SYNTHESIS OF ALLYLIC ORGANOTIN COMPOUNDS FOR THE PREPARATION OF HOMOALLYLIC ALCOHOLS

By

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Submitted in partial fufillment
of the requirements for
Honors in the Department of Chemistry

UNION COLLEGE

June, 1988

ABSTRACT

HERMANCE, DEBORAH Synthesis of Allylic Organotin Compounds for the Preparation of Homoallylic Alcohols. Department of Chemistry June 1988.

The addition of an allylic organotin compound to an aldehyde in the presence of a Lewis acid affords the erythro homoallylic alcohol.

Organotin compounds containing optically active constituents such as menthyl and myrtanyl have been prepared. The myrtanyl compound was used in the preparation of an allylic organotin, cinnamyl trimyrtanyl tin, for future reaction with benzaldehyde.

The objective is to obtain both enantio- and diastereoselectivity in the addition reaction.

I would like to acknowledge the guidance and patience of Professor McGahey over the past year. I feel that I have learned more about the realm of chemistry within the past year in his laboratory than in any undergraduate chemistry class. I would like to thank Professor McGahey for all his advice and support in helping in my decision about graduate school.

I would also like to acknowledge and thank Dorothy Taylor for her preparation of a compound used in my research project.

Finally, I would like to thank the faculty of the Chemistry Department for their guidance, patience and support during my matriculation at Union College.

Deborah R. Hermance

TABLE OF CONTENTS

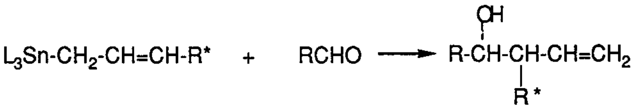
TABLE OF FIGURES

TABLE OF TABLES

INTRODUCTION

The focus of this project has been on the synthesis of allylic organotin compounds for the preparation of homoallylic alcohols. Synthesis of cinnamyl trimyrtanyl tin, an allylic organotin containing three optically active constituents, is of importance in the study of enantio- and diastereoselectivity in the preparation of homoallylic alcohols. The optically active constituents attached to tin will allow investigation into their involvement in the reaction mechanism and stereochemical outcome in the preparation of homoallylic alcohols.

The reaction of allylic organotins with aldehydes affords homoallylic alcohols. Rearrangement of the allylic group attached to the organotin occurs as it adds to the carbonyl carbon of the aldehyde.

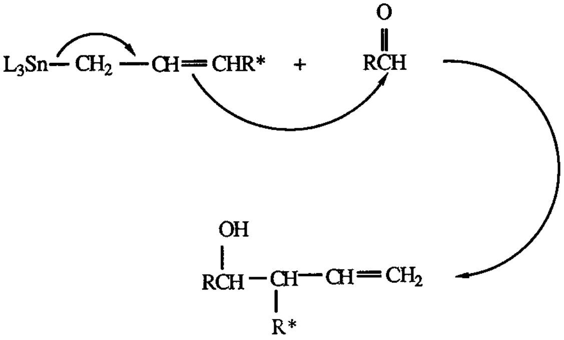


$$L_3Sn\text{-}CH_2\text{-}CH{=}CH\text{-}R^* \quad + \quad RCHO \longrightarrow R\text{-}\overset{OH}{\overset{|}{C}}H\text{-}\underset{R^*}{\underset{|}{C}}H\text{-}CH{=}CH_2$$

L = butyl or phenyl

R* = alkyl or aryl

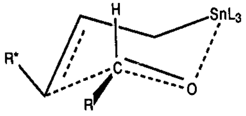
Rearrangement



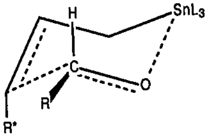
Alcohols of this type are called homoallylic because the hydroxyl group is attached to the carbon two carbons away from the carbon double bond. Homoallylic alcohols are found in insect pheromones and are used in the preparation of antibiotics. The synthesis of homoallylic alcohols is pertinent in the preparation of naturally occurring compounds.

It is important to note that the homoallylic alcohol contains two chiral carbons. This means there are four possible stereoisomers: two pairs of enantiomers which are diastereomers to each other. A purposeful study is the investigation into the stereoselectivity of homoallylic alcohol formed from the reaction of an aldehyde with an organotin containing optically active sites. Optical rotation measurements can be employed to determine stereochemistry of resulting homoallylic alcohol.

Previous studies have shown that the thermal reaction of an allylic tin compound with an aldehyde proceeds through a six-membered cyclic transition state.[1] From this transition state, the metal cation interacts with the partially negative carbonyl oxygen of the aldehyde at the same time the sp^2 carbon of the alkene forms a bond to the aldehyde carbon.



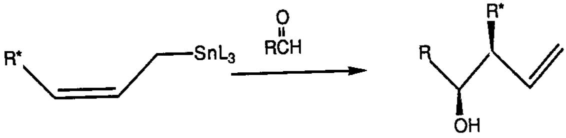
E



Z

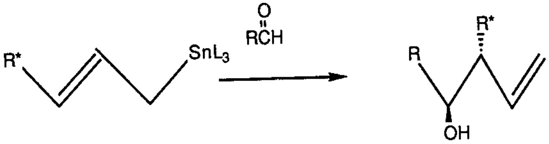
The zusammen , or Z isomer of the allylic tin compound produces the erythro homoallylic alcohol and the entgegen, or E allylic tin isomer affords the threo homoallylic alcohol. Therefore, inorder to form a pure diastereometric homoallylic alcohol, a pure alkene must be present in the reaction.

Z



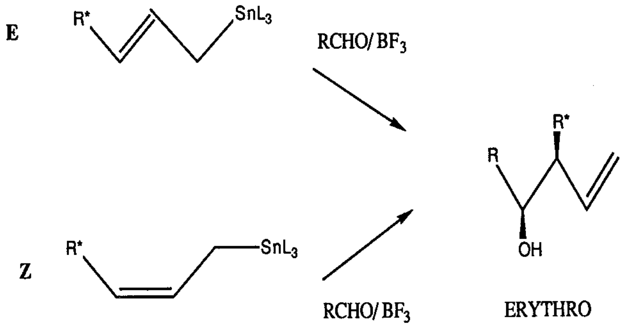
ERYTHRO

E



THREO

However, when the E or Z allylic tin isomers are reacted with an aldehyde in the presence of a catalyst and no heat, the erythro homoallylic alcohol is formed and an acyclic transition state is responsible for this stereochemical outcome.[2]



The presence of the Lewis acid makes the aldehyde more reactive to the weak allylic tin nucleophile by increasing the positive charge on the carbonyl carbon. The presence of the Lewis acid, boron triflouride, leads to the coordination of the boron to the oxygen of the carbonyl, preventing the coordination of the metal to the oxygen atom, thereby preventing the formation of the six -membered cyclic transition state.

There are steric reasons for the formation of the acyclic transition state. The two conformers leading to the erythro homoallylic alcohol place the R and R* substituents far from one another; therefore there is less guache interaction involved (See Figure I-1). The conformers leading to the threo homoallylic alcohol are unfavorable due to the steric hindrance associated with three guache interactions (See Figure I-2). R is guache to R*, R* is guache to the carbonyl oxygen and R is guache to the allylic group (carbon double bond). The E conformers have two guache interactions: R and the carbon double bond and R* with the carbonyl oxygen (See Figure I-1). Therefore, the presence of the Lewis acid greatly influences the reaction mechanism and the stereochemistry.

The focus of this project has been mainly on the influence of optically active constituents, attached to a tin compound, on the reaction mechanism and on the selection of enantiomer. Attention has been drawn to reactions which proceed rather quickly through a cyclic transition state inorder to discover the importance of chirality in the synthesis of homoallylic alcohols.

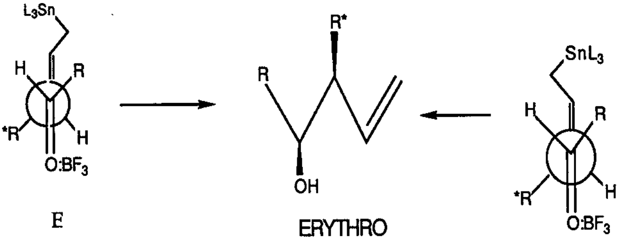


Figure I-1: Conformers leading to erythro homoalylic alcohol

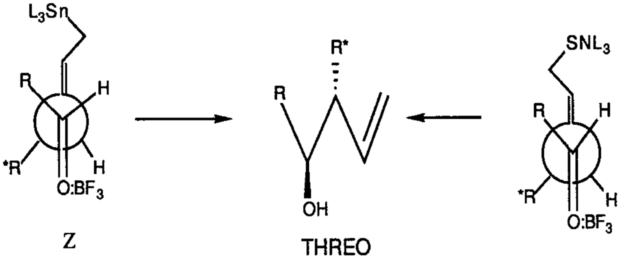
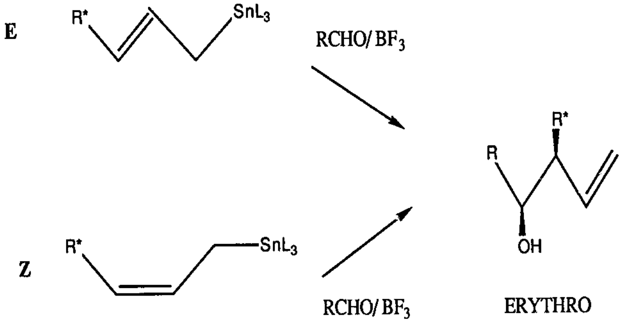


Figure I-2: Conformers leading to threo homoallylic alcohol

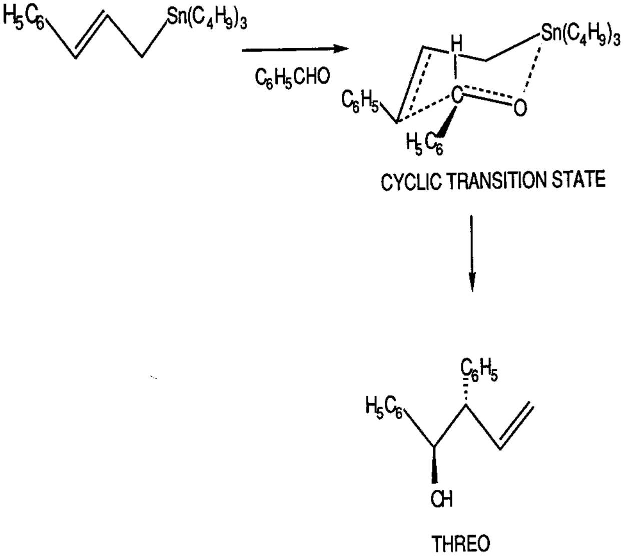
However, when the E or Z allylic tin isomers are reacted with an aldehyde in the presence of a catalyst and no heat, the erythro homoallylic alcohol is formed and an acyclic transition state is responsible for this stereochemical outcome.[2]



The presence of the Lewis acid makes the aldehyde more reactive to the weak allylic tin nucleophile by increasing the positive charge on the carbonyl carbon. The presence of the Lewis acid, boron triflouride, leads to the coordination of the boron to the oxygen of the carbonyl, preventing the coordination of the metal to the oxygen atom, thereby preventing the formation of the six -membered cyclic transition state.

There are steric reasons for the formation of the acyclic transition state. The two conformers leading to the erythro homoallylic alcohol

This project has been modeled after a reaction believed to proceed through a six-membered cyclic transition state studied by Yamamoto.[3] Yamamoto reacted tributyl cinnamyl tin of the E isomer with benzaldehyde in the presence of boron triflouride, forming the threo homoallylic alcohol.



