48.5	33.0	18.5	-	-
7	$NaHCO_3$	CH_3CN	-	>99.5	-	-	-
8	NaOH	CH_3CN	-	60.0	40.0	-	-
9	KOH	CH_3CN	-	53.0	47.0	-	-
10	LiOAc	CH_3CN	-	73.0	27.0	-	-
11	NaOAc	CH_3CN	-	68.5	31.5	-	-
12	KOAc	CH_3CN	-	50.0	20.0	30.0	-
13	$NaHCO_3$	THF	63.0	37.0	-	-	-
14	$NaHCO_3$	MeOH	-	50.0	21.0	29.0	-
15	$NaHCO_3$	CH_2Cl_2	58.0	42.0	-	-	-
16	$NaHCO_3$	THF:Et_2O	69.0	31.0	-	-	-
17	$NaHCO_3$	DMSO	-	12.0	55.0	33.0	-

[a]numbers show ratio of the starting material and the products in the ^{1}HNMR spectra

To corroborate the nature of this reaction *N*-(4-methylbenzyl)-1-phenylbut-3-en-1-amine (**192c**), derived from *p*-tolyl benzaldehyde, was exposed to the same reaction conditions. The corresponding *p*-tolyl imine (**196c**) was isolated in 74% yield and the structure of **196c** was determined by COSY, HSQC and HMBC (Scheme 41).



Scheme 41. Oxidation of homoallylic amine **192c** with iodine and caesium carbonate

The cyclisation of homoallylic amine **192a** was also tried with different reagents. NIS, NBS and Br_2 were used instead of iodine. Analysis of the crude ^{1}H NMR spectra showed a mixture of products in all cases proving molecular iodine to be the best halide source of those tried for this reaction. Different imines **189a-y** were prepared using a standard literature protocol.[117] Aldehydes and amines were refluxed for four hours in ethanol to afford the corresponding imines in moderate to excellent yields (40-99%) (Table 22).

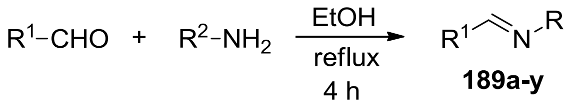


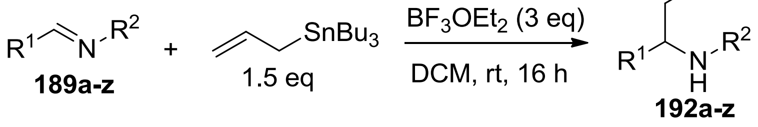
Table 22. Synthesis of imines

entry		R^1	R^2	yield of **189** (%)	ratio (E/Z)
1	**a**	Ph	Bn	99	99.3/0.7[c]
2	**b**	Ph	PMB	99	99.3/0.7[b]
3	**c**	Ph	PTB	99	99.3/0.7[c]
4	**d**	3-Py	Bn	99	99.8/0.2[b]
5	**e**	4-Py	Bn	99	99.7/0.3[b]
6	**f**	PNP	Bn	99	89.4/10.6[c]
7	**g**	2-Br-Ph	Bn	99	98.7/1.3[b]
8	**h**	*t*-Bu	Bn	83	98.6/1.4[c]
9	**i**	3-OMe-Ph	Bn	99	99.4/0.6[c]
10	**j**	3-furyl	Bn	99	99.2/0.8[c]
11	**l**	Ph	PNB	42	99.3/0.7[b]
12	**k**	Cy	Bn	-[a]	-
13	**m**	ONP	PMB	99	99.4/0.6[c]
14	**n**	Ph	(*S*)-CH(Me)Ph	81	99.2/0.8[c]
15	**o**	Fc	Bn	40	97.2/2.8[c]
16	**p**	Ph	Cy	92	99.4/0.6[c]
17	**q**	Ph	*n*-Pr	87	99.3/0.7[c]
18	**r**	4-OMe-Ph	Bn	95	98.3/0.7[c]
19	**s**	2-Py	Bn	99	99.1/0.9[b]
20	**t**	Ph	$(CH_2)_2NHC{=}OMe$	52	98.9/1.1[c]
21	**u**	9-anthracenyl	Bn	69	100/0
22	**v**	Ph	*t*-Bu	46	99.4/0.6[c]
23	**w**	2-thiophenyl	Bn	99	99.4/0.6[c]
24	**x**	3-1H-indolyl	Bn	94	99.3/0.7[b]
25	**y**	Me	Bn	-[a]	-

[a] impurities were still present after purification, [b] the resonance for $\mathrm{CH{=}NC}\mathit{H}_2$ in the ^{1}H NMR spectrum was used to elaborate the (E/Z) ratio, [c] the resonance for $\mathrm{C}\mathit{H}\mathrm{{=}NCH_2}$ in the ^{1}H NMR spectrum was used to elaborate the (E/Z) ratio

The synthesised imines were freshly used and converted into homoallylic amines using two different methods reported in the literature.[113, 115, 118] Boron trifluoride as Lewis acid and allyltributylstannane as allyl species were used in method a, whereas an *in situ* preformed allyl-Grignard, using magnesium and allylbromide, was employed in method b (Table 23). In general, method b proved to be more efficient than method a in terms of yields but in one case, homoallylic amine **192f** could not be obtained with method b. Nevertheless, homoallylic amine **192f** was produced in 81% yield when method a was used (entry 6, Table 23).

method a



method b

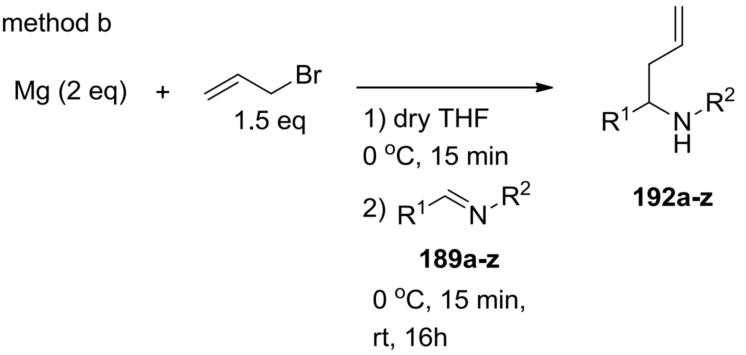


Table 23. Synthesis of homoallylic amines *via* method a or b

entry		R^1	R^2	yield of **192** (%) method a	yield of **192** (%) method b
1	**a**	Ph	Bn	86	99
2	**b**	Ph	PMB	99	99
3	**c**	Ph	PTB	42	99
4	**d**	3-Py	Bn	98	99
5	**e**	4-Py	Bn	92	99
6	**f**	PNP	Bn	81	-
7	**g**	2-Br- Ph	Bn	56	96
8	**h**	*t*-Bu	Bn	89	71
9	**i**	3-OMe-Ph	Bn	*	99
10	**j**	3-furyl	Bn	21	90
11	**k**	Cy	Bn	*	96
12	**l**	Ph	PNB	57	88
13	**m**	ONP	PMB	45	*
14	**n**	Ph	(*S*)-CH(Me)Ph		
15	**o**	Fc	Bn	13	*
16	**p**	Ph	Cy	*	99
17	**q**	Ph	*n*-Pr	92	99
18	**r**	4-OMe-Ph	Bn	34	90
19	**s**	2-Py	Bn	*	93
20	**t**	Ph	$(CH_2)_2$NHC=OMe	30	*
21	**u**	9-anthracenyl	Bn	-	-
22	**v**	Ph	*t*-Bu	*	68
23	**w**	2-thiophenyl	Bn	58	*
24	**x**	3-1H-indolyl	Bn	-	*
25	**y**	Me	Bn	*	65

*the reaction was not tried under these conditions

2.1.2 Synthesis of Azetidines: Scope and Limitations

With satisfactory reaction conditions in hand, the homoallylic amines **192b-o** were also cyclised, with iodine, to the corresponding azetidines *cis*-**194b-o** (entry1-15, Table 24). Purification by column chromatography gave only around 45% isolated yield in all cases. Analysis of the crude materials' proton NMR spectra revealed some pyrrolidine had formed when **192d, e, f, g, I, l, m** and **n,** were used as starting materials but azetidines *cis*-**194** were always the major products. The cyclisation of the 2-pyridyl analogue was also attempted but failed to give the desired product(s).

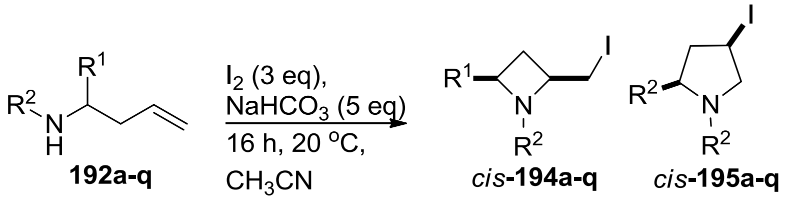


Table 24. Synthesis of azetidine: Scope and limitations

entry		R^1	R^2	**194** +**195**/%^{a}	**194**:**195**^{b}
1	**a**	Ph	Bn	>99	>99:1
2	**b**	Ph	PMB	>99	>99:1
3	**c**	Ph	PTB	>99	>99:1
4	**d**	3-Py	Bn	>99	5:1
5	**e**	4-Py	Bn	>99	6:1
6	**f**	PNP	Bn	>99	3:1
7	**g**	2-Br- Ph	Bn	>99	3:1
8	**h**	*t*-Bu	Bn	>99	>99:1
9	**i**	3-OMe-Ph	Bn	>99	6:1
10	**j**	3-furyl	Bn	>99	>99:1
11	**k**	Cy	Bn	>99	>99:1
12	**l**	Ph	PNB	>99	7:1^c
13	**m**	ONP	PMB	>99	3:1
14	**n**	Ph	(*S*)-CH(Me)Ph	>99	3:1
15	**o**	Fc	Bn	>99	>99:1
16	**p**	Ph	Cy	38	1:>99^c
17	**q**	Ph	*n*-Pr	33	1:>99^c
18	**r**^{d}	4-OMe-Ph	Bn	-	-

PMB = para-methoxybenzyl. PTB = para-tolylbenzyl. PNP = para-nitro-phenyl. PNB = para-nitro-benzyl. ONP = ortho-nitrophenyl. Fc = ferrocenyl. [a] **194** + **195** consumption of the starting material **192** by ^{1}H NMR spectroscopy. [b] *cis*-(**194**:**195**) ratio obtained by inspection of the ^{1}H NMR spectrum post aqueous work-up. [c] Sodium carbonate was used as base. [d] **192r** suffered loss of allyl group and oxidation to corresponding imine.

The X-ray crystal structure of **194b** (Figure 16), solved by Dr Louise Male, along with inspection of nOe data and comparison among the NMR spectra obtained, confirmed *cis* stereochemistry for the azetidines.[116]

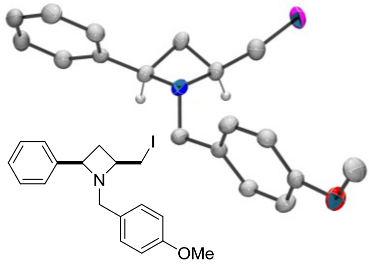
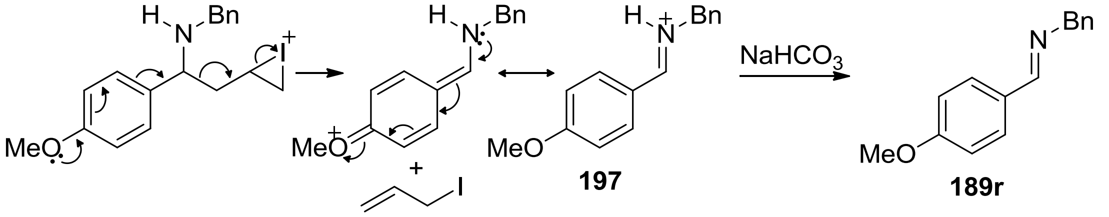


Figure 16. X-ray crystal structures with ellipsoids drawn at the 50% probability level of *cis*-**194b**. Most of the hydrogen atoms have been omitted for clarity and *cis*-stereochemistry is confirmed

Homoallylic amine **192l** was converted to the corresponding azetidine using sodium carbonate as base (entry 12, Table 24). No reaction occurred when sodium bicarbonate was used. When R^2 = cyclohexyl or propyl (entry 16 and 17, Table 24) no product was obtained under these conditions, suggesting that a benzylic group is crucial for the reaction to happen. However, when **192p** and **192q** were treated with sodium carbonate and iodine at room temperature for 16 hours, pyrrolidines *cis*-**195p** and *cis*-**195q** were obtained in poor yields (38% and 33%) and more than 50% of starting material was recovered (entry 16 and 17, Table 24). Cyclisations of **192p** and **192q** were also performed at room temperature for three days and at 50 °C for 16 hours but no improvement in terms of yields was observed, starting material was still more than 50%. It was clear after these experiments that only homoallylic amines with R^2 = aryl or benzyl could be converted to the corresponding azetidines under the iodo-mediated cyclisation conditions, in fact, homoallylic amines **192p** and **192q** did not convert to the azetidines. Ring closing of compound **192r** failed but complete conversion to (*E*)-*N*-(4-methoxybenzylidene)-1-phenylmethanamine **189r**, the only product detected in the ^{1}H NMR spectrum, was observed. This might be explained with a different pathway of the reaction where loss of allyl group occurs due to the formation of the highly conjugated intermediate **197**, which can convert to imine **169r** after treatment with sodium bicarbonate (Scheme 42).

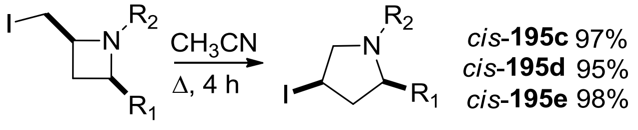


Scheme 42. Different pathway for ring closing of homoallylic amine **192r**

Homoallylic amine **192i** with the methoxy group in the meta position was also exposed to the cyclisation conditions resulting in complete conversion to the corresponding azetidine *cis*-**194i** and pyrrolidine *cis*-**195i** in a 6:1 ratio (entry 9, Table 24).

2.1.1 Ring expansion: Conversion of Iodo-Azetidines to Iodo-Pyrrolidines

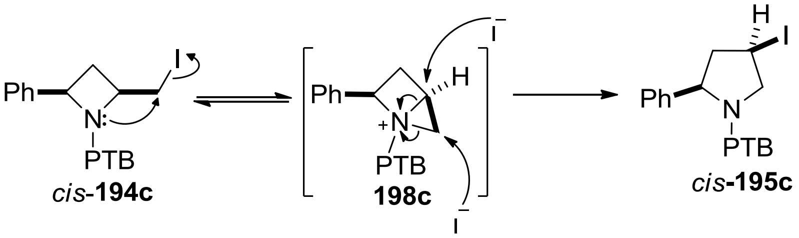
It was rapidly discovered that storage of iodo-azetidines *cis*-**194a** (even at 4 °C) resulted in the formation of some of the corresponding pyrrolidines *cis*-**195a**. In order to confirm isomerisation of iodo-azetidines to iodo-pyrrolidines, thermal ring-expansion, in accordance with the literature,[2, 61-62] was confirmed, heating *cis*-**194c-e** in acetonitrile at reflux for four hours gave *cis*-**195c-e** in 97%, 95% and 98% overall yield respectively (Scheme 43).[116]



cis-**194c-e**

Scheme 43. Thermal isomerisation of azetidines *cis*-**194c-e** to pyrrolidines *cis*-**195c-e**

A possible mechanism for the ring expansion might be explained by an intramolecular halogen displacement by the nitrogen to give the intermediate aziridinium salt **198c**, which could then be attacked by the iodide to afford the corresponding pyrrolidine *cis*-**195c** with inversion of stereochemistry (Scheme 44). Attack by the iodide to the less hindered carbon (reversible process) would reform azetidine *cis*-**194c**, whereas attack to the more hindered carbon (irreversible process) would produce the more thermodynamically favoured pyrrolidine *cis*-**195c**. It might be speculated that release of tortional strain is the driving force of this ring expansion.



Scheme 44. Possible mechanism for the ring expansion of *cis*-azetidine into *cis*-pyrrolidine

X-ray crystal structure analysis of compound **195c**, solved by Dr Louise Male, also confirmed *cis* iodo-pyrrolidine was formed (Figure 17).[116]

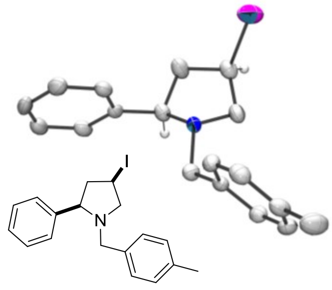
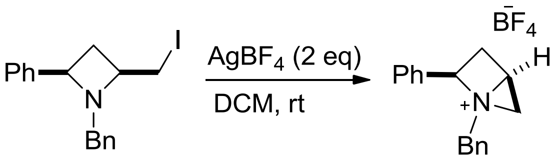


Figure 17. X-ray crystal structure with ellipsoids drawn at the 50% probability level of *cis*-**195c**. Most of the hydrogen atoms have been omitted for clarity and *cis*-stereochemistry is confirmed.

2.1.2 Attempts to isolate aziridinium salt 198a

Several attempts were tried to isolate aziridinium salt **198a** following the procedure reported by Davies and co-workers.[70] Iodo-azetidine **194a** was reacted with two equivalents of silver tetrafluoroborate at room temperature in dichloromethane (Scheme 45).



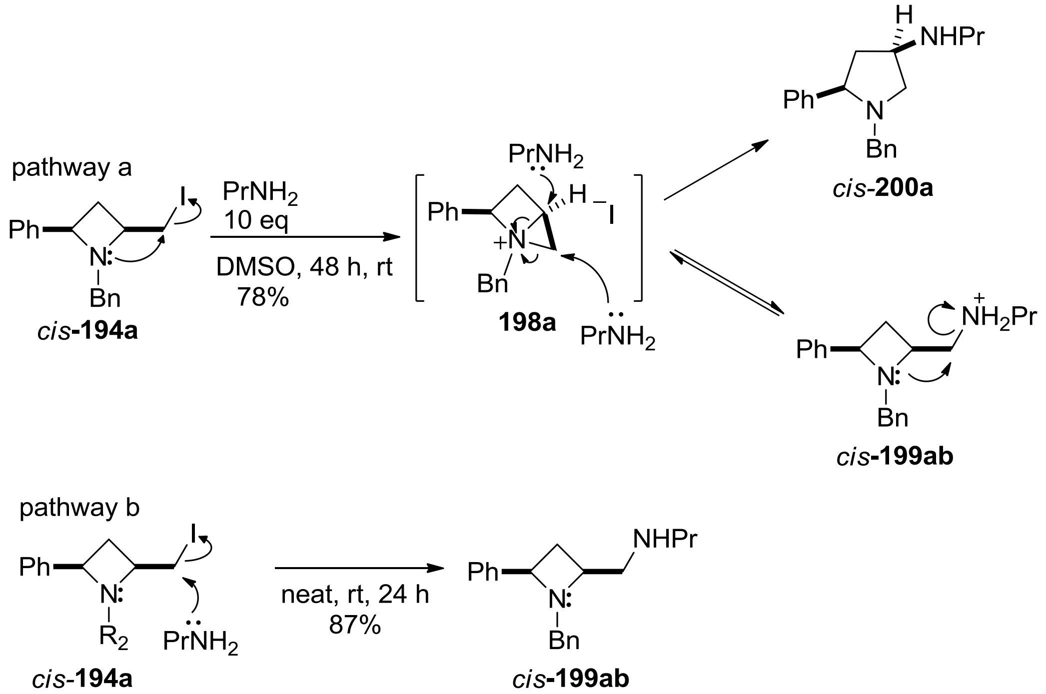
cis-**194a** **198a**

Scheme 45. Attempt to isolate aziridinium tetrafluoroborate salt **198a**

The reaction was carried out multiple times but with different purification procedures. Unfortunately although there was evidence for starting material consumption, as monitored by TLC, the product could not be accurately characterised due to the presence of broad resonances in the ^{1}H NMR spectra.

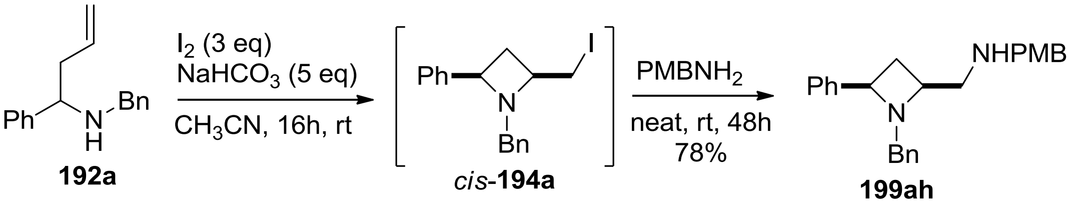
2.1.3 Synthesis of Amino-Azetidines: Replacement of Iodine with Amines

With the new azetidines synthesised (entry 1-15**,** Table 24), bearing in mind that iodo-azetidines are not thermally stable and that analysis of the crude ^{1}H NMR showed that only the product could be detected, with starting material completely consumed, just after the work-up, no flash chromatography was applied and the post-work-up azetidine *cis*-**194a** was readily converted to the corresponding amino-azetidine *cis*-**199ab** with a simple nucleophilic substitution to displace iodine. The iodo-azetidine *cis*-**194a** was initially exposed to ten equivalents of propylamine in DMSO at room temperature for 48 hours and unexpectedly afforded amino-pyrrolidine derivative *cis*-**200ab** in 78% yield (over two steps from **192a**) as single diastereoisomer. Amino-azetidine *cis*-**199ab** was then synthesised in 87% yield (over two steps from **192a**) by stirring *cis*-**194a** in a neat propylamine for 48 hours at room temperature. It was vital that liquid amines were used neat (as solvent) in the iodine displacement step, when co-solvent were used isomerisation to the corresponding pyrrolidine *cis*-**200ab** became problematic, however this feature can be exploited (as discussed later) in pyrrolidine synthesis. The formation of amino-azetidine *cis*-**199ab**, could be explained by considering the competition between intramolecular and intermolecular nucleophilic substitution. Aziridinium salt **198a** could be formed with iodine displacement by intramolecular nitrogen attack, followed by attack with an external amine to afford the more thermodynamically stable pyrrolidine *cis*-**200ab** (pathway a, Scheme 46). Using amine as solvent allowed the intermolecular nucleophilic substitution to be the favoured pathway in order to access amino-azetidine derivative *cis*-**199ab** (pathway b, Scheme 46).



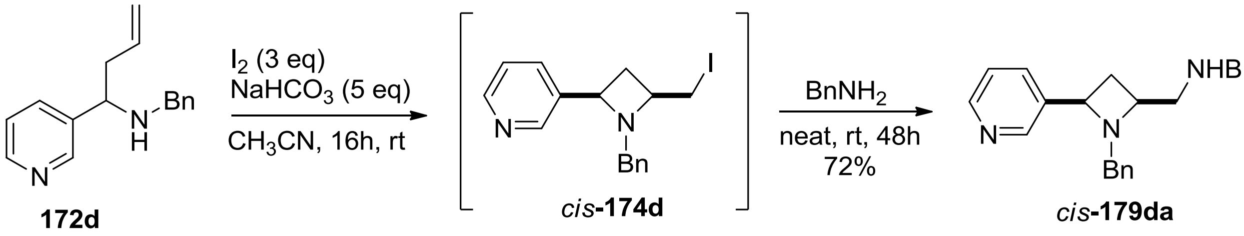
Scheme 46. Intramolecular versus intermolecular nucleophilic substitution

Iodo-cyclisation of **192a** was repeated, after aqueous work-up the obtained material *cis*-**194a** was dissolved in neat *p*-methoxy benzylamine, and stirred at room temperature for 48 hours to give the corresponding amino-azetidine *cis*-**199ah** in 78% yield (over two steps from **192a**) (Scheme 47). Thus, demonstrating derivitisation of material obtained from the cyclisation reactions may be performed without purification, to give higher yields than would be possible otherwise (Table 20). In fact, iodo-azetidine *cis*-**194a** could be obtained in only 45% yield after flash chromatography (Table 20), whereas the amino-azetidine *cis*-**199ah** was synthesised in much higher yield (78% over two steps from **192a**) after flash chromatography when the post-work-up iodo-azetidine *cis*-**194a** was directly used (Scheme 47).[116]



Scheme 47. Synthesis of amino-azetidine *cis*-**199ah**

Next **192d** was exposed to an analogous two step cyclisation-derivatisation sequence. Derivatives of *cis*-**194d** (and *cis*-**195d**) are especially attractive owing to the 3-pyridyl motif, allowing access to a potentially useful class of azetidine (and pyrrolidine) nicotine analogues and derivatives. The pharmacological activity of such analogues is an area of persistent interest.[8-9, 74, 119-122] In the case of the cyclisation of **192d**, it had already been shown a 5:1 mixture of *cis*-**194d**:*cis*-**195d** in high conversion was obtained, yet only 42% of *cis*-**194d** could be isolated by column chromatography (entry 4, Table 24). Pleasingly, purification post derivatisation gave the corresponding amino azetidine *cis*-**199da** as a single diastereoisomer in 72% overall isolated yield (Scheme 48).[116]



Scheme 48. Synthesis of amino-azetidine *cis*-**199da**

Displacement of iodide with nitrogen nucleophiles gave thermally stable azetidines. In order to confirm thermal stability of azetidines, samples of *cis*-**199ah** and *cis*-**199da** were each heated in refluxing DMSO for four hours. Solvent removal *in vacuo* gave materials with unchanged proton NMR spectra, confirming the robustness of the azetidine motif in the absence of iodide.[116] With this robust methodology that provides iodo-azetidine in hand, a small library of amino-azetidines with potential biological activity was obtained. Most of the iodo-azetidines (*cis*-**194a-m**) synthesised were converted to different amino-azetidines (*cis*-**199aa-mb)** *via* halogen displacement by a range of primary and secondary aromatic and aliphatic amines (Table 25). Analysis of the ^1H NMR spectra of the reaction mixture after work-up, showed complete conversion from iodo-azetidines *cis*-**194a-m** to amino-azetidine *cis*-**199aa-mb** after 24 hours. Simple flash chromatography afforded the products with moderate to good overall yields 65-87% as shown in Table 25. Stereochemistry of most of the new amino-azetidines was confirmed by nOe correlations. nOe enhancements were observed for protons H^5, H^{2a}, H^{2b} and H^{4b} when proton H^3 was irradiated, confirming the expected *cis* configuration (Figure 18).

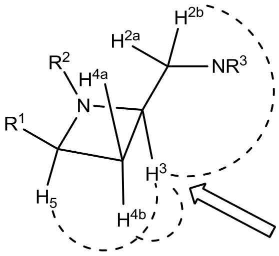


Figure 18. nOe correlations to assign relative stereochemistry of amino-azetidines *cis*-**199aa-mb**: Irradiating H3 nOe has been seen with H^5, H^{2a}, H^{2b} ,H^{4b}

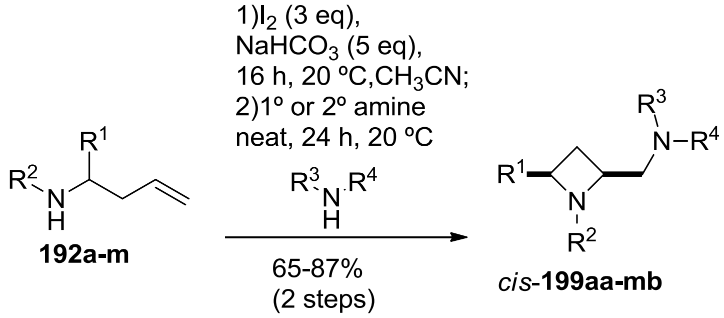
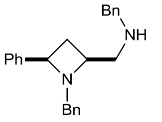
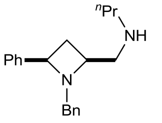
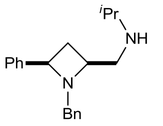
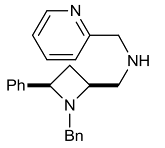
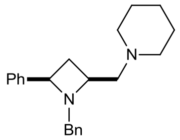
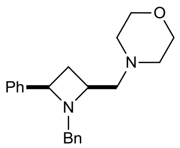
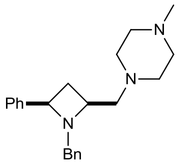
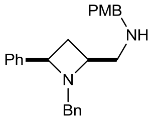
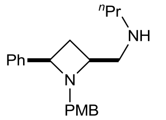
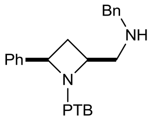
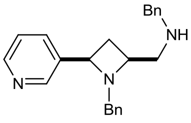
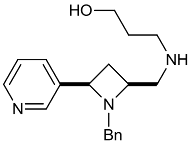
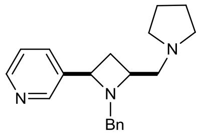
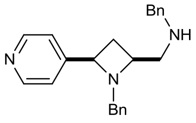
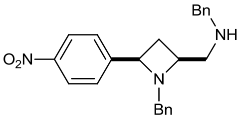
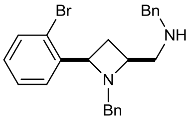
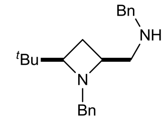
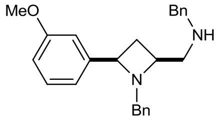
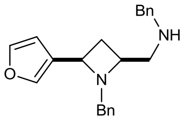
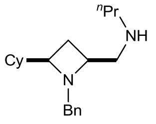
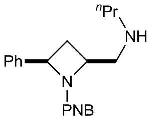
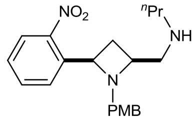
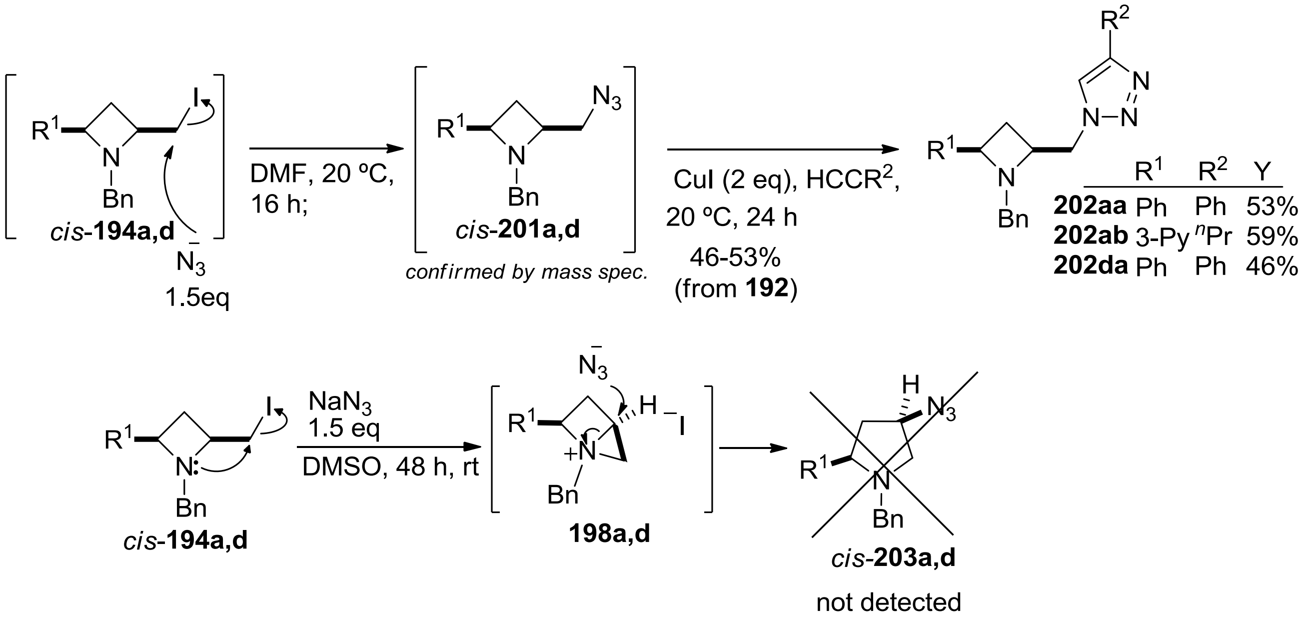


Table 25. Synthesis of amino-azetidines *cis*-**199aa-mb**

 *cis*-**199aa** 86%	 *cis*-**199ab** 87%	 *cis*-**199ac** 83%	 *cis*-**199ad** 69%	 *cis*-**199ae** 83%
 *cis*-**199af** 71%	 *cis*-**199ag** 81%	 *cis*-**199ah** 78%	 *cis*-**199bb** 74%	 *cis*-**199ca** 75%
 *cis*-**199da** 72%	 *cis*-**199di** 82%	 *cis*-**199dj** 76%	 *cis*-**199ea** 71%	 *cis*-**199fa** 76%
 *cis*-**199ga** 65%	 *cis*-**199ha** 86%	 *cis*-**199ib** 85%	 *cis*-**199ja** 79%	 *cis*-**199kb** 81%
 *cis*-**199lb** 82%	 *cis*-**199mb** 69%			

2.1.4 Synthesis of Azetidine-Triazoles: Replacement of Iodine with NaN_3, Click Chemistry

Displacement of iodine was attempted with a different nucleophile to access a new class of azetidines. Addition of 1.5 equivalents of sodium azide to the *in situ* generated *cis*-**194a** and *cis*-**194d** at room temperature in DMF, followed by addition of two equivalents of copper(I) iodide and one equivalent of phenyl acetylene or 1-pentyne, gave azetidine triazole derivatives *cis*-**202aa, ab, da**[116] in respectively 53%, 59% and 46 % isolated yield from **192** (Scheme 49). It is noteworthy that only 1.5 equivalents of sodium azide were enough to displace iodine to produce the azido-azetidine intermediates **201a,d** showing the higher nucleophilicity of azide compared to the amine nucleophiles. The fact that no formation of pyrrolidine **203** was observed is proof that intermolecular nucleophilic substitution is favoured compared to the intramolecular nucleophilic substitution when 1.5 equivalents of azide are used (Scheme 49).

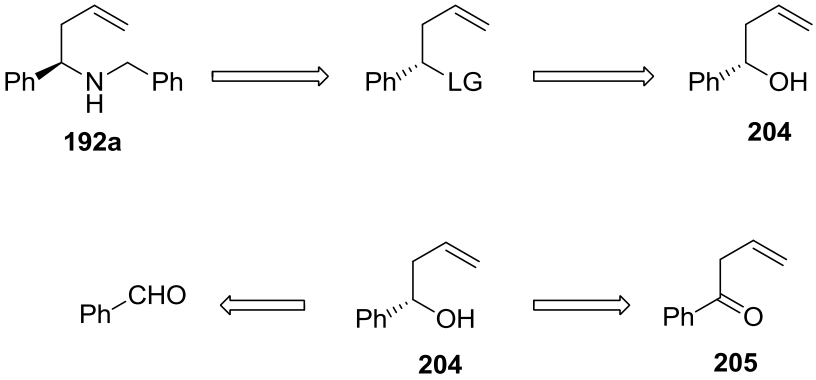


Scheme 49. Synthesis of triazole-azetidine *cis*-**201aa,ab,da**

2.1.4.1 Asymmetric Synthesis of Azetidines using a Chiral Catalyst

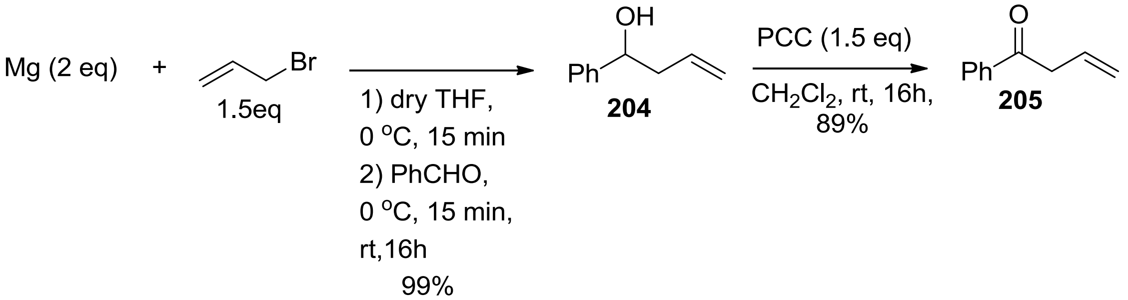
Allylation of imines has always been a very challenging reaction, whereas several procedures can be found in the literature for the synthesis of enantioenriched homoallylic alcohol. In particular asymmetric allylation of aldehydes[123-131] and asymmetric reduction of ketones[132-134] proved to be very successful procedures in terms of yields and *ee*. Homoallylic alcohol **204** might be converted to the desired enantioenriched amine **192a** by transforming the OH in a good leaving group followed by displacement with benzylamine (Scheme

50). Enantioenriched alcohol **204** could also be obtained by an asymmetric reduction of ketone **185** (Scheme 50).



Scheme 50. Retrosynthesis of homoallylic amine **192a**

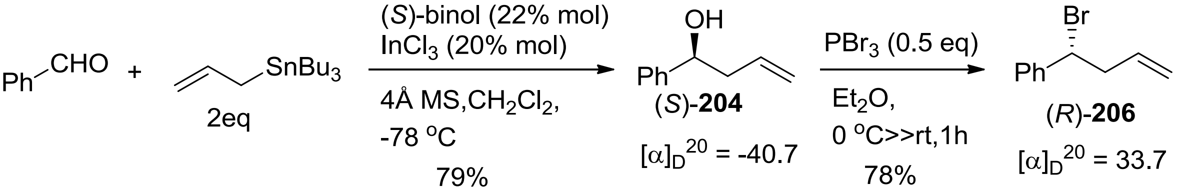
Homoallylic alcohol **204** was prepared with the same procedure as shown previously in (Table 23). Benzaldehyde was added to an *in situ* prepared allyl-Grignard to afford compound **204** in 99% yield. The homoallylic alcohol **204** prepared, was then oxidised to the corresponding ketone **205** with PCC in CH_2Cl_2 in 89% yield (Scheme 51).[135]



Scheme 51. Synthesis of homoallylic alcohol **204** and ketone **205**

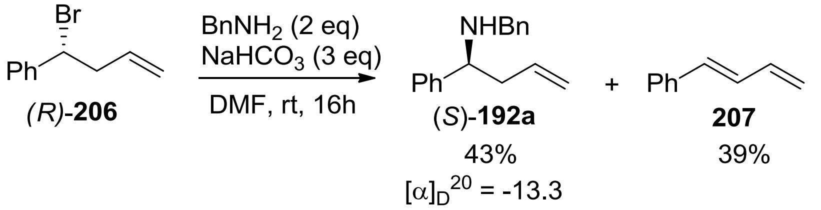
Asymmetric allylation of benzaldehyde was attempted with two equivalents of allyltributylstannane in the presence of (*S*)-binol (22% mol), indium chloride (20% mol) and 4Å MS in dichloromethane for 48 hours at -78 °C to afford compound (*S*)-**204** in 79% yield.[136] Specific rotation of compound (*S*)-**204** ($[\alpha]_D^{20}$ = -40.7) was compared to the literature value (*ee* = 92%, $[\alpha]_D^{20}$ = -42.7)[137] to determine the *ee*, which was 88%. Limit of accuracy for the enantiomeric excess calculation from the specific rotation values must be considered. In 1968, Krow and Hill reported that the specific rotation of (*S*)-2-ethyl-2-methyl succinic acid with an enantiomeric excess of 85% changes with the concentration showing non linear correlations between specific rotation and enantiomeric excess.[138] Tosylation of compound (*S*)-**204** to transform the OH in a better living group was performed twice following a literature procedure but the desired product could not be obtained.[139]

However a different literature procedure was attempted and compound (*S*)-**204** was converted to compound (*R*)-**206**, which could now be exposed to a nucleophilic substitution with benzylamine to access the enantioenriched homoallylic amine **192a**. The homoallylic alcohol (*S*)-**204** was reacted with 0.5 equivalents of PBr_3 in diethyl ether for one hour to deliver the bromide derivative (*R*)-**206** in 78% yield (Scheme 52).[140]



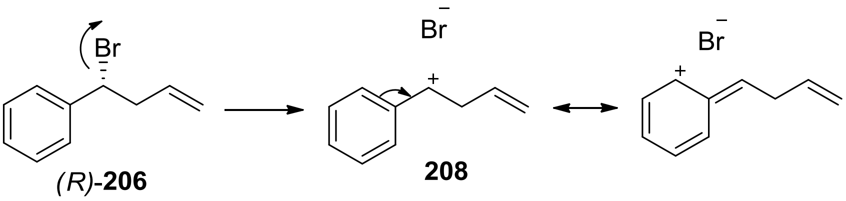
Scheme 52. Synthesis of enantioenriched alcohol (*S*)-**204** *via* asymmetric allylation of benzaldehyde and functional group interconversion

Compound (*R*)-**206** was then exposed to two equivalents of benzylamine and three equivalents of sodium bicarbonate in DMF at room temperature for 16 hours to obtain the desired homoallylic amine (*S*)-**192a** in 43% yield (Scheme 53). Unfortunately there were two problems related to this halogen displacement: the formation of the highly conjugated product **207** and loss of enantiopurity, which decreased to 23% *ee,* of compound (*S*)-**192a** confirmed by comparison with the literature value (*ee* = 91%, $[\alpha]_D^{20}$ = 52.9) (Scheme 53).[141]



Scheme 53. Halogen displacement by benzylamine

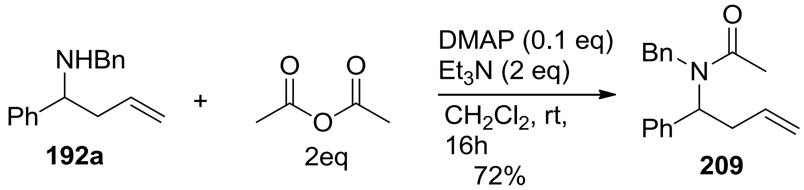
The loss of enantiopurity might be explained by the possible stabilisation of the carbocation **208** by the benzylic group, which does not allow the reaction to proceed *via* a pure S_N2, resulting in a mixture of S_N1 and S_N2 (Scheme 54).



Scheme 54. Stabilisation of the carbocation **208** by the benzylic group

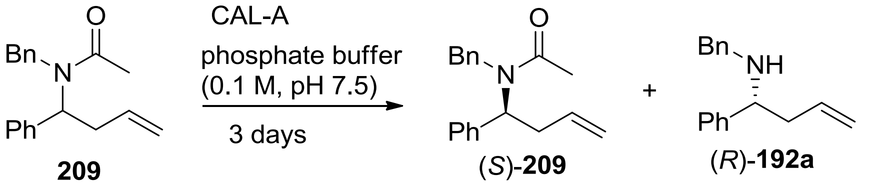
2.1.4.2 Enzimatic Kinetic Resolution

It has been previously reported that racemic alcohols and amines can be resolved by enzymatic kinetic resolution.[142-146] *Candida antarctica* lipase A was chosen as suitable enzyme to access the desired homoallylic amine (*S*)-**192a** needed for the synthesis of enantiopure azetidines. The homoallylic amine **192a** was acylated with two equivalents of acetic anhydride, 0.1 equivalents of DMAP and two equivalents of Et_3N in DCM at room temperature to afford compound **209** in 72% yield (Scheme 55).[147]



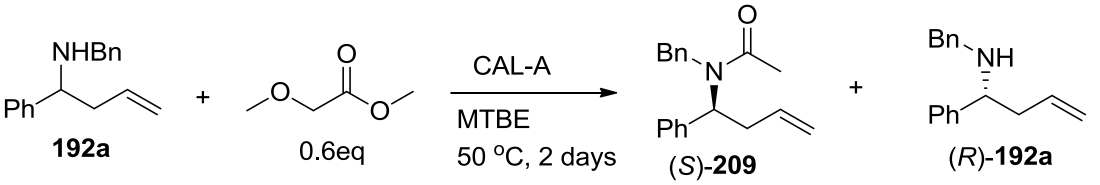
Scheme 55. Acylation of homoallylic amine **192a**

Kinetic resolution of compound **209** to obtain enantiopure homoallylic amine **192a** was attempted. Compound **209** was stirred with the enzyme CAL-A in 0.1 M phosphate buffer pH 7.5. The reaction was monitored every 30 minutes by TLC for three days after which a crude ^1H NMR spectrum was obtained and analysed. Unfortunately, starting material **209** was recovered as a racemate, confirmed by lack of any optical rotation (Scheme 56).



Scheme 56. Kinetic resolution of compound **209**

Compound **192a** was then stirred for two days with CAL-A and methyl 2-methoxyacetate in MTBE at 50 °C but unreacted racemic amine **192a** was quantitatively recovered (Scheme 57).



Scheme 57. Kinetic resolution of compound **192a**

2.1.4.3 Chiral Auxiliary Approach

2.1.4.3.1 Ellman's Chiral Sulfinamides

Asymmetric synthesis of azetidines proved to be unsuccessfull when a functional group interconversion strategy was applied (Scheme 53). Also the kinetic resolution approach did not furnish the desired products (Scheme 56, Scheme 57) so a chiral auxiliary approach was investigated. Ellman's chiral sulfinamides[148] (Figure 19) were chosen as the most suitable auxiliaries for the asymmetric synthesis of **192a**.

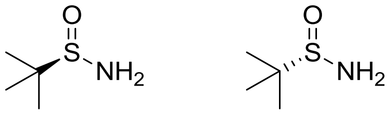
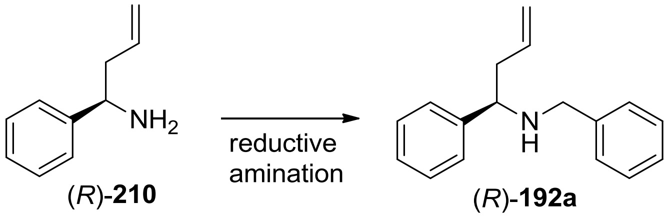


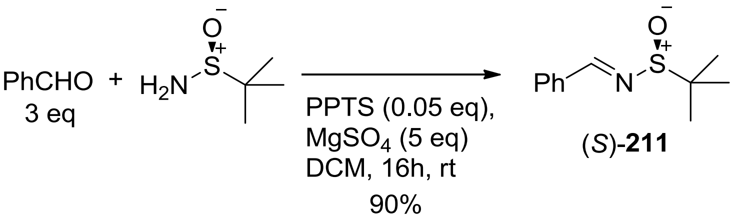
Figure 19. Ellman's chiral sulfinamides

Several papers regarding the asymmetric synthesis of enantioenriched homoallylic amines using Ellman's chiral auxiliaries have already been published[149] and in particular the synthesis of homoallylic amine (*R*)-**210** in excellent *ee* (up to >99%) have also been reported.[111, 150] A simple reductive amination of compound (*R*)-**210** would furnish the desired homoallylic amine (*R*)-**192a** in high yield and enantioselectivity.



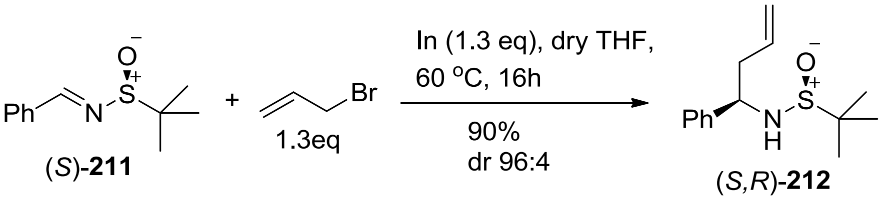
Scheme 58. Proposed reductive amination of compound (*R*)-**211** to access the desired homoallylic amine (*R*)-**192a**

(*S*)-*N*-*tert*-butylsulfinylamine (*S*)-**211** was prepared in 90% yield by using a literature procedure.[151] Benzaldehyde was stirred for 16 hours in dichloromethane with (*S*)-*N*-*tert*-butylsulfinylamine, PPTS and anhydrous magnesium sulphate (Scheme 59).



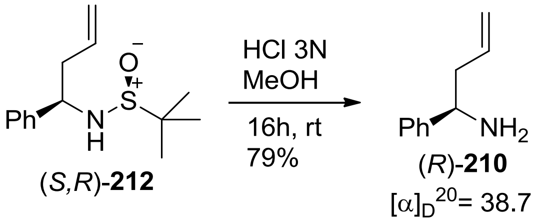
Scheme 59. Preparation of (*S*)-*N*-*tert*-butylsulfinylamine (*S*)-**211**

The (*S*)-*N*-*tert*-butylsulfinyl aldimines (*S*)-**211** was stirred with allylbromide (1.3eq) and indium (powder, -100 mesh) (1.3 eq) in dry THF for 16 hours to afford homoallylic amine (*S*,*R*)-**212** in 90% yield and 96:4 dr, confirmed by analysis of ^{1}H NMR spectrum of (*S*,*R*)-**212** (Scheme 60).[150]



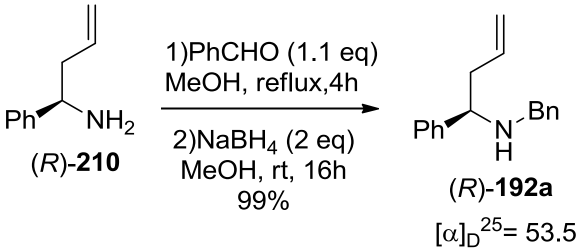
Scheme 60. Asymmetric allylation of (*S*)-**211**

Removal of the chiral auxiliary under acidic conditions yielded the homoallylic amine (*R*)-**210** in 79% yield and 92% *ee* compared to the literature value ($[\alpha]_D^{20}$ = 42.8)[111] (Scheme 61).



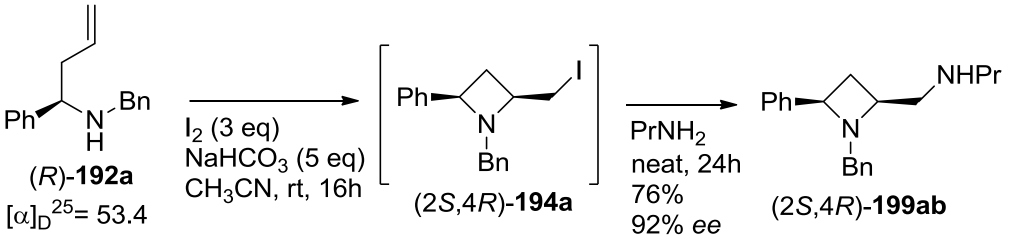
Scheme 61. Removal of the chiral auxiliary under acidic conditions

Non racemic homoallylic amine (*R*)-**210** was converted to the non racemic homoallylic amine (*R*)-**192a** with a reductive amination in >99% yield and 92% *ee*. The enantiomeric eccess was confirmed by comparison of the specific rotation value with the literature value ($[\alpha]_D^{20}$ = 52.9; 91% *ee*).[152] Compound (*R*)-**210** and benzaldehyde were refluxed in methanol for four hours and, after cooling to 20 °C, the imine thus formed was reduced by stirring with $NaBH_4$ over night (Scheme 62).[153]



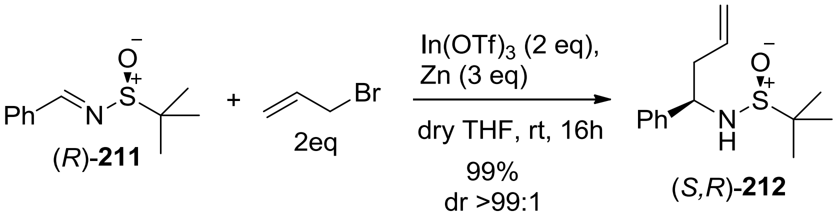
Scheme 62. Reductive amination of compound (*R*)-**210** to access the desired homoallylic amine (*R*)-**192a**

No loss of enantiopurity was observed and the homoallylic synthesised was exposed to the conditions described above (Scheme 47) to afford the amino-azetidine (2*S*,4*R*)-**199ab** in 76% yield over two steps and 92% *ee* confirmed by chiral HPLC (Scheme 63).



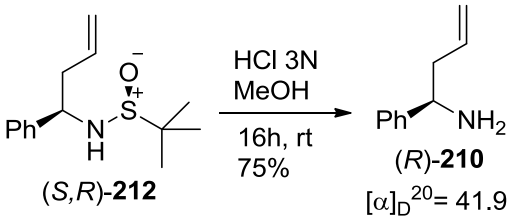
Scheme 63. Synthesis of enantioenriched amino-azetidine (2*S*,4*R*)-**199ab**

Allylation of compound (*R*)-**211** was attempted with a different method. Indium triflate, zinc and allylbromide were used to afford the homoallylic amine (*R*)-**192a** in 99% yield. Only one diastereoisomer was detected by analysis of ^{1}H NMR spectrum (Scheme 64).[111]



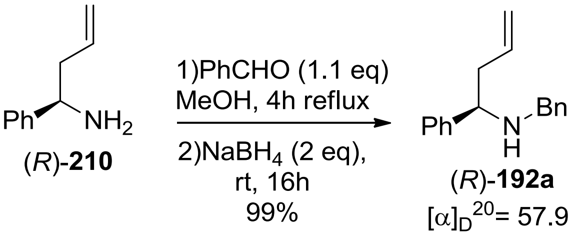
Scheme 64. Asymmetric allylation of (*S*)-**211** with a different method

The chiral auxiliary group was removed as shown above (Scheme 61) to afford compound (*R*)-**210** in 75% yield and >99% *ee*. The enantiomeric excess was confirmed by comparison of the specific rotation value with the literature value ($[\alpha]_D^{20} = 42.8$)[111] (Scheme 65).



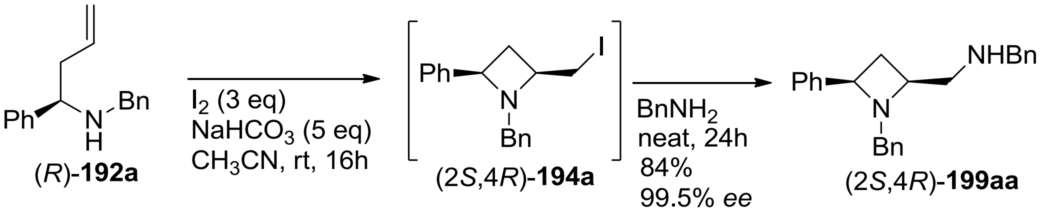
Scheme 65. Removal of the chiral auxiliary under acidic conditions

Compound (*R*)-**210** was reacted with benzaldehyde to form the corresponding imine, which was readily reduced with $NaBH_4$ in methanol for 16 hours to produce the homoallylic amine (*R*)-**192a** in 99% yield and >99% *ee*. The enantiomeric excess of (*R*)-**192a** was confirmed by comparison of the specific rotation value with the literature value ($[\alpha]_D^{20} = 52.9$; 91% *ee*) (Scheme 66).



Scheme 66. Reductive amination of compound (*R*)-**210** to access the desired homoallylic amine (*R*)-**192a**

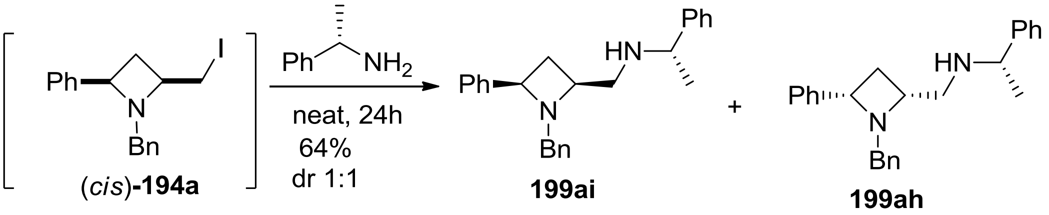
The enantioenriched homoallylic amine (*R*)-**192a** was exposed to previously optimised iodine cyclisation followed by halogen displacement with benzylamine to afford the enantioenriched amino-azetidine (2*S*,4*R*)-**199aa** in 84% yield over two steps and 99.5% *ee* confirmed by chiral HPLC (Scheme 67).



Scheme 67. Synthesis of enantioenriched amino-azetidine (2*S*,4*R*)-**199aa**

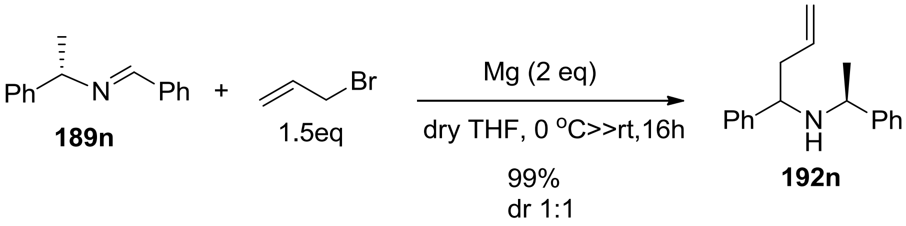
2.1.4.3.2 (*S*)-1-Phenylethanamine Chiral Auxiliary

Synthesis of enantioenriched amino-azetidine was also tried using a different chiral auxiliary. The post-work-up iodo-azetidine **194a** was reacted with (*S*)-1-phenylethanamine for 24 hours at room temperature neat to obtain a 1:1 mixture of diastereoisomers **199ai** and **199ah** in 64% yield over two steps. Different flash chromatography conditions were tried to separate the diastereoisomers with no success (Scheme 68).



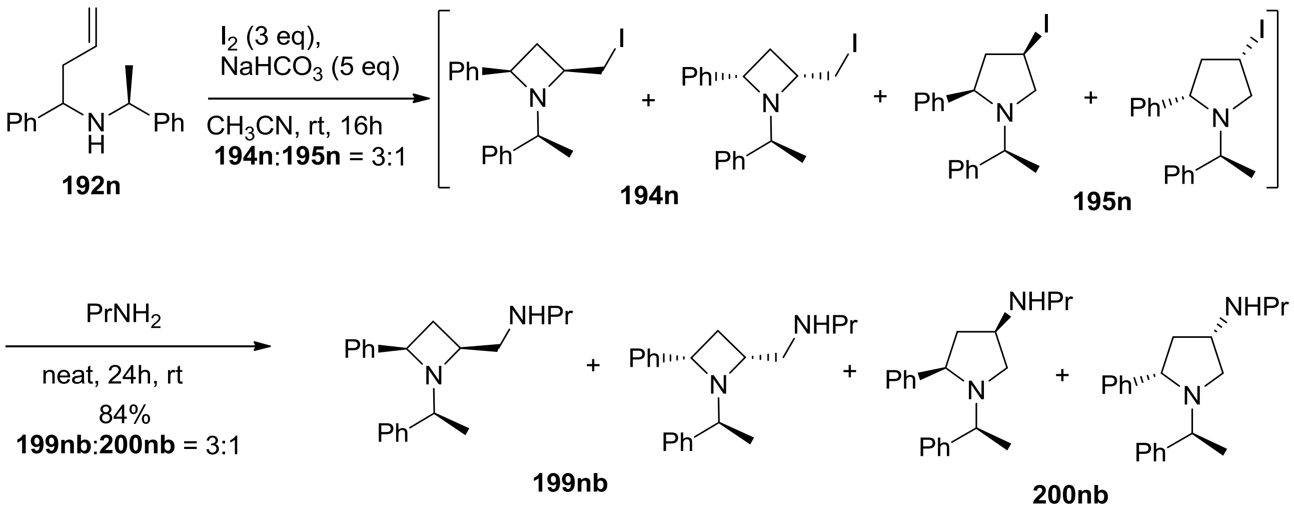
Scheme 68. Halogen displacement with the chiral (*S*)-1-phenylethanamine auxiliary group

The chiral auxiliary group (*S*)-1-phenylethanamine could also be used in an earlier stage of the synthesis. Allylation of (*S*,*E*)-*N*-benzylidene-1-phenylethanamine **189n** with magnesium and allylbromide in dry THF afforded the homoallylic amine **192n** in 99% yield and 1:1 diastereomeric ratio. The two different diastereoisomers were exposed to several flash chromatography conditions but the diastereomeric ratio could only be improved to 4:1 with a dramatic loss in yield (Scheme 69).



Scheme 69. Allylation of (*S*,*E*)-*N*-benzylidene-1-phenylethanamine **189n**

However the allylation was repeated and the 1:1 mixture of diastereoisomers prepared was treated with the cyclisation conditions to afford a 3:1 mixture of iodo-azetidines **194n** and iodo-pyrrolidines **195n** elaborated by analysis of the crude ^{1}H NMR spectrum. The isomers were successfully exposed to preparative HPLC separation and only one single enantiomer *cis*-amino-azetidine could be obtained pure in 23% yield (Scheme 70).



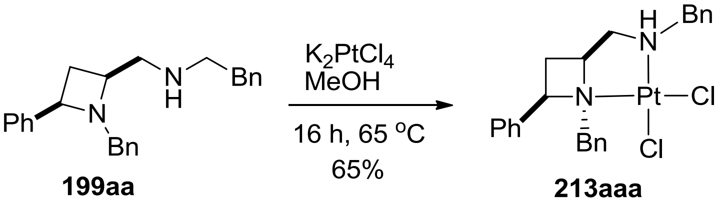
Scheme 70. Iodine mediated cyclisation of homoallylic amine **192n**

2.1.5 Synthesis of Azetidine Metal Complexes

There are only few examples of amino-azetidine metal complexes as catalysts in the literature.[49, 154] Herein the synthesis of new palladium and platinum amino-azetidine complexes is illustrated. These new racemic azetidine metal complexes were synthesised with the purpose of obtaining and analysing the X-ray structures in order to design new enantioenriched amino-azetidines metal complexes to be used as catalysts.

Amino-azetidine **199aa** (1.1 eq) was stirred with one equivalent of K_2PtCl_4 in refluxing MeOH for 16 hours to afford Pt(II)-amino-azetidine complex **213aaa** in 65% yield (Scheme 71).[155] The product was purified by flash chromatography and crystallisation with acetonitrile and diethyl ether. The structure of compound

213aaa was confirmed by 2D-NMR spectroscopy techniques. X-ray crystal structure analysis of compound **213aaa**, solved by Dr Louise Male, also confirmed Pt(II)-amino-azetidine complex was formed (Figure 20).



Scheme 71. Synthesis of Pt(II)-amino-azetidine complex **213aaa**

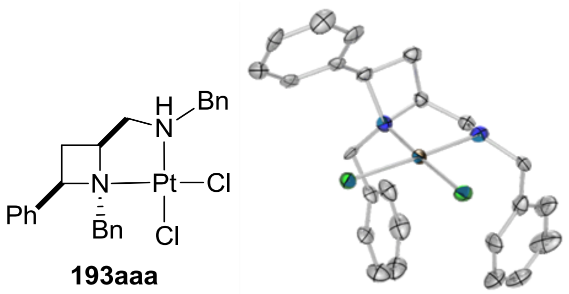
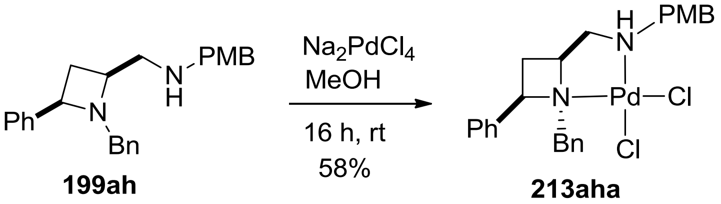
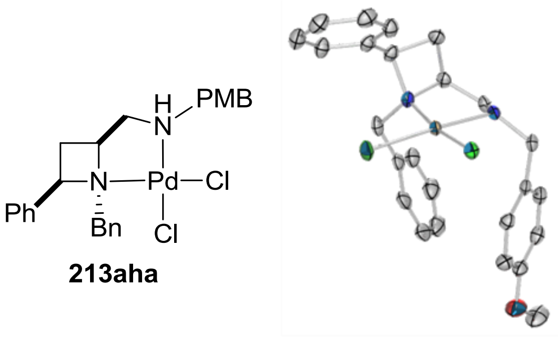


Figure 20. X-ray crystal structure with ellipsoids drawn at the 50% probability level of Pt(II)-amino-azetidine complex **213aaa**. Most of the hydrogen atoms have been omitted for clarity

Amino-azetidine **199ah** (1.1 eq) was stirred with one equivalent of Na_2PdCl_4 in MeOH for 16 hours at room temperature to afford Pd(II)-amino-azetidine complex **213aha.**[155] The product was obtained in 57% yield after purification by flash chromatography and crystallisation with acetonitrile and diethyl ether (Scheme 72). X-ray crystal structure, solved by Dr Louise Male, along with 2D-NMR spectra analysis of compound **213aha** confirmed Pd(II)-amino-azetidine complex was formed (Figure 21).



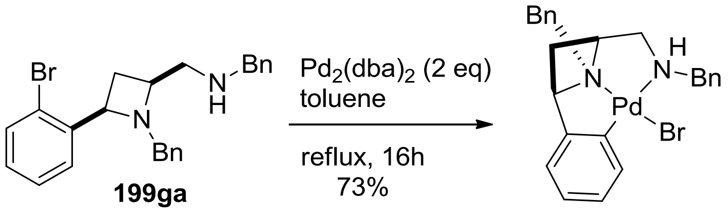
Scheme 72. Synthesis of Pd(II)-amino-azetidine complex **213aha**



213aha

Figure 21. X-ray crystal structure with ellipsoids drawn at the 50% probability level of Pd(II)-amino-azetidine complex **213aha**. Most of the hydrogen atoms have been omitted for clarity

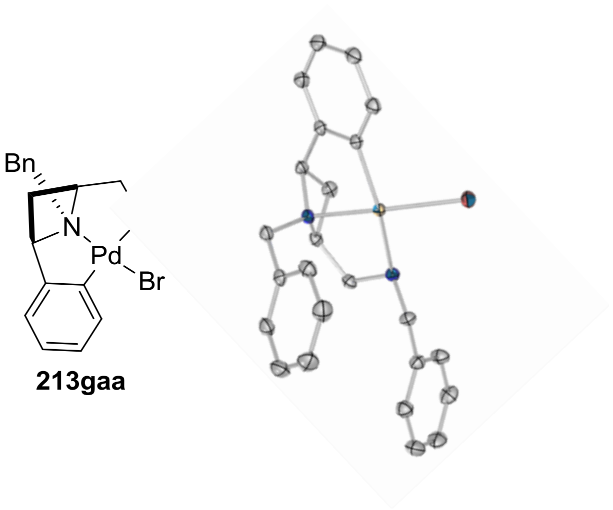
Amino-azetidine **199ga** was refluxed with two equivalents of $Pd_2(dba)_2$ in toluene for 16 hours to afford the *C,N,N* Pd(II)-amino-azetidine complex **213gaa**. The product was purified by flash chromatography and crystallisation with acetonitrile and diethyl ether in 73% yield (Scheme 73).[156] Analysis of ^1H NMR spectrum of compound **213gaa** proved to be inefficient in order to assign the structure of compound **213gaa** due to the presence of too many broad peaks. However, X-ray crystal structure analysis of compound **213gaa**, solved by Dr Louise Male, showed the actual structure of *C,N,N* Pd(II)-amino-azetidine complex **213gaa** (Figure 22).



199ga

213gaa

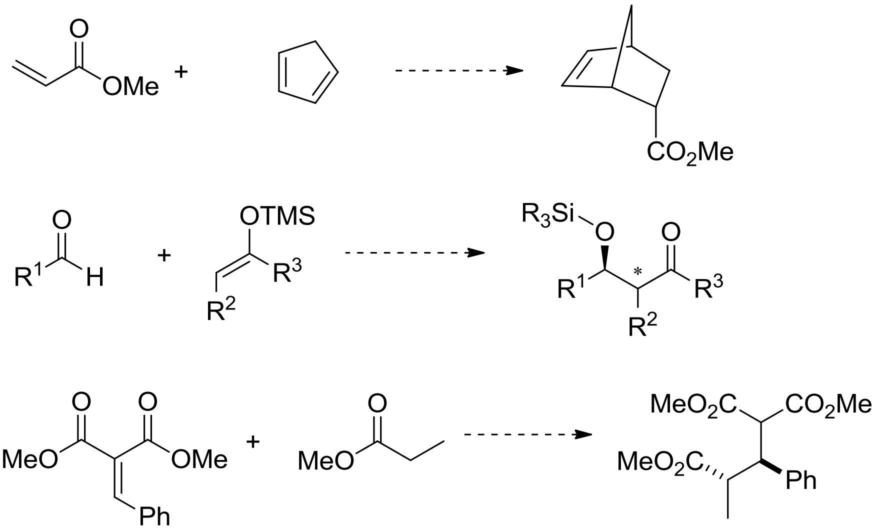
Scheme 73. Synthesis of *C,N,N* Pd(II)-amino-azetidine complex **213gaa**



213gaa

Figure 22. X-ray crystal structure with ellipsoids drawn at the 50% probability level of *C,N,N* Pd(II)-amino-azetidine complex **213gaa**. Most of the hydrogen atoms have been omitted for clarity

Analysis of the X-ray structures of compounds **213aaa**, **213aha** and **213gaa** revealed that the metal (palladium or platinum) is completely shielded by the two phenyl groups on the bottom face, whereas the top face is shielded only by one phenyl with the possibility to approach one side of the top face. This shielding effect of the phenyl groups would create a very good chiral environment around the metals making these amino-azetidine complexes suitable chiral Lewis acid catalysts for Diels Alder, Aldol and Michael type reactions (Scheme 74).[157-159]



Scheme 74. Suitable reactions for asymmetric Lewis-Acid catalysis with azetidine complexes

2.2 Synthesis of Pyrrolidines

It was already proved (Scheme 46) that *cis*-amino-pyrrolidines can be synthesised by reacting iodo-azetidine with ten equivalents of propylamine in DMSO at room temperature for 48 hours. Two different post-work-up iodo-azetidine *cis*-**194a,k** were reacted with ten equivalents of propylamine or pyrrolidine in DMSO at room temperature for 48 hours affording amino-pyrrolidines *cis*-**200aj,kb** as single diastereoisomers (no *trans* diastereoisomers were detected) in respectively 78%, 81% and 82% yields (Table 26).

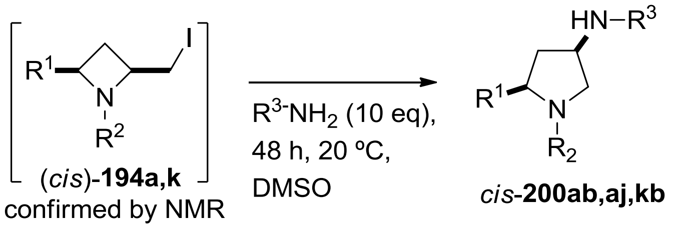


Table 26. Synthesis of *cis*-amino-pyrrolidines

compound	R^1	R^2	R^3	d.r.	yield (%) (from **192**)
cis-**200ab**	Ph	Bn	^{n}Pr	>99:1	78
cis-**200aj**	Ph	Bn	pyr	>99:1	81
cis-**200kb**	Cy	Bn	^{n}Pr	>99:1	82

Cy = cyclohexyl, pyr = pyrrolidine

A similar approach was attempted with a different nucleophile such as hydroxide to probe whether *cis*-hydroxyl-pyrrolidines could also be obtained. Post-work-up iodo-azetidine *ci*s-**194a,b,d** were reacted with a solution of sodium hydroxide 2N in DMSO for 48 hours at room temperature to afford hydroxyl-pyrrolidines (*cis*)-**214a,b,d** as single diastereoisomers in respectively 82%, 79% and 72% yields (Table 27).

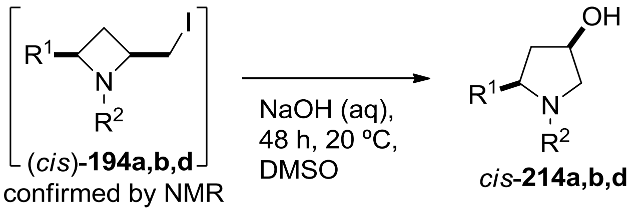
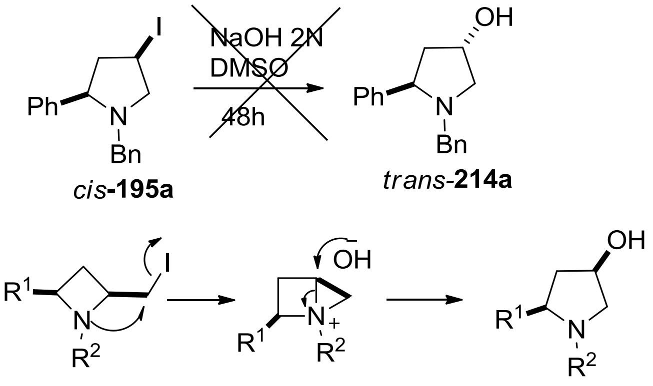


Table 27. Synthesis of *cis*-hydroxyl-pyrrolidines

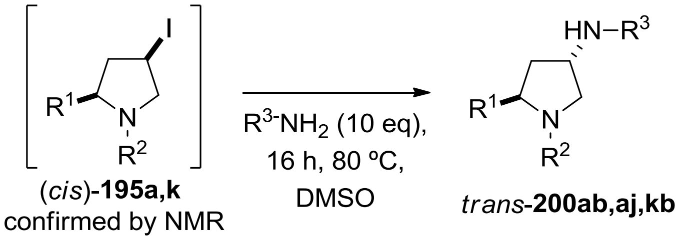
compound	R^1	R^2	d.r.	yield (%) (from **192**)
cis-**214a**	Ph	Bn	>99:1	82
cis-**214b**	Ph	Bn	>99:1	79
cis-**214d**	Cy	Bn	>99:1	72

As reported in the literature, the possible mechanism for the formation of the alcohol might be *via* aziridinium salt formation as described in the introduction (Scheme 18).[62] To support the hypothesis of an aziridinium salt formation iodo-pyrrolidine *cis*-**195a** was stirred for 48 hours with a solution of NaOH 2N in DMSO for 48 hours but the expected hydroxyl-pyrrolidine *trans*-**214a** was not obtained and starting material was fully recovered. Such experiment might perhaps suggest that the formation of an aziridinium salt intermediate is necessary for the synthesis of hydroxyl-pyrrolidines (Scheme 75).



Scheme 75. Reaction of iodo-pyrrolidine *cis*-**195a** with NaOH

Iodo-pyrrolidine *cis*-**195a** was then exposed to the same reaction conditions as shown above in (Scheme 75) but the temperature was changed to 80 °C and the desired hydroxyl-pyrrolidine *trans*-**214a** could still not be obtained. However, amino-pyrrolidines *trans*-**200ab,aj,kb** or triazole-pyrrolidines *trans*-**215aa,ca,da** were synthesised, when two different nucleophiles such as amine or azide, where used to displace iodine. Amino-pyrrolidines *trans*-**200ab,aj,kb** were synthesised in 74-79% overall yields (from homoallylic amine **192**) by treating iodo-pyrrolidines *cis*-**195a,k** with ten equivalents of the corresponding amines in DMSO at 80 °C for 16 hours. The ratio of diastereoisomers was very good in all cases (>99:1) and only the *trans* diastereoisomers were detected from the analysis of the crude ^{1}H NMR spectra (Table 28).



(*cis*)-**195a,k** confirmed by NMR

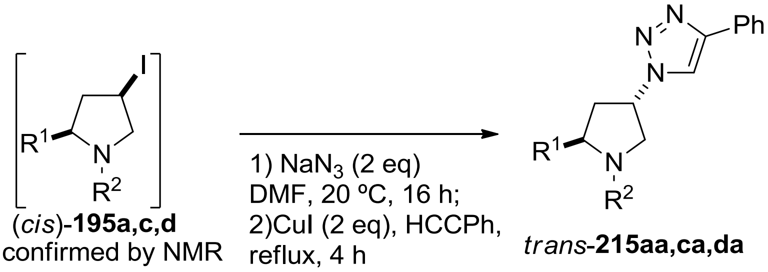
trans-**200ab,aj,kb**

Table 28. Synthesis of *trans*-amino-pyrrolidines

compound	R^1	R^2	R^3	d.r.	yield (%) (from **192**)
trans-**200ab**	Ph	Bn	^{n}Pr	>99:1	74
trans-**200aj**	Ph	Bn	pyr	>99:1	78
trans-**200kb**	Cy	Bn	^{n}Pr	>99:1	79

Cy = cyclohexyl, pyr = pyrrolidine

To synthesise triazole-pyrrolidines, iodo-pyrrolidines *cis*-**195a,c,d** were reacted with NaN_3 at room temperature in DMF for 16 hours, at which point they were treated with copper iodide and phenylacetylene at 120 °C for four hours to afford triazole-pyrrolidines *trans*-**215aa,ca,da** as single diastereoisomers in respectively 65%, 61% and 57% yields (Table 29). The structures of the triazole-pyrrolidines were all assigned by 2D-NMR spectroscopy techniques and X-ray crystal structure analysis of compound *trans*-**215da**, solved by Dr Louise Male, also confirmed the *trans*-stereochemistry (Figure 23).

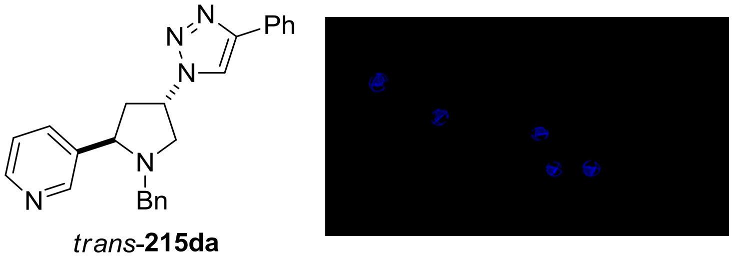


(*cis*)-**195a,c,d** confirmed by NMR

trans-**215aa,ca,da**

Table 29. Synthesis of *trans*-triazole-pyrrolidines

compound	R^1	R^2	d.r.	yield (%) (from **192**)
trans-**215aa**	Ph	Bn	>99:1	65
trans-**215ca**	Ph	PTB	>99:1	61
trans-**215da**	3-Py	Bn	>99:1	57



trans-**215da**

Figure 23. X-ray crystal structure with ellipsoids drawn at the 50% probability level of *trans*-**215da**. Most of the hydrogen atoms have been omitted for clarity and *trans*-stereochemistry is confirmed

2.3 Oxidation of Secondary and Tertiary amines

Oxidation of amines is a very important reaction for the synthesis of imines which are useful intermediates to access biological active nitrogen-containing compounds or nitrogen-containing molecules which could be used as catalysts. Oxidation of secondary benzylic amines to imines could also be a good method for *N*-dibenzylation of secondary amines. Different procedures for oxidation of amines and *N*-debenzylation have already been reported in the literature[160-167] and most of them involve the use of metals such as palladium, ruthenium and gold. Herein, a new methodology for the oxidation of secondary and tertiary amines and selective *N*-benzyl deprotection of secondary amines over *N*-benzyl deprotection of tertiary amines with commercially available reagents such as iodine and caesium carbonate is illustrated. This is the first time iodine and caesium carbonate have been reported as a very powerful tool for oxidation of amines affording excellent yields with no need of purification. Some of the needed secondary amines were prepared by condensation of different amines and aldehydes followed by reduction with $NaBH_4$. Primary amines **216a-f** were reacted with aldehydes **217a-f** in refluxing methanol for four hours to produce the corresponding imines intermediate (**218a-f**), which were directly reduced with 1.5 equivalents of $NaBH_4$ at room temperature for 16 hours to afford secondary amines **219a-f** in 99% yield (Table 30).

