# SUPPORTING INFORMATION

## Gold nanoparticles-catalyzed activation of 1,2-disilanes: Hydrolysis, silyl protection of alcohols and reduction of *tert*-benzylic alcohols

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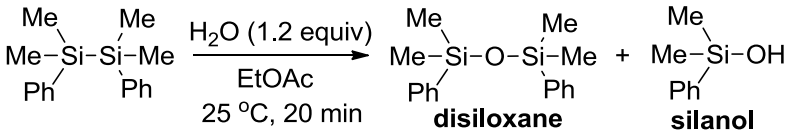
## 1,2-Disilanes

Hexamethyldisilane, 1,2-diphenyl-l,1,2,2-tetramethyldisilane, 1,2-dimethyl-l,1,2,2-tetraphenyldisilane, and hexaphenyldisilane are commercially available. Hexaethyldisilane, was synthesized in 63% isolated yield by the reaction between triethylsilyl chloride and Na metal (2 equiv) in the absence of solvent, at 120 $^{o}$C for 12 h.[1] $^{1}$H NMR (300 MHz, $CDCl_3$): 0.97 (t, $J$ = 8.0 Hz, 9H), 0.64 (q, $J$ = 8.0 Hz, 6H); $^{13}$C NMR (75 MHz, $CDCl_3$): 8.4, 4.1.

## Typical procedure for the homogeneous $Ph_3PAuNTf_2$-catalyzed hydrolysis of $PhMe_2SiSiMe_2Ph$

To a tube containing 1,1,2,2-tetramethyl-1,2-diphenyldisilane (10 mg, 0.037 mmol) and $H_2O$ (1 μL, 0.055 mmol) in 0.3 mL of chloroform-D was added $Ph_3PAuNTf_2$ (4 mg, 15 mol%). The reaction was stirred at room temperature and monitored by $^{1}$H NMR. After 40 h the starting material had been completely consumed providing the corresponding 1,3-disiloxane as a single product. Under the same conditions, [(2-biphenyl)di-*tert*-butylphosphine]$AuSbF_6$ (15 mol%) provided traces of products.

## Screening of catalysts during the hydrolysis of $Me_2PhSiSiPhMe_2$




| Entry | Catalyst | Conversion[a] | disiloxane/silanol[a] |
|---|---|---|---|
| 1 | $Au/TiO_2$ (1%) | 99% | 80/20[b] |
| 2 | $Au/Al_2O_3$ (1%) | 72% | 20/80[c] |
| 3 | Au/ZnO (1%) | 55% | 40/60[d] |

[a] Based on GC analysis. [b] $PhMe_2SiH$ was also seen in 11% relative yield. [c] $PhMe_2SiH$ was also seen in 9% relative yield. . [d] $PhMe_2SiH$ was also seen in 13% relative yield.

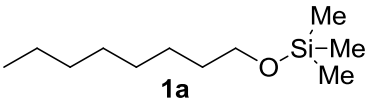
## General procedure for the $Au/TiO_2$-catalyzed silylative protection of alcohols with hexamethyldisilane

To a vial containing 0.5 mmol of an alcohol, 0.3 mmol of hexamethyldisilane, and 1 mL of dry ethyl acetate under an inert atmosphere are added 100 mg of $Au/TiO_2$ (~1.0 mol% in Au). The gradual evolution of hydrogen gas is immediately obvious. In case of using non-dried solvent and open air conditions, 1-2 mmol of disilane should be used, to compensate its competing hydrolytic destruction. After a certain period of time (see Table 2) and at

room temperature, the reaction is complete (TLC, GC-MS). The slurry is filtered with the aid of ethyl acetate (3 mL) under a low pressure through a short pad of silica gel, and the filtrate is evaporated to afford the TMS-protected alcohols in high yields and purity.

**Spectroscopic data of silylated products from the alcoholysis of 1,2-disilanes**

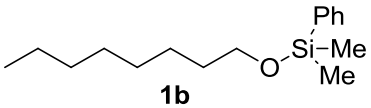
**Trimethyl(octyloxy)silane (1a)**[2]




**1a**

$^1$H NMR (300 MHz, $CDCl_3$): 3.56 (t, *J* = 6.5 Hz, 2H), 1.52 (m, 2H), 1.27 (m, 10H), 0.88 (t, *J* = 6.5 Hz, 3H), 0.11 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 62.8, 32.8, 31.8, 29.4, 29.3, 25.8, 22.7, 14.1, -0.5.

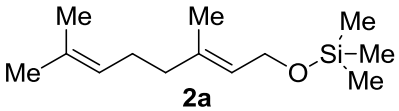
**Dimethyl(octyloxy)(phenyl)silane (1b)**[3]




**1b**

$^1$H NMR (300 MHz, $CDCl_3$): 7.55-7.62 (m, 2H), 7.34-7.43 (m, 3H), 3.59 (t, *J*=6.5 Hz, 2H), 1.53 (m, 2H), 1.26 (m, 10H), 0.88 (t, *J*=6.5 Hz, 3H), 0.38 (s, 6H); $^{13}$C NMR (75 MHz, $CDCl_3$): 138.1, 133.5, 129.5, 127.8, 63.2, 32.6, 31.8, 29.3, 25.8, 22.6, 14.1, -1.8.

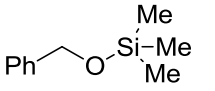
**(*E*)-(3,7-Dimethylocta-2,6-dienyloxy)trimethylsilane (2a)**[4]




**2a**

$^1$H NMR (300 MHz, $CDCl_3$): 5.32 (t, *J* = 6.5 Hz, 1H), 5.09 (t, *J* = 6.5 Hz, 1H), 4.15 (d, *J* = 6.5 Hz, 2H), 2.09 (m, 2H), 2.03 (m, 2H), 1.67 (br s, 3H), 1.64 (br s, 3H), 1.60 (br s, 3H), 0.13 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 137.6, 131.5, 124.1, 123.8, 59.5, 39.6, 26.3, 25.6, 17.6, 16.2, -0.3.

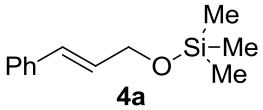
**Benzyloxytrimethylsilane (3a)**[4]




**3a**

$^1$H NMR (300 MHz, $CDCl_3$): 7.24-7.38 (m, 5H), 4.71 (s, 2H), 0.16 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 141.0, 128.3, 127.1, 126.5, 64.6, -0.4.

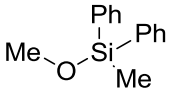
**(Cinnamyloxy)trimethylsilane (4a)**[5]




**4a**

$^1$H NMR (300 MHz, $CDCl_3$): 7.19-7.42 (m, 5H), 6.60 (d, $J$ = 16.0 Hz, 1H), 6.31 (dt, $J_1$ = 16.0 Hz, $J_2$ = 5.5 Hz, 1H), 4.33 (dd, $J_1$ = 5.5 Hz, $J_2$ = 1.5 Hz, 2H), 0.19 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 137.0, 130.1, 128.8, 128.5, 127.4, 126.4, 63.4, -0.3.

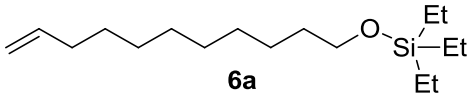
**Methoxy(methyl)diphenylsilane (5a)**[6]




**5a**

$^1$H NMR (300 MHz, $CDCl_3$): 7.62-7.69 (m, 4H), 7.39-7.50 (m, 6H), 3.60 (s, 3H), 0.70 (s, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$): 135.6, 134.3, 129.8, 127.9, 51.2, -3.4.

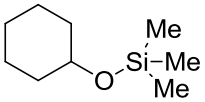
**Triethyl(undec-10-enyloxy)silane (6a)**[7]




**6a**

$^1$H NMR (300 MHz, $CDCl_3$): 5.74-5.88 (m, 1H), 4.99 (dd, $J_1$ = 17.0 Hz, $J_2$ = 2.0 Hz, 1H), 4.93 (dd, $J_1$ = 10.5 Hz, $J_2$ = 2.0 Hz, 1H), 3.59 (t, $J$ = 6.5 Hz, 2H), 2.04 (m, 2H), 1.46-1.57 (m, 2H), 1.24-1.42 (m, 12H), 0.96 (t, $J$ = 8.0 Hz, 9H), 0.60 (q, $J$ = 8.0 Hz, 6H); $^{13}$C NMR (75 MHz, $CDCl_3$): 139.2, 114.1, 63.0, 33.8, 32.9, 29.6, 29.4, 29.1, 28.9, 25.8, 6.8, 4.4.

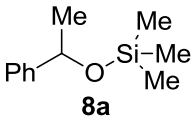
**(Cyclohexyloxy)trimethylsilane (7a)**[8]




**7a**

$^1$H NMR (300 MHz, $CDCl_3$): 3.53 (m, 1H), 1.74 (m, 4H), 1.52 (m, 1H), 1.22 (m, 5H), 0.10 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 71.1, 36.1, 25.5, 24.5, 0.2.

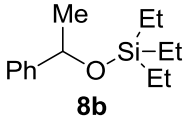
**Trimethyl(1-phenylethoxy)silane (8a)**[9]




**8a**

$^1$H NMR (300 MHz, $CDCl_3$): 7.20-7.38 (m, 4H), 4.87 (q, $J$ = 6.5 Hz, 1H), 1.45 (d, $J$ = 6.5 Hz, 3H), 0.09 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 146.4, 128.1, 126.8, 125.3, 70.6, 26.8, 0.1.

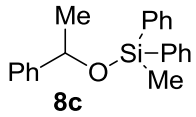
**Triethyl(1-phenylethoxy)silane (8b)**[10]




**8b**

$^1$H NMR (300 MHz, $CDCl_3$): 7.19-7.38 (m, 5H), 4.86 (q, *J* = 6.5 Hz, 1H), 1.43 (d, *J* = 6.5 Hz, 3H), 0.91 (t, *J* = 8.0 Hz, 9H), 0.57 (m, 6H); $^{13}$C NMR (75 MHz, $CDCl_3$): 146.9, 128.1, 126.7, 125.2, 70.5, 27.2, 6.8, 4.8.

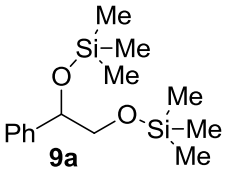
**Methyldiphenyl(1-phenylethoxy)silane (8c)**[11]




**8c**

$^1$H NMR (300 MHz, $CDCl_3$): 7.22-7.65 (m, 15H), 4.97 (q, *J* = 6.5 Hz, 1H), 1.48 (d, *J* = 6.5 Hz, 3H), 0.58 (s, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$): 146.1, 136.5, 136.4, 134.4, 134.3, 129.7, 128.1, 127.8, 127.7, 126.9, 125.4, 71.5, 26.9, -2.4.

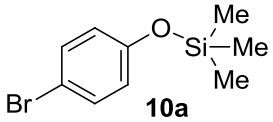
**2,2,7,7-Tetramethyl-4-phenyl-3,6-dioxa-2,7-disilaoctane (9a)**[5]




**9a**

$^1$H NMR (300 MHz, $CDCl_3$): 7.21-7.39 (m, 5H), 4.71 (dd, $J_1$ = 6.5 Hz, $J_2$ = 5.0 Hz, 1H), 3.63 (dd, $J_1$ = 10.5 Hz, $J_2$ = 6.5 Hz, 1H), 3.59 (dd, $J_1$ = 10.5 Hz, $J_2$ = 5.0 Hz, 1H), 0.09 (s, 9H), 0.06 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 142.2, 128.0, 127.3, 126.3, 75.8, 69.1, 0.2, -0.5.

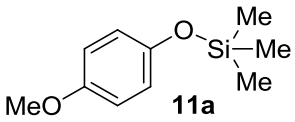
**(4-Bromobenzyloxy)trimethylsilane (10a)**[5]




**10a**

$^1$H NMR (300 MHz, $CDCl_3$): 7.33 (d, *J* = 8.5 Hz, 2H), 6.72 (d, *J* = 8.5 Hz, 2H), 0.26 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 154.4, 132.3, 121.9, 113.8, 0.1.

**(4-Methoxybenzyloxy)trimethylsilane (11a)**[5]



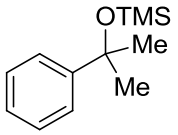

**11a**

$^1$H NMR (300 MHz, $CDCl_3$): 6.78 (br s, 4H), 3.76 (s, 3H), 0.24 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 154.2, 148.8, 120.7, 114.5, 55.6, 0.1.

## Spectroscopic data of products from the reaction of hexamethyldisilane with tertiary alcohols

Among the products of Table 2, cumene (**12a**) *p*-cymene (**13a**), and triphenylmethane (**15a**) are comemrcially avilable substances.

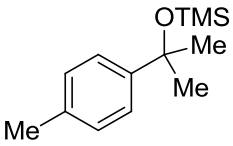
**Trimethyl(2-phenylpropan-2-yloxy)silane (12b)**[5]



**12b**

$^1$H NMR (300 MHz, $CDCl_3$): 7.45 (d, *J* = 7.5 Hz, 2H), 7.18-7.33 (m, 3H), 1.60 (s, 6H), 0.10 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 150.1, 127.9, 126.3, 124.7, 75.2, 32.5, 2.4.

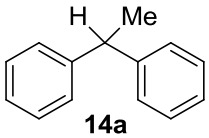
**Trimethyl(2-*p*-tolylpropan-2-yloxy)silane (13b)**



**13b**

$^1$H NMR (300 MHz, $CDCl_3$): 7.38 (d, *J* = 7.5 Hz, 2H), 7.14 (d, *J* = 7.5 Hz, 2H), 2.38 (s, 3H), 1.62 (s, 6H), 0.14 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 147.1, 135.1, 128.5, 124.6, 75.0, 32.5, 20.9, 2.4; MS (EI): 222 ($M^+$, 1%), 207 ($M^+$-Me, 31%), 132 (22%), 91 (34%), 75 (100%).

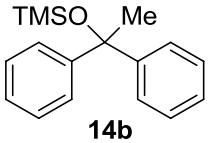
**Ethane-1,1-diyldibenzene (14a)**



**14a**

$^1$H NMR (300 MHz, $CDCl_3$): 7.20-7.34 (m, 10H), 4.18 (q, *J* = 7.0 Hz, 1H), 1.67 (d, *J* = 7.0 Hz, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$): 146.3, 128.3, 127.6, 126.0, 44.8, 21.8.

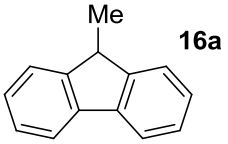
**(1,1-Diphenylethoxy)trimethylsilane (14b)**[4]



**14b**

$^1$H NMR (300 MHz, $CDCl_3$): 7.40 (d, *J* = 7.5 Hz, 4H), 7.17-7.32 (m, 6H), 1.97 (s, 3H), 0.01 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 149.3, 127.8, 126.5, 126.1, 78.4, 30.6, 2.0.

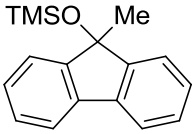
**9-Methyl-9*H*-fluorene (16a)**



**16a**

$^1$H NMR (300 MHz, $CDCl_3$): 7.69 (d, *J* = 7.0 Hz, 2H), 7.53 (d, *J* = 7.0 Hz, 2H), 7.32-7.43 (m, 4H), 3.97 (q, *J* = 7.5 Hz, 1H), 1.55 (d, *J* = 7.5 Hz, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$): 148.9, 140.5, 126.9, 124.0, 119.8, 42.4, 18.2.

