**Electronic Supplementary Information**

# Efficient Dehydrative Alkylation of Thiols with Alcohols Catalyzed by Alkyl Halides

Yaqi Yang,[a] Zihang Ye,[a] Xu Zhang,[b] Yipeng Zhou,[a] Xiantao Ma,[a,b] Hongen Cao,[b] Huan Li,[a] Lei Yu,[b] and Qing Xu[a,b,*]

[a] *College of Chemistry and Materials Engineering, Wenzhou University, Wenzhou, Zhejiang 325035, P. R. China*

[b] *Institute of Pesticide, School of Horticulture and Plant Protection and School of Chemistry and Chemical Engineering, Yangzhou University, Yangzhou, Jiangsu 225002, P. R. China*

*Email: qing-xu@wzu.edu.cn*

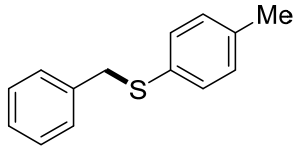
## Table of Contents

## Experimental

**General.** The starting alcohols, thiols, alkyl halides, hydrobromic acid (33 wt% in HOAc) and solvents were all purchased and used without further purification. $Et_3N{\cdot}HBr$ was prepared from the reaction of $Et_3N$ and HBr (33 wt% in HOAc) in EtOAc according to our previous method (Q. Xu, H. Xie, E.-L. Zhang, X. Ma, J. Chen, X.-C. Yu, H. Li, *Green Chem.* **2016**, *18,* 3940). Most of the reactions were carried out in sealed 10 mL Schlenk tubes and then monitored by TLC and/or GC-MS. All products were purified by column chromatography on silica gel using petroleum ether (PE) as the eluent. $^1H$ and $^{13}C$ NMR spectra were recorded on a Bruker Avance III AV500 instrument (500 MHz for $^1H$ and 125.4 MHz for $^{13}C$ NMR spectroscopy) by using $CDCl_3$ or $d_6$-DMSO as the solvent. Chemical shift values for $^1H$ and $^{13}C$ NMR were referred to internal $Me_4Si$ (0 ppm). Mass spectra were measured on a Shimadzu GCMS-QP2010 Plus or a Shimadzu GCMS-QP2010 Ultra spectrometer (EI).

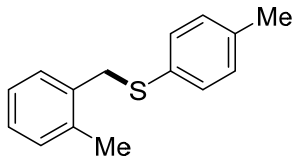
**General Procedure for Alkyl Halide-Catalyzed Dehydrative S-Alkylation of Thiols with Alcohols for the Synthesis of Unsymmetrical Thioethers.** The neat mixture of an alcohol **1** (2.4 mmol), a thiol **2** (2 mmol), and an alkyl halide **3** (0.4 mmol, 20 mol%, corresponds to the alcohol **1**) in a 10 mL Schlenk tube was sealed under air and then heated at 120 $^oC$ for 12 h. The reaction was then monitored by TLC and/or GC-MS. Column chromatography of the crude products using petroleum ether as the eluent gave the corresponding thioether **4**.

**Typical Procedure for Alkyl Halide-Catalyzed Dehydrative S-Alkylation of Thiols with Alcohols for the Synthesis of Unsymmetrical Thioethers.** The neat mixture of benzyl alcohol **1a** (0.2592 g, 2.4 mmol), *p*-tolylthiol **2a** (0.2480 g, 2 mmol), and $PhCH_2Br$ **3a** (0.048 mL, 0.4 mmol, 20 mol%, the alkyl halide corresponds to alcohol **1a**) in a 10 mL Schlenk tube was sealed under air and then heated at 120 $^oC$ for 12 h. The reaction was then monitored by TLC and/or GC-MS. Column chromatography of the crude products using petroleum ether as the eluent gave **4aa** in 95% isolated yield.