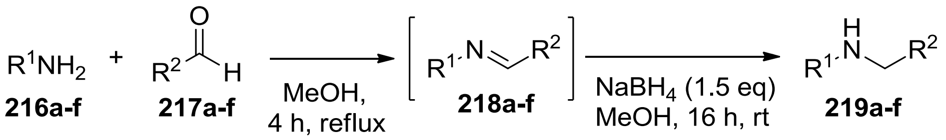


Table 30. Preparation of secondary amines **219a-f**

entry	R^1	R^2	yield of **219** (%)
a	PMB	Ph	99
b	PNB	Ph	99
c	^{n}Pr	Ph	99
d	CH_2CH_2OH	Ph	99
e	Bn	2-Th	99
f	$CH_2(CH_3)Ph$	Ph	99

PMB = para-methoxy benzyl, PNB = para-nitro benzyl, Th = thiophene

In order to establish optimum reaction conditions for oxidation of secondary amines, *N*-benzyl-1-phenylethanamine was reacted with three equivalents of iodine under different base and solvent conditions. Caesium carbonate (entry 2, Table 31) and potassium carbonate (entry 5, Table 31) with acetonitrile as solvent, proved to be the best bases, affording the product (*E*)-*N*-benzylidene-1-phenylethanamine **189n** in 99% yield. When the reaction was tried without the base, starting material was completely recovered (entry

1, Table 31), showing the crucial role of the base. Benzaldehyde was formed as side product when sodium bicarbonate, sodium acetate and lithium acetate (entry 3, 4 and 8, Table 31) with acetonitrile as solvent, were used. (*E*)-*N*-benzylidene-1-phenylethanamine **189n** was the main product in most of the cases suggesting that the less hindered proton was abstracted by the base. Acetonitrile and THF (entry 2 and 12, Table 31) proved to be the best solvents when caesium carbonate was used as base, yielding the product **189n** in >99%, whereas the use of DMSO favoured the formation of 1-phenyl-*N*-(1-phenylethylidene)methanamine **220f** (entry 11, Table 31).[168]

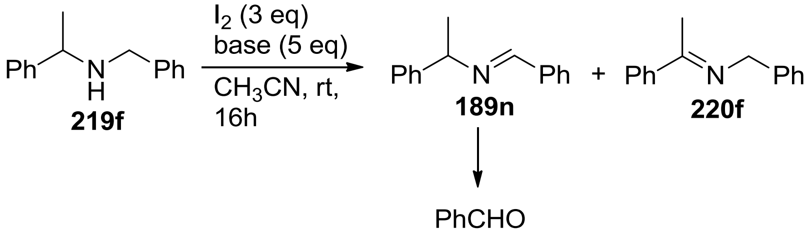


Table 31. Oxidation of secondary amines: Base and solvent screening

entry	solvent	base	ratio of **219f** (%) [a]	ratio of **189n** (%) [a]	ratio of **220f** (%) [a]	ratio of PhCHO (%) [a]
1	CH_3CN	-	100	-	-	-
2	**CH_3CN**	**Cs_2CO_3**	**-**	**>99**	**-**	**-**
3	CH_3CN	$NaHCO_3$	81	13	-	6
4	CH_3CN	NaOAc	49	35	-	16
5	**CH_3CN**	**K_2CO_3**	**-**	**>99**	**-**	**-**
6	CH_3CN	Li_2CO_3	65	27	-	8
7	CH_3CN	LiOH	50	50	-	-
8	CH_3CN	LiOAc	74	7	-	19
9	MeOH	Cs_2CO_3	75	25	-	-
10	Et_2O	Cs_2CO_3	42	58	-	-
11	DMSO	Cs_2CO_3	-	46	54	-
12	**THF**	**Cs_2CO_3**	**-**	**>99**	**-**	**-**
13	DMF	Cs_2CO_3	-	75	25	-

[a] ratio elaborated by analysis of ^{1}H NMR spectrum

With the best conditions in hand, a screening of the oxidation reaction under different equivalents of iodine and caesium carbonate was also studied. One equivalent of iodine and three equivalents of caesium carbonate were deemed to be the best conditions (entry 6, Table 32). Only 8% of product **189n** was obtained when 0.1 equivalents of caesium carbonate with one equivalent of iodine were used, showing no catalytic activity of the base (entry 1, Table 32). Iodine did not show catalytic activity either. In fact, the product **189n** was obtained in only 20% yield when 0.1 equivalents of iodine and three equivalents of caesium carbonate were used (entry2, Table 32). It is of interest to note that by increasing the equivalents of iodine three-fold, the reaction did not lead to more oxidised products (entry 7, Table 32).[168]

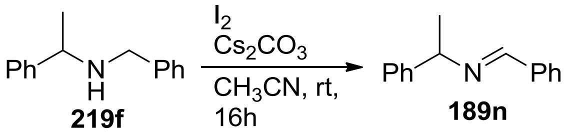


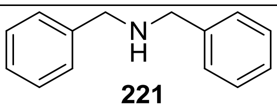
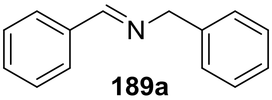
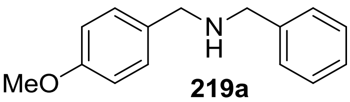
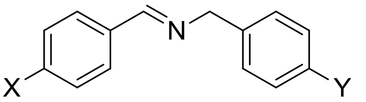
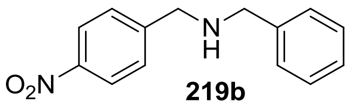
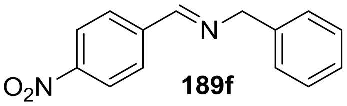
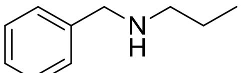
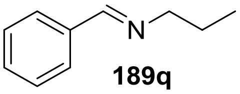
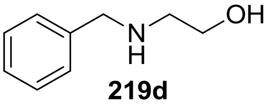
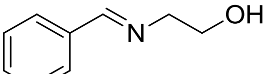
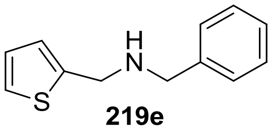
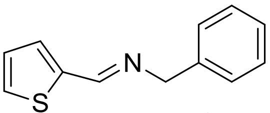
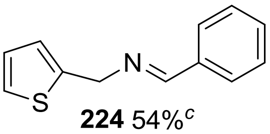
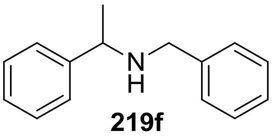
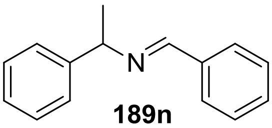
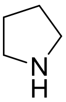
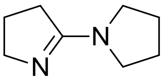
Table 32. Screening of iodine and caesium carbonate equivalents.

entry	eq of I_2	eq of Cs_2CO_3	conversion **189n** (%) [a]
1	1	0.1	8
2	0.1	3	21
3	1	1	41
4	1	1.5	86
5	1	2	88
6	**1**	**3**	**>99**
7	3	5	>99

[a] ratio elaborated by analysis of ^{1}H NMR spectrum.

Several secondary amines were exposed to the optimised reaction conditions to understand the scope and limitation of this oxidation. A simple work-up with sodium thiosulfate, furnished the imines in very high yield (99%) and no further purification was needed (Table 33). The regioselective formation of the imine **189f** (entry 3, Table 33) suggested a possible mechanism where the most acidic proton reacts with the base (Scheme 76). A mixture of four isomers was detected by analysis of the ^{1}H NMR spectrum when amine **219a** was exposed to the reaction conditions, due to hydrolysis and recondensation of the two possible isomers **189b** and **189r**. Nonetheless, only the two isomers **189b** and **189r** were obtained when five equivalents of anhydrous magnesium sulphate were added to the reaction mixture (entry 2, Table 33). The formation of imine **283** (entry 5, Table 33) shows that iodine reacts selectively with the nitrogen over the oxygen.[168]

Table 33. Oxidation of secondary amines with one equivalent of iodine and three equivalents of Cs_2CO_3 in CH_3CN at rt.

entry	substrate	product	time (min)	yield % [a]
1	 **221**	 **189a**	90	99
2	 **219a**	 **189b** X= H, Y= OMe 50%[c] **189r** X= OMe, Y= H 50%[c]	90	99[b]
3	 **219b**	 **189f**	40	99
4	 **219c**	 **189q**	240	99[b]
5	 **219d**	 **223**	120	99
6	 **219e**	 **189w** 46%[c]  **224** 54%[c]	60	99[b]
7	 **219f**	 **189n**	60	99
8	 **222**	 **225**	40	99

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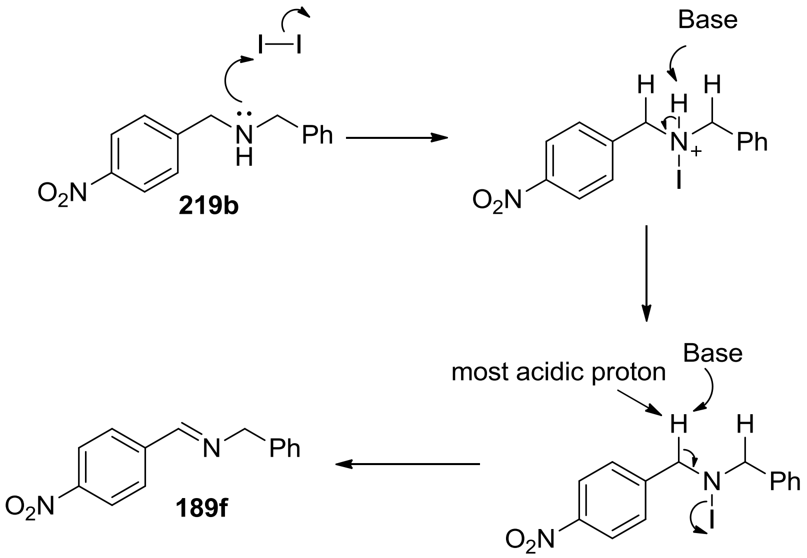
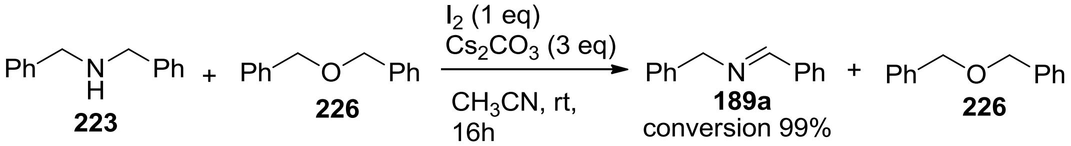
[a] isolated yield with no chromatography needed; [b] 5 equivalent of $MgSO_4$ were added to the reaction conditions; [c] ratio elaborated by analysis of ^{1}H NMR spectrum.

Dibenzylamine **221** was reacted with one equivalent of iodine and three equivalents of caesium carbonate in acetonitrile for 90 minutes in the dark and product (*E*)-*N*-benzylidene-1-phenylmethanamine **189a** (entry 1, Table 33) was formed in >99 % yield. The reaction proceeded with essentialy the same yield and selectivity in the presence and absence of light which suggests a minor role of any radical character to the reaction.



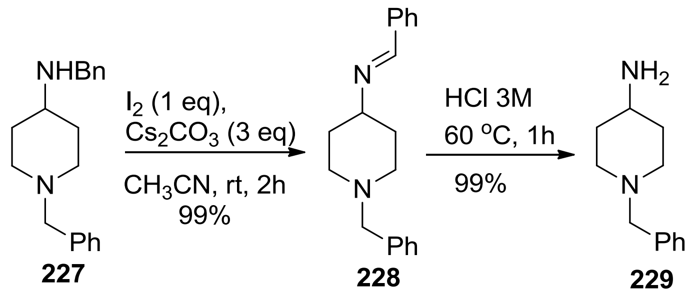
Scheme 76. Most acidic proton is abstracted by the base

To prove that this oxidation reaction might be completely selective between nitrogen and oxygen, dibenzylamine **221** and dibenzyl ether **226** were mixed together with one equivalent of iodine and three equivalents of caesium carbonate in acetonitrile for 16 hours. After work-up compound **226** was completely recovered unchanged, whereas compound **223** was completely converted to imine **189a** in 99% (Scheme 77). This experiment suggested that a selective *N*-Benzyl deprotection over *O*-Benzyl might be possible.[168]



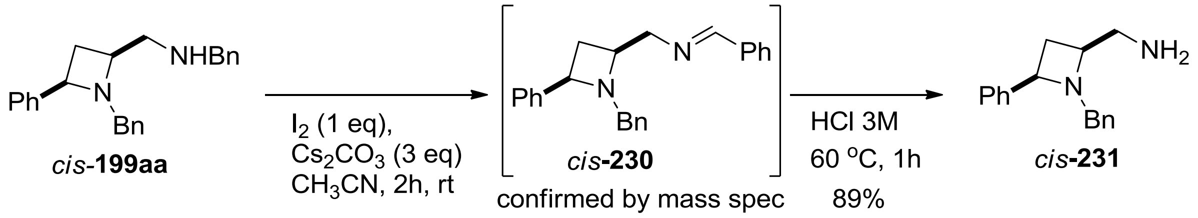
Scheme 77. Oxidation of dibenzylamine in the presence of dibenzyl either

The oxidation was tried on diamine **227** to show whether selective oxidation of secondary amine over tertiary amine could be possible. Diamine **227**, prepared in 60% yield by condensation of the commercially available 1-benzylpiperidin-4-amine with benzaldehyde, followed by reduction with $NaBH(OAc)_3$, was exposed to the oxidation reaction conditions. The imine **228** obtained in 99%, was hydrolised with a 3M solution of HCl at 60 °C to afford compound **229** in 99% yield. This experiment shows that *N*-benzyl deprotection of secondary amines over *N*-benzyl deprotection of tertiary amines is possible (Scheme 78).[168]



Scheme 78. Benzylic deprotection of secondary amine over tertiary amine

N-benzyl deprotection of secondary amine over tertiary amine was also attempted on amino-azetidine *cis*-**199aa.** Compound *cis*-**199aa** was reacted with one equivalent of iodine and three equivalents of caesium carbonate in acetonitrile for two hours to produce the intermediate imine *cis*-**230** (confirmed by mass spec), which was hydrolised with HCl 3M at 60 °C to deliver the unprotected amino-azetidine *cis*-**231** in 89% overall yield (Scheme 79).[168]



Scheme 79. Benzylic deprotection of secondary amine over tertiary amine applied to amino-azetidine *cis*-**199aa**

Different oxidising agent sources such as bromine, NBS and NIS were compared to iodine. Dibenzylamine **221** was exposed to one equivalent of oxidising agent. Caesium carbonate was used as base and acetonitrile was the solvent of choice. When the reaction was left stirring for 1.5 hours, molecular iodine exhibited the best result (entry 2, Table 34). When the reaction was left stirring overnight, NIS proved to be a good oxidant showing complete conversion to the product although molecular iodine was still the best reagent due to the more straightforward purification. Molecular bromine and NBS did not allow the reaction to reach completion with 67% and 70% conversion of the starting material (entry 1 and 2, Table 34).

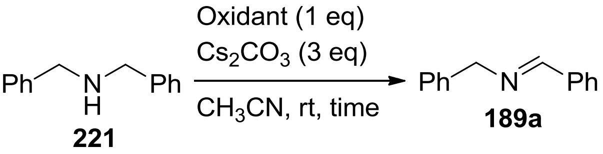
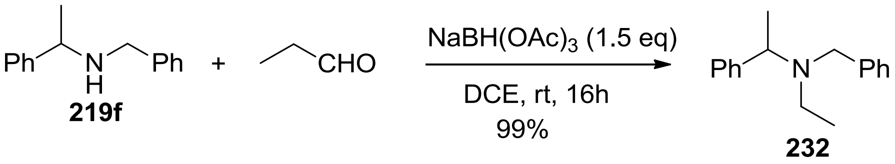


Table 34. Oxidation of dibenzylamine: Comparison between different oxidising agent sources

		conversion after	
entry	oxidant	1.5 h % [a]	16 h % [a]
1	Br_2	31	67
2	$\mathbf{I_2}$	**99**[b]	**99**[b]
3	NBS	62	70
4	NIS	63	>99

[a] ratio elaborated by analysis of ^{1}H NMR spectrum.; [b] isolated yield with no chromatography needed.

With the best conditions in hand, a solvent and base screening was investigated on the tertiary amine **232**, which was prepared in 99% by reductive amination of compound **219f** with acetaldehyde in the presence of 1.5 equivalents of $NaBH(OAc)_3$ in 1,2-dichloroethane at room temperature for 16 hours (Scheme 80).[169]



Scheme 80. Preparation of tertiary amine **232**

Compound **232** was initially reacted with one equivalent of iodine and three equivalents of caesium carbonate in acetonitrile, and unfortunately, it was fully recovered unchanged after 24 hours. However, when three equivalents of iodine were used, secondary amine **219f** was obtained in 83% yield. Imine **220f** (11%) and benzaldehyde (6%) were also detected along with compound **219f** through the analysis of the crude ^{1}H NMR spectrum. The best conditions for this retro-alkylation of tertiary benzylamine **232** reaction were achieved when $DMSO:H_2O$ (5:1) as solvent and caesium carbonate as base were used. Starting material **232** was completely converted to secondary amine **219f** in 99% yield after work-up with no need of further purification (entry 9, Table 35). It is noteworthy that loss of benzyl group was observed when sodium acetate and $CH_3CN:H_2O$ (5:1) were used, affording compound **233** in 38% yield against the most favoured product **219f** (entry 3, Table 35).[168]

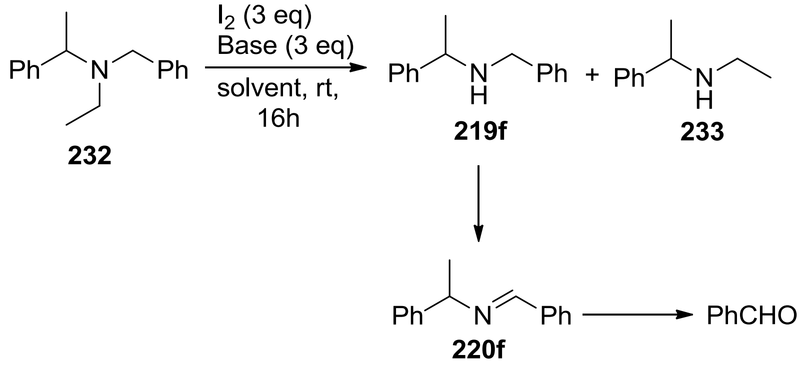


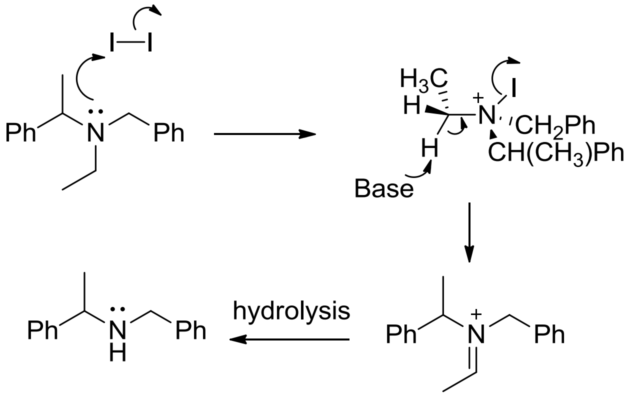
Table 35. Oxidation of tertiary amine **232**: Base and solvent screening

entry	Solvent:H_2O 5:1	base	ratio of **232** (%)[a]	ratio of **219f** (%)[a]	ratio of **220f** (%)[a]	ratio of PhCHO (%)[a]	ratio of **233** (%)[a]
1	CH_3CN	Cs_2CO_3	-	83	11	6	-
1	CH_3CN	$NaHCO_3$	-	73	-	-	27
2	CH_3CN	Na_2CO_3	-	56	39	5	-
3	CH_3CN	NaOAc	-	62	-	-	38
4	CH_3CN	K_2CO_3	-	59	34	7	-
5	CH_3CN	Li_2CO_3	-	59	33	8	-
6	CH_3CN	LiOH	50	50	-	-	-
7	CH_3CN	LiOAc	-	56	39	5	-
8	DMF	Cs_2CO_3	-	74	26	-	-
9	**DMSO**	**Cs_2CO_3**	**-**	**99**[b]	**-**	**-**	**-**
10	THF	Cs_2CO_3	58	28	12	2	-
11	MeOH	Cs_2CO_3	-	89	-	-	11

[a] ratio elaborated by analysis of ^{1}H NMR spectrum; [b] isolated yield with no chromatography needed.

Loss of alkyl group *via* iminium salt formation, followed by hydrolysis, occurred with a E2 elimination process where the base and the leaving group are in an antiperiplanar conformation (

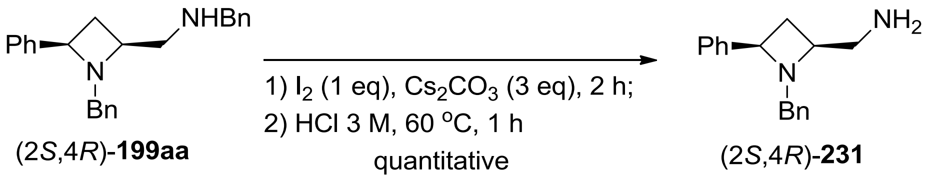
Scheme **81**).



Scheme 81. Possible mechanism for the loss of alkyl group

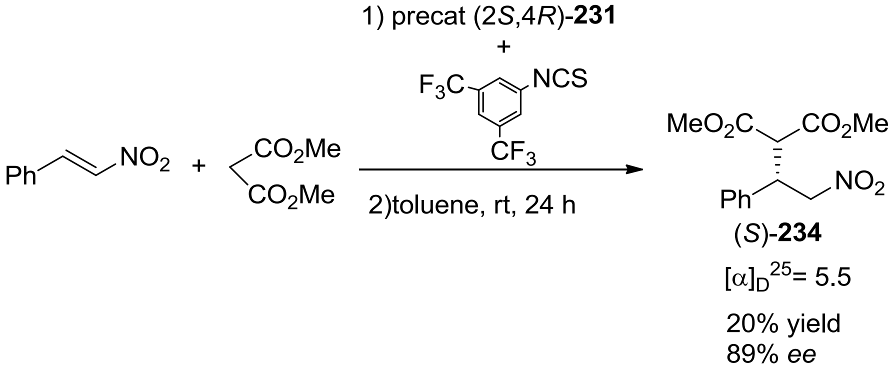
2.4 Azetidine as Organocatalyst for a Michael Addition Reaction

The amino-azetidine (2*S*,4*R*)-**199aa** was exposed to the oxidation conditions previously described (Scheme 79). Compound (2*S*,4*R*)-**199aa** was first reacted with one equivalent of iodine and three equivalents of caesium carbonate in acetonitrile for two hours, after which, it was treated with a 3M solution of HCl at 60 °C for one hour to afford compound (2*S*,4*R*)-**231** in quantitative yield (Scheme 82).[168]



Scheme 82. *N*-benzyl deprotection of enantioenriched amino-azetidine (2*S*,4*R*)-**199aa**

Compound (2*S*,4*R*)-**231** was tested as organocatalyst for a Michael addition reaction. As shown in the introduction (Scheme 16), azetidines with structure similar to (2*S*,4*R*)-**231** had already been used in a Michael addition reaction.[51] Dimethyl malonate (2 eq) was added to nitrostyrene in toluene for 24 hours, with 10% mol of the catalyst previously formed by stirring compound (2*S*,4*R*)-**231** with 3-(-bis(trifluoromethyl)phenyl isothiocyanate for 30 minutes (Scheme 83). Although the Michael adduct (*S*)-dimethyl 2-(2-nitro-1-phenylethyl)malonate **234** was obtained in only 20% yield, the 89% *ee* showed azetidine (2*S*,4*R*)-**231** is an active precatalyst for this reaction. Absolute stereochemistry (*S*) and *ee* of compound **234** were assigned by comparison of the specific rotation value with the literature value ($[\alpha]_D^{25}$ = 5.9; 96% *ee*).[170]



Scheme 83. Amino-azetidine (2*S*,4*R*)-**231** as organocatalyst for a Michael addition reaction

A possible transition state is shown below (Figure 24). The *si*-face attack might be speculated as favourable, considering the shielding effect of the phenyl group that the nucleophile might experience in a *re*-face attack.

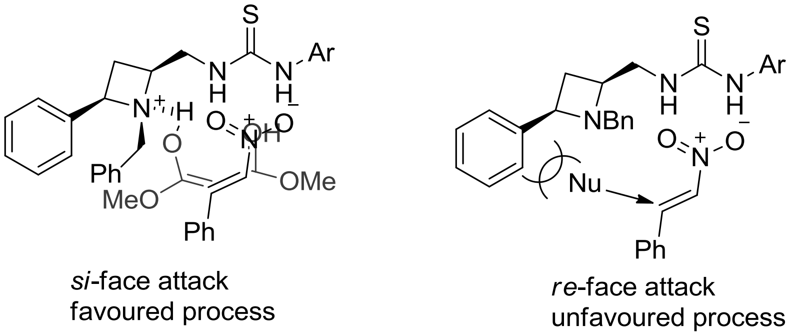


Figure 24. Possible transition state for the Michael addition of malonate to nitrostyrene using amino-azetidine (2*S*,4*R*)-**231** as precatalyst

2.5 Biological Activity

2.5.1 Exploration of Activity in a Zebrafish Assay with Selected Amino-Azetidines

Zebrafish is an important vertebrate model organism for scientific research. It has been largely used for several biological screenings in the field of drug discovery.[171] There are many advantages for the use of zebrafish. First of all, they are 1-1.5 inches long when they reach the adult stage, which means housing space is effectively reduced compared to when rats are used. Moreover, zebrafish embryos are transparent and this allows for easy identification of phenotypic traits. In addition to the optical clarity, there are many histochemical markers for zebrafish to be used with immunochemistry techniques. The rapid maturation of these organisms also allows easy experimentation for mutagenesis screenings.[172]

Six different amino-azetidines were selected to be tested in a zebrafish assay (Figure 25). The biological screenings were conducted by Sundeep Dhillon under the supervision of Dr Ferenc Mueller from the Medical School at the University of Birmingham. The transgenic zebrafish were obtained by injecting the zebrafish's embryos with a green fluorescent protein (GFP) and they were visualised with a fluorescent microscope (stereomicroscope Nikon).

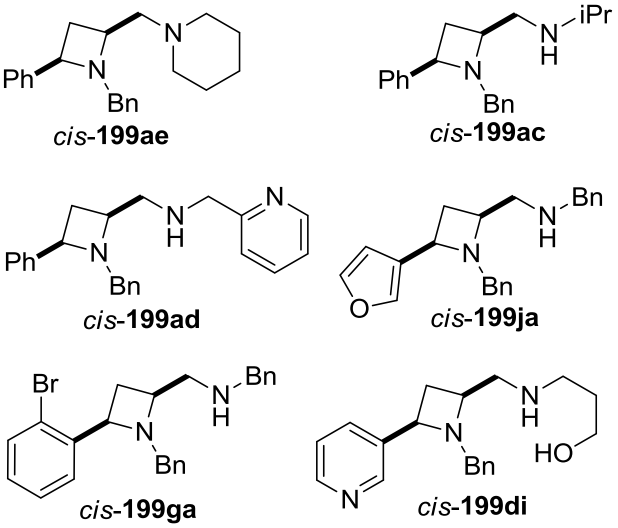
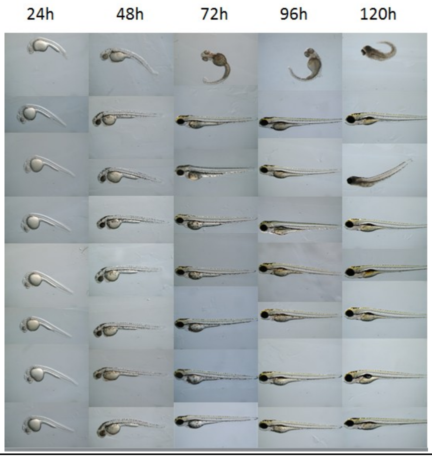

cis-**199ae** *cis*-**199ac** *cis*-**199ad** *cis*-**199ja** *cis*-**199ga** *cis*-**199di**

Figure 25. Azetidines selected for preliminary biological screening

2.5.1.1 Morphology

Table 36 shows images of the development of zebrafish embryos treated with the six selected azetidines at 24 hrs post fertilization (hpf) (added as DMSO solutions) against a control and a DMSO blank. Three different concentration regimes were tested (10, 25 and 30 µM). Compound **199ae** was found to cause morphological effects over the whole exposure period and **199ga** was found to cause morphological effects at later time points.

Table 36. Observation of zebrafish treated with DMSO solutions of chosen azetidines over 5 days: **A**) 10 µM, **B**) 25 µM and **C**) 30 µM (24 hpf start).

Additive	**A: 10 µM**	**B: 25 µM**	**C: 30 µM (24 hpf start)**
199ae **199ad** **199ga** **199ac** **199ja** **199di** **Control** **Blank**	 	 	

***Control**: DMSO added (xx mol.dm^{-3}) 24 hpf. **Blank**: No additive.*

Table 37. Summary of effects of chosen azetidines on zebrafish embryos after 5 days.

Additive	Morphological Defects								
	Curved tails	**Abnormal jaw**	**Delayed growth**	**Lack of pigmentation**	**Slowed heart rate**	**Tail necrosis**	**Cardiac oedema**	**Brain oedema**	**Reduced circulation / blood clots**
199ae	++++	++++	++++	++++	++++	++++	++++	+++	++++
199ja	+	-	+	-	++	-	++	-	++
199ga	+++	-	+	-	+++	-	+++	-	+++
199ac	+	-	+/-	-	+	-	+	-	+
199di	+/-	-	-	-	+/-	-	+/-	-	+/-
199ad	+/-	+/-	+/-	-	+	-	+	-	+
Control	+/-	-	+/-	-	+/-	-	+/-	-	+/-
Blank	-	-	-	-	+/-	-	+/-	-	+/-

++++ = very severe effect (75-100%); +++ = severe effect 50-75%); ++ moderate effect (25-50%);
+ = minimal effect (5-25%); +/- = either minimal or no effect (0-5%); - = no effect (0%).

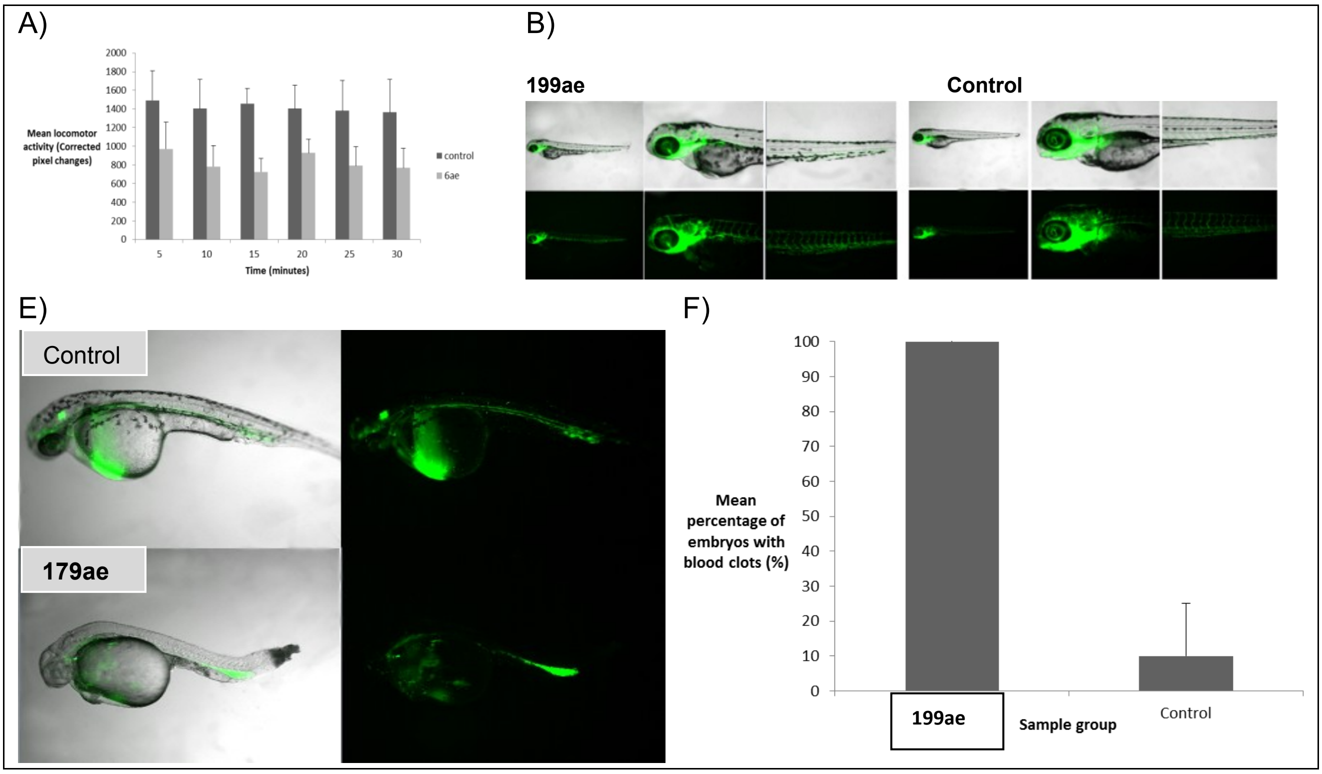


Figure 26. Specific characterisation of compound **199ae** showed that it caused various effects. Compound **199ae** at a concentration of 20 µM was found to significantly reduce movement of 6dpf zebrafish compared to controls (A), (n=60, p=<0.05). Analysis of 4dpf FLI fish that were treated with 50 µM **199ae** at 2dpf showed no difference in vascular development when compared to their respective control, but they did present with delayed development. Analysis of 2dpf FLIGATA zebrafish treated at 8hpf with 50 µM **199ae** (C) under the green channel showed severely delayed growth with the tip of the tail not fully formed and the beginning of tail necrosis evident. Tail necrosis was found to occur in all embryos treated with 50 µM **199ae** (D), (n=40). Analysis of 2dpf FLIGATA zebrafish treated at 8hpf with 50 µM **199ae** (E) under the red channel showed reduced circulation with the formation of blood clots. The formation of blood clots was found to occur in all embryos treated with 50 µM **199ae** (F), (n=40; p=<0.05)

2.5.2 Herbicide, Insecticide and Fungicide Screening of Azetidines and Pyrrolidines

Nine azetidines and four pyrrolidines were provided to Syngenta to be tested as potential herbicide, fungicide or insecticide leads. Syngenta conducted the experiments and elaborated the following results.

2.5.2.1 Results

Test compounds- the results of the DES screening are given in Tables 42-45 (experimental section).

Fungicide: Numerous compounds produced consistent weak activity against *Septoria tritici*, but this was not sufficient to warrant further testing, except for compound *trans*-**200ab**, which showed strong activity against two replicates.

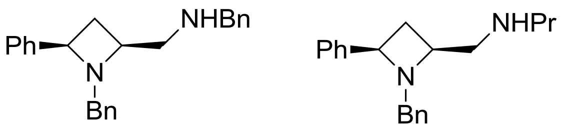
Herbicide: compound *trans*-**200ab** was also herbicidal against the dicotyledon *Arabidopsis thaliana.* No other compounds produced interesting activity.

Insecticide: Only compound *cis*-**199mb** showed interesting activity being active against *Diabrotica balteata* on two replicates. Compound *cis*-**199lb** was active on one replicate against *Plutella xylostella*. This was not interesting enough to investigate further. No other compounds produced any activity.

Positive controls- The positive control compounds performed as expected.

3 Conclusion and Future Work

A new methodology for the synthesis of *cis* iodo-azetidines and *cis* iodo-pyrrolidines employing iodine has been developed. Iodine displacement with different nucleophiles has furnished a new library of amino-azetidines and amino-pyrrolidines with potential biological activity. Some of the amino-azetidine synthesised have shown biological activity in a zebrafish assay and herbicide, fungicide or insecticide assays. Compound *trans*-**200ab** proved to be active against *Septoria tritici* on two out of three replicates and it is currently under investigation in higher tier screening. This compound also showed herbicide activity against *Arabidopsis thaliana* and it is currently under investigation in the soil based glasshouse herbicide studies. Compound *cis*-**199mb** proved to be active against the insect *Diabrotica balteata* on two out of three replicates and it is currently under investigation in higher tier insecticide screens. No other compounds were of interest. None of the compounds progressed to higher tier testing were active enough on these platforms to be of further interest to Syngenta. Synthesis of new azetidines and pyrrolidines as potential drugs is currently under investigation in Dr John Fossey's research group. Synthesis of enantioenriched amino-azetidines has also been achieved (Figure 27).



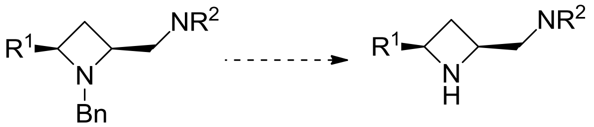
(2*S*,4*R*)-**199aa**
99.5% ee

(2*S*,4*R*)-**199ab**
92% ee

Figure 27. Enantioenriched amino-azetidines (2*S*,4*R*)-**199aa** and (2*S*,4*R*)-**199ab**

Amino-azetidine (2*S*,4*R*)-**231** was used as organocatalyst for a Michael addition reaction, affording the product in 89% *ee* (Scheme 83). Work on the amino azetidines as organocatalysts is currently in progress in Dr John Fossey's research group in order to improve yield and *ee* of the products.

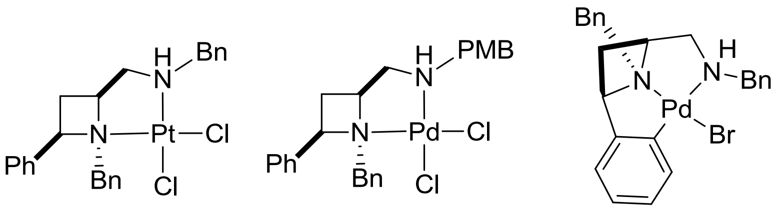
A successful oxidation of secondary and tertiary amines using iodine and caesium carbonate has been discovered. Such reaction has also been investigated as a method for *N*-debenzyl deprotection of secondary amines over *N*-debenzyl deprotection of tertiary amines (Scheme 79). *N*-benzyl deprotection of compound **199** to access a new class of azetidines as catalysts is also under investigation in Dr John Fossey's research group (Scheme 84).



199

Scheme 84. *N*-benzyl deprotection of amino-azetidines **199**

Racemic amino-azetidines metal complexes have been synthesised. Asymmetric synthesis to afford enantioenriched **213aaa**, **213aha**, **213gaa** and their uses as chiral Lewis acid catalysts is under investigation in Dr John Fossey's research group (Figure 28).



213aaa **213aha** **213gaa**

Figure 28. Amino-azetidine metal complexes

4 Experimental Section

Commercially available solvents and reagents were used without further purification. ^{1}H NMR spectra were recorded at 300 MHz on a Bruker AVIII300 NMR spectrometer, at 400 MHz on a AV400 NMR spectrometer and at 500 MHz on a DRX500 spectrometer, ^{13}C NMR spectra at 100 MHz on a Bruker AVIII400 NMR spectrometer are proton decoupled and were recorded at room temperature unless otherwise stated, data was processed with Mestrec version 5.2.5-4731 and Topspin 2.0 (Version of: Nov 9th 2006). Chemical shifts (δ) are reported in ppm relative to TMS (δ 0.00) for the ^{1}H NMR and to chloroform (δ 77.0) for the ^{13}C NMR measurements, coupling constant *J* are expressed in Hertz, pendant technique was used for ^{13}C NMR assignment. Mass spectra were recorded with electrospray MS Waters LCT Time of Flight Mass Spectrometer and with EI (GC/MS) Waters GCT Premier Time of Flight Mass Spectrometer. Enantiomeric excesses of compounds have been calculated by comparison of the specific rotation values

4.1 General procedures

4.1.1 General procedure A: synthesis of imine

Amine (1.1 eq) was added to a solution of aldehyde (1eq) in ethanol (25 mL) and the mixture was stirred for four hours at 60 °C. Ethanol was removed *in vacuo* and the product was purified by quick filtration through a silica plug (EtOAc).

4.1.2 General procedure B: synthesis of homoallylic amine (method a)

Boron trifluoride diethyl etherate (3 eq) was added to a solution of imine (1 eq) in chloroform (25 mL) for 30 minutes at rt, allyltributylstannane (1.5 eq) was added and the mixture was left stirring for 16 hours at rt. Chloroform was removed *in vacuo*, diethyl ether and H_2O were added, the aqueous layer was neutralised with a solution of sodium bicarbonate and the product was extracted three times with ethyl acetate which was removed *in vacuo* to afford the product.

4.1.3 General procedure C: synthesis of homoallylic amine (method b)

Magnesium (2 eq) and allylbromide (1.5 eq) were added to dry THF (25 mL) at 0 °C and stirred for 15 minutes after which imine (1 eq) was added. The mixture was left stirring at 0 °C for 15 minutes before it was left for 16 hours at rt. A saturated solution of sodium bicarbonate and ethylacetate were added. The product was extracted from the aqueous layer with ethylacetate three times. Flash chromatography was used for further purification of the product in some cases.

4.1.4 General procedure D: synthesis of *cis*-iodoazetidine

Sodium bicarbonate (5 eq) iodine (3 eq) were added to homoallylamine (1 eq) in acetonitrile (25 mL). The mixture was stirred at rt for 16 hours and was monitored by TLC. When the reaction was completed solvent was removed *in vacuo*. To the residue thus obtained a solution of sodium thiosulfate was added, the compound was extracted with ethyl acetate, washed with water, dried over anhydrous magnesium sulfate and dried *in vacuo* to deliver "post-work-up" material.

4.1.5 General procedure E: ring expansion of *cis*-iodoazetidine to *cis*-iodopyrrolidine

Azetidines were refluxed for four hours in acetonitrile (20 mL). At which point the reactions were judged to be complete (by TLC), the solvent was removed *in vacuo* to deliver isomerised product.

4.1.6 General procedure F: synthesis of *cis*-aminoazetidine

Sodium bicarbonate (5 eq) and iodine (3 eq) were added to the homoallylamine (1 eq) in acetonitrile (50 mL). The mixture was stirred at rt for 16 hours and it was monitored by TLC. When the reaction was completed, the solvent was removed *in vacuo*. To the residue thus obtained a solution of sodium thiosulfate was added, the compound was extracted with ethyl acetate, washed with water, dried over anhydrous magnesium sulfate and dried *in vacuo* to deliver "post-work-up" material. Post-work-up azetidine was stirred at rt for 24 hours in the corresponding neat amine, after which time sodium bicarbonate was added and the product was extracted with ethyl acetate. Unreacted amine was removed *in vacuo* and the residue was purified by flash chromatography.

4.1.7 General procedure G: synthesis of *cis*-triazoleazetidine

Post-work-up azetidine (1 eq) and sodium azide (2eq) were dissolved in DMF (20 mL) and were stirred at rt for 16 hours. Alkyne (1 eq) and copper(I) iodide (2 eq) were added and the reaction mixture was stirred at rt for 16 hours. The solvent was removed *in vacuo*, ethyl acetate was added and the resulting suspension was filtered through Celite to remove the inorganic salts. The filtrate was concentrated under reduced pressure and the product was purified by flash chromatography.

4.1.8 General procedure H: synthesis of *cis*-aminopyrrolidine

Post-work-up iodo-azetidine (1 eq) was stirred with amine (10 eq) in DMSO (25 mL) for 48 hours at rt. Diethyl ether was added and the organic layer washed with a saturated solution of sodium bicarbonate and H_2O three times. The solvent was removed in vacuo and the product purified by flash chromatography.

4.1.9 General procedure J: synthesis of *trans*-aminopyrrolidine

Post-work-up iodo-azetidine (1 eq) was heated at 50 °C in acetonitrile (20 mL) for four hours. The solvent was removed in *vacuo*, amine (10 eq) was added and the mixture was stirred at 80 ^{o}C for 16 hours in DMSO. Diethyl ether was added and the organic layer was washed with a saturated solution of sodium bicarbonate and H_2O three times. The residue was concentrated under reduced pressure and the product was purified by flash chromatography.

4.1.10 General procedure I: synthesis of *cis*-hydroxypyrrolidine

Post-work-up iodo-azetidine was stirred in a 2N solution of NaOH (25 mL) and DMSO (25 mL) for 48 hours rt. Diethyl ether was added and the organic layer was washed with H_2O three times. The solvent was removed *in vacuo* and the product purified by flash chromatography.

4.1.11 General procedure L: synthesis of *trans*-triazolepyrrolidine

Post-work-up iodo-azetidine was heated at 70 ^{o}C in DMSO (20 mL) for four hours, after cooling down, sodium azide (1.5 eq) was added and the mixture was stirred at rt for 16 hours. Ethynylbenzene (1eq) and copper (I) iodide (2eq) were added and the reaction mixture was heated at 80 °C for 4 hours. The solvent was removed *in vacuo*, ethyl acetate was added and the resulting suspension was filtered through Celite to remove the inorganic salts. The filtrate was concentrated under reduced pressure and the product was purified by flash chromatography.

4.1.12 General procedure M: reductive amination (method a)

Amine (1.1 eq) was added to a solution of aldehyde (1 eq) in methanol (25 mL) and the mixture was stirred for four hours at 60 ^{o}C after which it was cooled to rt. $NaBH_4$ (2 eq) was added and the reaction was left stirring for 16 hours. The solvent was removed *in vacuo* and diethyl ether and a solution of HCl 1N were added. The aqueous layer was basified with a saturated solution of sodium bicarbonate and the product was extracted with ethyl acetate three times and purified by flash chromatography in some cases.

4.1.13 General procedure N: oxidation of secondary amine to imine

Caesium carbonate (3 eq) and iodine (1 eq) were added to amine in acetonitrile (10 mL). Consumption of starting material was monitored by TLC. When the reaction was completed solvent was removed *in vacuo*. To the residue thus obtained a solution of sodium thiosulfate was added. The residue was extracted with ethyl acetate, washed with water, dried over anhydrous magnesium sulfate and dried *in vacuo* to deliver the corresponding imine.

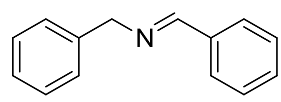
4.1.14 General procedure O: reductive amination (method b)

Amine (1.1 eq) was added to a solution of aldehyde (1 eq) in dichloroethane (25 mL) after $NaBH(OAc)_3$ (1.5 eq) was added slowly. The mixture was stirred for 16 hours at rt. The solvent was removed *in vacuo* and diethyl ether and a solution of HCl 1N were added. The aqueous layer was basified with a saturated solution of sodium bicarbonate and the product extracted with ethyl acetate three times and purified by flash chromatography in some cases.

4.1.15 General procedure P: hydrolysis of imine

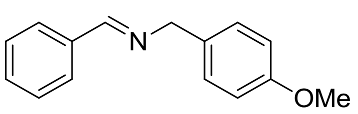
The imine was stirred at 60 °C in HCl 3 M (15 mL) for one hour. Diethyl ether was added and the aqueous layer was neutralised with a solution of NaOH 2 M after which the product was extracted with chloroform three times. The solvent was removed *in vacuo* and the product was obtained with no need of further purification.

4.1.16 (189a) (*E*)-*N*-benzylidene-1-phenylmethanamine



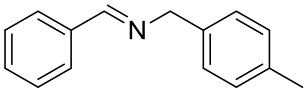
General procedure A was used: benzaldehyde (9.42 mmol, 1.00 g), benzylamine (10.36 mmol, 1.11 g). Yellow oil, 1.83 g, 99%. IR 3062, 3027, 2871, 2839, 1642, 1580, 1495, 1451, 1378, 1292; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 4.67 (2H, s, PhC*H$_2$*), 7.13-7.31 (8H, m, Ph*H*), 7.68-7.74 (2H, m, Ph*H*), 8.18 (1H, s, C*H*=N); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 65.23 (CH_2), 127.25 (CH), 128.26 (CH), 128.59 (CH), 128.78 (CH), 128.86 (CH), 131.00 (CH), 136.53 (C), 139.75 (C), 162.04 (CH). M/z: (ES^+) 196.1 $[M + H]^+$.

4.1.17 (189b) (*E*)-*N*-benzylidene-1-(4-methoxyphenyl)methanamine



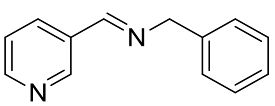
General procedure A was used: benzaldehyde (9.42 mmol, 1.00 g), (4-methoxyphenyl)methanamine (10.36 mmol, 1.42 g). Yellow oil, 2.11 g, 99% .^{1}H NMR (δ; 300 MHz, CDCl$_3$); 3.77 (3H, s, OC*H*$_3$), 4.75 (2H, s, PhC*H*$_2$), 6.87 (2H, d, *J* = 8.7, Ar*H*), 7.24 (2H, d, *J* = 8.7, Ar*H*), 7.37-7.41 (3H, m, Ar*H*), 7.74-7.78 (2H, m, Ar*H*), 8.34 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 55.31 (CH$_3$), 64.52 (CH$_2$), 113.97 (CH), 128.29 (CH), 128.61 (CH), 129.23 (CH), 130.73 (CH), 131.42 (C), 136.26 (C), 158.74 (C), 161.60 (CH). M/z: (ES$^+$) 226.1 [M + H]$^+$.

4.1.18 (189c) (*E*)-*N*-benzylidene-1-(p-tolyl)methanamine



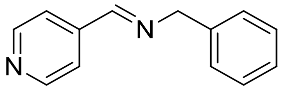
General procedure A was used: benzaldehyde (9.42 mmol, 1.00 g), p-tolylmethanamine (10.36 mmol, 1.26 g). Yellow oil, 1.96 g, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 2.23 (3H, s, C*H*$_3$), 4.66 (2H, s, NC*H*$_2$), 7.06 (2H, d, *J* = 8.0, Ar*H*), 7.17 (2H, d, *J* = 8.0, Ar*H*), 7.25-7.29 (3H, m, Ar*H*), 7.68-7.72 (2H, m, Ar*H*), 8.19 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 21.39 (CH$_3$), 65.03 (CH$_2$), 128.25 (CH), 128.56 (CH), 128.81 (CH), 129.45 (CH), 130.90 (CH), 136.60 (C), 136.67 (C), 161.67 (CH). M/z: (ES$^+$) 210.1 [M + H]$^+$.

4.1.19 (189d) (*E*)-1-phenyl-*N*-(pyridin-3-ylmethylene)methanamine



General procedure A was used: nicotinaldehyde (9.34 mmol, 1.00 g), benzylamine (10.27 mmol, 1.10 g). Yellow oil, 1.82 g, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 4.70 (2H, s, PhC*H*$_2$), 7.11-7.29 (6H, m, Ar*H*), 8.00 (1H, dt, *J*= 7.9 & 1.8, Ar*H*), 8.19 (1H, s, C*H*=NCH$_2$), 8.54 (1*H*, dd, *J*= 4.8 & 1.6, Ar*H*), 8.85 (1H, d, *J* = 1.9, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 64.93 (CH$_2$), 123.50 (CH), 127.02 (CH), 127.91 (CH), 128.45 (CH), 131.56 (C), 134.39 (CH), 138.94 (C), 150.13 (CH), 151.35 (CH), 158.78 (CH). M/z: (ES$^+$) 197.1 [M + H]$^+$.

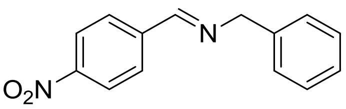
4.1.20 (189e) (*E*)-1-phenyl-*N*-(pyridin-4-ylmethylene)methanamine



General procedure A was used: isonicotinaldehyde (9.34 mmol, 1.00 g), benzylamine (10.27 mmol, 1.10 g). Yellow oil, 1.82 g, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 4.88 (2H, s, PhC*H*$_2$), 7.28-7.41 (5H, m, ArH), 7.65 (2H, dd, *J* = 4.5 & 1.6, ArH), 8.38 (1H, s, C*H*=NCH$_2$), 8.71 (2H, dd, *J* = 4.5 & 1.6, ArH); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 65.13 (CH$_2$), 122.03

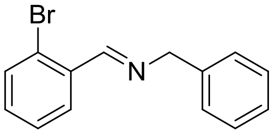
(CH), 127.29 (CH), 128.05 (CH), 128.63 (CH), 138.42 (C), 142.86 (C), 150.43 (CH), 159.88 (CH). M/z: (ES$^+$) 197.1 [M + H]$^+$.

4.1.21 (169f) (*E*)-*N*-(4-nitrobenzylidene)-1-phenylmethanamine



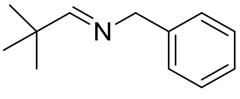
General procedure A was used: 4-nitrobenzaldehyde (6.62 mmol, 1.00 g), benzylamine (7.28 mmol, 780 mg). Yellow solid, 1.48 g, 99%. IR 3000, 2934, 2904, 2835, 1636 1509, 1372, 1342, 1243; ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 4.75 (2H, s, PhC*H$_2$*), 7.13-7.28 (5H, m, Ph*H*), 7.80 (2H, d, *J* = 8.9, Ar*H*), 8.11 (2H, d, *J* = 8.9, Ar*H*), 8.32 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 65.19 (CH$_2$), 123.85 (CH), 127.32 (CH), 128.10 (CH), 128.67 (CH), 128.95 (CH), 138.57 (C), 141.67 (C), 149.08 (C), 159.49 (CH). M/z: (ES$^+$) 241.1 [M + H]$^+$.

4.1.22 (189g) (*E*)-*N*-(2-bromobenzylidene)-1-phenylmethanamine



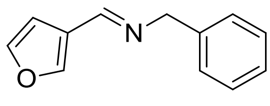
General procedure A was used: 2-bromobenzaldehyde (5.40 mmol, 1.00 g), benzylamine (5.94 mmol, 637 mg). Brown oil, 1.47 g, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 4.82 (2H, s, PhC*H$_2$*), 7.17-7.34 (7H, m, Ar*H*), 7.63 (m, 1H, Ar*H*), 8.06 (1H, dd, *J* = 7.7 & 1.9, Ar*H*), 8.75 (s, 1H); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 65.23 (CH$_2$), 125.22 (C), 127.16 (CH), 127.67 (CH), 128.09 (CH), 128.62 (CH), 129.05 (CH), 131.95 (CH), 133.08 (CH), 134.63 (C), 139.12 (C), 160.96 (CH). M/z: (ES$^+$) 274.02 [M + H]$^+$.

4.1.23 (189h) (*E*)-*N*-(2,2-dimethylpropylidene)-1-phenylmethanamine



General procedure A was used: pivalaldehyde (11.61 mmol, 1.00 g), benzylamine (12.77 mmol, 1.37 g). Yellow oil, 1.69 g, 83%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.11 (9H, s, *tert*-butyl), 4.57 (2H, s, PhC*H$_2$*), 7.19-7.33 (5H, m, Ph*H*), 7.64 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 27.01, 3 x (CH$_3$), 64.58 (CH$_2$), 126.75 (CH), 127.59 (CH), 128.36 (CH), 139.73 (C), 173.35 (CH). M/z: (ES$^+$) 176.1 [M + H]$^+$.

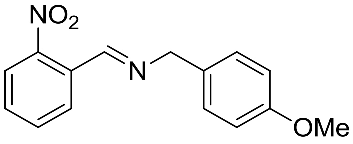
4.1.24 (189j) (*E*)-*N*-(furan-3-ylmethylene)-1-phenylmethanamine



General procedure A was used: furan-3-carbaldehyde (10.41 mmol, 1.00 g), benzylamine (11.45 mmol, 1.23 g). Yellow oil, 1.92 g, 99%. ^{1}H NMR (δ; 300

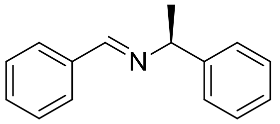
MHz,CDCl$_3$); 4.56 (2H, s, PhC*H$_2$*), 6.70 (1H, d, *J*= 2.1, Ar*H*), 7.05-7.22 (6H, m, Ar*H*), 7.52 (1H, s, Ar*H*), 8.08 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 65.22 (CH$_2$), 108.12 (CH), 125.69 (C), 127.11 (CH), 128.12 (CH), 128.61 (CH) 139.39 (C), 144.12 (CH), 145.45 (CH), 153.65 (CH). M/z: (ES$^+$) 186.1 [M + H]$^+$.

4.1.25 (189m) (*E*)-1-(4-methoxyphenyl)-*N*-(2-nitrobenzylidene)methanamine



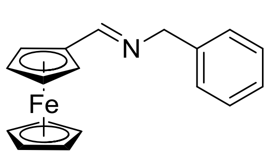
General procedure A was used: 2-nitrobenzaldehyde (6.62 mmol, 1.00 g), (4-methoxyphenyl)methanamine (7.28 mmol, 998 mg). Yellow oil, 1.77 g, 99%.^{1}H NMR (δ; 300 MHz, CDCl$_3$); 3.80 (3H, s, OC*H$_3$*), 4.83 (2H, s, NC*H$_2$*), 6.92 (2H, d, *J* = 8.7, Ar*H*), 7.30 (2H, d, *J* = 8.7, Ar*H*), 7.54 (1H, t, *J* = 8.1, Ar*H*), 7.64 (1H, t, *J* = 7.5, Ar*H*), 8.01 (1H, dd, *J* = 8.1 & 1.2, Ar*H*), 8.08 (1H, dd, *J* = 7.7 & 1.4, Ar*H*), 8.80 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 55.27 (CH$_3$), 64.70 (CH$_2$), 114.04 (CH), 124.28 (CH), 129.39 (CH), 129.84 (CH), 130.62 (C), 130.70 (CH), 131.28 (C), 133.45 (CH), 148.88 (C), 157.35 (CH), 158.88 (C). M/z: (ES$^+$) 271.1 [M + H]$^+$.

4.1.26 (189n) (S,*E*)-*N*-benzylidene-1-phenylethanamine



General procedure A was used: benzaldehyde (9.42 mmol, 1.00 g), (*S*)-1-phenylethanamine (10.36 mmol, 1.26 g). Yellow oil, 1.60 g, 81%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.64 (3H, d, *J* = 6.0, C*H$_3$*), 4.61 (1H, q, *J* = 6.0, C*H*CH$_3$), 7.30 (1H, m, Ph*H*), 7.45 (7H, m, Ph*H*), 7.85 (2H, m, Ph*H*), 8.43 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 24.92 (CH$_3$), 69.78 (CH), 126.67 (CH), 126.86 (CH), 128.30 (CH), 128.46 (CH), 128.56 (CH), 130.60 (CH), 136.47 (C), 145.25 (C), 159.46 (CH). M/z: (ES$^+$) 210.1 [M + H]$^+$.

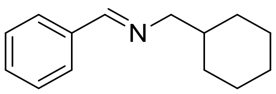
4.1.27 (189o) (*E*)-(3-((benzylimino)methyl)cyclopent-3-en-1-yl)(cyclopent-3-en-1-yl)iron



General procedure A was used: cyclopent-3-en-1-yl(3-formylcyclopent-3-en-1-yl)iron (2.34 mmol, 500 mg), benzylamine (2.80 mmol, 302 mg). Black oil, 289 mg, 40%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 3.87 (3H, m, PhC*H$_2$*N & Fc*H*), 4.28 (2H, t, *J*

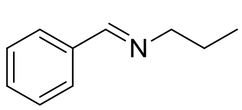
= 1.8, Fc*H*), 4.58-4.60 (4H, m, Fc*H*), 7.12-7.29 (5H, m, Ph*H*), 8.15 (1H, s, N=C*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 65.15 (CH_2), 68.66 (CH), 69.12 (CH), 69.70 (CH), 70.53 (CH), 73.27 (CH), 80.59 (C), 126.91 (CH), 127.90 (CH), 128.51 (CH), 139.70 (C), 162.24 (CH). M/z: (ES^+) 308.1 $[M + H]^+$.

4.1.28 (189p) (*E*)-*N*-benzylidene-1-cyclohexylmethanamine



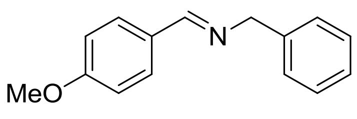
General procedure A was used: benzaldehyde (9.42 mmol, 1.00 g), cyclohexylmethanamine (10.36 mmol, 1.17 g). Colourless oil, 1.84 g, 97%. ^1H NMR (δ; 300 MHz, $CDCl_3$); 0.81-0.92 (2H, m), 1.02-1.23 (3H, m), 1.53-1.68 (6H, m), 3.33 (2H, d, *J* = 6.3, NCH_2) 7.23-7.29 (3H, m, Ph*H*), 7.59-7.62 (2H , m, Ph*H*), 8.08 (1H, s, C*H*=N); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 26.17 (CH_2), 26.66 (CH_2), 31.52 (CH_2), 39.04 (CH), 68.71 (CH_2), 128.05 (CH), 128.52 (CH), 130.36 (CH), 136.45 (C), 160.67 (CH). M/z: (ES^+) 202.1 $[M + H]^+$.

4.1.29 (189q) (*E*)-*N*-benzylidenepropan-1-amine



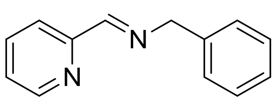
General procedure A was used: benzaldehyde (9.42 mmol, 1.00 g), propylamine (10.36 mmol, 612 mg). Yellow oil, 1.21 g, 87%. IR 2962, 2931, 2874, 1645, 1580, 1451, 1379, 1338; ^1H NMR (δ; 300 MHz, $CDCl_3$); 0.85 (3H, t, *J* = 7.4, CH_3), 1.56-1.68 (2H, m, CH_2CH_3), 3.46 (2H, td, *J* = 6.9 & 1.1, NCH_2), 7.27-7.29 (3H, m, Ph*H*), 7.60-7.63 (2H, m, Ph*H*), 8.14 (1H, s, C*H*=N); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 11.88 (CH_3), 24.10 (CH_2), 65.33 (CH_2), 128.03 (CH), 128.55 (CH), 130.43 (CH), 136.40 (C), 160.74 (CH). M/z: (EI^+) 146.1 $[M + H]^+$.

4.1.30 (189r) (*E*)-*N*-(4-methoxybenzylidene)-1-phenylmethanamine



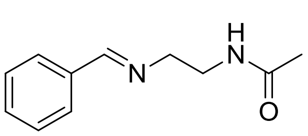
General procedure A was used: 4-methoxybenzaldehyde (7.34 mmol, 1.00 g), benzylamine (8.08 mmol, 868 mg). Yellow oil, 1.57 g, 95%. ^1H NMR (δ; 300 MHz, $CDCl_3$); 3.74 (3H, s, OCH_3), 4.74 (2H, s, PhCH_2), 6.88 (2H, d, *J* = 9.0, Ar*H*), 7.19-7.26 (1H, m, Ar*H*), 7.30-7.31 (4H, m, Ar*H*), 7.70 (2H, d, *J* = 8.7, Ar*H*), 8.26 (1H, s, C*H*=N); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 55.36 (CH_3), 65.02 (CH_2), 114.06 (CH), 126.97 (CH), 128.02 (CH), 128.53 (CH), 129.25 (C), 129.91 (CH), 139.73 (C), 161.31 (CH), 161.79 (C). M/z: (ES^+) 226.1 $[M + H]^+$.

4.1.31 (189s) (*E*)-1-phenyl-*N*-(pyridin-2-ylmethylene)methanamine



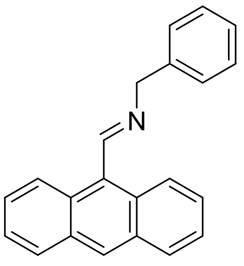
General procedure A was used: picolinaldehyde (9.34 mmol, 1.00 g), benzylamine (10.27 mmol, 1.10 g). Yellow oil, 1.82 g, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 4.82 (2H, s, PhCH_2), 7.15-7.25 (2H, m, Ar*H*), 7.27-7.35 (4H, m, Ar*H*), 7.59 (1H, t, *J*= 8.1, Ar*H*), 8.02 (1H, d, *J* = 8.1, Ar*H*), 8.47 (1H, s, C*H*=NCH$_2$), 8.57-8.60 (1H, m, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 64.83 (CH$_2$), 121.22 (CH), 124.73 (CH), 127.10 (CH), 128.14 (CH), 128.52 (CH), 136.38 (CH), 138.82 (C), 149.33 (CH), 154.55 (C), 162.73 (CH). M/z: (ES$^+$) 176.1 [M + H]$^+$.

4.1.32 (189t) (*E*)-*N*-(2-(benzylideneamino)ethyl)acetamide



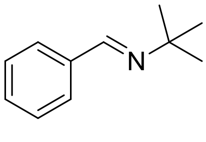
General procedure A was used: benzaldehyde (9.42 mmol, 1.00 g), N-(2-aminoethyl)acetamide (10.36 mmol, 1.06 g). Yellow oil, 932 mg, 52%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.98 (3H, s, CH_3), 3.59 (2H, t, *J* = 5.8, CH_2NH), 3.70-3.74 (2H, m, CH_2CH$_2$NH), 6.09 (1H, br, NH), 7.38-7.49 (3H, m, Ph*H*), 7.72-7.75 (2H, m, Ph*H*), 8.31 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 23.22 (CH$_3$), 40.36 (CH$_2$), 60.35 (CH$_2$) 128.15 (CH), 128.68 (CH), 130.97 (CH), 135.85 (C), 162.71 (CH), 170.19 (C). M/z: (ES$^+$) 191.1 [M + H]$^+$.

4.1.33 (189u) (*E*)-*N*-(anthracen-9-ylmethylene)-1-phenylmethanamine



General procedure A was used: anthracene-9-carbaldehyde (4.85 mmol, 1.00 g), benzylamine (5.33 mmol, 571 mg). Orange solid, 988 mg, 69%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 5.18 (2H, s, PhCH_2), 7.31-7.57 (9H, m, Ar*H*), 8.05 (2H, dd, *J* = 7.3 & 2.5, Ar*H*), 8.53-8.57 (3H, m, Ar*H*), 9.59 (1H, s, C*H*=N); ^{13}C{^{1}H}NMR (δ; 100 MHz, CDCl$_3$), 57.66 (C), 66.80 (CH$_2$), 124.82 (CH), 125.26 (CH), 126.76 (CH), 127.18 (CH), 128.25 (CH), 128.69 (CH), 128.89 (CH), 129.51 (CH), 130.11 (C), 131.30 (C), 139.20 (C), 161.18 (CH). M/z: (ES$^+$) 296.1 [M + H]$^+$.

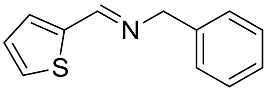
4.1.34 (189v) (*E*)-*N*-benzylidene-2-methylpropan-2-amine



General procedure A was used: benzaldehyde (4.71 mmol, 500 mg), 2-methylpropan-2-amine (5.18 mmol, 379 mg). Colourless Oil, 349 mg, 46%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.29 (9H, s, *tert*-butyl), 7.34-7.38 (3H, m, Ph*H*), 7.72-7.75 (2H, m, Ph*H*), 8.25

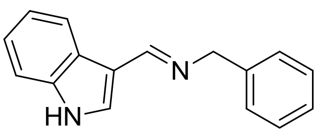
(1H, s, *CH*=N); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 29.79 3x(CH_3), 127.95 (CH), 128.53 (CH), 130.18 (CH), 137.25 (C), 155.07 (CH). M/z: (ES^+) 162.1 $[M + H]^+$.

4.1.35 (189w) (*E*)-1-phenyl-*N*-(thiophen-2-ylmethylene)methanamine



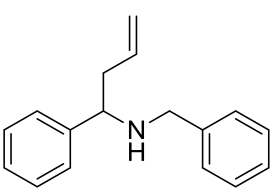
General procedure A was used: thiophene-2-carbaldehyde (8.92 mmol, 1.00 g), benzylamine (9.81 mmol, 1.05 g). Yellow oil, 1.78 g, 99%. ^1H NMR (δ; 300 MHz, $CDCl_3$); 4.86 (2H, s, PhC*H₂*), 7.12 (1H, dd, *J* = 5.0 & 3.6, Ar*H*), 7.32-7.49 (7H, m, Ar*H*), 8.50 (1H, s, C*H*=N); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 64.54 (CH_2), 127.13 (CH), 127.50 (CH), 128.14 (CH), 128.62 (CH), 129.15 (CH), 130.79 (CH), 139.24 (C), 142.60 (C), 155.27 (CH). M/z: (ES^+) 202.1 $[M + H]^+$.

4.1.36 (189x) (*E*)-*N*-((1H-indol-3-yl)methylene)-1-phenylmethanamine



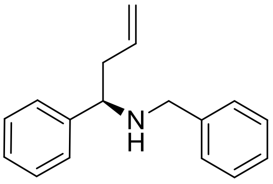
General procedure A was used: 1H-indole-3-carbaldehyde (6.89 mmol, 1.00 g), benzylamine (7.58 mmol, 812 mg). Yellow solid, 1.52 g, 94%. ^1H NMR (δ; 300 MHz, $CDCl_3$); 4.73 (2H, s, PhC*H₂*), 7.07-7.32 (9H, m, Ar*H*), 8.20-8.26 (1H, m, Ar*H*), 8.45 (1H, s, C*H*=N); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 65.44 (CH_2), 111.46 (CH), 115.36 (C), 121.38 (CH), 121.58 (CH), 123.28 (CH), 125.53 (C), 126.83 (CH), 127.90 (CH), 128.50 (CH), 128.85 (CH), 136.80 (C), 140.39 (C), 156.76 (CH). M/z: (ES^+) 235.1 $[M + H]^+$.

4.1.37 (192a) *N*-benzyl-1-phenylbut-3-en-1-amine



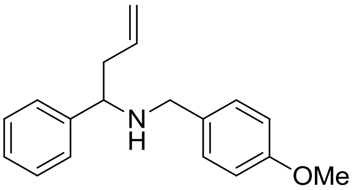
General procedure B was used: (*E*)-*N*-benzylidene-1-phenylmethanamine (5.63 mmol, 1.10 g), allyltributylstannane (8.44 mmol, 2.80 g), boron trifluoride diethyl etherate (16.89 mmol, 2.34 g). Yellow oil, 1.15 g, 86%. General procedure C was used: (*E*)-*N*-benzylidene-1-phenylmethanamine (5.12 mmol, 1.00 g), allylbromide (7.68 mmol, 929 mg), magnesium (10.24 mmol, 249 mg). Yellow oil, 1.21 g, 99%. ^1H NMR (δ; 300 MHz, $CDCl_3$); 1.86 (1H, br, N*H*), 2.26-2.36 (2H, m, NHCHC*H₂*), 3.49 (2H, ABq, J_{AB} = 13.3, PhC*H₂*), 3.56-3.60 (1H, m, NHC*H*), 4.96 (1H, ddt, *J* = 10.3, 2, 2, CH=C*H*H), 5.01, (1H, ddt, *J* = 17.1, 2, 2, CH=CH*H*), 5.59 (1H, ddt, *J* = 17.1, 10.3, 7.1, C*H*=CH_2), 7.09-7.28 (10H, m, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 43.28 (CH_2), 51.57 (CH_2), 61.76 (CH), 117.63 (CH_2), 126.93 (CH), 127.17 (CH), 127.41 (CH), 128.22 (C), 128.44 (CH), 128.51 (CH), 135.58 (CH), 140.76 (C), 143.96 (C). High-resolution MS calcd for $C_{17}H_{20}N$: 238.1595; found: 238.1584.

4.1.38 (192a) (*R*)-*N*-benzyl-1-phenylbut-3-en-1-amine



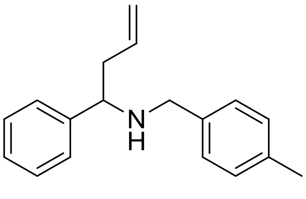
$[\alpha]_D^{20}$ = 57.8 (c 11.4, CHCl$_3$). ^{1}H NMR and ^{13}C{^{1}H} NMR same as **172a.** M/z: (ES$^+$) 238.1 [M + H]$^+$.

4.1.39 (192b) *N*-(4-methoxybenzyl)-1-phenylbut-3-en-1-amine



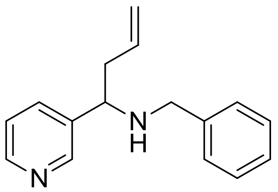
General procedure B was used: (*E*)-*N*-benzylidene-1-(4-methoxyphenyl)methanamine (4.44 mmol, 1.00 g), allyltributylstannane (6.66 mmol, 2.20 g), boron trifluoride diethyl etherate (13.32 mmol, 1.89 g). Yellow oil, 1.18 g, 99%. General procedure C was used: (*E*)-*N*-benzylidene-1-(4-methoxyphenyl)methanamine (4.44 mmol, 1.00 g), allylbromide (6.66 mmol, 805 mg), magnesium (8.88 mmol, 216 mg). Yellow oil, 1.21 g, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 2.13 (1H, br, N*H*), 2.38-2.43 (2H, m, NHCHC*H$_2$*), 3.54 (2H, ABq, J_{AB} = 13.0, NHC*H$_2$*), 3.68 (1H, $_{apt.}$t, $_{obs.}J$ = 6.8, NHC*H*), 3.77 (3H, s, C*H$_3$*), 5.01-5.09 (2H, m, CH=C*H$_2$*), 5.68 (1H, ddt, *J* = 16.2, 10.1, 6.5, C*H*=CH$_2$), 6.83 (2H, d, *J* = 8.6, Ar*H*), 7.16 (2H, d, *J* = 8.6, Ar*H*), 7.22-7.35 (5H, m, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 42.99 (CH$_2$), 50.80 (CH$_2$), 55.27 (CH$_3$), 61.57 (CH), 113.79 (CH), 117.61 (CH$_2$), 127.14 (CH), 127.37 (CH), 128.35 (CH), 129.36 (CH), 132.44 (C), 135.38 (CH), 143.58 (C), 158.76 (C). M/z: (ES$^+$) 268.3 [M + H]$^+$.

4.1.40 (192c) *N*-(4-methylbenzyl)-1-phenylbut-3-en-1-amine



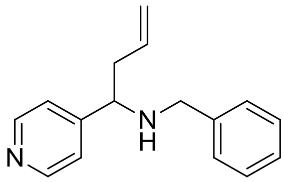
General procedure B was used: (*E*)-*N*-benzylidene-1-(p-tolyl)methanamine (4.78 mmol, 1.00 g), allyltributylstannane (7.17 mmol, 2.37 g), boron trifluoride diethyl etherate (14.34 mmol, 2.03 g). Yellow oil, 505 mg, 42%. General procedure C was used: (*E*)-*N*-benzylidene-1-(p-tolyl)methanamine (8.74 mmol, 1.83 g), allylbromide (13.12 mmol, 1.59 g), magnesium (17.48 mmol, 425 mg). Yellow oil, 2.18 g, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.70 (1H, br, N*H*), 2.32 (3H, s, C*H$_3$*), 2.37-2.43 (2H, m, NHCHC*H$_2$*), 3.55 (2H, ABq, J_{AB} = 13.2, NHC*H$_2$*), 3.68 (1H, dd, *J* = 7.6 & 6.2, NHC*H*), 5.00-5.09 (2H, m, CH=C*H$_2$*), 5.76 (1H, ddt, *J* = 17.1, 10.3, 7.1, C*H*=CH$_2$), 7.09-7.37 (9H, m, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 21.13 (CH$_3$), 43.17 (CH$_2$), 51.17 (CH$_2$), 61.56 (CH), 117.53 (CH$_2$), 127.05 (CH), 127.36 (CH), 128.11 (CH), 128.40 (CH), 129.05 (CH), 135.53 (CH), 136.37 (C), 137.60 (C), 143.91 (C). M/z: (ES$^+$) 252.1 [M + H]$^+$.

4.1.41 (192d) *N*-benzyl-1-(pyridin-3-yl)but-3-en-1-amine



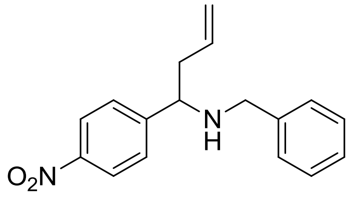
General procedure B was used: (*E*)-1-phenyl-*N*-(pyridin-3-ylmethylene)methanamine (7.64 mmol, 1.50 g), allyltributylstannane (11.46 mmol, 3.80 g), boron trifluoride diethyl etherate (22.92 mmol, 3.25 g). Yellow oil, 1.78 g, 98%. General procedure C was used: (*E*)-1-phenyl-*N*-(pyridin-3-ylmethylene)methanamine (5.09 mmol, 1.00 g), allylbromide (7.63 mmol, 925 mg), magnesium (10.18 mmol, 247 mg). Yellow oil, 1.21 g, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 2.10 (1H, br, N*H*), 2.39-2.44 (2H, m, NHCHC*H$_2$*), 3.60 (2H, ABq, J_{AB} = 13.3, NHC*H$_2$*), 3.74 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 6.8, NHC*H*), 5.05-5.12 (2H, m, CH=C*H$_2$*), 5.63-5.77 (1H, m, C*H*=CH$_2$), 7.22-7.35 (6H, m, Ar*H*), 7.75 (1H, dt, *J* = 7.9 & 1.9, Ar*H*), 8.52 (1H, dd, *J* = 4.8 & 1.7, Ar*H*), 8.57 (1H, d, *J* = 2.0, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 42.86 (CH$_2$), 51.46 (CH$_2$), 59.20 (CH), 118.34 (CH$_2$), 123.53 (CH), 127.02 (CH), 128.06 (CH), 128.43 (CH), 134.53 (CH), 134.81 (CH), 139.02 (C), 140.07 (C), 148.66 (CH), 149.49 (CH). M/z: (ES$^+$) 239.1 [M + H]$^+$.

4.1.42 (192e) *N*-benzyl-1-(pyridin-4-yl)but-3-en-1-amine



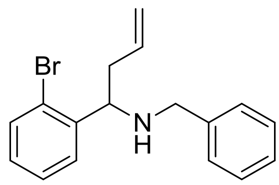
General procedure B was used: (*E*)-1-phenyl-*N*-(pyridin-4-ylmethylene)methanamine (5.09 mmol, 1.00 g), allyltributylstannane (7.63 mmol, 2.53 g), boron trifluoride diethyl etherate (15.27 mmol, 2.17 g). Yellow oil, 1.12 g, 92%. General procedure C was used: (*E*)-1-phenyl-*N*-(pyridin-4-ylmethylene)methanamine (5.09 mmol, 1.00 g), allylbromide (7.63 mmol, 925 mg), magnesium (10.18 mmol, 247 mg). Yellow oil, 1.21 g, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 2.32-2.48 (2H, m, NHCHC*H$_2$*), 3.62 (2H, ABq, J_{AB} = 13.3, NHC*H$_2$*), 3.67-3.75 (1H, m, NHC*H*), 4.97-5.11 (2H, m, CH=C*H$_2$*), 5.61-5.75 (1H, m, C*H*=CH$_2$), 7.25-7.42 (7H, m, Ar*H*), 8.56 (2H, d, *J* = 6.0, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 42.37 (CH$_2$), 51.50 (CH$_2$), 60.70 (CH), 118.57 (CH$_2$), 122.67 (CH), 127.22 (CH), 128.10 (CH), 128.47 (CH), 134.16 (CH), 139.65 (C), 149.74 (CH), 152.96 (C). M/z: (ES$^+$) 239.1 [M + H]$^+$.

4.1.43 (192f) *N*-benzyl-1-(4-nitrophenyl)but-3-en-1-amine



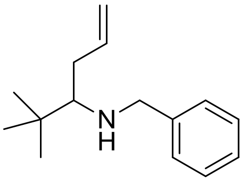
General procedure B was used: (*E*)-*N*-(4-nitrobenzylidene)-1-phenylmethanamine (4.16 mmol, 1.00 g), allyltributylstannane (6.24 mmol, 2.07 g), boron trifluoride diethyl etherate (12.48 mmol, 1.77 g). Yellow oil, 951 mg, 81%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.88 (1H, br, N*H*), 2.30-2.45 (2H, m, NHCHC*H$_2$*), 3.61 (2H, ABq, J_{AB} = 13.5, NHC*H$_2$*), 3.82 (1H, dd, *J* = 7.8 & 5.8), 5.03-5.10 (2H, m, CH=C*H$_2$*), 5.61-5.75 (1H, m, C*H*=CH$_2$), 7.22-7.36 (5H, m, Ar*H*), 7.56 (1H, d, *J* = 8.7, Ar*H*), 8.21 (1H, d, *J* = 8.7, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 42.94 (CH$_2$), 51.61 (CH$_2$), 61.16 (CH), 118.60 (CH$_2$), 123.72 (CH), 126.97 (CH), 128.01 (CH), 128.13 (CH), 128.47 (CH), 134.23 (CH), 139.92 (C), 147.20 (C), 151.83 (C). M/z: (ES$^+$) 283.1 [M + H]$^+$.

4.1.44 (192g) *N*-benzyl-1-(2-bromophenyl)but-3-en-1-amine



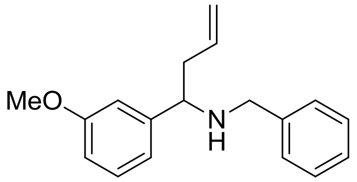
General procedure B was used: (*E*)-*N*-(2-bromobenzylidene)-1-phenylmethanamine (2.70 mmol, 740 mg), allyltributylstannane (4.05 mmol, 1.34 g), boron trifluoride diethyl etherate (8.10 mmol, 1.15 g). Yellow oil, 478 mg, 56%. General procedure C was used: (*E*)-*N*-(2-bromobenzylidene)-1-phenylmethanamine (4.33 mmol, 1.37 g), allylbromide (6.50 mmol, 786 mg), magnesium (8.66 mmol, 210 mg). Brown oil, 1.31 g, 96%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.85 (1H, br, N*H*), 2.19-2.30 (1H, m, NHCHC*H*H), 2.46-2.56 (1H, m, NHCHCH*H*), 3.58 (2H, ABq, J_{AB} = 13.1, NHC*H$_2$*), 4.22 (1H, dd, *J* = 8.5 & 4.5), 5.05-5.12 (2H, m, CH=C*H$_2$*), 5.70-5.84 (1H, m, C*H*=CH$_2$), 7.10 (1H, td, *J* = 7.5 & 1.8, Ar*H*), 7.20-7.36 (6H, m, Ar*H*), 7.54 (1H, dd, *J* = 8.0 & 1.2, Ar*H*), 7.65 (1H, dd, *J* = 7.8 & 1.7, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 41.41 (CH$_2$), 51.64 (CH$_2$), 59.94 (CH), 117.92 (CH$_2$), 124.15 (C), 126.91(CH), 127.66 (CH), 128.16 (CH), 128.37 (CH), 132.87 (CH), 135.09 (CH), 140.45 (C), 142.32 (C). M/z: (ES$^+$) 316.1 [M + H]$^+$.

