THE ABSTRACT OF THE THESIS OF

Erik Carlson for the degree of Master of Science in Chemistry presented on November 23, 2009.

Title: Development of Organocatalyzed, Intramolecular Heteroatom Michael Addition and Application Towards Alkaloid Synthesis

Abstract approved:

Rich G. Carter

Effective methods for the enantiopure formation of substituted piperidine rings are significantly important due to their presence in alkaloid products. A valuable method to form these ring systems would be via an intramolecular heteroatom Michael addition from the corresponding enone or enal. Described herein is a methodology that has been developed in order to form piperidine, pyrrolidine and indoline ring systems using organocatalysis. These ring systems have been prepared with yields of

50-87% and ee as high as 95%. This methodology has been utilized in the synthesis of three natural products: homopipecolic acid, homoproline, and pelletierine. Homopipecolic acid was synthesized in 7 steps and 28% yield from commercially available 1-bromo-5-hexene. Homoproline was synthesized in 7 steps and 10% overall yield from commercially available 1-bromo-4-heptene. Pelletierine was synthesized in 8 steps and 26% overall yield from commercially available 1-bromo-5-hexene.

Synthetic efforts toward cermizine D are also disclosed. This synthesis involves the use of our organocatalytic methodology in order to form the initial piperidine ring. Using the Boc protected amine for this reaction gave the desired piperidine ring in 86% yield and 92% ee. One key step is the $Ti(O\text{-}iPr)_4$ mediated coupling to produce the core carbon structure in 68% yield and 1:1 dr. This reaction is has not yet been optimized. Another key step is the use of RCM in order to form the second ring in the system with a 94% yield.

Development of Organocatalyzed, Intramolecular Heteroatom Michael Addition and Application Towards Alkaloid Synthesis

by

Erik Carlson

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APPROVED:

Major Professor, representing Chemistry

Chair of the Department of Chemistry

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Erik Carlson, Author

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

Development of Organocatalyzed, Intramolecular Heteroatom Michael Addition and Application Towards Alkaloid Synthesis

Chapter I. Introduction into organocatalyzed heteroatom Michael additions and other piperidine forming reactions

1.1 Introduction

Pyrrolidine and piperidine-based ring systems are ubiquitous in natural products. Consequently, construction of these heterocyclic ring systems in an enantioenriched fashion has been a subject of considerable synthetic attention. A variety of groups have showcased the ability to asymmetrically deprotonate *N*-protected pyrrolidines and piperidines, for example one can look at work by Beak,[1] Hoppe,[2] and others.[3] In addition, Comins has developed an asymmetric pyridinium salt reaction for the synthesis of enantioenriched piperidines.[4] More recently, dipolar cycloadditions[5] have been exploited for the construction of these heterocyclic ring systems; however, there are limited examples in the use of organocatalysts for the construction of these ring systems.[6,7] This, combined with our general interest in alkaloid total synthesis, caused us to investigate this valuable transformation.

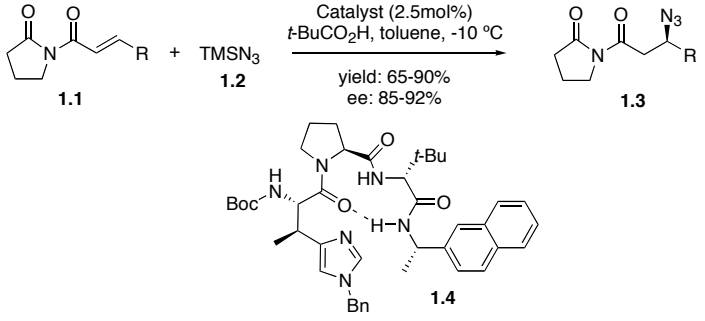
1.2 Previous Studies

1.2.1 Organocatalytic Asymmetric Aza-Michael Reactions

1.2.1.1 Miller's Asymmetric Azidation

First, here is an example of an organocatalytic asymmetric aza-Michael reaction reported by Miller in 2002.[8] Miller demonstrated that the use of a chiral tripeptide **1.4** was effective in the conjugate addition of TMS azide to α,β-unsaturated imides. It was found in optimizing the reaction that is was key to have the intramolecular hydrogen bonding to lock the peptide secondary structure to allow for high enantioselectivities (Scheme 1.1).

Scheme 1.1. Asymmetric Azidation Using Miller's Method

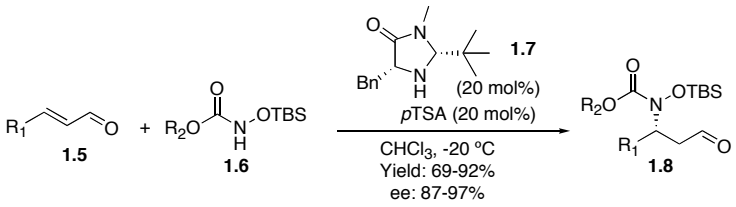


A key challenge that existed with the general scope of this transformation was with moderating reactivity. Both the catalyst and the nucleophile are amine-containing species; therefore, the chiral secondary amine chosen as the catalyst must not undergo a conjugate addition. At the same time the amine reagent must not produce an iminium ion, as this would lead to the production of a racemic product.

1.2.1.2 MacMillan's Amine Conjugate Addition

In 2006, MacMillan and co-workers reported an enantioselective organocatalytic amine conjugate addition using a *N*-silyloxycarbamate as the nitrogen nucleophile.[9] These reagents have an enhanced nucleophilicity due to the presence of the silyoxy moiety, the α-effect. In addition to the increased nucleophilicity of the nitrogen reagent, it also contained a carbamate functionality that muted the reversibility of the reaction. MacMillan and co-workers tested out a variety of catalysts for this reaction starting with proline and eventually finding that the use of imidazolidinone **1.7** as its *p*TSA salt gave excellent selectivity (Scheme 1.2).

Scheme 1.2. Amine Conjugate Addition Using MacMillan's Method

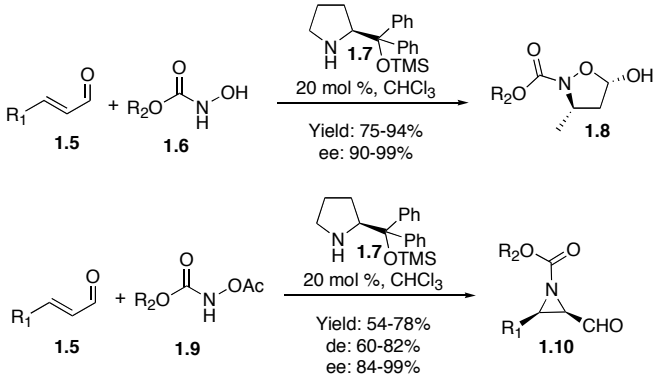


1.2.1.3 Córdova's Aziridination

Córdova and co-workers used a similar nucleophile for their addition, using a hydroxy amine with a carbamate-protecting group. The use of this substrate only differs in that there is no silyl group on the hydroxy group; however, this causes an interestingly different reaction to occur. Rather then just having the conjugate addition, in this case, the Michael product

undergoes an intramolecular hemiacetal formation to produce 5-hydroxyazolines (Scheme 1.3). Córdova changed the catalyst as well using a proline based catalyst in the TMS protected diphenyl prolinol **1.7**. This catalyst system gave yield to the desired products with excellent yields and selectivity. Córdova also showed that replacement of the hydroxy amine substrate for a substrate with a suitable leaving group that aziridine formation occurs.[10]

Scheme 1.3. Enantioselective Aziridination Catalyzed by a Chiral Pyrrolidine

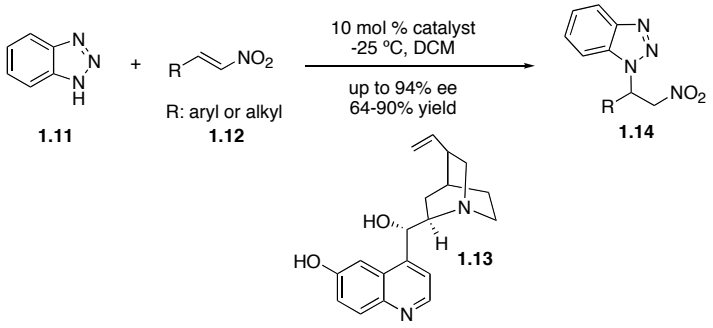


1.2.1.4 Wang's Michael and Aldol Additions

Wang and co-workers reported a method for a Michael addition using *N*-heterocycles to nitroolefins.[11] The process used a cinchona alkaloid derivative as the organocatalyst. It was shown that the process could be carried out using a wide variety of substituents on the nitroolefin and a benzotriazole as the nucleophilic nitrogen (Scheme 1.4). He also demonstrated that the alternate *N*-heterocycle nucleophile such as 1*H*-

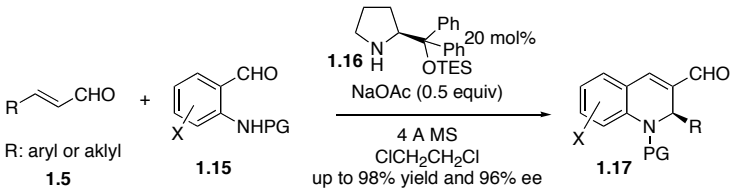
[1,2,3] triazole or 5-phenyl-1*H*-tetrazole could be used.

Scheme 1.4. Michael Addition Reaction by Wang



In a later report, Wang and co-workers also developed a conjugate addition-aldol-dehydration reaction between α,β-unsaturated aldehydes with 2-*N*-protected amino benzaldehydes. The organocatalyst used for this transformation was (*S*)-diphenylprolinol TES ether and the process gave 1,2-dihydroquinolines in high enantioselectivity with good yields (Scheme 1.5).[12]

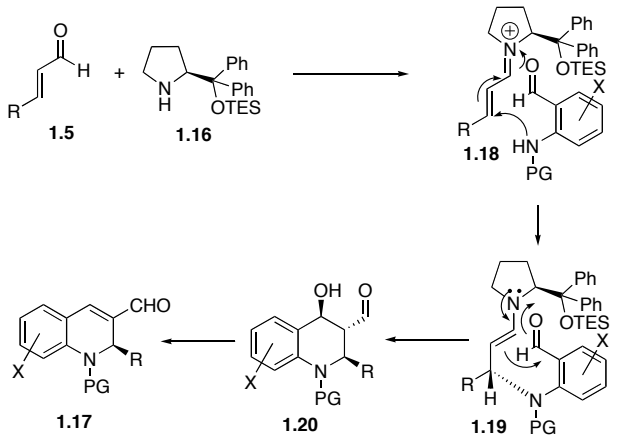
Scheme 1.5. Cascade Conjugate Addition-Aldol-Dehydration Reaction by Wang



In this case, it was key that the product from the conjugate addition reaction underwent an intermolecular aldol reaction and dehydration. This cascade process was required in order to push the equilibrium in the catalytic conjugate addition toward the final product. The proposed

mechanisim for this process is shown in Scheme 1.6.

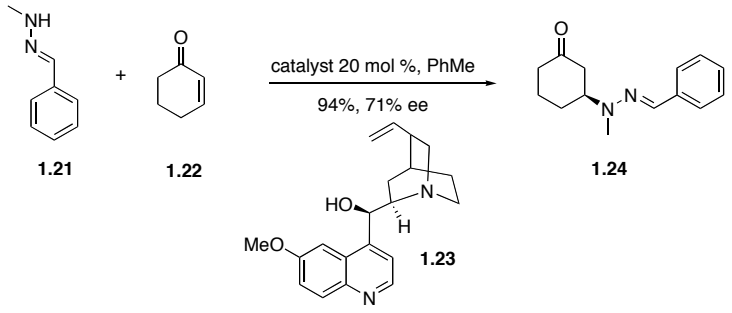
Scheme 1.6. Cascade Organocatalytic Enantioselective Conjugate Addition-Aldol-Dehydration Reactions



1.2.1.5 Jørgensen's contributions

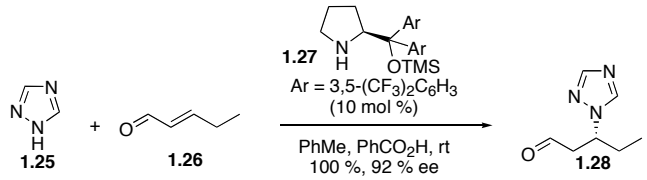
Jørgensen and co-workers reported an organocatalyzed asymmetric aza-Michael addition using hydrazones to cyclic eneones. This process used a cinchona alkaloid as the catalyst to yield the addition product in good yield and stereoselectivity (Scheme 1.7). A study was conducted to determine the influence that the structure of the enone had on the stereoselectivity giving products with up to 77% ee that could be recrystalized to give nearly enantiopure products.

Scheme 1.7. Jørgensen's Aza-Michael Reaction with Hydrazones



In a later report, Jørgensen and co-workers disclosed a process in which a variety of nitrogen heterocycles were used as the nucleophiles employed in enantioselective organocatalytic conjugate additions to α,β-unsaturated aldehydes. For this process, the catalyst used was 2-[bis(3,5-bis-trifluoromethylphenyl)trimethylsilanyloxymethyl]pyrrolidine. This process was shown to be successful using a variety of nitrogen heterocycles such as 1,2,4-triazoles (Scheme 1.8), 5-phenyl-1*H*-tetrazoles, benzotriazoles and 1,2,3-triazoles.[13]

Scheme 1.8. Conjugate Addition of N Heterocycles

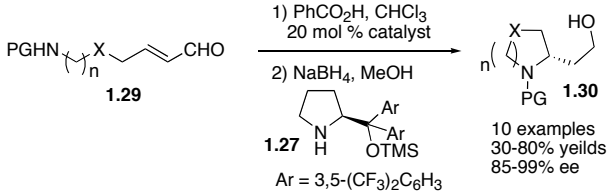


1.2.1.6 Fustero's Intramolecular Aza-Michael Reaction

Independently and concurrent to our work Fustero and co-workers reported on an organocatalytic intramolecular aza-Michael reaction.[14] This work was similar to ours in that it was forming pyrrolidine and piperidine

ring systems even using the same catalyst (Scheme 1.9). They reported the effectiveness of this reaction on a range of substrates with generally high levels of enantioselectiviy; however, there are some general advantages to our methodology over this report. Specifically, the reaction temperatures for these transformations are low (typically starting at -50ºC) and require a slow warming over long periods of time (such as -50ºC to -30ºC over a period of 48 h). Additionally, the use of benzoic acid as an additive was used in order to have the reaction proceed at a suitable rate. This additive may not be advantageous for acid-sensitive substrates.

Scheme 1.9. Organocatalytic Intramolecular Aza-Michael Reaction



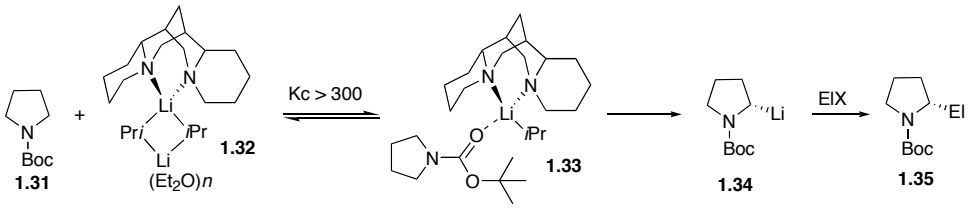
1.2.2 Asymmetric Deprotonation of *N*-Protected Pyrrolidines and Piperidines.

1.2.2.1 Asymmetric Deprotonation of *N*-Boc-Pyrrolidine

Beak and co-workers reported a variety of asymmetric lithiations. Included in these was the asymmetric deprotonation lithiation of *N*-Boc-pyrrolidines shown in Scheme 1.10.[15] In this report Beak discusses the rate of this reaction and how it precedes via the prelithiation complex **1.33**

that is the rate limiting step with the complex being highly favored in the equilibrium. It was also reported that the addition of a variety of electrophiles following the lithiation led to an enantioenriched product.

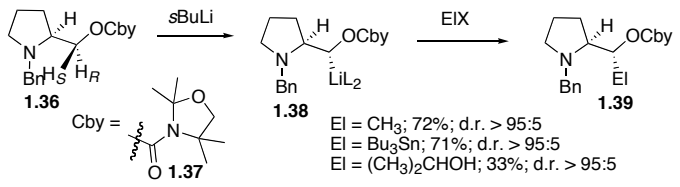
Scheme 1.10. The deprotonation of *N*-Boc-pyrrolidine via prelithiation complex



1.2.2.2 Substrate-Directed Deprotonation

Hoppe and co-workers also reported a variety of asymmetric lithiations. Shown in scheme 1.11 is the substrate-directed deprotonation of the prolinol carbamate **1.36**.[16] Hoppe reported that even with out the use of sparteine similar stereoselectivity was obtained. Due to this observation he concluded that the less shielded amino function intervenes in the deprotonation step in an intra- or intermolecular way.

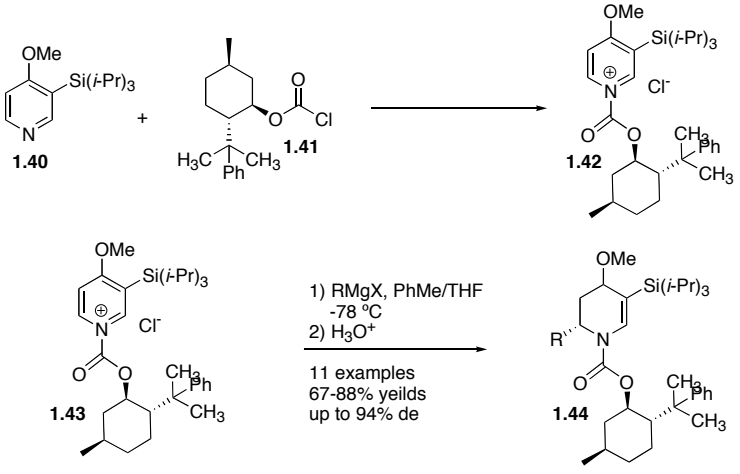
Scheme 1.11. Diastereoselective deprotonation of the prolinol carbamate **1.36**



1.2.3 Asymmetric Pyridinium Salt Reactions

Comins and co-workers reported in 1994 the use of pyridinium salts formed with chiral acids to produce 2-alkyl(aryl)-2,3-dihydro-4-pyridones via Grignard addition (Scheme 1.12).[4] After optimization the pyridinium salt formed using (-)-8-phenylmenthyl as the homochiral chloroformate gave the best results. In addition to using the (-)-8-phenylmenthyl salt it was reported that either the (-)- or (+)-*trans*-(α-cumyl)cyclohexanol (TCC) could be used in order to obtain both enantiomers. Further optimization was done with the substitution at the C-3 position of the starting pyridine. This was necessary because the pyridinium salt is susceptible to nucleophilic attack at either α-position if there is not some sort of substituent to assist in directing the nucleophile. It was decided that a bulky substituent such as a tri-substituted silyl group would help in the directing; the tri-isopropyl silyl group was found to give the best results.

Scheme 1.12. Comins use of pyridinium salts

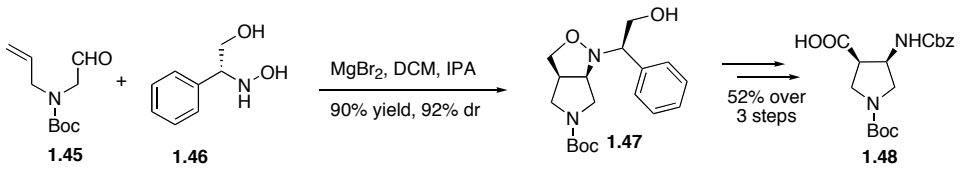


1.2.4 Dipolar Cycloadditions

1.2.4.1 Chelation-Controlled 1,3-Dipolar Cycloaddition

Confalone and co-workers reported the synthesis of isoxazolidines via a $MgBr_2$-induced chelation-controlled 1,3-Dipolar Cycloaddition (Scheme 1.13).[17] *N*-hydroxyphenylglycinol was used as a chiral auxiliary and diastereomeric ratios up to 94% were obtained. A variety of these isoxazolidines were formed and depending on the linking atoms between the aldehyde and alkene they were able to obtain pyrrolidines, tetrahydrofurans, and cyclopentane ring systems following hydrogenation of the isoxazolidine.

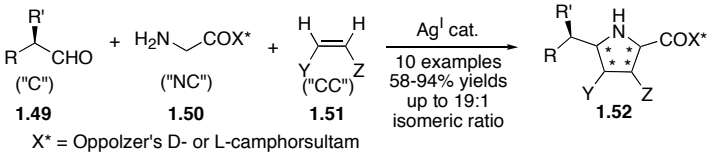
Scheme 1.13. Chelation-Controlled 1,3-Dipolar Cycloaddition



1.2.4.2 Ag^I-Catalyzed Asymmetric [C+NC+CC] Reaction

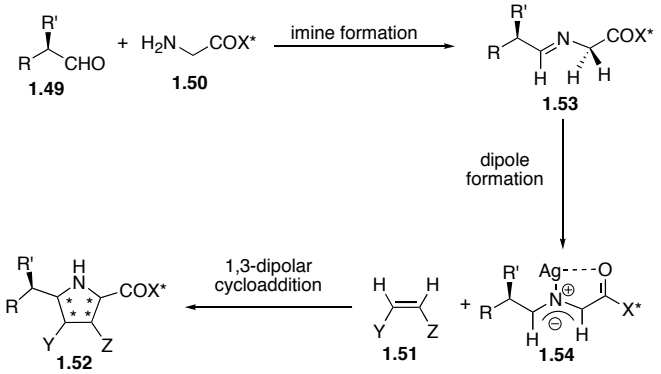
Garner and co-workers reported selective Ag^I-catalyzed asymmetric [C+NC+CC] coupling process in order to synthesize highly functionalized pyrrolidines in a single chemical step (Scheme 1.14).[18] Oppolzer's camphorsultam was the chrial auxiliary that enables the desired cascade reaction and provides a reliable method to control the stereochemistry of the products. AgOAc was used as the Ag^I catalyst in order to coordinate with the imine formed to facilitate the 1,3-dipolar cycloaddition.

Scheme 1.14. Ag^{I}-Catalyzed Asymmetric [C+NC+CC] Synthesis of Pyrrolidines



The proposed step-wise process requires the rapid condensation of the starting amine and aldehyde to form the resulting imine intermediate. The imine intermediate then coordinates with the silver catalyst forming the reactive azomethine ylide **1.54**. This intermediate will then react with the alkene present in a 1,3-dipolar cycloaddiition to produce the final highly functionalized pyrrolidine product (Scheme 1.15).

Scheme 1.15. Ag^{I}-Catalyzed Asymmetric [C+NC+CC] Coupling Reaction Cascade

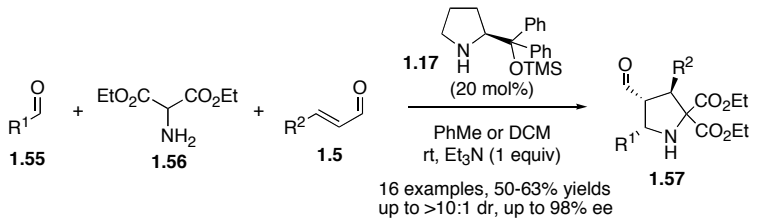


1.2.4.3 Organocatalytic [C+NC+CC] Reaction

Córdova and co-workers later altered the [C+NC+CC] reaction such that a proline derivative could be used in an organocatalytic fashion to achieve similar results (Scheme 1.16).[19] Using α,β-unsaturated aldehydes

to form iminium intermediates with a proline derivative they were able to accomplish the same 1,3-dipolar cycloaddition with an azomethine ylide. The TMS ether of diphenyl prolinol was found to be the optimal catalyst for the reaction. The step-wise mechanism proceeds in a similar fashion where the azomethine ylide is formed invoking a hydrogen bonding intermediate with which the alkene can react.

Scheme 1.16. Organocatalytic [C+NC+CC] Synthesis of Pyrrolidines



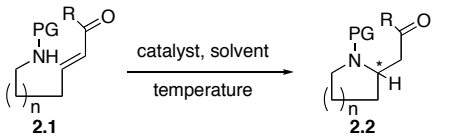
In recent years, there has been a wealth of research in the field of organocatalytic aza-Michael reactions. Despite these advances there have only been a few examples of intramolecular aza-Michael reaction for the formation of piperidine ring systems. There has been a variety of research done on the optimization of catalyst systems for this type of reaction as well as a general scope of reactivity. Our plans to advance this field of chemistry involve the use of an intramolecular aza-Michael in order to form piperidine and pyrrolidine ring systems to be used as building blocks in the synthesis of alkaloids.

Chapter 2. Intramolecular Organocatalyzed Heteroatom Michael Addition

2.1 Introduction

With a strong interest in the synthesis of alkaloids, there was use for an effective method for the enantiopure formation of substituted piperidine rings. A valuable method to form these ring systems would be via an intramolecular heteroatom Michael addition from the corresponding enone or enal. This transformation is ideally suited for the use of organocatalysis. It was envisioned that a general transformation as shown in Scheme 2.1 could not only be useful for the rapid construction of piperidine rings but possibly pyrrolidine and hexahydroazapine ring systems as well. Also shown in Scheme 2.1 is an ideal starting material for this reaction in the enal or alkyl enone. In order to reduce the reactivity of the amine and to help minimize the background reaction of a spontaneous Michael reaction, it was felt that a carbamate-protecting group such as Boc and Cbz was necessary.

Scheme 2.1. General Transformation for Development



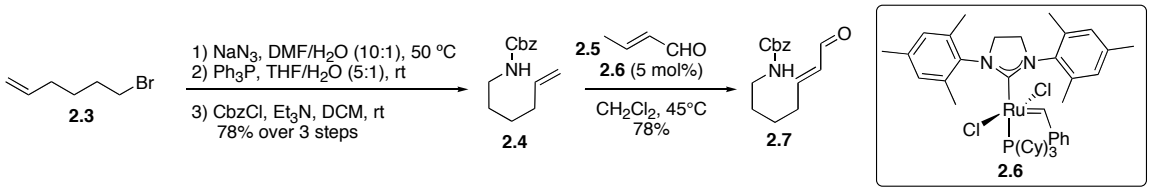
2.1
n = 1,2,3
R = H, Me
PG = Boc, Cbz

2.2
n = 1,2,3
R = H, Me
PG = Boc, Cbz

2.2 Optimization of Reaction

We chose to first explore the cyclization of the piperidine precursor **2.7**. The synthesis of this known enal[14] was readily prepared in four steps from commercially available 6-bromo-hexene (Scheme 2.2). Displacement of the bromide with sodium azide followed by Staudinger reduction and Cbz protection of the resulting amine gave **2.4** in 78% yield over 3 steps. Cross metathesis of the mono-substituted alkene (**2.4**) with crotonaldehyde (**2.5**) using 2nd generation Grubbs catalyst (**2.6**) gave the desired enal **2.7** in 78% yield and only the *Z* isomer was observed.

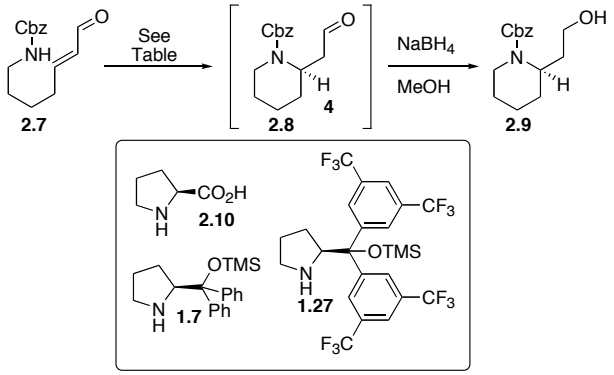
Scheme 2.2. Synthesis of Starting Enal



It is worth noting that in these reactions the use of acrolein in place of crotonaldehyde gave consistently lower yields as was shown by research preformed by a fellow graduate student. The intramolecular organocatalytic heteroatom Michael addition along with the three catalysts used is shown in Scheme 2.3. The enantioselectivity of the reaction was determined using chiral HPLC. The aldehyde product from the cyclization was unstable on the chiral HPLC column so it was reduced at the end of

each reaction with $NaBH_4$ to provide the more stable alcohol.

Scheme 2.3. Optimization of Heteroatom Michael Addition



The optimization of this reaction is shown in Table 1. Initial use of proline as the catalyst (20 mol%) with ethanol as the solvent gave the desired product, however, with a modest 9% ee (Entry 1). Scanning the number of possible organocatalysts, the TMS diphenylprolinol catalyst had been observed to give increased control in enantioselectivity. Using this catalyst gave an improved 59% ee when using a 20 mol% catalyst loading and still using ethanol as the solvent (Entry 2). Further optimization with Jørgensen's trifluoromethyl derivative **1.27**[20] led to an additional improvement in enantioselectivity (Entry 3). While the enantioselectivity had continued to increase, the yields for the transformation remained unacceptably low. Changing to a mixed solvent system with $CHCl_3$ led to a dramatic increase in the yield to 62% with a gain in the enantioselectivity (Entry 4). Use of 1,2-dichloroethane (DCE) improved the yield to 80% (Entry 5). Changing ethanol for the more polar methanol accelerated the

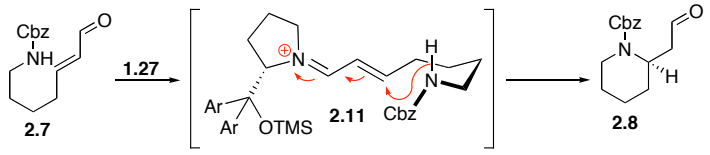
rate of the reaction and gave a modest improvement in enantioselectivity (Entry 6). Final optimization required the reaction to be cooled to -25 ºC (typically by placing the flask unstirred in the freezer until complete by TLC) to give the product **2.9** in 70% yield along with excellent enantioselectivity (95% ee) (Entry 7).

Table 1. Optimization of Heteroatom Michael Addition

Entry	Catalyst	Conditions	% ee (% yield)
1	**2.10** (20 mol%)	EtOH, rt 48 h	9% ee (40%)
2	**1.7** (20 mol%)	EtOH, rt 48 h	59% ee (41%)
3	**1.27** (20 mol %)	EtOH, rt 48 h	71% ee (29%)
4	**1.27** (20 mol%)	EtOH / $CHCl_3$ (1:1), rt, 48 h	80% ee (62%)
5	**1.27** (20 mol%)	EtOH / DCE (1:1), rt, 48 h	78% ee (80%)
6	**1.27** (20 mol%)	MeOH / DCE (1:1), rt, 24 h	83% ee (78%)
7	***1.27*** *(20 mol%)*	*MeOH / DCE (1:1), -25°C, 3 d*	*95% ee (70%)*

A possible mechanistic model to address the stereochemical outcome of the reaction is put forth in Scheme 2.4. After imine formation with the aldehyde the conformation can be set such that the molecule sits in a chair-type intermediate where the large side chain of the prolinol derivative is blocking attack from the back face. This allows for cyclization to occur with high enantioselectivity.

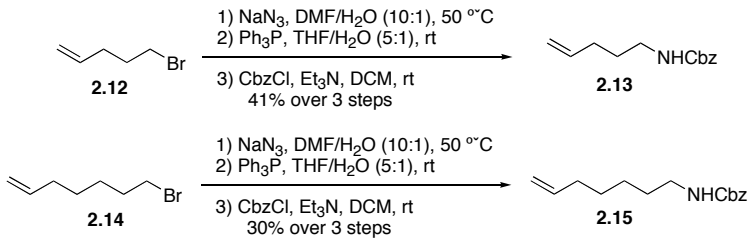
Scheme 2.4. Possible Mechanistic Model for Observed Sterochemical Outcome



2.3 Scope of Reaction

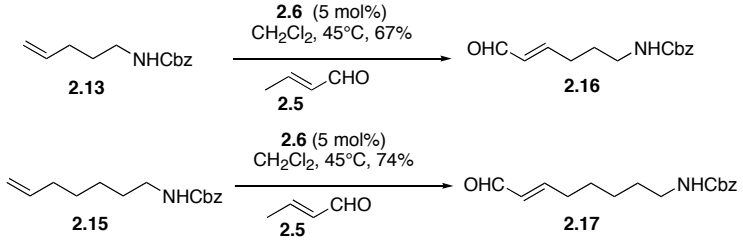
With a working catalyst system, we next began to explore the scope of the transformation. We set out to study the effect of ring size (five versus six versus seven) as well as the effect of substitution. First, we chose to explore the effect of different ring sizes. The 5-membered and 7-membered precursors were made in a similar fashion as the previous enal (Scheme 2.5). Displacement of the respective starting bromides with sodium azide followed by Staudinger reduction, and Cbz protection gave the desired starting Cbz protected amines. It should be mentioned that the yield for the five- and seven-membered substrates was considerably lower; 41% and 30% yields respectively over the same 3 steps.

Scheme 2.5. Synthesis of Starting Cbz Protected Amines



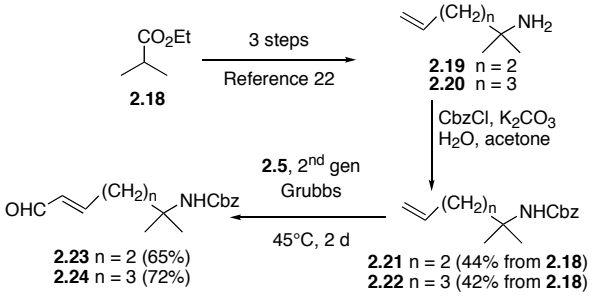
Interestingly, the use of the previously discussed 2nd generation Grubbs conditions (crotonaldehyde, CH_2Cl_2, 45ºC) on the five membered series gave inconsistent results (Scheme 2.6). These inconsistencies appeared to depend solely on the bottle of Grubbs catalyst that was used. With older bottles, clean conversion was observed, however, with newer bottles of Grubbs catalyst, a complex mixture of compounds was observed in the metathesis reaction. After considerable experimentation, it was discovered that an "aging" of the commercial catalyst was required to obtain reproducible results. The catalyst was removed from the sealed bottle and allowed to sit on the bench top or in a desiccator exposed to air for a period of 3 days. This "aging" process has proven critical to the success of any cross metathesis where the Cbz nitrogen is located 5 atoms away from the internal alkene carbon (alkenes **2.13**, **2.21**, and **2.28**). While we are unsure as to the exact nature of this "aging" process careful inspection of the aged 2nd generation Grubbs catalyst by ^{1}H NMR spectrum reveals some subtle changes in the splitting pattern in the aromatic region. It should be noted that a somewhat related observation has been reported by Belchert.[21]

Scheme 2.6. Metathesis of the 5- and 7-Membered Precursors



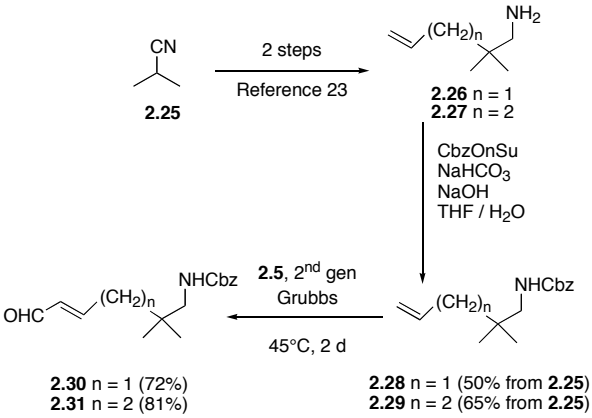
In addition to the different ring sizes we were interested in exploring the effect of substitution on the chain. We prepared the precursors for both the 5-membered and 6-membered ring systems with dimethyl substitution in the α position and the β position relative to the Cbz nitrogen. Substitution at the α position was accomplished by a Curtis rearrangement following other known procedures[22] followed by Cbz protection of the free amine giving the α-dimethyl substrates in 44% and 42% yields for the five and six membered systems respectively over the 4 steps (Scheme 2.7). The subsequent enals were formed by metathesis with crotonaldehyde using 2nd generation Grubb's catalyst. For the 5-membered system the "aged" Grubb's was used to give consistent results. The resulting enals were obtained in 65% and 75% yields for the five and six membered systems respectively.

Scheme 2.7. Synthesis of α-dimethyl substrates



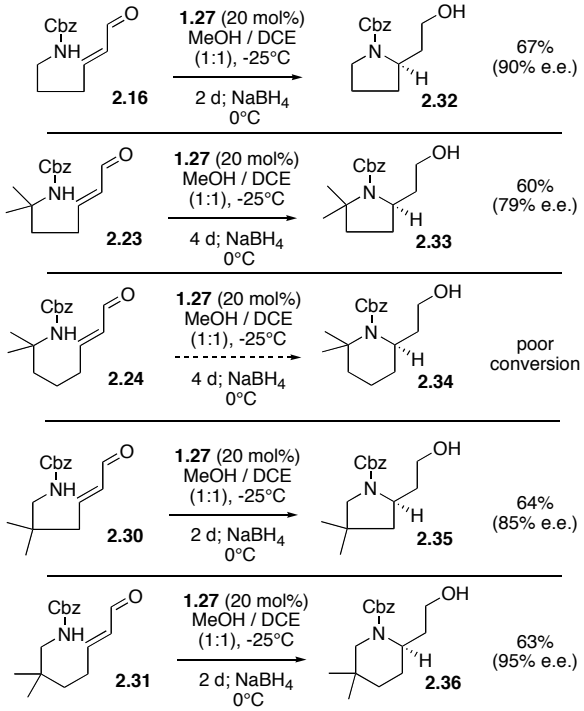
The β-substituted enals were constructed from alkylation of the starting nitrile **2.25** followed by reduction with $LiAlH_4$ to give the β-dimethyl amine (Scheme 2.7).[23] Cbz protection of these substrates gave higher yields using CbzOnSu rather then the CbzCl previously used. The Cbz protected amines were isolated in 50% and 65% over 3 steps for the five and six membered systems respectively. Metathesis with crotonaldehyde using 2nd generation Grubb's catalyst under the same conditions used in earlier substrates gave the desired enals in 72% and 81% for the five and six membered systems respectively.

Scheme 2.7. Synthesis of β-dimethyl substrates



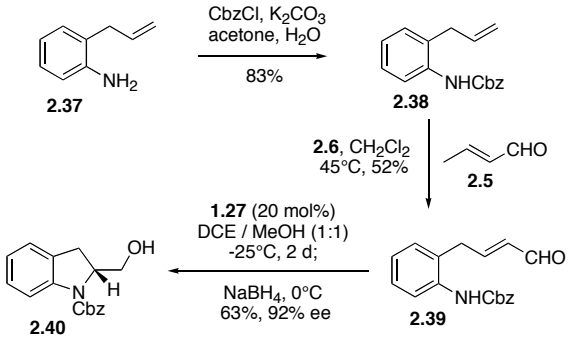
With the required precursors in hand, we studied their reactivity using the optimized reaction conditions (Scheme 2.8). The parent non-substituted pyrrolidine was constructed from the corresponding enal in 67% with 90% ee. Substitution on the carbon backbone yielded some interesting results. In general, dimethyl substitution in the α position led to a reduced reactivity, presumably on steric grounds. The α-dimethyl pyrrolidine required extended reaction time to go to completion and led to a reduced level of enantioselectivity. Formation of the piperidine analogue was not reliable even under extended reaction times and increased amounts of catalyst. Conversely, dimethyl substitution β to the amino group yielded increased reactivity with good levels of enantiomeric excess. The increased reaction rate is likely due to the reduced level of conformational flexibility for the backbone - in accord with Thorpe and Ingold's observations.[24] We were unable to obtain a cyclized product from the 7-membered system. In the formation of **2.33** and **2.35** the alcohols contained a minor impurity that could be removed after hydrogenation of the Cbz protecting group (87-90% yields). We were unable to determine the ee for alcohols **2.33**, **2.35**, and **2.36** due to lack of separation on the HPLC. Therefore, the (*S*) Mosher ester of these alcohols were made in order to obtain sufficient separation on HPLC to determine ee.

Scheme 2.8. Exploration of Scope for Organocatalyzed Intramolecular Heteroatom Michael Addition



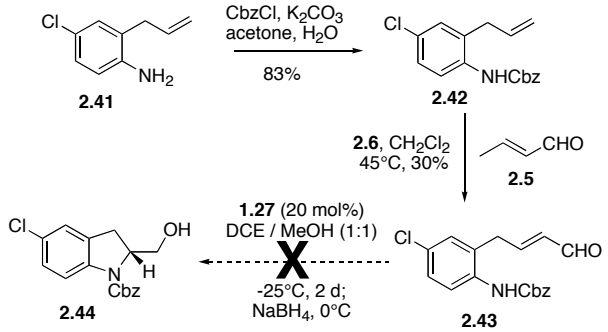
We were also interested in exploring the possibility of accessing indoline ring systems in an enantioselective manner (Scheme 2.9). The precursor was accessed from its corresponding known *o*-allyl aniline **2.37**.[25] Cbz protection gave aniline **2.38**[26] followed by Grubbs cross metathesis using the "aged" catalyst provided the desired enal **2.39**. Not surprisingly, this compound was unstable and had to be immediately submitted into the cyclization reaction upon formation. Despite this instability, the level of enantioselectivity in the cyclization to form indoline **2.40** was still quite good at 92% ee with a reasonable 63% yield.

Scheme 2.9. Enantioselective Construction of Indoline Ring System



We also looked into using the *p*-chloro substituted precursor for the cyclization. Following the same conditions to obtain the Cbz protected amine in 83% yield worked well, however, metathesis using the "aged" catalyst provided the enal in a poor 30% yield (Scheme 2.10). The low yield of the metathesis was contributed to the lack of stability of the resulting enal. In addition to the metathesis giving a poor yield the construction of the indoline ring under typical conditions was not observed nor was the enal ever recovered; this is likely due to the instability of the enal.

Scheme 2.10. Construction of the *p*-Chloro Indoline



In conclusion, an organocatalyzed, intramolecular heteroatom

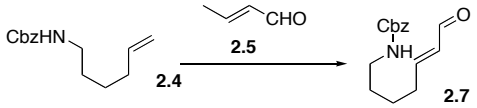
Michael addition protocol has been developed for the asymmetric synthesis of pyrrolidine, indoline, and piperidine derivatives. The protocol takes advantage of simple reaction conditions along with the absence of any additives. The catalyst is commercially available or is readily prepared in 4 steps from either enantiomer of proline. The scope of this transformation has been explored on a series of enal precursors, highlighting differences in reactivity involving ring size and substitution. In general, this methodology is useful in the asymmetric synthesis of a variety of nitrogen ring systems and can be used in alkaloid synthesis.

2.4. Experimental

General. Infrared spectra were recorded neat unless otherwise indicated and are reported in cm^{-1}. ^{1}H NMR spectra were recorded in deuterated solvents and are reported in ppm relative to tetramethylsilane and referenced internally to the residually protonated solvent. ^{13}C NMR spectra were recorded in deuterated solvents and are reported in ppm relative to tetramethylsilane and referenced internally to the residually protonated solvent.

Routine monitoring of reactions was performed using EM Science DC-Alufolien silica gel, aluminum-backed TLC plates. Flash chromatography was performed with the indicated eluents on EM Science Gedurian 230-400 mesh silica gel.

Air and/or moisture sensitive reactions were performed under usual inert atmosphere conditions. Reactions requiring anhydrous conditions were performed under a blanket of argon, in glassware dried in an oven at 120°C or by a bunsen flame, then cooled under argon. Solvents and commercial reagents were purified in accord with literature procedures or used without further purification.



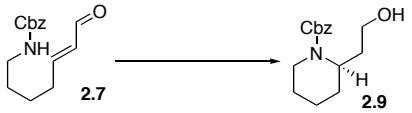
Aldehyde 2.7: To a pressure vessel containing known 1-carbobenzyloxyamino-5-hexene (**2.4**) (200 mg, 0.86 mmol) and CH_2Cl_2 (20 mL) was added **2.5** (300 mg, 4.29 mmol, 0.35 mL) and 2nd generation Grubbs catalyst (36 mg, 0.042 mmol, 5 mol %). The vessel was sealed and heated to 45˚C. After 48 h the mixture was then cooled to rt, concentrated *in vacuo* and purified by chromatography over silica gel, eluting with 10-25% EtOAc/Hexanes to give **2.7** (175 mg, 0.67 mmol, 78%) as a brownish oil. IR (neat) 3348, 3032, 2932, 2862, 2731, 1684, 1635, 1240 ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.45 (d, *J* = 7.8 Hz, 1H), 7.25-7.32 (m, 5H), 6.77 (dt, *J* = 15.6, 6.4 Hz, 1H), 6.06 (dd, *J* = 7.6, 15.2 Hz, 1H), 5.34 (bs, NH), 5.06 (s, 2H), 3.15-3.18 (m, 2H), 2.28-2.30 (m, 2H), 1.45-1.55 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.2, 158.4, 156.6, 136.7, 133.0, 128.5, 128.04, 127.99, 66.5, 40.6, 32.2, 29.4, 24.9; HRMS (EI+) calc. For $C_{15}H_{19}NO_3$ (M+) 261.1365, found 261.1360.

General Procedure of Organocatalyzed Heteroatom Michael Addition with in situ $NaBH_4$ reduction: To a solution of aldehyde (1 equiv.) and MeOH (0.2 M) was added a solution of the catalyst **1.27** (20 mol %) in DCE (0.04 M in catalyst **1.27**) via syringe at -25°C. The reaction was placed in the freezer (-25°C). After judged to be complete by TLC, the

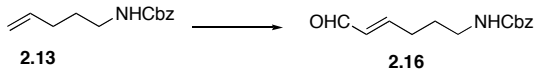
solution was warmed to 0˚C and $NaBH_4$ (3 equiv.) was added. The solution was then allowed to warm to rt. After 2 h, the reaction was quenched with HCl (2 ml per mmol of aldehyde, 10% aq.), diluted with H_2O (50 mL per mmol aldehyde) and extracted with Et_2O (3 X 100 mL per mmol aldehyde). The combined organic layers were washed with sat. aq. NaCl (300 mL per mmol aldehyde) and the dried extract ($MgSO_4$) was concentrated *in vacuo.* The crude product was purified by chromatography over silica gel, eluting with EtOAc/Hexanes to give the alcohol (60-71%).

General Procedure of Racemic Heteroatom Michael Addition with in situ $NaBH_4$ reduction: To a solution of aldehyde (1 equiv.) and CH_3CN (0.2 M) was added BF_3-Et_2O (2 equiv.) at rt. The solution was allowed to stir at rt. for 1 h. The reaction was then quenched with aqueous sodium bicarbonate, then extracted with Et_2O (3 X 100 mL per mmol of aldehyde) and the combined organic layers were washed with sat. aq. NaCl, dried over $MgSO_4$, and concentrated *in vacuo.* The crude mixture was then dissolved in MeOH (0.1 M), cooled to 0˚C and 20 mg of $NaBH_4$ was added. The solution was then allowed to warm to rt and stir for 2 h. The reaction was quenched with 10% HCl, extracted with Et_2O (3 X 100 mL per mmol of aldehyde) and the combined organic layers were dried over $MgSO_4$, and concentrated *in vacuo.* The crude product was purified by

chromatography over silica gel, eluting with 100% hexanes up to 30% EtOAc/Hexanes to give the desired cyclized alcohols with yields ranging from 59-71%.



Alcohol (*R*)-2.9: Purified by chromatography over silica gel, eluting with 10-30% EtOAc/Hexanes to give the known alcohol **2.9**[14] (17.7 mg, 0.067 mmol, 70%) as a pale yellow oil. $[\alpha]_D$ +14.2 (c = 0.8, $CHCl_3$), ^1H NMR (400 MHz, $CDCl_3$) δ 7.33-7.42 (m, 5H), 5.17 (s, 2H), 4.50-4.60 (m, 1H), 4.05-4.12 (m, 1H), 3.55-3.65 (m, 1H), 3.35-3.50 (m, 1H), 2.79 (t, *J* = 12.8 Hz, 1H), 1.98 (t, *J* = 13.6 Hz, 1H), 1.52-1.70 (m, 5H), 1.40-1.52 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.8, 136.7, 128.6, 128.1, 127.9, 67.4, 58.7, 47.0, 39.5, 32.6, 29.2, 25.5, 19.1; HRMS (EI+) calcd. For $C_{15}H_{21}NO_3$ (M+) 263.1522, found 263.1522.



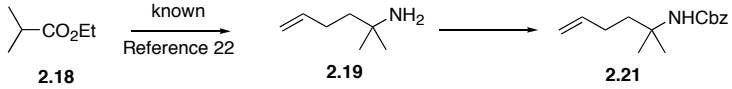
Aldehyde 2.16: To a pressure vessel containing a solution of known 1-carbobenzyloxyamino-4-pentene (**2.13**)[14] (100 mg, 0.457 mmol) in CH_2Cl_2 (10 mL) was added sequentially aldehyde **2.5** (159.7 mg, 0.186 mL, 2.28 mmol) and aged[27] 2nd generation Grubbs catalyst (19.4 mg, 0.023 mmol, 5 mol %). The vessel was sealed and heated to 45˚C. After 48 h, the

solution was cooled to rt and concentrated *in vacuo*. The crude product was purified by chromatography over silica gel, eluting with 10%-30% EtOAc/Hexanes to yield known **2.16**[14] (76 mg, 0.306 mmol, 67%) as a brownish oil. IR (neat) 3338, 3070, 2940, 1684, 1532, 1247 ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.51 (d, *J* = 7.5 Hz, 1H), 7.30-7.38 (m, 5H), 6.81-6.88 (m, 1H), 6.15 (dd, *J* = 8.1, 15.6 Hz, 1H), 5.12 (s, 2H), 4.80 (bs, 1H), 3.25-3.30 (m, 2H), 2.37-2.44 (m, 2H), 1.71-1.81 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 194.0, 157.4, 156.5, 136.5, 133.2, 128.53, 128.14, 128.07, 66.6, 40.4, 29.8, 28.3; HRMS (EI+) calcd. For $C_{14}H_{17}NO_3$ (M+) 247.1209, found 247.1213.

2.15 **2.17**

Aldehyde 2.17: To a pressure vessel containing a solution of known 1-carbobenzyloxyamino-6-heptene (**2.15**)[14] (100 mg, 0.358 mmol) in CH_2Cl_2 (10 mL) was added sequentially aldehyde **2.5** (125.5 mg, 1.79 mmol, 0.146 mL) and aged[28] 2nd generation Grubbs catalyst (19.4 mg, 0.023 mmol, 5 mol %). The vessel was sealed and heated to 45˚C. After 48 h, the solution was cooled to rt and concentrated *in vacuo*. The crude product was purified by chromatography over silica gel, eluting with 10%-30% EtOAc/Hexanes to yield known **2.17**[14] (86 mg, 0.265 mmol, 75%) as a brownish oil. IR (neat) peaks 3340, 3062, 2934, 1683, 1532, 1249 ^{1}H NMR

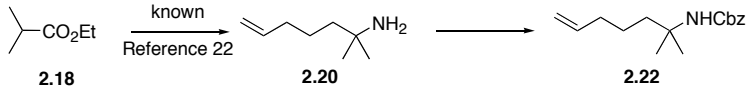
(300 MHz, CD_3Cl) δ peaks 9.53-9.51 (d, J = 7.8, 1H), 7.38-7.30 (m, 5H), 6.89-6.79 (m, 1H), 6.17-6.09 (m, 1H), 5.12 (s, 2H), 4.75 (bs, 1H), 3.23-3.21 (m, 2H), 2.37-2.34 (m, 2H), 1.58-1.50 (m, 4H), 1.50-1.35 (m, 2H); ^{13}C NMR (300 MHz, CD_3Cl) δ peaks 194.1, 158.5, 156.5, 136.6, 133.1, 128.5, 128.1, 66.6, 40.8, 32.5, 29.7, 27.4, 26.2 HRMS (FAB+) calcd. For $C_{16}H_{21}O_3N$ (M+) 275.3389, found 276.16061.



2.18 **2.19** **2.21**

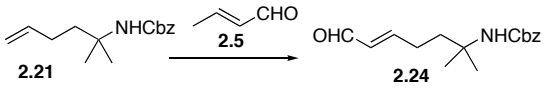
Carbamate 2.21: To a stirred solution of the known amine **2.19**[29] (8.6 mmol) in acetone (10 mL) and H_2O (10 mL) at rt was added sequentially K_2CO_3 (1.14 g, 8.60 mmol) and CbzCl (2.93 g, 2.45 mL, 17.2 mmol). After 30 min, the reaction was quenched with H_2O (15 mL) and extracted with CH_2Cl_2 (3 X 25 mL). The combined organic layers were washed with sat. aq. NaCl (25 mL) and the dried extract ($MgSO_4$) was concentrated *in vacuo.* The crude product was purified by chromatography over silica gel, eluting with 0-20% EtOAc/Hexanes to yield **2.21** (936 mg, 3.784 mmol, 44% over 4 steps) as a light yellow oil. IR (neat) 3419, 3349, 3070, 3032, 2973, 1776, 1715, 1638, 1506; ^1H NMR (400 MHz, $CDCl_3$) δ 7.34-7.43 (m, 5H), 5.80-5.90 (m, 1H), 5.10 (s, 2H), 4.98-5.04 (m, 2H), 4.82 (bs, 1H), 2.06-2.12 (m, 2H), 1.78-1.82 (m, 2H), 1.34 (s, 6H); ^{13}C NMR (400 MHz, $CDCl_3$) δ 154.6, 138.6, 136.9, 128.9, 128.5, 128.0, 114.5, 73.5, 66.0,

52.7, 39.5, 28.6, 27.1; HRMS (EI+) calcd. For $C_{15}H_{21}NO_2$ (M+) 247.1572, found 247.1573.

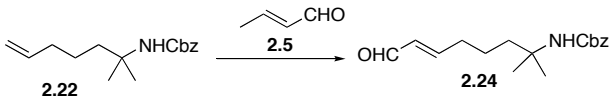


2.18 **2.20** **2.22**

Carbamate 2.22: To a stirred solution of the known amine **2.20**[29] (8.6 mL) in acetone (10 mL) and H_2O (10 mL) at rt was added sequentially K_2CO_3 (1.14 g, 8.60 mmol) and CbzCl (2.93 g, 2.45 mL, 17.2 mmol). After 30 min, the reaction was quenched with H_2O (15 mL) and extracted with CH_2Cl_2 (3 X 25mL). The combined organic layers were washed with sat. aq. NaCl (25 mL) and the dried extract ($MgSO_4$) was concentrated *in vacuo.* The crude product was purified by chromatography over silica gel, eluting with 0-20% EtOAc/Hexanes to yield **2.22** (943 mg, 3.612 mmol, 42% over 4 steps) as a light yellow oil. IR (neat) 3350, 3062, 3023, 2940, 2864, 1715, 1640, 1506; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30-7.41 (m, 5H), 5.78-5.90 (m, 1H), 4.98-5.21 (m, 4H), 4.69 (bs, 1H), 2.07-2.09 (m, 2H), 1.66-1.71 (m, 2H), 1.34 (s, 6H); ^{13}C NMR (400 MHz, $CDCl_3$) δ 154.6, 138.7, 136.8, 128.6, 128.5, 128.3, 114.7, 66.0, 52.8, 40.4, 34.0, 27.8, 27.0, 23.7 HRMS (EI+) calcd. For $C_{16}H_{23}NO_2$ (M+) 261.1729, found 261.17389.

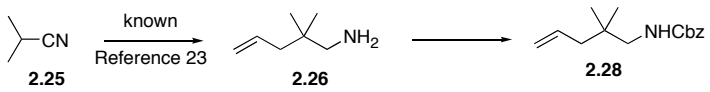


Aldehyde 2.24: To a pressure vessel containing a solution of alkene **2.21** (200 mg, 0.796 mmol) in CH_2Cl_2 (20 mL) was added sequentially aldehyde **2.5** (279 mg, 3.98 mmol, 0.324 mL) and aged[27] 2nd generation Grubbs catalyst (33.8 mg, 0.040 mmol, 5 mol %). The vessel was sealed and heated to 45˚C. After 48 h, the solution was cooled to rt and concentrated *in vacuo*. The crude product was purified by chromatography over silica gel, eluting with 0-30% EtOAc/Hexanes to yield **2.24** (144 mg, 0.516 mmol, 65%) as a brownish oil. IR (neat) 3341, 2968, 1688, 1526, 1454 ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.47 (d, *J* = 7.8 Hz, 1H), 7.30-7.38 (m, 5H), 6.83 (dt, *J* = 15.6, 6.0 Hz, 1H), 6.12 (dd, *J* = 7.5, 15.6 Hz, 1H), 5.07 (s, 2H), 4.66 (bs, 1H), 2.29-2.37 (m, 2H), 1.91-1.96 (m, 2H), 1.33 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.9, 158.4, 154.7, 136.6, 133.0, 128.6, 128.20, 128.16, 66.3, 52.6, 37.6, 27.9, 27.4; HRMS (EI+) calcd. For $C_{16}H_{21}NO_3$ (M+) 275.1521, found 275.1522.



Aldehyde 2.24: To a pressure vessel containing a solution of alkene **2.22** (200 mg, 0.796 mmol) in CH_2Cl_2 (20 mL) was added sequentially aldehyde **2.5** (279 mg, 3.98 mmol, 0.324 mL) and 2nd

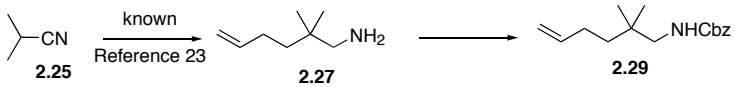
generation Grubbs catalyst (33.8 mg, 0.040 mmol, 5 mol %). The vessel was sealed and heated to 45˚C. After 48 h, the solution was cooled to rt and concentrated *in vacuo*. The crude product was purified by chromatography over silica gel, eluting with 0-30% EtOAc/Hexanes to yield **2.24** (166 mg, 0.573 mmol, 72%) as a brownish oil. IR (neat) 3345, 3027, 2944, 1690, 1525, 1455 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.52 (d, *J* = 7.8 Hz, 1H), 7.30-7.37 (m, 5H), 6.83 (dt, *J* = 15.6, 6.6 Hz, 1H), 6.13 (dd, *J* = 7.8, 15. 6 Hz, 1H), 5.07 (s, 2H), 4.64 (bs, 1H), 2.33-2.38 (m, 2H), 1.73-1.78 (m, 2H), 1.50-1.57 (m, 2H), 1.31 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 194.1, 158.3, 154.6, 136.7, 133.1, 128.5, 128.0, 66.1, 52.7, 39.5, 27.3, 22.5; HRMS (EI+) calcd. For $C_{17}H_{23}NO_3$ (M+1) 290.1756, found 290.1755.



2.25 **2.26** **2.28**

Carbamate 2.28: To a stirred solution of the known amine **2.26**[30] (3.62 mmol) in THF (6 mL) and H_2O (6 mL) was added sequentially $NaHCO_3$ (304 mg, 3.62 mmol), NaOH (2 mL, 10% aq.) and Cbz-OnSu (902 mg, 3.62 mmol). After 16 h, the organic solvent was removed *in vacuo* and the residual aqueous solution was extracted with Et_2O (3 X 30 mL). The combined organic layers were washed with sat. aq. NaCl (30 mL) and the dried extract ($MgSO_4$) was concentrated *in vacuo.* The crude product was purified by chromatography over silica gel, eluting with 0- 20%

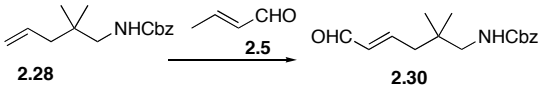
EtOAc/Hexanes to yield **2.28** (444.5 mg, 1.81 mmol, 50% over 3 steps) as a light yellow oil. IR (neat) 3343, 3071, 3033, 2960, 1698, 1639; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.33-7.39 (m, 5H), 5.74-5.90 (m, 1H), 5.13 (s, 2H), 5.03-5.10 (m, 2H), 4.87 (bs, 1H), 3.05 (d, *J* = 6.6 Hz, 2H), 2.00 (d, *J* = 7.5 Hz, 2H), 0.90 (s, 6H); ^{13}C NMR (300 MHz, $CDCl_3$) δ 156.7, 136.7, 134.7, 128.5, 128.4, 128.2, 117.6, 66.7, 50.9, 44.3, 34.8, 24.7; HRMS (EI+) calcd. For $C_{15}H_{21}O_2N$ (M+) 247.1572, found 247.1580.



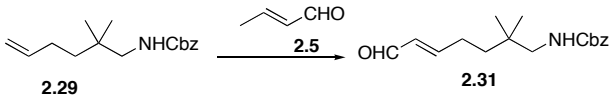
2.25 **2.27** **2.29**

Carbamate 2.29: To a stirred solution of the known amine **2.27**[30] (7.24 mmol) in THF (12 mL) and H_2O (12 mL) was added sequentially $NaHCO_3$ (563 mg, 7.24 mmol), NaOH (3 mL, 10% aq.) and Cbz-OnSu (1.67 mg, 7.24 mmol). After 16 h, the organic solvent was removed *in vacuo* and the residual aqueous solution was extracted with Et_2O (3 X 30 mL). The combined organic layers were washed with sat. aq. NaCl (30 mL) and the dried extract ($MgSO_4$) was concentrated *in vacuo.* The crude product was purified by chromatography over silica gel, eluting with 0- 20% EtOAc/Hexanes to yield **2.29** (1.22 g (4.69 mmol, 65% over 3 steps) as a light yellow oil. IR (neat) 3432, 3341, 3062, 2959, 2916, 1733, 1533; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.33-7.39 (m, 5H), 5.76-5.83 (m, 1H), 5.13 (s, 2H), 4.94-5.05 (m, 2H), 4.79 (bs, 1H), 3.06 (d, *J* = 6.6 Hz, 2H), 2.03-2.06 (m, 2H), 1.28-1.40 (m, 4H), 0.90 (s, 6H); ^{13}C NMR (300 MHz, $CDCl_3$) δ

156.7, 139.2, 128.6, 128.4, 128.2, 114.2, 69.7, 66.7, 51.0, 38.8, 34.3, 28.3, 24.7; HRMS (EI+) calcd. For $C_{16}H_{23}NO_2$ (M+) 261.1729, found 261.1732.

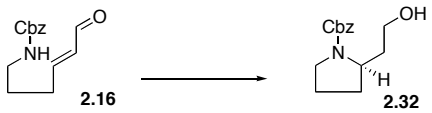


Aldehyde 2.30: To a pressure vessel containing a solution of **2.28** (200 mg, 0.796 mmol) in CH_2Cl_2 (20 mL) was added sequentially aldehyde **2.5** (279 mg, 3.98 mmol, 0.324 mL) and aged[27] 2nd generation Grubbs catalyst (33.8 mg, 0.040 mmol, 5 mol %). The vessel was sealed and heated to 45˚C. After 48 h, the solution was cooled to rt and concentrated *in vacuo*. The crude product was purified by chromatography over silica gel, eluting with 0-30% EtOAc/Hexanes to yield **2.30** (160 mg, 0.573 mmol, 72%) as a brownish oil. IR (neat) 3354, 2958, 2864, 2713, 1699, 1455, 1417, 1280; ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.53 (d, *J* = 7.8 Hz, 1H), 7.30-7.38 (m, 5H), 6.90 (dt, *J* = 16.2, 6.9 Hz, 1H), 6.13 (dd, *J* =7.8, 15.3 Hz, 1H), 5.12 (s, 2H), 4.93 (bs, NH), 3.10 (d, *J* = 6.6 Hz, 2H), 2.26 (d, *J* = 7.8 Hz, 2H), 1.03 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 193.7, 156.7, 154.7, 136.4, 135.5, 128.6, 128.2, 66.9, 50.9, 42.7, 35.8, 24.9; HRMS (EI+) calcd. For $C_{16}H_{21}NO_3$ (M+) 275.1522, found 275.1513.



2.29 2.31

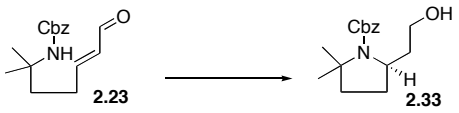
Aldehyde 2.31: To a pressure vessel containing a solution of **2.29** (100 mg, 0.383 mmol) in CH_2Cl_2 (10 mL) was added sequentially aldehyde **2.5** (134 mg, 0.32 mL, 1.92 mmol) and aged[27] 2nd generation Grubbs catalyst (16 mg, 0.019 mmol, 5 mol %). The vessel was sealed and heated to 45˚C. After 48 h, the solution was cooled to rt and concentrated *in vacuo*. The crude product was purified by chromatography over silica gel, eluting with 0-30% EtOAc/Hexanes to yield **2.31** (89.8 mg, 0.310 mmol, 81%) as a brownish oil. IR (neat) 3344, 2959, 2864, 2722, 1689, 1653, 1539, 1455, 1242 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 9.49 (d, *J* = 8.1 Hz, 1H), 7.30-7.30 (m, 5H), 6.82 (dt, *J* = 15.6, 6.7 Hz, 1H), 6.12 (dd, *J* = 8.4, 15.6 Hz, 1H), 5.11 (s, 2H), 4.80-4.90 (m, 1H), 3.06 (d, *J* = 6.6 Hz, 2H), 2.30-2.30 (m, 2H), 1.36-1.42 (m, 2H), 0.92 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 194.1, 159.0, 156.7, 136.5, 132.7, 128.6, 128.2, 66.8, 50.6, 37.2, 34.5, 27.5, 24.7; HRMS (EI+) calcd. For $C_{17}H_{23}NO_3$ (M+) 289.1678, found 289.1688.



2.16 2.32

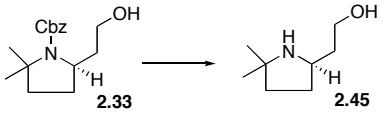
Alcohol 2.32: The reaction time was 48 h at -25°C. The crude product was purified by chromatography over silica gel, eluting with 10-

30% EtOAc/Hexanes to give the known alcohol **2.32**[14] (15 mg, 0.060 mmol, 67%) as a pale yellow oil. Enantiomeric excess was determined by chiral HPLC [4.6 X 250 mm Diacel OD column, 95:5 hexanes/iPrOH, retention times 16.03 (major) and 17.24 min (minor)] to be 95% ee. $[\alpha]_D$ = +7.2 (c = 1.0, $CHCl_3$); ^1H NMR (300 MHz, $CDCl_3$) δ 7.30-7.41 (m, 5H), 5.18 (d, *J* = 3.6 Hz, 1H), 5.13 (d, *J* = 3.6 Hz, 1H), 4.75 (bs, OH), 4.20-4.30 (m, 1H), 4.05-4.13 (m, 1H), 3.60-3.70 (m, 2H), 3.40-3.50 (m, 1H), 3.15-3.25 (m, 1H), 1.90-2.10 (m, 1H), 1.65-1.80 (m, 1H), 1.50-1.70 (m, 2H), 1.30-1.47 (m, 2H); ^{13}C NMR (300 MHz, $CDCl_3$) δ 156.7, 136.7, 128.5, 128.0, 127.8, 67.1, 59.1, 54.3, 46.3, 38.2, 31.1, 23.6; HRMS (EI+) calc. for $C_{14}H_{19}NO_3$ (M+) 249.1142, found 249.1355.

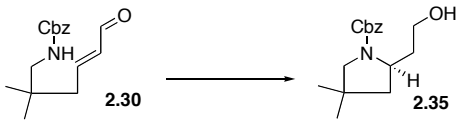


Alcohol 2.33: The reaction time was 96 h at -25°C. The crude product was purified by chromatography over silica gel, eluting with 10-30% EtOAc/Hexanes to give the alcohol **2.33** (15 mg, 0.054 mmol, 60%) as a pale yellow oil. A minor inseparable impurity was present in this product that could be readily removed by hydrogenation. Alternatively, enantiomeric excess was determined by chiral HPLC of Mosher ester derivative[31] [4.6 X 250 mm Diacel OD column, 98:2 hexanes/iPrOH,

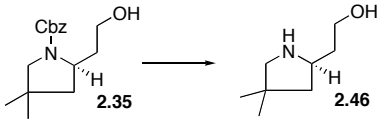
retention times 17.78 (major) and 16.96 min (minor)] to be 79% ee. IR (neat) 3449, 2962, 1691; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.8-7.39 (m, 5H), 5.12-5.23 (m, 2H), 4.30 (bs, 1H), 4.10 (bs, 1H), 3.50-3.58 (m, 2H), 1.90-2.15 (m, 3H), 1.50-1.85 (m, 5H), 1.43 (s, 3H), 1.32 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.6, 136.6, 128.5, 128.0, 67.3, 61.4, 59.0, 56.6, 40.7, 39.0, 29.3, 28.2, 26.3; HRMS (EI+) calc. for $C_{16}H_{23}NO_3$ (M+) 277.1678, found 277.1670.



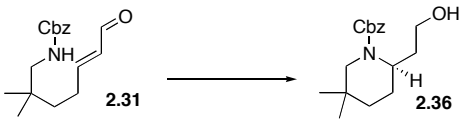
Alcohol 2.45: To a solution of **2.33** (11.0 mg, 0.0389 mmol) in MeOH (0.5 mL) was added Pd/C (2 mg, 10% Pd), and then the reaction flask was flushed and filled with hydrogen gas. The reaction was done under 1 atm of hydrogen gas and was stirred for 16 h. The reaction mixture was filtered over celite to remove the Pd/C and was concentrated *in vacuo* to give **2.45** (5.0 mg, 0.350 mmol, 90%) as a pale yellow waxy oil. $[\alpha]_D$ 13.2 (c = 0.65, $CHCl_3$); IR (neat) 3391, 2959, 1683; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.92-3.87 (m, 1H), 3.80-3.74 (m, 1H), 3.57-3.54 (m, 1H), 3.27 (bs, 1H), 2.03-1.99 (m, 1H), 1.82-1.78 (m, 1H), 1.76-1.63 (m, 4H), 1.23 (s, 3H), 1.19 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 62.0, 59.6, 58.4, 39.4, 36.6, 31.5, 30.3, 29.2; HRMS (CI+) calcd. For $C_8H_{18}NO$ (M+H) 144.1388, found 144.1383.



Alcohol 2.35: The reaction time was 48 h at -25°C. The crude product was purified by chromatography over silica gel, eluting with 10-30% EtOAc/Hexanes to give the alcohol **2.35** (16 mg, 0.058 mmol, 64%) as a pale yellow oil. A minor inseparable impurity was present in this product that could be readily removed by hydrogenation. Alternatively, enantiomeric excess was determined by chiral HPLC of Mosher ester derivative[31] [4.6 X 250 mm Diacel OD column, 95:5 hexanes/iPrOH, retention times 13.92 (major) and 10.58 min (minor)] to be 85% ee. $[\alpha]_D$ -3.4 (c = 0.35, $CHCl_3$); IR (neat) 3450, 2956, 1702; ^1H NMR (300 MHz, $CDCl_3$) δ 7.37-7.30 (m, 5H), 5.16 (s, 2H), 4.25 (m, 1H), 3.65-3.3 (m, 3H), 2.00-1.94 (m, 1H), 1.9-1.5 (m, 5H), 1.11 (s. 3H), 0.97 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.8, 136.7, 128.5, 128.1, 67.3, 61.4, 59.0, 56.6, 40.7, 39.0, 29.3, 28.2, 26.3**;** HRMS (EI+) calcd. For $C_{16}H_{23}NO_3$ (M+) 277.1678, found 277.1671.

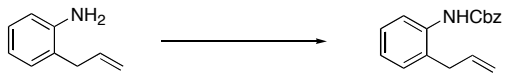


Alcohol 2.46: To a solution of **2.35** (8.0 mg, .028 mmol) in MeOH (0.5 mL) was added Pd/C (2 mg, 10% Pd), and then the reaction flask was flushed and filled with hydrogen gas. The reaction was done under 1 atm of hydrogen gas and was stirred for 16 h. The reaction mixture was filtered over celite to remove the Pd/C and was concentrated *in vacuo* to give **2.46** (3.5 mg, 0.0280 mmol, 87%) as a pale yellow waxy oil. $[\alpha]_D$ 36 (c = 0.1, $CHCl_3$); IR (neat) 3370, 2959, 1692; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.93-3.87 (m, 1H), 3.80-3.75 (m, 1H), 3.57-3.53 (m, 1H), 2.05-1.98 (m, 1H), 1.83-1.76 (m, 1H), 1.75-1.56 (m, 4H), 1.24 (s, 3H), 1.20 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 62.0, 59.7, 58.5, 39.3, 36.6; 31.4, 30.2, 29.1; HRMS (CI+) calcd. For $C_8H_{18}NO$ (M+H) 144.1388, found 144.1391.



Alcohol 2.36: The reaction time was 48 h at -25°C. The crude product was purified by chromatography over silica gel, eluting with 10-30% EtOAc/Hexanes to give the alcohol **2.36** (15.7 mg, 0.054 mmol, 63%) as a pale yellow oil. Enantiomeric excess was determined by chiral HPLC of Mosher ester derivative[31] [4.6 X 250 mm Diacel OD column, 97:3 hexanes/iPrOH, retention times 11.25 (major) and 10.12 min (minor)] to be

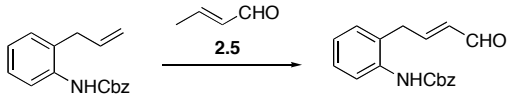
95% ee. $[\alpha]_D$ -9.2 (c = 0.25, $CHCl_3$); IR (neat) 3470, 2927, 1692; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.30-7.40 (m, 5H), 5.17 (s, 2H), 4.50-4.60 (m, 1H), 3.30-3.70 (m, 3H), 2.54 (d, *J* = 13.2 Hz, 1H), 1.85-2.05 (m, 2H), 1.30-1.60 (m, 5H), 0.94 (s, 3H), 0.92 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 157.2, 136.7, 128.5, 128.0, 127.7, 67.4, 58.5, 50.0, 46.3, 32.7, 32.0, 30.5, 28.9, 25.2, 22.9; HRMS (EI+) calcd. For $C_{17}H_{25}NO_3$ (M+) 291.1835 found 291.1828.



2.37 **2.38**

Carbamate 2.38: To a stirred solution of the known amine **2.37**[32] (500 mg, 3.00 mmol) in acetone (16 mL) and H_2O (16 mL) at rt was added sequentially K_2CO_3 (414 mg, 3.00 mmol) and CbzCl (608 mg, 0.64 mL, 4.5 mmol). After 30 min, the reaction was quenched with H_2O (10 mL) and extracted with CH_2Cl_2 (3 X 30 mL). The combined organic layers were washed with sat. aq. NaCl (30 mL) and the dried extract ($MgSO_4$) was concentrated *in vacuo.* The crude product was purified by chromatography over silica gel, eluting with 0-20% EtOAc/Hexanes to yield the known **2.38**[33] (750 mg, 2.49 mmol, 83%) as a flaky while solid. Mp 57-60˚C; IR (neat) 3283, 3030, 1692, 1533, 1244, 744; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.86-7.83 (d, J = 7.2, 1H), 7.45-7.38 (m, 5H), 7.29-7.25 (m, 1H), 7.19-7.17

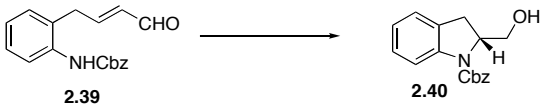
(m, 1H), 7.13-7.08 (m, 1H), 6.68 (bs, 1H), 6.02-5.91 (m, 1H), 5.23 (s, 2H), 5.19 (dd, *J* = 0.9, 9.6 Hz, 1H), 5.04 (dd, *J* = 0.9, 17.1 Hz, 1H), 3.35 (d, *J* = 6.0 Hz, 1H); ^{13}C NMR (400 MHz, $CDCl_3$) δ 153.8, 136.2, 136.0, 135.7, 130.2, 128.6, 128.3, 127.5, 124.5, 122.2, 116.8, 67.0, 36.5; HRMS (EI+) calcd. For $C_{17}H_{17}O_2N$ (M+) 267.1259, found 267.1250.



2.38 **2.39**

Aldehyde 2.39: To a pressure vessel containing a solution of **2.38** (100 mg, 0.374 mmol) in CH_2Cl_2 (10 mL) was added sequentially aldehyde **2.5** (131 mg, 0.15 mL, 1.87 mmol) and aged[27] 2nd generation Grubbs catalyst (16 mg, 0.019 mmol, 5 mol %). The vessel was sealed and heated to 45˚C. After 48 h, the solution was cooled to rt and concentrated *in vacuo*. The crude product was purified by chromatography over silica gel, eluting with 0-30% EtOAc/Hexanes to yield **2.39** (57.4 mg, 0.194 mmol, 52%) as a brownish oil. IR (neat) 3378, 2944, 1672, 1500^{1}H NMR (300 MHz, $CDCl_3$) δ 9.52 (d, *J* = 7.8 Hz, 1H), 7.65-7.70 (m, 1H), 7.30-7.45 (m, 5H), 7.15-7.30 (m, 2H), 6.90-7.00 (m, 21H), 6.45 (bs, 1H), 6.04 (dd, *J* = 7.8, 15.6 Hz, 1H), 5.20 (s, 2H), 3.63 (dd, *J* = 1.2, 6.0 Hz, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 193.4, 154.7, 154.1, 135.9, 135.4, 133.7, 130.2, 128.7,

128.4, 128.3, 125.8, 124.4, 67.3, 34.9; HRMS (EI+) calcd. For $C_{18}H_{17}NO_3$ (M+) 295.1209, found 295.1209.



2.39 **2.40**

Alcohol 2.40: The reaction time was 48 h at -25°C. The crude product was purified by chromatography over silica gel, eluting with 10-30% EtOAc/Hexanes to give the alcohol **2.40** (15.7 mg, 0.053 mmol, 63%) as a pale yellow oil. Enantiomeric excess was determined by chiral HPLC [4.6 X 250 mm Diacel OD column, 95:5 hexanes/iPrOH, retention times 22.34 (major) and 26.92 min (minor)] to be 92% ee. $[\alpha]_D$ +7.4 (c = 1.0, $CHCl_3$); IR (neat) 3422, 2915, 1704, 1599, 1485; ^{1}H NMR (400 MHz, DMSO-d_6 at 80°C) δ 7.63 (d, *J* = 8 Hz, 1H), 7.50-7.30 (m, 5H) 7.22 (d, *J* = 7.6 Hz, 1H), 7.16 (t, *J* = 7.6 Hz, 1H), 6.97 (t, *J* = 6.8 Hz, 1H), 5.28 (s, 2H), 4.61-4.56 (m, 1H), 4.24 (bs, 1H), 3.50 (t, *J* = 6.4 Hz, 2H), 3.32 (dd, *J* = 9.6, 16.4 Hz, 1H), 2.90 (dd, *J* = 2.4, 16.4 Hz, 1H), 1.98-1.92 (m, 1H), 1.69-1.63 (m, 1H); ^{13}C NMR (100 MHz, DMSO-d_6 at 80°C) δ 152.9, 142.0, 137.0, 131.2, 128.9, 128.4, 128.2, 127.5, 125.5, 123.2, 115.3, 67.0, 58.0, 37.9, 33.7; HRMS (EI+) calcd. For $C_{18}H_{19}NO_3$ (M+) 297.1365 found 297.1364.

Chapter 3. Application of Intramolecular Organocatalyzed Heteroatom Michael Addition

3.1 Introduction

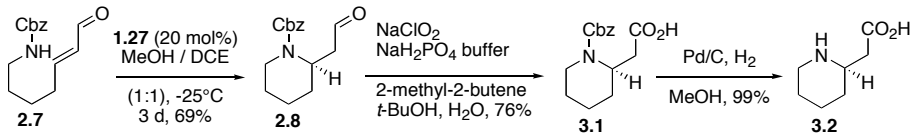
With a working catalyst system, we next sought to demonstrate the utility of the route for the construction of selected alkaloids and cyclic β-amino acid derivatives. In addition to demonstrating the utility of this cyclization we did not currently know the absolute configuration of the cyclization, and needed to synthesize a known compound with which to compare the optical rotation. The three compounds chosen were known compounds with some significance to them, as well as being of similar structure to our previously synthesized piperidine and pyrrolidine rings. These compounds were β-amino acid derivatives homopipecolic acid, homoproline, and the alkaloid pelleterine.

3.2 Synthesis of Homopipecolic Acid

First, the cyclic β-amino acid, homopipecolic acid,[34] was selected as an initial target for the application of this methodology. The cyclization to the β-amino aldehyde was accomplished using our methodology to achieve the piperidine ring. The aldehyde was then oxidized to the corresponding acid via the Pinnick oxidation, which proceeded smoothly to give the acid in 76% isolated yield. The final step was the Cbz deprotection that afforded

the desired β-amino acid in near quantitative yield and rapid fashion (Scheme 3.1). Comparison of the observed optical rotation for the synthetic homopipercolic acid {$[\alpha]_D$ = -23.6° (*c* = 0.11, H_2O)} with the literature value {(S)- isomer lit.[35] $[\alpha]_D$ = +24° (c = 0.87, H_2O)} also allowed us to establish the *R* absolute configuration of synthetic homopiperecolic acid **3.2**, which in turn confirms the absolute configuration of the cyclization to give the *R* enantiomer as the major product.

Scheme 3.1. Synthesis of Homopipecolic Acid

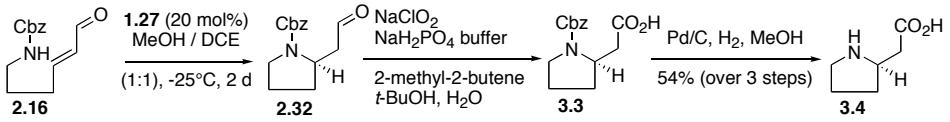


3.3 Synthesis of Homoproline

Homoproline has attracted considerable attention for its use in medicinal chemistry as well as organocatalysis.[36] As anticipated, homoproline was synthesized following the same sequence of steps used in the synthesis of homopipecolic acid. Starting from the enal, the cyclization proceeded well to give the 5-membered pyrrolidine ring system. The aldehyde was oxidized to the acid using the Pinnick oxidation and final deprotection of the amine using H_2 (g) and Pd/C yielded the desired product, homoproline, in 54% over the 3 steps (Scheme 3.2). Again, the synthesized material matched the literature values for this compound,[35] confirming the absolute configuration of the 5-membered ring systems as

well. It should be noted that the oxidation of the cyclized β-amino aldehyde **2.32** needed to be conducted immediately after its formation; use of purified aldehyde **2.32** led to considerable erosion in enantioselectivity. The synthesis of homoproline demonstrates the usefulness of this methodology in the rapid and efficient synthesis of both 5 and 6-membered cyclic β-amino acids.

Scheme 3.2. Synthesis of Homoproline

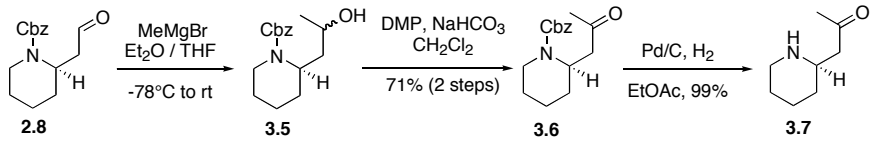


3.4 Synthesis of Pelletierine

Next we set out to synthesize pelletierine; an alkaloid with an interesting history in natural products. Tanert first isolated pelletierine in 1878;[37] however, debate swirled in the chemical community for years as to the exact structure of this natural product – in part due to chemists' inability to synthesize it.[38] Gilman and Marion finally resolved the issue through NMR studies 83 years after it was originally isolated.[39] Further confirmation came through synthesis by Beyerman and Maat in 1963.[40] This natural product was synthesized starting from the 6-membered cyclized β-amino aldehyde. Grignard addition yielded the secondary alcohol as an inconsequential 3:1 ratio of diastereomers which was oxidized using Dess-Martin's periodinane to give methyl ketone **3.6** in 71% yield over 2 steps.

Finally, hydrogenation of the Cbz protection group revealed (-)-pelletierine in 99% yield (Scheme 3.3). The observed optical rotation for synthetic pelletierine {$[\alpha]_D$ = -18.0° (c = 0.5, EtOH)} matched nicely with the literature value.[41]

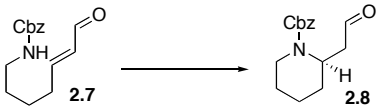
Scheme 3.3. Synthesis of Pelletierine



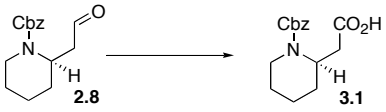
2.8 **3.5** **3.6** **3.7**

The application of this methodology to the synthesis of homoproline, homopipecolic acid, and pelletierine demonstrates its usefulness in total synthesis. Along with the high enantioselectivity obtained, it gives access to the rapid construction of a variety of *N* cyclic ring systems, which are valuable for the synthesis of alkaloids. Further utilization of this methodology is shown in the synthetic progress towards cermizine D.

3.5 Experimental

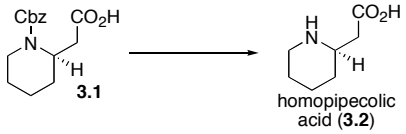


Aldehyde 2.8: To a solution of **2.7** (150 mg, 0.574 mmol), and MeOH (3 mL) was added a solution of the catalyst **1.27** (68.5 mg, 0.115 mmol) in DCE (2.75 mL) via syringe and placed in the freezer unstirred (-25°C). After 3 d, the solution was concentrated *in vacuo.* The crude product was purified by chromatography over silica gel, eluting with 0-25% EtOAc/Hexanes to give known **2.8**[14] (103.5 mg, 0.40 mmol, 69%) as a pale yellow oil. $[\alpha]_D$ 25.3 (c = 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 9.73 (s, 1H), 7.30-7.38 (m, 5H), 5.13 (s, 2H), 4.90-5.00 (m, 1H), 4.05-4.15 (m, 1H), 2.88 (t, *J* = 12.4 Hz, 1H) 2.72-2.80 (m, 1H), 2.58-2.66 (m, 1H), 1.58-1.78 (m, 4H), 1.45-1.55 (m, 2H); ^{13}C NMR (400 MHz, $CDCl_3$) δ 200.5, 155.2, 136.7, 128.5, 128.0, 127.9, 67.2, 46.2, 44.5, 39.6, 28.7, 25.2, 18.8.