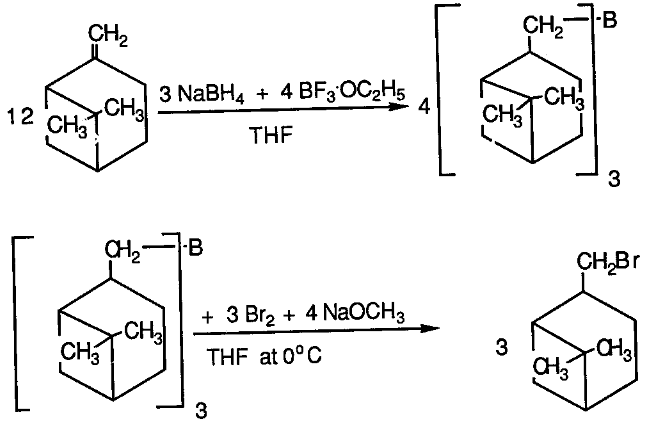
This reaction is an exception to the stereochemistry proposed earlier. Also, the formation of the six-membered cyclic transition state will allow the optically active constituents to come in close proximity to the reaction center. This will enable investigation of their influence on the stereochemical outcome. Therefore, attention has been focused on the preparation of organotins and allylic organotins containing optically active constituents.

RESULTS

A future goal of this project is the reaction of cinnamyl trimyrtanyl tin with benzaldehyde to afford 1,2 - diphenyl - 3 - butene - 1 - ol, a homoallylic alcohol. Preparation for this reaction involves several syntheses. The first synthesis is the hydroboration - bromination of β - pinene to form myrtanyl bromide, an optically active alkyl halide. Myrtanyl bromide was made into a Grignard reagent and reacted with trichlorophenyl tin inorder to attach three optically active myrtanyl constituents to tin. Trimyrtanylphenyl tin was brominated and reacted with an allyltin Grignard, cinnamyl magnesium chloride, to afford cinnamyl trimyrtanyl tin. Unfortunately, purification of cinnamyl trimyrtanyl tin by vacuum fractional distillation gave small fraction yields. Also, the solution in the reaction flask decomposed during the distillation. Proton and carbon - 13 NMRs of cinnamyl trimyrtanyl tin contain complicated splitting patterns which make it difficult at this time to assign characteristic peaks. Further discussion on these spectra will follow.

Preparation of Myrtanyl Bromide:

Three different preparations were investigated in the synthesis of an alkyl halide. **Methods 1** and **2 (See EXPERIMENTAL)** afforded myrtanyl bromide **(1)**:

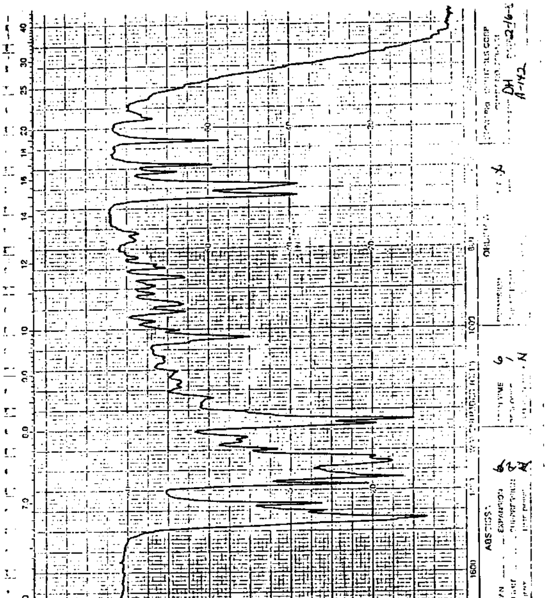


1

Method 1 produced a 42.5 % yield of myrtanyl bromide. IR of **1** (See Figure R-1) indicates that all the β - pinene reacted. This is evident by the absences of C=C bands at 1640 cm^{-1} and 875 cm^{-1}, which are characteristic of β – pinene (See Figure R-2).

Method 2 produced a 54 % yield of **1**. IR of **1** formed by **Method 2** also indicates all the β – pinene reacted. Pertinent IR bands are referred to in Table R-1.

Figure R-1: IR Spectrum of Myrtanyl Bromide


MICROMETERS
3.0
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5.0
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18
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1800
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1200
1000
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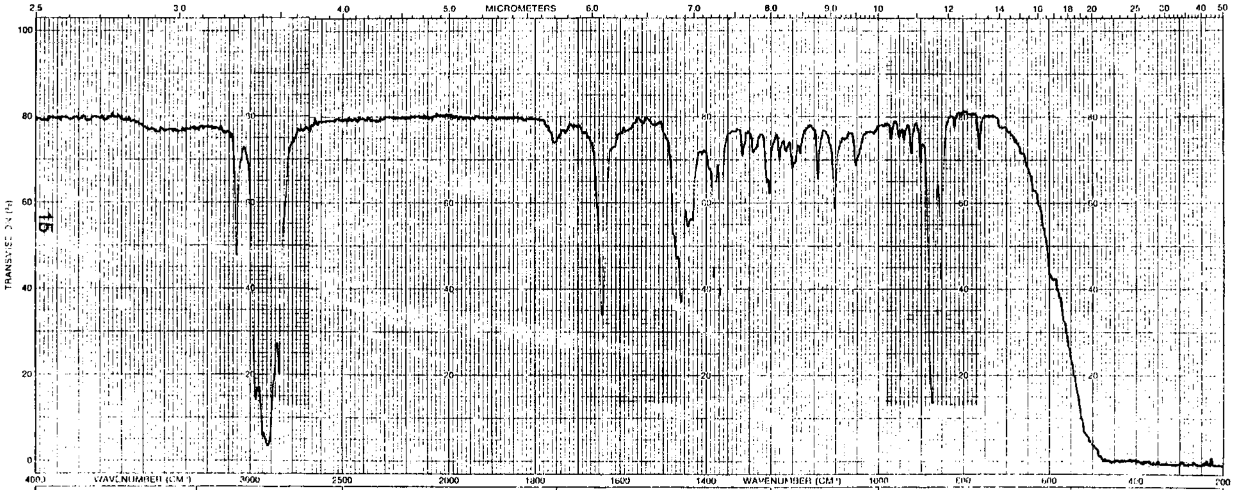
KBr disk
SOLVENT
CONCENTRATION
CELL PATH
REF. SCAN
ABSCISSA
EXPANSION
ORDINATE
SCAN TIME
SLIT
DH
A-142
2-16-

Figure R-2: IR Spectrum of β – Pinene



SAMPLE β-Pinene.

ORIGIN

REMARKS Neat

SOLVENT

CONCENTRATION

CELL PATH

REFERENCE

ABSCISSA

REP. SCAN

HIGH LIMIT

LOW LIMIT

EXPANSION 1

SUPPRESSION

TIME DRIVE

SCAN TIME 6

RESPONSE 1

SLIT PROGRAM N

ORDINATE

EXPANSION 1

SINGLE BEAM

REF. SAMPLE CHOPPER

%T X

ABS

☒ GRAPHIC CONTROLS CORP

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OPERATOR DH

DATE 1/12/88

REF. NO. A-124E

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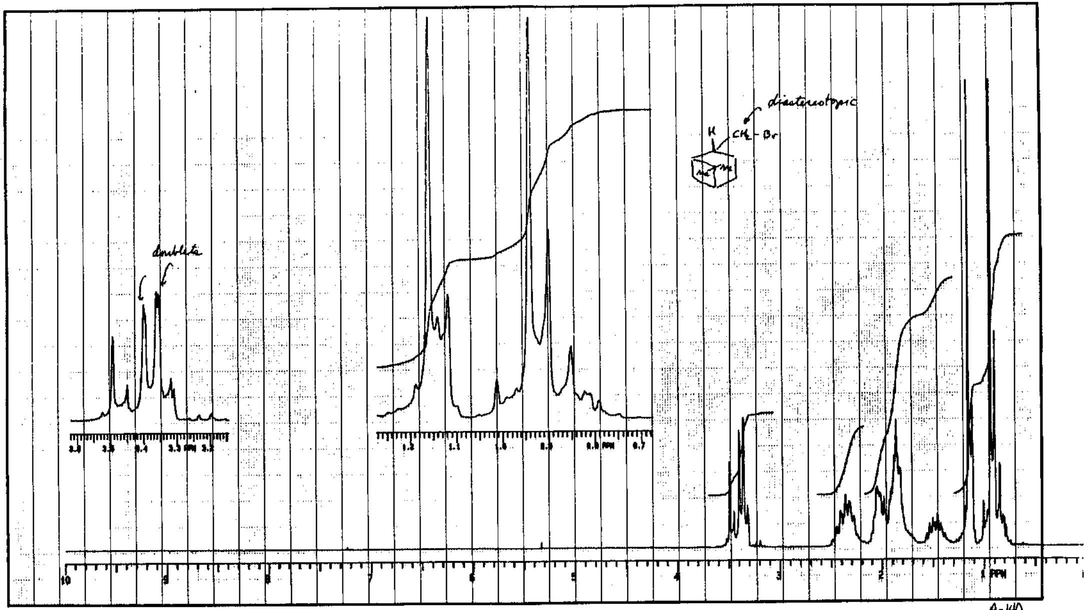
Table R-1: Data of IR bands for **Method 1** and β – Pinene

Compound	Frequency (cm^{-1})	Functional Group[a]
1	1385	C - H bending
	640	- CH_2 - Br stretch
β – Pinene	1640	C = C stretch
	875	C = C bending

[a] Pasto, D. J.; Johnson, C. R. Laboratory Text For Organic Chemistry (New York: Prentice - Hall, Inc., 1979), pp.134 - 141.

Proton NMR of **1** (See Figure R-3) and carbon - 13 NMR of **1** (See Figure R-4) from **Method 2** were taken. Table R-2 contains important NMR data for the characterization of **1**. Carbon - 13 NMR indicates there are ten different carbons present at low ppm values, which is the region characteristic of alkyl carbons. This is in agreement with the molecular formula of **1**, $C_{10}H_{17}$ Br. Proton and carbon - 13 NMRs of **1** synthesized from **Method 1** have similar characteristics to those taken of **1** from **Method 2**.

Figure R-3: Proton NMR Spectrum of Myrtanyl Bromide

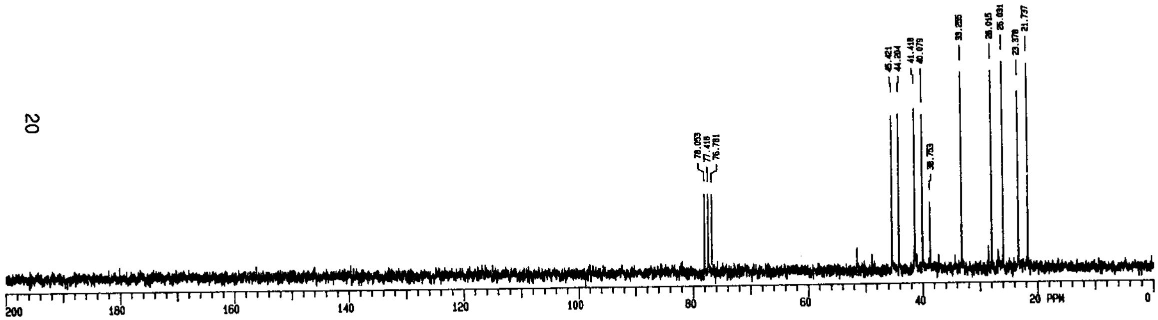


OBSERVE	Nucleus ______ Freq [illegible] MHz 200	Spec. Width ______ Hz [illegible] Offset ______ Hz 0	Acq. Time ______ sec 2.[illegible] Delay ______ sec 0
	Pulse Width ______ μsec 12.[illegible] Transients ______ 16		
DECOUPLE	Nucleus ______ [illegible] Offset ______ Hz [illegible].0	Mode ______ Power ______ db 20.0	Modulation Mode ______ Freq ______ Hz 200
	Pulse Width ______ μsec Power Mode ______ 1.0		
PLOT/PROCESSING	FN ______ K AE 10 sec CD ______ sec —	LB ______ Hz AF ______ sec CCD ______ —	Width ______ Hz [illegible].0 Start ______ Hz/ppm 0
	Reference ______		
EXPERIMENT	Pulse Sequence ______ SAMPLE	Tube OD ______ mm	Temp ______ °C —
	Solvent ______ CDCl3		