4.1.45 (192h) *N*-benzyl-2,2-dimethylhex-5-en-3-amine



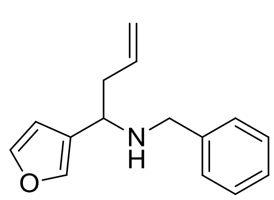
General procedure B was used: (*E*)-*N*-(2,2-dimethylpropylidene)-1-phenylmethanamine (3.99 mmol, 700 mg), allyltributylstannane (5.99 mmol, 1.98 g), boron trifluoride diethyl etherate (11.97 mmol, 1.70 g). Yellow oil, 771 mg, 89%. General procedure C was used: (*E*)-*N*-(2,2-dimethylpropylidene)-1-phenylmethanamine (7.36 mmol, 1.29 g), allylbromide (11.04 mmol, 1.33 g), magnesium (14.72 mmol, 358 mg). Purified by flash chromatography (Hexane : EtOAc 95:5 Rf 0.3), coulourless oil, 1.14 g, 71%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 0.93 (9H, s, *tert*-butyl), 1.94 (1H, dt, *J* = 14.2 & 8.7, NHCHC*H*H), 2.22 (1H, dd, *J* = 9.0 & 3.4, NHC*H*), 2.39-2.48 (1H, m, NHCHCH*H*), 3.77 (2H, ABq, J_{AB} = 12.6, NHC*H$_2$*), 5.00-5.10 (2H, m, CH=C*H$_2$*), 5.81-5.94 (1H, m, C*H*=CH$_2$), 7.18-7.35 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 26.91 (CH$_3$), 35.62 (C), 36.07 (CH$_2$), 54.93 (CH$_2$), 66.28 (CH), 116.48 (CH$_2$), 126.99 (CH), 128.30 (CH), 128.45 (CH), 137.65 (CH), 140.52 (C). M/z: (ES$^+$) 218.1 [M + H]$^+$.

4.1.46 (192i) *N*-benzyl-1-(3-methoxyphenyl)but-3-en-1-amine



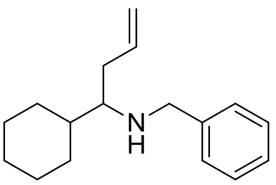
General procedure C was used: (*E*)-*N*-(3-methoxybenzylidene)-1-phenylmethanamine (4.40 mmol, 1.00 g), allylbromide (6.60 mmol, 798 mg), magnesium (8.80 mmol, 214 mg). Yellow oil, 1.17 g, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.79 (1H, br, N*H*), 2.38-2.43 (2H, m, NHCHC*H$_2$*), 3.61 (2H, ABq, J_{AB} = 13.3, NHC*H$_2$*), 3.67 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 6.8, NHC*H*), 3.86 (3H, s, C*H$_3$*), 5.04-5.15 (2H, m, CH=C*H$_2$*), 5.68-5.81 (1H, m, C*H*=CH$_2$), 6.84-6.91 (2H, m, Ar*H*), 7.04 (1H, s, Ar*H*) 7.21-7.35 (6H, m, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 44.21 (CH$_2$), 51.58 (CH$_2$), 55.32 (CH$_3$), 61.08 (CH), 112.62 (CH), 113.81 (CH), 117.47 (CH$_2$), 121.02 (CH), 126.85 (CH), 128.17 (CH), 128.36 (CH), 135.67 (CH), 135.86 (C), 140.75 (C), 158.72 (C). M/z: (ES$^+$) 268.1 [M + H]$^+$.

4.1.47 (192j) *N*-benzyl-1-(furan-3-yl)but-3-en-1-amine



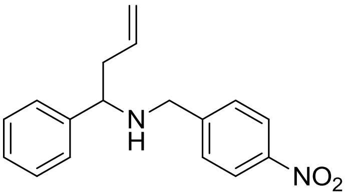
General procedure B was used: (*E*)-*N*-(furan-3-ylmethylene)-1-phenylmethanamine (5.40 mmol, 1.00 g), allyltributylstannane (8.10 mmol, 2.68 g), boron trifluoride diethyl etherate (16.20 mmol, 2.30 g). Yellow oil, 258 mg, 21%. General procedure C was used: (*E*)-*N*-(furan-3-ylmethylene)-1-phenylmethanamine (3.72 mmol, 690 mg), allylbromide (5.59 mmol, 676 mg), magnesium (7.44 mmol, 181 mg). Yellow oil, 761 mg, 90%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 2.32 (2H, dd, J = 9.8 & 4.0, NHCHC*H$_2$*), 3.58 (2H, ABq, J_{AB} = 13.2, NHC*H$_2$*), 3.58 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 6.7, NHC*H*), 4.97 (1H, ddt, J = 10.2, 2.2, 2.0, CH=C*H*H), 5.49 (1H, ddt, J = 17.1, 2.2, 2.0, CH=CH*H*) 5.62 (1H, ddt, J = 17.1, 10.2, 6.6, C*H*=CH$_2$), 6.32 (1H, s, Ar*H*), 7.13-7.30 (7H, m, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 45.05 (CH$_2$), 51.67 (CH$_2$), 57.34 (CH), 111.65 (CH), 116, 73 (CH$_2$), 126.84 (CH), 128.07 (CH), 128.18 (CH), 136.75 (CH), 131.52 (C), 138.14 (CH), 140.62 (C), 142.24 (CH). M/z: (ES$^+$) 227.1 [M + H]$^+$.

4.1.48 (192k) *N*-benzyl-1-cyclohexylbut-3-en-1-amine



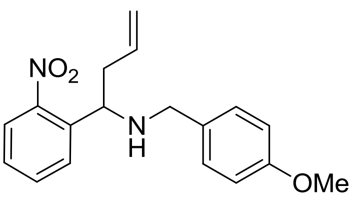
General procedure C was used: (*E*)-*N*-benzylidene-1-cyclohexylmethanamine (5.46 mmol, 1.10 g), allylbromide (8.26 mmol, 1.00 g), magnesium (11.06 mmol, 269 mg). Colourless oil, 1.26 g, 96%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 0.96-1.75 (11H, m), 2.05-2.42 (3H, m), 3.74 (2H, s, NHC*H*$_2$Ph), 5.03-5.15 (2H, m, CH=C*H*$_2$), 5.65-5.94 (1H, m, C*H*=CH2), 7.19-7.39 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 26.28 (CH$_2$), 26.69 (CH$_2$), 26.84 (CH$_2$), 28.92 (CH$_2$), 29.61 (CH$_2$), 35.44 (CH$_2$), 41.58 (CH), 52.49 (CH$_2$), 61.67 (CH), 116.86 (CH$_2$), 126.86 (CH), 128.18 (CH), 128.28 (CH), 136.84 (CH), 142.29 (C). M/z: (ES$^+$) 244.2 [M + H]$^+$.

4.1.49 (192l) *N*-(4-nitrobenzyl)-1-phenylbut-3-en-1-amine



General procedure B was used: (*E*)-*N*-benzylidene-1-(4-nitrophenyl)methanamine (3.99 mmol, 960 mg), allyltributylstannane (5.99 mmol, 1.98 g), boron trifluoride diethyl etherate (11.97 mmol, 1.70 g). Yellow oil, 642 mg, 57%. General procedure C was used: (*E*)-*N*-benzylidene-1-(4-nitrophenyl)methanamine (3.01 mmol, 723 mg), allylbromide (4.51 mmol, 546 mg), magnesium (6.02 mmol, 146 mg). Yellow oil, 748 mg, 88%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.78 (1H, br, N*H*), 2.26-2.42 (2H, m, NHCHC*H*$_2$), 3.57 (1H, dd, *J* = 12.3 & 5.2 NHC*H*), 3.73 (2H, ABq, J_{AB} = 14.5, NHC*H*$_2$), 4.97-5.05 (2H, m, CH=C*H*$_2$), 5.58-5.71 (1H, m, C*H*=CH$_2$), 7.15-7.30 (5H, m, Ar*H*), 7.35 (2H, d, *J*= 8.7, Ar*H*), 8.05 (2H, d, *J* = 8.7, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 43.07 (CH$_2$), 50.70 (CH$_2$), 61.84 (CH), 117.84 (CH$_2$), 123.53 (CH), 127.18 (CH), 127.32 (CH), 128.54 (CH), 128.65 (CH), 135.22 (CH), 143.27 (C), 146.94 (C), 148.52 (C). M/z: (ES$^+$) 283.1 [M + H]$^+$.

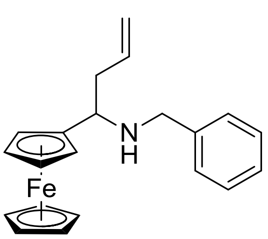
4.1.50 (192m) *N*-(4-methoxybenzyl)-1-(2-nitrophenyl)but-3-en-1-amine



General procedure B was used: (*E*)-1-(4-methoxyphenyl)-*N*-(2-nitrobenzylidene)methanamine (3.70 mmol, 1.00 g), allyltributylstannane (5.55 mmol, 1.84 g), boron trifluoride diethyl etherate (11.10 mmol, 1.57 g). Yellow oil, 520 mg, 45%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 2.29-2.43 (2H, m, NHCHC*H*H), 2.61-2.69 (1H, m, NHCHCH*H*), 3.49 (2H, ABq, J_{AB} = 8.4, NHC*H*$_2$), 3.80 (3H, s, C*H*$_3$), 4.25-4.31 (1H, m, NHC*H*), 5.10-

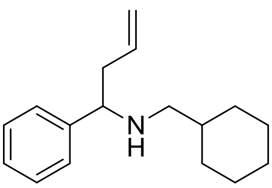
5.15 (2H, m, CH=C*H₂*), 5.74-5.88 (1H, m, C*H*=CH₂), 6.85 (2H, d, *J* = 8.7, Ar*H*), 7.15 (2H, d, *J* = 8.7, Ar*H*), 7.39 (1H, t, *J* = 8.1, Ar*H*), 7.63 (1H, t, *J* = 8.1, Ar*H*), 7.81 (1H, d, *J* = 8.1, Ar*H*), 7.97 (1H, d, *J* = 8.1, Ar*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 42.26 (CH_2), 51.19 (CH_2), 55.23 (CH_3), 56.20 (CH), 113.81 (CH), 118.36 (CH_2), 123.96 (CH), 127.60 (CH), 128.99 (CH), 129.20 (CH), 132.11 (C), 132.81 (CH), 134.76 (CH), 138.85 (C), 150.13 (C), 158.68 (C). M/z: (ES^+) 313.1 $[M + H]^+$.

4.1.51 (192o) (3-(1-(benzylamino)but-3-en-1-yl)cyclopent-3-en-1-yl)(cyclopent-3-en-1-yl)iron



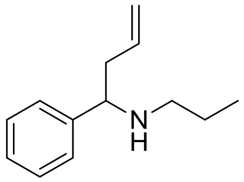
General procedure B was used: (*E*)-(3-((benzylimino)methyl)cyclopent-3-en-1-yl)(cyclopent-3-en-1-yl)iron (0.65 mmol, 200 mg), allyltributylstannane (0.97 mmol, 323 mg), boron trifluoride diethyl etherate (1.3 mmol, 184 mg). Purified by flash chromatography ($CHCl_3$: MeOH 9:1, Rf 0.4), yellow oil, 29 mg, 13%. ^1H NMR (δ; 300 MHz, $CDCl_3$); 2.44-2.68 (1H, m, NHCHC*H*H), 2.59-2.68 (1H, m, NHCHCH*H*), 3.51 (dd, 1H, *J* = 7.3 & 5.0, NHC*H*CH₂), 3.83 (2H, s, NHC*H₂*Ph), 4.10-4.23 (7H, m), 5.08-5.16 (2H, m, CH=C*H₂*), 5.81-5.95 (1H, m, C*H*=CH₂), 7.28-7.36 (5H, m, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 40.29 (CH_2), 51.25 (CH_2), 55.75 (CH), 66.70 (CH), 67.18 (CH), 67.24 (CH), 67.4 (CH), 68.45 (CH), 92.3 (C), 116.67 (CH_2), 126.95 (CH), 128.23 (CH), 128.45 (CH), 135.89 (CH), 140.53 (C). M/z: (ES^+) 350.1 $[M + H]^+$.

4.1.52 (192p) *N*-(cyclohexylmethyl)-1-phenylbut-3-en-1-amine



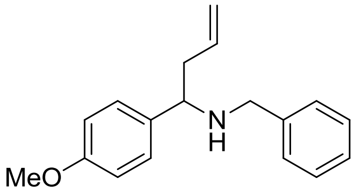
General procedure C was used: (*E*)-*N*-benzylidene-1-cyclohexylmethanamine (4.97 mmol, 1.00 g), allylbromide (7.45 mmol, 901 mg), magnesium (9.94 mmol, 242 mg). Yellow oil, 1.20 g, 99%.^1H NMR (δ; 300 MHz, $CDCl_3$); 0.81-0.94 (2H, m), 1.09-1.33 (3H, m), 1.33-1.49 (1H, m), 1.69-1.79 (6H, m), 2.30 (2H, dd, *J* = 6.6 & 3.9), 2.40-2.45 (2H, m), 3.64 (1H, dd, *J* = 7.6 & 6.1, NHC*H*), 5.07-5.16 (2H, m, CH=C*H₂*), 5.69-5.83 (1H, m, C*H*=CH2), 7.23-7.36 (5H, m, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 26.08 (CH_2), 26.73 (CH_2), 31.44 (CH_2), 38.08 (CH), 43.19 (CH_2), 54.49 (CH_2), 62.67 (CH), 117.41 (CH_2), 128.86 (CH), 127.18 (CH), 128.26 (CH), 135.64 (CH), 144.29 (C). M/z: (ES^+) 244.2 $[M + H]^+$.

4.1.53 (192q) 1-phenyl-*N*-propylbut-3-en-1-amine



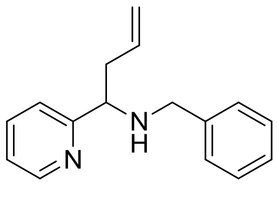
General procedure B was used: (*E*)-*N*-benzylidenepropan-1-amine (7.47 mmol, 1.10 g), allyltributylstannane (11.21 mmol, 3.71 g), boron trifluoride diethyl etherate (22.41 mmol, 3.18 g). Yellow oil, 1.30 g, 92%. General procedure C was used: (*E*)-*N*-benzylidenepropan-1-amine (8.15 mmol, 1.20 g), allylbromide (12.23 mmol, 1.48 g), magnesium (16.30 mmol, 396 mg). Yellow oil, 1.53 g, 99%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 0.75 (3H, t, *J* = 7.4, C*H₃*), 1.40 (2H, sextet, CH_2CH_3), 2.28-2.43 (4H, m, NHC*H₂* & NHCHC*H₂*), 3.63 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 7.0, NHC*H*), 4.90-5.01 (2H, m, CH=C*H₂*), 5.50-5.64 (1H, m, C*H*=CH₂), 7.11-7.27 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 11.65 (CH_3) 22.59 (CH_2), 42.26 (CH_2), 49.34 (CH), 62.76 (CH), 117.81 (CH_2), 127.38 (CH), 128.50 (CH), 134.87 (CH), 142.38 (C). M/z: (ES^+) 190.2 $[M + H]^+$.

4.1.54 (192r) *N*-benzyl-1-(4-methoxyphenyl)but-3-en-1-amine



General procedure B was used: (*E*)-*N*-(4-methoxybenzylidene)-1-phenylmethanamine (6.66 mmol, 1.50 g), allyltributylstannane (9.99 mmol, 3.31 g), boron trifluoride diethyl etherate (19.98 mmol, 2.84 g). Yellow oil, 600 mg, 34%. General procedure C was used: (*E*)-*N*-(4-methoxybenzylidene)-1-phenylmethanamine (7.28 mmol, 1.64 g), allylbromide (14.56 mmol, 1.75 g), magnesium (21.84 mmol, 531 mg). Yellow oil, 1.75 g, 90%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.76 (1H, br, N*H*), 2.36-2.41 (2H, m, NHCHC*H₂*), 3.58 (2H, ABq, J_{AB} = 13.3, NHC*H₂*), 3.64 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 6.8, NHC*H*), 3.80 (3H, s, C*H₃*), 5.07 (1H, ddt, *J* = 10.2, 2.0, 2.0, CH=C*H*H), 5.11 (1H, ddt, *J* = 16.2, 2.0. 2.0, CH=CH*H*), 5.69 (1H, ddt, *J* = 16.2, 10.2, 7.2, C*H*=CH₂), 6.89 (2H, d, *J* = 8.7, Ar*H*), 7.19-7.33 (7H, m, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 43.19 (CH_2), 51.38 (CH_2), 55.25 (CH_3), 60.97 (CH), 113.77 (CH), 117.42 (CH_2), 126.80 (CH), 128.13 (CH), 128.32 (CH), 135.61 (CH), 135.82 (C), 140.70 (C), 158.67 (C). M/z: (ES^+) 268.1 $[M + H]^+$.

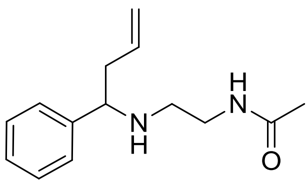
4.1.55 (192s) *N*-benzyl-1-(pyridin-2-yl)but-3-en-1-amine



General procedure C was used: (*E*)-1-phenyl-*N*-(pyridin-2-ylmethylene)methanamine (2.64 mmol, 519 mg), allylbromide (3.97 mmol, 480 mg), magnesium (5.28 mmol, 128 mg). Yellow oil, 585 mg, 93%. ^{1}H NMR (δ; 300

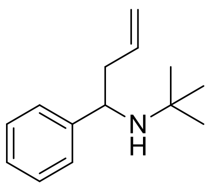
MHz, CDCl$_3$); 2.43-2.62 (2H, m, NHCHC*H*H), 2.65 (1H, br, N*H*), 3.67 (2H, ABq, J_{AB} = 13.2, PhC*H*H), 3.89 (1H, dd, *J* = 7.4 & 6.1, NHC*H*), 5.03-5.10 (2H, m, CH=C*H*$_2$), 5.67-5.81 (1H, m, C*H*=CH$_2$), 7.17-7.40 (7H, m, Ar*H*), 7.68 (1H, td, *J* = 7.7 & 1.7, Ar*H*), 8.61 (1H, d, *J* = 4.3, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 41.41 (CH$_2$), 51.66 (CH$_2$), 62.85 (CH), 118.02 (CH$_2$), 122.04 (CH), 122.13(CH), 126.89 (CH), 128.23 (CH), 128.39 (CH), 134.94 (CH), 136.41 (CH), 139.88 (C), 149.41 (CH), 162.63 (C). M/z: (ES$^+$) 239.1 [M + H]$^+$.

4.1.56 (192t) *N*-(2-((1phenylbut-3-en-1-yl)amino)ethyl)acetamide



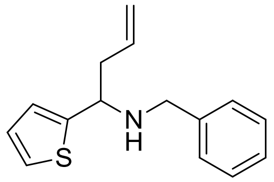
General procedure B was used: (*E*)-*N*-(2-(benzylideneamino)ethyl)acetamide (3.10 mmol, 590 mg), allyltributylstannane (4.65 mmol, 1.54 g), boron trifluoride diethyl etherate (9.30 mmol, 1.32 g). Yellow oil, 216 mg, 30%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.94 (3H s, C*H*$_3$), 2.36-2.44 (3H, m, NHCHC*H*H & CHNHC*H*$_2$), 2.63-2.70 (1H, m, NHCHCH*H*), 3.14-3.30 (2H, m, C*H2*NHC=O), 3.64 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}$*J* = 7.2, NHC*H*), 5.05-5.12 (2H, m, CH=C*H*$_2$), 5.65-5.78 (1H, ddt, *J* = 17.1, 2.0, 2.0, C*H*=CH$_2$), 6.15 (1H, br, N*H*), 7.22-7.36 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 23.22 (CH$_3$), 39.34 (CH$_2$), 42.69 (CH$_2$), 46.35 (CH$_2$), 62.29 (CH), 117.72 (CH$_2$), 127.07 (CH), 127.27 (CH), 128.47 (CH), 135.20 (CH), 143.47 (C), 170.30 (C). M/z: (ES$^+$) 233.1 [M + H]$^+$.

4.1.57 (192v) *N*-(tert-butyl)-1-phenylbut-3-en-1-amine



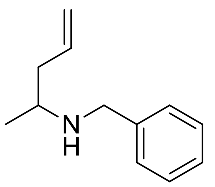
General procedure C was used: (*E*)-*N*-benzylidene-2-methylpropan-2-amine (1.71 mmol, 276 mg), allylbromide (2.57 mmol, 311 mg), magnesium (3.42 mmol, 83.14 mg). Yellow oil, 236 mg, 68%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 0.97 (9H, s, *tert*-butyl), 2.18-2.28 (1H, m, NHCHC*H*H), 2.33-2.42 (1H, m, NHCHCH*H*), 3.81 (1H, dd, *J* = 8.4 & 5.5, NHC*H*), 5.03-5.10 (2H, m, CH=C*H*$_2$), 5.61-5.75 (1H, m, C*H*=CH$_2$), 7.15-7.39 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 30.13 (CH$_3$), 45.189 (CH$_2$), 51.20 (C), 56.78 (CH), 117.48 (CH$_2$), 126.39 (CH), 127.01 (CH), 128.09 (CH), 136.16 (CH), 147.71 (C). M/z: (ES$^+$) 204.1 [M + H]$^+$.

4.1.58 (192w) *N*-benzyl-1-(thiophen-2-yl)but-3-en-1-amine



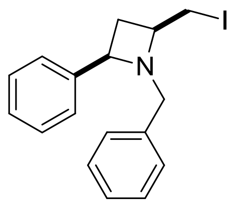
General procedure B was used: (*E*)-1-phenyl-*N*-(thiophen-2-ylmethylene)methanamine (4.97 mmol, 1.00 g), allyltributylstannane (7.45 mmol, 2.47 g), boron trifluoride diethyl etherate (14.91 mmol, 2.12 g). Yellow oil, 701 mg, 58%.^{1}H NMR (δ; 300 MHz, $CDCl_3$); 2.78-3.02 (2H, m, NHCHC*H*$_2$), 3.91-4.00 (2H, m, NHC*H*$_2$), 4.46 (1H, dd, *J* = 9.7 & 4.4, NHC*H*), 5.01-5.13 (2H, m, CH=C*H*$_2$), 5.43-5.57 (1H, ddt, *J* = 16.1, 10.0, 6.9, C*H*=CH_2), 7.07 (1H, dd, *J* = 5.0 & 3.6, Ar*H*), 7.30-7.41 (7H, m, Ar*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 43.40 (CH_2), 51.18 (CH_2), 56.95 (CH), 117.92 (CH_2), 124.10 (CH), 124.30 (CH), 126.22 (CH), 126.94 (CH), 128.20 (C), 128.40 (CH), 134.80 (CH), 140.30 (C), 150.17 (C). M/z: (ES^+) 244.1 $[M + H]^+$.

4.1.59 (192y) *N*-benzylpent-4-en-2-amine



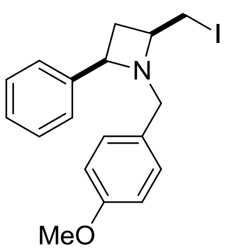
General procedure A and C were used: crude (*E*)-*N*-ethylidene-1-phenylmethanamine (20.86 mmol, 2.78 g), allylbromide (31.28 mmol, 3.78 g), magnesium (41.72 mmol, 1.01 g). Yellow oil, yield over 2 steps = 259 mg, 65%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.08 (3H, d, *J* = 6.3 C*H*$_3$), 2.08-2.29 (2H, m, NHCHC*H*H & NHC*H*), 2.68-2.79 (1H, m, NHCHCH*H*), 3.76 (1H, ABq, J_{AB} = 13.1, NHC*H*$_2$), 5.00-5.11 (2H, m, CH=C*H*$_2$), 5.69-5.83 (1H, m, C*H*=CH_2), 7.17-7.36 (5H, m, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 20.30 (CH_3), 41.47 (CH_2), 51.41 (CH_2), 51.81 (CH), 117.22 (CH_2), 126.87 (CH), 128.13 (CH), 128.42 (CH), 135.75 (CH), 140.78 (C). M/z: (ES^+) 176.1 $[M + H]^+$.

4.1.60 (194a) *cis*-1-Benzyl-2-(Iodomethyl)-4-phenylazetidine.



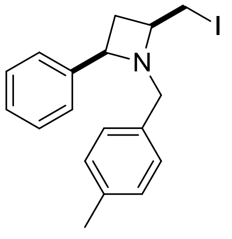
General procedure D was used: homoallylamine **192a** (500 mg, 2.1 mmol), iodine (1.60 g, 6.3 mmol), sodium bicarbonate (885 mg, 11.00 mmol) and acetonitrile (50 mL). Yellow oil, yield (post-work up) 732 mg, 96%; after flash chromatography (Hexane/CH_2Cl_2/Et_3N = 5.5/4/0.5 Rf 0.4) 343 mg, 45%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.74 (1H, dt, *J* = 12.0 & 9.0, PhCHCH*H*), 2.65 (1H, dt, *J* = 9.0 & 6.0, PhCHC*H*H), 2.91 (1H, dd, *J* = 10.5 & 3.0, CH*H*I), 2.98 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}$*J* = 9.0, C*H*HI), 3.28 (1H, m, NC*H*CH_2I), 3.80 (2H, ABq, J_{AB} = 15.0, NC*H*$_2$Ph), 4.01 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}$*J* = 9.0, NC*H*Ph), 7.36 (7H, m, Ar*H*), 7.55 (2H, m, Ar*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 12.77 (CH_2), 35.65 (CH_2), 60.75 (CH_2), 62.96 (CH), 63.00 (CH), 126.94 (CH), 127.37 (CH), 128.29 (CH), 128.34 (CH), 129.37 (CH), 138.16(C), 143.02 (C). High-resolution MS calcd for $C_{17}H_{18}NI$: 363.0484; found: 363.0485.

4.1.61 (194b) *cis*-2-(Iodomethyl)-1-(4-methoxybenzyl)-4-phenylazetidine.



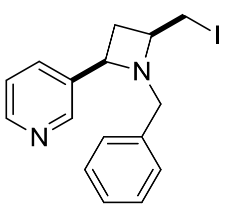
General procedure D was used: homoallylamine **192b** (644 mg, 2.54 mmol), iodine (1.94 g, 7.63 mmol), sodium bicarbonate (1.07 g, 12.70 mmol) and acetonitrile (50 mL). Yellow oil, yield (post-work up) 849 mg, 85%; after flash chromatography (Hexane/CH_2Cl_2/Et_3N = 5.5/4/0.5 Rf 0.4) 409 mg, 41%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.68 (1H, dt, J = 12.0 & 9.0, PhCHCH*H*), 2.60 (1H, dt, J = 9.0 & 6.0, PhCHC*H*H), 2.86 (1H, dd, J = 9.0 & 6.0, CH*H*I), 2.93 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 9.0, C*H*HI), 3.21 (1H, m, NC*H*CH$_2$I), 3.70 (2H, ABq, J_{AB} = 12.0, NC*H*HAr), 3.82 (3H, s, OM*e*), 3.95 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 9.0, NC*H*Ph), 6.86 (2H, d, J = 9.0, Ar*H*), 7.29 (3H, m, Ar*H*), 7.38 (2H, t, J = 6.0, Ar*H*), 7.50 (2H, d, J = 9.0, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$) δ 12.89 (CH_2), 35.56 (CH_2), 55.28 (CH_3), 59.95 (CH_2), 62.68 (CH), 62.76 (CH), 113.65 (CH), 126.89 (CH), 127.29 (CH), 128.31 (CH), 130.20 (C), 130.44(CH), 143.08 (C), 158.91 (C). High-resolution MS calcd for formula $C_{18}H_{21}NOI$: 394.0668; found: 394.0674.

4.1.62 (194c) *cis*-2-(Iodomethyl)-1-(4-methylbenzyl)-4-phenylazetidine.



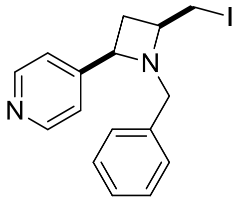
General procedure D was used: homoallylamine **192c** (1.0 g, 3.98 mmol), iodine (3.02 g, 11.90 mmol), sodium bicarbonate (1.67 g, 19.90 mmol) and acetonitrile (50 mL). Yellow oil, yield (post-work up) 1.40 g, 93%; after flash chromatography (Hexane/CH_2Cl_2/Et_3N = 5.5/4/0.5 Rf 0.4) 615 mg, 45%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.72 (1H, dt, J = 12.0 & 9.0, PhCHCH*H*), 2.40 (3H, s, tolyl-Me), 2.64 (1H, dt, J = 9.0 & 6.0, PhCHC*H*H), 2.90 (1H, dd, J = 9.0 & 6.0, CH*H*I), 2.96 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 9.0, CH*H*I), 3.26 (1H, m, NC*H*CH$_2$I), 3.75 (2H, ABq, J_{AB} = 12.0, NC*H$_2$*Ar), 3.99 (1H, t, J = 9.0, NC*H*Ph), 7.17 (2H, d, J = 9.0, Ar*H*), 7.32 (3H, m, Ar*H*), 7.42 (2H, t, J = 6.0, Ar*H*), 7.55 (2H, d, J = 9.0, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 12.94 (CH_2), 21.25 (CH_3), 35.63 (CH_2), 60.29 (CH_2), 62.79 (CH), 126.91 (CH), 127.31 (CH), 128.33 (CH), 128.98 (CH), 129.30(CH), 135.04 (C), 136.90 (C), 143.09 (C). High-resolution MS calcd for formula $C_{18}H_{21}NI$: 378.0718; found: 378.0725.

4.1.63 (194d) 3-*cis*-1-Benzyl-4-(iodomethyl)azetidin-2-yl)pyridine.



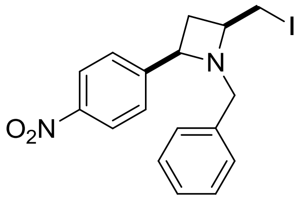
General procedure D was used: homoallylamine **192d** (1.50 g, 6.29 mmol), iodine (4.80 g, 19.00 mmol), sodium bicarbonate (2.64 g, 31.50 mmol), and acetonitrile (50 mL). Yellow oil, yield (post-work up), 2.08 g, 91%; after flash chromatography (EtOAc/ Hexane = 8/2 Rf 0.4) 961 mg, 42%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.68 (1H, dt, *J* = 12.0 & 9.0, PyCHCH*H*), 2.60 (1H, dt, *J* = 9.0 & 6.0, PyCHC*H*H), 2.93 (2H, d, *J* = 9.0, C*H$_2$*I), 3.24 (1H, m, *J* = 6.0, NC*H*CH$_2$I), 3.73 (2H, ABq, J_{AB} = 12.0, NC*H$_2$*Ph), 3.98 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 9.0, NC*H*Py), 7.26 (6H, m, Ar*H*), 7.82 (1H, dt, *J* = 6.0 & 3.0, Py*H*), 8.47 (1H, d, *J* = 3.0, Py*H*), 8.59 (1H, s, Py*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 12.32 (CH$_2$), 35.22 (CH$_2$), 60.72 (CH$_2$), 60.76 (CH), 62.84 (CH), 123.30 (CH), 127.45 (CH), 128.24 (CH), 129.27 (CH), 134.68 (CH), 137.31 (C), 138.14 (C), 148.71 (CH). High-resolution MS calcd for formula $C_{16}H_{17}N_2Na$: 387.0334; found: 387.0349.

4.1.64 (194e) 4-(*cis*-1-Benzyl-4-(iodomethyl)azetidin-2-yl)pyridine.



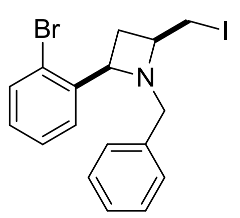
General procedure D was used: homoallylamine **192e** (1.00 g, 4.20 mmol), iodine (3.30 g, 13.00 mmol), sodium bicarbonate (1.76 g, 21.00 mmol) and acetonitrile (50 mL). Yellow oil, yield (post-work up), 1.45 g, 95%; after flash chromatography (EtOAc/ Hexane = 8/2 Rf 0.4) 642 mg, 51%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.60 (1H, dt, *J* = 12.0 *&* 9.0, PyCHCH*H*), 2.59 (1H, dt, *J* = 9.0 & 6.0, PyCHC*H*H), 2.89 (2H, d, *J* = 9.0, C*H$_2$*I), 3.23 (1H, m, NC*H*CH$_2$I), 3.71 (2H, ABq, J_{AB} = 12.0, NC*H$_2$*Ph), 3.93 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 9.0, NC*H*Py), 7.25 (7H, m, Ar*H*), 8.50 (2H, d, *J* = 3.0, Py*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 12.29 (CH$_2$), 34.76 (CH$_2$), 60.89 (CH$_2$), 61.70 (CH), 62.75 (CH), 121.62 (CH), 127.53 (CH), 128.29 (CH), 129.29 (CH), 137.36 (C), 149.74 (CH), 151.53 (C). High-resolution MS calcd for formula $C_{16}H_{17}N_2NaI$: 387.0334; found: 387.0341.

4.1.65 (194f) *cis*-1-Benzyl-2-(iodomethyl)-4-(4-nitrophenyl)azetidine.



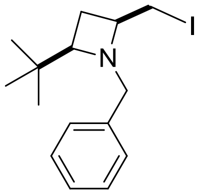
General procedure D was used: homoallylamine **192f** (350 mg, 1.24 mmol), iodine (944 mg, 3.72 mmol), sodium bicarbonate (520 mg, 6.20 mmol) and acetonitrile (50 mL). Yellow oil, yield (post-work up) 459 mg, 90%; after flash chromatography 233 mg, 46%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.65 (1H, dt, *J* = 12.0 & 9.0, ArCHCH*H*), 2.66 (1H, m, ArCHC*H*H), 2.96 (2H, m, C*H$_2$*I), 3.28 (1H, m, NC*H*CH$_2$I), 3.76 (2H, ABq, J_{AB} = 12.0, NC*H*$_2$Ph), 4.07 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 9.0, NC*H*Ar), 7.28 (5H, m, Ar*H*), 7.58 (2H, d, J = 6.0, Ar*H*), 8.16 (2H, d, J = 9.0, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 11.96 (CH$_2$), 35.29 (CH$_2$), 60.90 (CH$_2$), 62.37 (CH), 62.63 (CH), 123.50 (CH), 127.39 (CH), 127.55 (CH), 128.27 (CH), 129.28(CH), 137.18 (C), 147.12 (C), 150.56 (C). High-resolution MS calcd for formula $C_{17}H_{17}N_2O_2I$: 408.0335; found: 408.0318.

4.1.66 (194g) *cis*-1-Benzyl-2-(2-bromophenyl)-4-(iodomethyl)azetidine.



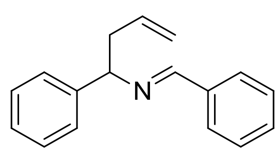
General procedure D was used: homoallylamine **192g** (750 mg, 2.40 mmol), iodine (1.81 g, 7.14 mmol), sodium bicarbonate (1.00 g, 12.00 mmol), and acetonitrile (50 mL). Yellow oil, yield (post-work up), 881 mg, 83%; after flash chromatography (EtOAc/ Hexane/Et$_3$N = 98/1.5/0.5 Rf 0.4) 445 mg; 42%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.51 (1H, dt, J = 12.0 & 9.0, ArCHCH*H*), 2.85 (3H, m, ArCHC*H*H and C*H*$_2$I), 3.30 (1H, m, NC*H*CH$_2$I), 3.77 (2H, ABq, J_{AB} = 12.0, NC*H*$_2$Ph), 4.29 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 9.0, NC*H*Ar), 7.12 (1H, td, J = 9.0 & 6.0, Ar*H*), 7.35 (6H, m, Ar*H*), 7.50 (dd, 1H, J = 9.0 & 6.0, Ar*H*), 7.87 (1H, dd, J = 6.0 & 3.0, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 12.88 (CH$_2$), 34.37 (CH$_2$), 60.92 (CH$_2$), 62.04 (CH), 62.87 (CH), 121.85 (C), 127.43 (CH), 127.45 (CH), 128.23 (CH), 128.33(CH), 129.28 (CH), 132.22 (CH), 137.97 (C), 142.04 (C). High-resolution MS calcd for formula $C_{17}H_{18}NBrI$: 441.9667; found: 441.9660.

4.1.67 (194h) *cis*-1-Benzyl-2-(tert-butyl)-4-(iodomethyl)azetidine.



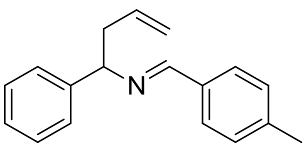
General procedure D was used: homoallylamine **192h** (900 mg 4 mmol), iodine (3.00 g, 12.00 mmol), sodium bicarbonate (1.74 g, 21.00 mmol) and acetonitrile (50 mL). Yellow oil, yield (post-work up) 1.20 g, 87%; after flash chromatography (Hexane/CH$_2$Cl$_2$/Et$_3$N = 6/3.5/0.5 Rf 0.4) 563 mg, 41%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 0.91 (9H, s, *tert*-Bu), 1.45 (1H, dt, J = 12.0 & 9.0, *tert*-BuCHCH*H*), 2.17 (1H, dt, J = 9.0 & 6.0, *tert*-BuCHC*H*H), 2.60 (1H, dd, J = 9.0 & 3.0, CH*H*I), 2.75 (2H, m, C*H*HI and *tert*-BuC*H*), 3.04 (1H, m, NC*H*CH$_2$I), 3.73 (2H, ABq, J_{AB} = 12.0, NC*H*$_2$Ph), 7.32 (5H, m, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 12.75 (CH$_2$), 25.92 (CH$_3$), 26.52 (CH$_2$), 26.52 (CH$_2$), 33.44 (C), 63.28 (CH$_2$), 69.40 (CH), 127.15 (CH), 128.21 (CH), 128.94 (CH), 139.41 (C). High-resolution MS calcd for formula $C_{15}H_{23}NI$: 344.0875; found: 344.0874.

4.1.68 (196a) (*E*)-*N*-benzylidene-1-phenylbut-3-en-1-amine



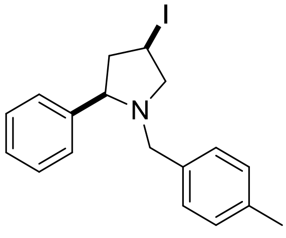
Five equivalents of caesium carbonate (1.37 g, 4.20 mmol) and three equivalents of iodine (640 mg, 2.52 mmol) were added to **192a** (200 mg, 0.84 mmol) in acetonitrile (25 mL), the mixture was stirred at room temperature for 16 hours and was monitored by TLC. When the reaction was completed solvent was removed *in vacuo*. To the residue thus obtained a solution of sodium thiosulfate was added, the compound was extracted with ethyl acetate for three times, washed with water, dried over magnesium sulfate and dried *in vacuo,* the crude product was purified by distillation. Yellow oil, 157 mg, 79%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 2.69 (2H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 7.5, PhCHC*H₂*), 4.33 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 7.5, PhC*H*CH$_2$), 4.98-5.07 (2H, m, CH=C*H₂*), 5.64-5.78 (1H, m, C*H*=CH$_2$), 7.20-7.40 (8H, m, Ar*H*), 7.44 (2H, d, *J* = 7.2, Ar*H*), 7.75-7.78 (2H, m, Ar*H*), 8.28 (1H, s, C*H*=N). ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$) 43.26 (CH$_2$), 75.39 (CH), 117.28 (CH$_2$), 127.07 (CH), 127.16 (CH), 128.39 (CH), 128.48 (CH), 128.58 (CH), 130.65 (CH), 135.53 (CH), 136.39 (C), 143.93 (C), 160.08 (CH). High-resolution MS calcd for $C_{17}H_{17}N$: 235.1361; found: 235.1355.

4.1.69 (196c) (*E*)-*N*-(4-methylbenzylidene)-1-phenylbut-3-en-1-amine



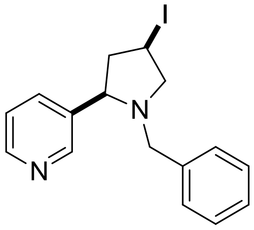
Five equivalents of caesium carbonate (3.26 g, 10.00 mmol) and three equivalents of iodine (1.50 g, 6.00 mmol) were added to **192c** (500 mg, 2.0 mmol) in acetonitrile (25 mL), the mixture was stirred at rt for 16 hours and was monitored by TLC. When the reaction was completed solvent was removed *in vacuo*. To the residue thus obtained a solution of sodium thiosulfate was added, the compound was extracted with ethylacetate three times, washed with water, dried over anhydrous magnesium sulfate and dried *in vacuo,* the crude product was purified by distillation. Yellow oil, 367 mg, 74%. ^{1}H NMR (δ; 400 MHz, CDCl$_3$); 2.47 (3H, s, Me), 2.83 (2H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8, PhCHC*H₂*), 4.46 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 7.2, PhC*H*CH$_2$), 5.12-5.21 (2H, m, CH=C*H₂*), 5.81-5.92 (1H, m, C*H*=CH$_2$), 7.28-7.38 (3H, m, Ar*H*), 7.46 (2H, t, *J* = 8, Ar*H*), 7.58 (2H, d, *J* = 7.2 Ar*H*), 7.80 (2H, d, *J* = 8.4, Ar*H*), 8.38 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$) 21.59 (CH$_3$), 43.36 (CH$_2$), 75.36 (CH), 117.22 (CH$_2$), 127.19 (CH), 128.38 (CH), 128.42 (CH), 128.48 (CH), 129.32 (CH), 133.89 (C), 135.64 (CH), 140.97 (C), 144.11 (C), 159.90 (CH). High-resolution MS calcd for $C_{18}H_{19}NNa$: 272.1415; found: 272.1425.

4.1.70 (195c) *cis*-4-Iodo-1-(4-methylbenzyl)-2-phenylpyrrolidine.



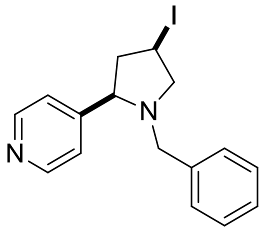
General procedure E was used: **194c** (20 mg, 0.05 mmol) and acetonitrile (20 mL), yellow oil, 19 mg, 97%. ^{1}H NMR (δ; 500 MHz, CDCl$_3$); 2.35 (s, 3H, Me), 2.41 (m, 1H, PhCHC*H*H), 2.76 (1H, dd, *J* = 10.0 & 5.0, NCH*H*CHI), 2.94 (1H, dt, *J* = 15.0 & 10.0, PhCHCH*H*), 3.43 (1H, dd, *J* = 10.0 & 5.0, NC*H*HCHI), 3.52 (2H, ABq, J_{AB} = 15.0, NC*H$_2$*Ar), 3.57 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 10.0, PhC*H*CH$_2$), 4.40 (1H, m, NCH$_2$C*H*I), 7.14 (2H, d, *J* = 10.0, Ar*H*), 7.23 (2H, d, *J* = 10.0, Ar*H*), 7.30 (1H, t, *J* = 5.0, Ar*H*), 7.39 (2H, t, *J* = 10.0, Ar*H*), 7.57 (2H, d, *J* = 5.0, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 17.97 (CH), 21.07 (CH$_3$), 48.85 (CH$_2$), 56.32 (CH$_2$), 64.29 (CH$_2$), 69.28 (CH), 127.44 (CH), 127.78 (CH), 128.26 (CH), 128.33 (CH), 128.54 (CH), 128.59 (CH), 128.89 (CH), 128.94 (CH), 128.96 (CH), 129.22 (CH), 135.73 (C), 136.41(C), 141.92 (C). High-resolution MS calcd for formula $C_{18}H_{21}NNaI$: 400.0538; found: 400.0542.

4.1.71 (195d) 3-(*cis*-1-Benzyl-4-iodopyrrolidin-2-yl)pyridine.



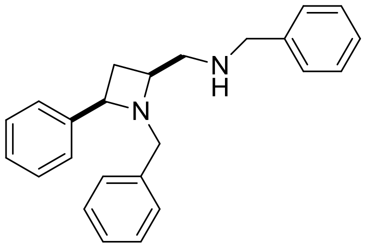
General procedure E was used: **194d** (50 mg, 0.14 mmol) and acetonitrile (20 mL), yellow oil, 47 mg, 95%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 2.36 (1H, m, PyCHC*H*H), 2.77 (1H, dd, *J* = 12.0 & 6.0, NCH*H*CHI), 2.99 (1H, dt, *J* = 15.0 & 12.0, PyCHCH*H*), 3.42 (1H, dd, *J* = 12.0 & 6.0, NC*H*HCHI), 3.55 (2H, ABq, J_{AB} = 12.0, NC*H$_2$*Ph), 3.64 (1H, t, *J* = 9.0, PyC*H*CH$_2$), 4.40 (1H, m, NCH$_2$C*H*I), 7.14 (2H, d, *J* = 10.0, Ar*H*), 7.28 (6H, m, Ar*H*), 8.02 (1H, d, *J* = 9.0, Py*H*), 8.55 (1H, d, *J* = 6.0, Py*H*), 8.68 (1H, s, Py*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 17.41 (CH), 48.44 (CH$_2$), 56.73 (CH$_2$), 64.38 (CH$_2$), 66.60 (CH), 123.88 (CH), 126.96 (CH), 128.03 (CH), 128.24(CH), 128.32 (CH), 135.40 (CH), 138.32 (C), 147.60(C), 149.14 (CH), 149.74 (CH). High-resolution MS calcd for formula $C_{16}H_{17}N_2I$: 364.0436; found: 364.0440.

4.1.72 (195e) 4-(*cis*-1-Benzyl-4-iodopyrrolidin-2-yl)pyridine.



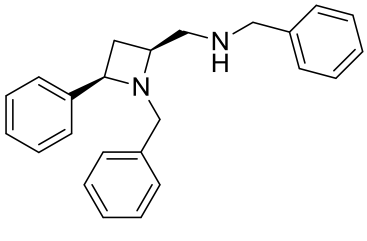
General procedure E was used: **194e** (50 mg, 0.14 mmol) and acetonitrile (20 mL), yellow oil, 49 mg, 98%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 2.36 (1H, m, PyCHC*H*H), 2.80 (1H, dd, *J* = 12.0 & 6.0, NCH*H*CHI), 2.99 (1H, dt, *J* = 15.0 & 9.0, PyCHCH*H*), 3.43 (1H, dd, *J* = 12.0 & 6.0, NC*H*HCHI), 3.59 (2H, ABq, J_{AB} = 15.0, NC*H$_2$*Ph), 3.65 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 9.0, PyC*H*CH$_2$), 4.40 (1H, m, NCH$_2$C*H*I), 7.30 (5H m, Ar*H*), 7.52 (2H, d, *J* = 6.0, Py*H*), 8.61 (2H, d, J = 6.0, PyH); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 17.23 (CH), 48.17 (CH_2), 56.98 (CH_2), 64.31 (CH_2), 67.94 (CH), 122.78 (CH), 127.17 (CH), 128.25 (CH), 128.37(CH), 138.21 (C), 150.15 (CH), 151.47 (C). High-resolution MS calcd for formula $C_{18}H_{21}NI$: 364.0436; found 364.0440.

4.1.73 (199aa) *N*-benzyl-1-((*cis*)-1-benzyl-4-phenylazetidin-2-yl)methanamine



General procedure F was used: **192a** (200 mg, 0.84 mmol), flash chromatography (Hexane/EtOAc = 1/1 Rf 0.4), yellow oil, yield (from **192a**) = 248 mg, 86%. IR 3316, 2983, 1645, 1494, 1453, 1373, 1242, 1158; ^1H NMR (δ; 300 MHz, $CDCl_3$); 2.00 (1H, $_{apt.}$q, $_{obs.}J$= 9.9, PhCHCHH), 2.35-2.45 (2H, m, PhCHCHH and NCHCHHNH), 2.53 (1H, dd, J = 12.0 & 4.5, NCHCHHNH), 3.28-3.36 (1H, m, CHCH$_2$NH), 3.58 (2H, s, NHCH_2Ph), 3.67 (2H, ABq, J_{AB} = 12.9, NCH_2Ph), 4.02 (1H, $_{apt.}$t, $_{obs.}J$ = 8.1, PhCHCH$_2$), 7.20-7.37 (13H, m, PhH), 7.45-7.48 (2H, m, PhH); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 31.12 (CH_2), 53.75 (CH_2), 54.14 (CH_2), 61.49 (CH_2), 62.72 (CH), 65.24 (CH), 126.67 (CH), 126.85 (CH), 127.05 (CH), 127.93 (CH), 128.14 (CH), 128.18 (CH), 128.23 (CH), 128.49 (CH), 129.11 (CH),138.88 (C), 140.58 (C), 143.54 (C). High-resolution MS calcd for formula $C_{24}H_{27}N_2$: 343.2174; found: 343.2163.

4.1.74 (199aa) *N*-benzyl-1-((2*S*,4*R*)-1-benzyl-4-phenylazetidin-2-yl)methanamine



General procedure F was used: (*R*)-**192a** (200 mg, 0.84 mmol), flash chromatography (Hexane/EtOAc = 1/1 Rf 0.4), yellow oil, yield (from (*R*)-**192a**) = 242 mg, 84%. HPLC: Chiralpak AD column, detected at 210 nm, eluent: *n*-hexane/*iso*-propanol 99/1, flow rate: 0.250 ml/min. $[\alpha]_D^{20}$ = +96.8 (c 0.32, $CHCl_3$), 99.5% *ee*. IR 3061, 3027, 2821, 1672, 1603, 1494, 1453, 1353, 1206, 1157; ^1H NMR and $^{13}C\{^1H\}$ NMR same as **199aa.** High-resolution MS calcd for formula $C_{24}H_{26}N_2Na$: 365.1994; found: 365.1999. Several chiral columns were tried under different conditions but a clear baseline separation of the enantiomers (2*S*,4*R*)-**199aa** and (2*R*,4*S*)-**199aa** was not possible when the racemate was analysed (Table 38). However, when the enantioenriched (2*S*,4*R*)-**199aa** was used, a clear separation was obtained and the enantiomeric excess could be calculated (Table 39).

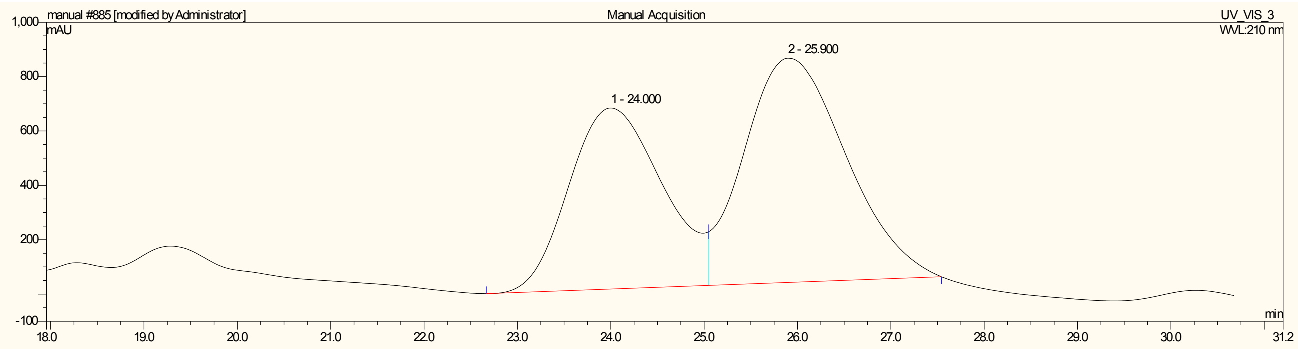


Table 38. HPLC data for racemate **199aa**

No.	Ret.Time	Peak Name	Height	Area	Rel.Area	Amount	Type
	min		mAU	mAU*min	%		
1	24.00	n.a.	665.968	774.560	42.53	n.a.	BM *
2	25.90	n.a.	824.818	1046.813	57.47	n.a.	MB*
Total:			1490.786	1821.373	100.00	0.000	

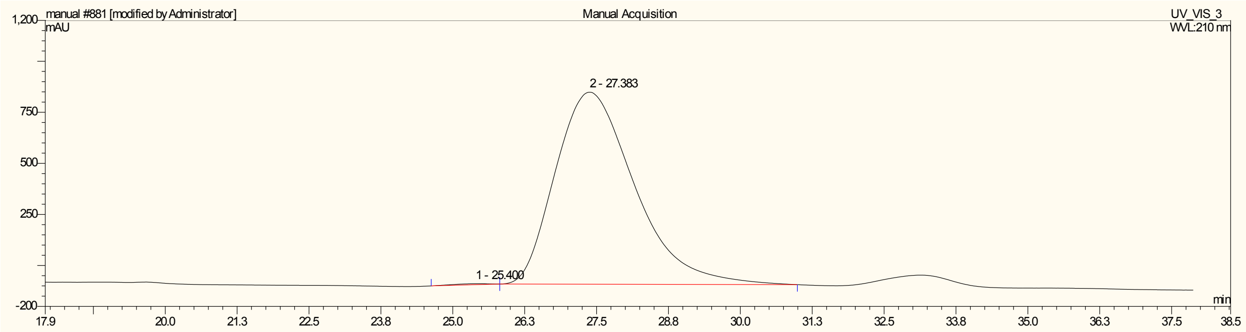
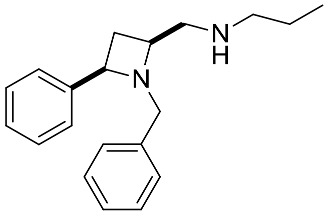


Table 39. HPLC data for (2*S*,4*R*)-**199aa**

No.	Ret.Time	Peak Name	Height	Area	Rel.Area	Amount	Type
	min		mAU	mAU*min	%		
1	25.40	n.a.	4.710	3.538	0.23	n.a.	BM *
2	27.38	n.a.	939.967	1503.597	99.77	n.a.	MB*
Total:			944.677	1507.134	100.00	0.000	

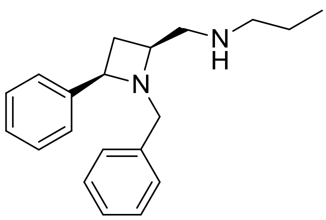
4.1.75 (199ab) *N*-(((*cis*)-1-benzyl-4-phenylazetidin-2-yl)methyl)propan-1-amine



General procedure F was used: **192a** (200 mg, 0.84 mmol), flash chromatography (CHCl$_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192a**) = 216 mg, 87%. IR 3313, 2944, 2832, 1449, 1115; ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 0.84 (3H, t, *J* = 7.5, Me), 1.30-1.42 (2H, m,C*H*$_2$CH$_3$), 1.91-2.00 (1H, m, PhCHCH*H*), 2.26-2.50 (5H, m, NHC*H*$_2$CH$_2$, PhCHC*H*H, NCHCH*H*NH, NH), 2.57 (1H, dd, *J* = 12.3 & 4.2, NCHC*H*HNH), 3.29-3.37 (1H, m, NC*H*CH$_2$NH), 3.68 (2H, ABq, J_{AB} = 12.6, NC*H*$_2$Ph), 4.03 (1H, $_{\text{apt.}}$t,

${}_{\text{obs}}J$ = 8.1, PhC*H*CH$_2$), 7.24-7.38 (8H, m, Ph*H*), 7.46-7.49 (2H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 11.68 (CH$_3$), 22.61 (CH$_2$), 31.27 (CH$_2$), 51.84 (CH$_2$), 54.03 (CH$_2$), 61.44 (CH$_2$), 62.32 (CH), 65.30 (CH), 126.84 (CH), 127.13 (CH), 128.22 (CH), 129.14 (CH), 138.92 (C), 143.31 (C). High-resolution MS calcd for formula $C_{20}H_{27}N_2$: 295.2174; found: 295.2162.

4.1.76 (199ab) *N*-(((2*S*,4*R*)-1-benzyl-4-phenylazetidin-2-yl)methyl)propan-1-amine



General procedure F was used: (*R*)-**192a** (400 mg, 1.68 mmol), flash chromatography (CHCl$_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from (*R*)-**192a**) = 377 mg, 76%. HPLC: Chiralpak AD column, detected at 210 nm, eluent: *n*-hexane/*iso*-propanol 95/5, flow rate: 0.250 ml/min. $[\alpha]_D^{20}$ = +97.2 (c 1.17, CHCl$_3$), 92.5% *ee*. IR 3029, 2960, 2933, 2873, 1654, 1493, 1454, 1382, 1156; ^{1}H NMR and ^{13}C{^{1}H} NMR same as **199ab.** High-resolution MS calcd for formula $C_{20}H_{27}N_2$: 295.2174; found: 295.2179. Several chiral columns were tried under different conditions but a clear baseline separation of the enantiomers (2*S*,4*R*)-**199ab** and (2*R*,4*S*)-**199ab** was not possible when the racemate was analysed (Table 40). However, when the enantioenriched (2*S*,4*R*)-**199ab** was used, a clear separation was obtained and the enantiomeric excess could be calculated (Table 41).

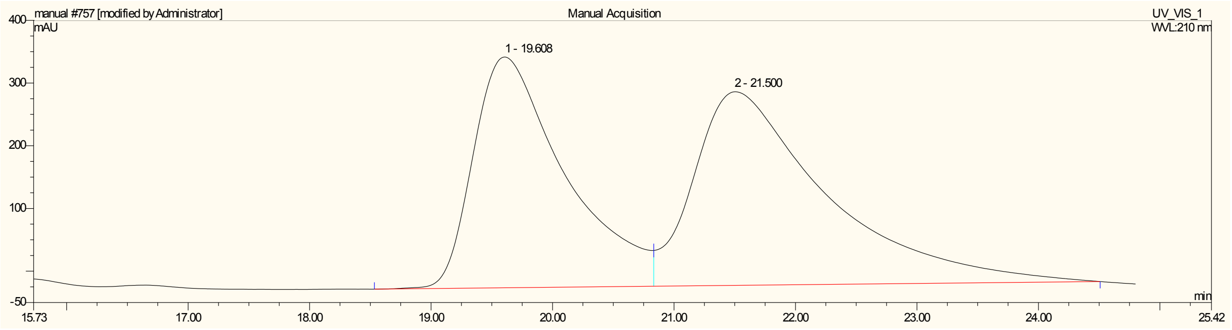


Table 40. HPLC data for racemate **199ab**

No.	Ret.Time	Peak Name	Height	Area	Rel.Area	Amount	Type
	min		mAU	mAU*min	%		
1	19.61	n.a.	367.958	321.959	45.15	n.a.	BM *
2	21.50	n.a.	308.704	391.150	54.85	n.a.	MB*
Total:			676.662	713.109	100.00	0.000	

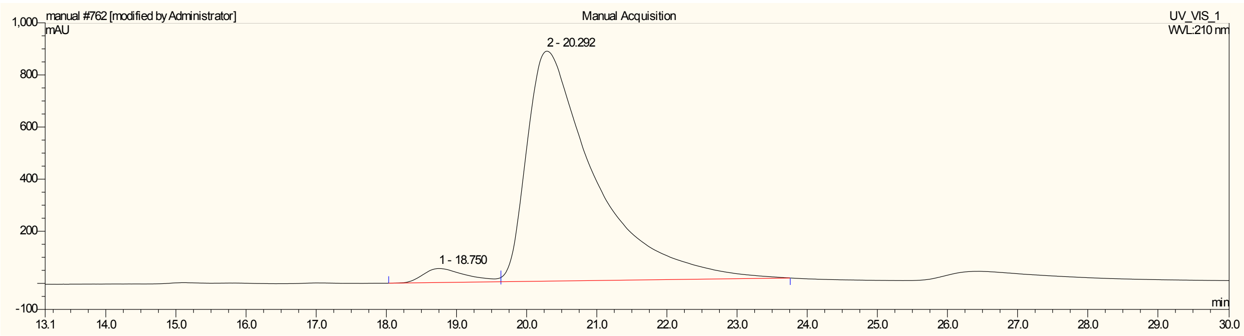
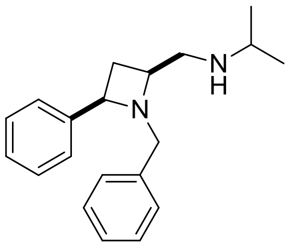


Table 41. HPLC data for (2*S*,4*R*)-**199ab**

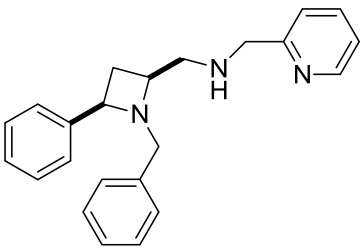
No.	Ret.Time	Peak Name	Height	Area	Rel.Area	Amount	Type
	min		mAU	mAU*min	%		
1	18.75	n.a.	53.655	38.600	3.73	n.a.	BM *
2	20.29	n.a.	882.679	996.706	96.27	n.a.	MB*
Total:			936.334	1035.306	100.00	0.000	

4.1.77 (199ac) *N*-(((*cis*)-1-benzyl-4-phenylazetidin-2-yl)methyl)propan-2-amine



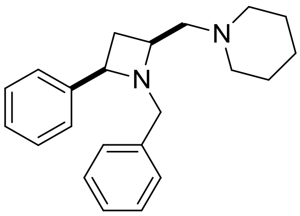
General procedure F was used: **192a** (200 mg, 0.84 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192a**) = 206 mg, 83%. IR 3661, 3300, 3062, 3027, 2927, 2969, 1649, 1603, 1494, 1454, 1382, 1250, 1172, 1066; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 0.87 (3H, d, *J* = 6, Me), 0.96 (3H, d, *J* = 6, Me), 1.96 (1H, $_{apt.}$q, $_{obs.}J$= 8.4, PhCHCH*H*), 2.35 (1H, dd, *J* = 11.7 & 4.8, NCHC*H*HNH), 2.41-2.52 (2H, m, PhCHC*H*H & NHC*H*(CH_3)$_2$), 2.58 (1H, dd, *J* = 11.7 & 4.8, NCHCH*H*NH), 3.31-3.38 (1H, m, NC*H*CH_2NH), 3.67 (2H, ABq, J_{AB} = 12.9, NCH_2Ph), 4.04 (1H, $_{apt.}$t, $_{obs.}J$ = 8.1, PhC*H*CH_2), 7.25-7.38 (8H, m, Ph*H*), 7.48 (2H, d, *J*= 6.9, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 21.63 (CH_3), 22.21 (CH_3), 31.24 (CH_2), 49.27 (CH), 51.64 (CH_2), 61.40 (CH_2), 62.30 (CH), 65.33 (CH), 126.84 (CH), 127.20 (CH), 127.27 (CH), 128.26 (CH), 128.34 (CH), 129.21 (CH), 139.00 (C), 143.11 (C). High-resolution MS calcd for formula $C_{20}H_{27}N_2$: 295.2174; found: 295.2172.

4.1.78 (199ad) 1-((*cis*)-1-benzyl-4-phenylazetidin-2-yl)-*N*-(pyridin-2-ylmethyl)methanamine



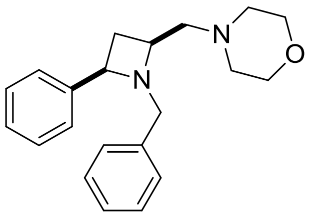
General procedure F was used: **192a** (200 mg, 0.84 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192a**) = 199 mg, 69%. IR 3311, 3061, 3029, 2926, 2820, 1671, 1590, 1570, 1493, 1474, 1454, 1433, 1356, 1289, 1210, 1149; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 2.00 (1H, $_{apt.}$q, $_{obs.}J$ = 8.4, PhCHCH*H*), 2.39-2.49 (2H, m, PhCHC*H*H and NCHCH*H*NH), 2.55 (1H, dd, *J* = 12.3 & 4.2, NCHC*H*HNH), 2.92 (1H, br, NH), 3.29-3.37 (1H, m, C*H*CH_2NH), 3.67 (2H, ABq, J_{AB} = 12.9, NC*H*$_2$Ph), 3.74 (2H, s, NHC*H*$_2$Py), 4.02 (1H, $_{apt.}$t, $_{obs.}J$ = 8.1, PhC*H*CH_2), 7.10-7.35 (13H, m, Ph*H*), 7.46-7.48 (1H, m, Ph*H*), 7.60 (1H, td; *J*= 7.8 & 1.8, Py*H*), 8.52-8.54 (1H, m, Py*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 31.13 (CH_2), 53.69 (CH_2), 55.29 (CH_2), 61.42 (CH_2), 62.28 (CH), 65.26 (CH), 121.78 (CH), 121.91 (CH), 126.86 (CH), 127.05 (CH), 128.10 (CH), 128.17 (CH), 129.18 (CH), 136.35 (CH), 138.65 (C), 143.47 (C),149.30 (CH), 159.83 (C). High-resolution MS calcd for formula $C_{23}H_{26}N_3$: 344.2126; found: 344.2118.

4.1.79 (192ae) 1-(((*cis*)-1-benzyl-4-phenylazetidin-2-yl)methyl)piperidine



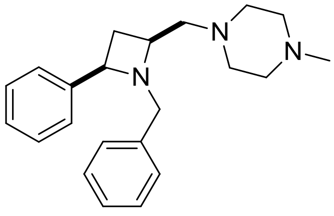
General procedure F was used: **192a** (200 mg, 0.84 mmol), flash chromatography (Hexane/EtOAc = 1/1 Rf 0.3), yellow oil, yield (from **192a**) = 229 mg, 85%. IR 3062, 3027, 2933, 2852, 2799, 1676, 1603, 1521, 1493, 1453, 1382, 1353, 1324, 1273, 1252, 1209, 1156, 1122; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.37-1.42 (2H, m, NCH_2CH_2C*H*$_2$), 1.50-1.57 (4H, m, NCH_2C*H*$_2$), 1.79 (1H, dt, *J* = 9.9 & 8.7, PhCHCH*H*), 2.23-2.35 (6H, m, NC*H*$_2$$CH_2$ & NCHC*H*$_2$N), 2.57 (1H, dt, *J* = 9.9 & 8.7, PhCHC*H*H), 3.28-3.37 (1H, m, NC*H*CH_2N), 3.70 (2H, ABq, J_{AB} = 12.9, NC*H*$_2$Ph), 4.00 (1H, $_{apt.}$t, $_{obs.}J$ = 8.1, PhC*H*CH_2), 7.19-7.32 (8H, m, Ph*H*), 7.39-7.42 (2H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 24.21 (CH_2), 25.89 (CH_2), 35.57 (CH_2), 55.16 (CH_2), 60.92 (CH), 61.25 (CH_2), 65.36 (CH_2), 65.90 (CH), 126.78 (CH), 126.88 (CH), 127.89 (CH), 128.04 (CH), 129.47 (CH), 138.43 (C), 143.67 (C). High-resolution MS calcd for formula $C_{22}H_{29}N_2$: 321.2330; found: 321.2327.

4.1.80 (192af) 4-(((*cis*)-1-benzyl-4-phenylazetidin-2-yl)methyl)morpholine



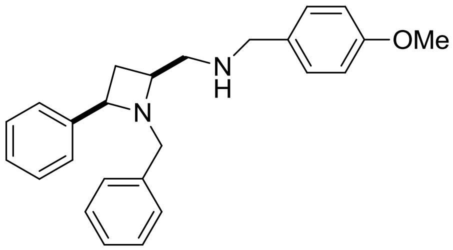
General procedure F was used: **192a** (200 mg, 0.84 mmol), flash chromatography (Hexane/EtOAc = 1/1 Rf 0.3), yellow oil, yield (from **192a**) = 192 mg, 71%. IR 3061, 3028, 2954, 2853, 2807, 1641, 1603, 1566, 1493, 1454, 1357, 1327, 1302, 1277, 1241, 1207, 1139; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.83 (1H, dt, *J* = 9.9 & 8.7, PhCHCH*H*), 2.26-2.44 (6H, m, NCHC*H*$_2$N & NC*H*$_2$CH$_2$O), 2.55 (1H, dt, *J*= 9.9 & 8.7, PhCHC*H*H), 3.27-3.36 (1H, m, NC*H*CH$_2$N), 3.66 (4H, t, *J* = 4.8, C*H*$_2$O), 3.71 (2H, ABq, J_{AB} = 12.9, NC*H*$_2$Ph), 4.02 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.1, PhC*H*CH$_2$), 7.21-7.36 (8H, m, Ph*H*), 7.43 (2H, dd, *J* = 8.1 & 1.5, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 34.71 (CH_2), 54.29 (CH_2), 60.54 (CH), 61.35 (CH_2), 64.74 (CH_2), 65.79 (CH), 66.91 (CH_2), 126.77 (CH), 126.93 (CH), 127.01 (CH), 127.96 (CH), 128.12 (CH), 129.45 (CH), 138.39 (C), 143.52 (C). High-resolution MS calcd for formula $C_{21}H_{26}N_2ONa$: 345.1943; found: 345.1939.

4.1.81 (192ag) 1-(((*cis*)-1-benzyl-4-phenylazetidin-2-yl)methyl)-4-methylpiperazine



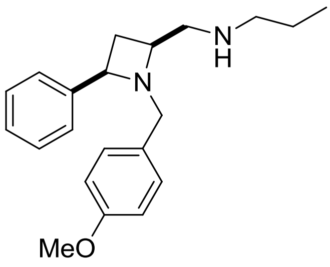
General procedure F was used: **192a** (200 mg, 0.84 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192a**) = 228 mg, 81%. IR 3675, 3391, 2988, 2972, 2901, 2800, 1634, 1603, 1565, 1493, 1453, 1406, 1394, 1381, 1264, 1231, 1165, 1066, 1056; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.80 (1H, dt, *J* = 9.9 & 8.7, PhCHCH*H*), 2.27 (3H, s, Me), 2.30-2.49 (10H, m, NCHC*H*$_2$N & NC*H*$_2$C*H*$_2$N), 2.55 (1H, dt, *J* = 9.9 & 8.7, PhCHC*H*H), 3.27-3.36 (1H, m, NC*H*CH$_2$N), 3.69 (2H, ABq, J_{AB} = 12.9, NC*H*$_2$Ph), 4.00 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.1, PhC*H*CH$_2$), 7.18-7.33 (8H, m, Ph*H*), 7.41 (2H, dd, *J* = 8.25 & 1.5, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 35.05 (CH_2), 45.05 (CH_3), 53.69 (CH_2), 55.03 (CH_2), 60.69 (CH), 61.31 (CH_2), 64.30 (CH_2), 65.85 (CH), 126.75 (CH), 126.89 (CH), 126.94 (CH), 127.93 (CH), 128.08 (CH), 129.45 (CH), 138.38 (C), 143.56 (C). High-resolution MS calcd for formula $C_{22}H_{30}N_3$: 336.2439; found: 336.2427.

4.1.82 (199ah) 1-((*cis*)-1-benzyl-4-phenylazetidin-2-yl)-*N*-(4-methoxybenzyl)methanamine.



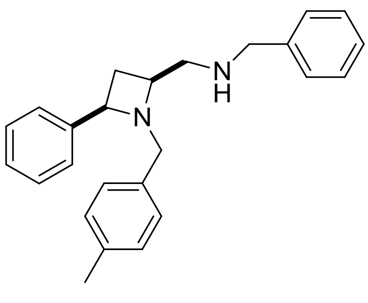
General procedure F was used: **192a** (200 mg, 0.84 mmol), flash chromatography (CHCl$_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192a**) = 245 mg, 78%. IR 3300, 2926, 1611, 1584, 1512, 1496, 1454, 1349, 1304, 1250, 1178, 1073; ^{1}H NMR (δ; 400 MHz, CDCl$_3$); 1.61 (1H, br, N*H*), 1.88 (1H, m, PhCHCH*H*), 2.27 (2H, m, PhCHC*H*H and NCHCH*H*NH), 2.40 (1H, dd, *J* = 12.0 & 6.0, NCHC*H*HNH), 3.19 (1H, m, C*H*CH$_2$NH), 3.53 (2H, ABq, J_{AB} = 9.0, NC*H*$_2$Ph), 3.61 (2H, ABq, J_{AB} = 3.0, NHC*H*$_2$Ar), 3.69 (3H, s, OMe), 3.89 (1H, $_{\mathrm{apt.}}$t, $_{\mathrm{obs.}}J$ = 12.0, PhC*H*CH$_2$), 6.70 (2H, d, *J* = 6.0, Ar*H*), 7.00 (2H, d, *J* = 9.0, Ar*H*), 7.12 (8H, m, Ph*H*), 7.34 (2H, d, *J* = 9.0, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 30.78 (CH$_2$), 53.15 (CH$_2$), 53.96 (CH$_2$), 61.48 (CH$_2$), 62.52 (CH), 62.96 (CH), 123.29 (CH), 126.96 (CH), 127.30 (CH), 128.10 (CH), 128.24 (CH), 129.16 (CH), 134.66 (CH), 138.10 (C), 138.58 (C), 139.80 (C), 148.52 (CH), 148.74 (CH). High-resolution MS calcd for formula C$_{25}$H$_{29}$N$_2$O: 373.2280; found: 373.2277.

4.1.83 (199bb) *N*-(((*cis*)-1-(4-methoxybenzyl)-4-phenylazetidin-2-yl)methyl)propan-1-amine



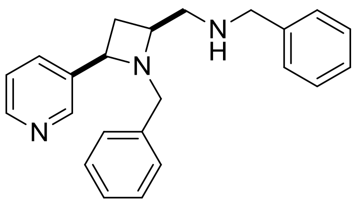
General procedure F was used, **192b** (760 mg, 2.84 mmol), flash chromatography (CHCl$_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192b**) = 682 mg, 74%. IR 3315, 2936, 1625, 1544, 1426, 1319, 1273, 1178; ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 0.85 (3H, t, *J* = 7.5, Me), 1.32-1.44 (2H, m, C*H*$_2$CH$_3$), 1.95 (1H, $_{\mathrm{apt.}}$q, $_{\mathrm{obs.}}J$ = 8.7, PhCHCH*H*), 2.27-2.50 (4H, m, NHC*H*$_2$CH$_2$, PhCHC*H*H, NCHCH*H*NH), 2.57 (1H, dd, *J* = 12.1 & 4.5 NCHC*H*HNH), 3.28-3.36 (1H, m, NC*H*CH$_2$NH), 3.62 (2H, ABq, J_{AB} = 12.9, NC*H*$_2$Ar), 3.80 (3H, s, OC*H*$_3$), 4.01 (1H, $_{\mathrm{apt.}}$t, $_{\mathrm{obs.}}J$ = 8.1, PhC*H*CH$_2$), 6.84 (2H, d, *J* = 8.4, Ar*H*), 7.24-7.29 (3H, m, Ar*H*), 7.35 (2H, t, *J* = 7.5, Ar*H*), 7.45-7.48 (2H, m, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 11.68 (CH$_3$), 22.66 (CH$_2$), 31.18 (CH$_2$), 51.91 (CH$_2$), 54.15 (CH$_2$), 55.26 (CH$_3$), 60.66 (CH$_2$), 62.00 (CH), 65.09 (CH), 113.65 (CH), 126.81 (CH), 127.12 (CH), 128.23 (CH), 130.24 (CH), 130.95 (C), 143.34 (C), 158.84 (C). High-resolution MS calcd for formula C$_{21}$H$_{29}$N$_2$O: 325.2280; found: 325.2285.

4.1.84 (199ca) *N*-benzyl-1-((*cis*)-1-(4-methylbenzyl)-4-phenylazetidin-2-yl)methanamine



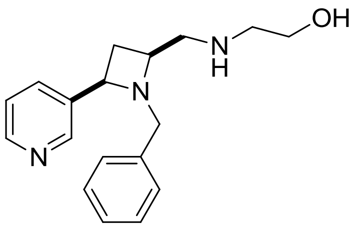
General procedure F was used: **192c** (530 mg, 2.11 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192c**) = 564 mg, 75%. IR 3653, 3284, 2956, 2878, 2753, 2528, 1596, 1496, 1476, 1467, 1382, 1345, 1289, 1215, 1112; ^{1}H NMR (δ; 500 MHz, $CDCl_3$); 2.01 (1H, $_{\text{apt.}}$q, $_{\text{obs.}}J$ = 10.0, PhCHCH*H*), 2.33 (3H, s, Me), 2.41-2.48 (2H, m, PhCHC*H*H and NCHCH*H*NH), 2.58 (1H, dd, *J* = 12.0 & 4.5, NCHC*H*HNH), 3.32-3.37 (1H, m, NC*H*CH_2NH), 3.61 (2H, ABq, J_{AB} = 13.0, NHCH_2Ph), 3.66 (2H, ABq, J_{AB} = 13.0, NCH_2Ar), 4.03 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.5, PhC*H*CH_2), 7.08 (2H, d, *J* = 8.0, Ar*H*), 7.21-7.39 (10H, m, Ar*H*), 7.49 (2H, d, *J* = 8.0, Ar*H*); ^{13}C{^{1}H} NMR (δ; 125 MHz, $CDCl_3$), 21.12 (CH_3), 31.08 (CH_2), 53.68 (CH_2), 53.97 (CH_2), 61.02 (CH_2), 62.28 (CH), 65.07 (CH), 126.80 (CH), 126.85 (CH), 127.07 (CH), 128.02 (CH), 128.22 (CH), 128.26 (CH), 128.90 (CH), 129.07 (CH), 135.73 (C), 136.66 (C), 140.01 (C), 143.49 (C). High-resolution MS calcd for formula $C_{25}H_{28}N_2Na$: 379.2150; found: 379.2144.

4.1.85 (199da) *N*-Benzyl-1-(*cis*-1-benzyl-4-(pyridin-3-yl)azetidin-2-yl)methanamine.



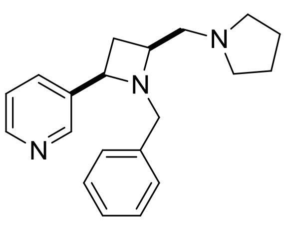
General procedure F was used: **192d** (328 mg, 1.37 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192d**) = 340 mg, 72%. IR 3302, 3027, 2819, 1643, 1578, 1494, 1479, 1453, 1427, 1356, 1314, 1207, 1156; ^{1}H NMR (δ; 400 MHz, $CDCl_3$); 1.31 (1H, br, NH), 2.16 (1H, $_{\text{apt.}}$q, $_{\text{obs.}}J$ = 8.0, PyCHCH*H*), 2.52 (2H, m, PyCHC*H*H and NCHCH*H*NH), 2.83 (1H, dd, *J* = 12.0 & 4.0, NCHC*H*HNH), 3.56 (1H, m, NC*H*CH_2NH), 3.68 (2H, ABq, J_{AB} = 12.0, NCH_2Ph), 3.92 (2H, ABq, J_{AB} = 12.0, NHCH_2Ph), 4.08 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.0, PyC*H*CH_2), 7.16 (1H, t, *J* = 8.0, Ar*H*), 7.21 (1H, t, *J* = 8.0, Ar*H*), 7.23 (2H, t, *J* = 8.0, Ar*H*), 7.28 (1H, d, *J* = 8.0, Ar*H*), 7.29 (2H, d, *J* = 8.0, Ar*H*), 7.34 (2H, m, Ar*H*), 7.38 (2H, d, *J* = 12.0, Ar*H*), 7.69 (1H, dt, *J* = 8.0 & 4.0, Ar*H*), 8.42 (dd, 1H, *J* = 6.0 & 4.0, Py*H*), 8.91 (1H, s, Py*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 30.78 (CH_2), 53.15 (CH_2), 53.96 (CH_2), 61.48 (CH_2), 62.52 (CH), 62.96 (CH), 123.29 (CH), 126.96 (CH), 127.30 (CH), 128.10 (CH), 128.24(CH), 129.16 (CH), 134.66 (CH), 138.10 (C), 138.58 (C), 139.80 (C), 148.52 (CH), 148.74 (CH). High-resolution MS calcd for formula $C_{23}H_{25}N_3Na$: 366.1946; found: 366.1949.

4.1.86 (199di) 2-((((*cis*)-1-benzyl-4-(pyridin-3-yl)azetidin-2yl)methyl)amino)ethanol



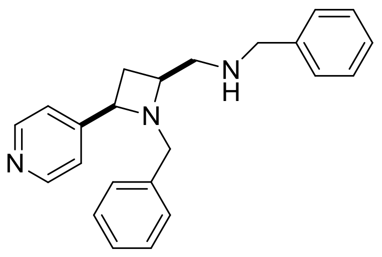
General procedure F was used: **192d** (410 mg, 1.72 mmol), flash chromatography ($CHCl_3$/MeOH = 1/1 Rf 0.4), yellow oil, yield (from **192d**) = 419 mg, 82%. IR 3333, 2939, 2829, 1639, 1596, 1580, 1495, 1454, 1359, 1315, 1209, 1155; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 2.25 (1H, $_{apt.}$q, $_{obs.}J = 9.3$, PyCHCH*H*), 2.62-2.94 (7H, m, NCHCH_2NH, PyCHC*H*H, CH_2CH$_2$OH, N*H*, O*H*), 3.59-3.67 (1H, m, NC*H*CH$_2$NH), 3.79 (2H, t, $J = 5.1$, CH_2OH), 3.95 (2H, ABq, $J_{AB} = 12.6$, NCH_2Ph), 4.32 (1H, $_{apt.}$t, $_{obs.}J = 8.1$, PyC*H*CH$_2$), 7.49-7.56 (6H, m, Ar*H*), 8.06 (1H, dd, $_{obs.}J = 7.8$ & 1.2, Py*H*), 8.75 (1H, d, $J = 4.5$, Py*H*), 8.88 (1H, s, Py*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 30.83 (CH_2), 51.17 (CH_2), 53.13 (CH_2), 60.58 (CH_2), 61.53 (CH_2), 62.68 (CH), 62.85 (CH), 123.32 (CH), 127.32 (CH), 128.22 (CH), 129.17 (CH), 134.56 (CH), 138.14 (C), 138.54 (C), 148.50 (CH), 148.63 (CH). High-resolution MS calcd for formula $C_{18}H_{23}N_3ONa$: 320.1739; found: 320.1744.