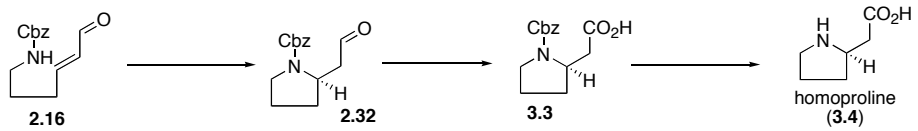
Acid 3.1: To a solution of **2.8** (63 mg, 0.241 mmol), *t*-BuOH (3 mL) water (3 mL) and 2-methyl-2-butene (0.6 mL, 5.6mmol) was added NaH_2PO_4 (332.6 mg, 2.41 mmol) followed by $NaClO_2$ (98.4 mg, 1.085 mmol). The reaction was stirred at rt for 1 h before quenching it with 15 mL of saturated NaCl. Then the solution was extracted with Et_2O (3 X 15 mL),

the combined organic layers were dried over $MgSO_4$, and concentrated *in vacuo.* The crude product was purified by chromatography over silica gel, eluting with 0-40% EtOAc/Hexanes to give known **3.1**[42] (51 mg, 0.183 mmol, 76%) as a colorless oil. $[\alpha]_D$ -18 (c = 0.5, $CHCl_3$); IR (neat): 3060, 3033, 2934, 1732, 1703; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30-7.39 (m, 5H), 5.16 (s, 2H), 4.84 (bs, 1H), 4.11 (d, *J* = 13.2 Hz, 1H), 2.90 (t, *J* = 12.4 Hz, 1H), 2.65-2.69 (m, 2H), 1.62-1.70 (m, 4H), 1.00-1.60 (m, 2H); ^{13}C NMR (400 MHz, $CDCl_3$) δ 176.6, 155.8, 136.8, 128.5, 128.0, 127.8, 67.3, 48.0, 39.7, 35.1, 28.2, 25.2, 18.8.



(*R*)-**Homopipercolic Acid (3.2):** To a solution of **3.1** (51mg, 0.183 mmol) in MeOH (1.5 mL) was added Pd/C (5 mg, 10% Pd), and then the reaction flask was flushed and filled with hydrogen gas. The reaction was done under 1 atm of hydrogen gas and was stirred for 16 h. The reaction mixture was filtered over Celite® to remove the Pd/C and was concentrated *in vacuo* to give **3.2** (26 mg, 0.183 mmol, 99%) as a pale yellow waxy oil. $[\alpha]_D$ -23.6 (c = 0.11, H_2O), lit. Value[43] (*S*)-**3.2**: $[\alpha]_D$ +24.0 (c = 0.87, H_2O); ^{1}H NMR (400 MHz, MeOD) δ 5.00 (bs, 1H), 3.44 (d, *J* = 12.0 Hz, 1H), 3.30-3.38 (m, 1H), 3.00 (t, *J* = 12.8 Hz, 1H), 2.40-2.52 (m, 2H), 1.88-1.93 (m, 3H), 1.55-1.72 (m, 3H); ^{13}C NMR (100 MHz, MeOD) δ 176.0, 54.6, 44.0,

39.2, 28.3, 22.3, 21.8; HRMS (EI+) calcd. For $C_7H_{13}NO_2$ (M+) 143.1852, found 143.0950.

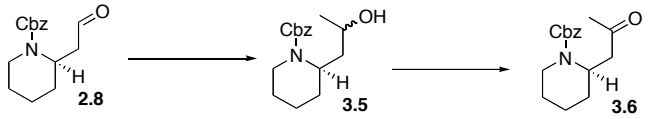


(*R*)-Homoproline (3.4): To a solution of **2.16** (54 mg, 0.217 mmol) in MeOH (2 mL) cooled to -25˚C was added a cooled solution of **1.27** (22.5 mg, 0.038 mmol) in DCE (4.75 mL), the reaction mixture was kept at -25˚C for 48 h. The solution was then concentrated *in vacuo.* The crude and unstable aldehyde **2.32** was carried on without farther purification.

To a solution of crude aldehyde **2.32** (0.217 mmol), *t*-BuOH (2 mL), water (2 mL), and 1.0 mL (9.32mmol) of 2-methyl-2-butene was added NaH_2PO_4 (299 mg, 2.17 mmol) followed by $NaClO_2$ (88.6 mg, 0.98 mmol) of was added. The reaction was stirred at rt for 1 h before quenching it with 30 mL of saturated NaCl. Then the solution was extracted with Et_2O (3 X 10 mL), the combined organic layers were dried over $MgSO_4$, and concentrated *in vacuo.* The crude acid **3.3** was dissolved in 10 mL of Et_2O, extracted into a 20% NaOH (10 mL) aqueous layer washed with Et_2O (1 X 10 mL), and then reacidified with 10% HCl (25 mL) and extracted with Et_2O (3 X 20 mL), the combined organic layers were dried over $MgSO_4$, and

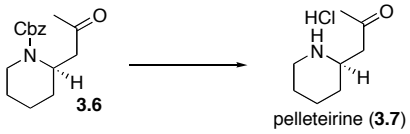
concentrated *in vacuo.* The crude acid **3.3** was carried on without further purification.

To a solution of crude acid **3.3** (0.217 mmol) and MeOH (1.0 mL) was added Pd/C (5 mg, 10% Pd). Then the reaction flask was flushed with hydrogen gas. The reaction was done under 1 atm of hydrogen gas and was stirred for 16 h. The reaction mixture was filtered over Celite® to remove the Pd/C and was concentrated *in vacuo* to yield the desired amino acid **3.4** (17 mg, 0.117 mmol, 54% over 3 steps) as a waxy oil. $[\alpha]_D$ -3.25 (c = 0.4, H_2O) lit. value[43] (*S*)-**3.4**: $[\alpha]_D$ +3.4 (c = 1.0, H_2O); ^1H NMR (400 MHz, D_2O) δ 3.60-3.80 (m, 1H), 3.20-3.30 (m, 2H), 2.50-2.60 (m, 2H), 2.10-2.20 (m, 1H), 1.95-2.10 (m, 2H), 1.55-1.65 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.9, 57.6, 45.0, 38.3, 29.3, 23.0.



Ketone 3.6: To a solution of **2.8** (130 mg, 0.498 mmol) in THF (5 mL) at -78˚C was slowly added a solution of MeMgBr (0.3 mL, 1.0 mmol, 3.0 M in Et_2O). The mixture was allowed to stir at -78˚C for 30 min. Then the solution was warmed to rt and stirring for 4 h. The reaction was quenched with water (2 mL). Then the solution was extracted with Et_2O (3 X 15 mL), the combined organic layers were dried over $MgSO_4$, and

concentrated *in vacuo.* To a solution of crude **3.5** (0.498 mmol) in CH_2Cl_2 (6 mL) was added sodium bicarbonate (209 mg, 2.49 mmol) followed by Dess Martin's reagent (268 mg, 0.62 mmol). The mixture was allowed to stir for 4 h before the reaction was quenched with 10% aqueous sodium bicarbonate (2 mL). Then the solution was extracted with Et_2O (3 X 15 mL), the combined organic layers were dried over $MgSO_4$, concentrated *in vacuo* and purified by chromatography over silica gel, eluting with 0-25% EtOAc/Hexanes to give known **3.6**[44] (97 mg, 0.353 mmol, 71% over 2 steps) as a colorless oil. $[\alpha]_D$ +10.1 (c = 0.9, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 7.30-7.41 (m, 5H), 5.16 (d, *J* = 12.8 Hz, 1H), 5.13 (d, *J* = 12.8 Hz, 1H), 4.84 (s, 1H), 4.07 (bs, 1H), 2.88 (t, *J* = 12.4 Hz, 1H), 2.70-2.75 (m, 2H), 2.17 (s, 3H), 1.60-1.80 (m, 4H), 1.40-1.55 (m, 2H); ^{13}C NMR (400 MHz, $CDCl_3$) δ 206.9, 155.3, 136.8, 128.5, 128.0, 127.9, 67.1, 47.5, 44.3, 39.8, 30.1, 28.3, 25.3, 18.8.



3.6 pelleteirine (**3.7**)

(*R*)-Pelletierine (3.7): To a solution of **3.6** (25 mg, 0.091 mmol) in EtOAc (1 mL) was added Pd/C (3 mg, 10% Pd). The flask was flushed and filled with hydrogen gas. The mixture was stirred under 1 atm of hydrogen for 2 h. The solution was filtered over Celite® to remove the carbon then conc. HCl (0.1 mL) was added to form the hydrochloride salt. The solution

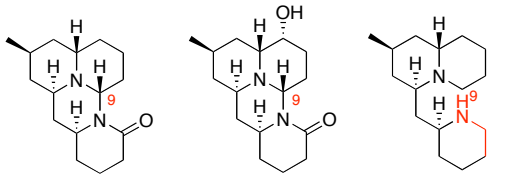
was concentrated *in vacuo* to give **3.7** (16 mg, 0.09 mmol, >99%) as a white granular solid. mp 218-219˚C; $[\alpha]_D$ -18.0 (c = 0.5, EtOH), lit. Value[44] (*R*)-**3.7**: $[\alpha]_D$ -18.1 (c = 8.18, EtOH); mp 218-220˚C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.65 (bs, 1H), 9.22 (bs, 1H), 3.51 (bs, 2H), 3.36 (d, *J* = 16.0 Hz, 1H), 2.90-3.05 (m, 2H), 2.24 (s, 3H), 1.90-2.10 (m, 2H), 1.80-1.90 (m, 2H), 1.70-1.80 (m, 1H), 1.50-1.65 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 205.1, 53.2, 45.9, 45.1, 30.6, 28.4, 22.3, 22.2.

Chapter 4. Application Toward the Synthesis of Cermizine D

4.1 Introduction

Plants of the *Lycopodium* species have been known to produce a number of structurally diverse and complex alkaloids. Many of these compounds continue to have interesting biogenetic[45] and biological[46] points of view as well as serving for challenging targets for total synthesis. Cernuine (**4.1**) and lycocernuine (**4.2**) are a few of the cernuane-type *Lycopodium* alkaloids that contain a fused tetracyclic ring system containing an aminal moiety (Figure 4.1). Cermizine D (**4.3**) also falls into the cernuane-type *Lycopodium* alkaloids - despite not having either a tetracyclic ring system or the aminal moiety. Cermizine D is considered to have a *N*-C_9 *seco*-cernuane skeleton as the *N*-C_9 bond that would form the tetracyclic core is missing. In addition to the lack of the *N*-C_9 there is also no carbonyl group to make the aminal moiety that is generally seen in this type of alkaloids (Scheme 4.1). The total synthesis of various types of *Lycopodium* alkaloids have been reported,[47] however, there has only been one report on the synthesis of cernuane-type alkaloids in 2008 by Takayama and co-workers.[48]

Scheme 4.1. Cernuane-type *Lycopodium* alkaloids isolated from *Lycopodium cernuum*



4.2 Isolation and Bioactivity of Cermizine D

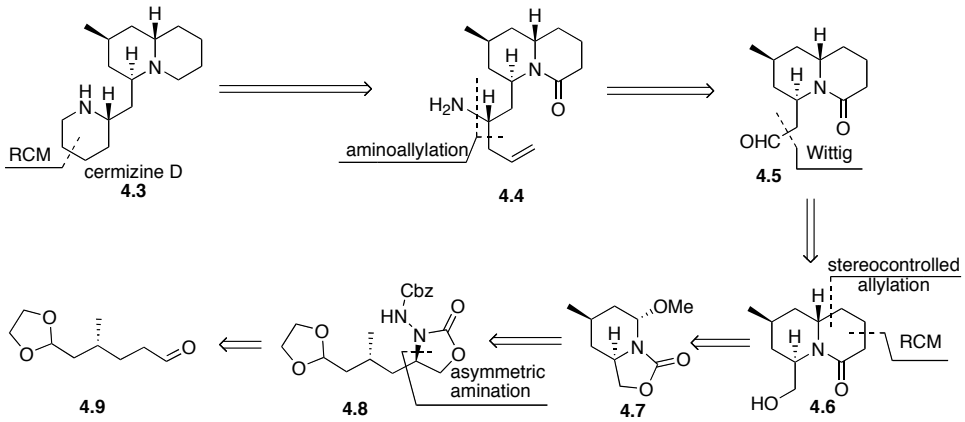
In 2004, Kobayashi and co-workers reported the isolation of cermizine D from the club moss *lycopodium cernuum*. It was also reported that cermizine exhibited cytotoxicity against murine lymphoma L1210 cells with an IC_{50} of 7.5 μg/mL.[49] Although the structure of cermizine D was proposed by Kobayashi based on spectroscopic methods, the relative stereochemistry was deduced from cross-peaks observed in the phase sensitive NOESY spectrum the absolute configuration has not been confirmed. In addition to the absolute configuration not being clear, the counteranion of the natural product has not been reported so far. To date, there has been only one total synthesis of cermizine D by Takayama in 2008.[50]

4.3 Other Synthetic Studies Towards Cermizine D

In 2008, Takayama and co-workers reported the first asymmetric total syntheses of cernuine and cermizine D. They accomplished these syntheses by going through the advanced intermediate **4.4** and starting

from (+)-citronellal. The synthesis involved organocatalytic α-amination to give the oxazolidinone, followed by diasereoselective allylation and asymmetric transfer aminoallylation as key steps. The retrosynthesis of cermizine D is outlined in Scheme 4.2. Construction of the final ring in cermizine D would be accomplished using RCM. The aminolactam **4.4** was the common intermediate used for the synthesis of both cermizine D and cernuine. Homoallylamine **4.4** was prepared by a stereoselective installation of both the allyl and amino groups onto aldehyde **4.5** which came from Wittig homologation of **4.6**. The quinolizidine moiety in **4.6** was obtained from diastereoselective allylation to aminoacetal **4.7** followed by RCM. Oxazolidinone **4.8** was constructed from organocatalytic α-amination of the known aldehyde **4.9**.

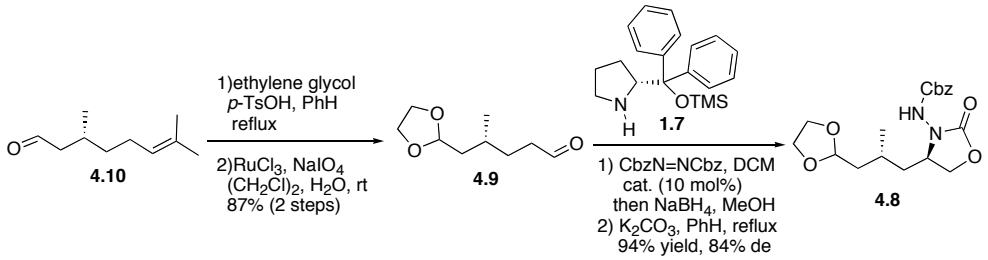
Scheme 4.2. Retrosynthetic Analysis of Cermizine D



Started with (+)-citronellal **4.10**, the oxazolidinone was formed by protecting the aldehyde as an acetal, followed by oxidative cleavage of the

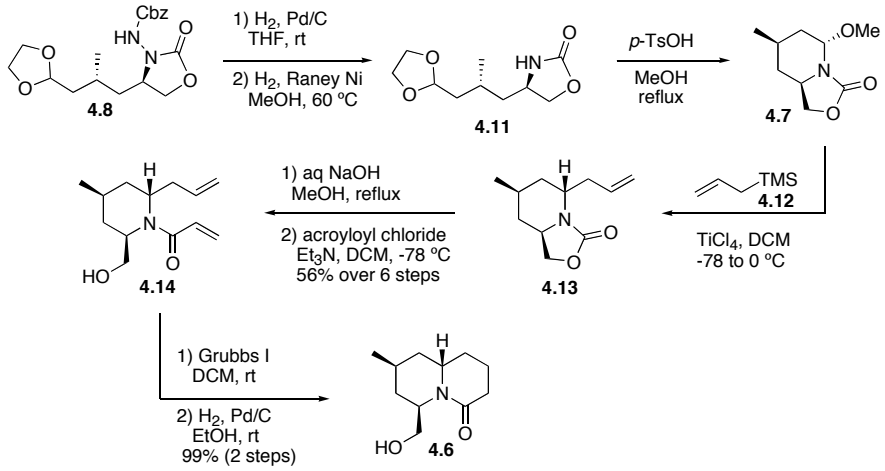
alkene to give the aldehyde (Scheme 4.3).[51] The amination was carried out using dibenzyl azodicarboxylate in the presence of catalytic **1.7** in CH_2Cl_2 at room temperature, followed by *in situ* reduction. The resulting mixture was then converted to the oxazolidinone using K_2CO_3 in toluene to give the desired product **4.8** in 94% yield and 84% de.

Scheme 4.3. Organocatalytic Oxazolidinone Synthesis



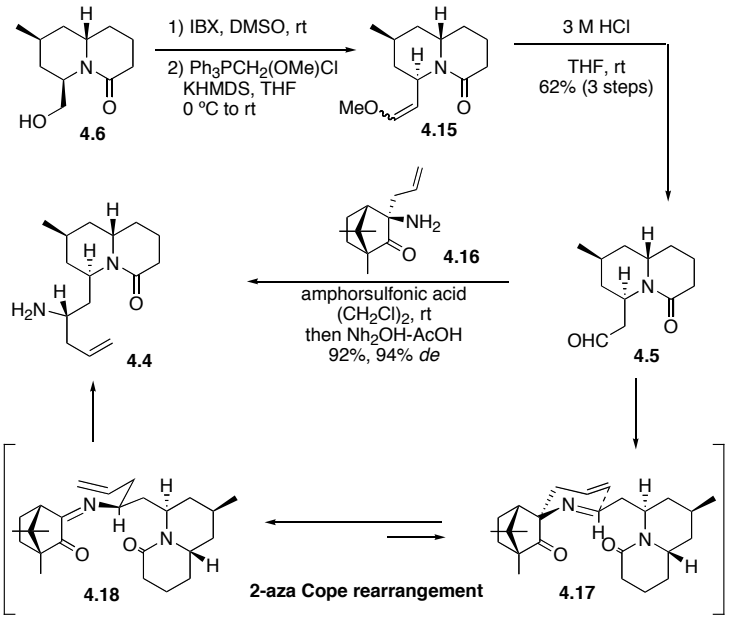
Sequential reduction of the Cbz group followed by hydrogenation of the resulting hydrazine gave oxazolidinone **4.11** (Scheme 4.4). Treatment of **4.11** with a catalytic amount of *p*-TsOH in refluxing MeOH caused cyclization to occur and gave the aminoacetal **4.7**.[52] Upon reaction of the aminoacetal with allyltrimethylsilane in the presence of $TiCl_4$,[53] oxazolidinone **4.13** was formed as a single isomer. Hydrolysis of the oxazolidinone followed by acryloylation of the resulting amine gave acrylamide **4.14** as a single diastereomer in 56% over 6 steps. The quinolizidinone **4.6** was formed in 99% by RCM using Grubbs' first-generation catalyst followed by hydrogenation of the resulting alkene.

Scheme 4.4. Synthesis of Key Intermediate **4.6**



In Scheme 4.5, the synthesis of the homoallylamine is shown. The alcohol in **4.6** was oxidized with IBX in DMSO to the aldehyde which was then homologated to **4.15** using the Wittig reaction with $Ph_3PCH_2(OMe)Cl$ and KHMDS in THF followed by mild acid hydrolysis to give aldehyde **4.5** in 62% over three steps. Next, the installation of an alkyl chain and an amine function was accomplished simultaneously and stereoselectively by aminoallylation developed by Kobayashi et al.[54] Using **4.16** derived from (1*R*)-camphor quinone, the homoallyamine **4.4** was obtained in 92% with 94% de.

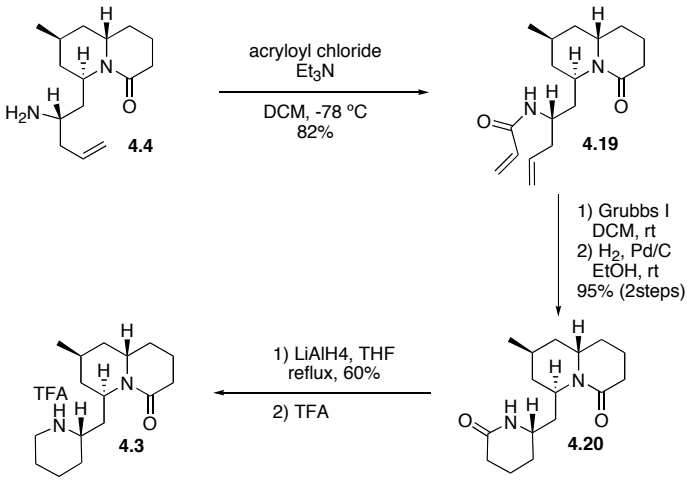
Scheme 4.5. Synthesis of Homoallylamine



The completion of cermizine D is shown in Scheme 4.6. The homoallylamine **4.4**, was converted into piperidone **4.20** in three steps using an acryloylation, RCM and hydrogenation to obtain the final lactam ring in 78%. Complete reduction of the bisamide in **4.20** was achieved using $LiAlH_4$ in THF to give the target compound **4.3** in 60% yield; however, the ^1H NMR data of the synthetic **4.3** was *not* identical to that reported for the natural cermizine D. Based off of the reported isolation of the compound, they chose to form the TFA salt. The ^1H and ^{13}C NMR data from the TFA salt of the synthetic **4.3** did match the reported data of the isolated compound. While the NMR spectra matched, the optical rotation showed a significantly different value and opposite sign to that of the natural product: synthetic TFA salt, $[\alpha]^{20}_D$ +24.2 (c 0.50, MeOH); natural,

$[\alpha]^{25}_{D}$ -33 (c 0.6, MeOH). Due to this discrepancy, the absolute configuration of natural cermizine D remains a question.

Scheme 4.6. Completion of Synthesis of Cermizine D



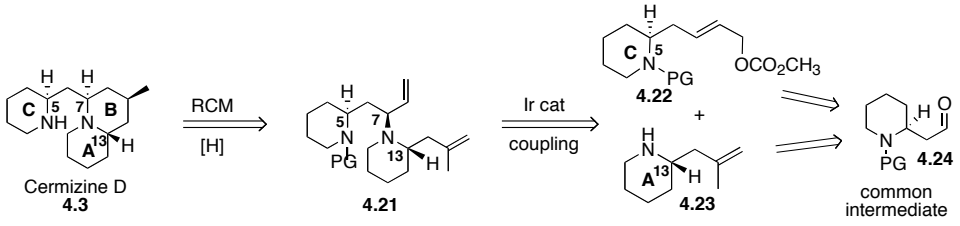
Overall, Takayama and co-workers have completed the first asymmetric total synthesis of (+)-cermizine D in 20 steps with a 12% overall yield. Highlights in this synthesis include the organocatalytic α-amination to construct the oxazolidinone, which was then used for the diastereoselective allylation. Other key steps include the synthesis of the homoallylamine by asymmetric transfer aminoallylation and the stereoselective construction of the aminal ring system. In addition to these highlights the general and scalable process in which the quinolizidine ring system was synthesized allows for the rapid construction of other quinolizidine-type alkaloids.

4.4 Our Approach to Cermizine D

We were interested in using our recently developed methodology in

the synthesis of cermizine D. We envisioned using our cyclized piperidine as a common intermediate that could be used for making both the A and C rings (Scheme 4.7). The retrosynthetic analysis would have the B ring being formed from a Grubbs' RCM followed by hydrogenation taking us to intermediate **4.21**. Iridium-mediated coupling of the amine **4.23** and allyl carbonate **4.22** using a ligand developed by Hartwig[55] could give the desired coupling. While this catalyst system has generated considerable attention in recent years,[56] to our knowledge no application to natural product synthesis. The two coupling fragments could both be derived from a common intermediate, which had been previously made. The A ring fragment could come from methyl Grignard addition, followed by functional group manipulations. The C ring fragment could come from a Wittig reaction to the ester, reduction, and conversion to the allyl carbonate. Overall, this strategy would provide us with a rapid and convergent synthesis of the desired target.

Scheme 4.7. Retrosynthesis of Cermizine D

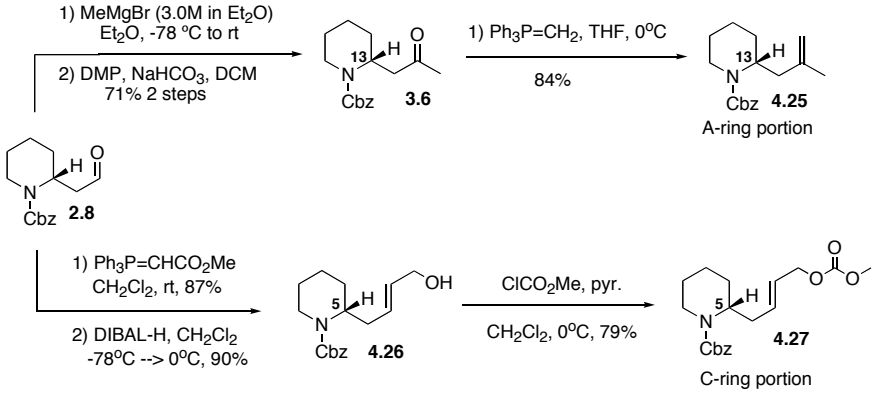


4.5 Synthesis of Key Iridium Coupling Precursors

The first step was to synthesize the two fragments for the coupling

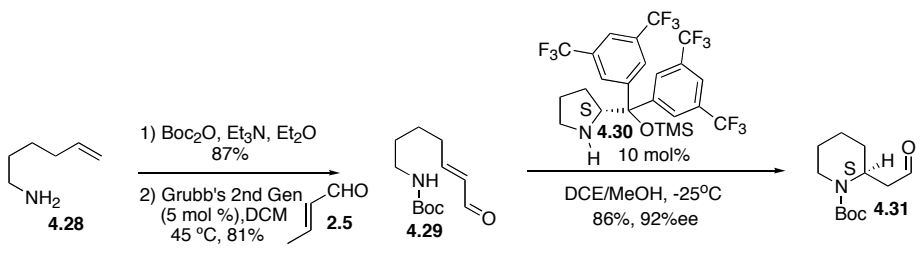
reaction (Scheme 4.8). Using the cyclized aldehyde **2.8**, which had been made previously, as a common intermediate we carried it along two paths to obtain both the A and C ring fragments for the key coupling. To get to the allyl carbonate fragment, the starting aldehyde was reacted with the methyl ester Wittig reagent to give the allyl ester in 87%. The methyl ester was then reduced using DIBAL-H to give the corresponding alcohol **4.26** in 90%. The alcohol was then reacted with methyl chloroformate to give the desired allyl carbonate **4.27** in 79% yield. In order to get ring fragment A, we used the same procedure to get to the methyl ketone as was used in the synthesis of pelletierine**.** Methyl Grignard addition to the aldehyde gave the corresponding alcohol as a mixture of diastereomers which was oxidized to the methyl ketone using Dess-Martin's periodinane in 71% over both steps. Methylenation using the methyl Wittig reagent at 0 ºC preceded well giving the methylene product in 84%. Attempts to deprotect the Cbz using sodium naphthalene proved to be problematic as the free base was volatile and could not be isolated. Further attempts to form the HCl salt in situ using TMSCl and sodium iodide was also plagued with low yields and a variety of impurities that could not be separated. Due to the problems in removing the Cbz protecting group, we chose to change to the Boc group.

Scheme 4.8. Synthesis of the Cbz protected A and C ring fragments



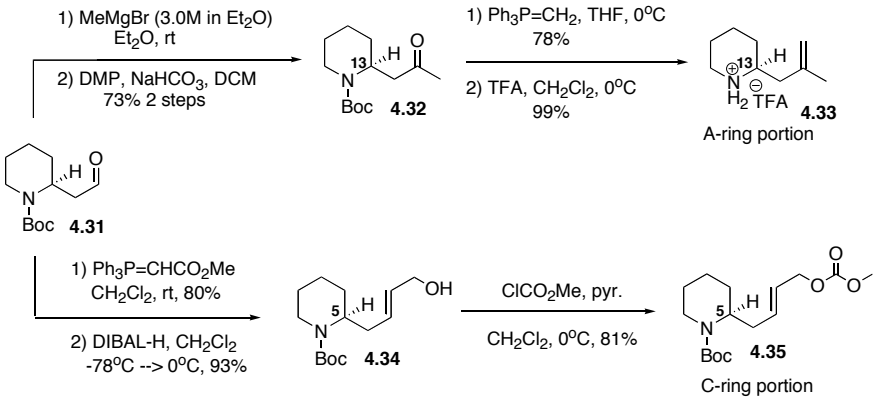
Instead of deprotecting and reprotecting at an advanced intermediate, we chose to go back to the initial protecting step and change to the Boc group at that point (Scheme 4.9). The protection proceeded well as did the Grubbs' metathesis to provide the desired Boc protected enal **4.29** in 71% yield over 2 steps. The desired stereocenter in cermizine D had the *S* configuration, thus the *S* version of the catalyst was needed. In addition, we were able to reduce catalyst loading to 10mol% by increaseing concentration and reaction time. The Boc protected amine cyclized as expected to give the desired aldehyde **4.31** in 86% yield and 92% ee.

Scheme 4.9. Final Optimization of Cyclization with N-Boc Protecting Group



With the cyclized Boc protected aldehyde **4.31** in hand, efforts shifted to constructing key A and C-ring fragments. Following the same procedures used with the Cbz substrate, the Boc protected substrate reacted similarly. The methyl Grignard addition followed by DMP oxidation to the methyl ketone proceeded in 73% yield. The methylenation worked in 78% yield and now the deprotection of the Boc protecting group worked nicely using TFA to form the TFA salt in *situ*. Synthesis of the C-ring fragment from the starting aldehyde proceeded similarly to the Cbz protected substrate yielding the allyl carbonate in 60% over 3 steps (Scheme 4.10). With both ring fragments synthesized, we moved on to the iridium coupling system.

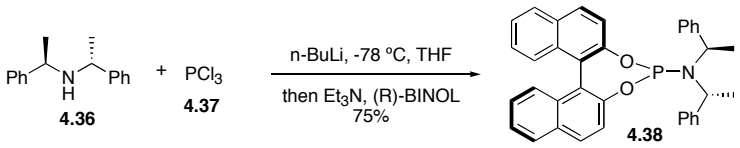
Scheme 4.10. Synthesis of the Boc protected A and C ring fragments



Based on literature precedenct,[57] the (*R*, *R*, *R*,) ligand **4.38** was prepared in order to obtain the desired *S* stereocenter from the reaction (Scheme 4.11). The ligand, which is air sensitive, was prepared following a literature procedure.[58] The product was identified using ^{31}P NMR,

however, the product was air sensitive and needed to be purified under a nitrogen atmosphere as the phosphorus was readily oxidized which was observed using ^{31}P NMR.

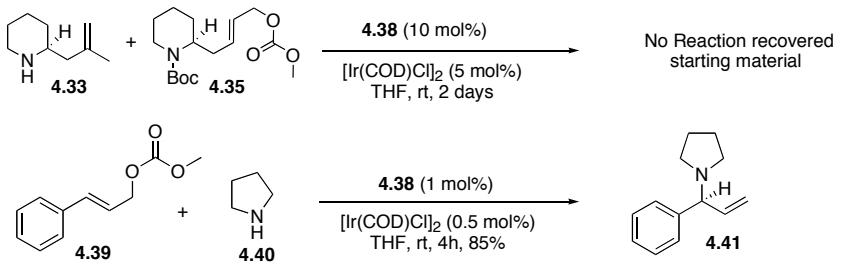
Scheme 4.11. Synthesis of the Iridium ligand



4.6 Studies on the Iridium Coupling

With our components in hand, we were ready to test out the desired iridium coupling (Scheme 4.12). The key coupling on the actual substrates, however, gave no reaction and only the starting allyl carbonate was recovered. The free amine was volatile and thus was never recovered from any reactions where it was used. First, we needed to insure that our ligand and catalyst system were working as intended. To test our reaction conditions, the known allyl carbonate **4.39** was prepared following Hartwig's protocol, and was reacted with pyrrolidine using the same conditions reported by Hartwig. Using these substrates, the reaction worked as reported giving us the desired product with a yield to that of what was reported.

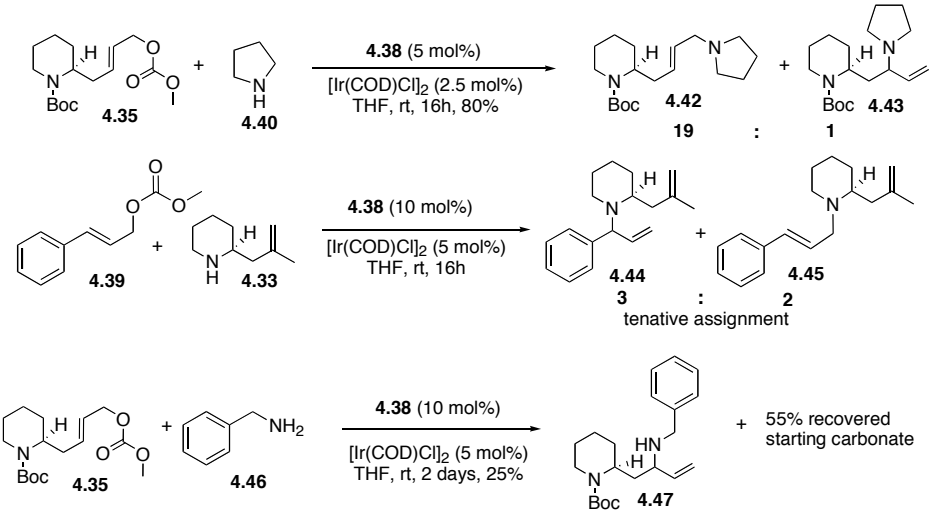
Scheme 4.12. Initial Iridium couplings.



Based on these results, we suspected the problem was one of our substrates. Consequently, we designed a few model systems to test this prediction out (Scheme 4.13). One model system had the known allyl carbonate reacting with our amine substrate. The other model had our allyl carbonate reacting with a known amine, pyrrolidine. These model systems gave way to some interesting results. From the reaction between our allyl carbonate and pyrrolidine, we obtained almost entirely the undesired linear product **4.42** in a mixture of 19:1. The linear product had been reported as a second product from many of these reactions previously, however, never was it the major product, and typically only obtained as a small by-product. Based off of earlier reports, we believed that this is due to the steric bulk of our piperidine ring off of the allyl carbonate. The second model system reaction was between our substituted piperidine **4.33** and the known allyl carbonate. This reaction proceeded to give a 3:2 mixture of isomers favoring the desired branched product **4.44** based off of crude ^{1}H NMR. Unfortunately, the mixture was unstable on silica and could not be purified.

These two model systems helped to demonstrate that it was our likely the allyl carbonate substrate that was problematic in the iridium coupling. One final model system was performed using our allyl carbonate with a primary activated amine, benzyl amine. This final reaction was much slower to react, however, only the internal substituted product was observed in a 25% yield. These results helped to demonstrate some of the limitations to this reaction. In the end, it was decided to use an alternative route to couple the two fragments.

Scheme 4.13. Results from Iridium Model System Couplings

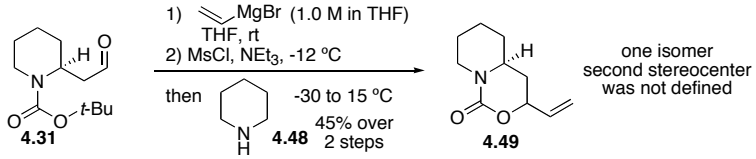


4.7 Alternate Synthetic Strategies for the Synthesis of Cermizine D

After the variety of iridium coupling model systems, we decided to devise an alternative synthesis for cermizine D. One possibility would be the direct coupling of the two fragments through a substitution process. We chose to carry out the direct substitution on an activated version of the

allylic alcohol. Vinyl Grignard addition gave a mixture of diastereomers in 68% yield that were separated. We chose to use a model system with piperidine as the amine to test out the reaction conditions (Scheme 4.14). Directly coupling the two fragments using an activated allylic alcohol as the leaving group proved to be problematic as once the allylic alcohol was activated, as its mesylate, internal carbamate formation with the Boc carbamate occurred to give the bicycle **4.49** as a single isomer in a 66% yield. While the newly formed stereocenter was not confirmed, it is likely that the reaction proceeded with inversion at this stereocenter.

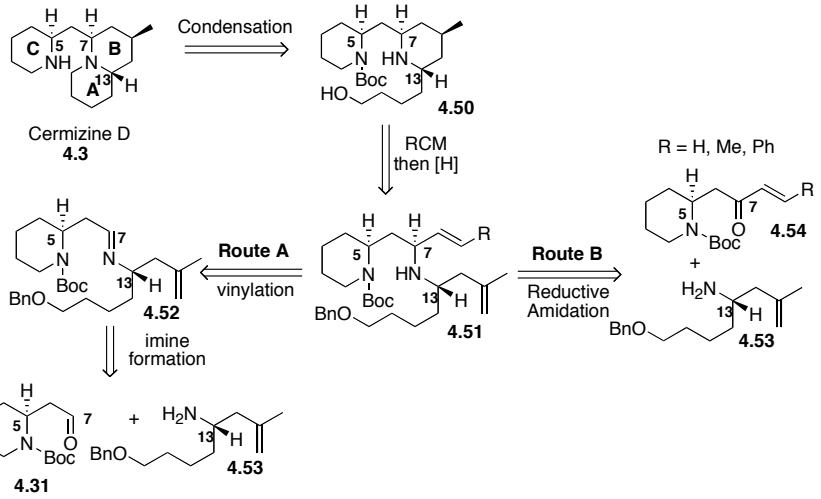
Scheme 4.14. Self-cyclization resulting from direct coupling route



A revised retrosynthesis is proposed in Scheme 4.15. In this approach, we chose to alter the second coupling fragment to an open chain with a primary amine (Scheme 4.15), while leaving the synthesis of the first piperidine ring the same using our heteroatom Michael reaction. There were two possible options with this approach. The first option was to generate an imine with the cyclized aldehyde followed by addition of the vinyl Grignard leading us to a similar intermediate as we had in our original retrosynthesis. Alternatively, reductive amination with a α,β-unsaturated ketone and the amine **4.53** followed by RCM and reduction would yield

compound **4.50**. Both of these alternative syntheses would first involve the synthesis of the chiral amine **4.53**.

Scheme 4.15. Revised Retrosynthesis for Cermizine D

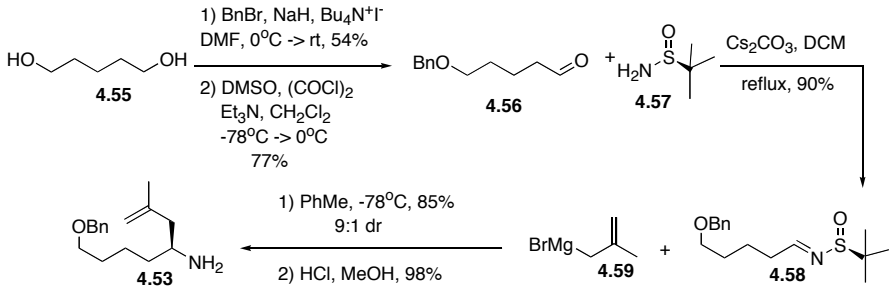


4.7.1 Synthesis of Chiral Amine 4.53

We envisioned synthesizing the chiral amine **4.53** from the known benzyl protected aldehyde[59] **4.56** following chemistry developed by Ellman and co-workers using the chiral *tert*-butanesulfonamide **4.57** (Scheme 4.16).[60] Monoprotection of the 1,5-pentanediol with benzyl bromide followed by Swern oxidation yielded the aldehyde **4.56**. This aldehyde was then condensed with the *S tert*-butylsulfonamide using Cs_2CO_3 in refluxing CH_2Cl_2 to give the sulfimide **4.58** in 90%. The sulfimide was then reacted with the desired Grignard reagent to produce the sulfamide with a 9:1 dr as determined by ^1H NMR. Cleavage of the sulfamide under acid hydrolysis yielded the chiral α-substituted amine **4.53**. With our amine in hand, we

next focused on the two potential strategies for fragment coupling.

Scheme 4.16. Synthesis of Chiral Amine **4.53**

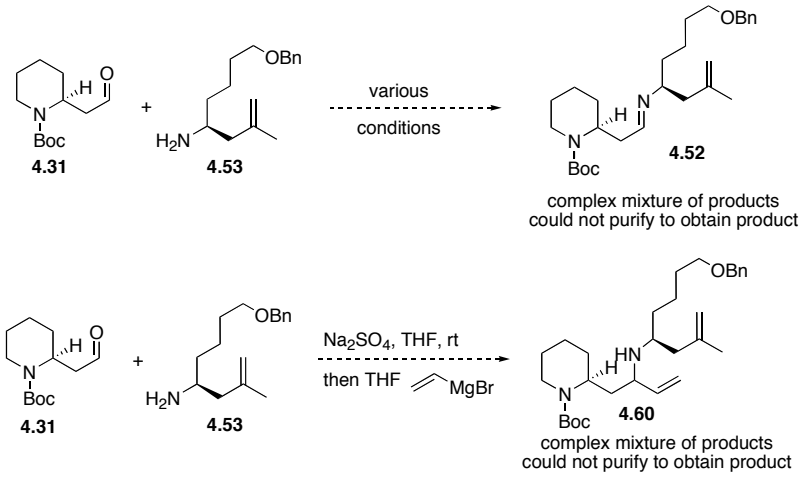


4.7.2 Imine Formation Route

We first selected to explore Route A (Scheme 4.17). Unfortunately, under a wide variety of conditions we were unable to generate the desired imine **4.52**. Selected conditions explored included: (a) Cs_2CO_3, CH_2Cl_2 reflux; (b) PhMe, mol sieves; (c) Na_2SO_4, THF. Each of these conditions resulted in similar complex mixtures with multiple distinct spots via TLC analysis. Any attempts to purify these mixtures using silica gel chromatography resulted in further decomposition - this is possibly due to the amine being α-branched and hindered. The crude ^1H showed some indications of imine formation and the original aldehyde signal was absent. We then considered using a one-pot system where the imine would be formed and without purification the vinyl Grignard would be added. This would allow us to react any of the imine formed without allowing for further decomposition (Scheme 4.17). Using one of our imine forming conditions, (Na_2SO_4, THF) to form the imine the vinyl Grignard was added *in situ*,

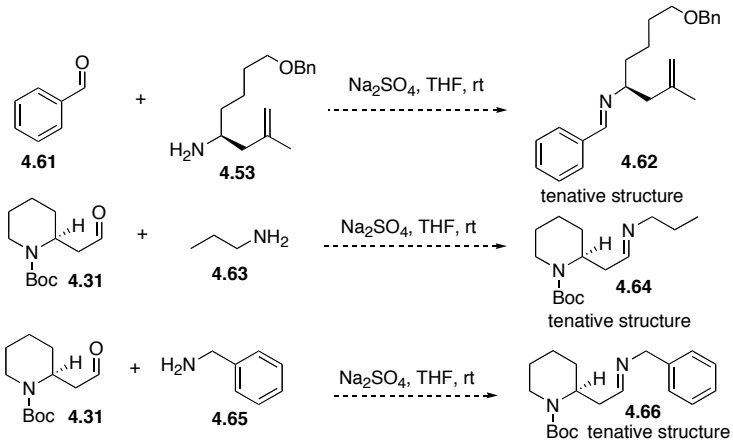
however, we were unable to form any of the desired amine and obtained a complex mixture of compounds that further decomposed on silica.

Scheme 4.17. Attempts at imine formation



To test out the stability and the reactivity of our substrates, we ran a series of model systems to determine if the imine formation was problematic (Scheme 4.18). The imine formation on these systems proved to be much cleaner - crude NMR analysis showed the formation of a single product. The key ^{1}H NMR signals were observed in the crude mixture **4.62** (the loss of the aldehyde peak at 10.0 ppm and the presence of a new singlet peak at 8.19 ppm), **4.64 (**the loss of the aldehyde peak at 9.75 ppm and the presence of a new triplet peak at 7.59 ppm), **4.66** (the loss of the aldehyde peak at 9.75 ppm and the presence of a new triplet at 7.78 ppm). While the crude NMR analysis showed that the imines were formed, they were unstable on silica gel and could not by purified. Based on these results, it was determined that Route B was likely to prove more promising.

Scheme 4.18. Model systems to determine imine stability



4.7.3 Reductive Amination Route

Given the problems with forming a stable aldehyde-derived imine substrate, we shifted our focus to Route B, which would employ a α,β-unsaturated ketone-derived imine substrate. This imine should be better behaved and reductive amination would yield access to the key amine function. It should be noted that typically methods, such as $NaBH(OAc)_3$ and AcOH, for reductive amination often do not work well on α,β-unsaturated ketones.[61] An alternative method for reductive amination is a stepwise process using $Ti(OiPr)_4$, followed by reduction of the titanium intermediate with $NaBH_4$. It has been shown that this reaction works on phenyl substituted α,β-unsaturated ketones,[62] while we were unaware of any precedence for the use of these conditions on the methyl substituted α,β-unsaturated or vinyl ketones. We chose to investigate the reactivity of all three versions of the α,β-unsaturated ketone (Scheme 4.19). All three

were synthesized using the same conditions - only varying the Grignard reagent concentration (Table 2).

Scheme 4.19. Grignard addition, oxidation, reductive amination sequence

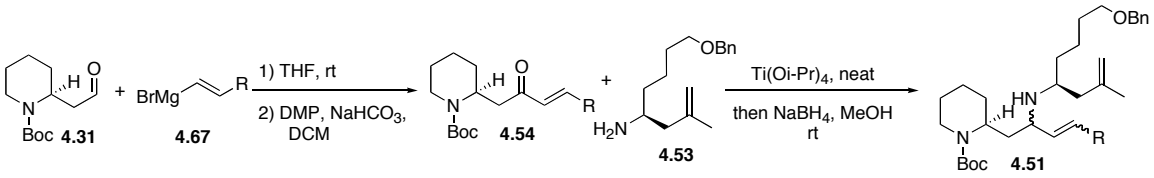


Table 2. Results for three-step sequence

R	Grignard Conc.	Ketone Yield	Reductive Amination
Ph	2.0 M in THF	48% over 2 steps	68% 1:1 dr at rt
Me	0.5 M in THF	54% over 2 steps	Recovered alcohol
H	1.0 M in THF	73% over 2 steps	Recovered alcohol

The phenyl substituted α,β-unsaturated ketone was synthesized in the lowest yield of the three with only 48% yield over the two steps. The vinyl ketone was the highest yielding substrate with a 73% yield and the methyl substituted α,β-unsaturated ketone was obtained in 54% over the same two steps. When the three α,β-unsaturated ketones were submitted to the reductive amination conditions, only the phenyl substituted α,β-unsaturated ketone gave the desired product, while the other two gave only reduced alcohol. This is believed to be due to the increased reactivity that phenyl ring gives to the ketone through conjugation. It is worth noting that the reduction is performed at rt with short (5 min) reaction times; extended

reduction times resulted in lower yields as over reduction of the alkene was observed. While the coupled product was obtained in a reasonable 68% yield, the diastereoselectivity was a disappointing 1:1 mixture. No attempts to improve this level of selectivity have been made to date. We believe that the diastereoselectivity may increase if the reduction is carried out at reduced temperature.

With the coupled amine in hand, the next step was to close the ring using RCM (Scheme 4.20). The alkene system is a 1,2 di-substitued alkene being coupled with a 1,1 di-substitued alkene which represents a challenging RCM to do despite forming a six membered ring. A variety of conditions were used in order to close the ring: **2.6** (5 mol%), CH_2Cl_2, rt and 45 ºC; **2.6** (10 mol%), PhMe, 80 ºC; **4.70** (5 mol%), CH_2Cl_2, 45 ºC; **4.70** (5 mol%), PhMe, 80 ºC; **4.70** (5 mol%), PhMe, CH_2CH_2, 80 ºC; **4.70** (10 mol%), CH_2Cl_2, CH_2CH_2, 45 ºC; **4.70** (25 mol%), PhMe, CH_2CH_2, 80 ºC; none of these conditions gave the desired RCM product.

Scheme 4.20. RCM reactions

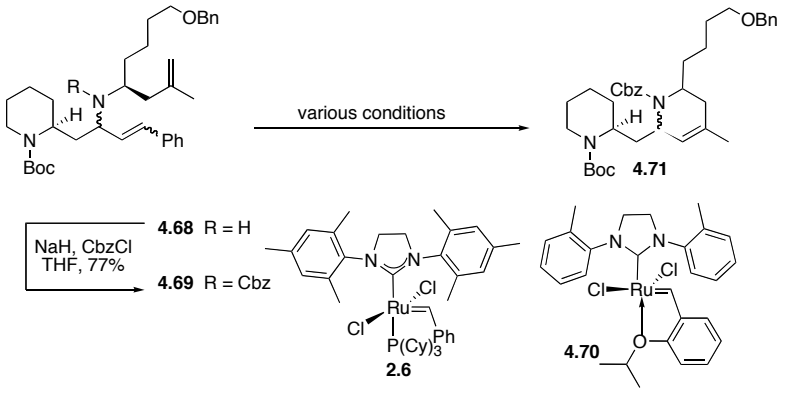


Table 3. RCM conditions

R	Catalyst	Conditions	Yield
H	**2.6**	10 mol%, PhMe, 80 ºC	NR
H	**4.70**	5 mol%, PhMe 80 ºC	NR
Cbz	**4.70**	10 mol%, PhMe, 80 ºC	NR
Cbz	**2.6**	30 mol% slow addition PhMe, reflux	***94%***

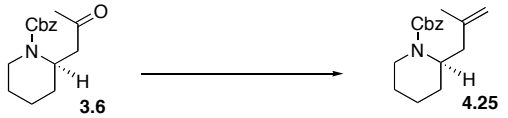
With the RCM proving to be problematic, we then considered the presence of the free amine proton to be a possible problem for the RCM, and chose to protect the amine. Due to positioning of the amine, Cbz protection using bases such as K_2CO_3, or Et_3N did not work. Using a stronger base such as NaH, however, did allow for Cbz protection yielding **4.69** in 77% yield.

Initial attempts at RCM on the Cbz protected amine continued to be unsuccessful. A set of forcing conditions reported by Gennari has been shown to facilitate some RCM reactions that would not take place

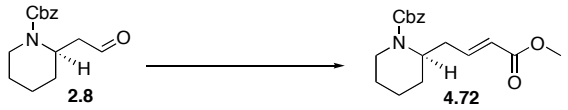
otherwise.[63] The conditions reported were slow addition via syringe pump of a 30 mol % catalyst solution of Grubbs' 2nd Generation catalyst in toluene over 2 h to a solution of the alkene in refluxing toluene, *did* give the RCM product (**4.71)** in an excellent 94% yield.

With the second ring closed, large advancements in the total synthesis of cermizine D had been achieved. The final few remaining steps include a global hydrogenation, activation of the resulting alcohol that is expected to spontaneously cyclize with the free amine and one final deprotection of the remaining Boc group. We are uncertain of the diastereoselectivity on the alkene reduction at this time. The remaining key optimization is to improve the diastereoselectivity of the titanium mediated reductive amination.

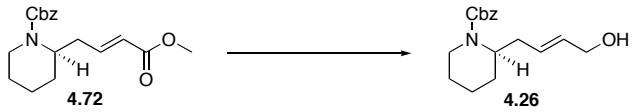
4.8 Experimental



Alkene 4.25: To a solution of **3.6** (53 mg, 0.193 mmol) in THF (1 mL) was added a pre-made solution of methyl triphenylphosphonium bromide (136.5 mg, 0.382 mmol) with n-BuLi (145 µL, 0.363 mmol, 2.5 M in hexanes) in THF (0.7 mL) at 0 °C. After 2 h, the yellow reaction mixture was quenched with water (1 mL), extracted with EtOAc (3 x 5 mL). Then dried over $MgSO_4$, and concentrated *in vacuo* and purified by chromatography over silica gel, eluting with 0-25% EtOAc/Hexanes to give **4.25** (44 mg, 0.161 mmol, 84%) as a pale yellow oil. $[\alpha]_D$ -30.4 (c = 1.15, $CHCl_3$); IR (neat) 3069, 3027, 2937, 2857, 1699, 1421, 1343, 1259, 1166; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30-7.43 (m, 5H), 5.16 (d, *J* = 12.4 Hz, 1H), 5.12 (d, *J* = 12.4 Hz, 1H), 4.74 (d, *J* = 19.2 Hz, 2H), 4.49 (bs, 1H), 4.07 (d, *J* = 11.2 Hz, 1H), 2.90 (t, *J* = 14.8 Hz, 1H), 2.36-2.41 (m, 1H), 2.19-2.26 (m, 1H), 1.60-1.80 (m, 6H), 1.56 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.5, 142.7, 137.0, 128.4, 127.9, 112.8, 66.9, 48.8, 39.3, 38.2, 29.7, 27.5, 25.5, 22.0, 18.7; HRMS (EI+) calcd. For $C_{17}H_{23}NO_2$ (M+) 273.17288, found 273.17317.

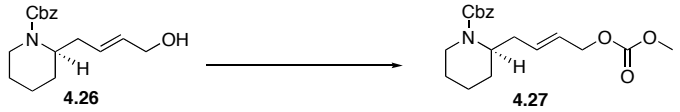


Ester 4.72: To a solution of **2.8** (385 mg, 1.45 mmol) in CH_2Cl_2 was added $Ph_3P{=}CHCO_2Me$ (510 mg, 2.9 mmol) at rt. After 16 h, the reaction was concentrated *in vacuo* then suspended in a 3:1 mixture of hexanes/ether (60 mL) and filtered over Celite®, then rinsed with a 3:1 mixture of hexanes/ether (30 mL). The resulting solution was concentrated *in vacuo* and purified by chromatography over silica gel, eluting with 10-30% EtOAc/Hexanes to give **4.72** (400 mg, 1.26 mmol, 87%) as a colorless oil. $[\alpha]_D$ +24.25 (c = 4.0, $CHCl_3$); IR (neat) 2945, 2857, 1724, 1697, 1421, 1258; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.30-7.41 (m, 5H), 6.90 (dt, *J* = 15.3 Hz, *J* = 7.8 Hz, 1H), 5.87 (d, *J* = 15.6 Hz, 1H), 5.13 (s, 2H), 4.48 (bs, 1H), 4.09 (d, *J* = 12 Hz, 1H), 3.73 (s, 3H), 2.86 (t, *J* = 12.9 Hz, 1H), 2.54-2.61 (m, 1H), 2.40-2.45 (m, 1H), 1.60-1.80 (m, 4H), 1.40-1.56 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.6, 155.4, 145.5, 136.8, 128.5, 127.9, 127.8, 123.0, 67.1, 51.4, 49.9, 39.3, 32.8, 27.9, 25.3, 18.7; HRMS (EI+) calcd. For $C_{18}H_{23}NO_4$ (M+) 318.17053, found 318.17130.

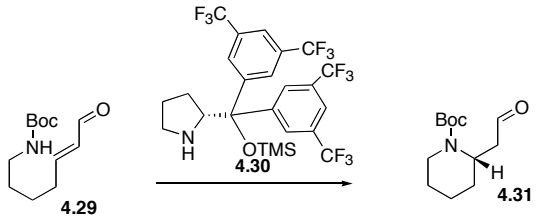


4.72 **4.26**

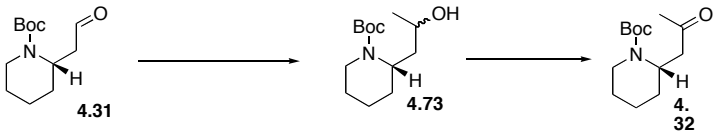
Alcohol 4.26: To a solution of **4.72** (73.5 mg, 0.232 mmol) in CH_2Cl_2 (1.5 mL) at -78 °C was added DIBAL-H (695 µL, 0.695 mmol, 1.0 M in CH_2Cl_2) at -78 ºC. After 2 h, and then it was warmed to room temp. and quenched with sat. aq. sodium tartrate (30 mL). After vigorous stirring for 1 h the mixture was extracted with CH_2Cl_2 (3 x 15 mL) and washed with brine (30 mL). The dried ($MgSO_4$) extract was concentrated *in vacuo* and purified by chromatography over silica gel eluting with 20-40% EtOAc/Hexanes to give **4.26** (60 mg, 0.207 mmol, 90%) as a colorless oil. $[\alpha]_D$ -34.5 (c = 2.0, $CHCl_3$); IR (neat) 3432, 2937, 2861, 1694, 1424, 1353, 1257; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30-7.41 (m, 5H), 5.5-5.7 (m, 2H), 5.16 (d, *J* = 12.4 Hz, 1H), 5.12 (d, *J* = 12.4 Hz, 1H) 4.37 (bs, 1H), 3.99-4.08 (m, 3H), 2.86 (t, *J* = 12.8 Hz, 1H), 2.42-2.51 (m, 1H), 2.18-2.25 (m, 1H), 1.50-1.70 (m, 5H), 1.40-1.50 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.8, 137.0, 131.7, 128.8, 128.5, 128.0, 127.9, 66.9, 63.3, 62.6, 51.0, 50.6, 39.3, 32.8, 27.9, 25.4, 18.8; HRMS (EI+) calcd. For $C_{17}H_{23}NNaO_3$ (M+) 312.1576, found 312.1583.



Carbonate 4.27: To a solution of **4.26** (60 mg, 0.207 mmol) in CH_2Cl_2 (2.5 mL) at 0 °C was added pyridine (49 mg, 50 µL, 0.622 mmol), followed by dropwise addition of $ClCO_2Me$ (21.5 mg, 18 µL, 0.228 mmol) at 0 ºC. After 1 h, the solution was then diluted with water (5 mL), and sequentially extracted with EtOAc (3 x 10 mL). The combined organic layers were washed with brine (10 mL) and sat. aq. NH_4Cl (10 mL). The dried ($MgSO_4$) extract was concentrated *in vacuo* and purified by chromatography over silica gel eluting with 10-25% EtOAc/Hexanes to give **4.27** (57 mg, 0.164 mmol, 79%) as a colorless oil. $[\alpha]_D$ -32.3 (c = 2.85, $CHCl_3$); IR (neat) 2939, 2859, 1749, 1695, 1444, 1422, 1262; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30-7.41 (m, 5H), 5.65-5.8 (m, 1H), 5.56-5.64 (m, 1H), 5.15 (d, *J* = 12.4 Hz, 1H), 5.11 (d, *J* = 12.4 Hz, 1H) 4.51 (d, *J* = 5.2 Hz, 2H), 4.38 (bs, 1H), 4.06 (d, *J* = 12.4 Hz, 1H), 3.78 (s, 3H), 2.84 (t, *J* = 12.8 Hz, 1H), 2.41-2.49 (m, 1H), 2.20-2.30 (m, 1H), 1.50-1.70 (m, 5H), 1.40-1.50 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.5, 137.0, 133.2, 128.5, 127.9, 127.8, 125.7, 68.2, 66.9, 54.7, 50.3, 39.3, 32.8, 27.7, 25.4, 18.8; HRMS (EI+) calcd. For $C_{19}H_{26}NO_5$ (M+) 348.18109, found 348.18175.



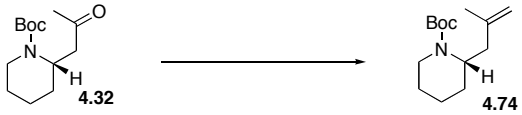
Aldehyde 4.31: To a solution of **4.29** (970 mg, 4.25 mmol), and MeOH (12 mL) was added a solution of the catalyst **4.30** (254 mg, 0.425 mmol) in DCE (12 mL) via syringe and placed in the freezer unstirred (-25°C). After 7 d, the solution was concentrated *in vacuo.* The crude product was purified by chromatography over silica gel eluting with 0-25% EtOAc/Hexanes to give known **4.31** (820 mg, 3.57 mmol, 84%) as a colorless oil. $[\alpha]_D$ = -36.4 (c = 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 9.66 (d, *J* = 2.8 Hz, 1H), 4.76 (bs, 1H), 3.92 (d, *J* = 11.2 Hz, 1H), 2.63-2.74 (m, 2H), 2.44-2.50 (m, 1H), 1.50-1.70 (m, 5H), 1.34-1.50 (m, 2H), 1.38 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.7, 154.6, 79.8, 45.8, 44.5, 39.2, 28.8, 28.3, 25.2, 18.8. (b6p29)



Ketone 4.32: To a solution of **4.31** (410 mg, 1.80 mmol) in Et_2O (15 mL) at rt was slowly added a solution of MeMgBr (1.8 mL, 5.4 mmol, 3.0 M in Et_2O). The mixture was allowed to stir at rt for 2 h. The reaction was quenched with saturated aqueous NH_4Cl (5 mL). Then the solution was

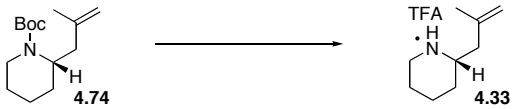
extracted with Et_2O (3 X 30 mL), the combined organic layers were dried over $MgSO_4$, and concentrated *in vacuo.*

To a solution of crude **4.73** (1.8 mmol) in CH_2Cl_2 (20 mL) was added sodium bicarbonate (756 mg, 9 mmol) followed by Dess Martin's reagent (1.56 g, 3.6 mmol). After 2 h the reaction was quenched with 10% aqueous sodium bicarbonate (10 mL), and extracted with Et_2O (3 X 30 mL). The combined organic layers were dried over $MgSO_4$, concentrated *in vacuo* and purified by chromatography over silica gel, eluting with 0-25% EtOAc/Hexanes to give known **4.32** (315 mg, 1.3 mmol, 73% over 2 steps) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 4.74 (d, *J* = 4.5 Hz, 1H), 3.98 (d, *J* = 12, 1H), 2.79 (t, *J* = 12.9 Hz, 1H), 2.66 (dd, *J* = 7.8, 1.8 Hz, 2H), 2.20 (s, 3H), 1.50-1.75 (m, 5H), 1.40-1.55 (m, 2H), 1.47 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 207.1, 154.7, 79.6, 47.3, 44.3, 39.4, 30.1, 29.7, 28.4, 25.3, 18.9. (b6p24/b6p27)



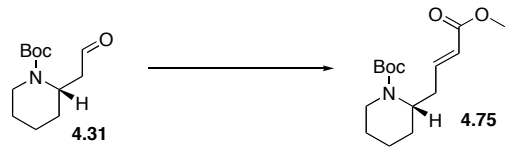
Alkene 4.74: To a solution of **4.32** (315 mg, 1.3 mmol) in THF (8 mL) was added a pre made solution of methyl triphenylphosphonium bromide (932.7 mg, 2.61 mmol) with n-BuLi (1.55 mL, 2.48 mmol, 1.6 M in hexanes) in THF (5 mL) at 0 °C. After 2 h, the reaction was quenched with water (5 mL), extracted with EtOAc (3 x 25 mL), the combined organic

layers were dried over $MgSO_4$, and concentrated *in vacuo* and purified by chromatography over silica gel, eluting with 0-25% EtOAc/Hexanes to give **4.74** (242 mg, 1.01 mmol, 78%) as a colorless oil. $[\alpha]_D$ -26.1 (c = 1.0, $CHCl_3$); IR (neat) 3073, 2974, 2934, 2856, 1693, 1647, 1413, 1364, 1266, 1161; ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.74 (d, *J* = 15.9 Hz, 2H), 4.38 (bs, 1H), 3.98 (d, *J* = 11.1 Hz, 1H), 2.81 (t, *J* = 12.9 Hz, 1H), 2.30-2.37 (m, 1H), 2.18-2.26 (m, 1H), 1.79 (s, 3H), 1.50-1.66 (m, 5H), 1.47 (s, 9H), 1.25-1.50 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0, 142.8, 112.6, 79.0, 48.5, 38.8, 38.1, 28.2, 27.3, 25.5, 22.1, 18.8; HRMS (EI+) calcd. for $C_{14}H_{25}NO_2$ (M+) 238.1807, found 238.1830. (b6p28)

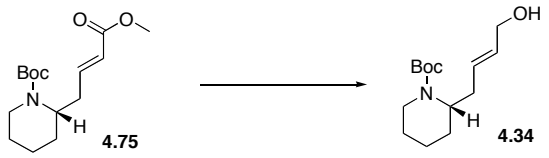


Alkene 4.33: To a solution of **4.74** (120 mg, .50 mmol) in CH_2Cl_2 (2.3 mL) was added TFA (2.3 mL). The solution was allowed to stir for 2 h. The solution was concentrated *in vacuo* to give **4.33** (127 mg, 0.5 mmol, >99%) as a colorless glassy solid. $[\alpha]_D$ -9.8 (c = 1.0, $CHCl_3$); IR (neat) 2950, 2865, 2545, 1780, 1674, 1437, 1202; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.46 (bs, 1H), 4.84 (d, *J* = 36.8 Hz, 2H), 3.39 (bs, 1H), 3.12 (bs, 1H), 2.90 (bs, 1H), 2.43 (bs, 1H), 2.26 (m, 1H), 1.70-1.90 (m, 3H), 1.60-1.70 (m, 4H), 1.40-1.55 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 138.9, 115.5, 55.2, 45.1,

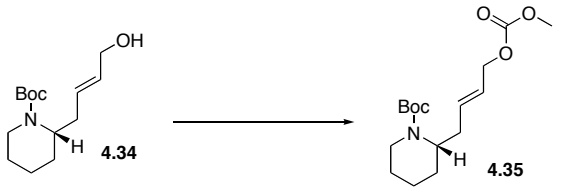
42.0, 28.4, 22.2, 21.7; HRMS (EI+) calcd. for $C_{11}H_{18}F_3NO_2$ (M+) 253.1290, found 253.1287. (b6p30)



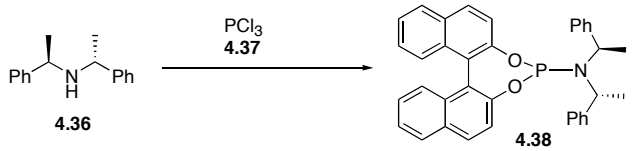
Ester 4.75: To a solution of **4.31** (450 mg, 1.97 mmol) in CH_2Cl_2 was added $Ph_3P{=}CHCO_2Me$ (522 mg, 2.96 mmol). After 16 h, the resulting solution was concentrated *in vacuo* then suspended in a 3:1 mixture of hexanes/ether (60 mL) and filtered over Celite®, then rinsed with a 3:1 mixture of hexanes/ether (30 mL). The resulting solution was concentrated *in vacuo* and purified by chromatography over silica gel, eluting with 10-30% EtOAc/Hexanes to give **4.74** (445 mg, 1.58 mmol, 80%) as a colorless oil. $[\alpha]_D$ -16.5 (c = 1.0, $CHCl_3$); IR (neat) 2975, 2936, 2858, 1725, 1689, 1412, 1272; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.86 (dt, *J* = 15.6 Hz, *J* = 7.6 Hz, 1H), 5.80 (d, *J* = 15.6, 1H), 4.34 (bs, 1H), 3.96 (d, *J* = 12 Hz, 1H), 3.66 (s, 3H), 2.71 (t, *J* = 12.9 Hz, 1H), 2.52-2.61 (m, 1H), 2.25-2.32 (m, 1H), 1.50-1.70 (m, 5H), 1.30-1.46 (m, 1H), 1.39 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.6, 154.8, 146.0, 122.6, 79.4, 51.3, 49.6, 38.7, 32.9, 28.3, 25.3, 18.8; HRMS (EI+) calcd. For $C_{15}H_{26}NO_4$ (M+) 284.1862, found 284.1868. (b6p25)



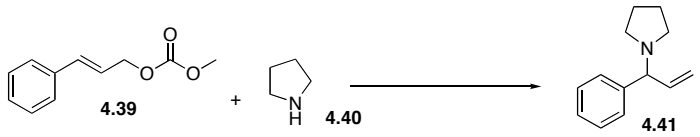
Alcohol 4.34: To a solution of **4.75** (356 mg, 1.258 mmol) in CH_2Cl_2 (12 mL) at -78 °C was added DIBAL-H (3.77 mL, 3.77 mmol, 1.0 M in CH_2Cl_2). After 2 h, the mixture was warmed to room temp and quenched with sat. aq. sodium tartrate (150 mL). After vigorous stirring for 1 h, the mixture was extracted with CH_2Cl_2 (3 x 50 mL) and washed with brine (30 mL). The dried ($MgSO_4$) extract was concentrated *in vacuo* and purified by chromatography over silica gel eluting with 20-40% EtOAc/Hexanes to give **4.34** (298 mg, 1.17 mmol, 93%) as a colorless oil. $[\alpha]_D$ -33.3 (c = 2.0, $CHCl_3$); IR (neat) 3446, 2933, 2859, 1685, 1418, 1364, 1162; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.54-5.66 (m, 2H), 4.22 (bs, 1H), 3.99-4.02 (m, 2H), 3.91 (d, *J* = 12.4 Hz, 1H), 2.72 (t, *J* = 12.8 Hz, 1H), 2.40 (bs, 1H), 2.33-2.38 (m, 1H), 2.12-2.19 (m, 1H), 1.50-1.70 (m, 5H), 1.40-1.50 (m, 1H), 1.39 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.2, 131.4, 129.0, 79.2, 63.2, 50.2, 38.9, 32.8, 28.4, 27.7, 25.4, 18.8; HRMS (EI+) calcd. For $C_{14}H_{26}NO_3$ (M+) 256.1913, found 256.1918. (b6p26)



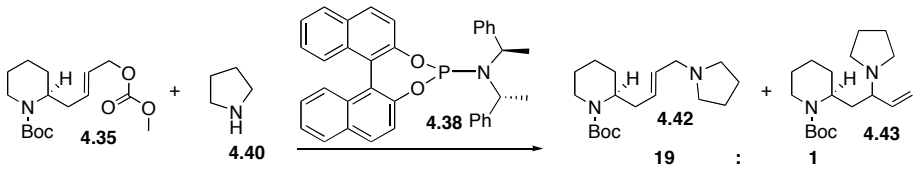
Carbonate 4.35: To a solution of **4.34** (158 mg, 0.62 mmol) in CH_2Cl_2 (10.0 mL) at 0 °C was added sequentially pyridine (147 mg, 0.150 mL, 1.86 mmol) and $ClCO_2Me$ (64.4 mg, 0.054 mL, 0.68 mmol). After 1 h, the solution was then diluted with water (15 mL) and sequentially extracted with EtOAc (3 x 20 mL). The combined organic layers were washed sequentially with brine (20 mL) and sat. aq. NH_4Cl (20 mL). The dried ($MgSO_4$) extract was concentrated *in vacuo* and purified by chromatography over silica gel eluting with 10-25% EtOAc/Hexanes to give **4.35** (158 mg, 0.502 mmol, 81%) as a colorless oil. $[\alpha]_D$ -27.4 (c = 1.0, $CHCl_3$); IR (neat) 2934, 2857, 1750, 1688, 1266; ^{1}H NMR (300 MHz, $CDCl_3$) 5.69-5.76 (m, 1H), 5.60-5.68 (m, 1H), 4.56 (d, *J* = 6 Hz, 2H), 4.28 (bs, 1H), 3.95 (d, *J* = 12.4 Hz, 1H), 3.78 (s, 3H), 2.75 (t, *J* = 12.8 Hz, 1H), 2.41-2.49 (m, 1H), 2.20-2.30 (m, 1H), 1.50-1.70 (m, 5H), 1.40-1.50 (m, 1H), 1.39 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 155.0, 133.6, 125.3, 79.2, 68.3, 54.7, 49.9, 38.9, 32.9, 28.4, 27.7, 25.4, 18.8; HRMS (EI+) calcd. For $C_{16}H_{28}NO_5$ (M+) 314.1967, found 314.1961. (b6p37)



Phosphoramidite 4.38: To a solution of **4.36** (143 mg, 0.546 mmol) in THF (9 mL) at -78 °C was added n-BuLi (0.375 mL, 0.6 mmol, 1.6 M in hexanes). After 30 min, a solution of **4.37** (75 mg, 48 µL, 0.546 mmol) in THF (1 mL) was added. The mixture was slowly warmed to 0 °C. After 3 h, Et_3N (275.7 mg, 0.38 mL, 2.73 mmol) was added to the solution followed by a solution of R-BINOL (148.5 mg, 0.546 mmol) in THF (6 mL). After 18 h, the mixture was concentrated *in vacuo* and purified by chromatography over silica gel, under N_2, eluting with 4:1 CH_2Cl_2/PE to give known **4.38** (221 mg, 0.41 mmol, 75%) as a fine white powder. m.p. 87-89 °C, ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.02 (d, *J* = 9 Hz, 1H), 7.94 (d, *J* = 9 Hz, 1H), 7.83 (d, *J* = 9 Hz, 1H), 7.75 (d, *J* = 9 Hz, 1H), 7.58 (d, *J* = 9 Hz, 1H), 7.30-7.45 (m, 4H), 7.10-7.25 (m, 13H), 4.47 (dq, *J* = 10.8 Hz, 6.9 Hz, 2H), 1.70 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.5, 149.8, 143.1, 132.8, 131.4, 130.4, 129.6, 128.3, 128.1, 128.0, 127.8, 127.3, 127.2, 126.7, 126.0, 125.8, 124.8, 124.3, 122.5, 122.4, 121.2, 54.5 (d, *J* = 10 Hz), 23.0 (d, *J* = 12 Hz); ^{31}P NMR (121 MHz, $CDCl_3$) 150.5.

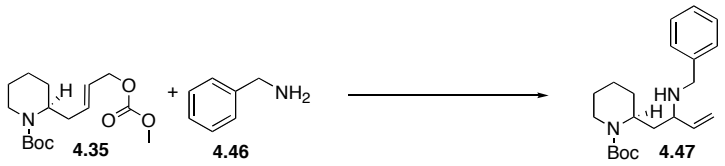


Amine 4.41: To a solution of **4.39** (50 mg, 0.26 mmol) in THF (0.1 mL) was added sequentially a pre-made solution (0.1 mL) of $[Ir(COD)Cl]_2$ (14 mg 0.026 mmol) and **4.38** (8.8 mg, 0.013 mmol) in THF (1 mL) and piperidine **4.40** (24 mg, 28 µL, 0.338 mmol). After 18 h, the reaction was concentrated *in vacuo* and purified by chromatography over silica gel eluting with 5-20% EtOAc/Hexanes to give known **4.41** (31.5 mg, 0.17 mmol, 65%) as a colorless oil. $[\alpha]_D$ -69.7 (c = 1.55, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.28-7.37 (m, 4H), 7.20-7.25 (m, 1H), 6.0-6.12 (m, 1H), 5.20 (dd, *J* = 17.2, 1.2 Hz, 1H), 5.00 (dd, *J* = 10.0, 1.2 Hz, 1H), 3.58 (d, *J* = 8.8 Hz, 1H), 2.45-2.54 (m, 2H), 2.33-2.42 (m, 2H), 1.76 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.7, 141.0, 128.5, 127.6, 127.1, 115.1, 75.2, 53.0, 23.3.



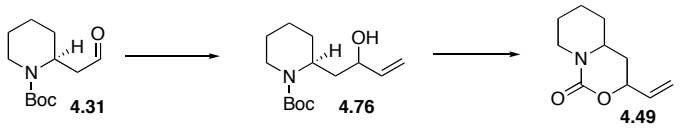
Amines 4.42/4.43: To a solution of **4.35** (25 mg, 0.08 mmol) and **4.40** (7.4 mg, 0.10 mmol) in THF (0.5 mL) was added a pre-made solution of **4.38** (2.7 mg, 0.004 mmol) and $[Ir(COD)Cl]_2$ (4.3 mg, 0.008 mmol) in THF (0.25 mL) at rt. After 16h, the solution was concentrated *in vacuo* and

purified by chromatography over basic alumina eluting 10-30% EtOAc/Hexanes to give a 19:1 mixture of **4.42** (19 mg, 0.064 mmol, 80%) and **4.43** (1 mg, 0.003 mmol, 4%) as colorless oils. $[\alpha]_D$ -28.5, (c = 0.85, $CHCl_3$); IR (neat) 2930, 2850, 2778, 1694, 1164; ^1H NMR (300 MHz, $CDCl_3$) 5.48-5.68 (m, 2H), 4.25 (bs, 1H), 3.95 (d, *J* = 12.4 Hz, 1H), 3.01 (d, *J* = 6 Hz, 2H), 2.75 (t, *J* = 12.8 Hz, 1H), 2.48 (s, 3H), 2.20-2.45 (m, 2H), 1.77 (s, 4H), 1.50-1.60 (m, 6H), 1.44 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0, 129.8, 79.0, 58.2, 53.9, 39.0, 33.0, 30.3, 29.7, 28.5, 27.5, 25.5, 23.4, 18.8; HRMS (EI+) calcd. For $C_{18}H_{32}N_2O_2$ (M+) 308.4589, found 309.2543. (b6p44)



Amine 4.47: To a solution of **4.35** (23 mg, 0.073 mmol) and **4.46** (11.8 mg, 0.11 mmol) in THF (0.45 mL) was added a pre-made solution of **4.38** (4.0 mg, 0.007 mmol) and $[Ir(COD)Cl]_2$ (2.5 mg, 0.0035 mmol) in THF (0.25 mL) at rt. After 16 h, the solution was then concentrated *in vacuo* and purified by chromatography over silica gel eluting with 20-60% EtOAc/Hexanes to obtain **4.47** (6.3 mg, 0.0018 mmol, 25%) as a colorless oil. $[\alpha]_D$ -22.0, (c = 0.7, $CHCl_3$); IR (neat) 3307, 2928, 2853, 1684, 1167; ^1H NMR (300 MHz, $CDCl_3$) δ 7.22-7.36 (m, 5H), 5.63-5.75 (m, 1H), 5.13-5.21 (m, 2H), 4.36 (bs, 1H) 3.95 (bs, 1H), 3.84 (d, *J* = 13.2 Hz, 1H), 3.64 (d, *J* =

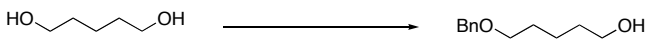
12.9 Hz, 1H), 3.00-3.10 (m, 1H), 2.72-2.88 (m, 1H), 1.82-1.98 (m, 1H), 1.77 (s, 4H), 1.50-1.60 (m, 6H), 1.44 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 140.6, 128.4, 128.2, 126.8, 116.4, 79.3, 58.7, 51.2, 36.5, 30.3, 29.7, 29.3, 29.0, 28.5, 25.6, 22.7, 19.1; HRMS (EI+) calcd. For $C_{21}H_{32}N_2O_2$ (M+) 344.2464, found 344.2470. (b6p52)



Carbonate 4.49: To a stirred solution of **4.31** (100 mg, 0.439 mmol) in THF (4 mL) was added vinyl magnesium bromide (1.3 mL, 1.316 mmol, 1.0 M in THF) at rt. After 2 h, the reaction was quenched with sat. aq. NH_4Cl (1 mL) and extracted with Et_2O (5 mL x 3). The dried ($MgSO_4$) extract was concentrated *in vacuo* and purified by chromatography over silica gel eluting 10-40% EtOAc/Hexanes to give **4.76** (76 mg, 0.298 mmol, 68%) as a colorless oil and a 1:1 mixture of diastereomers that were carried on without further purification.

