Electronic Supplementary Material (ESI) for Chemical Communications

Supporting Information

Gold(I)-Catalysed Direct Allylic Etherification of Unactivated Alcohols

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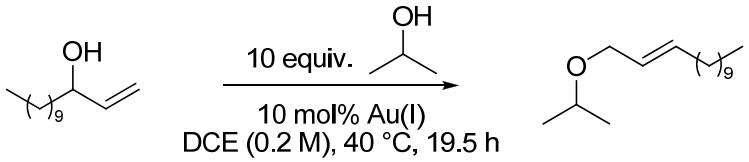
General Experimental Section

^{1}H NMR spectra were recorded on Bruker AV 300 and AV 400 spectrometers at 300 and 400 MHz respectively and referenced to residual solvent. ^{13}C NMR spectra were recorded using the same spectrometers at 75 and 100 MHz respectively. Chemical shifts (δ in ppm) were referenced to tetramethylsilane (TMS) or to residual solvent peaks ($CDCl_3$ at δ_H 7.26). *J* values are given in Hz and s, d, dd, t, q, qn and m abbreviations correspond to singlet, doublet, doublet of doublet, triplet, quartet, quintet and multiplet. Mass spectra were obtained at the EPSRC National Mass Spectrometry Service Centre in Swansea. Infrared spectra were obtained on Perkin-Elmer Spectrum 100 FT-IR Universal ATR Sampling Accessory, deposited neat or as a chloroform solution to a diamond/ZnSe plate. Flash column chromatography was carried out using Matrix silica gel 60 from Fisher Chemicals and TLC was performed using Merck silica gel 60 F254 precoated sheets and visualised by UV (254 nm) or stained by the use of aqueous acidic KMnO4 or aqueous acidic ceric ammonium molybdate as appropriate. Petrol ether refers to petroleum ether (40–60 ^{o}C). Dichloromethane (DCM) was purchased from Fisher and used without further purification. All alcohol nucleophiles were purchased from Sigma-Aldrich or Acros, and used without further purification. The gold(I)-catalysed reactions were carried out without the need for dry solvents or inert atmosphere, unless stated otherwise.

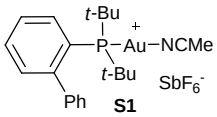
Representative Optimisation Results

Below are representative screens that were carried out in order to optimise the reaction conditions.

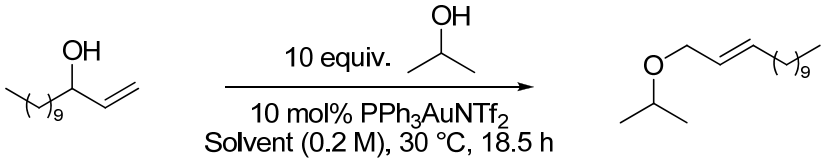
Catalyst Screen:



Entry	Catalyst	Yield	*E:Z*	S_N2':S_N2
1	(2,4-^{t}Bu-Ph-O)$_3$PAuCl / AgOTf	63%	3.4:1	≈ 10:1
2	PPh_3AuCl / AgOTf	47%	5.3:1	≈ 16:1
3	Echavarren's cat. **S1**	59%	6.6:1	≈ 11:1
4	PPh_3AuNTf_2	80%	6.1:1	> 20:1
5	IPr(NHC)AuCl / AgOTf	36%	5.4:1	≈ 10:1

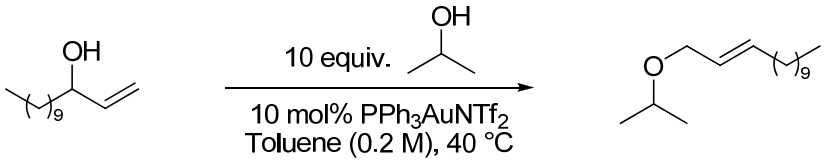


Solvent Screen:



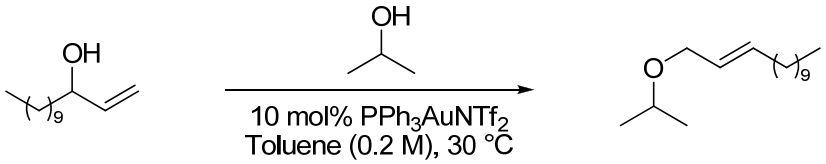
Solvent	Conversion	*E:Z*	S_N2':S_N2	Other
DCM	38%	4.8:1	≈ 15.7:1	
Chloroform	26%	4.1:1	≈ 19:1	
DCE	53%	~6.2:1	≈ 10:1	Traces of side-product
Toluene	42%	8:1	> 20:1	Seems cleaner than chlorinated solvents
MeCN	0	N/A	N/A	
DMF	0	N/A	N/A	
Dioxane	14%	No Z-isomer?	≈ 11.5:1	
THF	17%	3.3:1	> 20:1	

Reaction Time Screen:



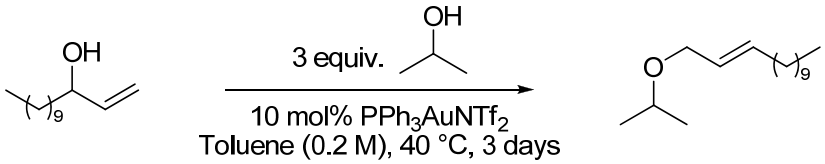
Entry	Time	Conversion	*E:Z*	S_N2':S_N2
1	1 day	42%	5.33:1	> 20:1
2	2 days	60%	7.26:1	> 20:1
3	3 days	87%	7.73:1	> 20:1
4	5 days	90%	8.39:1	≈8:1

^{i}PrOH Equivalents Screen:



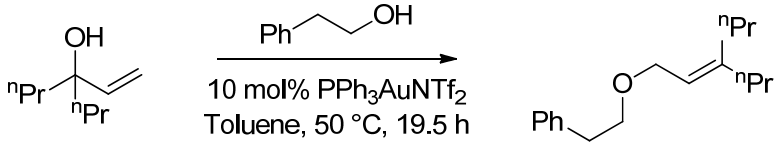
Entry	Equiv. ^{i}PrOH	Time	Conversion	*E:Z*	S_N2':S_N2	Comments
1	1	1 day	17%		> 20:1	
		3 days	42%	7.75:1	> 20:1	≈ 5:1 S_N2':self
2	2	1 day	19%		≈ 15:1	
		3 days	45%	7.40:1	≈ 9.5:1	≈ 6.8:1 S_N2':self
3	3	1 days	26%		> 20:1	
		3 days	54%	7.82:1	≈ 11.5:1	≈ 8.4:1 S_N2':self
4	4	1 day	25%		> 20:1	Self-reaction not observed
		3 days	56%	7.76:1	> 20:1	
5	5	1 day	26%		> 20:1	
		3 days	57%	8.67:1	> 20:1	

Concentration Screen:

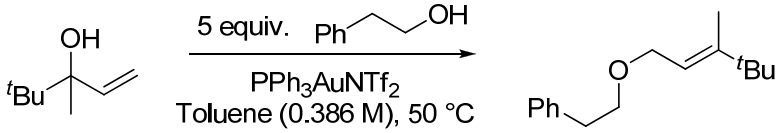


Entry	Concentration (mol L^{-1})	Conversion	*E:Z* ratio	S_N2':S_N2
1	0.05	7%	1:0	> 20:1
s2	0.1	20%	7.5:1	≈ 15.7:1
3	0.2	52%	9.7:1	≈ 15:1
4	0.5	80%	7.7:1	≈ 15.5:1
5	1.0	86%	6.8:1	≈ 13.6:1

Representative screens with tertiary allylic alcohols:

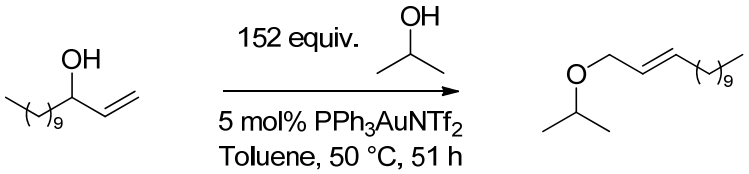


Entry	Equiv. Alcohol	Conversion	S_N2':S_N2	Comments
1	1	>95%	N/D	Very messy with self-reaction product present
2	2	>95%	15:1	
3	3	>95%	>20:1	
4	5	100%	>20:1	Very clean, only S_N2'



Entry	Catalyst Loading	Time (h)	Isolated Yield	Comments
1	10 mol%	17.5	57%	
2	5 mol%	17.5	62%	
3	5 mol%	29.5	76%	Reaction requires over 24 hours

^{i}PrOH as solvent:



Result: >95% conversion, S_N2':S_N2 ≈ 5:1, *E*:*Z* ≈ 3:1

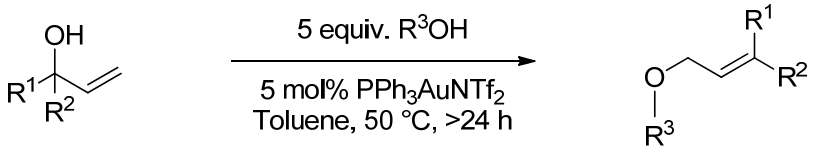
Experimental Procedures

Allylic Alcohol Starting Materials:

Allylic alcohol **1b** was purchased from Sigma-Aldrich.

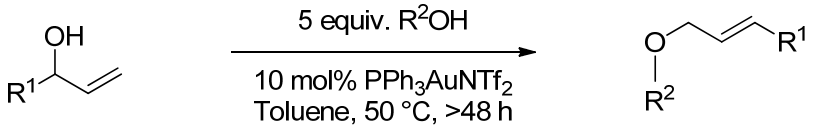
Allylic alcohols **1a**, **1c-k** were obtained following known literature procedure with Grignard addition to ketones/aldehydes.[1] Allylic alcohols **1l-m** were obtained following known literature procedures by reduction of alkyne.[2,3] All characterisation was comparable to literature values; **1a**, **e** & **f**,[1] **1c**,[4] **1d**,[5] **1g**,[6] **1h**,[7] **1i**,[8] **1j**,[9] **1k**,[10] **1l**,[11] **1m**.[3]

A: General Synthetic Procedure for Tertiary Allylic Alcohol Substrates:



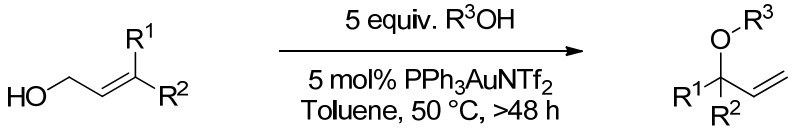
The gold-catalysed reactions were all carried out in 1 dram screw-cap vials. To a toluene solution (0.386 M) of allylic alcohol (1 equiv.) and alcohol nucleophile (5 equiv.), 5 mol% of PPh_3AuNTf_2 was added. The reaction mixture was allowed to stir at 50 °C for over 24 hours. The reaction was then filtered through a plug of silica (40:1 petroleum ether:diethyl ether). The filtrate was concentrated under reduced pressure, and a crude ^1H NMR was obtained to determine S_N2':S_N2 and *E*:*Z* ratios. The crude material was purified by flash column chromatography.

B: General Synthetic Procedure for Secondary Allylic Alcohol Substrates:



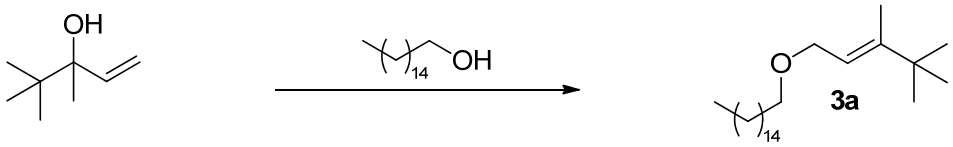
The gold-catalysed reactions were all carried out in 1 dram screw-cap vials. To a toluene solution (0.386 M) of allylic alcohol (1 equiv.) and alcohol nucleophile (5 equiv.), 10 mol% of PPh_3AuNTf_2 was added. The reaction mixture was allowed to stir at 50 °C for over 48 hours. The reaction was then filtered through a plug of silica (40:1 petroleum ether:diethyl ether). The filtrate was concentrated under reduced pressure, and a crude ^1H NMR was obtained to determine S_N2':S_N2 and *E*:*Z* ratios. The crude material was purified by flash column chromatography.

C: General Synthetic Procedure for Primary Allylic Alcohol Substrates:



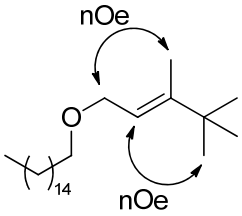
As for **A**, but reaction time was >48 h instead of >24 h.

(*E*)-1-((3,4,4-Trimethylpent-2-en-1-yl)oxy)hexadecane **3a**:

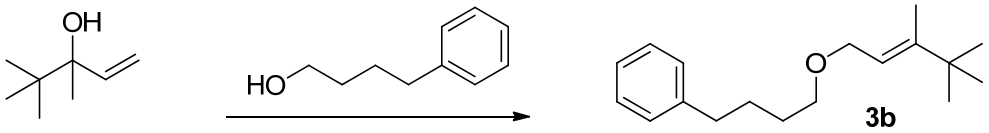


Purified using flash column chromatography; using a gradient eluent system of neat petroleum ether → 80:1 petroleum ether:diethyl ether. Product obtained as a colourless oil (33.7 mg, 0.096 mmol, 83%). ν_{max}/cm^{-1} 2955 s 2852 s (C-H), 1651 w (C=C), 1465 m 1360 m (C-H bending), 1106 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 5.39 (1H, tq, *J* = 6.2, 1.2 Hz, $OCH_2C\underline{H}$), 4.00 (2H, d, *J* = 6.2, $OC\underline{H_2}CH$), 3.41 (2H, t, *J* = 6.8 Hz, $OC\underline{H_2}CH_2$), 1.64 (3H, d, *J* = 1.2 Hz, $CH=C(C\underline{H_3})$), 1.25 (28H, s, alkyl CH_2), 1.05 (9H, s, $C(C\underline{H_3})_3$), 0.91 – 0.85 (3H, m, $CH_2C\underline{H_3}$); δ_C (75 MHz, $CDCl_3$) 146.8 (C), 118.5 (CH), 70.7 (CH_2), 68.3 (CH_2), 36.4 (C), 32.1 (CH_2), 30.0 (CH_2), 29.9 (CH_3), 29.82 (3 x CH_2 overlapping peaks), 29.77 (2 x CH_2 overlapping peaks), 29.7 (CH_2), 29.5 (CH_2), 29.0 (3 x CH_2 overlapping peaks), 26.4 (CH_2), 22.9 (CH_2), 14.9 (CH_3), 13.2 (CH_3). Found (ESI) $[M+NH_4]^+$ 370.4048, $C_{24}H_{52}NO$ requires 370.4043.

2D NOESY confirms *E*-isomer is major isomer:

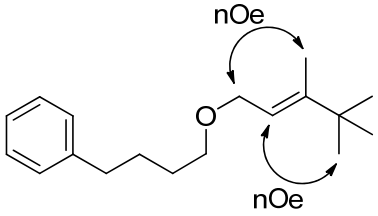


(*E*)-(4-((3,4,4-Trimethylpent-2-en-1-yl)oxy)butyl)benzene **3b**:

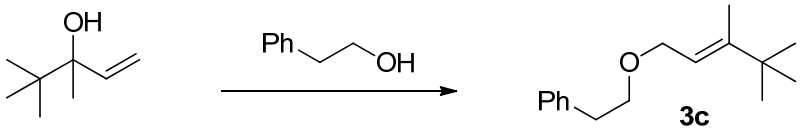


Analysis of crude reaction mixture showed that S_N2':S_N2 ratio was 12:1. Purified using flash column chromatography; using a gradient eluent system of neat hexane → 20:1 hexane:diethyl ether. Product obtained as a colourless oil with S_N2':S_N2 ratio of 15:1 (23.3 mg, 0.089 mmol, 75%). ν_{max}/cm^{-1} 3027 w 2954 m 2937 m 2862 m (C-H), 1655 w (C=C), 1604 w 1496 m 1453 m (aromatic C=C), 1107 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 7.31 – 7.15 (5H, m, aromatic CH), 5.39 (1H, tq, *J* = 6.2, 1.2 Hz, $OCH_2C\underline{H}$), 4.00 (2H, d, *J* = 6.2 Hz, $OC\underline{H_2}CH$), 3.45 (2H, t, *J* = 6.4 Hz, $OC\underline{H_2}CH_2$), 2.65 (2H, t, *J* = 7.4 Hz, $CH_2C\underline{H_2}Ph$), 1.77 – 1.58 (7H, m, alkyl $C\underline{H_2}$ & $C(C\underline{H_3})$), 1.06 (9H, s, $C(C\underline{H_3})_3$); δ_C (75 MHz, $CDCl_3$) 147.0 (C), 142.6 (C), 128.6 (CH), 128.4 (CH), 125.8 (CH), 118.4 (CH), 70.4 (CH_2), 68.3 (CH_2), 36.4 (C), 35.9 (CH_2), 29.6 (CH_2), 29.0 (CH_3), 28.3 (CH_2), 13.2 (CH_3). Found (EI) $[M]^+$ 260.2136, $C_{18}H_{28}O$ requires 260.2135.

2D NOESY confirms *E*-isomer:



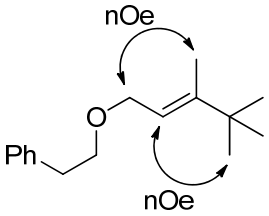
(*E*)-(2-((3,4,4-Trimethylpent-2-en-1-yl)oxy)ethyl)benzene **3c**:



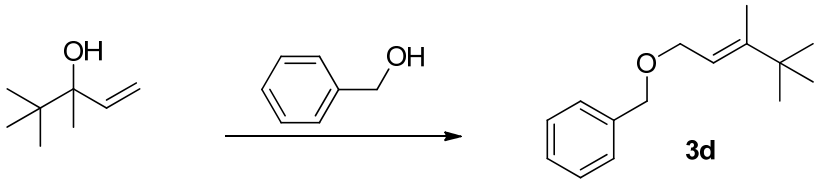
3c

Purified using flash column chromatography; using a gradient eluent system of neat hexane → 50:1 hexane:diethyl ether. Product obtained as a colourless oil (16.7 mg, 0.072 mmol, 76%). ν_{max}/cm^{-1} 3028 w 2963 m 2867 m (C-H), 1657 w (C=C), 1605 w 1497 m 1454 m (aromatic C=C), 1105 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 7.33 – 7.18 (5H, m, aromatic CH), 5.39 (1H, tq, J = 6.2, 1.1 Hz, $OCH_2C\underline{H}$), 4.05 (2H, d, J = 6.2 Hz, $OC\underline{H_2}CH$), 3.65 (2H, t, J = 7.4 Hz, $OC\underline{H_2}CH_2$), 2.92 (2H, t, J = 7.4 Hz, $OCH_2C\underline{H_2}$), 1.64 (3H, d, J = 1.1 Hz, $CH{=}CC\underline{H_3}$), 1.06 (9H, s, $C(C\underline{H_3})_3$); δ_C (101 MHz, $CDCl_3$) 147.2 (C), 139.2 (C), 129.0 (CH), 128.5 (CH), 126.3 (CH), 118.2 (CH), 71.4 (CH_2), 68.4 (CH_2), 36.6 (CH_2), 36.4 (C), 29.0 (CH_3), 13.2 (CH_3). Found (APCI) $[M+H]^+$ 233.1899, $C_{16}H_{25}O$ requires 233.1900.

2D NOESY confirms *E*-isomer:

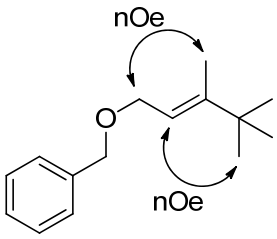


(*E*)-(((3,4,4-Trimethylpent-2-en-1-yl)oxy)methyl)benzene **3d**:

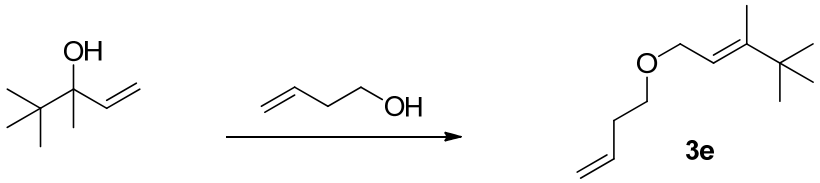


Purified using flash column chromatography; using a gradient eluent system of neat hexane → 50:1 hexane:diethyl ether. Product obtained as a colourless oil (19.9 mg, 0.091 mmol, 77%). ν_{max}/cm^{-1} 2964 s 2867 m (C-H), 1655 w (C=C), 1496 w 1454 m 1360 s (aromatic C=C), 1101 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 7.38 – 7.26 (5H, m, aromatic CH), 5.45 (tq, J = 6.3, 1.2 Hz, 1H, $OCH_2C\underline{H}$), 4.52 (2H, s, $OC\underline{H_2}Ar$), 4.06 (2H, dq, J = 6.3, 0.7 Hz, $OC\underline{H_2}CH$), 1.65 – 1.62 (3H, m, $CHCC\underline{H_3}$), 1.06 (9H, s, $C(C\underline{H_3})_3$); δ_C (75 MHz, $CDCl_3$) 147.6 (C), 138.7 (C), 128.5 (CH), 128.0 (CH), 127.7 (CH), 118.1 (CH), 72.4 (CH_2), 67.6 (CH_2), 36.4 (C), 29.0 (CH_3), 13.2 (CH_3). Found (APCI) $[M+NH_4]^+$ 236.2007, $C_{15}H_{26}NO$ requires 236.2009.

2D NOESY confirms *E*-isomer:

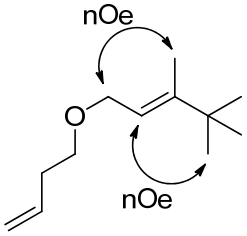


(*E*)-1-(But-3-en-1-yloxy)-3,4,4-trimethylpent-2-ene **3e**:

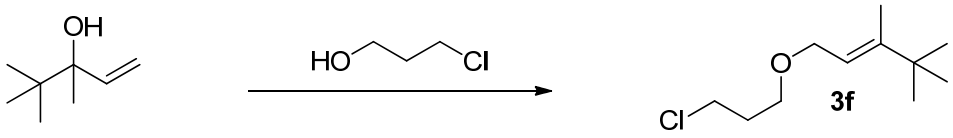


Purified using flash column chromatography; using an eluent system of 75:1 petroleum ether:diethyl ether. Product obtained as a colourless oil (16.0 mg, 0.088 mmol, 75%). ν_{max}/cm^{-1} 3075 w 2960 m 2925 m 2855 w (C-H), 1642 w (C=C), 1464 w 1360 w (C-H bending), 1087 s (C-O-C); δ_H (300 MHz, $CDCl_3$) 5.79 (1H, ddt, *J* = 17.0, 10.2, 6.7 Hz, CH_2=C<u>H</u>), 5.34 (1H, t, *J* = 6.2 Hz, $OCH_2C\underline{H}$=), 5.21 – 4.90 (2H, m, $C\underline{H_2}$=CH), 3.98 (2H d, *J* = 6.2 Hz, $OC\underline{H_2}CH$=), 3.44 (2H, t, *J* = 6.9 Hz, $CH_2C\underline{H_2}O$), 2.38 – 2.23 (2H, m, =$CHC\underline{H_2}CH_2$), 1.59 (3H, s, $C\underline{H_3}C$=), 1.00 (9H, s, $(C\underline{H_3})_3C$); δ_C (75 MHz, $CDCl_3$) 147.07 (C), 135.81 (CH), 117.94 (CH), 116.21 (CH_2), 69.86 (CH_2), 68.12 (CH_2), 36.56 (C), 34.53 (CH_2), 29.01 (CH_3), 13.45 (CH_3). Found (APCI) [$M+H^+$] 183.1744, $C_{12}H_{23}O$ requires 183.1743.

2D NOESY confirms *E*-isomer:

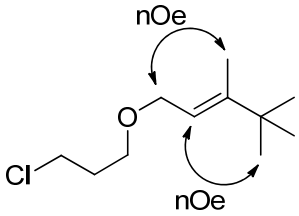


(*E*)-1-(3-Chloropropoxy)-3,4,4-trimethylpent-2-ene **3f**:

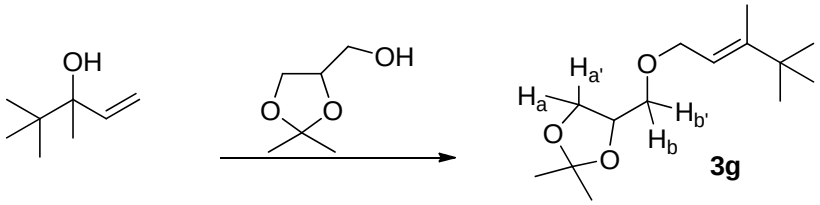


Purified using flash column chromatography; using a gradient eluent system of neat petroleum ether → 50:1 petroleum ether:diethyl ether. Product obtained as a colourless oil (15.5 mg, 0.076 mmol, 65%). ν_{max}/cm^{-1} 2971 s 2902 s (C-H), 1656 w (C=C), 1452 m 1406 m 1394 m 1381 m (C-H bending), 1066 s 1057 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 5.37 (tq, J = 6.2, 1.2 Hz, 1H, $OCH_2C\underline{H}$), 4.02 (d, J = 6.2 Hz, 2H, $OC\underline{H_2}CH$), 3.65 (t, J = 6.5 Hz, 2H, $OC\underline{H_2}CH_2$), 3.56 (t, J = 5.9 Hz, 2H, $CH_2C\underline{H_2}Cl$), 2.03 (app. p, J = 6.2 Hz, 2H, $CH_2C\underline{H_2}CH_2$), 1.66 – 1.63 (m, 3H, $CH=C(C\underline{H_3})$), 1.05 (s, 9H, $C(C\underline{H_3})_3$); δ_C (75 MHz, $CDCl_3$) 147.5 (C), 118.0 (CH), 68.41 (CH_2), 66.6 (CH_2), 42.3 (CH_2), 36.4 (C), 32.9 (CH_2), 29.0 (CH_3), 13.2 (CH_3). Found (APCI) $[M+H]^+$ 205.1356, $C_{11}H_{22}ClO$ requires 205.1354.

2D NOESY confirms *E*-isomer:

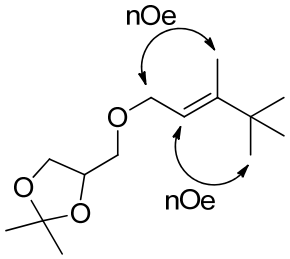


(*E*)-2,2-Dimethyl-4-(((3,4,4-trimethylpent-2-en-1-yl)oxy)methyl)-1,3-dioxolane **3g**:

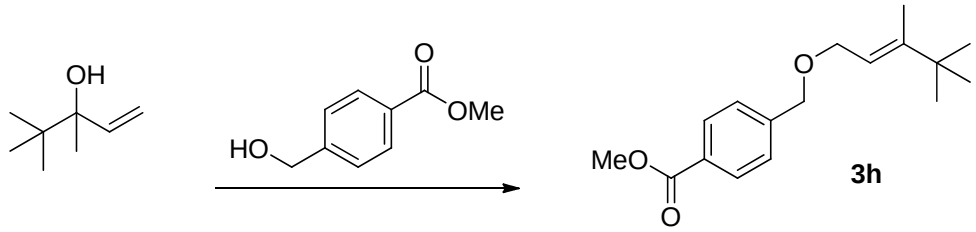


Purified using flash column chromatography; using a gradient eluent system of neat hexane → 40:1 hexane:diethyl ether. Product obtained as a colourless oil (22.0 mg, 0.091 mmol, 77%). ν_{max}/cm^{-1} 2965 s 2870 s (C-H), 1655 w (C=C), 1456 m 1370 s (C-H bending), 1068 s 1054 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 5.38 (1H, tq, *J* = 6.2, 1.2 Hz, $OCH_2C\underline{H}$=C), 4.29 (1H, app. qn, *J* = 6.3 Hz, $OC\underline{H}CH_2O$), 4.10 – 4.04 (3H, m, $OC\underline{H_2}CH$=C & $H_a/H_{a'}$), 3.72 (1H, dd, *J* = 8.3, 6.4 Hz, $H_a/H_{a'}$), 3.52 (1H, dd, *J* = 9.8, 5.9 Hz, $H_b/H_{b'}$), 3.42 (1H, dd, *J* = 9.8, 5.6 Hz, $H_b/H_{b'}$), 1.64 (3H, d, *J* = 1.2 Hz, CH=C($C\underline{H_3}$)), 1.42 (3H, s, $OC(C\underline{H_3})_2O$), 1.36 (3H, s, $OC(C\underline{H_3})_2O$), 1.04 (9H, s, CH=C($C\underline{H_3})_3$); δ_C (75 MHz, $CDCl_3$) 147.5 (C), 117.9 (CH), 109.5 (C), 74.9 (CH), 71.4 (CH_2), 69.0 (CH_2), 67.2 (CH_2), 36.4 (C), 29.0 (CH_3), 27.0 (CH_3), 25.5 (CH_3), 13.2 (CH_3). Found (ESI) $[M+H]^+$ 243.1960, $C_{14}H_{27}O_3$ requires 243.1955.