MYRTANYL BR
MAIN FRACTION
BP 70-73 11.2 MM

Number A-140
File ______ H
Date 2-9-88
XL ______

Figure R-4: Carbon -13 NMR Spectrum of Myrtanyl Bromide



13.000 50 1.000 -300.2 32

14[illegible].5 0 YYY 20.0 1.000

1.001 0 5 [illegible] 10007.0 0

5.0 300 20.0 1.0

[illegible]

CDCL3

MYRTANYL BR
MAIN FRACTION
BP 70-73 (1.2 MM)

C

[illegible]
21:[illegible]:25
[illegible] 300

ref. A-140
date 2-9-88

Table R-2: Important Proton NMR data for the characterization of Myrtanyl Bromide produced by **Method 2**

Peak (δ)	Type	Comment
.94	singlet	- CH_3
1.16	singlet	- CH_3
3.36	doublet	- CH_2Br diastereotopic hydrogens
3.39	doublet	- CH_2Br; diastereotopic hydrogens

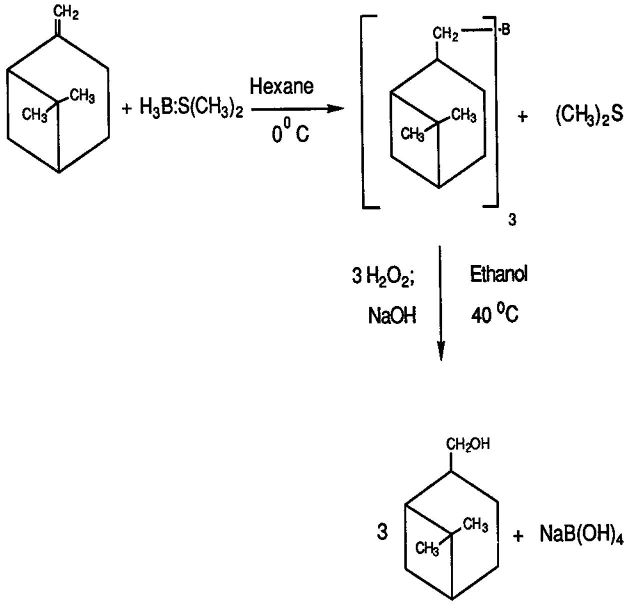
Optical rotation measurements were taken on fractions from **Methods 1** and **2** (See Table R-3).

Table R-3: Optical rotation data of **1**

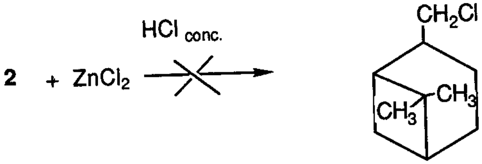
Method	Fraction	α_{obs} [a]	$[\alpha]_D$23-23.5 C
1	2	- 51.36 ± .01 °	- 37.07 ± .01 °
	3	- 50.55 ± .01°	- 36.49 ± .01°
2	2	- 53.01 ± .01 °	- 30.68 ± .01 °
	3	- 51.83 ± .01 °	- 31.18 ± .01 °

([a] neat preparation, l = 1 dm; c = 1.2 g/ mL)

The reaction of (-) - myrtanol **(2)** with a Lucas reagent (See **Method 3**) was unsuccessful in the preparation of myrtanyl chloride. Before preparation of myrtanyl chloride, **2** needed to be prepared from β – pinene by the following steps:



2



IR (See Figure R-5) and GC (See Figure R-6) of **2** indicates the absence of β – pinene (See Figure R-2) by lack of characteristic C = C band at 875 cm^{-1} (See Table R-4). GC verifies purity of **2** by the presence of only one peak (See Table R-5). Fractions 3a, 3b and 4 were combined because of similarity in IRs and GCs.

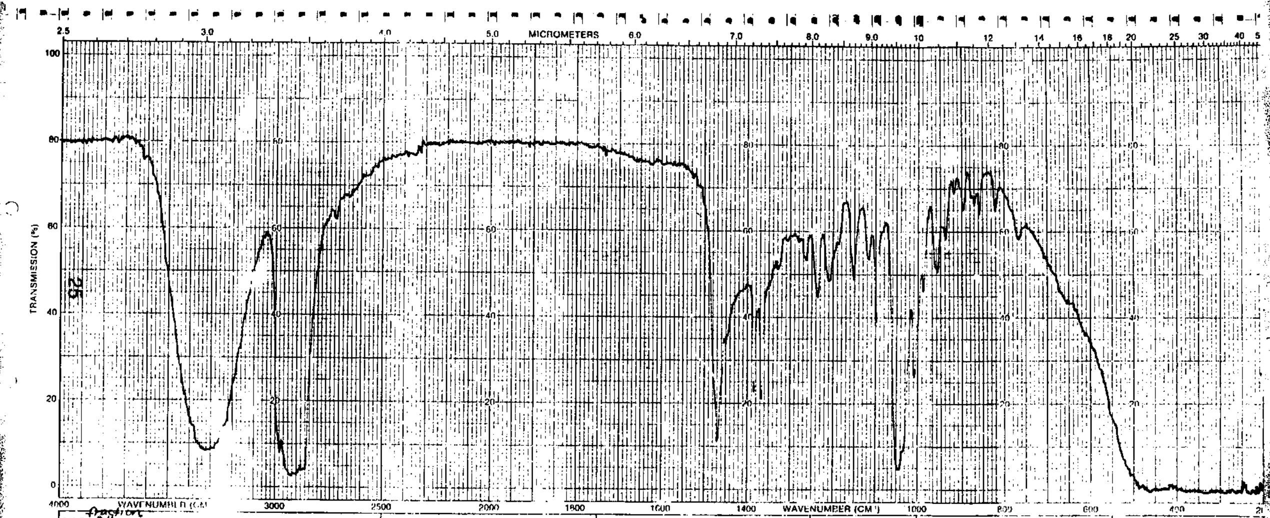
Table R-4: Data of important IR bands of **2**

Frequency (cm^{-1})	Functional Group
3310	- OH; O - H stretching
2900	- CH_3; C - H stretching
1045	C - O

Table R-5: GC data of **2**

Detector temperature = 280°C
Injector temperature = 250°C
Oven temperature = 125°C
FID detector
He carrier gas
Run time = 16 minutes
Retention time = 5.20
Area percent = 85.67 %

Figure R-5: IR Spectrum of (-) - Myrtanol



SAMPLE fraction #4 of distillation of
ORIGIN (−)-myrantol

REMARKS Neat

SOLVENT
CONCENTRATION
CELL PATH
REFERENCE

ABSCISSA
REP. SCAN
HIGH LIMIT
LOW LIMIT
EXPANSION 1
SUPPRESSION
TIME DRIVE

SCAN TIME 6
RESPONSE 1
SLIT PROGRAM N

ORDINATE
EXPANSION 1
SINGLE BEAM
%T X
ABS

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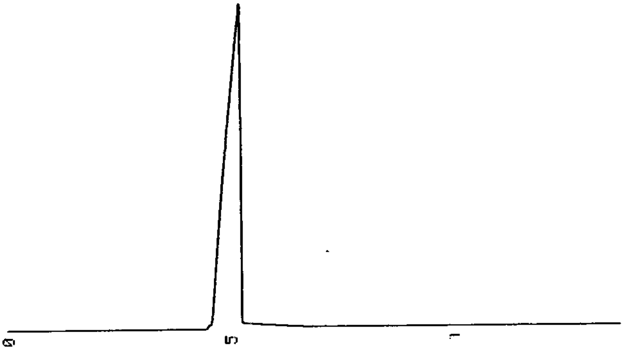
Figure R-6: GC of (-) - Myrtanol



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              AREA     BC               -

             0.1169    T
 1.546       0.0802    T           0.0042
 1.762       0.0244    T           0.0013
 1.938       0.0592    T           0.0031
 2.172       0.0483    T           0.0025
 2.449       0.0590                0.0031
  2.90       0.8397    T           0.0447
  3.53       5.1776    T           0.2759
  5.20    1607.2925    V          85.6735
  5.22      16.5074    T           0.8798
  5.44     138.6575    T           7.3908
  8.52       8.3430    T           0.4447
  8.82      12.4975    T           0.6661
  9.40      30.6036    T           1.6312
 10.69      11.0153    T           0.5871
 11.16       9.2248    T           0.4917
 11.71       2.3036    T           0.1227
 11.82       9.0474    T           0.4822
 12.51      15.9725    T           0.8513
 13.99       2.8550    T           0.1521
 14.35       1.0332    T           0.0550
 14.49       1.5169    T           0.0808
 14.           6776    T
               1122    V

              AREA/HT REJECT
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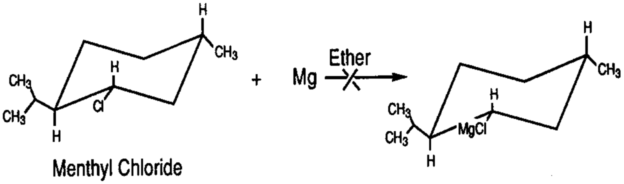
Preparation of Grignard Reagents:

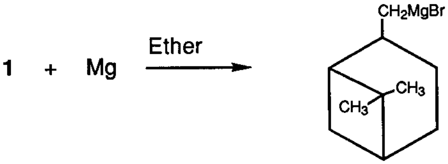
Several Grignard reagents were prepared from optically active alkyl halides. Menthyl chloride was the first compound in which the preparation of a Grignard reagent was attempted.



Menthyl Chloride

A large quantity of magnesium did not react, indicating that not much of the Grignard formed by the above reaction. No further work was done with menthyl chloride.

Myrtanyl magnesium bromide (**3**) was prepared from **1**. The unreacted magnesium (2.80 g) was recovered from this Grignard preparation. Therefore, a simple calculation indicates that a maximum of .436 moles of **3** was prepared, giving approximately 79.3 % yield.



3

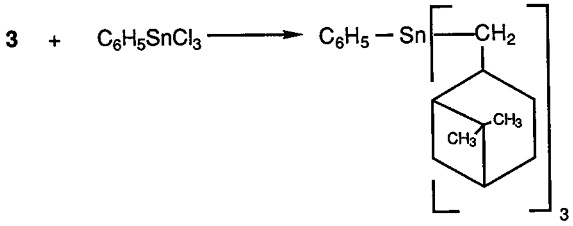
The third Grignard reagent, cinnamyl magnesium chloride (**4**), was prepared from cinnamyl chloride. Previous preparation of this Grignard reagent by Kharasch and Reinmuth[5], produced yields of 83 to 87 %.

$$C_6H_5CH{=}CHCH_2Cl \quad + \quad Mg \xrightarrow{\text{Ether}} C_6H_5CH{=}CHCH_2MgCl$$

4

Preparation of Trimyrtanylphenyl Tin:

Grignard reagent **3** was further reacted with trichlorophenyl tin to yield an allyltin with three optically active constituents, trimyrtanylphenyl tin (**5**).