To a stirred solution of **4.76** (30 mg, 0.117 mmol) in CH2CL2 (1.1 mL) at -10 ºC was added sequentially Et_3N (15.5 mg, 21 µL, 0.153 mmol) and MsCl (15.5 mg, 10.5 µL, 0.135 mmol) dropwise. After 30 min. the reaction was cooled to -30 ºC and piperidine (15 mg, 17.5 µL, 0.176 mmol) was added. The resulting mixture was allowed to warm to -15 ºC and after 16 h, the reaction was quenched with sat. aq. $NaHCO_3$ (1 mL) and

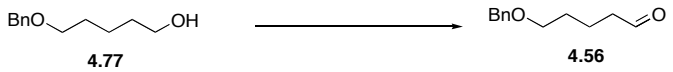
extracted with CH_2Cl_2 (5 mL x 3). The dried ($MgSO_4$) extract was concentrated *in vacuo* and purified by chromatography over silica gem eluting 10-40% EtOAc/Hexanes to give **4.49** (14 mg, 0.077 mmol, 66%) as a white waxy oil. $[\alpha]_D$ -6.3, (c = 0.75, $CHCl_3$); IR (neat) 3322, 2941, 2859, 1681, 1456, 1119, 748; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.84-5.93 (m, 1H), 5.38 (d, *J* = 17.2 Hz, 1H), 5.25 (d, *J* = 10.8 Hz, 1H), 4.61-4.66 (m, 1H), 4.49 (d, *J* = 11.2 Hz, 1H), 3.32-3.37 (m, 1H), 2.66 (t, *J* = 13.2 Hz, 1H), 2.12-2.18 (m, 1H), 1.86 (d, *J* = 10.4 Hz, 2H), 1.61-1.69 (m, 3H), 1.40-1.52 (m, 3H), 1.19-1.41 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 153.3, 135.3, 117.1, 75.2, 53.9, 44.7, 36.0, 33.5, 24.9, 23.6; HRMS (EI+) calcd. For $C_{10}H_{15}NO_2$ (M+) 181.1103, found 181.1110. (b6p58)



4.55 **4.77**

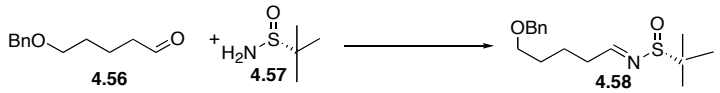
Alcohol 4.77: To a suspension of NaH (384 mg, 9.6 mmol, 60 % in mineral oil) in DMF (20 mL) was added **4.55** (1000 mg, 9.6 mmol) at 0ºC. After 30 min, the solution was recooled to 0ºC and BnBr (1,641 mg, 1.148 mL, 9.6 mmol) was added slowly followed by TBAI (176.8 mg, 0.48 mmol). Next, the mixture was allowed to warm to rt. After 16h, the reaction was quenched with sat. NH_4Cl (50 mL) and extracted with EtOAc (3 x 50 mL). The dried ($MgSO_4$) extract was concentrated *in vacuo* and purified by chromatography over silica gel eluting with 20-50% EtOAc/Hexanes to obtain known **4.77** (1.01 g, 5.184 mmol, 54%) as a colorless oil. ^{1}H NMR

(300 MHz, $CDCl_3$) 7.25-7.40 (m, 5H), 4.52 (s, 2H), 3.63 (t, *J* = 6.6 Hz, 2H), 3.50 (t, *J* = 6.3 Hz, 2H), 1.88 (bs, 1H), 1.55-1.70 (m, 4H), 1.42-1.51 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 138.6, 128.4, 127.7, 127.6, 72.9, 70.3, 62.7, 32.5, 29.5, 22.4. (b6p71)

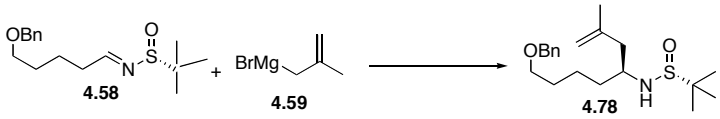


4.77 **4.56**

Aldehyde 4.56: To a solution of oxalyl chloride (980.7 mg, 0.663 mL, 7.726 mmol) in CH_2Cl_2 (15 mL) at -78ºC was added a solution of DMSO (644 mg, 0.585 mL, 8.24 mmol) in CH_2Cl_2 (4 mL). After 10 min, **4.77** (1000 mg, 5.15 mmol) in CH_2Cl_2 (5 mL) was added at -78ºC dropwise. After 1.5 h, Et_3N (2,343 mg, 3.23 mL, 23.18 mmol) was added and the mixture was warmed to 0ºC. Once the mixture reached 0 ºC, the reaction was quenched with water (25 mL) and extracted with CH_2Cl_2 (3 x 25 mL). The combined organic layers were washed with brine (25 mL) and the dried ($MgSO_4$) extract was concentrated *in vacuo* and purified by chromatography over silica gel eluting with 10-25% EtOAc/Hexanes to obtain **4.56** (760 mg, 3.9 mmol, 77%) as a colorless oil. ^1H NMR (300 MHz, $CDCl_3$) 9.78 (s, 1H), 7.25-7.40 (m, 5H), 4.52 (s, 2H), 3.51 (t, *J* = 6.3 Hz, 2H), 2.45-2.54 (m, 2H), 1.55-1.80 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 202.5, 138.5, 128.4, 127.7, 72.9, 69.7, 43.6, 29.2, 19.0. (b6p72)



Sulfonimine 4.58: To a solution of **4.56** (740 mg, 3.85 mmol) and **4.57** (389 mg, 3.21 mmol) in CH_2Cl_2 (15 mL) was added Cs_2CO_3 (1254 mg, 3.85 mmol) and the mixture was heated to reflux. After 18 h, the mixture was cooled to rt and filtered through a pad of Celite®. Then washed with CH_2Cl_2 (3 x 15 mL), the combined filtrates were dried ($MgSO_4$), concentrated *in vacuo* and purified by chromatography over silica gel eluting with 10-25% EtOAc/Hexanes to obtain known **4.58** (856 mg, 2.89 mmol, 90%) as a pale yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.08 (t, J = 6 Hz, 1H), 7.25-7.40 (m, 5H), 4.51 (s, 2H), 3.50 (t, J = 6.3 Hz, 2H), 2.45-2.54 (m, 2H), 1.70-1.85 (m, 4H), 1.20 (s, 9H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 169.4, 138.5, 128.4, 127.6, 72.9, 69.7, 56.5, 35.8, 29.3, 22.3. (b6p73)



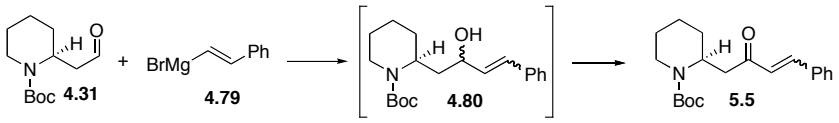
Sulfonamide 4.78: To a solution of **4.58** (700 mg, 2.37 mmol) in PhMe (12 mL) at -78ºC was added a premade solution of **4.59** (7.11 mL, 3.55 mmol, 0.2 M in THF) slowly. After 2 h the reaction mixture was quenched with aq. sat. Na_2SO_4 (15 mL) and warmed to rt. The dried ($MgSO_4$) mixture was filtered through Celite®, concentrated *in vacuo*, and purified by chromatography over silica gel eluting with 20-50% EtOAc/Hexanes to obtain **4.78** (708 mg, 2.01 mmol, 85%) as a colorless

oil. $[\alpha]_D$ -66.3 (c = 1.00, $CHCl_3$); IR (neat) 3268, 3225, 3069, 3030, 2937, 2861, 1652, 1455, 1363, 1069; ^1H NMR (400 MHz, $CDCl_3$) δ 7.25-7.40 (m, 5H), 4.84 (d, *J* = 28.4 Hz, 2H), 4.50 (s, 2H), 3.49 (t, *J* = 6.3 Hz, 2H), 3.36-3.48 (m, 1H), 3.25 (s, 1H), 2.32-2.45 (m, 1H), 2.22-2.32 (m, 1H), 1.75 (s, 3H), 1.60-1.71 (m, 2H), 1.45-1.60 (m, 4H), 1.20 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.4, 138.6, 130.1, 128.4, 127.6, 114.2, 72.9, 69.9, 56.5, 51.5, 44.4, 35.1, 29.5, 22.6, 21.7. HRMS (EI+) calcd. For $C_{20}H_{34}O_2NS$ (M+) 352.2310, found 352.2304. (b6p77)

4.78 **4.53**

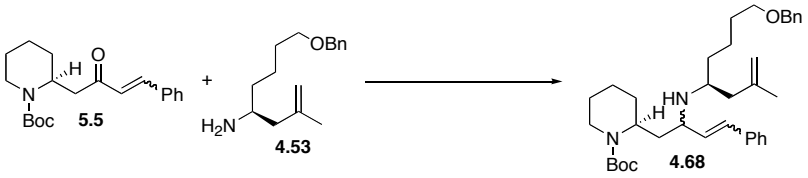
Amine 4.53: To a solution of **4.78** (190 mg, 0.54 mmol) in MeOH (3.5 mL) was added conc. HCl (0.084 mL, 1.08 mmol, 12.8 M). The resulting solution was allowed to stir for 1h before being concentrated *in vacuo*, and purified by chromatography over silica gel eluting with 50% EtOAc/Hexanes to 10% MeOH/CH_2Cl_2 to obtain **4.53** (155 mg, 0.54 mmol, >99%) as the HCl salt which was then dissolved in aq. sat. Na_2CO_3 (15 mL), and extracted with CH_2Cl_2 (3 x 15 mL) to obtain **4.53** as the free amine. $[\alpha]_D$ -0.57 (c = 1.15, $CHCl_3$); IR (neat) 3069, 3030, 2933, 2856, 1646, 1455, 1102; ^1H NMR (300 MHz, $CDCl_3$) δ 7.25-7.40 (m, 5H), 4.80 (d, *J* = 23.4 Hz, 2H), 4.52 (s, 2H), 3.50 (t, *J* = 6.3 Hz, 2H), 2.90 (bs, 1H), 2.15-2.21 (m, 1H), 1.86-1.98 (m, 1H), 1.74 (s, 3H), 1.60-1.71 (m, 2H), 1.35-1.60

(m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.3, 138.6, 128.3, 127.6, 127.5, 112.7, 72.9, 70.3, 48.4, 46.9, 37.7, 29.8, 22.9, 22.3. HRMS (EI+) calcd. For $C_{16}H_{25}NO$ (M+) 248.2014, found 248.2012. (b6p80)



Ketone 5.5: To a solution of **4.31** (530 mg, 2.09 mmol) in THF (15 mL) was added a premade solution of **4.39** (8 mL, 4.0 mmol, 0.2 M in THF) at rt. After 2 h the reaction was quenched with saturated (aq) NH_4Cl (5 mL), extracted with Et_2O (3 x 30 mL) and washed with brine (15 mL). The dried ($MgSO_4$) extract was concentrated *in vacuo* to provide crude **4.80** that was carried on without purification. To a solution of crude **4.80** (2.09 mmol) in CH_2Cl_2 (45 mL) was added sodium bicarbonate (877.8 mg, 10.45 mmol) followed by Dess Martin's reagent (1.77 g, 4.18 mmol) at rt. After 3 h the reaction was quenched with saturated aq. sodium bicarbonate (15 mL). Then the solution was extracted with Et_2O (3 x 30 mL). The dried ($MgSO_4$) extract was concentrated *in vacuo* and purified by chromatography over silica gel, eluting with 5-20% EtOAc/Hexanes to give **5.5** (327 mg, 1.0 mmol, 48% over 2 steps) as a pale yellow oil. $[\alpha]_D$ +28.3 (c = 0.8, $CHCl_3$); IR (neat) 2975, 2934, 2861, 1685, 1163 ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53-7.63 (m, 2H), 7.38-7.41 (m, 2H), 7.31-7.36 (m, 1H), 6.86 (d, *J* = 12.8 Hz, 1H of the minor isomer), 6.79 (d, *J* = 16 Hz, 1H of

major isomer), 6.24 (d, *J* = 12.8 Hz, 1H or minor isomer), 4.81 (bs, 1H), 4.05 (bs, 1H), 2.81-2.96 (m, 2H), 2.68 (d, *J* = 7.6, 1H of major isomer), 1.50-1.80 (m, 5H), 1.48 (s, 11H); ^{13}C NMR (400 MHz, $CDCl_3$) δ 200.9, 198.4, 154.8, 154.7, 143.0, 140.2, 135.2, 134.5, 133.1, 130.5, 129.2, 128.9, 128.6, 128.4, 128.3, 126.7, 126.1, 79.6, 47.9, 44.2, 41.6, 39.4, 28.4, 28.2, 25.3, 18.9. HRMS (EI+) calcd. For $C_{20}H_{28}NO_3$ (M+) 330.2069, found 330.2074. (b7p63/64)

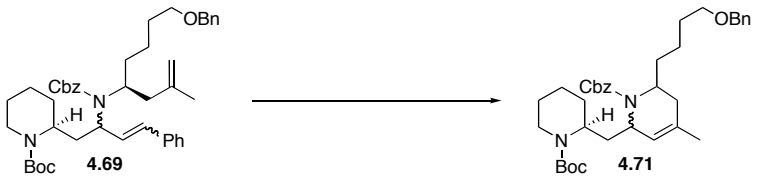


Amine 4.68: To a neat mixture of **5.5** (320 mg, 0.966 mmol) and **4.53** (263mg, 1.06 mmol) was added Ti(O*i*-Pr)$_4$ (439 mg, 0.47 mL, 1.545 mmol) at rt. After 3 h, MeOH (4.5 mL) was added followed by $NaBH_4$ (58.5 mg, 1.55 mmol). After 5 min, the reaction was quenched with 1 M NaOH (1 mL, 1 mmol). The mixture was diluted with Et_2O (10 mL) and filtered through Celite®, washed with Et_2O (15 mL), and extracted with Et_2O (15 mL). The dried ($MgSO_4$) extract was concentrated *in vacuo*, and purified by chromatography over silica eluting with 10-50% EtOAc/Hexanes to obtain **4.68** (276 mg, 0.492 mmol, 51%) as a colorless 1:1 mixture of diastereomers. IR (neat) 2932, 2855, 1686, 1165; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.23-7.40 (m, 20H, mixed isomers), 6.49 (d, *J* = 15.6 Hz, 1H, single isomer), 6.38 (d, *J* = 15.6 Hz, 1H, single isomer), 5.99 (dd, *J* = 16,

8.4 Hz, 1H, single isomer), 5.86 (m, 1H, single isomer), 4.82 (d, *J* = 15.6 Hz, 2H, single isomer), 4.76 (d, *J* = 14.8 Hz, 2H, single isomer), 4.52 (s, 2H, single isomer), 4.46 (s, 2H, single isomer), 4.34 (bs, 2H, mixed isomers), 3.98 (bs, 2H, mixed isomers), 3.50 (t, *J* = 6.4 Hz, 2H, single isomer), 3.43 (t, *J* = 6.4 Hz, 2H, single isomer), 3.25-3.35 (m, 1H, single isomer), 3.17-3.25 (m, 1H, single isomer), 2.70-2.90 (m, 4H, mixed isomers), 2.20-2.30 (m, 2H,mixted isomers), 1.90-2.10 (m, 4H, mixed isomers), 1.78 (s, 3H, single isomer), 1.63 (s, 3H, single isomer), 1.30-1.65 (m, 26H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9, 143.7, 143.5, 138.7, 137.2, 136.9, 133.7, 132.5, 131.2, 130.9, 128.5, 128.4, 128.3, 127.6, 127.5, 127.4, 127.3, 127.2, 126.8, 126.3, 113.3, 112.7, 79.2, 72.9, 72.8, 70.43, 70.38, 56.5, 55.6, 52.5, 50.6, 48.0, 43.8, 43.5, 39.4, 37.2, 36.5, 35.1, 34.2, 30.2, 29.9, 29.7, 29.1, 28.5, 27.6, 25.6, 22.7, 22.5, 22.2, 22.0; HRMS (EI+) calcd. For $C_{36}H_{52}N_2O_3$ (M+) 560.3978, found 561.4636. (b7p66)

Alkene 4.69: To a stirred solution of **4.68** (56 mg, 0.10 mmol) in THF (1.5 mL) was added NaH (5 mg, 0.125 mmol, 60 % in mineral oil) at rt. After 30 min, CbzCl (43 mg, 36 µL, 0.25 mmol) was added. After 2 h, the reaction was quenched with sat. aq. $NaHCO_3$ (1 mL). The mixture was diluted with H_2O (5 mL) and extracted with Et_2O (5 mL x 3). The dried

($MgSO_4$) filtered was concentrated *in vacuo* and purified by chromatography over silica eluting with 10-50% EtOAc/Hexanes to obtain **4.69** (52 mg, 0.077 mmol, 77%) as a colorless oil and a mixture of 2 diastereomers. ^{1}H NMR (400 MHz, $CDCl_3$) δ 725-7.42 (m, 15H), 6.69 (bs, 1H), 6.37 (bs, 1H), 5.3 (bs, 1H), 5.15 (s, 2H), 4.60-4.85 (m, 3H), 4.50 (s, 2H), 4.25-4.35 (m, 2H), 4.15-4.25 (m, 1H), 3.85-4.05 (bs, 1H), 3.78 (t, *J* = 6.8 Hz, 1H), 3.4-3.55 (m, 2H), 3.20-3.30 (m, 1H), 2.60-2.95 (m, 2H), 2.20-2.45 (m, 2H), 1.88 (t, *J* = 3.6 Hz, 1H), 1.30-1.70 (m, 22H); ^{1}H NMR (400 MHz, DMSO) δ 7.20-7.37 (m, 15H), 6.50 (bs, 2H), 5.10 (m, 2H), 4.76 (d, *J* = 17.6 Hz, 1H), 4.63 (d, *J* = 28 Hz, 1H), 4.44 (s, 1H), 4.27 (s, 1H), 4.16 (bs, 1H), 3.70-3.95 (m, 2H), 3.41 (s, 1H), 3.19 (s, 1H), 2.65-2.80 (m, 1H), 2.15-2.45 (m, 2H), 2.03 (m, 1H), 1.20-1.80 (m, 24H); ^{13}C NMR (100 MHz, DMSO) δ 154.7, 154.4, 143.3, 142.7, 139.2, 139.1, 137.4, 137.2, 131.6, 129.0, 128.9, 128.8, 128.7, 128.6, 128.5, 128.3, 128.2, 127.9, 127.7, 127.6, 113.0, 79.1, 78.8, 72.3, 72.1, 70.1, 70.0, 66.5, 55.3, 48.9, 42.0, 32.5, 30.2, 29.6, 29.4, 28.5, 28.4, 27.4, 25.8, 25.5, 23.9, 23.2, 22.6, 19.3, 19.0; HRMS (EI+) calcd. For $C_{45}H_{58}N_2O_5$ (M+) 694.4346, found 694.6009. (b7p68)



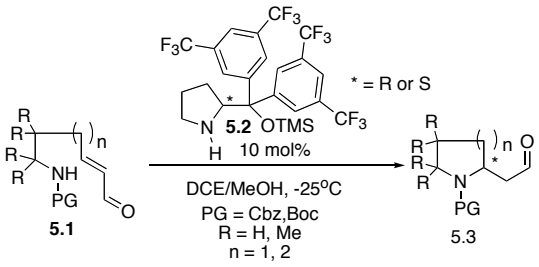
Alkene 4.71: To a refluxing stirred solution of **4.69** (55 mg, 0.81

mmol) in PhMe (5 mL) was added via syringe pump over 2 h a solution of Grubb's 2nd generation catalyst (20.6 mg, 0.024 mmol, 30 mol % of catalyst) in PhMe (10 mL). After 2 h, the addition was complete. The mixture was then cooled to rt, concentrated *in vacuo*, and purified by chromatography over silica eluting with 10-35% EtOAc/Hexanes to obtain **4.71** (45 mg, 0.076 mmol, 94%) as a light brown oil and a mixture of diastereomers. ^{1}H NMR (400 MHz, DMSO) δ 7.28-7.37 (m, 10H), 5.79 (bs, 1H), 5.15 (d, *J* =12.4 Hz, 1H), 5.01 (d, *J* = 12.4 Hz, 1H), 4.42 (s, 2H), 3.91 (bs 1H), 3.80-3.94 (m, 2H), 3.71 (bs, 1H), 3.37 (t, *J* = 4 Hz, 2H) 2.78 (bs, 1H), 2.42 (bs, 1H), 2.30 (d, *J* = 14.4 Hz, 1H), 1.97 (d, *J* = 16 Hz, 1H), 1.73 (s, 3H), 1.2-1.6 (m, 20H); ^{13}C NMR (100 MHz, DMSO) δ 155.3, 154.4, 139.2, 137.2, 132.9, 128.8, 128.6, 128.5, 128.4, 127.8, 127.7, 122.8, 78.9, 72.3, 69.9, 66.6, 52.3, 50.2, 35.8, 33.5, 31.9, 29.6, 28.6, 25.6, 24.2, 23.6, 19.1; HRMS (EI+) calcd. For $C_{36}H_{51}N_2O_5$ (M+) 591.3798, found 591.3794. (b7p74)

Chapter 5. Future Plans and Conclusion

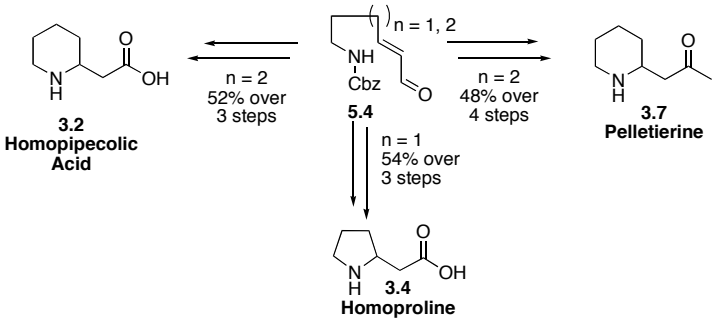
The work highlighted in this dissertation has illustrated the advances that our research group has made in the area organocatalysis for heteroatom Michael additions and the application of this methodology to synthesize multiple natural products. The process of this work started with the development and optimization of the organocatalyzed heteroatom Michael addition (Scheme 5.1). A general scope for the synthesis of piperidine, pyrrolidine and indoline ring systems has been explored.

Scheme 5.1. Organocatalyzed Heteroatom Michael Addition



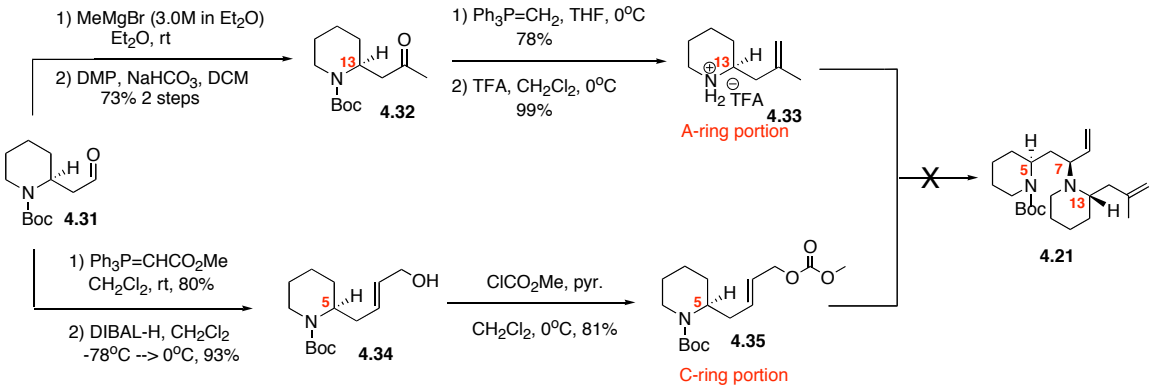
The methodology was applied to the synthesis of several natural products. Using this methodology we were able to use a similar intermediate for the rapid synthesis of homoproline, homopipecolic acid and pelleterine (Scheme 5.2). This highlights some of the advantages of the methodology in the ability to access a variety of products starting from similar simple materials.

Scheme 5.2. Synthesis of natural products



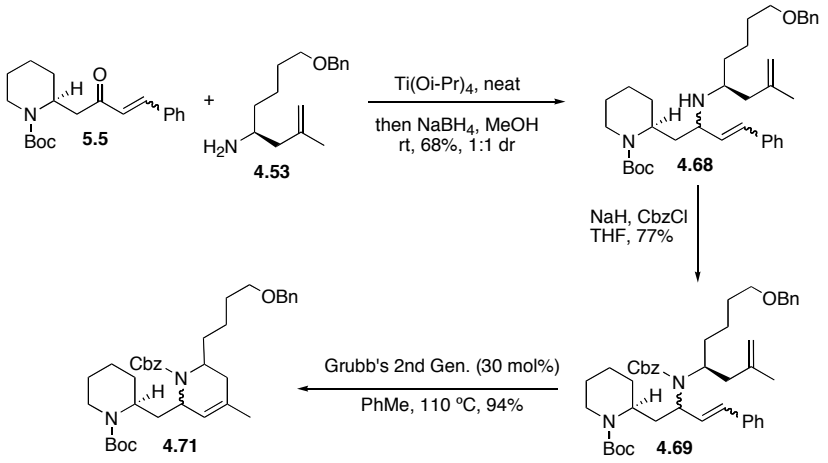
We have also applied this methodology toward the total synthesis of cermizine D (Scheme 5.3). Our original approach accessed the A and C rings of cermizine D via our organocatalyzed Micheal reaction. Unfortunately, subsequent Hartwig style amination proved problematic.

Scheme 5.3. Original Synthetic Plan for Cermizine D



Our revised approach continued to exploit the organocatalyzed Micheal addition (Scheme 5.4). Reductive amination using $Ti(OiPr)_4$ was now used to couple the two fragments successfully. The following ring closing metathesis on the Cbz protected amine has been accomplished to form the ring.

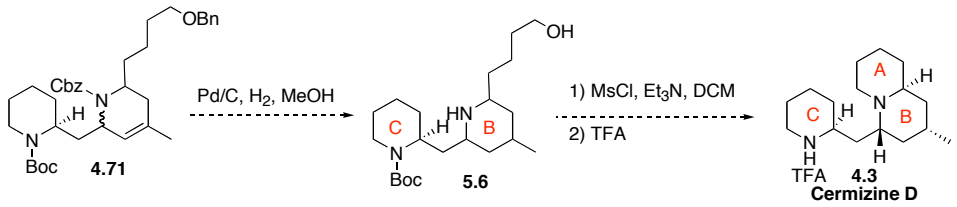
Scheme 5.4. Revised Synthesis for Cermizine D



The synthesis of cermizine is well on its way with two of the rings formed and all of the carbons present in the current advanced intermediate **4.71**. The remaining work on the total synthesis of cermizine D includes the optimization of the reductive amination in order to improve the diastereoselectivity of the product. It is possible that just by reducing the temperature at which the reduction takes place that the selectivity may increase. Following the RCM, global hydrogenation should remove both the Cbz and the benzyl protecting groups as well as reduce the alkene in the newly formed ring. We are uncertain of the diastereoselectivity on the alkene reduction. Activation of the alcohol with mesyl chloride should allow for spontaneous cyclization with the amine to close the third and final ring and complete the carbon structure of cermizine D. Final deprotection of the Boc protecting group and formation of a salt, most likely the TFA salt formed from in the same step will complete the total synthesis of cermizine

D (Scheme 5.5).

Scheme 5.5. Proposed Completion of Cermizine D.



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[28]. An "aged" catalyst is defined as exposure of 2nd Generation Grubbs catalyst purchased from Sigma-Aldrich Corporation (Cat# 569747) to air *via* an unsealed (open) vial. After 72 h, the vial was resealed that catalyst was ready for use.

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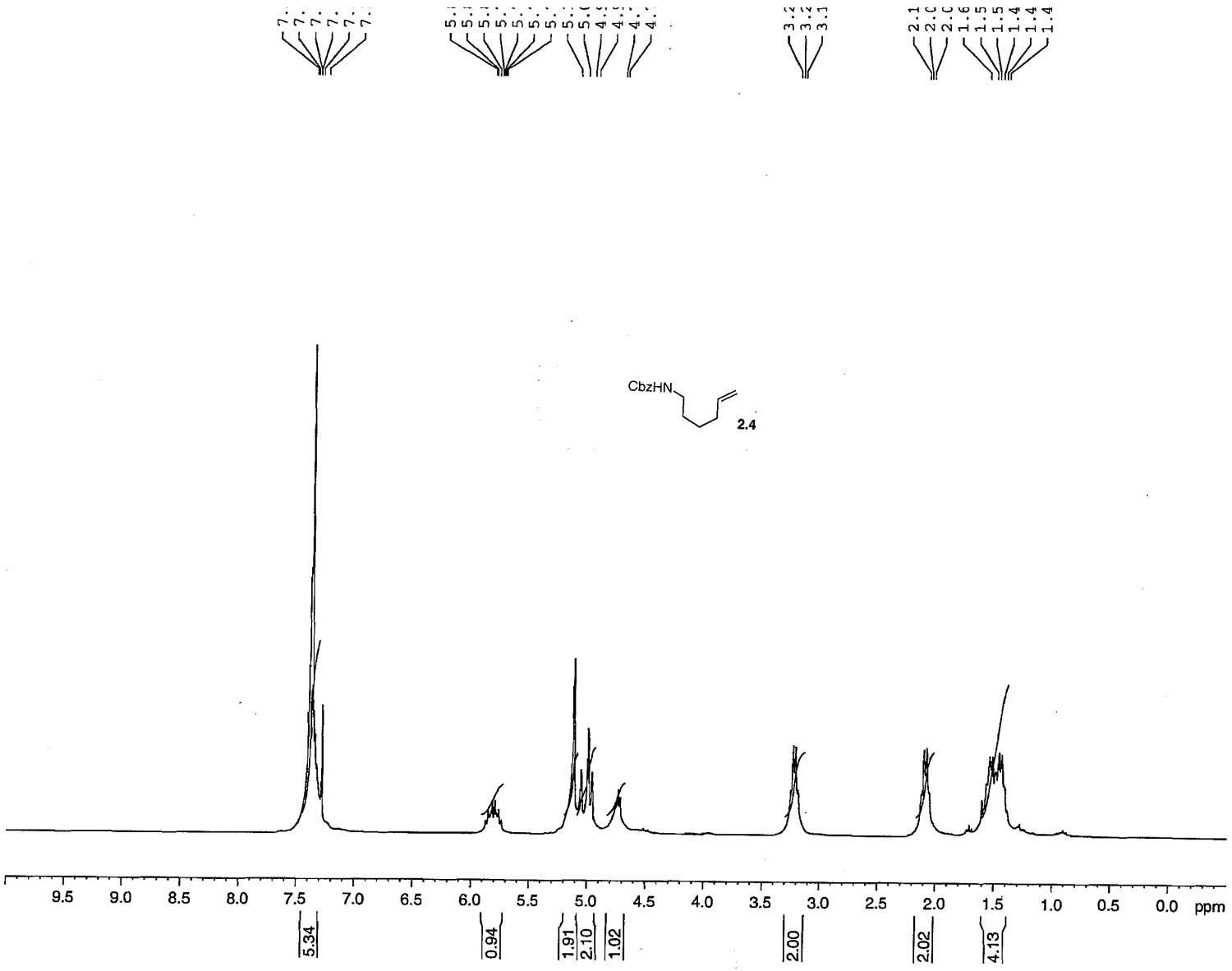
Appendices

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DU
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Time                    1
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PROBHD     5 mm QNP
PULPROG
TD                      3
SOLVENT                 C
NS
DS
SWH                  4789
FIDRES               0.14
AQ                3.421
RG                      4
DW                    104
DE
TE                      2
D1                2.0000
TD0

========= CHANNEL f1
NUC1
P1
PL1                     -
SFO1             300.132

F2 - Processing par
SI                      3
SF             300.130
WDW
SSB
LB                      (
GB
PC                      1
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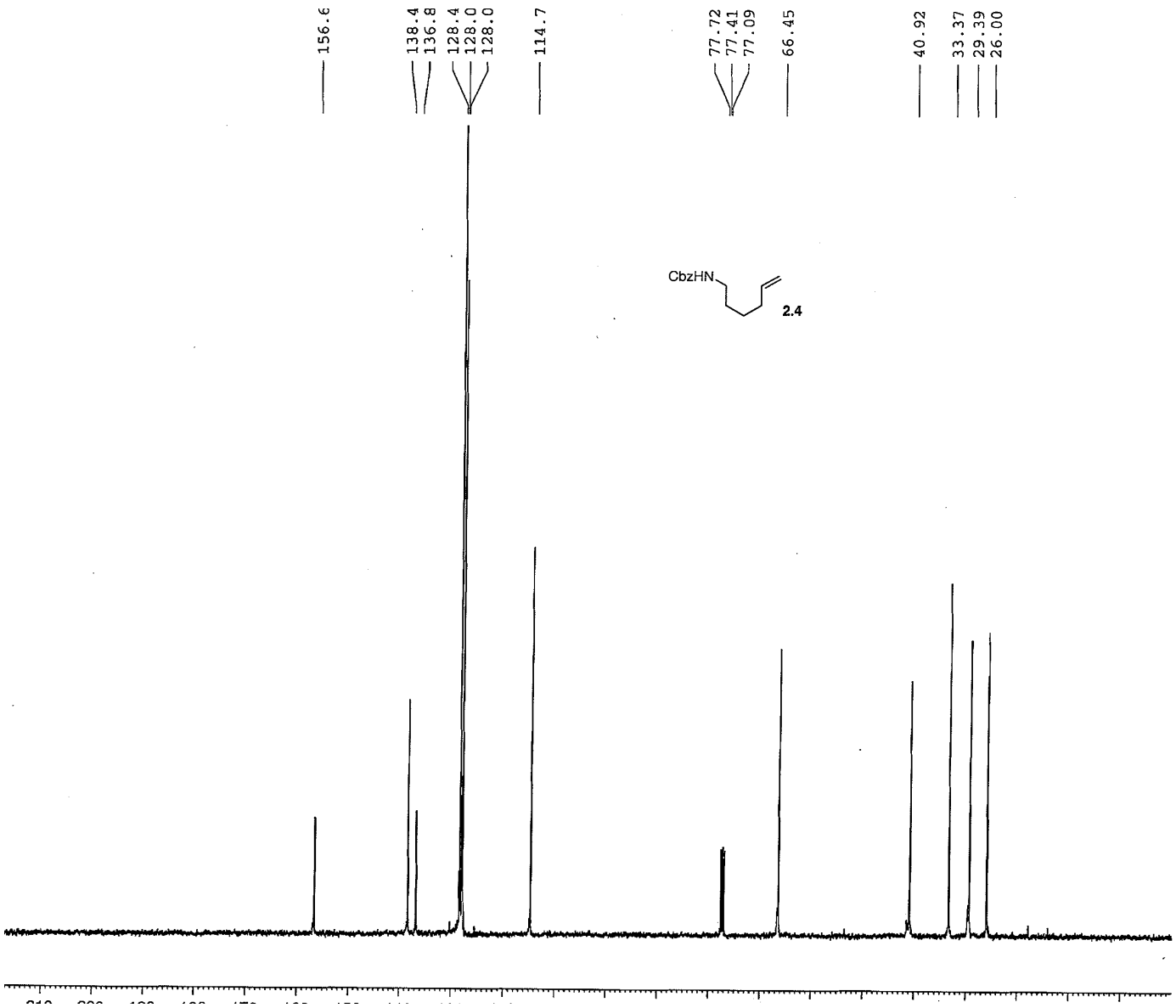

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DU	/m
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PULPROG	zgpg30
TD	65536
SOLVENT	
NS	95
DS	4
SWH	25125.629 Hz
FIDRES	0.383387 Hz
AQ	1.3042164 sec
RG	9195.2
DW	19.900 usec
DE	6.00 usec
TE	298.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1

======== CHANNEL f1 ========

NUC1	13C
P1	7.80 usec
PL1	-3.00 dB
SFO1	100.5936591 MHz

======== CHANNEL f2 ========

CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00 usec
PL2	17.40 dB
PL12	17.40 dB
PL13	17.40 dB
SFO2	400.0116000 MHz

F2 - Processing parameters

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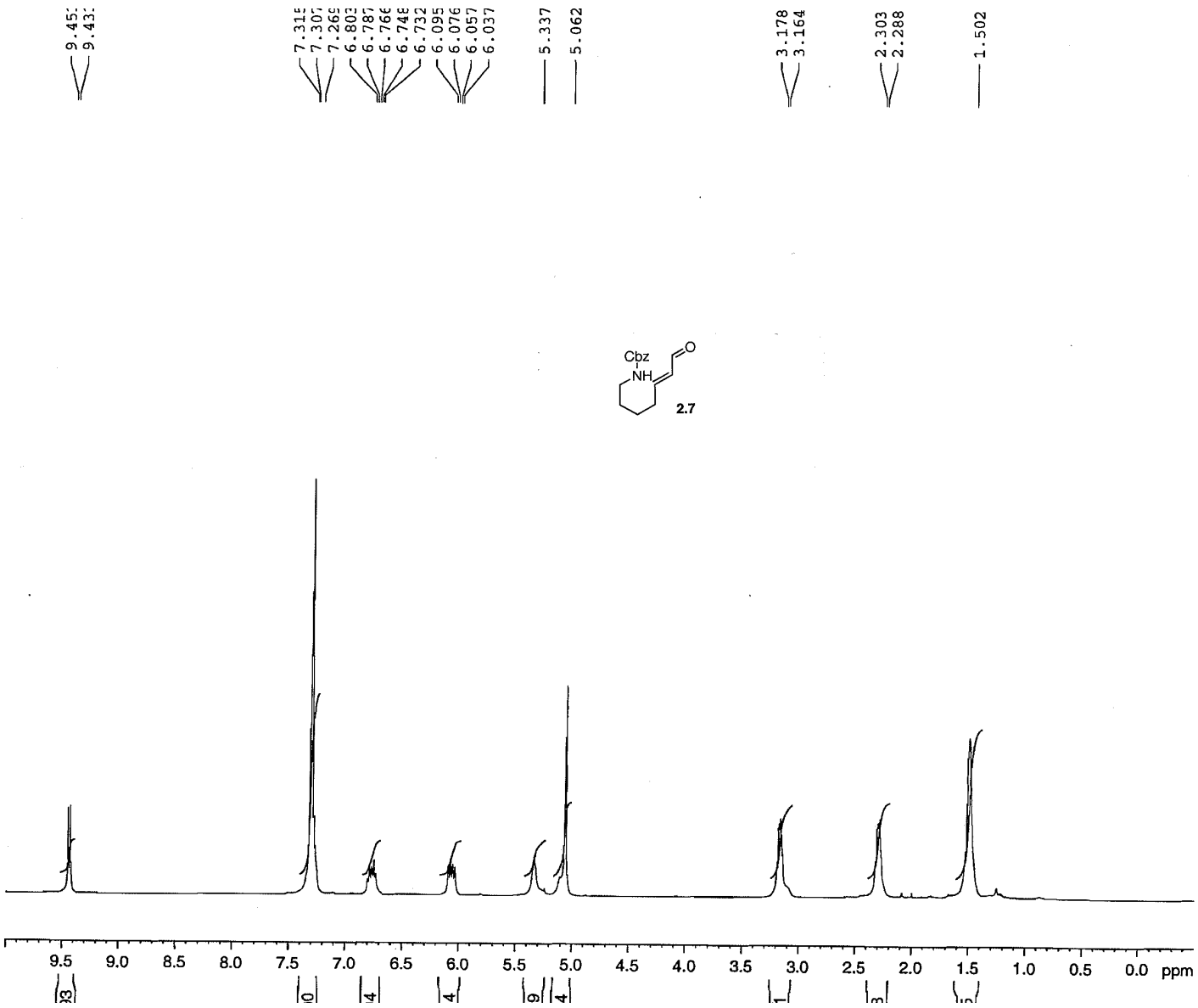

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PROCNO	7643
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USER	erikc

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PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	9
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	28.5
DW	78.000 usec
DE	6.00 usec
TE	299.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

NUC1	1H
P1	14.70 usec
PL1	0.00 dB
SFO1	400.0128001 MHz

F2 - Processing parameters

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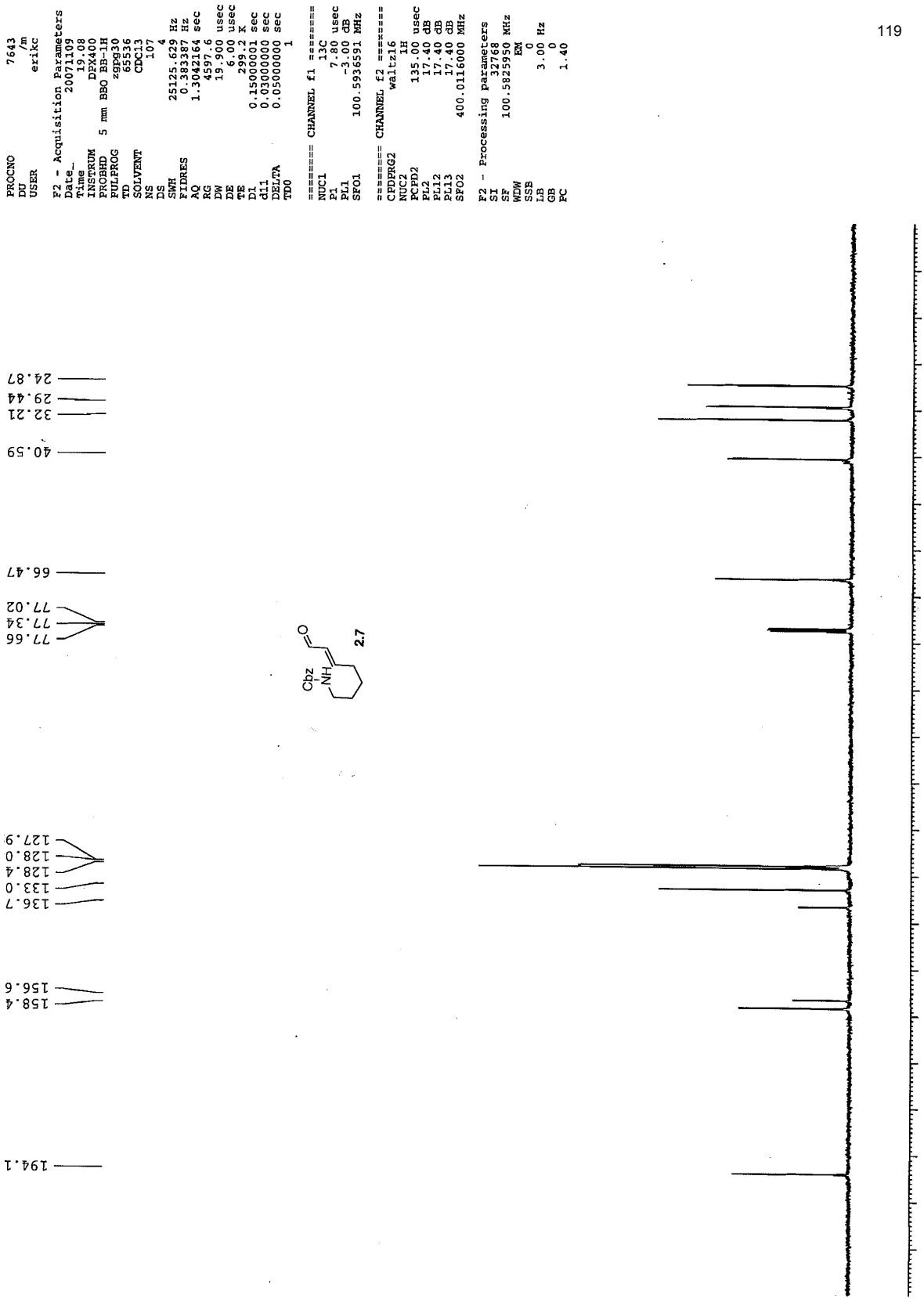
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DS 4
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FIDRES 0.383387 Hz
AQ 1.3042164 sec
RG 4597.6
DW 19.900 usec
DE 6.00 usec
TE 299.2 K
D1 0.15000001 sec
d11 0.03000000 sec
DELTA 0.05000000 sec
TD0 1
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NUC1 13C
P1 7.80 usec
PL1 -3.00 dB
SFO1 100.5936591 MHz
========== CHANNEL f2 ==========
CPDPRG2 waltz16
NUC2 1H
PCPD2 135.00 usec
PL2 17.40 dB
PL12 17.40 dB
PL13 17.40 dB
SFO2 400.0116000 MHz
F2 - Processing parameters
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SSB 0
LB 3.00 Hz
GB 0
PC 1.40
24.87
29.44
32.21
40.59
66.47
77.02
77.34
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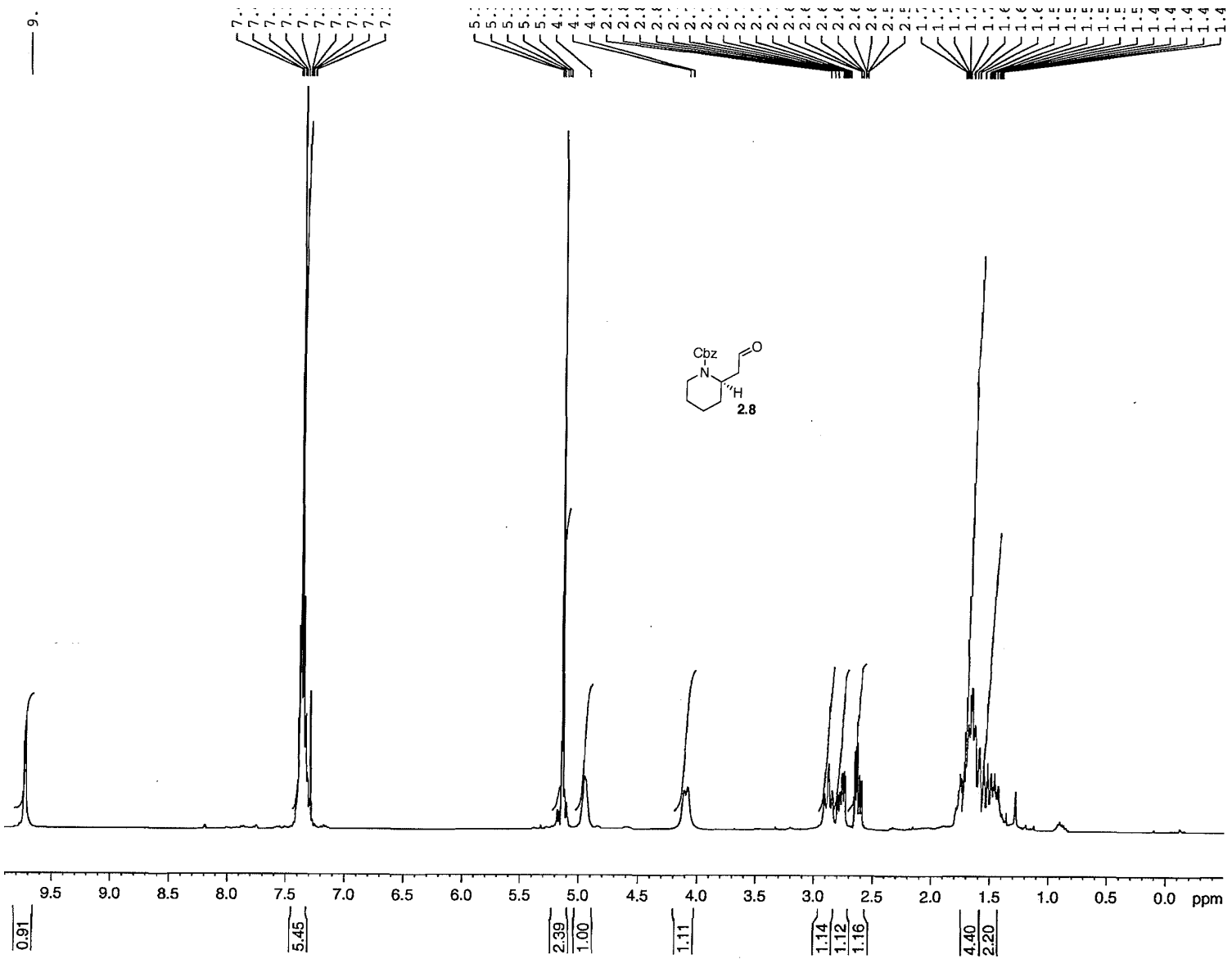

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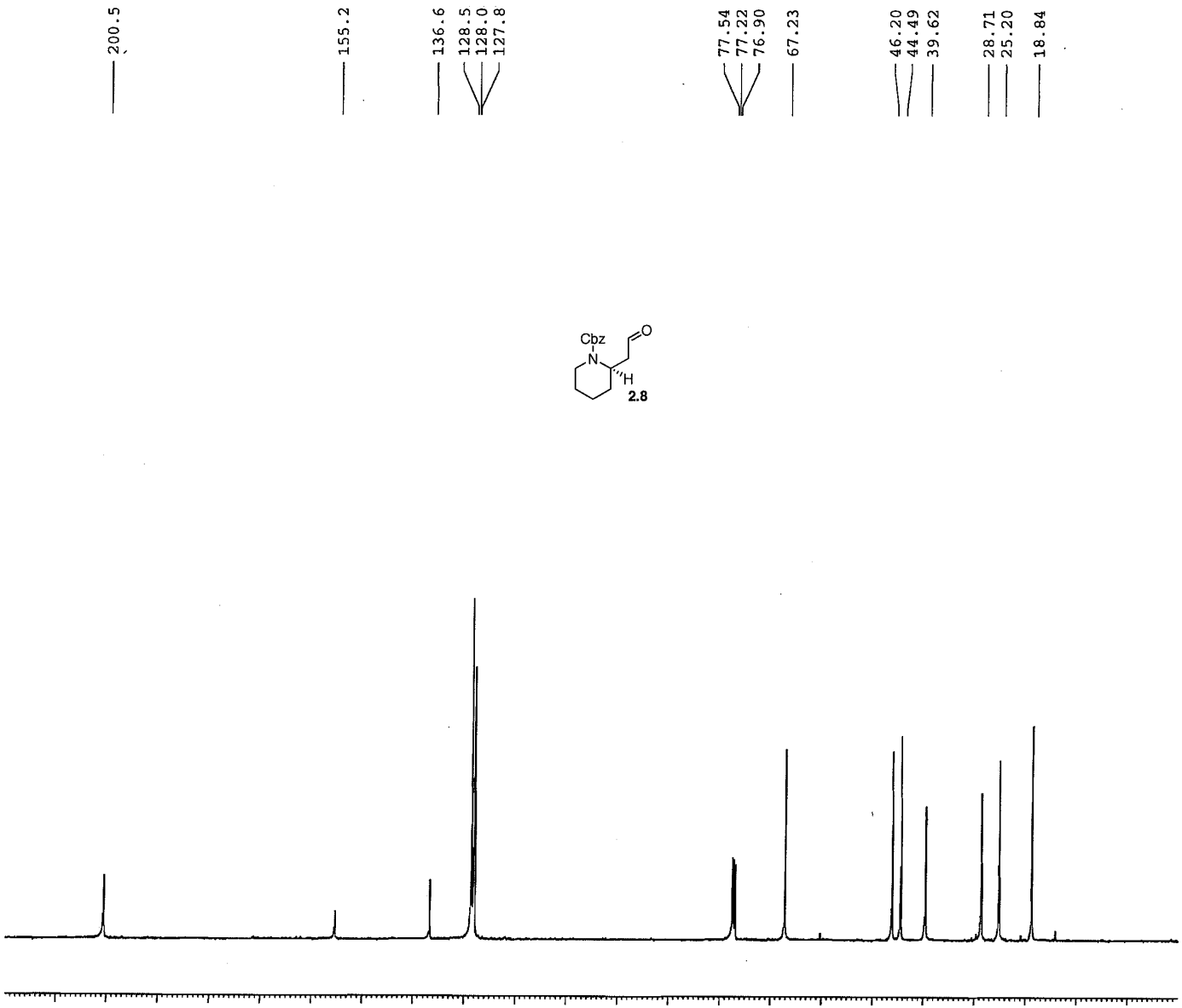
DU
USER nat

F2 - Acquisition Pa
Date_ 2007
Time 1
INSTRUM DP
PROBHD 5 mm BBO B
PULPROG
TD 3
SOLVENT C
NS
DS
SWH 6410
FIDRES 0.19
AQ 2.555
RG
DW 78
DB
TE 2
D1 2.0000
TD0

======== CHANNEL f1
NUC1
P1 1
PL1
SFO1 400.012

F2 - Processing para
SI 3
SF 400.010
WDW
SSB
LB
GB
PC 1



PROCNO	7643
DU	/m
USER	erikc

F2 - Acquisition Parameters

Date_	20071114
Time	15.05
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zgpg30
TD	65536
SOLVENT	CDCl3
NS	2450
DS	4
SWH	25125.629 Hz
FIDRES	0.383387 Hz
AQ	1.3042164 sec
RG	4597.6
DW	19.900 usec
DE	6.00 usec
TE	299.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1

======== CHANNEL f1 ========

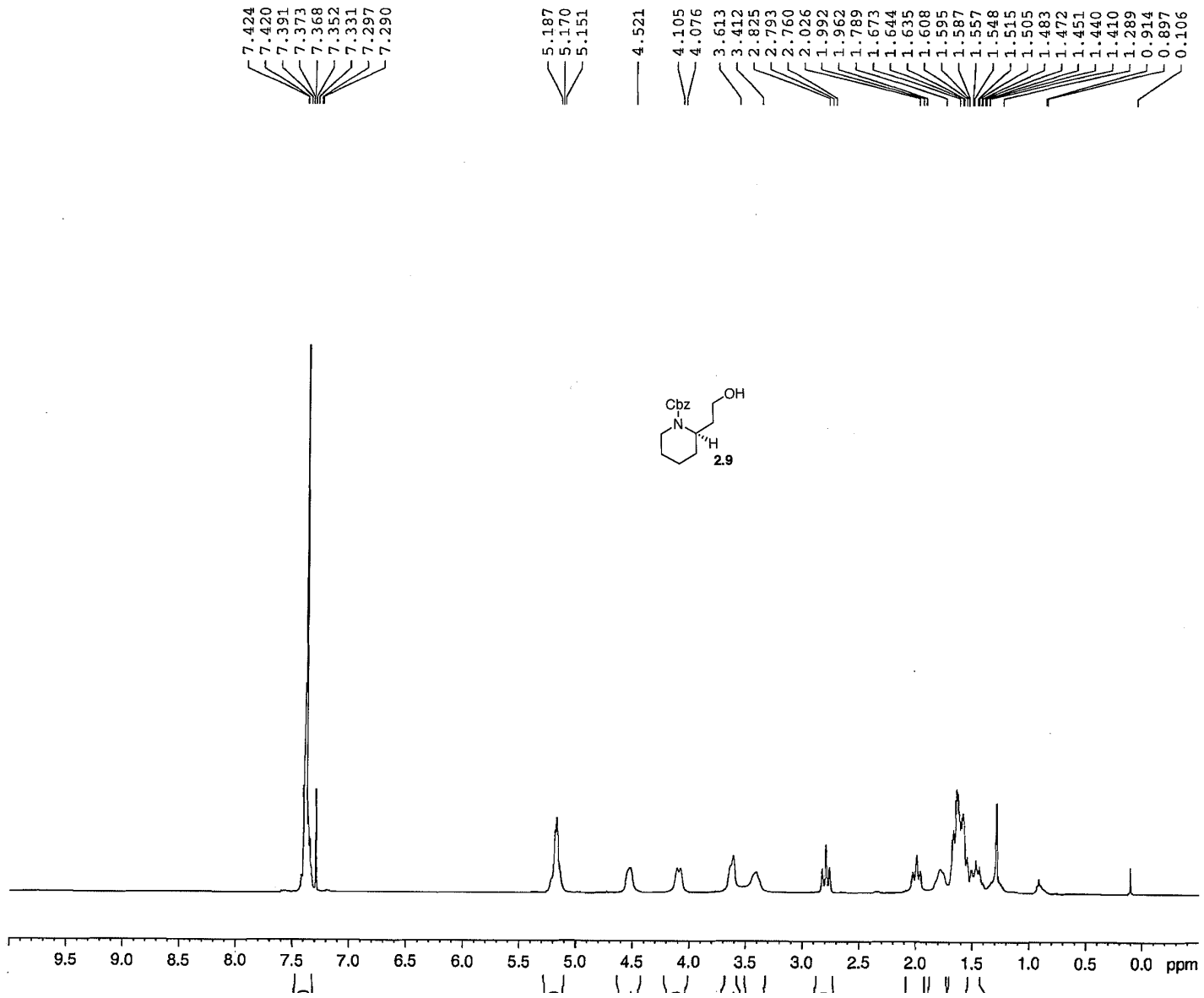
NUC1	13C
P1	7.80 usec
PL1	-3.00 dB
SFO1	100.5936591 MHz

======== CHANNEL f2 ========

CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00 usec
PL2	17.40 dB
PL12	17.40 dB
PL13	17.40 dB
SFO2	400.0116000 MHz

F2 - Processing parameters

SI	32768
SF	100.5825950 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40



Current Data Parameters

NAME	b4p043a
EXPNO	293
PROCNO	7643
DU	/m
USER	erikc

F2 - Acquisition Parameters

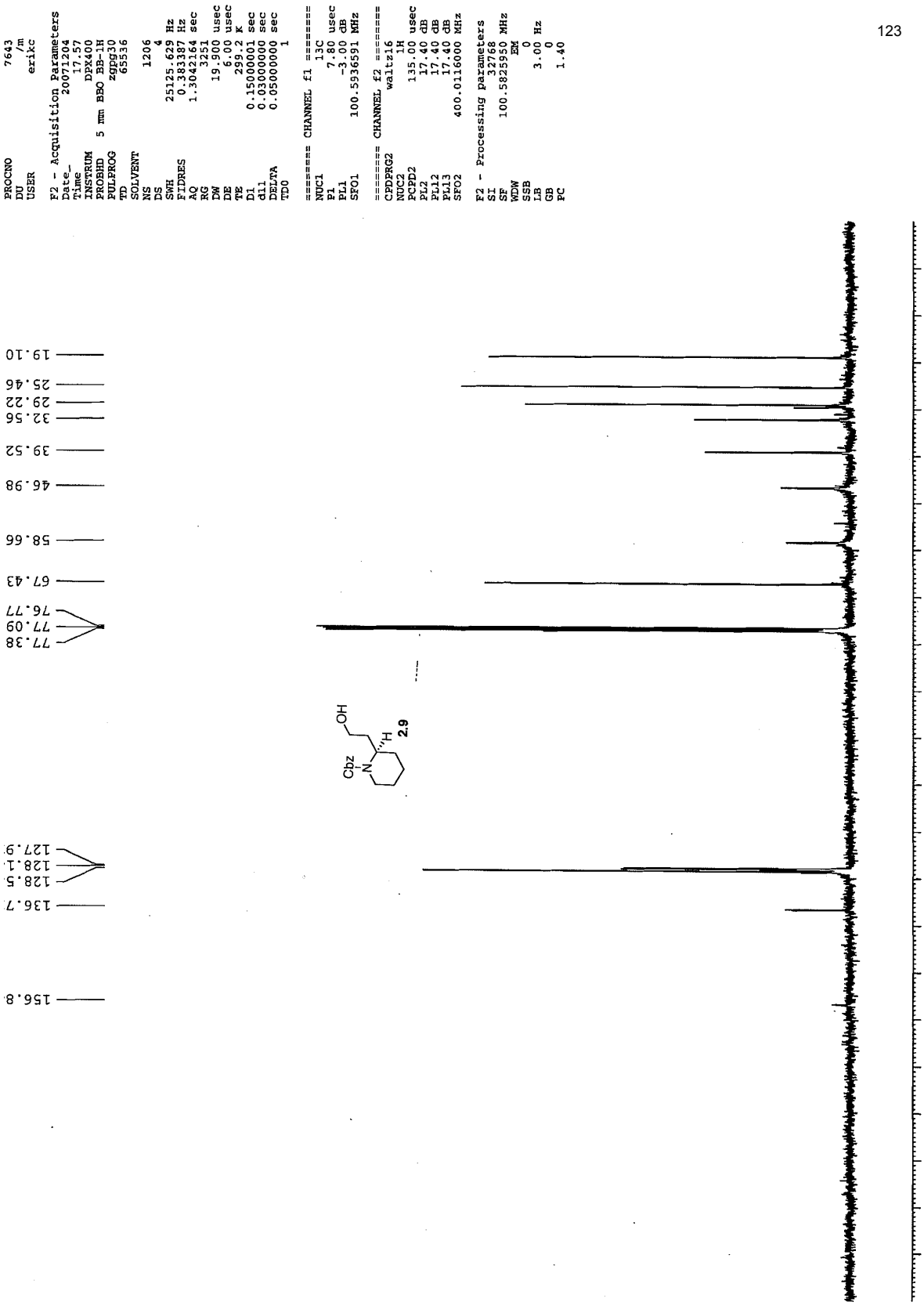
Date_	20071203
Time	15.26
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zg30
TD	32768
SOLVENT	CDC13
NS	17
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	143.7
DW	78.000 usec
DE	6.00 usec
TE	299.2 K
D1	2.00000000 sec
TD0	1

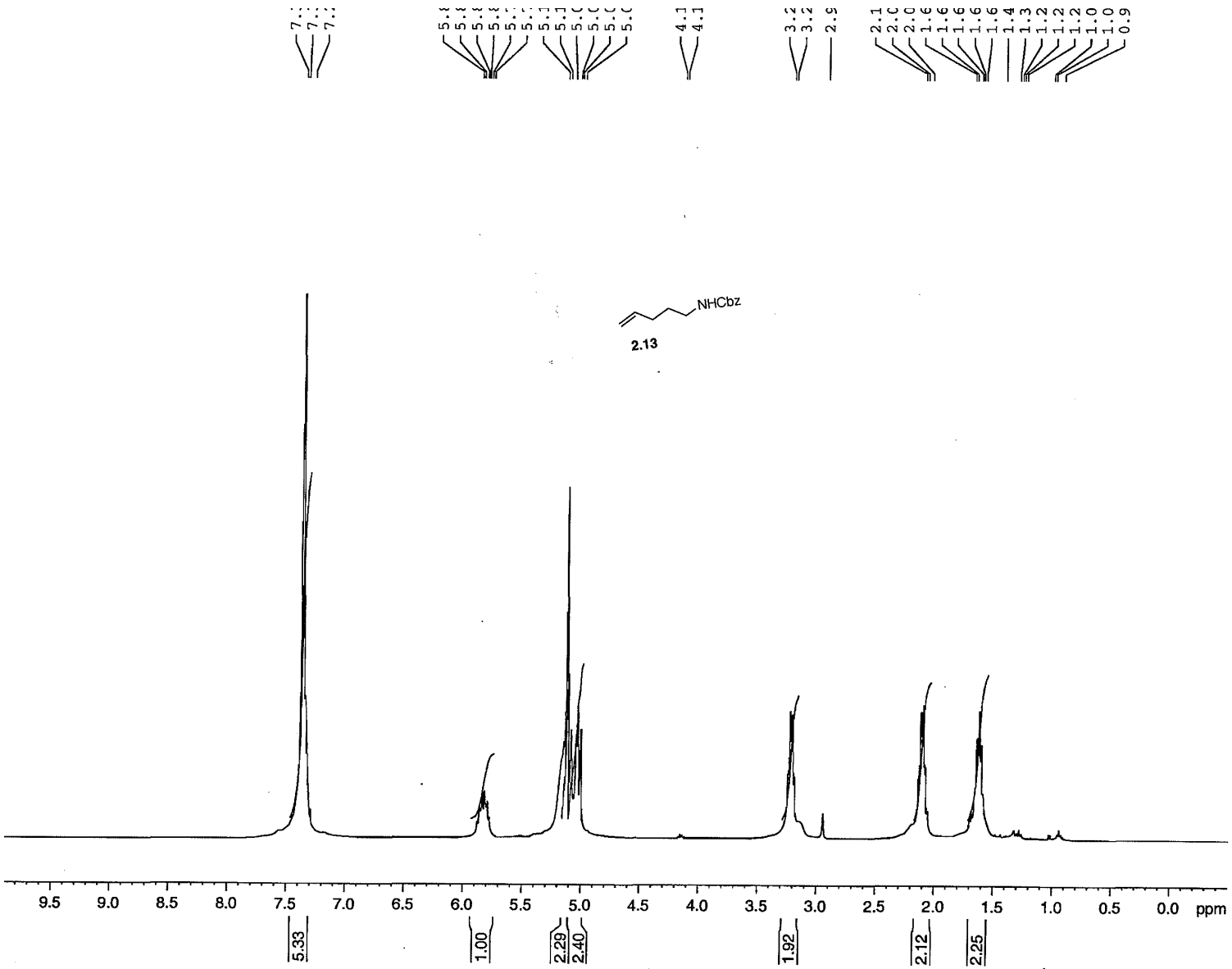
======== CHANNEL f1 ========

NUC1	1H
P1	14.70 usec
PL1	0.00 dB
SFO1	400.0128001 MHz

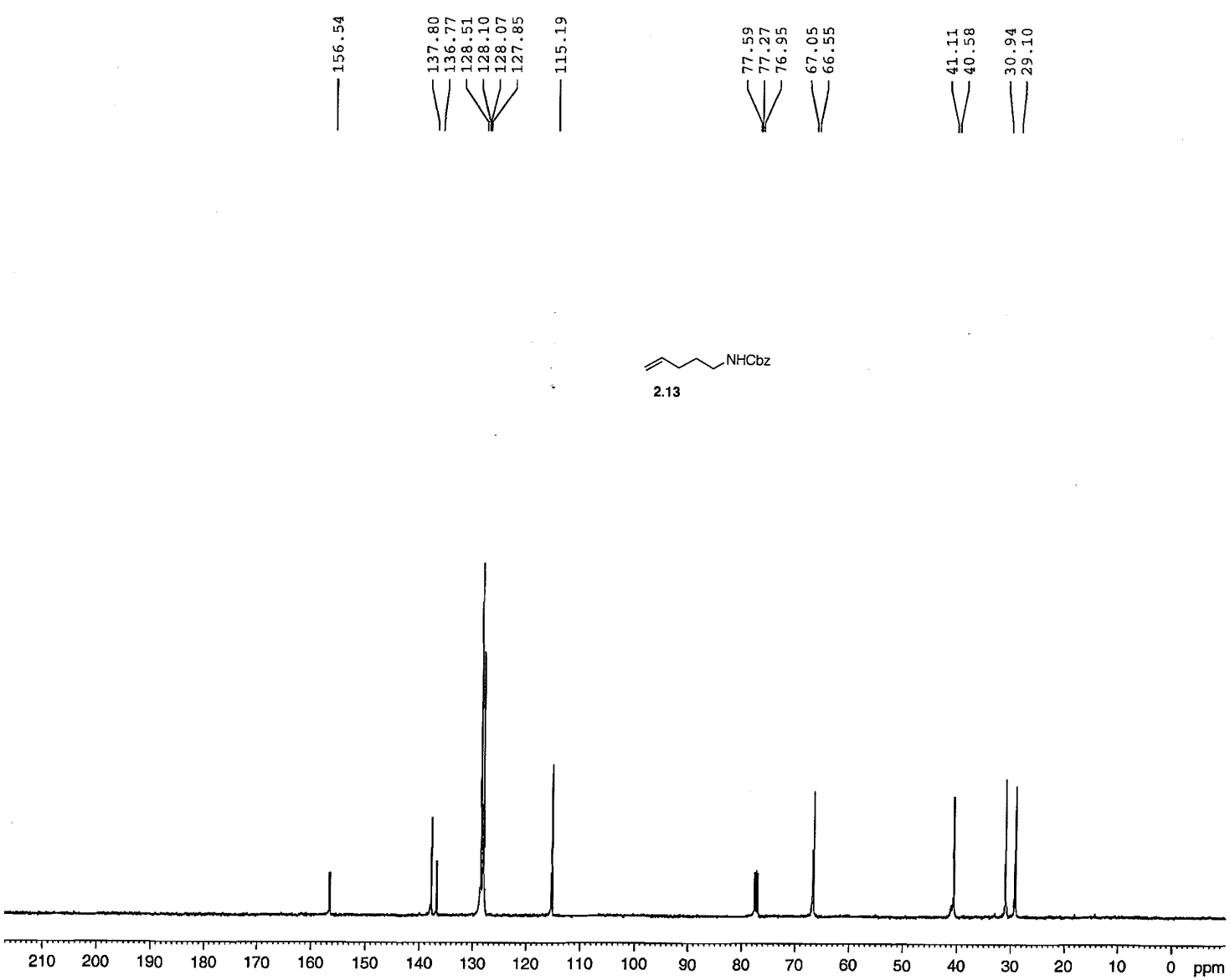
F2 - Processing parameters

SI	32768
SF	400.0100000 MHz
WDW	no
SSB	0
LB	0.00 Hz
GB	0
PC	1.00

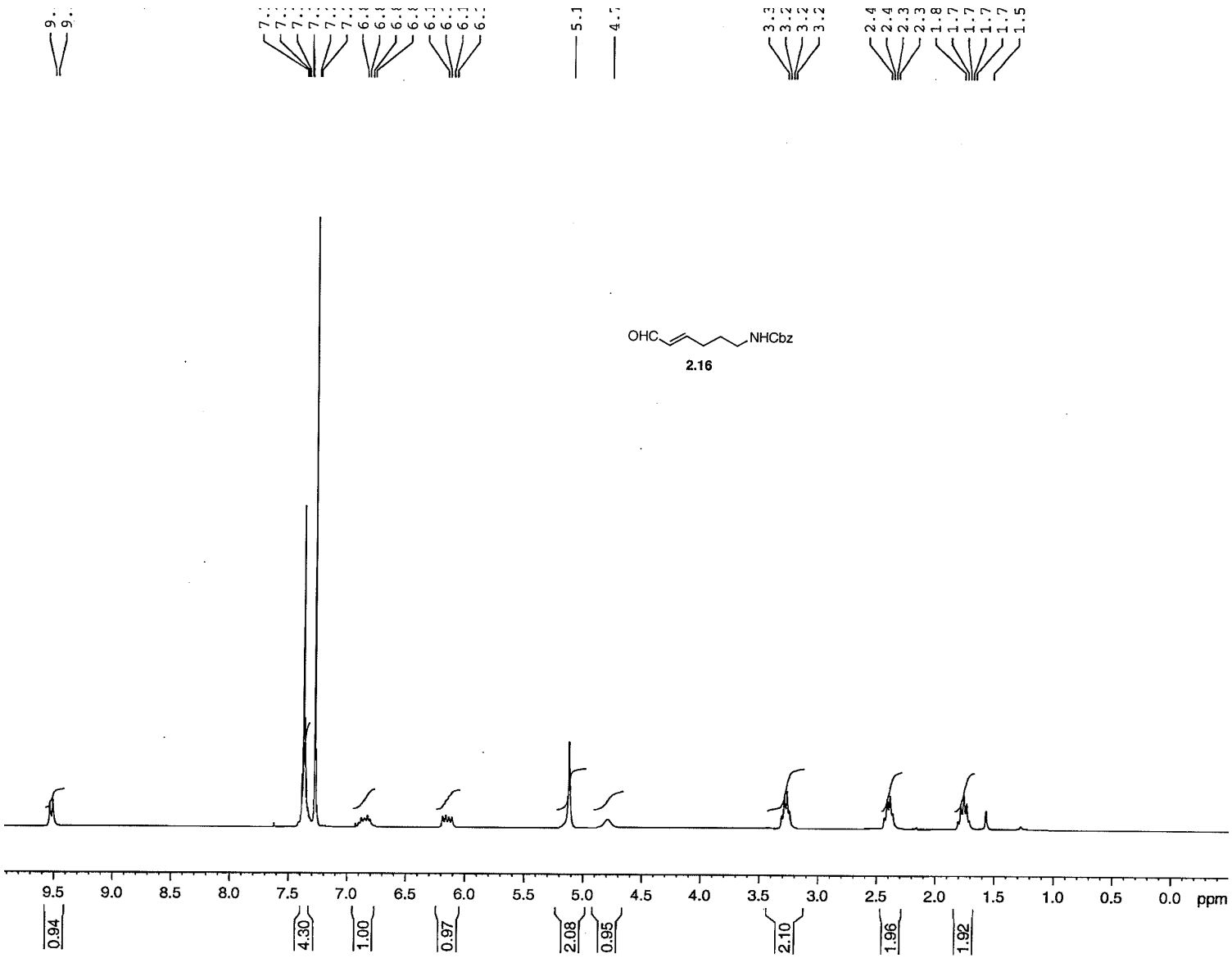

PROCNO 7643
DU /m
USER erikc
F2 - Acquisition Parameters
Date_ 20071204
Time 17.57
INSTRUM DPX400
PROBHD 5 mm BBO BB-1H
PULPROG zgpg30
TD 65536
SOLVENT
NS 1206
DS 4
SWH 25125.629 Hz
FIDRES 0.383387 Hz
AQ 1.30442164 sec
RG 3251
DW 19.900 usec
DE 6.00 usec
TE 299.2 K
D1 0.15000001 sec
d11 0.03000000 sec
DELTA 0.05000000 sec
TD0 1
======== CHANNEL f1 ========
NUC1 13C
P1 7.80 usec
PL1 -3.00 dB
SFO1 100.5936591 MHz
======== CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 135.00 usec
PL2 17.40 dB
PL12 17.40 dB
PL13 17.40 dB
SFO2 400.0116000 MHz
F2 - Processing parameters
SI 32768
SF 100.5825950 MHz
WDW EM
SSB 0
LB 3.00 Hz
GB 0
PC 1.40
19.10
25.46
29.22
32.56
39.52
46.98
58.66
67.43
76.77
77.09
77.38
127.9
128.1
128.5
136.7
156.8
Cbz
OH
2.9



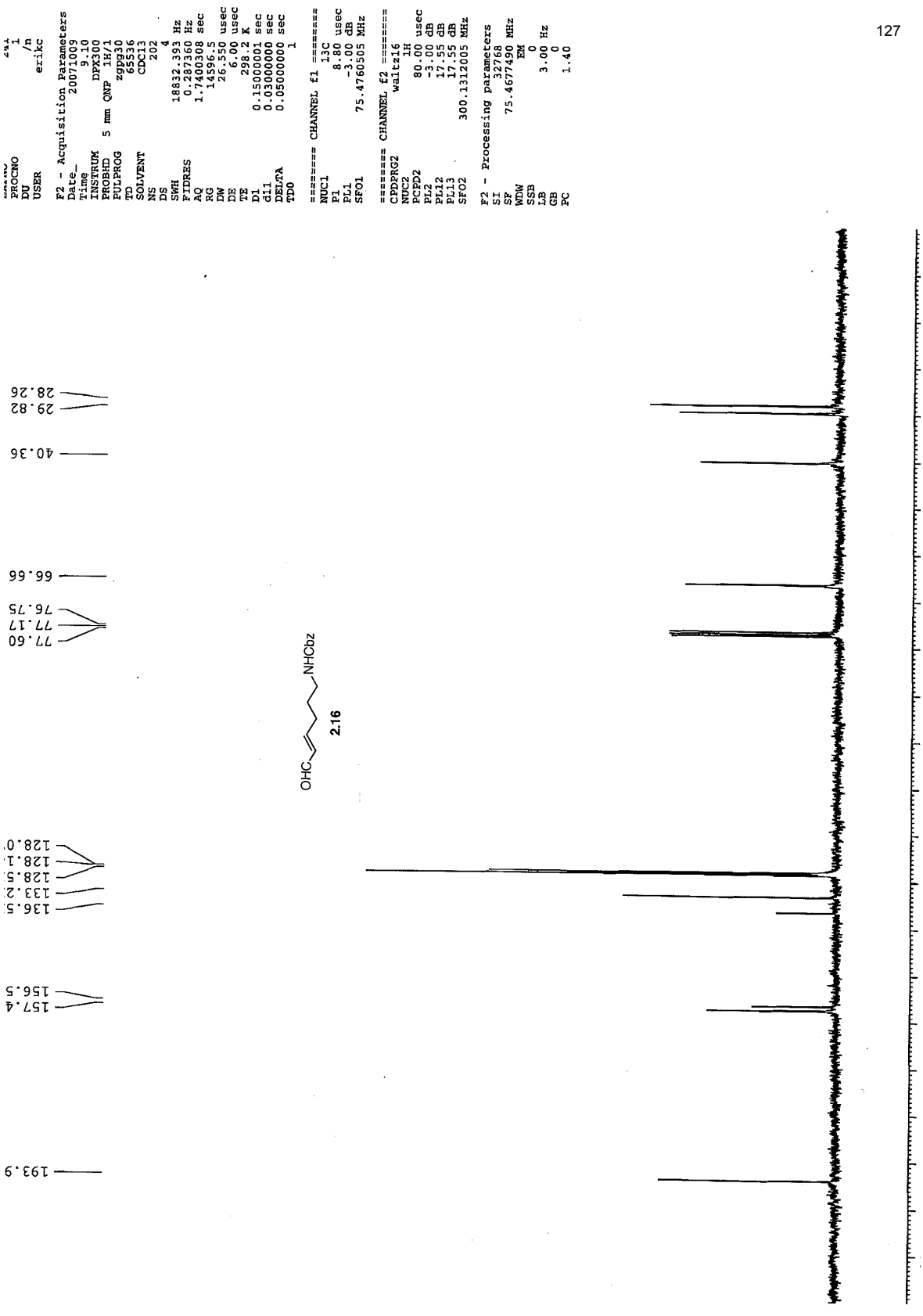
NAME	b4
EXPNO	
PROCNO	
DU	
USER	e
F2 - Acquisition Pa	
Date_	2007
Time	1
INSTRUM	DP
PROBHD	5 mm BBO B
PULPROG	
TD	3
SOLVENT	C
NS	
DS	
SWH	6410.
FIDRES	0.19
AQ	2.555
RG	
DW	78.
DE	
TE	2
D1	2.0000
TD0	
======== CHANNEL f1	
NUC1	
P1	1
PL1	
SFO1	400.012
F2 - Processing para	
SI	3
SF	400.010
WDW	
SSB	
LB	
GB	
PC	

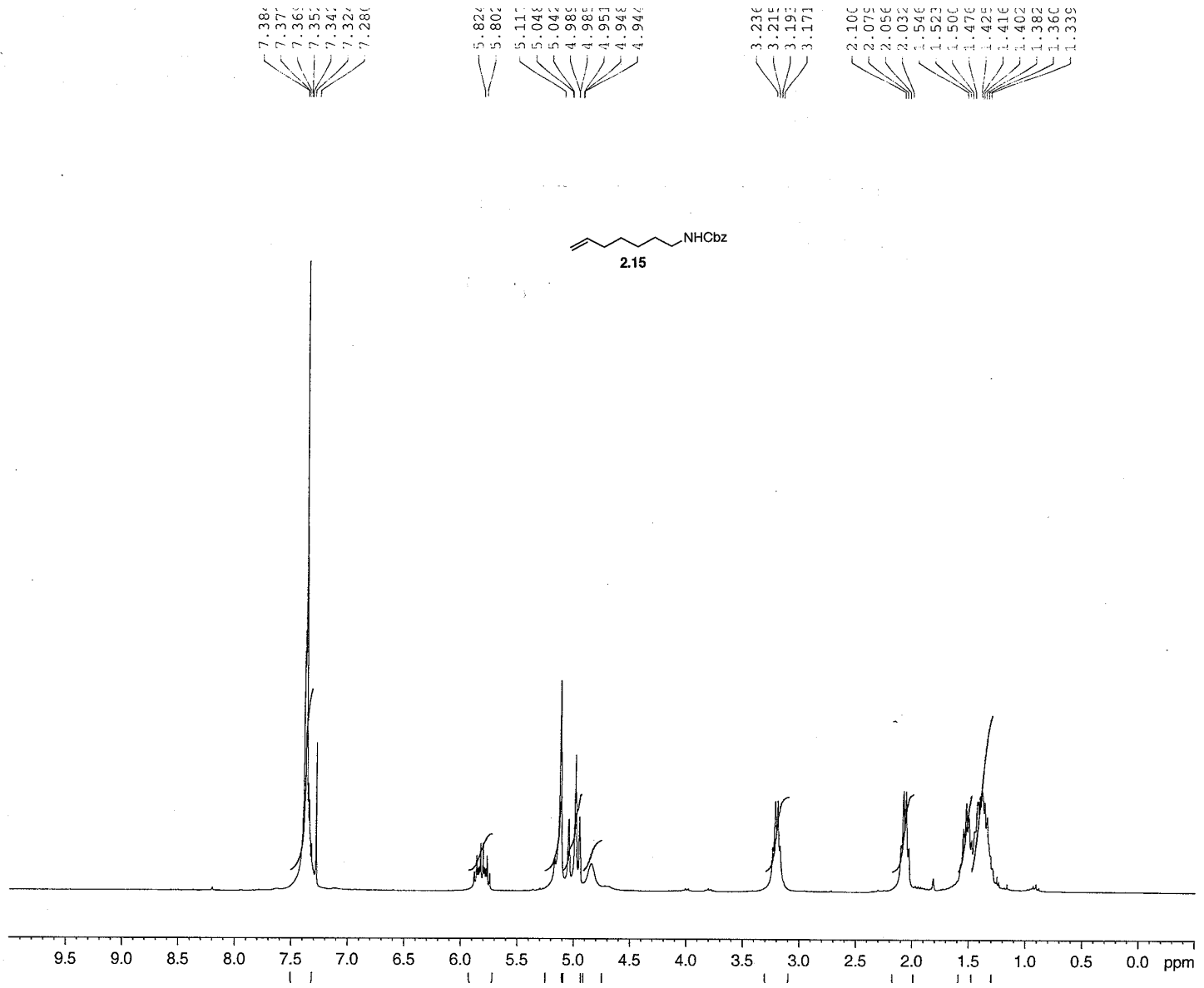


Current Data Parameter	
NAME	b4p005
EXPNO	29
PROCNO	764
DU	/1
USER	erik
F2 - Acquisition Param	
Date_	2007110
Time	18.5
INSTRUM	DPX40
PROBHD	5 mm BBO BB-1
PULPROG	zgpg3
TD	6553
SOLVENT	CDC1
NS	43
DS	4
SWH	25125.62
FIDRES	0.38338
AQ	1.3042164
RG	3649.1
DW	19.90
DE	6.0
TE	299.2
D1	0.1500000
d11	0.0300000
DELTA	0.0500000
TD0	1
======== CHANNEL f1 ===	
NUC1	13
P1	7.8
PL1	-3.0
SFO1	100.5936591
======== CHANNEL f2 ===	
CPDPRG2	waltz16
NUC2	1H
PCPD2	135.0
PL2	17.4
PL12	17.4
PL13	17.4
SFO2	400.0116000
F2 - Processing paramet	
SI	32768
SF	100.5825950
WDW	EM
SSB	0
LB	3.00
GB	0
PC	1.40




```
NAME                 n
EXPNO
PROCNO
DU
USER               nat

F2 - Acquisition Pa
Date_             2007
Time                 1
INSTRUM             DP
PROBHD   5 mm QNP
PULPROG
TD                   3
SOLVENT              C
NS
DS
SWH               4789
FIDRES            0.14
AQ               3.421
RG                   9
DW                 104
DE
TE                   2
D1            2.0000
TD0

======== CHANNEL f1
NUC1
P1                   -
PL1                  -
SFO1          300.132

F2 - Processing para
SI                   3
SF            300.130
WDW
SSB
LB                   (
GB
PC                   1
```


PROCNO 1
USER erikc
F2 - Acquisition Parameters
Date_ 20071009
INSTRUM DPX300
PROBHD 5 mm QNP 1H/1
PULPROG zgpg30
TD 65536
SOLVENT CDCl3
NS 202
DS 4
SWH 18832.393 Hz
FIDRES 0.287360 Hz
AQ 1.7400308 sec
RG 14596.5
DW 26.550 usec
DE 6.00 usec
TE 298.2 K
D1 0.15000001 sec
d11 0.03000000 sec
DELTA 0.05000000 sec
TD0 1
CHANNEL f1 13C
NUC1 13C
P1 8.80 usec
PL1 -3.00 dB
SFO1 75.4760505 MHz
CHANNEL f2 waltz16
NUC2 1H
PCPD2 80.00 usec
PL2 -3.00 dB
PL12 17.55 dB
PL13 17.55 dB
SFO2 300.1312005 MHz
F2 - Processing parameters
SI 32768
SF 75.4677490 MHz
WDW EM
SSB 0
LB 3.00 Hz
GB 0
PC 1.40
28.26
29.82
40.36
66.66
76.75
77.17
77.60
128.0
128.1
128.5
133.2
136.5
156.5
157.4
193.9
OHC
NHCbz
2.16



NAME	NCi78
EXPNO	1
PROCNO	1
DU	/n
USER	nathanc

F2 - Acquisition Parameters

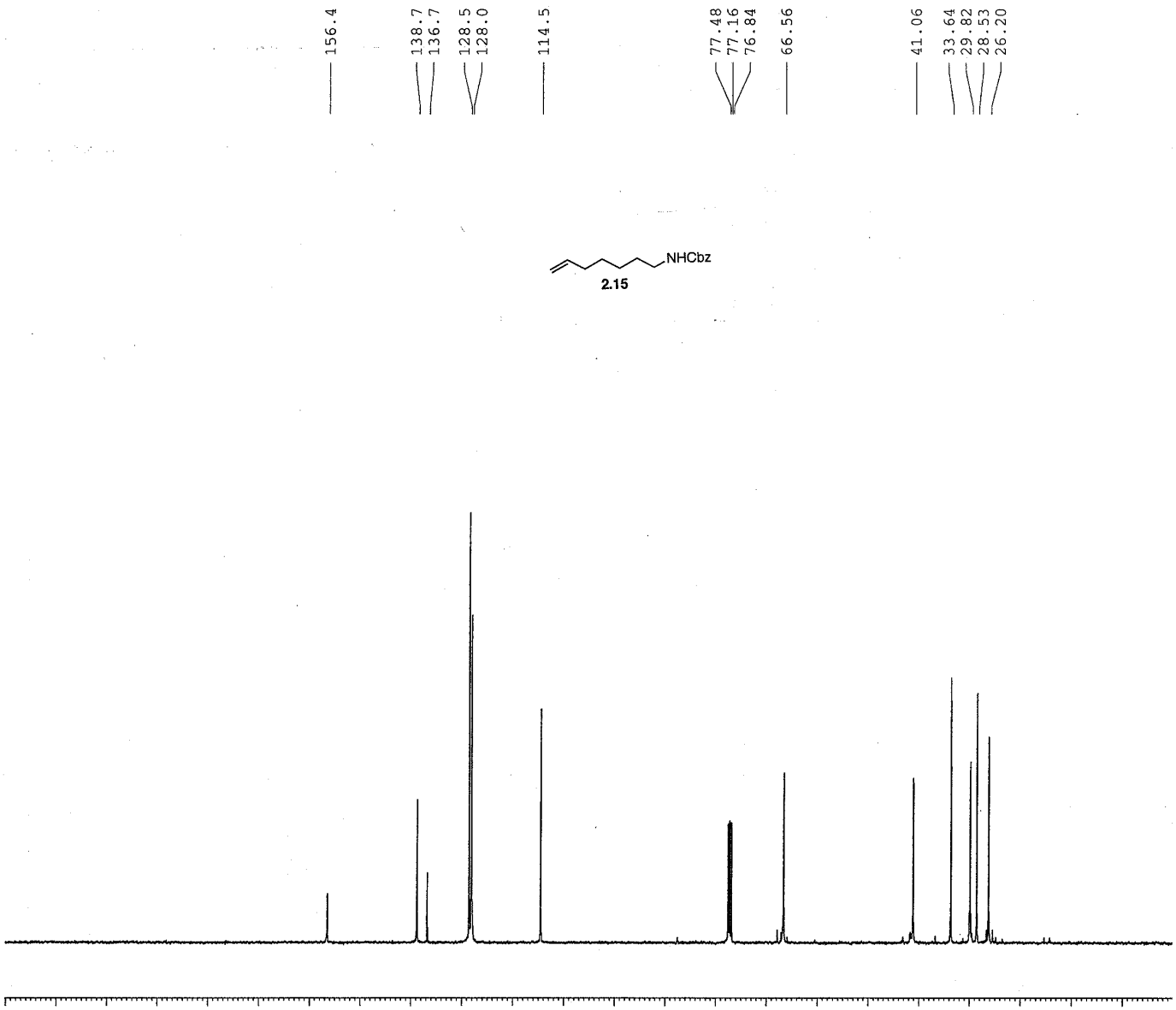
Date_	20071214
Time	13.26
INSTRUM	DPX300
PROBHD	5 mm QNP 1H/1
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	32
DS	2
SWH	4789.272 Hz
FIDRES	0.146157 Hz
AQ	3.4210291 sec
RG	64
DW	104.400 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

NUC1	1H
P1	9.00 usec
PL1	-3.00 dB
SFO1	300.1321009 MHz

F2 - Processing parameters

SI	32768
SF	300.1300000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00



PROCNO	1
DU	/m
USER	erikc

F2 - Acquisition Parameters

Date_	20071214
Time	17.15
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zgpg30
TD	65536
SOLVENT	
NS	1256
DS	4
SWH	25125.629 Hz
FIDRES	0.383387 Hz
AQ	1.3042164 sec
RG	4597.6
DW	19.900 usec
DE	6.00 usec
TE	299.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1

======== CHANNEL f1 ========

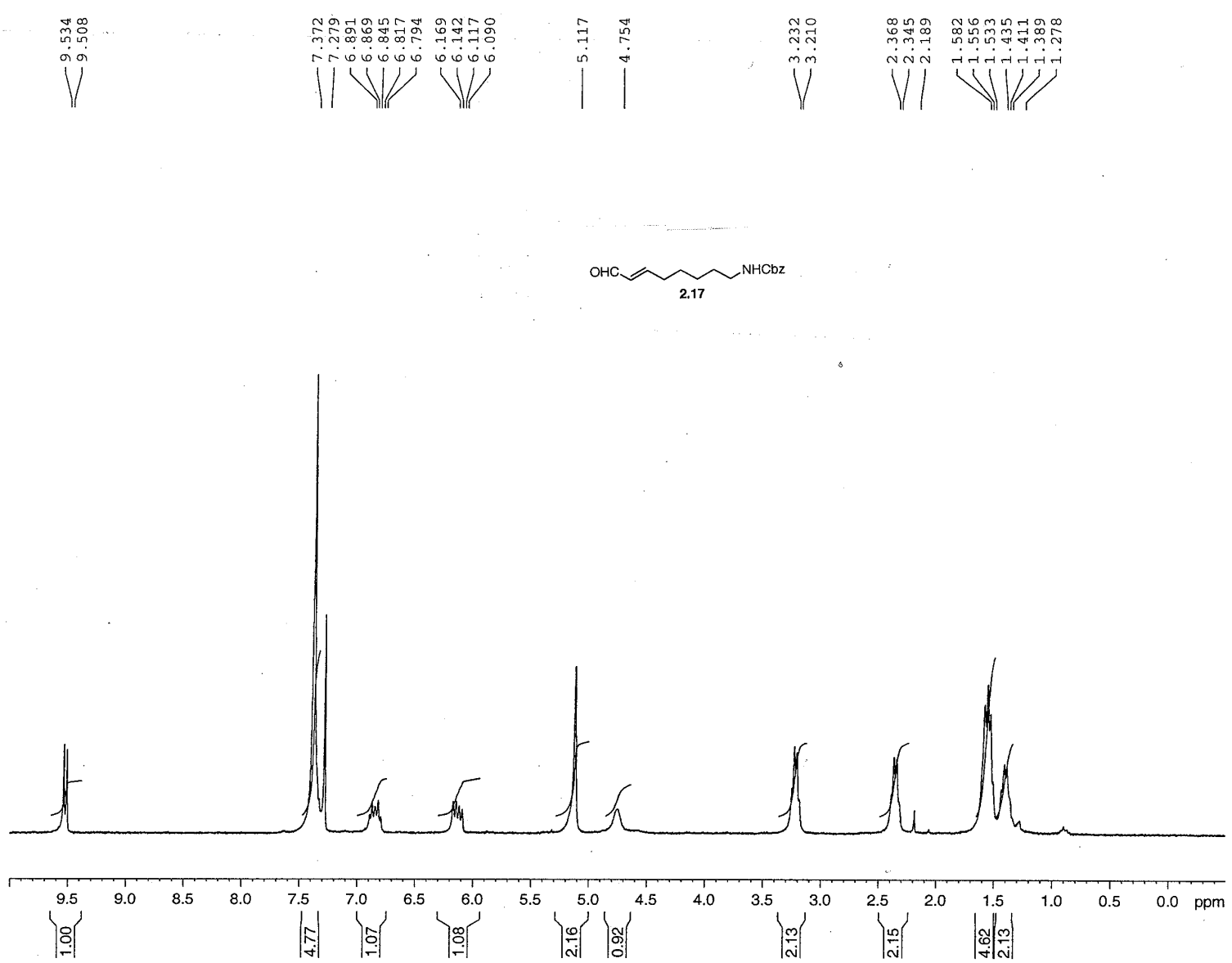
NUC1	13C
P1	7.80 usec
PL1	-3.00 dB
SFO1	100.5936591 MHz

======== CHANNEL f2 ========

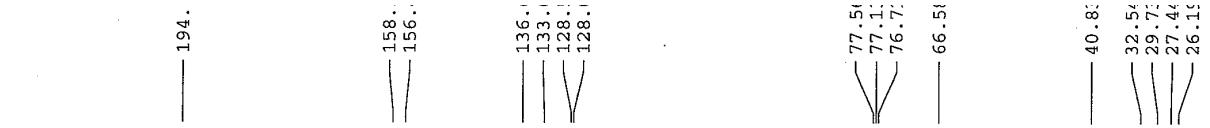
CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00 usec
PL2	17.40 dB
PL12	17.40 dB
PL13	17.40 dB
SFO2	400.0116000 MHz