2D NOESY confirms *E*-isomer:

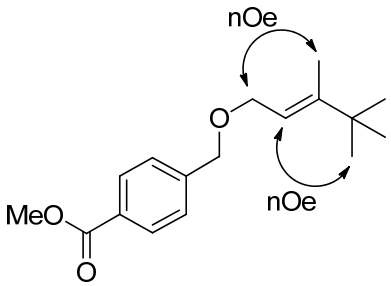


(*E*)-Methyl 4-(((3,4,4-trimethylpent-2-en-1-yl)oxy)methyl)benzoate **3h**:

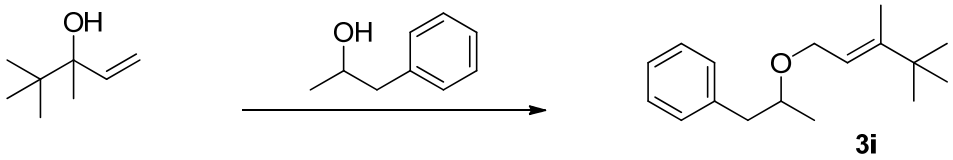


Purified using flash column chromatography; using a gradient eluent system of neat hexane → 10:1 hexane:diethyl ether. Product obtained as a colourless oil (23.9 mg, 0.086 mmol, 74%). ν_{max}/cm^{-1} 2954 m 2868 m (C-H), 1722 s (C=O), 1658 w (C=C), 1613 m, 1578 w 1435 m (aromatic C=C), 1275 s 1105 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 8.02 (2H, d, *J* = 8.0 Hz, Ar-H), 7.42 (2H, d, *J* = 8.0 Hz, Ar-H), 5.44 (1H, tq, *J* = 6.3, 1.2 Hz, $OCH_2C\underline{H}$), 4.56 (2H, s, $OC\underline{H_2}Ar$), 4.07 (2H, d, *J* = 6.3 Hz, $OC\underline{H_2}CH$), 3.91 (3H, s, $OC\underline{H_3}$), 1.63 (3H, d, *J* = 1.2 Hz, $CH=C(C\underline{H_3})$), 1.05 (9H, s, $C(C\underline{H_3})_3$); δ_C (75 MHz, $CDCl_3$) 167.1 (C), 148.0 (C), 144.1 (C), 129.8 (CH), 129.4 (C), 127.5 (CH), 117.7 (CH), 71.7 (CH_2), 67.9 (CH_2), 52.2 (CH_3), 36.4 (C), 29.0 (CH_3), 13.2 (CH_3). Found (ESI) $[M+NH_4]^+$ 294.2069, $C_{17}H_{28}NO_3$ requires 294.2064.

2D NOESY confirms *E*-isomer:



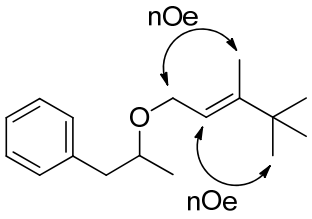
(*E*)-(2-((3,4,4-Trimethylpent-2-en-1-yl)oxy)propyl)benzene **3i**:



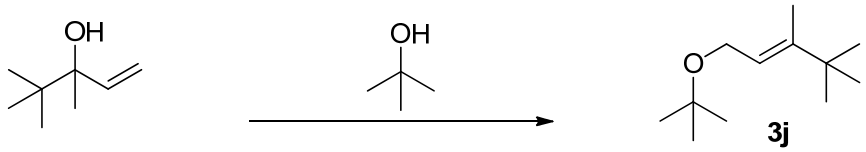
3i

Purified using flash column chromatography; using a gradient eluent system of neat petroleum ether → 50:1 petroleum ether:diethyl ether. Product obtained as a colourless oil (20.7 mg, 0.084 mmol, 71%). ν_{max}/cm^{-1} 3028 w 2965 s 2867 m (C-H), 1656 w (C=C), 1604 w 1496 m 1453 m (aromatic C=C), 1096 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 5.33 (1H, tq, J = 6.2, 1.2 Hz, $OCH_2C\underline{H}$), 4.06 (1H, dd, J = 12.0, 6.2 Hz, $OC\underline{H}H'CH$), 3.99 (1H, dd, J = 12.0, 6.2 Hz, $OCH\underline{H}'CH$), 3.64 (1H, dp, J = 6.8, 6.1 Hz, $OC\underline{H}$), 2.96 (1H, dd, J = 13.4, 6.1 Hz, $PhC\underline{H}H'CH$), 2.63 (1H, dd, J = 13.4, 6.8 Hz, $PhCH\underline{H}'CH$), 1.60 (3H, d, J = 1.2 Hz, $CH=C(C\underline{H_3})$), 1.15 (3H, d, J = 6.1 Hz, $OCHC\underline{H_3}$), 1.03 (9H, s, $C(C\underline{H_3})_3$); δ_C (75 MHz, $CDCl_3$) 146.7 (C), 139.4 (C), 129.6 (CH), 128.3 (CH), 126.1 (CH), 118.7 (CH), 76.1 (CH), 66.1 (CH_2), 43.3 (CH_2), 36.3 (C), 29.0 (CH_3), 19.8 (CH_3), 13.2 (CH_3). Found (APCI) $[M+H]^+$ 247.2054, $C_{17}H_{27}O$ requires 247.2056.

2D NOESY confirms *E*-isomer is major isomer:

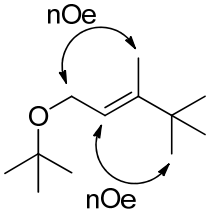


(*E*)-1-(*tert*-Butoxy)-3,4,4-trimethylpent-2-ene **3j**:

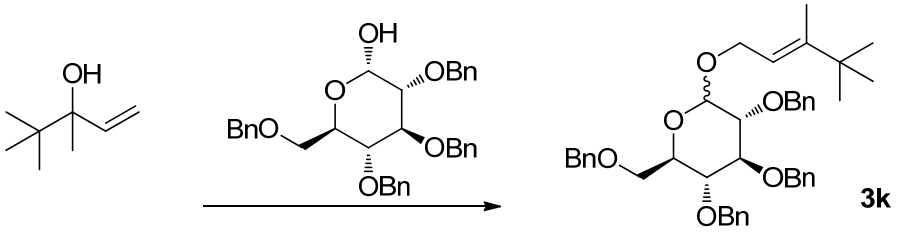


Purified using flash column chromatography; using a gradient eluent system of neat petroleum ether → 80:1 petroleum ether:diethyl ether. Product obtained as a colourless oil (12.6 mg, 0.068 mmol, 57%). ν_{max}/cm^{-1} 2966 s 2928 m 2869 m (C-H), 1659 w (C=C), 1464 m 1388 m 1361 s (C-H bending), 1055 s (C-O-C); δ_H (300 MHz, $CDCl_3$) 5.33 (1H, tq, *J* = 5.9, 1.1 Hz, $OCH_2C\underline{H}$), 3.96 (2H, d, *J* = 5.9 Hz, $OC\underline{H_2}CH$), 1.62 (3H, d, *J* = 1.1 Hz, $CC\underline{H_3}$), 1.23 (9H, s, $OC(C\underline{H_3})_3$), 1.04 (9H, s, $C(C\underline{H_3})_3$)); δ_C (75 MHz, $CDCl_3$) 145.2 (C), 119.8 (CH), 73.0 (C), 59.8 (CH_2), 36.3 (C), 29.0 (CH_3), 27.8 (CH_3), 13.2 (CH_3). Found (APCI) $[M-H]^+$ 183.1742, $C_{12}H_{23}O$ requires 183.1743.

2D NOESY confirms *E*-isomer is major isomer:



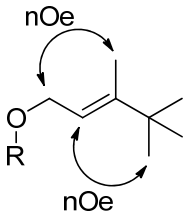
(2*R*,3*R*,4*S*,5*R*)-3,4,5-Tris(benzyloxy)-2-((benzyloxy)methyl)-6-(((*E*)-3,4,4-trimethylpent-2-en-1-yl)oxy)tetrahydro-2*H*-pyran **3k**:



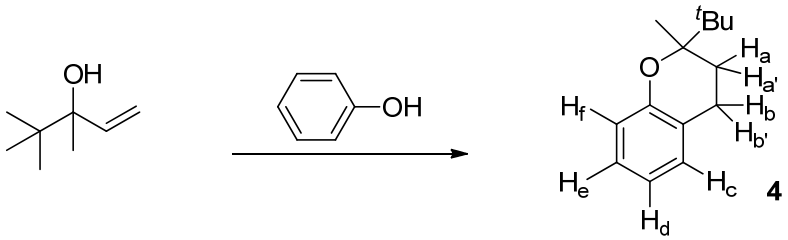
For solubility reasons, chloroform was used instead of toluene for this reaction. Purified using flash column chromatography; using a gradient eluent system of neat petroleum ether → 2:1 petroleum ether:diethyl ether. Product obtained as a colourless oil as a mixture of anomers with α:β ratio of ≈ 3:1 (39.1 mg, 0.060 mmol, 52%). ν_{max}/cm^{-1} 2959 w 2913 w 2866 w (C-H), 1694 w (C=C), 1605 w 1496 w 1453 m (aromatic C=C), 1084 s 1069 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 7.43 – 7.15 (20H+20H', m, α & β aromatic CH), 5.54 – 5.48 (1H', m, β-$OCH_2C\underline{H}$), 5.50 – 5.45 (1H, m, α-$OCH_2C\underline{H}$), 5.09 – 3.48 (17H+17H', m, α & β benzyl CH_2 & alkyl CH), 1.70 (3H', d, *J* = 1.9 Hz, β-$CC\underline{H_3}$), 1.69 (3H, d, *J* = 1.8 Hz, α-$CC\underline{H_3}$), 1.10 (9H+9H', d, *J* = 0.6 Hz, α & β $C(C\underline{H_3})_3$); only major α-anomer characterised by ^{13}C NMR; δ_C (101 MHz, $CDCl_3$) 148.2 (C), 139.2 (C), 138.42 (C), 138.36 (C), 138.1 (C), 128.54 (CH), 128.50 (CH), 128.49 (CH), 128.47 (CH), 128.2 (CH), 128.10 (CH), 128.06 (CH), 128.0 (CH), 127.94 (CH), 127.87 (CH), 127.8 (CH), 127.7 (CH), 117.3 (CH), 95.4 (CH), 82.4 (CH), 79.8 (CH), 78.0 (CH), 75.9 (CH_2), 75.2 (CH_2), 73.6 (CH_2), 73.1 (CH_2), 70.3 (CH), 68.7 (CH_2), 64.3 (CH_2), 36.5 (C), 29.1 (CH_3), 13.2 (CH_3). Found (ESI) $[M+NH_4]^+$ 668.3944, $C42H_{54}NO_6$ requires 668.3946.

α & β Anomer ratio determined with assistance from 2D NMR work (C-H correlation); δ_H (400 MHz, $CDCl_3$) 4.89 (d, *J* = 4.9 Hz, 4H, α-OC<u>H</u>O), 4.48 (d, *J* = 7.8 Hz, 1H, β-OC<u>H</u>O).

2D NOESY confirms *E*-isomer is major isomer (both α & β anomers):

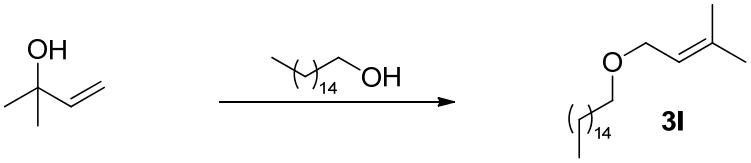


2-(*tert*-Butyl)-2-methylchroman **4**:



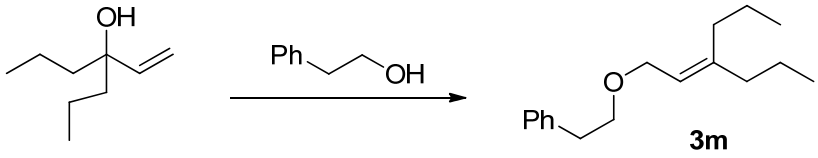
Purified using flash column chromatography; using a gradient eluent system of neat hexane → 50:1 hexane:diethyl ether. Product obtained as a colourless oil (12.7 mg, 0.062 mmol, 53%). ν_{max}/cm^{-1} 2965 m 2921 m 2873 (C-H), 1583 m 1488 m 1456 m (aromatic C=C), 1125 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 7.11 – 7.01 (2H, m, Ar-H), 6.81 – 6.74 (2H, m, Ar-H), 2.88 – 2.77 (1H, ddd, *J* = 16.6, 13.1, 6.1 Hz, $H_b/H_{b'}$), 2.69 (1H, ddd, *J* = 16.6, 5.8, 1.8 Hz, $H_b/H_{b'}$), 1.90 (1H, tdq, *J* = 13.1, 5.8, 0.8 Hz, $H_a/H_{a'}$), 1.75 (1H, ddd, *J* = 13.1, 6.1, 1.8 Hz, $H_a/H_{a'}$), 1.17 (3H, d, *J* = 0.8 Hz, OCC$\underline{H_3}$), 1.04 (9H, s, C(C$\underline{H_3}$)$_3$); δ_C (75 MHz, $CDCl_3$) 154.8 (C), 129.3 (CH), 127.3 (CH), 121.5 (C), 119.3 (CH), 117.4 (CH), 80.1 (C), 37.9 (C), 25.8 (CH_2), 25.3 (CH_3), 22.5 (CH_2), 17.7 (CH_3). Found (APCI) $[M+H]^+$ 205.1586, $C_{14}H_{21}O_1$ requires 205.1587.

1-((3-Methylbut-2-en-1-yl)oxy)hexadecane **3l**:



Analysis of crude reaction mixture showed that S_N2':S_N2 ratio was 5:1. Purified using flash column chromatography; using a gradient eluent system of neat hexane → 25:1 hexane:diethyl ether. Product obtained as a colourless oil with S_N2':S_N2 ratio of 6.5:1 (33.1 mg, 0.107 mmol, 62%). ν_{max}/cm^{-1} 2922 s 2853 s (C-H), 1675 w (C=C), 1466 m 1377 m (C-H bending), 1089 m (C-O-C); δ_H (300 MHz, $CDCl_3$) 5.36 (1H, tsept, *J* = 6.9, 1.4 Hz, $OCH_2C\underline{H}$), 3.93 (2H, d, *J* = 6.9 Hz, $OC\underline{H_2}CH$), 3.39 (2H, t, *J* = 6.7 Hz, $OC\underline{H_2}CH_2$), 1.74 (3H, app. s, C(C$\underline{H_3}$)$_2$), 1.67 (3H, app. s, C(C$\underline{H_3}$)$_2$), 1.38-1.16 (28H, m, alkyl CH_2), 0.91 – 0.83 (3H, m, $CH_2C\underline{H_3}$); δ_C (75 MHz, $CDCl_3$) 136.7 (C), 121.5 (CH), 70.6 (CH_2), 67.4 (CH_2), 32.1 (CH_2), 30.0 (CH_2 overlapping signals), 29.9 (CH_2), 29.82 (CH_2), 29.77 (CH_2), 29.7 (CH_2), 29.5 (CH_2), 26.4 (CH_2), 26.0 (CH_3), 22.9 (CH_2), 18.2 (CH_3), 14.3 (CH_3). Found (APCI) $[M+NH_4]^+$ 328.3567, $C_{21}H_{46}NO$ requires 328.3574.

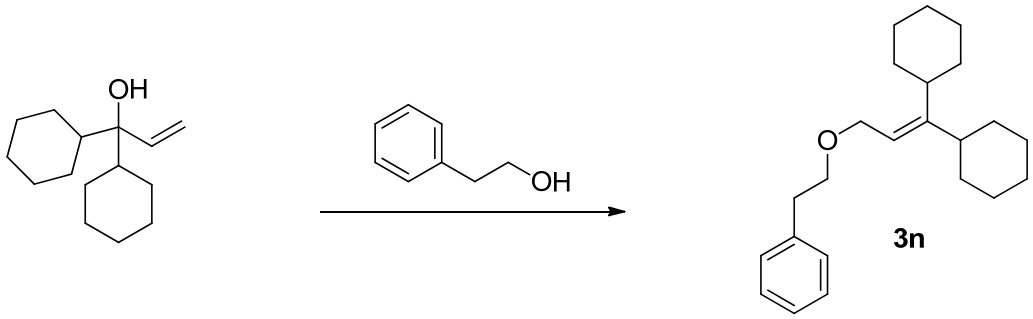
(2-((3-Propylhex-2-en-1-yl)oxy)ethyl)benzene **3m**:



3m

Purified using flash column chromatography with silver nitrate impregnated silica; using a gradient eluent system of neat petroleum ether → 50:1 petroleum ether:diethyl ether. Product obtained as a colourless oil (19.8 mg, 0.080 mmol, 78%). ν_{max}/cm^{-1} 2959 m 2931 m 2871 m (C-H), 1662 w (C=C), 1605 w 1497 w 1455 m (aromatic C=C), 1093 (C-O-C); δ_H (300 MHz, $CDCl_3$) 7.33 – 7.17 (5H, m, aromatic CH), 5.34 (1H, t, *J* = 6.7 Hz, $OCH_2C\underline{H}$), 4.02 (2H, d, *J* = 6.7 Hz, $OC\underline{H_2}CH$), 3.64 (2H, t, *J* = 7.4 Hz, $OC\underline{H_2}CH_2$), 2.91 (2H, t, *J* = 7.4 Hz, $OCH_2C\underline{H_2}$), 2.07 – 1.93 (4H, m, $=CC\underline{H_2}CH_2$), 1.51 – 1.30 (4H, m, $=CCH_2C\underline{H_2}$), 0.89 (3H, t, *J* = 7.3 Hz, $CH_2C\underline{H_3}$), 0.88 (3H, t, *J* = 7.3 Hz, $CH_2C\underline{H_3}$); δ_C (75 MHz, $CDCl_3$) 144.3 (C), 139.2 (C), 129.0 (CH), 128.5 (CH), 126.3 (CH), 121.4 (CH), 71.2 (CH_2), 67.4 (CH_2), 39.1 (CH_2), 36.6 (CH_2), 32.8 (CH_2), 21.9 (CH_2), 21.2 (CH_2), 14.3 (CH_3), 14.1 (CH_3). Found (ESI) $[M+NH_4]^+$ 264.2326, $C_{17}H_{30}NO$ requires 264.2322.

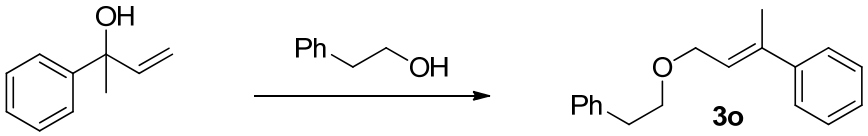
(3-Phenethoxyprop-1-ene-1,1-diyl)dicyclohexane **3n**:



3n

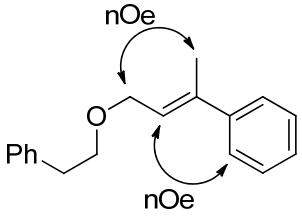
Purified using flash column chromatography; using a gradient eluent system of neat petroleum ether → 50:1 petroleum ether:diethyl ether. Product obtained as a colourless oil (20.1 mg, 0.062 mmol, 91%). ν_{max}/cm^{-1} 2988 s 2922 s (C-H), 1653 w (C=C), 1495 m 1449 m (aromatic C=C), 1057 s (C-O-C); δ_H (300 MHz, $CDCl_3$) 7.40 – 7.13 (5H, m, aromatic CH), 5.26 (1H, t, *J* = 6.5 Hz, $OCH_2C\underline{H}$), 4.09 (2H, d, *J* = 6.5 Hz, $OC\underline{H_2}CH$), 3.64 (2H, t, *J* = 7.3 Hz, $OC\underline{H_2}CH_2$), 2.91 (2H, t, *J* = 7.3 Hz, $CH_2C\underline{H_2}Ph$), 2.44 – 2.24 (1H, m, cyclohexyl CH), 1.97 – 1.84 (1H, m, cyclohexyl CH'), 1.83 – 1.06 (20H, m, alkyl CH_2); δ_C (75 MHz, $CDCl_3$) 154.4 (C), 139.3 (C), 129.0 (CH), 128.5 (CH), 126.3 (CH), 119.2 (CH), 71.0 (CH_2), 67.2 (CH_2), 41.4 (CH), 40.8 (CH), 36.6 (CH_2), 34.9 (CH_2), 31.1 (CH_2), 27.3 (CH_2), 26.8 (CH_2), 26.4 (CH_2), 26.3 (CH_2). Found (APCI) $[M+H]^+$ 327.2679, $C_{23}H_{35}O$ requires 327.2682.

(*E*)-(4-Phenethoxybut-2-en-2-yl)benzene **3o**:

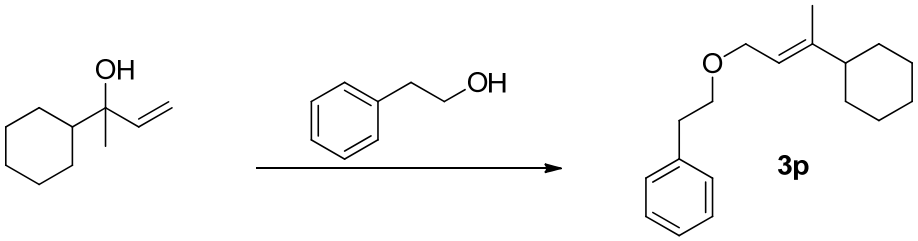


Analysis of crude reaction mixture showed that *E*:*Z* ratio was 6:1. Purified using flash column chromatography; using a gradient eluent system of neat hexane → 50:1 hexane:diethyl ether. Product obtained as a colourless oil with *E*:*Z* isomers present in 6:1 ratio (17.1 mg, 0.068 mmol, 67%). ν_{max}/cm^{-1} 3027 m 2919 m 2855 m (C-H), 1647 w (C=C), 1601 w 1495 m 1445 m (aromatic C=C), 1097 (C-O-C); δ_H (400 MHz, $CDCl_3$) 7.45 – 7.15 (10H, m, aromatic CH), 5.94 (1H, tq, *J* = 6.5, 1.2 Hz, $OCH_2C\underline{H}$), 4.22 (2H, d, *J* = 6.5 Hz, $OC\underline{H_2}CH$), 3.72 (2H, t, *J* = 7.3 Hz, $OC\underline{H_2}CH_2$), 2.95 (2H, t, *J* = 7.3 Hz, $OCH_2C\underline{H_2}$), 2.07 (3H, s, $CC\underline{H_3}$); δ_C (75 MHz, $CDCl_3$) 143.0 (C), 139.1 (C), 138.3 (C), 129.1 (CH), 128.5 (CH), 128.3 (CH), 127.3 (CH), 126.3 (CH), 125.9 (CH), 124.5 (CH), 71.5 (CH_2), 68.1 (CH_2), 36.6 (CH_2), 16.3 (CH_3). Found (APCI) $[M+NH_4]^+$ 270.1851, $C_{18}H_{24}NO$ requires 270.1858.

2D NOESY confirms *E*-isomer is major isomer:

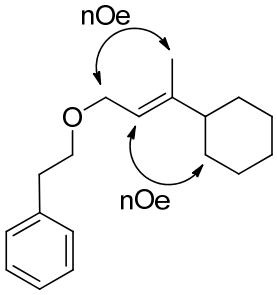


(*E*)-(2-((3-Cyclohexylbut-2-en-1-yl)oxy)ethyl)benzene **3p**:

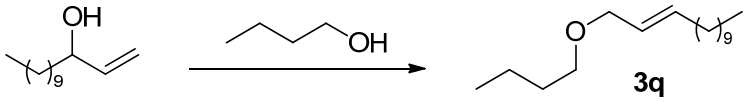


Analysis of crude reaction mixture showed that S_N2':S_N2 ratio was >20:1. The *E*:*Z* ratio was found to be ~5:1 Purified using flash column chromatography; using a gradient eluent system of neat hexane → 10:1 hexane:diethyl ether. Product obtained as a colourless oil with *E*:*Z* ratio of 5:1 (17.7 mg, 0.068 mmol, 71%). ν_{max}/cm^{-1} 3028 w 2923 s 2851 s (C-H), 1661 w (C=C), 1605 w 1496 m 1449 m (aromatic C=C), 1100 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 7.33 – 7.18 (5H, m, aromatic CH), 5.33 (1H, tp, *J* = 6.6, 1.1 Hz, $OCH_2C\underline{H}$), 4.03 (2H, d, *J* = 6.5 Hz, $OC\underline{H_2}CH$), 3.64 (2H, t, *J* = 7.4 Hz, $OC\underline{H_2}CH_2$), 2.91 (2H, t, *J* = 7.4 Hz, $CH_2C\underline{H_2}Ph$), 1.91 – 1.64 (5H, m, alkyl CH_2), 1.62 (3H, app. s, $CH=C(C\underline{H_3})$), 1.36 – 1.09 (5H, m, alkyl CH_2); δ_C (75 MHz, $CDCl_3$) 145.2 (C), 139.2 (C), 129.0 (CH), 128.5 (CH), 126.3 (CH), 119.1 (CH), 71.2 (CH_2), 67.7 (CH_2), 47.3 (CH), 36.6 (CH_2), 31.7 (CH_2), 26.8 (CH_2), 26.5 (CH_2), 15.0 (CH_3). Found (APCI) $[M+NH_4]^+$ 276.2315, $C_{18}H_{30}NO$ requires 276.2322.

2D NOESY confirms *E*-isomer is major isomer:



(*E*)-1-Butoxypent-2-ene **3q**:

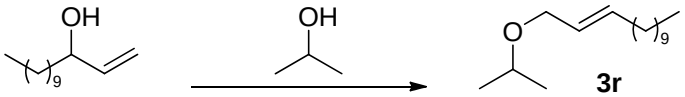


3q

To a 4 mL screw capped vial, tridec-1-en-3-ol (15.0 mg, 0.076 mmol) was added. n-Butanol (34.6 μL, 28.0 mg, 0.378 mmol) was added by microliter syringe. The solution was dissolved in 0.10 mL of toluene, and 2,6-di-*tert*-butylpyridine (1.2 mg, 0.0065 mmol) was added. To this solution, PPh_3AuNTf_2 (5.6 mg, 0.0076 mmol) was added, and washed in with 0.05 mL of toluene. The reaction was stirred at 40 °C for 65 hours, then was filtered through a plug of silica with diethyl ether and concentrated. Analysis of crude reaction mixture showed that *E*:*Z* ratio was 6:1, with S_N2':S_N2 ratio of 10:1. The product was purified using flash column chromatography with silver nitrate impregnated silica; using a gradient eluent system of neat petroleum ether → 100:1 petroleum ether:diethyl ether. Product obtained as a colourless oil in 6.3:1 *E*:*Z* ratio, with S_N2':S_N2 ratio of >20:1 (15.7 mg, 0.062 mmol, 82%).

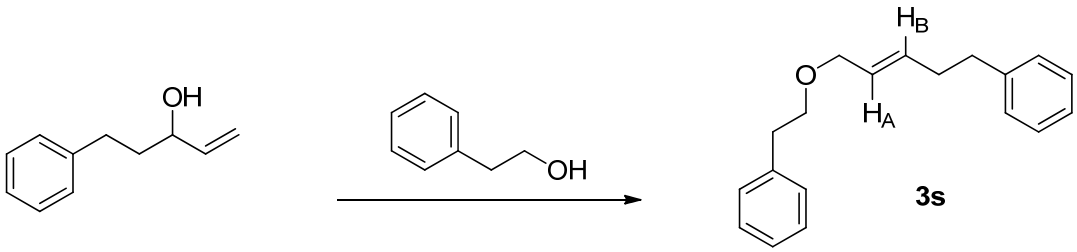
ν_{max}/cm^{-1} 2958 m 2924 s 2854 s (C-H), 1671 w (C=C), 1104 s (C-O-C); δ_H (300 MHz, $CDCl_3$) 5.72 – 5.39 (2H, m, C<u>H</u>=C<u>H</u>), 3.83 (2H, d, *J* = 6.0 Hz, OC<u>H</u>$_2$CH), 3.33 (2H, t, *J* = 6.7 Hz, OC<u>H</u>$_2$CH$_2$), 1.96 (2H, q, *J* = 6.6 Hz, CHC<u>H</u>$_2$CH$_2$), 1.56 – 1.43 (2H, m, OCH$_2$C<u>H</u>$_2$CH$_2$), 1.41 – 1.08 (18H, m, alkyl CH_2), 0.85 (3H, t, *J* = 7.3 Hz, CH$_2$C<u>H</u>$_3$), 0.81 (3H, t, *J* = 6.7 Hz, CH$_2$C<u>H</u>$_3$); δ_C (75 MHz, $CDCl_3$) 134.7 (CH), 126.6 (CH), 71.8 (CH_2), 70.0 (CH_2), 32.5 (CH_2), 32.1 (CH_2), 32.0 (CH_2), 29.8 (CH_2 x 2), 29.7 (CH_2), 29.5 (CH_2), 29.4 (CH_2), 29.3 (CH_2), 22.9 (CH_2), 19.5 (CH_2), 14.3 (CH_3), 14.1 (CH_3). Found (EI) $[M]^+$ 254.2604, $C_{17}H_{34}O$ requires 254.2604.