4.1.87 (199dj) 3-((*cis*)-1-benzyl-4-(pyrrolidin-1-ylmethyl)azetidin-2-yl)pyridine



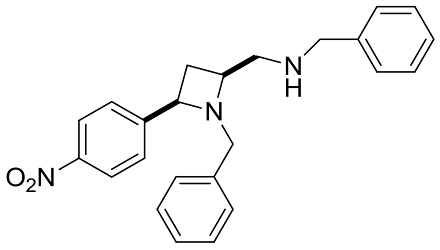
General procedure F was used: **192d** (200 mg, 0.84 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192d**) = 196 mg, 76%. IR 3413, 3029, 2960, 2690, 2195, 1635, 1495, 1453, 1430, 1357, 1317, 1189, 1156; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 2.01- 2.08 (5H, m, NCH$_2$CH_2 & PyCHCH*H*), 2.75 (1H, dd, $J = 12.3$ & 3.0, NCHC*H*HN), 2.83 (1H, dt, $J = 10.5$ & 7.5, PyCHC*H*H), 2.94-3.02 (1H, m, NCHCH*H*N), 3.15 (4H, br, NCH_2CH$_2$), 3.71 (2H, ABq, $J_{AB} = 12.3$, NCH_2Ph), 3.77-3.84 (1H, m, NC*H*CH$_2$N), 4.11 (1H, $_{apt.}$t, $_{obs.}J = 8.1$, PyC*H*CH$_2$), 7.18-7.31 (6H, m, Ar*H*), 7.68 (1H, dt, $J = 7.8$ & 2.1, Py*H*), 8.44 (1H, d, $J = 4.8$, Py*H*), 8.57 (1H, d, $J = 1.8$, Py*H*); ^{13}C{^{1}H} NMR (δ; 125 MHz, $CDCl_3$), 23.26 (CH_2), 34.82 (CH_2), 54.44 (CH_2), 57.91 (CH), 59.70 (CH_2) 60.98 (CH), 63.47 (CH), 123.31 (CH), 127.72 (CH), 128.51 (CH), 129.65 (CH), 134.43 (CH), 136.85 (C), 137.37 (C), 148.48 (CH), 148.80 (CH). High-resolution MS calcd for formula $C_{20}H_{25}N_3Na$: 330.1946; found: 330.1940.

4.1.88 (199ea) *N*-benzyl-1-((*cis*)-1-benzyl-4-(pyridin-4-yl)azetidin-2yl)methanamine



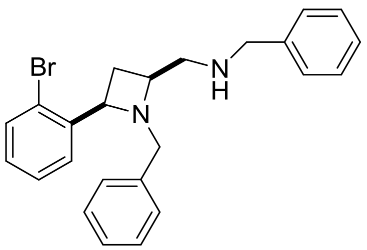
General procedure F was used: **192e** (600 mg, 2.52 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192e**) = 615 mg, 71%. IR 3031, 2818, 1671, 1600, 1495, 1453, 1412, 1311, 1356, 1206, 1156; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.96 (1H, $_{\text{apt.}}$q, $_{\text{obs.}}J$ = 9.0, PyCHCH*H*), 2.41-2.50 (2H, m, PyCHC*H*H and NCHCH*H*NH), 2.56 (1H, dd, *J* = 12.3 & 4.5, NCHC*H*HNH), 2.94 (1H, br, N*H*), 3.35-3.45 (1H, m, NC*H*CH_2NH), 3.63 (2H, s, NHCH_2Ph), 3.68 (2H, ABq, J_{AB} = 15.0, NCH_2Ph), 4.02 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 9.0, PyC*H*CH_2), 7.19-7.40 (12H, m, Ar*H*), 8.50 (2H, d, *J* = 5.1, Py*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 30.39 (CH_2), 53.14 (CH_2), 53.91 (CH_2), 61.68 (CH_2), 62.52 (CH), 63.92 (CH), 121.64 (CH), 126.93 (CH), 127.38 (CH), 128.03 (CH), 128.27(CH), 128.34 (CH), 129.15 (CH), 138.03 (C), 139.87 (C), 149.56 (CH), 152.37 (C). High-resolution MS calcd for formula $C_{23}H_{26}N_3$: 344.2126; found: 344.2130.

4.1.89 (199fa) *N*-benzyl-1-((*cis*)-1-benzyl-4-(4-nitrophenyl)azetidin-2-yl)methanamine



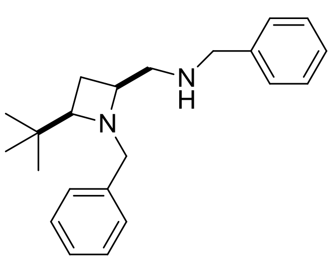
General procedure F was used: **192f** (200 mg, 0.71 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192f**) = 208 mg, 76%. IR 3062, 3028, 2924, 2851, 1671, 1599, 1516, 1494, 1453, 1343, 1287, 1213, 1157; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.70 (1H, br, NH), 1.94-2.03(1H, $_{\text{apt.}}$q, $_{\text{obs.}}J$ = 8.7, ArCHCH*H*), 2.46-2.54 (2H, m, ArCHC*H*H and NCHCH*H*NH), 2.59 (1H, dd, *J* = 12.0 & 4.2, NCHC*H*HNH), 3.38-3.45 (1H, m, NC*H*CH_2NH), 3.67 (2H, s, NHCH_2Ph), 3.70 (2H, ABq, J_{AB} = 12.3, NCH_2Ph), 4.13 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.1, ArC*H*CH_2), 7.20-7.37 (10H, m, Ar*H*), 7.55 (2H, d, *J* = 8.7, Ar*H*), 8.14 (2H, d, *J* = 8.7, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$) 30.99 (CH_2), 53.35 (CH_2), 54.11 (CH_2), 61.73 (CH_2), 62.65 (CH), 64.53 (CH), 123.47 (CH), 126.85 (CH), 127.37 (CH), 127.95 (CH), 128.25 (CH), 137.98 (C), 140.39 (C), 146.95 (C), 151.22 (C). High-resolution MS calcd for formula $C_{24}H_{26}N_3O_2$: 388.2025; found: 388.2023.

4.1.90 (199ga) *N*-benzyl-1-((*cis*)-1-benzyl-4-(2-bromophenyl)azetidin-2-yl)methanamine



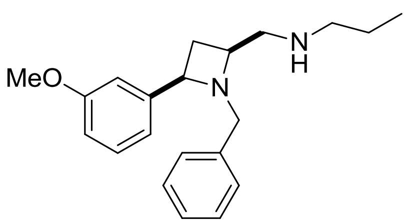
General procedure F was used: **192g** (1.30 g, 4.11 mmol), flash chromatography (Hexane/EtOAc = 1/1 Rf 0.4), yellow oil, yield (from **192g**) = 1.26 g, 65%. IR 3675, 2988, 2901, 1406, 1394, 1250, 1075, 1066, 1056; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.54 (1H, br, NH), 1.81 (1H, dt, *J* = 10.2 & 8.4, ArCHCH*H*), 2.36 (1H, dd, *J* = 12.0 & 4.5, NCHCH*H*NH), 2.50 (1H, dd, *J* = 12.0 & 4.5, NCHC*H*HNH), 2.70 (1H, dt, *J* = 10.2 & 8.4, ArCHC*H*H), 3.37-3.45 (1H, m, C*H*CH_2NH), 3.58 (2H, $_{apt.}$d, $_{obs.}J$ = 3.3, NHCH_2Ph), 3.71 (2H, ABq, J_{AB} = 12.9, NCH_2Ph), 4.36 (1H, $_{apt.}$t, $_{obs.}J$ = 8.1, ArC*H*CH_2), 7.15 (1H, td, *J* = 7.5 & 1.8, Ar*H*), 7.18-7.40 (11H, m, Ar*H*), 7.50 (1H, dd, *J* = 7.8 & 1.2, Ar*H*), 7.84 (1H, dd, *J*= 7.6 & 1.5, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 30.17 (CH_2), 53.79 (CH_2), 54.06 (CH_2), 61.77 (CH_2), 62.79 (CH), 64.24 (CH), 121.94 (C), 126.69 (CH), 127.25 (CH), 127.39 (CH), 127.91 (CH), 128.12 (CH), 128.24 (CH), 128.27 (CH), 129.13 (CH), 132.20 (CH), 138.74 (C), 140.49 (C), 142.60 (C). High-resolution MS calcd for formula $C_{24}H_{26}N_2Br$: 421.1279; found: 421.1271.

4.1.91 (199ha) *N*-benzyl-1-((*cis*)-1-benzyl-4-(tert-butyl)azetidin-2-yl)methanamine



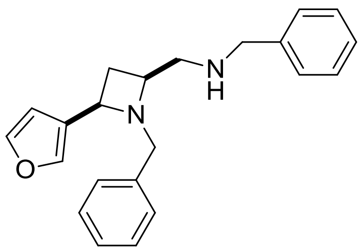
General procedure F was used: **192h** (928 mg, 4.27 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192h**) = 1.18 g, 86%. IR 3675, 3214, 2987, 2969, 2901, 1664, 1603, 1494, 1476, 1453, 1394, 1360, 1250, 1229, 1075, 1066, 1056; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.00 (9H, s, *tert*-butyl), 1.89 (1H, dt, *J* = 10.5 & 8.4, *tert*-butylCHCH*H*), 2.04 (1H, dt, *J* = 10.5 & 8.4, *tert*-butylCHC*H*H), 2.29 (1H, dd, *J* = 12.0 & 4.5, NCHC*H*HNH), 2.48 (1H, dd, *J* = 12.0 & 4.5, NCHCH*H*NH), 2.93 (1H, $_{apt.}$t, $_{obs.}J$ = 8.4, *tert*-butylC*H*CH_2), 3.17 (1H, m, C*H*CH_2NH), 3.59 (2H, s, NHCH_2Ph), 3.77 (2H, ABq, J_{AB} = 13.5, NHCH_2Ph), 7.24-7.44 (10H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 125 MHz, $CDCl_3$), 22.13 (CH_2), 26.17 (CH_3), 33.8 (C), 54.11 (CH_2), 54.28 (CH_2), 62.47 (CH), 64.22 (CH_2), 71.88 (CH), 126.62 (CH), 127.0 (CH), 127.87 (CH), 128.23 (CH), 128.82 (CH), 140.28 (C), 140.73 (C). High-resolution MS calcd for formula $C_{22}H_{31}N_2$: 323.2487; found: 323.2471.

4.1.92 (199ib) *N*-(((*cis*)-1-benzyl-4-(3-methoxyphenyl)azetidin-2-yl)methyl)propan-1-amine



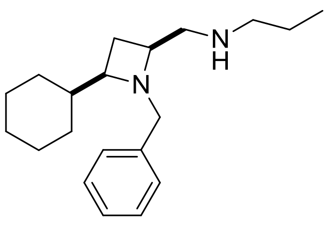
General procedure F was used: **192i** (700 mg, 2.62 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192i**) = 723 mg, 85%. IR 3290, 2966, 2937, 2876, 1654, 1602, 1549, 1454, 1372, 1239, 1155; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 0.86 (3H, t, *J*= 7.5, Me), 1.37-1.49 (2H, m,C*H*$_2$CH$_3$), 2.05-2.21 (2H, m, *J* = 8.7, PhCHCH*H*, NHC*H*HCH$_2$CH$_3$), 2.26 (1H, dd, *J* = 12.3 & 4.8, NCHCH*H*NH), 2.40-2.54 (2H, m, PhCHC*H*H & NHCH*H*CH$_2$CH$_3$), 2.70 (1H, dd, *J* = 12.3 & 4.8, NCHC*H*HNH), 3.38-3.45 (1H, m, NC*H*CH$_2$NH), 3.69 (2H, ABq, J_{AB} = 12.6, NC*H*$_2$Ph), 3.85 (3H, s, OC*H*$_3$), 4.08 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}$*J* = 8.1, PhC*H*CH$_2$), 6.83 (1H, dd, *J* = 8.2 & 2.7, Ar*H*), 7.01-7.05 (2H, m, Ar*H*), 7.25-7.37 (6H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 11.47 (CH_3), 21.96 (CH_2), 30.68 (CH_2), 51.38 (CH_2), 52.87 (CH_2), 55.33 (CH_3), 61.21 (CH_2), 65.33 (CH), 112.20 (CH), 112.84 (CH), 119.05 (CH), 127.50 (CH), 128.13 (CH), 128.56 (CH), 129.21 (CH), 129.40 (CH), 138.69 (C), 144.41 (C), 159.78 (C). High-resolution MS calcd for formula $C_{21}H_{29}N_2O$: 325.2280; found: 325.2270.

4.1.93 (199ja) *N*-benzyl-1-((*cis*)-1-benzyl-4-(furan-3-yl)azetidin-2-yl)methanamine



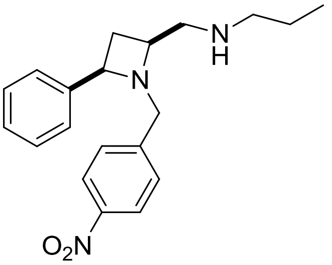
General procedure F was used: **192j** (758 mg, 3.30 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192j**) = 867 mg, 79%. IR 3197, 3027, 2934, 2858, 2797, 1642, 1594, 1544, 1523, 1495, 1453, 1416, 1380, 1338, 1265, 1227, 1197, 1166; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.76 (1H, br, NH), 2.09 (1H, $_{\text{apt.}}$ q, $_{\text{obs.}}$ *J* = 9.0, ArCHCH*H*), 2.32-2.40 (1H, m, ArCHC*H*H), 2.41 (1H, dd, *J* = 12.0 & 4.2, NCHC*H*HNH), 2.55 (1H, dd, *J* = 12.0 & 4.2, NCHCH*H*NH), 3.25-3.33 (1H, m, C*H*CH$_2$NH), 3.62 (2H, s, NHC*H*$_2$Ph), 3.68 (2H, ABq, J_{AB} = 12.9, NC*H*$_2$Ph), 3.95 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}$*J* = 9.0, ArC*H*CH$_2$), 6.42 (1H, s, Ar*H*), 7.18-7.44 (12H, m, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$) 29.58 (CH_2), 53.48 (CH_2), 54.19 (CH_2), 56.96 (CH), 61.45 (CH_2), 62.87 (CH), 109.41 (CH), 126.72 (CH), 127.10 (CH), 127.94 (CH), 128.10 (C), 128.14 (CH), 128.26 (CH), 129.13 (CH), 138.75 (C), 139.28 (CH), 140.08 (C), 142.91 (CH). High-resolution MS calcd for formula $C_{22}H_{25}N_2O$: 333.1964; found: 333.1962.

4.1.94 (199kb) *N*-(((*cis*)-1-benzyl-4-cyclohexylazetidin-2-yl)methyl)propan-1-amine



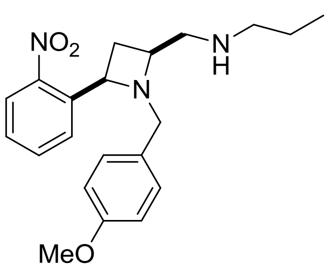
General procedure F was used: **192k** (840 mg, 3.50 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192k**) = 852 mg, 81%. IR 2922, 2850, 1641, 1494, 1449, 1351, 1260, 1073; ^1H NMR (δ; 300 MHz, $CDCl_3$); 0.82 (3H, t, *J* = 7.5, Me), 0.89-0.96 (2H, m, NCHCHC*H*H), 1.23-1.35 (5H, m, $NHCH_2CH_2CH_3$, $NCHCHCH_2C$*H*H, $NCHCHCH_2CH_2C$*H*H, NCHC*H*), 1.61-1.75 (6H, m, NCHCHCH*H*, $NCHCHCH_2CH$*H*, $NCHCHCH_2CH_2CH$*H*, $NHCH_2CH_2$), 2.06-2.35 (4H, m, $NHCH_2CHC$*H*H, $NHCH_2CH_2CH_3$, NCHC*H*HNH), 2.40 (1H, dd, *J* = 12.0 & 4.2, NCHCH*H*NH), 2.78 (1H, $_{apt.}$q, $_{obs.}$*J* = 8.4, NC*H*CH), 3.05-3.15 (1H, m, $NCHCH_2NH$), 3.65 (2H, ABq, J_{AB} = 12.6, NCH_2Ph), 7.25-7.36 (5H, m, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 11.68 (CH_3), 22.70 (CH_2), 22.51 (CH_2), 25.95 (CH_2), 26.64 (CH_2), 28.12 (CH_2), 29.57 (CH_2), 29.70 (CH_2), 44.38 (CH), 51.91 (CH_2), 54.31 (CH_2), 62.45 (CH), 63.55 (CH_2), 67.67 (CH) ,127.08 (CH), 128.22 (CH), 129.05 (CH), 139.60 (C). High-resolution MS calcd for formula $C_{20}H_{33}N_2$: 301.2643; found: 301.2636.

4.1.95 (199lb) *N*-(((*cis*)-1-(4-nitrobenzyl)-4-phenylazetidin-2-yl)methyl)propan-1-amine



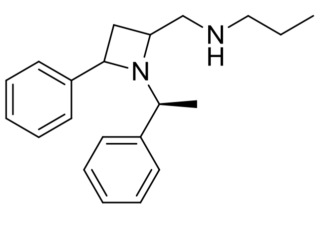
General procedure F was used: **192l** (279 mg, 0.99 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192l**) = 275 mg, 82%. IR 3387, 2925, 2851, 1604, 1518, 1493, 1456, 1344, 1261, 1159; ^1H NMR (δ; 300 MHz, $CDCl_3$); 0.89 (3H, t, *J* = 7.2, Me), 1.50-1.63 (2H, m,CH_2CH_3), 2.00 (1H, dt, *J* = 10.8 & 8.4, PhCHCH*H*), 2.57-2.72 (4H, m, $NHCH_2CH_2$, PhCHC*H*H, NCHCH*H*NH), 2.79 (1H, dd, *J* = 12.4 & 3.9, NCHC*H*HNH), 3.45-3.54 (1H, m, $NCHCH_2NH$), 3.80 (2H, ABq, J_{AB} = 13.2, NCH_2Ar), 4.03 (1H, $_{apt.}$t, *J* = 8.1, $PhCHCH_2$), 7.26-7.37 (5H, m, Ph*H*), 7.44 (2H, d, *J* = 8.4, Ar*H*), 8.09 (2H, d, *J* = 8.4, Ar*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 11.32 (CH_3), 20.57 (CH_2), 32.43 (CH_2), 50.37 (CH_2), 52.09 (CH_2), 60.30 (CH), 60.56 (CH_2), 66.28 (CH), 123.40 (CH), 126.81 (CH), 127.68 (CH), 128.35 (CH), 129.77 (CH), 141.93 (C), 145.86 (C), 147.18 (C). High-resolution MS calcd for formula $C_{20}H_{25}NO_2$: 340.2025; found: 340.2023.

4.1.96 (199mb) *N*-(((*cis*)-1-(4-methoxybenzyl)-4-(2-nitrophenyl)azetidin-2-yl)methyl)propan-1-amine



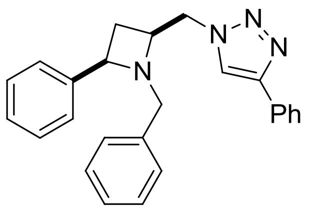
General procedure F was used: **192m** (200 mg, 0.64 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192m**) = 163 mg, 69%. IR 2959, 2932, 2874, 1611, 1584, 1523, 1513, 1463, 1346, 1248, 1176, 1109; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 0.77 (3H, t, *J*= 7.5, Me), 1.22-1.32 (2H, m, C*H₂*CH₃), 1.73 (1H, dt, *J* = 10.5 & 8.4, ArCHCH*H*), 2.22-2.37 (3H, m, NHC*H₂*CH₂, NCHCH*H*NH), 2.46 (1H, dd, *J* = 12.2 & 4.8, NCHC*H*HNH), 2.73 (1H, dt, *J* = 10.5 & 8.4, ArCHC*H*H), 3.29-3.36 (1H, m, NC*H*CH₂NH), 3.53 (2H, ABq, J_{AB} = 12.6, NC*H₂*Ar), 3.72 (3H, s, OC*H₃*), 4.47 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.4, ArC*H*CH₂), 6.76 (2H, d, *J* = 8.7, Ar*H*), 7.18 (2H, d, *J* = 8.7, Ar*H*), 7.30 (1H, t, *J* = 7.2, Ar*H*), 7.57 (1H, t, *J* = 7.2, Ar*H*), 7.90 (1H, d, *J* = 7.2, Ar*H*), 8.10 (1H, d, *J* = 7.2, Ar*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$) 11.71 (CH_3), 22.94 (CH_2), 31.18 (CH_2), 51.98 (CH_2), 54.63 (CH_2), 55.26 (CH_3), 61.14 (CH_2), 61.50 (CH), 62.32 (CH), 113.71 (CH), 124.33 (CH), 127.40 (CH), 128.91 (CH), 130.24 (CH), 130.52 (C), 133.56 (CH), 139.55 (C), 147.31 (C), 158.92 (C). High-resolution MS calcd for formula $C_{21}H_{27}N_3O_3Na$: 392.1950; found: 392.1951.

4.1.97 (199nb) *N*-((4-phenyl-1-((*S*)-1-phenylethyl)azetidin-2-yl)methyl)propan-1-amine



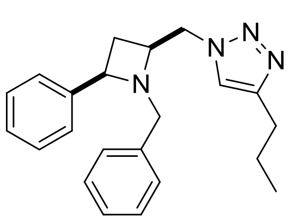
General procedure F was used, yellow oil, $[\alpha]_D^{20}$ = -19.0, (c 0.5 , CH_2Cl_2). IR 2969, 2872, 1656, 1491, 1454, 1372, 1283, 1156; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 0.86 (3H, t, *J* = 7.4, Me), 1.00 (3H, d, *J* = 6.6, PhCHMe), 1.28-1.40 (2H, m, NHC*H₂*CH₃), 1.84 (1H, $_{\text{apt.}}$q, $_{\text{obs.}}J$ = 10.2, PhCHC*H*H), 1.94 (1H, dd, *J* = 12.0 & 5.0, NCHC*H*HNH), 2.12-2.30 (3H, NCHCH*H*NH & NHC*H₂*CH₂), 2.42 (1H, dt, *J* = 10.2 & 8.7, PhCHCH*H*), 3.14-3.23 (1H, m, NC*H*CH₂NH), 3.51 (1H, q, *J* = 6.6, NC*H*CH₃), 4.03 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.2, PhC*H*CH₂), 7.27-7.42 (8H, m, Ar*H*), 7.58-7.61 (1H, m, Ar*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$) 11.79 (CH_3), 21.66 (CH_3), 23.02 (CH_2), 31.14 (CH_2), 52.06 (CH_2), 54.06 (CH_2), 61.91 (CH), 65.03 (CH), 68.60 (CH), 126.75 (CH), 126.84 (CH), 127.34 (CH), 127.60 (CH), 128.17 (CH), 128.28 (CH), 144.92 (C), 145.83 (C). High-resolution MS calcd for formula $C_{21}H_{29}N_2$: 309.2330; found: 309.2339.

4.1.98 (202aa) 1-(((*cis*)-1-benzyl-4-phenylazetidin-2-yl)methyl)-4-phenyl-1H-1,2,3-triazole



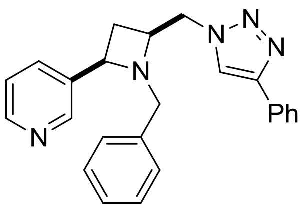
General procedure G was used: post-work up iodo-azetidine **194a** (1.00 g, 2.70 mmol), sodium azide (357 mg, 5.50 mmol), DMF (20 mL), ethynylbenzene (276 mg, 2.70 mmol), copper (I) iodide (1.05 g, 5.50 mmol), flash chromatography (Hexane/EtOAc = 6/4 Rf 0.4), yellow oil, yield (from **192a**) = 680 mg, 53%. IR 3675, 2971, 2901, 2163, 1493, 1453, 1406, 1393, 1066, 1056; ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.72 (1H, dt, J = 10.8 & 8.4, PhCHCH*H*), 2.48 (1H, dt, J = 10.8 & 8.4 , PhCHC*H*H), 3.62-3.70 (1H, m, NC*H*CH$_2$N), 3.71 (2H, ABq, J_{AB} = 12.3, NC*H*$_2$Ph), 3.94 (1H, dd, J = 14.2 & 3.6, NCHCH*H*N), 4.06 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.1, Ph*CH*CH$_2$), 4.29 (1H, dd, J = 14.2 & 3.6, NCHC*H*HN), 7.21-7.40 (11H, m, Ph*H*), 7.48 (2H, t, J = 7.8, Ph*H*), 7.65 (1H, s, C*H*N$_3$), 7.83-7.86 (2H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 30.18 (CH$_2$), 53.53 (CH$_2$), 61.21 2X(CH), 64.97 (CH$_2$), 121.41 (CH), 125.71 (CH), 126.73 (CH), 127.43 (CH), 127.67 (CH), 127.97 (CH), 128.29 (CH), 128.57 (CH), 128.81 (CH), 129.54 (CH), 130.90 (C), 137.87 (C), 142.27 (C), 147.26 (C). High-resolution MS calcd for formula $C_{25}H_{25}N_4$: 381.2079; found 381.2078.

4.1.99 (202ab) 1-(((*cis*)-1-benzyl-4-phenylazetidin-2-yl)methyl)-4-propyl-1H-1,2,3-triazole



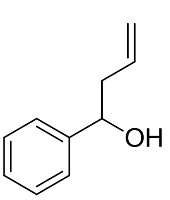
General procedure G was used: post-work up iodo-azetidine **194a** (895 mg, 2.50 mmol), sodium azide (320 mg, 5.00 mmol), DMF (20 mL), 1-pentyne (170 mg, 2.50 mmol), copper (I) iodide (952 mg, 5.00 mmol), flash chromatography (Hexane/EtOAc = 6/4 Rf 0.4), yellow oil, yield (from **192a**) = 516 mg, 59%. IR 3062, 3029, 2958, 2927, 2870, 1673, 1603, 1551, 1494, 1383, 1358, 1287, 1214, 1157; ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.01 (3H, t, J = 7.2, Me), 1.62-1.77 (3H, m, PhCHCH*H* & C*H*$_2$CH$_3$), 2.42 (1H, dt, J = 10.8 & 7.2, PhCHC*H*H), 2.68-2.74 (2H, m, N=NCC*H*$_2$), 3.58 (1H, m, NC*H*CH$_2$N), 3.66 (2H, ABq, J_{AB} = 12.6, NC*H*$_2$Ph), 3.85 (1H, dd, J = 14.2 & 3.6, NCHCH*H*N), 4.01 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.1, Ph*CH*CH$_2$), 4.20 (1H, dd, J = 14.25 & 3.6, NCHC*H*HN), 7.19 (1H, s, C*H*N$_3$) 7.22-7.34 (10H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 13.85 (CH$_3$), 22.83 (CH$_2$), 27.70 (CH$_2$), 30.28 (CH$_2$), 53.31 (CH$_2$), 61.13 2x(CH), 64.89 (CH$_2$), 122.32 (CH), 126.72 (CH), 127.37 (CH), 127.55 (CH), 128.19 (CH), 128.46 (CH), 128.88 (C), 129.53 (CH), 137.79 (C), 142.38 (C). High-resolution MS calcd for formula $C_{22}H_{26}N_4Na$: 369.2055; found 369.2039.

4.1.100 (202da) 3-(*cis*-1-Benzyl-4-((4-phenyl-1H-1,2,3-triazol-1-yl)methyl)azetidin-2-yl)pyridine.



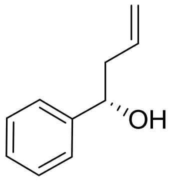
General procedure G was used: post-work up iodo-azetidine **194d** (500 mg, 1.37 mmol) and sodium azide (178 mg, 2.74 mmol) DMF (20 mL), ethynylbenzene (140 mg, 1.37 mmol), copper (I) iodide (521 mg, 2.74 mmol), flash chromatography ($CHCl_3$/MeOH = 95/5 Rf 0.4), yellow oil, yield (from **192d**) = 303 mg, 46%. IR 3029, 2915, 2850, 1578, 1454, 1427, 1383, 1311, 1222, 1178; ^{1}H NMR (δ; 500 MHz, $CDCl_3$); 1.82 (1H, $_{\text{apt.}}$q, $_{\text{obs.}}J$ = 10.0, PyCHCH*H*), 2.56 (1H, $_{\text{apt.}}$q, $_{\text{obs.}}J$ = 10.0, PyCHC*H*H), 3.68 (2H, ABq, J_{AB} = 10.0, NCH_2Ph), 3.74 (1H, m, NC*H*CH_2N), 4.08 (1H, dd, *J* = 12.5 & 5.0, NCHCH*H*N), 4.15 (1H, m, PyC*H*CH_2), 4.36 (1H, d, *J* = 15.0, NCHC*H*HN), 7.10 (1H, m, Py*H*), 7.27 (1H, t, *J* = 10.0, Ph*H*), 7.29 (2H, d, *J* = 5.0, Ph*H*), 7.31 (2H, t, *J* = 10.0, Ph*H*), 7.37 (1H, t, *J* = 10.0, Ph*H*), 7.47 (2H, t, *J* = 10.0, Ph*H*), 7.59 (1H, d, *J* = 5.0, Ph*H*), 7.62 (1H, s, C*H*N_3), 7.81 (2H, d, *J* = 10.0, Py*H*), 8.35 (2H, br, Py*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 28.97 (CH_2), 52.54 (CH_2), 60.75 (CH), 60.75 (CH_2), 61.75 (CH), 121.84 (CH), 123.64 (CH), 125.20 (CH), 125.22 (CH), 127.77 (CH), 128.03 (CH), 128.58 (CH), 128.83 (CH), 129.39 (CH), 130.06 (C), 137.00 (C), 137.20 (C), 146.70 (C), 147.80 (CH), 148.40 (CH). High-resolution MS calcd for formula $C_{24}H_{23}N_5Na$: 404.1851; found 404.1839.

4.1.101 (204) 1-phenylbut-3-en-1-ol



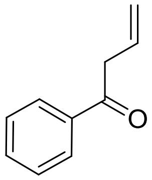
Magnesium (37.69 mmol, 916 mg) and allylbromide (28.27 mmol, 3.42 g) were added to dry THF (50 mL) at 0 °C and stirred for 15 minutes after which benzaldehyde (18.85 mmol, 2.00 g) was added. The mixture was left stirring at 0 °C for 15 minutes before stirring the reaction for 16 hours at rt. A saturated solution of sodium bicarbonate and ethyl acetate were added. The product was extracted from the aqueous layer with ethyl acetate three times. Ethyl acetate was removed *in vacuo* to afford the homoallylic alcohol **204** with no need of further purification. Yellow oil, 2.78 g, >99%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 2.32-2.37 (2H, m, OHCHCH_2), 2.58 (1H, br, O*H*), 4.52 (1H $_{\text{apt.}}$t, *J* = 6.5, OHC*H*), 4.96-5.03 (2H, m, CH=CH_2), 5.57-5.71 (1H, m, C*H*=CH_2), 7.09-7.24 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 43.77 (CH_2), 73.44 (CH), 118.15 (CH_2), 125.96 (CH), 127.53 (CH), 128.42 (CH), 134.62 (CH), 144.06 (C). High-resolution MS calcd for $C_{10}H_{12}O$: 148.0888; found: 148.0900.

4.1.102 (204) (*S*)-1-phenylbut-3-en-1-ol



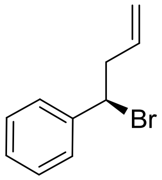
Indium (III) chloride (1.90 mmol, 420 mg) and (*S*)-Binol (2.07 mmol, 592 mg) were stirred for two hours at rt under nitrogen atmosphere in dry dichloromethane in presence of 4Å molecular sieve (50 mg). Allyltributylstannane (19.00 mmol, 6.24 g) was added and the mixture was stirred for ten minutes after which it was cooled to -78 °C for 15 minutes followed by slow addition of benzaldehyde (9.40 mmol, 1.00 g). The reaction mixture was left stirring at -78 °C for four hours and then for 48 hours at rt. A saturated solution of sodium bicarbonate was added and the product was extracted with dichloromethane three times. The solvent was removed *in vacuo* and the homoallylic alcohol (*S*)-**204** was purified by flash chromatography using hexane:ethyl acetate (8:2) as solvent. Colourless oil, 1.10 g, 79%. $[\alpha]_D^{20}$ = -40.7 (c 32.7, $CHCl_3$). ^{1}H NMR and ^{13}C{^{1}H} NMR and High-resolution MS same as **204**.

4.1.103 (205) 1-phenylbut-3-en-1-one



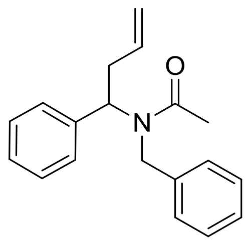
Celite (1.00 g) was added to a suspension of PCC (3.71 g, 17.00 mmol) in CH_2Cl_2 (15mL). The resultant slurry was stirred vigorously for 5 min before being cooled to 0 °C. A solution of homoallylic alcohol **204** (1.70 g, 11.50 mmol) in CH_2Cl_2 (5 mL) was then added in one portion. The resulting solution was allowed to warm to rt and stirred for further four hours. Sodium thiosulfate, sodium bicarbonate and diethyl ether were added and the mixture was stirred vigorously for 15 min before being filtered though a silica plug, washed with diethyl ether and dried over anhydrous magnesium suflate. The solvent was removed *in vacuo* to yield the crude product as a yellow oil, which was purified by flash column chromatography (Hexane:EtOAc, 98:2 Rf 0.3) to afford the ketone **205** (1.5 g, 89%). ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 3.69 (1H, t, *J* = 1.4, C=OC*H*H), 3.71 (1H, t, *J* = 1.4, C=OCH*H*), 5.11-5.19 (2H, m, CH=C*H₂*), 5.95-6.09 (1H, m, C*H*=CH_2), 7.37-7.50 (3H, m, Ph*H*), 7.88-7.92 (2H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 43.69 (CH_2), 118.73 (CH_2), 128.29 (CH), 128.63 (CH), 131.07 (CH), 133.17 (CH), 136.59 (C), 198.02 (C). High-resolution MS calcd for $C_{10}H_{10}O$: 146.0732; found: 146.0737.

4.1.104 (206) (*R*)-(1-bromobut-3-en-1-yl)benzene



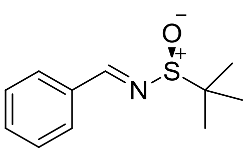
PBr_3 (1.35 mL, 1.35 mmol) was added to a stirred solution of compound (*S*)-**204** (400 mg, 1.70 mmol) in diethyl ether (20 mL) cooled to 0 °C. The resulting solution was stirred for a further 60 min before being quenched with a saturated aqueous solution containing sodium bicarbonate (20 mL) and diluted with diethyl ether (10 mL). The organic layer was separated and the aqueous layer extracted with diethyl ether (3 x 10 mL). The combained organic layers were washed with brine and dried over anhydrous magnesium sulfate before the solvent was removed *in vacuo* to give compound (*R*)-**206** as a colourless oil (378 mg, 66%). $[\alpha]_D^{20} = +33.7$ (c 32.2, $CHCl_3$). ^1H NMR (δ; 300 MHz, $CDCl_3$); 2.74-2.94 (2H m, BrCHC*H₂*), 4.84 (1H, $_{apt.}$t, $_{obs.}J = 7.5$, BrC*H*), 4.95-5.03 (2H, m, CH=C*H₂*), 5.54-5.68 (1H, m, C*H*=CH₂), 7.11-7.29 (m, 5H, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 400 MHz, $CDCl_3$), 42.95 (CH_2), 52.98 (CH), 117.03 (CH_2), 126.27 (CH), 127.29 (CH), 127.56 (CH), 133.63 (CH), 140.5 (C). M/z: (ES^+) 211.0 $[M + H]^+$.

4.1.105 (209) *N*-benzyl-*N*-(1-phenylbut-3-en-1-yl)acetamide



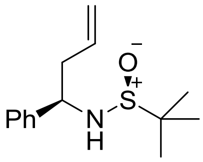
N-benzyl-1-phenylbut-3-en-1-amine **192a** (2.11 mmol, 500 mg), acetic anhydride (4.22 mmol, 430 mg), DMAP (0.21 mmol, 26 mg) and triethylamine (4.22 mmol, 427 mg) were stirred for 16 hours at rt in DCM. When the starting material was consumed (monitored by TLC) the reaction was quenched with methanol and the solvents removed *in vacuo*. Ethyl acetate and water were added to the residue and the water layer extracted with ethyl acetate three times. Ethyl acetate was removed *in vacuo* and the crude product purified by flash chromatography (CH_2Cl_2 Rf 0.4). Yellow oil, 424 mg, 72%. ^1H NMR (δ; 300 MHz, $CDCl_3$); 1.87 (3H, s, C*H₃*), 2.68 (2H, t, $J = 13.1$ & 6.2, NCHC*H₂*), 4.19 (2H, ABq, $J_{AB} = 17.7$, NC*H₂*Ph), 4.87-4.99 (2H, m, CH=C*H₂*), 5.37-5.70 (1H, m, C*H*=CH₂), 6.00 (1H, $_{apt.}$t, $_{obs.}J = 7.9$, NC*H*), 6.82 (2H, d, $J= 6.6$, Ph*H*), 6.97-7.24 (8H, m, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 22.74 (CH_3), 35.27 (CH_2), 48.08 (CH_2), 56.16 (CH), 117.38 (CH_2), 126.18 (CH), 127.07 (CH), 127.74 (CH), 128.10 (CH), 128.49 (CH), 128.65 (CH), 135.00 (CH), 137.86 (C), 139.25 (C), 171.95 (C). High-resolution MS calcd for $C_{19}H_{21}NONa$: 302.1521; found: 302.1512.

4.1.106 (211) (*S*,*E*)-*N*-benzylidene-2-methylpropane-2-sulfinamide



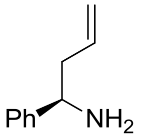
(*R*)-2-methylpropane-2-sulfinamide (16.50 mmol, 2.00 g) was stirred for 24 hours in dichloromethane with PPTS (0.82 mmol, 207 mg), anhydrous magnesium sulphate (82.50 mmol, 9.93 g) and benzaldehyde (49.50 mmol, 5.25 g) after which the suspension was filtered and the solvent was removed *in vacuo*. The crude obtained was purified by flash chromatography using hexane:ethyl acetate (10:1) as solvent. Yellow oil, 3.11 g, 90%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.29 (9H, s, *tert*-butyl), 7.45-7.58 (3H, m, Ph*H*), 7.87 (2H, dd, *J* = 7.8 & 1.8, Ph*H*), 8.61 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 22.61 (CH_3)x3, 57.77 (C), 128.94 (CH), 129.39 (CH), 132.41 (CH), 134.14 (C), 162.79 (CH). M/z: (ES$^+$) 210.1 [M + H]$^+$.

4.1.107 (212) (*S*)-2-methyl-*N*-((*R*)-1-phenylbut-3-en-1-yl)propane-2-sulfinamide



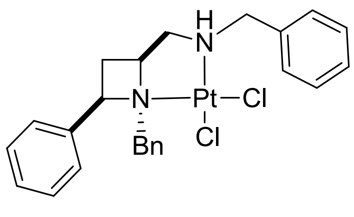
Procedure a: (*S*)-*N*-*tert*-butylsulfinyl aldimines (*S*)-**211** (13.10 mmol, 2.75 g) was added to allylbromide (17.10 mmol, 2.07 g) and indium (powder, -100 mesh) (17.10 mmol, 1.96 g) in dry THF at rt. The mixture was heated to 60 °C and left stirring for 16 hours after which it was quenched with brine and the product was extracted with ethyl acetate three times. The solvent was removed *in vacuo* to afford (*S*,*R*)-**212** in 90% yield (2.94 g). Procedure b: allyl bromide (18.2 mmol, 2.20 g) was added to a suspension of activated zinc powder (27.3 mmol, 1.78 g), indium triflate (18.2 mmol, 10.20 g) and (*S*)-*N*-*tert*-butylsulfinyl aldimines (*S*)-**211** (9.10 mmol, 1.90 g) in dry THF under nitrogen atmosphere. The mixture was stirred at rt for 24 hours after which it was quenched with brine and the product was extracted with ethyl acetate three times. The solvent was removed *in vacuo* to afford (*S*,*R*)-**212** in 99% yield (2.30 g). $[\alpha]_D^{25}$ = +121.6 (c 9.7, $CHCl_3$). ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.19 (9H, s, *tert*-butyl), 2.44-2.62 (2H, m, PhCHC*H*$_2$), 4.49 (1H, br, N*H*) 4.68 (1H, $_{apt.}$t, $_{obs.}J$ = 6.0, PhC*H*NH), 5.01-5.11 (2H, m, CH=C*H*$_2$), 5.57-5.70 (1H, m, C*H*=CH_2), 7.19-7.32 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 22.94 (CH_3)x3, 42.75 (CH_2), 57.59 (C), 58.00 (CH), 119.40 (CH_2), 127.85 (CH), 128.14 (CH), 128.44 (CH), 133.75 (CH), 140.48 (C). M/z: (ES$^+$) 252.1 [M + H]$^+$.

4.1.108 (210) (*R*)-1-phenylbut-3-en-1-amine



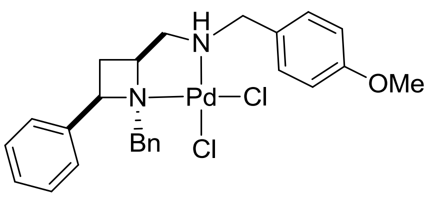
A solution of HCl 3N in methanol (20 mL) was added to compound (*S*)-**211** (7.90 mmol, 2.00 g) and the mixture was left stirring was 16 hours at rt. Methanol was removed *in vacuo*, diethyl ether was added and the HCl salt of (*R*)-**210** was extracted with water three times. The aqueous layer was basified with a solution of NaOH 2M till pH 14 and compound (*R*)-**210** was extracted with dichloromethane three times. The product (*R*)-**210** was obtained as a yellow oil in 75% yield (878 mg). $[\alpha]_D^{20}$ = +58.5 (c 8.2, $CHCl_3$). ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.60 (1H, br, N*H*), 2.30-2.51 (2H, m, PhCHCH_2), 3.98 (1H, dd, *J* = 8.0 & 5.4, PhC*H*CH$_2$), 5.06-5.15 (2H, m, CH=CH_2), 5.68-5.81 (1H, m, C*H*=CH$_2$), 7.21-7.36 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 44.20 (CH_2), 55.40 (CH), 117.59 (CH_2), 126.32 (CH), 126.96 (CH), 128.40 (CH), 135.45 (CH), 145.85 (C). M/z: (ES^+) 148.1 $[M + H]^+$.

4.1.109 Pt(II)-amino-azetidine metal complex 213aaa



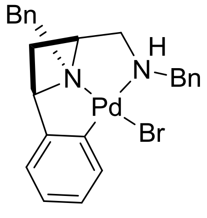
Under nitrogen atmosphere, K_2PtCl_4 (0.26 mmol, 110 mg) was added to a solution of methanol and compound **199ah** (0.29 mol, 100 mg). The mixture was left stirring for 16 hours at 60 °C after which the solvent was removed *in vacuo* and the product purified by crystallisation (CH_3CN:Et_2O). Yellow crystals, 115 mg, 65%. ^{1}H NMR (δ; 400 MHz, $CDCl_3$), 1.16-1.27 (1H), 1.95-2.16 (3H, m), 3.04 (2H, s), 3.48 (1H, dd, *J* = 11.9 & 9.0), 3.75 (1H, t, *J* = 11.6), 3.91-3.99 (2H, m), 4.84 (2H, ABq, J_{AB} = 15.0), 4.84 (2H, s), 7.12-7.41 (15H, m). ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 29.69 (CH_2), 49.95 (CH_2), 52.45 (CH_2), 54.0 (CH_2), 56.49 (CH), 58.07 (CH), 126.18 (CH), 127.63 (CH) 128.24 (CH), 128.45 (CH), 128.77 (CH), 128.84 (CH), 128.87 (CH), 128.94 (CH), 129.24 (CH), 132.58 (C), 132.75 (C), 139.79 (C). M/z: (ES^+) 572.4 $[M-Cl]^+$, 536.1 $[M-2Cl]^+$.

4.1.110 Pd(II)-amino-azetidine metal complex 213aha



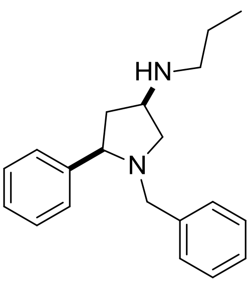
Under nitrogen atmosphere, Na_2PdCl_4 (0.15 mmol, 43 mg) was added to a solution of methanol and compound **199ah** (0.16 mmol, 60 mg). The mixture was left stirring for 16 hours at rt after which the solvent was removed *in vacuo* and the product purified by crystallisation (CH_3CN:Et_2O). Yellow crystals, 50 mg, 57%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.21-1.31 (1H, m), 1.75 (1H, dd, *J* = 13.9 & 5.3), 2.02-2.10 (1H, m), 3.11 (1H, dd, *J* = 13.6 & 9.6), 3.23 (1H, d, *J* = 11.0), 3.37 (1H, d, *J* = 11.7), 3.45-3.53 (1H, m), 3.70 (3H, s), 4.19 (1H, dd, *J* = 10.9 & 7.2), 5.00 (2H, ABq, J_{AB} = 11.7), 5.29 (1H, br), 6.67 (2H, d, *J* = 8.6), 6.91-6.93 (3H, m), 7.05 (2H, d, *J* = 8.6), 7.50-7.53 (3H, m), 7.74-7.77 (2H, m), 8.28-8.31 (2H, m); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 24.42 (CH_2), 55.09 (CH_2), 55.28 (CH_3), 57.80 (CH_2), 66.38 (CH_2), 67.26 (CH), 75.83 (CH), 114.19 (CH), 115.40 (C), 126.23 (C), 128.37 (CH), 128.78 (CH), 129.12 (CH), 129.33 (CH), 130.28 (CH), 131.61 (CH), 132.04 (CH), 133.48 (C), 134.65 (C). M/z: (ES^+) 515.4 $[M-Cl]^+$, 477.4 $[M-2Cl]^+$.

4.1.111 C,N,N Pd(II)-amino-azetidine metal complex 213gaa



Under nitrogen atmosphere, $Pd_2(dba)_2$ (0.24 mmol, 136 mg) was added to amino-azetidine **199ga** (0.12 mmol, 50 mg), the mixture was left stirring for 16 hours in toluene at 100 °C. The solvent was removed *in vacuo* and the product purified by crystallisation ($CH_3CN:Et_2O$). Yellow crystals, 46 mg, 73%. $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 45.20 (CH_2), 62.57 (CH_2), 65.82 (CH), 67.55 (CH_2), 72.50 (CH), 117.27 (CH_2), 122.28 (CH), 123.21 (CH), 125.25 (CH), 125.65 (CH), 127.64 (CH), 128.35 (CH), 128.45 (CH), 128.89 (CH), 128.99 (CH), 129.04 (CH), 130.22 (C), 130.43 (CH), 131.12 (CH), 131.77 (C), 134.20 (C), 135.02 (C), 137.68 (CH), 142.63 (CH). High-resolution MS calcd for formula $C_{24}H_{25}N_2Pd$: 447.1053; found: 447.1060.

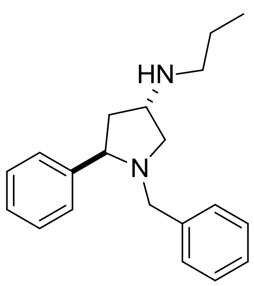
4.1.112 (200ab) (*cis*)-1-benzyl-5-phenyl-*N*-propylpyrrolidin-3-amine



General procedure H was used: homoallylic amine **192a** (100 mg, 0.42 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192a**) = 96 mg, 78%. IR 3662, 2923, 2852, 1641, 1494, 1451, 1379, 1256, 1066; ^1H NMR (δ; 300 MHz, $CDCl_3$); 0.90 (3H, t, *J* = 7.5, Me), 1.47-1.59 (2H, m, $CH_2CH_2CH_3$), 1.61-1.71 (1H, m, PhCHC*H*H), 2.39 (1H, dd, *J* = 10.1 & 7.3, NC*H*HCHNH), 2.48-2.60 (3H, m, *J* = 7.5, PhCHCH*H* & NHC*H*$_2$), 3.06 (1H, dd, $_{obs.}J$ = 10.1 & 1.8, NCH*H*CHNH), 3.28-3.35 (1H, m, NCH_2CHNH), 3.41 (1H, dd, *J* = 9.6 & 7.0, PhC*H*CH_2), 3.45 (2H, ABq, J_{AB} = 13.2, NCH_2Ph), 7.23-7.39 (8H, m, Ph*H*), 7.45-7.52 (2H, m, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 125 MHz, $CDCl_3$), 11.77 (CH_3), 22.74 (CH_2), 43.12 (CH_2), 49.33 (CH_2), 55.61 (CH), 57.53 (CH_2), 58.46 (CH_2), 68.80 (CH), 126.75 (CH), 127.25 (CH), 127.49

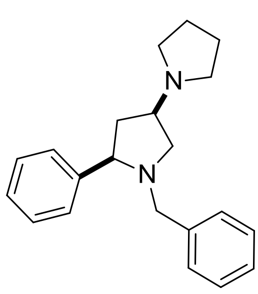
(CH), 128.13 (CH), 128.53 (CH), 129.19 (CH), 139.14 (C), 142.62 (C). High-resolution MS calcd for formula $C_{20}H_{27}N_2$: 295.2174; found: 295.2171.

4.1.113 (200ab) (*trans*)-1-benzyl-5-phenyl-*N*-propylpyrrolidin-3-amine



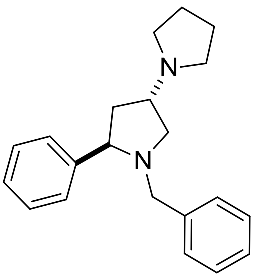
General procedure J was used: homoallylic amine **192a** (50 mg, 0.21 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192a**) = 46 mg, 74%. IR 3675, 3391, 2966, 2930, 2796, 1602, 1493, 1453, 1376, 1288, 1241, 1075, 1066; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 0.92 (3H, t, *J* = 7.5, Me), 1.56-1.68 (2H, m, $CH_2CH_2CH_3$), 2.03-2.23 (3H, m, PhCHC*H*H, PhCHCH*H*, NC*H*HCHNH), 2.50 (2H, t, *J* = 7.5, NHC*H*$_2$), 3.39-3.53 (2H, m, NCH*H*CHNH & NCH_2C*H*NH), 3.45 (2H, ABq, J_{AB} = 12.9, NC*H*$_2$Ph), 3.72 (1H, $_{apt.}$t, $_{obs.}J$ = 8.1, PhC*H*CH_2), 7.23-7.30 (6H, m, Ph*H*), 7.33-7.39 (2H, m, Ph*H*), 7.45-7.48 (2H, m, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 125 MHz, $CDCl_3$), 11.69 (CH_3), 22.53 (CH_2), 41.95 (CH_2), 49.85 (CH_2), 55.53 (CH), 57.66 (CH_2), 59.50 (CH_2), 67.82 (CH), 126.83 (CH), 127.24 (CH), 127.56 (CH), 128.16 (CH), 128.52 (CH), 128.59 (CH), 139.21 (C), 142.88 (C). High-resolution MS calcd for formula $C_{20}H_{27}N_2$: 295.2174; found: 295.2155.

4.1.114 (200aj) (*cis*)-1'-benzyl-5'-phenyl-1,3'-bipyrrolidine



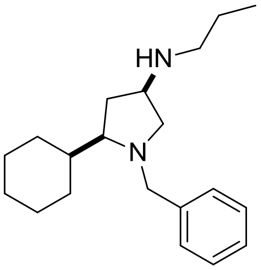
General procedure H was used: homoallylic amine **192a** (100 mg, 0.42 mmol), flash chromatography ($CHCl_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192a**) = 104 mg, 81%. IR 3414, 3061, 3028, 2962, 2790, 1602, 1493, 1453, 1331, 1289, 1208, 1154; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.86-1.96 (5H, m, NCH_2C*H*$_2$ & PhCHCH*H*), 2.42-2.51 (1H, m, NC*H*HCHN & PhCHC*H*H), 2.77 (4H, br, NC*H*$_2$$CH_2$), 3.22 (1H, dd, *J* = 10.95 & 3.0, NCH*H*CHN), 3.24 (1H, br, NCH_2C*H*N), 3.46 (2H, ABq, J_{AB} = 13.5, NC*H*$_2$Ph), 3.52 (1H, dd, *J* = 10.6 & 5.8, PhC*H*CH_2), 7.21-7.40 (8H, Ph*H*), 7.51-7.54 (2H, m, Ph*H*); $^{13}C\{^1H\}$ NMR (δ; 125 MHz, $CDCl_3$), 23.75 (CH_2), 40.77 (CH_2), 51.55 (CH_2), 56.40 (CH), 57.80 (CH_2), 60.93 (CH), 69.05 (CH_2), 126.93 (CH), 127.40 (CH), 127.59 (CH), 128.26 (CH), 128.37 (CH), 128.66 (CH), 138.89 (C), 141.85 (C). High-resolution MS calcd for formula $C_{21}H_{27}N_2$: 307.2174; found: 307.2171.

4.1.115 (200aj) (*trans*)-1'-benzyl-5'-phenyl-1,3'-bipyrrolidine



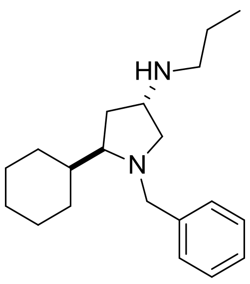
General procedure J was used: homoallylic amine **192a** (400 mg, 1.68 mmol), flash chromatography (CHCl$_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192a**) = 403 mg, 78%. IR 3402, 3028, 2875, 2793, 1453, 1374, 1154; ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.87 (4H, br, NCH$_2$C*H*$_2$), 2.00 (1H, dt, *J* = 13.3 & 9.0 PhCHC*H*H), 2.35-2.45 (2H, m, PhCHCH*H* & NC*H*HCHN), 2.66-2.68 (4H, m, NC*H*$_2$CH$_2$), 3.00-3.09 (1H, m, NCH$_2$C*H*N), 3.16 (1H, dd, *J* = 8.7 & 6.6, NCH*H*CHN), 3.47 (2H, ABq, J_{AB} = 12.9, NC*H*$_2$Ph), 3.76 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.4, PhC*H*CH$_2$), 7.24-7.39 (8H, Ph*H*), 7.47-7.49 (2H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 23.26 (CH$_2$), 40.53 (CH$_2$), 53.07 (CH$_2$), 57.60 (CH$_2$), 58.34 (CH$_2$), 62.71 (CH), 68.07 (CH$_2$), 126.86 (CH), 127.23 (CH), 127.52 (CH), 128.18 (CH), 128.53 (CH), 128.63 (CH), 139.20 (C), 143.18 (C). High-resolution MS calcd for formula $C_{21}H_{27}N_2$: 307.2174; found: 307.2159.

4.1.116 (200ka) (*cis*)-1-benzyl-5-cyclohexyl-*N*-propylpyrrolidin-3-amine



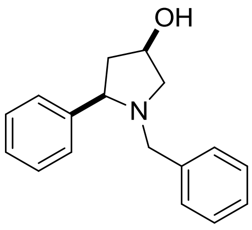
General procedure H was used: homoallylic amine **192k** (17 mg, 0.07 mmol), flash chromatography (CHCl$_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192k**) = 17 mg, 82%. IR 3408, 2925, 2853, 1643, 1495, 1450, 1373, 1241; ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 0.94 (3H, t, *J* = 7.5, Me), 1.05-1.26 (5H, m, NCHCHC*H*H, NCHCHCH$_2$C*H*H, NCHCHCH$_2$CH$_2$C*H*H), 1.72-1.90 (8H, m, NCHC*H*, NCHCHCH*H*, NCHCHCH$_2$CH*H*, NCHCHCH$_2$CH$_2$CH*H*, NHCH$_2$C*H*$_2$), 1.96-2.05 (1H, m, NCHC*H*HCH), 2.20-2.30 (1H, m, NCHCH*H*CH), 2.36-2.49 (2H, m, NC*H*CH$_2$CH, NC*H*HCHNH), 2.79-2.95 (2H, m, NHC*H*$_2$CH2), 3.10-3.14 (2H, m, NCH*H*CHNH), 3.59 (2H, ABq, J_{AB} = 13.2, NC*H*$_2$Ph), 3.71-3.78 (1H, m, NCH$_2$C*H*NH), 7.24-7.38 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 11.42 (CH$_3$), 20.20 (CH$_2$), 25.86 (CH$_2$), 26.12 (CH$_2$), 26.68 (CH$_2$), 26.71 (CH$_2$), 30.17 (CH$_2$), 30.80 (CH$_2$), 38.09 (CH), 46.84 (CH$_2$), 54.86 (CH), 55.62 (CH$_2$), 57.03 (CH$_2$), 67.45 (CH), 127.38 (CH), 128.51 (CH), 128.64 (CH), 137.95 (C). High-resolution MS calcd for formula $C_{20}H_{33}N_2$: 301.2643; found: 301.2643.

4.1.117 (200ka) (*trans*)-1-benzyl-5-cyclohexyl-*N*-propylpyrrolidin-3-amine



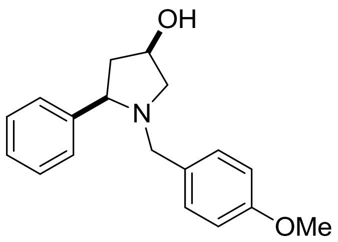
General procedure J was used: homoallylic amine **192k** (67 mg, 0.27 mmol), flash chromatography (CHCl$_3$/MeOH = 9/1 Rf 0.4), yellow oil, yield (from **192k**) = 65 mg, 79%. IR 3376, 3027, 2923, 2851, 2792, 2505, 2422, 1586, 1494, 1451, 1375, 1326, 1147; ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 0.93 (3H, t, *J*= 7.5, Me), 1.00-1.27 (5H, m, NCHCHC*H*H, NCHCHCH$_2$C*H*H, NCHCHCH$_2$CH$_2$C*H*H), 1.64-1.84 (8H, m, NCHC*H*, NCHCHCH*H*, NCHCHCH$_2$CH*H*, NCHCHCH$_2$CH$_2$CH*H*, NHCH$_2$C*H*$_2$), 1.97-2.19 (2H, m, NCHC*H*$_2$CH & NCHCH*H*CH), 2.32-2.41 (1H, m, NC*H*CH$_2$CH), 2.68-2.73 (2H, m, NHC*H*$_2$CH2), 2.76-2.83 (1H, m, NC*H*HCHNH), 3.17-3.25 (2H, m, NCH*H*CHNH), 3.35-3.41 (1H, m, NCH$_2$C*H*NH), 3.63 (2H, ABq, J_{AB} = 13.2, NC*H*$_2$Ph), 7.27-7.32 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 11.53 (CH$_3$), 21.25 (CH$_2$), 25.74 (CH$_2$), 26.28 (CH$_2$), 26.82 (CH$_2$), 26.92 (CH$_2$), 30.76 (CH$_2$), 39.11 (CH), 49.48 (CH$_2$), 55.44 (CH), 58.19 (CH$_2$), 66.98 (CH$_2$), 126.89 (CH), 128.27 (CH), 128.51 (CH), 139.53 (C). High-resolution MS calcd for formula $C_{20}H_{33}N_2$: 301.2643; found: 301.2630.

4.1.118 (214a) (*cis*)-1-benzyl-5-phenylpyrrolidin-3-ol



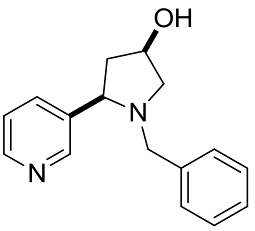
General procedure I was used: homoallylic amine **192a** (100 mg, 0.42 mmol), flash chromatography (Hexane/EtOAc = 2/1 Rf 0.3), yellow oil, yield (from **192a**) = 87 mg, 82%. IR 3370, 2970, 2906, 2794, 1493, 1453, 1408, 1376, 1250, 1229, 1144; ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.71-1.79 (1H, m, PhCHC*H*H), 2.09 (1H, br, OH), 2.33 (1H, dd, *J* = 10.3 & 4.8, NCH*H*CHOH), 2.61-2.70 (1H, m, PhCHCH*H*), 3.02-3.07 (1H, m, NC*H*HCHOH), 3.36 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}$*J* = 8.4, PhC*H*CH$_2$), 3.45 (2H, ABq, J_{AB} = 13.2, NC*H*$_2$Ph), 4.20-4.29 (1H, m, CH$_2$C*H*OH), 7.22-7.31 (6H, m, Ph*H*), 7.34-7.39 (2H, m, Ph*H*), 7.47 (2H, d, *J* = 6.9, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 45.97 (CH$_2$), 57.16 (CH$_2$), 62.13 (CH$_2$), 68.28 (CH), 70.12 (CH), 126.90 (CH), 127.29 (CH), 127.55 (CH), 128.20 (CH), 128.62 (CH), 128.67 (CH), 138.83 (C), 142.84 (C). High-resolution MS calcd for formula $C_{17}H_{19}NONa$: 276.1364; found: 276.1373.

4.1.119 (214b) (*cis*)-1-(4-methoxybenzyl)-5-phenylpyrrolidin-3-ol



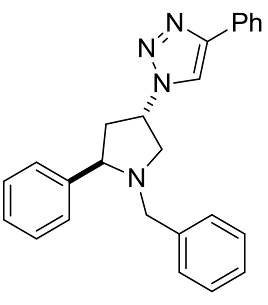
General procedure I was used: homoallylic amine **192b** (100 mg, 0.37 mmol), flash chromatography (Hexane/EtOAc = 2/1 Rf 0.3), yellow oil, yield (from **192b**) = 83 mg, 79%. IR 3346, 2925, 1682, 1611, 1512, 1454, 1302, 1248, 1178, 1106; ^{1}H NMR (δ; 500 MHz, CDCl$_3$); 1.72-1.77 (1H, m, PhCHC*H*H), 2.11 (1H, br, OH), 2.33 (1H, dd, *J* = 10.5 & 5.0, NCH*H*CHOH), 2.59-2.67 (1H, m, PhCHCH*H*), 2.99-3.03 (1H, m, NC*H*HCHOH), 3.34 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.5, PhC*H*CH$_2$), 3.40 (2H, ABq, J_{AB} = 13.0, NC*H*$_2$Ph), 3.78 (3H, s, OMe), 4.23-4.25 (1H, m, CH$_2$C*H*OH), 6.82 (2H, d, *J* = 8.5, Ar*H*), 7.15 (2H, d, *J* = 8.5, Ar*H*), 7.27 (1H, t, *J* = 7.5, Ph*H*), 7.36 (2H, t, *J* = 7.5, Ph*H*), 7.46 (2H, d, *J* = 7.5, Ph*H*); ^{13}C{^{1}H} NMR (δ; 125 MHz, CDCl$_3$), 45.90 (CH$_2$), 55.19 (CH$_3$), 56.29 (CH$_2$), 61.89 (CH$_2$), 68.17 (CH), 69.95 (CH), 113.53 (CH), 127.26 (CH), 127.60 (CH), 128.56 (CH), 129.92 (CH), 130.61 (C), 142.63 (C), 158.61 (C). High-resolution MS calcd for formula $C_{18}H_{21}NO_2Na$: 306.1470; found: 306.1464.

4.1.120 (214d) (*cis*)-1-benzyl-5-(pyridin-3-yl)pyrrolidin-3-ol



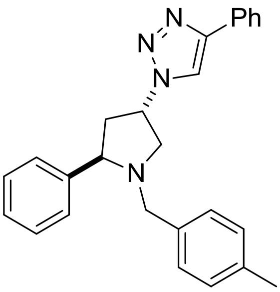
General procedure I was used: homoallylic amine **192d** (100 mg, 0.42 mmol), flash chromatography (EtOAc Rf 0.4), yellow oil, yield (from **192d**) = 77 mg, 72%. IR 3298, 3028, 2925, 2793, 1579, 1495, 1480, 1453, 1428, 1373, 1318, 1217, 1149; ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.68-1.75 (1H, m, PyCHC*H*H), 2.20 (1H, br, OH), 2.36 (1H, dd, *J* = 10.5 & 4.8, NCH*H*CHOH), 2.58-2.68 (1H, m, PyCHCH*H*), 3.01-3.10 (1H, m, NC*H*HCHOH), 3.42 (2H, ABq, J_{AB} = 13.2, NC*H*$_2$Ph), 3.39 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.4, PyC*H*CH$_2$), 3.42 (2H, ABq, J_{AB} = 13.2, NC*H*$_2$Ph), 4.23-4.28 (1H, m, CH$_2$C*H*OH), 7.13-7.27 (6H, m, Ar*H*), 7.84 (1H, d, *J* = 8.1, Py*H*), 8.46 (1H, d, *J* = 3.6, Py*H*), 8.57 (1H, s, Py*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 45.86 (CH$_2$), 57.20 (CH$_2$), 62.38 (CH$_2$), 66.08 (CH), 70.02 (CH), 124.02 (CH), 127.47 (CH), 128.34 (CH), 128.75 (CH), 135.36 (CH), 137.83 (C), 138.02(C), 148.92 (CH), 149.60 (CH). High-resolution MS calcd for formula $C_{16}H_{18}N_2ONa$: 277.1317; found: 277.1323.

4.1.121 (215aa) 1-((*trans*)-1-benzyl-5-phenylpyrrolidin-3-yl)-4-phenyl-1H-1,2,3-triazole



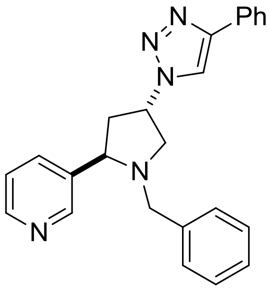
General procedure L was used: post-work up iodo-azetidine **194a** (71 mg, 0.19 mmol), DMSO (20 mL), sodium azide (25 mg, 0.38 mmol), ethynylbenzene (20 mg, 0.19 mmol), copper (I) iodide (36 mg, 0.19 mmol), flash chromatography (Hexane/EtOAc = 7/3 Rf 0.3), yellow oil, yield (from **192a**) = 52 mg, 65% . IR 3063, 3028, 2925, 2853, 1603, 1494, 1454, 1216, 1156; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 2.39 (1H, dt, *J* = 13.8 & 9.6, PhCHCH*H*), 2.61-2.69 (1H, m, PhCHC*H*H), 2.72 (1H, dd, *J* = 9.7 & 7.4, NC*H*HCHN$_3$), 3.49 (2H, ABq, J_{AB} = 12.9, NCH_2Ph), 3.61 (1H, dd, *J* = 9.7 & 7.4, NCH*H*CHN$_3$), 3.92 (1H, $_{apt.}$t, $_{obs.}$*J* = 7.8, PhC*H*CH$_2$), 5.09-5.19 (1H, m, CH$_2$C*H*N$_3$), 7.17-7.28 (7H, m, Ph*H*), 7.31-7.38 (4H, m, Ph*H*), 7.46 (2H, d, *J* = 7.2, Ph*H*), 7.67 (1H, s, C*H*N$_3$), 7.75 (1H, d, *J* = 6.9, Ph*H*). ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 42.38 (CH_2), 57.11 (CH_2), 57.88 (CH), 59.44 (CH_2), 67.90 (CH), 118.68 (CH), 125.70 (CH), 127.17 (CH), 127.61 (CH), 127.76 (CH), 128.17 (CH), 128.33 (CH), 128.69 (CH), 128.77 (CH), 128.83 (CH), 130.58 (C), 138.42 (C), 141.68 (C), 147.81 (C). High-resolution MS calcd for formula $C_{25}H_{24}N_4Na$: 403.1899; found: 403.1917.

4.1.122 (215ca) (1-((*trans*)-1-(4-methylbenzyl)-5-phenylpyrrolidin-3-yl)-4-phenyl-1H-1,2,3-triazole



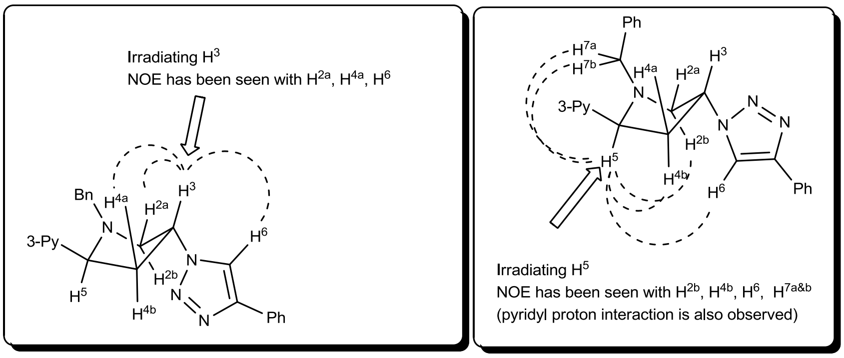
General procedure L was used: post-work up iodo-azetidine **194c** (70 mg, 0.18 mmol) DMSO (20 mL), sodium azide (24 mg, 0.37 mmol), ethynylbenzene (18 mg, 0.18 mmol), copper (I) iodide (68 mg, 0.37 mmol), (Hexane/EtOAc = 7/3 Rf 0.3), yellow oil, yield (from **192c**) = 48 mg, 61%. IR 3356, 3070, 3026, 1674, 1600, 1523, 1493, 1456, 1341, 1170; ^{1}H NMR (δ; 500 MHz, $CDCl_3$); 2.33 (3H, s, Me), 2.44 (1H, dt, *J* = 13.8 & 9.5, PhCHCH*H*), 2.69-2.74 (1H, m, PhCHC*H*H), 2.80 (1H, dd, *J* = 9.9 & 7.5, NC*H*HCHN$_3$), 3.53 (2H, ABq, J_{AB} = 13.0, NCH_2Ar), 3.69 (1H, dd, *J* = 9.9 & 7.5, NCH*H*CHN$_3$), 3.97 (1H, $_{apt.}$t, $_{obs.}$*J* = 8.0, PhC*H*CH$_2$), 5.17-5.23 (1H, m, CH$_2$C*H*N$_3$), 7.11 (2H, d, *J* = 8.0, Ar*H*), 7.15 (2H, d, *J* = 8.0, Ar*H*), 7.30-7.34 (2H, m, Ar*H*), 7.39-7.44 (4H, m, Ar*H*), 7.52 (2H, d, *J* = 7.0, Ar*H*), 7.71 (1H, s, C*H*N$_3$), 7.81 (1H, d, *J* = 7.0, Ar*H*); ^{13}C{^{1}H} NMR (δ; 125 MHz, $CDCl_3$), 21.08 (CH_3), 42.49 (CH_2), 56.65 (CH_2), 57.94 (CH), 59.23 (CH_2), 67.76 (CH), 118.61 (CH), 125.69 (CH), 127.59 (CH), 127.70 (CH), 128.14 (CH), 128.69 (CH), 128.74 (CH), 128.82 (CH), 129.00 (CH), 130.68 (C), 135.19 (C), 136.80 (C), 141.63 (C), 147.90 (C). High-resolution MS calcd for formula $C_{26}H_{26}N_4Na$: 417.2055; found: 417.2054.

4.1.123 (215da) 3-(*trans*-1-Benzyl-4-(4-phenyl-1H-1,2,3-triazol-1-yl)pyrrolidin-2-yl)pyridine.



General procedure L was used: post-work up iodo-azetidine **194d** (110 mg, 0.30 mmol), DMSO (20 mL), sodium azide (30 mg, 0.45 mmol), ethynylbenzene (32 mg, 0.30 mmol), copper (I) iodide (115 mg, 0.60 mmol), (EtOAc Rf 0.4), yellow oil, yield (from **192d**) = 86 mg, 57%. IR 3127, 3026, 2920, 2822, 1579, 1495, 1481, 1455, 1428, 1375, 1322, 1289, 1229, 1178, 1160; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 2.43(1H, dt, J = 15.0 & 9.0, PyCHCH*H*), 2.78 (1H, m, PyCHC*H*H), 2.86 (1H, dd, J = 9.0 & 6.0, CH*H*N_3), 3.57 (2H, ABq, J_{AB} = 15.0, N$C\mathit{H_2}$Ph), 3.71 (1H, t, J = 9.0, C*H*HN_3), 4.07 (1H, t, J = 9.0, PyC*H*CH_2), 5.21 (1H, m, NC*H*CH_2N_3), 7.33 (9H, m, Ar*H*), 7.75 (1H, s, C*H*N_3), 7.81 (2H, d, J = 9.0, Ar*H*), 7.87 (1H, d, J = 6.0, Ar*H*), 8.61 (1H, br, Py*H*), 8.78 (1H, br, Py*H*); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 42.30 (CH_2), 56.20 (CH_2), 57.82 (CH), 59.42 (CH_2), 65.45 (CH), 118.87 (CH), 125.71(CH), 127.36 (CH), 128.25 (CH), 128.45 (CH), 128.65 (CH), 128.87 (CH), 130.47 (C), 135.15 (CH), 137.93(C), 147.87(C), 149.29(CH), 149.57(CH) (quat C=$\underline{C}_{triazole}$ not observed). High-resolution MS calcd for formula $C_{24}H_{23}N_5Na$: 404.1851; found: 404.1867.

To confirm stereochemistry nOe experiments were performed, revealing a *trans* substitution arrangement about the pyrrolidine ring, suggesting compound **195d**, formed *in situ* is cleanly converted via an S_N2 mechanism to the corresponding azide which is subsequently converted to the corresponding triazole:



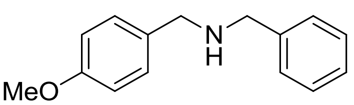
Irradiating H^3
NOE has been seen with H^{2a}, H^{4a}, H^6

Irradiating H^5
NOE has been seen with H^{2b}, H^{4b}, H^6, $H^{7a\&b}$
(pyridyl proton interaction is also observed)

That H^3 and H^5 display nOe between different protons on the same methylene carbons (corresponding to $H^{2a\&b}$ and $H^{4a\&b}$) is convincing evidence of *trans* geometry. Also, no nOe between H^3 and H^5 was observed.

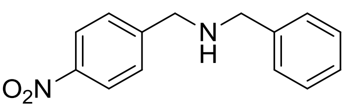
trans-**215da**

4.1.124 (219a) *N*-benzyl-1-(4-methoxyphenyl)methanamine



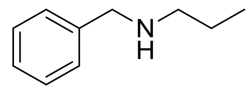
General procedure M was used: (4-methoxyphenyl)methanamine (10.35 mmol, 1.42 g), benzaldehyde (9.42 mmol, 1.00 g), sodium borohydride (18.84 mmol, 713 mg), yellow oil, 2.13 g, 99%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.87 (1H, s, N*H*), 3.85 (2H, s, MeOPhC*H₂*NH), 3.86 (3H, s, OC*H₃*), 3.90 (2H, s, PhC*H₂*NH), 7.0 (2H, d, *J* = 8.6, Ar*H*), 7.35-7.49 (7H, m, Ar*H*). ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$); 52.66 (CH_2), 53.16 (CH_2), 55.27 (CH_3), 113.92 (CH), 127.04 (CH), 128.51 (CH), 129.47 (CH), 132.58 (C), 140.56 (C), 158.81 (C). M/z: (ES$^+$) 228.1 [M + H]$^+$.

4.1.125 (219b) *N*-benzyl-1-(4-nitrophenyl)methanamine



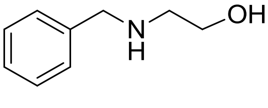
General procedure M was used: benzylamine (1.02 mmol, 109 mg), 4-nitrobenzaldehyde (0.93 mmol, 140 mg), sodium borohydride (1.86 mmol, 70 mg), yellow oil, 224 mg, 99%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 3.73 (2H, s, C*H₂*Ph-*p*-NO_2), 3.83 (2H, s, C*H₂*Ph), 7.17-7.27 (5H, m, Ar*H*), 7.45 (2H, d, *J* = 8.7, Ar*H*), 8.09 (2H, d, *J* = 8.7, Ar*H*). ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$); 52.29 (CH_2), 53.26 (CH_2), 123.62 (CH), 127.24 (CH), 128.14 (CH), 128.54 (CH), 128.69 (CH), 139.75 (C), 147.07 (C), 148.29 (C). High-resolution MS calcd for $C_{14}H_{15}N_2O_2$: 243.1134; found: 243.1135.

4.1.126 (219c) *N*-benzylpropan-1-amine



General procedure M was used: propylamine (10.36 mmol, 612 mg), benzaldehyde (9.42 mmol, 1.00 g), sodium borohydride (18.84 mmol, 713 mg), yellow oil, 1.39 g, 99%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 0.96 (3H, t, *J* = 7.4, C*H₃*CH_2CH_2), 1.39 (1H, br, N*H*), 1.57 (2H, sextet, *J* = 7.4, CH_3C*H₂*CH_2), 2.63 (2H, t, *J* = 7.4, CH_3CH_2C*H₂*), 3.83 (2H, s, PhC*H₂*NH), 7.25-7.39 (5H, m, Ph*H*). ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$); 11.81 (CH_3), 23.24 (CH_2), 51.40 (CH_2), 54.05 (CH_2), 126.84 (CH), 128.11 (CH), 128.36 (CH), 140.64 (C). M/z: (ES$^+$) 150.1 [M + H]$^+$.

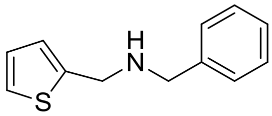
4.1.127 (219d) 2-(benzylamino)ethanol



General procedure M was used: 2-aminoethanol (17.98 mmol, 1.10 g), benzaldehyde (16.35 mmol, 1.83 g), sodium borohydride (32.70 mmol, 6.94 g), yellow oil, 2.46 g, 99%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 2.67 (2H, t, *J* = 5.4, C*H₂*CH_2OH), 3.03 (2H, br, O*H*

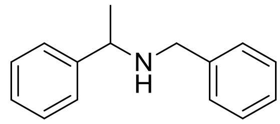
& N*H*), 3.55 (2H, t, *J* = 5.4, C*H*$_2$OH), 3.69 (2H, s, PhC*H*$_2$NH), 7.14-7.28 (5H, m, Ar*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$) 50.63 (CH$_2$), 53.48 (CH$_2$), 60.68 (CH$_2$), 127.20 (CH), 128.26 (CH), 128.51 (CH), 139.57 (C). High-resolution MS calcd for $C_9H_{14}NO$: 152.1075; found: 152.1080.

4.1.128 (219e) *N*-benzyl-1-(thiophen-2-yl)methanamine



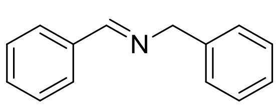
General procedure M was used: benzylamine (4.91 mmol, 526 mg), thiophene-2-carbaldehyde (4.46 mmol, 500 mg), sodium borohydride (8.92 mmol, 337 mg), yellow oil, 901 mg, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.84 (1H, br, NH), 3.77 (2H, s, PhC*H*$_2$NH), 3.93 (2H, s, SCC*H*$_2$), 6.85-6.90 (2H, m, Th*H*), 7.16 (1H, dd, *J* = 4.9 & 1.4, Th*H*), 7.19-7.28 (5H, m, Ar*H*). ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$) 47.51 (CH$_2$), 52.74 (CH$_2$), 124.44 (CH), 124.98 (CH), 126.64 (CH), 127.07 (CH), 128.24 (CH), 128.45 (CH), 139.89 (C), 144.03 (C). High-resolution MS calcd for $C_{12}H_{14}NS$: 204.0847; found: 204.0840.

4.1.129 (219f) *N*-benzyl-1-phenylethanamine



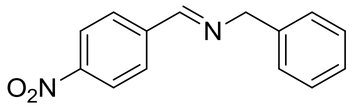
General procedure M was used: 1-phenylethanamine (20.72 mmol, 2.51 g), benzaldehyde (18.84 mmol, 2.00 g), sodium borohydride (37.69 mmol, 1.42 g), yellow oil, 3.96 g, 99%. ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 1.47 (3H, d, *J* = 6.6, Me), 1.73 (1H, br, N*H*), 3.73 (2H, ABq, J_{AB} = 13.2, NHC*H*$_2$Ph), 3.91 (1H, q, *J* = 6.6, PhC*H*NH), 7.30-7.48 (10H, m, Ar*H*). ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$) 24.65 (CH$_3$), 51.79 (CH$_2$), 57.63 (CH), 126.83 (CH), 126.96 (CH), 127.06 (CH), 128.26 (CH), 128.48 (CH), 128.60 (CH), 140.79 (C), 145.72 (C). High-resolution MS calcd for $C_{15}H_{17}N$: 211.1361; found: 211.1360.

