Université de Montréal

Progress Towards a Total Synthesis of (±)-Longithorone C

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Progress Towards a Total Synthesis of (±)-Longithorone C

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Mémoire accepté le:

To my Wife Araks

For the loving support

Table of Contents

Summary

The growing number of cyclophane containing natural products and total syntheses that employ cyclophane intermediates has stimulated renewed interest in their asymmetric preparation and planar chirality. A synthetic approach is proposed towards the total synthesis of longithorone C. This [12]paracyclophane quinone is a member of a group of macrocyclic farnesylated quinones isolated from the tunicate *Aplidium longithorax*. The development of an efficient preparative method will be discussed for the macrocyclic *ansa*-bridge by ring-closing olefin metathesis (RCM) in racemic form. The investigation of various fluorinated auxiliaries as novel gearing elements and their effect on macrocyclization is presented. The mechanism by which these gearing elements function has been studied by molecular modeling. Copper-catalyzed Grignard reactions have been optimized in order to selectively couple prenylated side chains to aromatic halides. Finally, a variety of olefin metathesis catalysts were studied for the preparation of a [12]paracyclophane containing three stereodefined tri-substituted olefins.

Key Words: gearing elements, longithorone C, paracyclophanes, ring-closing olefin metathesis (RCM).

Résumé

Le nombre grandissant de produits naturels contenant des cyclophanes ou de synthèses totales utilisant des cyclophanes comme intermédiaires a stimulé un nouvel intérêt pour la synthèse asymétrique de ces molécules possédant une chiralité plane. Une approche synthétique vers la synthèse totale de la longithorone C a été proposée. Cette quinone, possédant un [12]paracyclophane, est membre d'un groupe de quinones macrocycliques contenant une chaîne ressemblant à farnesol dans leur squelette et a été isolée à partir de *Aplidium longithorax*. Le développement d'une méthode efficace pour la préparation de ce macrocycle contenant un pont-*ansa* par métathèse d'oléfines par fermeture de cycle dans sa forme racémique sera discuté. L'investigation d'une variété d'auxiliaires fluorés comme nouveaux éléments directeurs et leur effet sur la macrocyclisation seront présentés. Le mécanisme par lequel ces éléments directeurs fonctionnent a été étudié par modélisation moléculaire. Une réaction de Grignard catalysée par le cuivre a été optimisée dans le but d'installer les chaînes latérales allyliques à l'halogénure aromatique. Finalement, une variété de catalyseurs de métathèse d'oléfines a été étudié pour la préparation d'un [12]paracyclophane contenant trois oléfines trisubstitués stéréodéfinies.

Mots clés: éléments directeurs, longithorone C, paracyclophanes, métathèse d'oléfine par fermeture de cycle (RCM).

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List of Figures

List of Schemes

List of Tables

Abbreviations

Ac	acetyl
ACN	acetonitrile
Ar	aryl
COSY	correlation spectroscopy
d	doublet
dba	dibenzylideneacetone
DCM	dichloromethane
dd	doublet of doublets
DIAD	*iso*propyldiazodicarboxylate
DIBAL-H	diisobutylaluminum hydride
DMF	dimethylformamide
dppf	(diphenylphosphino)ferrocene
dt	doublet of triplets
ee	enantiomeric excess
eq	equivalent
FePc	iron tetrasulfophthalocyanine
g	gram
GC	gas chromatography
h	hour
HM	half-metathesis
HMPA	hexamethylphosphoramide
HRMS	high resolution mass spectrometry

Hz	hertz
HWE	Horner-Wadsworth-Emmons
imid.	imidazole
J	coupling constant
kcal	kilocalorie
KHMDS	potassium hexamethyldisilazide
m	multiplet
min	minute
mL	milliliter
mol	mole
mmol	millimole
NBS	*N*-bromosuccinimide
NMP	*N*-methylpyrrolidone
NMR	nuclear magnetic resonance
NOESY	nuclear overhauser enhancement spectroscopy
PG	protecting group
ppm	parts per million
py	pyridine
q	quartet
RCM	ring-closing olefin metathesis
RRCM	relay ring-closing metathesis
r.t.	room temperature
s	singlet

t	triplet
TBAF	tetrabutylammonium floride
TBDMS	*tert*-butyldimethylsilyl
TBDPS	*tert*-butyldiphenylsilyl
TFA	trifluoroacetic acid
TLC	thin layer chromatography
UV	ultraviolet

Chapter I:

Introduction to the Longithorones: Paracyclophane Natural Products

This chapter will focus on the longithorone family of natural products that contain a paracyclophane core and the synthesis of these macrocyclic natural products.

I.1 – Ring Closing Olefin Metathesis as a Route to Strained Systems.

The olefin ring-closing metathesis (RCM) reaction has emerged as one of the most powerful transforms in organic synthesis.[1] Indeed, the broad scope and reliability of this reaction has greatly simplified the total synthesis of a wide variety of architecturally complex natural and unnatural products.[2] For example, Smith and co-workers developed in 1999, the first total synthesis of cylindrocyclophane F, a unique natural product possessing a 22-membered [7,7]paracyclophane ring.[3]

Recent advancements in metathesis catalyst design have allowed chemists to re-examine olefin metathesis as a route to systems bearing strained olefins embedded in

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[1] (a) Trnka, T. M.; Grubbs, R. H. *Acc. Chem. Res.* **2001**, *34*, 18. (b) Fürstner, A. *Angew. Chem., Int. Ed.* **2000**, *39*, 3012. (c) Nicolaou, K. C.; Bulger, P. G.; Sarlah, D. *Angew. Chem., Int. Ed.* **2005**, *44*, 4490-4527. (d) Grubbs, R. H. *Handbook of Metathesis, Three Volume Set* **2003.**

[2] Fürstner, A.; Langemann, K. *J. Org. Chem,* **1996**, *61*, 8746-8749.

[3] Smith, A. B. III; Kozmin, S. A.; Paone, D. V. *J. Am. Chem. Soc.* **1999**, *121*, 7423-7424.

their skeletons.[4] The variety of different catalysts that have been developed allows for the possibility to select a catalyst having the necessary level of reactivity to access a strained system but also to avoid catalysts which may be so reactive as to favor ring-opening of the desired ring system.[5]

Ring closing metathesis (RCM) is now a standard method for the preparation of both carbocyclic and heterocyclic ring systems in sizes ranging from five- and six-membered cycles to macrocyclic compounds.[6] Despite its popularity, the preparation of certain molecules via olefin metathesis remains a challenge. In particular, strained ring systems are problematic. In some cases, the ring opening process can be far more thermodynamically favorable than ring closing while in other cases the system may be too strained to permit cyclization.[6]

A fascinating challenge for olefin metathesis could be the preparation of strained macrocyclic structures such as the longithorone natural products. In 1997, Schmitz and co-workers isolated a group of nine farnesylated quinones isolated from a tunicate *Aplidium longithorax* that featured new macrocyclic skeletons. Their carbon skeletons resemble a farnesyl unit bridging a quinone at either the *meta*- or *para*-positions (Figure

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[4] (a) Scholl, M.; Ding, S.; Lee, C. W.; Grubbs, R. H. *Org. Lett.* **1999**, *1*, 953-956. (b) Ackermann, L.; Fürstner, A.; Weskamp, T.; Kohl, F. J.; Herrmann, W. A. *Tetrahedron Lett.* **1999**, *40*, 4787-4790. (c) Huang, J. K.; Schanz, H.-J.; Stevens, E. D.; Nolan, S. P. *Organometallics.* **1999**, *18*, 5375-5380. (d) Jafarpour, L.; Schanz, H.-J.; Stevens, E. D.; Nolan, S. P. *Organometallics.* **1999**, *18*, 5416-5419. (e) Fürstner, A.; Thiel, O. R.; Ackermann, L.; Schanz, H.-J.; Nolan, S. P. *J. Org. Chem.* **2000**, *65*, 2204-2207. (f) Collins, S. K. *J. Organomet. Chem.* **2006**, *691*, 5122-5128.

[5] Tang, H.; Yusuff, N.; Wood, J. L. *Org. Lett.* **2001**, *3*, 1563-1566.

[6] (a) Paquette, L. A.; Basu, K.; Eppich, J. C.; Hofferberth, J. E. *Helv. Chim. Acta* **2002**, *10*, 3033-3051. (b) Deiters, A.; Martin, S. F. *Chem. Rev.* **2004**, *5*, 2199-2238. (c) Nakamura, I.; Yamamoto, Y. *Chem. Rev.* **2004**, *5*, 2127-2198.

1).[7] To date, the only biological activity reported for these marine compounds pertains to longithorone A.[8]

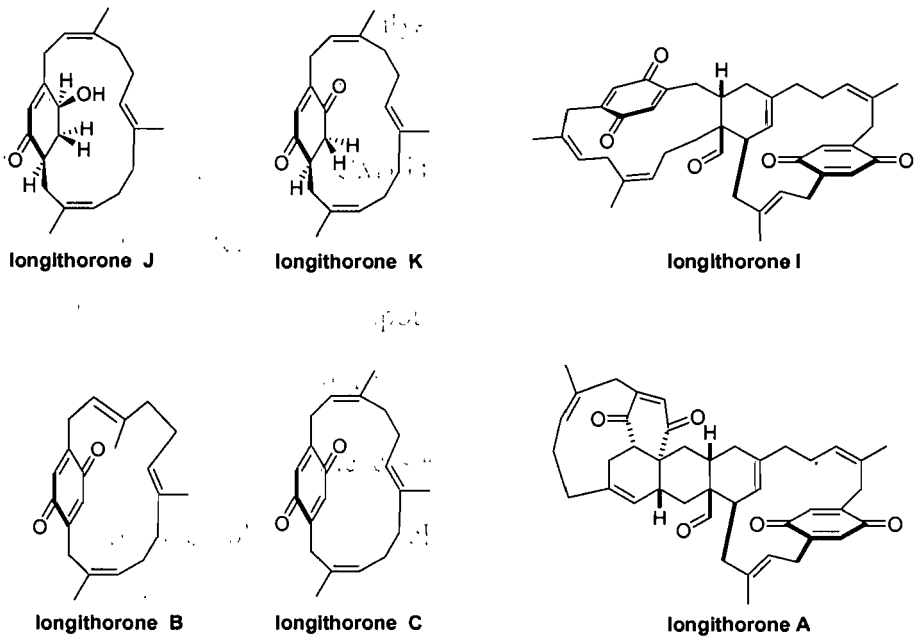

Figure 1 – The Longithorone Family of Natural Products.

I.2 – Synthesis of Longithorone A.

I.2.1 – Introduction and Synthetic Challenges.

In 2002, Shair and co-workers reported an elegant synthesis of the cytotoxic marine natural product longithorone A, based on the original proposed biosynthesis by Schmitz and co-workers.[9,10] The Shair group proposed the following retrosynthetic analysis comprised of both intermolecular and transannular Diels-Alder reactions in the

[7] Fu, X.; Hossain, B.; Schmitz, F. J.; van der Helm, D. *J. Org. Chem.* **1997**, *62*, 3810-3819.
[8] For information on the biological activity of longithorone A, see: (a) Fu, X.; Ferreira, M. L. G.; Schmitz, F. J. *J. Nat. Prod.* **1999**, *62*, 1306-1310. (b) Davidson, B. S. *Chem. Rev.* **1993**, *93*, 1771-1791. (c) Faulkner, D. J. *Nat. Prod. Rep.* **1998**, *15*, 113-158.
[9] Layton, M. E.; Morales, C. A.; Shair, M. D. *J. Am. Chem. Soc.* **2002**, *124*, 773-775.
[10] Fu, X.; Hossain, M. B.; van Der Helm, D.; Schmitz, F. J. *J. Am. Chem. Soc.* **1994**, *116*, 12125-12126.

presence of two macrocyclic ring systems which are strained and extremely rigidified (Figure 2).

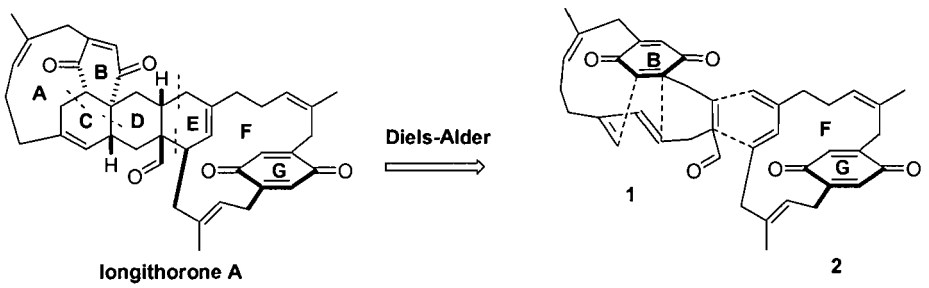

Figure 2 – Retrosynthetic Analysis of Longithorone A Involving Molecular and Transannular Diels-Alder Reactions.

Both the macrocycles **1** and **2** are tied across quinone ring systems, where the hindered rotation of the macrocycle results in atropisomerism. It was believed by the Shair group that the absolute and relative stereochemistry of the stereocenters found in the C, D, and E ring systems of longithorone A may be derived from the planar chirality of both **1** and **2** (Figure 2). It was therefore necessary to prepare enantioenriched paracyclophanes **1** and **2** possessing a 1,3-diene functionality embedded in the *ansa*-bridge. Consequently, Shair and co-workers envisioned using a macrocyclic enyne metathesis reaction to install the necessary diene functionality (Figure 3).

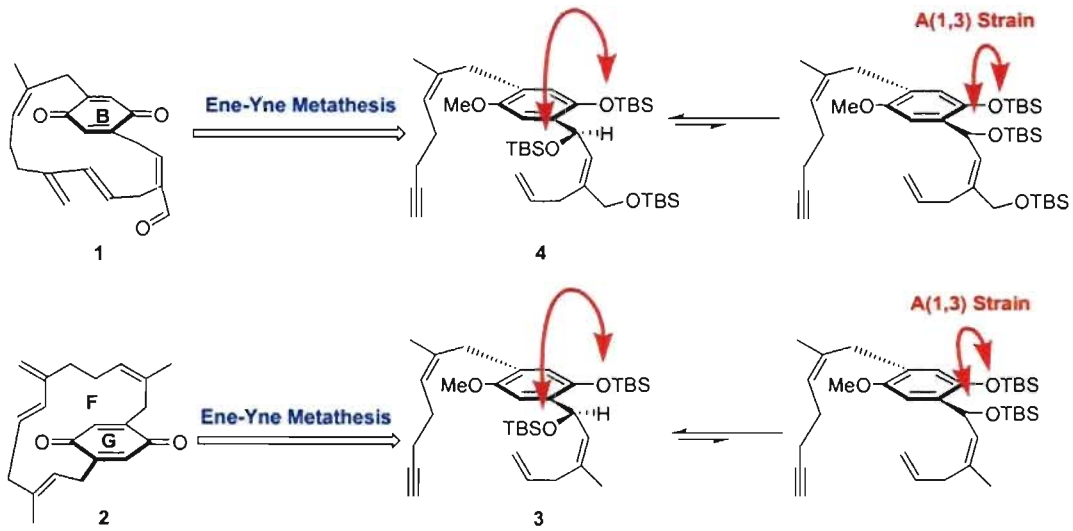

Figure 3 – Retrosynthetic Analysis of Longithorone A Involving Enyne Metathesis.

Although dilution, templates and slow-addition techniques can improve some macrocyclizations,[11] typically chemists resort to the installation of conformational control elements to favor cyclization.[12] Most often, this takes the form of a large substituent on the methylene group adjacent to the aromatic moiety. Consequently, in the Shair synthesis, a *t*-butyldimethylsilyloxy (OTBS) group was strategically placed adjacent to the aromatic ring of enynes **3** and **4** as a conformational control element. Minimization of the $A^{1,3}$ strain was believed to be responsible for the gearing of the alkenyl and alkynyl side chains (Figure 3).

[11] Chuchuryukin, A. V.; Dijkstra, H. P.; Suijkerbuijk, R. J. M.; van Klink, G. P. M.; Mills, A. M.; Spek, A. L.; van Koten, G. *Angew. Chem., Int. Ed.* **2003**, *42*, 228-230.
[12] Sello, J. K.; Andreana, P. R.; Lee, D.; Schreiber, S. L. *Org. Lett.* **2003**, *22*, 4125-4127.

I.2.2 – Preparing [12]Paracyclophanes by Enyne Metathesis.

Relatively little use has been reported in the literature on macrocyclization via enyne metathesis.[13] However, it is known that intramolecular enyne metathesis affords 1,2-disubstituted dienes (**5**) and intermolecular enyne metathesis reactions afford 1,3-disubstiuted dienes (**6**) (Figure 4).[14]

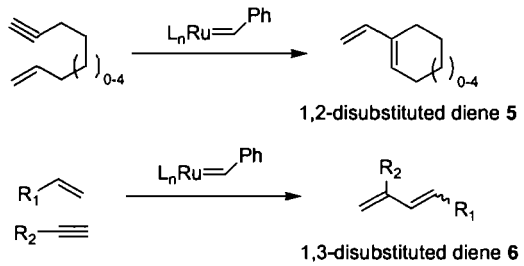

Figure 4 – Intramolecular and Intermolecular Enyne Metathesis Reactions.

The Shair group used model structures to determine the optimum enyne metathesis conditions.[15] It was found that under an ethylene atmosphere, ethylene-yne cross metathesis of **7**, **8**, and **9** occurs first using catalyst **14**, affording a terminal 1,3-diene followed by terminal olefin-olefin metathesis macrocyclization, affording the desired 1,3-disubstituted olefins **10**, **11**, and **12**. No 1,2-disubstiuted olefin **13** was observed (Scheme 1).

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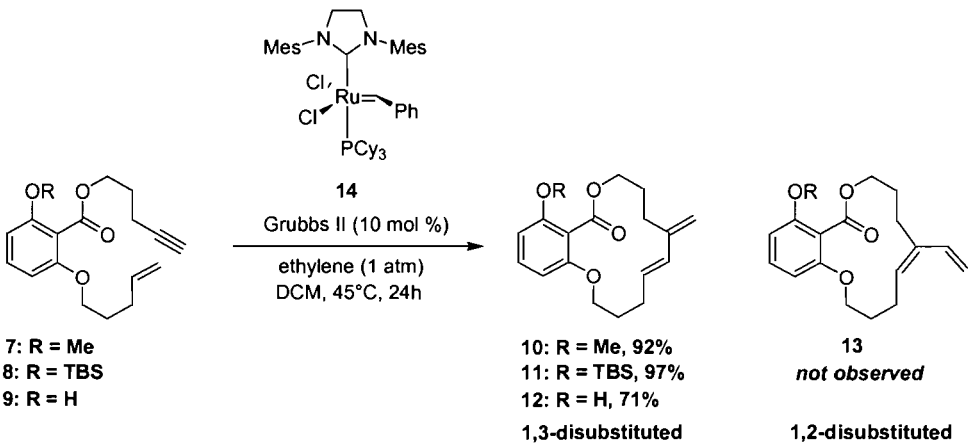
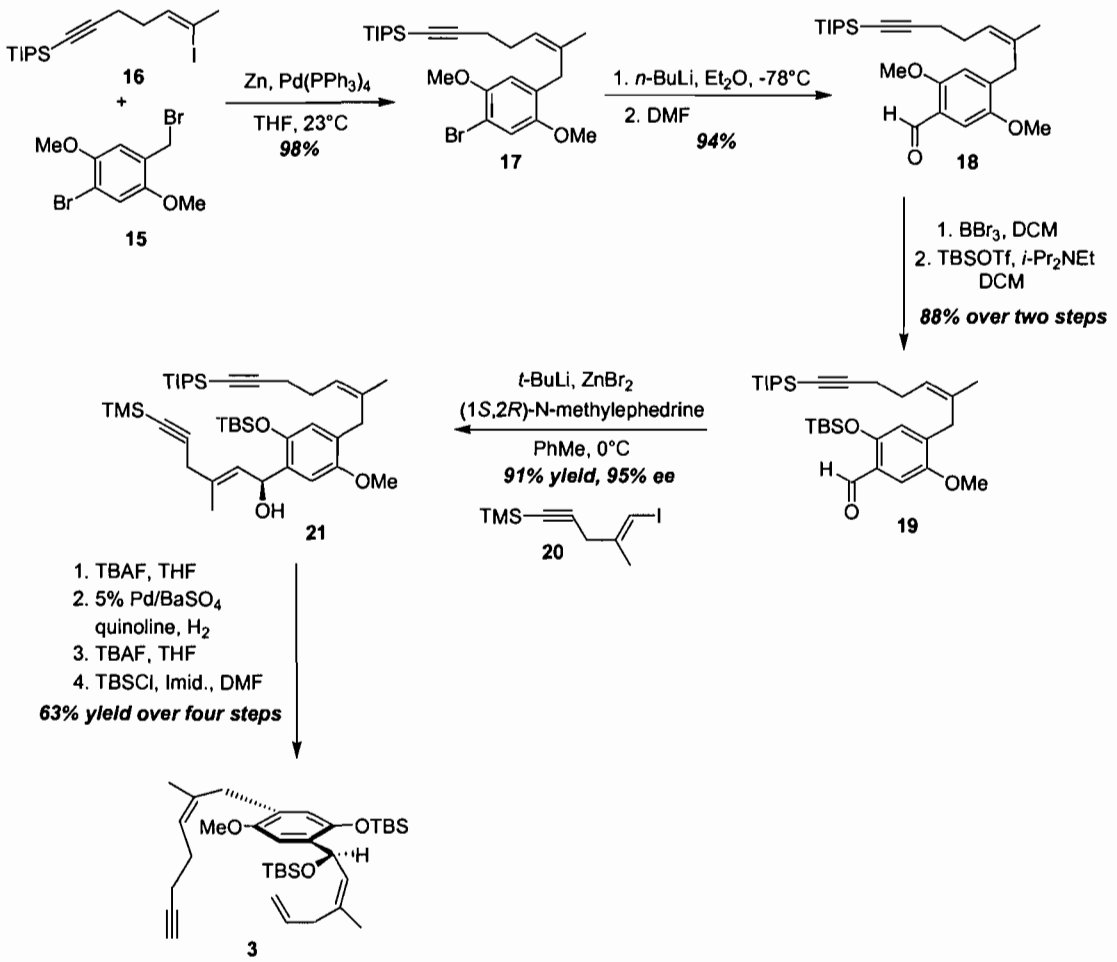
[13] Hensen, E. C.; Lee, D. *J. Am. Chem. Soc.* **2003**, *125*, 9582-9583.
[14] Mori, M.; Kitamura, T; Sato, Y. *Synthesis* **2001**, 654-664.
[15] Morales, C. A.; Layton, M. E.; Shair, M. D. *Proc. Natl. Acad. Sci.* **2004**, *101*, 12036-12041.



Scheme 1 – Studies of Enyne Metathesis in Macrocyclization Reactions.

I.2.3 – Installation of the Atropisomeric Control Element.

The enantioselective synthesis of enyne **3** was achieved following a nine-step reaction sequence (Scheme 2).[15]



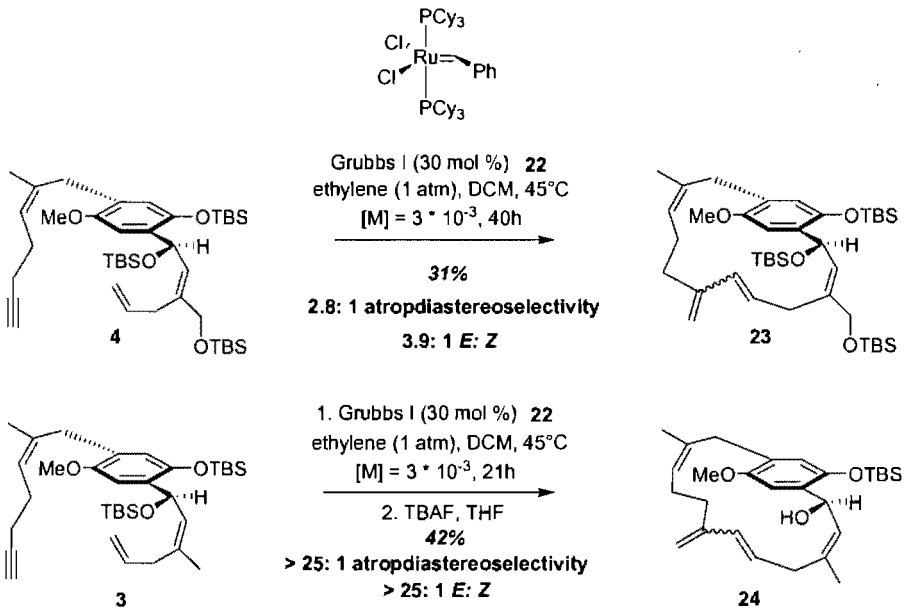
Scheme 2 – Preparation of Enyne Precursor 3.

Pd-mediated cross coupling of vinyl-iodide **16** and a benzylic zinc reagent derived from **15** afforded aromatic bromide **17** in 98% yield. Formylation of the aromatic bromide **17** with *n*-BuLi and DMF delivered aldehyde **18** in 94% yield. Selective demethylation was achieved by treating aldehyde **18** with BBr_3 followed by silylation with TBSOTf to afford silyl ether **19** in 88% yield over two steps. Enantioselective alkylation of silyl ether **19** using a bromozinc reagent derived from **20** in combination with the lithium alkoxide of (1*S*,2*R*)-*N*-methylephedrine provided benzylic alcohol **21** in

91% yield and in 95% ee. Benzylic alcohol **21** was treated with TBAF where the simultaneous deprotection of both the TMS and TBS group was carried out. Subsequent Lindlar hydrogenation of the terminal acetylene, TBAF promoted removal of the TIPS group and silylation of the phenol and benzylic alcohol with TBSCl afforded enyne **3** in 63% yield over four steps.

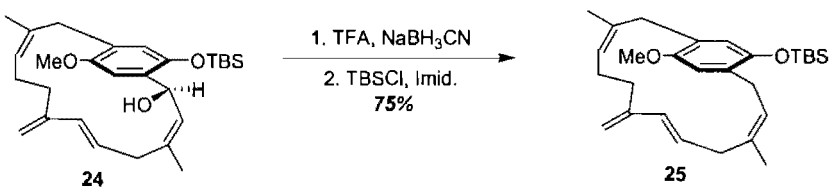
I.2.4 – Enyne Metathesis Macrocyclization using an Atropisomeric Control Element.

Both enyne **3** and **4** were taken up in CH_2Cl_2 and treated with Grubbs first generation catalyst **22** under an ethylene atmosphere to afford the desired macrocycles **23** and **24**. High dilution conditions and extended reaction times were necessary in order to obtain the macrocyclic products. Despite optimizing the conditions, enyne **4** cyclized to afford macrocycle **23** in only 31% yield. Furthermore the *E*:*Z* ratio was 3.9:1 and the atropdiastereoselectivity was modest at 2.8:1. It is important to note that the nature of the substrate controlled the resulting *E*:*Z* ratios and atropdiastereoselectivity.[15] For example, when enyne **3** was subjected to nearly identical reaction conditions, the yield of macrocycle **24** was 42%. However, both the *E*:*Z* ratio and atropdiastereoselectivity had increased to greater than 25:1 in the formation of **24** (Scheme 3).



Scheme 3 – Enyne Metathesis using an Atropisomeric Control Element.

The removal of the atropisomeric control element was achieved by hydride reduction of the benzylic silyloxy group using TFA and $NaBH_3CN$, followed by silylation of the phenol to afford paracyclophane **25** in 75% yield (Scheme 4).[15,16]

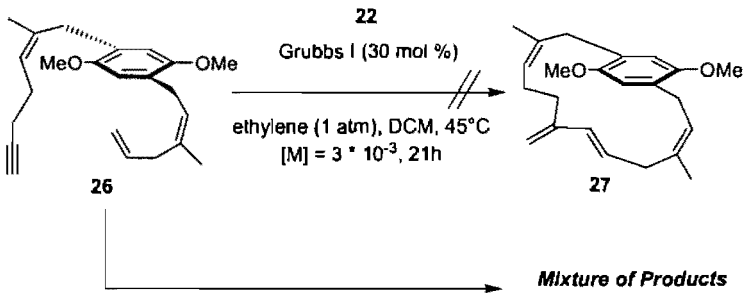


Scheme 4 – Removal of the Atropisomeric Control Element.

Although Shair and co-workers demonstrated that the formation of macrocycles such as [12]paracyclophanes was possible using RCM, these macrocyclization reactions

[16] Kursanov, D. N.; Parnes, Z. N. *Russ. Chem. Rev.* **1969**, *38*, 812-821.

proved to be difficult due to ring strain and no cyclization was observed in forming **27** without the pendant OTBS group in **26** (Scheme 5).



Scheme 5 – Enyne Metathesis Lacking an Atropisomeric Control Element.

I.2.5 – Conclusion.

Shair and co-workers have demonstrated the first examples of enyne metathesis in forming macrocyclic ring structures such as [12]paracyclophanes. These results demonstrate the ability of substituted methylene groups to act as conformation controlling groups, and to control the transfer of their chirality to atropisomeric centers. Although the Shair group successfully applied this methodology towards the asymmetric total synthesis of longithorone A, large amounts of catalyst were necessary as well as extended reaction times, high dilution and the presence of an ethylene atmosphere in order to accomplish macrocyclization. Although the control element was easily removed, the installation process involved difficult reaction steps, and afforded paracyclophanes **23** and **24** in low yields, and variable diastereoselectivity.

I.3 – Synthesis of Longithorone B.

Longithorone B is a [12]paracyclophane containing a macrocyclic structure based on a farnesyl unit, bridging a benzoquinone at the *para*-position. The macrocycle is composed of two *trans*, and one *cis* double bonds. The hindered rotation of its macrocyclic structure about the quinone core affords this natural product an element of planar chirality. The synthetic challenge in synthesizing longithorone B is directly linked to the difficulty in forming the highly substituted, planar chiral macrocycle. These synthetic challenges had inspired Tadahiro and co-workers to develop an efficient synthesis of the macrocyclic ring structure of longithorone B, by way of intramolecular Friedel-Crafts alkylation reaction forming the *ansa*-bridge (Figure 5).[17]

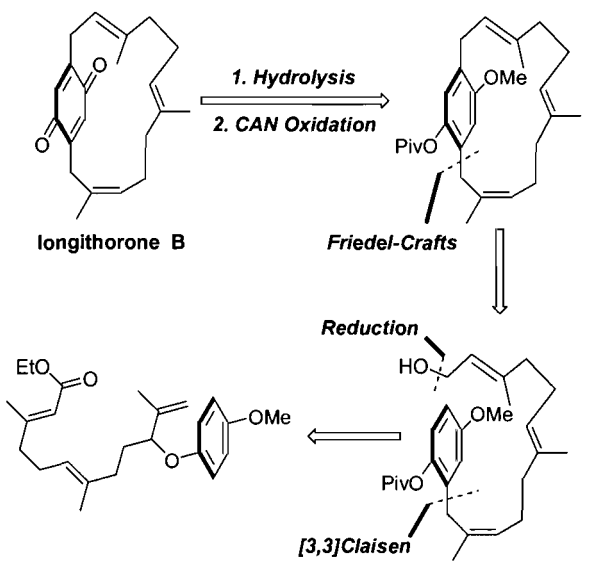
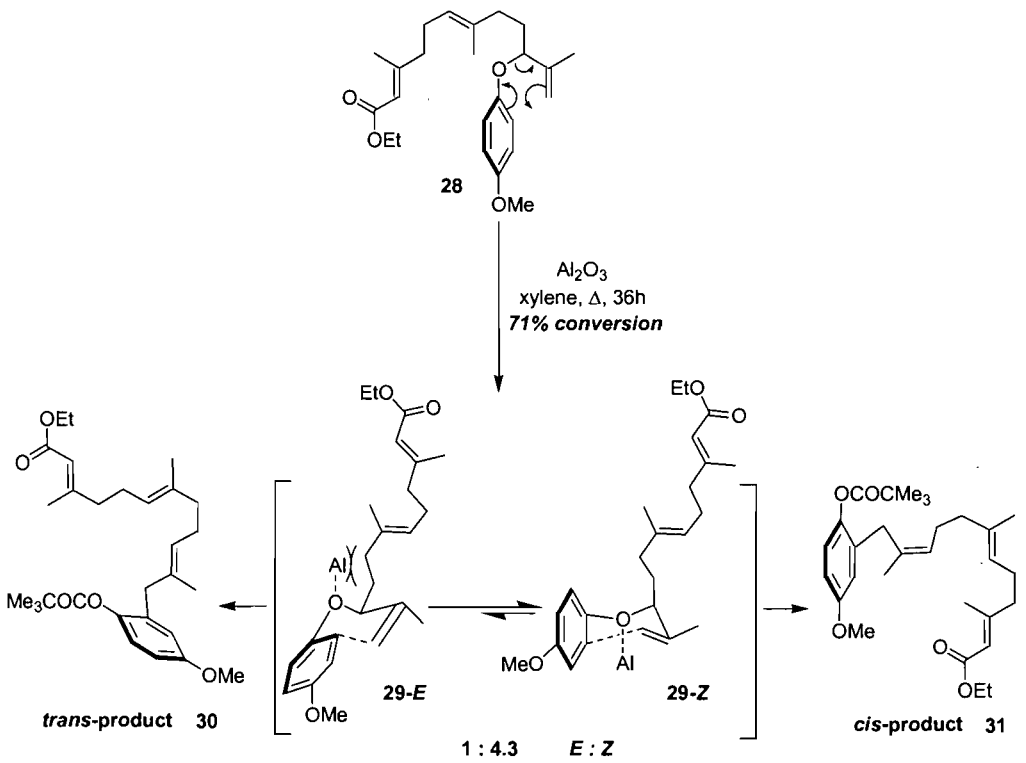


Figure 5 – Retrosynthetic Analysis of Longithorone B.

[17] Tadahiro, K.; Kentaro, N.; Masahiro, H. *Tetrahedron Lett.* **1999**, *40*, 1941-1944.

I.3.1 – [3,3]-Rearrangement in Forming *Ortho*-Allyl Phenol 31.

[3,3]-Sigmatropic rearrangements of allyl aryl ethers provide convenient access to *ortho*-allyl phenols.[18] However, one of the challenges encountered by the Tadahiro group was in controlling the *E*:*Z* ratios of the products.[17] They determined a strong dependence of the rearrangement reaction on the reaction conditions (Scheme 6).



Scheme 6 – Additive Effect on the Transition States of the [3,3]-Sigmatropic Rearrangements.

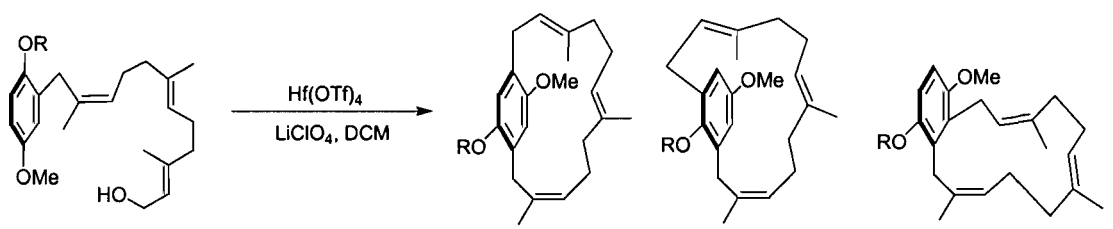
The rearrangement of **28** afforded a 71% conversion with a low 1:4.3 *E*/*Z* product ratio. The proposed mechanism involved the coordination of the Lewis acid with the

[18] Krohn, K.; Bernhard, S. *Synthesis* **1996**, *6*, 699-701.

oxygen atom of phenyl ether **28** forming the two possible transition states **29-*E*** and **29-*Z***. In the absence of a Lewis acid, **29-*E*** was the major intermediate leading to the formation of the *trans*-olefin **30**. In the presence of a Lewis acid such as Al_2O_3 or SiO_2, the Al or Si atoms complex with the oxygen atom of the ether linkage, increasing the repulsion between it and the side chain at the equatorial position of transition state **29-*E***, leading to the formation of the desired *cis*-phenol **31** through transition state **29-*Z***.

I.3.2 – Intramolecular Coupling of the Farnesylated Side Chain by Friedel-Crafts Alkylation.

The intramolecular coupling reaction was examined using three types of protected alcohols (**32**, **33**, and **34**) derived from phenol **31** and the ester at the terminal position of the farnesyl chain was reduced to the alcohol using DIBAL-H. The intramolecular coupling reaction was achieved by way of the Friedel-Crafts alkylation at the C-1 position of the farnesyl moiety in the presence of the acids $Hf(OTf)_4$ and $LiClO_4$ in CH_2Cl_2 (Scheme 7).



	35		36	37
32: R = TBDMS	*8%*	*1 : 8*	*64%*	*traces*
33: R = Bn	*0%*			
34: R = $COCMe_3$	*78%*	*6 : 1*	*13%*	*traces*

Scheme 7 – Preparation of [12]Paracyclophanes by Friedel –Crafts Alkylation.

When silyl ether **32** was treated with $Hf(OTf)_4$ in the presence of $LiClO_4$, a mixture of **35** and **36** was obtained, where HPLC purification afforded macrocycle **36** in 64% yield. The predominant *meta*-coupling with respect to the methyl ether of silyl ether **36** was believed to be caused by the electron-withdrawing nature of the TBDMS group. When benzyl ether **33** was treated under the same reaction conditions, a complex mixture was detected without formation of any product. When pivilate **34** was subjected to the coupling reaction under the same conditions, the desired macrocycle **35** was isolated in 78% yield. Steric hindrance as well as the electron-withdrawing nature of the pivaloyl group of **34** was believed to control the reaction, leading to the desired *para*-substituted (with respect to the macrocyclic ring structure) macrocycle **35** as the major product. Hydrolysis of macrocycle **35** with KOH in MeOH followed by CAN oxidation lead to the formation of longithorone B in 58% yield over two steps.

I.3.3 – Conclusion.

Although the Tadahiro group demonstrated an efficient synthesis of the [12]paracyclophane longithorone B, the [3,3]-rearrangement as well as the intramolecular cyclization proved difficult. Complete conversion was never achieved in the rearrangement step and the Friedel-Crafts alkylation afforded a mixture of *ortho*- and *meta*-substituted products.

In light of the work performed by both the Tadahiro and Shair groups, it is clear that there is a need for new and more efficient methods for forming highly hindered, planar chiral macrocyclic ring structures.

I.4 – Longithorone C: A Representative Compound.

I.4.1 – Synthetic Challenges and Goals.

Longithorone C, a member of a family of nine farnesylated quinones, features a macrocyclic skeleton derived from a farnesyl unit bridging a quinone at the *para*-position. Longithorone C also exhibits atropisomerism due to the hindered rotation of the macrocyclic ring structure. Its structural features resemble those of longithorone B and the two monomers that make up longithorone A (Figure 6).

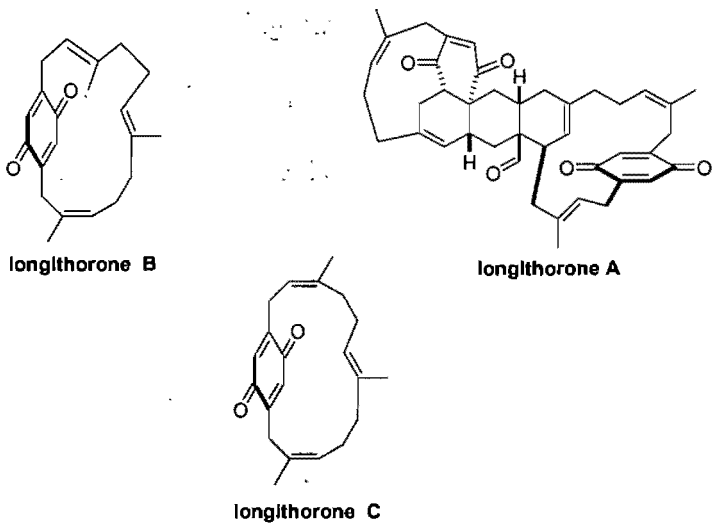


Figure 6 – Structural Similarities Between Longithorones A, B, and C.

The synthetic challenge associated with the synthesis of longithorone C was linked to the difficulty in forming the highly strained, planar chiral macrocycle that contains three stereodefined tri-substituted olefins. It has been reported that heating longithorone C at reflux for 7 days in toluene resulted in no racemization of its

macrocyclic structure.[7] These synthetic challenges inspired our group to develop an efficient synthesis towards longithorone C using ring closing olefin metathesis (RCM) in forming the *ansa*-bridge (Figure 7).

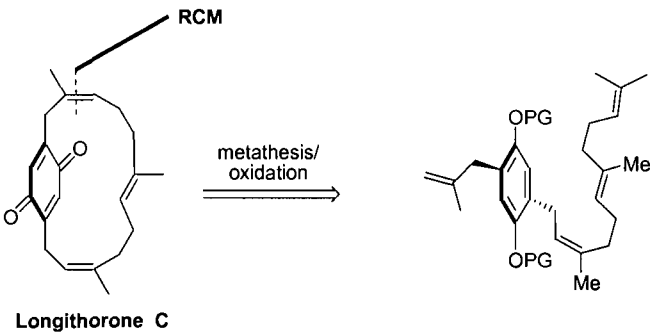


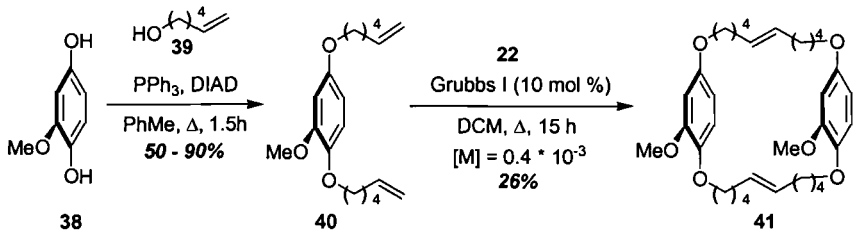
Figure 7 – Initial Retrosynthetic Analysis of Longithorone C.

The ultimate goal would be to install the planar chirality in this molecule via an enantioselective olefin metathesis reaction using a chiral catalyst. Since the formation of [12]paracyclophanes had been achieved using enyne metathesis, it was therefore necessary to determine whether RCM could be used in forming the macrocyclic ring structure of longithorone C. Other synthetic variables to optimize included determining the ideal site for macrocyclization, and stereoselectively forming the tri-substituted olefins within the macrocycle.

I.4.2 – Forming [12]Paracyclophanes: A Model Study.

[12]Paracyclophanes are relatively strained macrocyclic structures. Chiral gearing elements such as the benzylic silyl ether group used by Shair and co-workers

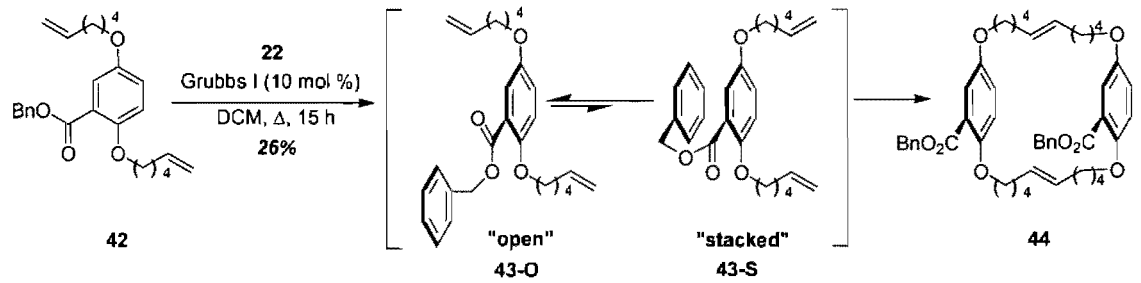
have been employed in directing macrocyclization processes to form [12]paracyclophanes. However, since the ultimate goal would entail using asymmetric olefin metathesis, the substituted methylene gearing elements located on the side chains would be undesirable (i.e. leading to diastereoselective cyclization in place of an enantioselectively cyclization). Yassir El-Azizi, a member of the Collins group, investigated whether RCM could be used to access strained macrocyclic systems in the absence of gearing elements on the side chains (Scheme 8).[19]



Scheme 8 – Initial Attempts in Forming [12]Paracyclophanes.

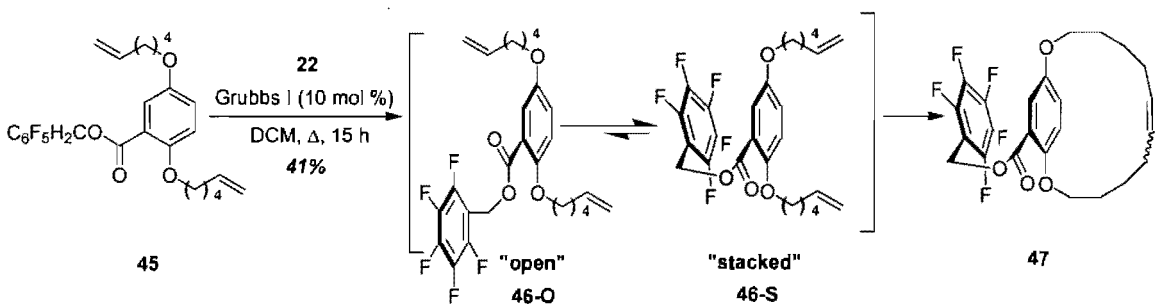
Unfortunately, numerous attempts to cyclize various substituted [12]paracyclophanes using Grubbs first generation catalyst **22** lead to the preferential formation of the dimer **41**, demonstrating the importance of controlling the orientation of the side chains. It was believed that the use of a benzyl ester would allow the formation of the "stacked" conformer **43-S** in solution, which in turn would "gear" the two side chains together through steric bias facilitating macrocyclization (Scheme 9).

[19] El-Azizi, Y.; Schmitzer, A.; Collins, S. K. *Angew. Chem., Int. Ed.* **2006**, *6*, 968-973.



Scheme 9 – Benzyl Esters as Gearing Elements.

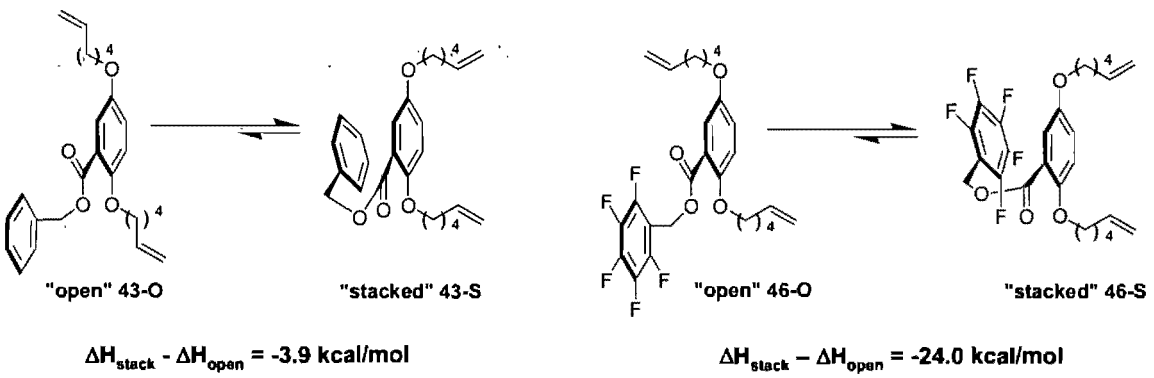
Despite varying the concentration and mode of addition, the use of the benzyl ester did not form the desired macrocyclic product, and once again the dimer was obtained as the major product. Consequently, a strategy employing pentafluorophenyl-phenyl interactions as a novel gearing element to favor the desired intramolecular macrocyclization was envisioned (Scheme 10).



Scheme 10 – Pentafluorobenzylester as a Gearing Elements.

When olefin **45** was treated with catalyst **22**, cyclophane **47** was isolated in 41% yield. Hence the formation of [12]paracyclophanes by RCM was made possible using novel gearing elements such as the pentafluorobenzyl ester **45**. The quadrupolar non-

bonding interactions between pentafluoroarenes and arenes are the result of the orthogonal densities of aromatics and pentafluoroaromatics.[20] These interactions have spiked significant interest in medicinal chemistry and materials science due to the predictable preference for the face-to-face stacking with the aromatics in the solid state.[21] However, relatively little use of these non-bonding interactions has been reported in catalysis.[22] The pentafluorobenzyl ester **45** has been predicted through molecular modeling to prefer the solution state conformation **46-S** to a much greater degree than **46-O** (Scheme 11).[23]

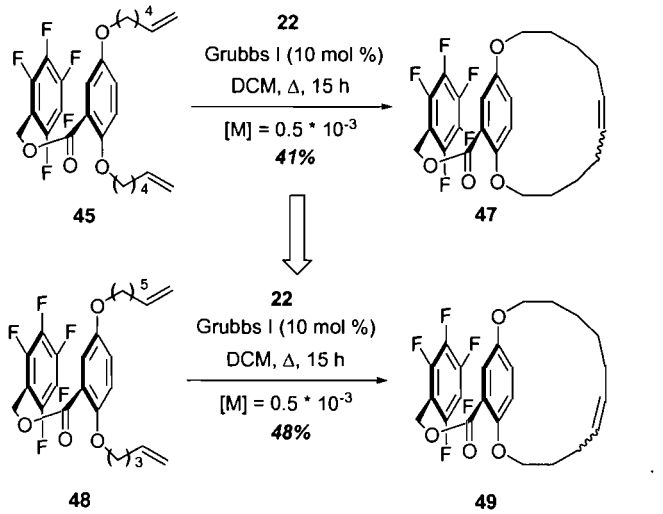


Scheme 11 – Energy Minimization using AM1 and MP2 Methods.[23]

[20] Brown, N. M. D.; Swinton, F. L. *J. Chem. Soc., Chem. Comm.* **1974**, *19*, 770-771.
[21] Mann, E.; Mahia, J.; Maestro, M. A.; Herradon, B. *J. Mol. Struct.* **2002**, *641*, 101-107.
[22] Ponzini, F.; Zagha, R.; Hardcastle, K.; Siegel, J. S. *Angew. Chem., Int. Ed.* **2000**, *39*, 2323-2325.
[23] For a complete list of methods and results used in the molecular modeling studies see: Collins, S.; El-Azizi, Y.; Schmitzer, A. R. *J. Org. Chem.* **2007**, *72*, 6397-6408.

I.4.3 – Determining the Optimal Site for Metathesis along the *Ansa*-Bridge and Formation of Tri-substituted Olefins by RCM.

Previously it had been demonstrated by Yassir El-Azizi that moving the site of metathesis closer to the aromatic core resulted in a higher reaction yield when forming [12]paracyclophanes via olefin metathesis (Scheme 12).[24]

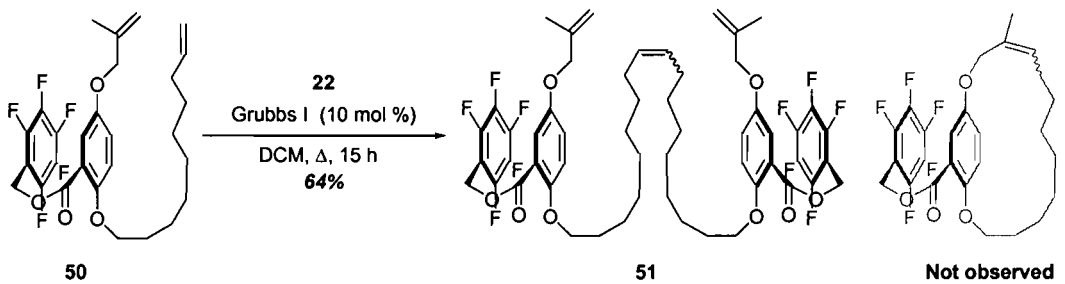


Scheme 12 – Determining the Ideal Site for Metathesis.

When olefin **45** was subjected to metathesis conditions using catalyst **22** under dilute conditions, macrocycle **47** was obtained in 41% yield. When moving the site of metathesis closer to the central arene in olefin **48**, the reaction yield had increased from 41 to 48% yield under the same reaction conditions, indicating that the site of metathesis for the formation macrocycles should be performed closer to the aromatic core.

[24] Collins, S. K.; El-Azizi, Y. *Pure Appl. Chem.* **2006**, *78*, 783-789.

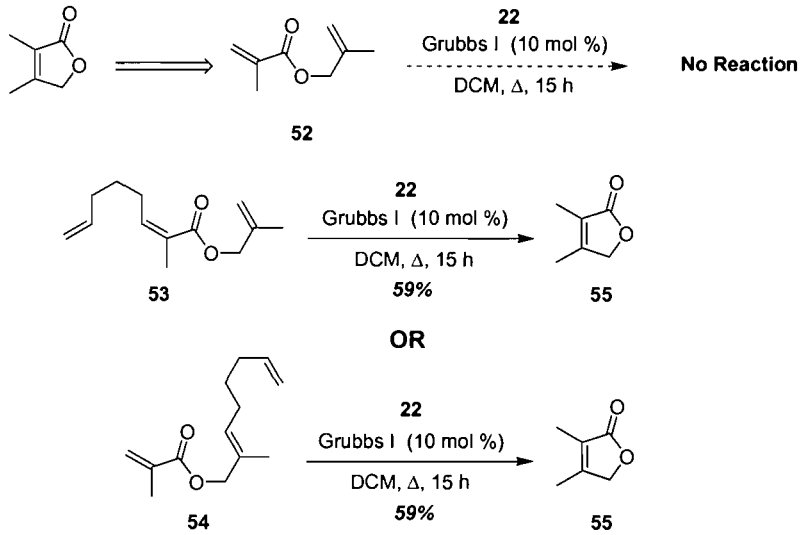
Our group subsequently attempted to prepare even more strained macrocycles incorporating a stereodefined tri-substituted olefin similar to those present in longithorone C (Scheme 13).[19]



Scheme 13 – Attempted Formation of a Tri-substituted Olefin by RCM.

Unfortunately, cyclization of olefin **50** led to the preferred formation of the dimer **51** and no macrocyclic product was isolated, even in the presence of the pentafluorobenzyl ester. Recently, Hoye and co-workers had developed an efficient method for forming highly substituted olefins by RCM called relay-ring closing metathesis (RRCM) (Scheme 14).[25]

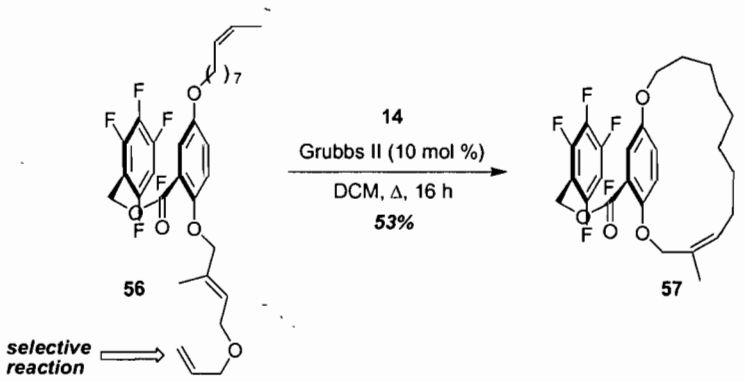
[25] Hoye, T. R.; Jeffrey, C. S.; Tennakoon, M. A.; Wang, J.; Zhao, H. *J. Am. Chem. Soc.* **2004,** *126*, 10210-10211.



Scheme 14 – Relay-Ring Closing Metathesis.

In an attempt to cyclize olefin **52** containing both an electron deficient and a substituted olefin, the catalyst **22** was not reactive enough to perform the desired cyclization. When the olefins of the electron deficient (**53**) or hindered olefin (**54**) were appended with a five carbon chain containing a terminal olefin the cyclization was now successful, affording lactam **55** in 59% yield. The catalyst **22** can now react selectively at the primary olefin of this "relay chain", producing a very fast intramolecular cyclization kicking out a cyclopentene, thereby placing the catalyst onto the desired olefin and allowing facile cyclization to the desired lactam **55**.

Exploiting a relay ring closing metathesis protocol in tandem with the gearing effect of the pentafluorophenyl-phenyl interaction, the cyclophane **57** was isolated in 53% yield on treatment of olefin **56** with catalyst **14** in CH_2Cl_2 at reflux (Scheme 15).[19] Cyclophane **57** was isolated as a single isomer with the tertiary olefin in the *Z* configuration.



Scheme 15 – Model Study Incorporating Relay-Ring Closing Metathesis.

I.5 – Conclusion.

These studies suggest that pentafluorophenyl–phenyl interactions represent a novel π-shielding element for application in face selective transformations,[24] and with potential for use as chiral auxiliaries. The following chapters will focus on the model studies carried out in order to optimize the use of this gearing element for macrocyclizations with the goal of achieving the total synthesis of longithorone C.

Chapter II:

Model Studies Directed Towards the Total Synthesis of Longithorone C via Macrocyclic Olefin Metathesis

The goal of the following model studies was to study the formation of a [14]paracyclophane by ring-closing olefin metathesis (RCM).

II.1 – Retrosynthetic Analysis and Model Studies.

The following retrosynthetic analysis was devised in order to prepare a macrocycle that contained three stereodefined tri-substituted olefins that would resemble the macrocyclic ring of longithorone C (Figure 8).

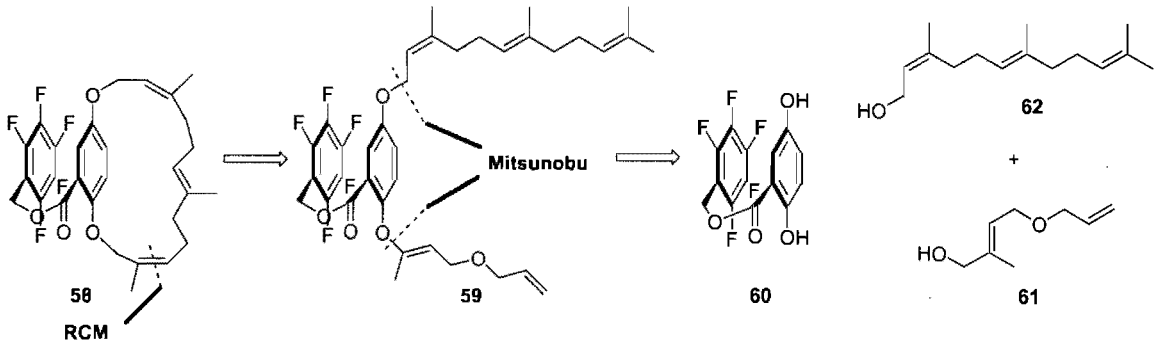


Figure 8 – Retrosynthetic Analysis of a Model System using *cis*-Farnesol 62.

The target [14]paracyclophane **58** contained a macrocycle with three stereodefined tri-substituted olefins, coupled to a bis-phenol with the pentafluorobenzyl ester as functional group. Metathesis of olefin **59** should allow for the successful formation of paracyclophane **58.** In this manner, the two side chains **61**, and **62** could be coupled to bis-phenol **60** via the Mitsunobu reaction (Figure 8).

Unfortunately, *cis,trans*-farnesol **62** required for the formation of **58** in the correct configuration, was not commercially available. As a result *trans,trans*-farnesol **65** was used in order to determine whether or not [14]paracyclophanes such as **63** could be generated using the RRCM technique (Figure 9).

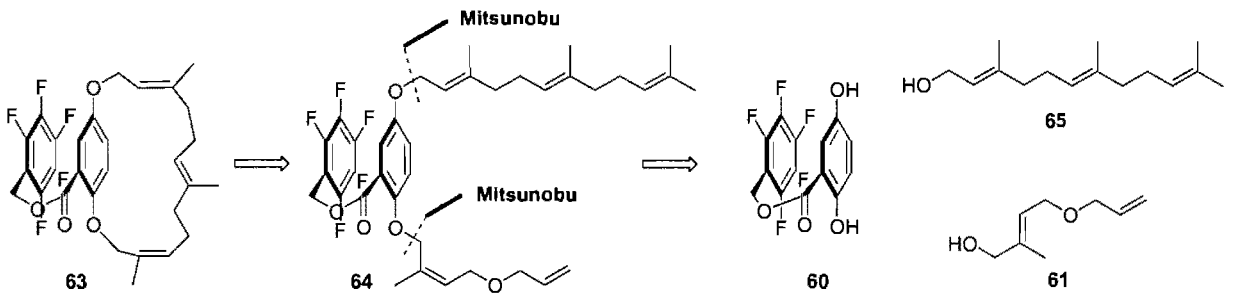
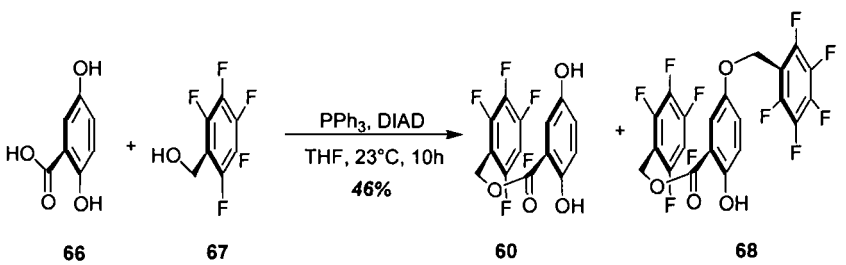


Figure 9 –Retrosynthetic Analysis of Revised Model System using *trans*-Farnesol 65.

II.2 – Synthesis of Pentafluoro-2,5-dihydroxybenzoate 60.

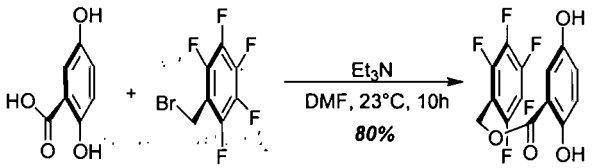
Installation of the pentafluorobenzyl ester gearing element was initially achieved via an esterification procedure. Pentafluorobenzyl ester **60** was formed via the Mitsunobu reaction using pentafluorobenzyl alcohol **67** and 2,5-dihydroxybenzoic acid **66** with a slight excess of PPh_3 and DIAD in anhydrous THF. Diphenol **60** was obtained in 46% yield as a white solid (Scheme 16).



Scheme 16 – Synthesis of Pentafluoro-2,5-dihydroxybenzoate 60 via Mitsunobu Chemistry.

The low reaction yield was a result of the formation of an undesired byproduct, dialkyl **68**. In addition, purification of pentafluorobenzylester **60** was very difficult; the excess DIAD would always co-elute along with diphenol **60**.

In contrast to the Mitsunobu alkylation mentioned above (Scheme 16), alkylation of 2,5-dihydroxybenzoic acid **66** with pentafluorobenzyl bromide **69** proved to be much more selective. Diphenol **60** was obtained following a simple column purification in 80% yield (Scheme 17).



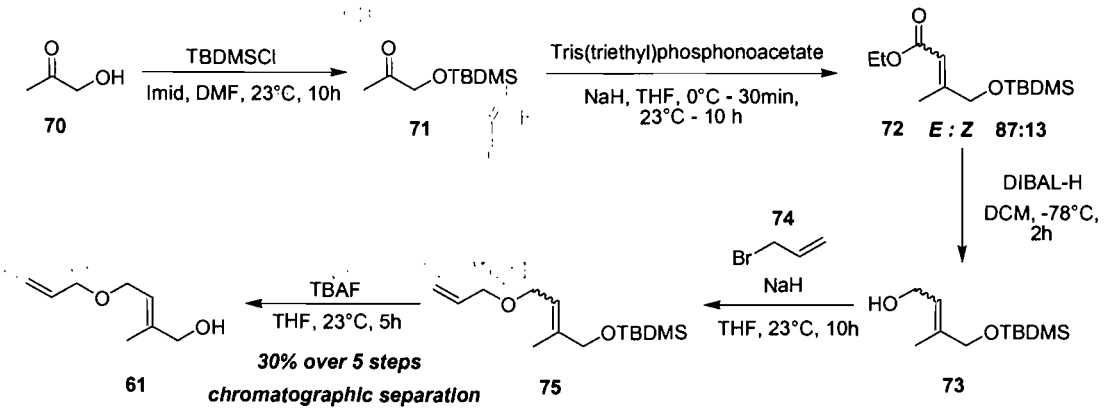
66 69 60

Scheme 17 – Synthesis of Pentafluoro-2,5-dihydroxybenzoate 60 via an Alkylation Procedure.

II.3 – Synthesis of the Allylic Alcohol 61.

Our group had previously demonstrated that relay ring closing metathesis (RRCM) was crucial in forming tri-substituted olefins in macrocyclization.[25] A retrosynthetic analysis for the preparation of **61** was devised following the precedent by Eisenreich and co-workers.[26] The procedure was slightly modified using a silyl ether protecting group rather than a tetrahydropyranyl protecting group. The volatility of the products incorporating the latter protecting group was frequently problematic. The overall reaction yields in either case were identical (Scheme 18).

[26] Amslinger, S.; Kis, K.; Hecht, S.; Adam, P.; Rohdich, F.; Arigoni, D.; Bacher, A.; Eisenreich, W. *J. Org. Chem.* **2002**, *67*, 4590-4594.

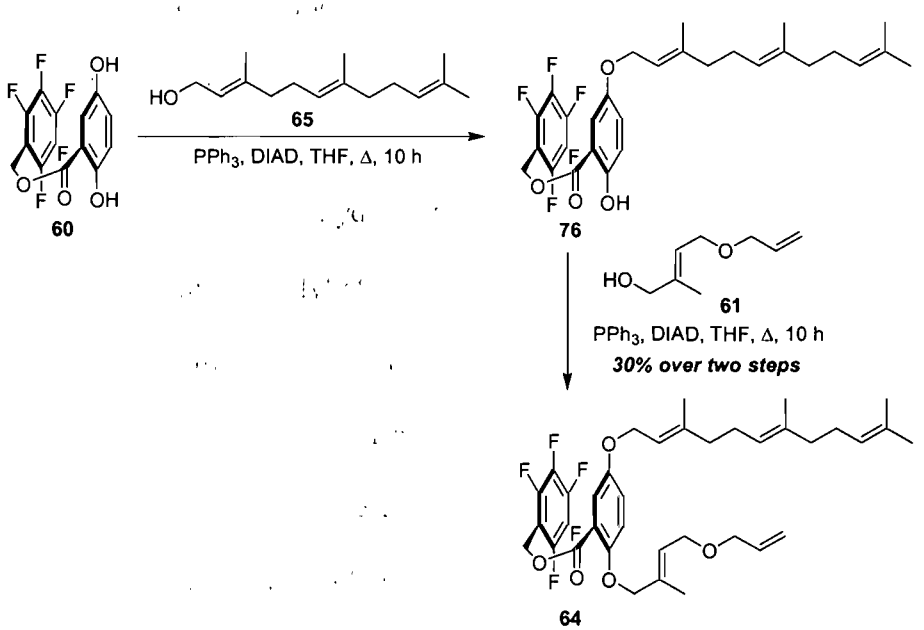


Scheme 18 – Synthesis of Allylic Side Chain 61.