(*E*)-1-*iso*Propoxypent-2-ene **3r**:



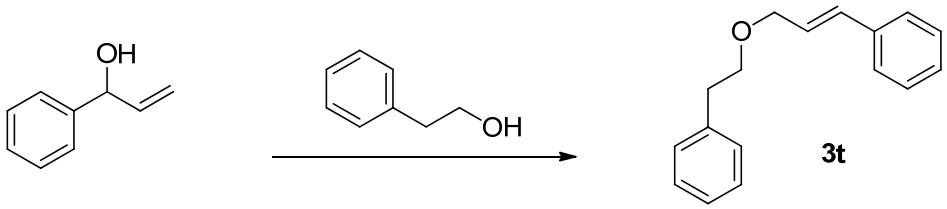
Analysis of crude reaction mixture showed that *E*:*Z* ratio was 8:1, with S_N2':S_N2 ratio of 11:1. Purified by flash column chromatography with silver nitrate impregnated silica; using petroleum ether as an eluent. Product obtained as a colourless oil in 13:1 *E*:*Z* ratio, with S_N2':S_N2 ratio of >20:1 (22.5 mg, 0.094 mmol, 91%). ν_{max}/cm^{-1} 2918 s 2852 s (C-H), 1684 m (C=C), 1453 m 1372 m (C-H bending), 1090 s (C-O-C); δ_H (300 MHz, $CDCl_3$) 5.76 – 5.46 (2H, m, C<u>H</u>=C<u>H</u>), 3.90 (2H, d, *J* = 6.0 Hz, OC<u>H</u>$_2$), 3.61 (1H, hept, *J* = 6.1 Hz, OC<u>H</u>$(CH_3)_2$), 2.03 (2H, q, *J* = 6.7 Hz, CHC<u>H</u>$_2$$CH_2$), 1.41 – 1.21 (16H, m, alkyl CH_2), 1.16 (6H, d, *J* = 6.1 Hz, OCH(C<u>H</u>$_3$)$_2$), 0.93 – 0.83 (3H, m, CH_2C<u>H</u>$_3$); δ_C (75 MHz, $CDCl_3$) 134.4 (CH), 126.9 (CH), 70.7 (CH), 69.1 (CH_2), 32.5 (CH_2), 32.1 (CH_2), 29.8 (CH_2 x 2), 29.7 (CH_2), 29.5 (CH_2), 29.4 (CH_2), 29.2 (CH_2), 22.9 (CH_2), 22.3 (CH_3), 14.3 (CH_3). Found (APCI) $[M+NH_4]^+$ 258.2794, $C_{16}H_{36}NO$ requires 258.2791.

(*E*)-(5-Phenethoxypent-3-en-1-yl)benzene **3s**:



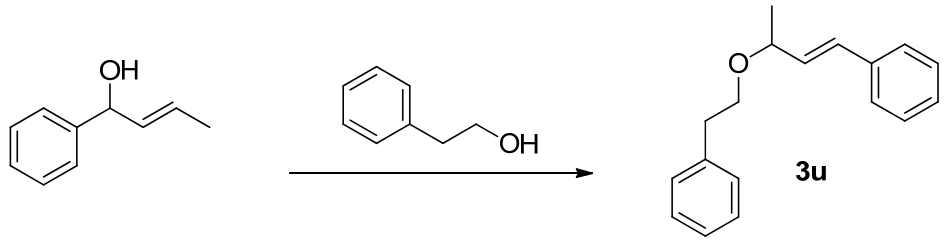
Analysis of crude ^{1}H NMR spectrum shows that *E*:*Z* ratio is 7:1, with S_N2':S_N2 ratio of 4.5:1 Purified using flash column chromatography; using a gradient eluent system of neat petroleum ether → 50:1 petroleum ether:diethyl ether. Product obtained as a colourless oil in 7:1 *E*:*Z* ratio (17.0 mg, 0.064 mmol, 69%). ν_{max}/cm^{-1} 3026 m 2922 m 2852 m (C-H), 1669 w (C=C), 1603 w 1496 m 1453 m (aromatic C=C), 1099 m (C-O-C); δ_H (400 MHz, $CDCl_3$) 7.35 – 7.13 (10H, m, aromatic CH), 5.73 (1H, dtt, *J* = 15.3, 6.4, 1.0 Hz, CH_B), 5.59 (1H, dtt, *J* = 15.3, 6.0, 1.0 Hz, CH_A), 3.94 (2H, dq, *J* = 6.0, 1.0 Hz, OC<u>H</u>$_2$CH), 3.61 (2H, t, *J* = 7.4 Hz, OC<u>H</u>$_2$$CH_2$), 2.90 (2H, t, *J* = 7.4 Hz, OCH_2C<u>H</u>$_2$Ph), 2.71 (2H, t, *J* = 7.9 Hz, $CHCH_2$C<u>H</u>$_2$Ph), 2.43 – 2.33 (2H, m, CH=CHC<u>H</u>$_2$$CH_2$).; δ_C (75 MHz, $CDCl_3$) 141.9 (C_{quat}), 139.1 (C_{quat}), 133.6 (CH), 129.0 (CH), 128.5 (CH), 128.5 (CH), 128.4 (CH), 127.1 (CH), 126.3 (CH), 126.0 (CH), 71.7 (CH_2), 71.1 (CH_2), 36.5 (CH_2), 35.6 (CH_2), 34.2 (CH_2). Found (ESI) $[M+NH_4]^+$ 284.2014, $C_{19}H_{26}NO$ requires 284.2009.

(*E*)-(2-(Cinnamyloxy)ethyl)benzene **3t**:[12]



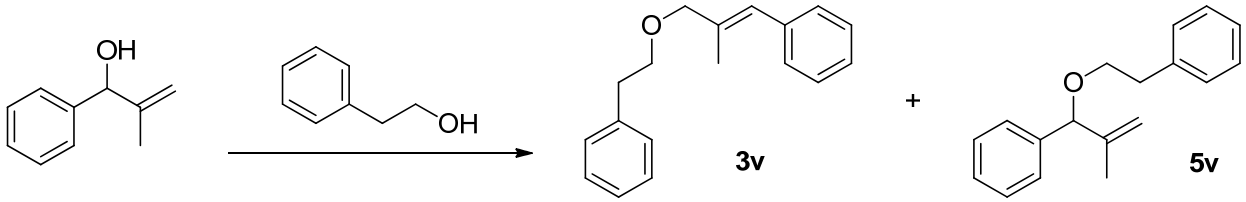
Analysis of crude ^{1}H NMR spectrum shows that *E*:*Z* ratio is 17:1. Purified using flash column chromatography; using an eluent system 80:1 petroleum ether:diethyl ether. Product obtained as a colourless oil (16.4 mg, 0.069 mmol, 61%). ν_{max}/cm^{-1} 3083 w 3063 w 3027 w 2924 w 2852 w (C-H), 1601 w (C=C), 1577 w 1495 m 1451 m (aromatic C=C), 1099 s 1080 s (C-O-C); δ_H (300 MHz, $CDCl_3$) 7.37 – 6.96 (10H, m, Ar-H), 6.51 (1H, d, *J* = 16.0 Hz, Ph-C<u>H</u>=CH), 6.21 (1H, dt, *J* = 16.0, 5.9 Hz, Ph-CH=C<u>H</u>), 4.10 (2H, dd, *J* = 5.9, 1.4 Hz, CH=CH-C<u>H</u>$_2$), 3.64 (2H, t, *J* = 7.2 Hz, $CH_2C\underline{H}_2O$), 2.87 (2H, t, *J* = 7.2 Hz, Ph-C<u>H</u>$_2CH_2$); δ_C (75 MHz, $CDCl_3$) 138.6 (C), 136.4 (C), 132.0 (CH), 128.7 (CH), 128.2 (CH), 128.1 (CH), 127.3 (CH), 126.2 (CH), 125.94 (CH), 125.85 (CH), 71.2 (CH_2), 71.0 (CH_2), 36.2 (CH_2).

(*E*)-(3-Phenethoxybut-1-en-1-yl)benzene **3u**:[13]



Analysis of crude ^{1}H NMR spectrum shows that S_N2':S_N2 ratio is 14:1. Purified using flash column chromatography; using a gradient eluent system of neat petroleum ether → 50:1 petroleum ether:diethyl ether. Product obtained as a colourless oil with *E*:*Z* ratio of >20:1 (9.5 mg, 0.038 mmol, 68%). ν_{max}/cm^{-1} 3026 m 2972 m 2926 m 2856 m (C-H), 1647 w (C=C), 1601 w 1495 m 1452 m (aromatic C=C), 1089 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 7.39 – 7.18 (10H, m, aromatic CH), 6.48 (1H, d, *J* = 16.0 Hz, CH=C<u>H</u>Ph), 6.10 (1H, dd, *J* = 16.0, 7.5 Hz, CHC<u>H</u>=CH), 4.07 – 3.98 (1H, m, OC<u>H</u>(CH_3)CH), 3.73 (1H, ddd, *J* = 9.3, 8.0, 6.7 Hz, OC<u>H</u>H'CH_2), 3.58 (1H, ddd, *J* = 9.3, 8.0, 6.7 Hz, OCH<u>H</u>'CH_2), 2.91 (2H, t, *J* = 6.7 Hz, $CH_2C\underline{H}_2$Ph), 1.34 (3H, d, *J* = 6.4 Hz, OCH($C\underline{H}_3$)); δ_C (75 MHz, $CDCl_3$) 139.2 (C), 136.8 (C), 132.0 (CH), 131.1 (CH), 129.1 (CH), 128.7 (CH), 128.4 (CH), 127.7 (CH), 126.6 (CH), 126.3 (CH), 76.8 (CH), 69.6 (CH_2), 36.8 (CH_2), 21.8 (CH_3).

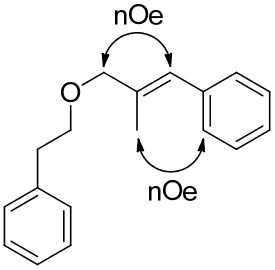
(*E*)-(2-Methyl-3-phenethoxyprop-1-en-1-yl)benzene **3v** + (2-methyl-1-phenethoxyallyl)benzene **5v**:



Analysis of crude ^{1}H NMR spectrum shows that S_N2':S_N2 ratio is 1:1. Purified using flash column chromatography; using a gradient eluent system of neat petroleum ether → 50:1 petroleum ether:diethyl ether. Product **3v** obtained as a colourless oil with *E*:*Z* ratio of >20:1 (9.5 mg, 0.038 mmol, 38%) and **5v** as a colourless oil (9.1 mg, 0.036 mmol, 36%).

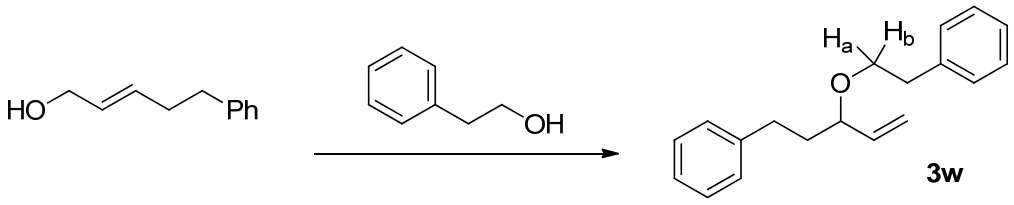
3v: ν_{max}/cm^{-1} 3025 m 2920 m 2854 m (C-H), 1659 w (C=C), 1600 m 1494 m 1453 m (aromatic C=C), 1095 s (C-O-C); δ_H (400 MHz, $CDCl_3$) 7.42 – 7.12 (10H, m, aromatic CH), 6.48 (1H, s, C=C<u>H</u>Ph), 4.04 (2H, d, *J* = 1.2 Hz, OC<u>H$_2$</u>C(CH$_3$)), 3.69 (2H, t, *J* = 7.1 Hz, OC<u>H$_2$</u>CH$_2$), 2.95 (2H, t, *J* = 7.1 Hz, CH$_2$C<u>H$_2$</u>Ph), 1.85 (3H, d, *J* = 1.2 Hz, OCH$_2$C(C<u>H$_3$</u>)); δ_C (75 MHz, $CDCl_3$) 139.2 (C), 137.7 (C), 135.4 (C), 129.10 (CH), 129.05 (CH), 128.5 (CH), 128.2 (CH), 126.8 (CH), 126.5 (CH), 126.3 (CH), 77.3 (CH_2), 71.1 (CH_2), 36.6 (CH_2), 15.5 (CH_3). Found (APCI) $[M]^+$ 252.1506, $C_{18}H_{20}O$ requires 252.1509.

2D NOESY confirms *E*-isomer is major isomer:



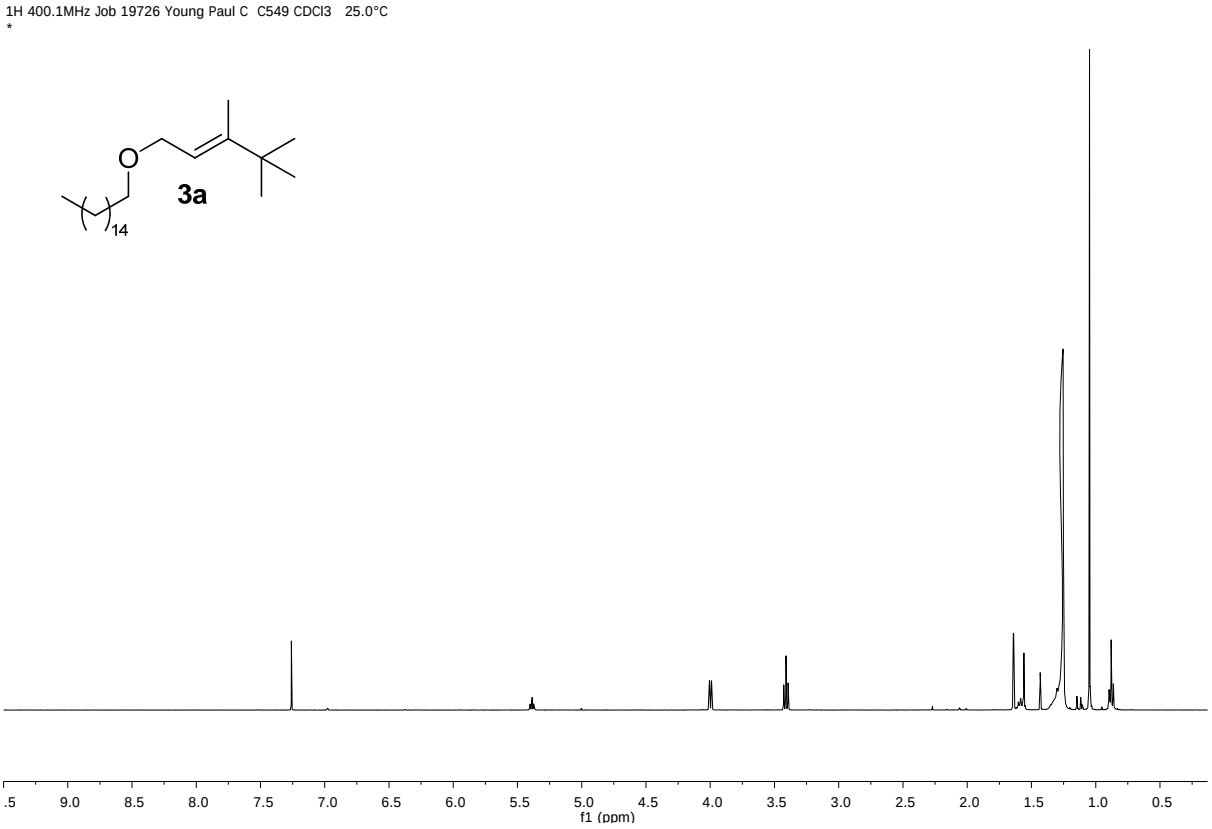
5v: ν_{max}/cm^{-1} 3027 m 2918 m 2857 m (C-H), 1650 w (C=C), 1602 w 1493 m 1451 m (aromatic C=C), 1096 s (C-O-C); δ_H (300 MHz, $CDCl_3$) 7.30 – 7.13 (10H, m, aromatic CH), 5.06 (1H, dq, *J* = 1.5, 0.9 Hz, C=CH<u>H</u>), 4.90 (1H, app. p, *J* = 1.5 Hz, C=C<u>H</u>H), 4.68 (1H, s, OC<u>H</u>Ph), 3.68 – 3.48 (2H, m, OC<u>H$_2$</u>CH$_2$), 2.91 (2H, t, *J* = 7.1 Hz, OCH$_2$C<u>H$_2$</u>), 1.49 – 1.45 (3H, m, C(CH$_2$)C<u>H$_3$</u>); δ_C (75 MHz, $CDCl_3$) 145.4 (C), 140.8 (C), 139.4 (C), 129.2 (CH), 128.4 (CH), 128.2 (CH), 127.4 (CH), 126.7 (CH), 126.2 (CH), 113.0 (CH_2), 85.5 (CH), 69.7 (CH_2), 36.6 (CH_2), 17.6 (CH_3). Found (APCI) $[M+H]^+$ 253.1585, $C_{18}H_{21}O$ requires 253.1587.

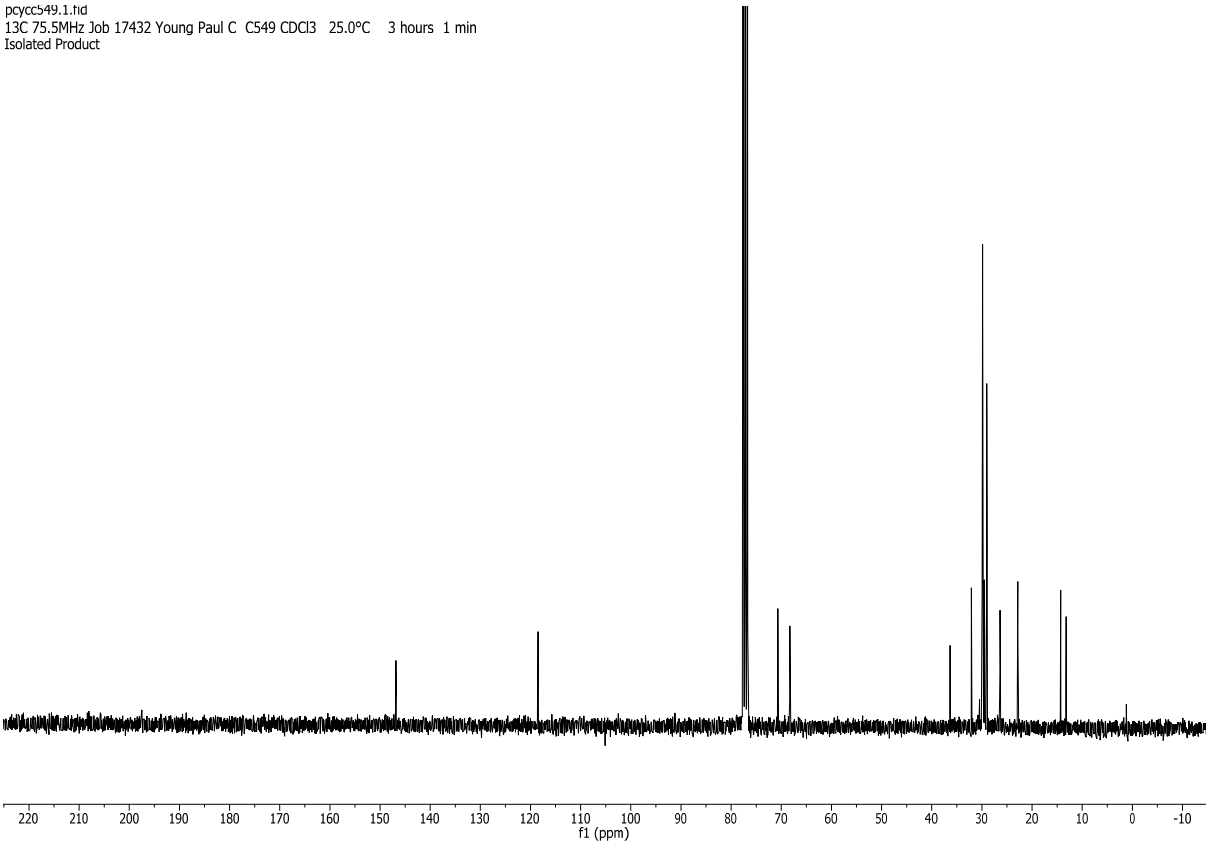
(3-Phenethoxypent-4-en-1-yl)benzene **3w**:



Analysis of crude ^{1}H NMR spectrum shows that S_N2':S_N2 ratio is 6:1. Purified using flash column chromatography; using a eluent system of 50:1 hexane:diethyl ether. Product obtained as a colourless oil (15.4 mg, 0.058 mmol, 63%). ν_{max}/cm^{-1} 3083 w 3063 w 3026 m 2920 m 2857 m (C-H), 1603 m (C=C), 1495 m 1453 m 1420 m (aromatic C=C), 1088 s (C-O-C). δ_H (300 MHz, $CDCl_3$) 7.30 – 7.00 (10H, m, Ar-H), 5.63 (1H, ddd, *J* = 16.9, 10.6, 7.6 Hz, C<u>H</u>=CH_2), 5.16 – 5.00 (2H, m, CH=C<u>H</u>$_2$), 3.66 (1H, ddd, *J* = 9.3, 7.5, 6.7 Hz, H_a/H_b), 3.54 (1H, app.q, *J* = 7.6 Hz, C<u>H</u>OCH_2), 3.37 (1H, ddd, *J* = 9.3, 7.7, 7.0 Hz, H_a/H_b), 2.89 – 2.75 (2H, m, PhC<u>H</u>$_2$$CH_2$CHO), 2.67 – 2.49 (2H, m, PhC<u>H</u>$_2$$CH_2$O), 1.93 – 1.62 (2H, m, PhCH_2C<u>H</u>$_2$CHO); δ_C (75 MHz, $CDCl_3$) 142.2 (C), 139.4 (C), 139.2 (CH), 129.1 (CH), 128.6 (CH), 128.4 (2 x CH), 126.3 (CH), 125.8 (CH), 117.0 (CH_2), 80.7 (CH), 69.6 (CH_2), 37.2 (CH_2), 36.7 (CH_2), 31.6 (CH_2). Found (APCI) $[M+NH_4]^+$ 284.2012, $C_{19}H_{26}NO$ requires 284.2009.

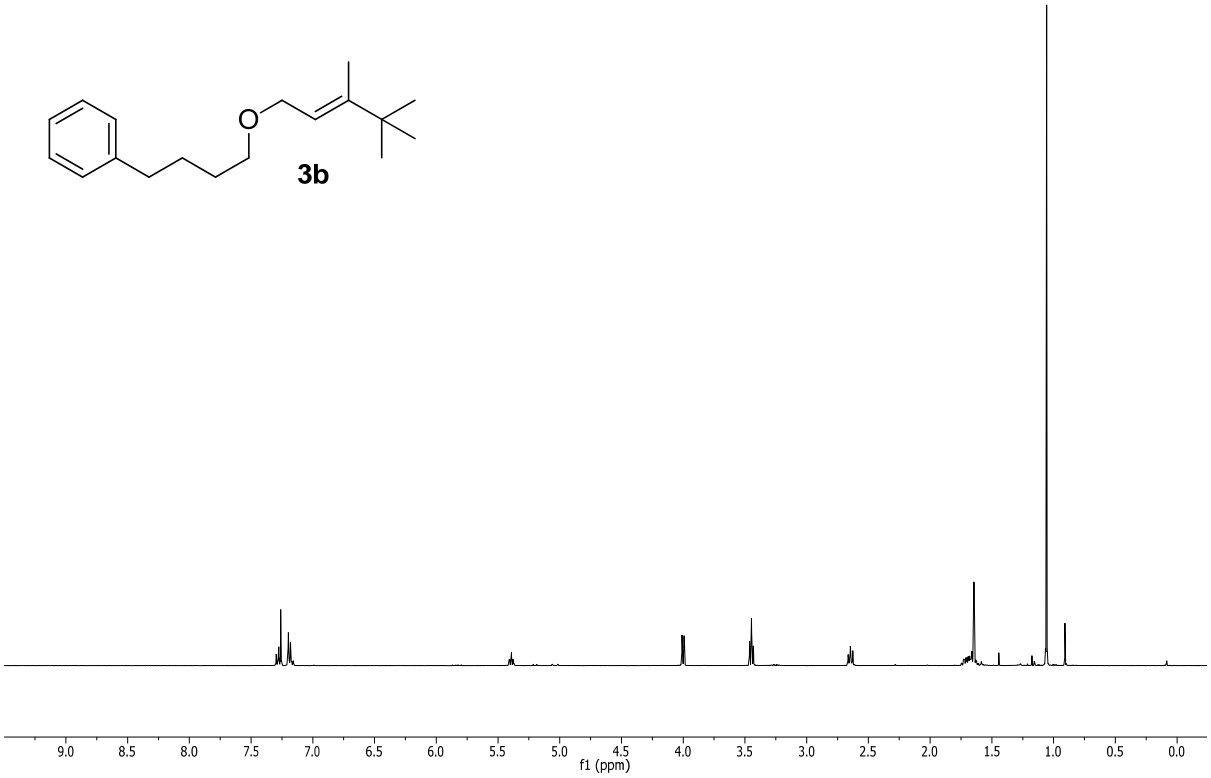
^{1}H-NMR and ^{13}C-NMR Spectra of Synthesised Compounds



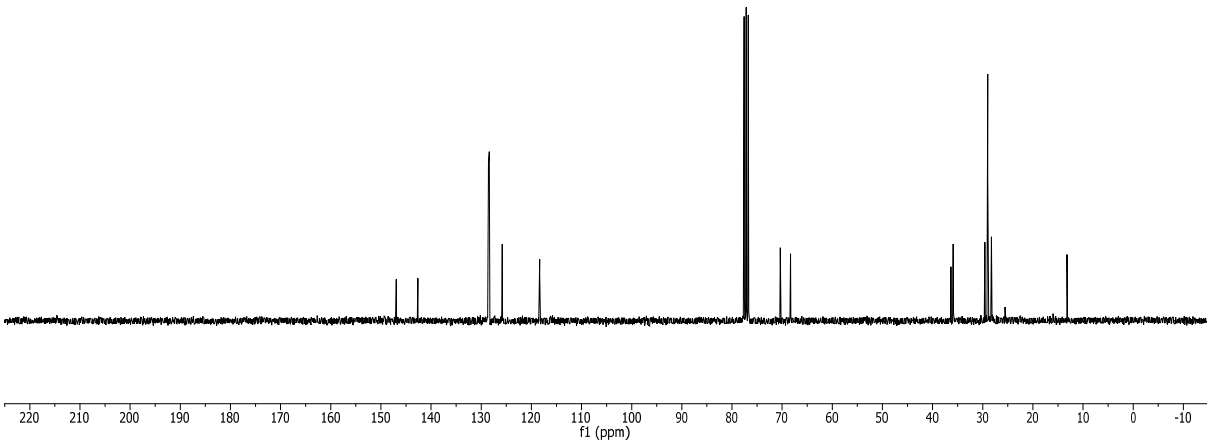


1H 400.1MHz Job 19665 Young Paul C B523 CDCl3 25.0°C
*

3b

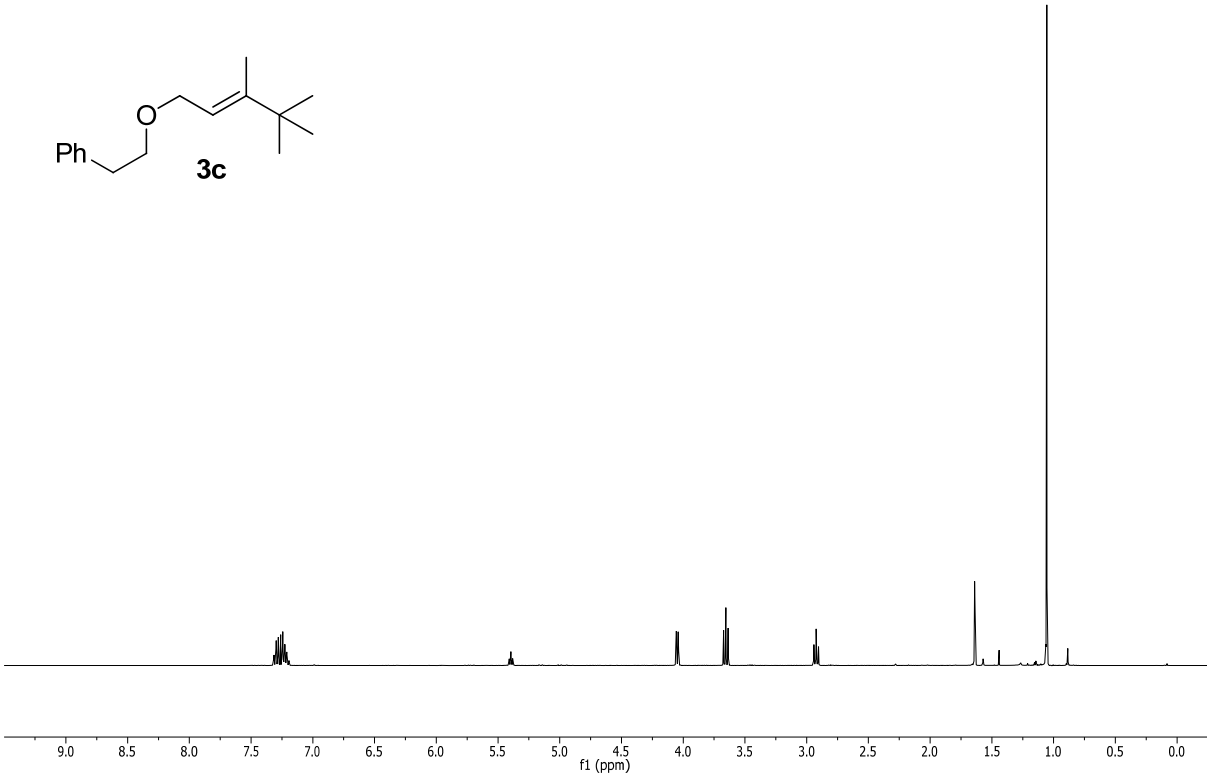


pcycb523.1.fid
13C 75.5MHz Job 16342 Young Paul C B523 CDCl3 22.2°C 0 hour 36 min
Isolated