4.1.130 (189a) (*E*)-*N*-benzylidene-1-phenylmethanamine



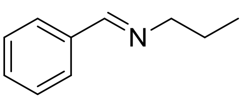
General procedure N was used: dibenzylamine (0.25 mmol, 50 mg), caesium carbonate (0.76 mmol, 248 mg,), I$_2$ (0.25 mmol, 63 mg,), CH$_3$CN (10 mL), yellow oil, 49 mg, 99%. IR 3062, 3027, 2871, 2839, 1642, 1580, 1495, 1451, 1378, 1292; ^{1}H NMR (δ; 300 MHz, CDCl$_3$); 4.67 (2H, s, PhC*H*$_2$), 7.13-7.31 (8H, m, Ph*H*), 7.68-7.74 (2H, m, Ph*H*), 8.18 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, CDCl$_3$), 65.23 (CH$_2$), 127.25 (CH), 128.26 (CH), 128.59 (CH), 128.78 (CH), 128.86 (CH), 131.0 (CH), 136.53 (C), 139.75 (C), 162.04 (CH). M/z: (ES$^+$) 196.1 [M + H]$^+$.

4.1.131 (189f) (*E*)-*N*-(4-nitrobenzylidene)-1-phenylmethanamine



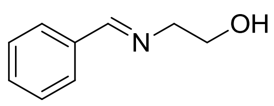
General procedure N was used: *N*-benzyl-1-(4-nitrophenyl)methanamine (0.16 mmol, 40 mg), caesium carbonate (0.49 mmol, 160 mg,), I_2 (0.16 mmol, 41 mg,), CH_3CN (10 mL), yellow solid, 38 mg, 99%. IR 3000, 2934, 2904, 2835, 1636 1509, 1372, 1342, 1243; ^1H NMR (δ; 300 MHz, $CDCl_3$); 4.75 (2H, s, PhC*H₂*), 7.13-7.28 (5H, m, Ph*H*), 7.80 (2H, d, *J* = 8.9, Ar*H*), 8.11 (2H, d, *J* = 8.9, Ar*H*), 8.32 (1H, s, C*H*=N); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 65.19 (CH_2), 123.85 (CH), 127.32 (CH), 128.10 (CH), 128.67 (CH), 128.95 (CH), 138.57 (C), 141.67 (C), 149.08 (C), 159.49 (CH). M/z: (ES^+) 241.1 $[M + H]^+$.

4.1.132 (189q) (*E*)-*N*-benzylidenepropan-1-amine



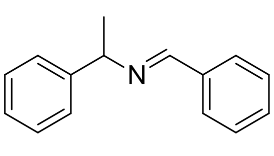
General procedure N was used: *N*-benzylpropan-1-amine (0.67 mmol, 100 mg), caesium carbonate (2.01 mmol, 656 mg), I_2 (0.67 mmol, 170 mg), magnesium sulphate (3.35 mmol, 400 mg), CH_3CN (15 mL), yellow oil, 98 mg, 99 %. IR 2962, 2931, 2874, 1645, 1580, 1451, 1379, 1338; ^1H NMR (δ; 300 MHz, $CDCl_3$); 0.85 (3H, t, *J* = 7.4, CH_3), 1.56-1.68 (2H, m, CH_2CH_3), 3.46 (2H, td, *J* = 6.9 & 1.1, NCH_2), 7.27-7.29 (3H, m, Ph*H*), 7.60-7.63 (2H , m, Ph*H*), 8.14 (1H, s, C*H*=N); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 11.88 (CH_3), 24.10 (CH_2), 65.33 (CH_2), 128.03 (CH), 128.55 (CH), 130.43 (CH), 136.40 (C), 160.74 (CH). M/z: (EI^+) 146.1 $[M + H]^+$.

4.1.133 (223) (*E*)-2-(benzylideneamino)ethanol



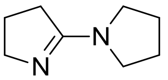
General procedure N was used: 2-(benzylamino)ethanol (0.44 mmol, 67 mg), caesium carbonate (1.33 mmol, 434 mg), I_2 (0.44 mmol, 112 mg), CH_3CN (10 mL), yellow oil, 65 mg, 99%. IR 3345, 3062, 3029, 2878, 1645, 1450, 1382, 1294; ^1H NMR (δ; 300 MHz, $CDCl_3$); 3.75-3.78 (2H, m, CH_2OH), 3.91-3.94 (2H, m, NCH_2CH_2), 4.53 (1H, br, O*H*), 7.40-7.45 (3H, m, Ph*H*), 7.72-7.74 (2H, m, Ph*H*), 8.33 (1H, s, C*H*=N); $^{13}C\{^1H\}$ NMR (δ; 100 MHz, $CDCl_3$), 62.33 (CH_2), 63.32 (CH_2), 128.21 (CH_2), 128.64 (CH), 130.90 (CH), 135.81 (C), 163.27 (CH). M/z: (ES^+) 149.1 $[M + H]^+$.

4.1.134 (189n) (*E*)-*N*-benzylidene-1-phenylethanamine



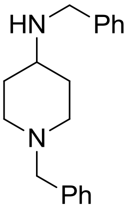
General procedure N was used: *N*-benzyl-1-phenylethanamine (0.24 mmol, 50 mg), caesium carbonate (0.71 mmol, 237 mg), I_2 (0.24 mmol, 61 mg), CH_3CN (10 mL), colourless oil, 49 mg, 99%. IR 3061, 3026, 2971, 2926, 2866, 1645, 1492, 1450, 1380, 1292; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.51 (3H, d, *J* = 6.6, Me), 4.45 (1H, q, *J* = 6.6, PhC*H*CH_3), 7.11-7.36 (8H, m, Ph*H*), 7.68-7.71 (2H, m, Ph*H*), 8.27 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 24.93 (CH_3), 69.78 (CH), 126.69 (CH), 126.87 (CH), 128.31 (CH), 128.47 (CH), 128.57 (CH), 130.61 (CH), 136.48 (C), 145.26 (C), 159.48 (CH). High-resolution MS calcd for $C_{15}H_{15}N$: 209.1204; found: 209.1199.

4.1.135 (225) 5-(pyrrolidin-1-yl)-3,4-dihydro-2H-pyrrole



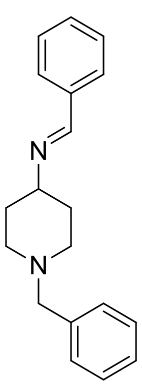
General procedure N was used: pyrrolidine (1.41 mmol, 100 mg), caesium carbonate (4.22 mmol, 1.38 g), I_2 (358 mg, 1.41 mmol), CH_3CN (15 mL), yellow oil, 97 mg, 99%. IR 3392, 2973, 2920, 1677, 1503, 1454, 1421, 1343, 1300, 1259; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 2.01-2.08 (4H, m, N=CNCH_2C*H_2*), 2.25 (2H, quintet, *J* = 7.6, N=CCH_2C*H_2*), 2.94 (2H, t, *J* = 7.6, N=CC*H_2*), 3.62 (2H, t, *J* = 6.4, N=CNC*H_2*), 3.74-3.79 (4H, m, C=NC*H_2* & N=CNC*H_2*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 20.68 (CH_2), 25.24 (CH_2), 25.30 (CH_2), 31.95 (CH_2), 47.44 (CH_2), 51.13 (CH_2), 51.86 (CH_2), 165.51 (C). M/z: (ES$^+$) 139.1 [M + H]$^+$.

4.1.136 (227) *N*,1-dibenzylpiperidin-4-amine



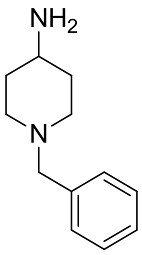
General procedure O was used: 1-benzylpiperidin-4-amine (2.60 mmol, 500 mg), benzaldehyde (2.60 mmol, 291 mg), sodium acethoxyborohydride (3.94 mmol, 835 mg), yellow oil, 435 mg, 60%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.44 (1H, br, N*H*), 1.44-1.55 (2H, m, NHCHC*H_2*), 1.91-1.94 (2H, m, NHCHC*H_2*), 2.06 (2H, td, *J* = 11.6 & 2.0, NC*H_2*CH_2NH_2), 2.53-2.60 (1H, m, C*H*NH), 2.88- 2.91 (2H, m, NC*H_2*CH_2NH_2), 3.54 (2H, s, NC*H_2*Ph), 3.85 (2H, s, NHC*H_2*Ph), 7.26-7.37 (10H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$) 32.84 (CH_2), 50.91 (CH_2), 52.45 (CH_2), 54.32 (CH), 63.18 (CH_2) 126.92 (CH), 126.97 (CH), 128.13 (CH), 128.23 (CH), 128.47 (CH), 129.14 (CH), 138.75 (C), 140.87 (C). High-resolution MS calcd for $C_{19}H_{25}N_2$: 281.2017; found: 281.2021.

4.1.137 (228) (*E*)-1-benzyl-*N*-benzylidenepiperidin-4-amine



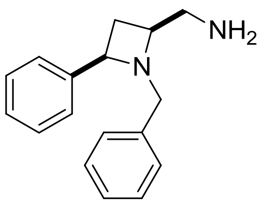
General procedure N was used: *N*,1-dibenzylpiperidin-4-amine (100 mg, 0.36 mmol), caesium carbonate (348 mg, 1.07 mmol), I_2 (91 mg, 0.36 mmol), CH_3CN (15 mL), yellow oil, 98 mg, 99%. IR 3060, 3026, 2937, 2804, 2760, 1639, 1450, 1389, 1293; ^{1}H NMR (δ; 400 MHz, $CDCl_3$); 1.67-1.70 (2H, m, CH=NCHC*H₂*), 1.79-1.88 (2H, m, CH=NCHC*H₂*), 2.12 (2H, t, *J* = 10.8, NC*H₂*CH₂), 2.87-2.91 (2H, m, NC*H₂*CH₂), 3.18 (1H, m, CH=NC*H*), 3.50 (2H, s, NC*H₂*Ph), 7.17-7.34 (8H, m, Ph*H*), 7.64-7.66 (2H, m, Ph*H*), 8.25 (1H, s, C*H*=N); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$) 33.49 (CH_2), 52.08 (CH_2), 63.16 (CH_2), 67.54 (CH), 126.99 (CH), 128.12 (CH), 128.22 (CH), 128.56 (CH), 129.15 (CH), 130.48 (CH), 136.51 (C), 138.56 (C), 159.11 (CH). High-resolution MS calcd for $C_{19}H_{23}N_2$: 279.1861; found: 279.1869.

4.1.138 (229) 1-benzylpiperidin-4-amine



General procedure P was used: (*E*)-1-benzyl-*N*-benzylidenepiperidin-4-amine (0.09 mmol, 25 mg), yellow oil, 17 mg, 99%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.33-1.45 (2H, m, NH₂CHC*H₂*), 1.59 (2H, br, N*H₂*) 1.76-1.81 (2H, m, NH₂CHC*H₂*), 2.02 (2H, td, *J* = 11.7 & 2.4, NC*H₂*CH₂NH₂), 2.60-2.70 (1H, m, C*H*NH₂), 2.80- 2.86 (2H, m, NC*H₂*CH₂NH₂), 3.49 (2H, s, NC*H₂*Ph), 7.21-7.35 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$) 35.94 (CH_2), 48.77 (CH), 52.43 (CH_2), 63.08 (CH_2), 126.91 (CH), 128.14 (CH), 129.10 (CH), 138.56 (C). M/z: (EI$^+$) 190.1 $[M + H]^+$.

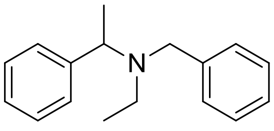
4.1.139 (231) ((*cis*)-1-benzyl-4-phenylazetidin-2-yl)methanamine



Procedures N and P were used: caesium carbonate (0.82 mmol, 268 mg) and I_2 (0.27 mmol, 70 mg), were added to *N*-benzyl-1-((*cis*)-1-benzyl-4-phenylazetidin-2-yl)methanamine (0.27 mmol, 89 mg), in CH_3CN (15 mL). Yellow oil, 61 mg, 89%. IR 3393, 2924, 1603, 1493, 1453, 1356, 1215, 1157; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 2.15 (1H, $_{\text{apt.}}$q, $_{\text{obs.}}J$ = 11.1, PhCHCH*H*), 2.40-2.52 (2H, m, PhCHC*H*H and NCHCH*H*NH₂), 2.90 (1H, dd, *J* = 13.2 & 1.8, NCHC*H*HNH₂), 3.60-3.61 (1H, m, C*H*CH₂NH), 3.71 (2H, ABq, J_{AB} = 12.3, NC*H₂*Ph), 4.19 (1H, $_{\text{apt.}}$t, $_{\text{obs.}}J$ = 8.2, PhC*H*CH₂), 6.15 (2H, br, N*H₂*), 7.17-7.35 (10H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 29.80 (CH_2), 40.99 (CH_2), 57.74 (CH), 59.91 (CH_2), 65.40 (CH), 127.02 (CH), 127.99 (CH), 128.54

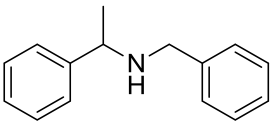
(CH), 128.63 (CH), 129.27 (CH), 129.51 (CH), 135.73 (C), 140.13 (C). High-resolution MS calcd for formula $C_{17}H_{21}N_2$: 253.1704; found: 253.1696.

4.1.140 (232) *N*-benzyl-*N*-ethyl-1-phenylethanamine



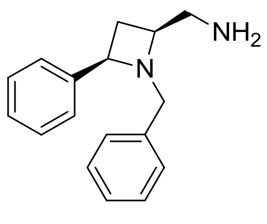
General procedure O was used: *N*-benzyl-1-phenylethanamine (7.18 mmol, 1.50 g), acetaldehyde (7.18 mmol, 316 mg), sodium acethoxyborohydride (10.77 mmol, 2.28 g), yellow oil, 1.72 g, 99%. ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 0.91 (3H, t, *J* = 7.1, C*H*$_3$CH$_2$), 1.28 (3H, d, *J* = 6.8, C*H*$_3$CH), 2.34 (1H, m, CH$_3$C*H*HN), 2.51 (1H, m, CH$_3$CH*H*N), 3.45 (2H, ABq, J_{AB} = 14.1, NC*H*$_2$Ph), 3.81 (1H, q, *J* = 6.8, PhC*H*CH$_3$), 7.08-7.35 (10H, m, Ph*H*). ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$) 12.21 (CH_3), 16.20 (CH_3), 43.09 (CH_2), 53.92 (CH_2), 58.06 (CH), 126.60 (CH), 126.64 (CH), 127.80 (CH), 128.10 (CH), 128.17 (CH), 128.54 (CH), 141.23 (C), 144.59 (C). High-resolution MS calcd for $C_{17}H_{22}N$: 240.1752; found: 240.1755.

4.1.141 (219f) *N*-benzyl-1-phenylethanamine



Procedure: caesium carbonate (0.63 mmol, 205 mg) and I_2 (0.63 mmol, 159 mg), were added to amine *N*-benzyl-*N*-ethyl-1-phenylethanamine (0.21 mmol, 50 mg), in DMSO:H_2O (10:2 mL). Consumption of starting material was monitored by TLC. When the reaction was completed diethyl ether and a solution of sodium thiosulfate were added, the organic layer was washed with water three times and dried *in vacuo* to deliver the corresponding amine. Yellow oil, 44 mg, 99%. IR 3062, 3026, 2974, 1493, 1451, 1372, 1302, 1238; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.47 (3H, d, *J* = 6.6, Me), 1.73 (1H, br, NH), 3.73 (2H, ABq, J_{AB} = 13.2, NHC*H*$_2$Ph), 3.91 (1H, q, *J* = 6.6, PhC*H*NH), 7.30-7.48 (10H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 24.65 (CH_3), 51.79 (CH_2), 57.63 (CH), 126.83 (CH), 126.96 (CH), 127.06 (CH), 128.26 (CH), 128.48 (CH), 128.60 (CH), 140.79 (C), 145.72 (C). High-resolution MS calcd for $C_{15}H_{17}N$: 211.1361; found: 211.1360.

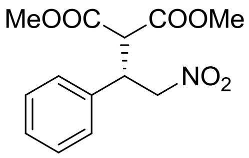
4.1.142 (231) ((2*S*,4*R*)-1-benzyl-4-phenylazetidin-2-yl)methanamine



Procedures N and P were used: caesium carbonate (0.87 mmol, 283 mg) and I_2 (0.29 mmol, 74 mg), were added to *N*-benzyl-1-((2*S*,4*R*)-1-benzyl-4-phenylazetidin-2-yl)methanamine **199aa** (0.29 mmol, 100 mg), in CH_3CN (15 mL).

Yellow oil, 73 mg, 99%. $[\alpha]_D^{20}$ = +107.8 (c 1.4, $CHCl_3$). IR 3061, 3027, 2019, 2851, 1601, 1493, 1454, 1353, 1303, 1209, 1157; ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 1.22 (2H, br, N*H₂*), 1.76 (1H, $_{apt.}$q, $_{obs.}J$ = 8.7, PhCHCH*H*), 2.26-2.35 (3H, m, PhCHC*H*H and NCHC*H₂*NH₂), 3.07-3.15 (1H, m, NC*H*CH₂NH₂), 3.59 (2H, ABq, J_{AB} = 12.9, NC*H₂*Ph), 3.95 (1H, $_{apt.}$t, $_{obs.}J$ = 8.1, PhC*H*CH₂), 7.12-7.40 (10H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 29.79 (CH_2), 45.60 (CH_2), 61.45 (CH_2), 64.59 (CH), 64.89 (CH), 126.70 (CH), 127.05 (CH), 127.08 (CH), 128.17 (CH), 128.21 (CH), 129.12 (CH), 138.97 (C), 143.56 (C). High-resolution MS calcd for formula $C_{17}H_{21}N_2$: 253.1704; found: 253.1717.

4.1.143 (234) (*S*)-dimethyl 2-(2-nitro-1-phenylethyl)malonate



1-isothiocyanato-3,5-bis(trifluoromethyl)benzene (0.04 mmol, 11 mg) was stirred with (2*S*,4*R*)-**231** (0.04 mmol, 10 mg) for 30 minutes in dry toluene under argon atmosphere after which (*E*)-(2-nitrovinyl)benzene (0.40 mmol, 59 mg) and dimethyl malonate (0.80 mmol, 106 mg) were added and the mixture was left stirring at rt temperature for 48 hours. Toluene was removed in vacuo and the product was purified by flash chromatography using hexane:ethyl acetate (7:3) as solvent. Yield = 23 mg, 20%. $[a]_D^{25}$= +5.5 (c 1.0, $CHCl_3$). ^{1}H NMR (δ; 300 MHz, $CDCl_3$); 3.49 (3H, s, OC*H₃*), 3.70 (3H, s, OC*H₃*), 3.80 (1H, d, *J* = 9.0, MeO(O)CC*H*), 4.14-4.22 (1H, m, PhC*H*CH₂NO₂), 4.80-4.90 (2H, m, C*H₂*NO₂), 7.14-7.29 (5H, m, Ph*H*); ^{13}C{^{1}H} NMR (δ; 100 MHz, $CDCl_3$), 45.34 (CH), 53.69 (CH_3), 54.01 (CH_3), 56.46 (CH), 79.41 (CH_2), 129.92 (CH), 130.11 (CH), 130.39 (CH), 138.69 (C), 169.65 (C), 170.12 (C). M/z: (EI$^+$) 281 [M]$^+$.

4.2 Syngenta screening: materials and methods

Methodology

Herbicide assays: The compound was tested for herbicidal activity against *Arabidopsis thaliana* at 10 ppm and *Poa annua* at 32ppm. Test plates were stored for seven days in a controlled environment cabinet. They were scored as 0 or 99, where 99 = significant herbicidal effect, and 0 = no effect.

Test species	Treatment timing	Rate (ppm)
Arabidopsis thaliana	Pre-emergence	10
Poa annua	Pre-emergence	32

Insecticide assays: The compound was tested for activity against an aphid species at 1000ppm on a leaf-piece based assay, and against *Plutella xylostella* and *Diabrotica balteata* at 500ppm in artificial diet assays. Chemicals were applied to feeding aphids, or prior to infestation with *P. xylostella* and D. *balteata* larvae. The compound was also screened against the nematode *Caernorhabditis elegan*s at 50ppm in a liquid culture medium.

Mortality was assessed relative to control wells using a 2 band system (0 or 99 where 99 = significant mortality, 0 = no effect), 5-9d after the treatments depending on the assay.

Test species	Treatment type	Media	Rate (ppm)
Aphid species	Feeding/contact	Leaf disc	1000
Diabrotica balteata	Feeding/contact	Artificial diet	500
Plutella xylostella	Feeding/contact	Artificial diet	500
*Caenorhabditis elegan*s	Feeding/contact	Liquid culture	50

Fungicide assays: The compound was evaluated in mycelial growth tests in artificial media against *Pythium dissimile, Alternaria solani, Botryotinia fuckeliana* and *Gibberella zeae*, at rates of 20ppm and 2ppm.

Test species	Media	Rate (ppm)
Pythium dissimile	Semi-solid	20 and 2
Alternaria solani	Semi-solid	20 and 2
Botryotinia fuckeliana (*Botrytis cinerea)*	Semi-solid	20 and 2
Gibberella zeae (*Fusarium graminearum*)	Semi-solid	20 and 2

The compound was also evaluated against several pathogens on leaf-piece assays, at the rate of 100ppm for *Septoria tritici* on wheat and *Uromyces viciae-fabae* on bean, and rates of 200ppm and 60ppm for *Phytophthora* *infestans* on tomato. The compound was applied prior to inoculation with the pathogens.

Test species	Host	Rate (ppm)
Septoria tritici	Wheat	100
Phytophthora infestans	Tomato	200 and 60
Uromyces viciae-fabae	Bean	100

Mycelial growth or disease inhibition was assessed visually and scored using a three band system (0, 55 and 99 where 99 = total inhibition of hyphal growth/disease development, 55 = partial inhibition, 0 = no inhibition), 4-14d after inoculation depending on the assay.

Positive controls: In addition to the test compounds, positive control compounds were included in each test azoxystrobin and prochloraz for fungicide assays, thiamethoxam, indoxacarb and levamisole for insecticide assays and norflurazon for herbicide assays.

Table 42. Scores are given average scores for the replicates (avg); Scores are 99 any herbicide effect (Herbicide assays); >70% mortality (Insecticide assays); complete control of pathogen in that replicate (Fungicide assays), 55- Partial control of pathogen (Fungicide assays only), 0-no activity.

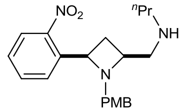
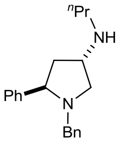
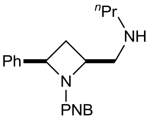
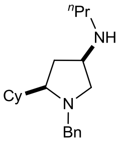
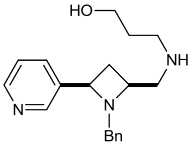
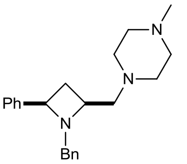
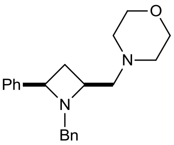
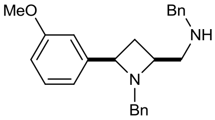
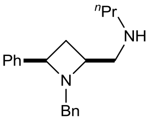
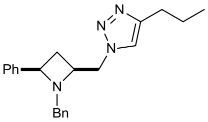
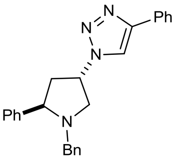
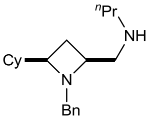
compound name	structure	*Phytophthora infestans* (tomato) efficacy DCR (AVG %ASS)	*Septoria tritici* (wheat) efficacy DCR (AVG %ASS)	*Uromyces viciae-fabae* (bean) efficacy DCR (AVG %ASS)
cis-**199mb**		0	36	0
trans-**200ab**		0	66	0
cis-**199lb**		0	0	0
cis-**200kb**		0	0	27
cis-**199di**		0	0	0
cis-**199ag**		0	0	0
cis-**199af**		0	36	0
cis-**199ib**		0	0	0
cis-**199ab**		0	33	0
cis-**202ab**		0	0	0
trans-**215aa**		0	0	0
cis-**199kb**		0	33	0

Table 43 Scores are given average scores for the replicates (avg); Scores are 99 any herbicide effect (Herbicide assays); >70% mortality (Insecticide assays); complete control of pathogen in that replicate (Fungicide assays), 55- Partial control of pathogen (Fungicide assays only), 0-no activity.

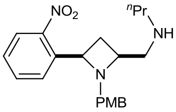
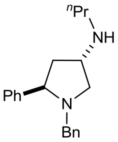
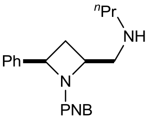
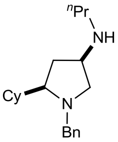
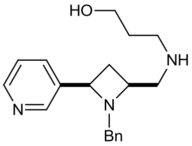
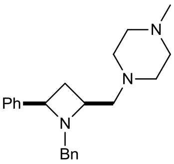
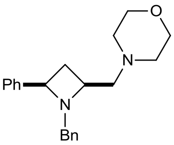
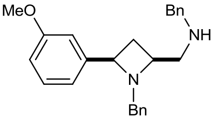
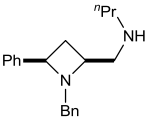
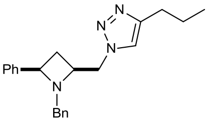
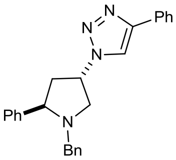
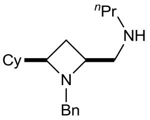
compound name	structure	*Pythium dissimile* efficacy DCR (AVG %ASS)	*Alternaria solani* efficacy DCR (AVG %ASS)	*Botryotinia fuckeliana* efficacy DCR (AVG %ASS)
***cis*-199mb**		0	0	0
***trans*-200ab**		0	0	0
***cis*-199lb**		0	0	0
***cis*-200kb**		0	0	0
***cis*-199di**		0	0	0
***cis*-199ag**		0	0	0
***cis*-199af**		0	0	0
***cis*-199ib**		0	0	0
***cis*-199ab**		0	0	0
***cis*-202ab**		55	0	0
***trans*-215aa**		0	0	0
***cis*-199kb**		0	0	0

Table 44. Scores are given average scores for the replicates (avg); Scores are 99 any herbicide effect (Herbicide assays); >70% mortality (Insecticide assays); complete control of pathogen in that replicate (Fungicide assays), 55- Partial control of pathogen (Fungicide assays only), 0-no activity.

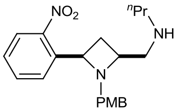
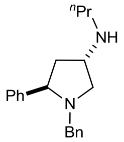
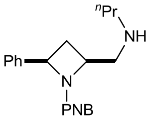
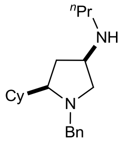
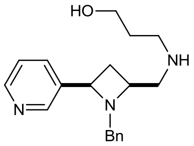
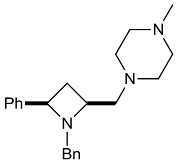
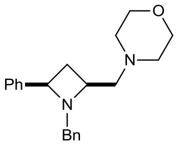
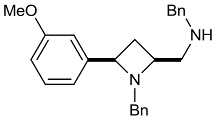
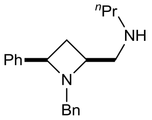
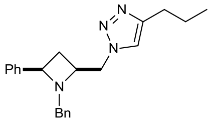
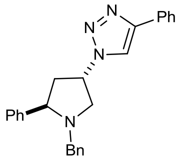
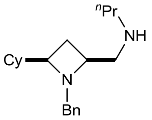
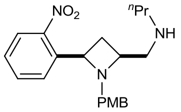
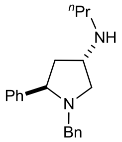
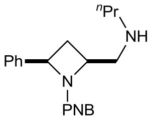
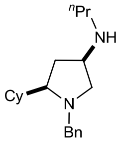
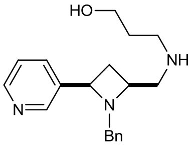
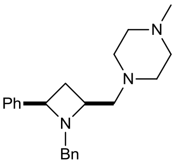
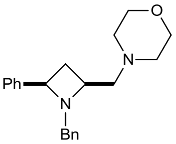
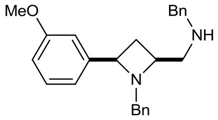
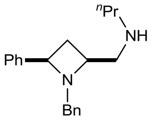
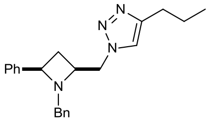
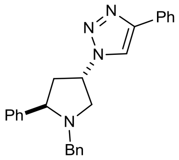
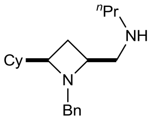
compound name	structure	*Gibberella zeae* efficacy DCR (AVG %ASS)	*Arabidopsis thaliana* efficacy DCR (AVG %ASS)	*Poa annua* efficacy DCR (AVG %ASS)
cis-**199mb**		0	0	0
trans-**200ab**		0	99	0
cis-**199lb**		0	0	0
cis-**200kb**		0	0	49
cis-**199di**		0	0	0
cis-**199ag**		0	0	0
cis-**199af**		0	0	0
cis-**199ib**		0	0	0
cis-**199ab**		0	0	0
cis-**202ab**		0	0	0
trans-**215aa**		0	49	0
cis-**199kb**		0	0	0

Table 45. Scores are given average scores for the replicates (avg); Scores are 99 any herbicide effect (Herbicide assays); >70% mortality (Insecticide assays); complete control of pathogen in that replicate (Fungicide assays), 55- Partial control of pathogen (Fungicide assays only), 0-no activity.

compound name	structure	*Aphid species* efficacy DCR (AVG %ASS)	*Plutella xylostella* efficacy DCR (AVG %ASS)	*Diabrotica balteata* efficacy DCR (AVG %ASS)	*Caenorhabditis elegans* efficacy DCR (AVG %ASS)
cis-**199mb**		0	0	66	0
trans-**200ab**		0	0	0	0
cis-**199lb**		0	33	0	0
cis-**200kb**		0	0	0	0
cis-**199di**		0	0	0	0
cis-**199ag**		0	0	0	0
cis-**199af**		0	0	0	0
cis-**199ib**		0	0	0	0
cis-**199ab**		0	0	0	0
cis-**202ab**		0	0	0	0
trans-**215aa**		0	0	0	0
cis-**199kb**		0	0	0	0

4.3 **X-Ray Crystallographic Information** (All the following X-ray structures have been solved by Dr Louise Male).

4.3.1 X-Ray Crystallographic Information for Iodo-Azetidine (*cis*)-194b

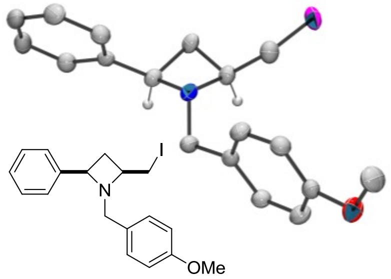


Table 46. Crystal data and structure refinement for (*cis*)-**194b**.

Identification code	(*cis*)-**194b**	
Empirical formula	$C_{18} H_{20} I N O$	
Formula weight	393.25	
Temperature	120(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P -1	
Unit cell dimensions	a = 10.6159(3) Å	α= 81.7569(15)°.
	b = 12.3314(3) Å	β= 74.4479(14)°.
	c = 13.4921(3) Å	γ = 81.2906(14)°.
Volume	1672.13(7) Å^3	
Z	4	
Density (calculated)	1.562 Mg/m^3	
Absorption coefficient	1.914 mm^{-1}	
F(000)	784	
Crystal size	0.70 x 0.45 x 0.12 mm^3	
Theta range for data collection	3.02 to 27.50°.	
Index ranges	-13<=h<=13, -16<=k<=16, -17<=l<=17	
Reflections collected	35064	
Independent reflections	7664 [R(int) = 0.0341]	
Completeness to theta = 27.50°	99.8 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.8028 and 0.3476	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	7664 / 0 / 381	
Goodness-of-fit on F^2	1.149	
Final R indices [I>2sigma(I)]	R1 = 0.0366, wR2 = 0.0983	
R indices (all data)	R1 = 0.0444, wR2 = 0.1022	

Largest diff. peak and hole 1.500 and -1.591 e.Å^{-3}

Notes: The structure is a racemate, and contains two crystallographically independent molecules per asymmetric unit.

Hydrogen atoms were fixed as riding models.

Table 47. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for (*cis*)-**194b**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
C(1)	517(3)	952(3)	1602(3)	35(1)
C(2)	418(3)	-114(2)	2305(2)	29(1)
C(3)	1582(3)	-1030(2)	2137(2)	29(1)
C(4)	511(3)	-1819(2)	2326(2)	26(1)
C(5)	-1766(3)	-831(3)	2622(2)	29(1)
C(6)	-2600(3)	201(2)	2324(2)	25(1)
C(7)	-3441(3)	811(3)	3085(2)	27(1)
C(8)	-4243(3)	1738(3)	2834(2)	31(1)
C(9)	-4226(3)	2088(2)	1804(2)	26(1)
C(10)	-3381(3)	1516(3)	1033(2)	29(1)
C(11)	-2588(3)	580(3)	1301(2)	32(1)
C(12)	-4975(4)	3501(3)	616(3)	42(1)
C(13)	753(3)	-2783(2)	1707(2)	24(1)
C(14)	652(3)	-2648(3)	694(2)	31(1)
C(15)	930(4)	-3549(3)	125(3)	39(1)
C(16)	1316(3)	-4580(3)	569(3)	39(1)
C(17)	1412(3)	-4724(3)	1564(3)	37(1)
C(18)	1126(3)	-3839(3)	2142(2)	30(1)
N(1)	-396(2)	-856(2)	2042(2)	26(1)
O(1)	-5085(2)	3008(2)	1651(2)	35(1)
I(1)	2006(1)	1826(1)	1864(1)	39(1)
C(101)	3053(3)	4085(3)	5380(2)	32(1)
C(102)	2021(3)	5024(2)	5729(2)	26(1)
C(103)	1617(3)	5897(3)	4901(2)	28(1)
C(104)	1712(3)	6759(2)	5594(2)	26(1)
C(105)	2296(3)	5874(3)	7235(2)	28(1)
C(106)	3081(3)	4872(3)	7646(2)	26(1)
C(107)	2500(3)	3941(3)	8131(2)	29(1)
C(108)	3232(3)	2983(3)	8444(2)	30(1)
C(109)	4587(3)	2960(3)	8254(2)	28(1)
C(110)	5188(3)	3893(3)	7783(2)	31(1)
C(111)	4447(3)	4836(3)	7482(2)	28(1)
C(112)	4871(4)	1046(3)	8852(3)	42(1)
C(113)	2324(3)	7780(2)	5096(2)	25(1)
C(114)	3656(3)	7726(3)	4599(2)	32(1)
C(115)	4208(3)	8670(3)	4099(2)	35(1)
C(116)	3427(4)	9672(3)	4087(2)	35(1)
C(117)	2118(4)	9740(3)	4569(3)	37(1)
C(118)	1561(3)	8804(3)	5077(2)	31(1)
N(101)	2528(2)	5897(2)	6111(2)	25(1)
O(101)	5412(2)	2064(2)	8515(2)	36(1)
I(101)	2310(1)	3099(1)	4511(1)	41(1)

Table 48. Bond lengths [Å] and angles [°] for (*cis*)-**194b**.

C(1)-C(2)	1.507(4)
C(1)-I(1)	2.170(3)
C(1)-H(1A)	0.9900
C(1)-H(1B)	0.9900
C(2)-N(1)	1.486(4)
C(2)-C(3)	1.534(4)
C(2)-H(2)	1.0000
C(3)-C(4)	1.553(4)
C(3)-H(3A)	0.9900
C(3)-H(3B)	0.9900
C(4)-N(1)	1.485(4)
C(4)-C(13)	1.501(4)
C(4)-H(4)	1.0000
C(5)-N(1)	1.454(4)
C(5)-C(6)	1.506(4)
C(5)-H(5A)	0.9900
C(5)-H(5B)	0.9900
C(6)-C(11)	1.389(4)
C(6)-C(7)	1.394(4)
C(7)-C(8)	1.377(5)
C(7)-H(7)	0.9500
C(8)-C(9)	1.391(4)
C(8)-H(8)	0.9500
C(9)-O(1)	1.372(4)
C(9)-C(10)	1.379(4)
C(10)-C(11)	1.386(5)
C(10)-H(10)	0.9500
C(11)-H(11)	0.9500
C(12)-O(1)	1.422(4)
C(12)-H(12A)	0.9800
C(12)-H(12B)	0.9800
C(12)-H(12C)	0.9800
C(13)-C(14)	1.384(4)
C(13)-C(18)	1.395(4)
C(14)-C(15)	1.391(5)
C(14)-H(14)	0.9500
C(15)-C(16)	1.378(5)
C(15)-H(15)	0.9500
C(16)-C(17)	1.358(5)
C(16)-H(16)	0.9500
C(17)-C(18)	1.382(5)
C(17)-H(17)	0.9500
C(18)-H(18)	0.9500
C(101)-C(102)	1.502(4)
C(101)-I(101)	2.161(3)
C(101)-H(10A)	0.9900
C(101)-H(10B)	0.9900
C(102)-N(101)	1.483(4)
C(102)-C(103)	1.537(4)
C(102)-H(102)	1.0000
C(103)-C(104)	1.543(4)
C(103)-H(10C)	0.9900
C(103)-H(10D)	0.9900
C(104)-N(101)	1.484(4)
C(104)-C(113)	1.493(4)
C(104)-H(104)	1.0000
C(105)-N(101)	1.466(4)
C(105)-C(106)	1.506(4)
C(105)-H(10E)	0.9900
C(105)-H(10F)	0.9900
C(106)-C(107)	1.381(4)
C(106)-C(111)	1.403(4)
C(107)-C(108)	1.390(5)
C(107)-H(107)	0.9500
C(108)-C(109)	1.388(4)
C(108)-H(108)	0.9500
C(109)-O(101)	1.368(4)
C(109)-C(110)	1.389(4)
C(110)-C(111)	1.377(5)
C(110)-H(110)	0.9500
C(111)-H(111)	0.9500
C(112)-O(101)	1.424(4)
C(112)-H(11A)	0.9800
C(112)-H(11B)	0.9800
C(112)-H(11C)	0.9800
C(113)-C(114)	1.390(4)
C(113)-C(118)	1.395(4)
C(114)-C(115)	1.387(5)
C(114)-H(114)	0.9500
C(115)-C(116)	1.380(5)
C(115)-H(115)	0.9500
C(116)-C(117)	1.363(5)
C(116)-H(116)	0.9500
C(117)-C(118)	1.383(5)
C(117)-H(117)	0.9500
C(118)-H(118)	0.9500
C(2)-C(1)-I(1)	109.8(2)
C(2)-C(1)-H(1A)	109.7
I(1)-C(1)-H(1A)	109.7
C(2)-C(1)-H(1B)	109.7
I(1)-C(1)-H(1B)	109.7
H(1A)-C(1)-H(1B)	108.2
N(1)-C(2)-C(1)	113.1(3)
N(1)-C(2)-C(3)	88.9(2)
C(1)-C(2)-C(3)	119.1(3)
N(1)-C(2)-H(2)	111.3
C(1)-C(2)-H(2)	111.3
C(3)-C(2)-H(2)	111.3
C(2)-C(3)-C(4)	85.0(2)
C(2)-C(3)-H(3A)	114.5
C(4)-C(3)-H(3A)	114.5
C(2)-C(3)-H(3B)	114.5
C(4)-C(3)-H(3B)	114.5
H(3A)-C(3)-H(3B)	111.6
N(1)-C(4)-C(13)	116.8(2)
N(1)-C(4)-C(3)	88.2(2)
C(13)-C(4)-C(3)	119.9(2)
N(1)-C(4)-H(4)	110.0
C(13)-C(4)-H(4)	110.0
C(3)-C(4)-H(4)	110.0
N(1)-C(5)-C(6)	112.6(2)
N(1)-C(5)-H(5A)	109.1
C(6)-C(5)-H(5A)	109.1
N(1)-C(5)-H(5B)	109.1
C(6)-C(5)-H(5B)	109.1
H(5A)-C(5)-H(5B)	107.8
C(11)-C(6)-C(7)	117.2(3)
C(11)-C(6)-C(5)	122.6(3)
C(7)-C(6)-C(5)	120.2(3)
C(8)-C(7)-C(6)	121.3(3)
C(8)-C(7)-H(7)	119.3
C(6)-C(7)-H(7)	119.3
C(7)-C(8)-C(9)	120.2(3)
C(7)-C(8)-H(8)	119.9
C(9)-C(8)-H(8)	119.9
O(1)-C(9)-C(10)	125.4(3)
O(1)-C(9)-C(8)	114.9(3)
C(10)-C(9)-C(8)	119.7(3)

C(9)-C(10)-C(11)	119.2(3)
C(9)-C(10)-H(10)	120.4
C(11)-C(10)-H(10)	120.4
C(10)-C(11)-C(6)	122.3(3)
C(10)-C(11)-H(11)	118.9
C(6)-C(11)-H(11)	118.9
O(1)-C(12)-H(12A)	109.5
O(1)-C(12)-H(12B)	109.5
H(12A)-C(12)-H(12B)	109.5
O(1)-C(12)-H(12C)	109.5
H(12A)-C(12)-H(12C)	109.5
H(12B)-C(12)-H(12C)	109.5
C(14)-C(13)-C(18)	118.6(3)
C(14)-C(13)-C(4)	121.5(3)
C(18)-C(13)-C(4)	119.9(3)
C(13)-C(14)-C(15)	120.3(3)
C(13)-C(14)-H(14)	119.8
C(15)-C(14)-H(14)	119.8
C(16)-C(15)-C(14)	119.9(3)
C(16)-C(15)-H(15)	120.0
C(14)-C(15)-H(15)	120.0
C(17)-C(16)-C(15)	120.3(3)
C(17)-C(16)-H(16)	119.8
C(15)-C(16)-H(16)	119.8
C(16)-C(17)-C(18)	120.4(3)
C(16)-C(17)-H(17)	119.8
C(18)-C(17)-H(17)	119.8
C(17)-C(18)-C(13)	120.5(3)
C(17)-C(18)-H(18)	119.8
C(13)-C(18)-H(18)	119.8
C(5)-N(1)-C(2)	117.6(2)
C(5)-N(1)-C(4)	116.1(2)
C(2)-N(1)-C(4)	89.2(2)
C(9)-O(1)-C(12)	117.4(3)
C(102)-C(101)-I(101)	109.1(2)
C(102)-C(101)-H(10A)	109.9
I(101)-C(101)-H(10A)	109.9
C(102)-C(101)-H(10B)	109.9
I(101)-C(101)-H(10B)	109.9
H(10A)-C(101)-H(10B)	108.3
N(101)-C(102)-C(101)	113.5(3)
N(101)-C(102)-C(103)	88.6(2)
C(101)-C(102)-C(103)	118.4(2)
N(101)-C(102)-H(102)	111.5
C(101)-C(102)-H(102)	111.5
C(103)-C(102)-H(102)	111.5
C(102)-C(103)-C(104)	86.2(2)
C(102)-C(103)-H(10C)	114.3
C(104)-C(103)-H(10C)	114.3
C(102)-C(103)-H(10D)	114.3
C(104)-C(103)-H(10D)	114.3
H(10C)-C(103)-H(10D)	111.4
N(101)-C(104)-C(113)	116.5(2)
N(101)-C(104)-C(103)	88.3(2)
C(113)-C(104)-C(103)	118.8(2)
N(101)-C(104)-H(104)	110.5
C(113)-C(104)-H(104)	110.5
C(103)-C(104)-H(104)	110.5
N(101)-C(105)-C(106)	109.7(2)
N(101)-C(105)-H(10E)	109.7
C(106)-C(105)-H(10E)	109.7
N(101)-C(105)-H(10F)	109.7
C(106)-C(105)-H(10F)	109.7
H(10E)-C(105)-H(10F)	108.2
C(107)-C(106)-C(111)	118.1(3)
C(107)-C(106)-C(105)	121.4(3)
C(111)-C(106)-C(105)	120.3(3)
C(106)-C(107)-C(108)	121.9(3)
C(106)-C(107)-H(107)	119.1
C(108)-C(107)-H(107)	119.1
C(109)-C(108)-C(107)	119.0(3)
C(109)-C(108)-H(108)	120.5
C(107)-C(108)-H(108)	120.5
O(101)-C(109)-C(110)	115.6(3)
O(101)-C(109)-C(108)	124.3(3)
C(110)-C(109)-C(108)	120.1(3)
C(111)-C(110)-C(109)	120.2(3)
C(111)-C(110)-H(110)	119.9
C(109)-C(110)-H(110)	119.9
C(110)-C(111)-C(106)	120.7(3)
C(110)-C(111)-H(111)	119.6
C(106)-C(111)-H(111)	119.6
O(101)-C(112)-H(11A)	109.5
O(101)-C(112)-H(11B)	109.5
H(11A)-C(112)-H(11B)	109.5
O(101)-C(112)-H(11C)	109.5
H(11A)-C(112)-H(11C)	109.5
H(11B)-C(112)-H(11C)	109.5
C(114)-C(113)-C(118)	118.3(3)
C(114)-C(113)-C(104)	120.8(3)
C(118)-C(113)-C(104)	120.8(3)
C(115)-C(114)-C(113)	120.6(3)
C(115)-C(114)-H(114)	119.7
C(113)-C(114)-H(114)	119.7
C(116)-C(115)-C(114)	119.8(3)
C(116)-C(115)-H(115)	120.1
C(114)-C(115)-H(115)	120.1
C(117)-C(116)-C(115)	120.4(3)
C(117)-C(116)-H(116)	119.8
C(115)-C(116)-H(116)	119.8
C(116)-C(117)-C(118)	120.2(3)
C(116)-C(117)-H(117)	119.9
C(118)-C(117)-H(117)	119.9
C(117)-C(118)-C(113)	120.7(3)
C(117)-C(118)-H(118)	119.7
C(113)-C(118)-H(118)	119.7
C(105)-N(101)-C(102)	117.2(2)
C(105)-N(101)-C(104)	116.8(2)
C(102)-N(101)-C(104)	90.4(2)
C(109)-O(101)-C(112)	117.2(3)

Symmetry transformations used to generate equivalent atoms

Table 49. Anisotropic displacement parameters (Å^{2}x 10^3)for (*cis*)-**194b**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[\, h^2 a^{*2} U^{11} + ... + 2\, h\, k\, a^*\, b^*\, U^{12}\,]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
C(1)	39(2)	30(2)	38(2)	-4(1)	-13(1)	-2(1)
C(2)	33(2)	25(2)	29(1)	-7(1)	-9(1)	-2(1)
C(3)	30(2)	28(2)	31(2)	-11(1)	-11(1)	1(1)
C(4)	28(2)	28(2)	23(1)	-5(1)	-8(1)	1(1)
C(5)	27(2)	28(2)	30(2)	-3(1)	-2(1)	-2(1)
C(6)	22(1)	25(1)	29(1)	-6(1)	-4(1)	-5(1)
C(7)	28(2)	31(2)	23(1)	-4(1)	-5(1)	-3(1)
C(8)	32(2)	35(2)	27(1)	-10(1)	-5(1)	0(1)
C(9)	27(2)	24(1)	29(1)	-4(1)	-7(1)	-5(1)
C(10)	33(2)	30(2)	24(1)	-2(1)	-5(1)	-6(1)
C(11)	34(2)	32(2)	26(1)	-8(1)	0(1)	-2(1)
C(12)	47(2)	37(2)	37(2)	8(2)	-11(2)	-1(2)
C(13)	20(1)	28(2)	26(1)	-6(1)	-4(1)	-5(1)
C(14)	38(2)	32(2)	24(1)	-1(1)	-6(1)	-8(1)
C(15)	49(2)	45(2)	26(2)	-13(1)	-4(1)	-14(2)
C(16)	33(2)	33(2)	49(2)	-17(2)	1(2)	-9(1)
C(17)	30(2)	26(2)	55(2)	-9(2)	-10(2)	-2(1)
C(18)	30(2)	31(2)	31(2)	-3(1)	-12(1)	-3(1)
N(1)	25(1)	26(1)	26(1)	-7(1)	-5(1)	0(1)
O(1)	42(1)	29(1)	31(1)	-2(1)	-13(1)	4(1)
I(1)	49(1)	26(1)	45(1)	-4(1)	-12(1)	-13(1)
C(101)	31(2)	34(2)	31(2)	-9(1)	-7(1)	0(1)
C(102)	27(2)	29(2)	23(1)	-5(1)	-4(1)	-4(1)
C(103)	25(1)	31(2)	29(1)	-4(1)	-10(1)	-2(1)
C(104)	24(1)	29(2)	24(1)	-4(1)	-5(1)	0(1)
C(105)	31(2)	31(2)	21(1)	-3(1)	-5(1)	-4(1)
C(106)	32(2)	30(2)	16(1)	-5(1)	-5(1)	-5(1)
C(107)	26(2)	37(2)	24(1)	-1(1)	-6(1)	-8(1)
C(108)	29(2)	36(2)	25(1)	2(1)	-5(1)	-11(1)
C(109)	31(2)	31(2)	24(1)	-2(1)	-10(1)	-4(1)
C(110)	26(2)	37(2)	32(2)	-5(1)	-8(1)	-9(1)
C(111)	31(2)	30(2)	25(1)	-2(1)	-7(1)	-10(1)
C(112)	42(2)	35(2)	45(2)	7(2)	-11(2)	-5(2)
C(113)	28(2)	25(1)	21(1)	-4(1)	-7(1)	1(1)
C(114)	31(2)	28(2)	33(2)	-2(1)	-3(1)	2(1)
C(115)	33(2)	38(2)	32(2)	1(1)	-3(1)	-6(1)
C(116)	51(2)	26(2)	31(2)	3(1)	-18(1)	-7(1)
C(117)	49(2)	26(2)	42(2)	-5(1)	-24(2)	4(2)
C(118)	30(2)	31(2)	35(2)	-9(1)	-13(1)	5(1)
N(101)	28(1)	24(1)	22(1)	-3(1)	-7(1)	-2(1)
O(101)	32(1)	34(1)	43(1)	1(1)	-13(1)	-2(1)
I(101)	38(1)	37(1)	50(1)	-22(1)	-7(1)	-1(1)

Table 50. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10^3) for (*cis*)-**194b**.

	x	y	z	U(eq)
H(1A)	-345	1417	1740	42
H(1B)	752	796	871	42
H(2)	104	24	3049	34
H(3A)	2087	-1141	2670	34
H(3B)	2170	-988	1430	34
H(4)	215	-2071	3081	31
H(5A)	-1816	-882	3370	35
H(5B)	-2126	-1482	2501	35
H(7)	-3461	582	3791	33
H(8)	-4809	2140	3366	38
H(10)	-3343	1761	326	35

H(11)	-2017	184	767	38
H(12A)	-4074	3682	310	63
H(12B)	-5594	4177	615	63
H(12C)	-5180	2984	210	63
H(14)	392	-1936	386	38
H(15)	854	-3453	-569	47
H(16)	1515	-5193	177	46
H(17)	1678	-5438	1864	44
H(18)	1184	-3950	2840	36
H(10A)	3273	3625	5988	38
H(10B)	3864	4377	4941	38
H(102)	1235	4754	6246	32
H(10C)	718	5878	4827	33
H(10D)	2269	5924	4221	33
H(104)	836	6952	6078	31
H(10E)	1347	5852	7568	33
H(10F)	2560	6550	7399	33
H(107)	1574	3956	8255	34
H(108)	2812	2355	8782	36
H(110)	6113	3879	7668	37
H(111)	4866	5471	7161	34
H(11A)	4214	1104	9515	62
H(11B)	5575	454	8938	62
H(11C)	4451	878	8337	62
H(114)	4194	7036	4601	39
H(115)	5121	8628	3765	42
H(116)	3804	10318	3741	42
H(117)	1586	10432	4556	45
H(118)	649	8861	5417	37

Table 51. Torsion angles [°] for (*cis*)-**194b**.

I(1)-C(1)-C(2)-N(1)	-169.40(19)
I(1)-C(1)-C(2)-C(3)	-67.2(3)
N(1)-C(2)-C(3)-C(4)	-21.6(2)
C(1)-C(2)-C(3)-C(4)	-137.6(3)
C(2)-C(3)-C(4)-N(1)	21.7(2)
C(2)-C(3)-C(4)-C(13)	141.9(3)
N(1)-C(5)-C(6)-C(11)	49.7(4)
N(1)-C(5)-C(6)-C(7)	-131.2(3)
C(11)-C(6)-C(7)-C(8)	1.1(4)
C(5)-C(6)-C(7)-C(8)	-178.0(3)
C(6)-C(7)-C(8)-C(9)	-0.1(5)
C(7)-C(8)-C(9)-O(1)	178.8(3)
C(7)-C(8)-C(9)-C(10)	-1.4(5)
O(1)-C(9)-C(10)-C(11)	-178.3(3)
C(8)-C(9)-C(10)-C(11)	1.9(5)
C(9)-C(10)-C(11)-C(6)	-0.9(5)
C(7)-C(6)-C(11)-C(10)	-0.6(5)
C(5)-C(6)-C(11)-C(10)	178.4(3)
N(1)-C(4)-C(13)-C(14)	27.4(4)
C(3)-C(4)-C(13)-C(14)	-77.1(4)
N(1)-C(4)-C(13)-C(18)	-154.5(3)
C(3)-C(4)-C(13)-C(18)	101.0(3)
C(18)-C(13)-C(14)-C(15)	-0.5(5)
C(4)-C(13)-C(14)-C(15)	177.6(3)
C(13)-C(14)-C(15)-C(16)	-0.4(5)
C(14)-C(15)-C(16)-C(17)	0.7(5)
C(15)-C(16)-C(17)-C(18)	-0.1(5)
C(16)-C(17)-C(18)-C(13)	-0.9(5)
C(14)-C(13)-C(18)-C(17)	1.2(5)
C(4)-C(13)-C(18)-C(17)	-176.9(3)
C(6)-C(5)-N(1)-C(2)	73.1(3)
C(6)-C(5)-N(1)-C(4)	176.9(2)
C(1)-C(2)-N(1)-C(5)	-96.7(3)
C(3)-C(2)-N(1)-C(5)	141.9(3)

C(1)-C(2)-N(1)-C(4)	143.9(3)
C(3)-C(2)-N(1)-C(4)	22.6(2)
C(13)-C(4)-N(1)-C(5)	94.1(3)
C(3)-C(4)-N(1)-C(5)	-143.0(2)
C(13)-C(4)-N(1)-C(2)	-145.2(3)
C(3)-C(4)-N(1)-C(2)	-22.3(2)
C(10)-C(9)-O(1)-C(12)	-9.0(5)
C(8)-C(9)-O(1)-C(12)	170.8(3)
I(101)-C(101)-C(102)-N(101)	-166.26(18)
I(101)-C(101)-C(102)-C(103)	-64.5(3)
N(101)-C(102)-C(103)-C(104)	-18.9(2)
C(101)-C(102)-C(103)-C(104)	-135.1(3)
C(102)-C(103)-C(104)-N(101)	18.9(2)
C(102)-C(103)-C(104)-C(113)	138.5(3)
N(101)-C(105)-C(106)-C(107)	-101.3(3)
N(101)-C(105)-C(106)-C(111)	74.4(3)
C(111)-C(106)-C(107)-C(108)	-0.7(4)
C(105)-C(106)-C(107)-C(108)	175.1(3)
C(106)-C(107)-C(108)-C(109)	-0.6(5)
C(107)-C(108)-C(109)-O(101)	-179.3(3)
C(107)-C(108)-C(109)-C(110)	1.7(5)
O(101)-C(109)-C(110)-C(111)	179.5(3)
C(108)-C(109)-C(110)-C(111)	-1.4(5)
C(109)-C(110)-C(111)-C(106)	0.0(5)
C(107)-C(106)-C(111)-C(110)	1.0(4)
C(105)-C(106)-C(111)-C(110)	-174.8(3)
N(101)-C(104)-C(113)-C(114)	36.8(4)
C(103)-C(104)-C(113)-C(114)	-66.9(4)
N(101)-C(104)-C(113)-C(118)	-146.2(3)
C(103)-C(104)-C(113)-C(118)	110.2(3)
C(118)-C(113)-C(114)-C(115)	0.0(5)
C(104)-C(113)-C(114)-C(115)	177.2(3)
C(113)-C(114)-C(115)-C(116)	-0.5(5)
C(114)-C(115)-C(116)-C(117)	0.3(5)
C(115)-C(116)-C(117)-C(118)	0.2(5)
C(116)-C(117)-C(118)-C(113)	-0.6(5)
C(114)-C(113)-C(118)-C(117)	0.5(5)
C(104)-C(113)-C(118)-C(117)	-176.6(3)
C(106)-C(105)-N(101)-C(102)	67.5(3)
C(106)-C(105)-N(101)-C(104)	173.1(2)
C(101)-C(102)-N(101)-C(105)	-99.1(3)
C(103)-C(102)-N(101)-C(105)	140.4(3)
C(101)-C(102)-N(101)-C(104)	140.2(3)
C(103)-C(102)-N(101)-C(104)	19.7(2)
C(113)-C(104)-N(101)-C(105)	97.8(3)
C(103)-C(104)-N(101)-C(105)	-140.6(2)
C(113)-C(104)-N(101)-C(102)	-141.2(2)
C(103)-C(104)-N(101)-C(102)	-19.6(2)
C(110)-C(109)-O(101)-C(112)	-170.7(3)
C(108)-C(109)-O(101)-C(112)	10.3(4)

Symmetry transformations used to generate equivalent atoms:

4.3.2 X-ray Crystallographic Information for Iodo-Pyrrolidine (*cis*)-195c

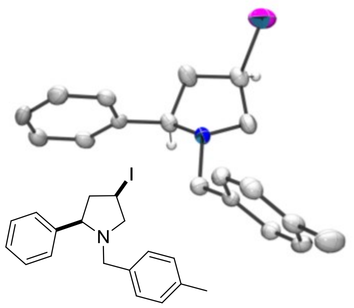


Table 52. Crystal data and structure refinement for (*cis*)-**195c**.

Identification code	(*cis*)-**195c**	
Empirical formula	$C_{18} H_{20} I N$	
Formula weight	377.25	
Temperature	120(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P 2(1)/n	
Unit cell dimensions	a = 6.9828(2) Å	α= 90°.
	b = 9.0924(5) Å	β= 93.829(3)°.
	c = 25.8129(12) Å	γ = 90°.
Volume	1635.21(13) $Å^3$	
Z	4	
Density (calculated)	1.532 Mg/m^3	
Absorption coefficient	1.949 mm^{-1}	
F(000)	752	
Crystal size	0.32 x 0.16 x 0.03 mm^3	
Theta range for data collection	2.98 to 27.48°.	
Index ranges	-8<=h<=9, -11<=k<=11, -33<=l<=33	
Reflections collected	18336	
Independent reflections	3720 [R(int) = 0.0551]	
Completeness to theta = 27.48°	99.8 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.9438 and 0.5743	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	3720 / 0 / 182	
Goodness-of-fit on F^2	1.057	
Final R indices [I>2sigma(I)]	R1 = 0.0503, wR2 = 0.1088	
R indices (all data)	R1 = 0.0875, wR2 = 0.1240	
Largest diff. peak and hole	1.462 and -1.456 e.$Å^{-3}$	

Table 53. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for (*cis*)-**195c**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
C(1)	2565(6)	2456(5)	858(2)	34(1)
C(2)	3957(7)	1389(5)	618(2)	38(1)
C(3)	4671(6)	376(5)	1073(2)	28(1)
C(4)	2539(7)	1998(5)	1422(2)	36(1)
C(5)	3556(6)	-139(5)	1932(2)	30(1)
C(6)	1780(6)	-286(5)	2235(2)	27(1)
C(7)	1568(6)	505(5)	2687(2)	28(1)
C(8)	-50(6)	328(5)	2965(2)	32(1)
C(9)	-1508(6)	-626(5)	2795(2)	31(1)
C(10)	-1308(6)	-1396(5)	2339(2)	35(1)
C(11)	312(6)	-1221(5)	2062(2)	31(1)
C(12)	-3232(7)	-856(6)	3109(2)	45(1)
C(13)	5101(6)	-1175(5)	910(2)	25(1)
C(14)	3605(6)	-2107(5)	742(2)	30(1)
C(15)	3978(7)	-3521(5)	584(2)	37(1)
C(16)	5845(8)	-4022(5)	587(2)	41(1)
C(17)	7340(7)	-3101(6)	750(2)	39(1)
C(18)	6976(6)	-1670(5)	909(2)	33(1)
N(1)	3065(5)	443(4)	1414(1)	26(1)
I(1)	-258(1)	2370(1)	469(1)	59(1)

Table 54. Bond lengths [Å] and angles [°] for (*cis*)-**195c.**

C(1)-C(4)	1.514(7)
C(1)-C(2)	1.534(6)
C(1)-I(1)	2.154(4)
C(1)-H(1)	1.0000
C(2)-C(3)	1.549(6)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-N(1)	1.472(5)
C(3)-C(13)	1.507(6)
C(3)-H(3)	1.0000
C(4)-N(1)	1.461(5)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(5)-N(1)	1.459(5)
C(5)-C(6)	1.515(6)
C(5)-H(5A)	0.9900
C(5)-H(5B)	0.9900
C(6)-C(11)	1.383(6)
C(6)-C(7)	1.386(6)
C(7)-C(8)	1.387(6)
C(7)-H(7)	0.9500
C(8)-C(9)	1.386(6)
C(8)-H(8)	0.9500
C(9)-C(10)	1.383(6)
C(9)-C(12)	1.511(6)
C(10)-C(11)	1.388(6)
C(10)-H(10)	0.9500
C(11)-H(11)	0.9500
C(12)-H(12A)	0.9800
C(12)-H(12B)	0.9800
C(12)-H(12C)	0.9800
C(13)-C(18)	1.384(6)
C(13)-C(14)	1.392(6)
C(14)-C(15)	1.379(6)
C(14)-H(14)	0.9500
C(15)-C(16)	1.381(7)
C(15)-H(15)	0.9500
C(16)-C(17)	1.382(7)
C(16)-H(16)	0.9500
C(17)-C(18)	1.393(7)
C(17)-H(17)	0.9500
C(18)-H(18)	0.9500
C(4)-C(1)-C(2)	105.3(4)
C(4)-C(1)-I(1)	111.7(3)
C(2)-C(1)-I(1)	111.9(3)
C(4)-C(1)-H(1)	109.3
C(2)-C(1)-H(1)	109.3
I(1)-C(1)-H(1)	109.3
C(1)-C(2)-C(3)	104.5(4)
C(1)-C(2)-H(2A)	110.9
C(3)-C(2)-H(2A)	110.9
C(1)-C(2)-H(2B)	110.9
C(3)-C(2)-H(2B)	110.9
H(2A)-C(2)-H(2B)	108.9
N(1)-C(3)-C(13)	112.3(3)
N(1)-C(3)-C(2)	102.0(3)
C(13)-C(3)-C(2)	113.9(4)
N(1)-C(3)-H(3)	109.5
C(13)-C(3)-H(3)	109.5
C(2)-C(3)-H(3)	109.5
N(1)-C(4)-C(1)	103.5(4)
N(1)-C(4)-H(4A)	111.1
C(1)-C(4)-H(4A)	111.1
N(1)-C(4)-H(4B)	111.1
C(1)-C(4)-H(4B)	111.1
H(4A)-C(4)-H(4B)	109.0
N(1)-C(5)-C(6)	110.8(3)
N(1)-C(5)-H(5A)	109.5
C(6)-C(5)-H(5A)	109.5
N(1)-C(5)-H(5B)	109.5
C(6)-C(5)-H(5B)	109.5

H(5A)-C(5)-H(5B)	108.1
C(11)-C(6)-C(7)	118.2(4)
C(11)-C(6)-C(5)	120.1(4)
C(7)-C(6)-C(5)	121.7(4)
C(6)-C(7)-C(8)	120.8(4)
C(6)-C(7)-H(7)	119.6
C(8)-C(7)-H(7)	119.6
C(9)-C(8)-C(7)	121.0(4)
C(9)-C(8)-H(8)	119.5
C(7)-C(8)-H(8)	119.5
C(10)-C(9)-C(8)	118.2(4)
C(10)-C(9)-C(12)	121.1(4)
C(8)-C(9)-C(12)	120.7(4)
C(9)-C(10)-C(11)	120.8(4)
C(9)-C(10)-H(10)	119.6
C(11)-C(10)-H(10)	119.6
C(6)-C(11)-C(10)	121.1(4)
C(6)-C(11)-H(11)	119.5
C(10)-C(11)-H(11)	119.5
C(9)-C(12)-H(12A)	109.5
C(9)-C(12)-H(12B)	109.5
H(12A)-C(12)-H(12B)	109.5
C(9)-C(12)-H(12C)	109.5
H(12A)-C(12)-H(12C)	109.5
H(12B)-C(12)-H(12C)	109.5
C(18)-C(13)-C(14)	119.5(4)
C(18)-C(13)-C(3)	120.7(4)
C(14)-C(13)-C(3)	119.8(4)
C(15)-C(14)-C(13)	120.5(4)
C(15)-C(14)-H(14)	119.8
C(13)-C(14)-H(14)	119.8
C(14)-C(15)-C(16)	120.2(5)
C(14)-C(15)-H(15)	119.9
C(16)-C(15)-H(15)	119.9
C(15)-C(16)-C(17)	119.7(4)
C(15)-C(16)-H(16)	120.1
C(17)-C(16)-H(16)	120.1
C(16)-C(17)-C(18)	120.4(4)
C(16)-C(17)-H(17)	119.8
C(18)-C(17)-H(17)	119.8
C(13)-C(18)-C(17)	119.7(4)
C(13)-C(18)-H(18)	120.1
C(17)-C(18)-H(18)	120.1
C(5)-N(1)-C(4)	112.4(3)
C(5)-N(1)-C(3)	113.1(3)
C(4)-N(1)-C(3)	104.6(3)

Symmetry transformations used to generate equivalent atoms:

Table 55. Anisotropic displacement parameters ($Å^2$x 10^3) for (*cis*)-**195c**. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
C(1)	28(2)	31(3)	42(3)	3(2)	1(2)	0(2)
C(2)	35(3)	37(3)	43(3)	11(2)	12(2)	7(2)
C(3)	26(2)	26(2)	34(2)	3(2)	3(2)	2(2)
C(4)	31(2)	34(3)	42(3)	-4(2)	-3(2)	9(2)
C(5)	25(2)	36(3)	29(2)	0(2)	2(2)	4(2)
C(6)	29(2)	26(2)	24(2)	1(2)	-3(2)	5(2)
C(7)	29(2)	27(2)	27(2)	-1(2)	-1(2)	-2(2)
C(8)	36(2)	37(3)	22(2)	3(2)	1(2)	4(2)
C(9)	24(2)	38(3)	31(2)	10(2)	2(2)	2(2)
C(10)	29(2)	35(3)	40(3)	1(2)	-6(2)	1(2)
C(11)	32(2)	34(3)	27(2)	-8(2)	-4(2)	6(2)
C(12)	36(3)	64(4)	36(3)	12(3)	5(2)	-2(2)
C(13)	28(2)	29(2)	18(2)	2(2)	5(2)	4(2)
C(14)	30(2)	33(3)	25(2)	4(2)	2(2)	5(2)
C(15)	51(3)	29(3)	29(2)	1(2)	0(2)	0(2)
C(16)	68(4)	30(3)	24(2)	-3(2)	6(2)	16(2)
C(17)	44(3)	44(3)	28(3)	6(2)	6(2)	17(2)
C(18)	31(2)	40(3)	28(2)	7(2)	4(2)	5(2)
N(1)	28(2)	25(2)	25(2)	1(2)	3(2)	6(2)
I(1)	33(1)	109(1)	34(1)	6(1)	4(1)	15(1)

Table 56. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for (*cis*)-**195c**.

	x	y	z	U(eq)
H(1)	3079	3480	839	41
H(2A)	5041	1927	477	45
H(2B)	3292	811	335	45
H(3)	5843	814	1256	34
H(4A)	3480	2570	1643	43
H(4B)	1247	2131	1551	43
H(5A)	4484	528	2120	36
H(5B)	4172	-1113	1904	36
H(7)	2541	1176	2807	33
H(8)	-160	868	3276	38
H(10)	-2293	-2053	2215	42
H(11)	415	-1753	1748	38
H(12A)	-4265	-1320	2891	68
H(12B)	-3672	96	3234	68
H(12C)	-2877	-1493	3406	68
H(14)	2317	-1766	736	35
H(15)	2947	-4152	472	44
H(16)	6101	-4997	478	49
H(17)	8625	-3446	753	46
H(18)	8009	-1036	1016	39

Table 57. Torsion angles [°] for (*cis*)-**195c**.

C(4)-C(1)-C(2)-C(3)	-0.7(5)
I(1)-C(1)-C(2)-C(3)	-122.1(3)
C(1)-C(2)-C(3)-N(1)	26.3(4)
C(1)-C(2)-C(3)-C(13)	147.6(4)
C(2)-C(1)-C(4)-N(1)	-25.6(5)
I(1)-C(1)-C(4)-N(1)	96.0(3)
N(1)-C(5)-C(6)-C(11)	62.3(5)
N(1)-C(5)-C(6)-C(7)	-117.4(4)
C(11)-C(6)-C(7)-C(8)	1.8(6)
C(5)-C(6)-C(7)-C(8)	-178.4(4)
C(6)-C(7)-C(8)-C(9)	-1.0(6)
C(7)-C(8)-C(9)-C(10)	-0.1(6)
C(7)-C(8)-C(9)-C(12)	177.8(4)
C(8)-C(9)-C(10)-C(11)	0.3(7)
C(12)-C(9)-C(10)-C(11)	-177.6(4)
C(7)-C(6)-C(11)-C(10)	-1.7(6)
C(5)-C(6)-C(11)-C(10)	178.6(4)
C(9)-C(10)-C(11)-C(6)	0.6(7)
N(1)-C(3)-C(13)-C(18)	-136.7(4)
C(2)-C(3)-C(13)-C(18)	107.9(5)
N(1)-C(3)-C(13)-C(14)	45.4(5)
C(2)-C(3)-C(13)-C(14)	-70.0(5)
C(18)-C(13)-C(14)-C(15)	1.1(6)
C(3)-C(13)-C(14)-C(15)	179.0(4)
C(13)-C(14)-C(15)-C(16)	-0.4(7)
C(14)-C(15)-C(16)-C(17)	0.0(7)
C(15)-C(16)-C(17)-C(18)	-0.2(7)
C(14)-C(13)-C(18)-C(17)	-1.3(6)
C(3)-C(13)-C(18)-C(17)	-179.1(4)
C(16)-C(17)-C(18)-C(13)	0.8(7)
C(6)-C(5)-N(1)-C(4)	71.6(5)
C(6)-C(5)-N(1)-C(3)	-170.3(3)
C(1)-C(4)-N(1)-C(5)	166.8(3)
C(1)-C(4)-N(1)-C(3)	43.8(4)
C(13)-C(3)-N(1)-C(5)	71.5(4)
C(2)-C(3)-N(1)-C(5)	-166.2(4)
C(13)-C(3)-N(1)-C(4)	-165.9(3)
C(2)-C(3)-N(1)-C(4)	-43.6(4)

Symmetry transformations used to generate equivalent atoms:

4.3.1 X-ray Crystallographic Information for Pt(II)-amino-azetidine complex 213aaa

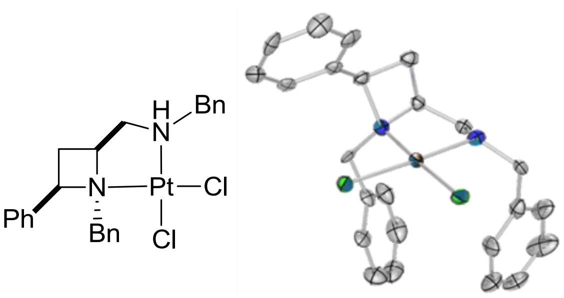


Table 58. Crystal data and structure refinement for **2193aaa**.

Identification code	**213aaa**	
Empirical formula	$C_{24}H_{26}Cl_2N_2Pt$, C_2H_3N	
Formula weight	649.51	
Temperature	120(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P 2(1)	
Unit cell dimensions	a = 10.6958(2) Å	α= 90°.
	b = 10.4600(2) Å	β= 93.9630(10)°.
	c = 43.9267(10) Å	γ = 90°.
Volume	4902.68(17) Å^3	
Z, Z'	8, 4	
Density (calculated)	1.760 Mg/m^3	
Absorption coefficient	5.961 mm^{-1}	
F(000)	2544	
Crystal size	0.16 x 0.12 x 0.10 mm^3	
Theta range for data collection	2.92 to 25.03°.	
Index ranges	-12<=h<=12, -12<=k<=12, -52<=l<=52	
Reflections collected	44832	
Independent reflections	16268 [R(int) = 0.1064]	
Completeness to theta = 25.03°	97.1 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.5871 and 0.4489	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	16268 / 277 / 1165	
Goodness-of-fit on F^2	1.043	
Final R indices [I>2sigma(I)]	R1 = 0.0623, wR2 = 0.0856	
R indices (all data)	R1 = 0.0871, wR2 = 0.0908	
Absolute structure parameter	0.041(7)	
Largest diff. peak and hole	1.236 and -1.882 e.Å^{-3}	

Notes: The structure contains four crystallographically-independent platinum complexes with one acetonitrile molecule per platinum complex.

The hydrogen atoms bonded to N(2), N(102), N(202) and N(302) (one per crystallographically-independent platinum complex) were located in the electron density and their positions refined subject to suitable distance restraints, (N-H = 0.91 (2) Å and Pd … H = 2.48 (4) Å and C(104)-H(12C) = C(112)-H(12C) = 1.92 (4) Å). The isotropic thermal parameters (U_{iso}) of these hydrogen atoms were set at 1.2 times the equivalent isotropic thermal parameter (U_{eq}) of the parent nitrogen atom. All remaining hydrogen atoms were fixed as riding models. The hydrogen bonding is detailed in Table 7, page 33 of this document.

Table 59. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for **213aaa**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
C(1)	4373(10)	1349(10)	4311(2)	24(2)
C(2)	4417(10)	2692(10)	4176(2)	27(2)
C(3)	3934(9)	2097(9)	3869(2)	22(2)
C(4)	4454(8)	2506(10)	3573(2)	21(2)
C(5)	3592(9)	-336(10)	3927(2)	23(2)
C(6)	3359(9)	-760(10)	3599(3)	24(2)
C(7)	2369(11)	-234(11)	3425(3)	38(3)
C(8)	2076(12)	-718(13)	3140(3)	45(3)
C(9)	2752(13)	-1712(13)	3016(3)	47(3)
C(10)	3747(12)	-2219(12)	3197(3)	42(3)
C(11)	4045(10)	-1746(10)	3489(3)	28(3)
C(12)	6385(10)	2546(10)	3294(2)	26(2)
C(13)	5763(10)	1802(10)	3029(2)	29(2)
C(14)	5900(11)	505(11)	2994(2)	38(3)
C(15)	5379(13)	-131(12)	2743(3)	50(3)
C(16)	4645(11)	482(14)	2522(3)	47(3)
C(17)	4538(14)	1797(13)	2549(3)	60(4)
C(18)	5077(11)	2434(12)	2803(2)	45(3)
C(19)	5241(9)	865(9)	4566(2)	20(2)
C(20)	5029(9)	-339(9)	4688(2)	21(2)
C(21)	5781(10)	-815(10)	4933(2)	28(2)
C(22)	6736(11)	-71(11)	5062(3)	32(3)
C(23)	6952(10)	1112(12)	4950(3)	35(3)
C(24)	6217(9)	1582(11)	4697(2)	29(3)
N(1)	4432(7)	792(8)	3982(2)	24(2)
N(2)	5836(7)	2299(9)	3598(2)	22(2)
Cl(1)	6644(2)	-1248(2)	4098(1)	22(1)
Cl(2)	8233(2)	506(3)	3661(1)	23(1)
Pt(1)	6231(1)	612(1)	3828(1)	18(1)
C(101)	8463(9)	1280(11)	684(2)	23(2)
C(102)	7203(9)	1239(12)	828(2)	23(2)
C(103)	7907(9)	1661(10)	1127(2)	20(2)
C(104)	7656(10)	1083(11)	1427(3)	24(3)
C(105)	10241(9)	2079(10)	1043(3)	24(3)
C(106)	10727(10)	2330(12)	1369(2)	26(3)
C(107)	10204(10)	3265(12)	1541(3)	31(3)
C(108)	10681(12)	3548(13)	1831(3)	46(4)
C(109)	11707(14)	2872(13)	1948(3)	48(4)
C(110)	12296(13)	1988(12)	1785(3)	42(3)
C(111)	11791(11)	1662(11)	1497(3)	30(3)
C(112)	7735(9)	-922(10)	1724(3)	26(3)
C(113)	8519(11)	-301(11)	1983(3)	35(3)
C(114)	9816(10)	-463(13)	2007(3)	33(3)
C(115)	10502(13)	72(13)	2252(3)	47(4)
C(116)	9906(14)	759(14)	2473(3)	50(3)
C(117)	8646(14)	898(13)	2456(3)	52(4)
C(118)	7936(12)	348(13)	2204(3)	46(3)
C(119)	8776(9)	454(11)	425(2)	24(2)
C(120)	9948(10)	538(13)	311(2)	31(2)
C(121)	10247(13)	-155(13)	53(3)	44(3)

C(122)	9379(13)	-889(12)	-95(3)	42(3)
C(123)	8158(14)	-979(11)	9(3)	43(3)
C(124)	7889(12)	-328(10)	271(3)	32(3)
N(101)	9140(7)	1207(9)	1007(2)	19(2)
N(102)	7885(8)	-311(8)	1416(2)	23(2)
Cl(11)	11247(2)	-933(2)	925(1)	24(1)
Cl(12)	9695(2)	-2689(3)	1372(1)	25(1)
Pt(11)	9460(1)	-628(1)	1182(1)	18(1)
C(201)	10235(9)	6385(9)	4329(2)	21(2)
C(202)	10125(9)	7742(9)	4193(2)	22(2)
C(203)	10465(9)	7148(9)	3887(2)	20(2)
C(204)	9800(9)	7546(10)	3593(2)	25(2)
C(205)	10859(10)	4721(10)	3951(2)	26(3)
C(206)	10967(9)	4322(12)	3628(3)	27(3)
C(207)	10290(10)	3250(10)	3506(3)	27(3)
C(208)	10498(12)	2819(11)	3215(3)	38(3)
C(209)	11370(12)	3405(11)	3043(3)	38(3)
C(210)	12030(11)	4483(13)	3157(3)	41(3)
C(211)	11818(10)	4906(11)	3454(3)	29(3)
C(212)	7764(9)	7516(10)	3288(2)	24(2)
C(213)	8259(9)	6793(11)	3033(2)	26(2)
C(214)	8107(10)	5459(12)	3012(3)	34(3)
C(215)	8533(14)	4787(13)	2770(3)	50(4)
C(216)	9143(13)	5462(18)	2543(3)	59(4)
C(217)	9278(15)	6752(17)	2556(3)	65(4)
C(218)	8825(10)	7419(12)	2801(3)	36(3)
C(219)	9506(8)	5875(9)	4575(2)	20(2)
C(220)	9776(9)	4686(10)	4706(2)	26(2)
C(221)	9156(10)	4170(11)	4944(3)	31(3)
C(222)	8256(11)	4937(13)	5070(3)	39(3)
C(223)	7985(10)	6138(13)	4956(2)	33(3)
C(224)	8584(10)	6617(11)	4709(2)	29(3)
N(201)	10011(7)	5842(7)	4002(2)	19(2)
N(202)	8438(7)	7286(9)	3601(2)	21(2)
Cl(21)	7889(2)	3754(2)	4099(1)	22(1)
Cl(22)	6077(2)	5499(3)	3654(1)	23(1)
Pt(21)	8162(1)	5625(1)	3833(1)	17(1)
C(301)	3462(9)	5499(12)	688(2)	21(2)
C(302)	2201(8)	5561(14)	834(2)	26(2)
C(303)	2923(9)	5114(10)	1134(2)	21(2)
C(304)	2658(8)	5689(11)	1430(2)	17(2)
C(305)	5271(9)	4732(10)	1048(3)	26(3)
C(306)	5777(9)	4509(11)	1373(2)	22(2)
C(307)	6754(10)	5227(12)	1503(3)	36(3)
C(308)	7255(14)	5001(13)	1789(3)	50(4)
C(309)	6758(14)	3980(13)	1967(3)	50(4)
C(310)	5765(13)	3288(14)	1840(3)	47(4)
C(311)	5274(12)	3518(12)	1535(3)	38(3)
C(312)	2719(10)	7685(11)	1731(2)	26(3)
C(313)	3536(9)	7139(10)	1986(2)	21(2)
C(314)	4823(10)	7403(13)	2031(3)	35(3)
C(315)	5571(12)	6879(12)	2274(3)	39(3)
C(316)	5066(12)	6087(13)	2477(3)	46(3)
C(317)	3815(12)	5783(14)	2432(3)	47(3)
C(318)	3067(11)	6317(14)	2195(3)	40(3)
C(319)	3806(10)	6380(10)	435(2)	24(3)
C(320)	4997(11)	6275(12)	318(2)	32(3)
C(321)	5268(12)	6945(12)	63(3)	36(3)
C(322)	4336(14)	7717(12)	-91(3)	46(4)
C(323)	3178(13)	7787(12)	16(3)	41(3)
C(324)	2891(12)	7112(10)	276(3)	33(3)
N(301)	4155(7)	5613(10)	1010(2)	20(1)
N(302)	2888(8)	7111(9)	1424(2)	24(2)
Cl(31)	6230(2)	7767(2)	924(1)	23(1)
Cl(32)	4663(2)	9527(2)	1372(1)	25(1)
Pt(31)	4451(1)	7448(1)	1187(1)	18(1)
C(401)	3472(11)	1302(14)	642(3)	31(3)
N(401)	3093(11)	2284(11)	690(3)	52(3)

C(402)	3953(11)	74(12)	576(3)	33(3)
C(501)	4321(11)	6358(11)	4315(2)	28(3)
C(502)	5562(9)	6008(10)	4441(3)	29(3)
N(501)	3349(10)	6666(11)	4220(3)	52(3)
C(601)	8457(10)	5490(13)	639(2)	25(2)
C(602)	8921(11)	6786(10)	583(3)	32(3)
N(601)	8061(10)	4483(11)	681(3)	49(3)
C(701)	300(10)	1384(10)	4311(3)	26(2)
C(702)	-849(9)	1030(10)	4449(3)	28(3)
N(701)	1207(9)	1620(10)	4211(3)	47(3)

Table 60. Bond lengths [Å] and angles [°] for **213aaa**.

