Total Synthesis of Class II and Class III Galbulimima Alkaloids

by

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To my parents, Mardjuki Tjandra and Julianti Bianto,

to my brothers, Yuhanes Tjandra and Asming Tjandra,

to my sister, Selviana Tjandra, and

to my fiancé, Erfan Gunawan

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Preface

Portions of this work have been adapted from the following articles that were co-written by the author and are reproduced in part with permission from:

Movassaghi, M.; Hunt, D. K.; Tjandra, M. "Total Synthesis and Absolute Stereochemical Assignment of (+)- and (-)-Galbulimima Alkaloid 13." *J. Am. Chem. Soc.* **2006**, *128,* 8126.

Movassaghi, M.; Tjandra, M.; Qi, Jun. "Total Synthesis of (-)-Himandrine." *J. Am. Chem. Soc.* **2009,** *131*, 9648–9650.

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ABSTRACT

I. Total Synthesis of All Class III Galbulimima Alkaloids

We describe the total synthesis of (+)- and (–)-galbulimima alkaloid 13, (–)-himgaline anad (–)-himbadine. The absolute stereochemistry of natural (–)-galbulimima alkaloid 13 is revised to 2*S*. Sequential use of catalytic cross-coupling and cross-metathesis reactions followed by an intramolecular Diels-Alder reaction provided the required *trans*-decalin AB-ring system and masked the C16-carbonyl as an *N*-vinyl carbamate for late stage unveiling in the form of the necessary C16-enone. A vinyl-radical cyclization secured the C-ring while successful execution of our strategy for introduction of the CDE-ring system in complex galbulimima alkaloids provided the target pentacycle with complete diastereoselection.

II. Total Synthesis of (–)-Himandrine

We describe the first total synthesis of (–)-himandrine, a member of the class II galbulimima alkaloids. Noteworthy features of this chemistry include a diastereoselective Diels-Alder reaction in the rapid synthesis of the tricycle ABC-ring system in enantiomerically enriched form, the use of a formal [3+3] annulation strategy to secure the CDE-ring system with complete diastereoselection, and successful implementation of our biogenetically inspired oxidative spirocyclization of an advanced intermediate. The successful and direct late-stage formation of the F-ring in the hexacyclic core of himandrine drew on the power of biogenetic considerations and fully utilized the inherent chemistry of a plausible biosynthetic intermediate.

Thesis Supervisor: Professor Mohammad Movassaghi
Title: Associate Professor of Chemistry

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Abbreviations

Å	angstrom
[α]	specific rotation
Ac	acetyl
AIBN	2,2'-azobisisobutyronitrile
anis	anisaldehyde
aq	aqueous
atm	atmosphere
br	broad
brsm	yield based on recovered starting material
Bu	butyl
°C	degree Celcius
calcd	calculated
CAM	ceric ammonium molybdate
cm	centimeter
cm^{-1}	wavenumber
COSY	correlation spectroscopy
d	doublet
d	deuterium
δ	parts per million
DEAD	diethyl azodicarboxylate
diam	diameter
DMAP	4-dimethylaminopyridine
DMF	*N*,*N*-dimethylformamide
DMSO	dimethylsulfoxide
DTBMP	2,6-di-*tert*-butyl-4-methylpyridine
dr	diastereomeric ratio
ee	enantiomeric excess
EI	electron ionization
equiv	equivalent
ESI	electronspray ionization
Et	ethyl
FT	Fourier transform
g	gram
g	gradient
GB	galbulimima
GC	gas chromatography
h	hour
ht	height
hν	photochemical irradiation
HMBC	heteronuclear multiple bond correlation
HPLC	high performance liquid chromatography
HRMS	high resolution mass spectroscopy
HSQC	heteronuclear single quantum correlation
Hz	Hertz

i	iso
IBX	2-iodoxybenzoic acid
IR	infrared
J	coupling constant
kcal	kilocalorie
KHMDS	potassium hexamethyldislylamide
L	liter
LAH	lithium aluminum hydride
LDA	lithium diisopropylamide
LHMDS	lithium hexadislylamide
lit.	literature value
m	medium
m	multiplet
M	molar
μ	micro
Me	methyl
mg	milligram
MHz	megahertz
min	minute
mL	mililiter
mm	millimeter
mmol	millimole
μmol	micromole
mol	mole
MS	mass spectrometry
m/z	mass to charge ratio
n	normal
NBS	*N*-bromosucinnimide
NCS	*N*-chlorosucinnimide
nm	nanometer
NMR	nuclear magnetic resonance
nOe	nuclear Overhauser effect
NOESY	nuclear Overhauser effect spectroscopy
o.d.	outer diameter
p	para
Ph	phenyl
PMA	phosphomolybdic acid
ppm	parts per million
PPTS	pyridinium *p*-toluenesulfonate
Pr	propyl
Pyr	pyridine
q	quartet
R*f*	retention factor
ROESY	rotating frame Overhauser effect spectroscopy
s	singlet
s	strong

str	stretch
t	triplet
TBAF	tetra-*n*-butylammonium fluoride
TBS	*tert*-butyldimethylsilyl
TFA	trifluoroacetic acid
THF	tetrahydrofuran
TLC	thin layer chromatography
TMS	trimethyl silyl
UV	ultraviolet
W	weak
Z	benzylcarbamate

Chapter I.

Total Synthesis of All Class III Galbulimima Alkaloids

Introduction and Background

The galbulimima alkaloids are a family of structurally fascinating polycyclic compounds isolated from the bark of *Galbulimima belgraveana*, a tree native to northern Australia and Papua New Guinea (Figure 1).[1] These alkaloids are classified into three distinct groups (classes I-III) based on the amount of alkaloids isolated from the bark of trees with class I compounds as the most dominant and class III compounds as the most rare (class I:III, ~100:1). The biological activity[2] of himbacine (**1**), a potential treatment for Alzheimer's disease, has prompted several inventive syntheses of in this area.[3,4] Our laboratory is interested in the class II and class III galbulimima alkaloids because of their molecular complexity. In this chapter, we describe the total synthesis of all class III galbulimima alkaloids: (+)- and (–)-GB 13 (**2**),[5] (–)-himgaline (**3**) and (–)-himbadine (**4**), allowing revision of their absolute stereochemical assignment.

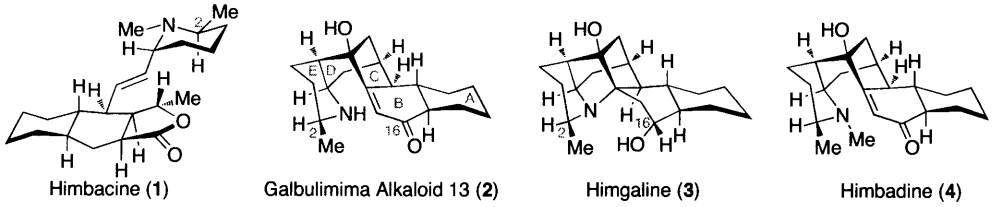
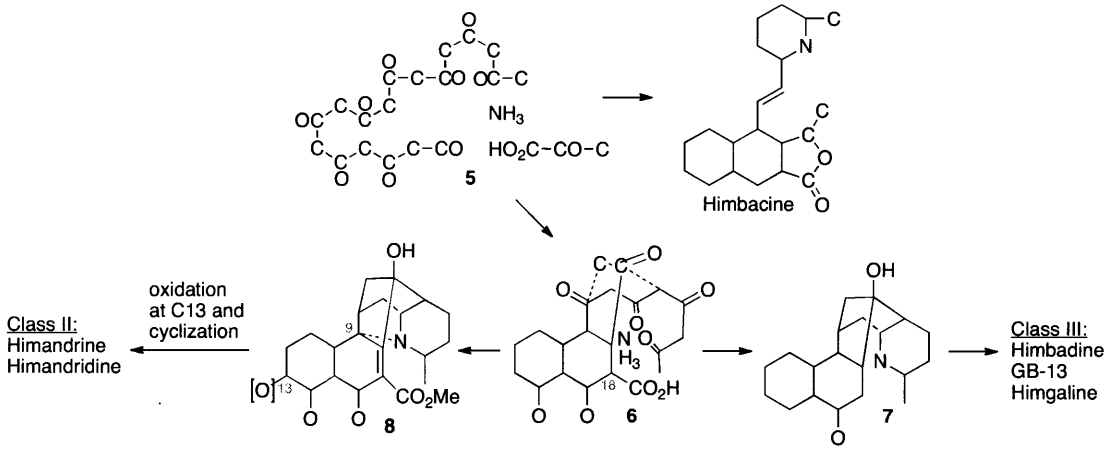


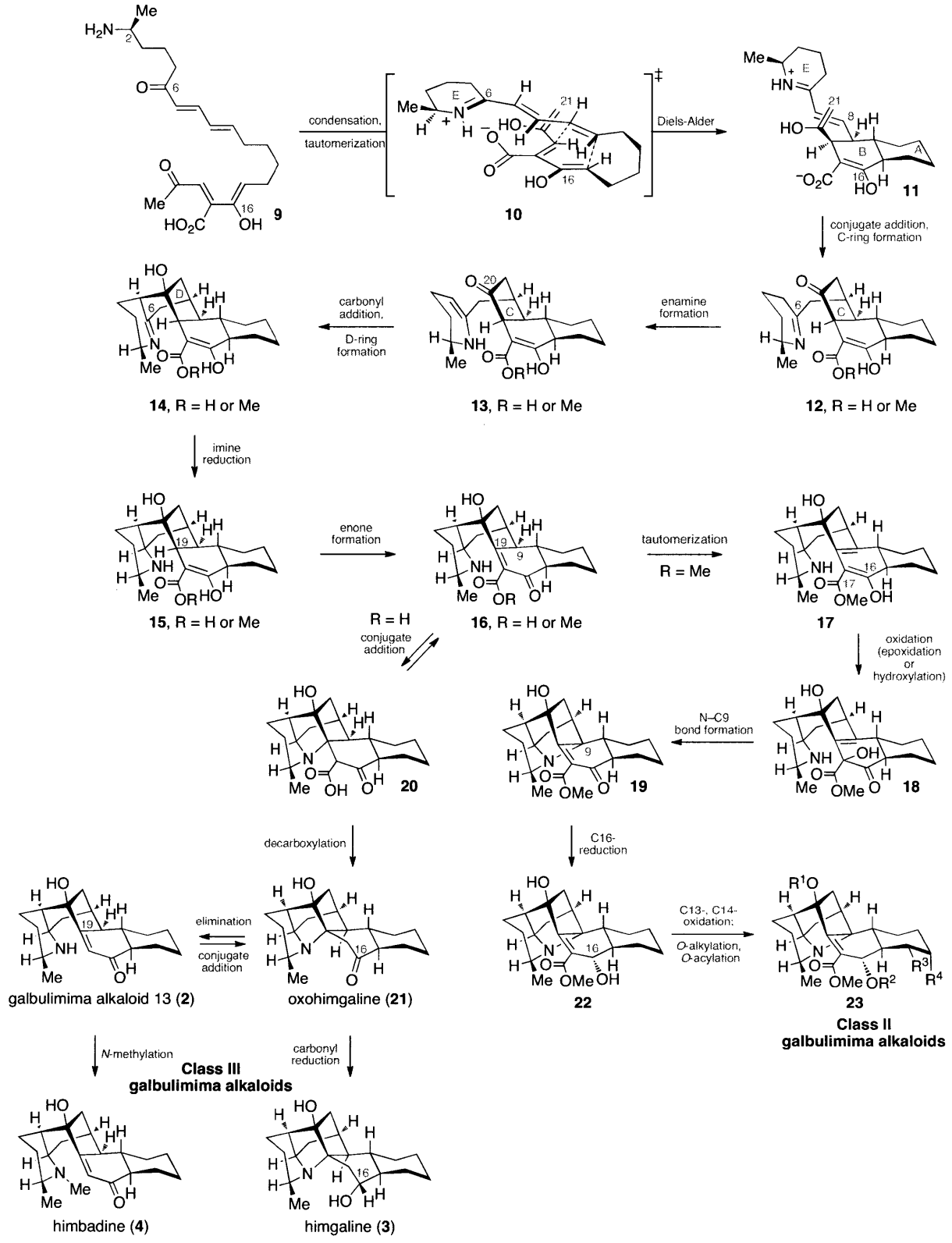
Figure 1. Representative galbulimima alkaloids.[1a]

Hypothesis for the Biosynthesis of Galbulimima alkaloids:

A compelling hypothesis by Mander, Ritchie and Taylor in 1967 linked various galbulimima alkaloids to a common polyacetate derived precursor: nine-acetate unit, a pyruvate, and NH_3 **5** (Scheme 1).[1d] They postulated that bicycle **6** could be the point of divergence to the



Scheme 1. Carbon mapping of Galbulimima alkaloids proposed by Mander, Ritchie and Taylor.

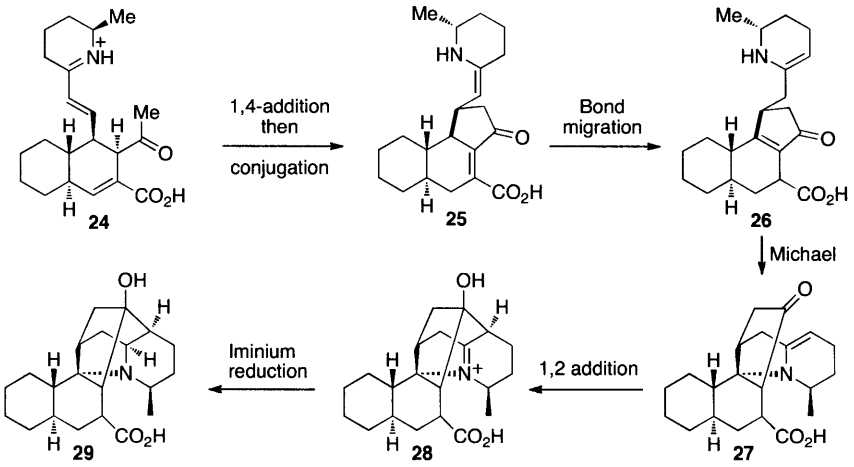


Scheme 2. Our biosynthetic hypothesis of class II and class III galbulimima alkaloids.

class II (himandrine and himandridine) and class III (galbulimima alkaloid 13, himbadine, and himgaline). Conversion of bicycle **6** to pentacycle **7** would provide access to the class III galbulimima alkaloids. Oxidation at C13 followed by N-C9 bond formation of pentacyclic ester **8** would afford the class II GB alkaloids.

Based on Mander, Ritchie and Taylor's consideration on the biosynthesis of galbulimima alkaloids described above,[1d] we developed a unified biosynthetic hypothesis of Class II and Class III galbulimima alkaloids specifying stereochemical control and timing of events (Scheme 2).[5] In particular, we envisioned the pentacyclic amino ketoester **16** to be the point of divergence to access class II and class III galbulimima alkaloids. We postulated that intramolecular conjugate addition of the enol tautomer of the C20-ketone of **11** to the unsaturated iminium ion would result in formation of tetracycle **12** that would be subject to rapid C6-enamine addition to the C20-carbonyl giving the pentacyclic imine **14**. Imine reduction followed by enone formation to give pentacyclic aminoketoester **16** would then set the stage for decarboxylation for the Class III alkaloids (GB 13, himbadine and himgaline). Alternatively, tautomerization of pentacyclic amino ketoester **16** and C17-hydroxylation, followed by an intramolecular allylic displacement by the amine would give the N–C9 bond present in Class II alkaloids (see chapter II). This refined biosynthetic hypothesis guided the first enantioselective total syntheses of both class II and class III alkaloids as described in the remainder of this thesis.

During our studies directed toward the synthesis of Class II and Class III alkaloids, Baldwin and co-workers reported the total synthesis of himbacine and himandravine, members of the Class I alkaloids, employing their independent biomimetic route that was distinct from

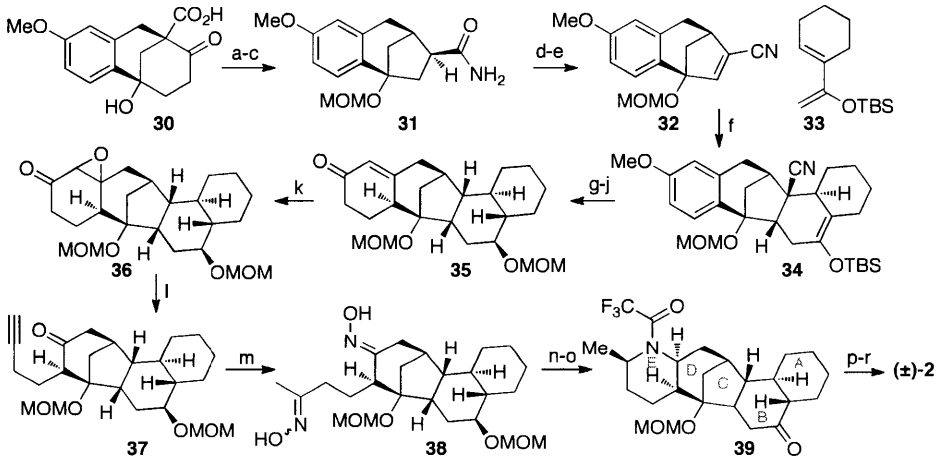


Scheme 3. Baldwin's biosynthetic hypothesis of galbulimima alkaloids.

ours.[3d,e] In their report, they also proposed the biosynthetic hypothesis of class II and class III Gb alkaloids starting from the tricycle **24** derived from intramolecular Diels Alder reaction of the tetraene precursor (Scheme 3). Conjugate addition of enol tautomer of methyl ketone **24** to the iminium moiety would give the tetracycle **25**. Tautomerization of the enamine **25** followed by double bond migration produced enone **26** which would undergo Michael addition first to give the spirocycle **27**. At this point, 1,2 addition of the enamine **27** provided the hexacyclic **28**, which upon imminium reduction was proposed to give the hexacyclic amino alcohol **29**, their speculated intermediate in the biosynthesis of class II and III galbulimima alkaloids. However, our mechanistic and methodological studies did not support the sequence of events described in conversion of **25** to **28**.

Review of Prior Synthetic Studies of Class III Galbulimima alkaloids:

An overview of the literature concerning the class III galbulimima alkaloids is presented in this section. Mander reported the first total synthesis of (±)-GB 13 in 2003.[4a] The key steps in the synthesis involved a Diels-Alder cycloaddition and elaboration of the benzenoid moiety to

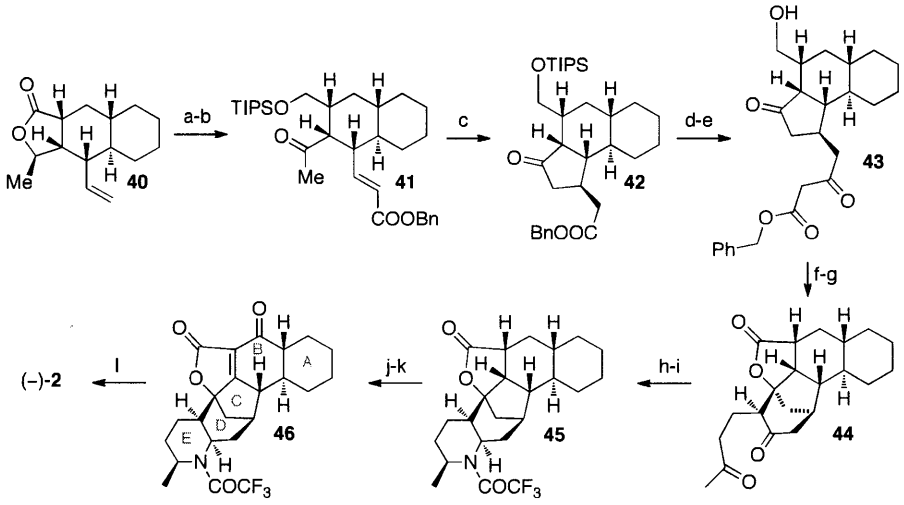


Scheme 4. Mander's total synthesis of (±)-GB 13. Conditions: (a) AcOH, H_2O, 89%. (b) MOM-Cl, DMAP, ^{i}PrNEt, DCM, 97%. (c) NaH, EtOCHO; NEt_3, CH_3CN, p-$NO_2C_6H_4SO_2N_3$; hν, THF, $((CH_3)_3Si)_2NH$, 0 °C, H_3O^+, 68% (3 steps). (d) Cl_3CCOCl, NEt_3, 98%. (e) KDA, Ph_2Se_2; H_2O_2, THF, 74%. (f) **33**, $Yb(thd)_3$, 110 °C, 87%. (g) TBAF, THF, 74%. (h) $LiAlH_4$, THF, 94%. (i) MOM-Cl, DMAP, ^{i}PrNEt, DCM, 96%. (j) Li, NH_3; HCl, MeOH, THF, 55%. (k) $LiAlH_4$, THF; MCPBA, DCM; DMP, $NaHCO_3$, 77% (3 steps). (l) p-$NO_2ArSO_2NHNH_2$, py, EtOH, THF, 76%. (m) H_2NOH·HCl, py, 100 °C. (n) $ZrCl_4$, $NaBH_4$; Zn, AcOH, Et_2O; TFAA, NEt_3, DCM, 32% (4 steps). (o) dil. HCl; DMP, DCM; MOM-Cl, DMAP, ^{i}PrNEt, DCM, 57% (3 steps). (p) LDA, TMSCl, THF; $Pd(OAc)_2$, DMSO, CH_3CN, 82% (2 steps). (q) K_2CO_3, H_2O, 60 C, 90%. (r) dil. HCl, acetone, 37%.

afford the piperidine ring of GB 13 (Scheme 4). The synthesis began with [3.3.1]bicyclononane **30** which underwent decarboxylation of β-keto acid followed by protection of alcohol, and Wolff ring contraction[6] of the corresponding diazoketone to provide amide **31**. At this point, dehydration of the amide moiety of **31** provided the corresponding nitrile in high yield followed by selenoxide elimination to afford alkene **32**, which underwent Diels-Alder reaction with diene **33** in the presence of ytterbium tris(2,2,6,6-tetramethyl-3,5-heptane-dionate) ($Yb(thd)_3$) at 110 °C to provide the desired *endo* adduct **34** in excellent yield. Hydrolysis of silyl enol ether **34**, followed by reduction of the resulting ketone, protection of the corresponding alcohol as the methoxymethyl ether, and Birch reduction[7] afforded the desired enone **35**. Enone **35** then underwent a 3-step sequence to provide the corresponding epoxy ketone **36**, which was subjected to Eschenmoser fragmentation[8] to afford the alkynyl ketone **37**. Treatment of alkynyl ketone **37** with excess hydroxylamine in pyridine gave bis-oxime **38**, which was subjected to reductive cyclization in the presence of zirconium tetrachloride and sodium borohydride to provide the corresponding N-hydroxypiperidine, which, upon reduction and protection, produced the pentacylic amine **39** with the desired all-*cis*-piperidine ring stereochemistry required for the synthesis of GB 13. Introduction of enone moiety on the B-ring via Saegusa oxidatian,[9] followed by global deprotection completed the total synthesis of (±)-GB 13.

At that time. the absolute streochemical assignment of GB 13 remained ambiguous, and in 2006, our laboratory reported the first total syntheses of both (+)- and (–)-GB 13 (**2**), allowing unequivocal revision of their absolute stereochemical assignment.[5] The first enantioselective total synthesis of (+)- and (–)-GB 13 (**2**) is outlined in the following page of this chapter. We reported our first total syntheses of (+)- and (–)-galbulimima alkaloid 13, 2-*epi*-galbulimima alkaloid 13, (–)-himbadine, 2-*epi*-oxohimgaline, 2-*epi*-himgaline, oxohimgaline, and (–)-himgaline in the Organic Syntheses symposium at MIT on May 18th, 2006. Subsequent to our reports, our structural revision was further supported by total syntheses from Shah,[10] Evans,[11] in addition to further X-ray analysis by Mander.[12]

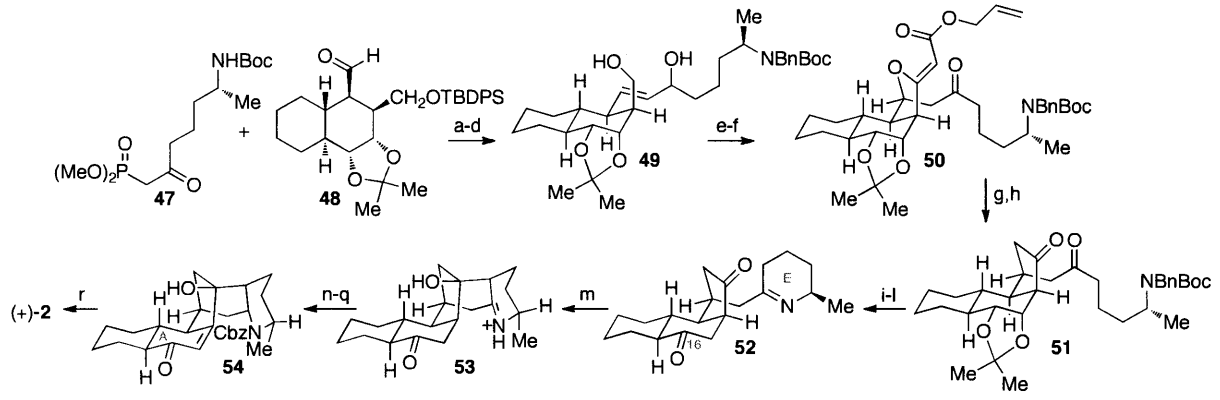
In 2006, Shah and co-workers reported the total synthesis of (–)-GB 13 which involved diastereoselective Diels-Alder reaction, radical cyclization, reductive amination, and aza-Michael reaction as the key steps in their synthesis (Scheme 5).[10] The synthesis started with the previously reported alkene **40**[13] (synthesized in 10 steps from (*R*)-3-butyn-2-ol) which underwent lactone reduction, protection and oxidation to give the corresponding methyl ketone, followed by



Scheme 5. Shah's total synthesis of (−)-GB 13. Conditions: (a) $LiAlH_4$, THF; Et_3N, TIPSOTf, CH_2Cl_2, −60 °C; Dess-Martin, CH_2Cl_2, 0 °C, 90% (3 steps). (b) O_3, Zn/AcOH, cat. $AgNO_3$, CH_2Cl_2; $BnOCOCH_2P(O)(OEt)_2$, NaHMDS, THF, 78% (2 steps). (c) TMSOTf, Et_3N; NBS, THF; $^nBu_3SnH$, AIBN, PhH, reflux, 56% (3 steps). (d) H_2/Pd-C, EtOAc; DCC, DMAP, Meldrum's acid; BnOH, PhH, reflux, 74% (3 steps). (e) HCl (aq.), THF, 85%. (f) $Zn(OTf)_2$, $CHCl_3$, reflux, 82%. (g) Methyl vinyl ketone, NaOEt, toluene, 0 °C; H_2/Pd-C; EtOH, H_3O^+, 65 °C, 77% (2 steps). (h) (*R*)-α-methylbenzylamine, MeOH; $Na(CN)BH_3$, MeOH, AcOH; HCO_2NH_4, MeOH, $Pd(OH)_2$, reflux; $Na(CN)BH_3$, MeOH, AcOH; $(CF_3CO)_2O$, Et_3N, CH_2Cl_2, 61% (5 steps). (i) $NaIO_4$, $RuCl_3{\cdot}3H_2O$, CCl_4:MeCN:H_2O, 86%. (j) LHMDS, THF, 0 °C, Me_2S_2; NaIO4, MeOH; toluene, 100 °C, 65% (3 steps). (k) NBS, AIBN, CCl_4, 80 °C; $AgOCOCF_3$, DMF; $NaHCO_3$ (aq.), THF; Dess Martin, 77% (4 steps). (l) HCl (6N), microwave, 1h, 80%.

ozonolysis and Horner-Wadsworth-Emmons reaction to provide alkene **41**. Methyl ketone **41** was subjected to α-bromination followed by highly diastreoselective radical ring closure to afford tricyclic ketone **42** (ABC ring system). Formation of the D ring was achieved through Lewis acid catalyzed intramolecular cyclization of β-keto ester **43** followed by conjugate addition with methyl vinyl ketone to provide diketone **44**. At this point, selective reductive amination, protection of the amine, and ruthenium oxide mediated oxidation provided the hexacylic amino lactone **45**. Introduction of enone moiety on the B ring was achieved through sulfoxide elimination, allylic bromination and displacement, followed by hydrolysis and oxidation to afford enone **46**. Decarboxylative unraveling of lactone **46** completed the total synthesis of (−)-GB 13.

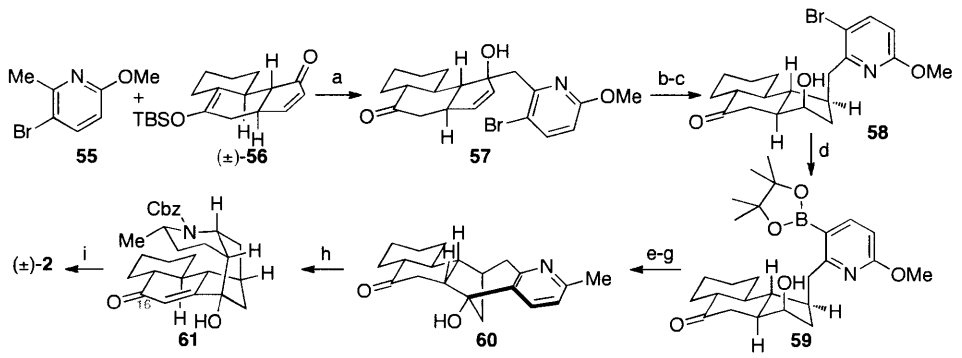
In 2007, Evans and co-workers disclosed an elegant total synthesis of (+)-GB 13.[11] Their key transformations included the asymmetric intramolecular Diels Alder reaction, Michael and Aldol reaction (Scheme 6). The synthesis began with the Horner-Wadsworth-Emmons olefination of *trans* decalin aldehyde **48** (synthesized via intramolecular Diels Alder reaction)



Scheme 6. Evan's total synthesis of (+)-GB 13. Conditions: $LiClO_4$, $^iPr_2Net$, CH_3CN, 50 °C, 85%. (b) DIBAL-H, PhMe, –90 °C. (c) TBAF, HOAc, THF, 87% (2 steps). (d) TBSOTf, 2,6-lutidine; NaH, BnBr; TBAF 85% (3 steps). (e) DMP, $NaHCO_3$, CH_2Cl_2. (f) allyldiazoacetate, $SnCl_2$. (g) LiOMe, $LiClO_4$, Et_2O, 0° → 23 °C, 62% (3 steps). (h) $Pd(PPh_3)_4$, morpholine, THF, 86%. (i) DBU, PhH. (j) $Pd(OH)_2$, H_2, THF. (k) DMP, $NaHCO_3$, CH_2Cl_2, 72% (3 steps). l) 20% TFA/CH_2Cl_2, 0 °C, aq. $NaHCO_3$ workup; 4 Å MS, PhH. (m) HOAc, THF, 0° → 23 °C. (n) $NaBH_3CN$, EtOH, 0 °C. (o) DMP, $NaHCO_3$, CH_2Cl_2. (p) benzyl chloroformate, Na_2CO_3, CH_2Cl_2/H_2O, 0° → 23 °C, 39% (5 steps). (q) IBX, $TsOH{\cdot}H_2O$, DMSO/PhH, 65 °C. (r) TMS-I, CH_2Cl_2, 0 °C; HCl; NaOH, 23 °C, 81% (2 steps).

using the previously reported (*R*)-β-ketophosphonate **47**[3c] to afford the corresponding unsaturated ketone followed by reduction and deprotection to give the allylic alcohol **49**. Diol **49** was oxidized, and the resulting aldehyde was selectively subjected to Roskamp reaction[14] to introduce the necessary β-ketoester for the planned Michael reaction; however, under the reaction condition, the isolated product was enol ester **50**. The undesired formation of enol ester **50** can be reversed under basic condition followed by decarboxylation to afford the tricyclic ketone **51**. The C16 ketone was introduced through DBU promoted elimination of the acetonide, hydrogenation and oxidation of the corresponding alcohol. The E ring of **52** was formed through deprotection of the amine under acidic condition and dehydration to the corresponding imine. Under acidic condition, imine **52** underwent aldol addition to give the desired pentacycle as its imminium ion **53**. Reduction of imminium **53** followed by regeneration of the C16-ketone and protection of amine provided the corresponding pentacyclic amino alcohol. At this point, we were delighted to see application of the final stages strategy in our synthesis was used in this solution. Unsaturated ketone on the A ring was introduced through IBX oxidation[15], and the benzyl carbamate was removed with TMS-I[16] to afford (+)-GB 13.

In 2009, Sarpong and co-workers reported another total synthesis of galbulimima alkaloid-13 in racemic form which involved the Rh(I)-catalyzed ketone hydroarylation reaction

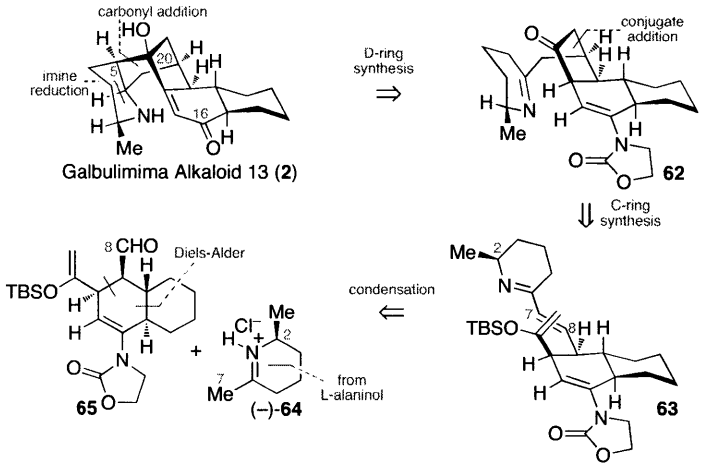


Scheme 7. Sarpong's total synthesis of (±)-GB 13. Conditions: (a) LDA, THF, 78 °C, **56**; HCl, THF/MeOH, 0 °C; K_2CO_3, 23 °C, 58% (2 steps). (b) SO_3•pyr, DMSO, pyridine, CH_2Cl_2, 23 °C; $KHPO_4$/NaOH buffer, 60 °C, 55% (2 steps). (c) H_2, cat. PtO_2, Na_2CO_3, EtOAc, 0 °C, 93%. (d) $(Bpin)_2$, cat. $Pd_2(dba)_3$•$CHCl_3$, cat. Pcy_3HBF_4, KOAc, DMF, 80 °C, 65%. (e) DMP, CH_2Cl_2; Et_3N, SiO_2, CH_2Cl_2, 78% (2 steps). (f) cat. $[Rh(cod)(MeCN)_2]^+BF4^-$, Et_3N, PhMe, 80 °C, 77%. (g) NaSEt, DMF, 120 °C; Tf_2O, pyridine, 0 °C; $AlMe_3$, cat. $Pd(Ph_3)_4$, THF, 54% (3 steps). (h) cat. Rh/Al_2O_3, H_2 (1000 psi), EtOH; BnOCOCl, aq. $NaHCO_3$/PhMe; IBX, TsOH, DMSO/PhH, 65 °C, 60% (3 steps). (i) TMS-I, CH_2Cl_2, 0 °C; HCl, NaOH, 79%.

(Scheme 7).[17] The synthesis started with coupling between cyclopentenone **56** and lithioanion of bromomethoxypicoline **55** to provide allylic alcohol **57**. 1,3 Allylic transposition of **57** could be accomplished using modified Parikh-Doering Swern conditions[18] followed by selective hydrogenation to give alcohol **58**. Introduction of boronic ester moiety proceeded in good yield to provide intermediate **59**. Oxidation of alcohol **59**, epimerization to the cis [6-5] ring fusion, treatment of the corresponding pinacolboronic ester with the Rh(I) catalyst to undergo 1,2 addition, and installation of the pyridinyl methyl group provided the desired pentacycle **60**. Hydrogenation of the pyridine ring provided the desired piperidine moiety. At this point, application of the final stages strategy in our synthesis was used to complete the total synthesis of (±)-GB-13. Cbz protection, and IBX oxidation[15] afforded the desired enone **61**. Removal of the Cbz group with TMS-I[16] gave (±)-GB 13.

Results and Discussion

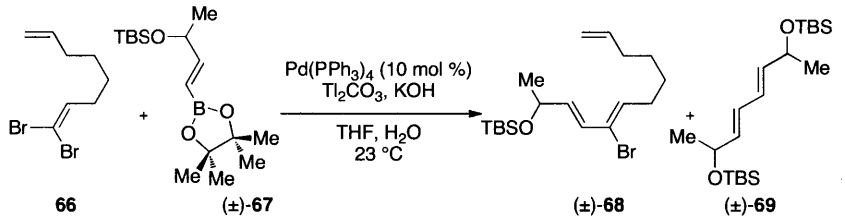
Our goals in the study and total synthesis of galbulimima alkaloids were to develop the first enantioselective synthesis of (+)- and (–)-GB 13 (**2**) and to confirm the absolute streochemical assignment of class II and III GB alkaloids. Furthermore, we wanted to explore our own biosynthetic hypothesis of class II and III GB alkaloids and to chemically validate our proposal for their biogenesis. Guided by our original biosynthetic hypothesis,[5] we envisioned a



Scheme 8. Retrosynthetic analysis of (–)-GB 13.

strategic C5-C20 bond disconnection to greatly simplify the structure of **2** to the tetracyclic precursor **62** (Scheme 8). We expected to obtain the imino-ketone **62** from the unsaturated imine **63**, in turn prepared by condensation of the iminium chloride **64** with aldehyde **65**. Given the uncertainty in the absolute stereochemistry of natural (–)-GB 13 (**2**), the coupling of the readily available (+)- or (–)-iminium chloride **64** with (±)-aldehyde **65** provided an expedient route to both enantiomers of advanced intermediates and alkaloid **2**.

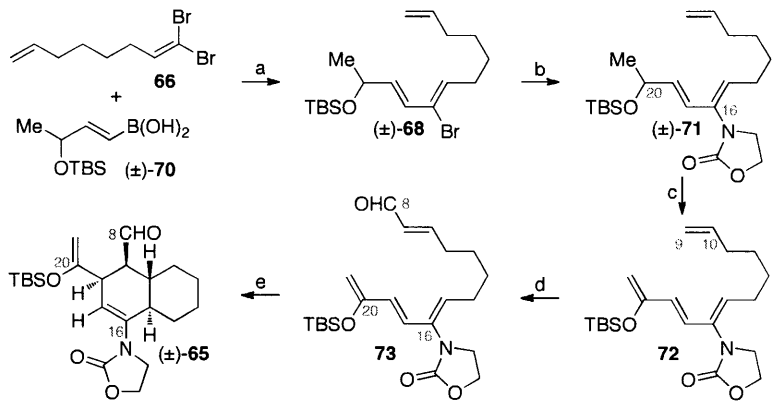
An efficient synthesis of *trans*-decalin aldehyde **65** is outlined in Scheme 9. Suzuki cross-coupling[19] of readily available dibromide **66** and vinyl boronic acid **70** using thallium carbonate[20] provided *cis*-vinyl bromide **68** in 75% yield. Efforts to substitute thallium carbonate



entry	Tl_2CO_3 (equiv)	KOH (equiv)	yield	ratio (±)-68:(±)-69[a]
1	1	none	70%	3:1
2	0.5	1.5	59%	2:1
3	0.25	1.75	39%	1:1
4	0.1	1.9	19%	1:1
5	0.1	4	38%	1:1

[a]Ratio determined by crude ^{1}H NMR.

Table 1. Optimization of Suzuki coupling for reduction of thallium carbonate

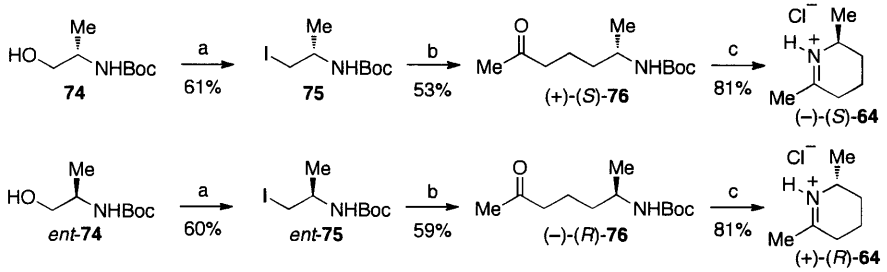


Scheme 9. Diastereoselective synthesis of (±)-aldehyde **65**. Conditions: (a) $Pd(PPh_3)_4$, Tl_2CO_3, THF, H_2O, 23 °C, 75%. (b) CuI, K_2CO_3, oxazolidin-2-one, $(MeNHCH_2)_2$, toluene, 110 °C, 95%. (c) 1. TBAF, THF, 95%. 2. MnO_2, CH_2Cl_2, 92%. 3. TBSOTf, Et_3N, CH_2Cl_2, –78 °C, 93%. (d) 4,5-DihydroIMesCl$_2$Ru=CH(*o*-^{i}PrO)Ph (10 mol%), acrolein, CH_2Cl_2, 23 °C, 85%. (e) toluene, 90 °C, 82%, (≥20:1, *endo*:*exo*).

with potassium hydroxide were unsuccessful, resulting in no improvement in the yield. In addition, unwanted dimerization of the boronate **69** ocurred when less Tl_2CO_3 was used (Table 1). Use of palladium acetate and SPhos ligand developed by Buchwald[21] produced 1:1 mixture of the desired vinyl bromide **68** and dimer **69**.

Subsequent copper-catalyzed coupling of bromodiene **68** with oxazolidin-2-one afforded the desired triene **71** in excellent yield[22] and proved an effective strategy for masking the C16-carbonyl. Conversion of the C20-silyl ether of triene **71** to the C20-silyl enol ether gave tetraene **72** (Scheme 9). Selective functionalization of the C9-C10 alkene of **72** to the corresponding unsaturated aldehyde **73** (C9-*E*:*Z*, >20:1) was achieved via an olefin cross-metathesis reaction with acrolein using the 4,5-dihydroIMesCl$_2$Ru=CH(*o*-^{i}PrO)Ph[23] catalyst. Heating a solution of tetraenal **73** in toluene at 90 °C afforded the desired *trans*-decalin aldehyde **65** in good yield (82%, >20:1, *endo*:*exo*).

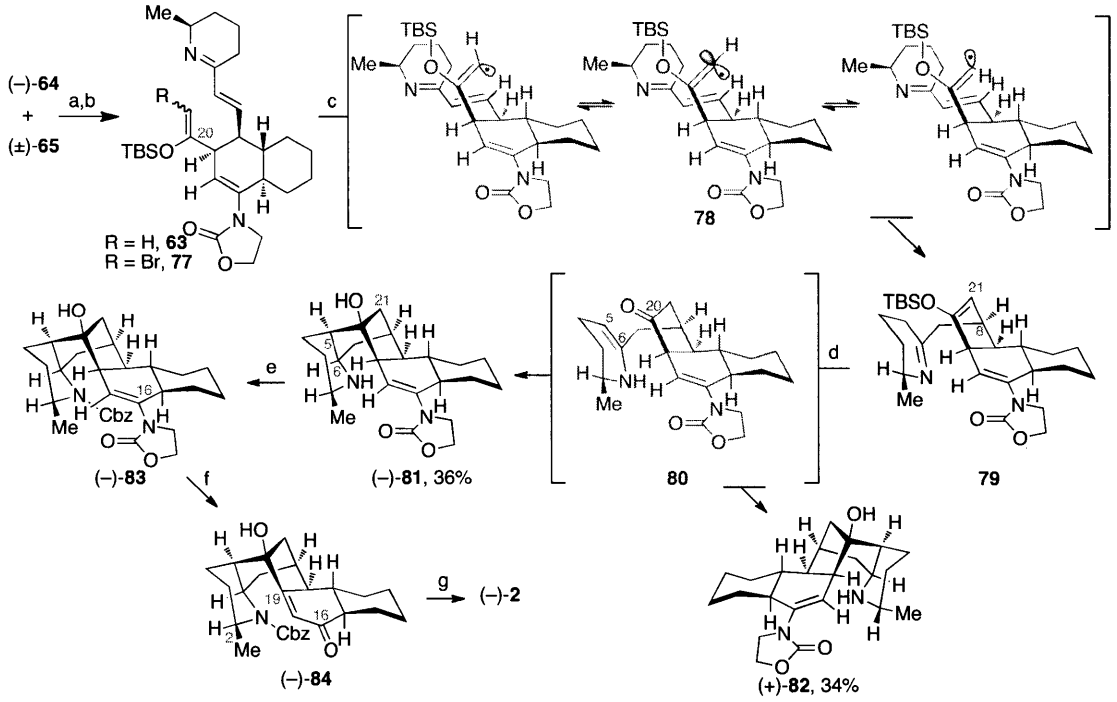
Having access to the *trans*-decalin aldehyde (±)-**65**, we proceeded to the synthesis of enantiomerically enriched iminium salt (*S*)-**64** and (*R*)-**64** in multi-gram scale (Scheme 10). Amino alcohol **74** derived from L-alanine was iodinated to provide alkyl halide **75**. Radical addition with methyl vinyl ketone afforded the desired amino ketone (+)-**76**. Deprotection of the Boc group under acidic conditions resulted in cyclization to give the desired iminium salt (–)-(*S*)-**64**. The enantioselecitivity of the iminium salt (–)-(*S*)-**64** was measured to be >99% ee by chiral HPLC analysis of the corresponding benzylated derivative. The corresponding enantiomer, iminium chloride (+)-(*R*)-**64** was prepared using the same route, starting with amino alcohol *ent*-



Scheme 10. Synthesis of iminium salt (–)-(*S*)-**64** and (+)-(*R*)-**64**. Conditions: (a) I_2, PPh_3, Imidazole, THF, 0 °C. (b) methyl vinyl ketone, $^nBu_3SnH$, AIBN, toluene, reflux. (c) HCl (aq.), 23 °C.

74 derived from D-alanine.

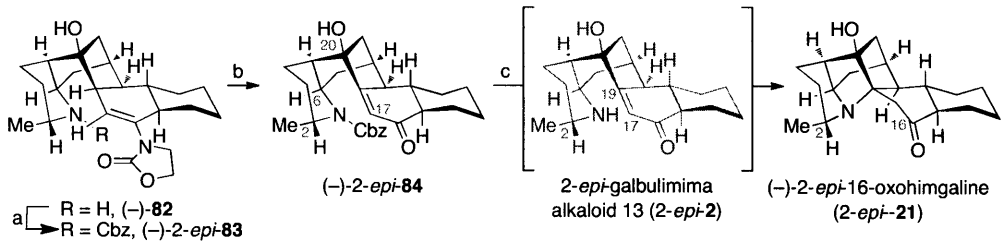
Deprotonation of the (–)-iminium chloride **64** (>99% ee, Scheme 11) with ^{n}butyl lithium gave the corresponding lithiated enamine,[24] which upon addition to a cold solution of aldehyde **65** provided the corresponding β-hydroxy imines in 85% yield. Dehydration using the Martin sulfurane reagent[25] afforded the desired (7*E*)-α,β-unsaturated imine **63** (Scheme 11) and the corresponding 2-*epi*-enantiomer (not shown in Scheme 11) as a 1:1 mixture of inseparable



Scheme 11. Concise total synthesis of (–)-GB 13 (**2**). Conditions: (a) ^{n}BuLi, THF, –78 °C, 5 min, 85%. (b) Martin sulfurane, benzene, 23 °C, 81%. (c) NBS, $NaHCO_3$, THF, 0 °C; $^nBu_3SnH$, AIBN, benzene, 60→90 °C, 55% (2-steps). (d) $Et_3N•(HF)_3$, THF, 23 °C; $NaBH_4$, EtOH, 0 °C, 70% (2 steps). (e) $ClCO_2Bn$, Na_2CO_3, H_2O, CH_2Cl_2, 65%. (f) IBX, $TsOH•H_2O$, benzene, DMSO, 65 °C, 10 h, 80%. (g) TMSI, CH_2Cl_2, 0 °C; HCl; NaOH, 23 °C, 89%. For brevity, the corresponding *ent*-2-*epi*-isomer of compounds **63** and **77**-**80** are not shown.

diastereomers in 81% yield. The diastereomers were chromatographically separated after the next two steps. Diastereoselective introduction of the C21-C8 bond in tetracycle **79** was accomplished via a 5-exo-trig vinyl-radical cyclization.[26] Conversion of silyl enol ether **63** to the vinyl bromide **77** (Scheme 11, ~1:1.5 mixture of C20-olefin isomers), followed by heating of the crude vinyl bromide **77** with excess tributyltin hydride and AIBN provided the desired tetracycle **79** along with the C2-*epi*-enantiomer in 55% yield. Treatment of enol ether **79** with triethylamine–trihydrofluoride resulted in C5-C6 enamine addition to the unmasked C20 carbonyl, directly providing the corresponding pentacyclic imine. Removal of the volatiles under reduced pressure and introduction of sodium borohydride in ethanol resulted in diastereoselective C6-imine reduction, affording the corresponding stable pentacyclic amine in a one-pot process (Scheme 11). Optically active pentacyclic amine (–)-**81** (36%) and the corresponding 2-*epi*-enantiomer, amine (+)-**82** (34%), were readily separated by flash column chromatography. Remarkably, formation of the C8 stereocenter during the radical cyclization as well as the introduction of the three contiguous stereocenters (C20, C5, and C6) in the conversion of silyl enol ether **79** to pentacyclic amine (–)-**81** occur with a high level of diastereoselection. To date, no other diastereomers have been detected. Introduction of the enone was accomplished by treatment of *N*-vinyl carbamate (–)-**83** with excess *p*-TsOH•H_2O and IBX[15] in benzene–DMSO at 65 °C for 10 h to provide carbamate (–)-**84** in 80% yield. Subsequent deprotection of (–)-*N*-Cbz GB 13 (**84**) with trimethylsilyl iodide (TMSI)[16] followed by an aqueous work-up provided synthetic GB 13 (**2**) in 89% yield (Scheme 11). All spectroscopic data for our enantiomerically enriched (–)-**2** matched literature data.[1,4a] The sign of rotation for our synthetic **2** ($[\alpha]^{22}_D$ = –64 (*c* 0.06, $CHCl_3$)), was consistent with that reported for the natural enantiomer ([α] = –84 ($CHCl_3$)[1b]), unambiguously securing the absolute stereochemistry. Synthesis of (+)-GB 13 (*ent*-**2**, $[\alpha]^{22}_D$ = +66 (*c* 0.07, $CHCl_3$)) using (+)-**64** (>99% ee) via the route described above confirmed our absolute stereochemical assignment. Interestingly, intramolecular amine conjugate addition at C19 was observed upon *N*-deprotection of **84** and acidic treatment. This conjugate addition was subject to reversion on mild base treatment (1N $NaOH_{aq}$, 1h).

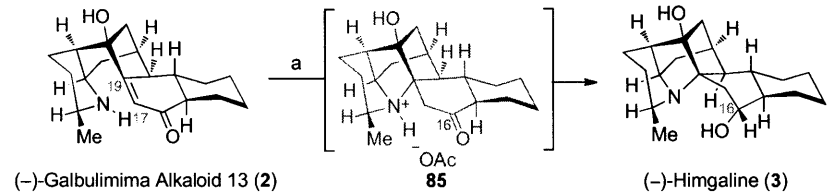
With access to pentacyclic amines (+)- and (–)-**81** (Scheme 11), we explored the synthesis of optically active 2-*epi*-GB 13 (2-*epi*-**2**) (Scheme 12). Interestingly, removal of the



Scheme 12. Synthesis of (–)-2-*epi*-16-oxohimgaline (2-*epi*-**21**). Conditions: (a) $ClCO_2Bn$, Na_2CO_3, H_2O, CH_2Cl_2, 54%. (b) IBX, $TsOH•H_2O$, benzene, DMSO, 65 °C, 10 h, 59%. (c) TMSI, CH_2Cl_2, 0 °C; HCl; NaOH, 23 °C, 93%.

nitrogen-protective group of (–)-2-*epi*-*N*-Cbz GB 13 (2-*epi*-**84**, Scheme 12), under identical conditions to those described for *N*-Cbz GB 13 (**84**), led to exclusive isolation of (–)-2-*epi*-16-oxohimgaline (2-*epi*-**21**, Scheme 12, $[\alpha]^{22}_D = -24$ (*c* 0.085, CH_2Cl_2)) even after treatment with base. Similarly, (+)-2-*epi*-16-oxohimgaline ($[\alpha]^{22}_D = +24$ (*c* 0.07, CH_2Cl_2)) was prepared from (+)-2-*epi*-**84**. The more facile conjugate addition observed with 2-*epi*-GB 13 (2-*epi*-**2**), compared to that seen with GB 13 (**2**, Scheme 11) is likely due to decreased steric interactions between the C2-substituent and the C17-methine in the 2-*epi* series. This observation further supports the hypothesis for the biosynthesis of himgaline (**3**) via sequential conjugate addition and carbonyl reduction of GB 13 (**2**).

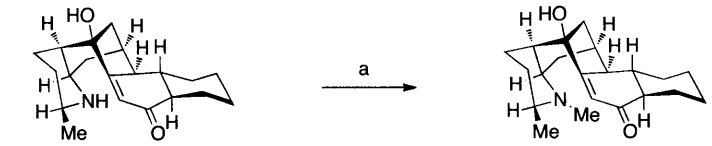
Immediately after we completed the total synthesis of (+)- and (–)-GB 13 (**2**), in Spring 2006, we synthesized (–)-himgaline (**3**) by converting (–)-galbulimima alkaloid 13 (**2**) to (–)-himgaline (**3**) in the presence of sodium triacetoxyborohydride and acetic acid (Scheme 13). In the event, intramolecular conjugate addition of the nitrogen onto the C17-C19 alkene occurred rapidly in the presence of acetic acid to provide the oxohimgaline intermediate **85**. Subsequent reduction with sodium triacetoxyborohydride[27] effected C16 carbonyl reduction diasteroselectively through intramolecular hydride delivery to give the (–)-himgaline (**3**) in 73% yield. All spectroscopic data for our enantiomerically enriched (–)-himgaline matched literature data.[1] The sign of rotation of our synthetic (–)-himgaline $[\alpha]^{22}_D = -82$ (*c* 0.11, $CHCl_3$) , was



Scheme 13. Total Synthesis of (–)-himgaline. Conditions: (a) $NaBH(OAc)_3$, CH_3CN, AcOH, 23 °C, 5 min, 73%.

consistent with that reported for the natural enantiomer [α] = – 76 ($CHCl_3$).[1]

Conversion of (–)-galbulimima alkaloid 13 (**2**) to (–)-himbadine (**4**) was achieved via reductive methylation in the presence of formalin and sodium triacetoxyborohydride. All spectroscopic data for our enantiomerically enriched (–)-himbadine matched literature data.[1] The sign of rotation of our synthetic (–)-himbadine $[\alpha]^{22}{}_D$ = – 47 (*c* 0.045, $CHCl_3$) , was consistent with that reported for the natural enantiomer [α] = 60 ($CHCl_3$).[1]



Scheme 14. Total synthesis of (–)-himbadine. Conditions: Formalin, CH_3CN, $NaBH(OAc)_3$, 50% (2 steps).

Conclusion

The total synthesis of all class III galbulimima alkaloids: (+)- and (–)-GB 13 (**2**), (–)-himgaline (**3**), and (–)-himbadine (**4**) has been described. The absolute stereochemistry of natural (–)-**2** is revised to 2*S*. Noteworthy features of this chemistry include a vinyl-radical cyclization strategy to secure the C-ring and the successful execution of our biomimetically inspired strategy for introduction of the CDE-ring system in **2** (**79**→**81**, Scheme 11).

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Experimental Section

General Procedures. All reactions were performed in oven-dried or flame-dried round bottomed flasks or modified Schlenk (Kjeldahl shape) flasks. The flasks were fitted with rubber septa and reactions were conducted under a positive pressure of argon. Stainless steel syringes or cannulae were used to transfer air- and moisture-sensitive liquids. Flash column chromatography was performed as described by Still et al. using silica gel (60-Å pore size, 32–63 μm, standard grade, Sorbent Technologies).[1] Where necessary (so noted), silica gel was neutralized by treatment of the silica gel prior to chromatography with the eluent containing 1% triethylamine. Analytical thin-layer chromatography was performed using glass plates pre-coated with 0.25 mm 230–400 mesh silica gel impregnated with a fluorescent indicator (254 nm). Where necessary (so noted), silica gel plates were neutralized by treatment with a solution of 5% triethylamine in dichloromethane followed by heating on a hot plate (~250 °C). Thin layer chromatography plates were visualized by exposure to ultraviolet light and/or by exposure to an ethanolic phosphomolybdic acid (PMA), an acidic solution of *p*-anisaldehyde (anis), an aqueous solution of ceric ammonium molybdate (CAM), an aqueous solution of potassium permanganate ($KMnO_4$) or an ethanolic solution of ninhydrin followed by heating (<1 min) on a hot plate (~250 °C). Organic solutions were concentrated on Büchi R-200 rotary evaporators at ~20 Torr at 25–35 °C, then at ~1 Torr unless otherwise indicated.

Materials. Commercial reagents and solvents were used as received with the following exceptions: dichloromethane, diethyl ether, tetrahydrofuran, acetonitrile, and toluene were purchased from J.T. Baker (Cycletainer™) and were purified by the method of Grubbs et al. under positive argon pressure.[2] Triethylamine, diisopropylethylamine, and benzene were distilled over calcium hydride immediately before use. Acrolein was distilled over calcium sulfate immediately before use. Methyl vinyl ketone was distilled over potassium carbonate and calcium chloride immediately prior to use. Martin sulfurane was purchased from Aldrich and stored in a glove box under nitrogen atmosphere. *N*-Bromosuccinimide (NBS) was recrystallized from boiling water prior to use. 2-Iodoxybenzoic acid (IBX) was prepared according to literature procedure.[3] Activated γ-manganese dioxide (MnO_2) was prepared according to literature procedure.[4] The molarity of *n*-butyllithium solutions was determined by titration using diphenylacetic acid as an indicator (average of three determinations).[5] Ammonia saturated dichloromethane was obtained by agitation of dichloromethane in the presence of ammonium hydroxide followed by drying over anhydrous sodium sulfate. Where necessary (so noted) solutions were deoxygenated by alternate freeze (liquid nitrogen)/evacuation/argon-flush/thaw cycles (FPT, three iterations) or degassed by purging with argon for several minutes.

Instrumentation. Proton nuclear magnetic resonance (^{1}H NMR) spectra were recorded with a Varian 300 Mercury or a Varian inverse probe 500 INOVA spectrometer or a Bruker inverse probe 600 Avance spectrometer. Chemical shifts are recorded in parts per million from internal

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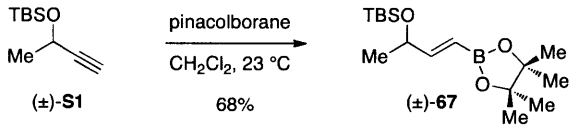
tetramethylsilane on the δ scale and are referenced from the residual protium in the NMR solvent ($CHCl_3$: δ 7.27, C_6D_5H: δ7.16). Data is reported as follows: chemical shift [multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, app = apparent, br = broad), coupling constant(s) in Hertz, integration, assignment]. Carbon-13 nuclear magnetic resonance (^{13}C NMR) spectra were recorded with a Varian 500 INOVA spectrometer or a Bruker 400 spectrometer with a Magnex Scientific superconducting magnet and are recorded in parts per million from internal tetramethylsilane on the δ scale and are referenced from the carbon resonances of the solvent ($CDCl_3$: δ 77.2, benzene-d_6: δ 128.4). Infrared data were obtained with a Perkin-Elmer 2000 FTIR and are reported as follows: [frequency of absorption (cm^{-1}), intensity of absorption (s = strong, m = medium, w = weak, br = broad), assignment]. Gas chromatography was performed on an Agilent Technologies 6890N Network GC System with a HP-5 5% Phenyl Methyl Siloxane column (50 °C, 6 min; 25 °C/min to 250 °C; 250 °C, 6 min). We are grateful to Dr. Li Li for obtaining the mass spectroscopic data at the Department of Chemistry's Instrumentation Facility, Massachusetts Institute of Technology. High-resolution mass spectra (HRMS) were recorded on a Bruker APEX 4.7 Tesler FTMS spectrometer using electronspray ion source (ESI) or electronspray (ES).

Compound Numbering. For compounds **2**, **63**, **65**, **79**, **81**, **82**, **83**, **84**, 2-*epi*-**83**, 2-*epi*-**21**, the atom numbering system used is consistent with correlated atoms in the final product as numbered in the isolation papers of the natural alkaloids.[6]

[6] Ritchie, E.; Taylor, W. C. In *The Alkaloids*; Manske, R. H. F., Ed.; Academic Press: New York, 1967; Vol. 9, Chapter 14.



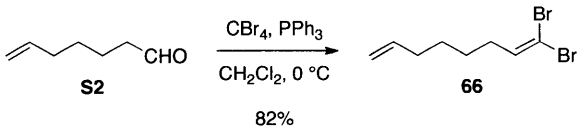
(±)-*trans*-2-[3-(*tert*-Butyl-dimethyl-silanyloxy)-but-1-enyl]-4,4,5,5-tetramethyl-[1,3,2]dioxaborolane (67):

Terminal alkyne **S1**[7] (4.70 g, 25.5 mmol, 1 equiv) was added dropwise via syringe to a solution of freshly prepared pinacolborane[8] in dichloromethane (5 M, 10 mL, 50.2 mmol, 2.00 equiv) at 0°C. The solution was stirred and allowed to warm to ambient temperature. After 24 h, the solution was partitioned between diethyl ether (300 mL) and saturated aqueous ammonium chloride solution (150 mL). The aqueous phase was extracted with diethyl ether (2 × 150 mL) and the combined organic phases were washed with saturated aqueous ammonium chloride solution (100 mL), were washed with brine (80 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification of the resulting oil by flash column chromatography (silica gel: diam. 9 cm, ht. 10 cm; eluent: hexanes:EtOAc [95:5] to hexanes:EtOAc [80:20]) provided boronate (±)-**67** (5.40 g, 68%) as a colorless oil.

^{1}H NMR (500 MHz, $CDCl_3$, 20°C):	6.60 (dd, J = 18, 4.0 Hz, 1H, C**H**=CHB), 5.63 (dd, J = 18, 1.7 Hz, 1H, CH=C**H**B), 4.37-4.32 (m, 1H, CH_3C**H**CH=CH), 1.28 (s, 6H, BOC($C\mathbf{H}_3$)CH_3), 1.28 (s, 6H, BOC(CH_3)$C\mathbf{H}_3$), 1.22 (d, J = 6.7 Hz, 3H, CHC$\mathbf{H}_3$), 0.91 (s, 9H, SiC($C\mathbf{H}_3$)$_3$), 0.05 (s, 6H, Si($C\mathbf{H}_3$)$_2$).
^{13}C NMR (125 MHz, $CDCl_3$, 20°C):	157.2 (B**C**=C), 83.3 (BC=**C**), 70.0 ((Me)$_2$**C**), 26.1, 25.0, 24.9, 23.9, 18.5, –4.5 (Si**C**H_3), –4.6 (Si**C**H_3).
FTIR (thin film) cm^{-1}:	2929 (m), 1996 (w), 1611 (w), 1370 (w), 1337 (w), 1146 (w).
HRMS (ESI):	calcd for $C_{16}H_{33}BNaO_3Si$ $[M+Na]^+$: 335.2184, found: 335.2177.
GC, t_R:	11.73 min
TLC (20% EtOAc in hexanes), *Rf*:	0.63 ($KMnO_4$)

[7] Prepared from 3-butynol, *tert*-butyldimethylsilylchloride, imidazole, dimethylformamide, 23 °C, 12h; see: Cotterill, A. S.; Gill, M.; Gimenez, A.; Milanovic N. M. *J. Chem. Soc., Perkin Trans. 1* **1994**, *22*, 3269.

[8] Pinacolborane was prepared according to Tucker, C. E.; Davidson, J.; Knochel, P. *J. Org. Chem.* **1992**, *57*, 3482.

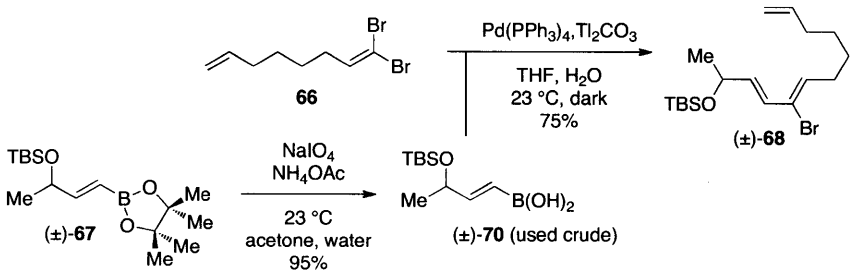


1,1-Dibromo-octa-1,7-diene (66):

Triphenylphosphine (6.34 g, 24.2 mmol, 2.40 equiv) was added in three portions to a solution of carbon tetrabromide (4.00 g, 12.1 mmol, 1.20 equiv) in dichloromethane (30 mL) at 0°C in an ice bath to produce a yellow-orange solution. The solution was stirred at 0 °C for 10 min. A solution of aldehyde **S2**[9] (1.12 g, 10.0 mmol, 1 equiv) in dichloromethane (6 mL) was introduced via cannula to the cold reaction mixture. The transfer was completed using a second 4–mL portion of dichloromethane and the mixture was vigorously stirred at 0°C. The solution became dark orange and white solid precipitated. After 1 h, excess dibromophosphorane was quenched by sequential addition of triethylamine (3.4 mL, 24 mmol, 2.4 equiv) and methanol (1.0 mL, 25 mmol, 2.5 equiv). The solution was allowed to warm to room temperature, transferred to a separatory funnel and added dropwise to a solution of ^{n}pentane–diethyl ether (5:1, 300 mL), resulting in precipitation of triphenylphosphine oxide. The resulting light brown solid was removed by filtration and washed with ^{n}pentane (100 mL). The combined organic filtrate was concentrated and purified by flash column chromatography (silica gel: diam. 5 cm, ht. 10 cm; eluent: hexanes:EtOAc [90:10]) to yield dibromide **66** as a colorless oil (2.21 g, 82%).

^{1}H NMR (500 MHz, $CDCl_3$, 20°C):	6.40 (t, J = 7.4 Hz, 1H, Br_2C=C**H**), 5.85-5.76 (m, 1H, **H**C=CH_2), 5.02 (app-dq, J = 17, 1.5 Hz, 1H, *trans*-HC=C**H**$_2$), 4.97 (m, 1H, *cis*-HC=C**H**$_2$), 2.14-2.05 (m, 4H, Br_2C=CHC**H**$_2$, H_2C=CHC**H**$_2$), 1.47-1.41 (m, 4H, CH_2(C**H**$_2$)$_2$$CH_2$).
^{13}C NMR (125 MHz, $CDCl_3$, 20°C):	138.9, 138.7, 114.9 (HC=**C**H_2), 88.9 (Br_2**C**=CH), 33.6, 33.0, 28.4, 27.4.
FTIR (thin film) cm^{-1}:	2928 (s), 2857 (m), 1641 (m), 911 (s), 804 (m), 780 (m).
HRMS–EI (*m/z*):	calcd for $C_8H_{13}Br_2$ $[M+H]^+$: 265.9300, found: 265.9324.
GC, t_R:	10.16 min
TLC (40% EtOAc in hexanes), *Rf*:	**S2**, 0.64 ($KMnO_4$) **66**, 0.75 (UV, $KMnO_4$)

[9] 6-Heptenal was prepared from 7-octene-1,2-diol (commercially available), sodium metaperiodate, diethyl ether, water, 1h, 93%. Spectroscopic data matched published data; see: Taylor, R. E.; Galvin, G. M.; Hilfiker, K. A.; Chen, Y. *J. Org. Chem.* **1998**, *63*, 9580.

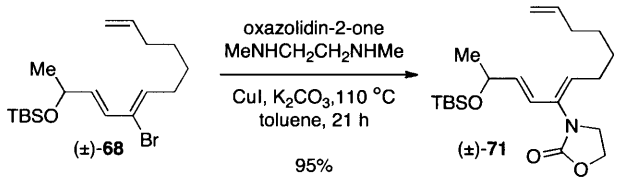


(±)-(2*E*,4*Z*)-(4-Bromo-1-methyl-undeca-2,4,10-trienyloxy)-*tert*-butyl-dimethyl-silane (68):

To a solution of boronate (±)-**67** (0.94 g, 3.0 mmol, 1 equiv) in acetone and water (30 mL, 2:1) was added sodium metaperiodate (2.0 g, 9.4 mmol, 3.1 equiv) and ammonium acetate (0.71 g, 9.2 mmol, 3.0 equiv). The resulting cloudy solution was stirred at ambient temperature. After 48 h, the reaction mixture was placed under reduced pressure to remove acetone, was diluted with ethyl acetate (100 mL) and the phases separated. The aqueous layer was extracted with ethyl acetate (100 mL) and the combined organic layers were washed with brine (50 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure to provide boronic acid (±)-**70** as a light brown oil (0.66 g, 95%). Dibromide **66** (150 mg, 0.56 mmol, 1 equiv) and crude boronic acid (±)-**70** (160 mg, 0.69 mmol, 1.2 equiv) were combined, dissolved in THF–water (3:1, 11 mL), and the solution was degassed thoroughly (FPT). Tetrakis(triphenylphosphine)palladium (33 mg, 0.028 mmol, 0.050 equiv) was added as a solid, light was excluded, and the resulting clear yellow solution was stirred for 5 min. Thallium carbonate (0.53 g, 1.1 mmol, 2.0 equiv) was added as a solid, and the resulting heterogeneous yellow-white mixture was stirred in the dark. After 25 h, the light tan reaction mixture was diluted with ethyl acetate and passed through a silica plug and the clear solution was concentrated. The resulting brown oil was purified by flash column chromatography (silica gel: diam. 2.5 cm, ht. 4 cm; eluent: hexanes:EtOAc [98:2] to hexanes:EtOAc [96:4]) to provide triene (±)-**68** as a yellow oil (156 mg, 75%).

^{1}H NMR (500 MHz, $CDCl_3$, 20°C):	6.19 (d, J = 14.6 Hz, 1H, BrCC**H**=CH), 6.03 (dd, J = 14.6, 4.8 Hz, 1H, BrCCH=C**H**), 5.91-5.75 (m, 2H, BrC=C**H**; CH_2=C**H**), 5.06-4.93 (m, 2H, CH_2=CH), 4.44 (m, 1H, TBSOC**H**CH_3), 2.35-2.28 (m, 2H, BrC=CHCH_2), 2.10-2.06 (m, 2H, CH_2=CHCH_2), 1.49-1.43 (m, 4H, (CH_2)$_2$), 1.25 (d, J = 6.4 Hz, 3H, CH_3), 0.92 (s, 9H, SiC(CH_3)$_3$), 0.08 (s, 3H, SiCH_3), 0.07 (s, 3H, SiCH_3).
^{13}C NMR (125 MHz, $CDCl_3$, 20°C):	138.9, 138.3, 133.7, 127.5, 125.2, 114.7, 68.5 (TBSOCH), 33.8, 31.6, 28.7, 28.1, 26.1 (C(CH_3)$_3$), 24.8, 18.5, –4.4 (SiCH_3), –4.5 (SiCH_3).
FTIR (thin film) cm^{-1}:	2955 (s), 2929 (s), 2857 (s), 1472 (w), 1462 (w), 1255 (m), 1149 (m), 1089 (m), 835 (s), 776 (s).

HRMS (ESI):	calcd for $C_{18}H_{33}NaBrOSi$ $[M+Na]^+$: 395.1376, found: 395.1365.
TLC (40% EtOAc in hexanes), *Rf*:	**70**, 0.26 ($KMnO_4$) **68**, 0.83 (UV, KMnO4)

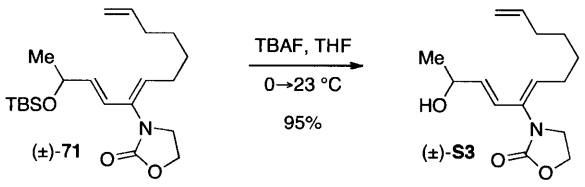


(±)-3-{(1*Z*)-1-[(*E*)-3-(*tert*-Butyl-dimethyl-silanyloxy)-but-1-enyl]-octa-1,7-dienyl}-oxazolidin-2-one (71):

Vinyl bromide (±)-**68** (3.10 g, 8.30 mmol, 1 equiv) was transferred in dry toluene to a flame-dried Schlenk pressure vessel, the solvent was removed under reduced pressure, and the vessel filled with argon. Oxazolidin-2-one (869 mg, 9.96 mmol, 1.20 equiv), copper iodide (790 mg, 4.15 mmol, 0.500 equiv), and potassium carbonate (2.29 g, 16.6 mmol, 2.00 equiv) were added under argon, and the vessel was evacuated and back-filled with argon three times. Dimethylethylenediamine (2.23 mL, 20.8 mmol, 2.50 equiv) and toluene (33 mL) were added. The reaction vessel was sealed under argon atmosphere and the green-gray heterogeneous mixture was heated to 110 °C. The solution turned slate-blue after five minutes, then light yellow-green. After 21 h, the solution was cooled to ambient temperature and partitioned between ethyl acetate (200 mL) and water (100 mL). The blue aqueous layer was extracted with ethyl acetate (3 × 150 mL), and the combined yellow organic layers were washed with brine (50 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting brown oil was purified by flash column chromatography (silica gel: diam. 7 cm, ht. 10 cm; eluent: CH_2Cl_2:acetone [99:1] to CH_2Cl_2:acetone [96:4] to CH_2Cl_2:acetone [85:15]) to provide triene (±)-**71** as a light yellow oil (2.98 g, 95%).

^{1}H NMR (500 MHz, C_6D_6, 20°C):	6.09 (dd, J = 15.4, 1.0 Hz, 1H, (TBSO)CHCH=C**H**), 5.77-5.69 (m, 1H, C**H**=CH_2), 5.63 (dd, J = 15.6, 5.5 Hz, 1H, (TBSO)CHC**H**=CH), 5.46 (t, J = 7.4 Hz, 1H, (N)C=C**H**), 5.04-4.97 (m, 2H, CH=C**H**$_2$), 4.27 (app-p, J = 6.1 Hz, 1H, (TBSO)C**H**), 3.55-3.51 (m, 2H, OC**H**$_2$$CH_2$N), 3.02-2.91 (m, 2H, OCH$_2$C**H**$_2$N), 2.04-1.98 (m, 2H, C**H**$_2$CH=CH$_2$), 1.94-1.90 (m, 2H, (N)C=CHC**H**$_2$), 1.28-1.24 (m, 4H, (C**H**$_2$)$_2$), 1.21 (d, J = 6.3 Hz, 3H, TBSOCHC**H**$_3$), 1.01 (s, 9H, SiC(C**H**$_3$)$_3$), 0.11 (s, 3H, Si(C**H**$_3$)$_2$), 0.10 (s, 3H, Si(C**H**$_3$)$_2$).
^{13}C NMR (125 MHz, C_6D_6, 20°C):	156.2 (O=**C**), 139.2, 134.5, 134.1, 134.0, 125.6, 115.1, 69.5, 61.9, 46.2, 34.3, 29.3, 28.8, 28.3, 26.5, (C(**C**H$_3$)$_3$), 25.2, 18.8, –4.0 (Si**C**H$_3$), –4.2 (Si**C**H$_3$).
FTIR (thin film) cm^{-1}:	2928 (w), 2856 (w), 1758 (s), 1414 (m), 1251 (w), 834 (m).
HRMS (ESI):	calcd for $C_{21}H_{37}NaNO_3Si$ [M+Na]$^+$: 402.2435, found: 402.2444.

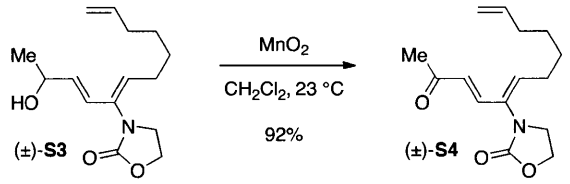
TLC (3% acetone in CH_2Cl_2), *Rf:*	**68**, 0.89 (UV, CAM) **71**, 0.54 (UV, CAM)



(±)-3-[(1*Z*)-1-((*E*)-3-Hydroxy-but-1-enyl)-octa-1,7-dienyl]-oxazolidin-2-one (S3):

A solution of tetrabutylammonium fluoride in THF (1M, 1.9 mL, 1.9 mmol, 1.5 equiv) was added to a solution of silyl ether (±)-**71** (487 mg, 1.28 mmol, 1 equiv) in THF (10 mL) at 0 °C. The resulting light yellow solution was vigourously stirred and allowed to warm to ambient temperature. After 3.5 h, the reaction mixture was diluted with ethyl acetate (50 mL), water (5 mL), and saturated aqueous ammonium chloride solution (25 mL). The aqueous layer was extracted with ethyl acetate (3 × 50 ml), and the combined organic layers were washed with brine (25 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting yellow oil was purified by flash column chromatography (silica gel: diam. 2.5 cm, ht. 6.5 cm; eluent: CH_2Cl_2:acetone [95:5] to CH_2Cl_2:acetone [80:20] to CH_2Cl_2:acetone [50:50]) to provide the alcohol (±)-**S3** as a clear oil (321 mg, 95%).

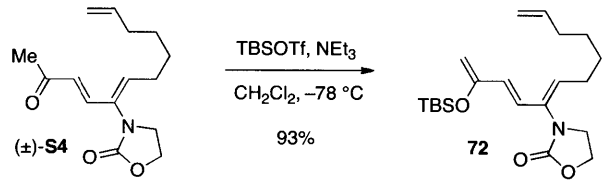
^{1}H NMR (500 MHz, C_6D_6, 20°C):	5.99 (d, J = 15.6 Hz, 1H, MeC(OH)CH=C**H**), 5.81-5.71 (m, 1H, C**H**=CH_2), 5.64 (dd, J = 15.6, 5.5 Hz, 1H, MeC(OH)C**H**=CH), 5.41 (t, J = 7.4 Hz, 1H, (N)C=C**H**), 5.07-4.97 (m, 2H, CH=C**H**$_2$), 4.24 (br-s, 1H, C**H**OH), 3.67-3.57 (m, 2H, OC**H**$_2$$CH_2$N), 2.97 (t, J = 8.0 Hz, 2H, OCH_2C**H**$_2$N), 2.36-2.18 (br-s, O**H**), 2.03-1.91 (m, 4H, (allylic C**H**$_2$), 1.32-1.25 (m, 4H, (C**H**$_2$)$_2$, 1.23 (d, J = 6.3 Hz, 3H, C**H**$_3$).
^{13}C NMR (125 MHz, C_6D_6, 20°C):	156.7 (O=**C**), 139.2 (C=**C**N), 134.5, 134.1, 128.7, 126.1, 115.1 (HC=**C**H_2), 68.3, 62.2, 46.2, 34.3, 29.3, 28.9, 28.2, 24.0.
FTIR (thin film) cm^{-1}:	3421 (br-m, OH), 2973 (w), 2927 (m), 2857 (w), 1741 (s, C=O), 1419 (s), 1247 (m), 1037 (m).
HRMS (ESI):	calcd for $C_{15}H_{23}NaNO_3$ $[M+Na]^+$: 288.1572, found: 288.1572.
TLC (10% acetone in CH_2Cl_2), *Rf*:	**71**, 0.75 (UV, CAM) **S3**, 0.16 (UV, CAM)



(±)-3-[(1*Z*)-1-((*E*)-3-Oxo-but-1-enyl)-octa-1,7-dienyl]-oxazolidin-2-one (S4):

γ-Manganese dioxide (1.21 g, 13.9 mmol, 11.7 equiv) was added under an argon atmosphere in one portion to a solution of alcohol (±)-**S3** (317 mg, 1.20 mmol, 1 equiv) in dichloromethane (6 mL) and the mixture was stirred at ambient temperature. After 19.5 h, the reaction mixture was diluted with dichloromethane and passed through celite. The resulting solution was concentrated under reduced pressure to provide spectroscopically clean ketone (±)-**S4** as a clear oil (289 mg, 92%). If desired, purification of ketone (±)-**S4** could be achieved via flash column chromatography (silica gel, eluent: CH_2Cl_2:acetone [98:2] to CH_2Cl_2:acetone [90:10]).

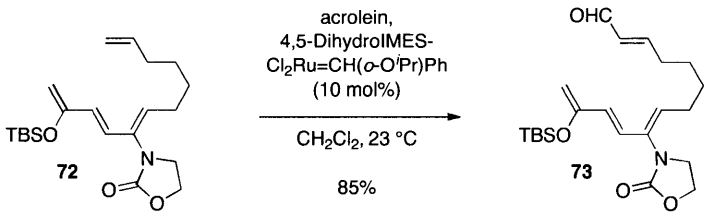
^{1}H NMR (500 MHz, C_6D_6, 20°C):	6.77 (d, J = 15.8 Hz, 1H, MeCOCH=C**H**), 6.00 (d, J = 15.8 Hz, 1H, MeCOC**H**=CH), 5.78-5.70 (m, 1H, C**H**=CH_2), 5.52 (t, J = 7.6 Hz, 1H, (N)C=C**H**), 5.06-4.99 (m, 2H, CH=C**H**$_2$), 3.47 (app-t, J = 7.8 Hz, 2H, OC**H**$_2$$CH_2$N), 2.73 (app-t, J = 7.8 Hz, 2H, OCH_2C**H**$_2$N), 1.94-1.90 (m, 7H, allylic-C**H**$_2$, allylic-C**H**$_2$, Me), 1.21-1.20 (m, 4H, (C**H**$_2$)$_2$).
^{13}C NMR (125 MHz, C_6D_6, 20°C):	196.6 (ketone-C=O), 156.1 (carbamate-C=O), 143.7, 140.2, 139.0, 134.1, 126.6, 115.3, 62.2 (O**C**$H_2$$CH_2$N), 46.0 ($OCH_2$**C**$H_2$N), 34.2, 29.3, 28.8, 28.3, 27.9.
FTIR (thin film) cm^{-1}:	2924 (m), 1754 (s, C=O), 1746 (s, C=O), 1666 (m), 1631 (m), 1599 (m), 1414 (s), 1251 (m).
HRMS (ESI):	calcd for $C_{15}H_{21}NaNO_3$ $[M+Na]^+$: 286.1414, found: 286.1421.
TLC (10% acetone in CH_2Cl_2), *Rf:*	**S3**, 0.16 (UV, CAM) **S4**, 0.42 (UV, CAM)



3-{(1*Z*)-1-[(*Z*)-3-(*tert*-Butyl-dimethyl-silanyloxy)-but-1,3 dienyl]-octa-1,7-dienyl}-oxazolidin-2-one (72):

Triethylamine (860 μL, 6.12 mmol, 1.50 equiv) was added to a solution of ketone (±)-**S4** (1.07 g, 4.08 mmol, 1 equiv) in dichloromethane (20 mL) at –78 °C, followed by dropwise addition of TBSOTf (1.12 mL, 4.89 mmol, 1.20 equiv). After 15 min, the excess silylating agent was quenched by the addition of saturated aqueous sodium bicarbonate solution (5 mL) and allowed to warm to ambient temperature. The reaction mixture was diluted with ethyl acetate (80 mL) and washed with saturated aqueous sodium bicarbonate solution (30 mL). The aqueous phase was extracted with ethyl acetate (4 × 75 mL), and the combined organic layers were washed with brine (20 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting oil was purified by flash column chromatography (neutralized silica gel: diam. 5 cm, ht. 9 cm; eluent: CH_2Cl_2:acetone [97:3]) to provide the silyl enol ether **72** as a white solid (1.44 g, 93%).

^{1}H NMR (500 MHz, C_6D_6, 20°C):	6.80 (d, J = 15.3 Hz, 1H, **H**C=CHCOTBS), 6.06 (d, J = 15.3 Hz, 1H, HC=C**H**COTBS), 5.76-5.68 (m, 1H, C**H**=CH_2), 5.60 (t, J = 7.4 Hz, 1H, (N)C=C**H**), 5.03-4.96 (m, 2H, CH=C**H**$_2$), 4.42 (s, 1H, C**H**$_2$=CHOTBS), 4.33 (s, 1H, C**H**$_2$=CHOTBS), 3.51 (app-t, J = 7.6 Hz. 2H, OC**H**$_2$CH$_2$N), 2.89 (app-t, J = 8.0 Hz, 2H, OCH$_2$C**H**$_2$N), 2.03-1.99 (m, 2H, C**H**$_2$CH=CH$_2$), 1.95-1.85 (m, 2H, (N)C=CHC**H**$_2$), 1.24-1.21 (m, 4H, (C**H**$_2$)$_2$), 1.02 (s, 9H, SiC(C**H**$_3$)$_3$), 0.18 (s, 6H, Si(C**H**$_3$)$_2$).
^{13}C NMR (125 MHz, C_6D_6, 20°C):	156.3, 155.6, 139.2, 136.1, 134.8, 127.3, 126.5, 115.1, 97.4, 62.1, 46.3, 34.2, 29.3, 28.7, 28.6, 26.4, 18.9, –4.2.
FTIR (thin film) cm^{-1}:	2930 (s), 2858 (s), 1759 (s, C=O), 1415 (m), 1316 (m), 1254 (m), 1030 (m), 840 (m).
HRMS (ESI):	calcd for $C_{21}H_{36}NO_3Si$ $[M+H]^+$: 378.2459, found: 378.2465.
TLC, *Rf*:	
(10% acetone in CH_2Cl_2, neutralized plates):	**S4**, 0.58 (UV, CAM) **72**, 0.79 (UV, CAM)

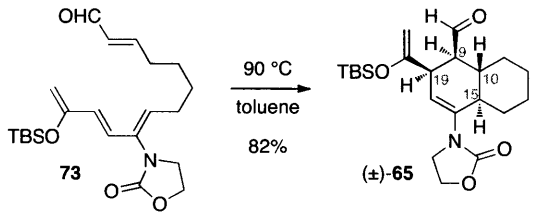


(2*E*,8*Z*,10*E*)-12-(*tert*-Butyl-dimethyl-silanyloxy)-9-(2-oxo-oxazolidin-3-yl)-trideca-2,8,10,12-tetraen-1-al (73):

To a solution of silyl enol ether **72** (500 mg, 1.32 mmol, 1 equiv) in dichloromethane (6.6 mL) was added freshly distilled acrolein (354 μL, 5.30 mmol, 4.00 equiv, no stabilizer present), followed by 4,5-(DihydroIMES)Cl2Ru=CH(*o*-O*i*Pr)Ph[10] (82 mg, 0.13 mmol, 0.10 equiv). The green solution was stirred at ambient temperature for 10 minutes, then purified immediately without concentration via flash column chromatography (neutralized silica gel: diam. 5 cm, ht. 8 cm; eluent: CH_2Cl_2:acetone:NEt_3 [98:1:1]) to provide the tetraene **73** as a tan solid (455 mg, 85%).

^{1}H NMR (500 MHz, C_6D_6, 20°C):	9.34 (d, J = 7.6 Hz, 1H, C**H**O), 6.71 (d, J = 15.3 Hz, 1H, **H**C=CHCOTBS) 6.07 (d, J = 15.3 Hz, 1H, HC=C**H**COTBS), 6.01 (dd, J = 15.6, 6.6 Hz, 1H, C**H**=CHCHO), 5.90 (dd, J = 15.6, 7.6 Hz, 1H, CH=C**H**CHO), 5.55 (t, J = 7.4 Hz, 1H, (N)C=C**H**), 4.43 (s, 1H, C**H**$_2$=CHOTBS), 4.34 (s, 1H, C**H**$_2$=CHOTBS), 3.55 (app-t, J = 7.9 Hz, 2H, OC**H**$_2$CH$_2$N), 2.90 (app-t, J = 7.4 Hz, 2H, OCH$_2$C**H**$_2$N), 1.93 (app-q, J = 7.2 Hz, 2H, C**H**$_2$CH=CH$_2$), 1.67 (app-q, J = 6.9 Hz, 2H, (N)C=CHC**H**$_2$), 1.11-0.94 (m, 13H, (C**H**$_2$)$_2$, SiC(C**H**$_3$)$_3$), 0.18 (s, 6H, Si(C**H**$_3$)$_2$).
^{13}C NMR (125 MHz, C_6D_6, 20°C):	193.2 (**C**HO), 157.5, 156.4, 155.5, 135.5, 135.0, 133.6, 127.0, 126.8, 97.5, 62.2, 46.3, 32.6, 28.5, 28.3, 27.9, 26.3, 18.8, –4.2.
FTIR (thin film) cm^{-1}:	2951 (s), 2930 (s), 2858 (m), 1753 (s), 1689 (s), 1414 (m), 1253 (m), 840 (m).
HRMS (ESI):	calcd for $C_{22}H_{35}NaNO_4Si$ $[M+Na]^+$: 428.2228, found: 428.2226.
TLC, *Rf*: (3% acetone in CH_2Cl_2, neutralized plates)	**72**, 0.63 (UV, CAM) **73**, 0.30 (UV, CAM)

[10] Garber, S. B.; Kingsbury, J. S.; Gray, B. L.; Hoveyda, A. H. *J. Am. Chem. Soc.* **2000**, *122*, 8168. Grubbs' G1 and G2 Ru-catalysts required above ambient temperatures found to be incompatible with the sensitive tetraene product **73**.



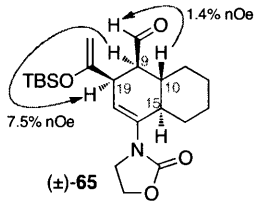
(±)-(9*S*, 10*R*, 15*R*, 19*S*)-*trans*-Decalin aldehyde (65):

A flame-dried Schlenk flask was charged with tetraene **73** (279 mg, 0.688 mmol, 1 equiv) and toluene (34 mL) and sealed under argon atmosphere. The vessel was heated to 90 °C. After 13 h, the solvent was removed under reduced pressure and the resulting oil was purified by flash column chromatography (neutralized silica gel: diam. 2.5 cm, ht. 8 cm; eluent: CH_2Cl_2:acetone:NEt_3 [94:5:1]) to provide the (±)-*trans*-decalin aldehyde **65** as a yellow oil (228 mg, 82%).

^{1}H NMR (500 MHz, C_6D_6, 20°C): 9.66 (d, J = 5.2 Hz, 1H, C**H**O), 5.01 (dd, J = 5.2, 2.1 Hz, 1H, NC=C**H**), 4.37 (d, J = 1.1 Hz, 1H, C=C$\mathbf{H}_2$), 4.34 (d, J = 1.0 Hz, 1H, C=C$\mathbf{H}_2$), 3.42-3.33 (m, 2H, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 2.98-2.95 (m, 1H, C**H**COTBS), 2.79 (q, J = 8.6 Hz, 1H, OCH$_2$C$\mathbf{H}_2$N), 2.50-2.45 (m, 1H, OCH$_2$C$\mathbf{H}_2$N), 2.33-2.28 (m, 1H, HCC(N)C**H**), 2.26-2.21 (m, 1H, CHOC**H**), 2.04-1.97 (m, 2H, CHOCHC**H**), 1.67-1.62 (m, 2H, (C$\mathbf{H}_2$)$_4$), 1.54-1.52 (m, 1H, (C$\mathbf{H}_2$)$_4$), 1.26 (qt, J = 13.2, 3.8 Hz, 1H, (C$\mathbf{H}_2$)$_4$), 1.17-1.09 (m, 1H, (C$\mathbf{H}_2$)$_4$), 1.03-0.92 (m, 1H, (C$\mathbf{H}_2$)$_4$), 0.97 (s, 9H, SiC(C$\mathbf{H}_3$)$_3$), 0.83 (qd, J = 3.8, 12.6 Hz, 1H, (C$\mathbf{H}_2$)$_4$), 0.14 (s, 3H, SiC$\mathbf{H}_3$), 0.12 (s, 3H, SiC$\mathbf{H}_3$).

^{13}C NMR (125 MHz, C_6D_6, 20°C): 203.6 (**C**HO), 158.2 (carbamate-**C**=O), 156.2, 140.8, 117.8, 95.4, 62.0 (O**C**H$_2$CH$_2$N), 53.9, 46.7 (OCH$_2$**C**H$_2$N), 44.4, 42.7, 37.4, 30.9, 27.2, 27.0, 26.4 (SiC(**C**H$_3$)$_3$, 18.8, –3.9 (Si**C**H$_3$), –4.3 (Si**C**H$_3$).

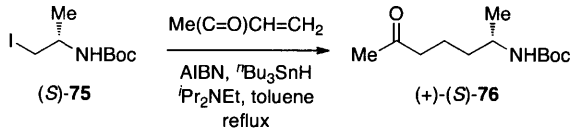
nOe data (500 MHz, C_6D_6, 20°C):



FTIR (thin film) cm^{-1}: 2929 (s), 2857 (m), 1756 (s), 1724 (s), 1408 (m), 1255 (m), 1220 (m), 837 (s).

HRMS (ESI): calcd for $C_{22}H_{36}NO_4Si$ $[M+H]^+$: 406.2408, found: 406.2403.

TLC, *Rf*:
(30% acetone in hexanes, neutralized plates) **73**, 0.26 (UV, CAM)
65, 0.33 (CAM)



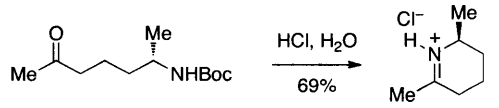
(+)-(*S*)-(1-Methyl-5-oxo-hexyl)-carbamic acid *tert*-butyl ester (76):

A solution of alkyl iodide (*S*)-**75**[11] (5.10 g, 17.7 mmol, 1 equiv) in toluene (95 mL) was treated sequentially with methyl vinyl ketone (9.40 mL, 115 mmol, 6.50 equiv) and diisopropylethylamine (10.0 mL, 88.5 mmol, 3.00 equiv). The reaction mixture was heated to reflux and a solution of tributyltin hydride (7.5 mL, 28 mmol, 1.6 equiv) and AIBN (0.40 g, 2.4 mmol, 0.15 equiv) in toluene (30 mL) was added via cannula. After heating at reflux for 1 h, the reaction mixture was cooled to ambient temperature and triethylamine (10 mL) was added. Excess tributyltin hydride was quenched by dropwise addition of a solution of iodine in toluene (0.2 M, 0.5 mL) until an orange color persisted. The orange solution was stirred for 10 min, then a solution of potassium fluoride (5.2 g) in water (40 mL) was added, and the resulting suspension was stirred for 1.5 h. The reaction mixture was filtered through celite, and the filtrate was partitioned between diethyl ether (100 mL) and water (50 mL). The aqueous layer was extracted with diethyl ether (3 × 100 mL) and the combined organic layers were washed sequentially with saturated aqueous sodium bicarbonate solution (20 mL) and brine (20 mL). The organic phases were dried over anhydrous sodium sulfate, were filtered and were concentrated under reduced pressure. Purification of the yellow residue by flash chromatography (silica gel: diam. 7, ht. 15 cm; eluent: hexanes:EtOAc [1:1]) afforded the ketone (+)-(*S*)- **76** as a brown solid (2.2 g, 53%, $[\alpha]^{22}_D = +3$ (*c* 0.5, EtOAc)).

The corresponding enantiomer, ketone (–)-(*R*)-**76** (6.9 g, 59%, $[\alpha]^{22}_D = -3$ (*c* 0.5, EtOAc)), was prepared using the same procedure and starting with alkyl iodide (*R*)-**75**.

^{1}H NMR (500 MHz, $CDCl_3$, 20°C):	4.33 (br-s, 1H, N**H**Boc), 3.65 (br-s, 1H, $(CH_3)C\mathbf{H}NH$), 2.52-2.40 (m, 2H, $C(O)C\mathbf{H}_2$), 2.14 (s, 3H, $C\mathbf{H}_3C(O)$, 1.66-1.54 (m, 3H, $C\mathbf{H}_2C(CH_3)$, $(CH_3)CHCH_2C\mathbf{H}_2$), 1.45 (s, 9H, $C(C\mathbf{H}_3)_3$), 1.44-1.38 (m, 1H, $C\mathbf{H}_2C(CH_3)$), 1.12 (d, 3H, J = 6.6 Hz, $CH(C\mathbf{H}_3)$).
^{13}C NMR (125 MHz, $CDCl_3$, 20°C):	209.1, 155.6, 79.2, 46.3, 43.4, 36.7, 30.2, 28.6, 21.4, 20.3.
FTIR (thin film), cm^{-1}:	3351 (m, N-H), 2975 (m), 1710 (br-s, C=O), 1523 (m), 1172 (m).
HRMS (EI):	calcd for $C_{12}H_{24}NO_3$ $[M+H]^+$: 230.1751, found: 230.1752.
TLC (50% EtOAc in hexane):	**75**, 0.73 (ninhydrin, UV) **76**, 0.52 (ninhydrin, anis)

[11] Prepared from L-alaninol; see: Caputo, R.; Cassano, E.; Longobardo, L.; Palumbo, G. *Tetrahedron* **1995**, *51*, 12337.



(+)-(*S*)-**76** (–)-(2*S*)-**64**

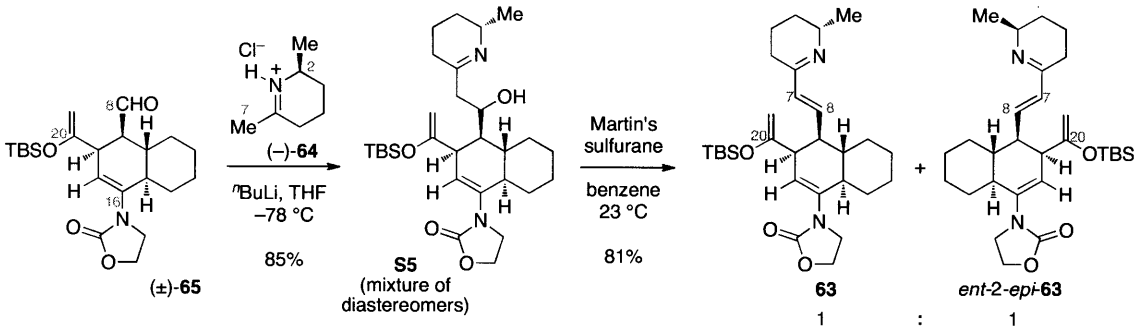
(–)-(2*S*)-2,6-Dimethyl-2,3,4,5-tetrahydro-pyridinium chloride (64):

The *N*-Boc ketone (+)-(*S*)-**76** (3.40 g, 14.9 mmol, 1 equiv) was dissolved in aqueous hydrochloric acid (10M, 60.0 mL). After stirring for 12 h, the reaction mixture was concentrated under reduced pressure (1 Torr) to give a dark brown oil. This residue was triturated from THF (2 × 10 mL) to provide the iminium chloride (–)-(2*S*)-**64** as a beige solid (1.5 g, 69%, $[\alpha]^{22}_D$ = –19 (*c* 0.5, EtOAc)) and vigorously dried. [12] The optical activity of (–)-**64** was measured to be >99% ee by chiral HPLC analysis of the corresponding benzylated derivative[13] [(*S*,*S*)-Whelk-O; 3.0 mL/min; 13% ^{i}PrOH in hexanes; t_R(major) = 19.53 min; t_R(minor, not seen) = 17.64 min].

The corresponding enantiomer, iminium chloride (+)-(2*R*)-**64** (0.4 g, 81%, $[\alpha]^{22}_D$ = +19 (*c* 0.5, EtOAc)), was prepared using the same procedure and starting with *N*-Boc ketone (–)-(*R*)-**76**. The optical activity of (+)-**64** was measured to be >99% ee by chiral HPLC analysis of the corresponding benzylated derivative[13] [(*S*,*S*)-Whelk-O; 3.0 mL/min; 13% ^{i}PrOH in hexanes; t_R(major) = 17.64 min; t_R(minor, not seen) = 19.53 min][14].

^{1}H NMR (500 MHz, $CDCl_3$, 20°C):	15.24 (m, 1H, C=N**H**$^+$), 3.97 (br-s, 1H, NH$^+$C**H**(CH$_3$)CH$_2$), 2.64 (br-s, 5H, (C**H**$_3$)CNH$^+$=C, CH$_3$CC**H**$_2$), 2.08-2.02 (m, 1H, (CH$_3$)CC**H**$_2$), 1.97-1.90 (m, 1H, (CH$_3$)CC**H**$_2$), 1.84-1.76 (m, 1H, HN$^+$=CCH$_2$C**H**$_2$), 1.61 (d, 3H, *J* = 6.8 Hz, C(C**H**$_3$), 1.58-1.55 (m, 1H, HN$^+$=CCH$_2$C**H**$_2$).
^{13}C NMR (125 MHz, $CDCl_3$, 20°C):	186.6, 51.9, 31.6, 27.5, 24.4, 20.1, 16.0.
FTIR (thin film), cm^{-1}:	3406 (br-s, N-H), 2936 (m), 2839 (m), 1686 (m), 1457 (w), 1386 (w).
HRMS (EI):	calcd for $C_7H_{14}N$ [M-Cl]$^+$: 112.1121, found: 112.1120.

[12] Iminium chloride **64** was highly hygroscopic and required handling under inert atmosphere for optimal results.
[13] Iminium chloride **64** was lithiated and acylated with benzoyl chloride to give the corresponding vinylogous amide.
[14] Additionally, to ensure elution of the major compound after the minor compound, the (*R*,*R*)-Whelk-O was also used: [(*R*,*R*)-Whelk-O; 3.0 mL/min; 13% ^{i}PrOH in hexanes; t_R(major) = 20.34 min; t_R(minor, not seen) = 19.39 min].



3-{3-[1-*tert*-Butyl-dimethyl-silanyloxy)-vinyl]-4-[2-(6-methyl-3,4,5,6-tetrahydro-pyridin-2-yl)-vinyl]-3,4,4a,5,6,8,8s-octahydro-naphthalene-1-yl}-oxazolidin-2-one (63):

To a suspension of iminium chloride (–)-(2*S*)-**64** (101 mg, 0.68 mmol, 2.00 equiv) in THF at –78 °C and sealed under argon[15] was added a solution of *n*-butyllithium in hexanes (2.53 M, 520 μL, 1.32 mmol, 3.87 equiv). The resulting brown solution was maintained at –78 °C for 30 min, was warmed to 0 °C for 10 min, then cooled to –78 °C. A sample of aldehyde (±)-**65** (137 mg, 0.34 mmol, 1 equiv) in a round-bottomed flask was azeotropically dried from toluene (2 × 4 mL), the flask was evacuated and backfilled with argon three times, charged with THF (700 μL), and cooled to –78 °C. The lithiated enamine solution was transferred cold via cannula to the cold aldehyde solution. After ten minutes excess anion was quenched at –78 °C by the addition of saturated aqueous ammonium chloride solution (2 mL) and the reaction mixture was allowed to warm to room temperature. The reaction mixture was diluted with ethyl acetate (40 mL) and saturated aqueous ammonium chloride solution (15 mL) and the layers separated. The aqueous layer was extracted with ethyl acetate (2 × 40 mL) and the combined organic layers were washed with brine (15 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting yellow oil was purified by flash column chromatography (neutralized silica gel: diam. 2.5 cm, ht. 10 cm; eluent: CH_2Cl_2:acetone:NEt_3 [98:1:1] to CH_2Cl_2:acetone:NEt_3 [97:2:1] to CH_2Cl_2:acetone:NEt_3 [96:3:1]) to provide β–hydroxyimine **S5** (168 mg, 85%, equal mixture of 4 diastereomers) as a light yellow oil. Additionally, the starting aldehyde (±)-**65** was recovered (8.1 mg, 6%).

A solution of Martin sulfurane (219 mg, 0.326 mmol, 1.18 equiv) in benzene (2 mL) under argon atmosphere,[15] was transferred via cannula to a solution of β–hydroxyimine **S5** (153 mg, 0.276 mmol, 1 equiv) in benzene (4 mL) at 23 °C. After 25 min, the reaction mixture was concentrated under reduced pressure, and the resulting oil was purified by flash column chromatography (neutralized silica gel: diam. 5 cm, ht. 18 cm; eluent: hexanes:acetone:NEt_3 [89:10:1] to acetone:hexanes:NEt_3 [84:15:1] to acetone:hexanes:NEt_3 [74:25:1] to acetone:hexanes:NEt_3 [64:35:1]) to provide the α,β-unsaturated imines (119 mg, 81%, **63**:*ent*-2-*epi*-**63**, ~1:1) as a yellow oil.

The corresponding enantiomers of the β–hydroxyimine (203 mg, 70%, equal mixture of 4 diastereomers) and the α,β-unsaturated imine (167 mg, 85%, *ent*-**63**:2-*epi*-**63**, ~1:1) were prepared using the same procedure and the imine salt (+)-(2*R*)-**64**.

[15] Rigorous inert atmosphere and anhydrous conditions were required for optimal results.

^{1}H NMR (500 MHz, C_6D_6, 20°C, equal mixture of two diastereomers, **63**:*ent*-2-*epi*-**63**, ~1:1): 6.46 (d, J = 4.6 Hz, 1H, C7-H), 6.43 (d, J = 4.6 Hz, 1H, C7-H), 6.13-6.05 (m, 2H, C8-H, C8-H), 5.14-5.11 (m, 2H, C17-H, C17-H), 4.29 (br-s, 2H, C21-H, C21-H), 3.62-3.52 (m, 2H, C2-H, C2-H), 3.46-3.41 (m, 4H, OCH_2CH_2N, OCH_2CH_2N), 2.95-2.89 (m, 2H, OCH_2CH_2N, OCH_2CH_2N), 2.79-2.75 (m, 2H, C19-H, C19-H), 2.65-2.60 (m, 2H, OCH_2CH_2N, OCH_2CH_2N), 2.40-2.31 (m, 4H, C5-H, C5-H, C15-H, C15-H), 2.19-2.07 (m, 6H, C5-H, C5-H, C9-H, C9-H, CH_2, CH_2), 2.01-1.94 (m, 2H, C10-H, C10-H), 1.86-1.71 (m, 8H, CH_2, CH_2), 1.57-1.49 (m, 8H, C3-H, C3-H, C4-H, C4-H), 1.39 (br-s, 3H, C1-H), 1.38 (br-s, 3H, C1-H), 1.36-1.21 (m, 6H, CH_2, CH_2), 0.97 (br-s, 18H, $SiC(CH_3)_3$), 0.19 (br-s, 3H, $Si(CH_3)_2$), 0.18 (br-s, 3H, $Si(CH_3)_2$), 0.17 (br-s, 3H, $Si(CH_3)_2$), 0.17 (br-s, 3H, $Si(CH_3)_2$).

^{13}C NMR (125 MHz, C_6D_6, 20°C, equal mixture of two diastereomers, **63**:*ent*-2-*epi*-**63**, ~1:1): 163.99, 163.98, 159.64, 159.63, 156.01, 155.99, 140.46 (br-s, 2 carbons), 137.99 (C8), 137.95 (C8), 136.26 (C7), 136.19 (C7), 119.44 (C17), 119.25 (C17), 94.39 (C21), 94.34 (C21), 61.80 (br-s, 2 carbons, OCH_2CH_2N, OCH_2CH_2N), 54.53, 54.41, 48.05 (C19), 48.04 (C19), 46.82 (OCH_2CH_2N), 46.78 (OCH_2CH_2N), 46.63 (C9), 46.60 (C9), 43.21 (C15), 43.16 (C15), 40.39 (C10), 40.36 (C10), 31.74 (C11), 31.67 (C11), 30.65 (C14), 30.61 (C14), 30.42, 30.37, 27.39, 27.36, 27.11 (br-s, 2 carbons), 26.31, 26.29, 25.88, 25.85, 24.30, 24.26, 19.66, 19.47, 18.69 ($SiC(CH_3)_3$), –4.03 ($Si(CH_3)_2$),–4.05 ($Si(CH_3)_2$), –4.17 ($Si(CH_3)_2$), –4.23 ($Si(CH_3)_2$).

FTIR (thin film, equal mixture of two diastereomers, **63**:*ent*-2-*epi*-**63**, ~1:1) cm^{-1}: 2929 (s), 2856 (m), 1756 (s), 1615 (m), 1406 (m), 1259 (m), 1215 (m), 839 (s).

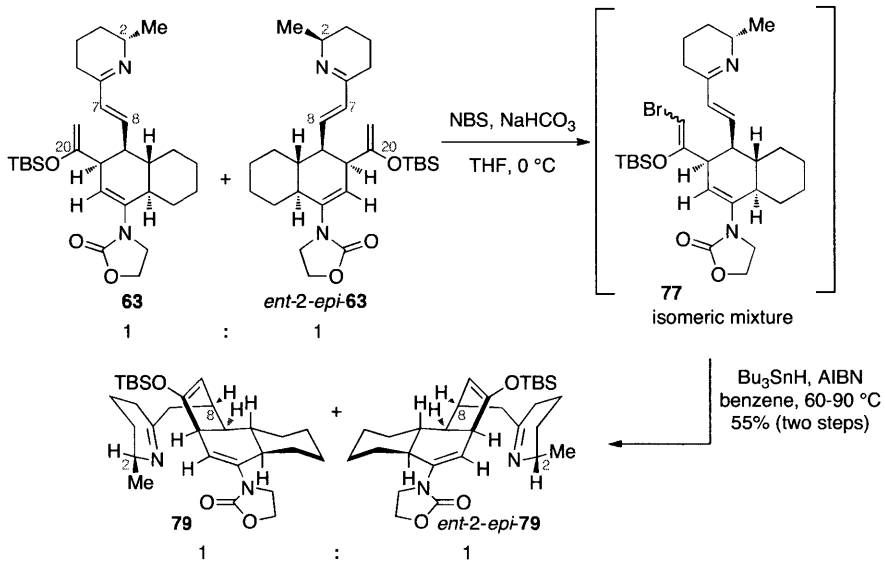
HRMS (ESI, **S5**): calcd for $C_{29}H_{47}N_2O_4Si$ $[M+H]^+$: 517.3456, found: 517.3464.

HRMS (ESI, **63**:*ent*-2-*epi*-**63**, ~1:1): calcd for $C_{29}H_{46}N_2O_3Si$ $[M]^+$: 499.3351, found: 499.3354.

TLC Rf (neutralized plates):

(CH_2Cl_2:acetone:NEt_3 [96:3:1]) **65**, 0.59 (CAM)
S5, 0.21 (CAM)

(hexanes:acetone:NEt_3 [69:30:1]) **S5**, 0.40 (UV, CAM)
63 and *ent*-2-*epi*-**63,** 0.44 (UV, CAM)



3-[3-(*tert*-Butyl-dimethyl-silanyloxy)-1-(6-methyl-3,4,5,6-tetrahydro-pyridin-2-ylmethyl)-3a,5a,6,7,8,9,9a,9b-octahydro-1*H*-cyclopenta[*a*]naphthalen-5-yl]-oxazolidin-2-one (79 and *ent*-2-*epi*-79):

A solution of α,β–unsaturated imine **63** (119 mg, 0.238 mmol, 1 equiv, equal mixture of **63** and *ent*-2-*epi*-**63**) in THF (12 mL) was degassed via an argon purge. To this solution was added solid sodium bicarbonate (106 mg, 1.26 mmol, 5.29 equiv) under argon. The reaction mixture was cooled to 0 °C, light was excluded, and NBS (50.5 mg, 0.284 mmol, 1.19 equiv) was added as a solid. The reaction mixture was maintained at 0 °C for ten minutes, then diluted with hexanes:acetone:NEt_3 ([50:50:1], 10 mL), was filtered cold through a silica plug (diam. 1 cm, ht. 2.5 cm) and the filtrate was concentrated under reduced pressure to produce an orange-brown foam. This residue was dissolved in benzene and filtered to remove excess insoluble succinimide. It was then concentrated and placed under reduced pressure (~ 0.5 Torr) for 1 h. The resulting brominated product was used crude for the cyclization step.