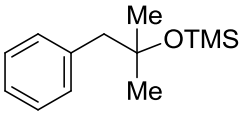
**Trimethyl(9-methyl-9*H*-fluoren-9-yloxy)silane (16b)**




**16b**

$^1$H NMR (300 MHz, $CDCl_3$): 7.63 (d, *J* = 7.0 Hz, 2H), 7.53 (d, *J* = 7.0 Hz, 2H), 7.29-7.36 (m, 4H), 1.72 (s, 3H), -0.34 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 150.1, 138.9, 128.6, 127.6, 123.9, 119.9, 81.2, 29.3, 1.3; MS (EI): 268 ($M^+$, 4%), 253 ($M^+$-Me, 27%), 178 (56%), 152 (17%), 75 (100%).

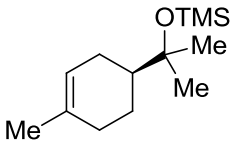
**Trimethyl(2-methyl-1-phenylpropan-2-yloxy)silane (17b)**[12]




**17b**

$^1$H NMR (300 MHz, $CDCl_3$): 7.15-7.35 (m, 5H), 2.73 (s, 2H), 1.22 (s, 6H), 0.07 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 138.8, 130.7, 127.5, 125.9, 74.1, 51.1, 29.7, 2.5.

**(*S*)-Trimethyl(2-(4-methylcyclohex-3-enyl)propan-2-yloxy)silane (18b)**[2]




**18b**

$^1$H NMR (300 MHz, $CDCl_3$): 5.38 (br s, 1H), 1.97 (m, 2H), 1.72-2.10 (m, 5H), 1.65 (br s, 3H), 1.45 (m, 1H), 1.18-1.24 (m, 1H), 1.18 (s, 3H), 1.16 (s, 3H), 0.09 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): 133.9, 121.1, 75.7, 45.8, 31.2, 27.7, 27.0, 26.9, 24.0, 23.4, 2.6.

## References

**1.** H. Gilman, R. K. Ingham and A. G. Smith, *J. Org. Chem.*, 1953, **18**, 1743.

**2.** Y. Tanabe, H. Okumura, A. Maeda and M. Murakami, *Tetrahedron Lett.*, 1994, **35**, 8413.

**3.** K. Hara, R. Akiyama, S. Takakusagi, K. Uosaki, T. Yoshino, H. Kagi and M. Sawamura, *Angew. Chem., Int. Ed.*, 2008, **47**, 5627.

**4.** S. T. Kadam and S. S. Kim, *Green Chem.*, 2010, **12**, 94.

**5.** M. Jereb, *Tetrahedron*, 2012, **68**, 3861.

**6.** T. R. Owens, J. Grinyer and W. J. Leigh, *Organometallics*, 2005, **24**, 2307.

**7.** R. Bourhis, E. Frainnet and F. Moulines, *J. Organometal. Chem.*, 1977, **141**, 157.

**8.** H. Wang, R. Frohlich, G. Kehr and G. Erker, *Chem. Commun.*, 2008, 5966.

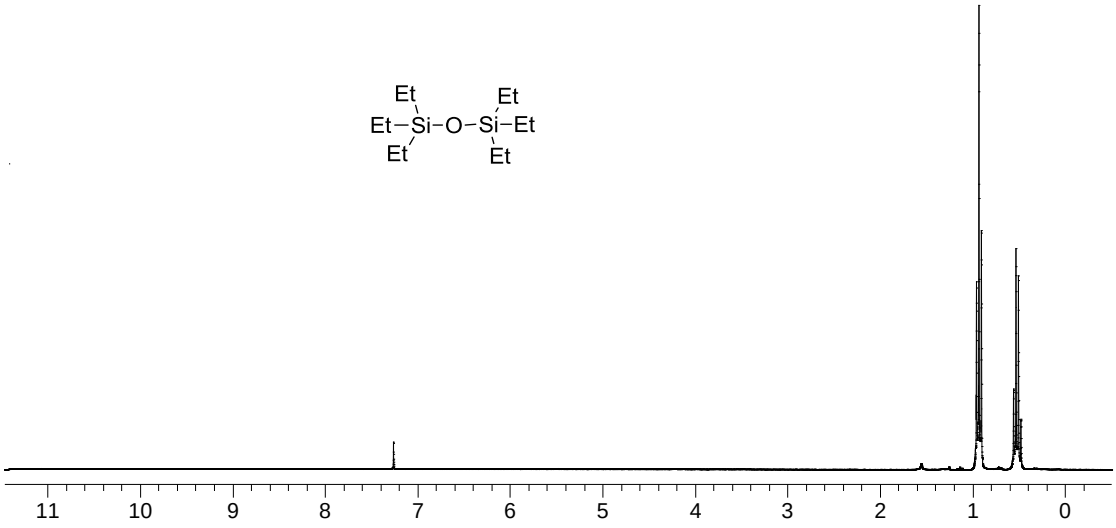
**9.** E. Shirakawa, K. Hironaka, H. Otsuda and T. Hayashi, *Chem. Commun.*, 2006, 3927.

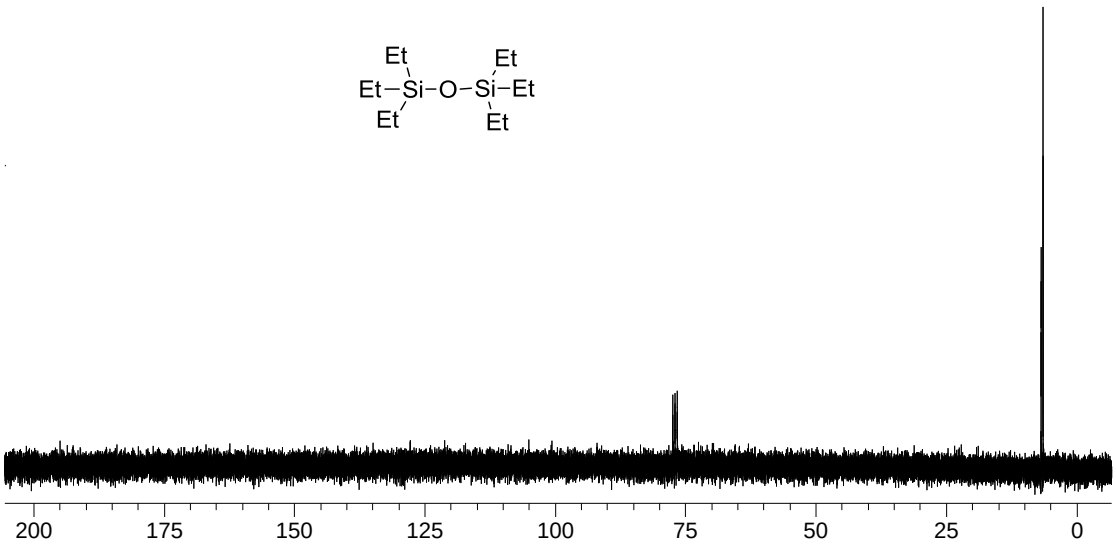
**10.** H. Ito, K. Takagi, T. Miyahara and M. Sawamura, *Org. Lett.*, 2005, **7**, 3001.

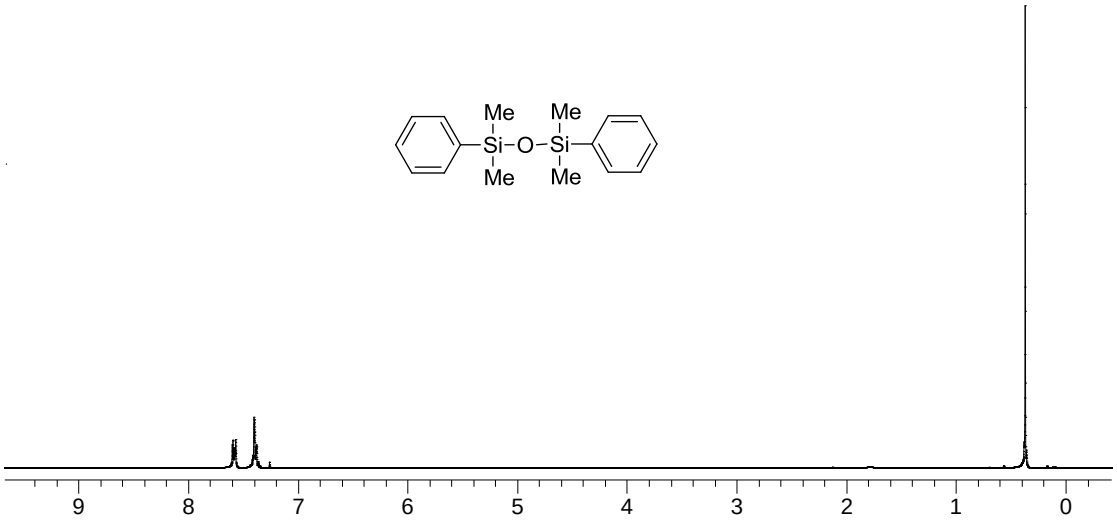
**11.** M. Mewald, R. Frohlich and M. Oestreich, *Chem. Eur. J.*, 2011, **17**, 9406.