C(1)-C(19)	1.495(15)
C(1)-C(2)	1.526(15)
C(1)-N(1)	1.564(12)
C(1)-H(1)	1.0000
C(2)-C(3)	1.545(15)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-C(4)	1.511(13)
C(3)-N(1)	1.535(13)
C(3)-H(3)	1.0000
C(4)-N(2)	1.491(12)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(5)-N(1)	1.492(13)
C(5)-C(6)	1.513(15)
C(5)-H(5A)	0.9900
C(5)-H(5B)	0.9900
C(6)-C(11)	1.373(15)
C(6)-C(7)	1.377(16)
C(7)-C(8)	1.367(18)
C(7)-H(7)	0.9500
C(8)-C(9)	1.397(18)
C(8)-H(8)	0.9500
C(9)-C(10)	1.387(18)
C(9)-H(9)	0.9500
C(10)-C(11)	1.391(16)
C(10)-H(10)	0.9500
C(11)-H(11)	0.9500
C(12)-C(13)	1.515(15)
C(12)-N(2)	1.517(13)
C(12)-H(12A)	0.9900
C(12)-H(12B)	0.9900
C(13)-C(18)	1.363(12)
C(13)-C(14)	1.374(13)
C(14)-C(15)	1.374(13)
C(14)-H(14)	0.9500
C(15)-C(16)	1.365(14)
C(15)-H(15)	0.9500
C(16)-C(17)	1.385(14)
C(16)-H(16)	0.9500
C(17)-C(18)	1.390(14)
C(17)-H(17)	0.9500
C(18)-H(18)	0.9500
C(19)-C(24)	1.378(14)
C(19)-C(20)	1.392(13)
C(20)-C(21)	1.392(15)
C(20)-H(20)	0.9500
C(21)-C(22)	1.375(16)
C(21)-H(21)	0.9500
C(22)-C(23)	1.359(16)
C(22)-H(22)	0.9500
C(23)-C(24)	1.403(16)
C(23)-H(23)	0.9500
C(24)-H(24)	0.9500
N(1)-Pt(1)	2.092(7)
N(2)-Pt(1)	2.062(9)
N(2)-H(2C)	0.92(2)
Cl(1)-Pt(1)	2.306(2)
Cl(2)-Pt(1)	2.314(2)
C(101)-C(119)	1.486(15)
C(101)-C(102)	1.529(14)
C(101)-N(101)	1.547(13)
C(101)-H(101)	1.0000
C(102)-C(103)	1.532(14)
C(102)-H(10A)	0.9900
C(102)-H(10B)	0.9900
C(103)-C(104)	1.492(15)
C(103)-N(101)	1.530(12)
C(103)-H(103)	1.0000
C(104)-N(102)	1.479(14)
C(104)-H(10C)	0.9900
C(104)-H(10D)	0.9900
C(105)-N(101)	1.490(13)
C(105)-C(106)	1.512(15)
C(105)-H(10E)	0.9900
C(105)-H(10F)	0.9900
C(106)-C(107)	1.378(16)
C(106)-C(111)	1.419(16)
C(107)-C(108)	1.374(18)
C(107)-H(107)	0.9500
C(108)-C(109)	1.38(2)
C(108)-H(108)	0.9500
C(109)-C(110)	1.352(18)
C(109)-H(109)	0.9500
C(110)-C(111)	1.383(17)
C(110)-H(110)	0.9500
C(111)-H(111)	0.9500
C(112)-C(113)	1.511(17)
C(112)-N(102)	1.516(14)
C(112)-H(11A)	0.9900
C(112)-H(11B)	0.9900
C(113)-C(118)	1.369(16)
C(113)-C(114)	1.394(16)
C(114)-C(115)	1.379(17)
C(114)-H(114)	0.9500
C(115)-C(116)	1.395(18)
C(115)-H(115)	0.9500
C(116)-C(117)	1.352(18)
C(116)-H(116)	0.9500
C(117)-C(118)	1.419(19)
C(117)-H(117)	0.9500
C(118)-H(118)	0.9500
C(119)-C(120)	1.385(13)
C(119)-C(124)	1.392(16)
C(120)-C(121)	1.398(18)
C(120)-H(120)	0.9500

C(121)-C(122)	1.339(19)
C(121)-H(121)	0.9500
C(122)-C(123)	1.416(19)
C(122)-H(122)	0.9500
C(123)-C(124)	1.382(16)
C(123)-H(123)	0.9500
C(124)-H(124)	0.9500
N(101)-Pt(11)	2.088(9)
N(102)-Pt(11)	2.060(9)
N(102)-H(12C)	0.901(18)
Cl(11)-Pt(11)	2.309(2)
Cl(12)-Pt(11)	2.319(3)
C(201)-C(219)	1.476(13)
C(201)-C(202)	1.541(14)
C(201)-N(201)	1.549(12)
C(201)-H(201)	1.0000
C(202)-C(203)	1.547(14)
C(202)-H(20A)	0.9900
C(202)-H(20B)	0.9900
C(203)-C(204)	1.491(14)
C(203)-N(201)	1.545(11)
C(203)-H(203)	1.0000
C(204)-N(202)	1.484(12)
C(204)-H(20C)	0.9900
C(204)-H(20D)	0.9900
C(205)-C(206)	1.493(15)
C(205)-N(201)	1.508(12)
C(205)-H(20E)	0.9900
C(205)-H(20F)	0.9900
C(206)-C(211)	1.372(14)
C(206)-C(207)	1.419(16)
C(207)-C(208)	1.388(15)
C(207)-H(207)	0.9500
C(208)-C(209)	1.383(16)
C(208)-H(208)	0.9500
C(209)-C(210)	1.403(17)
C(209)-H(209)	0.9500
C(210)-C(211)	1.409(16)
C(210)-H(210)	0.9500
C(211)-H(211)	0.9500
C(212)-C(213)	1.480(14)
C(212)-N(202)	1.526(13)
C(212)-H(21A)	0.9900
C(212)-H(21B)	0.9900
C(213)-C(218)	1.383(14)
C(213)-C(214)	1.406(16)
C(214)-C(215)	1.377(15)
C(214)-H(214)	0.9500
C(215)-C(216)	1.420(19)
C(215)-H(215)	0.9500
C(216)-C(217)	1.36(2)
C(216)-H(216)	0.9500
C(217)-C(218)	1.397(18)
C(217)-H(217)	0.9500
C(218)-H(218)	0.9500
C(219)-C(220)	1.391(14)
C(219)-C(224)	1.413(13)
C(220)-C(221)	1.389(15)
C(220)-H(220)	0.9500
C(221)-C(222)	1.396(16)
C(221)-H(221)	0.9500
C(222)-C(223)	1.375(17)
C(222)-H(222)	0.9500
C(223)-C(224)	1.393(15)
C(223)-H(223)	0.9500
C(224)-H(224)	0.9500
N(201)-Pt(21)	2.075(8)
N(202)-Pt(21)	2.047(9)
N(202)-H(22C)	0.91(2)
Cl(21)-Pt(21)	2.308(2)
Cl(22)-Pt(21)	2.317(2)
C(301)-C(319)	1.508(15)
C(301)-C(302)	1.532(12)
C(301)-N(301)	1.554(12)
C(301)-H(301)	1.0000
C(302)-C(303)	1.556(14)
C(302)-H(30A)	0.9900
C(302)-H(30B)	0.9900
C(303)-C(304)	1.476(13)
C(303)-N(301)	1.552(12)
C(303)-H(303)	1.0000
C(304)-N(302)	1.508(14)
C(304)-H(30C)	0.9900
C(304)-H(30D)	0.9900
C(305)-N(301)	1.508(13)
C(305)-C(306)	1.512(15)
C(305)-H(30E)	0.9900
C(305)-H(30F)	0.9900
C(306)-C(307)	1.377(16)
C(306)-C(311)	1.387(16)
C(307)-C(308)	1.352(18)
C(307)-H(307)	0.9500
C(308)-C(309)	1.448(19)
C(308)-H(308)	0.9500
C(309)-C(310)	1.37(2)
C(309)-H(309)	0.9500
C(310)-C(311)	1.426(18)
C(310)-H(310)	0.9500
C(311)-H(311)	0.9500
C(312)-C(313)	1.489(15)
C(312)-N(302)	1.496(13)
C(312)-H(31A)	0.9900
C(312)-H(31B)	0.9900
C(313)-C(318)	1.376(15)
C(313)-C(314)	1.404(15)
C(314)-C(315)	1.401(17)
C(314)-H(314)	0.9500
C(315)-C(316)	1.357(17)
C(315)-H(315)	0.9500
C(316)-C(317)	1.376(17)
C(316)-H(316)	0.9500
C(317)-C(318)	1.386(17)
C(317)-H(317)	0.9500
C(318)-H(318)	0.9500
C(319)-C(324)	1.393(16)
C(319)-C(320)	1.411(15)
C(320)-C(321)	1.369(16)
C(320)-H(320)	0.9500
C(321)-C(322)	1.417(19)
C(321)-H(321)	0.9500
C(322)-C(323)	1.356(18)
C(322)-H(322)	0.9500
C(323)-C(324)	1.395(16)
C(323)-H(323)	0.9500
C(324)-H(324)	0.9500
N(301)-Pt(31)	2.087(10)
N(302)-Pt(31)	2.061(9)
N(302)-H(32C)	0.91(2)
Cl(31)-Pt(31)	2.317(2)
Cl(32)-Pt(31)	2.327(3)
C(401)-N(401)	1.130(16)
C(401)-C(402)	1.420(17)
C(402)-H(40A)	0.9800
C(402)-H(40B)	0.9800
C(402)-H(40C)	0.9800
C(501)-N(501)	1.140(14)

C(501)-C(502)	1.450(16)
C(502)-H(50A)	0.9800
C(502)-H(50B)	0.9800
C(502)-H(50C)	0.9800
C(601)-N(601)	1.154(16)
C(601)-C(602)	1.470(16)
C(602)-H(60A)	0.9800
C(602)-H(60B)	0.9800
C(602)-H(60C)	0.9800
C(701)-N(701)	1.121(13)
C(701)-C(702)	1.455(14)
C(702)-H(70A)	0.9800
C(702)-H(70B)	0.9800
C(702)-H(70C)	0.9800
C(19)-C(1)-C(2)	124.6(9)
C(19)-C(1)-N(1)	120.3(8)
C(2)-C(1)-N(1)	88.9(7)
C(19)-C(1)-H(1)	107.0
C(2)-C(1)-H(1)	107.0
N(1)-C(1)-H(1)	107.0
C(1)-C(2)-C(3)	87.1(8)
C(1)-C(2)-H(2A)	114.1
C(3)-C(2)-H(2A)	114.1
C(1)-C(2)-H(2B)	114.1
C(3)-C(2)-H(2B)	114.1
H(2A)-C(2)-H(2B)	111.3
C(4)-C(3)-N(1)	112.9(8)
C(4)-C(3)-C(2)	121.2(8)
N(1)-C(3)-C(2)	89.3(8)
C(4)-C(3)-H(3)	110.5
N(1)-C(3)-H(3)	110.5
C(2)-C(3)-H(3)	110.5
N(2)-C(4)-C(3)	108.4(8)
N(2)-C(4)-H(4A)	110.0
C(3)-C(4)-H(4A)	110.0
N(2)-C(4)-H(4B)	110.0
C(3)-C(4)-H(4B)	110.0
H(4A)-C(4)-H(4B)	108.4
N(1)-C(5)-C(6)	116.3(8)
N(1)-C(5)-H(5A)	108.2
C(6)-C(5)-H(5A)	108.2
N(1)-C(5)-H(5B)	108.2
C(6)-C(5)-H(5B)	108.2
H(5A)-C(5)-H(5B)	107.4
C(11)-C(6)-C(7)	120.9(11)
C(11)-C(6)-C(5)	120.0(10)
C(7)-C(6)-C(5)	118.8(10)
C(8)-C(7)-C(6)	118.6(12)
C(8)-C(7)-H(7)	120.7
C(6)-C(7)-H(7)	120.7
C(7)-C(8)-C(9)	122.6(12)
C(7)-C(8)-H(8)	118.7
C(9)-C(8)-H(8)	118.7
C(10)-C(9)-C(8)	117.3(12)
C(10)-C(9)-H(9)	121.3
C(8)-C(9)-H(9)	121.3
C(9)-C(10)-C(11)	120.6(12)
C(9)-C(10)-H(10)	119.7
C(11)-C(10)-H(10)	119.7
C(6)-C(11)-C(10)	119.8(11)
C(6)-C(11)-H(11)	120.1
C(10)-C(11)-H(11)	120.1
C(13)-C(12)-N(2)	114.4(8)
C(13)-C(12)-H(12A)	108.7
N(2)-C(12)-H(12A)	108.7
C(13)-C(12)-H(12B)	108.7
N(2)-C(12)-H(12B)	108.7
H(12A)-C(12)-H(12B)	107.6
C(18)-C(13)-C(14)	117.0(11)
C(18)-C(13)-C(12)	119.8(10)
C(14)-C(13)-C(12)	123.2(9)
C(15)-C(14)-C(13)	121.8(11)
C(15)-C(14)-H(14)	119.1
C(13)-C(14)-H(14)	119.1
C(16)-C(15)-C(14)	121.7(12)
C(16)-C(15)-H(15)	119.2
C(14)-C(15)-H(15)	119.2
C(15)-C(16)-C(17)	116.8(12)
C(15)-C(16)-H(16)	121.6
C(17)-C(16)-H(16)	121.6
C(16)-C(17)-C(18)	120.9(12)
C(16)-C(17)-H(17)	119.6
C(18)-C(17)-H(17)	119.6
C(13)-C(18)-C(17)	121.6(12)
C(13)-C(18)-H(18)	119.2
C(17)-C(18)-H(18)	119.2
C(24)-C(19)-C(20)	118.1(10)
C(24)-C(19)-C(1)	122.8(9)
C(20)-C(19)-C(1)	119.0(9)
C(21)-C(20)-C(19)	121.3(10)
C(21)-C(20)-H(20)	119.4
C(19)-C(20)-H(20)	119.4
C(22)-C(21)-C(20)	119.4(10)
C(22)-C(21)-H(21)	120.3
C(20)-C(21)-H(21)	120.3
C(23)-C(22)-C(21)	120.3(12)
C(23)-C(22)-H(22)	119.8
C(21)-C(22)-H(22)	119.8
C(22)-C(23)-C(24)	120.5(12)
C(22)-C(23)-H(23)	119.8
C(24)-C(23)-H(23)	119.8
C(19)-C(24)-C(23)	120.4(11)
C(19)-C(24)-H(24)	119.8
C(23)-C(24)-H(24)	119.8
C(5)-N(1)-C(3)	117.3(8)
C(5)-N(1)-C(1)	112.4(7)
C(3)-N(1)-C(1)	86.1(7)
C(5)-N(1)-Pt(1)	115.7(6)
C(3)-N(1)-Pt(1)	106.4(5)
C(1)-N(1)-Pt(1)	115.4(6)
C(4)-N(2)-C(12)	110.6(8)
C(4)-N(2)-Pt(1)	109.3(6)
C(12)-N(2)-Pt(1)	119.8(6)
C(4)-N(2)-H(2C)	118(6)
C(12)-N(2)-H(2C)	94(6)
Pt(1)-N(2)-H(2C)	105(3)
N(2)-Pt(1)-N(1)	85.4(3)
N(2)-Pt(1)-Cl(1)	178.1(2)
N(1)-Pt(1)-Cl(1)	93.3(2)
N(2)-Pt(1)-Cl(2)	92.8(2)
N(1)-Pt(1)-Cl(2)	177.5(3)
Cl(1)-Pt(1)-Cl(2)	88.56(9)
C(119)-C(101)-C(102)	123.6(10)
C(119)-C(101)-N(101)	123.9(8)
C(102)-C(101)-N(101)	89.4(7)
C(119)-C(101)-H(101)	105.9
C(102)-C(101)-H(101)	105.9
N(101)-C(101)-H(101)	105.9
C(101)-C(102)-C(103)	87.2(8)
C(101)-C(102)-H(10A)	114.1
C(103)-C(102)-H(10A)	114.1
C(101)-C(102)-H(10B)	114.1
C(103)-C(102)-H(10B)	114.1
H(10A)-C(102)-H(10B)	111.3
C(104)-C(103)-N(101)	113.1(8)
C(104)-C(103)-C(102)	122.2(9)

N(101)-C(103)-C(102)	90.0(7)
C(104)-C(103)-H(103)	110.0
N(101)-C(103)-H(103)	110.0
C(102)-C(103)-H(103)	110.0
N(102)-C(104)-C(103)	109.2(9)
N(102)-C(104)-H(10C)	109.8
C(103)-C(104)-H(10C)	109.8
N(102)-C(104)-H(10D)	109.8
C(103)-C(104)-H(10D)	109.8
H(10C)-C(104)-H(10D)	108.3
N(101)-C(105)-C(106)	115.1(8)
N(101)-C(105)-H(10E)	108.5
C(106)-C(105)-H(10E)	108.5
N(101)-C(105)-H(10F)	108.5
C(106)-C(105)-H(10F)	108.5
H(10E)-C(105)-H(10F)	107.5
C(107)-C(106)-C(111)	118.5(11)
C(107)-C(106)-C(105)	121.1(10)
C(111)-C(106)-C(105)	120.3(10)
C(108)-C(107)-C(106)	121.5(12)
C(108)-C(107)-H(107)	119.2
C(106)-C(107)-H(107)	119.2
C(107)-C(108)-C(109)	118.2(12)
C(107)-C(108)-H(108)	120.9
C(109)-C(108)-H(108)	120.9
C(110)-C(109)-C(108)	122.8(13)
C(110)-C(109)-H(109)	118.6
C(108)-C(109)-H(109)	118.6
C(109)-C(110)-C(111)	119.1(14)
C(109)-C(110)-H(110)	120.4
C(111)-C(110)-H(110)	120.4
C(110)-C(111)-C(106)	119.6(12)
C(110)-C(111)-H(111)	120.2
C(106)-C(111)-H(111)	120.2
C(113)-C(112)-N(102)	113.8(8)
C(113)-C(112)-H(11A)	108.8
N(102)-C(112)-H(11A)	108.8
C(113)-C(112)-H(11B)	108.8
N(102)-C(112)-H(11B)	108.8
H(11A)-C(112)-H(11B)	107.7
C(118)-C(113)-C(114)	120.4(12)
C(118)-C(113)-C(112)	119.3(11)
C(114)-C(113)-C(112)	120.2(10)
C(115)-C(114)-C(113)	118.9(12)
C(115)-C(114)-H(114)	120.5
C(113)-C(114)-H(114)	120.5
C(114)-C(115)-C(116)	120.5(12)
C(114)-C(115)-H(115)	119.8
C(116)-C(115)-H(115)	119.8
C(117)-C(116)-C(115)	121.2(13)
C(117)-C(116)-H(116)	119.4
C(115)-C(116)-H(116)	119.4
C(116)-C(117)-C(118)	118.6(12)
C(116)-C(117)-H(117)	120.7
C(118)-C(117)-H(117)	120.7
C(113)-C(118)-C(117)	120.5(12)
C(113)-C(118)-H(118)	119.8
C(117)-C(118)-H(118)	119.8
C(120)-C(119)-C(124)	117.7(11)
C(120)-C(119)-C(101)	119.9(11)
C(124)-C(119)-C(101)	122.1(9)
C(119)-C(120)-C(121)	121.5(12)
C(119)-C(120)-H(120)	119.2
C(121)-C(120)-H(120)	119.2
C(122)-C(121)-C(120)	120.1(12)
C(122)-C(121)-H(121)	119.9
C(120)-C(121)-H(121)	119.9
C(121)-C(122)-C(123)	120.2(12)
C(121)-C(122)-H(122)	119.9
C(123)-C(122)-H(122)	119.9
C(124)-C(123)-C(122)	119.1(12)
C(124)-C(123)-H(123)	120.4
C(122)-C(123)-H(123)	120.4
C(123)-C(124)-C(119)	121.2(11)
C(123)-C(124)-H(124)	119.4
C(119)-C(124)-H(124)	119.4
C(105)-N(101)-C(103)	117.9(8)
C(105)-N(101)-C(101)	112.6(8)
C(103)-N(101)-C(101)	86.6(7)
C(105)-N(101)-Pt(11)	114.5(6)
C(103)-N(101)-Pt(11)	106.3(6)
C(101)-N(101)-Pt(11)	116.0(7)
C(104)-N(102)-C(112)	110.9(9)
C(104)-N(102)-Pt(11)	108.6(7)
C(112)-N(102)-Pt(11)	121.2(7)
C(104)-N(102)-H(12C)	108(3)
C(112)-N(102)-H(12C)	103(3)
Pt(11)-N(102)-H(12C)	104(3)
N(102)-Pt(11)-N(101)	85.3(3)
N(102)-Pt(11)-Cl(11)	178.5(3)
N(101)-Pt(11)-Cl(11)	93.8(2)
N(102)-Pt(11)-Cl(12)	92.5(3)
N(101)-Pt(11)-Cl(12)	176.7(2)
Cl(11)-Pt(11)-Cl(12)	88.56(9)
C(219)-C(201)-C(202)	125.9(8)
C(219)-C(201)-N(201)	119.5(8)
C(202)-C(201)-N(201)	88.6(7)
C(219)-C(201)-H(201)	106.9
C(202)-C(201)-H(201)	106.9
N(201)-C(201)-H(201)	106.9
C(201)-C(202)-C(203)	87.2(7)
C(201)-C(202)-H(20A)	114.1
C(203)-C(202)-H(20A)	114.1
C(201)-C(202)-H(20B)	114.1
C(203)-C(202)-H(20B)	114.1
H(20A)-C(202)-H(20B)	111.3
C(204)-C(203)-N(201)	112.8(8)
C(204)-C(203)-C(202)	121.0(8)
N(201)-C(203)-C(202)	88.5(7)
C(204)-C(203)-H(203)	110.9
N(201)-C(203)-H(203)	110.9
C(202)-C(203)-H(203)	110.9
N(202)-C(204)-C(203)	109.8(8)
N(202)-C(204)-H(20C)	109.7
C(203)-C(204)-H(20C)	109.7
N(202)-C(204)-H(20D)	109.7
C(203)-C(204)-H(20D)	109.7
H(20C)-C(204)-H(20D)	108.2
C(206)-C(205)-N(201)	116.4(9)
C(206)-C(205)-H(20E)	108.2
N(201)-C(205)-H(20E)	108.2
C(206)-C(205)-H(20F)	108.2
N(201)-C(205)-H(20F)	108.2
H(20E)-C(205)-H(20F)	107.4
C(211)-C(206)-C(207)	118.9(11)
C(211)-C(206)-C(205)	120.3(11)
C(207)-C(206)-C(205)	120.5(10)
C(208)-C(207)-C(206)	119.5(10)
C(208)-C(207)-H(207)	120.2
C(206)-C(207)-H(207)	120.2
C(209)-C(208)-C(207)	121.1(11)
C(209)-C(208)-H(208)	119.4
C(207)-C(208)-H(208)	119.4
C(208)-C(209)-C(210)	120.2(10)
C(208)-C(209)-H(209)	119.9
C(210)-C(209)-H(209)	119.9

C(209)-C(210)-C(211)	118.2(10)
C(209)-C(210)-H(210)	120.9
C(211)-C(210)-H(210)	120.9
C(206)-C(211)-C(210)	122.1(11)
C(206)-C(211)-H(211)	119.0
C(210)-C(211)-H(211)	119.0
C(213)-C(212)-N(202)	115.5(8)
C(213)-C(212)-H(21A)	108.4
N(202)-C(212)-H(21A)	108.4
C(213)-C(212)-H(21B)	108.4
N(202)-C(212)-H(21B)	108.4
H(21A)-C(212)-H(21B)	107.5
C(218)-C(213)-C(214)	118.5(11)
C(218)-C(213)-C(212)	120.8(10)
C(214)-C(213)-C(212)	120.6(9)
C(215)-C(214)-C(213)	120.8(11)
C(215)-C(214)-H(214)	119.6
C(213)-C(214)-H(214)	119.6
C(214)-C(215)-C(216)	118.8(13)
C(214)-C(215)-H(215)	120.6
C(216)-C(215)-H(215)	120.6
C(217)-C(216)-C(215)	121.0(13)
C(217)-C(216)-H(216)	119.5
C(215)-C(216)-H(216)	119.5
C(216)-C(217)-C(218)	119.3(13)
C(216)-C(217)-H(217)	120.4
C(218)-C(217)-H(217)	120.4
C(213)-C(218)-C(217)	121.5(13)
C(213)-C(218)-H(218)	119.3
C(217)-C(218)-H(218)	119.3
C(220)-C(219)-C(224)	116.8(9)
C(220)-C(219)-C(201)	121.3(9)
C(224)-C(219)-C(201)	121.6(9)
C(221)-C(220)-C(219)	124.2(10)
C(221)-C(220)-H(220)	117.9
C(219)-C(220)-H(220)	117.9
C(220)-C(221)-C(222)	117.0(11)
C(220)-C(221)-H(221)	121.5
C(222)-C(221)-H(221)	121.5
C(223)-C(222)-C(221)	121.0(11)
C(223)-C(222)-H(222)	119.5
C(221)-C(222)-H(222)	119.5
C(222)-C(223)-C(224)	121.0(11)
C(222)-C(223)-H(223)	119.5
C(224)-C(223)-H(223)	119.5
C(223)-C(224)-C(219)	119.9(10)
C(223)-C(224)-H(224)	120.1
C(219)-C(224)-H(224)	120.1
C(205)-N(201)-C(203)	115.7(7)
C(205)-N(201)-C(201)	111.4(7)
C(203)-N(201)-C(201)	86.9(7)
C(205)-N(201)-Pt(21)	115.5(6)
C(203)-N(201)-Pt(21)	107.1(6)
C(201)-N(201)-Pt(21)	117.0(5)
C(204)-N(202)-C(212)	110.7(8)
C(204)-N(202)-Pt(21)	110.0(6)
C(212)-N(202)-Pt(21)	120.5(7)
C(204)-N(202)-H(22C)	106(6)
C(212)-N(202)-H(22C)	99(6)
Pt(21)-N(202)-H(22C)	110(3)
N(202)-Pt(21)-N(201)	85.3(3)
N(202)-Pt(21)-Cl(21)	178.9(3)
N(201)-Pt(21)-Cl(21)	93.6(2)
N(202)-Pt(21)-Cl(22)	92.7(2)
N(201)-Pt(21)-Cl(22)	176.7(2)
Cl(21)-Pt(21)-Cl(22)	88.37(9)
C(319)-C(301)-C(302)	123.2(10)
C(319)-C(301)-N(301)	119.8(9)
C(302)-C(301)-N(301)	89.8(7)
C(319)-C(301)-H(301)	107.4
C(302)-C(301)-H(301)	107.4
N(301)-C(301)-H(301)	107.4
C(301)-C(302)-C(303)	86.7(7)
C(301)-C(302)-H(30A)	114.2
C(303)-C(302)-H(30A)	114.2
C(301)-C(302)-H(30B)	114.2
C(303)-C(302)-H(30B)	114.2
H(30A)-C(302)-H(30B)	111.4
C(304)-C(303)-N(301)	113.1(8)
C(304)-C(303)-C(302)	120.7(9)
N(301)-C(303)-C(302)	89.0(7)
C(304)-C(303)-H(303)	110.7
N(301)-C(303)-H(303)	110.7
C(302)-C(303)-H(303)	110.7
C(303)-C(304)-N(302)	110.2(8)
C(303)-C(304)-H(30C)	109.6
N(302)-C(304)-H(30C)	109.6
C(303)-C(304)-H(30D)	109.6
N(302)-C(304)-H(30D)	109.6
H(30C)-C(304)-H(30D)	108.1
N(301)-C(305)-C(306)	115.3(8)
N(301)-C(305)-H(30E)	108.5
C(306)-C(305)-H(30E)	108.5
N(301)-C(305)-H(30F)	108.5
C(306)-C(305)-H(30F)	108.5
H(30E)-C(305)-H(30F)	107.5
C(307)-C(306)-C(311)	120.4(11)
C(307)-C(306)-C(305)	121.2(10)
C(311)-C(306)-C(305)	118.3(11)
C(308)-C(307)-C(306)	121.9(12)
C(308)-C(307)-H(307)	119.0
C(306)-C(307)-H(307)	119.0
C(307)-C(308)-C(309)	119.7(14)
C(307)-C(308)-H(308)	120.2
C(309)-C(308)-H(308)	120.2
C(310)-C(309)-C(308)	118.2(13)
C(310)-C(309)-H(309)	120.9
C(308)-C(309)-H(309)	120.9
C(309)-C(310)-C(311)	121.1(13)
C(309)-C(310)-H(310)	119.4
C(311)-C(310)-H(310)	119.4
C(306)-C(311)-C(310)	118.5(13)
C(306)-C(311)-H(311)	120.7
C(310)-C(311)-H(311)	120.7
C(313)-C(312)-N(302)	115.1(8)
C(313)-C(312)-H(31A)	108.5
N(302)-C(312)-H(31A)	108.5
C(313)-C(312)-H(31B)	108.5
N(302)-C(312)-H(31B)	108.5
H(31A)-C(312)-H(31B)	107.5
C(318)-C(313)-C(314)	115.5(11)
C(318)-C(313)-C(312)	121.3(9)
C(314)-C(313)-C(312)	123.2(10)
C(315)-C(314)-C(313)	122.1(11)
C(315)-C(314)-H(314)	118.9
C(313)-C(314)-H(314)	118.9
C(316)-C(315)-C(314)	120.5(12)
C(316)-C(315)-H(315)	119.8
C(314)-C(315)-H(315)	119.8
C(315)-C(316)-C(317)	118.3(12)
C(315)-C(316)-H(316)	120.8
C(317)-C(316)-H(316)	120.8
C(316)-C(317)-C(318)	121.4(12)
C(316)-C(317)-H(317)	119.3
C(318)-C(317)-H(317)	119.3
C(313)-C(318)-C(317)	122.2(11)

C(313)-C(318)-H(318)	118.9
C(317)-C(318)-H(318)	118.9
C(324)-C(319)-C(320)	118.6(11)
C(324)-C(319)-C(301)	120.5(10)
C(320)-C(319)-C(301)	119.6(10)
C(321)-C(320)-C(319)	120.4(12)
C(321)-C(320)-H(320)	119.8
C(319)-C(320)-H(320)	119.8
C(320)-C(321)-C(322)	120.0(11)
C(320)-C(321)-H(321)	120.0
C(322)-C(321)-H(321)	120.0
C(323)-C(322)-C(321)	119.6(12)
C(323)-C(322)-H(322)	120.2
C(321)-C(322)-H(322)	120.2
C(322)-C(323)-C(324)	120.9(13)
C(322)-C(323)-H(323)	119.5
C(324)-C(323)-H(323)	119.5
C(319)-C(324)-C(323)	120.2(11)
C(319)-C(324)-H(324)	119.9
C(323)-C(324)-H(324)	119.9
C(305)-N(301)-C(303)	116.2(8)
C(305)-N(301)-C(301)	112.2(8)
C(303)-N(301)-C(301)	86.0(7)
C(305)-N(301)-Pt(31)	115.0(6)
C(303)-N(301)-Pt(31)	106.8(6)
C(301)-N(301)-Pt(31)	117.4(7)
C(312)-N(302)-C(304)	110.5(8)
C(312)-N(302)-Pt(31)	122.6(7)
C(304)-N(302)-Pt(31)	108.4(6)
C(312)-N(302)-H(32C)	109(6)
C(304)-N(302)-H(32C)	98(7)
Pt(31)-N(302)-H(32C)	105(3)
N(302)-Pt(31)-N(301)	85.6(3)
N(302)-Pt(31)-Cl(31)	178.3(3)
N(301)-Pt(31)-Cl(31)	93.2(2)
N(302)-Pt(31)-Cl(32)	92.6(3)
N(301)-Pt(31)-Cl(32)	176.6(2)
Cl(31)-Pt(31)-Cl(32)	88.62(9)
N(401)-C(401)-C(402)	179.0(13)
C(401)-C(402)-H(40A)	109.5
C(401)-C(402)-H(40B)	109.5
H(40A)-C(402)-H(40B)	109.5
C(401)-C(402)-H(40C)	109.5
H(40A)-C(402)-H(40C)	109.5
H(40B)-C(402)-H(40C)	109.5
N(501)-C(501)-C(502)	178.0(14)
C(501)-C(502)-H(50A)	109.5
C(501)-C(502)-H(50B)	109.5
H(50A)-C(502)-H(50B)	109.5
C(501)-C(502)-H(50C)	109.5
H(50A)-C(502)-H(50C)	109.5
H(50B)-C(502)-H(50C)	109.5
N(601)-C(601)-C(602)	178.1(13)
C(601)-C(602)-H(60A)	109.5
C(601)-C(602)-H(60B)	109.5
H(60A)-C(602)-H(60B)	109.5
C(601)-C(602)-H(60C)	109.5
H(60A)-C(602)-H(60C)	109.5
H(60B)-C(602)-H(60C)	109.5
N(701)-C(701)-C(702)	177.4(12)
C(701)-C(702)-H(70A)	109.5
C(701)-C(702)-H(70B)	109.5
H(70A)-C(702)-H(70B)	109.5
C(701)-C(702)-H(70C)	109.5
H(70A)-C(702)-H(70C)	109.5
H(70B)-C(702)-H(70C)	109.5

Symmetry transformations used to generate equivalent atoms:

Table 61. Anisotropic displacement parameters ($Å^2$x 10^3) for **213aaa**. The anisotropic displacement factor exponent takes the form: $-2\pi^2$[$h^2a^{*2}U^{11}$ + ... + 2 h k a* b* U^{12}]

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
C(1)	24(4)	28(4)	21(4)	-6(3)	9(4)	-4(4)
C(2)	23(4)	29(4)	29(5)	-5(3)	7(4)	0(4)
C(3)	20(4)	20(4)	27(4)	0(3)	6(4)	-1(4)
C(4)	20(5)	21(5)	23(6)	-1(5)	-1(4)	0(5)
C(5)	23(5)	37(6)	10(5)	-5(4)	8(4)	-8(5)
C(6)	18(5)	21(5)	31(6)	1(5)	-4(5)	-8(5)
C(7)	36(7)	29(6)	47(8)	7(6)	-8(6)	2(5)
C(8)	39(7)	50(8)	44(8)	13(7)	-20(6)	-4(7)
C(9)	55(8)	57(9)	29(7)	-1(6)	-6(7)	-19(7)
C(10)	43(7)	41(7)	40(8)	-9(6)	-7(6)	-4(6)
C(11)	26(6)	28(6)	29(6)	-4(5)	0(5)	-14(5)
C(12)	35(6)	13(5)	32(6)	0(5)	11(5)	-2(5)
C(13)	29(6)	32(5)	28(6)	10(5)	6(4)	10(5)
C(14)	67(7)	22(5)	22(5)	9(5)	-5(5)	4(6)
C(15)	78(9)	48(7)	24(6)	-2(5)	11(6)	0(6)
C(16)	51(6)	68(6)	23(5)	-12(5)	3(4)	5(6)
C(17)	71(9)	82(7)	26(7)	-3(6)	-18(6)	35(8)
C(18)	69(8)	43(6)	23(6)	9(5)	2(5)	24(6)
C(19)	21(5)	21(6)	20(5)	-2(4)	8(4)	10(4)
C(20)	16(5)	23(5)	26(6)	-8(5)	12(4)	4(4)
C(21)	33(6)	25(6)	25(6)	-4(5)	3(5)	1(5)
C(22)	32(5)	46(6)	20(5)	6(5)	15(5)	1(5)
C(23)	17(5)	56(8)	29(7)	-3(6)	-4(5)	-5(5)
C(24)	23(6)	43(7)	23(6)	-5(5)	16(5)	-2(5)
N(1)	26(4)	22(4)	23(4)	1(3)	2(3)	1(4)
N(2)	16(4)	29(5)	21(5)	-5(4)	-1(4)	-4(4)
Cl(1)	23(1)	21(1)	23(1)	3(1)	4(1)	5(1)
Cl(2)	17(1)	24(1)	30(1)	-5(1)	9(1)	1(1)
Pt(1)	15(1)	17(1)	21(1)	-1(1)	2(1)	0(1)
C(101)	20(4)	24(4)	23(4)	0(4)	-4(3)	5(4)
C(102)	18(3)	26(4)	25(5)	2(4)	-4(3)	2(4)
C(103)	18(4)	20(4)	23(4)	4(4)	-3(3)	6(4)
C(104)	21(5)	29(6)	22(6)	-5(5)	4(5)	2(5)
C(105)	16(5)	20(6)	37(7)	2(5)	16(5)	6(4)
C(106)	31(6)	30(6)	19(6)	8(5)	1(5)	-13(6)
C(107)	23(6)	40(7)	29(7)	-9(6)	6(5)	1(5)
C(108)	41(8)	44(8)	55(9)	-21(7)	17(7)	1(7)
C(109)	66(9)	57(9)	23(7)	-16(7)	7(7)	-18(8)
C(110)	49(8)	40(7)	35(8)	2(6)	-4(6)	-22(6)
C(111)	33(7)	28(6)	28(7)	12(5)	2(5)	-7(5)
C(112)	18(5)	23(6)	36(7)	11(5)	4(5)	-1(5)
C(113)	37(7)	37(7)	31(7)	3(6)	6(6)	2(6)
C(114)	21(6)	51(8)	25(6)	-4(6)	2(5)	7(6)
C(115)	38(7)	54(8)	46(9)	1(7)	-19(6)	-5(7)
C(116)	84(7)	43(8)	22(6)	-6(7)	-5(6)	-4(8)
C(117)	79(6)	50(8)	29(6)	-8(5)	12(5)	11(6)
C(118)	54(7)	60(10)	27(6)	-1(6)	13(5)	21(7)
C(119)	24(5)	20(6)	28(6)	12(6)	8(4)	8(5)
C(120)	41(6)	32(6)	22(5)	0(7)	6(5)	7(7)
C(121)	43(8)	44(8)	44(9)	9(7)	4(7)	-1(7)
C(122)	71(9)	36(8)	21(7)	4(6)	12(7)	14(7)
C(123)	76(10)	28(7)	23(7)	-2(6)	1(6)	-11(7)
C(124)	45(7)	29(7)	22(6)	-5(5)	-2(5)	-1(6)
N(101)	15(3)	22(4)	19(4)	-4(4)	1(3)	-1(3)
N(102)	27(5)	18(5)	22(5)	-11(4)	-2(4)	-10(4)
Cl(11)	21(1)	25(2)	28(2)	2(1)	9(1)	6(1)
Cl(12)	21(1)	22(1)	31(2)	5(1)	1(1)	2(1)
Pt(11)	16(1)	20(1)	20(1)	0(1)	2(1)	0(1)
C(201)	15(4)	24(4)	22(4)	-1(3)	-5(4)	-3(4)
C(202)	13(4)	20(4)	32(5)	-4(3)	-2(4)	1(4)
C(203)	18(4)	13(4)	30(4)	3(3)	4(4)	1(4)
C(204)	32(6)	14(5)	30(6)	8(5)	4(5)	2(5)

C(205)	26(6)	28(6)	23(6)	-6(5)	-8(5)	16(5)
C(206)	20(5)	32(6)	30(6)	5(6)	6(5)	2(5)
C(207)	31(6)	25(6)	23(6)	2(5)	-2(5)	4(5)
C(208)	56(8)	30(6)	26(6)	-11(5)	-4(6)	-2(6)
C(209)	52(8)	45(7)	20(6)	-10(6)	11(6)	0(6)
C(210)	43(7)	57(8)	24(6)	14(6)	18(6)	-8(7)
C(211)	25(6)	34(6)	30(6)	6(5)	6(5)	-7(5)
C(212)	19(5)	18(5)	35(6)	6(5)	-2(5)	7(5)
C(213)	11(5)	43(7)	24(6)	0(5)	-3(4)	-6(5)
C(214)	39(6)	32(7)	32(6)	-3(6)	5(5)	0(6)
C(215)	85(10)	42(7)	24(7)	-3(6)	13(7)	16(7)
C(216)	70(9)	88(8)	19(6)	-7(8)	0(6)	28(10)
C(217)	73(10)	100(9)	26(7)	19(7)	29(7)	13(9)
C(218)	41(6)	39(6)	29(6)	18(5)	3(5)	-2(6)
C(219)	15(5)	25(7)	18(5)	-1(4)	-2(4)	5(4)
C(220)	18(5)	41(7)	19(6)	-6(5)	-6(4)	-3(5)
C(221)	34(6)	29(6)	28(6)	-2(5)	-7(5)	-11(5)
C(222)	22(6)	64(8)	30(7)	3(6)	-2(5)	0(6)
C(223)	25(6)	58(8)	17(6)	0(6)	4(5)	9(6)
C(224)	29(6)	33(6)	25(6)	1(5)	-4(5)	1(5)
N(201)	23(4)	19(4)	17(4)	3(3)	2(3)	-2(3)
N(202)	13(4)	29(5)	22(5)	-4(4)	9(3)	9(4)
Cl(21)	21(1)	20(1)	26(1)	2(1)	0(1)	-4(1)
Cl(22)	15(1)	25(1)	30(1)	-3(1)	-2(1)	0(1)
Pt(21)	15(1)	17(1)	20(1)	-2(1)	1(1)	0(1)
C(301)	28(4)	16(4)	20(3)	-6(4)	4(3)	4(4)
C(302)	24(3)	25(4)	27(4)	0(5)	-2(3)	-2(5)
C(303)	21(4)	21(4)	22(4)	2(3)	2(3)	-5(4)
C(304)	17(4)	9(4)	27(4)	4(4)	4(3)	6(4)
C(305)	20(5)	24(6)	34(7)	-7(5)	-7(5)	6(5)
C(306)	11(5)	30(6)	25(6)	3(5)	3(4)	10(5)
C(307)	27(6)	48(9)	31(7)	14(6)	-4(5)	7(6)
C(308)	56(9)	39(7)	51(10)	-1(7)	-17(7)	9(7)
C(309)	69(10)	53(9)	26(7)	-5(7)	-3(7)	12(8)
C(310)	45(8)	56(9)	40(8)	15(7)	13(7)	14(7)
C(311)	40(7)	37(7)	37(8)	9(6)	5(6)	19(6)
C(312)	26(6)	31(7)	23(6)	-6(5)	15(5)	3(5)
C(313)	16(5)	29(6)	20(6)	-9(5)	5(4)	1(5)
C(314)	29(6)	45(7)	32(7)	14(7)	-1(5)	1(6)
C(315)	33(7)	52(8)	30(7)	-6(6)	-3(6)	9(6)
C(316)	53(6)	45(8)	38(8)	6(6)	-9(6)	15(6)
C(317)	65(7)	58(9)	19(6)	13(6)	4(5)	-7(7)
C(318)	33(6)	67(8)	21(6)	4(6)	9(5)	-4(6)
C(319)	36(6)	23(6)	13(5)	-2(5)	-7(5)	-2(5)
C(320)	36(5)	47(6)	15(5)	-7(5)	9(4)	-4(5)
C(321)	46(8)	41(7)	20(7)	-11(6)	7(6)	-19(6)
C(322)	81(10)	28(7)	34(8)	1(6)	31(8)	-21(7)
C(323)	64(9)	34(7)	25(7)	-1(6)	-7(6)	8(7)
C(324)	48(7)	33(7)	18(6)	-2(5)	0(5)	-8(6)
N(301)	23(3)	15(3)	22(3)	-2(4)	4(3)	-2(4)
N(302)	18(4)	30(6)	24(5)	-5(4)	-7(4)	6(4)
Cl(31)	20(1)	26(2)	26(1)	-4(1)	10(1)	-4(1)
Cl(32)	24(1)	22(1)	30(2)	-5(1)	1(1)	-2(1)
Pt(31)	16(1)	19(1)	20(1)	-1(1)	1(1)	0(1)
C(401)	30(7)	36(7)	28(7)	5(6)	2(5)	-9(6)
N(401)	60(7)	35(7)	66(9)	-1(7)	27(7)	-7(6)
C(402)	36(7)	41(7)	24(7)	17(6)	8(5)	1(6)
C(501)	39(7)	32(6)	13(5)	9(5)	-1(5)	-9(6)
C(502)	31(6)	30(6)	28(6)	6(5)	12(5)	4(5)
N(501)	30(6)	65(8)	58(8)	26(6)	-6(6)	-8(6)
C(601)	38(6)	21(6)	16(5)	-1(6)	10(4)	5(6)
C(602)	36(7)	27(6)	34(7)	2(6)	10(6)	-3(5)
N(601)	55(7)	36(6)	61(8)	-4(6)	37(6)	14(6)
C(701)	25(6)	23(6)	31(6)	3(5)	4(5)	1(5)
C(702)	29(6)	29(6)	28(6)	0(5)	8(5)	-2(5)
N(701)	20(5)	63(7)	59(8)	24(6)	7(5)	14(5)

Table 62. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10^3) for **213aaa**.

	x	y	z	U(eq)
H(1)	3500	1210	4372	29
H(2A)	5271	3058	4177	32
H(2B)	3827	3302	4262	32
H(3)	2997	2096	3849	27
H(4A)	4064	1998	3401	25
H(4B)	4266	3420	3533	25
H(5A)	2773	-134	4008	28
H(5B)	3956	-1064	4047	28
H(7)	1900	452	3501	45
H(8)	1384	-366	3021	55
H(9)	2540	-2027	2816	57
H(10)	4228	-2895	3120	51
H(11)	4721	-2105	3612	33
H(12A)	6317	3470	3248	31
H(12B)	7288	2325	3313	31
H(14)	6367	36	3148	45
H(15)	5534	-1020	2722	60
H(16)	4228	29	2357	57
H(17)	4089	2268	2393	72
H(18)	4966	3332	2820	54
H(20)	4358	-845	4601	25
H(21)	5637	-1646	5010	33
H(22)	7246	-385	5232	38
H(23)	7606	1625	5042	42
H(24)	6394	2399	4616	35
H(2C)	6320(70)	2910(40)	3699(16)	26
H(101)	8567	2180	614	27
H(10A)	6830	374	836	28
H(10B)	6585	1871	743	28
H(103)	7902	2614	1143	24
H(10C)	8213	1474	1591	28
H(10D)	6777	1247	1473	28
H(10E)	10010	2907	945	28
H(10F)	10929	1709	931	28
H(107)	9497	3725	1456	37
H(108)	10312	4193	1948	55
H(109)	12015	3032	2153	58
H(110)	13047	1597	1867	50
H(111)	12154	994	1386	36
H(11A)	6842	-878	1769	31
H(11B)	7968	-1836	1714	31
H(114)	10220	-935	1858	39
H(115)	11387	-28	2271	57
H(116)	10394	1137	2638	60
H(117)	8245	1353	2609	62
H(118)	7049	430	2189	56
H(120)	10563	1080	409	38
H(121)	11067	-106	-16	52
H(122)	9582	-1351	-271	51
H(123)	7534	-1480	-99	51
H(124)	7083	-416	347	39
H(12C)	7260(30)	-670(40)	1297(8)	27
H(201)	11140	6244	4393	25
H(20A)	10757	8352	4282	27
H(20B)	9271	8107	4188	27
H(203)	11393	7145	3871	24
H(20C)	9936	8469	3559	30
H(20D)	10139	7068	3422	30
H(20E)	11708	4933	4041	32
H(20F)	10555	3981	4065	32
H(207)	9697	2831	3623	32
H(208)	10035	2110	3133	45

H(209)	11522	3078	2847	46
H(210)	12604	4915	3037	49
H(211)	12278	5619	3536	35
H(21A)	6868	7293	3299	29
H(21B)	7807	8440	3241	29
H(214)	7705	5017	3167	41
H(215)	8421	3888	2756	60
H(216)	9462	5004	2378	71
H(217)	9676	7196	2401	78
H(218)	8907	8323	2809	43
H(220)	10426	4196	4626	32
H(221)	9335	3333	5019	37
H(222)	7825	4626	5237	47
H(223)	7379	6648	5048	40
H(224)	8374	7441	4630	35
H(22C)	8120(90)	7960(30)	3702(15)	25
H(301)	3574	4602	616	25
H(30A)	1571	4941	748	31
H(30B)	1844	6432	843	31
H(303)	2931	4160	1149	26
H(30C)	3203	5294	1595	21
H(30D)	1775	5523	1472	21
H(30E)	5952	5090	932	32
H(30F)	5034	3895	955	32
H(307)	7085	5901	1388	43
H(308)	7931	5510	1872	60
H(309)	7110	3794	2167	60
H(310)	5398	2644	1958	56
H(311)	4616	3004	1445	46
H(31A)	2883	8615	1720	31
H(31B)	1834	7574	1778	31
H(314)	5198	7955	1891	43
H(315)	6439	7081	2297	46
H(316)	5563	5750	2646	55
H(317)	3457	5195	2566	57
H(318)	2200	6109	2176	48
H(320)	5615	5737	417	39
H(321)	6080	6892	-11	43
H(322)	4522	8184	-268	56
H(323)	2554	8302	-88	50
H(324)	2069	7152	344	40
H(32C)	2230(30)	7330(100)	1293(12)	29
H(40A)	4072	12	357	50
H(40B)	3361	-584	633	50
H(40C)	4759	-52	692	50
H(50A)	6029	5606	4283	44
H(50B)	5489	5405	4610	44
H(50C)	6007	6776	4517	44
H(60A)	8209	7360	537	47
H(60B)	9450	6768	409	47
H(60C)	9413	7094	764	47
H(70A)	-1438	652	4293	43
H(70B)	-1226	1794	4534	43
H(70C)	-658	407	4612	43

Table 63. Torsion angles [°] for **213aaa**.

C(19)-C(1)-C(2)-C(3)	148.7(9)
N(1)-C(1)-C(2)-C(3)	21.7(7)
C(1)-C(2)-C(3)-C(4)	-138.8(9)
C(1)-C(2)-C(3)-N(1)	-22.2(7)
N(1)-C(3)-C(4)-N(2)	-46.9(11)
C(2)-C(3)-C(4)-N(2)	57.1(12)
N(1)-C(5)-C(6)-C(11)	97.3(11)
N(1)-C(5)-C(6)-C(7)	-89.4(12)
C(11)-C(6)-C(7)-C(8)	0.4(17)
C(5)-C(6)-C(7)-C(8)	-172.9(10)
C(6)-C(7)-C(8)-C(9)	-1.1(18)
C(7)-C(8)-C(9)-C(10)	0.9(18)
C(8)-C(9)-C(10)-C(11)	0.0(18)
C(7)-C(6)-C(11)-C(10)	0.5(16)
C(5)-C(6)-C(11)-C(10)	173.7(10)
C(9)-C(10)-C(11)-C(6)	-0.7(17)
N(2)-C(12)-C(13)-C(18)	112.0(11)
N(2)-C(12)-C(13)-C(14)	-71.3(13)
C(18)-C(13)-C(14)-C(15)	0.4(18)
C(12)-C(13)-C(14)-C(15)	-176.4(11)
C(13)-C(14)-C(15)-C(16)	-3(2)
C(14)-C(15)-C(16)-C(17)	5(2)
C(15)-C(16)-C(17)-C(18)	-5(2)
C(14)-C(13)-C(18)-C(17)	0.2(18)
C(12)-C(13)-C(18)-C(17)	177.1(12)
C(16)-C(17)-C(18)-C(13)	2(2)
C(2)-C(1)-C(19)-C(24)	-3.2(14)
N(1)-C(1)-C(19)-C(24)	109.0(10)
C(2)-C(1)-C(19)-C(20)	173.9(8)
N(1)-C(1)-C(19)-C(20)	-73.9(11)
C(24)-C(19)-C(20)-C(21)	-0.4(13)
C(1)-C(19)-C(20)-C(21)	-177.6(9)
C(19)-C(20)-C(21)-C(22)	1.5(14)
C(20)-C(21)-C(22)-C(23)	-0.8(15)
C(21)-C(22)-C(23)-C(24)	-0.9(15)
C(20)-C(19)-C(24)-C(23)	-1.4(13)
C(1)-C(19)-C(24)-C(23)	175.8(9)
C(22)-C(23)-C(24)-C(19)	2.0(15)
C(6)-C(5)-N(1)-C(3)	69.4(11)
C(6)-C(5)-N(1)-C(1)	166.8(9)
C(6)-C(5)-N(1)-Pt(1)	-57.6(11)
C(4)-C(3)-N(1)-C(5)	-101.3(10)
C(2)-C(3)-N(1)-C(5)	134.8(7)
C(4)-C(3)-N(1)-C(1)	145.5(8)
C(2)-C(3)-N(1)-C(1)	21.6(7)
C(4)-C(3)-N(1)-Pt(1)	30.1(9)
C(2)-C(3)-N(1)-Pt(1)	-93.8(6)
C(19)-C(1)-N(1)-C(5)	89.8(10)
C(2)-C(1)-N(1)-C(5)	-139.9(8)
C(19)-C(1)-N(1)-C(3)	-152.2(9)
C(2)-C(1)-N(1)-C(3)	-21.9(7)
C(19)-C(1)-N(1)-Pt(1)	-45.9(10)
C(2)-C(1)-N(1)-Pt(1)	84.4(7)
C(3)-C(4)-N(2)-C(12)	173.3(8)
C(3)-C(4)-N(2)-Pt(1)	39.4(9)
C(13)-C(12)-N(2)-C(4)	-53.4(11)
C(13)-C(12)-N(2)-Pt(1)	75.0(10)
C(4)-N(2)-Pt(1)-N(1)	-18.6(7)
C(12)-N(2)-Pt(1)-N(1)	-147.6(7)
C(4)-N(2)-Pt(1)-Cl(2)	163.0(6)
C(12)-N(2)-Pt(1)-Cl(2)	34.0(7)
C(5)-N(1)-Pt(1)-N(2)	126.4(7)
C(3)-N(1)-Pt(1)-N(2)	-5.9(6)
C(1)-N(1)-Pt(1)-N(2)	-99.4(7)
C(5)-N(1)-Pt(1)-Cl(1)	-54.9(7)

C(3)-N(1)-Pt(1)-Cl(1)	172.8(6)
C(1)-N(1)-Pt(1)-Cl(1)	79.3(6)
C(119)-C(101)-C(102)-C(103)	150.9(10)
N(101)-C(101)-C(102)-C(103)	19.5(8)
C(101)-C(102)-C(103)-C(104)	-137.3(10)
C(101)-C(102)-C(103)-N(101)	-19.7(8)
N(101)-C(103)-C(104)-N(102)	-46.8(12)
C(102)-C(103)-C(104)-N(102)	58.7(13)
N(101)-C(105)-C(106)-C(107)	-84.5(12)
N(101)-C(105)-C(106)-C(111)	99.8(11)
C(111)-C(106)-C(107)-C(108)	-0.7(17)
C(105)-C(106)-C(107)-C(108)	-176.4(11)
C(106)-C(107)-C(108)-C(109)	0.2(18)
C(107)-C(108)-C(109)-C(110)	3.2(19)
C(108)-C(109)-C(110)-C(111)	-5.8(19)
C(109)-C(110)-C(111)-C(106)	5.1(16)
C(107)-C(106)-C(111)-C(110)	-2.0(15)
C(105)-C(106)-C(111)-C(110)	173.8(10)
N(102)-C(112)-C(113)-C(118)	112.7(12)
N(102)-C(112)-C(113)-C(114)	-71.7(14)
C(118)-C(113)-C(114)-C(115)	-1.9(19)
C(112)-C(113)-C(114)-C(115)	-177.5(11)
C(113)-C(114)-C(115)-C(116)	0(2)
C(114)-C(115)-C(116)-C(117)	1(2)
C(115)-C(116)-C(117)-C(118)	-1(2)
C(114)-C(113)-C(118)-C(117)	2(2)
C(112)-C(113)-C(118)-C(117)	177.6(11)
C(116)-C(117)-C(118)-C(113)	0(2)
C(102)-C(101)-C(119)-C(120)	-179.0(11)
N(101)-C(101)-C(119)-C(120)	-63.5(15)
C(102)-C(101)-C(119)-C(124)	7.2(17)
N(101)-C(101)-C(119)-C(124)	122.7(11)
C(124)-C(119)-C(120)-C(121)	-1.3(18)
C(101)-C(119)-C(120)-C(121)	-175.4(11)
C(119)-C(120)-C(121)-C(122)	2.3(19)
C(120)-C(121)-C(122)-C(123)	-0.7(19)
C(121)-C(122)-C(123)-C(124)	-1.8(19)
C(122)-C(123)-C(124)-C(119)	2.8(18)
C(120)-C(119)-C(124)-C(123)	-1.2(17)
C(101)-C(119)-C(124)-C(123)	172.7(11)
C(106)-C(105)-N(101)-C(103)	65.5(12)
C(106)-C(105)-N(101)-C(101)	164.0(9)
C(106)-C(105)-N(101)-Pt(11)	-60.6(10)
C(104)-C(103)-N(101)-C(105)	-101.3(11)
C(102)-C(103)-N(101)-C(105)	133.3(9)
C(104)-C(103)-N(101)-C(101)	144.8(9)
C(102)-C(103)-N(101)-C(101)	19.5(8)
C(104)-C(103)-N(101)-Pt(11)	28.8(10)
C(102)-C(103)-N(101)-Pt(11)	-96.6(7)
C(119)-C(101)-N(101)-C(105)	90.4(12)
C(102)-C(101)-N(101)-C(105)	-138.4(8)
C(119)-C(101)-N(101)-C(103)	-150.8(11)
C(102)-C(101)-N(101)-C(103)	-19.5(8)
C(119)-C(101)-N(101)-Pt(11)	-44.3(12)
C(102)-C(101)-N(101)-Pt(11)	87.0(8)
C(103)-C(104)-N(102)-C(112)	175.8(8)
C(103)-C(104)-N(102)-Pt(11)	40.2(10)
C(113)-C(112)-N(102)-C(104)	-53.5(12)
C(113)-C(112)-N(102)-Pt(11)	75.6(10)
C(104)-N(102)-Pt(11)-N(101)	-19.6(8)
C(112)-N(102)-Pt(11)-N(101)	-149.7(7)
C(104)-N(102)-Pt(11)-Cl(12)	162.8(7)
C(112)-N(102)-Pt(11)-Cl(12)	32.7(7)
C(105)-N(101)-Pt(11)-N(102)	127.4(7)
C(103)-N(101)-Pt(11)-N(102)	-4.6(6)
C(101)-N(101)-Pt(11)-N(102)	-98.8(6)
C(105)-N(101)-Pt(11)-Cl(11)	-51.5(6)
C(103)-N(101)-Pt(11)-Cl(11)	176.6(6)

C(101)-N(101)-Pt(11)-Cl(11)	82.3(6)
C(219)-C(201)-C(202)-C(203)	-148.3(10)
N(201)-C(201)-C(202)-C(203)	-22.2(7)
C(201)-C(202)-C(203)-C(204)	138.1(9)
C(201)-C(202)-C(203)-N(201)	22.2(7)
N(201)-C(203)-C(204)-N(202)	43.3(11)
C(202)-C(203)-C(204)-N(202)	-59.4(12)
N(201)-C(205)-C(206)-C(211)	85.6(12)
N(201)-C(205)-C(206)-C(207)	-101.0(12)
C(211)-C(206)-C(207)-C(208)	-0.1(16)
C(205)-C(206)-C(207)-C(208)	-173.6(10)
C(206)-C(207)-C(208)-C(209)	1.0(17)
C(207)-C(208)-C(209)-C(210)	-2.3(19)
C(208)-C(209)-C(210)-C(211)	2.7(18)
C(207)-C(206)-C(211)-C(210)	0.6(17)
C(205)-C(206)-C(211)-C(210)	174.2(11)
C(209)-C(210)-C(211)-C(206)	-1.9(18)
N(202)-C(212)-C(213)-C(218)	-113.7(11)
N(202)-C(212)-C(213)-C(214)	69.5(13)
C(218)-C(213)-C(214)-C(215)	1.2(17)
C(212)-C(213)-C(214)-C(215)	178.1(11)
C(213)-C(214)-C(215)-C(216)	0.6(19)
C(214)-C(215)-C(216)-C(217)	-2(2)
C(215)-C(216)-C(217)-C(218)	1(2)
C(214)-C(213)-C(218)-C(217)	-2.1(17)
C(212)-C(213)-C(218)-C(217)	-178.9(12)
C(216)-C(217)-C(218)-C(213)	1(2)
C(202)-C(201)-C(219)-C(220)	-172.5(9)
N(201)-C(201)-C(219)-C(220)	75.5(12)
C(202)-C(201)-C(219)-C(224)	1.4(15)
N(201)-C(201)-C(219)-C(224)	-110.6(11)
C(224)-C(219)-C(220)-C(221)	3.5(15)
C(201)-C(219)-C(220)-C(221)	177.7(9)
C(219)-C(220)-C(221)-C(222)	-3.8(16)
C(220)-C(221)-C(222)-C(223)	1.4(16)
C(221)-C(222)-C(223)-C(224)	1.0(17)
C(222)-C(223)-C(224)-C(219)	-1.3(16)
C(220)-C(219)-C(224)-C(223)	-0.9(15)
C(201)-C(219)-C(224)-C(223)	-175.0(10)
C(206)-C(205)-N(201)-C(203)	-68.1(12)
C(206)-C(205)-N(201)-C(201)	-165.2(9)
C(206)-C(205)-N(201)-Pt(21)	58.2(11)
C(204)-C(203)-N(201)-C(205)	102.4(9)
C(202)-C(203)-N(201)-C(205)	-134.4(8)
C(204)-C(203)-N(201)-C(201)	-145.3(8)
C(202)-C(203)-N(201)-C(201)	-22.1(7)
C(204)-C(203)-N(201)-Pt(21)	-28.0(8)
C(202)-C(203)-N(201)-Pt(21)	95.2(6)
C(219)-C(201)-N(201)-C(205)	-90.0(10)
C(202)-C(201)-N(201)-C(205)	138.6(8)
C(219)-C(201)-N(201)-C(203)	153.5(9)
C(202)-C(201)-N(201)-C(203)	22.2(7)
C(219)-C(201)-N(201)-Pt(21)	45.9(10)
C(202)-C(201)-N(201)-Pt(21)	-85.4(6)
C(203)-C(204)-N(202)-C(212)	-172.4(8)
C(203)-C(204)-N(202)-Pt(21)	-36.7(10)
C(213)-C(212)-N(202)-C(204)	55.4(12)
C(213)-C(212)-N(202)-Pt(21)	-74.9(9)
C(204)-N(202)-Pt(21)-N(201)	16.9(7)
C(212)-N(202)-Pt(21)-N(201)	147.6(7)
C(204)-N(202)-Pt(21)-Cl(22)	-165.7(6)
C(212)-N(202)-Pt(21)-Cl(22)	-35.0(6)
C(205)-N(201)-Pt(21)-N(202)	-124.8(7)
C(203)-N(201)-Pt(21)-N(202)	5.7(5)
C(201)-N(201)-Pt(21)-N(202)	101.1(6)
C(205)-N(201)-Pt(21)-Cl(21)	55.2(6)
C(203)-N(201)-Pt(21)-Cl(21)	-174.3(5)
C(201)-N(201)-Pt(21)-Cl(21)	-78.9(6)

C(319)-C(301)-C(302)-C(303)	-148.1(10)
N(301)-C(301)-C(302)-C(303)	-21.8(8)
C(301)-C(302)-C(303)-C(304)	138.3(10)
C(301)-C(302)-C(303)-N(301)	21.8(8)
N(301)-C(303)-C(304)-N(302)	44.4(11)
C(302)-C(303)-C(304)-N(302)	-59.0(11)
N(301)-C(305)-C(306)-C(307)	-94.7(12)
N(301)-C(305)-C(306)-C(311)	88.4(12)
C(311)-C(306)-C(307)-C(308)	0.0(18)
C(305)-C(306)-C(307)-C(308)	-176.9(11)
C(306)-C(307)-C(308)-C(309)	-0.2(19)
C(307)-C(308)-C(309)-C(310)	-1.4(19)
C(308)-C(309)-C(310)-C(311)	3.3(19)
C(307)-C(306)-C(311)-C(310)	1.8(16)
C(305)-C(306)-C(311)-C(310)	178.8(10)
C(309)-C(310)-C(311)-C(306)	-3.5(18)
N(302)-C(312)-C(313)-C(318)	-105.0(12)
N(302)-C(312)-C(313)-C(314)	74.2(14)
C(318)-C(313)-C(314)-C(315)	-0.9(18)
C(312)-C(313)-C(314)-C(315)	179.8(11)
C(313)-C(314)-C(315)-C(316)	0(2)
C(314)-C(315)-C(316)-C(317)	2(2)
C(315)-C(316)-C(317)-C(318)	-3(2)
C(314)-C(313)-C(318)-C(317)	-0.3(18)
C(312)-C(313)-C(318)-C(317)	179.0(12)
C(316)-C(317)-C(318)-C(313)	2(2)
C(302)-C(301)-C(319)-C(324)	-14.0(16)
N(301)-C(301)-C(319)-C(324)	-125.8(10)
C(302)-C(301)-C(319)-C(320)	178.8(11)
N(301)-C(301)-C(319)-C(320)	67.0(14)
C(324)-C(319)-C(320)-C(321)	4.0(17)
C(301)-C(319)-C(320)-C(321)	171.4(10)
C(319)-C(320)-C(321)-C(322)	-2.0(17)
C(320)-C(321)-C(322)-C(323)	-0.1(18)
C(321)-C(322)-C(323)-C(324)	0.2(19)
C(320)-C(319)-C(324)-C(323)	-3.8(16)
C(301)-C(319)-C(324)-C(323)	-171.1(10)
C(322)-C(323)-C(324)-C(319)	1.8(18)
C(306)-C(305)-N(301)-C(303)	-67.1(11)
C(306)-C(305)-N(301)-C(301)	-163.8(9)
C(306)-C(305)-N(301)-Pt(31)	58.7(10)
C(304)-C(303)-N(301)-C(305)	102.5(10)
C(302)-C(303)-N(301)-C(305)	-134.3(9)
C(304)-C(303)-N(301)-C(301)	-144.7(9)
C(302)-C(303)-N(301)-C(301)	-21.5(8)
C(304)-C(303)-N(301)-Pt(31)	-27.3(9)
C(302)-C(303)-N(301)-Pt(31)	95.9(7)
C(319)-C(301)-N(301)-C(305)	-92.5(11)
C(302)-C(301)-N(301)-C(305)	138.5(9)
C(319)-C(301)-N(301)-C(303)	150.9(9)
C(302)-C(301)-N(301)-C(303)	21.8(9)
C(319)-C(301)-N(301)-Pt(31)	44.0(10)
C(302)-C(301)-N(301)-Pt(31)	-85.0(8)
C(313)-C(312)-N(302)-C(304)	57.8(11)
C(313)-C(312)-N(302)-Pt(31)	-72.0(11)
C(303)-C(304)-N(302)-C(312)	-175.5(8)
C(303)-C(304)-N(302)-Pt(31)	-38.5(9)
C(312)-N(302)-Pt(31)-N(301)	149.1(8)
C(304)-N(302)-Pt(31)-N(301)	18.4(6)
C(312)-N(302)-Pt(31)-Cl(32)	-33.8(8)
C(304)-N(302)-Pt(31)-Cl(32)	-164.5(6)
C(305)-N(301)-Pt(31)-N(302)	-126.4(7)
C(303)-N(301)-Pt(31)-N(302)	4.1(6)
C(301)-N(301)-Pt(31)-N(302)	98.4(6)
C(305)-N(301)-Pt(31)-Cl(31)	52.5(6)
C(303)-N(301)-Pt(31)-Cl(31)	-177.1(6)
C(301)-N(301)-Pt(31)-Cl(31)	-82.8(5)

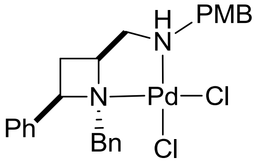
Symmetry transformations used to generate equivalent atoms:

Table 64. Hydrogen bonds for **213aaa** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(2)-H(2C)...Cl(21)	0.92(2)	2.50(3)	3.363(9)	156(4)
N(2)-H(2C)...Cl(22)	0.92(2)	2.73(4)	3.365(10)	127(4)
N(102)-H(12C)...Cl(31)#1	0.901(18)	2.52(2)	3.365(9)	157(4)
N(102)-H(12C)...Cl(32)#1	0.901(18)	2.83(3)	3.443(9)	127(3)
N(202)-H(22C)...Cl(1)#2	0.91(2)	2.57(4)	3.375(8)	148(5)
N(202)-H(22C)...Cl(2)#2	0.91(2)	2.68(4)	3.387(10)	136(4)
N(302)-H(32C)...Cl(11)#3	0.91(2)	2.60(5)	3.398(10)	146(7)
N(302)-H(32C)...Cl(12)#3	0.91(2)	2.75(4)	3.413(9)	130(4)

Symmetry transformations used to generate equivalent atoms:
#1 x,y-1,z #2 x,y+1,z #3 x-1,y+1,z

4.3.2 X-ray Crystallographic Information for Pd(II)-amino-azetidine complex 213aha



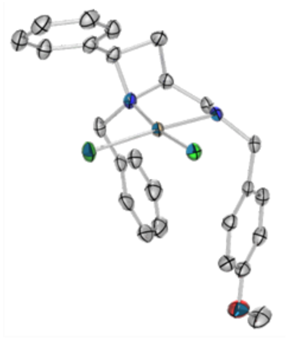


Table 65. Crystal data and structure refinement for **213aha**.

Identification code	**213aha**	
Empirical formula	$C_{25}H_{28}Cl_2N_2OPd$, 0.125($C_4H_{10}O$)	
Formula weight	559.06	
Temperature	120(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P -1	
Unit cell dimensions	a = 13.4719(2) Å	α= 94.4120(10)°.
	b = 19.3528(2) Å	β= 106.4250(10)°.
	c = 21.6914(3) Å	γ = 108.6670(10)°.
Volume	5051.22(12) Å^3	
Z, Z’	8, 4	
Density (calculated)	1.470 Mg/m^3	
Absorption coefficient	0.967 mm^{-1}	
F(000)	2282	
Crystal size	0.24 x 0.12 x 0.07 mm^3	

Theta range for data collection	2.91 to 27.48°.
Index ranges	-17<=h<=17, -25<=k<=25, -28<=l<=28
Reflections collected	105481
Independent reflections	23160 [R(int) = 0.0436]
Completeness to theta = 27.48°	99.8 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.9354 and 0.8012
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	23160 / 57 / 1155
Goodness-of-fit on F^2	1.085
Final R indices [I>2sigma(I)]	R1 = 0.0387, wR2 = 0.0945
R indices (all data)	R1 = 0.0506, wR2 = 0.0999
Largest diff. peak and hole	1.252 and -1.004 e.Å^{-3}

Notes: The structure contains four crystallographically-independent palladium complexes with 1/8th of a diethyl ether molecule per palladium complex (1/2 per asymmetric unit). It was not possible to refine the atoms of the diethyl ether molecule anisotropically.

The hydrogen atoms bonded to N(2), N(102), N(202) and N(302) (one per crystallographically-independent palladium complex) were located in the electron density and their positions refined subject to suitable distance restraints, (N-H = 0.91 (2) Å and Pd … H = 2.48 (4) Å). The isotropic thermal parameters (U_{iso}) of these hydrogen atoms were set at 1.2 times the equivalent isotropic thermal parameter (U_{eq}) of the parent nitrogen atom. All remaining hydrogen atoms were fixed as riding models. The hydrogen bonding is detailed in Table 7, page 33 of this document.

Table 66. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for **213aha**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
C(1)	9419(3)	2088(2)	9344(2)	26(1)
C(2)	10448(3)	2168(2)	9921(2)	29(1)
C(3)	11017(3)	2075(2)	9414(2)	24(1)
C(4)	11684(3)	1580(2)	9460(2)	21(1)
C(5)	9771(3)	1984(2)	8256(2)	27(1)
C(6)	10551(3)	1844(2)	7929(2)	28(1)
C(7)	10270(4)	1167(2)	7527(2)	37(1)
C(8)	11008(4)	1055(2)	7232(2)	48(1)
C(9)	12034(4)	1601(3)	7340(2)	51(1)
C(10)	12315(4)	2270(2)	7734(2)	44(1)
C(11)	11573(3)	2392(2)	8026(2)	33(1)
C(12)	11558(3)	277(2)	9435(2)	22(1)
C(13)	11784(2)	155(2)	8800(2)	21(1)
C(14)	11007(3)	-371(2)	8263(2)	25(1)
C(15)	11252(3)	-521(2)	7703(2)	29(1)
C(16)	12299(3)	-140(2)	7669(2)	29(1)
C(17)	13084(3)	390(2)	8194(2)	29(1)
C(18)	12821(3)	531(2)	8753(2)	26(1)
C(19)	13566(4)	-54(3)	7076(2)	51(1)
C(20)	8257(3)	1687(2)	9332(2)	25(1)
C(21)	7387(3)	1831(2)	8902(2)	29(1)
C(22)	6307(3)	1466(2)	8867(2)	33(1)
C(23)	6071(3)	963(2)	9275(2)	32(1)
C(24)	6924(3)	822(2)	9714(2)	31(1)
C(25)	8010(3)	1184(2)	9742(2)	28(1)
N(1)	9886(2)	1722(1)	8892(1)	22(1)

N(2)	10983(2)	818(1)	9485(1)	20(1)
O(1)	12461(2)	-325(2)	7092(1)	41(1)
Cl(1)	7731(1)	359(1)	8061(1)	28(1)
Cl(2)	8865(1)	-658(1)	8970(1)	21(1)
Pd(1)	9412(1)	583(1)	8848(1)	18(1)
C(101)	5992(3)	1953(2)	6698(2)	35(1)
C(102)	6128(3)	1221(2)	6853(2)	36(1)
C(103)	7216(3)	1498(2)	6701(2)	35(1)
C(104)	7591(3)	990(2)	6343(2)	35(1)
C(105)	7545(4)	2766(2)	6329(2)	41(1)
C(106)	8455(3)	2756(2)	6062(2)	43(1)
C(107)	8311(4)	2749(3)	5404(2)	62(1)
C(108)	9123(5)	2710(4)	5160(2)	95(2)
C(109)	10103(4)	2670(4)	5567(3)	94(2)
C(110)	10267(4)	2692(3)	6224(2)	69(2)
C(111)	9457(4)	2741(2)	6464(2)	52(1)
C(112)	7456(4)	516(2)	5236(2)	44(1)
C(113)	8081(3)	12(2)	5483(2)	37(1)
C(114)	7534(3)	-687(2)	5585(2)	38(1)
C(115)	8081(3)	-1183(2)	5745(2)	34(1)
C(116)	9191(3)	-979(2)	5796(2)	30(1)
C(117)	9754(3)	-267(2)	5718(2)	35(1)
C(118)	9205(3)	218(2)	5564(2)	40(1)
C(119)	9224(3)	-2162(2)	5982(2)	37(1)
C(120)	4902(4)	2030(2)	6427(2)	44(1)
C(121)	4838(6)	2729(3)	6519(2)	80(2)
C(122)	3819(9)	2820(5)	6288(3)	118(3)
C(123)	2873(7)	2215(6)	5980(3)	114(3)
C(124)	2916(5)	1518(4)	5888(2)	82(2)
C(125)	3922(4)	1421(3)	6105(2)	50(1)
N(101)	6761(3)	2001(2)	6282(1)	32(1)
N(102)	6837(2)	696(2)	5660(1)	28(1)
O(101)	9797(2)	-1431(1)	5916(1)	34(1)
Cl(11)	5248(1)	2272(1)	4987(1)	35(1)
Cl(12)	5255(1)	712(1)	4284(1)	28(1)
Pd(11)	6044(1)	1417(1)	5332(1)	24(1)
C(201)	3596(3)	2209(2)	3251(2)	23(1)
C(202)	3226(3)	1389(2)	2950(2)	26(1)
C(203)	4378(3)	1560(2)	2878(2)	22(1)
C(204)	4511(3)	1283(2)	2255(2)	21(1)
C(205)	5646(3)	2885(2)	3421(2)	24(1)
C(206)	6590(3)	2788(2)	3228(2)	24(1)
C(207)	6964(3)	3160(2)	2772(2)	30(1)
C(208)	7792(3)	3025(2)	2573(2)	39(1)
C(209)	8239(3)	2515(2)	2823(2)	42(1)
C(210)	7876(3)	2145(2)	3282(2)	40(1)
C(211)	7066(3)	2285(2)	3490(2)	31(1)
C(212)	3965(3)	1284(2)	1071(2)	23(1)
C(213)	5143(3)	1535(2)	1064(1)	21(1)
C(214)	5624(3)	2205(2)	885(2)	26(1)
C(215)	6710(3)	2436(2)	885(2)	28(1)
C(216)	7338(3)	1997(2)	1076(2)	24(1)
C(217)	6867(3)	1320(2)	1248(2)	26(1)
C(218)	5784(3)	1095(2)	1234(2)	24(1)
C(219)	8900(3)	2834(2)	889(2)	37(1)
C(220)	2812(3)	2622(2)	3114(2)	25(1)
C(221)	1888(3)	2404(2)	2559(2)	33(1)
C(222)	1137(3)	2779(2)	2477(2)	42(1)
C(223)	1330(4)	3371(2)	2941(2)	44(1)
C(224)	2250(4)	3599(2)	3484(2)	45(1)
C(225)	2986(3)	3224(2)	3572(2)	35(1)
N(201)	4546(2)	2385(1)	2954(1)	20(1)
N(202)	3847(2)	1536(1)	1712(1)	19(1)
O(201)	8431(2)	2184(1)	1125(1)	30(1)
Cl(21)	4534(1)	3878(1)	2438(1)	25(1)
Cl(22)	3460(1)	2861(1)	978(1)	27(1)
Pd(21)	4121(1)	2642(1)	2026(1)	17(1)
C(301)	2467(3)	4755(2)	1948(2)	27(1)

C(302)	2002(3)	4149(2)	1337(2)	28(1)
C(303)	2912(3)	4633(2)	1102(2)	26(1)
C(304)	2697(3)	4706(2)	394(2)	27(1)
C(305)	4080(3)	5877(2)	1901(2)	29(1)
C(306)	4644(3)	6242(2)	1440(2)	27(1)
C(307)	4463(3)	6856(2)	1204(2)	28(1)
C(308)	4942(3)	7166(2)	758(2)	34(1)
C(309)	5612(3)	6861(2)	535(2)	40(1)
C(310)	5811(3)	6258(2)	771(2)	45(1)
C(311)	5331(3)	5949(2)	1223(2)	38(1)
C(312)	2225(3)	5585(2)	-295(2)	26(1)
C(313)	2255(3)	5171(2)	-903(2)	24(1)
C(314)	3089(3)	5485(2)	-1168(2)	25(1)
C(315)	3073(3)	5157(2)	-1769(2)	26(1)
C(316)	2224(3)	4496(2)	-2101(2)	27(1)
C(317)	1395(3)	4170(2)	-1837(2)	30(1)
C(318)	1401(3)	4506(2)	-1248(2)	29(1)
C(319)	2845(4)	4481(2)	-3024(2)	46(1)
C(320)	1764(3)	4919(2)	2323(2)	35(1)
C(321)	622(4)	4711(2)	2041(2)	40(1)
C(322)	-22(5)	4801(3)	2412(3)	59(1)
C(323)	437(6)	5108(3)	3046(3)	73(2)
C(324)	1568(6)	5339(2)	3345(2)	69(2)
C(325)	2259(4)	5235(2)	2981(2)	48(1)
N(301)	2959(2)	5310(1)	1540(1)	23(1)
N(302)	1932(2)	5122(1)	190(1)	19(1)
O(301)	2108(2)	4125(1)	-2694(1)	38(1)
Cl(31)	1941(1)	6525(1)	1873(1)	28(1)
Cl(32)	551(1)	6115(1)	297(1)	22(1)
Pd(31)	1878(1)	5748(1)	984(1)	18(1)
C(401)	3683(14)	5259(10)	5326(9)	125(6)
C(402)	4449(14)	4936(9)	5742(8)	123(5)
C(403)	2059(14)	5424(9)	5332(8)	112(5)
C(404)	1175(18)	5472(12)	5636(11)	162(8)
O(401)	2835(10)	5159(6)	5594(6)	126(4)

Table 67. Bond lengths [Å] and angles [°] for **213aha**.