The crude vinyl bromide was dissolved in benzene-d_6[16] (4.8 mL), was degassed via an argon purge, and was charged with tributyltin hydride (192 μL, 0.722 mmol, 3.00 equiv). A solution of AIBN in benzene-d_6 (0.30M) was prepared in a flame-dried flask, degassed via bubbling argon, and a portion[17] (200 μL, 0.060 mmol, 0.25 equiv) was transferred to the reaction mixture. The reaction solution was placed in a pre-heated 60 °C oil bath and heated to 90 °C over 20 min. After 30 min, the reaction mixture was cooled, an additional portion of AIBN was added (200 μL, 0.060 mmol, 0.25 equiv), and the mixture was returned to 90 °C. After a subsequent 20 min, the solution was cooled, additional tributyltin hydride (96 μL, 0.36 mmol, 1.5 equiv) and AIBN (400 μL, 0.030 mmol, 0.50 equiv) were added, and the reaction was returned to 90 °C. After 20 min, the reaction was cooled, a final portion of AIBN was added (400 μL, 0.030 mmol, 0.50 equiv), and the mixture was returned to 90 °C. After an additional 20 min at 90 °C, the reaction appeared complete by direct ^{1}H NMR spectral analysis. The reaction solution was cooled, triethylamine (1 mL) was added to neutralize adventitious hydrobromic

[16] Deuterated solvent was used to facilitate evaluation of reaction progress by direct ^{1}H NMR monitoring.
[17] Sequential addition of the reagents was necessary for optimal results.

acid, and the solution was concentrated to ~400 μL under reduced pressure. The resulting brown oil was purified via flash column chromatography (neutralized silica gel: diam. 2.5 cm, ht. 10 cm; eluent: hexanes:acetone:NEt_3 [97:2:1] to acetone:hexanes:NEt_3 [95:4:1] to acetone:hexanes:NEt_3 [92:7:1] to acetone:hexanes:NEt_3 [84:15:1]) to provide an equal mixture of two diastereomeric tetracycles **79** and *ent*-2-*epi*-**79** as a tan foam (65.7 mg, 55% (two steps)). The corresponding enantiomers, tetracycles *ent*-**79** and 2-*epi*-**79** (90 mg, 54% (two steps), (~1:1)) were prepared using the same procedure and starting with α,β-unsaturated imines *ent*-**63**:2-*epi*-**63**, (~1:1)).

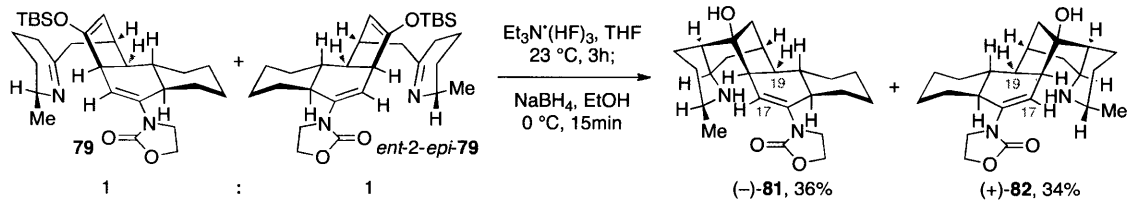
^{1}H NMR (500 MHz, C_6D_6, 20°C, equal mixture of two diastereomers, **79**:*ent*-2-*epi*-**79**, ~1:1): 5.66-5.63 (m, 2H, C17-H, C17-H), 4.83 (app-t, J = 2.9 Hz, 1H, C21-H), 4.70 (app-t, J = 2.9 Hz, 1H, C21-H), 3.46-3.35 (m, 8H, OCH_2CH_2N, OCH_2CH_2N, C2-H, C2-H, C19-H, C19-H), 3.11-3.05 (m, 2H, OCH_2CH_2N, OCH_2CH_2N), 2.99-2.94 (m, 1H, C8-H), 2.94-2.88 (m, 1H, C8-H), 2.74-2.69 (m, 2H, OCH_2CH_2N, OCH_2CH_2N), 2.50-2.44 (m, 2H, C15-H, C15-H), 2.21-2.15 (m, 4H, C7-H, C7-H, CH_2, CH_2), 2.15-2.09 (m, 2H, CH_2, CH_2), 2.09-2.02 (m, 2H, CH_2, CH_2), 1.79-1.65 (m, 8H, C9-H, C9-H, CH_2, CH_2), 1.56-1.43 (m, 4H, CH_2, CH_2), 1.43-1.26 (m, 4H, C10-H, C10-H, CH_2, CH_2), 1.36 (d, J = 6.7 Hz, 3H, C1-H), 1.35 (d, J = 6.7 Hz, 3H, C1-H), 1.24-1.11 (m, 4H, CH_2, CH_2), 1.01 (br-s, 18H, $SiC(CH_3)_3$), 0.99-0.83 (m, 8H, CH_2, CH_2), 0.21 (s, 3H, $SiCH_3)_2$), 0.20 (s, 3H, $SiCH_3)_2$), 0.19 (s, 3H, $SiCH_3)_2$), 0.18 (s, 3H, $SiCH_3)_2$).

^{13}C NMR (125 MHz, C_6D_6, 20°C, equal mixture of two diastereomers, **79**:*ent*-2-*epi*-**79**, ~1:1): 167.31, 167.16, 156.35 (br-s, 2 carbons), 155.48, 155.24, 139.62 (br-s, 2 carbons), 128.93 (br-s, 2 carbons), 118.02, 117.96, 105.25, 104.82, 61.89 (br-s, 2 carbons), 53.97, 53.84, 47.27, 47.24, 46.95, 46.82, 44.87, 44.76, 43.99, 43.95, 43.63 (br-s, 2 carbons), 32.10, 32.01, 30.36 (br-s, 2 carbons), 30.29, 30.24, 30.14, 30.05, 27.38 (br-s, 2 carbons), 27.36, 27.34, 26.34, 26.32, 24.42, 24.38, 19.84, 19.67, 18.76, 18.73, –4.17, –4.18, –4.20, –4.21.

FTIR (thin film, equal mixture of two diastereomers, **79**:*ent*-2-*epi*-**79**, ~1:1) cm^{-1}: 3397 (br-w), 2928 (s), 2856 (m), 1758 (s, C=O), 1650 (m), 1408 (m), 1254 (m), 1212 (w), 865 (m), 841 (m), 782 (w).

HRMS (ESI): calcd for $C_{29}H_{47}N_2O_3Si$ $[M+H]^+$: 499.3351, found: 499.3357.

TLC, *Rf*:
(30% acetone in hexanes, neutralized plates) **79**, 0.44 (UV, CAM)
ent-2-*epi*-**79**, 0.51 (UV, CAM)



Pentacyclic amines (–)-81 and (+)-82:

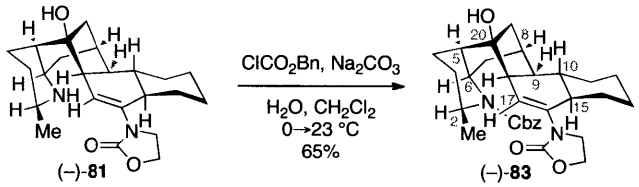
To a solution of tetracycle **79** (65.7 mg, 0.132 mmol, 1 equiv, equal mixture of **79** and *ent*-2-*epi*-**79**) in THF (13 mL) at 23 °C was added triethylamine trihydrogen fluoride (107 μL, 0.660 mmol, 5.00 equiv). After 3 h, the solution was cooled to 0 °C and the volatiles were removed under reduced pressure on a manifold and allowed to warm to ambient temperature (3 h). The crude reaction mixture was dissolved in ethanol (10 mL) and cooled to 0 °C. A suspension of sodium borohydride (10 mg, 0.26 mmol, 2.0 equiv) in ethanol (2 mL) was added dropwise to the cold reaction mixture under an argon atmosphere. The resulting solution was stirred at 0 °C for ten minutes, then excess hydride was quenched at 0 °C by the addition of ethanolic hydrochloric acid (0.5 M, 1.5 mL) and the solution was vigorously stirred for five minutes. The reaction mixture was neutralized by the addition of triethylamine (2 mL), was stirred for five minutes, and the volatiles were removed under reduced pressure on a manifold (1 h). The resulting white solid was dissolved in ethyl acetate (50 mL), saturated aqueous sodium bicarbonate solution (25 mL) and water (5 mL). The layers were separated and the aqueous layer was extracted with ethyl acetate (3 × 50 mL). The combined organic layers were washed with brine (10 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification of the resulting yellow oil via flash column chromatography (neutralized silica gel: diam. 1 cm, ht. 10 cm; eluent: CH_2Cl_2:methanol [95:5] to ammonia saturated CH_2Cl_2:methanol [92:8]) afforded the readily separable pentacyclic amines (–)-**81** (18.4 mg, 36%, $[\alpha]^{22}_D = -29$ (*c* 0.44, CH_2Cl_2)) and (+)-**82** (17.3 mg, 34%, $[\alpha]^{22}_D = +65$ (*c* 0.43, CH_2Cl_2)).

The corresponding enantiomeric amines, (+)-**81** and (–)-**82** (20.0 mg and 25.0 mg, respectively, 66%), were obtained using the same procedure and starting with a mixture of *ent*-**79** and 2-*epi*-**79** (~1:1).

^{1}H NMR (500 MHz, C_6D_6, 20°C): Pentacyclic amine (–)-**81**: 6.09 (br-s, 1H, C17-H), 3.85-3.80 (m, 1H, C19-H), 3.50 (app-q, J = 7.4 Hz, 1H, OC**H**$_2$CH$_2$N), 3.44 (app-q, J = 6.6 Hz, 1H, OC**H**$_2$CH$_2$N), 3.02-2.91 (m, 2H, OCH$_2$C**H**$_2$N), 2.79-2.71 (m, 2H, OCH$_2$C**H**$_2$N), 2.42-2.33 (m, 1H), 2.13 (t, J = 9.8 Hz, 1H), 2.00-1.94 (m, 1H), 1.90-1.84 (m, 2H), 1.74 (ddd, J = 14.0, 6.2, 3.6 Hz, 1H), 1.71-1.61 (m, 2H), 1.56-1.46 (m, 2H), 1.44-1.31 (m, 3H), 1.23-1.09 (m, 6H), 0.98-0.88 (m, 2H) 0.85 (d, J = 6.2 Hz, 3H, C1-H).

^{1}H NMR (500 MHz, C_6D_6, 20°C): Pentacyclic amine (+)-**82**: 6.00 (br-s, 1H, C17-H), 3.70-3.65 (m, 1H, C19-H), 3.56-3.46 (m, 2H, OC**H**$_2$CH$_2$N), 3.26 (t, J = 6.1 Hz, 1H, C6-H), 3.07 (app-q, J = 6.3 Hz, 1H, C2-H), 3.04-2.96 (m, 1H,

	$OCH_2C\mathbf{H}_2N$), 2.77 (app-q, J = 6.5 Hz, 1H, $OCH_2C\mathbf{H}_2N$), 2.07-1.67 (m, 11H), 1.30-1.09 (m, 6H), 1.09-1.02 (m, 2H), 1.00-0.98 (m, 2H), 0.93 (d, J = 6.5 Hz, 3H, C1-H).
^{13}C NMR (125 MHz, C_6D_6, 20°C):	Pentacyclic amine (–)-**81**: 157.4 (carbamate C=O), 137.5 (C16), 128.9 (C17), 80.6 (C20), 61.7 ($O\mathbf{C}H_2CH_2N$), 56.2, 53.8, 47.8, 47.6, 46.3, 45.8, 45.1, 42.1, 40.6, 40.1, 38.1, 33.8, 31.6, 29.4, 27.1, 26.9, 24.0, 23.4.
^{13}C NMR (125 MHz, C_6D_6, 20°C):	Pentacyclic amine (+)-**82**: 157.5 (carbamate C=O), 138.0 (C16), 128.9 (C17), 81.1 (C20), 61.9 ($O\mathbf{C}H_2CH_2N$), 48.6, 48.0, 47.3, 46.2, 44.0 (br), 40.9, 40.6, 40.0 (br), 37.6, 33.9, 29.7, 28.2, 27.3, 27.1, 21.1, 20.6.
FTIR (thin film) cm^{-1}:	Pentacyclic amine (–)-**81**: 3430 (br-s, OH), 2926 (s), 2855 (m), 1748 (s), 1662 (m), 1481 (w), 1447 (w), 1413 (m), 1279 (w), 1101 (m), 735 (m).
FTIR (thin film) cm^{-1}:	Pentacyclic amine (+)-**82**: 3424 (br-s, OH), 2926 (s), 2856 (m), 1743 (s), 1666 (w), 1482 (w), 1446 (w), 1416 (m), 1280 (w), 1101 (w), 734 (m).
HRMS (ESI):	Pentacyclic amine (–)-**81**: calcd for $C_{23}H_{35}N_2O_3$ $[M+H]^+$: 387.2642, found: 387.2635.
HRMS (ESI):	Pentacyclic amine (+)-**82**: calcd for $C_{23}H_{35}N_2O_3$ $[M+H]^+$: 387.2642, found: 387.2636.
TLC, *Rf*: (10% MeOH:NH_3 satd CH_2Cl_2)	(–)-**81**, 0.63 ($KMnO_4$) (+)-**82**, 0.26 ($KMnO_4$)



Carbamate (–)-83:

A solution of sodium carbonate (21 mg, 0.19 mmol, 10 equiv) in water (475 μL) was added to a solution of amine (–)-**81** (7.5 mg, 0.019 mmol, 1 equiv) in dichloromethane (600 μL) at 23 °C. The heterogeneous mixture was stirred vigorously and cooled to 0 °C. Benzylchloroformate (8.2 μL, 0.057 mmol, 3.0 equiv) was added dropwise and the resulting mixture was warmed to room temperature for 15 minutes. Two additional portions of benzylchloroformate (8.2 μL, 0.057 mmol, 3.0 equiv each) were added over 30 minutes, followed by dilution of the reaction mixture with dichloromethane (10 mL) and saturated aqueous sodium bicarbonate solution (5 mL). The layers were separated and the aqueous layer was extracted with dichloromethane (2 × 10 mL). The combined organic layers were washed with brine (5 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification of the resulting yellow oil via flash column chromatography (silica gel: diam. 1 cm, ht. 2.5 cm; eluent: hexanes:acetone [90:10] to hexanes:acetone [80:20] to hexanes:acetone [75:25] to hexanes:acetone [70:30]) provided the carbamate (–)-**83** ($[\alpha]^{22}_D = -62$ (*c* 0.6, CH_2Cl_2)) as a clear film (6.6 mg, 65%).

The corresponding enantiomer, carbamate (+)-**83** (17.0 mg, 63%), was obtained using the same procedure and starting with amine (+)-**81**.

^{1}H NMR (500 MHz, C_6D_6, 20°C): 7.32 (d, J = 7.2 Hz, 2H, ArH), 7.18 (m, 2H, ArH), 7.07 (t, J = 7.4 Hz, 1H, ArH), 5.86 (br-s, 1H, C17-H), 5.27-5.19 (m, 2H, PhC**H**$_2$OC(O)N), 4.66-4.57 (m, 1H, C6-H), 4.39 (br-s, 1H, C2-H), 3.55-3.43 (m, 2H, OC**H**$_2$CH$_2$N), 3.01 (app-q, J = 8.3 Hz, 1H, OCH$_2$C**H**$_2$N), 2.75 (td, J = 8.6, 5.9 Hz, 1H, OCH$_2$C**H**$_2$N), 2.66-2.61 (m, 1H, C19-H), 2.45-2.37 (m, 2H, OH, C7-H), 2.09-2.01 (m, 3H, C5-H, C15-H), 1.78-1.65 (m, 3H, C8-H), 1.64 (m, 2H, C21-H), 1.56-1.43 (m, 3H, C4-H, C4-H, C3-H), 1.37-1.28 (m, 2H, C3-H, C21-H), 1.26 (dt, J = 13.2, 3.2 Hz, 1H), 1.20 (app-t, J = 9.7 Hz, 1H, C9-H), 1.13 (m, 1H), 1.12 (d, J = 6.9 Hz, 3H, C1-H), 1.04-0.95 (m, 2H, C7-H), 0.83-0.74 (m, 2H, C10-H).

^{13}C NMR (125 MHz, C_6D_6, 20°C): 157.3 (carbamate-C=O), 156.0 (PhCH$_2$O**C**(O)N), 139.3 (C16), 138.3 (HC=**C**CH$_2$OC(O)N), 129.1 (Ar-C), 128.9 (Ar-C), 128.6 (Ar-C), 127.9 (Ar-C), 123.6 (br, C17), 80.5 (C20), 67.4 (Ph**C**H$_2$OC(O)N), 62.0 (O**C**H$_2$CH$_2$N), 52.9 (C9), 48.1 (C5), 48.0 (OCH$_2$**C**H$_2$N), 47.9 (C6), 46.8 (C2), 45.0 (C10), 40.8 (C15), 39.4 (C19), 34.7 (C21), 34.4 (C4), 33.5

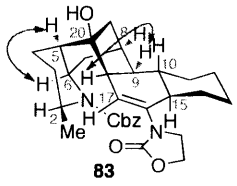
(C8), 33.0, 30.2 (C3), 29.6, 27.1, 27.0, 20.7 (C1), 17.8 (C4).

FTIR (thin film) cm^{-1}: 3427 (br-s, OH), 2928 (s), 2855 (w), 1733 (s), 1688 (s), 1415 (s), 1316 (s), 1093 (s).

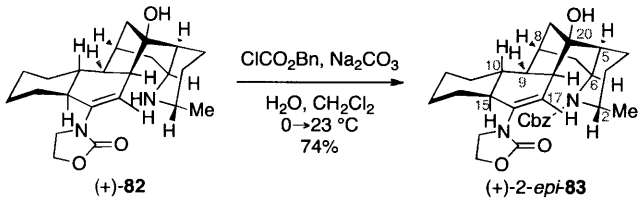
HRMS (ESI): calcd for $C_{31}H_{40}NaN_2O_5$ $[M+Na]^+$: 543.2829, found: 543.2808.

TLC, *Rf*: (50% acetone:hexanes)
81, <0.05 ($KMnO_4$)
83, 0.31 ($KMnO_4$)

NOESY correlations (600 MHz, C_6D_6, 20°C): Additional data: H2-H3, H3-H4, H4-H5, H4-H19, H3-H5, **H5-H6**, H6-H7a, H6-H21a, H7a-H8, H7b-H9, **H9-H19**, H17-H19, H19-H4a,b. Key correlations are shown in bold.



83



Carbamate (+)-2-*epi*-83

A solution of sodium carbonate (62 mg, 0.58 mmol, 10 equiv) in water (1 mL) was added to a solution of pentacyclic amine (+)-**82** (22.5.0 mg, 0.0580 mmol, 1 equiv) in dichloromethane (1.2 mL) at 23 °C. The heterogeneous mixture was stirred vigorously and cooled to 0 °C. Benzylchloroformate (25 μL, 0.18 mmol, 3.0 equiv) was added dropwise and the resulting solution was warmed to room temperature for 15 minutes. The reaction mixture was diluted with dichloromethane (15 mL) and saturated aqueous sodium bicarbonate solution (10 mL), and water (3 mL). The layers were separated and the aqueous layer was extracted with dichloromethane (4 × 15 mL). The combined organic layers were washed with brine (20 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification of the resulting yellow oil via flash column chromatography (silica gel: diam. 1 cm, ht. 7.5 cm; eluent: hexanes:acetone [90:10] to hexanes:acetone [80:20] to hexanes:acetone [75:25] to hexanes:acetone [70:30]) provided the carbamate (+)-2-*epi*-**83** ($[\alpha]^{22}_{D}$ = +63 (*c* 0.7, CH_2Cl_2)) as a clear film (22.4 mg, 74%).

The corresponding enantiomer, carbamate (–)-2-*epi*-**83** (18.2 mg, 54%), was obtained using the same procedure and starting with amine (–)-**82**.

^{1}H NMR (500 MHz, C_6D_6, 20°C): 7.28 (d, J = 7.6 Hz, 2H, ArH), 7.08 (app-t, J = 8.1 Hz, ArH), 5.69 (br-s, 1H, C17-H), 5.21 (d, J = 12.4 Hz, 1H, PhC**H**$_2$OC(O)N), 5.11 (d, J = 12.4 Hz, 1H, PhC**H**$_2$OC(O)N), 4.13 (app-q, J = 8.2 Hz, 1H, C6-H), 4.05 (app-q, J = 6.0 Hz, 1H, C2-H), 3.53-3.43 (m, 2H, OC**H**$_2$CH$_2$N), 2.96 (app-q, J = 8.5 Hz, 1H, OCH$_2$C**H**$_2$N), 2.85-2.80 (m, 1H, C19-H), 2.73-2.67 (m, 1H, OCH$_2$C**H**$_2$N), 2.30-2.21 (m, 2H, C15-H, C5-H), 2.01-1.97 (m, 3H, C8-H, C10-H), 1.87-1.85 (m, 2H, C9-H, C4-H), 1.79 (br-d, J = 12.6 Hz, 1H, C7-H), 1.68-1.61 (m, 3H, C3-H), 1.58-1.53 (m, 2H, C4-H, C21-H), 1.38 (d, J = 11.4 Hz, 1H, C21-H), 1.27-1.24 (m, 2H), 1.16-1.14 (m, 2H), 1.15-1.13 (m, 3H, C1-H), 1.09 (m, 2H, C3-H), 0.86-0.85 (m, 2H, C7-H).

^{13}C NMR (125 MHz, C_6D_6, 20°C): 157.3 (carbamate-C=O), 156.4 (PhCH$_2$O**C**(O)N), 139.2 (C16), 138.3 (HC=**C**CH$_2$OC(O)N), 129.1 (Ar-C), 128.9 (Ar-C), 128.7 (Ar-C), 123.3 (br, C17), 81.3 (C20), 67.1 (Ph**C**H$_2$OC(O)N), 62.0 (O**C**H$_2$CH$_2$N), 49.2 (C2), 49.1 (C9), 48.8 (C6), 47.6 (OCH$_2$**C**H$_2$N), 46.9 (C15), 43.5, 40.9 (C10), 39.1

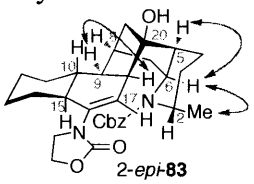
(C19), 34.2 (C5), 33.6 (C8), 32.4 (C7), 29.8, 29.7, 28.9 (C3), 27.1, 27.0, 20.1, 18.9 (C4).

FTIR (thin film) cm^{-1}: 3423 (br-s, OH), 2927 (s), 2855 (w), 1734 (s), 1691 (s), 1407 (m), 1297 (m), 1095 (w), 1039 (w).

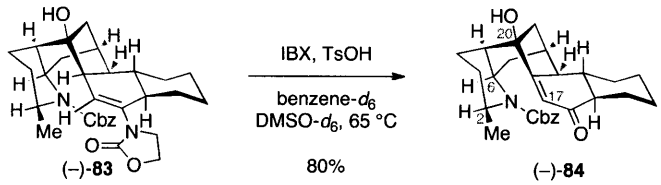
HRMS (ESI): calcd for $C_{31}H_{40}NaN_2O_5$ $[M+Na]^+$: 543.2829, found: 543.2817.

TLC, *Rf*:
(50% acetone:hexanes)
82, <0.05 ($KMnO_4$)
2-*epi*-**83**, 0.31 ($KMnO_4$)

NOESY correlations (600 MHz, C_6D_6, 20°C): Additional data: **H1-H6**, **H5-H6**, **H9-H19**, H17-Hb, H17-H19, H19-H4, H15-H9, H4-H2, H4-H6. Key correlations are shown in bold.



2-*epi*-**83**



(–)-*N*-Cbz-Galbulimima alkaloid 13 (84):

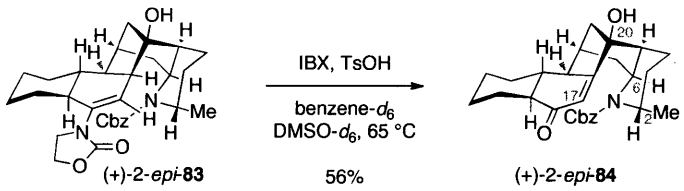
p-Toluenesulfonic acid monohydrate (12 mg, 60 μmol, 4.0 equiv) and IBX (47 mg, 0.16 mmol, 11 equiv) were added to a solution of vinyl oxazolidinone (–)-**83** (8.0 mg, 15 μmol, 1 equiv) in benzene-d_6 (300 μL) and DMSO-d_6[18] (400 μL) at 23 °C. The resulting suspension was sonicated (1.5 h) until it became homogeneous, then heated to 65 °C. ^{1}H NMR spectral analysis of the reaction mixture was used to monitor conversion to product. After 10 h, the solution was diluted with ethyl acetate (10 mL), saturated aqueous sodium bicarbonate solution (5 mL) and water (3 mL). The layers were separated and the aqueous layer was extracted with ethyl acetate (2 × 10 mL). The combined organic layers were washed with brine (5 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification of the resulting yellow residue via flash column chromatography (silica gel: diam. 0.5 cm, ht. 3.5 cm; eluent: hexanes:acetone [85:15] to hexanes:acetone [70:30]) provided enone (–)-**84** (5.5 mg, 80%, ($[\alpha]^{22}_D$ = –71 (*c* 0.3, CH_2Cl_2)).

The corresponding enantiomer, enone (+)-**84** (3.5 mg, 67%) was obtained using the same procedure and starting with vinyl oxazolidinone (+)-**83**.

^{1}H NMR (500 MHz, C_6D_6, 20°C):	7.32 (d, *J* = 7.2 Hz, 2H, ArH), 7.20-7.15 (m, 2H, ArH 7.09 (t, *J* = 7.2 Hz, 1H, ArH), 5.99 (d, *J* = 2.1 Hz, 1H, C17-H), 5.23 (m, 2H, PhC**H**$_2$OC(O)N), 4.69 (app-q, *J* = 8.5 Hz, C6-H), 4.46-4.39 (m, 1H, C2-H), 2.67-2.52 (m, 2H), 1.97-1.90 (m, 1H), 1.75-1.64 (m, 4H), 1.55-1.44 (m, 3H), 1.38-1.24 (m, 3H), 1.21-1.13 (m, 2H), 1.12-1.04 (m, 5H, C1-H), 1.04-0.85 (m, 3H), 0.84 (dd, *J* = 11.6, 5.2 Hz, 1H), 0.61 (app-dq, *J* = 12.2, 3.3 Hz, 1H) .
^{13}C NMR (125 MHz, C_6D_6, 20°C):	199.0 (C16), 172.5 (C19), 155.8 (PhCH$_2$O**C**(O)N), 138.1 (HC=**C**CH$_2$OC(O)N), 129.1 (Ar-C), 128.7 (Ar-C), 128.5 (Ar-C), 119.3 (C17), 81.1 (C20), 67.5 (Ph**C**H$_2$OC(O)N), 56.7, 52.6, 47.4, 47.3, 46.2, 45.2, 36.1, 35.7, 31.7, 30.3, 30.2, 26.9, 26.5, 25.9, 20.4, 19.3.
FTIR (thin film) cm^{-1}:	3428 (br-s, OH), 2924 (s), 2852 (m), 1687 (m), 1666 (s), 1412 (w), 1314 (w).
HRMS (ESI):	calcd for $C_{28}H_{37}N_1O_4$ $[M+H]^+$: 450.2639, found: 450.2639.

[18] Deuterated solvent was used to facilitate evaluation of reaction progress by direct ^{1}H NMR monitoring.

TLC, *Rf*:	
(50% acetone:hexanes)	**83**, 0.31 ($KMnO_4$)
	84, 0.57 (UV, CAM)



(+)-*N*-Cbz-2-*epi*-Galbulimima alkaloid 13 (84):

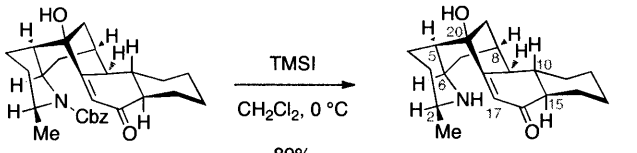
p-Toluenesulfonic acid monohydrate (8.0 mg, 42 μmol, 4.6 equiv) and IBX (31 mg, 0.11 mmol, 12 equiv) were added to a solution of vinyl oxazolidinone (+)-2-*epi*-**83** (4.8 mg, 9.2 μmol, 1 equiv) in benzene-d_6 (300 μL) and DMSO-d_6[19] (450 μL) at 23 °C. The suspension was sonicated (1 h) until it became homogeneous, then heated to 65 °C. ^{1}H NMR analysis of the reaction mixture was used to monitor conversion to product. After 10 h, the solution was diluted with ethyl acetate (8 mL), saturated aqueous sodium bicarbonate solution (8 mL) and water (3 mL). The layers were separated and the aqueous layer was extracted with ethyl acetate (3 × 8 mL). The combined organic layers were washed with brine (5 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification of the resulting yellow residue via flash column chromatography (silica gel: diam. 1 cm, ht. 2 cm; eluent: hexanes:acetone [85:15] to hexanes:acetone [80:20]) provided enone (+)-2-*epi*-**84** (2.3 mg, 56%, ($[\alpha]^{22}_D$ = +70 (*c* 0.3, CH_2Cl_2)).

The corresponding enantiomer, enone (–)-2-*epi*-**84** (4.8 mg, 59%) was obtained using the same procedure and starting with vinyl oxazolidinone (–)-2-*epi*-**83**.

^{1}H NMR (500 MHz, C_6D_6, 20°C):	7.30-7.27 (m, 2H, ArH), 7.15-7.12 (m, 2H, ArH), 7.09-7.05 (m, 1H, ArH), 5.99-5.96 (m, 1H, C17-H), 5.18 (d, *J* = 12.4 Hz, PhC**H**$_2$OC(O)N), 5.14 (d, *J* = 12.4 Hz, PhC**H**$_2$OC(O)N), 4.50 (app-q, *J* = 9.2 Hz, 1H, C6-H), 3.71-3.64 (m, 1H, C2-H), 2.64-2.59 (m, 1H), 2.30 (dt, *J* = 13.8, 8.0 Hz, 1H), 2.23-2.16 (m, 1H), 1.77-1.65 (m, 3H), 1.64-1.43 (m, 6H), 1.36-1.27 (m, 2H), 1.22 (d, *J* = 6.5 Hz, 3H, C1-H), 1.18-1.04 (m, 4H), 1.04-0.96 (m, 1H), 0.96-0.86 (m, 2H), 0.74-0,65 (m, 1H).
^{13}C NMR (125 MHz, C_6D_6, 20°C):	199.0 (C16), 173.3 (C19), 156.6 (PhCH$_2$O**C**(O)N), 138.1 (HC=**C**CH$_2$OC(O)N), 129.1 (Ar-C), 128.7 (Ar-C), 128.5 (Ar-C), 119.6 (C17), 82.0 (C20), 67.3 (O**C**H$_2$CH$_2$N), 54.4, 52.4, 49.1, 48.5, 47.4, 43.1, 39.3, 35.6, 31.8, 30.6, 29.9, 27.0, 26.5, 26.0, 21.1, 21.0.
FTIR (thin film) cm^{-1}:	3423 (br-s, OH), 2929 (m), 2857 (w), 1687 (m), 1662 (s), 1300 (m), 1154 (w).

[19] Deuterated solvent was used to facilitate evaluation of reaction progress by direct ^{1}H NMR monitoring.

HRMS (ESI):	calcd for $C_{28}H_{37}N_1O_4$ $[M+H]^+$: 450.2639, found: 450.2644.
TLC, *Rf*: (50% acetone:hexanes)	2-*epi*-**83**, 0.31 ($KMnO_4$)
	2-*epi*-**84**, 0.57 (UV, CAM)



(–)-**84** (–)-galbulimima alkaloid 13 (**2**)

(–)-Galbulimima alkaloid 13 (2):[20]

N-Cbz enone (–)-**84** (2.7 mg, 6.0 μmol, 1 equiv) was azeotropically dried from toluene (3 × 1 mL), was dissolved in dichloromethane (1.0 mL), and was cooled to 0 °C. Trimethylsilyliodide (TMSI, 1.2 μL, 9.0 μmol, 1.5 equiv) was added to the cooled solution, and the resulting yellow solution was stirred at 0 °C. Additional portions of TMSI were added at 20 minute intervals until complete consumption of (–)-**84** was observed by TLC analysis (70 min). The reaction mixture on completion was a cloudy yellow solution, with a brown residue. Excess silylated products were quenched at 0 °C by the addition of aqueous hydrochloric acid solution (1N, 1.5 mL) and the mixture was allowed to warm to ambient temperature. The reaction mixture was diluted with hexanes (10 mL) and aqueous hydrochloric acid solution (1N, 2 mL) and the layers were separated. The organic layer was extracted with aqueous hydrochloric acid solution (1N, 4 mL). The combined acidic aqueous layers were washed sequentially with hexanes (2 × 10 mL), dichloromethane (10 mL), and hexanes (10 mL). The aqueous layer was then basified to pH 13 with aqueous sodium hydroxide solution (1N, 10 mL). The resulting solution was stirred at ambient temperature for 1 h. The aqueous solution was extracted with dichloromethane (3 × 20 mL) and the combined organic layers were washed sequentially with water (18 mL) and brine (20 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure to provide (–)-galbulimima alkaloid 13 (**2**, $[\alpha]^{22}_D$ = –34 (*c* 0.045, CH_2Cl_2)[21]) as a white film (1.7 mg, 89%).

The corresponding enantiomer, (+)-galbulimima alkaloid 13 (**2**, 1.4 mg, 58%, $[\alpha]^{22}_D$ = +34 (*c* 0.090, CH_2Cl_2)[21]), was obtained using the same procedure and starting with *N*-Cbz amine *ent*-**84**.

^{1}H NMR (500 MHz, C_6D_6, 20°C): 6.07 (d, *J* = 2.2 Hz, 1H, C17-H), 3.28 (dt, *J* = 11.4, 2.3 Hz, 1H, C9-H), 2.88 (app-t, *J* = 5.1 Hz, 1H, C6-H), 2.72-2.66 (m, 1H), 2.60-2.55 (m, 1H), 2.15 (app-qd, *J* = 6.1, 2.3 Hz, 1H, C2-H), 1.98 (m, 1H, OH), 1.91 (app-t, *J* = 4.4 Hz, 1H, C5-H), 1.84-1.81 (m, 1H, C8-H), 1.78 (dd, *J* = 11.2, 3.6 Hz, 1H, C15-H), 1.75-1.69 (m, 1H), 1.67-1.60 (m, 1H), 1.55

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[20] a) For the prior synthesis of (±)-**2**, please see: Mander, L. N.; McLachlan, M. M. *J. Am. Chem. Soc.* **2003**, *125*, 2400. The Supporting Information of this same report contains copies of the NMR spectra of the natural (–)-**2** along with synthetic (±)-**2**. b) For isolation and optical rotation data, see: Ritchie, E.; Taylor, W. C. In *The Alkaloids*; Manske, R. H. F., Ed.; Academic Press: New York, 1967; Vol. 9, Chapter 14 and references therein.

[21] Literature value: [α] = –84 ($CHCl_3$); see reference 22b. We have also measured the rotation of (–)-**2** in chloroform (2 sources): a) chloroform passed through basic alumina (Grade I) and dried over 4Å-MS, $[\alpha]^{22}_D$ = –51 (*c* 0.06, $CHCl_3$), and b) chloroform passed through basic alumina (Grade I) and distilled from P_2O_5, $[\alpha]^{22}_D$ = –64 (*c* 0.06, $CHCl_3$). Additionally, we have measured the rotation of (+)-**2** in chloroform: a) chloroform passed through basic alumina (Grade I) and dried over 4Å-MS, $[\alpha]^{22}_D$ = +51 (*c* 0.07, $CHCl_3$), and b) chloroform passed through basic alumina (Grade I) and distilled from P_2O_5, $[\alpha]^{22}_D$ = +66 (*c* 0.07, $CHCl_3$).

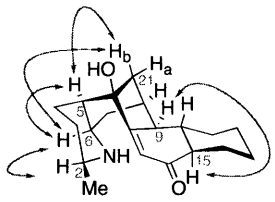
(app-dq, J = 13.9, 2.9 Hz, 1H, C7-Ha), 1.53-1.47 (m, 1H), 1.40 (ddd, J = 10.8, 5.6, 2.1 Hz, 1H, C21-Ha), 1.26 (dd, J = 5.6, 2.4 Hz, 1H, C21-Hb), 1.23-0.90 (m, 8H, C10-H, C7-Hb), 0.77 (m, 1H), 0.75 (d, J = 6.1 Hz, 3H, C1-H).

^{13}C NMR (125 MHz, C_6D_6, 20°C): 199.4 (C16), 178.9 (C19), 119.2 (C17), 79.7 (C20), 55.4 (C6), 53.3 (C15), 53.2 (C2), 51.2 (C9), 48.2 (C21), 47.6 (C10), 46.6 (C5), 41.0 (C7), 33.1 (C8), 31.9, 30.6, 27.3 (C3 or C4), 26.7, 26.1, 25.0 (C3 or C4), 23.6 (C1).

FTIR (thin film) cm^{-1}: 3403 (br-s, OH), 2921 (s), 2851 (m), 1708 (w), 1646 (s), 1447 (m), 1261 (m). (Literature values: 3406, 2929, 2854, 1705, 1646, 1446).[20]

HRMS (ESI): calcd for $C_{20}H_{30}N_1O_2$ $[M+H]^+$: 316.2271, found: 316.2280.

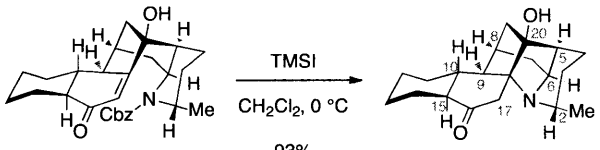
NOESY correlations (600 MHz, C_6D_6, 20°C): Additional data: H1-H2, **H2-H6**, **H5-H6**, **H5-H21b**, H6-H7a, **H6-H21b**, H7a-H8, H7a-H6, H8-H21a, **H9-H15**. Key correlations are shown in bold.



(–)-galbulimima alkaloid 13 (**2**)

Comparison of our assignments for (–)-galbulimima alkaloid 13 (2) with prior assignments for (±)-2:

Assignment	Mander's report[20] (±)-GB 13 (**2**) (^{1}H, 300 MHz, $CDCl_3$)	This report (–)-GB 13 (**2**) (^{1}H, 500 MHz, $CDCl_3$)	This report (–)-GB 13 (**2**) (^{1}H, 500 MHz, C_6D_6)	This report (–)-GB 13 (**2**) ^{13}C (125 MHz, C_6D_6)
C1	0.89, (d, J = 6.2 Hz)	0.89, (d, J = 6.1 Hz)	0.75, (d, J = 6.1 Hz)	23.6
C2			2.15, (app-qd, J = 6.1, 2.3 Hz)	53.2
C3,C4			2.72-2.66 (m); 2.60-2.55 (m)	27.3, 25.0
C5			1.91 (app-t, J = 4.4 Hz)	46.6
C6	3.34, (t, J = 5.1 Hz)	3.34, (t, J = 5.1 Hz)	2.88, (app-t, J = 5.1 Hz)	55.4
C7			1.55 (app-dq, J = 13.9, 2.9); 1.02 (m)	41.0
C8			1.84-1.81 (m)	33.1
C9	3.47, (dt, J = 11.3, 2.2 Hz)	3.47, (dt, J = 11.2, 2.1 Hz)	3.28, (dt, J = 11.4, 2.3 Hz)	51.2
C10			~1.13, m	47.6
C11-C14				31.9, 30.6, 26.7, 26.1
C15			1.78, dd, J = 11.2, 3.6 Hz	53.3
C16	–	–	–	199.4
C17	5.92, (d, J = 2.0 Hz)	5.93 (d, J = 2.1 Hz)	6.07, (d; J = 2.2 Hz)	119.2
C19	–	–	–	178.9
C20	–	–	–	79.7
C21			1.40 (ddd, J = 10.8, 5.6, 2.1 Hz); 1.26 (dd, J = 5.6, 2.4 Hz)	48.2



(+)-2-*epi*-**84** (+)-2-*epi*-16-oxohimgaline (2-*epi*-**21**)

(+)-2-*epi*-16-Oxohimgaline (2-*epi*-21):

N-Cbz enone (+)-2-*epi*-**84** (2.1 mg, 4.7 μmol, 1 equiv) was azeotropically dried from toluene (3 × 1 mL), was dissolved in dichloromethane (800 μL), and was cooled to 0 °C. Trimethylsilyliodide (TMSI, 1.5 μL, 11 μmol, 2.2 equiv) was added to the cooled solution, and the resulting yellow solution was stirred at 0 °C. Additional portions of TMSI were added at 20 minute intervals until complete consumption of (+)-2-*epi*-**84** was observed by TLC analysis (50 min). The reaction mixture on completion was a cloudy yellow solution, with a brown residue. Excess silylated products were quenched at 0 °C by the addition of aqueous hydrochloric acid solution (1N, 1.5 mL) and the reaction mixture was allowed to warm to ambient temperature. The reaction mixture was diluted with hexanes (10 mL) and aqueous hydrochloric acid solution (1N, 3 mL) and the layers were separated. The organic layer was extracted with aqueous hydrochloric acid solution (1N, 4 mL). The combined acidic aqueous layers were washed sequentially with hexanes (2 × 10 mL), dichloromethane (10 mL), and hexanes (10 mL). The aqueous layer was then basified to pH 13 with aqueous sodium hydroxide solution (1N, 11 mL). The resulting solution was stirred at ambient temperature for 1 h. The aqueous solution was extracted with dichloromethane (3 × 20 mL) and the combined organic layers were washed sequentially with water (18 mL) and brine (10 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure to provide (+)-2-*epi*-oxohimgaline ((+)-2-*epi*-**21**, $[\alpha]^{22}_D = +24$ (*c* 0.07, CH_2Cl_2)) as a white film (1.4 mg, 93%).

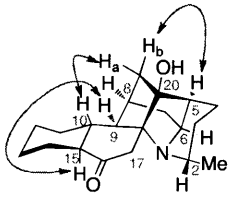
The corresponding enantiomer, (–)-2-*epi*-oxohimgaline ((–)-2-*epi*-**21**, 2.8 mg, 82%, $[\alpha]^{22}_D = -24$ (*c* 0.085, CH_2Cl_2)), was obtained using the same procedure and starting with *N*-Cbz enone (–)-2-*epi*-**84**.

^{1}H NMR (500 MHz, C_6D_6, 20°C):	3.08-3.02 (m, 2H, C2-H, C6-H), 3.02 (d, *J* = 13.5 Hz, 1H, C17-Ha), 2.55 (br-d, *J* = 12.9 Hz, 1H, C17-Hb), 1.99-1.91 (m, 2H, C9-H, OH), 1.91-1.88 (m, 1H, C8-H), 1.87-1.81 (m, 1H), 1.80-1.72 (m, 2H, C15-H, C21-Ha), 1.68-1.48 (m, 7H, C5-H, C21-Hb, C7-Ha), 1.43-1.30 (m, 3H), 1.26 (br-d, *J* = 12.7 Hz, 1H, C7-Hb), 1.14 (qd, *J* = 11.4, 3.4 Hz, 1H, C10-H), 1.06 (d, *J* = 7.0 Hz, 3H, C1-H), 1.02-0.89 (m, 3H), 0.79 (dd, *J* = 13.6, 6.5 Hz, 1H), 0.73-0.63 (m, 1H).
^{13}C NMR (125 MHz, C_6D_6, 20°C):	212.3 (C16), 87.4 (C20), 75.7 (C19), 60.5 (C9), 57.3 (C6), 55.0 (C5), 52.8 (C15), 50.6 (C2), 47.9 (C21), 44.4 (C10), 40.9 (C17), 37.1 (C7), 36.2 (C8), 32.5, 30.3, 26.4, 25.7, 24.1, 22.4, 20.7 (C1).

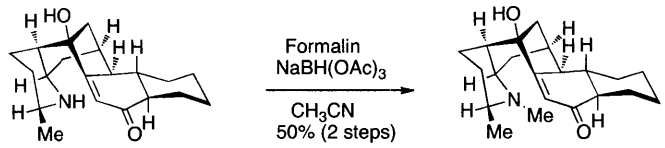
FTIR (thin film) cm^{-1}: 3302 (br-m, OH), 2929 (s), 2853 (w), 1706 (m, C=O), 1314 (w), 1300 (w), 1182 (w).

HRMS (ESI): calcd for $C_{20}H_{30}N_1O_2$ $[M+H]^+$: 316.2271, found: 316.2270.

NOESY correlations (600 MHz, C_6D_6, 20°C): H6-H7b, H8-H7a, H8-H7b, **H9-H15**, **H5-H21b**, **H5-H7b**, **H10-H21a**. Key correlations are shown in bold.



(+)-2-*epi*-16-oxohimgaline
(2-*epi*-**21**)



(–)-Galbulimima Alkaloid 13 (**2**) (–)-Himbadine (**4**)

(–)-Himbadine (4):

A solution of crude (–)-galbulimima alkaloid 13 (1.4 mg, 4.4 mmol, 1 equiv) in acetonitrile (0.75 mL) was treated sequentially with formaldehyde, 37 wt% in H_2O (18 mL, 0.60 mmol, 50 equiv) and sodium triacetoxyborohydride (19 mg, 88 mmol, 20 equiv) at 23 °C, and the reaction mixture was sealed under an argon atmosphere. After 1 h, a mixture of saturated aqueous sodium bicarbonate solution and saturated aqueous sodium chloride solution (1:1, 8 mL) was added, and the layers were separated. The aqueous layer was extracted with ethyl acetate (2 × 5 mL). The combined organic layers were washed with brine (5 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification via flash column chromatography (silica gel: diam. 0.5 cm, ht. 5.5 cm; eluent: 1% NEt_3 in [1% ^{i}propanol in dichloromethane] to 1% NEt_3 in [1% methanol in dichloromethane] to 1% NEt_3 in [2% methanol in dichloromethane] to 1% NEt_3 in [4% methanol in dichloromethane] afforded (–)-himbadine (**4**, 0.7 mg, 50%, two steps) ($[\alpha]^{22}_D$ = –47 (*c* 0.045, $CHCl_3$)). Complete assignment was possible with the aid of additional information from gCOSY, HSQC, HMBC, and ROESY.

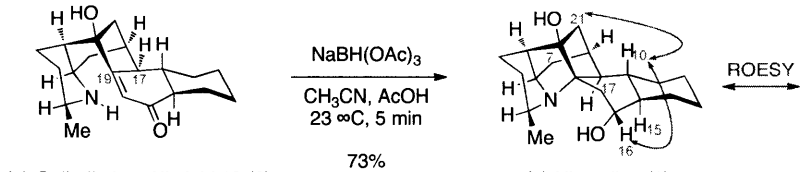
^{1}H NMR (500 MHz, C_6D_6, 20 °C):	6.06 (s, 1H, C_{17}**H**), 3.18-3.15 (m, 1H, C_9**H**), 2.70-2.67 (m, 1H, C_3**H**H'), 2.49-2.46 (m, 1H, C_4**H**H'), 2.21 (app-t, J = 9.3 Hz, 4.7 Hz, 1H, C_6**H**), 2.03-1.96 (br-s, 3H, C_5**H**, N-C**H**$_3$, C_7**H**H'), 1.82-1.77 (m, 2H, C_{15}**H**, C_8**H**), 1.74-1.71 (m, 1H, C**H**$_2$), 1.67-1.64 (m, 2H, C_{11}**H**H', C_2**H**), 1.57-1.49 (m, 2H, C**H**$_2$), 1.36-1.32 (m, 1H, C_{21}**H**H'), 1.25-1.23 (m, 1H, C_{21}H**H'**), 1.21-0.96 (m, 7H, C_7H**H'**, C_3H**H'**, C_4H**H'**, C_{10}**H**, C**H**$_2$), 0.86 (d, J = 6.0 Hz, 3H, C_1**H**), 0.85-0.78 (m, 1H, C_{11}H**H'**).
^{13}C NMR (125 MHz, C_6D_6, 20 °C):	199.7 (**C**$_{16}$), 179.5 (**C**$_{19}$), 119.2 (**C**$_{17}$), 80.3 (**C**$_{20}$), 63.3 (**C**$_6$), 59.8 (**C**$_2$), 53.1 (**C**$_{15}$), 49.7 (**C**$_9$), 48.7 (**C**$_{21}$), 48.1 (**C**$_5$), 47.5 (**C**$_{10}$), 40.0 (N-CH$_3$), 34.7 (**C**$_7$), 33.2 (**C**$_8$), 32.2 (**C**$_{11}$), 30.9 (**C**H$_2$), 27.2 (**C**$_3$), 26.6 (**C**H$_2$), 26.1 (**C**H$_2$), 24.8 (**C**$_4$), 22.9 (**C**$_1$).
FTIR (neat) cm^{-1}:	3407 (br-s, OH), 2923 (s), 2853 (m), 2774 (w), 1737 (w), 1648 (s), 1447 (w).
HRMS (ESI):	calcd for $C_{21}H_{32}NO_2$ $[M+Na]^+$: 330.2428, found: 330.2425.

TLC (1% NEt_3 in [4% MeOH in CH_2Cl_2]) *Rf* 0.25 (UV, CAM).

Comparison of our assignments for (–)-himbadine (4) with literature:

Assignment	**Isolation paper**[22] (–)-himbadine (**4**) (^{1}H, 300 MHz, $CDCl_3$)	**This report** (–)-himbadine (**4**) (^{1}H, 500 MHz, $CDCl_3$)	**This report** (–)-himbadine (**4**) (^{1}H, 500 MHz, C_6D_6)	**This report** (–)-himbadine (**4**) (^{13}C, 125 MHz, C_6D_6)
C_{17}	5.95 (d, 1H)	5.91 (d, 1H)	6.06 (s, 1H)	119.2
C_9	–	–	3.18-3.15 (m, 1H)	49.7
C_3	–	–	2.70-2.67 (m, 1H)	27.2
C_4	–	–	2.49-2.46 (m, 1H)	24.8
C_6	–	–	2.21 (app-t, J = 9.3 Hz, 4.7 Hz, 1H, C6-H)	63.3
C_5, N-CH_3, C_7	2.2 (br-s, 3H, N-CH_3)	2.17 (br-s, 3H, N-CH_3)	2.03-1.96 (br-s, 3H)	48.1 (C5), 40.0 (N-CH_3), 34.7 (C7)
C_{15}, C_8	–	–	1.82-1.77 (m, 2H)	53.1 (C15), 33.2 (C8)
CH_2	–	–	1.74-1.71 (m, 1H)	26.6 (CH_2)
C_{11}, C_2	–	–	1.67-1.64 (m, 2H)	32.3 (C11), 59.8 (C2)
CH_2		–	1.57-1.49 (m, 2H)	30.9 (CH_2)
C_{21}	–	–	1.36-1.32 (m, 1H)	48.7
C_{21}'	–	–	1.25-1.23 (m, 1H)	48.7
C_7, C_3, C_4, C_{10}, CH_2	–	–	1.21-0.96 (m, 7H)	34.7 (C7), 27.2 (C2), 23.8 (C4), 47.5 (C10), 26.1 (CH_2)
C_1	0.93 (d, 3H)	0.92 (d, 3H)	0.86 (d, J = 6.0 Hz, 1H)	22.9
C_{11}	–	–	0.85-0.78 (m, 1H)	32.2

[22] Mander, L. N.; Prager, R. H.; Rasmussen, M.; Ritchie, E.; Taylor, W. C. *Aust. J. Chem.*, **1967**, *20*, 1473.



(–)-Galbulimima Alkaloid 13 (**2**) (–)-Himgaline (**3**)

(–)-Himgaline (3):

A solution of (–)-galbulimima alkaloid 13 (1.4 mg, 4.4 mmol, 1 equiv) in acetonitrile (0.75 mL) was treated sequentially with acetic acid (14 mL, 0.24 mmol, 50 equiv) and sodium triacetoxyborohydride (19 mg, 88 mmol, 20 equiv) at 23 °C, and the reaction mixture was sealed under an argon atmosphere. After 30 min, aqueous potassium carbonate solution (1M, 2 mL) was added, and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 5 mL). The combined organic layers were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification via flash column chromatography (silica gel: diam. 0.5 cm, ht. 1 cm; eluent: 10% methanol in dichloromethane to 3% NH_3 in [10% methanol in dichloromethane] afforded (–)-himgaline (**3**, 1.1 mg, 73%) ($[\alpha]^{22}_D = -82$ (*c* 0.11, $CHCl_3$)). Complete assignment was possible with the aid of additional information from gCOSY, HSQC, HMBC, and ROESY.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C):	3.20-3.24 (m, 1H, C_{16}**H**), 3.07 (br-s, 1H, C_6**H**), 2.96 (br-s, 1H, C_2**H**), 2.40 (dd, J = 12.2, 2.9 Hz, 1H, C_{17}**H**), 2.16 (br-d, 1H, C_{21}**H**H'), 2.12-2.08 (m, 2H, C_{14}**H**H', C_8**H**), 2.03-1.99 (m, 2H, C_5**H**, C_4**H**H'), 1.95-1.85 (m, 2H, C_7**H**, C_{17}**H**), 1.81 (br-d, 1H, C_{21}H**H'**), 1.77-1.68 (m, 4H, C_{11}**H**H', C_{12}H**H'**, C_{13}H**H'**, C_9**H**), 1.61-1.54 (m, 3H, C_3**H**H', C_4H**H'**, C_7**H**), 1.50-1.44 (m, 1H, C_3H**H'**), 1.28 (d, J = 6.5 Hz, 3H, C_1**H**), 1.20-1.12 (m, 2H, C_{13}H**H'**, C_{12}H**H'**), 1.03-1.01 (m, 1H, C_{15}**H**), 0.91-0.82 (m, 3H, C_{10}**H**, C_{11}H**H'**, C_{14}H**H'**).
^{13}C NMR (125 MHz, $CDCl_3$, 20 °C):	86.8 (4°), 74.2 (4°), 72.4 (**C**$_{16}$), 68.5 (**C**$_6$), 61.5 (**C**$_2$), 60.0. 55.0 (**C**$_5$), 48.0 (**C**$_{21}$), 47.6 (**C**$_{15}$), 42.7 (**C**$_{10}$), 37.3 (**C**$_{17}$), 36.8 (**C**$_7$), 35.9 (**C**$_8$), 32.3 (**C**$_{11}$), 29.9 (**C**$_1$), 28.8 (**C**$_{14}$), 27.1 (**C**$_3$), 26.5 (**C**$_{12}$), 25.9 (**C**$_{13}$), 25.4 (C_4).
FTIR (neat) cm^{-1}:	3340 (br-s, OH), 2919 (s), 2850 (m), 1738 (w), 1448 (w), 1261 (w).
HRMS (ESI):	calcd for $C_{20}H_{32}NO_2$ $[M+Na]^+$: 318.2428, found: 318.2438.
TLC (3% NH_3 in [10% MeOH in CH_2Cl_2])	*Rf* 0.1 (CAM).

Comparison of our assignments for (–)-himgaline (3) with literature:

Assignment	Chackalamannil's report[23] (–)-himgaline (**3**) (^{1}H, 500 MHz, $CDCl_3$)	**This report** (–)-himgaline (**3**) (^{1}H, 500 MHz, $CDCl_3$)	**This report** (–)-himgaline (**3**) (^{13}C, 125 MHz, $CDCl_3$)
C16	3.34 (m, 1H)	3.23-3.27 (m, 1H)	–
C6	3.05 (t, J = 2.8 Hz, 1H)	3.10 (br-s, 1H)	68.5
C2	2.98-2.89 (m, 1H)	2.99 (br-s, 1H)	61.5
C17	2.46 (dd, J = 12.3, 3.5 Hz, 1H)	2.43 (dd, J = 12.2, 2.9 Hz, 1H)	37.3
C21, C14, C8	2.25-2.12 (m, 3H)	2.19 (br-d, 1H, C21-H') 2.15-2.11 (m, 2H, C14-H, C8-H)	48.0 (C21), 28.8 (C14), 35.9 (C8)
C5, C4	2.09-2.03 (m, 2H)	2.06-2.02 (m, 2H)	55.0 (C5), 25.4 (C4)
C7, C17ax, C21' C11, C12, C13, C9 C3'	1.96-1.48 (m, 11H)	1.98-1.88 (m, 2H) 1.84 (br-d, 1H) 1.80-1.71 (m, 4H) 1.53-1.47 (m, 3H)	36.8 (C7), 37.3 (C17) 48.0 32.3 (C11), 26.5 (C12), 25.9 (C13) 27.1 (C3), 25.4 (C4), 36.8 (C7)
C1	1.34 (d, J = 7.3 Hz, 3H)	1.31 (d, J = 6.5 Hz, 3H)	29.9
C13', C12'	1.32-1.15 (m, 2H)	1.23-1.15 (m, 2H)	25.9 (C13), 26.5 (C12)
C15	1.11-1.03 (m, 1H)	1.06-1.04 (m, 1H)	47.6 (C15)
C10, C11', C14ax	0.99-0.88 (m, 3H)	0.94-0.85 (m, 3H)	42.7 (C10), 32.3 (C11), 28.8 (C14)

[23] Chackalamannil, S. et. Al. *J. Am. Chem. Soc.*, **2006**, *128*, 12654-12655.

Chapter II.

Total Synthesis of (–)-Himandrine

Introduction and Background

The galbulimima alkaloid (–)-himandrine (**3**) is a topologically fascinating compound isolated from the bark of *Galbulimima belgraveana*, a tree indigenous to Papua New Guinea and northern Australia.[1] The promise that natural and synthetic derivatives of galbulimima alkaloids have shown for treatment of human ailments[2] has resulted in substantial attention in both academia and industry. In chapter 1, we reported the first enantioselective total synthesis of (–)-galbulimima alkaloid 13 (**2**, class III)[3] and revised the absolute stereochemical assignment of the class II and III derivatives.[4] As continuation of this program, we describe the total synthesis of class II alkaloid **3** guided by our previously disclosed hypothesis for its biogenesis,[3] featuring a final stage oxidative spirocyclization to secure the BCF ring juncture.[5]

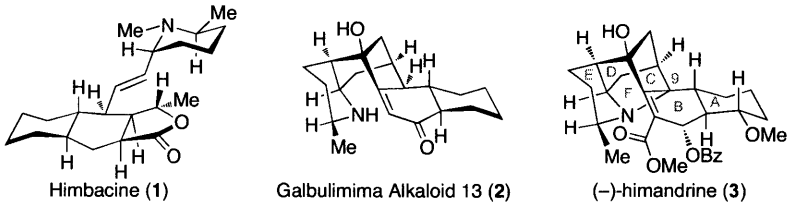
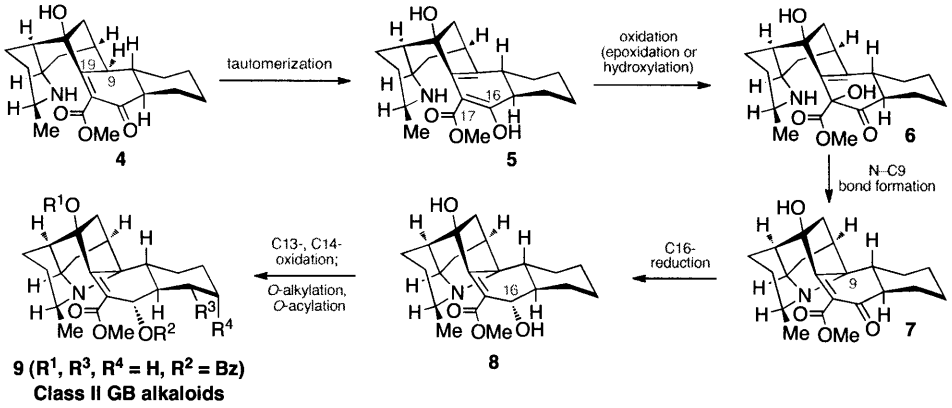


Figure 1. Representative galbulimima alkaloids.

Hypothesis for the Biosynthesis of (–)-Himandrine:

Based on our biomimetic hypothesis for the biogenesis of class II and III galbulimima alkaloids,[3] we identified aminoketoester **4** (Scheme 1) as a plausible point of divergence en route to more complex alkaloids. We envisioned that aminoketoester **4** would tautomerize to form the conjugated enol **5**. At this point, enol **5** could undergo a C17-oxidation (or a synthetic

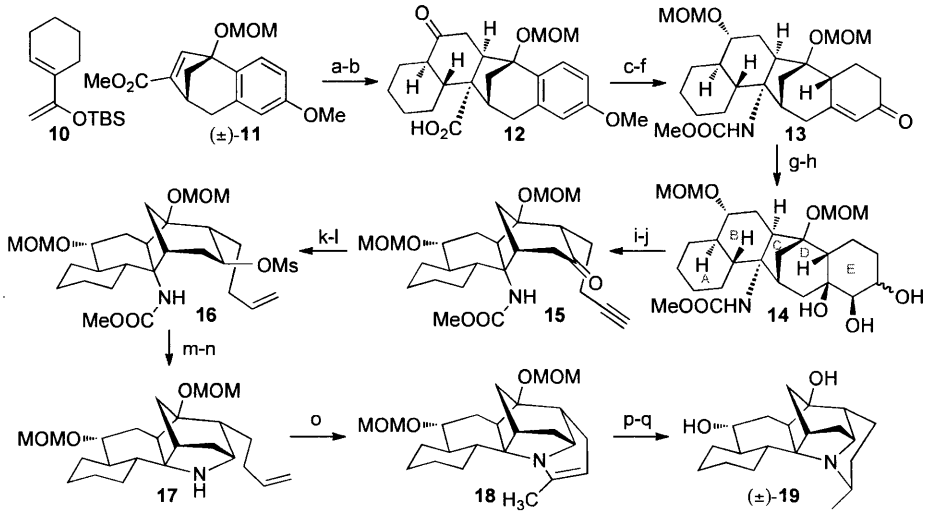


Scheme 1. Our biosynthetic hypothesis of (–)-himandrine.

equivalent) to give the hydroxy ketoester **6**, followed by an intramolecular allylic displacement by the amine to give the N–C9 bond present in the Class II galbulimima alkaloids (himandrine and himandridine).

Previous Synthetic Study of class II Galbulimima alkaloids:

While there have been several outstanding syntheses of himbacine **1**, class I (Figure 1)[6] and class III[7] galbulimima alkaloids, no total synthesis of the class II galbulimima alkaloids possessing the unique N-C9 spirofused polycyclic framework has been reported. In 2004, Mander and co-workers disclosed an intriguing synthesis of the himandrine skeleton (Scheme 2).[8] The key steps in the synthesis included a Diels Alder reaction, Curtius rearrangement, Birch reduction, an intramolecular nucleophilic amination, and a palladium mediated alkene amination. The synthesis began with cycloaddition between dienophile **10** and diene **11** to give the corresponding *endo* product, which was subjected to hydrolysis of the resulting enol ether followed by thiolate-mediated cleavage of the corresponding ester to afford carboxylic acid **12**. Generation of methyl carbamate moiety of **13** was achieved by refluxing the corresponding acyl

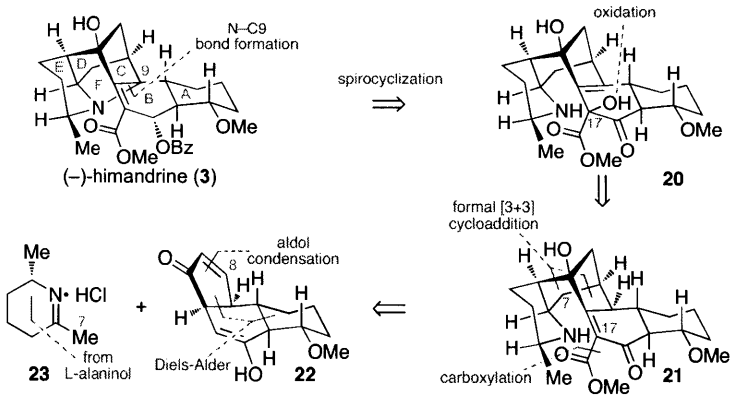


Scheme 2. Mander's synthesis of himandrine skeleton. Conditions: (a) **10**, 48 h, 100 °C; AcOH, THF, H_2O, 87% (2 steps). (b) HMPA, NaH, EtSH, 97%. (c) $(COCl)_2$, DMF, py, D; NaN_3, RT, THF, 5h, 77%. (d) Δ, toluene, 20 min, ~100%. (e) MeOH, NaOMe, ~100%. (f) Li, NH_3, MeOH; AcOH, THF, H_2O; MOM-Cl, $^iPr_2NEt$, DMAP; HCl, $CHCl_3$, 32% (4 steps). (g) 9-BBN, THF, MeOH, H_2O_2, 87%. (h) OsO_4, py, THF, ~75%. (i) $Pb(OAc)_4$, MeOH, 2h, 0 °C, ~70%. (j) $(MeO)_2POC(N_2)COMe$, K_2CO_3, MeOH, 4h, 0 C, 91%. (k) Li/NH_3, MeOH, 20 s, ~95%. (l) CH_3SO_2Cl, Et_3N, DCM, 0 C, 2h, 93%. (m) NaH, DMF, 97%. (n) NaH, HMPA, EtSH, 90%. (o) $PdCl_2$, CuCl, O_2, $^nBu_4NCl$, K_2CO_3, CH_3CN, Δ, 16h, 85%. (p) Rh/Al_2O_3, H_2, $(CF_3)_2CHOH$, 95%. (r) Dowex® 50W, MeOH/H_2O, 5:1, Δ, 8h, ~60%.

azide in toluene followed by methanolysis. At this point, Birch reduction[9] reduced the aromatic ring and the decalone functionality, followed by hydrolysis of the methyl enol ether and isomerization to provide unsaturated ketone **13** in moderate yield. Oxidative cleavage of the E ring was accomplished in a 3-step sequence. First, selective 1,2-reduction of enone **13** followed by OsO_4 oxidation of the resulting allylic alcohol gave triol **14**. Ring cleavage of triol **14** afforded the corresponding ketoaldehyde, that was converted to alkyne **15,** which contained all the requisite carbon atoms to construct the remaining pyrrolidine and piperidine rings. Ring closure to form the pyrrolidine **17** was accomplished in excellent yield by treatment of mesylate **16** with NaH in DMF followed by thiolate-mediated carbamate cleavage. Final ring closure was achieved via oxidative amination to afford hexacycle **18**, followed by hydrogenation and deprotection to provide the himandrine skeleton **19** in racemic form.

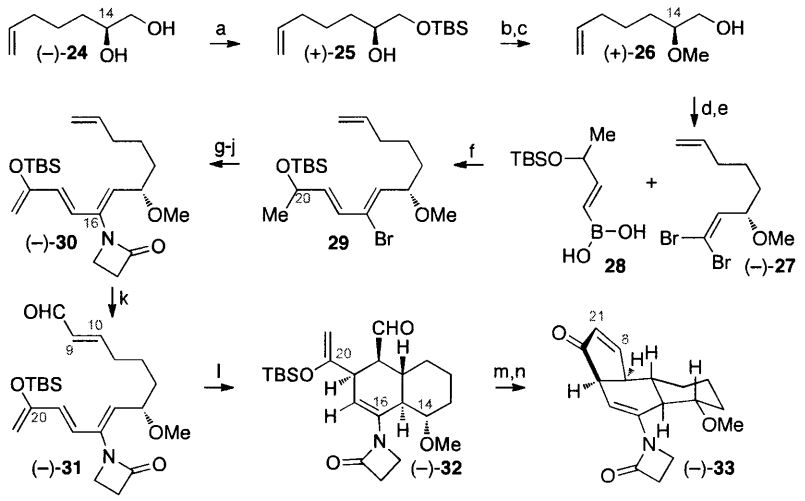
Results and Discussion

Guided by our biosynthetic hypothesis,[3] we envisioned formation of the N-C9 bond by a late stage oxidative spirocyclization of the pentacyclic aminoketoester **21** (Scheme 3). We envisioned that oxidation of **21**, potentially facilitated by dienol formation, would afford allylic alcohol **20**, which is poised for the critical condensative spirocyclization. We expected that application of our annulation methodology[10] to enone **22** and iminium chloride **23** would convergently assemble a pentacycle primed for our proposed biomimetic oxidative spirocyclization.



Scheme 3. Retrosynthetic analysis of (–)-himandrine (**3**).

Our enantioselective synthesis of a tricyclic enone **22** mimic is illustrated in Scheme 4.

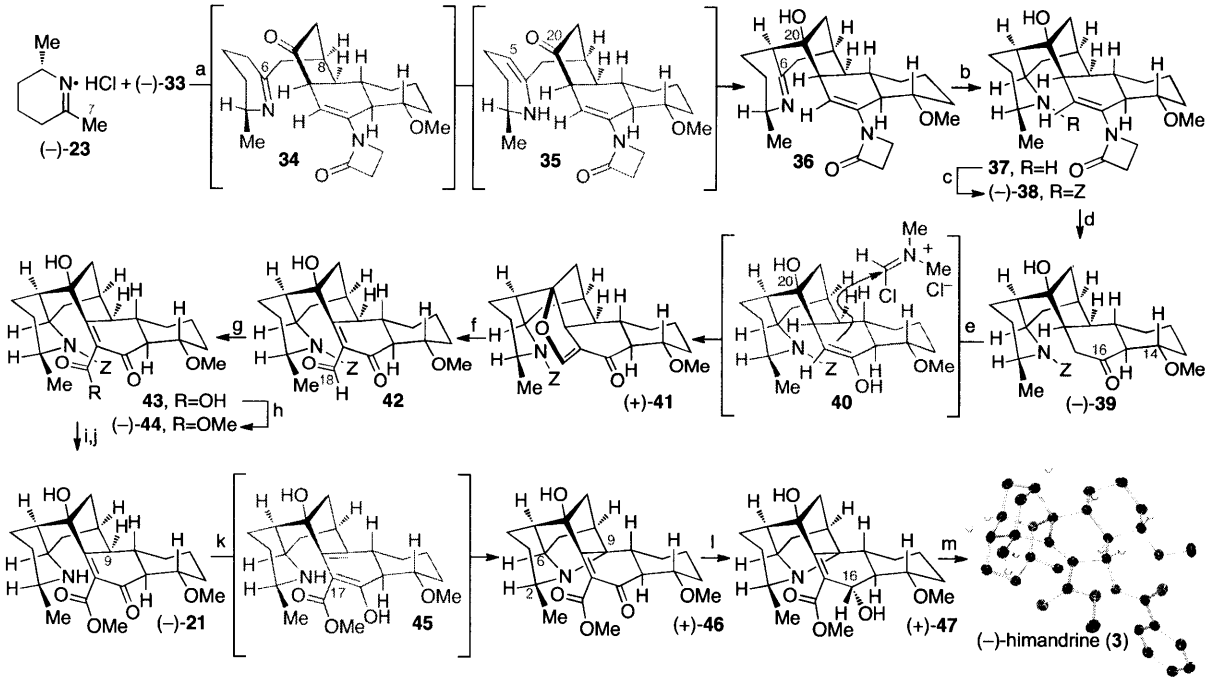


Scheme 4. Enantioselective synthesis of tricyclic enone (–)-**31**. Conditions: (a) TBSCl, imidazole, DMAP, DMF, 0 °C, 94%. (b) 4Å-MS, Proton Sponge®, $Me_3O{\bullet}BF_4$, CH_2Cl_2, 23 °C, 93%. (c) HCl, MeOH, 23 °C, 98%. (d) DMSO, $^iPr_2NEt$, $SO_3{\bullet}$pyr, CH_2Cl_2, 23 °C. (e) CBr_4, PPh_3, CH_2Cl_2, 0 °C, 65% (2-steps). (f) $Pd(PPh_3)_4$, Tl_2CO_3, THF, H_2O, 23 °C, 97%. (g) 2-azetidinone, CuI, K_2CO_3, $(MeNHCH_2)_2$, PhMe, 120 °C, 85%. (h) TBAF, THF, 0→23 °C. (i) DMSO, $^iPr_2NEt$, $SO_3{\bullet}$pyr, CH_2Cl_2, 23 °C, 80% (2-steps). (j) TBSOTf, Et_3N, CH_2Cl_2, –78 °C, 82%. (k) acrolein, 4,5-dihydroIMesCl$_2$Ru=CH(2-^{i}PrO)Ph (10 mol%), CH_2Cl_2, 23 °C, 85%. (l) BHT, *N,N*-diethylaniline, MeCN, 95 °C, 75%, 5:1 dr. (m) $TiCl_4$, CH_2Cl_2, –78 °C. (n) Martin sulfurane, PhH, 23 °C, 57% (2-steps).

The C14-stereochemistry, introduced through the use of MacMillan's D-proline–catalyzed α-oxidation[11], of hept-6-enal, afforded the enantiomerically enriched diol (–)-**24** (>98.5% ee).[12] The C14-methyl ether was then secured by etherification[13] of alcohol (+)-**25** to provide the methoxyalcohol (+)-**26**, setting the stage for the substrate-directed synthesis of the *trans*-decalin AB-ring system. Oxidation[14] of alcohol (+)-**26** followed by conversion of the corresponding aldehyde to dibromoolefin provided (–)-**27**. A highly efficient Suzuki cross-coupling reaction[3,15] involving boronic acid **28** and dibromide (–)-**27** afforded the *cis*-vinyl bromide **29** in 97% yield. A copper-promoted coupling[16] of vinyl bromide **29** with 2-azetidinone followed by conversion of the C20-silyl ether to the corresponding C20-silyl enol ether gave the desired tetraene (–)-**30**. The 2-azetidinone group at C16 was strategically introduced to serve a dual role in facilitating the planned Diels–Alder reaction by providing a 2-*N*-acylaminodiene with greater preference for *s*-cis C16-C17 conformation, and masking the C16-carbonyl for subsequent transformations. A Ru-catalyzed olefin cross-metathesis reaction[17] with acrolein enabled selective functionalization of the acid sensitive tetraene (–)-**30** to the corresponding unsaturated aldehyde (–)-**31** in 85% yield. Heating a solution of tetraenal (–)-**31** in acetonitrile at 95 °C afforded the desired *trans*-

decalin aldehyde (–)-**32** as the major endo Diels-Alder product (75%, dr = 5:1) as supported by nOe studies. Treatment of aldehyde (–)-**32** with titanium tetrachloride provided the corresponding Mukaiyama aldol[18] product, which upon exposure to Martin sulfurane[19] afforded the oxygen and acid sensitive enone (–)-**33** in 57% yield over two steps (Scheme 4).

Lithiation of the readily available iminium chloride (–)-**23**[3] followed by copper-promoted conjugate addition[10] to the enantiomerically enriched enone (–)-**33** afforded the highly air sensitive pentacyclic iminoalcohol **34** (Scheme 5). Importantly, blocking of the *si*-face of the enone by the *trans*-decalin AB-ring system imposed exquisite stereochemical control during the C7-C8 bond formation. Rapid tautomerization of the transiently formed iminoketone **34** enabled nucleophilic addition of C5 to the C20-ketone of **35**, consistent with our biosynthetic hypothesis for the D-ring formation.[3] Addition of sodium borohydride to crude imino alcohol **36** resulted in completely diastereoselective C6-imine reduction, at which point benzyloxycarbonylation of the resulting aminoalcohol **37** provided the desired product (–)-**38** (Scheme 5, Z =



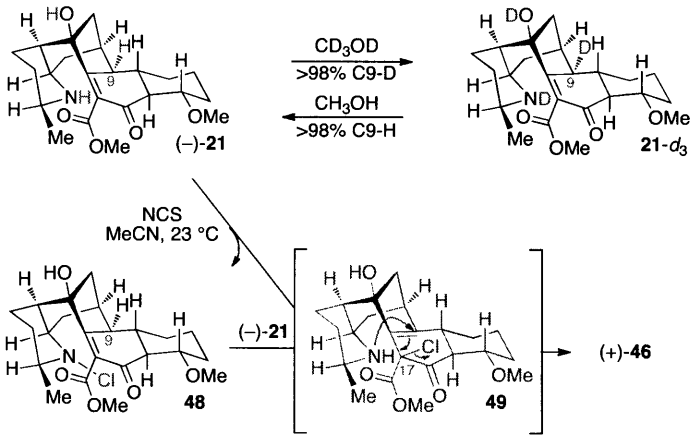
Scheme 5. Enantioselective total synthesis of (–)-himandrine (**3**). Conditions: (a) ^{n}BuLi, THF, (–)-**23**, –78→ 0 °C; CuBr•SMe$_2$; (–)-**33**, –78→–10 °C. (b) NaBH$_4$, EtOH, 0 °C. (c) ClCO$_2$Bn, ^{i}Pr$_2$NEt, K$_2$CO$_3$, THF, H$_2$O, 50% (3-steps). (d) TsOH•H$_2$O, PhH, 23 °C, 81%. (e) POCl$_3$, DMF, CH$_2$Cl$_2$, 0→23 °C, 71%. (f) DDQ, SiO$_2$, MeCN, H$_2$O, 23 °C. (g) NaClO$_2$, NaH$_2$PO$_4$•H$_2$O, 2-methyl-2-butene, ^{t}BuOH, H$_2$O, 23 °C. (h) CH$_2$N$_2$, THF, 0 °C, 61% (3-steps). (i) TMS-I, 2,6-di-^{t}Bu-4-Me-Pyr, CH$_2$Cl$_2$, 0 °C, 66%. (j) Et$_3$N•(HF)$_3$, THF, 23 °C, 90%. (k) NCS, MeCN, 23 °C, 45 min, 89%. (l) NaBH$_4$, EtOH, 0 °C, 90%. (m) BzCl, pyridine, 23 °C, 7 d, 87%.

benzyloxycarbonyl) in 50% yield over three steps. Importantly, the formal cycloaddition between iminium chloride (–)-**23** and enone (–)-**33** and subsequent C6-reduction of imine **36** secured four stereogenic centers and expediently assembled the pentacyclic substructure of (–)-himandrine (**3**) as a single diastereomer.

Mild hydrolysis of *N*-vinyl-carbamate (–)-**38** with *p*-toluene sulfonic acid monohydrate in benzene afforded the key intermediate ketone (–)-**39** in 75% yield. The mild reaction conditions used in hydrolysis of the C16 *N*-vinyl lactam circumvent the competing acid catalyzed β-elimination of the C14-methyl ether in ketone (–)-**39**.[20] At this juncture, we required a mild method for introduction of the C17-methoxycarbonyl group in order to access the aminoketoester **21**. After exploring a variety of strategies, we found that treatment of ketone (–)-**39** with Vilsmeier's reagent[21] provided the vinyl ether (+)-**41** in 71% yield, likely occurring through nucleophilic addition of enol **40** (Scheme 5) followed by trapping with the C20-alcohol. Exposure of vinyl ether (+)-**41** to 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ)[22] furnished the corresponding unsaturated β-ketoaldehyde **42**. Immediate oxidation of the acid sensitive C18-aldehyde **42** to the corresponding carboxylic acid **43** followed by treatment with diazomethane provided the desired β-ketoester (–)-**44** in 61% yield over three steps (Scheme 5). Sequential treatment of carbamate (–)-**44** with trimethylsilyliodide (TMS-I)[3,23] and triethylamine trihydrofluoride provided pentacyclic aminoketoester (–)-**21**, our proposed common biosynthetic intermediate to the class II and class III galbulimima alkaloids.

With the key intermediate in hand, we were able to evaluate the feasibility of our postulated biomimetic late stage N-C9 bond formation. We expected that β-ketoester **21** might undergo rapid tautomerization to the electron rich dienol **45**, enabling facile C17 oxidation as a prelude to intramolecular allylic displacement by the amine to give the N-C9 spirocycle. Deuterium labeling studies were employed in monitoring H/D exchange at C9 (Scheme 6). Compellingly, simple dilution of aminoketoester (–)-**21** in methanol-d_4 resulted in immediate and quantitative deuterium incorporation at C9 in the form of aminoketoester **21**-d_3 (Scheme 6).[24] Dissolution of aminoketoester **21**-d_3 in methanol returned aminoketoester (–)-**21**, indicating the exchange of C9-methine occurs with retention of C9-stereochemistry.[25] Cumulatively, our results are consistent with the amino group being intimately involved in facilitating C9-deprotonation.[26,27] The preservation of the C9-stereochemistry is consistent with intramolecular

protium/deuterium delivery by the corresponding ammonium ion from the more sterically hindered face of the C19-C9 tetrasubstituted alkene of **45**.



Scheme 6. Key observations relevant to N-C9 bond formation.

Guided by our biosynthetic hypothesis and with evidence for rapid dienol formation from aminoketoester (–)-**21**, we wished to capitalize on the inherent chemistry of this plausible biosynthetic intermediate. In the event, treatment of aminoketoester (–)-**21** with *N*-chlorosuccinimide (NCS) in acetonitrile at 23 °C over 45 min afforded the desired spirofused hexacyclic enone (+)-**46** in 89% yield. The structure of (+)-**46** was supported through detailed 2D NMR analysis.[28] Treatment of ketone (+)-**46** with sodium borohydride in ethanol effected completely diastereoselective C16-reduction to the desired diol (+)-**47** in 90% yield. Benzoylation of the C16-hydroxyl group of diol (+)-**47** proceeded to give the first synthetic sample of (–)-himandrine (**3**) in 87% yield ($[\alpha]^{22}_{D} = -21$ (*c*, 0.12 $CHCl_3$); Lit.[1a] ($[\alpha] = -38$ (*c* 1.22, $CHCl_3$).[29] All spectroscopic data for synthetic (–)-**3** matched those reported for the natural compound.[1] The structure of our synthetic (–)-**3** was unequivocally confirmed by X-ray crystallographic analysis.

Intrigued by the high efficiency in the conversion of aminoketoester (–)-**21** to hexacyclic enone (+)-**46**, we sought to gain further mechanistic insight into this transformation. Close monitoring of the reaction mixture indicated that exposure of aminoketoester (–)-**21** to NCS in acetonitrile resulted in concomitant formation of hexacycle (+)-**46** and the light–sensitive *N*-chloro pentacycle **48** (Scheme 6) that would disappear by the end of the reaction. Use of benzene as solvent for this transformation reduced the overall rate of hexacycle (+)-**46** formation

and allowed for the isolation of *N*-chloro pentacycle **48**.[30] Importantly, dissolution of *N*-chloro pentacycle **48** in acetonitrile for 12 h did not result in formation of any hexacycle (+)-**46** and completely returned **48**.[31,32] Additionally, when the deuterium incorporation studies described above were conducted with **48**, there was no evidence for formation of the corresponding dienol, suggesting the nitrogen of **48** is not basic enough to enable deprotonation at C9. Interestingly, exposure of aminoketoester (–)-**21** to samples of *N*-chloro pentacycle **48** in acetonitrile resulted in formation of hexacycle (+)-**46** and (–)-**21**.[33] This result is consistent with an intermolecular N to C halogen transfer from *N*-chloro pentacycle **48** to aminoketoester (–)-**21** (likely via **45**). A plausible mechanism for conversion of aminoketoester (–)-**21** to spirofused hexacycle (+)-**46** is halogenation of the dienol **45** to give α–chloroester **49**,[34] followed by intramolecular allylic displacement by the amine. Significantly, this mechanism is consistent with our proposed biomimetic hypothesis for the advanced stage oxidative spirocyclization of aminoketoester (–)-**21**.[3b]

Conclusion

We have described the first total synthesis of all class II galbulimima alkaloid (–)-himandrine (**3**), a member of the class II galbulimima alkaloids. Noteworthy features of this chemistry include the diastereoselective Diels-Alder reaction for rapid synthesis of the *trans*-decalin containing tricycle (–)-**33** in enantiomerically enriched form, the formal [3+3] annulation strategy to secure the CDE-ring system with complete diastereoselection, and successful implementation of our biogenetically inspired oxidative spirocyclization in converting **48** to (+)-**46**. The successful and direct conversion of (–)-**21** to (+)-**46** drew on the power of biogenetic considerations and fully utilized the inherent chemistry of this plausible biosynthetic intermediate.

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[1] (a) Binns, S. V.; Dustan, P. J.; Guise, G. B.; Holder, G. M.; Hollis, A. F.; McCredie, R. S.; Pinhey, J. T.; Prager, R. H.; Rasmussen, M.; Ritchie, E.; Taylor, W. C. *Aust. J. Chem.* **1965**, *18*, 569. (b) Guise, G. B.; Mander, L. N.; Prager, R. H.; Rasmussen, M.; Ritchie, E.; Taylor, W. C. *Aust. J. Chem.* **1967**, *20*, 1029. (c) Mander, L. N.; Prager, R. H.; Rasmussen, M.; Ritchie, E.; Taylor, W. C. *Aust. J. Chem.* **1967**, *20*, 1473. (d) Mander, L. N.; Prager, R. H.; Rasmussen, M.; Ritchie, E. Taylor, W. C. *Aust. J. Chem.* **1967**, *20*, 1705.

[2] For SCH-530348, a galbulimima alkaloid derived antiplatelet agent, in Phase-III clinical trials for acute coronary syndrome, see (a) Chackalamannil, S.; Wang, Y.; Greenlee, W. J.; Hu, Z.; Xia, Y.; Ahn, H.-S.; Boykow, G.; Hsieh, Y.; Palamanda, J.; Agans-Fantuzzi, J.; Kurowski, S.; Graziano, M.; Chintala, M. *J. Med. Chem.* **2008**, *51*, 3061. (b) Malaska, M. J.; Fauq, A. H.; Kozikowski, A. P.; Aagaard, P. J.; McKinney, M. *Bioorg. Med. Chem. Lett.* **1995**, *5*, 61.

[3] (a) Movassaghi, M.; Hunt, D. K.; Tjandra, M. *J. Am. Chem. Soc.* **2006**, *128*, 8126. (b) Please see SI of ref 3a (page S4, Scheme S2) for a detailed unified biosynthetic hypothesis for class II and III galbulimima alkaloids.

[4] (a) The direct stereochemical and structural relationship between (–)-galbulimima alkaloid 13 (class III) and (–)-himandrine (**3**, class II) was established through instructive chemical degradation studies in the context of the isolation work (ref. 1c). (b) For revision of the stereochemical assignment based on new X-ray analysis, see Willis, A. C.; O'Connor, P. D.; Taylor, W. C.; Mander, L. N. *Aust. J. Chem.* **2006**, *59*, 629.

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[6] For prior syntheses of class I galbulimima alkaloids, see (a) Hart, D. J.; Wu, W.-L.; Kozikowski, A. P. *J. Am. Chem. Soc.* **1995**, *117*, 9369. (b) Chackalamannil, S.; Davies, R. J.; Aserom, T.; Doller, D.; Leone, D. *J. Am. Chem. Soc.* **1996**, *118*, 9812. (c) Tchabanenko, K.; Adlington, R. M.; Cowley, A. R.; Baldwin, J. E. *Org. Lett.* **2005**, *7*, 585

[7] For prior syntheses of class III galbulimima alkaloids, see (a) Mander, L. N.; McLachlan, M. M. *J. Am. Chem. Soc.* **2003**, *125*, 2400. (b) Shah, U. Chackalamannil, S.; Ganguly, A. K.; Chelliah, M.; Kolotuchin, S.; Bulevich, A.; McPhail, A. *J. Am. Chem. Soc.* **2006**, *128*, 12654. (c) Evans, D. A.; Adams, D. J. *J. Am. Chem. Soc.* **2007**, *129,* 1048.

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[12] Diol (–)-**24** is prepared in 3-steps from commercially available 7-octene-1,2-diol on greater than 8-g scale.

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[15] (a) Miyaura, N.; Yamada, K.; Suginome, H.; Suzuki, A. *J. Am. Chem. Soc.* **1985**, *107*, 972. (b) For rate enhancement with TlOH, see Uenishi, J.-i.; Beau, J.-M.; Armstrong, R. W.; Kishi, Y. *J. Am. Chem. Soc.* **1987**, *109*, 4756. (c) Roush, W. R.; Moriarty, K. J.; Brown, B. B. *Tetrahedron Lett.* **1990**, *31*, 6509. (d) Evans, D. A.; Starr, J. T. *J. Am. Chem. Soc.* **2003**, *125*, 13531.

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[20] The more forcing reaction conditions needed for hydrolysis of an *N*-vinyl oxazolidinone (ref. 3) derivative of **38** led to competing b-elimination of the C14-methyl ether.

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[24] The ^{1}H NMR spectrum of **21**-d_3 was the same as the starting aminoketoester (–)-**21** with the exception of the C9-methine spin systems.

[25] Similar results were obtained using a C20 *O*-trimethylsilylated derivative of (–)-**21**.

[26] Attempts at intermolecular C9 deprotonation were unsuccessful; the proximity of the amine to C9-methine seems to facilitate tautomerization.

[27] Use of derivatives of aminoketoester **21** not possessing a basic amine (i.e., *N*-Cbz, N-Cl) resulted in no C9-deuterium incorporation over 24 h.

[28] Key HMBC correlations between C9/C2-H and C9/C6-H confirmed the N-C9 bond connectivity.

[29] The C14-methyl ether and the C17-methoxycarbonyl substituents greatly shield the C16 alcohol leading to slow benzoylation.

[30] The reaction had to be stopped within 10 min otherwise significantly more hexacycle (+)-**46** would be generated.

[31] Addition of succinimide does not lead to conversion of **48** to (+)-**46**.

[32] While the sensitivity of **48** precluded its derivatization, use of its more stable C20-*O*-trimethylsilyl derivative under basic, acidic, or photo-chemical conditions predominantly led to elimination and decomposition.

[33] Complete mass balance was observed and the amount of hexacycle (+)-**46** formed was exactly proportional to amount of **48** used.

[34] While C9 halogenation cannot be ruled out, C17 halogenation is consistent with the lack of product formation using the C20-*O*-trimethylsilyl derivative of **48** with significantly blocked access to C17.

Experimental Section

General procedure. All reactions were performed in oven-dried or flame-dried round-bottomed flasks, modified Schlenk (Kjeldahl shape) flasks, or glass pressure vessels. The flasks were fitted with rubber septa and reactions were conducted under a positive pressure of argon. Stainless steel syringes or cannulae were used to transfer air- and moisture-sensitive liquids. Flash column chromatography was performed as described by Still et al. using silica gel (60 Å pore size, 40-63 μm, 4-6% H_2O content, Zeochem).[1] Where necessary (so noted), silica gel was neutralized by treatment of the silica gel prior to chromatography with the eluent containing 1% triethylamine or 1% ammonium hydroxide. Analytical thin-layer chromatography was performed using glass plates pre-coated with 0.25 mm 230–400 mesh silica gel impregnated with a fluorescent indicator (254 nm). Where necessary (so noted), silica gel plates were neutralized by treatment with a solution of 1% triethylamine or 1% ammonium hydroxide in dichloromethane followed by heating on a hot plate (~250 °C). Thin layer chromatography plates were visualized by exposure to ultraviolet light and/or by exposure to an ethanolic phosphomolybdic acid (PMA), an acidic solution of *p*-anisaldehyde (anis), an aqueous solution of ceric ammonium molybdate (CAM), an aqueous solution of potassium permanganate ($KMnO_4$) or an ethanolic solution of ninhydrin followed by heating (<1 min) on a hot plate (~250 °C). Organic solutions were concentrated on Büchi R-200 rotary evaporators at ~20 Torr at 25–35 °C unless otherwise indicated.

Materials. Commercial reagents and solvents were used as received with the following exceptions: dichloromethane, diethyl ether, tetrahydrofuran, acetonitrile, and toluene were purchased from J.T. Baker (Cycletainer™) and were purified by the method of Grubbs et al. under positive argon pressure.[2] Triethylamine, diisopropylethylamine, and benzene were distilled over calcium hydride immediately before use. Acrolein was distilled over calcium sulfate immediately before use. Methyl vinyl ketone was distilled over potassium carbonate and calcium chloride immediately prior to use. Martin sulfurane was purchased from Aldrich and stored in a glove box under nitrogen atmosphere. *N*-Chlorosuccinimide (NCS) was recrystallized from benzene prior to use. Phosphorus oxychloride was distilled under reduced pressure before use. The molarity of *n*-butyllithium solutions was determined by titration using diphenylacetic acid as an indicator (average of three determinations).[3] Ammonia saturated dichloromethane was obtained by agitation of dichloromethane in the presence of ammonium hydroxide followed by drying over anhydrous sodium sulfate. Where necessary (so noted) solutions were deoxygenated by alternate freeze (liquid nitrogen)/evacuation/argon-flush/thaw cycles (FPT, three iterations) or degassed by purging with argon for several minutes.

Instrumentation. Proton nuclear magnetic resonance (^{1}H NMR) spectra were recorded with a Varian 300 Mercury or a Varian inverse probe 500 INOVA spectrometer or a Bruker 400 spectrometer or a Bruker inverse probe 600 Avance spectrometer. Chemical shifts are recorded in parts per million on the δ scale and are referenced from the residual protium in the NMR solvent ($CHCl_3$: δ 7.27, C_6D_5H: δ7.16). Data is reported as follows: chemical shift [multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, app = apparent, br = broad),

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[1] Still, W. C.; Kahn, M.; Mitra, A. *J. Org. Chem.* **1978**, *43*, 2923.
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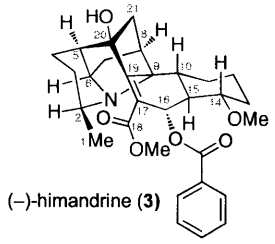
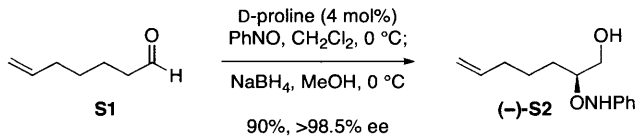
coupling constant(s) in Hertz, integration, assignment]. Carbon-13 nuclear magnetic resonance (^{13}C NMR) spectra were recorded with a Bruker 600 Avance spectrometer, a Varian 500 INOVA spectrometer or a Bruker 400 spectrometer with a Magnex Scientific superconducting magnet and are recorded in parts per million on the δ scale and are referenced from the carbon resonances of the solvent ($CDCl_3$: δ 77.2, benzene-d_6: δ 128.4). Infrared data were obtained with a Perkin-Elmer 2000 FT-IR and are reported as follows: [frequency of absorption (cm^{-1}), intensity of absorption (s = strong, m = medium, w = weak, br = broad), assignment]. Optical rotations were measured on a Jasco-1010 polarimeter. We are grateful to Dr. Li Li for obtaining the mass spectroscopic data at the Department of Chemistry's Instrumentation Facility, Massachusetts Institute of Technology. High-resolution mass spectra (HRMS) were recorded on a Bruker APEX 4.7 Tesler FTMS spectrometer using electronspray ion source (ESI) or electronspray (ES). The structure of (–)-himandrine was obtained with the assistance of Dr. Peter Muller at the X-ray diffraction facility of Department of Chemistry, Massachusetts Institute of Technology, and Justin Kim of the Movassaghi group.

Additional Notes. Positional numbering system: For ease of direct comparison, particularly from *trans*-decalin (–)-**32** to himandrine (–)-**3**, the numbering scheme used by Taylor and coworkers in the isolation paper[4] is used in this supporting document. In key instances the products are accompanied by the numbering system as shown below for this document.



(–)-himandrine (**3**)

[4] Ritchie, E.; Taylor, W. C. *In the Alkaloids*; Manske, R. H. F., Ed.; Academic Press; New York, 1967; Vol. 9, Chapter 14.



(–)-(*S*)-2-(*N*-Phenyl-aminooxy)-hept-6-en-1-ol (S2):

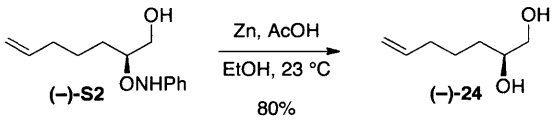
Nitrosobenzene (9.7 g, 0.090 mmol, 1 equiv) was added as a solid to a suspension of D-proline (0.46 g, 4.0 mmol, 4.0 mol%) in chloroform (50 mL) at 0 °C, and the resulting mixture was sealed under an argon atmosphere. After 15 min, hept-6-enal[5] (11.2 g, 10.0 mmol, 1.10 equiv) was added drop-wise via additional funnel to the bright green solution. After 3 h, the resulting brown reaction mixture was added dropwise via additional funnel to a suspension of sodium borohydride (14.2 g, 0.375 mol, 4.17 equiv) in methanol (50 mL) at 0 °C. After 30 min, saturated aqueous sodium bicarbonate solution (100 mL) was added, and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 150 mL). The combined organic layers were washed with brine (200 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting oil was purified by flash column chromatography (silica gel: diam. 7 cm, ht. 7 cm; eluent: 33% EtOAc in hexanes) to afford alcohol (–)-**S2** (18.1 g, 91%) as a yellow oil ($[\alpha]^{22}_D$ = –26.4 (*c* 1.0, CH_2Cl_2)). This compound was determined to be of >98.5% ee by chiral HPLC analysis (Chirapak AD-H, 95% hexanes / 5% *iso*-propanol, 3 mL/min, 215 nm t_R (major) = 18.03 min; t_R (minor) = 22.15 min).

The corresponding enantiomer, (+)-(*R*)-2-(*N*-Phenyl-aminooxy)-hept-6-en-1-ol (3.22 g, 80%, $[\alpha]^{22}_D$ = +26 (*c* 0.90, CH_2Cl_2)), was prepared according to the same procedure using L-proline as the catalyst. This compound was determined to be of >98.5% ee by chiral HPLC analysis (Chirapak AD-H, 95% hexanes / 5% *iso*-propanol, 3 mL/min, 215 nm t_R (minor) = 18.12 min; t_R (major) = 22.02 min). Structural assignment utilized additional information from gCOSY and HSQC.

^{1}H NMR (400 MHz, $CDCl_3$, 20 °C):	7.29-7.23 (m, 2H, Ar**H**), 7.03 (br-s, 1H, N**H**Ph), 7.00-6.94 (m, 3H, Ar**H**), 5.90-5.72 (m, 1H, C**H**=CH_2), 5.07-4.90 (m, 2H, CH=C**H**$_2$), 4.00-3.91 (m, 1H, C**H**ONHPh), 3.88-3.71 (m, 2H, C**H**$_2$OH), 2.60 (br-s, 1H, CH_2O**H**), 2.13-2.02 (m, 2H, CH_2=CHC**H**$_2$), 1.72-1.43 (m, 4H, C**H**$_2$C**H**$_2$).
^{13}C NMR (100 MHz, $CDCl_3$, 20 °C):	148.5 (Ar**C**), 138.5 (CH_2=**C**H), 129.3 (Ar**C**H), 122.8 (Ar**C**H), 115.1 (**C**H$_2$=CH), 115.0 (Ar**C**H), 84.0 (**C**HNHPh), 65.7 (**C**H$_2$OH), 34.0 (**C**H$_2$CH=CH$_2$), 29.6 (**C**H$_2$CHNHPh), 25.2 (**C**H$_2$CH$_2$CH=CH$_2$).
FTIR (thin film) cm^{-1}:	3385 (br, s), 3273 (s), 3076 (w), 2939 (s), 1641 (m), 1602 (s), 1494 (s), 1460 (w), 1241 (m), 1028 (s), 997 (m), 911 (s), 767 (m), 693 (m).

[5] 6-Heptenal was prepared from 7-octene-1,2-diol (commercially available), sodium metaperiodate, diethyl ether, water, 1h, 93%. Spectroscopic data matched those in the literature; see: Taylor, R. E.; Galvin, G. M.; Hilfiker, K. A.; Chen, Y. *J. Org. Chem.* **1998**, *63*, 9580.

HRMS (ESI):	calc'd for $C_{13}H_{19}NNaO_2$ $[M+Na]^+$: 244.1308, found: 244.1308.
TLC (17% EtOAc in hexanes), *Rf*:	0.20 (UV, CAM).

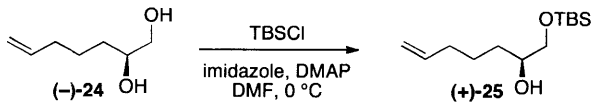


(–)-(*S*)-Hept-6-ene-1,2-diol (24):

Zinc powder (8.89 g, 136 mmol, 2.00 equiv) was added as a solid to a solution of alcohol (–)-**S2** (15.1 g, 68.0 mmol, 1 equiv) in a mixture of ethanol and acetic acid (3:1, 340 mL) at 23 °C. After 2 h, the resulting mixture was filtered through a plug of celite (diam. 8.5 cm, ht. 2 cm), and the residue was washed with ethanol (3 × 150 mL). The filtrate was concentrated under reduced pressure at 30 °C. The residue was dissolved in ethyl acetate (400 mL), was washed with saturated aqueous sodium bicarbonate solution (100 mL), was dried over anhydrous sodium sulfate, was filtered, and was concentrated under reduced pressure. The resulting light yellow oil was purified via flash column chromatography (silica gel: diam. 5 cm, ht. 25 cm; eluent: 5% EtOAc in hexanes to 75% EtOAc in hexanes) to afford diol (–)-**24** (7.1 g, 80%) as a yellow oil ($[\alpha]^{22}_D$ = –21 (*c* 0.44, EtOH)). The spectroscopic data was consistent with the literature.[6] Structural assignment utilized additional information from gCOSY and HSQC.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C):	5.83-5.71 (m, 1H, CH_2=C**H**), 5.04-4.87 (m, 2H, C**H**$_2$=CH), 3.65 (br-s, 1H, C**H**OH), 3.59 (app-d, *J* = 11.0Hz, 1H, C**H**H'OH), 3.43-3.34 (m, 1H, CH**H**'OH), 3.33-3.12 (br-s, 2H, O**H**, O**H**), 2.08-1.99 (m, 2H, C**H**$_2$CH=CH_2), 1.57-1.34 (m. 4H, C**H**$_2$C**H**$_2$).
^{13}C NMR (100 MHz, $CDCl_3$, 20 °C):	138.6 (CH_2=**C**H), 115.0 (**C**H_2=CH), 72.4 (**C**HOH), 66.9 (**C**H_2OH), 33.8 (CH_2=CH**C**H_2), 32.6 (CH_2=CHCH_2-C**H**$_2$CH_2), 25.0 (CH_2=CHCH_2**C**H_2CH_2).
FTIR (thin film) cm^{-1}:	3364 (br, s), 1641 (m), 1064 (m), 908 (m), 666 (w).
HRMS (ESI):	calc'd for $C_7H_{14}NaO_2$ $[M+Na]^+$: 153.0886, found: 153.0892.
TLC (75% EtOAc in hexanes), *Rf*:	0.40 ($KMnO_4$, CAM).

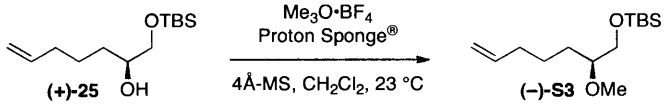
[6] Takahata, H.; Takahashi, S.; Kouno, S.; Momose, T. *J. Org. Chem.* **1998**, *63*, 2224.



(+)-(*S*)-1-(*tert*-Butyl-dimethyl-silanyloxy)-hept-6-en-2-ol (25):

tert-Butylchlorodimethylsilane (6.4 g, 42 mmol, 1 equiv) was added as a solid to a solution of diol (–)-**24** (6.10 g, 47.0 mmol. 1.05 equiv), 4-dimethylaminopyridine (229 mg, 1.90 mmol, 4.00 mol%), and imidazole (4.1 g, 60 mmol, 1.5 equiv) in *N,N*-dimethylformamide (230 mL) at 0 °C, and the reaction mixture was sealed under an argon atmosphere. After 3 h, the reaction mixture was diluted with diethyl ether (300 mL) and brine (150 mL), and the layers were separated. The aqueous layer was extracted with diethyl ether (3 × 150 mL). The combined organic layers were washed with brine (250 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting oil was purified via flash column chromatography (silica gel: diam. 5 cm, ht. 17 cm; eluent: 10% EtOAc in hexanes) to provide silyl ether (+)-**25** (9.6 g, 94%) as a pale yellow oil ($[\alpha]^{22}_D$ = +3.5 (*c* 1.4, CH_2Cl_2)).

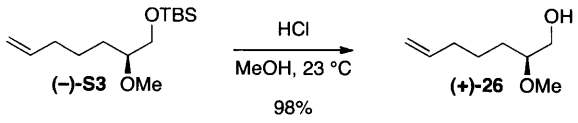
^{1}H NMR (600 MHz, $CDCl_3$, 20 °C):	5.82-5.72 (m, 1H, CH_2=C**H**), 4.99-4.91 (m, 2H, CH_2=CH), 3.61-3.57 (m, 2H, C**H**OH, C**H**H'OTBS), 3.37-3.34 (m, 1H, CH**H**'OTBS), 2.45 (br-s, 1H, CHO**H**), 2.08-2.03 (m, 2H, CH_2=CHCH_2), 1.58-1.49 (m, 1H, C**H**H'CH_2), 1.44-1.33 (m, 3H, CH**H**'CH_2), 0.87 (s, 9H, SiC(CH_3)$_3$), 0.04 (s, 6H, Si(CH_3)$_2$).
^{13}C NMR (100 MHz, $CDCl_3$, 20 °C):	138.9 (CH_2=**C**H), 114.8 (**C**H=CH), 71.8, 67.4, 34.1, 32.3, 26.1 (SiC(**C**H_3)$_3$), 25.1, 18.6, –5.2 (Si(**C**H_3)$_2$).
FTIR (thin film) cm^{-1}:	3446 (br, s), 3078 (m), 2859 (s), 1642 (m), 1463 (m), 1472 (m), 1362 (w), 1257 (m).
HRMS (ESI):	calc'd for $C_{13}H_{28}NaO_2Si$ $[M+Na]^+$: 267.1751, found: 267.1750.
TLC (10% EtOAc in hexanes), *Rf*:	0.55 ($KMnO_4$).



(–)-(*S*)-*tert*-Butyl-(2-methoxy-hept-6-enyloxy)-dimethyl-silane (S3):

Oven-dried 4Å molecular sieves (19.6 g, 2:1, wt/wt), Proton Sponge® (25.5 g, 118 mmol, 3.00 equiv), and trimethoxyl oxonium tetrafluoroborate (14.5 g, 98.0 mmol, 2.51 equiv) were added sequentially to a solution of alcohol (+)-**25** (9.6 g, 39 mmol, 1 equiv) in dichloromethane (392 mL) at 23 °C, and the reaction mixture was sealed under an argon atmosphere. After 3 h, the reaction mixture was filtered through a plug of celite (diam. 8.5 cm, ht. 3 cm), and the residue was washed with dichloromethane (3 × 100 mL). The filtrate was concentrated under reduced pressure. The residue was dissolved in a mixture of hexanes and ethyl acetate (1 : 1, 400 mL), and the residual insoluble light brown solid was removed by filtration, and was washed with a mixture of hexanes and ethyl acetate (1 : 1, 2 × 100 mL). The filtrate was washed with saturated aqueous copper sulfate solution (150 mL) and brine (150 mL), was dried over anhydrous sodium sulfate, was filtered, and was concentrated under reduced pressure. The resulting oil was purified via flash column chromatography (silica gel: diam. 5 cm, ht. 17 cm; eluent: 3% EtOAc in hexanes) to afford methyl ether (–)-**S3** (9.3 g, 93%) as a colorless oil ($[\alpha]^{22}_D$ = –11 (*c* 1.4, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY and HSQC.

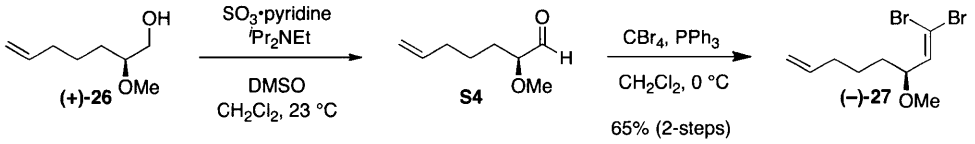
^{1}H NMR (600 MHz, $CDCl_3$, 20 °C):	5.83-5.73 (m, 1H, CH_2=C**H**), 5.01-4.88 (m, 2H, C**H**$_2$=CH), 3.60 (dd, *J* = 6.0, 10.2 Hz, 1H, CH**H**'OTBS), 3.52 (dd, *J* = 4.8, 10.2 Hz, 1H, CH**H**'OTBS), 3.38 (s, 3H, OC**H**$_3$), 3.19-3.16 (m, 1H, C**H**OCH$_3$), 2.04-2.03 (m, 2H, CH_2=CHC**H**$_2$), 1.53-1.46 (m, 2H, C**H**$_2$CH$_2$), 1.45-1.36 (m, 2H, CH_2C**H**$_2$), 0.87 (s, 9H, SiC(C**H**$_3$)$_3$), 0.03 (s, 6H, Si(C**H**$_3$)$_2$).
^{13}C NMR (100 MHz, $CDCl_3$, 20 °C):	139.0 (CH_2=**C**H), 114.8 (**C**H=CH), 82.1 (O**C**H$_3$), 65.4, 58.2, 34.1, 31.0, 26.2 (SiC(**C**H$_3$)$_3$), 24.9, 18.4, –5.1 (Si(**C**H$_3$)$_2$).
FTIR (thin film) cm^{-1}:	2929 (s), 2859 (s), 1642 (w), 1472 (m), 1463 (m), 1256 (s), 1107 (s), 837 (s), 776 (s).
HRMS (ESI):	calc'd for $C_{14}H_{30}NaO_2Si$ $[M+Na]^+$: 281.1907, found: 281.1918.
TLC (3% EtOAc in hexanes), *Rf*:	0.63 ($KMnO_4$).



(+)-(*S*)-2-Methoxy-hept-6-en-1-ol (26):

Thionyl chloride (0.495 mL, 13.6 mmol, 0.400 equiv) was added dropwise to methanol (340 mL) at 23 °C. After 5 min, the resulting methanolic hydrochloric acid solution (0.04 M) was added to a solution of silyl ether (–)-**S3** (8.6 g, 34 mmol, 1 equiv) in methanol (340 mL) at 23 °C. After 15 min, the reaction solvent was removed under reduced pressure, and the residue was purified by flash column chromatography (silica gel: diam. 3 cm, ht. 10 cm; eluent: 33% EtOAc in hexanes) to afford alcohol (+)-**26** (4.9 g, 98%) as a pale yellow oil ($[\alpha]^{22}_{D}$ = + 22 (*c* 0.70, CH_2Cl_2)).

^{1}H NMR (400 MHz, $CDCl_3$, 20 °C):	5.80-5.67 (m, 1H, CH_2=C**H**), 5.00-4.87 (m, 2H, C**H**$_2$=CH), 3.64-3.57 (m, 1H, C**H**$_2$OH), 3.45-3.39 (m, 1H, C**H**$_2$OH), 3.34 (s, 3H, OC**H**$_3$), 3.23-3.16 (m, 1H, C**H**OCH$_3$), 2.56-2.53 (m, 1H, CH$_2$O**H**), 2.05-1.98 (m, 2H, CH_2=CHC**H**$_2$), 1.55-1.44 (m, 1H, C**H**H'CH$_2$), 1.44-1.32 (m, 3H, CH**H**'C**H**$_2$).
^{13}C NMR (125 MHz, $CDCl_3$, 20 °C):	138.5 (CH_2=**C**H), 114.9 (**C**H=CH), 81.7 (O**C**H$_3$), 63.9, 57.2, 33.9 (CH_2=CH**C**H$_2$), 29.8, 24.7.
FTIR (thin film) cm^{-1}:	3421 (br, s), 2935 (s), 1641 (w), 1458 (w), 1093 (s), 910 (m).
HRMS (ESI):	calc'd for $C_8H_{16}NaO_2$ $[M+Na]^+$: 167.1043, found: 167.1040.
TLC (33% EtOAc in hexanes), *Rf*:	0.60 ($KMnO_4$).