**12.** A. Rostamit, A. Khazaei, M. Mahboubifar and S. Rahmati, *Org. Prep. Proc. Int.*, 2008, **40**, 303.

# $^{1}$H and $^{13}$C NMR spectra

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O
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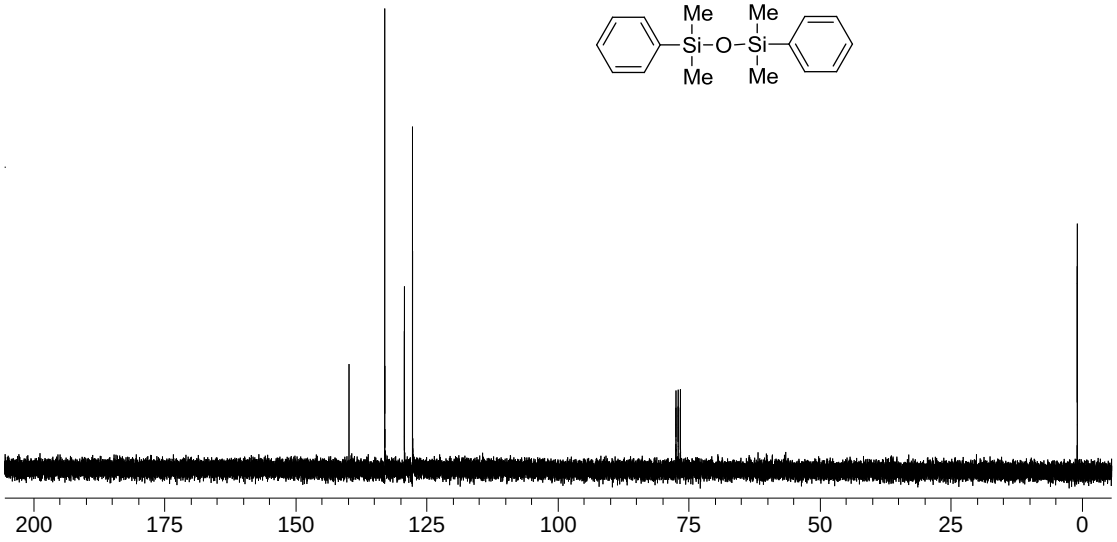
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Me
Si
O
Si
Me
Me
200
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50
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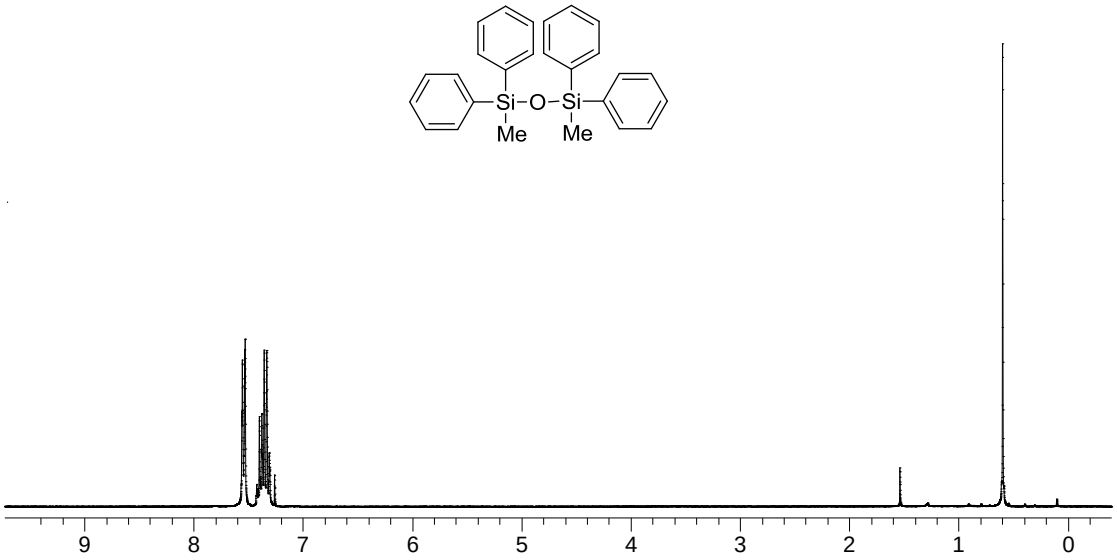
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O
Si
Me
Me
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6
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2
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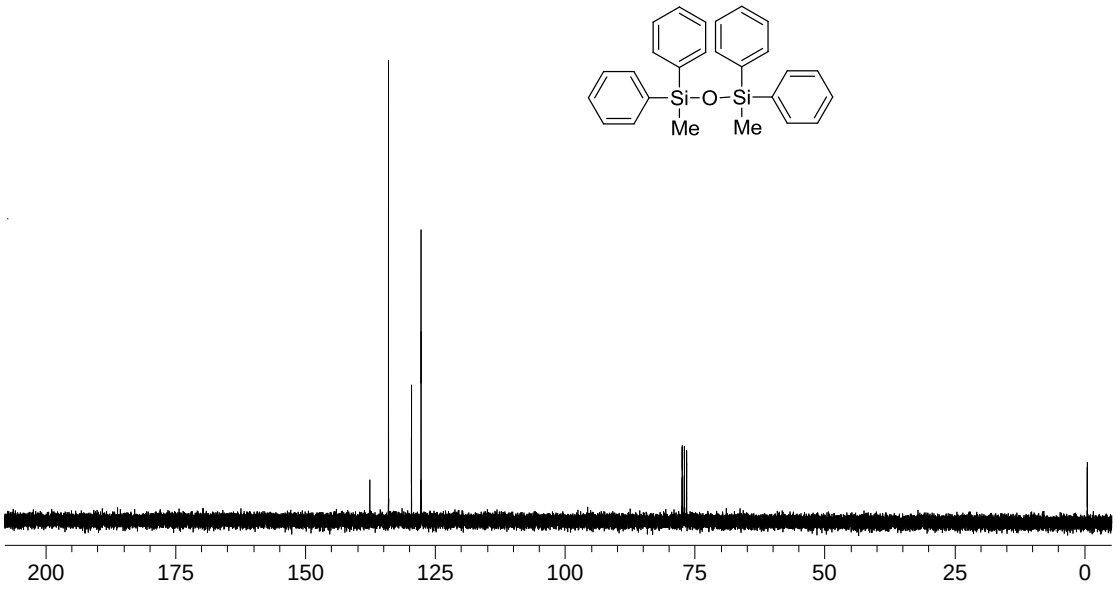
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Si
Me
Me
200
175
150
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100
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50
25
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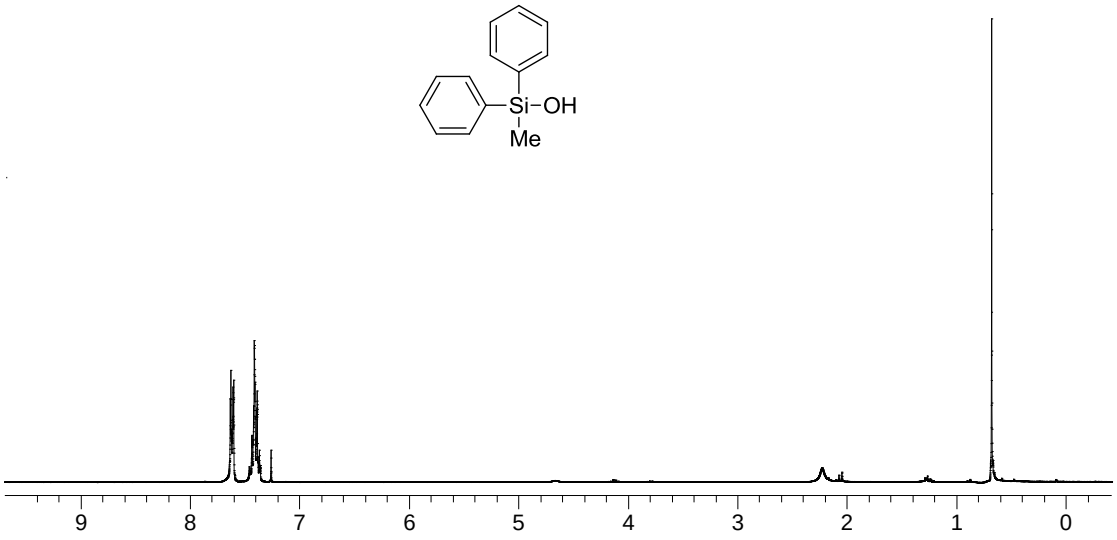
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Me
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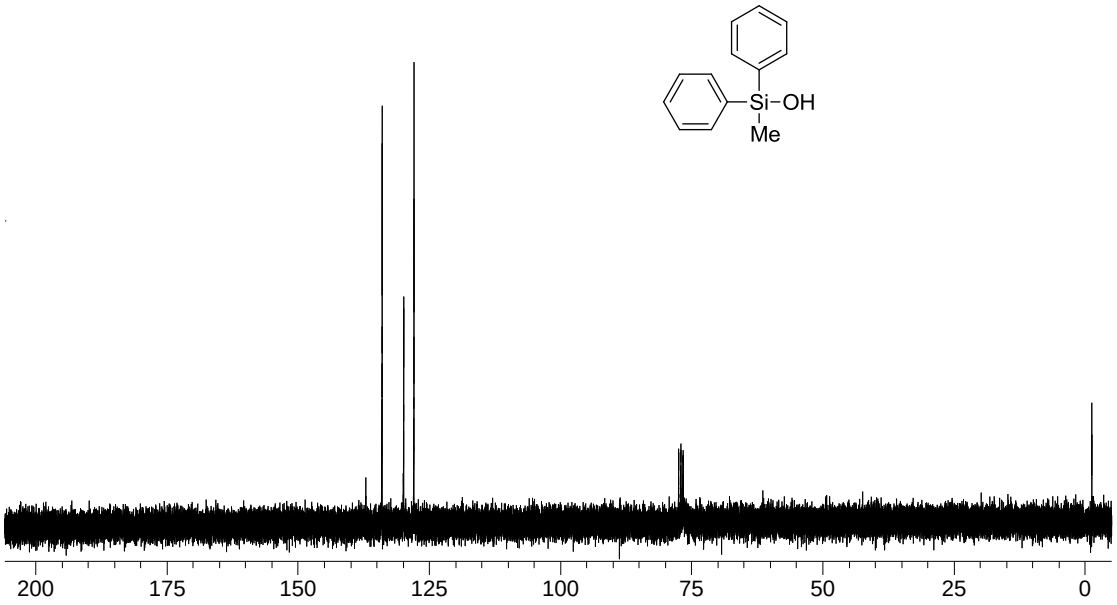
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200
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150
125
100
75
50
25
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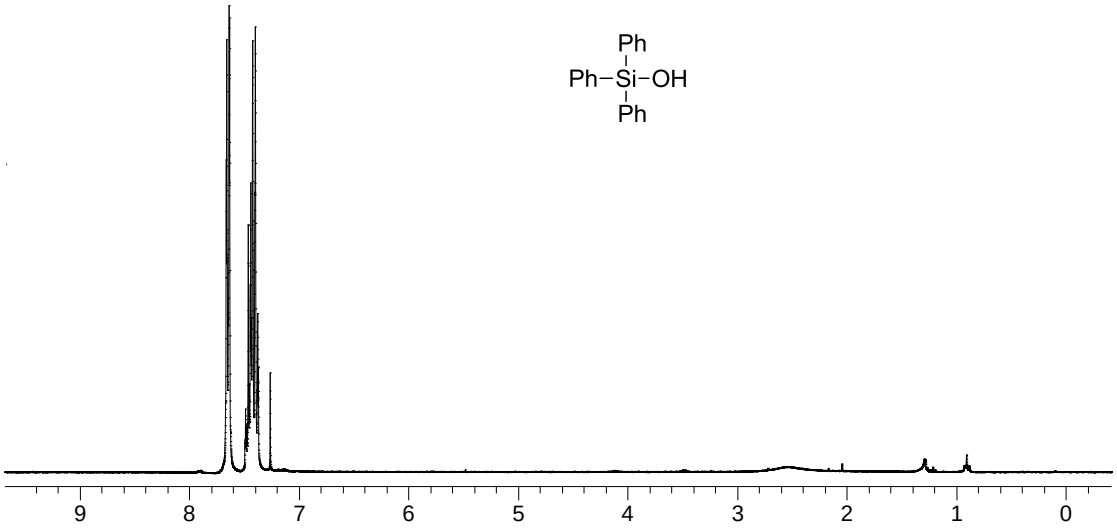