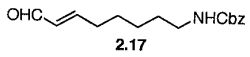
F2 - Processing parameters

SI	32768
SF	100.5825950 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40

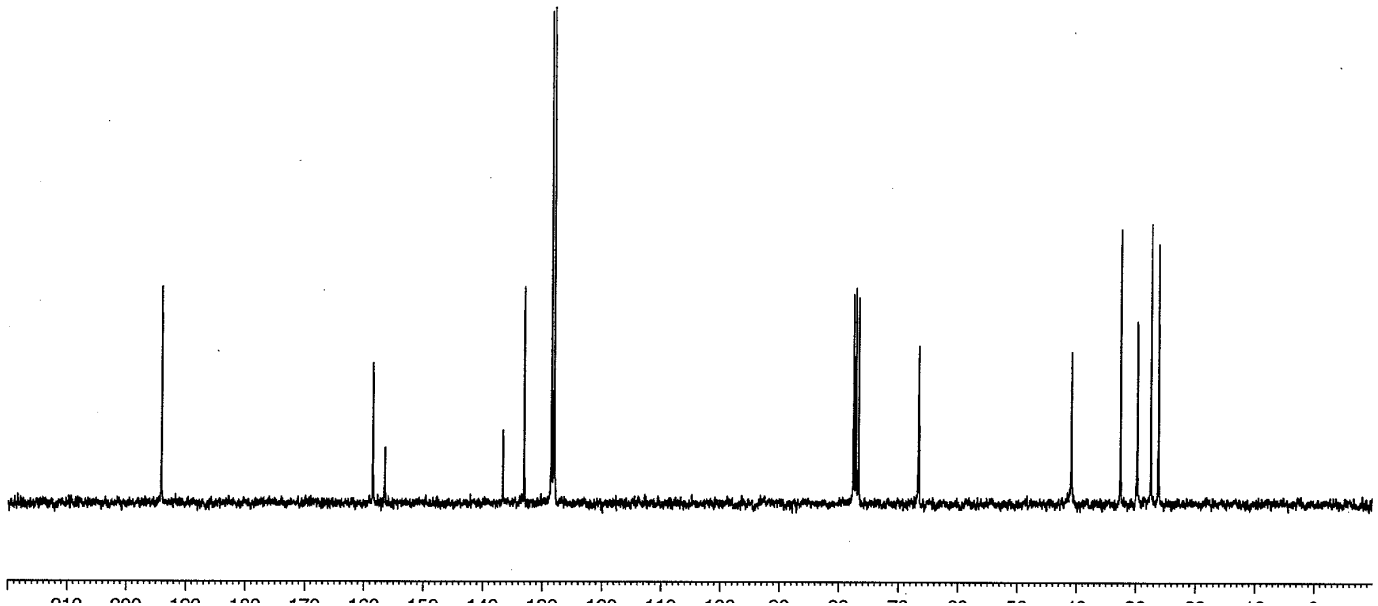



```
NAME                 k
EXPNO
PROCNO
DU
USER

F2 - Acquisition
Date_               20
Time
INSTRUM
PROBHD     5 mm QNP
PULPROG
TD
SOLVENT
NS
DS
SWH                 47
FIDRES              0.
AQ                  3.4
RG
DW                   1
DE
TE
D1                2.00
TD0

======== CHANNEL
NUC1
P1
PL1
SFO1           300.1

F2 - Processing p
SI
SF             300.1
WDW
SSB
LB
GB
PC
```

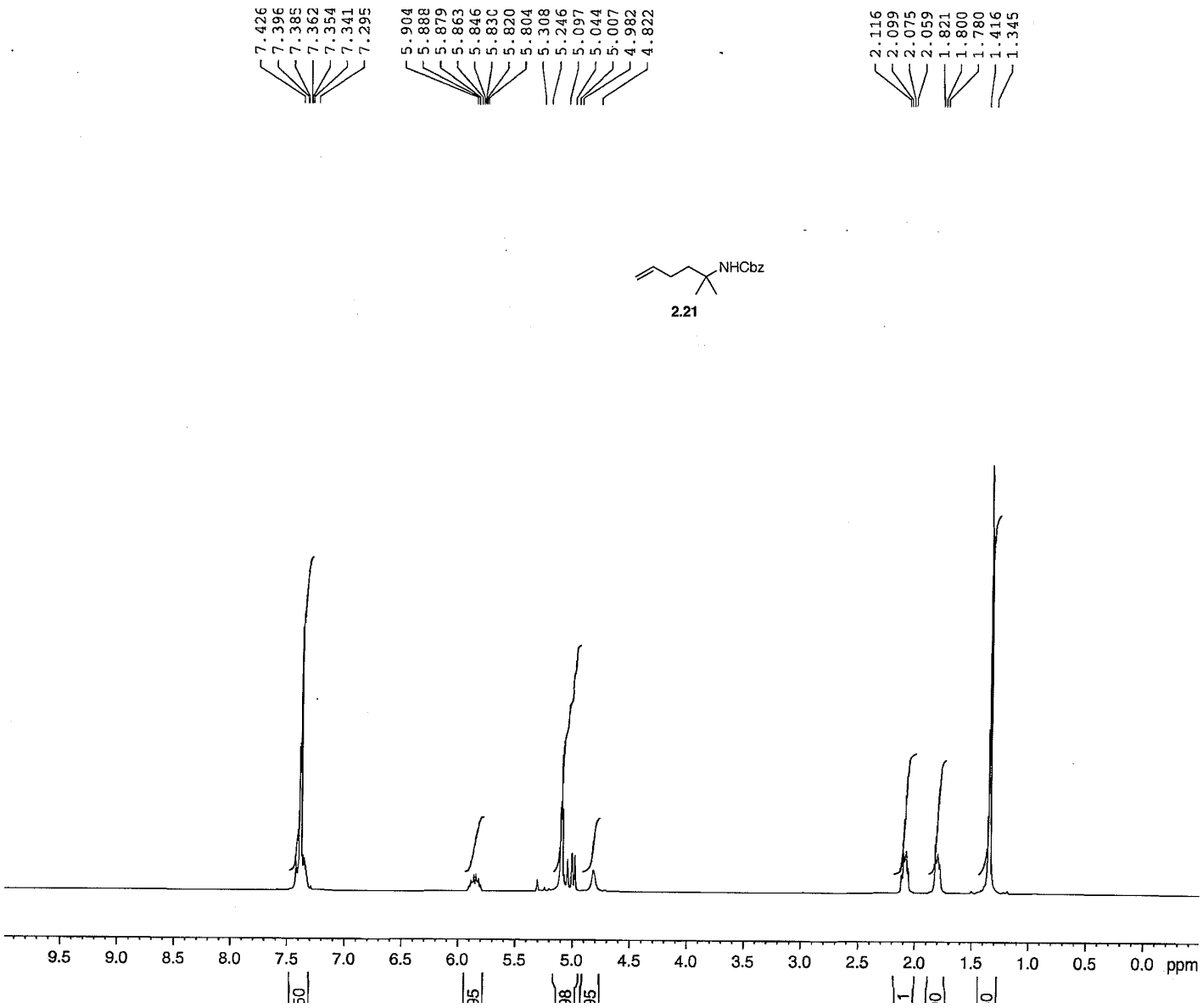




2.17



```
DU                              /n
USER                         erikc

F2 - Acquisition Parameters
Date_                     20070806
Time                         12.16
INSTRUM                     DPX300
PROBHD    5 mm QNP  1H/1
PULPROG                     zgpg30
TD                           65536
SOLVENT                      CDCl3
NS                             355
DS                               4
SWH                    18832.393 Hz
FIDRES                   0.287360 Hz
AQ                       1.7400308 sec
RG                          9195.2
DW                          26.550 usec
DE                           6.00 usec
TE                          298.2 K
D1                    0.15000001 sec
d11                   0.03000000 sec
DELTA                 0.05000000 sec
TD0                             1

======== CHANNEL f1 ========
NUC1                          13C
P1                           8.80 usec
PL1                         -3.00 dB
SFO1                 75.4760505 MHz

======== CHANNEL f2 ========
CPDPRG2                   waltz16
NUC2                          1H
PCPD2                       80.00 usec
PL2                         -3.00 dB
PL12                        17.55 dB
PL13                        17.55 dB
SFO2                300.1312005 MHz

F2 - Processing parameters
SI                            32768
SF                   75.4677490 MHz
WDW                              EM
SSB                               0
LB                            3.00 Hz
GB                                0
PC                             1.40
```



Current Data Parameters

NAME	b3p3b
EXPNO	138
PROCNO	1
DU	/m
USER	erikc

F2 - Acquisition Parameters

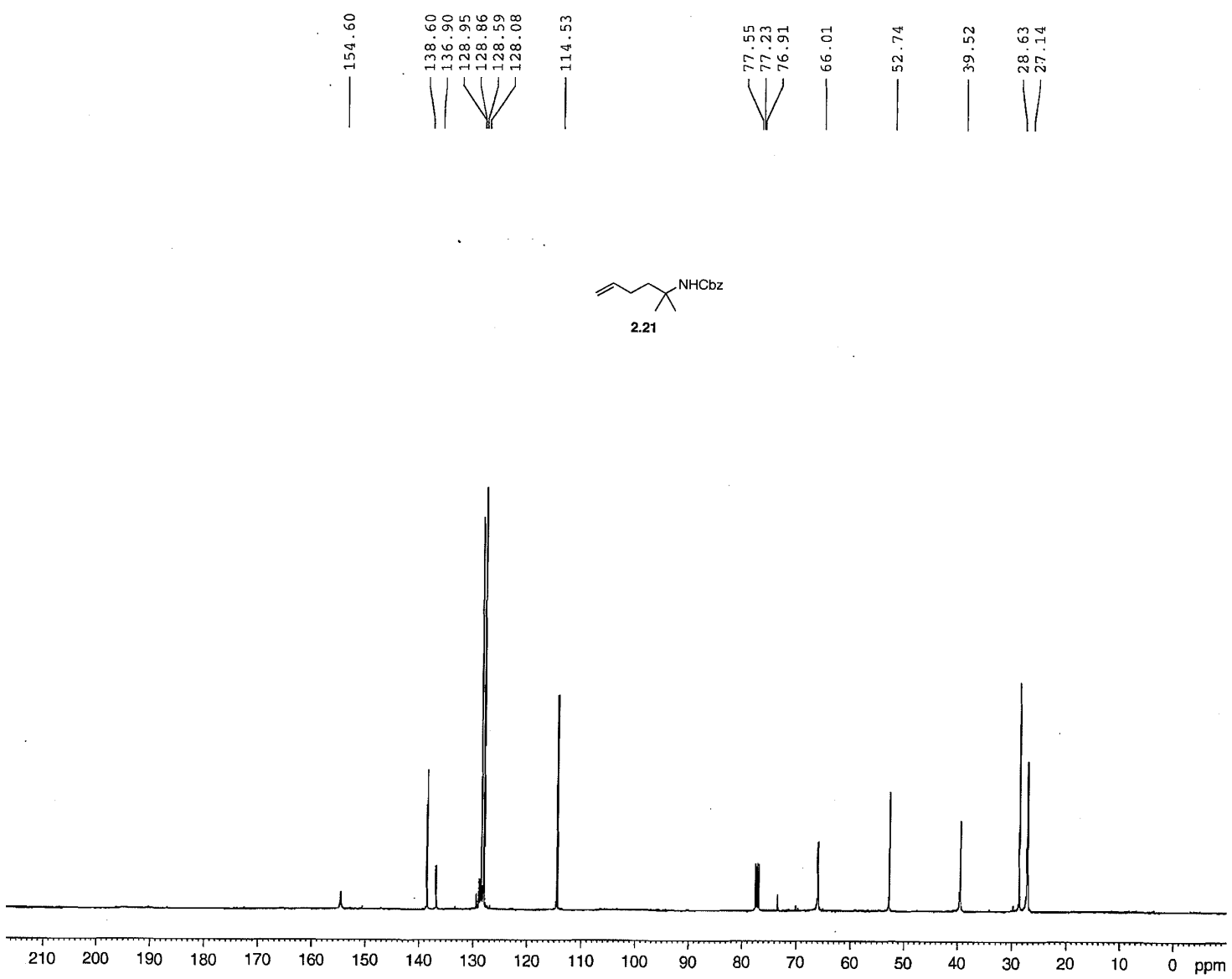
Date_	20070830
Time	17.46
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	7
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	28.5
DW	78.000 usec
DE	6.00 usec
TE	299.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

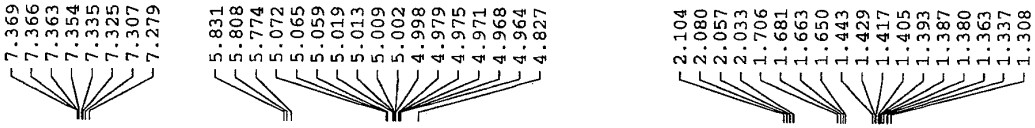
NUC1	1H
P1	14.70 usec
PL1	0.00 dB
SFO1	400.0128001 MHz

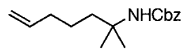
F2 - Processing parameters

SI	32768
SF	400.0100000 MHz
WDW	EM
SSB	0
LB	0.70 Hz
GB	0
PC	1.00



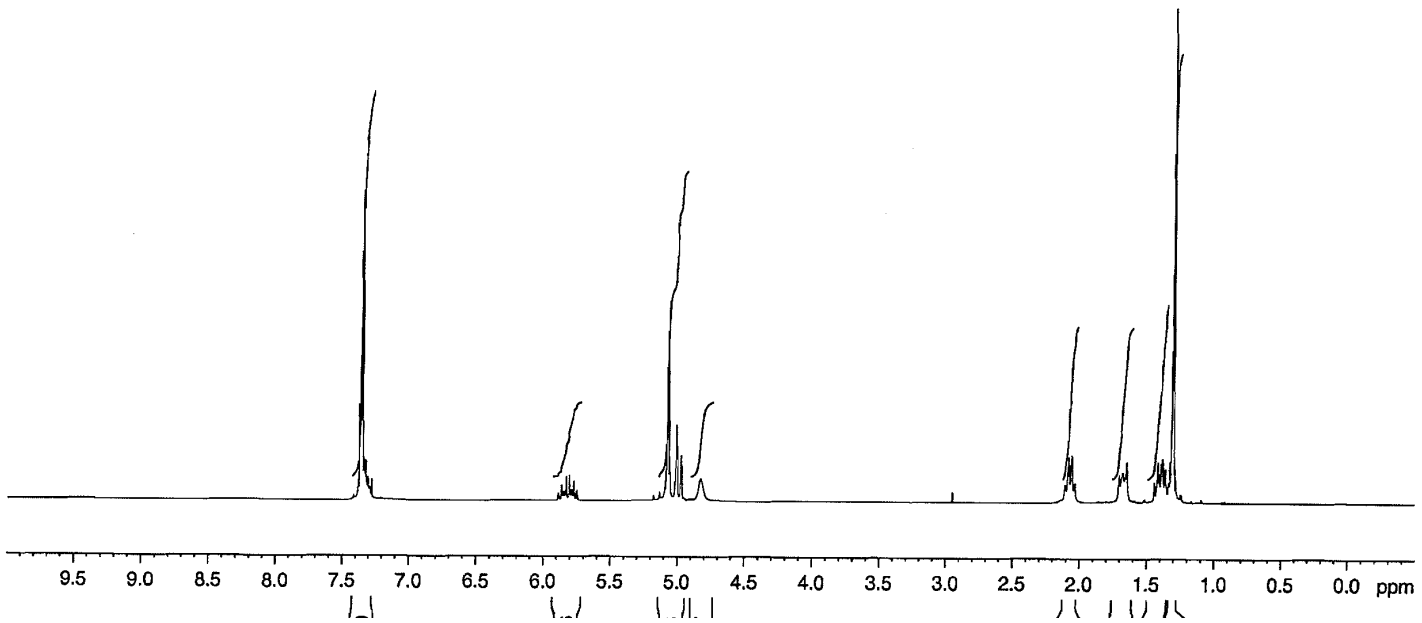
NAME	b3p3
EXPNO	13
PROCNO	
DU	/n
USER	erik
F2 - Acquisition Param	
Date_	2007083
Time	18.0
INSTRUM	DPX40
PROBHD	5 mm BBO BB-1
PULPROG	zgpg3
TD	6553
SOLVENT	CDC1
NS	61
DS	4
SWH	25125.62
FIDRES	0.38338
AQ	1.3042164
RG	3649.1
DW	19.90
DE	6.0
TE	299.2
D1	0.15000001
d11	0.03000000
DELTA	0.05000000
TD0	1
======== CHANNEL f1 ===	
NUC1	13C
P1	7.80
PL1	-3.00
SFO1	100.5936591
======== CHANNEL f2 ===	
CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00
PL2	17.40
PL12	17.40
PL13	17.40
SFO2	400.0116000
F2 - Processing paramet	
SI	32768
SF	100.5825950
WDW	EM
SSB	0
LB	3.00
GB	0
PC	1.40

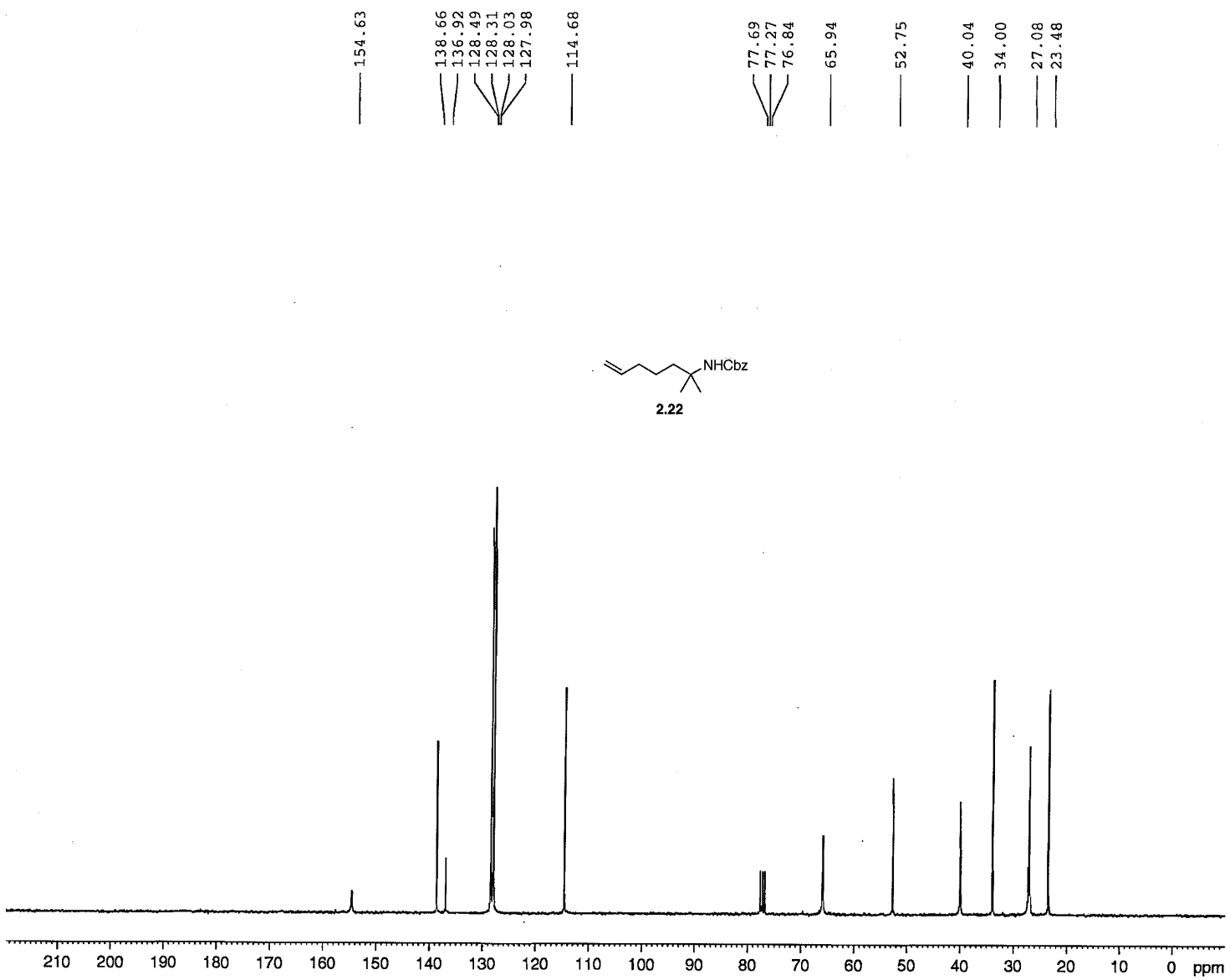




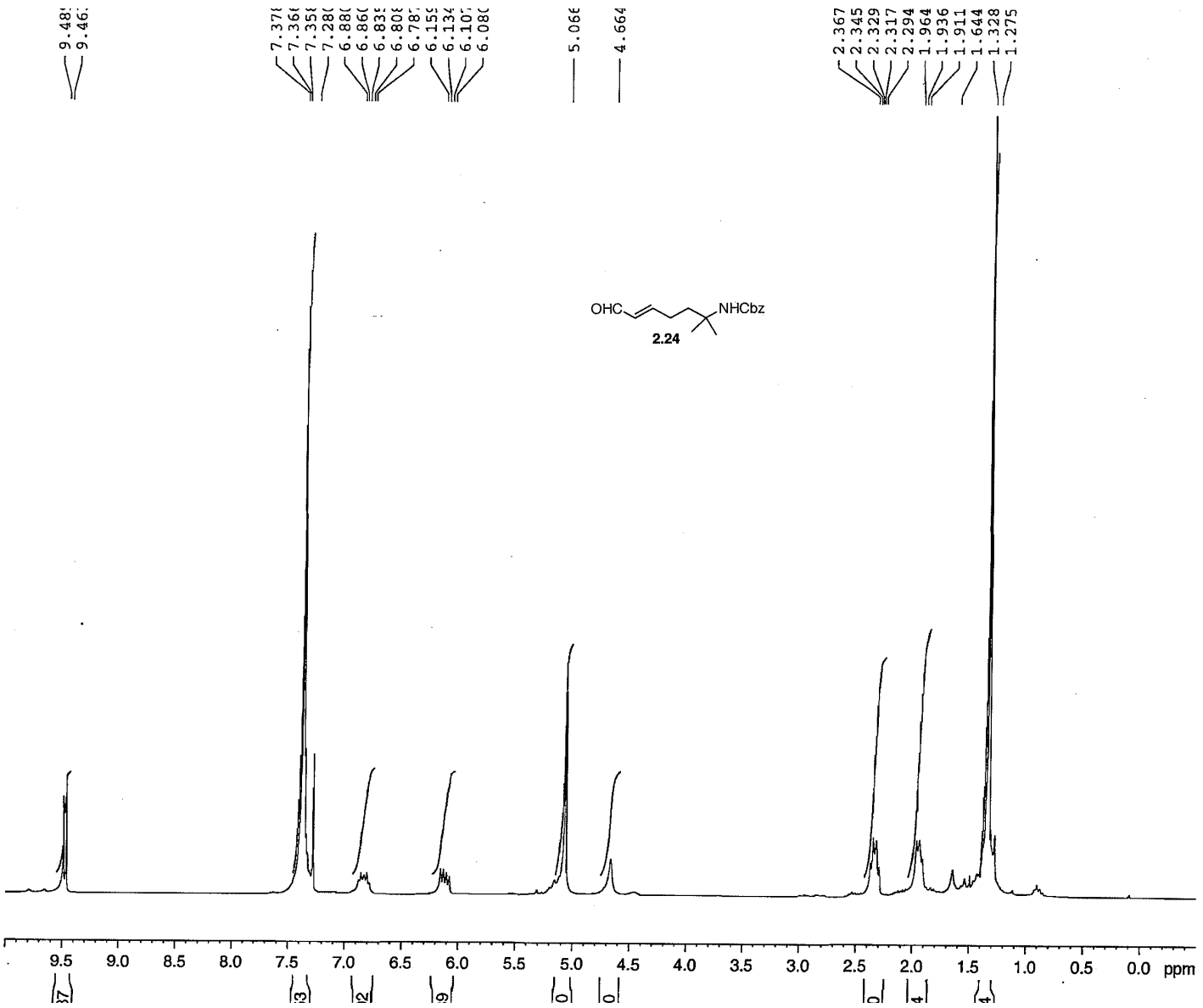
2.22

```
Current Data Parameters
NAME                b4p0800h
EXPNO                    293
PROCNO                  7643
DU                        /n
USER                  erikc

F2 - Acquisition Parameters
Date_               20080213
Time                   10.19
INSTRUM              DPX300
PROBHD    5 mm QNP  1H/1
PULPROG                zg30
TD                    32768
SOLVENT               CDCl3
NS                        5
DS                        2
SWH                4789.272 Hz
FIDRES                0.146157 Hz
AQ                 3.4210291 sec
RG                     22.6
DW                   104.400 usec
DE                     6.00 usec
TE                   298.2 K
D1                 2.00000000 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                      1H
P1                     9.00 usec
PL1                   -3.00 dB
SFO1           300.1321009 MHz

F2 - Processing parameters
SI                    32768
SF             300.1300000 MHz
WDW                      no
SSB                       0
LB                     0.00 Hz
GB                        0
PC                     1.00
```





NAME	b4p0800
EXPNO	29
PROCNO	764
DU	/:
USER	erik
P2 - Acquisition Param	
Date_	2008021
Time	10.3
INSTRUM	DPX30
PROBHD	5 mm QNP 1H/
PULPROG	zgpg3
TD	6553
SOLVENT	CDC1
NS	36
DS	
SWH	18832.39
FIDRES	0.28736
AQ	1.740030
RG	9195.2
DW	26.55
DE	6.0
TE	298.2
D1	0.1500000
d11	0.0300000
DELTA	0.0500000
TD0	1
======== CHANNEL f1 ===	
NUC1	13
P1	8.8
PL1	-3.0
SFO1	75.4760505
======== CHANNEL f2 ===	
CPDPRG2	waltz16
NUC2	1H
PCPD2	80.00
PL2	-3.00
PL12	17.55
PL13	17.55
SFO2	300.1312005
F2 - Processing paramet	
SI	32768
SF	75.4677490
WDW	EM
SSB	0
LB	3.00
GB	0
PC	1.40



Current Data Parameters

NAME	b4p0022
EXPNO	293
PROCNO	7643
DU	/m
USER	erikc

F2 - Acquisition Parameters

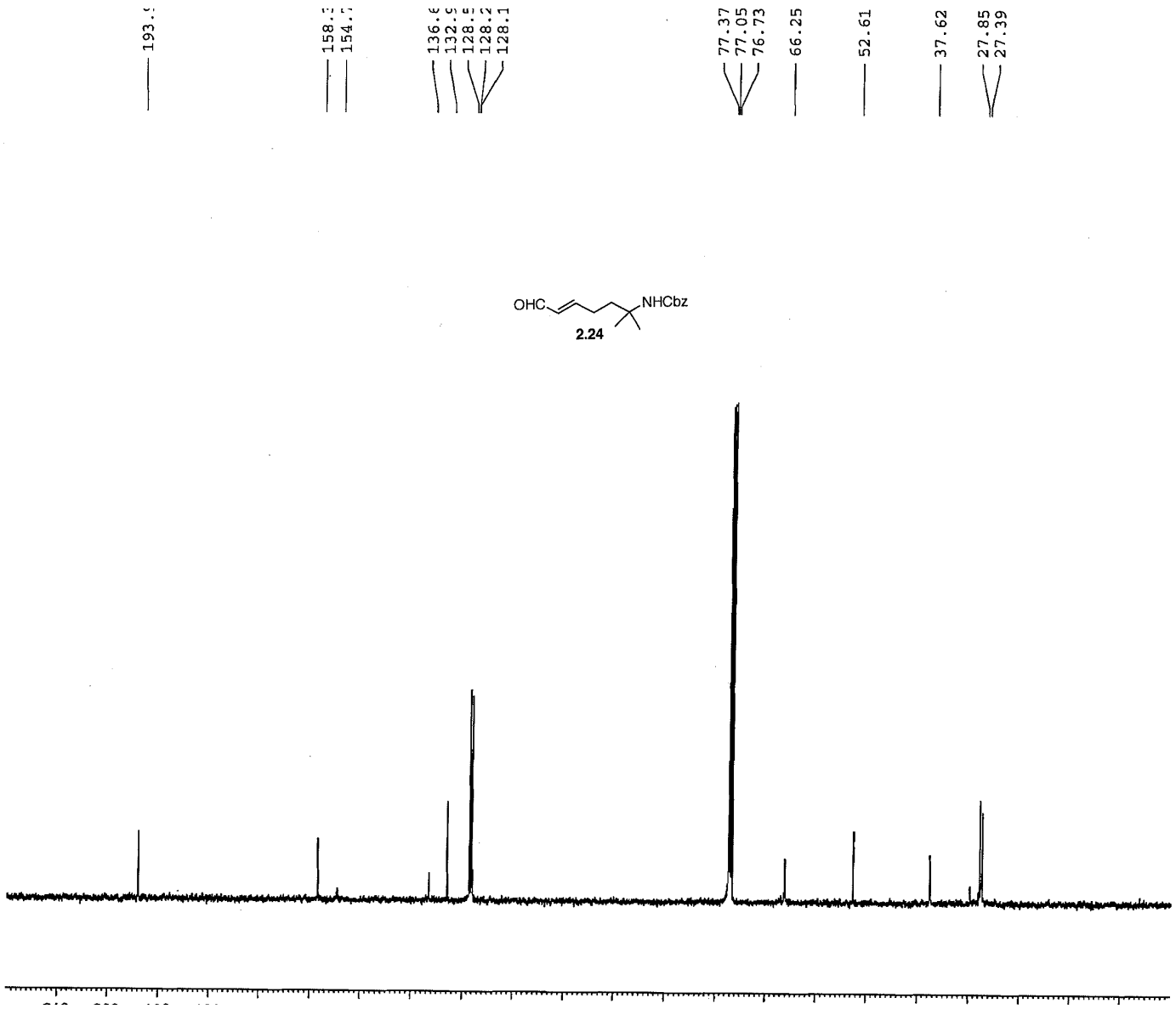
Date_	20071113
Time	17.07
INSTRUM	DPX300
PROBHD	5 mm QNP 1H/1
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	32
DS	2
SWH	4789.272 Hz
FIDRES	0.146157 Hz
AQ	3.4210291 sec
RG	287.4
DW	104.400 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

NUC1	1H
P1	9.00 usec
PL1	-3.00 dB
SFO1	300.1321009 MHz

F2 - Processing parameters

SI	32768
SF	300.1300000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00



PROCNO	7643
DU	/m
USER	erikc

F2 - Acquisition Parameters

Date_	20071113
Time	18.18
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zgpg30
TD	65536
SOLVENT	CDC13
NS	2450
DS	4
SWH	25125.629 Hz
FIDRES	0.383387 Hz
AQ	1.3042164 sec
RG	7298.2
DW	19.900 usec
DE	6.00 usec
TE	299.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1

======== CHANNEL f1 ========

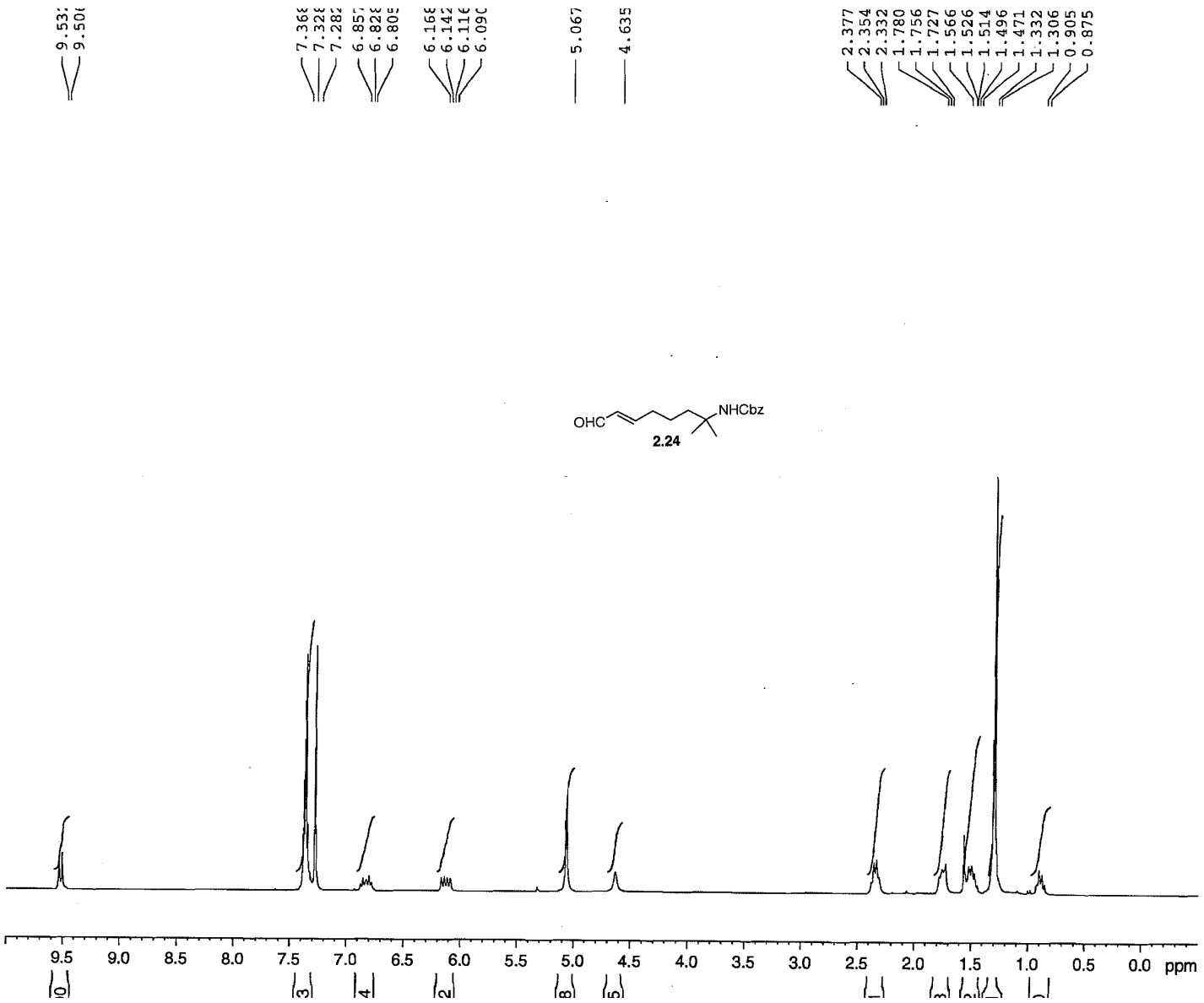
NUC1	13C
P1	7.80 usec
PL1	-3.00 dB
SFO1	100.5936591 MHz

======== CHANNEL f2 ========

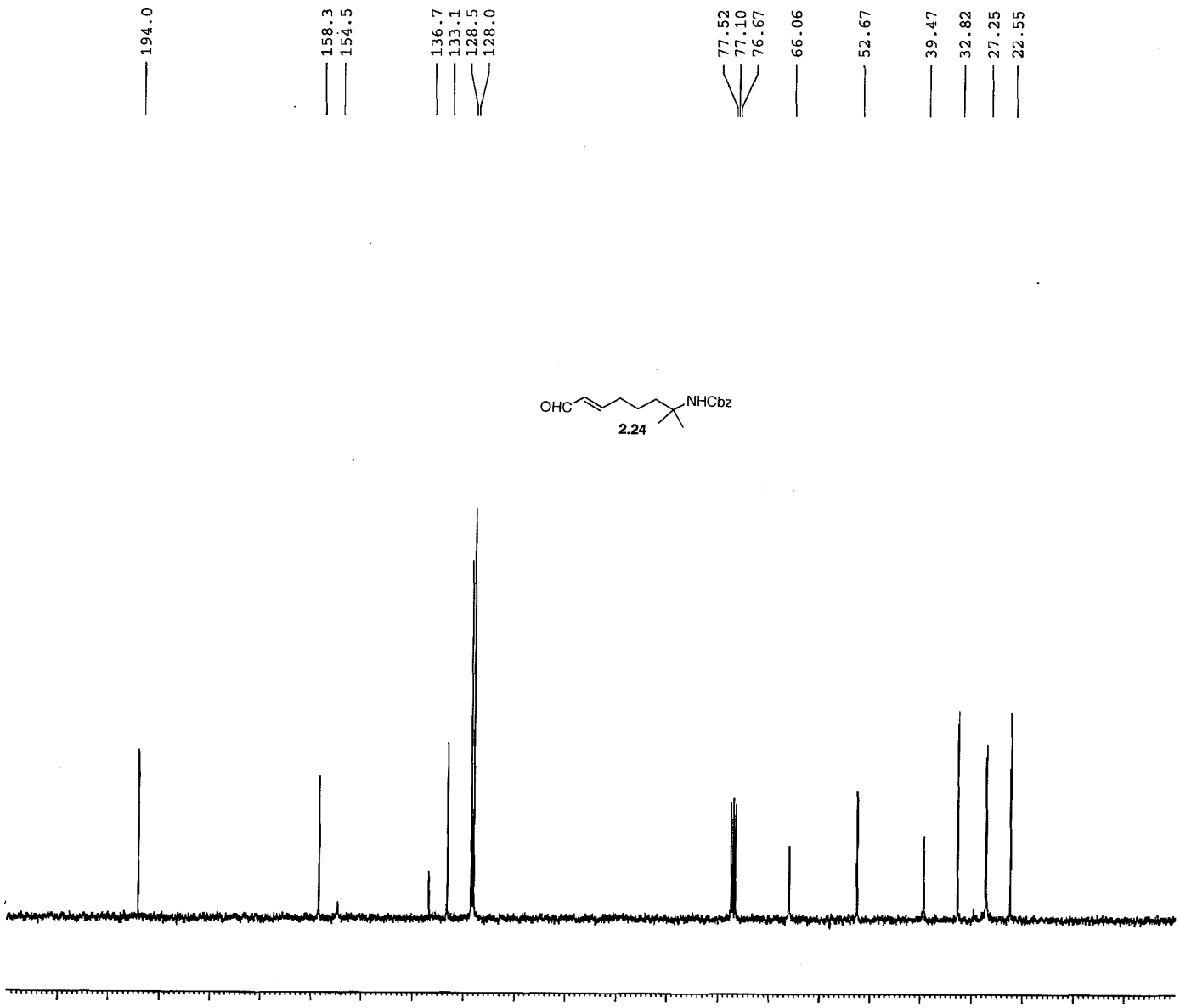
CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00 usec
PL2	17.40 dB
PL12	17.40 dB
PL13	17.40 dB
SFO2	400.0116000 MHz

F2 - Processing parameters

SI	32768
SF	100.5825950 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40




```
Current Data Parameters
NAME                  b2p98
EXPNO                   198
PROCNO                    1
DU                       /n
USER                  erikc

F2 - Acquisition Parameters
Date_              20070802
Time                  16.58
INSTRUM              DPX300
PROBHD    5 mm QNP  1H/1
PULPROG                zg30
TD                    32768
SOLVENT               CDCl3
NS                       32
DS                        2
SWH                4789.272 Hz
FIDRES            0.146157 Hz
AQ                3.4210291 sec
RG                    912.3
DW                  104.400 usec
DE                    6.00 usec
TE                  298.2 K
D1                2.00000000 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                      1H
P1                     9.00 usec
PL1                   -3.00 dB
SFO1          300.1321009 MHz

F2 - Processing parameters
SI                    32768
SF            300.1300000 MHz
WDW                      EM
SSB                       0
LB                     0.30 Hz
GB                        0
PC                     1.00
```



PROCNO	1
DU	/n
USER	erikc

F2 - Acquisition Parameters

Date_	20070802
Time	17.48
INSTRUM	DPX300
PROBHD	5 mm QNP 1H/1
PULPROG	zgpg30
TD	65536
SOLVENT	CDCl3
NS	344
DS	4
SWH	18832.393 Hz
FIDRES	0.287360 Hz
AQ	1.7400308 sec
RG	9195.2
DW	26.550 usec
DE	6.00 usec
TE	298.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1

======== CHANNEL f1 ========

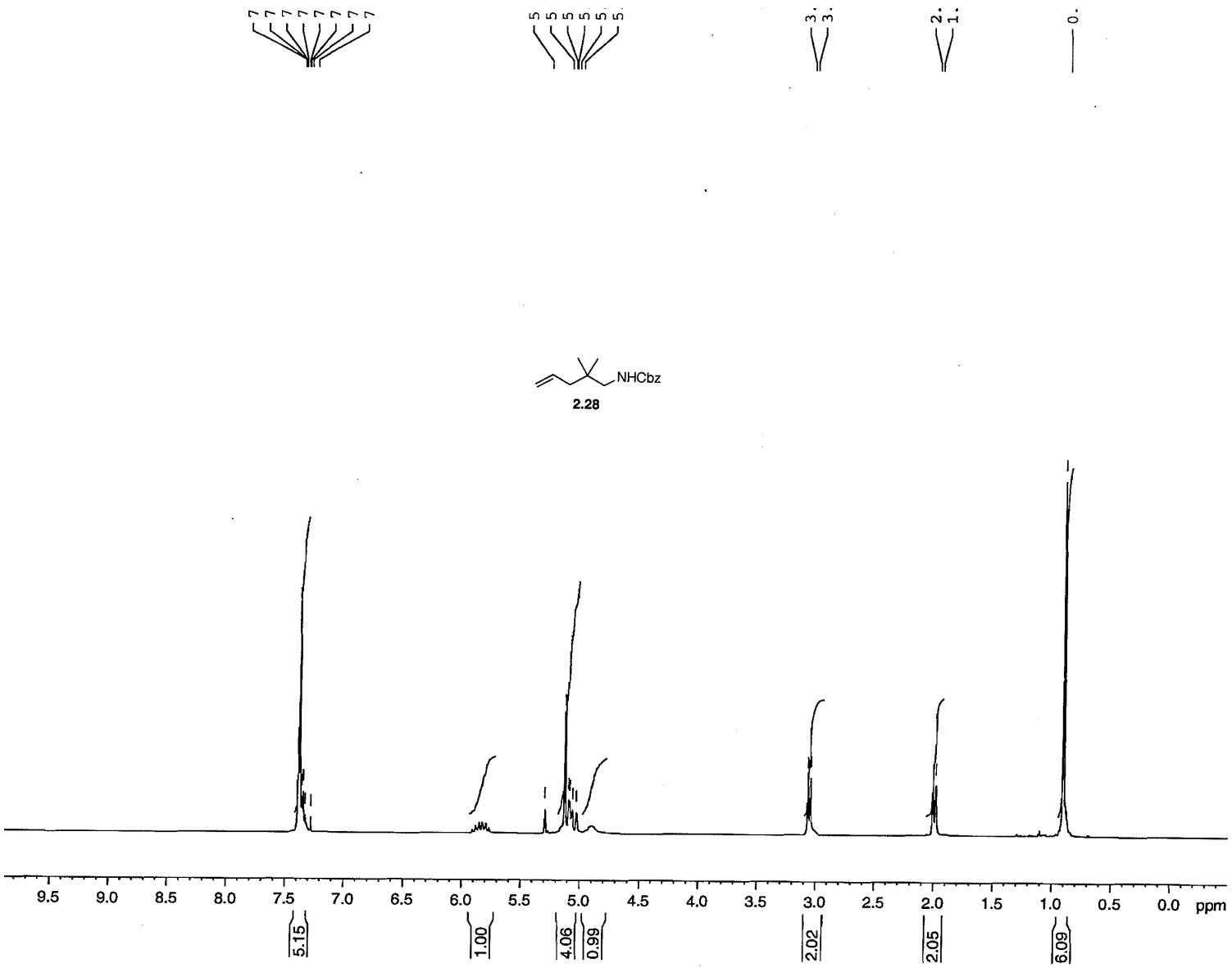
NUC1	13C
P1	8.80 usec
PL1	-3.00 dB
SFO1	75.4760505 MHz

======== CHANNEL f2 ========

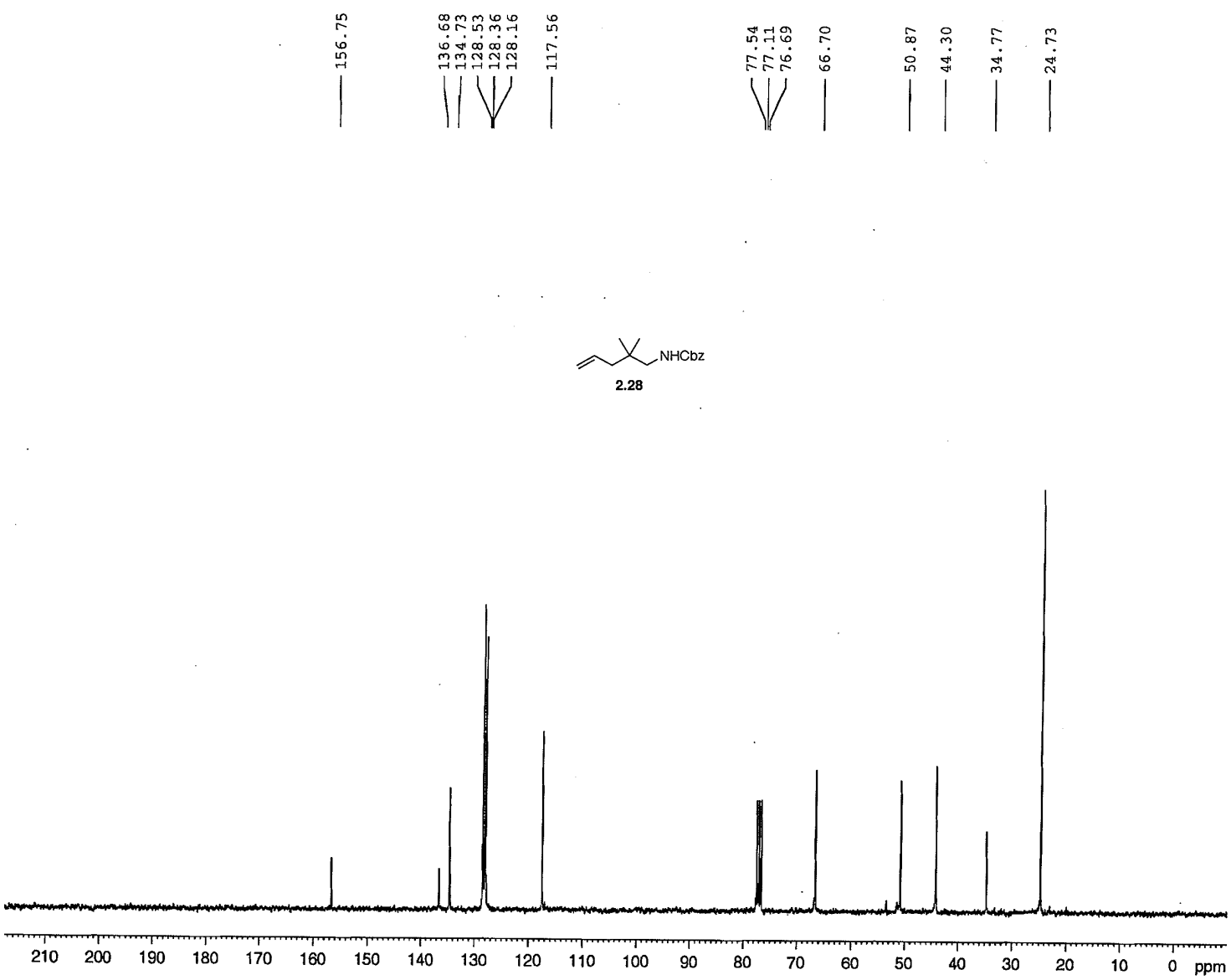
CPDPRG2	waltz16
NUC2	1H
PCPD2	80.00 usec
PL2	-3.00 dB
PL12	17.55 dB
PL13	17.55 dB
SFO2	300.1312005 MHz

F2 - Processing parameters

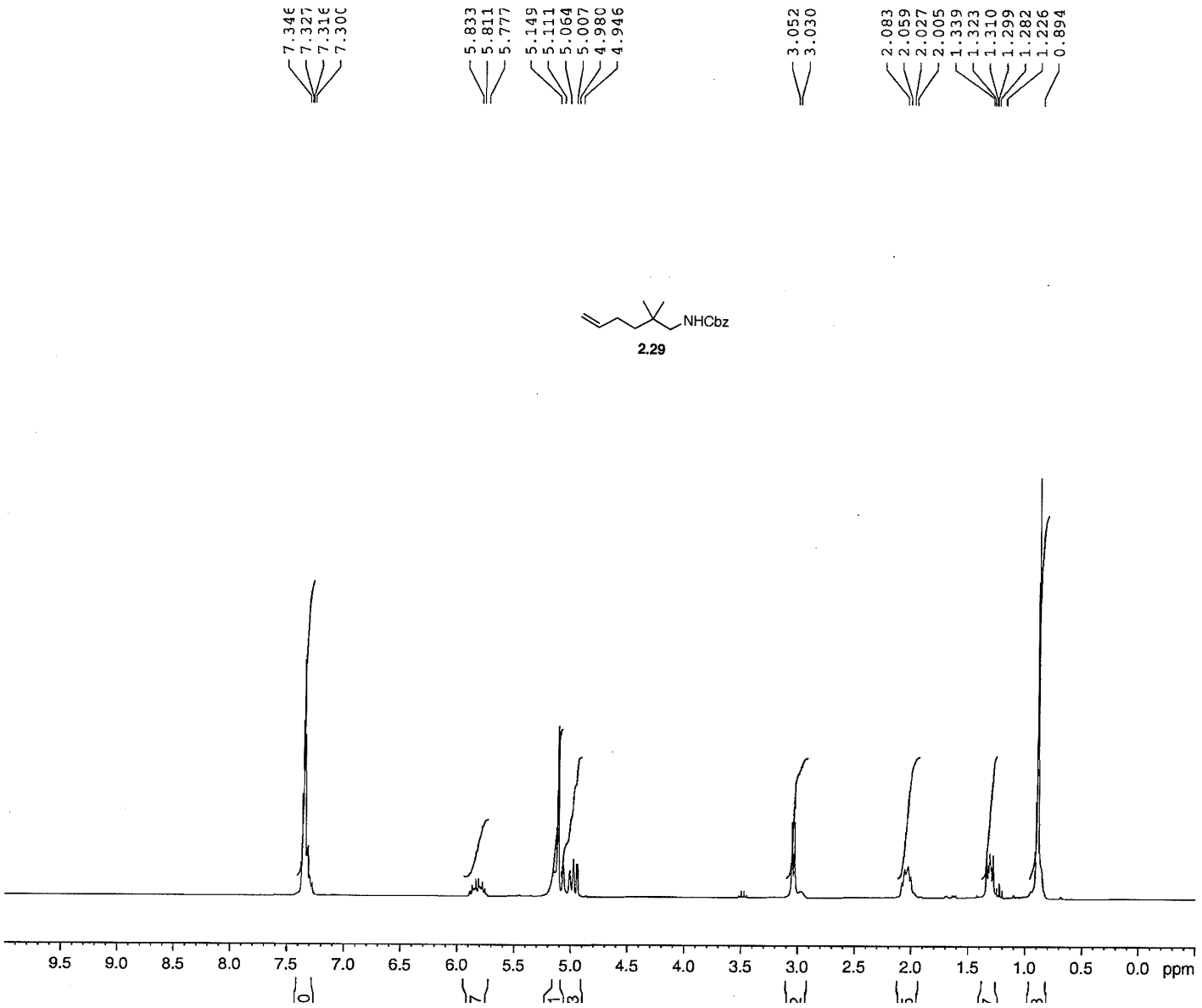
SI	32768
SF	75.4677490 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40



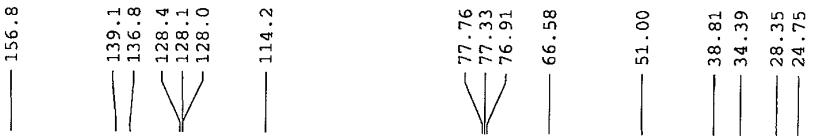

```
NAME                    N
EXPNO
PROCNO
DU
USER                  nat

F2 - Acquisition Pa
Date_               2007
Time                   1
INSTRUM               DP
PROBHD     5 mm QNP
PULPROG
TD                     3
SOLVENT                C
NS
DS
SWH                 4789
FIDRES             0.14
AQ                 3.421
RG                     
DW                   104
DE                     
TE                    2
D1                 2.0000
TD0

======== CHANNEL f1
NUC1
P1                     
PL1                    
SFO1           300.1321

F2 - Processing para
SI                    32
SF             300.1300
WDW
SSB
LB                     0
GB
PC                     1
```



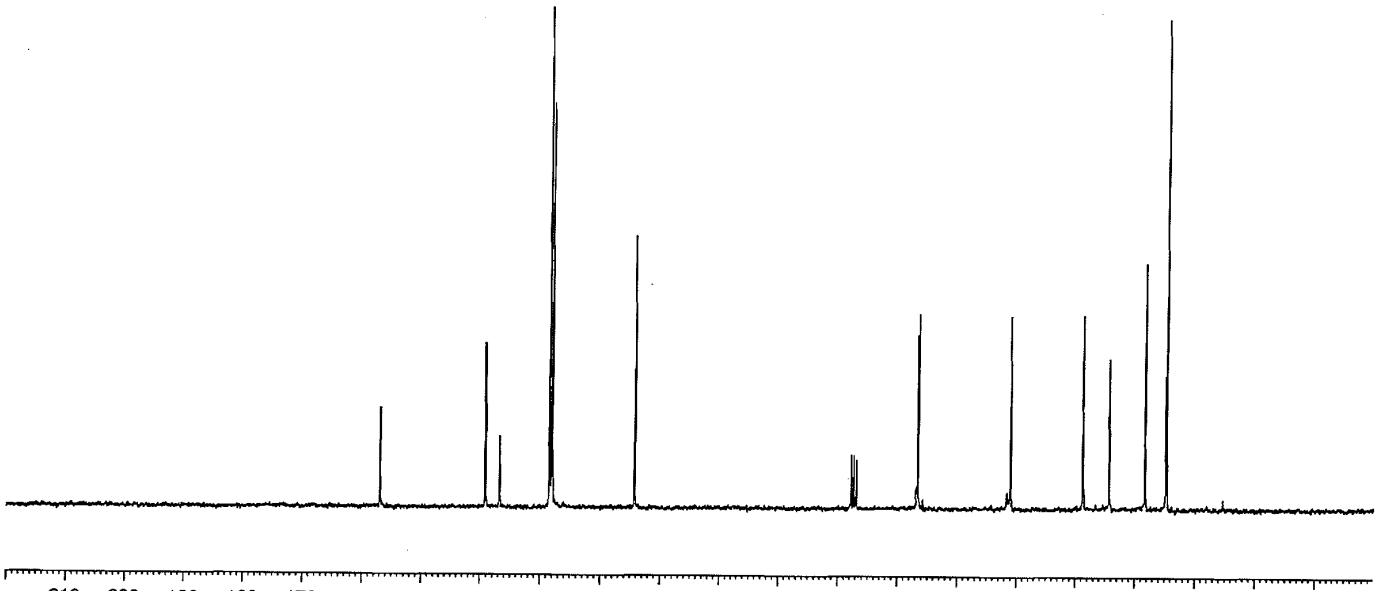
Current Data Parameter	
NAME	NCi4
EXPNO	
PROCNO	
DU	/
USER	nathan
F2 - Acquisition Param	
Date_	2007082
Time	13.3
INSTRUM	DPX30
PROBHD	5 mm QNP 1H/
PULPROG	zgpg3
TD	6553
SOLVENT	CDC1
NS	44
DS	
SWH	18832.39
FIDRES	0.28736
AQ	1.740030
RG	9195.
DW	26.55
DE	6.0
TE	298.
D1	0.1500000
d11	0.0300000
DELTA	0.0500000
TD0	
======== CHANNEL f1 ==	
NUC1	13
P1	8.8
PL1	-3.0
SFO1	75.4760505
======== CHANNEL f2 ==	
CPDPRG2	waltz1
NUC2	1H
PCPD2	80.0
PL2	-3.0
PL12	17.5
PL13	17.5
SFO2	300.1312005
F2 - Processing paramet	
SI	32768
SF	75.4677490
WDW	EM
SSB	0
LB	3.00
GB	0
PC	1.40



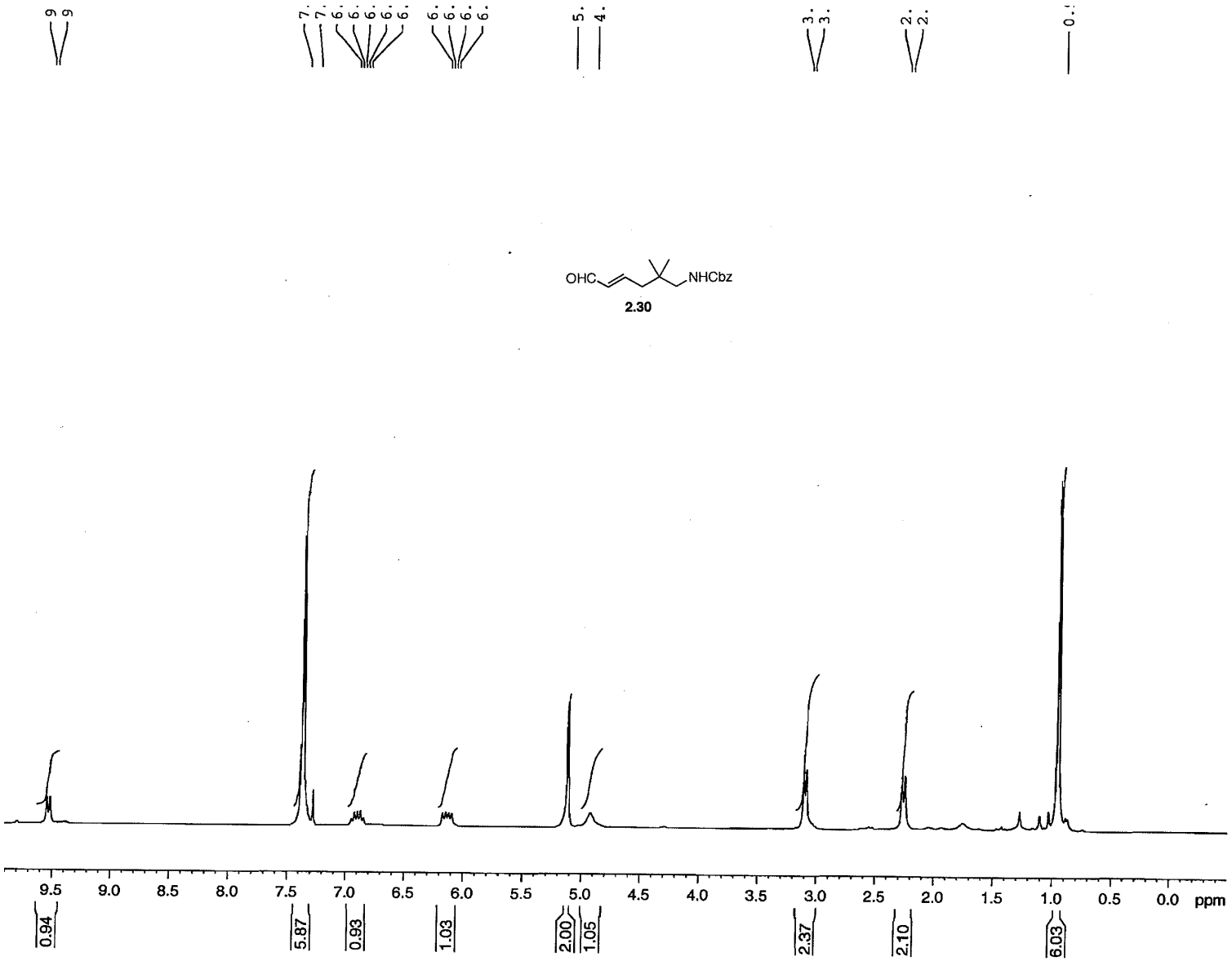

```
Current Data Parameters
NAME                  b4p0049a
EXPNO                      301
PROCNO                       1
DU                          /n
USER                    erikc

F2 - Acquisition Parameters
Date_                20071204
Time                    15.09
INSTRUM                DPX300
PROBHD   5 mm QNP  1H/1
PULPROG                 zg30
TD                     32768
SOLVENT                CDCl3
NS                           7
DS                           2
SWH                 4789.272 Hz
FIDRES              0.146157 Hz
AQ                3.4210291 sec
RG                        20.2
DW                  104.400 usec
DE                    6.00 usec
TE                    298.2 K
D1                2.00000000 sec
TD0                          1

======== CHANNEL f1 ========
NUC1                       1H
P1                    9.00 usec
PL1                  -3.00 dB
SFO1           300.1321009 MHz

F2 - Processing parameters
SI                       32768
SF             300.1300000 MHz
WDW                         EM
SSB                          0
LB                    0.30 Hz
GB                           0
PC                        1.00
```



2.29



```
PROCNO                  1
DU                     /n
USER                erikc

F2 - Acquisition Parameters
Date_           20071204
Time               15.14
INSTRUM          DPX300
PROBHD   5 mm QNP  1H/1
PULPROG          zgpg30
TD                65536
SOLVENT           CDCl3
NS                  111
DS                    4
SWH           18832.393 Hz
FIDRES         0.287360 Hz
AQ             1.7400308 sec
RG                9195.2
DW                26.550 usec
DE                 6.00 usec
TE                298.2 K
D1           0.15000001 sec
d11          0.03000000 sec
DELTA        0.05000000 sec
TD0                   1

======== CHANNEL f1 ========
NUC1                13C
P1                 8.80 usec
PL1               -3.00 dB
SFO1         75.4760505 MHz

======== CHANNEL f2 ========
CPDPRG2          waltz16
NUC2                1H
PCPD2             80.00 usec
PL2               -3.00 dB
PL12              17.55 dB
PL13              17.55 dB
SFO2        300.1312005 MHz

F2 - Processing parameters
SI                 32768
SP           75.4677490 MHz
WDW                  EM
SSB                   0
LB                 3.00 Hz
GB                    0
PC                 1.40
```

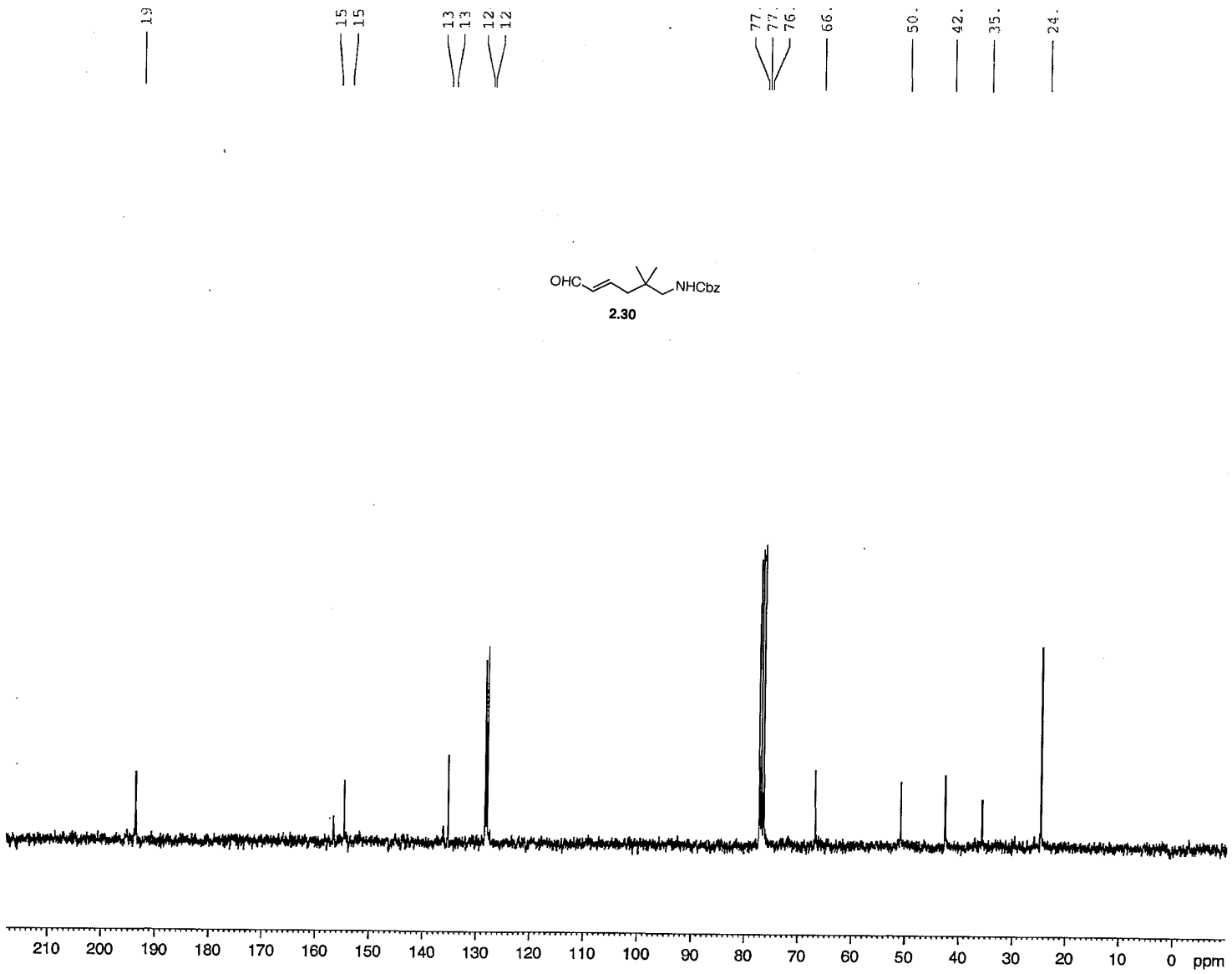


NAME
EXPNO
PROCNO
DU
USER na

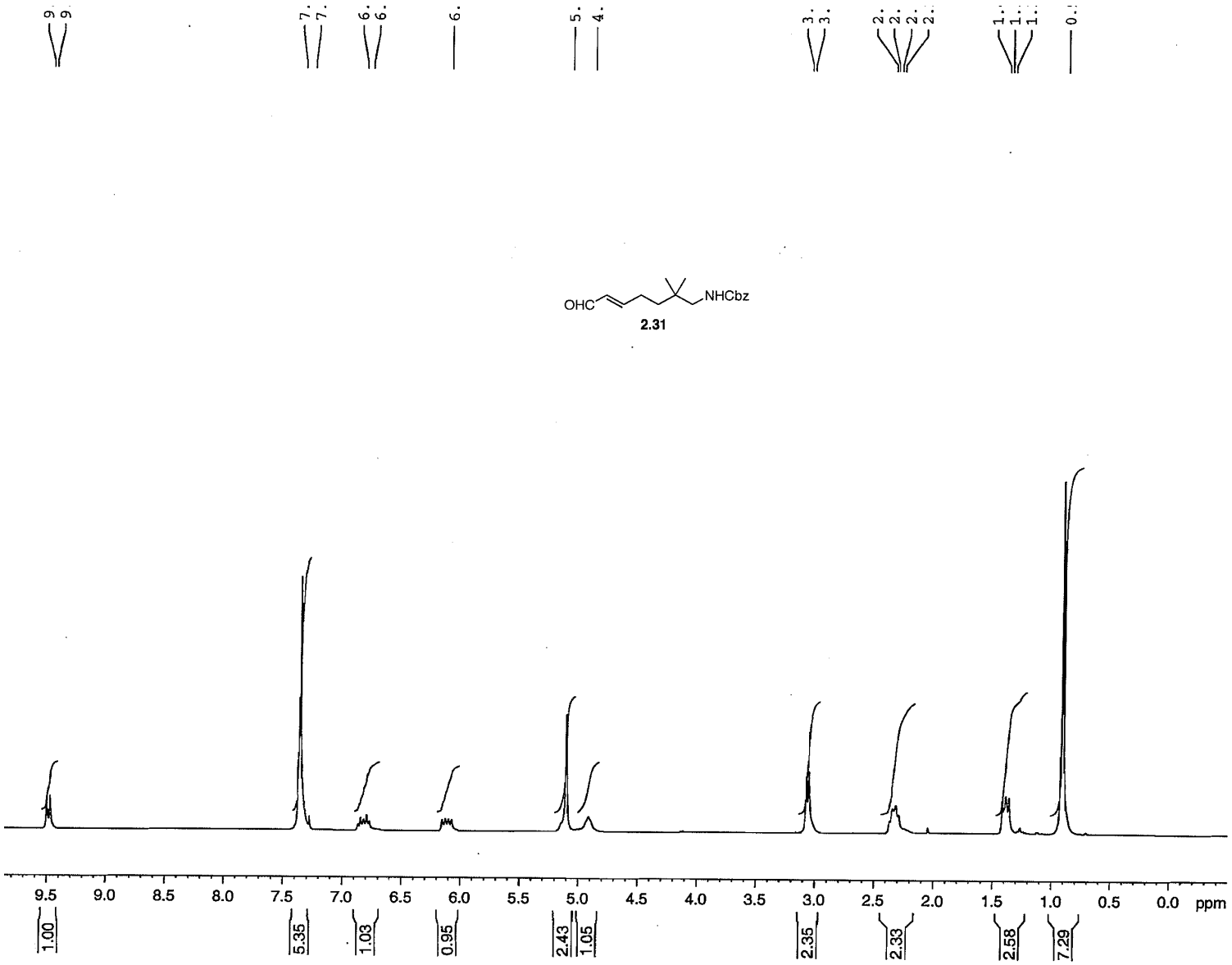
F2 - Acquisition P
Date_ 200
Time
INSTRUM D
PROBHD 5 mm QNP
PULPROG
TD
SOLVENT
NS
DS
SWH 478
FIDRES 0.1
AQ 3.42
RG
DW 10
DE
TE
D1 2.000
TD0

======== CHANNEL f1
NUC1
P1
PL1
SFO1 300.132

F2 - Processing par
SI 3
SF 300.130
WDW
SSB
LB
GB
PC



NAME	NCi
EXPNO	
PROCNO	
DU	
USER	nathar
F2 - Acquisition Paran	
Date_	200708
Time	16.4
INSTRUM	DPX3(
PROBHD	5 mm QNP 1H/
PULPROG	zgpg3
TD	655
SOLVENT	CDCl
NS	3(
DS	
SWH	18832.39
FIDRES	0.28736
AQ	1.740030
RG	9195.
DW	26.55
DE	6.0
TE	298.
D1	0.1500000
d11	0.0300000
DELTA	0.0500000
TD0	
======== CHANNEL f1 ==	
NUC1	13
P1	8.8
PL1	-3.0
SFO1	75.476050
======== CHANNEL f2 ==	
CPDPRG2	waltz1
NUC2	1
PCPD2	80.0
PL2	-3.0
PL12	17.5
PL13	17.5
SFO2	300.131200
F2 - Processing paramet	
SI	32768
SF	75.467749(
WDW	EM
SSB	(
LB	3.00
GB	(
PC	1.40

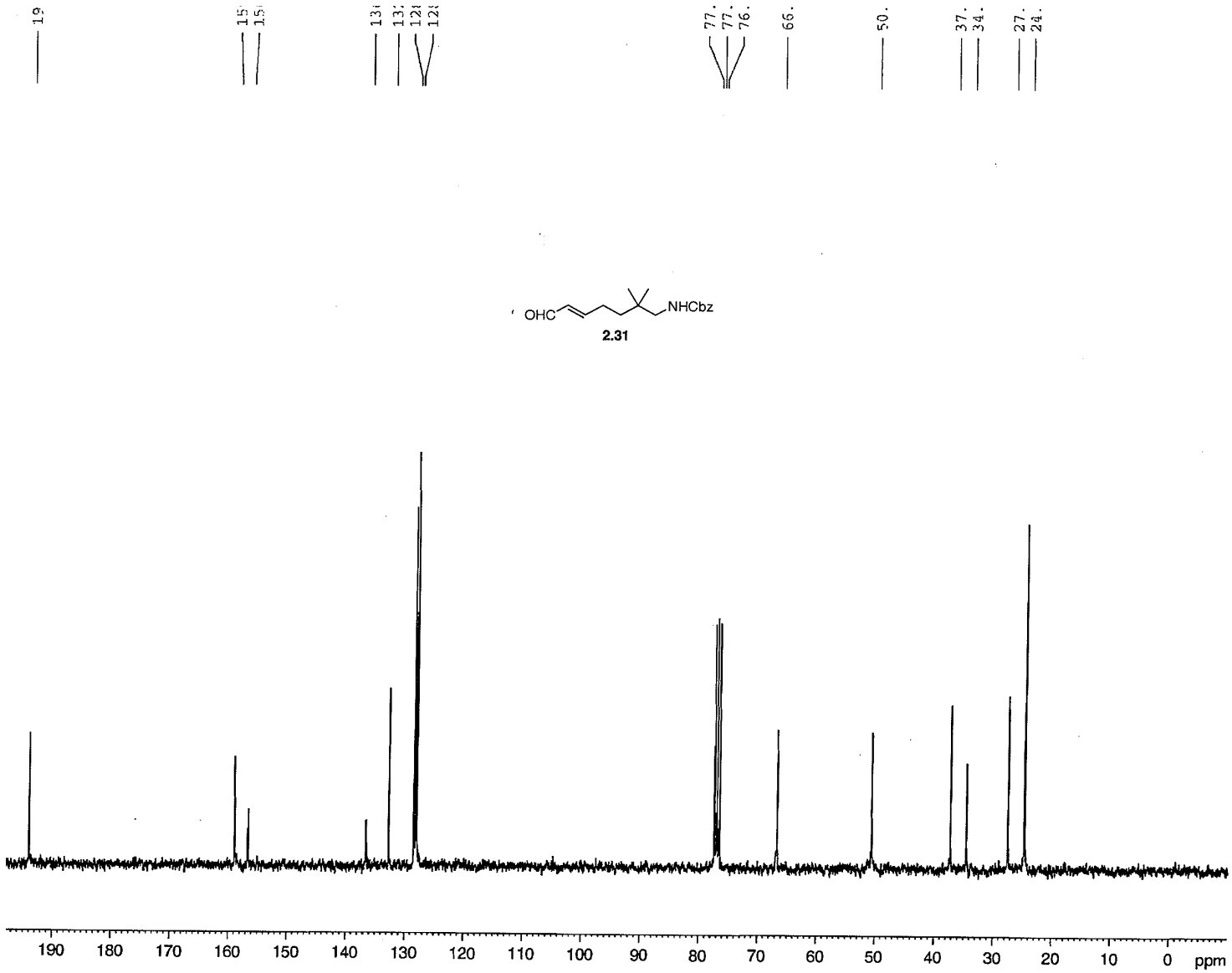


NAME N
EXPNO
PROCNO
DU
USER nat

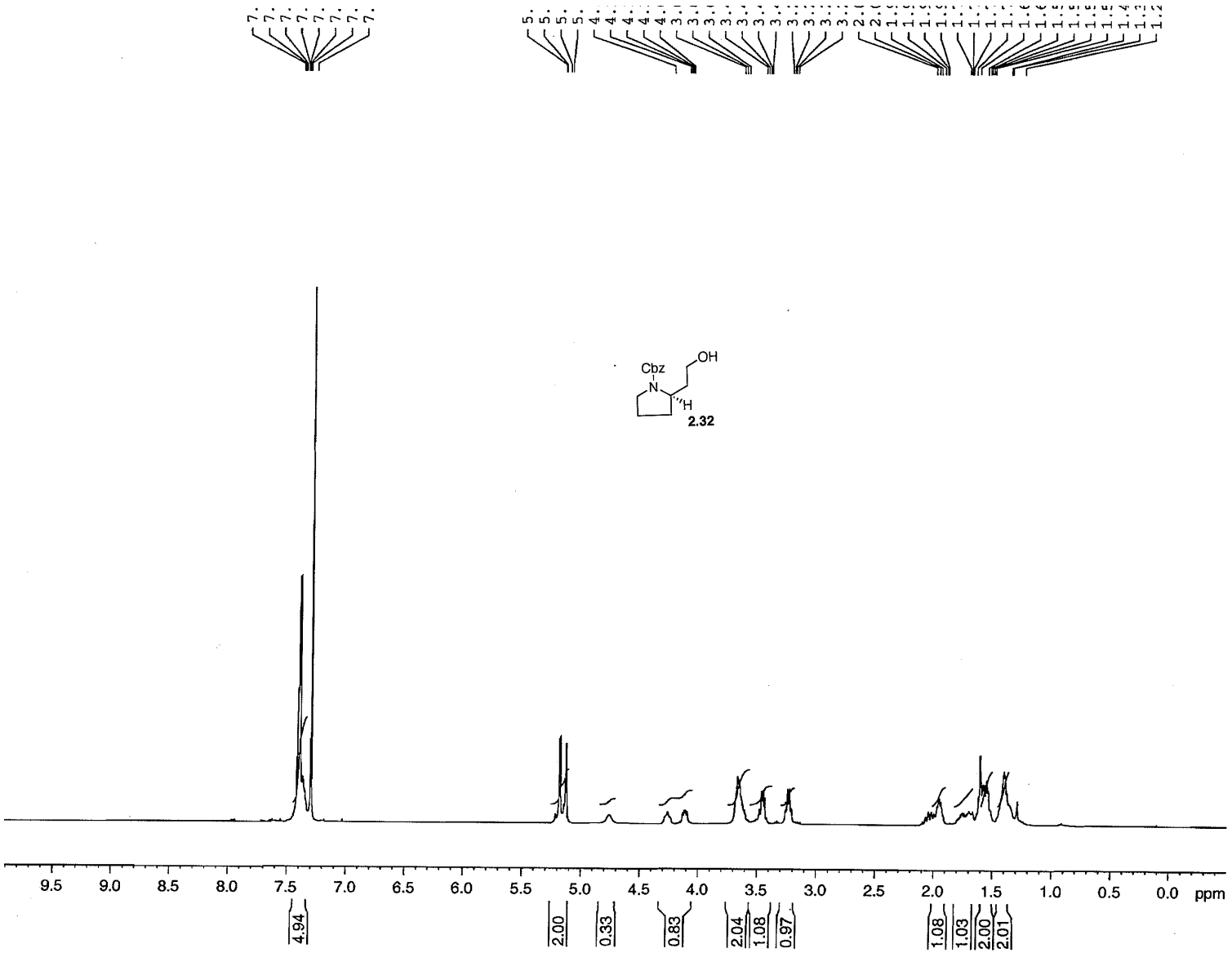
F2 - Acquisition Pa
Date_ 2007
Time 1
INSTRUM DP
PROBHD 5 mm QNP
PULPROG
TD 3
SOLVENT C
NS
DS
SWH 4789
FIDRES 0.14
AQ 3.421
RG
DW 104
DE
TE 2
D1 2.0000
TD0

======== CHANNEL f1
NUC1
P1
PL1
SFO1 300.132

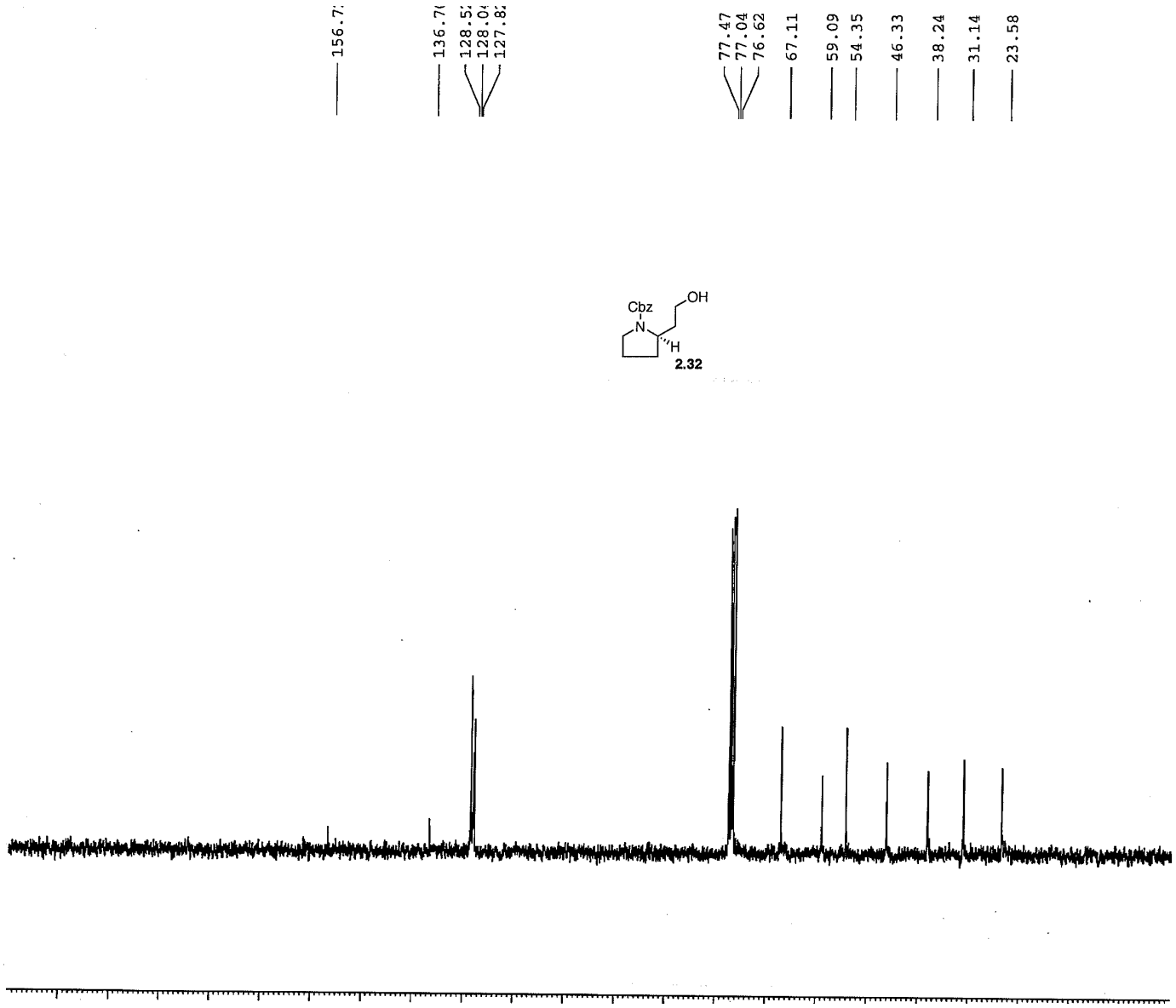
F2 - Processing para
SI 32
SF 300.130
WDW
SSB
LB
GB
PC 1



NAME	NCi3
EXPNO	
PROCNO	
DU	/
USER	nathan
F2 - Acquisition Param	
Date_	2007081
Time	11.2
INSTRUM	DPX30
PROBHD	5 mm QNP 1H/
PULPROG	zgpg3
TD	6553
SOLVENT	CDCl
NS	44
DS	
SWH	18832.39
FIDRES	0.28736
AQ	1.740030
RG	9195.
DW	26.55
DE	6.0
TE	298.
D1	0.1500000
d11	0.0300000
DELTA	0.0500000
TD0	
======== CHANNEL f1 ==	
NUC1	13
P1	8.8
PL1	-3.0
SFO1	75.476050
======== CHANNEL f2 ==	
CPDPRG2	waltz1
NUC2	1
PCPD2	80.0
PL2	-3.0
PL12	17.5
PL13	17.5
SFO2	300.131200
F2 - Processing paramet	
SI	3276
SF	75.467749
WDW	EM
SSB	0
LB	3.00
GB	0
PC	1.40




```
EXPNO
PROCNO
DU
USER                nat

F2 - Acquisition Pa
Date_                200
Time                  1
INSTRUM              DI
PROBHD    5 mm BBO F
PULPROG
TD                    3
SOLVENT
NS
DS
SWH                6410
FIDRES             0.19
AQ                2.555
RG
DW                   78
DE
TE                    2
D1               2.0000
TD0

======== CHANNEL f1
NUC1
P1                    1
PL1
SFO1           400.012

F2 - Processing par
SI                    3
SF             400.010
WDW
SSB
LB
GB
PC
```



EXPNO	232
PROCNO	1
DU	/n
USER	erikc

F2 - Acquisition Parameters

Date_	20070821
Time	13.15
INSTRUM	DPX300
PROBHD	5 mm QNP 1H/1
PULPROG	zgpg30
TD	65536
SOLVENT	CDCl3
NS	401
DS	4
SWH	18832.393 Hz
FIDRES	0.287360 Hz
AQ	1.7400308 sec
RG	9195.2
DW	26.550 usec
DE	6.00 usec
TE	298.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1

======== CHANNEL f1 ========

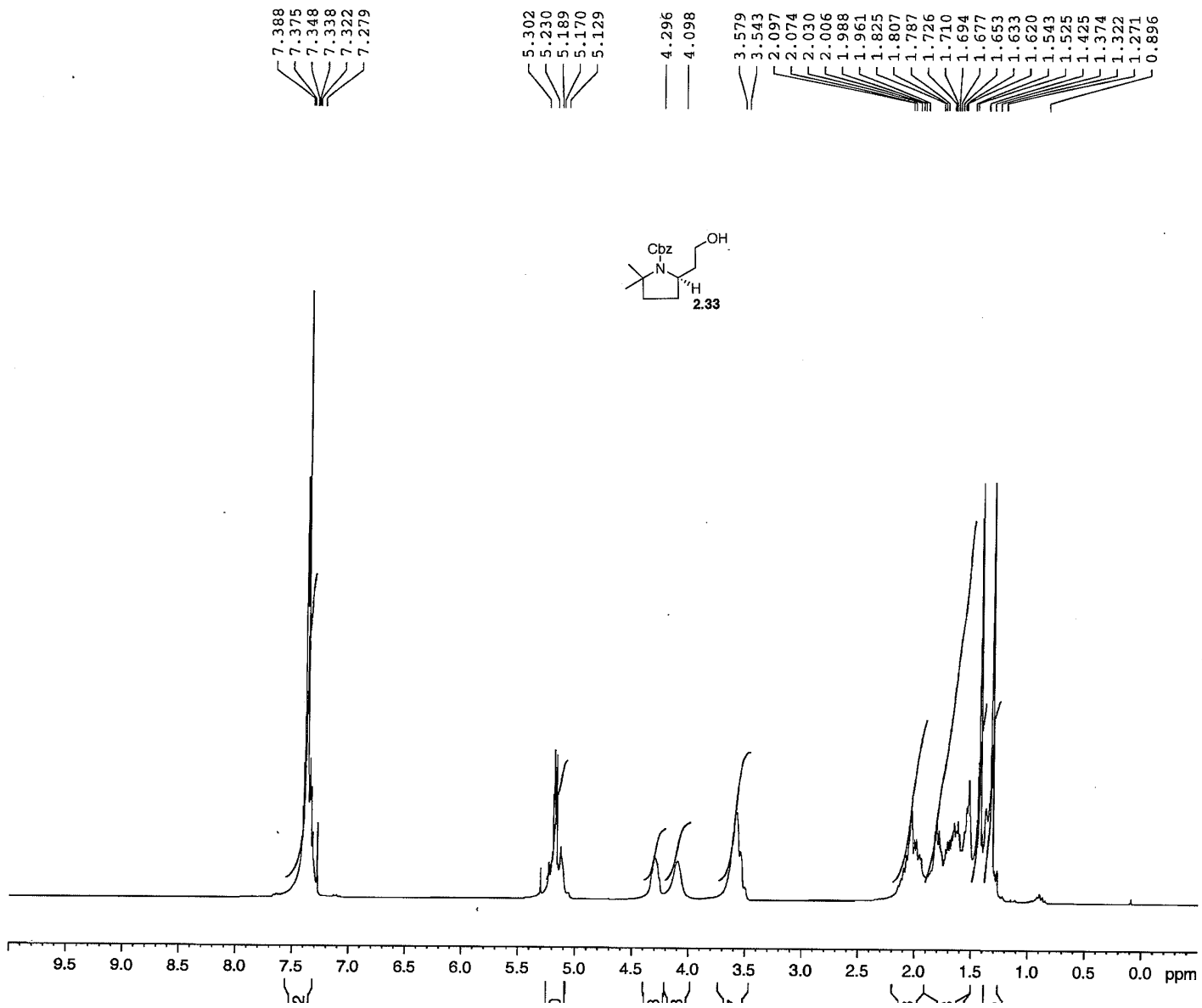
NUC1	13C
P1	8.80 usec
PL1	-3.00 dB
SFO1	75.4760505 MHz