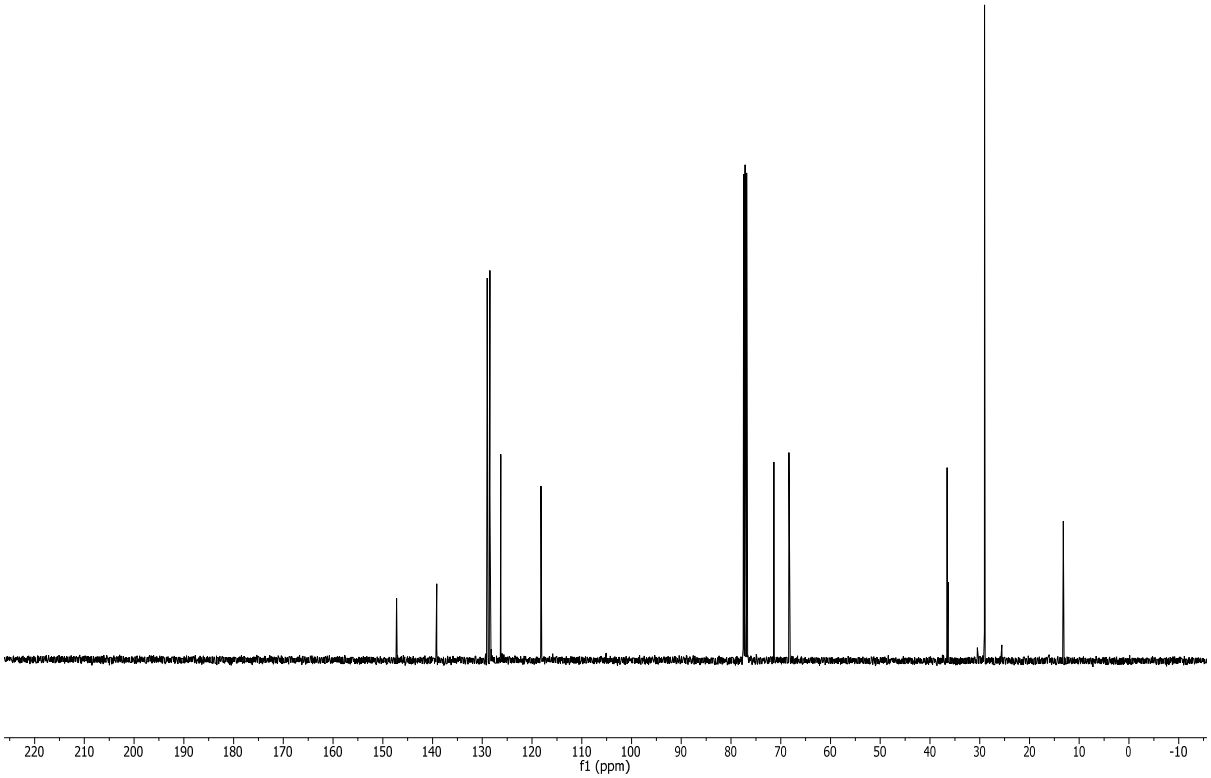


1H 400.1MHz Job 19583 Young Paul C B481 CDCl3 25.0°C
*

3c

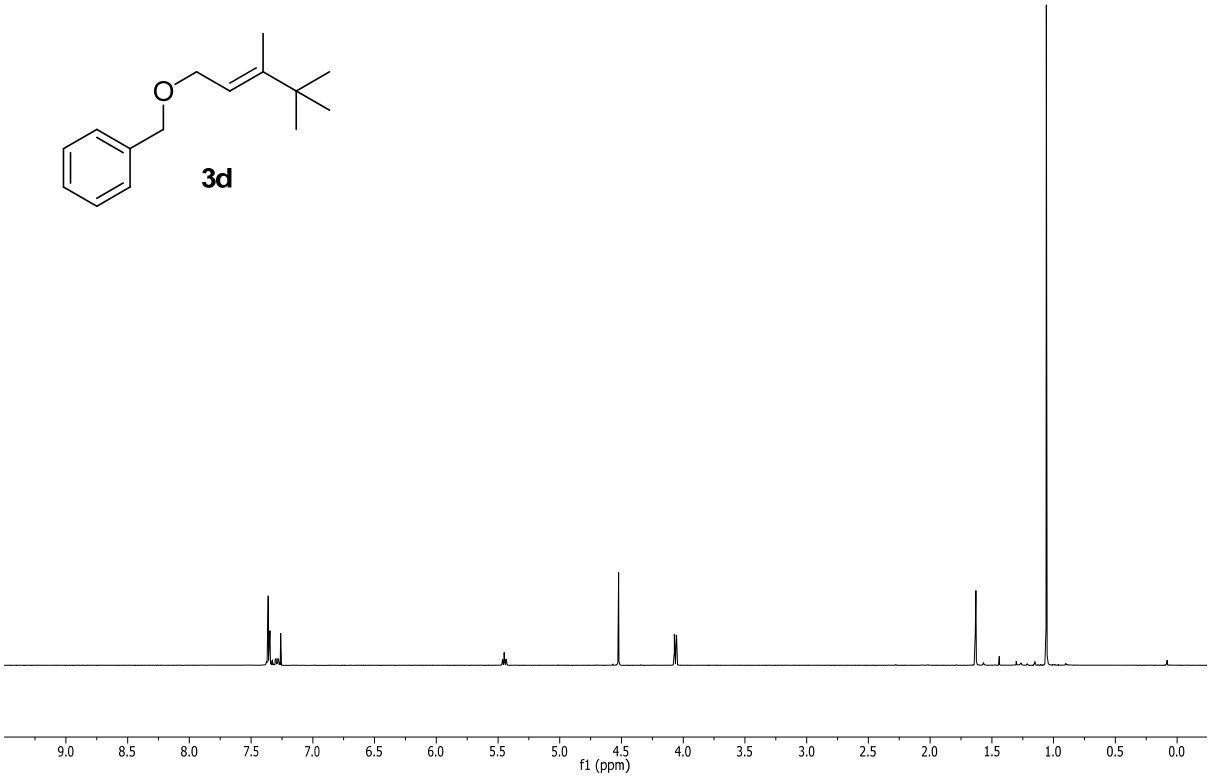


pcycb481.1.fid
13C 100.6MHz Job 19586 Young Paul C B481 CDCl3 25.0°C 0 hour 29 min
*

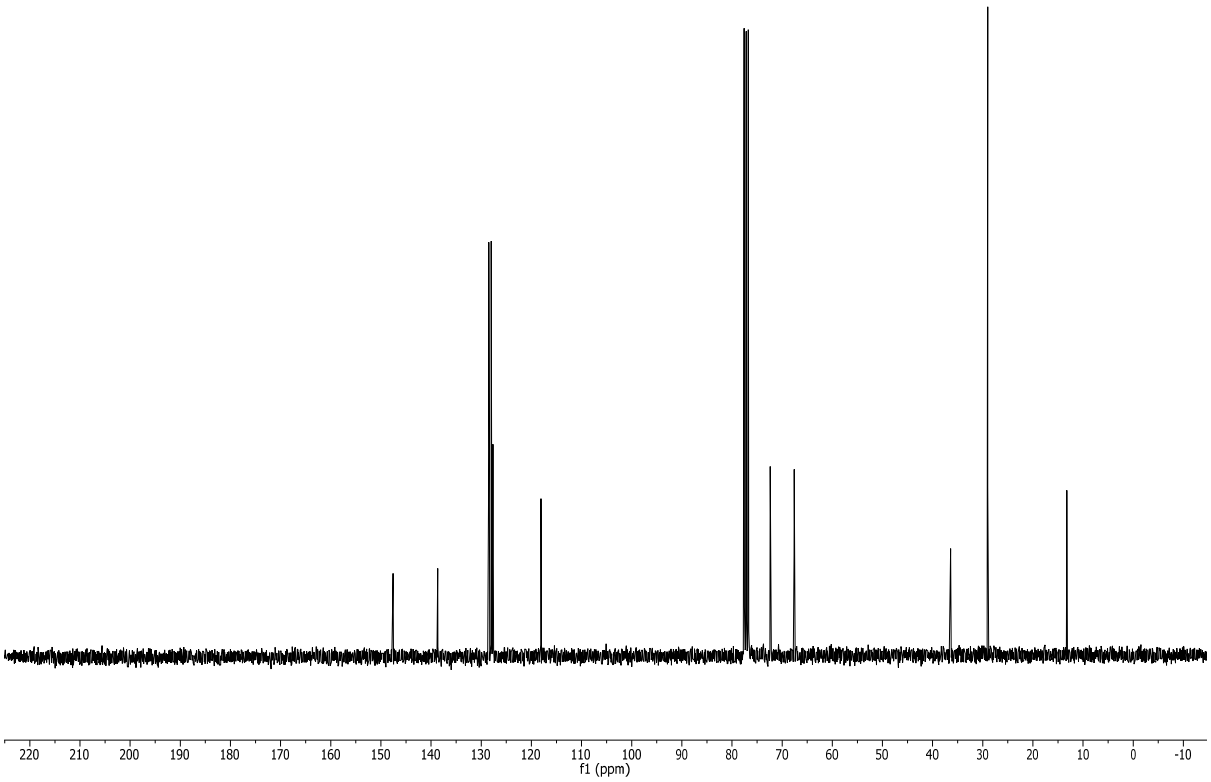


1H 400.1MHz Job 19614 Young Paul C A489 CDCl3 25.0°C
*

3d

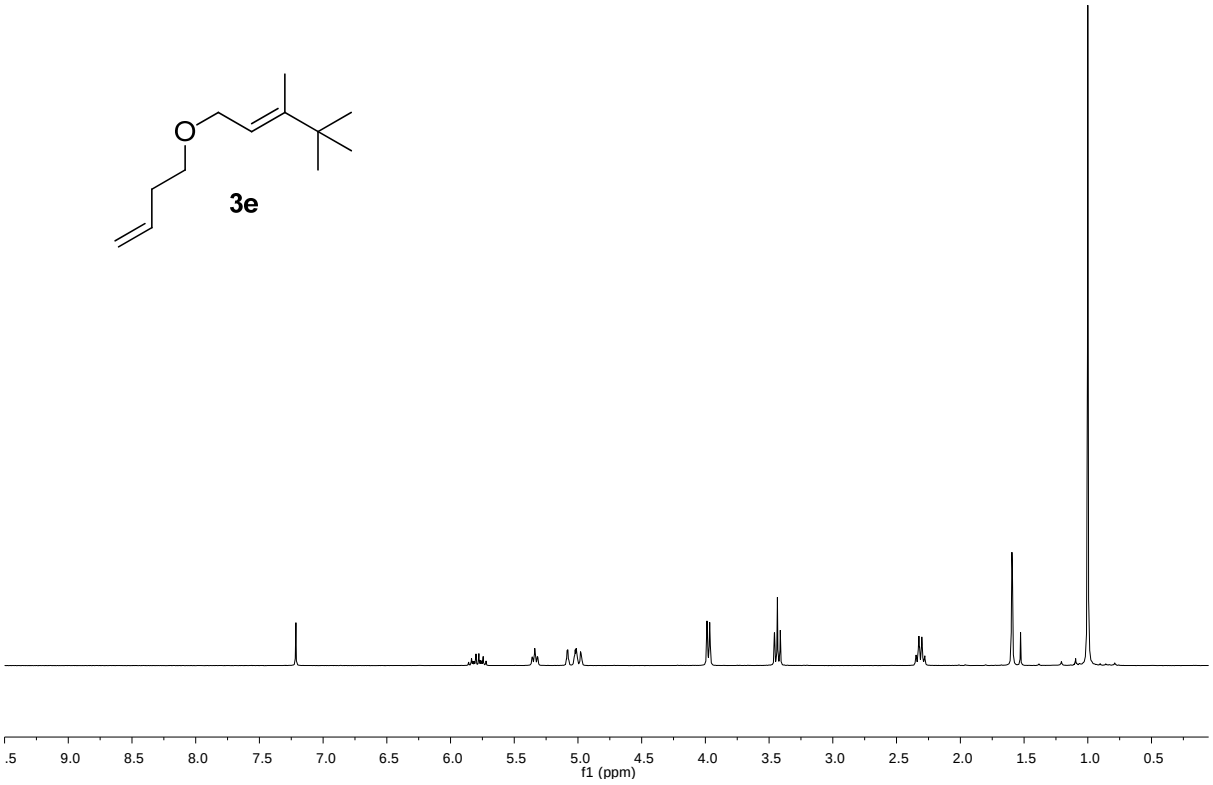


pcyca489.1.fid
13C 75.5MHz Job 15381 Young Paul C A489 CDCl3 21.9°C 0 hour 36 min
Isolated

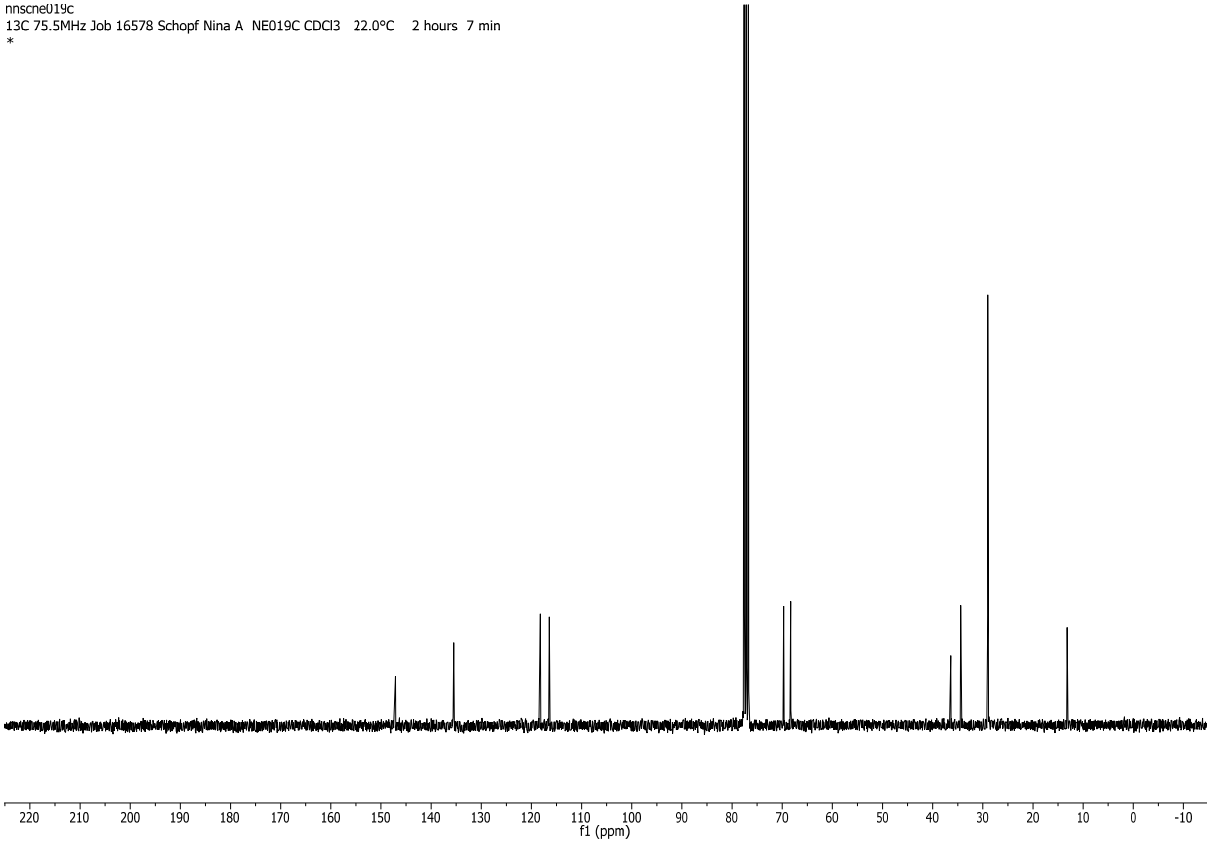


nnshne019
1H 300.1MHz Job 16570 Schopf Nina A NE019 CDCl3 21.5°C
*

3e

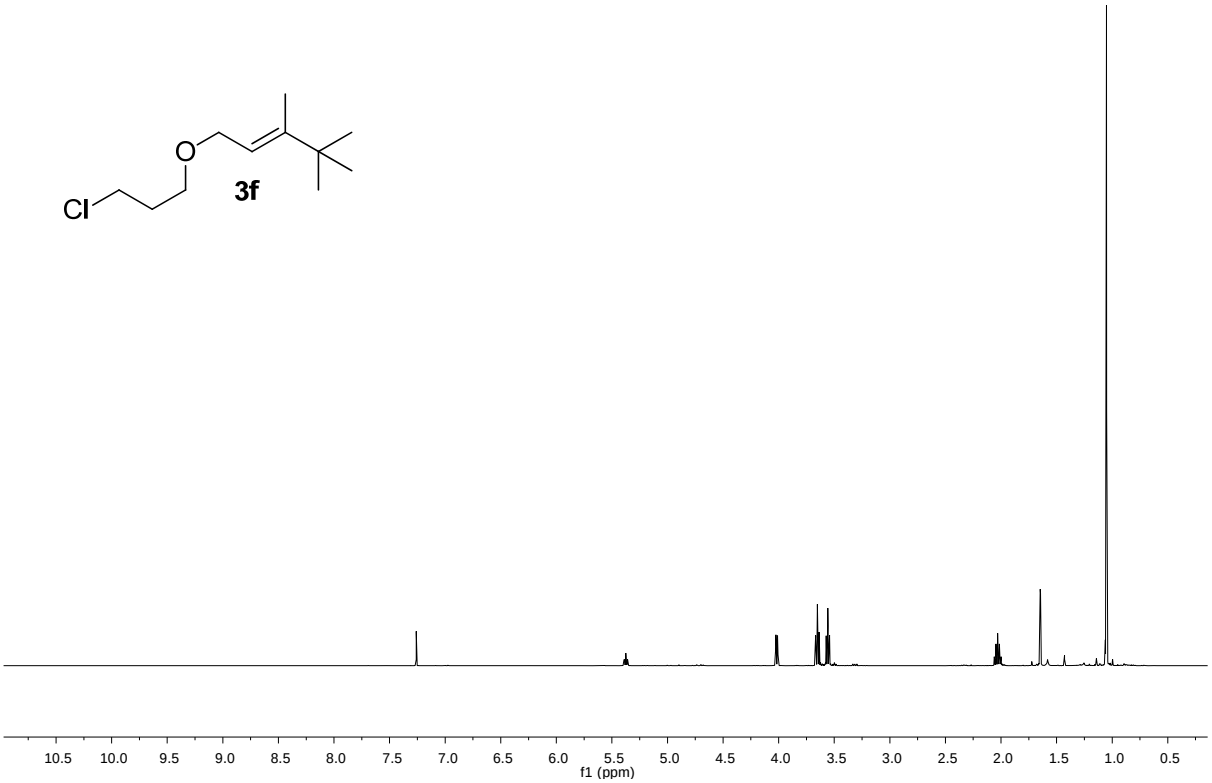


nnscne019c
13C 75.5MHz Job 16578 Schopf Nina A NE019C CDCl3 22.0°C 2 hours 7 min
*

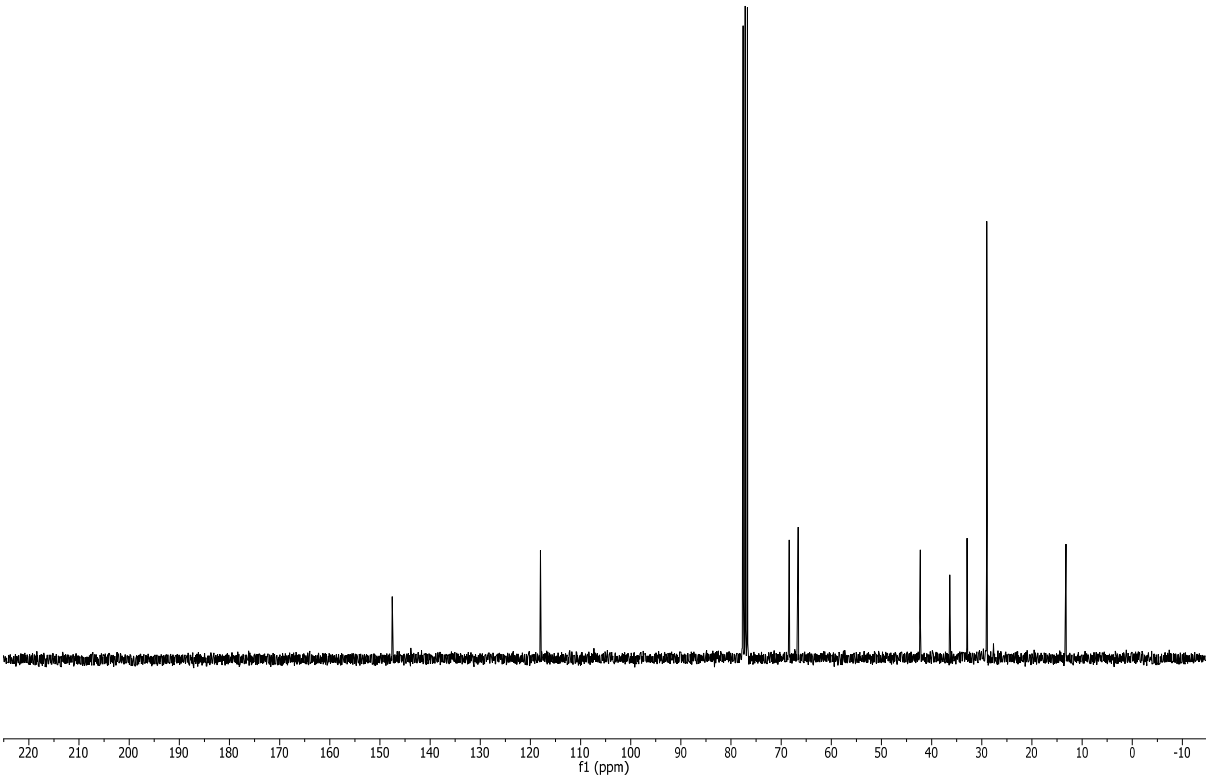


1H 400.1MHz Job 19706 Young Paul C B532 CDCl3 25.0°C
*

3f

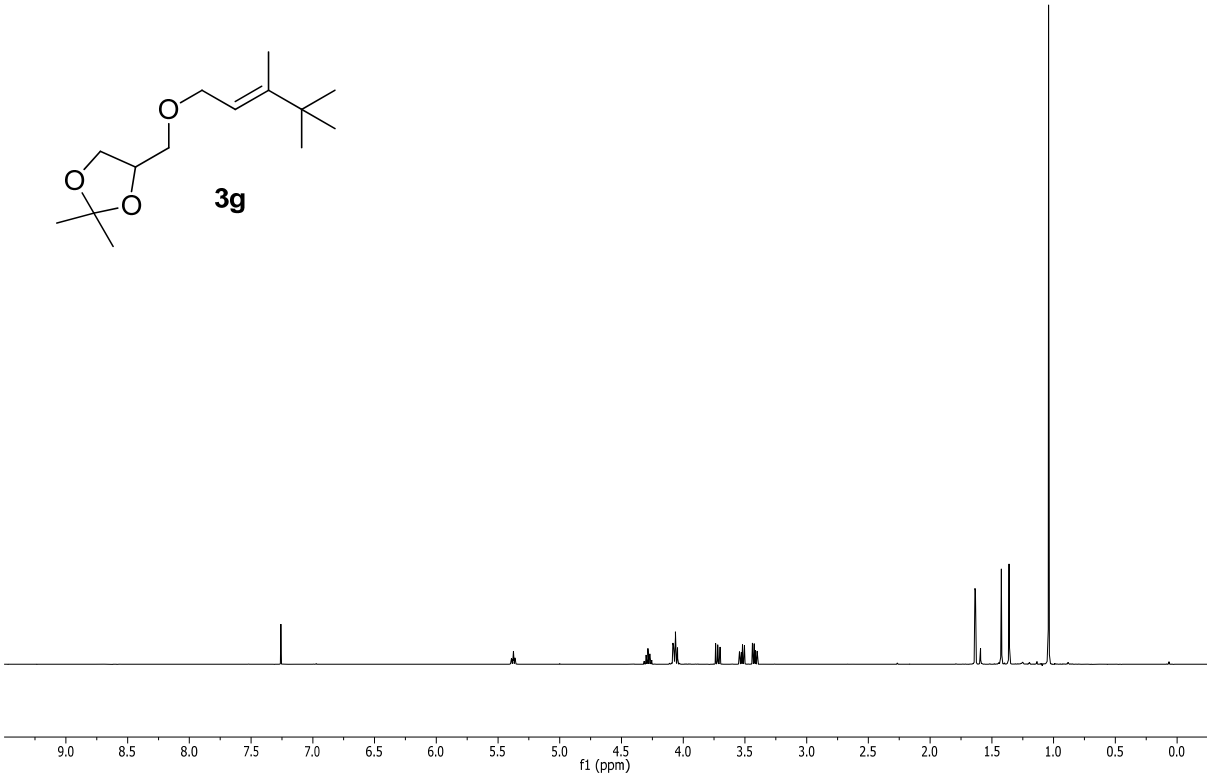


pcycb532.1.fid
13C 75.5MHz Job 16929 Young Paul C B532 CDCl3 21.3°C 0 hour 54 min
Isolated