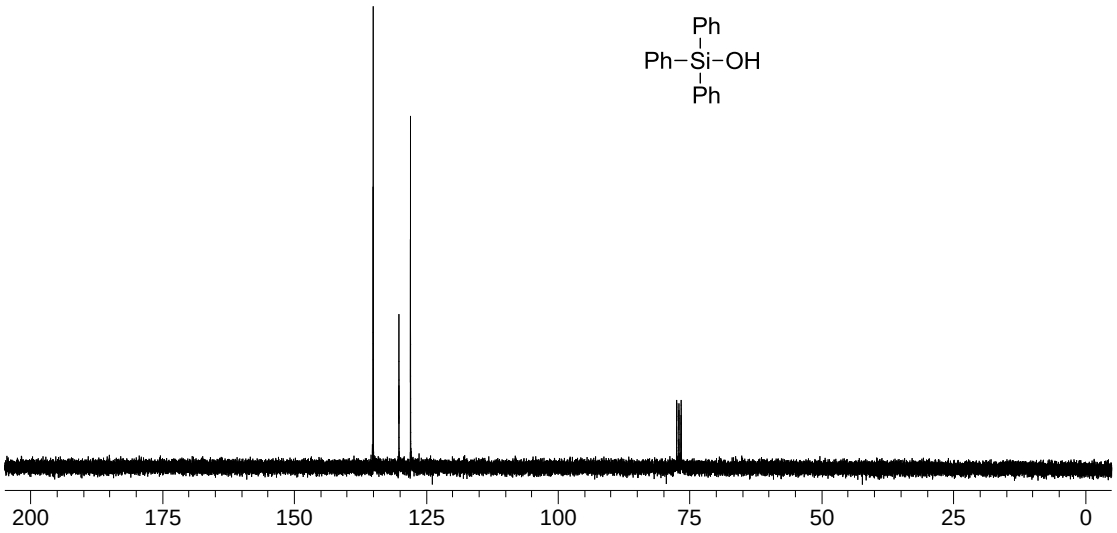

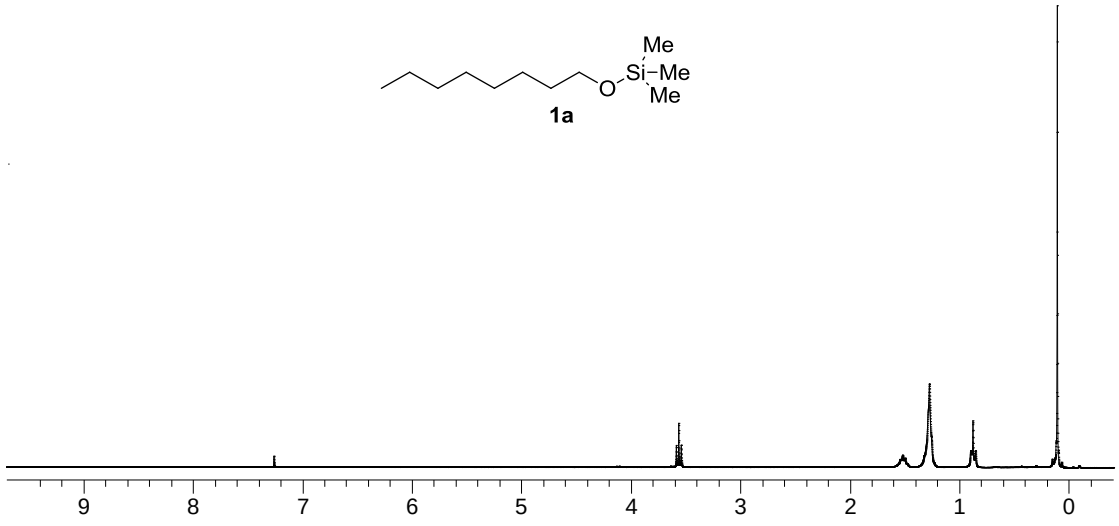
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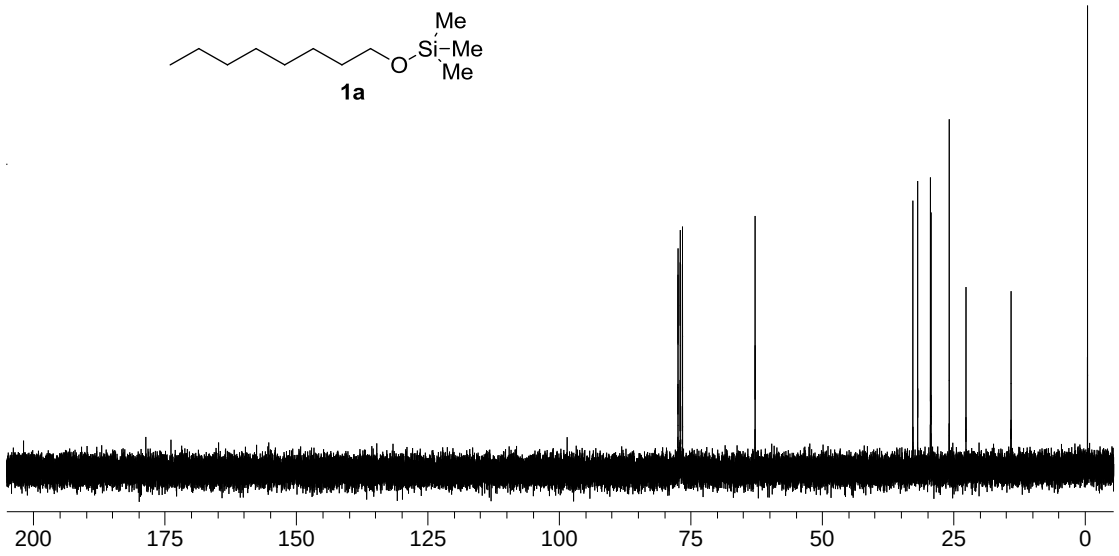
Si
Me
Me
O
1a
9
8
7
6
5
4
3
2
1
0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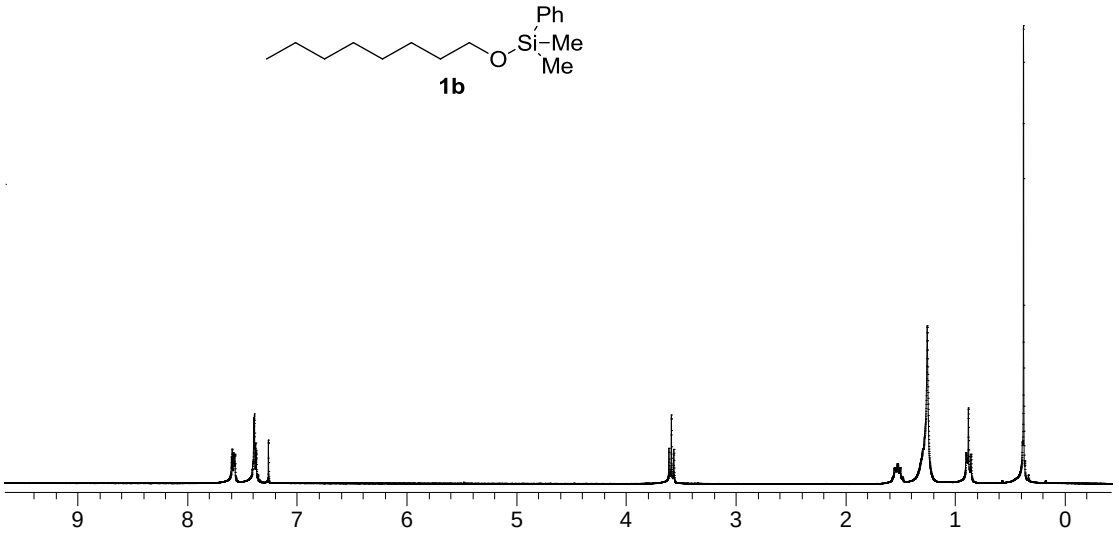
Si
Me
Me
O
1a
200
175
150
125
100
75
50
25
0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Si
Me
Me
O
1b
9
8
7
6
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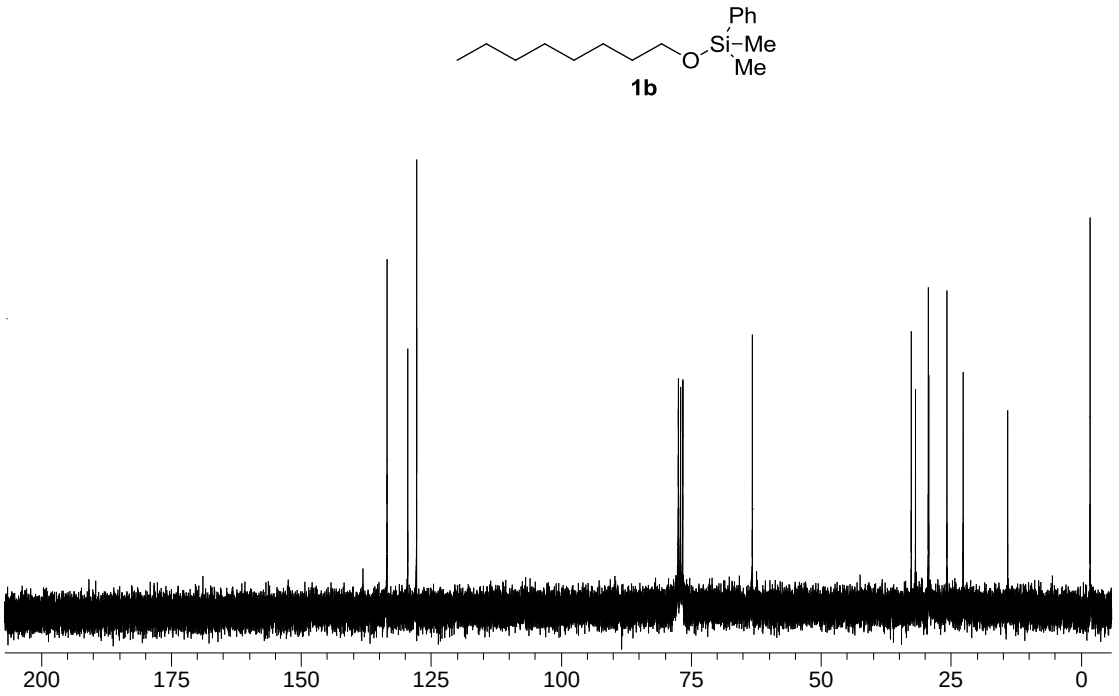
4
3
2
1
0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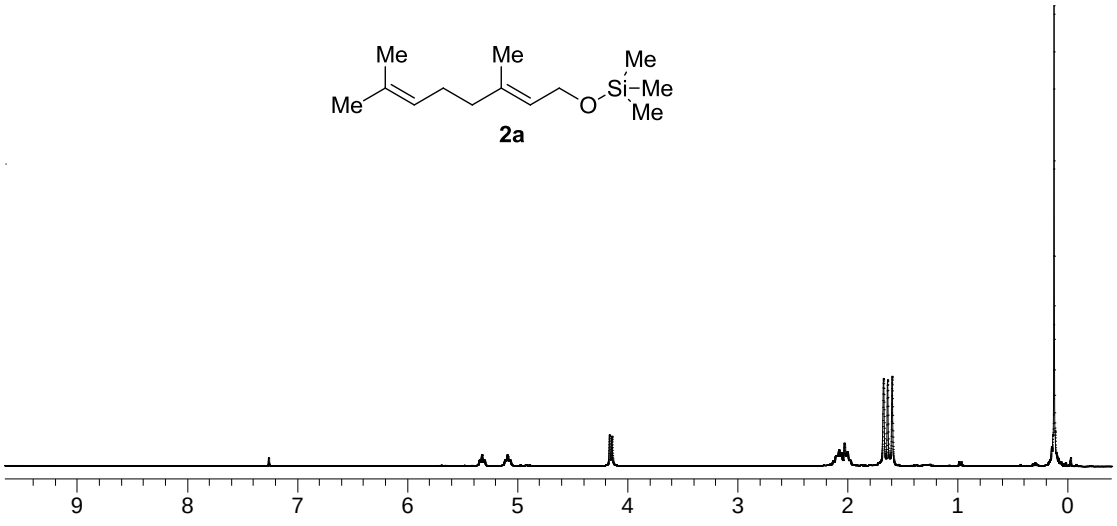
Si
Me
Me
O
1b
200
175
150
125
100
75
50
25
0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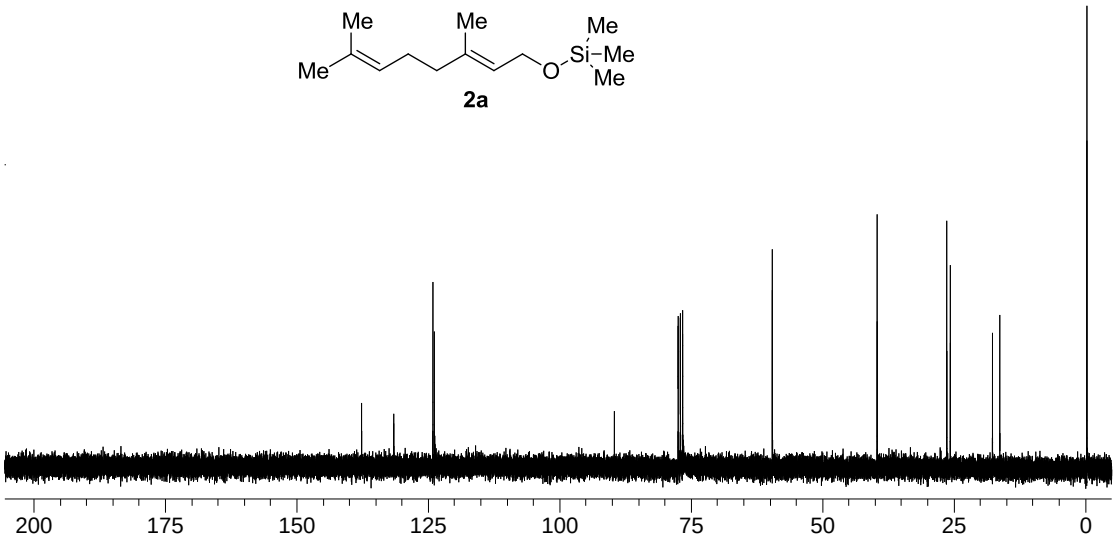
Me
Me
Me
Si
Me
Me
O
2a
9
8
7
6
5
4
3
2
1
0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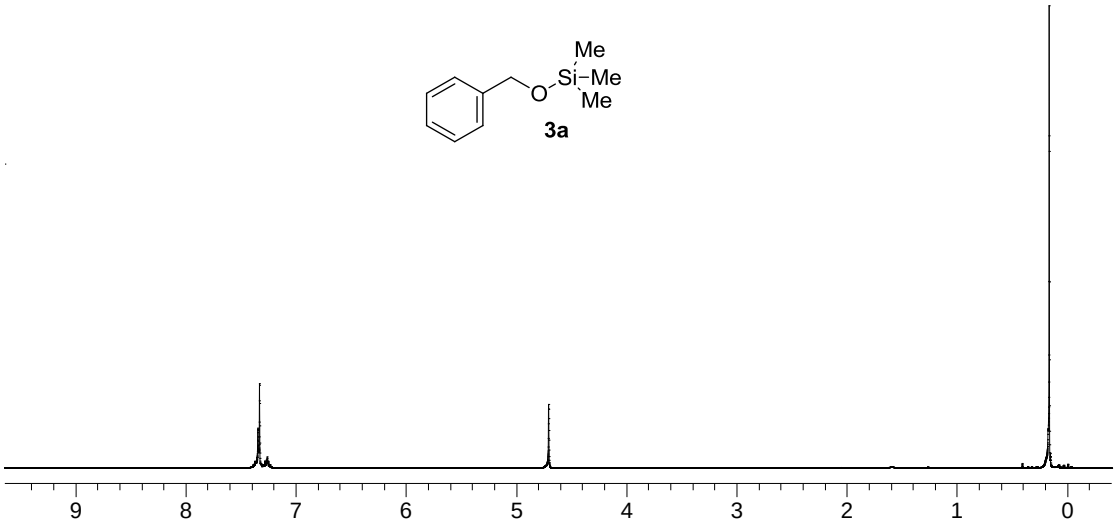
Me
Me
Si
Me
Me
O
2a
200
175
150
125
100
75
50
25
0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Si–Me
Me
O
3a
9
8
7
6
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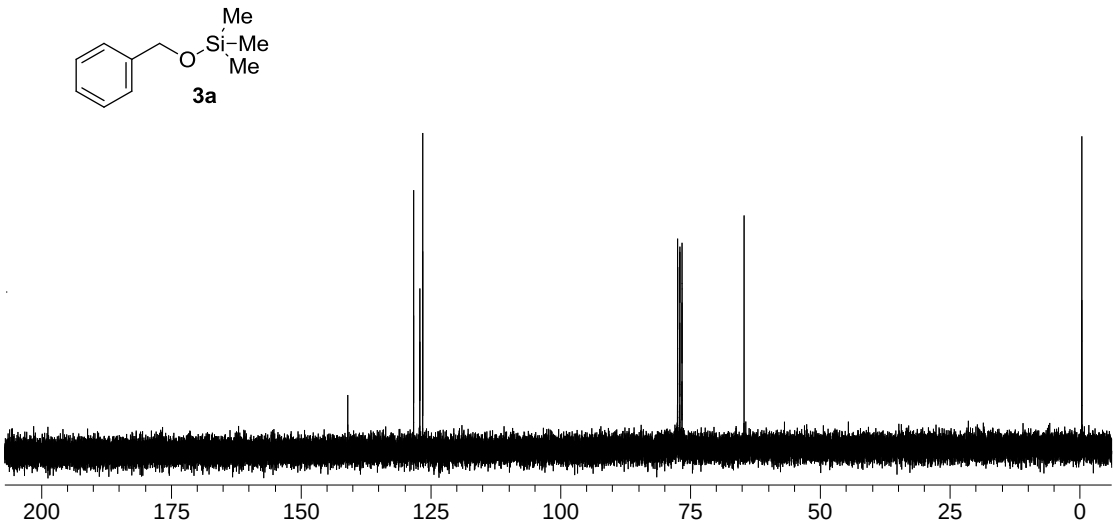
4
3
2
1
0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Me
O
3a
200
175
150
125
100
75
50
25
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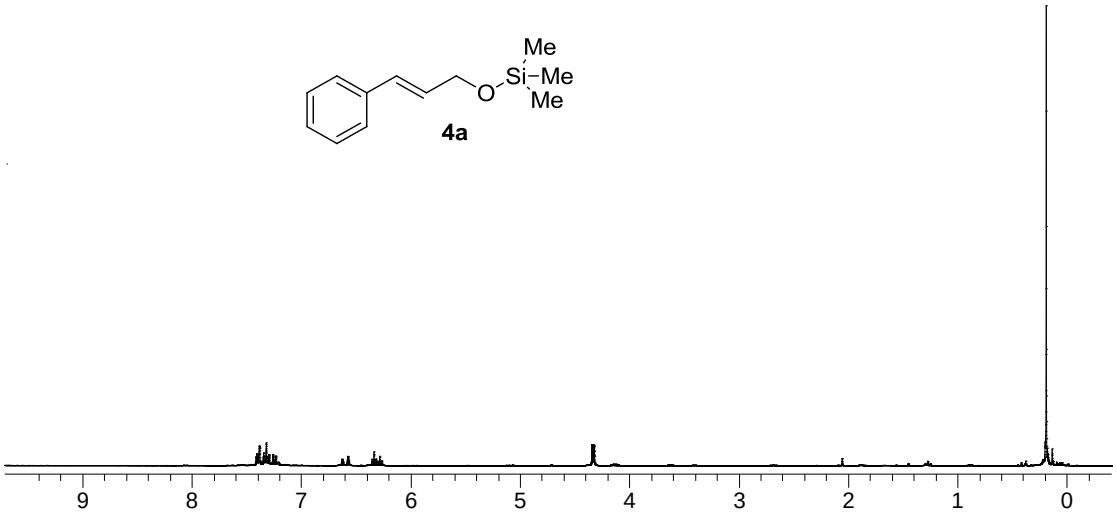
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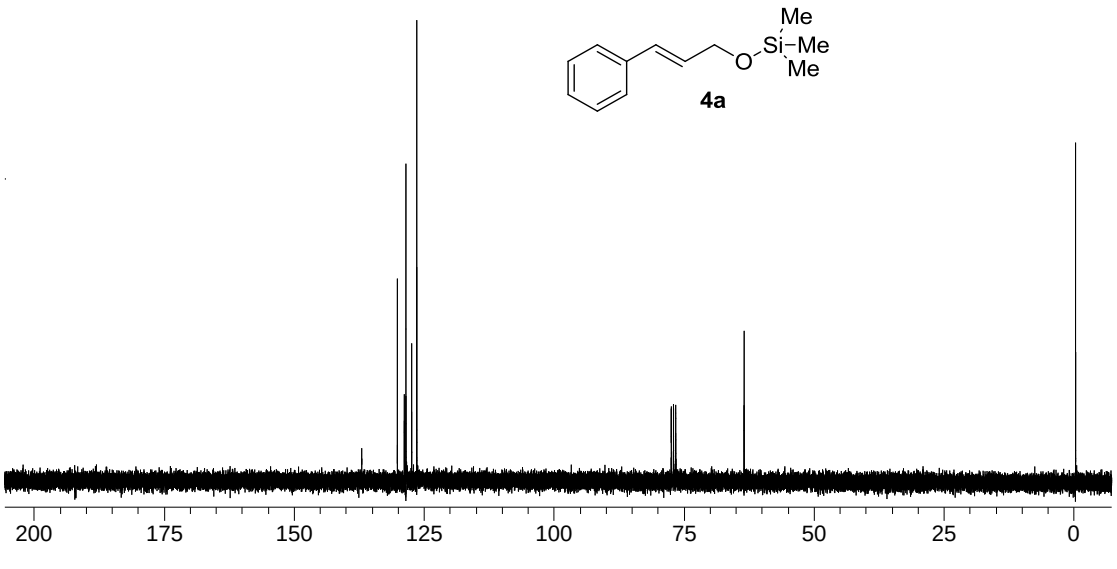
Si
Me
Me
O
4a
9
8
7
6
5
4
3
2
1
0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Si
Me
Me
O
4a
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150
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100
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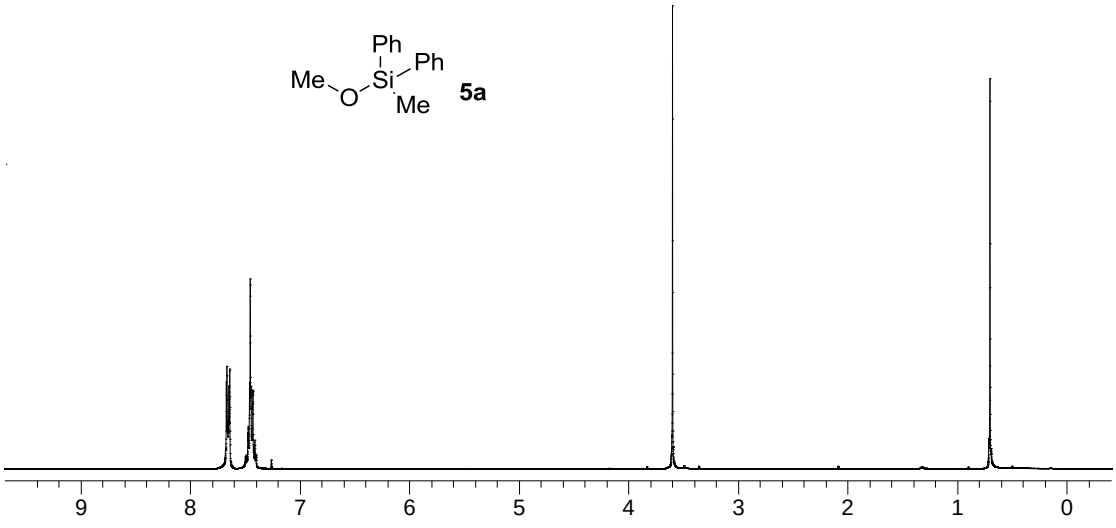
25
0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Ph
Me
O
Si
Me
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8
7
6
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4
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1
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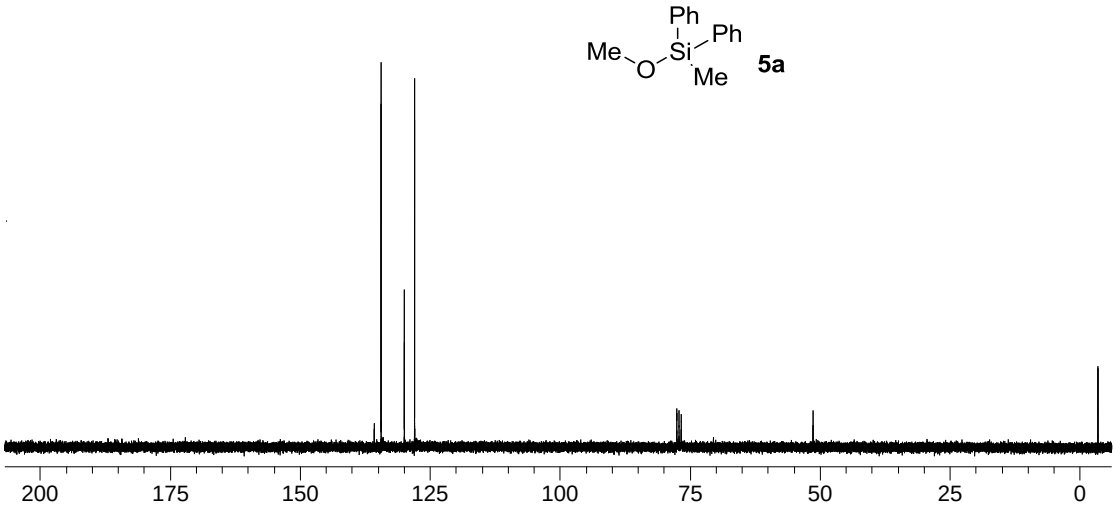
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Ph
Me
O
Si
Me
5a
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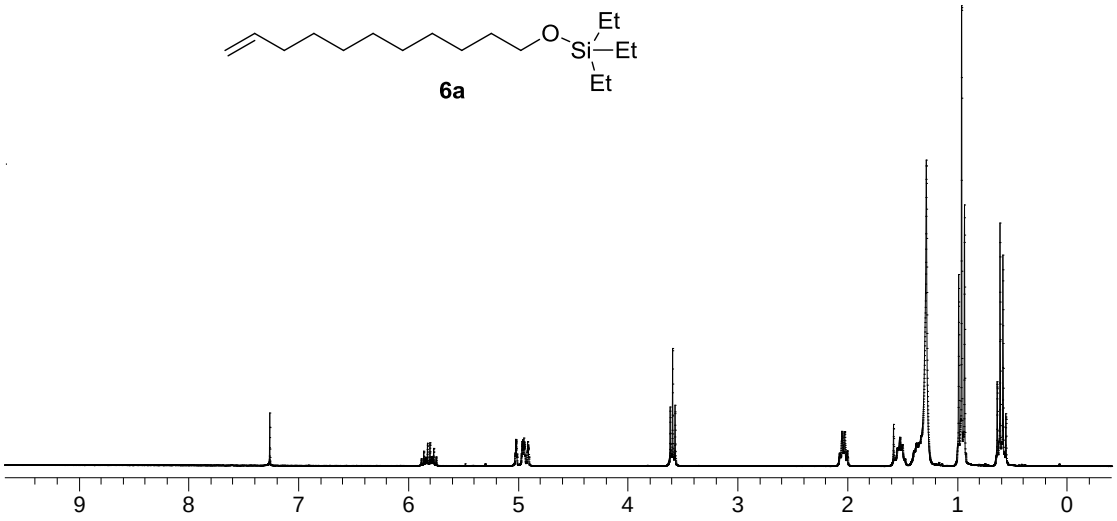
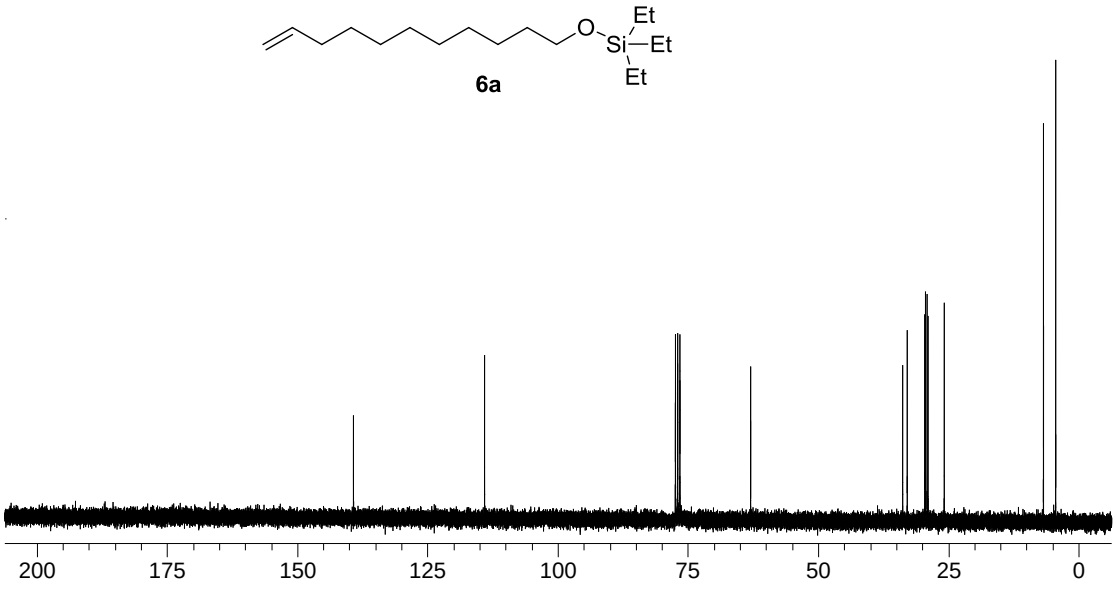