======== CHANNEL f2 ========

CPDPRG2	waltz16
NUC2	1H
PCPD2	80.00 usec
PL2	-3.00 dB
PL12	17.55 dB
PL13	17.55 dB
SFO2	300.1312005 MHz

F2 - Processing parameters

SI	32768
SF	75.4677490 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40



Current Data Parameters

NAME	b3p26a
EXPNO	226
PROCNO	1
DU	/n
USER	erikc

F2 - Acquisition Parameters

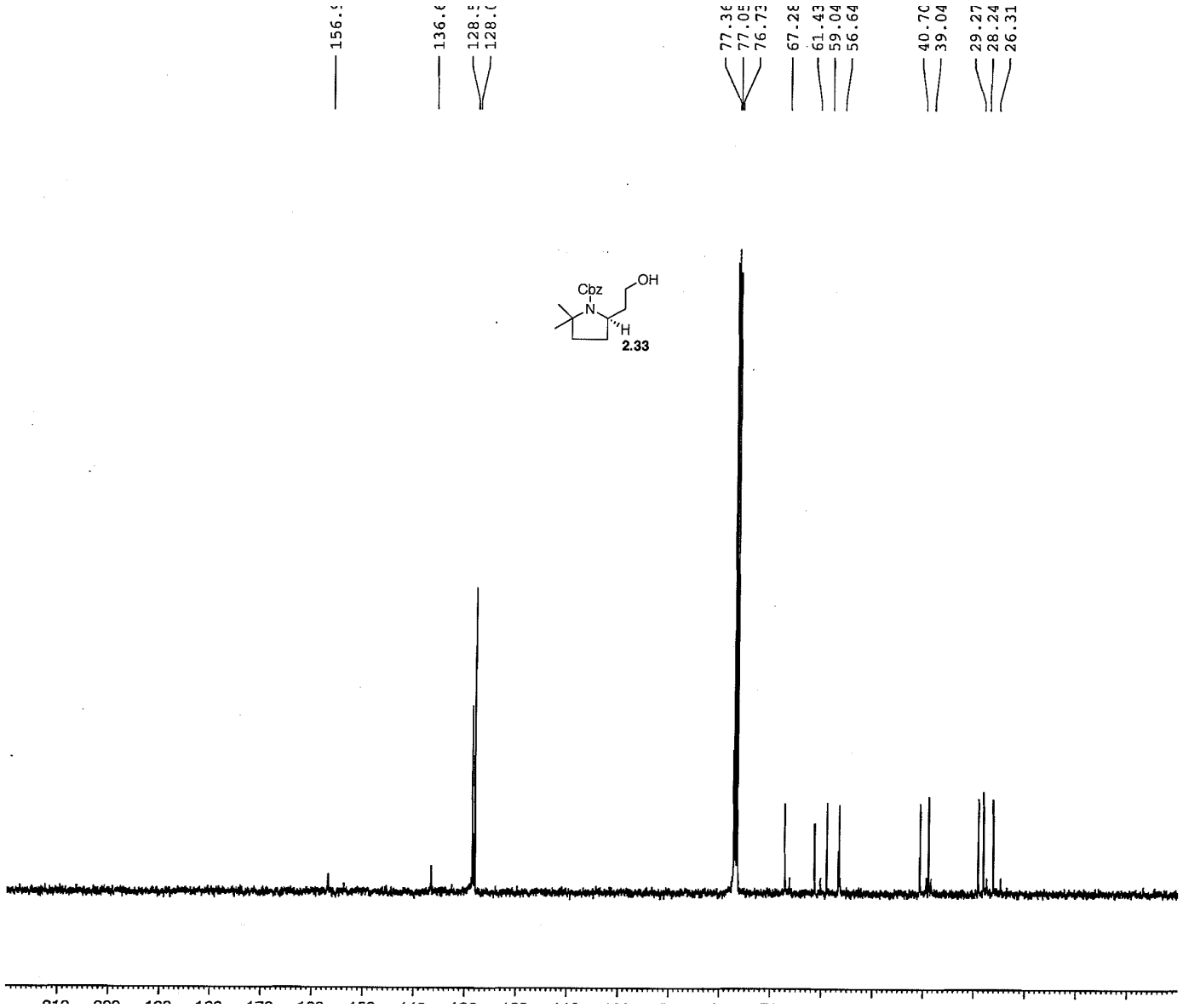
Date_	20070821
Time	16.09
INSTRUM	DPX300
PROBHD	5 mm QNP 1H/1
PULPROG	zg30
TD	32768
SOLVENT	CDC13
NS	20
DS	2
SWH	4789.272 Hz
FIDRES	0.146157 Hz
AQ	3.4210291 sec
RG	128
DW	104.400 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

NUC1	1H
P1	9.00 usec
PL1	-3.00 dB
SFO1	300.1321009 MHz

F2 - Processing parameters

SI	32768
SF	300.1300000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00



PROCNO	1
DU	/m
USER	erikc

F2 - Acquisition Parameters

Date_	20080109
Time	17.36
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zgpg30
TD	65536
SOLVENT	
NS	2450
DS	4
SWH	25125.629 Hz
FIDRES	0.383387 Hz
AQ	1.3042164 sec
RG	4597.6
DW	19.900 usec
DE	6.00 usec
TE	299.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1

======== CHANNEL f1 ========

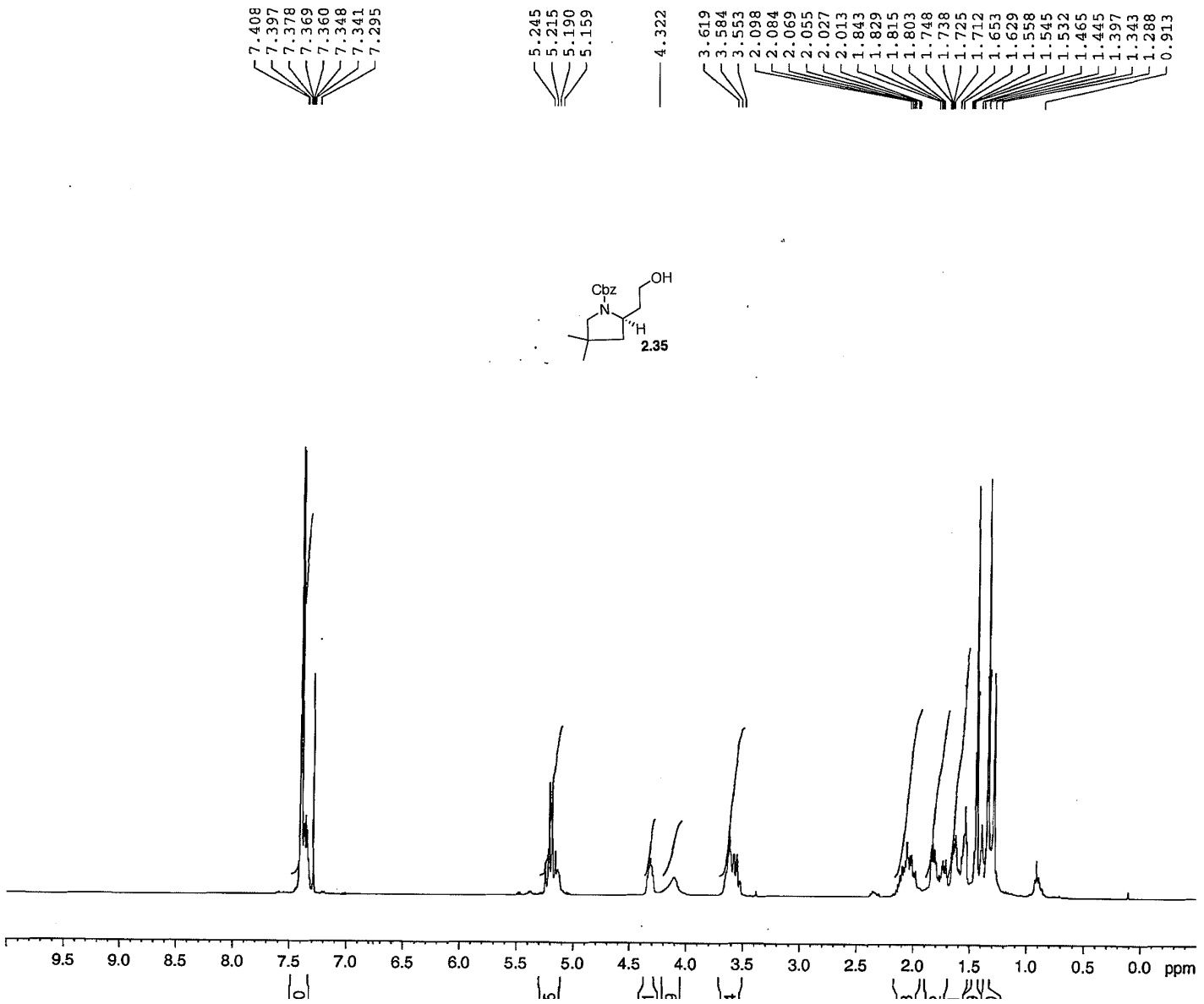
NUC1	13C
P1	7.80 usec
PL1	-3.00 dB
SFO1	100.5936591 MHz

======== CHANNEL f2 ========

CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00 usec
PL2	17.40 dB
PL12	17.40 dB
PL13	17.40 dB
SFO2	400.0116000 MHz

F2 - Processing parameters

SI	32768
SF	100.5825950 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40



Current Data Parameters

NAME	b4p070d
EXPNO	3
PROCNO	1
DU	/m
USER	erikc

F2 - Acquisition Parameters

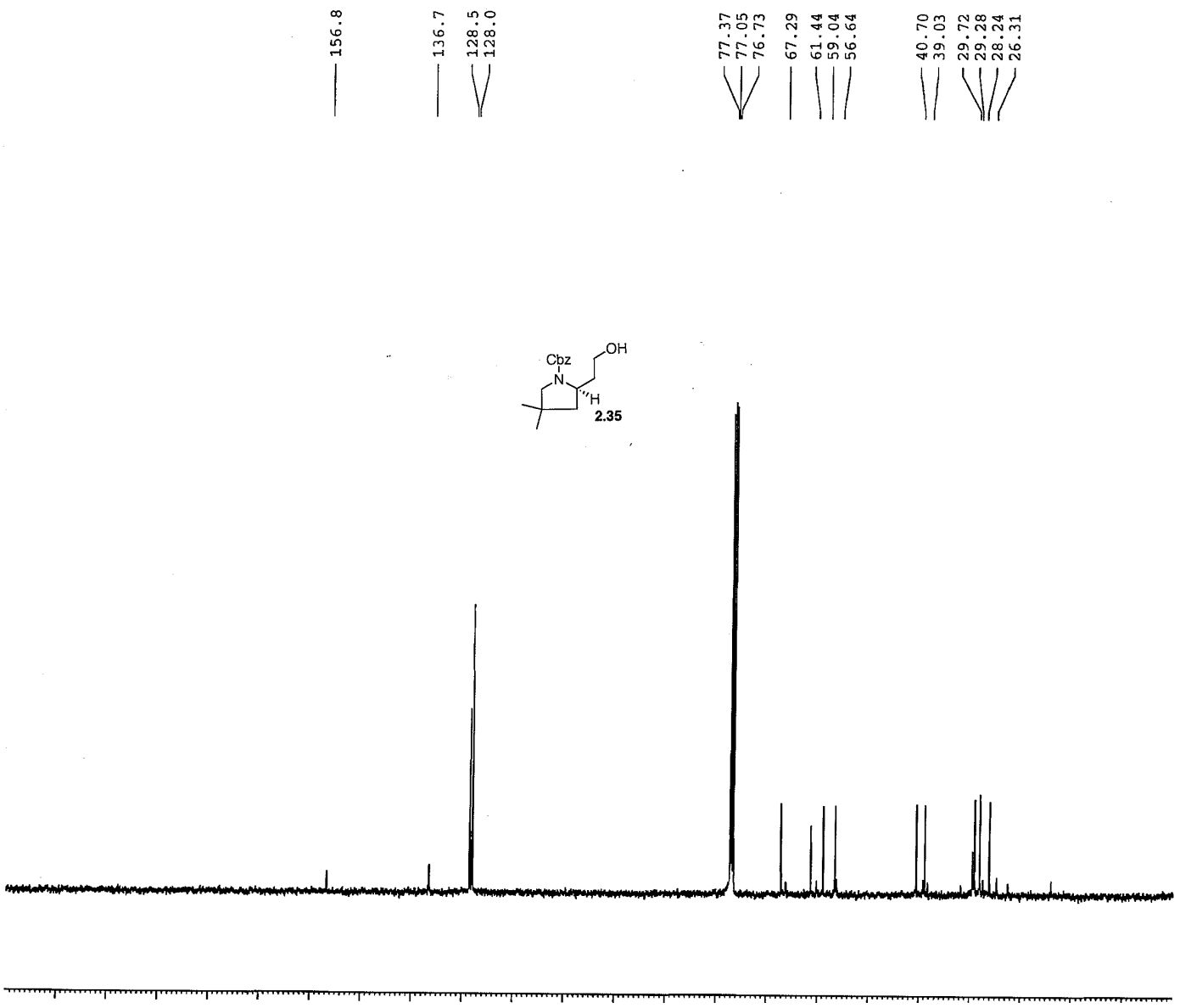
Date_	20080124
Time	16.27
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	32
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	203.2
DW	78.000 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

NUC1	1H
P1	14.70 usec
PL1	0.00 dB
SFO1	400.0128001 MHz

F2 - Processing parameters

SI	32768
SF	400.0100000 MHz
WDW	EM
SSB	0
LB	0.70 Hz
GB	0
PC	1.00



PROCNO	1
DU	/m
USER	erikc

F2 - Acquisition Parameters

Date_	20080124
Time	17.30
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zgpg30
TD	65536
SOLVENT	CDCl3
NS	2407
DS	4
SWH	25125.629 Hz
FIDRES	0.383387 Hz
AQ	1.3042164 sec
RG	3649.1
DW	19.900 usec
DE	6.00 usec
TE	298.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1

======== CHANNEL f1 ========

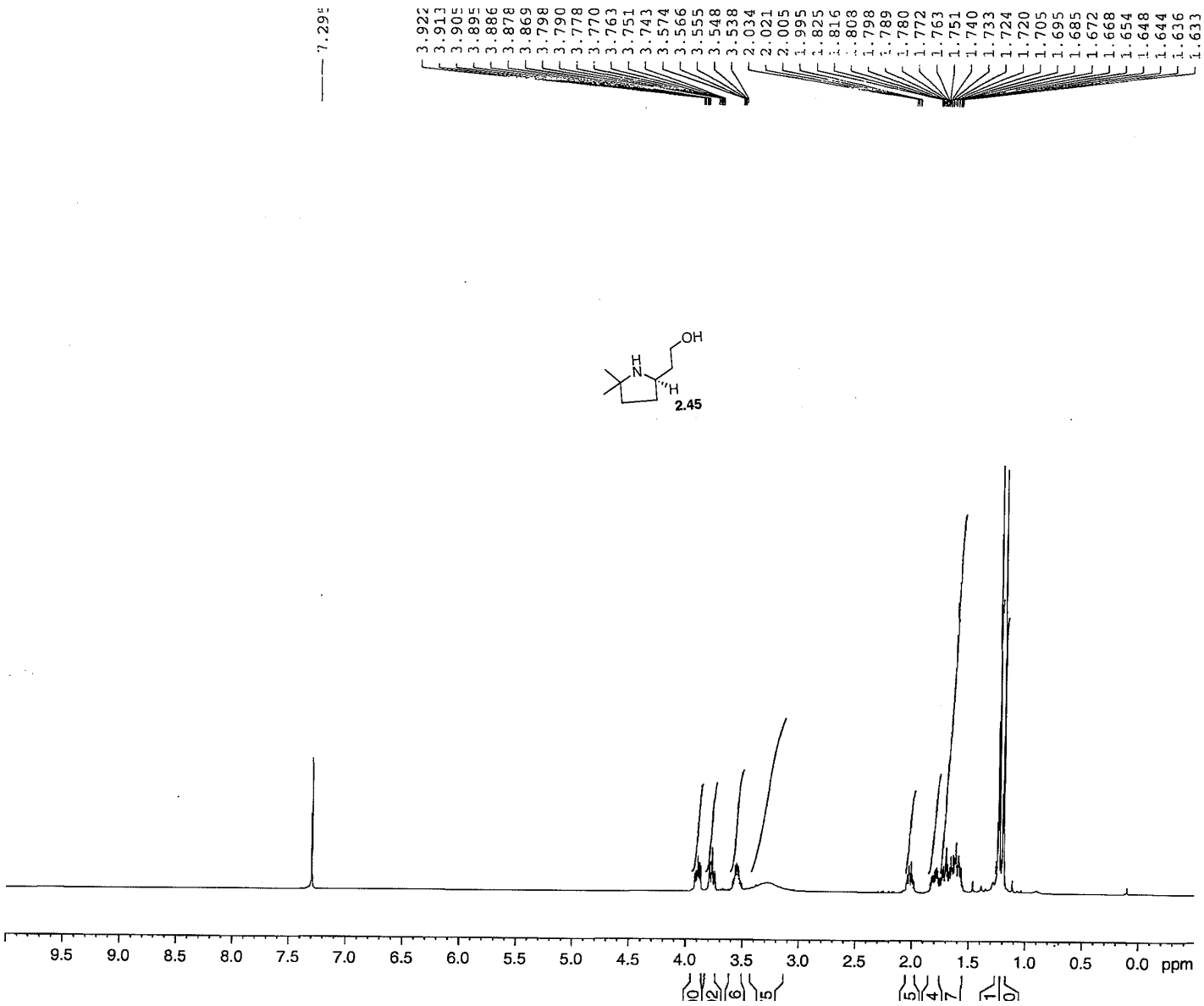
NUC1	13C
P1	7.80 usec
PL1	-3.00 dB
SFO1	100.5936591 MHz

======== CHANNEL f2 ========

CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00 usec
PL2	17.40 dB
PL12	17.40 dB
PL13	17.40 dB
SFO2	400.0116000 MHz

F2 - Processing parameters

SI	32768
SF	100.5825950 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40



Current Data Parameters

NAME	b4p72
EXPNO	3
PROCNO	1
DU	/m
USER	erikc

F2 - Acquisition Parameters

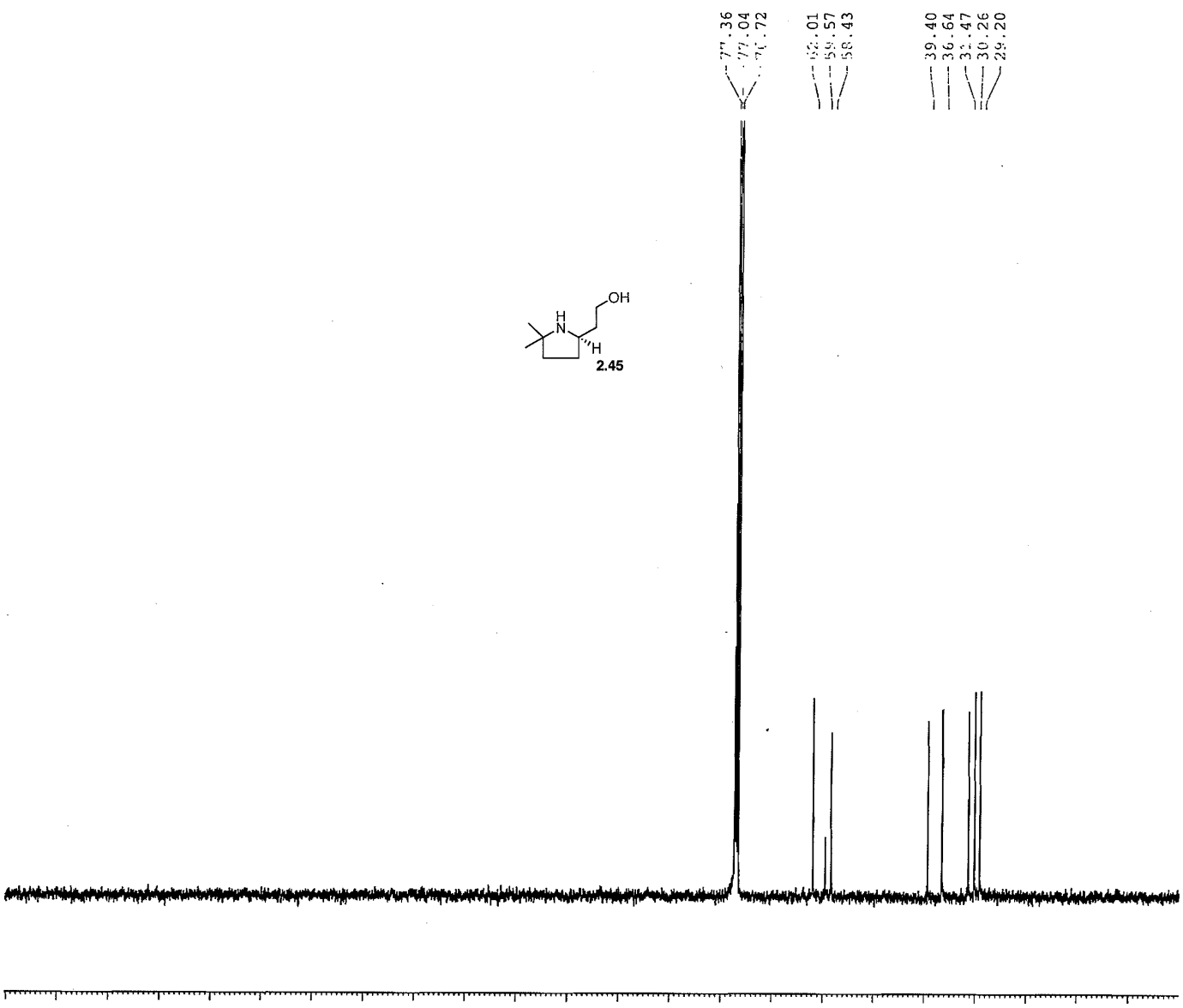
Date_	20080116
Time	10.13
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	32
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	362
DW	78.000 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

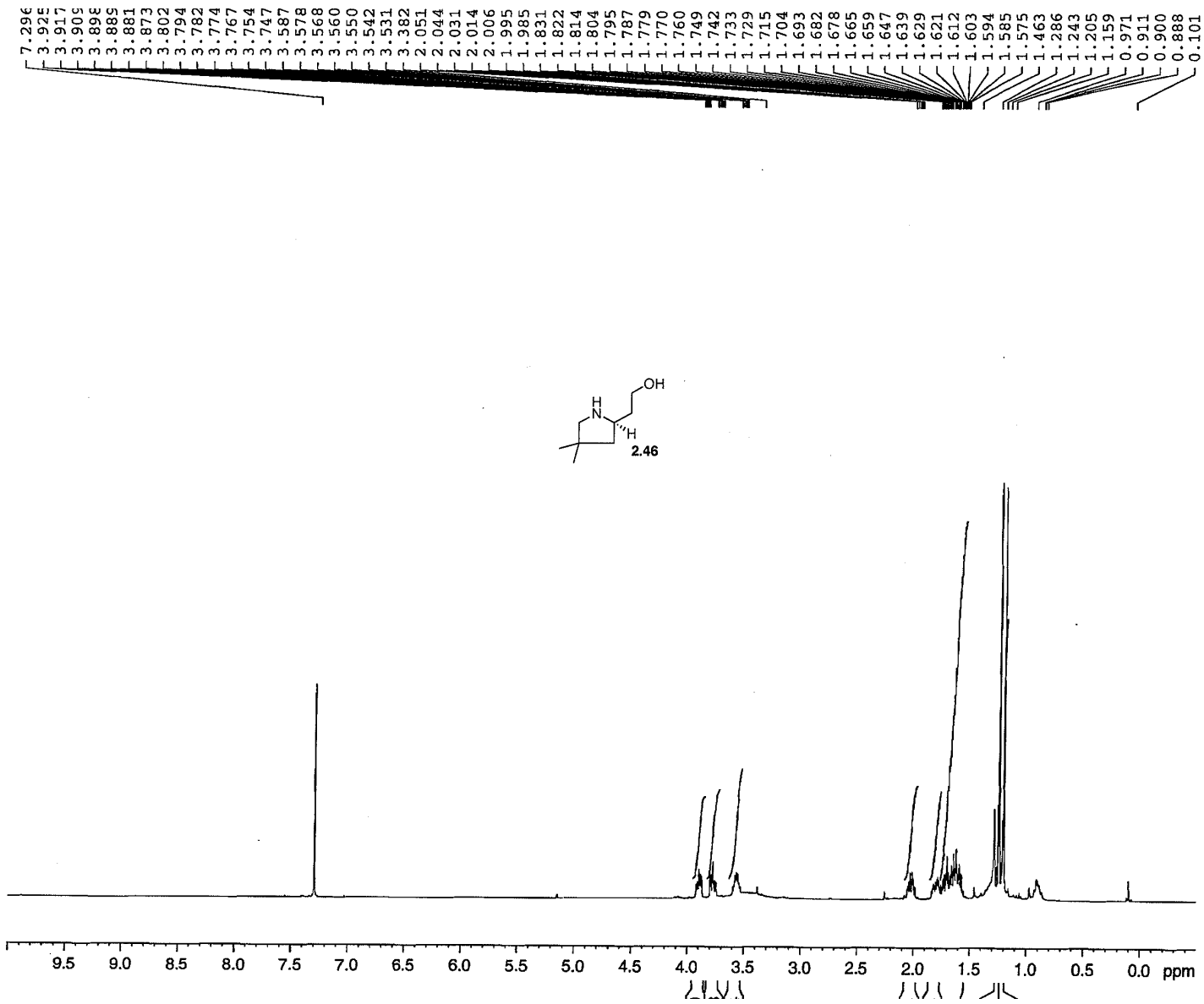
NUC1	1H
P1	14.70 usec
PL1	0.00 dB
SFO1	400.0128001 MHz

F2 - Processing parameters

SI	32768
SF	400.0100000 MHz
WDW	EM
SSB	0
LB	0.70 Hz
GB	0
PC	1.00



PROCNO	1
DU	/m
USER	erikc
F2 - Acquisition Parameters	
Date_	20080116
Time	11.11
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zgpg30
TD	65536
SOLVENT	
NS	2292
DS	4
SWH	25125.629 Hz
FIDRES	0.383387 Hz
AQ	1.3042164 sec
RG	2580.3
DW	19.900 usec
DE	6.00 usec
TE	299.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1
======== CHANNEL f1 ========	
NUC1	13C
P1	7.80 usec
PL1	-3.00 dB
SFO1	100.5936591 MHz
======== CHANNEL f2 ========	
CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00 usec
PL2	17.40 dB
PL12	17.40 dB
PL13	17.40 dB
SFO2	400.0116000 MHz
F2 - Processing parameters	
SI	32768
SF	100.5825950 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40



Current Data Parameters

NAME	75
EXPNO	3
PROCNO	1
DU	/m
USER	erikc

F2 - Acquisition Parameters

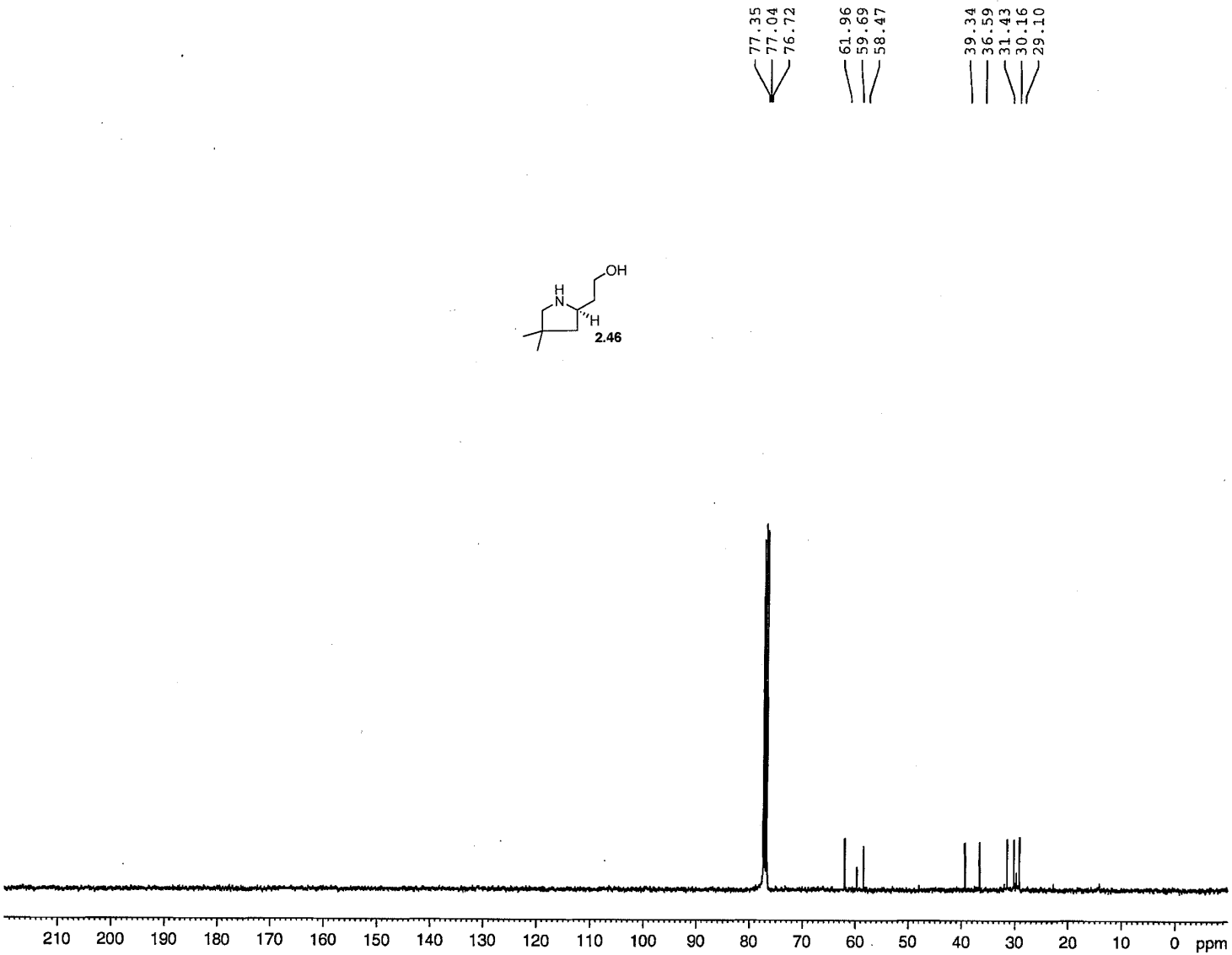
Date_	20080128
Time	22.15
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zg30
TD	32768
SOLVENT	
NS	32
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	512
DW	78.000 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

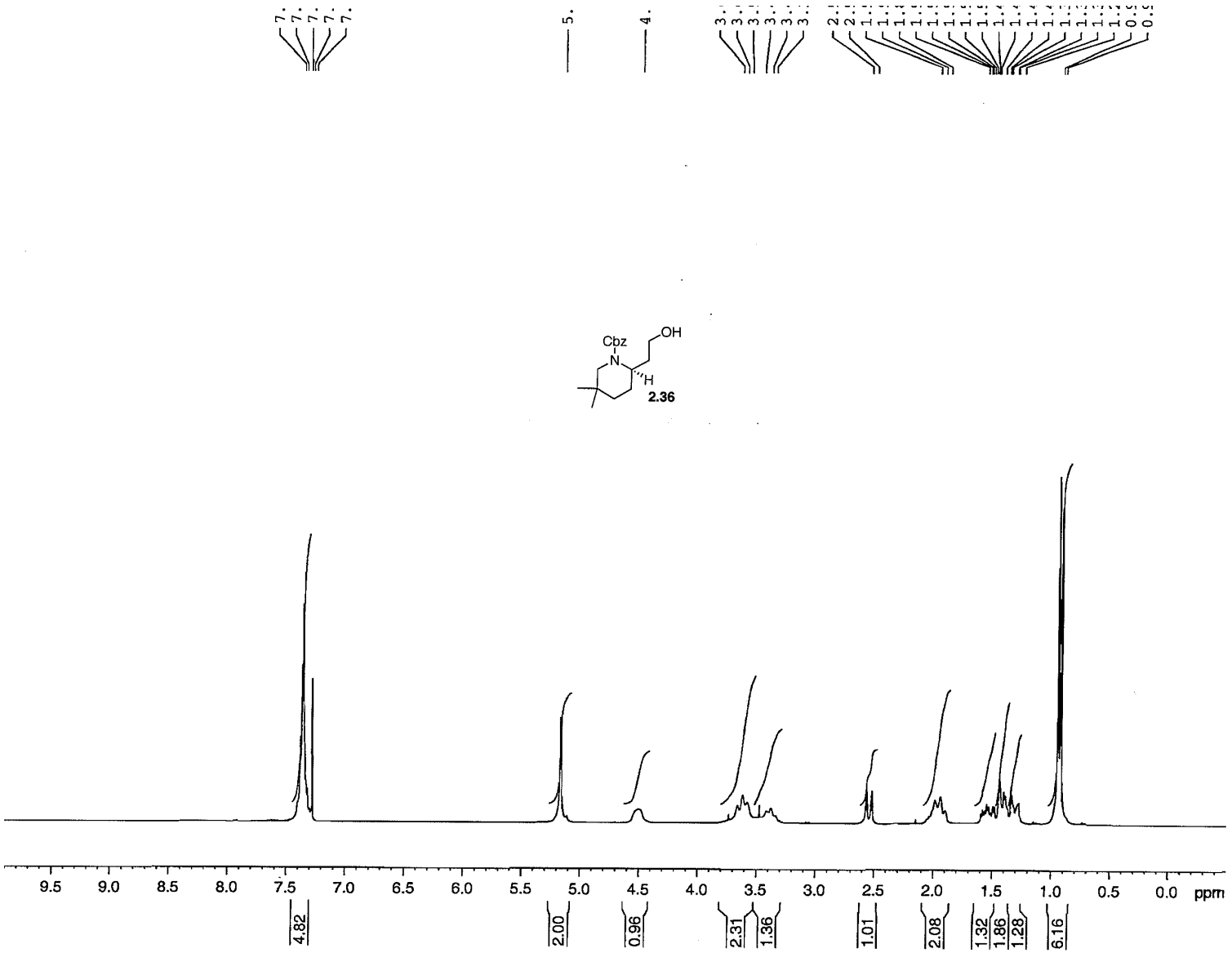
NUC1	1H
P1	14.70 usec
PL1	0.00 dB
SFO1	400.0128001 MHz

F2 - Processing parameters

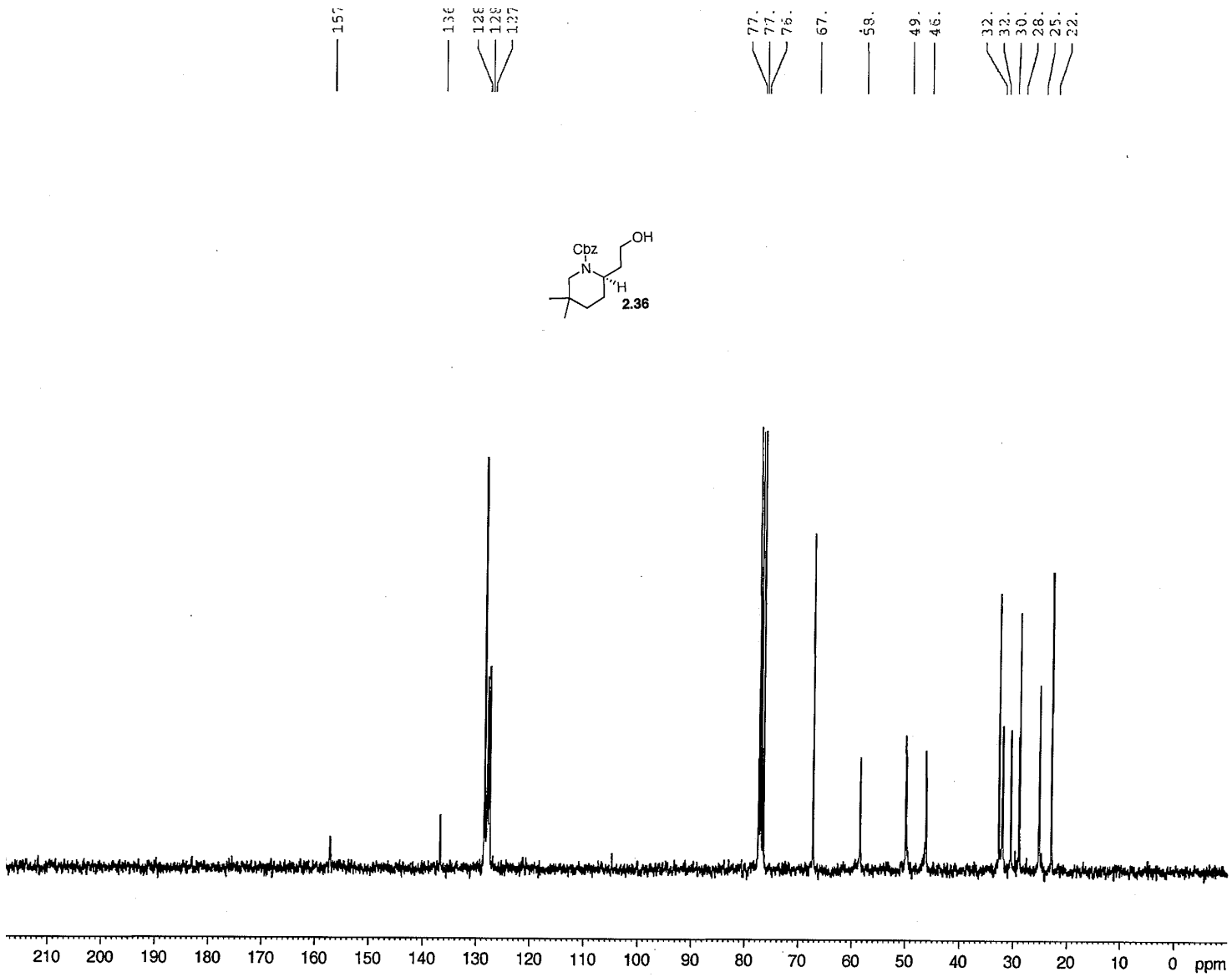
SI	32768
SF	400.0100000 MHz
WDW	EM
SSB	0
LB	0.70 Hz
GB	0
PC	1.00



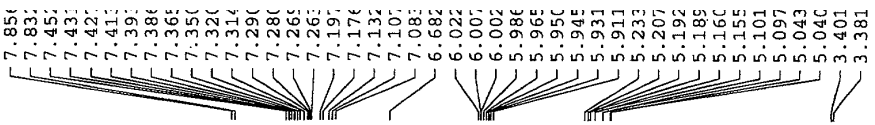
NAME	75b
EXPNO	3
PROCNO	1
DU	/m
USER	erikc
F2 - Acquisition Parame	
Date_	20080128
Time	23.21
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zgpg30
TD	65536
SOLVENT	CDCl3
NS	2450
DS	4
SWH	25125.629
FIDRES	0.383387
AQ	1.3042164
RG	4597.6
DW	19.900
DE	6.00
TE	298.2
D1	0.15000001
d11	0.03000000
DELTA	0.05000000
TD0	1
======== CHANNEL f1 ===	
NUC1	13C
P1	7.80
PL1	-3.00
SFO1	100.5936591
======== CHANNEL f2 ===	
CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00
PL2	17.40
PL12	17.40
PL13	17.40
SFO2	400.0116000
F2 - Processing paramet	
SI	32768
SF	100.5825950
WDW	EM
SSB	0
LB	3.00
GB	0
PC	1.40

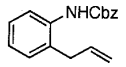



```
EXPNO
PROCNO
DU
USER                nat

F2 - Acquisition Pa
Date_              2007
Time                  1
INSTRUM              DP
PROBHD    5 mm QNP
PULPROG
TD                    3
SOLVENT               C
NS
DS
SWH                4789
FIDRES             0.14
AQ                3.421
RG
DW                  104
DE
TE                    2
D1               2.0000
TD0

======== CHANNEL f1
NUC1
P1
PL1                   -
SFO1           300.132

F2 - Processing par
SI                    3
SF             300.130
WDW
SSB
LB
GB
PC                    1
```

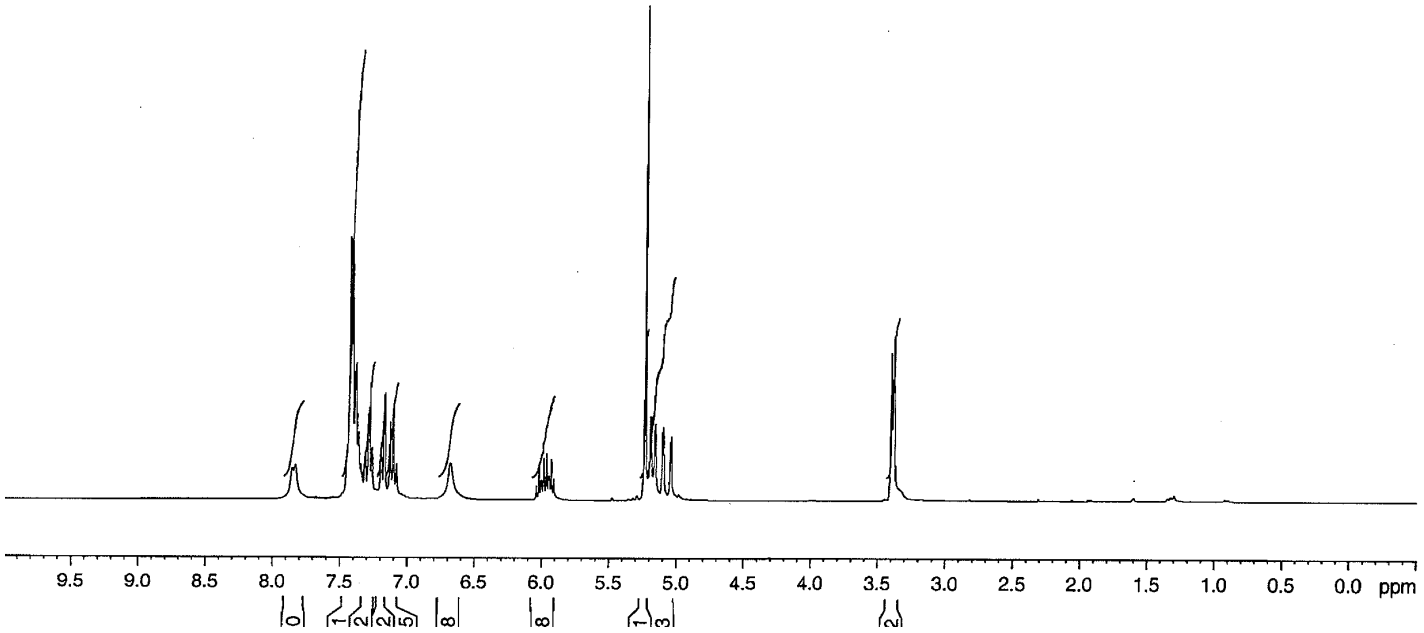


NAME	b4p5
EXPNO	
PROCNO	
DU	/
USER	nathar
F2 - Acquisition Param	
Date_	2007122
Time	11.3
INSTRUM	DPX30
PROBHD	5 mm QNP 1H/
PULPROG	zgpg3
TD	6553
SOLVENT	CDCl
NS	86
DS	
SWH	18832.39
FIDRES	0.28736
AQ	1.740030
RG	9195.
DW	26.55
DE	6.0
TE	298.
D1	0.1500000
d11	0.0300000
DELTA	0.0500000
TD0	
======== CHANNEL f1 ==	
NUC1	13
P1	8.8
PL1	-3.0
SFO1	75.476050
======== CHANNEL f2 ==	
CPDPRG2	waltz1
NUC2	1
PCPD2	80.0
PL2	-3.0
PL12	17.5
PL13	17.5
SFO2	300.131200
F2 - Processing paramet	
SI	3276
SF	75.467749
WDW	E
SSB	
LB	3.0
GB	
PC	1.4

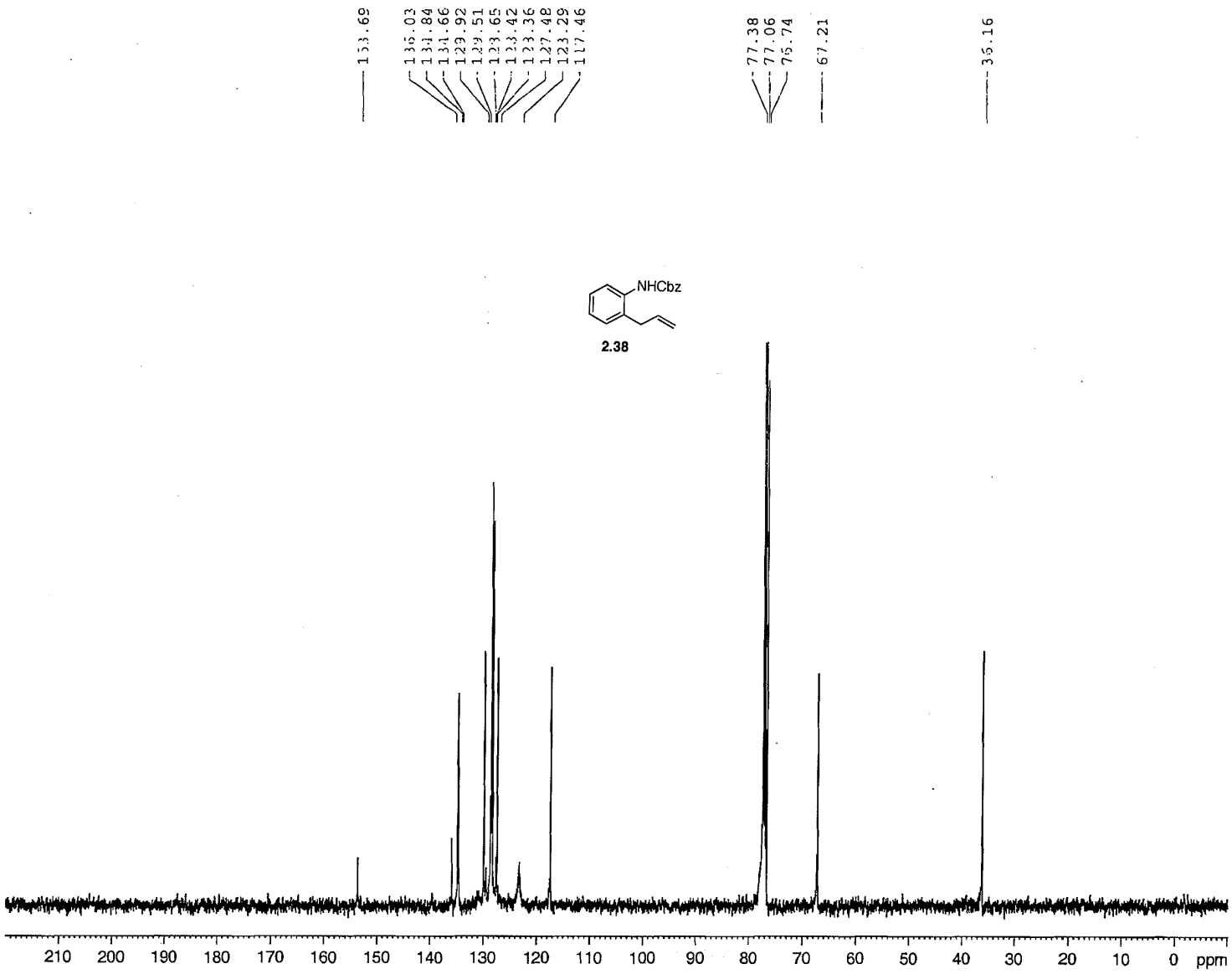




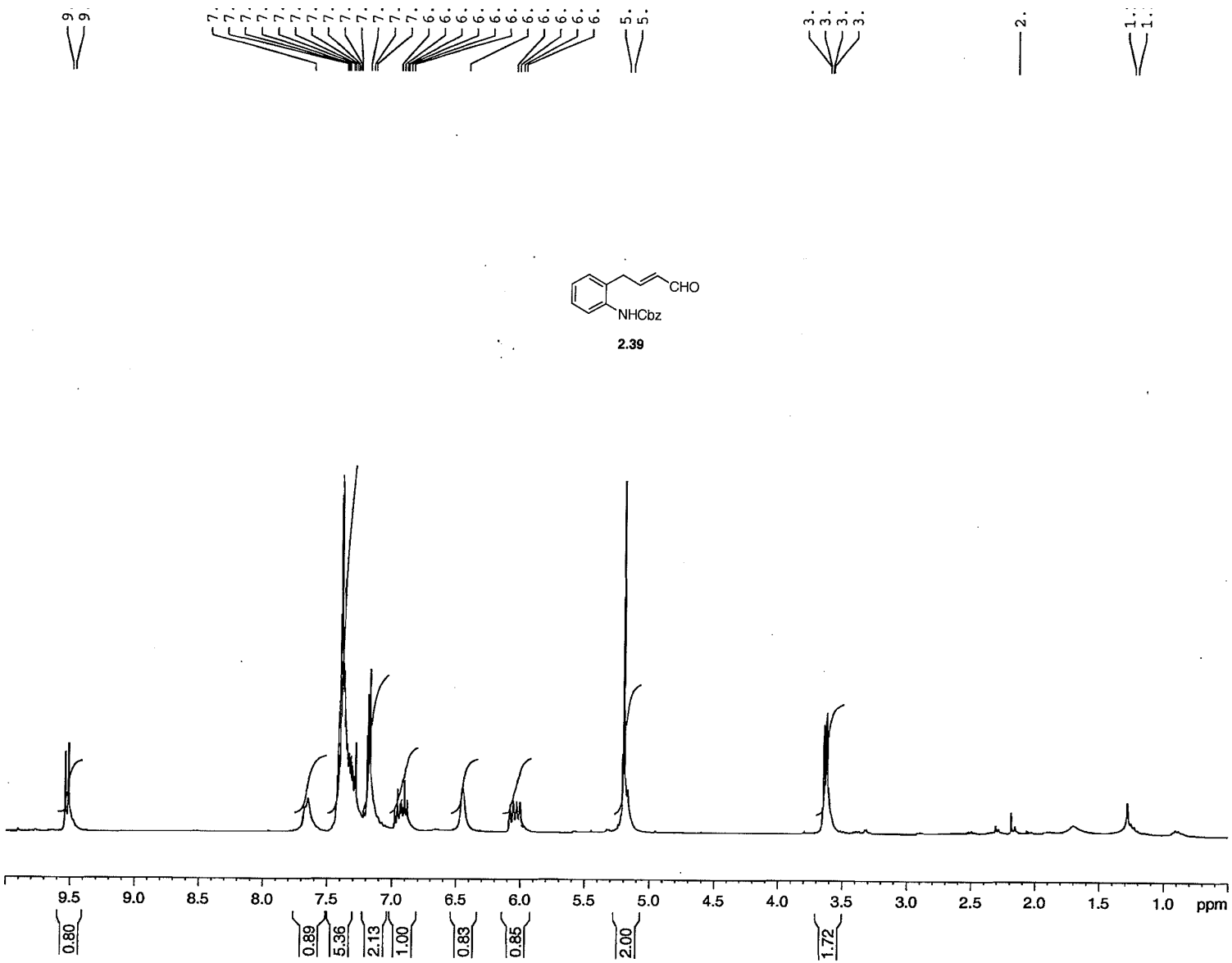
2.38




```
Current Data Parameters
NAME                  b3p58f
EXPNO                    267
PROCNO                     1
DU                        /n
USER                  erikc

F2 - Acquisition Parameters
Date_              20070925
Time                   9.57
INSTRUM              DPX300
PROBHD   5 mm QNP  1H/1
PULPROG                zg30
TD                    32768
SOLVENT               CDCl3
NS                        5
DS                        2
SWH                4789.272 Hz
FIDRES             0.146157 Hz
AQ                 3.4210291 sec
RG                     322.5
DW                   104.400 usec
DE                     6.00 usec
TE                    298.2 K
D1                2.00000000 sec
TD0                        1

======== CHANNEL f1 ========
NUC1                      1H
P1                     9.00 usec
PL1                   -3.00 dB
SFO1           300.1321009 MHz

F2 - Processing parameters
SI                    32768
SF             300.1300000 MHz
WDW                      EM
SSB                       0
LB                     0.30 Hz
GB                        0
PC                     1.00
```



NAME	[illegible]
EXPNO	29
PROCNO	764
DU	
USER	[illegible]
F2 - Acquisition Param	
Date_	2007110
Time	21.3
INSTRUM	DPX40
PROBHD	5 mm BBO BB-1
PULPROG	zgpg3
TD	6553
SOLVENT	CDCl
NS	179
DS	
SWH	25125.62
FIDRES	0.383382
AQ	1.304216
RG	9195.
DW	19.90
DE	6.0
TE	299.
D1	0.15000000
d11	0.03000000
DELTA	0.05000000
TD0	
======== CHANNEL f1 ==	
NUC1	13
P1	7.8
PL1	-3.0
SFO1	100.593659
======== CHANNEL f2 ==	
CPDPRG2	waltz1
NUC2	1
PCPD2	135.0
PL2	17.4
PL12	17.4
PL13	17.4
SFO2	400.011600
F2 - Processing parame	
SI	3276
SF	100.582595
WDW	E
SSB	
LB	3.0
GB	
PC	1.4

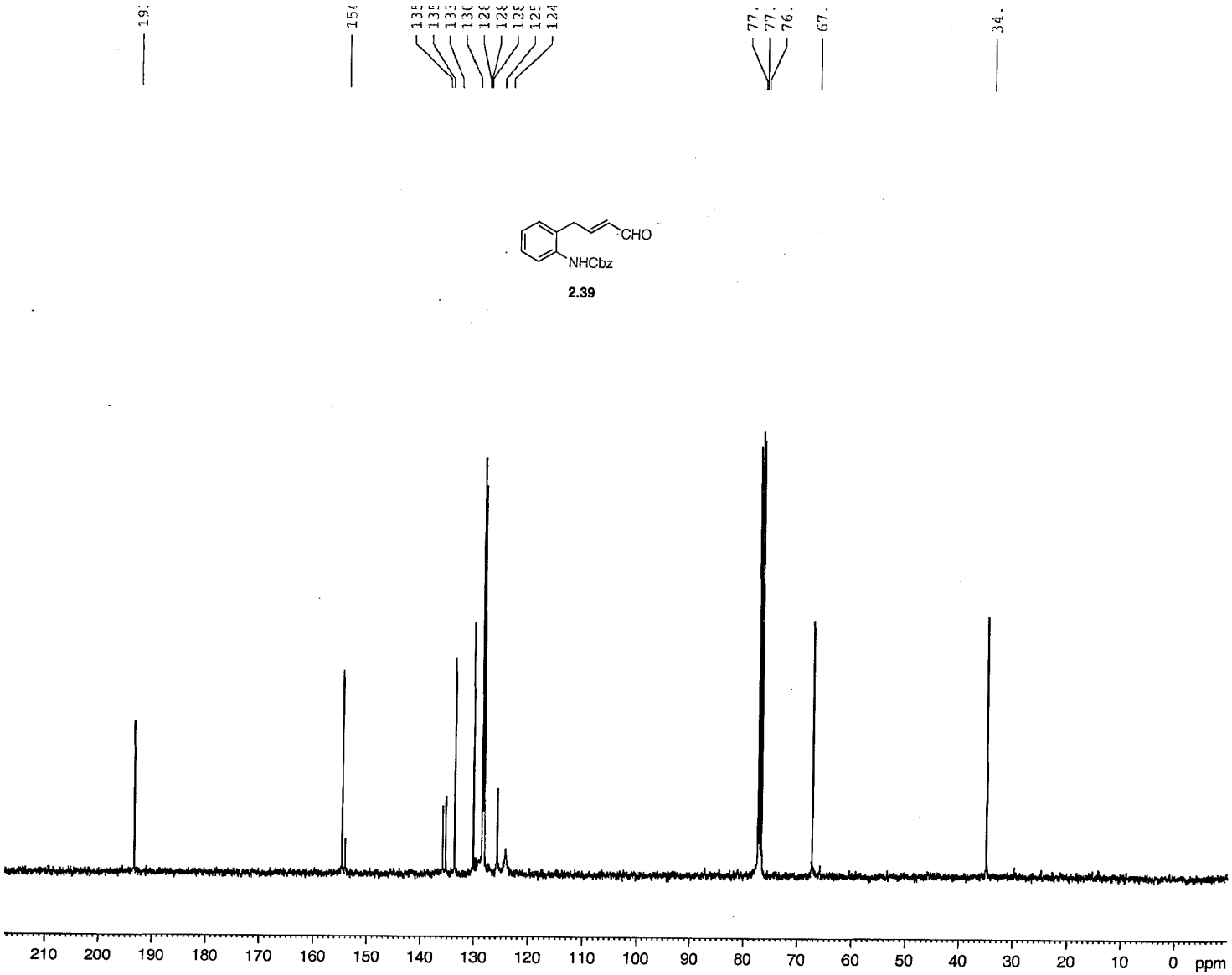


EXPNO
PROCNO
DU
USER e

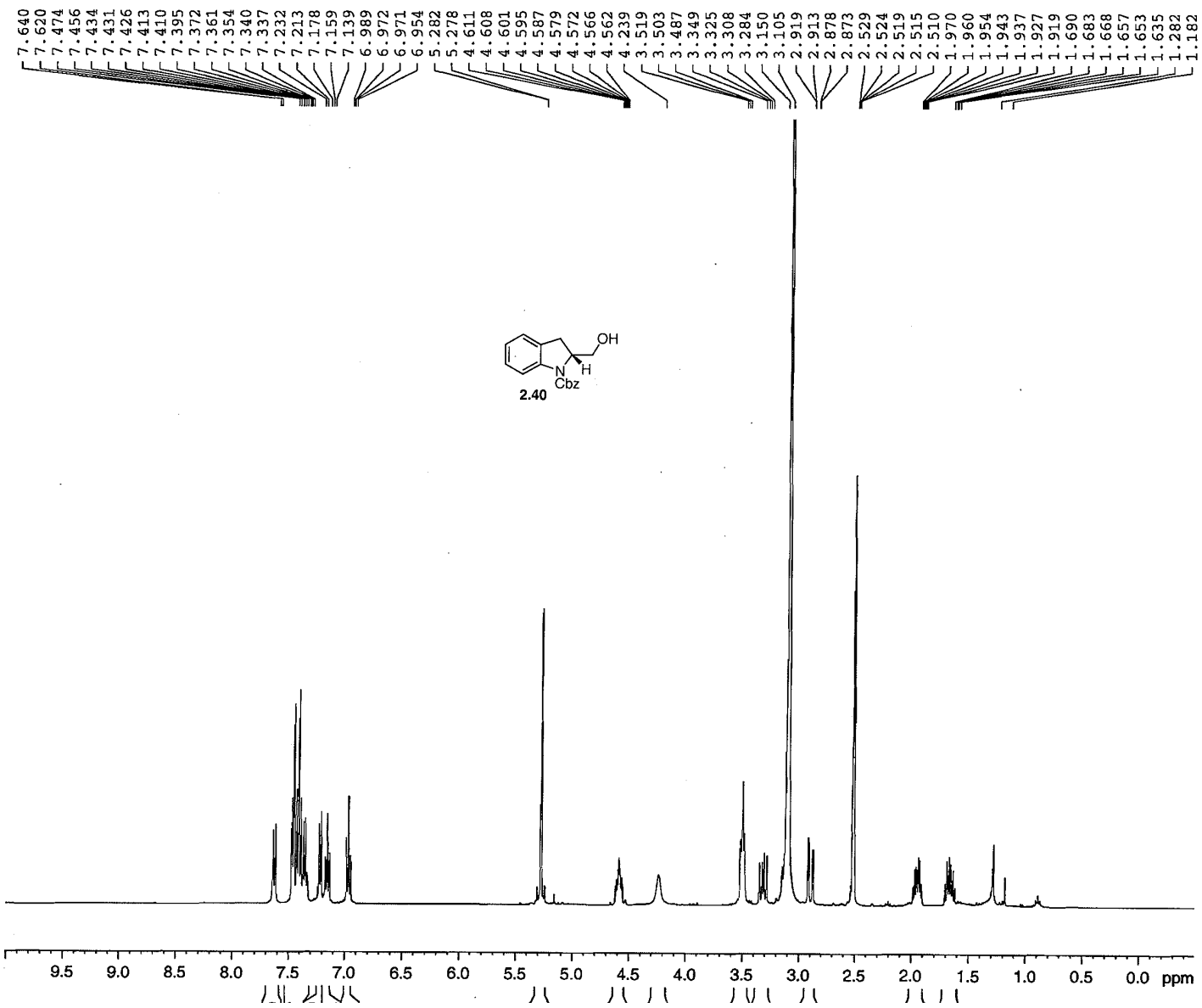
F2 - Acquisition Pa
Date_ 2007
Time
INSTRUM DP
PROBHD 5 mm QNP
PULPROG
TD 3
SOLVENT C
NS
DS
SWH 4789
FIDRES 0.14
AQ 3.421
RG 2
DW 104
DE
TE 2
D1 2.0000
TD0

======== CHANNEL f1
NUC1
P1
PL1
SFO1 300.132

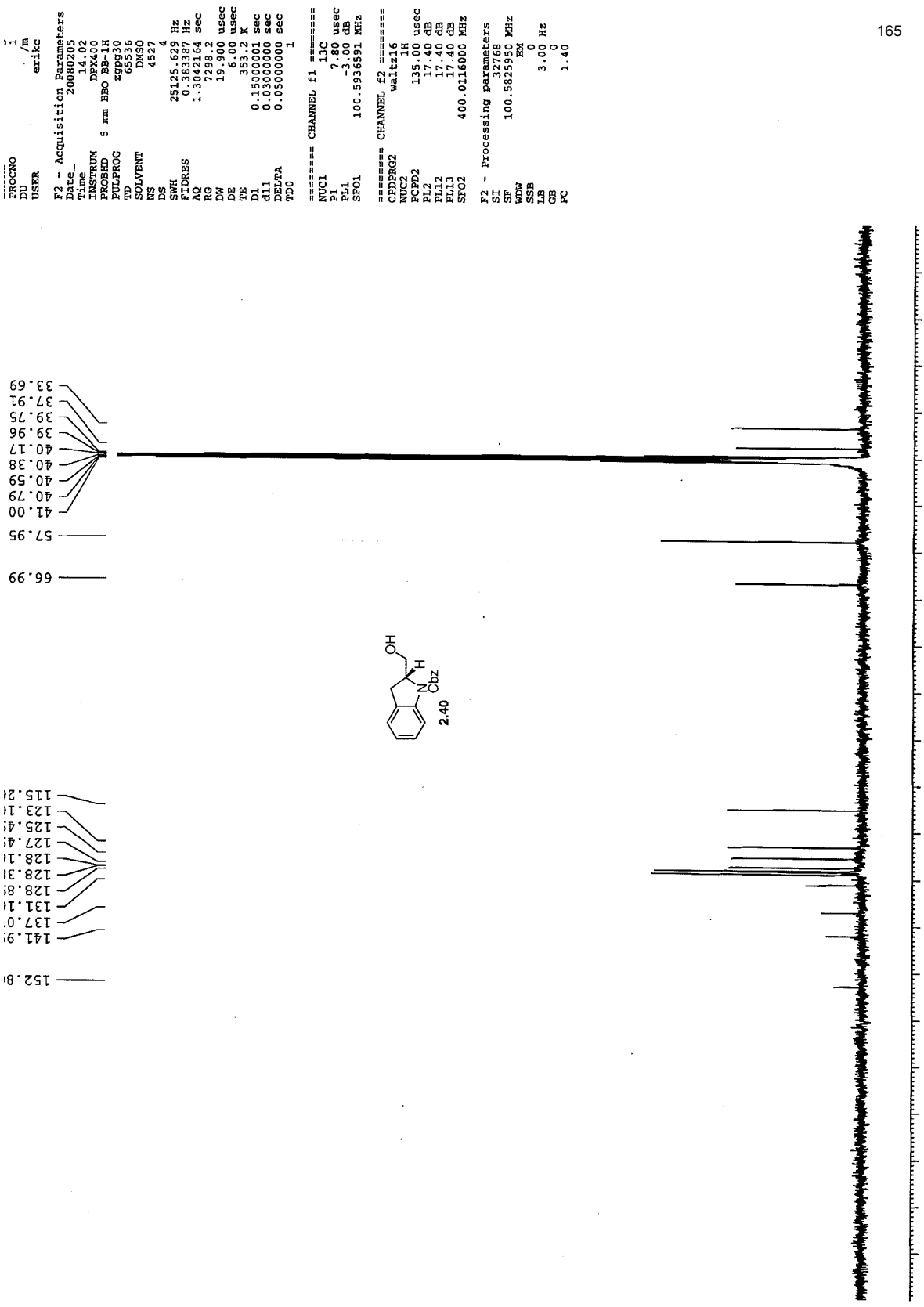
F2 - Processing para
SI 3
SF 300.130
WDW
SSB
LB
GB
PC

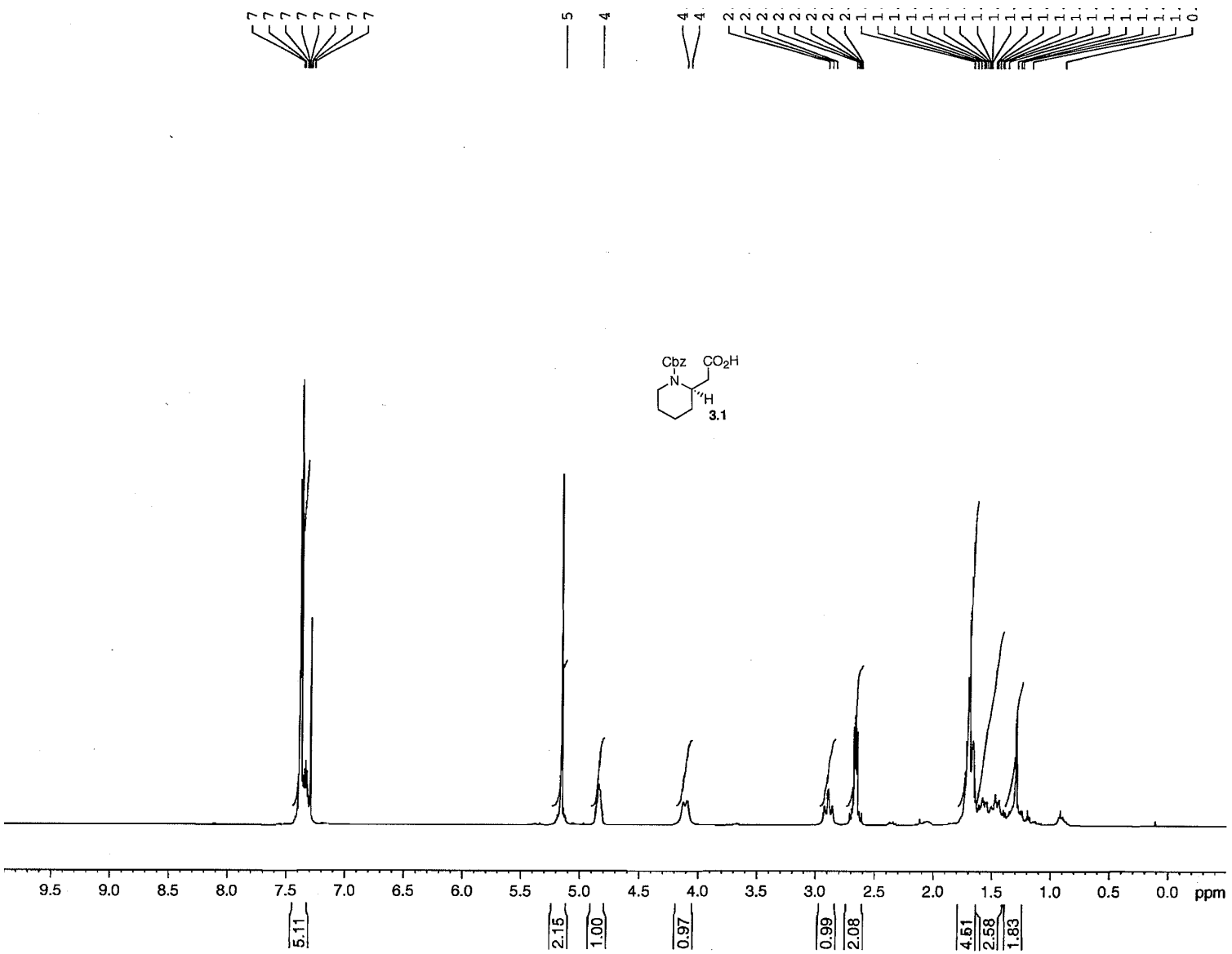


NAME	NCi
EXPNO	
PROCNO	
DU	
USER	nathar
F2 - Acquisition Param	
Date_	2007121
Time	15.5
INSTRUM	DPX4(
PROBHD	5 mm BBO BB-1
PULPROG	zgpg3
TD	6553
SOLVENT	
NS	196
DS	
SWH	25125.62
FIDRES	0.38338
AQ	1.304216
RG	4597.
DW	19.90
DE	6.0
TE	299.
D1	0.1500000
d11	0.0300000
DELTA	0.0500000
TD0	
======== CHANNEL f1 ==	
NUC1	13
P1	7.8
PL1	-3.0
SFO1	100.593659
======== CHANNEL f2 ==	
CPDPRG2	waltz1
NUC2	1
PCPD2	135.0
PL2	17.4
PL12	17.4
PL13	17.4
SFO2	400.011600
F2 - Processing paramet	
SI	3276
SF	100.582595
WDW	E
SSB	
LB	3.0
GB	
PC	1.4

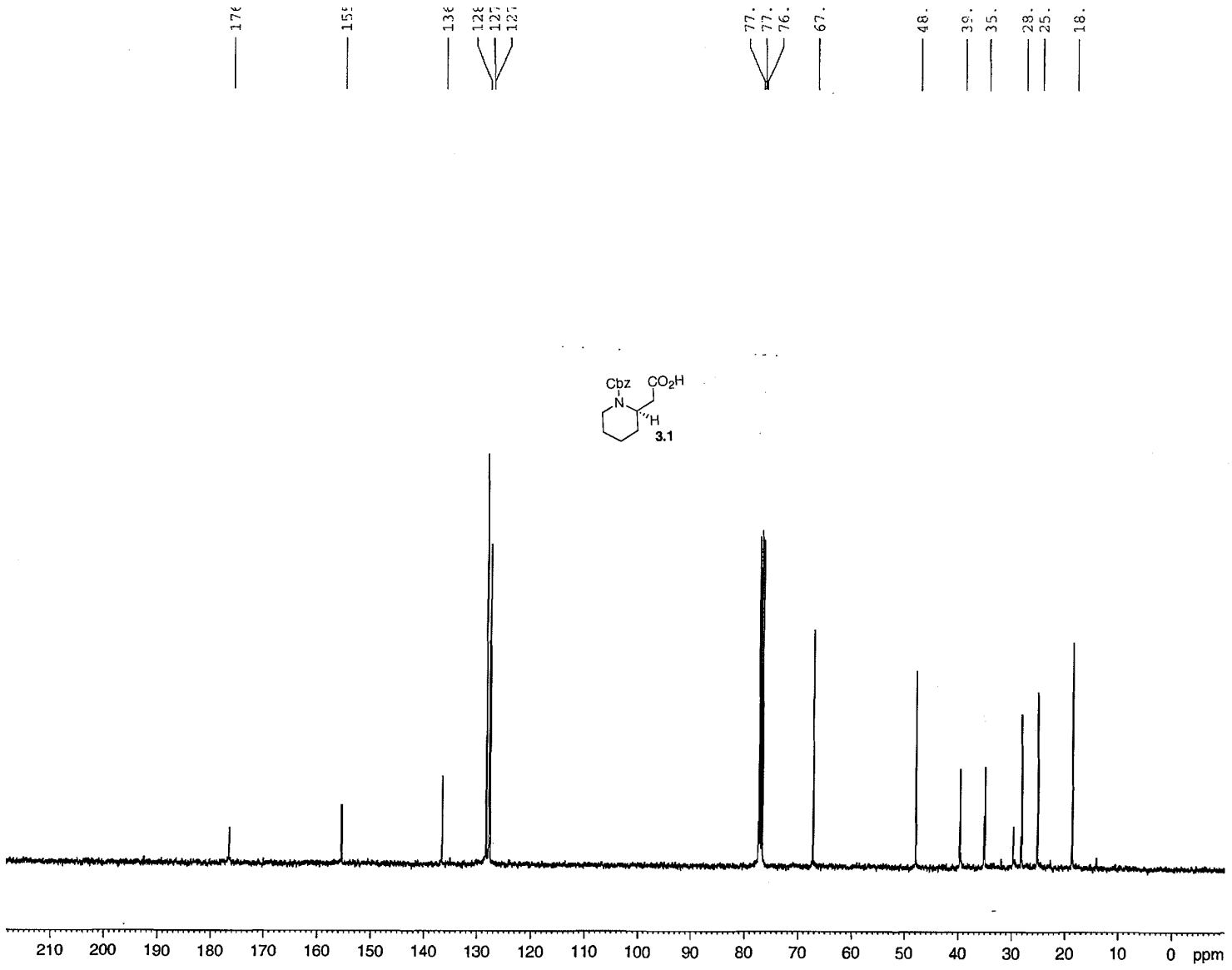



```
Current Data Parameters
NAME                  076g
EXPNO                    3
PROCNO                   1
DU                      /m
USER                 erikc

F2 - Acquisition Parameters
Date_              20080205
Time                 14.25
INSTRUM             DPX400
PROBHD   5 mm BBO BB-1H
PULPROG               zg30
TD                   32768
SOLVENT               DMSO
NS                       32
DS                        2
SWH               6410.256 Hz
FIDRES           0.195625 Hz
AQ               2.5559540 sec
RG                      512
DW                78.000 usec
DE                 6.00 usec
TE                353.2 K
D1             2.00000000 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                    1H
P1                  14.70 usec
PL1                  0.00 dB
SFO1          400.0128001 MHz

F2 - Processing parameters
SI                   32768
SF            400.0100000 MHz
WDW                     EM
SSB                      0
LB                  0.70 Hz
GB                       0
PC                    1.00
```

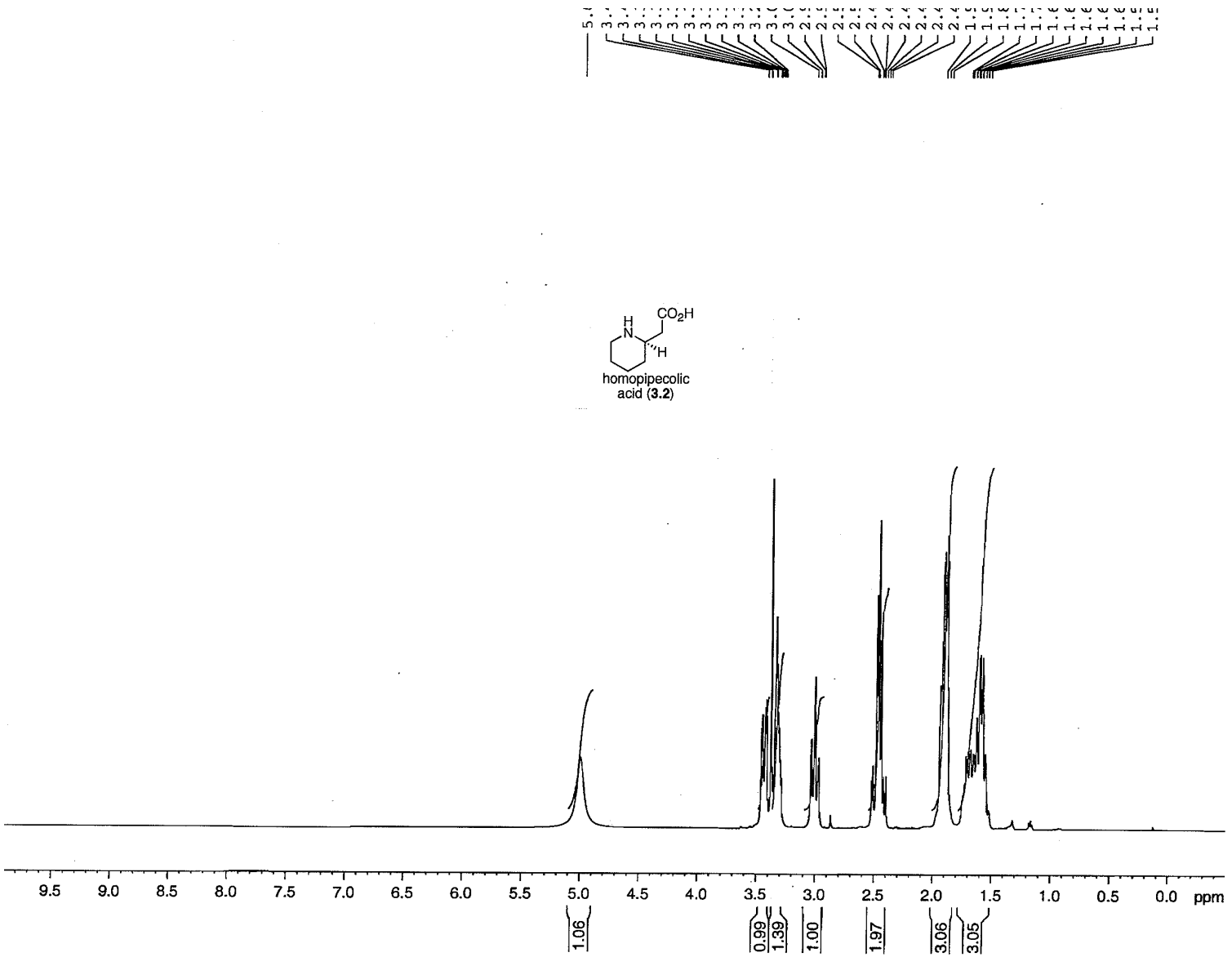

OH
H
N
Cbz
2.40
33.69
37.91
39.75
39.96
40.17
40.38
40.59
40.79
41.00
57.95
66.99
115.2
123.1
125.4
127.4
128.1
128.3
128.8
131.1
137.0
141.9
152.8



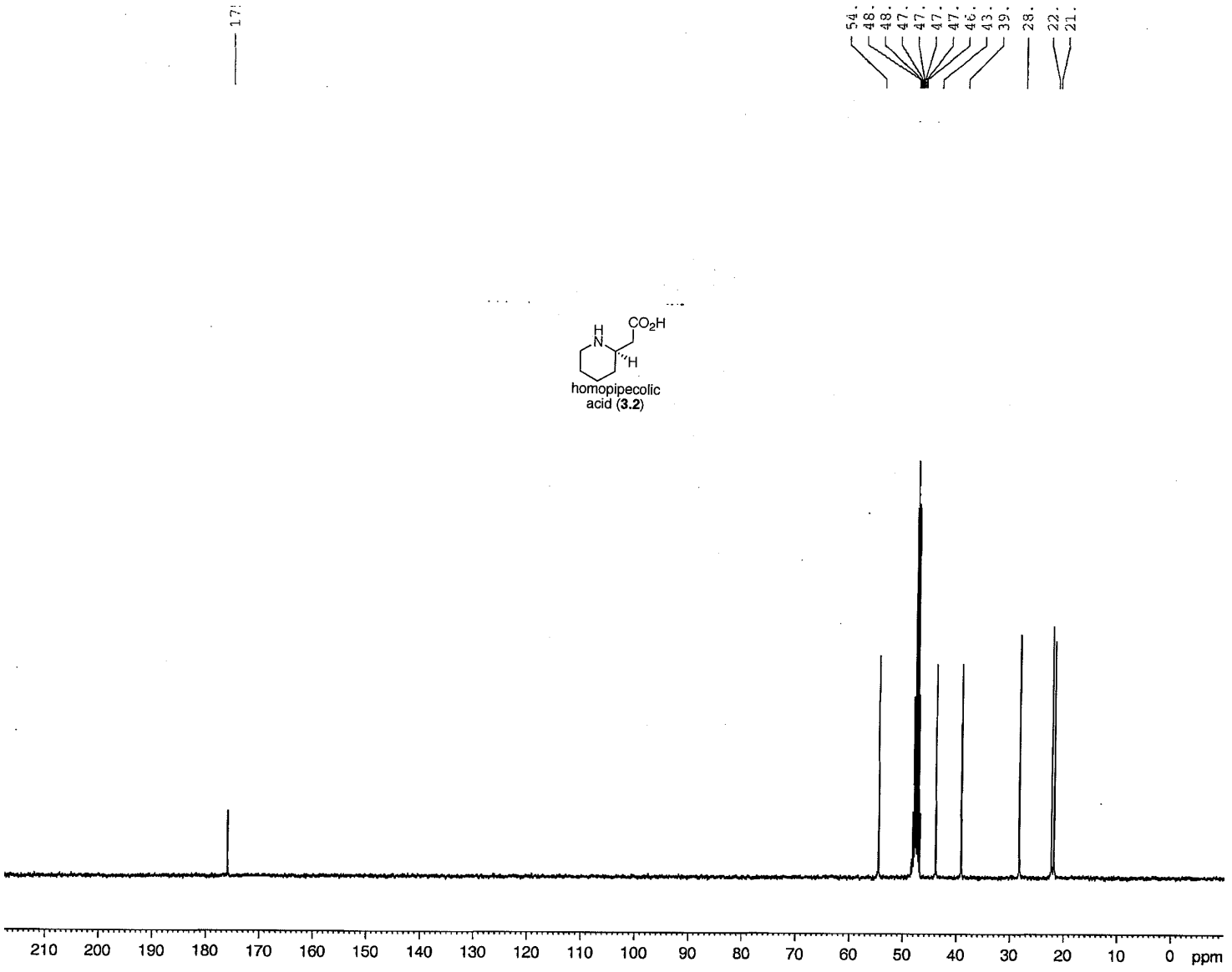

```
EXPNO
PROCNO
DU
USER                nat

F2 - Acquisition Pa
Date_              2007
Time                  1
INSTRUM              DP
PROBHD    5 mm BBO B
PULPROG
TD                    3
SOLVENT
NS
DS
SWH                6410
FIDRES             0.19
AQ                2.555
RG
DW                   78
DE
TE                    2
D1             2.0000
TD0

======== CHANNEL f1
NUC1
P1                    1
PL1
SFO1           400.012

F2 - Processing par
SI                    3
SF             400.010
WDW
SSB
LB                    (
GB
PC                    :
```



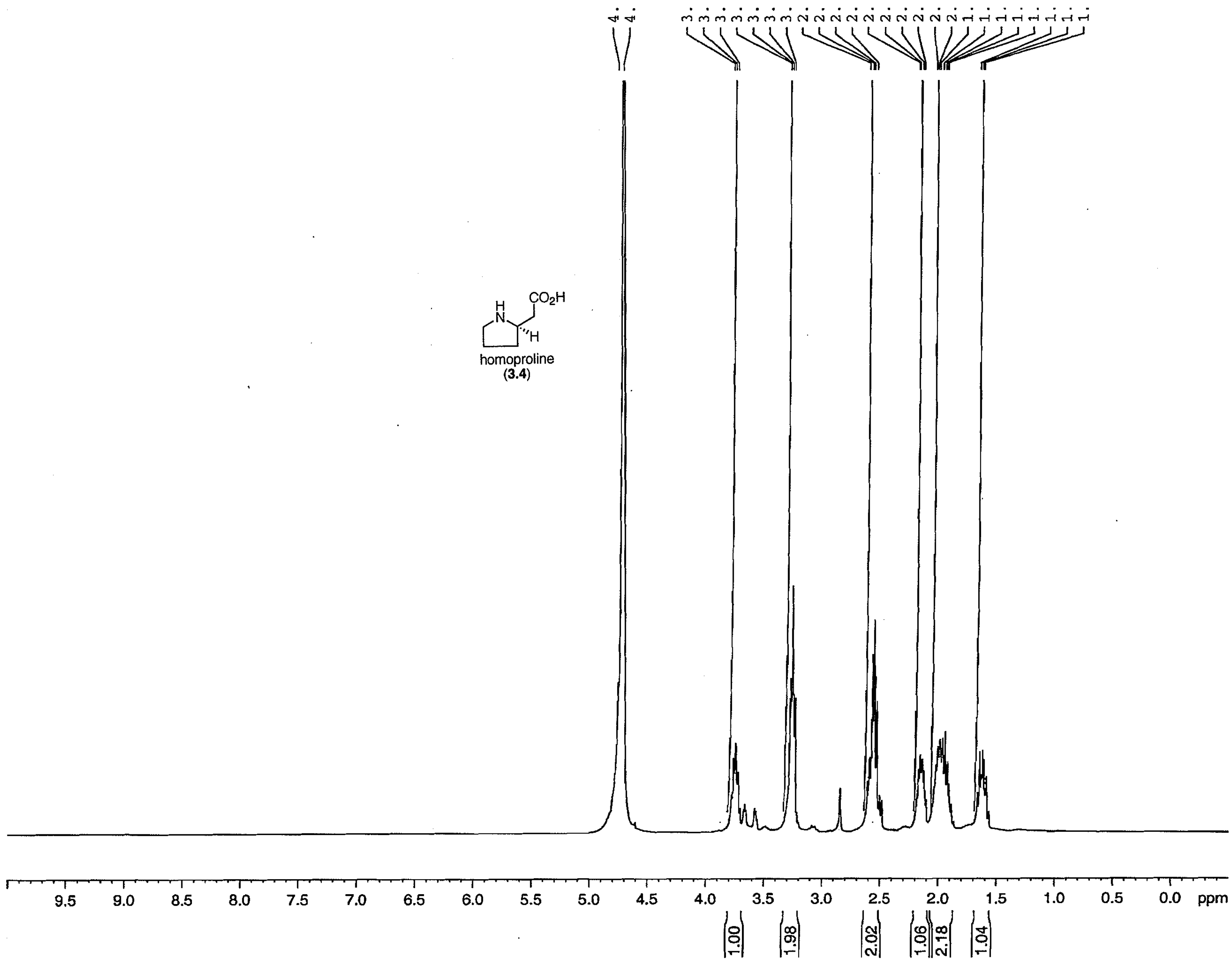
NAME	b4p3
EXPNO	
PROCNO	
DU	/
USER	nathar
F2 - Acquisition Param	
Date_	2007111
Time	17.0
INSTRUM	DPX40
PROBHD	5 mm BBO BB-1
PULPROG	zgpg3
TD	6553
SOLVENT	
NS	126
DS	
SWH	25125.62
FIDRES	0.38338
AQ	1.304216
RG	4597.
DW	19.90
DE	6.0
TE	298.
D1	0.1500000
d11	0.0300000
DELTA	0.0500000
TD0	
======== CHANNEL f1 ==	
NUC1	13
P1	7.8
PL1	-3.0
SFO1	100.593659
======== CHANNEL f2 ==	
CPDPRG2	waltz1
NUC2	1
PCPD2	135.0
PL2	17.4
PL12	17.4
PL13	17.4
SFO2	400.011600
F2 - Processing parame	
SI	32768
SF	100.582595
WDW	EM
SSB	0
LB	3.00
GB	0
PC	1.40




```
EXPNO
PROCNO
DU
USER                nat

F2 - Acquisition Pa
Date_               2007
Time                   1
INSTRUM               DP
PROBHD    5 mm BBO B
PULPROG
TD                     3
SOLVENT
NS
DS
SWH                 6410
FIDRES              0.19
AQ                 2.555
RG
DW                    78
DE
TE                     2
D1                2.0000
TD0

======== CHANNEL f1
NUC1
P1                     1
PL1
SFO1           400.012

F2 - Processing par
SI                     3
SF                400.010
WDW
SSB
LB
GB
PC
```