5

Fractional vacuum distillation and several recrystallizations in hot absolute ethanol proved to be unsuccessful attempts at purifying **5**. During distillation, white solid froze in the delivery tube (See Table E-8). Compound **5** is most likely a solid which has a melting point below 100°C. Structure characterization of crude **5** was accomplished by analyses of proton NMR (See Figure R-7) and carbon - 13 NMR (See Figure R-8) with pertinent data of proton NMR listed in Table R-6. Crude **5** was brominated in carbon tetrachloride. Justification for this decision

Figure R-7: Proton NMR Spectrum of Trimyrtanylphenyl Tin

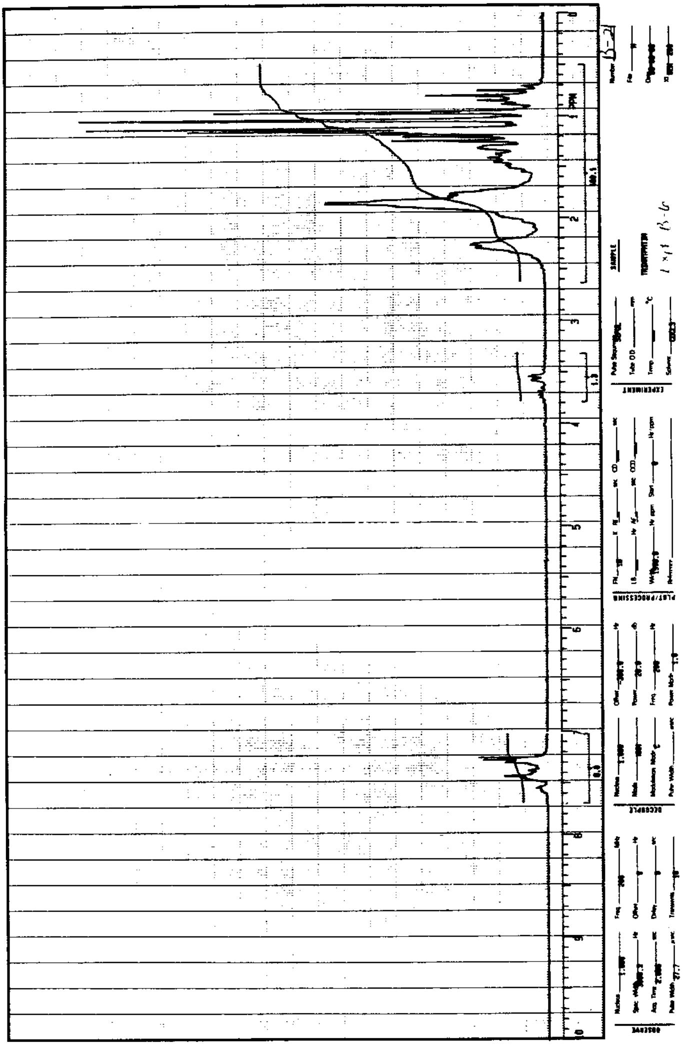
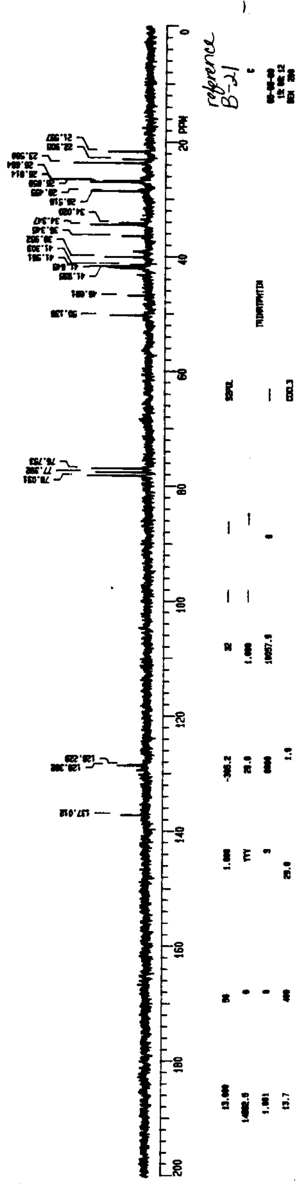

B-21
1×11 B-6
SAMPLE
EXPERIMENT
PLOT/PROCESSING
DECOUPLE
OBSERVE
Solvent CDCl3
PPM
0
1
2
3
4
5
6
7
8
9
10
100.1
1.3
6.0

Figure R-8: Carbon - 13 NMR Spectrum of Trimyrtanylphenyl Tin



reference
B-21

centered around the hope that the impurities present with **5** will be removed in the purification of the brominated tin compound.

Table R-6: Data of proton NMR of **5**

Peak (δ)	Type	Comment
1.05	singlet	- CH_3 (on myrtanyl bridge)
1.15	singlet	- CH_3 (on myrtanyl bridge)
3.5	doublet	- CH_2 -; attached to Sn
7.35	multiplet	aromatic hydrogens

Splitting patterns appearing upfield in Figure R-7 are complicated because of the presence of diastereotopic hydrogens (- CH_2). The splitting pattern observed for the aromatic hydrogens can be explained by the shielding effect created by the adjacent tin atom. Tin donates electron density to attached bonds, causing a shielding effect on the ortho hydrogens of the phenyl ring. This creates the observed splitting pattern at 7.35 δ. This also contributes to the complicated splitting pattern found upfield. The hydrogens on carbons bonded to tin, experience greater shielding effects and appear farther upfield, resulting in the congestion of peaks located upfield in this NMR spectrum.

Preparation of Cinnamyl Triphenyl Tin:

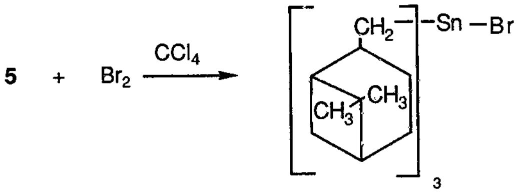
Grignard reagent **4** was reacted with triphenyl tin chloride to synthesize an allyl tin, cinnamyl triphenyl tin (**6**).

$$\mathbf{4} + (C_6H_5)_3SnCl \xrightarrow{\text{Ether}} (C_6H_5)_3SnCH_2CH{=}CHC_6H_5$$

6

Preparation of Trimyrtanyl Tin Bromide:

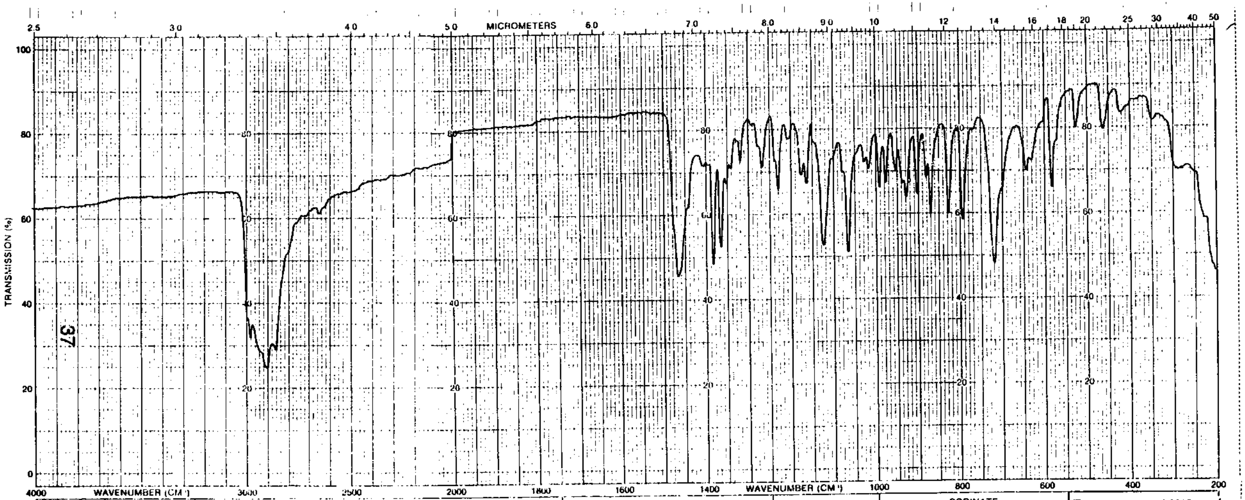
Bromination of **5** allows one bromine atom to replace the phenyl constituent on **5**, forming trimyrtanyl tin bromide (**7**).



7

A yield of 31.7 % was calculated and its melting point was determined to be 114 to 115 ^{0}C. A small sample of **7** was pressed into a KBr pellet and an IR (See Figure R-9) was taken. Also, proton NMR (See Figure R-10) and carbon -13 NMR (See Figure R-11) were taken to verify product structure. The small singlet peak at 7.2 δ is most likely from the solvent, $CDCl_3$, and not from the presence of phenyl hydrogens. During the reaction, the bromine color (orangish - red) was present. This indicates replacement of the phenyl group by bromine. Therefore, there should not be any signal present from phenyl hydrogens. Two singlets at

Figure R-9: IR Spectrum of Trimyrtanyl Tin Bromide



SAMPLE (myrt)$_3$SnBr

ORIGIN

REMARKS KBr disk

SOLVENT

CONCENTRATION

CELL PATH

REFERENCE

ABSCISSA

REP SCAN

HIGH LIMIT

LOW LIMIT

EXPANSION 1

SUPPRESSION

TIME DRIVE

SCAN TIME 4

RESPONSE 1

SLIT PROGRAM 7

ORDINATE

EXPANSION

SINGLE BEAM

PRE SAMPLE CHOPPER

%T X

ABS -

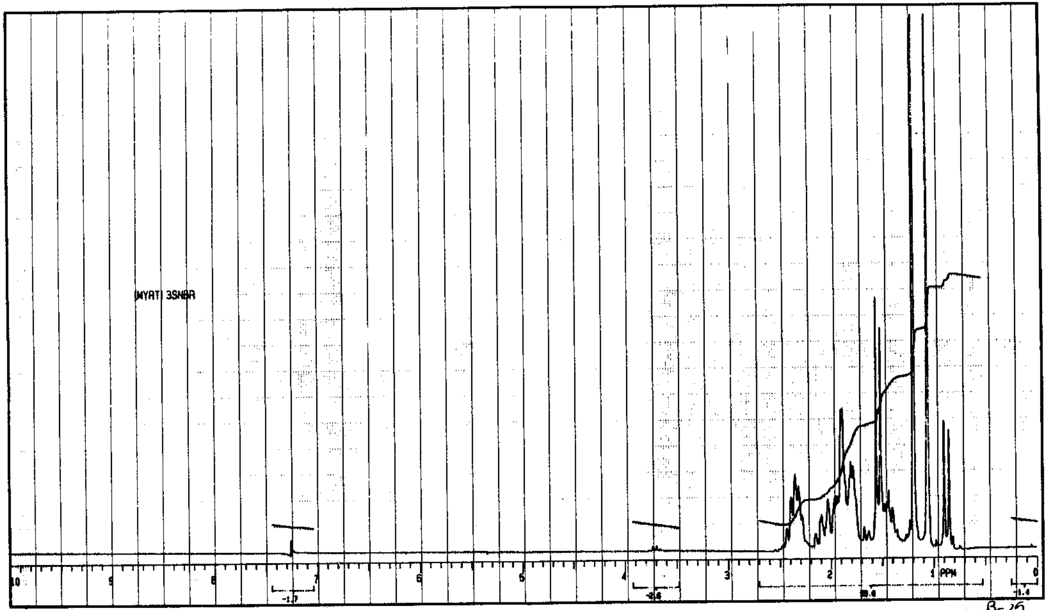
GRAPHIC CONTROLS CORP

CHART NO 283-1251

OPERATOR DH DATE 5/26/88

REF NO B-25

Figure R-10: Proton NMR Spectrum of Trimyrtanyl Tin Bromide



OBSERVE

Nucleus ____________ Freq ____________ MHz
Spec. Width ____________ Hz Offset ____________ Hz
Acq. Time ____________ sec Delay ____________ sec
Pulse Width ____________ μsec Transients ____________

DECOUPLE

Nucleus ____________ Offset ____________ Hz
Mode ____________ Power ____________ db
Modulation Mode ____________ Freq ____________ Hz
Pulse Width ____________ μsec Power Mode ____________

PLOT/PROCESSING

FN ________ K RE ________ sec CD ________ sec
LB ________ Hz AF ________ sec CCD ________
Width ________ Hz ppm Start ________ Hz ppm
Reference ____________