The hydroxyl group of α-hydroxyketone **70** was protected through etherification with TBDMSCl affording the silyl ether **71** in quantitative yield. The silyl ether **71** was used crude in the following Horner-Wadsworth-Emmons reaction (HWE) using tris-triethylphosphonoacetate and NaH in anhydrous THF, affording ester **72** as an 87/13 mixture of *E/Z* isomers. Due to the difficult separation of the two isomers, the crude mixture was simply carried over to the next reaction step. Reduction of the *E/Z* isomers of ester **72** by DIBAL-H in CH_2Cl_2 afforded the allylic alcohol **73** with no chromatographic purification necessary. Allylic alcohol **73** was alkylated using NaH and allyl bromide in anhydrous THF affording silyl ether **75** that was immediately carried over to the next reaction step. The TBAF deprotection of crude silyl ether **75** followed by chromatographic purification afforded the desired allylic alcohol **61** in a 30% yield over five steps as a single *trans*-isomer according to the ^{1}H-NMR spectrum.

II.4 – Macrocyclic Olefin Metathesis of Model System using *trans,trans*-Farnesol 65.

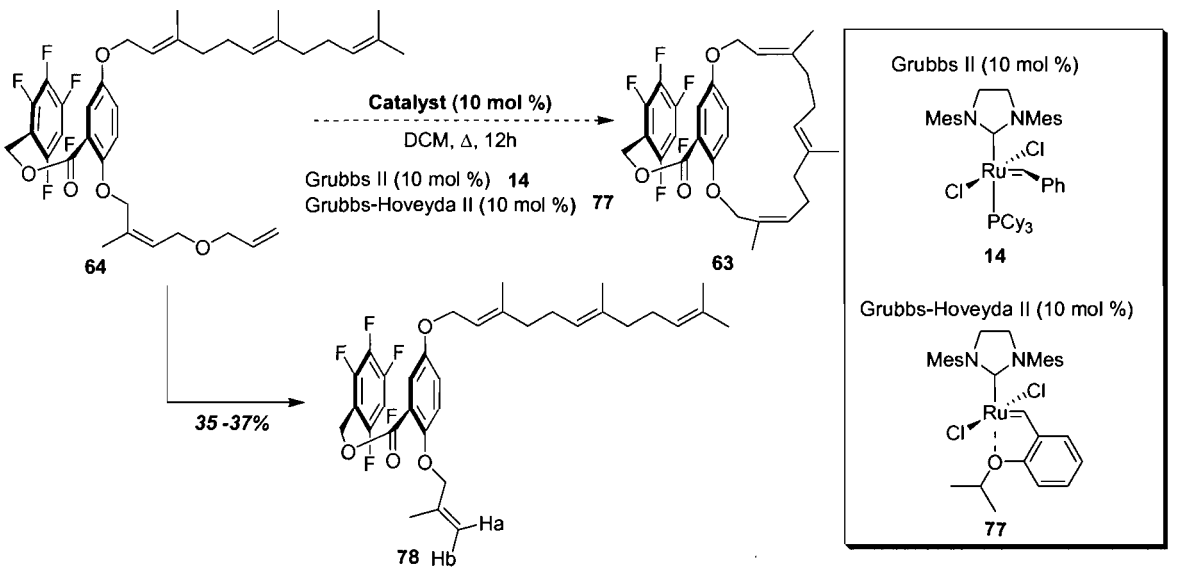
Olefin **76** was formed as the major product by Mitsunobu coupling of 0.5 equivalent of *trans,trans*-farnesol **65** to pentafluorobenzylester **60** using PPh_3 and DIAD in anhydrous THF at reflux (Scheme 19).



Scheme 19 – Alkylation using *trans,trans*-Farnesol 65 and Allylic Alcohol 61.

Unfortunately, due to the presence of the two hydroxyl groups in ester **60**, some dialkylated product was isolated along with phenol **76**. Both products were very difficult to separate by silica gel column purification. As a result, crude olefin **76** was carried over to the next reaction sequence. Another Mitsunobu reaction was performed to alkylate phenol **76** with relay side chain **61**. However, this time the desired pentafluorobenzyl ester **64** was separated from the crude mixture by flash chromatography and obtained in

30% yield over two steps. With both side chains in place, olefin **64** was subjected to metathesis conditions using 2nd generation Grubbs catalyst **14** as well as 2nd generation Grubbs-Hoveyda catalyst **77** in attempts to obtain macrocycle **63** (Scheme 20).



Scheme 20 – RRCM of Macrocycle 63.

Unfortunately, no signs of the desired macrocycle were obtained. Only traces of olefin **78**, commonly referred to as a half-metathesis product (HM) was observed by ^{1}H-NMR. The failed macrocyclization could be due to the configuration of the olefins or the substitution pattern in the prenylated side chain. In either case, the configuration about the allylic double bond on the prenylated side chain should in fact be *cis* in order for macrocycle **58** to resemble that of longithorone C (Figure 10).

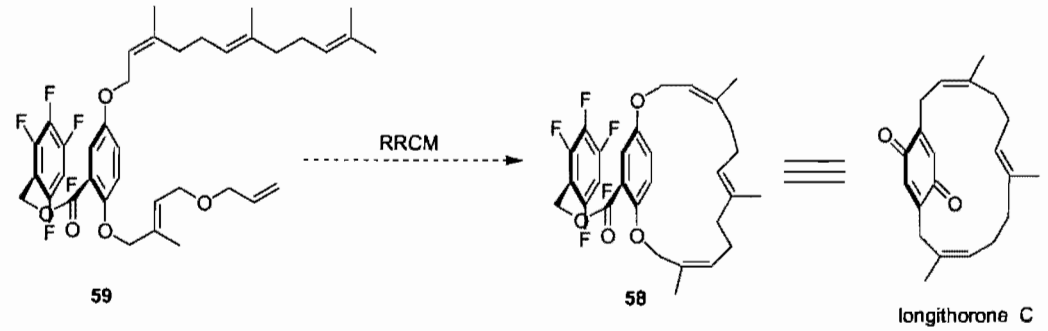


Figure 10 – Revised Model System.

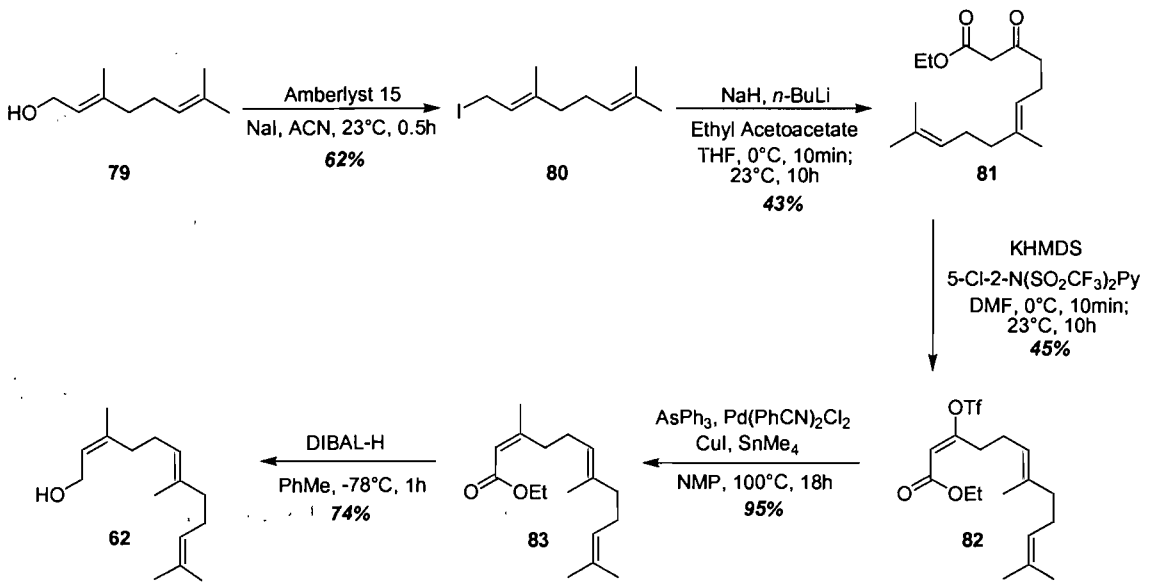
As such, the next target was to prepare *cis*-farnesol and incorporate it into our model system.

II.5 - Synthesis of *cis*-Farnesol 62.

II.5.1 – First Generation Synthesis of *cis*-Farnesol 62.

(2*Z*,6*E*)-Farnesol **62** has been synthesized by a 5 step synthesis developed by Gibbs and co-workers (Scheme 21).[27]

[27] Gibbs, R. A.; Eummer, J. T.; Shao, Y. *Org. Lett.* **1999**, *1*, 627-630.



Scheme 21 – Gibbs' Synthesis of *cis,trans*-Farnesol 62.

Geranyl iodide **80** was synthesized from geraniol **79** using the acidic resin Amberlyst 15 and NaI, affording the iodide **80** in 62% yield. Iodide **80** was then alkylated using the Weiler dianion formed from ethylacetoacetate using NaH and *n*-BuLi which afforded the *β*-ketoester **81** in 43% yield. Ester **81** was then converted to triflate **82** with high stereoselectivity in 45% yield using DMF as solvent. The polar aprotic solvent disrupts the potassium enolate from coordinating to the carbonyl of the ester, leading to the *cis*-isomer (Figure 11).

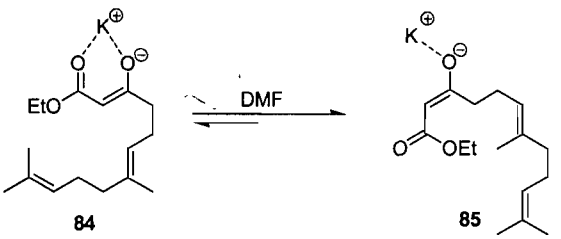
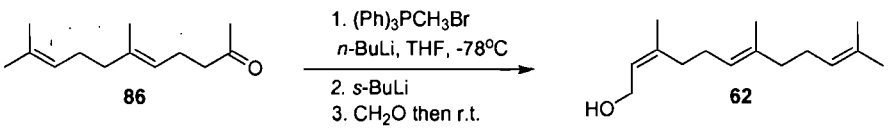


Figure 11 – Stereocontrol During Triflation of β-Ketoester 81 using DMF as Solvent.

Triflate **82** was then coupled with tetramethyltin under catalytic amounts of $Pd(AsPh_3)_2$ and CuI as co-catalyst to afford ester **83** in 95% yield. Ester **83** was then reduced with DIBAL-H to afford the desired (2*Z*,6*E*)-farnesol **62** in 74% yield. Due to the overall length of the reaction sequence, low yield, high cost of reagents, and health hazard, the above procedure was abandoned.

II.5.2 – Second Generation Synthesis of *cis*-Farnesol 62.

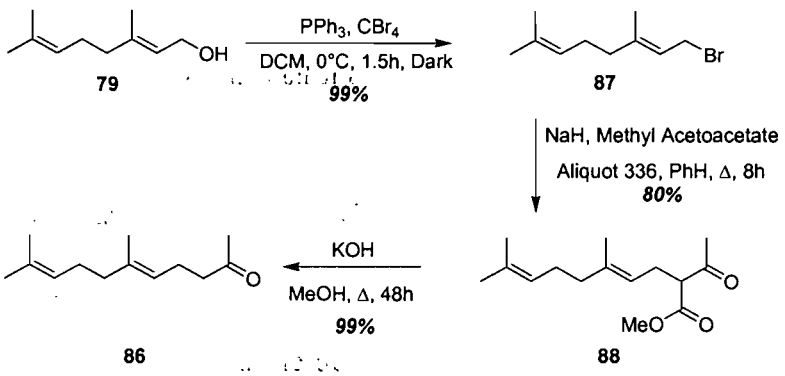
In order to obtain a fair amount of *cis*-olefin **62**, Wiemer *et al.* reported the following procedure using a modified Wittig reaction (Scheme 22).[28]



Scheme 22 – Synthesis of *cis*-Farnesol 62 using Geranylacetone 86.

[28] Yu, J. S.; Kleckley, T. S.; Wiemer, D. F. *Org. Lett.* **2005**, *7*, 4803-4806.

Although geranylacetone **86** was fairly expensive, it could easily be synthesized starting from commercially available geraniol (Scheme 23).[29]



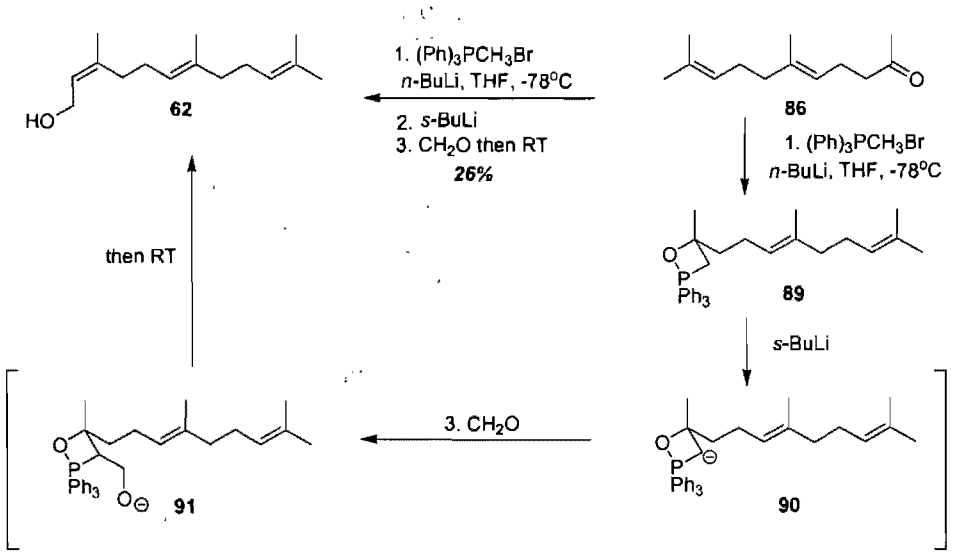
Scheme 23 – Synthesis of Geranylacetone 86.

Geraniol **79** was converted to geranyl bromide **87** using PPh_3 and CBr_4 dissolved in anhydrous CH_2Cl_2. The bromide was used immediately following the removal of triphenylphosphine oxide. The *β*-ketoester **88** was prepared by alkylating methylacetoacetate with bromide **87** using NaH in anhydrous benzene. The phase-transfer catalyst Aliquot 336 was essential in order for the reaction to progress. Ester **88** was obtained in 80% yield following column purification and removal of excess methylacetoacetate. Geranylacetone **86** was formed from ester **88** following saponification and decarboxylation of the ester using KOH and MeOH at reflux for 48 h. Geranylacetone **86** was obtained in 99% yield.

Geranylacetone **86** was then converted to *cis*-farnesol **62** in a modified Wittig procedure which involved deprotonation of the oxaphosphatane **89**, generated from

[29] Durst, H. D.; Liebeskind, L. *J. Org. Chem.* **1974**; *39*, 3271-3273.

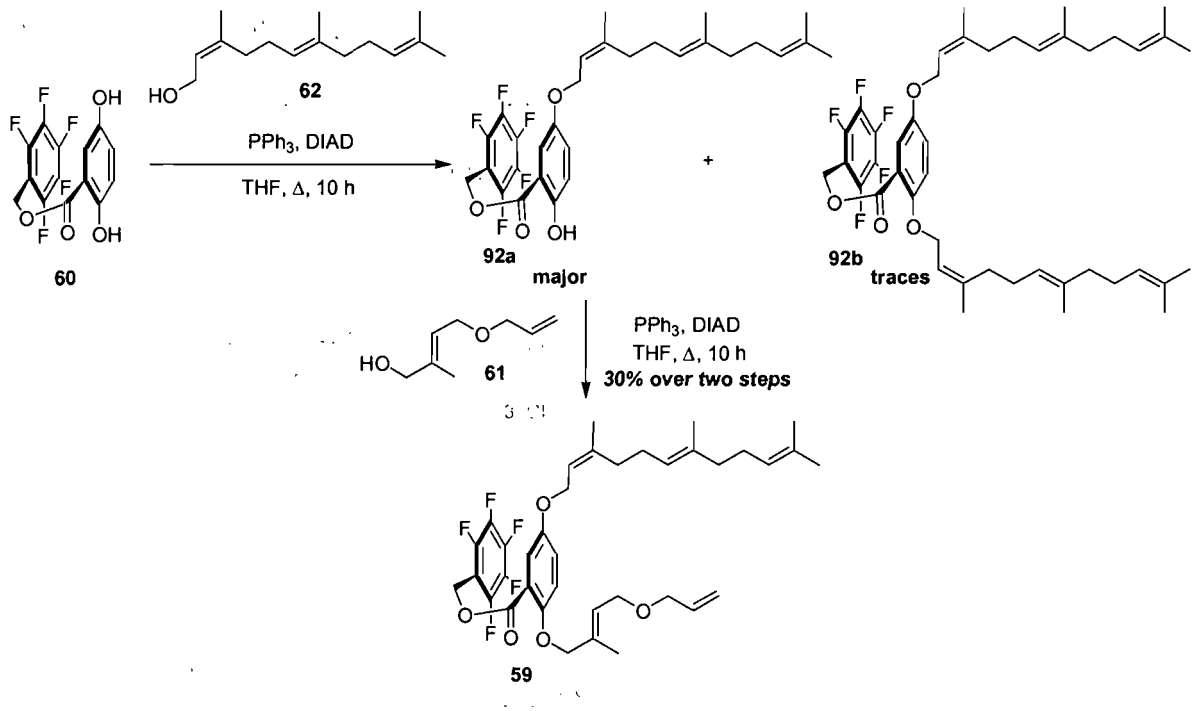
geranylacetone **86** in the presence of methyl triphenylphosphonium bromide and *n*-BuLi, with *s*-BuLi and then quenching intermediate **90** with dry paraformaldehyde, affording *cis*-farnesol **62** in 26% yield (Scheme 24).



Scheme 24 – Preparation of *cis,trans*-Farnesol 62 from Geranylacetone 86.

II.6 - Metathesis of Model System Incorporating *cis*-Farnesol 62.

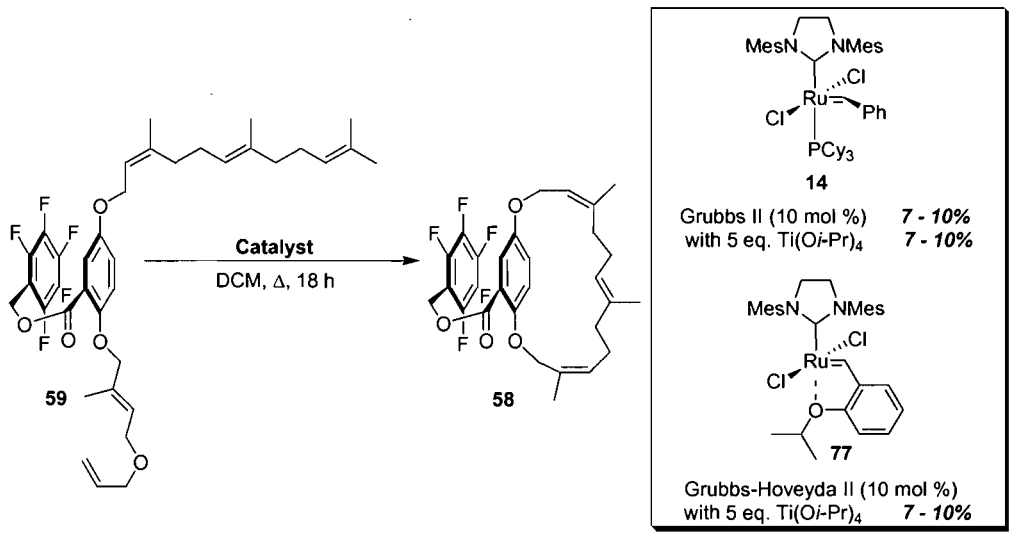
Olefin **92a** was formed by Mitsunobu coupling of 0.5 equivalents of (2*Z*,6*E*)-farnesol **62** to pentafluorobenzylester **60** using PPh_3 and DIAD in anhydrous THF at reflux (Scheme 25).



Scheme 25 – Alkylation using *cis,trans*-Farnesol 62 and Allylic Alcohol 61.

Once again, due to the presence of the two hydroxyl groups in ester **60**, traces of olefin **92b** were observed by ^{1}H-NMR along with the desired olefin **92a** in the first Mitsunobu reaction step mentioned above (Scheme 25). Due to the difficulty in separating the trace amount of dialkyl **92b** by silica gel column purification, the crude phenol **92** (a and b) was carried over to the next reaction sequence. As such, minor olefin **92b** was never isolated. Another Mitsunobu reaction was then performed to alkylate olefin **92a** with relay side chain **61**. Olefin **59** was separated from the crude reaction mixture by flash chromatography and obtained in 30% yield over two steps. With both side chains in place, olefin **59** was subjected to metathesis conditions using 2nd generation

Grubbs catalyst **14** as well as 2nd generation Grubbs-Hoveyda catalyst **77** in attempts to obtain macrocycle **58** (Scheme 26).



Scheme 26 – RRCM of Macrocycle 58.

Macrocycle **58** was obtained in 10% yield in anhydrous CH_2Cl_2 at reflux using either of the above mentioned catalysts (Scheme 26). The use of Ti(O*i*-Pr)$_4$ was believed to block the catalyst from coordinating to the carbonyl group of the ester and was determined to be essential for successful macrocyclization.[30] The next step was to increase the macrocyclization yield by reducing the steric bulk of the terminal olefin of *cis*-farnesol to facilitate olefin metathesis at that position (Figure 12).

[30] Pschirer, N. G.; Bunz, U. H. F. *Tetrahedron Lett.* **1999**, *40*, 2481-2484.

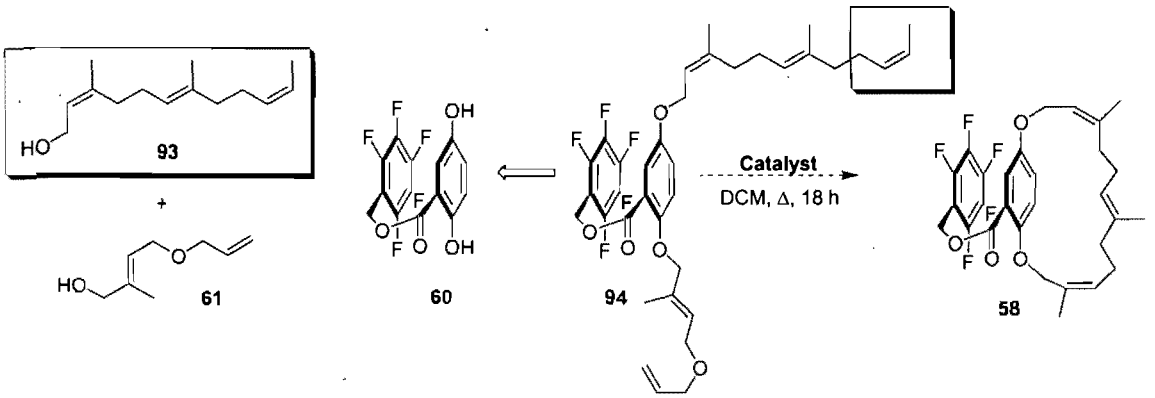
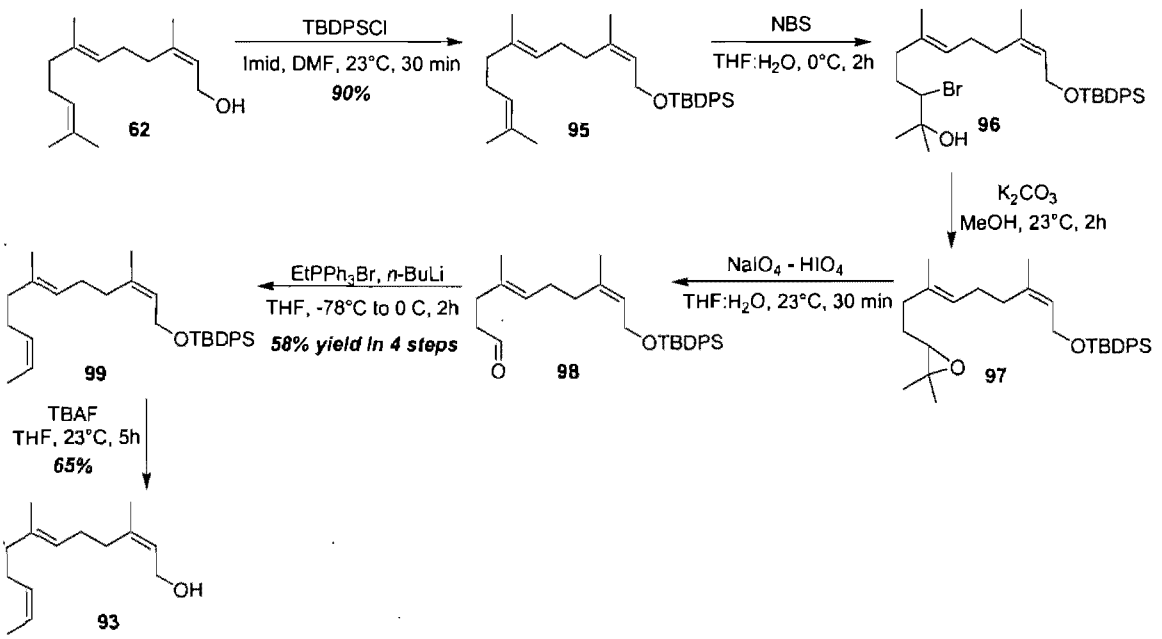


Figure 12 – Proposed Model Study using Disubstituted Olefin 93.

II.7 – Synthesis of *cis*-Olefin 93.

The following procedure developed by Corey and co-workers has been modified in an attempt to prepare the desired olefin **93** (Scheme 27).[31]



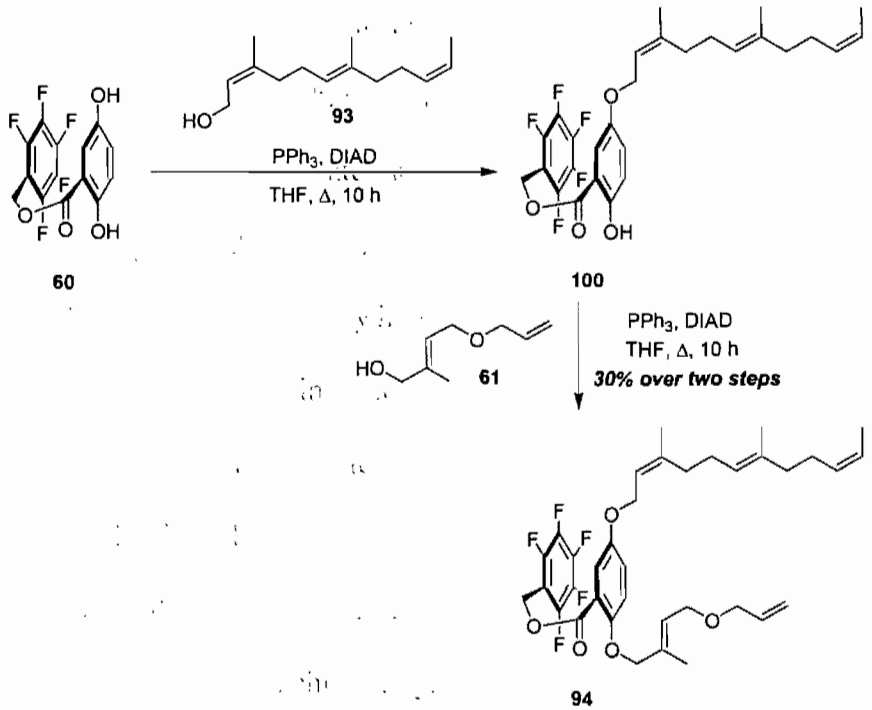
Scheme 27 – Preparation of Olefin 93 Following Modified Corey Procedure.

[31] For the exact procedure see: Corey, E. J.; Kania, R. S. *J. Am. Chem. Soc.* **1996**, *118*, 1229-1230.

Cis,trans-Farnesol **62** was protected using TBDPSCl to afford silyl ether **95** in 90% yield. Without chromatographic purification over the next five reaction steps, silyl ether **95** was taken up in THF and water and reacted with NBS to afford the bromohydrin **96**. Epoxide **97** was prepared on treatment of bromohydrin **96** with potassium carbonate in MeOH. Aldehyde **98** was formed by hydrolytic opening of epoxide **97** and subsequent oxidative cleavage of the resulting diol using sodium periodate and periodic acid. Aldehyde **98** was converted to olefin **99** via Wittig reaction using ethyltriphenylphosphonium bromide and *n*-BuLi. Alcohol **93** was formed by the deprotection of silyl ether **99** using TBAF in anhydrous THF. The final olefin **93** was isolated following silica gel flash chromatography in an overall reaction yield of 44%.

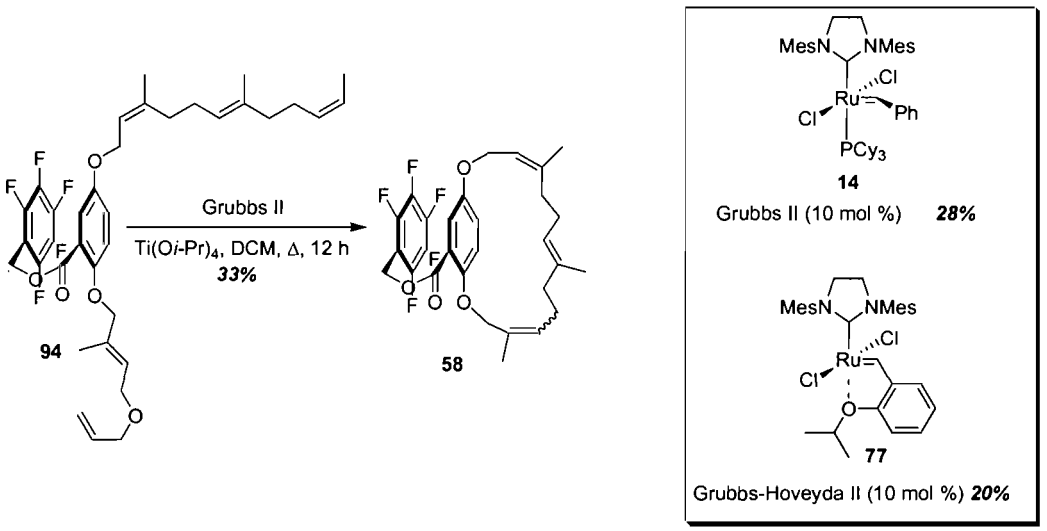
II.8 – Metathesis of Model System 94 using *cis*-Olefin 93.

Pentafluorobenzyl ester **60** was coupled with 0.5 equivalents of *cis*-olefin **93** via the Mitsunobu alkylation using PPh_3 and DIAD in anhydrous THF at reflux. With no further purification, the relay side chain **61** was then coupled to crude phenol **100** (containing trace amounts of the dialkylated product) via the Mitsunobu reaction affording olefin **94** in 30% yield over two steps following column purification (Scheme 28).



Scheme 28 – Alkylation using Side Chain 93 and Allylic Alcohol 61.

Now with both side chains in place, olefin **94** was subjected to metathesis conditions in anhydrous CH_2Cl_2 at reflux (Scheme 29).



Scheme 29 – RRCM of Model System 94.

The macrocycle **58** was obtained in 33% yield using Grubbs catalyst **14** with 5.0 equivalents of titanium *iso*-propoxide. No improvement on reaction yields was observed using the more reactive catalyst **77**.

II.9 – Conclusion.

In the present chapter, the formation of a [14]paracyclophane was accomplished by relay ring-closing metathesis of a farnesylated *cis*-olefin prepared in our group. The importance of these model studies suggest that the formation of highly hindered macrocyclic structures such as [14]paracyclophanes can be accomplished using RCM. In this manner, a macrocyclic ring structure containing three tri-substituted olefins was obtained, resembling that of longithorone C.

Chapter III:

Attacking the Total Synthesis of (±)-Longithorone C: Attachment of Alkyl Chains via Coupling Reactions

In this chapter, the method of attaching the side chains on the central arene for olefin metathesis will be described via coupling reactions (Figure 13).

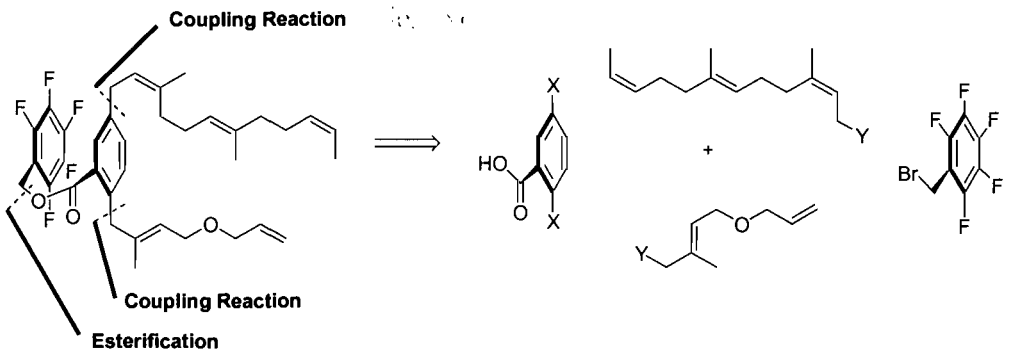
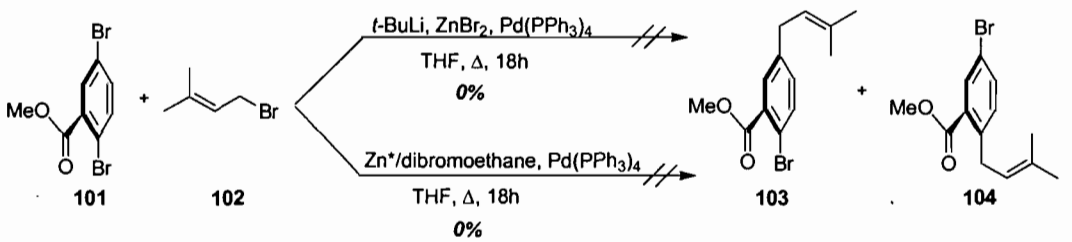


Figure 13 – Retrosynthetic Analysis of Longithorone C.

The goal was to couple both chains, at the desired *para*-position in order to obtain an all carbon [12]paracyclophane with three stereodefined tri-substituted olefins, starting from a 2,5-dihalobenzoic acid. Herein, we report the model studies used to determine the appropriate coupling reactions to obtain the desired target.

III.1 – Negishi Coupling Reactions.

Under the following Negishi conditions,[32] our group attempted to couple the organozincate of 1-bromo-3-methyl-but-2-ene to methyl-2,5-dibromobenzoate. Unfortunately, neither bromides **103** nor **104** were observed, and only bromide **101** was obtained in full (Scheme 30).



Scheme 30 – Negishi Coupling using Prenylbromide 102.

The organozincate was prepared through two different methods; allylic bromide **102** was either treated with *t*-BuLi and transmetallated with $ZnBr_2$ or the zincate was formed using zinc and dibromoethane,[32] but neither case provided any product.

Coupling was also attempted on dibromide **101** with the organozincate of geranyl iodide **80**.[32] Unfortunately, neither diene **105** nor **106** were observed (Scheme 31).

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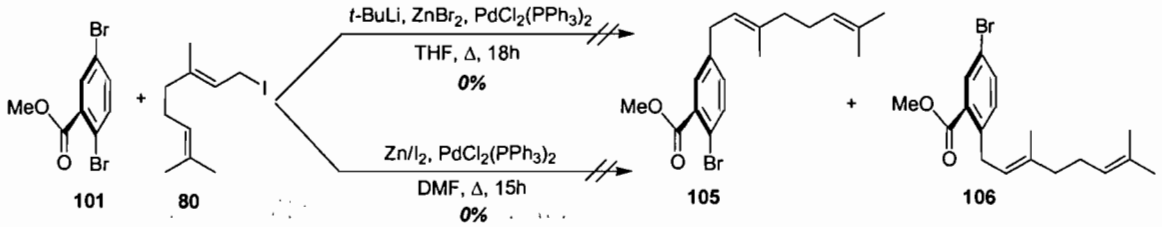
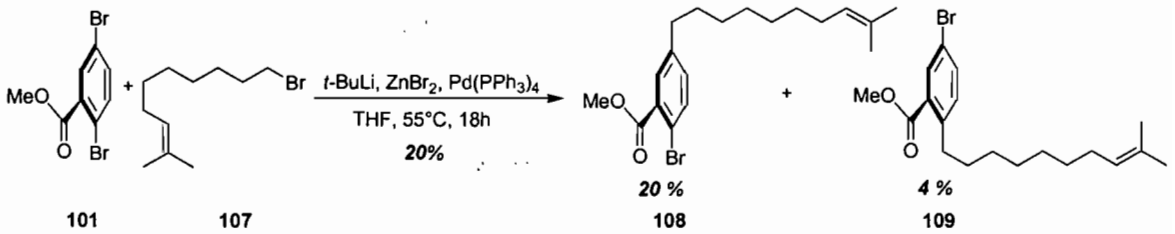
[32] (a) Gomez-Reino, C.; Vitale, C.; Maestro, M.; Mourino, A. *Org. Lett.* **2005**, *7*, 5885-5887. (b) Palmgren, A.; Thorarenson, A.; Backvall, J. E. *J. Org. Chem.* **1998**, *63*, 3764-3768. (c) Xie, M.; Wang, J.; Gu, X.; Sun, Y.; Wang, S. *Org. Lett.* **2006**, *8*, 431-434. (d) Rodriguez, A.; Miller, D. D.; Jackson, R. F. W. *Org. Biomol. Chem.* **2003**, *1*, 973-977.



Scheme 31 – Negishi Coupling using Iodide 80.

In a third and final attempt, alkyl bromide **107** was coupled to dibromide **101** affording olefin **108** in 20% yield, suggesting prenyl-derived organozincates may be the source of the difficulties. Olefin **108** was preferably formed over olefin **109** likely due to steric interactions (Scheme 32).



Scheme 32 – Negishi Coupling using Alkyl Bromide 107.

Negishi couplings of prenylated halides with dibromobenzoate **101** could not be achieved, and as a result this chemistry had to be abandoned.

III.2 – Copper Catalyzed Grignard Reaction.

Knochel and co-workers have demonstrated that functionalized organomagnesium reagents prepared through halogen-metal exchange could be used in cross-coupling

reactions. Allyl and prenyl electrophiles were coupled to aromatic Grignard reagents containing ester functional groups (Figure 14).[33]

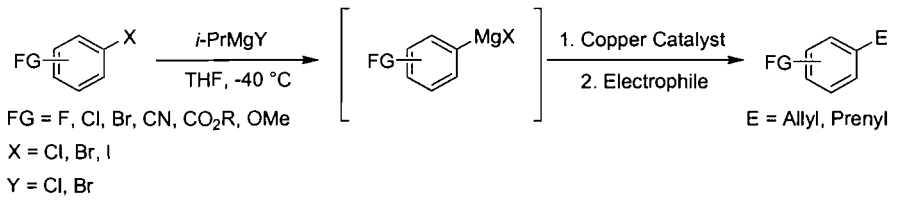


Figure 14 – Copper Catalyzed Grignard Reactions.

As such, the following retrosynthetic analysis was devised in order to obtain both the cis-olefin and relay piece at the correct *para*-position (Figure 15).

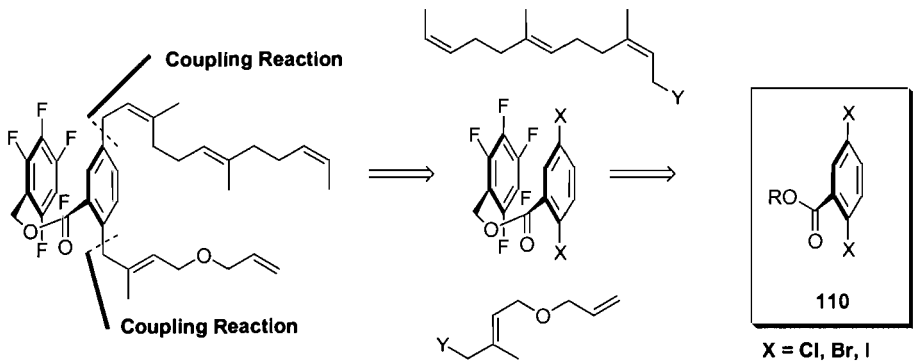


Figure 15 – Retrosynthetic Analysis using Copper Catalyzed Grignard Reactions.

Many reactions of organomagnesium compounds with electrophiles require room temperature or heating for completion. Knochel and co-workers have demonstrated that

[33] (a) Dohle, W.; Gommermann, N.; Kneisel, F. F.; Kopp, F.; Korn, T.; Sapountzis, I.; Vu, V. A.; Knochel, P. *Angew. Chem., Int. Ed.* **2003**, *42*, 4302-4320. (b) Rottlander, M.; Boymond, L.; Berillon, L.; Lepretre, A.; Varchi, G.; Avolio, S.; Laaziri, H.; Queguiner, G.; Ricci, A.; Cahiez, G.; Knochel, P. *Chem. Eur. J.* **2000**, *6*, 767-770. (c) Jensen, A. E.; Dohle, W.; Sapountzis, I.; Lindsay, D. M.; Vu, V. A.; Knochel, P. *Synthesis* **2002**, *4*, 565-569. (d) Ila, H.; Baron, O.; Wagner, A. J.; Knochel, P. *Chem. Comm.* **2006**, *6*, 583-593. (e) Krasovskiy, A.; Knochel, P. *Angew. Chem., Int. Ed.* **2004**, *25*, 3333-3336. (f) Krasovskiy, A.; Straub, B. F.; Knochel, P. *Angew. Chem., Inter. Ed.* **2006**, *1*, 159-162.

a low-temperature preparation of Grignard reagents could allow the synthesis of polyfunctional magnesium organometallic reagents. In addition, at low enough temperatures, organomagnesium species with highly sensitive functional groups could be stable for several hours.

2,5-Dihalobenzoates such as **110** containing chelating groups at the *ortho*-position rapidly undergo Mg-X exchange.[33] The chelating group was believed to complex to the Grignard prior to Mg-X exchange, which could facilitate this exchange. Dihalides such as **110** were thus expected to undergo a chemoselective Mg-X exchange, leading selectively to Grignard reagents such as **111**, in which the magnesium was *ortho* to the ester functionality (Figure 16).

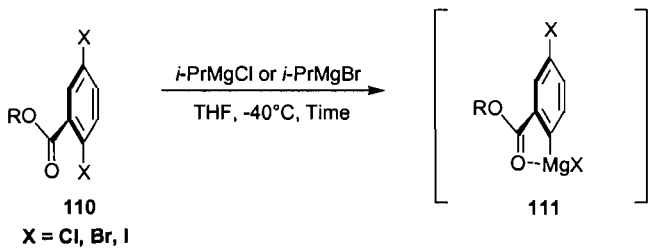


Figure 16 – Magnesium-Halogen Exchange.

Grignard reagents of type **111** may then react to allow the selective coupling of the relay chain at the 2-position.

Knochel and co-workers used copper catalysts in the cross-coupling reactions of aryl magnesates such as **112** in order to achieve successful coupling with allyl or prenylhalides under fast reaction rates (Figure 17).[34]

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[34] Rottlander, M.; Boymond, L.; Berillon, L.; Lepretre, A.; Varchi, G.; Avolio, S.; Laaziri, H.; Queguiner, G.; Ricci, A.; Cahiez, G.; Knochel, P. *Chem. Eur. J.* **2000**, *6*, 767-770.

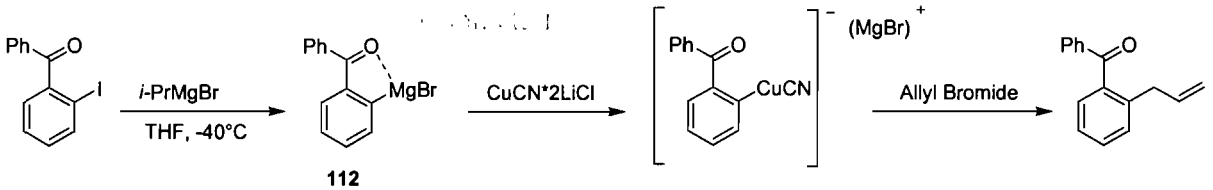


Figure 17 – Role of Copper Catalyst in Organomagnesium Cross-Coupling Reactions.

As such it was considered that a 2,5-dihalobenzoate such as **110** could be used, in conjunction with a copper catalyst, to accomplish the installation of the desired relay and *cis*-olefins at the correct *para*-positions prior to macrocyclization.

The choice of the halogen precursor required evaluation, as well as the issue of the stereochemistry retention of the side chains (Figure 18).

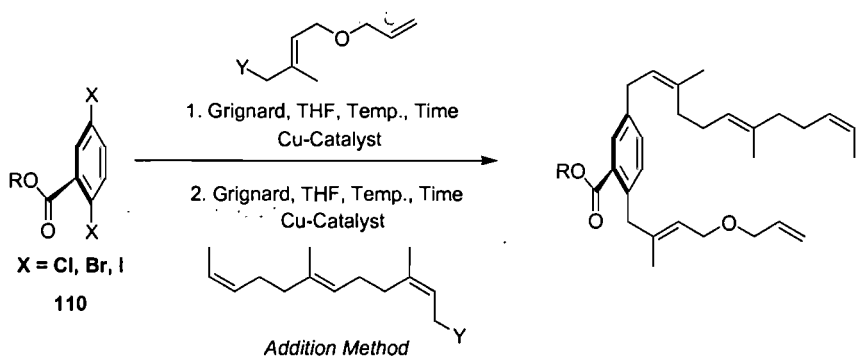
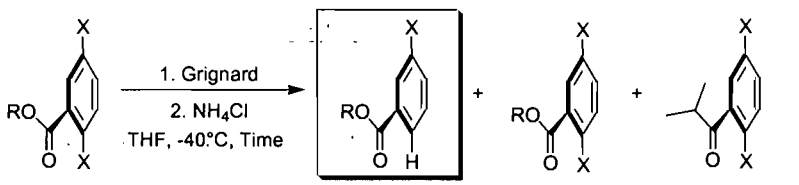


Figure 18 – Proposed Synthetic Pathway for Copper Catalyzed Coupling of Grignard Reagents.

III.2.1 – Optimizing Mg-X Exchange.

Reaction conditions were explored to obtain successful Mg-X exchange, in a reasonable amount of time, without affecting the ester functional group (Table 1).

Table 1 – Effect of Ester Group, Halide, and Grignard Reagent on Mg-X exchange.



113 X = Br, R = Me; **114** X = Br, R = Me; **115** X = Br, R = Me

116 X = Br, R = *i*Pr; **117** X = Br, R = *i*Pr; **118** X = Br, R = *i*Pr

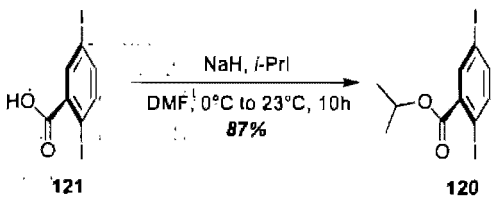
119 X = I, R = *i*Pr; **120** X = I, R = *i*Pr; **121** X = I, R = *i*Pr

Entry	X	R	Grignard (eq.)	Temp (°C)	Time (h)	Products	Yield Ratio (%)
1	Br	Me	*i*-PrMgCl (1.1)	-40.0	3.0	113/114/115	16/58/25
2	Br	*i*-Pr	*i*-PrMgCl (1.1)	-20.0	3.0	116/117/118	83/17/0
3	I	*i*-Pr	*i*-PrMgBr (1.2)	-40.0	0.5	119/120/121	100/0/0

When methyl-2,5-dibromobenzoate (GC R_t = 9.88 min, $[M+H]^+$ found 294) was reacted with 1.1 equivalents of *i*-PrMgCl followed by an NH_4Cl quench, a 16/58/25 mixture was obtained of bromide **113** (GC R_t = 8.30 min, $[M+H]^+$ found 216), dibromide **114**, and ketone **115** (GC R_t = 11.60 min, [M+H]+ found 307) after 3 h ascertained by GC analysis (Entry 1, Table 1).

When the methyl ester of dibromide **114** was substituted for *iso*-propyl ester **117** (GC R_t = 11.45 min, $[M+H]^+$ found 322), the Grignard reagent attack on the ester was suppressed and the major product was bromide **116** (GC R_t = 10.00 min, $[M+H]^+$ found 243) (Entry 2, Table 1). However, even after 3 h dibromide **117** was still observed by GC. When dibromide **117** was substituted by diiodide **120** (GC R_t =11.87 min, $[M+H]^+$ found 416), the exchange was complete in 0.5 h and only iodide **119** was obtained (GC R_t

= 9.70 min, $[M+H]^+$ found 291) (Entry 3, Table 1). Employment of 1.2 eq of *i*-PrMgBr with respect to diiodide **120** resulted in a complete Mg-I exchange *ortho* to the *iso*-propyl ester in 0.5 h at -40°C. Although methyl 2,5-dibromobenzoate **114** was commercially available, *iso*-propyl-2,5-diiodobenzoate **120** was prepared via alkylation of 2,5-diiodobenzoic acid with *i*-propyl bromide in 87% yield under the presence of NaH in DMF (Scheme 33).

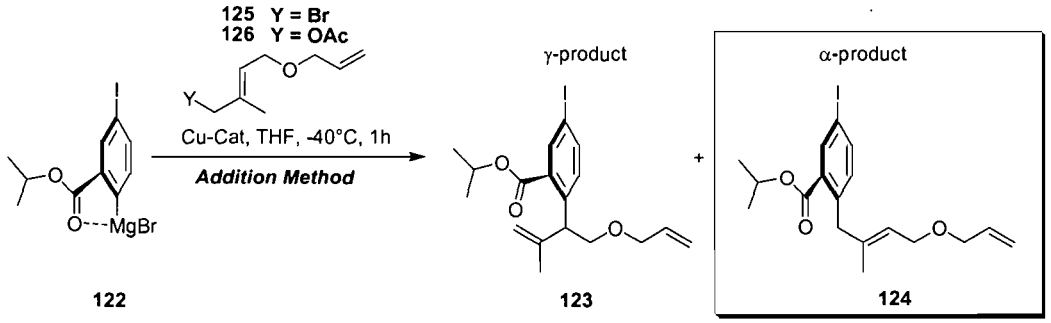


Scheme 33 – Synthesis of *i*-Propyl-2,5-diiodobenzoate 120.

III.2.2 – Optimizing S_N2'/S_N2-type Product Ratio.

In this section, the optimum reaction conditions will be discussed in order to obtain the desired α-product **124** with high reaction yields. The outcome of these results was dependant on choice of catalyst, electrophile, and addition method (Table 2).

Table 2 – Optimizing γ / α Product Ratio.



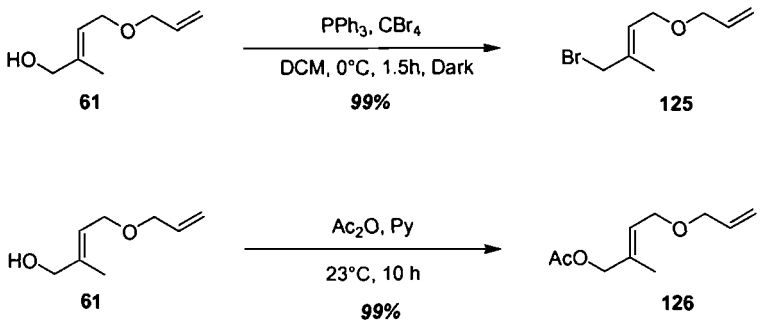
Entry	Aryl-I (eq)	Catalyst (10 mol %)	Y (eq)	Addition Method	γ / α (% Yield)[c]
1	1.0	CuCN*2LiCl	Br (1.0)	A[a]	32 / 20
2	1.0	Li_2CuI_4	Br (1.3)	A	11 / 7
3	1.0	Li_2CuI_4	OAc (1.5)	A	0 / 19
4	1.5	Li_2CuI_4	OAc (1.0)	A	0 / 43
5	1.5	Li_2CuI_4	OAc (1.0)	B[b]	0 / 80

[a] Cu-catalyst added to Grignard reagent, followed by allylic electrophile

[b] Grignard reagent added to a solution of Cu-cat and allylic electrophile

[c] Based on ^{1}H-NMR yields

Two methods of addition were explored in order to prepare the desired *a*-product **124**. Either the copper catalyst and side chain **125/126** were added to Grignard **122**, prepared from *i*-PrMgBr and *iso*-propyl-2,5-diiodobenzoate (Method A), or copper catalyst and side chain **125/126** were mixed together prior to treatment with the Grignard reagent **122** (Method B, inverse addition). The requisite allylic electrophiles **125** and **126** were prepared from allylic alcohol **61**, treated with either PPh_3 and CBr_4 or Ac_2O and pyridine respectively (Scheme 34).



Scheme 34 – Synthesis of Bromide 125 and Acetate 126.

Using bromide **125** and addition method A, a 32/20 mixture of S_N2'/S_N2-type products was obtained based on the ^{1}H-NMR yield (Entry 1, Table 2). By employing Li_2CuCl_4 as catalyst, the formation of the S_N2-type products, or α–products was favored.[35] Employing Li_2CuCl_4 as catalyst in this reaction with bromide **125** did not give any improvement in the product ratio (Entry 2, Table 2). Switching to acetate **126** as electrophile eliminated the S_N2'-type product, or the γ-product and provided olefin **124** using Li_2CuCl_4 as catalyst (Entry 3, Table 2). Fast addition of the freshly formed Grignard reagent **122**, to a premixed solution of Li_2CuCl_4 (10 mol%) and acetate **126** (Method B), gave the desired α-product in 80% yield (Entry 5, Table 2).

Backvall and co-workers have conducted numerous studies in order to explain the α/γ product ratios in cuprate additions to allylic acetates, bromides, and chlorides.[35, 36] They have demonstrated that in most cases, the more reactive allylic chlorides and bromides showed a preference for γ-substitution in copper catalyzed Grignard reactions, where allylic acetates showed a preference for α-substitution.

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[35] Backvall, J.E.; Sellen, M.; Grant, B. *J. Am. Chem. Soc.* **1990**, *112*, 6615-6621.
[36] Schmid, M.; Gerber, F.; Hirth, G. *Helv. Chim. Acta.* **1982**, *65*, 684-702.

III.2.3 – Mechanism behind the α/γ Product Ratios.

The goal of the preceding study was to obtain the desired α-product, and maintain the stereochemistry of the olefins in the side chain. Following the mechanism explained by Backvall, the transmetallation step with the copper catalyst and the Grignard reagent produces the monoarylcuprate species **127** (Figure 19).[35]

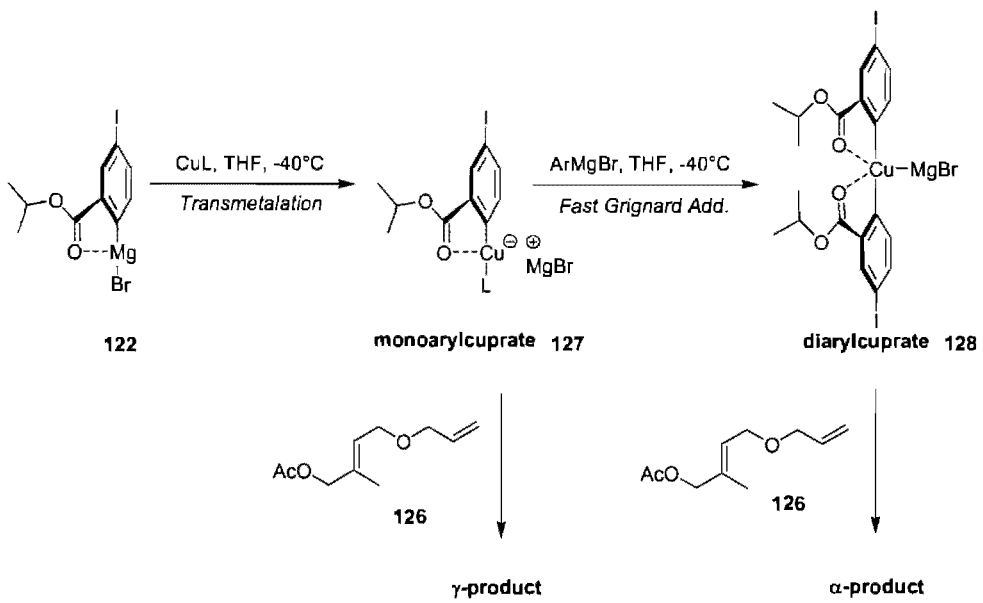


Figure 19 – Regiocontrol in Copper Catalyzed Grignard Reactions.

Cuprate **127** can either react with the electrophile or a second equivalent of organomagnesium **122**, affording the dialkylcuprate species **128**. It was known in the literature that monoalkylcuprates tend to form γ-products whereas dialkylcuprates tend to form α-products.[35] Fast addition of Grignard reagent **122**, low catalyst loading, and low

concentration of the allylic acetate **126** are all expected to favour the formation of the dialkylcuprate **128**, which in turn should favour the formation of the α-product.[35]

It was believed that following oxidative addition of either mono- or diarylcuprates onto acetate **126**, the cuprate may add at the γ-position to form σ-allyl complex **129** (Figure 20).[35]

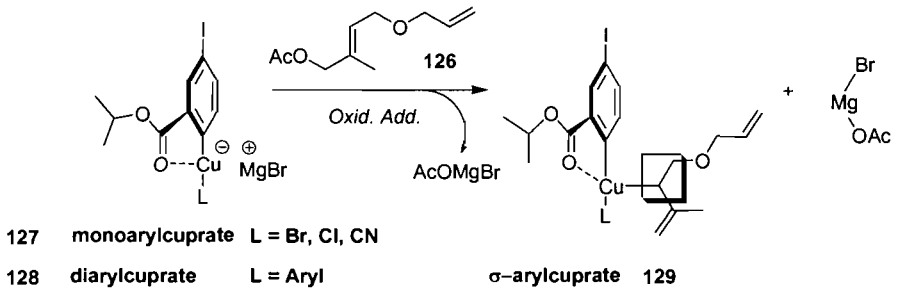


Figure 20 – Formation of σ-Allyl Copper Species 129 with the Allylic Acetate 126.

Following formation of the σ-allyl complex **129**, the cuprate can either undergo reductive elimination to generate the γ-product, or reversible isomerization to generate π-allyl complex **130**, which on reductive elimination would give the α-product (Figure 21).

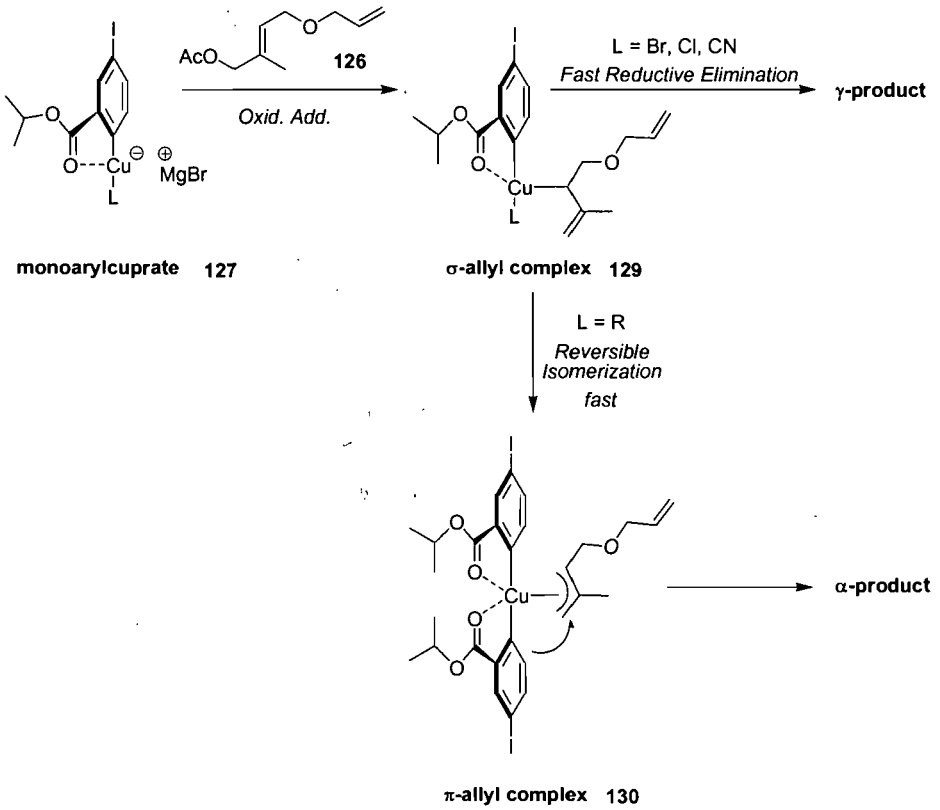


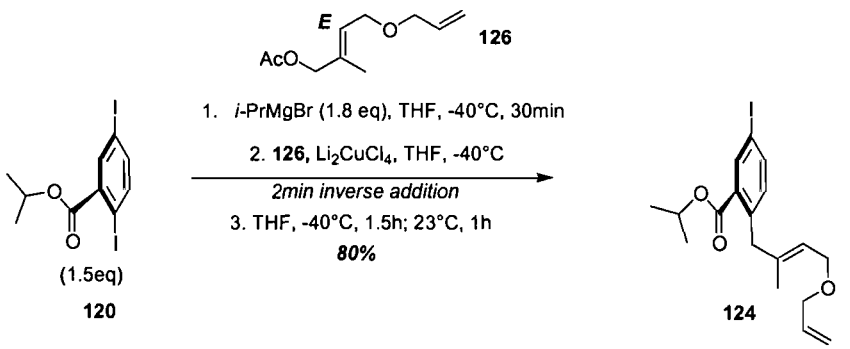
Figure 21 – Formation of π-Allyl Copper Species 130 with Acetate 126.

Electron-withdrawing ligands such as Br, Cl, and CN on complex **129** have been suggested to accelerate reductive elimination leading to the γ-product.[37] The latter may result from using catalysts such as CuBr, CuCl, and CuCN, respectively. If the ligand L on complex **129** is an alkyl or aryl group (resulting from the formation of the diarylcuprate intermediate), then reductive elimination would be slow and σ-allyl complex **129** may undergo reversible isomerization leading to π-allyl complex **130**, and α-product **124** following reductive elimination (Figure 21).

[37] Yamamoto, T.; Yamamoto, A.; Ikeda, S. *J. Am. Chem. Soc.* **1971**, *93*, 3350-3360.

Catalysts such as Li_2CuCl_4 lead to the formation of the diarylcuprate **130.** Delivery of the aryl group to the less hindered position of π-allylic complex **130** would favor addition to the α-position. In addition, the aryl group delivery is believed to be faster with Li_2CuCl_4 as catalyst such that complete retention of stereochemistry is observed (Figure 21).[38]

To sum up thus far, starting from *i*-propyl-2,5-diiodobenzoate **120**, 1.2 equivalents of *i*-PrMgBr was required with respect to **120** in order to have complete Mg-I exchange in under 0.5 h at -40°C. The newly formed Grignard reagent was then added to a flask containing a premixed solution of allylic acetate **126** and Li_2CuCl_4 as copper catalyst over a 2-min period, affording iodide **124** in 80% yield (Scheme 35).



Scheme 35 – Optimized Reaction Conditions in Forming Aryl Iodide 124.

III.2.4 – Attaching *cis*-Olefin 93 via the Copper Catalyzed Grignard Reaction.

In light of the previous coupling reaction, *cis*-olefin **93** was converted to allylic acetate **131** in the presence of acetic anhydride and pyridine to afford acetate **131** in 96% yield (Scheme 36).

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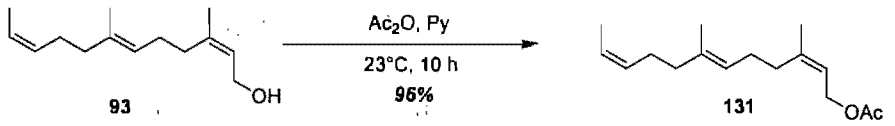
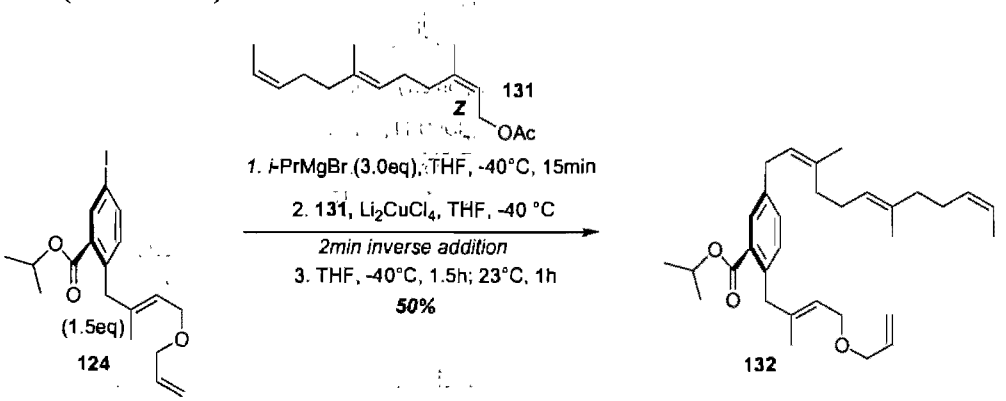
[38] Levisalles, J.; Rudler-Chauvin, M.; Rudler, H. *J. Organomet. Chem.* **1977**, *136*, 103-110.



Scheme 36 – Formation of the Allylic Acetate 131 Derived from *cis*-Olefin 93.