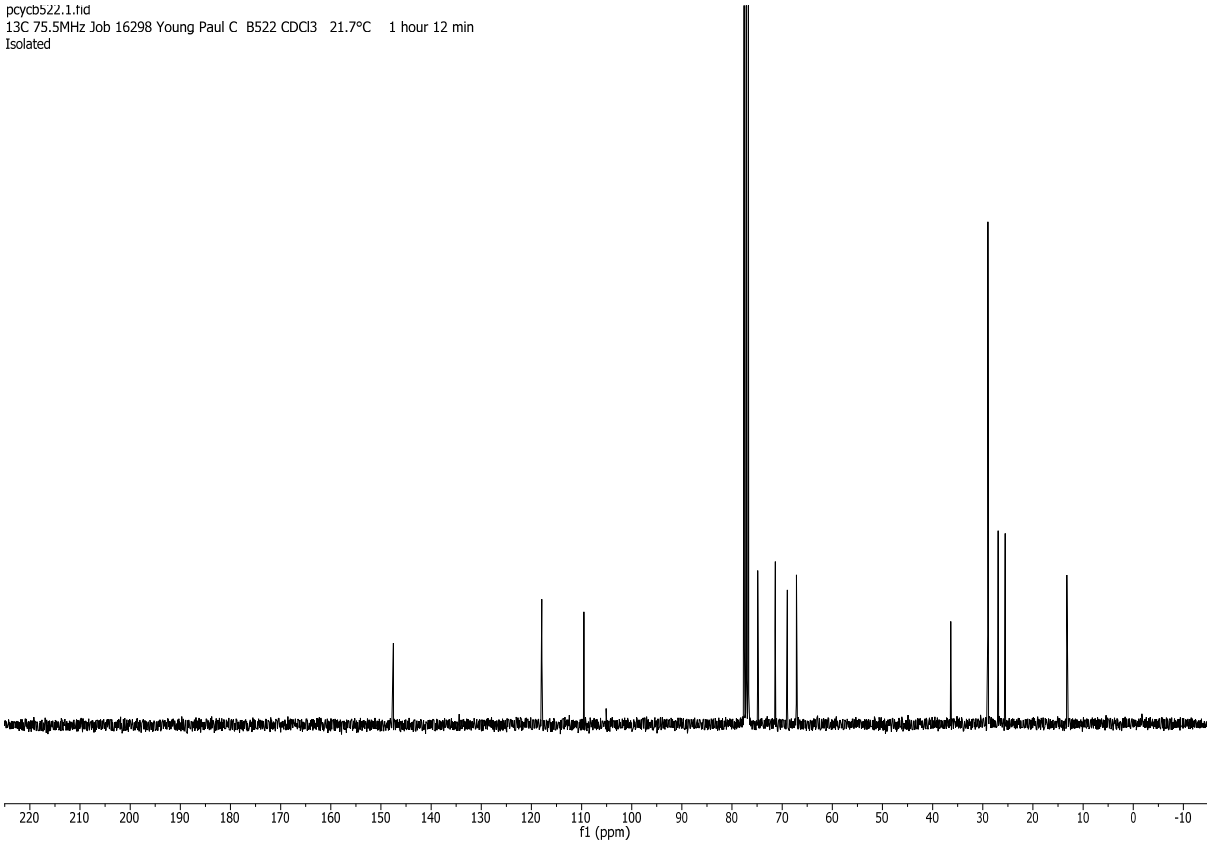


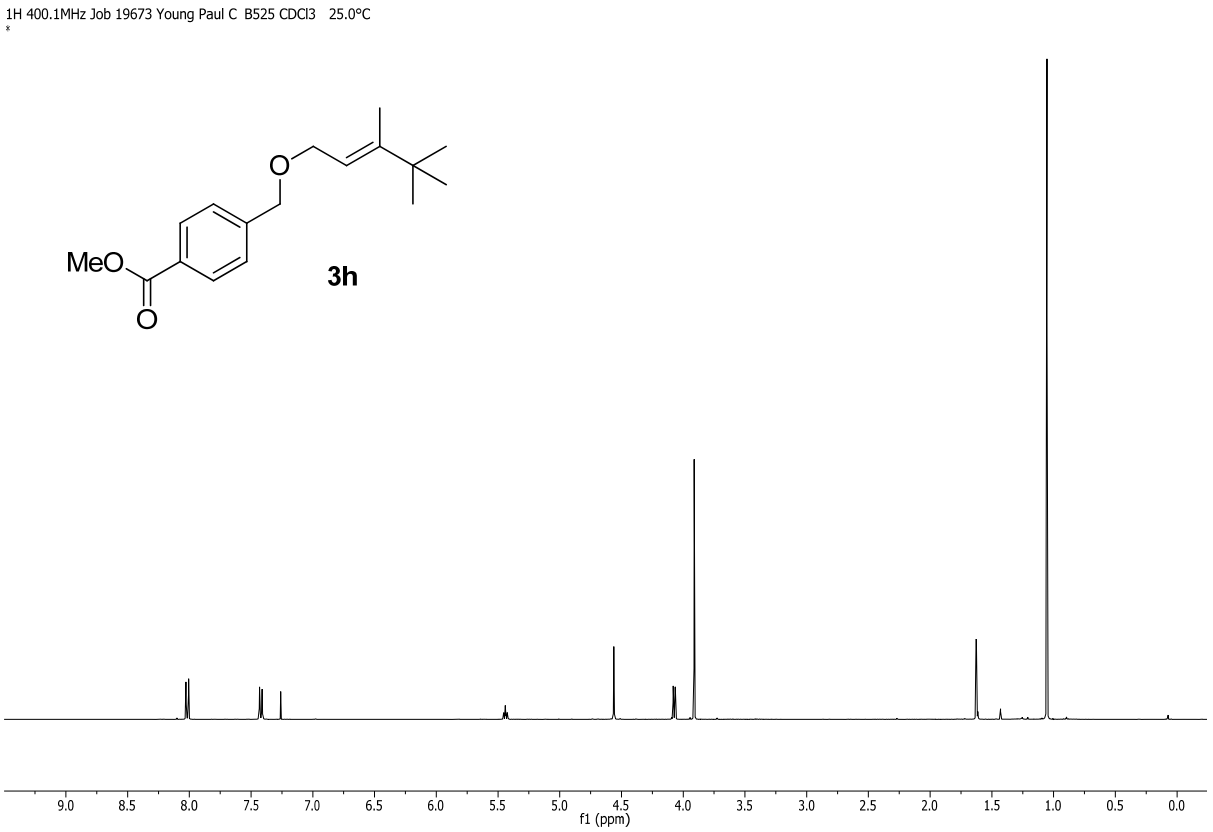
1H 400.1MHz Job 19666 Young Paul C B522 CDCl3 25.0°C
*

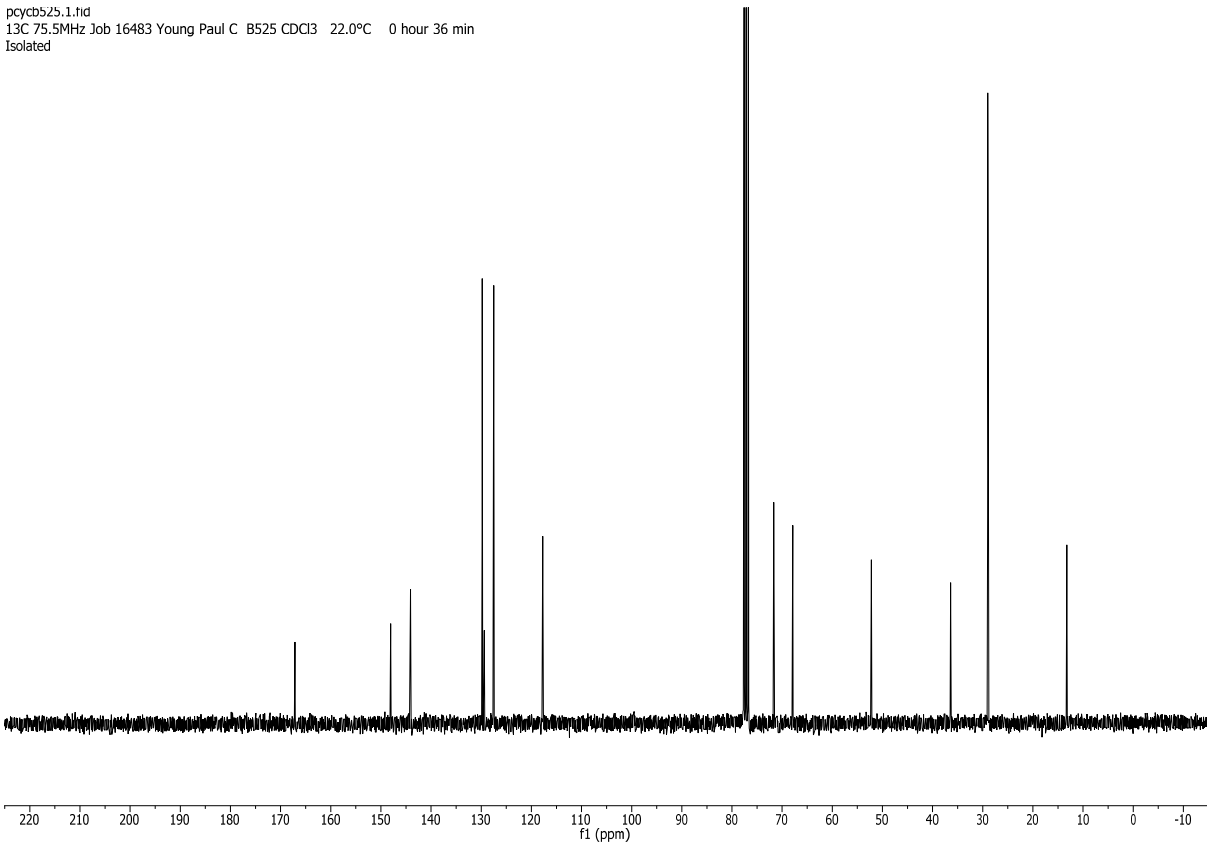
3g



pcycb522.1.fid
13C 75.5MHz Job 16298 Young Paul C B522 CDCl3 21.7°C 1 hour 12 min
Isolated

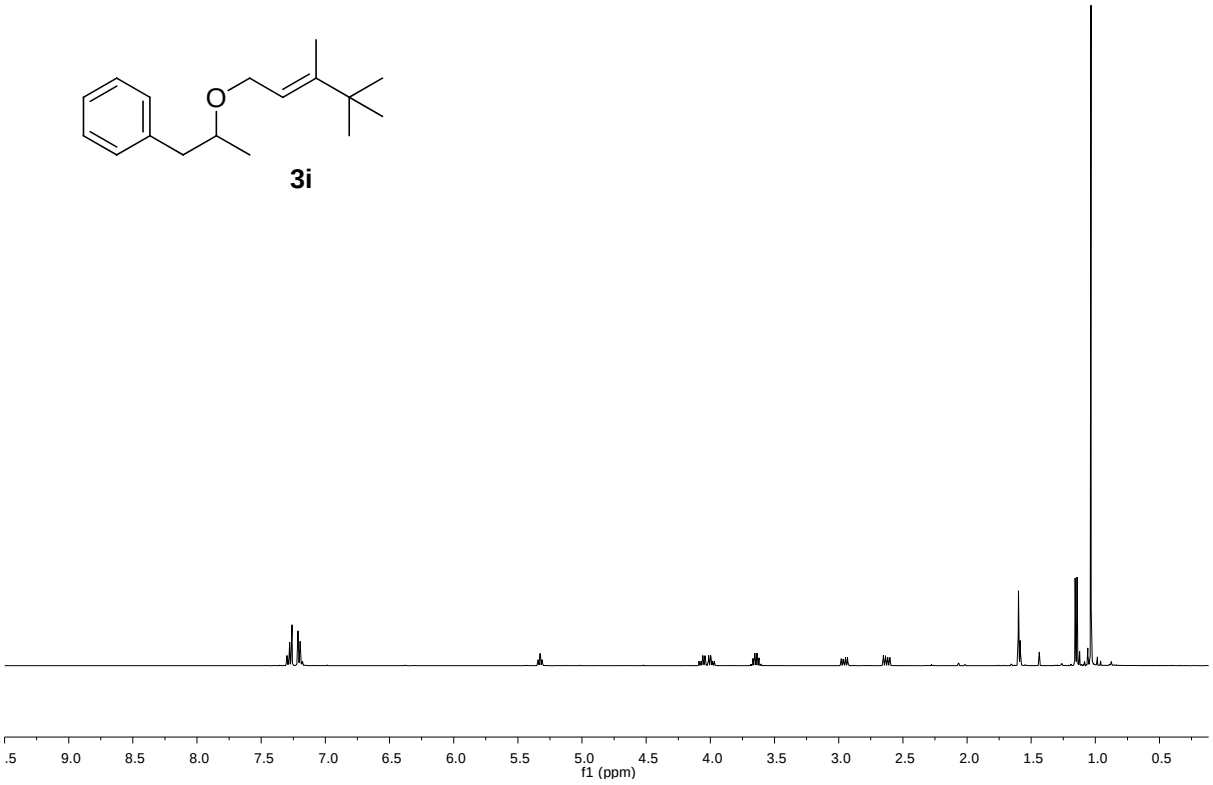



1H 400.1MHz Job 19673 Young Paul C B525 CDCl3 25.0°C
*
MeO
O
O
3h
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

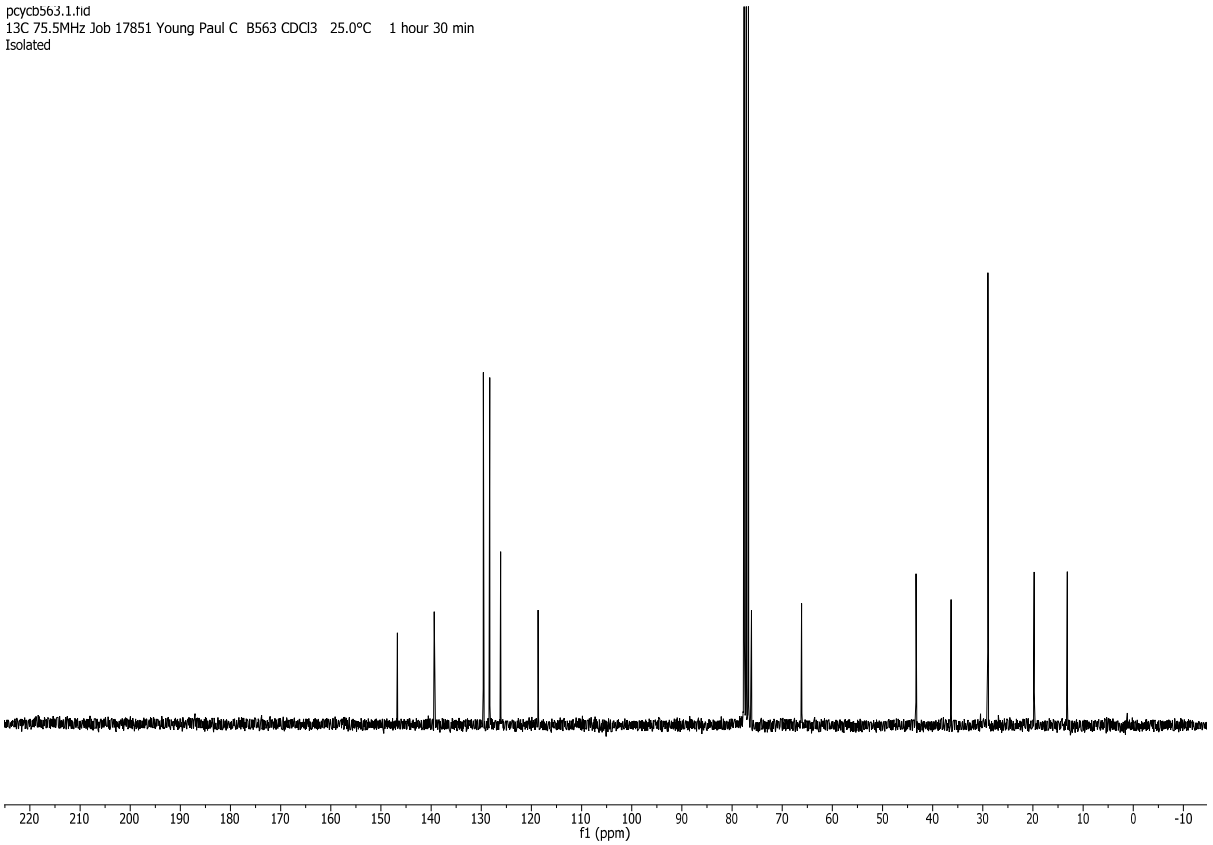

pcycb525.1.fid
13C 75.5MHz Job 16483 Young Paul C B525 CDCl3 22.0°C 0 hour 36 min
Isolated
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

1H 400.1MHz Job 19735 Young Paul C B563 CDCl3 25.0°C
*

3i

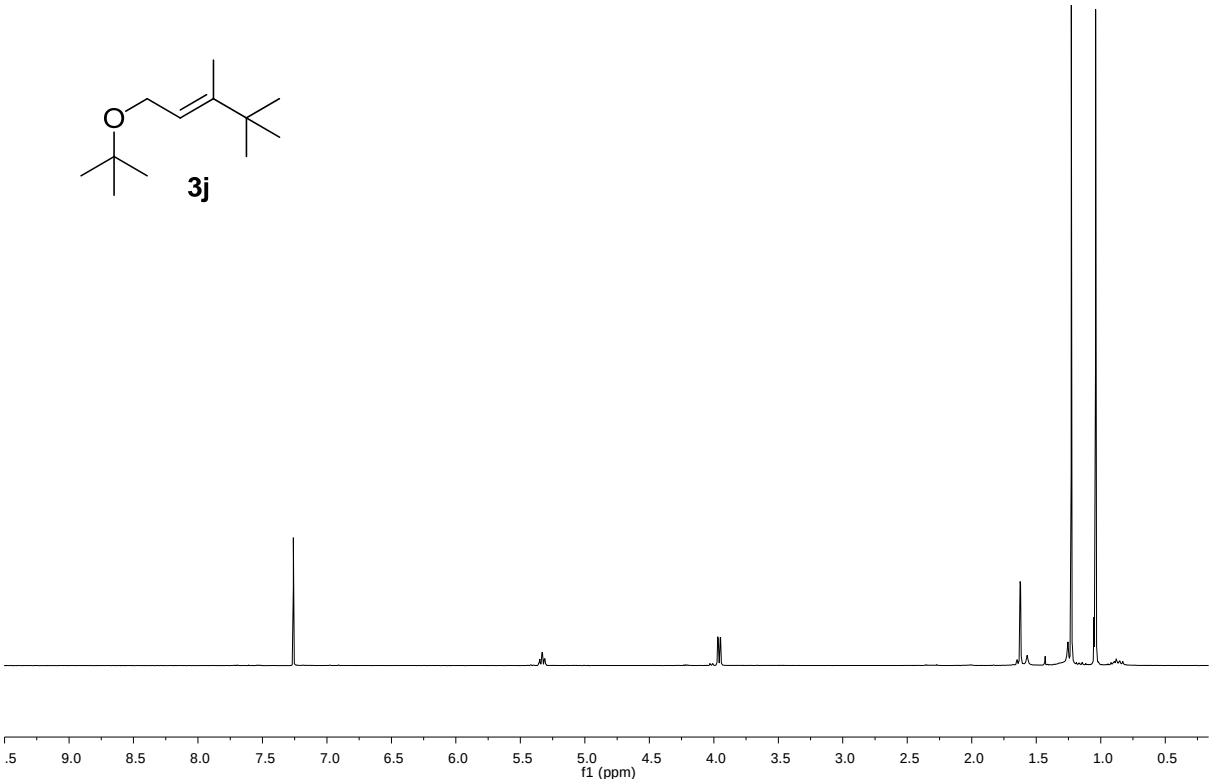


pcycb563.1.fid
13C 75.5MHz Job 17851 Young Paul C B563 CDCl3 25.0°C 1 hour 30 min
Isolated

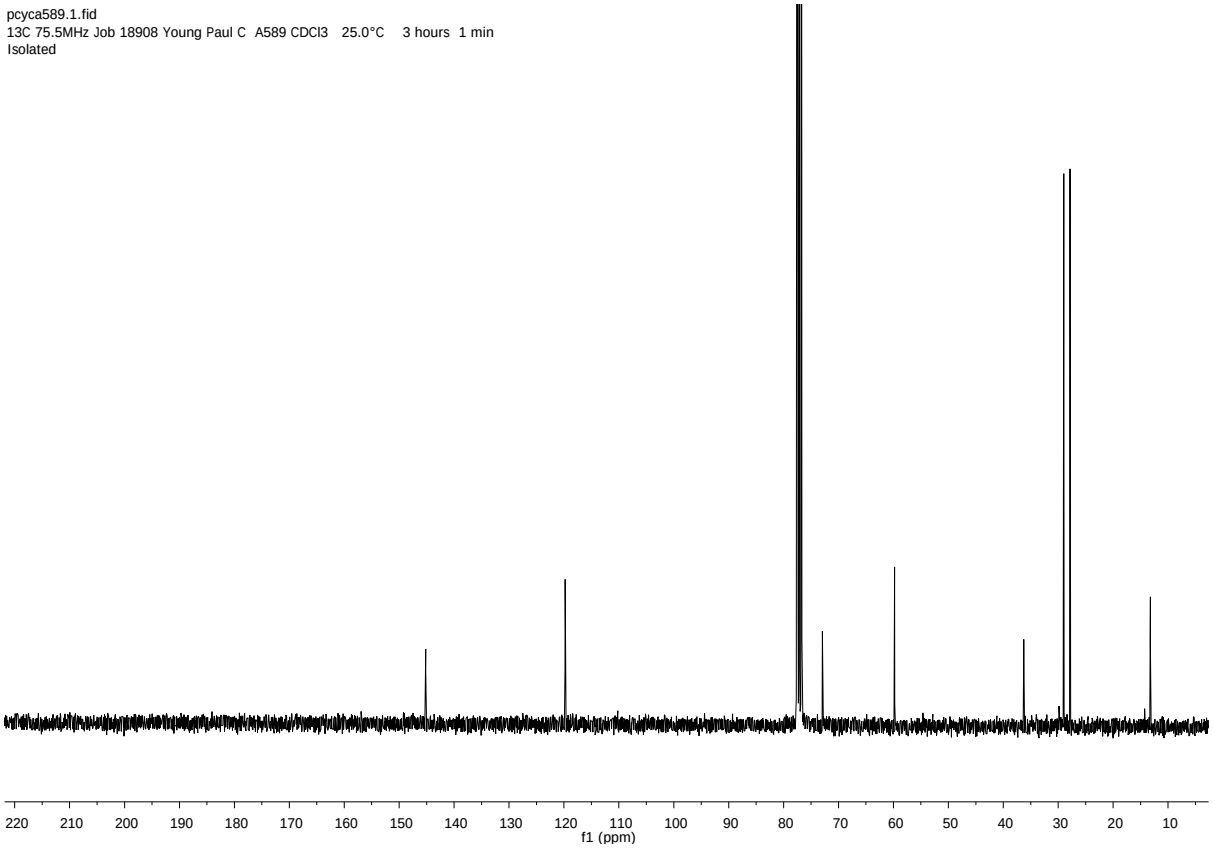


pcyha589.1.fid
1H 300.1MHz Job 18895 Young Paul C A589 CDCl3 25.0°C
Isolated

3j

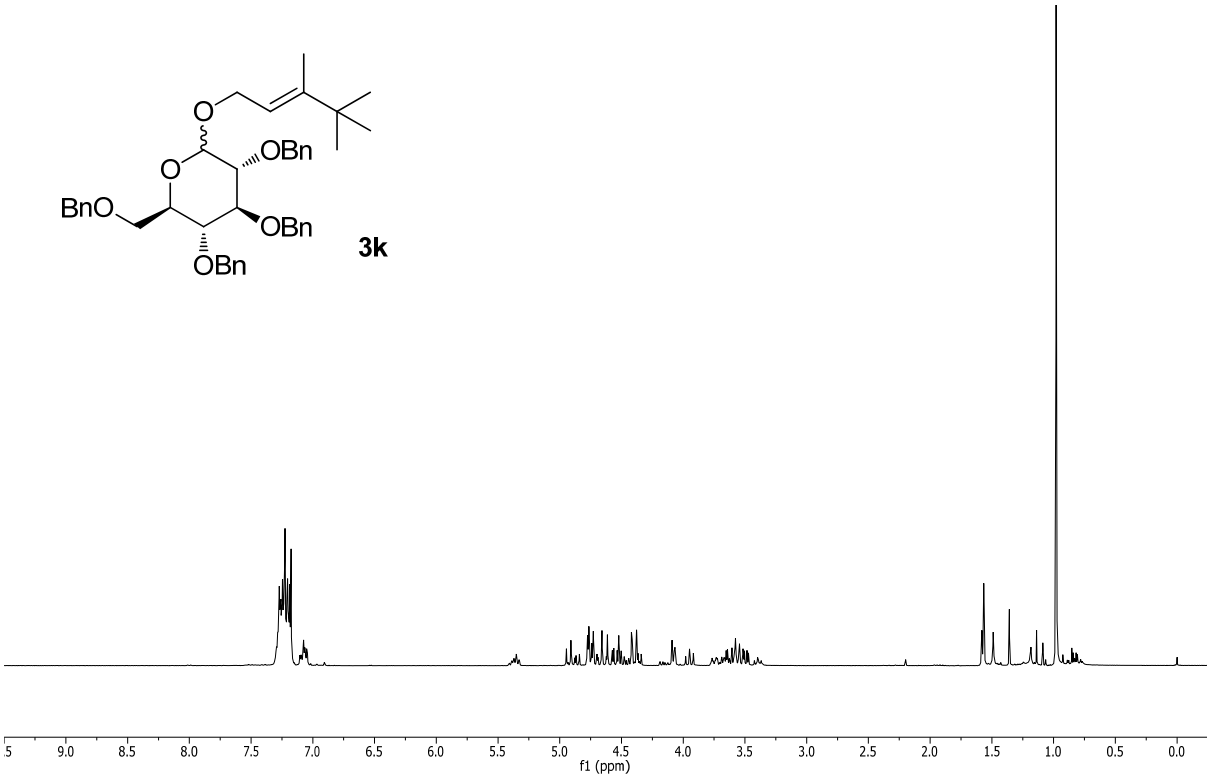


pcyca589.1.fid
13C 75.5MHz Job 18908 Young Paul C A589 CDCl3 25.0°C 3 hours 1 min
Isolated