Et
O
Si
Et
Et
9
8
7
6
5
4
3
2
1
0

**6a**


Et
O
Si
Et
Et
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150
125
100
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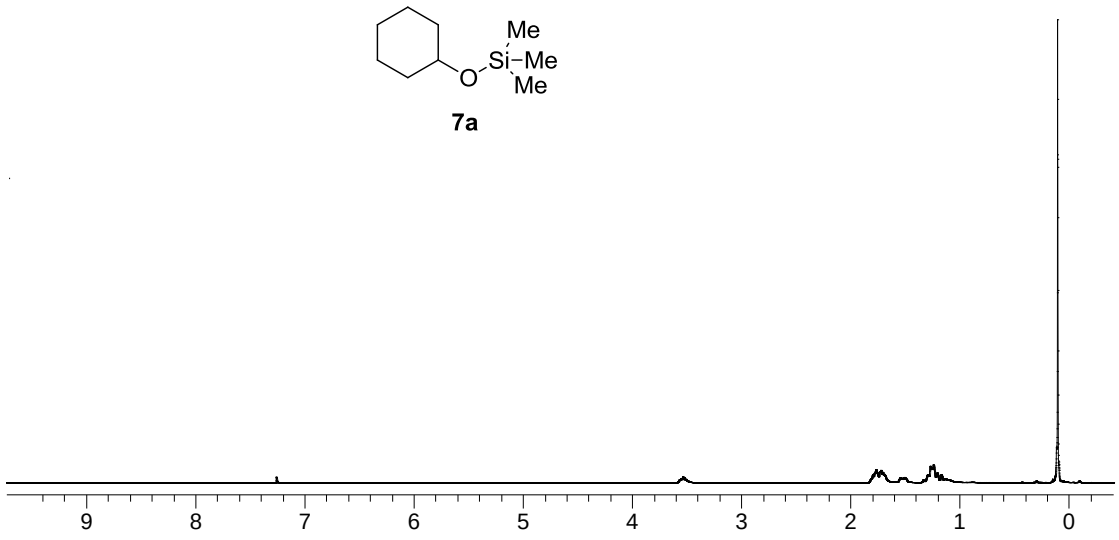
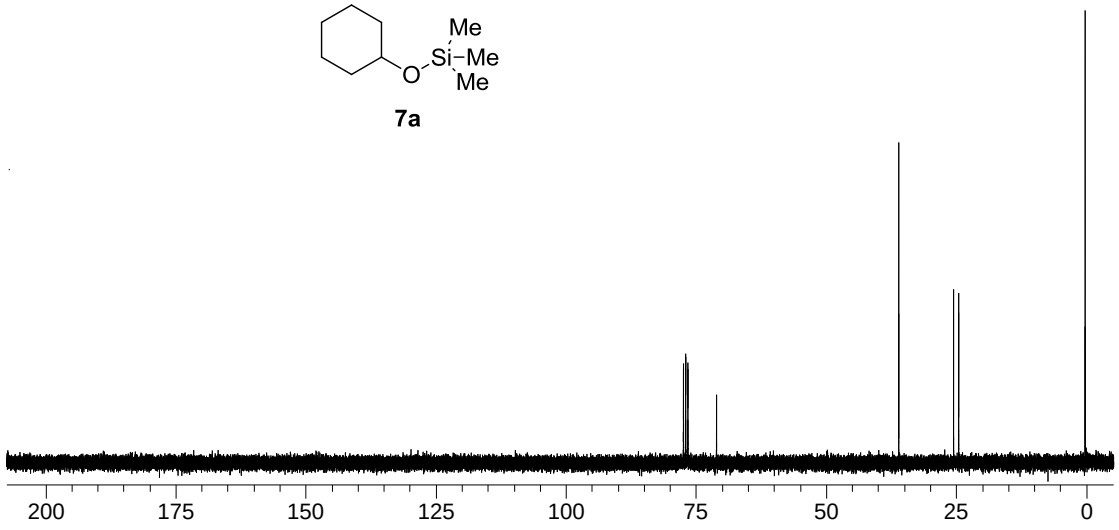
50
25
0

**6a**


Me
Si
Me
Me
O
9
8
7
6
5
4
3
2
1
0

**7a**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Si
Me
Me
O
200
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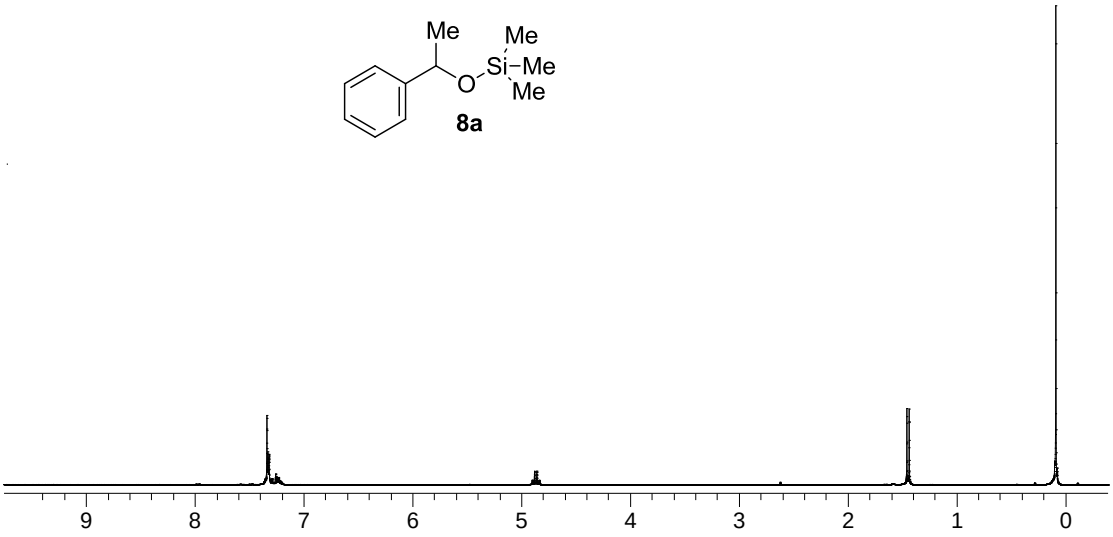
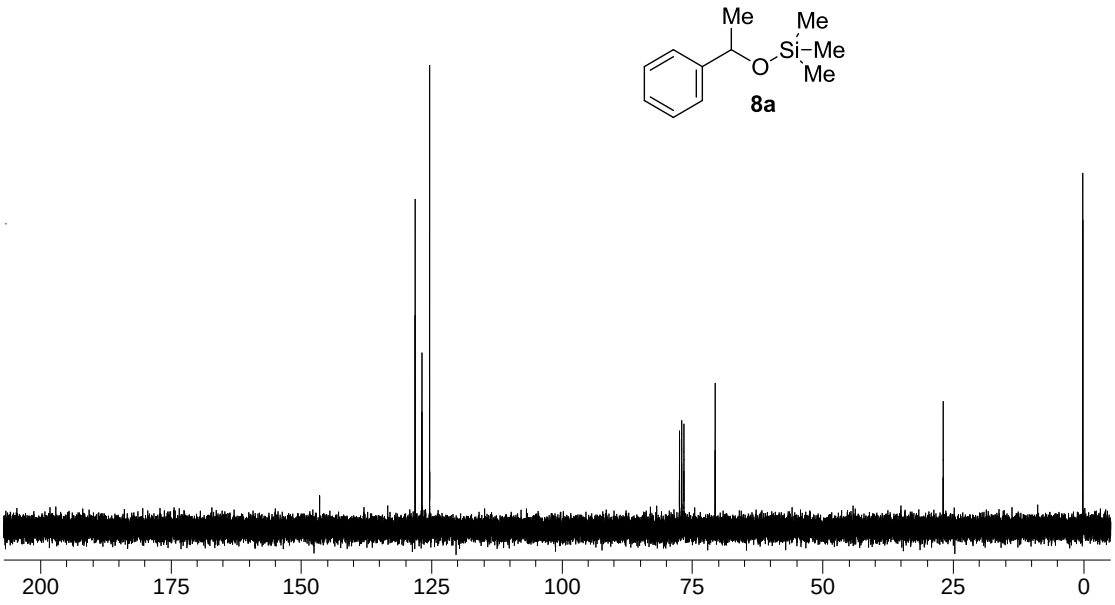
150
125
100
75
50
25
0