When subjecting aryl iodide **124** to the same reaction conditions, the absence of a chelating group *ortho* to the iodine atom was expected to slow Mg-I exchange. Two equivalents of *i*-PrMgBr were required to obtain complete Mg-I exchange with aryl iodide **124** in 0.25 h at -40°C. The freshly formed Grignard reagent was then added to a premixed solution of *cis*-acetate **131** and the Li_2CuCl_4 to afford the desired olefin **132** in 50% yield (Scheme 37).



Scheme 37 – Optimized Reaction Conditions in Forming Olefin 132.

With reaction protocols for both allylic acetates **126** and **131** in hand, the next step was to determine whether there was retention of olefin stereochemistry in the coupling reactions.

III.3 – Determining Stereochemistry of the Side Chains.

In the NOESY spectrum of trans-allylic acetate **126**, nOe was observed between the methyl signal at 1.66 ppm and the allylic methylene signal at 4.00 ppm. No nOe was observed between the methyl signal (1.66 ppm) and vinyl proton (5.60 ppm) (Figure 22).

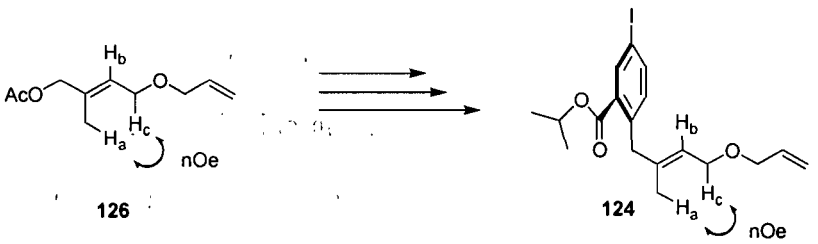
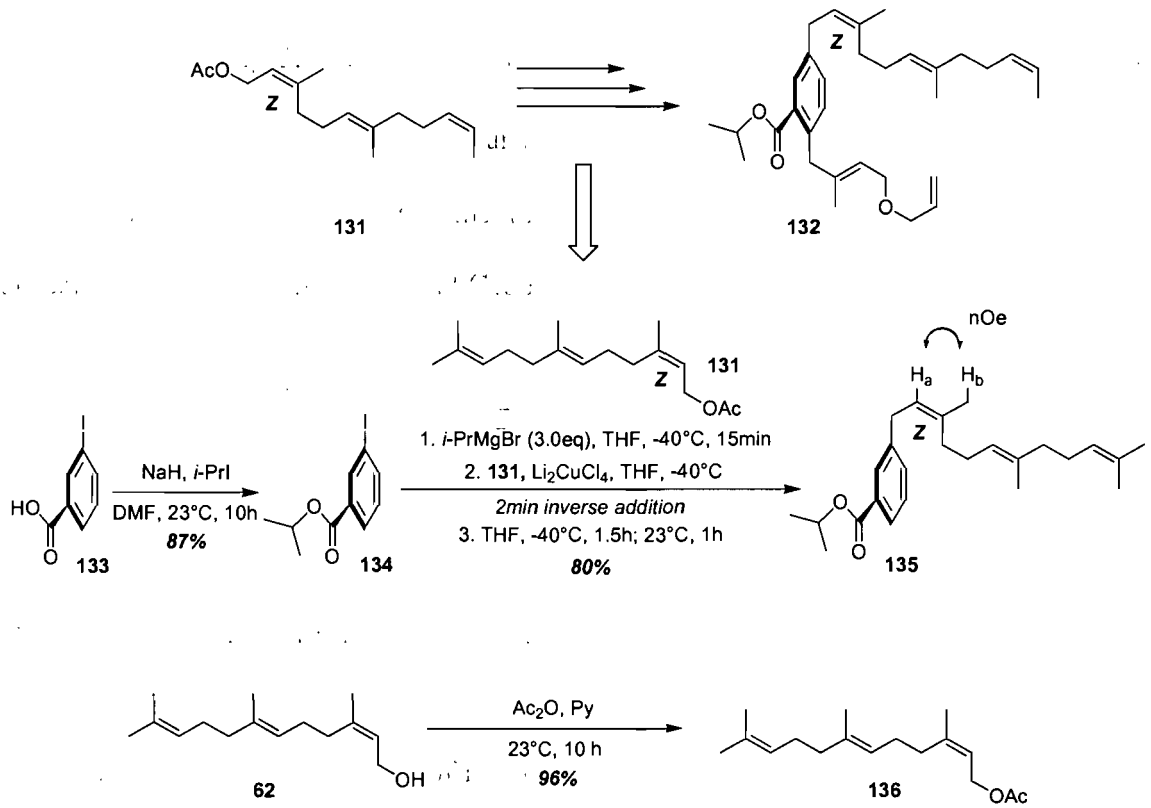


Figure 22 – Stereochemistry of Relay Side Chain.

In the NOESY spectrum of iodide **124**, the methyl signal exhibited nOe with the methylene signal at 3.97 ppm and not with the vinyl proton (5.21 ppm) indicating retention of stereochemistry in coupling of the allylic acetate **126** to iodide **120**.

The NOESY spectrum of ester **132** was complicated due to overlapping signals for the alkenyl protons. As a model system, ester **135** was formed following a similar Cu-catalyzed Grignard reaction employing acetate **136** that was derived from *cis*-farnesol **62** (Scheme 38).



Scheme 38 – Synthesis of Acetate 136 and Stereochemistry of Olefin 153.

In the NOESY spectrum of ester **135**, the vinyl proton at 5.33 ppm and methyl signal at 1.76 ppm exhibited an nOe indicative of a *cis*-olefin. Based on this result, a similar retention of configuration has been assumed for ester **132**.

III.4 – Conclusion.

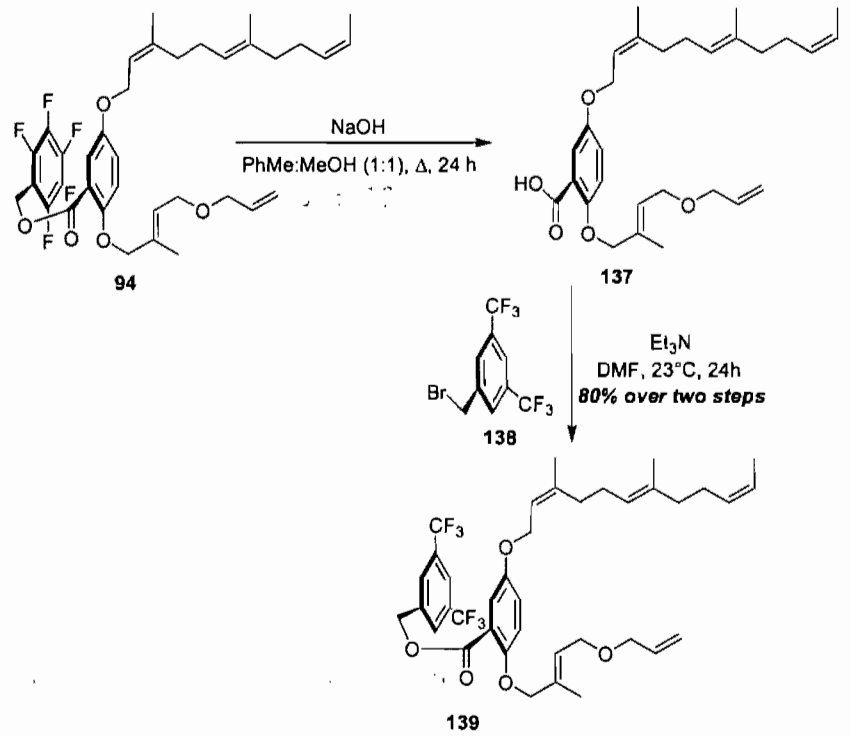
In summary, copper-catalyzed cross coupling of aryl Grignard reactions to allylic acetates **126** and **131** gave ester **132** with retention of stereochemistry. The stage was set to explore the total synthesis of longithorone C by formation of the macrocycle by RCM.

Chapter IV:

Improved Gearing Elements for Macrocyclic Olefin Metathesis: A Model Study

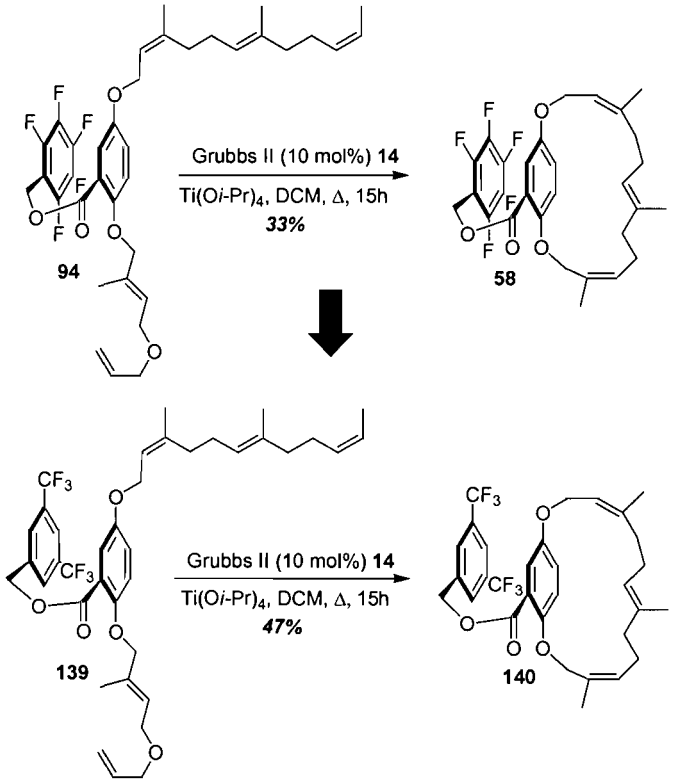
IV.1 – Improved Gearing Element used in Model Systems.

Our group has continued to investigate new and improved gearing elements for olefin metathesis. During studies directed towards developing gearing elements that function via non-covalent interactions, we investigated substituting the pentafluorobenzyl ester with other fluorinated aromatics. One such attempt involved use of a 3,5-bis(trifluoromethyl)benzylester (Scheme 39). This gearing element was first examined in model systems before application to the total synthesis of longithorone C.



Scheme 39 – Preparation of Bistrifluoromethyl Benzyl Ester 139.

Ester **94** was hydrolyzed using NaOH in a mixture of toluene and methanol at reflux for 24 h. The crude acid **137** was alkylated with 3,5-bistrifluoromethylbenzyl bromide and triethylamine in DMF to afford ester **139** in 80% yield over two steps. Previously, ring closing metathesis using pentafluorobenzyl ester **94** gave 33% yield of [12]paracyclophane **58**. With bis(trifluoromethyl)benzyl ester **51** the same conditions gave macrocycle **140** in 47% yield (Scheme 40).



Scheme 40 – Improved Bistrifluoromethyl Gearing Element on Model System.

Qualitatively, the results may be explained by electronic effects of the fluorine substituents. Since the fluorine atoms of the pentafluorobenzyl ester are directly attached to the arene in ester **141**, the electron density is concentrated on the fluorine atoms and the center of the arene is considered electropositive. The same effect can be caused by the bistrifluoromethyl groups in ester **142**. However, the fluorine atoms of the pentafluorobenzyl ester may have both electron donating and electron withdrawing abilities, where as the trifluoromethyl groups in the bistrifluoromethyl gearing element are solely electron withdrawing.[24] One may consider that the CF_3 groups make the arene more electropositive than that of the pentafluorobenzyl ester (Figure 23).

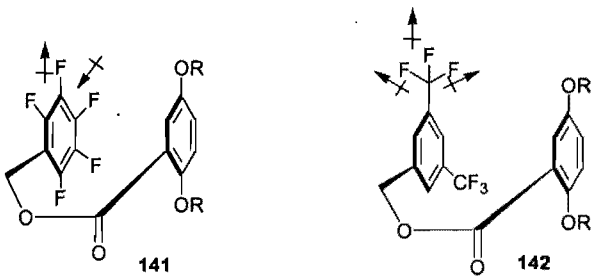


Figure 23 – Quadrupolar Interactions using a CF_3-Based Gearing Element.

IV.2 – Molecular Modeling using the Bistrifluoromethyl Auxiliary on Model Systems.

Molecular modeling was used in order to understand how the non-bonding interactions affected the product distribution using high order DFT method calculations (Figure 24).[39]

[39] For a complete list of methods and results used in the molecular modeling studies see: Collins, S.; El-Azizi, Y.; Schmitzer, A. R. *J. Org. Chem.* **2007**, *72*, 6397-6408.

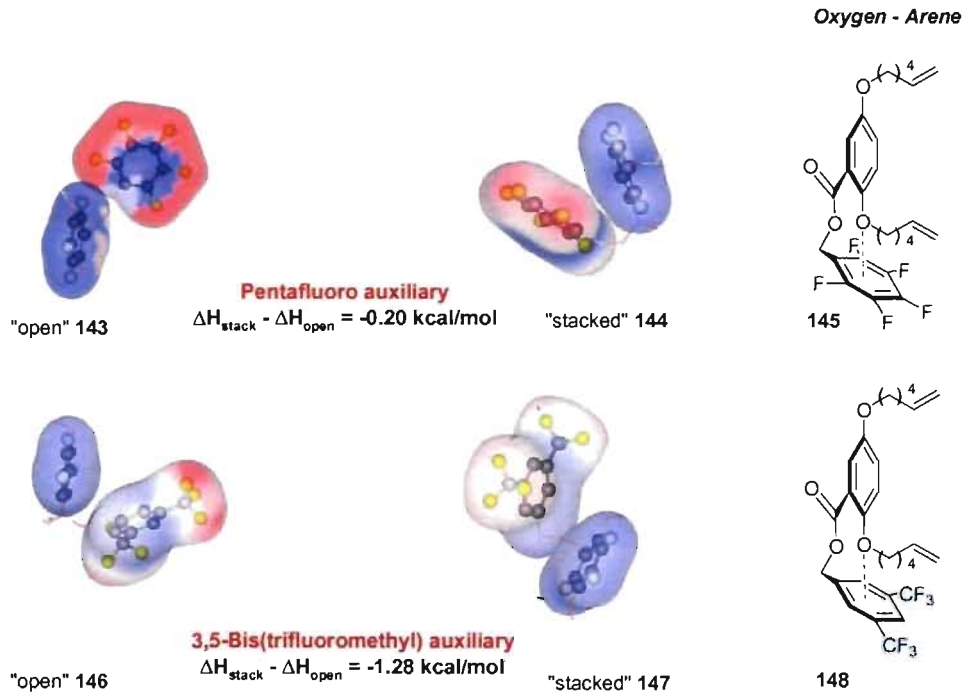


Figure 24 – Results of Higher Order DFT Calculations on Model System (Red color denotes areas of increased electronic density due to fluorine atoms).

In the above model systems (that incorporate the oxygen atoms about the central arene), the "stacked" conformer **144** of the pentafluorobenzyl ester was preferred over the "open" conformer **143** by 0.20 kcal/mol. With the bistrifluoromethylbenzyl ester as gearing element, the "stacked" conformer **147** was preferred over the "open" conformer **146** by 1.28 kcal/mol. These findings correlate with the increased yield for the bistrifluoromethylbenzyl ester **140** relative to the pentafluorobenzyl ester **58** in the RCM reaction. The "stacked" conformers above do not, however, engage in $\pi:\pi$ stacking interactions, instead the benzyl group sits over an oxygen atom (**145/148**) and is believed to engage in lone pair:π interactions between the electron deficient pendant arene and an

oxygen atom (Figure 24). These interactions, although rare, have been previously documented for systems in solutions.[40]

IV.3 – Molecular Modeling using the Bistrifluoromethyl Auxiliary on an All Carbon System.

Molecular modeling was carried out in order to probe how the non-bonding interactions between the electron deficient auxiliaries and electron rich arenes would effect the product distribution in forming an all carbon [12]paracyclophane (Figure 25).

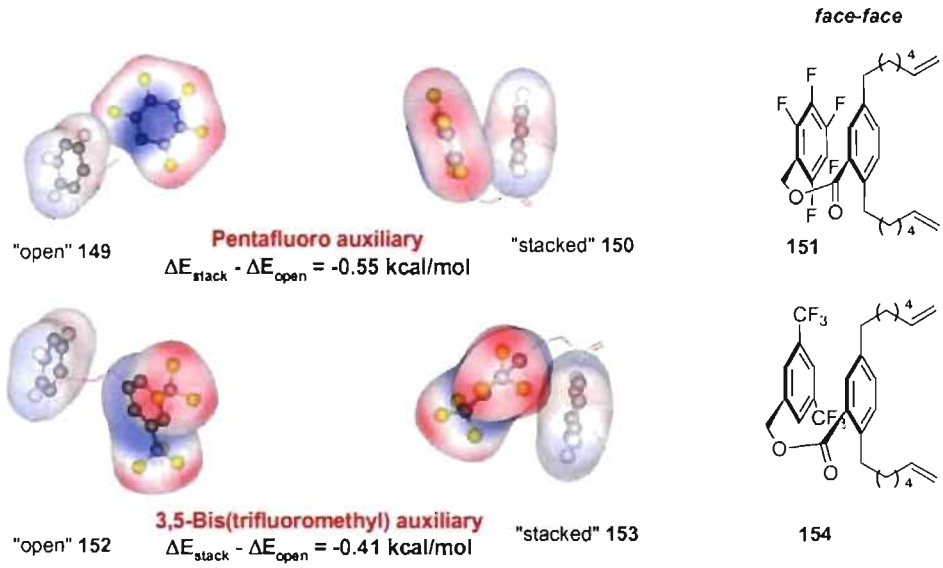


Figure 25 – Results of Higher Order DFT Calculations on All Carbon System (Red color denotes area of in

creased electron density due to the fluorine atoms).

[40] Egli, M.; Sarkhel, S. *Acc. Chem. Res.* **2007**, *40*, 197-205.

The "stacked" conformer **150** of the pentafluorobenzyl ester was preferred over the open conformer **149** by 0.55 kcal/mol. The "stacked" conformer **153** of the bistrifluoromethyl auxiliary was preferred over the open conformer **152** by only 0.41 kcal/mol. The lower energy difference calculated for the bistrifluoromethylbenzyl gearing element may be due to steric repulsion between the trifluoromethyl groups and the central arene. In the absence of oxygen atoms, the "stacked" conformers were predicted to engage in quadrupolar π:π interactions (**151/154**) (Figure 25).

The pentafluorobenzyl ester was thus predicted to be more likely to form the all carbon macrocycle. Consequently, RCM was examined on olefins **155** and **156** containing both auxiliaries to correlate the above findings with the paracyclophane product distribution (Figure 26).

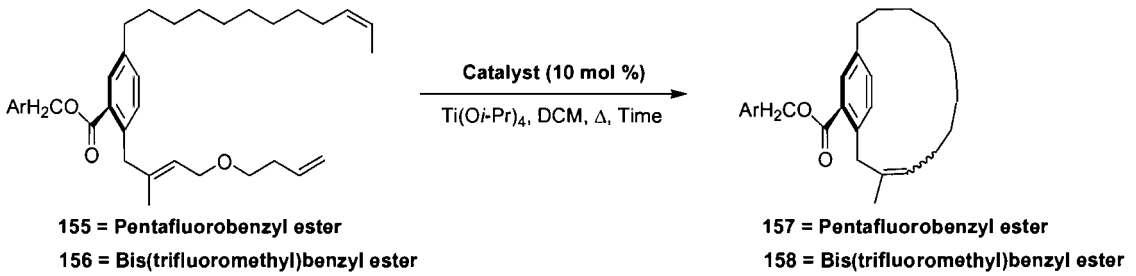


Figure 26 – Model System used in Determining the Ideal Gearing Element.

IV.4 – Determining the Ideal Gearing Element in the Formation of an All-Carbon [12]Paracyclophane.

The following retrosynthetic analysis was proposed to study the gearing element for the formation of an all carbon macrocycle (Figure 27).

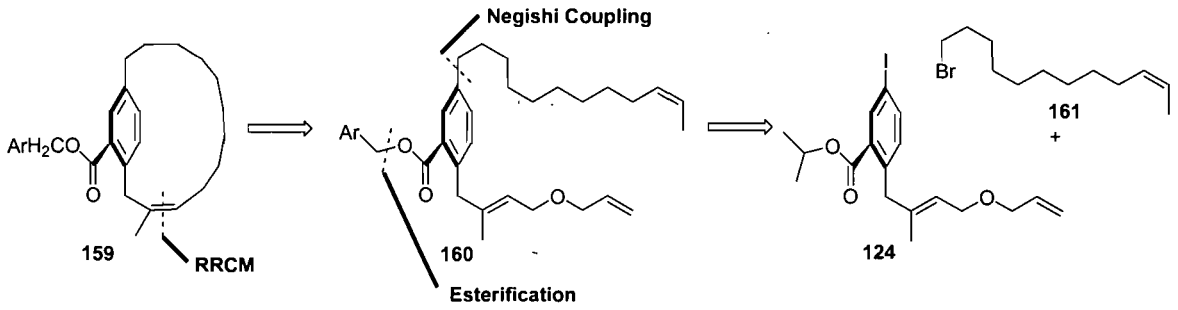
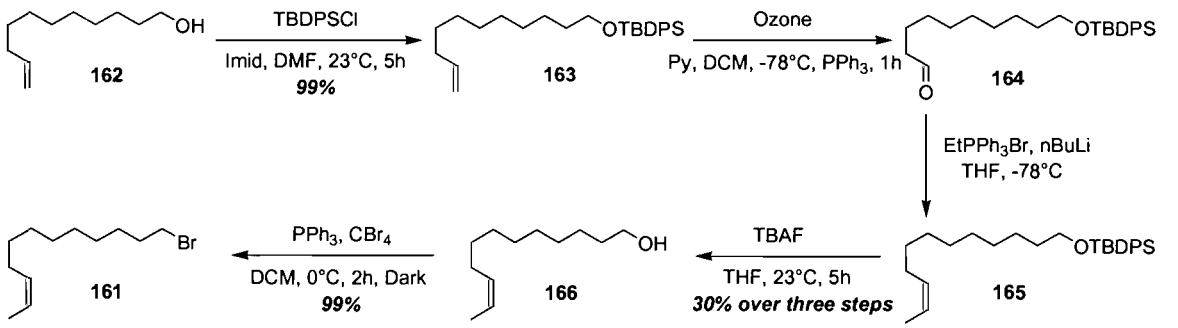


Figure 27 – Retrosynthetic Analysis for the Model System used for Determining the Ideal Gearing Element.

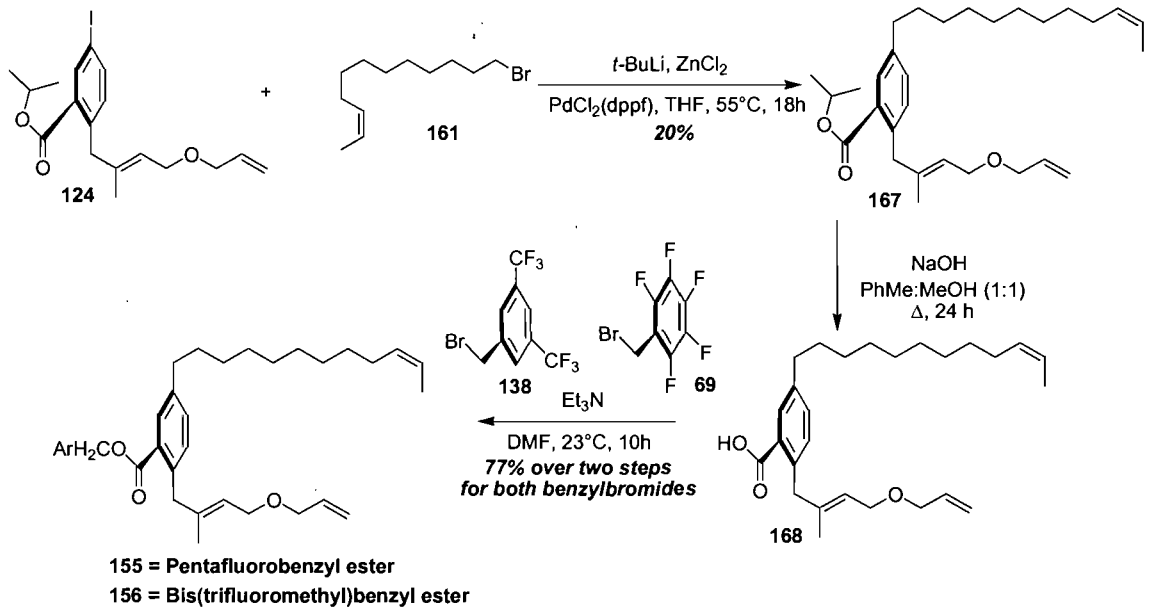
Aryl iodide **124** was made as described in chapter III. Bromide **161** was made from commercially available olefin **162** (Scheme 41).



Scheme 41 – Synthesis of Bromide 161.

Protection with TBDPSCl afforded silyl ether **163** in quantitative yield. Without further purification silyl ether **163** was cleaved by ozonolysis for 1 h at -78°C to afford aldehyde **164** that was immediately converted to olefin **165** by a Wittig reaction using ethyl triphenylphosphonium bromide and *n*-BuLi in anhydrous THF. Triphenylphosphine oxide was precipitated out using hexanes and was filtered during workup, and the silyl

ether of olefin **165** was removed with TBAF to afford alcohol **166** in 30% yield over four steps. Finally, bromide **161** was prepared from alcohol **166** in the dark using PPh_3 and CBr_4 in CH_2Cl_2 for 1.5-2 h and was used without further purification in the next synthetic step (Scheme 42).

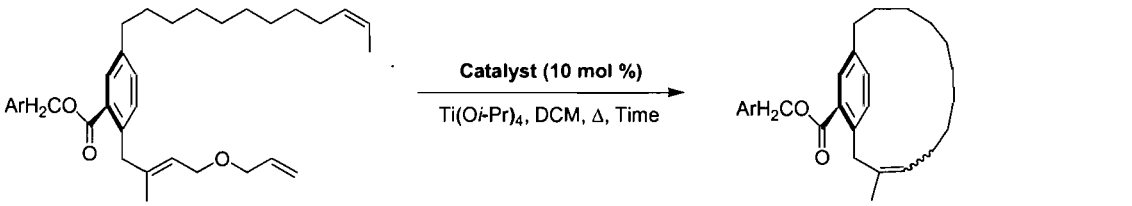


Scheme 42 – Synthesis of Pentafluorobenzyl ester 155 and Trifluoromethylbenzyl ester 156.

Triene **167** was formed by coupling the organozincate of bromide **161** to aryl iodide **124** using $PdCl_2$(dppf) in anhydrous THF, albeit in 20% yield. Pentafluorobenzyl ester **155** and trifluoromethylbenzyl ester **156** were both made in 77% yield over two steps by saponification of ester **167** with NaOH in a 1:1 mixture of toluene and methanol, and alkylation of acid **168** with the respective benzyl bromide (**69** and **138**).

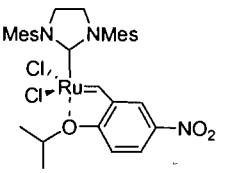
Metathesis of esters **155** and **156** were conducted in anhydrous CH_2Cl_2 using Grela catalyst **169** and the Blechert catalyst **170** in attempts to form [12]paracyclophanes **157** and **158** (Table 3).

Table 3 – RRCM of Model Compound [12]Paracyclophane 157 and 158.

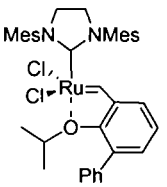


155 = Pentafluorobenzyl ester
156 = Bis(trifluoromethyl)benzyl ester

157 = Pentafluorobenzyl ester
158 = Bis(trifluoromethyl)benzyl ester



Grela 169



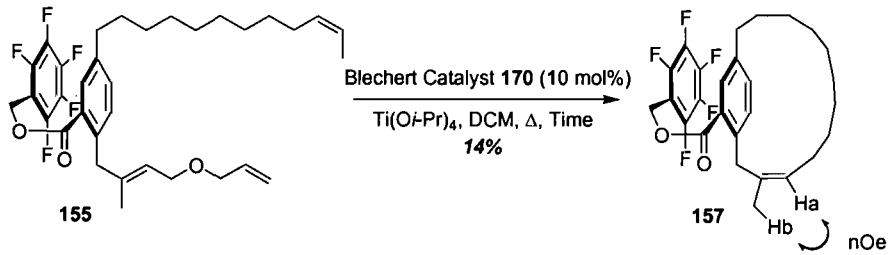
Blechert 170

Entry	Aryl-CH_2	Catalyst (10 mol %)	Solvent	Addition Time (h)	Reaction Time (h)	Yield (%)
1	3,5-bistrifluoromethylbenzyl ester	Grela 169	CH_2Cl_2	1.0	4.0	0
2	pentafluorobenzyl ester	Grela 169	CH_2Cl_2	1.0	4.0	7-10
3	pentafluorobenzyl ester	Grela 169	PhMe	1.0	4.0	7-10
4	pentafluorobenzyl ester	Blechert 170	CH_2Cl_2	1.0	4.0	14

No trace of macrocycle **158** was observed after treatment of the bistrifluoromethylbenzyl ester **156** with catalyst **169** for 4 h in CH_2Cl_2 (Entry 1, Table 3). On the other hand, pentafluorobenzyl ester **155** reacted under the same reaction conditions to furnish macrocycle **157** in 10% yield (Entry 2, Table 3). Using toluene and increased reaction temperatures did not produce any improvement in the yield of **157**

(Entry 3, Table 3). However, with the use of Blechert's catalyst **170**, macrocycle **157** was obtained in a cleaner reaction and in 14% yield (Entry 4, Table 3).

In the NOESY spectrum of macrocycle **157,** the configuration about the newly formed double bond was shown to be *cis* on observation of a nOe between the signals for the methyl (1.73 ppm) and vinyl (4.36 ppm) proton signals (Scheme 43).



Scheme 43 – NOESY of Macrocycle 157.

In light of the *cis*-geometry of trisubstituted olefin **157** the ring strain involved in forming [12]paracyclophanes was expected to lead to a *cis*-olefin in the RCM reaction to form longithorone C.

IV.5 – Conclusion.

In this chapter, other fluorinated aromatics were demonstrated to serve as gearing elements. Formation of all carbon [12]paracyclophane **157** containing a tri-substituted olefin was achieved by olefin metathesis albeit in low yield. As suggested by molecular modeling calculations using the high order DFT method, the pentafluorobenzyl ester proved superior to the bistrifluoromethylbenzyl ester for favoring a "stacked" conformer as a result of the stronger non-bonding interactions between the pentafluorobenzyl ester

and the pendant arene that may be necessary for RCM.[39] These suggestions correlated with the formation of [12]paracyclophane **157** containing one tri-substituted olefin (Table 3). Although the yields in these macrocyclizations were low, the macrocyclization to form longithorone C was expected to proceed more efficiently due to the presence of the *cis*-olefin adjacent to the aromatic core.

Chapter V:

Approach Towards the Total Synthesis of (±)-Longithorone C

The present chapter will focus on the approach towards the completion of the total synthesis of longithorone C. The following retrosynthetic analysis could be followed in order to arrive to the desired target (Figure 28).

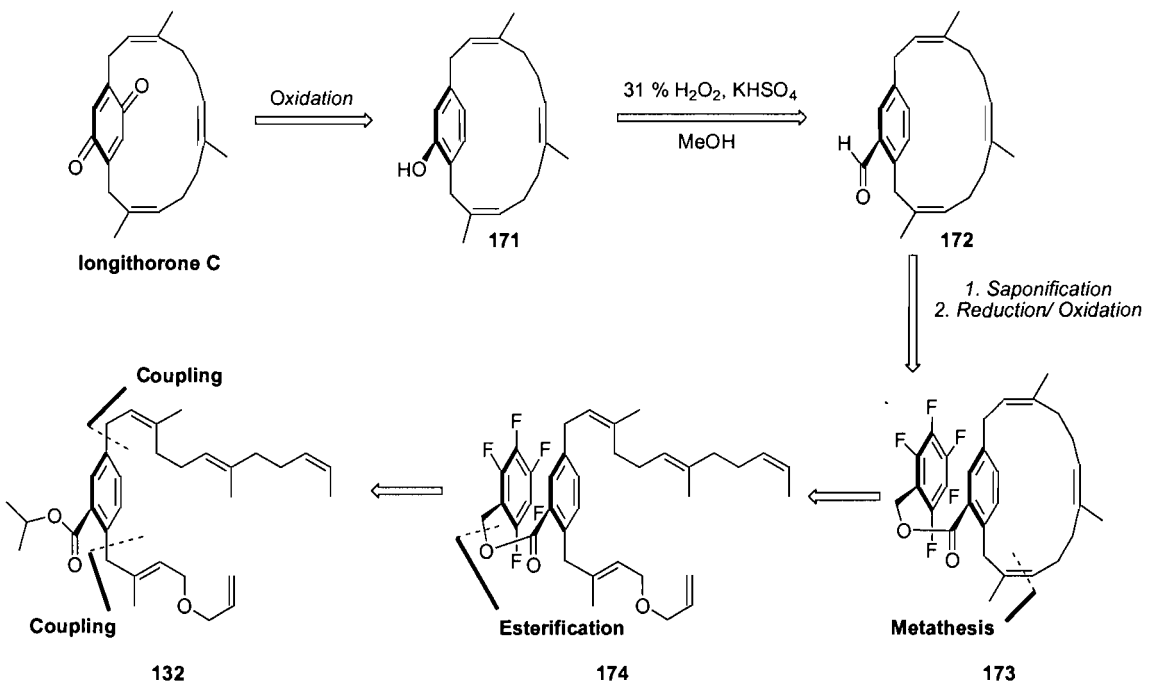
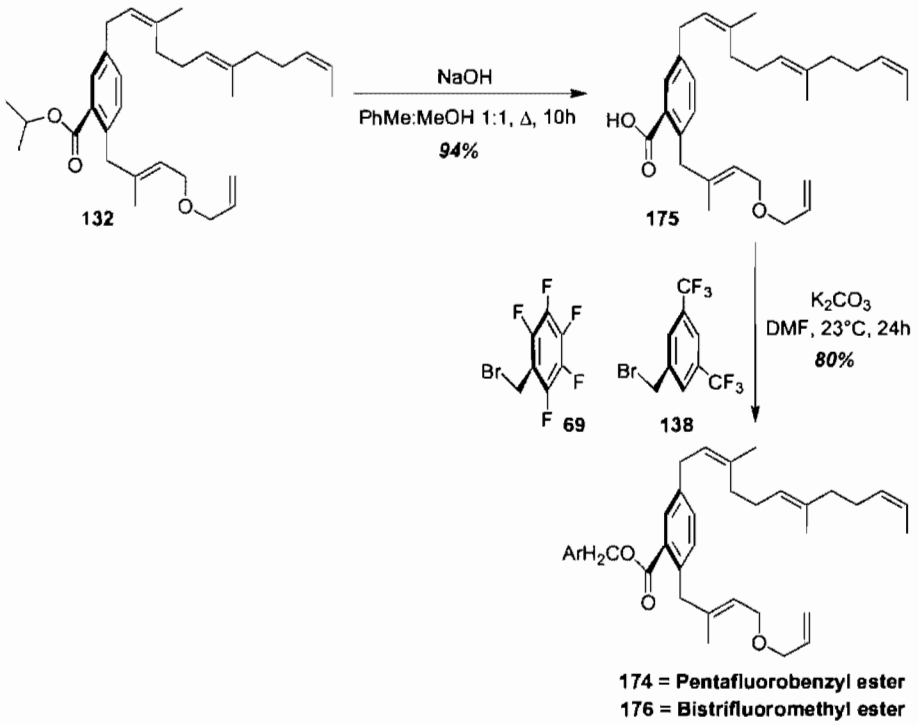


Figure 28 – Retrosynthetic Analysis for Longithorone C.

Synthesis of ester **132** was described in chapter III. Following saponification of the *iso*-propyl group of ester **132**, and esterification with the gearing element of choice, olefin **174** was expected to undergo RCM to form macrocycle **173**. The remaining synthetic steps would involve a series of oxidation/reduction reactions in order to form the quinone core of longithorone C.

V.1 – RRCM in Forming an All-Carbon [12]Paracyclophane.

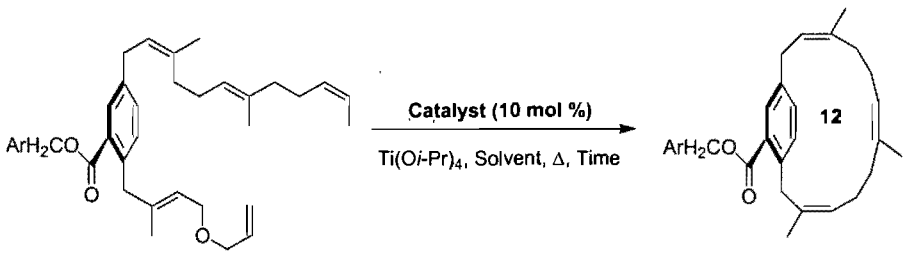
Saponification of the *iso*-propyl group of ester **132** was performed using an excess of NaOH in a 1:1 mixture of toluene:methanol at reflux. Olefin **175** was obtained in 94% yield, and without further purification, alkylated with either pentafluorobenzyl bromide **69** or bis-3,5-(trifluoromethyl)benzyl bromide **138** using K_2CO_3 as base. The bromides **69** and **138** were passed through basic alumina twice prior to their use in alkylation of olefin **175** in order to obtain 80% yield of olefins **174** and **176** respectively (Scheme 44).



Scheme 44 – Synthesis of Macrocyclization Precursors 174 and 176.

A series of catalysts were next screened in the macrocyclization step in forming macrocycles **173** and **177** (Table 4).

Table 4 – RRCM in forming Cyclophanes 173 and 177.



174 = Pentafluorobenzyl ester
176 = Bistrifluoromethylbenzyl ester

173 = Pentafluorobenzyl ester
177 = Bistrifluoromethylbenzyl ester

Entry	Substrate	Catalyst (10 mol %)	Solvent	Addition Time (h)[a]	Reaction Time (h)	Yield (%)
1	174	G II 14	CH_2Cl_2	1.0	18.0	traces[b]
2	174	G-H II 77	CH_2Cl_2	1.0	18.0	traces
3	174	Grela 169	CH_2Cl_2	3.0	4.0	23
4	174	Grela 169	PhMe	3.0	4.0	20
5	176	Grela 169	CH_2Cl_2	1.0	4.0	10
6	176	Grela 169	PhMe	3.0	4.0	32
7	176	Blechert 170	CH_2Cl_2	3.0	4.0	37

[a] All additions were conducted using a syringe pump

[b] Traces of product were observed by ^{1}H-NMR

From the macrocyclization of bistrifluoromethylbenzyl ester **176** in CH_2Cl_2 with either 10 mol% of catalyst **14** or **77,** after 18 h only traces of macrocycle **177** were observed by ^{1}H-NMR (Entries 1 and 2, Table 4). Macrocycle **177** was isolated in 23 and 20% yields for 4 h using the Grela catalyst **169** in CH_2Cl_2 and PhMe respectively (Entry 3 and 4, Table 4).

Pentafluorobenzyl ester **174** with catalyst **169** in CH_2Cl_2 afforded macrocycle **173** in 10% yield (Entry 5, Table 4). An increased yield of 32% was obtained from reaction of **174** in toluene (Entry 6, Table 4). In addition, using the Blechert catalyst **170** on pentafluorobenzyl ester **174,** afforded macrocycle **173** in 37% yield (Entry 7, Table 4). The higher reaction yields observed using pentafluorobenzyl ester **174** relative to

bistrifluoromethylbenzyl ester **176** agreed with the findings of the molecular modeling calculations that suggested superior stacking effects of the pentafluorobenzyl gearing element would be preferred (Chapter IV).

V.2 – Future Work for Completing the Total Synthesis of Longithorone C.

The best reaction conditions for RRCM was found using pentafluorobenzyl ester **69** as gearing element (olefin **174**), in anhydrous CH_2Cl_2, with 10 mol% of catalyst **170**, and 5.0 equivalents of Ti(O*i*-Pr)$_4$, affording macrocycle **173** in 37% yield (Table 4). Our group is presently working on further optimizing the auxiliaries for macrocyclization of the above all carbon system. The following synthetic steps would complete the total synthesis of longithorone C (Figure 29).

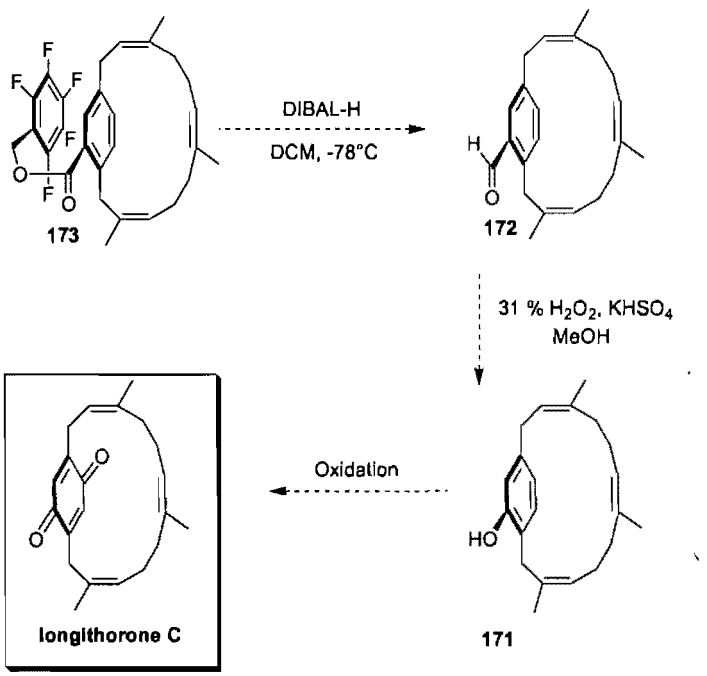


Figure 29 – Proposed Reaction Steps for the Completion of Longithorone C.

Following the formation of macrocycle **173** via RRCM, removal of the gearing element may be achieved using DIBAL-H at low temperatures. An interesting procedure developed by Backvall and co-workers may allow for the successful oxidation of aldehyde **172** to phenol **171** resembling the Baeyer-Villiger reaction. The challenge with the latter oxidation being unfavorable for substrates possessing functional groups labile to peracids, was overcome by the acid-catalyzed oxidation of benzaldehydes such as **172** with hydrogen peroxide in methanol, that proceed through peroxy hemiacetal intermediates such as **178b** (Figure 30).[41]

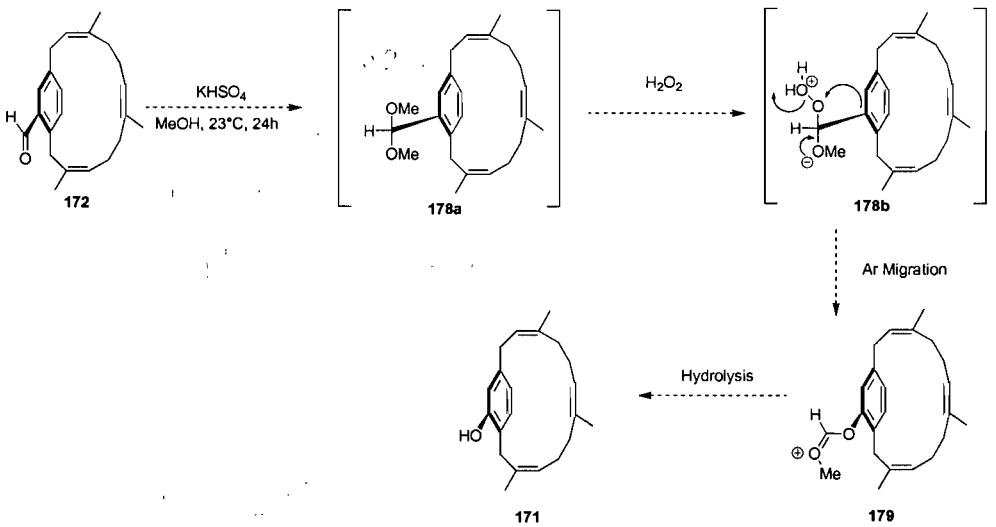


Figure 30 – Proposed Mechanism for Oxidation of Benzaldehydes to Phenols.

The formation of hemiacetals of type **178b** was made possible through dimethyl acetal intermediates of such as **178a** prepared by treating aryl aldehydes of type **172** in acidic

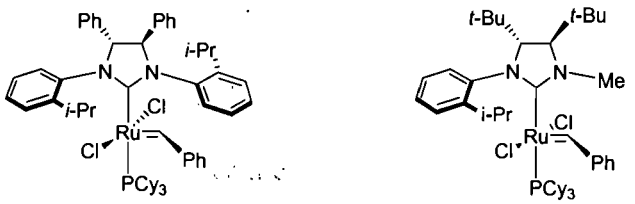
41 Matsumoto, M., Kobayashi, K., Hotta, Y. *J. Org. Chem.* **1984**, *49*, 4740-4741.

methanol. Aryl migration of intermediate **178b** would therefore provide ester **179**, and subsequent hydrolysis would afford phenol **171**. In this manner, olefinic substituents in benzaldehydes should be stable under the present reaction conditions and the oxidation products should be phenols as opposed to benzoic acids obtained via the Baeyer-Villiger reaction (Figure 30).

In order to form the quinone core of longithorone C from phenol **171**, Sorokin and co-workers developed a controlled oxidation for phenols bearing oxidizable olefinic functional groups under mild conditions using iron tetrasulfophthalocyanine supported on silica as a heterogeneous catalyst and *tert*-butylhydroperoxide as the oxidant.[42] Their group observed that aromatic oxidation was the major pathway and the proposed mechanism was based on an iron complex-based oxo species formed when iron complexes in combination with hydroperoxides involved in oxidation reactions.

Following the completion of longithorone C, the asymmetric synthesis should be attempted by employing either a chiral catalyst or a chiral auxiliary. For example Grubbs has developed a chiral catalyst such as catalyst **180** that may be used in the asymmetric synthesis of longithorone C, however bulky catalysts such as **180** have been known to show low reactivity.[43] Recently, Pierre-André Fournier within our group had developed a reactive and less bulky catalyst, **PAF-1 181**, in order to have an increased level of reactivity compared to existing chiral Ru-based catalysts (Figure 31).[43]

[42] Sorokin, A.B.; Zalomaeva, O.V. *New J. Chem.* **2006**, *30*, 1768-1773.
[43] Seiders, T. J.; Ward, D. W.; Grubbs, R. H. *Org. Lett*, **2001**, *3*, 3225-3228.

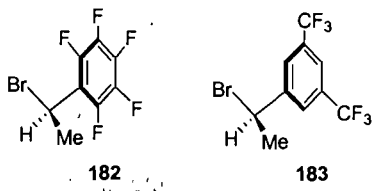


Grubbs 180 **PAF-1 181**

Figure 31 – Proposed Chiral Catalysts for the Asymmetric Synthesis of Longithorone C.[43]

The results found while cyclizing the precursor **174** suggest that more reactive catalysts are necessary in order to obtain high reaction yields. As such, catalyst **PAF-1 181** would seem to be a promising choice (Figure 31).

Yet another method for performing the asymmetric synthesis would be to use chiral gearing elements prepared from bromides such **182** and **183** (Figure 32).



182 **183**

Figure 32 – Proposed Chiral Auxiliaries for the Asymmetric Synthesis of Longithorone C.

Esterification with these auxiliaries may lead to chiral gearing elements, which in turn may lead to the asymmetric synthesis of longithorone C.

V.3 – Conclusion

Inspired by the independent work performed by Tadahiro and co-workers in forming Longithorone B, and Shair and co-workers in forming Longithorone A, our group had focused on optimizing macrocyclization reactions forming the [12]paracyclophane longithorone C. Model studies revealed that ring-closing olefin metathesis can be used in forming [12] and [14]paracyclophanes with macrocycles resembling that of longithorone C. The formation of various macrocyclic cyclophanes via ring-closing olefin metathesis was possible through the use of a pendant fluorinated benzyl ester group. Bis(trifluoromethyl)benzyl ester proved best for model system **139** incorporating the oxygen atoms about the central aromatic core. Pentafluorobenzyl ester was more effective in making the all carbon paracyclophane **157**. Model studies revealed that the use of relay side chain **126** was necessary in order to form highly substituted double bonds by a novel technique called relay ring-closing metathesis. In addition, our group was able to stereoselectively form the [12]paracyclophane **173** using copper catalyzed Grignard reactions optimized in our labs. The advanced precursor **173** has been prepared and may be converted to longithorone C by a sequence of reactions featuring an ester reduction and aromatic ring oxidation.

Chapter VI:

Experimental

VI.1 - General Experimental Notes

Reagents

All reagents were purchased from Aldrich, Sigma, or Alfa Aeser and were used without further purification, unless otherwise noted.

Anhydrous Reaction Conditions

All anhydrous reactions were performed under an atmosphere of dry nitrogen. The glass vessels, needles, stirring bars, and reflux condensers were either oven dried at 110-140°C, or flame dried, and cooled to room temperature under a flow of nitrogen. Solvents such as tetrahydrofuran, dichloromethane, diethyl ether, toluene, hexane, methanol, and dimethylformamide were obtained by filtration through the Seca Solvent System by GlassContour, which filters the solvents over a column of alumina under an atmosphere of argon. Acetonitrile and benzene were purchased from Aldrich and were dried using molecular sieves (4-8 mesh, 0.125 inch, type 4 Å).

Temperature Control

The temperatures indicated in the reaction schemes and in the procedures are all external temperatures. The following bath temperatures were obtained from the following mixtures:

-78°C	dry ice-acetone bath
-40°C	dry ice-acetonitrile bath
0°C	ice water bath
23°C	ambient temperature

Chromatography

Silica gel flash chromatography was carried out according to the procedure of Still,[44] using silica gel obtained from Silicycle Chemical Division (40-63 nm; 230-240 mesh). Thin layer chromatography (TLC) was performed using commercially available, precoated glass backed Silica Gel 60 F254 plates with a thickness of 25 μm. Visualization of the UV active compounds on the TLC plates was done with the aid of a UV254 lamp. The TLC plates were stained with either of the following stains:

- Cerium molybdate stain:[45] Prepared by dissolving 12 g ammonium molybdate, and 0.5 g ceric ammonium molybdate in 235 mL H_2O and 15 mL concentrated sulfuric acid.

[44] Still, W. C.; Kahn, M.; Mitra, A. *J. Org. Chem.* **1978**, *43*, 2923-2925.
[45] El Khadem, H.; Hanessian, S. *Anal. Chem.* **1958**, *30*, 1965-1965.

- Potassium permanganate stain: Prepared by dissolving 1.5 g potassium permanganate, 10 g potassium carbonate and 1.25 mL 10% NaOH in 200 mL H_2O.

Instrumentation

Nuclear Magnetic Resonance Spectroscopy:

Routine nuclear magnetic resonance spectra were recorded on Bruker AMX 300 (^{1}H 300 MHz, ^{13}C 75 MHz), Bruker AV 300 (^{1}H 300 MHz, ^{13}C 75 MHz), Bruker ARX 400 (^{1}H 400 MHz, ^{13}C 100 MHz), and Bruker AV 400 (^{1}H 400 MHz, ^{13}C 100 MHz) instruments. Chemical shifts (δ) and coupling constants (J) are expressed in parts per million (ppm) and hertz (Hz) respectively. Abbreviations used describing the splitting of the peaks are as follows:

s	singlet
d	doublet
t	triplet
q	quartet
dd	doublet of doublets
ddt	doublet of doublet of triplets
m	multiplet
sept	septet

Please note that all ^{13}C signals for carbons bearing fluorine substituents are often observed as very weak signals. These signals are often unobservable or barely distinguishable from the baseline. As such, the signals are not reported.

Gas Chromatography:

GC-MS data were measured using an Agilent Capillary Column model number 19091s-433 HP-5MS, 30.0 m length, 250.0 μm diameter, and 0.25 μm thickness. Front inlet Splitless, with an initial temperature of 250°C. The run time was 0 – 27.5 min. The oven temperature was 50°C – 275°C, with an instrumental rate of 10°C/min. The flow rate was established at 1.0 mL/min, using helium gas and the Front detector μECD was set at 250°C.

Mass spectra:

High resolution mass spectroscopy (HRMS) was done by the Centre régional de spectrométrie de masse at the Department of Chemistry, Université de Montréal using an LC-MSD-TOF instrument from Agilent Technologies in positive electrospray mode. Either protonated molecular ions $(M + H)^+$ or sodium adducts $(M + Na)^+$ were used for empirical formula confirmation. Iodide **152** proved to be too unstable for HRMS by FAB, API, EI, and CI. As such, iodide **152** did not ionize and consequently did not provide any valid mass spectral data.

VI.2 – Experimental Procedures and data

Preparation and Titration of *i*-PrMgBr

The preparation of *i*-PrMgBr has been described by Steglich and co-workers.[46] The titration of *i*-PrMgBr has been described by Paquette and co-workers.[47]

Titration of *n*-BuLi, *s*-BuLi, and *t*-BuLi

The titration of organolithium reagents has been described by Baclawski and co-workers.[48]

Preparation of dilithium tetrachlorocuprate

LiCl and $CuCl_2$ were independently dried for 10 h at 100°C under reduced pressure. Both reagents were transferred to a glove box under a nitrogen atmosphere. To a round bottom flask containing $CuCl_2$ (0.67 g, 5 mmol) and LiCl (0.42 g, 10 mmol) anhydrous THF (10 mL) was added. The solution was allowed to stir at room temperature for 10 min affording a homogeneous dark-red colored solution. The concentration of Li_2CuCl_4 prepared in this manner was 0.5 M and was used immediately. This solution was never stored for more than a couple of hours.[46]

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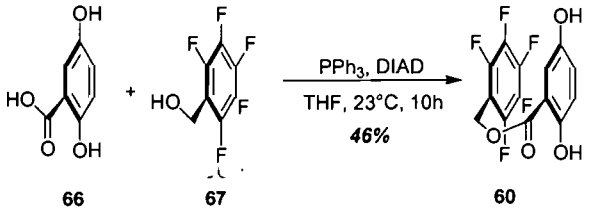
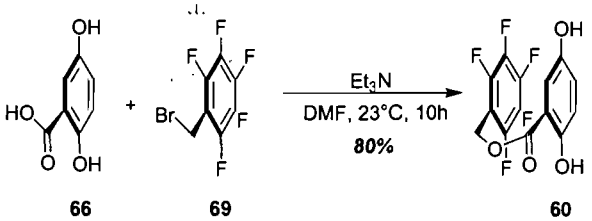
[46] Steglich, W. *Synthesis* **2005**, *6*, 1019-1027.
[47] Lin, H. S.; Paquette, L. *Synth. Commun.* **1994**, *24*, 2503-2506.
[48] Kofron, W. G.; Baclawski, L. M. *J. Org. Chem.* **1976**, *41*, 1879-1880.

Pentafluorobenzyl-2,5-dihydroxybenzoate (60)



In a round bottom flask, benzoic acid **66** (1.54 g, 9.99 mmol), PPh_3 (4.20 g, 16.0 mmol), and alcohol **67** (0.99 mg, 5.00 mmol) were dissolved in anhydrous THF (100 mL), cooled to 0°C, and treated over a 2 min period with DIAD (3.10 mL, 16.0 mmol). The reaction was allowed to stir at room temperature for 10 h, and was monitored by TLC (diphenol **60**: R_f = 0.2, 100% ethyl acetate, product appeared purple under UV irradiation). Additional PPh_3 (2.10 g, 8.00 mmol) was added to the mixture until the yellow color of DIAD had disappeared. The volatiles were evaporated to a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes). Evaporation of the collected fractions gave ester **60** as a white solid (1.52 g, 46%). Spectral data for **60** matched that reported in the literature.[49]

Pentafluorobenzyl 2,5-dihydroxybenzoate (60)

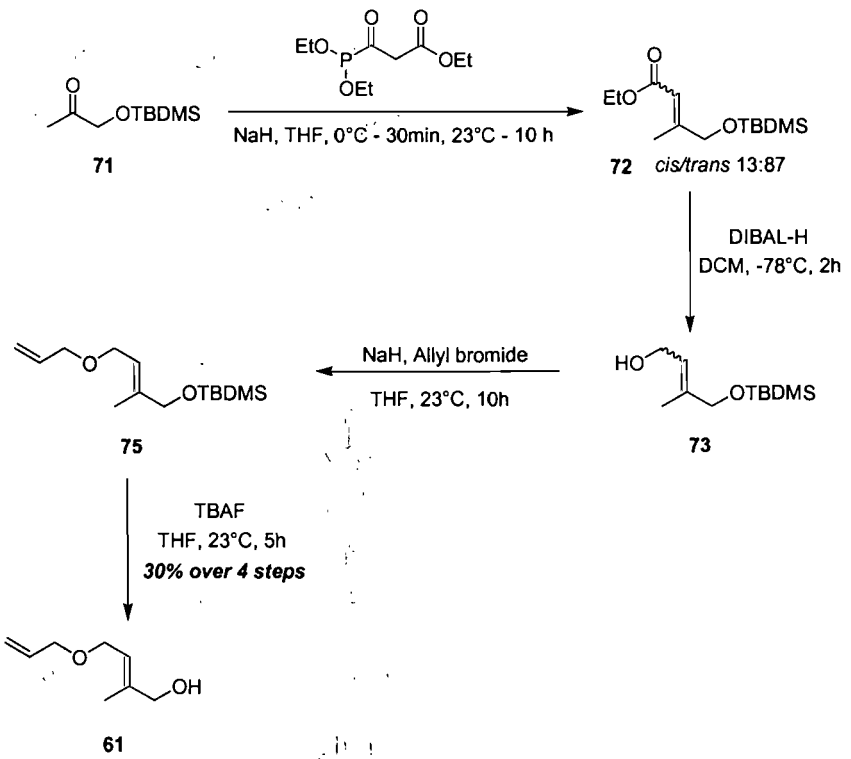


In a round bottom flask, benzoic acid **66** (0.20 g, 1.30 mmol) and bromide **69** (0.18 mL, 1.30 mmol, previously passed through a short plug of basic alumina) were dissolved in

[49] Collins, S. K.; El-Azizi, Y. *Pure Appl. Chem.* **2006**, *78*, 783-789.

anhydrous DMF (13 mL), cooled to 0°C, treated dropwise with Et_3N (0.20 mL, 1.42 mmol) and stirred at 0°C for 10 min. The solution was allowed to warm to room temperature and stirred for 10 h. The reaction was monitored by TLC (100% ethyl acetate). The reaction was cooled to 0°C and quenched with 1N HCl (7.1 mL, 7.13 mmol). The mixture was extracted with Et_2O (3 x 15 mL). The combined organic extracts were washed with brine (1 x 45 mL), and dried over Na_2SO_4. The volatiles were evaporated to a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes). Collection of the fractions gave ester **60** as a white solid (0.35 g, 80%). Spectral data for **60** matched that reported in the literature.[49]

(*E*)-4-(Allyloxy)-2-methylbut-2-en-1-ol (61)

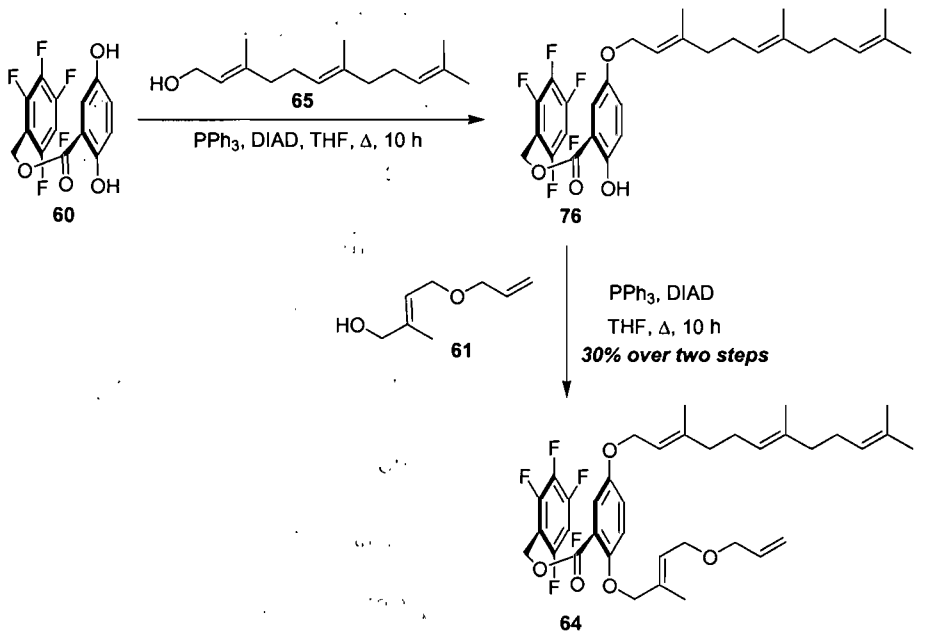


In a round bottom flask, under nitrogen, NaH (15.2 g, 0.38 mol) was washed with anhydrous hexane (3 x 100 mL), taken up in anhydrous THF (500 mL), cooled to 0°C, and treated dropwise with *tris*(triethyl)phosphonoacetate (70.0 mL, 0.35 mol) monitoring closely the release of hydrogen gas. The solution was allowed to stir at 0°C for 1 h. The solution gradually changed appearance, becoming transparent. Silyl ether **71** (55.0 g, 0.29 mol) was added dropwise at 0°C to the reaction mixture, that was stirred for 0.5 h and allowed to warm to room temperature, with stirring for 10 h. The reaction was monitored by TLC (16% ethyl acetate/hexanes). The solution was quenched with water (100 mL) at 0°C. The mixture was extracted with Et_2O (3 x 100 mL). The combined organic extracts were washed with brine (1 x 100 mL), and dried over Na_2SO_4. The volatiles were evaporated to a residue as *cis*:*trans* isomers (13:87, determined by LCMS: Gimini C-18, 5 μ, 50 x 4.6 mm Column, 0.5 mL/min, 70% ACN/H_2O). The pale yellow oil was immediately carried over to the next reaction. Spectral data for **72** matched that reported in the literature.[50] In a round bottom flask, a solution of ester **72** (75.0 g, 0.29 mol) in anhydrous CH_2Cl_2 (500 mL) was cooled to -78°C, treated dropwise over 2 h with DIBAL-H (697 mL, 0.69 mol), stirred at -78°C for 2 h, and monitored by TLC (13% ethyl acetate/hexanes). The reaction was quenched at -78°C with a saturated solution of Rochelle's salt, and stirred at room temperature until a successful partition between the two phases had been achieved. At times, the separation was achieved by adding more Rochelle's salt. The mixture was extracted with Et_2O (3 x 100 mL). The combined organic extracts were washed with brine (1 x 100 mL), and dried over Na_2SO_4, and evaporated to give crude **73** as a pale-yellow oil used without further purification.

[50] Baldwin, I. R.; Whitby, R. J. *Chem. Comm.* **2003**, *22*, 2786-2787.

Spectral data for **73** matched that reported in the literature.[50] In a round bottom under nitrogen, NaH (15.2 g, 0.38 mol) was washed with anhydrous hexane (3 x 100 mL), suspended in anhydrous DMF (500 mL), cooled to 0°C, and treated dropwise with alcohol **73** (63.0 g, 0.29 mol) monitoring closely the release of hydrogen gas. After stirring for 1 h at 0°C, the mixture was treated dropwise with allyl bromide (27.0 mL, 0.32 mol, previously passed through a short plug of basic alumina), stirred for 0.5 h, warmed to room temperature, stirred for 10 h, monitored by TLC (10% ethyl acetate/hexanes), cooled to 0°C, and quenched with water (100 mL). The mixture was extracted with Et_2O (3 x 100 mL), dried over Na_2SO_4, and evaporated to give crude **75** as a pale-yellow oil, that was used without further purification. In a round bottom flask, silyl ether **75** (36.7 g, 0.14 mol) was dissolved in anhydrous THF (500 mL), cooled to 0°C, treated dropwise with TBAF (430 mL, 0.43 mol), and allowed to warm to room temperature. The reaction was monitored by TLC (20% ethyl acetate/hexanes). After stirring for 12 h, the reaction was quenched with $NaHCO_3$ (500 mL), and extracted with Et_2O (3 x 250 mL). The combined organic extracts were washed with brine (1 x 250 mL), dried over Na_2SO_4, and evaporated to give a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes) to afford alcohol **61** as a pale-yellow oil (8.10 g, 30% over four steps). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.83 (ddt, J = 17.1, 10.5, 5.7 Hz, 1H), 5.51 (t, J = 6.7 Hz, 1H), 5.19 (dd, J = 17.1, 3.3 Hz, 1H), 5.10 (dd, J = 10.5, 3.3 Hz 1H), 3.95 (d, J = 6.7 Hz, 2H), 3.89 (m, 4H), 3.29 (s, 1H), 1.59 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 139.2, 134.4, 120.5, 116.9, 70.9, 67.2, 65.9, 13.5; HRMS (ESI) calculated for $C_8H_{15}O_2$ $[M + H]^+$, 143.1067, found 143.1064.