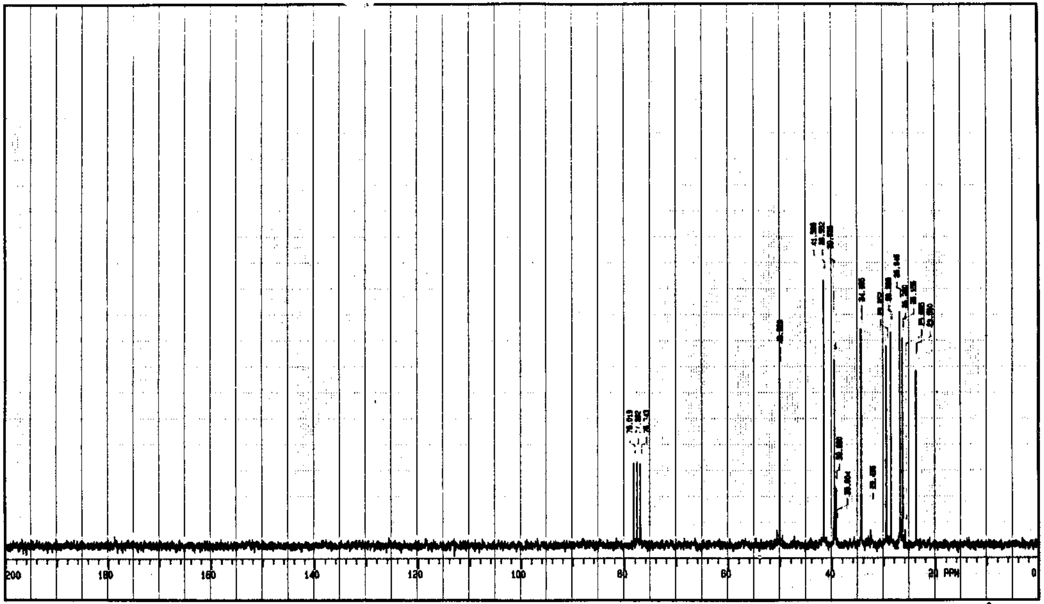
EXPERIMENT

Pulse Sequence ____________
Tube O.D. ____________ mm
Temp ____________ °C
Solvent ____________

SAMPLE

Number B-25
File ____________
Date ____________
XL ____________

Figure R-11: Carbon - 13 NMR Spectrum of Trimyrtanyl Tin Bromide



OBSERVE
Nucleus 13.000
Spec. Width 14002.5 Hz
Acq. Time 1.001 sec
Pulse Width 13.7 μsec
Freq 50 MHz
Offset 0 Hz
Delay 0 sec
Transients 800

DECOUPLE
Nucleus 1.000
Mode YYY
Modulation Mode 3
Pulse Width 20.0 μsec
Offset 305.2 Hz
Power 20.0 db
Freq 0000 Hz
Power Mode 1.0

PLOT/PROCESSING
FN 32 K
LB 1.000 Hz
Width 10050.1 Hz/μm
Start 0 Hz/ppm
Reference
RE sec
AE sec
CD sec
CCD

EXPERIMENT
Pulse Sequence
Tube O.D. mm
Temp °C
Solvent CDCl3

SAMPLE

800 transients

Number B-25
File 0
Date
12:01:10
XL

CHART XL SERIES

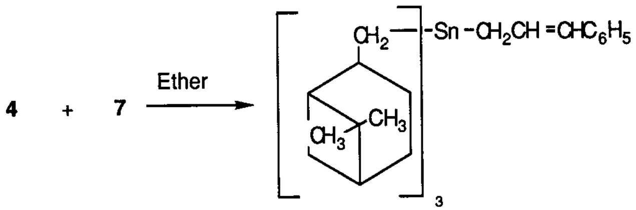
41

PART NO 997259

1.05 δ and 1.20 δ are from the - CH_3 bridge head hydrogens.

Preparation of Cinnamyl Trimyrtanyl Tin:

The final step for the preparation of the allyl tin with optically active constituents, is the reaction of Grignard reagent **4** with **7** in anhydrous ether solvent to afford cinnamyl trimyrtanyl tin (**8**).



8

Proton NMRs of Fraction 3 (See Figure R-12), Fraction 6 (See Figure R-13) and of the solid lining condenser wall (See Figure R-14) were taken. A carbon - 13 NMR was taken of Fraction 6 (See Figure R-15). Proton NMR of Fraction 3 has a strong aromatic hydrogen peak at 7.40 δ, relative to peaks located upfield. The signals located upfield are primarily from the hydrogens attached to alkyl carbons of the myrtanyl constituent. This indicates that Fraction 3 may be cinnamyl chloride. The NMRs of Fraction 6 and of the solid lining the condenser wall have complicated splitting patterns which makes hydrogen assignments difficult, if not impossible. A few conclusions can be drawn about these NMRs. Most importantly, these NMRs provide some evidence that cinnamyl trimyrtanyl tin is not present in any of the fractions. Figures

Figure R-12: Proton NMR Spectrum of Fraction 3 of Cinnamyl Trimyrtanyl Tin

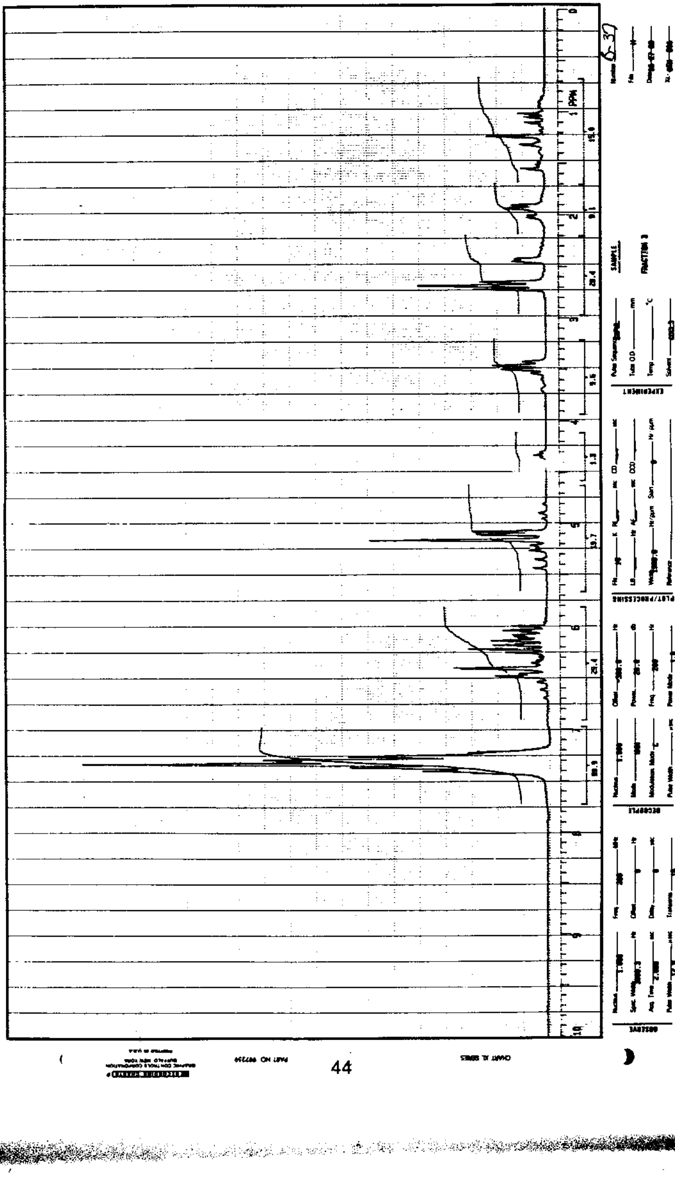
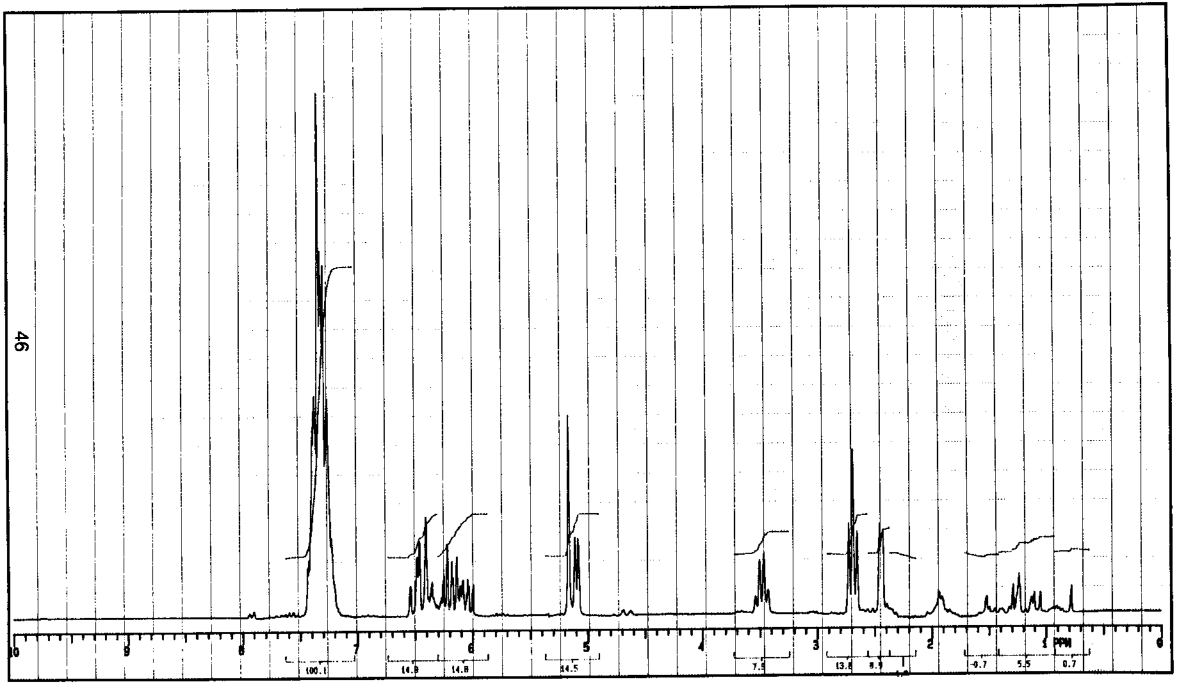

6-37
SAMPLE
FRACTION 3
PPM
0
1
2
3
4
5
6
7
8
9
10
15.0
9.1
29.4
9.6
1.8
13.7
25.4
80.9
OBSERVE
DECOUPLE
PLOT/PROCESSING
EXPERIMENT
CHART XL SERIES

Figure R-13: Proton NMR Spectrum of Fraction 6 of Cinnamyl Trimyrtanyl Tin



OBSERVE

Nucleus 1.000
Spec Width 3000.3 Hz
Acq Time 2.000 sec
Pulse Width 27.7 μsec
Freq 200 MHz
Offset 0 Hz
Delay 0 sec
Transients 16

DECOUPLE

Nucleus 1.000
Mode 1001
Modulation Mode C
Pulse Width μsec
Offset 300.0 Hz
Power 20.0 db
Freq 200 Hz
Power Mode 1.0

PLOT/PROCESSING

FN 16 K RE sec CD sec
LB Hz AF sec CCD
Width 1999.0 Hz/ppm Start 0 Hz/ppm
Reference