**7a**


Me
Me
Si–Me
O
Me
8a
9
8
7
6
5
4
3
2
1
0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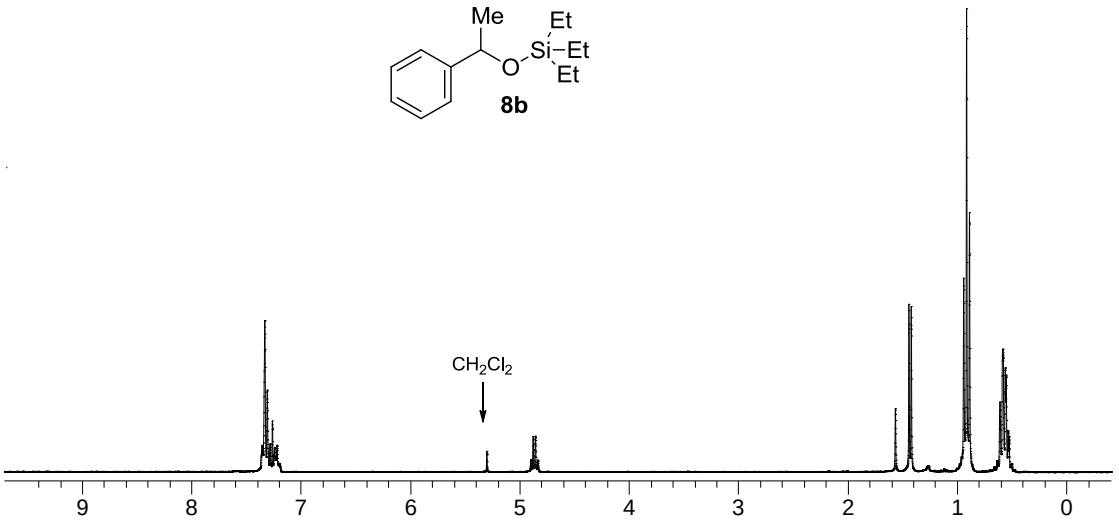
Me
Si–Me
O
Me
8a
200
175
150
125
100
75
50
25
0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Et
Si–Et
O
Et
8b
CH2Cl2
9
8
7
6
5
4
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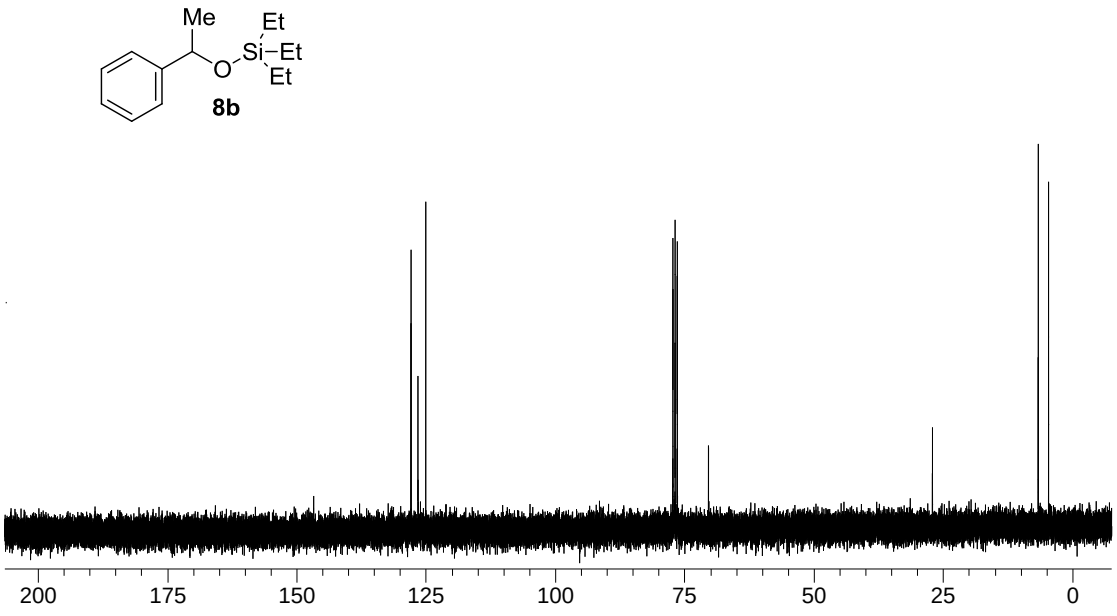
2
1
0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Si–Et
O
Et
8b
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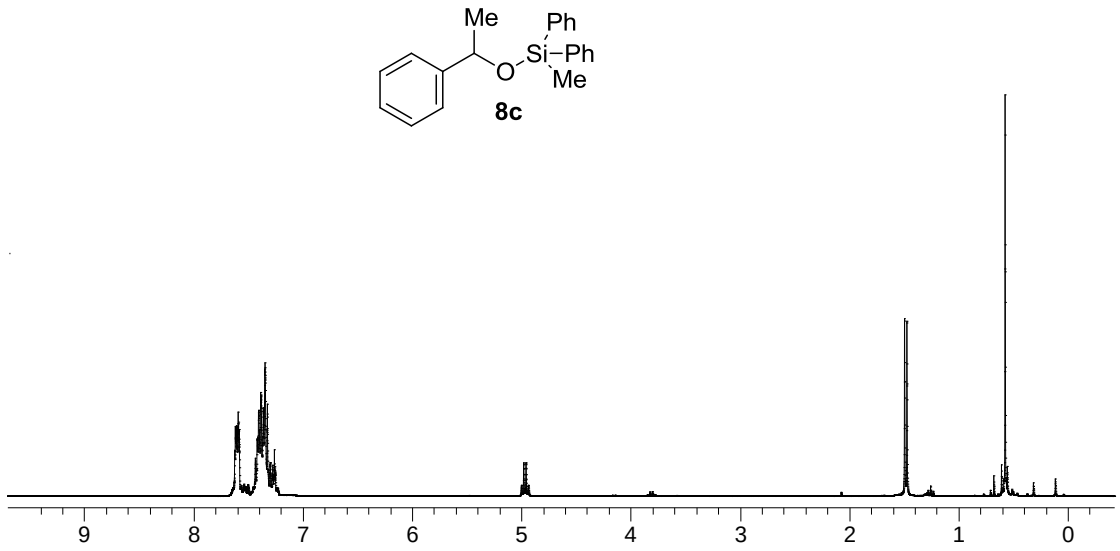
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Si–Ph
O
Me
8c
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8
7
6
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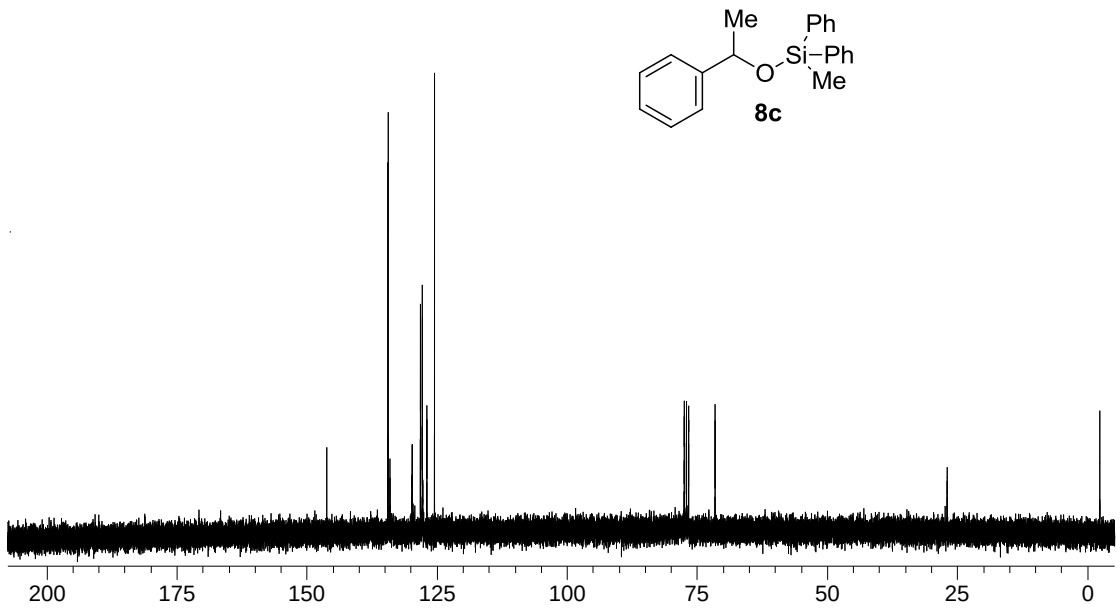
1
0


Me
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Si–Ph
O
Me
8c
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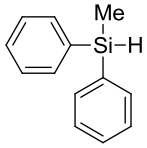
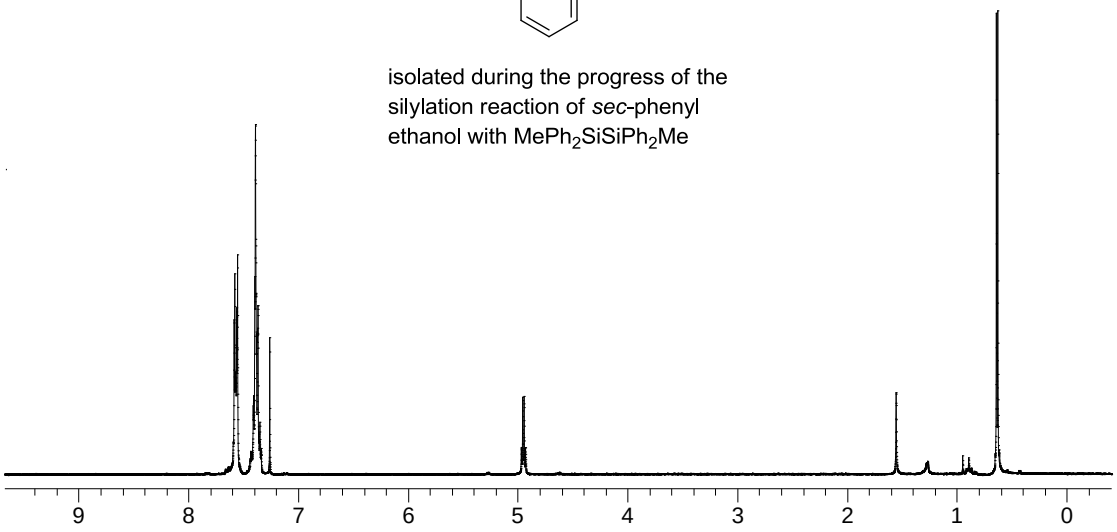
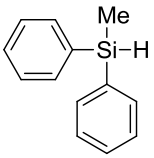
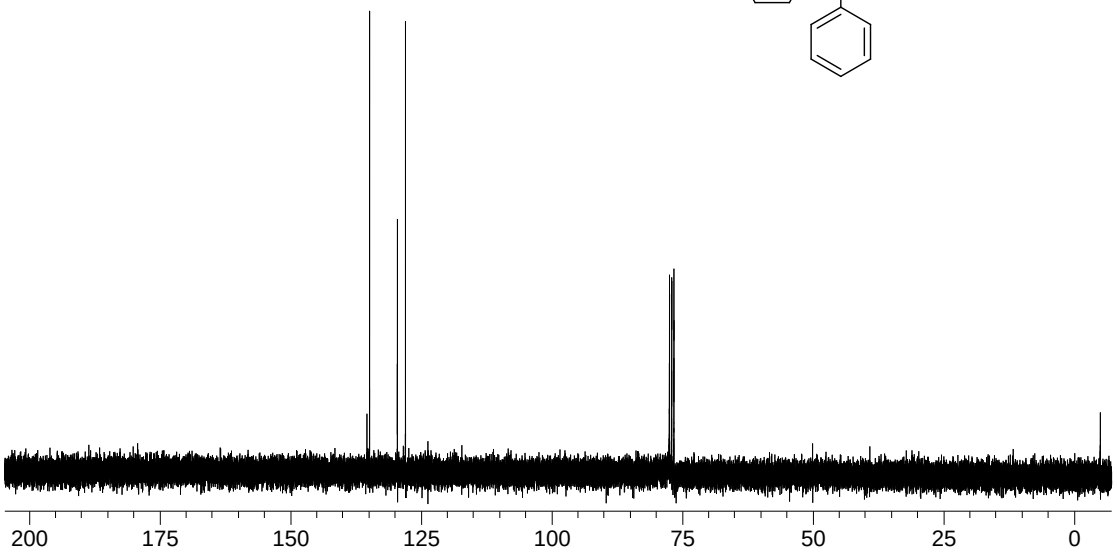
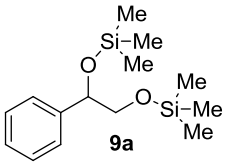



isolated during the progress of the silylation reaction of *sec*-phenyl ethanol with $MePh_2SiSiPh_2Me$



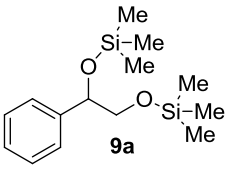




Me
Si–Me
Me
O
Me
O
Si–Me
Me

**9a**


9
8
7
6
5
4
3
2
1
0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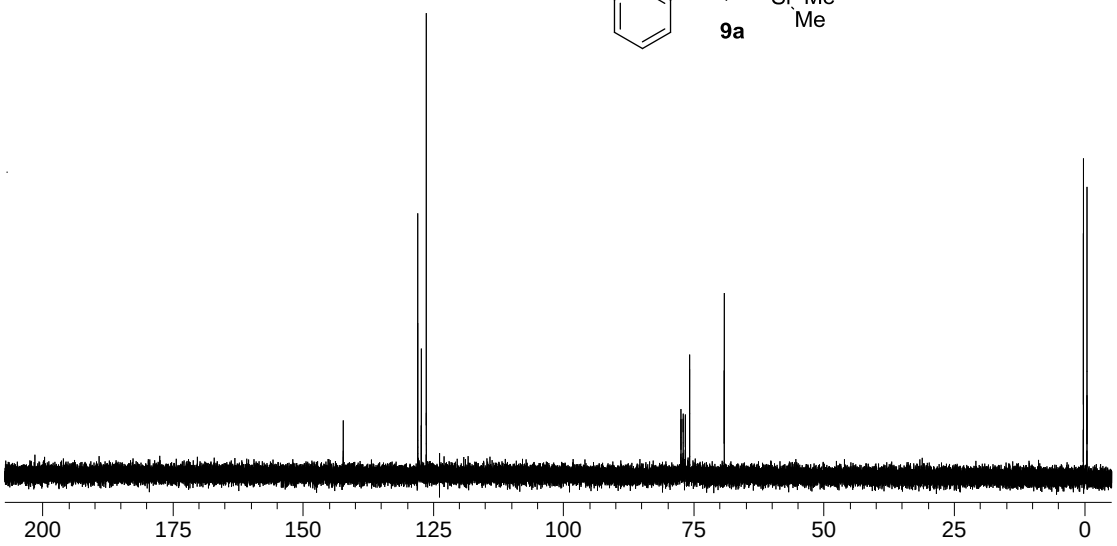
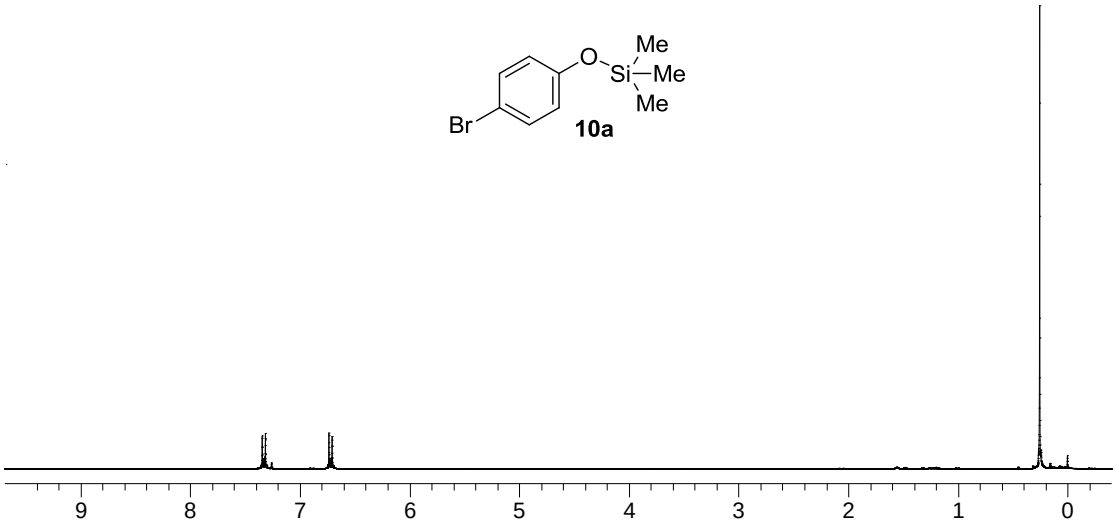
Si–Me
Me
O
Me
O
Si–Me
Me