NAME	b4p5
EXPNO	
PROCNO	
DU	/
USER	nathan
F2 - Acquisition Param	
Date_	2007121
Time	16.4
INSTRUM	DPX40
PROBHD	5 mm BBO BB-1
PULPROG	zgpg3
TD	6553
SOLVENT	MeO
NS	91
DS	
SWH	25125.62
FIDRES	0.38338
AQ	1.304216
RG	4597.
DW	19.90
DE	6.0
TE	299.
D1	0.1500000
d11	0.0300000
DELTA	0.0500000
TD0	
======== CHANNEL f1 ==	
NUC1	13
P1	7.8
PL1	-3.0
SFO1	100.593659
======== CHANNEL f2 ==	
CPDPRG2	waltz1
NUC2	1
PCPD2	135.0
PL2	17.4
PL12	17.4
PL13	17.4
SFO2	400.011600
F2 - Processing paramet	
SI	3276
SF	100.582595
WDW	E
SSB	
LB	3.0
GB	
PC	1.40



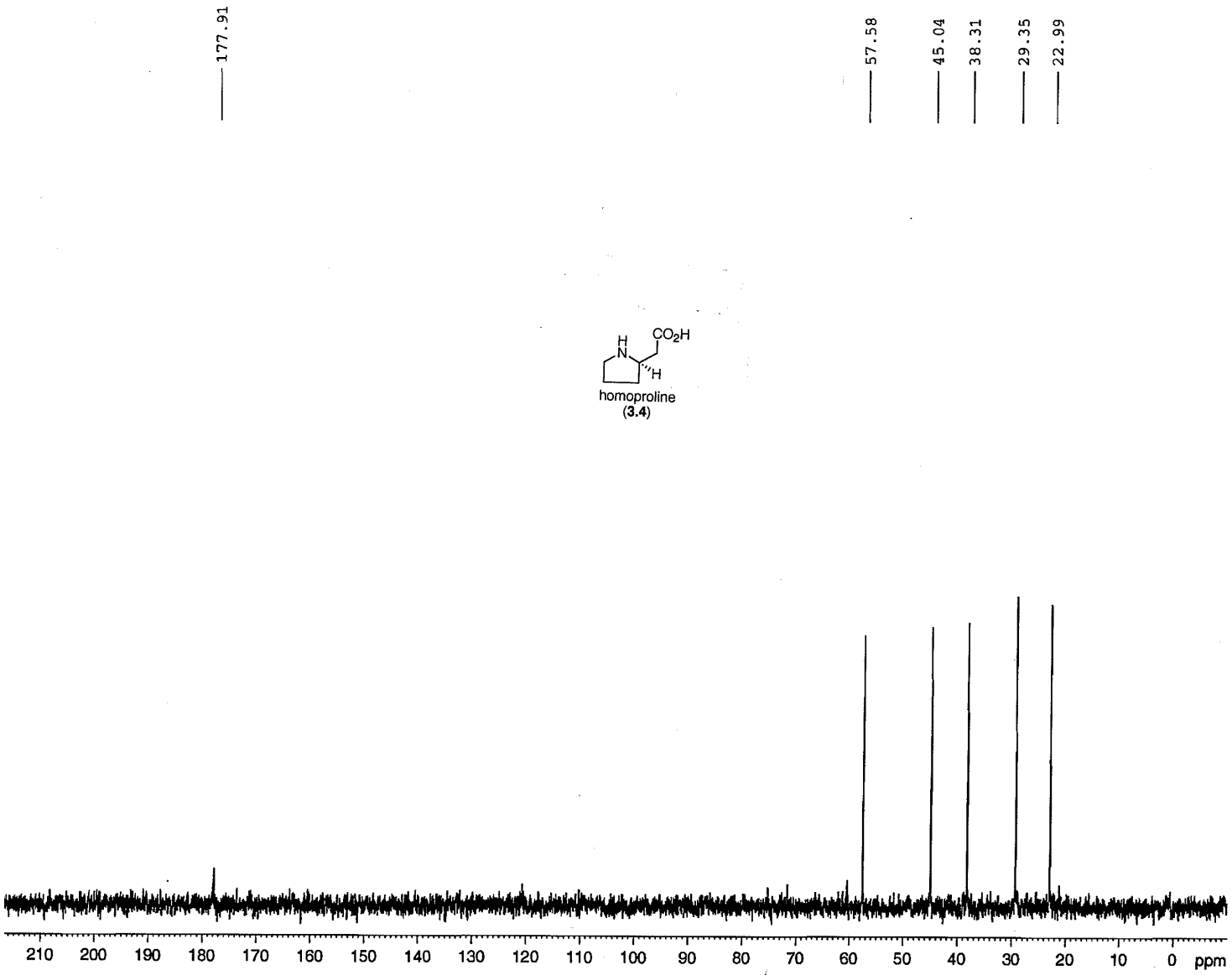
homoproline
(3.4)

EXPNO
PROCNO
DU
USER

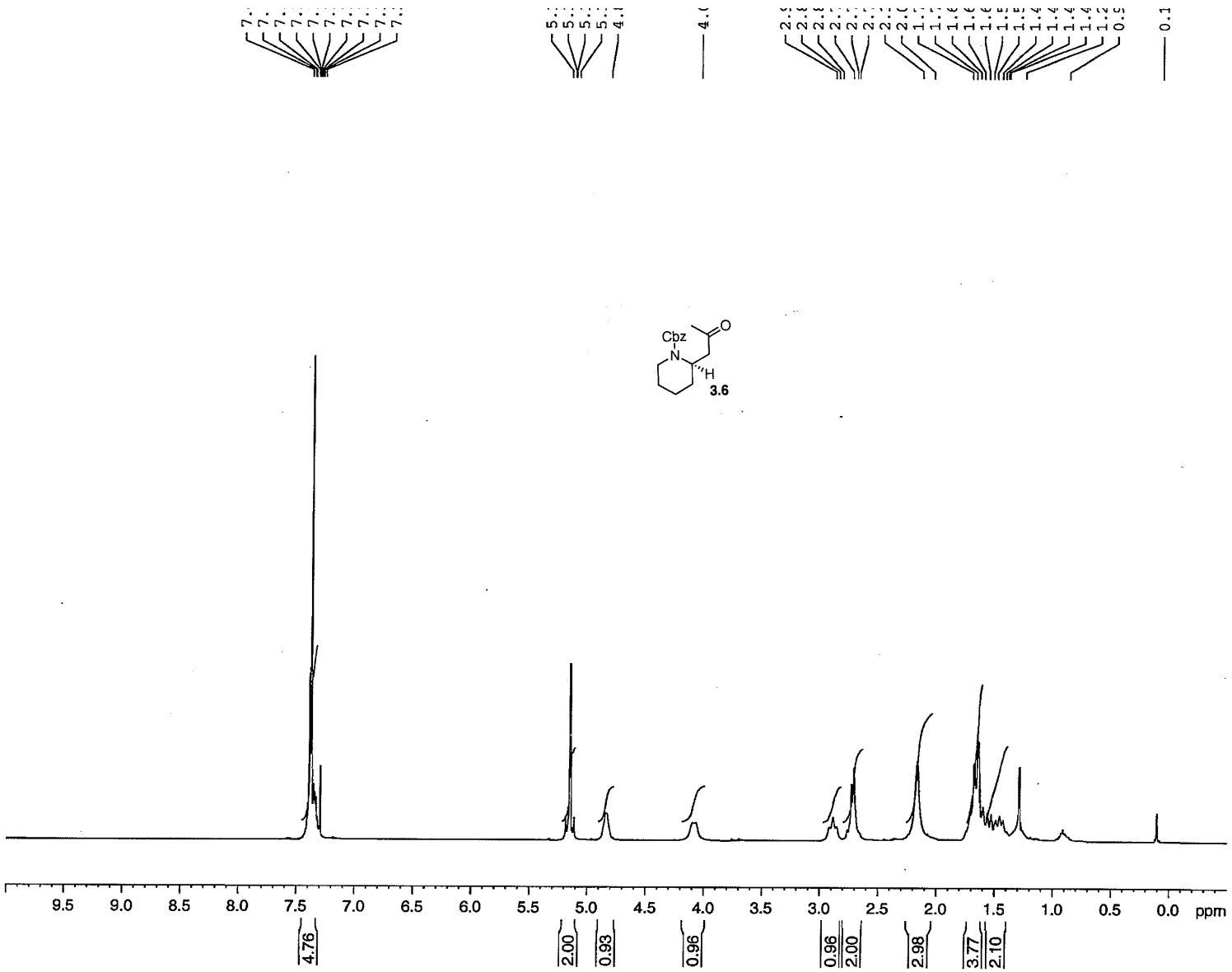
F2 - Acquisition Pa
Date_ 200
Time
INSTRUM DI
PROBHD 5 mm BBO
PULPROG
TD
SOLVENT
NS
DS
SWH 641
FIDRES 0.1
AQ 2.55
RG
DW 7
DE
TE
D1 2.000
TD0

======== CHANNEL f1
NUC1
P1
PL1
SFO1 400.01

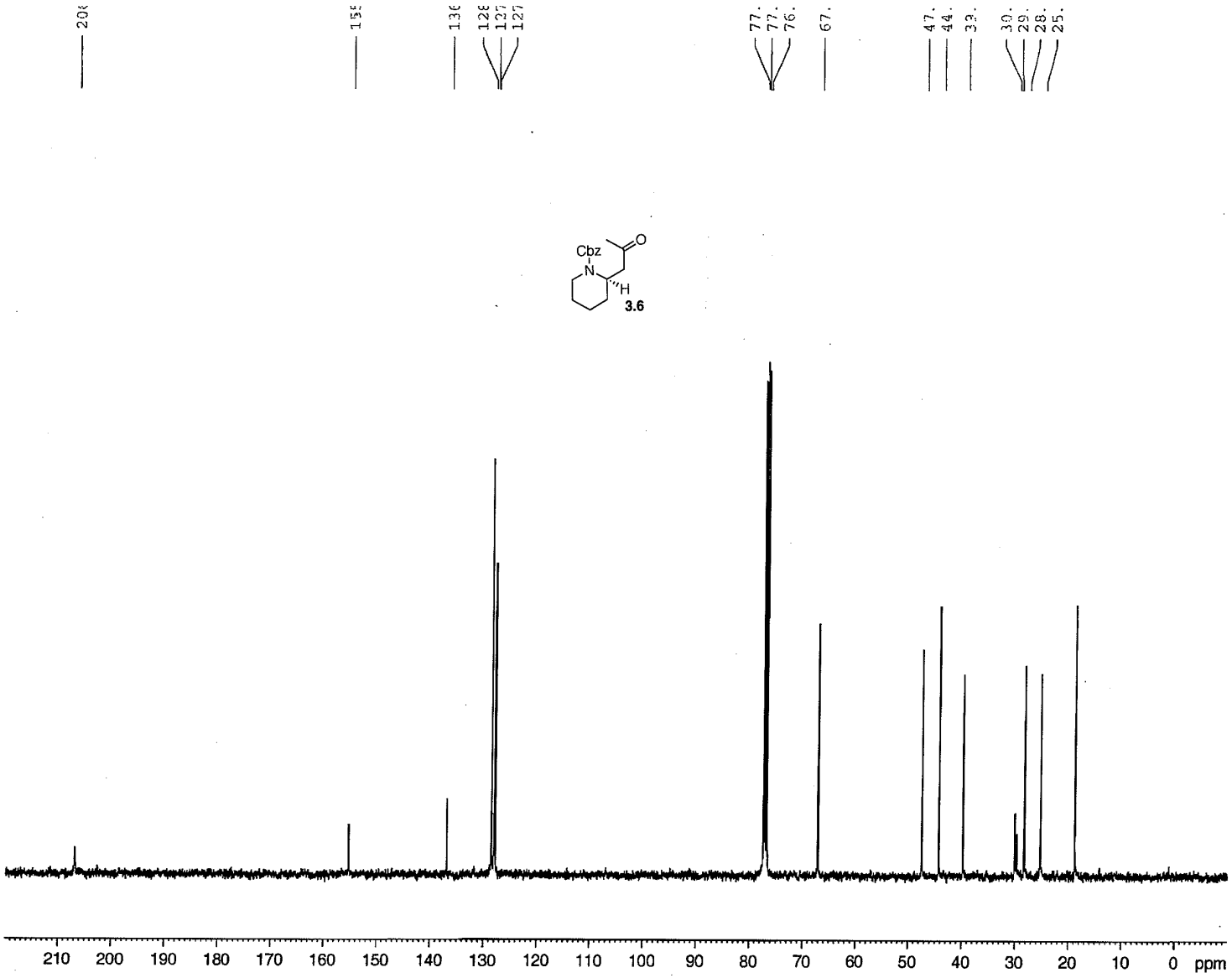
F2 - Processing pa
SI
SF 400.01
WDW
SSB
LB
GB
PC



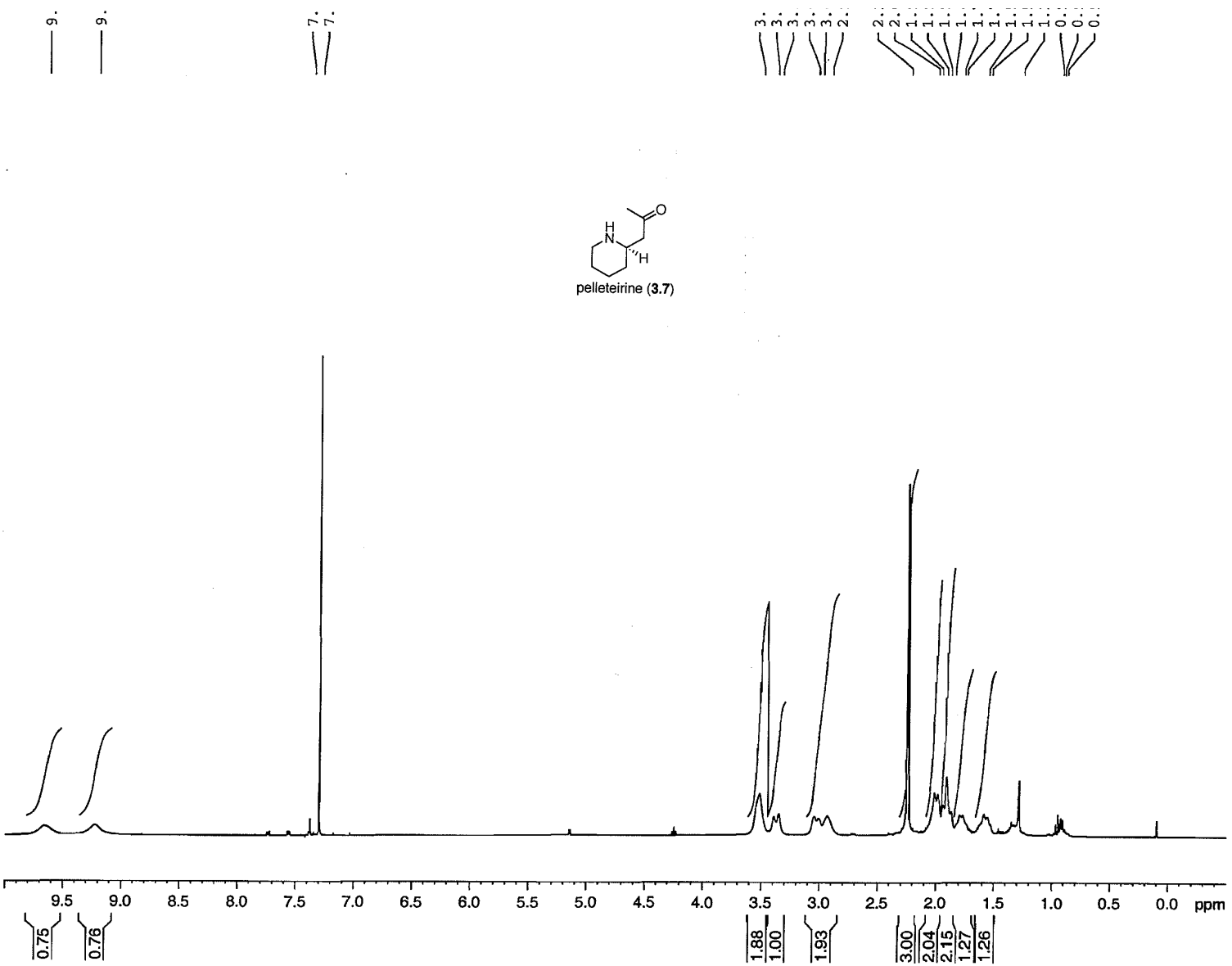
NAME	b4p39
EXPNO	29
PROCNO	764
DU	/1
USER	erik
F2 - Acquisition Param	
Date_	2007111
Time	12.0
INSTRUM	DPX40
PROBHD	5 mm BBO BB-1
PULPROG	zgpg3
TD	6553
SOLVENT	D2
NS	200
DS	4
SWH	25125.62
FIDRES	0.38338
AQ	1.304216
RG	5160.
DW	19.90
DE	6.0
TE	299.
D1	0.15000001
d11	0.03000000
DELTA	0.05000000
TD0	1
======== CHANNEL f1 ===	
NUC1	13
P1	7.8
PL1	-3.0
SFO1	100.5936591
======== CHANNEL f2 ===	
CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00
PL2	17.40
PL12	17.40
PL13	17.40
SFO2	400.0116000
F2 - Processing paramet	
SI	32768
SF	100.5825950
WDW	EM
SSB	0
LB	3.00
GB	0
PC	1.40




```
NAME            b4p0
EXPNO
PROCNO
DU
USER            e

F2 - Acquisition Pa
Date_           2007
Time            1
INSTRUM         DP
PROBHD   5 mm BBO B
PULPROG
TD              3
SOLVENT         C
NS
DS
SWH          6410.
FIDRES       0.19
AQ           2.555
RG              1
DW             78.
DE              6
TE             29
D1           2.00000
TD0

======== CHANNEL f1
NUC1
P1              14
PL1              0
SFO1       400.0128

F2 - Processing para
SI              32
SF         400.0100
WDW
SSB
LB               0
GB
PC               1
```



NAME	b4p0021
EXPNO	29
PROCNO	764
DU	/
USER	erik
F2 - Acquisition Param	
Date_	2007111
Time	17.1
INSTRUM	DPX40
PROBHD	5 mm BBO BB-1
PULPROG	zgpg3
TD	6553
SOLVENT	
NS	131
DS	
SWH	25125.62
FIDRES	0.38338
AQ	1.304216
RG	4597.
DW	19.90
DE	6.0
TE	299.
D1	0.1500000
d11	0.0300000
DELTA	0.0500000
TD0	
======== CHANNEL f1 ===	
NUC1	13
P1	7.8
PL1	-3.0
SFO1	100.5936591
======== CHANNEL f2 ===	
CPDPRG2	waltz1
NUC2	1
PCPD2	135.0
PL2	17.4
PL12	17.4
PL13	17.4
SFO2	400.0116000
F2 - Processing paramet	
SI	32768
SF	100.5825950
WDW	EM
SSB	0
LB	3.00
GB	0
PC	1.40

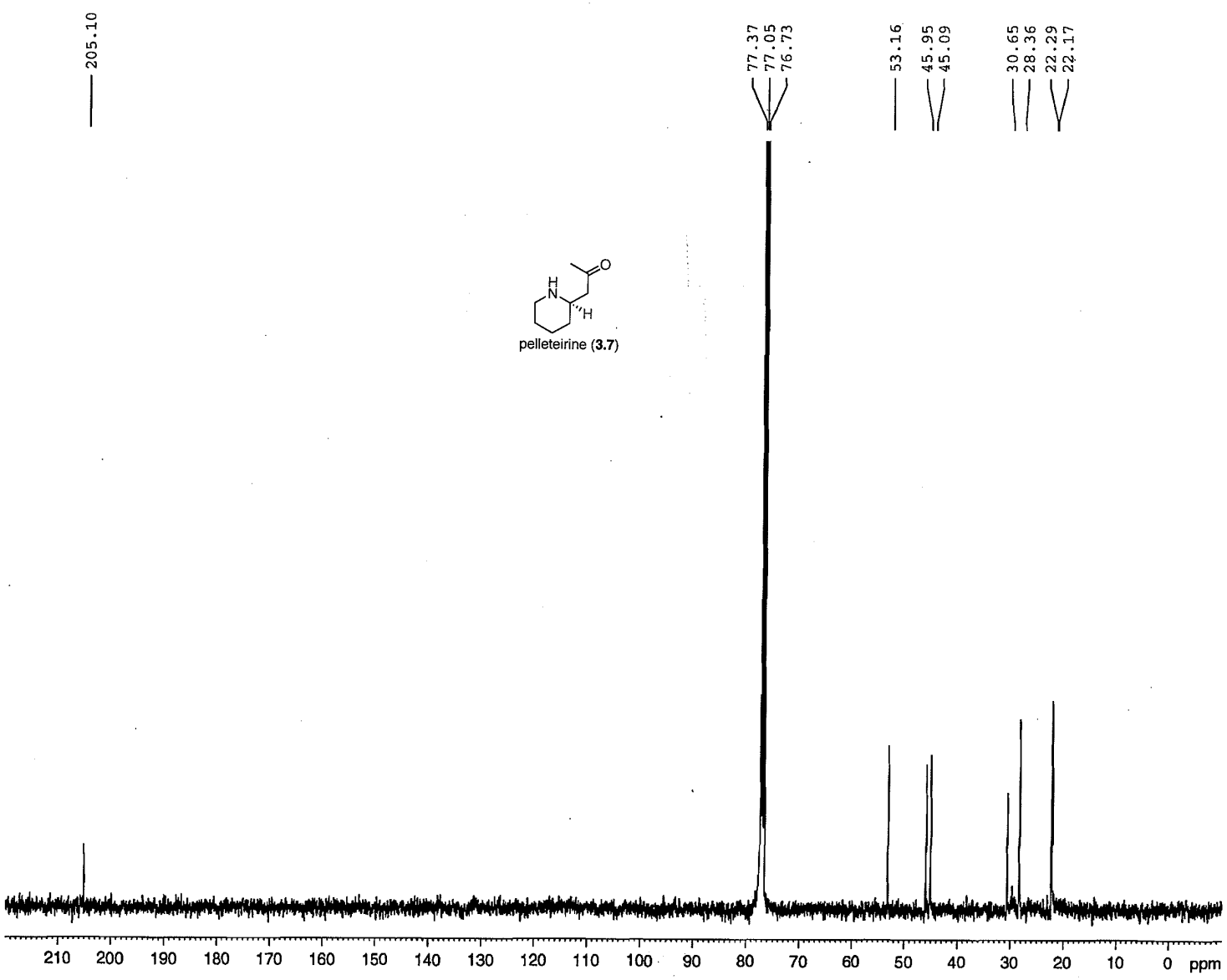


EXPNO
PROCNO
DU
USER e

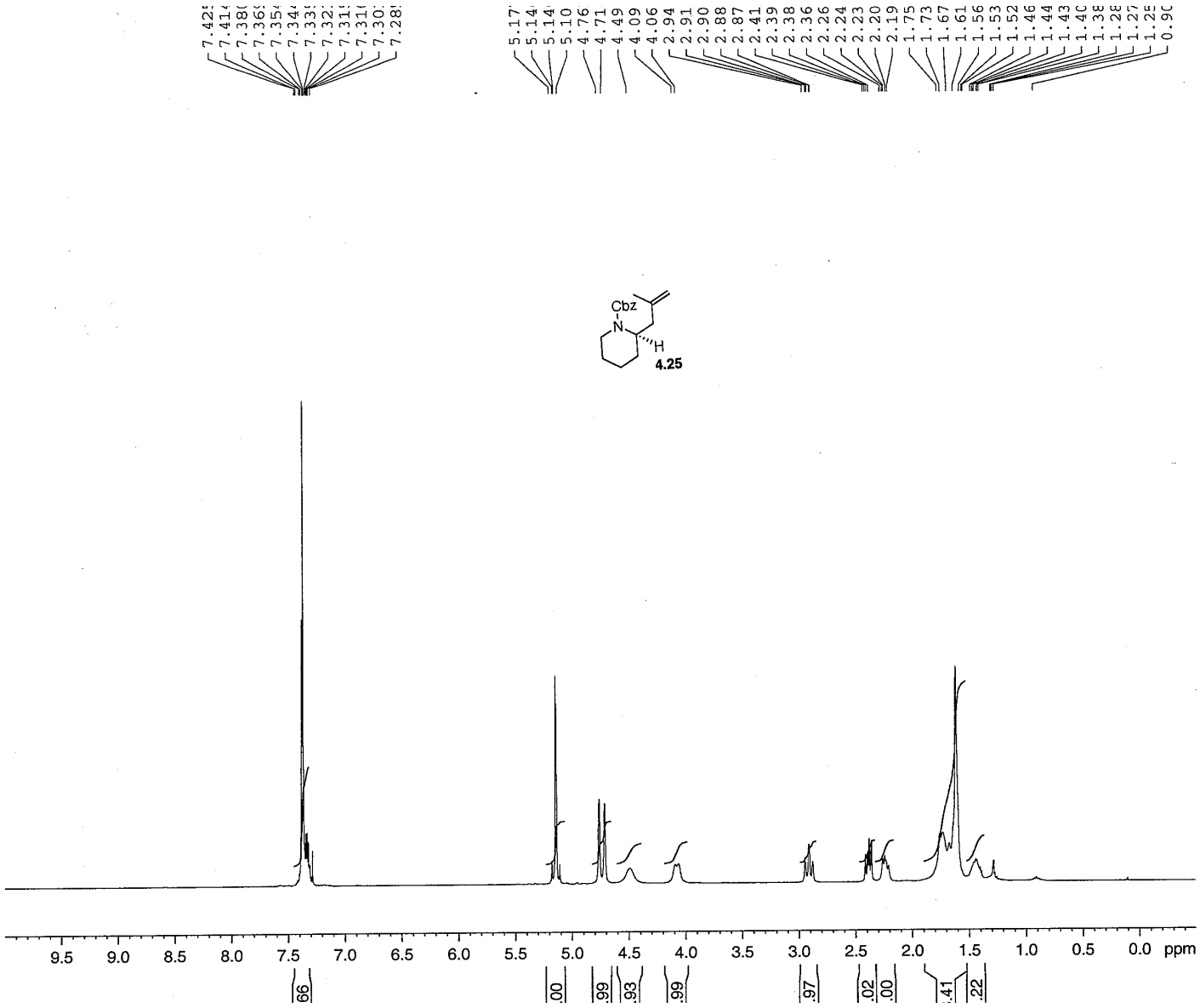
F2 - Acquisition Pa
Date_ 2008
Time 1
INSTRUM DP
PROBHD 5 mm BBO B
PULPROG
TD 3
SOLVENT
NS
DS
SWH 6410
FIDRES 0.19
AQ 2.555
RG
DW 78
DE
TE 2
D1 2.0000
TD0

======== CHANNEL f1
NUC1
P1 1
PL1
SFO1 400.012

F2 - Processing par
SI 3
SF 400.010
WDW
SSB
LB
GB
PC



Current Data Parameter	
NAME	b4p71
EXPNO	
PROCNO	
DU	/
USER	erik
F2 - Acquisition Param	
Date_	2008011
Time	12.2
INSTRUM	DPX40
PROBHD	5 mm BBO BB-1
PULPROG	zgpg3
TD	6553
SOLVENT	
NS	226
DS	
SWH	25125.62
FIDRES	0.38338
AQ	1.304216
RG	4597.
DW	19.90
DE	6.0
TE	299.
D1	0.1500000
d11	0.0300000
DELTA	0.0500000
TD0	
======== CHANNEL f1 ==	
NUC1	13
P1	7.8
PL1	-3.0
SFO1	100.593659
======== CHANNEL f2 ==	
CPDPRG2	waltz1
NUC2	1
PCPD2	135.0
PL2	17.4
PL12	17.4
PL13	17.4
SFO2	400.011600
F2 - Processing paramet	
SI	32768
SF	100.582595
WDW	EM
SSB	0
LB	3.00
GB	0
PC	1.40



EXPNO	1
PROCNO	1
DU	/m
USER	erikc

F2 - Acquisition Parameters

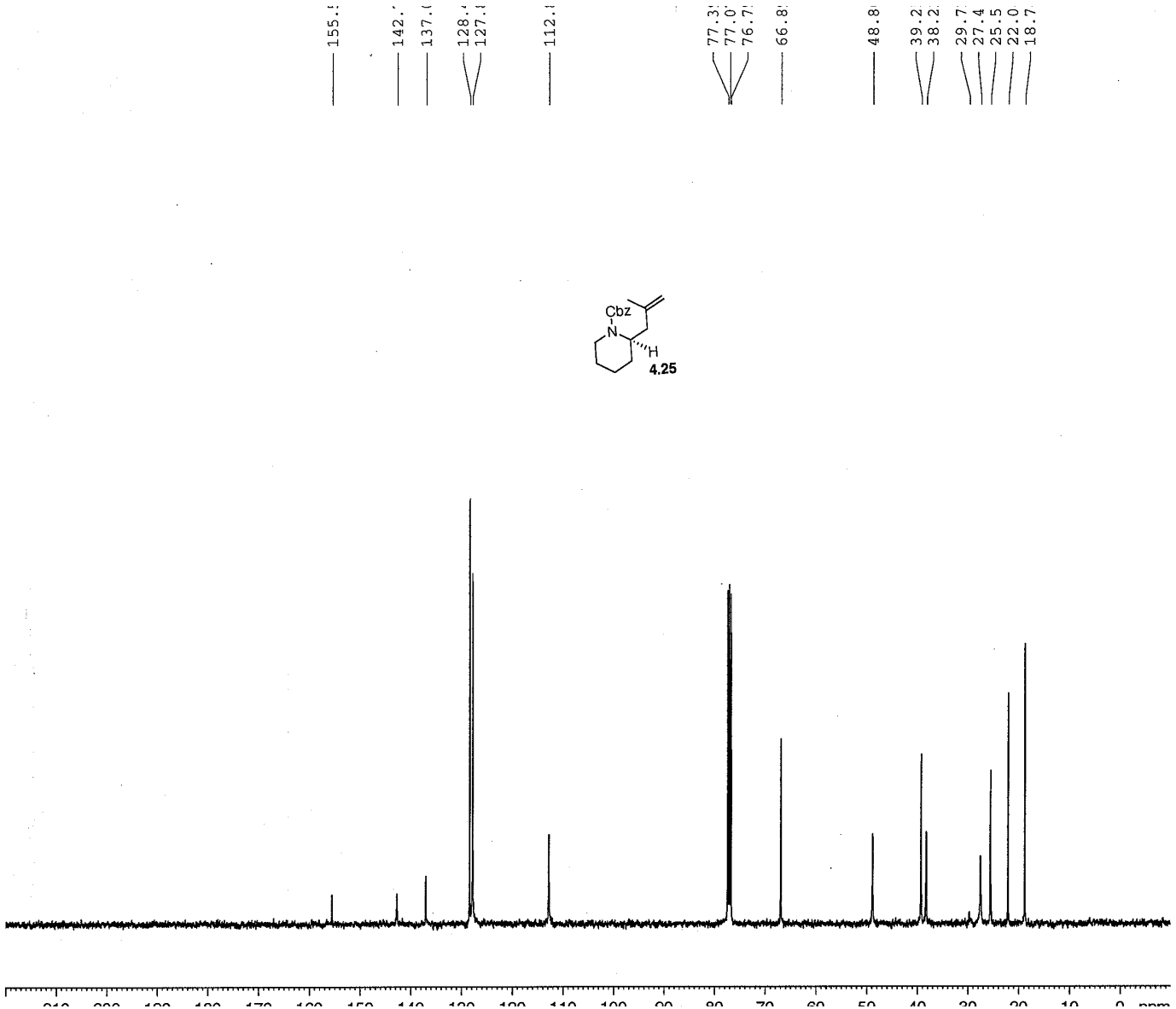
Date_	20080425
Time	17.47
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	17
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	90.5
DW	78.000 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

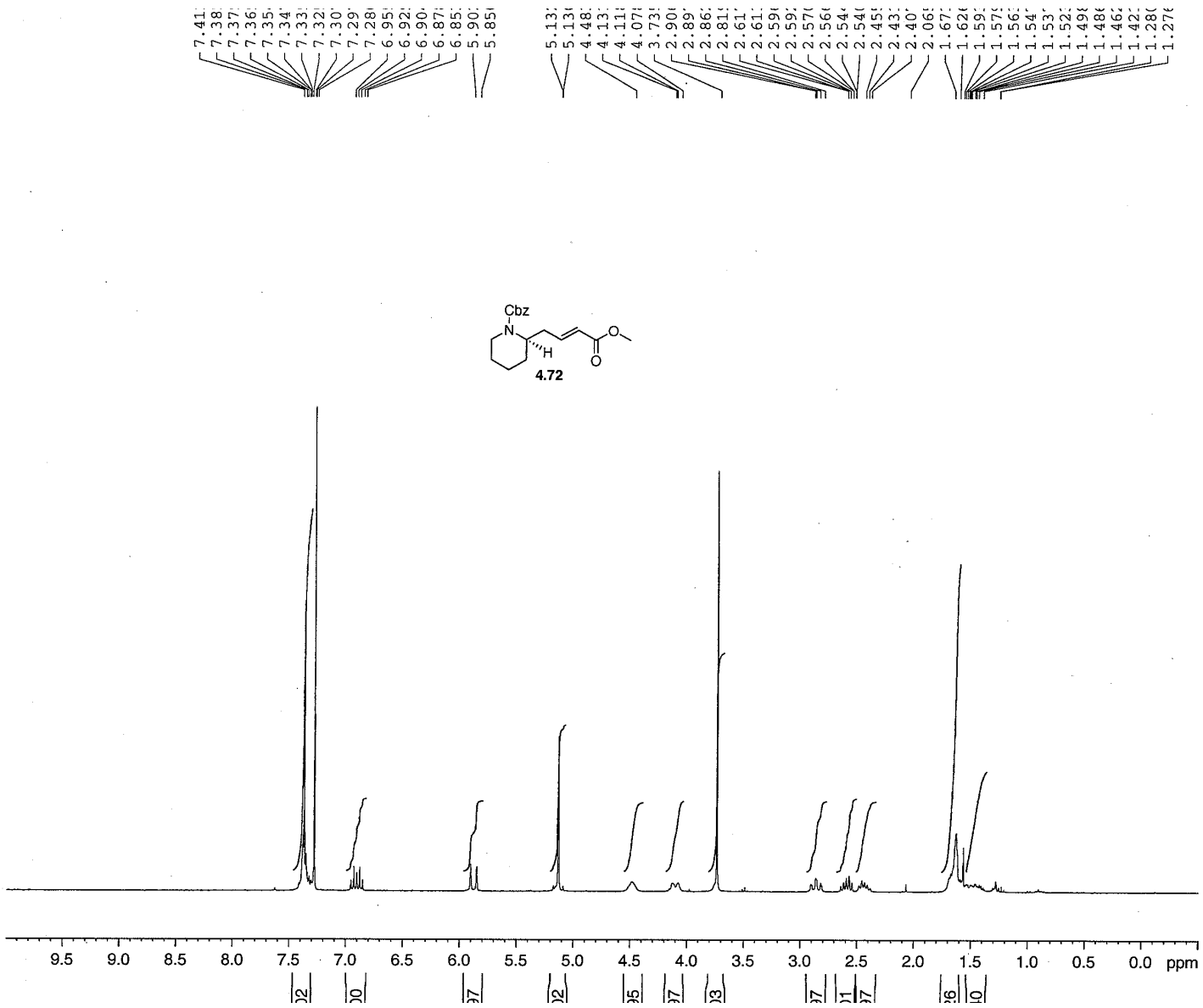
NUC1	1H
P1	14.70 usec
PL1	0.00 dB
SFO1	399.9528000 MHz

F2 - Processing parameters

SI	32768
SF	399.9500000 MHz
WDW	EM
SSB	0
LB	0.70 Hz
GB	0
PC	1.00




```
DU                      /m
USER                 erikc

F2 - Acquisition Parameters
Date_              20080425
Time                  18.14
INSTRUM              DPX400
PROBHD   5 mm BBO BB-1H
PULPROG              zgpg30
TD                    65536
SOLVENT
NS                      931
DS                        4
SWH              25125.629 Hz
FIDRES            0.383387 Hz
AQ               1.3042164 sec
RG                    16384
DW                19.900 usec
DE                 6.00 usec
TE                 298.2 K
D1             0.15000001 sec
D11            0.03000000 sec
DELTA          0.05000000 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                   13C
P1                  7.80 usec
PL1                -3.00 dB
SFO1         100.5785700 MHz

======== CHANNEL f2 ========
CPDPRG2           waltz16
NUC2                   1H
PCPD2             135.00 usec
PL2                17.40 dB
PL12               17.40 dB
PL13               17.40 dB
SFO2         399.9516000 MHz

F2 - Processing parameters
SI                    32768
SF           100.5675080 MHz
WDW                      EM
SSB                       0
LB                   3.00 Hz
GB                        0
PC                     1.40
```



NAME	b5p13
EXPNO	1
PROCNO	1
DU	/n
USER	erikc

F2 - Acquisition Parameters

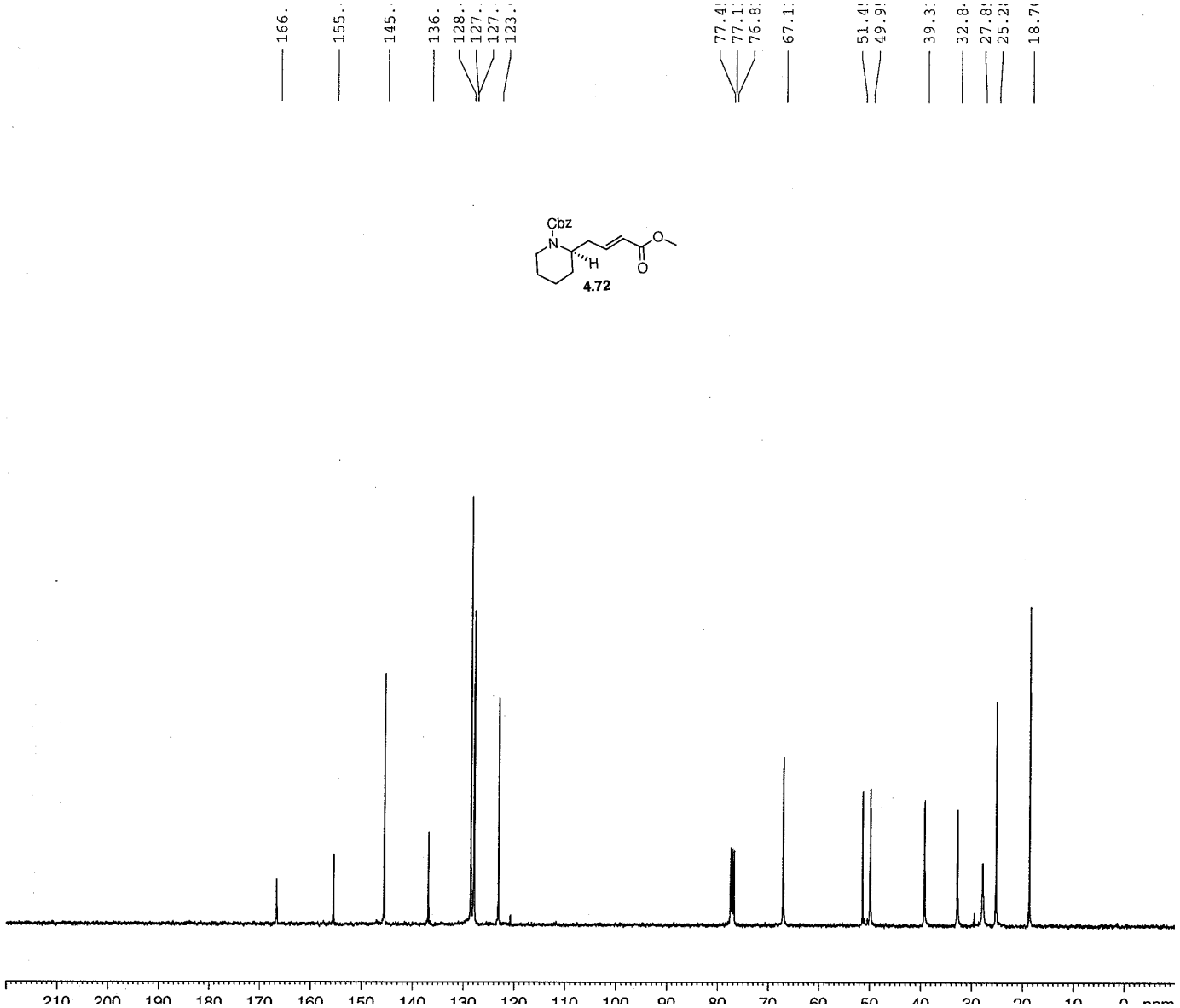
Date_	20080416
Time	15.26
INSTRUM	DPX300
PROBHD	5 mm QNP 1H/1
PULPROG	zg30
TD	32768
SOLVENT	CDC13
NS	32
DS	2
SWH	4789.272 Hz
FIDRES	0.146157 Hz
AQ	3.4210291 sec
RG	812.7
DW	104.400 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

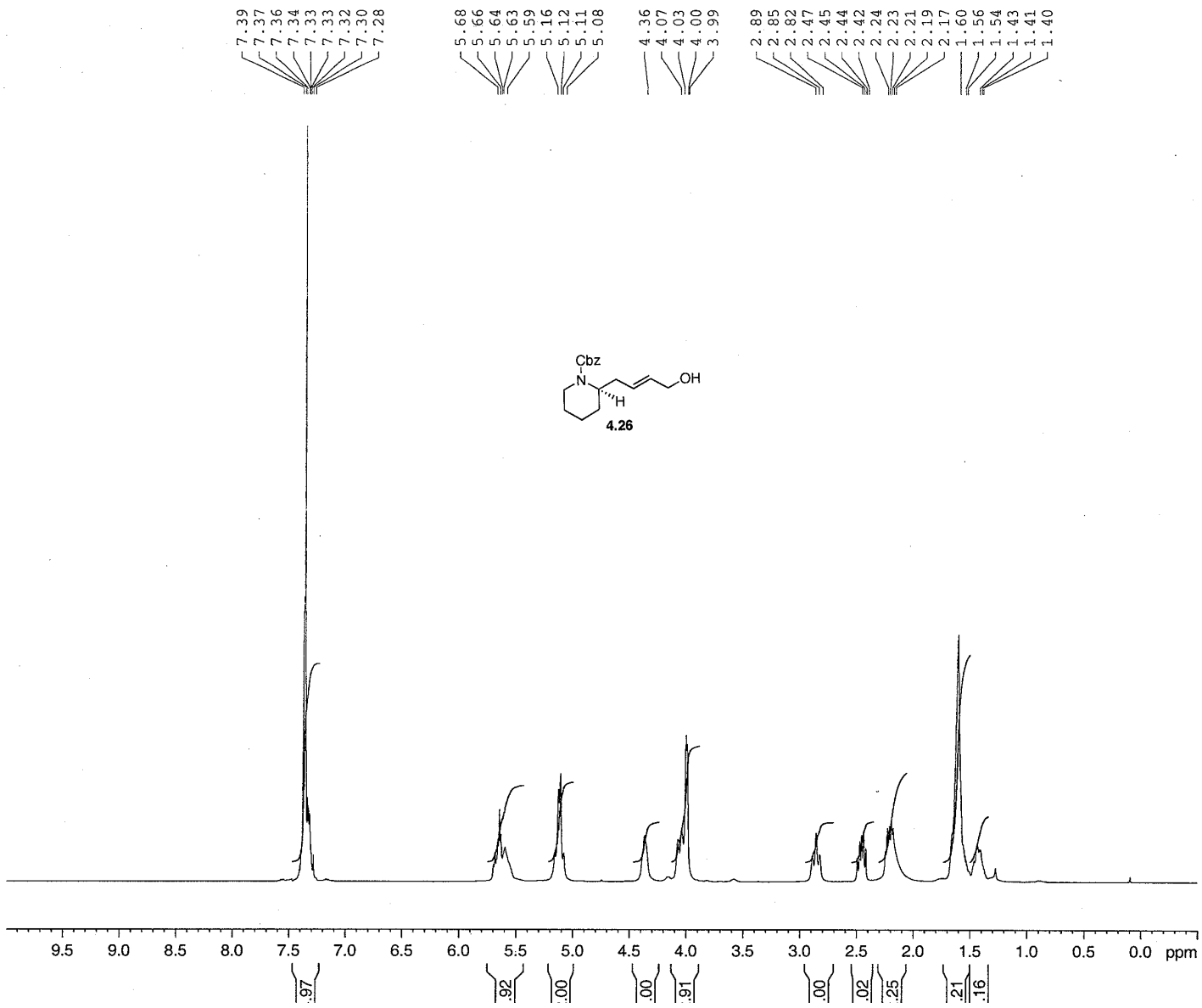
NUC1	1H
P1	9.00 usec
PL1	-3.00 dB
SFO1	300.1321009 MHz

F2 - Processing parameters

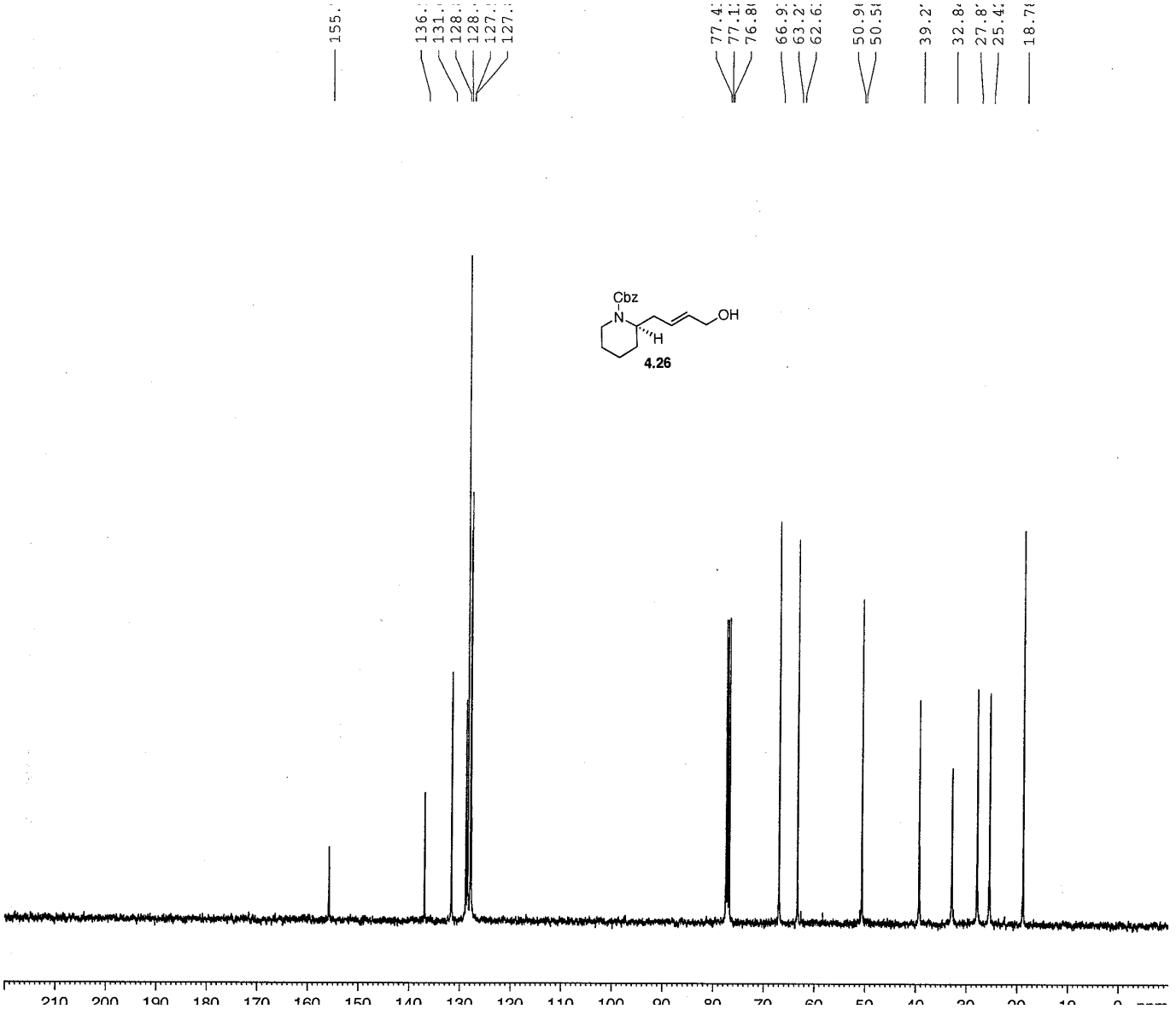
SI	32768
SF	300.1300000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00




```
DU                              /m
USER                         erikc

F2 - Acquisition Parameters
Date_                     20080519
Time                         16.28
INSTRUM                     DPX400
PROBHD    5 mm BBO BB-1H
PULPROG                     zgpg30
TD                           65536
SOLVENT
NS                             866
DS                               4
SWH                    25125.629 Hz
FIDRES                  0.383387 Hz
AQ                     1.3042164 sec
RG                        7298.2
DW                       19.900 usec
DE                        6.00 usec
TE                        298.2 K
D1                    0.15000001 sec
d11                   0.03000000 sec
DELTA                 0.05000000 sec
TD0                            1

======== CHANNEL f1 ========
NUC1                         13C
P1                        7.80 usec
PL1                      -3.00 dB
SFO1                100.5785700 MHz

======== CHANNEL f2 ========
CPDPRG2                  waltz16
NUC2                         1H
PCPD2                   135.00 usec
PL2                      17.40 dB
PL12                     17.40 dB
PL13                     17.40 dB
SFO2                399.9516000 MHz

F2 - Processing parameters
SI                           32768
SF                  100.5675080 MHz
WDW                             EM
SSB                              0
LB                        3.00 Hz
GB                               0
PC                            1.40
```




```
NAME                 b5p64
EXPNO                    1
PROCNO                   1
DU                      /n
USER                 erikc

F2 - Acquisition Parameters
Date_             20080728
Time                 15.07
INSTRUM            DPX400
PROBHD   5 mm BBO BB-1H
PULPROG               zg30
TD                   32768
SOLVENT              CDCl3
NS                       9
DS                       2
SWH              6410.256 Hz
FIDRES           0.195625 Hz
AQ               2.5559540 sec
RG                      64
DW                78.000 usec
DE                 6.00 usec
TE                298.2 K
D1             2.00000000 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                    1H
P1                  14.70 usec
PL1                  0.00 dB
SFO1          399.9528000 MHz

F2 - Processing parameters
SI                   32768
SF            399.9500000 MHz
WDW                     EM
SSB                      0
LB                    0.70 Hz
GB                       0
PC                    1.00
```



DU	/m
USER	erikc

F2 - Acquisition Parameters

Date_	20080728
Time	15.28
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zgpg30
TD	65536
SOLVENT	
NS	677
DS	4
SWH	25125.629 Hz
FIDRES	0.383387 Hz
AQ	1.3042164 sec
RG	9195.2
DW	19.900 usec
DE	6.00 usec
TE	298.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1

======== CHANNEL f1 ========

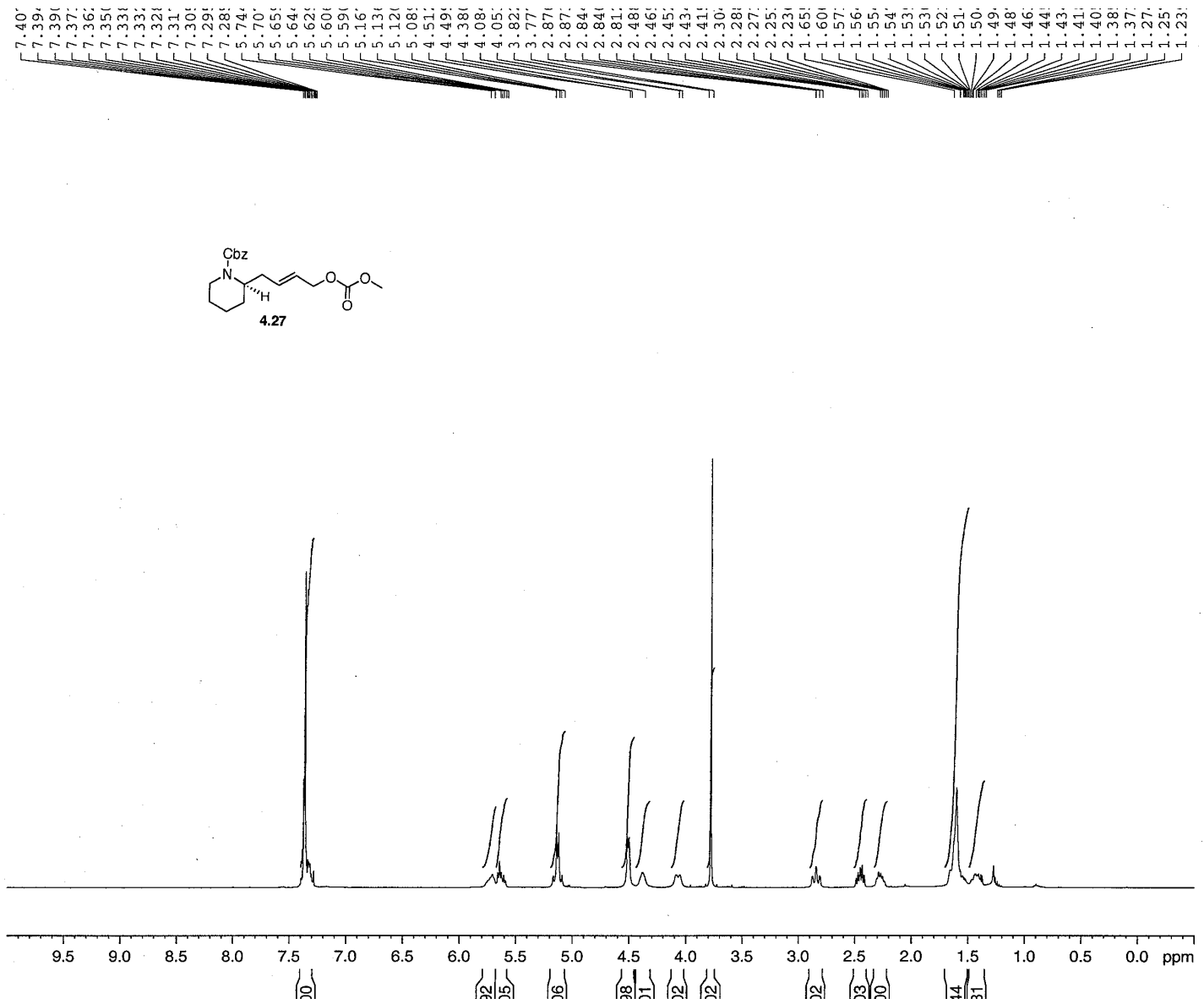
NUC1	13C
P1	7.80 usec
PL1	-3.00 dB
SFO1	100.5785700 MHz

======== CHANNEL f2 ========

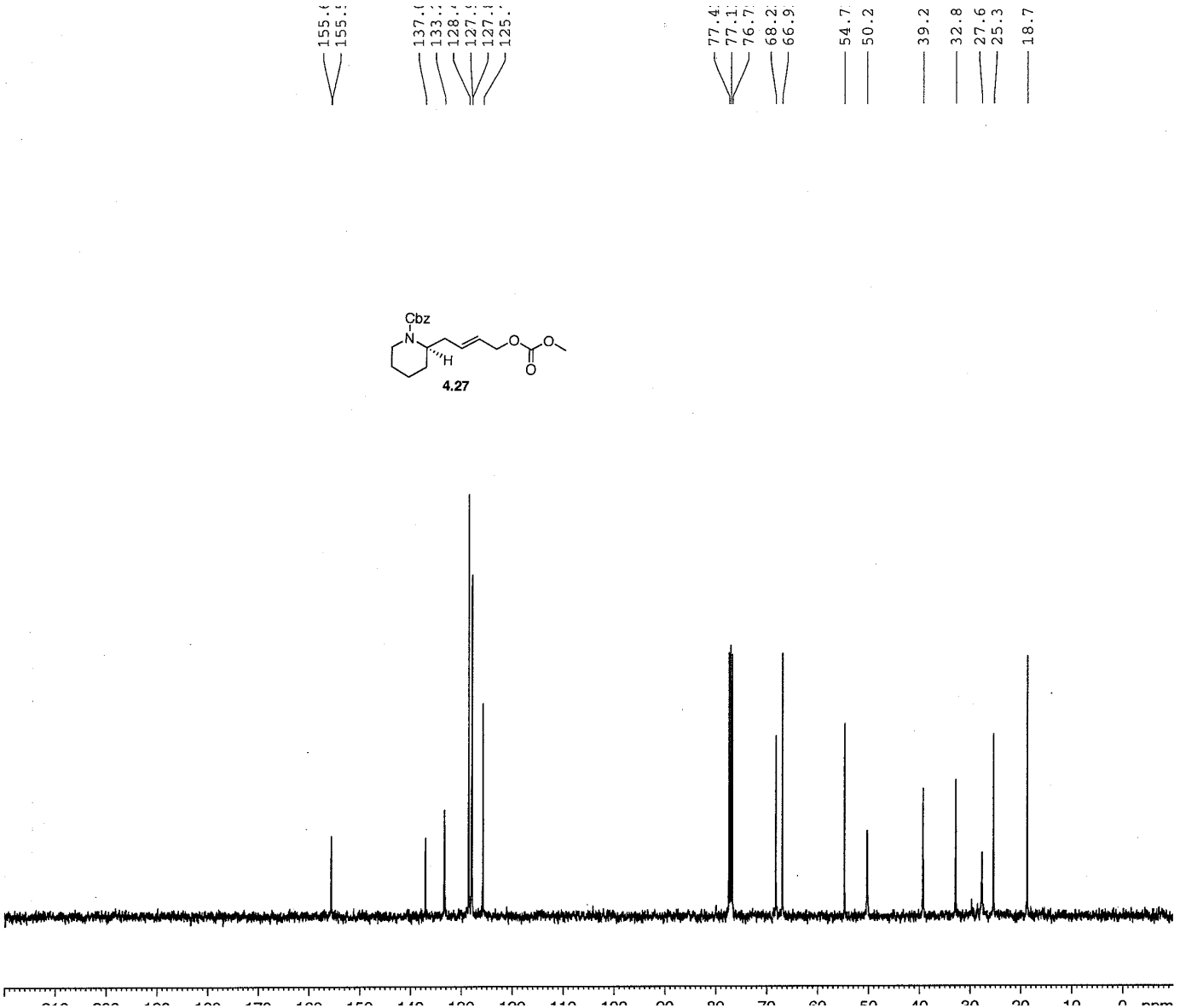
CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00 usec
PL2	17.40 dB
PL12	17.40 dB
PL13	17.40 dB
SFO2	399.9516000 MHz

F2 - Processing parameters

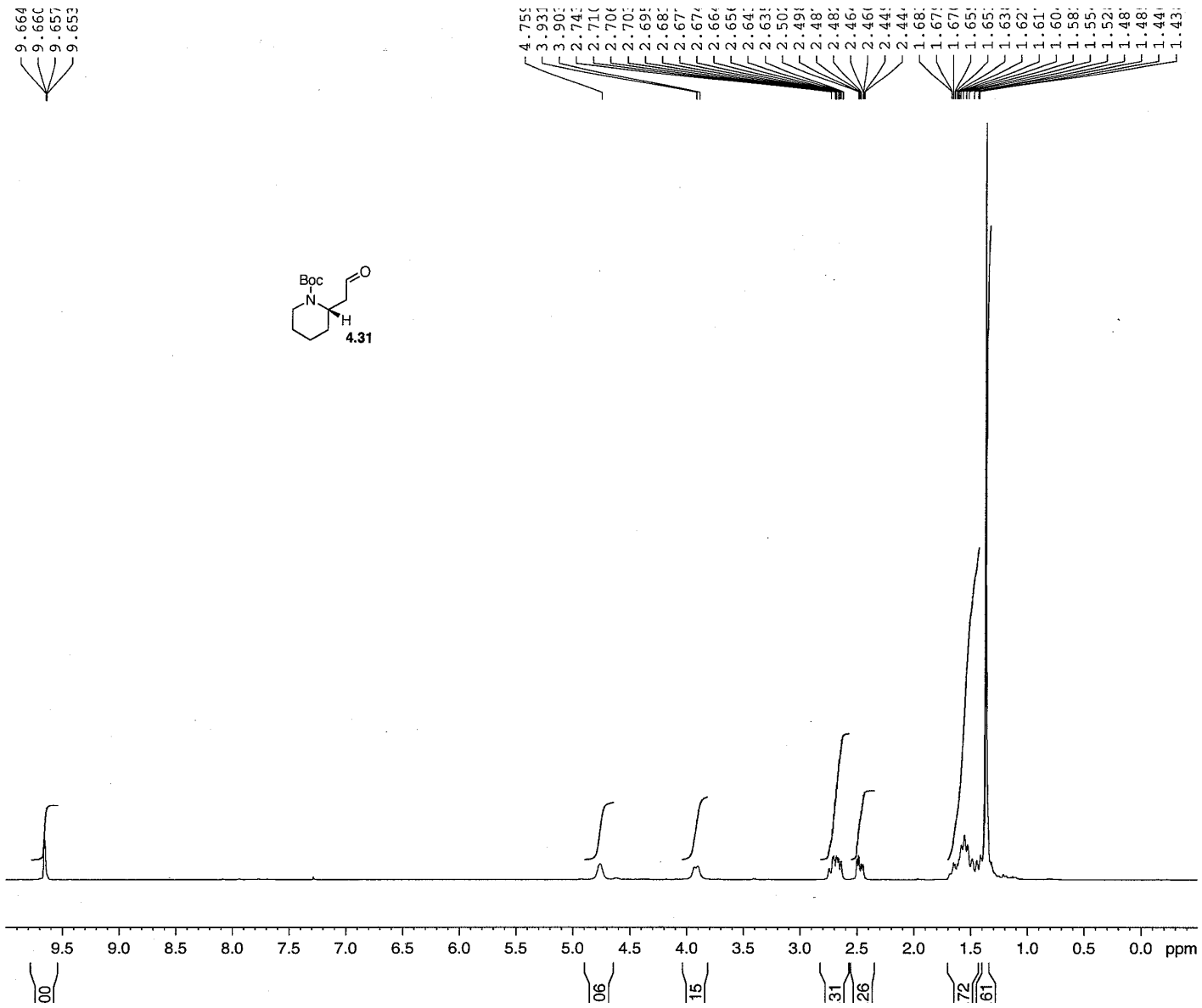
SI	32768
SF	100.5675080 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40



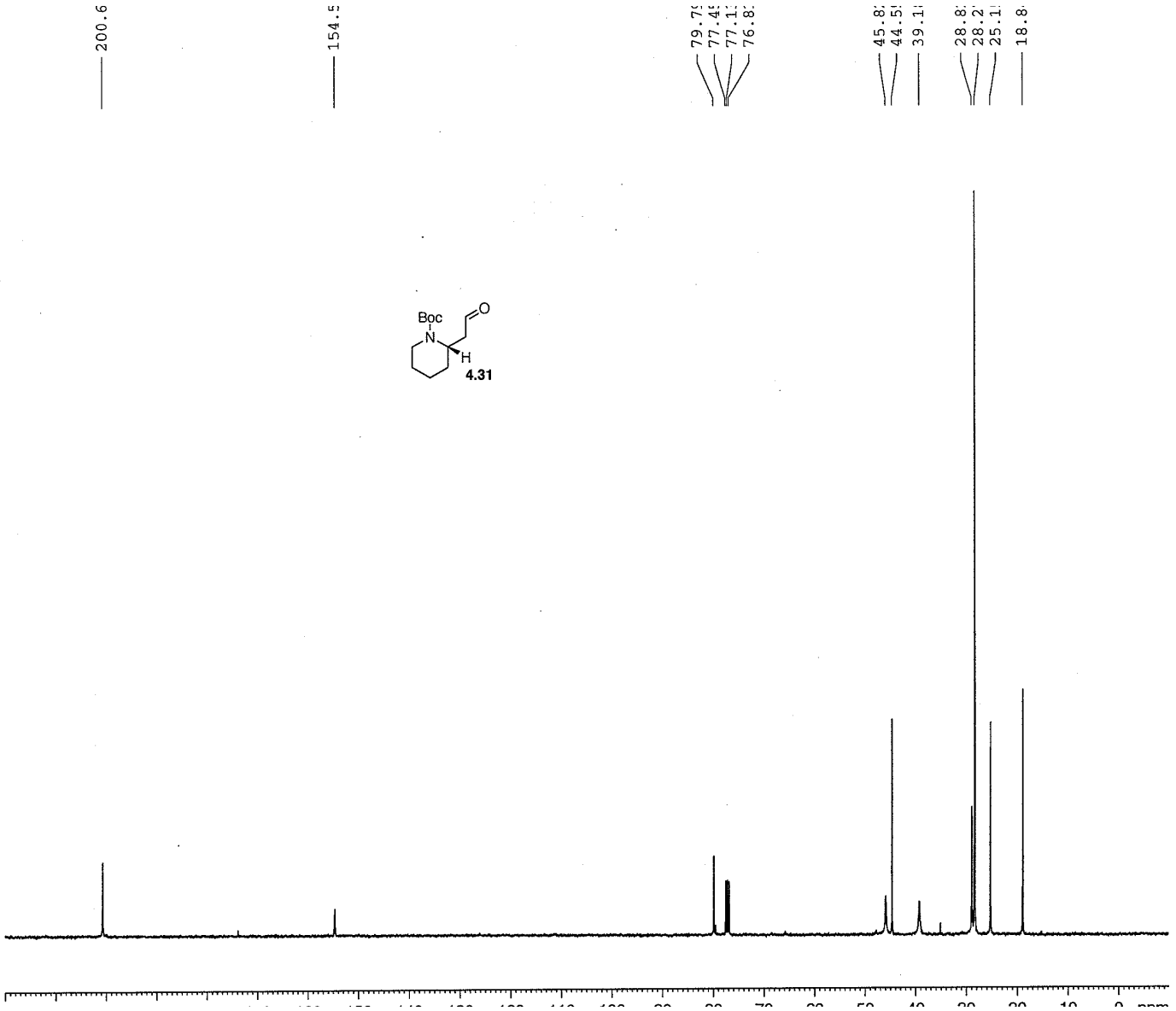

```
NAME                 b5p18
EXPNO                    2
PROCNO                   1
DU                      /n
USER                 erikc

F2 - Acquisition Parameters
Date_             20080418
Time                 16.52
INSTRUM            DPX400
PROBHD   5 mm BBO BB-1H
PULPROG              zg30
TD                  32768
SOLVENT             CDCl3
NS                     32
DS                      2
SWH             6410.256 Hz
FIDRES          0.195625 Hz
AQ              2.5559540 sec
RG                   71.8
DW                78.000 usec
DE                 6.00 usec
TE                298.2 K
D1           2.00000000 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                   1H
P1                 14.70 usec
PL1                 0.00 dB
SFO1        399.9528000 MHz

F2 - Processing parameters
SI                  32768
SF          399.9500000 MHz
WDW                    EM
SSB                     0
LB                 0.70 Hz
GB                      0
PC                   1.00
```



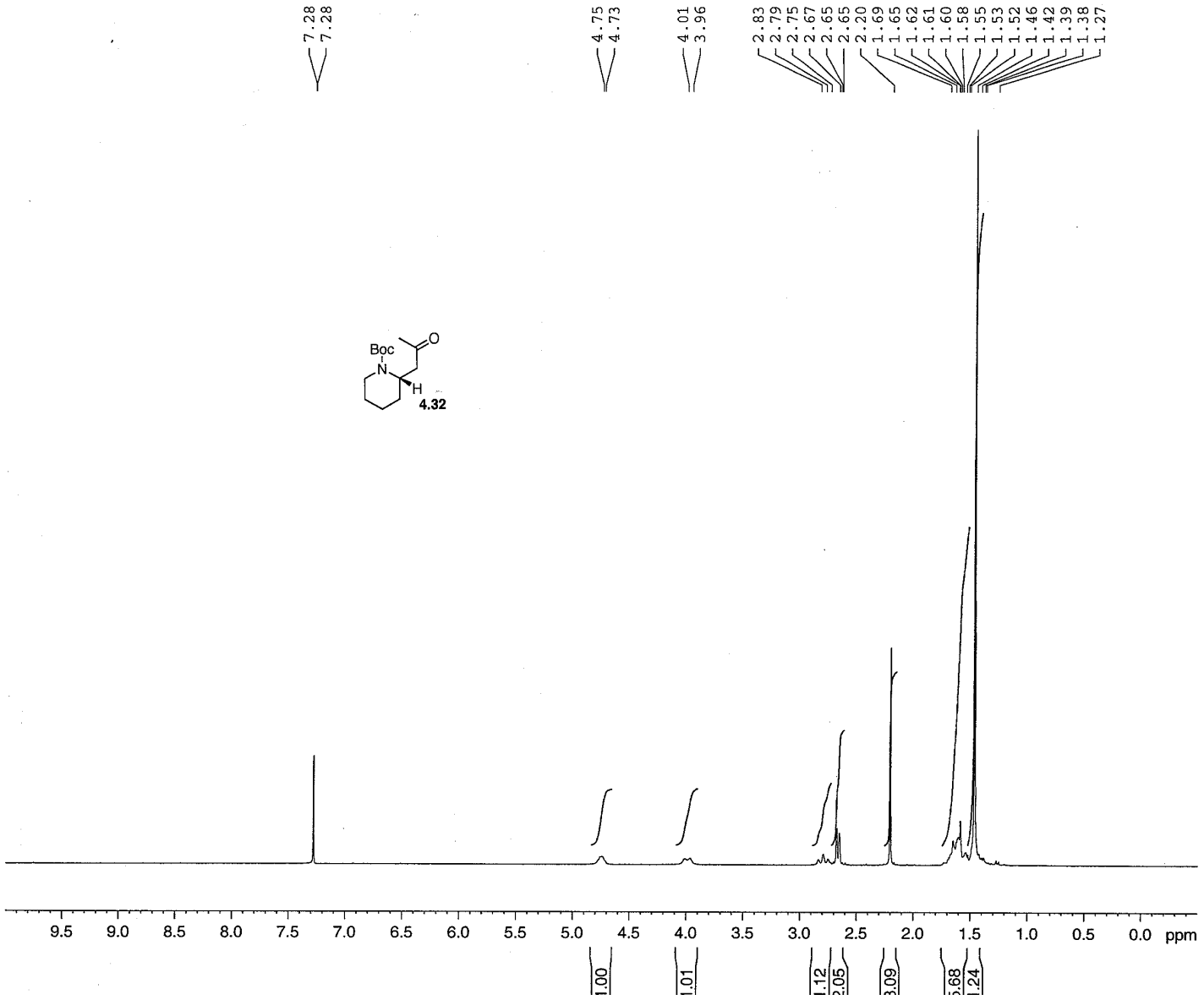

```
DU                              /n
USER                         erikc

F2 - Acquisition Parameters
Date_                     20080418
Time                         17.06
INSTRUM                     DPX400
PROBHD    5 mm BBO BB-1H
PULPROG                     zgpg30
TD                           65536
SOLVENT                      CDC13
NS                             186
DS                               4
SWH                    25125.629 Hz
FIDRES                  0.383387 Hz
AQ                     1.3042164 sec
RG                           16384
DW                        19.900 usec
DE                         6.00 usec
TE                          298.2 K
D1                    0.15000001 sec
D11                   0.03000000 sec
DELTA                 0.05000000 sec
TD0                              1

======== CHANNEL f1 ========
NUC1                          13C
P1                         7.80 usec
PL1                        -3.00 dB
SFO1                100.5785700 MHz

======== CHANNEL f2 ========
CPDPRG2                   waltz16
NUC2                          1H
PCPD2                    135.00 usec
PL2                        17.40 dB
PL12                       17.40 dB
PL13                       17.40 dB
SFO2                399.9516000 MHz

F2 - Processing parameters
SI                           32768
SF                  100.5675080 MHz
WDW                             EM
SSB                              0
LB                            3.00 Hz
GB                               0
PC                            1.40
```



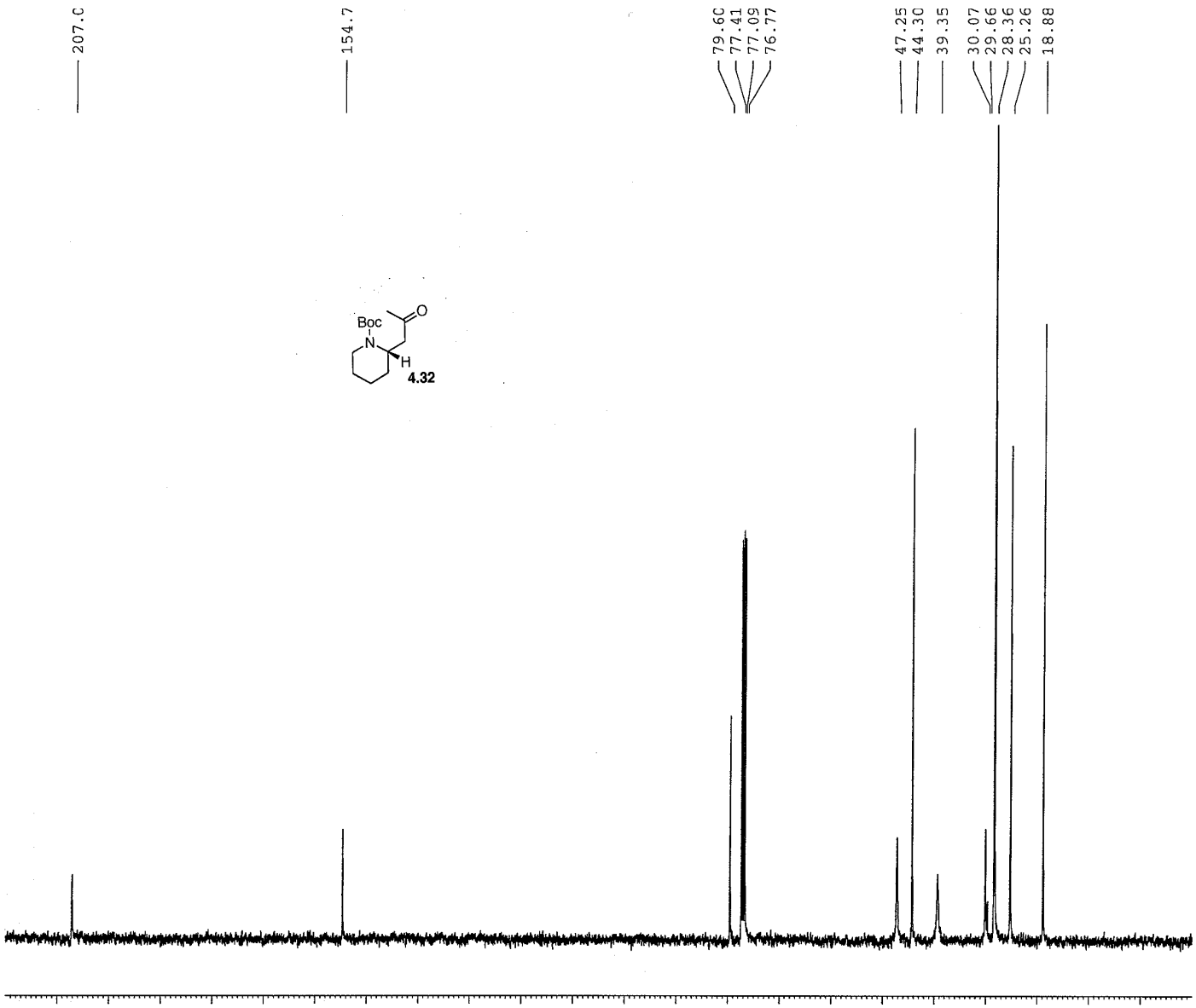

```
NAME                  b6p34
EXPNO                     1
PROCNO                    1
DU                       /m
USER                  erikc

F2 - Acquisition Parameters
Date_              20080929
Time                  14.26
INSTRUM              DPX400
PROBHD   5 mm BBO BB-1H
PULPROG                zg30
TD                    32768
SOLVENT               CDCl3
NS                        5
DS                        2
SWH              6410.256 Hz
FIDRES           0.195625 Hz
AQ             2.5559540 sec
RG                       32
DW                78.000 usec
DE                 6.00 usec
TE                298.2 K
D1             2.00000000 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                    1H
P1                  14.70 usec
PL1                  0.00 dB
SFO1         399.9528000 MHz

F2 - Processing parameters
SI                    32768
SF           399.9500000 MHz
WDW                     EM
SSB                      0
LB                  0.70 Hz
GB                       0
PC                    1.00
```




```
DU                      /m
USER                 erikc

F2 - Acquisition Parameters
Date_              20080929
Time                  14.39
INSTRUM             DPX400
PROBHD   5 mm BBO BB-1H
PULPROG             zgpg30
TD                   65536
SOLVENT
NS                     383
DS                       4
SWH              25125.629 Hz
FIDRES           0.383387 Hz
AQ               1.3042164 sec
RG                    3251
DW                19.900 usec
DE                 6.00 usec
TE                 298.2 K
D1             0.15000001 sec
d11            0.03000000 sec
DELTA          0.05000000 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                   13C
P1                  7.80 usec
PL1                -3.00 dB
SFO1         100.5785700 MHz

======== CHANNEL f2 ========
CPDPRG2           waltz16
NUC2                   1H
PCPD2             135.00 usec
PL2                17.40 dB
PL12               17.40 dB
PL13               17.40 dB
SFO2         399.9516000 MHz

F2 - Processing parameters
SI                   32768
SF           100.5675080 MHz
WDW                    EM
SSB                     0
LB                   3.00 Hz
GB                      0
PC                   1.40
```




```
NAME                 b6p39
EXPNO                    1
PROCNO                   1
DU                      /n
USER                 erikc

F2 - Acquisition Parameters
Date_             20081001
Time                 11.59
INSTRUM             DPX300
PROBHD   5 mm QNP  1H/1
PULPROG              zg30
TD                  32768
SOLVENT              CDC13
NS                       9
DS                       2
SWH              4789.272 Hz
FIDRES           0.146157 Hz
AQ               3.4210291 sec
RG                   912.3
DW                 104.400 usec
DE                   6.00 usec
TE                  298.2 K
D1              2.00000000 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                    1H
P1                   9.00 usec
PL1                 -3.00 dB
SFO1           300.1321009 MHz

F2 - Processing parameters
SI                   32768
SF             300.1300000 MHz
WDW                     EM
SSB                      0
LB                  0.30 Hz
GB                       0
PC                    1.00
```



PROCNO	1
DU	/m
USER	laurenr

F2 - Acquisition Parameters

Date_	20061208
Time	14.26
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zgpg30
TD	65536
SOLVENT	
NS	487
DS	4
SWH	25125.629 Hz
FIDRES	0.383387 Hz
AQ	1.3042164 sec
RG	4597.6
DW	19.900 usec
DE	6.00 usec
TE	298.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1

======== CHANNEL f1 ========

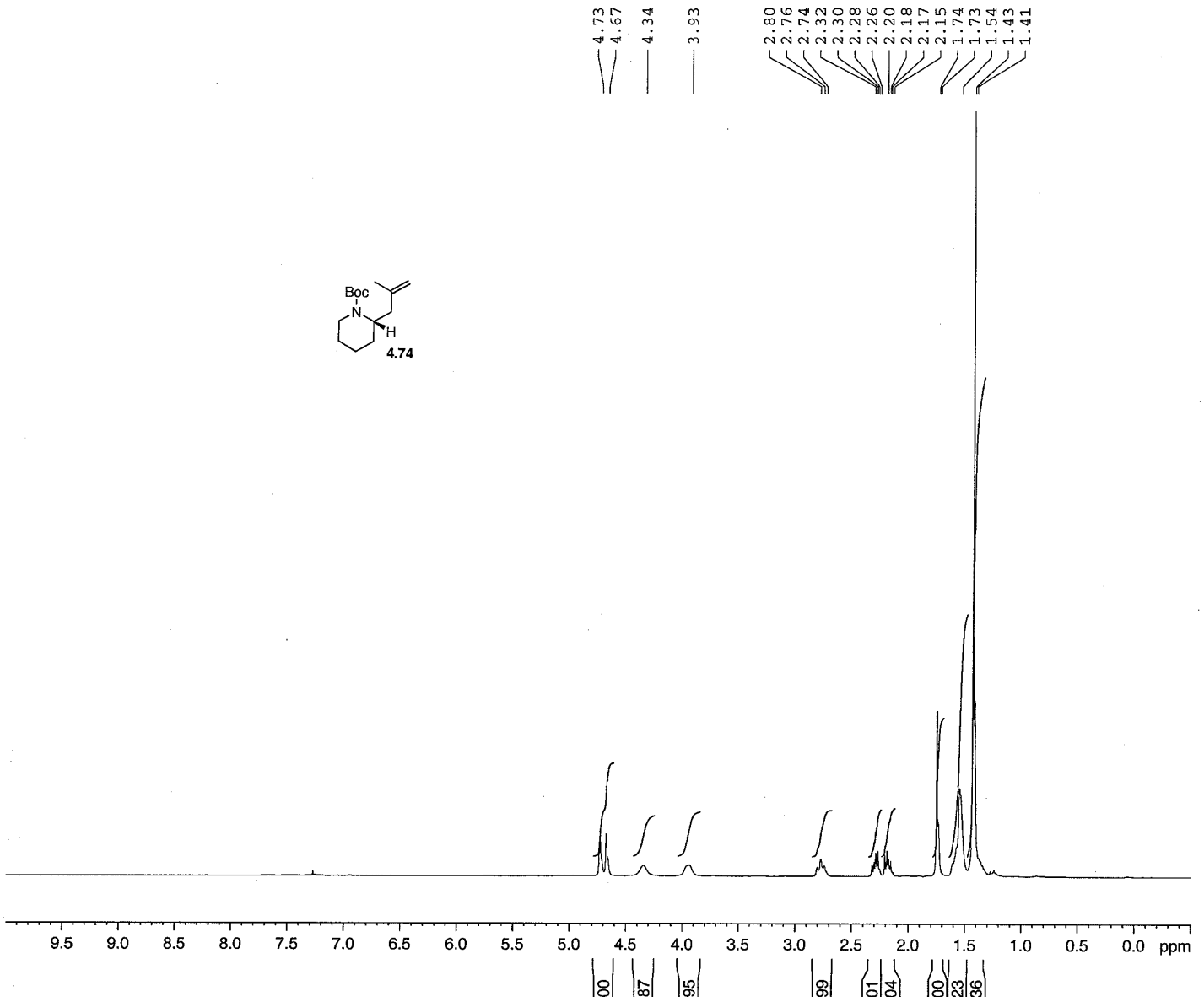
NUC1	13C
P1	7.80 usec
PL1	-3.00 dB
SFO1	100.5936591 MHz

======== CHANNEL f2 ========

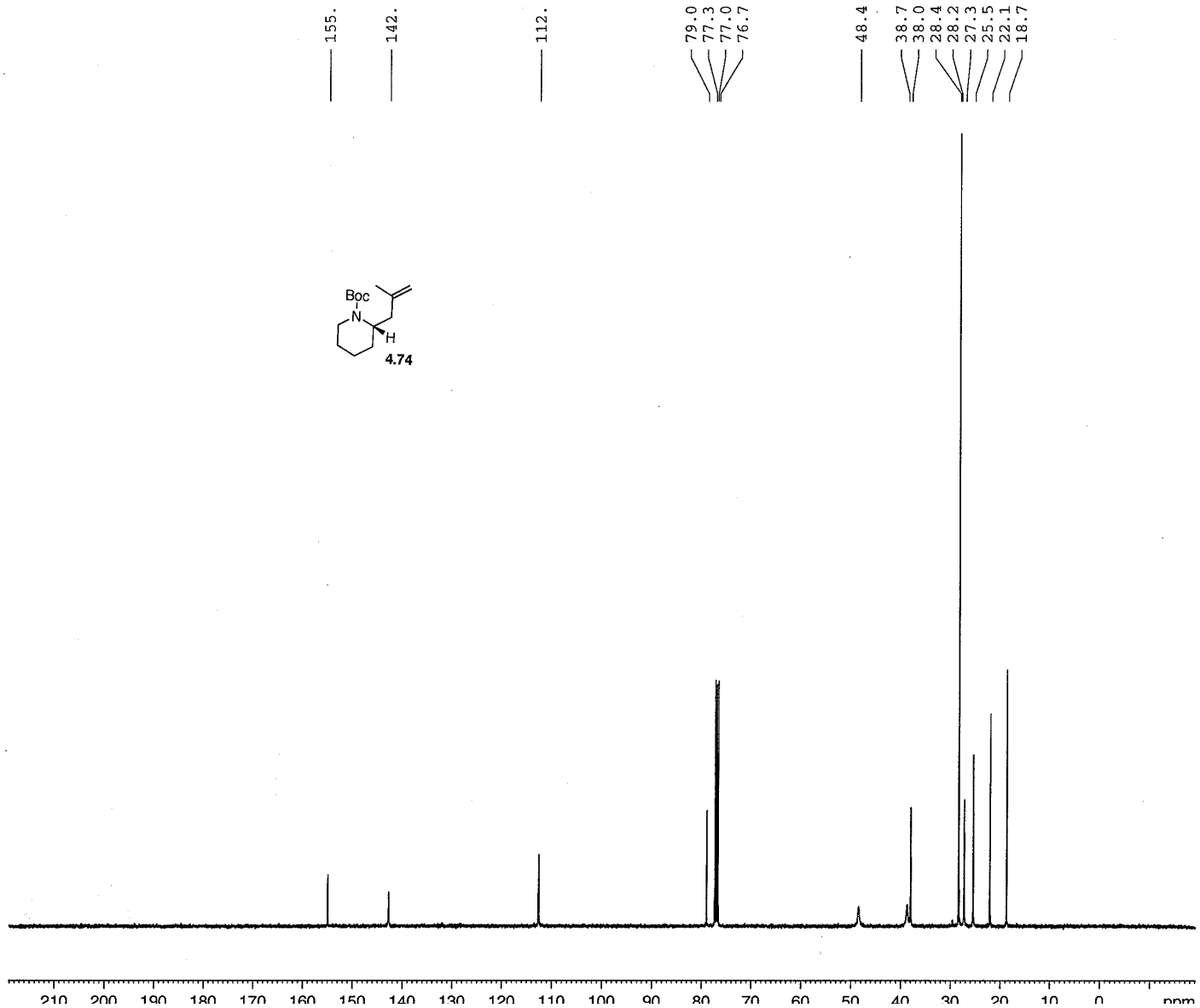
CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00 usec
PL2	17.40 dB
PL12	17.40 dB
PL13	17.40 dB
SFO2	400.0116000 MHz