(–)-1,1-Dibromo-3-methoxy-octa-1,7-diene (27):

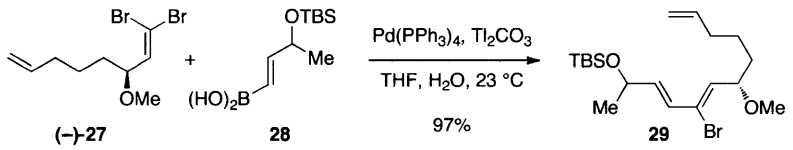
Dimethyl sulfoxide (24.2 mL, 340 mmol, 10.0 equiv), diisopropylethylamine (30.5 mL, 170 mmol, 5.00 equiv) and sulfur trioxide pyridine complex (16.2 g, 102 mmol, 3.00 equiv) were added sequentially to a solution of alcohol (+)-**26** (4.9 g, 34 mmol, 1 equiv) in dichloromethane (170 mL) at 23 °C, and the reaction mixture was sealed under an argon atmosphere. After 15 min, the reaction mixture was diluted with diethyl ether (250 mL) and water (100 mL), and the layers were separated. The aqueous layer was extracted with diethyl ether (3 × 150 mL). The combined organic layers were washed sequentially with aqueous hydrochloric acid solution (1M, 100 mL), saturated aqueous sodium bicarbonate solution (100 mL), and brine (100 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting oil was purified via flash column chromatography (silica gel: diam. 3 cm, ht. 10 cm; eluent: 33% diethyl ether in hexanes) to afford aldehyde **S4** as a colorless oil.[7]

Triphenylphosphine (21.4 g, 81.6 mmol, 2.40 equiv) was added as a solid to a solution of carbon tetrabromide (13.5 g, 40.8 mmol, 1.20 equiv) in dichloromethane at 0 °C, and the reaction mixture was sealed under an argon atmosphere. After 15 min, the solution of aldehyde **S4** in dichloromethane (10 mL) was added dropwise via cannula to the resulting orange reaction mixture. After 15 min, excess dibromophosphorane was quenched by sequential addition of triethylamine (11.5 mL, 81.6 mmol, 2.40 equiv) and methanol (3.5 mL, 81.6 mmol, 2.40 equiv). The reaction mixture was added dropwise to a mixture of hexanes and ethyl acetate (5:1, 400 mL). The resulting light brown solid was removed by filtration, and was washed with a mixture of hexanes and ethyl acetate (5:1, 100 mL). The filtrate was concentrated, and the residue was purified by flash column chromatography (silica gel: diam. 5 cm, ht. 17 cm; eluent: 10% diethyl ether in hexanes) to provide dibromide (–)-**27** (6.1 g, 65% 2-steps) as a colorless oil ($[\alpha]^{22}_D$ = –19 (*c* 2.8, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C):	6.30 (d, *J* = 8.5 Hz, 1H, CBr_2=C**H**), 5.83-5.72 (m, 1H, CH_2=C**H**), 5.03-4.91 (m, 2H, C**H**$_2$=CH), 3.89-3.84 (m, 1H, C**H**CH=CBr_2), 3.28 (s, 3H, OC**H**$_3$), 2.08-2.03 (m, 2H, CH_2=CHC**H**$_2$), 1.65-1.57 (m, 1H, C**H**H'CH_2), 1.53-1.37 (m, 3H, CH**H'**C**H**$_2$).
^{13}C NMR (125 MHz, $CDCl_3$, 20 °C):	140.1 (CH_2=**C**H), 138.7, 115.1 (**C**H_2=CH), 91.4, 81.5 (O**C**H_3), 57.2, 33.9, 33.8, 24.3.
FTIR (thin film) cm^{-1}:	2931 (s), 2822 (w), 1641 (m), 1617 (m), 1458 (m), 1105 (s), 912 (s), 782 (s).

[7] Reduction of a sample of aldehyde **S4** ($NaBH_4$) returned the alcohol (+)-**26** with the same optical activity as compared to the starting alcohol (+)-**26**.

Elemental Analysis:	calc'd for $C_9H_{14}Br_2O$: C, 36.27; H, 4.74, found: C, 35.98; H, 4.70.
TLC (10% Et_2O in hexanes), *Rf*:	0.78 (UV, CAM).



(4-Bromo-6-methoxy-1-methyl-undeca-2,4,10-trienyloxy)-*tert*-butyl-dimethyl-silane (29):

Tetrakis(triphenylphosphine)palladium (1.54 g, 1.30 mmol, 8.00 mol%) and thallium carbonate (15.7 g, 33.0 mmol, 2.00 equiv) were added sequentially to a degassed solution of dibromide (–)-**27** (4.99 g, 17.0 mmol, 1 equiv) and boronic acid **28**[8] (4.04 g, 17.6 mmol, 1.10 equiv) in a mixture of tetrahydrofuran and water (2:1, 68 mL) at 23 °C in the dark, and the reaction mixture was sealed under an argon atmosphere. After 10 h, the pale yellow heterogeneous reaction mixture was diluted with ethyl acetate, was filtered through a plug of silica gel (diam. 5 cm, ht. 3 cm), and the residue was washed with ethyl acetate (3 × 100 mL). The filtrate was washed with saturated aqueous sodium bicarbonate solution (100 mL) and brine (100 mL), was dried over anhydrous sodium sulfate, was filtered and was concentrated under reduced pressure. The resulting oil was purified by flash column chromatography (silica gel: diam. 5 cm, ht. 10 cm; eluent: 33% EtOAc in hexanes) to afford vinyl bromide **29** (6.7 g, 97%) as a 1:1 mixture of two diastereomers. Structural assignment utilized additional information from gCOSY.

^{1}H NMR (500 MHz, $CDCl_3$, 20 °C, one diastereomer noted by *): 6.23-6.19 (m, 1H, CH=C**H**–CBr; 1H, CH=C**H**–CBr*), 6.12-6.08 (m, 1H, C**H**=CH–CBr; 1H, C**H**=CH–CBr*), 5.83-5.73 (m, 2H, CBr=C**H**, CH_2=C**H**; 2H, CBr=C**H***, CH_2=C**H***), 5.03-4.90 (m, 2H, C**H**$_2$=CH; 2H, C**H**$_2$=CH*), 4.47-4.40 (m, 1H, C**H**OTBS; 1H, C**H**OTBS*), 4.22-4.15 (m, 1H, C**H**OCH_3; 1H, C**H**OCH_3*), 3.29 (s, 3H, $OC\mathbf{H}_3$), 3.28 (s, 3H, $OC\mathbf{H}_3$*), 2.06 (app-q, J = 7.0 Hz, 2H, $C\mathbf{H}_2CH{=}CH_2$; 2H, $C\mathbf{H}_2CH{=}CH_2$*), 1.67-1.40 (m, 4H, $CH_2C\mathbf{H}_2$; 4H, $CH_2C\mathbf{H}_2$*), 1.24 (d, J = 6.0 Hz, 3H, $C\mathbf{H}_3$CHOTBS; 3H, $C\mathbf{H}_3$CHOTBS*), 0.89 (s, 9H, $SiC(C\mathbf{H}_3)_3$; 9H, $SiC(C\mathbf{H}_3)_3$*), 0.05 (s, 6H, $Si(C\mathbf{H}_3)_2$), 0.05 (s, 6H, $Si(C\mathbf{H}_3)_2$*).

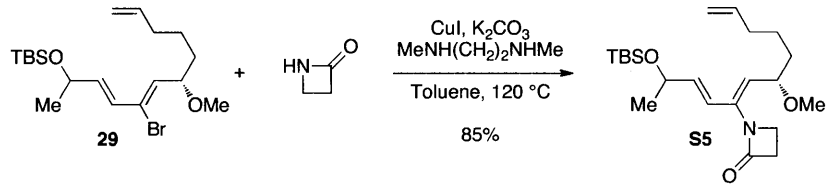
^{13}C NMR (100 MHz, $CDCl_3$, 20 °C): 140.5, 140.4, 138.8, 138.8, 134.2, 134.1, 127.0, 126.9, 126.9, 126.8, 114.9, 80.5, 77.4, 68.3, 56.9, 34.4, 33.9, 26.1, 24.6, 18.5, –4.5.

FTIR (thin film) cm^{-1}: 2929 (s), 1470 (m), 1368 (w), 1253 (s), 1147 (s), 1093 (s), 835 (m), 776 (m).

HRMS (ESI): calc'd for $C_{19}H_{35}BrNaO_2Si$ $[M+Na]^+$: 425.1482, found: 425.1491.

[8] The boronic acid was prepared as described previously; see Movassaghi, M.; Hunt, D. K.; Tjandra, M. *J. Am. Chem. Soc.* **2006**, *128*, 8126.

TLC (10% EtOAc in hexanes), *Rf*: 0.65(UV, CAM).



1-{1-[3-(*tert*-Butyl-dimethyl-silanyloxy)-but-1-enyl]-3-methoxy-octa-1,7-dienyl}-azetidin-2-one (S5):

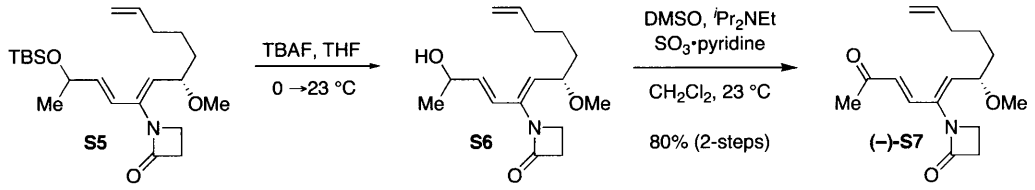
2-Azetidinone (1.16 g, 16.3 mmol, 2.50 equiv), copper iodide (1.58 g, 8.30 mmol, 50.0 mol%), potassium carbonate (5.74 g, 41.5 mmol, 2.50 equiv) and *N,N*-dimethyl ethylene diamine (4.50 mL, 41.5 mmol, 2.50 equiv) were added sequentially to a solution of vinyl bromide **29** (6.72 g, 16.6 mmol, 1 equiv) in anhydrous toluene (16 mL) at 23 °C in a 50-mL schlenk flask. The reaction vessel was sealed under an argon atmosphere, and it was heated to 120 °C. After 16 h, the reaction mixture was cooled to 23 °C and filtered through a plug of silica gel (diam. 3 cm, ht. 3 cm), and the residue was washed with ethyl acetate (3 × 200 mL). The filtrate was concentrated under reduced pressure, and the residue was purified by flash column chromatography (silica gel: diam. 3 cm, ht. 15 cm; eluent: 33% EtOAc in hexanes) to afford triene **S5** (5.4 g, 85%) as a 1:1 mixture of two diastereomers. Structural assignment utilized additional information from gCOSY.

^{1}H NMR (400 MHz, $CDCl_3$, 20 °C, one diastereomer noted by *): 6.02 (app-dt, J = 4.0, 15.6 Hz, 1H, CH=C**H**–CN; 1H, CH=C**H**–CN*), 5.83-5.65 (m, 2H, CH_2=C**H**, C**H**=CHCN; 2H, CH_2=C**H***, C**H**=CHCN*), 5.30 (app-dd, J = 2.0, 8.8 Hz, 1H, NC=C**H**; 1H, NC=C**H***), 5.00-4.89 (m, 2H, CH_2=CH; 2H, CH_2=CH*), 4.40-4.31 (m, 1H, CHOTBS; 1H, CHOTBS*), 3.95-3.85 (m, 1H, $CHOCH_3$; 1H, $CHOCH_3$*), 3.50-3.39 (m, 2H, CH_2C=O; 2H, CH_2C=O*), 3.25 (s, 3H, OCH_3), 3.24 (s, 3H, OCH_3*), 3.11-3.05 (app-t, J = 4.4 Hz, 2H, CH_2N; 2H, CH_2N*), 2.06 (app-q, J = 6.8 Hz, 2H, CH_2CH=CH_2; 2H, CH_2CH=CH_2*), 1.65-1.33 (m, 4H, CH_2CH_2; 4H, CH_2CH_2*), 1.23 (d, J = 6.5 Hz, 3H, CH_3CHOTBS; 3H, CH_3CHOTBS*), 0.87 (s, 9H, $SiC(CH_3)_3$; 9H, $SiC(CH_3)_3$*), 0.04 (s, 6H, $Si(CH_3)_2$), 0.03 (s, 6H, $Si(CH_3)_2$*).

^{13}C NMR (100 MHz, $CDCl_3$, 20 °C): 166.1, 166.0, 138.9, 138.8, 136.9, 136.9, 135.1, 135.0, 130.1, 130.1, 124.1, 124.1, 114.8, 114.7, 77.1, 77.1, 68.6, 68.5, 56.7, 56.7, 41.7, 41.7, 36.7, 34.8, 34.7, 33.9, 26.1, 24.8, 24.6, 18.4, –4.5.

FTIR (thin film) cm^{-1}: 2929 (s), 1761 (s), 1640 (w), 1472 (w), 1396 (m), 1252 (w), 1093 (s), 966 (m), 909 (m), 834 (m), 777 (m).

HRMS (ESI):	calc'd for $C_{22}H_{39}NNaO_3Si$ $[M+Na]^+$: 416.2591, found: 416.2599.
TLC (33% EtOAc in hexanes), *Rf*:	0.50 (UV, CAM).



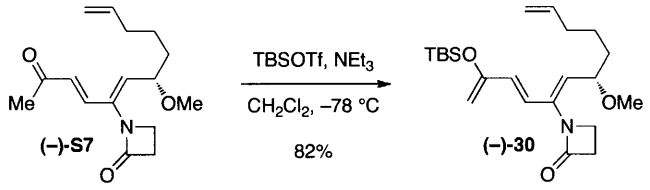
(–)-(*S*)-1-[3-Methoxy-1-(3-oxo-but-1-enyl)-octa-1,7-dienyl]-azetidin-2-one (S7):

Tetrabutylammonium fluoride solution in tetrahydrofuran (1.0 M, 21 mL, 21 mmol, 1.5 equiv) was added via syringe to a solution of triene **S5** (6.9g, 17.6 mmol) in tetrahydrofuran (176 mL) at 0 °C under an argon atmosphere, and the reaction mixture was allowed to warm to 23 °C. After 2 h, the reaction mixture was diluted with diethyl ether (400 mL) and brine (150 mL), and the layers were separated. The aqueous layer was extracted with diethyl ether (3 × 150 mL). The combined organic layers were washed with brine (100 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The residue was purified by flash column chromatography (silica gel: diam. 3 cm, ht. 8 cm; eluent: 75% EtOAc in hexanes) to afford alcohol **S6** (4.6 g, 95%) as a pale yellow oil, which was used directly in the following oxidation step.

Dimethyl sulfoxide (12.5 mL, 175 mmol, 10.0 equiv), diisopropylethylamine (15.7 mL, 87.5 mmol, 5.00 equiv), and sulfur trioxide pyridine complex (8.40 g, 52.5 mmol, 3.00 equiv) were added sequentially to a solution of alcohol **S6** (4.62 g, 16.6 mmol, 1 equiv) in dichloromethane (176 mL) at 23 °C, and the reaction mixture was sealed under an argon atmosphere. After 15 min, the reaction mixture was diluted with diethyl ether (250 mL) and brine (100 mL), and the layers were separated. The aqueous layer was extracted with diethyl ether (3 × 100 mL). The combined organic layers were washed with brine (200 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting oil was purified by flash column chromatagraphy (silica gel: diam. 3 cm, ht. 10 cm; eluent: 75% EtOAc in hexanes) to afford ketone (–)-**S7** (3.9 g, 83%) as a pale yellow oil ($[\alpha]^{22}_D$ = –29 (*c* 0.27, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY and HSQC.

^{1}H NMR (600 MHz, $CDCl_3$, 20 °C):	6.94 (d, *J* = 15.6 Hz, 1H, CH=C**H**CN), 6.08 (d, *J* = 16.2 Hz, 1H, C**H**=CHCN), 5.80 (d, *J* = 9.0 Hz, 1H, CN=C**H**), 5.78-5.71 (m, 1H, CH_2=C**H**), 4.97-4.90 (m, 2H, C**H**$_2$=CH), 3.95-3.90 (m, 1H, C**H**OCH_3), 3.51-3.44 (m, 2H, C**H**$_2$C=ON), 3.24 (s, 3H, O**CH**$_3$), 3.09 (t, *J* = 10.2 Hz, 2H, C**H**$_2$N), 2.26 (s, 3H, C**H**$_3$C=O), 2.01 (app-q, *J* = 7.2 Hz, 2H, C**H**$_2$CH=CH_2), 1.64-1.36 (m, 4H, C**H**$_2$C**H**$_2$).
^{13}C NMR (100 MHz, $CDCl_3$, 20 °C):	197.7 (**C**=O), 166.0 (**C**=ON), 140.1 (CN=**C**H), 139.5 (CH=**C**HCN), 138.5 (CH_2=**C**H), 134.1 (**C**N=CH), 128.5 (**C**H=CHCN), 115.0 (CH_2=CH), 77.1 (**C**HOCH_3), 57.1 (O**C**H$_3$), 42.1 (**C**H$_2$C=O), 37.2 (**C**H$_2$NC=O), 34.3 (**C**H$_2$CHOTBS), 33.7 (**C**H$_2$CH=CH_2), 27.8 (**C**H$_3$C=O), 24.6 (**C**H$_2$C**H**$_2$CH=CH_2).

FTIR (thin film) cm^{-1}:	2932 (s), 1756 (s), 1692 (w), 1673 (m), 1603 (m), 1401 (m), 1361 (w), 1256 (m), 1101 (m), 977 (w), 911 (w), 779 (w).
HRMS (ESI):	calc'd for $C_{16}H_{32}NNaO_3$ $[M + Na]^+$: 300.1570, found: 300.1579.
TLC (75% EtOAc-hexanes), *Rf*:	0.65 (UV, CAM).

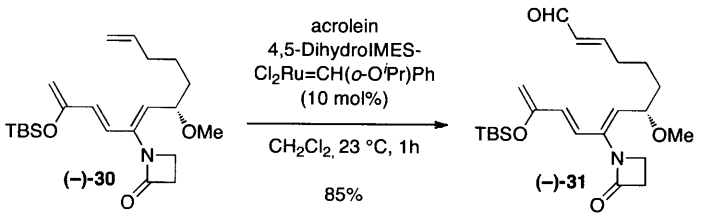


(–)-(*S*)1-{1-[3-(*tert*-Butyl-dimethyl-silanyloxy)-buta-1,3-dienyl]-3-methoxy-octa-1,7-dienyl}-azetidin-2-one (30):

Triethylamine (2.1 mL, 15 mmol, 1.5 equiv) and *tert*-butyldimethylsilyl trifluoromethanesulfonate (2.9 mL, 12 mmol, 1.2 equiv) were added sequentially to a solution of ketone (–)-**S7** (2.77g, 10.0 mmol, 1 equiv) in dichloromethane (100 mL) at –78 °C under an argon atmosphere. After 2 h, saturated aqueous sodium bicarbonate solution (40 mL) was added, and the reaction mixture was allowed to warm to 23 °C. The layers were separated, and the aqueous layer was extracted with dichloromethane (3 × 100 mL). The combined organic layers were washed with brine, were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The resulting oil was then purified by flash column chromatography (silica gel, treated with 1% NEt_3 in [49% EtOAc in hexanes], diam. 3 cm, ht. 10 cm; eluent: 1% of NEt_3 in [49% EtOAc in hexanes]) to afford silyl enol ether (–)-**30** (3.4 g, 86%) as a pale yellow oil ($[\alpha]^{22}_D$ = –28 (*c* 0.27, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY and HSQC.

^{1}H NMR (600 MHz, C_6D_6, 20 °C):	6.67 (d, *J* = 15 Hz, 1H, CH=C**H**CN), 6.19 (d, *J* = 15.6 Hz, 1H, C**H**=CHCN), 5.81-5.72 (m, 1H, CH_2=C**H**), 5.48 (d, *J* = 9.0 Hz, 1H, NC=C**H**), 5.04-4.95 (m, 2H, C**H**$_2$=CH), 4.42 (s, 1H, C**H**H'=COTBS), 4.38 (s, 1H, CH**H'**=COTBS), 4.09-4.04 (m, 1H, C**H**OCH_3), 3.21 (s, 3H, O**CH**$_3$), 2.87 (app-q, *J* = 4.8 Hz, 1H, C**H**$_2$C(=O)N), 2.80 (app-q, *J* = 4.8 Hz, 1H, C**H**$_2$C(=O)N), 2.45 (t, *J* = 4.2 Hz, 2H, C**H**$_2$NC=O), 2.00 (app-t, *J* = 6.6 Hz, 2H, CH**H'**CH=CH_2), 1.74-1.49 (m, 4H, C**H**$_2$C**H**$_2$), 0.98 (s, 9H, SiC(C**H**$_3$)$_3$), 0.14 (s, 6H, Si(C**H**$_3$)$_2$).
^{13}C NMR (100 MHz, C_6D_6, 20 °C):	165.3, 155.4, 139.4, 135.9, 131.5, 129.2, 126.6, 115.1, 98.0, 77.6, 56.8, 41.8, 37.1, 35.5, 34.4, 26.3, 25.6, 18.8, –4.2, –4.2.
FTIR (thin film) cm^{-1}:	2930 (m), 1760 (s), 1622 (w), 1583 (w), 1396 (m), 1318 (m), 1254 (m), 1102 (m), 1028 (m), 840 (m), 782 (m).
HRMS (ESI):	calc'd for $C_{22}H_{37}NNaO_3Si$ $[M+Na]^+$: 414.2435, found: 414.2436.

TLC (1% NEt_3 in [32% EtOAc in hexanes]), *Rf*: 0.55 (UV, CAM).

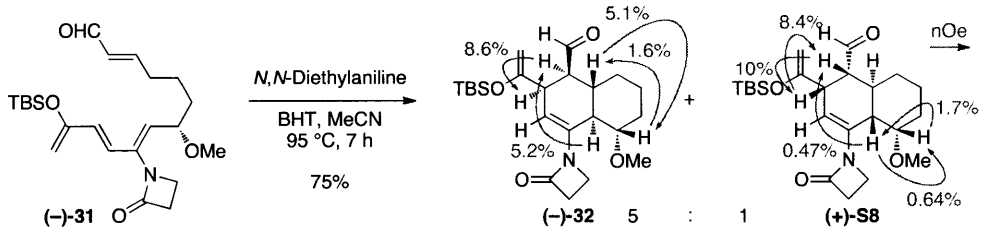


(–)-(*S*,2*E*,8*Z*,10*E*)-12-(*tert*-Butyl-dimethyl-silanyloxy)-7-methoxy-9-(2-oxo-azetidin-1-yl)-trideca-2,8,10,12-tetraenal (31):

Acrolein (0.80 mL, 12 mmol, 5.0 equiv) and the Grubbs-Hoveyda catalyst (150 mg, 0.240 mmol, 10.0 mol%) were added sequentially to a solution of silyl enol ether (–)-**30** (0.95 g, 2.4 mmol, 1 equiv) in dichloromethane (8 mL) at 23 °C, and the reaction vessel was sealed under an argon atmosphere. After 1 h, the reaction mixture was directly loaded onto and purified by flash column chromatography (silica gel, treated with 1% NEt_3 in [32% EtOAc in hexanes], diam. 5 cm, ht. 15 cm; eluent: 1% NEt_3 in [32% EtOAc in hexanes]) to afford tetraenal (–)-**31** (855 mg, 85%) as a pale yellow oil ($[\alpha]^{22}_D = -70$ (*c* 0.20, benzene)). The starting material (–)-**30** (140 mg, 15%) was also recovered.

^{1}H NMR (500 MHz, C_6D_6, 20 °C):	9.32 (d, J = 7.5 Hz, 1H, HC=O), 6.68 (d, J = 15.0 Hz, 1H, CH=C**H**CN), 6.19 (d, J = 15.5 Hz, 1H, C**H**=CHCN), 6.14-6.06 (m, 1H, CHOCH=C**H**), 5.99-5.92 (m, 1H, CHOC**H**=CH), 5.47 (d, J = 9.5 Hz, 1H, N–C=C**H**), 4.44 (s, 1H, C**H**H'=COTBS), 4.37 (s, 1H, CH**H**'=COTBS), 4.08-4.02 (m, 1H, C**H**OCH$_3$), 3.18 (s, 3H, OC**H**$_3$), 2.92-2.89 (m, 1H, C**H**H'C=ON), 2.76-2.73 (m, 1H, CH**H**'C=ON), 2.43 (t, J = 4.8 Hz, 2H, C**H**$_2$NC=O), 1.87-1.80 (m, 2H, CH$_2$=CHC**H**$_2$), 1.61-1.57 (m, 2H, C**H**$_2$), 1.53-1.38 (m, 2H), 0.99 (s, 9H SiC(C**H**$_3$)$_3$), 0.15 (s, 6H, Si(C**H**$_3$)$_2$).
^{13}C NMR (125 MHz, C_6D_6, 20 °C):	193.1, 165.3, 157.6, 155.3, 135.9, 133.8, 130.7, 129.5, 128.9, 128.7, 126.3, 98.2, 77.5, 56.8, 41.5, 37.0, 35.3, 32.8, 26.3, 24.3, 18.6, –4.2, –4.2.
FTIR (thin film) cm^{-1}:	2931 (s), 1756 (s), 1694 (s), 1628 (m), 1466 (m), 1398 (m), 1097 (m), 840 (m), 782 (m).
HRMS (ESI):	calc'd for $C_{23}H_{37}NNaO_4Si$ $[M+Na]^+$: 442.2384, found: 442.2381.

TLC (1% NEt_3 in [32% EtOAc in hexanes]), *Rf*: 0.33 (UV, CAM).



***trans*-Decalin aldehyde (–)-32:**

2,6-Di-*tert*-butyl-4-methylphenol (10 mg, 45 μmol, 0.56 mol%) and *N,N*-diethyl aniline (0.13 mL, 0.81 mmol, 10 mol%) were added sequentially to a solution of tetraenal (–)-**31** (3.4 g, 8.1 mmol, 1 equiv) in acetonitrile (800 mL). The resulting solution was degassed thoroughly by passage of a stream of argon. The resulting pale yellow solution was partitioned into two 500-mL pressure vessels. The vessels were sealed under an argon atmosphere and heated to 95 °C. After 7 h, the reaction vessels were allowed to cool to 23 °C, and the combined mixture was concentrated under reduced pressure. The residue was purified by flash column chromatography (silica gel, treated with 1% NEt_3 in [32% EtOAc in hexanes], diam. 5 cm, ht. 10 cm; 1% NEt_3 in [32% EtOAc in hexanes]) to afford the desired *trans*-decalin aldehyde (–)-**32** (2.1 g, 63%) as a pale yellow oil ($[\alpha]^{22}_D$ = –39 (*c* 1.5, CH_2Cl_2)). The minor diastereomer (+)-**S8** (420 mg, 13%) was also isolated ($[\alpha]^{22}_D$ = +66 (*c* 0.45, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY, HSQC, and HMBC.

Data for the major and desired diastereomer (–)-**32**:

^{1}H NMR (400 MHz, C_6D_6, 20 °C): 9.62 (d, *J* = 5.2 Hz, 1H, C_8**H**), 5.70 (dd, *J* = 2.0, 5.2 Hz, 1H, C_{17}**H**), 4.63 (d, *J* = 1.6 Hz, 1H, C_{21}H**H'**), 4.39 (d, *J* = 1.2 Hz, 1H, C_{21}H**H'**), 3.36-3.31 (m, 1H, C**H**H'C=ON), 3.05 (s, 3H, OC**H**$_3$), 2.92 (dt, *J* = 2.0, 6.0 Hz, 1H, C_{14}**H**), 2.71-2.65 (m, 1H, CH**H'**C=ON), 2.58-2.43 (m, 2H, C**H**$_2$NC=O), 2.17-2.08 (m, 1H, C_9**H**), 2.05-1.94 (m, C_{10}**H**), 1.90-1.83 (m, 1H, C_{13}**H**H'), 1.73 (app-tt, *J* = 2.4, 12.4 Hz, 1H, C_{15}**H**), 1.50-1.36 (m, 2H, C_{11}**H**H', C_{12}**H**H'), 1.05-0.90 (m, 2H, C_{12}H**H'**, C_{13}H**H'**), 0.97 (s, 9H, SiC(C**H**$_3$)$_3$), 0.64 (app-dq, *J* = 6.6, 18.0 Hz, 1H, C_{11}H**H'**), 0.15 (s, 3H, SiC**H**$_3$), 0.10 (s, 3H, SiC**H**$_3$).

^{13}C NMR (125 MHz, C_6D_6, 20 °C): 202.8 (**C**$_8$), 165.8, 157.1, 137.6, 124.8 (**C**$_{17}$), 96.2 (**C**$_{21}$), 82.3 (**C**$_{14}$), 56.3 (CHO**C**H$_3$), 53.4 (**C**$_9$), 47.4 (**C**$_{15}$), 44.4 (**C**$_{19}$), 42.1 (**C**H$_2$C=ON), 37.3 (**C**H$_2$CH$_2$C=ON), 35.2 (**C**$_{10}$), 32.1 (**C**$_{13}$), 29.8 (**C**$_{11}$), 26.2 (SiC(**C**H$_3$)$_3$), 24.0 (**C**$_{12}$), 18.6 (Si**C**(CH$_3$)$_3$), 4.0 (Si**C**H$_3$), 4.6 (Si**C**H$_3$).

FTIR (thin film) cm^{-1}: 2929 (s), 2863 (m), 1750 (s), 1723 (m), 1628 (w), 1383 (m), 1093 (m), 832 (m).

HRMS (ESI): calc'd for $C_{23}H_{37}NNaO_4Si$ $[M+Na]^+$: 442.2384, found: 442.2361.

TLC (1% NEt_3 in [32% EtOAc in hexanes]), *Rf*: 0.25 (UV, CAM).

Data for the minor diastereomer (+)-**S8**:

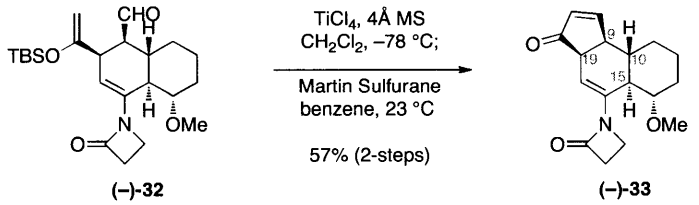
^1H NMR (600 MHz, C_6D_6, 20 °C): 9.69 (d, J = 5.4 Hz, 1H, C_8**H**), 4.74 (dd, J = 1.8, 5.4 Hz, 1H, C_{17}**H**), 4.54 (s, 1H, C_{21}**H**H'), 4.41 (s, 1H, C_{21}H**H'**), 4.23 (br-s, 1H, C_{14}**H**), 3.10 (s, 3H, OC**H**$_3$), 3.04-3.01 (m, 1H, C_{19}**H**), 2.75 (app-dq, J = 2.4, 12.0 Hz, C_{10}**H**), 2.67-2.65 (m, 1H, C**H**H'C=ON), 2.49-2.43 (m, 2H, CH**H'**C=ON, C_{15}**H**), 2.37-2.32 (m, 1H, C**H**H'NC=O), 2.23-2.19 (m, 1H, C_9**H**), 2.16-2.13 (m, 1H, CH**H'**NC=O), 1.89-1.87 (m, 1H, C_{13}**H**H'), 1.65-1.53 (m, 2H, C_{11}**H**H', C_{12}**H**H'), 1.32-1.27 (m, 2H, C_{13}H**H'**, C_{12}H**H'**), 0.98 (s, 9H, SiC(C**H**$_3$)$_3$), 0.84 (app-dq, J = 3.0, 12.6 Hz, 1H, C_{11}H**H'**), 0.14 (s, 6H, Si(C**H**$_3$)$_2$).

^{13}C NMR (125 MHz, C_6D_6, 20 °C): 203.6 (**C**$_8$), 164.1, 158.3, 139.8, 109.4 (**C**$_{17}$), 95.4 (**C**$_{21}$), 76.6 (**C**$_{14}$), 56.8 (O**C**H$_3$), 53.9 (**C**$_9$), 47.0 (**C**$_{15}$), 44.1 (**C**$_{19}$), 37.6 (**C**H$_2$C=ON), 35.1 (**C**H$_2$CH$_2$C=ON), 30.4 (**C**$_{11}$), 29.7 (**C**$_{10}$), 28.4 (**C**$_{13}$), 26.1 (SiC(**C**H$_3$)$_3$), 21.2 (**C**$_{12}$), 18.6 (Si**C**(CH$_3$)$_3$), –4.1 (Si**C**H$_3$), –4.6 (Si**C**H$_3$).

FTIR (thin film) cm^{-1}: 2931 (s), 2858 (m), 1750 (s), 1723 (m), 1629 (w), 1363 (m), 1254 (m), 1224 (s), 1094 (m), 1002 (w), 837 (m), 781 (m).

HRMS (ESI): calc'd for $C_{23}H_{37}NNaO_4Si$ $[M+Na]^+$: 442.2384, found: 442.2383.

TLC (1% NEt_3 in [32% EtOAc in hexanes]), *Rf*: 0.40 (UV, CAM).



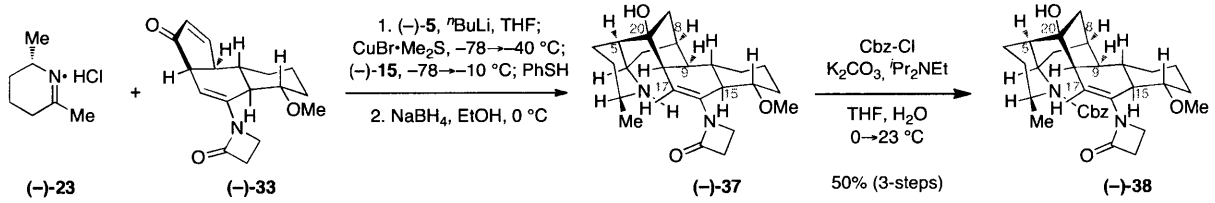
Tricyclic Enone (–)-33:

A freshly prepared solution of titanium tetrachloride in dichloromethane (1.0 M, 0.36 mL, 0.36 mmol, 2.0 equiv) was added in one portion via syringe to a suspension of *trans*-decalin aldehyde (–)-**32** (75 mg, 0.18 mmol, 1 equiv) and oven-dried 4Å-molecular sieves (100 mg) in dichloromethane (8.9 mL) at –78 °C under an argon atmosphere. After 2 min, saturated aqueous sodium chloride solution (10 mL) was added in one portion via syringe. The resulting mixture was allowed to warm to 23 °C, and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 50 mL). The combined organic layers were washed with brine (25 mL), were dried over anhydrous sodium sulfate, were filtered and were concentrated under reduced pressure to afford the desired crude intramolecular aldol addition product as an oil. The residue was dried by concentration from anhydrous benzene (2 × 5 mL) and was directly used in the following dehydration step.

A solution of the Martin sulfurane reagent (133 mg, 0.198 mmol, 1.10 equiv) in anhydrous benzene (3.6 mL) was added via cannula to the crude solution of aldol product in anhydrous benzene (3.6 mL) at 23 °C. After 30 min, the reaction mixture was directly loaded onto and purified via flash column chromatography (silica gel: diam. 1.5 cm, ht. 4 cm; eluent: 75% EtOAc in hexanes) to afford enone **(–)-33** (30 mg, 57%) as an oil ($[\alpha]^{22}_D = -18$ (*c* 0.65, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY, and HSQC.

^{1}H NMR (600 MHz, C_6D_6, 20 °C):	6.89 (dd, *J*= 3.0, 6.0 Hz, 1H, C_8**H**), 6.13, (app-t, *J* = 3.0 Hz, 1H, C_{17}**H**), 5.84 (dd, *J* = 1.8, 6.0 Hz, 1H, C_{21}**H**), 3.47-3.42 (m, 1H, C_{14}**H**), 3.14 (s, 3H, OCH_3), 3.11-3.08 (m, 1H, C**H**H'C=ON), 2.76-2.74 (m, 1H, CH**H'**C=ON), 2.52-2.41 (m, 3H, C_{19}**H**, C**H**H'NC=O, CH**H'**NC=O), 2.07-2.01 (m, 1H, C_{13}**H**H'), 1.99-1.93 (m, 1H, C_9**H**), 1.79-1.73 (m, 1H, C_{15}**H**), 1.43-1.35 (m, 2H, C_{12}**H**H', C_{11}**H**H'), 0.89-0.76 (m, 3H, C_{13}H**H'**, C_{10}H, C_{12}H**H'**), 0.48 (m, 1H, C_{11}H**H'**).
^{13}C NMR (150 MHz, C_6D_6, 20 °C):	205.7 (**C**$_{20}$), 166.1, 164.5 (**C**$_8$), 139.9, 132.7 (**C**$_{21}$), 125.2 (**C**$_{17}$), 78.6 (**C**$_{14}$), 55.4 (OCH_3), 48.1 (**C**$_{15}$), 47.4 (**C**$_9$), 46.7 (**C**$_{19}$), 43.8 (**C**$_{10}$), 42.9 (**C**H_2C=ON), 36.7 (**C**H_2NC=O), 30.8 (**C**$_{11}$), 30.7 (**C**$_{13}$), 23.0 (**C**$_{12}$).
FTIR (thin film) cm^{-1}:	2931 (s), 1741 (s), 1710 (s), 1384 (m), 1083 (m).

HRMS (ESI):	calc'd for $C_{17}H_{21}NaNO_3$ $[M+Na]^+$: 310.1414, found: 310.1421.
TLC (75% EtOAc in hexanes), *Rf*:	0.35 (UV, CAM).



Hydroxycarbamate (–)-38:

A solution of *n*-butyl lithium in hexanes (2.5 M, 0.80 mL, 2.0 mmol, 4.0 equiv) was added dropwise via syringe to a degassed suspension of the iminium chloride (–)-**23**[9] (145 mg, 0.980 mmol, 2.00 equiv) in tetrahydrofuran (1.4 mL) at –78 °C under an argon atmosphere. After 15 min, the reaction mixture was allowed to warm to 0 °C. Complete dissolution of the iminium chloride was detected after 15 min at which time the reaction mixture was cooled to –78 °C. The brown solution of the lithioenamine was transferred via cannula under positive argon pressure to a degassed suspension of copper bromide dimethyl sulfide (101 mg, 0.490 mmol, 1 equiv) in tetrahydrofuran (0.7 mL) at –78 °C. The reaction mixture was allowed to gradually warm to –40 °C over 1 h. The resulting brown reaction mixture was cooled to –78 °C, and a degassed solution of enone (–)-**33** (150 mg, 0.520 mmol, 1.05 equiv) in tetrahydrofuran (0.5 mL) was added via cannula. The resulting reaction mixture was allowed to warm to –10 °C over 1.5 h. A solution of degassed thiophenol (0.11 mL, 1.0 mmol, 2.2 equiv) in absolute ethanol (200 proof, 1 mL) was added to the reaction mixture. The resulting mixture was diluted with a degassed aqueous ammonium hydroxide in a saturated aqueous ammonium chloride solution (1:5, 2.4 mL), and the reaction was allowed to warm to 23 °C. After 1.5 h of vigorous stirring, the reaction mixture was diluted with degassed dichloromethane (8 mL), and the layers were separated under an argon atmosphere. The organic layer and the aqueous layer were partitioned, and the aqueous layer was extracted with degassed dichloromethane (3 × 8 mL) under an argon atmosphere. The combined organic layers were concentrated under reduced pressure, and the residue was dried by concentration from degassed anhydrous benzene (2 × 5 mL) and was directly used in the following reduction step.

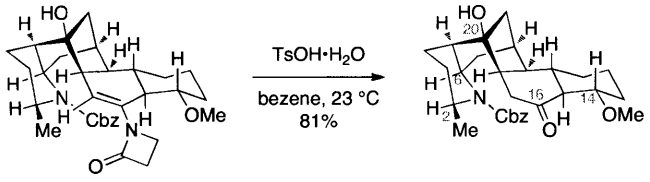
Sodium borohydride (59 mg, 1.6 mmol 3.2 equiv) was added as a solid to a degassed solution of the crude pentacylic imine in ethanol (8 mL) at 0 °C under an argon atmosphere. After 30 min, aqueous sodium carbonate solution (1.0 M, 10 mL) was added, and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 50 mL). The combined organic layers were washed with aqueous sodium carbonate solution (1.0 M, 15 mL), and were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The residue was filtered through a plug of silica gel (silica gel, treated with 1% NH_3 in [3% MeOH in CH_2Cl_2], diam. 1.5 cm, ht. 3 cm; eluent: 1% NH_3 in [3% methanol in dichloromethane]) to afford crude pentacyclic compound (–)-**37** and was directly used in the following step.

Benzyl chloroformate (0.32 mL, 2.2 mmol, 4.5 equiv) was added via syringe to a heterogeneous mixture of crude pentacyclic amine (–)-**37,** a solution of potassium carbonate (1.3 g, 9.4 mmol, 19 equiv) in water (9.2 mL), and diisopropylethyl amine (1.3 mL, 7.4 mmol, 15 equiv) in tetrahydrofuran (9.2 mL) at 0 °C. The reaction vessel was sealed under an argon atmosphere, and the reaction mixture was allowed to warm to 23 °C. Additional portions of benzyl chloroformate (2 × 0.32 mL) were added at 0 °C at 30 min intervals. Morpholine (0.58

[9] Movassaghi, M.; Hunt, D. K.; Tjandra, M. *J. Am. Chem. Soc.* **2006**, *128*, 8126

mL, 6.7 mmol, 14 equiv) was added to quench excess benzyl chloroformate. The reaction mixture was diluted with dichloromethane (50 mL), and the layers were separated. The aqueous layer was extracted with dichloromethane (2 × 35 mL). The combined organic layers were washed with aqueous sodium carbonate solution (1.0 M, 20 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The residue was purified by flash column chromatography (silica gel, treated with 1% NEt_3 in [5% acetone in hexanes], diam. 1.5 cm, ht. 4 cm; eluent: 1% NEt_3 in [5% acetone in hexanes] to 1% NEt_3 in [35% acetone in hexanes]) to afford hydroxy carbamate (–)-**38** (132 mg, 50%) as a white solid ($[\alpha]^{22}_D$ = –22 (*c* 1.0, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY, HSQC, HMBC, and NOESY.

^{1}H NMR (600 MHz, C_6D_6, 20 °C):	7.33-7.28 (m, 2H, Ar**H**), 7.16-7.12 (m, 2H, Ar**H**), 7.08-7.04 (m, 1H, Ar**H**), 6.18 (app-t, *J* = 2.4 Hz, 1H, C_{17}**H**), 5.24 (d, *J* = 12 Hz, 1H, PhC**H**H'OC=ON), 5.21 (d, *J* = 12 Hz, 1H, PhCH**H**'OC=ON), 4.57-4.50 (m, 1H, C_6**H**), 4.44-4.37 (m, 1H, C_2**H**), 3.50-3.41 (m, 1H, C_{14}**H**), 3.29-3.22 (m, 1H, C**H**H'C=ON), 3.14 (s, 3H, OC**H**$_3$), 2.84-2.77 (CH**H**'C=ON), 2.55-2.34 (m, 4H, C**H**$_2$NC=O, C_{19}**H**, C_7**H**H'), 2.16-2.05 (m, 1H, C_{13}**H**H'), 2.03-1.98 (m, 1H, C_5**H**), 1.78-1.72 (m, 1H, C_{15}**H**), 1.66-1.23 (m, 9H, C_8**H**, C_4**H**H', C_{12}**H**H', C_{11}**H**H', C_3**H**H', C_3**H**H', C_{21}**H**H', C_4H**H**', C_{21}H**H**'), 1.17 (t, *J* = 9.8 Hz, 1H, C_9**H**), 1.06 (d, *J* = 6.6 Hz, 3H, C_1**H**), 1.02-0.81 (m, 4H, **C**$_7$H**H**', C_{10}**H**, C_{12}H**H**', C_{13}H**H**'), 0.68 (app-q, *J* = 11.6 Hz, 1H, C_{11}H**H**').
^{13}C NMR (125 MHz, C_6D_6, 20 °C):	166.7 (**C**$_{amide}$), 155.9 (**C**$_{carbamate}$), 139.4 (**C**$_{16}$), 138.3 (Ar**C**), 129.5 (**C**$_{17}$), 129.0 (Ar**C**H), 128.9 (Ar**C**H), 128.6 (Ar**C**H), 80.2 (**C**$_{20}$), 79.5 (**C**$_{14}$), 67.4 (Ph**C**H$_2$), 55.4 (O**C**H$_3$), 54.8 (**C**$_9$), 48.3 (**C**$_5$), 47.8 (**C**$_6$), 47.0 (**C**$_{15}$), 46.4 (**C**$_2$), 44.6 (**C**$_{10}$), 43.5 (**C**H$_2$C=ON), 39.7 (**C**$_{19}$), 36.7 (**C**H$_2$NC=O), 34.7 (**C**$_4$), 34.4 (**C**$_7$), 34.6 (**C**$_{13}$), 32.5 (**C**$_8$), 31.2 (**C**$_{11}$), 30.3 (**C**$_{21}$), 23.6 (**C**$_{12}$), 20.5 (**C**$_1$), 17.8 (**C**$_3$).
FTIR (thin film) cm^{-1}:	3414 (br, s), 2932 (s), 1742 (s), 1722 (s), 1689 (s), 1454 (m), 1391 (s), 1315 (s), 1084 (s), 978 (w), 666 (m).
HRMS (ESI):	calc'd for $C_{32}H_{43}N_2O_5$ $[M+H]^+$: 535.3166, found: 535.3175.
TLC (40% acetone in hexanes), *Rf*:	0.50 (UV, $KMnO_4$, CAM).



(–)-38 (–)-39

Ketoalcohol (–)-39:

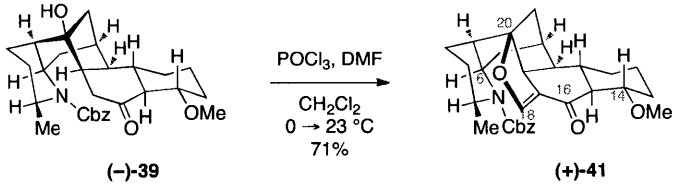
p-Toluenesulfonic acid monohydrate (8.3 mg, 0.043 mmol, 30 mol%) was added as a solid to a solution of hydroxy carbamate (–)-**38** (77 mg, 0.14 mmol, 1 equiv) in benzene (15 mL) at 23 °C, and the reaction mixture was sealed under an argon atmosphere. Because of the sensitivity of the product to acid, aqueous work-up was avoided. After 1.5 h, the reaction mixture was directly loaded onto and purified via flash column chromatography (silica gel, treated with 1% NEt_3 in [35% acetone in hexanes]: diam. 1.5 cm, ht. 4 cm; eluent: 1% NEt_3 in [35% acetone in hexanes]) to afford ketone (–)-**39** (54.8 mg, 81%) as a white solid ($[\alpha]^{22}_D$ = –62 (*c* 1.1, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY, HSQC, HMBC, and NOESY.

^{1}H NMR (600 MHz, C_6D_6, 20 °C): 7.32-7.29 (m, 2H, Ar**H**), 7.16-7.13 (m, 2H, Ar**H**), 7.07-7.04 (m, 1H, Ar**H**), 5.23 (br-s, 2H, $PhC\mathbf{H_2}OC{=}ON$), 4.54 (br-s, 1H, $C_6\mathbf{H}$), 4.43 (br-s, 1H, $C_2\mathbf{H}$), 3.53 (s, 3H, $OC\mathbf{H_3}$), 3.25-3.18 (m, 1H, $C_{14}\mathbf{H}$), 2.45-2.36 (m, 2H, $C_{17}\mathbf{H}H'$, $C_7\mathbf{H}H'$), 2.13-1.98 (m, 4H, $C_{17}H\mathbf{H}'$, $C_8\mathbf{H}$, $C_{13}\mathbf{H}H'$, $C_{19}\mathbf{H}$), 1.82 (dd, J = 9.1, 12.5 Hz, 1H, $C_{15}\mathbf{H}$), 1.61-1.56 (m, 1H, $C_5\mathbf{H}$), 1.47-1.36 (m, 3H, $C_{11}\mathbf{H}H'$, $C_{21}\mathbf{H}H'$, $C_{21}H\mathbf{H}'$), 1.35-1.20 (m, 3H, $C_{12}\mathbf{H}H'$, $C_3\mathbf{H}H'$, $C_3H\mathbf{H}'$), 1.16-1.09 (m, 2H, $C_{13}H\mathbf{H}'$, $C_4\mathbf{H}H'$), 1.07 (d, J = 7.2 Hz, 3H, $C_1\mathbf{H}$), 1.02 (app-t, J = 10.8 Hz, 1H, $C_9\mathbf{H}$), 1.00-0.94 (m, 2H, $C_4H\mathbf{H}'$, $C_7H\mathbf{H}'$), 0.80-0.71 (m, 1H, $C_{12}H\mathbf{H}'$), 0.67 (app-dq, J = 3.6, 12.0 Hz, 1H, $C_{10}\mathbf{H}$), 0.52-0.45 (m, 1H, $C_{11}H\mathbf{H}'$).

^{13}C NMR (125 MHz, C_6D_6, 20 °C): 210.8 ($\mathbf{C}_{16}$), 156.0 ($\mathbf{C}_{carbamate}$), 138.1 (Ar**C**), 133.3 (Ar**C**H), 130.4 (Ar**C**H), 129.9 (Ar**C**H), 80.6 ($\mathbf{C}_{20}$), 78.0 ($\mathbf{C}_{14}$), 67.5 ($Ph\mathbf{C}H_2$), 57.2 ($O\mathbf{C}H_3$), 56.7 ($\mathbf{C}_{15}$), 56.0 ($\mathbf{C}_9$), 48.9 ($\mathbf{C}_5$), 47.8 ($\mathbf{C}_6$), 46.4 ($\mathbf{C}_2$), 41.1 ($\mathbf{C}_{10}$), 39.3 ($\mathbf{C}_{17}$), 39.2 ($\mathbf{C}_8$), 37.1 ($\mathbf{C}_{19}$), 34.9 ($\mathbf{C}_7$, $\mathbf{C}_{21}$), 32.5 ($\mathbf{C}_{11}$), 31.7 ($\mathbf{C}_{13}$), 30.4 ($\mathbf{C}_3$), 23.3 ($\mathbf{C}_{12}$), 20.4 ($\mathbf{C}_1$), 18.4 ($\mathbf{C}_4$).

FTIR (thin film) cm^{-1}: 3429 (br, s), 2933 (s), 1739 (s), 1690 (s), 1440 (m), 1347 (m), 1317 (s), 1245 (w), 1188 (w), 1114 (m), 1088 (s), 741 (w), 697 (m).

HRMS (ESI):	calc'd for $C_{29}H_{39}NNaO_5$ $[M+Na]^+$: 504.2720, found: 504.2721.
TLC (50% acetone in hexanes), *Rf*:	0.63 (UV, CAM).



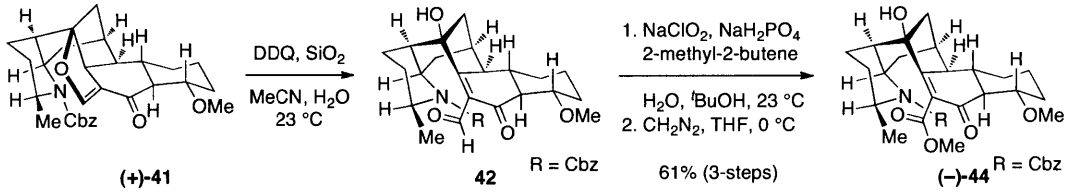
Vinyl ether (+)-41:

Freshly distilled phosphorus oxychloride (13 μL, 0.14 mmol, 2.0 equiv) was added dropwise via syringe to *N,N*-dimethylformamide (450 μL, 5.61 mmol, 81.0 equiv) at 0 °C under an argon atmosphere. After 30 min, a solution of ketone (–)-**39** (33.3 mg, 69.0 μmol, 1 equiv) in dichloromethane (1.4 mL) was added dropwise via cannula to the reaction mixture at 0 °C, and the resulting yellow solution was allowed to warm to 23 °C. After 30 min, saturated aqueous sodium bicarbonate solution (4 mL) was added to quench excess acid, and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 10 mL). The combined organic layers were washed with brine (10 mL), were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification of the resulting yellow oil via flash column chromatography (silica gel: diam. 1.5 cm, ht. 3 cm; eluent: 40% EtOAc in hexanes then 50% acetone in hexanes afforded the vinyl ether (+)-**41** (24 mg, 71%) as a white film ($[\alpha]^{22}_D$ = +19 (*c* 0.50, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY, HSQC, HMBC, and NOESY.

^{1}H NMR (600 MHz, C_6D_6, 20 °C): 7.29 (app-d, *J* = 7.2 Hz, 2H, Ar**H**), 7.16-7.13 (m, 2H, Ar**H**), 7.07 (app-t, *J* = 7.2 Hz, 1H, Ar**H**), 6.89 (app-d, *J* = 1.8 Hz, 1H, C_{18}**H**), 5.20 (br-s, 2H, PhCH_2OC=ON), 4.52 (br-s, 1H, C_6**H**), 4.26 (br-s, 1H, C_2**H**), 3.64 (s, 3H, OCH_3), 3.55-3.49 (m, 1H, C_{14}**H**), 3.00 (d, *J* = 9.0 Hz, 1H, C_{19}**H**), 2.33 (br-s, 1H, C_5**H**), 2.27 (br-s, 1H, C_7**H**H'), 2.11 (app-d, *J* = 15.0 Hz, 1H, C_{13}**H**H'), 1.89 (app-dd, 1H, *J* = 9.0, 12.0 Hz, C_{15}**H**), 1.49-1.44 (m, 4H, C_8**H**, C_{21}**H**H', C_{11}**H**H', C_{12}**H**H'), 1.30 (app-dd, *J* = 3.6, 11.4 Hz, 1H, C_{21}H**H'**), 1.27-1.07 (m, 6H, C_3**H**H', C_3H**H'**, C_4**H**H', C_4H**H'**, C_{13}H**H'**, C_9**H**), 1.05 (d, *J* = 6.6 Hz, 3H, C_1**H**), 0.82-0.70 (m, 3H, C_7H**H'**, C_{12}H**H'**, C_{10}**H**), 0.59 (app-q, *J* = 13.8 Hz, 1H, C_{11}H**H'**).

^{13}C NMR (125 MHz, C_6D_6, 20 °C): 194.7 (**C**$_{16}$), 155.7 (**C**$_{carbamate}$), 151.0 (**C**$_{18}$), 138.0 (Ar**C**), 129.1 (Ar**C**H), 128.9 (Ar**C**H), 128.7 (Ar**C**H), 119.4 (**C**$_{17}$), 102.7 (**C**$_{20}$), 77.1 (**C**$_{14}$), 67.5 (Ph**C**H_2OC=ON), 57.4 (OCH_3), 56.9 (**C**$_{15}$), 55.6 (**C**$_9$), 47.6 (**C**$_6$), 46.9 (**C**$_2$), 42.0 (**C**$_{19}$), 41.1 (**C**$_{10}$), 40.1 (**C**$_5$), 35.4 (**C**$_7$), 34.5 (**C**$_8$), 32.4 (**C**$_{11}$), 32.0 (**C**$_{21}$), 31.3 (**C**$_{13}$), 29.1 (**C**$_4$), 23.1 (**C**$_{12}$), 20.8 (**C**$_1$H), 18.0 (**C**$_3$).

FTIR (thin film) cm^{-1}:	2932 (s), 1693 (s, C=O), 1596 (s), 1312 (w), 1120 (m).
HRMS (ESI):	calc'd for $C_{30}H_{38}NO_5$ $[M+H]^+$: 492.2744, found: 492.2745.
TLC (50% EtOAc in hexanes), *Rf*:	0.49 (UV, CAM).



(+)-41 **42** (–)-44

Ketoester (–)-44:

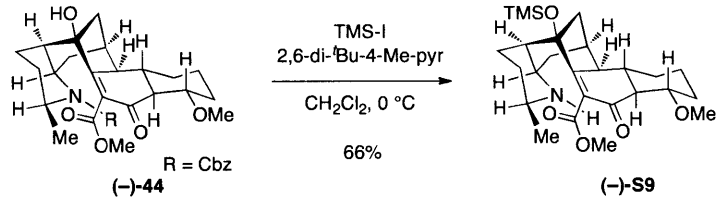
A solution of vinyl ether (+)-**41** (7.5 mg, 15 μmol, 1 equiv) in mixture of acetonitrile and water (5:1, 150 μL) was treated sequentially with silica gel (1.7 mg) and 2,3-dichloro-5,6-dicyano-*p*-benzoquinone (DDQ, 3.5 mg, 16 μmol, 1.1 equiv) at 23 °C, and the reaction vessel was sealed under an argon atmosphere. After 6 h, the reaction mixture was filtered through a plug of cotton to remove the silica gel and the filtrate was partitioned between water (1 mL) and dichloromethane (8 mL). The aqueous layer was extracted with dichloromethane (3 × 5 mL). The combined organic layers were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure to afford the crude ketoaldehyde **42**. The ketoaldehyde was directly used in the following oxidation step.

To a solution of the crude ketoaldehyde **42** in *tert*-butanol (380 μL) at 23 °C was added 2-methyl-2-butene (16 μL, 0.15 mmol 10 equiv) and a solution of sodium phosphate monohydrate monobasic (21 mg, 0.15 mmol, 10 equiv) in water (150 μL) followed by a solution of sodium chlorite (14 mg, 0.15 mmol, 10 equiv) in water (150 μL) via syringe. After 1 h, saturated aqueous sodium thiosulfate solution (1 mL) was added to quench excess oxidant, and the layers were separated. The aqueous layer was extracted with dichloromethane (3 × 5 mL). The combined organic layers were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure to afford the crude ketoacid that was directly used in the following methylation step.

Freshly prepared diazomethane solution in ether (1.50 mL, 1.60 mmol, 100 equiv) was added to a solution of the crude sample and acetic acid (31 μL, 61 μmol, 4.0 equiv) in THF (100 μL) at 0 °C. After 30 min, a tetrahydrofuran solution of acetic acid (2 M, 0.5 mL) was added to quench excess diazomethane and the volatiles were removed under reduced pressure. Purification of the resulting yellow oil via flash column chromatography (silica gel: diam. 1.5 cm, ht. 2 cm; eluent: 50% EtOAc in hexanes to 75% EtOAc in hexanes then 50% acetone in hexanes afforded the ketoester (–)-**44** (5 mg, 61%) as a clear film ($[\alpha]^{22}_D$ = –64 (*c* 0.42, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY, HSQC, and HMBC.

^{1}H NMR (500 MHz, C_6D_6, 20 °C): 7.29 (app-d, *J* = 7.2 Hz, 2H, Ar**H**), 7.16-7.14 (m, 2H, Ar**H**), 7.10-7.05 (m, 1H, Ar**H**), 5.22 (d, *J* = 12.5 Hz, 1H, PhC**H**H'OC=ON), 5.18 (d, *J* = 12.5 Hz, 1H, PhCH**H**'OC=ON), 4.66 (br-s, 1H, C_6**H**), 4.38 (br-s, 1H, C_2**H**), 3.57 (s, 3H, O**CH**$_3$), 3.55 (s, 3H, COO**CH**$_3$), 3.15 (dt, *J* = 5.5, 10.5 Hz, 1H, C_{14}**H**), 2.58-2.40 (m, 2H, C_7**H**H', O**H**), 2.10-1.94 (m, 3H, C_5**H**, C_{13}**H**H', C_{15}**H**), 1.94-1.86 (m, 1H, C_4**H**H'), 1.78 (app-d, *J* = 12.0 Hz, 1H, C_9**H**), 1.72 (br-s, 1H, C_{21}**H**H'), 1.57 (br-s, 1H, C_8**H**), 1.39-1.20

	(m, 4H, C_3**H**H', C_{12}**H**H', C_{11}**H**H', C_3H**H'**), 1.13-0.87 (m, 5H, C_{13}H**H'**, C_4H**H'**, C_7H**H'**, C_{21}H**H'**, C_{10}**H**), 1.02 (d, J = 7.0 Hz, 3H, C_1**H**$_3$), 0.75-0.64 (m, 1H, C_{12}H**H'**), 0.48-0.38 (m, 1H, C_{11}H**H'**).
^{13}C NMR (125 MHz, C_6D_6, 20 °C):	195.1 (**C**$_{16}$), 168.4 (**C**$_{18}$), 167.9 (**C**$_{19}$), 155.8 (**C**$_{carbamate}$), 138.1 (Ar**C**), 129.1 (Ar**C**H), 128.9 (Ar**C**H), 128.7 (Ar**C**H), 128.3 (**C**$_{17}$), 82.5 (**C**$_{20}$), 77.1 (**C**$_{14}$), 67.6 (Ph**C**H$_2$OC=ON), 58.3 (**C**$_9$), 58.1 (**C**$_{15}$), 57.6 (O**C**H$_3$), 52.4 (COO**C**H$_3$), 47.0 (**C**$_6$), 46.4 (**C**$_5$), 46.2 (**C**$_2$), 46.1 (**C**$_{10}$), 35.8 (**C**$_7$, **C**$_{21}$), 31.8 (**C**$_{13}$), 30.2 (**C**$_8$), 30.1 (**C**$_3$, **C**$_{11}$), 22.6 (**C**$_{12}$), 20.3 (**C**$_1$), 19.1 (**C**$_4$).
FTIR (thin film) cm^{-1}:	3440 (br, s, OH), 2928 (s), 2856 (m), 1733 (COOMe), 1675 (C=O), 1316 (w), 1111 (w).
HRMS (ESI):	calc'd for $C_{31}H_{40}NO_7$ $[M+H]^+$: 538.2799, found: 538.2803.
TLC (50% acetone in hexanes), *Rf*:	0.75 (UV, CAM).



Amino Ketoester (–)-S9:

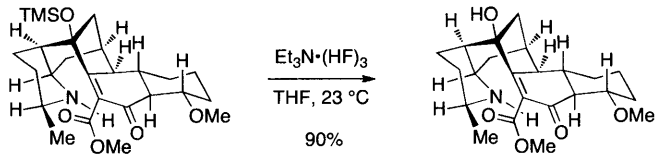
Iodotrimethylsilane (26 μL, 0.18 mmol, 14 equiv) was added via syringe to a solution of keto ester (–)-**44** (7.1 mg, 13 mmol, 1 equiv) and 2,6-di-*tert*-butyl-4-methyl-pyridine (670 mg, 3.25 mmol, 250 equiv) in dichloromethane (500 μL) at 0 °C under an argon atmosphere. Additional portions of iodotrimethylsilane (8 ×26 μL)were added at 1 h intervals until complete consumption of (–)-**44** was observed by TLC analysis (~8 h). Isopropanol (300 μL) and aqueous sodium carbonate solution (1 M, 6 mL) were added, and the biphasic reaction mixture was stirred vigorously at 23°C. After 2 h, the organic layer and the aqueous layer were separated. The aqueous layer was extracted with dichloromethane (4 × 5 mL). The combined organic layers were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification of the resulting yellow oil via flash column chromatography (silica gel, treated with 1% NEt_3 in [35% EtOAc in hexanes], diam. 1.5 cm, ht. 4 cm; eluent: 1% NEt_3 in [5% EtOAc in hexanes] to 1% NEt_3 in [35% EtOAc in hexanes] then 5% methanol in CH_2Cl_2) afforded the pentacyclic amino ketoester (–)-**S9** (4.1 mg, 66%) as a clear film ($[\alpha]^{22}_D$ = –4.7 (*c* 0.15, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY, HSQC, and HMBC.

^{1}H NMR (500 MHz, C_6D_6, 20 °C): 3.75 (app-d, *J* = 11.0 Hz, 1H, C_9**H**), 3.64 (s, 3H, $COOCH_3$), 3.57 (s, 3H, OCH_3), 3.19-3.11 (m, 1H, C_{14}**H**), 2.93 (app-t, *J* = 5.0 Hz, 1H, C_6**H**), 2.50 (app-d, *J* = 14.0 Hz, 1H, C_4**H'**), 2.22-2.13 (m, 2H, C_{15}**H**, C_2**H**), 2.00-1.91 (m, 2H, C_{21}**H**H', C_{13}**H**H'), 1.88-1.81 (m, 2H, C_8**H**, C_5**H**), 1.75-1.63 (m, 1H, C_3**H**H'), 1.57-1.49 (m, 1H, C_7**H**), 1.46-0.97 (m, 8H, C_{12}**H**H', C_{11}**H**H', C_{21}H**H'**, C_3H**H'**, C_{10}**H**, C_4H**H'**, C_{13}H**H'**, C_7H**H'**), 0.72 (d, *J* = 6.5 Hz, 3H, C_1**H**), 0.77-0.62 (m, 2H, C_{12}H**H'**, C_{11}H**H'**), 0.21 (br-s, 9H, $Si(CH_3)_3$).

^{13}C NMR (125 MHz, C_6D_6, 20 °C): 195.6 (**C**$_{16}$), 171.7 (**C**$_{19}$), 167.1 (**C**$_{18}$), 127.9 (**C**$_{17}$), 82.8 (**C**$_{20}$), 77.5 (**C**$_{14}$), 58.7 (**C**$_2$), 57.7 ($O\mathbf{C}H_3$), 55.4 (**C**$_6$), 53.3 (**C**$_{15}$), 51.4 ($COO\mathbf{C}H_3$), 50.6 (**C**$_9$), 48.2 (**C**$_5$), 47.2 (**C**$_{21}$), 46.2 (**C**$_{10}$), 41.0 (**C**$_7$), 33.6 (**C**$_8$), 32.2 (**C**$_{13}$), 31.0 (**C**$_3$), 30.4 (**C**$_{11}$), 24.8 (**C**$_4$), 23.7 (**C**$_1$), 22.7 (**C**$_{12}$), 2.6 ($Si(\mathbf{C}H_3)_3$).

FTIR (thin film) cm^{-1}: 2927 (s), 2855 (m), 1741 (s, COOMe), 1673 (s, C=O), 1251 (w), 1113 (w), 842 (m).

HRMS (ESI):	calc'd for $C_{26}H_{42}NO_5Si$ $[M+H]^+$: 476.2827, found: 476.2820.
TLC (5% Methanol in CH_2Cl_2), *Rf*:	0.33 (UV, CAM).



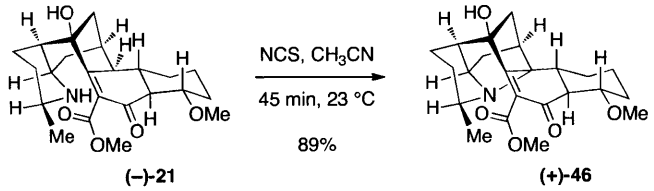
(–)-S9 (–)-21

Pentacyclic amino alcohol (–)-21:

Triethylamine trihydrogen fluoride (0.114 mL, 0.700 mmol, 82.0 equiv) was added via syringe to a solution of pentacyclic amine (–)-**S9** (4.0 mg, 8.4 μmol, 1 equiv) in tetrahydrofuran (100 μL) at 23°C under an argon atmosphere. After 4 h, aqueous sodium carbonate solution (1 M, 5 mL) was added to quench excess acid. The reaction mixture was diluted with dichloromethane (5 mL), and the layers were separated. The aqueous layer was extracted with dichloromethane (4 × 5 mL). The combined organic layers were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification of the resulting residue via flash column chromatography (silica gel: diam. 1.5 cm, ht. 3 cm; eluent: 2% to 5% to 10% methanol in CH_2Cl_2) afforded the pentacyclic amino alcohol (–)-**21** (3 mg, 90%) as a clear film ($[\alpha]^{22}_D = -24$ (*c* 0.080, CH_2Cl_2). Structural assignment utilized additional information from gCOSY, HSQC, and HMBC.

^{1}H NMR (600 MHz, C_6D_6, 20 °C):	3.69 (dd, *J* = 1.8, 11.4 Hz, 1H, C_9**H**), 3.55 (s, 6H, $COOCH_3$, OCH_3), 3.28-3.19 (m, 1H, C_{14}**H**), 2.93-2.83 (m, 2H, C_6**H**, O**H**), 2.57 (app-d, *J* = 12.6 Hz, 1H, C_4**H**H'), 2.21-2.13 (m, 2H, C_{15}**H**, C_2**H**), 1.97 (app-dd, *J* = 4.2, 13.2 Hz, 1H, C_{13}**H**H'), 1.89 (app-t, *J* = 5.4 Hz, 1H, C_5**H**), 1.76 (br-s, 1H, C_8**H**), 1.73-1.68 (m, 1H, C_{21}**H**H'), 1.57 (app-dd, *J* = 3.8, 11.2 Hz, 1H, C_3H**H**'), 1.50 (ddd, *J* = 3.2, 6.1, 14.3 Hz, 1H, C_7**H**H'), 1.45-1.17 (m, 6H, C_{11}**H**H', C_{12}**H**H', C_3H**H**', C_{21}H**H**', C_4H**H**', C_{10}**H**), 1.17-1.08 (m, 1H, C_{13}H**H**'), 0.97 (app-d, *J* = 16.2 Hz, 1H, C_7H**H**'), 0.85-0.74 (m, 1H, C_{12}H**H**'), 0.71 (d, *J* = 6.0 Hz, 3H, C_1**H**$_3$), 0.62 (app-dq, *J* = 3.4, 11.9 Hz, 1H, C_{11}H**H**').
^{13}C NMR (125 MHz, C_6D_6, 20 °C):	195.7 (**C**$_{16}$), 174.9 (**C**$_{19}$), 169.1 (**C**$_{18}$), 127.3 (**C**$_{17}$), 80.4 (**C**$_{20}$), 77.6 (**C**$_{14}$), 58.8 (**C**$_2$), 57.6 (O**C**H$_3$), 55.2 (**C**$_6$), 53.2 (**C**$_{15}$), 52.3 (**C**$_9$), 52.1 (COO**C**H$_3$), 48.1 (**C**$_{21}$), 47.8 (**C**$_5$), 46.3 (**C**$_{10}$), 40.9 (**C**$_7$), 32.7 (**C**$_8$), 32.1 (**C**$_{13}$), 30.9 (**C**$_3$), 30.3 (**C**$_{11}$), 24.9 (**C**$_4$), 23.6 (**C**$_1$), 22.9 (**C**$_{12}$).
FTIR (thin film) cm^{-1}:	2921 (s), 2850 (m), 1734 (m, COOMe), 1671 (m, C=O), 1460 (m), 1261 (w), 1111 (w).
HRMS (ESI):	calc'd for $C_{23}H_{34}NO_5$ $[M+H]^+$: 404.2431, found: 404.2432.

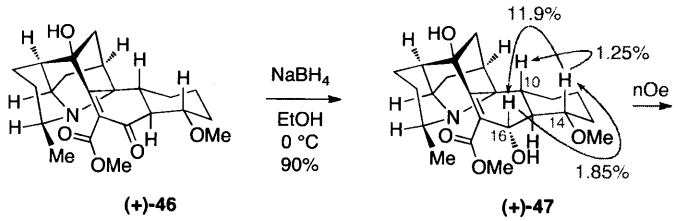
TLC (8% MeOH in CH_2Cl_2), *Rf*: 0.38 (UV, CAM).



(+)-Hexacyclic ketoester (46):

Freshly recrystallized *N*-chlorosuccinimide (1.6 mg, 12 μmol, 2.0 equiv) was added as a solid to a solution of amino alcohol (–)-**21** (2.5 mg, 6.2 μmol, 1 equiv) in acetonitrile (0.3 mL) at 23 °C, and the reaction mixture sealed under an argon atmosphere. After 45 min, the reaction solvent was removed under reduced pressure. The residue was immediately purified by flash column chromatography (silica gel: diam. 1.25 cm, ht. 2 cm; eluent: 3% methanol in dichloromethane) to afford hexacyclic ketoester (+)-**46** (2.2 mg, 89%) as a white solid ($[\alpha]^{22}_D$ = +20 (*c* 0.11, CH_2Cl_2)). Structural assignment utilized additional information from gCOSY, HSQC, HMBC, ROESY, and NOESY.

^{1}H NMR (600 MHz, C_6D_6, 20 °C):	3.56 (s, 3H, OC**H**$_3$), 3.48 (s, 3H, COOC**H**$_3$), 3.37 (br-s, 1H, O**H**), 3.24-3.18 (m, 1H, C_{14}**H**), 3.13-3.04 (m, 2H, C_2**H**, C_{15}**H**), 2.88 (br-s, 1H, C_6**H**), 2.39-2.33 (m, 1H, C_4H**H'**), 2.07-1.96 (m, 2H, C_3H**H'**, C_{13}H**H'**), 1.80 (br-s, 1H, C_5**H**), 1.77-1.73 (m, 1H, C_{21}H**H'**), 1.65-1.58 (m, 2H, C_8**H**, C_7H**H'**), 1.55-1.46 (m, 2H, C_{11}H**H'**, C_{12}H**H'**), 1.40-1.24 (m, 4H, C_{10}**H**, C_{11}H**H'**, C_4H**H'**, C_{21}H**H'**), 1.23-1.14 (m, 1H, C_{13}H**H'**), 1.11 (d, J = 7.2 Hz, 3H, C_1**H**), 1.07 (app-d, J = 9.6 Hz, 1H, C_7H**H'**), 0.97-0.78 (m, 2H, C_3H**H'**, C_{12}H**H'**).
^{13}C NMR (125 MHz, C_6D_6, 20 °C):	195.8 (**C**$_{16}$), 171.9 (**C**$_{19}$), 169.5 (**C**$_{18}$), 123.0 (**C**$_{17}$), 81.0 (**C**$_{20}$), 78.2 (**C**$_{14}$), 69.9 (**C**$_6$), 66.0 (**C**$_9$), 57.6 (O**C**H$_3$), 56.3 (**C**$_2$), 52.7 (COO**C**H$_3$), 52.6 (**C**$_{15}$), 49.9 (**C**$_5$), 49.9 (**C**$_8$), 46.2 (**C**$_{10}$), 45.0 (**C**$_{21}$), 37.5 (**C**$_7$), 32.1 (**C**$_{13}$), 27.9 (**C**$_3$), 27.3 (**C**$_{11}$), 26.4 (**C**$_4$), 25.0 (**C**$_1$), 23.8 (**C**$_{12}$).
FTIR (thin film) cm^{-1}:	3373 (br, s), 2923 (s), 1771 (m), 1712 (s), 1664 (s), 1461 (m), 1348 (m), 1269 (m), 1180 (m), 1091 (w), 802 (w).
HRMS (ESI):	calc'd for $C_{23}H_{32}NO_5$ $[M+H]^+$: 402.2275, found: 402.2290.
TLC (15% MeOH in CH_2Cl_2), *Rf*:	0.56 (CAM).



(+)-16-Debenzoyl-himandrine (47):

Sodium borohyride (4.0 mg, 0.11 mmol, 10 equiv) was added as a solid to a solution of hexacyclic ketoester (+)-**46** (4.0 mg, 9.9 mmol, 1 equiv) in ethanol (150 μL) at 0 °C, and the reaction mixture was sealed under an argon atmosphere. After 30 min, aqueous sodium carbonate solution (1 M, 0.5 mL) was added, and the layers were separated. The aqueous layer was extracted with dichloromethane (4 × 5 mL). The combined organic layers were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. Purification of the resulting residue via flash column chromatography (silica gel: diam. 1.25 cm, ht. 1.5 cm; eluent: 5% methanol in CH_2Cl_2) afforded the hexacyclic diol (+)-**47** (3.6 mg, 90%) as a single diastereomer ($[\alpha]^{22}_D$ = +28 (*c* 0.035, $CHCl_3$). Structural assignment utilized additional information from gCOSY, HSQC, and HMBC.

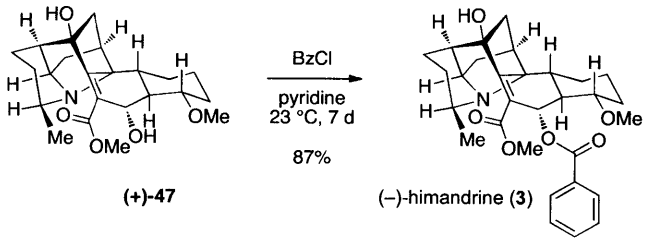
^{1}H NMR (600 MHz, $CDCl_3$, 20 °C):	4.53 (app-d, *J* = 7.2 Hz, 1H, C_{16}**H**), 4.22 (br-s, 1H, C_{20}**OH**), 3.84 (s, 3H, $COOCH_3$), 3.86-3.80 (br-s, 1H, C_{16}**OH**), 3.43-3.37 (m, 1H, C_2**H**), 3.40 (s, 3H, OCH_3), 3.31 (br-s, 1H, C_6**H**), 3.08 (dt, *J* = 4.2, 10.2 Hz, 1H, C_{14}**H**), 2.27-2.12 (m, 5H, C_4**H**H', C_{13}**H**H', C_{15}**H**, C_3**H**H', C_8**H**), 1.94 (br-s, 1H, C_5**H**), 1.90-1.68 (m, 4H, C_{12}**H**H', C_7**H**H', C_{21}**H**H', C_4H**H'**), 1.65-1.56 (m, 2H, C_{11}**H**H', C_{21}H**H'**), 1.52 (app-d, *J* = 10.2 Hz, 1H, C_7H**H'**), 1.46 (app-dq, *J* = 3.6, 12.6 Hz, 1H, C_{11}H**H'**), 1.34 (d, *J* = 7.2 Hz, 3H, C_1**H**), 1.38-1.30 (m, 1H, C_{10}**H**), 1.29-1.08 (m, C_3H**H'**, C_{12}H**H'**, C_{13}H**H'**).
^{13}C NMR (125 MHz, $CDCl_3$, 20 °C):	170.7 (**C**$_{18}$), 158.8 (**C**$_{19}$), 118.2 (**C**$_{17}$), 87.5 (**C**$_{14}$), 80.7 (**C**$_{20}$), 72.3 (**C**$_{16}$), 69.5 (**C**$_6$), 67.6 (**C**$_9$), 56.4 (OCH_3), 55.9 (**C**$_2$), 52.5 ($COOCH_3$), 49.6 (**C**$_5$), 49.3 (**C**$_8$), 48.4 (**C**$_{15}$), 44.9 (**C**$_{21}$), 42.9 (**C**$_{10}$), 37.6 (**C**$_7$), 30.4 (**C**$_{13}$), 27.3 (**C**$_3$), 27.0 (**C**$_{11}$), 25.7 (**C**$_4$), 24.3 (**C**$_{12}$), 24.0 (**C**$_1$).
FTIR (thin film) cm^{-1}:	3496 (br, s), 2930 (s), 2858 (m), 1733 (m), 1689 (m), 1459 (m), 1281 (m), 1262 (m), 1080 (m).
HRMS (ESI):	calc'd for $C_{23}H_{34}NO_5$ $[M+H]^+$: 404.2431, found: 404.2428.
TLC (10% Methanol in CH_2Cl_2), *Rf*:	0.19 (UV, CAM).

Comparison of our assignments for (+)-16-debenzoyl-himandrine (47) with literature data:

Assignment	Original report[10] (+)-16-Debenzoyl-himandrine (**47**) (^{1}H, 60 MHz, $CDCl_3$)	This report (+)-16-Debenzoyl-himandrine (**47**) (^{1}H, 600 MHz, $CDCl_3$)	This report (+)-16-Debenzoyl-himandrine (**47**) (^{13}C, 125 MHz, $CDCl_3$)
C1	1.33 (d, J = 7 Hz)	1.34 (d, J = 7.2 Hz)	24.0
C2	3.30 (br)	3.43-3.37 (m)[11]	55.9
C3, C4, C8, C13, C15	–	2.27-2.12 (m)	27.3 (C3), 25.7 (C4), 49.3 (C8), 30.4 (C13), 48.4 (C15)
C5	–	1.94 (br-s)	49.6
C6	3.30 (br)	3.31 (br-s)	69.5
C4, C7, C12, C21	–	1.90-1.68 (m)	25.7 (C4), 44.9 (C21), 24.3 (C12)
C7	–	1.52 (app-d, J = 10.2 Hz)	37.6
C9	–	–	67.6
C10	–	1.38-1.30 (m)	42.9
C11, C21		1.65-1.56 (m)	27.0 (C11), 44.9 (C21)
C11	–	1.46 (app-dq, J = 3.6, 12.6 Hz)	27.0
C3, C12, C13	–	1.29-1.08 (m)	27.3 (C3), 24.3 (C12), 30.4 (C13)
C14	3.10 (br)	3.08 (dt, J = 4.2, 10.2 Hz)	87.5
C1	4.60 (d, J = 8.0 Hz)	4.53 (app-d, J = 7.2 Hz)	72.3
C17	–	–	118.2
C18	–	–	170.7
C19	–	–	158.8
C20	–	–	80.7
C20-OH	4.20 (s)	4.22 (br-s)	–
C16-OH	3.80 (s)	3.86-3.80 (br-s)	–
$COOCH_3$	3.88 (s)	3.84 (s)	52.5
OCH_3	3.43 (s)	3.40 (s)	56.4

[10] Chemical degradation of himandrine (**3**) gave (+)-16-debenzoyl-himandrine (**47**); see Mander, L. N.; Prager, R. H.; Rasmussen, M.; Ritchie, E.; Taylor, W. C. *Aust. J. Chem.*, **1967**, *20*, 1473.

[11] Our assignment of the C2 methine is supported by our gCOSY, HSQC and HMBC data. The original paper (ref. 10) listed both C2 and C6 methines at 3.30 ppm (br). Our 2D data reveals the C2 methine is actually obscured by the methyl ether signal (3.40 ppm), while C6 methine alone corresponds to the signal at 3.31 ppm (br).



(–)-Himandrine (3):

Freshly distilled benzoyl chloride (0.1 mL) was added to a solution of alcohol (+)-**47** (2.0 mg, 4.9 μmol, 1 equiv) in pyridine (0.12 mL) at 23 °C under an argon atmosphere. After 7 d, the reaction mixture was diluted with dichloromethane (5 mL) and aqueous sodium carbonate solution (1.0 M, 2 mL). After 30 min, the layers were separated, and the aqueous layer was extracted with dichloromethane (3 × 10 mL). The combined organic layers were dried over anhydrous sodium sulfate, were filtered, and were concentrated under reduced pressure. The crude product was purified by flash column chromatography (silica gel: diam. 0.5 cm, ht. 5 cm; eluent: 3% methanol in CH_2Cl_2) to afford (–)-himandrine (**3**, 2.0 mg, 87%) ($[\alpha]^{22}_D = -21$ (*c* 0.12, $CHCl_3$)).[12] Structural assignment utilized additional information from gCOSY, HSQC, HMBC, and ROESY. Crystals suitable for X-ray diffraction were obtained from dichloromethane–hexanes (5:1). For a thermal ellipsoid representation of (–)-himandrine (**3**) see page 119

^{1}H NMR (600 MHz, $CDCl_3$, 20 °C): 7.94 (app-d, J = 7.8 Hz, 2H, Ar**H**), 7.49 (app-t, J = 7.2 Hz, 1H, Ar**H**), 7.39 (app-t, J = 7.2 Hz, 2H, Ar**H**), 6.18 (d, J = 7.8 Hz, 1H, C_{16}**H**), 4.54 (br-s, 1H, C_{20}O**H**), 3.58 (s, 3H, COOC**H**$_3$), 3.53-3.44 (m, 1H, C_2**H**), 3.35 (br-s, 1H, C_6**H**), 3.12 (s, 3H, OC**H**$_3$), 3.05 (dt, J = 4.2, 10.8 Hz, 1H, C_{14}**H**), 2.44-2.37 (m, 1H, C_{15}**H**), 2.34-2.27 (m, 1H, C_4H**H'**), 2.23-2.08 (m, 3H, C_8**H**, C_{13}H**H'**, C_3H**H'**), 2.03 (br-s, 1H, C_5**H**), 1.91-1.75 (m, 4H, C_7H**H'**, C_{12}H**H'**, C_4H**H'**, C_{21}H**H'**), 1.68-1.62 (m, 2H, C_{11}H**H'**, C_{21}H**H'**), 1.57 (app-d, J = 11.4 Hz, 1H, C_7H**H'**), 1.45 (d, J = 6.6 Hz, 3H, C_1**H**), 1.45-1.42 (m, 2H, C_{10}**H**, C_{11}H**H'**), 1.41-1.33 (m, 1H, C_3H**H'**), 1.33-1.27 (m, 1H, C_{12}H**H'**), 1.13-1.04 (m, 1H, C_{13}H**H'**).

^{13}C NMR (125 MHz, $CDCl_3$, 20 °C): 169.6 (**C**$_{18}$), 165.7 (Ar**C**=O), 163.2 (**C**$_{19}$), 132.7 (Ar**C**H), 131.4 (Ar**C**H), 129.6 (Ar**C**H), 128.6 (Ar**C**H), 116.6 (**C**$_{17}$), 85.5 (**C**$_{14}$), 81.1 (**C**$_{20}$), 72.9 (**C**$_{16}$), 69.5 (**C**$_6$), 67.7 (**C**$_9$), 56.7 (O**C**H$_3$), 55.8 (**C**$_2$), 52.3 (COO**C**H$_3$), 50.2 (**C**$_5$), 49.4 (**C**$_8$), 45.9 (**C**$_{15}$), 44.8 (**C**$_{21}$), 43.4 (**C**$_{10}$), 37.4 (**C**$_7$), 30.8 (**C**$_{13}$), 27.7 (**C**$_3$), 27.3 (**C**$_{11}$), 25.7 (**C**$_4$), 24.6 (**C**$_1$), 23.8 (**C**$_{12}$).

[12] The magnitude of the optical rotation of (–)-himandrine (**3**) is sensitive to concentration: $[\alpha]^{22}_D = -12$ (*c* 0.060, $CHCl_3$).

FTIR (thin film) cm^{-1}:	3429 (br, s), 2919 (s), 2852 (s), 1727 (s), 1687 (m), 1450 (w), 1276 (m), 1268 (s), 1097 (m), 1066 (w), 709 (w).
HRMS (ESI)	calc'd for $C_{30}H_{38}NO_6$ $[M+H]^+$: 508.2694, found: 508.2694.
TLC (15% MeOH in CH_2Cl_2), *Rf*:	0.60 (UV, CAM)

Comparison of our assignments for (–)-himandrine (3) with literature:

Assignment	Isolation paper[13] (–)-Himandrine (**3**) (^{1}H, 60 MHz, $CDCl_3$)	This report (–)-Himandrine (**3**) (^{1}H, 600 MHz, $CDCl_3$)	This report[14] (–)-Himandrine (**3**) (^{13}C, 125 MHz, $CDCl_3$)
C1	1.48 (d, J = 7 Hz)	1.45 (d, J = 6.6 Hz)	24.6
C2	3.38(br)	3.53-3.44 (m)[15]	55.8
C3	–	1.41-1.33 (m)	27.7 (C3), 23.8 (C12), 30.8 (C13)
C3, C8, C13	–	2.23-2.08 (m)	27.7 (C3), 49.4 (C8), 30.8 (C13)
C4		2.34-2.27 (m)	25.7
C5	–	2.03 (br-s)	50.2
C6	3.38 (br)	3.35 (br-s)	69.5
C4, C7, C12, C21	–	1.91-1.75 (m)	25.7 (C4), 44.8 (C21), 23.8 (C12)
C7	–	1.57 (app-d, J = 11.4 Hz)	37.4
C9	–	–	67.7
C10, C11	–	1.45-1.42 (m)	43.4 (C10), 27.3 (C11)
C11, C21		1.68-1.62 (m)	27.3 (C11), 44.8 (C21)
C12		1.33-1.27 (m)	23.8 (C12)
C13		1.13-1.04 (m)	30.8 (C13)
C14	3.10 (br)	3.05 (dt, J = 4.2, 10.8 Hz)	85.5
C15		2.44-2.37 (m)	45.9
C16	6.20 (d, J = 8 Hz)	6.18 (d, J = 7.8 Hz)	72.9
C17	–	–	116.6
C18	–	–	169.6
C19	–	–	163.2
C20	–	–	81.1
C20-OH	4.50	4.54 (br-s)	–

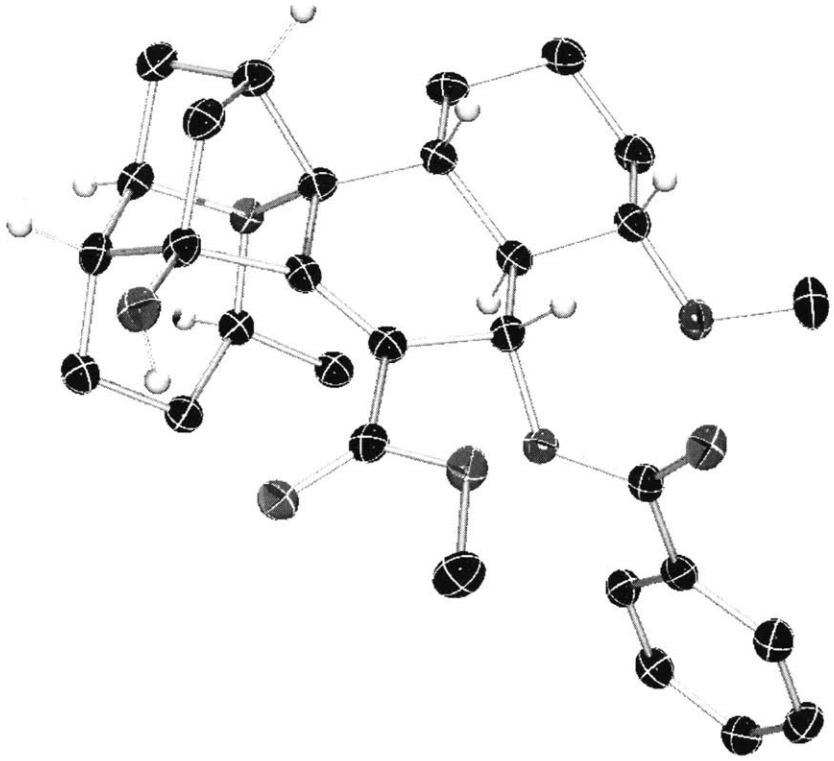
[13] The original structure of himandrine was based on X-ray crystallographic analysis of the corresponding hydrobromide salt of **3**; see (a) Guise, G. B.; Mander, L. N.; Prager, R. H.; Rasmussen, M.; Ritchie, E.; Taylor, W. C. *Aust. J. Chem.*, **1967**, *20*, 1029, and (b) Willis, A. C.; O'Connor, P. D.; Taylor, W. C.; Mander, L. N. *Aust. J. Chem.*, **2006**, *59*, 629.

[14] We confirmed the structure of our synthetic (–)-himandrine (**3**) by both X-ray crystallographic analysis and extensive 2D NMR data,

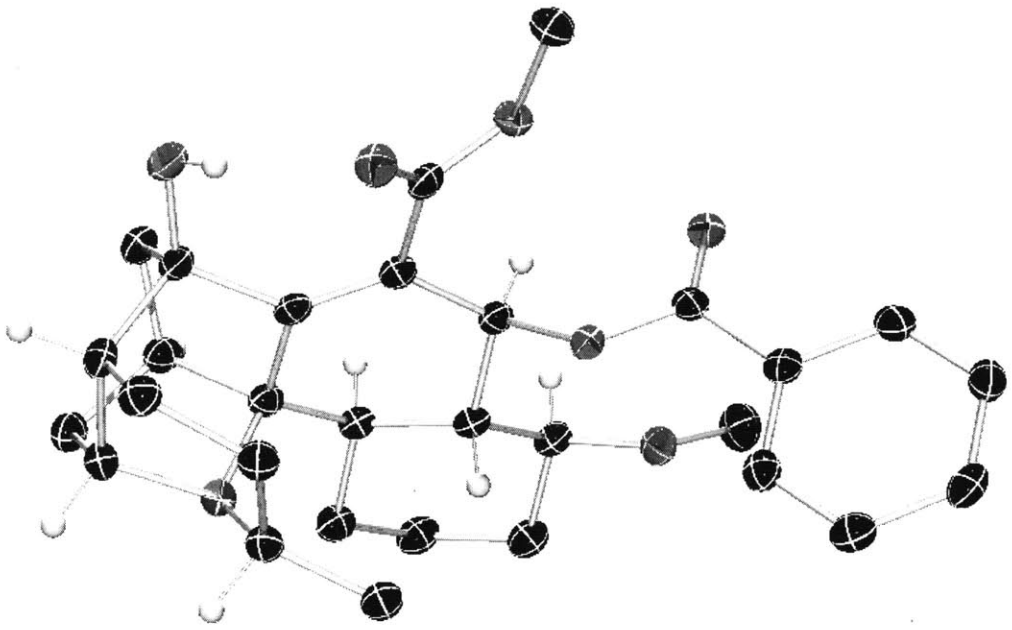
[15] Our assignment of the C2 methine is supported by our gCOSY, HSQC, HMBC, and ROESY data. Based on the isolation paper, the C2 and C6 methines correspond to the signal at 3.38 ppm (br). Our 2D data reveals the C2 methine is actually at 3.53-3.44 ppm (m), while C6 methine alone corresponds to the signal at 3.35 ppm (br-s).

$COOCH_3$	–	3.58 (s)	52.3
OCH_3	3.15 (s)	3.12 (s)	56.7
Bz	7.5 (m), 8.0 (m)	7.94 (app-d, J = 7.8 Hz), 7.49 (app-t, J = 7.2 Hz), 7.39 (app-t, J = 7.2 Hz)	165.7 (ArC=O), 163.2, 132.7, 131.4, 129.6, 128.6 (ArCH)

Crystal Structure of (–)-Himandrine (3).



View 1:



View 2:

Table S1. Crystal data and structure refinement for (–)-himandrine (**3**).

Identification code	d8_09005	
Empirical formula	C30 H37 N O6	
Formula weight	507.61	
Temperature	100(2) K	
Wavelength	1.54178 Å	
Crystal system	Triclinic	
Space group	P1	
Unit cell dimensions	a = 8.3136(2) Å	a= 78.8230(10)°.
	b = 8.7575(2) Å	b= 67.4340(10)°.
	c = 10.6508(3) Å	g = 62.0950(10)°.
Volume	632.72(3) $Å^3$	
Z	1	
Density (calculated)	1.332 Mg/m^3	
Absorption coefficient	0.746 mm^{-1}	
F(000)	272	
Crystal size	0.30 x 0.25 x 0.03 mm^3	
Theta range for data collection	4.50 to 68.74°.	
Index ranges	-10<=h<=10, -8<=k<=10, -12<=l<=12	
Reflections collected	11853	
Independent reflections	3819 [R(int) = 0.0157]	
Completeness to theta = 68.74°	95.4 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.9780 and 0.8072	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	3819 / 374 / 340	
Goodness-of-fit on F^2	1.050	
Final R indices [I>2sigma(I)]	R1 = 0.0268, wR2 = 0.0704	
R indices (all data)	R1 = 0.0273, wR2 = 0.0707	
Absolute structure parameter	0.12(12)	
Largest diff. peak and hole	0.160 and -0.149 $e.Å^{-3}$	

Table S2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for (–)-himandrine (**3**). U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
O(1)	9286(2)	-3433(2)	-3435(1)	24(1)
O(2)	6909(2)	3613(2)	906(1)	25(1)
O(3)	10744(1)	-1800(1)	-2501(1)	19(1)
O(4)	10437(2)	1690(2)	-759(1)	25(1)
O(5)	10469(2)	1605(2)	-2855(1)	24(1)
O(6)	11133(2)	-1066(2)	-4733(1)	25(1)
N(1)	5882(2)	-875(2)	1922(1)	20(1)
C(1)	9013(2)	-3652(2)	1181(2)	23(1)
C(2)	7830(2)	-2051(2)	2058(2)	21(1)
C(3)	9083(2)	-1168(2)	1986(2)	22(1)
C(4)	7936(2)	497(2)	2808(2)	25(1)
C(5)	5954(2)	1601(2)	2634(2)	23(1)
C(6)	4864(2)	465(2)	2972(2)	23(1)
C(7)	2890(2)	1421(2)	2799(2)	25(1)
C(8)	3544(2)	1824(2)	1278(2)	23(1)
C(9)	5574(2)	207(2)	662(2)	20(1)
C(10)	5535(2)	-649(2)	-444(2)	20(1)
C(11)	4371(2)	-1710(2)	141(2)	24(1)
C(12)	4213(2)	-2404(2)	-996(2)	26(1)
C(13)	6223(2)	-3455(2)	-1982(2)	25(1)
C(14)	7374(2)	-2392(2)	-2581(2)	21(1)
C(15)	7549(2)	-1665(2)	-1466(2)	19(1)
C(16)	8698(2)	-584(2)	-2059(2)	18(1)
C(17)	8412(2)	634(2)	-1068(2)	19(1)
C(18)	9843(2)	1376(2)	-1511(2)	20(1)
C(19)	6985(2)	1007(2)	139(2)	19(1)
C(20)	6117(2)	2420(2)	1172(2)	21(1)
C(21)	4089(2)	3327(2)	1048(2)	24(1)
C(22)	11947(2)	2234(2)	-3369(2)	28(1)
C(23)	9405(3)	-3736(3)	-4732(2)	34(1)

C(24)	11671(2)	-2049(2)	-3856(2)	20(1)
C(25)	13481(2)	-3698(2)	-4122(2)	20(1)
C(26)	14848(2)	-4000(2)	-5428(2)	24(1)
C(27)	16546(2)	-5528(2)	-5694(2)	26(1)
C(28)	16881(2)	-6760(2)	-4668(2)	25(1)
C(29)	15491(2)	-6478(2)	-3377(2)	25(1)
C(30)	13799(2)	-4961(2)	-3103(2)	22(1)

Table S3. Bond lengths [Å] and angles [°] for (–)-himandrine (**3**).

O(1)-C(23)	1.4142(19)	C(10)-C(15)	1.537(2)
O(1)-C(14)	1.4284(19)	C(11)-C(12)	1.528(2)
O(2)-C(20)	1.412(2)	C(12)-C(13)	1.526(2)
O(3)-C(24) 0.0	1.3541(17)	C(13)-C(14)	1.525(2)
O(3)-C(16)	1.4605(16)	C(14)-C(15)	1.533(2)
O(4)-C(18)	1.2153(19)	C(15)-C(16)	1.535(2)
O(5)-C(18)	1.3318(19)	C(16)-C(17)	1.522(2)
O(5)-C(22)	1.453(2)	C(17)-C(19)	1.340(2)
O(6)-C(24)	1.2094(19)	C(17)-C(18)	1.495(2)
N(1)-C(6)	1.482(2)	C(19)-C(20)	1.531(2)
N(1)-C(2)	1.5048(19)	C(20)-C(21)	1.539(2)
N(1)-C(9)	1.5195(19)	C(24)-C(25)	1.493(2)
C(1)-C(2)	1.523(2)	C(25)-C(26)	1.395(2)
C(2)-C(3)	1.535(2)	C(25)-C(30)	1.397(2)
C(3)-C(4)	1.534(2)	C(26)-C(27)	1.391(2)
C(4)-C(5)	1.536(2)	C(27)-C(28)	1.390(2)
C(5)-C(6)	1.547(2)	C(28)-C(29)	1.390(2)
C(5)-C(20)	1.566(2)	C(29)-C(30)	1.383(2)
C(6)-C(7)	1.521(2)		
C(7)-C(8)	1.525(2)	C(23)-O(1)-C(14)	114.26(13)
C(8)-C(21)	1.532(2)	C(24)-O(3)-C(16)	117.11(11)
C(8)-C(9)	1.599(2)	C(18)-O(5)-C(22)	115.22(12)
C(9)-C(19)	1.515(2)	C(6)-N(1)-C(2)	107.31(12)
C(9)-C(10)	1.533(2)	C(6)-N(1)-C(9)	101.81(12)
C(10)-C(11)	1.530(2)	C(2)-N(1)-C(9)	124.53(11)

N(1)-C(2)-C(1)	115.50(13)
N(1)-C(2)-C(3)	115.94(13)
C(1)-C(2)-C(3)	111.01(13)
C(4)-C(3)-C(2)	113.00(13)
C(3)-C(4)-C(5)	112.15(14)
C(4)-C(5)-C(6)	108.71(13)
C(4)-C(5)-C(20)	112.62(13)
C(6)-C(5)-C(20)	110.63(13)
N(1)-C(6)-C(7)	100.94(13)
N(1)-C(6)-C(5)	108.84(12)
C(7)-C(6)-C(5)	113.24(14)
C(6)-C(7)-C(8)	98.68(12)
C(7)-C(8)-C(21)	108.84(14)
C(7)-C(8)-C(9)	104.54(12)
C(21)-C(8)-C(9)	103.48(12)
C(19)-C(9)-N(1)	108.05(12)
C(19)-C(9)-C(10)	113.70(12)
N(1)-C(9)-C(10)	117.25(13)
C(19)-C(9)-C(8)	102.83(13)
N(1)-C(9)-C(8)	102.66(11)
C(10)-C(9)-C(8)	110.85(12)
C(11)-C(10)-C(9)	112.54(13)
C(11)-C(10)-C(15)	112.64(13)
C(9)-C(10)-C(15)	113.45(12)
C(12)-C(11)-C(10)	110.84(13)
C(13)-C(12)-C(11)	110.31(13)
C(14)-C(13)-C(12)	111.64(14)
O(1)-C(14)-C(13)	110.51(13)
O(1)-C(14)-C(15)	107.72(12)
C(13)-C(14)-C(15)	111.57(13)
C(14)-C(15)-C(16)	111.97(12)
C(14)-C(15)-C(10)	110.17(12)
C(16)-C(15)-C(10)	112.27(13)
O(3)-C(16)-C(17)	107.10(12)
O(3)-C(16)-C(15)	106.85(12)
C(17)-C(16)-C(15)	115.20(12)
C(19)-C(17)-C(18)	121.64(15)
C(19)-C(17)-C(16)	122.44(14)
C(18)-C(17)-C(16)	115.91(13)
O(4)-C(18)-O(5)	122.83(15)
O(4)-C(18)-C(17)	125.03(14)
O(5)-C(18)-C(17)	112.10(13)
C(17)-C(19)-C(9)	123.37(15)
C(17)-C(19)-C(20)	132.98(15)
C(9)-C(19)-C(20)	102.82(12)
O(2)-C(20)-C(19)	118.91(13)
O(2)-C(20)-C(21)	110.00(13)
C(19)-C(20)-C(21)	96.65(12)
O(2)-C(20)-C(5)	111.34(13)
C(19)-C(20)-C(5)	109.96(12)
C(21)-C(20)-C(5)	108.76(12)
C(8)-C(21)-C(20)	102.03(12)
O(6)-C(24)-O(3)	125.12(14)
O(6)-C(24)-C(25)	124.37(14)
O(3)-C(24)-C(25)	110.49(12)
C(26)-C(25)-C(30)	119.63(15)
C(26)-C(25)-C(24)	118.99(14)
C(30)-C(25)-C(24)	121.35(14)
C(27)-C(26)-C(25)	119.79(15)
C(28)-C(27)-C(26)	120.36(15)
C(29)-C(28)-C(27)	119.70(15)
C(30)-C(29)-C(28)	120.32(15)
C(29)-C(30)-C(25)	120.15(15)

Symmetry transformations used to generate equivalent atoms:

Table S4. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for (–)-himandrine (**3**). The anisotropic
displacement factor exponent takes the form: $-2p^2[\ h^2\ a^{*2}U^{11} + ...\ + 2\ h\ k\ a^*\ b^*\ U^{12}\ ]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
O(1)	27(1)	25(1)	22(1)	-4(1)	-8(1)	-12(1)
O(2)	26(1)	19(1)	30(1)	-4(1)	-7(1)	-10(1)
O(3)	18(1)	17(1)	21(1)	-2(1)	-6(1)	-7(1)
O(4)	24(1)	27(1)	27(1)	-3(1)	-9(1)	-13(1)
O(5)	28(1)	24(1)	22(1)	-1(1)	-5(1)	-16(1)
O(6)	28(1)	21(1)	22(1)	1(1)	-6(1)	-9(1)
N(1)	21(1)	20(1)	20(1)	-1(1)	-6(1)	-9(1)
C(1)	23(1)	20(1)	26(1)	1(1)	-11(1)	-7(1)
C(2)	21(1)	20(1)	20(1)	1(1)	-7(1)	-8(1)
C(3)	22(1)	22(1)	23(1)	1(1)	-9(1)	-10(1)
C(4)	28(1)	23(1)	26(1)	-1(1)	-11(1)	-11(1)
C(5)	25(1)	21(1)	22(1)	-6(1)	-6(1)	-8(1)
C(6)	23(1)	22(1)	18(1)	-2(1)	-3(1)	-9(1)
C(7)	22(1)	23(1)	26(1)	-4(1)	-4(1)	-8(1)
C(8)	20(1)	20(1)	26(1)	-1(1)	-7(1)	-6(1)
C(9)	18(1)	17(1)	22(1)	0(1)	-6(1)	-7(1)
C(10)	20(1)	18(1)	23(1)	0(1)	-8(1)	-8(1)
C(11)	20(1)	23(1)	30(1)	0(1)	-8(1)	-10(1)
C(12)	25(1)	22(1)	37(1)	-1(1)	-13(1)	-12(1)
C(13)	27(1)	22(1)	32(1)	-3(1)	-12(1)	-12(1)
C(14)	25(1)	17(1)	24(1)	-1(1)	-12(1)	-8(1)
C(15)	20(1)	16(1)	22(1)	0(1)	-10(1)	-8(1)
C(16)	19(1)	16(1)	20(1)	0(1)	-7(1)	-6(1)
C(17)	19(1)	16(1)	22(1)	0(1)	-9(1)	-6(1)
C(18)	19(1)	13(1)	25(1)	-3(1)	-7(1)	-4(1)
C(19)	22(1)	14(1)	22(1)	1(1)	-12(1)	-6(1)
C(20)	21(1)	16(1)	24(1)	-4(1)	-5(1)	-8(1)
C(21)	22(1)	18(1)	26(1)	-3(1)	-7(1)	-5(1)
C(22)	26(1)	28(1)	30(1)	1(1)	-3(1)	-16(1)
C(23)	43(1)	38(1)	24(1)	-5(1)	-13(1)	-17(1)

C(24)	23(1)	20(1)	20(1)	-1(1)	-7(1)	-13(1)
C(25)	22(1)	20(1)	24(1)	-3(1)	-8(1)	-12(1)
C(26)	28(1)	22(1)	24(1)	0(1)	-7(1)	-14(1)
C(27)	25(1)	26(1)	25(1)	-6(1)	-2(1)	-13(1)
C(28)	24(1)	19(1)	33(1)	-8(1)	-9(1)	-7(1)
C(29)	29(1)	21(1)	28(1)	1(1)	-14(1)	-12(1)
C(30)	23(1)	23(1)	23(1)	-4(1)	-6(1)	-12(1)

Table S5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for (–)-himandrine (**3**).

	x	y	z	U(eq)
H(2O)	8110(20)	3030(30)	640(20)	30
H(1A)	8143	-4058	1096	35
H(1B)	9910	-4563	1606	35
H(1C)	9746	-3367	277	35
H(2)	7524	-2517	3011	25
H(3A)	10141	-1984	2333	27
H(3B)	9677	-892	1024	27
H(4A)	8691	1182	2511	29
H(4B)	7748	194	3783	29
H(5)	5198	2559	3302	28
H(6)	4761	-69	3902	27
H(7A)	2059	2484	3344	31
H(7B)	2211	677	3027	31
H(8)	2579	2029	848	28
H(10)	4816	319	-979	24
H(11A)	5010	-2688	693	28
H(11B)	3059	-977	743	28
H(12A)	3524	-3143	-599	32
H(12B)	3459	-1428	-1491	32
H(13A)	6933	-4483	-1499	30
H(13B)	6095	-3862	-2728	30

H(14)	6709	-1411	-3134	26
H(15)	8282	-2670	-962	23
H(16)	8361	97	-2865	22
H(21A)	3174	4219	1749	29
H(21B)	4127	3867	136	29
H(22A)	11418	3381	-3004	43
H(22B)	12362	2309	-4364	43
H(22C)	13058	1435	-3086	43
H(23A)	8788	-4491	-4635	51
H(23B)	10767	-4294	-5306	51
H(23C)	8744	-2634	-5154	51
H(26)	14619	-3166	-6134	29
H(27)	17482	-5729	-6582	31
H(28)	18055	-7790	-4847	31
H(29)	15703	-7331	-2680	30
H(30)	12852	-4778	-2220	27

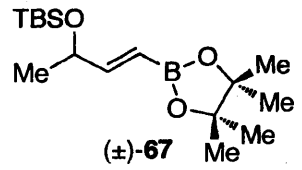
Table S6. Hydrogen bonds for (–)-himandrine (**3**) [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
O(2)-H(2O)...O(4)	0.834(15)	1.922(17)	2.6693(16)	148.7(19)

Symmetry transformations used to generate equivalent atoms:

Appendix A.