**9a**


200
175
150
125
100
75
50
25
0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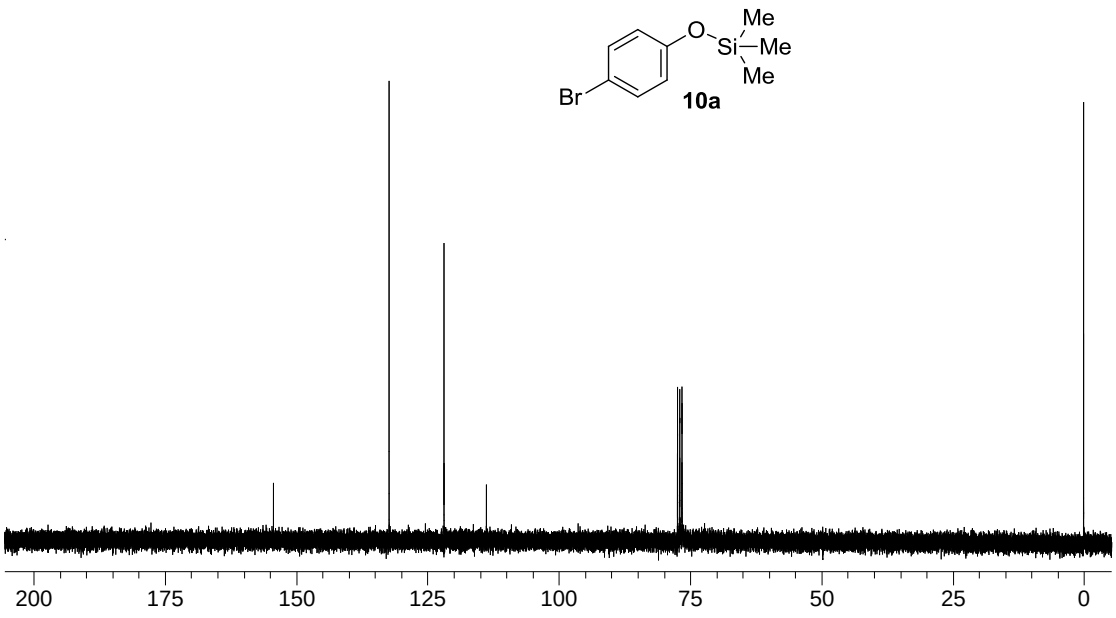
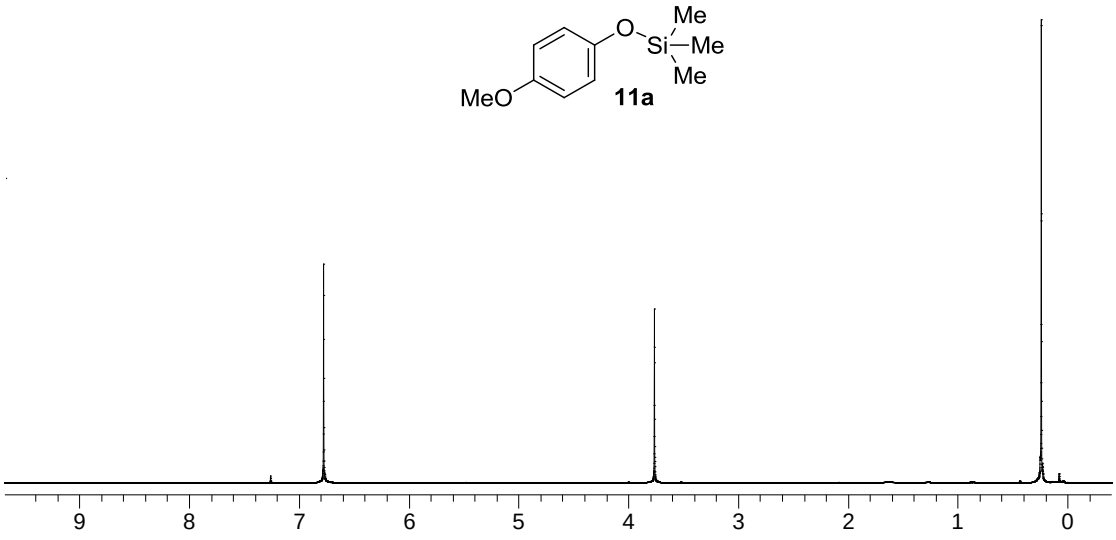
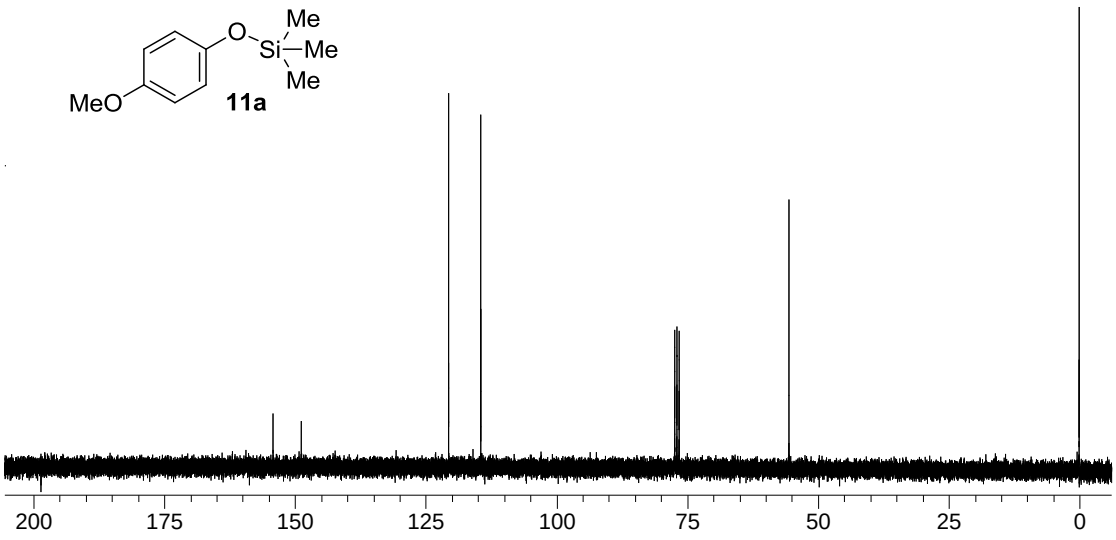
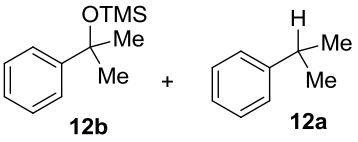
O
Si
Me
Me
Br
10a
9
8
7
6
5
4
3
2
1
0


Me
O
Si
Me
Me
Br
10a
200
175
150
125
100
75
50
25
0


Me
O
Si
Me
Me
MeO
11a
9
8
7
6
5
4
3
2
1
0

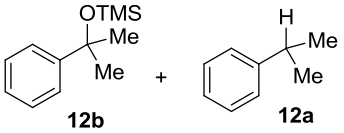

Me
O
Si
Me
Me
MeO
11a
200
175
150
125
100
75
50
25
0




**12b** **12a**

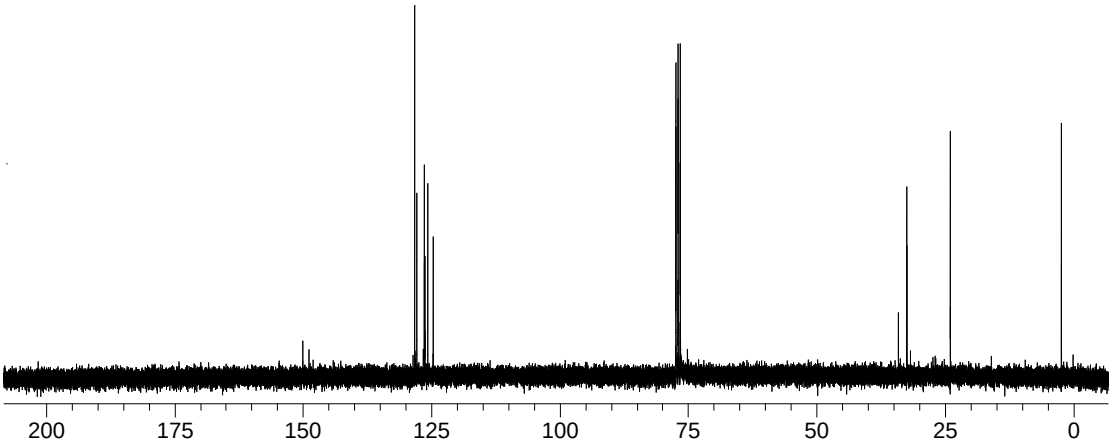
crude reaction mixture (**12a**:**12b**=25:75)

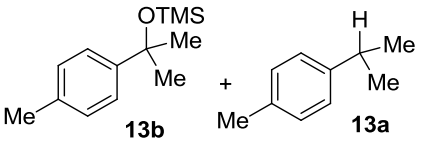


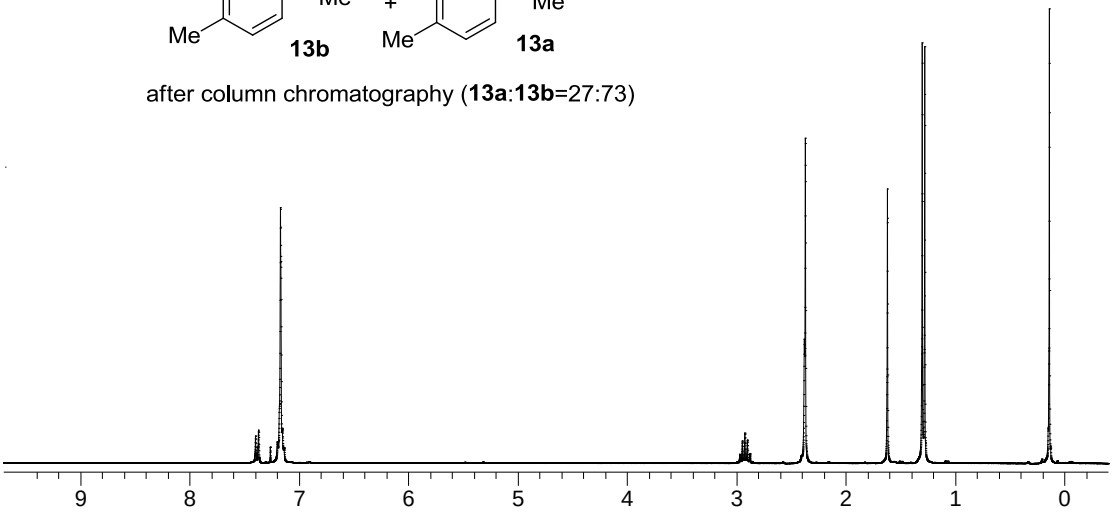

**12b** **12a**

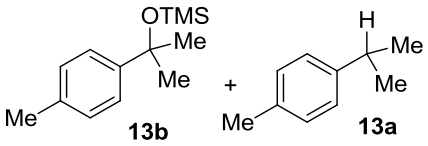
crude reaction mixture (**12a**:**12b**=25:75)



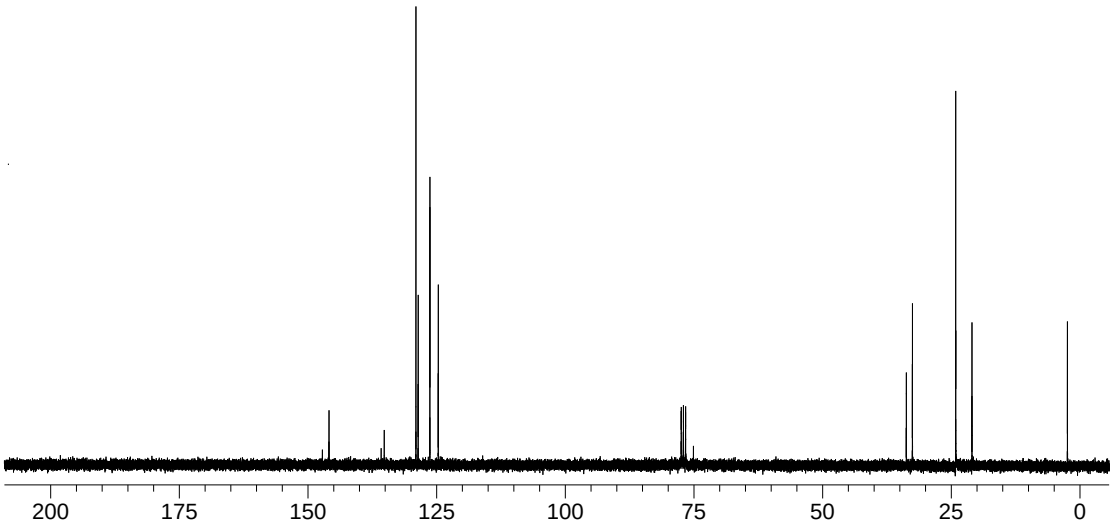


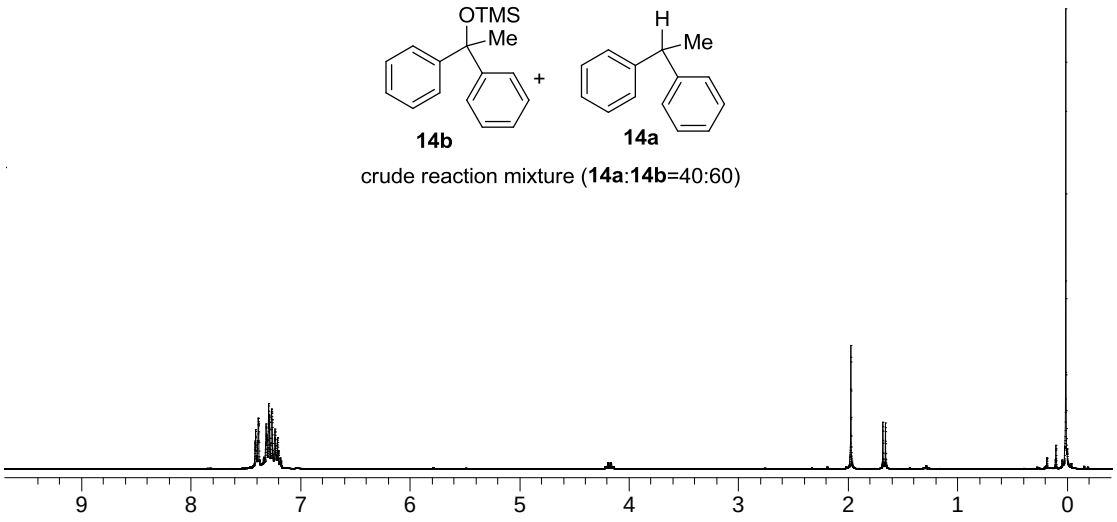

after column chromatography (**13a**:**13b**=27:73)