C(1)-C(20)	1.499(5)
C(1)-C(2)	1.537(5)
C(1)-N(1)	1.544(4)
C(1)-H(1)	1.0000
C(2)-C(3)	1.538(5)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-C(4)	1.500(4)
C(3)-N(1)	1.520(4)
C(3)-H(3)	1.0000
C(4)-N(2)	1.490(4)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(5)-N(1)	1.491(4)
C(5)-C(6)	1.501(5)
C(5)-H(5A)	0.9900
C(5)-H(5B)	0.9900
C(6)-C(11)	1.390(5)
C(6)-C(7)	1.393(5)
C(7)-C(8)	1.386(6)
C(7)-H(7)	0.9500
C(8)-C(9)	1.388(7)
C(8)-H(8)	0.9500
C(9)-C(10)	1.372(6)
C(9)-H(9)	0.9500
C(10)-C(11)	1.393(5)
C(10)-H(10)	0.9500
C(11)-H(11)	0.9500
C(12)-N(2)	1.502(4)
C(12)-C(13)	1.510(4)
C(12)-H(12A)	0.9900
C(12)-H(12B)	0.9900
C(13)-C(18)	1.391(4)
C(13)-C(14)	1.391(4)
C(14)-C(15)	1.380(5)
C(14)-H(14)	0.9500
C(15)-C(16)	1.392(5)
C(15)-H(15)	0.9500
C(16)-O(1)	1.371(4)
C(16)-C(17)	1.383(5)
C(17)-C(18)	1.389(5)
C(17)-H(17)	0.9500
C(18)-H(18)	0.9500
C(19)-O(1)	1.423(5)
C(19)-H(19A)	0.9800
C(19)-H(19B)	0.9800
C(19)-H(19C)	0.9800
C(20)-C(25)	1.392(4)
C(20)-C(21)	1.397(5)
C(21)-C(22)	1.377(5)
C(21)-H(21)	0.9500
C(22)-C(23)	1.388(5)
C(22)-H(22)	0.9500
C(23)-C(24)	1.387(5)
C(23)-H(23)	0.9500
C(24)-C(25)	1.386(5)

C(24)-H(24)	0.9500
C(25)-H(25)	0.9500
N(1)-Pd(1)	2.077(2)
N(2)-Pd(1)	2.057(3)
N(2)-H(2C)	0.900(17)
Cl(1)-Pd(1)	2.3023(8)
Cl(2)-Pd(1)	2.3347(7)
C(101)-C(120)	1.480(6)
C(101)-C(102)	1.535(5)
C(101)-N(101)	1.542(5)
C(101)-H(101)	1.0000
C(102)-C(103)	1.529(5)
C(102)-H(10A)	0.9900
C(102)-H(10B)	0.9900
C(103)-C(104)	1.499(5)
C(103)-N(101)	1.533(4)
C(103)-H(103)	1.0000
C(104)-N(102)	1.484(4)
C(104)-H(10C)	0.9900
C(104)-H(10D)	0.9900
C(105)-N(101)	1.495(5)
C(105)-C(106)	1.502(6)
C(105)-H(10E)	0.9900
C(105)-H(10F)	0.9900
C(106)-C(107)	1.383(6)
C(106)-C(111)	1.395(6)
C(107)-C(108)	1.363(7)
C(107)-H(107)	0.9500
C(108)-C(109)	1.395(8)
C(108)-H(108)	0.9500
C(109)-C(110)	1.373(7)
C(109)-H(109)	0.9500
C(110)-C(111)	1.360(7)
C(110)-H(110)	0.9500
C(111)-H(111)	0.9500
C(112)-N(102)	1.494(5)
C(112)-C(113)	1.516(5)
C(112)-H(11A)	0.9900
C(112)-H(11B)	0.9900
C(113)-C(114)	1.387(5)
C(113)-C(118)	1.392(5)
C(114)-C(115)	1.394(5)
C(114)-H(114)	0.9500
C(115)-C(116)	1.387(5)
C(115)-H(115)	0.9500
C(116)-O(101)	1.368(4)
C(116)-C(117)	1.394(5)
C(117)-C(118)	1.376(5)
C(117)-H(117)	0.9500
C(118)-H(118)	0.9500
C(119)-O(101)	1.419(4)
C(119)-H(11C)	0.9800
C(119)-H(11D)	0.9800
C(119)-H(11E)	0.9800
C(120)-C(121)	1.385(6)
C(120)-C(125)	1.407(7)
C(121)-C(122)	1.394(9)
C(121)-H(121)	0.9500
C(122)-C(123)	1.372(12)
C(122)-H(122)	0.9500
C(123)-C(124)	1.370(10)
C(123)-H(123)	0.9500
C(124)-C(125)	1.382(6)
C(124)-H(124)	0.9500
C(125)-H(125)	0.9500
N(101)-Pd(11)	2.066(3)
N(102)-Pd(11)	2.065(3)
N(102)-H(12C)	0.901(18)
Cl(11)-Pd(11)	2.3078(8)
Cl(12)-Pd(11)	2.3212(8)
C(201)-C(220)	1.498(4)
C(201)-C(202)	1.532(5)
C(201)-N(201)	1.545(4)
C(201)-H(201)	1.0000
C(202)-C(203)	1.535(4)
C(202)-H(20A)	0.9900
C(202)-H(20B)	0.9900
C(203)-C(204)	1.495(4)
C(203)-N(201)	1.528(4)
C(203)-H(203)	1.0000
C(204)-N(202)	1.484(4)
C(204)-H(20C)	0.9900
C(204)-H(20D)	0.9900
C(205)-N(201)	1.497(4)
C(205)-C(206)	1.507(4)
C(205)-H(20E)	0.9900
C(205)-H(20F)	0.9900
C(206)-C(207)	1.384(5)
C(206)-C(211)	1.400(5)
C(207)-C(208)	1.393(5)
C(207)-H(207)	0.9500
C(208)-C(209)	1.382(6)
C(208)-H(208)	0.9500
C(209)-C(210)	1.380(6)
C(209)-H(209)	0.9500
C(210)-C(211)	1.385(5)
C(210)-H(210)	0.9500
C(211)-H(211)	0.9500
C(212)-N(202)	1.504(4)
C(212)-C(213)	1.508(4)
C(212)-H(21A)	0.9900
C(212)-H(21B)	0.9900
C(213)-C(214)	1.391(4)
C(213)-C(218)	1.395(4)
C(214)-C(215)	1.387(5)
C(214)-H(214)	0.9500
C(215)-C(216)	1.386(4)
C(215)-H(215)	0.9500
C(216)-O(201)	1.370(4)
C(216)-C(217)	1.391(4)
C(217)-C(218)	1.373(5)
C(217)-H(217)	0.9500
C(218)-H(218)	0.9500
C(219)-O(201)	1.419(4)
C(219)-H(21C)	0.9800
C(219)-H(21D)	0.9800
C(219)-H(21E)	0.9800
C(220)-C(225)	1.382(5)
C(220)-C(221)	1.384(5)
C(221)-C(222)	1.403(5)
C(221)-H(221)	0.9500
C(222)-C(223)	1.372(6)
C(222)-H(222)	0.9500
C(223)-C(224)	1.365(6)
C(223)-H(223)	0.9500
C(224)-C(225)	1.386(5)
C(224)-H(224)	0.9500
C(225)-H(225)	0.9500
N(201)-Pd(21)	2.077(2)
N(202)-Pd(21)	2.075(2)
N(202)-H(22C)	0.901(18)
Cl(21)-Pd(21)	2.3182(8)
Cl(22)-Pd(21)	2.3210(7)
C(301)-C(320)	1.497(5)
C(301)-C(302)	1.533(5)
C(301)-N(301)	1.549(4)

C(301)-H(301)	1.0000
C(302)-C(303)	1.527(5)
C(302)-H(30A)	0.9900
C(302)-H(30B)	0.9900
C(303)-C(304)	1.508(4)
C(303)-N(301)	1.530(4)
C(303)-H(303)	1.0000
C(304)-N(302)	1.494(4)
C(304)-H(30C)	0.9900
C(304)-H(30D)	0.9900
C(305)-N(301)	1.496(4)
C(305)-C(306)	1.507(5)
C(305)-H(30E)	0.9900
C(305)-H(30F)	0.9900
C(306)-C(307)	1.392(5)
C(306)-C(311)	1.393(5)
C(307)-C(308)	1.382(5)
C(307)-H(307)	0.9500
C(308)-C(309)	1.393(5)
C(308)-H(308)	0.9500
C(309)-C(310)	1.382(6)
C(309)-H(309)	0.9500
C(310)-C(311)	1.392(6)
C(310)-H(310)	0.9500
C(311)-H(311)	0.9500
C(312)-N(302)	1.491(4)
C(312)-C(313)	1.507(4)
C(312)-H(31A)	0.9900
C(312)-H(31B)	0.9900
C(313)-C(314)	1.394(4)
C(313)-C(318)	1.398(5)
C(314)-C(315)	1.396(4)
C(314)-H(314)	0.9500
C(315)-C(316)	1.386(5)
C(315)-H(315)	0.9500
C(316)-O(301)	1.364(4)
C(316)-C(317)	1.394(5)
C(317)-C(318)	1.386(5)
C(317)-H(317)	0.9500
C(318)-H(318)	0.9500
C(319)-O(301)	1.419(4)
C(319)-H(31C)	0.9800
C(319)-H(31D)	0.9800
C(319)-H(31E)	0.9800
C(320)-C(325)	1.387(5)
C(320)-C(321)	1.392(6)
C(321)-C(322)	1.378(6)
C(321)-H(321)	0.9500
C(322)-C(323)	1.337(8)
C(322)-H(322)	0.9500
C(323)-C(324)	1.379(8)
C(323)-H(323)	0.9500
C(324)-C(325)	1.429(7)
C(324)-H(324)	0.9500
C(325)-H(325)	0.9500
N(301)-Pd(31)	2.061(3)
N(302)-Pd(31)	2.061(2)
N(302)-H(32C)	0.894(18)
Cl(31)-Pd(31)	2.3155(8)
Cl(32)-Pd(31)	2.3217(8)
C(401)-O(401)	1.390(18)
C(401)-C(402)	1.499(9)
C(401)-H(40A)	0.9900
C(401)-H(40B)	0.9900
C(402)-H(40C)	0.9800
C(402)-H(40D)	0.9800
C(402)-H(40E)	0.9800
C(403)-O(401)	1.315(17)
C(403)-C(404)	1.54(2)
C(403)-H(40F)	0.9900
C(403)-H(40G)	0.9900
C(404)-H(40H)	0.9800
C(404)-H(40I)	0.9800
C(404)-H(40J)	0.9800

C(20)-C(1)-C(2)	123.2(3)
C(20)-C(1)-N(1)	118.3(3)
C(2)-C(1)-N(1)	88.6(2)
C(20)-C(1)-H(1)	108.3
C(2)-C(1)-H(1)	108.3
N(1)-C(1)-H(1)	108.3
C(1)-C(2)-C(3)	87.3(2)
C(1)-C(2)-H(2A)	114.1
C(3)-C(2)-H(2A)	114.1
C(1)-C(2)-H(2B)	114.1
C(3)-C(2)-H(2B)	114.1
H(2A)-C(2)-H(2B)	111.3
C(4)-C(3)-N(1)	111.8(2)
C(4)-C(3)-C(2)	121.8(3)
N(1)-C(3)-C(2)	89.4(2)
C(4)-C(3)-H(3)	110.6
N(1)-C(3)-H(3)	110.6
C(2)-C(3)-H(3)	110.6
N(2)-C(4)-C(3)	109.1(2)
N(2)-C(4)-H(4A)	109.9
C(3)-C(4)-H(4A)	109.9
N(2)-C(4)-H(4B)	109.9
C(3)-C(4)-H(4B)	109.9
H(4A)-C(4)-H(4B)	108.3
N(1)-C(5)-C(6)	112.9(2)
N(1)-C(5)-H(5A)	109.0
C(6)-C(5)-H(5A)	109.0
N(1)-C(5)-H(5B)	109.0
C(6)-C(5)-H(5B)	109.0
H(5A)-C(5)-H(5B)	107.8
C(11)-C(6)-C(7)	118.8(3)
C(11)-C(6)-C(5)	120.2(3)
C(7)-C(6)-C(5)	121.0(3)
C(8)-C(7)-C(6)	119.6(4)
C(8)-C(7)-H(7)	120.2
C(6)-C(7)-H(7)	120.2
C(7)-C(8)-C(9)	121.1(4)
C(7)-C(8)-H(8)	119.4
C(9)-C(8)-H(8)	119.4
C(10)-C(9)-C(8)	119.6(4)
C(10)-C(9)-H(9)	120.2
C(8)-C(9)-H(9)	120.2
C(9)-C(10)-C(11)	119.8(4)
C(9)-C(10)-H(10)	120.1
C(11)-C(10)-H(10)	120.1
C(6)-C(11)-C(10)	121.1(4)
C(6)-C(11)-H(11)	119.5
C(10)-C(11)-H(11)	119.5
N(2)-C(12)-C(13)	115.9(2)
N(2)-C(12)-H(12A)	108.3
C(13)-C(12)-H(12A)	108.3
N(2)-C(12)-H(12B)	108.3
C(13)-C(12)-H(12B)	108.3
H(12A)-C(12)-H(12B)	107.4
C(18)-C(13)-C(14)	117.7(3)
C(18)-C(13)-C(12)	120.2(3)
C(14)-C(13)-C(12)	121.9(3)
C(15)-C(14)-C(13)	121.5(3)
C(15)-C(14)-H(14)	119.2
C(13)-C(14)-H(14)	119.2
C(14)-C(15)-C(16)	119.7(3)

C(14)-C(15)-H(15)	120.1
C(16)-C(15)-H(15)	120.1
O(1)-C(16)-C(17)	124.6(3)
O(1)-C(16)-C(15)	115.4(3)
C(17)-C(16)-C(15)	120.0(3)
C(16)-C(17)-C(18)	119.4(3)
C(16)-C(17)-H(17)	120.3
C(18)-C(17)-H(17)	120.3
C(17)-C(18)-C(13)	121.7(3)
C(17)-C(18)-H(18)	119.2
C(13)-C(18)-H(18)	119.2
O(1)-C(19)-H(19A)	109.5
O(1)-C(19)-H(19B)	109.5
H(19A)-C(19)-H(19B)	109.5
O(1)-C(19)-H(19C)	109.5
H(19A)-C(19)-H(19C)	109.5
H(19B)-C(19)-H(19C)	109.5
C(25)-C(20)-C(21)	118.5(3)
C(25)-C(20)-C(1)	122.5(3)
C(21)-C(20)-C(1)	119.0(3)
C(22)-C(21)-C(20)	120.8(3)
C(22)-C(21)-H(21)	119.6
C(20)-C(21)-H(21)	119.6
C(21)-C(22)-C(23)	120.1(3)
C(21)-C(22)-H(22)	120.0
C(23)-C(22)-H(22)	120.0
C(24)-C(23)-C(22)	120.0(3)
C(24)-C(23)-H(23)	120.0
C(22)-C(23)-H(23)	120.0
C(25)-C(24)-C(23)	119.7(3)
C(25)-C(24)-H(24)	120.1
C(23)-C(24)-H(24)	120.1
C(24)-C(25)-C(20)	120.9(3)
C(24)-C(25)-H(25)	119.6
C(20)-C(25)-H(25)	119.6
C(5)-N(1)-C(3)	116.0(2)
C(5)-N(1)-C(1)	113.8(2)
C(3)-N(1)-C(1)	87.7(2)
C(5)-N(1)-Pd(1)	116.39(19)
C(3)-N(1)-Pd(1)	107.10(17)
C(1)-N(1)-Pd(1)	112.32(18)
C(4)-N(2)-C(12)	111.2(2)
C(4)-N(2)-Pd(1)	108.41(17)
C(12)-N(2)-Pd(1)	118.77(19)
C(4)-N(2)-H(2C)	105(2)
C(12)-N(2)-H(2C)	107(2)
Pd(1)-N(2)-H(2C)	105.9(19)
C(16)-O(1)-C(19)	117.2(3)
N(2)-Pd(1)-N(1)	85.23(10)
N(2)-Pd(1)-Cl(1)	174.46(7)
N(1)-Pd(1)-Cl(1)	92.60(7)
N(2)-Pd(1)-Cl(2)	92.12(7)
N(1)-Pd(1)-Cl(2)	170.70(8)
Cl(1)-Pd(1)-Cl(2)	90.80(3)
C(120)-C(101)-C(102)	123.4(4)
C(120)-C(101)-N(101)	120.8(3)
C(102)-C(101)-N(101)	88.4(3)
C(120)-C(101)-H(101)	107.4
C(102)-C(101)-H(101)	107.4
N(101)-C(101)-H(101)	107.4
C(103)-C(102)-C(101)	86.5(3)
C(103)-C(102)-H(10A)	114.2
C(101)-C(102)-H(10A)	114.2
C(103)-C(102)-H(10B)	114.2
C(101)-C(102)-H(10B)	114.2
H(10A)-C(102)-H(10B)	111.4
C(104)-C(103)-C(102)	122.0(3)
C(104)-C(103)-N(101)	113.7(3)
C(102)-C(103)-N(101)	88.9(3)
C(104)-C(103)-H(103)	110.1
C(102)-C(103)-H(103)	110.1
N(101)-C(103)-H(103)	110.1
N(102)-C(104)-C(103)	111.4(3)
N(102)-C(104)-H(10C)	109.3
C(103)-C(104)-H(10C)	109.3
N(102)-C(104)-H(10D)	109.3
C(103)-C(104)-H(10D)	109.3
H(10C)-C(104)-H(10D)	108.0
N(101)-C(105)-C(106)	111.8(3)
N(101)-C(105)-H(10E)	109.3
C(106)-C(105)-H(10E)	109.3
N(101)-C(105)-H(10F)	109.3
C(106)-C(105)-H(10F)	109.3
H(10E)-C(105)-H(10F)	107.9
C(107)-C(106)-C(111)	118.1(4)
C(107)-C(106)-C(105)	120.5(4)
C(111)-C(106)-C(105)	121.4(4)
C(108)-C(107)-C(106)	120.3(5)
C(108)-C(107)-H(107)	119.9
C(106)-C(107)-H(107)	119.9
C(107)-C(108)-C(109)	120.5(5)
C(107)-C(108)-H(108)	119.8
C(109)-C(108)-H(108)	119.8
C(110)-C(109)-C(108)	119.9(5)
C(110)-C(109)-H(109)	120.0
C(108)-C(109)-H(109)	120.0
C(111)-C(110)-C(109)	119.0(5)
C(111)-C(110)-H(110)	120.5
C(109)-C(110)-H(110)	120.5
C(110)-C(111)-C(106)	122.1(4)
C(110)-C(111)-H(111)	118.9
C(106)-C(111)-H(111)	118.9
N(102)-C(112)-C(113)	114.6(3)
N(102)-C(112)-H(11A)	108.6
C(113)-C(112)-H(11A)	108.6
N(102)-C(112)-H(11B)	108.6
C(113)-C(112)-H(11B)	108.6
H(11A)-C(112)-H(11B)	107.6
C(114)-C(113)-C(118)	118.3(3)
C(114)-C(113)-C(112)	121.1(4)
C(118)-C(113)-C(112)	120.5(4)
C(113)-C(114)-C(115)	121.3(4)
C(113)-C(114)-H(114)	119.4
C(115)-C(114)-H(114)	119.4
C(116)-C(115)-C(114)	119.7(3)
C(116)-C(115)-H(115)	120.2
C(114)-C(115)-H(115)	120.2
O(101)-C(116)-C(115)	124.9(3)
O(101)-C(116)-C(117)	115.9(3)
C(115)-C(116)-C(117)	119.2(3)
C(118)-C(117)-C(116)	120.5(4)
C(118)-C(117)-H(117)	119.8
C(116)-C(117)-H(117)	119.8
C(117)-C(118)-C(113)	121.0(4)
C(117)-C(118)-H(118)	119.5
C(113)-C(118)-H(118)	119.5
O(101)-C(119)-H(11C)	109.5
O(101)-C(119)-H(11D)	109.5
H(11C)-C(119)-H(11D)	109.5
O(101)-C(119)-H(11E)	109.5
H(11C)-C(119)-H(11E)	109.5
H(11D)-C(119)-H(11E)	109.5
C(121)-C(120)-C(125)	118.6(5)
C(121)-C(120)-C(101)	118.5(5)
C(125)-C(120)-C(101)	122.8(4)
C(120)-C(121)-C(122)	120.2(7)

C(120)-C(121)-H(121)	119.9
C(122)-C(121)-H(121)	119.9
C(123)-C(122)-C(121)	120.1(7)
C(123)-C(122)-H(122)	119.9
C(121)-C(122)-H(122)	119.9
C(122)-C(123)-C(124)	120.7(6)
C(122)-C(123)-H(123)	119.6
C(124)-C(123)-H(123)	119.6
C(123)-C(124)-C(125)	119.8(7)
C(123)-C(124)-H(124)	120.1
C(125)-C(124)-H(124)	120.1
C(124)-C(125)-C(120)	120.6(5)
C(124)-C(125)-H(125)	119.7
C(120)-C(125)-H(125)	119.7
C(105)-N(101)-C(103)	117.2(3)
C(105)-N(101)-C(101)	114.6(3)
C(103)-N(101)-C(101)	86.1(2)
C(105)-N(101)-Pd(11)	112.5(2)
C(103)-N(101)-Pd(11)	106.8(2)
C(101)-N(101)-Pd(11)	117.1(2)
C(104)-N(102)-C(112)	110.0(3)
C(104)-N(102)-Pd(11)	110.6(2)
C(112)-N(102)-Pd(11)	113.8(2)
C(104)-N(102)-H(12C)	109(2)
C(112)-N(102)-H(12C)	110(2)
Pd(11)-N(102)-H(12C)	103(2)
C(116)-O(101)-C(119)	116.2(3)
N(102)-Pd(11)-N(101)	85.90(11)
N(102)-Pd(11)-Cl(11)	176.98(9)
N(101)-Pd(11)-Cl(11)	92.39(8)
N(102)-Pd(11)-Cl(12)	91.55(8)
N(101)-Pd(11)-Cl(12)	177.31(8)
Cl(11)-Pd(11)-Cl(12)	90.19(3)
C(220)-C(201)-C(202)	121.3(3)
C(220)-C(201)-N(201)	119.5(2)
C(202)-C(201)-N(201)	89.2(2)
C(220)-C(201)-H(201)	108.4
C(202)-C(201)-H(201)	108.4
N(201)-C(201)-H(201)	108.4
C(201)-C(202)-C(203)	87.7(2)
C(201)-C(202)-H(20A)	114.0
C(203)-C(202)-H(20A)	114.0
C(201)-C(202)-H(20B)	114.0
C(203)-C(202)-H(20B)	114.0
H(20A)-C(202)-H(20B)	111.2
C(204)-C(203)-N(201)	111.5(2)
C(204)-C(203)-C(202)	121.1(3)
N(201)-C(203)-C(202)	89.7(2)
C(204)-C(203)-H(203)	110.9
N(201)-C(203)-H(203)	110.9
C(202)-C(203)-H(203)	110.9
N(202)-C(204)-C(203)	108.7(2)
N(202)-C(204)-H(20C)	110.0
C(203)-C(204)-H(20C)	110.0
N(202)-C(204)-H(20D)	110.0
C(203)-C(204)-H(20D)	110.0
H(20C)-C(204)-H(20D)	108.3
N(201)-C(205)-C(206)	111.6(2)
N(201)-C(205)-H(20E)	109.3
C(206)-C(205)-H(20E)	109.3
N(201)-C(205)-H(20F)	109.3
C(206)-C(205)-H(20F)	109.3
H(20E)-C(205)-H(20F)	108.0
C(207)-C(206)-C(211)	119.0(3)
C(207)-C(206)-C(205)	121.3(3)
C(211)-C(206)-C(205)	119.7(3)
C(206)-C(207)-C(208)	120.0(3)
C(206)-C(207)-H(207)	120.0
C(208)-C(207)-H(207)	120.0
C(209)-C(208)-C(207)	120.7(3)
C(209)-C(208)-H(208)	119.7
C(207)-C(208)-H(208)	119.7
C(210)-C(209)-C(208)	119.7(4)
C(210)-C(209)-H(209)	120.1
C(208)-C(209)-H(209)	120.1
C(209)-C(210)-C(211)	120.1(4)
C(209)-C(210)-H(210)	120.0
C(211)-C(210)-H(210)	120.0
C(210)-C(211)-C(206)	120.6(3)
C(210)-C(211)-H(211)	119.7
C(206)-C(211)-H(211)	119.7
N(202)-C(212)-C(213)	114.3(2)
N(202)-C(212)-H(21A)	108.7
C(213)-C(212)-H(21A)	108.7
N(202)-C(212)-H(21B)	108.7
C(213)-C(212)-H(21B)	108.7
H(21A)-C(212)-H(21B)	107.6
C(214)-C(213)-C(218)	117.8(3)
C(214)-C(213)-C(212)	121.6(3)
C(218)-C(213)-C(212)	120.7(3)
C(215)-C(214)-C(213)	121.3(3)
C(215)-C(214)-H(214)	119.3
C(213)-C(214)-H(214)	119.3
C(214)-C(215)-C(216)	119.6(3)
C(214)-C(215)-H(215)	120.2
C(216)-C(215)-H(215)	120.2
O(201)-C(216)-C(215)	124.7(3)
O(201)-C(216)-C(217)	115.3(3)
C(215)-C(216)-C(217)	120.0(3)
C(218)-C(217)-C(216)	119.6(3)
C(218)-C(217)-H(217)	120.2
C(216)-C(217)-H(217)	120.2
C(217)-C(218)-C(213)	121.7(3)
C(217)-C(218)-H(218)	119.2
C(213)-C(218)-H(218)	119.2
O(201)-C(219)-H(21C)	109.5
O(201)-C(219)-H(21D)	109.5
H(21C)-C(219)-H(21D)	109.5
O(201)-C(219)-H(21E)	109.5
H(21C)-C(219)-H(21E)	109.5
H(21D)-C(219)-H(21E)	109.5
C(225)-C(220)-C(221)	118.6(3)
C(225)-C(220)-C(201)	119.0(3)
C(221)-C(220)-C(201)	122.4(3)
C(220)-C(221)-C(222)	120.1(4)
C(220)-C(221)-H(221)	119.9
C(222)-C(221)-H(221)	119.9
C(223)-C(222)-C(221)	119.9(4)
C(223)-C(222)-H(222)	120.0
C(221)-C(222)-H(222)	120.0
C(224)-C(223)-C(222)	120.3(4)
C(224)-C(223)-H(223)	119.9
C(222)-C(223)-H(223)	119.9
C(223)-C(224)-C(225)	120.0(4)
C(223)-C(224)-H(224)	120.0
C(225)-C(224)-H(224)	120.0
C(220)-C(225)-C(224)	121.1(4)
C(220)-C(225)-H(225)	119.5
C(224)-C(225)-H(225)	119.5
C(205)-N(201)-C(203)	114.6(2)
C(205)-N(201)-C(201)	114.0(2)
C(203)-N(201)-C(201)	87.5(2)
C(205)-N(201)-Pd(21)	115.63(18)
C(203)-N(201)-Pd(21)	108.12(17)
C(201)-N(201)-Pd(21)	113.72(17)
C(204)-N(202)-C(212)	111.0(2)

C(204)-N(202)-Pd(21)	107.64(18)
C(212)-N(202)-Pd(21)	121.18(19)
C(204)-N(202)-H(22C)	109(2)
C(212)-N(202)-H(22C)	104(2)
Pd(21)-N(202)-H(22C)	103.5(18)
C(216)-O(201)-C(219)	116.4(3)
N(202)-Pd(21)-N(201)	84.17(10)
N(202)-Pd(21)-Cl(21)	175.95(7)
N(201)-Pd(21)-Cl(21)	92.63(7)
N(202)-Pd(21)-Cl(22)	94.15(7)
N(201)-Pd(21)-Cl(22)	174.18(7)
Cl(21)-Pd(21)-Cl(22)	89.27(3)
C(320)-C(301)-C(302)	123.1(3)
C(320)-C(301)-N(301)	120.7(3)
C(302)-C(301)-N(301)	87.9(2)
C(320)-C(301)-H(301)	107.7
C(302)-C(301)-H(301)	107.7
N(301)-C(301)-H(301)	107.7
C(303)-C(302)-C(301)	86.9(2)
C(303)-C(302)-H(30A)	114.2
C(301)-C(302)-H(30A)	114.2
C(303)-C(302)-H(30B)	114.2
C(301)-C(302)-H(30B)	114.2
H(30A)-C(302)-H(30B)	111.3
C(304)-C(303)-C(302)	121.4(3)
C(304)-C(303)-N(301)	113.6(2)
C(302)-C(303)-N(301)	88.9(2)
C(304)-C(303)-H(303)	110.4
C(302)-C(303)-H(303)	110.4
N(301)-C(303)-H(303)	110.4
N(302)-C(304)-C(303)	111.6(3)
N(302)-C(304)-H(30C)	109.3
C(303)-C(304)-H(30C)	109.3
N(302)-C(304)-H(30D)	109.3
C(303)-C(304)-H(30D)	109.3
H(30C)-C(304)-H(30D)	108.0
N(301)-C(305)-C(306)	111.6(3)
N(301)-C(305)-H(30E)	109.3
C(306)-C(305)-H(30E)	109.3
N(301)-C(305)-H(30F)	109.3
C(306)-C(305)-H(30F)	109.3
H(30E)-C(305)-H(30F)	108.0
C(307)-C(306)-C(311)	118.8(3)
C(307)-C(306)-C(305)	121.3(3)
C(311)-C(306)-C(305)	119.8(3)
C(308)-C(307)-C(306)	120.9(3)
C(308)-C(307)-H(307)	119.5
C(306)-C(307)-H(307)	119.5
C(307)-C(308)-C(309)	119.9(3)
C(307)-C(308)-H(308)	120.1
C(309)-C(308)-H(308)	120.1
C(310)-C(309)-C(308)	119.8(3)
C(310)-C(309)-H(309)	120.1
C(308)-C(309)-H(309)	120.1
C(309)-C(310)-C(311)	120.2(4)
C(309)-C(310)-H(310)	119.9
C(311)-C(310)-H(310)	119.9
C(310)-C(311)-C(306)	120.3(4)
C(310)-C(311)-H(311)	119.8
C(306)-C(311)-H(311)	119.8
N(302)-C(312)-C(313)	115.3(2)
N(302)-C(312)-H(31A)	108.4
C(313)-C(312)-H(31A)	108.4
N(302)-C(312)-H(31B)	108.4
C(313)-C(312)-H(31B)	108.4
H(31A)-C(312)-H(31B)	107.5
C(314)-C(313)-C(318)	118.5(3)
C(314)-C(313)-C(312)	119.9(3)
C(318)-C(313)-C(312)	121.3(3)
C(313)-C(314)-C(315)	121.4(3)
C(313)-C(314)-H(314)	119.3
C(315)-C(314)-H(314)	119.3
C(316)-C(315)-C(314)	119.3(3)
C(316)-C(315)-H(315)	120.3
C(314)-C(315)-H(315)	120.3
O(301)-C(316)-C(315)	125.0(3)
O(301)-C(316)-C(317)	115.2(3)
C(315)-C(316)-C(317)	119.8(3)
C(318)-C(317)-C(316)	120.6(3)
C(318)-C(317)-H(317)	119.7
C(316)-C(317)-H(317)	119.7
C(317)-C(318)-C(313)	120.3(3)
C(317)-C(318)-H(318)	119.8
C(313)-C(318)-H(318)	119.8
O(301)-C(319)-H(31C)	109.5
O(301)-C(319)-H(31D)	109.5
H(31C)-C(319)-H(31D)	109.5
O(301)-C(319)-H(31E)	109.5
H(31C)-C(319)-H(31E)	109.5
H(31D)-C(319)-H(31E)	109.5
C(325)-C(320)-C(321)	119.4(4)
C(325)-C(320)-C(301)	118.7(4)
C(321)-C(320)-C(301)	121.7(3)
C(322)-C(321)-C(320)	120.8(5)
C(322)-C(321)-H(321)	119.6
C(320)-C(321)-H(321)	119.6
C(323)-C(322)-C(321)	120.9(5)
C(323)-C(322)-H(322)	119.6
C(321)-C(322)-H(322)	119.6
C(322)-C(323)-C(324)	120.6(5)
C(322)-C(323)-H(323)	119.7
C(324)-C(323)-H(323)	119.7
C(323)-C(324)-C(325)	120.1(5)
C(323)-C(324)-H(324)	119.9
C(325)-C(324)-H(324)	119.9
C(320)-C(325)-C(324)	118.2(5)
C(320)-C(325)-H(325)	120.9
C(324)-C(325)-H(325)	120.9
C(305)-N(301)-C(303)	117.1(3)
C(305)-N(301)-C(301)	114.9(2)
C(303)-N(301)-C(301)	86.2(2)
C(305)-N(301)-Pd(31)	113.39(19)
C(303)-N(301)-Pd(31)	107.37(18)
C(301)-N(301)-Pd(31)	115.0(2)
C(312)-N(302)-C(304)	111.3(2)
C(312)-N(302)-Pd(31)	111.42(18)
C(304)-N(302)-Pd(31)	111.63(19)
C(312)-N(302)-H(32C)	107(2)
C(304)-N(302)-H(32C)	111(2)
Pd(31)-N(302)-H(32C)	104.4(18)
C(316)-O(301)-C(319)	117.4(3)
N(302)-Pd(31)-N(301)	85.58(10)
N(302)-Pd(31)-Cl(31)	175.51(8)
N(301)-Pd(31)-Cl(31)	94.10(8)
N(302)-Pd(31)-Cl(32)	90.20(7)
N(301)-Pd(31)-Cl(32)	173.92(8)
Cl(31)-Pd(31)-Cl(32)	90.44(3)
O(401)-C(401)-C(402)	104.9(14)
O(401)-C(401)-H(40A)	110.8
C(402)-C(401)-H(40A)	110.8
O(401)-C(401)-H(40B)	110.8
C(402)-C(401)-H(40B)	110.8
H(40A)-C(401)-H(40B)	108.9
C(401)-C(402)-H(40C)	109.5
C(401)-C(402)-H(40D)	109.5
H(40C)-C(402)-H(40D)	109.5

C(401)-C(402)-H(40E)	109.5
H(40C)-C(402)-H(40E)	109.5
H(40D)-C(402)-H(40E)	109.5
O(401)-C(403)-C(404)	123.9(16)
O(401)-C(403)-H(40F)	106.3
C(404)-C(403)-H(40F)	106.3
O(401)-C(403)-H(40G)	106.3
C(404)-C(403)-H(40G)	106.3
H(40F)-C(403)-H(40G)	106.4
C(403)-C(404)-H(40H)	109.5
C(403)-C(404)-H(40I)	109.5
H(40H)-C(404)-H(40I)	109.5
C(403)-C(404)-H(40J)	109.5
H(40H)-C(404)-H(40J)	109.5
H(40I)-C(404)-H(40J)	109.5
C(403)-O(401)-C(401)	117.5(13)

Symmetry transformations used to generate equivalent atoms:

Table 68. Anisotropic displacement parameters (Å^{2}x 10^3) for **213aha**. The anisotropic displacement factor exponent takes the form: $-2\pi^2$[$h^2a^{*2}U^{11}$ + ... + 2 h k a* b* U^{12}]

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
C(1)	25(2)	18(2)	33(2)	2(1)	7(1)	10(1)
C(2)	26(2)	27(2)	29(2)	-3(1)	3(1)	10(1)
C(3)	20(2)	18(1)	26(2)	-1(1)	0(1)	4(1)
C(4)	17(2)	23(2)	20(2)	5(1)	1(1)	6(1)
C(5)	24(2)	23(2)	30(2)	12(1)	1(1)	9(1)
C(6)	32(2)	30(2)	23(2)	13(1)	3(1)	17(2)
C(7)	49(2)	36(2)	22(2)	9(1)	0(2)	22(2)
C(8)	82(4)	53(3)	24(2)	12(2)	11(2)	47(3)
C(9)	66(3)	76(3)	39(2)	31(2)	26(2)	50(3)
C(10)	43(2)	58(3)	41(2)	24(2)	17(2)	25(2)
C(11)	34(2)	35(2)	32(2)	14(2)	8(2)	16(2)
C(12)	22(2)	24(2)	23(2)	10(1)	5(1)	12(1)
C(13)	16(2)	21(1)	25(2)	6(1)	2(1)	10(1)
C(14)	20(2)	24(2)	30(2)	4(1)	6(1)	9(1)
C(15)	30(2)	29(2)	29(2)	3(1)	9(2)	13(2)
C(16)	36(2)	33(2)	30(2)	13(1)	16(2)	21(2)
C(17)	24(2)	29(2)	40(2)	14(2)	14(2)	13(1)
C(18)	21(2)	24(2)	30(2)	7(1)	3(1)	9(1)
C(19)	61(3)	63(3)	56(3)	26(2)	41(2)	34(2)
C(20)	26(2)	17(1)	32(2)	3(1)	8(1)	10(1)
C(21)	26(2)	23(2)	39(2)	9(1)	8(2)	11(1)
C(22)	26(2)	30(2)	42(2)	7(2)	6(2)	14(2)
C(23)	26(2)	26(2)	45(2)	5(2)	14(2)	10(1)
C(24)	36(2)	24(2)	37(2)	8(1)	16(2)	13(2)
C(25)	28(2)	23(2)	32(2)	7(1)	7(2)	13(1)
N(1)	18(1)	18(1)	26(1)	3(1)	2(1)	7(1)
N(2)	19(1)	22(1)	17(1)	4(1)	2(1)	8(1)
O(1)	48(2)	51(2)	38(2)	11(1)	26(1)	23(1)
Cl(1)	20(1)	25(1)	31(1)	3(1)	-4(1)	7(1)
Cl(2)	20(1)	19(1)	23(1)	6(1)	6(1)	5(1)
Pd(1)	16(1)	17(1)	18(1)	3(1)	2(1)	6(1)
C(101)	50(2)	37(2)	14(2)	1(1)	7(2)	15(2)
C(102)	43(2)	44(2)	21(2)	13(2)	7(2)	17(2)
C(103)	37(2)	42(2)	19(2)	8(1)	-4(2)	15(2)
C(104)	31(2)	41(2)	28(2)	11(2)	-1(2)	15(2)
C(105)	51(3)	30(2)	27(2)	2(2)	2(2)	6(2)
C(106)	41(2)	39(2)	30(2)	7(2)	1(2)	-1(2)
C(107)	38(3)	104(4)	31(2)	23(2)	4(2)	12(3)
C(108)	45(3)	191(7)	30(2)	24(3)	7(2)	21(4)
C(109)	36(3)	188(7)	41(3)	18(4)	6(2)	24(4)
C(110)	33(3)	103(4)	43(3)	17(3)	-3(2)	1(3)
C(111)	47(3)	54(3)	28(2)	8(2)	-2(2)	-4(2)
C(112)	55(3)	65(3)	34(2)	26(2)	23(2)	41(2)
C(113)	45(2)	55(2)	31(2)	22(2)	20(2)	32(2)
C(114)	31(2)	61(3)	36(2)	23(2)	16(2)	26(2)
C(115)	34(2)	46(2)	34(2)	19(2)	18(2)	22(2)
C(116)	29(2)	44(2)	22(2)	8(1)	10(1)	18(2)
C(117)	27(2)	44(2)	38(2)	10(2)	13(2)	14(2)
C(118)	43(2)	43(2)	42(2)	14(2)	21(2)	20(2)
C(119)	35(2)	41(2)	46(2)	16(2)	19(2)	20(2)
C(120)	69(3)	60(3)	19(2)	10(2)	17(2)	42(2)
C(121)	139(5)	92(4)	40(3)	7(3)	25(3)	85(4)
C(122)	195(7)	172(6)	58(4)	19(4)	41(5)	159(6)
C(123)	134(6)	236(8)	49(4)	48(4)	41(4)	151(6)
C(124)	67(3)	178(6)	38(3)	41(3)	31(2)	74(4)
C(125)	50(3)	85(3)	29(2)	22(2)	18(2)	33(2)
N(101)	40(2)	31(2)	18(1)	5(1)	1(1)	13(1)
N(102)	33(2)	34(2)	20(1)	11(1)	6(1)	17(1)
O(101)	27(1)	40(1)	43(2)	14(1)	16(1)	17(1)
Cl(11)	49(1)	40(1)	21(1)	12(1)	7(1)	26(1)

Cl(12)	36(1)	32(1)	16(1)	5(1)	6(1)	14(1)
Pd(11)	30(1)	28(1)	15(1)	7(1)	3(1)	13(1)
C(201)	19(2)	34(2)	19(2)	10(1)	9(1)	11(1)
C(202)	22(2)	31(2)	29(2)	13(1)	13(1)	11(1)
C(203)	19(2)	24(2)	23(2)	10(1)	7(1)	8(1)
C(204)	16(2)	24(2)	24(2)	10(1)	5(1)	9(1)
C(205)	20(2)	33(2)	15(1)	4(1)	1(1)	9(1)
C(206)	16(2)	31(2)	21(2)	2(1)	1(1)	5(1)
C(207)	20(2)	37(2)	27(2)	6(1)	4(1)	5(1)
C(208)	26(2)	52(2)	31(2)	6(2)	12(2)	2(2)
C(209)	23(2)	51(2)	47(2)	-6(2)	13(2)	8(2)
C(210)	23(2)	43(2)	46(2)	1(2)	2(2)	14(2)
C(211)	19(2)	40(2)	29(2)	6(2)	2(1)	9(1)
C(212)	22(2)	25(2)	19(2)	-1(1)	3(1)	8(1)
C(213)	24(2)	24(2)	17(1)	3(1)	6(1)	11(1)
C(214)	30(2)	30(2)	25(2)	12(1)	10(1)	17(1)
C(215)	32(2)	23(2)	31(2)	12(1)	13(2)	11(1)
C(216)	26(2)	29(2)	22(2)	8(1)	11(1)	11(1)
C(217)	32(2)	30(2)	28(2)	15(1)	15(2)	18(1)
C(218)	31(2)	22(2)	24(2)	9(1)	12(1)	12(1)
C(219)	33(2)	34(2)	48(2)	15(2)	23(2)	9(2)
C(220)	21(2)	32(2)	27(2)	13(1)	12(1)	11(1)
C(221)	30(2)	47(2)	29(2)	16(2)	12(2)	18(2)
C(222)	29(2)	64(3)	47(2)	38(2)	18(2)	26(2)
C(223)	44(2)	41(2)	75(3)	36(2)	36(2)	28(2)
C(224)	46(3)	25(2)	73(3)	12(2)	31(2)	14(2)
C(225)	28(2)	31(2)	44(2)	6(2)	14(2)	7(2)
N(201)	17(1)	27(1)	16(1)	7(1)	6(1)	8(1)
N(202)	17(1)	22(1)	19(1)	5(1)	4(1)	7(1)
O(201)	27(1)	38(1)	36(1)	19(1)	17(1)	15(1)
Cl(21)	28(1)	24(1)	25(1)	5(1)	8(1)	11(1)
Cl(22)	34(1)	34(1)	16(1)	7(1)	5(1)	20(1)
Pd(21)	16(1)	21(1)	15(1)	5(1)	4(1)	7(1)
C(301)	35(2)	23(2)	24(2)	14(1)	8(1)	11(1)
C(302)	32(2)	23(2)	29(2)	8(1)	8(2)	12(1)
C(303)	29(2)	24(2)	26(2)	6(1)	7(1)	14(1)
C(304)	30(2)	30(2)	25(2)	5(1)	8(1)	17(1)
C(305)	25(2)	32(2)	22(2)	8(1)	-2(1)	6(1)
C(306)	20(2)	30(2)	27(2)	5(1)	1(1)	7(1)
C(307)	23(2)	29(2)	30(2)	6(1)	7(1)	8(1)
C(308)	29(2)	34(2)	35(2)	12(2)	10(2)	5(2)
C(309)	24(2)	53(2)	35(2)	8(2)	11(2)	2(2)
C(310)	28(2)	55(3)	52(3)	2(2)	15(2)	14(2)
C(311)	28(2)	41(2)	48(2)	12(2)	10(2)	16(2)
C(312)	39(2)	23(2)	23(2)	7(1)	14(2)	13(1)
C(313)	31(2)	26(2)	21(2)	8(1)	10(1)	14(1)
C(314)	28(2)	23(2)	24(2)	6(1)	6(1)	11(1)
C(315)	29(2)	29(2)	26(2)	12(1)	12(1)	15(1)
C(316)	35(2)	30(2)	21(2)	7(1)	10(1)	17(2)
C(317)	37(2)	25(2)	27(2)	5(1)	12(2)	7(2)
C(318)	33(2)	31(2)	24(2)	7(1)	11(2)	11(2)
C(319)	51(3)	62(3)	30(2)	5(2)	23(2)	19(2)
C(320)	57(3)	22(2)	33(2)	15(1)	24(2)	15(2)
C(321)	51(3)	32(2)	57(2)	26(2)	32(2)	25(2)
C(322)	82(4)	51(3)	88(4)	44(3)	63(3)	44(3)
C(323)	121(5)	53(3)	101(5)	46(3)	82(5)	54(4)
C(324)	152(6)	32(2)	40(2)	17(2)	52(3)	36(3)
C(325)	85(3)	27(2)	35(2)	16(2)	27(2)	17(2)
N(301)	24(1)	23(1)	21(1)	7(1)	5(1)	8(1)
N(302)	22(1)	20(1)	16(1)	3(1)	6(1)	8(1)
O(301)	52(2)	37(1)	28(1)	0(1)	20(1)	13(1)
Cl(31)	44(1)	21(1)	19(1)	4(1)	12(1)	10(1)
Cl(32)	25(1)	20(1)	22(1)	6(1)	7(1)	10(1)
Pd(31)	22(1)	17(1)	15(1)	4(1)	5(1)	7(1)

Table 69. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10^3) for **213aha**.

	x	y	z	U(eq)
H(1)	9477	2592	9244	31
H(2A)	10336	1763	10176	35
H(2B)	10791	2660	10212	35
H(3)	11431	2569	9331	28
H(4A)	11941	1568	9076	26
H(4B)	12344	1775	9859	26
H(5A)	9911	2523	8331	32
H(5B)	9000	1729	7959	32
H(7)	9576	785	7455	44
H(8)	10809	595	6952	58
H(9)	12537	1513	7141	61
H(10)	13013	2649	7808	52
H(11)	11769	2857	8296	40
H(12A)	11100	-207	9501	27
H(12B)	12273	453	9796	27
H(14)	10290	-631	8282	30
H(15)	10710	-884	7342	35
H(17)	13797	656	8171	35
H(18)	13364	894	9114	31
H(19A)	13817	486	7112	77
H(19B)	13590	-280	6663	77
H(19C)	14052	-182	7442	77
H(21)	7544	2185	8630	35
H(22)	5722	1559	8563	40
H(23)	5326	716	9254	38
H(24)	6765	478	9994	37
H(25)	8593	1088	10044	33
H(2C)	10920(20)	849(18)	9889(9)	24
H(101)	6419	2337	7105	42
H(10A)	6221	1164	7313	43
H(10B)	5559	773	6545	43
H(103)	7834	1806	7103	42
H(10C)	8349	1264	6341	42
H(10D)	7616	572	6575	42
H(10E)	7874	3018	6793	49
H(10F)	7131	3054	6084	49
H(107)	7644	2770	5122	74
H(108)	9021	2711	4708	114
H(109)	10655	2628	5391	113
H(110)	10937	2673	6506	83
H(111)	9578	2765	6920	62
H(11A)	7991	985	5196	52
H(11B)	6925	277	4794	52
H(114)	6771	-832	5544	46
H(115)	7697	-1657	5818	40
H(117)	10522	-116	5771	43
H(118)	9600	702	5512	47
H(11C)	8974	-2141	6363	55
H(11D)	9721	-2445	6041	55
H(11E)	8581	-2405	5588	55
H(121)	5489	3147	6741	96
H(122)	3781	3301	6343	141
H(123)	2181	2281	5830	137
H(124)	2256	1103	5676	99
H(125)	3951	938	6036	60
H(12C)	6280(20)	284(13)	5653(18)	33
H(201)	3925	2269	3736	27
H(20A)	2613	1231	2528	31
H(20B)	3070	1045	3254	31
H(203)	4893	1458	3263	26
H(20C)	5301	1478	2285	26
H(20D)	4253	734	2173	26

H(20E)	5710	2776	3866	29
H(20F)	5694	3407	3431	29
H(207)	6657	3508	2593	36
H(208)	8053	3286	2263	47
H(209)	8794	2419	2679	51
H(210)	8181	1794	3455	47
H(211)	6832	2038	3814	37
H(21A)	3527	1473	724	28
H(21B)	3646	736	965	28
H(214)	5201	2511	761	31
H(215)	7022	2891	754	33
H(217)	7292	1016	1375	32
H(218)	5462	626	1342	29
H(21C)	8465	2788	432	55
H(21D)	9665	2897	920	55
H(21E)	8894	3267	1153	55
H(221)	1762	2000	2234	39
H(222)	495	2622	2099	50
H(223)	820	3624	2885	53
H(224)	2387	4015	3801	54
H(225)	3621	3383	3953	42
H(22C)	3122(16)	1305(14)	1654(16)	23
H(301)	3095	4665	2264	32
H(30A)	2072	3669	1424	34
H(30B)	1242	4080	1061	34
H(303)	3606	4524	1273	31
H(30C)	3408	4969	325	32
H(30D)	2368	4206	117	32
H(30E)	4544	5636	2174	35
H(30F)	4005	6260	2195	35
H(307)	4003	7064	1353	33
H(308)	4815	7586	603	41
H(309)	5931	7066	221	48
H(310)	6277	6054	625	54
H(311)	5473	5535	1385	46
H(31A)	2962	5976	-78	32
H(31B)	1682	5835	-427	32
H(314)	3681	5932	-935	30
H(315)	3638	5385	-1947	31
H(317)	820	3712	-2063	36
H(318)	822	4285	-1078	34
H(31C)	2797	4968	-3078	69
H(31D)	2642	4177	-3454	69
H(31E)	3605	4543	-2767	69
H(321)	283	4506	1588	48
H(322)	-803	4641	2214	70
H(323)	-19	5169	3293	88
H(324)	1888	5568	3793	83
H(325)	3037	5379	3184	57
H(32C)	1233(17)	4810(15)	-1(14)	23
H(40A)	4070	5793	5341	150
H(40B)	3388	4997	4866	150
H(40C)	4830	5254	6175	184
H(40D)	4998	4905	5536	184
H(40E)	4022	4438	5788	184
H(40F)	1652	5128	4886	134
H(40G)	2446	5933	5280	134
H(40H)	576	4987	5527	243
H(40I)	874	5842	5462	243
H(40J)	1511	5618	6112	243

Table 70. Torsion angles [°] for **213aha.**

C(20)-C(1)-C(2)-C(3)	142.9(3)
N(1)-C(1)-C(2)-C(3)	19.5(2)
C(1)-C(2)-C(3)-C(4)	-135.4(3)
C(1)-C(2)-C(3)-N(1)	-19.8(2)
N(1)-C(3)-C(4)-N(2)	-47.9(3)
C(2)-C(3)-C(4)-N(2)	55.7(4)
N(1)-C(5)-C(6)-C(11)	-93.8(3)
N(1)-C(5)-C(6)-C(7)	86.1(4)
C(11)-C(6)-C(7)-C(8)	-0.1(5)
C(5)-C(6)-C(7)-C(8)	180.0(3)
C(6)-C(7)-C(8)-C(9)	1.1(5)
C(7)-C(8)-C(9)-C(10)	-1.2(6)
C(8)-C(9)-C(10)-C(11)	0.4(6)
C(7)-C(6)-C(11)-C(10)	-0.7(5)
C(5)-C(6)-C(11)-C(10)	179.2(3)
C(9)-C(10)-C(11)-C(6)	0.5(5)
N(2)-C(12)-C(13)-C(18)	97.8(3)
N(2)-C(12)-C(13)-C(14)	-87.1(4)
C(18)-C(13)-C(14)-C(15)	0.6(4)
C(12)-C(13)-C(14)-C(15)	-174.6(3)
C(13)-C(14)-C(15)-C(16)	-0.2(5)
C(14)-C(15)-C(16)-O(1)	-179.6(3)
C(14)-C(15)-C(16)-C(17)	-0.4(5)
O(1)-C(16)-C(17)-C(18)	179.8(3)
C(15)-C(16)-C(17)-C(18)	0.7(5)
C(16)-C(17)-C(18)-C(13)	-0.3(5)
C(14)-C(13)-C(18)-C(17)	-0.3(4)
C(12)-C(13)-C(18)-C(17)	175.0(3)
C(2)-C(1)-C(20)-C(25)	-18.7(5)
N(1)-C(1)-C(20)-C(25)	89.9(4)
C(2)-C(1)-C(20)-C(21)	160.3(3)
N(1)-C(1)-C(20)-C(21)	-91.1(4)
C(25)-C(20)-C(21)-C(22)	-2.1(5)
C(1)-C(20)-C(21)-C(22)	178.9(3)
C(20)-C(21)-C(22)-C(23)	1.8(5)
C(21)-C(22)-C(23)-C(24)	-0.7(5)
C(22)-C(23)-C(24)-C(25)	0.0(5)
C(23)-C(24)-C(25)-C(20)	-0.3(5)
C(21)-C(20)-C(25)-C(24)	1.4(5)
C(1)-C(20)-C(25)-C(24)	-179.6(3)
C(6)-C(5)-N(1)-C(3)	60.2(4)
C(6)-C(5)-N(1)-C(1)	159.8(3)
C(6)-C(5)-N(1)-Pd(1)	-67.2(3)
C(4)-C(3)-N(1)-C(5)	-100.5(3)
C(2)-C(3)-N(1)-C(5)	135.1(3)
C(4)-C(3)-N(1)-C(1)	144.0(3)
C(2)-C(3)-N(1)-C(1)	19.7(2)
C(4)-C(3)-N(1)-Pd(1)	31.4(3)
C(2)-C(3)-N(1)-Pd(1)	-93.0(2)
C(20)-C(1)-N(1)-C(5)	95.2(3)
C(2)-C(1)-N(1)-C(5)	-137.2(3)
C(20)-C(1)-N(1)-C(3)	-147.2(3)
C(2)-C(1)-N(1)-C(3)	-19.7(2)
C(20)-C(1)-N(1)-Pd(1)	-39.7(3)
C(2)-C(1)-N(1)-Pd(1)	87.9(2)
C(3)-C(4)-N(2)-C(12)	171.9(2)
C(3)-C(4)-N(2)-Pd(1)	39.6(3)
C(13)-C(12)-N(2)-C(4)	-64.1(3)
C(13)-C(12)-N(2)-Pd(1)	62.7(3)
C(17)-C(16)-O(1)-C(19)	12.1(5)
C(15)-C(16)-O(1)-C(19)	-168.8(3)
C(4)-N(2)-Pd(1)-N(1)	-17.86(19)
C(12)-N(2)-Pd(1)-N(1)	-145.9(2)
C(4)-N(2)-Pd(1)-Cl(2)	171.08(18)

C(12)-N(2)-Pd(1)-Cl(2)	43.0(2)
C(5)-N(1)-Pd(1)-N(2)	124.7(2)
C(3)-N(1)-Pd(1)-N(2)	-7.02(19)
C(1)-N(1)-Pd(1)-N(2)	-101.7(2)
C(5)-N(1)-Pd(1)-Cl(1)	-50.2(2)
C(3)-N(1)-Pd(1)-Cl(1)	178.08(18)
C(1)-N(1)-Pd(1)-Cl(1)	83.40(19)
C(120)-C(101)-C(102)-C(103)	150.1(3)
N(101)-C(101)-C(102)-C(103)	23.6(2)
C(101)-C(102)-C(103)-C(104)	-141.3(3)
C(101)-C(102)-C(103)-N(101)	-23.7(2)
C(102)-C(103)-C(104)-N(102)	65.7(4)
N(101)-C(103)-C(104)-N(102)	-38.9(4)
N(101)-C(105)-C(106)-C(107)	87.5(5)
N(101)-C(105)-C(106)-C(111)	-91.4(4)
C(111)-C(106)-C(107)-C(108)	1.5(8)
C(105)-C(106)-C(107)-C(108)	-177.5(5)
C(106)-C(107)-C(108)-C(109)	0.7(10)
C(107)-C(108)-C(109)-C(110)	-2.0(12)
C(108)-C(109)-C(110)-C(111)	1.0(10)
C(109)-C(110)-C(111)-C(106)	1.2(8)
C(107)-C(106)-C(111)-C(110)	-2.5(7)
C(105)-C(106)-C(111)-C(110)	176.5(4)
N(102)-C(112)-C(113)-C(114)	58.5(5)
N(102)-C(112)-C(113)-C(118)	-126.7(4)
C(118)-C(113)-C(114)-C(115)	-1.8(6)
C(112)-C(113)-C(114)-C(115)	173.2(4)
C(113)-C(114)-C(115)-C(116)	-0.8(6)
C(114)-C(115)-C(116)-O(101)	-176.3(3)
C(114)-C(115)-C(116)-C(117)	3.1(5)
O(101)-C(116)-C(117)-C(118)	176.8(3)
C(115)-C(116)-C(117)-C(118)	-2.7(5)
C(116)-C(117)-C(118)-C(113)	0.0(6)
C(114)-C(113)-C(118)-C(117)	2.2(6)
C(112)-C(113)-C(118)-C(117)	-172.8(4)
C(102)-C(101)-C(120)-C(121)	157.3(4)
N(101)-C(101)-C(120)-C(121)	-92.0(4)
C(102)-C(101)-C(120)-C(125)	-19.8(5)
N(101)-C(101)-C(120)-C(125)	90.9(5)
C(125)-C(120)-C(121)-C(122)	-0.8(7)
C(101)-C(120)-C(121)-C(122)	-178.1(5)
C(120)-C(121)-C(122)-C(123)	1.4(9)
C(121)-C(122)-C(123)-C(124)	-0.9(10)
C(122)-C(123)-C(124)-C(125)	-0.2(9)
C(123)-C(124)-C(125)-C(120)	0.8(7)
C(121)-C(120)-C(125)-C(124)	-0.3(6)
C(101)-C(120)-C(125)-C(124)	176.8(4)
C(106)-C(105)-N(101)-C(103)	66.4(4)
C(106)-C(105)-N(101)-C(101)	165.1(3)
C(106)-C(105)-N(101)-Pd(11)	-57.9(4)
C(104)-C(103)-N(101)-C(105)	-95.8(4)
C(102)-C(103)-N(101)-C(105)	139.3(3)
C(104)-C(103)-N(101)-C(101)	148.5(3)
C(102)-C(103)-N(101)-C(101)	23.6(3)
C(104)-C(103)-N(101)-Pd(11)	31.3(4)
C(102)-C(103)-N(101)-Pd(11)	-93.6(2)
C(120)-C(101)-N(101)-C(105)	89.7(4)
C(102)-C(101)-N(101)-C(105)	-141.7(3)
C(120)-C(101)-N(101)-C(103)	-152.2(4)
C(102)-C(101)-N(101)-C(103)	-23.5(3)
C(120)-C(101)-N(101)-Pd(11)	-45.3(4)
C(102)-C(101)-N(101)-Pd(11)	83.4(3)
C(103)-C(104)-N(102)-C(112)	152.7(3)
C(103)-C(104)-N(102)-Pd(11)	26.1(4)
C(113)-C(112)-N(102)-C(104)	53.0(5)
C(113)-C(112)-N(102)-Pd(11)	177.7(3)
C(115)-C(116)-O(101)-C(119)	0.7(5)
C(117)-C(116)-O(101)-C(119)	-178.7(3)

C(104)-N(102)-Pd(11)-N(101)	-7.0(2)
C(112)-N(102)-Pd(11)-N(101)	-131.4(3)
C(104)-N(102)-Pd(11)-Cl(12)	173.8(2)
C(112)-N(102)-Pd(11)-Cl(12)	49.4(3)
C(105)-N(101)-Pd(11)-N(102)	117.1(3)
C(103)-N(101)-Pd(11)-N(102)	-12.7(2)
C(101)-N(101)-Pd(11)-N(102)	-107.1(2)
C(105)-N(101)-Pd(11)-Cl(11)	-60.4(2)
C(103)-N(101)-Pd(11)-Cl(11)	169.8(2)
C(101)-N(101)-Pd(11)-Cl(11)	75.4(2)
C(220)-C(201)-C(202)-C(203)	142.7(3)
N(201)-C(201)-C(202)-C(203)	18.1(2)
C(201)-C(202)-C(203)-C(204)	-133.5(3)
C(201)-C(202)-C(203)-N(201)	-18.3(2)
N(201)-C(203)-C(204)-N(202)	-48.3(3)
C(202)-C(203)-C(204)-N(202)	55.2(3)
N(201)-C(205)-C(206)-C(207)	84.4(4)
N(201)-C(205)-C(206)-C(211)	-92.6(3)
C(211)-C(206)-C(207)-C(208)	0.9(5)
C(205)-C(206)-C(207)-C(208)	-176.1(3)
C(206)-C(207)-C(208)-C(209)	0.7(5)
C(207)-C(208)-C(209)-C(210)	-1.1(6)
C(208)-C(209)-C(210)-C(211)	0.0(6)
C(209)-C(210)-C(211)-C(206)	1.5(6)
C(207)-C(206)-C(211)-C(210)	-2.0(5)
C(205)-C(206)-C(211)-C(210)	175.0(3)
N(202)-C(212)-C(213)-C(214)	-89.7(4)
N(202)-C(212)-C(213)-C(218)	90.9(3)
C(218)-C(213)-C(214)-C(215)	-1.0(5)
C(212)-C(213)-C(214)-C(215)	179.5(3)
C(213)-C(214)-C(215)-C(216)	-1.0(5)
C(214)-C(215)-C(216)-O(201)	-176.7(3)
C(214)-C(215)-C(216)-C(217)	1.8(5)
O(201)-C(216)-C(217)-C(218)	178.0(3)
C(215)-C(216)-C(217)-C(218)	-0.6(5)
C(216)-C(217)-C(218)-C(213)	-1.5(5)
C(214)-C(213)-C(218)-C(217)	2.3(5)
C(212)-C(213)-C(218)-C(217)	-178.2(3)
C(202)-C(201)-C(220)-C(225)	153.2(3)
N(201)-C(201)-C(220)-C(225)	-97.8(4)
C(202)-C(201)-C(220)-C(221)	-23.8(4)
N(201)-C(201)-C(220)-C(221)	85.2(4)
C(225)-C(220)-C(221)-C(222)	-1.6(5)
C(201)-C(220)-C(221)-C(222)	175.5(3)
C(220)-C(221)-C(222)-C(223)	1.2(5)
C(221)-C(222)-C(223)-C(224)	0.1(6)
C(222)-C(223)-C(224)-C(225)	-1.0(6)
C(221)-C(220)-C(225)-C(224)	0.6(5)
C(201)-C(220)-C(225)-C(224)	-176.5(3)
C(223)-C(224)-C(225)-C(220)	0.7(6)
C(206)-C(205)-N(201)-C(203)	57.4(3)
C(206)-C(205)-N(201)-C(201)	156.0(2)
C(206)-C(205)-N(201)-Pd(21)	-69.4(3)
C(204)-C(203)-N(201)-C(205)	-103.0(3)
C(202)-C(203)-N(201)-C(205)	133.4(2)
C(204)-C(203)-N(201)-C(201)	141.7(3)
C(202)-C(203)-N(201)-C(201)	18.1(2)
C(204)-C(203)-N(201)-Pd(21)	27.5(3)
C(202)-C(203)-N(201)-Pd(21)	-96.1(2)
C(220)-C(201)-N(201)-C(205)	99.9(3)
C(202)-C(201)-N(201)-C(205)	-134.0(2)
C(220)-C(201)-N(201)-C(203)	-144.2(3)
C(202)-C(201)-N(201)-C(203)	-18.1(2)
C(220)-C(201)-N(201)-Pd(21)	-35.5(3)
C(202)-C(201)-N(201)-Pd(21)	90.6(2)
C(203)-C(204)-N(202)-C(212)	179.0(2)
C(203)-C(204)-N(202)-Pd(21)	44.3(3)
C(213)-C(212)-N(202)-C(204)	-57.1(3)

C(213)-C(212)-N(202)-Pd(21)	70.6(3)
C(215)-C(216)-O(201)-C(219)	-7.6(5)
C(217)-C(216)-O(201)-C(219)	173.8(3)
C(204)-N(202)-Pd(21)-N(201)	-23.14(19)
C(212)-N(202)-Pd(21)-N(201)	-152.3(2)
C(204)-N(202)-Pd(21)-Cl(22)	162.46(17)
C(212)-N(202)-Pd(21)-Cl(22)	33.3(2)
C(205)-N(201)-Pd(21)-N(202)	127.8(2)
C(203)-N(201)-Pd(21)-N(202)	-2.11(18)
C(201)-N(201)-Pd(21)-N(202)	-97.5(2)
C(205)-N(201)-Pd(21)-Cl(21)	-49.7(2)
C(203)-N(201)-Pd(21)-Cl(21)	-179.62(17)
C(201)-N(201)-Pd(21)-Cl(21)	85.01(19)
C(320)-C(301)-C(302)-C(303)	149.5(3)
N(301)-C(301)-C(302)-C(303)	23.6(2)
C(301)-C(302)-C(303)-C(304)	-141.0(3)
C(301)-C(302)-C(303)-N(301)	-23.9(2)
C(302)-C(303)-C(304)-N(302)	68.7(4)
N(301)-C(303)-C(304)-N(302)	-35.3(4)
N(301)-C(305)-C(306)-C(307)	86.2(4)
N(301)-C(305)-C(306)-C(311)	-91.5(4)
C(311)-C(306)-C(307)-C(308)	0.8(5)
C(305)-C(306)-C(307)-C(308)	-176.9(3)
C(306)-C(307)-C(308)-C(309)	0.4(5)
C(307)-C(308)-C(309)-C(310)	-1.3(6)
C(308)-C(309)-C(310)-C(311)	1.0(6)
C(309)-C(310)-C(311)-C(306)	0.2(6)
C(307)-C(306)-C(311)-C(310)	-1.0(6)
C(305)-C(306)-C(311)-C(310)	176.7(3)
N(302)-C(312)-C(313)-C(314)	-139.5(3)
N(302)-C(312)-C(313)-C(318)	46.8(4)
C(318)-C(313)-C(314)-C(315)	1.1(5)
C(312)-C(313)-C(314)-C(315)	-172.8(3)
C(313)-C(314)-C(315)-C(316)	-1.5(5)
C(314)-C(315)-C(316)-O(301)	179.2(3)
C(314)-C(315)-C(316)-C(317)	0.5(5)
O(301)-C(316)-C(317)-C(318)	-177.9(3)
C(315)-C(316)-C(317)-C(318)	1.0(5)
C(316)-C(317)-C(318)-C(313)	-1.5(5)
C(314)-C(313)-C(318)-C(317)	0.4(5)
C(312)-C(313)-C(318)-C(317)	174.2(3)
C(302)-C(301)-C(320)-C(325)	154.1(3)
N(301)-C(301)-C(320)-C(325)	-96.2(4)
C(302)-C(301)-C(320)-C(321)	-21.1(5)
N(301)-C(301)-C(320)-C(321)	88.7(4)
C(325)-C(320)-C(321)-C(322)	-1.6(5)
C(301)-C(320)-C(321)-C(322)	173.5(3)
C(320)-C(321)-C(322)-C(323)	2.0(6)
C(321)-C(322)-C(323)-C(324)	-0.5(7)
C(322)-C(323)-C(324)-C(325)	-1.4(7)
C(321)-C(320)-C(325)-C(324)	-0.3(5)
C(301)-C(320)-C(325)-C(324)	-175.5(3)
C(323)-C(324)-C(325)-C(320)	1.8(6)
C(306)-C(305)-N(301)-C(303)	64.2(3)
C(306)-C(305)-N(301)-C(301)	163.1(3)
C(306)-C(305)-N(301)-Pd(31)	-61.8(3)
C(304)-C(303)-N(301)-C(305)	-96.3(3)
C(302)-C(303)-N(301)-C(305)	139.7(3)
C(304)-C(303)-N(301)-C(301)	147.6(3)
C(302)-C(303)-N(301)-C(301)	23.6(2)
C(304)-C(303)-N(301)-Pd(31)	32.6(3)
C(302)-C(303)-N(301)-Pd(31)	-91.4(2)
C(320)-C(301)-N(301)-C(305)	90.3(4)
C(302)-C(301)-N(301)-C(305)	-141.7(3)
C(320)-C(301)-N(301)-C(303)	-151.5(3)
C(302)-C(301)-N(301)-C(303)	-23.5(2)
C(320)-C(301)-N(301)-Pd(31)	-44.1(4)
C(302)-C(301)-N(301)-Pd(31)	83.9(2)

C(313)-C(312)-N(302)-C(304)	56.2(4)
C(313)-C(312)-N(302)-Pd(31)	-178.4(2)
C(303)-C(304)-N(302)-C(312)	145.2(3)
C(303)-C(304)-N(302)-Pd(31)	19.9(3)
C(315)-C(316)-O(301)-C(319)	-6.9(5)
C(317)-C(316)-O(301)-C(319)	171.9(3)
C(312)-N(302)-Pd(31)-N(301)	-126.7(2)
C(304)-N(302)-Pd(31)-N(301)	-1.5(2)
C(312)-N(302)-Pd(31)-Cl(32)	57.7(2)
C(304)-N(302)-Pd(31)-Cl(32)	-177.1(2)
C(305)-N(301)-Pd(31)-N(302)	114.5(2)
C(303)-N(301)-Pd(31)-N(302)	-16.50(19)
C(301)-N(301)-Pd(31)-N(302)	-110.5(2)
C(305)-N(301)-Pd(31)-Cl(31)	-61.0(2)
C(303)-N(301)-Pd(31)-Cl(31)	167.99(18)
C(301)-N(301)-Pd(31)-Cl(31)	74.0(2)
C(404)-C(403)-O(401)-C(401)	-169.8(17)
C(402)-C(401)-O(401)-C(403)	177.4(14)

Symmetry transformations used to generate equivalent atoms:

Table 71. Hydrogen bonds for **213aha** [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(2)-H(2C)...Cl(2)#1	0.900(17)	2.483(19)	3.345(3)	161(3)
N(102)-H(12C)...Cl(12)#2	0.901(18)	2.377(19)	3.273(3)	173(3)
N(202)-H(22C)...Cl(2)#2	0.901(18)	2.47(2)	3.318(3)	156(3)
N(302)-H(32C)...Cl(32)#3	0.894(18)	2.364(19)	3.244(3)	168(3)

Symmetry transformations used to generate equivalent atoms:

#1 -x+2,-y,-z+2 #2 -x+1,-y,-z+1 #3 -x,-y+1,-z

4.3.3 X-ray Crystallographic Information for *C,N,N* Pd(II)-amino-azetidine complex 213gaa

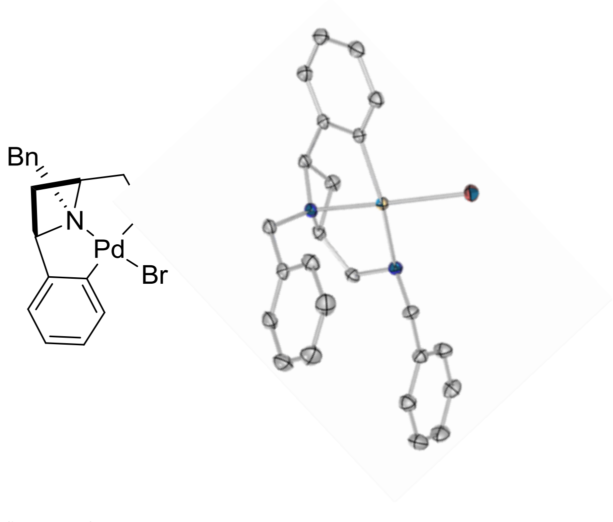


Table 72. Crystal data and structure refinement for **213gaa**.

Identification code	**213gaa**
Empirical formula	$C_{24}H_{25}Br\,N2Pd$, 0.62($C_4H_8O_2$), 0.38($C_4H_{10}O$)
Formula weight	610.56
Temperature	120(2) K

Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	C 2/c	
Unit cell dimensions	a = 30.2910(5) Å	α= 90°.
	b = 9.6252(2) Å	β= 90.9440(10)°.
	c = 17.6711(4) Å	γ = 90°.
Volume	5151.43(18) Å^3	
Z	8	
Density (calculated)	1.574 Mg/m^3	
Absorption coefficient	2.298 mm^{-1}	
F(000)	2478	
Crystal size	0.20 x 0.12 x 0.10 mm^3	
Theta range for data collection	2.92 to 27.48°.	
Index ranges	-39<=h<=39, -12<=k<=12, -22<=l<=22	
Reflections collected	27495	
Independent reflections	5888 [R(int) = 0.0353]	
Completeness to theta = 27.48°	99.6 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.8028 and 0.6565	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	5888 / 149 / 351	
Goodness-of-fit on F^2	1.119	
Final R indices [I>2sigma(I)]	R1 = 0.0287, wR2 = 0.0612	
R indices (all data)	R1 = 0.0344, wR2 = 0.0643	
Largest diff. peak and hole	0.489 and -0.686 e.Å^{-3}	

Notes: The structure includes a molecule of solvent disordered such that O(101), O(102), C(101)-C(104) is an ethyl acetate molecule while O(11’), C(11’)-C(14’) is an ether molecule, with a refined percentage occupancy ratio of 62:38 respectively.
Hydrogen atoms were fixed as riding models.

Table 73. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for **213gaa**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
C(1)	969(1)	5647(3)	3473(1)	17(1)
C(2)	529(1)	4847(3)	3350(1)	20(1)
C(3)	768(1)	4021(3)	2721(1)	18(1)
C(4)	586(1)	3760(3)	1935(1)	18(1)
C(5)	447(1)	2457(3)	1683(2)	22(1)
C(6)	321(1)	2270(3)	927(2)	24(1)
C(7)	341(1)	3385(3)	426(2)	22(1)
C(8)	478(1)	4692(3)	678(1)	19(1)
C(9)	597(1)	4902(2)	1434(1)	16(1)
C(10)	1003(1)	7208(3)	3604(1)	18(1)
C(11)	1095(1)	9273(2)	2777(1)	18(1)
C(12)	1157(1)	10302(3)	3419(1)	19(1)
C(13)	813(1)	10623(3)	3903(2)	24(1)
C(14)	872(1)	11601(3)	4474(2)	28(1)
C(15)	1271(1)	12285(3)	4557(2)	29(1)
C(16)	1614(1)	11984(3)	4080(2)	30(1)
C(17)	1558(1)	10992(3)	3513(2)	24(1)
C(18)	1555(1)	4853(3)	2518(2)	20(1)
C(19)	1828(1)	6089(3)	2287(1)	19(1)
C(20)	1782(1)	6599(3)	1554(2)	22(1)
C(21)	2027(1)	7735(3)	1321(2)	28(1)
C(22)	2322(1)	8365(3)	1822(2)	32(1)
C(23)	2371(1)	7873(3)	2551(2)	32(1)
C(24)	2123(1)	6736(3)	2787(2)	24(1)
N(1)	1092(1)	5217(2)	2683(1)	16(1)
N(2)	829(1)	8027(2)	2949(1)	16(1)
Br(1)	263(1)	8207(1)	1312(1)	19(1)
Pd(1)	742(1)	6602(1)	2011(1)	13(1)
C(101)	3464(10)	7430(20)	4425(15)	27(3)
C(102)	3500(30)	6250(80)	3850(40)	39(3)
C(103)	2895(4)	9002(18)	4793(9)	27(2)
C(104)	2454(5)	9590(20)	4602(11)	41(2)
O(101)	3044(7)	8130(19)	4251(12)	23(2)
O(102)	3120(1)	9330(5)	5350(3)	49(2)
C(11')	3451(17)	7190(40)	4380(30)	34(5)
C(12')	3490(40)	6210(130)	3810(70)	39(3)
C(13')	3008(7)	9000(30)	4895(15)	35(4)
C(14')	2566(8)	9680(30)	4759(16)	53(6)
O(11')	3042(13)	7890(30)	4350(20)	24(3)

Table 74. Bond lengths [Å] and angles [°] for **213gaa**.