Spectra for Chapter I



(±)-**67**

SAMPLE

ACQUISITION

sfrq	499.757
tn	H1
at	3.278
np	40960
sw	6248.0
fb	not used
bs	4
tpwr	56
pw	8.2
d1	2.000
tof	374.5
nt	128
ct	4
alock	n
gain	not used

FLAGS

il	n
in	n
dp	y
hs	nn

DISPLAY

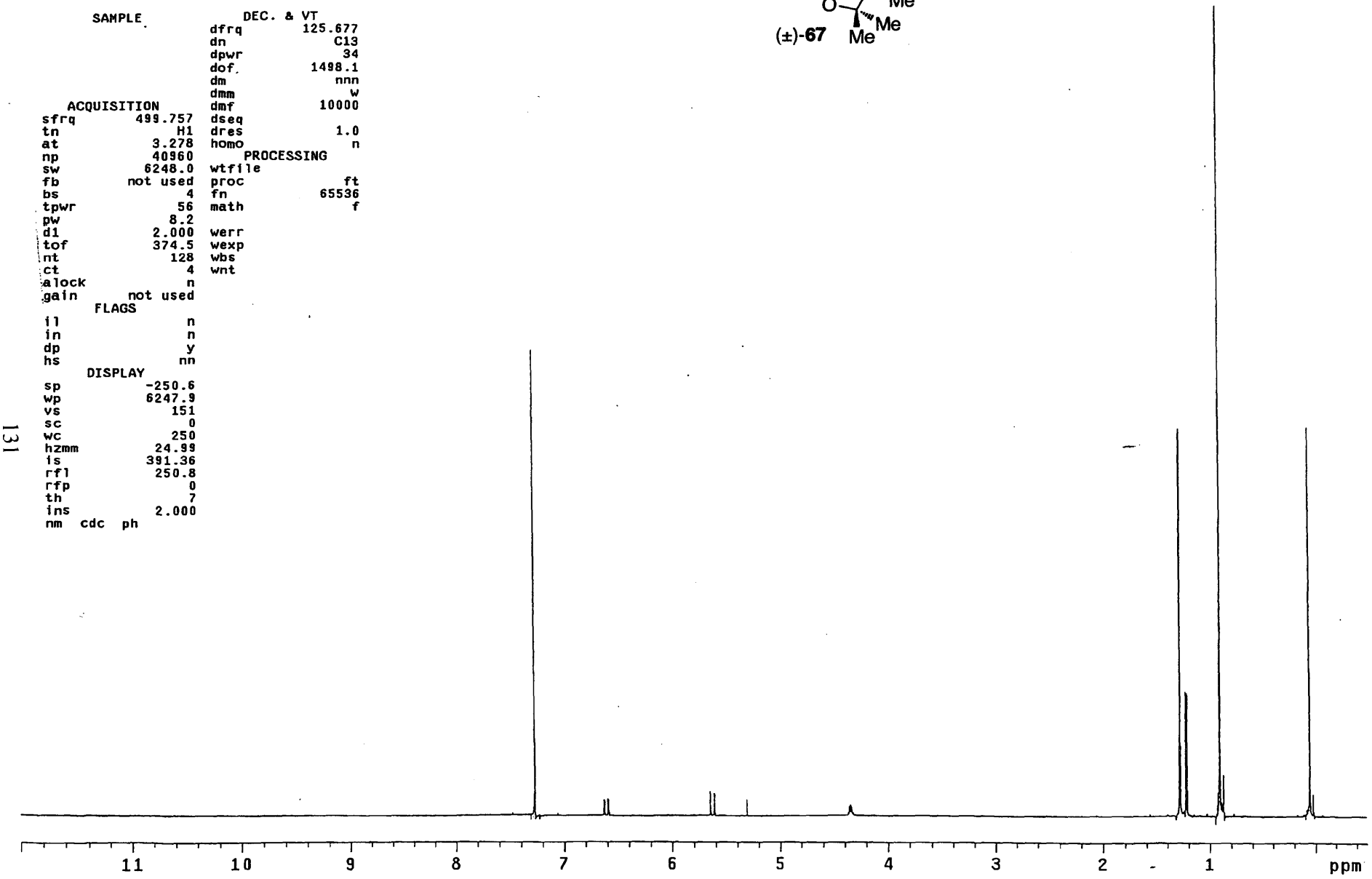
sp	-250.6
wp	6247.9
vs	151
sc	0
wc	250
hzmm	24.99
is	391.36
rfl	250.8
rfp	0
th	7
ins	2.000
nm	cdc ph

DEC. & VT

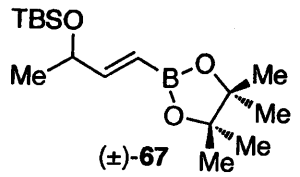
dfrq	125.677
dn	C13
dpwr	34
dof	1498.1
dm	nnn
dmm	W
dmf	10000
dseq	
dres	1.0
homo	n

PROCESSING

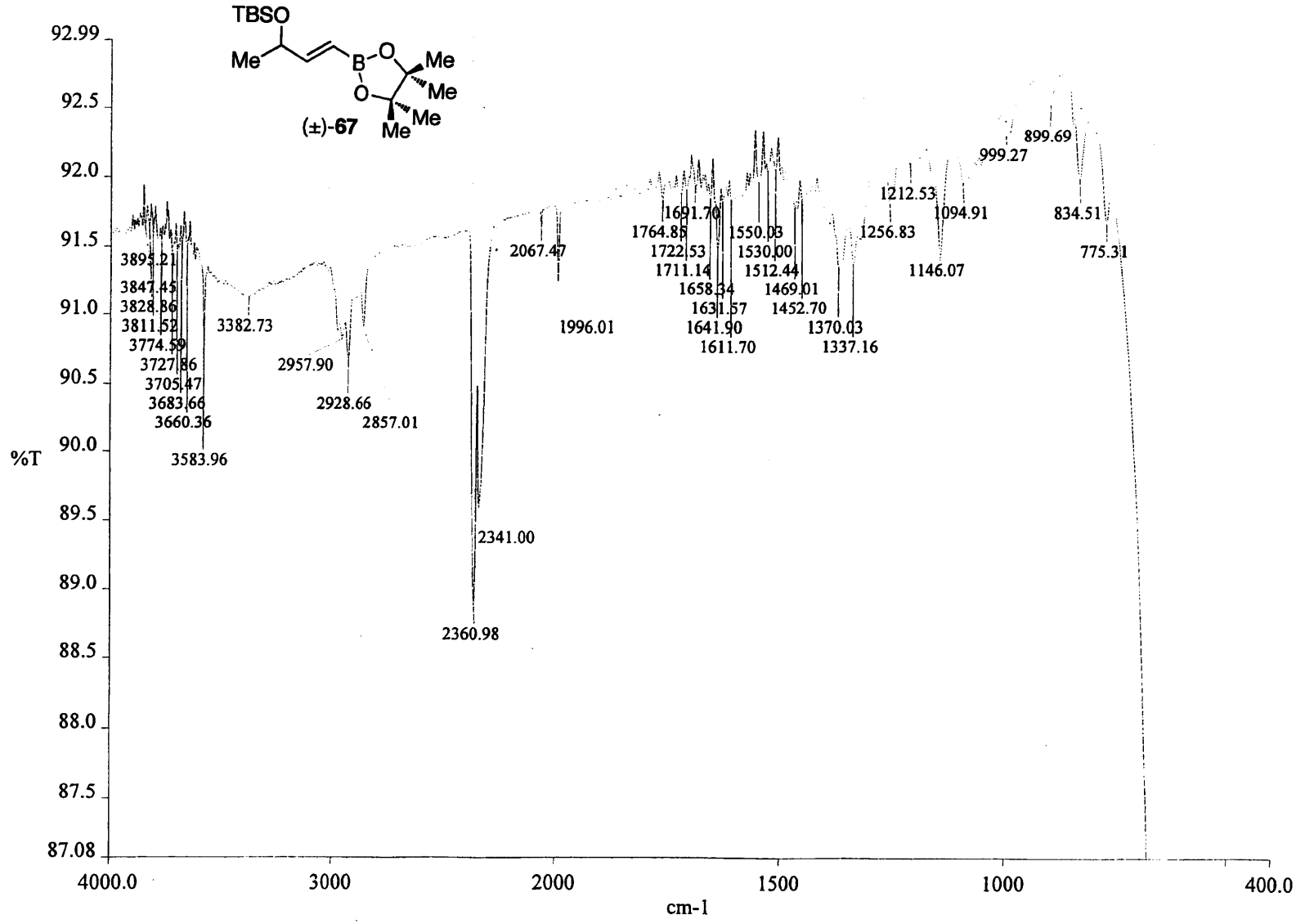
wtfile	
proc	ft
fn	65536
math	f
werr	
wexp	
wbs	
wnt	



SAMPLE		DEC. & VT	
		dfrq	500.233
		dn	H1
		dpwr	37
		dof	-500.0
		dm	y
ACQUISITION		dmm	w
sfrq	125.796	dmf	10000
tn	C13	dseq	
at	1.736	dres	1.0
np	131010	homo	n
sw	37735.8	PROCESSING	
fb	not used	lb	0.30
bs	8	wtfile	
ss	1	proc	ft
tpwr	53	fn	131072
pw	6.9	math	f
d1	0.763		
tof	631.4	werr	
nt	1e+06	wexp	
ct	0	wbs	
alock	n	wnt	
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-2556.8		
wp	30247.5		
vs	1034		
sc	0		
wc	250		
hzmm	120.99		
is	500.00		
rfl	15911.8		
rfp	9686.0		
th	20		
ins	1.000		
ai	ph		



(±)-**67**


TBSO
Me
B
O
O
Me
Me
Me
(±)-67
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92.5
92.0
91.5
91.0
90.5
90.0
89.5
89.0
88.5
88.0
87.5
87.08
%T
3895.21
3847.45
3828.86
3811.52
3774.59
3727.86
3705.47
3683.66
3660.36
3583.96
3382.73
2957.90
2928.66
2857.01
2360.98
2341.00
2067.47
1996.01
1764.85
1722.53
1711.14
1691.70
1658.34
1641.90
1631.57
1611.70
1550.03
1530.00
1512.44
1469.01
1452.70
1370.03
1337.16
1256.83
1212.53
1146.07
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999.27
899.69
834.51
775.31
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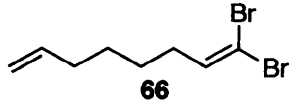
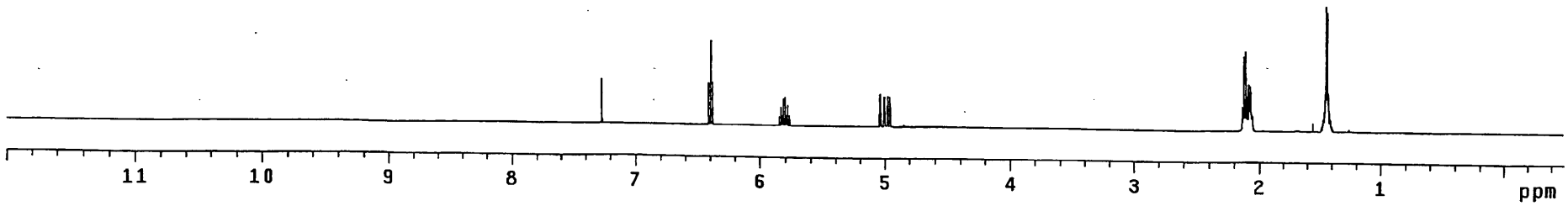
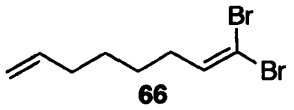
3000
2000
1500
1000
400.0
cm-1



66

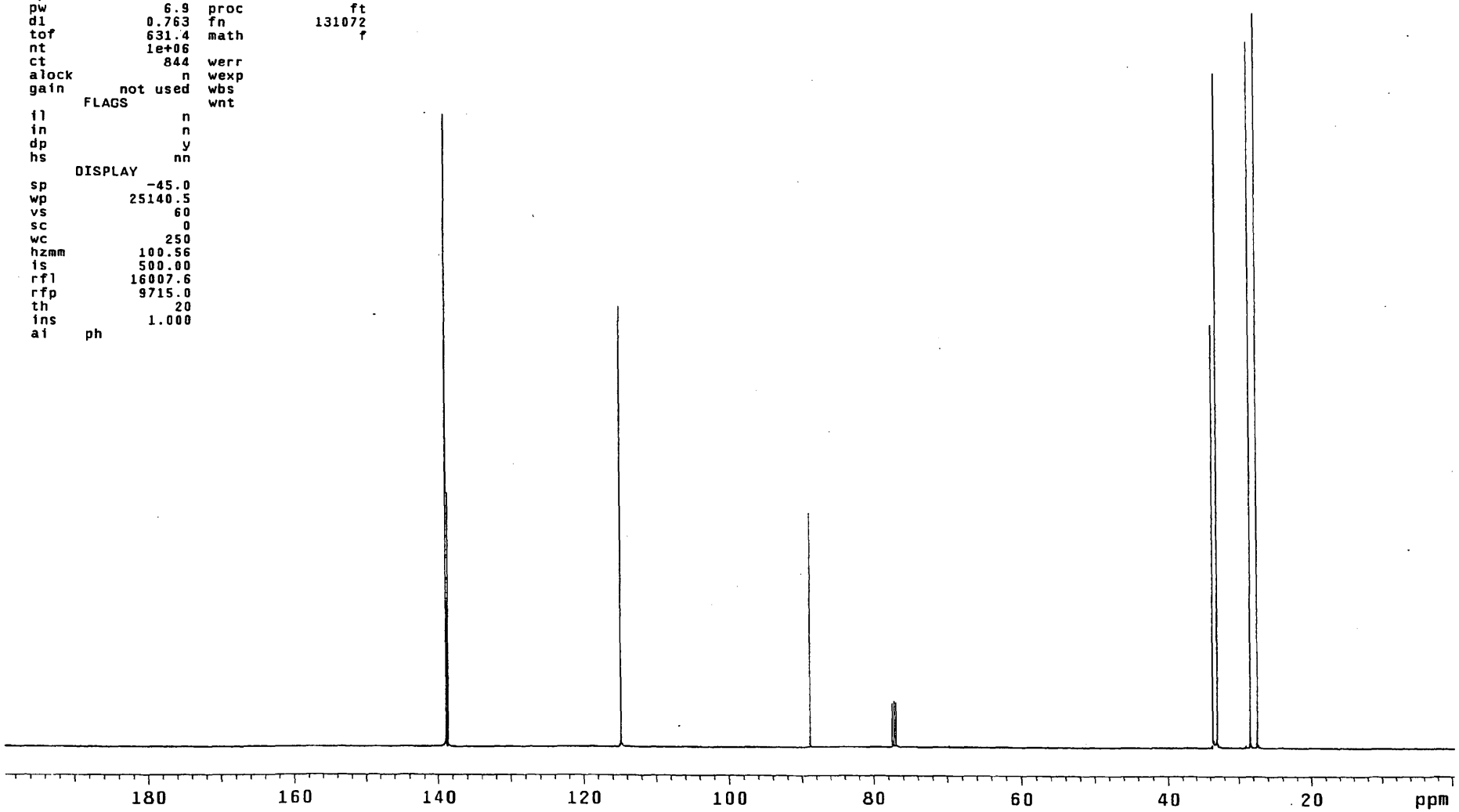
SAMPLE		DEC. & VT	
		dfrq	125.677
		dn	C13
		dpwr	34
		dof	1498.1
		dm	nnn
ACQUISITION		dmm	w
sfrq	499.757	dmf	10000
tn	H1	dseq	
at	3.278	dres	1.0
np	40960	homo	n
sw	6248.0	PROCESSING	
fb	not used	wtfile	
bs	16	proc	ft
tpwr	56	fn	65536
pw	8.2	math	f
d1	0		
tof	374.5	werr	
nt	4	wexp	
ct	4	wbs	
alock	n	wnt	
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-250.6		
wp	6247.9		
vs	20		
sc	0		
wc	250		
hzmm	24.99		
is	33.57		
rfl	250.8		
rfp	0		
th	7		
ins	1.000		
nm cdc ph			

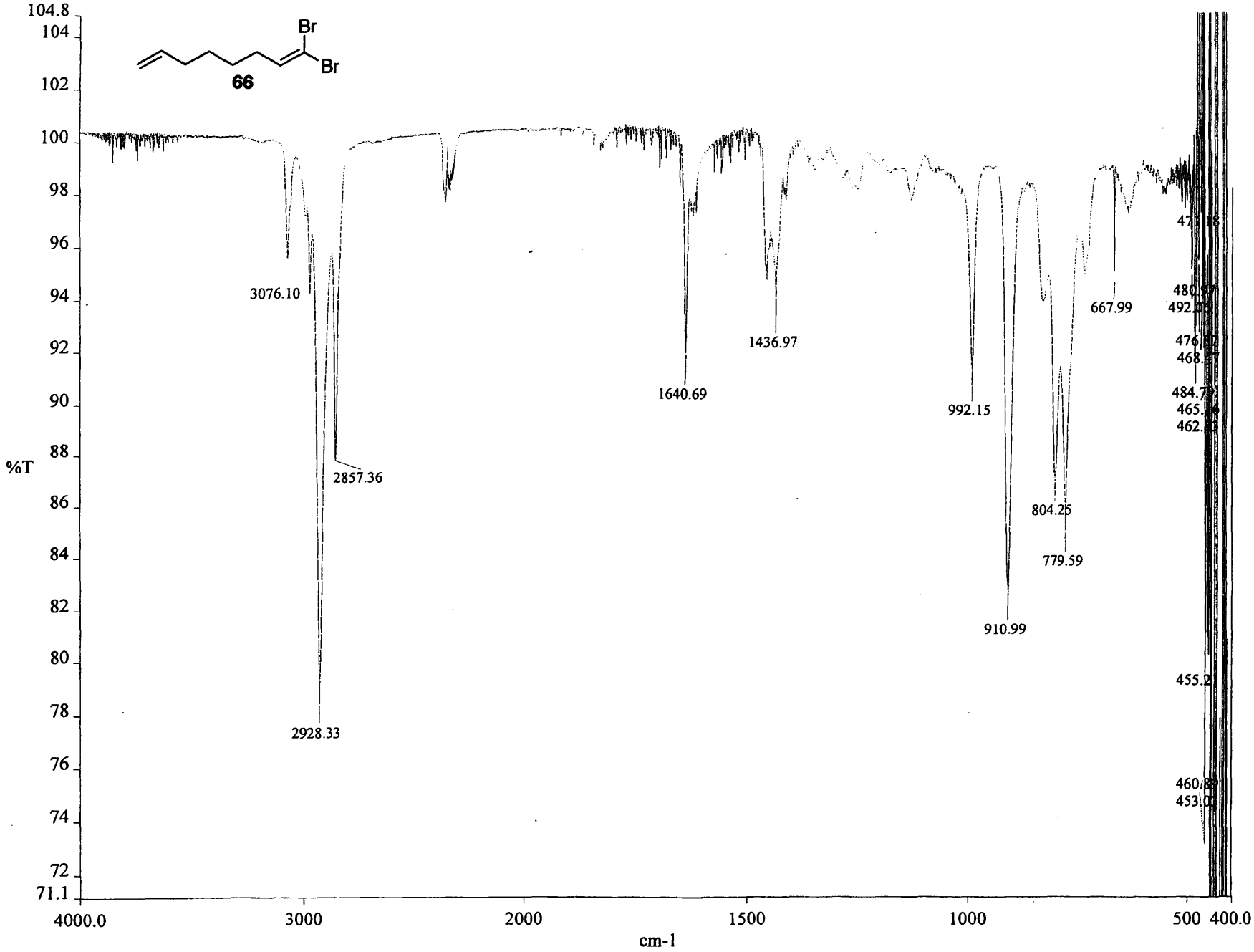


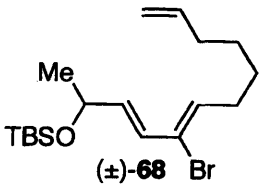


66

SAMPLE		DEC. & VT	
solvent	CDCl3	dfrq	500.233
file	exp	dn	H1
ACQUISITION		dpwr	37
sfrq	125.796	dof	-500.0
tn	C13	dm	y
at	1.736	dmm	w
np	131010	dmf	10000
sw	37735.8	dseq	
fb	not used	dres	1.0
bs	4	homo	n
ss	1	PROCESSING	
tpwr	53	lb	0.30
pw	6.9	wtfile	
d1	0.763	proc	ft
tof	631.4	fn	131072
nt	1e+06	math	f
ct	844	werr	
alock	n	wexp	
gain	not used	wbs	
FLAGS		wnt	
fl	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-45.0		
wp	25140.5		
vs	60		
sc	0		
wc	250		
hzmm	100.56		
is	500.00		
rfl	16007.6		
rfp	9715.0		
th	20		
ins	1.000		
ai	ph		

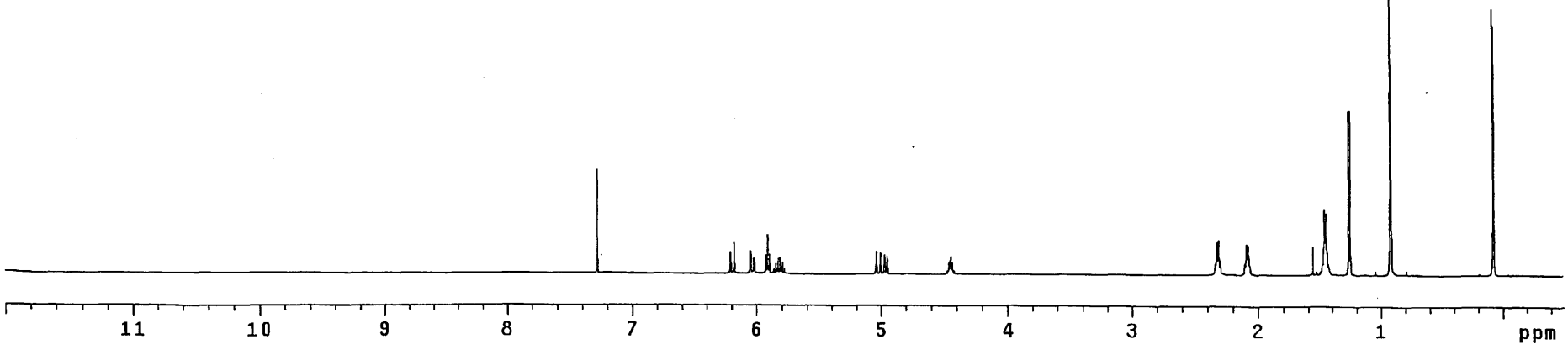


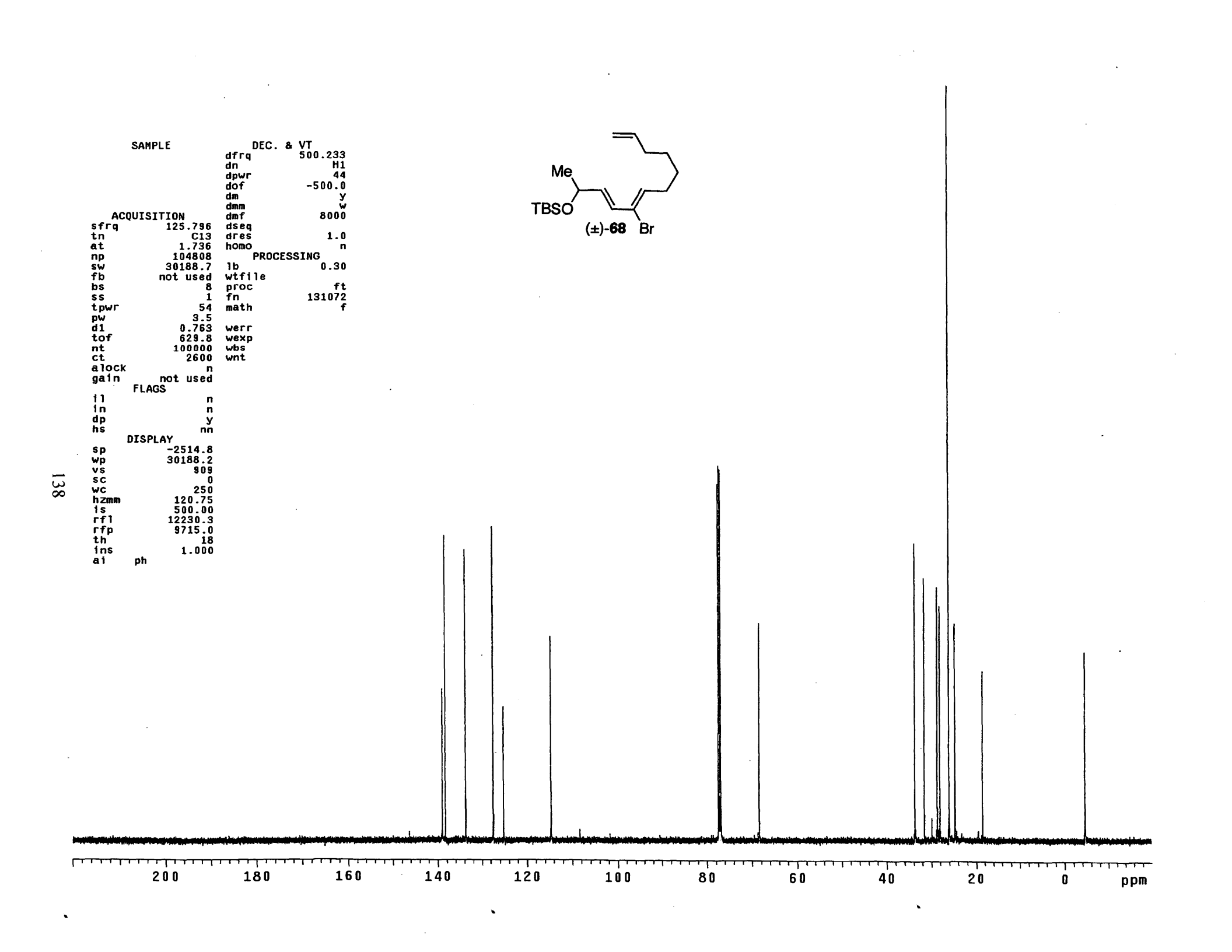

104.8
104
102
100
98
96
94
92
90
88
86
84
82
80
78
76
74
72
71.1
%T
Br
Br
66
3076.10
2928.33
2857.36
1640.69
1436.97
992.15
910.99
804.25
779.59
667.99
4000.0
3000
2000
1500
1000
500
400.0
cm-1



(±)-**68**

ACQUISITION		DEC. & VT	
sfrq	499.748	dfrq	125.674
tn	H1	dn	C13
at	3.278	dpwr	34
np	40960	dof	1498.1
sw	6248.0	dm	nnn
fb	not used	dmm	w
bs	4	dmf	10000
tpwr	56	dseq	
pw	8.2	dres	1.0
d1	0	homo	n
tof	377.8	PROCESSING	
nt	128	wtfile	
ct	16	proc	ft
alock	n	fn	65536
gain	not used	math	f
FLAGS		werr	
il	n	wexp	
in	n	wbs	
dp	y	wnt	
hs	nn		
DISPLAY			
sp	-250.8		
wp	6247.9		
vs	172		
sc	0		
wc	250		
hzmm	24.99		
is	1e+09		
rfl	251.0		
rfp	0		
th	7		
ins	1.000		
nm	cdc ph		

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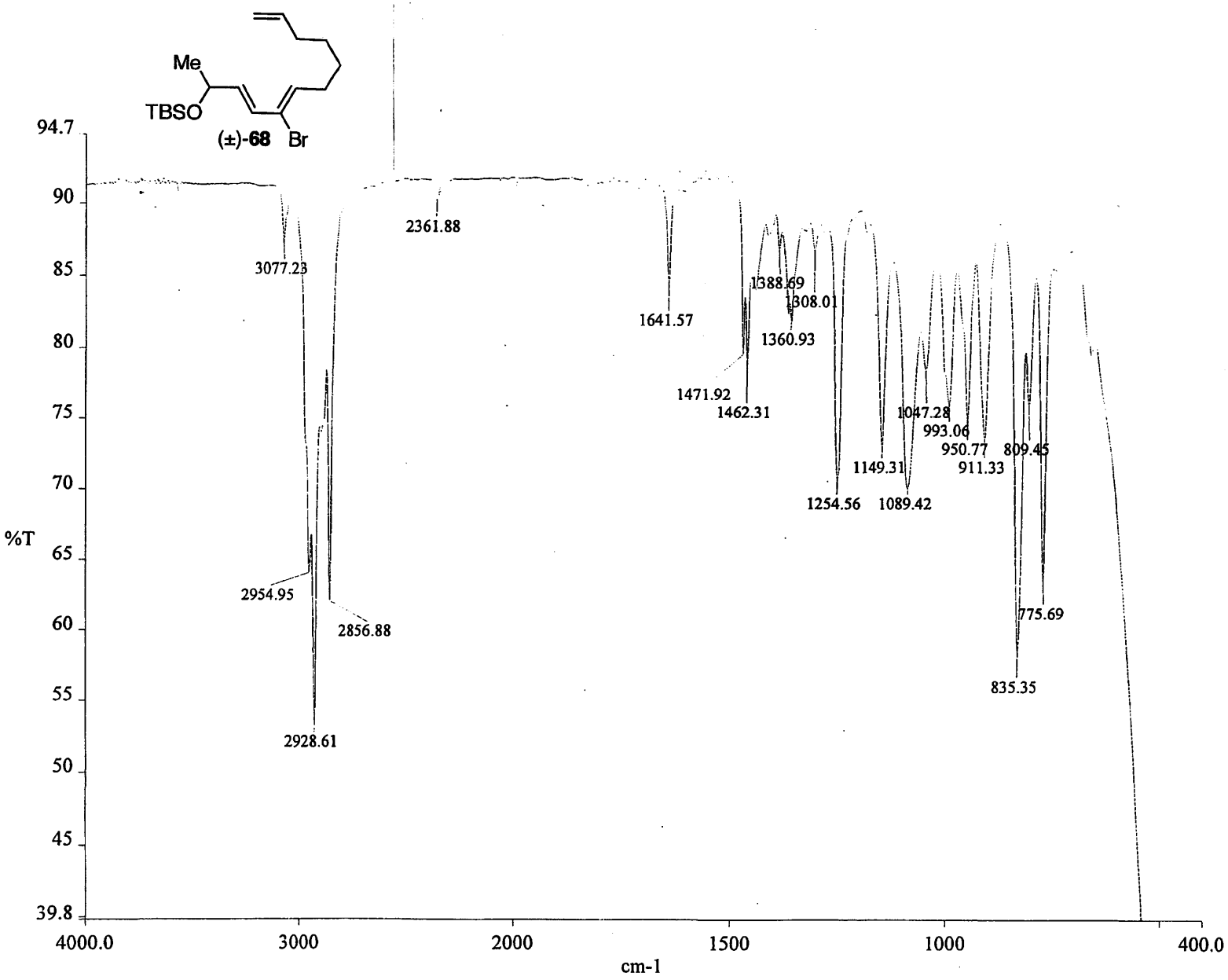
ACQUISITION
sfrq 125.796
tn C13
at 1.736
np 104808
sw 30188.7
fb not used
bs 8
ss 1
tpwr 54
pw 3.5
d1 0.763
tof 629.8
nt 100000
ct 2600
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -2514.8
wp 30188.2
vs 909
sc 0
wc 250
hzmm 120.75
is 500.00
rfl 12230.3
rfp 9715.0
th 18
ins 1.000
ai ph
DEC. & VT
dfrq 500.233
dn H1
dpwr 44
dof -500.0
dm y
dmm w
dmf 8000
dseq
dres 1.0
homo n
PROCESSING
lb 0.30
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
Me
TBSO
(±)-68 Br
200
180
160
140
120
100
80
60
40
20
0
ppm


Me
TBSO
(±)-68 Br
94.7
90
85
80
75
70
65
60
55
50
45
39.8
%T
3077.23
2954.95
2928.61
2856.88
2361.88
1641.57
1471.92
1462.31
1388.69
1360.93
1308.01
1254.56
1149.31
1089.42
1047.28
993.06
950.77
911.33
809.45
775.69
835.35
4000.0
3000
2000
1500
1000
400.0
cm-1

SAMPLE	
solvent	Benzene

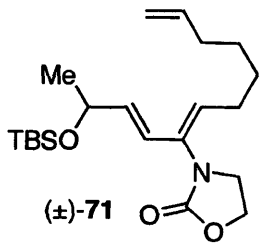
ACQUISITION	
sfrq	499.757
tn	H1
at	3.278
np	40960
sw	6248.0
fb	not used
bs	16
tpwr	56
pw	8.2
d1	0
tof	358.1
nt	8
ct	8
alock	n
gain	not used

FLAGS	
il	n
in	n
dp	y
hs	nn

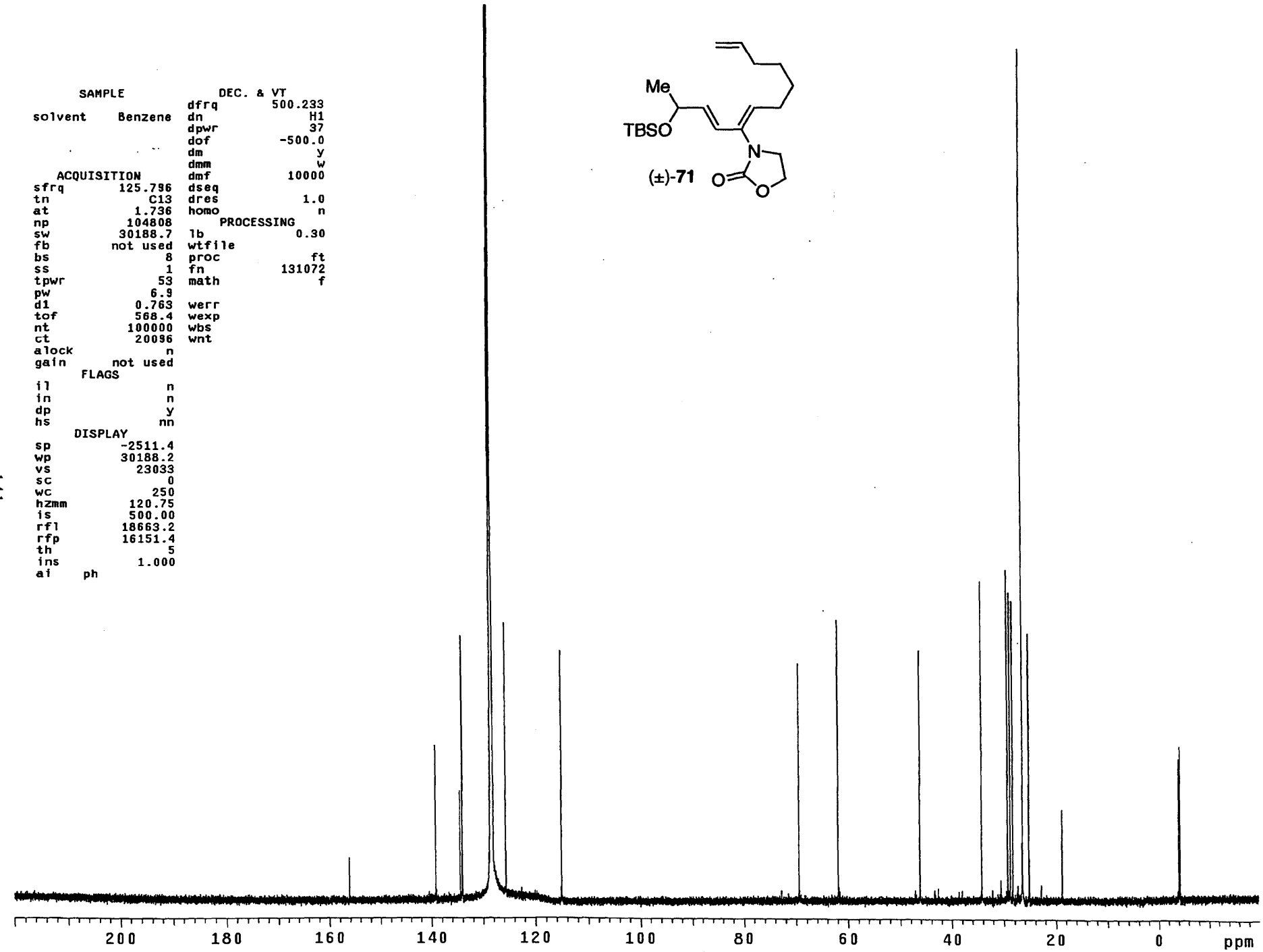
DISPLAY	
sp	-250.7
wp	6247.9
vs	151
sc	0
wc	250
hzmm	24.99
is	33.57
rfl	250.9
rfp	0
th	14
ins	1.000
nm	cdc ph

DEC. & VT	
dfrq	125.677
dn	C13
dpwr	34
dof	1498.1
dm	nnn
dmm	w
dmf	10400
dseq	
dres	1.0
homo	n

PROCESSING	
wtfile	
proc	ft
fn	65536
math	f
werr	
wexp	
wbs	
wnt	



(±)-71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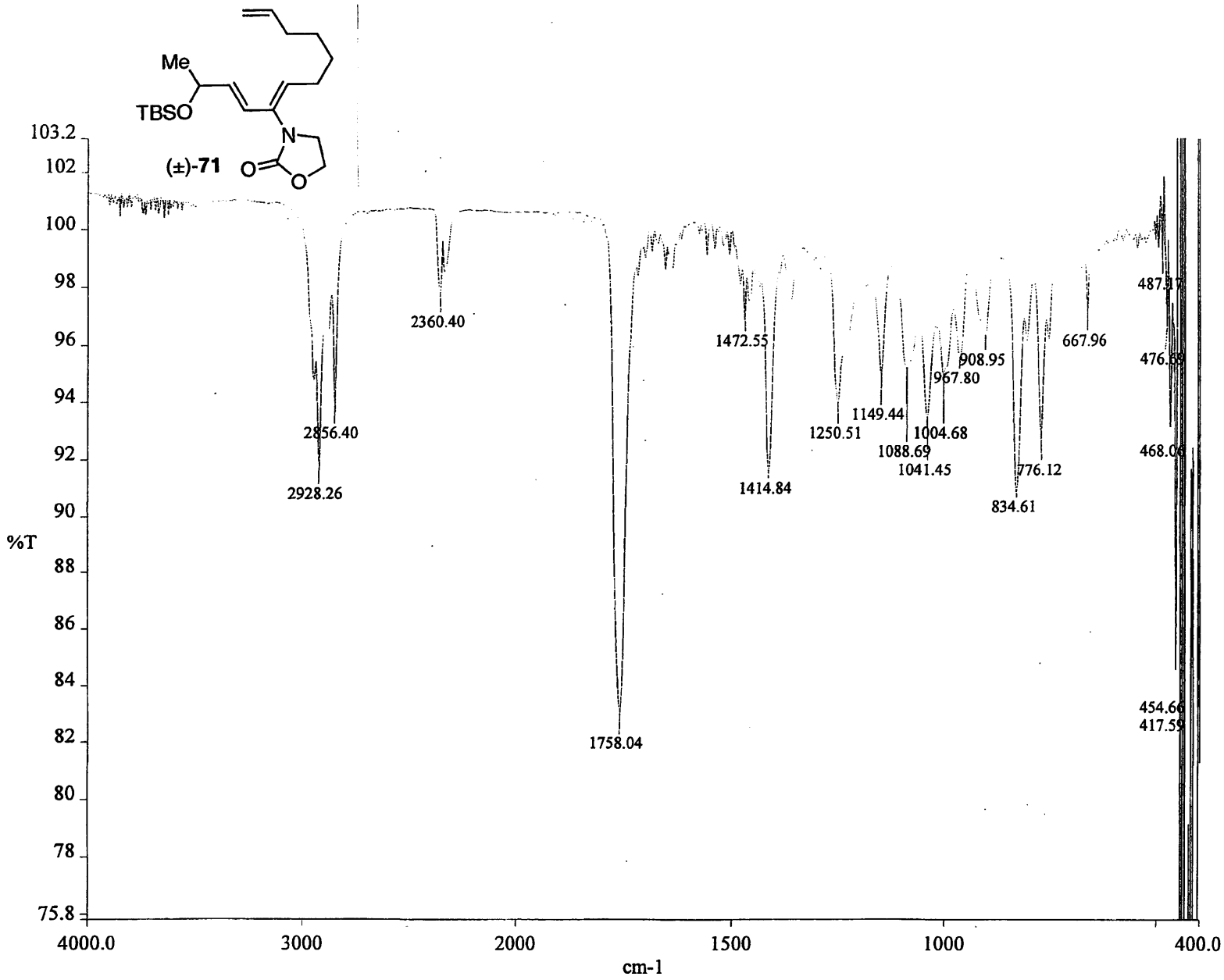
solvent Benzene
ACQUISITION
sfrq 125.796
tn C13
at 1.736
np 104808
sw 30188.7
fb not used
bs 8
ss 1
tpwr 53
pw 6.9
d1 0.763
tof 568.4
nt 100000
ct 20096
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -2511.4
wp 30188.2
vs 23033
sc 0
wc 250
hzmm 120.75
is 500.00
rfl 18663.2
rfp 16151.4
th 5
ins 1.000
ai ph
DEC. & VT
dfrq 500.233
dn H1
dpwr 37
dof -500.0
dm y
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
lb 0.30
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
Me
TBSO
N
O
O
(±)-71
200
180
160
140
120
100
80
60
40
20
0
ppm


Me
TBSO
N
O
O
(±)-71
103.2
102
100
98
96
94
92
90
88
86
84
82
80
78
75.8
%T
4000.0
3000
2000
1500
1000
400.0
cm-1
2928.26
2856.40
2360.40
1758.04
1472.55
1414.84
1250.51
1149.44
1088.69
1041.45
1004.68
967.80
908.95
834.61
776.12
667.96
487.97
476.69
468.06
454.66
417.59

SAMPLE	
solvent	benzene

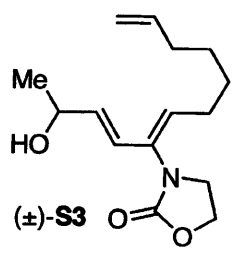
ACQUISITION	
sfrq	499.757
tn	H1
at	3.278
np	40960
sw	6248.0
fb	not used
bs	4
tpwr	56
pw	8.2
d1	4.000
tof	358.1
nt	128
ct	16
alock	n
gain	not used

FLAGS	
il	n
in	n
dp	y
hs	nn

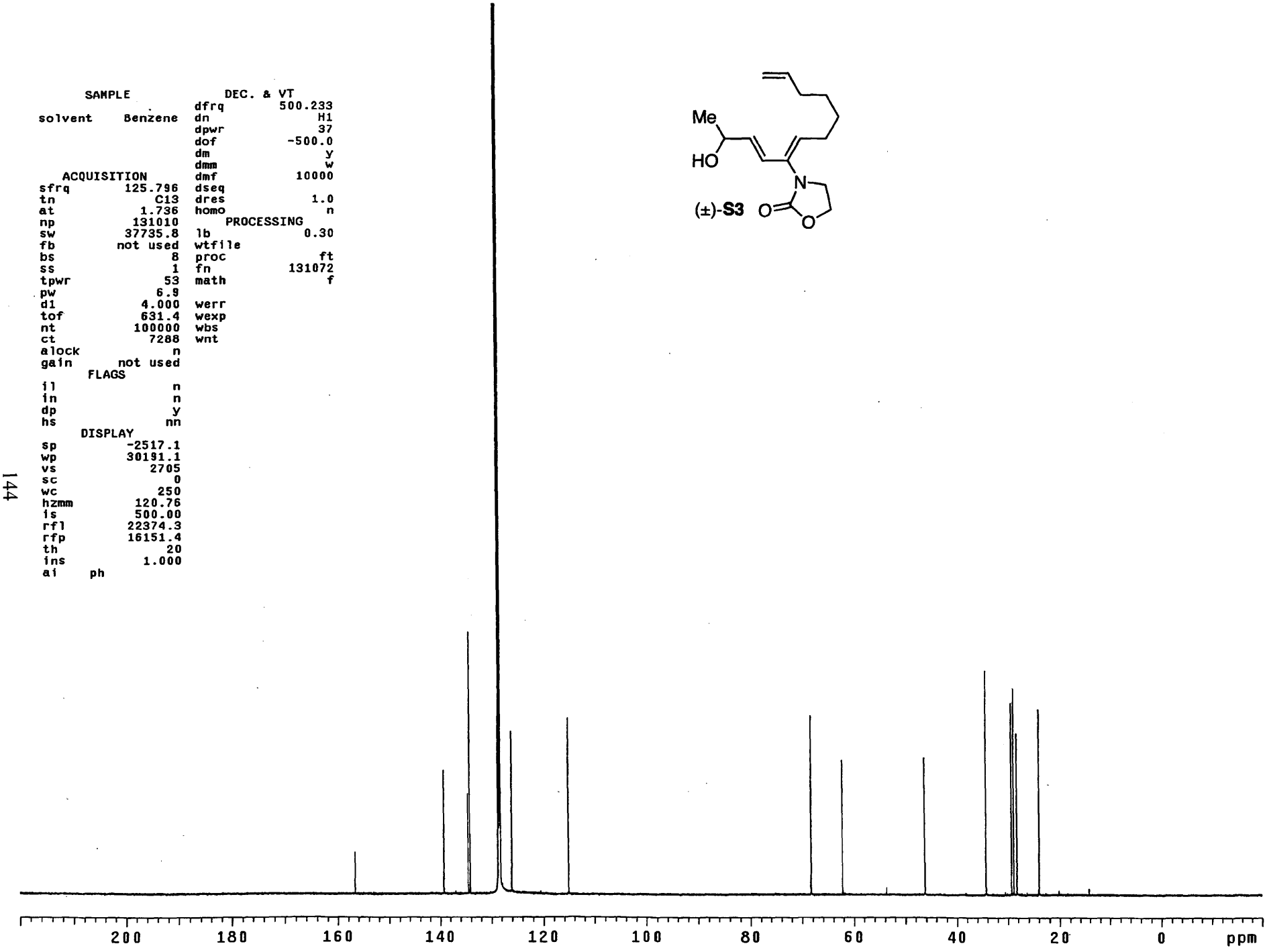
DISPLAY	
sp	-250.7
wp	6247.9
vs	161
sc	0
wc	250
hzmm	24.99
is	33.57
rfl	250.9
rfp	0
th	7
ins	1.000
nm cdc ph	

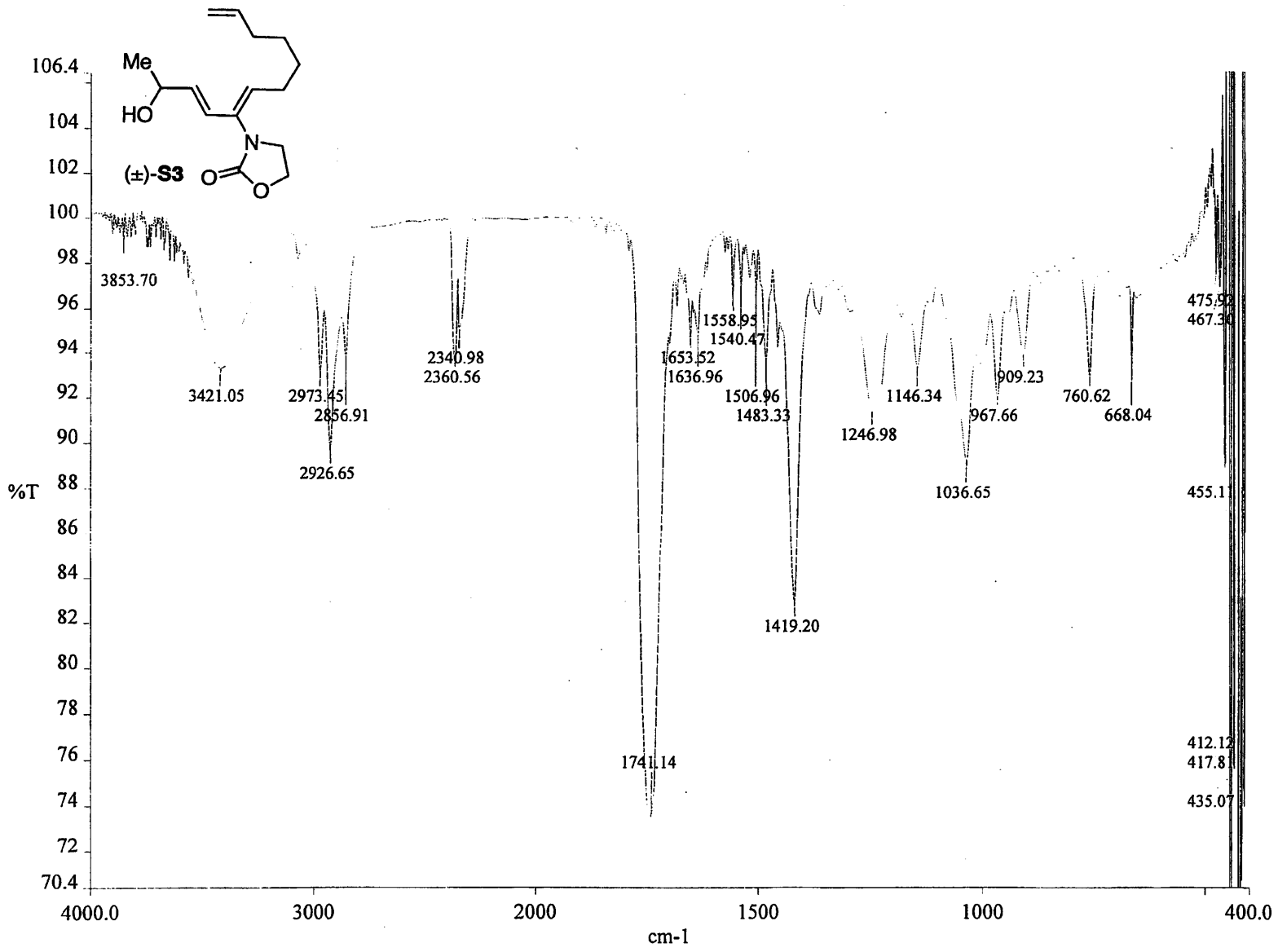
DEC. & VT	
dfrq	125.677
dn	C13
dpwr	34
dof	1498.1
dm	nnn
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

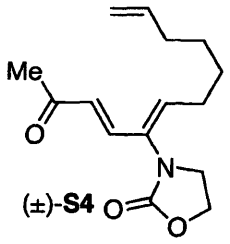
PROCESSING	
wtfile	
proc	ft
fn	65536
math	f
werr	
wexp	
wbs	
wnt	



(±)-**S3**

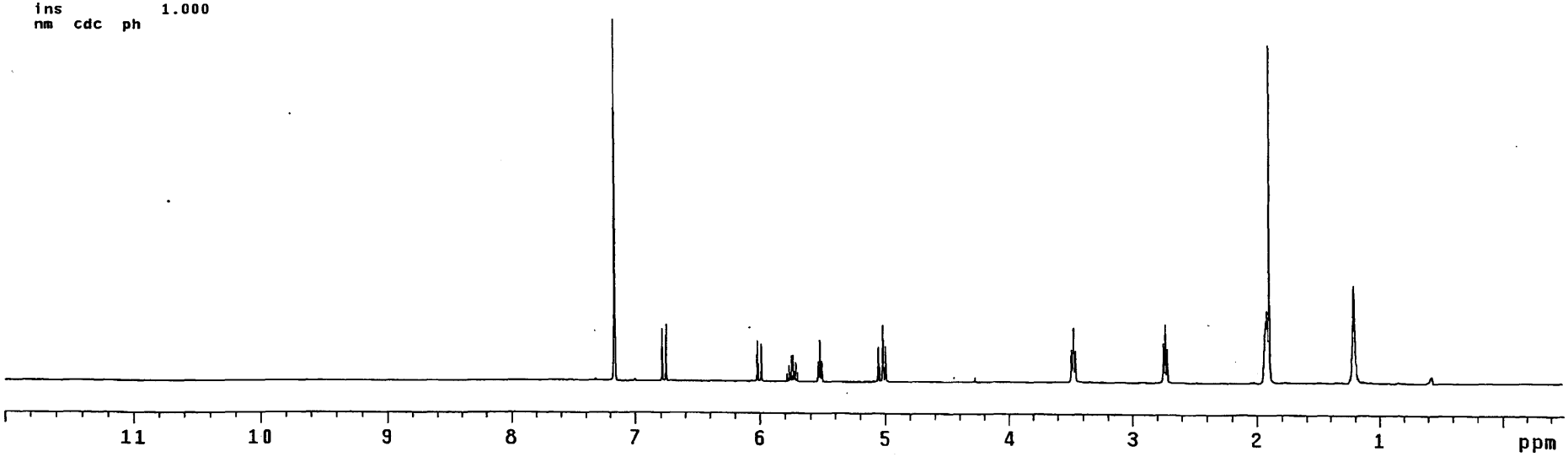

SAMPLE
solvent Benzene
ACQUISITION
sfrq 125.796
tn C13
at 1.736
np 131010
sw 37735.8
fb not used
bs 8
ss 1
tpwr 53
pw 6.9
d1 4.000
tof 631.4
nt 100000
ct 7288
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -2517.1
wp 30191.1
vs 2705
sc 0
wc 250
hzmm 120.76
is 500.00
rfl 22374.3
rfp 16151.4
th 20
ins 1.000
ai ph
DEC. & VT
dfrq 500.233
dn H1
dpwr 37
dof -500.0
dm y
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
lb 0.30
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
Me
HO
N
O
O
(±)-S3
200
180
160
140
120
100
80
60
40
20
0
ppm


Me
HO
N
O
O
(±)-S3
106.4
104
102
100
98
96
94
92
90
88
86
84
82
80
78
76
74
72
70.4
%T
4000.0
3000
2000
1500
1000
400.0
cm-1
3853.70
3421.05
2973.45
2856.91
2926.65
2340.98
2360.56
1741.14
1653.52
1636.96
1558.95
1540.47
1506.96
1483.33
1419.20
1246.98
1146.34
1036.65
967.66
909.23
760.62
668.04
475.52
467.30
455.11
412.12
417.81
435.07

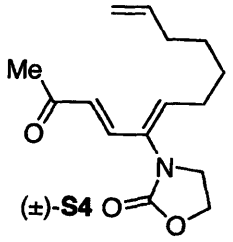


(±)-**S4**

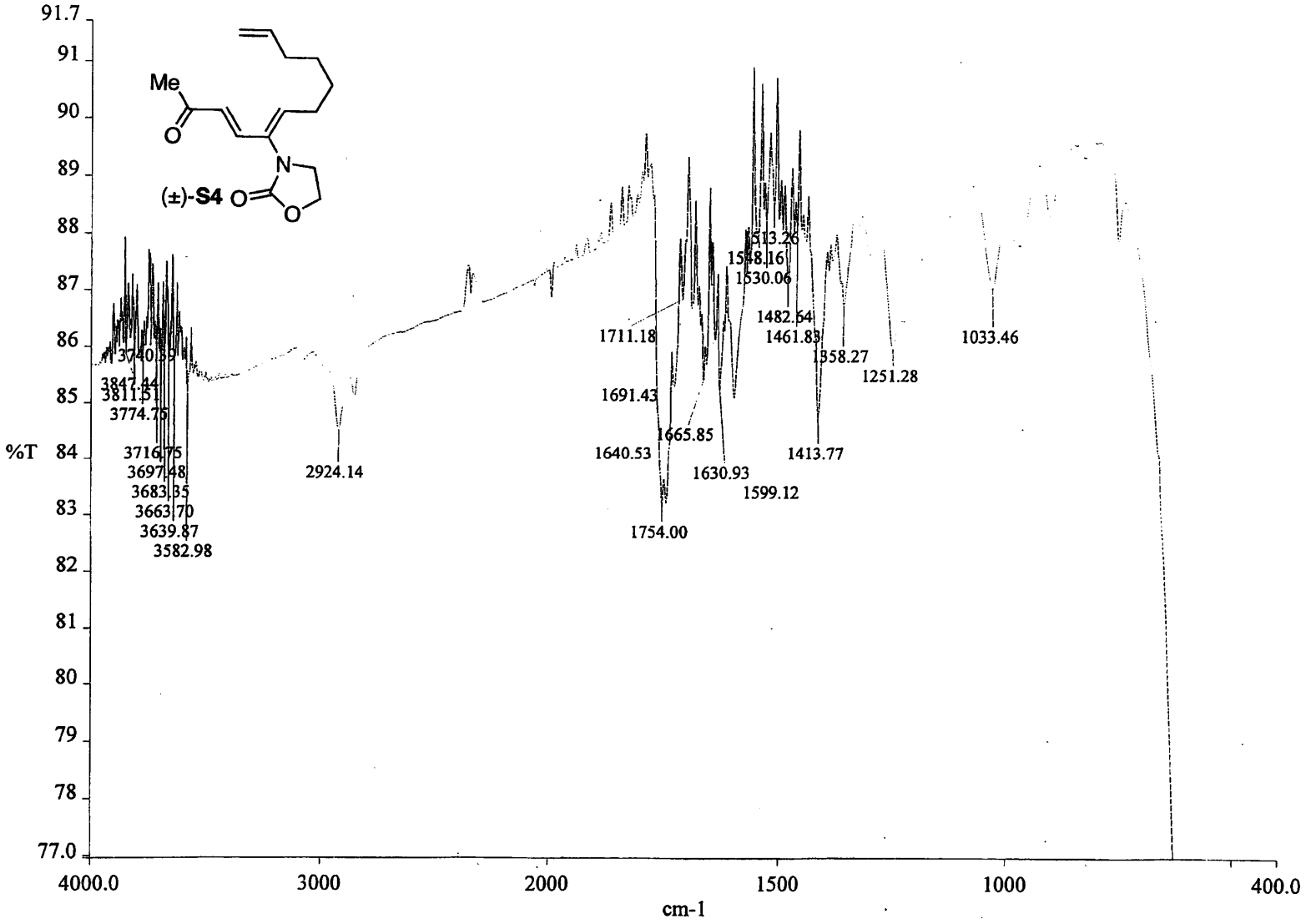
SAMPLE		DEC. & VT	
solvent	Benzene	dfrq	125.677
file	/data/movassa~	dn	C13
g/Mdh/DKH-IV-55cr_~		dpwr	34
	fid	dof	1498.1
ACQUISITION		dm	nnn
sfrq	499.757	dmm	w
tn	H1	dmf	10000
at	3.278	dseq	
np	40960	dres	1.0
sw	6248.0	homo	n
fb	not used	PROCESSING	
bs	16	wtfile	
tpwr	56	proc	ft
pw	8.2	fn	65536
d1	2.000	math	f
tof	357.8	werr	
nt	64	wexp	
ct	32	wbs	
alock	n	wnt	
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-250.7		
wp	6247.9		
vs	58		
sc	0		
wc	250		
hzmm	24.99		
is	33.57		
rfl	250.9		
rfp	0		
th	7		
ins	1.000		
nm cdc ph			

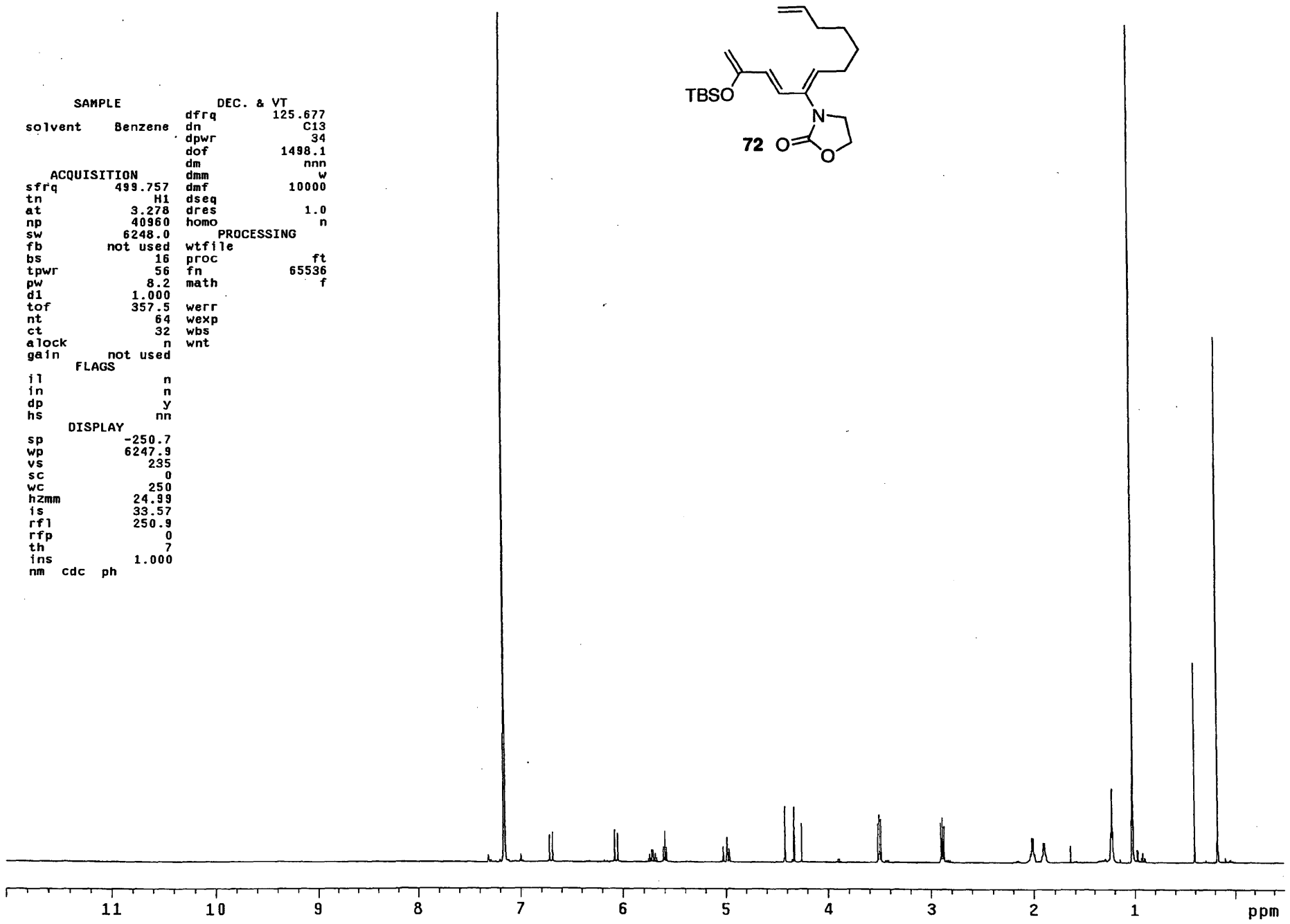


SAMPLE		DEC. & VT	
		dfrq	500.233
solvent	Benzene	dn	H1
file	/data/export/~	dpwr	37
home/movassag/Mdh/~		dof	-500.0
rocky/DKH-IV-55_ca~		dm	y
	rbon.fid	dmm	w
ACQUISITION		dmf	10000
sfrq	125.796	dseq	
tn	C13	dres	1.0
at	1.736	homo	n
np	104808	PROCESSING	
sw	30188.7	lb	0.30
fb	not used	wtfile	
bs	8	proc	ft
ss	1	fn	131072
tpwr	53	math	f
pw	6.9		
d1	2.000	werr	
tof	565.2	wexp	
nt	1e+08	wbs	
ct	12456	wnt	
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-2514.6		
wp	30188.2		
vs	25767		
sc	0		
wc	250		
hzmm	120.75		
is	500.00		
rfl	18666.4		
rfp	16151.4		
th	20		
ins	1.000		
ai	ph		



(±)-S4


(±)-S4
Me
O
N
O
O
91.7
91
90
89
88
87
86
85
84
83
82
81
80
79
78
77.0
%T
4000.0
3000
2000
1500
1000
400.0
cm-1
3740.39
3847.44
3811.51
3774.75
3716.75
3697.48
3683.35
3663.70
3639.87
3582.98
2924.14
1711.18
1691.43
1665.85
1640.53
1754.00
1630.93
1599.12
1548.16
1530.06
1513.26
1482.64
1461.83
1413.77
1358.27
1251.28
1033.46


SAMPLE
solvent Benzene
ACQUISITION
sfrq 499.757
tn H1
at 3.278
np 40960
sw 6248.0
fb not used
bs 16
tpwr 56
pw 8.2
d1 1.000
tof 357.5
nt 64
ct 32
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -250.7
wp 6247.9
vs 235
sc 0
wc 250
hzmm 24.99
is 33.57
rfl 250.9
rfp 0
th 7
ins 1.000
nm cdc ph
DEC. & VT
dfrq 125.677
dn C13
dpwr 34
dof 1498.1
dm nnn
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
wtfile
proc ft
fn 65536
math f
werr
wexp
wbs
wnt
TBSO
N
O
O
72
11
10
9
8
7
6
5
4
3
2
1
ppm

SAMPLE	
solvent	Benzene

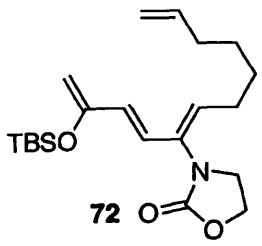
ACQUISITION	
sfrq	125.796
tn	C13
at	1.736
np	104808
sw	30188.7
fb	not used
bs	4
ss	1
tpwr	54
pw	6.9
d1	4.000
tof	565.8
nt	100000
ct	7260
alock	n
gain	not used

FLAGS	
fl	n
in	n
dp	y
hs	nn

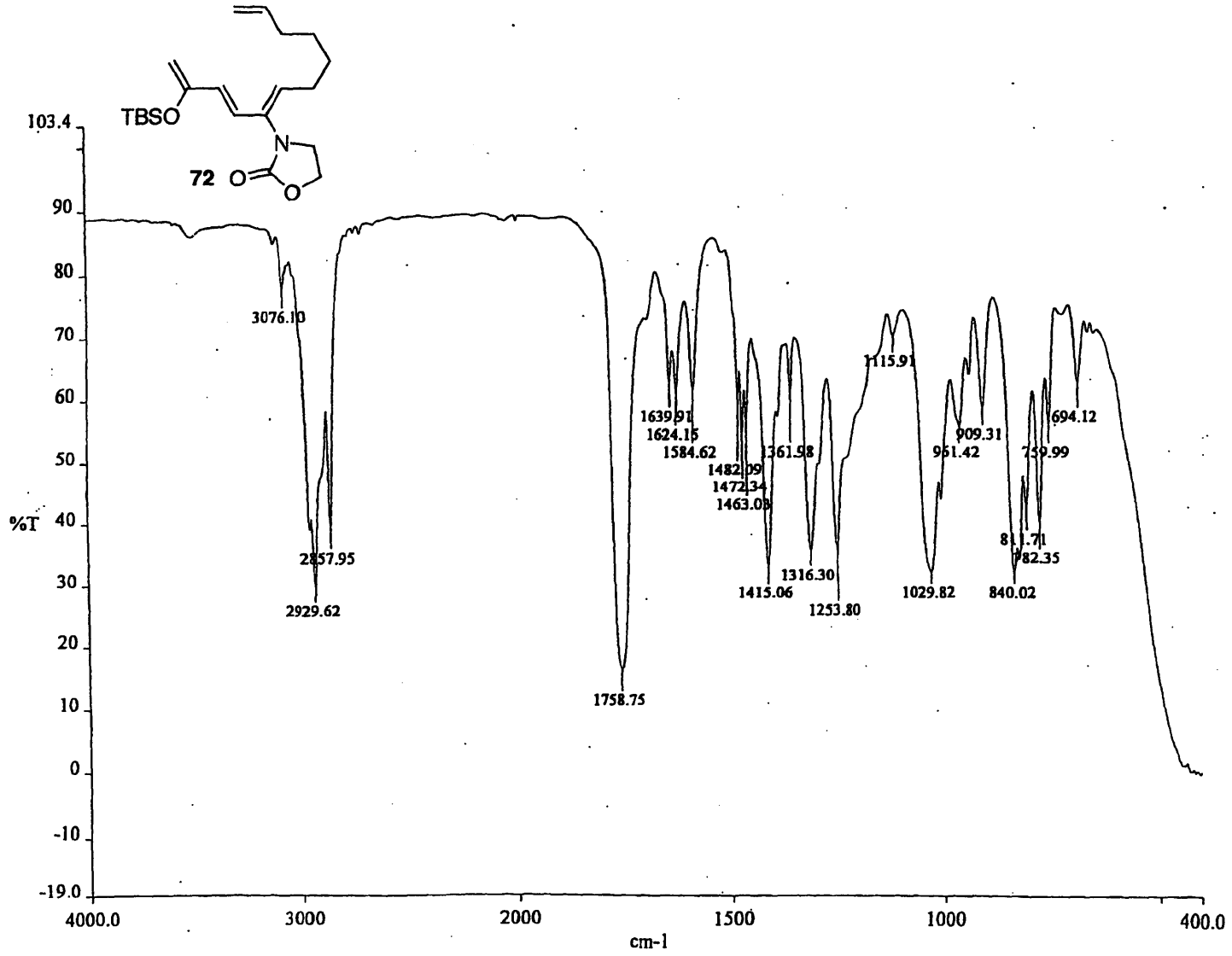
DISPLAY	
sp	-2514.6
wp	30188.2
vs	1584
sc	0
wc	250
hzmm	120.75
is	500.00
rfl	18666.4
rfp	16151.4
th	20
ins	1.000
ai	ph

DEC. & VT	
dfrq	500.233
dn	H1
dpwr	44
dof	-500.0
dm	y
dmm	w
dmf	8000
dseq	
dres	1.0
homo	n

PROCESSING	
lb	0.30
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	



72


TBSO
72
O
N
O
O
103.4
90
80
70
60
50
40
30
20
10
0
-10
-19.0
%T
3076.10
2857.95
2929.62
1758.75
1639.91
1624.15
1584.62
1482.09
1472.34
1463.03
1361.98
1415.06
1316.30
1253.80
1115.91
1029.82
961.42
909.31
840.02
759.99
694.12
4000.0
3000
2000
1500
1000
400.0
cm-1

SAMPLE	
solvent	Benzene

ACQUISITION	
sfrq	499.749
tn	H1
at	3.001
np	63050
sw	10504.2
fb	not used
bs	1
tpwr	56
pw	8.9
d1	2.000
tof	1519.5
nt	16
ct	16
alock	n
gain	not used

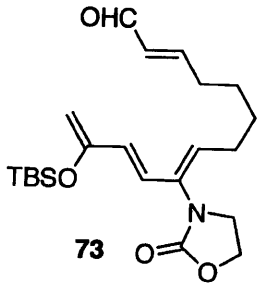
FLAGS	
il	n
in	n
dp	y
hs	nn

DISPLAY	
sp	-249.9
wp	6246.8
vs	151
sc	0
wc	250
hzmm	24.99
is	33.57
rfl	1233.8
rfp	0
th	7
ins	100.000

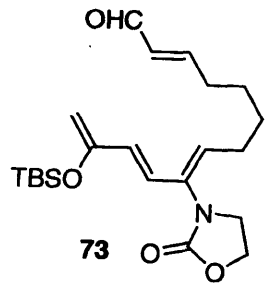
nm cdc ph

DEC. & VT	
dfrq	125.673
dn	C13
dpwr	30
dof	0
dm	nnn
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

PROCESSING	
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	wft

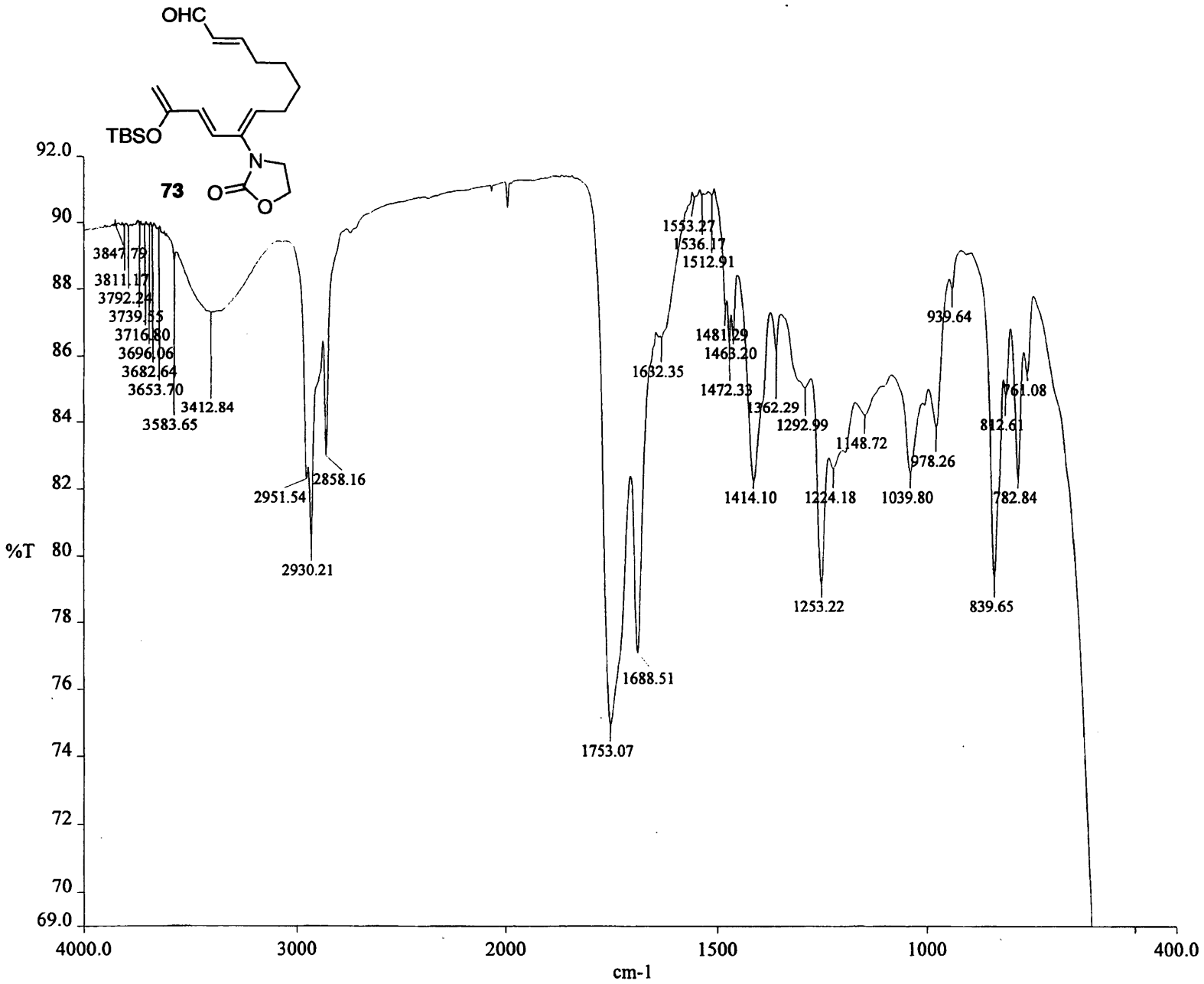


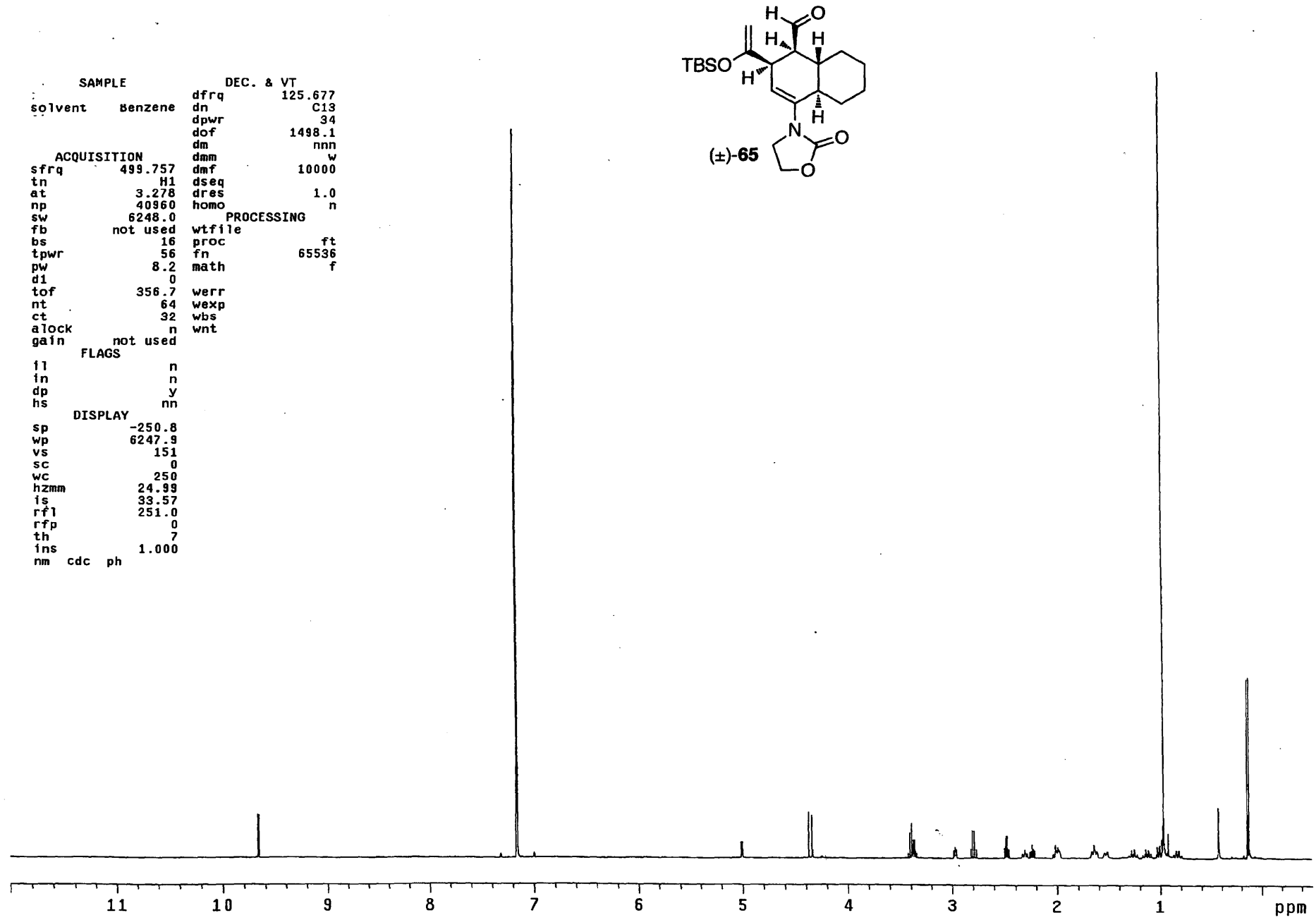
73

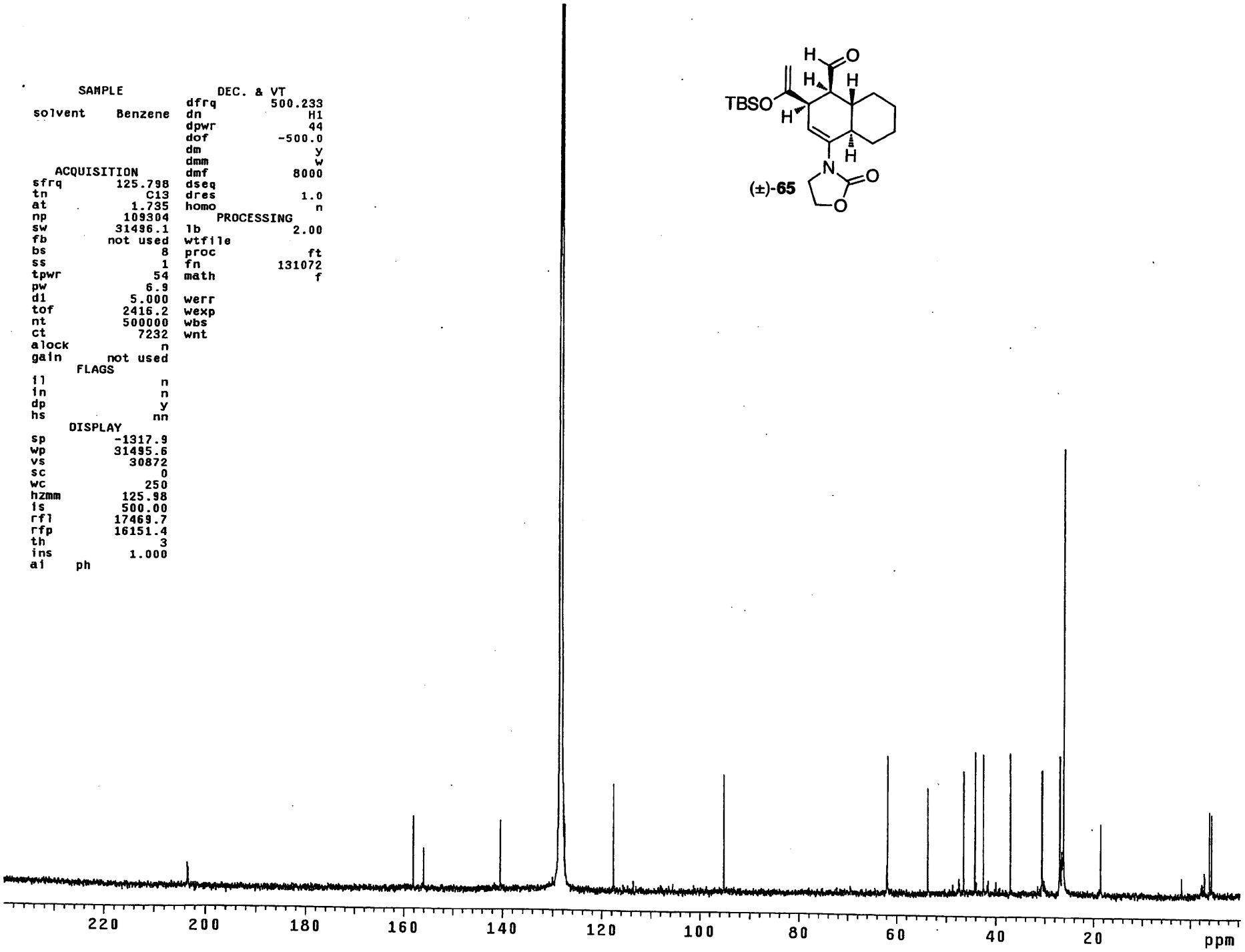


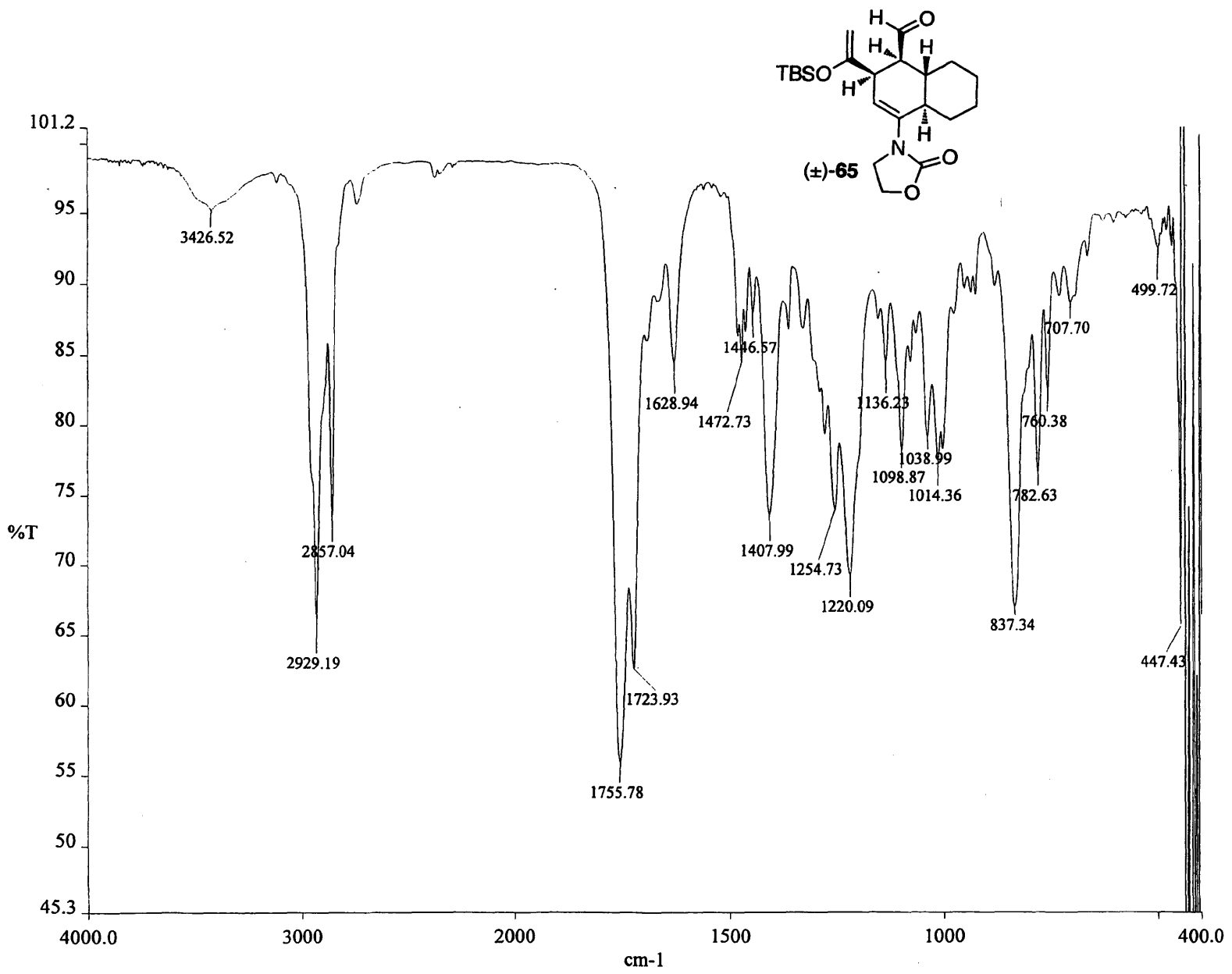
73

SAMPLE		DEC. & VT	
solvent	Benzene	dfrq	500.233
		dn	H1
		dpwr	37
		dof	-500.0
		dm	y
		dmm	w
ACQUISITION		dmf	10000
sfrq	125.797	dseq	
tn	C13	dres	1.0
at	1.736	homo	n
np	113086	PROCESSING	
sw	32573.3	lb	0.30
fb	not used	wtfile	
bs	4	proc	ft
ss	1	fn	131072
tpwr	53	math	f
pw	6.9		
d1	0.763	werr	
tof	1820.5	wexp	
nt	1e+09	wbs	
ct	18872	wnt	
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-2454.7		
wp	32572.8		
vs	191		
sc	0		
wc	250		
hzmm	130.29		
is	500.00		
rfl	15106.2		
rfp	12651.0		
th	20		
ins	128.390		
ai	ph		


OHC
TBSO
N
O
O
73
92.0
90
88
86
84
82
80
78
76
74
72
70
69.0
%T
4000.0
3000
2000
1500
1000
400.0
cm-1
3847.79
3811.17
3792.24
3739.55
3716.80
3696.06
3682.64
3653.70
3583.65
3412.84
2951.54
2930.21
2858.16
1753.07
1688.51
1632.35
1553.27
1536.17
1512.91
1481.29
1463.20
1472.33
1414.10
1362.29
1292.99
1253.22
1224.18
1148.72
1039.80
978.26
939.64
839.65
812.61
782.84
761.08


SAMPLE
solvent Benzene
ACQUISITION
sfrq 499.757
tn H1
at 3.278
np 40960
sw 6248.0
fb not used
bs 16
tpwr 56
pw 8.2
d1 0
tof 356.7
nt 64
ct 32
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -250.8
wp 6247.9
vs 151
sc 0
wc 250
hzmm 24.99
is 33.57
rfl 251.0
rfp 0
th 7
ins 1.000
nm cdc ph
DEC. & VT
dfrq 125.677
dn C13
dpwr 34
dof 1498.1
dm nnn
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
wtfile
proc ft
fn 65536
math f
werr
wexp
wbs
wnt
TBSO
H
O
N
(±)-65
11
10
9
8
7
6
5
4
3
2
1
ppm


SAMPLE
solvent Benzene
ACQUISITION
sfrq 125.798
tn C13
at 1.735
np 109304
sw 31496.1
fb not used
bs 8
ss 1
tpwr 54
pw 6.9
d1 5.000
tof 2416.2
nt 500000
ct 7232
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -1317.9
wp 31495.6
vs 30872
sc 0
wc 250
hzmm 125.98
is 500.00
rfl 17469.7
rfp 16151.4
th 3
ins 1.000
ai ph
DEC. & VT
dfrq 500.233
dn H1
dpwr 44
dof -500.0
dm y
dmm w
dmf 8000
dseq
dres 1.0
homo n
PROCESSING
lb 2.00
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
TBSO
(±)-65
220
200
180
160
140
120
100
80
60
40
20
ppm


TBSO
(±)-65
%T
cm-1
101.2
95
90
85
80
75
70
65
60
55
50
45.3
4000.0
3000
2000
1500
1000
400.0
3426.52
2857.04
2929.19
1755.78
1723.93
1628.94
1472.73
1446.57
1407.99
1254.73
1220.09
1136.23
1098.87
1038.99
1014.36
837.34
782.63
760.38
707.70
499.72
447.43

SAMPLE	
solvent	CDCl3

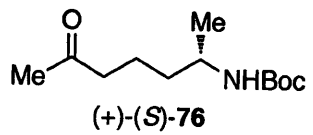
ACQUISITION	
sfrq	499.749
tn	H1
at	3.277
np	65536
sw	9998.8
fb	not used
bs	1
tpwr	56
pw	8.2
d1	0
tof	1498.1
nt	16
ct	16
alock	n
gain	not used

FLAGS	
il	n
in	n
dp	y
hs	nn

DISPLAY	
sp	-250.0
wp	6246.8
vs	151
sc	0
wc	250
hzmm	24.99
is	33.57
rfl	4638.1
rfp	3633.1
th	7
ins	1.000
nm	cdc ph

DEC. & VT	
dfrq	125.674
dn	C13
dpwr	34
dof	1498.1
dm	nnn
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

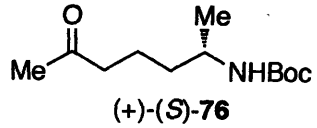
PROCESSING	
wtfile	
proc	ft
fn	65536
math	f
werr	
wexp	
wbs	
wnt	



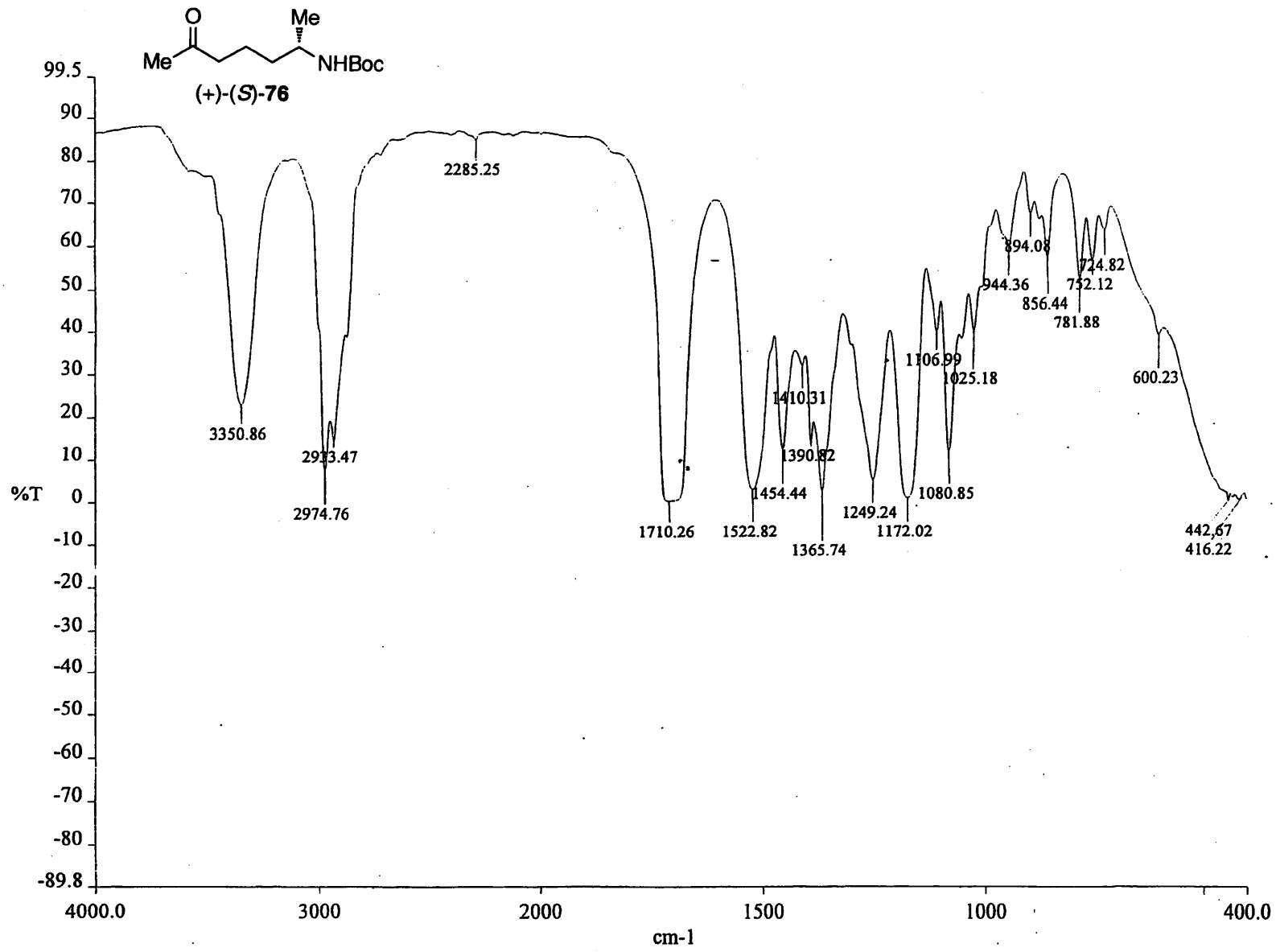
(+)-(*S*)-**76**

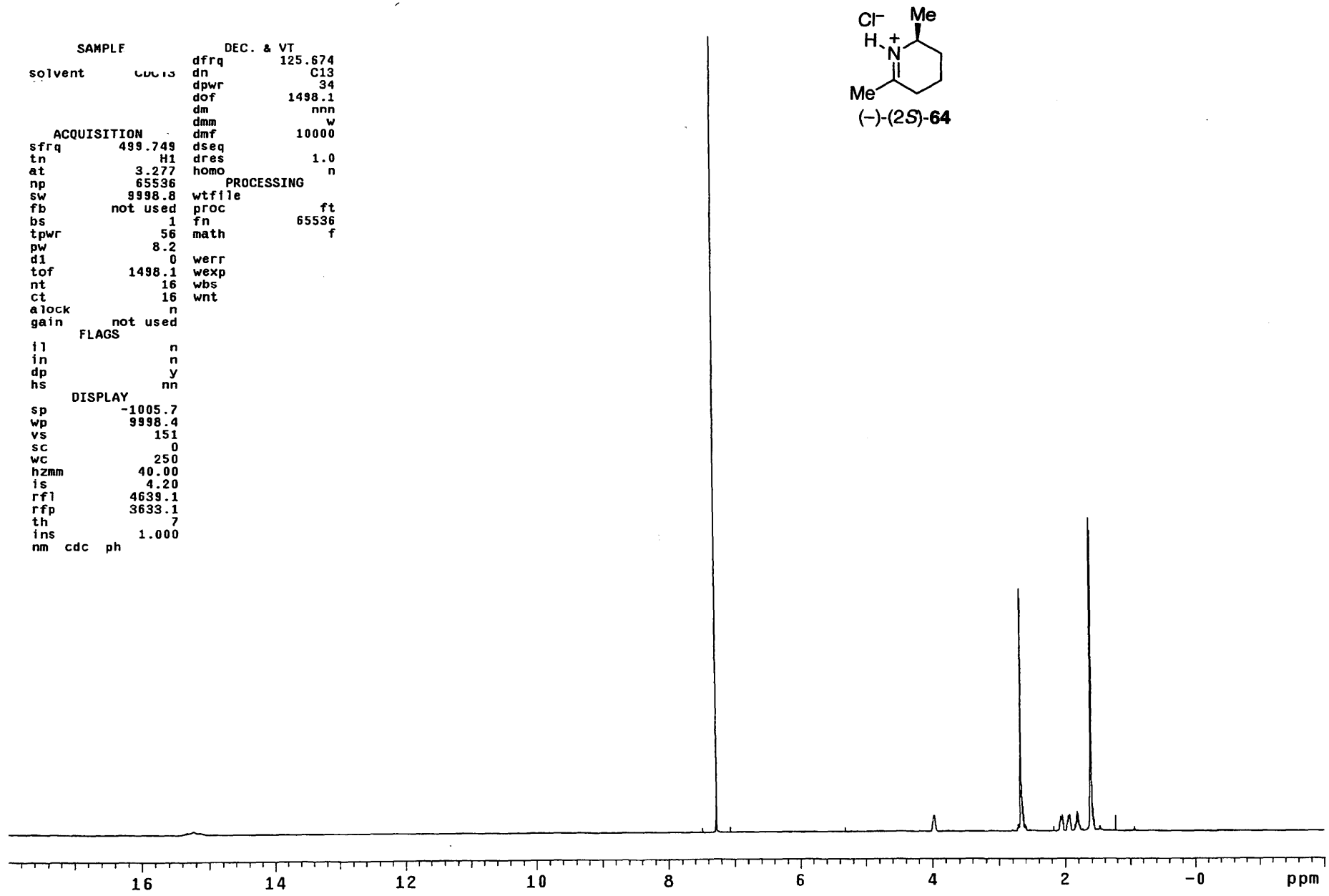
SAMPLE	
solvent	CDCl3
file	exp
ACQUISITION	
sfrq	125.676
tn	C13
at	3.000
np	226304
sw	37718.1
fb	not used
bs	16
ss	1
tpwr	58
pw	7.5
d1	3.000
tof	615.5
nt	3500
ct	1712
alock	n
gain	not used
FLAGS	
il	n
in	n
dp	y
hs	nn
DISPLAY	
sp	-2513.8
wp	32672.3
vs	1230
sc	0
wc	250
hzmm	130.69
is	500.00
rfl	16013.3
rfp	9705.0
th	3
ins	1.000
ai cdc ph	

DEC. & VT	
dfrq	499.756
dn	H1
dpwr	34
dof	0
dm	yyy
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n
DEC2	
dfrq2	0
dn2	
dpwr2	1
dof2	0
dm2	n
dmm2	c
dmf2	10000
dseq2	
dres2	1.0
homo2	n
DEC3	
dfrq3	0
dn3	
dpwr3	1
dof3	0
dm3	n
dmm3	c
dmf3	10000
dseq3	
dres3	1.0
homo3	n
PROCESSING	
lb	1.00
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	

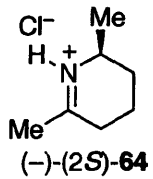


(+)-(*S*)-**76**

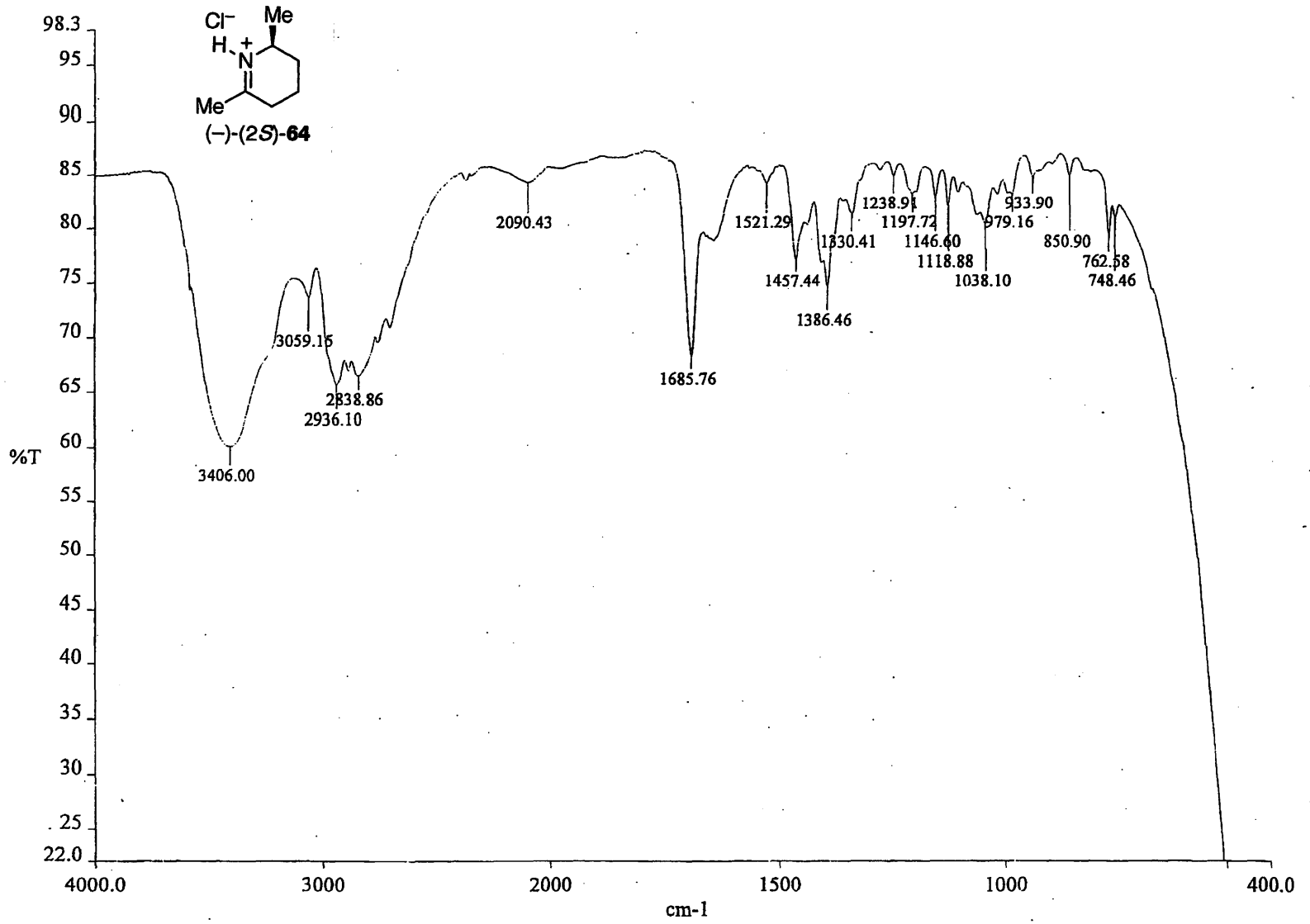

O
Me
Me
NHBoc
(+)-(S)-76
99.5
90
80
70
60
50
40
30
20
10
%T 0
-10
-20
-30
-40
-50
-60
-70
-80
-89.8
4000.0
3000
2000
1500
1000
400.0
cm-1
3350.86
2973.47
2974.76
2285.25
1710.26
1522.82
1454.44
1410.31
1390.82
1365.74
1249.24
1172.02
1106.99
1080.85
1025.18
944.36
894.08
856.44
781.88
752.12
724.82
600.23
442.67
416.22


SAMPLE
solvent CDCl3
ACQUISITION
sfrq 499.749
tn H1
at 3.277
np 65536
sw 9998.8
fb not used
bs 1
tpwr 56
pw 8.2
d1 0
tof 1498.1
nt 16
ct 16
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -1005.7
wp 9998.4
vs 151
sc 0
wc 250
hzmm 40.00
is 4.20
rfl 4639.1
rfp 3633.1
th 7
ins 1.000
nm cdc ph
DEC. & VT
dfrq 125.674
dn C13
dpwr 34
dof 1498.1
dm nnn
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
wtfile
proc ft
fn 65536
math f
werr
wexp
wbs
wnt
Cl⁻
H
N
Me
Me
(–)-(2S)-64
16
14
12
10
8
6
4
2
-0
ppm

SAMPLE		DEC. & VT	
solvent	CDCl3	dfrq	500.233
file	exp	dn	H1
ACQUISITION		dpwr	37
sfrq	125.796	dof	-500.0
tn	C13	dm	y
at	1.736	dmm	w
np	131010	dmf	10000
sw	37735.8	dseq	
fb	not used	dres	1.0
bs	8	homo	n
ss	1	PROCESSING	
tpwr	53	lb	0.30
pw	6.9	wtfile	
d1	0.763	proc	ft
tof	631.4	fn	131072
nt	10000	math	f
ct	10000		
alock	n	werr	
gain	not used	wexp	
FLAGS		wbs	
il	n	wnt	
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-2516.4		
wp	32706.1		
vs	15554		
sc	0		
wc	250		
hzmm	130.82		
is	500.00		
rfl	16005.9		
rfp	9715.0		
th	4		
ins	1.000		
ai	ph		

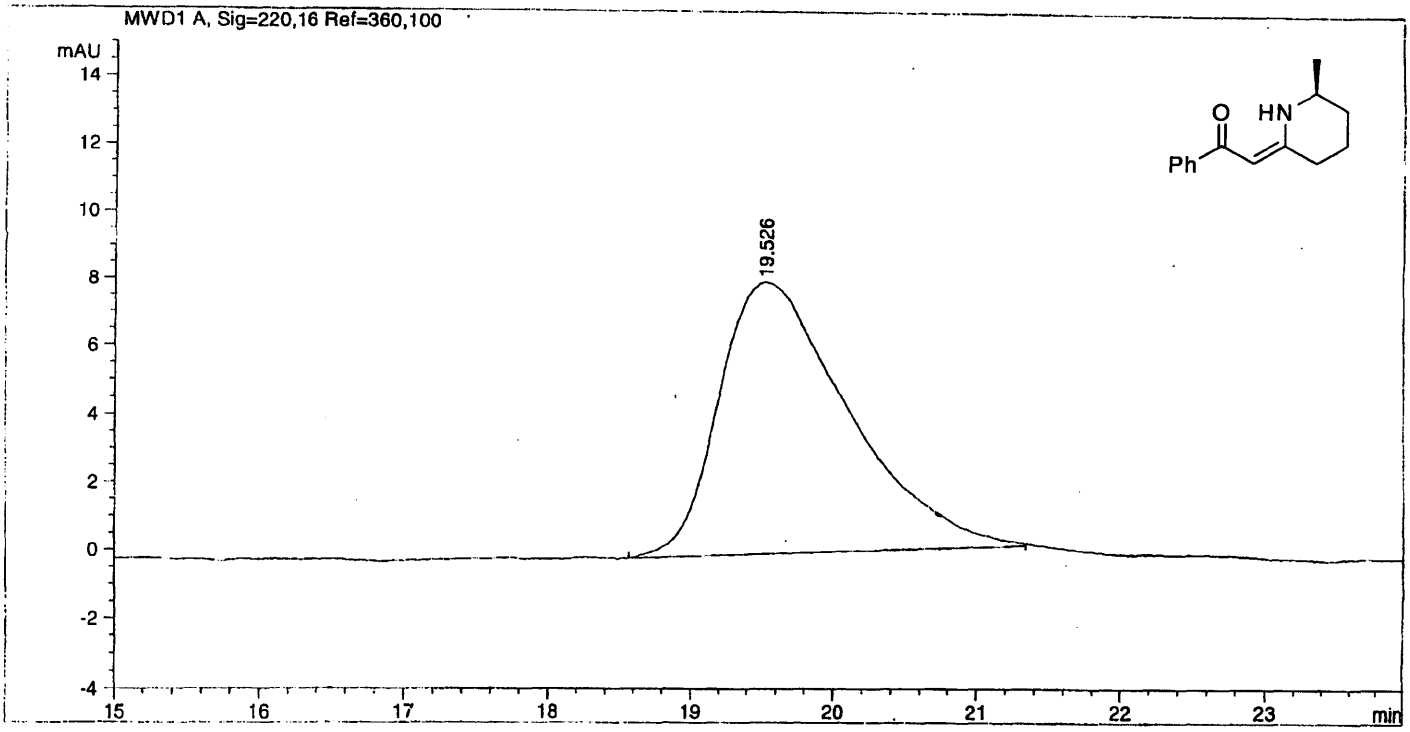


(–)-(2*S*)-**64**


Cl⁻
H
N
+
Me
Me
(–)-(2S)-64
98.3
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
22.0
%T
4000.0
3000
2000
1500
1000
400.0
cm-1
3406.00
3059.15
2936.10
2838.86
2090.43
1685.76
1521.29
1457.44
1386.46
1330.41
1238.91
1197.72
1146.60
1118.88
1038.10
979.16
933.90
850.90
762.58
748.46

```
Injection Date   :                                  Seq. Line :   1
Sample Name      :                                   Location : Vial 51
Acq. Operator    :                                        Inj :   1
                                                  Inj Volume : 1 µl
Acq. Method      :
Last changed     :
Analysis Method  :
Last changed     :
```

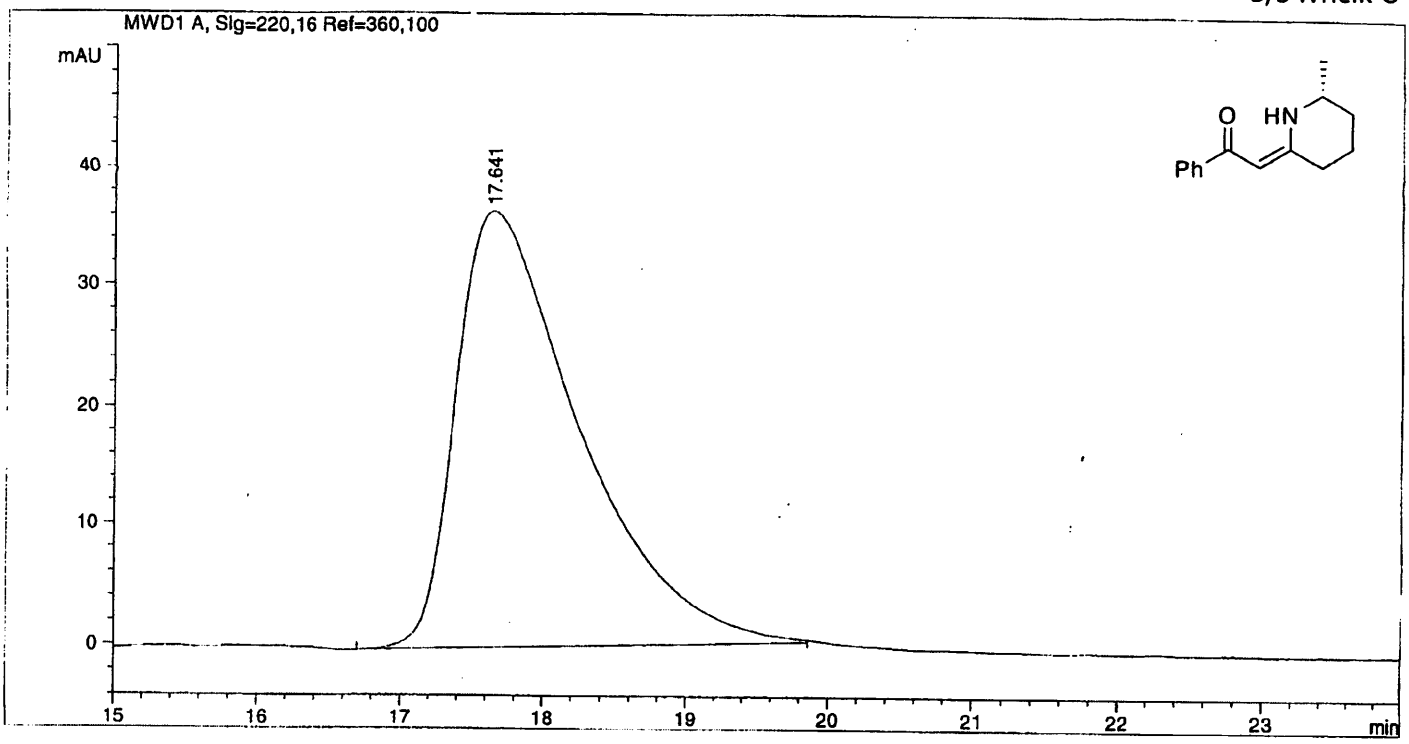
S, S Whelk-O




```
                          Area Percent Report

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: MWD1 A, Sig=220,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]       %
----|-------|----|-------|----------|----------|--------|
   1  19.526 PB    0.7477  504.22922    8.01823 100.0000

Totals :                   504.22922    8.01823

 Results obtained with enhanced integrator!

                          *** End of Report ***
```

```
==========================================================================
Injection Date  :                                   Seq. Line :   1
Sample Name     :                                    Location : Vial 51
Acq. Operator   :                                         Inj :   1
                                                  Inj Volume : 1 µl
Acq. Method     :
Last changed    :

Analysis Method :
Last changed    :
```

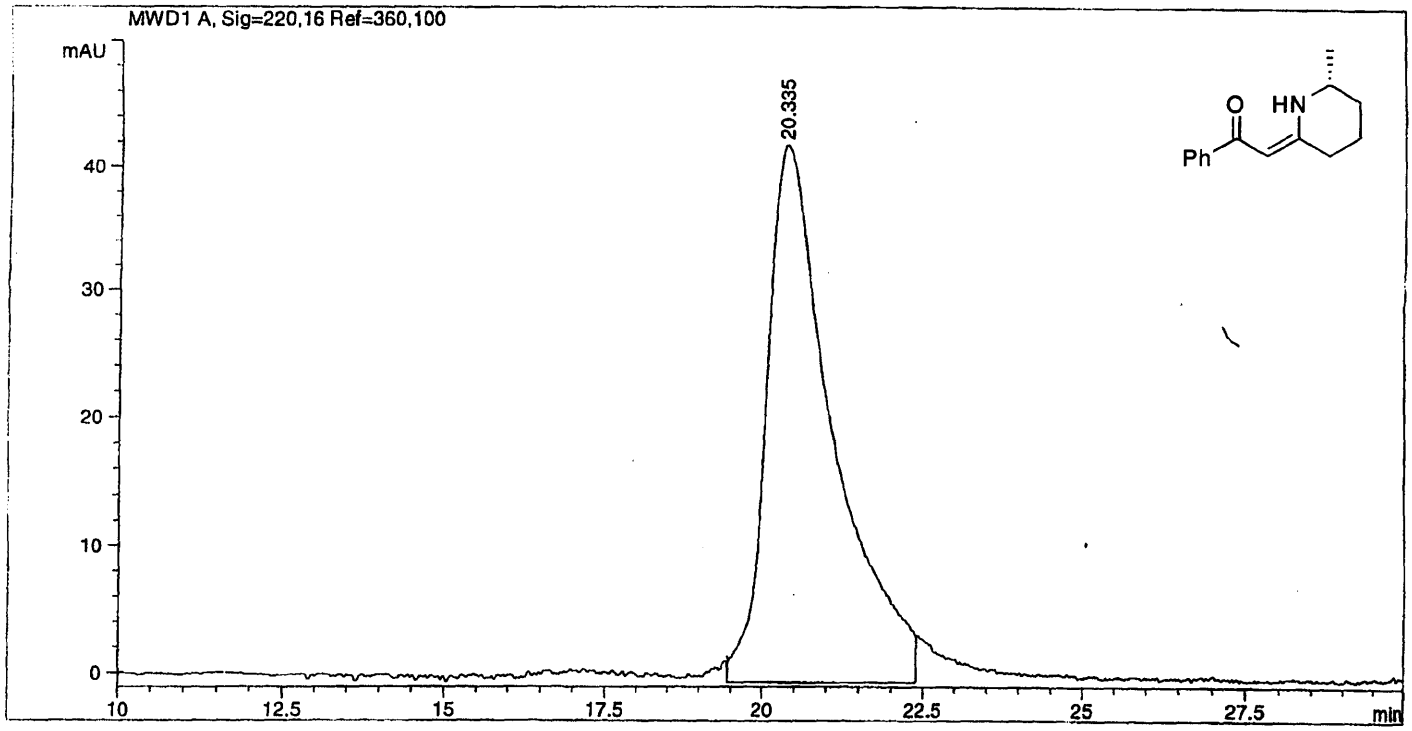
S, S Whelk-O




```
==========================================================================
                        Area Percent Report
==========================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: MWD1 A, Sig=220,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]       [min]    [mAU*s]    [mAU]       %
----|-------|----|-------|----------|----------|--------|
   1  17.641 PB    0.8517 2181.38892   36.47622 100.0000

Totals :                  2181.38892   36.47622

 Results obtained with enhanced integrator!
==========================================================================
                        *** End of Report ***
```

```
==========================================================================
Injection Date   :                                  Seq. Line :   1
Sample Name      :                                   Location : Vial 51
Acq. Operator    :                                        Inj :   1
                                                  Inj Volume : 1 µl
Acq. Method      :
Last changed     :
Analysis Method  :
Last changed     :
```