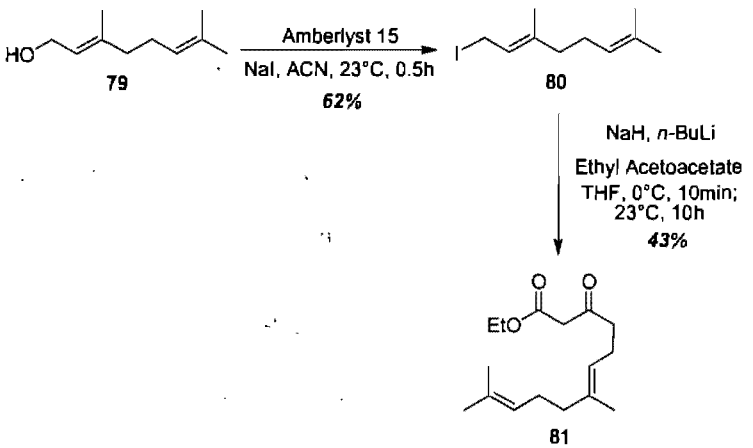
Pentafluorobenzyl 5-((2*E*,6*E*)-3,7,11-trimethyldodeca-2,6,10-trienoxy)-2-((*E*)-4-(allyloxy)-2-methylbut-2-enoxy)benzoate (64)



In a round bottom flask, ester **60** (0.17 g, 0.51 mmol), alcohol **65** (0.06 g, 0.25 mmol), and PPh_3 (0.11 g, 0.41 mmol) were dissolved in anhydrous THF (50 mL), heated to a reflux using an oil bath, treated dropwise with DIAD (0.08 mL, 0.41 mmol) such that the yellow color disappeared before the next drop, and stirred for 4 h. The reaction was monitored by TLC (13% ethyl acetate/hexanes). The solution was allowed to cool to room temperature, treated with PPh_3 (0.05 g, 0.21 mmol) until the yellow color disappeared, and evaporated to give a residue that was further purified by silica gel flash chromatography (5% ethyl acetate/hexanes). Evaporation of the collected fractions gave phenol **76** as a pale-yellow oil (0.08 g, 55%), contaminated with traces of dialkylated byproduct as indicated by both ^{1}H-NMR and ^{13}C-NMR spectroscopy. Without any

further purification, phenol **76** was treated with alcohol **61** (0.03 g, 0.23 mmol), and PPh_3 (0.10 g, 0.36 mmol), dissolved in anhydrous THF (50 mL), heated to a reflux using an oil bath and treated dropwise with DIAD (0.07 mL, 0.36 mmol) such that the yellow color disappeared before the next drop. The solution was stirred for 4 h, and monitored by TLC (13% ethyl acetate/hexanes). The reaction was allowed to cool to room temperature, treated with PPh_3 (0.05 g, 0.18 mmol) until the yellow color disappeared, and evaporated to a residue that was purified by silica gel flash chromatography (5% ethyl acetate/hexanes). Ether **64** was obtained as a pale-yellow oil (0.05 g, 30% over two steps). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.33 (d, J = 3.1 Hz, 1H), 7.01 (dd, J = 9.1, 3.1 Hz, 1H), 6.87 (d, J = 9.1 Hz, 1H), 5.92 (ddt, J = 17.1, 10.4, 5.7 Hz, 1H), 5.73 (t, J = 6.5 Hz, 1H), 5.45 (t, J = 6.6 Hz, 1H), 5.40 (s, 2H), 5.27 (dd, J = 17.1, 3.1 Hz, 1H), 5.19 (dd, J = 10.4, 3.1 Hz, 1H), 5.09 (d, J = 5.3 Hz, 2H), 4.49 (d, J = 6.6 Hz, 2H), 4.42 (s, 2H), 4.05 (d, J = 6.5 Hz, 2H), 3.97 (dt, J = 5.7, 1.2 Hz, 2H), 2.05-1.92 (m, 8H), 1.72 (s, 6H), 1.67 (s, 3H), 1.59 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.2, 152.7, 152.3, 141.6, 135.4, 134.8, 134.7, 131.3, 124.5, 124.3, 123.6 (2C), 120.8, 119.7, 119.2, 117.1 (2C), 115.4, 74.6, 71.2, 66.0, 65.5, 53.6, 39.7, 39.5, 26.7, 26.2, 25.7, 17.6, 16.6, 16.0, 13.8; HRMS (ESI) calculated for $C_{37}H_{43}F_5O_5Na$ $[M+Na]^+$, 685.2924, found 685.2926.

(*E*)-Ethyl 7,11-dimethyl-3-oxododeca-6,10-dienoate (81)

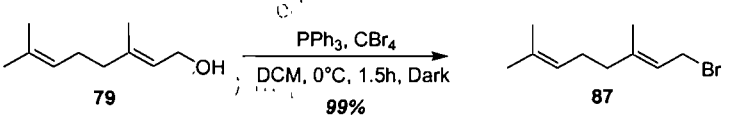


In a round bottom flask, geraniol **79** (5.00 mL, 28.8 mmol), NaI (4.30 g, 28.8 mmol) and anhydrous ACN (200 mL) were added. In the dark, the reaction was cooled to 0°C, treated with Amberlyst 15 (29.0 g) in portions over 15 min, and monitored every 5 min by TLC (25% ethyl acetate/hexanes). Once no more geraniol was observed by TLC, the solution was filtered to remove the resin, and evaporated in the dark at room temperature to yield crude **80** (4.71 g, 62%), which was used without further purification. To avoid using excess resin, the reaction must be closely monitored following each addition of Amberlyst 15, and filtered immediately after all the geraniol had been consumed. Spectral data for **80** matched that reported in the literature.[51] In a round bottom flask under nitrogen, NaH (0.08 g, 1.92 mmol) was washed with anhydrous hexane (3 x 10 mL), suspended in anhydrous THF (10 mL), cooled to 0°C, treated dropwise with ethylacetoacetate (0.20 mL, 1.54 mmol) monitoring closely the release of hydrogen gas. The reaction was stirred for 10 min. *n*-BuLi (0.81 mL, 1.92 mmol) was added, and the

[51] (a) Tajbakhsh, M.; Hosseinzadeh, R.; Lasemi, Z.; Rostami, A. *Synth. Commun.* **2005,** *35*, 2905-2911. (b) Tajbakhsh, M.; Hosseinzadeh, R.; Lasemi, Z. *Synlett* **2004**, *4*, 635-638.

solution was allowed to warm to room temperature. After stirring for 1 h, geranyl iodide **80** (0.20 g, 0.77 mmol) was added to the reaction mixture, which was stirred for 1 h, and monitored by TLC (5% ethyl acetate/hexanes). The solution was cooled to 0°C, quenched with 10% AcOH (10 mL), and extracted with Et_2O (3 x 25 mL). The combined organic extracts were washed with brine (1 x 10 mL), dried over Na_2SO_4, and evaporated to give a residue that was purified by silica gel flash chromatography (5% ethyl acetate/hexanes). Ester **81** was obtained as a pale-yellow oil (0.09 g, 43%) and exhibited spectral data as reported in the literature.[52]

Geranyl bromide (87)



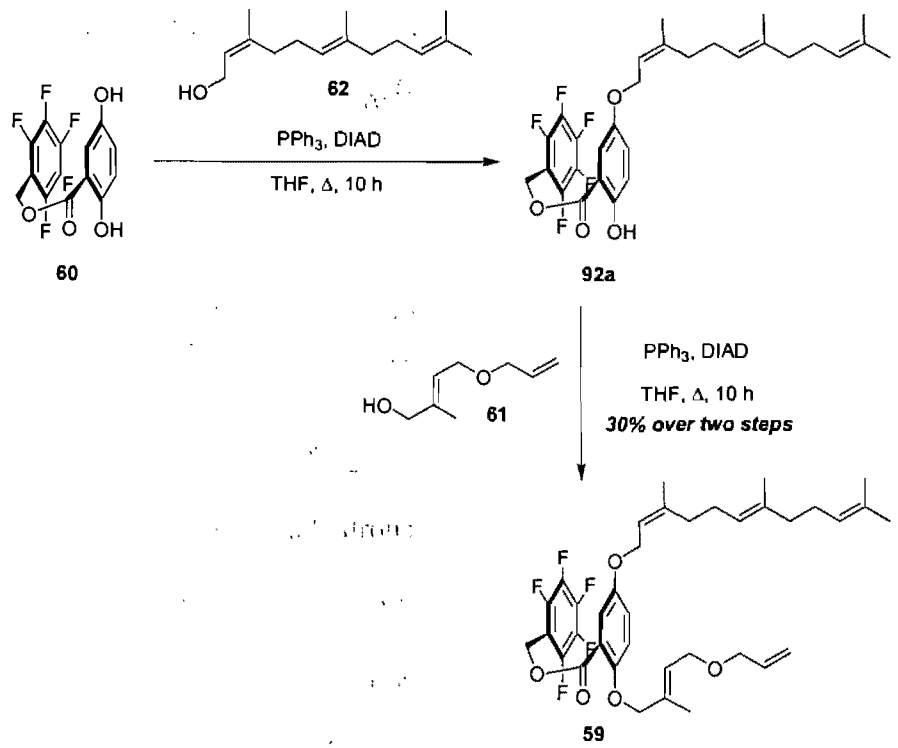
79 87

In a round bottom flask in the dark, geraniol **79** (3.00 mL, 17.1 mmol) and PPh_3 (6.73 g, 25.6 mmol) were treated with anhydrous CH_2Cl_2 (170 mL), cooled to 0°C, and treated with CBr_4 (8.5 g, 25.6 mmol) over 0.25 h, stirred for 1.5 h, and monitored by TLC (13% ethyl acetate/hexanes). The solution was treated with cold hexanes (100 mL), and transferred to a separatory funnel. The bottom layer, a pale orange oil, was removed and discarded. The top layer, a milky white solution, was evaporated to a white residue that was treated with cold hexanes (50 mL) and filtered using high vacuum filtration. The filtrate was evaporated to a pale-yellow oil that was treated with cold hexanes (50 mL) and filtered through a short plug of silica gel under high vacuum. The plug was washed three times with cold hexanes (3 x 50 mL) and the filtrate was evaporated to a pale-

[52] Xie, H.; Shao, Y.; Becker, J. M..; Naider, F.; Gibbs, R. A. *J. Org. Chem.* **2000**, *65*, 8552-8563.

yellow oil (3.70 g, 99%) that was used immediately in the next reaction step. Spectral data for bromide **87** matched that reported in the literature.[53] The product was stored in the freezer (-20°C) for several days.

Pentafluorobenzyl 5-((2*Z*,6*E*)-3,7,11-trimethyldodeca-2,6,10-trienoxy)-2-((*E*)-4-(allyloxy)-2-methylbut-2-enoxy)benzoate (59)

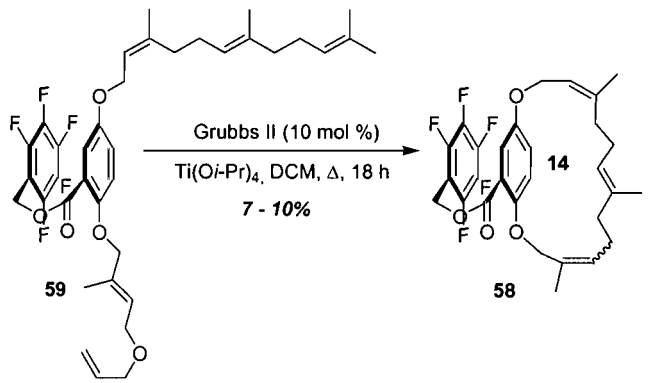


Follow experimental for pentafluorobenzyl 5-((2*E*,6*E*)-3,7,11-trimethyldodeca-2,6,10-trienoxy)-2-((*E*)-4-(allyloxy)-2-methylbut-2-enoxy)benzoate (**64**). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 3.1 Hz, 1H), 7.01 (dd, *J* = 9.1, 3.1 Hz, 1H), 6.87 (d, *J* = 9.1 Hz, 1H), 5.92 (ddt, *J* = 17.1, 10.4, 5.7 Hz, 1H), 5.73 (t, *J* = 6.5 Hz, 1H), 5.47 (t, *J* = 6.6 Hz, 1H), 5.40 (s, 2H), 5.27 (dd, *J* = 17.1, 3.1 Hz, 1H), 5.19 (dd, *J* = 10.4, 3.1 Hz, 1H), 5.11-

[53] Durst, H. D.; Liebeskind, L. *J. Org. Chem.* **1974**, *39*, 3271-3.

5.05 (m, 2H), 4.49 (d, J = 6.6 Hz, 2H), 4.42 (s, 2H), 4.05 (d, J = 6.5 Hz, 2H), 3.97 (dt, J = 5.7, 1.2 Hz, 2H), 2.12-2.03 (m, 6H), 1.99-1.95 (m, 2H), 1.79 (s, 3H), 1.72 (s, 3H), 1.67 (s, 3H), 1.59 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.2, 152.6, 152.2, 141.9, 135.7, 134.7, 134.6, 131.2, 124.3, 124.1, 124.1, 123.2, 120.6, 119.8, 119.6, 117.1, 117.1, 115.2, 74.4, 71.1, 65.9, 64.0, 53.5, 39.5, 32.2, 26.5, 26.0, 24.4, 17.5, 16.5, 15.8, 13.7; HRMS (ESI) calculated for $C_{37}H_{44}F_5O_5$ $[M + H]^+$, 663.3103, found 663.3101.

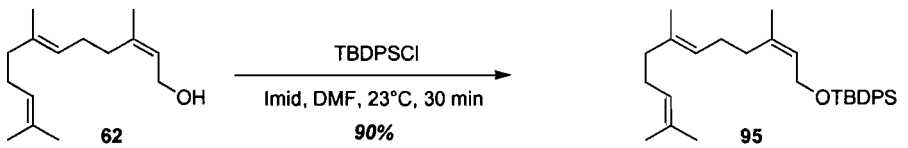
Cyclophane (58)



To a flame dried three neck round bottom flask equipped with a reflux condenser under nitrogen, 2nd Generation Grubbs Catalyst (0.002 g, 0.003 mmol) and anhydrous CH_2Cl_2 (100 mL) were added. The solution was heated to a reflux and treated dropwise with a solution of ester **59** (0.03 g, 0.05 mmol) and Ti(O*i*-Pr)$_4$ (0.07 mL, 0.25 mmol), dissolved in CH_2Cl_2 (30 mL) over 1 h using a syringe pump. The reaction was allowed to stir at reflux for 10 h and was monitored by TLC (10% ethyl acetate/hexanes). The reaction was quenched with ethyl vinyl ether (5 mL), evaporated down to about 1 mL, and purified by silica gel flash chromatography (5% ethyl acetate/hexanes). Macrocycle **58** was obtained as a pale-yellow oil (0.002 g, 7%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.26 (d,

J = 3.1 Hz, 1H), 7.12 (dd, J = 9.1, 3.1 Hz, 1H), 6.83 (d, J = 9.1 Hz, 1H), 5.38 (s, 2H), 5.41-5.37 (m, 2H), 5.23 (t, J = 7.6 Hz, 1H), 4.54-4.50 (m, 4H), 2.10-2.05 (m, 2H), 1.98-1.93 (m, 2H), 1.81-1.77 (m, 2H), 1.67 (s, 3H), 1.52 (s, 3H), 1.46 (s, 3H), 1.38-1.32 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.0, 152.9, 151.6, 144.5, 132.2, 130.6, 130.6, 128.3, 126.0, 123.9, 123.2, 119.8, 119.4, 116.0, 74.1, 68.0, 53.6, 38.9, 31.7, 27.0, 25.0, 23.6, 15.3, 13.2; HRMS (ESI) calculated for $C_{29}H_{30}F_5O_4$ $[M + H]^+$, 537.2059, found 537.2047.

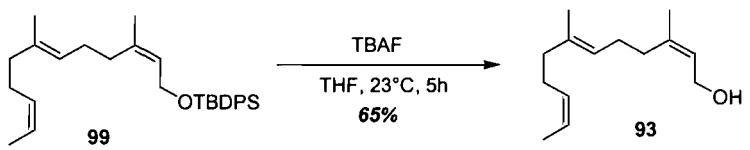
(2*Z*,6*E*)-1-*t*-Butyldiphenylsilyloxy-3,7,11-trimethyl-2,6,10-dodecatriene (95)



In a round bottom flask, alcohol **62** (1.23 g, 5.53 mmol), imidazole (0.56 g, 8.30 mmol), and TBDPSCl (1.70 mL, 6.64 mmol), were dissolved in anhydrous DMF (10 mL), and stirred at room temperature for 0.5 h. The reaction was monitored by TLC (13% ethyl acetate/hexanes). The reaction was partitioned between hexanes and water (83:17). The mixture was extracted with Et_2O (3 x 50 mL). The combined organic extracts were washed with saturated $NaHCO_3$ (1 x 10 mL) and brine (1 x 10 mL), dried over Na_2SO_4, and evaporated to a residue that was further purified by silica gel flash chromatography (100% hexanes, 1 column volume (cv), 2% ethyl acetate/hexanes, 1 cv, 5% ethyl acetate/hexanes). Ether **95** was obtained as a pale-yellow oil (2.24 g, 90%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68-7.66 (m, 4H), 7.38-7.37 (m, 6H), 5.39 (t, J = 6.2 Hz, 1H), 5.05 (t, J = 7.0 Hz, 1H), 4.99 (t, J = 5.8 Hz, 1H), 4.19 (d, J = 6.2 Hz 2H), 1.95-1.85 (m, 8H),

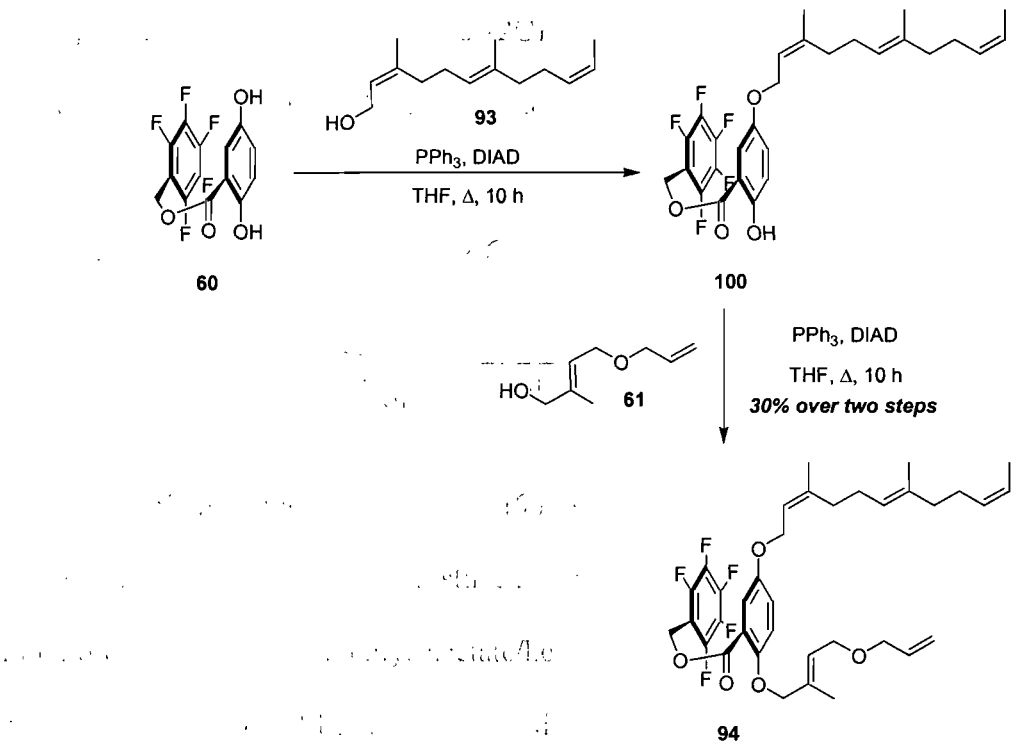
1.70 (s, 3H), 1.66 (s, 3H), 1.57 (s, 3H), 1.50 (s, 3H), 1.04 (s, 9H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 137.5, 135.6 (4C), 135.4, 134.8, 134.0, 131.3 (2C), 129.5, 128.3 (4C), 124.8, 124.3, 123.7, 60.8, 39.6, 32.2, 26.8 (2C), 26.6, 25.7, 23.4, 19.2, 17.7, 15.9, -5.6 (2C); HRMS (ESI) calculated for $C_{31}H_{44}OSiNa$ $[M + Na]^+$, 483.3054, found 483.3067.

(2*Z*,6*E*,10*Z*)-3,7-Dimethyldodeca-2,6,10-trien-1-ol (93)



A solution of silyl ether **99** (1.10 g, 2.46 mmol) in THF (50 mL) was treated with TBAF (7.40 mL, 7.39 mmol, 1 M) and stirred at room temperature for 5 h. The reaction was monitored by TLC (25% ethyl acetate/hexanes). The solvent was evaporated and the residue was partitioned between saturated $NaHCO_3$ (50 mL) and ethyl acetate (50 mL). The aqueous layer was extracted with EtOAc (3 x 50 mL). The combined organics were washed with brine (1 x 50 mL), dried over Na_2SO_4, evaporated to a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes to 33% ethyl acetate/hexanes). Alcohol **93** was obtained as a pale-yellow oil (0.33 g, 65%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.40-5.29 (m, 3H), 5.12 (t, J = 4.7 Hz, 1H), 4.10 (d, J = 6.4 Hz, 2H), 2.19-2.08 (m, 8H), 1.75 (s, 3H), 1.61 (s, 3H), 1.59 (s, 1H), 1.57 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 140.1, 135.7, 130.1, 124.3, 123.9, 123.7, 59.0, 39.3, 31.9, 26.5, 25.4, 23.4, 15.9, 12.8; HRMS (ESI) calculated for $C_{14}H_{25}O$ $[M + H]^+$, 209.1899, found 209.1900.

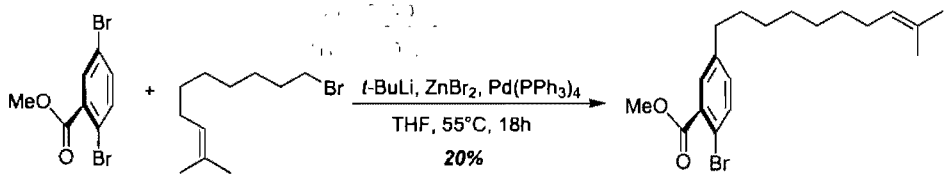
Pentafluorobenzyl 5-((2*Z*,6*E*,10*Z*)-3,7-dimethyldodeca-2,6,10-trienoxy)-2-((*E*)-4-(allyloxy)-2-methylbut-2-enoxy)benzoate (94)



Follow experimental for pentafluorobenzyl 5-((2*E*,6*E*)-3,7,11-trimethyldodeca-2,6,10-trienoxy)-2-((*E*)-4-(allyloxy)-2-methylbut-2-enoxy)benzoate (**64**). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.33 (d, *J* = 3.1 Hz, 1H), 7.01 (dd, *J* = 9.1, 3.1 Hz, 1H), 6.87 (d, *J* = 9.1 Hz, 1H), 5.92 (ddt, *J* = 17.1, 10.7, 5.7 Hz, 1H), 5.73 (t, *J* = 6.1 Hz, 1H), 5.47 (t, *J* = 6.2 Hz, 1H), 5.42-5.37 (m, 3H), 5.27 (dd, *J* = 17.1, 3.3 Hz, 1H), 5.19 (dd, *J* = 10.7, 3.3 Hz, 1H), 5.16-5.10 (m, 1H), 4.45 (d, *J* = 6.6 Hz, 2H), 4.42 (s, 2H), 4.05 (d, *J* = 6.5 Hz, 2H), 3.97 (dt, *J* = 5.7, 1.2 Hz, 2H), 2.16-2.11 (m, 6H), 2.04-1.99 (m, 2H), 1.79 (s, 3H), 1.72 (s, 3H), 1.64-1.60 (m, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.2, 152.7, 152.3, 141.1, 135.6, 134.8, 130.2, 124.5, 123.8, 123.7, 123.5, 120.7, 120.0, 119.7, 117.1 (3C), 115.4, 74.6,

71.2, 66.0, 65.1, 53.6, 39.3, 32.4, 26.5, 25.4, 23.5, 15.9, 13.9, 12.7; HRMS (ESI) calculated for $C_{36}H_{42}F_5O_5$ $[M + H]^+$, 639.2947, found 649.2935.

Methyl 2-bromo-5-(9-methyldec-8-enyl)benzoate (108)

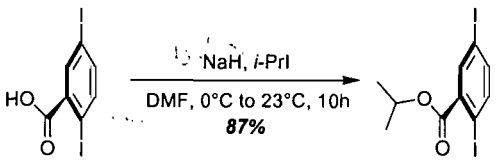


101 107 108

To a round bottom flask containing anhydrous THF (5 mL) -78°C, *t*-BuLi (0.70 mL, 0.90 mmol) was added dropwise followed by a solution of bromide **107** (0.11 g, 0.38 mmol) in THF (5 mL). The reaction was allowed to stir for 0.5 h at -78°C and the exchange was monitored by TLC (100% hexanes). A solution of $ZnBr_2$ (0.10 g, 0.45 mmol) in THF (1.0 mL) was added to the -78°C solution which was stirred for 1 h, allowed to warm to room temperature, and stirred for an additional 1 h. The reaction was monitored by TLC (100% hexanes). The zincate solution transferred by syringe to a round bottom flask containing a solution of ester **101** (0.11 g, 0.37 mmol) and tetrakis(triphenylphosphine)palladium (0.03 g, 0.03 mmol) in anhydrous THF (2 mL). The reaction mixture was stirred for 12h at 55°C, and was monitored by TLC (20% ethyl acetate/hexanes). The reaction was cooled to 23°C, quenched with $NaHCO_3$ (50 mL) and the mixture was extracted with Et_2O (3 x 20 mL). The combined organic extracts were washed with brine (1 x 20 mL), dried over Na_2SO_4, and evaporated to give a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes). Bromide **108** was obtained as a pale-yellow oil (0.03 g, 20%). ^1H NMR (300 MHz, $CDCl_3$) δ 7.98

(d, J = 2.2 Hz, 1H), 7.52 (dd, J = 8.3, 2.2 Hz, 1H), 7.12 (d, J = 8.3 Hz, 1H), 5.11 (t, J = 7.1 Hz, 1H), 3.89 (s, 3H), 2.92-2.88 (m, 2H), 2.00-1.94 (m, 2H), 1.68 (s, 3H), 1.59 (s, 3H), 1.40-1.31 (m, 10H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 167.7, 144.6, 135.5, 134.2, 133.4, 132.0, 132.0, 125.7, 119.9, 53.0, 34.7, 32.5, 30.7, 30.5, 30.2, 30.1, 28.9, 26.6, 18.5; HRMS (ESI) calculated for $C_{19}H_{28}BrO_2$ $[M + H]^+$, 367.1267, found 367.1261.

Iso-propyl 2,5-diiodobenzoate (120)

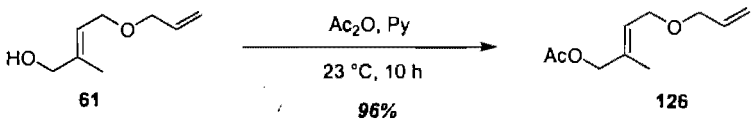


121 120

In a round bottom flask under nitrogen atmosphere, NaH (0.08 g, 2.00 mmol) was washed with hexane (3 x 50 mL), suspended in anhydrous DMF (20 mL), cooled to 0°C, treated dropwise with a solution of 2,5-diiodobenzoic acid **121** (0.50 g, 1.34 mmol) in DMF (5 mL), stirred for 0.5 h, treated with *iso*-propyl iodide (0.15 mL, 1.47 mmol), warmed to room temperature, and stirred for 12 h. The reaction was monitored by TLC (25% ethyl acetate/hexanes). The solvent was evaporated and the residue was taken up in Et_2O (50 mL), and treated with saturated NH_4Cl solution (25 mL). The aqueous phase was extracted with Et_2O (3 x 50 mL). The combined organic extracts were washed with brine (1 x 25 mL) dried over Na_2SO_4, and evaporated to give a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes). Ester **120** was obtained as a pale-yellow oil (0.48 g, 87%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.01 (d, J = 2.2 Hz, 1H), 7.64 (d, J = 8.3 Hz, 1H), 7.40 (dd, J = 8.3, 2.2 Hz, 1H), 5.25 (sept., J = 6.3 Hz, 1H),

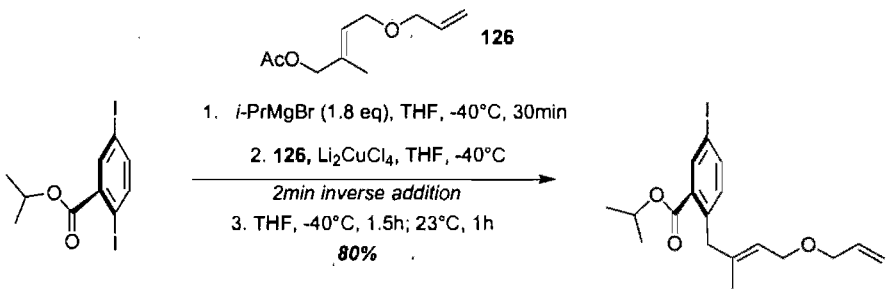
1.39 (s, 3H), 1.37 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 164.6, 142.5, 141.1, 139.1, 137.5, 93.2, 93.1, 70.0, 21.8, 21.8; HRMS (ESI) calculated for $C_{10}H_{10}I_2O_2Na$ $[M + Na]^+$, 438.8662, found 438.8650.

(*E*)-4-(Allyloxy)-2-methylbut-2-enyl acetate (126)



In a round bottom flask were added alcohol **61** (5.50 g, 38.7 mmol) and Ac_2O (4.40 mL, 46.4 mmol), followed by distilled pyridine (3.8 mL, 46.4 mmol) at 0°C. The reaction was stirred for 10 h at room temperature and was monitored by TLC (25% ethyl acetate/hexanes). The reaction mixture was purified as is by silica gel flash chromatography (25% ethyl acetate/hexanes) to give acetate **126** as a pale-yellow oil (6.83 g, 96%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.88 (ddt, J = 17.1, 10.5, 5.7 Hz, 1H), 5.60 (t, J = 6.6 Hz, 1H), 5.24 (dd, J = 17.1, 3.0 Hz, 1H), 5.15 (dd, J = 10.5, 3.0 Hz, 1H), 4.45 (s, 2H), 4.00 (d, J = 6.6 Hz, 2H), 3.94 (dt, J = 5.7, 1.2 Hz, 2H), 2.04 (s, 3H), 1.66 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.6, 134.6, 133.8, 124.5, 117.1, 71.2, 68.8, 65.9, 20.8, 14.1; HRMS (ESI) calculated for $C_{10}H_{16}O_3Na$ $[M + Na]^+$, 207.0992, found 207.0996.

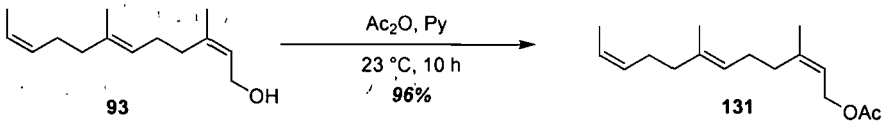
***Iso*-propyl 2-((*E*)-4-(allyloxy)-2-methylbut-2-enyl)-5-iodobenzoate (124)**



In a round bottom flask, a solution of *iso*-propyl ester **120** (6.87 g, 16.5 mmol) dissolved in anhydrous THF (55 mL) was added. The solution was cooled to -40°C and treated dropwise with *i*-PrMgBr (7.60 mL, 19.8 mmol) affording a color change from clear to yellow. The solution was stirred for 0.5 h and the Mg-I exchange was monitored by GC analysis (exchange intermediate R_t = 12.85 min). The Grignard reagent solution was transferred over 2 minutes via cannula to a second round bottom flask containing Li_2CuCl_4 (2.2 mL, 1.10 mmol) and acetate **126** (2.00 g, 11.0 mmol) in anhydrous THF (55 mL) at -40°C affording a color change from dark red to clear and then to orange. The reaction was stirred for 1 h at -40°C, warmed to room temperature, and stirred for 1 h. The reaction was monitored by TLC (10% ethyl acetate/hexanes). The reaction was quenched with saturated NH_4Cl solution (1 x 55 mL), diluted with water (1 x 55 mL), and extracted with Et_2O (3 x 55 mL). The combined organic extracts were washed with NH_4OH (1 x 55 mL) and brine (1 x 55 mL), dried over Na_2SO_4, and evaporated to a residue that was purified by silica gel flash chromatography (5% ethyl acetate/hexanes). Iodide **124** was obtained as a yellow oil (3.60 g, 80%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.10 (d, J = 1.8 Hz, 1H), 7.69 (dd, J = 8.1, 1.8 Hz, 1H), 6.96 (d, J = 8.1 Hz, 1H), 5.88

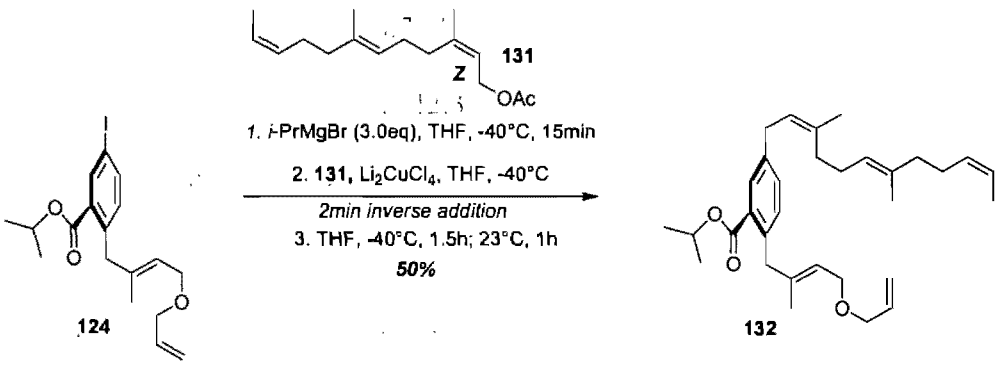
(ddt, J = 17.3, 10.5, 5.7 Hz, 1H), 5.28-5.23 (m, 2H), 5.21-5.16 (m, 2H), 3.97 (d, J = 6.5 Hz, 2H), 3.91 (d, J = 5.7 Hz, 2H), 3.64 (s, 2H), 1.63 (s, 3H), 1.34 (s, 3H), 1.32 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.7, 140.2, 139.9, 138.9, 138.7, 134.8, 133.1, 133.0, 122.9, 117.0, 90.8, 71.0, 68.8, 66.4, 42.3, 21.8, 21.8, 16.9; HRMS (ESI) calculated for $C_{18}H_{23}IO_3Na$ [M + Na]$^+$, 437.0582, found 437.0584.

(2*Z*,6*E*,10*Z*)-3,7-Dimethyldodeca-2,6,10-trienyl acetate (131)



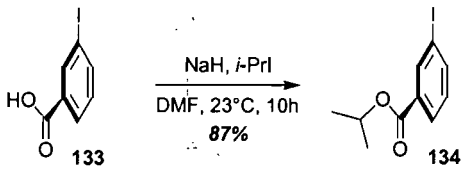
Follow experimental for (*E*)-4-(allyloxy)-2-methylbut-2-enyl acetate (**126**). The reaction was allowed to stir for 10 h at room temperature and was monitored by TLC (25% ethyl acetate/hexanes). The reaction mixture was purified as is by silica gel flash chromatography (13% ethyl acetate/hexanes) to give acetate **131** as a pale-yellow oil (96%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.50-5.39 (m, 3H), 5.12 (t, J = 6.1 Hz, 1H), 4.56 (d, J = 7.3 Hz, 2H), 2.18-2.07 (m, 8H), 2.05 (s, 3H), 1.77 (s, 3H), 1.61 (s, 3H), 1.59 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.1, 142.7, 135.6, 130.2, 123.8, 123.5, 119.1, 61.1, 39.4, 32.1, 26.5, 25.4, 23.5, 21.1, 15.9, 12.8; HRMS (ESI) calculated for $C_{16}H_{26}O_2Na$ [M + Na]$^+$, 273.1825, found 273.1827.

***Iso*-propyl 2-((*E*)-4-(allyloxy)-2-methylbut-2-enyl)-5-((2*Z*,6*E*,10*Z*)-3,7-dimethyldodeca-2,6,10-trienyl)benzoate (132)**



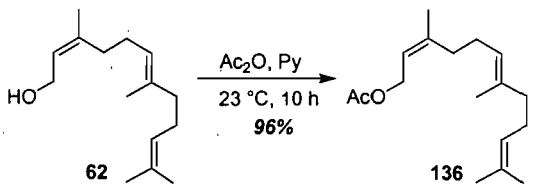
Follow experimental for *iso*-propyl 2-((*E*)-4-(allyloxy)-2-methylbut-2-enyl)-5-iodobenzoate (**124**). The Mg-I exchange reaction was allowed to stir for 0.25 h. The crude residue was purified by silica gel flash chromatography (5% ethyl acetate/hexanes) to afford olefin **132** as a pale yellow oil (0.24 g, 50%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (s, 1H), 7.21 (d, J = 7.9 Hz, 1H), 7.13 (d, J = 7.9 Hz, 1H), 5.90 (ddt, J = 17.3, 10.5, 5.7 Hz, 1H), 5.48-5.30 (m, 8H), 3.99 (d, J = 6.7 Hz, 2H), 3.93 (d, J = 5.7 Hz, 2H), 3.67 (s, 2H), 3.35 (d, J = 7.2 Hz, 2H), 2.13 (m, 6H), 2.01 (m, 2H), 1.76 (s, 3H), 1.65 (s, 3H), 1.62 (s, 6H), 1.35 (s, 3H), 1.33 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.6, 139.8 (2C), 137.4, 136.7, 135.2 (2C), 131.3 (2C), 130.3 (2C), 123.8, 123.5, 123.3, 122.3 (2C), 117.0, 70.9, 68.2, 66.5, 42.5, 39.4, 33.5, 32.0, 26.5, 25.4, 23.5, 21.9 (2C), 16.9, 16.0, 12.8; HRMS (ESI) calculated for $C_{32}H_{47}O_3$ $[M+H]^+$, 479.3520, found 479.3522.

***Iso*-propyl 3-iodobenzoate (134)**



Follow experimental for *iso*-propyl 2,5-diiodobenzoate (**120**). The crude residue was purified by silica gel flash chromatography (10% ethyl acetate/hexanes) to afford iodide **134** as a white solid (0.45 g, 87%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.35 (s, 1H), 7.99 (d, J = 1.6 Hz, 1H), 7.85 (d, J = 1.6 Hz, 1H), 7.16 (t, J = 8.0 Hz, 1H), 5.23 (sept., J = 6.3 Hz, 1H), 1.37 (s, 3H), 1.35 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 164.5, 141.4, 138.3, 132.7, 129.9, 128.6, 93.7, 68.9, 21.9 (2C). Iodide **134** proved too unstable for HRMS by FAB, API, EI, CI; product could not be ionized.

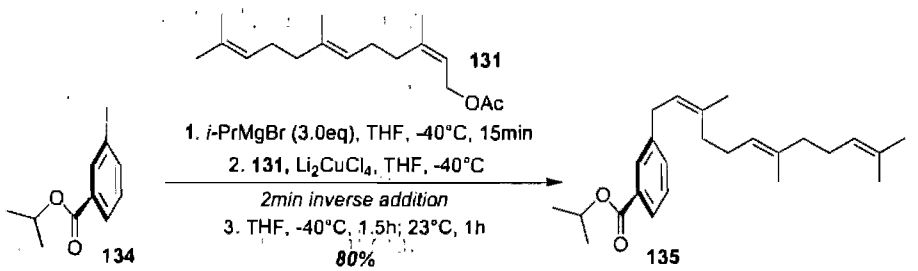
(2*Z*,6*E*)-3,7,11-Trimethyldodeca-2,6,10-triene acetate (136)



To a round bottom flask, Ac_2O (0.46 mL, 4.88 mmol) and pyridine (0.39 mL, 4.88 mmol) followed by alcohol **62** (0.90 g, 4.07 mmol) were added. The solution was stirred at room temperature for 10 h, and the reaction was monitored by TLC (25% ethyl acetate/hexanes). Once complete, the reaction mixture was purified by silica gel flash chromatography (10% ethyl acetate/hexanes). Acetate **136** was obtained as a pale-yellow oil (1.03 g, 96%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.30 (t, J = 7.3 Hz, 1H), 5.08-5.03 (m,

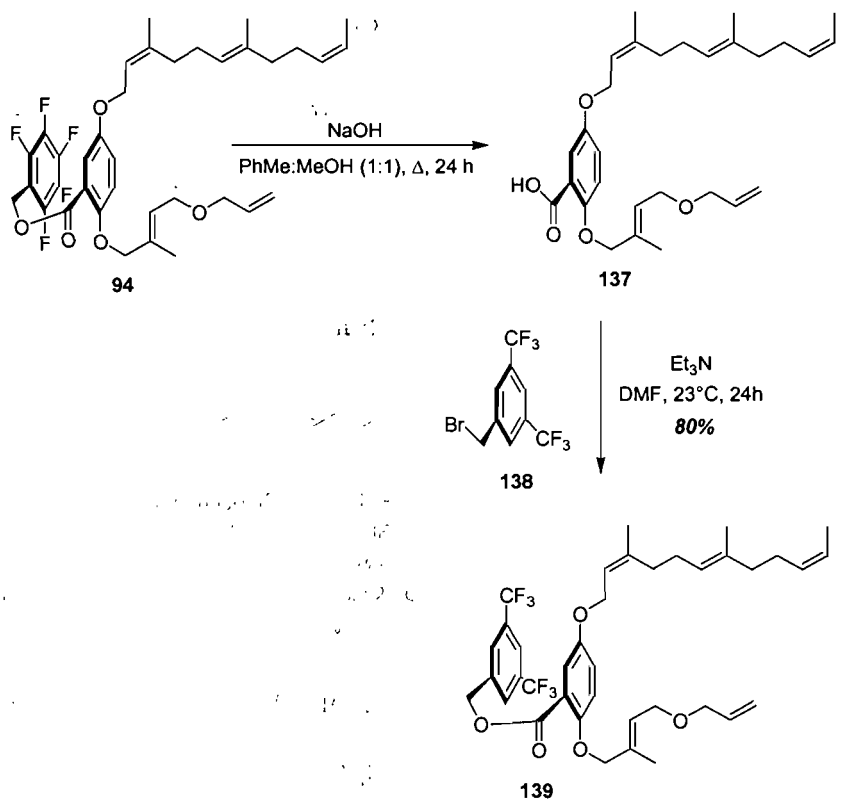
2H), 4.50 (d, J = 7.3 Hz, 2H), 2.05 (t, J = 4.9 Hz, 4H), 2.03-2.00 (m, 2H), 1.96 (s, 3H), 1.95-1.92 (m, 2H), 1.70 (s, 3H), 1.61 (s, 3H), 1.54 (s, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.6, 142.2, 135.5, 131.0, 124.1, 123.2, 119.0, 60.8, 39.5, 31.9, 26.4, 26.3, 25.4, 23.2, 20.7, 17.4, 15.7; HRMS (ESI) calculated for $C_{17}H_{28}O_2Na$ [M + Na]$^+$, 287.1982, found 287.1981.

***Iso*-propyl 3-((2*Z*,6*E*,10*Z*)-3,7-dimethyldodeca-2,6,10-trienyl)benzoate (135)**



Follow experimental for *iso*-propyl 2-((*E*)-4-(allyloxy)-2-methylbut-2-enyl)-5-iodobenzoate (**124**). The residue was purified by silica gel flash chromatography (5% ethyl acetate/hexanes) to afford olefin **135** as a yellow oil (0.53 g, 80%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.85 (s, 2H), 7.35 (s, 2H), 5.33 (t, J = 6.7 Hz, 1H), 5.24 (apparent septet, J = 6.3 Hz, 1H), 5.16 (t, J = 6.4, Hz, 1H), 5.09 (t, J = 6.7, Hz, 1H), 3.40 (d, J = 7.3 Hz, 2H), 2.19-2.15 (m, 4H), 2.10-2.06 (m, 2H), 2.02-1.90 (m, 2H), 1.76 (s, 3H), 1.68 (s, 3H), 1.61 (s, 3H), 1.60 (s, 3H), 1.37 (s, 3H), 1.35 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.3, 142.1, 136.9, 135.4, 132.7, 131.3, 130.9, 129.4, 128.2, 127.0, 124.3, 123.9, 123.1, 68.2, 39.7, 33.9, 32.0, 26.7, 26.5, 25.7, 23.5, 21.9 (2C), 17.7, 16.0; HRMS (ESI) calculated for $C_{25}H_{37}O_2$ [M + H]$^+$, 369.2788, found 369.2790.

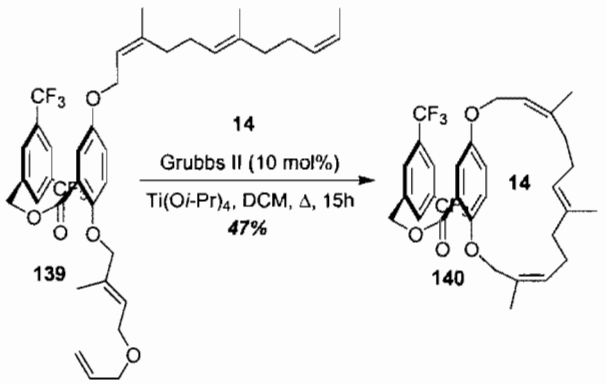
3,5-Bis(trifluoromethyl)benzyl 5-((2*Z*,6*Z*,10*Z*)-3,7-dimethyldodeca-2,6,10-trienyloxy)-2-((*E*)-4-(allyloxy)-2-methylbut-2-enyloxy)benzoate (139)



In a round bottom flask equipped with a reflux condenser, ester **94** (0.05 g, 0.10 mmol), was dissolved in a 1:1 mixture of toluene:methanol (10 mL), heated to a reflux, treated with NaOH pellets (0.05 g, 1.32 mmol), and stirred for 24 h. The reaction was monitored by TLC (13% ethyl acetate/hexanes). The solvent was removed by evaporation under reduced pressure, dissolved in ethyl acetate, quenched with 1 N HCl (6.50 mL, 6.50 mmol), extracted with Et_2O (3 x 20 mL), washed with brine, dried over Na_2SO_4, and evaporated to afford olefin **137** (0.11 g, 0.22 mmol) that was dissolved in anhydrous DMF (22 mL), cooled to 0°C, treated dropwise with Et_3N (0.04 mL, 0.25 mmol), stirred for 0.5 h, treated with bromide **138** (0.04 mL, 0.22 mmol, which prior to addition was

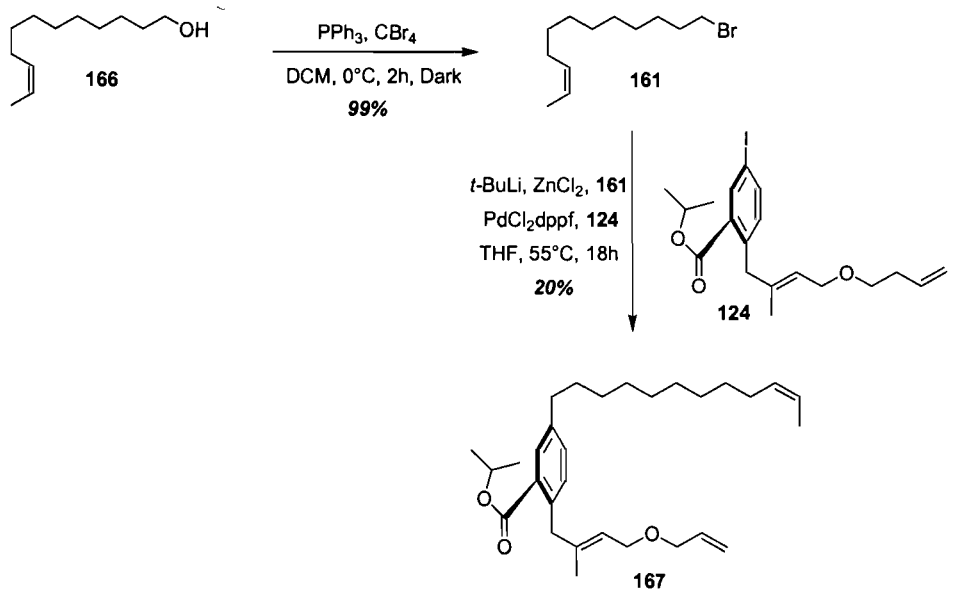
passed through a short plug of basic alumina), and stirred for 10 h at room temperature. The reaction was monitored by TLC (50% ethyl acetate/hexanes). The solvent was removed by evaporation, and the residue was taken up in Et_2O (20 mL). The solution was quenched with 1N HCl (5 mL), extracted with Et_2O (3 x 20 mL), washed with a 10% aqueous $CuSO_4$ solution (3 x 20 mL), brine (1 x 20 mL), dried over Na_2SO_4, and evaporated to a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes) to afford ester **139** as a pale-yellow solid (0.13 g, 80%). ^1H NMR (300 MHz, $CDCl_3$) δ 7.92 (s, 2H), 7.84 (s, 1H), 7.38 (d, J = 3.1 Hz, 1H), 7.03 (dd, J = 9.1, 3.1 Hz, 1H), 6.91 (d, J = 9.1 Hz, 1H), 5.89 (ddt, J = 17.1, 10.4, 5.7 Hz, 1H), 5.74 (t, J = 5.9 Hz, 1H), 5.49 (t, J = 5.6 Hz, 1H), 5.45 (s, 2H), 5.36 (m, 2H), 5.25 (dd, J = 17.3, 3.3 Hz, 1H), 5.17 (dd, J = 10.4, 3.3 Hz, 1H), 5.11-5.01 (m, 1H), 4.48-4.45 (m, 4H), 4.03 (d, J = 6.4 Hz, 2H), 3.94 (dt, J = 5.7, 1.3 Hz, 2H), 2.14-2.12 (m, 6H), 2.01-2.00 (m, 2H), 1.79 (s, 3H), 1.69 (s, 3H), 1.63-1.59 (m, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.8, 152.6, 152.4, 142.1, 138.8, 135.6, 134.7, 134.5, 131.0, 128.0, 125.3, 125.1, 124.9 (2C), 124.7, 124.6, 123.8, 123.4, 121.9, 120.2, 117.1, 116.9, 115.4, 74.3, 71.2, 66.0, 65.1, 64.9, 39.3, 32.3, 26.5, 25.4, 23.5, 15.9, 13.8, 12.7; HRMS (ESI) calculated for $C_{38}H_{45}F_6O_5$ $[M + H]^+$, 695.3166, found 695.3161.

Cyclophane (140)



Follow experimental procedure cyclophane (**58**) for the preparation of cyclophane **140**. The crude reaction mixture was purified by silica gel flash chromatography (5% ethyl acetate/hexanes) to afford cyclophane **140** as a pale-yellow oil (13.6 mg, 47%). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm 7.91 (d, J = 3.0 Hz, 1H), 7.71 (s, 1H), 7.58 (s, 2H), 7.02 (dd, J = 9.0, 3.0 Hz, 1H), 6.67 (d, J = 9.1 Hz, 1H), 5.47 (t, J = 8.1 Hz, 1H), 5.25 (t, J = 7.0 Hz, 1H), 4.88 (s, 2H), 4.67 (t, J = 6.3 Hz, 1H), 4.54-4.49 (m, 4H), 2.09-2.05 (m, 2H), 2.05-1.97 (m, 2H), 1.91-1.88 (m, 2H), 1.61 (s, 3H), 1.54 (s, 3H), 1.45 (s, 3H), 1.52-1.49 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.7, 152.8, 151.6, 144.5, 139.0, 132.2, 132.0, 131.7, 130.4, 128.0, 127.6, 126.0, 124.1, 123.4, 121.8, 119.8, 119.4, 115.8, 73.6, 68.1, 64.7, 39.0, 31.7, 27.1, 25.0, 23.6, 15.4, 13.2; HRMS (ESI) calculated for $C_{31}H_{33}F_6O_4$ [M + H]$^+$, 583.2278, found 583.2289.

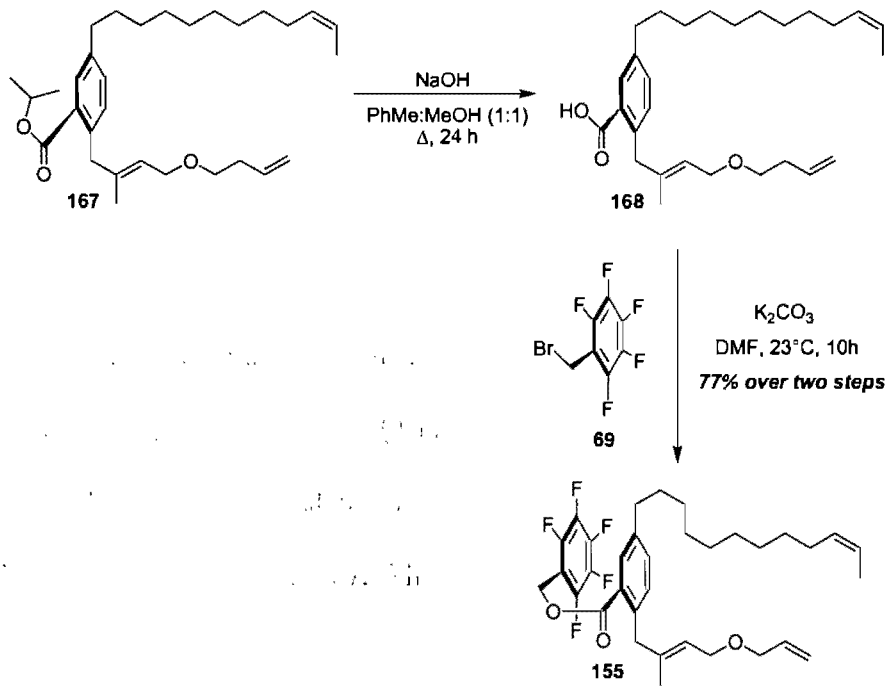
***Iso*-propyl 2-((*E*)-4-(but-3-enyloxy)-2-methylbut-2-enyl)-5-((*Z*)-dodec-10-enyl) benzoate (167)**



Follow experimental for geranyl bromide (**87**) for the preparation of bromide **161** that was obtained as a pale-yellow oil (4.17 g, 99%) and was used without further purification. Follow experimental for methyl 2-bromo-5-(9-methyldec-8-enyl)benzoate (**108**) for the preparation of olefin **167**. The zincate was added to a solution of iodide **124** (0.11 g, 0.37 mmol) and $PdCl_2$(dppf) catalyst (0.03 g, 0.03 mmol), dissolved in anhydrous THF (2 mL). The solvent was evaporated to give a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes) to afford olefin **167** as a pale-yellow oil (35.6 mg, 20%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (s, 1H), 7.19 (d, J = 7.7 Hz, 1H), 7.11 (d, J = 7.7 Hz, 1H), 5.88 (ddt, J = 17.1, 10.4, 5.7 Hz, 1H), 5.47-5.39 (apparent dt, 1H), 5.27-5.19 (m, 4H), 3.97 (d, J = 6.5 Hz, 2H), 3.91 (d, J = 5.2 Hz, 2H), 3.66 (s, 2H), 2.58 (t, J = 7.6 Hz, 2H), 2.01-1.98 (m, 2H), 1.64 (s, 3H), 1.63-1.58 (m, 2H), 1.37-1.28 (m, 21H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 167.6, 140.7, 139.7, 137.1, 134.9,

131.4, 131.1, 131.0, 130.7, 130.0, 124.4, 123.5, 122.2, 116.8, 70.8, 68.1, 66.4, 42.5, 35.3, 32.5, 31.3, 29.5 (2C), 29.2 (2C), 26.7, 21.8 (2C), 16.8, 12.7; HRMS (ESI) calculated for $C_{30}H_{46}O_3Na$ $[M + Na]^+$, 477.3363, found 477.3353.

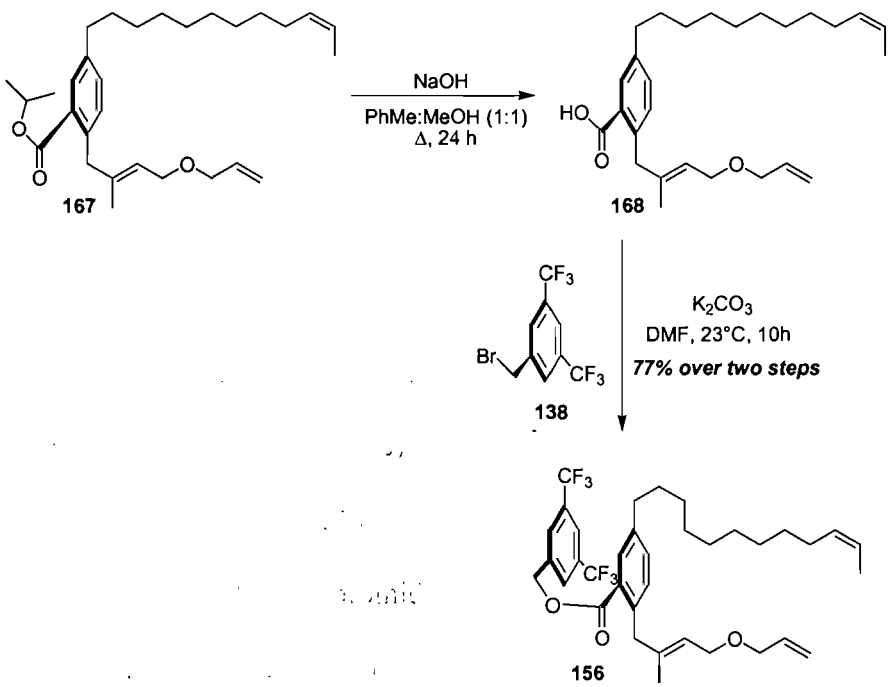
Pentafluorobenzyl 2-((*E*)-4-(allyloxy)-2-methylbut-2-enyl)-5-((*Z*)-dodec-10-enyl) benzoate (155)



Follow experimental procedure for 3,5-Bis(trifluoromethyl)benzyl 5-((2*Z*,6*Z*,10*Z*)-3,7-dimethyldodeca-2,6,10-trienyloxy)-2-((*E*)-4-(allyloxy)-2-methylbut-2-enyloxy)benzoate (**139**) for the preparation of olefin **155**. Olefin **168** (0.10 g, 0.23 mmol) was treated with K_2CO_3 (0.06 g, 0.46 mmol) and bromide **69** (0.04 mL, 0.25 mmol, which prior to addition was passed through a short plug of basic alumina) in DMF (22 mL) at room temperature, stirred for 10 h, filtered, evaporated *in vacuo* to give a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes) to afford olefin

155 as a pale-yellow solid (0.10 g, 77%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (s, 1H), 7.30 (d, J = 8.0 Hz, 1H), 7.20 (d, J = 8.0 Hz, 1H), 5.95 (ddt, J = 17.1, 10.9, 5.7 Hz, 1H), 5.52-5.47 (m, 1H), 5.42 (s, 2H), 5.30-5.18 (m, 4H), 4.02 (d, J = 6.7 Hz, 2H), 3.98 (d, J = 5.7 Hz, 2H), 3.71 (s, 2H), 2.63 (t, J = 7.6 Hz, 2H), 2.11-2.04 (m, 2H), 1.67 (s, 3H), 1.63-1.58 (m, 2H), 1.37-1.28 (m, 15H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.0, 141.1, 139.5, 138.1, 134.9, 133.1, 132.4, 131.5, 130.8, 130.5, 129.0, 124.5, 123.6, 122.4, 116.9, 71.0, 66.5, 53.5, 44.6, 42.6, 35.3, 32.6, 31.3, 30.0, 29.4 (4C), 26.8, 22.2, 17.9, 16.8 (2C), 12.7; HRMS (ESI) calculated for $C_{34}H_{41}F_5O_3Na$ $[M + Na]^+$, 615.2868, found 615.2863.

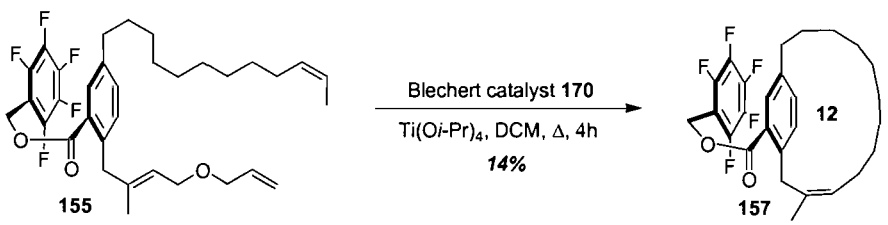
3,5-Bis(trifluoromethyl)benzyl 2-((*E*)-4-(allyloxy)-2-methylbut-2-enyl)-5-((*Z*)-dodec-10-enyl)benzoate (156)



Follow experimental procedure for 3,5-Bis(trifluoromethyl)benzyl 5-((2*Z*,6*Z*,10*Z*)-3,7-dimethyldodeca-2,6,10-trienyloxy)-2-((*E*)-4-(allyloxy)-2-methylbut-2-enyloxy)benzoate

(**139**) for the preparation of olefin **156**. Olefin **168** (0.10 g, 0.23 mmol) was treated with K_2CO_3 (0.06 g, 0.46 mmol) and bromide **138** (0.05 mL, 0.25 mmol, which prior to addition was passed through a short plug of basic alumina) in DMF (22 mL) at room temperature, stirred for 10 h, filtered, evaporated *in vacuo* to give a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes) to afford olefin **156** as a pale-yellow oil (0.11 g, 77%). ^{1}H NMR (300 MHz, CDCl3) δ 7.89 (s, 2H), 7.86 (s, 1H), 7.69 (d, J = 1.8 Hz, 1H), 7.29 (d, J = 1.9 Hz, 1H), 7.17 (d, J = 7.9 Hz, 1H), 5.88 (ddt, J = 17.0, 10.4, 5.7 Hz, 1H), 5.47-5.39 (m, 2H), 5.39 (s, 2H), 5.23 (dd, J = 17.4, 3.3, Hz, 1H), 5.15 (dd, J = 9.2, 3.3 Hz, 1H), 5.14-5.12 (m, 1H), 3.96-3.91 (m, 4H), 3.67 (s, 2H), 2.64-2.61 (m, 2H), 2.06-1.98 (m, 2H), 1.60 (s, 6H), 1.66-1.59 (m, 2H), 1.26 (s, 12H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.0, 141.1, 139.5, 138.7, 138.1, 134.9, 132.4, 131.6, 130.9, 130.4, 129.0, 124.5, 123.6, 122.4, 116.9, 71.0, 66.5, 64.8, 44.6, 42.6, 35.3, 32.6, 31.3, 30.0, 29.6, 29.5, 29.4, 29.4, 29.3, 26.8, 22.2, 17.9, 16.8, 12.7; HRMS (ESI) calculated for $C_{36}H_{44}F_6O_3Na$ $[M + Na]^+$, 661.3087, found 661.3094.

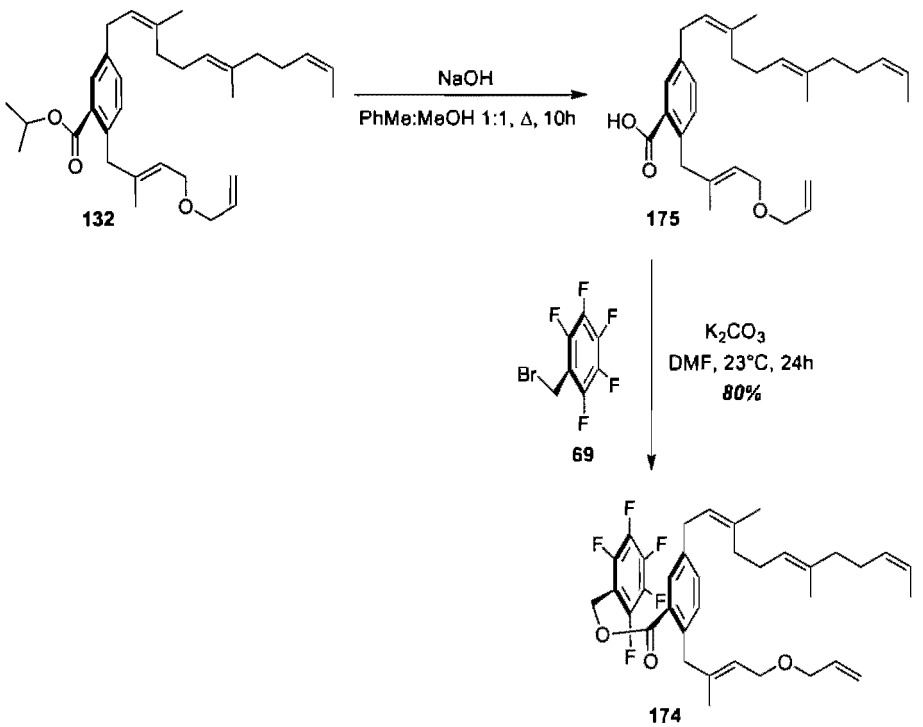
Cyclophane (157)



Follow experimental procedure cyclophane (**58**) for the preparation of cyclophane **157**. The reaction was quenched with ethyl vinyl ether (5 mL) and the solvent was evaporated to give a residue that was purified by silica gel flash chromatography (50%

toluene/hexanes) to afford cyclophane **157** as a pale-yellow oil (0.07 g, 14%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.93 (d, J = 1.6 Hz, 1H), 6.98 (dd, J = 7.8, 1.8 Hz, 1H), 6.91 (d, J = 7.8 Hz, 1H), 4.95 (d, J = 1.6 Hz, 2H), 4.49 (d, J = 15.3 Hz, 1H), 4.36 (t, J = 6.8 Hz, 1H), 3.05 (d, J = 15.5 Hz, 1H), 2.44 (t, J = 6.2 Hz, 2H), 1.99-1.92 (m, 2H), 1.73 (s, 3H), 1.60-1.15 (m, 14H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.5, 141.0, 140.7, 136.7, 133.0 (2C), 131.6 (2C), 129.5, 124.9, 53.2, 42.1, 35.2, 30.3, 28.9, 28.8, 28.5, 27.8, 26.9, 26.1, 25.8, 18.3; HRMS (ESI) calculated for $C_{27}H_{30}F_5O_2$ $[M + H]^+$, 481.2160, found 481.2166.