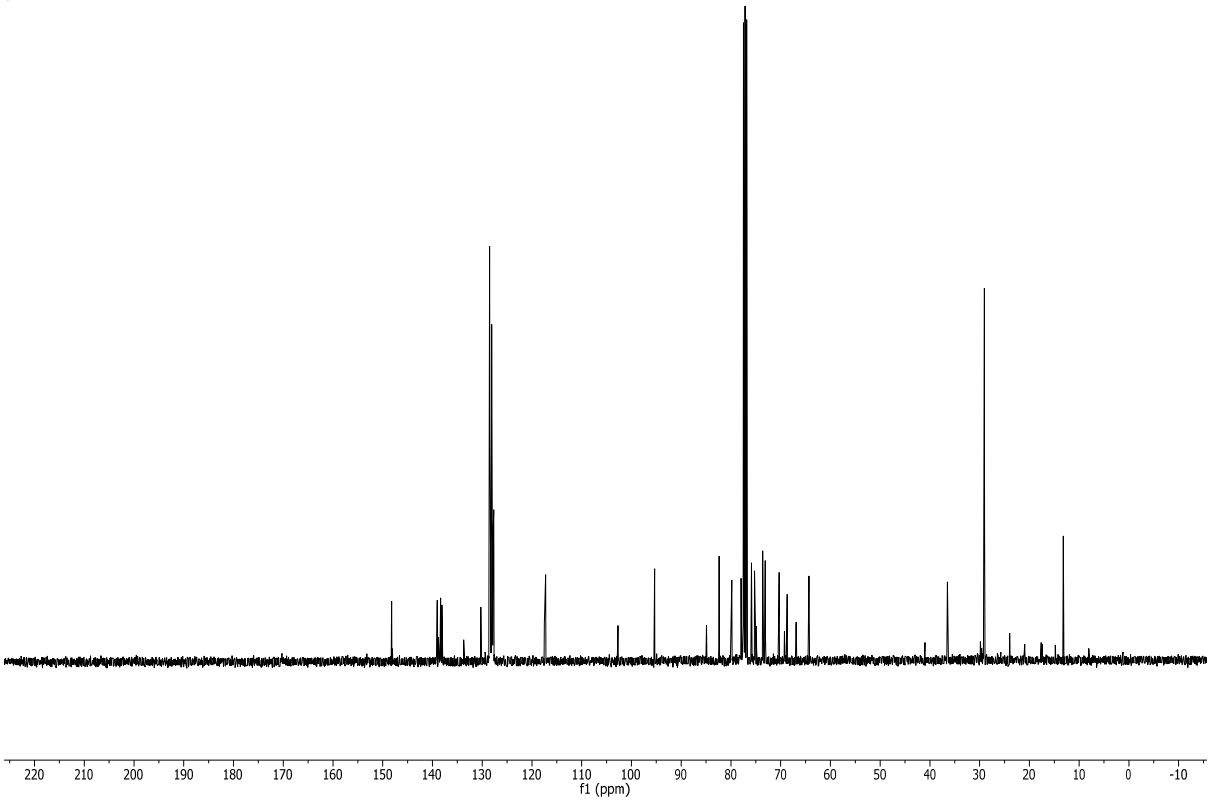


pcyht580.1.fid
1H 300.1MHz Job 18413 Young Paul C F580 CDCl3 25.0°C
Isolated

3k

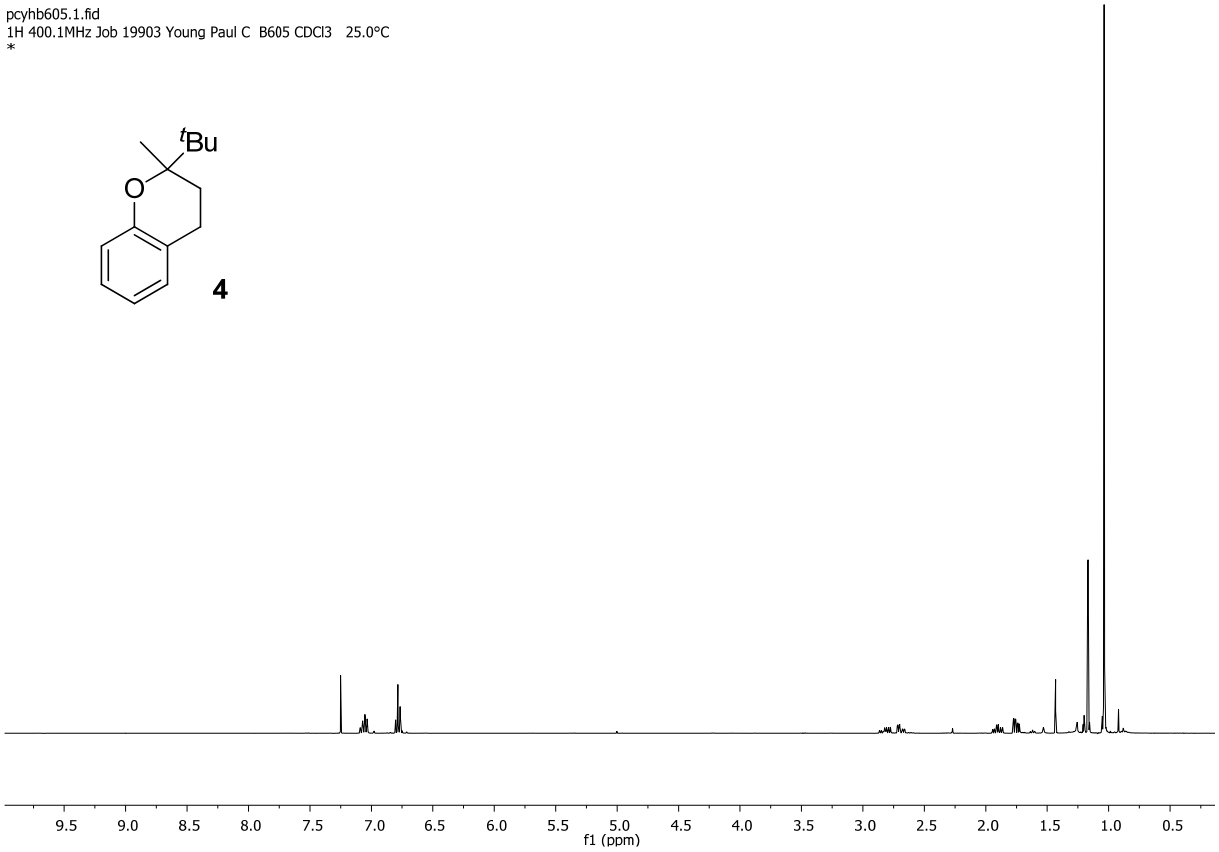


pcyca583.1.fid
13C 100.6MHz Job 19775 Young Paul C A583 CDCl3 25.0°C 0 hour 43 min
*

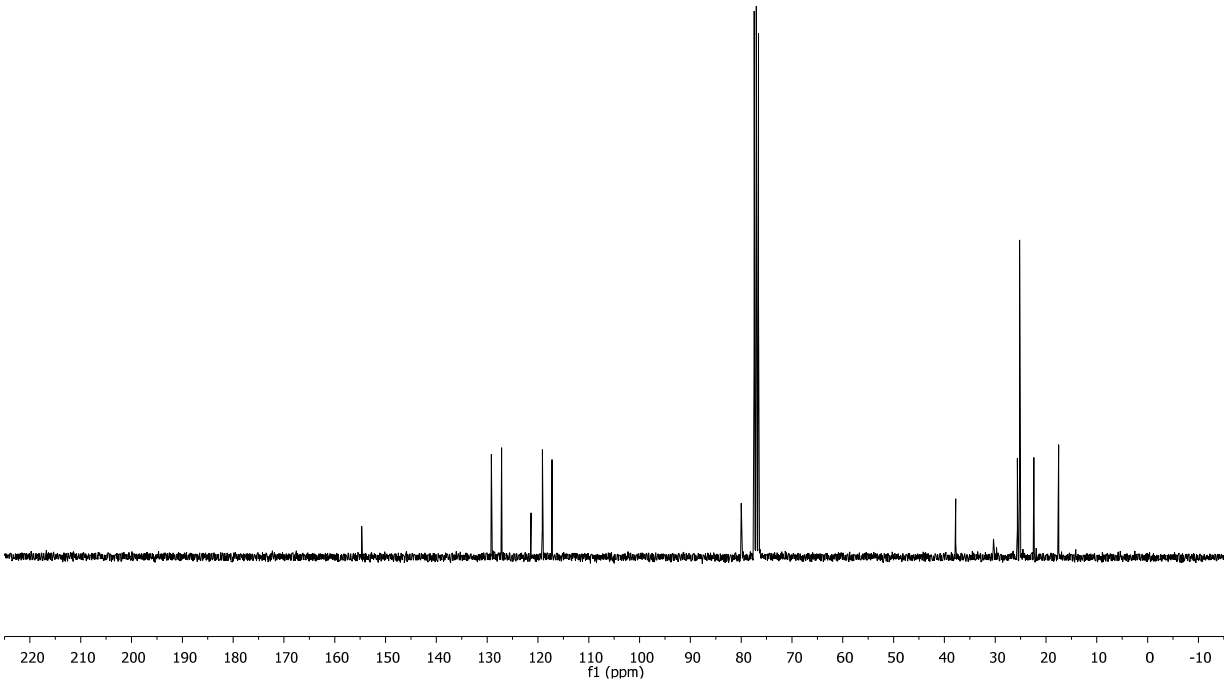


pcyhb605.1.fid
1H 400.1MHz Job 19903 Young Paul C B605 CDCl3 25.0°C
*

4

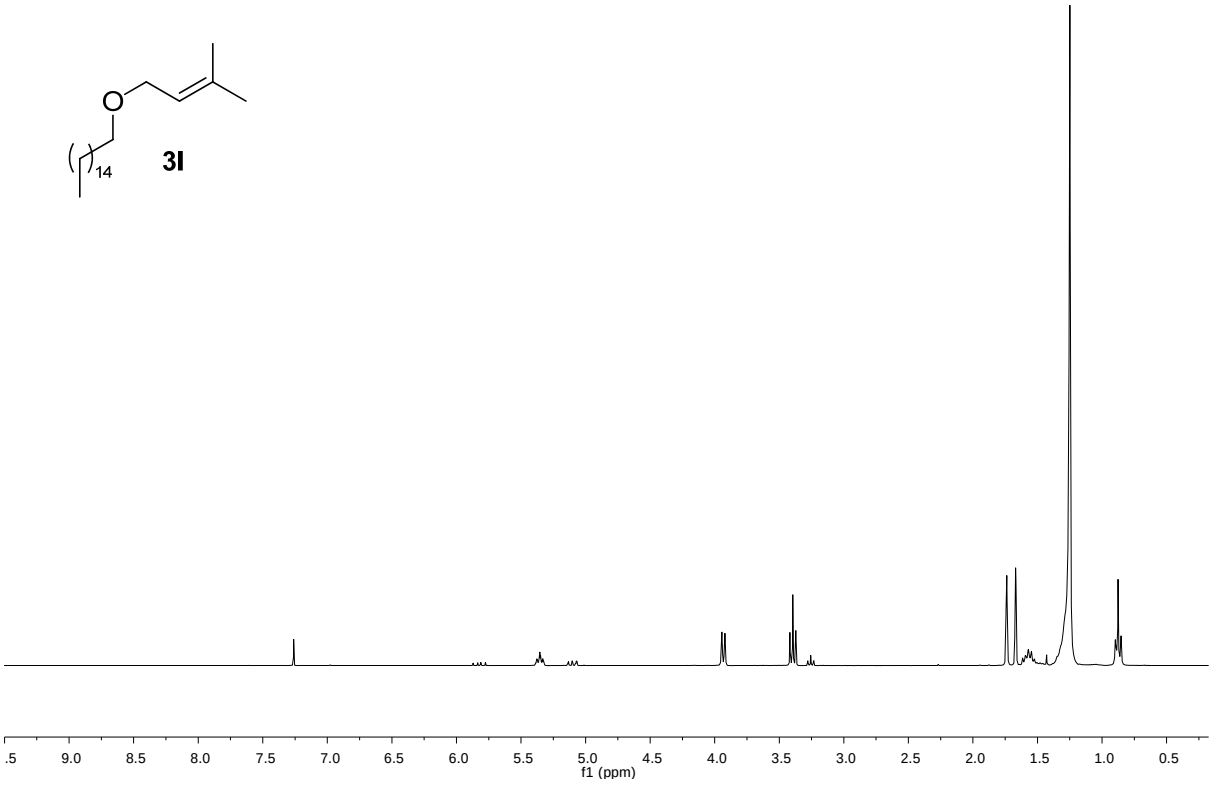


pcycb605.1.fid
13C 75.5MHz Job 20127 Young Paul C B605 CDCl3 25.0°C 1 hour 48 min
Isolated

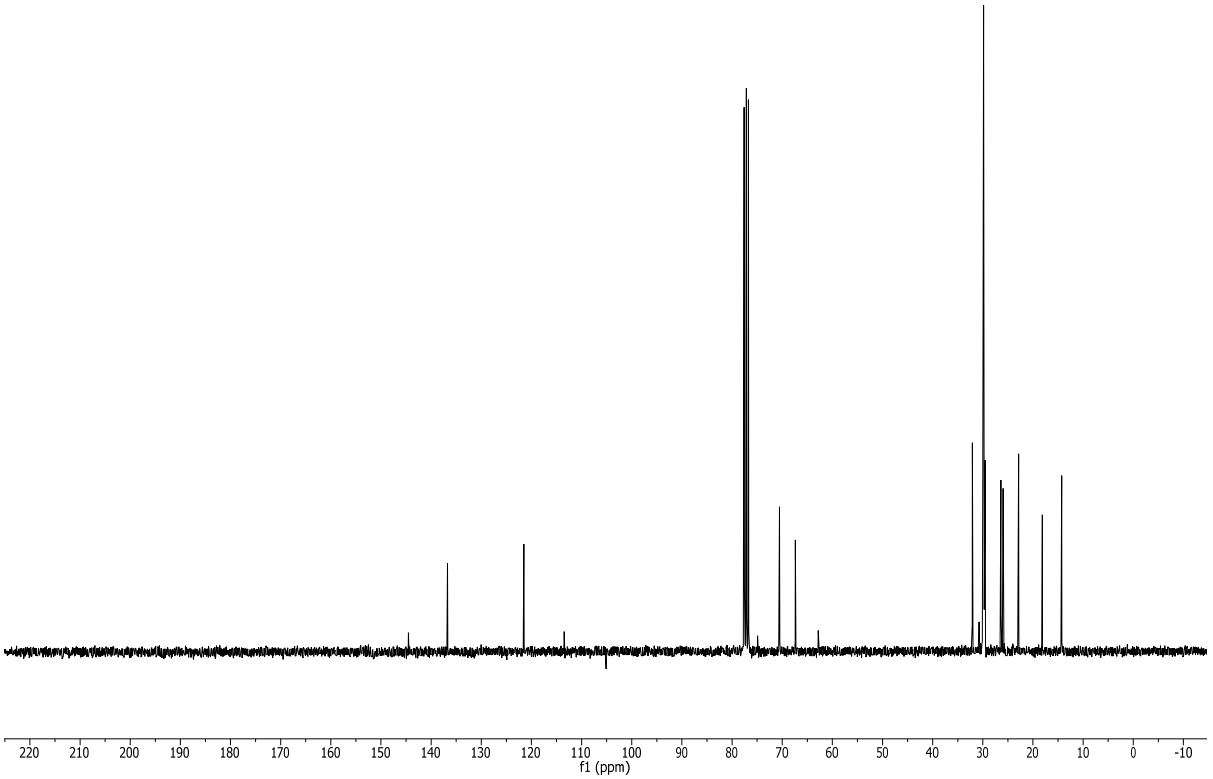


pcyhb528.1.fid
1H 300.1MHz Job 16521 Young Paul C B528 CDCl3 21.2°C
Columned

3l

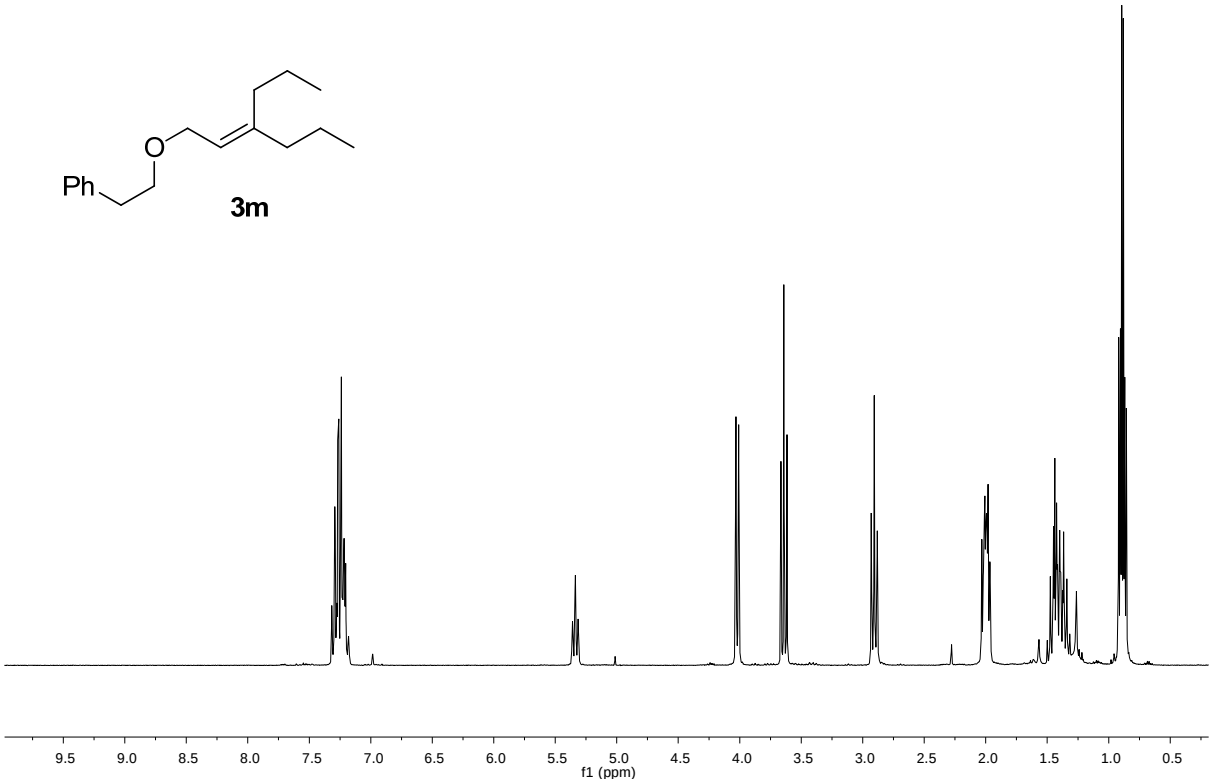


pcycb528.1.fid
13C 75.5MHz Job 16573 Young Paul C B528 CDCl3 22.1°C 0 hour 54 min
Columned

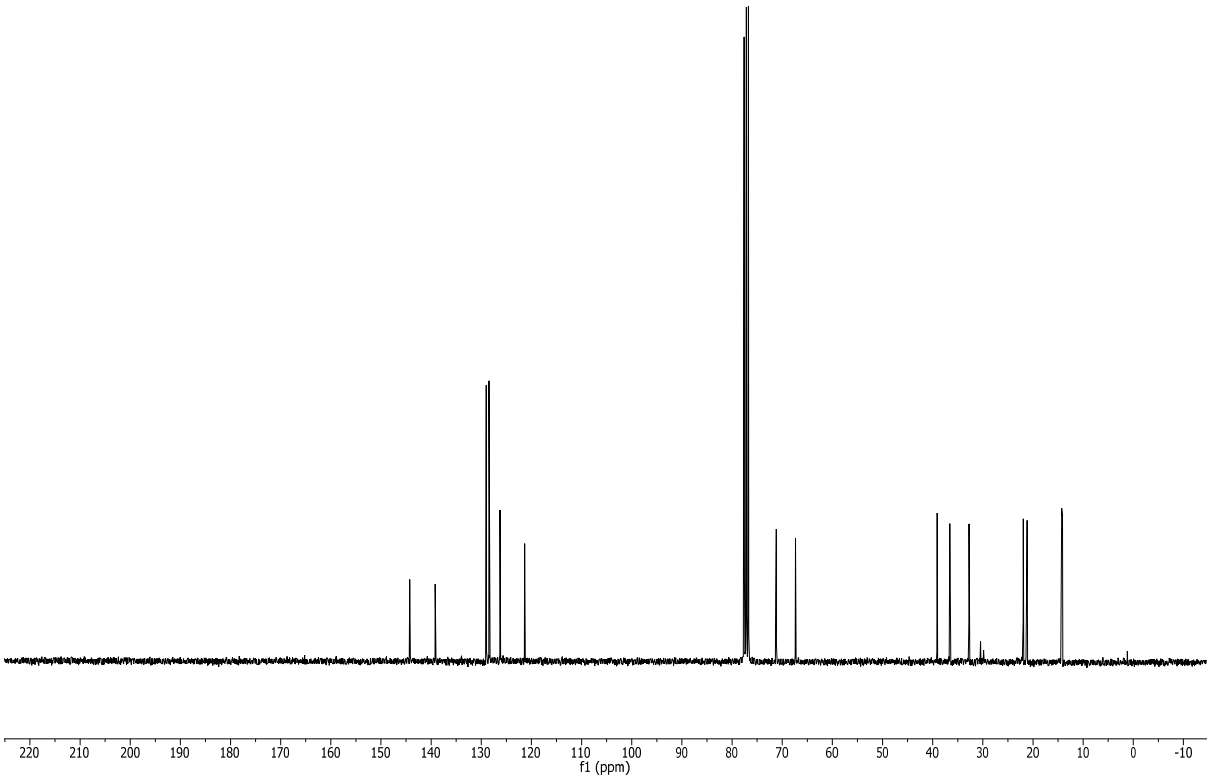


pcyhb468.1.fid
1H 300.1MHz Job 14406 Young Paul C B468 CDCl3 24.9°C
Isolated Product

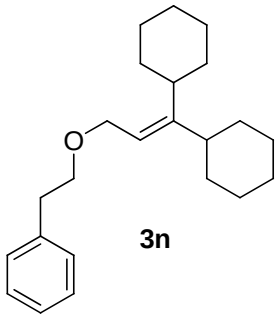
3m



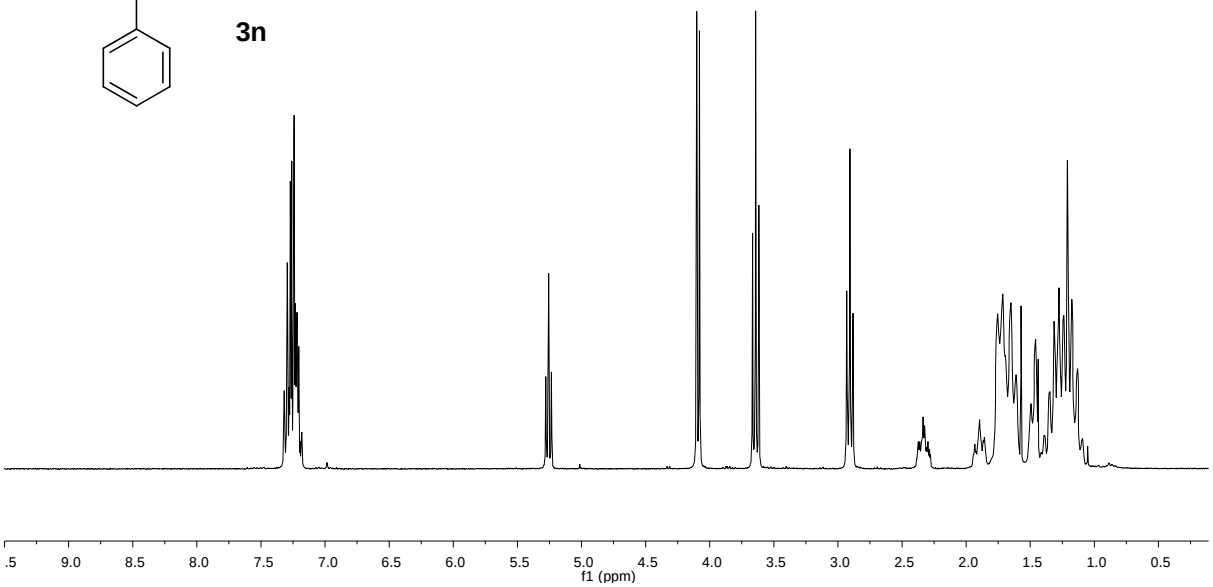
pcycb468.1.fid
13C 75.5MHz Job 14407 Young Paul C B468 CDCl3 25.0°C 3 hours 1 min
Isolated Product



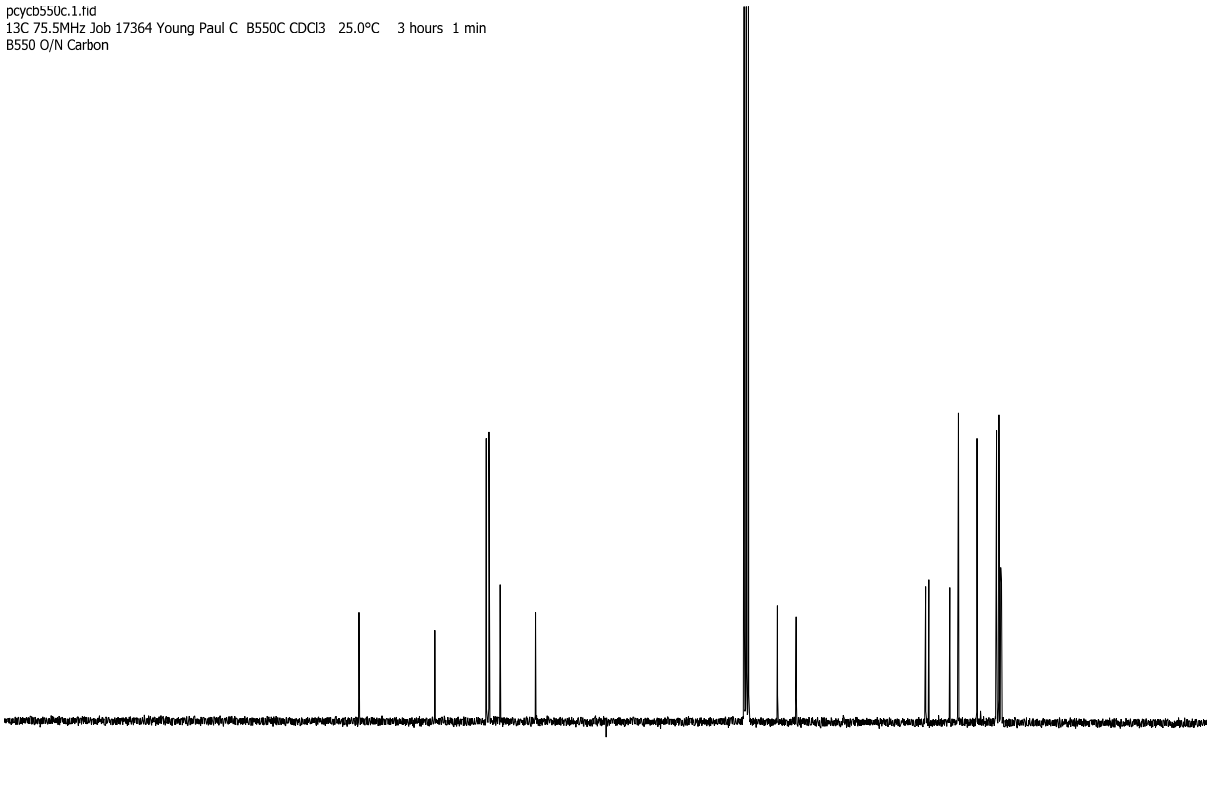
pcyhb550.1.fid
1H 300.1MHz Job 17363 Young Paul C B550 CDCl3 25.0°C
Isolated

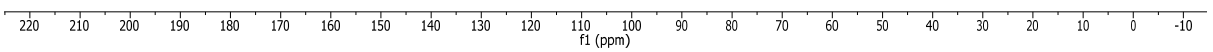


3n

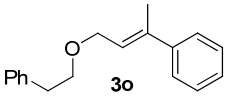


pcycb550c.1.fid
13C 75.5MHz Job 17364 Young Paul C B550C CDCl3 25.0°C 3 hours 1 min
B550 O/N Carbon

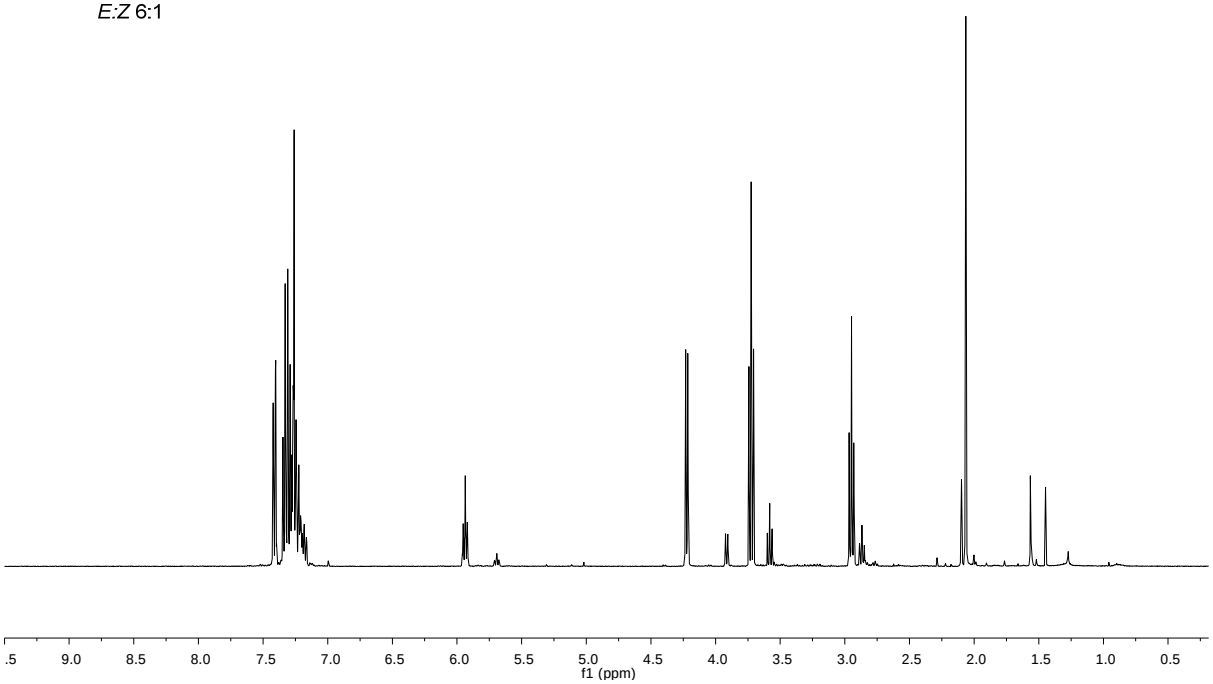




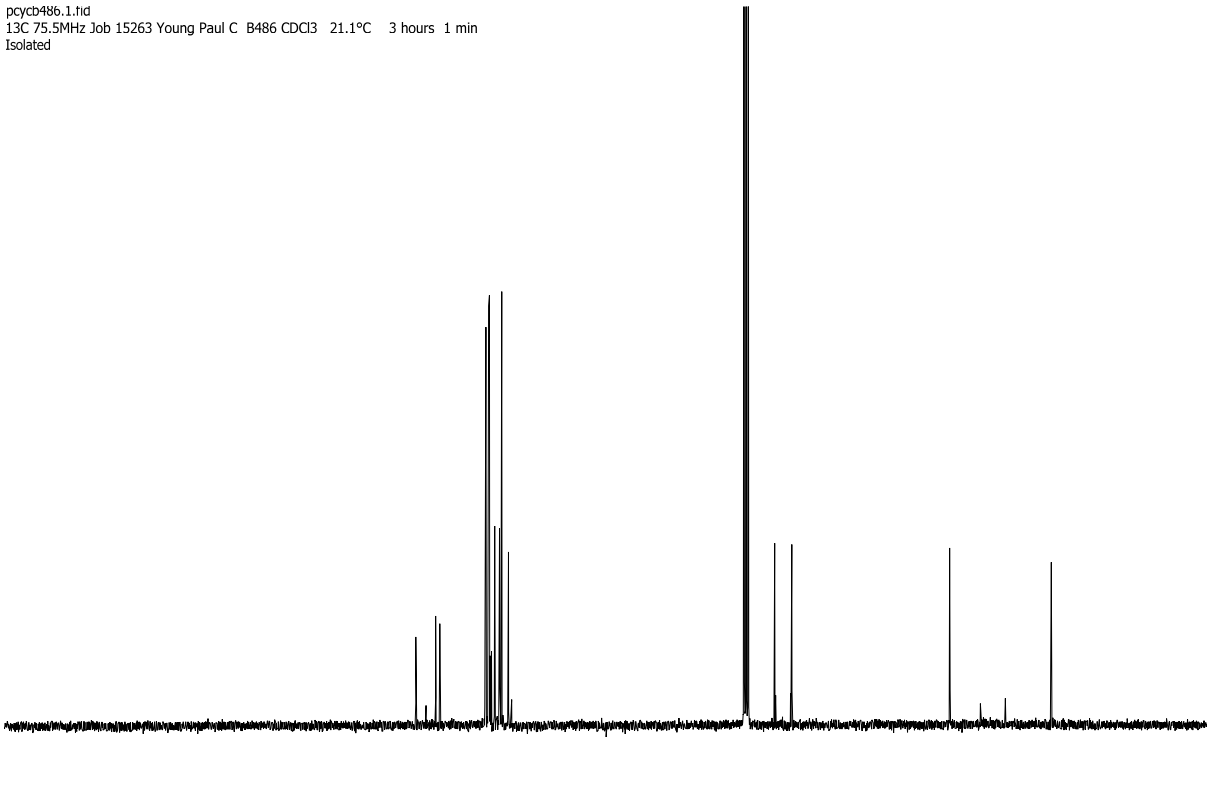
1H 400.1MHz Job 19612 Young Paul C C486 CDCl3 25.0°C
*