EXPERIMENT

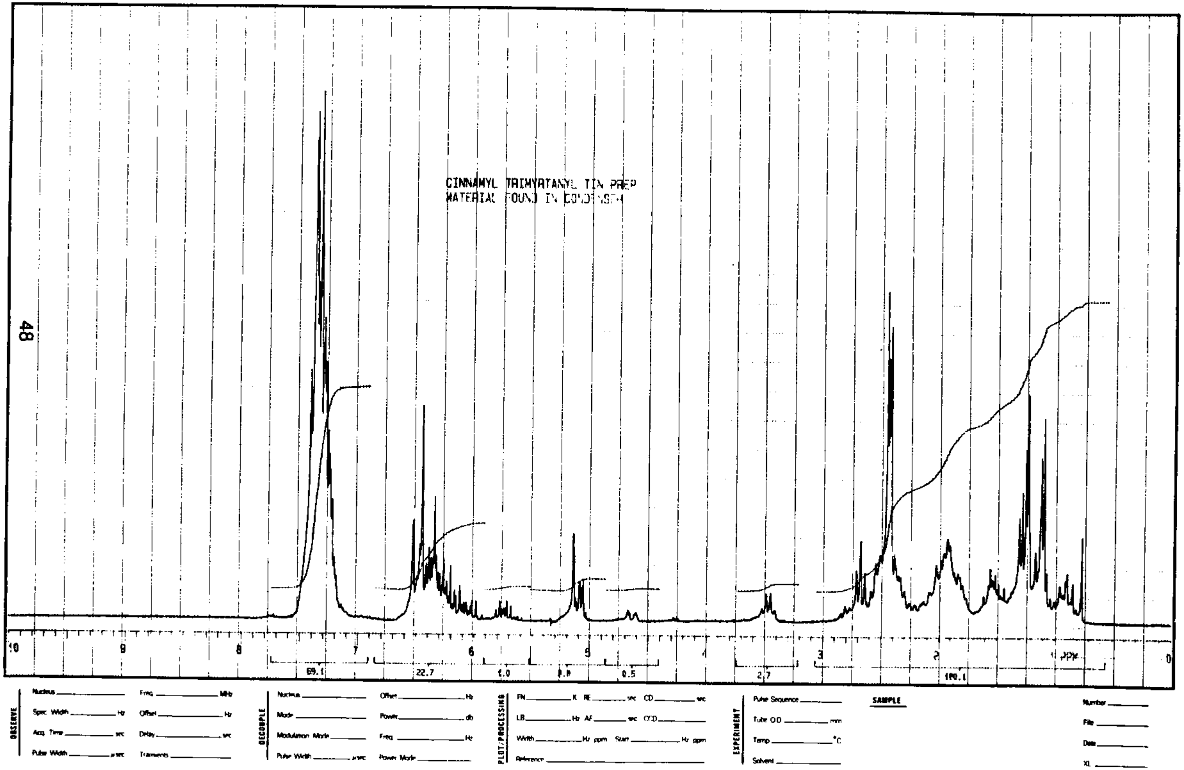
Pulse Sequence S2PUL
Tube OD mm
Temp °C
Solvent CDCL3

SAMPLE

TRIHYRFANYL CINNAMYL ETH[illegible]
[redacted]
semi-solid distillate

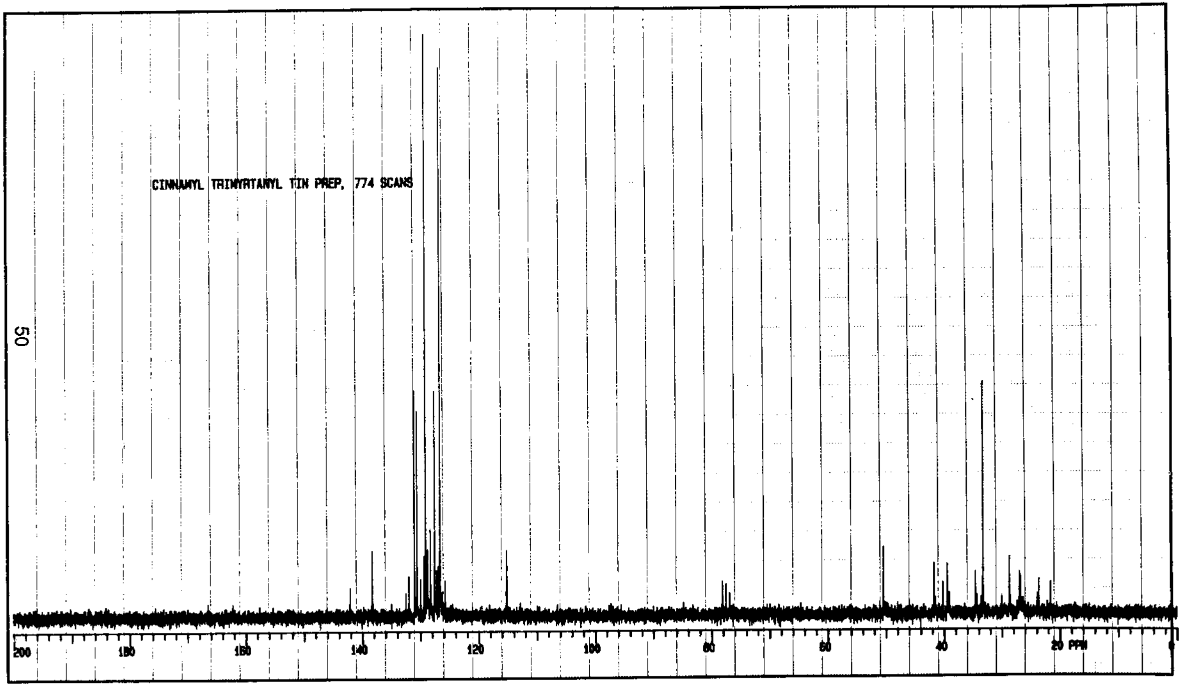
Number
File H
Date 80-02-08
XL BCH 200

Figure R-14: Proton NMR Spectrum of Solid on Wall of Condenser



CINNAMYL TRIMYRTANYL TIN PREP
MATERIAL FOUND IN CONDENSER
10
9
8
7
6
5
4
3
2
1 PPM
0
69.1
22.7
6.0
0.5
2.7
100.1
OBSERVE
Nucleus
Spec Width Hz
Acq. Time sec
Pulse Width μsec
Freq MHz
Offset Hz
Delay sec
Transients
DECOUPLE
Nucleus
Mode
Modulation Mode
Pulse Width μsec
Offset Hz
Power db
Freq Hz
Power Mode
PLOT/PROCESSING
FN K
RE sec
CD sec
LB Hz
AF sec
CCD
Width Hz ppm
Start Hz ppm
Reference
EXPERIMENT
Pulse Sequence
Tube OD mm
Temp °C
Solvent
SAMPLE
Number
File
Date
XL

Figure R-15: Carbon - 13 NMR of Fraction 6 of Cinnamyl Trimyrtanyl Tin



OBSERVE
Nucleus ______ Freq ______ MHz
Spec. Width ______ Hz Offset ______ Hz
Acq. Time ______ sec Delay ______ sec
Pulse Width ______ μsec Transients ______

DECOUPLE
Nucleus ______ Offset ______ Hz
Mode ______ Power ______ db
Modulation Mode ______ Freq ______ Hz
Pulse Width ______ μsec Power Mode ______

PLOT/PROCESSING
FN ______ K RE ______ sec CD ______ sec
LB ______ Hz AF ______ sec CCD ______
Width ______ Hz ppm Start ______ Hz/ppm
Reference ______

EXPERIMENT
Pulse Sequence ______
Tube O.D. ______ mm
Temp ______ °C
Solvent ______

SAMPLE

Number ______
File ______
Date ______
XL- ______

R-12 and R-13 are very similar. They both have a strong aromatic hydrogen peak located downfield. If **8** were present in either of these fractions, the intensity of the alkly hydrogen peaks located upfield should be stronger. The ratio of aromatic to three myrtanyl constituent hydrogens is 5:51. Therefore, if three myrtanyls are attached to tin, the peak signals located upfield should be relatively strong. Figure R-14 has stronger peak signals located upfield but the integrated area also indicates that there may not be three myrtanyls attached to tin. All three NMRs have a complicated splitting pattern around 6.0 - 6.5 δ, this is created by the electron density donating capability of tin. The NMRs provide some indication that there may not be three myrtanyls attached to tin but possibly two. However, these are complicated NMRs and further work needs to be done on the preparation of **8** for a more accurate analysis of this preparation.

EXPERIMENTAL

Preparation of Myrtanyl Bromide and Chloride:

Method 1:

Preparation of sodium methoxide was required for this particular synthesis of myrtanyl bromide.

Sodium (23.26 g, 1.01 moles) was placed in a two necked 2-L round-bottom flask equipped with 125-mL addition funnel, condenser fitted with a $CaCl_2$ drying tube, magnetic stirrer and a nitrogen gas inlet. Methanol (275 mL) was added from the addition funnel, while stirring, in approximately two hours. Continued stirring for an additional one-half hour, until most of the sodium had reacted.

β–Pinene (81.75 g, .60 moles), sodium boronhydride (6.30g, .16 moles) and 200 mL THF were placed in a three necked 2-L round-bottom flask which was immersed in an ice/ water bath. The flask was equipped with a 125-mL addition funnel, mechanical stirrer and thermometer. The addition funnel contained $BF_3 \cdot OC_2H_5$ (28 mL, .23 moles) which was added dropwise to the reaction flask at a rate which kept the reaction temperature at or below 5 °C. Once the addition was complete, the ice/ water bath was removed and the mixture was diluted with 150 mL THF. An ice/ salt bath was prepared around the flask in order to cool the mixture to -10 °C. Once this temperature was reached, 5 mL methanol was added.

Next, bromine (40 mL, .78 moles) was poured into the addition funnel and added dropwise at a rate which kept the reaction temperature below 0 °C. The addition funnel was rinsed with 50 mL THF after the bromine addition was complete. Added sodium methoxide (1 mole sodium in 275 mL methanol to make 3.67 M) dropwise, keeping the reaction temperature below 5 °C. The reaction mixture was left stirring in the ice/ salt bath for an additional three hours.

While gently stirring reaction mixture, 200 mL hexane, 80 mL water and 80 mL saturated Na_2CO_3 (15 % Na_2CO_3) were added. The top organic layer was removed via a glass T-tube and nitrogen pressure and saved. Gravity filtered solid NaBr from the aqueous layer. The aqueous layer was transferred to a 500-mL separatory funnel. This layer was washed three times with 200 mL portions of hexane. Combined hexane layers with the organic layer. The hexane and THF organic layer was washed twice with 200 mL portions of water and once with 100 mL brine. The organic layer was then dried over anhydrous potassium carbonate. The solution was gravity filtered and the solvents were removed by rotatory evaporation ("rotovapped").

Fractionally distilled under vacuum remaining solution at 1.2 mmHg (See Table E-1). The sludge remaining from this distillation was vacuumed distilled using a simple distillation apparatus (See Table E-2) at 4.7 mmHg.

Table E-1: Data for vacuum distillation of crude product

Fraction	T^{oil}	T^{column}	T^{head}	Comment
1	88-89°C	70 °C	56, 68-72°C	low boiling impurities
2	91-12°C	71-82°C	70-73°C	pressure fluctuated between 1.1 mmHg and 1.3 mmHg; lemon yellow color
3	121-122°C	82-83°C	74-72.5°C	temperature dropped; greenish color

Table E-2: Data for vacuum distillation of sludge

Fraction	T^{oil}	T^{head}	Comment
1	137°C	72°C	
2	137°C	81°C	nearly colorless to slightly pink

The fractions from the sludge distillation were discarded because felt that they were not pertinent to this synthesis (the coloration gave an indication that possibly these fractions were useless). The fractions from the distillation described in Table E-1 were combined and redistilled (See Table E-3) at 3.4 mmHg.

Table E-3: Data for the fractional vacuum distillation of crude product

Fraction	T^{oil}	T^{column}	T^{head}	Comment
1	99°C	87°C	75-81°C	P= 3.7 mmHg; cloudy-yellow drops
2	104°C	88-89°C	81-83°C	P= 3.4 mmHg; cloudy
3	106-114°C	90-93°C	84-85°C	slight cloudiness
4	122°C	97°C	82°C	

The cloudy composition of the fractions was due to grease contamination. Fractions 2,3 and 4 were recombined and redistilled (See Table E-4) at 3.4 mmHg. Fractions 2 and 3 from this distillation were combined and stored under nitrogen (Fraction 1 was low boiling impurity and discarded). IR, proton and carbon-13 NMRs and optical rotation were taken to determine the structure of the product and the yield was calculated to be 42.5 %.