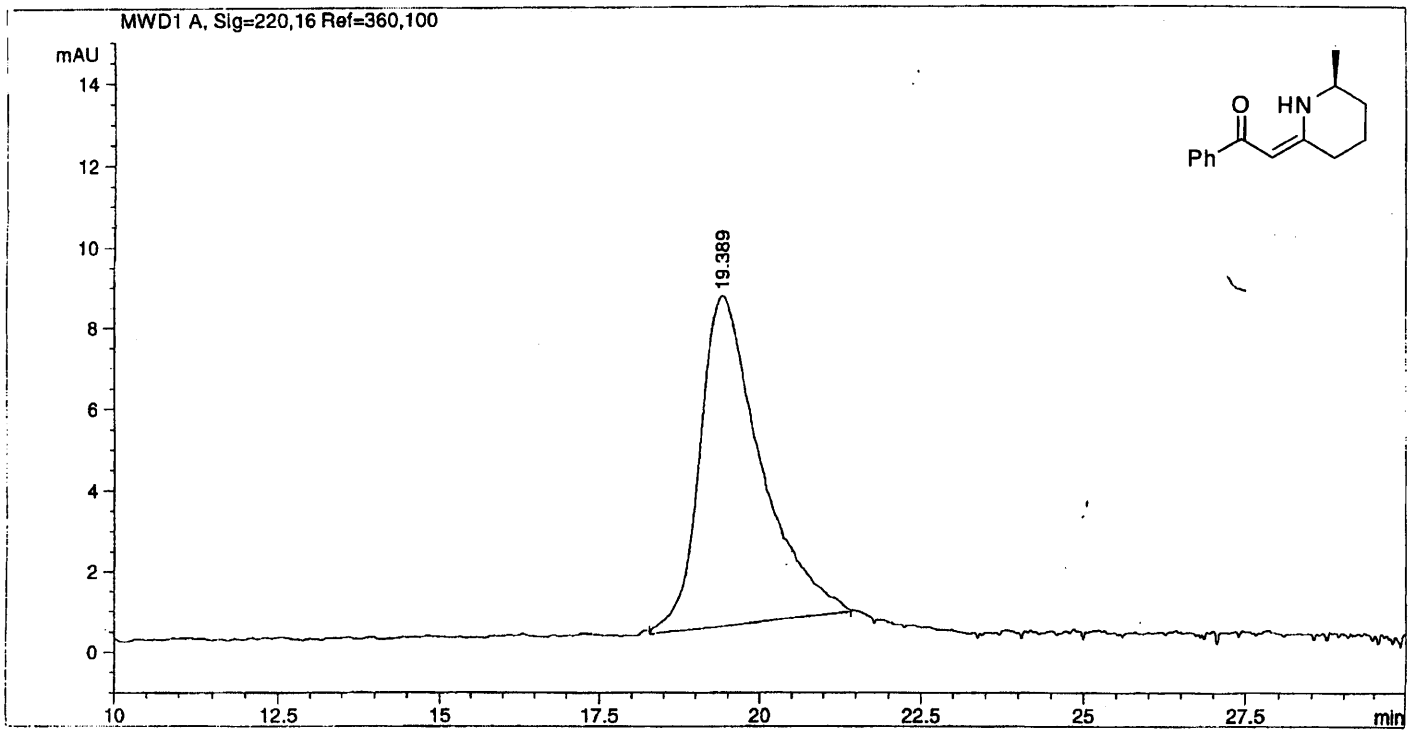
R, R Whelk-O




```
==========================================================================
                          Area Percent Report
==========================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: MWD1 A, Sig=220,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]       %
----|-------|----|-------|----------|----------|--------|
   1  20.335 VV    0.8630 3016.49365   42.44931 100.0000

Totals :                  3016.49365   42.44931

 Results obtained with enhanced integrator!
==========================================================================
                          *** End of Report ***
```

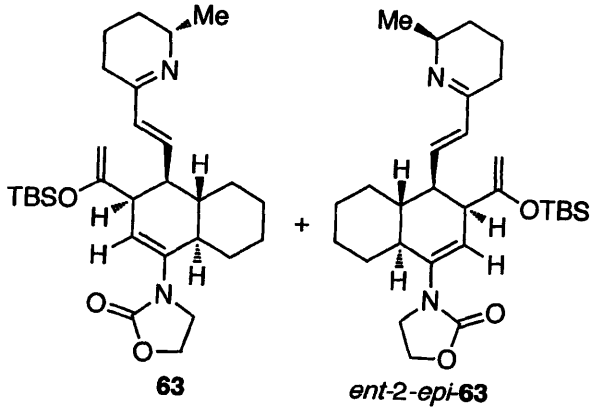
```
==========================================================================
Injection Date  :                                  Seq. Line :   1
Sample Name     :                                   Location : Vial 51
Acq. Operator   :                                        Inj :   1
                                                  Inj Volume : 1 µl
Acq. Method     :
Last changed    :
Analysis Method :
Last changed    :
```

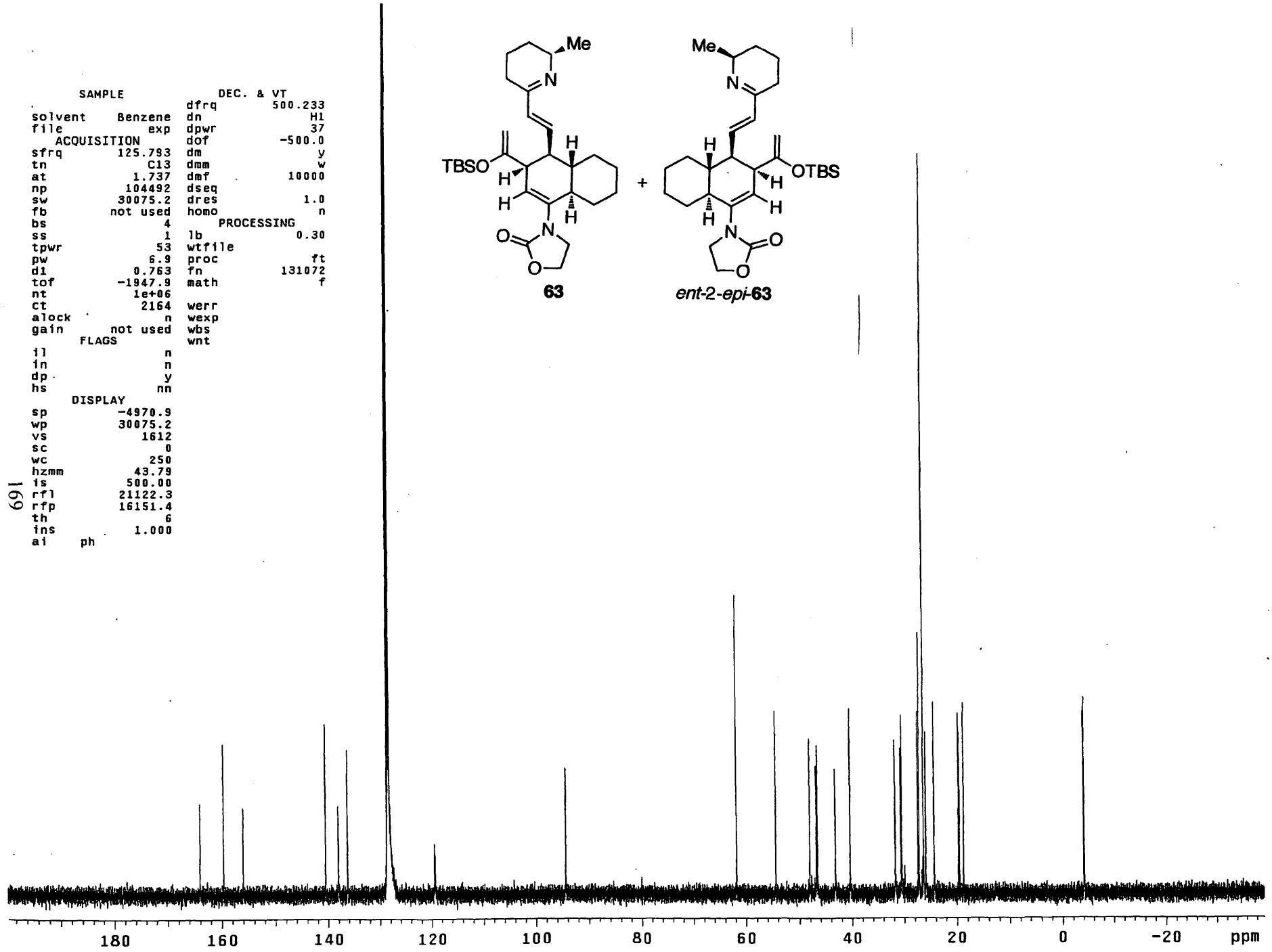
R, R Whelk-O

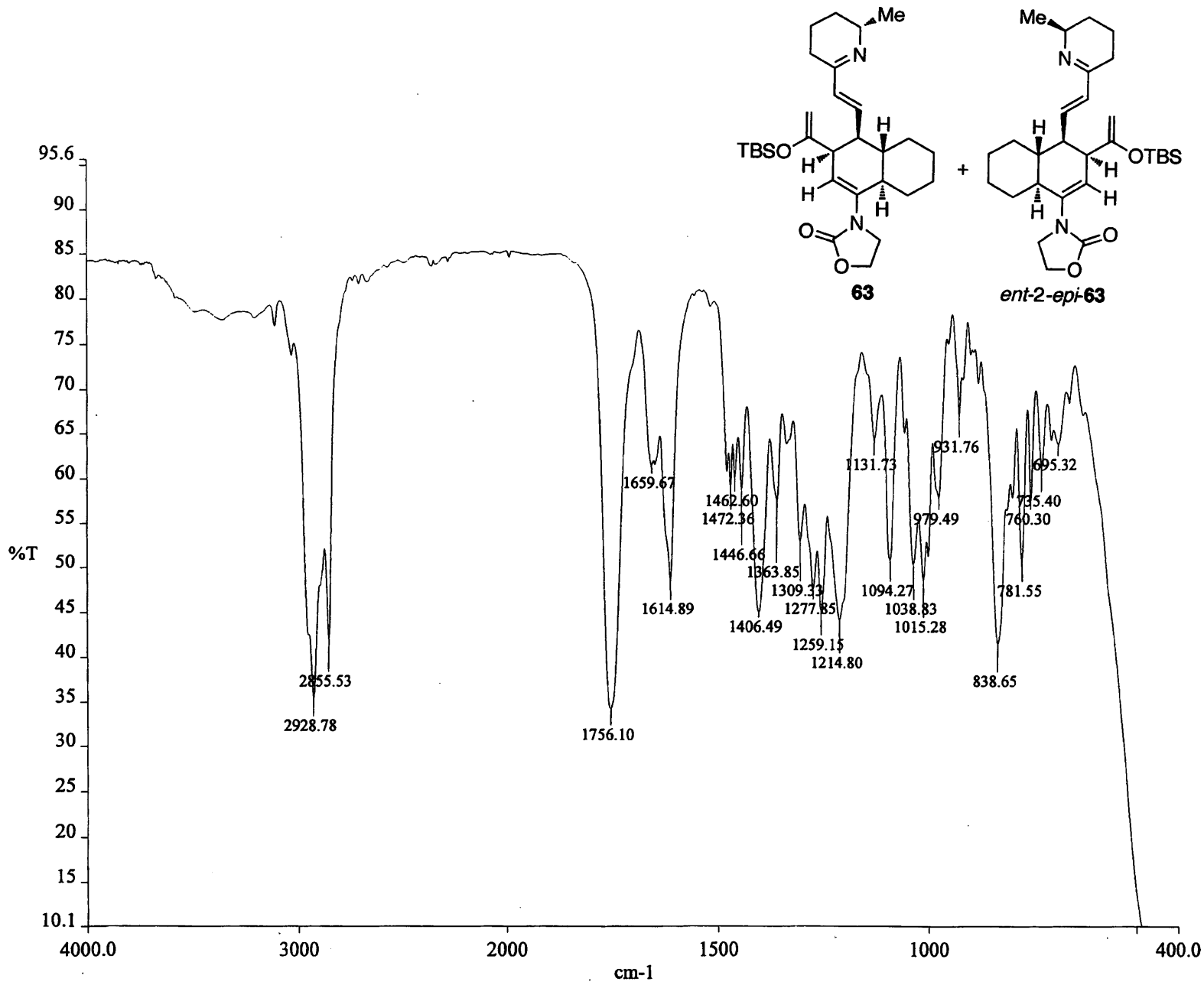


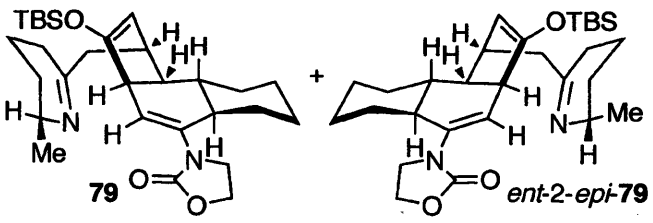

```
==========================================================================
                          Area Percent Report
==========================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: MWD1 A, Sig=220,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]       %
----|-------|----|-------|----------|----------|--------|
   1  19.389 VB    0.8069  537.40503    8.15439 100.0000

Totals :                   537.40503    8.15439

 Results obtained with enhanced integrator!
==========================================================================
                          *** End of Report ***
```

SAMPLE		DEC. & VT	
solvent	benzene	dfrq	125.674
		dn	C13
		dpwr	34
		dof	1498.1
		dm	nnn
ACQUISITION		dmm	w
sfrq	499.749	dmf	10000
tn	H1	dseq	
at	3.277	dres	1.0
np	65536	homo	n
sw	9998.8	DEC2	
fb	not used	dfrq2	0
bs	1	dn2	
tpwr	56	dpwr2	1
pw	8.2	dof2	0
d1	0	dm2	n
tof	1498.1	dmm2	c
nt	16	dmf2	200
ct	16	dseq2	
alock	n	dres2	1.0
gain	not used	homo2	n
FLAGS		DEC3	
il	n	dfrq3	0
in	n	dn3	
dp	y	dpwr3	1
hs	nn	dof3	0
DISPLAY		dm3	n
sp	-250.1	dmm3	c
wp	6246.7	dmf3	200
vs	151	dseq3	
sc	0	dres3	1.0
wc	250	homo3	n
hzmm	24.99	PROCESSING	
is	33.57	wtfile	
rfl	1002.6	proc	ft
rfp	0	fn	65536
th	7	math	f
ins	1.000		
nm cdc ph		werr	
		wexp	
		wbs	
		wnt	

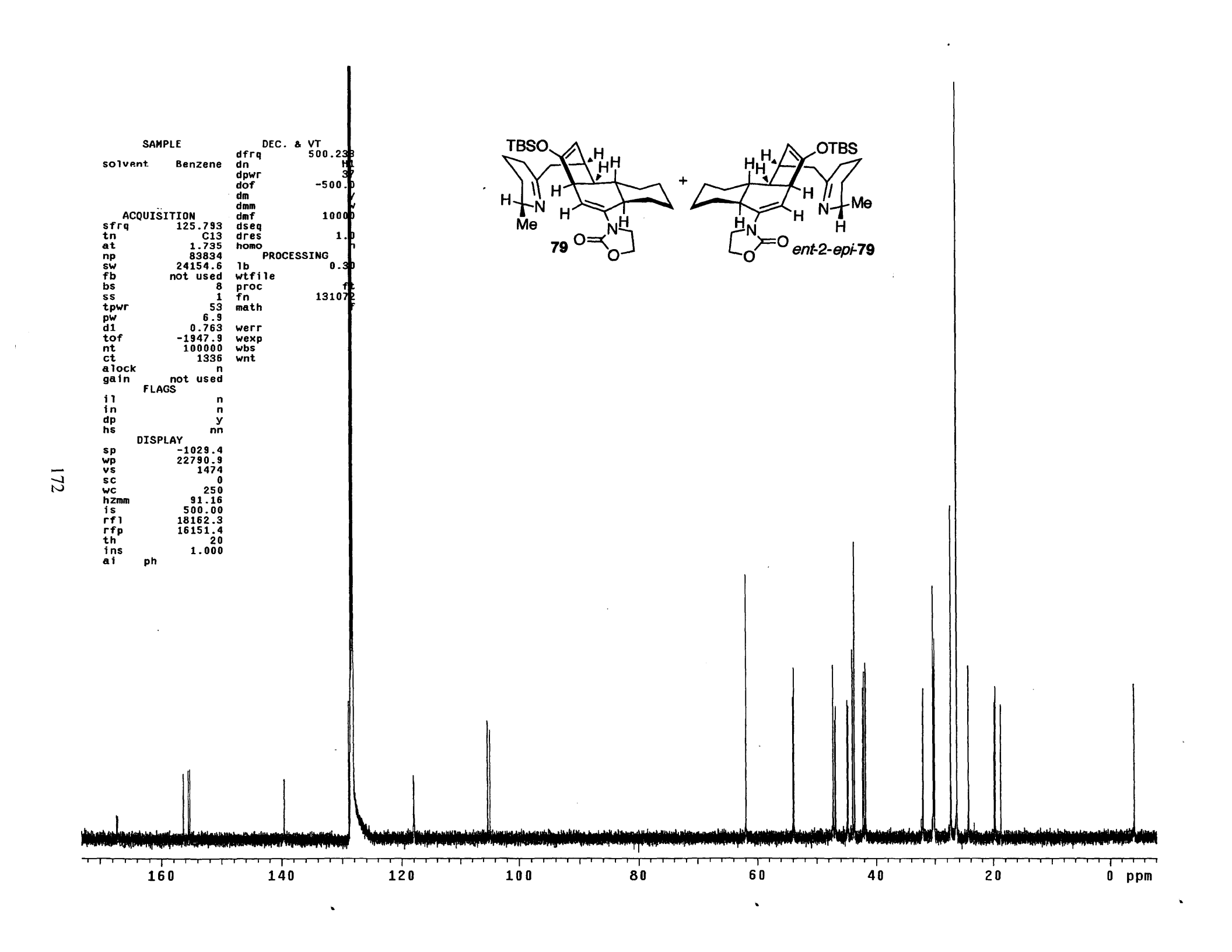


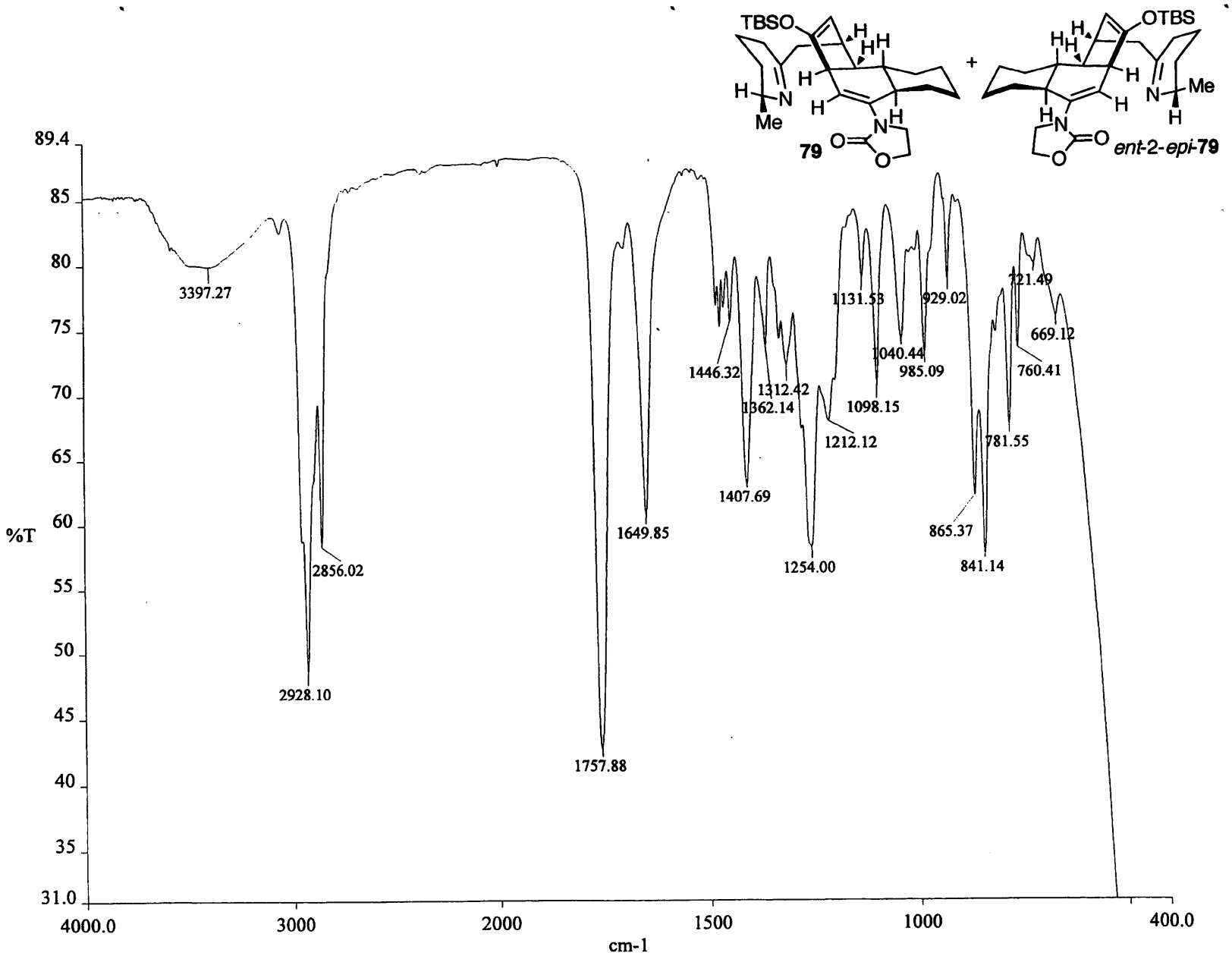

SAMPLE
solvent Benzene
file exp
ACQUISITION
sfrq 125.793
tn C13
at 1.737
np 104492
sw 30075.2
fb not used
bs 4
ss 1
tpwr 53
pw 6.9
d1 0.763
tof -1947.9
nt 1e+06
ct 2164
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -4970.9
wp 30075.2
vs 1612
sc 0
wc 250
hzmm 43.79
is 500.00
rfl 21122.3
rfp 16151.4
th 6
ins 1.000
ai ph
DEC. & VT
dfrq 500.233
dn H1
dpwr 37
dof -500.0
dm y
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
lb 0.30
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
Me
N
TBSO
H
O
OTBS
63
ent-2-epi-63
180
160
140
120
100
80
60
40
20
0
-20
ppm


Me
N
TBSO
H
H
H
N
O
O
63
+
Me
N
H
H
OTBS
H
H
N
O
O
ent-2-epi-63
95.6
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10.1
%T
2928.78
2855.53
1756.10
1659.67
1614.89
1462.60
1472.36
1446.66
1406.49
1363.85
1309.33
1277.85
1259.15
1214.80
1131.73
1094.27
1038.83
1015.28
979.49
931.76
838.65
781.55
760.30
735.40
695.32
4000.0
3000
2000
1500
1000
400.0
cm-1



SAMPLE		DEC. & VT	
solvent	Benzene	dfrq	125.673
		dn	C13
		dpwr	30
		dof	0
		dm	nnn
		dmm	w
ACQUISITION		dmf	10000
sfrq	499.748	dseq	
tn	H1	dres	1.0
at	3.001	homo	n
np	37494	PROCESSING	
sw	6247.6	wtfile	
fb	not used	proc	ft
bs	4	fn	131072
tpwr	56	math	f
pw	8.9		
d1	2.000	werr	
tof	359.2	wexp	
nt	128	wbs	
ct	32	wnt	wft
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-250.3		
wp	6247.5		
vs	165		
sc	0		
wc	250		
hzmm	24.99		
is	33.57		
rfl	250.4		
rfp	0		
th	7		
ins	100.000		
nm cdc ph			


SAMPLE
solvent Benzene
ACQUISITION
sfrq 125.793
tn C13
at 1.735
np 83834
sw 24154.6
fb not used
bs 8
ss 1
tpwr 53
pw 6.9
d1 0.763
tof -1947.9
nt 100000
ct 1336
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -1029.4
wp 22790.9
vs 1474
sc 0
wc 250
hzmm 91.16
is 500.00
rfl 18162.3
rfp 16151.4
th 20
ins 1.000
ai ph
DEC. & VT
dfrq 500.238
dn H1
dpwr 37
dof -500.0
dm y
dmm
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
lb 0.30
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
TBSO
OTBS
Me
79
ent-2-epi-79
160
140
120
100
80
60
40
20
0 ppm


TBSO
H
H
H
H
H
N
Me
H
N
H
O
O
79
+
OTBS
H
H
H
H
H
N
Me
H
N
H
O
O
ent-2-epi-79
89.4
85
80
75
70
65
60
55
50
45
40
35
31.0
%T
3397.27
2928.10
2856.02
1757.88
1649.85
1446.32
1407.69
1362.14
1312.42
1254.00
1212.12
1131.53
1098.15
1040.44
985.09
929.02
865.37
841.14
781.55
760.41
721.49
669.12
4000.0
3000
2000
1500
1000
400.0
cm-1

SAMPLE	
solvent	Benzene

ACQUISITION	
sfrq	499.748
tn	H1
at	3.001
np	37494
sw	6247.6
fb	not used
bs	4
tpwr	56
pw	8.9
d1	2.000
tof	358.6
nt	128
ct	24
alock	n
gain	not used

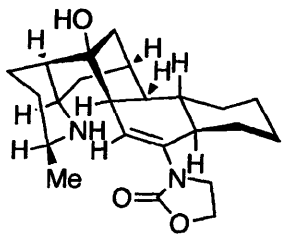
FLAGS	
il	n
in	n
dp	y
hs	nn

DISPLAY	
sp	-250.4
wp	6247.5
vs	186
sc	0
wc	250
hzmm	24.99
is	33.57
rfl	250.4
rfp	0
th	7
ins	1.000

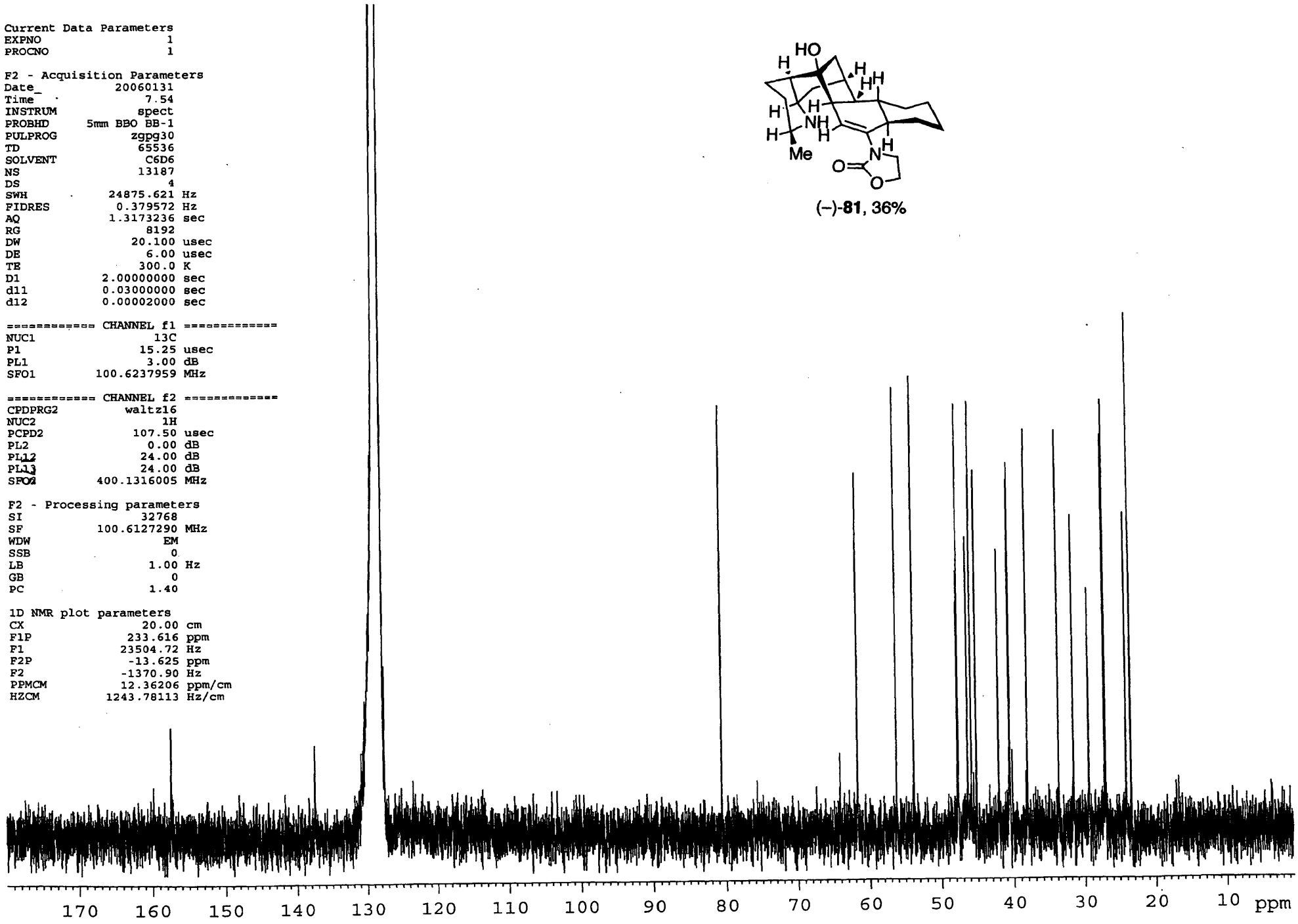
nm cdc ph

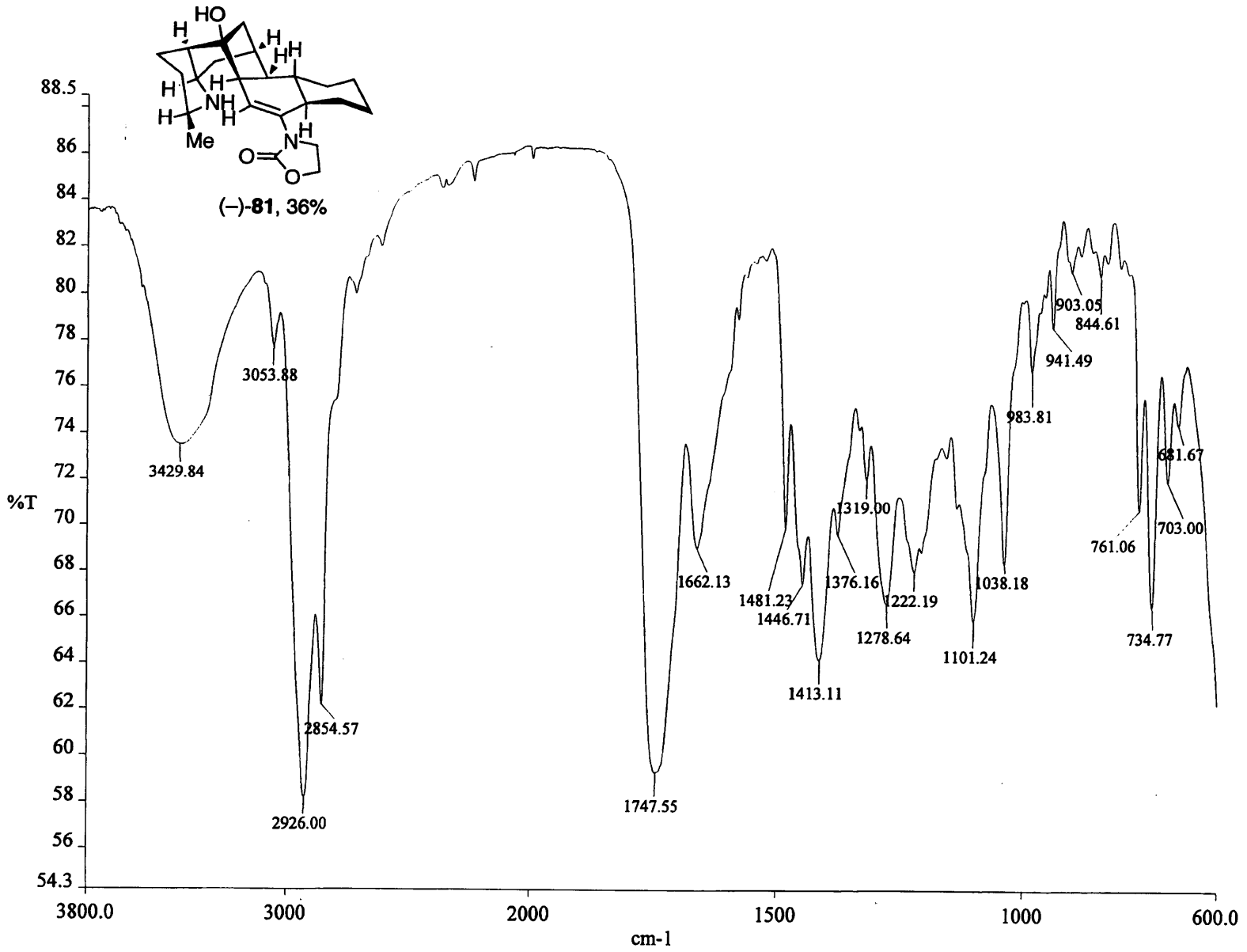
DEC. & VT	
dfrq	125.673
dn	C13
dpwr	30
dof	0
dm	nnn
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

PROCESSING	
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	wft



(–)-**81**, 36%


Current Data Parameters
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20060131
Time 7.54
INSTRUM spect
PROBHD 5mm BBO BB-1
PULPROG zgpg30
TD 65536
SOLVENT C6D6
NS 13187
DS 4
SWH 24875.621 Hz
FIDRES 0.379572 Hz
AQ 1.3173236 sec
RG 8192
DW 20.100 usec
DE 6.00 usec
TE 300.0 K
D1 2.00000000 sec
d11 0.03000000 sec
d12 0.00002000 sec
========== CHANNEL f1 ==========
NUC1 13C
P1 15.25 usec
PL1 3.00 dB
SFO1 100.6237959 MHz
========== CHANNEL f2 ==========
CPDPRG2 waltz16
NUC2 1H
PCPD2 107.50 usec
PL2 0.00 dB
PL12 24.00 dB
PL13 24.00 dB
SFO2 400.1316005 MHz
F2 - Processing parameters
SI 32768
SF 100.6127290 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
CX 20.00 cm
F1P 233.616 ppm
F1 23504.72 Hz
F2P -13.625 ppm
F2 -1370.90 Hz
PPMCM 12.36206 ppm/cm
HZCM 1243.78113 Hz/cm
HO
H
H
H
H
H
H
NH
H
H
Me
N
O
O
(–)-81, 36%
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


(–)-81, 36%
%T
cm-1
3429.84
3053.88
2926.00
2854.57
1747.55
1662.13
1481.23
1446.71
1413.11
1376.16
1319.00
1278.64
1222.19
1101.24
1038.18
983.81
941.49
903.05
844.61
761.06
734.77
703.00
681.67

SAMPLE	
solvent	Benzene

ACQUISITION	
sfrq	499.748
tn	H1
at	3.001
np	37494
sw	6247.6
fb	not used
bs	4
tpwr	56
pw	8.9
d1	2.000
tof	358.6
nt	128
ct	32
alock	n
gain	not used

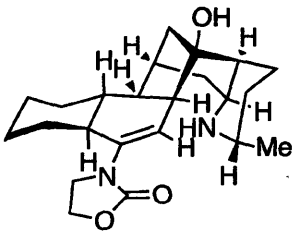
FLAGS	
il	n
in	n
dp	y
hs	nn

DISPLAY	
sp	-250.4
wp	6247.5
vs	350
sc	0
wc	250
hzmm	24.99
is	33.57
rfl	250.4
rfp	0
th	7
ins	1.000

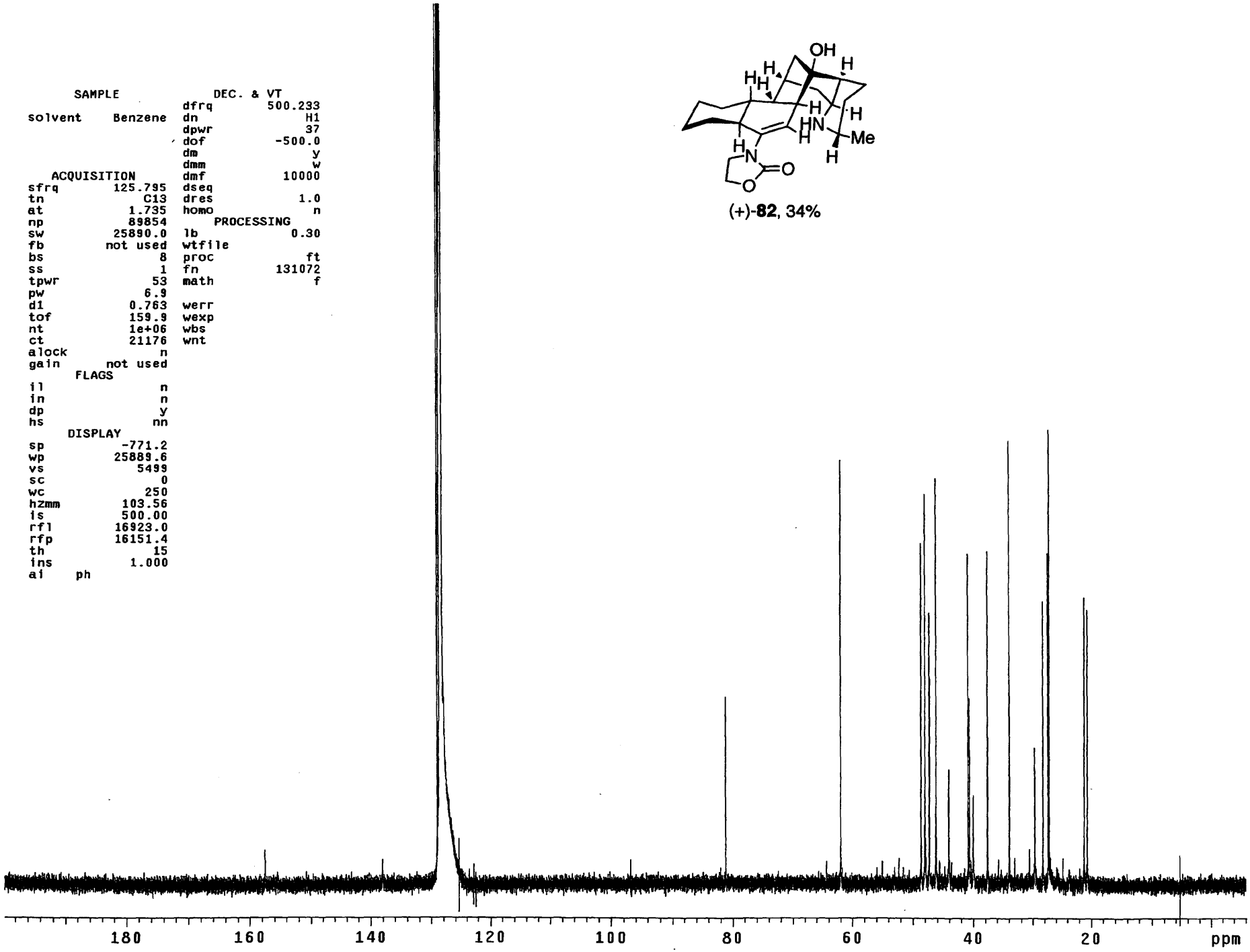
nm cdc ph

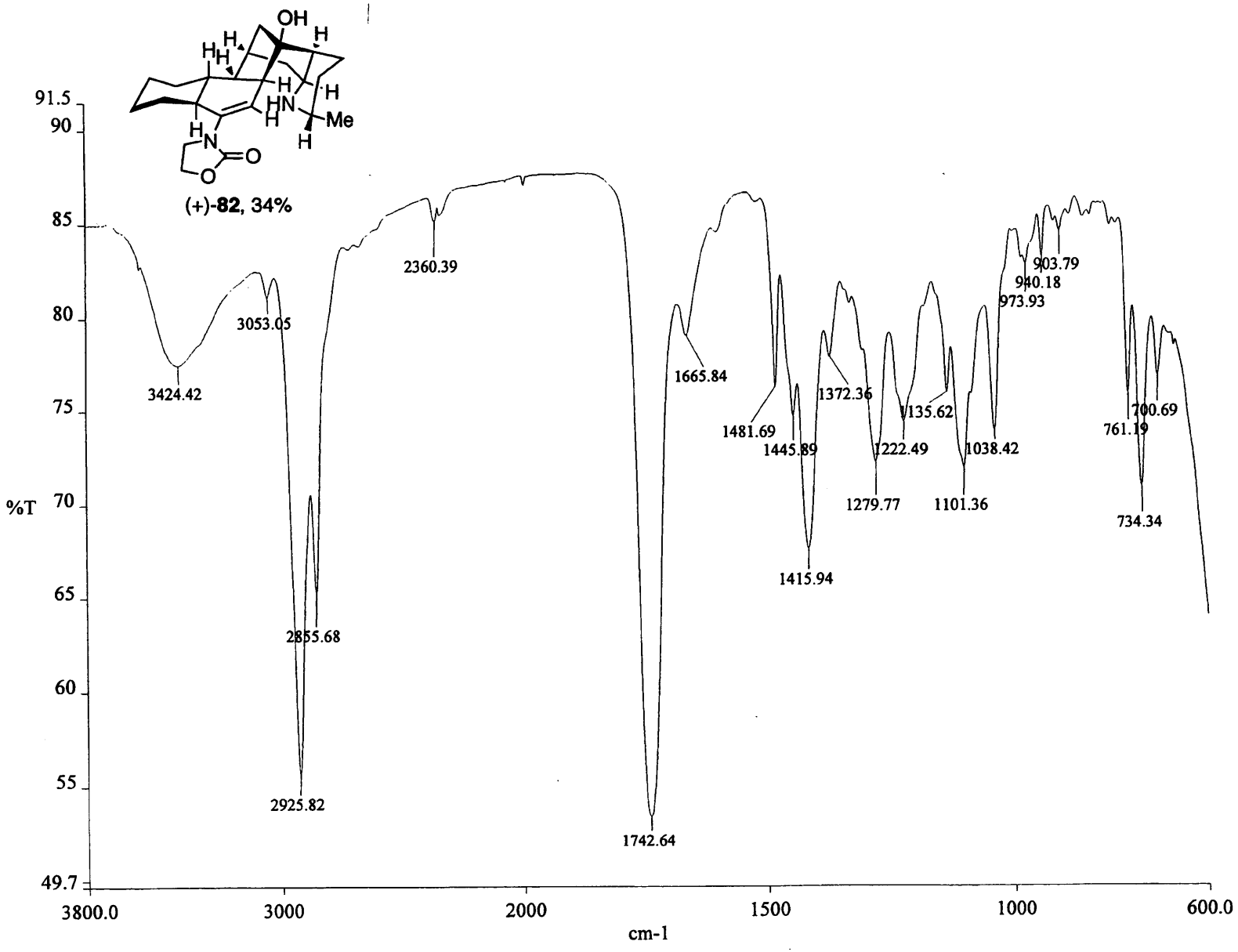
DEC. & VT	
dfrq	125.673
dn	C13
dpwr	30
dof	0
dm	nnn
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

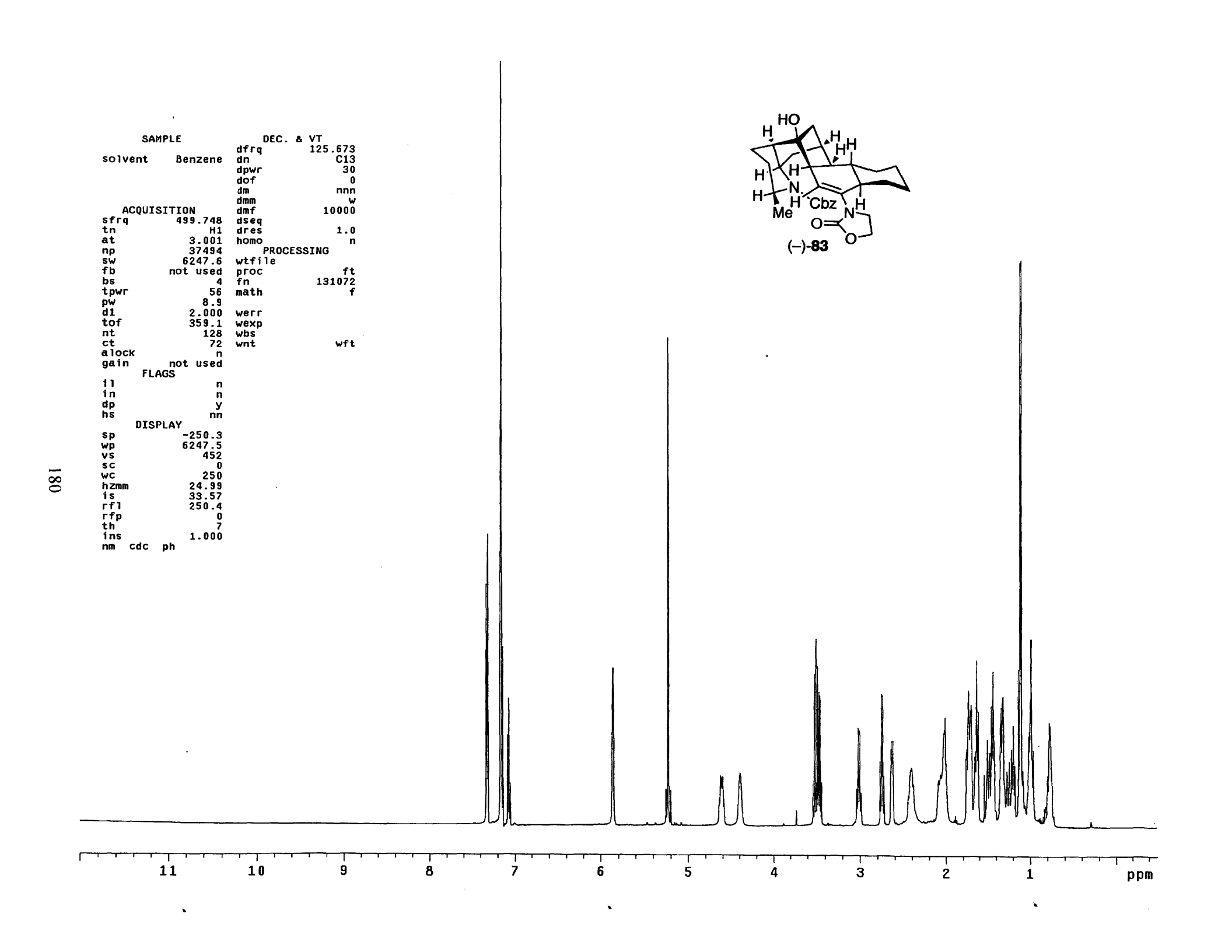
PROCESSING	
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	wft

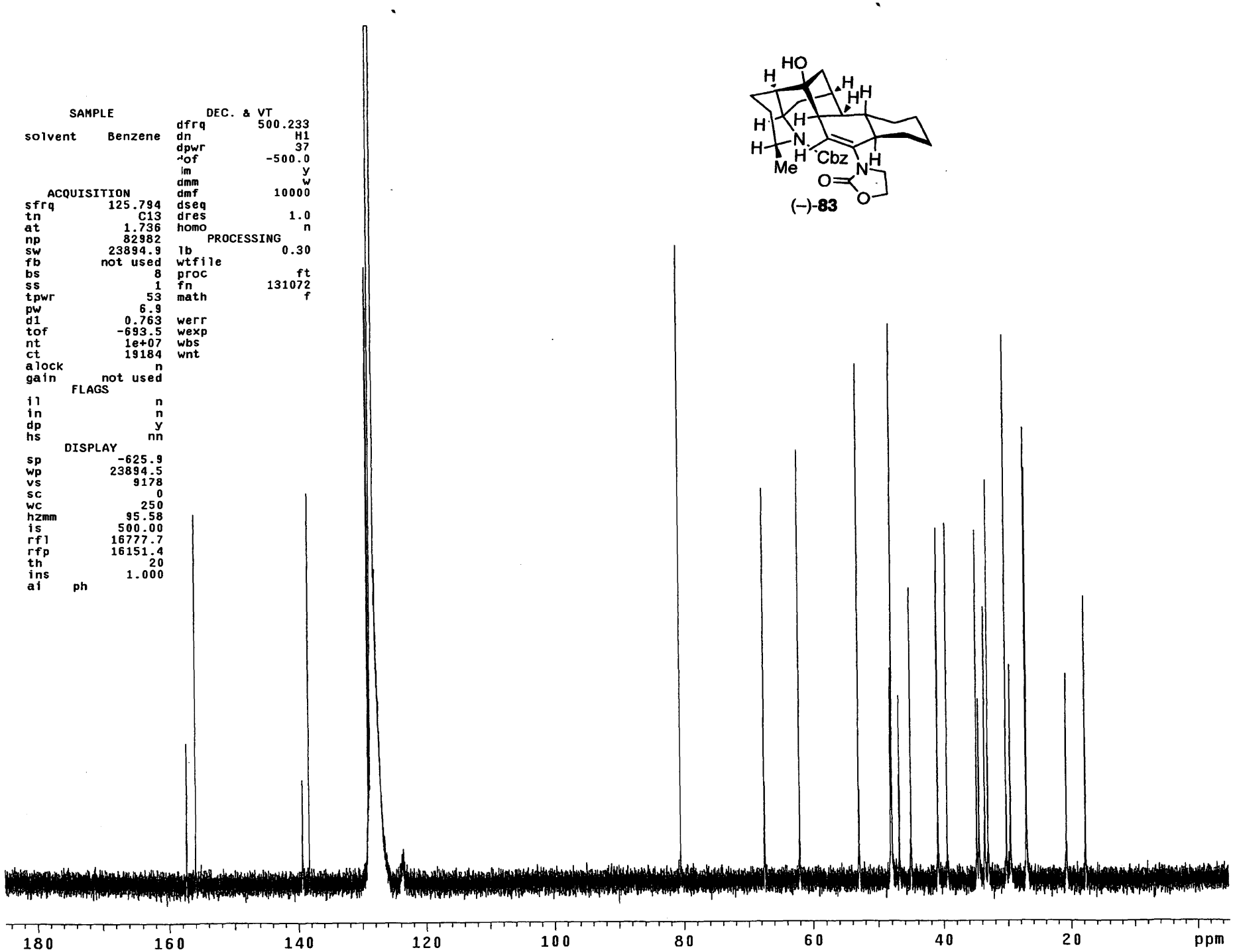


(+)-**82**, 34%


SAMPLE
solvent Benzene
ACQUISITION
sfrq 125.795
tn C13
at 1.735
np 89854
sw 25890.0
fb not used
bs 8
ss 1
tpwr 53
pw 6.9
d1 0.763
tof 159.9
nt 1e+06
ct 21176
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -771.2
wp 25889.6
vs 5499
sc 0
wc 250
hzmm 103.56
is 500.00
rfl 16923.0
rfp 16151.4
th 15
ins 1.000
ai ph
DEC. & VT
dfrq 500.233
dn H1
dpwr 37
dof -500.0
dm y
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
lb 0.30
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
OH
H
HN
Me
O
(+)-82, 34%
180
160
140
120
100
80
60
40
20
ppm


(+)-82, 34%
%T
cm-1
91.5
90
85
80
75
70
65
60
55
49.7
3800.0
3000
2000
1500
1000
600.0
3424.42
3053.05
2925.82
2855.68
2360.39
1742.64
1665.84
1481.69
1445.89
1415.94
1372.36
1279.77
1222.49
1135.62
1101.36
1038.42
973.93
940.18
903.79
761.19
734.34
700.69

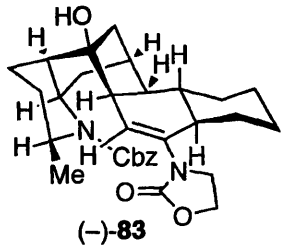

SAMPLE
solvent Benzene
ACQUISITION
sfrq 499.748
tn H1
at 3.001
np 37494
sw 6247.6
fb not used
bs 4
tpwr 56
pw 8.9
d1 2.000
tof 359.1
nt 128
ct 72
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -250.3
wp 6247.5
vs 452
sc 0
wc 250
hzmm 24.99
is 33.57
rfl 250.4
rfp 0
th 7
ins 1.000
nm cdc ph
DEC. & VT
dfrq 125.673
dn C13
dpwr 30
dof 0
dm nnn
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt wft
HO
H
H
H
H
H
H
N
H
Me
Cbz
N
H
O
O
(–)-83
11
10
9
8
7
6
5
4
3
2
1
ppm


SAMPLE
solvent Benzene
ACQUISITION
sfrq 125.794
tn C13
at 1.736
np 82982
sw 23894.9
fb not used
bs 8
ss 1
tpwr 53
pw 6.9
d1 0.763
tof -693.5
nt 1e+07
ct 19184
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -625.9
wp 23894.5
vs 9178
sc 0
wc 250
hzmm 95.58
is 500.00
rfl 16777.7
rfp 16151.4
th 20
ins 1.000
ai ph
DEC. & VT
dfrq 500.233
dn H1
dpwr 37
dof -500.0
dm y
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
lb 0.30
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
HO
H
H
H
H
H
N
H
Me
Cbz
N
H
O
O
(–)-83
180
160
140
120
100
80
60
40
20
ppm

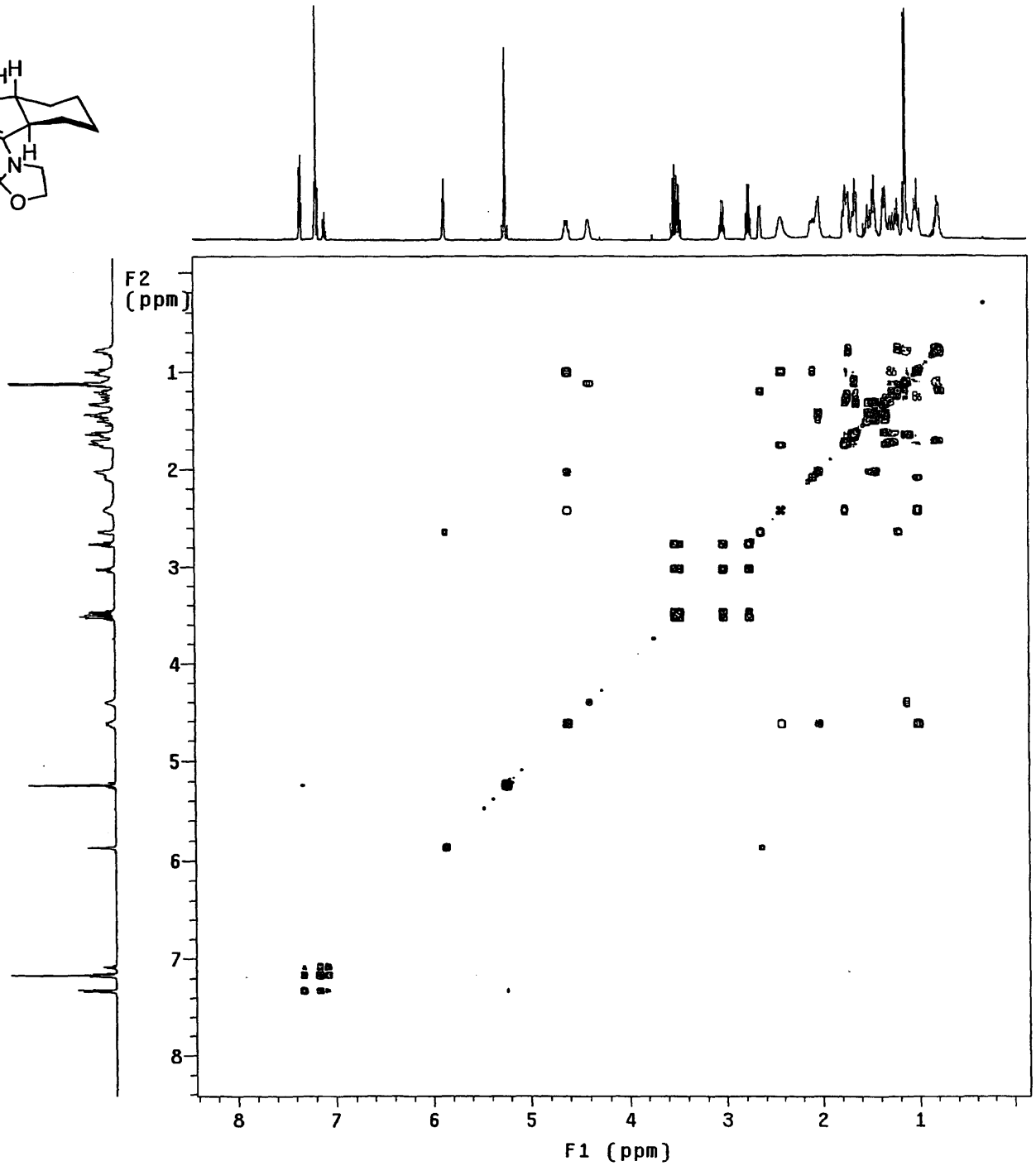
Pulse Sequence: gCOSY
Solvent: Benzene
Ambient temperature

INOVA-500

PULSE SEQUENCE: gCOSY
Relax. delay 1.000 sec
Acq. time 0.238 sec
Width 4293.7 Hz
2D Width 4293.7 Hz
26 repetitions
128 increments
OBSERVE H1, 499.7446815 MHz
DATA PROCESSING
Sq. sine bell 0.119 sec
F1 DATA PROCESSING
Sq. sine bell 0.030 sec
FT size 2048 x 2048
Total time 0 min, -1 sec



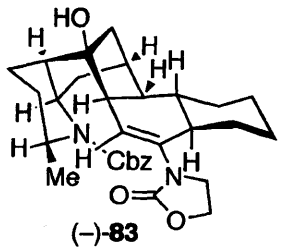
(–)-**83**



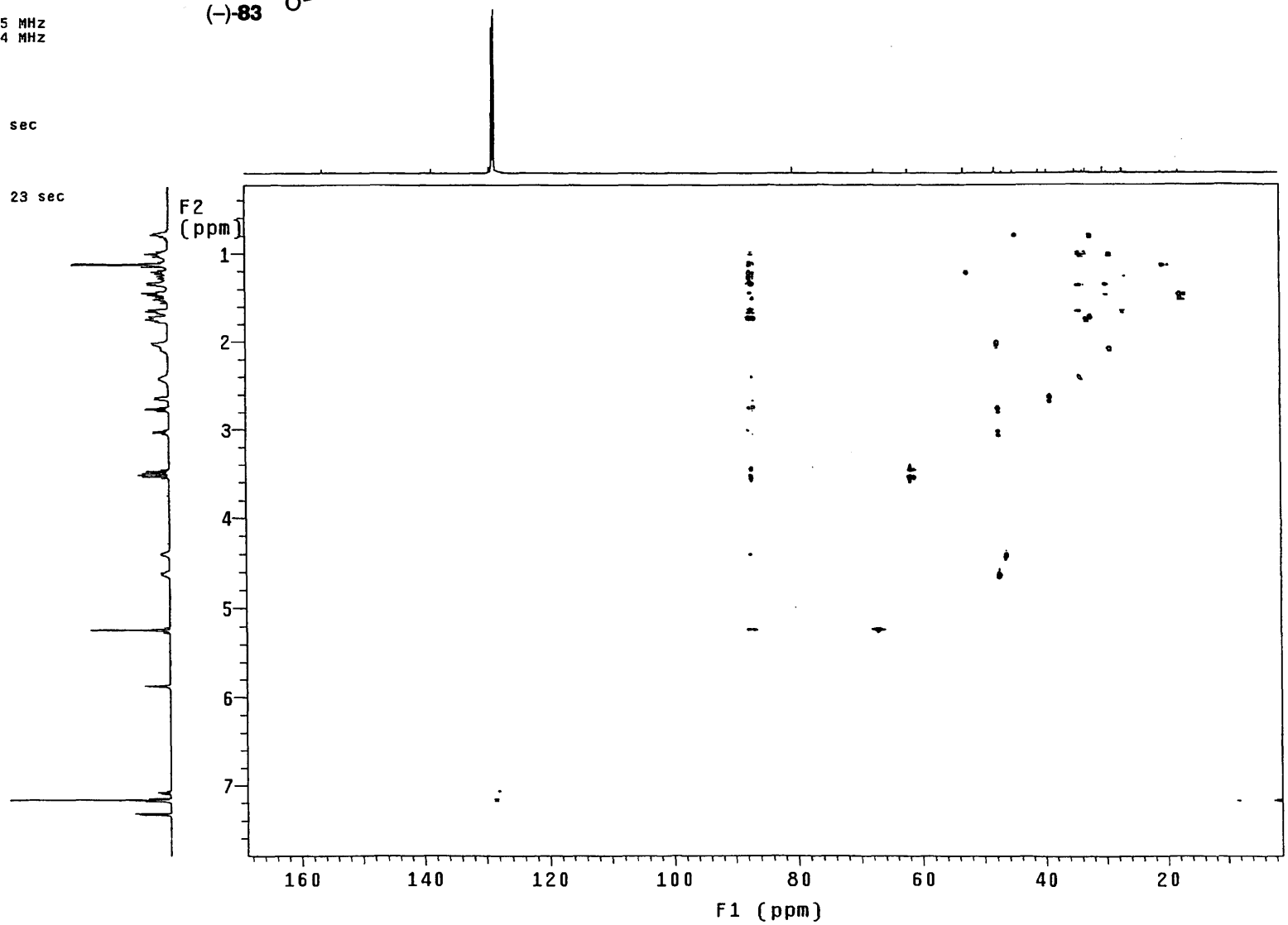
Pulse Sequence: HSQC
Solvent: Benzene
Ambient temperature
User:

INOVA-500

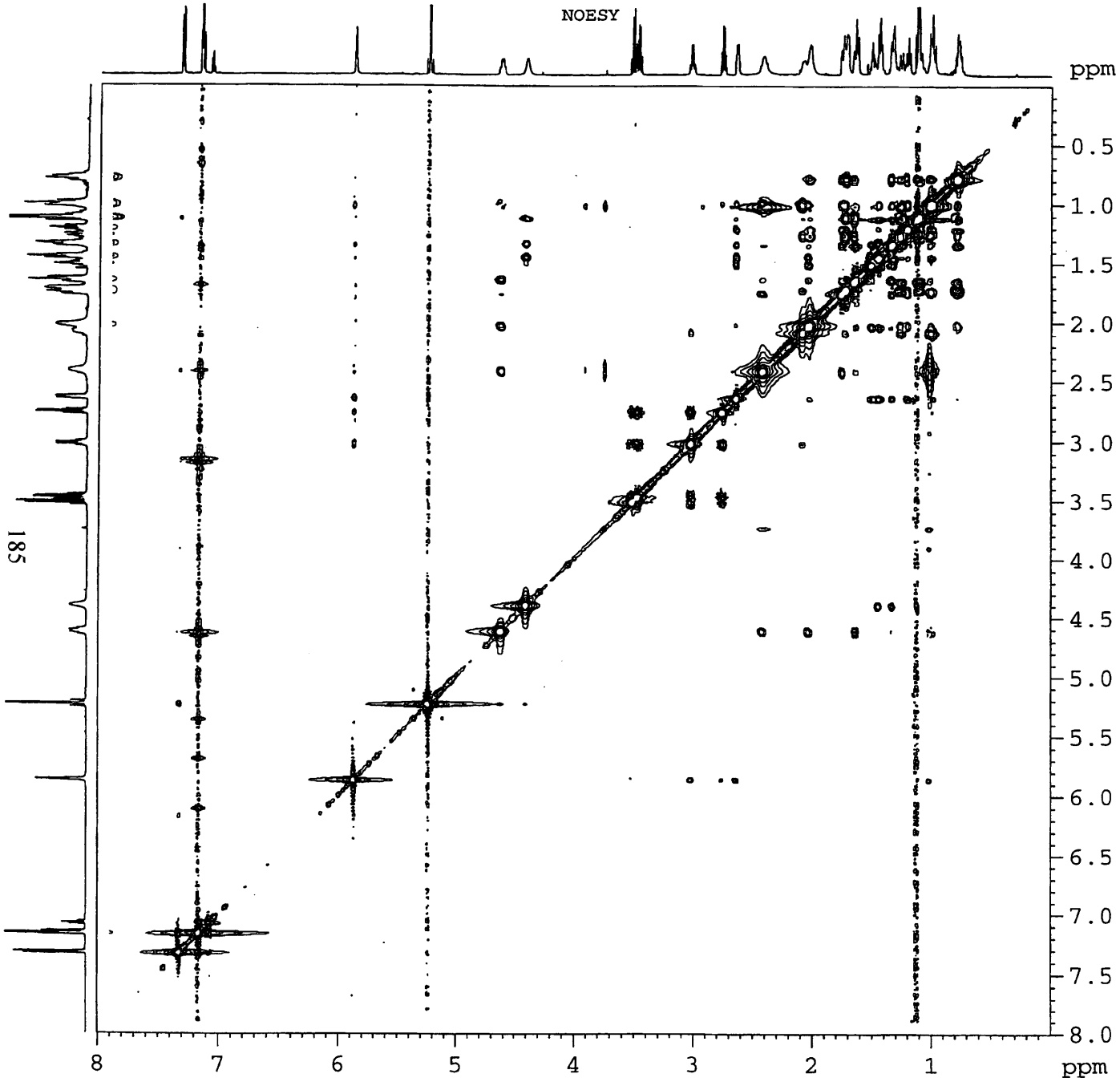
PULSE SEQUENCE: HSQC
Relax. delay 1.000 sec
Acq. time 0.099 sec
Width 4186.7 Hz
2D Width 23255.8 Hz
32 repetitions
2 x 256 increments
OBSERVE H1, 499.7446815 MHz
DECOUPLE C13, 125.6718434 MHz
Power 52 dB
on during acquisition
off during delay
GARP-1 modulated
DATA PROCESSING
Gauss apodization 0.113 sec
F1 DATA PROCESSING
Sq. sine bell 0.022 sec
Shifted by -0.022 sec
FT size 2048 x 2048
Total time 6 hr, 52 min, 23 sec

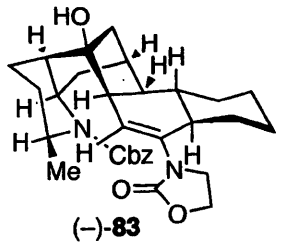


(–)-**83**



HMBC
ppm
(−)-83
Me
Cbz
HO
N
O
ppm





(–)-**83**

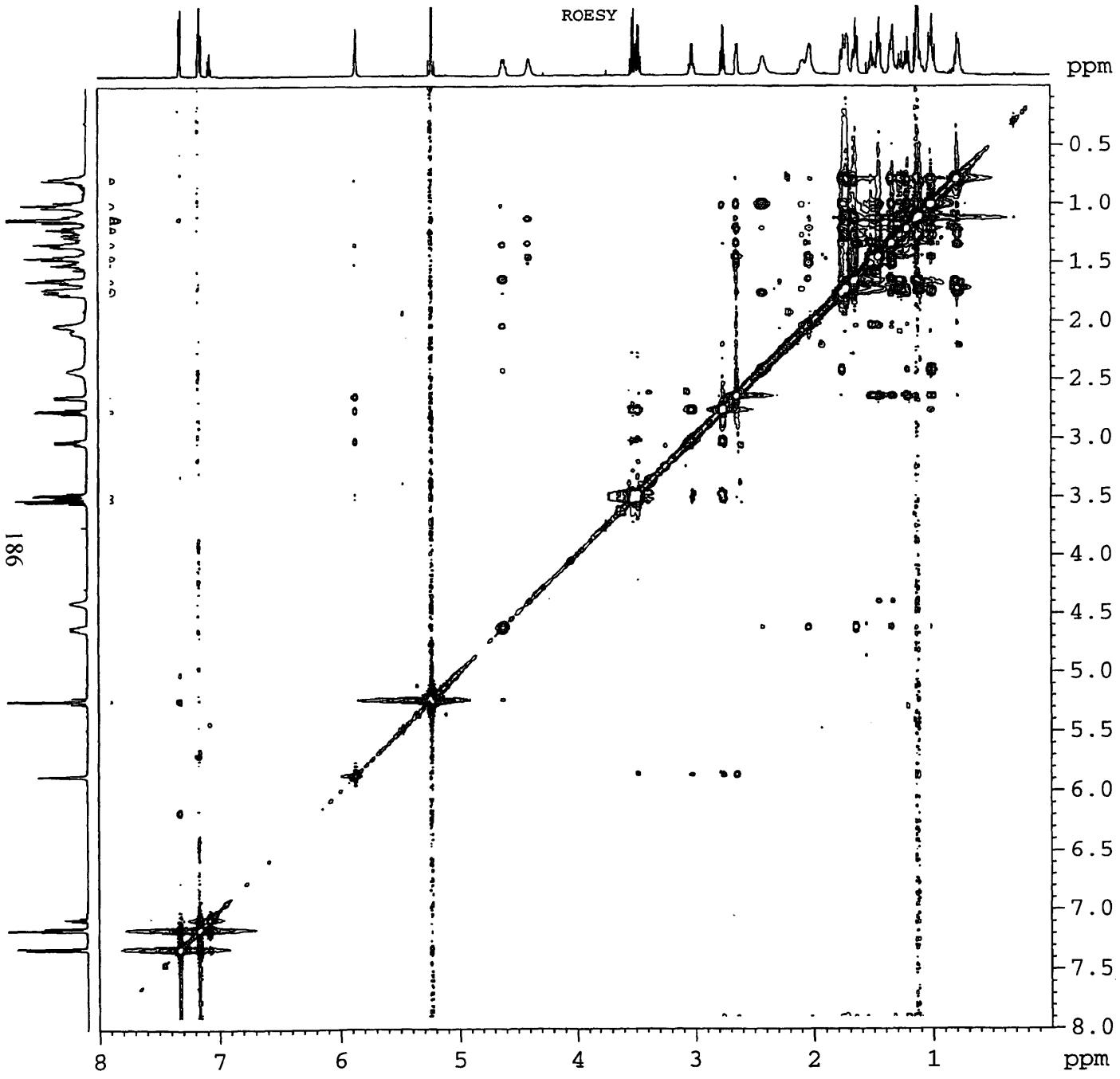
F2 - Acquisition Parameters	
Date_	20060124
Time	11.39
INSTRUM	spect
PROBHD	5 mm CPTXI Z-G
PULPROG	noesyph
TD	1024
SOLVENT	C6D6
NS	32
DS	16
SWH	4807.692 Hz
FIDRES	4.695012 Hz
AQ	0.1066500 sec
RG	64
DW	104.000 usec
DE	6.00 usec
TE	295.0 K
d0	0.00009267 sec
D1	0.80000001 sec
D8	0.40000001 sec
IN0	0.00020800 sec
MCREST	0.00000000 sec
MCWRK	0.80000001 sec

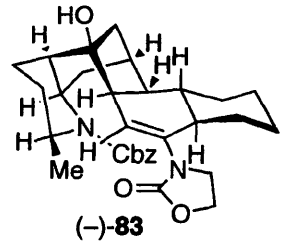
======== CHANNEL f1 ========	
NUC1	1H
P1	8.90 usec
PL1	-6.00 dB
SFO1	600.4674019 MHz

F1 - Acquisition parameters	
ND0	1
TD	512
SFO1	600.4674 MHz
FIDRES	9.390024 Hz
SW	8.007 ppm
FnMODE	TPPI

F2 - Processing parameters	
SI	2048
SF	600.4650000 MHz
WDW	SINE
SSB	2
LB	0.00 Hz
GB	0
PC	1.00

F1 - Processing parameters	
SI	1024
MC2	TPPI
SF	600.4650000 MHz
WDW	SINE
SSB	2
LB	0.00 Hz
GB	0





(–)-**83**

F2 - Acquisition Parameters

Date_	20060124
Time	17.45
INSTRUM	spect
PROBHD	5 mm CPTXI Z-G
PULPROG	roesyph
TD	1024
SOLVENT	C6D6
NS	32
DS	16
SWH	4807.692 Hz
FIDRES	4.695012 Hz
AQ	0.1066500 sec
RG	64
DW	104.000 usec
DE	6.00 usec
TE	295.0 K
d0	0.00009433 sec
D1	0.80000001 sec
d12	0.00002000 sec
IN0	0.00020800 sec
MCREST	0.00000000 sec
MCWRK	0.80000001 sec

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

NUC1	1H
P1	8.90 usec
P15	400000.00 usec
PL1	-6.00 dB
PL11	15.20 dB
SFO1	600.4674019 MHz

F1 - Acquisition parameters

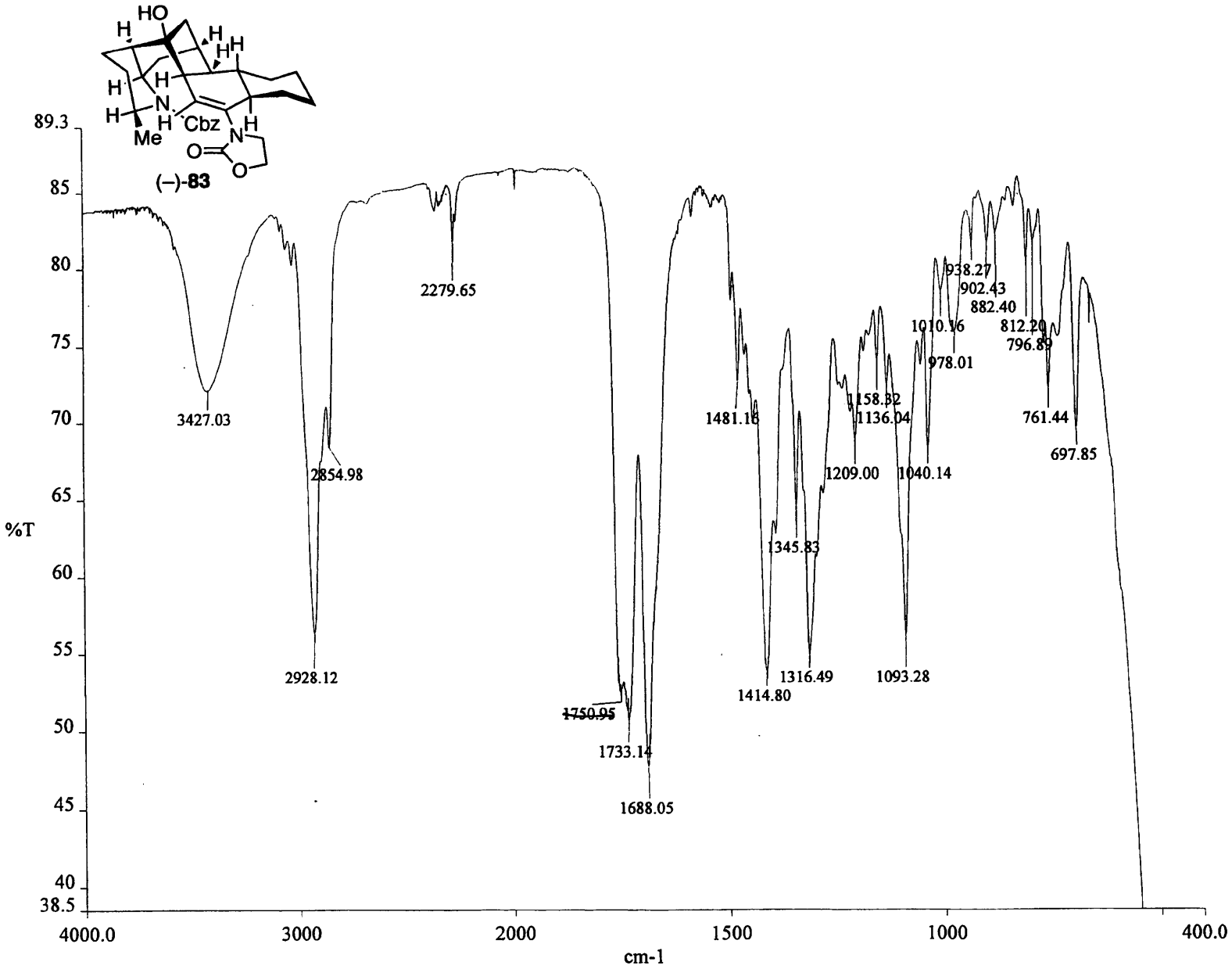
ND0	1
TD	512
SFO1	600.4674 MHz
FIDRES	9.390024 Hz
SW	8.007 ppm
FnMODE	TPPI

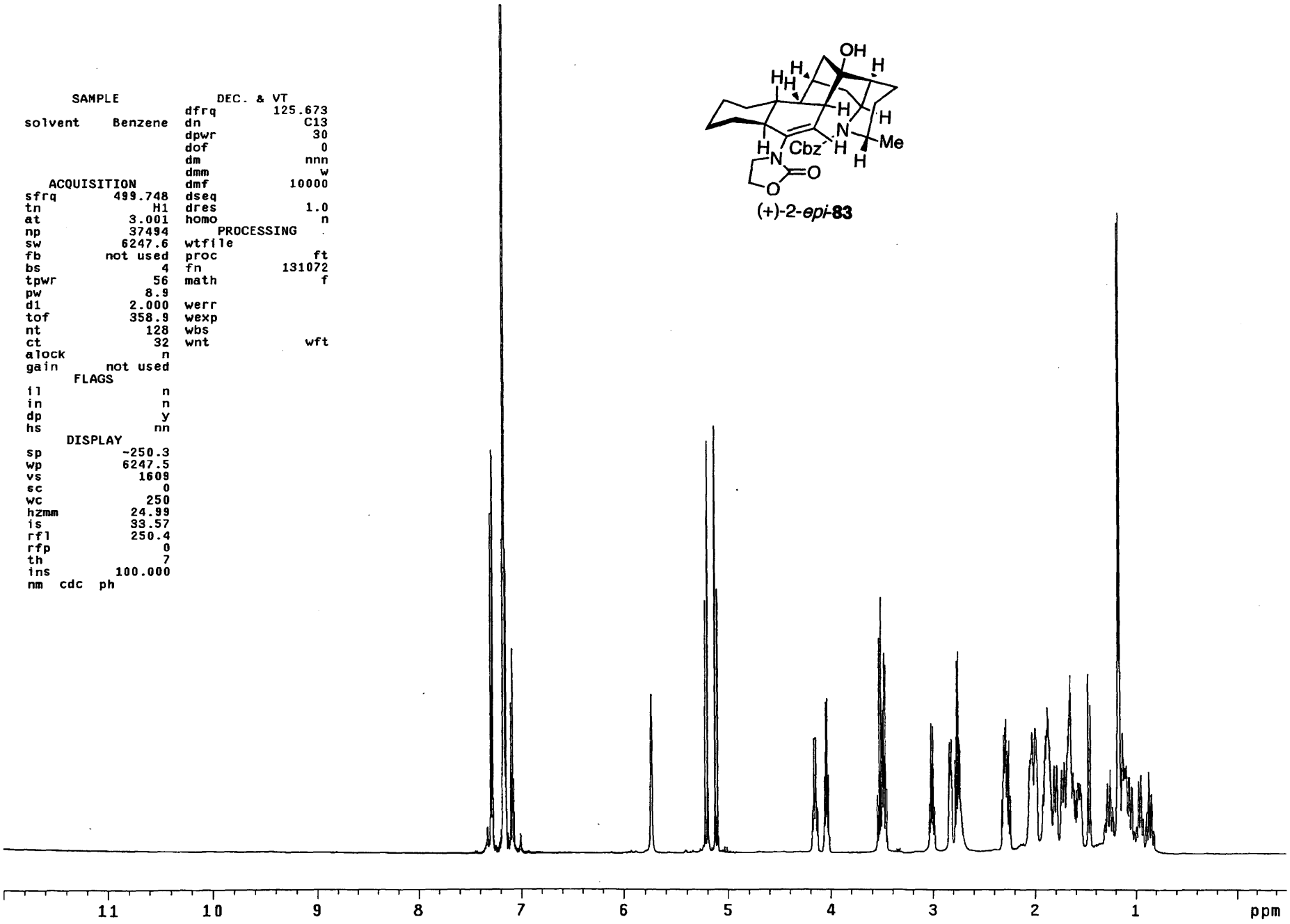
F2 - Processing parameters

SI	2048
SF	600.4650000 MHz
WDW	SINE
SSB	2
LB	0.00 Hz
GB	0
PC	1.00

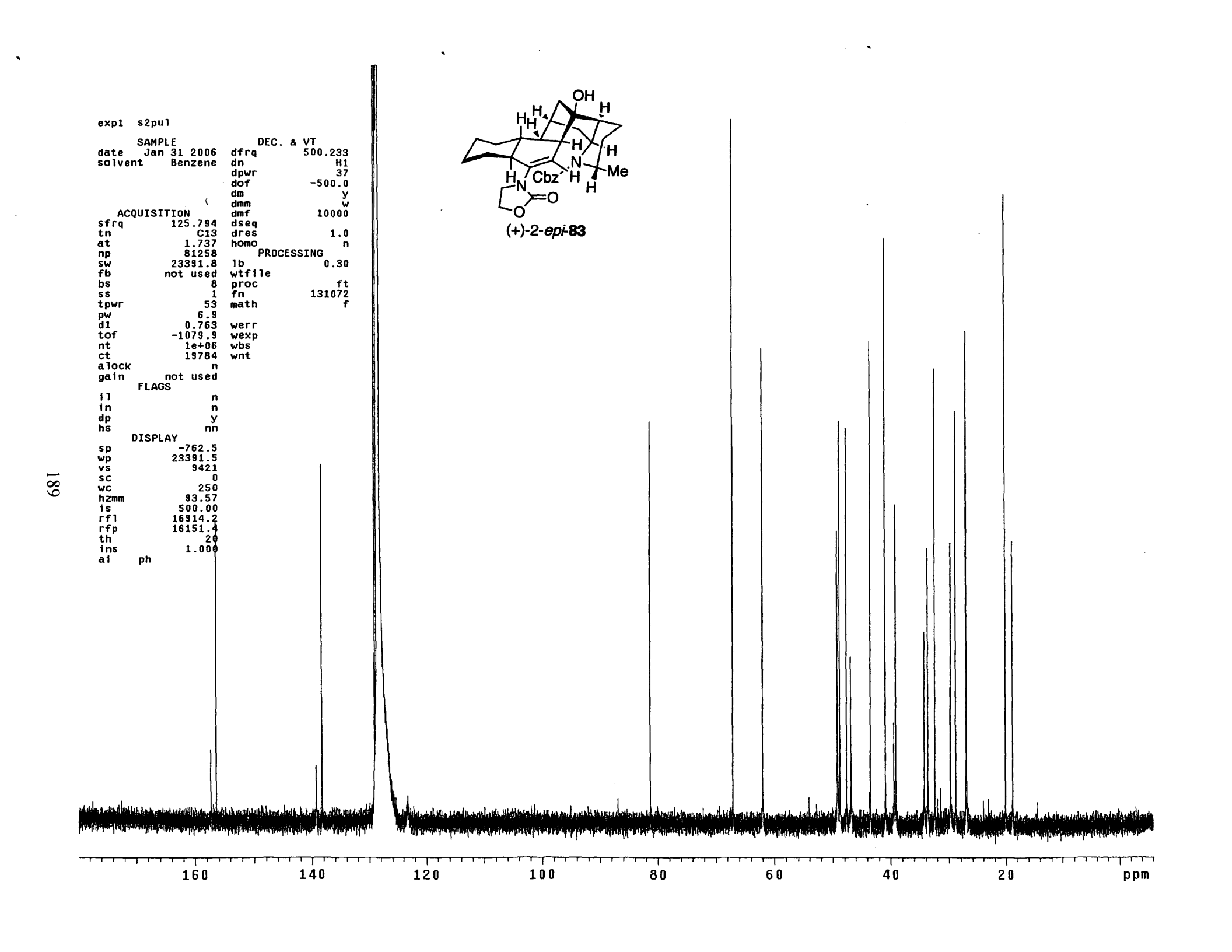
F1 - Processing parameters

SI	1024
MC2	TPPI
SF	600.4650000 MHz
WDW	SINE
SSB	2
LB	0.00 Hz
GB	0


HO
H
H
H
H
H
H
N
H
Me
H
Cbz
N
H
O
O
(–)-83
89.3
85
80
75
70
65
60
55
50
45
40
38.5
%T
3427.03
2928.12
2854.98
2279.65
1750.95
1733.14
1688.05
1481.18
1414.80
1345.83
1316.49
1209.00
1158.32
1136.04
1093.28
1040.14
1010.16
978.01
938.27
902.43
882.40
812.20
796.89
761.44
697.85
4000.0
3000
2000
1500
1000
400.0
cm-1


SAMPLE
solvent Benzene
ACQUISITION
sfrq 499.748
tn H1
at 3.001
np 37494
sw 6247.6
fb not used
bs 4
tpwr 56
pw 8.9
d1 2.000
tof 358.9
nt 128
ct 32
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -250.3
wp 6247.5
vs 1609
sc 0
wc 250
hzmm 24.99
is 33.57
rfl 250.4
rfp 0
th 7
ins 100.000
nm cdc ph
DEC. & VT
dfrq 125.673
dn C13
dpwr 30
dof 0
dm nnn
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt wft
OH
H
HH
H
H
N
H
Me
H
HN
Cbz
N
O
O
11
10
9
8
7
6
5
4
3
2
1
ppm

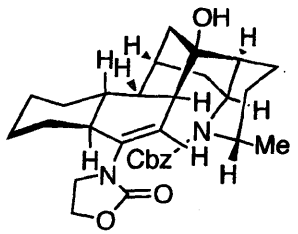
(+)-2-*epi*-**83**


exp1 s2pul
SAMPLE
date Jan 31 2006
solvent Benzene
ACQUISITION
sfrq 125.794
tn C13
at 1.737
np 81258
sw 23391.8
fb not used
bs 8
ss 1
tpwr 53
pw 6.9
d1 0.763
tof -1079.9
nt 1e+06
ct 19784
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -762.5
wp 23391.5
vs 9421
sc 0
wc 250
hzmm 93.57
is 500.00
rfl 16914.2
rfp 16151.4
th 20
ins 1.000
ai ph
DEC. & VT
dfrq 500.233
dn H1
dpwr 37
dof -500.0
dm y
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
lb 0.30
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
OH
H
H
H
H
N
Me
H
H
N
Cbz
H
O
O
(+)-2-epi-83
160
140
120
100
80
60
40
20
ppm

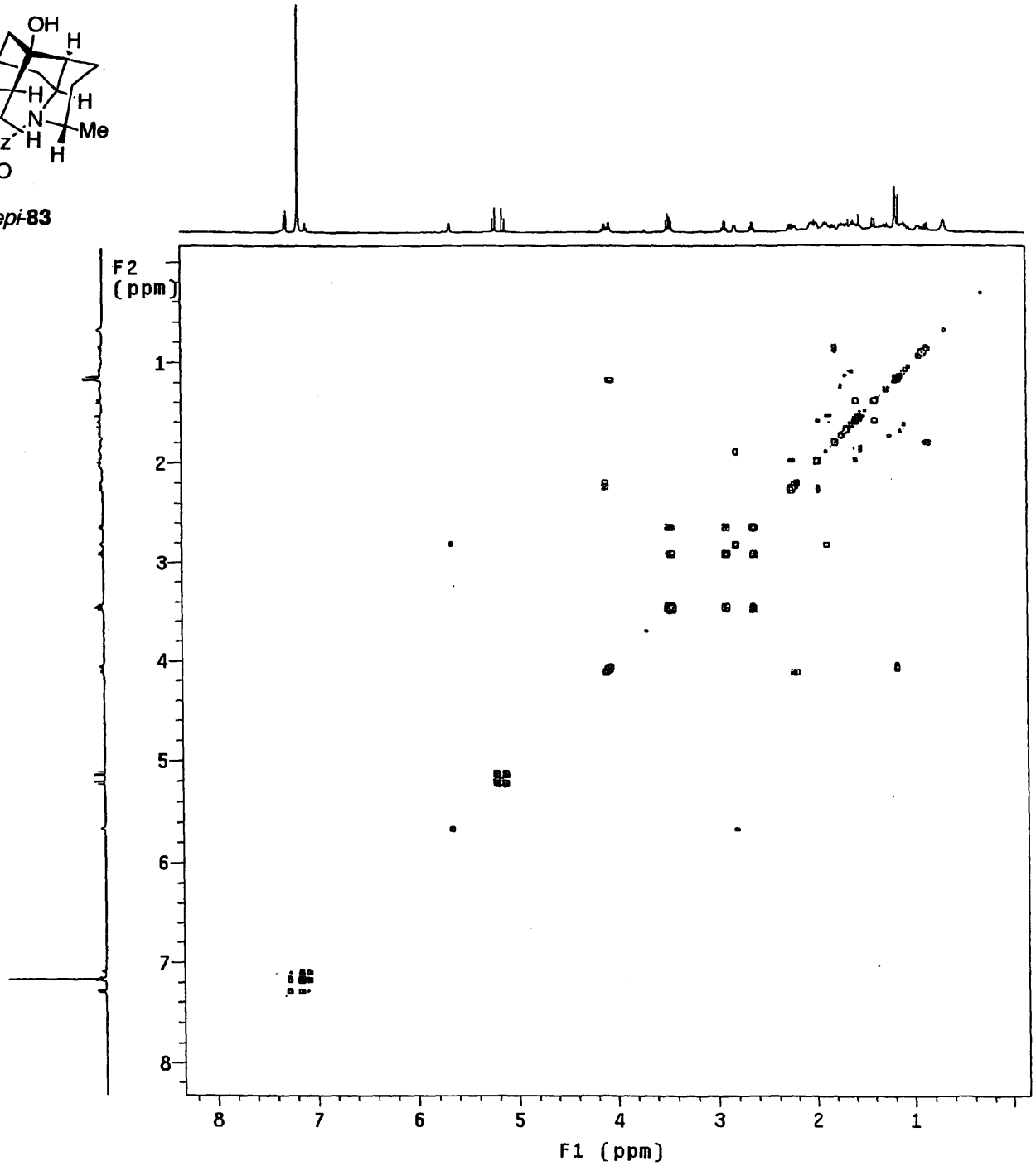
Pulse Sequence: gCOSY
Solvent: Benzene
Ambient temperature

INOVA-500

PULSE SEQUENCE: gCOSY
Relax. delay 1.000 sec
Acq. time 0.241 sec
Width 4247.2 Hz
2D Width 4247.2 Hz
24 repetitions
128 increments
OBSERVE H1, 499.7446814 MHz
DATA PROCESSING
Sq. sine bell 0.120 sec
F1 DATA PROCESSING
Sq. sine bell 0.030 sec
FT size 2048 x 2048
Total time 0 min, -1 sec



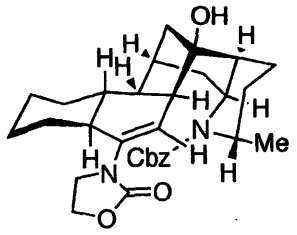
(+)-2-*epi*-**83**



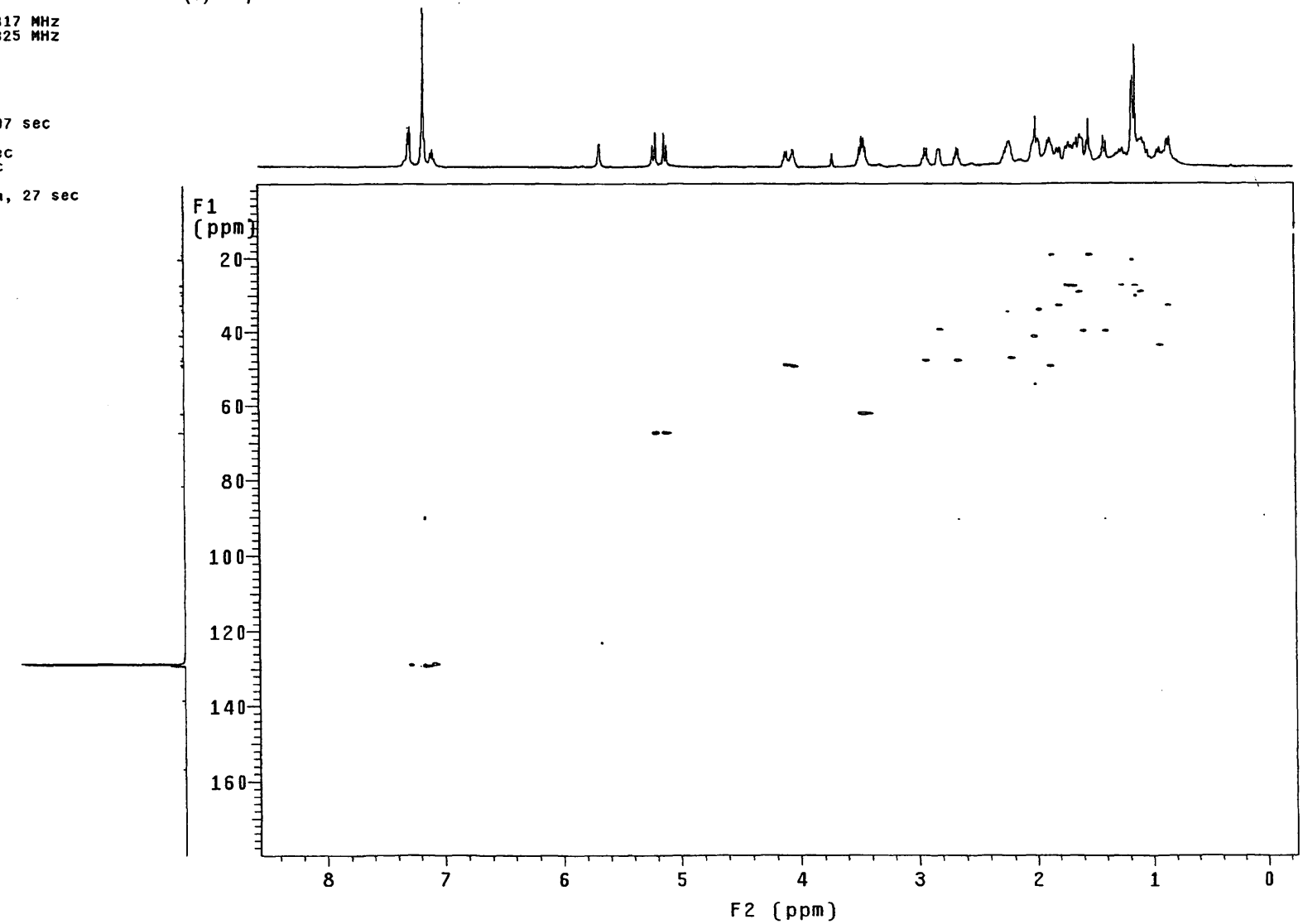
Pulse Sequence: HSQC
Solvent: Benzene
Ambient temperature
User:

INOVA-500

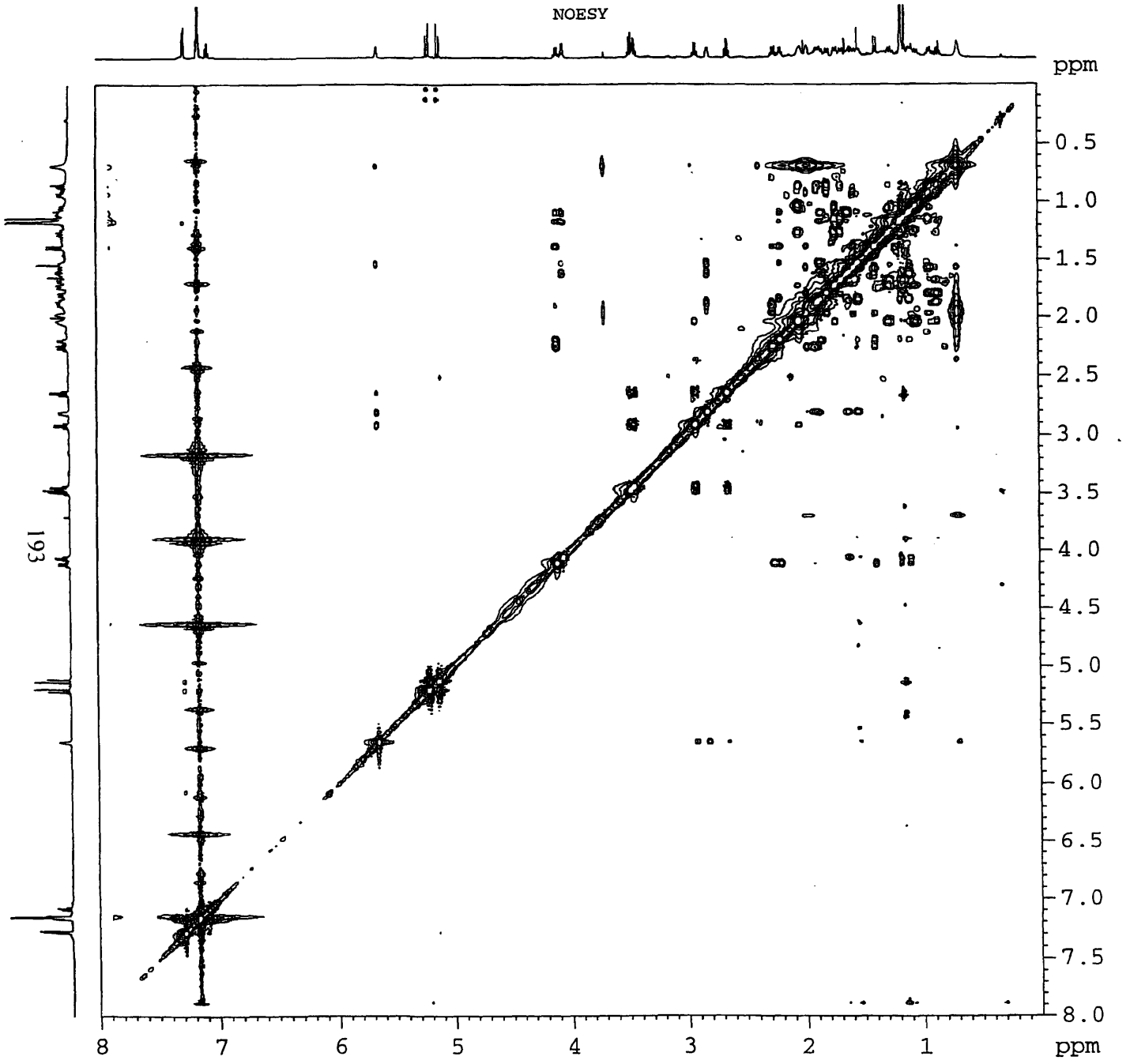
PULSE SEQUENCE: HSQC
Relax. delay 1.000 sec
Acq. time 0.099 sec
Width 4406.3 Hz
2D Width 22598.9 Hz
32 repetitions
2 x 256 increments
OBSERVE H1, 499.7446817 MHz
DECOUPLE C13, 125.6721325 MHz
Power 52 dB
on during acquisition
off during delay
GARP-1 modulated
DATA PROCESSING
Gauss apodization 0.107 sec
F1 DATA PROCESSING
Sq. sine bell 0.023 sec
Shifted by -0.023 sec
FT size 2048 x 2048
Total time 6 hr, 52 min, 27 sec

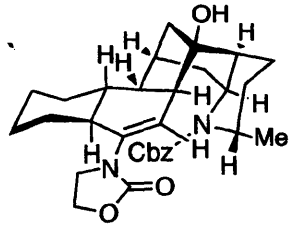


(+)-2-*epi*-**83**



HMBC
OH
H
H
H
H
H
N
Me
H
Cbz
H
N
O
O
(+)-2-epi-83
ppm
ppm





(+)-2-*epi*-**83**

F2 - Acquisition Parameters

Date_	20060127
Time	15.57
INSTRUM	spect
PROBHD	5 mm CPTXI Z-G
PULPROG	noesyph
TD	1024
SOLVENT	D2O
NS	24
DS	16
SWH	4807.692 Hz
FIDRES	4.695012 Hz
AQ	0.1066500 sec
RG	128
DW	104.000 usec
DE	6.00 usec
TE	295.0 K
d0	0.00009267 sec
D1	0.69999999 sec
D8	0.40000001 sec
IN0	0.00020800 sec
MCREST	0.00000000 sec
MCWRK	0.69999999 sec

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

NUC1	1H
P1	8.90 usec
PL1	-6.00 dB
SFO1	600.4674019 MHz

F1 - Acquisition parameters

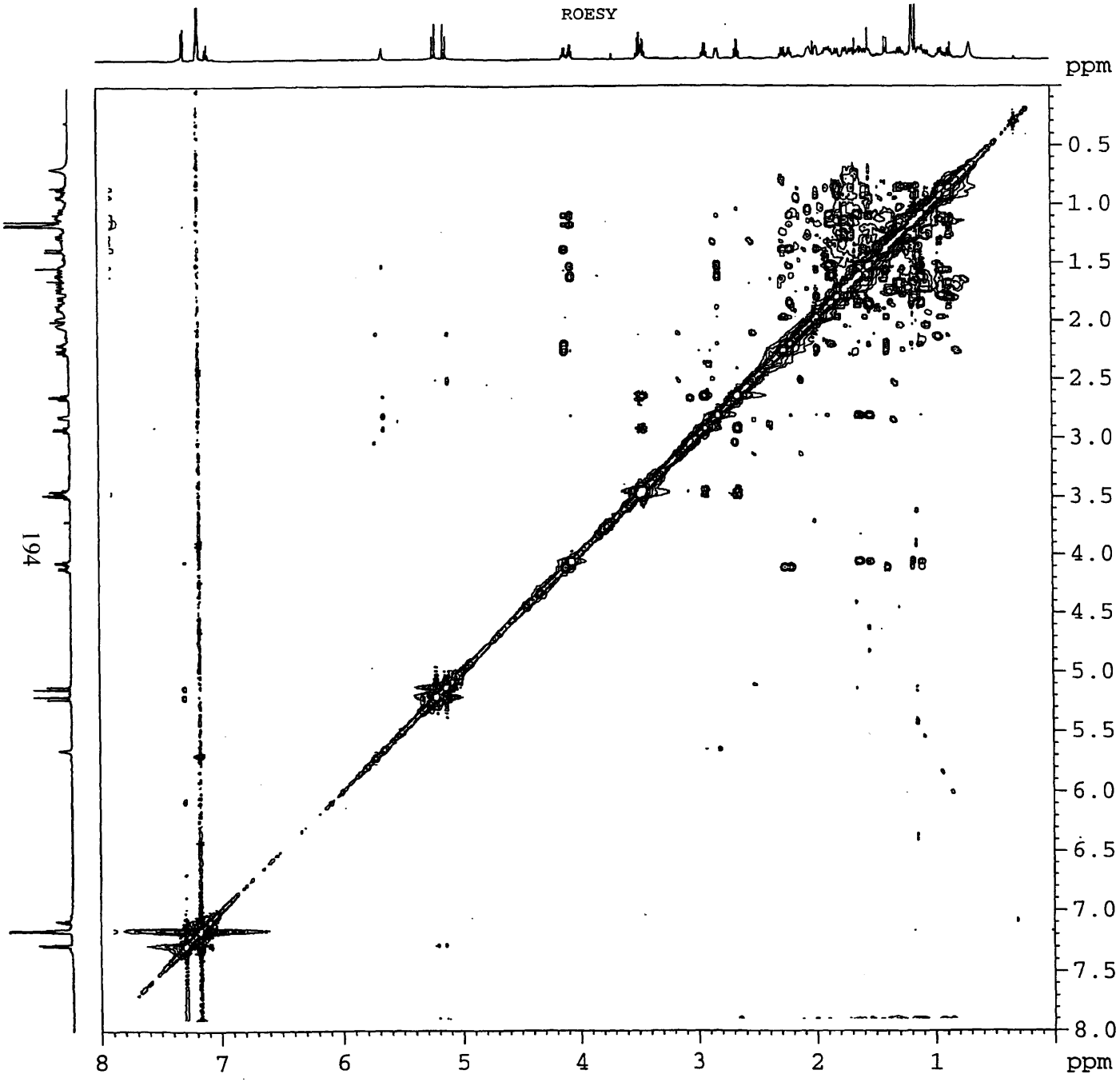
ND0	1
TD	480
SFO1	600.4674 MHz
FIDRES	10.016026 Hz
SW	8.007 ppm
FnMODE	TPPI

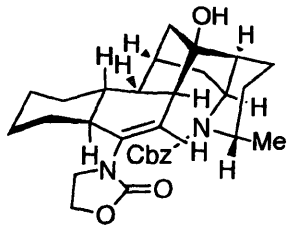
F2 - Processing parameters

SI	2048
SF	600.4650000 MHz
WDW	SINE
SSB	2
LB	0.00 Hz
GB	0
PC	1.00

F1 - Processing parameters

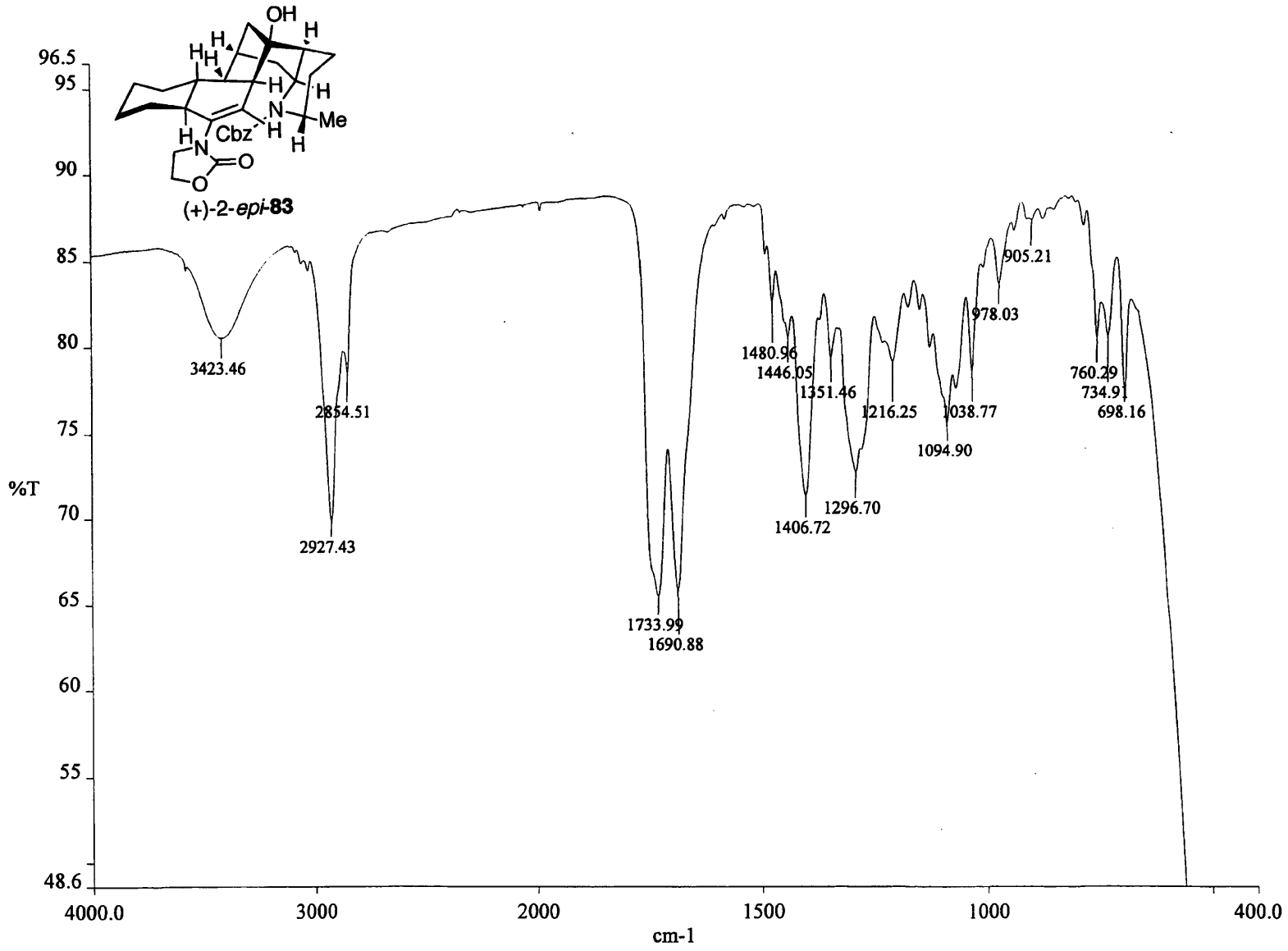
SI	1024
MC2	TPPI
SF	600.4650000 MHz
WDW	SINE
SSB	2
LB	0.00 Hz
GB	0