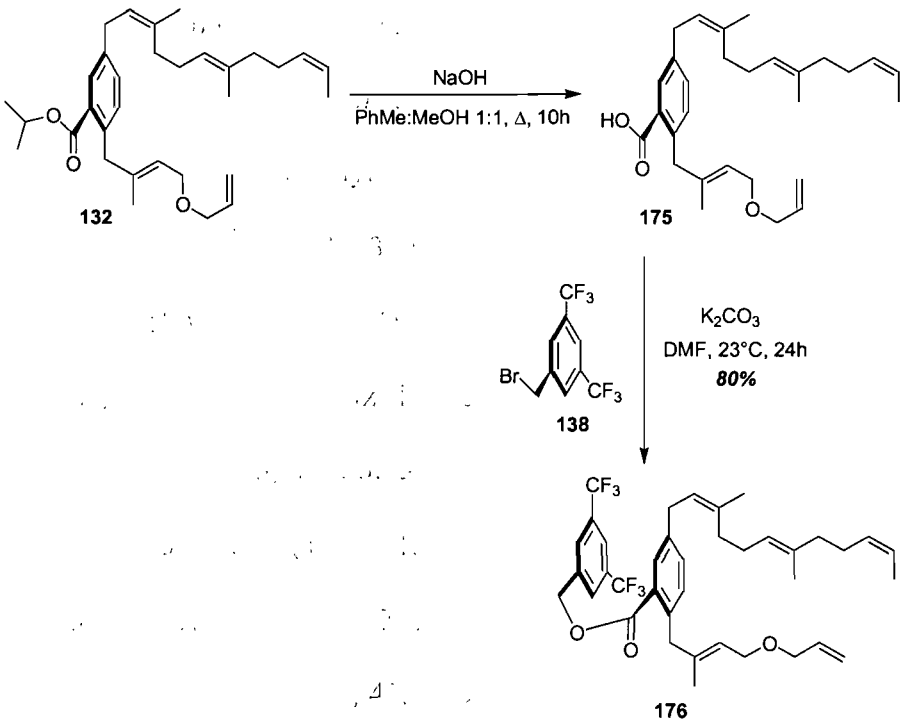
Pentafluorobenzyl 2-((*E*)-4-(allyloxy)-2-methylbut-2-enyl)-5-((2*Z*,6*E*,10*Z*)-3,7-dimethyldodeca-2,6,10-trienyl)benzoate (174)



Follow experimental procedure for 3,5-Bis(trifluoromethyl)benzyl 5-((2*Z*,6*Z*,10*Z*)-3,7-dimethyldodeca-2,6,10-trienyloxy)-2-((*E*)-4-(allyloxy)-2-methylbut-2-enyloxy)benzoate

(**139**) for the preparation of **174**. Olefin **175** (0.10 g, 0.23 mmol) was treated with K_2CO_3 (0.06 g, 0.46 mmol) and bromide **69** (0.05 mL, 0.25 mmol, which prior to addition was passed through a short plug of basic alumina) in DMF (22 mL) at room temperature, stirred for 10 h, filtered, evaporated *in vacuo* to give a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes) to afford olefin **174** as a pale-yellow oil (0.11 g, 80%). ^{1}H NMR (300 MHz, C_6D_6) δ 7.90 (d, J = 1.6 Hz, 1H), 7.10 (dd, J = 7.9, 1.6 Hz, 1H), 7.04 (d, J = 7.9 Hz, 1H), 5.85 (ddt, J = 17.1, 10.5, 5.7 Hz, 1H), 5.55-5.48 (m, 2H), 5.38 (t, J = 6.6 Hz, 1H), 5.31-5.23 (m, 3H), 5.06-5.03 (m, 3H), 3.90 (d, J = 6.6, 2H), 3.83-3.80 (m, 4H), 3.23 (d, J = 7.3 Hz, 2H), 2.21-2.15 (m, 2H), 2.15-2.10 (m, 6H), 1.65 (s, 3H), 1.58 (s, 3H), 1.54 (s, 6H); ^{13}C NMR (75 MHz, C_6D_6) δ 166.8, 140.3, 139.1, 138.9, 137.0, 135.8, 135.2, 132.6, 132.1, 130.9, 130.5, 129.9, 124.5, 124.0, 123.7, 123.6, 116.0, 71.0, 66.8, 53.4, 42.9, 39.8, 33.7, 32.2, 26.8, 25.8, 23.5, 16.9, 15.9, 15.8, 12.9; HRMS (ESI) calculated for $C_{36}H_{42}F_5O_3$ $[M + H]^+$, 617.3049, found 617.3069.

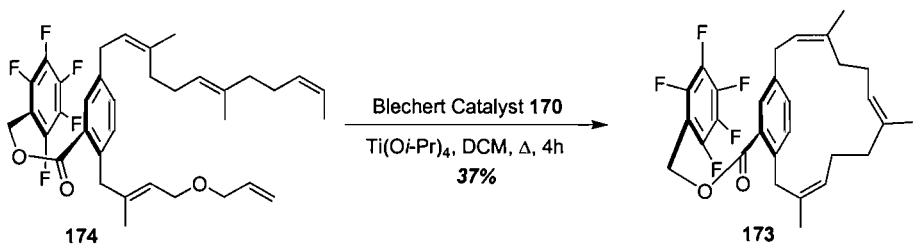
3,5-Bis(trifluoromethyl)benzyl 2-((*E*)-4-(allyloxy)-2-methylbut-2-enyl)-5-((2*Z*,6*E*,10*Z*)-3,7-dimethyldodeca-2,6,10-trienyl)benzoate (176)



Follow experimental procedure for 3,5-Bis(trifluoromethyl)benzyl 5-((2*Z*,6*Z*,10*Z*)-3,7-dimethyldodeca-2,6,10-trienyloxy)-2-((*E*)-4-(allyloxy)-2-methylbut-2-enyloxy)benzoate (**139**) for the preparation of **176**. Olefin **175** (0.10 g, 0.23 mmol) was treated with K_2CO_3 (0.06 g, 0.46 mmol) and bromide **138** (0.05 mL, 0.25 mmol, which prior to addition was passed through a short plug of basic alumina) in DMF (22 mL) at room temperature, stirred for 10 h, filtered, evaporated *in vacuo* to give a residue that was purified by silica gel flash chromatography (10% ethyl acetate/hexanes) to afford olefin **176** as a pale-yellow oil (0.12 g, 80%). ^{1}H NMR (300 MHz, C_6D_6) δ 7.88 (d, *J* = 1.5 Hz, 1H), 7.63 (s, 1H), 7.46 (s, 2H), 7.11 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.05 (d, *J* = 7.8 Hz, 1H), 5.81 (ddt, *J* = 17.1, 10.6, 5.3 Hz, 1H), 5.54-5.45 (m, 2H), 5.38 (t, *J* = 7.2 Hz, 1H), 5.30 (t, *J* = 6.8 Hz,

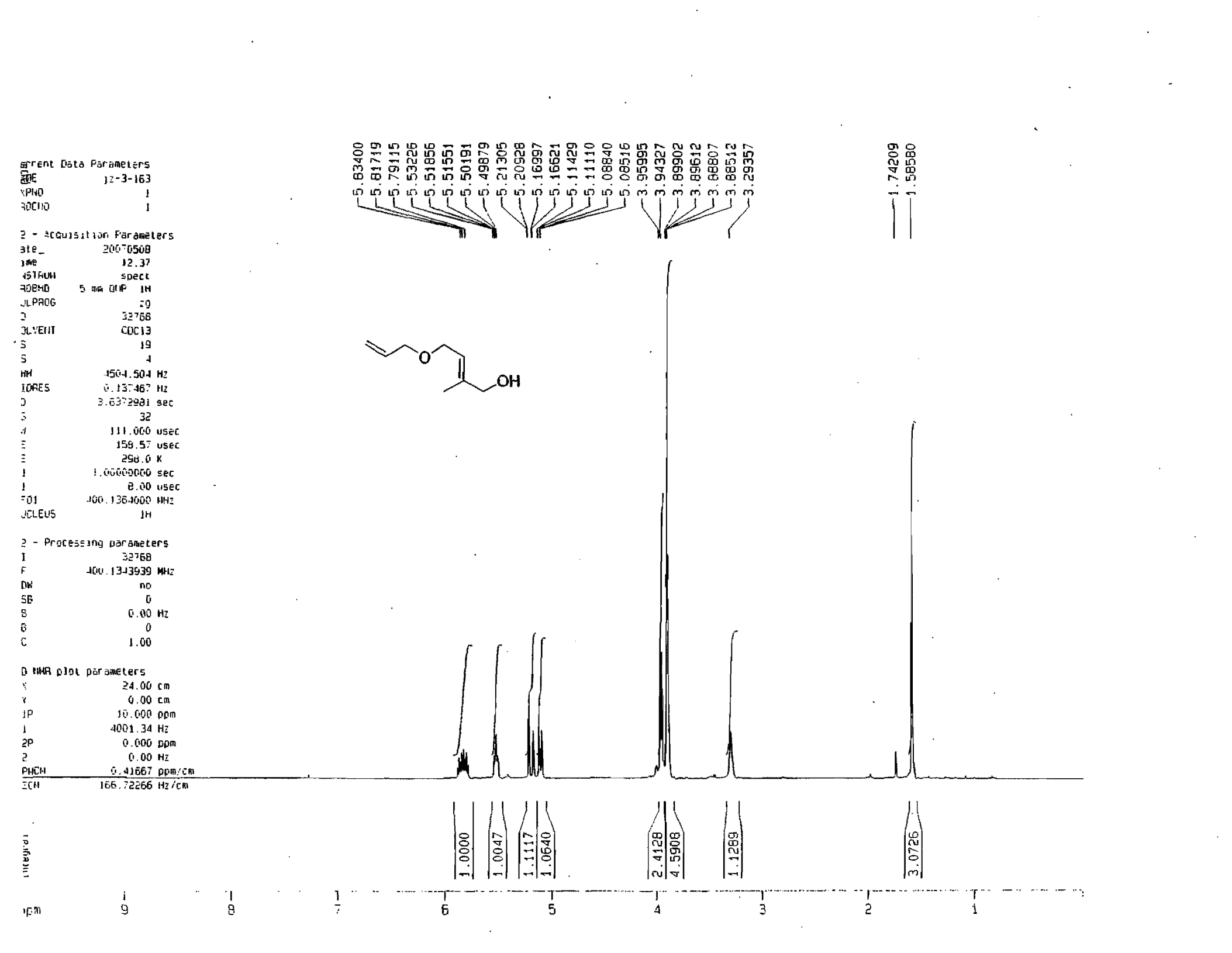
1H), 5.25-5.20 (m, 2H), 5.00 (ddd, J = 10.4, 3.3, 1.4 Hz, 1H), 4.81 (s, 2H), 3.87 (d, J = 6.6 Hz, 2H), 3.80-3.78 (m, 4H), 3.25 (d, J = 7.3 Hz, 2H), 2.21-2.10 (m, 8H), 1.67 (s, 3H), 1.55 (s, 9H); ^{13}C NMR (75 MHz, C_6D_6) δ 167.1, 140.4, 139.3, 139.0, 138.9, 137.0, 135.8, 135.2, 132.6, 132.1, 132.1, 131.6, 130.7, 130.5, 130.1, 124.5, 124.0, 123.6, 123.5, 121.9, 116.0, 71.0, 66.8, 64.8, 42.9, 39.8, 33.8, 32.2, 26.8, 25.8, 23.5, 16.9, 16.0, 12.9; HRMS (ESI) calculated for $C_{38}H_{45}F_6O_3$ $[M + H]^+$, 663.3267, found 663.3295.

Cyclophane (173)



Follow experimental procedure cyclophane (**58**) for the preparation of cyclophane **173**. The reaction was quenched with ethyl vinyl ether (5 mL) and the solvent was evaporated down to about 1 mL to give a residue that was further purified by silica gel flash chromatography (50% toluene/hexanes) to afford cyclophane **173** as a pale-yellow oil (18.7 mg, 37%). ^{1}H-NMR was carried out in C_6D_6 since running the sample in $CDCl_3$ caused decomposition. In addition, running the sample in C_6D_6 prevents overlapping of the three alkenyl proton signals. ^{1}H NMR (400 MHz, C_6C_6) δ 7.98 (d, J = 1.6 Hz, 1H), 7.04 (dd, J = 7.9, 1.9 Hz, 1H), 6.89 (d, J = 7.7 Hz, 1H), 5.47 (t, J = 7.0 Hz, 1H), 4.94 (d, J = 5.3 Hz, 2H), 4.50 (t, J = 5.8 Hz, 1H), 4.47-4.42 (m, 2H), 3.14 (d, J = 4.9 Hz, 1H), 3.03 (d, J = 15.8 Hz, 1H), 2.03-1.97 (m, 2H), 1.87 (t, J = 5.6 z, 2H), 1.80-1.79 (m, 4H),

1.73 (s, 3H), 1.58 (s, 3H), 1.29 (s, 3H); ^{13}C NMR (101 MHz, C_6D_6) δ 166.5, 141.2, 140.6, 140.4, 136.4, 133.2, 133.0, 131.3, 130.8, 124.0, 121.6, 42.1, 38.8, 33.4, 31.9, 30.8, 29.3, 25.6, 23.7, 22.5, 18.7, 15.0, 14.3, 11.2; HRMS (ESI) calculated for $C_{29}H_{30}F_5O_2$ $[M + H]^+$, 505.2160, found 505.2167.



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ROCNO 1

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ime 12.37
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D 32768
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S 4
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ORES 0.137467 Hz
D 3.6372981 sec
S 32
A 111.000 usec
E 156.57 usec
E 298.0 K
I 1.00000000 sec
I 8.00 usec
F01 400.1364000 MHz
UCLEUS 1H

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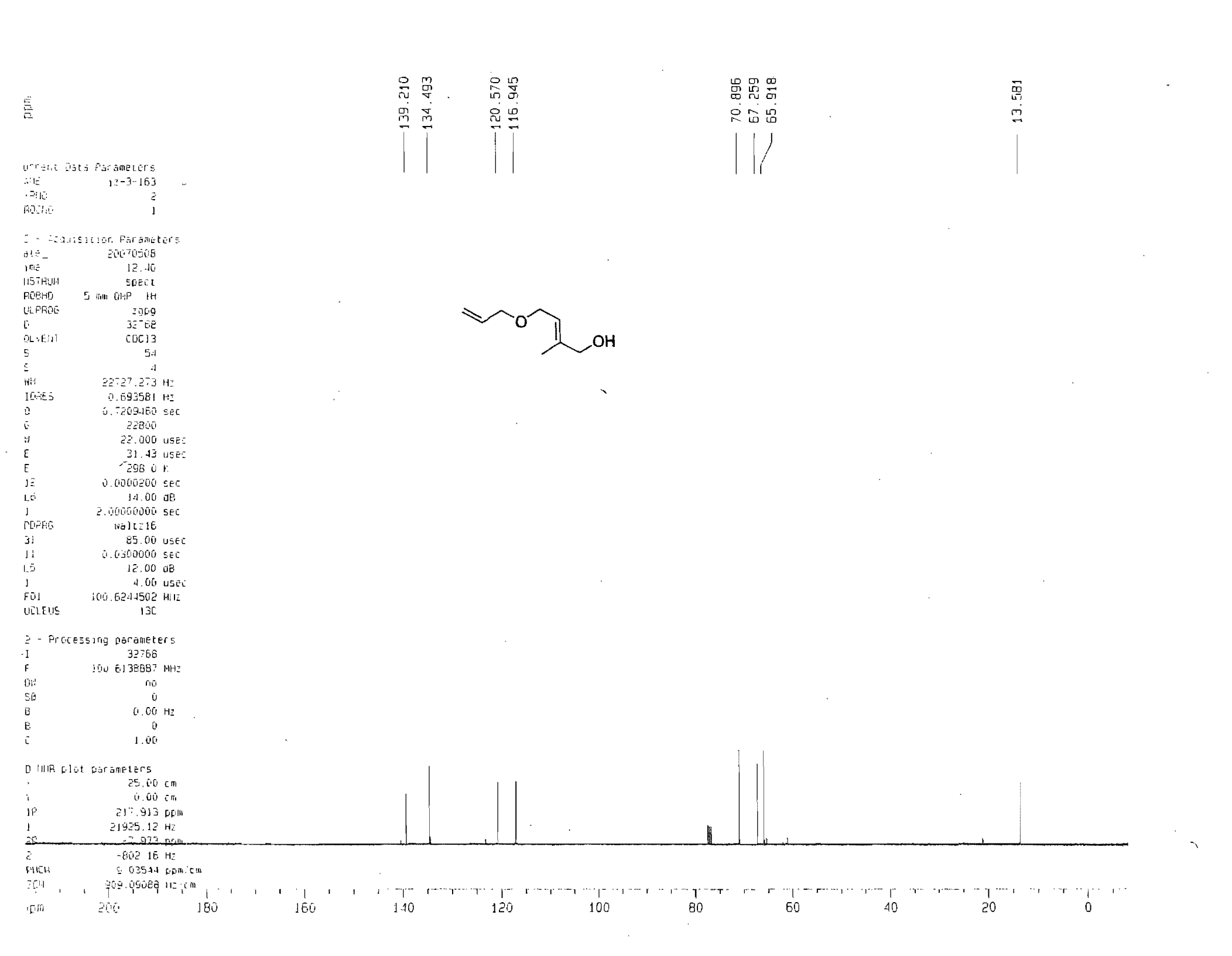
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OH
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ROCNO 1
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IME 12.40
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S 4
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IDRES 0.693581 Hz
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G 22800
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E 31.43 usec
E 298.0 K
JI 0.0000200 sec
L6 14.00 dB
J 2.00000000 sec
DDPRG waltz16
31 85.00 usec
J1 0.0300000 sec
L5 12.00 dB
J 4.00 usec
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ppm
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140
120
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80
60
40
20
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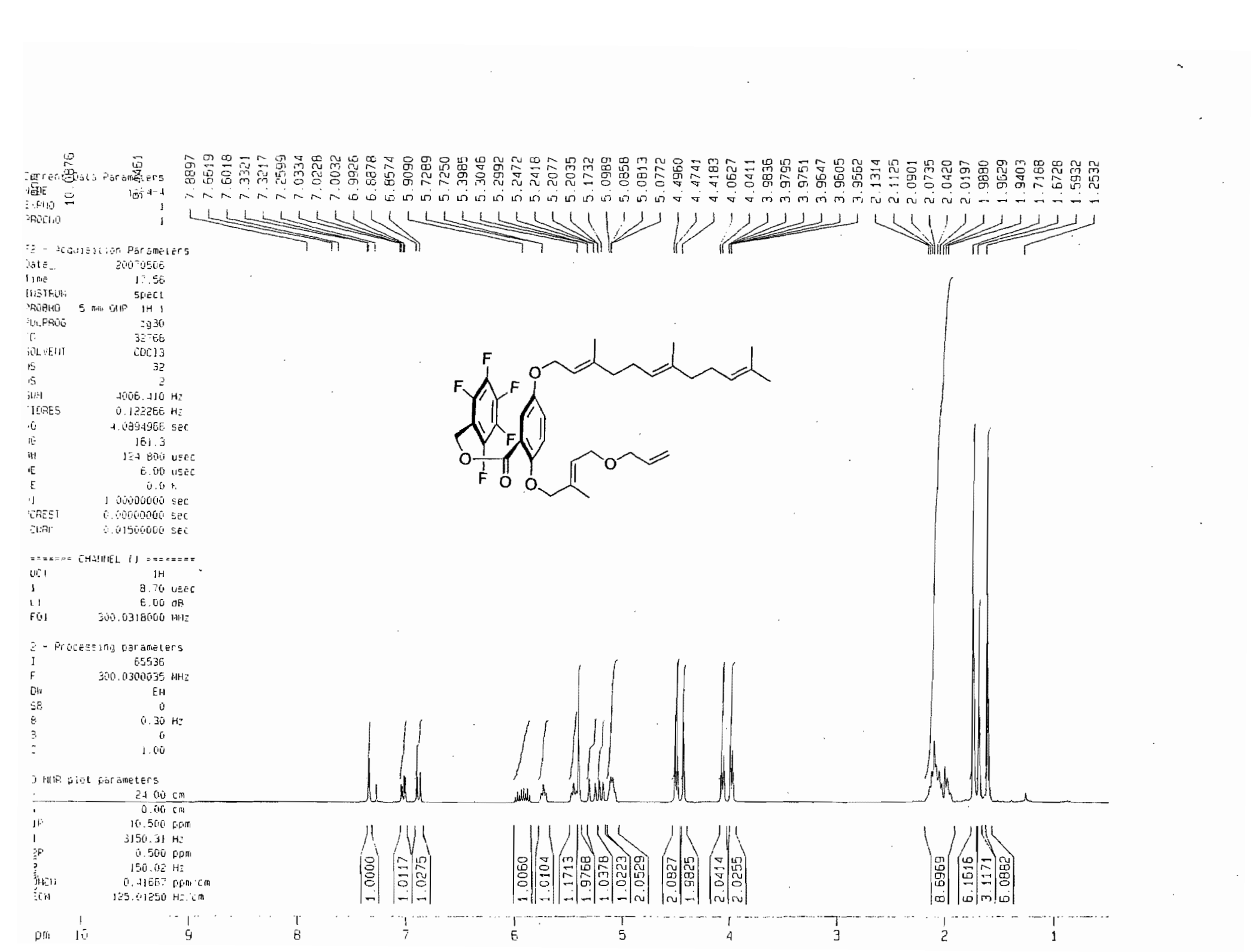
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NS 32
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LB 0.30 Hz
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PC 1.00
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CY 0.00 cm
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F2P 0.500 ppm
F2 150.02 Hz
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HZCM 125.01250 Hz/cm
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7.3321
7.3217
7.2599
7.0334
7.0228
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6.8878
6.8574
5.9090
5.7289
5.7250
5.3985
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5.2992
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5.2077
5.2035
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5.0813
5.0772
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3.9836
3.9795
3.9751
3.9647
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2.1125
2.0901
2.0735
2.0420
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1.9629
1.9403
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1.2532
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F
F
F
O
O
O
O
O
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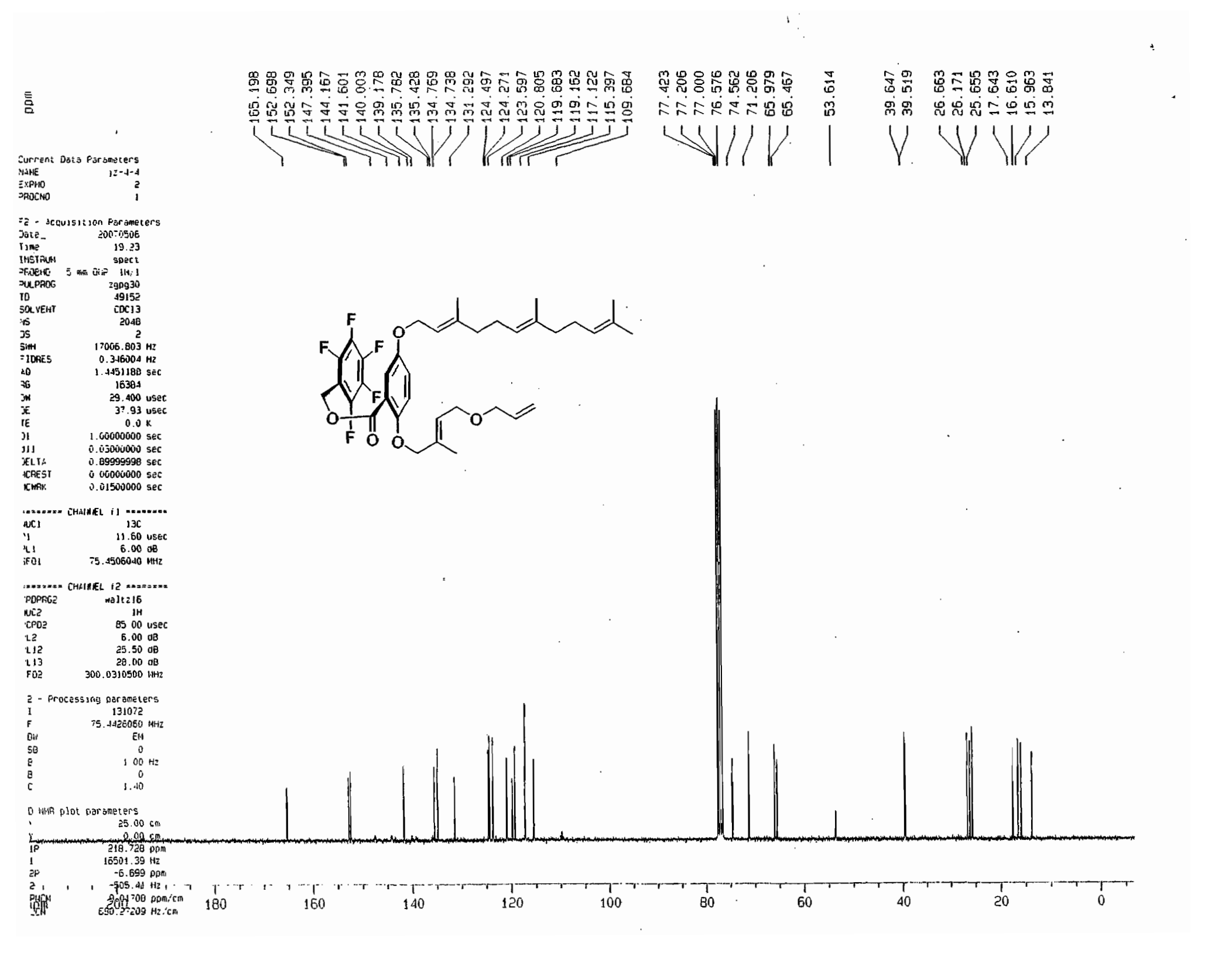
2
1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123.597
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117.122
115.397
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77.000
76.576
74.562
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53.614
39.647
39.519
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25.655
17.643
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15.963
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EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070506
Time 19.23
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PULPROG zgpg30
TD 49152
SOLVENT CDCl3
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DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451188 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
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D11 0.03000000 sec
DELTA 0.89999998 sec
ACREST 0.00000000 sec
ACQMAX 0.01500000 sec
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P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz
======== CHANNEL f2 ========
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NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
2 - Processing parameters
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SF 75.4426060 MHz
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SSB 0
LB 1.00 Hz
GB 0
PC 1.40
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WY 0.00 cm
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PLIN 16501.39 Hz
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HZCM 1287.97209 Hz/cm
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20
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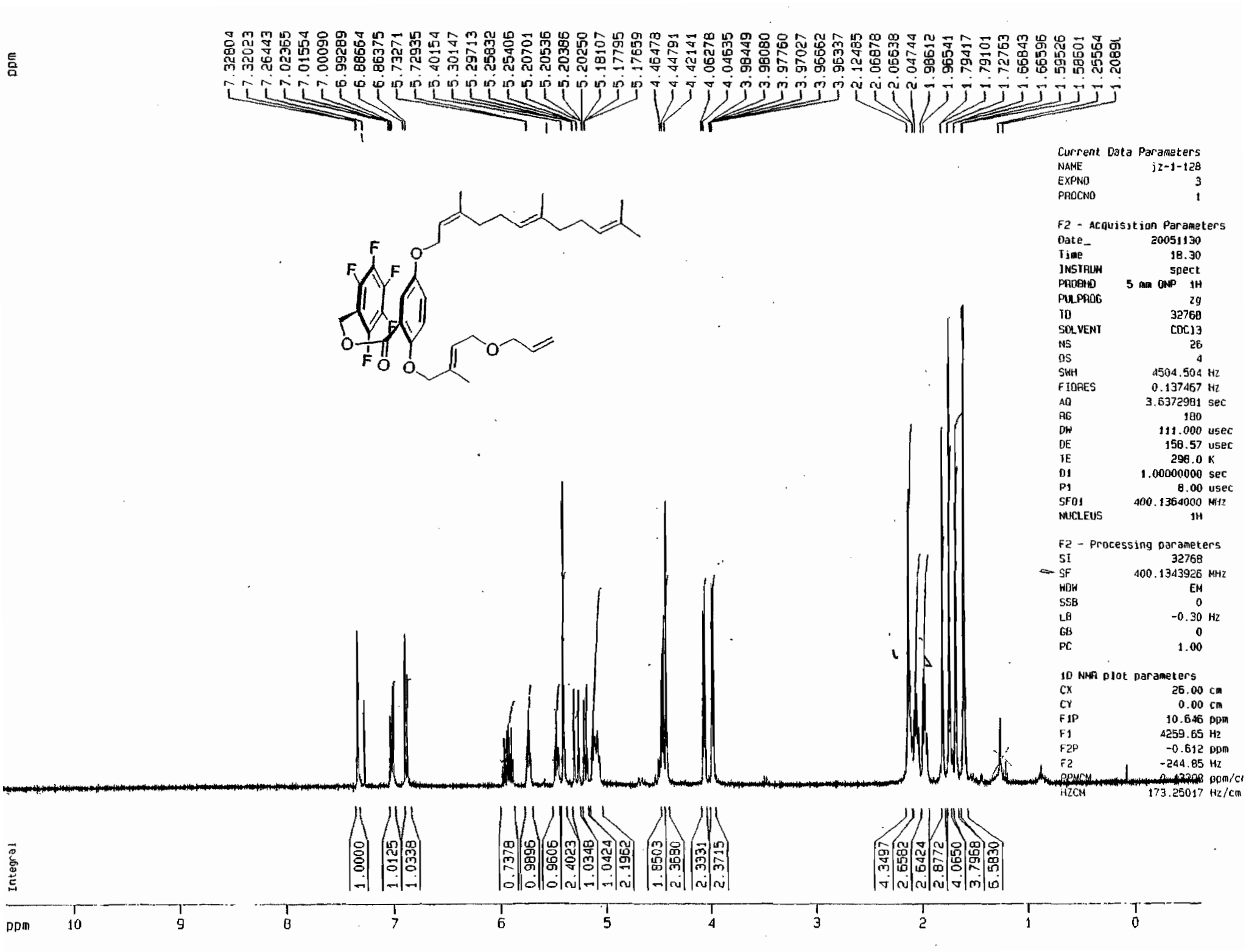
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5.29713
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5.20386
5.20250
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PROCNO 1
F2 - Acquisition Parameters
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Time 18.30
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PULPROG zg
TD 32768
SOLVENT CDCl3
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DS 4
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FIDRES 0.137467 Hz
AQ 3.6372981 sec
RG 180
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DE 158.57 usec
TE 298.0 K
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P1 8.00 usec
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NUCLEUS 1H
F2 - Processing parameters
SI 32768
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WDW EM
SSB 0
LB -0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 26.00 cm
CY 0.00 cm
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F2 -244.85 Hz
PPMCM 0.43208 ppm/cm
HZCM 173.25017 Hz/cm
Integral
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1.0125
1.0338
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0.9896
0.9606
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1.0424
2.1962
1.8503
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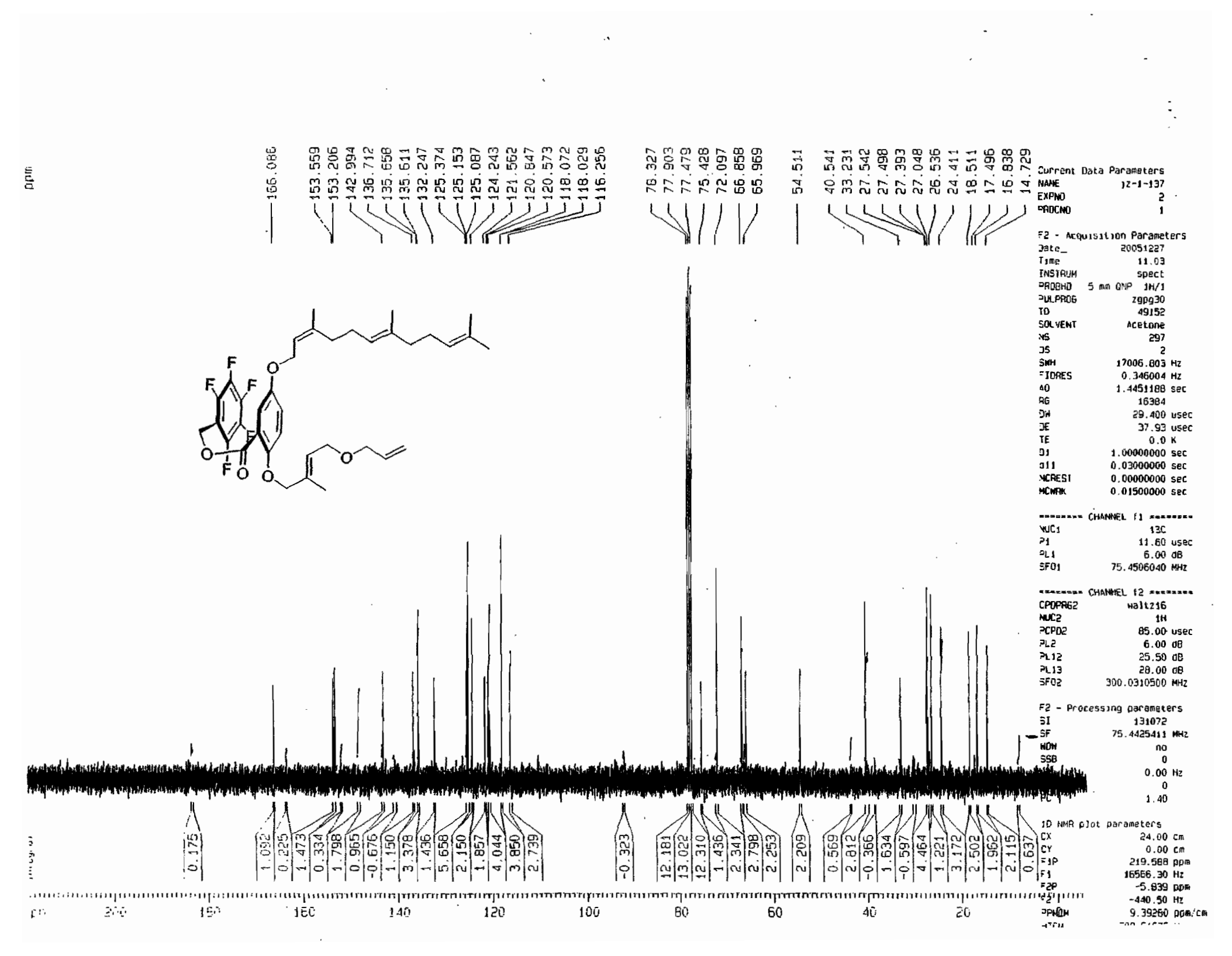

Current Data Parameters

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PROCNO	1

F2 - Acquisition Parameters

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SOLVENT	Acetone
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MCREST	0.00000000 sec
MCWRK	0.01500000 sec

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

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PL1	6.00 dB
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======== CHANNEL f2 ========

CPDPRG2	waltz16
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PCPD2	85.00 usec
PL2	6.00 dB
PL12	25.50 dB
PL13	28.00 dB
SFO2	300.0310500 MHz

F2 - Processing parameters

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SSB	0
LB	0.00 Hz
GB	0
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1D NMR plot parameters

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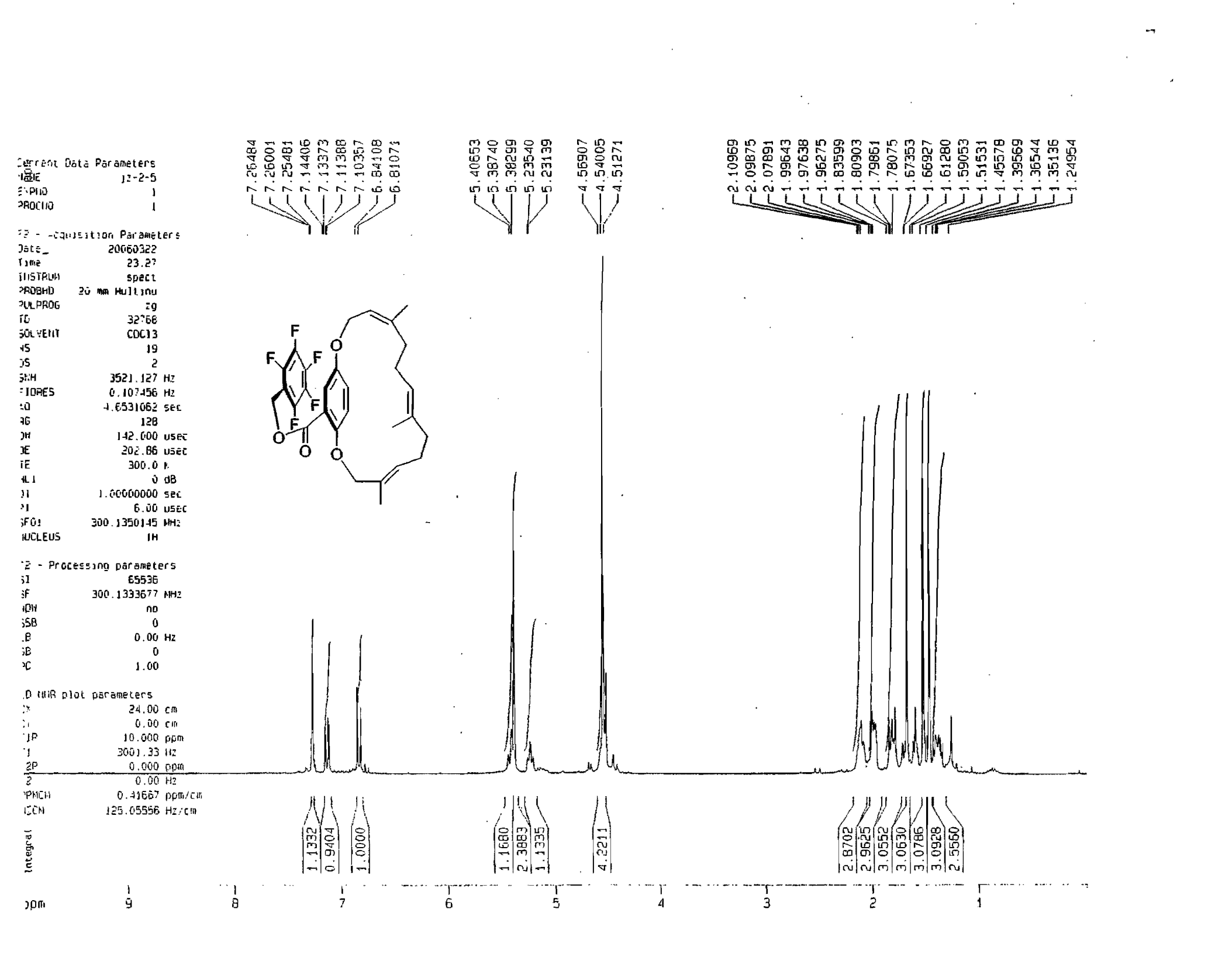
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PROCNO 1
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PULPROG zg
TD 32768
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DS 2
SWH 3521.127 Hz
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AQ 4.6531062 sec
RG 128
DW 142.000 usec
DE 202.86 usec
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NUCLEUS 1H
F2 - Processing parameters
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SSB 0
LB 0.00 Hz
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PC 1.00
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WY 0.00 cm
PLP 10.000 ppm
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F2 0.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 125.05556 Hz/cm
Integral
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7.10357
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5.38299
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1.45578
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1.24954
1.1332
0.9404
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1.1335
4.2211
2.8702
2.9625
3.0552
3.0630
3.0786
3.0928
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8
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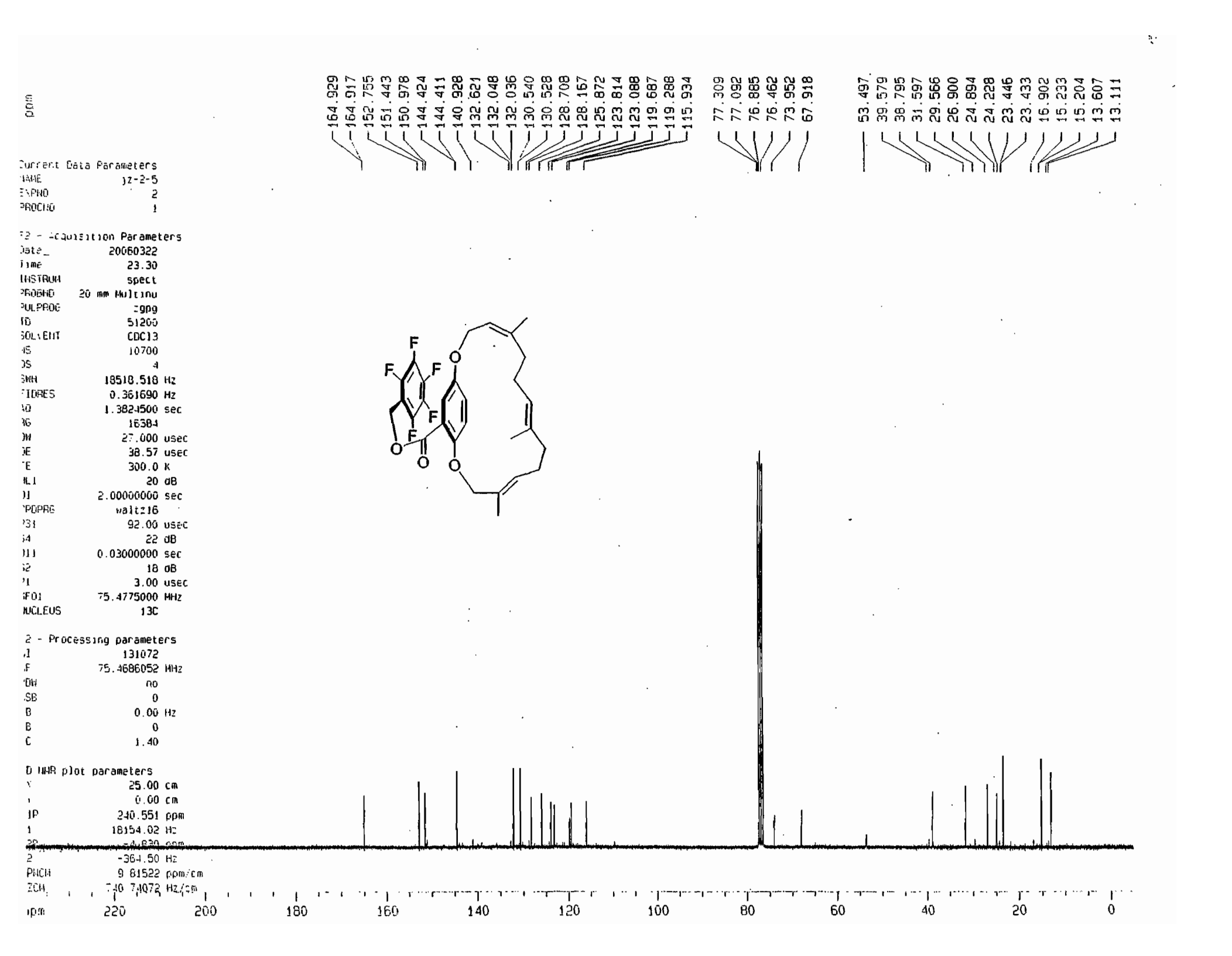
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PROCNO 1
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CPDPRG waltz16
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SI4 22 dB
D11 0.03000000 sec
SI2 18 dB
P1 3.00 usec
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NUCLEUS 13C
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SI 131072
SF 75.4686052 MHz
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LB 0.00 Hz
GB 0
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HZCM 740.74072 Hz/cm
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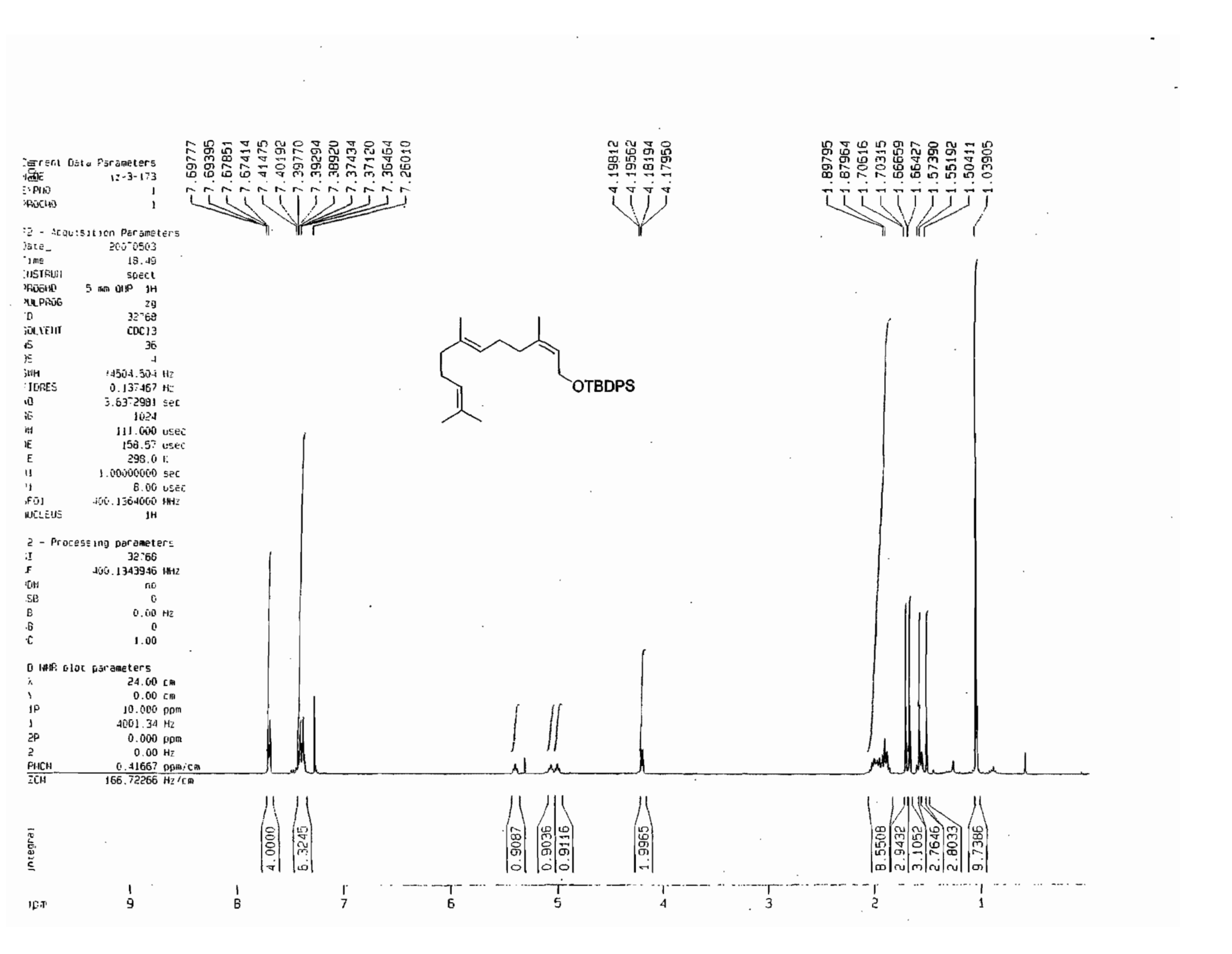
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PULPROG zg
TD 32768
SOLVENT CDCl3
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SWH 4504.504 Hz
FIDRES 0.137467 Hz
AQ 3.6372981 sec
RG 1024
DW 111.000 usec
DE 158.57 usec
TE 298.0 K
D1 1.00000000 sec
D11 6.00 usec
SFO1 400.1364000 MHz
NUCLEUS 1H
F2 - Processing parameters
SI 32768
SF 400.1343946 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
WX 24.00 cm
WY 0.00 cm
F1P 10.000 ppm
F1 4001.34 Hz
F2P 0.000 ppm
F2 0.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 166.72266 Hz/cm
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7.67851
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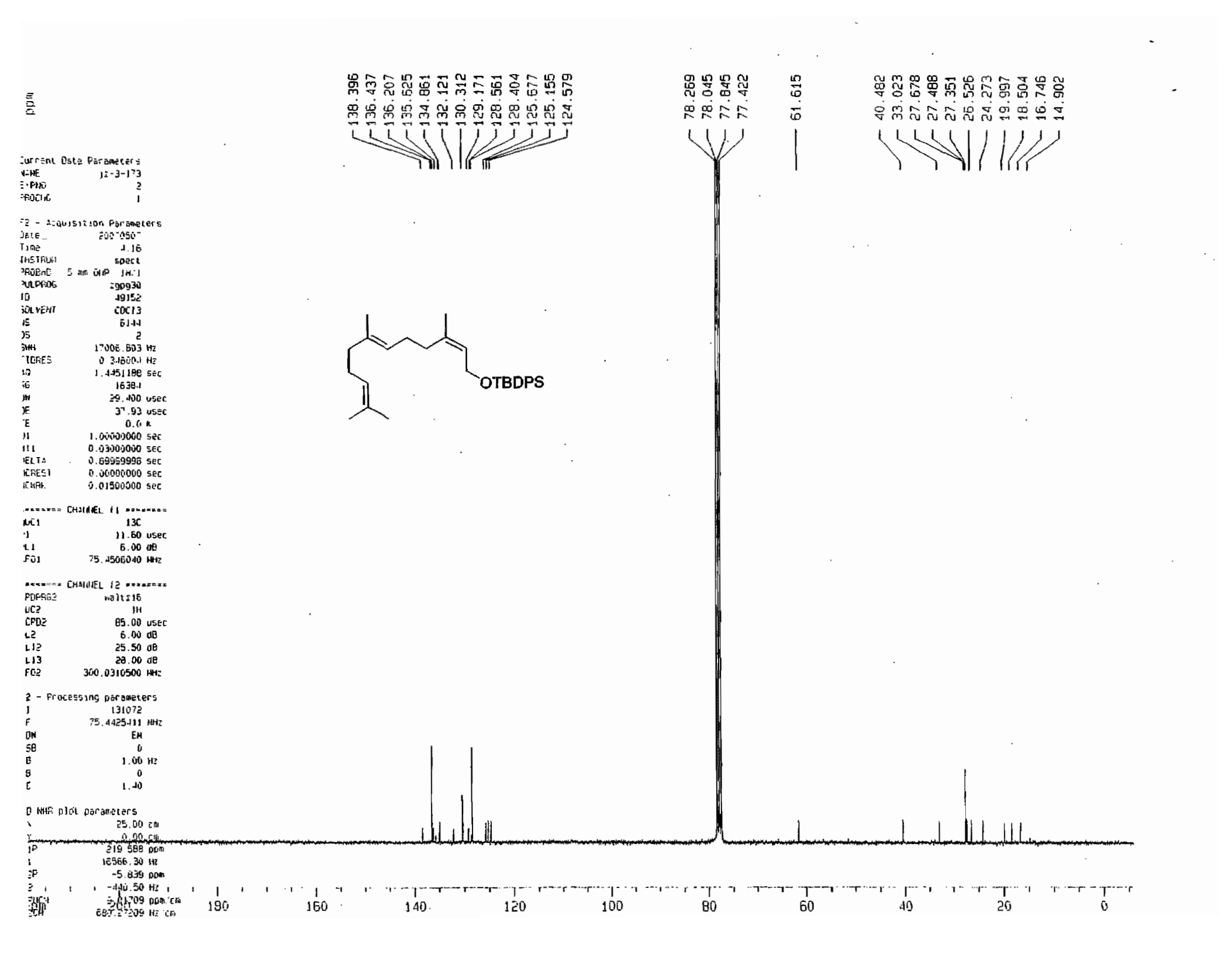
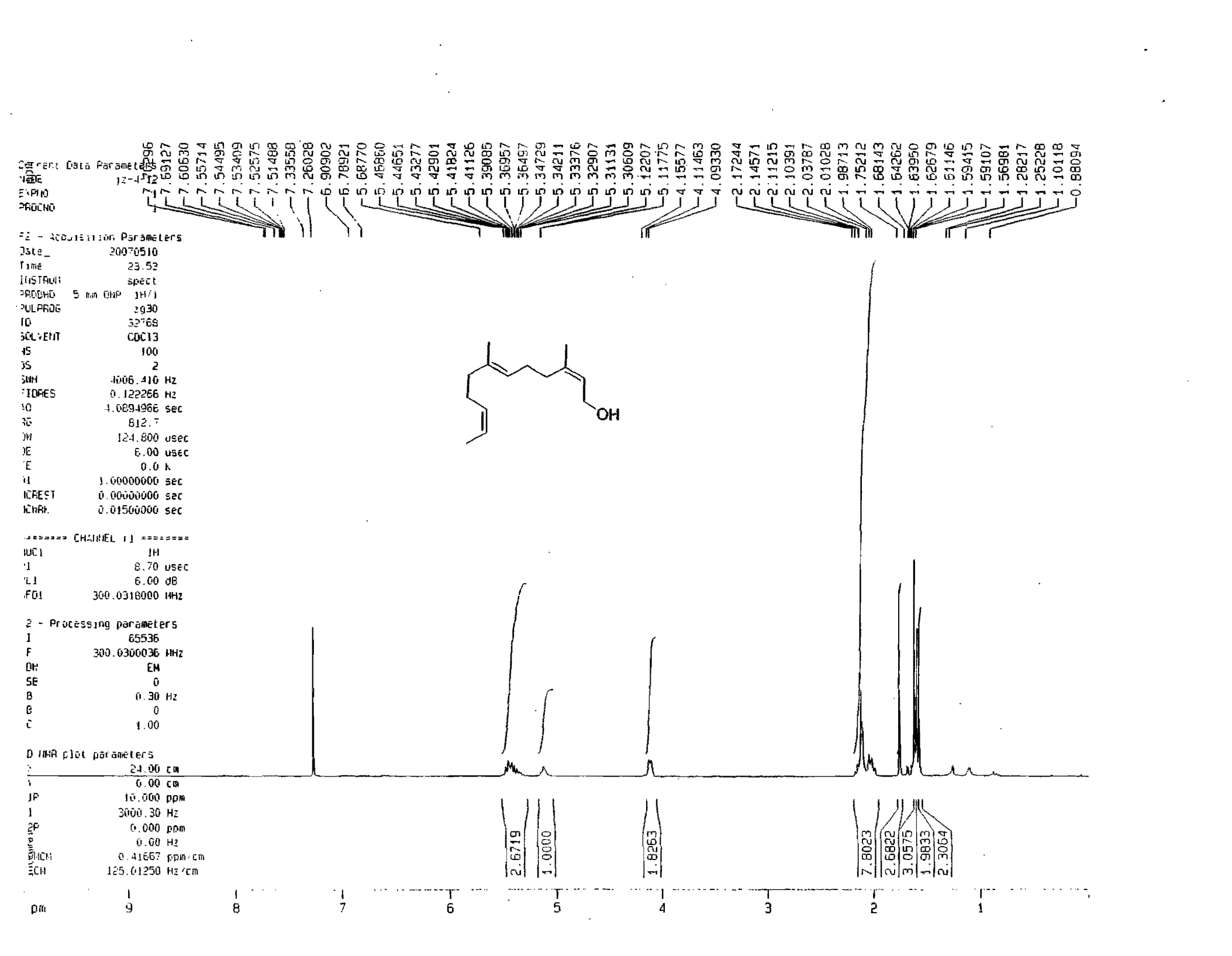
OTBDPS
Integral
4.0000
6.3245
0.9087
0.9036
0.9116
1.9965
8.5508
2.9432
3.1052
2.7646
2.8033
9.7386
ppm
9
8
7
6
5
4
3
2
1


ppm
138.396
136.437
136.207
135.625
134.861
132.121
130.312
129.171
128.561
128.404
125.677
125.155
124.579
78.269
78.045
77.845
77.422
61.615
40.482
33.023
27.678
27.488
27.351
26.526
24.273
19.997
18.504
16.746
14.902
OTBDPS
Current Data Parameters
NAME 12-3-173
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070507
Time 4.16
INSTRUM spect
PROBHD 5 mm QNP 1H/1
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 6144
DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451188 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
DELTA 0.68959998 sec
DCRES1 0.00000000 sec
DCRES2 0.01500000 sec
======== CHANNEL f1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz
======== CHANNEL f2 ========
PDPRG2 waltz16
NUC2 1H
CPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
F2 - Processing parameters
SI 131072
SF 75.4425411 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
WX 25.00 cm
WY 0.00 cm
PPMCM 219.588 ppm
HZCM 16566.30 Hz
PPMPOS -5.839 ppm
HZPOS -440.50 Hz
PPMCM 5.01709 ppm/cm
HZCM 687.17209 Hz/cm
190
160
140
120
100
80
60
40
20
0



1 - Acquisition Parameters

Date_	20070510
Time	23.53
INSTRUM	spect
PROBHD	5 mm DNP 1H/1
PULPROG	zg30
TD	32768
SOLVENT	CDCl3
NS	100
DS	2
SWH	4006.410 Hz
FIDRES	0.122266 Hz
AQ	4.0894966 sec
RG	812.7
DW	124.800 usec
DE	6.00 usec
TE	0.0 K
D1	1.00000000 sec
D12	0.00000000 sec
D13	0.01500000 sec

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

NUC1	1H
P1	8.70 usec
PL1	6.00 dB
SFO1	300.0318000 MHz

2 - Processing parameters

SI	65536
SF	300.0300036 MHz
WDW	EM
SSB	0
LB	0.30 Hz
GB	0
PC	1.00

1H NMR plot parameters

WC	24.00 cm
WS	0.00 cm
SPLP	10.000 ppm
SPL	3000.30 Hz
SPLP2	0.000 ppm
SPL2	0.00 Hz
SPECHCM	0.41667 ppm/cm
SPECHCH	125.01250 Hz/cm

ppm

Current Data Parameters
NAME 12-4-12
EXPNO 2
PROCNO 1

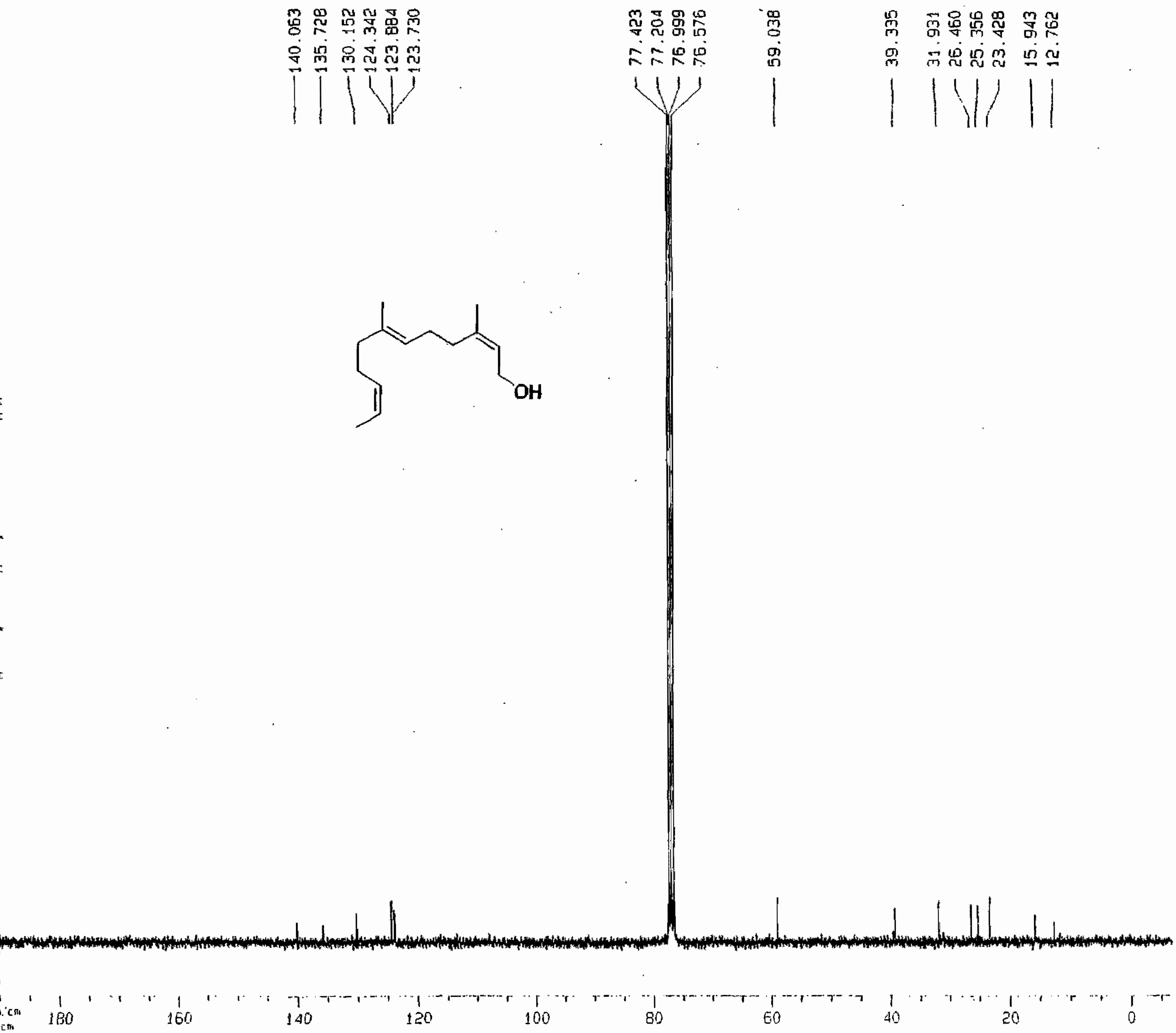
F2 - Acquisition Parameters
Date_ 20070511
Time 1 20
INSTRUM spect
PROBHD 5 mm QNP 1H.1
PULPROG zgpg30
TD 49152
SOLVENT CDC13
NS 2048
DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451168 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
d11 0.03000000 sec
DELTA 0.89999998 sec
INCREST 0.00000000 sec
DWRK 0.01500000 sec

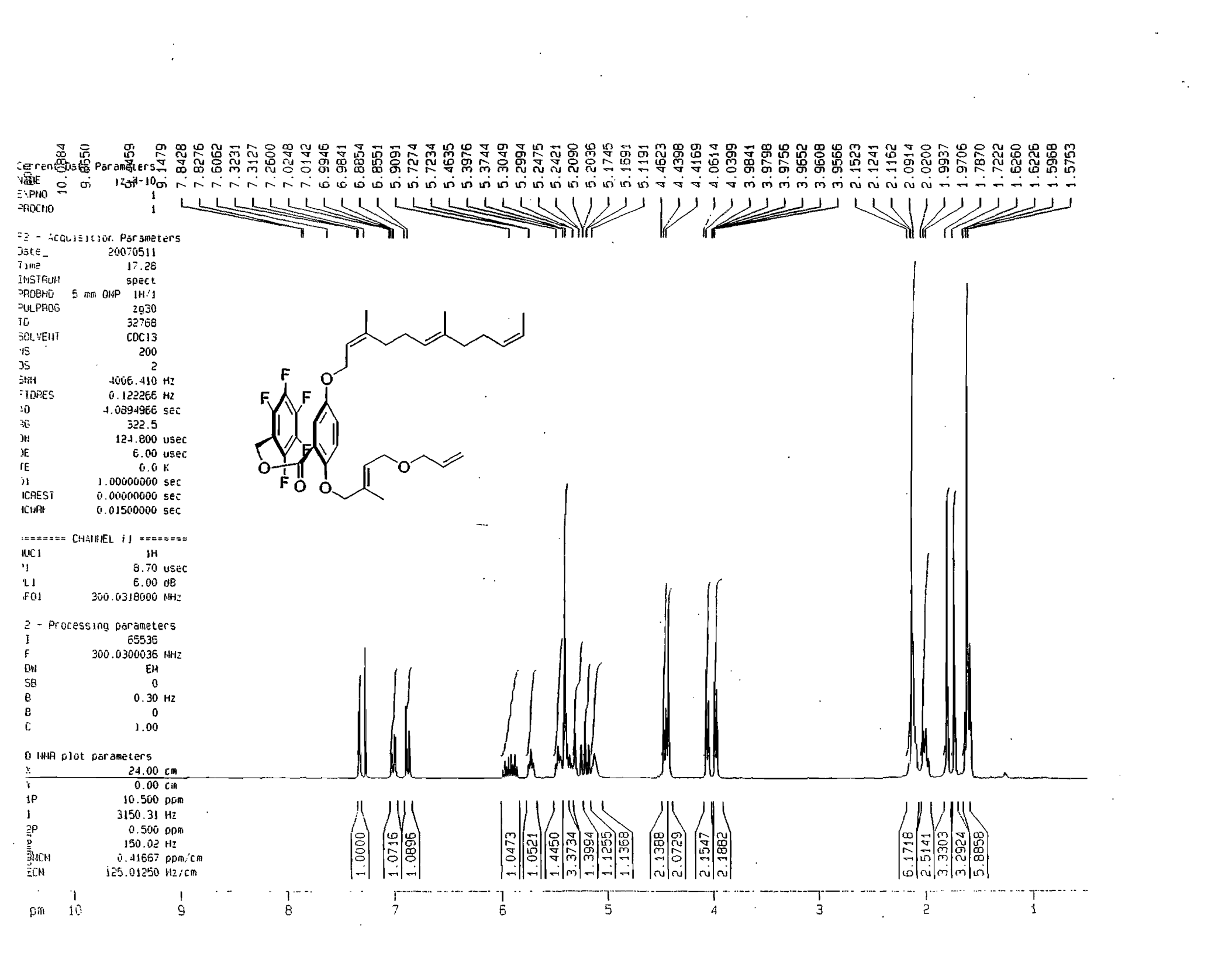
======= CHANNEL f1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz

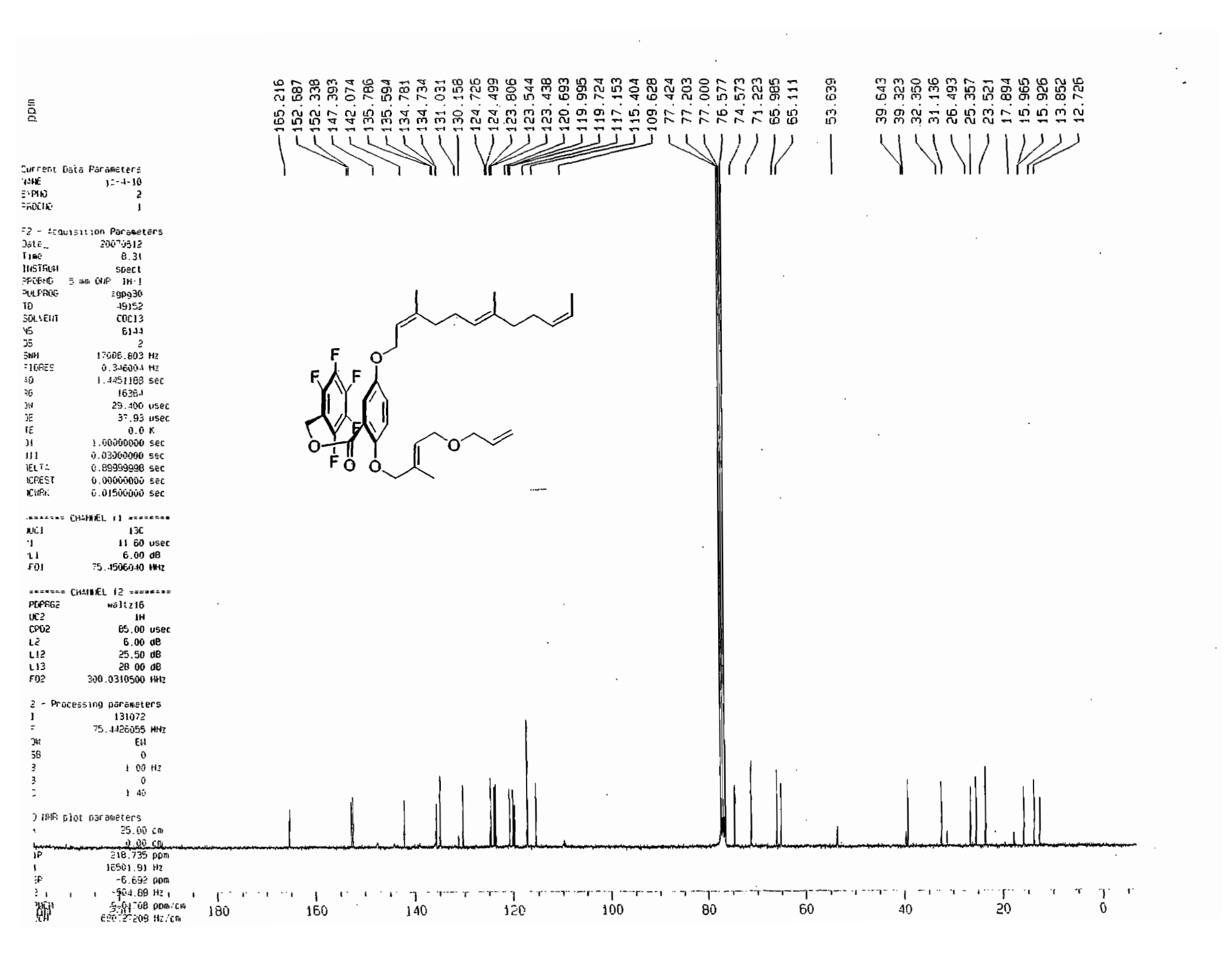
======= CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz