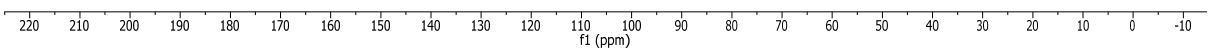


3o
E:*Z* 6:1

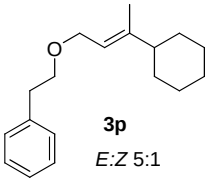


pcycb486.1.fid
13C 75.5MHz Job 15263 Young Paul C B486 CDCl3 21.1°C 3 hours 1 min
Isolated



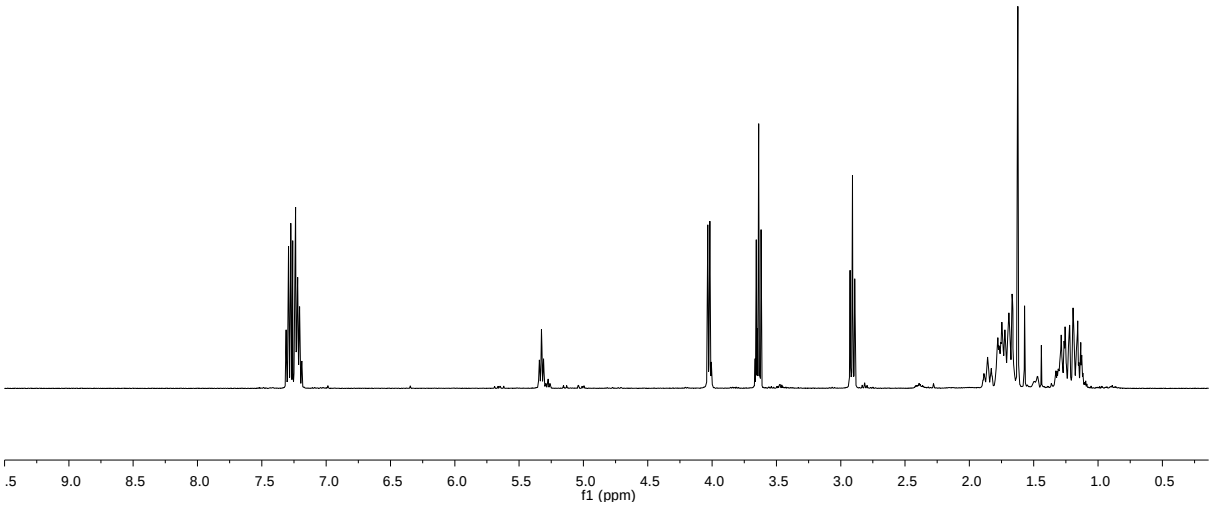


1H 400.1MHz Job 19676 Young Paul C B527 CDCl3 25.0°C
*

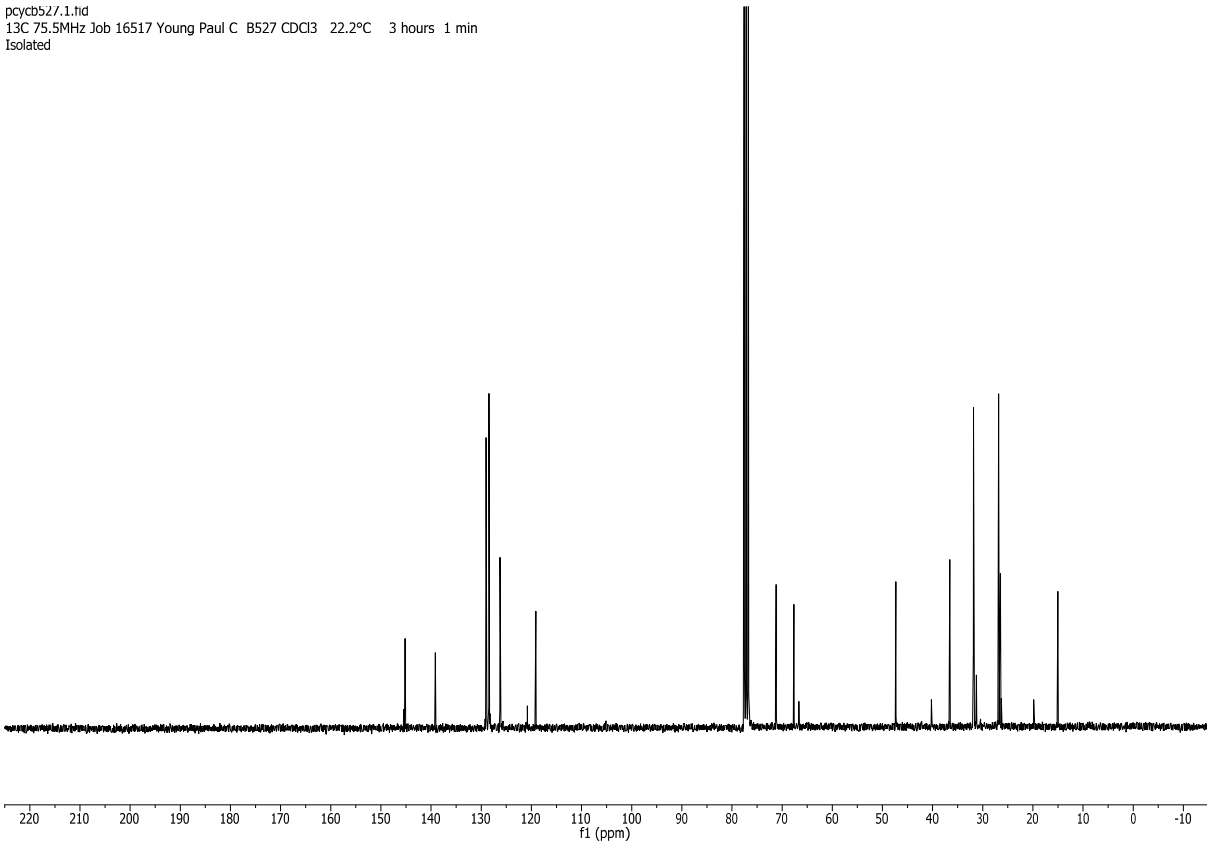


3p

E:*Z* 5:1



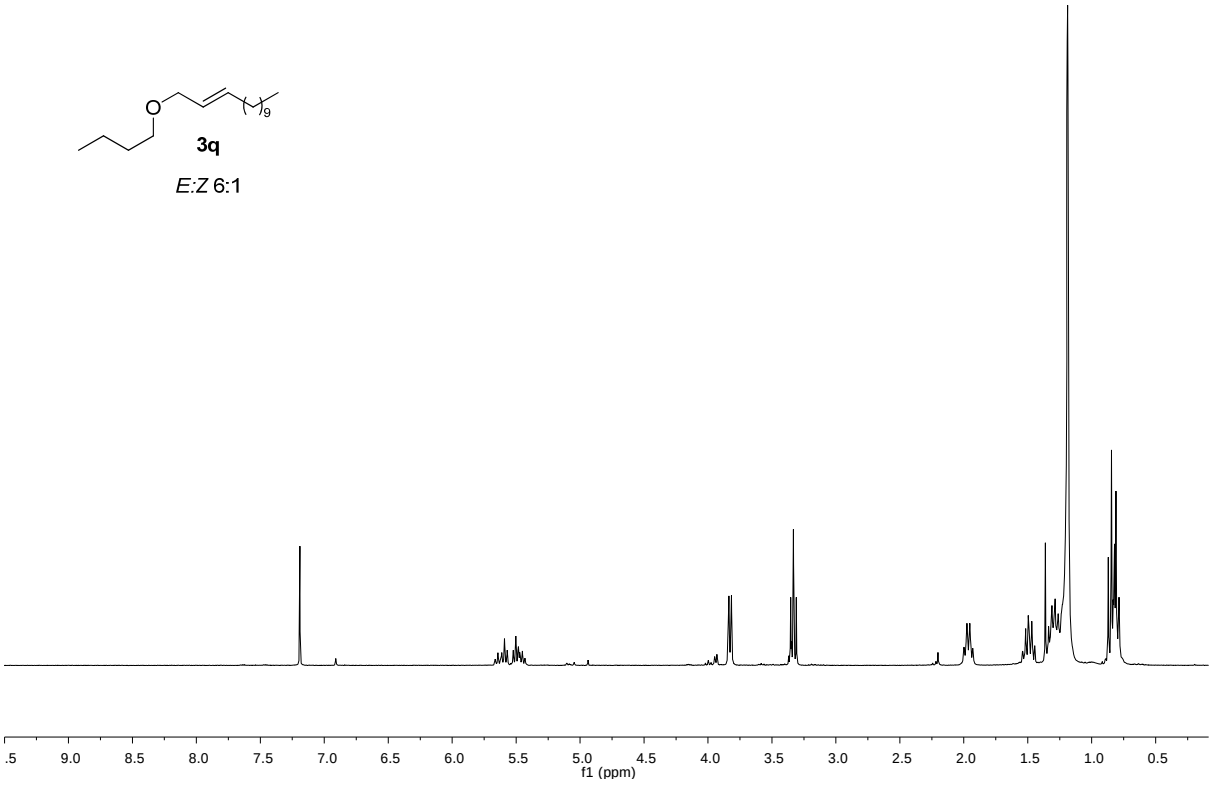
pcycb527.1.fid
13C 75.5MHz Job 16517 Young Paul C B527 CDCl3 22.2°C 3 hours 1 min
Isolated



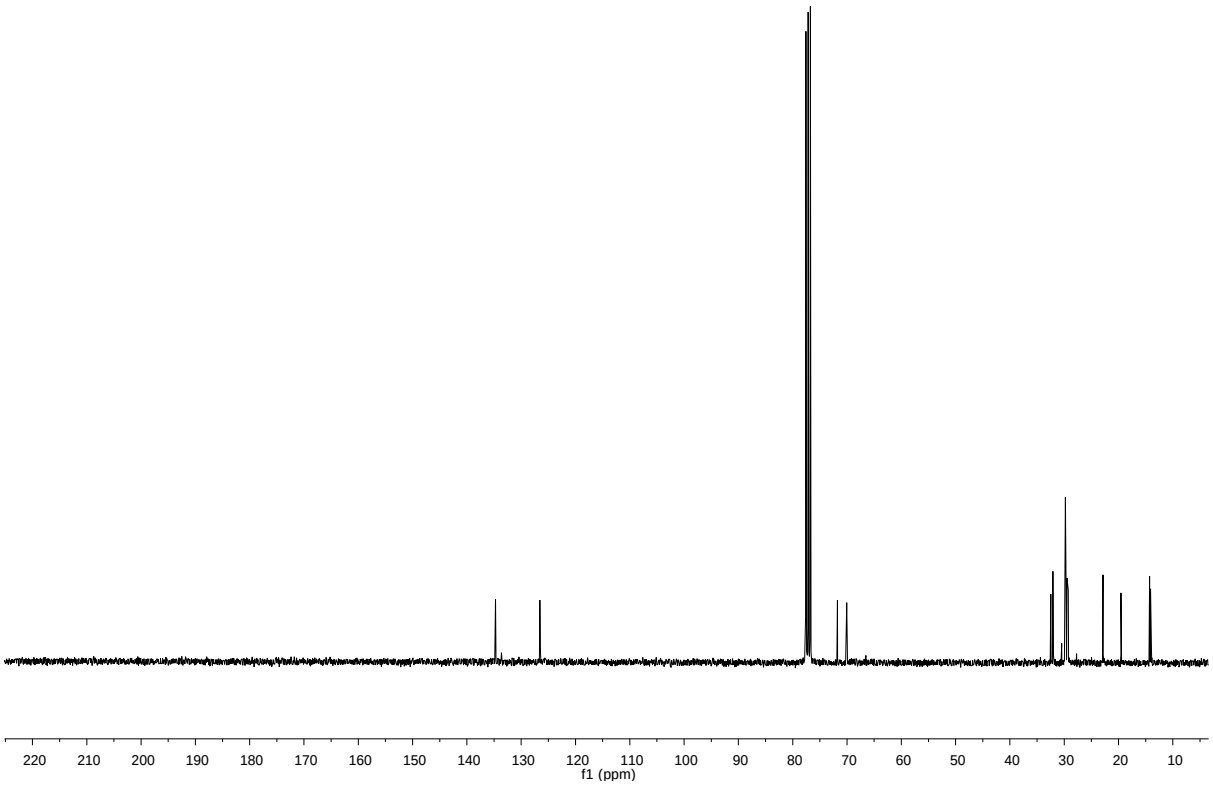
pcyhb452.1.fid
1H 300.1MHz Job 13711 Young Paul C B452 CDCl3 25.1°C
Isolated

3q

E:*Z* 6:1

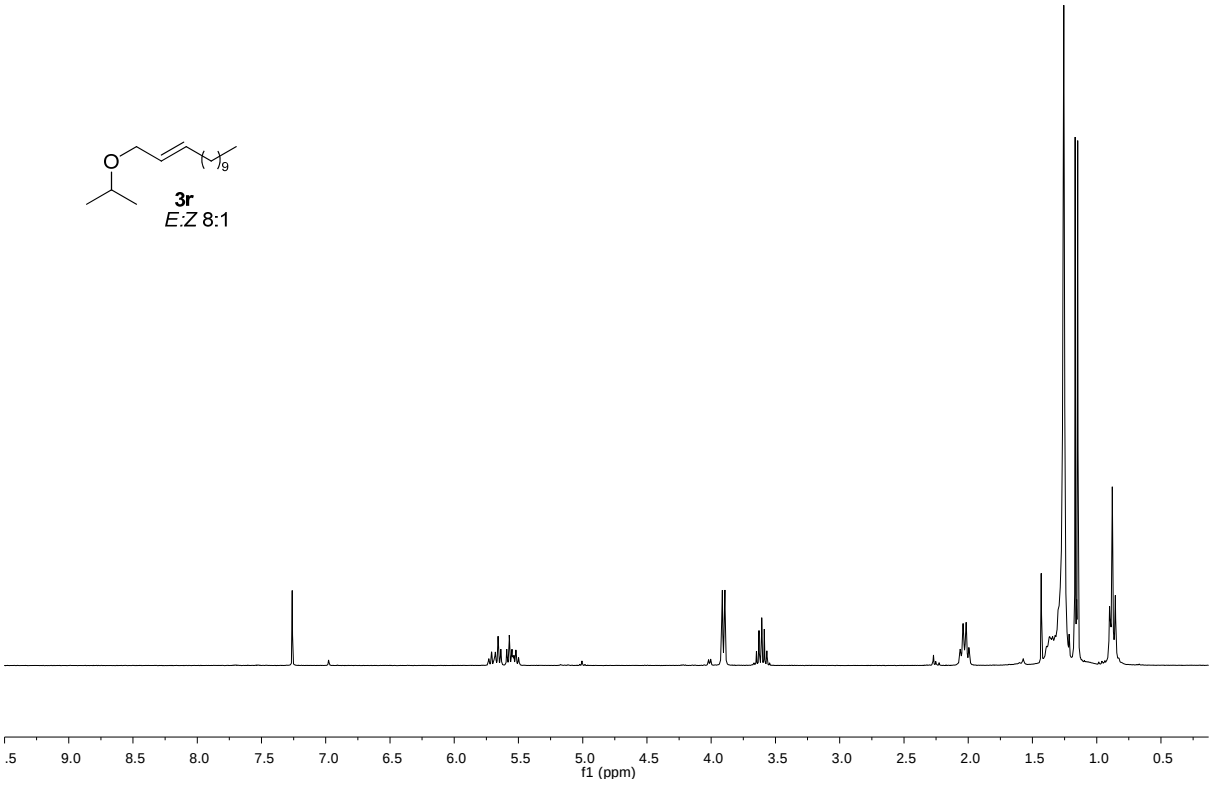


pcycb452.1.fid
13C 75.5MHz Job 13713 Young Paul C B452 CDCl3 25.0°C 3 hours 1 min
Isolated

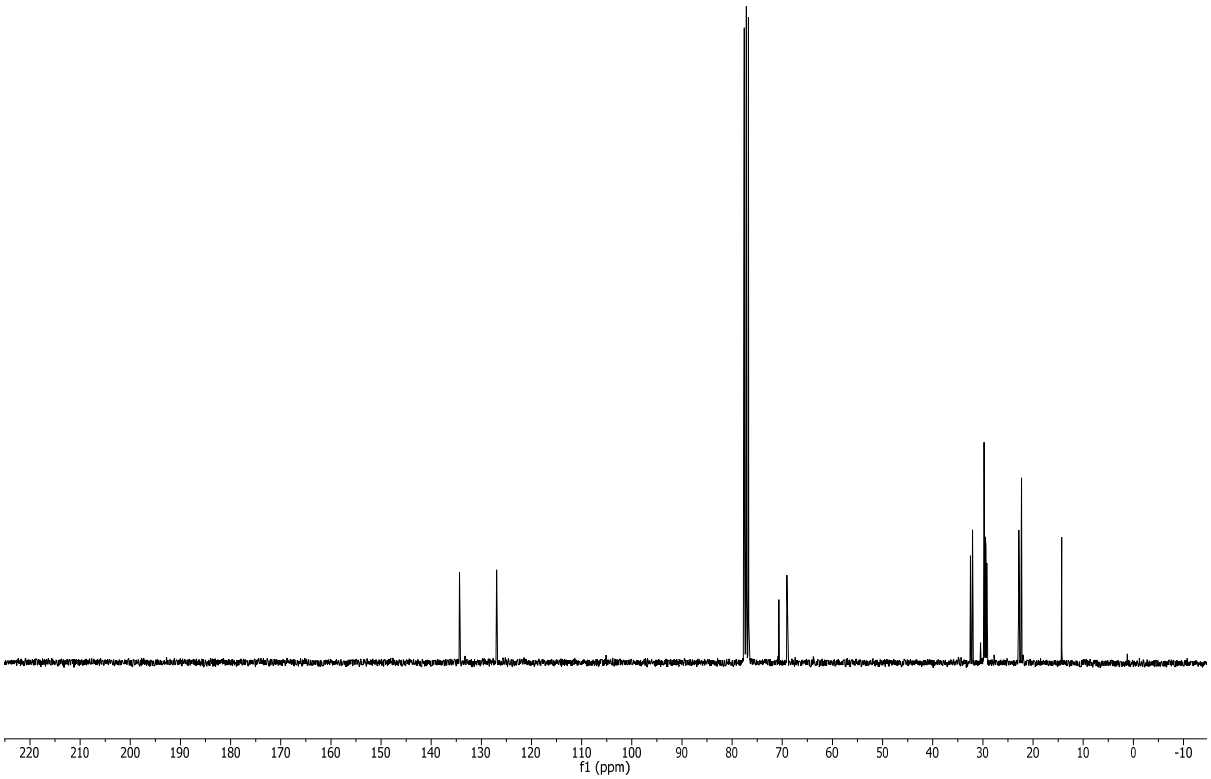


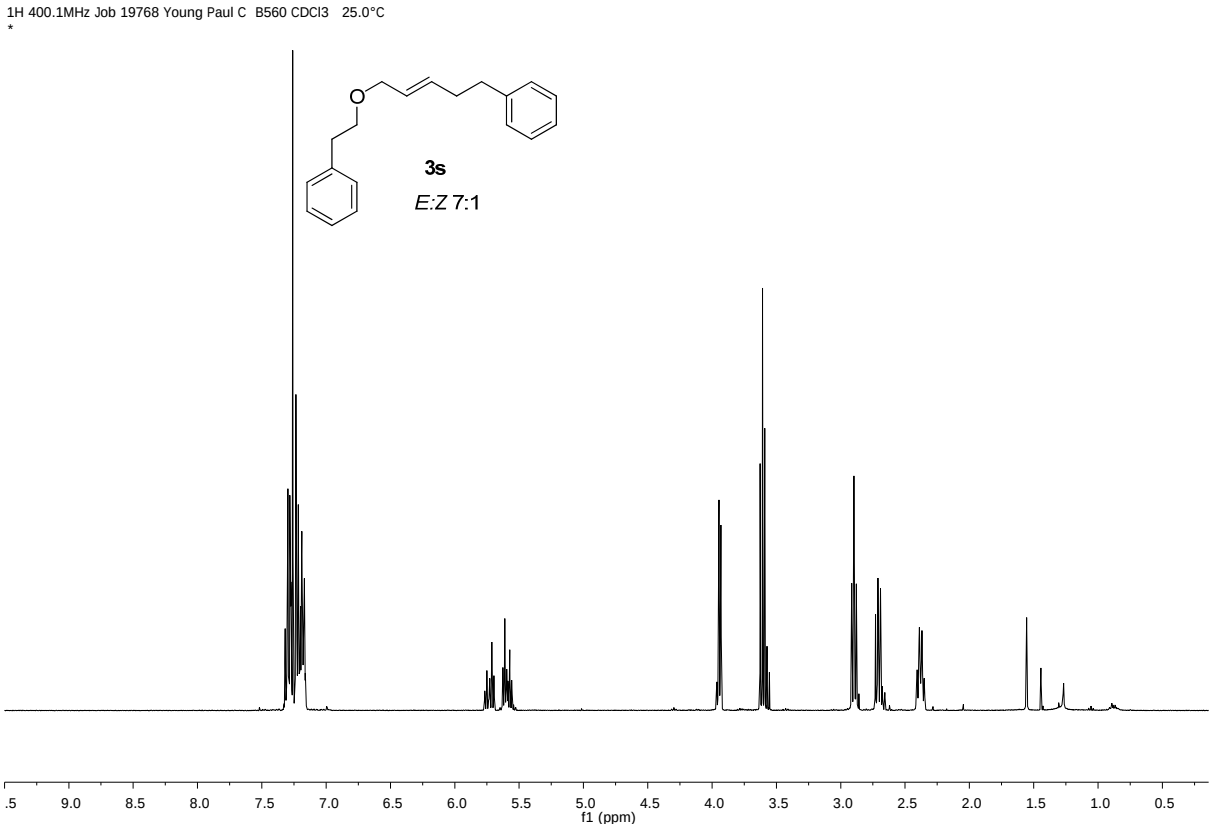
pcyhb438.1.fid
1H 300.1MHz Job 13185 Young Paul C B438 CDCl3 25.1°C
Isolated Product