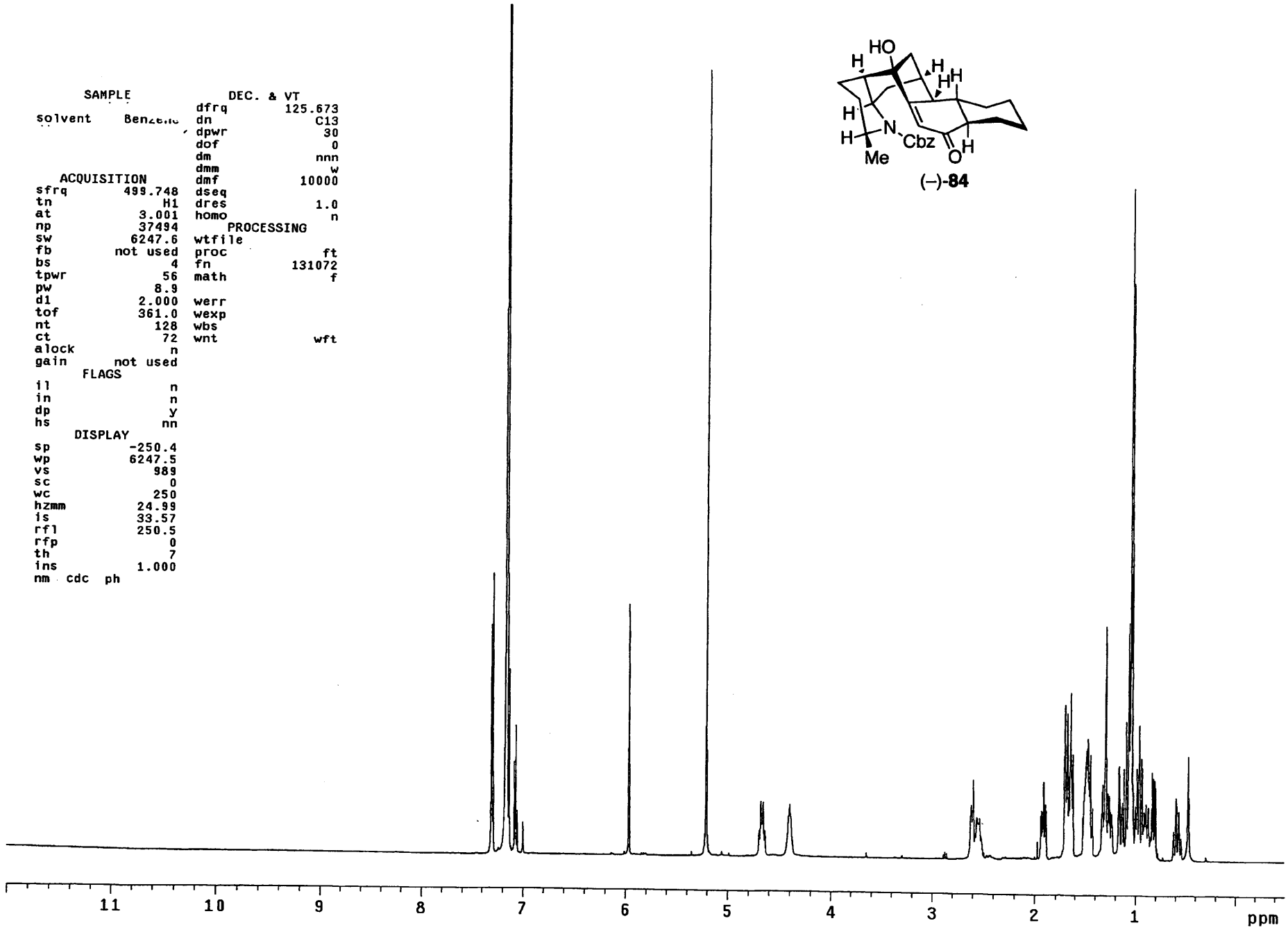


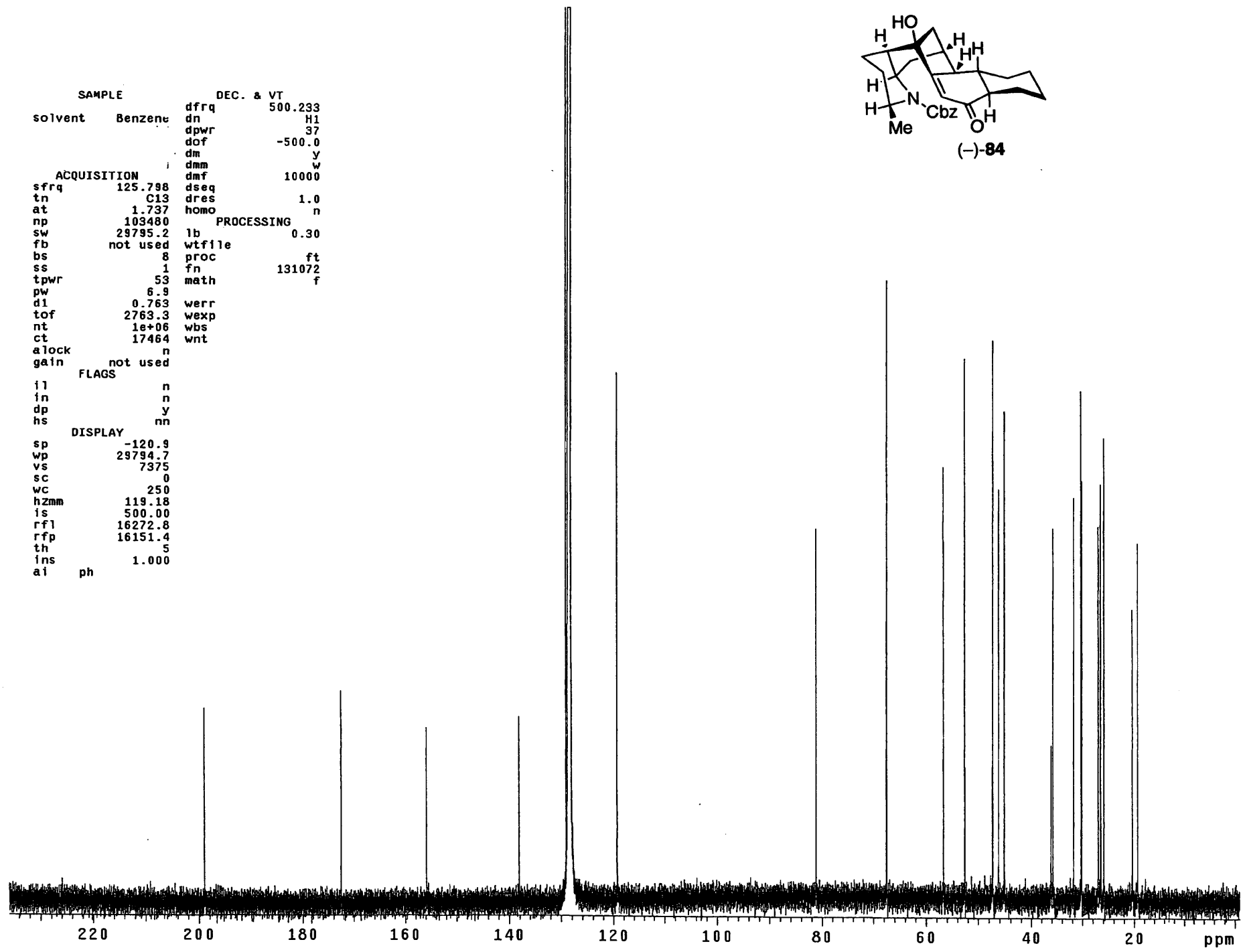


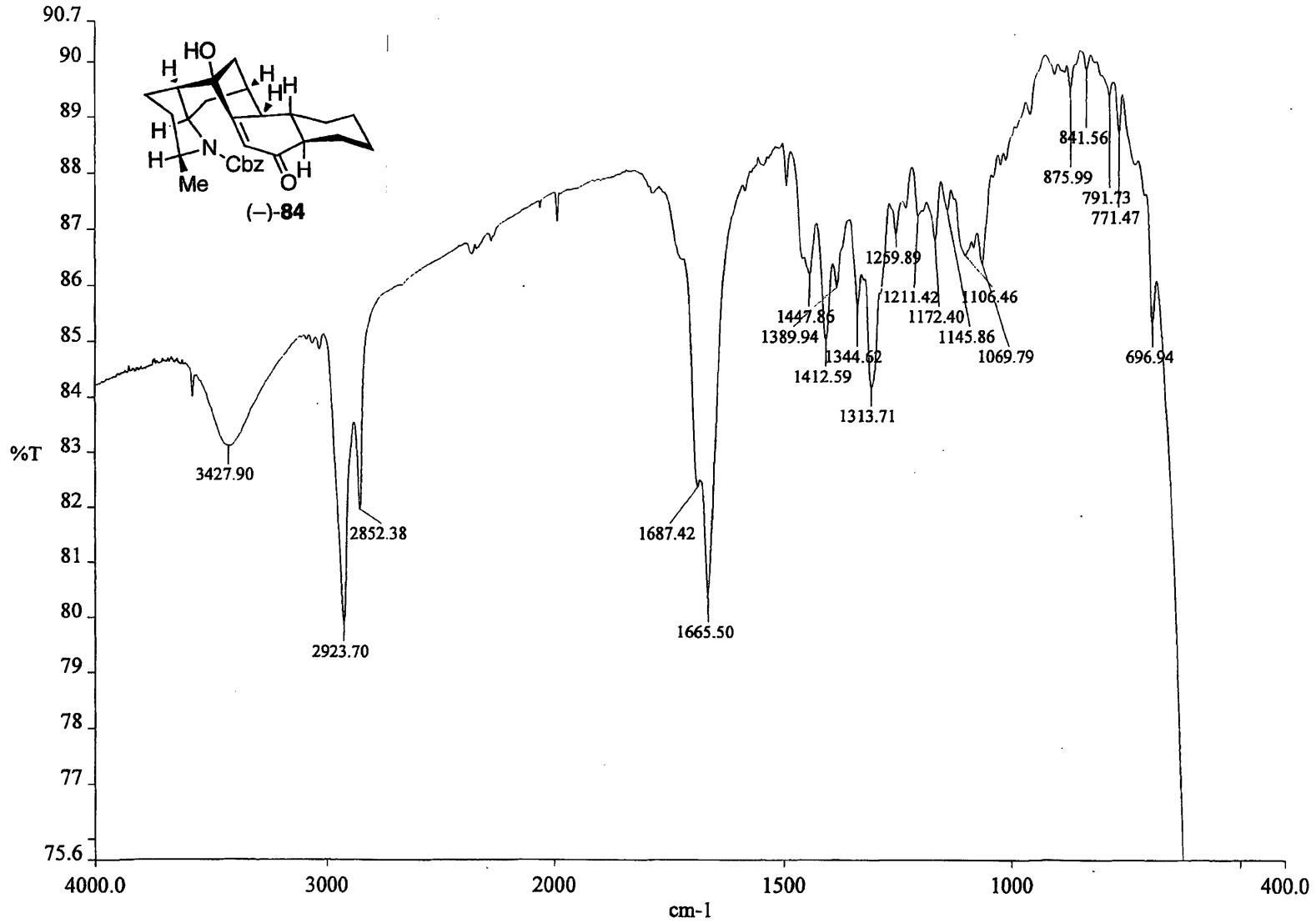
(+)-2-*epi*-**83**

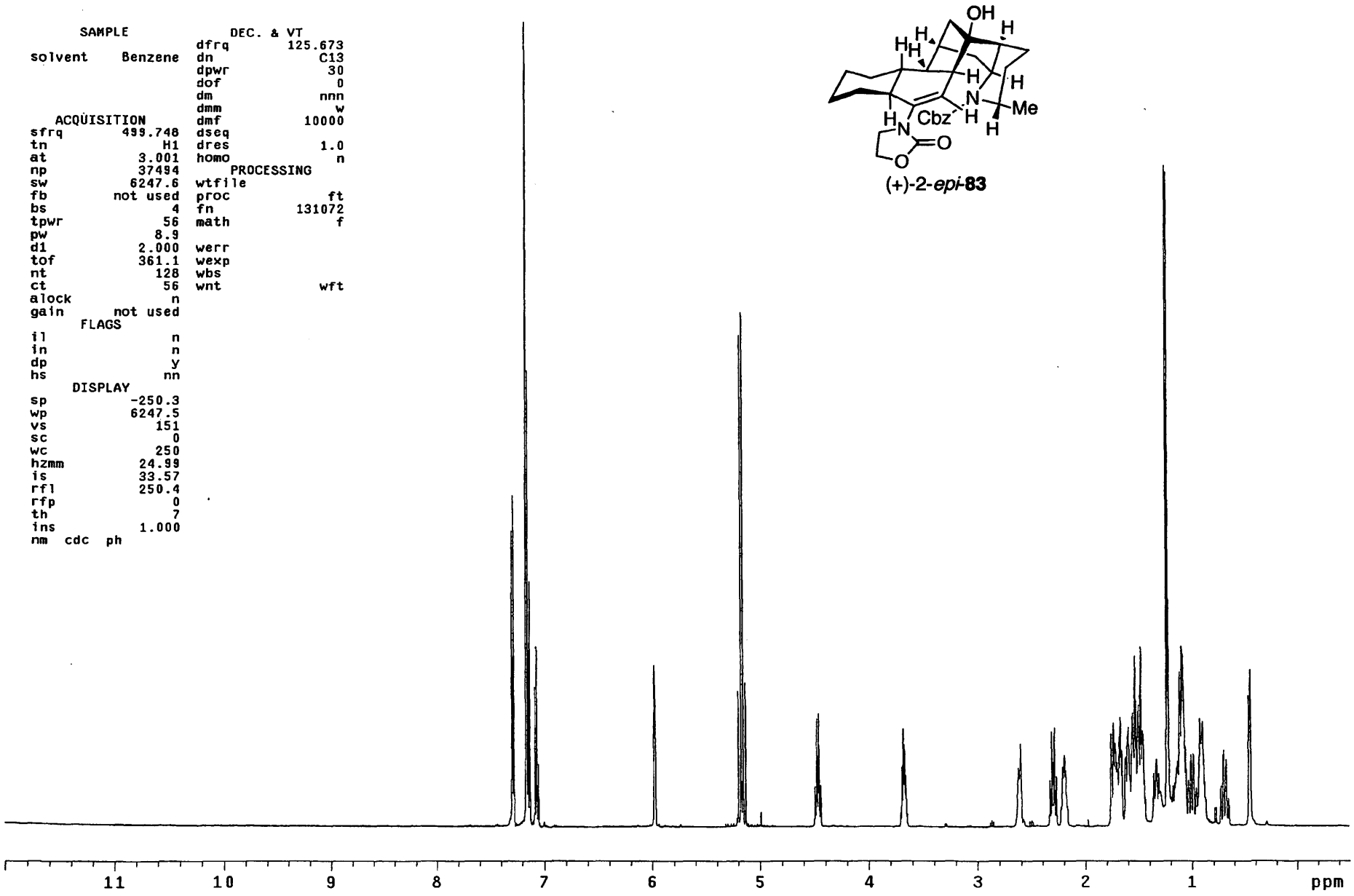
F2 - Acquisition Parameters	
Date_	20060127
Time	19.54
INSTRUM	spect
PROBHD	5 mm CPTXI Z-G
PULPROG	roesyph
TD	1024
SOLVENT	C6D6
NS	24
DS	16
SWH	4807.692 Hz
FIDRES	4.695012 Hz
AQ	0.1066500 sec
RG	128
DW	104.000 usec
DE	6.00 usec
TE	295.0 K
d0	0.00009433 sec
D1	0.69999999 sec
d12	0.00002000 sec
IN0	0.00020800 sec
MCREST	0.00000000 sec
MCWRK	0.69999999 sec
======== CHANNEL f1 ========	
NUC1	1H
P1	8.90 usec
P15	400000.00 usec
PL1	-6.00 dB
PL11	15.20 dB
SFO1	600.4674019 MHz
F1 - Acquisition parameters	
ND0	1
TD	480
SFO1	600.4674 MHz
FIDRES	10.016026 Hz
SW	8.007 ppm
FnMODE	TPPI
F2 - Processing parameters	
SI	2048
SF	600.4650000 MHz
WDW	SINE
SSB	2
LB	0.00 Hz
GB	0
PC	1.00
F1 - Processing parameters	
SI	1024
MC2	TPPI
SF	600.4650000 MHz
WDW	SINE
SSB	2
LB	0.00 Hz
GB	0

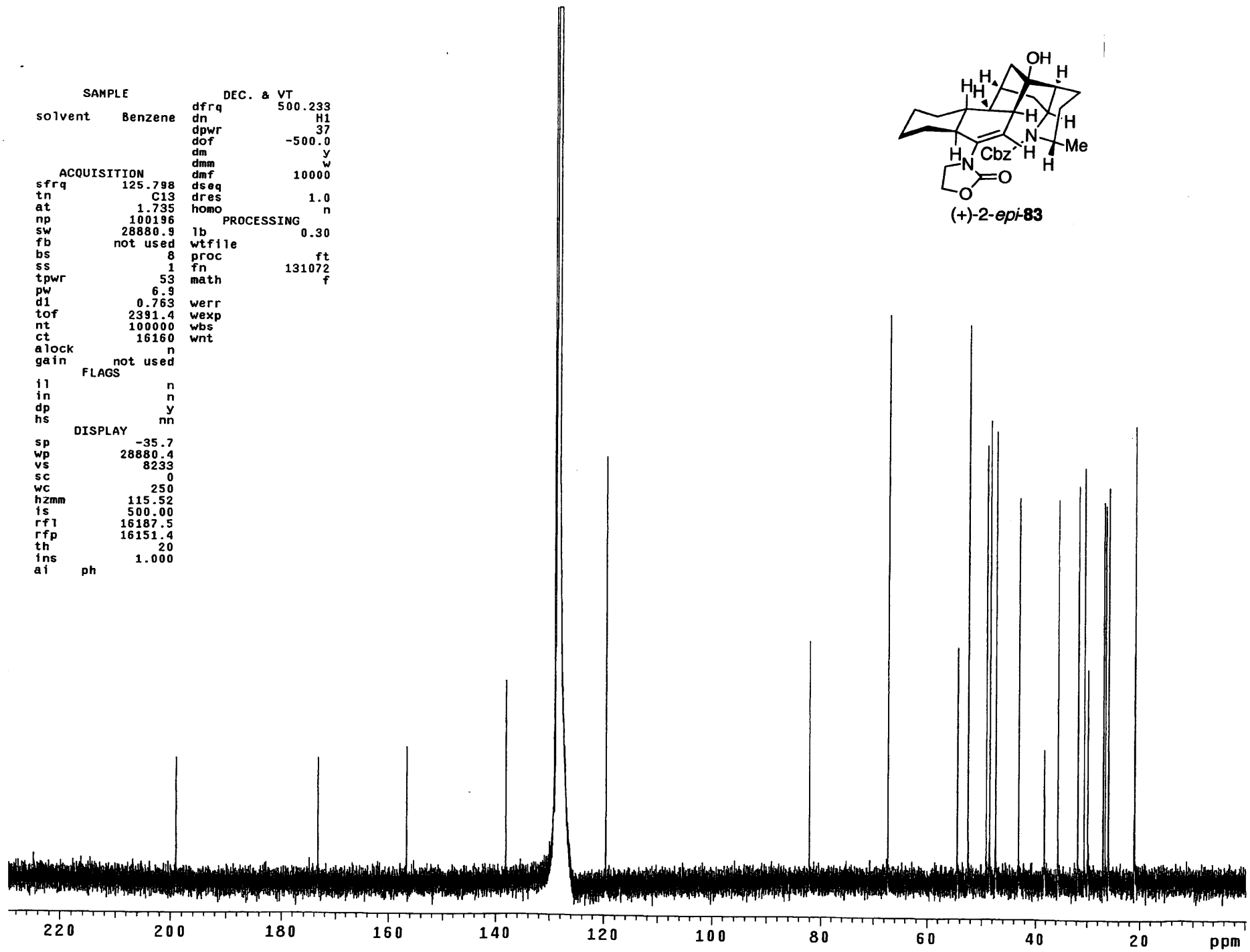

(+)-2-epi-83
96.5
95
90
85
80
75
70
65
60
55
48.6
%T
4000.0
3000
2000
1500
1000
400.0
cm-1
3423.46
2854.51
2927.43
1733.99
1690.88
1480.96
1446.05
1406.72
1351.46
1296.70
1216.25
1094.90
1038.77
978.03
905.21
760.29
734.91
698.16


SAMPLE
solvent Benzene
ACQUISITION
sfrq 499.748
tn H1
at 3.001
np 37494
sw 6247.6
fb not used
bs 4
tpwr 56
pw 8.9
d1 2.000
tof 361.0
nt 128
ct 72
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -250.4
wp 6247.5
vs 989
sc 0
wc 250
hzmm 24.99
is 33.57
rfl 250.5
rfp 0
th 7
ins 1.000
nm cdc ph
DEC. & VT
dfrq 125.673
dn C13
dpwr 30
dof 0
dm nnn
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt wft
HO
H
H
H
H
H
N
Cbz
Me
O
H
(–)-84
11
10
9
8
7
6
5
4
3
2
1
ppm

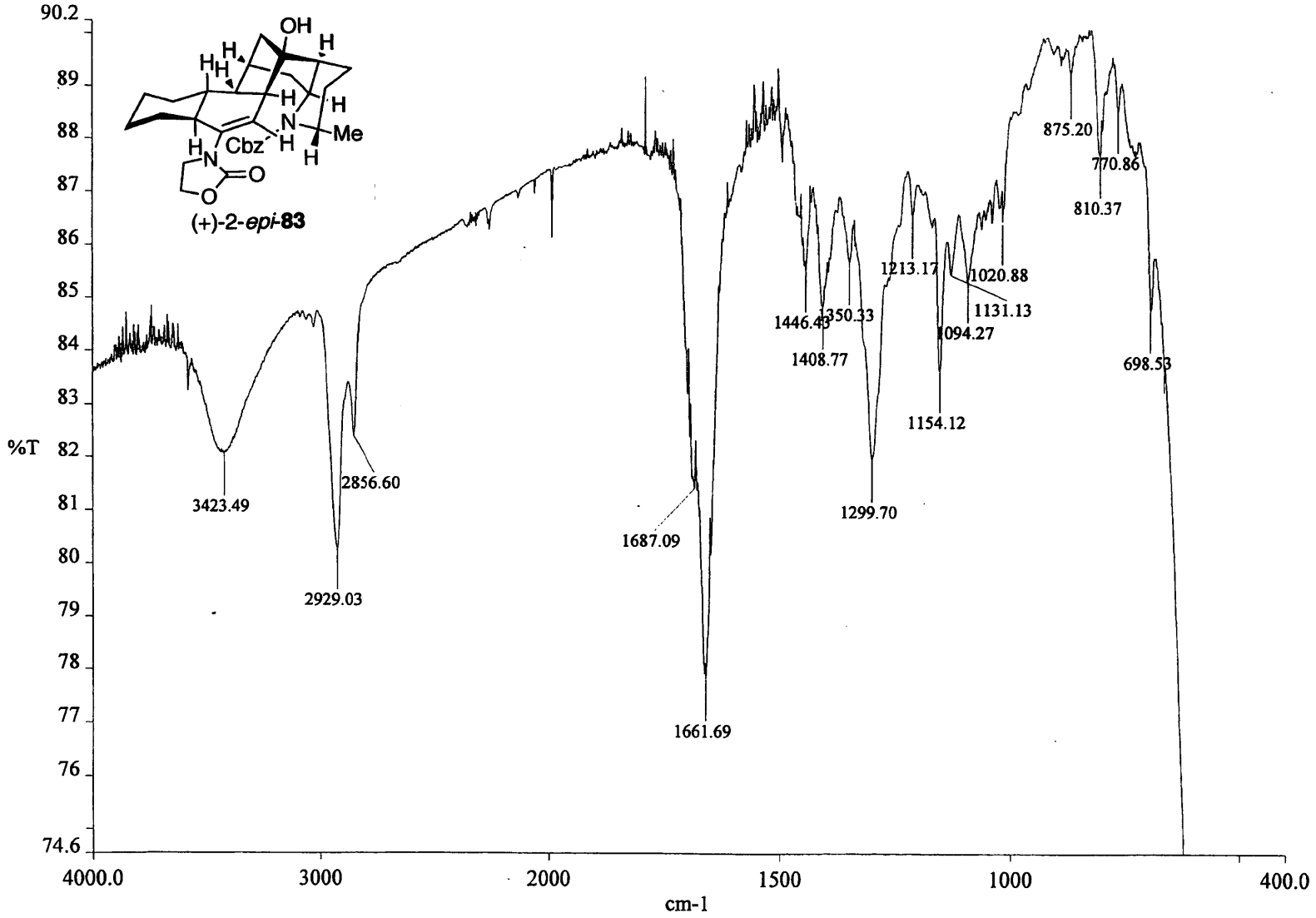

SAMPLE
solvent Benzene
ACQUISITION
sfrq 125.798
tn C13
at 1.737
np 103480
sw 29795.2
fb not used
bs 8
ss 1
tpwr 53
pw 6.9
d1 0.763
tof 2763.3
nt 1e+06
ct 17464
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -120.9
wp 29794.7
vs 7375
sc 0
wc 250
hzmm 119.18
is 500.00
rfl 16272.8
rfp 16151.4
th 5
ins 1.000
ai ph
DEC. & VT
dfrq 500.233
dn H1
dpwr 37
dof -500.0
dm y
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
lb 0.30
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
HO
H
H
H
H
H
N
Cbz
O
H
Me
(–)-84
220
200
180
160
140
120
100
80
60
40
20
ppm


90.7
90
89
88
87
86
85
84
83
82
81
80
79
78
77
75.6
%T
4000.0
3000
2000
1500
1000
400.0
cm-1
HO
H
H
H
H
H
N
Cbz
Me
O
H
(–)-84
3427.90
2923.70
2852.38
1687.42
1665.50
1447.86
1389.94
1412.59
1344.62
1313.71
1259.89
1211.42
1172.40
1145.86
1106.46
1069.79
841.56
875.99
791.73
771.47
696.94


SAMPLE
solvent Benzene
ACQUISITION
sfrq 499.748
tn H1
at 3.001
np 37494
sw 6247.6
fb not used
bs 4
tpwr 56
pw 8.9
d1 2.000
tof 361.1
nt 128
ct 56
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -250.3
wp 6247.5
vs 151
sc 0
wc 250
hzmm 24.99
is 33.57
rfl 250.4
rfp 0
th 7
ins 1.000
nm cdc ph
DEC. & VT
dfrq 125.673
dn C13
dpwr 30
dof 0
dm nnn
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt wft
OH
H
H
H
H
H
N
Me
H
Cbz
H
H
N
O
O
(+)-2-epi-83
11
10
9
8
7
6
5
4
3
2
1
ppm

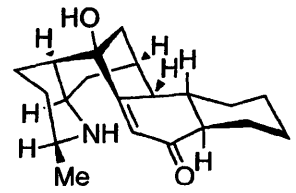

SAMPLE
solvent Benzene
ACQUISITION
sfrq 125.798
tn C13
at 1.735
np 100196
sw 28880.9
fb not used
bs 8
ss 1
tpwr 53
pw 6.9
d1 0.763
tof 2391.4
nt 100000
ct 16160
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -35.7
wp 28880.4
vs 8233
sc 0
wc 250
hzmm 115.52
is 500.00
rfl 16187.5
rfp 16151.4
th 20
ins 1.000
ai ph
DEC. & VT
dfrq 500.233
dn H1
dpwr 37
dof -500.0
dm y
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
lb 0.30
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
OH
H
H
H
H
H
N
Me
H
Cbz
H
N
H
O
O
220
200
180
160
140
120
100
80
60
40
20
ppm

(+)-2-*epi*-**83**


(+)-2-epi-83
%T
cm-1
90.2
89
88
87
86
85
84
83
82
81
80
79
78
77
76
74.6
4000.0
3000
2000
1500
1000
400.0
3423.49
2929.03
2856.60
1687.09
1661.69
1446.43
1408.77
1350.33
1299.70
1213.17
1154.12
1094.27
1020.88
1131.13
875.20
810.37
770.86
698.53

SAMPLE		DEC. & VT	
solvent	Benzene	dfrq	125.673
		dn	C13
		dpwr	30
		dof	0
		dm	nnn
		dmm	w
ACQUISITION		dmf	10000
sfrq	499.748	dseq	
tn	H1	dres	1.0
at	3.001	homo	n
np	37494	PROCESSING	
sw	6247.6	wtfile	
fb	not used	proc	ft
bs	4	fn	131072
tpwr	56	math	f
pw	8.9		
d1	2.000	werr	
tof	361.3	wexp	
nt	1024	wbs	
ct	76	wnt	wft
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-250.3		
wp	6247.5		
vs	163		
sc	0		
wc	250		
hzmm	24.98		
is	39.57		
rfl	250.4		
rfp	0		
th	7		
ins	1.000		

nm cdc ph



(–)-galbulimima alkaloid 13 (**2**)

SAMPLE	
solvent	Benzene

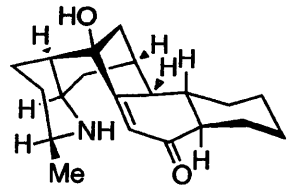
ACQUISITION	
sfrq	125.797
tn	C13
at	1.735
np	96070
sw	27681.7
fb	not used
bs	8
ss	1
tpwr	53
pw	6.9
d1	0.763
tof	1796.2
nt	120000
ct	32744
alock	n
gain	not used

FLAGS	
il	n
in	n
dp	y
hs	nn

DISPLAY	
sp	-30.6
wp	27681.2
vs	8161
sc	0
wc	250
hzmm	110.73
is	500.00
rfl	16182.4
rfp	16151.4
th	11
ins	1.000
ai	ph

DEC. & VT	
dfrq	500.233
dn	H1
dpwr	37
dof	-500.0
dm	y
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

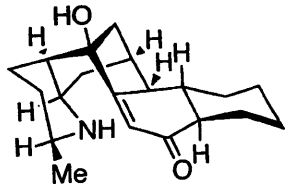
PROCESSING	
lb	0.30
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	



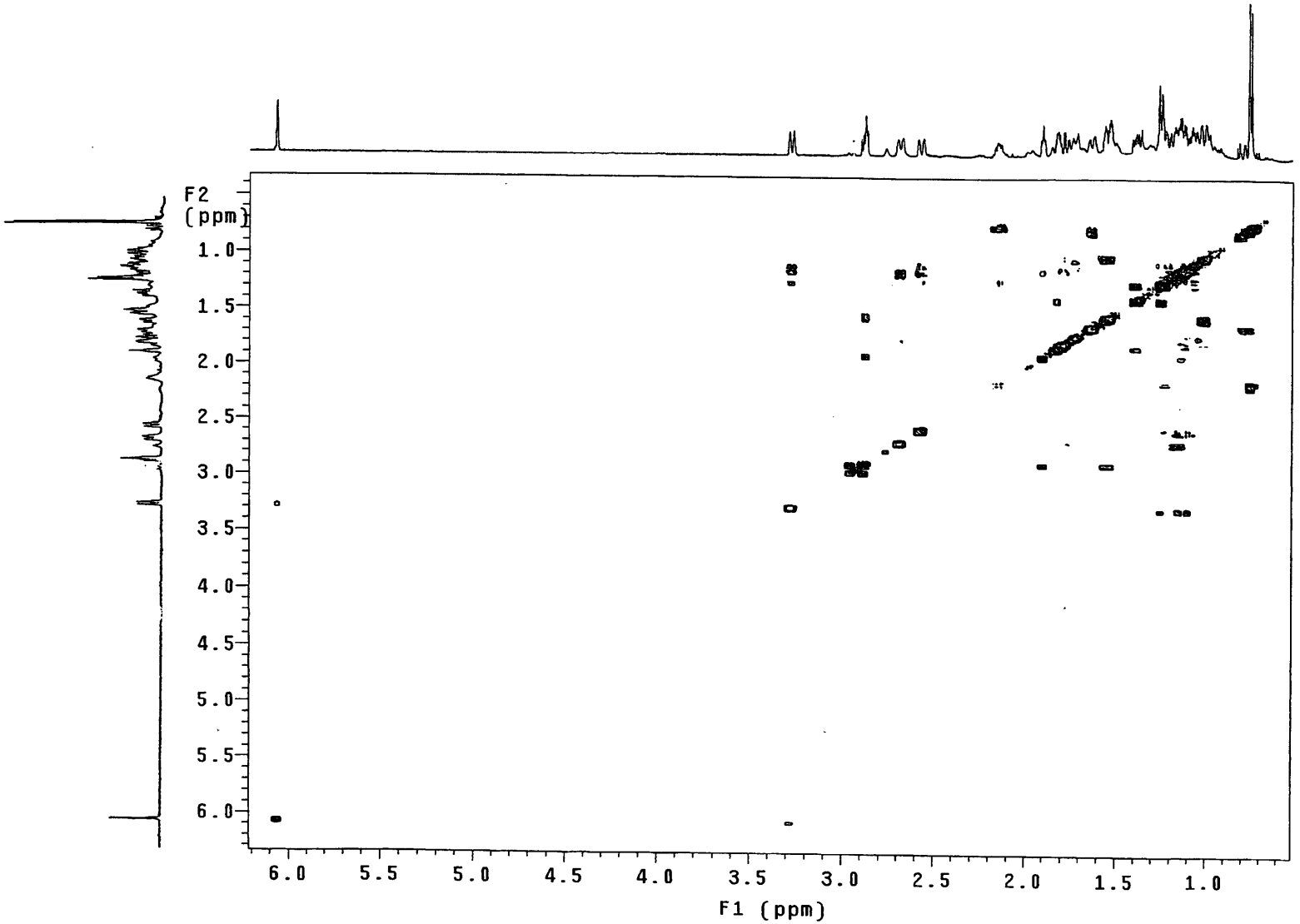
(–)-galbulimima alkaloid 13 (**2**)

Pulse Sequence: gCOSY

PULSE SEQUENCE: gCOSY
Relax. delay 1.000 sec
Acq. time 0.213 sec
Width 4801.9 Hz
2D Width 4801.9 Hz
16 repetitions
128 increments
OBSERVE H1, 499.7446819 MHz
DATA PROCESSING
Sq. sine bell 0.107 sec
F1 DATA PROCESSING
Sq. sine bell 0.027 sec
FT size 2048 x 2048
Total time 0 min, -1 sec

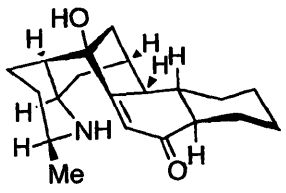


(–)-galbulimima alkaloid 13 (**2**)

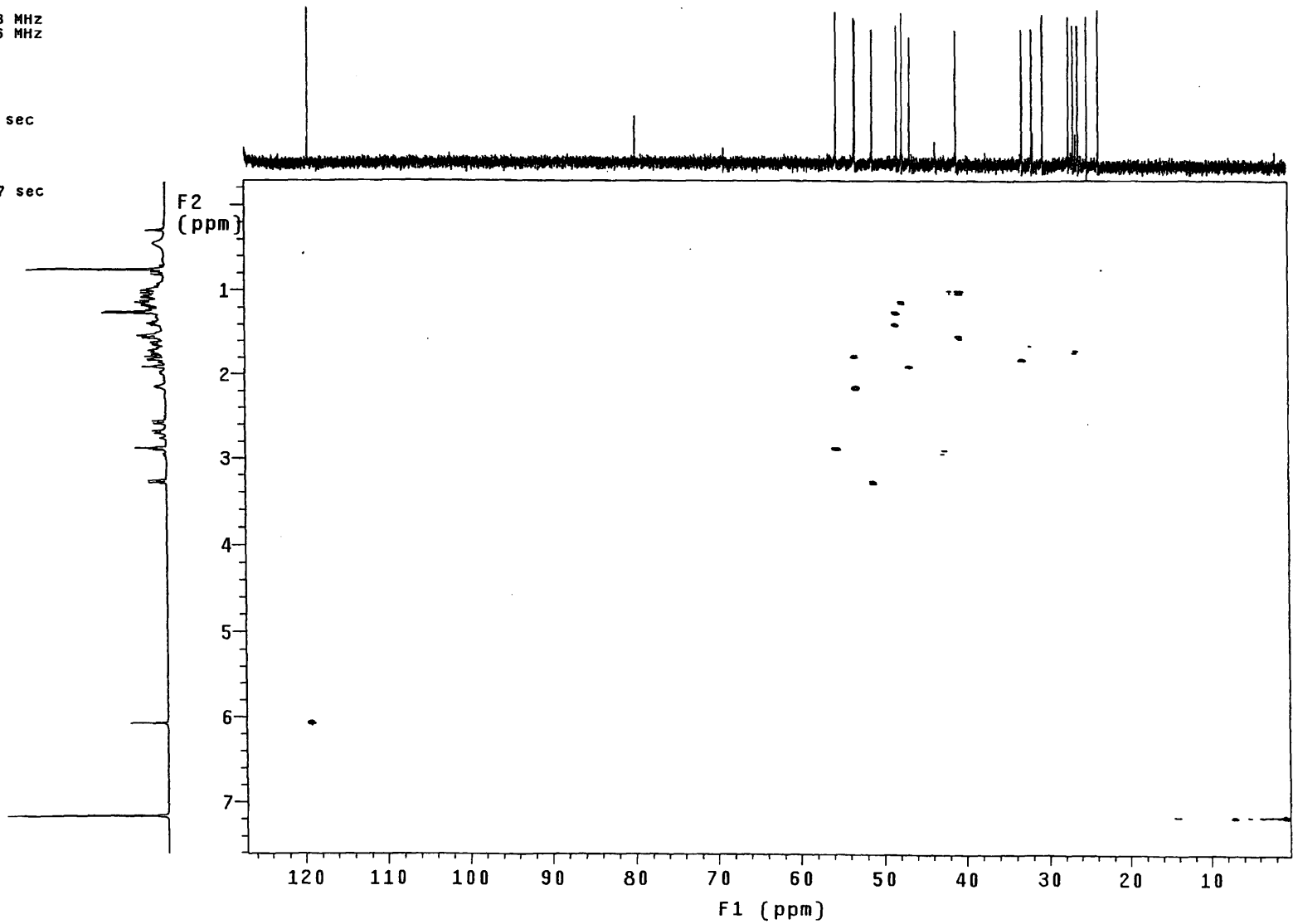


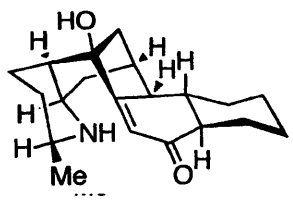
Pulse Sequence: HSQC
Solvent: Benzene
Ambient temperature
User: 1-14-87

PULSE SEQUENCE: HSQC
Relax. delay 1.000 sec
Acq. time 0.100 sec
Width 4542.4 Hz
2D Width 26490.1 Hz
36 repetitions
2 x 300 increments
OBSERVE H1, 499.7446838 MHz
DECOUPLE C13, 125.6740716 MHz
Power 52 dB
on during acquisition
off during delay
GARP-1 modulated
DATA PROCESSING
Gauss apodization 0.104 sec
F1 DATA PROCESSING
Sq. sine bell 0.019 sec
Shifted by -0.019 sec
FT size 2048 x 2048
Total time 9 hr, 2 min, 7 sec



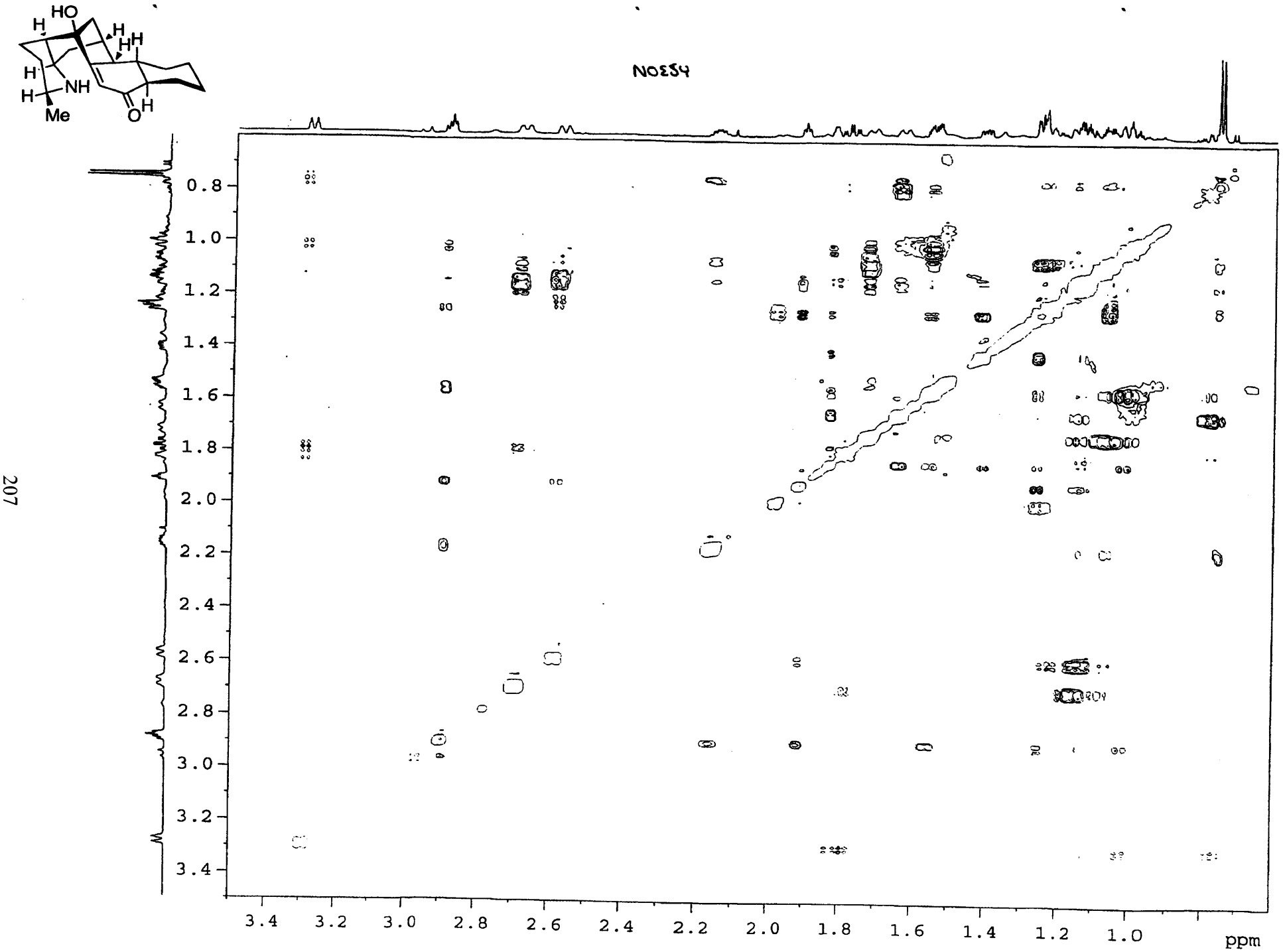
(–)-galbulimima alkaloid 13 (**2**)

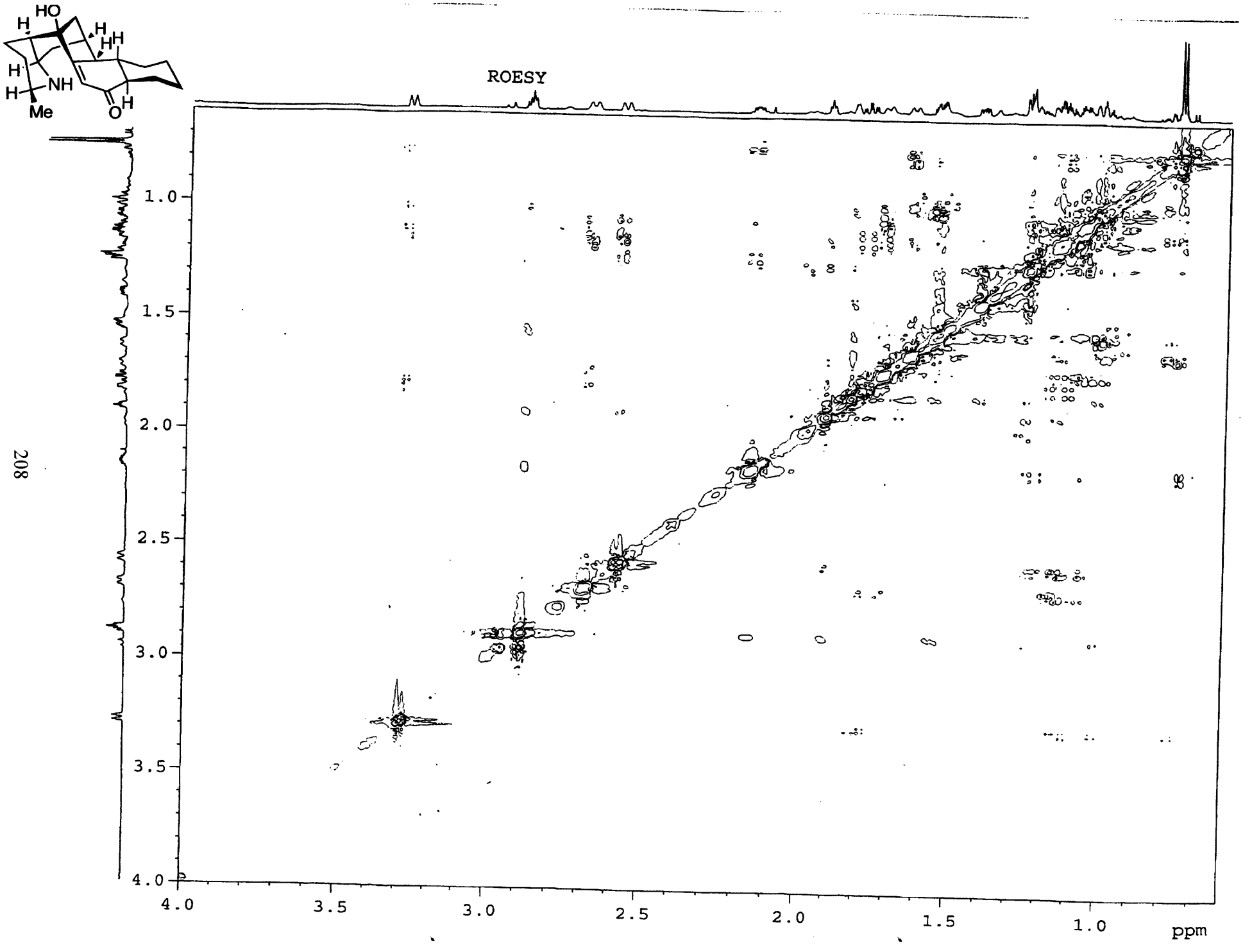


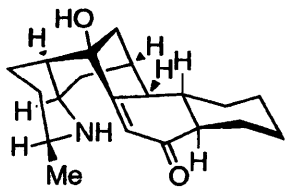

HO
H
H
H
H
NH
H
Me
O
H

HMBCLPND

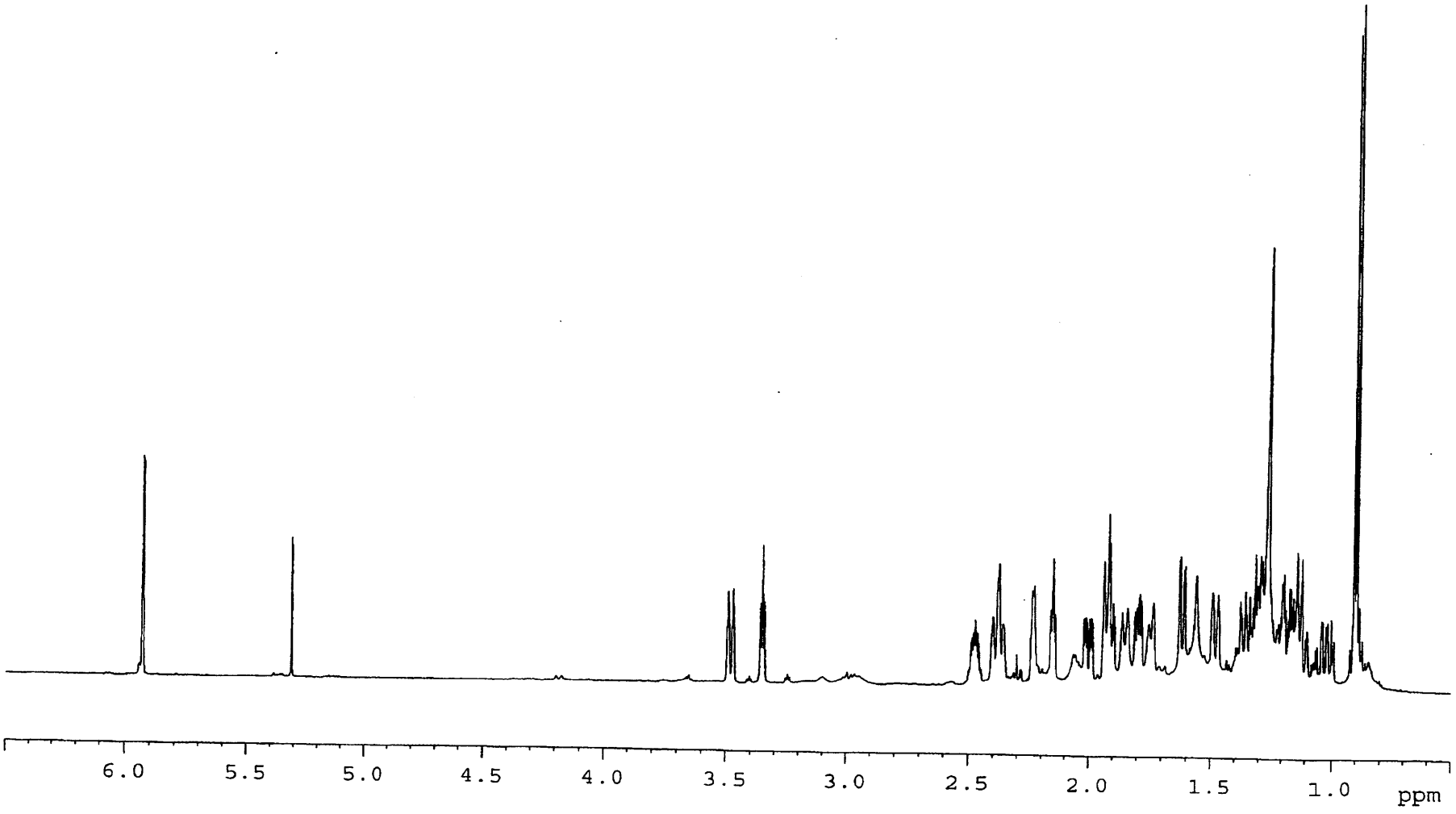
0
20
40
60
80
100
120
140
160
180
200
7
6
5
4
3
2
1
0
ppm

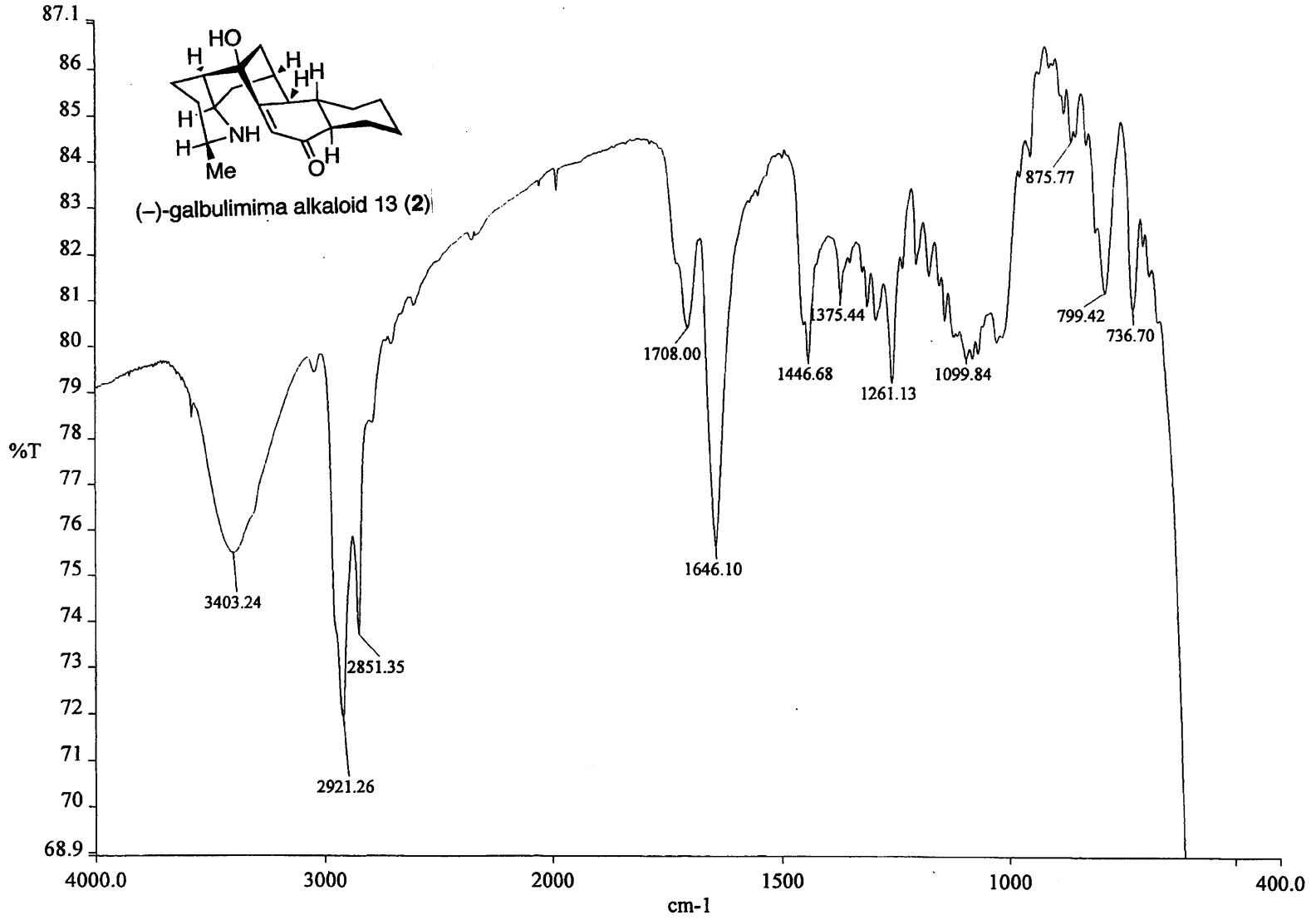

HO
H
H
H
H
NH
Me
O
H
NOESY
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
ppm


HO
H
H
HH
H
NH
H
Me
O
H
ROESY
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm



(–)-galbulimima alkaloid 13 (**2**)
in $CDCl_3$




87.1
86
85
84
83
82
81
80
79
78
77
76
75
74
73
72
71
70
68.9
%T
4000.0
3000
2000
1500
1000
400.0
cm-1
HO
H
H
H
H
H
NH
H
Me
O
H
(–)-galbulimima alkaloid 13 (2)
3403.24
2921.26
2851.35
1708.00
1646.10
1446.68
1375.44
1261.13
1099.84
875.77
799.42
736.70

SAMPLE	
solvent	Benzene

ACQUISITION	
sfrq	499.748
tn	H1
at	3.001
np	37494
sw	6247.6
fb	not used
bs	4
tpwr	56
pw	8.9
d1	2.000
tof	360.8
nt	1024
ct	112
alock	n
gain	not used

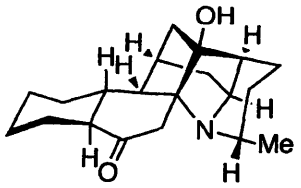
FLAGS	
il	n
in	n
dp	y
hs	nn

DISPLAY	
sp	-250.3
wp	6247.5
vs	141
sc	0
wc	250
hzmm	24.99
is	33.57
rfl	250.4
rfp	0
th	7
ins	3.000

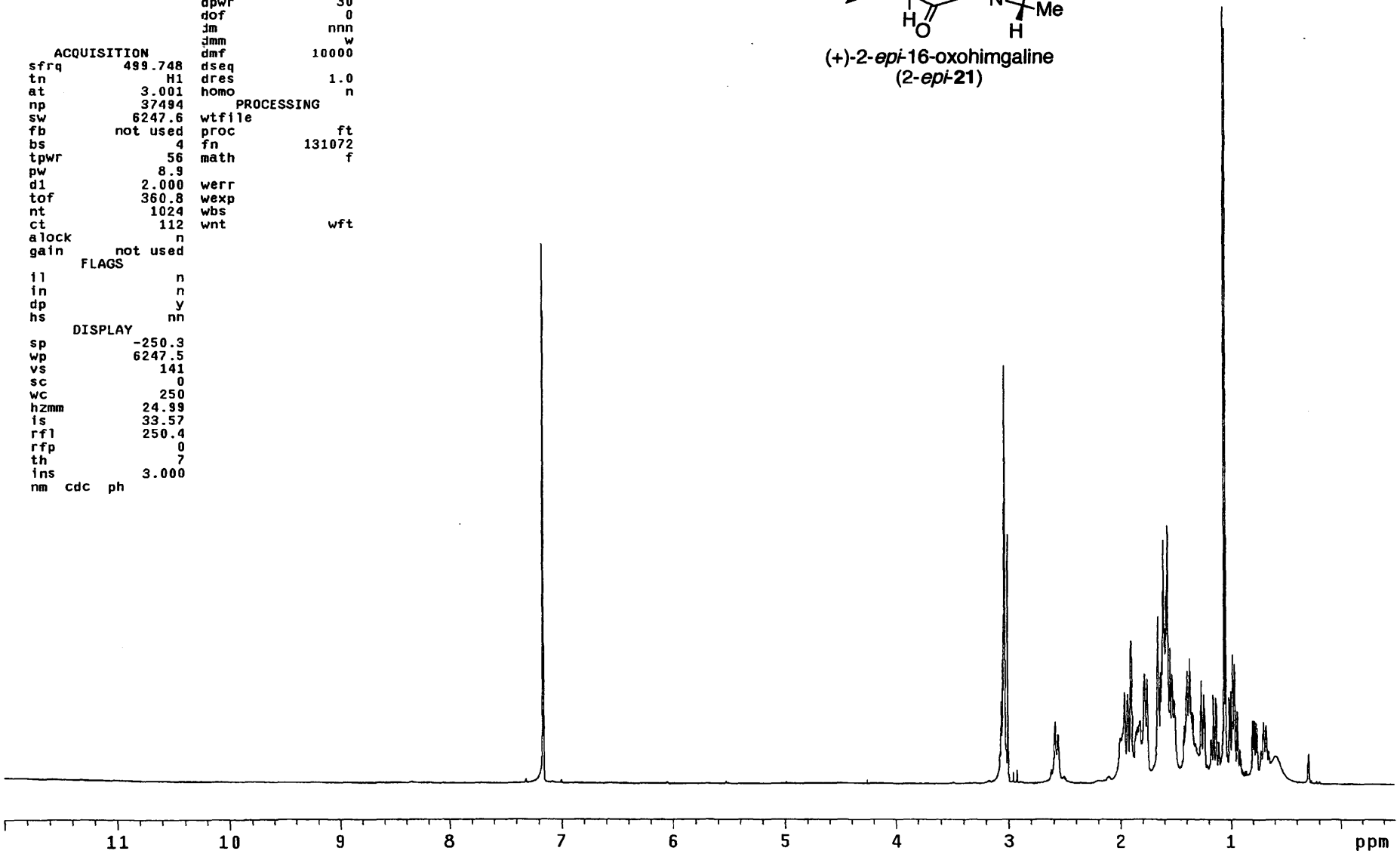
nm cdc ph

DEC. & VT	
dfrq	125.673
dn	C13
dpwr	30
dof	0
dm	nnn
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

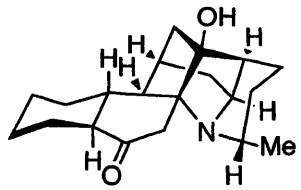
PROCESSING	
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	wft



(+)-2-*epi*-16-oxohimgaline
(2-*epi*-**21**)



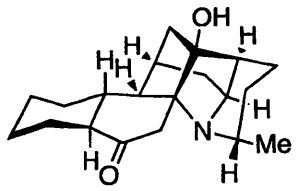
SAMPLE		DEC. & VT	
solvent	Benzene	dfrq	500.233
		dn	H1
		dpwr	37
		dof	-500.0
		dm	y
		dmm	w
ACQUISITION		dmf	10000
sfrq	125.797	dseq	
tn	C13	dres	1.0
at	1.736	homo	n
np	97624	PROCESSING	
sw	28119.5	lb	0.30
fb	not used	wtfile	
bs	8	proc	ft
ss	1	fn	131072
tpwr	53	math	f
pw	6.9		
d1	0.763	werr	
tof	2069.0	wexp	
nt	1e+06	wbs	
ct	60256	wnt	
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	22.6		
wp	28119.1		
vs	10530		
sc	0		
wc	250		
hzmm	112.48		
is	500.00		
rfl	16129.2		
rfp	16151.4		
th	6		
ins	1.000		
ai	ph		



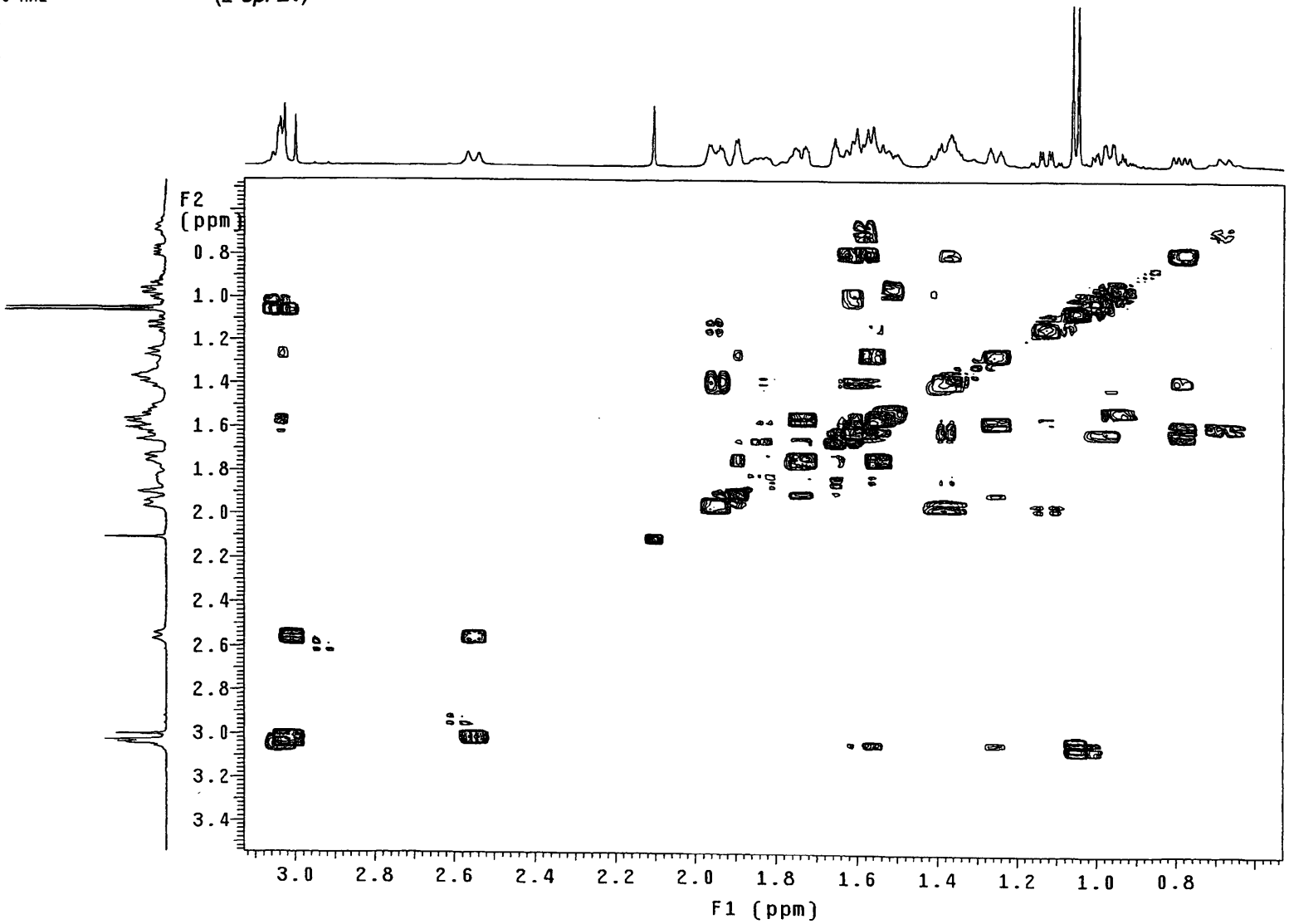
(+)-2-*epi*-16-oxohimgaline
(2-*epi*-**21**)

Pulse Sequence: gCOSY
Solvent: Benzene
Ambient temperature

PULSE SEQUENCE: gCOSY
Relax. delay 1.000 sec
Acq. time 0.227 sec
Width 4507.6 Hz
2D Width 4507.6 Hz
64 repetitions
128 increments
OBSERVE H1, 499.7446840 MHz
DATA PROCESSING
Sq. sine bell 0.113 sec
F1 DATA PROCESSING
Sq. sine bell 0.028 sec
FT size 2048 x 2048
Total time 0 min, -1 sec

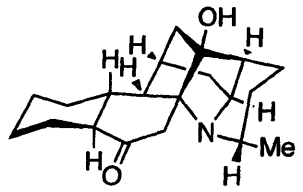


(+)-2-*epi*-16-oxohimgaline
(2-*epi*-**21**)

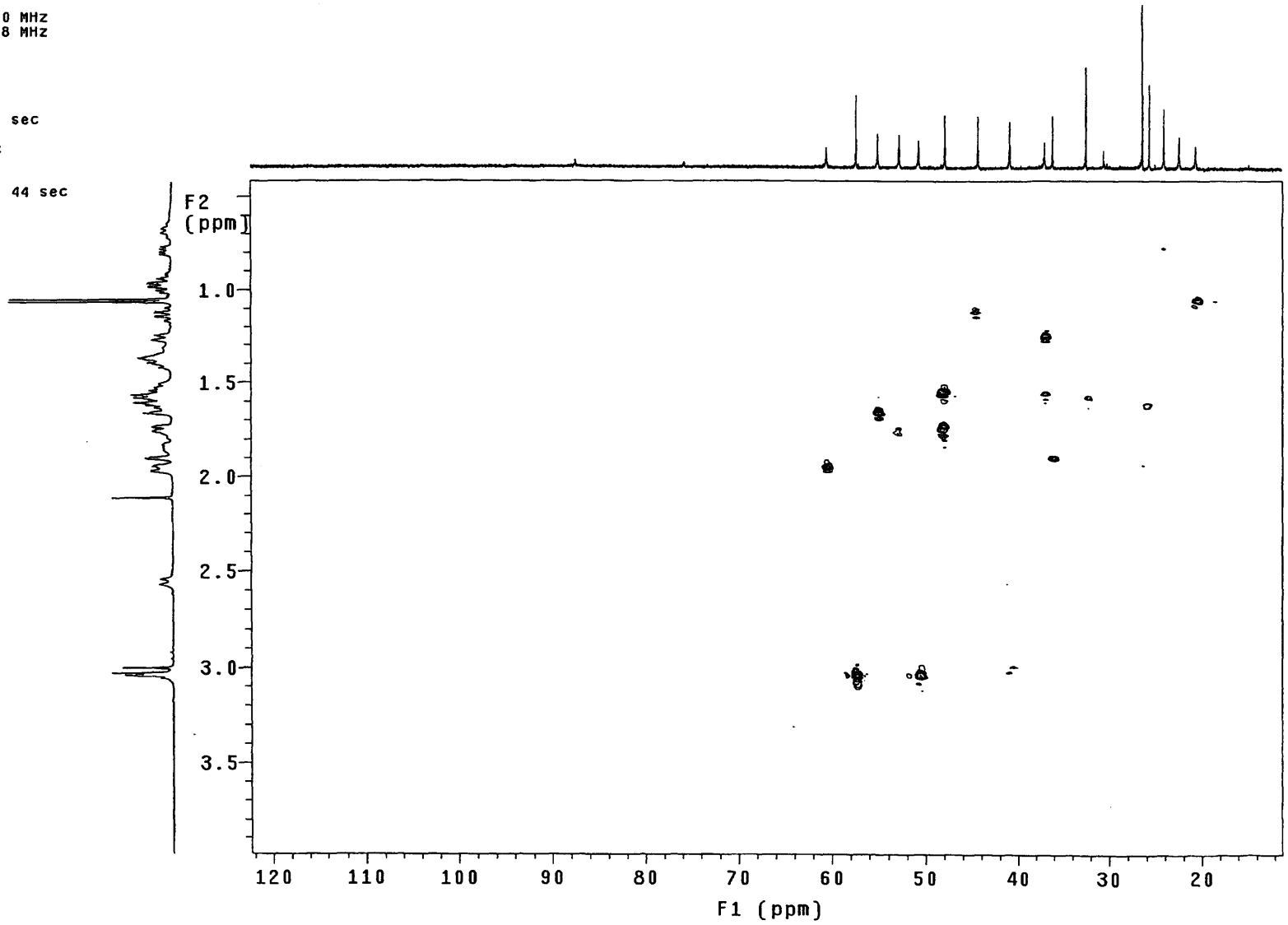


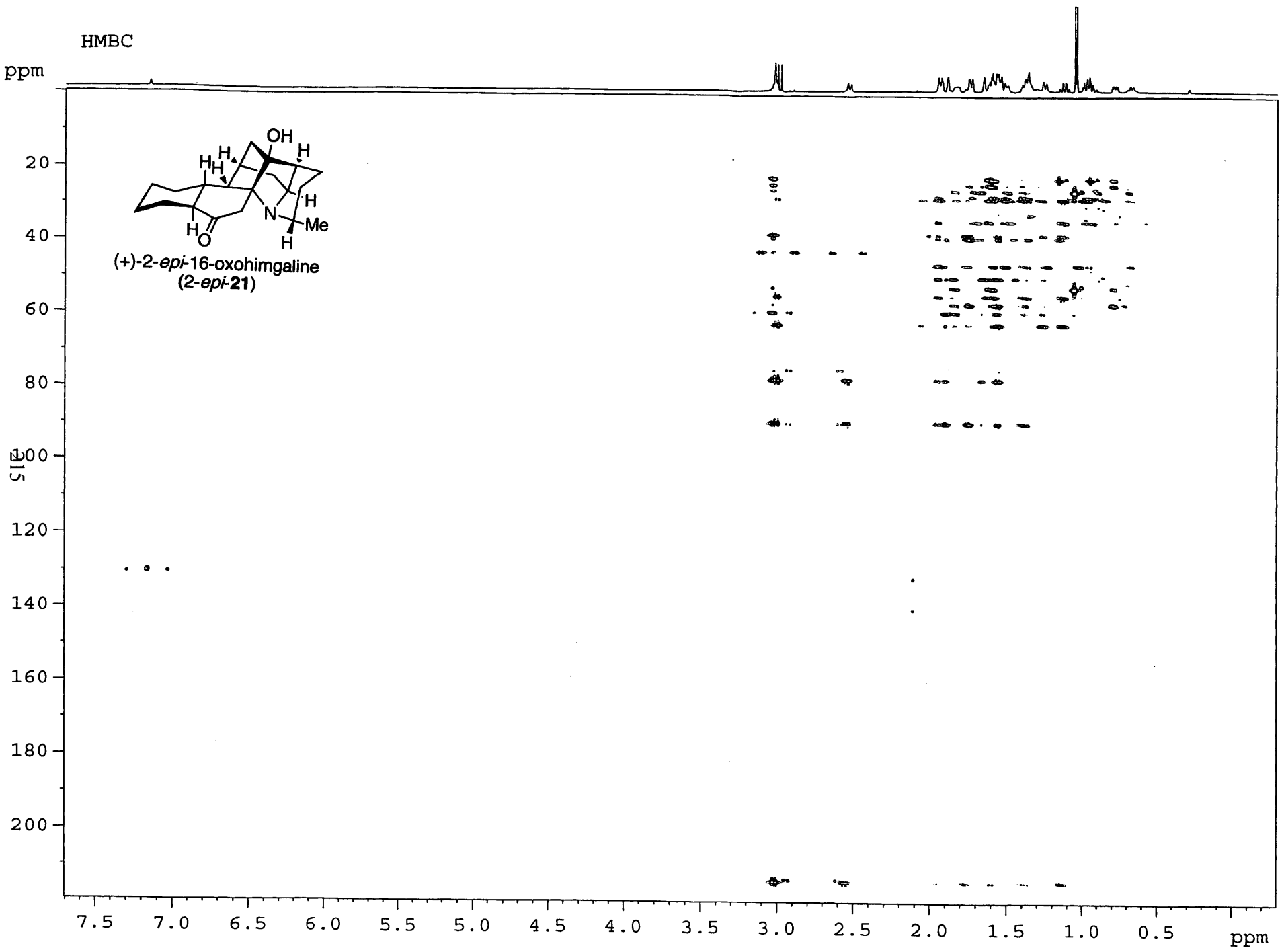
Pulse Sequence: HSQC
Solvent: Benzene
Ambient temperature

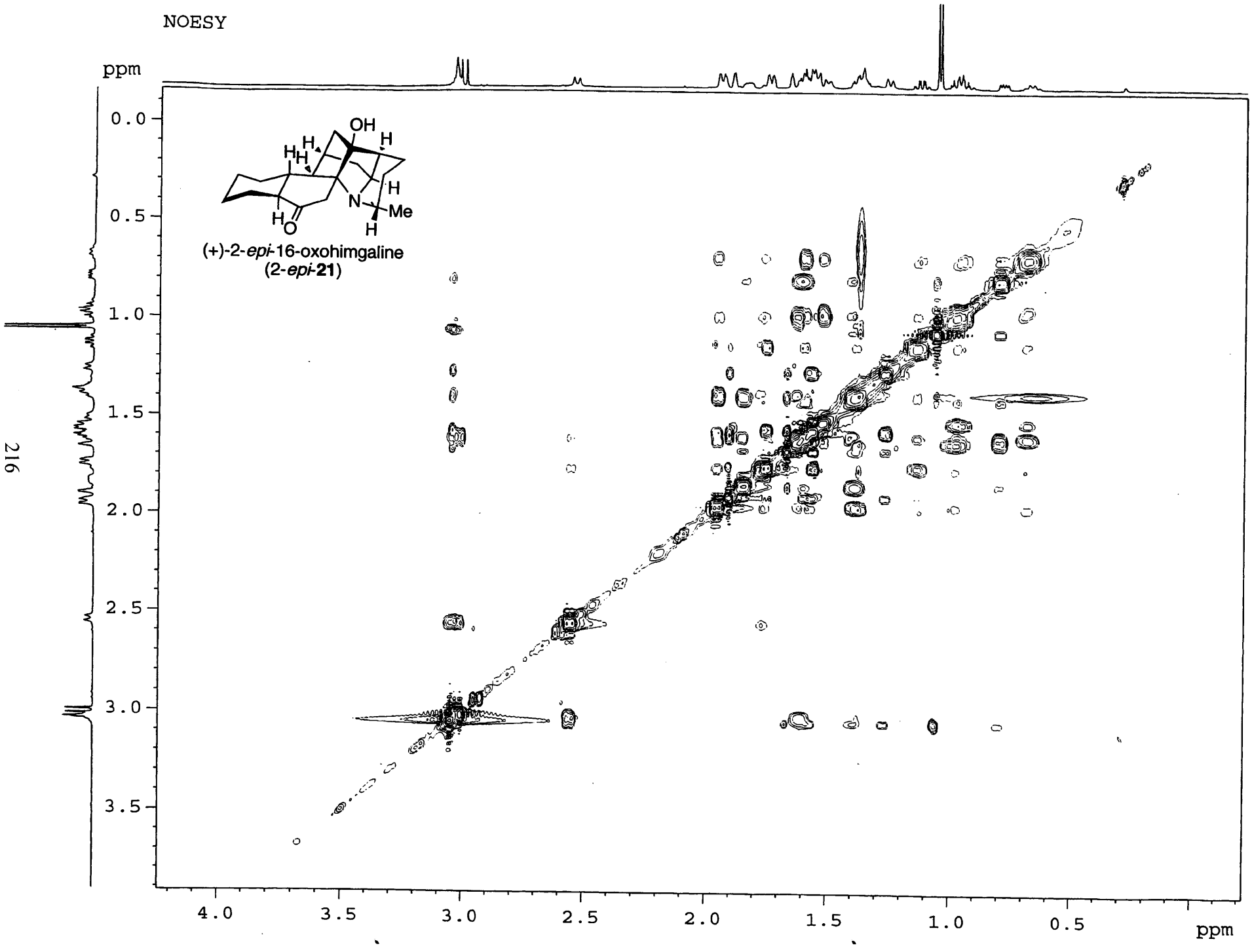
PULSE SEQUENCE: HSQC
Relax. delay 1.000 sec
Acq. time 0.227 sec
Width 4507.6 Hz
2D Width 27662.5 Hz
32 repetitions
2 x 256 increments
OBSERVE H1, 499.7446840 MHz
DECOUPLE C13, 125.6746698 MHz
Power 52 dB
on during acquisition
off during delay
GARP-1 modulated
DATA PROCESSING
Gauss apodization 0.105 sec
F1 DATA PROCESSING
Sq. sine bell 0.019 sec
Shifted by -0.019 sec
FT size 2048 x 2048
Total time 7 hr, 27 min, 44 sec



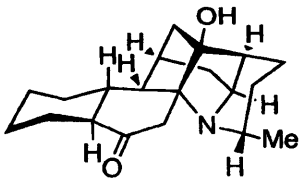
(+)-2-*epi*-16-oxohimgaline
(2-*epi*-**21**)




HMBC
ppm
OH
H
H
H
H
N
Me
H
H
O
(+)-2-epi-16-oxohimgaline
(2-epi-21)
20
40
60
80
100
120
140
160
180
200
215
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm

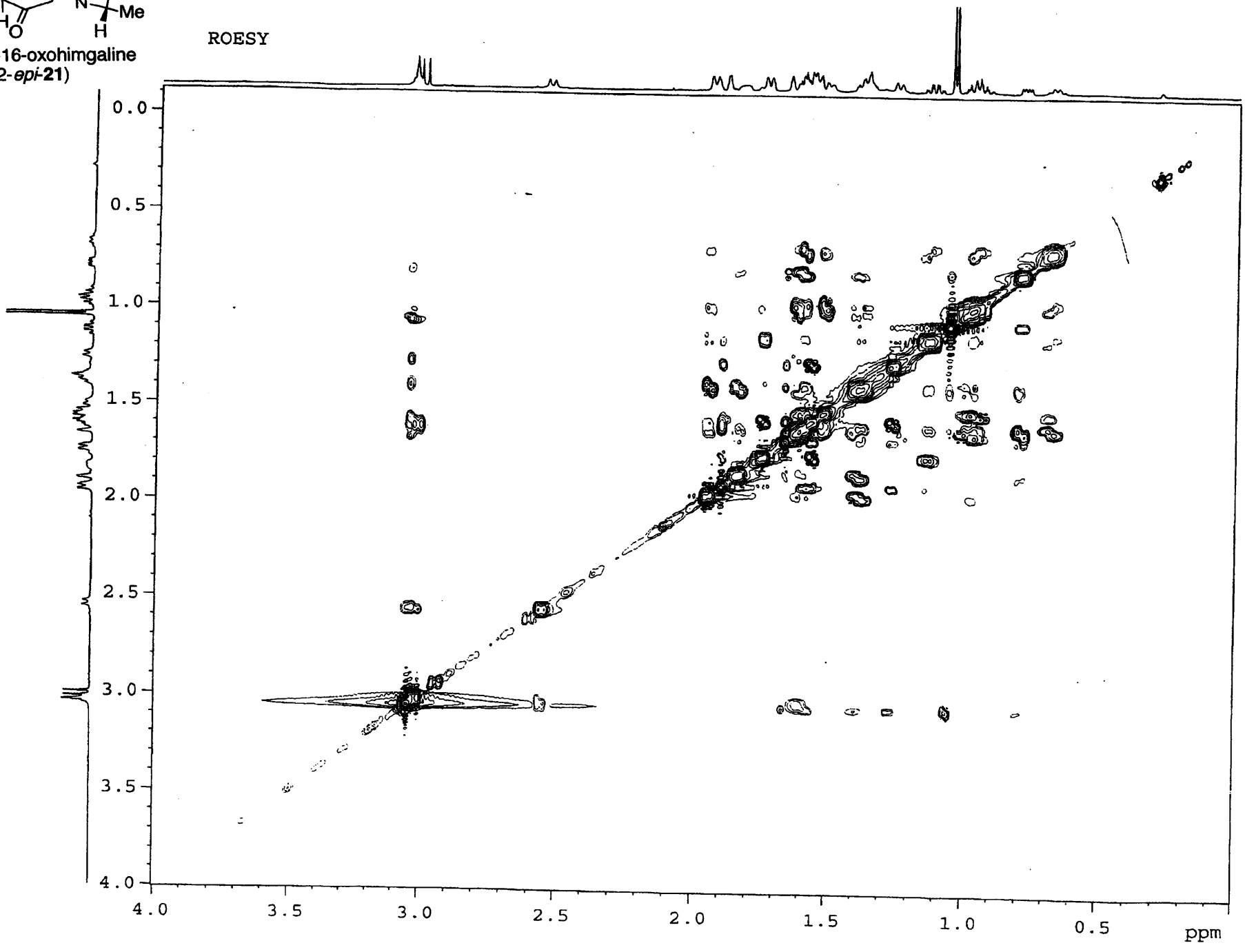


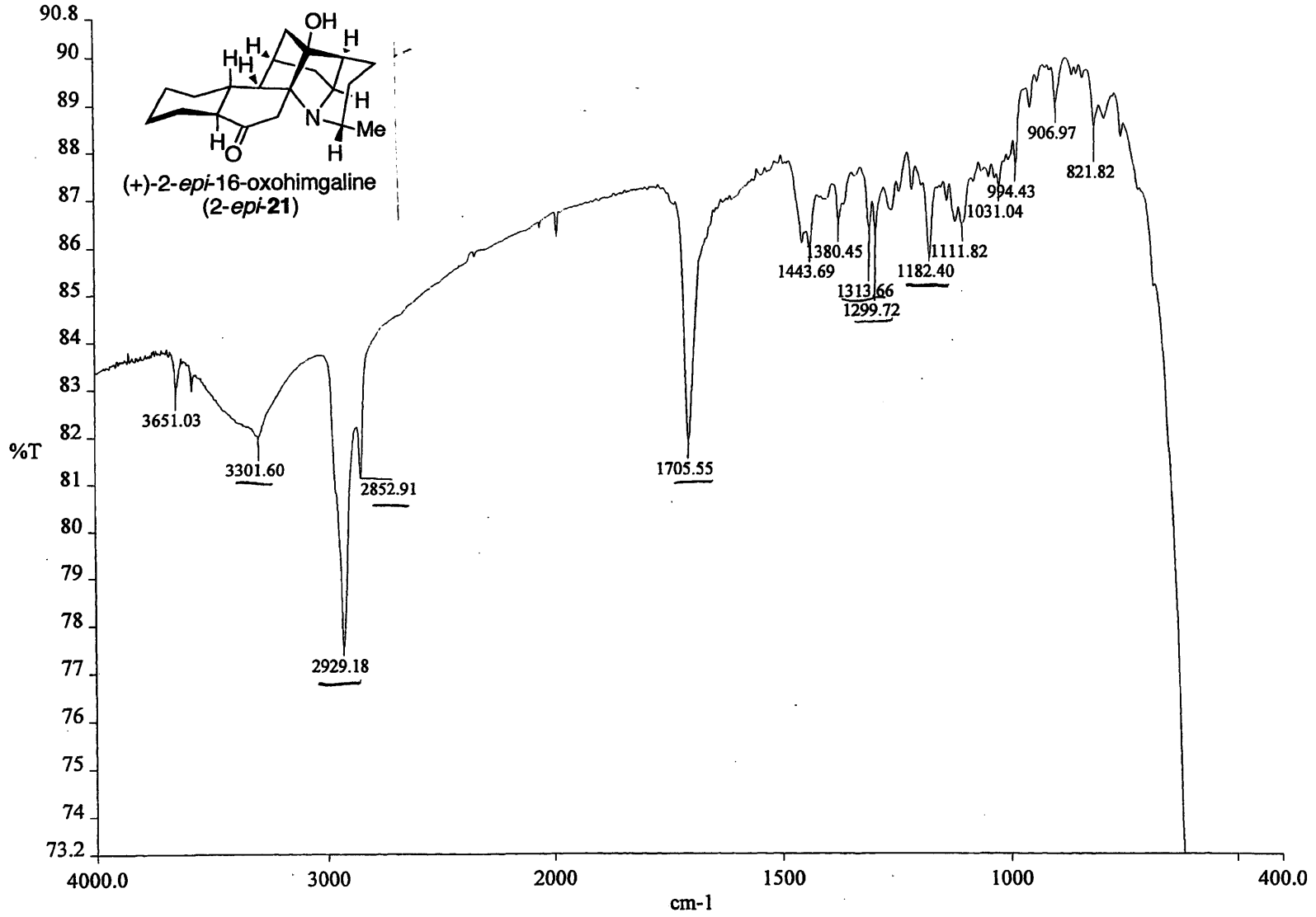
(+)-2-*epi*-16-oxohimgaline
(2-*epi*-**21**)

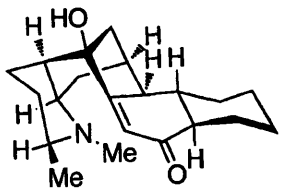


(+)-2-*epi*-16-oxohimgaline
(2-*epi*-**21**)

ROESY

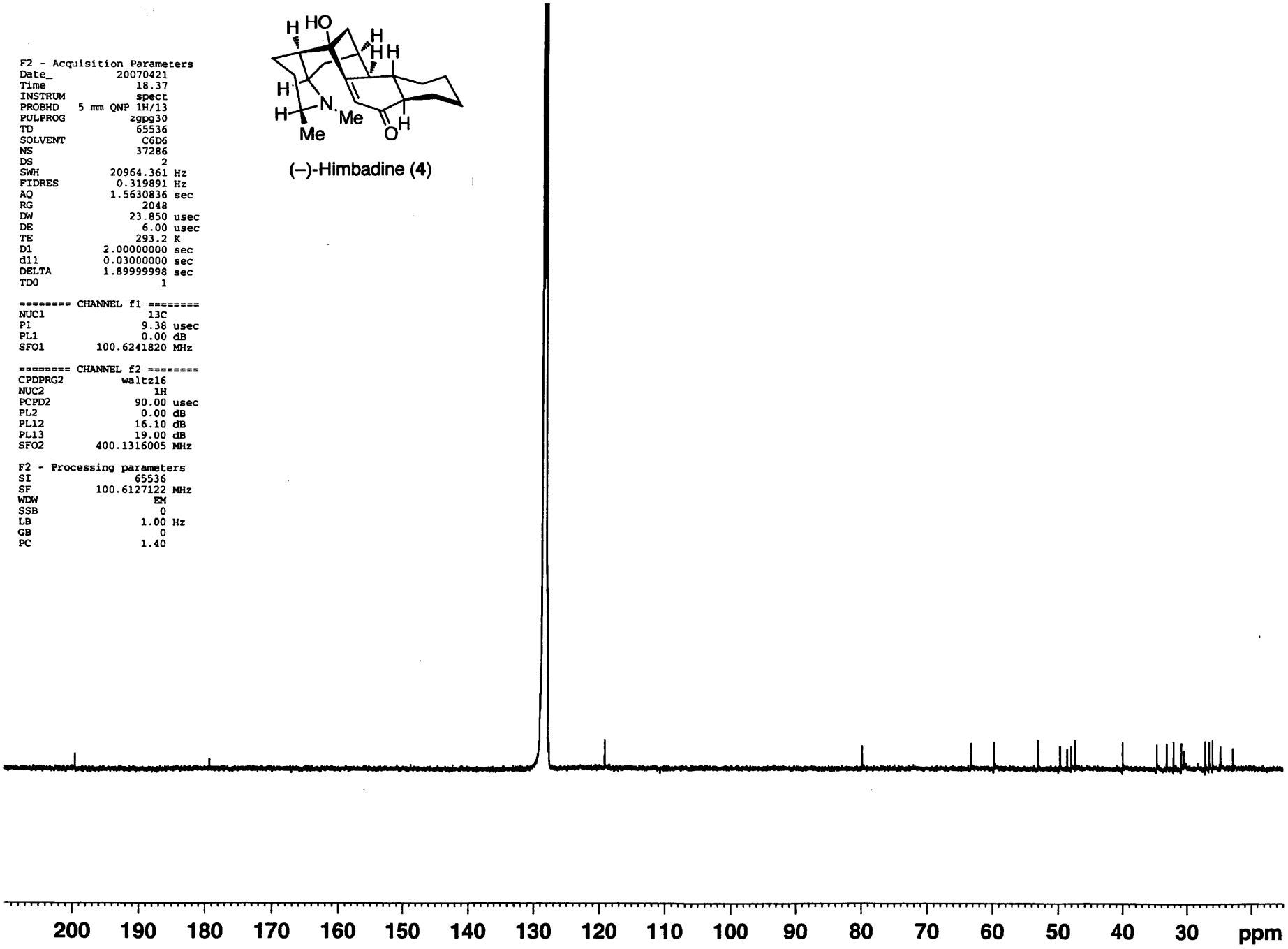


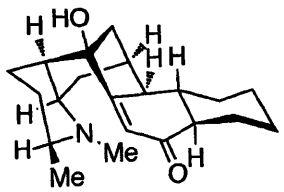

(+)-2-epi-16-oxohimgaline
(2-epi-21)
%T
cm-1
3651.03
3301.60
2929.18
2852.91
1705.55
1443.69
1380.45
1313.66
1299.72
1182.40
1111.82
1031.04
994.43
906.97
821.82



(–)-Himbadine (**4**)

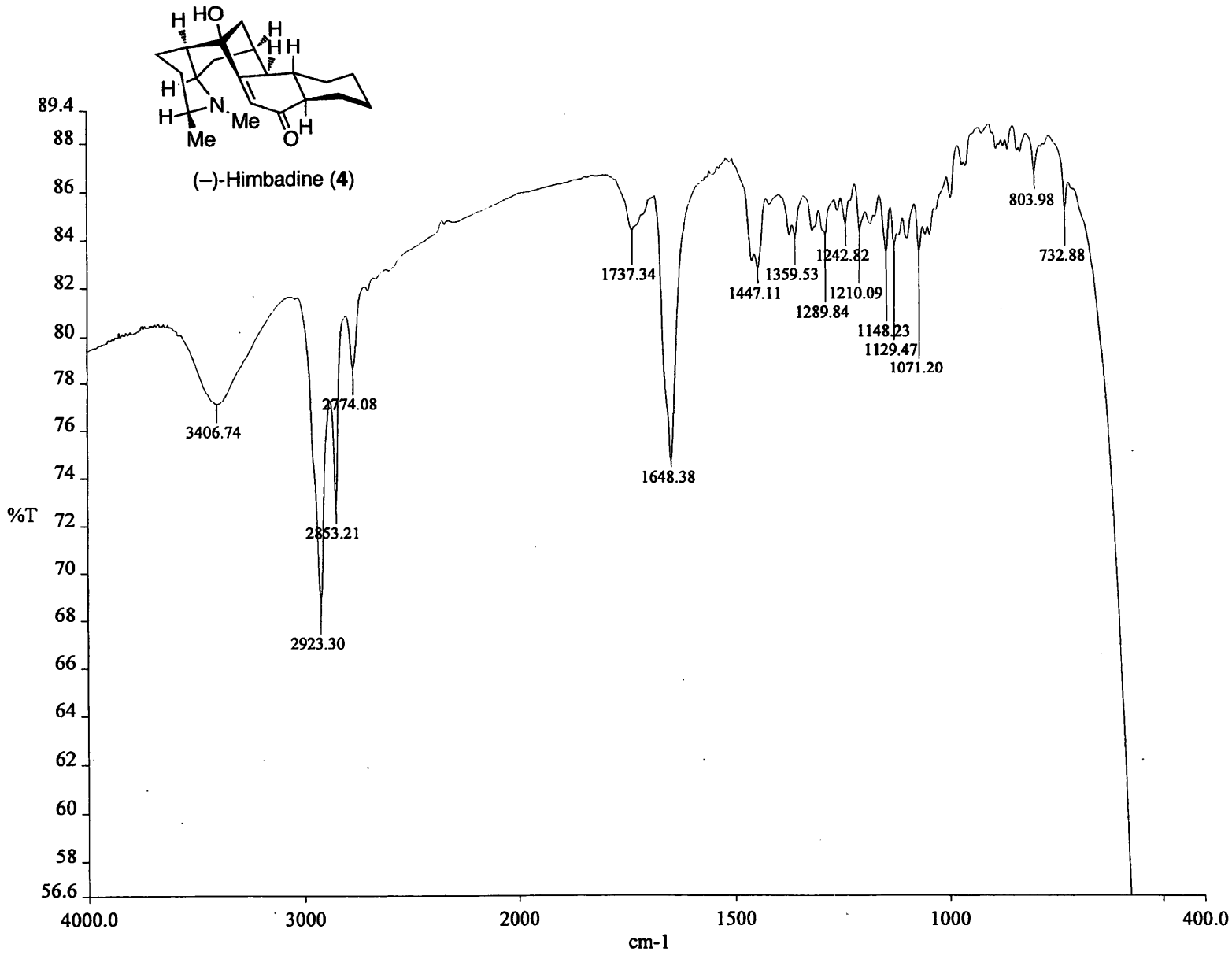
```
F2 - Acquisition Parameters
Date_            20090221
Time                17.40
INSTRUM             spect
PROBHD   5 mm CPTXI 1H-
PULPROG             zg30
TD                 65536
SOLVENT             C6D6
NS                    26
DS                     2
SWH             12376.237 Hz
FIDRES          0.188846 Hz
AQ              2.6477449 sec
RG                    57
DW                40.400 usec
DE                 6.00 usec
TE                305.0 K
D1           1.00000000 sec
TD0                    1

======== CHANNEL f1 ========
NUC1                  1H
P1                 11.00 usec
PL1                 4.00 dB
SFO1         600.1337060 MHz

F2 - Processing parameters
SI                 65536
SF           600.1300681 MHz
WDW                   EM
SSB                    0
LB                  0.30 Hz
GB                     0
PC                  1.00
```


F2 - Acquisition Parameters
Date_ 20070421
Time 18.37
INSTRUM spect
PROBHD 5 mm QNP 1H/13
PULPROG zgpg30
TD 65536
SOLVENT C6D6
NS 37286
DS 2
SWH 20964.361 Hz
FIDRES 0.319891 Hz
AQ 1.5630836 sec
RG 2048
DW 23.850 usec
DE 6.00 usec
TE 293.2 K
D1 2.00000000 sec
d11 0.03000000 sec
DELTA 1.89999998 sec
TD0 1
======== CHANNEL f1 ========
NUC1 13C
P1 9.38 usec
PL1 0.00 dB
SFO1 100.6241820 MHz
======== CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 90.00 usec
PL2 0.00 dB
PL12 16.10 dB
PL13 19.00 dB
SFO2 400.1316005 MHz
F2 - Processing parameters
SI 65536
SF 100.6127122 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
(–)-Himbadine (4)
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 ppm



(–)-Himbadine (**4**)

```
F2 - Acquisition Parameters
Date_            20090220
Time                18.43
INSTRUM             spect
PROBHD   5 mm CPTXI 1H-
PULPROG             zg30
TD                 65536
SOLVENT            CDCl3
NS                    63
DS                     2
SWH            12376.237 Hz
FIDRES          0.188846 Hz
AQ             2.6477044 sec
RG                  40.3
DW                40.400 usec
DE                 6.00 usec
TE                305.0 K
D1            1.00000000 sec
TD0                    1

======== CHANNEL f1 ========
NUC1                  1H
P1                 11.00 usec
PL1                 4.00 dB
SFO1         600.1337060 MHz

F2 - Processing parameters
SI                 65536
SF           600.1300277 MHz
WDW                   EM
SSB                    0
LB                  0.30 Hz
GB                     0
PC                  1.00
```


(–)-Himbadine (4)
%T
cm-1
89.4
88
86
84
82
80
78
76
74
72
70
68
66
64
62
60
58
56.6
4000.0
3000
2000
1500
1000
400.0
3406.74
2923.30
2853.21
2774.08
1737.34
1648.38
1447.11
1359.53
1289.84
1242.82
1210.09
1148.23
1129.47
1071.20
803.98
732.88

solvent	CDCl3

ACQUISITION	
sfrq	499.745
tn	H1
at	3.001
np	37494
sw	6247.6
fb	not used
bs	4
tpwr	56
pw	8.6
d1	2.000
tof	374.6
nt	1000
ct	420
alock	n
gain	not used

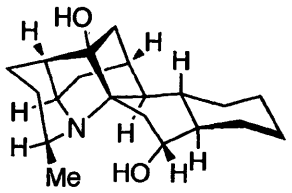
FLAGS	
il	n
in	n
dp	y
hs	nn

DISPLAY	
sp	-250.4
wp	6247.5
vs	113
sc	0
wc	250
hzmm	24.99
is	33.57
rfl	250.4
rfp	0
th	7
ins	100.000

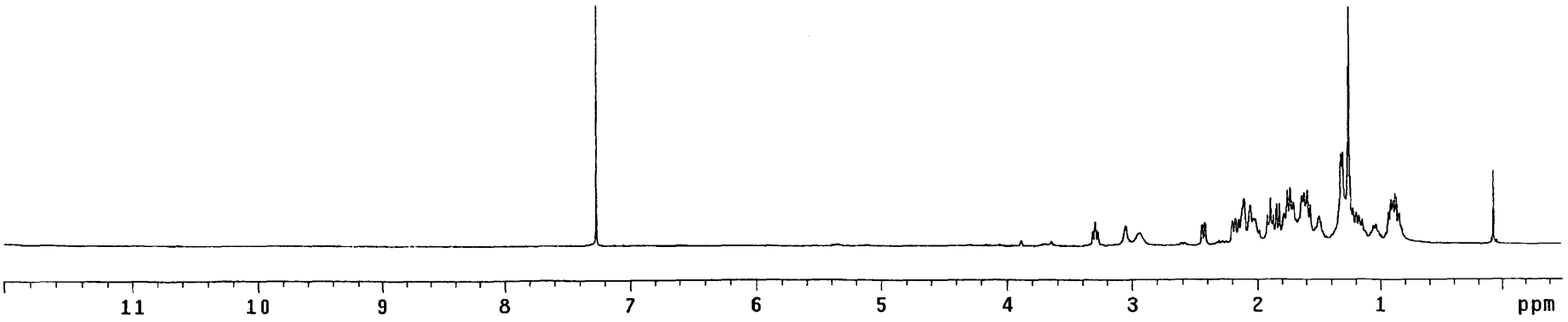
ai cdc ph

DEC. & VT	
dfrq	125.672
dn	C13
dpwr	30
dof	0
dm	nnn
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

PROCESSING	
wtfile	
proc	ft
fn	262144
math	f
werr	
wexp	
wbs	
wnt	wft



(–)-Himgaline (**3**)



solvent	CDCl3

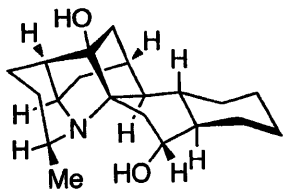
ACQUISITION	
sfrq	125.796
tn	C13
at	1.735
np	87286
sw	25157.2
fb	not used
bs	4
ss	1
tpwr	53
pw	6.9
d1	0.763
tof	630.8
nt	1e+06
ct	20704
alock	n
gain	not used

FLAGS	
il	n
in	n
dp	y
hs	nn

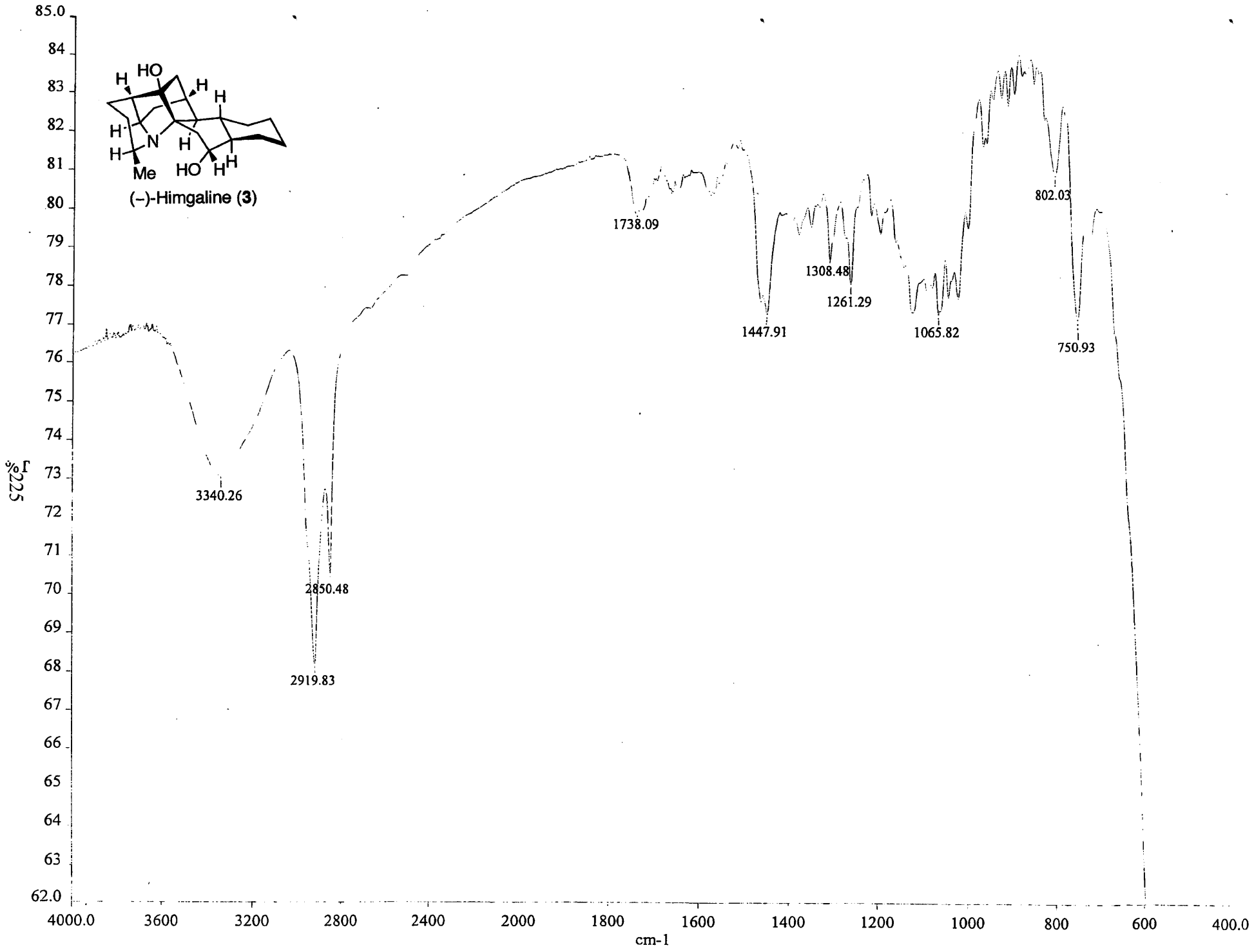
DISPLAY	
sp	1255.7
wp	23867.4
vs	1873
sc	0
wc	250
hzmm	95.47
is	500.00
rfl	9715.0
rfp	9714.2
th	18
ins	1.000
ai	ph

DEC. & VT	
dfrq	500.233
dn	H1
dpwr	37
dof	-500.0
dm	y
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

PROCESSING	
lb	0.30
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	

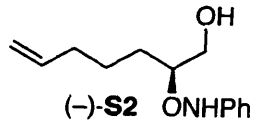


(–)-Himgaline (**3**)

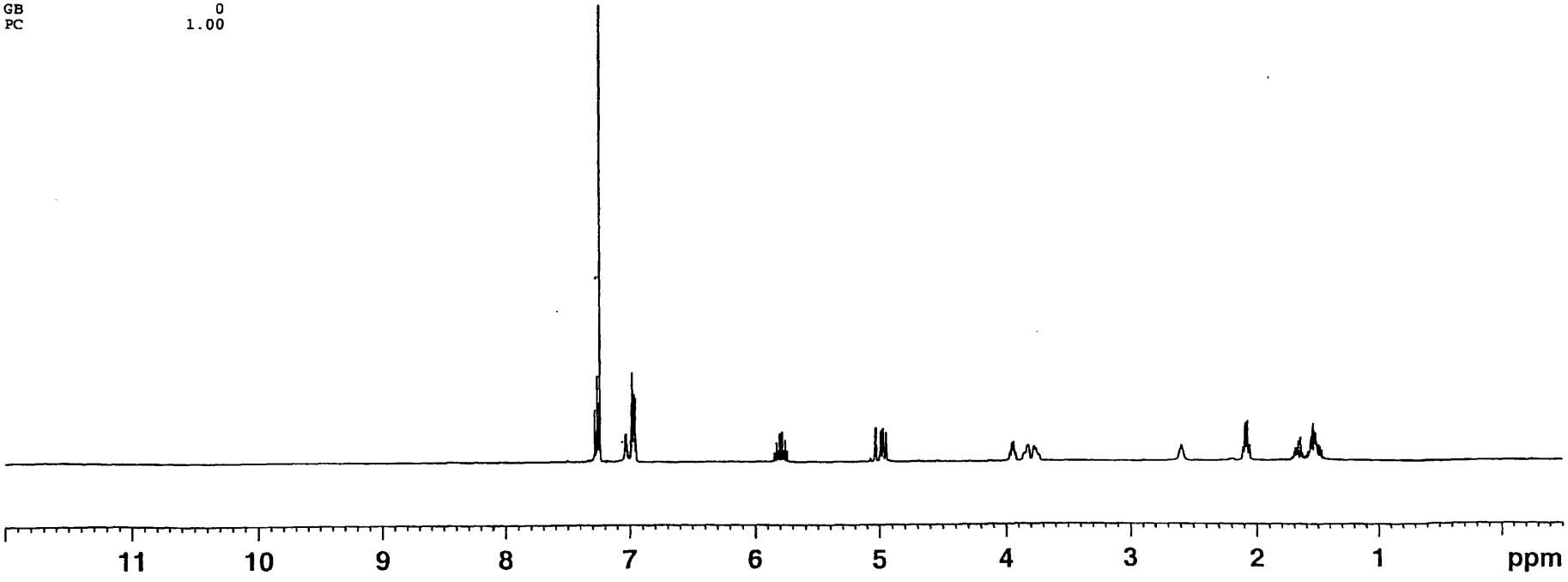

(–)-Himgaline (3)
3340.26
2919.83
2850.48
1738.09
1447.91
1308.48
1261.29
1065.82
802.03
750.93
%225
cm-1
85.0
84
83
82
81
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
64
63
62.0
4000.0
3600
3200
2800
2400
2000
1800
1600
1400
1200
1000
800
600
400.0

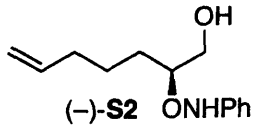
Appendix B.