C(1)-N(1)	1.509(3)
C(1)-C(10)	1.523(3)
C(1)-C(2)	1.550(3)
C(1)-H(1)	1.0000
C(2)-C(3)	1.555(3)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-C(4)	1.506(3)
C(3)-N(1)	1.515(3)
C(3)-H(3)	1.0000
C(4)-C(5)	1.395(3)
C(4)-C(9)	1.411(3)
C(5)-C(6)	1.395(4)
C(5)-H(5)	0.9500
C(6)-C(7)	1.394(4)
C(6)-H(6)	0.9500
C(7)-C(8)	1.395(4)
C(7)-H(7)	0.9500
C(8)-C(9)	1.393(3)
C(8)-H(8)	0.9500
C(9)-Pd(1)	1.974(2)
C(10)-N(2)	1.490(3)
C(10)-H(10A)	0.9900
C(10)-H(10B)	0.9900
C(11)-N(2)	1.479(3)
C(11)-C(12)	1.515(3)
C(11)-H(11A)	0.9900
C(11)-H(11B)	0.9900
C(12)-C(17)	1.393(4)
C(12)-C(13)	1.394(4)
C(13)-C(14)	1.388(4)
C(13)-H(13)	0.9500
C(14)-C(15)	1.383(4)
C(14)-H(14)	0.9500
C(15)-C(16)	1.379(4)
C(15)-H(15)	0.9500
C(16)-C(17)	1.392(4)
C(16)-H(16)	0.9500
C(17)-H(17)	0.9500
C(18)-N(1)	1.479(3)
C(18)-C(19)	1.509(3)
C(18)-H(18A)	0.9900
C(18)-H(18B)	0.9900
C(19)-C(20)	1.390(4)
C(19)-C(24)	1.393(4)
C(20)-C(21)	1.387(4)
C(20)-H(20)	0.9500
C(21)-C(22)	1.386(4)
C(21)-H(21)	0.9500
C(22)-C(23)	1.379(4)
C(22)-H(22)	0.9500
C(23)-C(24)	1.395(4)
C(23)-H(23)	0.9500
C(24)-H(24)	0.9500
N(1)-Pd(1)	2.0661(19)
N(2)-Pd(1)	2.164(2)
N(2)-H(2)	0.9300
Br(1)-Pd(1)	2.4405(3)
C(101)-O(101)	1.47(3)
C(101)-C(102)	1.54(6)
C(101)-H(11C)	0.9900
C(101)-H(11D)	0.9900
C(102)-H(12A)	0.9800
C(102)-H(12B)	0.9800
C(102)-H(12C)	0.9800
C(103)-O(102)	1.229(13)
C(103)-O(101)	1.36(3)
C(103)-C(104)	1.483(12)
C(104)-H(14A)	0.9800
C(104)-H(14B)	0.9800
C(104)-H(14C)	0.9800
C(11')-C(12')	1.39(10)
C(11')-O(11')	1.42(5)
C(11')-H(11E)	0.9900
C(11')-H(11F)	0.9900
C(12')-H(12E)	0.9800
C(12')-H(12F)	0.9800
C(12')-H(12G)	0.9800
C(13')-O(11')	1.44(5)
C(13')-C(14')	1.51(2)
C(13')-H(13A)	0.9900
C(13')-H(13B)	0.9900
C(14')-H(14D)	0.9800
C(14')-H(14E)	0.9800
C(14')-H(14F)	0.9800
N(1)-C(1)-C(10)	113.19(19)
N(1)-C(1)-C(2)	87.64(17)
C(10)-C(1)-C(2)	124.5(2)
N(1)-C(1)-H(1)	109.8
C(10)-C(1)-H(1)	109.8
C(2)-C(1)-H(1)	109.8
C(1)-C(2)-C(3)	86.91(18)
C(1)-C(2)-H(2A)	114.2
C(3)-C(2)-H(2A)	114.2
C(1)-C(2)-H(2B)	114.2
C(3)-C(2)-H(2B)	114.2
H(2A)-C(2)-H(2B)	111.3
C(4)-C(3)-N(1)	108.25(19)
C(4)-C(3)-C(2)	125.3(2)
N(1)-C(3)-C(2)	87.23(17)
C(4)-C(3)-H(3)	111.0
N(1)-C(3)-H(3)	111.0
C(2)-C(3)-H(3)	111.0
C(5)-C(4)-C(9)	120.7(2)
C(5)-C(4)-C(3)	123.2(2)
C(9)-C(4)-C(3)	115.9(2)
C(4)-C(5)-C(6)	119.9(2)
C(4)-C(5)-H(5)	120.1
C(6)-C(5)-H(5)	120.1
C(7)-C(6)-C(5)	119.7(2)
C(7)-C(6)-H(6)	120.2
C(5)-C(6)-H(6)	120.2
C(6)-C(7)-C(8)	120.5(2)
C(6)-C(7)-H(7)	119.8
C(8)-C(7)-H(7)	119.8
C(9)-C(8)-C(7)	120.5(2)
C(9)-C(8)-H(8)	119.7
C(7)-C(8)-H(8)	119.7
C(8)-C(9)-C(4)	118.7(2)
C(8)-C(9)-Pd(1)	131.87(19)
C(4)-C(9)-Pd(1)	109.19(17)
N(2)-C(10)-C(1)	112.44(19)
N(2)-C(10)-H(10A)	109.1
C(1)-C(10)-H(10A)	109.1
N(2)-C(10)-H(10B)	109.1
C(1)-C(10)-H(10B)	109.1
H(10A)-C(10)-H(10B)	107.8
N(2)-C(11)-C(12)	116.0(2)
N(2)-C(11)-H(11A)	108.3
C(12)-C(11)-H(11A)	108.3

N(2)-C(11)-H(11B)	108.3
C(12)-C(11)-H(11B)	108.3
H(11A)-C(11)-H(11B)	107.4
C(17)-C(12)-C(13)	118.7(2)
C(17)-C(12)-C(11)	119.9(2)
C(13)-C(12)-C(11)	121.3(2)
C(14)-C(13)-C(12)	120.6(2)
C(14)-C(13)-H(13)	119.7
C(12)-C(13)-H(13)	119.7
C(15)-C(14)-C(13)	120.1(3)
C(15)-C(14)-H(14)	120.0
C(13)-C(14)-H(14)	120.0
C(16)-C(15)-C(14)	120.0(3)
C(16)-C(15)-H(15)	120.0
C(14)-C(15)-H(15)	120.0
C(15)-C(16)-C(17)	120.1(3)
C(15)-C(16)-H(16)	120.0
C(17)-C(16)-H(16)	120.0
C(16)-C(17)-C(12)	120.5(3)
C(16)-C(17)-H(17)	119.7
C(12)-C(17)-H(17)	119.7
N(1)-C(18)-C(19)	113.1(2)
N(1)-C(18)-H(18A)	109.0
C(19)-C(18)-H(18A)	109.0
N(1)-C(18)-H(18B)	109.0
C(19)-C(18)-H(18B)	109.0
H(18A)-C(18)-H(18B)	107.8
C(20)-C(19)-C(24)	119.1(2)
C(20)-C(19)-C(18)	119.0(2)
C(24)-C(19)-C(18)	121.9(2)
C(21)-C(20)-C(19)	120.6(2)
C(21)-C(20)-H(20)	119.7
C(19)-C(20)-H(20)	119.7
C(22)-C(21)-C(20)	119.9(3)
C(22)-C(21)-H(21)	120.1
C(20)-C(21)-H(21)	120.1
C(23)-C(22)-C(21)	120.3(3)
C(23)-C(22)-H(22)	119.9
C(21)-C(22)-H(22)	119.9
C(22)-C(23)-C(24)	119.9(3)
C(22)-C(23)-H(23)	120.0
C(24)-C(23)-H(23)	120.0
C(19)-C(24)-C(23)	120.2(3)
C(19)-C(24)-H(24)	119.9
C(23)-C(24)-H(24)	119.9
C(18)-N(1)-C(1)	119.77(18)
C(18)-N(1)-C(3)	116.46(19)
C(1)-N(1)-C(3)	89.87(17)
C(18)-N(1)-Pd(1)	121.26(15)
C(1)-N(1)-Pd(1)	102.88(14)
C(3)-N(1)-Pd(1)	100.89(13)
C(11)-N(2)-C(10)	113.66(18)
C(11)-N(2)-Pd(1)	114.63(15)
C(10)-N(2)-Pd(1)	107.24(14)
C(11)-N(2)-H(2)	107.0
C(10)-N(2)-H(2)	107.0
Pd(1)-N(2)-H(2)	107.0
C(9)-Pd(1)-N(1)	82.49(9)
C(9)-Pd(1)-N(2)	160.82(9)
N(1)-Pd(1)-N(2)	85.07(8)
C(9)-Pd(1)-Br(1)	97.95(7)
N(1)-Pd(1)-Br(1)	173.85(5)
N(2)-Pd(1)-Br(1)	92.89(5)
O(101)-C(101)-C(102)	106(3)
O(101)-C(101)-H(11C)	110.6
C(102)-C(101)-H(11C)	110.6
O(101)-C(101)-H(11D)	110.6
C(102)-C(101)-H(11D)	110.6
H(11C)-C(101)-H(11D)	108.7
O(102)-C(103)-O(101)	122.7(13)
O(102)-C(103)-C(104)	124.7(13)
O(101)-C(103)-C(104)	112.5(15)
C(103)-O(101)-C(101)	115.6(19)
C(12')-C(11')-O(11')	112(6)
C(12')-C(11')-H(11E)	109.2
O(11')-C(11')-H(11E)	109.2
C(12')-C(11')-H(11F)	109.2
O(11')-C(11')-H(11F)	109.2
H(11E)-C(11')-H(11F)	107.9
C(11')-C(12')-H(12E)	109.5
C(11')-C(12')-H(12F)	109.5
H(12E)-C(12')-H(12F)	109.5
C(11')-C(12')-H(12G)	109.5
H(12E)-C(12')-H(12G)	109.5
H(12F)-C(12')-H(12G)	109.5
O(11')-C(13')-C(14')	107(2)
O(11')-C(13')-H(13A)	110.3
C(14')-C(13')-H(13A)	110.3
O(11')-C(13')-H(13B)	110.3
C(14')-C(13')-H(13B)	110.3
H(13A)-C(13')-H(13B)	108.6
C(13')-C(14')-H(14D)	109.5
C(13')-C(14')-H(14E)	109.5
H(14D)-C(14')-H(14E)	109.5
C(13')-C(14')-H(14F)	109.5
H(14D)-C(14')-H(14F)	109.5
H(14E)-C(14')-H(14F)	109.5
C(11')-O(11')-C(13')	114(3)

Symmetry transformations used to generate equivalent atoms:

Table 75. Anisotropic displacement parameters ($Å^2$x 10^3) for **213gaa**. The anisotropic displacement factor exponent takes the form: $-2\pi^2$[$h^2a^{*2}U^{11}$ + ... + 2 h k a* b* U^{12}]

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
C(1)	17(1)	19(1)	15(1)	3(1)	-1(1)	0(1)
C(2)	19(1)	22(1)	19(1)	4(1)	2(1)	-1(1)
C(3)	15(1)	16(1)	22(1)	4(1)	-1(1)	-1(1)
C(4)	11(1)	17(1)	25(1)	-2(1)	1(1)	2(1)
C(5)	18(1)	18(1)	29(1)	-1(1)	-1(1)	1(1)
C(6)	17(1)	22(1)	35(2)	-9(1)	-1(1)	2(1)
C(7)	16(1)	28(1)	22(1)	-9(1)	-2(1)	4(1)
C(8)	16(1)	22(1)	20(1)	-3(1)	0(1)	3(1)
C(9)	12(1)	16(1)	19(1)	-2(1)	0(1)	2(1)
C(10)	17(1)	21(1)	16(1)	-1(1)	-2(1)	0(1)
C(11)	20(1)	16(1)	18(1)	-2(1)	1(1)	-1(1)
C(12)	22(1)	17(1)	19(1)	1(1)	0(1)	-1(1)
C(13)	23(1)	24(1)	25(1)	-5(1)	3(1)	-3(1)
C(14)	34(2)	26(1)	24(1)	-6(1)	6(1)	3(1)
C(15)	39(2)	25(1)	24(1)	-8(1)	-8(1)	0(1)
C(16)	26(1)	29(2)	33(2)	-3(1)	-7(1)	-7(1)
C(17)	22(1)	24(1)	25(1)	-2(1)	1(1)	0(1)
C(18)	14(1)	21(1)	24(1)	2(1)	0(1)	3(1)
C(19)	13(1)	18(1)	24(1)	-2(1)	2(1)	4(1)
C(20)	17(1)	25(1)	22(1)	-1(1)	2(1)	0(1)
C(21)	25(1)	28(2)	32(2)	6(1)	4(1)	1(1)
C(22)	21(1)	26(2)	51(2)	2(1)	6(1)	-5(1)
C(23)	18(1)	31(2)	47(2)	-9(1)	-4(1)	-2(1)
C(24)	16(1)	28(1)	28(1)	-2(1)	-2(1)	4(1)
N(1)	13(1)	17(1)	17(1)	1(1)	0(1)	1(1)
N(2)	16(1)	16(1)	16(1)	-2(1)	0(1)	0(1)
Br(1)	20(1)	19(1)	18(1)	1(1)	-2(1)	3(1)
Pd(1)	13(1)	13(1)	14(1)	0(1)	0(1)	1(1)
C(101)	21(4)	31(7)	28(4)	-8(5)	-3(3)	-5(5)
C(102)	38(5)	33(4)	46(7)	-3(4)	8(4)	-6(3)
C(103)	29(5)	32(3)	18(4)	2(3)	0(3)	-6(4)
C(104)	32(5)	43(5)	49(6)	4(4)	8(4)	10(4)
O(101)	22(2)	24(5)	22(6)	5(4)	-1(3)	-2(3)
O(102)	55(3)	56(3)	35(3)	-13(2)	-9(2)	6(2)
C(11')	25(7)	33(12)	44(11)	4(6)	1(8)	-5(8)
C(12')	38(5)	33(4)	46(7)	-3(4)	8(4)	-6(3)
C(13')	41(11)	40(6)	25(8)	-8(5)	-5(7)	-2(7)
C(14')	51(13)	43(8)	66(15)	16(9)	35(9)	11(9)
O(11')	31(4)	26(9)	13(6)	10(5)	0(4)	-3(5)

Table 76. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10^3) for **213gaa.**

	x	y	z	U(eq)
H(1)	1159	5145	3851	20
H(2A)	282	5431	3163	24
H(2B)	441	4275	3788	24
H(3)	913	3169	2932	21
H(5)	437	1698	2026	26
H(6)	222	1386	755	29
H(7)	262	3254	-92	27
H(8)	489	5445	331	23
H(10A)	836	7456	4061	22
H(10B)	1316	7458	3698	22
H(11A)	953	9764	2345	21
H(11B)	1390	8964	2613	21
H(13)	536	10170	3842	29
H(14)	637	11800	4807	33
H(15)	1309	12963	4944	35
H(16)	1888	12454	4139	36
H(17)	1796	10785	3188	28
H(18A)	1557	4155	2107	24
H(18B)	1692	4424	2974	24
H(20)	1582	6166	1209	26
H(21)	1993	8080	820	34
H(22)	2491	9139	1662	39
H(23)	2573	8308	2893	38
H(24)	2155	6401	3291	29
H(2)	549	8337	3078	19
H(11C)	3465	7060	4947	32
H(11D)	3714	8091	4378	32
H(12A)	3234	5681	3853	58
H(12B)	3759	5668	3978	58
H(12C)	3540	6640	3340	58
H(14A)	2318	9941	5062	62
H(14B)	2267	8858	4379	62
H(14C)	2486	10345	4237	62
H(11E)	3694	7869	4346	41
H(11F)	3482	6711	4879	41
H(12E)	3248	5534	3840	58
H(12F)	3773	5726	3859	58
H(12G)	3473	6680	3315	58
H(13A)	3250	9675	4828	42
H(13B)	3028	8619	5415	42
H(14D)	2513	9787	4214	79
H(14E)	2566	10601	5000	79
H(14F)	2333	9109	4976	79

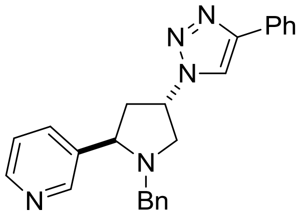
Table 77. Torsion angles [°] for **213gaa.**

N(1)-C(1)-C(2)-C(3)	21.37(17)
C(10)-C(1)-C(2)-C(3)	138.1(2)
C(1)-C(2)-C(3)-C(4)	-131.8(2)
C(1)-C(2)-C(3)-N(1)	-21.29(16)
N(1)-C(3)-C(4)-C(5)	150.5(2)
C(2)-C(3)-C(4)-C(5)	-109.6(3)
N(1)-C(3)-C(4)-C(9)	-24.5(3)
C(2)-C(3)-C(4)-C(9)	75.4(3)
C(9)-C(4)-C(5)-C(6)	0.8(4)
C(3)-C(4)-C(5)-C(6)	-174.0(2)
C(4)-C(5)-C(6)-C(7)	0.8(4)
C(5)-C(6)-C(7)-C(8)	-1.4(4)
C(6)-C(7)-C(8)-C(9)	0.3(4)
C(7)-C(8)-C(9)-C(4)	1.3(3)
C(7)-C(8)-C(9)-Pd(1)	-172.48(18)
C(5)-C(4)-C(9)-C(8)	-1.8(3)
C(3)-C(4)-C(9)-C(8)	173.3(2)
C(5)-C(4)-C(9)-Pd(1)	173.28(18)
C(3)-C(4)-C(9)-Pd(1)	-11.6(2)
N(1)-C(1)-C(10)-N(2)	41.7(3)
C(2)-C(1)-C(10)-N(2)	-62.2(3)
N(2)-C(11)-C(12)-C(17)	142.9(2)
N(2)-C(11)-C(12)-C(13)	-40.0(3)
C(17)-C(12)-C(13)-C(14)	-0.8(4)
C(11)-C(12)-C(13)-C(14)	-177.9(2)
C(12)-C(13)-C(14)-C(15)	1.2(4)
C(13)-C(14)-C(15)-C(16)	-0.9(4)
C(14)-C(15)-C(16)-C(17)	0.1(4)
C(15)-C(16)-C(17)-C(12)	0.3(4)
C(13)-C(12)-C(17)-C(16)	0.0(4)
C(11)-C(12)-C(17)-C(16)	177.2(2)
N(1)-C(18)-C(19)-C(20)	-77.8(3)
N(1)-C(18)-C(19)-C(24)	102.0(3)
C(24)-C(19)-C(20)-C(21)	0.1(4)
C(18)-C(19)-C(20)-C(21)	179.9(2)
C(19)-C(20)-C(21)-C(22)	0.4(4)
C(20)-C(21)-C(22)-C(23)	-0.4(4)
C(21)-C(22)-C(23)-C(24)	0.1(4)
C(20)-C(19)-C(24)-C(23)	-0.4(4)
C(18)-C(19)-C(24)-C(23)	179.8(2)
C(22)-C(23)-C(24)-C(19)	0.4(4)
C(19)-C(18)-N(1)-C(1)	-88.9(3)
C(19)-C(18)-N(1)-C(3)	164.7(2)
C(19)-C(18)-N(1)-Pd(1)	41.4(3)
C(10)-C(1)-N(1)-C(18)	90.4(2)
C(2)-C(1)-N(1)-C(18)	-142.7(2)
C(10)-C(1)-N(1)-C(3)	-148.8(2)
C(2)-C(1)-N(1)-C(3)	-21.93(17)
C(10)-C(1)-N(1)-Pd(1)	-47.6(2)
C(2)-C(1)-N(1)-Pd(1)	79.21(15)
C(4)-C(3)-N(1)-C(18)	-88.1(2)
C(2)-C(3)-N(1)-C(18)	145.5(2)
C(4)-C(3)-N(1)-C(1)	148.26(19)
C(2)-C(3)-N(1)-C(1)	21.86(17)
C(4)-C(3)-N(1)-Pd(1)	45.17(19)
C(2)-C(3)-N(1)-Pd(1)	-81.23(15)
C(12)-C(11)-N(2)-C(10)	-56.9(3)
C(12)-C(11)-N(2)-Pd(1)	179.27(16)
C(1)-C(10)-N(2)-C(11)	-140.3(2)
C(1)-C(10)-N(2)-Pd(1)	-12.5(2)
C(8)-C(9)-Pd(1)-N(1)	-154.7(2)
C(4)-C(9)-Pd(1)-N(1)	31.03(16)
C(8)-C(9)-Pd(1)-N(2)	155.3(2)
C(4)-C(9)-Pd(1)-N(2)	-19.0(4)

C(8)-C(9)-Pd(1)-Br(1)	31.5(2)
C(4)-C(9)-Pd(1)-Br(1)	-142.78(15)
C(18)-N(1)-Pd(1)-C(9)	88.15(18)
C(1)-N(1)-Pd(1)-C(9)	-134.59(15)
C(3)-N(1)-Pd(1)-C(9)	-42.21(14)
C(18)-N(1)-Pd(1)-N(2)	-106.49(18)
C(1)-N(1)-Pd(1)-N(2)	30.77(14)
C(3)-N(1)-Pd(1)-N(2)	123.16(14)
C(18)-N(1)-Pd(1)-Br(1)	-177.3(4)
C(1)-N(1)-Pd(1)-Br(1)	-40.1(6)
C(3)-N(1)-Pd(1)-Br(1)	52.3(6)
C(11)-N(2)-Pd(1)-C(9)	165.9(2)
C(10)-N(2)-Pd(1)-C(9)	38.7(3)
C(11)-N(2)-Pd(1)-N(1)	116.25(16)
C(10)-N(2)-Pd(1)-N(1)	-10.95(14)
C(11)-N(2)-Pd(1)-Br(1)	-69.57(15)
C(10)-N(2)-Pd(1)-Br(1)	163.23(14)
O(102)-C(103)-O(101)-C(101)	9(3)
C(104)-C(103)-O(101)-C(101)	-175.8(19)
C(102)-C(101)-O(101)-C(103)	166(4)
C(12')-C(11')-O(11')-C(13')	-175(7)
C(14')-C(13')-O(11')-C(11')	177(3)

Symmetry transformations used to generate equivalent atoms:

4.3.1 X-ray Crystallographic Information for Triazole-Pyrrolidine (*trans*)-215d



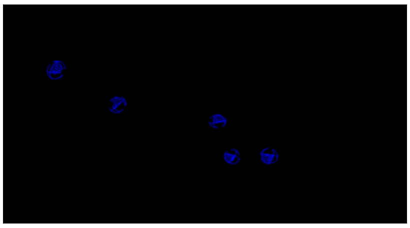


Table 78. Crystal data and structure refinement for (*trans*)-**215d**.

Identification code	(*trans*)-**215d**	
Empirical formula	$C_{24}H_{23}N_5$, 0.5($CHCl_3$)	
Formula weight	441.16	
Temperature	120(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P 2_1/n	
Unit cell dimensions	a = 5.8473(6) Å	α= 90°.
	b = 36.267(4) Å	β= 92.220(4)°.
	c = 20.608(2) Å	γ = 90°.
Volume	4366.9(8) Å^3	
Z	8	
Density (calculated)	1.342 Mg/m^3	
Absorption coefficient	0.259 mm^{-1}	
F(000)	1848	

Crystal size	0.17 x 0.04 x 0.01 mm^3
Theta range for data collection	2.98 to 25.03°.
Index ranges	-6<=h<=6, -40<=k<=43, -24<=l<=24
Reflections collected	21376
Independent reflections	7487 [R(int) = 0.1189]
Completeness to theta = 25.03°	97.4 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.9974 and 0.9574
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	7487 / 0 / 559
Goodness-of-fit on F^2	1.185
Final R indices [I>2sigma(I)]	R1 = 0.1380, wR2 = 0.2068
R indices (all data)	R1 = 0.2538, wR2 = 0.2569
Largest diff. peak and hole	0.363 and -0.386 e.Å^{-3}

Notes: There are two crystallographically-independent molecules in the structure, with half a molecule of chloroform per molecule.

The hydrogen atoms were fixed as riding models.

Table 79. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (Å^{2}x 10^3) for (*trans*)-**215d**. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
C(1)	5936(14)	1118(2)	5741(4)	30(2)
C(2)	7043(14)	730(2)	5668(4)	33(2)
C(3)	9251(14)	804(2)	5321(4)	32(2)
C(4)	8822(15)	1177(2)	4994(4)	34(2)
C(5)	6612(15)	1729(2)	5289(5)	41(2)
C(6)	8440(15)	2005(2)	5109(4)	35(2)
C(7)	10068(17)	2111(3)	5579(5)	47(3)
C(8)	11797(18)	2358(3)	5428(6)	54(3)
C(9)	11939(18)	2492(3)	4797(5)	49(3)
C(10)	10314(19)	2377(3)	4333(5)	52(3)
C(11)	8568(17)	2134(3)	4481(5)	47(3)
C(12)	8591(16)	349(2)	4386(4)	35(2)
C(13)	10135(14)	172(2)	4010(4)	28(2)
C(14)	9757(14)	-47(2)	3407(4)	31(2)
C(15)	7724(15)	-242(2)	3303(4)	37(2)
C(16)	7347(16)	-453(2)	2750(5)	41(2)
C(17)	9037(16)	-470(2)	2285(4)	36(2)
C(18)	11031(16)	-281(3)	2389(4)	38(2)
C(19)	11399(14)	-69(2)	2945(4)	35(2)
C(20)	5393(14)	1218(2)	6430(4)	30(2)
C(21)	7028(15)	1184(2)	6935(4)	35(2)
C(22)	6472(14)	1281(2)	7565(4)	36(2)
C(23)	4279(16)	1409(2)	7655(5)	39(2)
C(24)	3252(14)	1353(2)	6592(4)	32(2)
N(1)	7647(11)	1377(2)	5502(3)	31(2)
N(2)	9897(11)	522(2)	4841(3)	29(2)
N(3)	12160(11)	457(2)	4769(4)	35(2)
N(4)	12311(12)	247(2)	4259(4)	36(2)
N(5)	2651(12)	1449(2)	7191(4)	38(2)
C(101)	9192(15)	867(2)	1492(4)	33(2)
C(102)	8134(14)	658(2)	900(4)	37(2)
C(103)	5784(14)	522(2)	1138(4)	31(2)

C(104)	6092(14)	543(2)	1874(4)	33(2)
C(105)	8128(16)	968(3)	2628(4)	42(2)
C(106)	6285(14)	1156(2)	2997(4)	31(2)
C(107)	5990(16)	1538(3)	2950(4)	42(2)
C(108)	4184(17)	1709(3)	3246(4)	46(3)
C(109)	2666(16)	1506(3)	3593(4)	43(3)
C(110)	2939(15)	1129(3)	3657(5)	44(3)
C(111)	4704(16)	958(3)	3348(4)	38(2)
C(112)	6367(14)	-153(2)	828(4)	33(2)
C(113)	4809(13)	-431(2)	720(4)	30(2)
C(114)	5181(14)	-824(2)	609(4)	32(2)
C(115)	7237(15)	-952(3)	361(4)	39(2)
C(116)	7585(16)	-1326(3)	252(5)	43(2)
C(117)	5881(16)	-1576(3)	373(4)	43(2)
C(118)	3861(16)	-1457(3)	614(5)	45(3)
C(119)	3501(15)	-1083(3)	725(4)	38(2)
C(120)	10058(14)	1251(3)	1358(4)	35(2)
C(121)	12204(15)	1373(3)	1544(5)	43(3)
C(122)	12835(16)	1733(3)	1422(5)	44(3)
C(123)	11278(18)	1958(3)	1103(5)	51(3)
C(124)	8598(15)	1507(2)	1047(5)	40(2)
N(101)	7354(12)	888(2)	1958(3)	35(2)
N(102)	5107(11)	154(2)	920(3)	30(2)
N(103)	2854(11)	72(2)	865(3)	35(2)
N(104)	2638(12)	-281(2)	739(3)	38(2)
N(105)	9147(14)	1853(2)	910(4)	50(2)
C(201)	4925(15)	2829(3)	2558(5)	44(3)
Cl(21)	5574(5)	2861(1)	3403(1)	70(1)
Cl(22)	2034(4)	2723(1)	2420(2)	61(1)
Cl(23)	6659(4)	2494(1)	2206(1)	55(1)

Table 80. Bond lengths [Å] and angles [°] for (*trans*)-**215d.**

C(1)-N(1)	1.470(10)
C(1)-C(20)	1.510(11)
C(1)-C(2)	1.560(11)
C(1)-H(1)	1.0000
C(2)-C(3)	1.525(11)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-N(2)	1.480(10)
C(3)-C(4)	1.529(11)
C(3)-H(3)	1.0000
C(4)-N(1)	1.465(10)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(5)-N(1)	1.472(10)
C(5)-C(6)	1.520(12)
C(5)-H(5A)	0.9900
C(5)-H(5B)	0.9900
C(6)-C(11)	1.383(12)
C(6)-C(7)	1.385(12)
C(7)-C(8)	1.395(13)
C(7)-H(7)	0.9500
C(8)-C(9)	1.392(13)
C(8)-H(8)	0.9500
C(9)-C(10)	1.387(14)
C(9)-H(9)	0.9500
C(10)-C(11)	1.390(13)
C(10)-H(10)	0.9500
C(11)-H(11)	0.9500
C(12)-N(2)	1.342(10)
C(12)-C(13)	1.371(11)
C(12)-H(12)	0.9500
C(13)-N(4)	1.380(10)
C(13)-C(14)	1.486(12)
C(14)-C(19)	1.379(11)
C(14)-C(15)	1.391(11)
C(15)-C(16)	1.386(12)
C(15)-H(15)	0.9500
C(16)-C(17)	1.404(12)
C(16)-H(16)	0.9500
C(17)-C(18)	1.363(12)
C(17)-H(17)	0.9500
C(18)-C(19)	1.392(12)
C(18)-H(18)	0.9500
C(19)-H(19)	0.9500
C(20)-C(21)	1.392(11)
C(20)-C(24)	1.397(11)
C(21)-C(22)	1.396(11)
C(21)-H(21)	0.9500
C(22)-C(23)	1.383(12)
C(22)-H(22)	0.9500
C(23)-N(5)	1.332(11)
C(23)-H(23)	0.9500
C(24)-N(5)	1.343(10)
C(24)-H(24)	0.9500
N(2)-N(3)	1.359(9)
N(3)-N(4)	1.303(9)
C(101)-N(101)	1.471(10)
C(101)-C(120)	1.508(12)
C(101)-C(102)	1.546(11)
C(101)-H(101)	1.0000
C(102)-C(103)	1.558(11)
C(102)-H(10A)	0.9900
C(102)-H(10B)	0.9900
C(103)-N(102)	1.457(10)

C(103)-C(104)	1.523(11)
C(103)-H(103)	1.0000
C(104)-N(101)	1.459(10)
C(104)-H(10C)	0.9900
C(104)-H(10D)	0.9900
C(105)-N(101)	1.466(10)
C(105)-C(106)	1.506(11)
C(105)-H(10E)	0.9900
C(105)-H(10F)	0.9900
C(106)-C(107)	1.397(12)
C(106)-C(111)	1.396(11)
C(107)-C(108)	1.387(12)
C(107)-H(107)	0.9500
C(108)-C(109)	1.375(13)
C(108)-H(108)	0.9500
C(109)-C(110)	1.384(13)
C(109)-H(109)	0.9500
C(110)-C(111)	1.380(12)
C(110)-H(110)	0.9500
C(111)-H(111)	0.9500
C(112)-N(102)	1.351(10)
C(112)-C(113)	1.373(11)
C(112)-H(112)	0.9500
C(113)-N(104)	1.383(10)
C(113)-C(114)	1.460(12)
C(114)-C(119)	1.387(12)
C(114)-C(115)	1.403(11)
C(115)-C(116)	1.392(12)
C(115)-H(115)	0.9500
C(116)-C(117)	1.378(12)
C(116)-H(116)	0.9500
C(117)-C(118)	1.370(13)
C(117)-H(117)	0.9500
C(118)-C(119)	1.392(12)
C(118)-H(118)	0.9500
C(119)-H(119)	0.9500
C(120)-C(121)	1.372(12)
C(120)-C(124)	1.402(12)
C(121)-C(122)	1.382(12)
C(121)-H(121)	0.9500
C(122)-C(123)	1.371(13)
C(122)-H(122)	0.9500
C(123)-N(105)	1.348(12)
C(123)-H(123)	0.9500
C(124)-N(105)	1.328(11)
C(124)-H(124)	0.9500
N(102)-N(103)	1.351(9)
N(103)-N(104)	1.315(9)
C(201)-Cl(22)	1.746(9)
C(201)-Cl(23)	1.758(10)
C(201)-Cl(21)	1.772(10)
C(201)-H(201)	1.0000
N(1)-C(1)-C(20)	109.5(7)
N(1)-C(1)-C(2)	104.7(6)
C(20)-C(1)-C(2)	114.2(7)
N(1)-C(1)-H(1)	109.4
C(20)-C(1)-H(1)	109.4
C(2)-C(1)-H(1)	109.4
C(3)-C(2)-C(1)	104.3(7)
C(3)-C(2)-H(2A)	110.9
C(1)-C(2)-H(2A)	110.9
C(3)-C(2)-H(2B)	110.9
C(1)-C(2)-H(2B)	110.9
H(2A)-C(2)-H(2B)	108.9
N(2)-C(3)-C(2)	115.7(7)
N(2)-C(3)-C(4)	111.0(7)
C(2)-C(3)-C(4)	103.7(7)
N(2)-C(3)-H(3)	108.7
C(2)-C(3)-H(3)	108.7
C(4)-C(3)-H(3)	108.7
N(1)-C(4)-C(3)	101.3(6)
N(1)-C(4)-H(4A)	111.5
C(3)-C(4)-H(4A)	111.5
N(1)-C(4)-H(4B)	111.5
C(3)-C(4)-H(4B)	111.5
H(4A)-C(4)-H(4B)	109.3
N(1)-C(5)-C(6)	111.0(7)
N(1)-C(5)-H(5A)	109.4
C(6)-C(5)-H(5A)	109.4
N(1)-C(5)-H(5B)	109.4
C(6)-C(5)-H(5B)	109.4
H(5A)-C(5)-H(5B)	108.0
C(11)-C(6)-C(7)	119.9(9)
C(11)-C(6)-C(5)	121.1(9)
C(7)-C(6)-C(5)	119.0(8)
C(6)-C(7)-C(8)	120.6(9)
C(6)-C(7)-H(7)	119.7
C(8)-C(7)-H(7)	119.7
C(9)-C(8)-C(7)	120.1(10)
C(9)-C(8)-H(8)	119.9
C(7)-C(8)-H(8)	119.9
C(10)-C(9)-C(8)	118.3(10)
C(10)-C(9)-H(9)	120.8
C(8)-C(9)-H(9)	120.8
C(9)-C(10)-C(11)	121.9(10)
C(9)-C(10)-H(10)	119.0
C(11)-C(10)-H(10)	119.0
C(6)-C(11)-C(10)	119.1(10)
C(6)-C(11)-H(11)	120.4
C(10)-C(11)-H(11)	120.4
N(2)-C(12)-C(13)	104.2(8)
N(2)-C(12)-H(12)	127.9
C(13)-C(12)-H(12)	127.9
C(12)-C(13)-N(4)	108.4(8)
C(12)-C(13)-C(14)	130.1(8)
N(4)-C(13)-C(14)	121.4(7)
C(19)-C(14)-C(15)	118.7(8)
C(19)-C(14)-C(13)	121.5(8)
C(15)-C(14)-C(13)	119.8(8)
C(16)-C(15)-C(14)	120.9(8)
C(16)-C(15)-H(15)	119.5
C(14)-C(15)-H(15)	119.5
C(15)-C(16)-C(17)	119.5(9)
C(15)-C(16)-H(16)	120.3
C(17)-C(16)-H(16)	120.3
C(18)-C(17)-C(16)	119.5(8)
C(18)-C(17)-H(17)	120.3
C(16)-C(17)-H(17)	120.3
C(17)-C(18)-C(19)	120.8(9)
C(17)-C(18)-H(18)	119.6
C(19)-C(18)-H(18)	119.6
C(14)-C(19)-C(18)	120.7(8)
C(14)-C(19)-H(19)	119.7
C(18)-C(19)-H(19)	119.7
C(21)-C(20)-C(24)	116.6(8)
C(21)-C(20)-C(1)	121.2(7)
C(24)-C(20)-C(1)	122.2(8)
C(20)-C(21)-C(22)	119.7(8)
C(20)-C(21)-H(21)	120.1
C(22)-C(21)-H(21)	120.1
C(23)-C(22)-C(21)	117.5(9)
C(23)-C(22)-H(22)	121.3
C(21)-C(22)-H(22)	121.3
N(5)-C(23)-C(22)	125.5(9)
N(5)-C(23)-H(23)	117.3
C(22)-C(23)-H(23)	117.3
N(5)-C(24)-C(20)	125.5(8)
N(5)-C(24)-H(24)	117.3

C(20)-C(24)-H(24)	117.3
C(4)-N(1)-C(1)	105.6(6)
C(4)-N(1)-C(5)	114.4(7)
C(1)-N(1)-C(5)	112.1(6)
C(12)-N(2)-N(3)	111.8(7)
C(12)-N(2)-C(3)	129.5(7)
N(3)-N(2)-C(3)	117.9(7)
N(4)-N(3)-N(2)	106.7(7)
N(3)-N(4)-C(13)	108.9(7)
C(23)-N(5)-C(24)	115.3(8)
N(101)-C(101)-C(120)	109.5(7)
N(101)-C(101)-C(102)	105.1(7)
C(120)-C(101)-C(102)	115.8(7)
N(101)-C(101)-H(101)	108.8
C(120)-C(101)-H(101)	108.8
C(102)-C(101)-H(101)	108.8
C(101)-C(102)-C(103)	103.8(7)
C(101)-C(102)-H(10A)	111.0
C(103)-C(102)-H(10A)	111.0
C(101)-C(102)-H(10B)	111.0
C(103)-C(102)-H(10B)	111.0
H(10A)-C(102)-H(10B)	109.0
N(102)-C(103)-C(104)	112.0(7)
N(102)-C(103)-C(102)	115.2(7)
C(104)-C(103)-C(102)	103.1(7)
N(102)-C(103)-H(103)	108.8
C(104)-C(103)-H(103)	108.8
C(102)-C(103)-H(103)	108.8
N(101)-C(104)-C(103)	101.6(7)
N(101)-C(104)-H(10C)	111.5
C(103)-C(104)-H(10C)	111.5
N(101)-C(104)-H(10D)	111.5
C(103)-C(104)-H(10D)	111.5
H(10C)-C(104)-H(10D)	109.3
N(101)-C(105)-C(106)	111.4(7)
N(101)-C(105)-H(10E)	109.4
C(106)-C(105)-H(10E)	109.4
N(101)-C(105)-H(10F)	109.4
C(106)-C(105)-H(10F)	109.4
H(10E)-C(105)-H(10F)	108.0
C(107)-C(106)-C(111)	117.6(8)
C(107)-C(106)-C(105)	120.2(8)
C(111)-C(106)-C(105)	121.9(8)
C(108)-C(107)-C(106)	120.5(9)
C(108)-C(107)-H(107)	119.8
C(106)-C(107)-H(107)	119.8
C(109)-C(108)-C(107)	120.4(9)
C(109)-C(108)-H(108)	119.8
C(107)-C(108)-H(108)	119.8
C(108)-C(109)-C(110)	120.3(9)
C(108)-C(109)-H(109)	119.8
C(110)-C(109)-H(109)	119.8
C(111)-C(110)-C(109)	119.0(9)
C(111)-C(110)-H(110)	120.5
C(109)-C(110)-H(110)	120.5
C(110)-C(111)-C(106)	122.0(9)
C(110)-C(111)-H(111)	119.0
C(106)-C(111)-H(111)	119.0
N(102)-C(112)-C(113)	105.4(7)
N(102)-C(112)-H(112)	127.3
C(113)-C(112)-H(112)	127.3
C(112)-C(113)-N(104)	108.1(8)
C(112)-C(113)-C(114)	129.9(8)
N(104)-C(113)-C(114)	122.0(7)
C(119)-C(114)-C(115)	117.5(8)
C(119)-C(114)-C(113)	121.5(8)
C(115)-C(114)-C(113)	121.0(8)
C(116)-C(115)-C(114)	121.0(8)
C(116)-C(115)-H(115)	119.5
C(114)-C(115)-H(115)	119.5
C(117)-C(116)-C(115)	120.1(9)
C(117)-C(116)-H(116)	120.0
C(115)-C(116)-H(116)	120.0
C(118)-C(117)-C(116)	119.8(9)
C(118)-C(117)-H(117)	120.1
C(116)-C(117)-H(117)	120.1
C(117)-C(118)-C(119)	120.4(9)
C(117)-C(118)-H(118)	119.8
C(119)-C(118)-H(118)	119.8
C(114)-C(119)-C(118)	121.2(8)
C(114)-C(119)-H(119)	119.4
C(118)-C(119)-H(119)	119.4
C(121)-C(120)-C(124)	116.5(9)
C(121)-C(120)-C(101)	123.9(8)
C(124)-C(120)-C(101)	119.5(8)
C(120)-C(121)-C(122)	120.2(9)
C(120)-C(121)-H(121)	119.9
C(122)-C(121)-H(121)	119.9
C(123)-C(122)-C(121)	118.1(9)
C(123)-C(122)-H(122)	120.9
C(121)-C(122)-H(122)	120.9
N(105)-C(123)-C(122)	124.4(9)
N(105)-C(123)-H(123)	117.8
C(122)-C(123)-H(123)	117.8
N(105)-C(124)-C(120)	125.3(9)
N(105)-C(124)-H(124)	117.4
C(120)-C(124)-H(124)	117.4
C(104)-N(101)-C(105)	114.8(7)
C(104)-N(101)-C(101)	105.0(6)
C(105)-N(101)-C(101)	114.7(7)
N(103)-N(102)-C(112)	110.1(7)
N(103)-N(102)-C(103)	118.6(7)
C(112)-N(102)-C(103)	130.8(7)
N(104)-N(103)-N(102)	108.4(7)
N(103)-N(104)-C(113)	107.9(7)
C(124)-N(105)-C(123)	115.5(8)
Cl(22)-C(201)-Cl(23)	110.6(5)
Cl(22)-C(201)-Cl(21)	110.1(5)
Cl(23)-C(201)-Cl(21)	110.2(5)
Cl(22)-C(201)-H(201)	108.7
Cl(23)-C(201)-H(201)	108.7
Cl(21)-C(201)-H(201)	108.7

Symmetry transformations used to generate equivalent atoms:

Table 81. Anisotropic displacement parameters ($Å^2$x 10^3) for (*trans*)-**215d**. The anisotropic displacement factor exponent takes the form: $-2\pi^2$[$h^2a^{*2}U^{11}$ + ... + 2 h k a* b* U^{12}]

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
C(1)	30(5)	31(5)	31(5)	-2(4)	7(4)	-2(4)
C(2)	39(5)	25(5)	35(5)	-8(4)	0(4)	1(4)
C(3)	29(5)	34(6)	34(5)	3(4)	3(4)	-1(4)
C(4)	36(5)	29(5)	36(5)	1(4)	13(4)	-2(4)
C(5)	40(5)	29(6)	54(6)	6(5)	4(5)	2(4)
C(6)	36(5)	26(5)	42(6)	6(4)	1(5)	13(4)
C(7)	61(7)	36(6)	44(6)	13(5)	-2(6)	4(5)
C(8)	65(7)	25(6)	71(8)	-6(5)	8(6)	2(5)
C(9)	62(7)	31(6)	56(7)	7(6)	19(6)	-6(5)
C(10)	78(8)	36(6)	44(7)	4(5)	25(6)	11(6)
C(11)	59(7)	41(6)	40(6)	7(5)	2(5)	-3(5)
C(12)	43(6)	28(5)	33(5)	4(4)	-6(5)	-8(4)
C(13)	35(5)	27(5)	24(5)	3(4)	11(4)	-2(4)
C(14)	23(5)	31(5)	39(6)	15(4)	3(4)	7(4)
C(15)	42(6)	33(6)	38(6)	2(5)	17(5)	5(5)
C(16)	37(5)	28(6)	57(7)	5(5)	-7(5)	3(4)
C(17)	49(6)	27(5)	30(5)	-3(4)	-9(5)	14(5)
C(18)	42(6)	41(6)	31(5)	4(5)	6(5)	11(5)
C(19)	23(5)	36(6)	46(6)	0(5)	4(4)	-5(4)
C(20)	29(5)	20(5)	39(6)	3(4)	8(4)	-2(4)
C(21)	34(5)	37(6)	35(6)	2(5)	2(5)	9(4)
C(22)	31(5)	41(6)	36(6)	-1(5)	0(4)	-3(4)
C(23)	47(6)	24(5)	48(6)	-2(5)	7(5)	5(4)
C(24)	36(5)	23(5)	38(6)	1(4)	2(4)	-1(4)
N(1)	34(4)	24(4)	36(4)	5(3)	9(3)	-8(3)
N(2)	29(4)	23(4)	35(4)	4(3)	1(3)	-2(3)
N(3)	22(4)	31(4)	52(5)	1(4)	9(4)	6(3)
N(4)	36(5)	25(4)	47(5)	-7(4)	8(4)	-1(3)
N(5)	37(4)	45(5)	31(5)	-10(4)	5(4)	2(4)
C(101)	35(5)	34(6)	30(5)	-2(4)	0(4)	2(4)
C(102)	36(5)	33(6)	41(6)	2(5)	-2(5)	6(4)
C(103)	26(5)	25(5)	42(6)	-10(4)	3(4)	0(4)
C(104)	27(5)	37(6)	36(6)	-1(4)	0(4)	-1(4)
C(105)	43(6)	45(6)	39(6)	-11(5)	3(5)	4(5)
C(106)	27(5)	37(6)	28(5)	-2(4)	4(4)	-3(4)
C(107)	50(6)	36(6)	41(6)	-3(5)	7(5)	-2(5)
C(108)	64(7)	34(6)	41(6)	-10(5)	2(5)	-1(5)
C(109)	45(6)	48(7)	38(6)	-11(5)	18(5)	6(5)
C(110)	36(6)	45(7)	49(6)	-7(5)	7(5)	0(5)
C(111)	59(6)	30(5)	24(5)	3(4)	-9(5)	-3(5)
C(112)	22(5)	47(6)	30(5)	3(5)	3(4)	-1(4)
C(113)	15(4)	35(6)	39(6)	-5(4)	4(4)	-6(4)
C(114)	33(5)	41(6)	22(5)	-8(4)	-1(4)	-3(4)
C(115)	35(5)	45(6)	37(6)	-1(5)	11(5)	-8(5)
C(116)	35(5)	35(6)	60(7)	-9(5)	1(5)	-8(5)
C(117)	54(6)	34(6)	42(6)	-4(5)	4(5)	-4(5)
C(118)	43(6)	44(7)	50(6)	7(5)	5(5)	-17(5)
C(119)	28(5)	48(7)	38(6)	5(5)	0(4)	0(5)
C(120)	29(5)	44(6)	34(5)	-2(5)	7(4)	12(5)
C(121)	31(5)	39(6)	59(7)	-8(5)	7(5)	5(5)
C(122)	38(6)	37(6)	58(7)	-13(5)	1(5)	2(5)
C(123)	57(7)	27(6)	69(8)	-1(5)	10(6)	-15(5)
C(124)	25(5)	30(6)	66(7)	-10(5)	-2(5)	2(4)
N(101)	32(4)	43(5)	29(4)	-5(4)	4(4)	-7(4)
N(102)	20(4)	44(5)	26(4)	-5(4)	1(3)	-1(3)
N(103)	28(4)	38(5)	39(5)	-10(4)	6(4)	-1(4)
N(104)	30(4)	44(5)	39(5)	-9(4)	5(4)	-2(4)
N(105)	43(5)	34(5)	73(6)	3(5)	2(5)	-4(4)
C(201)	40(6)	33(6)	60(7)	-5(5)	-2(5)	-16(5)
Cl(21)	83(2)	77(2)	51(2)	6(2)	2(2)	-19(2)

Cl(22)	32(1)	51(2)	100(2)	-4(2)	6(1)	-3(1)
Cl(23)	38(1)	45(2)	82(2)	-6(2)	6(1)	-2(1)

Table 82. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (Å^{2}x 10^3) for (*trans*)-**215d**.

	x	y	z	U(eq)
H(1)	4510	1133	5459	36
H(2A)	7371	616	6099	40
H(2B)	6022	564	5408	40
H(3)	10532	831	5653	39
H(4A)	10274	1300	4888	40
H(4B)	7841	1153	4594	40
H(5A)	5707	1831	5643	49
H(5B)	5561	1685	4909	49
H(7)	10006	2016	6007	56
H(8)	12879	2436	5756	65
H(9)	13121	2658	4688	59
H(10)	10396	2466	3901	62
H(11)	7477	2058	4154	56
H(12)	6970	349	4336	42
H(15)	6578	-229	3617	45
H(16)	5954	-586	2685	49
H(17)	8793	-613	1902	43
H(18)	12183	-294	2077	46
H(19)	12796	63	3009	42
H(21)	8516	1095	6852	43
H(22)	7558	1260	7918	43
H(23)	3903	1474	8085	47
H(24)	2126	1378	6250	38
H(101)	10478	717	1687	40
H(10A)	9111	448	780	44
H(10B)	7925	824	520	44
H(103)	4572	701	992	37
H(10C)	4599	553	2084	40
H(10D)	6984	331	2050	40
H(10E)	9497	1129	2625	51
H(10F)	8568	735	2851	51
H(107)	7034	1681	2713	51
H(108)	3995	1969	3209	55
H(109)	1424	1626	3789	52
H(110)	1925	989	3909	52
H(111)	4847	697	3375	45
H(112)	7989	-172	836	39
H(115)	8408	-781	267	47
H(116)	9000	-1409	93	52
H(117)	6106	-1831	290	52
H(118)	2699	-1630	707	54
H(119)	2078	-1004	884	45
H(121)	13260	1210	1757	51
H(122)	14306	1822	1557	53
H(123)	11733	2203	1011	61
H(124)	7095	1428	925	49
H(201)	5242	3073	2354	53

Table 83. Torsion angles [°] for (*trans*)-**215d**.

N(1)-C(1)-C(2)-C(3)	-5.6(9)
C(20)-C(1)-C(2)-C(3)	-125.3(7)
C(1)-C(2)-C(3)-N(2)	-143.1(7)
C(1)-C(2)-C(3)-C(4)	-21.2(9)
N(2)-C(3)-C(4)-N(1)	165.5(6)
C(2)-C(3)-C(4)-N(1)	40.6(8)
N(1)-C(5)-C(6)-C(11)	116.1(9)
N(1)-C(5)-C(6)-C(7)	-60.5(11)
C(11)-C(6)-C(7)-C(8)	2.1(14)
C(5)-C(6)-C(7)-C(8)	178.7(8)
C(6)-C(7)-C(8)-C(9)	-1.8(15)
C(7)-C(8)-C(9)-C(10)	0.8(14)
C(8)-C(9)-C(10)-C(11)	0.0(15)
C(7)-C(6)-C(11)-C(10)	-1.3(14)
C(5)-C(6)-C(11)-C(10)	-177.9(8)
C(9)-C(10)-C(11)-C(6)	0.2(15)
N(2)-C(12)-C(13)-N(4)	0.2(9)
N(2)-C(12)-C(13)-C(14)	-175.9(8)
C(12)-C(13)-C(14)-C(19)	151.0(9)
N(4)-C(13)-C(14)-C(19)	-24.7(12)
C(12)-C(13)-C(14)-C(15)	-30.1(13)
N(4)-C(13)-C(14)-C(15)	154.2(8)
C(19)-C(14)-C(15)-C(16)	0.0(13)
C(13)-C(14)-C(15)-C(16)	-178.9(8)
C(14)-C(15)-C(16)-C(17)	-0.2(13)
C(15)-C(16)-C(17)-C(18)	0.5(13)
C(16)-C(17)-C(18)-C(19)	-0.5(13)
C(15)-C(14)-C(19)-C(18)	-0.1(13)
C(13)-C(14)-C(19)-C(18)	178.8(8)
C(17)-C(18)-C(19)-C(14)	0.3(13)
N(1)-C(1)-C(20)-C(21)	-66.5(10)
C(2)-C(1)-C(20)-C(21)	50.5(11)
N(1)-C(1)-C(20)-C(24)	112.6(9)
C(2)-C(1)-C(20)-C(24)	-130.4(8)
C(24)-C(20)-C(21)-C(22)	0.3(12)
C(1)-C(20)-C(21)-C(22)	179.5(8)
C(20)-C(21)-C(22)-C(23)	0.0(13)
C(21)-C(22)-C(23)-N(5)	-0.3(14)
C(21)-C(20)-C(24)-N(5)	-0.3(13)
C(1)-C(20)-C(24)-N(5)	-179.5(8)
C(3)-C(4)-N(1)-C(1)	-45.4(8)
C(3)-C(4)-N(1)-C(5)	-169.2(7)
C(20)-C(1)-N(1)-C(4)	154.8(7)
C(2)-C(1)-N(1)-C(4)	32.0(8)
C(20)-C(1)-N(1)-C(5)	-79.9(9)
C(2)-C(1)-N(1)-C(5)	157.2(7)
C(6)-C(5)-N(1)-C(4)	-65.5(10)
C(6)-C(5)-N(1)-C(1)	174.2(7)
C(13)-C(12)-N(2)-N(3)	-0.9(9)
C(13)-C(12)-N(2)-C(3)	169.2(8)
C(2)-C(3)-N(2)-C(12)	44.0(12)
C(4)-C(3)-N(2)-C(12)	-73.8(10)
C(2)-C(3)-N(2)-N(3)	-146.4(7)
C(4)-C(3)-N(2)-N(3)	95.8(8)
C(12)-N(2)-N(3)-N(4)	1.3(9)
C(3)-N(2)-N(3)-N(4)	-170.0(7)
N(2)-N(3)-N(4)-C(13)	-1.1(9)
C(12)-C(13)-N(4)-N(3)	0.6(10)
C(14)-C(13)-N(4)-N(3)	177.1(7)
C(22)-C(23)-N(5)-C(24)	0.4(13)
C(20)-C(24)-N(5)-C(23)	0.0(13)
N(101)-C(101)-C(102)-C(103)	-8.4(9)
C(120)-C(101)-C(102)-C(103)	-129.3(7)
C(101)-C(102)-C(103)-N(102)	-141.5(7)

C(101)-C(102)-C(103)-C(104)	-19.2(8)
N(102)-C(103)-C(104)-N(101)	164.6(6)
C(102)-C(103)-C(104)-N(101)	40.2(8)
N(101)-C(105)-C(106)-C(107)	-84.0(10)
N(101)-C(105)-C(106)-C(111)	90.4(10)
C(111)-C(106)-C(107)-C(108)	0.2(14)
C(105)-C(106)-C(107)-C(108)	174.8(8)
C(106)-C(107)-C(108)-C(109)	0.4(15)
C(107)-C(108)-C(109)-C(110)	0.7(15)
C(108)-C(109)-C(110)-C(111)	-2.3(15)
C(109)-C(110)-C(111)-C(106)	2.9(14)
C(107)-C(106)-C(111)-C(110)	-1.8(13)
C(105)-C(106)-C(111)-C(110)	-176.4(8)
N(102)-C(112)-C(113)-N(104)	1.1(10)
N(102)-C(112)-C(113)-C(114)	-178.2(8)
C(112)-C(113)-C(114)-C(119)	157.8(9)
N(104)-C(113)-C(114)-C(119)	-21.5(13)
C(112)-C(113)-C(114)-C(115)	-24.1(14)
N(104)-C(113)-C(114)-C(115)	156.7(8)
C(119)-C(114)-C(115)-C(116)	-1.4(13)
C(113)-C(114)-C(115)-C(116)	-179.6(8)
C(114)-C(115)-C(116)-C(117)	1.4(14)
C(115)-C(116)-C(117)-C(118)	-1.4(15)
C(116)-C(117)-C(118)-C(119)	1.3(15)
C(115)-C(114)-C(119)-C(118)	1.4(13)
C(113)-C(114)-C(119)-C(118)	179.6(8)
C(117)-C(118)-C(119)-C(114)	-1.4(14)
N(101)-C(101)-C(120)-C(121)	112.5(9)
C(102)-C(101)-C(120)-C(121)	-129.0(9)
N(101)-C(101)-C(120)-C(124)	-65.0(10)
C(102)-C(101)-C(120)-C(124)	53.4(11)
C(124)-C(120)-C(121)-C(122)	-0.1(13)
C(101)-C(120)-C(121)-C(122)	-177.7(8)
C(120)-C(121)-C(122)-C(123)	-1.2(14)
C(121)-C(122)-C(123)-N(105)	1.5(15)
C(121)-C(120)-C(124)-N(105)	1.4(14)
C(101)-C(120)-C(124)-N(105)	179.1(9)
C(103)-C(104)-N(101)-C(105)	-174.0(7)
C(103)-C(104)-N(101)-C(101)	-47.1(8)
C(106)-C(105)-N(101)-C(104)	-85.1(9)
C(106)-C(105)-N(101)-C(101)	153.2(8)
C(120)-C(101)-N(101)-C(104)	159.6(7)
C(102)-C(101)-N(101)-C(104)	34.7(8)
C(120)-C(101)-N(101)-C(105)	-73.4(9)
C(102)-C(101)-N(101)-C(105)	161.6(7)
C(113)-C(112)-N(102)-N(103)	-0.7(9)
C(113)-C(112)-N(102)-C(103)	170.6(8)
C(104)-C(103)-N(102)-N(103)	89.5(9)
C(102)-C(103)-N(102)-N(103)	-153.2(7)
C(104)-C(103)-N(102)-C(112)	-81.2(10)
C(102)-C(103)-N(102)-C(112)	36.2(12)
C(112)-N(102)-N(103)-N(104)	-0.1(9)
C(103)-N(102)-N(103)-N(104)	-172.6(7)
N(102)-N(103)-N(104)-C(113)	0.8(9)
C(112)-C(113)-N(104)-N(103)	-1.2(10)
C(114)-C(113)-N(104)-N(103)	178.2(8)
C(120)-C(124)-N(105)-C(123)	-1.2(14)
C(122)-C(123)-N(105)-C(124)	-0.3(15)

Symmetry transformations used to generate equivalent atoms:

4.3.2 General Remarks

The datasets were measured on a Bruker CCD diffractometer at the window of a Bruker FR591 rotating anode. The data collections were driven by COLLECT[166] and processed by DENZO.[167] Absorption corrections were applied using SADABS.[168] The structure was solved using ShelXS-97[169] and refined by a full-matrix least-squares procedure on F^2 in ShelXL-97.[169] All non-hydrogen atoms were refined with anisotropic displacement parameters. All hydrogen atoms were added at calculated positions and refined by use of a riding model with isotropic displacement parameters based on the equivalent isotropic displacement parameter (U_{eq}) of the parent atom.

5 References

1. Starmans, W. A. J.; Walgers, R. W. A.; Thijs, L.; de Gelder, R.; Smits, J. M. M.; Zwanenburg, B., *Tetrahedron* **1998**, *54*, 4991-5004.
2. Durrat, F.; Sanchez, M. V.; Couty, F.; Evano, G.; Marrot, J., *Eur. J. Org. Chem.* **2008**, 3286-3297.
3. Baeg, J. O.; Bensimon, C.; Alper, H., *J. Org. Chem* **1995**, *60*, 253-256.
4. Singh, S.; Crossley, G.; Ghosal, S.; Lefievre, Y.; Pennington, M. W., *Tetrahedron Lett.* **2005**, *46*, 1419-1421.
5. Yoda, H.; Uemura, T.; Takabe, K., *Tetrahedron Lett.* **2003**, *44*, 977-979.
6. Frigola, J.; Pares, J.; Corbera, J.; Vano, D.; Merce, R.; Torrens, A.; Mas, J.; Valenti, E., *J. Med. Chem.* **1993**, *36*, 801-810.
7. Schmitt, J. D.; Sharples, C. G. V.; Caldwell, W. S., *J. Med. Chem.* **1999**, *42*, 3066-3074.
8. Wang, D. X.; Booth, H.; Lerner-Marmarosh, N.; Osdene, T. S.; Abood, L. G., *Drug Dev. Res.* **1998**, *45*, 10-16.
9. Secor, H. V.; Edwards, W. B., *J. Org. Chem.* **1979**, *44*, 3136-3140.
10. Hillier, M. C.; Chen, C. Y., *J. Org. Chem.* **2006**, *71*, 7885-7887.
11. Barluenga, J.; Olano, B.; Fustero, S., *J. Org. Chem.* **1985**, *50*, 4052-4056.
12. Barluenga, J.; Fernández-Marí, F.; Viado, A. L.; Aguilar, E.; Olano, B., *J. Org. Chem.* **1996**, *61*, 5659-5662.
13. Outurquin, F.; Pannecoucke, X.; Berthe, B.; Paulmier, C., *Eur. J. Org. Chem.* **2002**, 1007-1014.
14. Pannecoucke, X.; Outurquin, F.; Paulmier, C., *Eur. J. Org. Chem.* **2002**, 995-1006.
15. Aelterman, W.; De Kimpe, N.; Declercq, J.-P., *J. Org. Chem.* **1998**, *63*, 6-11.
16. Evans, D. A.; Duffy, J. L.; Dart, M. J., *Tetrahedron Lett.* **1994**, *35*, 8537-8540.
17. Evans, D. A.; Dart, M. J.; Duffy, J. L., *Tetrahedron Lett.* **1994**, *35*, 8541-8544.
18. Brienne, M. J.; Ouannes, C.; Jacques, J., *Bull. Soc. Chem. Fr.* **1968**, 1036-&.
19. Cherest, M.; Felkin, H.; Prudent, N., *Tetrahedron Lett.* **1968**, 2199-&.
20. Cherest, M.; Felkin, H., *Tetrahedron Lett.* **1968**, 2205-&.
21. Anh, N. T.; Eisenstein, O., *New J. Chem.* **1977**, *1*, 61-70.
22. Concellon, J. M.; Bernad, P. L.; Perez-Andres, J. A., *Tetrahedron Lett.* **2000**, *41*, 1231-1234.
23. Concellon, J. M.; Bernad, P. L.; PerezAndres, J. A., *J. Org. Chem.* **1997**, *62*, 8902-8906.
24. Robin, S.; Rousseau, G., *Eur. J. Org. Chem.* **2000**, 3007-3011.
25. Pradhan, T. K.; Krishnan, K. S.; Vasse, J.-L.; Szymoniak, J., *Org. Lett.* **2011**, *13*, 1793-1795.
26. Couty, F.; Evano, G.; Vargas-Sanchez, M.; Bouzas, G., *J. Org. Chem.* **2005**, *70*, 9028-9031.
27. Van Brabandt, W.; Verniest, G.; De Smaele, D.; Duvey, G.; De Kimpe, N., *J. Org. Chem.* **2006**, *71*, 7100-7102.
28. Banide, E.; de Talance, V. L.; Schmidt, G.; Lubin, H.; Comesse, S.; Dechoux, L.; Hamon, L.; Kadouri-Puchot, C., *Eur. J. Org. Chem.* **2007**, 4517-4524.
29. Medjahdi, M.; Gonzalez-Gomez, J. C.; Foubelo, F.; Yus, M., *J. Org. Chem.* **2009**, *74*, 7859-7865.
30. Ye, Y.; Wang, H.; Fan, R. H., *Org. Lett.* **2010**, *12*, 2802-2805.
31. Leng, D.-H.; Wang, D.-X.; Pan, J.; Huang, Z.-T.; Wang, M.-X., *J. Org. Chem.* **2009**, *74*, 6077-6082.
32. He, G.; Zhao, Y. S.; Zhang, S. Y.; Lu, C. X.; Chen, G., *J. Am. Chem. Soc.* **2012**, *134*, 3-6.
33. He, G.; Chen, G., *Angew. Chem., Int. Ed.* **2011**, *50*, 5192-5196.
34. Harada, S.; Sakai, T.; Takasu, K.; Yamada, K.-i.; Yamamoto, Y.; Tomioka, K., *J. Org. Chem.*2012.
35. Lenagh-Snow, G. M. J.; Araújo, N.; Jenkinson, S. F.; Martínez, R. F.; Shimada, Y.; Yu, C.-Y.; Kato, A.; Fleet, G. W. J., *Org. Lett.* **2012**, *14*, 2142-2145.
36. Stanković, S.; Goossens, H.; Catak, S.; Tezcan, M.; Waroquier, M.; Van Speybroeck, V.; D'hooghe, M.; De Kimpe, N., *J. Org. Chem.* **2012**, *77*, 3181-3190.
37. Minakata, S.; Morino, Y.; Oderaotoshi, Y.; Komatsu, M., *Org. Lett.* **2006**, *8*, 3335-3337.
38. Couty, F.; David, O.; Durrat, F.; Evano, G.; Lakhdar, S.; Marrot, J.; Vargas-Sanchez, M., *Eur. J. Org. Chem.* **2006**, 3479-3490.
39. De Rycke, N.; David, O.; Couty, F., *Org. Lett.* **2011**, *13*, 1836-1839.
40. Kenis, S.; D'hooghe, M.; Verniest, G.; Dang Thi, T. A.; Pham The, C.; Van Nguyen, T.; De Kimpe, N., *J. Org. Chem.* **2012**, *77*, 5982-5992.
41. D'hooghe, M.; Catak, S.; Stankovic, S.; Waroquier, M.; Kim, Y.; Ha, H. J.; Van Speybroeck, V.; De Kimpe, N., *Eur. J. Org. Chem.* **2010**, 4920-4931.
42. Testa, L.; Akssira, M.; Zaballos-Garcia, E.; Arroyo, P.; Domingo, L. R.; Sepulveda-Arques, J., *Tetrahedron* **2003**, *59*, 677-683.

43. Kenis, S.; D'hooghe, M.; Verniest, G.; Nguyen, V. D.; Tuyet, A. D. T.; Nguyen, T. V.; De Kimpe, N., *Org. Biomol. Chem.* **2011**, *9*, 7217-7223.
44. Hermsen, P. J.; Cremers, J. G. O.; Thijs, L.; Zwanenburg, B., *Tetrahedron Lett.* **2001**, *42*, 4243-4245.
45. Wang, M.-C.; Zhang, Q.-J.; Zhao, W.-X.; Wang, X.-D.; Ding, X.; Jing, T.-T.; Song, M.-P., *J. Org. Chem.***2007**, *73*, 168-176.
46. Wang, M. C.; Hou, X. H.; Chi, C. X.; Tang, M. S., *Tetrahedron-Asymmetry* **2006**, *17*, 2126-2132.
47. Zhang, Z.; Bai, X.; Liu, R.; Zi, G., *Inorg. Chim. Acta* **2009**, *362*, 1687-1691.
48. Liu, R.; Bai, X.; Zhang, Z.; Zi, G., *Appl. Organomet. Chem.* **2008**, *22*, 671-675.
49. Keller, L.; Sanchez, M. V.; Prim, D.; Couty, F.; Evano, G.; Marrot, J., *J. Organomet. Chem.* **2005**, *690*, 2306-2311.
50. Kotha, S.; Lahiri, K.; Kashinath, D., *Tetrahedron* **2002**, *58*, 9633-9695.
51. Menguy, L.; Couty, F., *Tetrahedron-Asymmetry* **2010**, *21*, 2385-2389.
52. Wroblewski, J. T.; Fadda, E.; Mazzetta, J.; Lazarewicz, J. W.; Costa, E., *Neuropharmacology* **1989**, *28*, 447-452.
53. Wroblewski, J. T.; Nicoletti, F.; Costa, E., *Neuropharmacology* **1985**, *24*, 919-921.
54. Manev, H.; Favaron, M.; Guidotti, A.; Costa, E., *Mol. Pharmacol.* **1989**, *36*, 106-112.
55. Kozikowski, A. P.; Tuckmantel, W.; Liao, Y.; Manev, H.; Ikonomovic, S.; Wroblewski, J. T., *J. Med. Chem.* **1993**, *36*, 2706-2708.
56. Gerona-Navarro, G.; Pérez de Vega, M. J.; García-López, M. T.; Andrei, G.; Snoeck, R.; De Clercq, E.; Balzarini, J.; González-Muñiz, R., *J. Med. Chem.* **2005**, *48*, 2612-2621.
57. Casado, J. L.; Perez-Elias, M. J.; Marti-Belda, P.; Antela, A.; Suarez, M.; Ciancas, E.; Frutos, B.; Perez, M. D.; Guerrero, A., *Journal of Acquired Immune Deficiency Syndromes and Human Retrovirology* **1998**, *1*, 130-134.
58. Martinez, A.; Castro, A.; Gil, C.; Perez, C., *Med. Res. Rev.* **2001**, *21*, 227-244.
59. Leung, D.; Abbenante, G.; Fairlie, D. P., *J. Med. Chem.* **2000**, *43*, 305-341.
60. Han, Y.; Han, M.; Shin, D.; Song, C.; Hahn, H.-G., *J. Med. Chem.* **2012**.
61. Couty, F.; Durrat, F.; Prim, D., *Tetrahedron Lett.* **2003**, *44*, 5209-5212.
62. Van Brabandt, W.; Van Landeghem, R.; De Kimpe, N., *Org. Lett.* **2006**, *8*, 1105-1108.
63. Bott, T. M.; Vanecko, J. A.; West, F. G., *J. Org. Chem.* **2009**, *74*, 2832-2836.
64. Heard, G. L.; Yates, B. F., *Aust. J. Chem.* **1995**, *48*, 1413-1423.
65. Ollis, W. D.; Rey, M.; Sutherland, I. O., *J. Chem. Soc., Perkin Trans. 1* **1983**, , 1009-1027.
66. Ollis, W. D.; Rey, M.; Sutherland, I. O.; Closs, G. L., *J Chem Soc Chem Comm* **1975**, 543-545.
67. More, S. S.; Mohan, T. K.; Kumar, Y. S.; Kumar, U. K. S.; Patel, N. B., *Beilstein J. Org. Chem.* **2011**, *7*, 831-838.
68. Mack, D. J.; Njardarson, J. T., *Chem. Sci.* **2012**, *3*, 3321-3325.
69. Kim, D.-K.; Kim, G.; Kim, Y.-W., *J. Chem. Soc., Perkin Trans. 1* **1996**, *0*, 803-808.
70. Davies, S. G.; Nicholson, R. L.; Price, P. D.; Roberts, P. M.; Russell, A. J.; Savory, E. D.; Smith, A. D.; Thomson, J. E., *Tetrahedron: Asymmetry* **2009**, *20*, 758-772.
71. Jarvis, S. B. D.; Charette, A. B., *Org. Lett.* **2011**, *13*, 3830-3833.
72. Severin, R.; Doye, S., *Chem. Soc. Rev.* **2007**, *36*, 1407-1420.
73. Ruman, T.; Pogocki, D.; Danilczuk, M.; Danilczuk, M.; Celuch, M.; Walajtys-Rode, E., *Eur J Pharmacol* **2007**, *563*, 18-39.
74. Vagg, R.; Chapman, S., *Addiction* **2005**, *100*, 701-712.
75. Baldwin, J. E., *J. Chem. Soc., Chem. Commun.* **1976**, 734-736.
76. Baldwin, J. E.; Kruse, L. I., *J. Chem. Soc., Chem. Commun.* **1977**, 233-235.
77. Baldwin, J. E.; Lusch, M. J., *Tetrahedron* **1982**, *38*, 2939-2947.
78. Baldwin, J. E.; Thomas, R. C.; Kruse, L. I.; Silberman, L., *J. Org. Chem.* **1977**, *42*, 3846-3852.
79. Lee, W. S.; Jang, K. C.; Kim, J. H.; Park, K. H., *Chem. Commun.* **1999**, 251-252.
80. Ichikawa, J.; Lapointe, G.; Iwai, Y., *Chem. Commun.* **2007**, 2698-2700.
81. Auvray, P.; Knochel, P.; Normant, J. F., *Tetrahedron Lett.* **1985**, *26*, 4455-4458.
82. Chavdarian, C. G.; Sanders, E. B.; Bassfield, R. L., *J. Org. Chem.* **1982**, *47*, 1069-1073.
83. Loh, T. P.; Zhou, J. R.; Li, X. R.; Sim, K. Y., *Tetrahedron Lett.* **1999**, *40*, 7847-7850.
84. Welter, C.; Moreno, R. M.; Streiff, S.; Helmchen, G., *Org. Biomol. Chem.* **2005**, *3*, 3266-3268.
85. Zhang, H. L.; Mitsumori, S.; Utsumi, N.; Imai, M.; Garcia-Delgado, N.; Mifsud, M.; Albertshofer, K.; Cheong, P. H. Y.; Houk, K. N.; Tanaka, F.; Barbas, C. F., *J. Am. Chem. Soc.* **2008**, *130*, 875-886.
86. Xu, D.-Z.; Shi, S.; Wang, Y., *Eur. J. Org. Chem.* **2009**, *2009*, 4848-4853.

87. Gaunt, M. J.; Johansson, C. C. C.; McNally, A.; Vo, N. T., *Drug Discovery Today* **2007**, *12*, 8-27.
88. Northrup, A. B.; MacMillan, D. W. C., *J. Am. Chem. Soc.* **2002**, *124*, 6798-6799.
89. Mangion, I. K.; Northrup, A. B.; MacMillan, D. W. C., *Angew. Chem., Int. Ed.* **2004**, *43*, 6722-6724.
90. Chi, Y.; Gellman, S. H., *Org. Lett.* **2005**, *7*, 4253-4256.
91. Singh, K. N.; Singh, P.; Singh, P.; Lal, N.; Sharma, S. K., *Bioorganic & Medicinal Chemistry Letters* **2012**, *22*, 4225-4228.
92. Cao, C.-L.; Ye, M.-C.; Sun, X.-L.; Tang, Y., *Org. Lett.* **2006**, *8*, 2901-2904.
93. Betancort, J. M.; Barbas, C. F., *Org. Lett.* **2001**, *3*, 3737-3740.
94. List, B., *J. Am. Chem. Soc.* **2000**, *122*, 9336-9337.
95. Fustero, S.; Jiménez, D.; Sánchez-Roselló, M.; del Pozo, C., *J. Am. Chem. Soc.* **2007**, *129*, 6700-6701.
96. Terada, Y.; Arisawa, M.; Nishida, A., *Angew. Chem. Int. Ed.* **2004**, *43*, 4063-4067.
97. Wang, H. F.; Yang, T.; Xu, P. F.; Dixon, D. J., *Chem. Commun.* **2009**, 3916-3918.
98. Anderson, L. L.; Arnold, J.; Bergman, R. G., *Org. Lett.* **2004**, *6*, 2519-2522.
99. Shanbhag, G. V.; Halligudi, S. B., *J. Mol. Catal. A: Chem.* **2004**, *222*, 223-228.
100. Shimada, T.; Yamamoto, Y., *J. Am. Chem. Soc.* **2002**, *124*, 12670-12671.
101. Lai, R. Y.; Surekha, K.; Hayashi, A.; Ozawa, F.; Liu, Y. H.; Peng, S. M.; Liu, S. T., *Organometallics* **2007**, *26*, 1062-1068.
102. Tokunaga, M.; Eckert, M.; Wakatsuki, Y., *Angew. Chem. Int. Ed.* **1999**, *38*, 3222-3225.
103. Ackermann, L.; Kaspar, L. T.; Gschrei, C. J., *Chem. Commun.* **2004**, 2824-2825.
104. Carney, J. M.; Donoghue, P. J.; Wuest, W. M.; Wiest, O.; Helquist, P., *Org. Lett.* **2008**, *10*, 3903-3906.
105. Obika, S.; Kono, H.; Yasui, Y.; Yanada, R.; Takemoto, Y., *J. Org. Chem.* **2007**, *72*, 4462-4468.
106. Yanada, R.; Obika, S.; Kono, H.; Takemoto, Y., *Angew. Chem. Int. Ed.* **2006**, *45*, 3822-3825.
107. Li, S. W.; Batey, R. A., *Chem. Commun.* **2004**, 1382-1383.
108. Yamamoto, Y.; Komatsu, T.; Maruyama, K., *J. Org. Chem.* **1985**, *50*, 3115-3121.
109. Bao, M.; Nakamura, H.; Yamamoto, Y., *Tetrahedron Lett.* **2000**, *41*, 131-134.
110. Sun, X.-W.; Liu, M.; Xu, M.-H.; Lin, G.-Q., *Org. Lett.* **2008**, *10*, 1259-1262.
111. Sun, X.-W.; Xu, M.-H.; Lin, G.-Q., *Org. Lett.* **2006**, *8*, 4979-4982.
112. Masuyama, Y.; Tosa, J.; Kurusu, Y., *Chem. Commun.* **1999**, 1075-1076.
113. Wang, D. K.; Dai, L. X.; Hou, X. L.; Zhang, Y., *Tetrahedron Lett.* **1996**, *37*, 4187-4188.
114. Ramadhar, T. R.; Batey, R. A., *Synthesis-Stuttgart* **2011**, 1321-1346.
115. Yamamoto, Y.; Asao, N., *Chem. Rev.* **1993**, *93*, 2207-2293.
116. Feula, A.; Male, L.; Fossey, J. S., *Org. Lett.* **2010**, *12*, 5044-5047.
117. Ahmed, B.; Yusuf, M., *Indian Journal of Chemistry Section B-Organic Chemistry Including Medicinal Chemistry* **2010**, *49*, 241-246.
118. Yamamoto, Y.; Yatagai, H.; Naruta, Y.; Maruyama, K., *J. Am. Chem. Soc.* **1980**, *102*, 7107-7109.
119. Denton, T. T.; Zhang, X. D.; Cashman, J. R., *J. Med. Chem.* **2005**, *48*, 224-239.
120. Barlow, R. B.; Hamilton, J. T., *Brit J Pharm Chemoth* **1962**, *18*, 543-&.
121. Barlow, R. B.; Hamilton, J. T., *Brit J Pharm Chemoth* **1962**, *18*, 510-&.
122. Pogocki, D.; Ruman, T.; Danilczuk, M.; Danilczuk, M.; Celuch, M.; Walajtys-Rode, E., *Eur. J. Pharmacol.* **2007**, *563*, 18-39.
123. Teo, Y. C.; Goh, E. L.; Loh, T. P., *Tetrahedron Lett.* **2005**, *46,* 6209-6211.
124. Teo, Y. C.; Goh, E. L.; Loh, T. P., *Tetrahedron Lett.* **2005**, *46*, 4573-4575.
125. Lu, J.; Ji, S. J.; Teo, Y. C.; Loh, T. P., *Org. Lett.* **2005**, *7*, 159-161.
126. Teo, Y. C.; Tan, K. T.; Loh, T. P., *Chem. Commun.* **2005**, 1318-1320.
127. Teo, Y. C.; Loh, T. P., *Abstr. Pap. Am. Chem. Soc.* **2004**, *228*, U33-U33.
128. Costa, A. L.; Piazza, M. G.; Tagliavini, E.; Trombini, C.; Umanironchi, A., *J. Am. Chem. Soc.* **1993**, *115*, 7001-7002.
129. Keck, G. E.; Tarbet, K. H.; Geraci, L. S., *J. Am. Chem. Soc.* **1993**, *115*, 8467-8468.
130. Keck, G. E.; Geraci, L. S.; Tarbet, K. H., *Abstr. Pap. Am. Chem. Soc.* **1993**, *205*, 294-ORGN.
131. Gonzalez-Gomez, J. C.; Medjahdi, M.; Foubelo, F.; Yus, M., *J. Org. Chem.* **2010**, *75*, 6308-6311.
132. Mathre, D. J.; Thompson, A. S.; Douglas, A. W.; Hoogsteen, K.; Carroll, J. D.; Corley, E. G.; Grabowski, E. J. J., *J. Org. Chem.* **1993**, *58*, 2880-2888.
133. Corey, E. J.; Bakshi, R. K.; Shibata, S.; Chen, C. P.; Singh, V. K., *J. Am. Chem. Soc.* **1987**, *109*, 7925-7926.
134. Corey, E. J.; Bakshi, R. K.; Shibata, S., *J. Am. Chem. Soc.* **1987**, *109*, 5551-5553.

135. Corey, E. J.; Suggs, J. W., *Tetrahedron Lett.* **1975**, *16*, 2647-2650.
136. Teo, Y.-C.; Tan, K.-T.; Loh, T.-P., *Chem. Commun.* **2005**, 1318-1320.
137. Bai, B.; Shen, L.; Ren, J.; Zhu, H. J., *Adv. Synth. Catal.* **2012**, *354*, 354-358.
138. Krow, G.; Hill, R. K., *Chem. Commun.* **1968,** (8), 430-&.
139. Ding, R.; He, Y.; Wang, X.; Xu, J. L.; Chen, Y. R.; Feng, M.; Qi, C. M., *Molecules* **2011**, *16*, 5665-5673.
140. Harrison, G. C.; Diehl, H., *Org. Synth.* **1943**, *23*, 32-33.
141. Nakamura, H.; Nakamura, K.; Yamamoto, Y., *J. Am. Chem. Soc.* **1998**, *120*, 4242-4243.
142. Hietanen, A.; Saloranta, T.; Rosenberg, S.; Laitinen, E.; Leino, R.; Kanerva, L. T., *Eur. J. Org. Chem.* **2010**, 909-919.
143. Ohtani, T.; Nakatsukasa, H.; Kamezawa, M.; Tachibana, H.; Naoshima, Y., *J. Mol. Catal. B: Enzym.* **1998**, *4*, 53-60.
144. Gotor-Fernandez, V.; Fernandez-Torres, P.; Gotor, V., *Tetrahedron-Asymmetry* **2006**, *17*, 2558-2564.
145. Liljeblad, A.; Kallio, P.; Vainio, M.; Niemi, J.; Kanerva, L. T., *Org. Biomol. Chem.* **2010**, *8*, 886-895.
146. Gill, I. I.; Das, J.; Patel, R. N., *Tetrahedron-Asymmetry* **2007**, *18*, 1330-1337.
147. Spivey, A. C.; Arseniyadis, S., *Angew. Chem., Int. Ed.* **2004**, *43*, 5436-5441.
148. Liu, G. C.; Cogan, D. A.; Ellman, J. A., *J. Am. Chem. Soc.* **1997**, *119*, 9913-9914.
149. Ellman, J. A.; Owens, T. D.; Tang, T. P., *Acc. Chem. Res.* **2002**, *35*, 984-995.
150. Foubelo, F.; Yus, M., *Tetrahedron-Asymmetry* **2004**, *15*, 3823-3825.
151. Liu, G. C.; Cogan, D. A.; Owens, T. D.; Tang, T. P.; Ellman, J. A., *J. Org. Chem.* **1999**, *64*, 1278-1284.
152. Fernandes, R. A.; Yamamoto, Y., *J. Org. Chem.* **2004**, *69*, 735-738.
153. Baxter, E. W.; Reitz, A. B., *Org. React.*, John Wiley & Sons, Inc.: **2004**.
154. Brandi, A.; Cicchi, S.; Cordero, F. M., *Chem. Rev.* **2008**, *108*, 3988-4035.
155. Dunina, V. V.; Kuz'mina, L. G.; Kazakova, M. Y.; Golunova, O. N.; Grishin, Y. K.; Kazakova, E. I., *Eur. J. Inorg. Chem.* **1999**, 1029-1039.
156. Markies, B. A.; Wijkens, P.; Boersma, J.; Kooijman, H.; Veldman, N.; Spek, A. L.; Vankoten, G., *Organometallics* **1994**, *13*, 3244-3258.
157. Johnson, J. S.; Evans, D. A., *Acc. Chem. Res.* **2000**, *33*, 325-335.
158. Evans, D. A.; Rovis, T.; Kozlowski, M. C.; Downey, C. W.; Tedrow, J. S., *J. Am. Chem. Soc.* **2000**, *122*, 9134-9142.
159. Denmark, S. E.; Stavenger, R. A., *Acc. Chem. Res.* **2000**, *33*, 432-440.
160. Larsen, J.; Jorgensen, K. A., *J. Chem. Soc., Perkin Trans. 2,* **1992**, 1213-1217.
161. Goti, A.; Romani, M., *ChemInform* **1995**, *26*, no-no.
162. Wendlandt, A. E.; Stahl, S. S., *Org. Lett.* **2012**, *14*, 2850-2853.
163. Patil, R. D.; Adimurthy, S., *Adv. Synth. Catal.* **2011**, *353*, 1695-1700.
164. Zhu, B.; Angelici, R. J., *Chem. Commun.* **2007**, 2157-2159.
165. Nicolaou, K. C.; Mathison, C. J. N.; Montagnon, T., *J. Am. Chem. Soc.* **2004**, *126*, 5192-5201.
166. Müller, P.; Gilabert, D. M., *Tetrahedron* **1988**, *44*, 7171-7175.
167. Murahashi, S.; Yoshimura, N.; Tsumiyama, T.; Kojima, T., *J. Am. Chem. Soc.* **1983**, *105*, 5002-5011.
168. Feula, A.; Fossey, J. S., *RSC Advances* **2013**.
169. Abdel-Magid, A. F.; Carson, K. G.; Harris, B. D.; Maryanoff, C. A., *Abstr. Pap. Am. Chem. Soc.* **1998**, *216*, U934-U934.
170. Zhang, L.; Lee, M.-M.; Lee, S.-M.; Lee, J.; Cheng, M.; Jeong, B.-S.; Park, H.-g.; Jew, S.-s., *Adv. Synth. Catal.* **2009**, *351*, 3063-3066.
171. Zon, L. I.; Peterson, R. T., *Nat. Rev. Drug Discovery* **2005**, *4*, 35-44.
172. Hill, A. J.; Teraoka, H.; Heideman, W.; Peterson, R. E., *Toxicol. Sci.* **2005**, *86*, 6-19.
173. R. W. W. Hooft, COLLECT, Data Collection Software, Nonius B. V. (Delft), **1998**.
174. Z. Otwinowski, W. Minor in *Methods Enzymol., 276* (Eds.: C. W. Carter, R. M. Sweet), Academic Press, New York, **1997**, 307-326.
175. G. M. Sheldrick, SADABS. Bruker AXS Inc., Madison, Wisconsin (USA) **2007**.
176. G. M. Sheldrick, *Acta Cry*st. **2008**, *A64*, 112-122.