Table E-4: Data for the fractional vacuum distillation of recombined fractions 2,3 and 4

Fraction	T^{oil}	T^{column}	T^{head}	Comment
1	102°C	86°C	77-80°C	
2	104°C	86-90°C	81-83°C	clear solution
3	110-114°C	91-92°C	83.5-84°C	clear solution

Method 2:

Prior preparation of sodium methoxide was required.

Sodium (24.91 g, 1.08 moles) was placed in a flame dried three necked 1-L round-bottom flask which contained a 125-mL addition funnel, condenser fitted with $CaCl_2$ drying tube and magnetic stirrer. The apparatus was flushed with nitrogen gas. Methanol (300 mL) was added dropwise in one hour and stirred until last pieces of sodium had reacted.

β- Pinene (81.75 g, .60 moles), sodium boronhydride (6.21 g, .16 moles) and 200 mL THF were placed in a flame dried three necked 2-L round-bottom flask. The flask was equipped with an addition funnel, mechanical stirrer, nitrogen gas inlet and thermometer. $BF_3 \cdot OC_2H_5$ (28 mL, .23 moles) was added dropwise from the addition funnel at a rate which kept the temperature below 5° C (reaction flask was immersed in ice/ water bath). The reaction mixture was allowed to stir for an additional 15 minutes once the addition was complete. The ice/ water bath was removed. The reaction mixture was diluted with 150 mL THF.

The apparatus was adjusted so that a second addition funnel could be utilized. A Claisen head was placed on one neck which could now support the thermometer along with the 125-mL addition funnel. Bromine (40 mL, .78 moles) and sodium methoxide (1 mole sodium in 300 mL methanol to make 3.6 M) were added alternately or simultaneously at a rate which kept the color slightly yellow to orange and the temperature less than 25 °C. An ice/ water bath was used as needed to help maintain temperature control. Approximately 22 mL THF was added to each addition funnel to rinse the remaining traces of bromine and sodium methoxide into reaction flask. The reaction mixture was stirred at room temperature for an additional two hours.

Hexane (200 mL), water (100 mL) and saturated Na_2CO_3 (80 mL of 15 % Na_2CO_3) were added to the stirred reaction mixture. The organic layer was removed via glass tubing and nitrogen pressure and saved. The aqueous layer was washed three times with 200 mL portions of hexane. Hexane layers were combined with THF layer and washed twice with 200 mL portions of water and once with 200 mL brine. The hexane and THF layer was dried over anhydrous sodium bicarbonate. The solution was gravity filtered and the solvents were removed by rotovap.

Reaction mixture was fractionally vacuumed distilled at 2.4 mmHg (See Table E-5). IR, hydrogen and carbon-13 NMRs and optical rotation were taken of Fractions 1 and 2 to verify product structure. A yield of 54 % was calculated, assuming 100 % purity of product.

Table E-5: Data for the fractional vacuum distillation of Myrtanyl Bromide

Fraction	T^{oil}	T^{column}	T^{head}	Comment
1	98-110°C	84-89°C	75-77°C	temperature began to fall- switched receivers
2	111-130°C	90-81-90°C	77-75-77°C	temperature dropped briefly but returned to original temperature
3	130°C	91°C	74°C	temperature fluctuated between 60 to 69 °C

Method 3:

The Lucas reagent was used in the synthesis of myrtanyl chloride. (-)-Myrtanol needed to be prepared for the work done in **Method 3**.

Preparation of (-)-Myrtanol:

β-Pinene (204.4 g, 1.5 moles) and 500 mL hexane were added to a three necked 2-L round-bottom flask. The flask was fitted with 125-mL addition funnel with nitrogen gas inlet, Herschberg mechanical stirrer and thermometer. The reaction flask was flushed with nitrogen gas and immersed in an ice/ water bath to cool the mixture to 0-5°C. While stirring, borane-methyl sulfide (52.5 mL, .55 moles) was added gradually from the addition funnel for one hour. The formation of the orgoborane $(C_{10}H_{17}\text{-})_3\text{-B}$ as a white precipitate was observed. Once the addition was complete, the reaction mixture was stirred at room temperature for 3.25 hours.

The reaction flask was reimmersed in an ice/ water bath and 500 mL denatured ethanol and 185 mL 3M sodium hydroxide were poured into the reaction mixture. Over a period of one and one-half hours, 185 mL 30% hydrogen peroxide was added at such a rate that the temperature did not exceed 40 °C. Once all the hydrogen peroxide was added, the ice/ water bath was removed, a condenser replaced the addition funnel and the mixture was heated to approximately 50 °C for one hour.

Next the reaction mixture was quartered and the first quarter was poured over 1250 mL 50:50 solution of ice:water. It was stirred manually until all the ice had melted. The mixture was diluted with 500 mL ether, transferred to a 1-L separatory funnel and the aqueous layer was removed. The organic layer was washed twice with 250 mL portions of water and once with 250 mL brine. This procedure was followed for the remaining three quarters of reaction mixture. At this point the organic layers were combined and dried over anhydrous potassium carbonate. Organic layer was gravity filtered and rotovaped. High vacuum was pulled on the crude product while in a short path distillation apparatus to remove volatiles, such as ether (see Table E-6). IRs and GCs of Fractions 2, 3a, 3b and 4 were taken to verify structure of product . Fraction 2 was reacted with the Lucas Reagent and Fractions 3a, 3b and 4 were combined and stored under nitrogen gas for later use.

Concentrated hydrochloric acid (44 mL, 12 M) and zinc chloride (63.65 g, .47 moles) were placed in a 250-mL Erlenmyer immersed in an ice/ water bath. The solution was mechanically stirred until all the $ZnCl_2$

dissolved. The ice bath was replaced with a water bath and (-)-myrtanol (21.22 g, .14 moles) was added all at once while stirring. The temperature was regulated at 35 ± 2 °C. The mixtures color went through several transitions: bright lime green to yellow to orangish-red to dark red during the reaction.

The cooled mixture was washed with 78 mL hexane. The hexane layer did not combine with the reaction mixture layers. Proceeded with separation of solution. The hexane layer was extracted and washed once with 7 mL water, four times with 10 mL portions of concentrated sulfuric acid (or until layer was no longer discolored) and four times with 10 mL portions of water. The hexane layer was dried over magnesium sulfate. Reaction mixture was gravity filtered and hexane was removed by rotovap. Only a few drops of crude product remained after rotovap. An IR was taken to verify product structure which indicated that no (-)-myrtanyl chloride had formed.

Table E-6: Data for high vacuum short path distillation of (-)-Myrtanol

Fraction	T^{oil}	T^{column}	T^{head}	Comment
1	110°C	91°C	31-80°C	P= 2.2 mmHg; collected 2 mL cloudy low boiling impurity
2	90°C	85-88°C	72°C	
3a	90°C	80-84°C	72-74°C	P= .8 mmHg
3b	90-96°C	86-90°C	79-81.5°C	P= 1.3 mmHg
4	96°C	90-88.5°C	80.5-81°C	P= 1.3 mmHg; temperature fluctuated a few degrees

Preparation of Menthyl Magnesium Chloride:

A three necked 500-mL round-bottom flask equipped with 125-mL addition funnel, Friederich condenser with nitrogen gas inlet, mechanical stirrer and magnesium (8.50 g, .35 moles) were flame dried while flushing apparatus with nitrogen gas. Once apparatus was cooled, 15 mL anhydrous ether was added. Initially, a small portion of menthyl chloride, prepared by D. Taylor according to procedure by Smith and Wright ,[4] (6.05 g, .003 moles) in 10 mL ether was added directly to the magnesium solution. This did not facilitate a reaction so a heating mantle was used to heat the reaction to a reflux. Menthyl chloride (54.98 g, .31 moles) in 150 mL ether was added dropwise for one and one-half hours. Reaction was allowed to reflux and stir for approximately six additional hours. The cooled reaction mixture was light gray and a large quantity of unreacted magnesium remained. No further work was done in the preparation of the Grignard reagent, menthyl magnesium chloride.

Preparation of Myrtanyl Magnesium Bromide:

Magnesium (13.40 g, .55 moles) and a few iodine crystals` were placed in a three necked 1-L round-bottom flask equipped with 125-mL addition funnel, Friederich condenser with nitrogen gas inlet and mechanical stirrer. Glassware and magnesium were flame dried until a purple iodine gas became visible. Once apparatus was cooled to room temperature, 10 mL anhydrous ether was added to the magnesium and iodine mixture while stirring. Myrtanyl bromide (119.44 g, .55 moles) in 280 mL anhydrous ether was added dropwise from the addition funnel at a rate in which a gentle reflux was maintained. After addition was complete, the reaction mixture was heated and stirred for an additional three hours. The Grignard was stored under nitrogen gas for later use.

Preparation of Cinnamyl Magnesium Chloride:

A three necked 1-L round-bottom flask fitted with a 125-mL addition funnel, Friederich condenser with nitrogen gas inlet and mechanical stirrer. Magnesium (24.10 g, 1.00 mole) and a few iodine crystals were added to the flask and flame dried in a nitrogen atmosphere. The cooled magnesium and iodine mixture was diluted with 130 mL anhydrous ether. Cinnamyl chloride (18.37 g, .12 moles) dissolved in 14 mL anhydrous ether was added dropwise to the stirred reaction mixture over several hours. Initially, the reaction mixture was slightly golden, indicating the formation of magnesium iodide. This coloration disappeared within ten minutes and the reaction mixture became gray and opaque. Reaction was slightly exothermic and heating was not required. Once the addition of alkyl halide was complete, reaction was left stirring at room temperature for an additional hour. The Grignard was stored under nitrogen for later use.

Table E-7: Data for preparations of Cinnamyl Magnesium Chloride

Attempt	moles magnesium used	moles cinnamyl chloride used	[Cinnamyl MgCl]
1	.99	.30	1.5 M
2	1.00	.12	.5 M
3	.41	.12	.6 M

Preparation of Cinnamyl Triphenyl Tin:

Two preparations of this compound are in progress at this time.

Attempt 1:

A three necked 1-L round-bottom flask was equipped with a 125-mL addition funnel, Friederich condenser fitted with nitrogen gas inlet and a mechanical stirrer. Cinnamyl magnesium chloride (prepared by **Attempt 1**in Table E-7) was transferred via glass tubing and nitrogen pressure with 70 mL anhydrous ether to the reaction flask containing triphenyl tin chloride (115.6 g, .30 moles) in 100 mL anhydrous ether. The stirred reaction mixture, in a nitrogen atmosphere, was slightly exothermic and the condenser was turned on. The Friederich condenser was replaced with a stillhead and simple condenser in order to concentrate reaction mixture by a simple distillation, removing approximately 250 mL ether. Friederich condenser was reattached and concentrated reaction mixture was heated for one hour. At room temperature, the reaction mixture appeared to be thick and "sludgy." Reaction mixture was neutralized with 200 mL water (100 mL water added gradually from addition funnel and 100 mL water added directly to the flask) with gentle stirring. This caused an exothermic reaction and the flask was immersed in an ice/ water bath and the condenser was turned on. Transferred solution to 500-mL separatory funnel. Three layers were present: top layer - organic; middle layer - sludge and bottom layer - aqueous. Extracted aqueous layer and washed twice with 100 mL portions of ether. Second ether washing was saved separately from the first ether washing for small scale purification experiments. Sludge and ether layers were washed with 100 mL ether. Ether layers (except second ether washing of aqueous phase) were combined and dried over magnesium sulfate. Solution was gravity filtered

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H55Is/1988 Chemistry HRS. 6/88 2 of 2

and ether was rotovapped off. A partially solidified and slightly oily mixture formed at room temperature after rotovapping.

The ether layer from second washing of aqueous phase was dried over magnesium sulfate. Solution was gravity filtered and ether was removed by rotovap. Crystallization did not occur when solution was placed in a ice/ water bath. Solution was found to be insoluble in methanol when recrystallization was attempted in this solvent. Methanol was removed by rotovap. Hexane (75 mL) and methanol (5 mL) were added to the solution, which was immersed in ice/ water bath and magnetically stirred. A white powdery solid was Buchner filtered from the methanol solution (Crop B). The methanol solution was concentrated and crystal growth was not induced. An oily solution remained and was stored in icebox.