Spectra for Chapter II

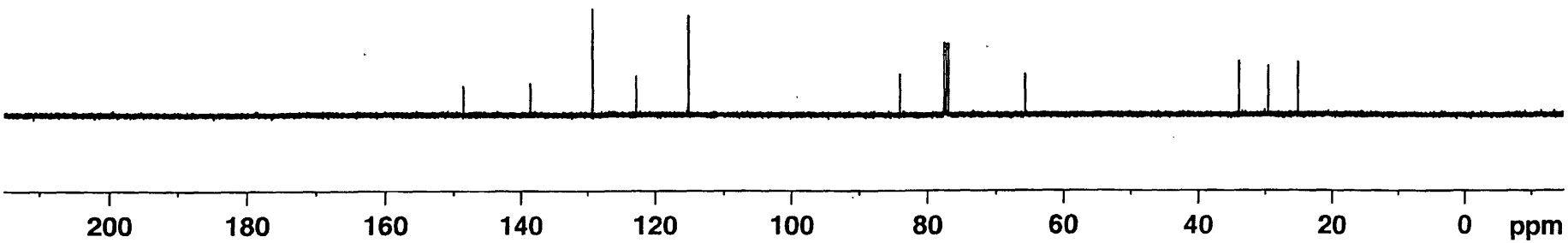


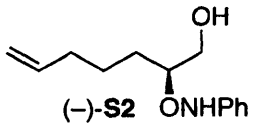

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD    5 mm QNP 1H/13
PULPROG              zg30
TD                  65536
SOLVENT             CDCl3
NS                     16
DS                      2
SWH              8278.146 Hz
FIDRES           0.126314 Hz
AQ               3.9584243 sec
RG                   203.2
DW                  60.400 usec
DE                   6.00 usec
TE                  293.2 K
D1             1.00000000 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                   1H
P1                  14.00 usec
PL1                  0.00 dB
SFO1         400.1324710 MHz

F2 - Processing parameters
SI                  65536
SF           400.1300178 MHz
WDW                    no
SSB                     0
LB                   0.00 Hz
GB                      0
PC                   1.00
```

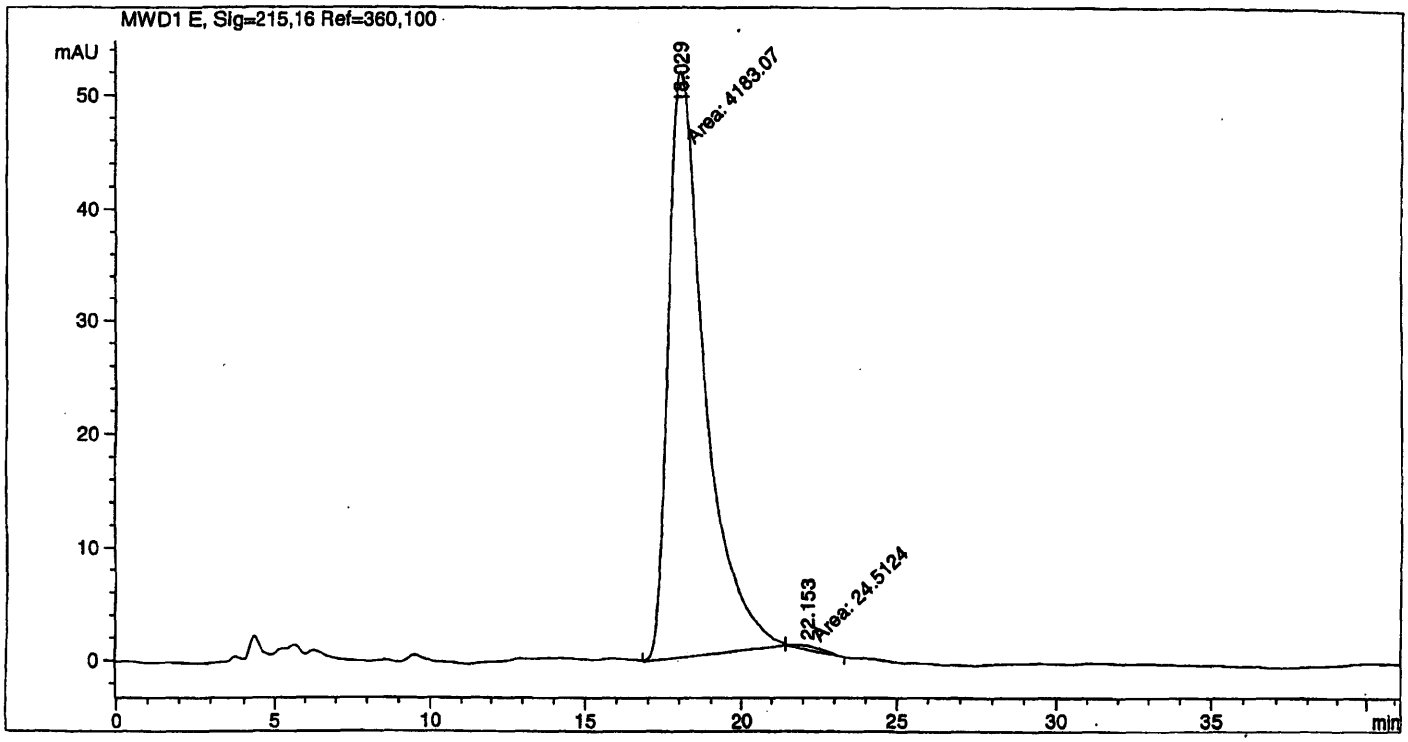




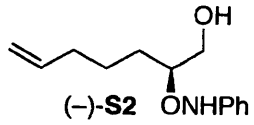

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD    5 mm QNP 1H/13
PULPROG             zgpg30
TD                   65536
SOLVENT              CDCl3
NS                     128
DS                       2
SWH              23980.814 Hz
FIDRES           0.365918 Hz
AQ               1.3664756 sec
RG                  2580.3
DW                  20.850 usec
DE                    6.00 usec
TE                   294.2 K
D1               2.00000000 sec
d11              0.03000000 sec
DELTA            1.89999998 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                   13C
P1                    9.38 usec
PL1                   0.00 dB
SFO1          100.6228298 MHz

======== CHANNEL f2 ========
CPDPRG2            waltz16
NUC2                    1H
PCPD2                90.00 usec
PL2                   0.00 dB
PL12                 16.10 dB
PL13                 19.00 dB
SFO2          400.1316005 MHz

F2 - Processing parameters
SI                   65536
SF            100.6127509 MHz
WDW                     no
SSB                      0
LB                    0.00 Hz
GB                       0
PC                    1.40
```

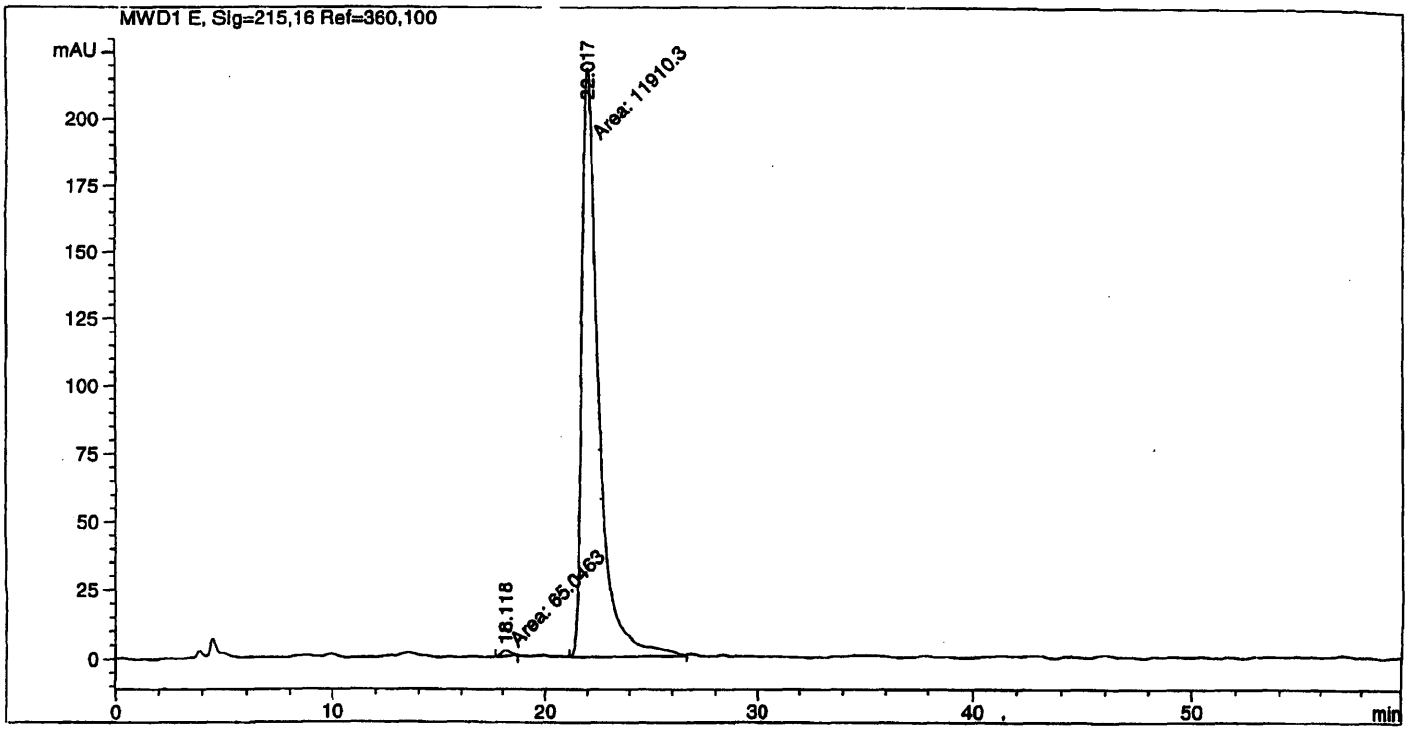





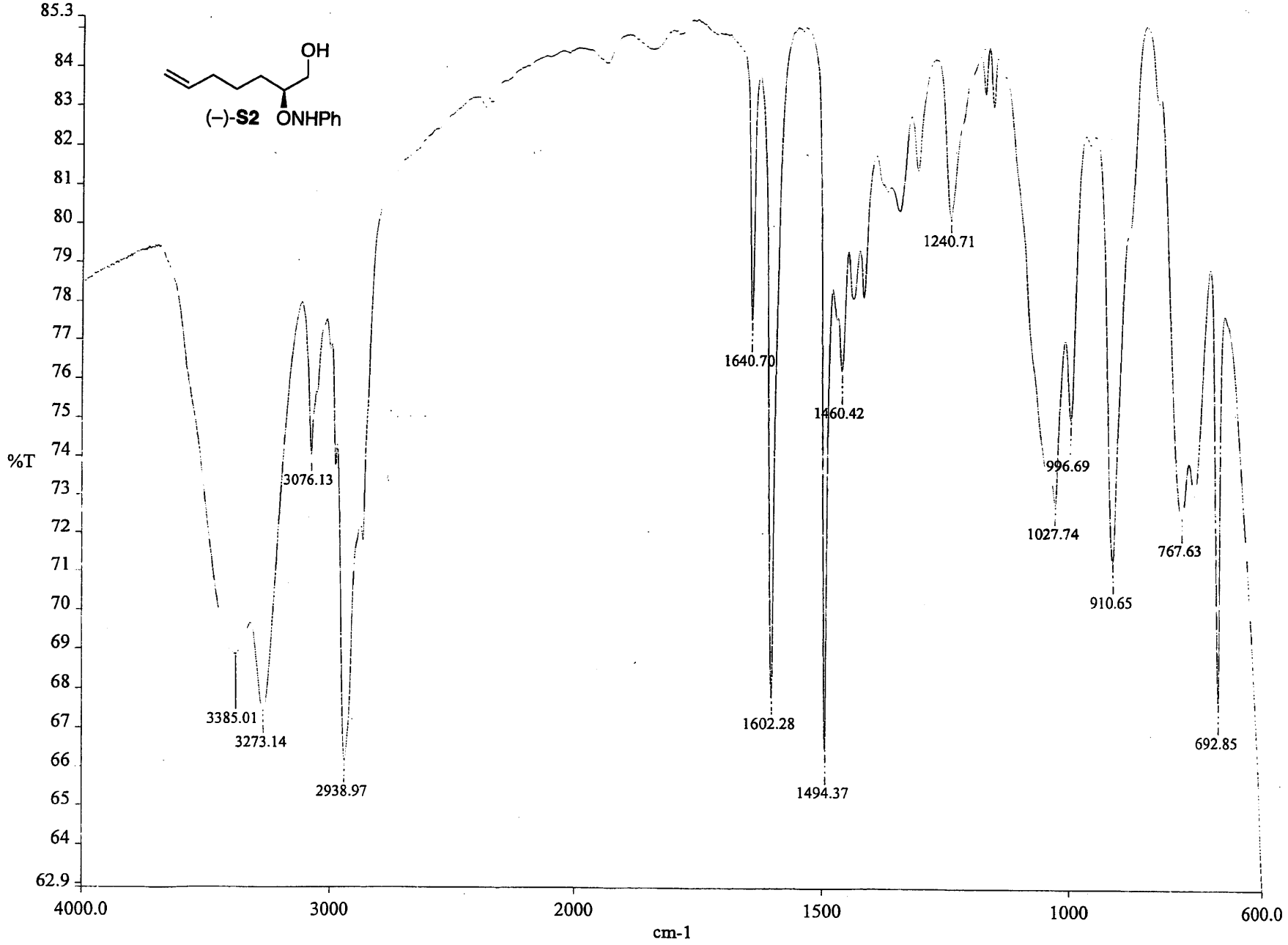



```
=====================================================================
                        Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: MWD1 E, Sig=215,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]       %
----|-------|----|-------|----------|----------|--------|
   1  18.029 MM    1.3433 4183.07324   51.89904  99.4174
   2  22.153 MM    1.0577   24.51239 3.86262e-1   0.5826

Totals :                  4207.58564   52.28530

 Results obtained with enhanced integrator!
=====================================================================
                        Summed Peaks Report
=====================================================================

Signal 1: MWD1 E, Sig=215,16 Ref=360,100
```

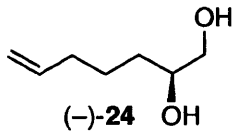




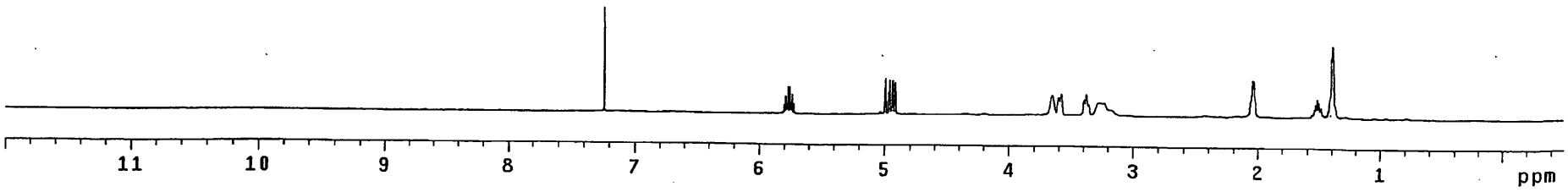

```
================================================================================
                            Area Percent Report
================================================================================

Sorted By             :      Signal
Multiplier            :      1.0000
Dilution              :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: MWD1 E, Sig=215,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]    [mAU*s]     [mAU]      %
----|-------|----|-------|----------|----------|--------|
   1  18.118 MM    0.5225   65.04629    2.07490   0.5432
   2  22.017 MM    0.9094 1.19103e4   218.27008  99.4568

Totals :                  1.19753e4   220.34498

 Results obtained with enhanced integrator!
================================================================================
                            Summed Peaks Report
================================================================================

Signal 1: MWD1 E, Sig=215,16 Ref=360,100
```


OH
(–)-S2 ONHPh
%T
cm-1
85.3
84
83
82
81
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
64
62.9
4000.0
3000
2000
1500
1000
600.0
3385.01
3273.14
3076.13
2938.97
1640.70
1602.28
1494.37
1460.42
1240.71
1027.74
996.69
910.65
767.63
692.85

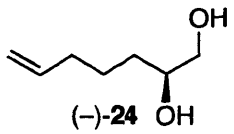
```
exp1  s2pul

date
solvent        CDCl3

   ACQUISITION
sfrq         500.435
tn                H1
at              4.999
np            120102
sw           12012.0
fb         not used
bs                 2
tpwr              56
pw               8.0
d1             0.100
tof           3003.2
nt                16
ct                10
alock              n
gain       not used
      FLAGS
il                 n
in                 n
dp                 y
hs                nn
     DISPLAY
sp             -250.2
wp             6255.3
vs                16
sc                 0
wc               250
hzmm           25.02
is             33.57
rfl            4139.5
rfp            3623.1
th                 7
ins           100.000
ai  cdc  ph

          DEC. & VT
dfrq         125.845
dn               C13
dpwr              30
dof                0
dm               nnn
dmm                c
dmf              200
dseq
dres             1.0
homo               n
     PROCESSING
wtfile
proc              ft
fn            262144
math               f

werr
wexp
wbs
wnt              wft
```



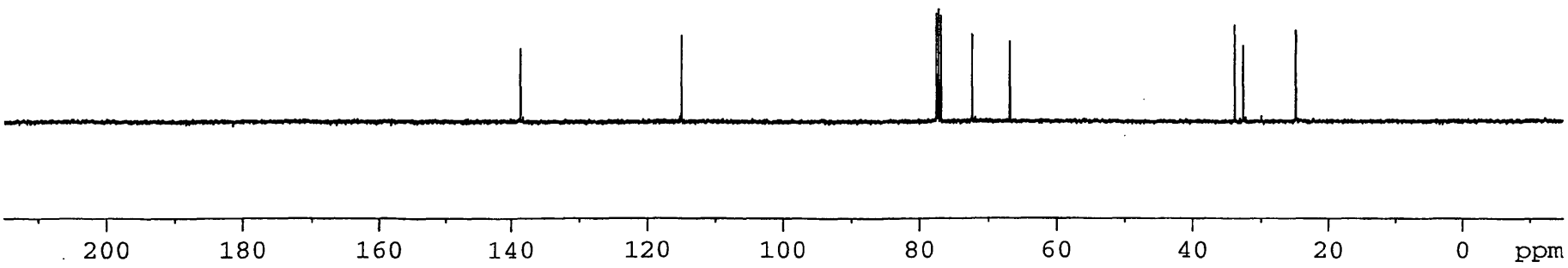
(–)-**24**

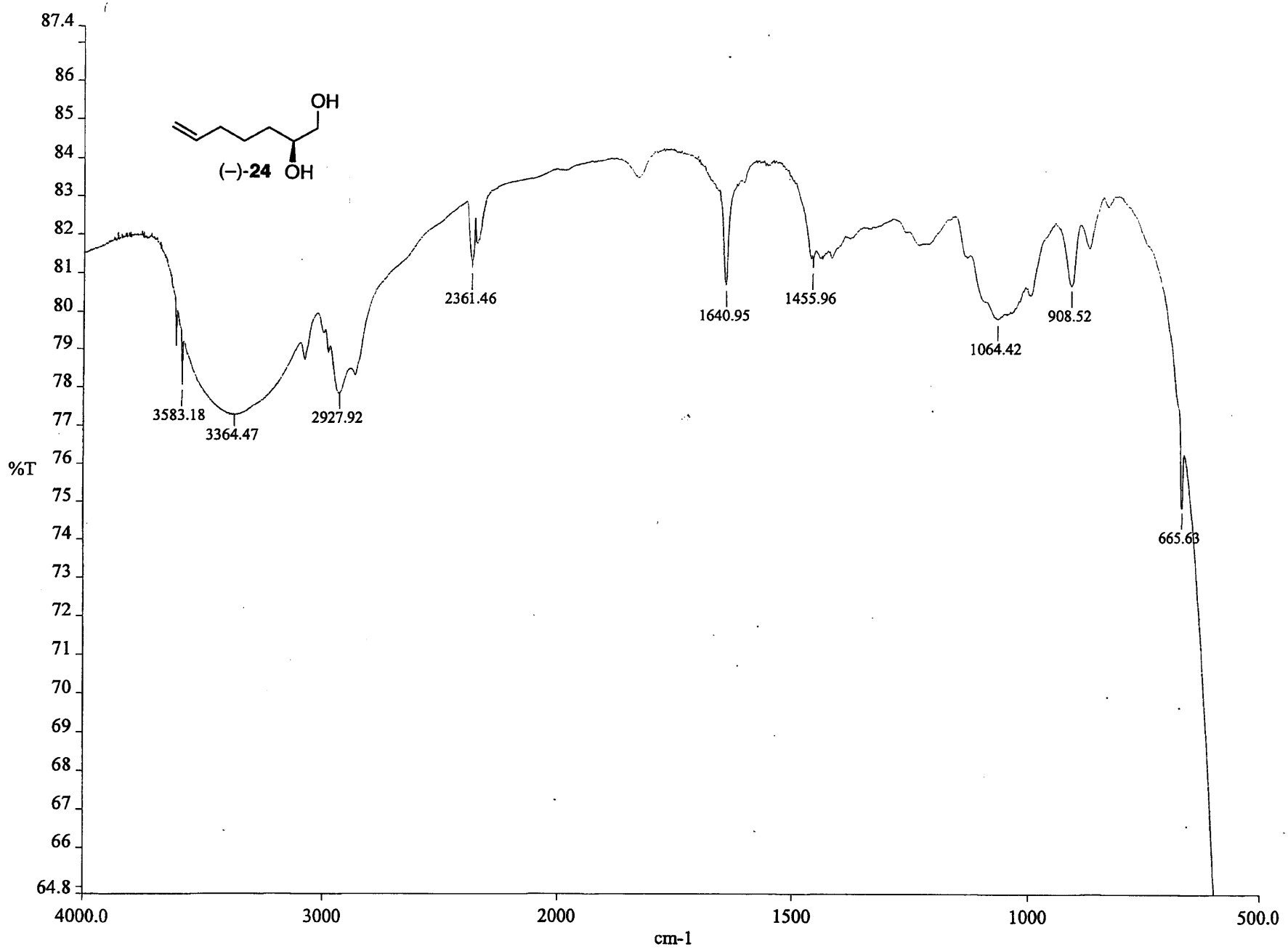


```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD    5 mm QNP 1H/13
PULPROG            zgpg30
TD                  65536
SOLVENT             CDCl3
NS                     64
DS                      4
SWH             23980.814 Hz
FIDRES              0.365918 Hz
AQ                1.3664756 sec
RG                   1824.6
DW                   20.850 usec
DE                    6.00 usec
TE                   292.2 K
D1              2.00000000 sec
d11             0.03000000 sec
DELTA           1.89999998 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                   13C
P1                    9.38 usec
PL1                   0.00 dB
SFO1          100.6228298 MHz

======== CHANNEL f2 ========
CPDPRG2            waltz16
NUC2                    1H
PCPD2                90.00 usec
PL2                   0.00 dB
PL12                 16.10 dB
PL13                 19.00 dB
SFO2          400.1316005 MHz

F2 - Processing parameters
SI                   32768
SF            100.6127520 MHz
WDW                     EM
SSB                      0
LB                    1.00 Hz
GB                       0
PC                    1.00
```

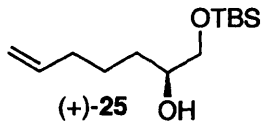


(−)-**24**

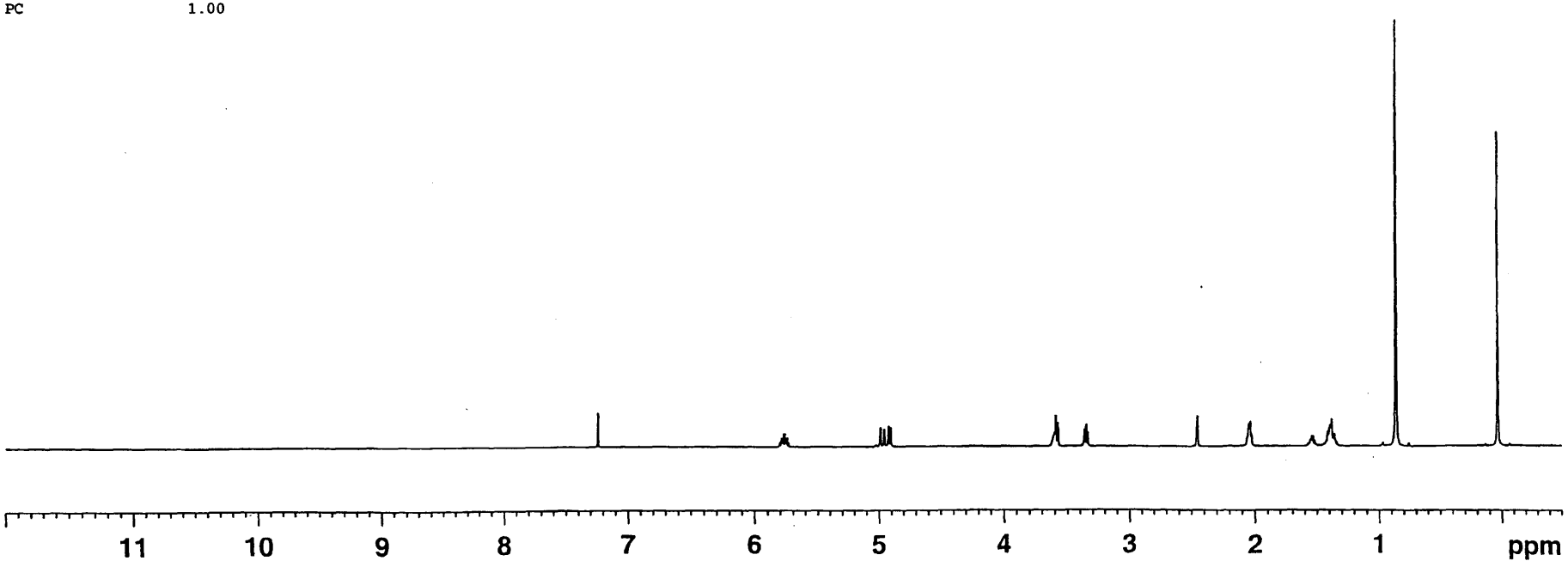


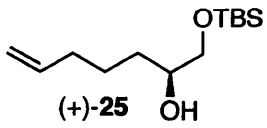

OH
(–)-24 OH
87.4
86
85
84
83
82
81
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
64.8
%T
3583.18
3364.47
2927.92
2361.46
1640.95
1455.96
1064.42
908.52
665.63
4000.0
3000
2000
1500
1000
500.0
cm-1

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD    5 mm CPTXI 1H-
PULPROG              zg30
TD                  65536
SOLVENT             CDCl3
NS                     16
DS                      2
SWH             12376.237 Hz
FIDRES          0.188846 Hz
AQ              2.6477044 sec
RG                      4
DW                 40.400 usec
DE                  6.00 usec
TE                 293.0 K
D1              1.00000000 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                   1H
P1                  11.00 usec
PL1                  4.00 dB
SFO1          600.1337060 MHz

F2 - Processing parameters
SI                  65536
SF            600.1300281 MHz
WDW                    EM
SSB                     0
LB                   0.30 Hz
GB                      0
PC                   1.00
```



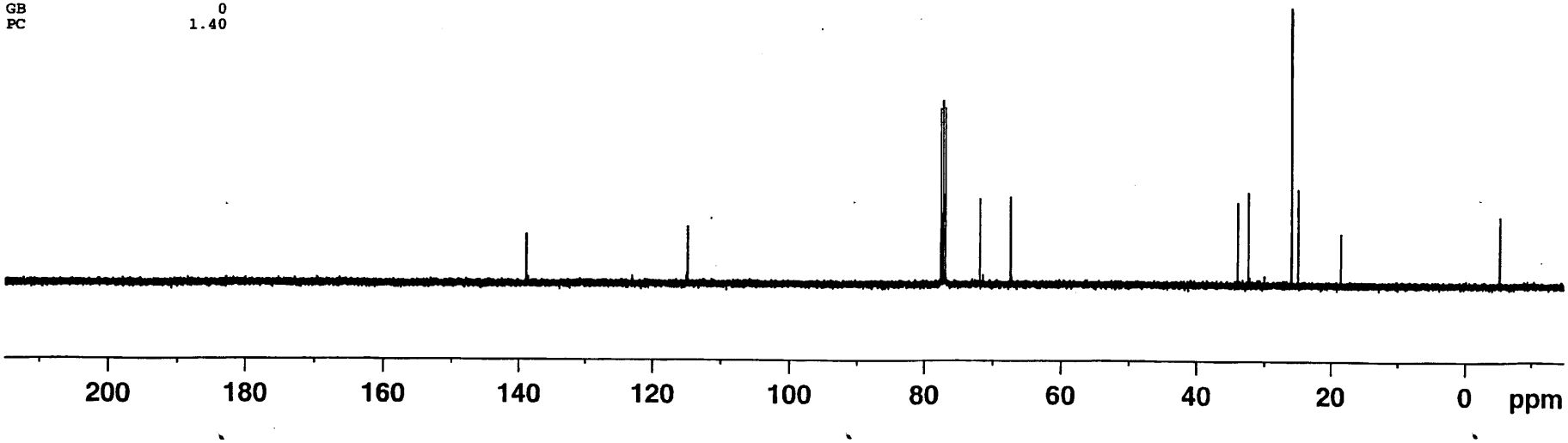
(+)-25

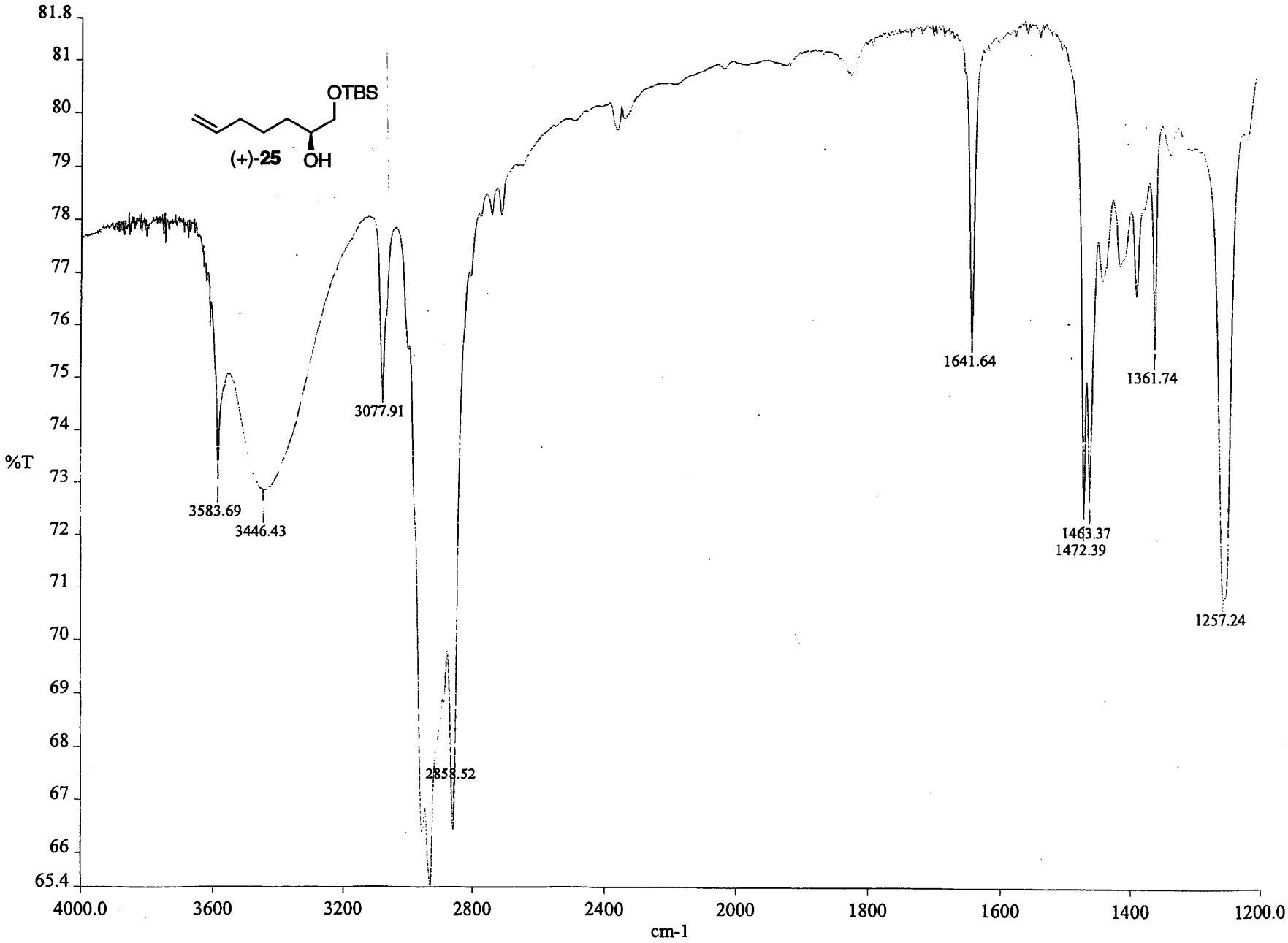




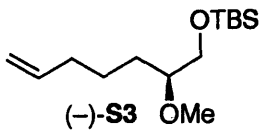
(+)-**25**

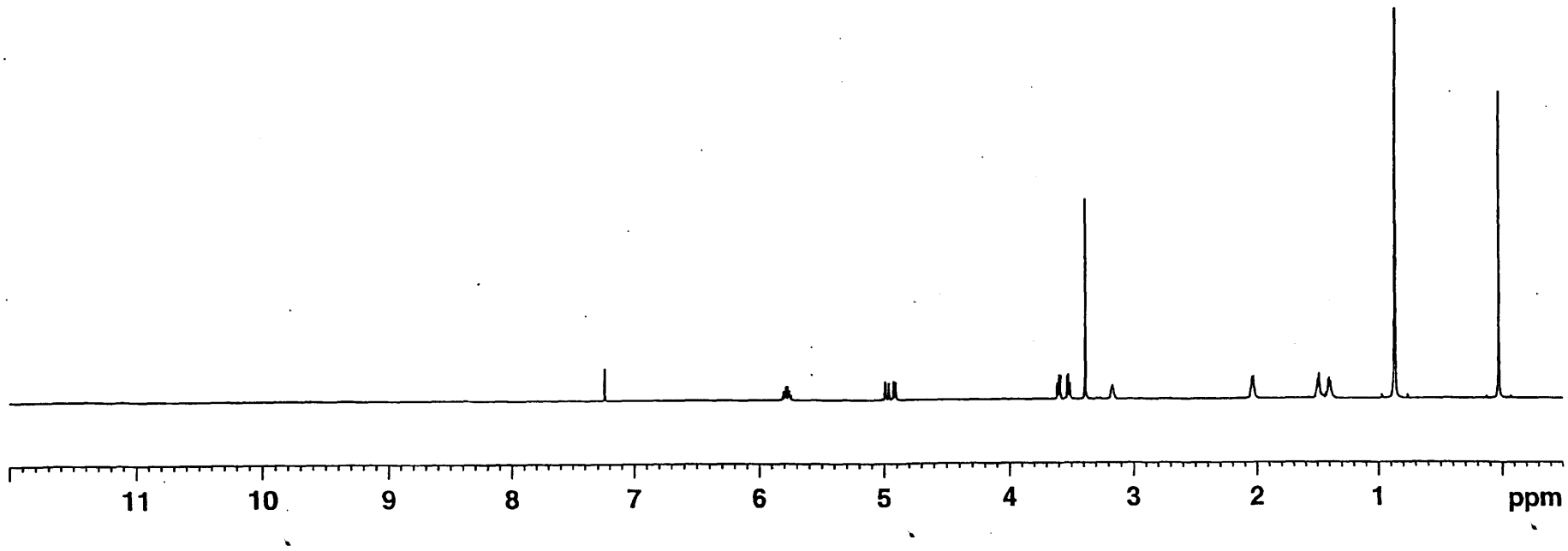
```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD   5 mm BBO BB-1H
PULPROG            zgpg30
TD                  65536
SOLVENT             CDCl3
NS                    615
DS                      2
SWH            23980.814 Hz
FIDRES          0.365918 Hz
AQ              1.3664756 sec
RG                18390.4
DW                 20.850 usec
DE                  6.00 usec
TE                 294.2 K
D1             2.00000000 sec
d11            0.03000000 sec
DELTA          1.89999998 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                  13C
P1                   8.75 usec
PL1                 -3.00 dB
SFO1          100.6228298 MHz

======== CHANNEL f2 ========
CPDPRG2           waltz16
NUC2                  1H
PCPD2               90.00 usec
PL2                 -1.00 dB
PL12                14.52 dB
PL13                18.00 dB
SFO2          400.1316005 MHz

F2 - Processing parameters
SI                  65536
SF            100.6127478 MHz
WDW                    no
SSB                     0
LB                   0.00 Hz
GB                      0
PC                   1.40
```

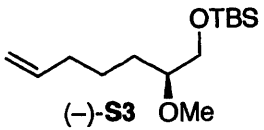



OTBS
(+)-25
OH
%T
81.8
81
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65.4
3583.69
3446.43
3077.91
2858.52
1641.64
1463.37
1472.39
1361.74
1257.24
4000.0
3600
3200
2800
2400
2000
1800
1600
1400
1200.0
cm-1

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD    5 mm CPTXI 1H-
PULPROG              zg30
TD                  65536
SOLVENT             CDCl3
NS                     13
DS                      2
SWH             12376.237 Hz
FIDRES              0.188846 Hz
AQ                2.6477044 sec
RG                      5.7
DW                   40.400 usec
DE                    6.00 usec
TE                   304.0 K
D1              1.00000000 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                   1H
P1                  11.00 usec
PL1                  4.00 dB
SFO1          600.1337060 MHz

F2 - Processing parameters
SI                  65536
SF            600.1300278 MHz
WDW                    EM
SSB                     0
LB                   0.30 Hz
GB                      0
PC                   1.00
```

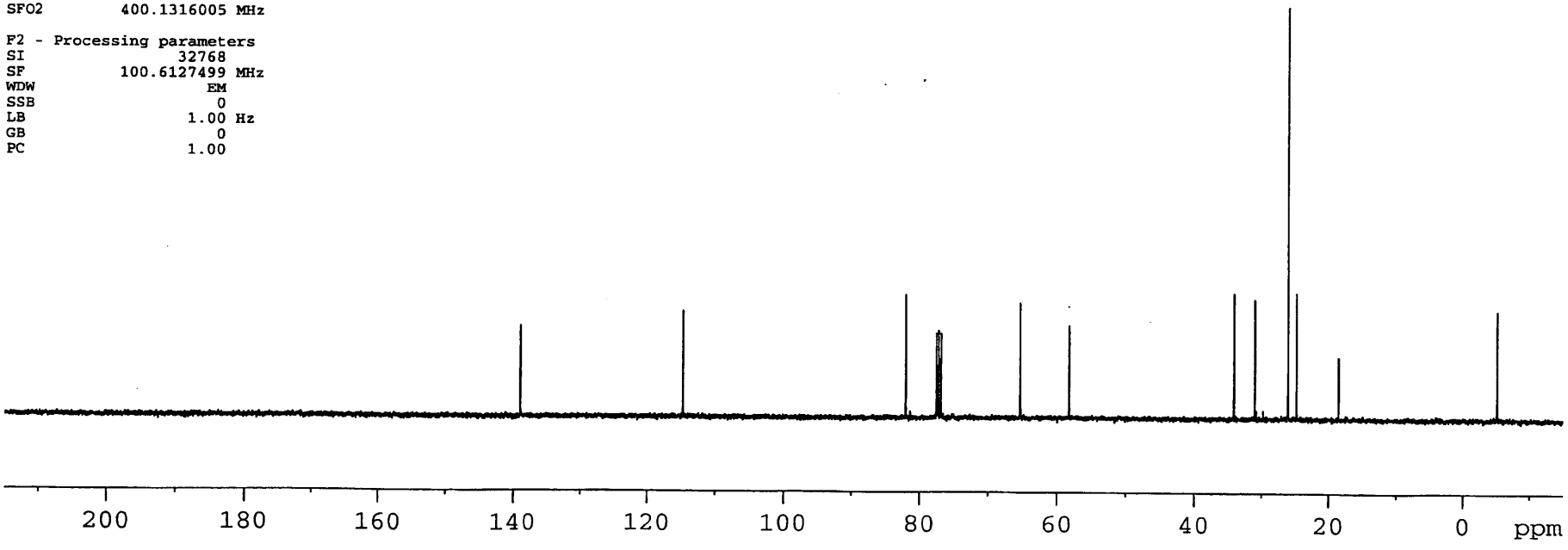


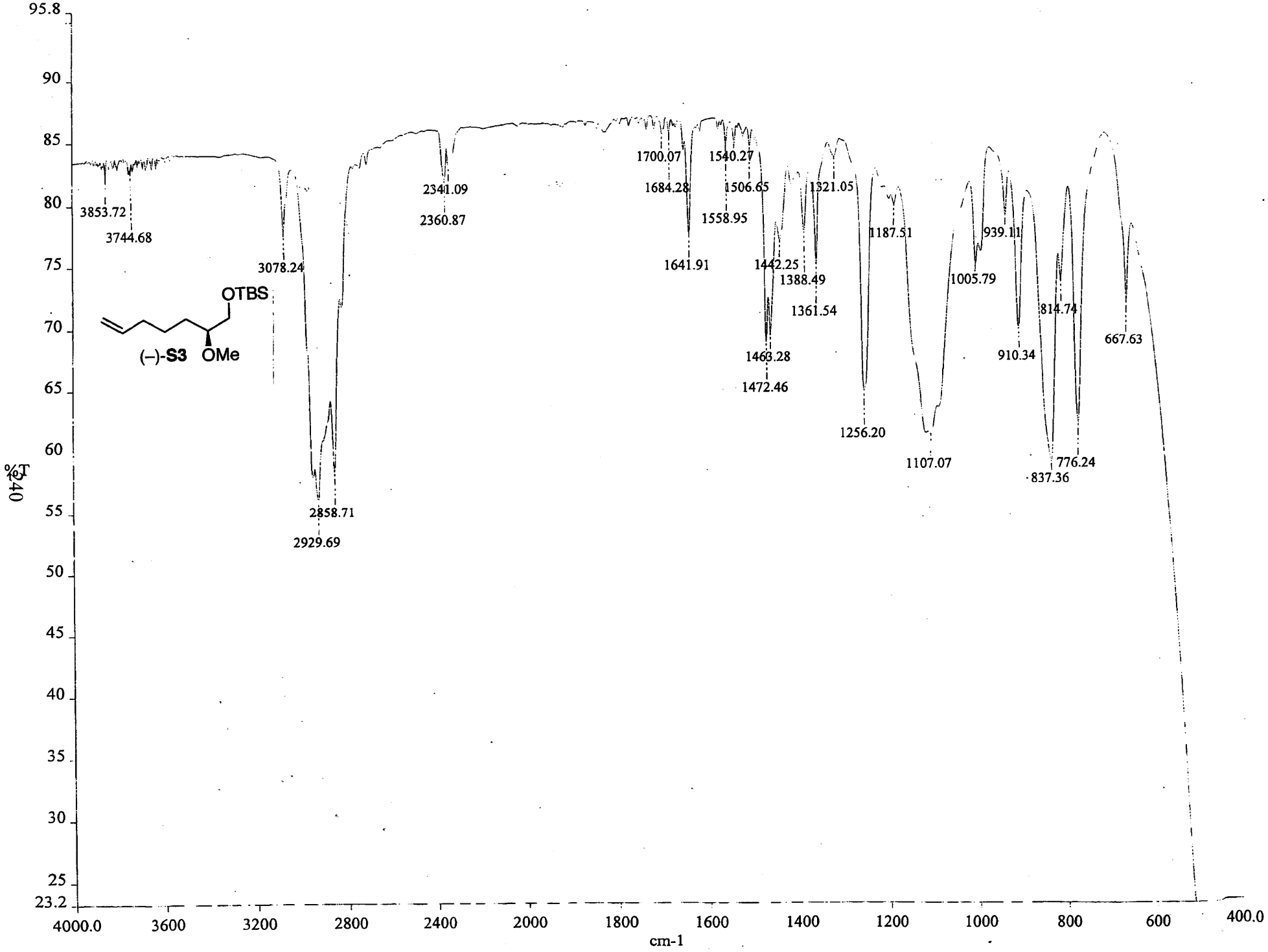


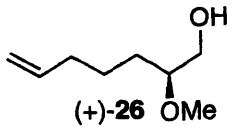


(–)-**S3**

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM                  spect
PROBHD     5 mm QNP 1H/13
PULPROG                zgpg30
TD                      65536
SOLVENT                 CDCl3
NS                         30
DS                          4
SWH                23980.814 Hz
FIDRES             0.365918 Hz
AQ                 1.3664756 sec
RG                    2580.3
DW                    20.850 usec
DE                     6.00 usec
TE                     291.2 K
D1                 2.00000000 sec
d11                0.03000000 sec
DELTA              1.89999998 sec
TD0                         1

======== CHANNEL f1 ========
NUC1                      13C
P1                       9.38 usec
PL1                      0.00 dB
SFO1             100.6228298 MHz

======== CHANNEL f2 ========
CPDPRG2               waltz16
NUC2                      1H
PCPD2                   90.00 usec
PL2                      0.00 dB
PL12                    16.10 dB
PL13                    19.00 dB
SFO2             400.1316005 MHz

F2 - Processing parameters
SI                        32768
SF               100.6127499 MHz
WDW                          EM
SSB                           0
LB                       1.00 Hz
GB                            0
PC                       1.00
```

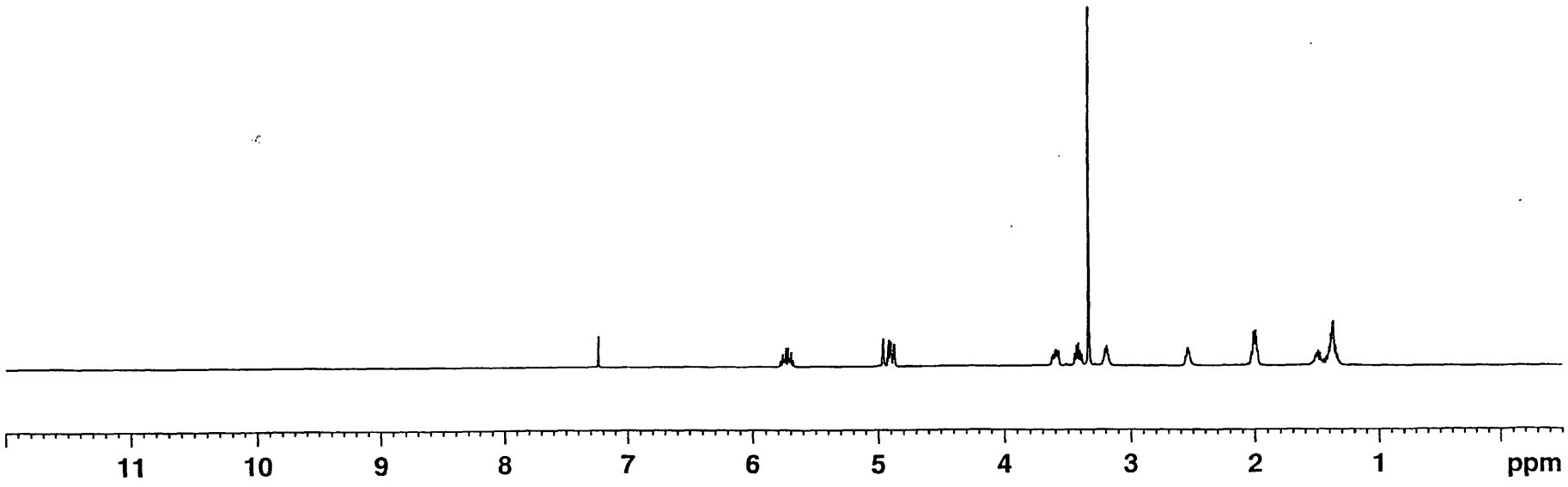


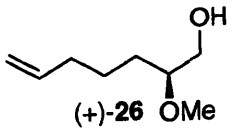

95.8
90
85
80
75
70
65
60
55
50
45
40
35
30
25
23.2
%T
4000.0
3600
3200
2800
2400
2000
1800
1600
1400
1200
1000
800
600
400.0
cm-1
3853.72
3744.68
3078.24
2929.69
2858.71
2360.87
2341.09
1700.07
1684.28
1641.91
1558.95
1540.27
1506.65
1472.46
1463.28
1442.25
1388.49
1361.54
1321.05
1256.20
1187.51
1107.07
1005.79
939.11
910.34
837.36
814.74
776.24
667.63
OTBS
(–)-S3
OMe



(+)-**26**

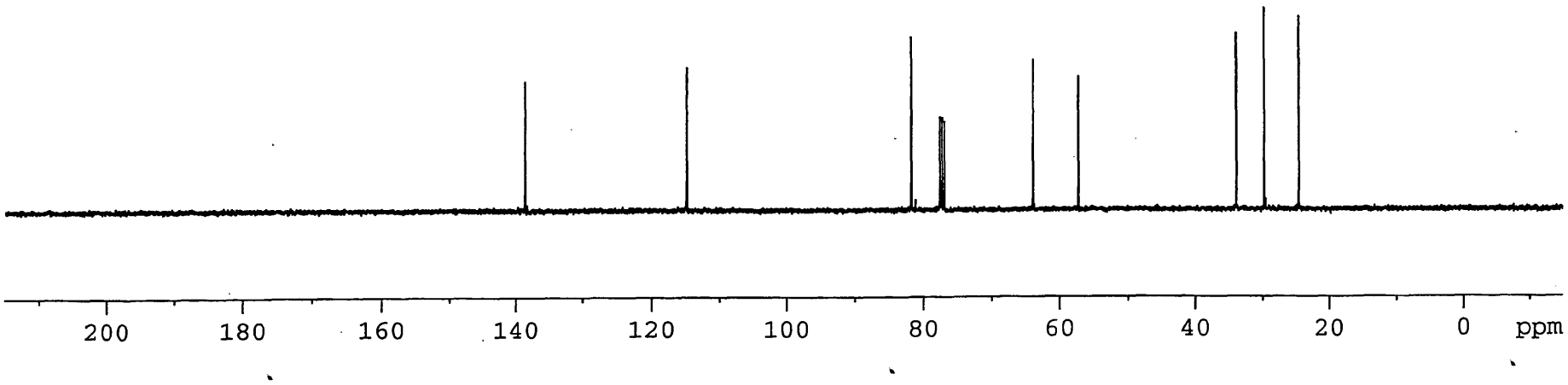
```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD   5 mm QNP 1H/13
PULPROG              zg30
TD                  65536
SOLVENT             CDCl3
NS                     13
DS                      2
SWH              8278.146 Hz
FIDRES           0.126314 Hz
AQ               3.9584243 sec
RG                    45.3
DW                  60.400 usec
DE                   6.00 usec
TE                  291.2 K
D1            1.00000000 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                   1H
P1                  14.00 usec
PL1                  0.00 dB
SFO1         400.1324710 MHz

F2 - Processing parameters
SI                  65536
SF           400.1300175 MHz
WDW                    EM
SSB                     0
LB                   0.30 Hz
GB                      0
PC                   1.00
```

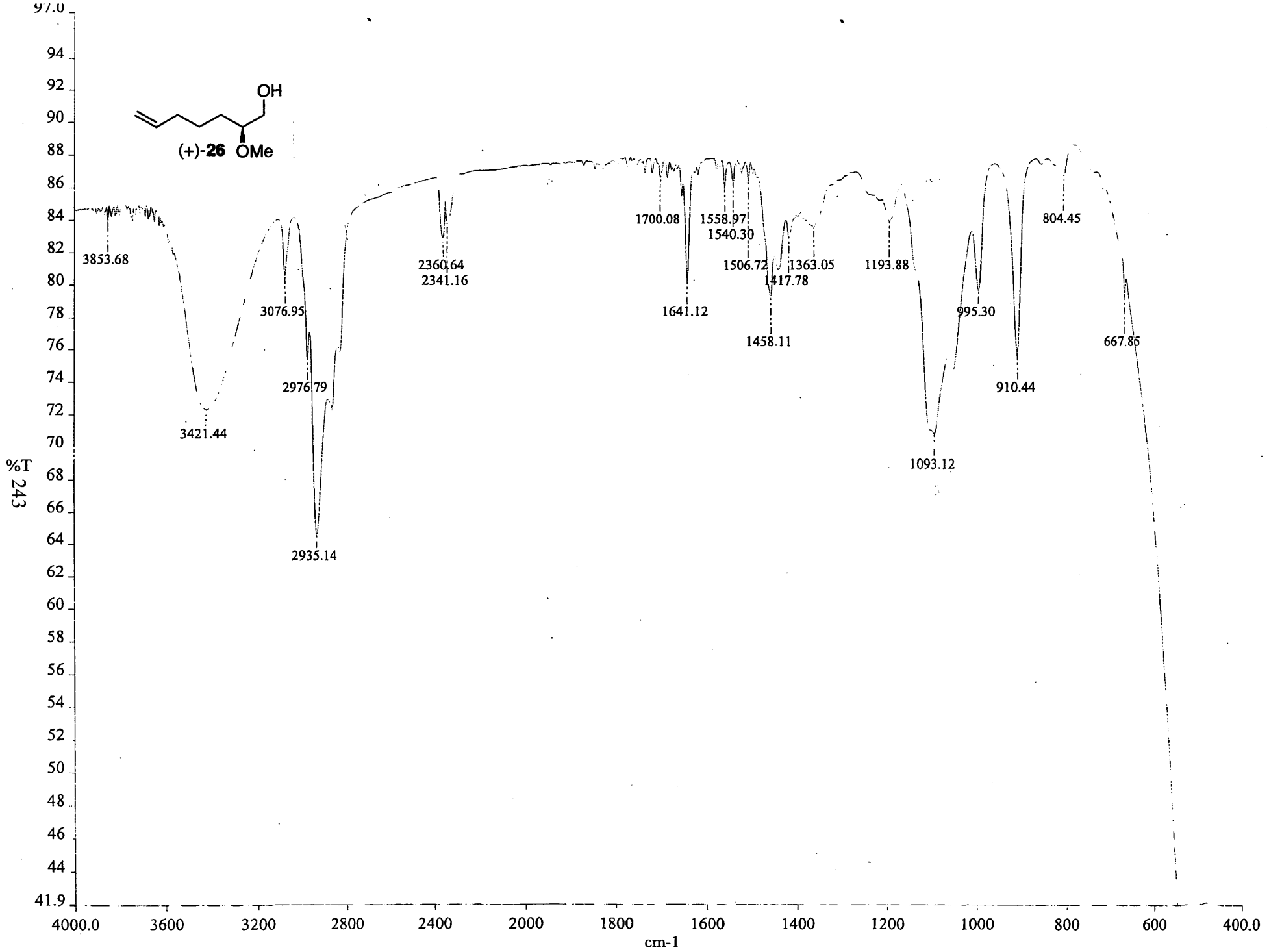



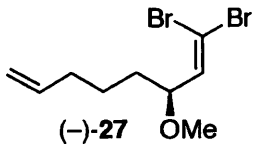


(+)-**26**

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM
PROBHD   5 mm QNP 1H/13
PULPROG          zgpg30
TD                65536
SOLVENT           CDCl3
NS                   21
DS                    4
SWH           23980.814 Hz
FIDRES         0.365918 Hz
AQ             1.3664756 sec
RG                1824.6
DW                20.850 usec
DE                 6.00 usec
TE                291.2 K
D1           2.00000000 sec
d11          0.03000000 sec
DELTA        1.89999998 sec
TD0                  1

======== CHANNEL f1 ========
NUC1                13C
P1                 9.38 usec
PL1                0.00 dB
SFO1        100.6228298 MHz

======== CHANNEL f2 ========
CPDPRG2         waltz16
NUC2                1H
PCPD2              90.00 usec
PL2                 0.00 dB
PL12               16.10 dB
PL13               19.00 dB
SFO2        400.1316005 MHz

F2 - Processing parameters
SI                32768
SF          100.6127571 MHz
WDW                EM
SSB                 0
LB                1.00 Hz
GB                  0
PC                1.00
```




OH
(+)-26 OMe
3853.68
3421.44
3076.95
2976.79
2935.14
2360.64
2341.16
1700.08
1641.12
1558.97
1540.30
1506.72
1458.11
1417.78
1363.05
1193.88
1093.12
995.30
910.44
804.45
667.86
%T
243
97.0
94
92
90
88
86
84
82
80
78
76
74
72
70
68
66
64
62
60
58
56
54
52
50
48
46
44
41.9
4000.0
3600
3200
2800
2400
2000
1800
1600
1400
1200
1000
800
600
400.0
cm-1



solvent	CDCl3

ACQUISITION	
sfrq	499.746
tn	H1
at	3.001
np	63050
sw	10504.2
fb	not used
bs	8
tpwr	56
pw	8.6
d1	2.000
tof	1519.5
nt	16
ct	16
alock	n
gain	not used

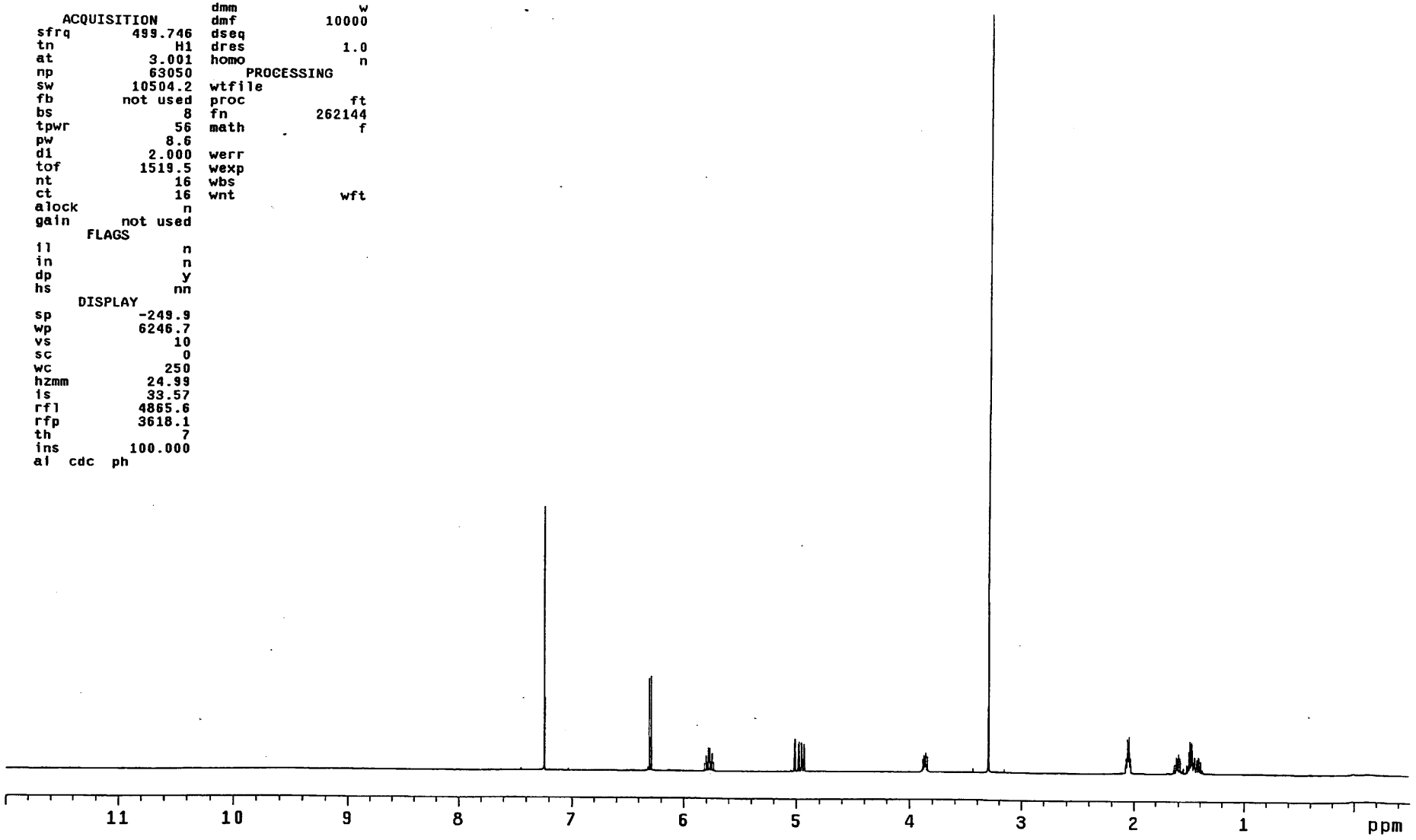
FLAGS	
il	n
in	n
dp	y
hs	nn

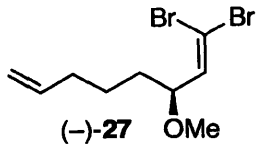
DISPLAY	
sp	-249.9
wp	6246.7
vs	10
sc	0
wc	250
hzmm	24.99
is	33.57
rfl	4865.6
rfp	3618.1
th	7
ins	100.000

ai cdc ph

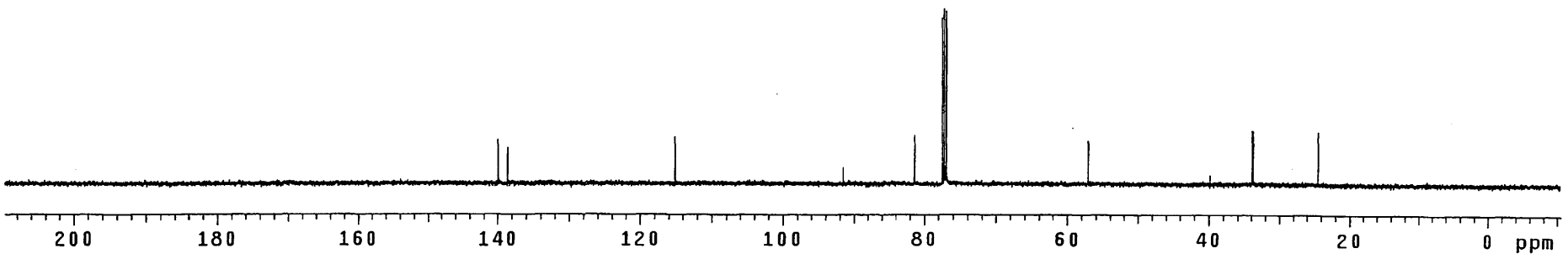
DEC. & VT	
dfrq	125.672
dn	C13
dpwr	30
dof	0
dm	nnn
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

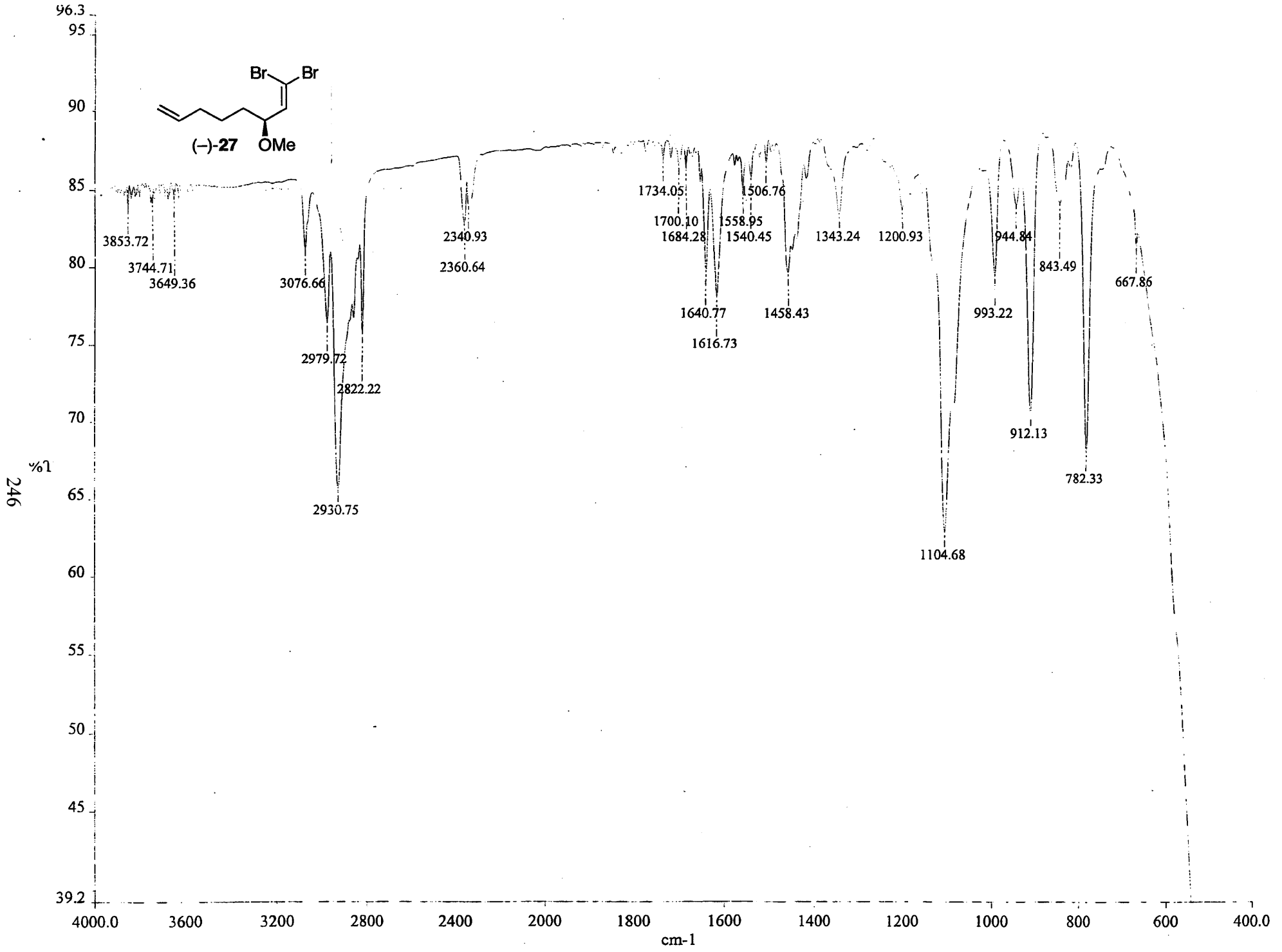
PROCESSING	
wtfile	
proc	ft
fn	262144
math	f
werr	
wexp	
wbs	
wnt	wft

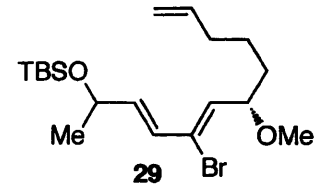




date		DEC. & VT	
solvent	CDCl3	dfrq	499.744
		dn	H1
		dpwr	34
		dof	0
		dm	yyy
		dmm	w
ACQUISITION		dmf	10000
sfrq	125.672	dseq	
tn	C13	dres	1.0
at	2.000	homo	n
np	125588	PROCESSING	
sw	31397.2	lb	1.00
fb	not used	wtfile	
bs	8	proc	ft
tpwr	58	fn	131072
pw	6.7	math	f
d1	3.000		
tof	0	werr	
nt	256	wexp	
ct	160	wbs	
alock	n	wnt	
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-1329.0		
wp	27683.3		
vs	172		
sc	0		
wc	250		
hzmm	110.73		
is	500.00		
rfl	13468.0		
rfp	9704.7		
th	68		
ins	100.000		
ai cdc ph			




96.3
95
90
85
80
75
70
65
60
55
50
45
39.2
%T
Br
Br
(–)-27
OMe
3853.72
3744.71
3649.36
3076.66
2979.72
2930.75
2822.22
2340.93
2360.64
1734.05
1700.10
1684.28
1640.77
1616.73
1558.95
1540.45
1506.76
1458.43
1343.24
1200.93
1104.68
993.22
944.84
912.13
843.49
782.33
667.86
4000.0
3600
3200
2800
2400
2000
1800
1600
1400
1200
1000
800
600
400.0
cm-1



29

solvent	CDCl3

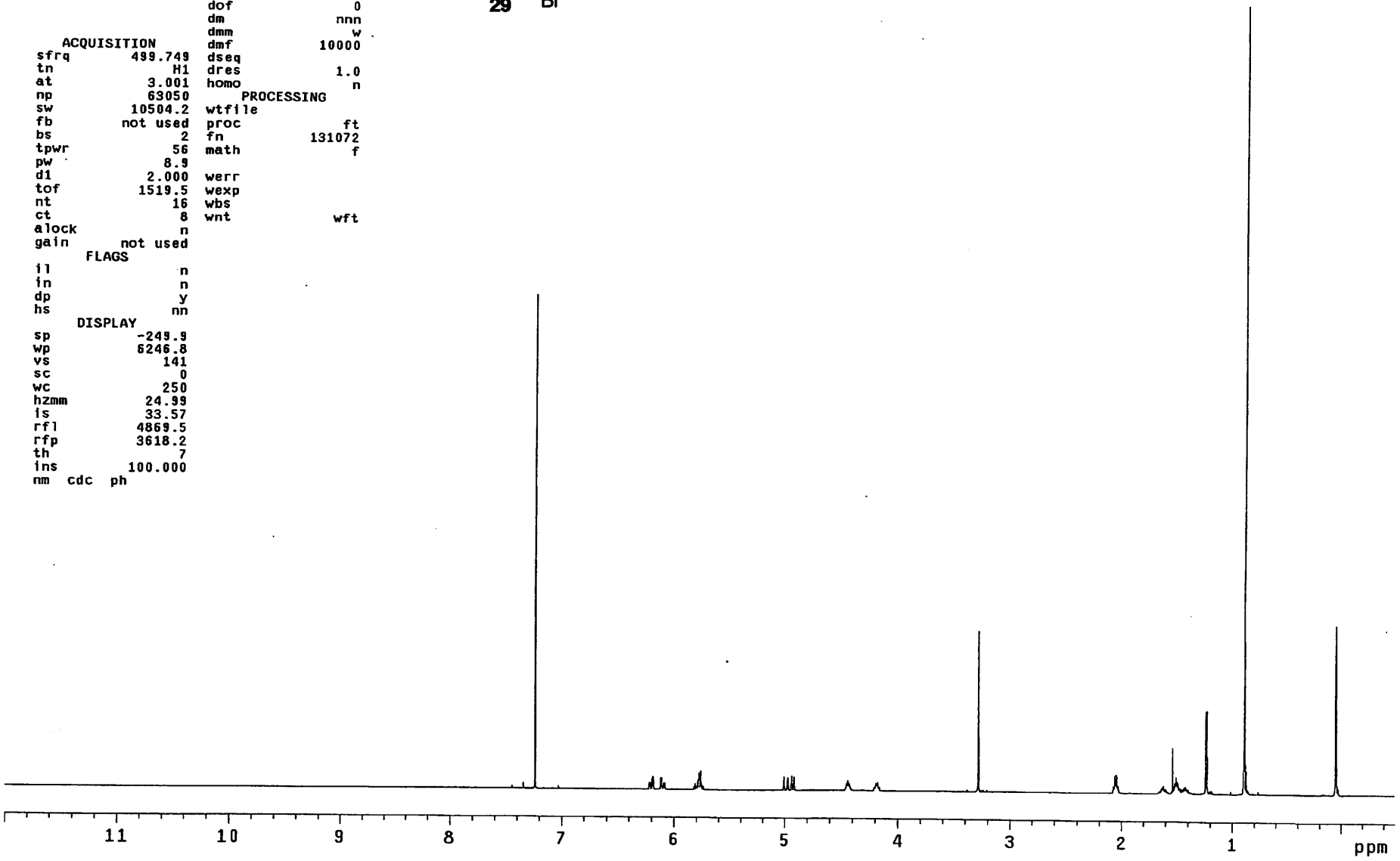
ACQUISITION	
sfrq	499.749
tn	H1
at	3.001
np	63050
sw	10504.2
fb	not used
bs	2
tpwr	56
pw	8.9
d1	2.000
tof	1519.5
nt	16
ct	8
alock	n
gain	not used

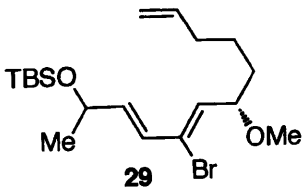
FLAGS	
il	n
in	n
dp	y
hs	nn

DISPLAY	
sp	-249.9
wp	6246.8
vs	141
sc	0
wc	250
hzmm	24.99
is	33.57
rfl	4869.5
rfp	3618.2
th	7
ins	100.000
nm	cdc ph

DEC. & VT	
dfrq	125.673
dn	C13
dpwr	30
dof	0
dm	nnn
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

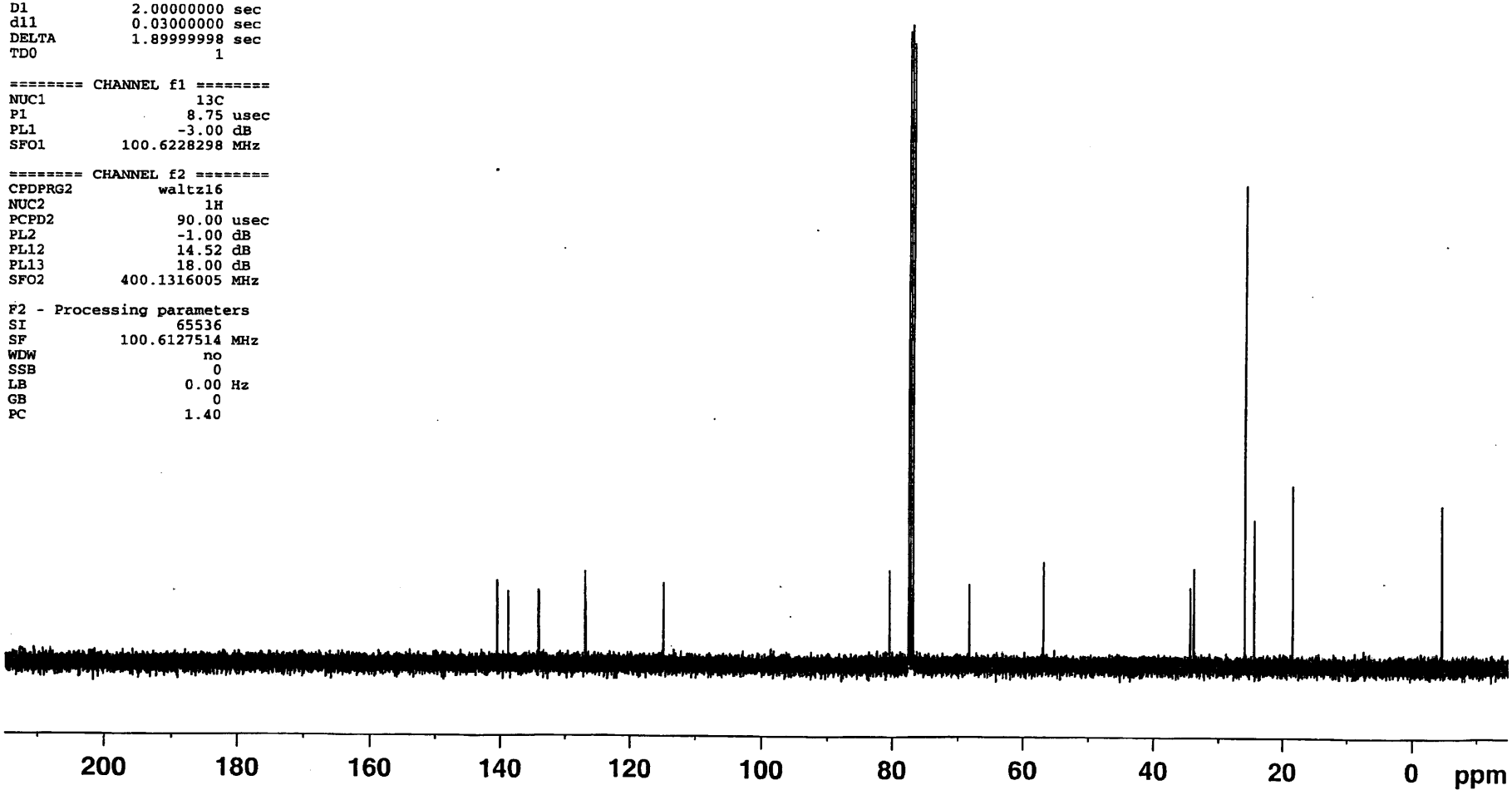
PROCESSING	
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	wft

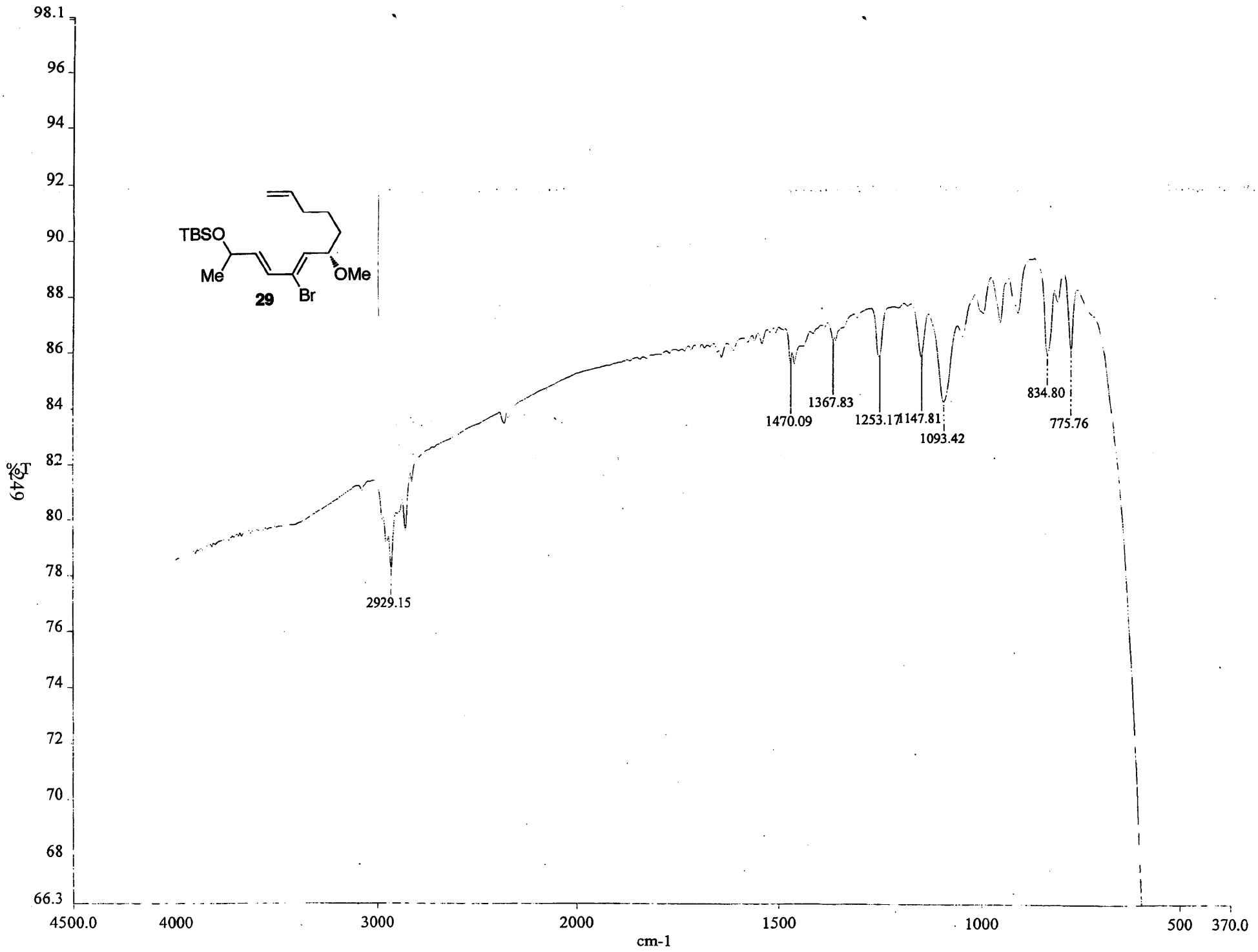




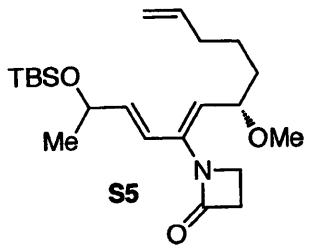
29

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD    5 mm BBO BB-1H
PULPROG            zgpg30
TD                  65536
SOLVENT             CDCl3
NS                   1024
DS                      2
SWH            23980.814 Hz
FIDRES          0.365918 Hz
AQ             1.3664756 sec
RG                   8192
DW                20.850 usec
DE                 6.00 usec
TE                293.2 K
D1             2.00000000 sec
d11            0.03000000 sec
DELTA          1.89999998 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                  13C
P1                   8.75 usec
PL1                 -3.00 dB
SFO1         100.6228298 MHz

======== CHANNEL f2 ========
CPDPRG2           waltz16
NUC2                  1H
PCPD2              90.00 usec
PL2                -1.00 dB
PL12               14.52 dB
PL13               18.00 dB
SFO2         400.1316005 MHz

F2 - Processing parameters
SI                  65536
SF           100.6127514 MHz
WDW                    no
SSB                     0
LB                 0.00 Hz
GB                      0
PC                   1.40
```

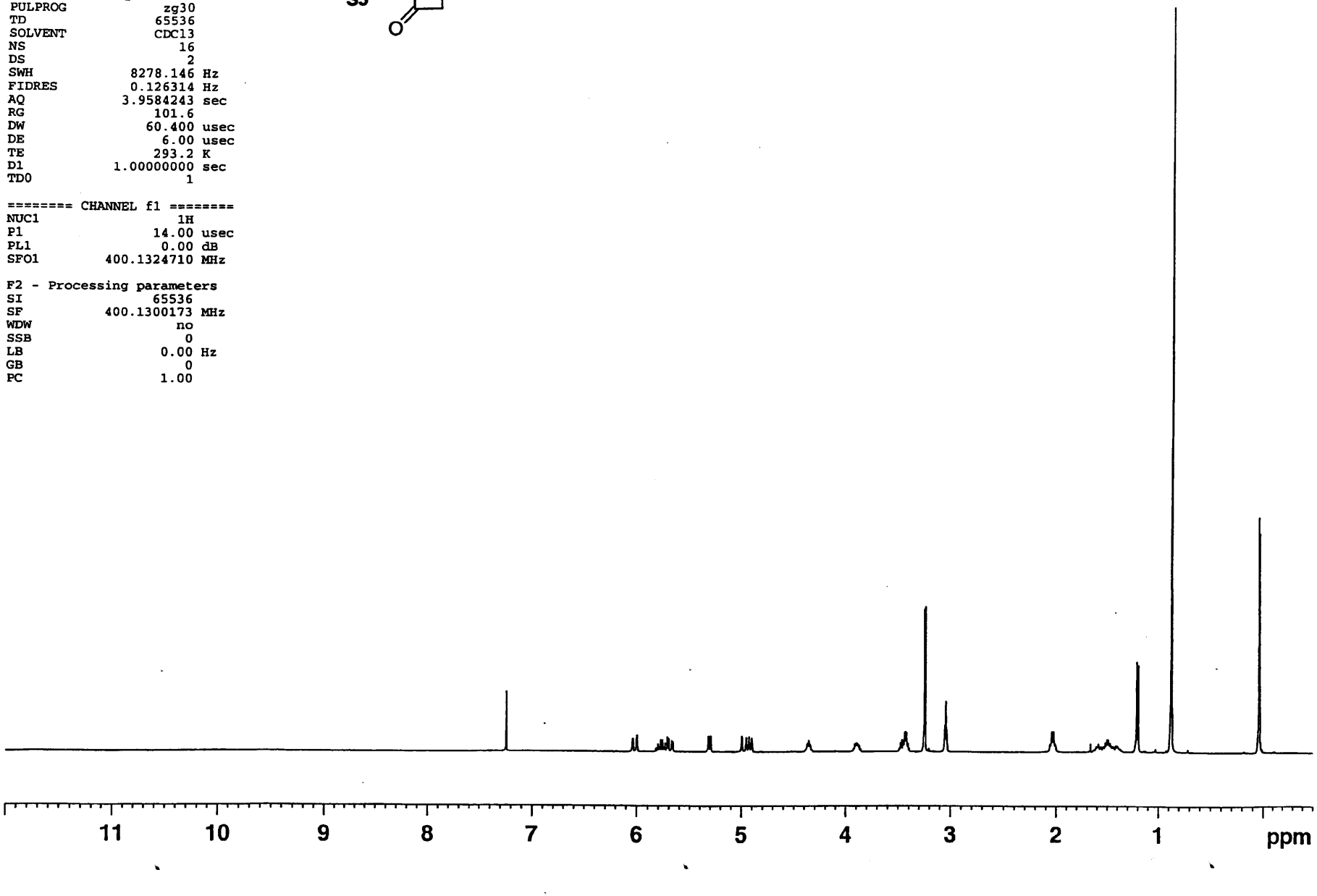


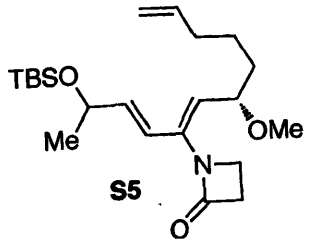

TBSO
Me
OMe
Br
29
98.1
96
94
92
90
88
86
84
82
80
78
76
74
72
70
68
66.3
%T
2929.15
1470.09
1367.83
1253.17
1147.81
1093.42
834.80
775.76
4500.0
4000
3000
2000
1500
1000
500
370.0
cm-1

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD    5 mm QNP 1H/13
PULPROG              zg30
TD                  65536
SOLVENT             CDCl3
NS                     16
DS                      2
SWH             8278.146 Hz
FIDRES          0.126314 Hz
AQ              3.9584243 sec
RG                  101.6
DW                 60.400 usec
DE                  6.00 usec
TE                 293.2 K
D1             1.00000000 sec
TD0                    1

======== CHANNEL f1 ========
NUC1                  1H
P1                 14.00 usec
PL1                 0.00 dB
SFO1          400.1324710 MHz

F2 - Processing parameters
SI                  65536
SF            400.1300173 MHz
WDW                    no
SSB                     0
LB                   0.00 Hz
GB                      0
PC                   1.00
```



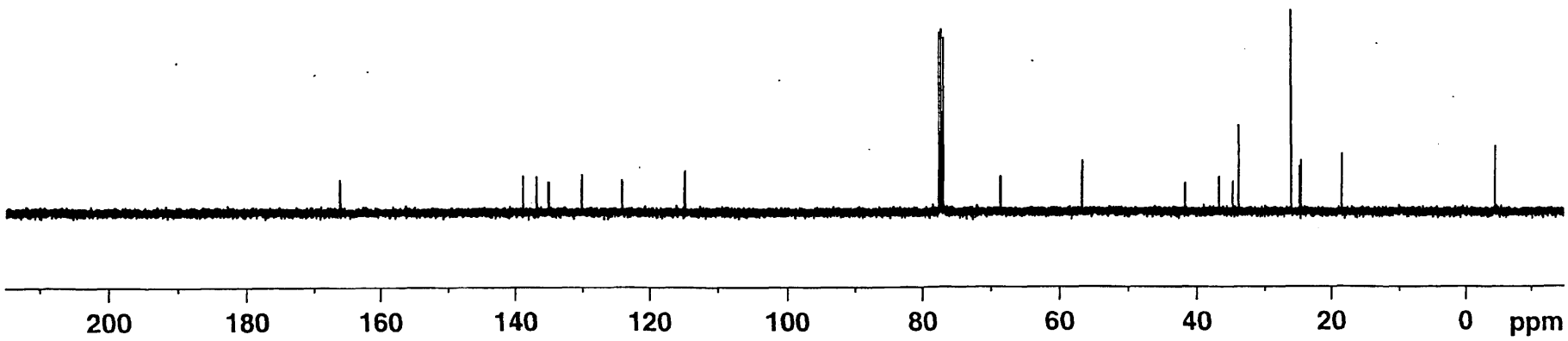
S5

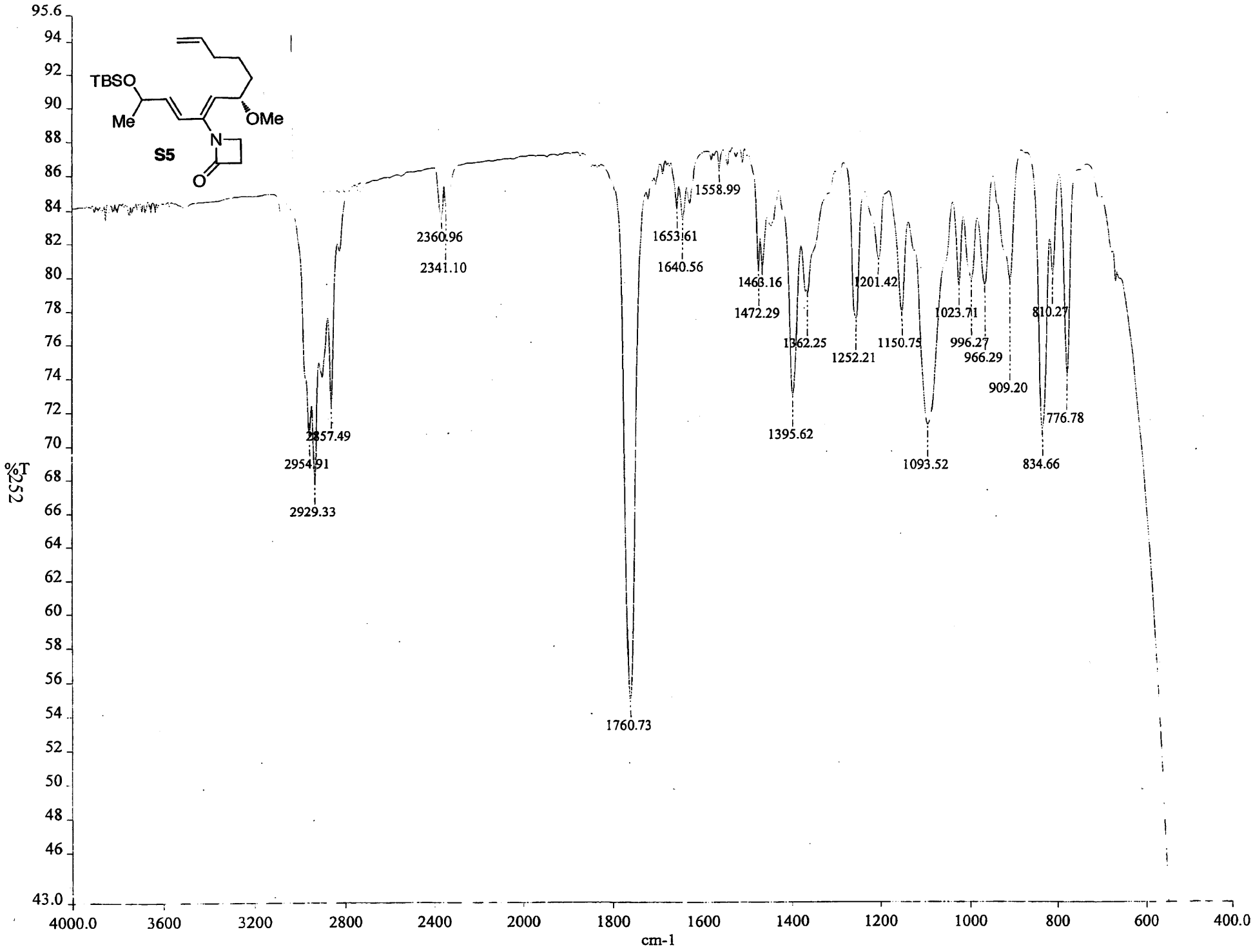


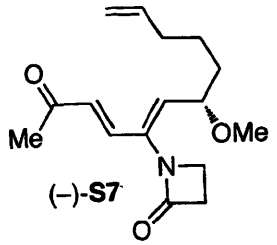


S5

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM
PROBHD    5 mm QNP 1H/13
PULPROG             zgpg30
TD                   65536
SOLVENT              CDCl3
NS                     512
DS                       2
SWH              23980.814 Hz
FIDRES           0.365918 Hz
AQ               1.3664756 sec
RG                    8192
DW                  20.850 usec
DE                   6.00 usec
TE                  293.2 K
D1             2.00000000 sec
d11            0.03000000 sec
DELTA          1.89999998 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                   13C
P1                    9.38 usec
PL1                   0.00 dB
SFO1          100.6228298 MHz

======== CHANNEL f2 ========
CPDPRG2            waltz16
NUC2                   1H
PCPD2                90.00 usec
PL2                   0.00 dB
PL12                 16.10 dB
PL13                 19.00 dB
SFO2          400.1316005 MHz

F2 - Processing parameters
SI                    65536
SF            100.6127511 MHz
WDW                      no
SSB                       0
LB                     0.00 Hz
GB                        0
PC                     1.40
```

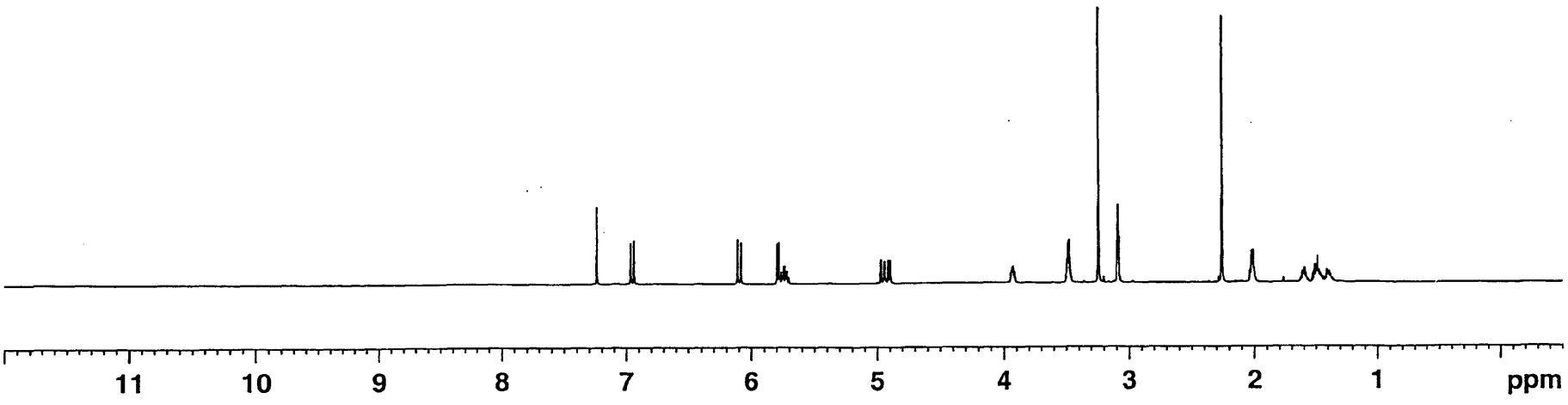



TBSO
Me
OMe
N
O
S5
%T
95.6
94
92
90
88
86
84
82
80
78
76
74
72
70
68
66
64
62
60
58
56
54
52
50
48
46
43.0
2954.91
2929.33
2857.49
2360.96
2341.10
1760.73
1653.61
1640.56
1558.99
1468.16
1472.29
1395.62
1362.25
1252.21
1201.42
1150.75
1093.52
1023.71
996.27
966.29
909.20
834.66
810.27
776.78
4000.0
3600
3200
2800
2400
2000
1800
1600
1400
1200
1000
800
600
400.0
cm-1

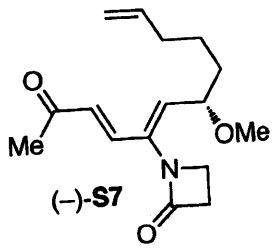


(–)-**S7**

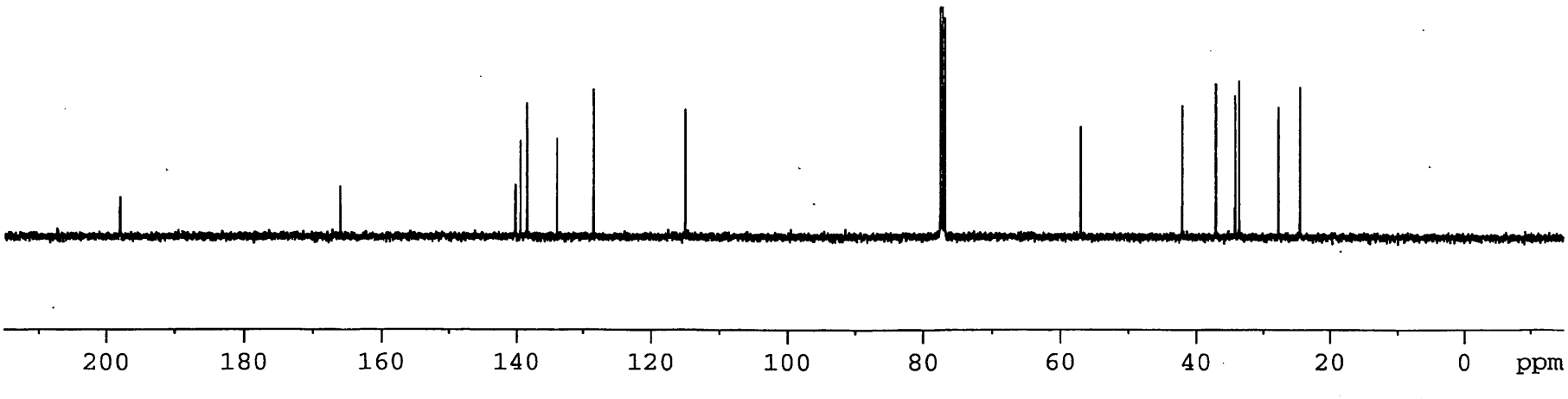
```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD   5 mm CPTXI 1H-
PULPROG              zg30
TD                  65536
SOLVENT             CDCl3
NS                     11
DS                      2
SWH             12376.237 Hz
FIDRES          0.188846 Hz
AQ              2.6477044 sec
RG                   12.7
DW                 40.400 usec
DE                  6.00 usec
TE                 304.0 K
D1             1.00000000 sec
TD0                    1

======== CHANNEL f1 ========
NUC1                  1H
P1                 11.00 usec
PL1                 4.00 dB
SFO1         600.1337060 MHz

F2 - Processing parameters
SI                  65536
SF           600.1300277 MHz
WDW                   EM
SSB                    0
LB                  0.30 Hz
GB                     0
PC                  1.00
```

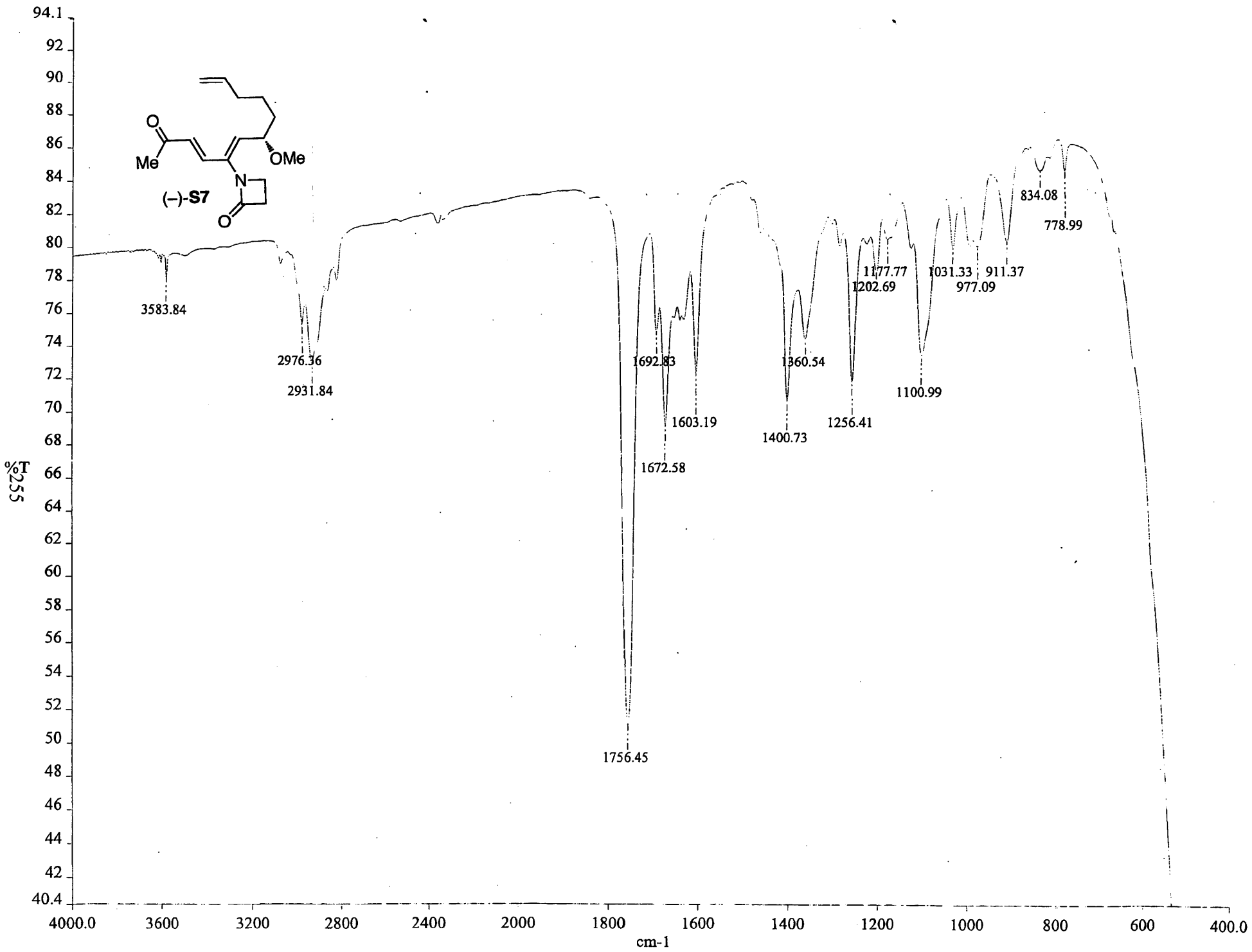


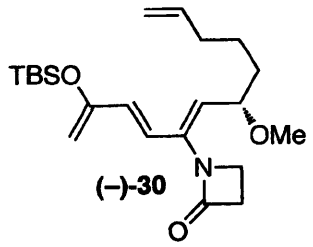
```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM                  spect
PROBHD    5 mm QNP 1H/13
PULPROG                zgpg30
TD                      65536
SOLVENT                 CDCl3
NS                         85
DS                          4
SWH                23980.814 Hz
FIDRES              0.365918 Hz
AQ                 1.3664756 sec
RG                    1824.6
DW                    20.850 usec
DE                     6.00 usec
TE                     291.2 K
D1                2.00000000 sec
d11               0.03000000 sec
DELTA             1.89999998 sec
TD0                         1

======== CHANNEL f1 ========
NUC1                      13C
P1                       9.38 usec
PL1                      0.00 dB
SFO1             100.6228298 MHz

======== CHANNEL f2 ========
CPDPRG2               waltz16
NUC2                      1H
PCPD2                 90.00 usec
PL2                      0.00 dB
PL12                    16.10 dB
PL13                    19.00 dB
SFO2             400.1316005 MHz

F2 - Processing parameters
SI                        32768
SF               100.6127562 MHz
WDW                          EM
SSB                           0
LB                       1.00 Hz
GB                            0
PC                       1.00
```



(–)-**S7**

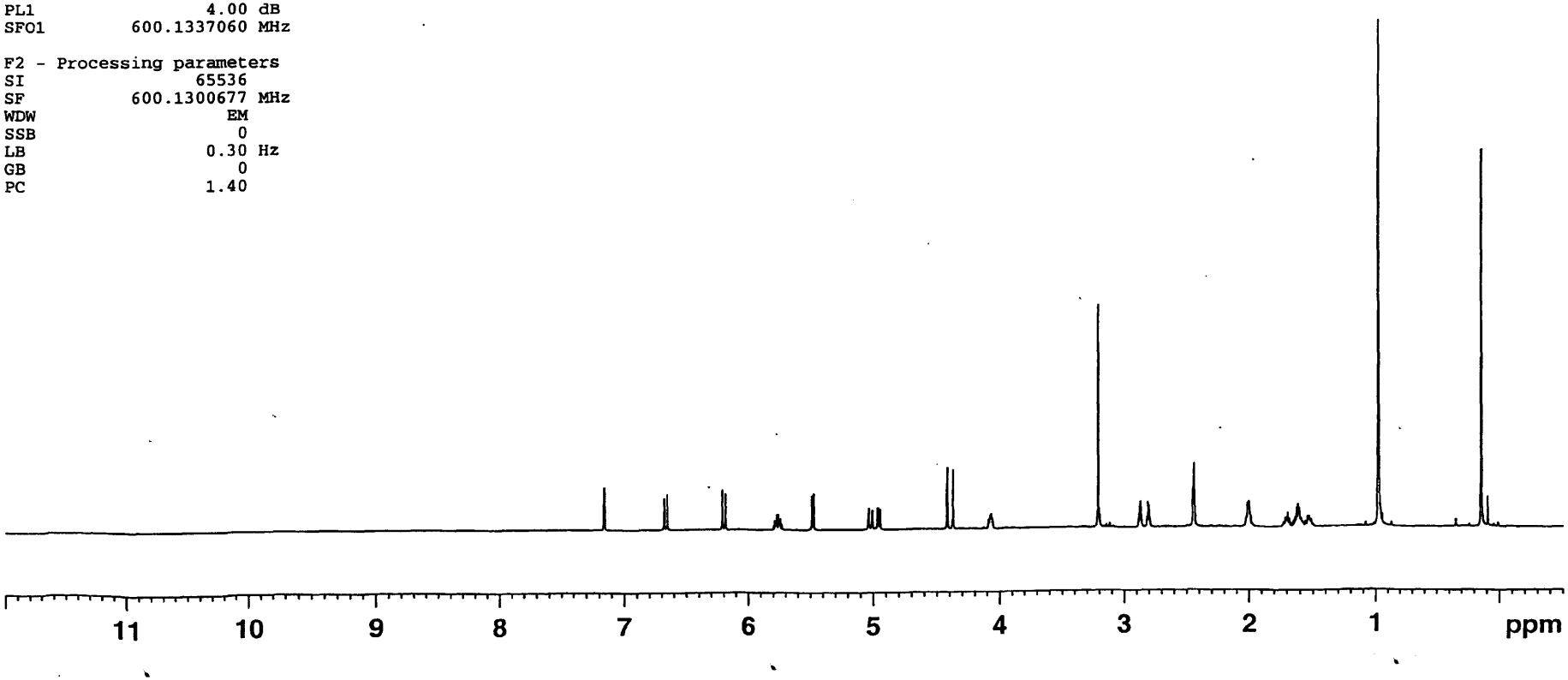


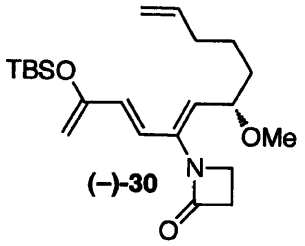

(–)-S7
3583.84
2976.36
2931.84
1756.45
1692.83
1672.58
1603.19
1400.73
1360.54
1256.41
1202.69
1177.77
1100.99
1031.33
977.09
911.37
834.08
778.99
%T
cm-1



(–)-30

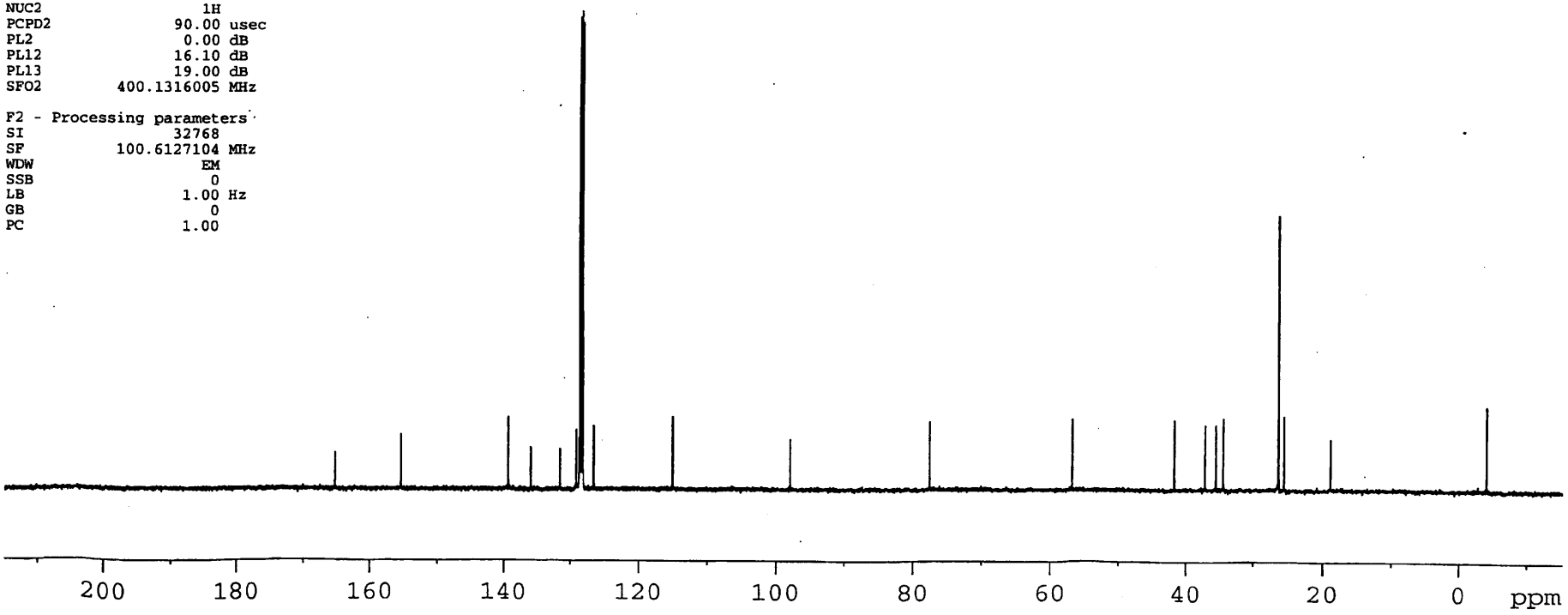
```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM            spect
PROBHD   5 mm CPTXI 1H-
PULPROG             zg30
TD                 65536
SOLVENT            CDCl3
NS                    15
DS                     2
SWH            12376.237 Hz
FIDRES          0.188846 Hz
AQ             2.6477044 sec
RG                   6.3
DW                40.400 usec
DE                 6.00 usec
TE                293.0 K
D1            1.00000000 sec
TD0                    1

======== CHANNEL f1 ========
NUC1                  1H
P1                 11.00 usec
PL1                 4.00 dB
SFO1         600.1337060 MHz

F2 - Processing parameters
SI                 65536
SF           600.1300677 MHz
WDW                   EM
SSB                    0
LB                  0.30 Hz
GB                     0
PC                  1.40
```

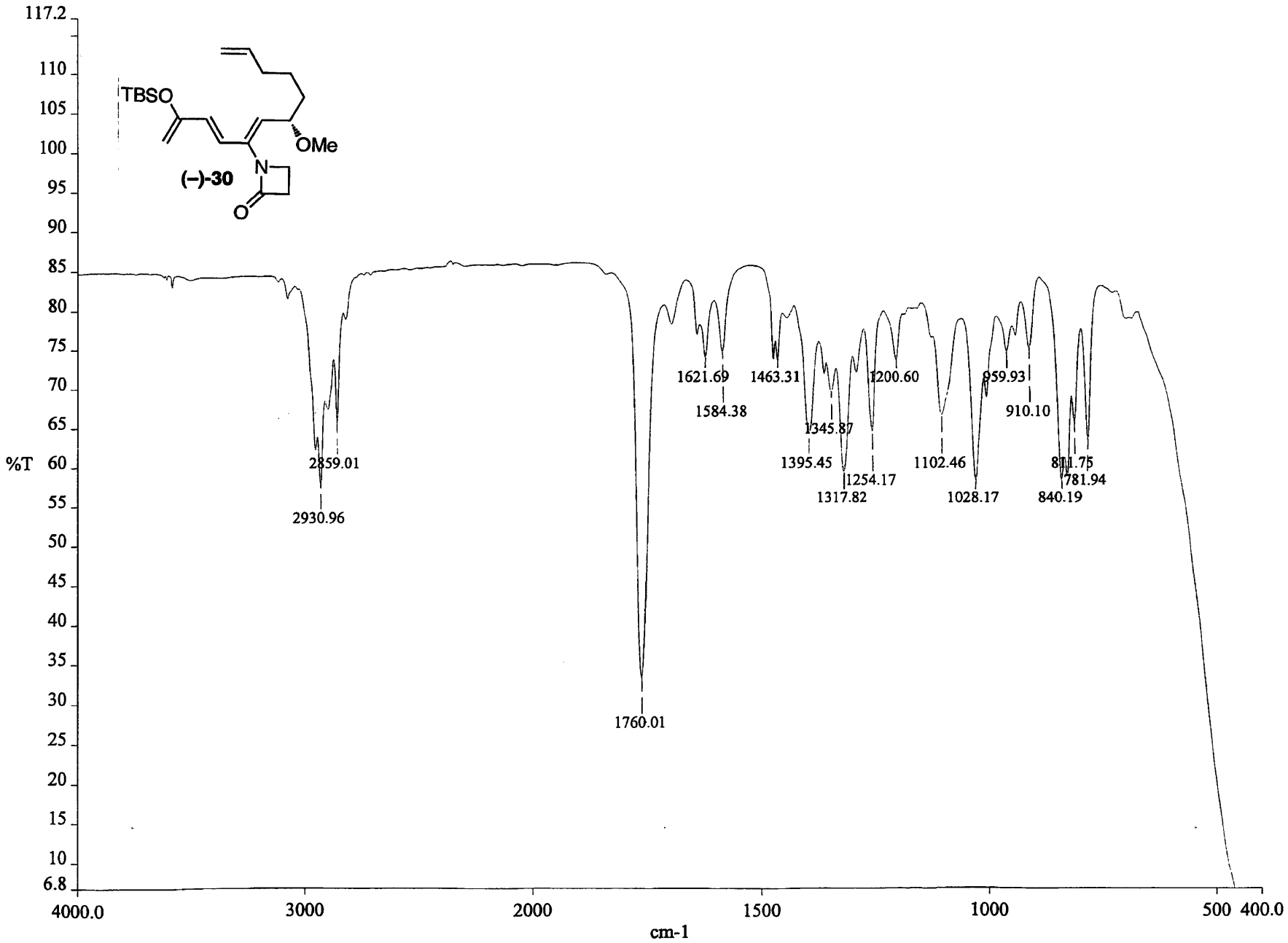


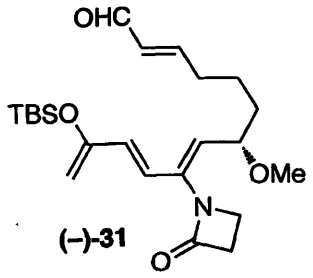


(−)-30

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM                  spect
PROBHD     5 mm QNP 1H/13
PULPROG                zgpg30
TD                      65536
SOLVENT                 CDCl3
NS                         40
DS                          4
SWH                23980.814 Hz
FIDRES             0.365918 Hz
AQ                 1.3664756 sec
RG                    1625.5
DW                    20.850 usec
DE                     6.00 usec
TE                     291.2 K
D1                2.00000000 sec
d11               0.03000000 sec
DELTA             1.89999998 sec
TD0                         1

======== CHANNEL f1 ========
NUC1                      13C
P1                       9.38 usec
PL1                      0.00 dB
SFO1             100.6228298 MHz

======== CHANNEL f2 ========
CPDPRG2               waltz16
NUC2                       1H
PCPD2                   90.00 usec
PL2                      0.00 dB
PL12                    16.10 dB
PL13                    19.00 dB
SFO2             400.1316005 MHz

F2 - Processing parameters
SI                       32768
SF                100.6127104 MHz
WDW                         EM
SSB                          0
LB                       1.00 Hz
GB                           0
PC                       1.00
```