F2 - Processing parameters
SI 131072
SF 75.4426050 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40

1D NMR plot parameters
CX 25.00 cm
CY 0.00 cm
F1P 218.741 ppm
F1 16502.43 Hz
F2P -6.666 ppm
F2 -504.37 Hz
PPMCM 9.01758 ppm/cm
HZCM 680.27209 Hz/cm




10.0884 9.8550 9.1479 7.8428 7.8276 7.6062 7.3231 7.3127 7.2600 7.0248 7.0142 6.9946 6.9841 6.8854 6.8551 5.9091 5.7274 5.7234 5.4635 5.3976 5.3744 5.3049 5.2994 5.2475 5.2421 5.2090 5.2036 5.1745 5.1691 5.1191 4.4623 4.4398 4.4169 4.0614 4.0399 3.9841 3.9798 3.9756 3.9652 3.9608 3.9566 2.1523 2.1241 2.1162 2.0914 2.0200 1.9937 1.9706 1.7870 1.7222 1.6260 1.6226 1.5968 1.5753
Current Data Parameters
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070511
Time 17.28
INSTRUM spect
PROBHD 5 mm QNP 1H/1
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 200
DS 2
SWH 4006.410 Hz
FIDRES 0.122266 Hz
AQ 4.0894966 sec
RG 322.5
DW 124.800 usec
DE 6.00 usec
TE 0.0 K
D1 1.00000000 sec
D12REST 0.00000000 sec
D13WAR 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 8.70 usec
PL1 6.00 dB
SFO1 300.0318000 MHz
F2 - Processing parameters
SI 65536
SF 300.0300036 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
WX 24.00 cm
WY 0.00 cm
PLVP 10.500 ppm
PLVI 3150.31 Hz
PLSP 0.500 ppm
PLSI 150.02 Hz
PLSCAL 0.41667 ppm/cm
PLSCAL 125.01250 Hz/cm
1.0000 1.0716 1.0896 1.0473 1.0521 1.4450 3.3734 1.3994 1.1255 1.1368 2.1388 2.0729 2.1547 2.1882 6.1718 2.5141 3.3303 3.2924 5.8858
F F F O O F O O O F O
ppm 10 9 8 7 6 5 4 3 2 1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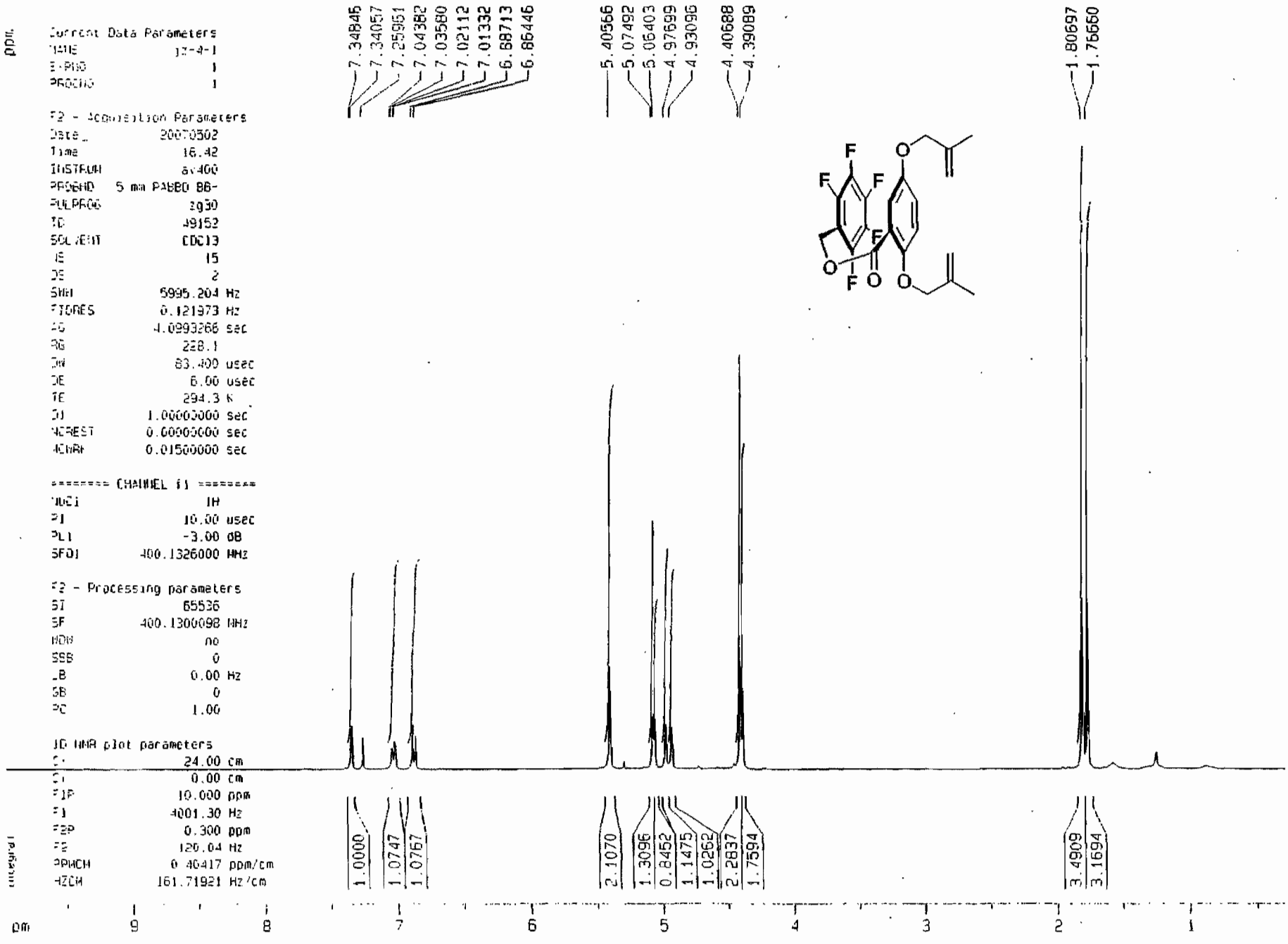
165.216
152.687
152.338
147.393
142.074
135.786
135.594
134.781
134.734
131.031
130.158
124.726
124.499
123.806
123.544
123.438
120.693
119.995
119.724
117.153
115.404
109.628
77.424
77.203
77.000
76.577
74.573
71.223
65.985
65.111
53.639
39.643
39.323
32.350
31.136
26.493
25.357
23.521
17.894
15.965
15.926
13.852
12.726
Current Data Parameters
F2 - Acquisition Parameters
Date_ 20070512
Time 8.31
INSTRUM spect
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 6144
DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451188 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
DELTA 0.89999998 sec
DCREST 0.00000000 sec
DCHAN 0.01500000 sec
======== CHANNEL f1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz
======== CHANNEL f2 ========
PCPD2 waltz16
NUC2 1H
CPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
F2 - Processing parameters
SI 131072
SF 75.4426055 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
WP 18501.91 Hz
SP -6.692 ppm
PCH 5.01708 ppm/cm
CH 666.27209 Hz/cm
180
160
140
120
100
80
60
40
20
0


Current Data Parameters
NAME jz-4-1
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070502
Time 16.42
INSTRUM av400
PROBHD 5 mm PABBO BB-
PULPROG zg30
TD 49152
SOLVENT CDCl3
NS 16
DS 2
SWH 5995.204 Hz
FIDRES 0.121973 Hz
AQ 4.0993266 sec
RG 228.1
DW 83.400 usec
DE 6.00 usec
TE 294.3 K
D1 1.00000000 sec
MCREST 0.00000000 sec
MCWRK 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 10.00 usec
PL1 -3.00 dB
SFO1 400.1326000 MHz
F2 - Processing parameters
SI 65536
SF 400.1300098 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 24.00 cm
CY 0.00 cm
F1P 10.000 ppm
F1 4001.30 Hz
F2P 0.300 ppm
F2 120.04 Hz
PPMCM 0.40417 ppm/cm
HZCM 161.71921 Hz/cm
7.34845
7.34057
7.25951
7.04382
7.03580
7.02112
7.01332
6.88713
6.86446
5.40566
5.07492
5.06403
4.97699
4.93096
4.40688
4.39089
1.80697
1.76660
1.0000
1.0747
1.0767
2.1070
1.3096
0.8452
1.1475
1.0262
2.2837
1.7594
3.4909
3.1694
ppm
Integral
9
8
7
6
5
4
3
2
1

ppm

Current Data Parameters
NAME jz-4-1
EXPNO 2
PROCNO 1

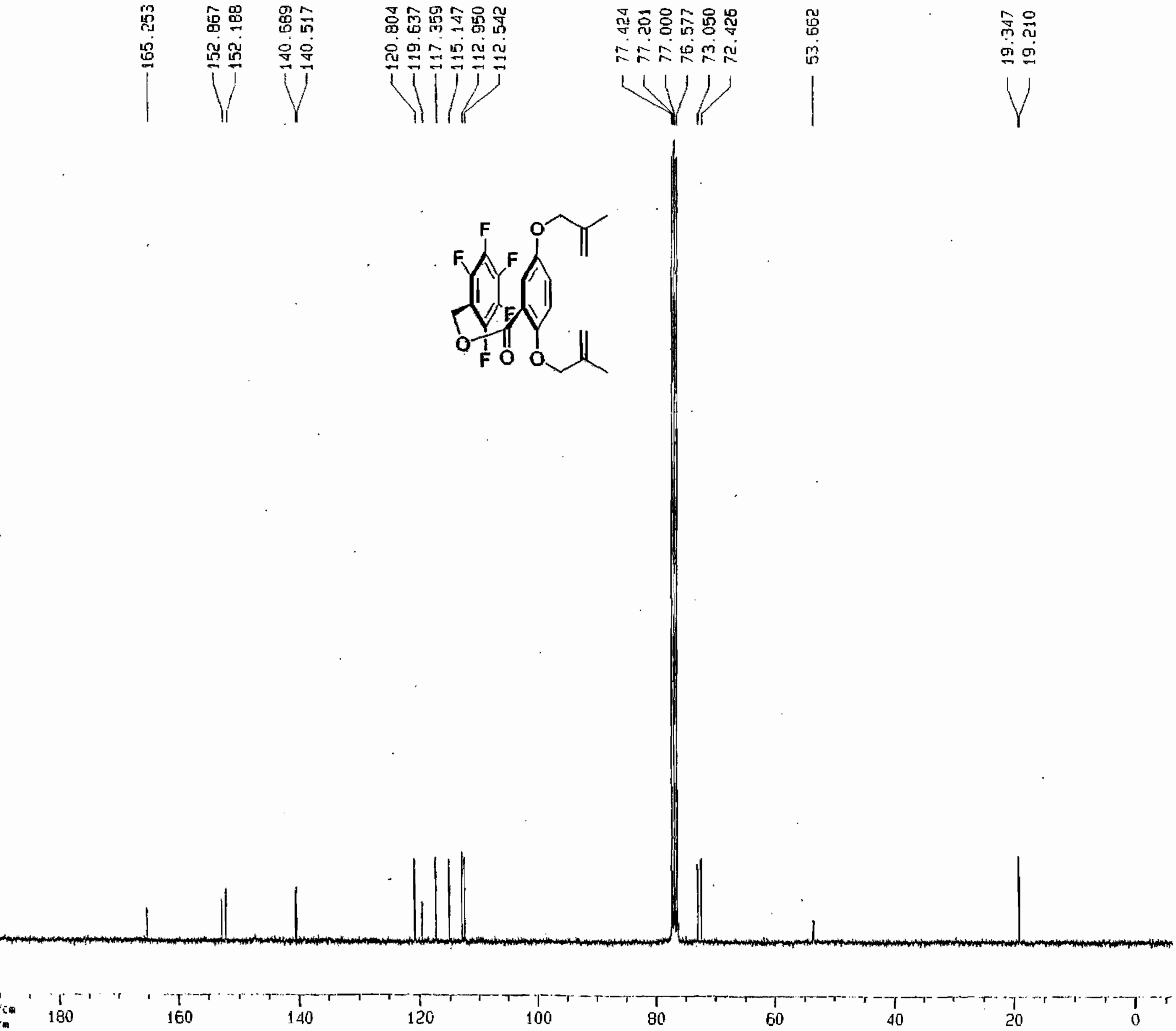
F2 - Acquisition Parameters
Date_ 20070502
Time 19.48
INSTRUM spect
PROBHD 5 mm DNP 1H/1
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 3000
DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451188 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
d11 0.03000000 sec
DELTA 0.89999998 sec
MCREST 0.00000000 sec
MCWRK 0.01500000 sec

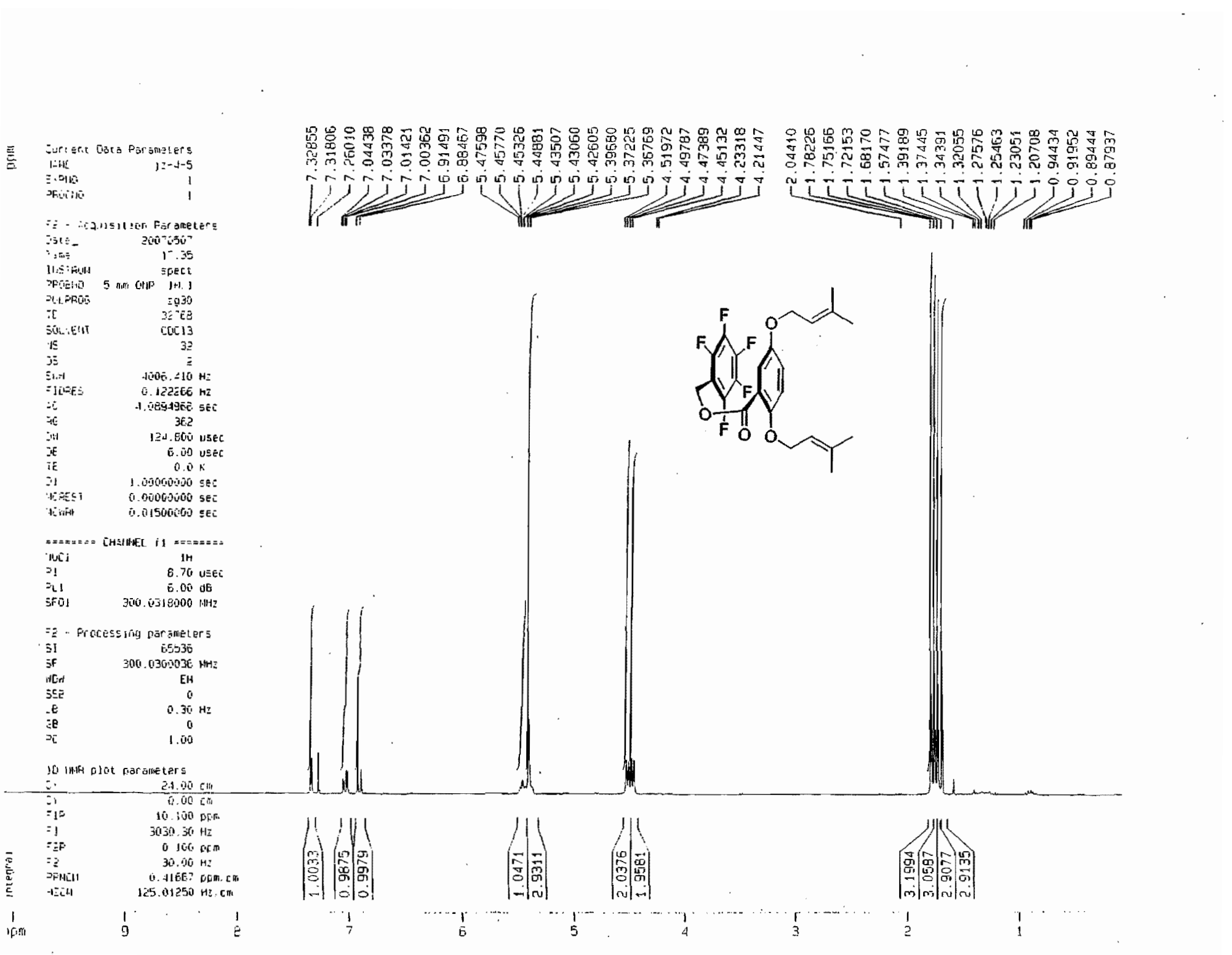
======= CHANNEL f1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz

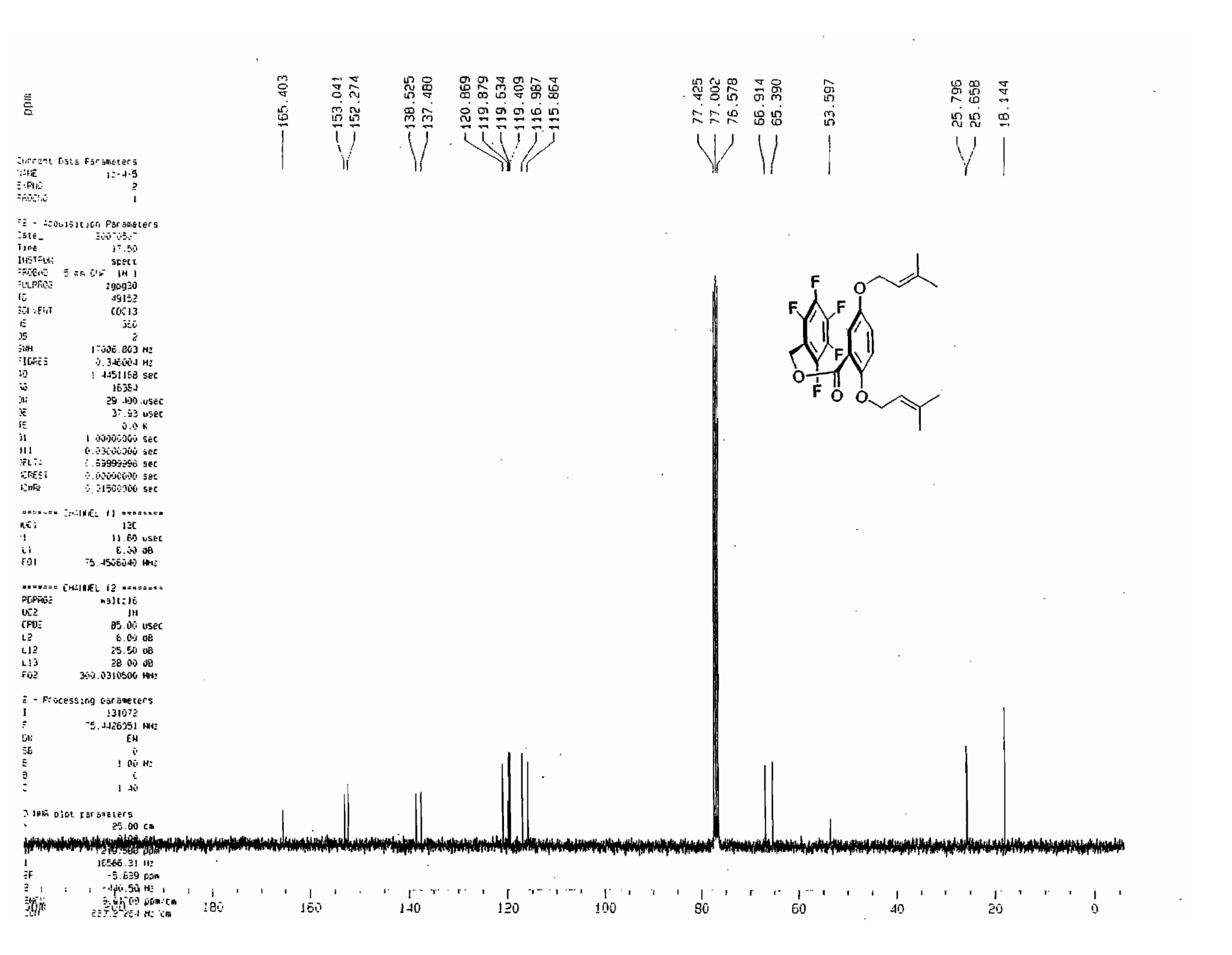
======= CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 26.00 dB
SFO2 300.0310500 MHz

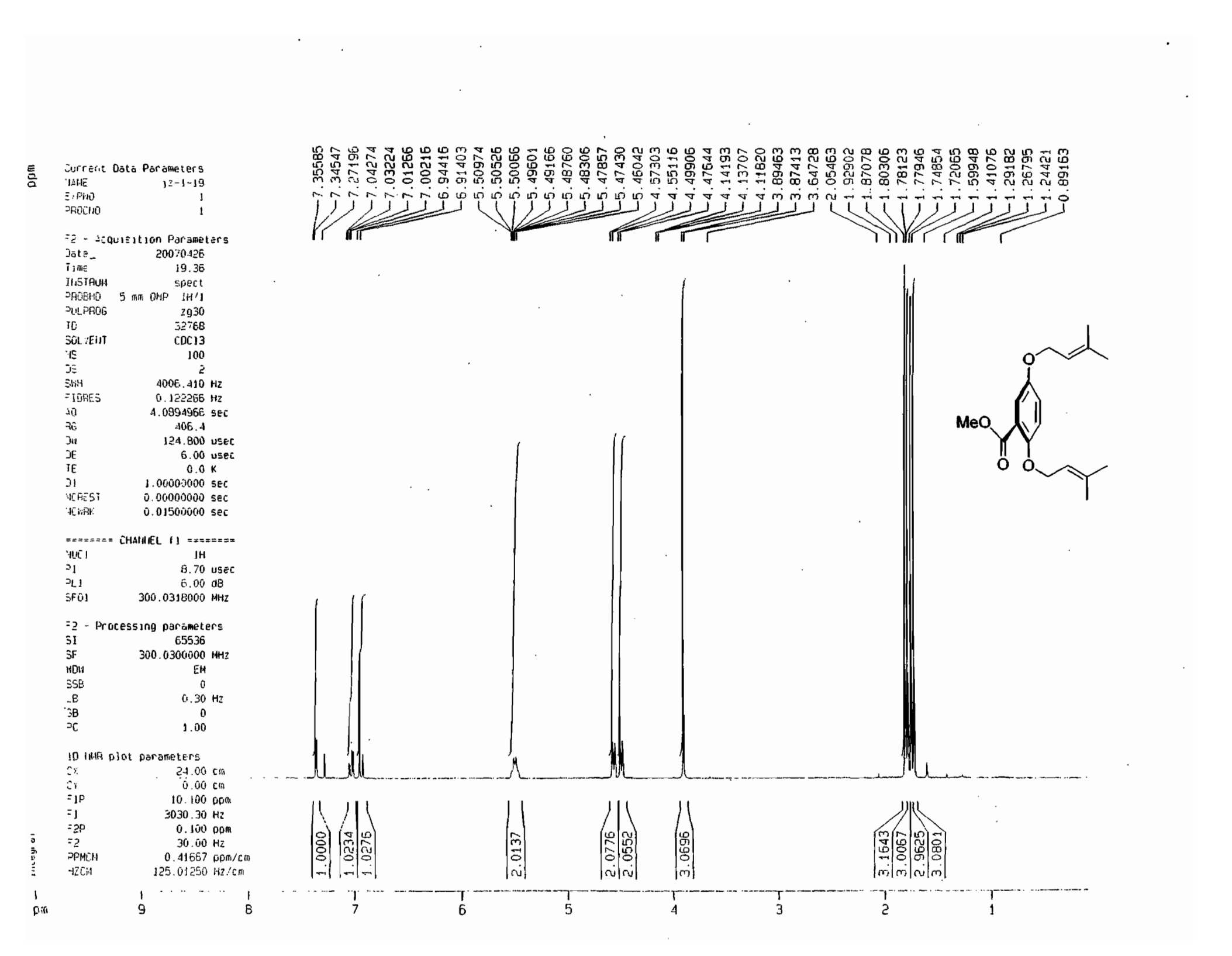
F2 - Processing parameters
SI 131072
SF 75.4426050 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40

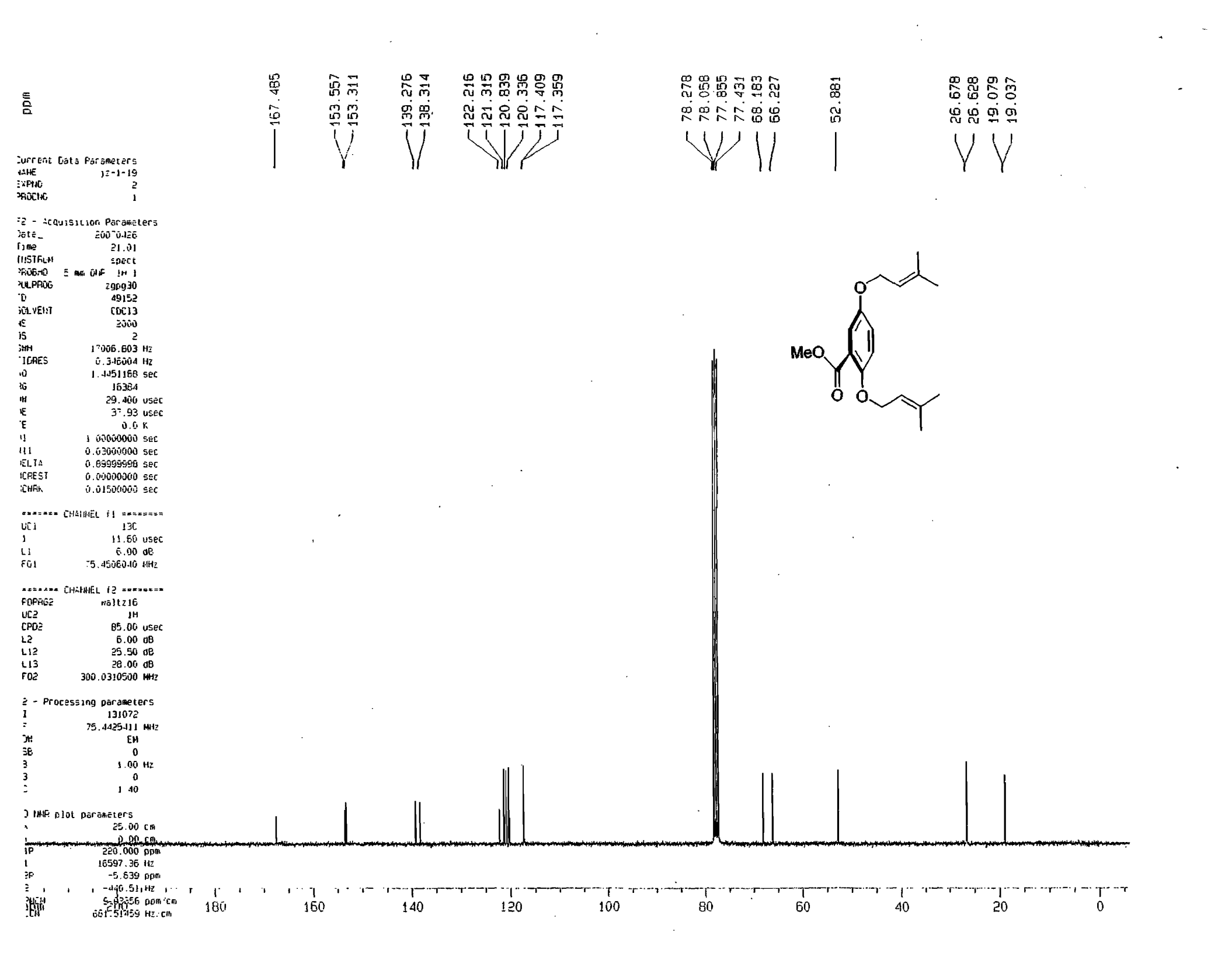
1D NMR plot parameters
CX 25.00 cm
CY 0.00 cm
F1P 219.588 ppm
F1 16566.31 Hz
F2P -5.839 ppm
F2 -440.50 Hz
PPMCM 9.01709 ppm/cm
HZCM 680.27264 Hz/cm




Current Data Parameters
NAME jz-4-5
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070507
Time 17.35
INSTRUM spect
PROBHD 5 mm ONP 1H-1
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 32
DS 2
SWH 4006.410 Hz
FIDRES 0.122266 Hz
AQ 4.0894968 sec
RG 362
DW 124.800 usec
DE 6.00 usec
TE 0.0 K
D1 1.00000000 sec
MCREST 0.00000000 sec
MCWRK 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 8.70 usec
PL1 6.00 dB
SFO1 300.0318000 MHz
F2 - Processing parameters
SI 65536
SF 300.0300036 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 24.00 cm
CY 0.00 cm
F1P 10.100 ppm
F1 3030.30 Hz
F2P 0.100 ppm
F2 30.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 125.01250 Hz/cm
7.32855
7.31806
7.26010
7.04438
7.03378
7.01421
7.00362
6.91491
6.88467
5.47598
5.45770
5.45326
5.44881
5.43507
5.43060
5.42605
5.39680
5.37225
5.36769
4.51972
4.49787
4.47389
4.45132
4.23318
4.21447
2.04410
1.78226
1.75166
1.72153
1.68170
1.57477
1.39189
1.37445
1.34391
1.32055
1.27576
1.25463
1.23051
1.20708
0.94434
0.91952
0.89444
0.87937
F
F
F
F
O
O
O
O
1.0033
0.9675
0.9979
1.0471
2.9311
2.0376
1.9581
3.1994
3.0587
2.9077
2.9135
ppm
9
8
7
6
5
4
3
2
1


ppm
165.403
153.041
152.274
138.525
137.480
120.869
119.879
119.634
119.409
116.987
115.864
77.425
77.002
76.578
66.914
65.390
53.597
25.796
25.658
18.144
Current Data Parameters
1 - Acquisition Parameters
Time 17.50
INSTRUM spect
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 32
DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451158 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
D12 0.00002000 sec
TD0 1
====== CHANNEL f1 ======
NUC1 13C
P1 11.60 usec
PL1 6.50 dB
SFO1 75.4506040 MHz
====== CHANNEL f2 ======
PCPD2 waltz16
NUC2 1H
CPDP 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
2 - Processing parameters
SI 131072
SF 75.4426051 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1 1H plot parameters
CX 25.00 cm
F1P 219.580 ppm
F1 16566.31 Hz
F2P -5.839 ppm
F2 -440.50 Hz
PPMCM 8.41709 ppm/cm
HZCM 357.2 284 Hz/cm
F
F
F
F
O
O
O
O
F
O
180
160
140
120
100
80
60
40
20
0


Current Data Parameters
NAME 12-1-19
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070426
Time 19.36
INSTRUM spect
PROBHD 5 mm ONP 1H/1
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 100
DS 2
SWH 4006.410 Hz
FIDRES 0.122266 Hz
AQ 4.0894966 sec
RG 406.4
DW 124.800 usec
DE 6.00 usec
TE 0.0 K
D1 1.00000000 sec
MCREST 0.00000000 sec
MCWRK 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 8.70 usec
PL1 6.00 dB
SFO1 300.0318000 MHz
F2 - Processing parameters
SI 65536
SF 300.0300000 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 24.00 cm
CY 0.00 cm
F1P 10.100 ppm
F1 3030.30 Hz
F2P 0.100 ppm
F2 30.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 125.01250 Hz/cm
7.35585
7.34547
7.27196
7.04274
7.03224
7.01266
7.00216
6.94416
6.91403
5.50974
5.50526
5.50066
5.49601
5.49166
5.48760
5.48306
5.47857
5.47430
5.46042
4.57303
4.55116
4.49906
4.47644
4.14193
4.13707
4.11820
3.89463
3.87413
3.64728
2.05463
1.92902
1.87078
1.80306
1.78123
1.77946
1.74854
1.72065
1.59948
1.41076
1.29182
1.26795
1.24421
0.89163
MeO
O
O
O
O
1.0000
1.0234
1.0276
2.0137
2.0776
2.0552
3.0696
3.1643
3.0067
2.9625
3.0801
ppm
9
8
7
6
5
4
3
2
1


ppm
167.485
153.557
153.311
139.276
138.314
122.216
121.315
120.839
120.336
117.409
117.359
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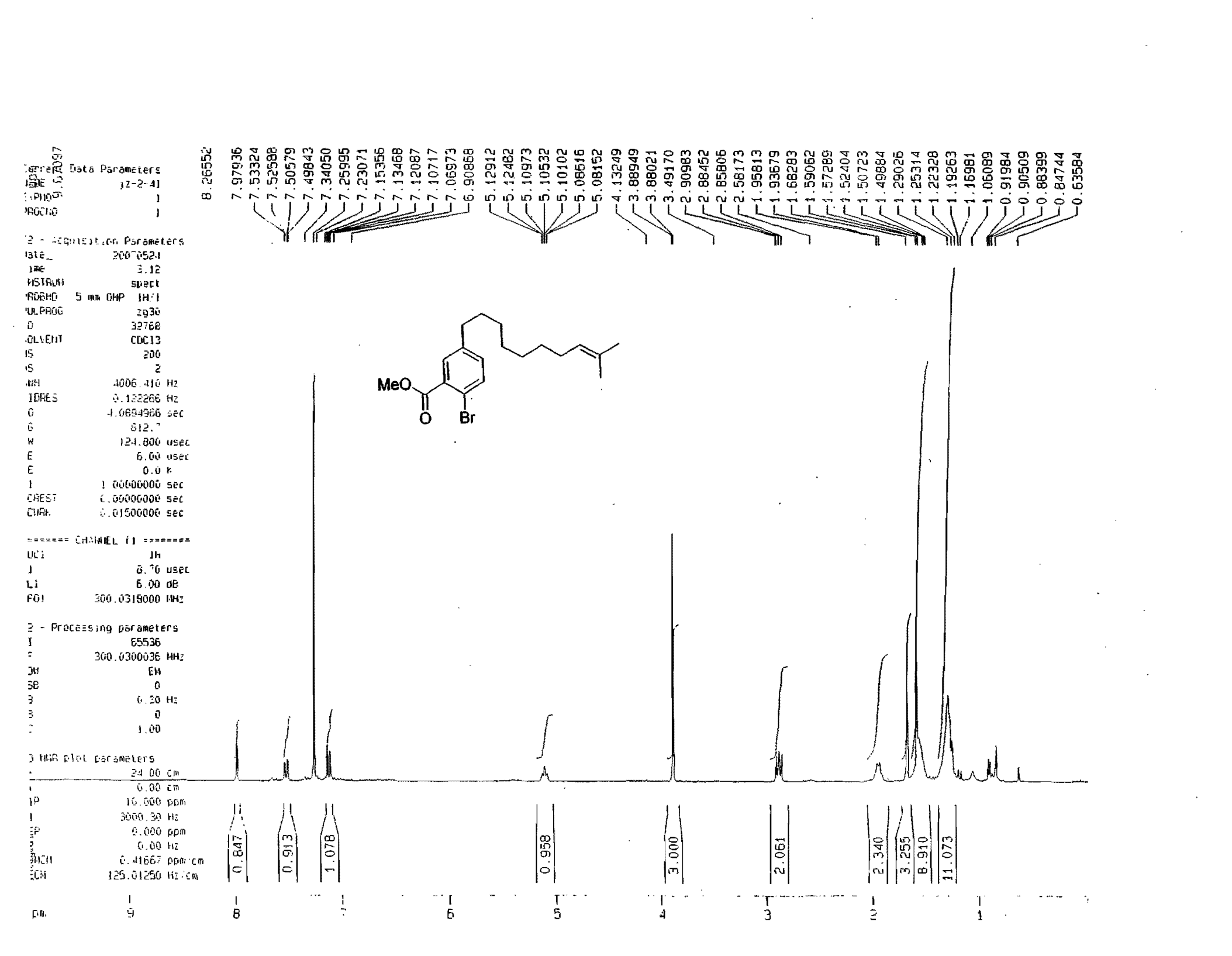
78.058
77.855
77.431
68.183
66.227
52.881
26.678
26.628
19.079
19.037
MeO
O
O
O
Current Data Parameters
NAME pz-1-19
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070426
Time 21.01
INSTRUM spect
PROBHD 5 mm DUL 1H-1
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451168 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
DELTA 0.89999998 sec
PCREST 0.00000000 sec
PCHRK 0.01500000 sec
======= CHANNEL f1 =======
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz
======= CHANNEL f2 =======
DECOUPLE waltz16
NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
F2 - Processing parameters
SI 131072
SF 75.4425411 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
WC 25.00 cm
WS 0.00 cm
FP 220.000 ppm
FL 16597.36 Hz
FP -5.639 ppm
FL -440.51 Hz
PHCH 5.83356 ppm/cm
HZCM 661.51459 Hz/cm
180
160
140
120
100
80
60
40
20
0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O
Br
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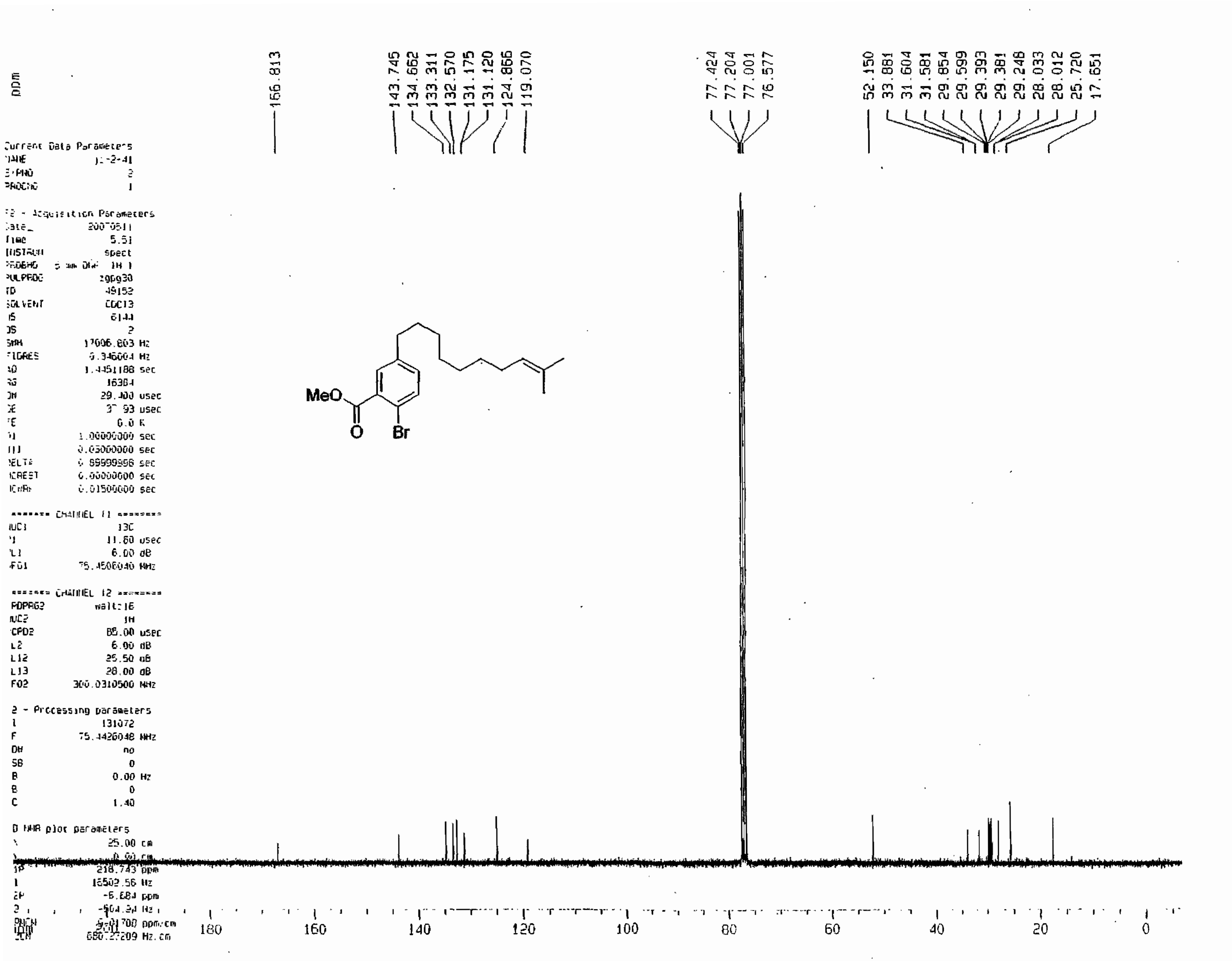
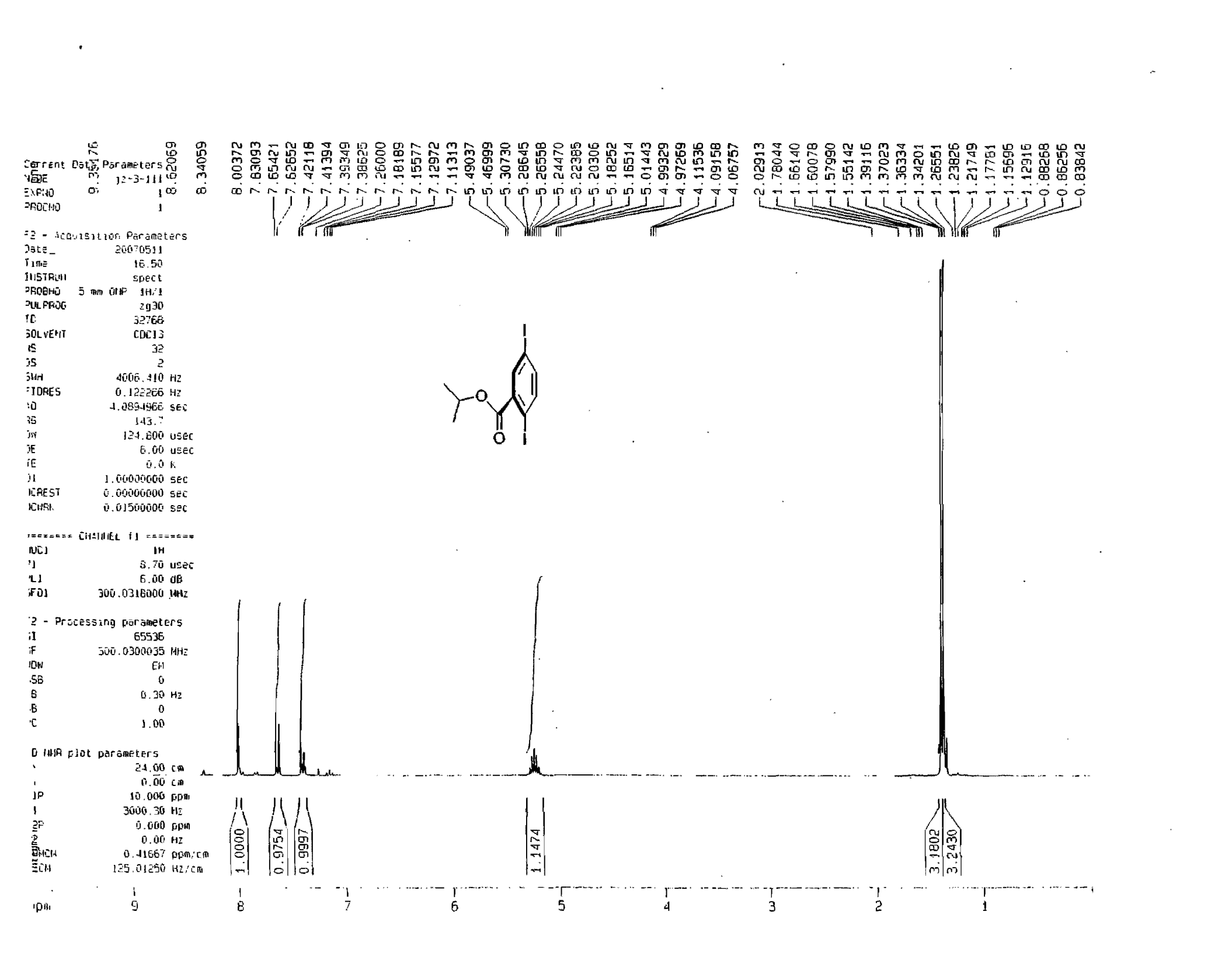
7.53324
7.52588
7.50579
7.49843
7.34050
7.25995
7.23071
7.15356
7.13468
7.12087
7.10717
7.06973
6.90868
5.12912
5.12482
5.10973
5.10532
5.10102
5.08616
5.08152
4.13249
3.88949
3.88021
3.49170
2.90983
2.88452
2.85806
2.58173
1.95813
1.93679
1.68283
1.59062
1.57289
1.52404
1.50723
1.49884
1.29026
1.25314
1.22328
1.19263
1.16981
1.06089
0.91984
0.90509
0.88399
0.84744
0.63584
0.847
0.913
1.078
0.958
3.000
2.061
2.340
3.255
8.910
11.073
ppm
9
8
6
5
4
3
1



ppm
166.813
143.745
134.662
133.311
132.570
131.175
131.120
124.866
119.070
77.424
77.204
77.001
76.577
52.150
33.881
31.604
31.581
29.854
29.599
29.393
29.381
29.248
28.033
28.012
25.720
17.651
Current Data Parameters
F2 - Acquisition Parameters
Time 5.51
INSTRUM spect
TD 49152
SOLVENT CDCl3
NS 6144
DS 2
DE 6.0 K
D1 1.00000000 sec
======= CHANNEL f1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
======= CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
F2 - Processing parameters
SI 131072
SF 75.4426048 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
CX 25.00 cm
F1P 218.743 ppm
F1 16502.56 Hz
F2P -6.684 ppm
MeO
O
Br
180
160
140
120
100
80
60
40
20
0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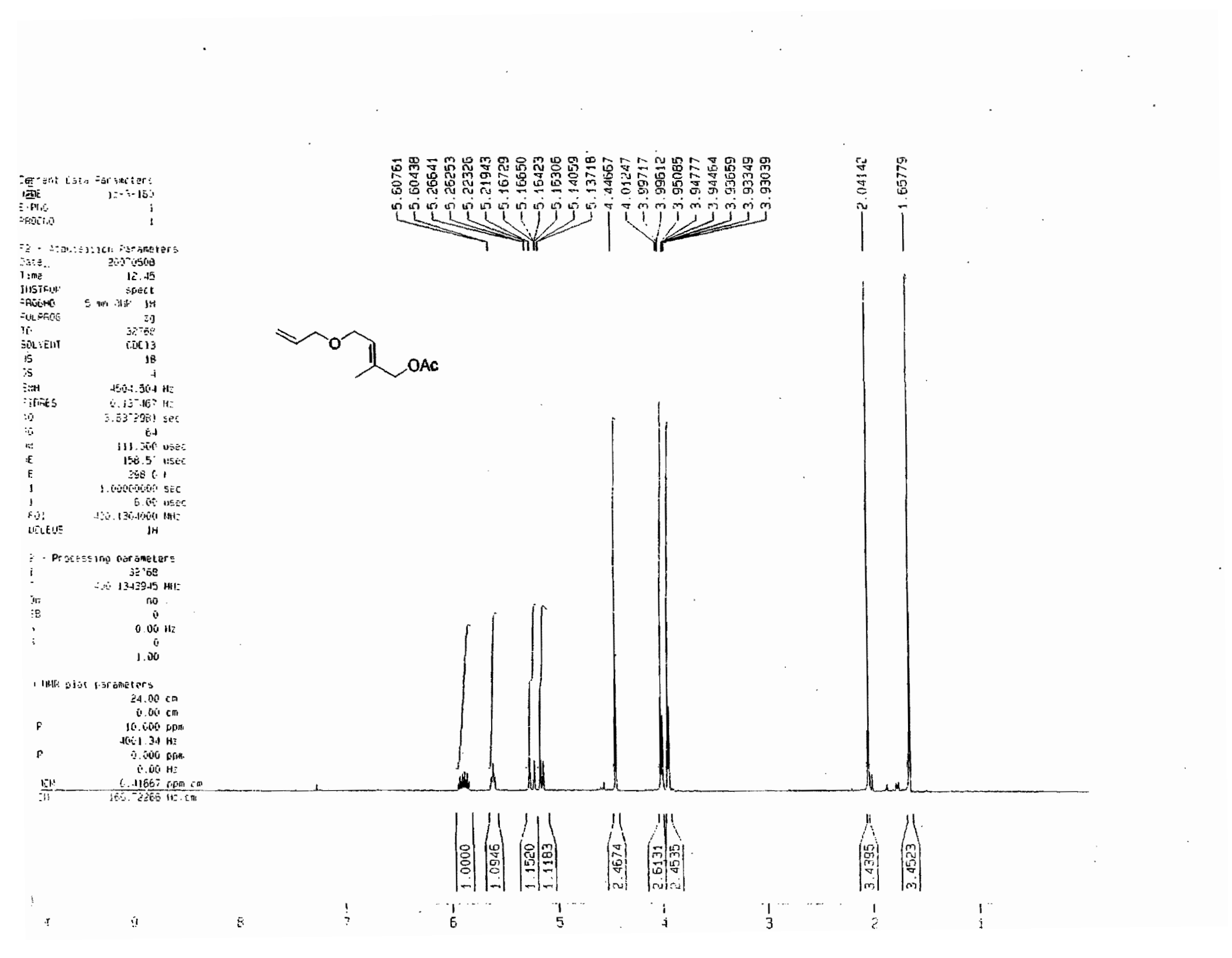
NAME 12-3-111
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070511
Time 16.50
INSTRUM spect
PROBHD 5 mm ONP 1H/1
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 32
DS 2
SWH 4006.410 Hz
FIDRES 0.122266 Hz
AQ 4.0894966 sec
RG 143.7
DW 124.800 usec
DE 6.00 usec
TE 0.0 K
D1 1.00000000 sec
D12REST 0.00000000 sec
D13RSR 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 8.70 usec
PL1 6.00 dB
SFO1 300.0318000 MHz
F2 - Processing parameters
SI 65536
SF 300.0300035 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
WC 24.00 cm
WC2 0.00 cm
SP 10.000 ppm
SW 3000.30 Hz
SP 0.000 ppm
SP 0.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 125.01250 Hz/cm
8.62069
8.34059
8.00372
7.83093
7.65421
7.62652
7.42118
7.41394
7.39349
7.38625
7.26000
7.18189
7.15577
7.12972
7.11313
5.49037
5.46999
5.30730
5.28645
5.26558
5.24470
5.22385
5.20306
5.18252
5.16514
5.01443
4.99329
4.97269
4.11536
4.09158
4.06757
2.02913
1.78044
1.66140
1.60078
1.57990
1.55142
1.39116
1.37023
1.36334
1.34201
1.26551
1.23826
1.21749
1.17761
1.15696
1.12916
0.88268
0.86256
0.83842
1.0000
0.9754
0.9997
1.1474
3.1802
3.2430
ppm
9
8
7
6
5
4
3
2
1

142.463
141.105
139.142
138.909
137.479
93.146
93.071
77.321
77.003
70.686
70.526
69.985
69.732
31.491
29.613
22.573
21.842
21.755
21.674
14.094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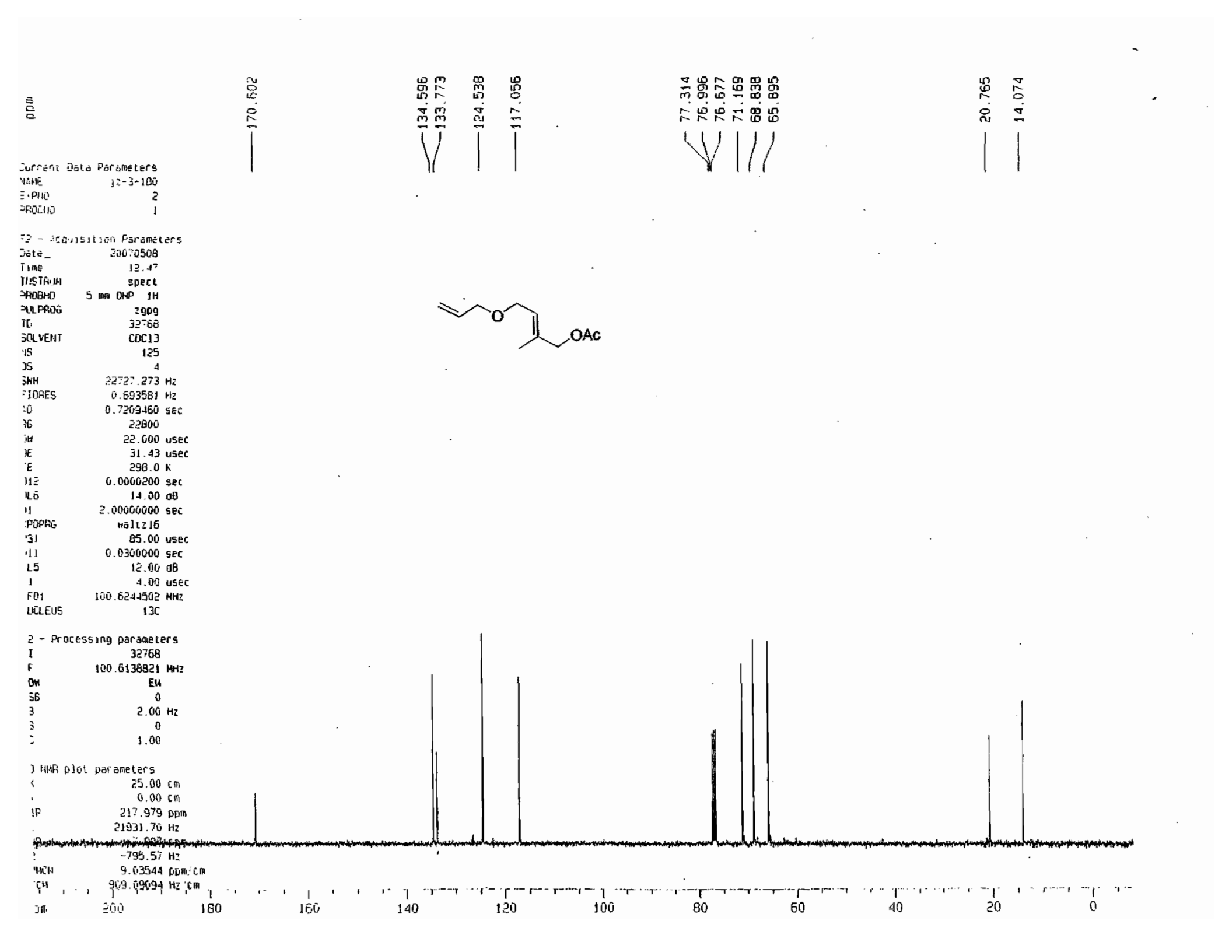
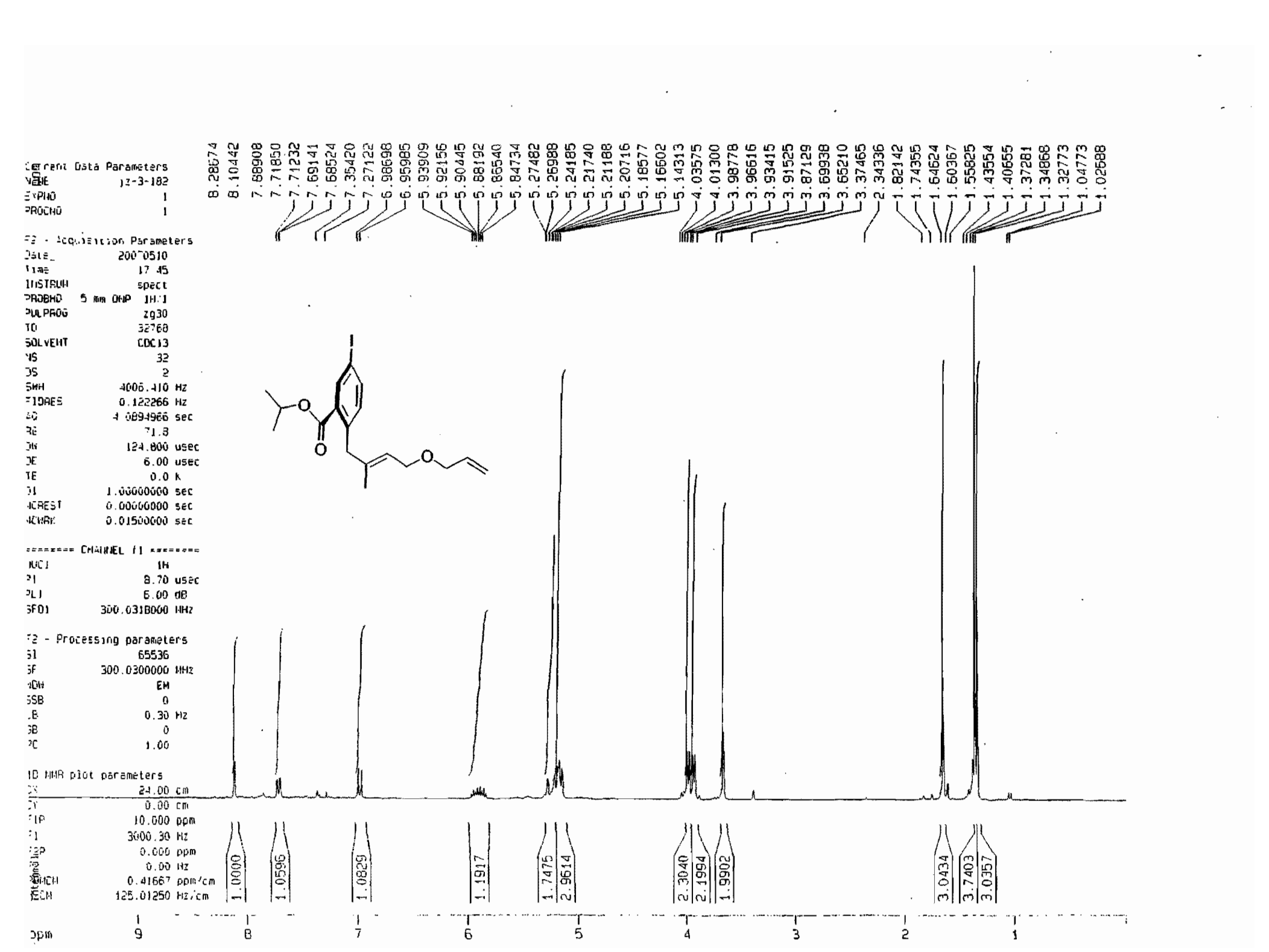
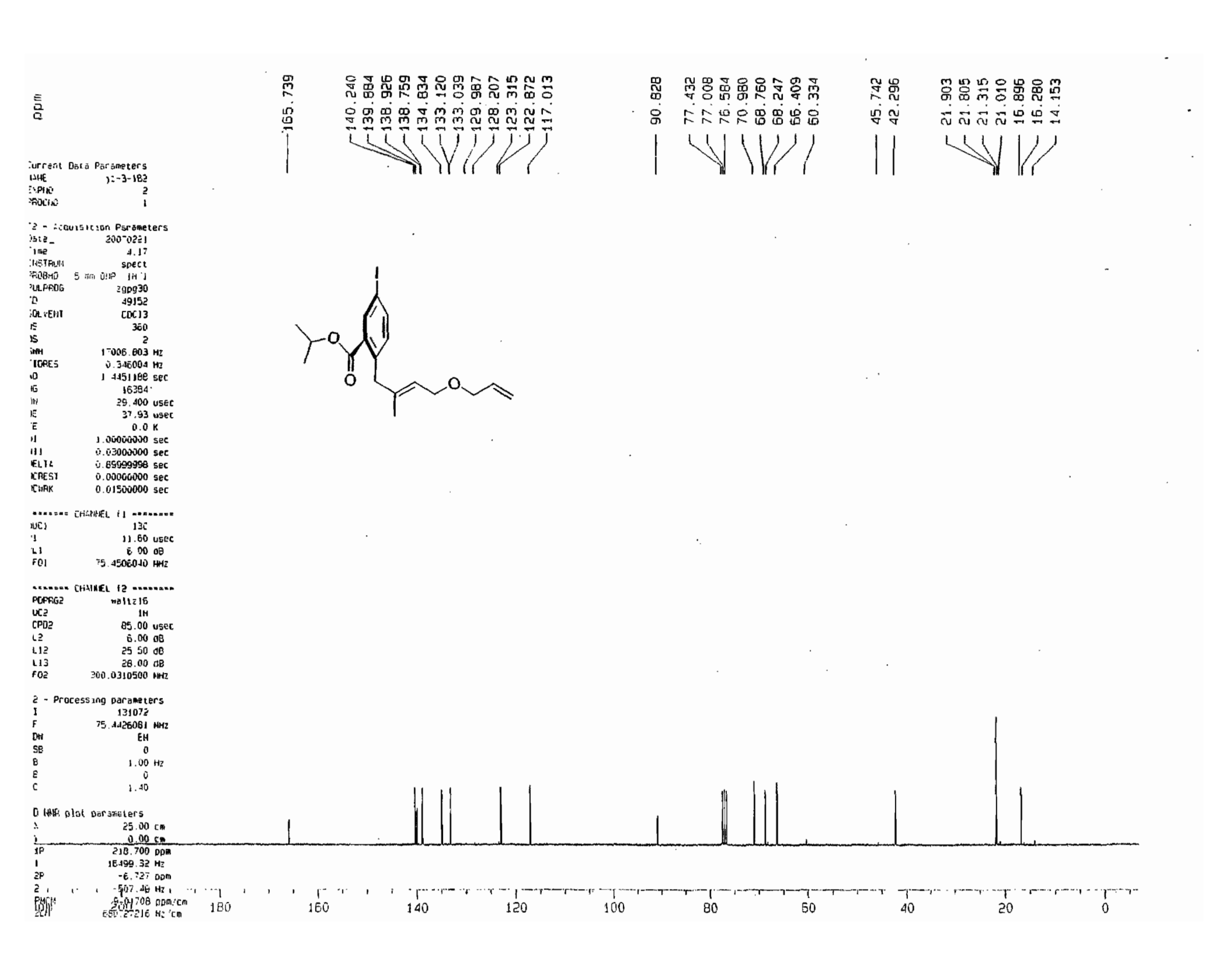
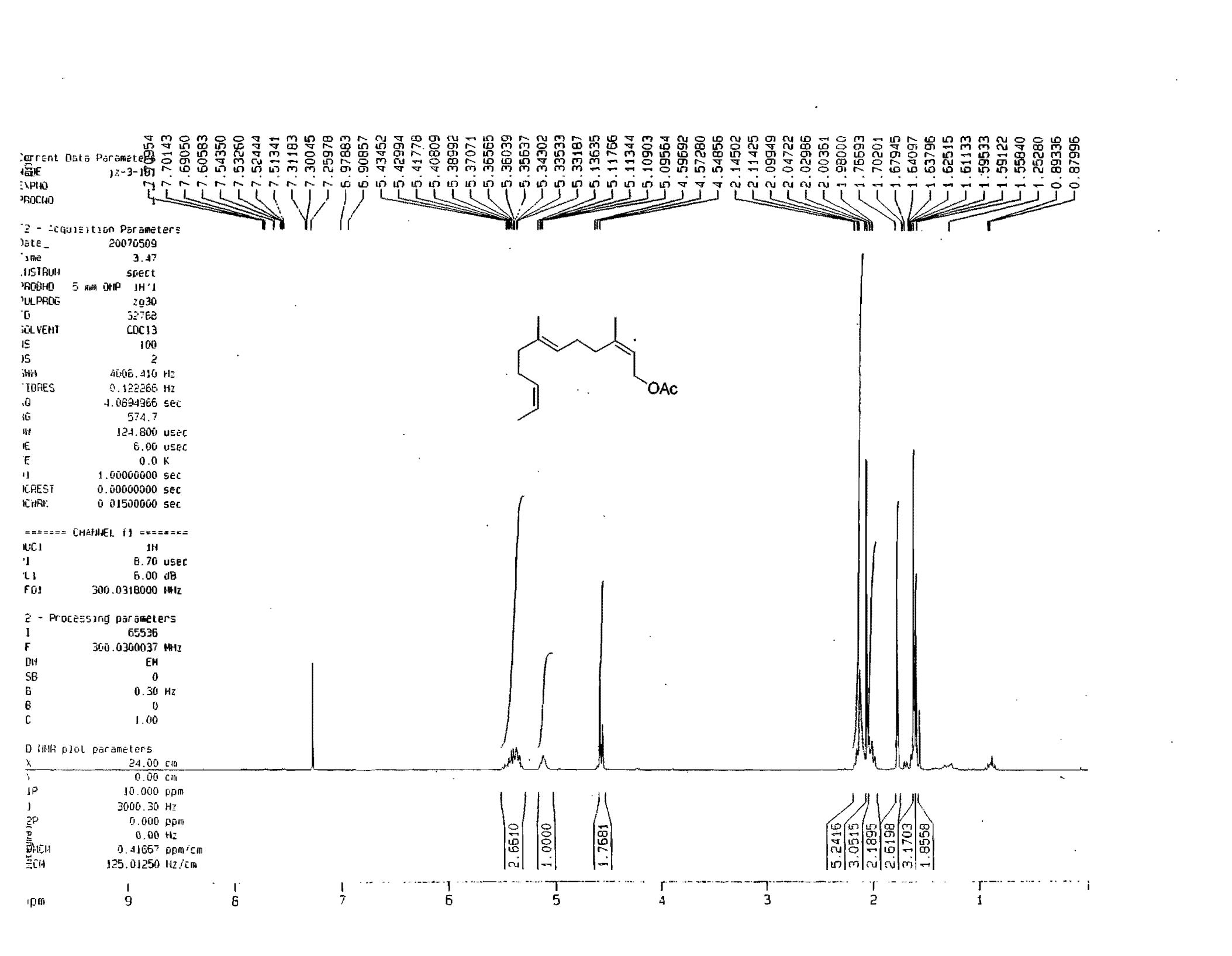
5.60438
5.26641
5.26253
5.22326
5.21943
5.16729
5.16650
5.16423
5.16306
5.14059
5.13718
4.44667
4.01247
3.99717
3.99612
3.95085
3.94777
3.94464
3.93659
3.93349
3.93039
2.04142
1.65779
O
OAc
1.0000
1.0946
1.1520
1.1183
2.4674
2.6131
2.4535
3.4395
3.4523
4
0
8
7
6
5
4
3
2
1


ppm
170.602
134.596
133.773
124.538
117.056
77.314
76.996
76.677
71.169
68.838
65.895
20.765
14.074
Current Data Parameters
NAME jz-3-180
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070508
Time 12.47
INSTRUM spect
PROBHD 5 mm DNP 1H
PULPROG zgpg
TD 32768
SOLVENT CDCl3
NS 125
DS 4
SWH 22727.273 Hz
FIDRES 0.693581 Hz
AQ 0.7209460 sec
RG 22800
DW 22.000 usec
DE 31.43 usec
TE 298.0 K
D12 0.0000200 sec
NL6 14.00 dB
D1 2.00000000 sec
CPDPRG waltz16
P31 85.00 usec
D11 0.0300000 sec
NL5 12.00 dB
P1 4.00 usec
SFO1 100.6244502 MHz
NUCLEUS 13C
F2 - Processing parameters
SI 32768
SF 100.6138821 MHz
WDW EM
SSB 0
LB 2.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
WC 25.00 cm
WS 0.00 cm
SP 217.979 ppm
WP 21931.76 Hz
PL1 -795.57 Hz
PLW1 9.03544 ppm/cm
PLW2 909.09094 Hz/cm
O
OAc
200
180
160
140
120
100
80
60
40
20
0