F2 - Processing parameters

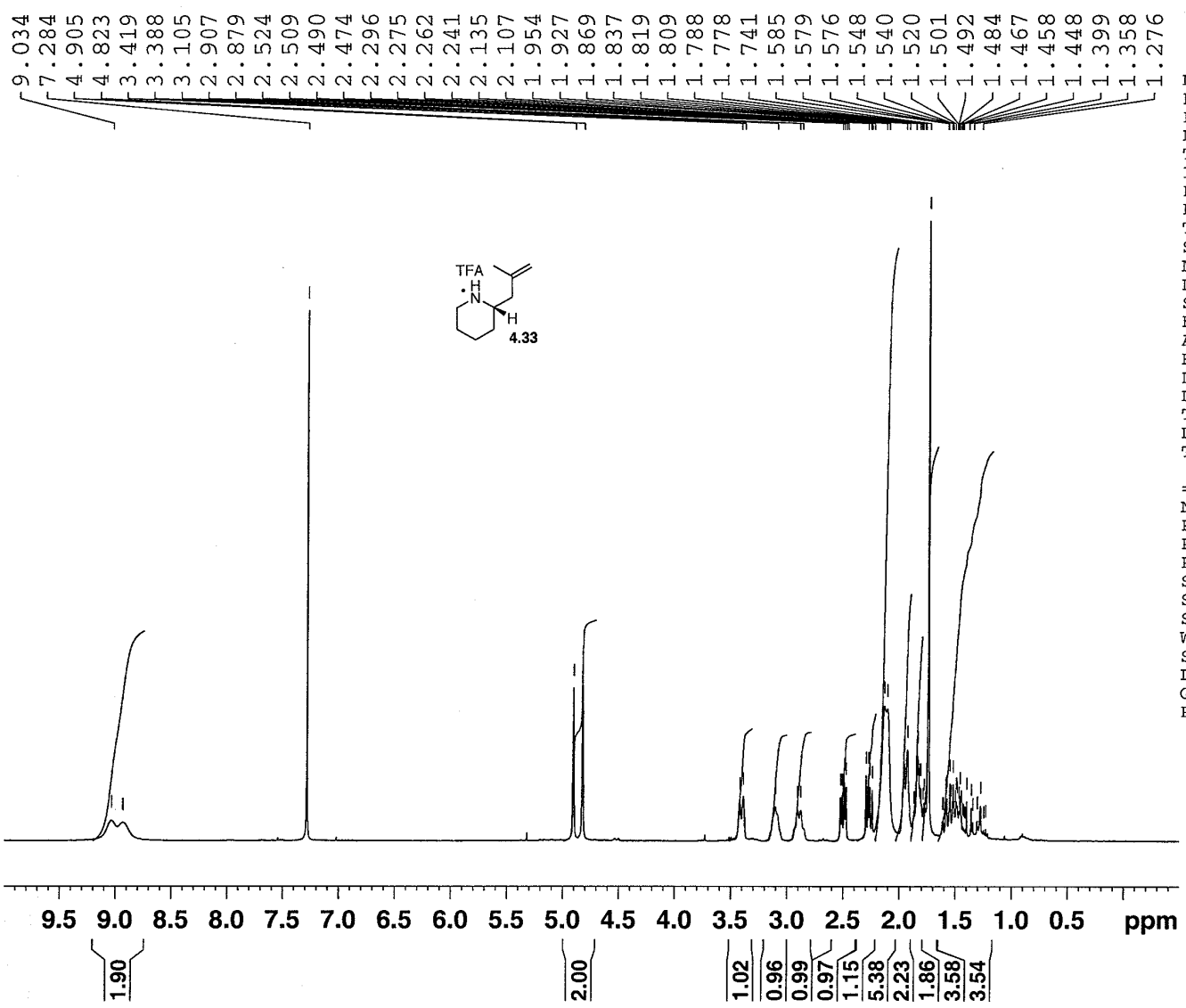
SI	32768
SF	100.5825950 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40



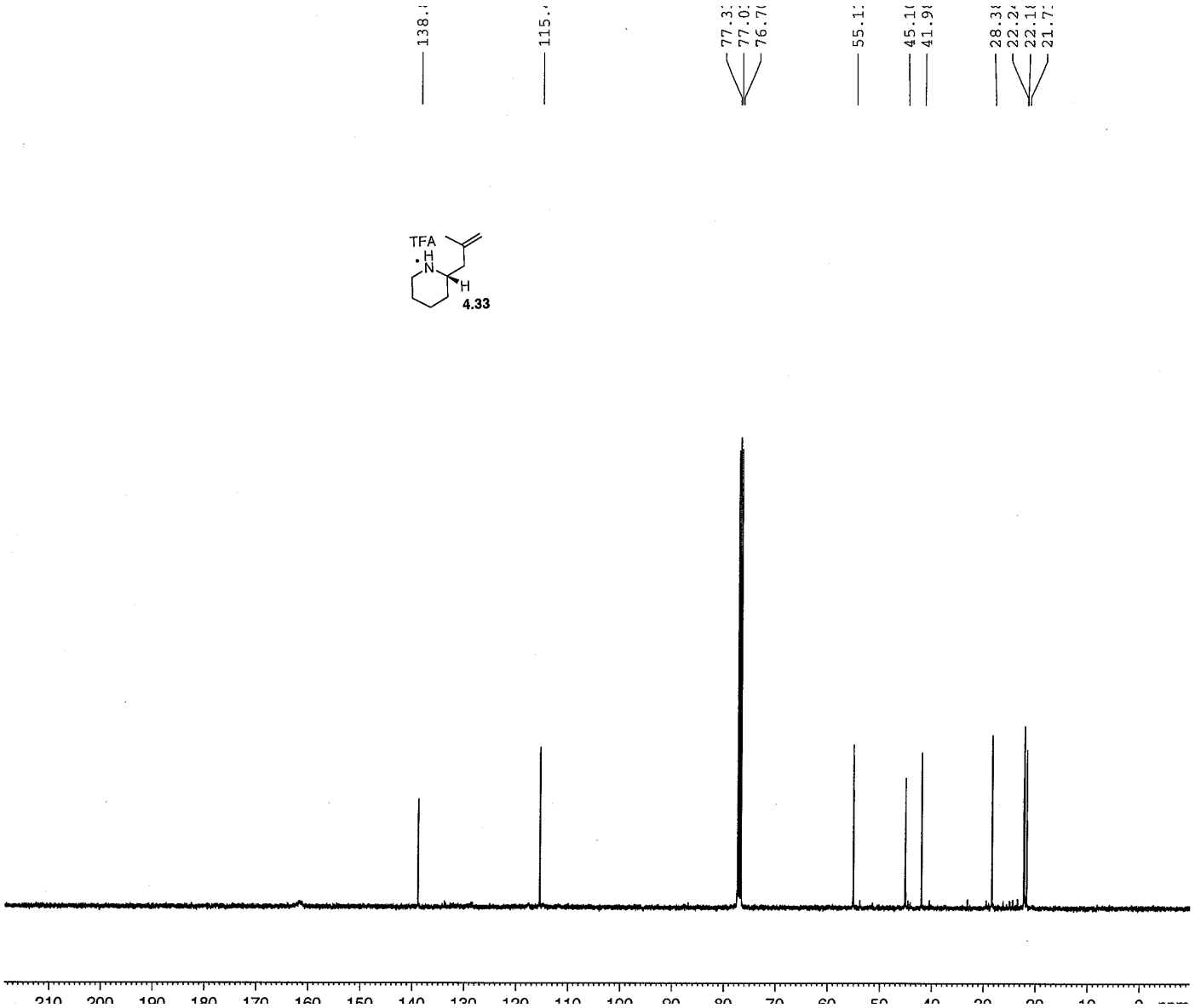

```
NAME                b6p28
EXPNO                  1
PROCNO                 1
DU                    /m
USER                erikc

F2 - Acquisition Parameters
Date_           20090911
Time               14.05
INSTRUM          DPX400
PROBHD   5 mm BBO BB-1H
PULPROG             zg30
TD                 32768
SOLVENT            CDCl3
NS                     9
DS                     2
SWH           6410.256 Hz
FIDRES        0.195625 Hz
AQ            2.5559540 sec
RG                    32
DW              78.000 usec
DE               6.00 usec
TE               299.2 K
D1           1.00000000 sec
TD0                    1

======== CHANNEL f1 ========
NUC1                  1H
P1                13.50 usec
PL1               -3.00 dB
SFO1        400.2428017 MHz

F2 - Processing parameters
SI                 32768
SF          400.2400000 MHz
WDW                   EM
SSB                    0
LB                0.30 Hz
GB                     0
PC                  1.00
```



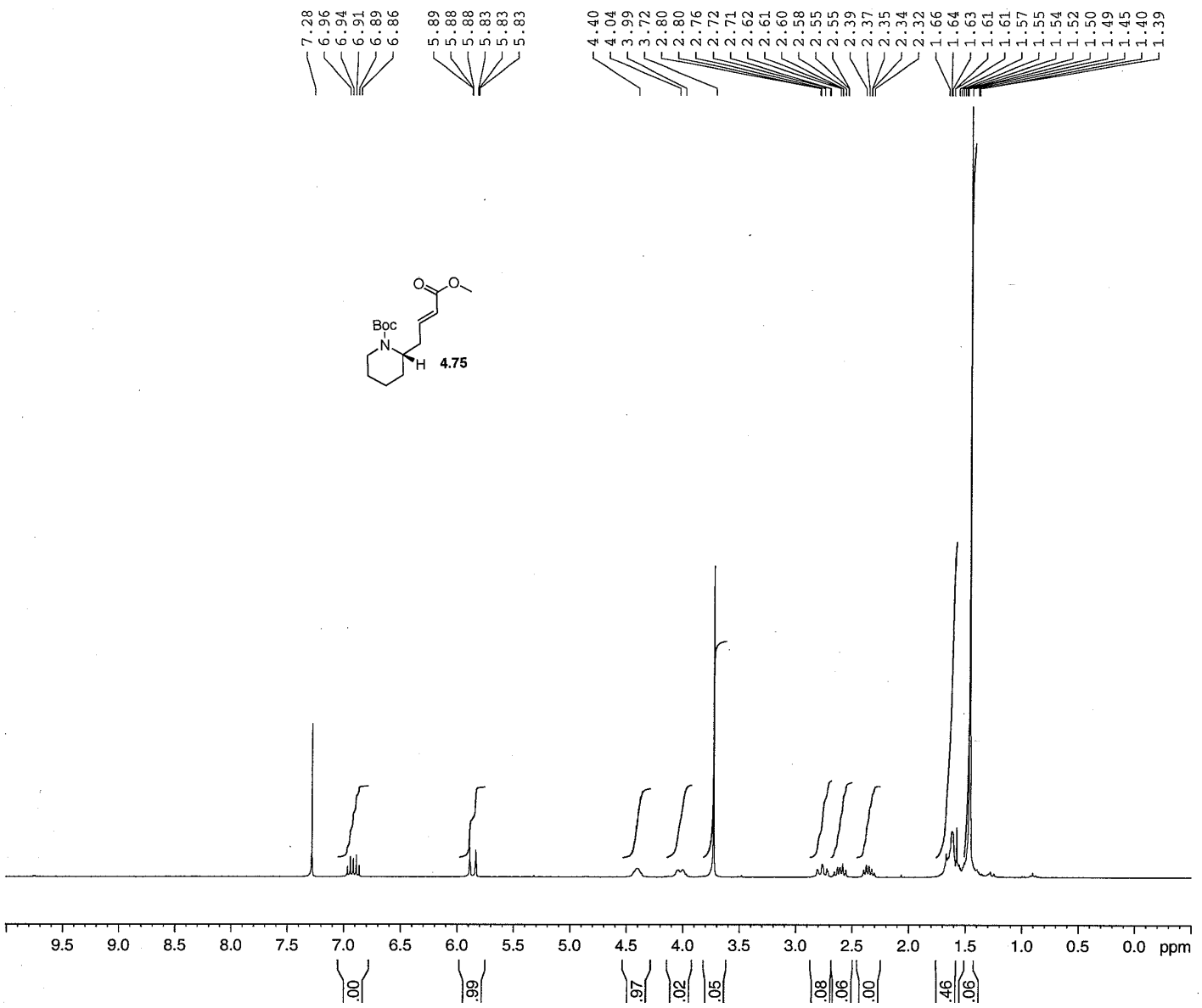

```
DU                      /m
USER                 erikc

F2 - Acquisition Parameters
Date_              20090911
Time                  14.49
INSTRUM             DPX400
PROBHD   5 mm BBO BB-1H
PULPROG             zgpg30
TD                   65536
SOLVENT              CDCl3
NS                     731
DS                       4
SWH              23980.814 Hz
FIDRES           0.365918 Hz
AQ               1.3664756 sec
RG                    8192
DW                20.850 usec
DE                 6.00 usec
TE                 300.2 K
D1            2.00000000 sec
d11           0.03000000 sec
DELTA         1.89999998 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                   13C
P1                  8.30 usec
PL1                -3.00 dB
SFO1         100.6504921 MHz

======== CHANNEL f2 ========
CPDPRG2            waltz16
NUC2                    1H
PCPD2              90.00 usec
PL2                -3.00 dB
PL12               15.00 dB
PL13               15.00 dB
SFO2         400.2416010 MHz

F2 - Processing parameters
SI                   32768
SF           100.6404280 MHz
WDW                     EM
SSB                      0
LB                  1.00 Hz
GB                       0
PC                    1.40
```



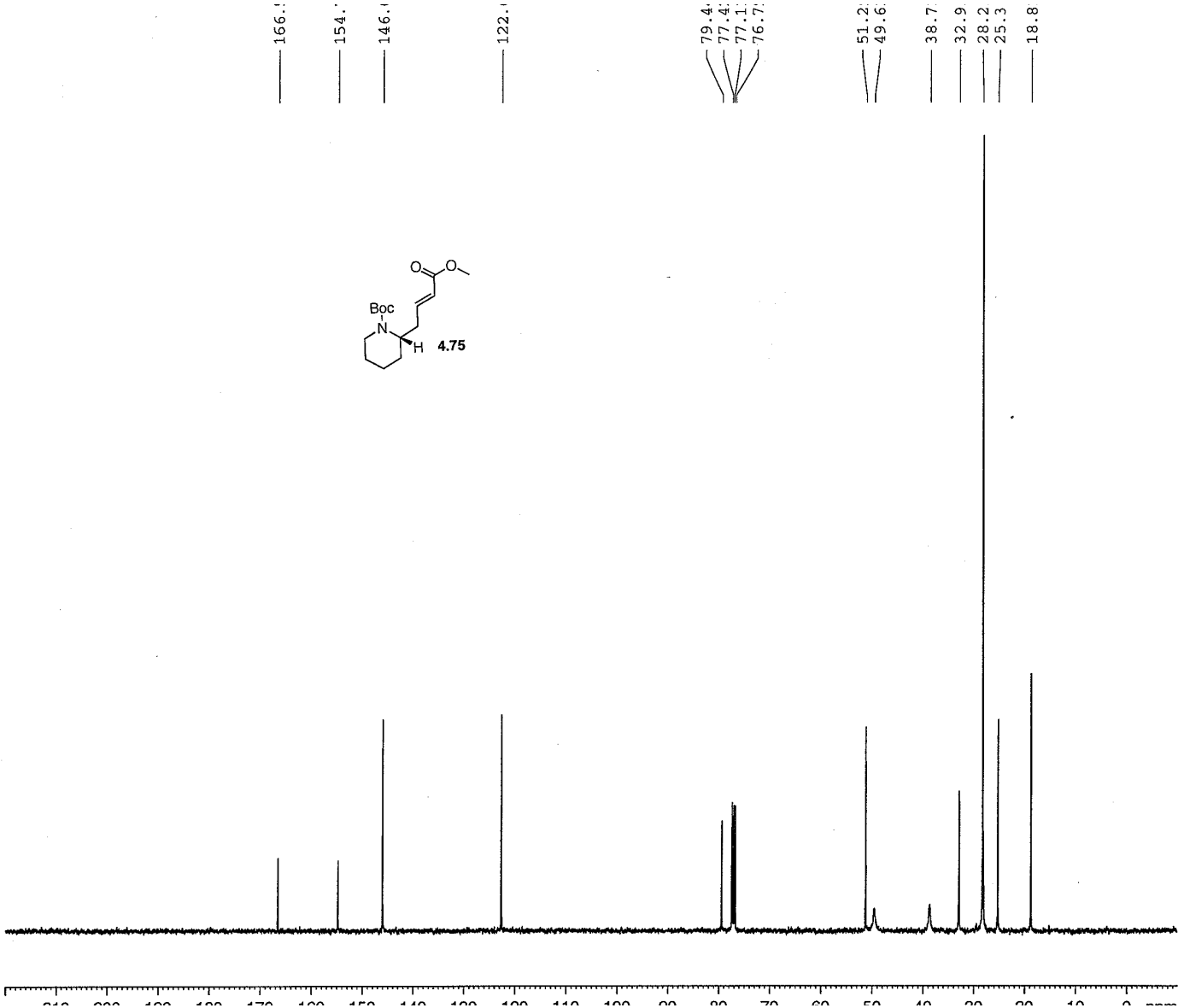
NAME	b7p38
EXPNO	1
PROCNO	1
Date_	20090812
Time	13.25
INSTRUM	spect
PROBHD	5 mm PABBO BB-
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	32
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	181
DW	78.000 usec
DE	6.50 usec
TE	299.3 K
D1	2.00000000 sec
TD0	1
======== CHANNEL f1 ========	
NUC1	1H
P1	14.00 usec
PL1	0.00 dB
PL1W	10.27361584 W
SFO1	400.1328009 MHz
SI	32768
SF	400.1300000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00



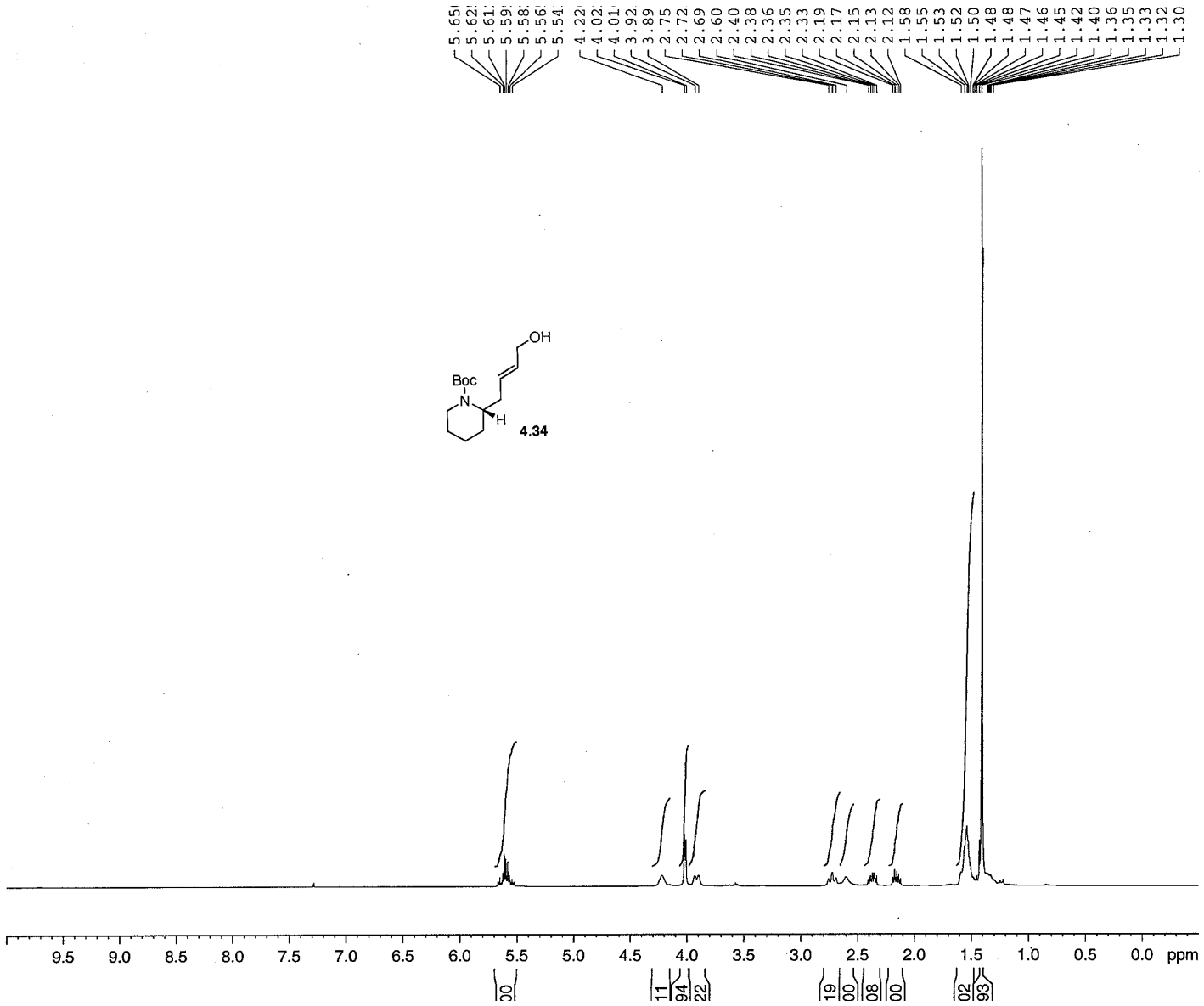

```
DU                              /m
USER                         erikc

F2 - Acquisition Parameters
Date_                      20090915
Time                          12.19
INSTRUM                      DPX400
PROBHD          5 mm BBO BB-1H
PULPROG                     zgpg30
TD                           65536
SOLVENT                      CDCl3
NS                             732
DS                               4
SWH                    23980.814 Hz
FIDRES                  0.365918 Hz
AQ                     1.3664756 sec
RG                        3649.1
DW                        20.850 usec
DE                         6.00 usec
TE                        300.2 K
D1                    2.00000000 sec
d11                   0.03000000 sec
DELTA                 1.89999998 sec
TD0                            1

======== CHANNEL f1 ========
NUC1                         13C
P1                         8.30 usec
PL1                       -3.00 dB
SFO1                100.6504921 MHz

======== CHANNEL f2 ========
CPDPRG2                  waltz16
NUC2                          1H
PCPD2                      90.00 usec
PL2                       -3.00 dB
PL12                      15.00 dB
PL13                      15.00 dB
SFO2                400.2416010 MHz

F2 - Processing parameters
SI                            32768
SF                  100.6404280 MHz
WDW                            EM
SSB                             0
LB                         1.00 Hz
GB                              0
PC                           1.40
```



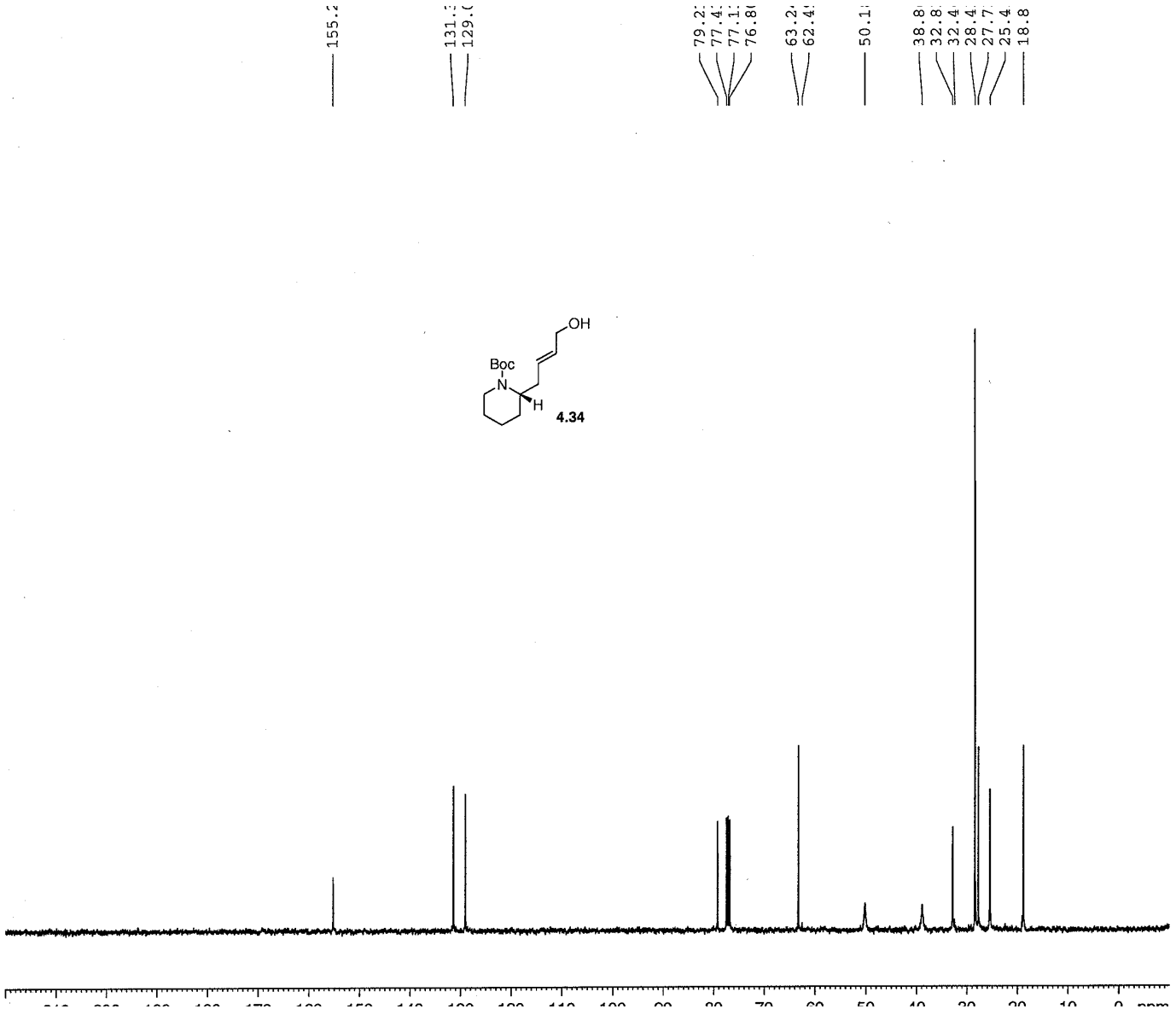

```
NAME                 b6p25
EXPNO                    1
PROCNO                   1
DU                      /n
USER                erikc

F2 - Acquisition Parameters
Date_            20080909
Time                16.56
INSTRUM           DPX300
PROBHD   5 mm QNP  1H/1
PULPROG              zg30
TD                  32768
SOLVENT             CDCl3
NS                     18
DS                      2
SWH              4789.272 Hz
FIDRES           0.146157 Hz
AQ               3.4210291 sec
RG                  1149.4
DW                104.400 usec
DE                  6.00 usec
TE                 298.2 K
D1              2.00000000 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                   1H
P1                   9.00 usec
PL1                 -3.00 dB
SFO1          300.1321009 MHz

F2 - Processing parameters
SI                  32768
SF            300.1300000 MHz
WDW                    EM
SSB                     0
LB                   0.30 Hz
GB                      0
PC                   1.00
```



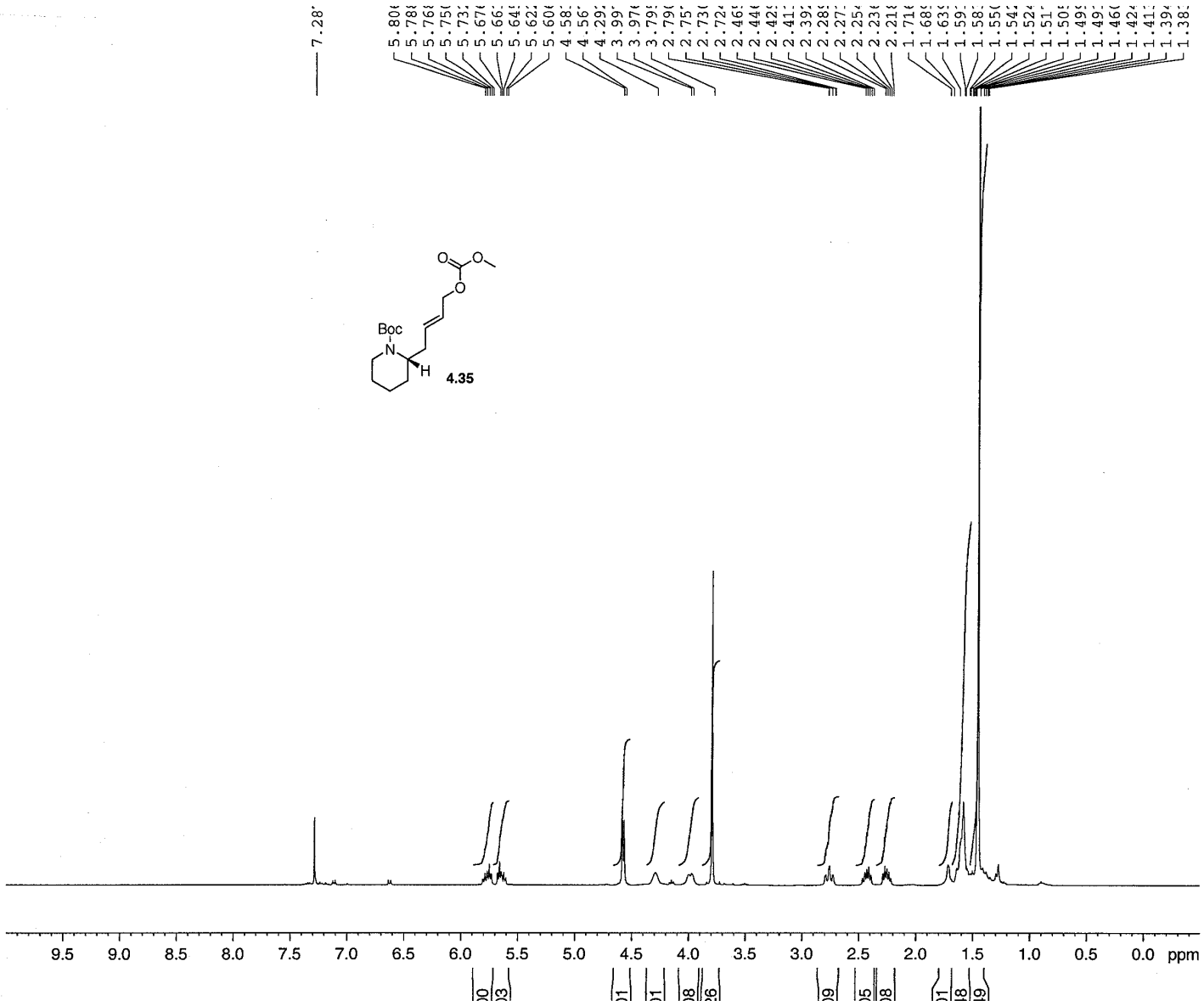

```
DU                          /m
USER                     erikc

F2 - Acquisition Parameters
Date_                 20081009
Time                     10.01
INSTRUM                DPX400
PROBHD    5 mm BBO BB-1H
PULPROG                zgpg30
TD                      65536
SOLVENT
NS                         218
DS                           4
SWH                 25125.629 Hz
FIDRES                0.383387 Hz
AQ                   1.3042164 sec
RG                       16384
DW                    19.900 usec
DE                     6.00 usec
TE                     298.2 K
D1                0.15000001 sec
d11               0.03000000 sec
DELTA             0.05000000 sec
TD0                          1

======== CHANNEL f1 ========
NUC1                       13C
P1                      7.80 usec
PL1                    -3.00 dB
SFO1             100.5785700 MHz

======== CHANNEL f2 ========
CPDPRG2                waltz16
NUC2                       1H
PCPD2                 135.00 usec
PL2                    17.40 dB
PL12                   17.40 dB
PL13                   17.40 dB
SFO2             399.9516000 MHz

F2 - Processing parameters
SI                         32768
SF               100.5675080 MHz
WDW                           EM
SSB                           0
LB                     3.00 Hz
GB                            0
PC                         1.40
```




```
NAME                 b6p26
EXPNO                    1
PROCNO                   1
DU                      /m
USER                 erikc

F2 - Acquisition Parameters
Date_             20080917
Time                 15.04
INSTRUM             DPX400
PROBHD   5 mm BBO BB-1H
PULPROG              zg30
TD                  32768
SOLVENT             CDC13
NS                      9
DS                      2
SWH              6410.256 Hz
FIDRES           0.195625 Hz
AQ               2.5559540 sec
RG                   35.9
DW                 78.000 usec
DE                  6.00 usec
TE                 298.2 K
D1              2.00000000 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                   1H
P1                  14.70 usec
PL1                  0.00 dB
SFO1          399.9528000 MHz

F2 - Processing parameters
SI                  32768
SF            399.9500000 MHz
WDW                    EM
SSB                     0
LB                   0.70 Hz
GB                      0
PC                   1.00
```




```
DU                              /m
USER                         erikc

F2 - Acquisition Parameters
Date_                     20080917
Time                         15.09
INSTRUM                     DPX400
PROBHD    5 mm BBO BB-1H
PULPROG                     zgpg30
TD                           65536
SOLVENT
NS                             130
DS                               4
SWH                    25125.629 Hz
FIDRES                  0.383387 Hz
AQ                     1.3042164 sec
RG                           16384
DW                      19.900 usec
DE                       6.00 usec
TE                        298.2 K
D1                   0.15000001 sec
d11                  0.03000000 sec
DELTA                0.05000000 sec
TD0                             1

======== CHANNEL f1 ========
NUC1                          13C
P1                         7.80 usec
PL1                          -3.00 dB
SFO1                100.5785700 MHz

======== CHANNEL f2 ========
CPDPRG2                   waltz16
NUC2                          1H
PCPD2                    135.00 usec
PL2                       17.40 dB
PL12                      17.40 dB
PL13                      17.40 dB
SFO2                399.9516000 MHz

F2 - Processing parameters
SI                            32768
SF                  100.5675080 MHz
WDW                            EM
SSB                             0
LB                           3.00 Hz
GB                              0
PC                           1.40
```



NAME	b6p50
EXPNO	8
PROCNO	1
DU	/m
USER	erikc

F2 - Acquisition Parameters

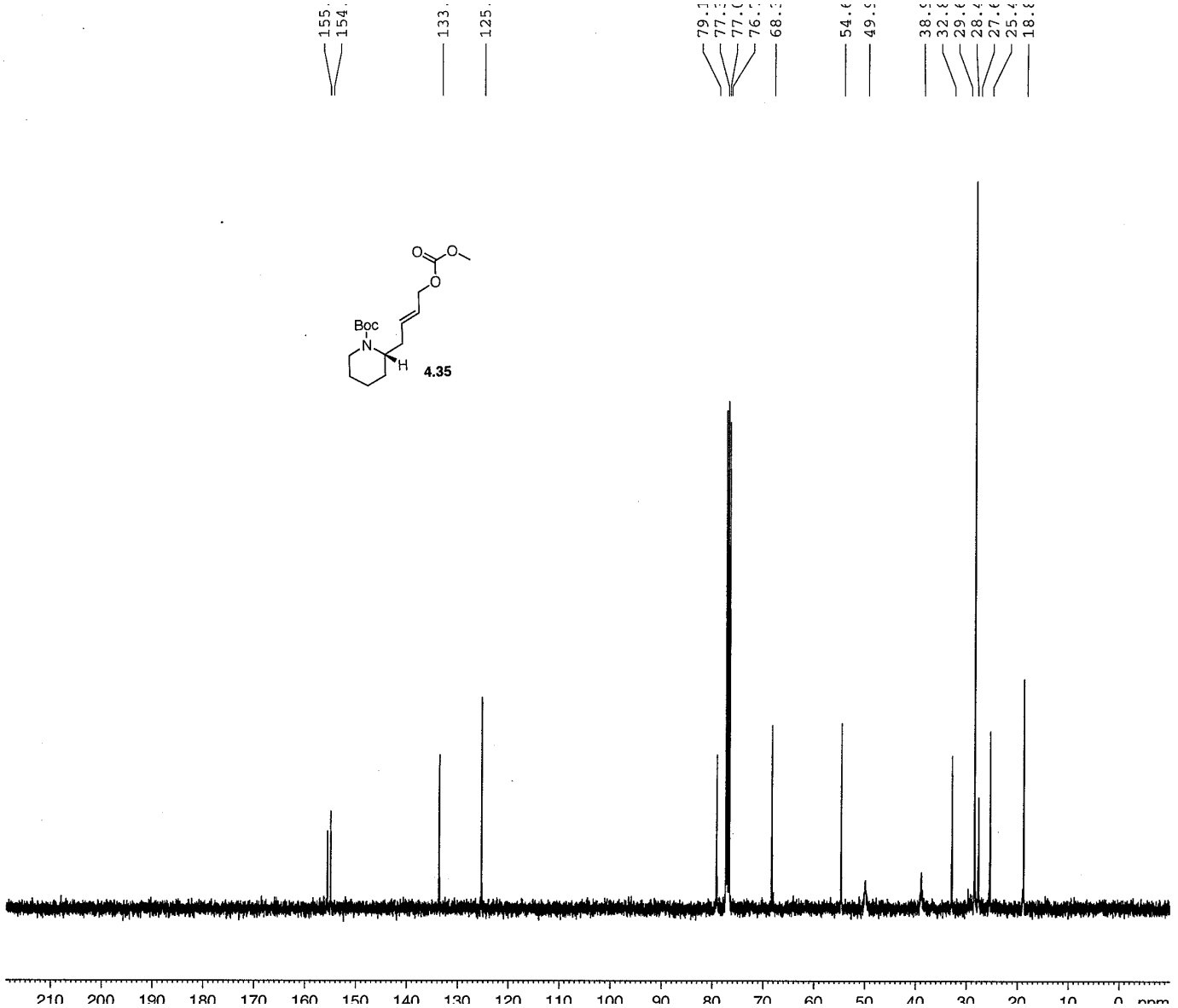
Date_	20081015
Time	13.47
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	32
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	181
DW	78.000 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

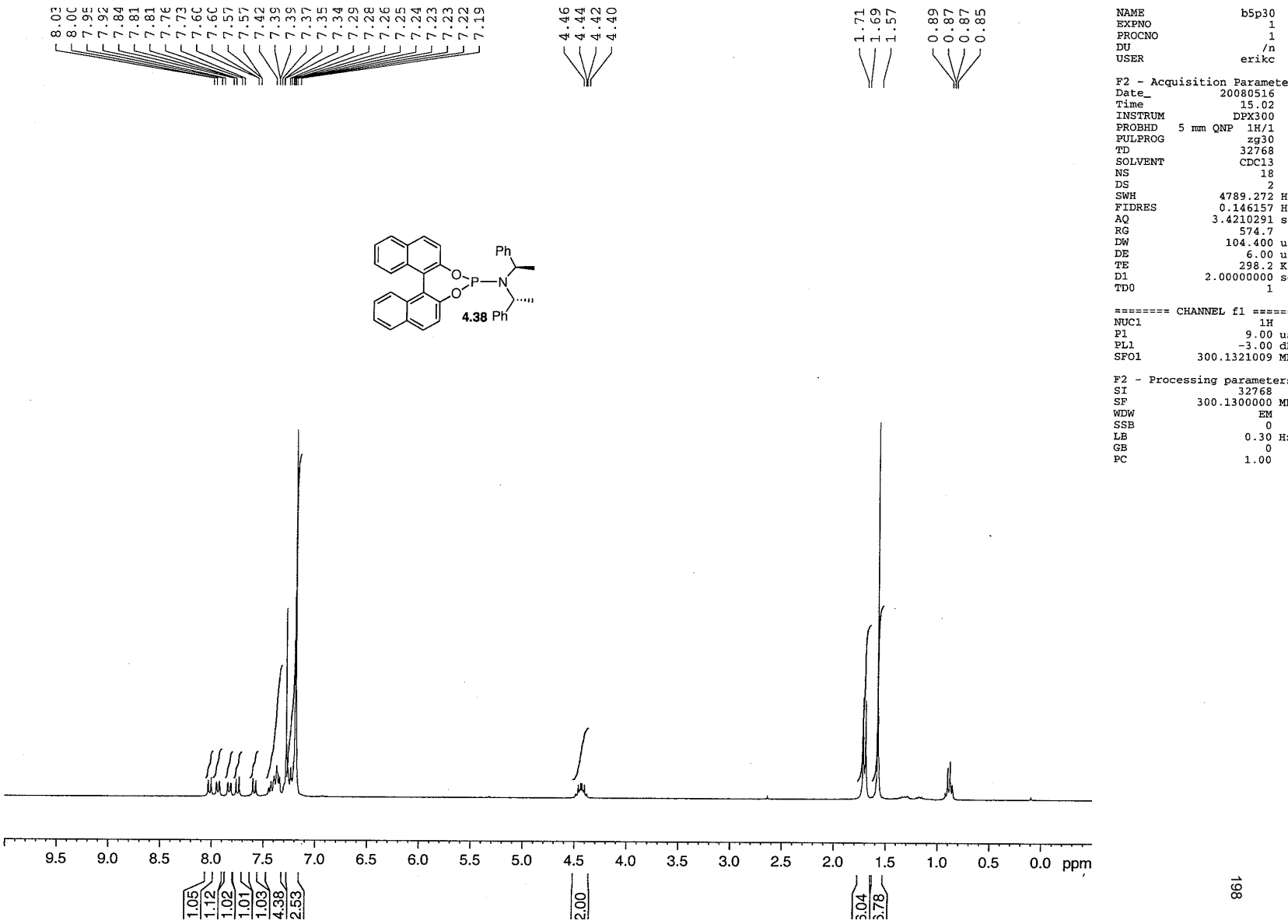
NUC1	1H
P1	14.70 usec
PL1	0.00 dB
SFO1	399.9528000 MHz

F2 - Processing parameters

SI	32768
SF	399.9500000 MHz
WDW	EM
SSB	0
LB	0.70 Hz
GB	0
PC	1.00




```
DU                          /m
USER                     erikc

F2 - Acquisition Parameters
Date_                 20090908
Time                     15.44
INSTRUM                DPX400
PROBHD    5 mm BBO BB-1H
PULPROG                zgpg30
TD                      65536
SOLVENT                 CDC13
NS                        319
DS                          4
SWH                 23980.814 Hz
FIDRES                0.365918 Hz
AQ                   1.3664756 sec
RG                      9195.2
DW                     20.850 usec
DE                      6.00 usec
TE                      300.2 K
D1                 2.00000000 sec
d11                0.03000000 sec
DELTA              1.89999998 sec
TD0                         1

======== CHANNEL f1 ========
NUC1                       13C
P1                      8.30 usec
PL1                    -3.00 dB
SFO1              100.6504921 MHz

======== CHANNEL f2 ========
CPDPRG2                waltz16
NUC2                       1H
PCPD2                  90.00 usec
PL2                    -3.00 dB
PL12                   15.00 dB
PL13                   15.00 dB
SFO2              400.2416010 MHz

F2 - Processing parameters
SI                        32768
SF                100.6404280 MHz
WDW                          EM
SSB                          0
LB                      1.00 Hz
GB                           0
PC                        1.40
```



NAME	b5p30
EXPNO	1
PROCNO	1
DU	/n
USER	erikc

F2 - Acquisition Parameters

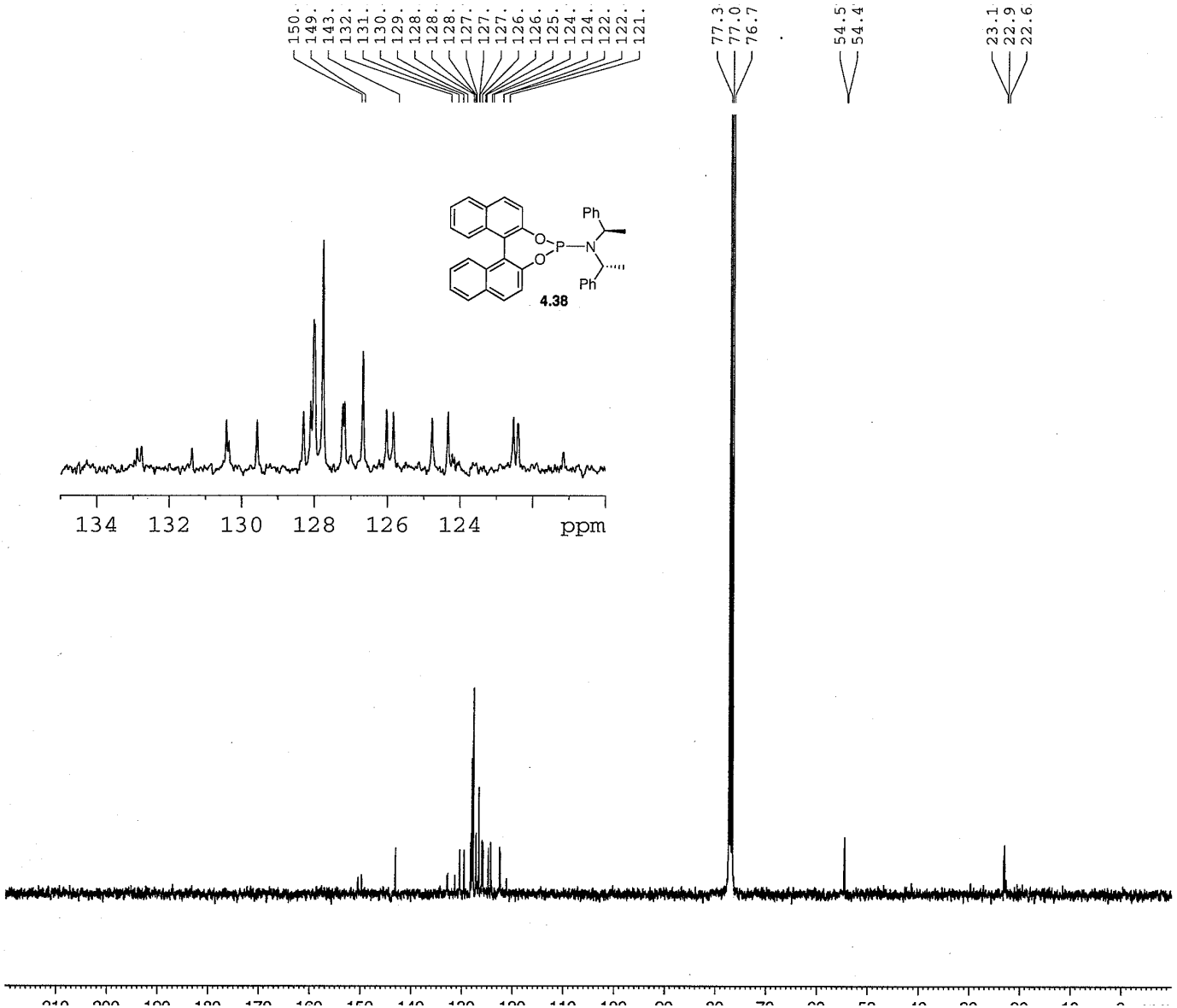
Date_	20080516
Time	15.02
INSTRUM	DPX300
PROBHD	5 mm QNP 1H/1
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	18
DS	2
SWH	4789.272 Hz
FIDRES	0.146157 Hz
AQ	3.4210291 sec
RG	574.7
DW	104.400 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

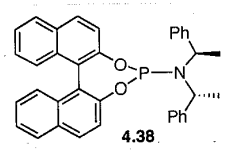
NUC1	1H
P1	9.00 usec
PL1	-3.00 dB
SFO1	300.1321009 MHz

F2 - Processing parameters

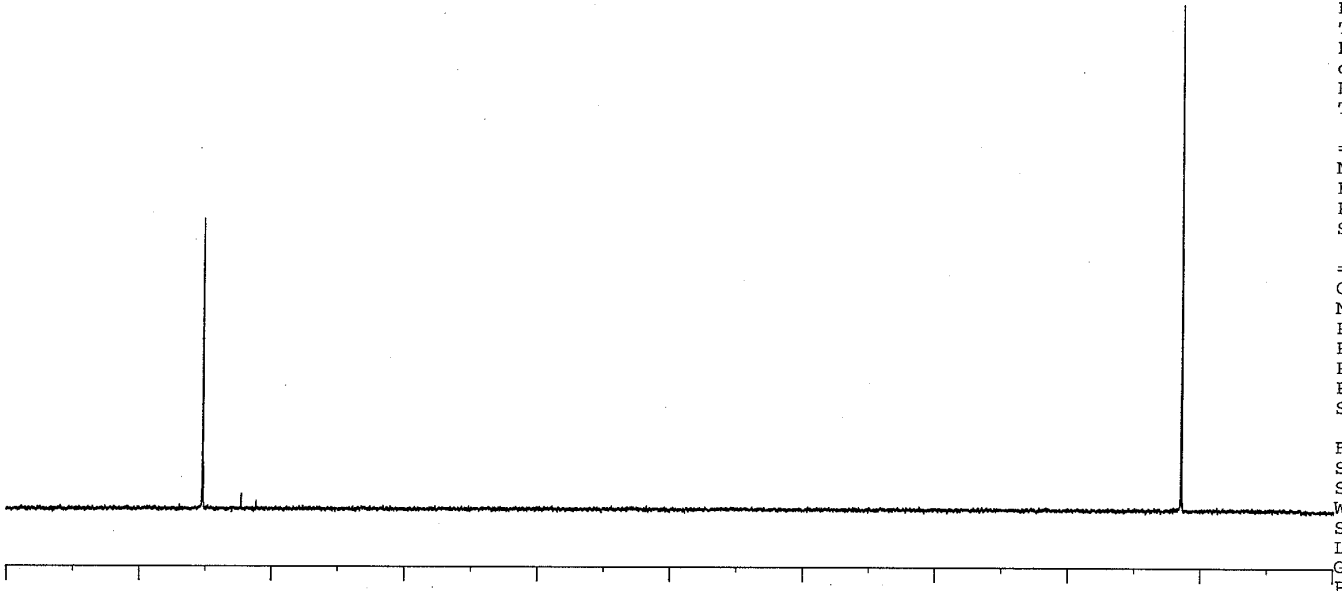
SI	32768
SF	300.1300000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00




```
DU                      /m
USER                 erikc

F2 - Acquisition Parameters
Date_              20080508
Time                  17.46
INSTRUM              DPX400
PROBHD    5 mm BBO BB-1H
PULPROG             zgpg30
TD                   65536
SOLVENT              CDCl3
NS                    2450
DS                       4
SWH             25125.629 Hz
FIDRES          0.383387 Hz
AQ              1.3042164 sec
RG                   16384
DW                19.900 usec
DE                 6.00 usec
TE                298.2 K
D1             0.15000001 sec
D11            0.03000000 sec
DELTA          0.05000000 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                   13C
P1                  7.80 usec
PL1                -3.00 dB
SFO1          100.5785700 MHz

======== CHANNEL f2 ========
CPDPRG2            waltz16
NUC2                    1H
PCPD2             135.00 usec
PL2                17.40 dB
PL12               17.40 dB
PL13               17.40 dB
SFO2          399.9516000 MHz

F2 - Processing parameters
SI                   32768
SF            100.5675080 MHz
WDW                     EM
SSB                      0
LB                  3.00 Hz
GB                       0
PC                    1.40
```



4.38



BRUKER

Current Data Parameters

NAME	b5p25
EXPNO	2
PROCNO	1
DU	/n
USER	erikc

F2 - Acquisition Parameters

Date_	20080508
Time	16.27
INSTRUM	DPX300
PROBHD	5 mm QNP 1H/1
PULPROG	zgpg30
TD	16384
SOLVENT	DMSO
NS	133
DS	2
SWH	24330.900 Hz
FIDRES	1.485040 Hz
AQ	0.3367412 sec
RG	20642.5
DW	20.550 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
d11	0.03000000 sec
DELTA	1.89999998 sec
TD0	1

======== CHANNEL f1 ========

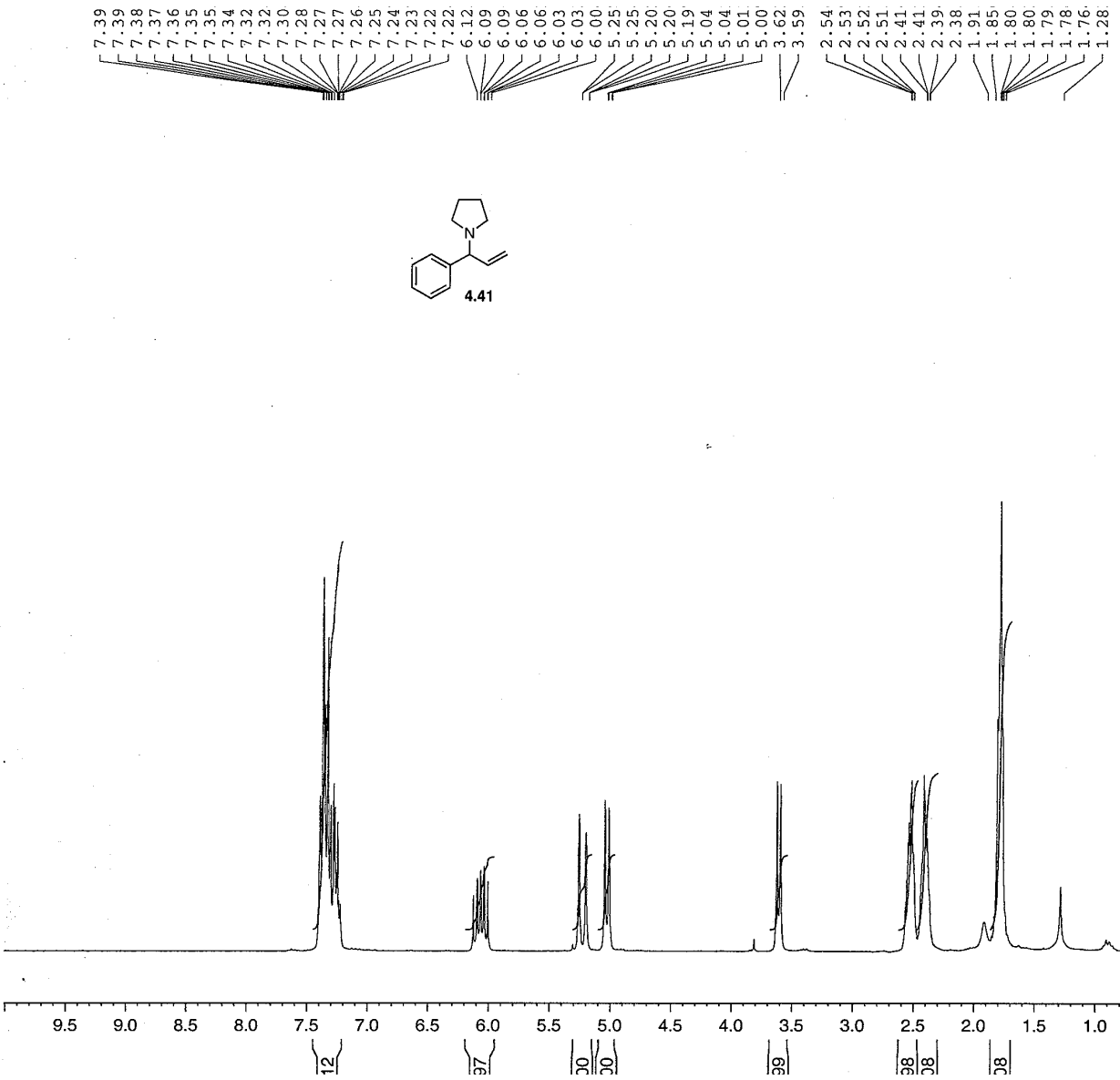
NUC1	31P
P1	7.65 usec
PL1	-3.00 dB
SFO1	121.5045706 MHz

======== CHANNEL f2 ========

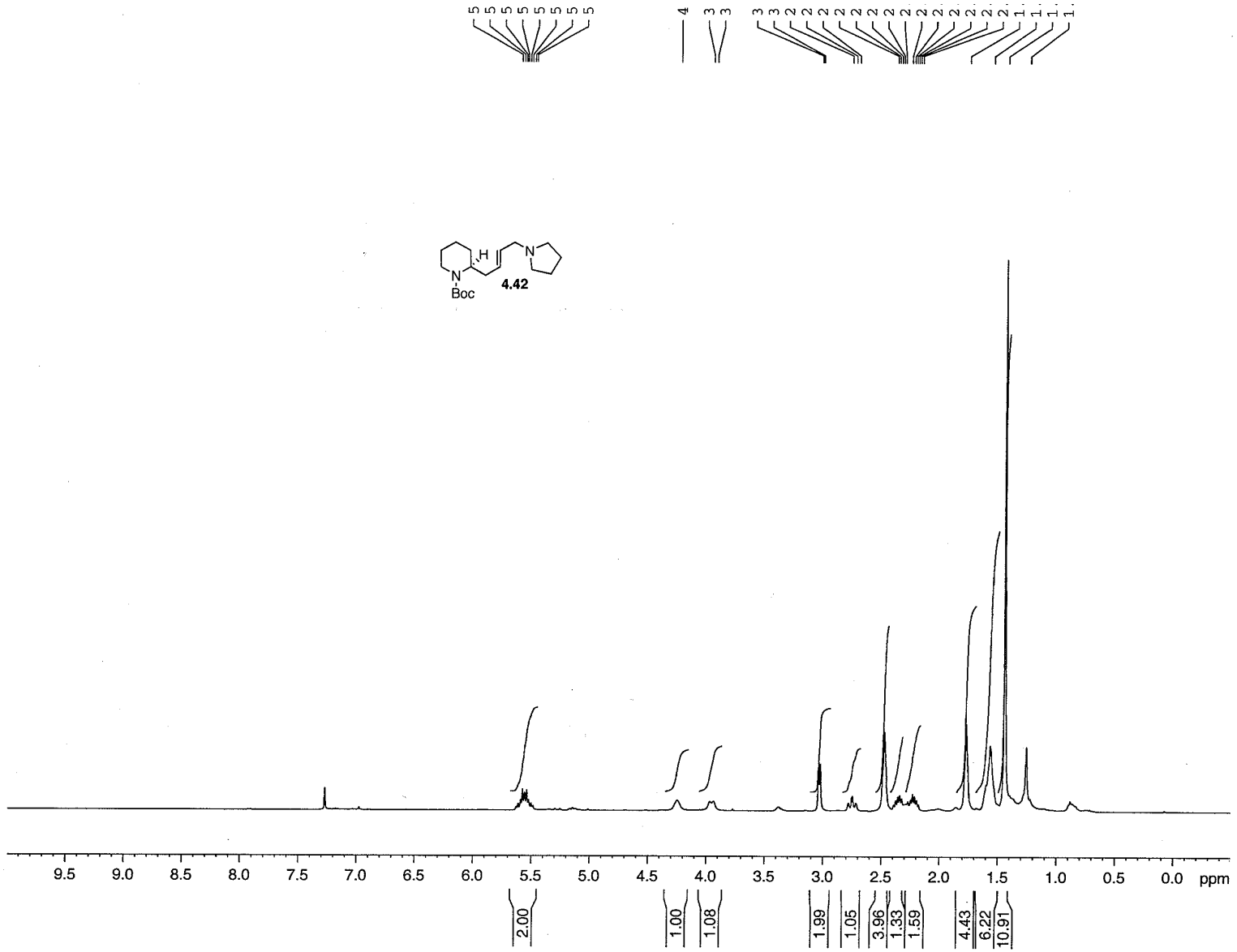
CPDPRG2	waltz16
NUC2	1H
PCPD2	80.00 usec
PL2	-3.00 dB
PL12	17.55 dB
PL13	17.55 dB
SFO2	300.1312005 MHz

F2 - Processing parameters

SI	32768
SF	121.4948510 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40




```
NAME                 b5p45
EXPNO                    3
PROCNO                   1
DU                      /n
USER                 erikc

F2 - Acquisition Parameters
Date_             20080603
Time                 17.06
INSTRUM             DPX300
PROBHD   5 mm QNP  1H/1
PULPROG              zg30
TD                  32768
SOLVENT             CDCl3
NS                      17
DS                       2
SWH              4789.272 Hz
FIDRES           0.146157 Hz
AQ               3.4210291 sec
RG                   228.1
DW                 104.400 usec
DE                   6.00 usec
TE                  298.2 K
D1              2.00000000 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                    1H
P1                    9.00 usec
PL1                  -3.00 dB
SFO1          300.1321009 MHz

F2 - Processing parameters
SI                   32768
SF            300.1300000 MHz
WDW                     EM
SSB                      0
LB                    0.30 Hz
GB                       0
PC                    1.00
```

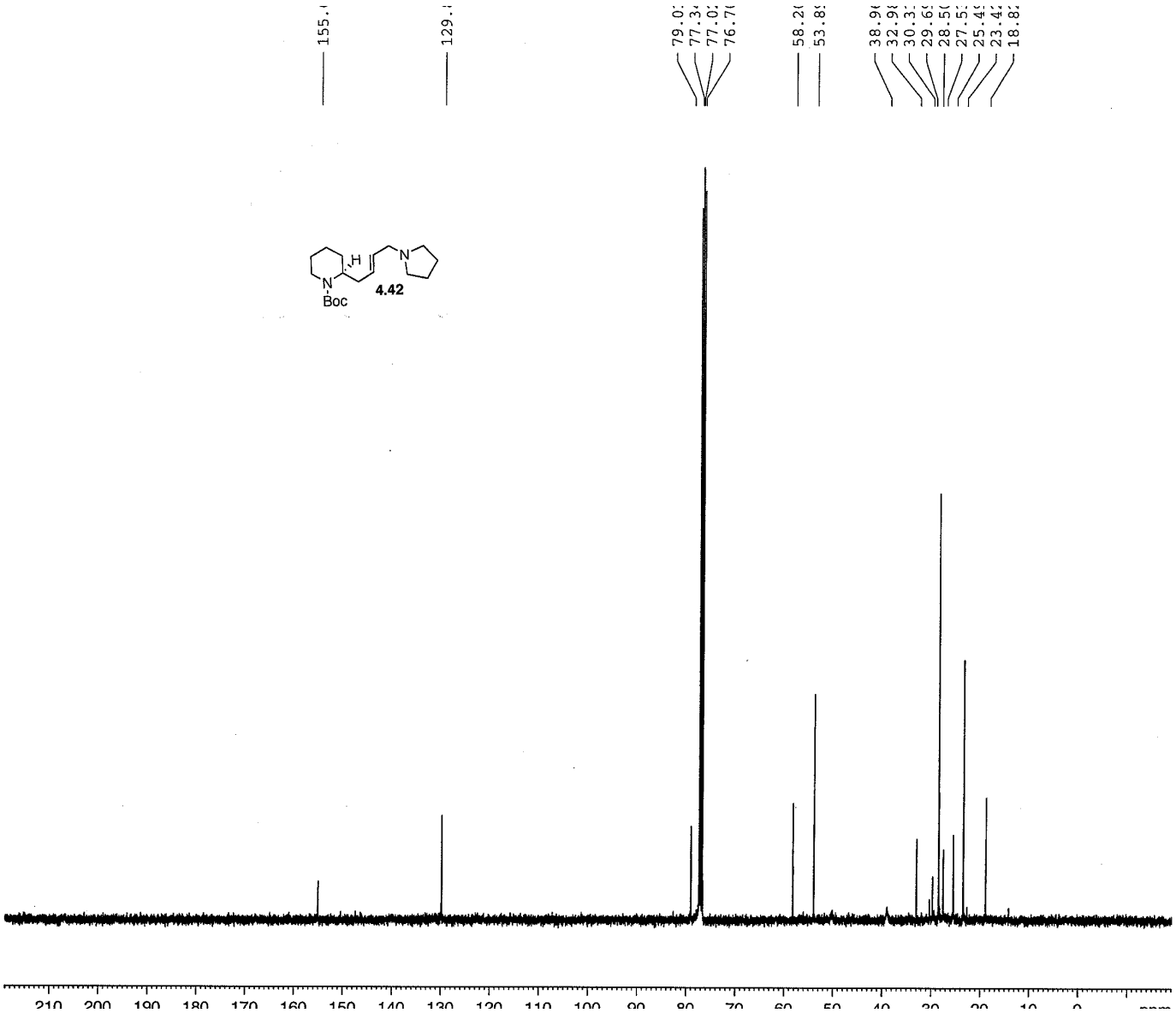


PROCNO
DU
USER

F2 - Acquisition
Date_ 2
Time
INSTRUM
PROBHD 5 mm BB
PULPROG
TD
SOLVENT
NS
DS
SWH 6
FIDRES 0
AQ 2.
RG
DW
DE
TE
D1 1.0
TD0

======== CHANNEL
NUC1
P1
PL1
SFO1 400.

F2 - Processing
SI
SF 400.
WDW
SSB
LB
GB
PC



DU	/m
USER	erikc

F2 - Acquisition Parameters

Date_	20090915
Time	13.20
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zgpg30
TD	65536
SOLVENT	CDCl3
NS	594
DS	4
SWH	23980.814 Hz
FIDRES	0.365918 Hz
AQ	1.3664756 sec
RG	9195.2
DW	20.850 usec
DE	6.00 usec
TE	300.2 K
D1	2.00000000 sec
d11	0.03000000 sec
DELTA	1.89999998 sec
TD0	1

======== CHANNEL f1 ========

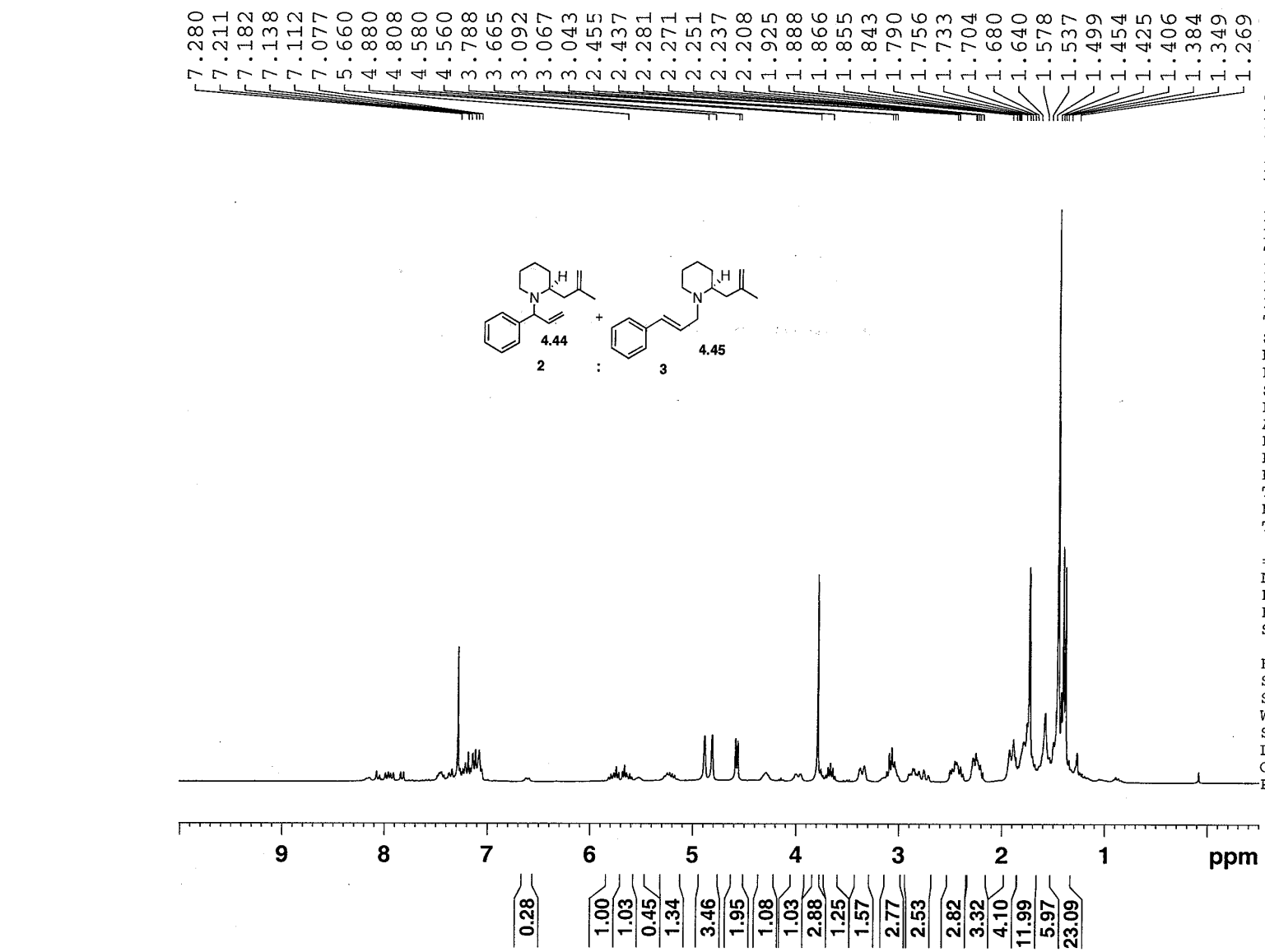
NUC1	13C
P1	8.30 usec
PL1	-3.00 dB
SFO1	100.6504921 MHz

======== CHANNEL f2 ========

CPDPRG2	waltz16
NUC2	1H
PCPD2	90.00 usec
PL2	-3.00 dB
PL12	15.00 dB
PL13	15.00 dB
SFO2	400.2416010 MHz

F2 - Processing parameters

SI	32768
SF	100.6404280 MHz
WDW	EM
SSB	0
LB	1.00 Hz
GB	0
PC	1.40



BRUKER

Current Data Parameters

NAME	b6p50
EXPNO	5
PROCNO	1
DU	/n
USER	erikc

F2 - Acquisition Parameters

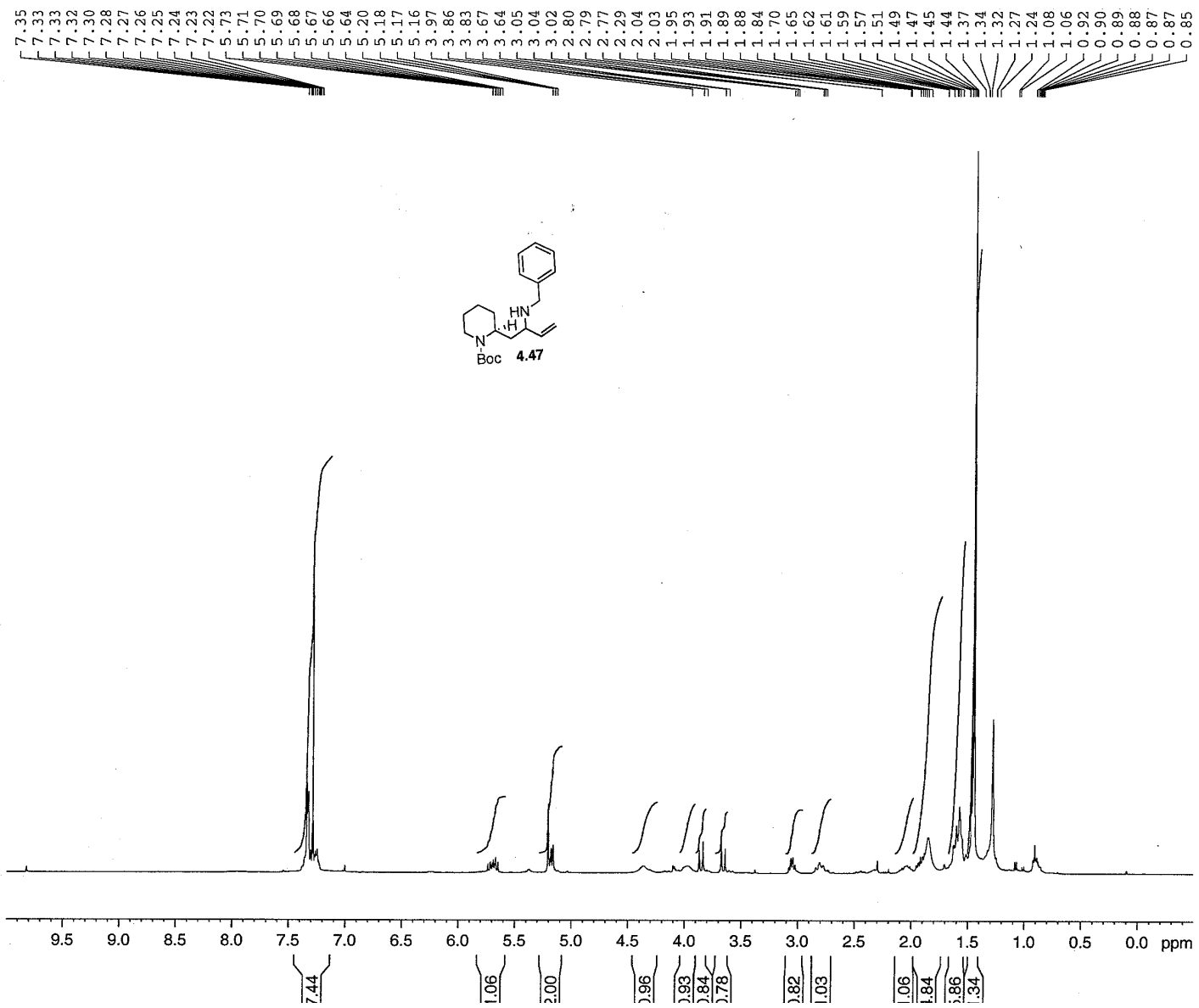
Date_	20081015
Time	9.26
INSTRUM	DPX300
PROBHD	5 mm QNP 1H/1
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	32
DS	2
SWH	4789.272 Hz
FIDRES	0.146157 Hz
AQ	3.4210291 sec
RG	181
DW	104.400 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

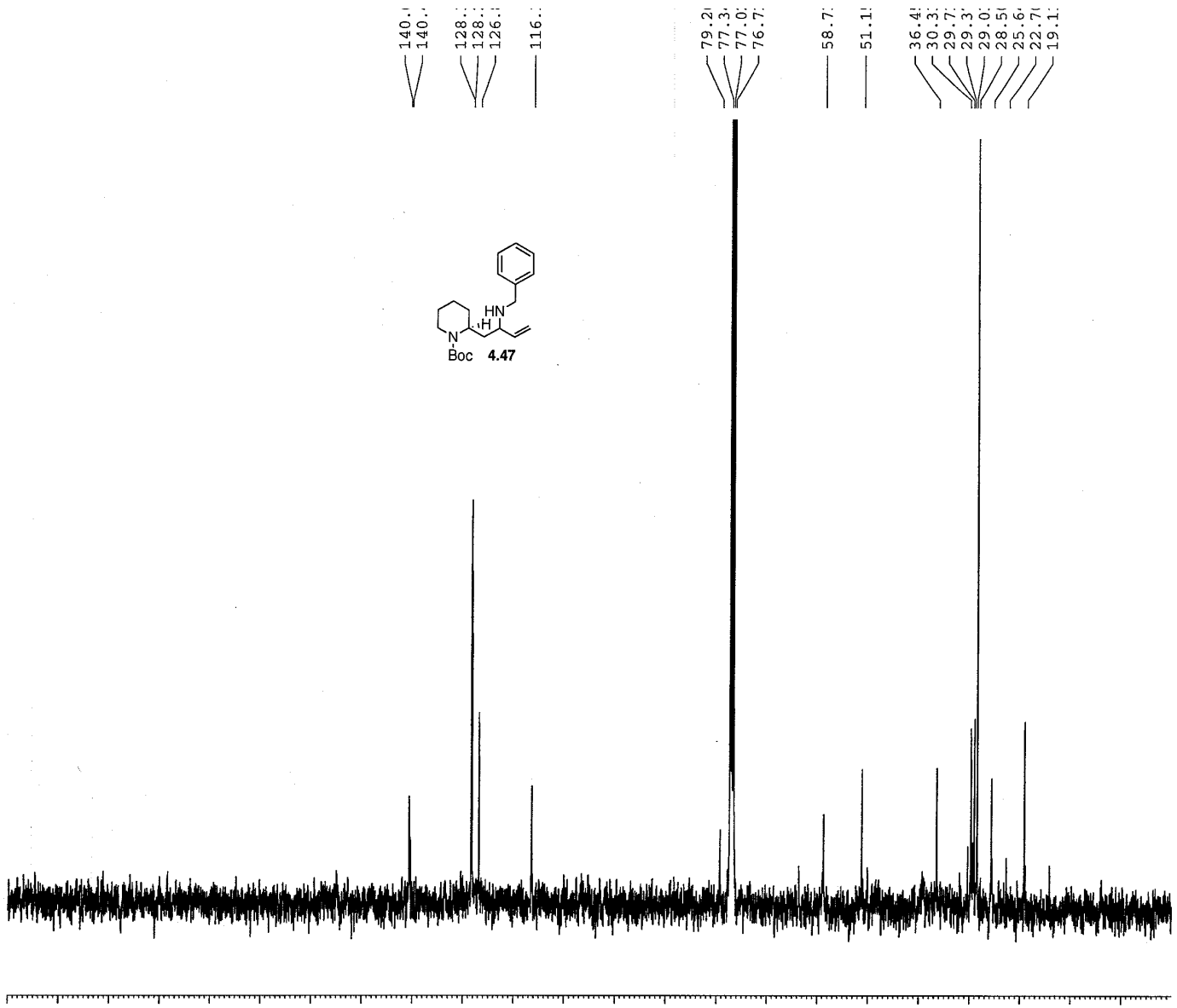
NUC1	1H
P1	9.00 usec
PL1	-3.00 dB
SFO1	300.1321009 MHz

F2 - Processing parameters

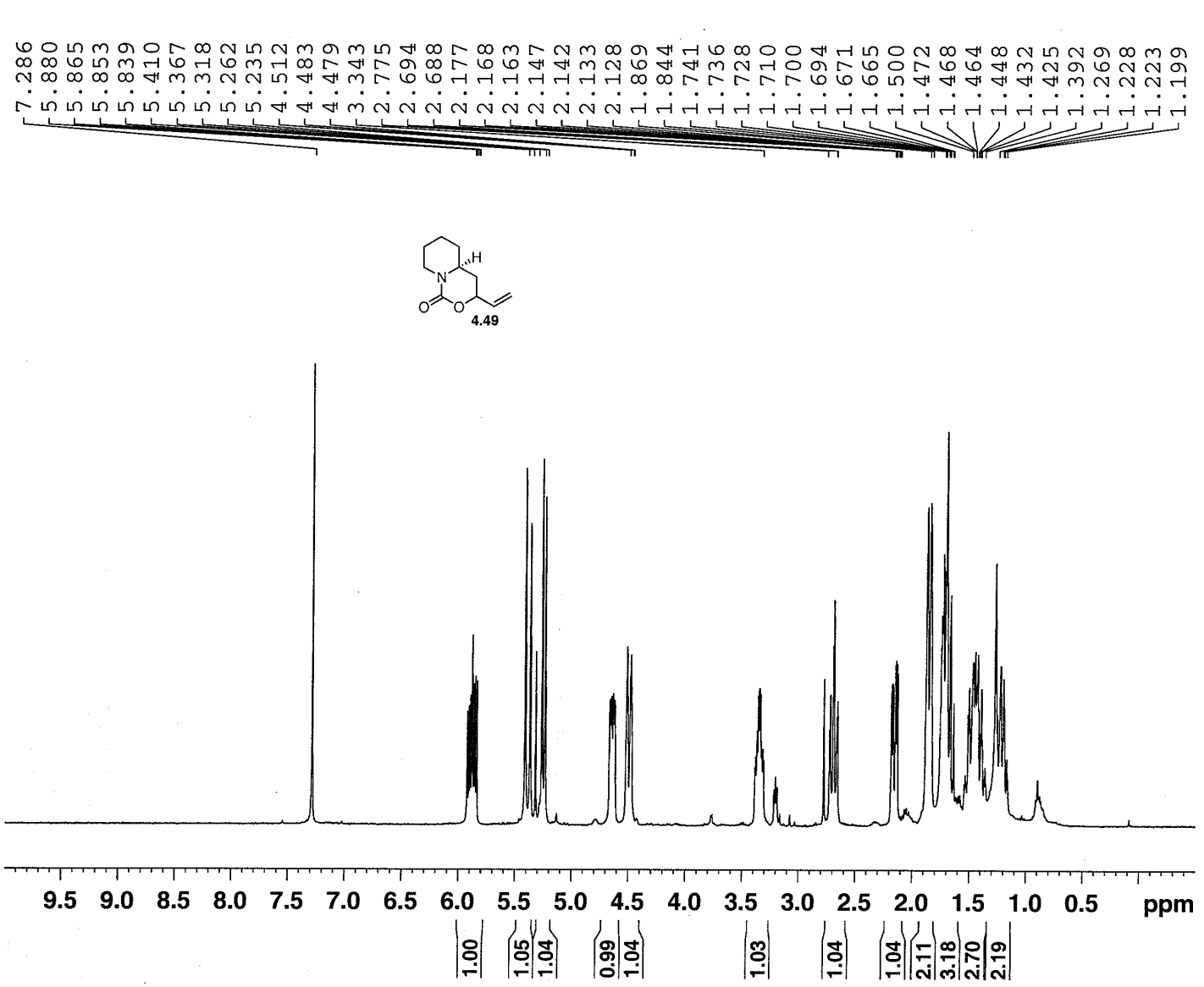
SI	32768
SF	300.1300000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00



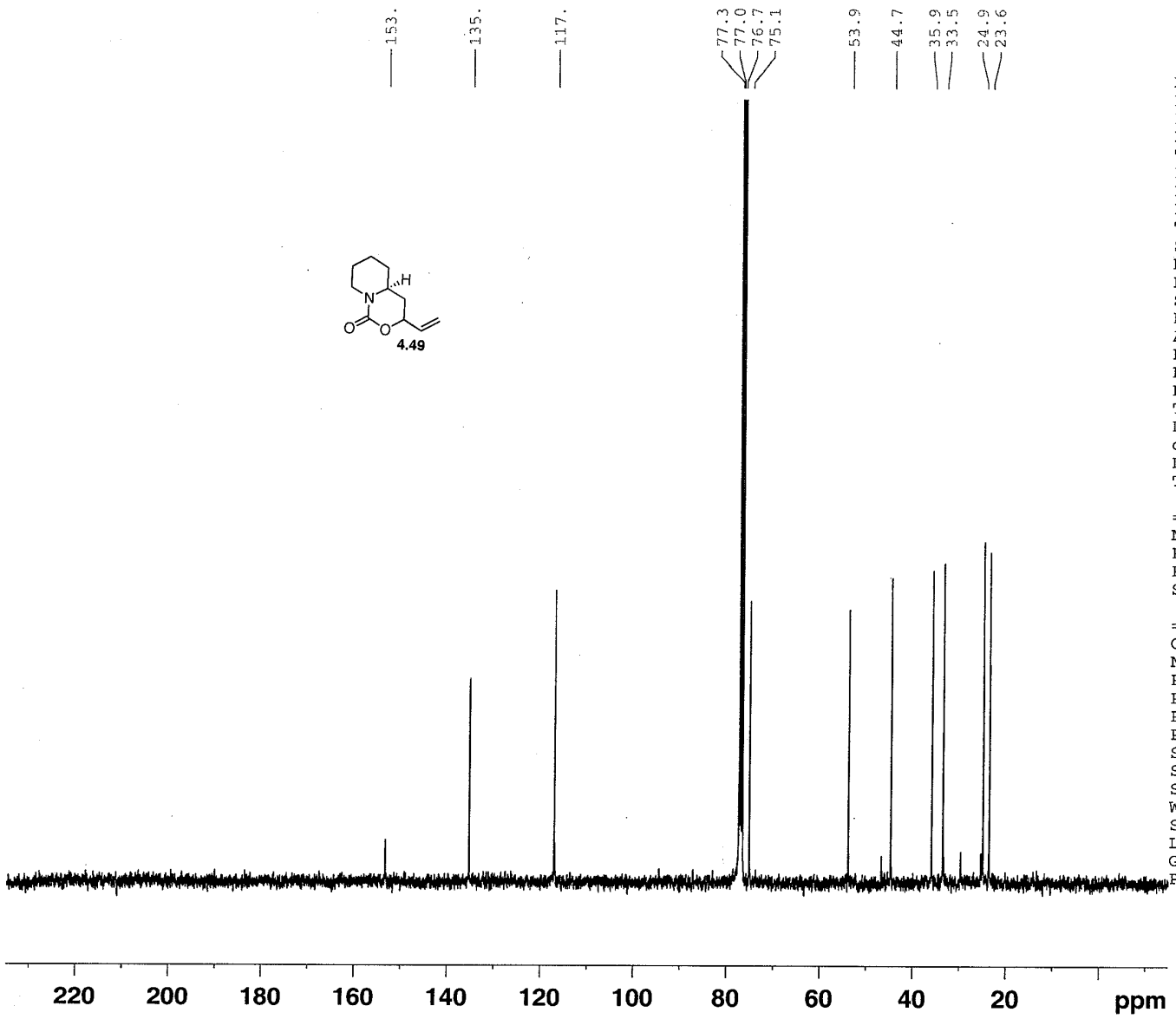

```
NAME                 b6p53
EXPNO                    1
PROCNO                   1
DU                      /m
USER                 erikc

F2 - Acquisition Parameters
Date_             20081020
Time                 14.13
INSTRUM             DPX400
PROBHD   5 mm BBO BB-1H
PULPROG               zg30
TD                   32768
SOLVENT              CDCl3
NS                      32
DS                       2
SWH              6410.256 Hz
FIDRES           0.195625 Hz
AQ               2.5559540 sec
RG                     512
DW                78.000 usec
DE                 6.00 usec
TE                298.2 K
D1           2.00000000 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                   1H
P1                 14.70 usec
PL1                 0.00 dB
SFO1         399.9528000 MHz

F2 - Processing parameters
SI                   32768
SF           399.9500000 MHz
WDW                    EM
SSB                     0
LB                 0.70 Hz
GB                      0
PC                   1.00
```




```
DU                              /m
USER                         erikc

F2 - Acquisition Parameters
Date_                     20081020
Time                         14.37
INSTRUM                     DPX400
PROBHD    5 mm BBO BB-1H
PULPROG                     zgpg30
TD                           65536
SOLVENT
NS                            2450
DS                               4
SWH                    25125.629 Hz
FIDRES                  0.383387 Hz
AQ                      1.3042164 sec
RG                           16384
DW                        19.900 usec
DE                         6.00 usec
TE                         298.2 K
D1                     0.15000001 sec
d11                    0.03000000 sec
DELTA                  0.05000000 sec
TD0                             1

======== CHANNEL f1 ========
NUC1                          13C
P1                         7.80 usec
PL1                          -3.00 dB
SFO1                100.5785700 MHz

======== CHANNEL f2 ========
CPDPRG2                   waltz16
NUC2                          1H
PCPD2                     135.00 usec
PL2                          17.40 dB
PL12                         17.40 dB
PL13                         17.40 dB
SFO2                399.9516000 MHz

F2 - Processing parameters
SI                            32768
SF                  100.5675080 MHz
WDW                              EM
SSB                              0
LB                            3.00 Hz
GB                               0
PC                            1.40
```

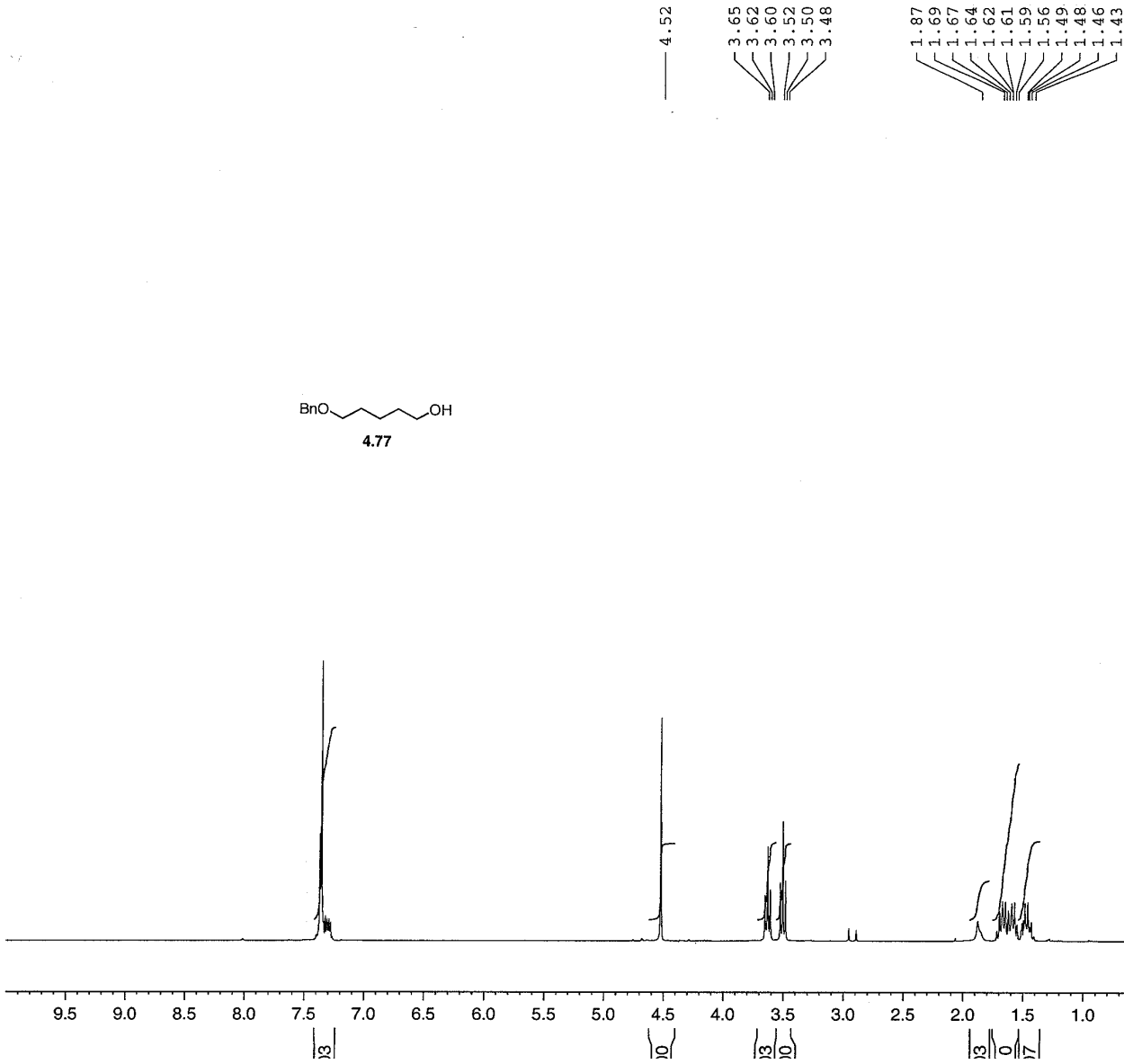


Date_	20081
Time	13
INSTRUM	DPX
PROBHD	5 mm BBO BB-
PULPROG	zg
TD	32
SOLVENT	CD
NS	
DS	
SWH	6410.2
FIDRES	0.1956
AQ	2.55595
RG	406
DW	78.0
DE	6.
TE	297
D1	2.00000
TD0	
======== CHANNEL f1 =	
NUC1	
P1	14.
PL1	0.
SFO1	399.95280
SI	327
SF	399.95000
WDW	
SSB	
LB	0.
GB	
PC	1.