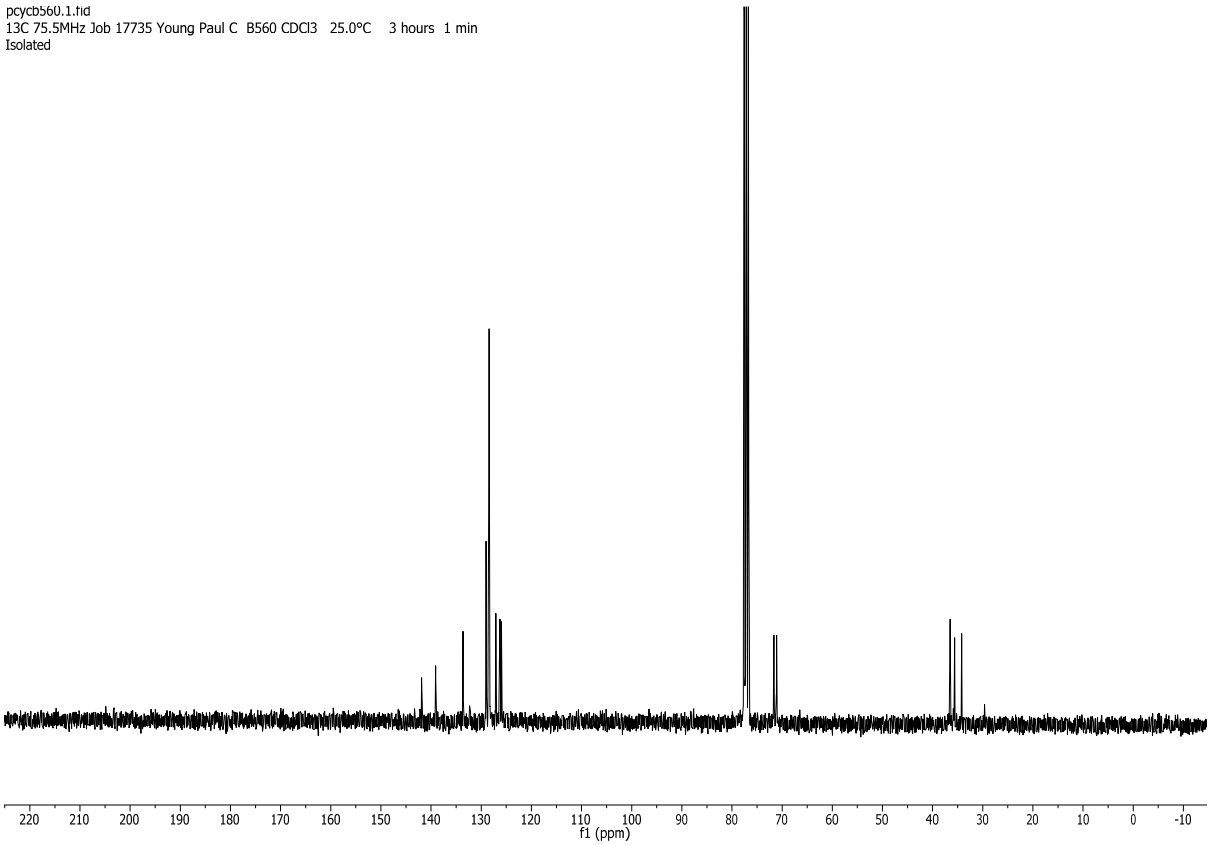
3r
E:*Z* 8:1

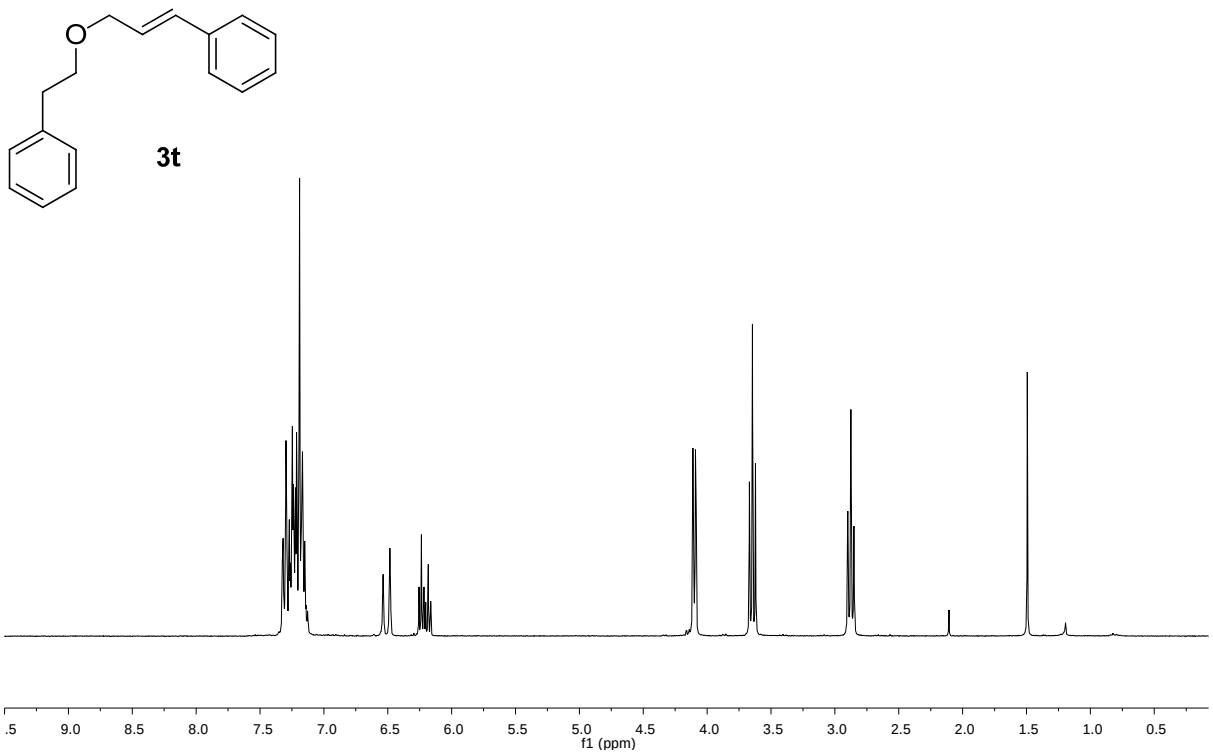


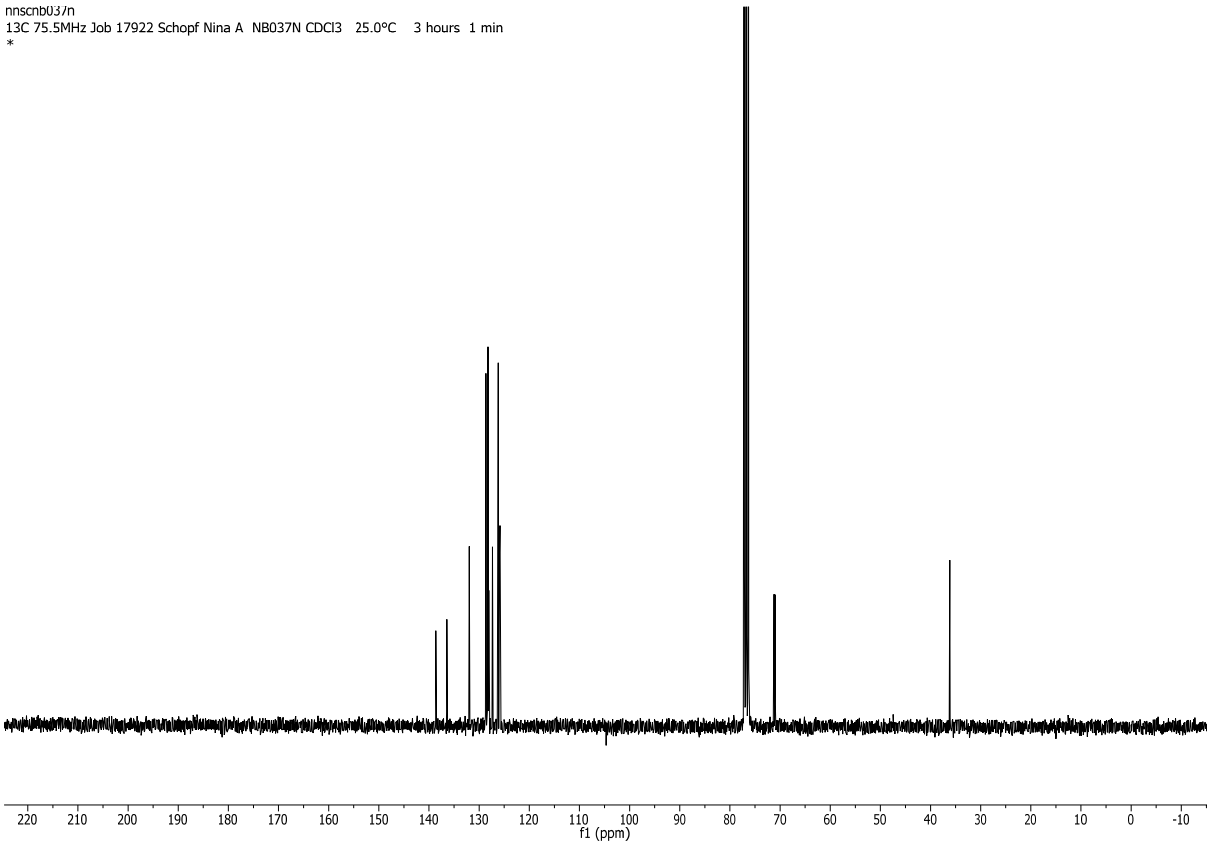
pcycb438.1.fid
13C 75.5MHz Job 13225 Young Paul C B438 CDCl3 25.0°C 3 hours 1 min
Isolated Product



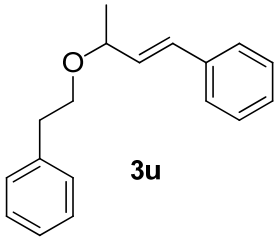

1H 400.1MHz Job 19768 Young Paul C B560 CDCl3 25.0°C
*
O
3s
E:Z 7:1
.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


pcycb560.1.fid
13C 75.5MHz Job 17735 Young Paul C B560 CDCl3 25.0°C 3 hours 1 min
Isolated
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

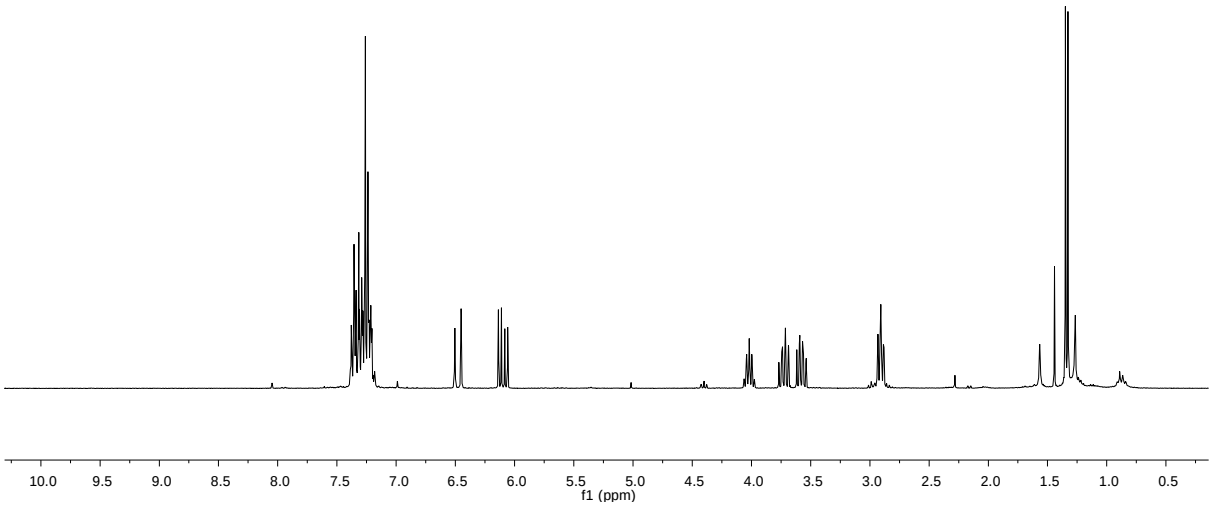

O
3t
.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


nnscnb037n
13C 75.5MHz Job 17922 Schopf Nina A NB037N CDCl3 25.0°C 3 hours 1 min
*
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

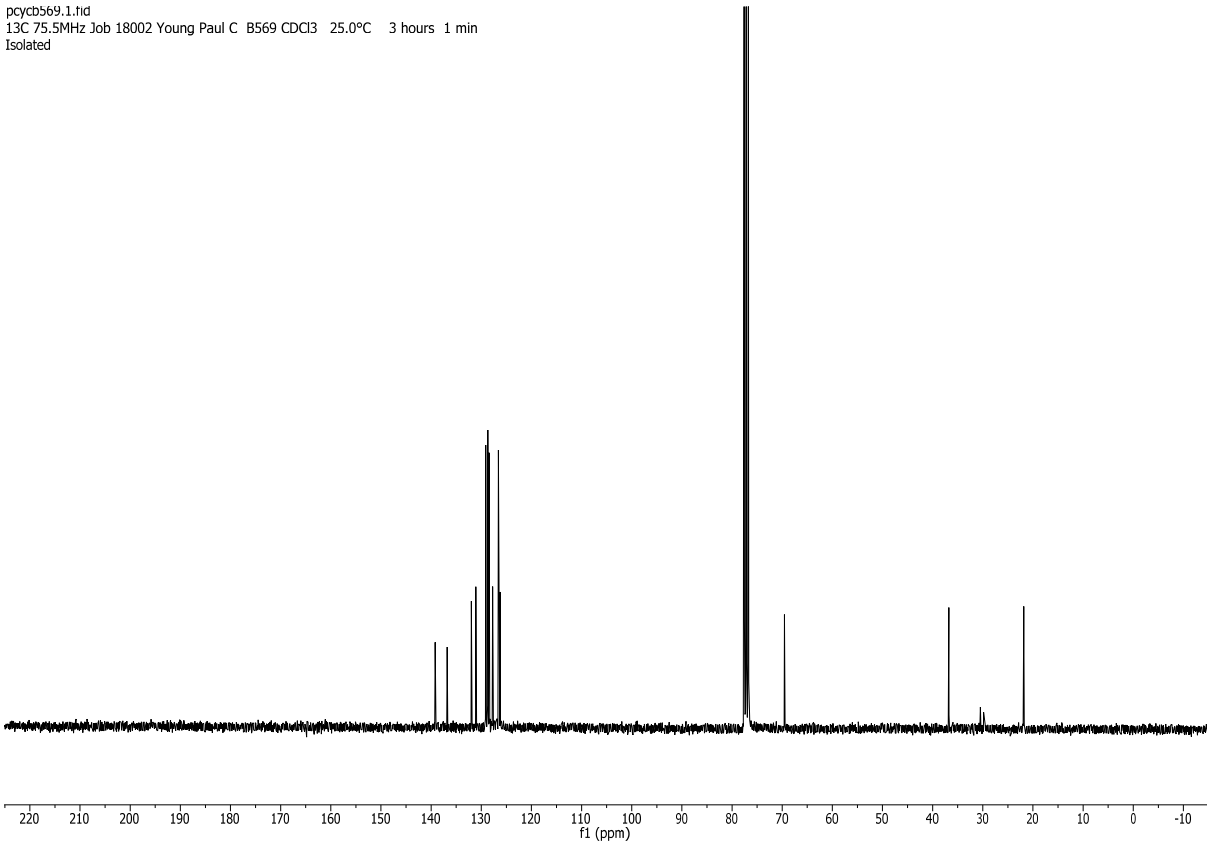
pcyhb569.1.fid
1H 300.1MHz Job 17989 Young Paul C B569 CDCl3 24.9°C
Isolated



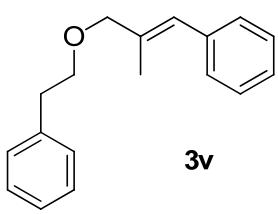
3u



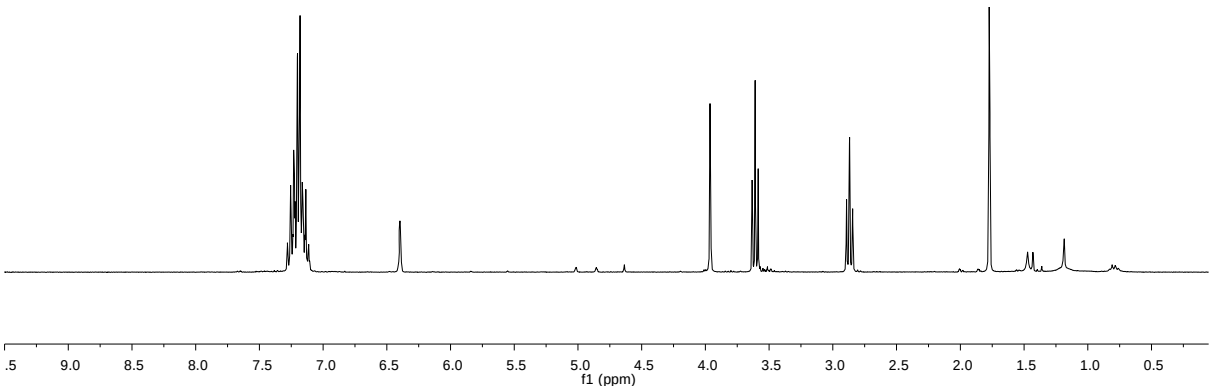
pcycb569.1.fid
13C 75.5MHz Job 18002 Young Paul C B569 CDCl3 25.0°C 3 hours 1 min
Isolated



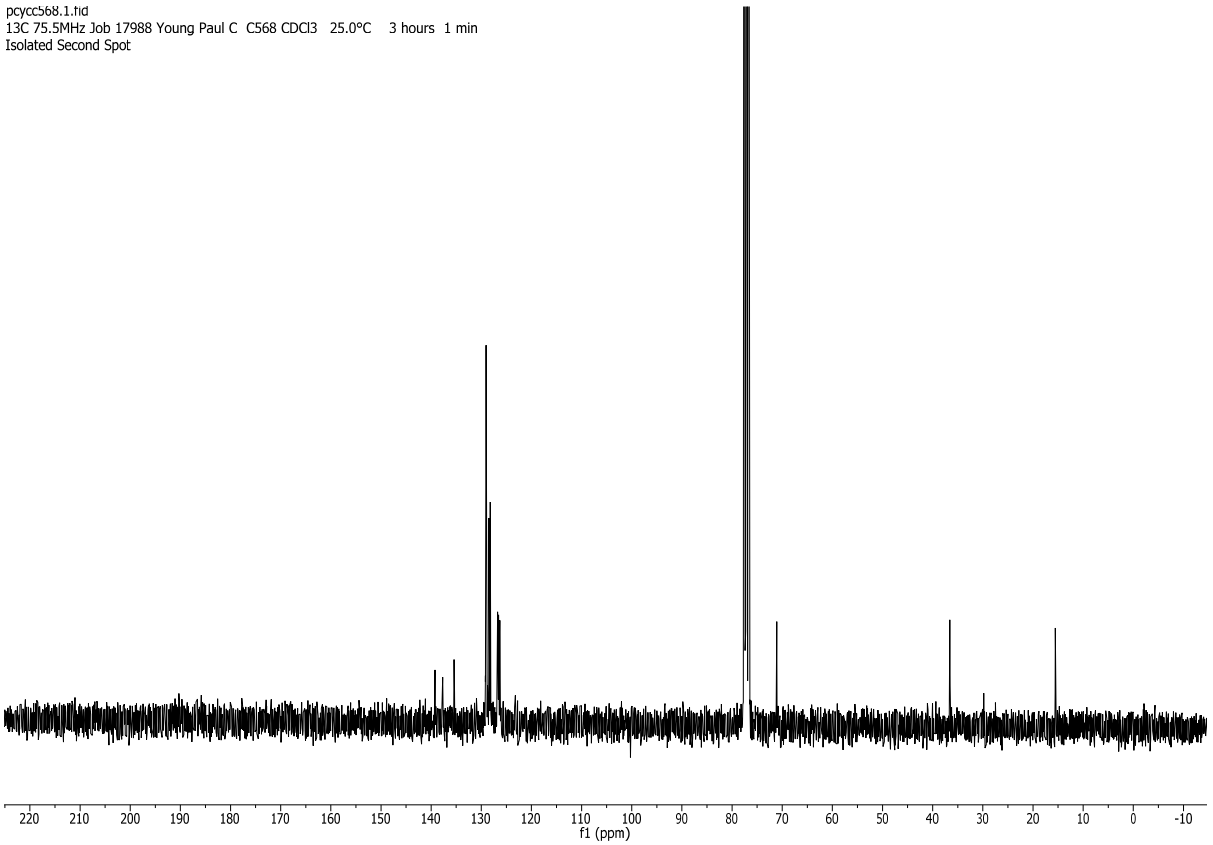
pcyhc568.1.fid
1H 300.1MHz Job 17979 Young Paul C C568 CDCl3 25.0°C
Isolated Second Spot



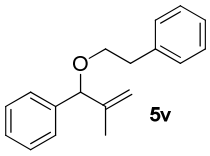
3v



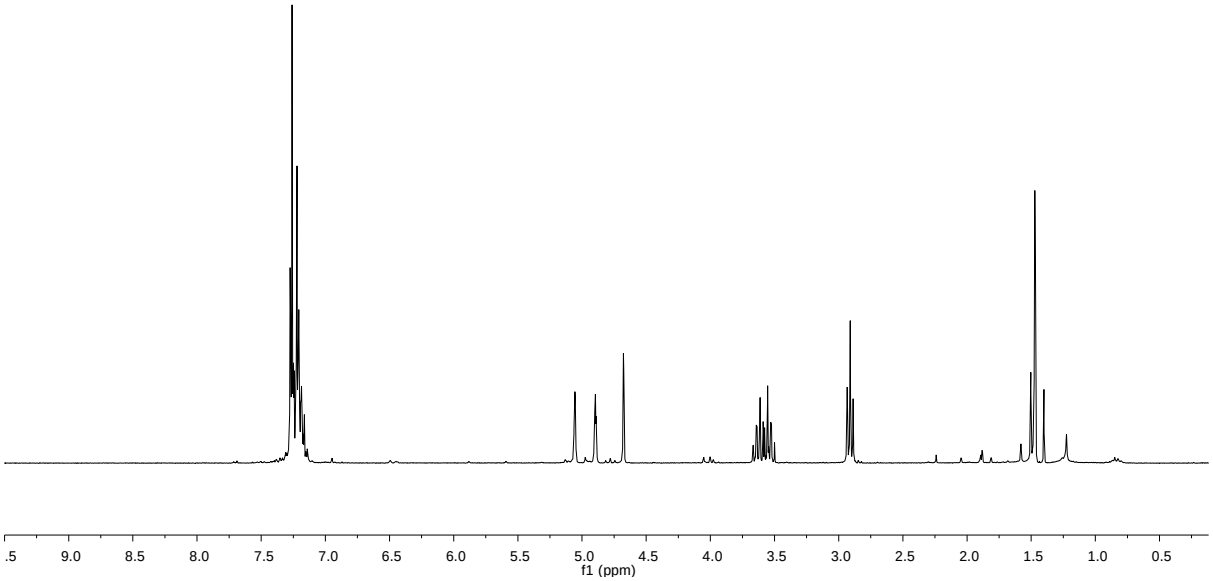
pcycc568.1.fid
13C 75.5MHz Job 17988 Young Paul C C568 CDCl3 25.0°C 3 hours 1 min
Isolated Second Spot



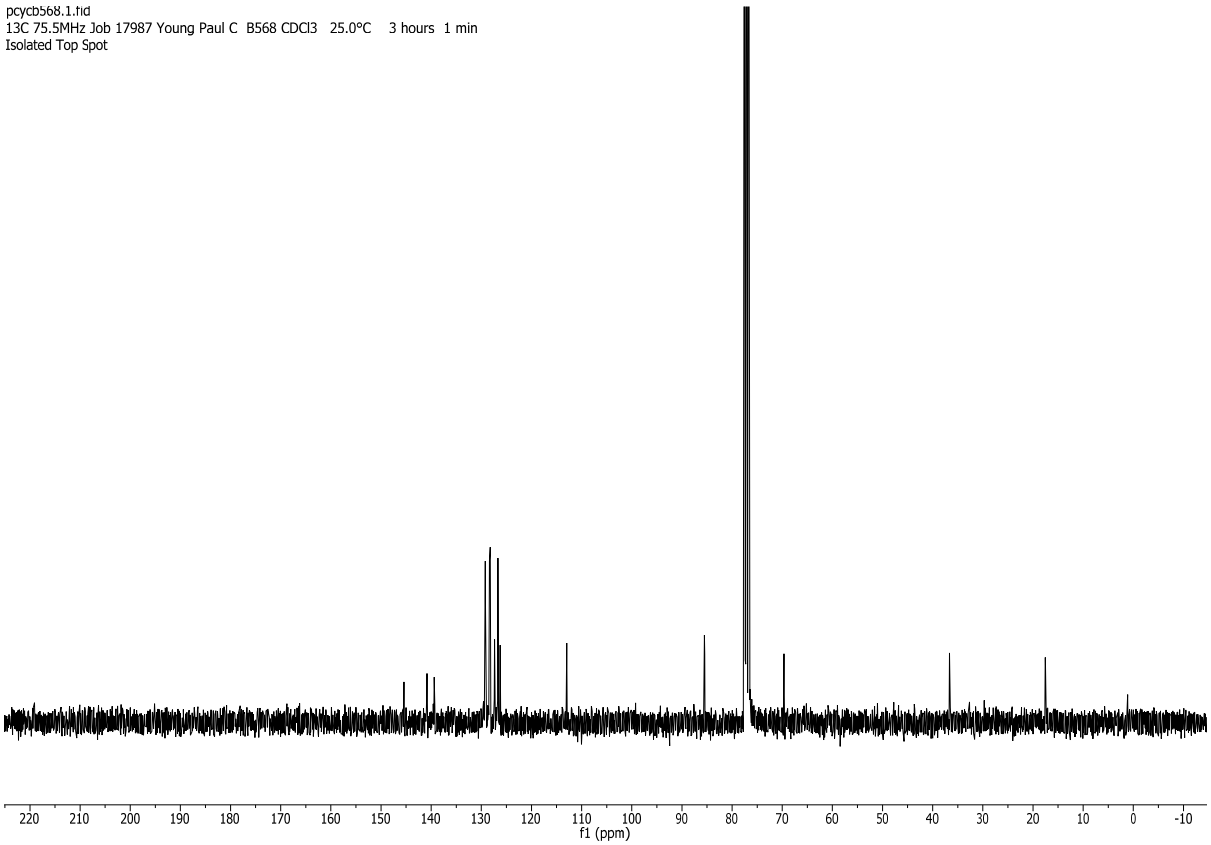
pcyhb568.1.fid
1H 300.1MHz Job 17978 Young Paul C B568 CDCl3 24.9°C
Isolated Top Spot

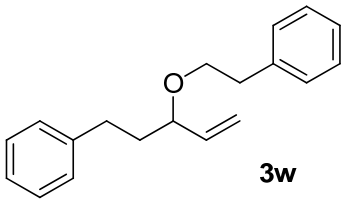


5v

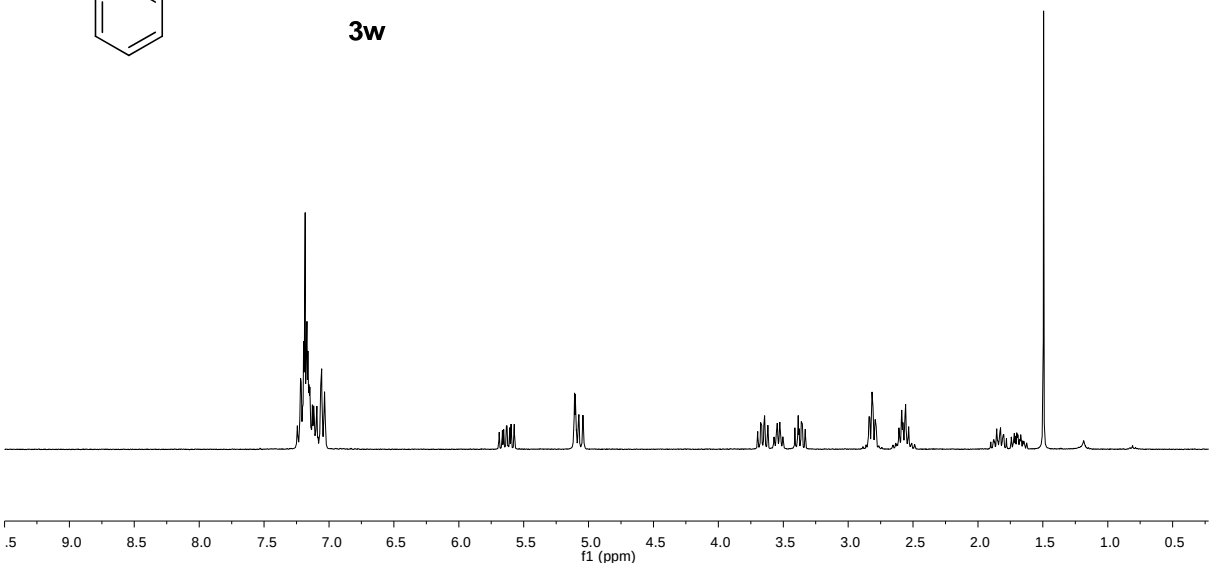


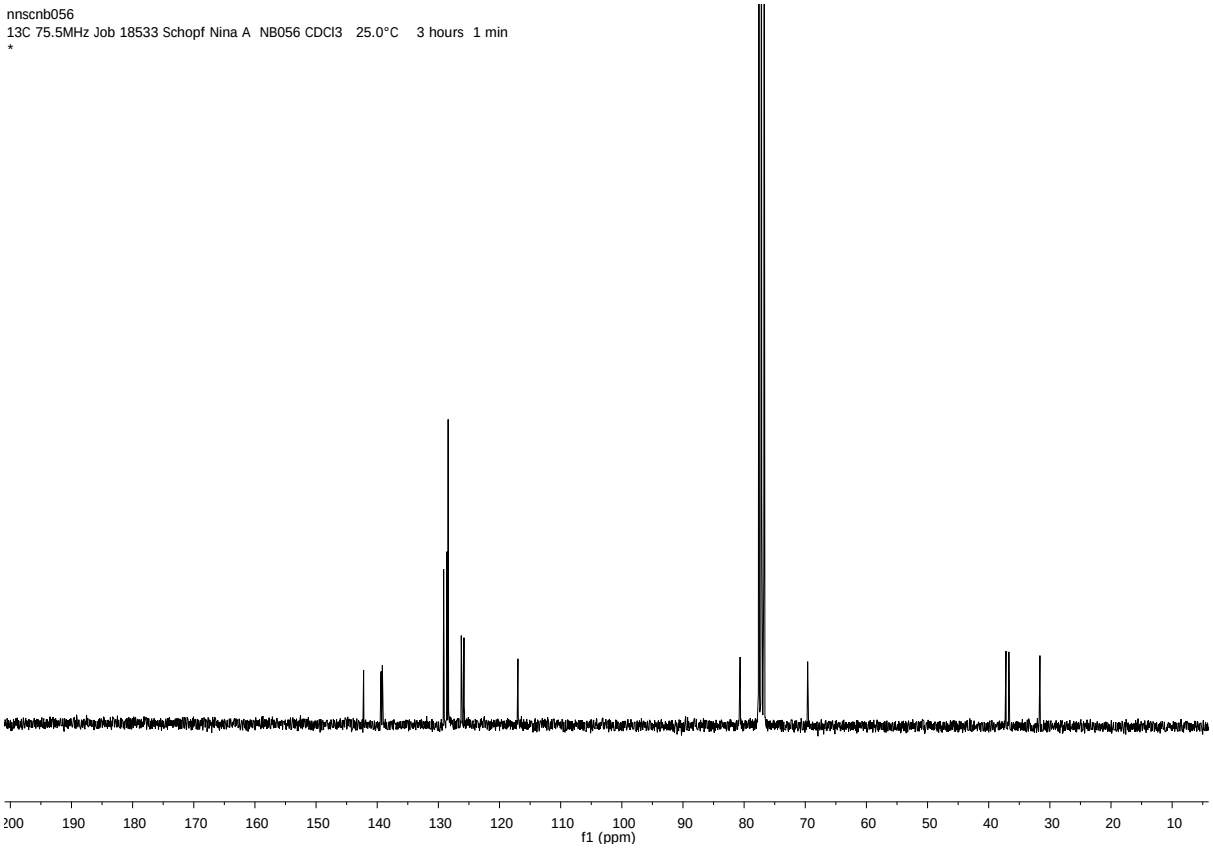
pcycb568.1.fid
13C 75.5MHz Job 17987 Young Paul C B568 CDCl3 25.0°C 3 hours 1 min
Isolated Top Spot





3w


.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


nnscnb056
13C 75.5MHz Job 18533 Schopf Nina A NB056 CDCl3 25.0°C 3 hours 1 min
*
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

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