Current Data Parameters
NAME jz-3-182
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070510
Time 17 45
INSTRUM spect
PROBHD 5 mm DNP 1H-1
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 32
DS 2
SWH 4006.410 Hz
FIDRES 0.122266 Hz
AQ 4.0894966 sec
RG 71.8
DW 124.800 usec
DE 6.00 usec
TE 0.0 K
D1 1.00000000 sec
D11REST 0.00000000 sec
D11MAX 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 8.70 usec
PL1 6.00 dB
SFO1 300.0318000 MHz
F2 - Processing parameters
SI 65536
SF 300.0300000 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
WX 24.00 cm
WY 0.00 cm
PLPP 10.000 ppm
PL1 3000.30 Hz
PLP2 0.000 ppm
PL2 0.00 Hz
PLPMCH 0.41667 ppm/cm
PLHZCM 125.01250 Hz/cm
8.28674
8.10442
7.88908
7.71850
7.71232
7.69141
7.68524
7.35420
7.27122
6.98698
6.95985
5.93909
5.92156
5.90445
5.88192
5.86540
5.84734
5.27482
5.26988
5.24185
5.21740
5.21188
5.20716
5.18577
5.16602
5.14313
4.03575
4.01300
3.98778
3.96616
3.93415
3.91525
3.87129
3.69938
3.65210
3.37465
2.34336
1.82142
1.74355
1.64624
1.60367
1.55825
1.43554
1.40655
1.37281
1.34868
1.32773
1.04773
1.02688
1.0000
1.0596
1.0829
1.1917
1.7475
2.9614
2.3040
2.1994
1.9902
3.0434
3.7403
3.0357
ppm
9
8
7
6
5
4
3
2
1


ppm
165.739
140.240
139.884
138.926
138.759
134.834
133.120
133.039
129.987
128.207
123.315
122.872
117.013
90.828
77.432
77.008
76.584
70.980
68.760
68.247
66.409
60.334
45.742
42.296
21.903
21.805
21.315
21.010
16.896
16.280
14.153
Current Data Parameters
NAME)2-3-182
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070221
Time 4.17
INSTRUM spect
PROBHD 5 mm DUP (H-1
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 360
DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451188 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
DELTA 0.69999998 sec
DCREST 0.00000000 sec
DCHRK 0.01500000 sec
======== CHANNEL f1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz
======== CHANNEL f2 ========
PCPD2 waltz16
NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
F2 - Processing parameters
SI 131072
SF 75.4426081 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
WX 25.00 cm
WY 0.00 cm
PPMCM 218.700 ppm
HZCM 16499.32 Hz
PPMPT -6.727 ppm
HZPT -507.49 Hz
PLPLM 73.01708 ppm/cm
HZPLM 5507.2216 Hz/cm
180
160
140
120
100
80
60
40
20
0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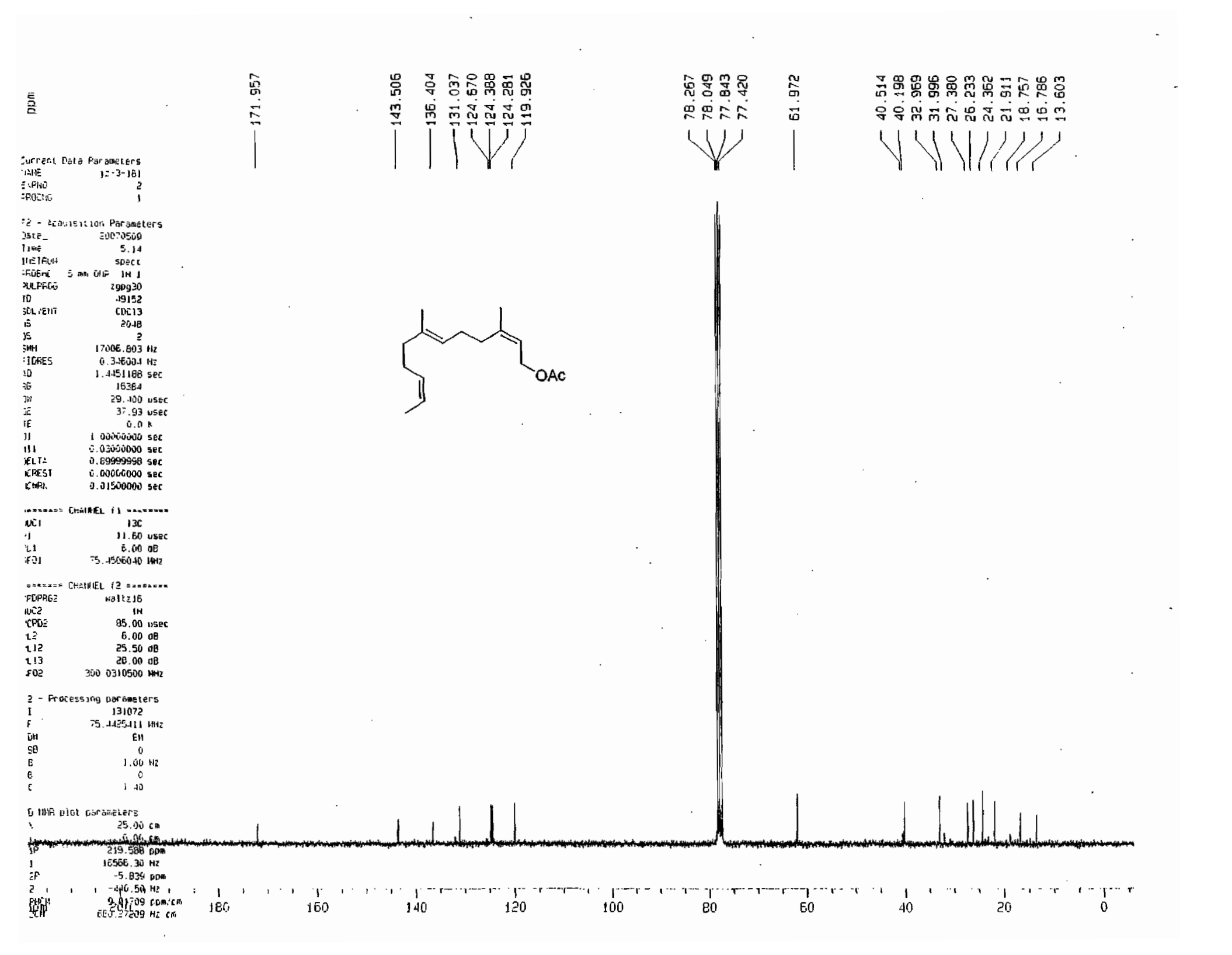
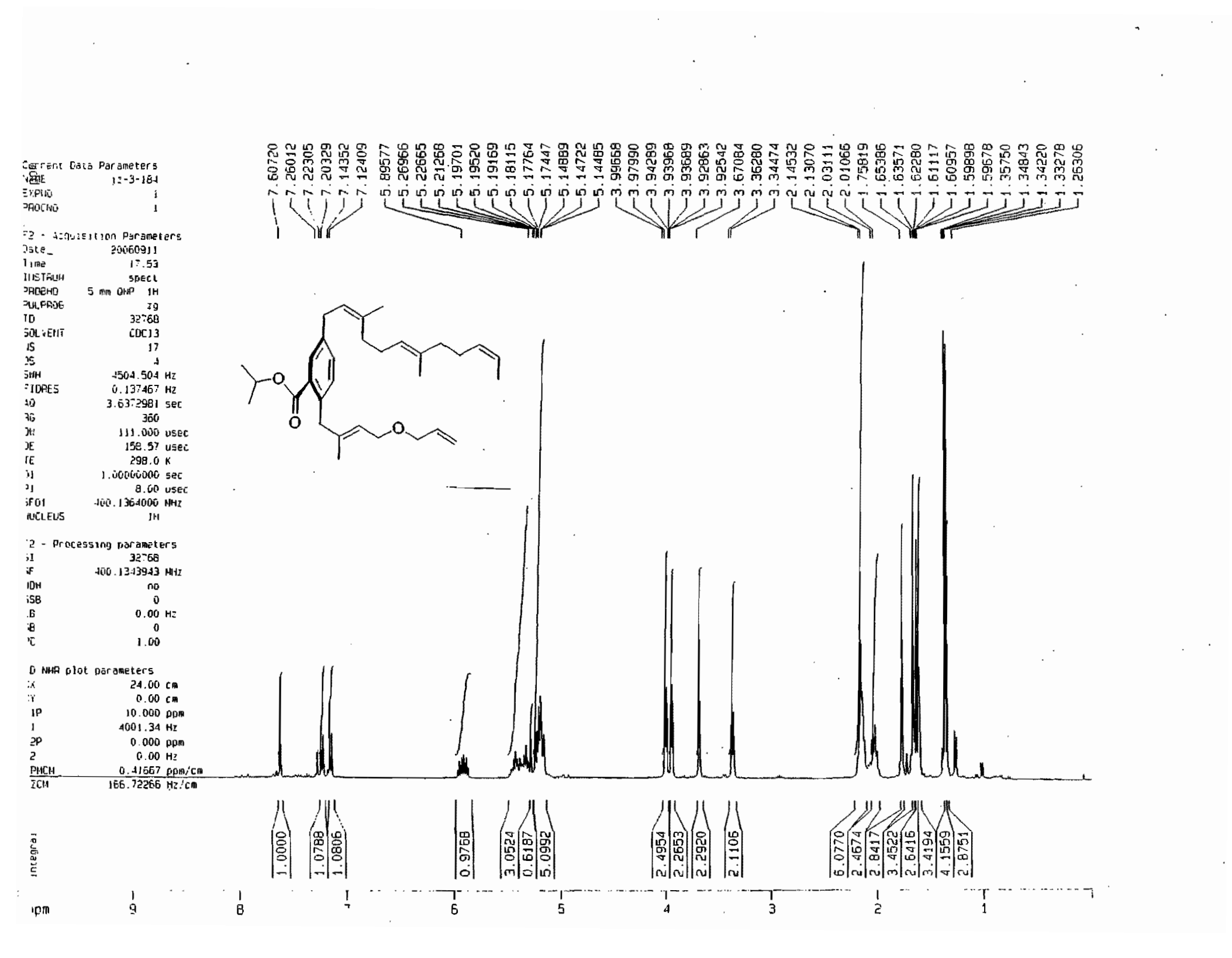
7.69050
7.60583
7.54350
7.53260
7.52444
7.51341
7.31183
7.30045
7.25978
6.97883
6.90857
5.43452
5.42994
5.41778
5.40809
5.38992
5.37071
5.36565
5.36039
5.35637
5.34302
5.33533
5.33187
5.13635
5.11766
5.11344
5.10903
5.09564
4.59692
4.57280
4.54856
2.14502
2.11425
2.09949
2.04722
2.02986
2.00361
1.98000
1.76693
1.70201
1.67945
1.64097
1.63796
1.62515
1.61133
1.59533
1.59122
1.55840
1.25280
0.89336
0.87996
OAc
2.6610
1.0000
1.7681
5.2416
3.0515
2.1895
2.6198
3.1703
1.8558
ppm
9
8
7
6
5
4
3
2
1


ppm
171.957
143.506
136.404
131.037
124.670
124.388
124.281
119.926
78.267
78.049
77.843
77.420
61.972
40.514
40.198
32.959
31.996
27.380
26.233
24.362
21.911
18.757
16.786
13.603
OAc
180
160
140
120
100
80
60
40
20
0
Current Data Parameters
NAME jz-3-161
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070509
Time 5.14
INSTRUM spect
PROBHD 5 mm CMP IH J
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 2048
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451188 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
DELTA 0.89999998 sec
DCREST 0.00000000 sec
DCHRN 0.01500000 sec
======== CHANNEL f1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz
======== CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
F2 - Processing parameters
SI 131072
SF 75.4485411 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
WC 25.00 cm
WP 219.588 ppm
SP -5.839 ppm
PHCM 0.01709 ppm/cm
PHCH 2.01709 ppm/cm
SCM 600.27209 Hz cm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NAME 12-3-184
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20060911
Time 17.53
INSTRUM spect
PROBHD 5 mm QNP 1H
PULPROG zg
TD 32768
SOLVENT CDCl3
NS 17
DS 4
SWH 4504.504 Hz
FIDRES 0.137467 Hz
AQ 3.6372981 sec
RG 360
DW 111.000 usec
DE 158.57 usec
TE 298.0 K
D1 1.00000000 sec
P1 8.00 usec
SFO1 400.1364000 MHz
NUCLEUS 1H
F2 - Processing parameters
SI 32768
SF 400.1343943 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
WX 24.00 cm
WY 0.00 cm
F1P 10.000 ppm
F1 4001.34 Hz
F2P 0.000 ppm
F2 0.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 166.72266 Hz/cm
7.60720
7.26012
7.22305
7.20329
7.14352
7.12409
5.89577
5.26966
5.22665
5.21268
5.19701
5.19520
5.19169
5.18115
5.17764
5.17447
5.14889
5.14722
5.14485
3.99668
3.97990
3.94289
3.93968
3.93689
3.92863
3.92542
3.67084
3.36280
3.34474
2.14532
2.13070
2.03111
2.01066
1.75819
1.65386
1.63571
1.62280
1.61117
1.60957
1.59898
1.59678
1.35750
1.34843
1.34220
1.33278
1.26306
Integral
1.0000
1.0788
1.0806
0.9768
3.0524
0.6187
5.0992
2.4954
2.2653
2.2920
2.1106
6.0770
2.4674
2.8417
3.4522
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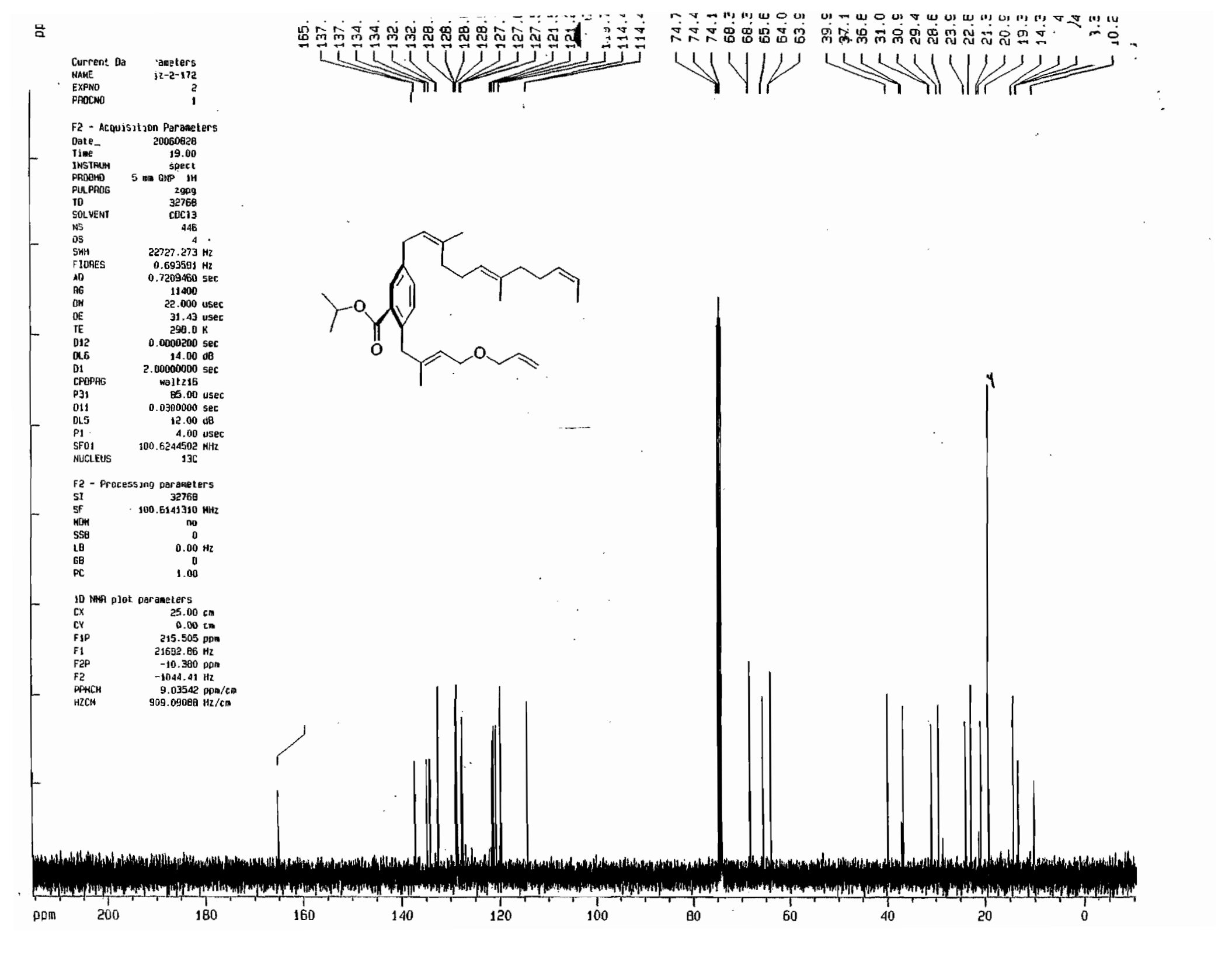
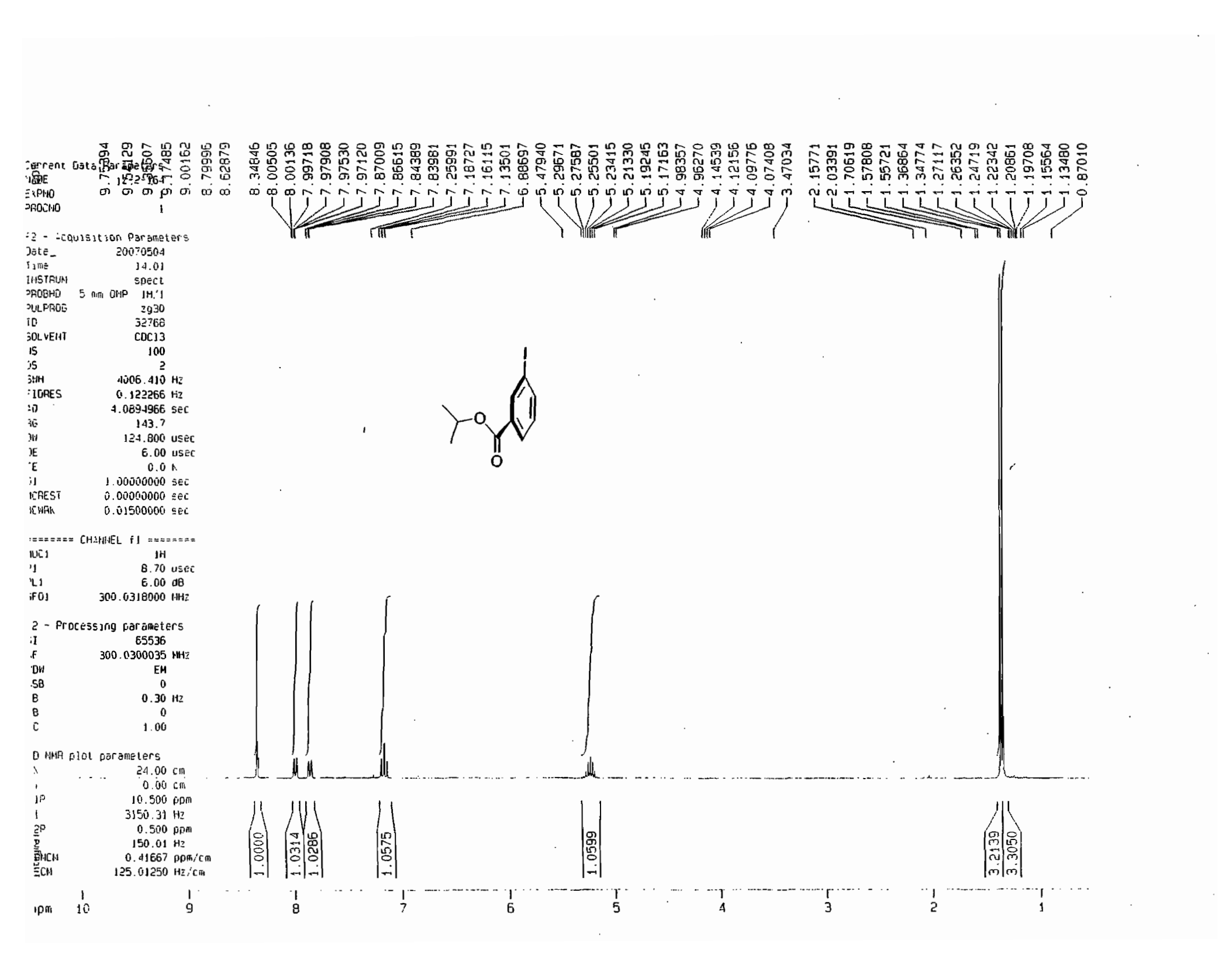
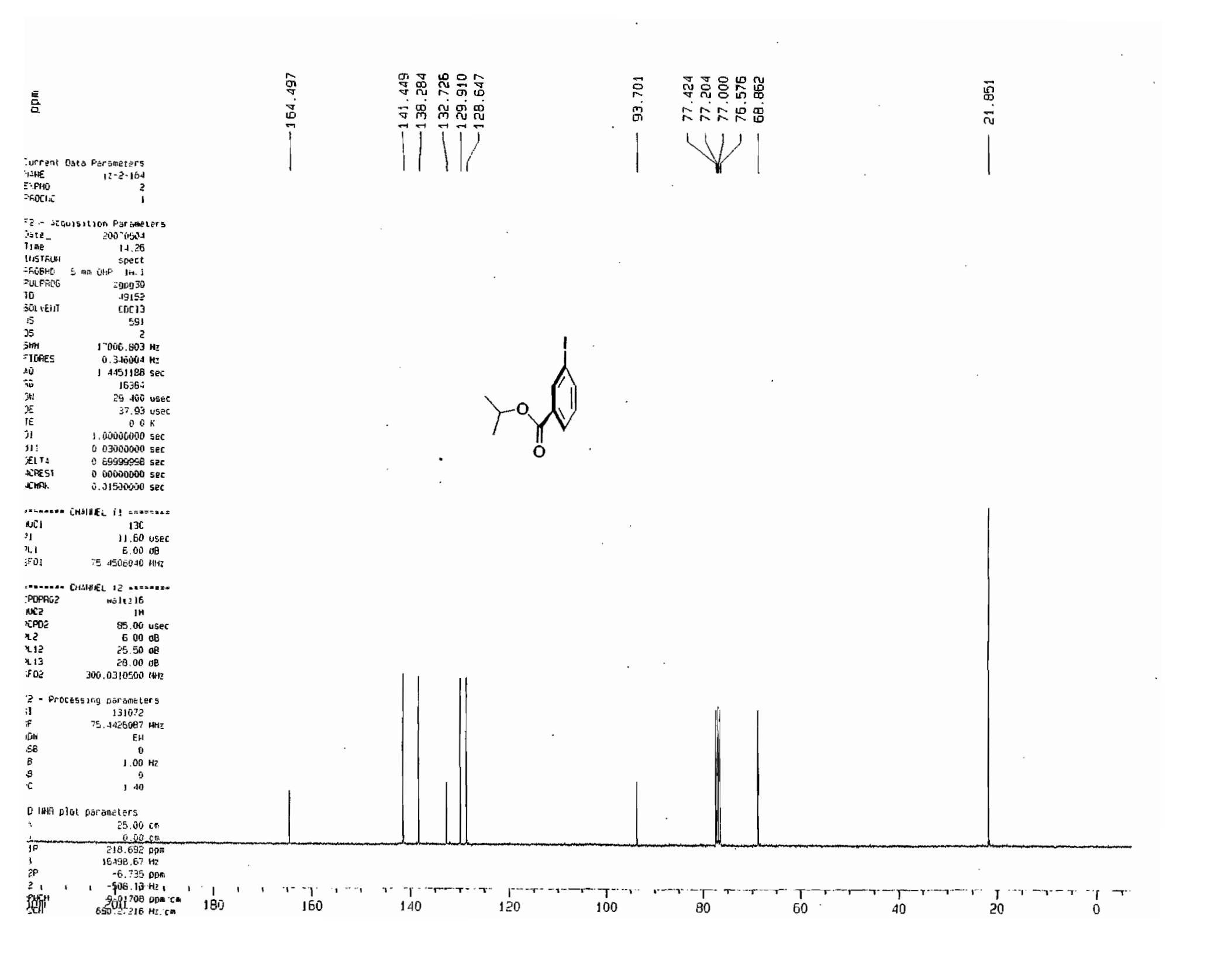
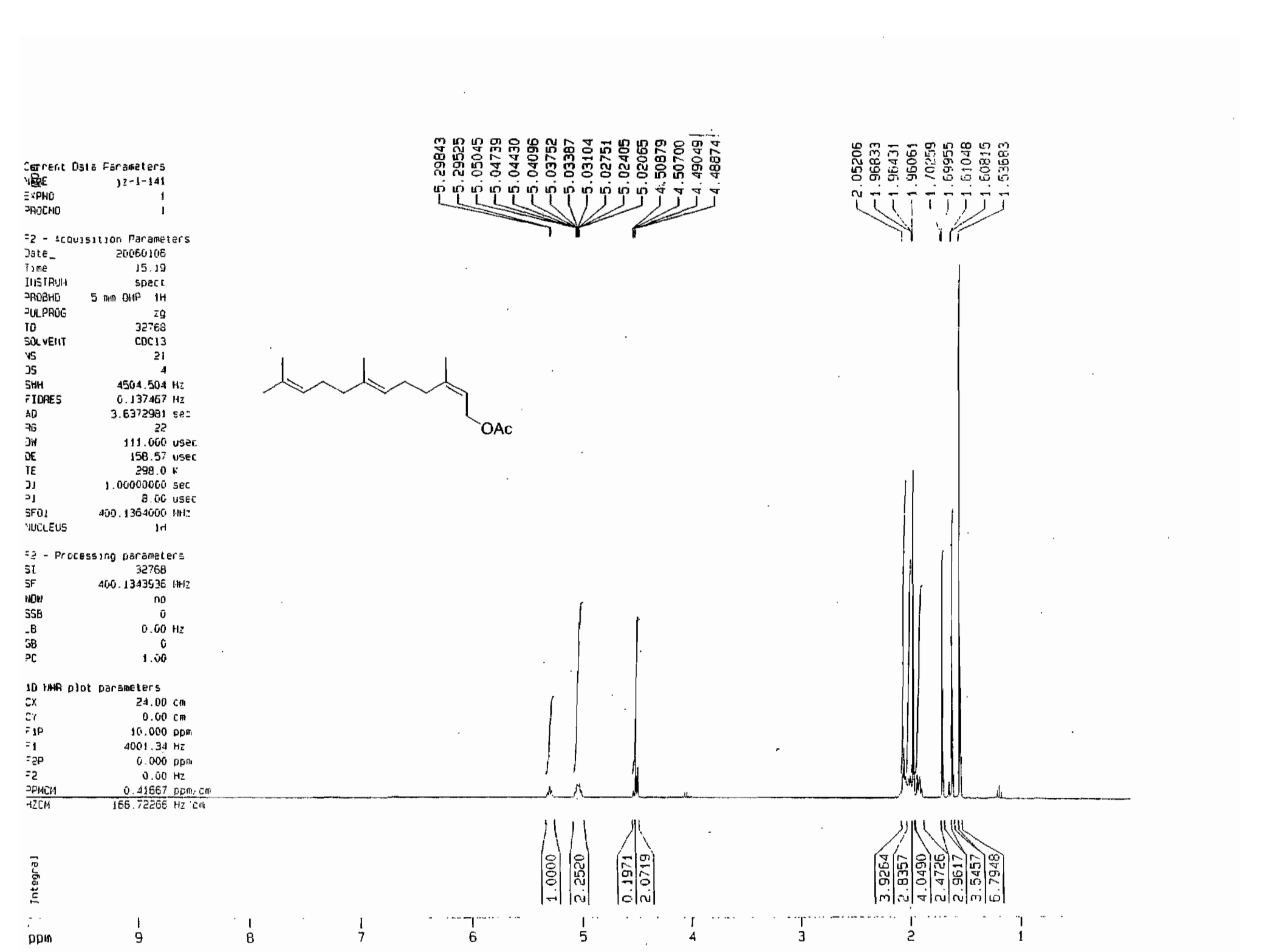
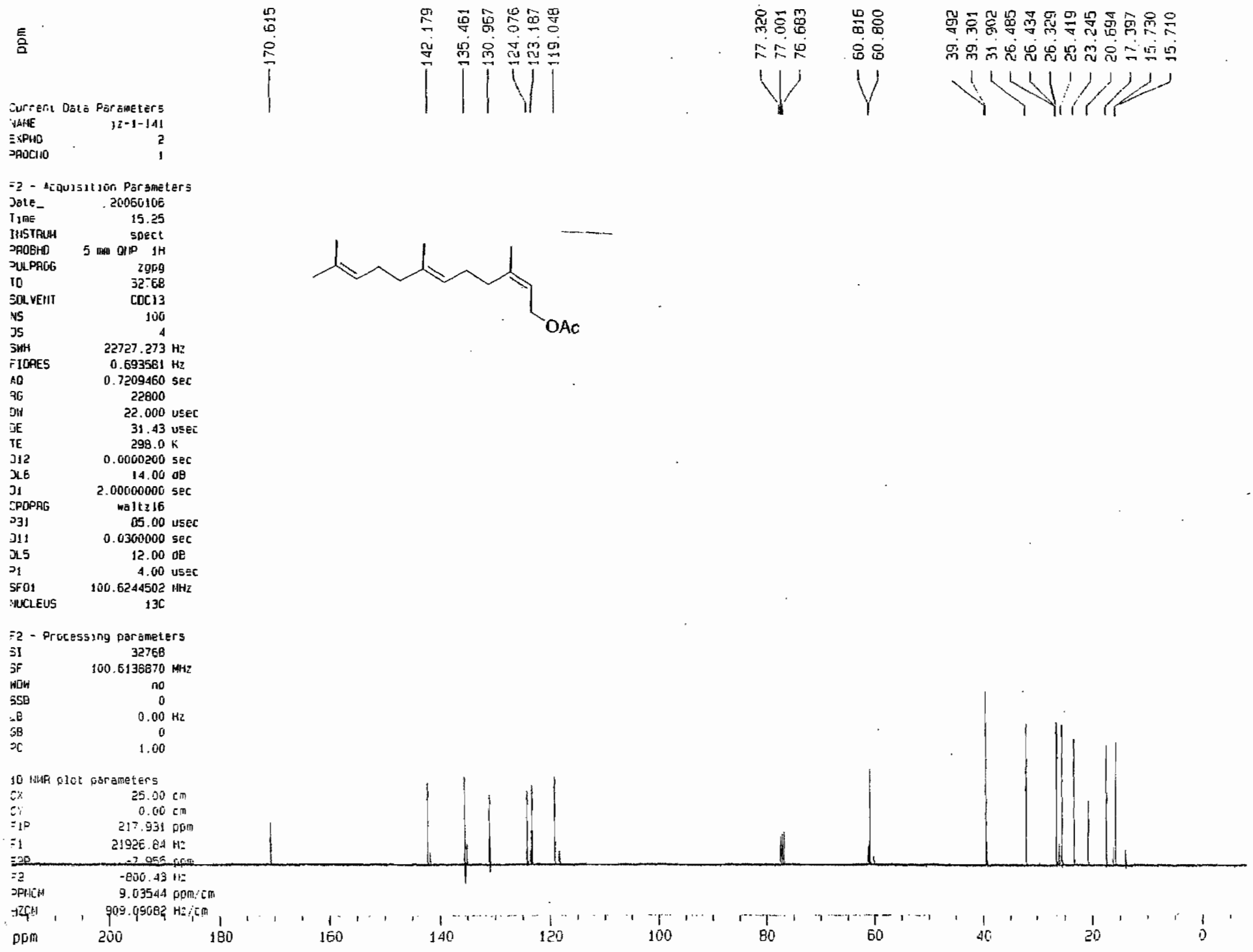
3.4194
4.1559
2.8751
ppm
9
8
7
6
5
4
3
2
1

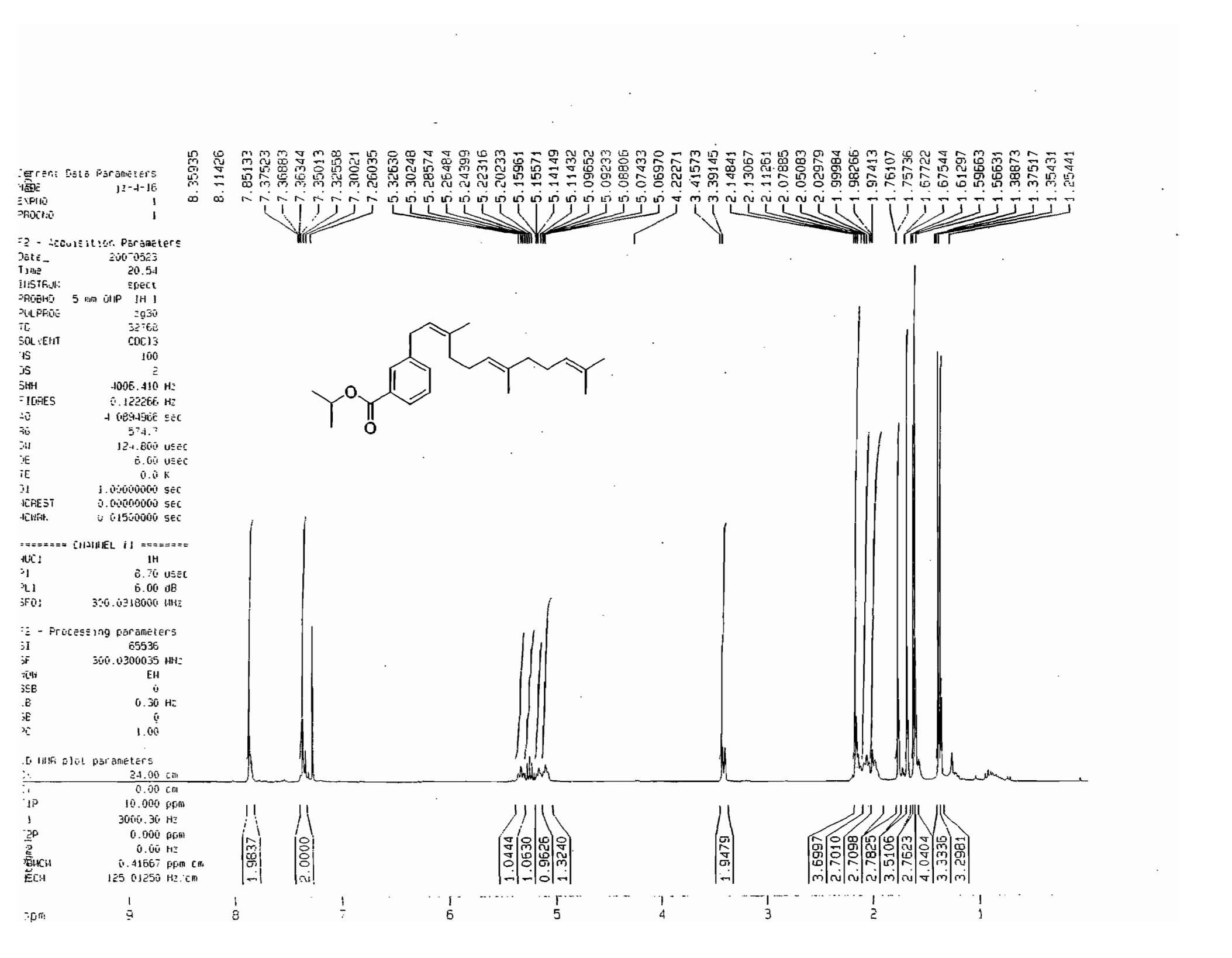

Current Da ameters
NAME jz-2-172
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20060828
Time 19.00
INSTRUM spect
PROBHD 5 mm QNP 1H
PULPROG zgpg
TD 32768
SOLVENT CDCl3
NS 446
DS 4
SWH 22727.273 Hz
FIDRES 0.693581 Hz
AQ 0.7209460 sec
RG 11400
DW 22.000 usec
DE 31.43 usec
TE 298.0 K
D12 0.0000200 sec
DL6 14.00 dB
D1 2.00000000 sec
CPDPRG waltz16
P31 85.00 usec
D11 0.0300000 sec
DL5 12.00 dB
P1 4.00 usec
SF01 100.6244502 MHz
NUCLEUS 13C
F2 - Processing parameters
SI 32768
SF 100.6141310 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 25.00 cm
CY 0.00 cm
F1P 215.505 ppm
F1 21682.86 Hz
F2P -10.380 ppm
F2 -1044.41 Hz
PPMCM 9.03542 ppm/cm
HZCM 909.09088 Hz/cm
ppm
200
180
160
140
120
100
80
60
40
20
0

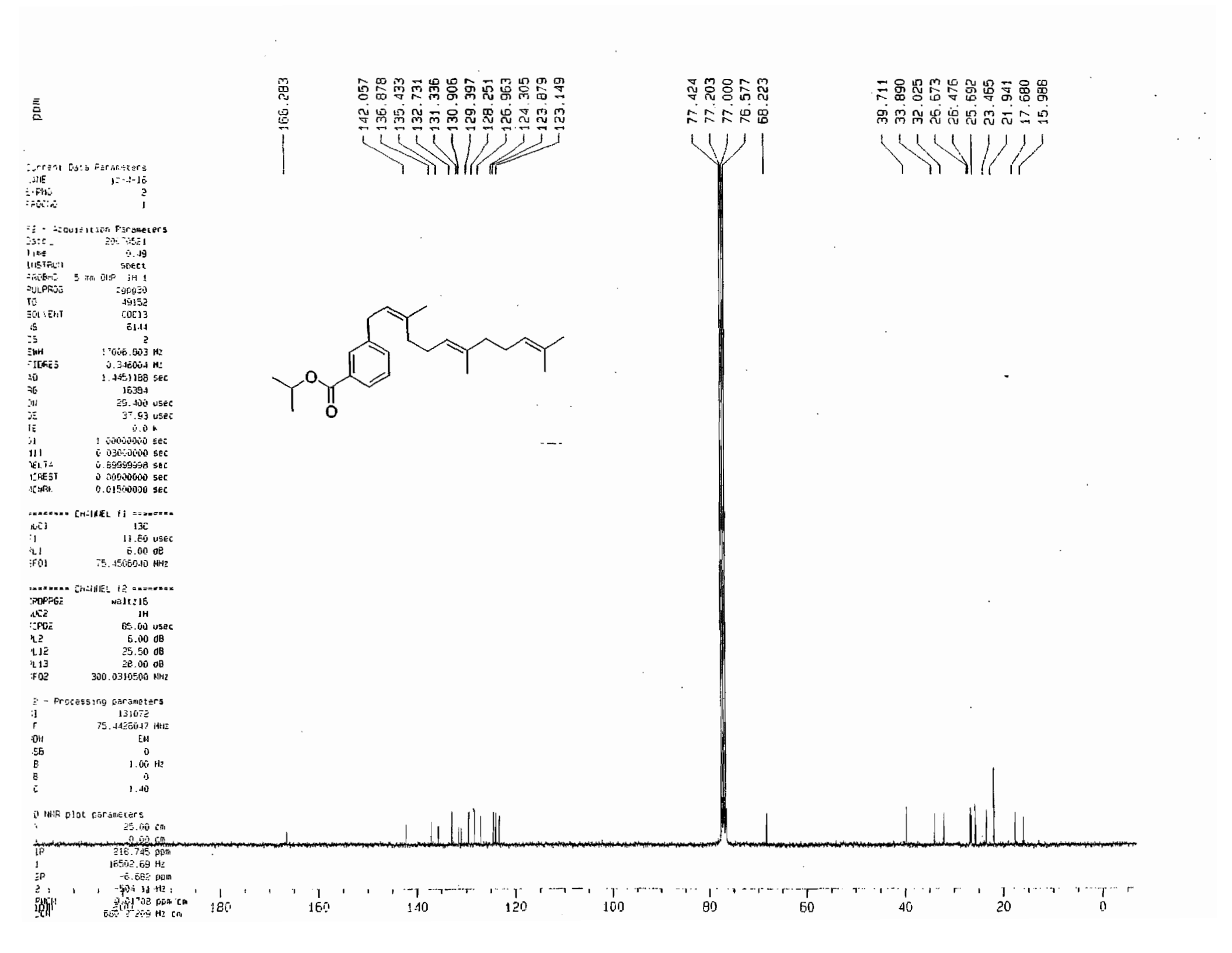

9.75394
9.22129
9.17507
9.17485
9.00162
8.79996
8.62879
8.34846
8.00505
8.00136
7.99718
7.97908
7.97530
7.97120
7.87009
7.86615
7.84389
7.83981
7.25991
7.18727
7.16115
7.13501
6.88697
5.47940
5.29671
5.27587
5.25501
5.23415
5.21330
5.19245
5.17163
4.98357
4.96270
4.14539
4.12156
4.09776
4.07408
3.47034
2.15771
2.03391
1.70619
1.57808
1.55721
1.36864
1.34774
1.27117
1.26352
1.24719
1.22342
1.20861
1.19708
1.15564
1.13480
0.87010
Current Data Parameters
NAME
EXPNO
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070504
Time 14.01
INSTRUM spect
PROBHD 5 mm QNP 1H/1
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 100
DS 2
SWH 4006.410 Hz
FIDRES 0.122266 Hz
AQ 4.0894966 sec
RG 143.7
DW 124.800 usec
DE 6.00 usec
TE 0.0 K
D1 1.00000000 sec
MCREST 0.00000000 sec
MCWRK 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 8.70 usec
PL1 6.00 dB
SFO1 300.0318000 MHz
F2 - Processing parameters
SI 65536
SF 300.0300035 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
WX 24.00 cm
HT 0.00 cm
FP 10.500 ppm
FL 3150.31 Hz
CY 0.500 ppm
CF 150.01 Hz
ICLNCN 0.41667 ppm/cm
ICCM 125.01250 Hz/cm
1.0000
1.0314
1.0286
1.0575
1.0599
3.2139
3.3050
ppm
10
9
8
7
6
5
4
3
2
1

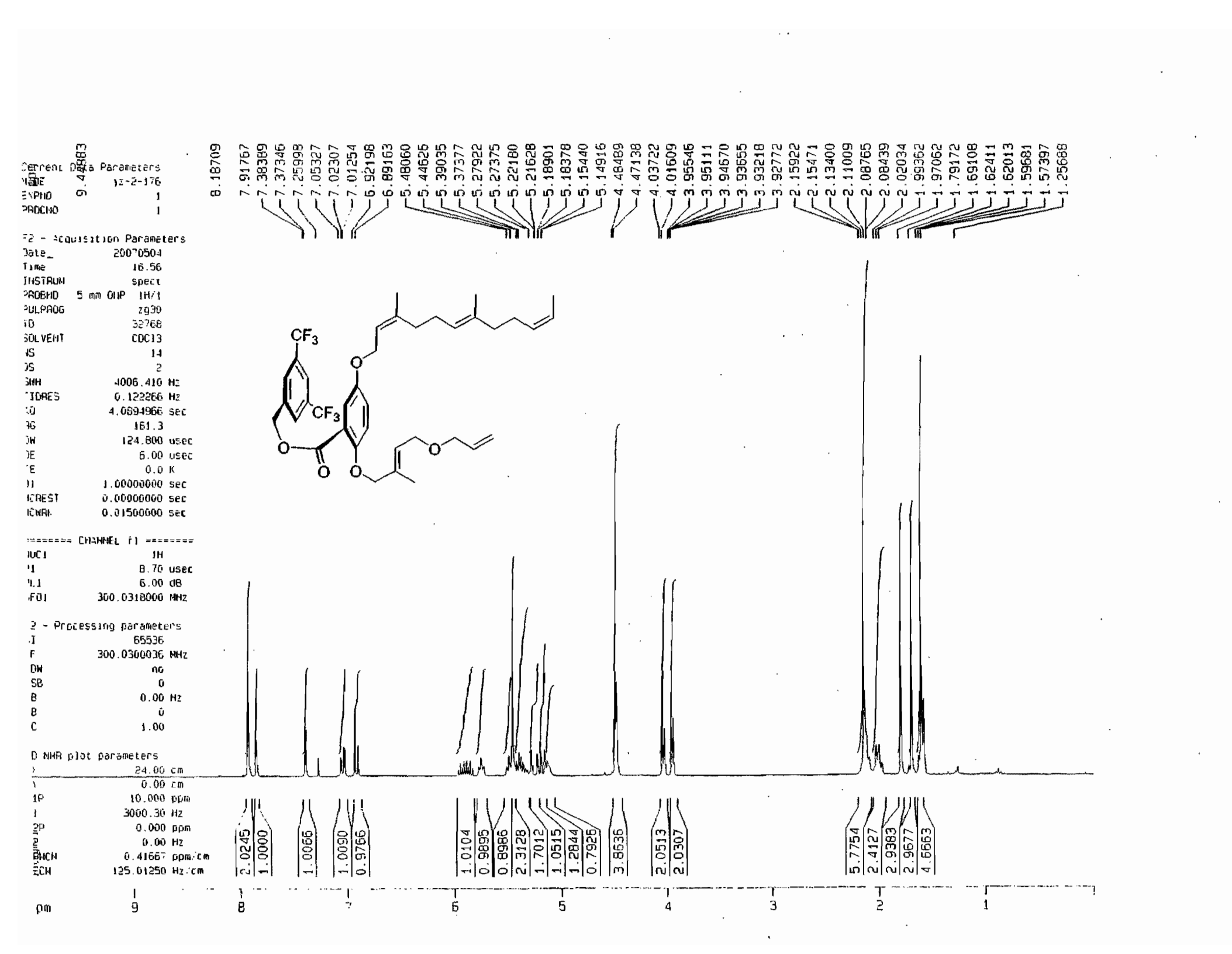

ppm
164.497
141.449
138.284
132.726
129.910
128.647
93.701
77.424
77.204
77.000
76.575
68.862
21.851
Current Data Parameters
NAME 12-2-164
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070504
Time 14.26
INSTRUM spect
PROBHD 5 mm DHP 1H-1
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 591
DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451188 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
D12 0.00000200 sec
D13 0.00000000 sec
ACQT 0.01500000 sec
======== CHANNEL f1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz
======== CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
F2 - Processing parameters
SI 131072
SF 75.4426087 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
WC 25.00 cm
WS 0.00 cm
PLPLP 218.692 ppm
PLW 16498.67 Hz
PLP 6.735 ppm
PLW 506.13 Hz
PLPMCH -9.01708 ppm/cm
PLWMCH 650.22216 Hz/cm
200
180
160
140
120
100
80
60
40
20
0

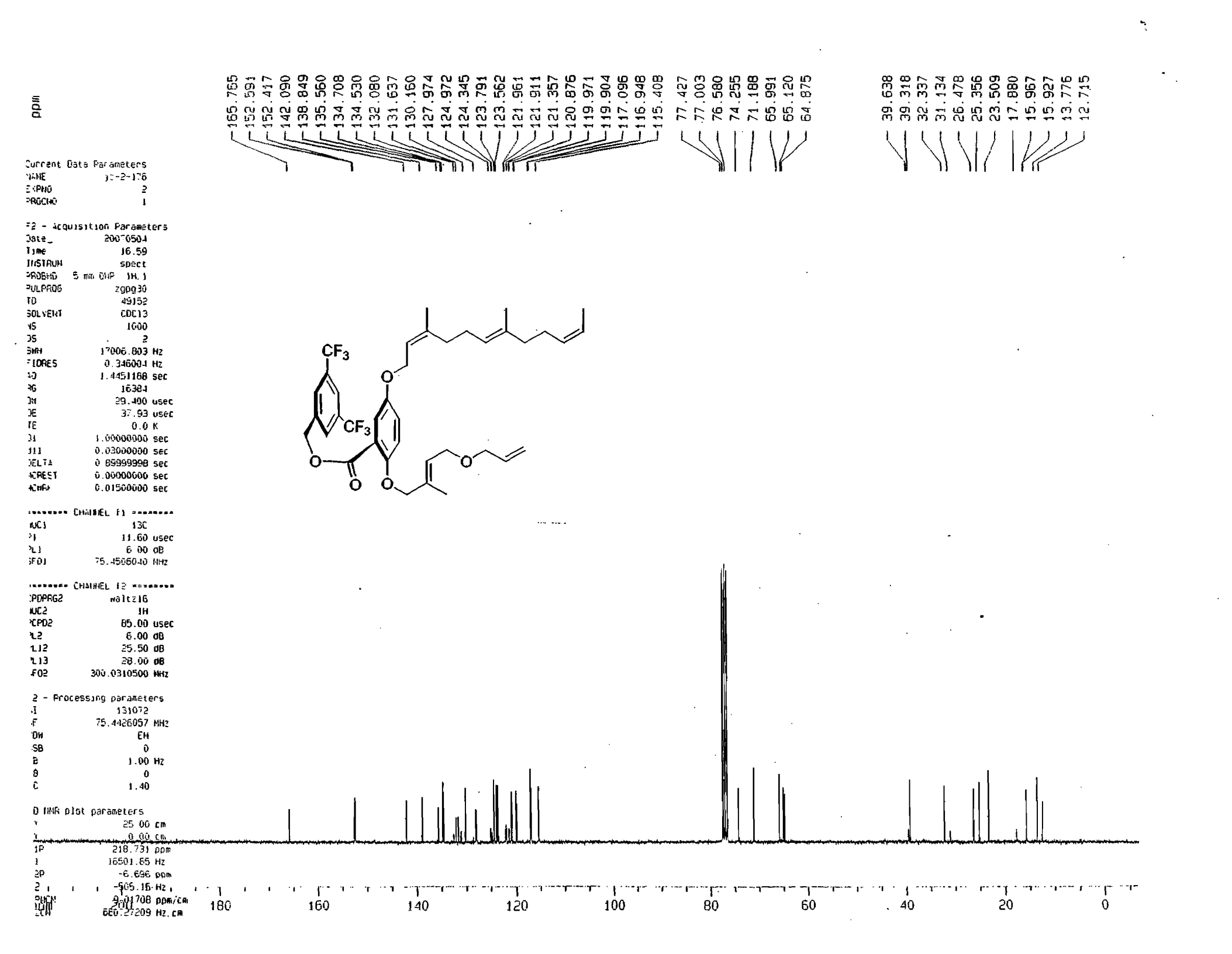

Current Data Parameters
NAME jz-1-141
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20060106
Time 15.19
INSTRUM spect
PROBHD 5 mm QNP 1H
PULPROG zg
TD 32768
SOLVENT CDCl3
NS 21
DS 4
SWH 4504.504 Hz
FIDRES 0.137467 Hz
AQ 3.6372981 sec
RG 22
DW 111.000 usec
DE 158.57 usec
TE 298.0 K
D1 1.00000000 sec
P1 8.00 usec
SFO1 400.1364000 MHz
NUCLEUS 1H
F2 - Processing parameters
SI 32768
SF 400.1343936 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 24.00 cm
CY 0.00 cm
F1P 10.000 ppm
F1 4001.34 Hz
F2P 0.000 ppm
F2 0.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 166.72266 Hz/cm
5.29843
5.29525
5.05045
5.04739
5.04430
5.04096
5.03752
5.03387
5.03104
5.02751
5.02405
5.02065
4.50879
4.50700
4.49049
4.48874
2.05206
1.96833
1.96431
1.96061
1.70259
1.69955
1.61048
1.60815
1.53683
OAc
Integral
1.0000
2.2520
0.1971
2.0719
3.9264
2.8357
4.0490
2.4726
2.9617
3.5457
6.7948
ppm
9
8
7
6
5
4
3
2
1

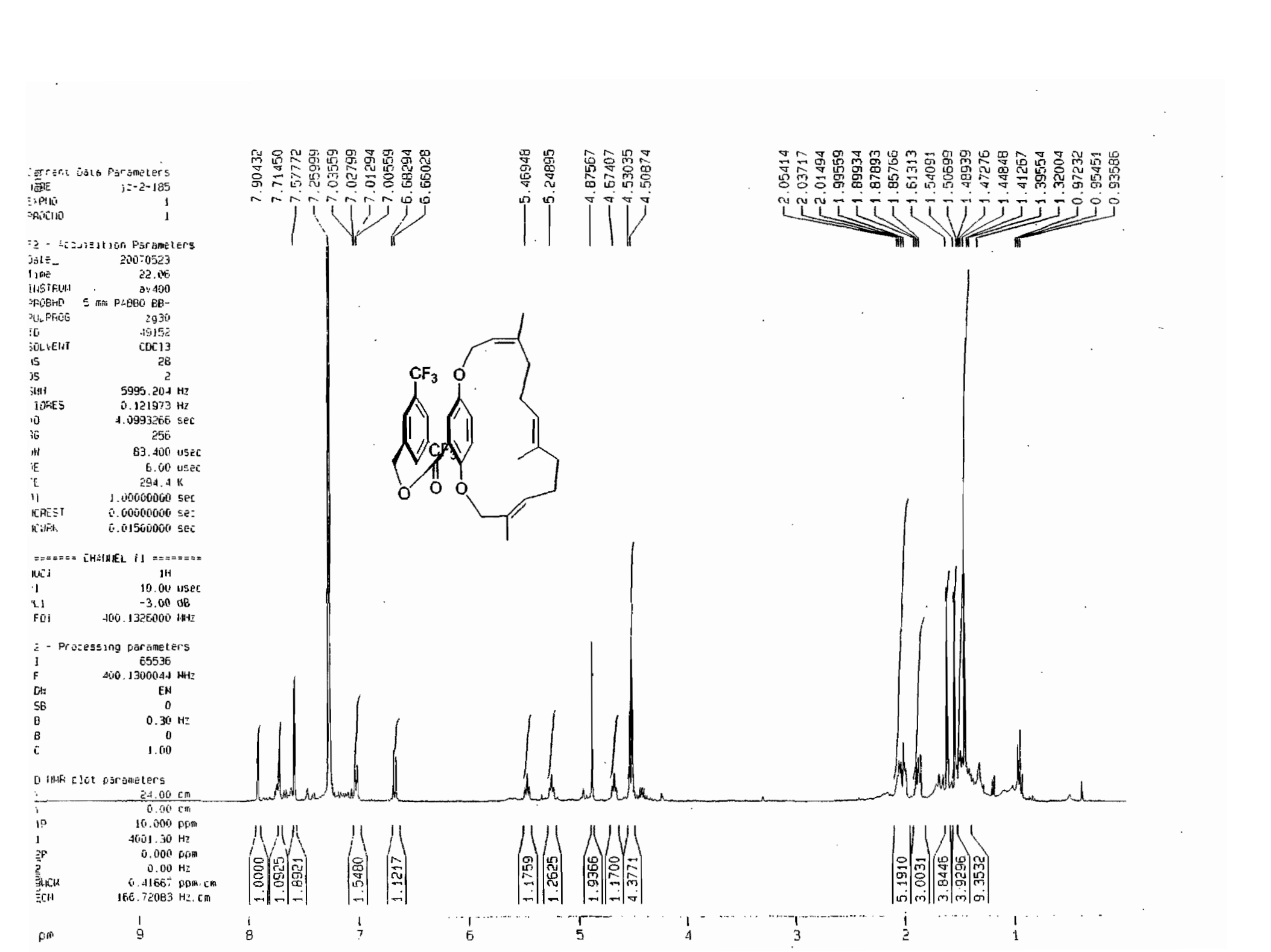

ppm
170.615
142.179
135.461
130.967
124.076
123.187
119.048
77.320
77.001
76.683
60.816
60.800
39.492
39.301
31.902
26.485
26.434
26.329
25.419
23.245
20.694
17.397
15.730
15.710
OAc
Current Data Parameters
NAME jz-1-141
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20060106
Time 15.25
INSTRUM spect
PROBHD 5 mm QNP 1H
PULPROG zgpg
TD 32768
SOLVENT CDCl3
NS 100
DS 4
SWH 22727.273 Hz
FIDRES 0.693581 Hz
AQ 0.7209460 sec
RG 22800
DW 22.000 usec
DE 31.43 usec
TE 298.0 K
D12 0.0000200 sec
DL6 14.00 dB
D1 2.00000000 sec
CPDPRG waltz16
P31 05.00 usec
D11 0.0300000 sec
DL5 12.00 dB
P1 4.00 usec
SFO1 100.6244502 MHz
NUCLEUS 13C
F2 - Processing parameters
SI 32768
SF 100.6136870 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 25.00 cm
CY 0.00 cm
F1P 217.931 ppm
F1 21926.84 Hz
F2P -7.956 ppm
F2 -800.43 Hz
PPMCM 9.03544 ppm/cm
HZCM 909.09082 Hz/cm
ppm
200
180
160
140
120
100
80
60
40
20
0

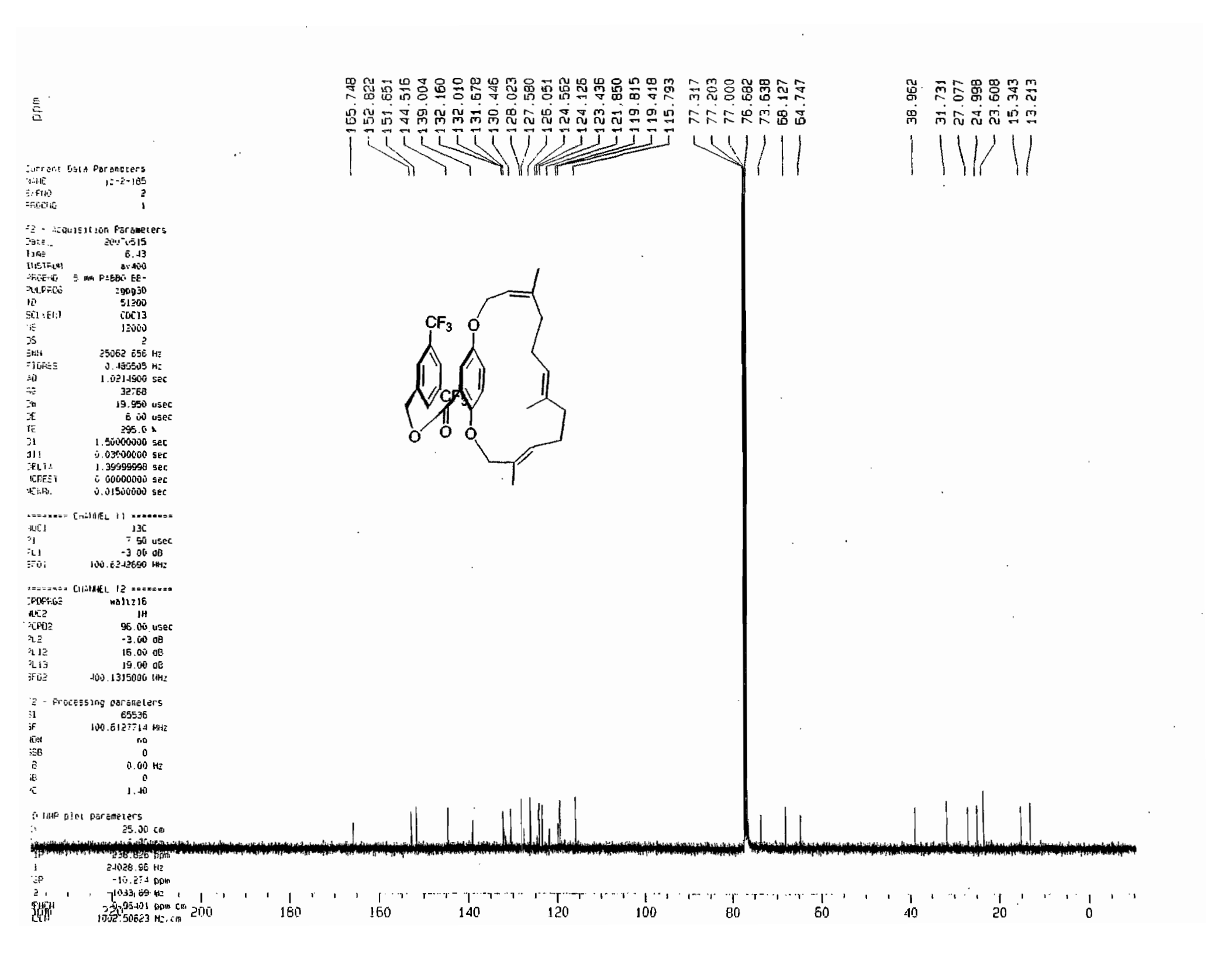

Current Data Parameters
NAME
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070523
Time 20.54
INSTRUM spect
PROBHD 5 mm QNP 1H 1
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 100
DS 2
SWH 4006.410 Hz
FIDRES 0.122266 Hz
AQ 4.0894908 sec
RG 574.7
DW 124.800 usec
DE 6.00 usec
TE 0.0 K
D1 1.00000000 sec
D12REST 0.00000000 sec
D12WAK 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 8.70 usec
PL1 6.00 dB
SFO1 300.0318000 MHz
F2 - Processing parameters
SI 65536
SF 300.0300035 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
WC 24.00 cm
WC 0.00 cm
PLP 10.000 ppm
PLP 3000.30 Hz
F2P 0.000 ppm
F2P 0.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 125.01250 Hz/cm
8.35935
8.11426
7.85133
7.37523
7.36883
7.36344
7.35013
7.32558
7.30021
7.26035
5.32630
5.30248
5.28574
5.26484
5.24399
5.22316
5.20233
5.15961
5.15571
5.14149
5.11432
5.09652
5.09233
5.08806
5.07433
5.06970
4.22271
3.41573
3.39145
2.14841
2.13067
2.11261
2.07885
2.05083
2.02979
1.99984
1.98266
1.97413
1.76107
1.75736
1.67722
1.67544
1.61297
1.59663
1.56631
1.38873
1.37517
1.35431
1.25441
O
O
O
1.9637
2.0000
1.0444
1.0630
0.9626
1.3240
1.9479
3.6997
2.7010
2.7098
2.7825
3.5106
2.7623
4.0404
3.3335
3.2981
ppm
9
8
7
6
5
4
3
2
1


ppm
166.283
142.057
136.878
135.433
132.731
131.336
130.906
129.397
128.251
126.963
124.305
123.879
123.149
77.424
77.203
77.000
76.577
68.223
39.711
33.890
32.025
26.673
26.476
25.692
23.465
21.941
17.680
15.986
Current Data Parameters
NAME jc-4-16
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20170621
Time 9.49
INSTRUM spect
PROBHD 5 mm DUL 13C-1
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 6144
DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451188 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
DELTA 0.69999998 sec
DREST 0.00000000 sec
DCHRR 0.01500000 sec
======== CHANNEL f1 ========
NUC1 13C
P1 11.80 usec
PL1 6.00 dB
SFO1 75.4506040 MHz
======== CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 65.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
F2 - Processing parameters
SI 131072
SF 75.4428047 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
WC 25.00 cm
WC2 0.00 cm
CFP 216.745 ppm
F1 16502.69 Hz
CFP 6.682 ppm
F2 -504.14 Hz
PHCM 2.21708 ppm/cm
HDM 600.37209 Hz/cm
180
160
140
120
100
80
60
40
20
0