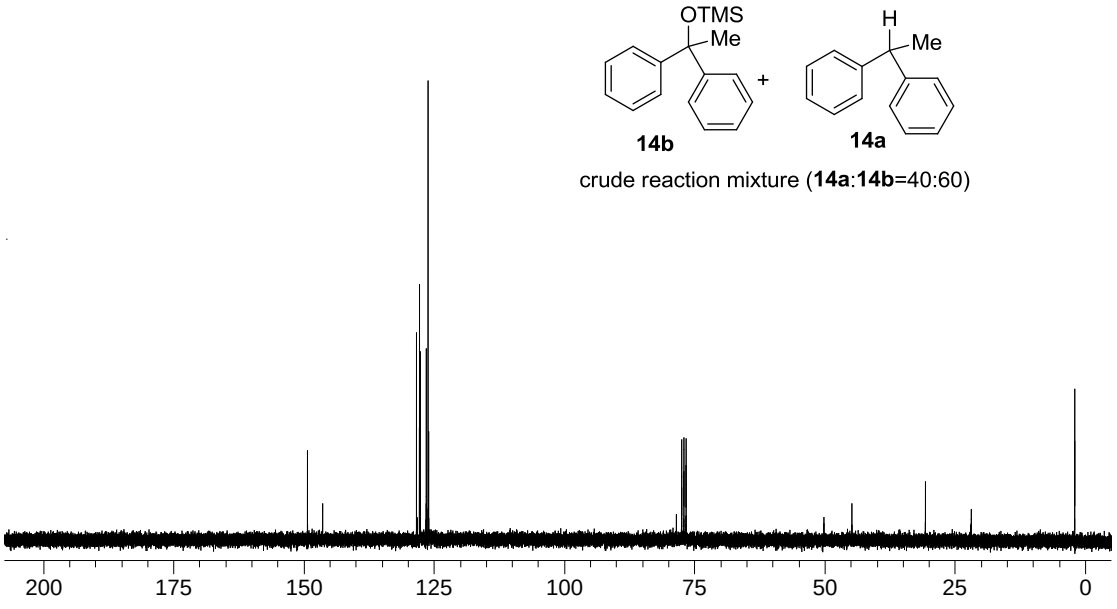


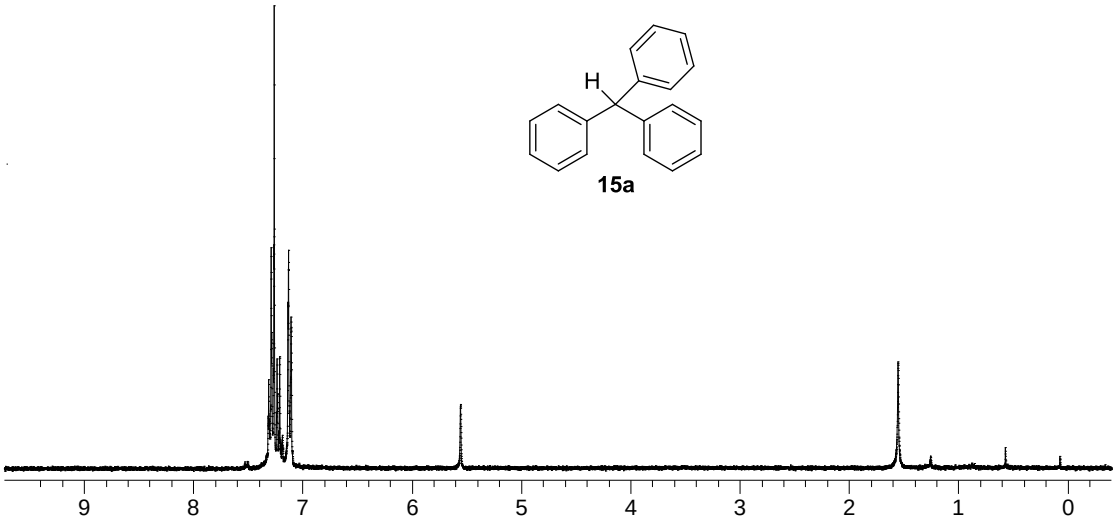



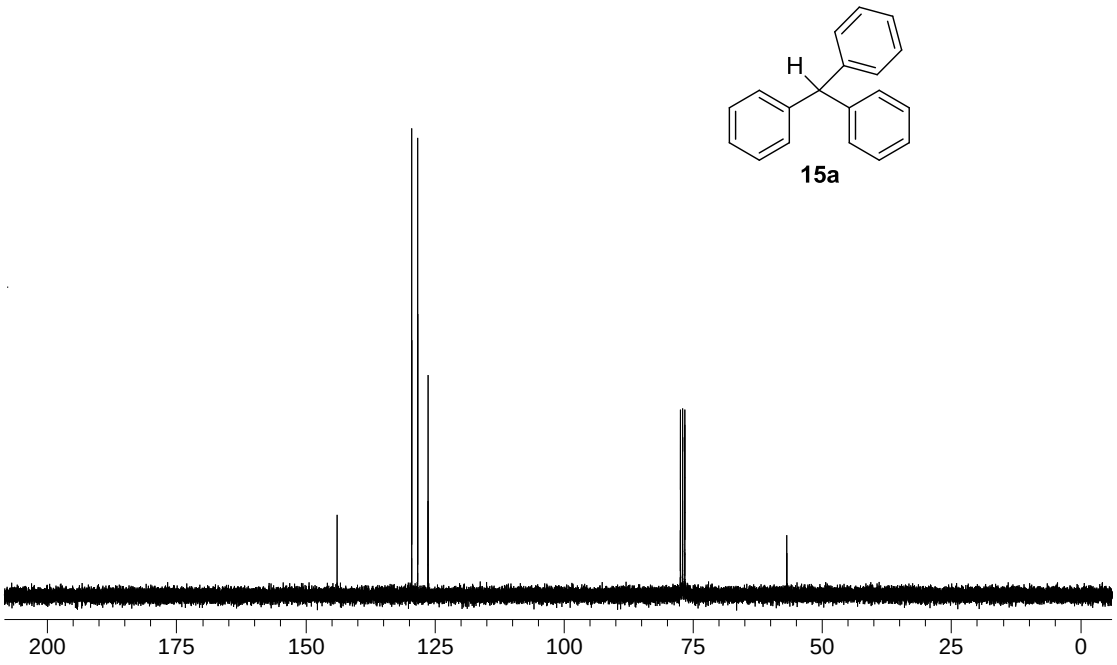

after column chromatography (**13a**:**13b**=27:73)

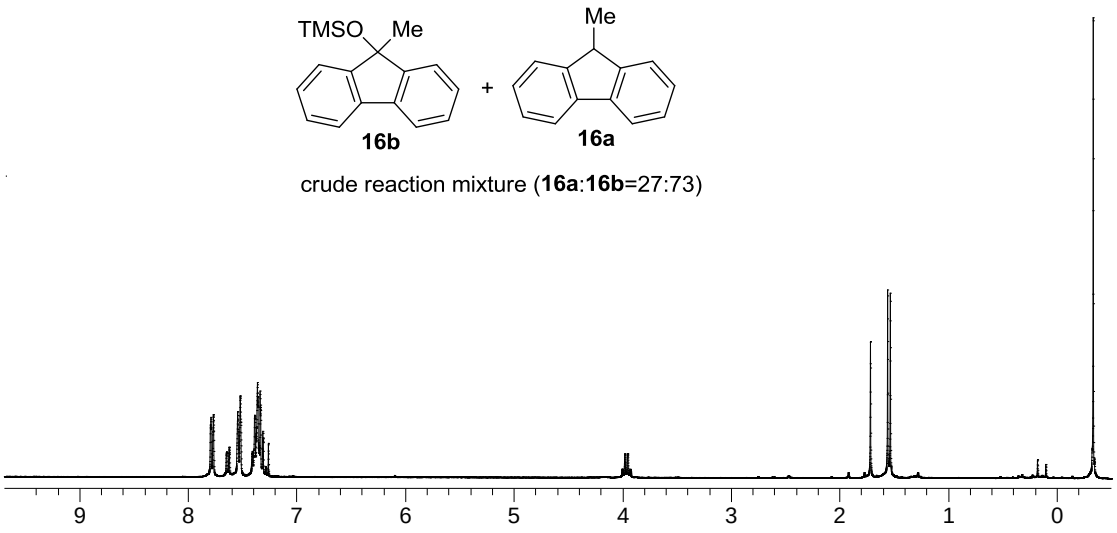


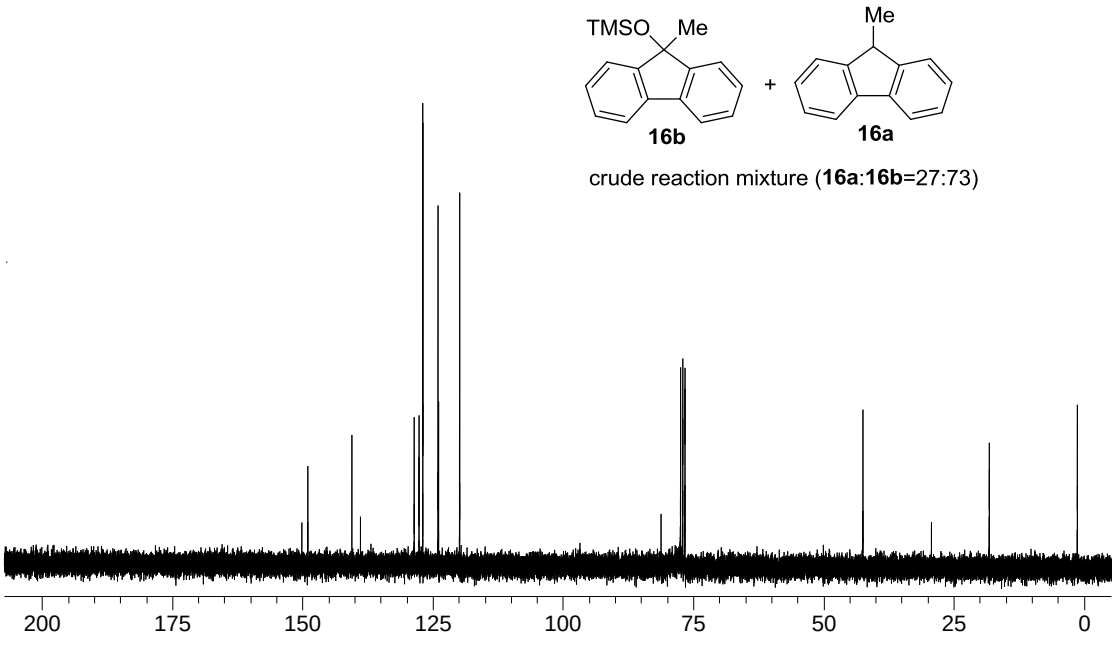

OTMS
Me
+
H
Me
14b
14a
crude reaction mixture (14a:14b=40:60)
9
8
7
6
5
4
3
2
1
0

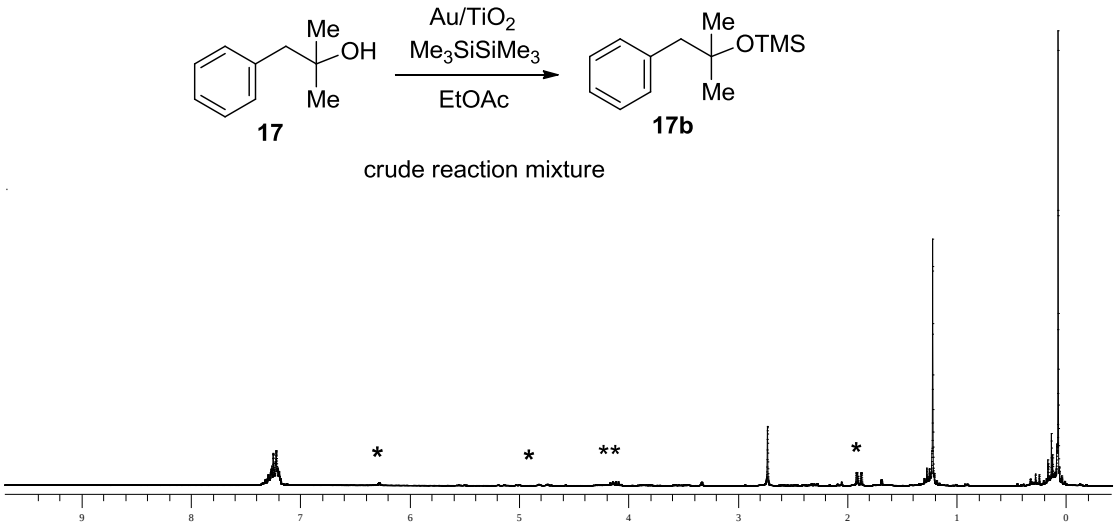

OTMS
Me
+
H
Me
14b
14a
crude reaction mixture (14a:14b=40:60)
200
175
150
125
100
75
50
25
0


H
15a
9
8
7
6
5
4
3
2
1
0


H
15a
200
175
150
125
100
75
50
25
0

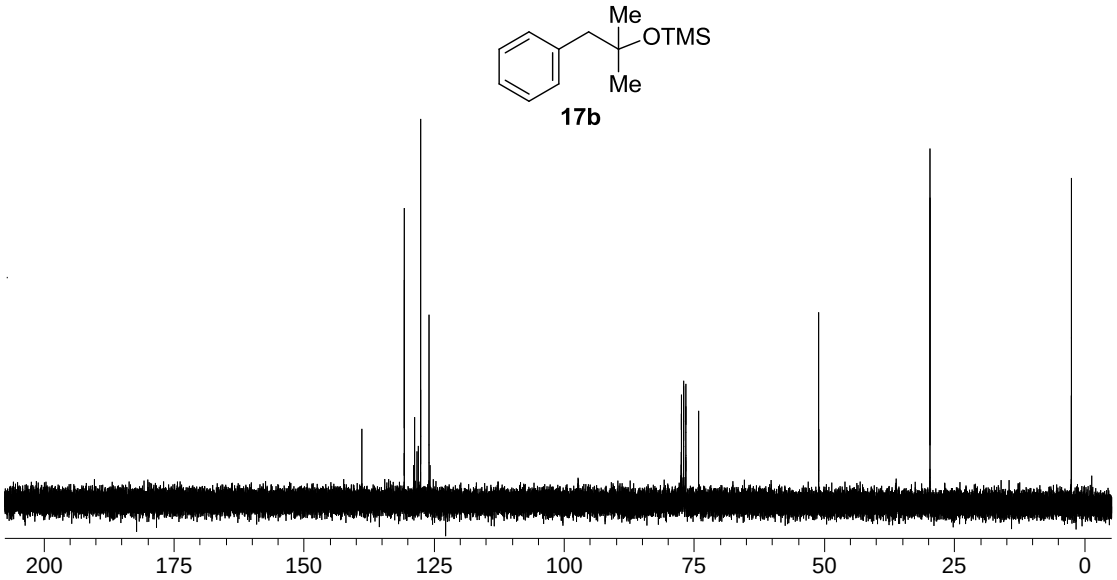

TMSO
Me
+
Me
16b
16a
crude reaction mixture (16a:16b=27:73)
9
8
7
6
5
4
3
2
1
0

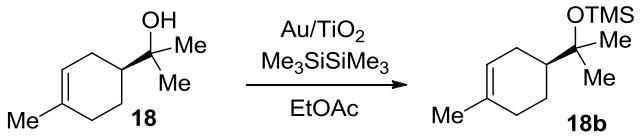

TMSO
Me
+
Me
16b
16a
crude reaction mixture (16a:16b=27:73)
200
175
150
125
100
75
50
25
0




*: Dehydration products from starting material

**: Solvent impurities






crude reaction mixture