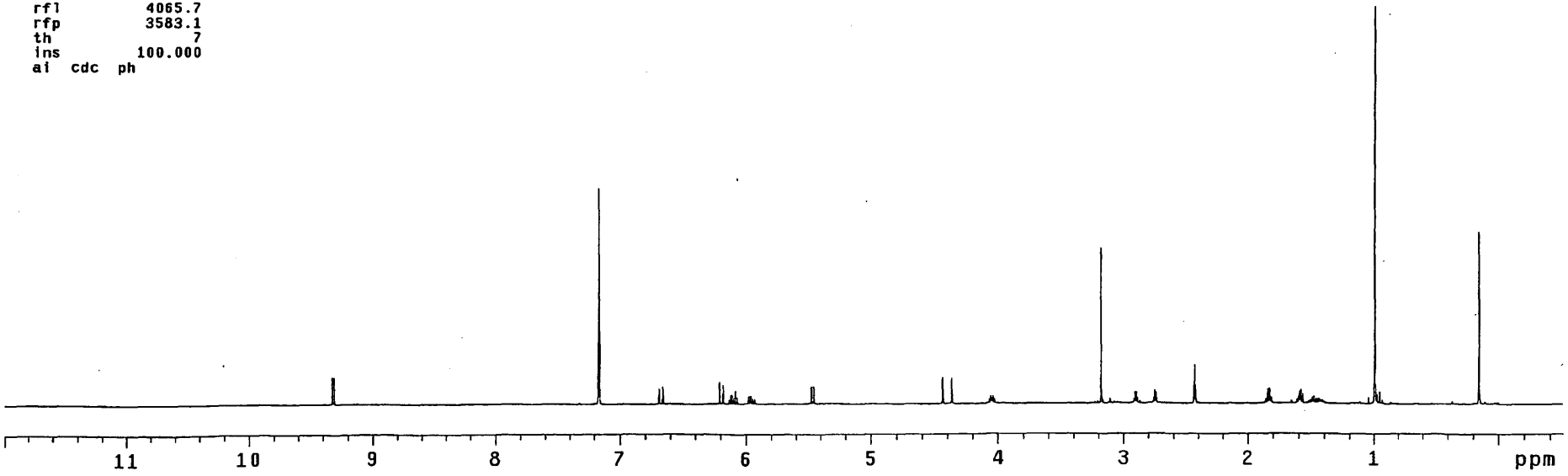


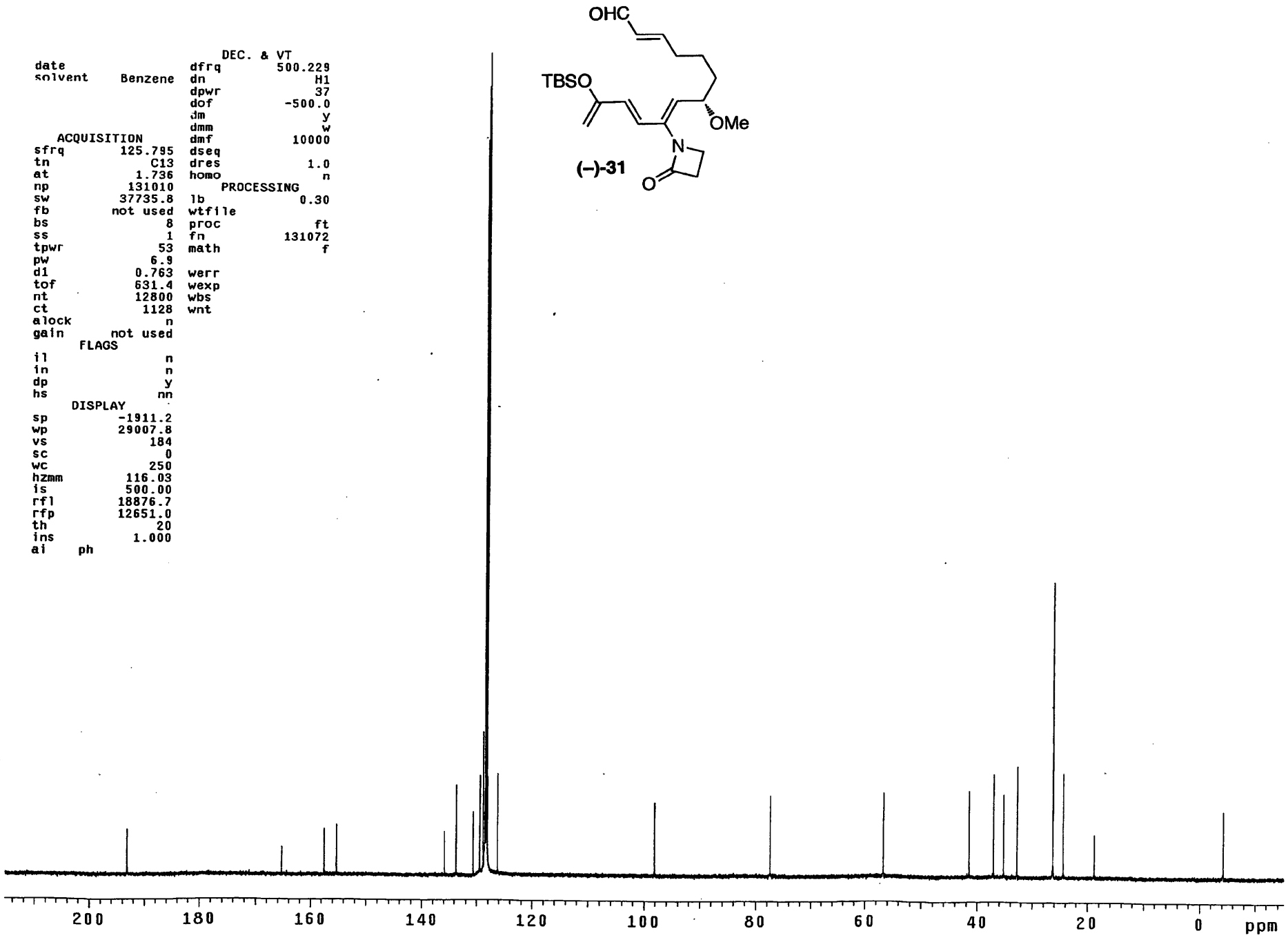

TBSO
OMe
N
O
(–)-30
%T
cm-1
117.2
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
6.8
4000.0
3000
2000
1500
1000
500
400.0
2930.96
2859.01
1760.01
1621.69
1584.38
1463.31
1395.45
1345.87
1317.82
1254.17
1200.60
1102.46
1028.17
959.93
910.10
840.19
811.75
781.94



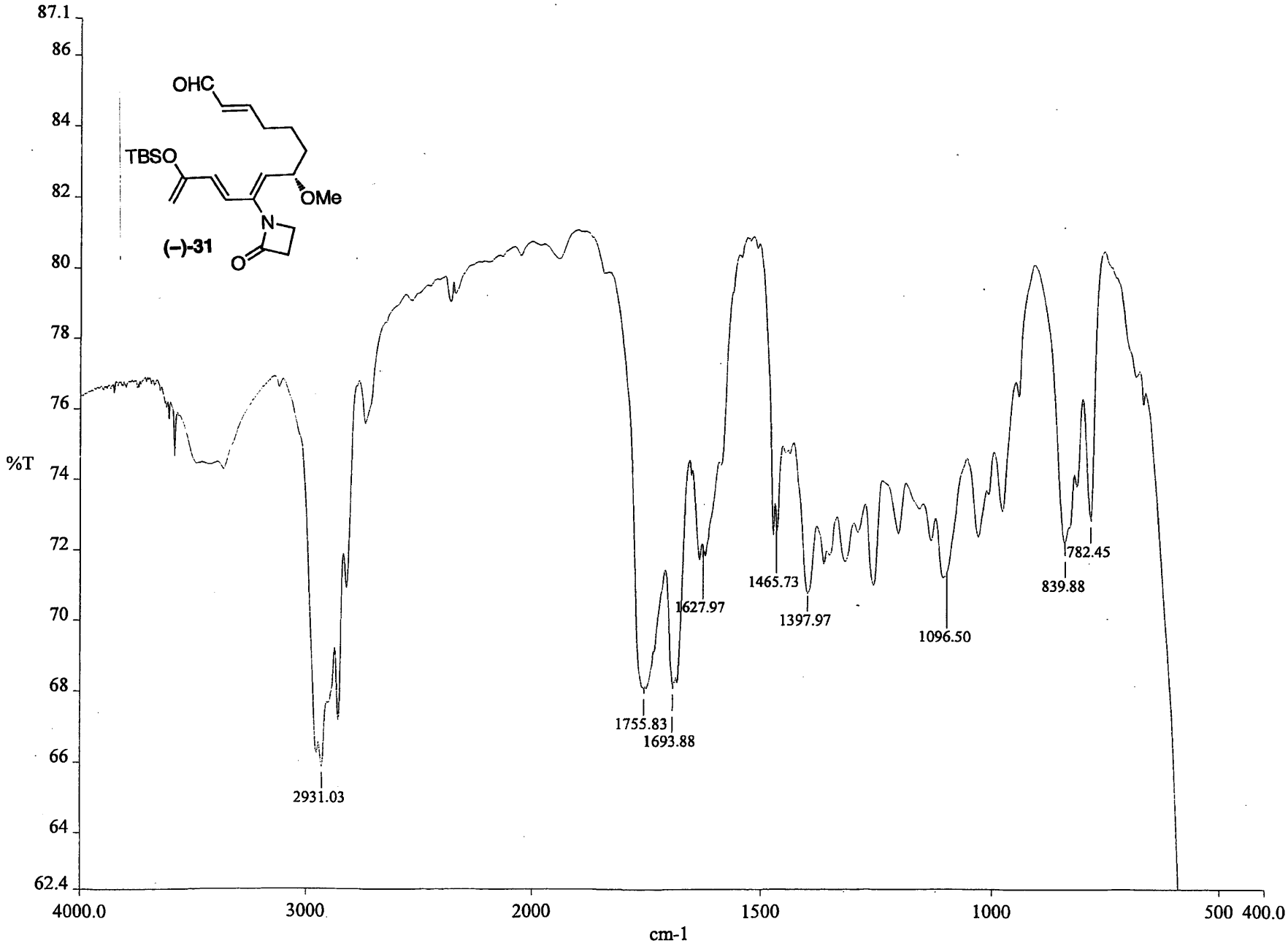
(−)-31

		DEC. & VT	
date		dfrq	125.845
solvent	Benzene	dn	C13
		dpwr	30
		dof	0
		dm	nnn
		dmm	c
ACQUISITION		dmf	200
sfrq	500.435	dseq	
tn	H1	dres	1.0
at	4.999	homo	n
np	120102	PROCESSING	
sw	12012.0	wtfile	
fb	not used	proc	ft
bs	8	fn	262144
tpwr	56	math	f
pw	8.0		
d1	0.100	werr	
tof	3003.2	wexp	
nt	16	wbs	
ct	16	wnt	wft
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-250.2		
wp	6255.3		
vs	14		
sc	0		
wc	250		
hzmm	25.02		
is	33.57		
rfl	4065.7		
rfp	3583.1		
th	7		
ins	100.000		
ai cdc ph			

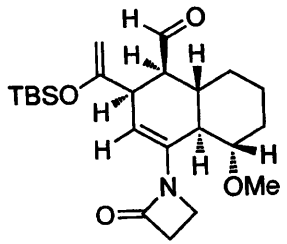




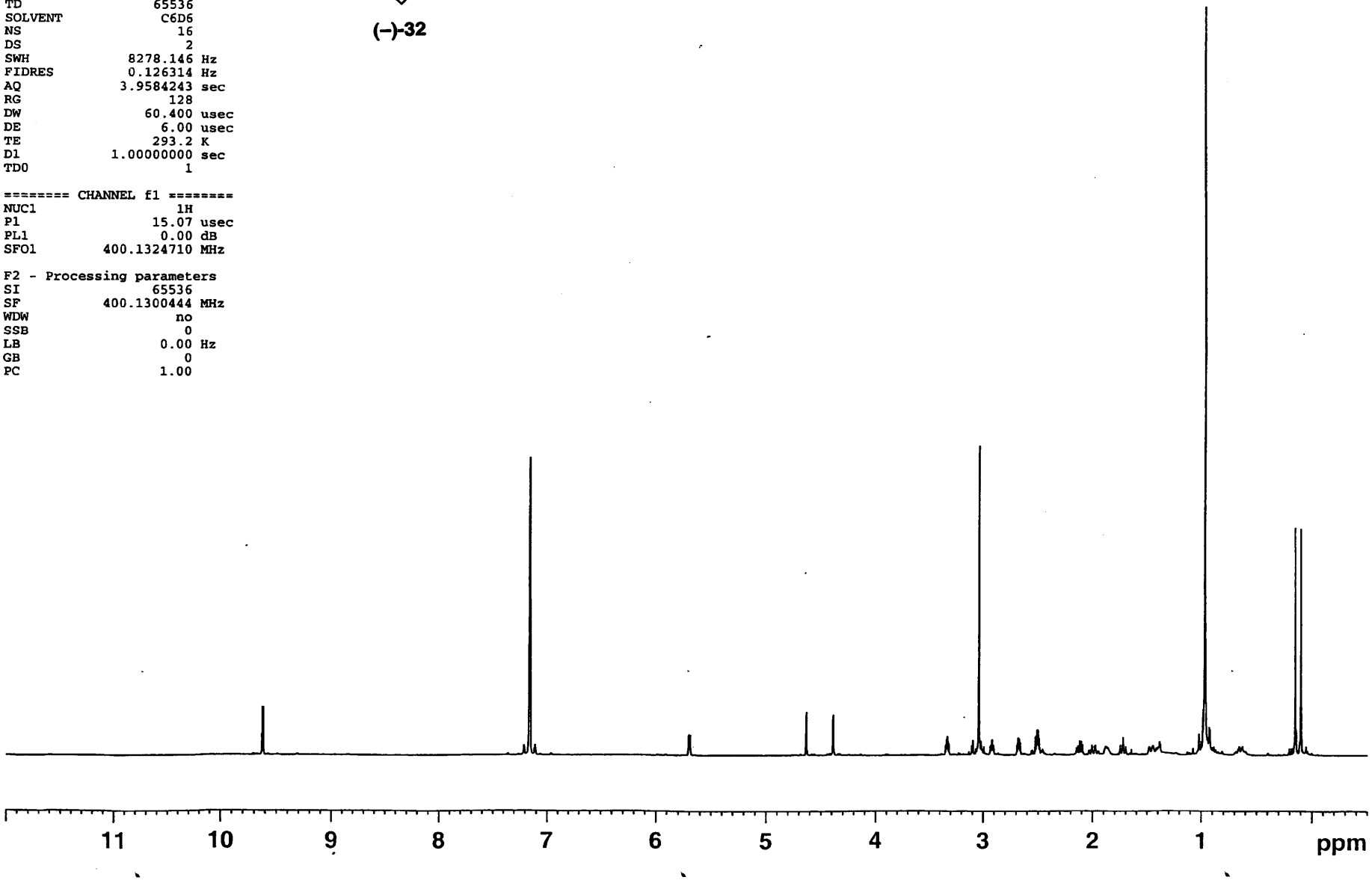
date		DEC. & VT	
solvent	Benzene	dfrq	500.229
		dn	H1
		dpwr	37
		dof	-500.0
		dm	y
		dmm	w
ACQUISITION		dmf	10000
sfrq	125.795	dseq	
tn	C13	dres	1.0
at	1.736	homo	n
np	131010	PROCESSING	
sw	37735.8	lb	0.30
fb	not used	wtfile	
bs	8	proc	ft
ss	1	fn	131072
tpwr	53	math	f
pw	6.9		
d1	0.763	werr	
tof	631.4	wexp	
nt	12800	wbs	
ct	1128	wnt	
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-1911.2		
wp	29007.8		
vs	184		
sc	0		
wc	250		
hzmm	116.03		
is	500.00		
rfl	18876.7		
rfp	12651.0		
th	20		
ins	1.000		
ai	ph		

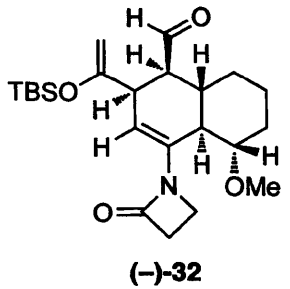

OHC
TBSO
OMe
N
O
(–)-31
87.1
86
84
82
80
78
76
74
72
70
68
66
64
62.4
%T
2931.03
1755.83
1693.88
1627.97
1465.73
1397.97
1096.50
839.88
782.45
4000.0
3000
2000
1500
1000
500
400.0
cm-1

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM                  spect
PROBHD    5 mm BBO BB-1H
PULPROG                  zg30
TD                      65536
SOLVENT                  C6D6
NS                         16
DS                          2
SWH                  8278.146 Hz
FIDRES               0.126314 Hz
AQ                   3.9584243 sec
RG                         128
DW                      60.400 usec
DE                       6.00 usec
TE                      293.2 K
D1                   1.00000000 sec
TD0                         1

======== CHANNEL f1 ========
NUC1                       1H
P1                      15.07 usec
PL1                      0.00 dB
SFO1             400.1324710 MHz

F2 - Processing parameters
SI                      65536
SF               400.1300444 MHz
WDW                        no
SSB                         0
LB                       0.00 Hz
GB                          0
PC                       1.00
```



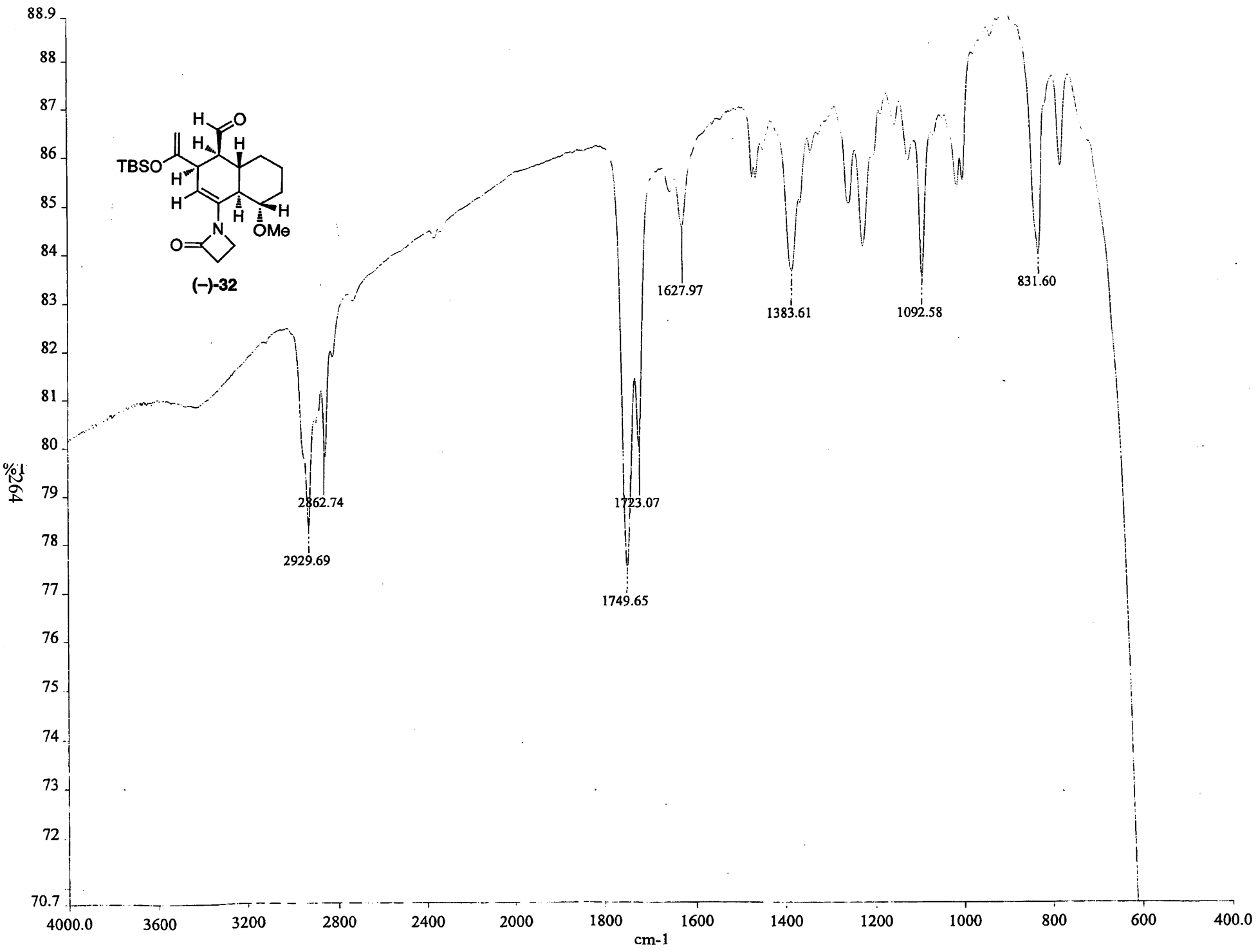
(–)-32



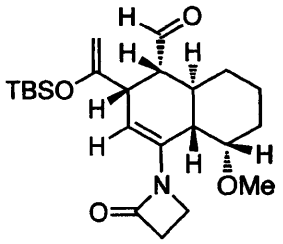


(–)-32

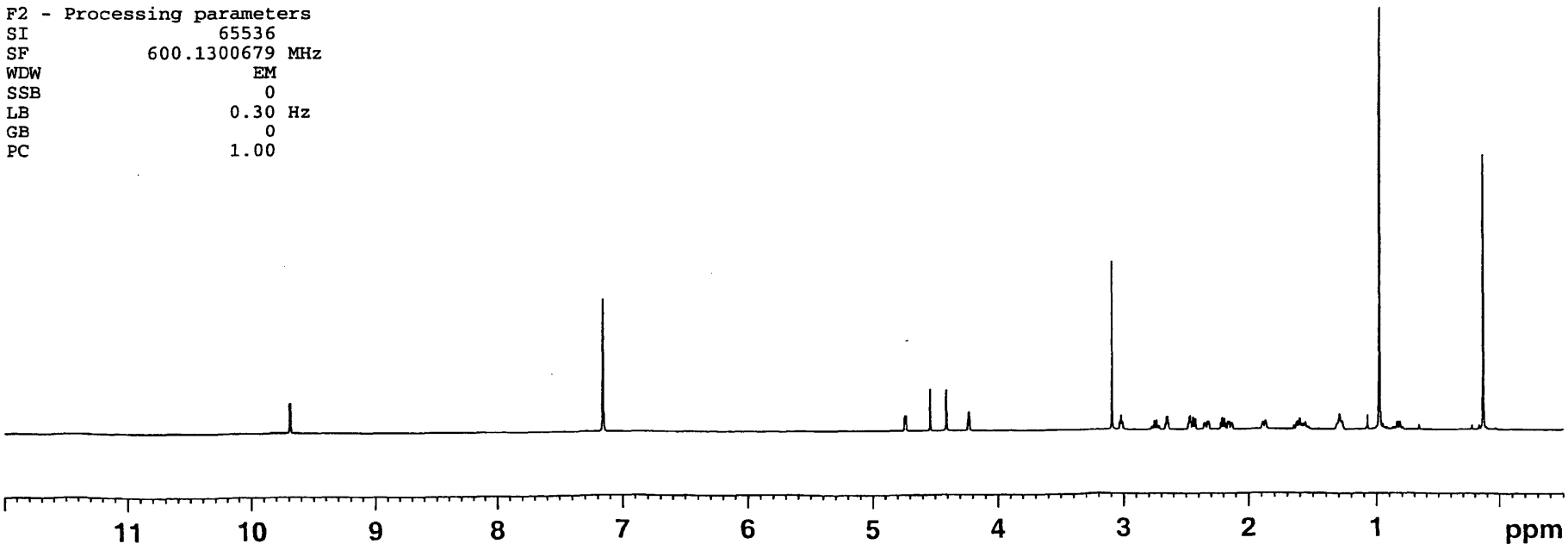
		DEC. & VT	
date		dfrq	500.233
solvent	Benzene	dn	H1
		dpwr	37
		dof	-500.0
		dm	y
		dmm	w
ACQUISITION		dmf	10000
sfrq	125.796	dseq	
tn	C13	dres	1.0
at	1.736	homo	n
np	131010	PROCESSING	
sw	37735.8	lb	0.30
fb	not used	wtfile	
bs	8	proc	ft
ss	1	fn	131072
tpwr	53	math	f
pw	6.9		
d1	0.763	werr	
tof	631.4	wexp	
nt	2560	wbs	
ct	296	wnt	
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-1887.5		
wp	28933.0		
vs	119		
sc	0		
wc	250		
hzmm	115.73		
is	500.00		
rfl	18876.6		
rfp	12651.0		
th	20		
ins	1.000		
ai	ph		


TBSO
H
O
H
H
H
H
H
H
N
O
OMe
(–)-32
%T
88.9
88
87
86
85
84
83
82
81
80
79
78
77
76
75
74
73
72
70.7
2929.69
2862.74
1749.65
1723.07
1627.97
1383.61
1092.58
831.60
4000.0
3600
3200
2800
2400
2000
1800
1600
1400
1200
1000
800
600
400.0
cm-1

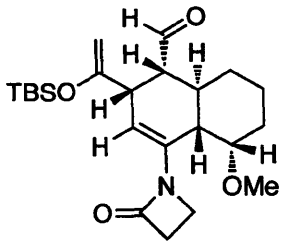
```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM                  spect
PROBHD    5 mm CPTXI 1H-
PULPROG                  zg30
TD                      65536
SOLVENT                  C6D6
NS                         16
DS                          2
SWH                 12376.237 Hz
FIDRES               0.188846 Hz
AQ                  2.6477044 sec
RG                         18
DW                     40.400 usec
DE                      6.00 usec
TE                     304.0 K
D1                1.00000000 sec
TD0                         1

======== CHANNEL f1 ========
NUC1                       1H
P1                     11.00 usec
PL1                     4.00 dB
SFO1             600.1337060 MHz

F2 - Processing parameters
SI                      65536
SF               600.1300679 MHz
WDW                        EM
SSB                         0
LB                      0.30 Hz
GB                          0
PC                      1.00
```



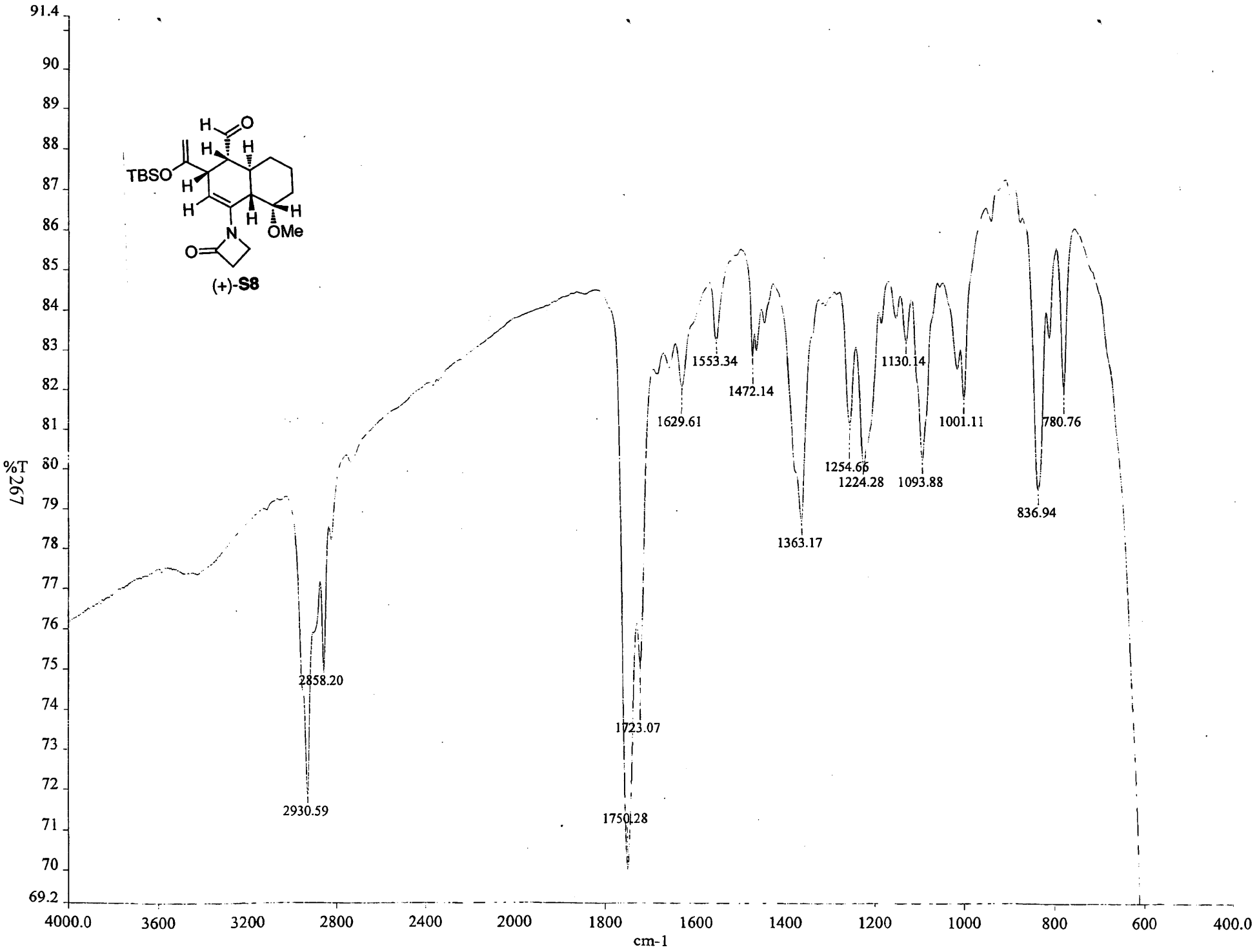
(+)-**S8**



		DEC. & VT	
date		dfrq	500.233
solvent	Benzene	dn	H1
		dpwr	37
		dof	-500.0
		dm	y
		dmm	w
ACQUISITION		dmf	10000
sfrq	125.796	dseq	
tn	C13	dres	1.0
at	1.736	homo	n
np	131010	PROCESSING	
sw	37735.8	lb	0.30
fb	not used	wtfile	
bs	8	proc	ft
ss	1	fn	131072
tpwr	53	math	f
pw	6.9		
d1	0.763	werr	
tof	631.4	wexp	
nt	25600	wbs	
ct	1168	wnt	
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-1887.5		
wp	28933.0		
vs	471		
sc	0		
wc	250		
hzmm	115.73		
is	500.00		
rfl	18876.6		
rfp	12651.0		
th	20		
ins	1.000		
ai	ph		



(+)-**S8**

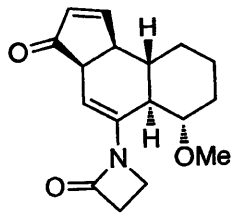

(+)-S8
%T 267
cm-1
2858.20
2930.59
1723.07
1750.28
1629.61
1553.34
1472.14
1363.17
1254.66
1224.28
1130.14
1093.88
1001.11
836.94
780.76

Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM spect
PROBHD 5 mm CPTXI 1H-
PULPROG zg30
TD 65536
SOLVENT C6D6
NS 16
DS 2
SWH 12376.237 Hz
FIDRES 0.188846 Hz
AQ 2.6477044 sec
RG 22.6
DW 40.400 usec
DE 6.00 usec
TE 300.0 K
D1 1.00000000 sec
TD0 1

======== CHANNEL f1 ========
NUC1 1H
P1 11.00 usec
PL1 4.00 dB
SFO1 600.1337060 MHz

F2 - Processing parameters
SI 65536
SF 600.1300667 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00



(–)-33

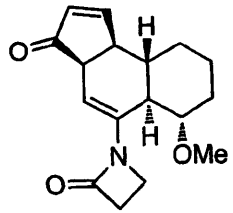
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM spect
PROBHD 5 mm CPTXI 1H-
PULPROG zgpg30
TD 65536
SOLVENT CDCl3
NS 256
DS 4
SWH 35971.223 Hz
FIDRES 0.548877 Hz
AQ 0.9110004 sec
RG 14596.5
DW 13.900 usec
DE 6.00 usec
TE 300.0 K
D1 2.00000000 sec
d11 0.03000000 sec
DELTA 1.89999998 sec
TD0 1

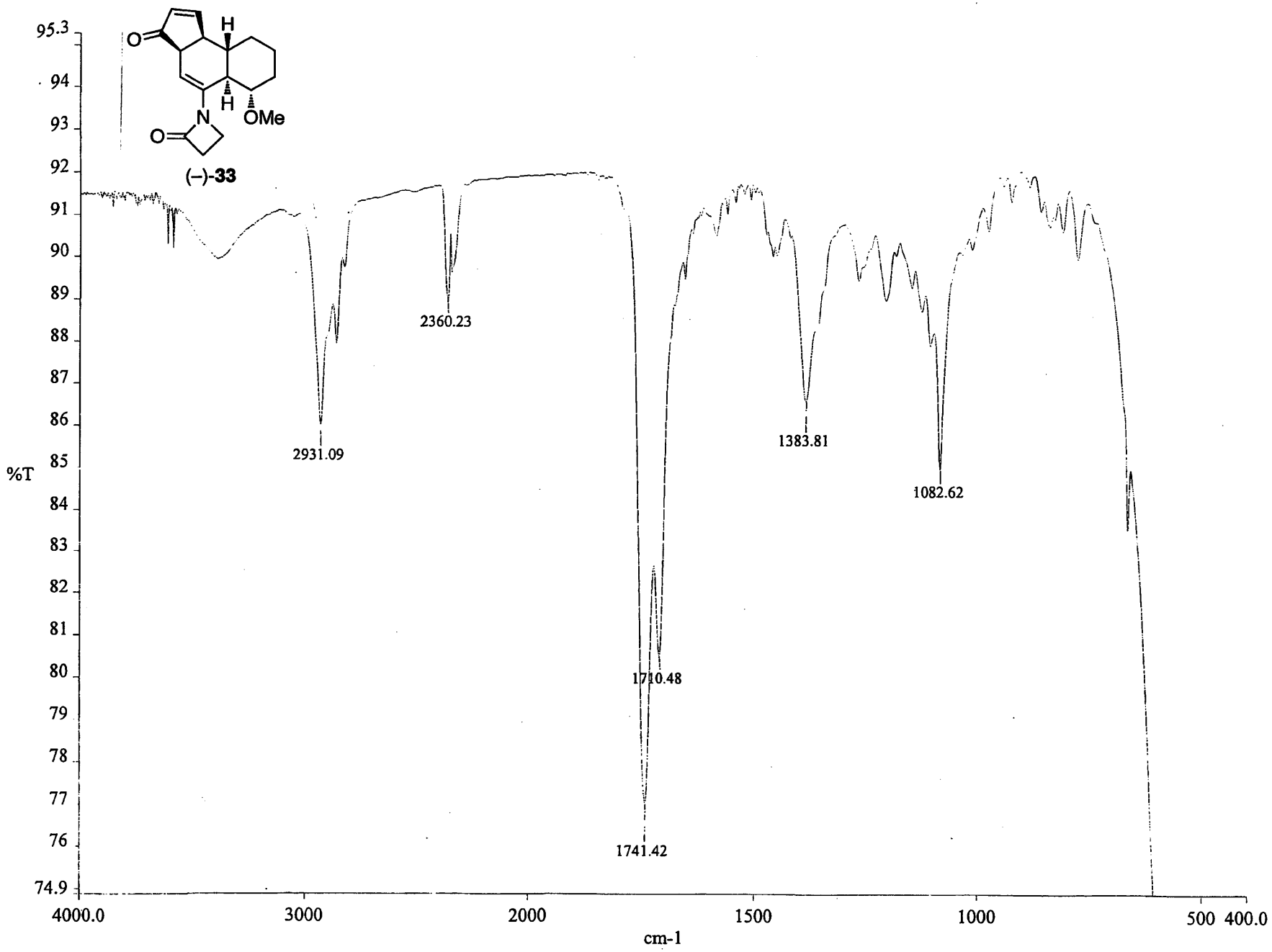
======== CHANNEL f1 ========
NUC1 13C
P1 15.00 usec
PL1 1.60 dB
SFO1 150.9178988 MHz

======== CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 70.00 usec
PL2 4.00 dB
PL12 22.84 dB
PL13 22.84 dB
SFO2 600.1324005 MHz

F2 - Processing parameters
SI 65536
SF 150.9027231 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.00



(–)-33

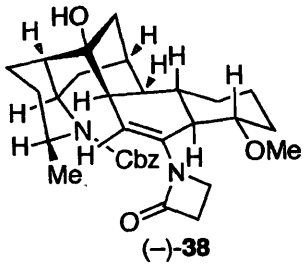

(–)-33
%T
95.3
94
93
92
91
90
89
88
87
86
85
84
83
82
81
80
79
78
77
76
74.9
2931.09
2360.23
1741.42
1710.48
1383.81
1082.62
4000.0
3000
2000
1500
1000
500
400.0
cm-1

Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM spect
PROBHD 5 mm CPTXI 1H-
PULPROG zg30
TD 65536
SOLVENT C6D6
NS 16
DS 2
SWH 12376.237 Hz
FIDRES 0.188846 Hz
AQ 2.6477044 sec
RG 32
DW 40.400 usec
DE 6.00 usec
TE 293.0 K
D1 1.00000000 sec
TD0 1

======== CHANNEL f1 ========
NUC1 1H
P1 11.00 usec
PL1 4.00 dB
SFO1 600.1337060 MHz

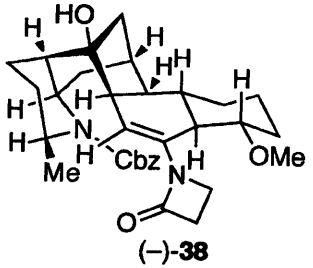
F2 - Processing parameters
SI 65536
SF 600.1300681 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00



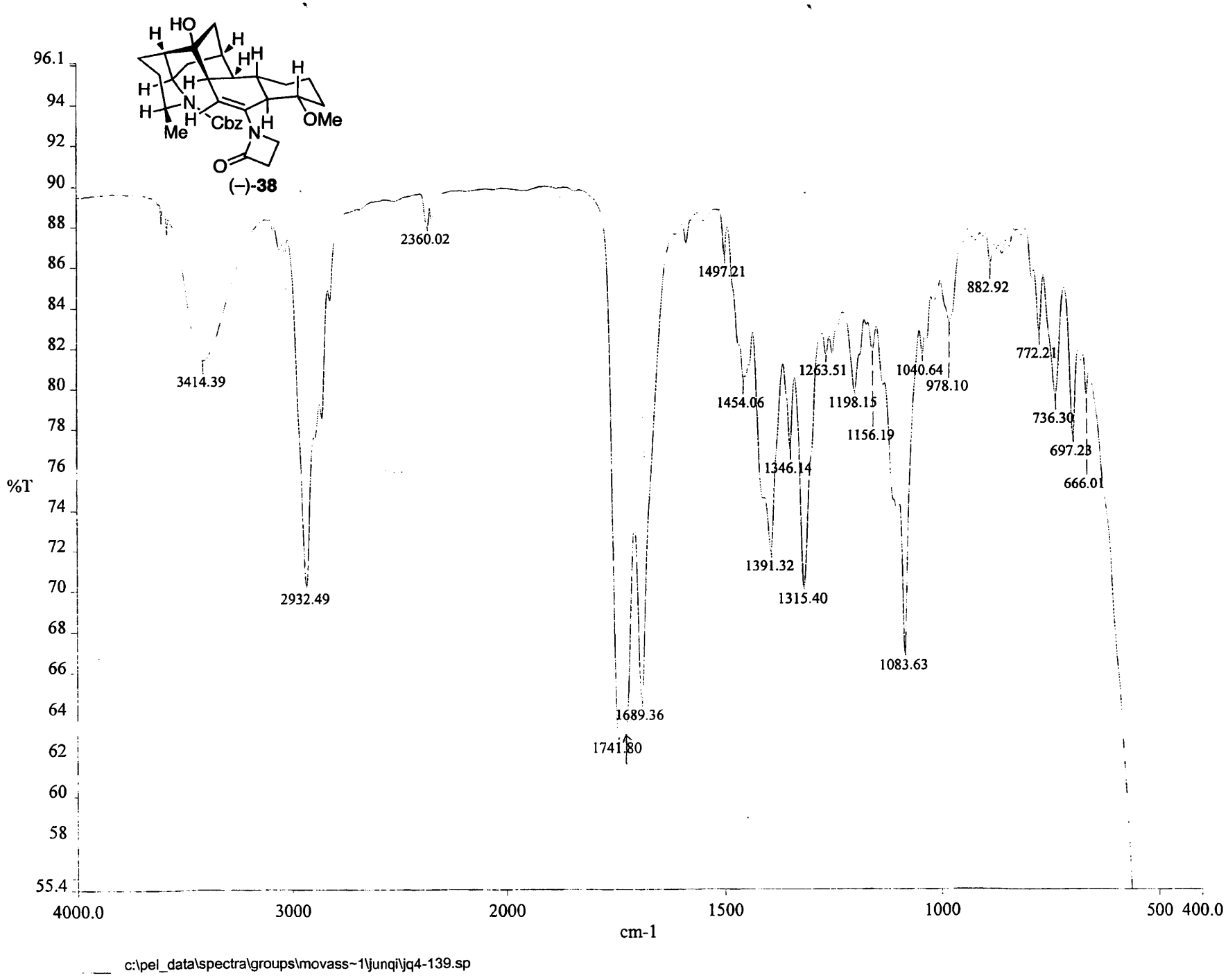
(–)-38

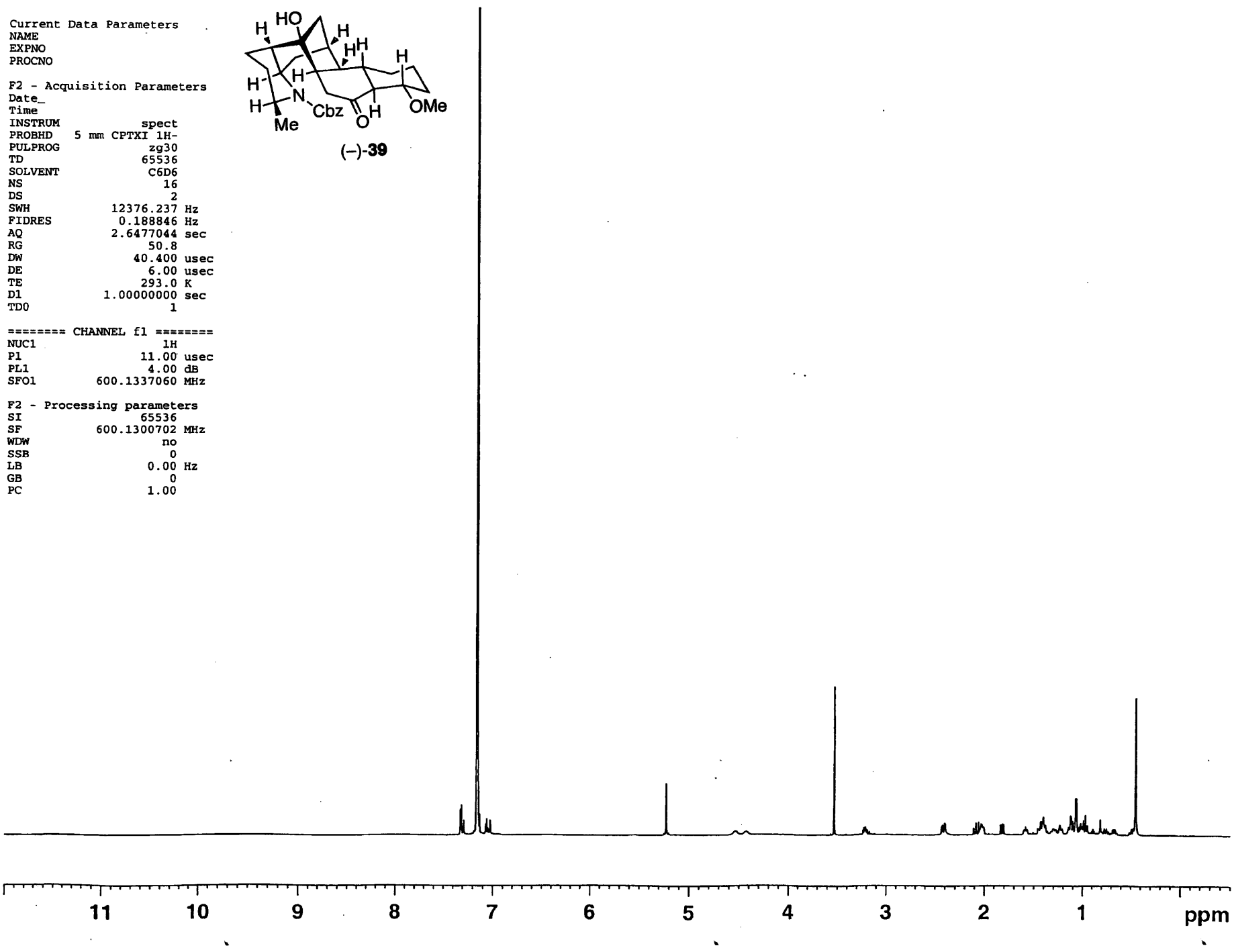
date	
solvent	Benzene
ACQUISITION	
sfrq	125.795
tn	C13
at	1.736
np	131010
sw	37735.8
fb	not used
bs	8
ss	1
tpwr	53
pw	6.9
d1	0.763
tof	631.4
nt	128000
ct	3064
alock	n
gain	not used
FLAGS	
il	n
in	n
dp	y
hs	nn
DISPLAY	
sp	-1960.7
wp	29007.8
vs	1238
sc	0
wc	250
hzmm	116.03
is	500.00
rfl	18876.7
rfp	12651.0
th	20
ins	1.000
ai	ph

DEC. & VT	
rq	500.229
dn	H1
dpwr	37
dof	-500.0
dm	y
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n
PROCESSING	
lb	0.30
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	



(–)-**38**


(–)-38
96.1
94
92
90
88
86
84
82
80
78
76
74
72
70
68
66
64
62
60
58
55.4
%T
3414.39
2932.49
2360.02
1741.80
1689.36
1497.21
1454.06
1391.32
1346.14
1315.40
1263.51
1198.15
1156.19
1083.63
1040.64
978.10
882.92
772.21
736.30
697.23
666.01
4000.0
3000
2000
1500
1000
500 400.0
cm-1
c:\pel_data\spectra\groups\movass~1\junqi\jq4-139.sp


Current Data Parameters
NAME
EXPNO
PROCNO
F2 - Acquisition Parameters
Date_
Time
INSTRUM spect
PROBHD 5 mm CPTXI 1H-
PULPROG zg30
TD 65536
SOLVENT C6D6
NS 16
DS 2
SWH 12376.237 Hz
FIDRES 0.188846 Hz
AQ 2.6477044 sec
RG 50.8
DW 40.400 usec
DE 6.00 usec
TE 293.0 K
D1 1.00000000 sec
TD0 1
======== CHANNEL f1 ========
NUC1 1H
P1 11.00 usec
PL1 4.00 dB
SFO1 600.1337060 MHz
F2 - Processing parameters
SI 65536
SF 600.1300702 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
HO
H
Me
N
Cbz
O
OMe
(–)-39
11
10
9
8
7
6
5
4
3
2
1
ppm

date	
solvent	Benzene

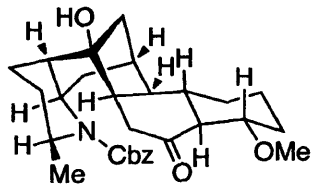
ACQUISITION	
sfrq	125.795
tn	C13
at	1.736
np	131010
sw	37735.8
fb	not used
bs	8
ss	1
tpwr	53
pw	6.9
d1	0.763
tof	631.4
nt	12800
ct	1808
alock	n
gain	not used

FLAGS	
il	n
in	n
dp	y
hs	nn

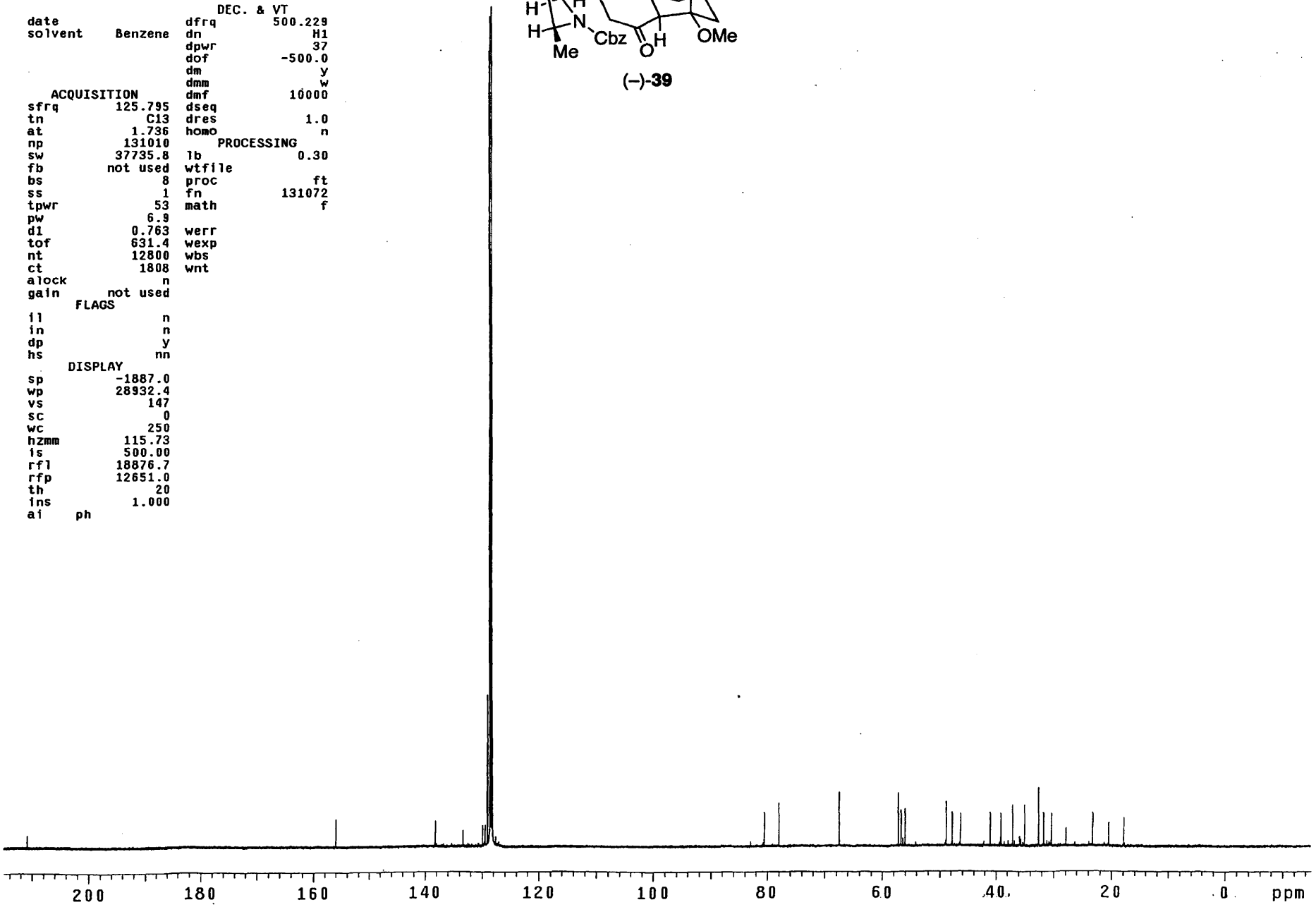
DISPLAY	
sp	-1887.0
wp	28932.4
vs	147
sc	0
wc	250
hzmm	115.73
is	500.00
rfl	18876.7
rfp	12651.0
th	20
ins	1.000
ai	ph

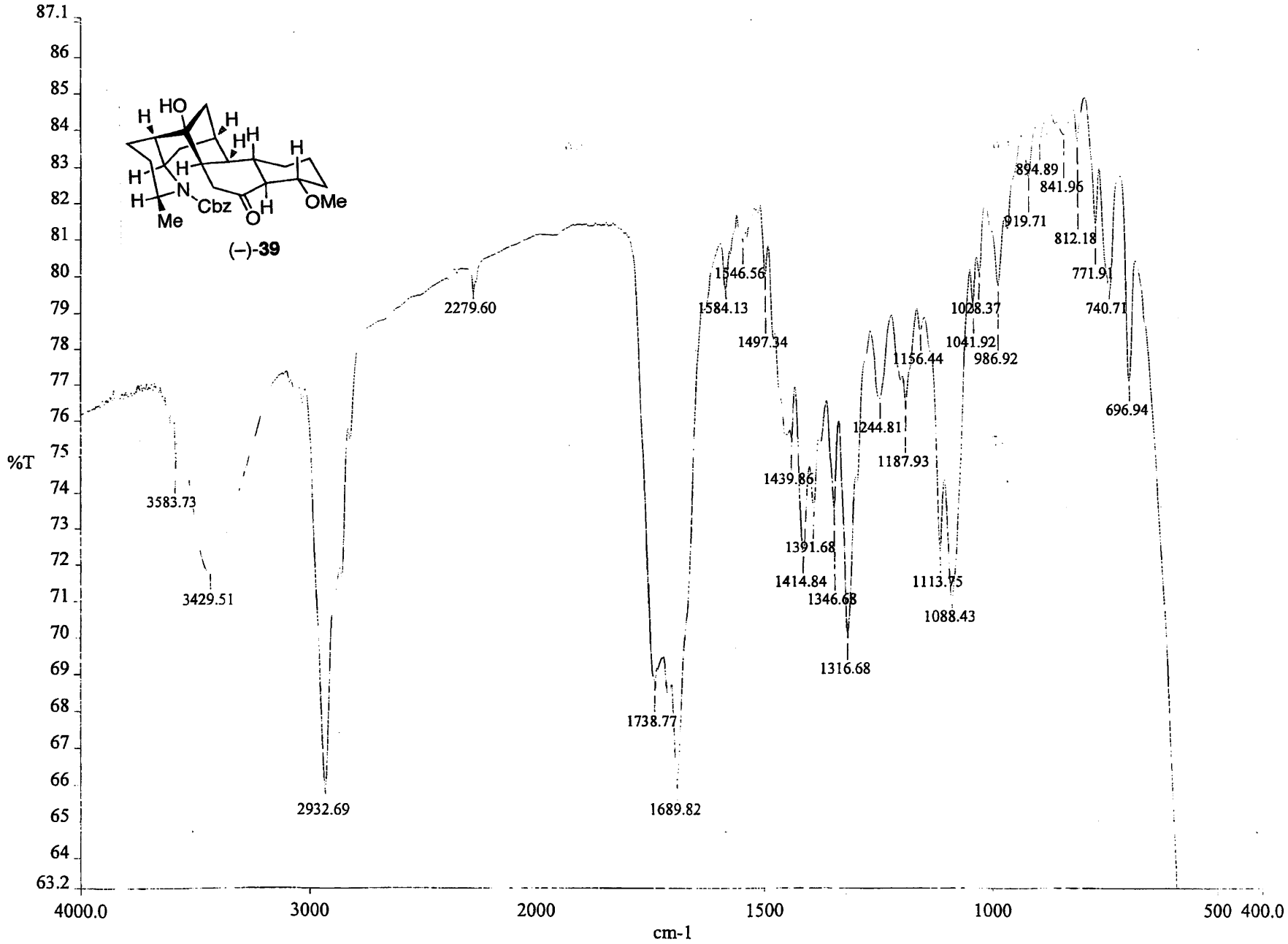
DEC. & VT	
dfrq	500.229
dn	H1
dpwr	37
dof	-500.0
dm	y
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

PROCESSING	
lb	0.30
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	

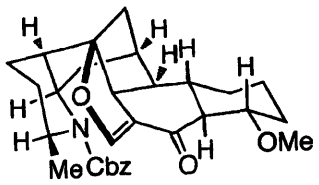


(–)-**39**

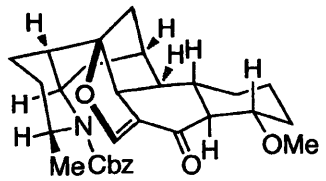



87.1
86
85
84
83
82
81
80
79
78
77
76
75
74
73
72
71
70
69
68
67
66
65
64
63.2
%T
4000.0
3000
2000
1500
1000
500
400.0
cm-1
HO
H
Me
N
Cbz
O
OMe
(–)-39
3583.73
3429.51
2932.69
2279.60
1738.77
1689.82
1584.13
1546.56
1497.34
1439.86
1391.68
1414.84
1346.68
1316.68
1244.81
1187.93
1156.44
1113.75
1088.43
1041.92
1028.37
986.92
919.71
894.89
841.96
812.18
771.91
740.71
696.94

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD    5 mm CPTXI 1H-
PULPROG              zg30
TD                  65536
SOLVENT             CDCl3
NS                     16
DS                      2
SWH             12376.237 Hz
FIDRES              0.188846 Hz
AQ              2.6477044 sec
RG                     28.5
DW                 40.400 usec
DE                  6.00 usec
TE                  293.0 K
D1             1.00000000 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                   1H
P1                 11.00 usec
PL1                 4.00 dB
SFO1          600.1337060 MHz

F2 - Processing parameters
SI                  65536
SF            600.1300667 MHz
WDW                    EM
SSB                     0
LB                   0.30 Hz
GB                      0
PC                   1.00
```

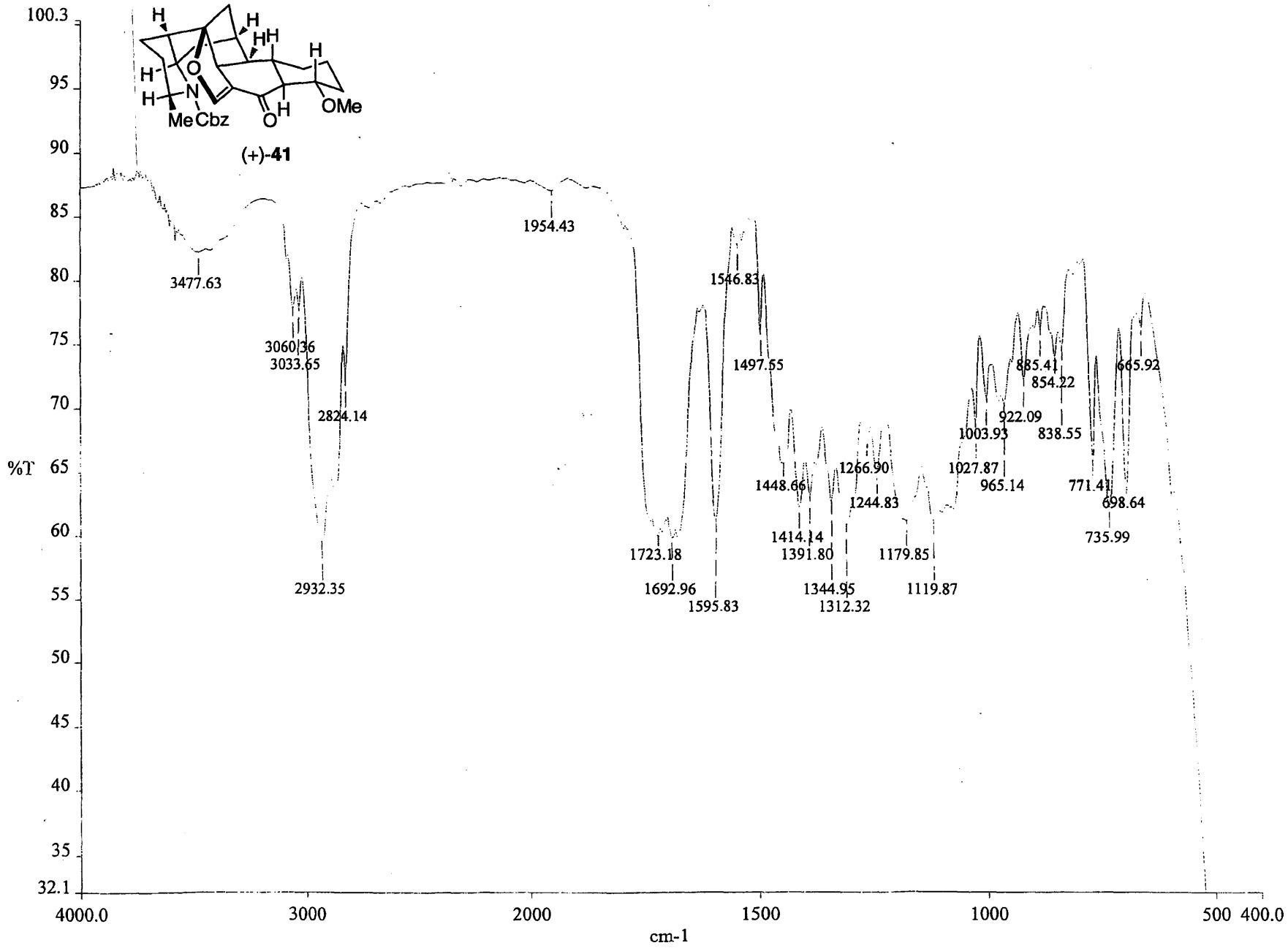


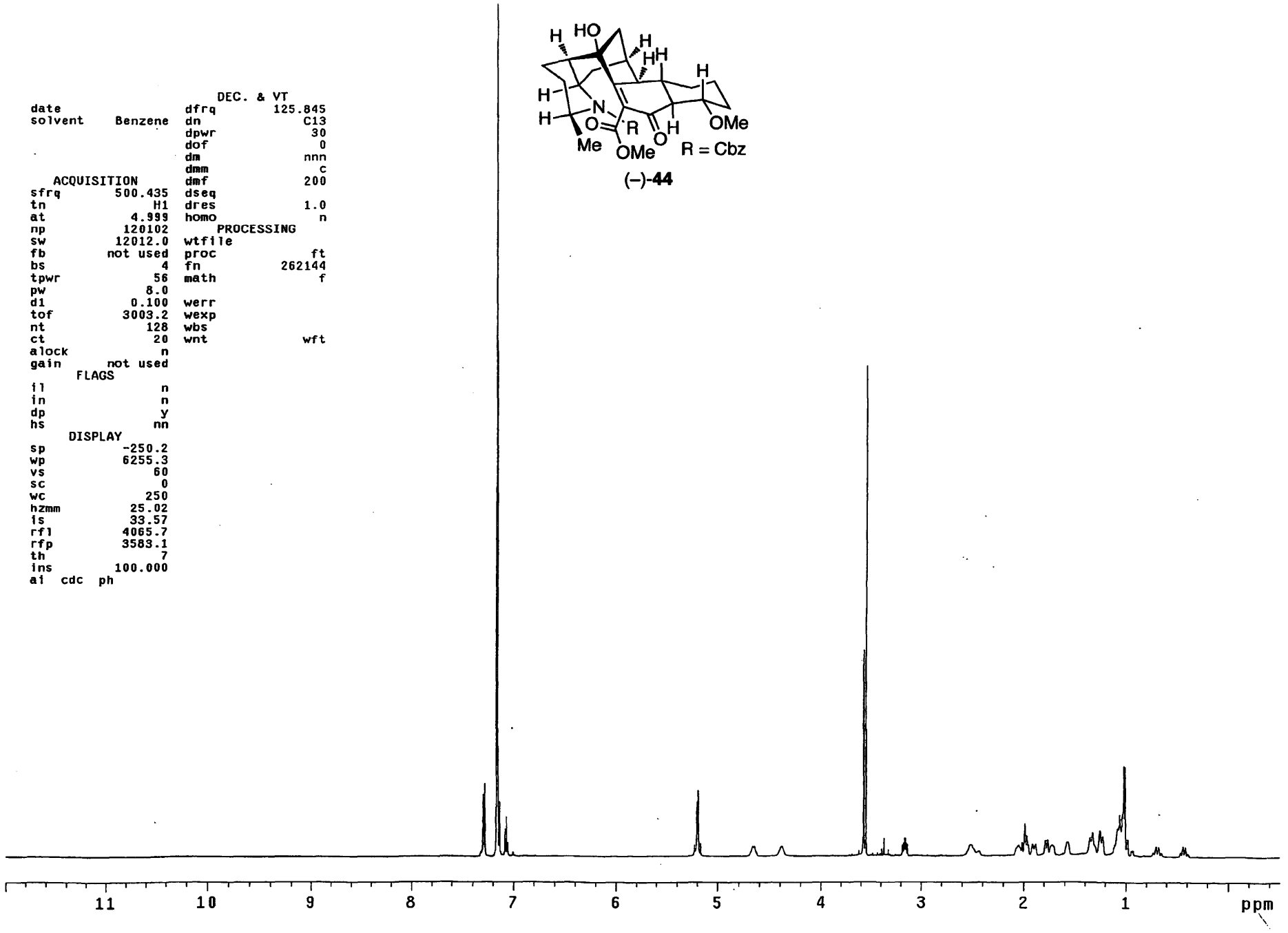
(+)-41

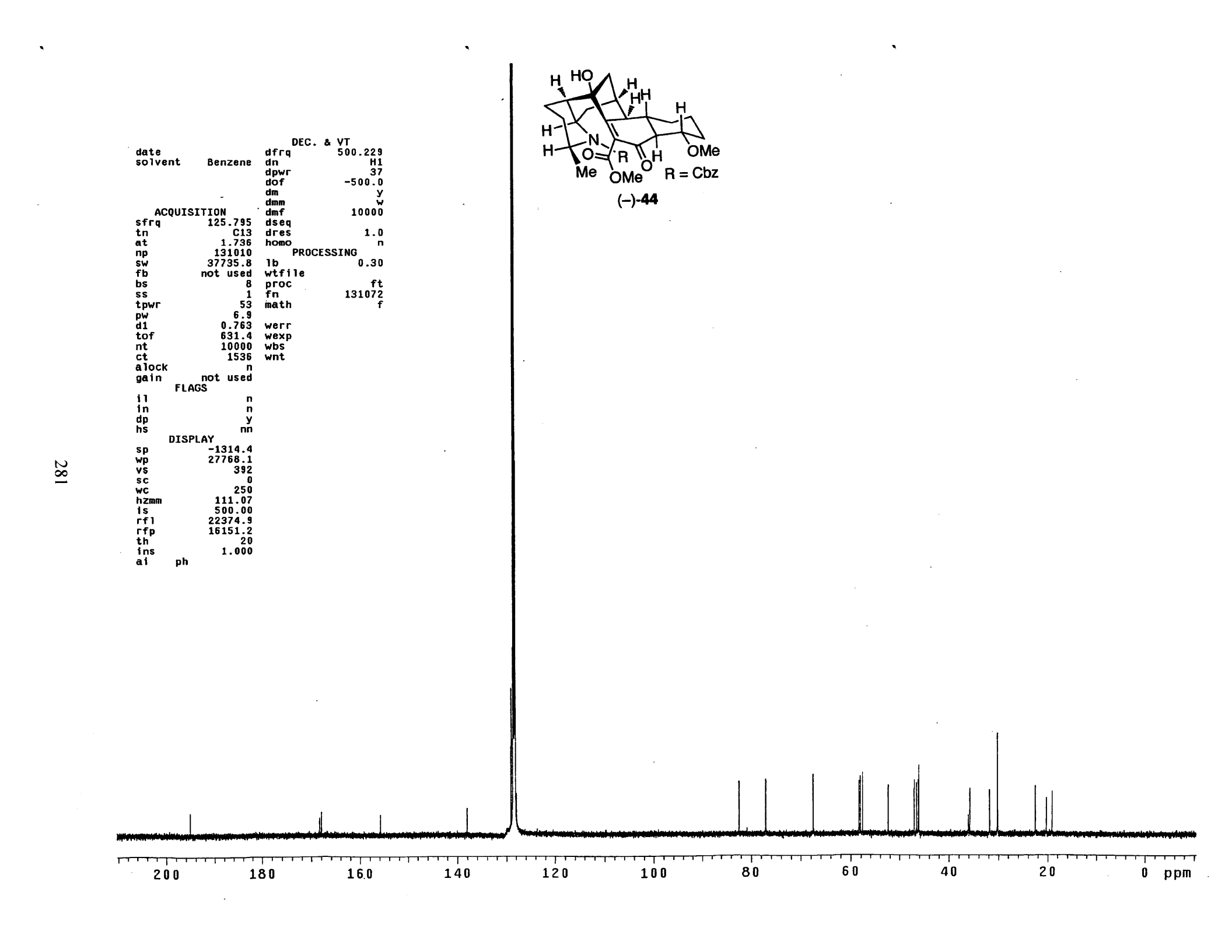


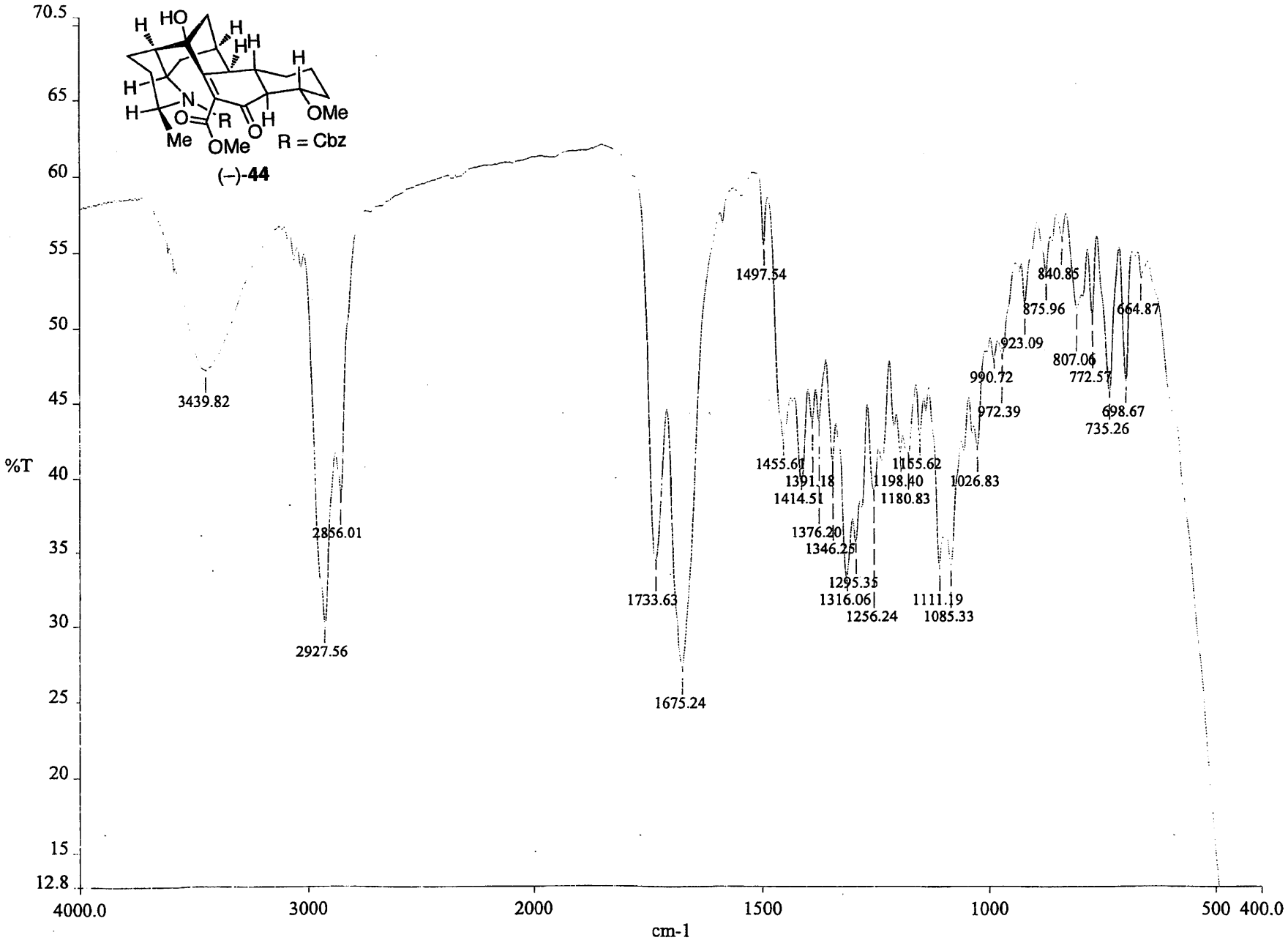
(+)-**41**

date		DEC. & VT	
solvent	Benzene	dfrq	500.229
		dn	H1
		dpwr	37
		dof	-500.0
		dm	y
		dmm	w
ACQUISITION		dmf	10000
sfrq	125.795	dseq	
tn	C13	dres	1.0
at	1.736	homo	n
np	131010	PROCESSING	
sw	37735.8	lb	0.30
fb	not used	wtfile	
bs	8	proc	ft
ss	1	fn	131072
tpwr	53	math	f
pw	6.9		
d1	0.763	werr	
tof	631.4	wexp	
nt	128000	wbs	
ct	1768	wnt	
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-1264.3		
wp	27669.1		
vs	983		
sc	0		
wc	250		
hzmm	110.68		
is	500.00		
rfl	22374.3		
rfp	16151.2		
th	20		
ins	1.000		
ai	ph		


(+)-41
%T
cm-1
100.3
95
90
85
80
75
70
65
60
55
50
45
40
35
32.1
4000.0
3000
2000
1500
1000
500
400.0
3477.63
3060.36
3033.65
2824.14
2932.35
1954.43
1723.18
1692.96
1595.83
1546.83
1497.55
1448.66
1414.14
1391.80
1344.95
1312.32
1266.90
1244.83
1179.85
1119.87
1027.87
1003.93
965.14
922.09
885.41
854.22
838.55
771.41
735.99
698.64
665.92


date
solvent Benzene
ACQUISITION
sfrq 500.435
tn H1
at 4.999
np 120102
sw 12012.0
fb not used
bs 4
tpwr 56
pw 8.0
d1 0.100
tof 3003.2
nt 128
ct 20
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -250.2
wp 6255.3
vs 60
sc 0
wc 250
hzmm 25.02
is 33.57
rfl 4065.7
rfp 3583.1
th 7
ins 100.000
ai cdc ph
DEC. & VT
dfrq 125.845
dn C13
dpwr 30
dof 0
dm nnn
dmm c
dmf 200
dseq
dres 1.0
homo n
PROCESSING
wtfile
proc ft
fn 262144
math f
werr
wexp
wbs
wnt wft
HO
H
N
O
R
Me
OMe
R = Cbz
(–)-44
11
10
9
8
7
6
5
4
3
2
1
ppm


date
solvent Benzene
ACQUISITION
sfrq 125.795
tn C13
at 1.736
np 131010
sw 37735.8
fb not used
bs 8
ss 1
tpwr 53
pw 6.9
d1 0.763
tof 631.4
nt 10000
ct 1536
alock n
gain not used
FLAGS
il n
in n
dp y
hs nn
DISPLAY
sp -1314.4
wp 27768.1
vs 392
sc 0
wc 250
hzmm 111.07
is 500.00
rfl 22374.9
rfp 16151.2
th 20
ins 1.000
ai ph
DEC. & VT
dfrq 500.229
dn H1
dpwr 37
dof -500.0
dm y
dmm w
dmf 10000
dseq
dres 1.0
homo n
PROCESSING
lb 0.30
wtfile
proc ft
fn 131072
math f
werr
wexp
wbs
wnt
H HO H H H H
H N H O R O H OMe
Me OMe
R = Cbz
(–)-44
200 180 160 140 120 100 80 60 40 20 0 ppm


(–)-44
R = Cbz
%T
cm-1
3439.82
2927.56
2856.01
1733.63
1675.24
1497.54
1455.61
1414.51
1391.18
1376.20
1346.25
1316.06
1295.35
1256.24
1198.40
1180.83
1155.62
1111.19
1085.33
1026.83
990.72
972.39
923.09
875.96
840.85
807.06
772.57
735.26
698.67
664.87

date	
solvent	Benzene

ACQUISITION	
sfrq	500.435
tn	H1
at	4.999
np	120102
sw	12012.0
fb	not used
bs	4
tpwr	56
pw	8.0
d1	0.100
tof	3003.2
nt	128
ct	24
alock	n
gain	not used

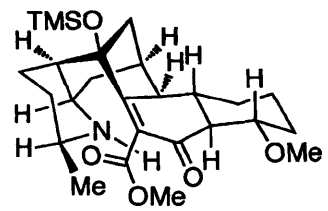
FLAGS	
il	n
in	n
dp	y
hs	nn

DISPLAY	
sp	-250.2
wp	6255.3
vs	60
sc	0
wc	250
hzmm	25.02
is	33.57
rfl	4068.0
rfp	3583.1
th	7
ins	100.000

ai cdc ph

DEC. & VT	
dfrq	125.845
dn	C13
dpwr	30
dof	0
dm	nnn
dmm	c
dmf	200
dseq	
dres	1.0
homo	n

PROCESSING	
wtfile	
proc	ft
fn	262144
math	f
werr	
wexp	
wbs	
wnt	wft



(–)-**S9**

date	
solvent	Benzene

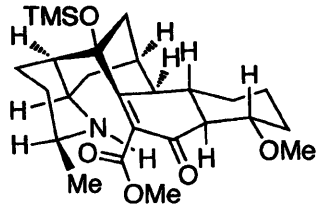
ACQUISITION	
sfrq	125.796
tn	C13
at	1.737
np	104492
sw	30075.2
fb	not used
bs	4
ss	1
tpwr	53
pw	6.9
d1	0.763
tof	1771.3
nt	1e+07
ct	23884
alock	n
gain	not used

FLAGS	
il	n
in	n
dp	y
hs	nn

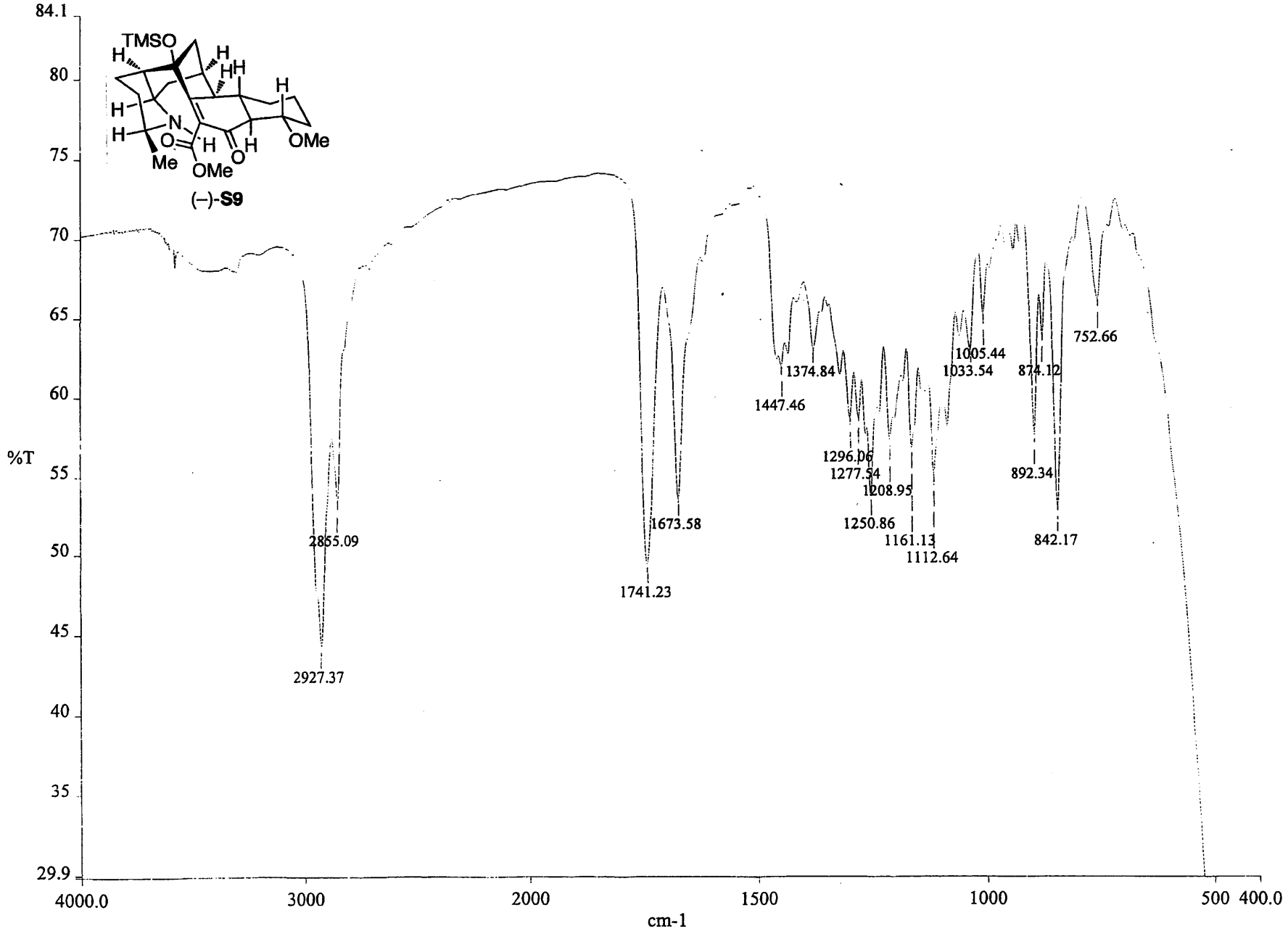
DISPLAY	
sp	-1255.0
wp	27743.0
vs	1986
sc	0
wc	250
hzmm	110.97
is	500.00
rfl	17404.7
rfp	16149.2
th	20
ins	1.000
ai	ph

DEC. & VT	
dfrq	500.229
dn	H1
dpwr	37
dof	-500.0
dm	y
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

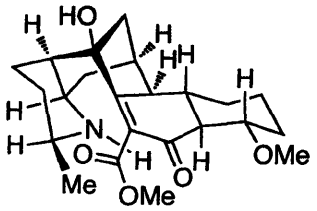
PROCESSING	
lb	0.30
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	



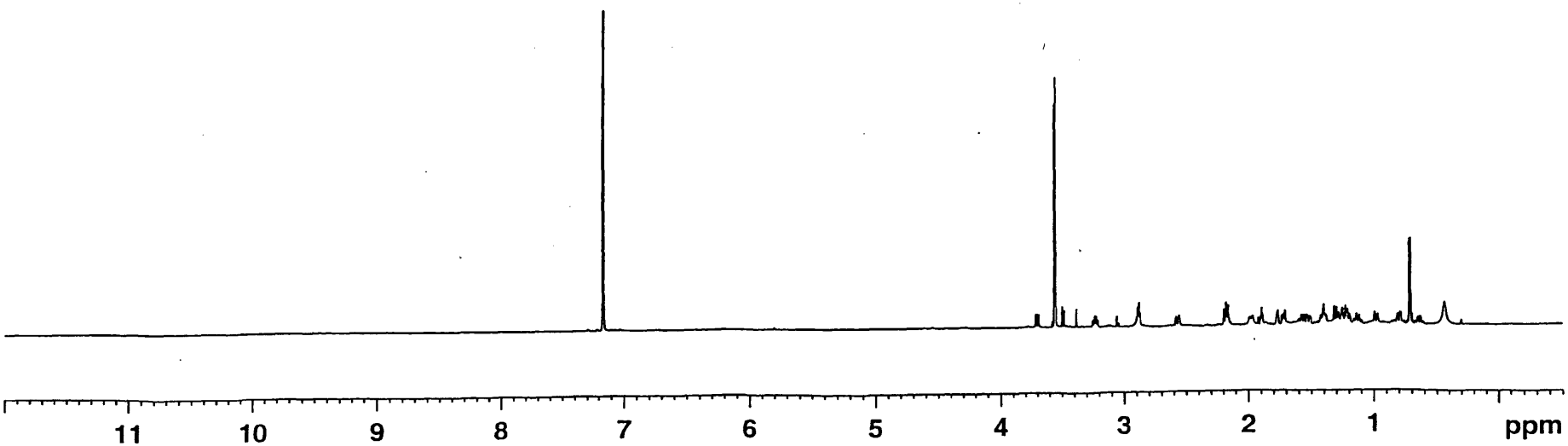
(–)-**S9**


84.1
80
75
70
65
60
55
50
45
40
35
29.9
%T
TMSO
H
H
HH
H
H
N
H
O
H
O
H
OMe
Me
OMe
(–)-S9
2927.37
2855.09
1741.23
1673.58
1447.46
1374.84
1296.06
1277.54
1208.95
1250.86
1161.13
1112.64
1033.54
1005.44
892.34
874.12
842.17
752.66
4000.0
3000
2000
1500
1000
500
400.0
cm-1

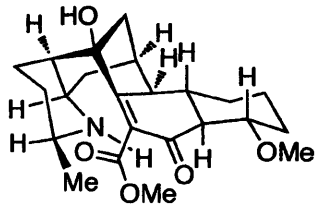
```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD   5 mm CPTXI 1H-
PULPROG              zg30
TD                  65536
SOLVENT              C6D6
NS                      8
DS                      2
SWH           12376.237 Hz
FIDRES         0.188846 Hz
AQ             2.6477044 sec
RG                   50.8
DW                40.400 usec
DE                 6.00 usec
TE                304.0 K
D1           1.00000000 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                   1H
P1                  11.00 usec
PL1                  4.00 dB
SFO1         600.1337060 MHz

F2 - Processing parameters
SI                  65536
SF           600.1300659 MHz
WDW                    EM
SSB                     0
LB                   0.30 Hz
GB                      0
PC                   1.00
```



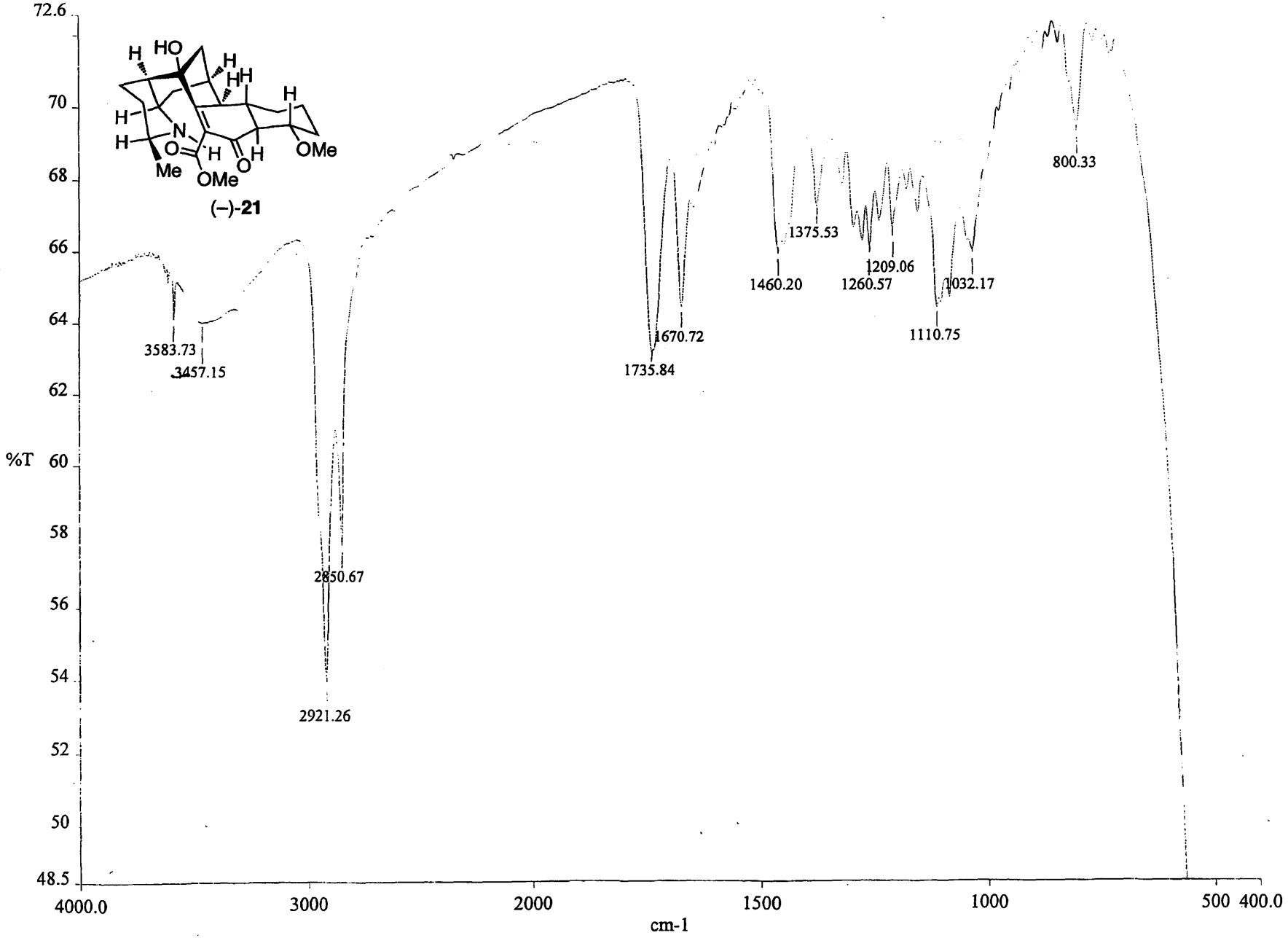
(–)-**21**



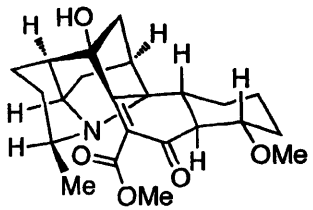
date		DEC. & VT	
solvent	Benzene	dfrq	500.229
		dn	H1
		dpwr	37
		dof	-500.0
		dm	y
		dmm	w
ACQUISITION		dmf	10000
sfrq	125.795	dseq	
tn	C13	dres	1.0
at	1.735	homo	n
np	91936	PROCESSING	
sw	26490.1	lb	0.30
fb	not used	wtfile	
bs	8	proc	ft
ss	1	fn	131072
tpwr	53	math	f
pw	6.9		
d1	0.763	werr	
tof	1250.7	wexp	
nt	100000	wbs	
ct	15240	wnt	
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	19.1		
wp	26489.7		
vs	1857		
sc	0		
wc	250		
hzmm	105.96		
is	500.00		
rfl	16132.5		
rfp	16151.2		
th	20		
ins	1.000		
ai	ph		



(–)-**21**

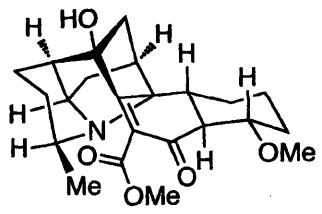

72.6
70
68
66
64
62
60
58
56
54
52
50
48.5
%T
4000.0
3000
2000
1500
1000
500
400.0
cm-1
3583.73
3457.15
2921.26
2850.67
1735.84
1670.72
1460.20
1375.53
1260.57
1209.06
1110.75
1032.17
800.33
(–)-21

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD   5 mm CPTXI 1H-
PULPROG              zg30
TD                  65536
SOLVENT
NS
DS                     2
SWH            12376.237 Hz
FIDRES             0.188846 Hz
AQ              2.6477044 sec
RG                    57
DW                 40.400 usec
DE                  6.00 usec
TE                 293.0 K
D1              1.00000000 sec
TD0                    1

======== CHANNEL f1 ========
NUC1                  1H
P1                 11.00 usec
PL1                 4.00 dB
SFO1          600.1337060 MHz

F2 - Processing parameters
SI                  65536
SF            600.1300696 MHz
WDW                   EM
SSB                    0
LB                  0.30 Hz
GB                     0
PC                  1.00
```

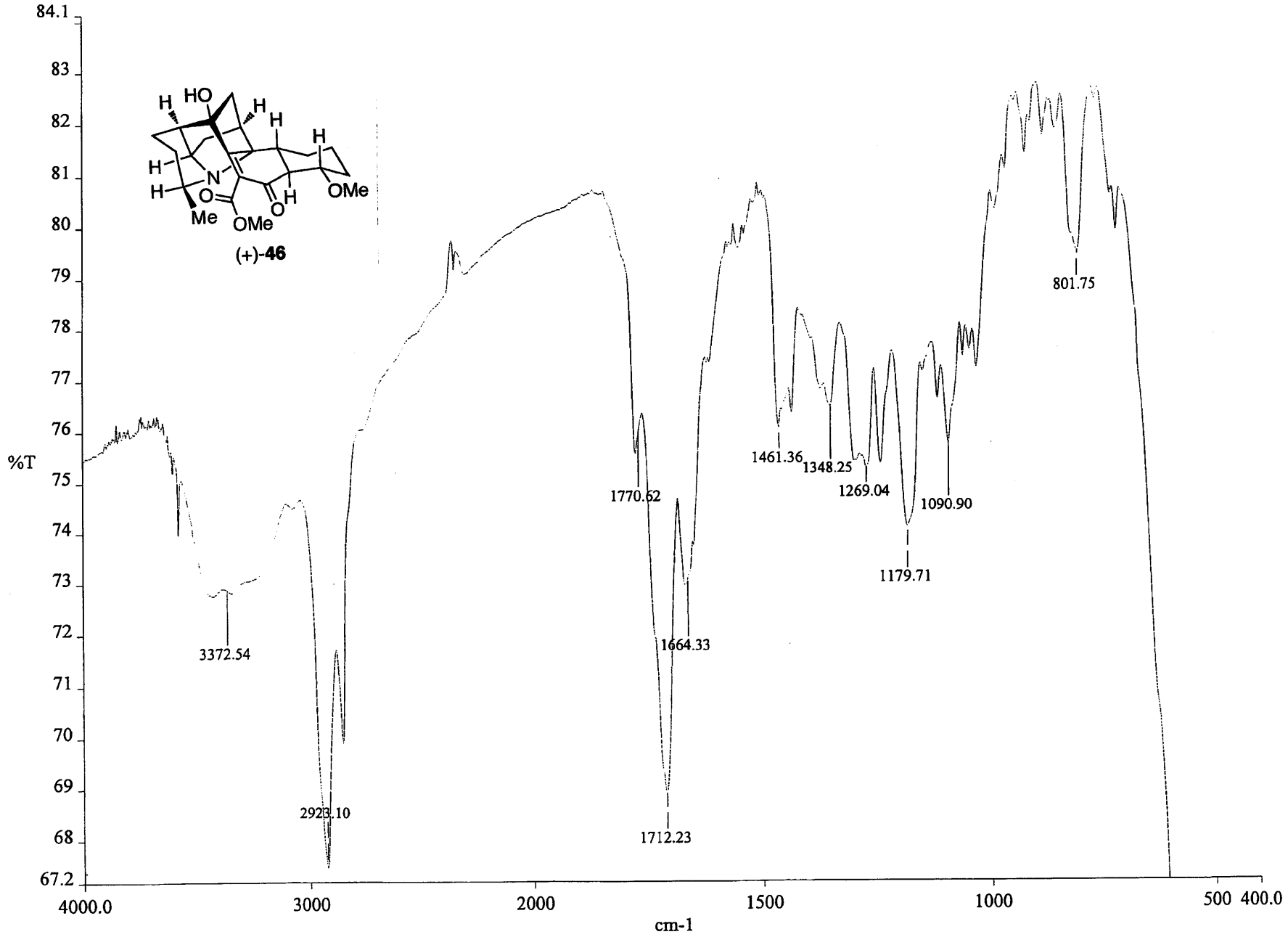


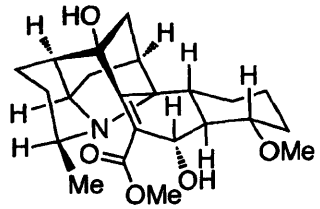
(+)-**46**

date		DEC. & VT	
solvent	Benzene	dfrq	500.229
		dn	H1
		dpwr	37
		dof	-500.0
		dm	y
		dmm	w
ACQUISITION		dmf	10000
sfrq	125.796	dseq	
tn	C13	dres	1.0
at	1.735	homo	n
np	96238	PROCESSING	
sw	27729.6	lb	0.30
fb	not used	wtfile	
bs	8	proc	ft
ss	1	fn	131072
tpwr	53	math	f
pw	6.9		
d1	0.763	werr	
tof	1722.0	wexp	
nt	1e+06	wbs	
ct	23576	wnt	
alock	n		
gain	not used		
FLAGS			
il	n		
in	n		
dp	y		
hs	nn		
DISPLAY			
sp	-131.2		
wp	27656.0		
vs	1496		
sc	0		
wc	250		
hzmm	110.62		
is	500.00		
rfl	16280.8		
rfp	16149.2		
th	20		
ins	1.000		
ai	ph		



(+)-**46**


84.1
83
82
81
80
79
78
77
76
75
74
73
72
71
70
69
68
67.2
%T
4000.0
3000
2000
1500
1000
500 400.0
cm-1
3372.54
2923.10
1770.62
1712.23
1664.33
1461.36
1348.25
1269.04
1179.71
1090.90
801.75
(+)-46



(+)-**47**

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM              spect
PROBHD    5 mm CPTXI 1H-
PULPROG                zg30
TD                    65536
SOLVENT               CDCl3
NS                       24
DS                        2
SWH               12376.237 Hz
FIDRES             0.188846 Hz
AQ                2.6477044 sec
RG                     40.3
DW                   40.400 usec
DE                    6.00 usec
TE                   293.0 K
D1               1.00000000 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                     1H
P1                    11.00 usec
PL1                    4.00 dB
SFO1           600.1337060 MHz

F2 - Processing parameters
SI                    65536
SF             600.1300284 MHz
WDW                      EM
SSB                       0
LB                     0.30 Hz
GB                        0
PC                     1.00
```

date	
solvent	CDCl3

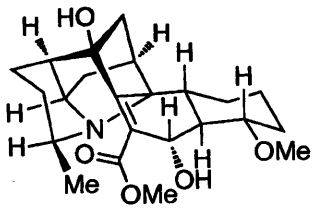
ACQUISITION	
sfrq	125.796
tn	C13
at	1.735
np	96404
sw	27777.8
fb	not used
bs	8
ss	1
tpwr	53
pw	6.9
d1	0.763
tof	1845.7
nt	100000
ct	24792
alock	n
gain	not used

FLAGS	
il	n
in	n
dp	y
hs	nn

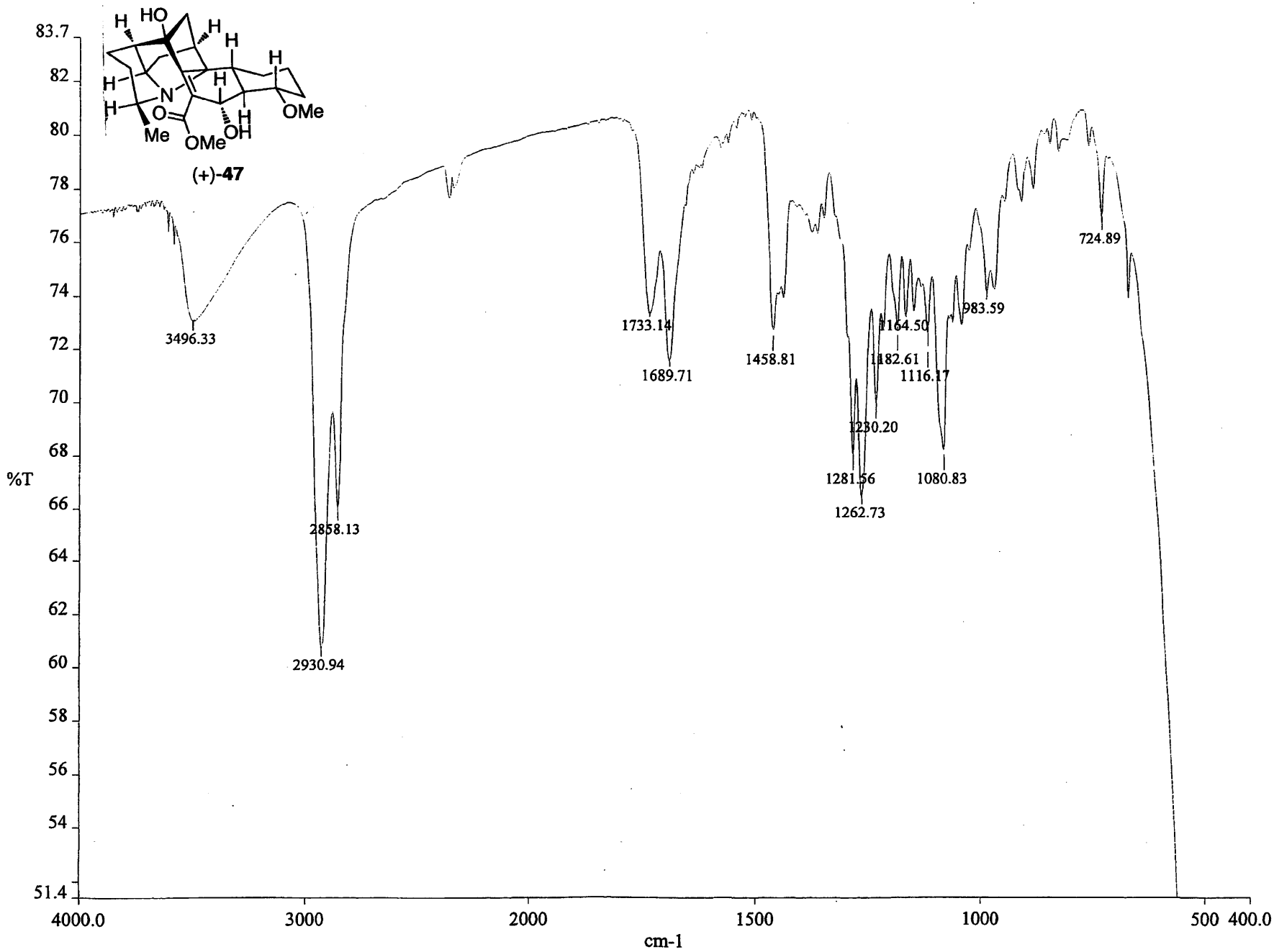
DISPLAY	
sp	-93.2
wp	26499.4
vs	2637
sc	0
wc	250
hzmm	106.00
is	500.00
rfl	9808.5
rfp	9714.9
th	11
ins	1.000
ai	ph

DEC. & VT	
dfrq	500.229
dn	H1
dpwr	37
dof	-500.0
dm	y
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

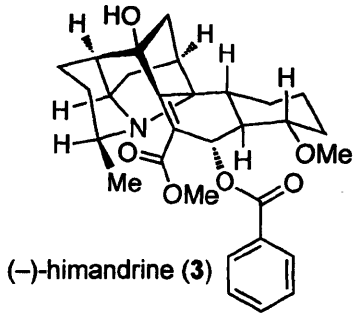
PROCESSING	
lb	0.30
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	



(+)-**47**


(+)-47
%T
cm-1
83.7
82
80
78
76
74
72
70
68
66
64
62
60
58
56
54
51.4
4000.0
3000
2000
1500
1000
500
400.0
3496.33
2858.13
2930.94
1733.14
1689.71
1458.81
1281.56
1262.73
1230.20
1182.61
1164.50
1116.17
1080.83
983.59
724.89

```
Current Data Parameters
NAME
EXPNO
PROCNO

F2 - Acquisition Parameters
Date_
Time
INSTRUM                  spect
PROBHD     5 mm CPTXI 1H-
PULPROG                  zg30
TD                      65536
SOLVENT                 CDCl3
NS                         16
DS                          2
SWH                12376.237 Hz
FIDRES              0.188846 Hz
AQ                  2.6477044 sec
RG                       45.3
DW                     40.400 usec
DE                      6.00 usec
TE                     305.0 K
D1                 1.00000000 sec
TD0                         1

======== CHANNEL f1 ========
NUC1                       1H
P1                      11.00 usec
PL1                      4.00 dB
SFO1             600.1337060 MHz

F2 - Processing parameters
SI                      65536
SF               600.1300275 MHz
WDW                        EM
SSB                         0
LB                       0.30 Hz
GB                          0
PC                       1.00
```



(–)-himandrine (**3**)

date	
solvent	CDCl3

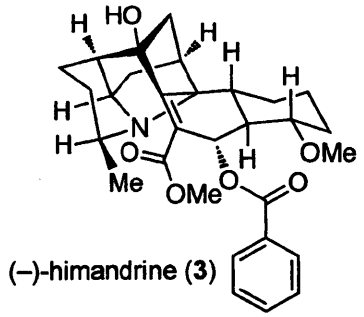
ACQUISITION	
sfrq	125.795
tn	C13
at	1.736
np	131010
sw	37735.8
fb	not used
bs	8
ss	1
tpwr	53
pw	6.9
d1	0.763
tof	631.4
nt	1e+06
ct	34480
alock	n
gain	not used

FLAGS	
il	n
in	n
dp	y
hs	nn

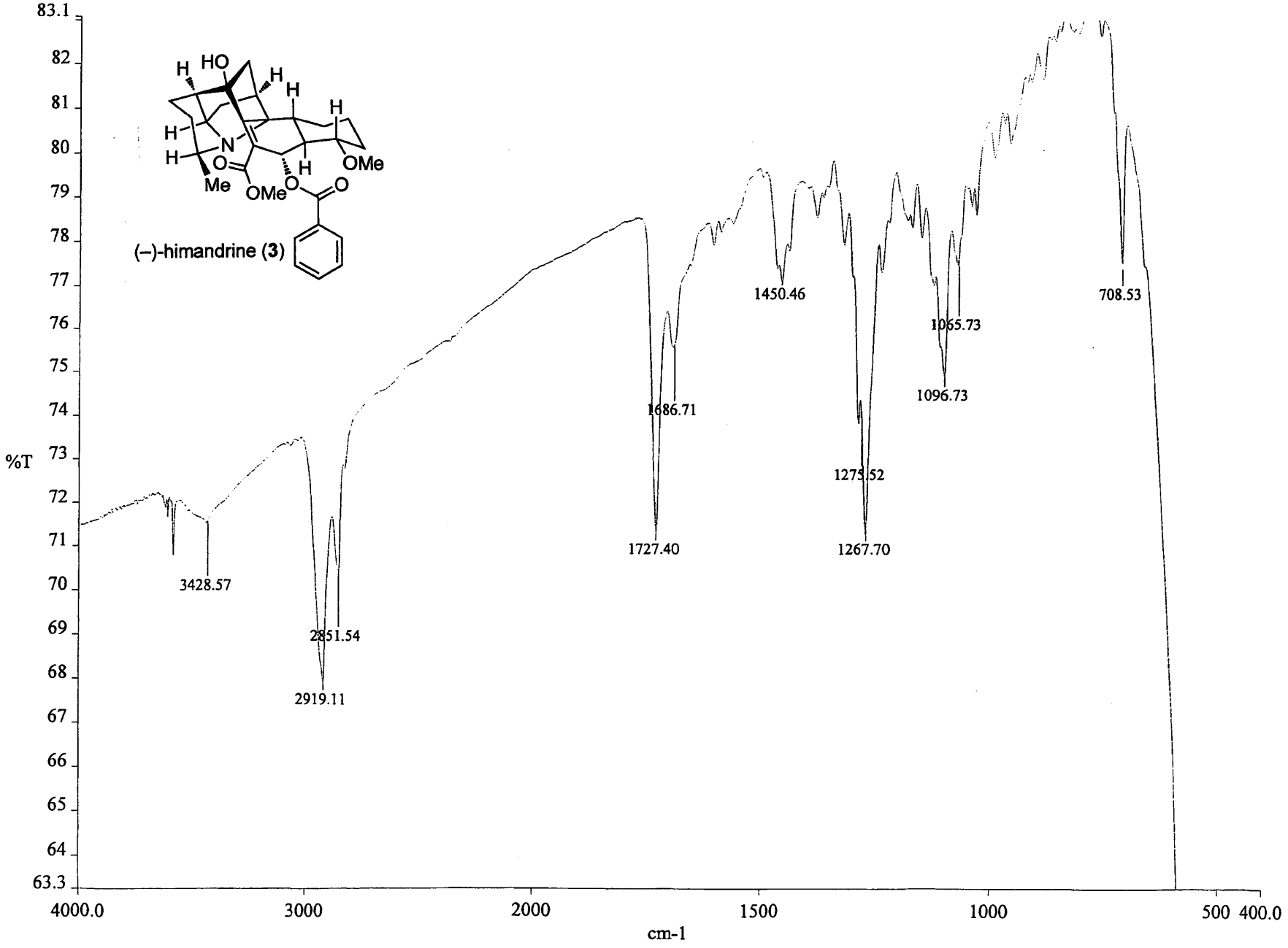
DISPLAY	
sp	1200.8
wp	25239.2
vs	2318
sc	0
wc	250
hzmm	100.96
is	500.00
rfl	16001.8
rfp	9714.9
th	20
ins	1.000
ai	ph

DEC. & VT	
dfrq	500.229
dn	H1
dpwr	37
dof	-500.0
dm	y
dmm	w
dmf	10000
dseq	
dres	1.0
homo	n

PROCESSING	
lb	0.30
wtfile	
proc	ft
fn	131072
math	f
werr	
wexp	
wbs	
wnt	



(–)-himandrine (**3**)


(–)-himandrine (3)
%T
cm-1
3428.57
2851.54
2919.11
1727.40
1686.71
1450.46
1275.52
1267.70
1096.73
1065.73
708.53

Meiliana Tjandra

Curriculum Vitae

EDUCATION

Massachusetts Institute of Technology, Cambridge, MA
Ph.D. Candidate, Organic Chemistry. Graduation: June 2010
Thesis title: "Total Synthesis of Class II and Class III Galbulimima Alkaloids."
Advisor: Professor Mohammad Movassaghi

University of California, Berkeley, Berkeley, CA
BS Chemistry, 2003

EXPERIENCE

2004-present **Massachusetts Institute of Technology**
Department of Chemistry, Advisor: Professor Mohammad Movassaghi
Graduate Research Assistant

- Completed the enantioselective total synthesis of all class III galbulimima alkaloids: galbulimima alkaloid 13, himbadine, and himgaline.
- Completed the enantioselecitve total synthesis of himandrine (class II).

2003-2004 **CHIRON, Research and Development**
Dr. Ronald Zuckermann and Dr. Deborah Charych
Research Associate.

- Performed a solid phase peptoid/peptide synthesis and combinatorial chemistry.
- Developed methods for on-bead high-throughput screening in a biological assay.

2002-2003 **University of California, Berkeley**
Department of Chemistry, Advisor: Professor Andrew Streitwieser
Undergraduate Research Assistant

- Performed a multistep synthesis of a chiral metal complex.

Department of Chemistry, Advisor: Dr. Ahamindra Jain
June 2002-August 2002

- Performed a multistep organic synthesis to prepare fluorobenzyl ether analogs of *Tamiflu*®.

AWARDS & HONORS

2009 Roche Excellence in Chemistry Awards (MIT, 2009).
2008 Bristol-Myers Squibb Graduate Fellowship in Organic Chemistry (MIT).
2006 Novartis Graduate Fellowship in Organic Chemistry (MIT).
2003 Merck Index Award (UC Berkeley).
2001 International Student Scholarship Award (2001).

2000 The National Dean's List.

PUBLICATIONS

- Movassaghi, M.; Tjandra, M.; Qi, Jun. "Total Synthesis of (-)-Himandrine." *J. Am. Chem. Soc.* **2009,** *131*, 9648–9650.
- Movassaghi, M.; Hunt, D. K.; Tjandra, M. "Total Synthesis and Absolute Stereochemical Assignment of (+)- and (-)-Galbulimima Alkaloid 13." *J. Am. Chem. Soc.* **2006**, *128,* 8126.
- Paulick, M. G.; Hart, K. M.; Brinner, K. M.; Tjandra, M.; Charych, D. H.; Zuckermann, R. N. "Cleavable Hydrophilic Linker for One-Bead-One-Compound Sequencing of Oligomer Libraries by Tandem Mass Spectrometry." *J. Comb. Chem.* **2006,** *8*, 417.

PRESENTATIONS

- "Total Synthesis of Galbulimima Alkalodis" Oral presentation, Roche award symposium, Nutley, NJ, 2009.
- "Total Synthesis of Galbulimima Alkaloids" Oral presentation, Bristol-Myers Squibb award symposium, Lawrenceville, NJ, 2009.
- "Total Synthesis of Galbulimima Alkaloids" Oral presentation, Massachusetts Institute of Technology Graduate research symposium, Cambridge, MA, 2008.
- Movassaghi, M.; Tjandra, M.; Hunt, D. K. "Total Synthesis of Galbulimima Alkaloids" Oral presentation, ACS 234th National Meeting, Boston, MA, 2007.
- Tjandra, M.; Hunt, D. K.; Movassaghi, M. "Total Synthesis of Galbulimima Alkaloids" Poster presentation, Novartis, Cambridge, MA, 2007.

TEACHING EXPERIENCE & SKILLS

2009 Teaching assistant for an undergraduate level second semester organic chemistry course (MIT, Professor Mohammad Movassaghi).

2009 Teaching assistant for a graduate level second semester organic synthesis course (MIT, Professor Mohammad Movassaghi).

2004 Teaching assistant for an undergraduate level first semester organic chemistry course (MIT, Professor Sarah E. O'Connor and Dr. Kimberly Berkowski).

2004 Teaching assistant for an undergraduate level organic chemistry laboratory (MIT, Dr. Janet Schrenk).

2006 Graduate student mentor for undergraduate and visiting graduate student (MIT).

Fluent in English and Indonesian.