Current Data Parameters
NAME yz-2-176
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070504
Time 16.56
INSTRUM spect
PROBHD 5 mm ONP 1H/1
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 14
DS 2
SWH 4006.410 Hz
FIDRES 0.122266 Hz
AQ 4.0894966 sec
RG 161.3
DW 124.800 usec
DE 6.00 usec
TE 0.0 K
D1 1.00000000 sec
D12REST 0.00000000 sec
D13RA 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 8.70 usec
PL1 6.00 dB
SFO1 300.0318000 MHz
F2 - Processing parameters
SI 65536
SF 300.0300036 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
WC 24.00 cm
WS 0.00 cm
SP 10.000 ppm
LP 3000.30 Hz
SP 0.000 ppm
LP 0.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 125.01250 Hz/cm
9.48883
8.18709
7.91767
7.38389
7.37346
7.25998
7.05327
7.02307
7.01254
6.92198
6.89163
5.48060
5.44626
5.39035
5.37377
5.27922
5.27375
5.22180
5.21628
5.18901
5.18378
5.15440
5.14916
4.48489
4.47138
4.03722
4.01609
3.95546
3.95111
3.94670
3.93655
3.93218
3.92772
2.15922
2.15471
2.13400
2.11009
2.08765
2.08439
2.02034
1.99362
1.97062
1.79172
1.69108
1.62411
1.62013
1.59681
1.57397
1.25688
CF3
CF3
O
O
O
O
O
2.0245
1.0000
1.0066
1.0090
0.9766
1.0104
0.9895
0.8986
2.3128
1.7012
1.0515
1.2844
0.7926
3.8636
2.0513
2.0307
5.7754
2.4127
2.9383
2.9677
4.6663
ppm
9
8
7
6
5
4
3
2
1


ppm
165.755
152.593
152.417
142.090
138.849
135.560
134.708
134.530
132.080
131.637
130.160
127.974
124.972
124.345
123.791
123.562
121.961
121.911
121.357
120.876
119.971
119.904
117.096
116.948
115.408
77.427
77.003
76.580
74.255
71.188
65.991
65.120
64.875
39.638
39.318
32.337
31.134
26.478
25.356
23.509
17.880
15.967
15.927
13.776
12.715
Current Data Parameters
NAME yc-2-176
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070504
Time 16.59
INSTRUM spect
PROBHD 5 mm DUP 1H, 1
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 1000
DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451168 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
DELTA 0.89999998 sec
ACREST 0.00000000 sec
ACMP 0.01500000 sec
======== CHANNEL F1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4586040 MHz
======== CHANNEL F2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
2 - Processing parameters
SI 131072
SF 75.4426057 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1 1HNMR plot parameters
CX 25.00 cm
CY 0.00 cm
F1P 218.731 ppm
F1 16501.65 Hz
F2P -6.696 ppm
F2 -505.16 Hz
PPMCM 9.01708 ppm/cm
HZCM 680.27209 Hz/cm
CF3
CF3
O
O
O
O
O
O
180
160
140
120
100
80
60
40
20
0


Current Data Parameters
NAME jc-2-185
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070523
Time 22.06
INSTRUM av400
PROBHD 5 mm PABBO BB-
PULPROG zg30
TD 49152
SOLVENT CDCl3
NS 28
DS 2
SWH 5995.204 Hz
FIDRES 0.121973 Hz
AQ 4.0993266 sec
RG 256
DW 83.400 usec
DE 6.00 usec
TE 294.4 K
D1 1.00000000 sec
MCREST 0.00000000 sec
MCWRK 0.01500000 sec
======= CHANNEL f1 =======
NUC1 1H
P1 10.00 usec
PL1 -3.00 dB
SFO1 400.1326000 MHz
F2 - Processing parameters
SI 65536
SF 400.1300044 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
WC 24.00 cm
WS 0.00 cm
PLPLP 10.000 ppm
PLFLP 4001.30 Hz
SPLP 0.000 ppm
SPFLP 0.00 Hz
PLPXCM 0.41667 ppm/cm
PLFXCM 166.72083 Hz/cm
7.90432
7.71450
7.57772
7.25999
7.03559
7.02799
7.01294
7.00559
6.68294
6.66028
5.46948
5.24895
4.87567
4.67407
4.53035
4.50874
2.05414
2.03717
2.01494
1.99559
1.89934
1.87893
1.85766
1.61313
1.54091
1.50699
1.48939
1.47276
1.44848
1.41267
1.39554
1.32004
0.97232
0.95451
0.93586
CF3
O
CF3
O
O
O
1.0000
1.0925
1.8921
1.5480
1.1217
1.1759
1.2625
1.9366
1.1700
4.3771
5.1910
3.0031
3.8446
3.9296
9.3532
ppm
9
8
7
6
5
4
3
2
1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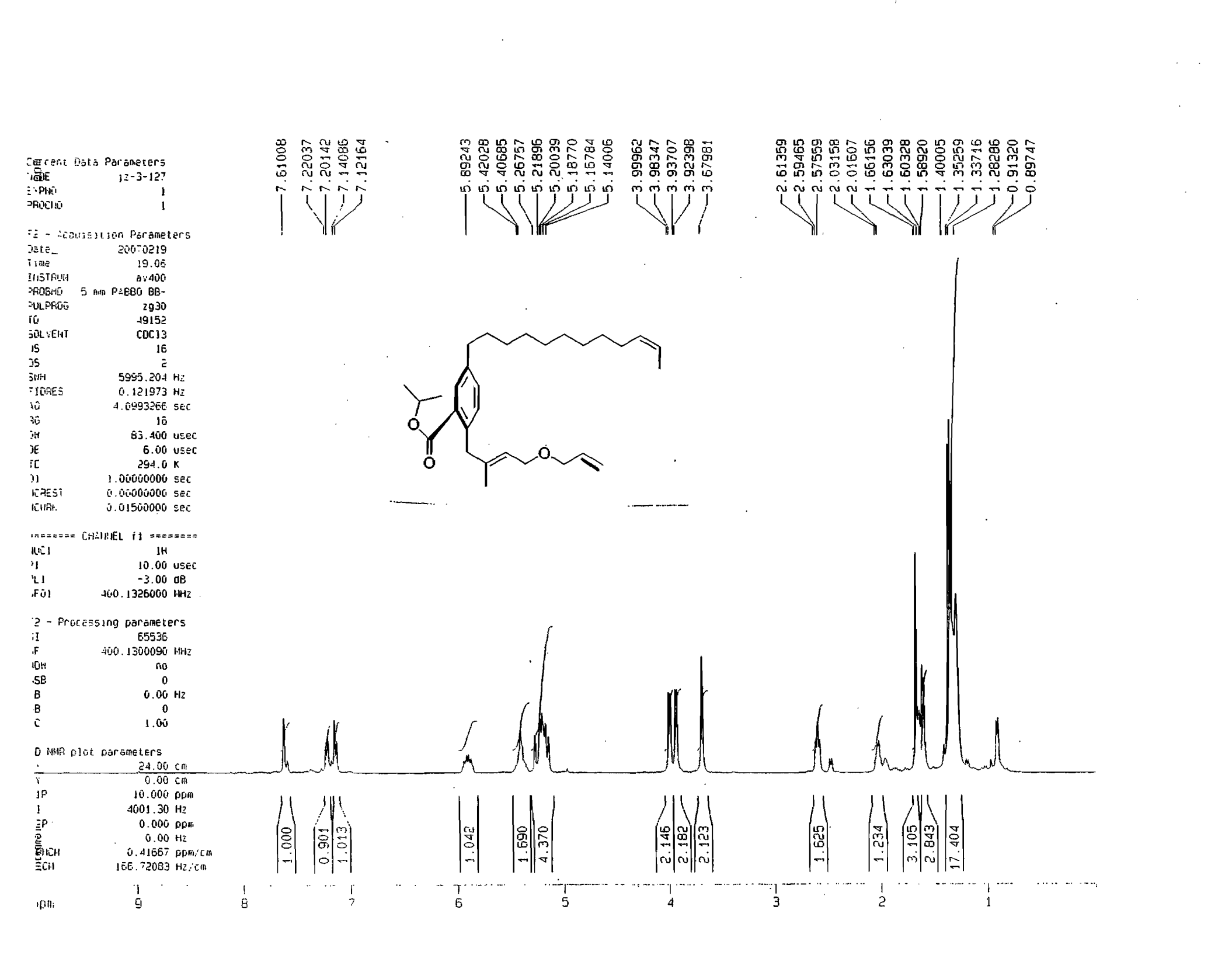
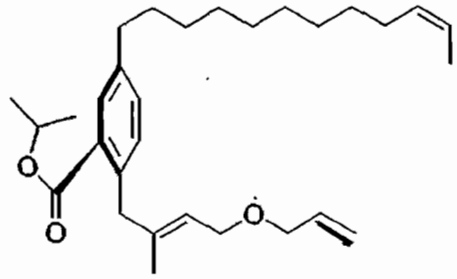
165.748
152.822
151.651
144.516
139.004
132.160
132.010
131.678
130.446
128.023
127.580
126.051
124.562
124.126
123.436
121.850
119.815
119.418
115.793
77.317
77.203
77.000
76.682
73.638
68.127
64.747
38.962
31.731
27.077
24.998
23.608
15.343
13.213
CF3
CF3
O
O
O
O
Current Data Parameters
NAME jz-2-185
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070515
Time 6.43
INSTRUM av400
PROBHD 5 mm PABBO BB-
PULPROG zgpg30
TD 51200
SOLVENT CDCl3
NS 12000
DS 2
SWH 25062.656 Hz
FIDRES 0.489505 Hz
AQ 1.0214900 sec
RG 32768
DW 19.950 usec
DE 6.00 usec
TE 295.0 K
D1 1.50000000 sec
D11 0.03000000 sec
DELTA 1.39999998 sec
TDRESET 0.00000000 sec
MCREV 0.01500000 sec
======== CHANNEL f1 ========
NUC1 13C
P1 7.50 usec
PL1 -3.00 dB
SFO1 100.6242690 MHz
======== CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 96.00 usec
PL2 -3.00 dB
PL12 16.00 dB
PL13 19.00 dB
SFO2 400.1315000 MHz
F2 - Processing parameters
SI 65536
SF 100.6127714 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
CX 25.00 cm
IP 238.826 ppm
IF 24028.96 Hz
SP -10.274 ppm
2 -1033.69 Hz
PHCH 0.96401 ppm cm
CDN 1002.50623 Hz/cm
220
200
180
160
140
120
100
80
60
40
20
0


Current Data Parameters
NAME jz-3-127
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070219
Time 19.08
INSTRUM av400
PROBHD 5 mm PABBO BB-
PULPROG zg30
TD 49152
SOLVENT CDCl3
NS 16
DS 2
SWH 5995.204 Hz
FIDRES 0.121973 Hz
AQ 4.0993266 sec
RG 16
DW 83.400 usec
DE 6.00 usec
TE 294.0 K
D1 1.00000000 sec
D12REST 0.00000000 sec
D12MAX 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 10.00 usec
PL1 -3.00 dB
SFO1 400.1326000 MHz
F2 - Processing parameters
SI 65536
SF 400.1300090 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
WC 24.00 cm
WX 0.00 cm
PLPP 10.000 ppm
PLLP 4001.30 Hz
PLRP 0.000 ppm
PLRP 0.00 Hz
INTEGRALCM 0.41667 ppm/cm
INTEGRALHZ 166.72083 Hz/cm
7.61008
7.22037
7.20142
7.14086
7.12164
5.89243
5.42028
5.40685
5.26757
5.21896
5.20039
5.18770
5.16784
5.14006
3.99962
3.98347
3.93707
3.92398
3.67981
2.61359
2.59465
2.57559
2.03158
2.01607
1.66156
1.63039
1.60328
1.58920
1.40005
1.35259
1.33716
1.28286
0.91320
0.89747
1.000
0.901
1.013
1.042
1.690
4.370
2.146
2.182
2.123
1.625
1.234
3.105
2.843
17.404
ppm
9
8
7
6
5
4
3
2
1

ppm

167.573
140.744
139.734
139.512
137.233
137.138
134.917
132.730
132.147
131.547
131.443
131.070
131.018
130.923
130.747
130.659
130.001
128.791
124.410
123.479
122.201
116.823
77.425
77.000
76.576
70.820
68.050
66.443
44.669
42.474
35.273
32.518
31.267
29.992
29.511
29.459
29.387
29.236
29.183
29.085
28.830
26.735
23.204
22.242
21.819
21.282
17.841
16.840
12.654



Current Data Parameters
NAME jc-3-127
EXPNO 2
PROCNO 1

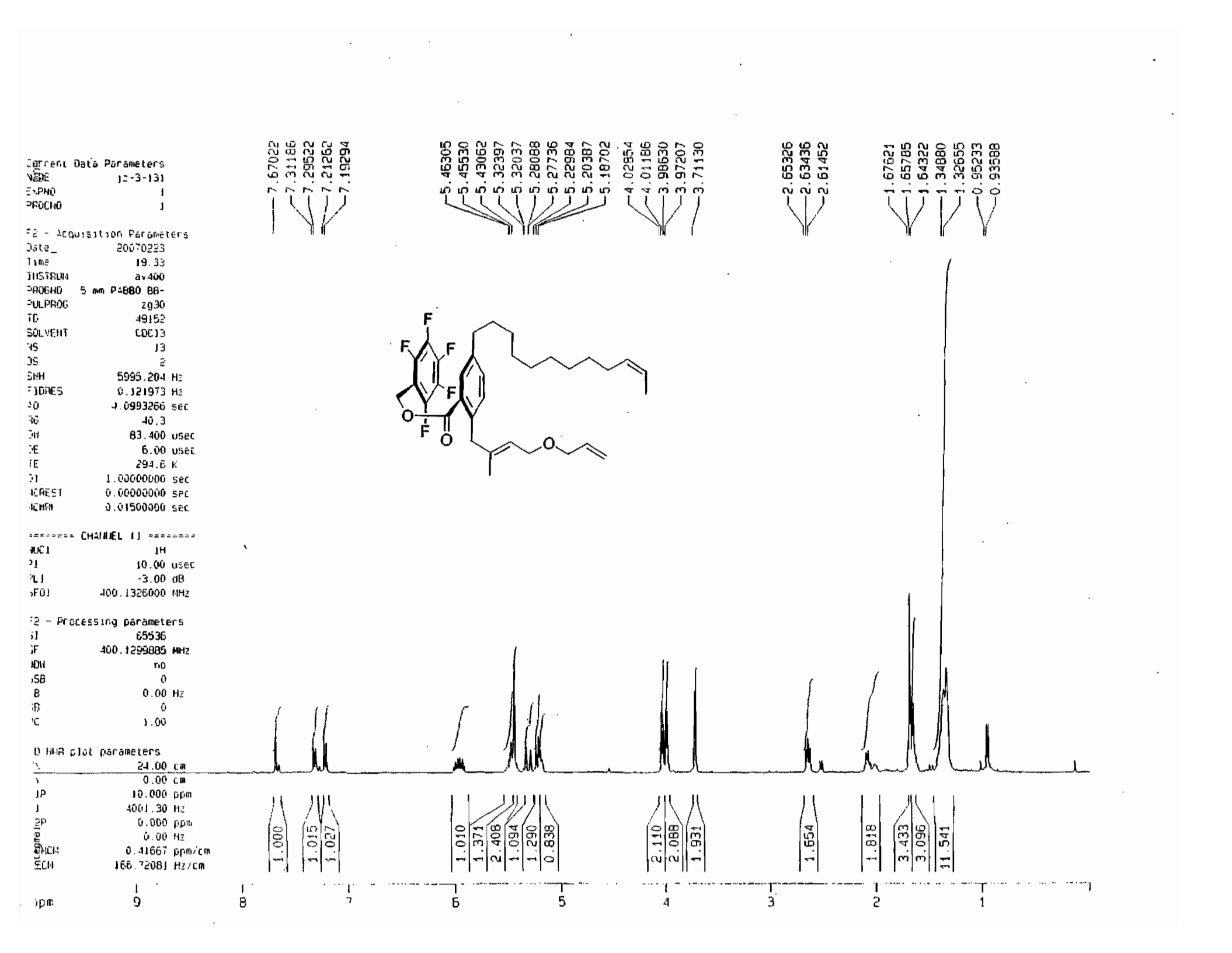
F2 - Acquisition Parameters
Date_ 20070219
Time 20.52
INSTRUM spect
PROBHD 5 mm QNP 1H 1
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 360
DS 2
SWH 17005.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451168 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
DELTA 0.69999998 sec
ACREST 0.00000000 sec
ACQUIRE 0.01500000 sec

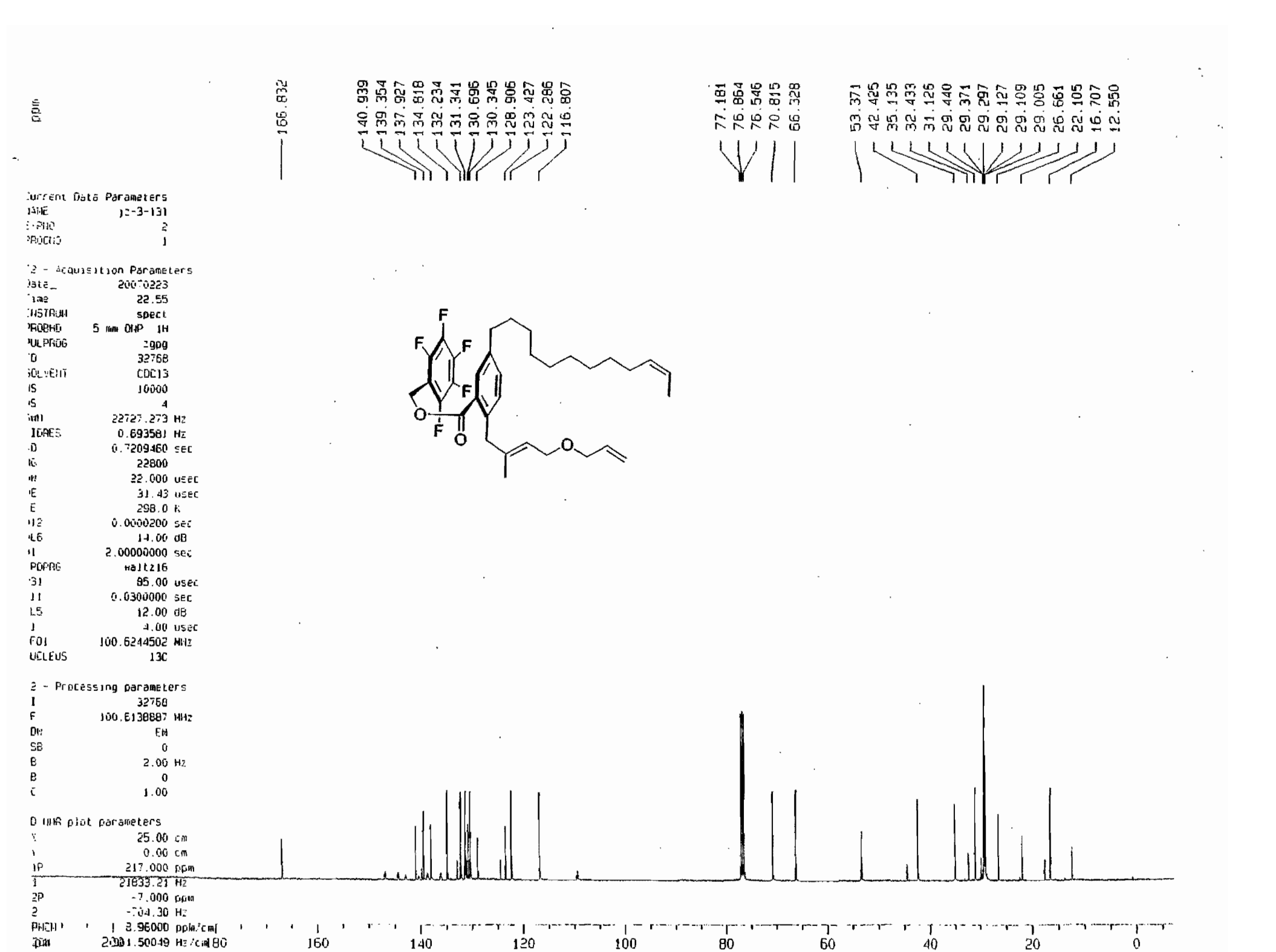
======== CHANNEL f1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz

======== CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 20.00 dB
SFO2 300.0310500 MHz

F2 - Processing parameters
SI 131072
SF 75.4426113 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40

1D NMR plot parameters
WX 25.00 cm
WY 0.00 cm
PLVP 218.657 ppm
PLVI 16496.07 Hz
PLVP2 -6.770 ppm
PLVI2 -510.78 Hz
PLPCH 0.001708 ppm cm
PLHZ 128.812 Hz cm


Current Data Parameters
NAME 12-3-131
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070223
Time 19.33
INSTRUM av400
PROBHD 5 mm PABBO BB-
PULPROG zg30
TD 49152
SOLVENT CDCl3
NS 13
DS 2
SWH 5995.204 Hz
FIDRES 0.121973 Hz
AQ 4.0993266 sec
RG 40.3
DW 83.400 usec
DE 6.00 usec
TE 294.6 K
D1 1.00000000 sec
ACREST 0.00000000 sec
ACQSM 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 10.00 usec
PL1 -3.00 dB
SFO1 400.1326000 MHz
F2 - Processing parameters
SI 65536
SF 400.1299885 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
WX 24.00 cm
WY 0.00 cm
PLVP 10.000 ppm
PLVI 4001.30 Hz
F2P 0.000 ppm
F2I 0.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 166.72081 Hz/cm
7.67022
7.31186
7.29522
7.21262
7.19294
5.46305
5.45530
5.43062
5.32397
5.32037
5.28088
5.27736
5.22984
5.20387
5.18702
4.02854
4.01186
3.98630
3.97207
3.71130
2.65326
2.63436
2.61452
1.67621
1.65785
1.64322
1.34880
1.32655
0.95233
0.93588
F
F
F
F
O
F
O
O
1.000
1.015
1.027
1.010
1.371
2.408
1.094
1.290
0.838
2.110
2.088
1.931
1.654
1.818
3.433
3.096
11.541
ppm
9
8
7
6
5
4
3
2
1


ppm
166.832
140.939
139.354
137.927
134.818
132.234
131.341
130.696
130.345
128.906
123.427
122.286
116.807
77.181
76.864
76.546
70.815
66.328
53.371
42.425
35.135
32.433
31.126
29.440
29.371
29.297
29.127
29.109
29.005
26.661
22.105
16.707
12.550
F
F
F
F
O
O
O
Current Data Parameters
NAME jz-3-131
EXPNO 2
PROCNO 1
2 - Acquisition Parameters
Date_ 20070223
Time 22.55
INSTRUM spect
PROBHD 5 mm CNP 1H
PULPROG zgpg
TD 32768
SOLVENT CDCl3
NS 10000
DS 4
SWH 22727.273 Hz
FIDRES 0.693581 Hz
AQ 0.7209460 sec
RG 22800
DW 22.000 usec
DE 31.43 usec
TE 298.0 K
D12 0.0000200 sec
PL6 14.00 dB
D1 2.00000000 sec
PCPD6 waltz16
P31 85.00 usec
D11 0.0300000 sec
PL5 12.00 dB
P1 4.00 usec
SFO1 100.6244502 MHz
NUCLEUS 13C
2 - Processing parameters
SI 32768
SF 100.6138887 MHz
WDW EM
SSB 0
LB 2.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
WX 25.00 cm
WY 0.00 cm
SP 217.000 ppm
F1 21833.21 Hz
PP -7.000 ppm
F2 -704.30 Hz
PHCH1 8.96000 ppm/cm
PPM 2001.50049 Hz/cm
200
160
140
120
100
80
60
40
20
0

Current Data Parameters
NAME 12-4-14
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070512
Time 19.26
INSTRUM spect
PROBHD 5 mm DHP 1H/1
PULPROG zg30
TD 32768
SOLVENT CDCl3
NS 100
DS 2
SWH 4006.410 Hz
FIDRES 0.122266 Hz
AQ 4.0694968 sec
RG 812.7
DW 124.800 usec
DE 6.00 usec
TE 0.0 K
D1 1.00000000 sec
D12CST 0.00000000 sec
D13CST 0.01500000 sec
======= CHANNEL f1 =======
NUC1 1H
P1 8.70 usec
PL1 6.00 dB
SFO1 300.0318000 MHz
F2 - Processing parameters
SI 65536
SF 300.0300036 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
WX 24.00 cm
WY 0.00 cm
PLPLP 10.000 ppm
PLPLM 3000.30 Hz
SPLP 0.000 ppm
SPLM 0.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 125.01250 Hz/cm
8.50599
8.28005
8.10247
7.88509
7.69205
7.68584
7.28905
7.28271
7.26003
7.18181
7.15560
5.87235
5.42458
5.40597
5.39200
5.26360
5.25811
5.20616
5.20067
5.16960
5.16418
5.13567
3.94369
3.91889
3.90373
3.89938
3.89501
3.66835
2.62886
2.60371
2.57707
2.04630
2.00737
1.64246
1.63813
1.63099
1.62700
1.60230
1.58612
1.58303
1.54902
1.35143
1.33096
1.31272
1.28306
1.26967
1.25946
0.91928
0.89447
0.88204
CF3
CF3
O
O
O
3.129
1.133
0.676
1.000
0.953
1.102
2.452
1.152
2.078
4.002
2.055
1.948
2.340
6.530
2.844
16.679
ppm
9
8
7
6
5
4
3
2
1

Current Data Param

NAME	jz-. .
EXPNO	2
PROCNO	1

F2 - Acquisition Parameters

Date_	20070515
Time	0.14
INSTRUM	spect
PROBHD	5 mm QNP 1H
PULPROG	zgpg
TD	32768
SOLVENT	CDCl3
NS	12000
DS	4
SWH	22727.273 Hz
FIDRES	0.693581 Hz
AQ	0.7209460 sec
RG	22800
DW	22.000 usec
DE	31.43 usec
TE	298.0 K
D12	0.0000200 sec
DL6	14.00 dB
D1	2.00000000 sec
CPDPRG	waltz16
P31	85.00 usec
D11	0.0300000 sec
DL5	12.00 dB
P1	4.00 usec
SFO1	100.6244502 MHz
NUCLEUS	13C

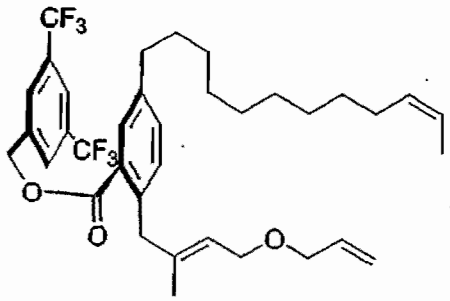
F2 - Processing parameters

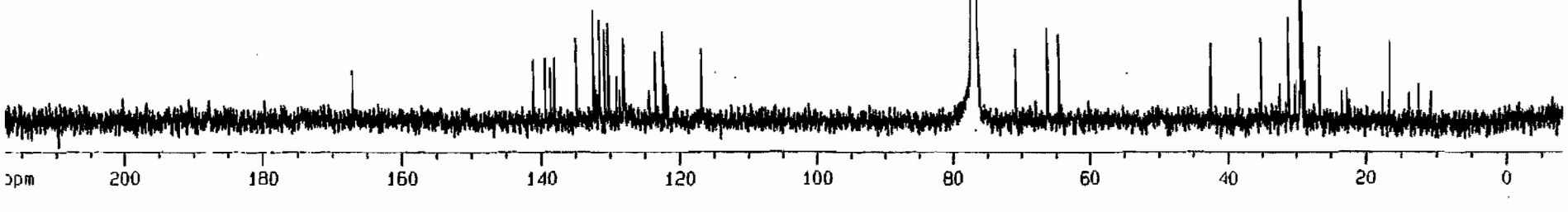
SI	32768
SF	100.6138887 MHz
WDW	EM
SSB	0
LB	2.00 Hz
GB	0
PC	1.00

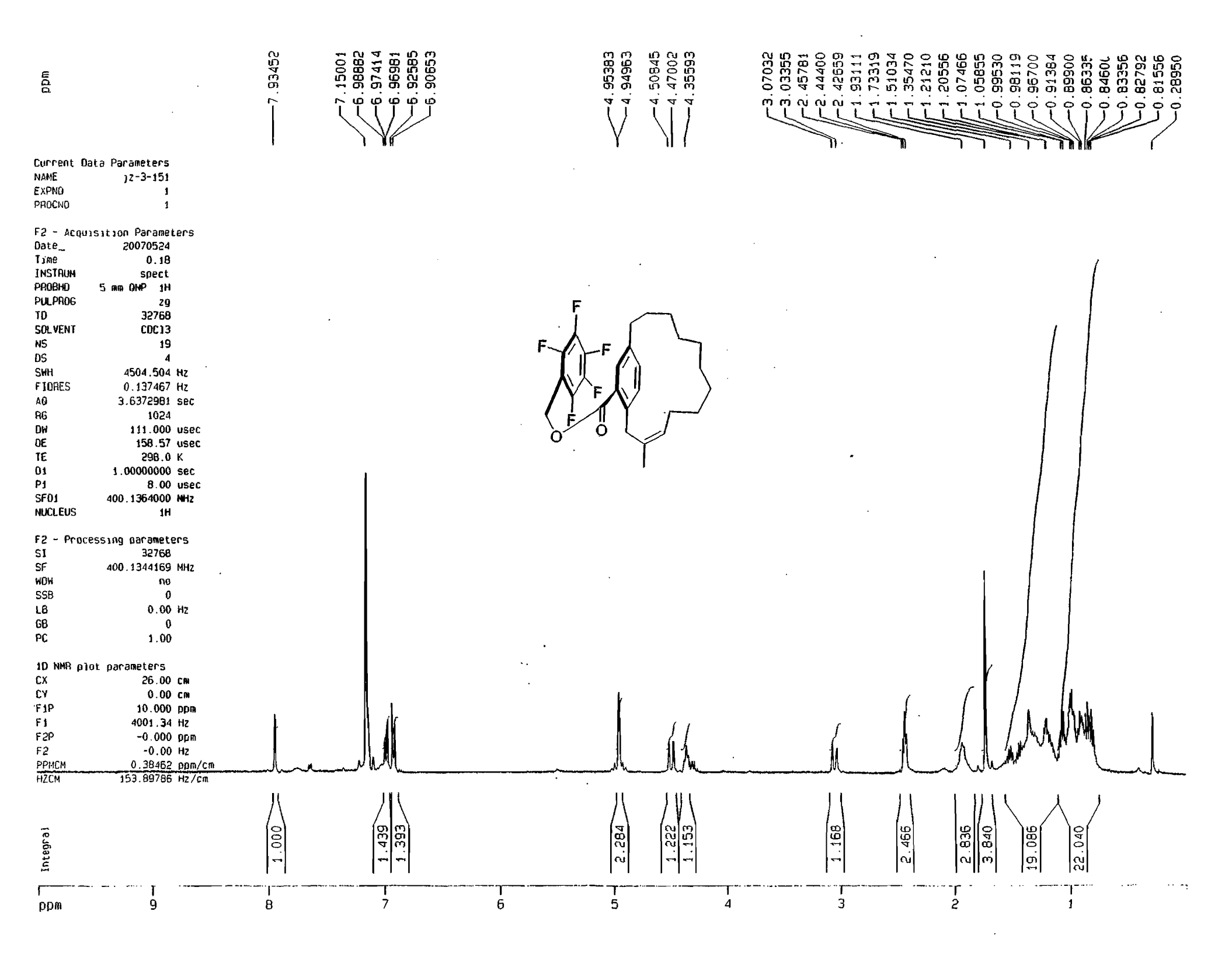
1D NMR plot parameters

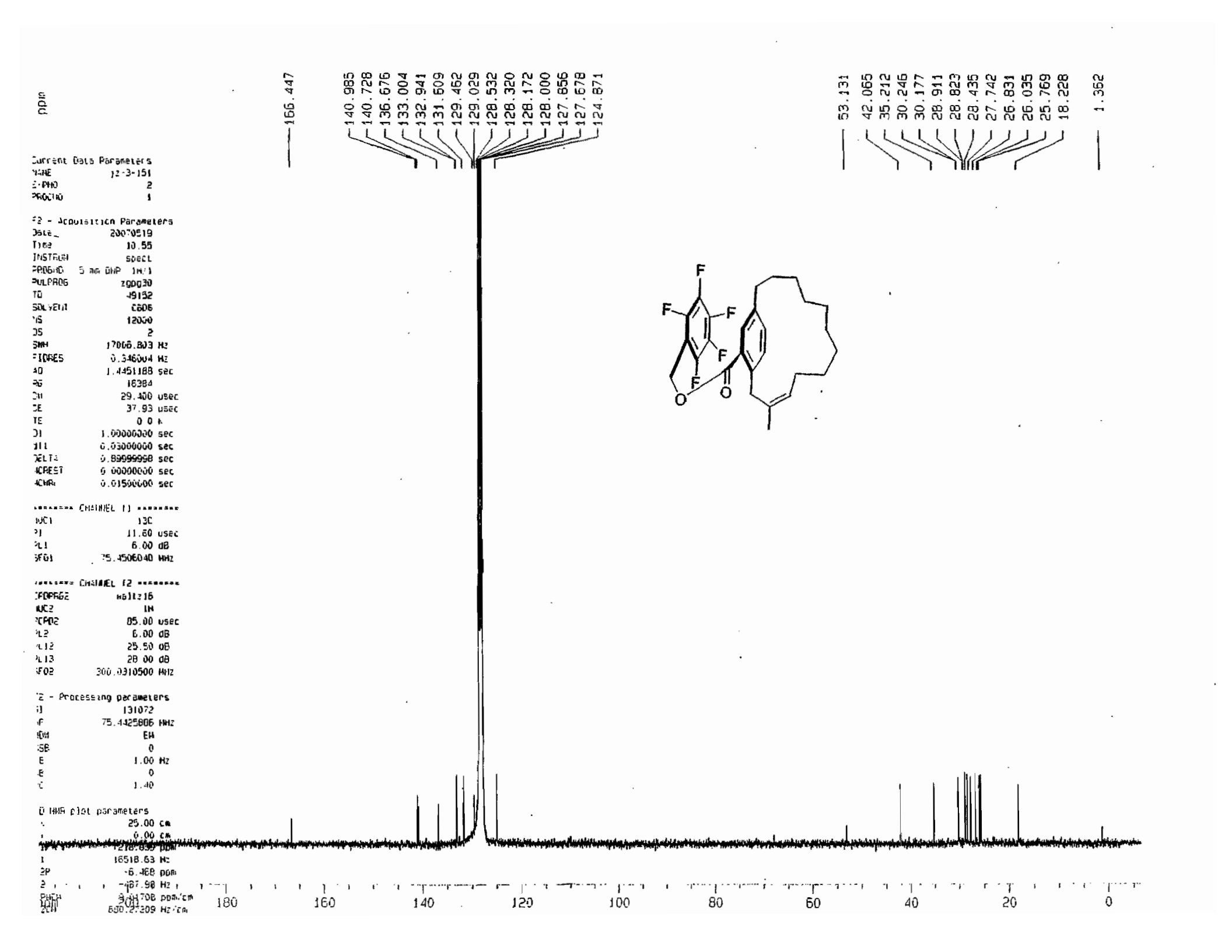
CX	25.00 cm
CY	0.00 cm
F1P	217.913 ppm
F1	21925.12 Hz
F2P	-7.973 ppm
F2	-802.16 Hz
PPMCM	9.03544 ppm/cm
HZCM	909.09088 Hz/cm

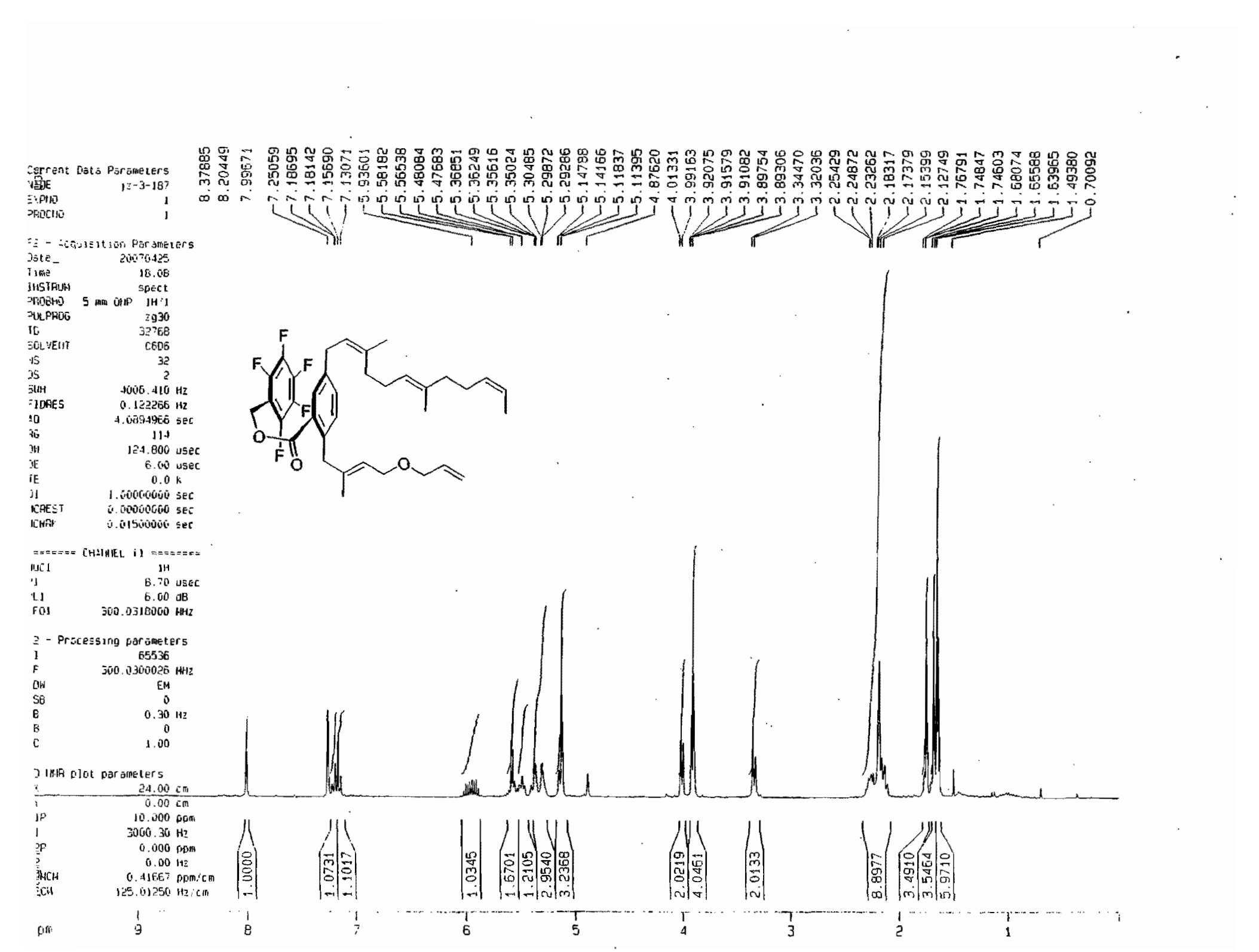
141.197
139.518
138.730
138.108
134.922
132.465
131.600
130.867
130.367
129.211
123.599
122.428
117.024
77.424
77.205
77.000
76.577
71.003
66.459
35.322
31.268
29.536
29.512
29.437
29.286
29.251
26.812
16.876
12.730

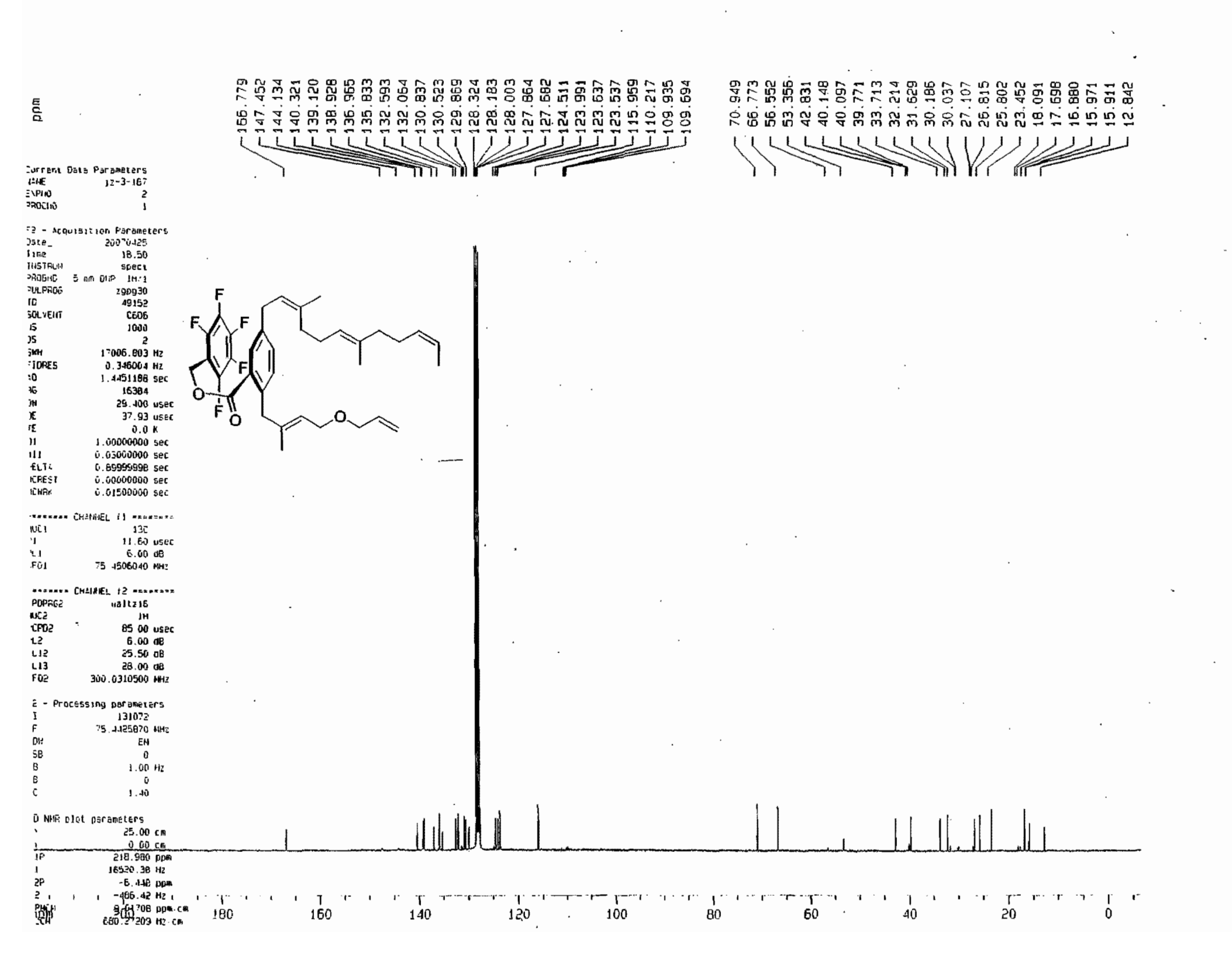


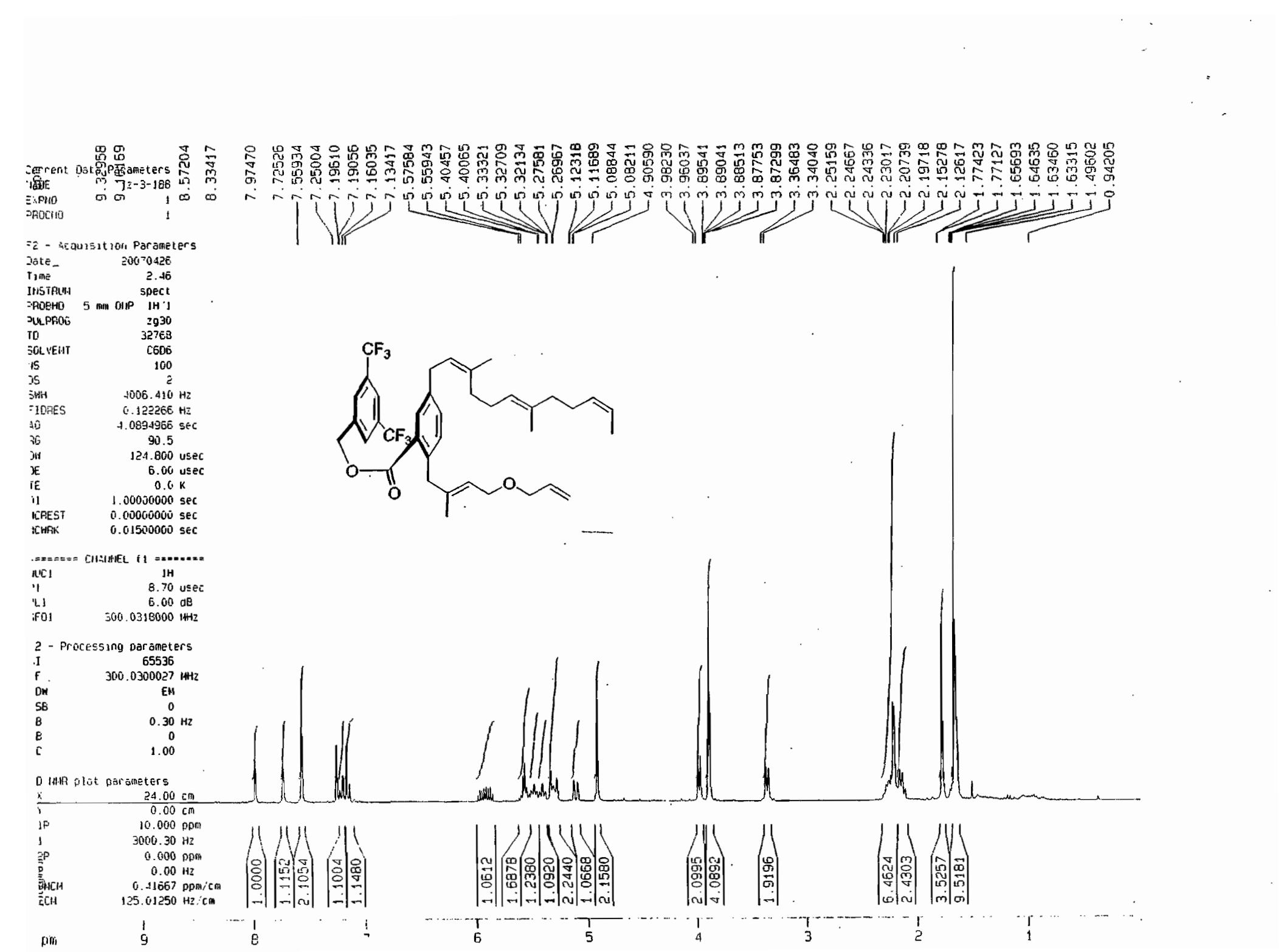


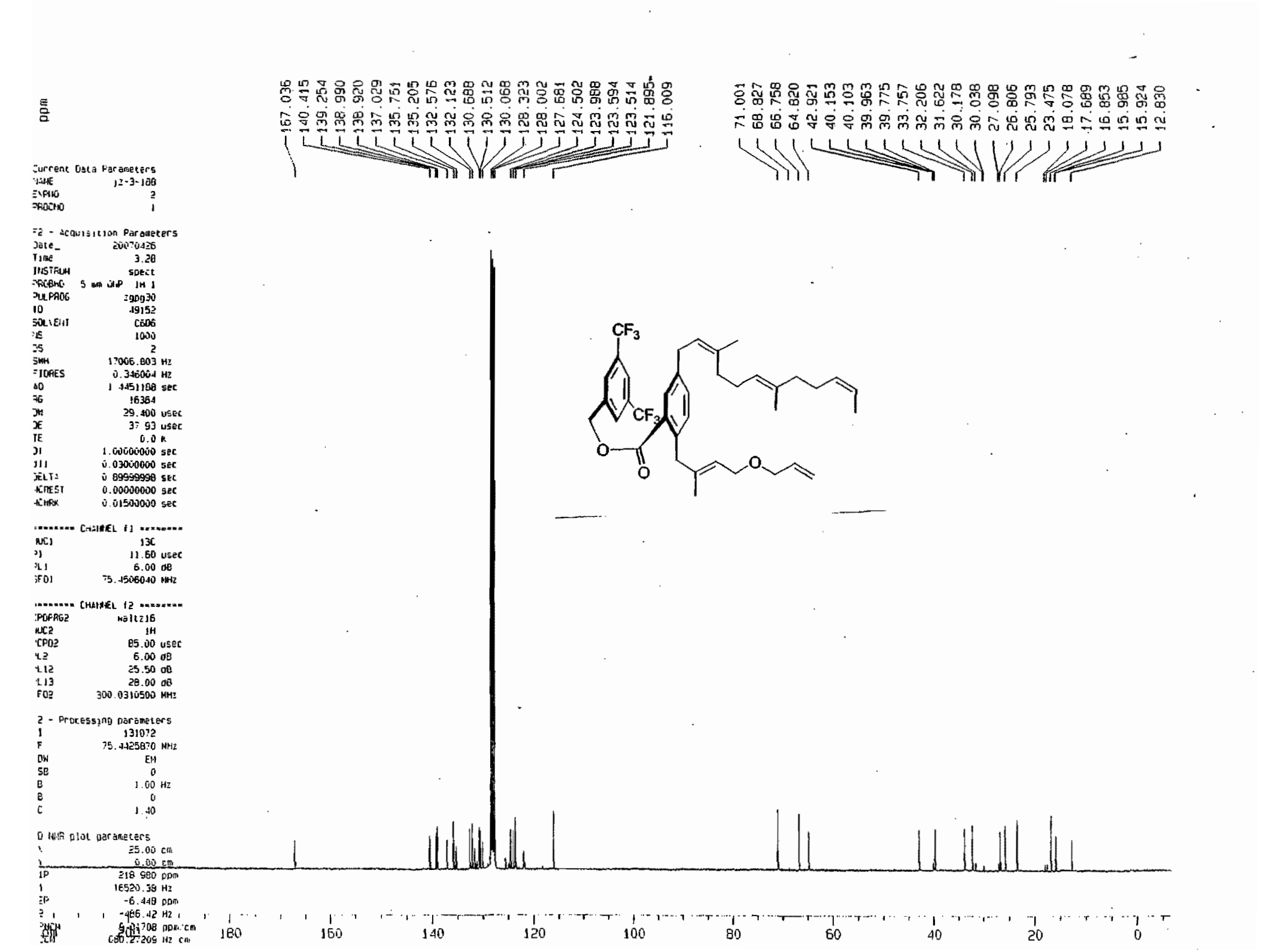

ppm
7.93452
7.15001
6.98882
6.97414
6.96981
6.92585
6.90653
4.95383
4.94963
4.50845
4.47002
4.35593
3.07032
3.03355
2.45781
2.44400
2.42659
1.93111
1.73319
1.51034
1.35470
1.21210
1.20556
1.07466
1.05855
0.99530
0.98119
0.96700
0.91384
0.89900
0.86335
0.84601
0.83356
0.82792
0.81556
0.28950
Current Data Parameters
NAME jz-3-151
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070524
Time 0.18
INSTRUM spect
PROBHD 5 mm QNP 1H
PULPROG zg
TD 32768
SOLVENT CDCl3
NS 19
DS 4
SWH 4504.504 Hz
FIDRES 0.137467 Hz
AQ 3.6372981 sec
RG 1024
DW 111.000 usec
DE 158.57 usec
TE 298.0 K
D1 1.00000000 sec
P1 8.00 usec
SFO1 400.1364000 MHz
NUCLEUS 1H
F2 - Processing parameters
SI 32768
SF 400.1344169 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 26.00 cm
CY 0.00 cm
F1P 10.000 ppm
F1 4001.34 Hz
F2P -0.000 ppm
F2 -0.00 Hz
PPMCM 0.38462 ppm/cm
HZCM 153.89786 Hz/cm
F
F
F
F
F
O
O
Integral
1.000
1.439
1.393
2.284
1.222
1.153
1.168
2.466
2.836
3.840
19.086
22.040
ppm
9
8
7
6
5
4
3
2
1


ppm
166.447
140.985
140.728
136.676
133.004
132.941
131.609
129.462
129.029
128.532
128.320
128.172
128.000
127.856
127.678
124.871
53.131
42.065
35.212
30.246
30.177
28.911
28.823
28.435
27.742
26.831
26.035
25.769
18.228
1.362
F
F
F
F
F
O
O
Current Data Parameters
NAME j2-3-151
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070519
Time 10.55
INSTRUM spect
PROBHD 5 mm DUP 1H/1
PULPROG zgpg30
TD 49152
SOLVENT CDCl3
NS 12000
DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451188 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
DELTA 0.89999958 sec
ACREST 0.00000000 sec
ACHRN 0.01500000 sec
======== CHANNEL f1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz
======== CHANNEL f2 ========
CPDPRG2 waltz16
NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
F2 - Processing parameters
SI 131072
SF 75.4425806 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
CX 25.00 cm
CY 0.00 cm
F1P 218.859 ppm
F1 16518.63 Hz
F2P -6.468 ppm
F2 -487.98 Hz
PPMCM 9.41708 ppm/cm
HZCM 830.27209 Hz/cm
200
180
160
140
120
100
80
60
40
20
0


8.37885
8.20449
7.99671
7.25059
7.18695
7.18142
7.15690
7.13071
5.93601
5.58182
5.56538
5.48084
5.47683
5.36851
5.36249
5.35616
5.35024
5.30485
5.29872
5.29286
5.14798
5.14166
5.11837
5.11395
4.87620
4.01331
3.99163
3.92075
3.91579
3.91082
3.89754
3.89306
3.34470
3.32036
2.25429
2.24872
2.23262
2.18317
2.17379
2.15399
2.12749
1.76791
1.74847
1.74603
1.68074
1.65588
1.63965
1.49380
0.70092
Current Data Parameters
NAME jz-3-187
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070425
Time 18.08
INSTRUM spect
PROBHD 5 mm ONP 1H/1
PULPROG zg30
TD 32768
SOLVENT C6D6
NS 32
DS 2
SWH 4006.410 Hz
FIDRES 0.122266 Hz
AQ 4.0894966 sec
RG 114
DW 124.800 usec
DE 6.00 usec
TE 0.0 K
D1 1.00000000 sec
MCREST 0.00000000 sec
MCWRK 0.01500000 sec
======= CHANNEL f1 =======
NUC1 1H
P1 8.70 usec
PL1 6.00 dB
SF01 300.0318000 MHz
F2 - Processing parameters
SI 65536
SF 300.0300026 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 24.00 cm
CY 0.00 cm
F1P 10.000 ppm
F1 3000.30 Hz
F2P 0.000 ppm
F2 0.00 Hz
PPMCM 0.41667 ppm/cm
HZCM 125.01250 Hz/cm
1.0000
1.0731
1.1017
1.0345
1.6701
1.2105
2.9540
3.2368
2.0219
4.0461
2.0133
8.8977
3.4910
3.5464
5.9710
pm
9
8
7
6
5
4
3
2
1


ppm
166.779
147.452
144.134
140.321
139.120
138.928
136.965
135.833
132.593
132.064
130.837
130.523
129.869
128.324
128.183
128.003
127.864
127.682
124.511
123.991
123.637
123.537
115.959
110.217
109.935
109.694
70.949
66.773
56.552
53.356
42.831
40.148
40.097
39.771
33.713
32.214
31.629
30.186
30.037
27.107
26.815
25.802
23.452
18.091
17.698
16.880
15.971
15.911
12.842
Current Data Parameters
NAME 12-3-167
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070425
Time 18.50
INSTRUM spect
PROBHD 5 mm DUP 1H/1
PULPROG zgpg30
TD 49152
SOLVENT C606
NS 1000
DS 2
SWH 17006.803 Hz
FIDRES 0.346004 Hz
AQ 1.4451186 sec
RG 16384
DW 29.400 usec
DE 37.93 usec
TE 0.0 K
D1 1.00000000 sec
D11 0.03000000 sec
DELTA 0.89999998 sec
PCREST 0.00000000 sec
PCNAM 0.01500000 sec
======== CHANNEL f1 ========
NUC1 13C
P1 11.60 usec
PL1 6.00 dB
SFO1 75.4506040 MHz
======== CHANNEL f2 ========
PCPRG2 waltz16
NUC2 1H
PCPD2 85.00 usec
PL2 6.00 dB
PL12 25.50 dB
PL13 28.00 dB
SFO2 300.0310500 MHz
F2 - Processing parameters
SI 131072
SF 75.4425870 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40
1D NMR plot parameters
CX 25.00 cm
CY 0.00 cm
F1P 218.980 ppm
F1 16520.38 Hz
F2P -6.448 ppm
F2 -486.42 Hz
PPM 9.0708 ppm/cm
HZ 680.2709 Hz/cm
180
160
140
120
100
80
60
40
20
0


Current Data Parameters
NAME
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070426
Time 2.46
INSTRUM spect
PROBHD 5 mm DUP 1H-1
PULPROG zg30
TD 32768
SOLVENT C6D6
NS 100
DS 2
SWH 4006.410 Hz
FIDRES 0.122266 Hz
AQ 4.0894966 sec
RG 90.5
DW 124.800 usec
DE 6.00 usec
TE 0.0 K
D1 1.00000000 sec
MCREST 0.00000000 sec
MCWRK 0.01500000 sec
======== CHANNEL f1 ========
NUC1 1H
P1 8.70 usec
PL1 6.00 dB
SFO1 300.0318000 MHz
2 - Processing parameters
SI 65536
SF 300.0300027 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
1D NMR plot parameters
WX 24.00 cm
WY 0.00 cm
PLPLP 10.000 ppm
PL1 3000.30 Hz
PLPLP 0.000 ppm
PL1P 0.00 Hz
PLPCH 0.41667 ppm/cm
PLCH 125.01250 Hz/cm
9.32958
9.31169
8.57204
8.33417
7.97470
7.72526
7.55934
7.25004
7.19610
7.19056
7.16035
7.13417
5.57584
5.55943
5.40457
5.40065
5.33321
5.32709
5.32134
5.27581
5.26967
5.12318
5.11689
5.08844
5.08211
4.90590
3.98230
3.96037
3.89541
3.89041
3.88513
3.87753
3.87299
3.36483
3.34040
2.25159
2.24667
2.24336
2.23017
2.20739
2.19718
2.15278
2.12617
1.77423
1.77127
1.65693
1.64635
1.63460
1.63315
1.49602
0.94205
CF3
CF3
O
O
O
1.0000
1.1152
2.1054
1.1004
1.1480
1.0612
1.6878
1.2380
1.0920
2.2440
1.0668
2.1580
2.0995
4.0892
1.9196
6.4624
2.4303
3.5257
9.5181
ppm
9
8
6
5
4
3
2
1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137.029
135.751
135.205
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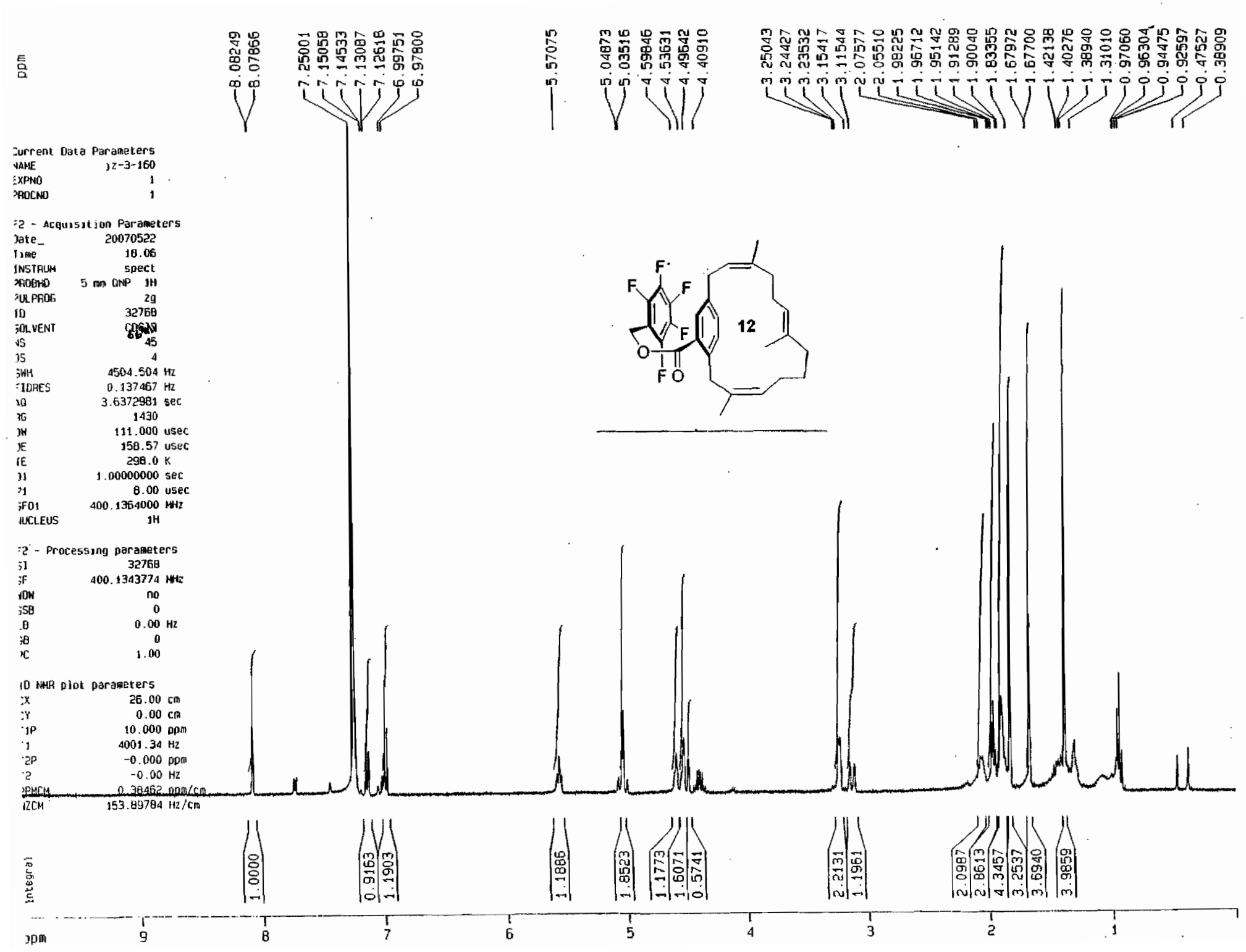
132.123
130.688
130.512
130.068
128.323
128.002
127.681
124.502
123.988
123.594
123.514
121.895
116.009
71.001
68.827
66.758
64.820
42.921
40.153
40.103
39.963
39.775
33.757
32.206
31.622
30.178
30.038
27.098
26.806
25.793
23.475
18.078
17.689
16.853
15.985
15.924
12.830
Current Data Parameters
NAME
EXPNO
PROCNO
F2 - Acquisition Parameters
Date_
Time
INSTRUM
PROBHD 5 mm DUP 1H 1
PULPROG
TD
SOLVENT
NS
DS
SWH
FIDRES
AQ
RG
DW
DE
TE
D1
D11
DELTA
ACQT
ACQTM
CF3
CF3
O
O
O
F1 - Processing parameters
SI
SF
WDW
SSB
LB
GB
PC
1D NMR plot parameters
180
160
140
120
100
80
60
40
20
0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8.07866
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7.13087
7.12618
6.99751
6.97800
5.57075
5.04873
5.03516
4.59846
4.53631
4.49642
4.40910
3.25043
3.24427
3.23532
3.15417
3.11544
2.07577
2.05510
1.98225
1.96712
1.95142
1.91289
1.90040
1.83355
1.67972
1.67700
1.42138
1.40276
1.38940
1.31010
0.97060
0.96304
0.94475
0.92597
0.47527
0.38909
Current Data Parameters
NAME yz-3-160
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20070522
Time 18.06
INSTRUM spect
PROBHD 5 mm QNP 1H
PULPROG zg
TD 32768
SOLVENT CDCl3
NS 45
DS 4
SWH 4504.504 Hz
FIDRES 0.137467 Hz
AQ 3.6372981 sec
RG 1430
DW 111.000 usec
DE 158.57 usec
TE 298.0 K
D1 1.00000000 sec
P1 8.00 usec
SFO1 400.1364000 MHz
NUCLEUS 1H
F2 - Processing parameters
SI 32768
SF 400.1343774 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00
1D NMR plot parameters
CX 26.00 cm
CY 0.00 cm
F1P 10.000 ppm
F1 4001.34 Hz
F2P -0.000 ppm
F2 -0.00 Hz
PPMCM 0.38462 ppm/cm
HZCM 153.89784 Hz/cm
F
F
F
F
O
F O
12
Integral
1.0000
0.9163
1.1903
1.1886
1.8523
1.1773
1.6071
0.5741
2.2131
1.1961
2.0987
2.8613
4.3457
3.2537
3.6940
3.9859
ppm
9
8
7
6
5
4
3
2
1

Current Data Param
NAME jz-
EXPNO 2
PROCNO 1

F2 - Acquisition Parameters
Date_ 20070531
Time 20.04
INSTRUM spect
PROBHD 5 mm QNP 1H
PULPROG zgpg
TD 32768
SOLVENT CDCl3
NS 15000
DS 4
SWH 22727.273 Hz
FIDRES 0.693581 Hz
AQ 0.7209460 sec
RG 22800
DW 22.000 usec
DE 31.43 usec
TE 298.0 K
D12 0.0000200 sec
DL6 14.00 dB
D1 2.00000000 sec
CPDPRG waltz16
P31 85.00 usec
D11 0.0300000 sec
DL5 12.00 dB
P1 4.00 usec
SFO1 100.6244502 MHz
NUCLEUS 13C

F2 - Processing parameters
SI 32768
SF 100.6138473 MHz
WDW no
SSB 0
LB 0.00 Hz
GB 0
PC 1.00

1D NMR plot parameters
CX 25.00 cm
CY 0.00 cm
F1P 218.326 ppm
F1 21966.57 Hz
F2P -7.561 ppm
F2 -760.70 Hz
PPMCM 9.03545 ppm/cm
HZCM 909.09082 Hz/cm

166.499
140.553
136.423
132.963
132.880
129.488
128.633
128.536
128.357
128.288
128.244
128.119
128.076
128.003
127.888
127.834
127.763
127.482
127.240
123.946
121.593
77.715
77.394
77.077
42.114
39.166
38.745
33.331
31.827
30.781
29.263
25.541
24.118
23.675
23.309
22.516
18.656
14.940
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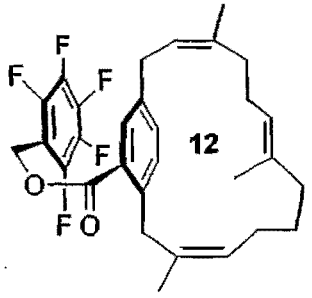
11.129



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