The concentrated ether solution was recrystallized in cold methanol. Crop A1 was Buchner filtered and the methanol solution was reconcentrated and another crop was grown (Crop A2). The masses and melting points of these crops are in Table E-8.

Crops A1 and A2 were combined and a second recrystallization in hot hexane was attempted. Crystal growth was not induced in hot hexane but rather at room temperature. Crop C was Buchner filtered from the hexane solution. Crop C was recrystallized in hot hexane. This resulted in the formation of a yellowish - brown oily residue at room temperature. This was stoppered and stored in an icebox for further investigation.

Table E-8: Data for recrystallizations of Cinnamyl Triphenyl Tin

Crop	Weight (g)	Melting Point (ºC)
A1	76.29	53-56
A2	6.82	39-44
B	7.06	55-59
C	74.80	58-61

Attempt 2:

A three necked 500-mL round-bottom flask was equipped with a condenser fitted with a nitrogen gas inlet, mechanical stirrer and glass stopper. Triphenyl tin chloride (15.41 g, .04 mole) was placed in the flask. The Grignard reagent, cinnamyl magnesium chloride (theoretical: 21.23 g, .12 moles), was transferred to the reaction flask via glass tubing and nitrogen pressure. The reaction mixture was stirred in a nitrogen atmosphere. The flask containing the Grignard reagent was washed with 50 mL anhydrous ether and added to the reaction mixture. The reaction was slightly exothermic upon addition of the Grignard reagent. However, the reaction mixture required additional heating provided by a heating mantle for one and one-half hours. The reaction mixture was left unstirred overnight.

The flask was immersed in an ice/ water bath and 100 mL water was added, while stirred. The reaction mixture was transferred to a 500-mL separatory funnel. The mixture had emulsified and two 50 mL portions of anhydrous ether were added to help separate the emulsified intermediate layer. The mixture was left in the separatory funnel for several hours. The addition of the anhydrous ether did not affect the emulsified layer. The ether and emulsified layers were extracted together and dried over magnesium sulfate. The solution was gravity filtered and ether was removed by rotovap. A solid began forming at room temperature. Further characterization and purification will be pursued at a later date.

Preparation of Trimyrtanylphenyl Tin:

A three necked 1-L round-bottom flask was immersed in a ice/ water bath. The flask was equipped with 125-mL addition funnel, condenser with nitrogen gas inlet, and mechanical stirrer. Myrtanyl magnesium bromide (.43 moles) was transferred to the flask via glass tubing and nitrogen pressure. The Grignard-containing flask was rinsed with 20 mL anhydrous ether and added to the 1-L reaction flask. Trichlorophenyl tin (35.67 g, .009 mole), prepared by L. McGahey according to procedure by Gilman and Gist,[5] in 25 mL anhydrous ether was placed in the addition funnel and added dropwise while stirring. The addition took approximately 15 minutes. The reaction was exothermic and a reflux was maintained. The reaction mixture was left in the ice/ water bath briefly, then allowed to react at room temperature. Shortly following the removal of the ice/ water bath, the mixture was heated to maintain reflux. An additional 100 mL anhydrous ether was added to the reaction mixture because the mixture was rather thick and some ether had evaporated. The mixture was left under nitrogen overnight.

The reaction flask was immersed in an ice/ water bath and stirred for the exothermic neutralization with 200 mL water. The reaction mixture was transferred to a 500-mL separatory funnel and washed with 100 mL water. Organic layer was removed and saved. The aqueous layer was washed with 100 mL anhydrous ether. An emulsified intermediate layer formed and was extracted with the aqueous layer. The attempt to break up emulsification with the addition of 25 mL saturated ammonium chloride was unsuccessful. The organic layers were combined and dried over magnesium sulfate. The organic solution was gravity filtered and rotovapped to remove ether solvent. Fractional vacuum distillation of crude reaction product was attempted at a pressure range of .8 to 1 mmHg, but found a solid formed during collection of Fraction 3 (See Table E-9). This gave some indication of the physical property of the product, that is, trimyrtanylphenyl tin probable has a melting point below 100 °C.

Three fractions from distillation were combined for an attempt at recrystallization using hot absolute ethanol. Crystallization was not induced by cooling, heating, scratching or seeding. The absolute ethanol was removed by rotovapping. Two phases were present once solvent was removed: liquid and oil. High vacuum was pulled on crude product for three hours inorder to remove last traces of solvent. Took hydrogen and carbon-13 NMRs of crude product. The trimyrtanylphenyl tin compound was later used in its crude form because of the unsuccessful attempts at purification.

Table E-9: Data for the fractional vacuum distillation of crude Trimyrtanylphenyl Tin

Fraction	T^{oil}	T^{head}	Comment
1	90°C	36-50°C	
2	146; 174°C	63; 100-142°C	P= 1.4 mmHg and 1 mmHg, respectively
3	186°C	151°C	solid formed in condenser; stopped distillation

Preparation of Trimyrtanyl Tin Bromide:

Crude trimyrtanylphenyl tin (theory: 72.90 g, .12 moles) and 325 mL carbon tetrachloride (.4 M) were placed in a one necked 1-L round-bottom flask equipped with 125-mL addition funnel and magnetic stirrer. The flask was immersed in an ice/ water bath. Bromine (4.7 mL, .009 moles) in 30 mL CCl_4 was placed in the addition funnel and added dropwise to the reaction flask while stirring. Addition of bromine in CCl_4 took several hours. Reaction mixture was faintly pink and decolorized with cyclohexene. The reaction mixture was stirred for an additional one-half hour. The solvent was removed by rotovap. A white solid suspended in a viscuous liquid formed at room temperature. Product was recrystallized twice using 29mL and 21 mL hot absolute ethanol, respectively. The cooled solution was filtered through a Buchner funnel and Crop A was collected. A melting point of Crop A was taken (See Table E-10). A third recrystallization was attempted using Crop A. Ironically, Crop A would not completely dissolve in 90 mL hot absolute ethanol (note the ease of dissolving solid in first two recrystallizations). As the solution cooled to room temperature, white crystals formed. The solution was filtered through a Buchner funnel and crystals (Crop B)were collected. A melting point of Crop B was taken(See Table E-10). IR and hydrogen and carbon-13 NMRs were used to identify structure of product. A yield of 31.7 % was calculated.

Table E-10: Data for recrystallization of Trimyrtanyl Tin Bromide

Crop	Weight (g)	Melting Point / (Voltage)	Comment
A	none taken	90-95 ^{o}C (35 V)	shrinks at 88-89 ^{o}C
B	23.24	114-114 ^{o}C (42 V)	shrinks at 112-113 ^{o}C

Preparation of Cinnamyl Trimyrtanyl Tin:

Trimyrtanyl tin bromide (20.02 g, .003 moles) and 50 mL anhydrous ether were placed in a three necked 1-L round-bottom flask. The flask was fitted with 125-mL addition funnel, condenser with nitrogen gas inlet and mechanical stirrer. Cinnamyl magnesium chloride (21.23 g of cinnamyl chloride, .12 moles) was transferred to the reaction flask via glass tubing and nitrogen pressure. The flask containing the Grignard reagent was rinsed with 30 mL anhydrous ether and added to the 1-L round-bottom. The reaction mixture was stirred and heated for approximately five hours. The reaction mixture contained some green coloration from the unreacted Grignard (Grignard was in excess to begin with).

Reaction mixture was neutralized with 100 mL water while being gently stirred. A slightly exothermic reaction resulted from the reaction of water with unreacted Grignard. Solution was transferred to a 500-mL separatory funnel. The magnesium hydroxide formed a "basic sludge." Gently swished 15 mL anhydrous ether with the reaction mixture in an attempt to break up basic sludge. The organic layer was removed and saved. The aqueous and basic sludge layers were washed twice with 25 mL portions of ether. The organic layers were combined and dried over magnesium sulfate. The solution was gravity filtered and solvent was removed by rotovap.

Performed a simple distillation at 1.1 to 1.4 mmHg (See Table E-11). Hydrogen NMRs of Fractions 3, 6 and solid formed on condenser wall were taken. A carbon - 13 NMR was taken of Fraction 6.

Table E-11: Data for simple vacuum distillation of Cinnamyl Trimyrtanyl Tin

Fraction	T_{head}	Comment
1	25-27°C	P= 1.4 mmHg
2	68-72°C	P= 1.1 mmHg
3	105-150°C	P= 1.1 mmHg
4	118-150-152°C	P= 1.2 mmHg
5	152-157°C	P= 1.3 - 1.4 mmHg
6	157-160°C	P= 1.3 - 1.4 mmHg; solid formed in condenser

Tried to distil the "gooey" residue in pot through a short stillhead. When the temperature was approximately 150°C at 1.1 to 1.2 mmHg, the residue decomposed.

SUMMARY

The series of reactions leading to the synthesis of cinnamyl trimyrtanyl tin gave some insight into the preparation of organotin compounds containing optically active constituents. Primarily, preparation of optically active organotins is a difficult task. Successful preparation of optically active myrtanyl bromide, as proven by polarimetry measurements, warrants its use for further reaction to synthesize an optically active organotin. Unfortunately, trimyrtanylphenyl tin was not purified by recrystallization or fractional vacuum distillation. The bromination of this organotin produced a 31.7 % yield of trimyrtanyl tin bromide. The orangish - red coloration of this solution indicates that the phenyl constituent on the tin has been replaced with a bromine, affording bromobenzene as a side product. The last step in the preparation of cinnamyl trimyrtanyl tin needs some further investigation. Presently, the purification of the allylic organotin by fractional vacuum distillation yielded small distillate fractions. The highest boiling fraction solidified during distillation and the residue in the reaction pot decomposed upon further heating. The NMR spectra indicate that cinnamyl trimyrtanyl tin is not one of the fractions recovered from the distillation. Further investigation of this preparation might warrant pertinent information which will lead to structure characterization of the product(s). At the present time, there is insufficient data for the identification of product(s) formed in the preparation of cinnamyl trimyrtanyl tin.

FUTURE WORK

The preparation of 1,2 - diphenyl - 3 - butene - 1 - ol, a homoallylic alcohol, by reaction of cinnamyl trimyrtanyl tin with benzaldehyde, could be a future endeavor in continuation of this project. This preparation is similar to the one proposed by Yamamoto. Yamamoto reacted an allylic organotin with an aldehyde in the presence of a Lewis acid. This reaction formed the threo homoallylic alcohol and lends support to the formation of the six-membered transition state.

Once the verification of the optical activity of cinnamy trimyrtanyl tin has been measured by polarimetry, a similar reaction scheme to Yamamoto's can be pursued. This preparation should give some insight on the effects of optically active constituents on tin in the reaction mechanism and the selection of enantiomer formed. Ideally, the reaction of cinnamyl trimyrtanyl tin with benzaldehyde, in the presence of boron triflouride, should afford the threo homoallylic alcohol. Comparison of NMR coupling constants will enable verification of stereochemistry of the homoallylic alcohol formed. If the synthesized homoallylic alcohol's NMR coupling constants are similar to those indicated in the literature, then it can be concluded that the proposed synthesis affords the threo homoallylic alcohol via the six-membered transition state. Further investigation with polarimetry measurements will give some indication of the optical purity of the synthesized homoallylic alcohol. The optical rotation of plane polarized light indicates the presence of two enantiomers in which the formation of one enantiomer is favored over the other. That is, the selection of enantiomer is dependent upon the difference of activation energyies in the transition state. The enantiomer with the lower energy of activation will be formed as the major product. The presence of the optically active myrtanyl constituents near the reaction center should provide enough steric hindrance, which will enable energy of activation measurements to be made. The energy of activation values obtained can be compared with literature values in order to assign R and S configurations to the chiral carbons located on the homoallylic alcohol. This will provide insight on the enantio- and diastereoselectivity in the preparation of homoallylic alcohols.

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