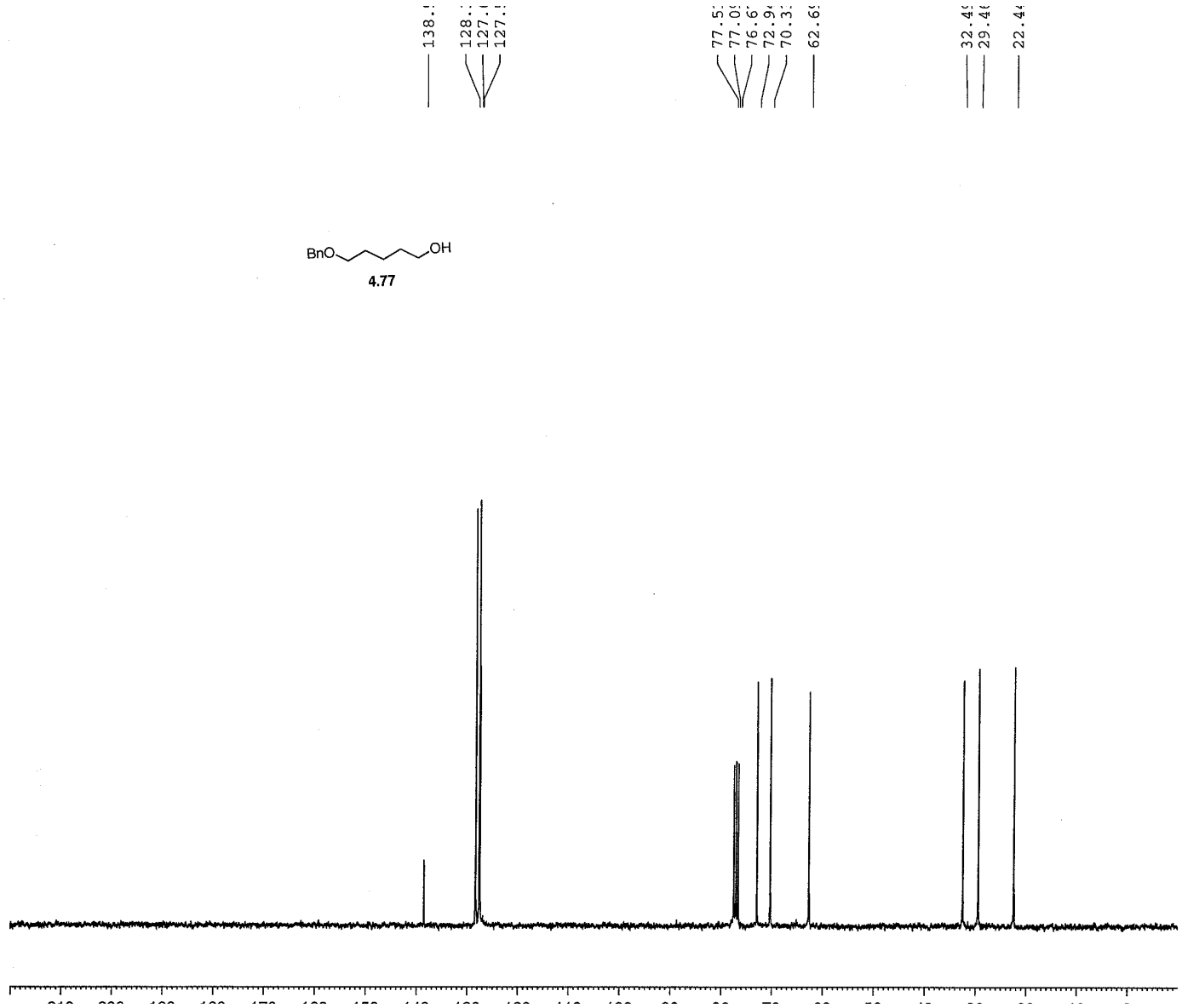


BRUKER

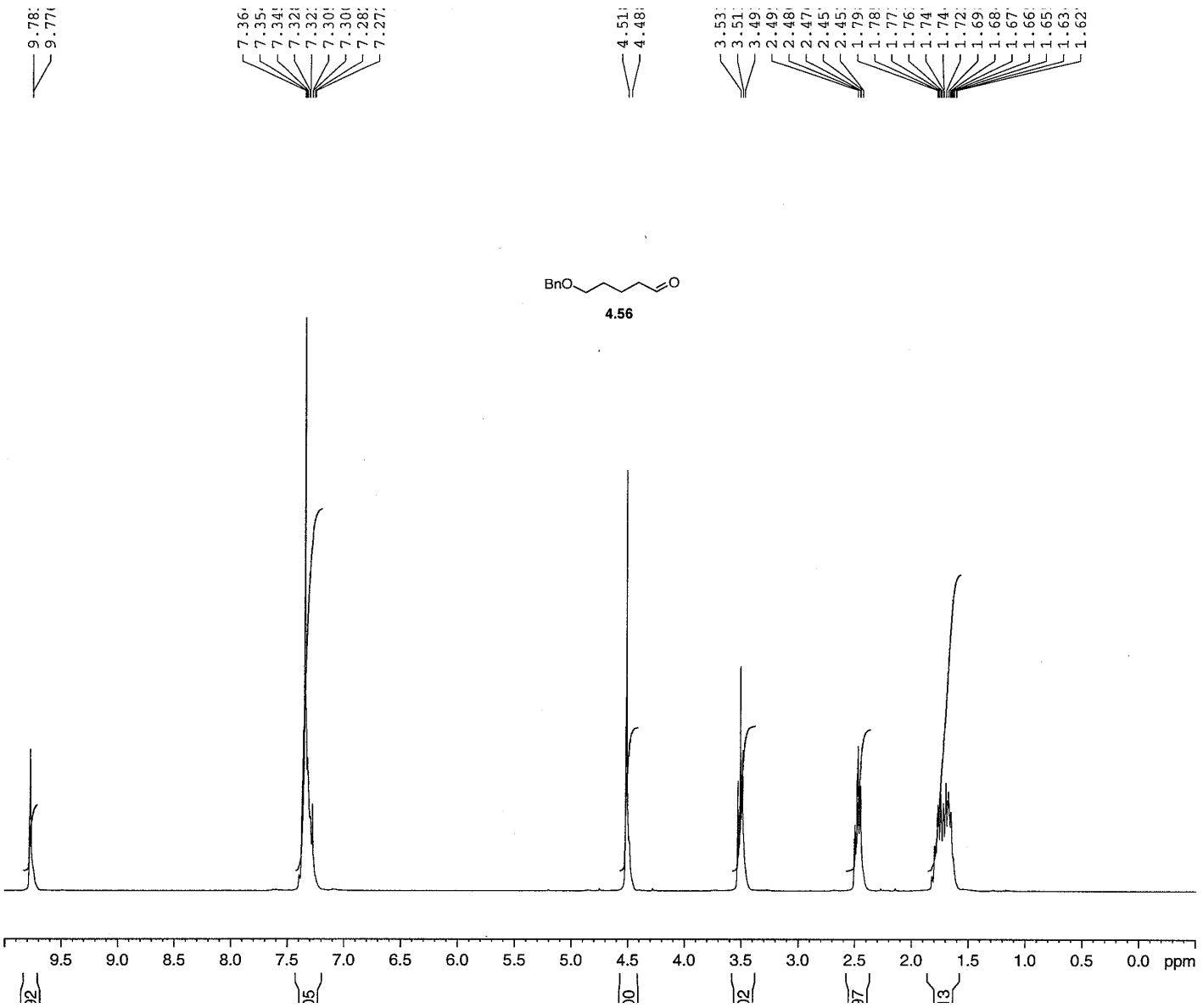
NAME	b6p58
EXPNO	2
PROCNO	1
Date_	20081229
Time	13.53
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zgpg30
TD	65536
SOLVENT	
NS	1833
DS	4
SWH	25125.629 Hz
FIDRES	0.383387 Hz
AQ	1.3042164 sec
RG	4597.6
DW	19.900 usec
DE	6.00 usec
TE	297.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1
======== CHANNEL f1 ========	
NUC1	13C
P1	7.80 usec
PL1	-3.00 dB
SFO1	100.5785700 MHz
======== CHANNEL f2 ========	
CPDPRG2	waltz16
NUC2	1H
PCPD2	135.00 usec
PL2	17.40 dB
PL12	17.40 dB
PL13	17.40 dB
SFO2	399.9516000 MHz
SI	32768
SF	100.5675080 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40




```
NAME                 b6p69
EXPNO                    1
PROCNO                   1
DU                      /n
USER                 erikc

F2 - Acquisition Parameters
Date_             20090223
Time                 13.13
INSTRUM             DPX300
PROBHD   5 mm QNP  1H/1
PULPROG              zg30
TD                  32768
SOLVENT              CDCl3
NS                       9
DS                       2
SWH              4789.272 Hz
FIDRES           0.146157 Hz
AQ               3.4210291 sec
RG                    80.6
DW                104.400 usec
DE                  6.00 usec
TE                 298.2 K
D1              2.00000000 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                    1H
P1                   9.00 usec
PL1                 -3.00 dB
SFO1           300.1321009 MHz

F2 - Processing parameters
SI                   32768
SF             300.1300000 MHz
WDW                     EM
SSB                      0
LB                    0.30 Hz
GB                       0
PC                    1.00
```




```
DU                                /n
USER                           erikc

F2 - Acquisition Parameters
Date_                       20090223
Time                           13.16
INSTRUM                       DPX300
PROBHD    5 mm QNP  1H/1
PULPROG                      zgpg30
TD                            65536
SOLVENT                       CDCl3
NS                              448
DS                                4
SWH                       18832.393 Hz
FIDRES                     0.287360 Hz
AQ                         1.7400308 sec
RG                            2298.8
DW                            26.550 usec
DE                             6.00 usec
TE                            298.2 K
D1                        0.15000001 sec
d11                       0.03000000 sec
DELTA                     0.05000000 sec
TD0                               1

======== CHANNEL f1 ========
NUC1                            13C
P1                             8.80 usec
PL1                           -3.00 dB
SFO1                   75.4760505 MHz

======== CHANNEL f2 ========
CPDPRG2                    waltz16
NUC2                            1H
PCPD2                         80.00 usec
PL2                           -3.00 dB
PL12                          17.55 dB
PL13                          17.55 dB
SFO2                  300.1312005 MHz

F2 - Processing parameters
SI                              32768
SF                     75.4677490 MHz
WDW                               EM
SSB                               0
LB                             3.00 Hz
GB                                0
PC                             1.40
```



NAME	b6p70
EXPNO	1
PROCNO	1
DU	/n
USER	erikc

F2 - Acquisition Parameters

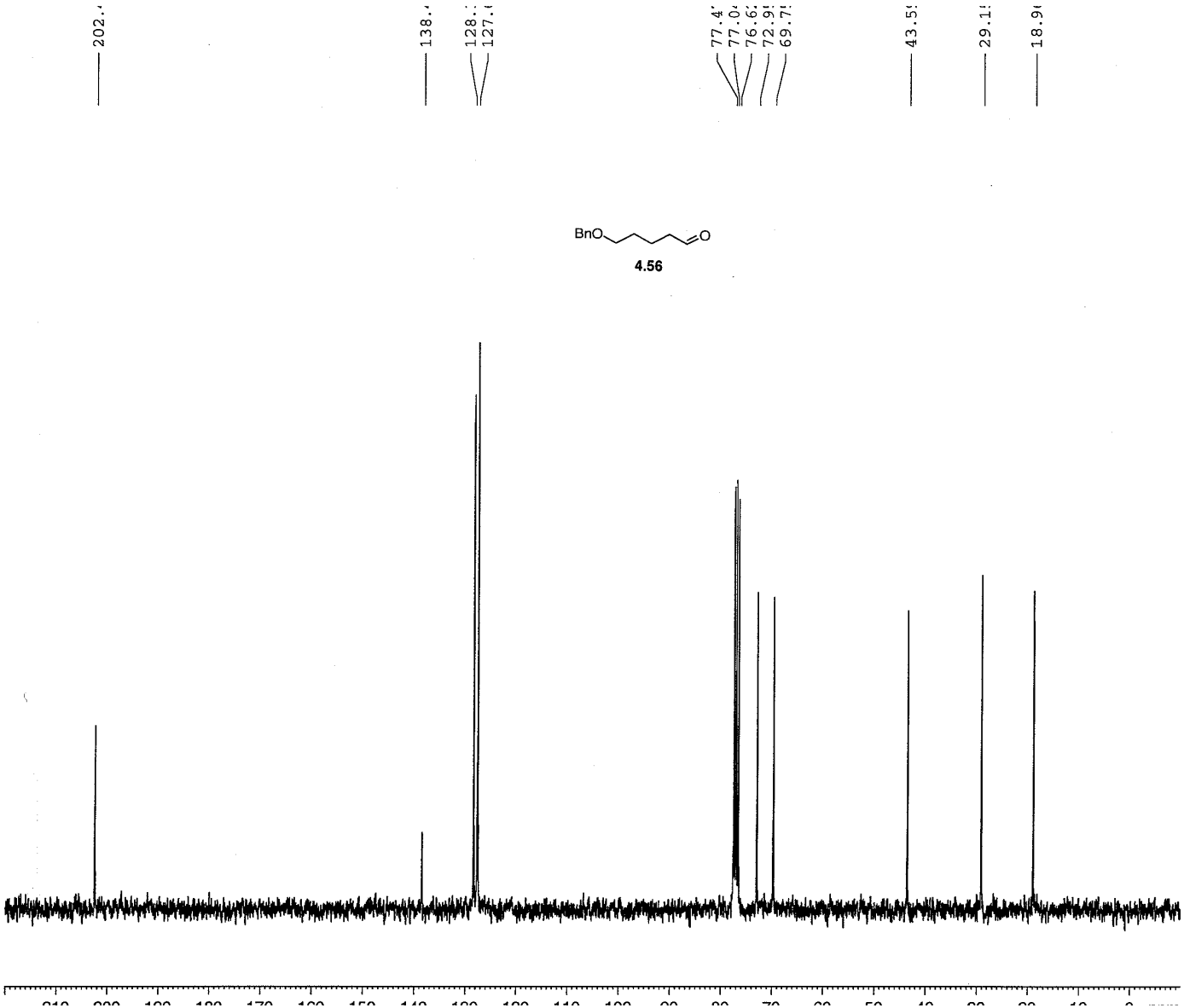
Date_	20090224
Time	12.43
INSTRUM	DPX300
PROBHD	5 mm QNP 1H/1
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	9
DS	2
SWH	4789.272 Hz
FIDRES	0.146157 Hz
AQ	3.4210291 sec
RG	228.1
DW	104.400 usec
DE	6.00 usec
TE	298.2 K
D1	2.00000000 sec
TD0	1

======== CHANNEL f1 ========

NUC1	1H
P1	9.00 usec
PL1	-3.00 dB
SFO1	300.1321009 MHz

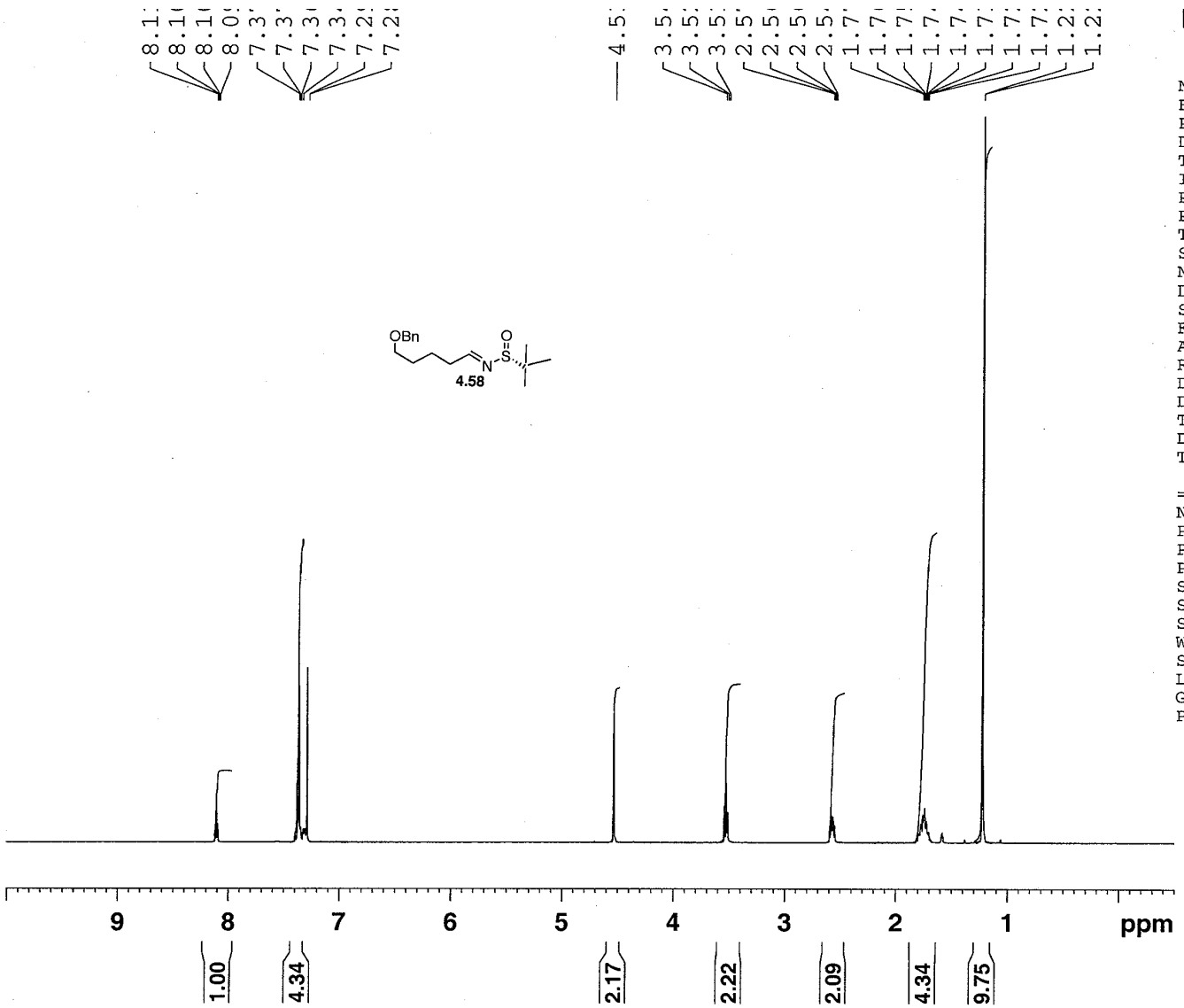
F2 - Processing parameters

SI	32768
SF	300.1300000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00



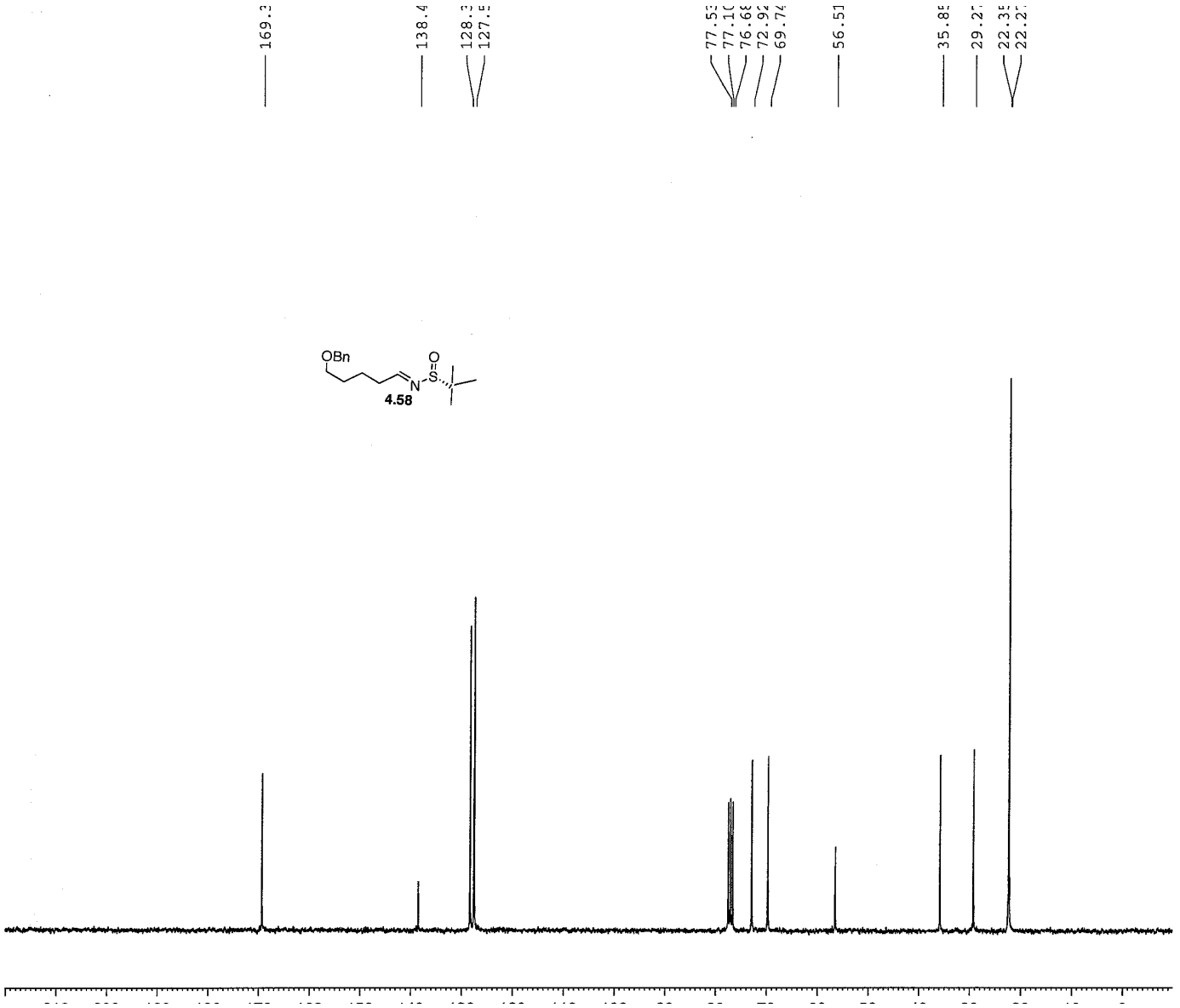
4.56

```
DU                              /n
USER                         erikc

F2 - Acquisition Parameters
Date_                     20090224
Time                         12.47
INSTRUM                     DPX300
PROBHD    5 mm QNP  1H/1
PULPROG                    zgpg30
TD                          65536
SOLVENT                     CDCl3
NS                            332
DS                              4
SWH                   18832.393 Hz
FIDRES                 0.287360 Hz
AQ                     1.7400308 sec
RG                         2298.8
DW                         26.550 usec
DE                          6.00 usec
TE                         298.2 K
D1                     0.15000001 sec
d11                    0.03000000 sec
DELTA                  0.05000000 sec
TD0                             1

======== CHANNEL f1 ========
NUC1                          13C
P1                           8.80 usec
PL1                         -3.00 dB
SFO1                 75.4760505 MHz

======== CHANNEL f2 ========
CPDPRG2                   waltz16
NUC2                           1H
PCPD2                       80.00 usec
PL2                         -3.00 dB
PL12                        17.55 dB
PL13                        17.55 dB
SFO2                300.1312005 MHz

F2 - Processing parameters
SI                            32768
SF                   75.4677490 MHz
WDW                            EM
SSB                             0
LB                           3.00 Hz
GB                              0
PC                           1.40
```



BRUKER

NAME	b7p57
EXPNO	1
PROCNO	1
Date_	20091001
Time	16.57
INSTRUM	spect
PROBHD	5 mm PABBO BB-
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	5
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	228.1
DW	78.000 usec
DE	6.50 usec
TE	300.1 K
D1	1.00000000 sec
TD0	1
======== CHANNEL f1 ========	
NUC1	1H
P1	14.00 usec
PL1	0.00 dB
PL1W	10.27361584 W
SFO1	400.1378009 MHz
SI	32768
SF	400.1350000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00



DU	/n
USER	erikc

F2 - Acquisition Parameters

Date_	20090227
Time	16.06
INSTRUM	DPX300
PROBHD	5 mm QNP 1H/1
PULPROG	zgpg30
TD	65536
SOLVENT	CDCl3
NS	439
DS	4
SWH	18832.393 Hz
FIDRES	0.287360 Hz
AQ	1.7400308 sec
RG	2580.3
DW	26.550 usec
DE	6.00 usec
TE	298.2 K
D1	0.15000001 sec
d11	0.03000000 sec
DELTA	0.05000000 sec
TD0	1

======== CHANNEL f1 ========

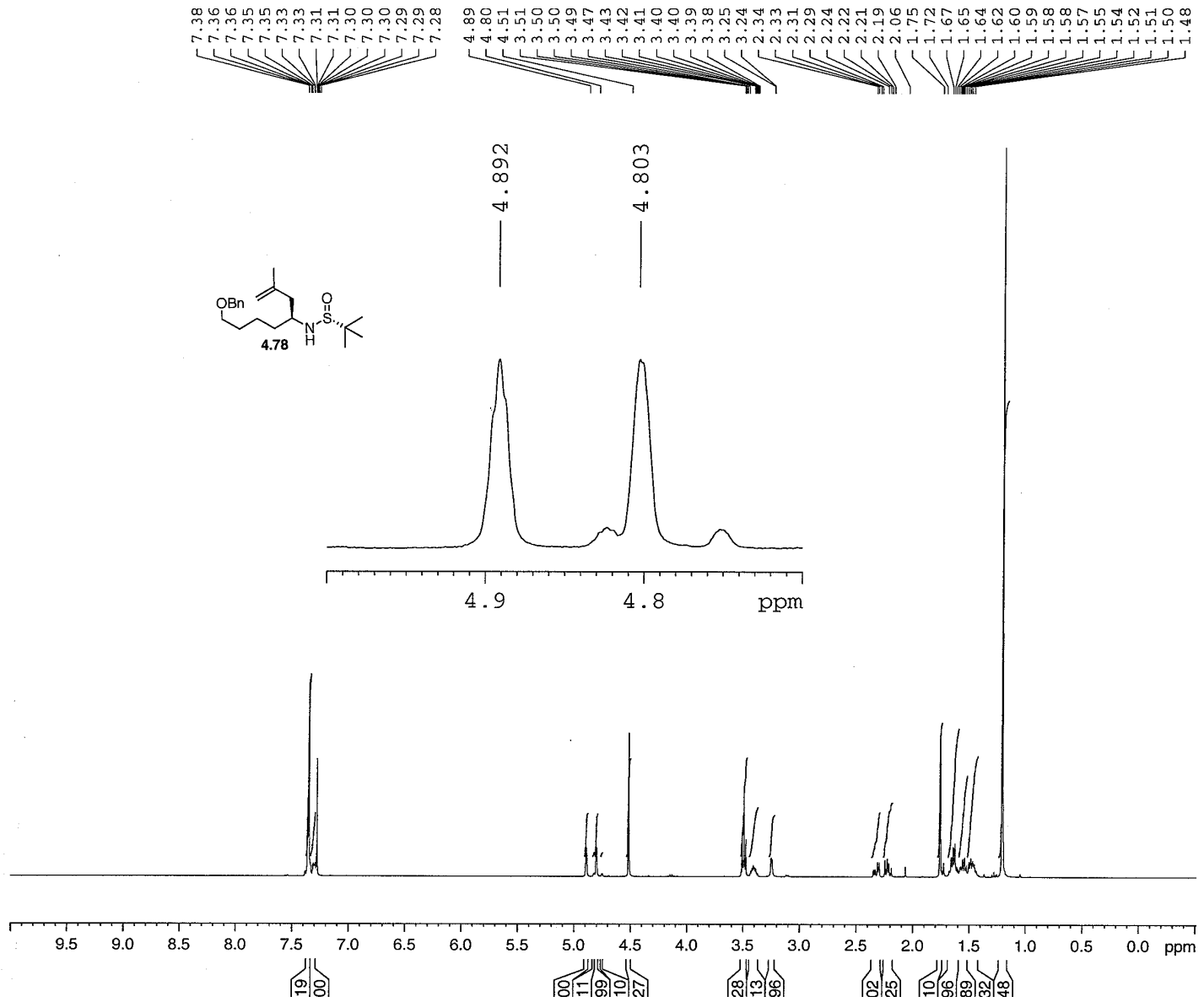
NUC1	13C
P1	8.80 usec
PL1	-3.00 dB
SFO1	75.4760505 MHz

======== CHANNEL f2 ========

CPDPRG2	waltz16
NUC2	1H
PCPD2	80.00 usec
PL2	-3.00 dB
PL12	17.55 dB
PL13	17.55 dB
SFO2	300.1312005 MHz

F2 - Processing parameters

SI	32768
SF	75.4677490 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40



NAME	b6p69
EXPNO	1
PROCNO	1
DU	/m
USER	erikc

F2 - Acquisition Parameters

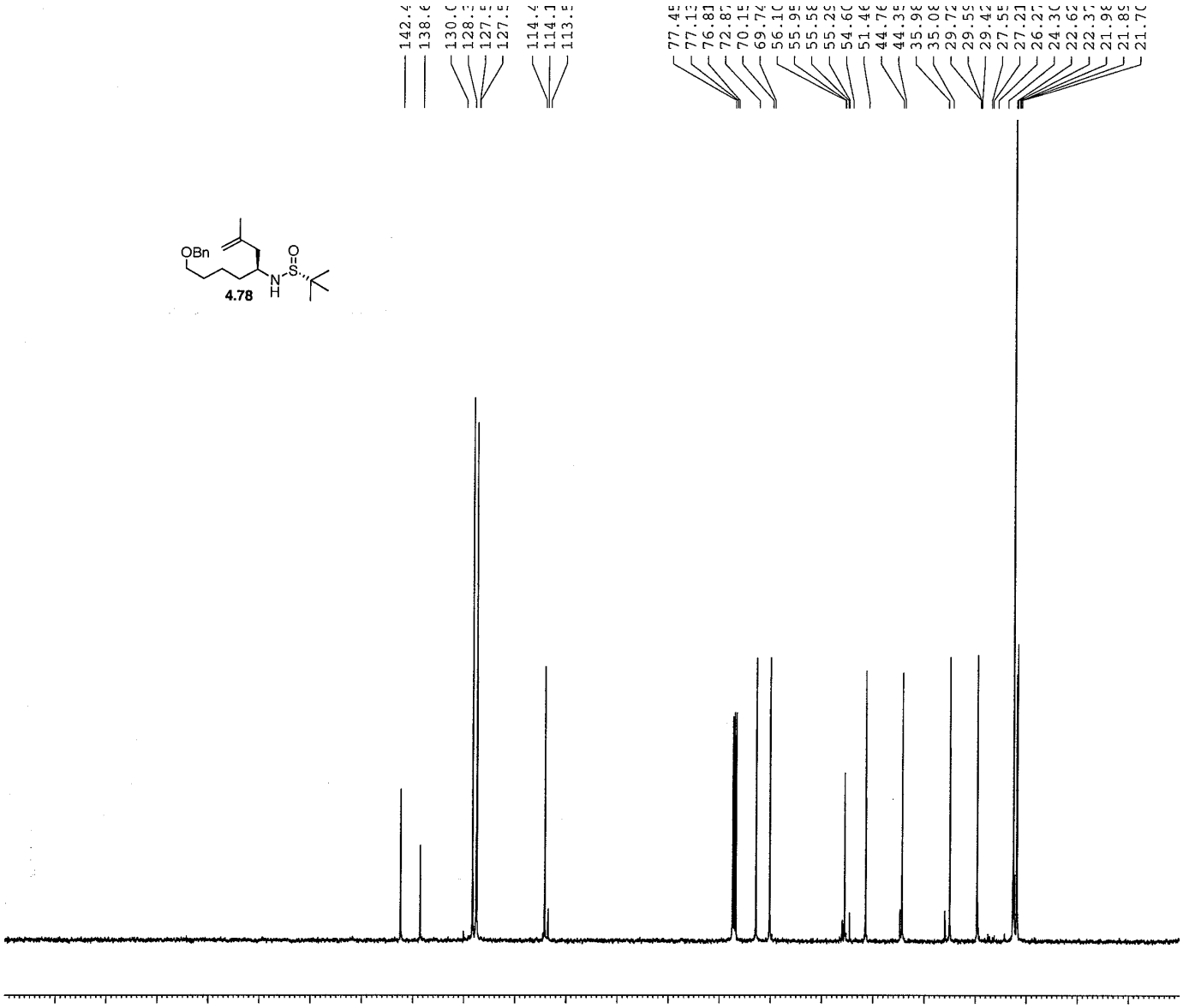
Date_	20091013
Time	17.37
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	32
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	456.1
DW	78.000 usec
DE	6.00 usec
TE	298.2 K
D1	1.00000000 sec
TD0	1

======== CHANNEL f1 ========

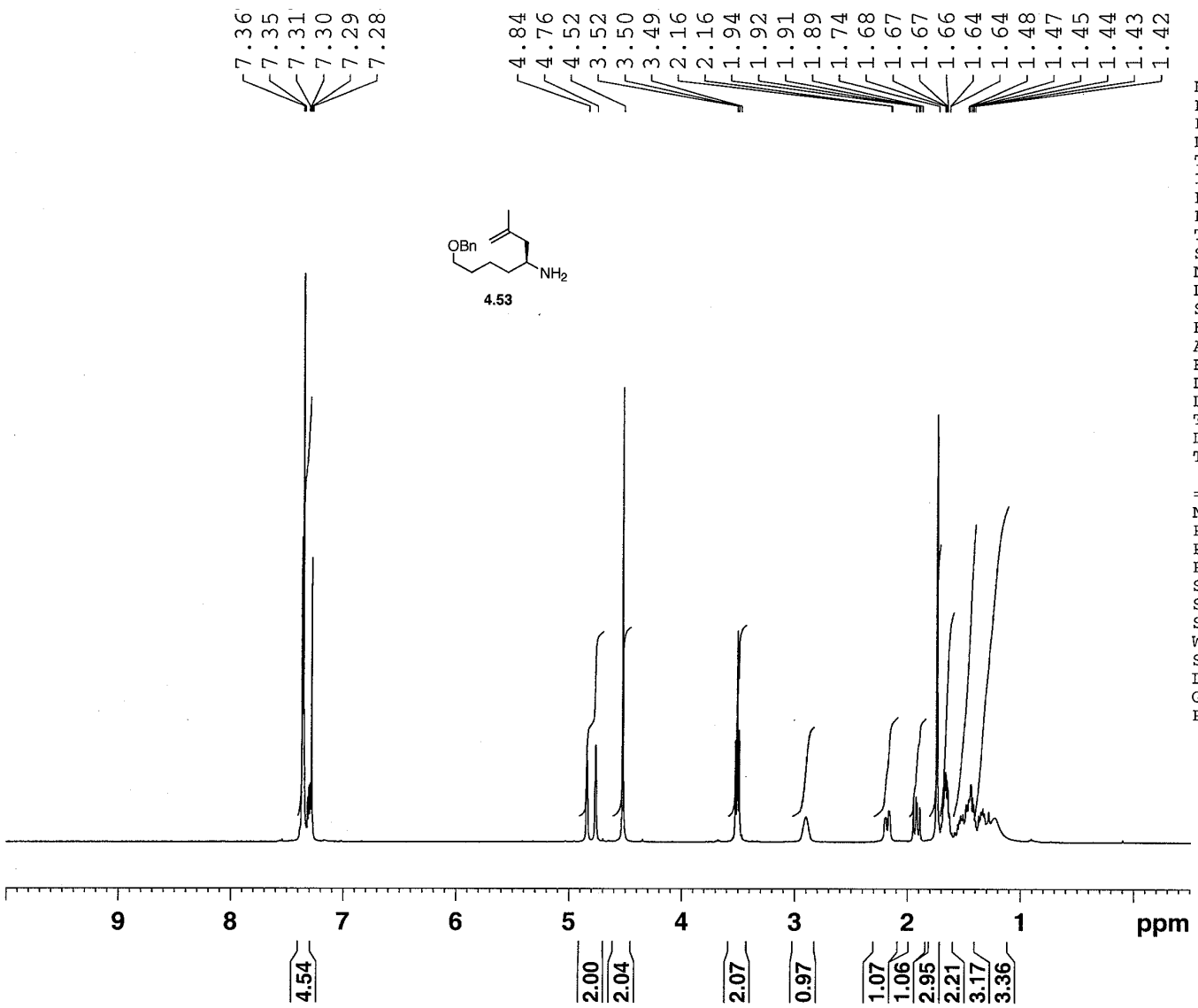
NUC1	1H
P1	13.50 usec
PL1	-3.00 dB
SFO1	400.2478017 MHz

F2 - Processing parameters

SI	32768
SF	400.2450000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00

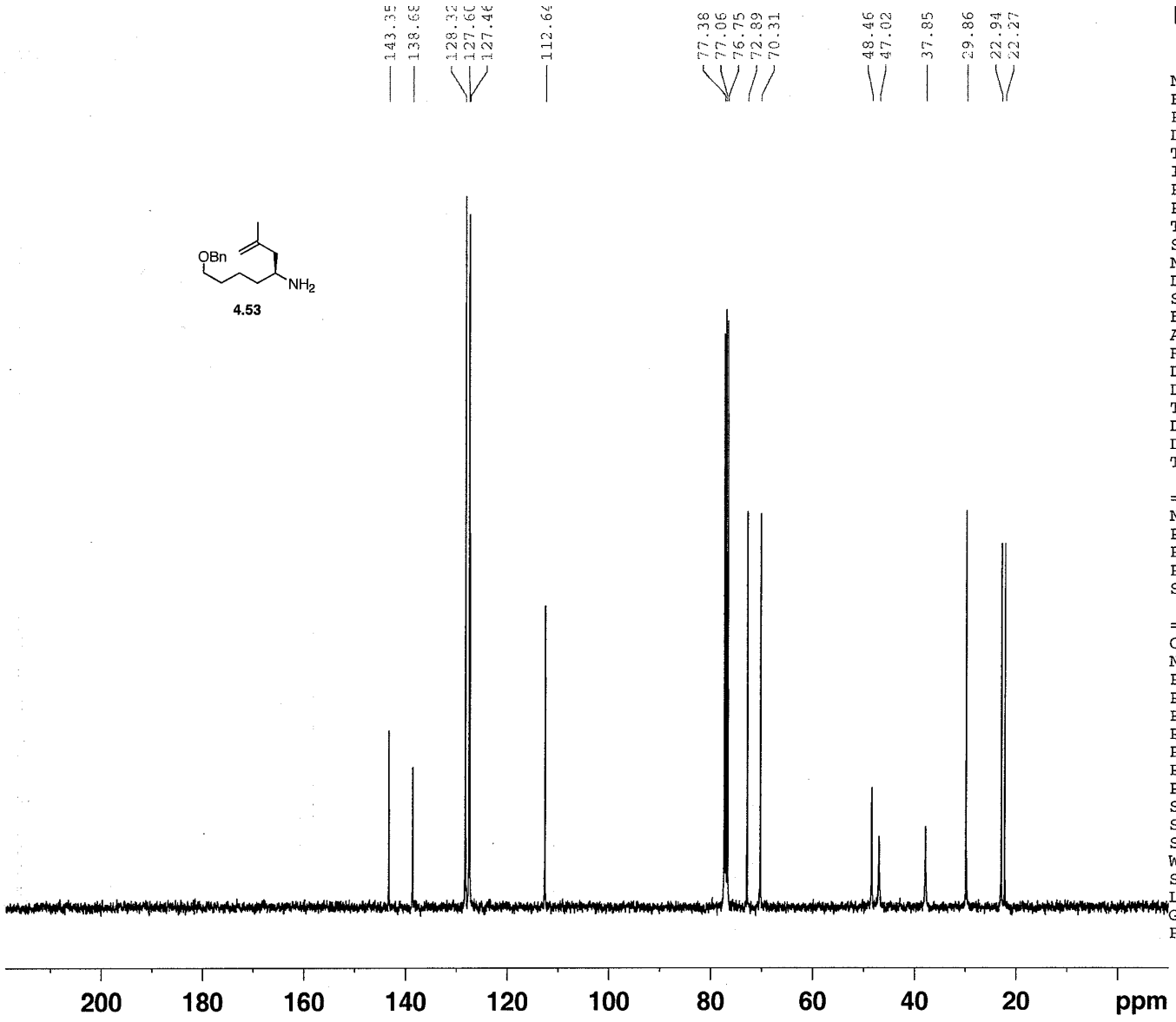



```
DU                              /m
USER                         erikc

F2 - Acquisition Parameters
Date_                     20090310
Time                         14.38
INSTRUM                     DPX400
PROBHD          5 mm BBO BB-1H
PULPROG                     zgpg30
TD                           65536
SOLVENT
NS                            1075
DS                               4
SWH                    25125.629 Hz
FIDRES                   0.383387 Hz
AQ                       1.3042164 sec
RG                            4096
DW                       19.900 usec
DE                        6.00 usec
TE                         298.2 K
D1                    0.15000001 sec
d11                   0.03000000 sec
DELTA                 0.05000000 sec
TD0                              1

======== CHANNEL f1 ========
NUC1                          13C
P1                        7.80 usec
PL1                        -3.00 dB
SFO1                100.5785700 MHz

======== CHANNEL f2 ========
CPDPRG2                  waltz16
NUC2                          1H
PCPD2                   135.00 usec
PL2                        17.40 dB
PL12                       17.40 dB
PL13                       17.40 dB
SFO2                399.9516000 MHz

F2 - Processing parameters
SI                            32768
SF                  100.5675080 MHz
WDW                              EM
SSB                               0
LB                         3.00 Hz
GB                                0
PC                             1.40
```



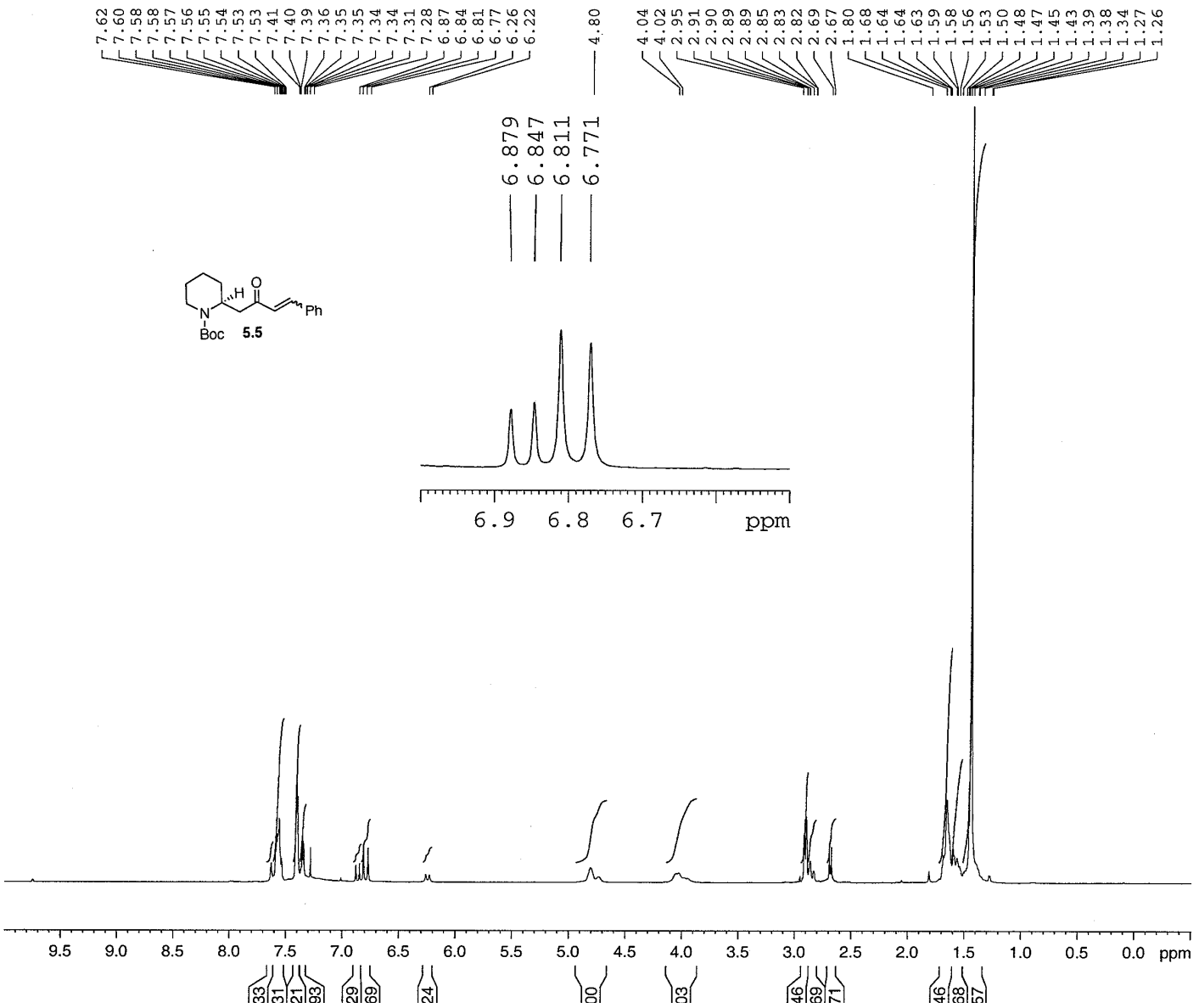
BRUKER

NAME	b7p53
EXPNO	1
PROCNO	1
Date_	20090918
Time	12.35
INSTRUM	spect
PROBHD	5 mm PABBO BB-
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	32
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	161.3
DW	78.000 usec
DE	6.50 usec
TE	300.8 K
D1	2.00000000 sec
TD0	1
======== CHANNEL f1 ========	
NUC1	1H
P1	14.00 usec
PL1	0.00 dB
PL1W	10.27361584 W
SFO1	400.1328009 MHz
SI	32768
SF	400.1300000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00



BRUKER

NAME	b7p53
EXPNO	2
PROCNO	1
Date_	20090918
Time	13.37
INSTRUM	spect
PROBHD	5 mm PABBO BB-
PULPROG	zgpg30
TD	65536
SOLVENT	CDCl3
NS	381
DS	4
SWH	23980.814 Hz
FIDRES	0.365918 Hz
AQ	1.3664756 sec
RG	18390.4
DW	20.850 usec
DE	6.50 usec
TE	302.5 K
D1	2.00000000 sec
D11	0.03000000 sec
TD0	1
======== CHANNEL f1 ========	
NUC1	13C
P1	9.00 usec
PL1	-2.00 dB
PL1W	46.89702606 W
SFO1	100.6228298 MHz
======== CHANNEL f2 ========	
CPDPRG2	waltz16
NUC2	1H
PCPD2	90.00 usec
PL2	0.00 dB
PL12	16.16 dB
PL13	17.00 dB
PL2W	10.27361584 W
PL12W	0.24872722 W
PL13W	0.20498557 W
SFO2	400.1316005 MHz
SI	32768
SF	100.6127690 MHz
WDW	EM
SSB	0
LB	3.00 Hz
GB	0
PC	1.40



NAME	b6p70
EXPNO	1
PROCNO	1
DU	/m
USER	erikc

F2 - Acquisition Parameters

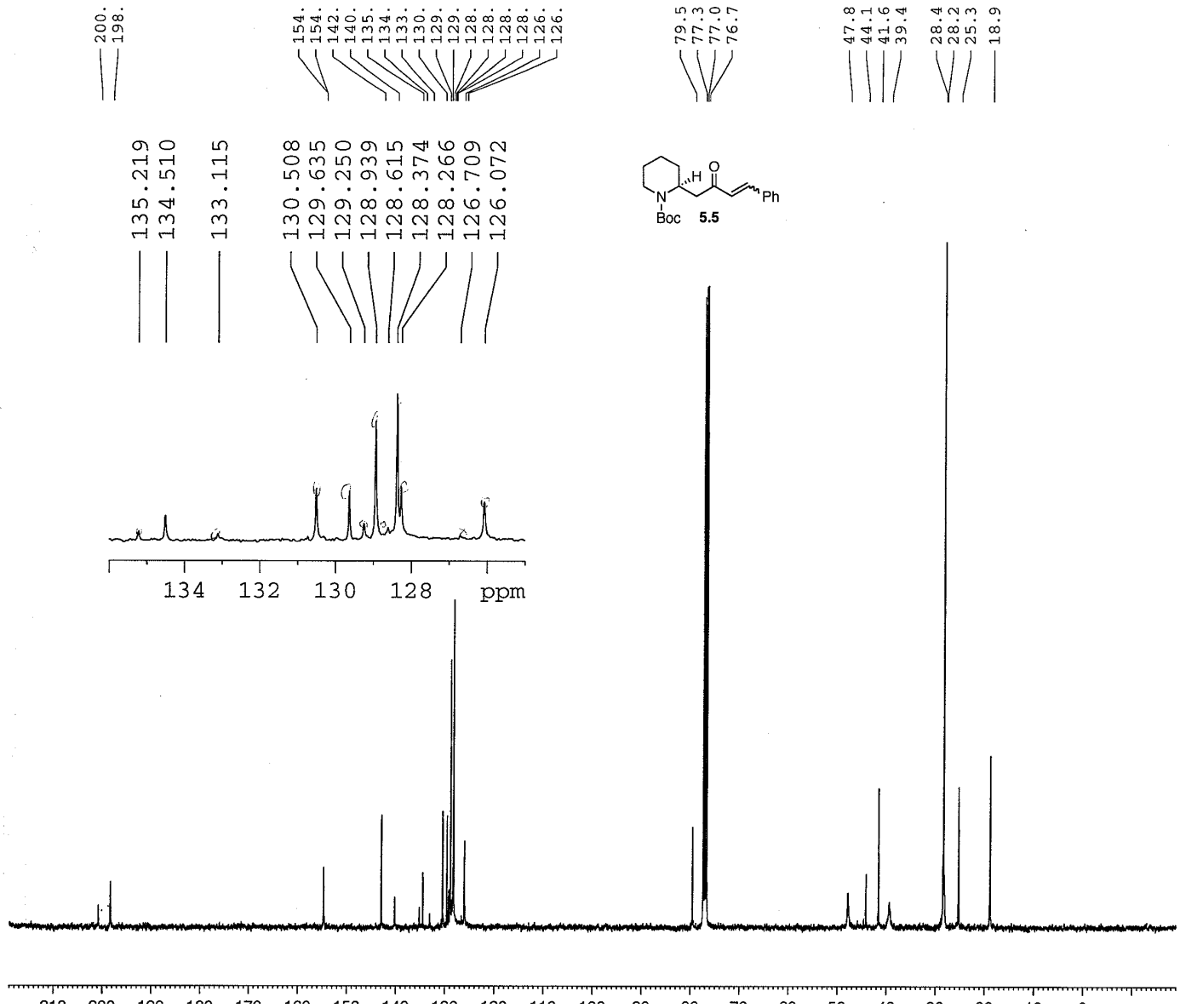
Date_	20091013
Time	16.13
INSTRUM	DPX400
PROBHD	5 mm BBO BB-1H
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	27
DS	2
SWH	6410.256 Hz
FIDRES	0.195625 Hz
AQ	2.5559540 sec
RG	101.6
DW	78.000 usec
DE	6.00 usec
TE	298.2 K
D1	1.00000000 sec
TD0	1

======== CHANNEL f1 ========

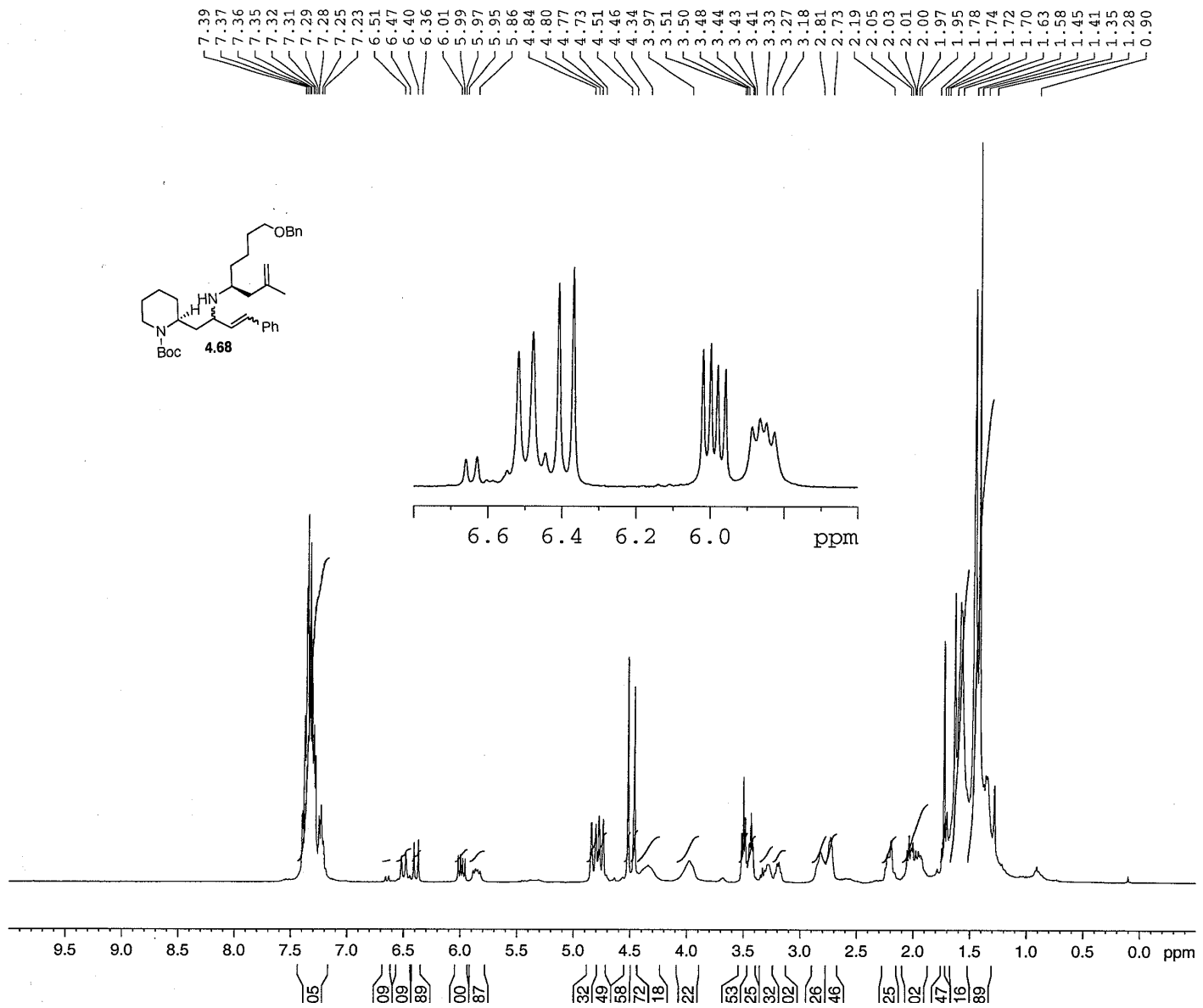
NUC1	1H
P1	13.50 usec
PL1	-3.00 dB
SFO1	400.2478017 MHz

F2 - Processing parameters

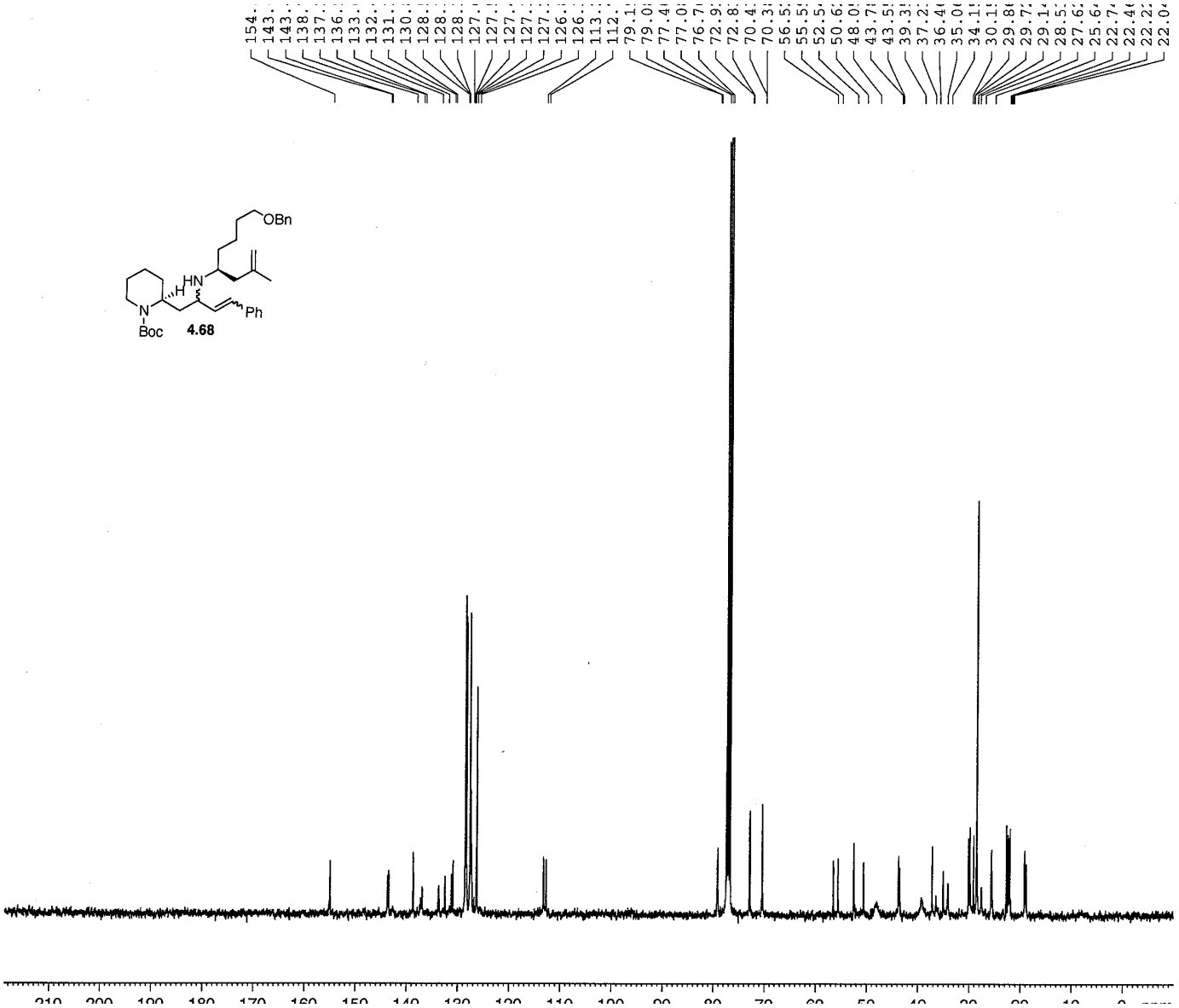
SI	32768
SF	400.2450000 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00



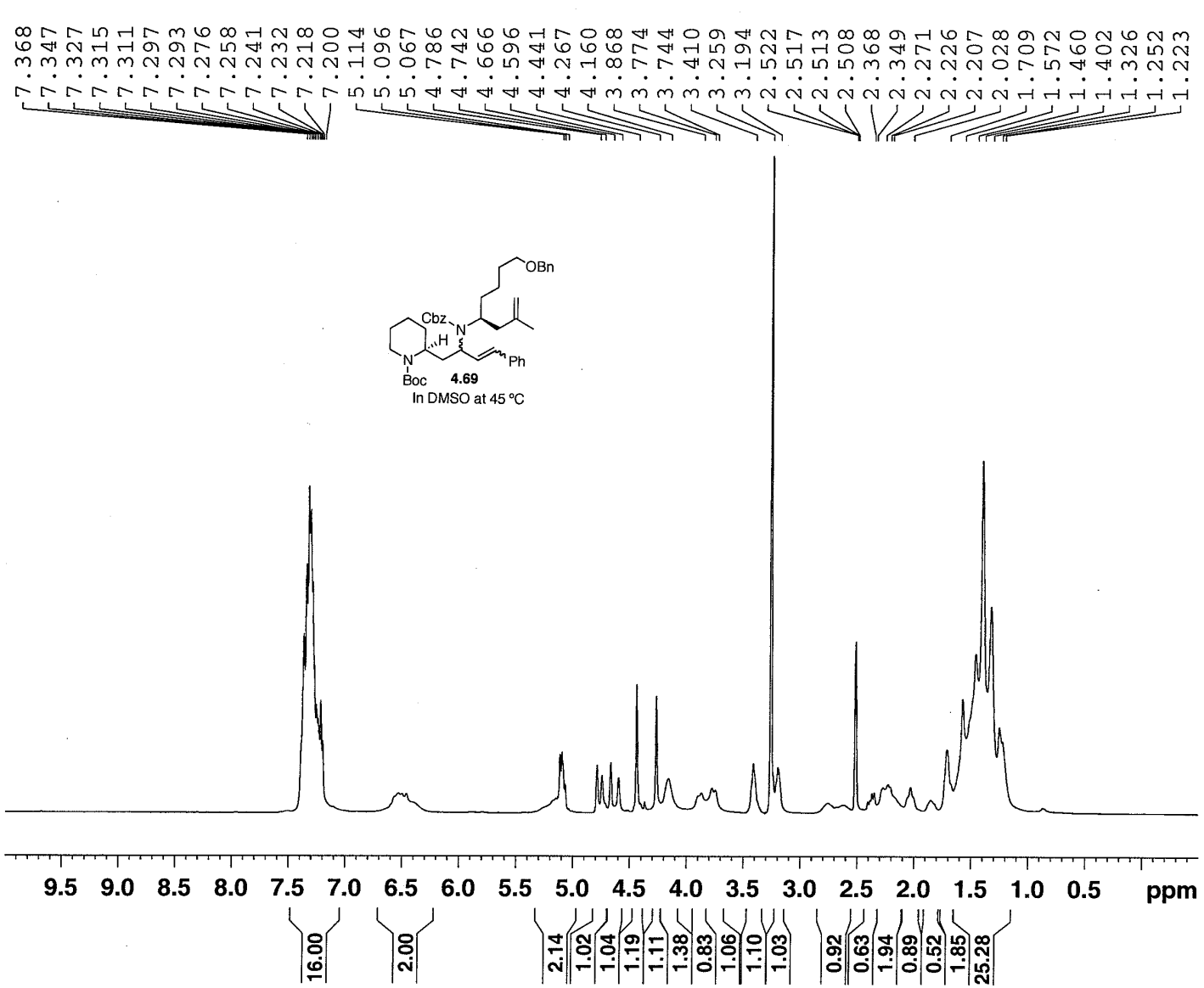

```
DU                              /m
USER                         erikc

F2 - Acquisition Parameters
Date_                     20091013
Time                         16.28
INSTRUM                     DPX400
PROBHD    5 mm BBO BB-1H
PULPROG                    zgpg30
TD                          65536
SOLVENT                     CDCl3
NS                            928
DS                              4
SWH                    23980.814 Hz
FIDRES                  0.365918 Hz
AQ                      1.3664756 sec
RG                           3251
DW                         20.850 usec
DE                          6.00 usec
TE                         299.2 K
D1                     2.00000000 sec
d11                    0.03000000 sec
DELTA                  1.89999998 sec
TD0                             1

======== CHANNEL f1 ========
NUC1                          13C
P1                          8.30 usec
PL1                        -3.00 dB
SFO1                100.6517495 MHz

======== CHANNEL f2 ========
CPDPRG2                   waltz16
NUC2                          1H
PCPD2                      90.00 usec
PL2                        -3.00 dB
PL12                       15.00 dB
PL13                       15.00 dB
SFO2                400.2466010 MHz

F2 - Processing parameters
SI                            32768
SF                  100.6416850 MHz
WDW                            EM
SSB                             0
LB                          3.00 Hz
GB                              0
PC                           1.40
```



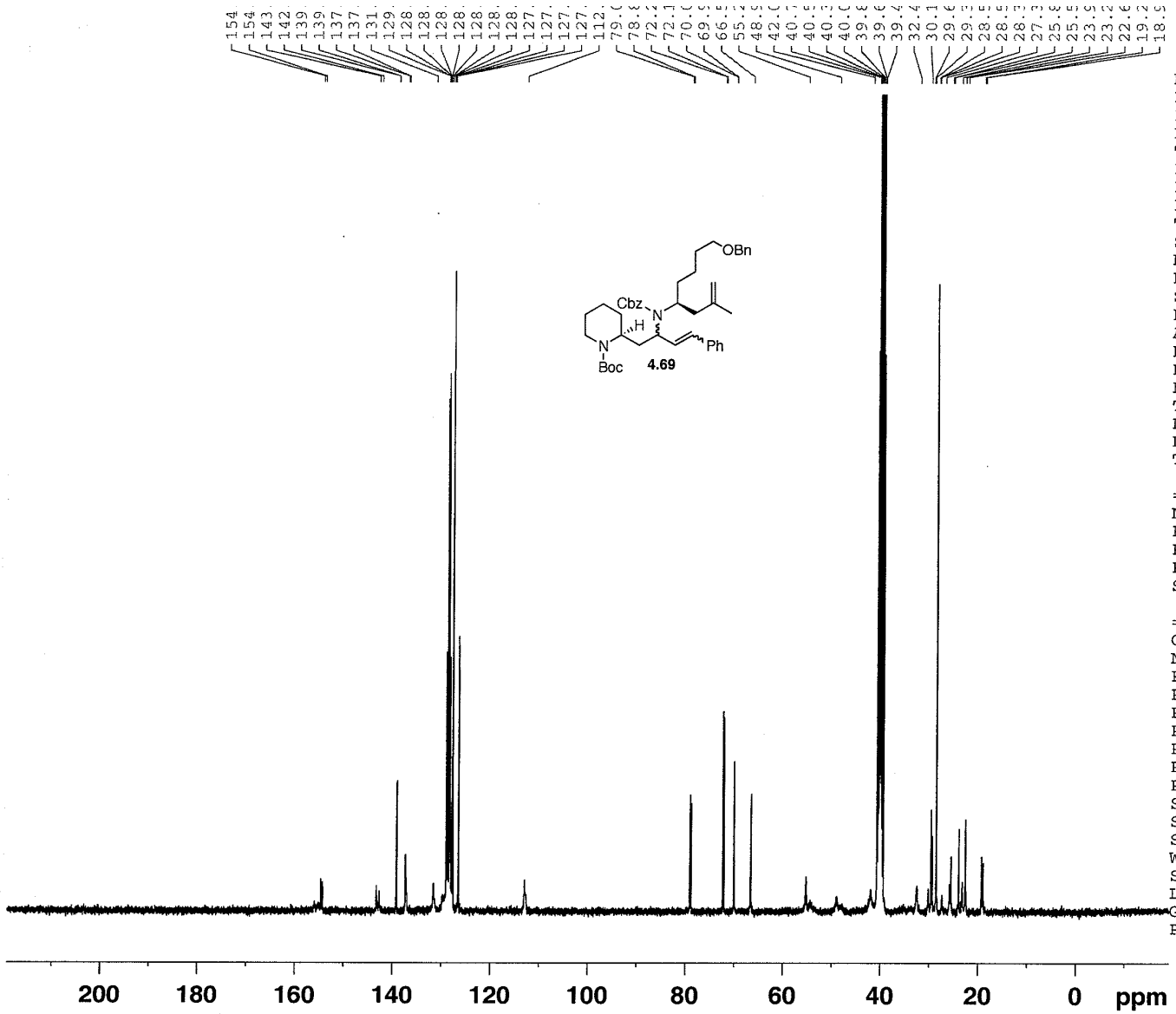

```
NAME                 b7p66
EXPNO                    1
PROCNO                   1
DU                      /m
USER                 erikc

F2 - Acquisition Parameters
Date_             20091106
Time                 14.06
INSTRUM            DPX400
PROBHD   5 mm BBO BB-1H
PULPROG               zg30
TD                   32768
SOLVENT              CDCl3
NS                      32
DS                       2
SWH               6410.256 Hz
FIDRES            0.195625 Hz
AQ               2.5559540 sec
RG                      64
DW                 78.000 usec
DE                  6.00 usec
TE                  298.2 K
D1             1.00000000 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                    1H
P1                  13.50 usec
PL1                 -3.00 dB
SFO1           400.2478017 MHz

F2 - Processing parameters
SI                   32768
SF             400.2450000 MHz
WDW                     EM
SSB                      0
LB                  0.30 Hz
GB                       0
PC                    1.00
```



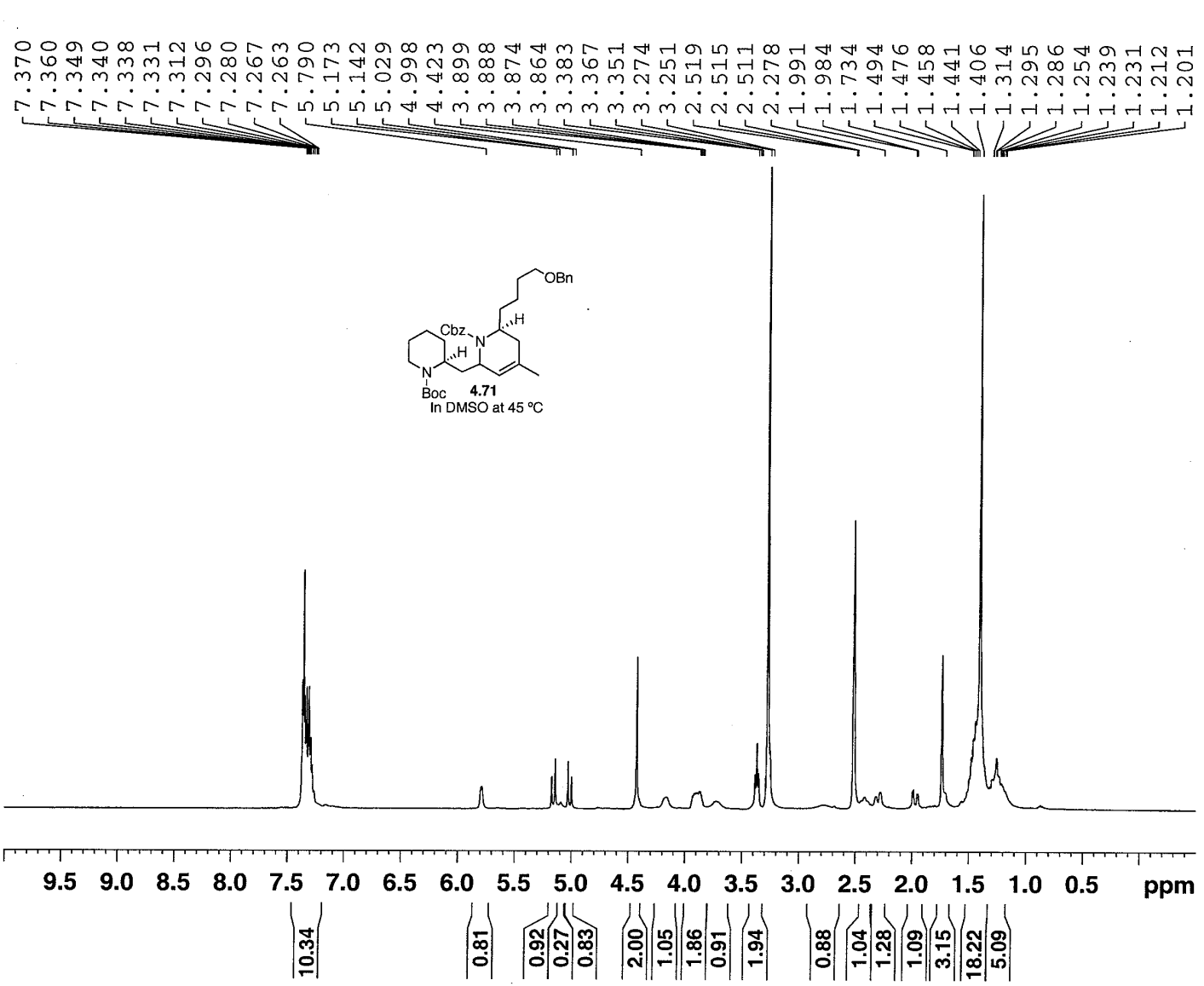

```
DU                              /m
USER                         erikc

F2 - Acquisition Parameters
Date_                     20091106
Time                         15.10
INSTRUM                     DPX400
PROBHD    5 mm BBO BB-1H
PULPROG                    zgpg30
TD                          65536
SOLVENT                      CDCl3
NS                            1024
DS                               4
SWH                    23980.814 Hz
FIDRES                  0.365918 Hz
AQ                      1.3664756 sec
RG                         9195.2
DW                        20.850 usec
DE                         6.00 usec
TE                        298.2 K
D1                     2.00000000 sec
d11                    0.03000000 sec
DELTA                  1.89999998 sec
TD0                              1

======== CHANNEL f1 ========
NUC1                          13C
P1                         8.30 usec
PL1                       -3.00 dB
SFO1                100.6517495 MHz

======== CHANNEL f2 ========
CPDPRG2                  waltz16
NUC2                          1H
PCPD2                     90.00 usec
PL2                       -3.00 dB
PL12                      15.00 dB
PL13                      15.00 dB
SFO2                400.2466010 MHz

F2 - Processing parameters
SI                           32768
SF                  100.6416850 MHz
WDW                             EM
SSB                              0
LB                        3.00 Hz
GB                               0
PC                            1.40
```



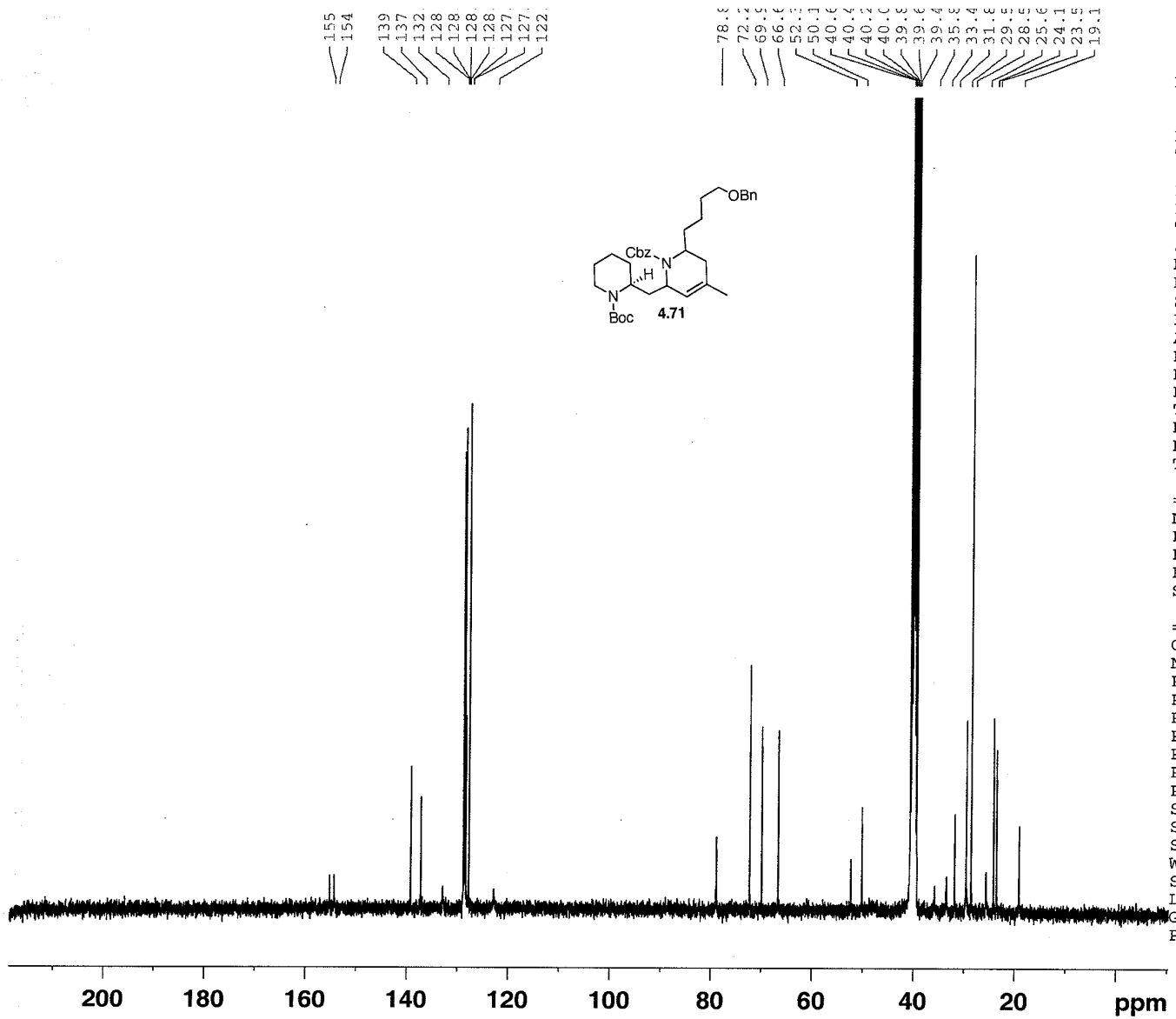
Date_	20091
Time	20
INSTRUM	sp
PROBHD	5 mm PABBO
PULPROG	z
TD	32
SOLVENT	D
NS	
DS	
SWH	6410.
FIDRES	0.195
AQ	2.5559
RG	4
DW	78.
DE	6
TE	31
D1	1.00000
TD0	
======== CHANNEL f1	=
NUC1	
P1	14
PL1	0
PL1W	10.27361
SFO1	400.1378
SI	32
SF	400.1350
WDW	
SSB	
LB	0
GB	
PC	1



NAME	b7p71
EXPNO	5
PROCNO	1
Date_	20091119
Time	8.11
INSTRUM	spect
PROBHD	5 mm PABBO BB-
PULPROG	zgpg30
TD	65536
SOLVENT	DMSO
NS	10500
DS	4
SWH	23980.814 Hz
FIDRES	0.365918 Hz
AQ	1.3664756 sec
RG	16384
DW	20.850 usec
DE	6.50 usec
TE	302.6 K
D1	2.00000000 sec
D11	0.03000000 sec
TD0	1
======== CHANNEL f1 ========	
NUC1	13C
P1	9.00 usec
PL1	-2.00 dB
PL1W	46.89702606 W
SFO1	100.6240872 MHz
======== CHANNEL f2 ========	
CPDPRG2	waltz16
NUC2	1H
PCPD2	90.00 usec
PL2	0.00 dB
PL12	16.16 dB
PL13	17.00 dB
PL2W	10.27361584 W
PL12W	0.24872722 W
PL13W	0.20498557 W
SFO2	400.1366005 MHz
SI	32768
SF	100.6140260 MHz
WDW	EM
SSB	0
LB	1.00 Hz
GB	0
PC	1.40




```
Date_              20091
Time                 16
INSTRUM             spe
PROBHD   5 mm PABBO I
PULPROG              zg
TD                   32
SOLVENT              DM
NS
DS
SWH             6410.2
FIDRES          0.1956
AQ              2.5559
RG                    1
DW                 78.0
DE                    6.
TE                  316
D1              1.00000
TD0

======== CHANNEL f1 =
NUC1
P1                 14.
PL1                 0.
PL1W        10.273615
SFO1        400.13780
SI                  327
SF          400.13500
WDW
SSB
LB                  0.
GB
PC                  1.
```



BRUKER

NAME	b7p74
EXPNO	10
PROCNO	1
Date_	20091118
Time	8.36
INSTRUM	spect
PROBHD	5 mm PABBO BB-
PULPROG	zgpg30
TD	65536
SOLVENT	DMSO
NS	11000
DS	4
SWH	23980.814 Hz
FIDRES	0.365918 Hz
AQ	1.3664756 sec
RG	20642.5
DW	20.850 usec
DE	6.50 usec
TE	302.3 K
D1	2.00000000 sec
D11	0.03000000 sec
TD0	1
======== CHANNEL f1 ========	
NUC1	13C
P1	9.00 usec
PL1	-2.00 dB
PL1W	46.89702606 W
SFO1	100.6240872 MHz
======== CHANNEL f2 ========	
CPDPRG2	waltz16
NUC2	1H
PCPD2	90.00 usec
PL2	0.00 dB
PL12	16.16 dB
PL13	17.00 dB
PL2W	10.27361584 W
PL12W	0.24872722 W
PL13W	0.20498557 W
SFO2	400.1366005 MHz
SI	32768
SF	100.6140260 MHz
WDW	EM
SSB	0
LB	1.00 Hz
GB	0
PC	1.40