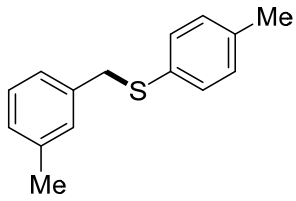



**Benzyl 4-tolyl thioether (4aa).** $^1H$ NMR (500 MHz, $CDCl_3$): $\delta$ 7.21-7.13 (m, 7H), 6.98 (d, $J$ = 8.0 Hz, 2H), 3.99 (s, 2H), 2.22 (s, 3H). $^{13}C$ NMR (125.4 MHz, $CDCl_3$): $\delta$ 138.0, 136.6, 132.9, 130.8, 129.9, 129.1, 128.7, 127.3, 39.9, 21.3. MS (EI): m/z (%) 214 (45), 123 (3), 91 (100), 65 (12). This

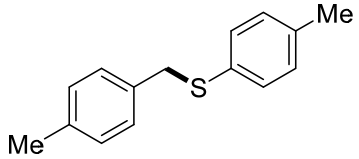
compound was known: Panova, Y. S.; Kashin, A. S.; Vorobev, M. G.; Degtyareva, E. S.; Ananikov, V. P. *ACS Catal,* **2016**, *6*, 3637.



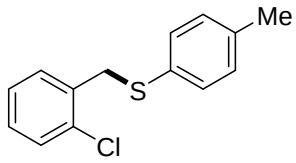

**2-Methylbenzyl 4-tolyl thioether (4ba).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.22 (dd, $J$ = 6.0, 1.5 Hz, 2H), 7.14 (dd, $J$ = 5.0, 1.0 Hz, 2H), 7.12-7.06 (m, 4H), 4.05 (s, 2H), 2.38 (s, 3H), 2.31 (s, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 136.73, 136.72, 135.4, 132.8, 131.1, 130.5, 129.8, 192.6, 127.4, 126.0, 38.2, 21.1, 19.2. MS (EI): *m/z* (%) 228 (32), 123 (3), 105 (100), 77 (11). This compound was known: Yao, J.; Yu, M.; Zhang, Y. *Adv. Synth. Catal.* **2012**, *354*, 3205.




**3-Methylbenzyl 4-tolyl thioether (4ca).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.21 (d, $J$ = 8.0 Hz, 2H), 7.16 (t, $J$ = 7.5 Hz, 1H), 7.06 (m, 5H), 4.03 (s, 2H), 2.31 (s, 6H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 138.1, 137.6, 136.5, 132.8, 130.5, 129.6, 128.3, 127.9, 125.9, 39.8, 21.4, 21.1. MS (EI): *m/z* (%) 228 (34), 123 (3), 105 (100), 77 (12). This compound was known: Yu, M.; Xie, Y.; Xie, C.; Zhang, Y. *Org. Lett.* **2012**, *14*, 2164.

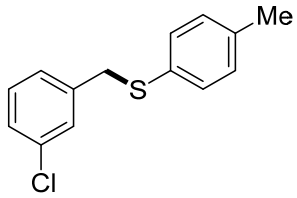



**4-Methylbenzyl 4-tolyl thioether (4da).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.21 (d, $J$ = 8.0 Hz, 2H), 7.16 (d, $J$ = 7.5 Hz, 2H), 7.07 (m, 4H), 4.04 (s, 2H), 2.31 (s, 3H), 2.30 (s, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 136.7, 136.4, 134.6, 132.8, 130.5, 129.6, 129.2, 128.7, 39.4, 21.1, 21.0. MS (EI): *m/z* (%) 228 (32), 123 (3), 105 (100), 77 (10). This compound was known: Miyazaki, T.; Kasai, S.; Ogiwara, Y.; Sakai, N. *Eur. J. Org. Chem.* **2016**, *5*, 1043.

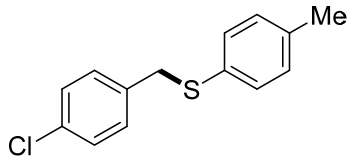



**2-Chlorobenzyl 4-tolyl thioether (4ea).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.34 (d, $J$ = 8.0Hz 1H), 7.22 (m, 2H), 7.18-7.10 (m, 3H), 7.06 (d, $J$ = 8.0 Hz, 2H), 4.16 (s, 2H), 2.31 (s, 3H). $^{13}$C NMR

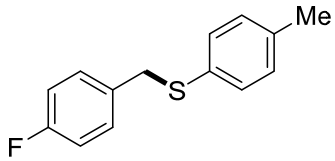
(125.4 MHz, $CDCl_3$): $\delta$ 137.0, 135.6, 134.0, 131.9, 131.6, 130.7, 129.7, 129.6, 128.5, 126.7, 37.7, 21.1. MS (EI): *m/z* (%) 248 (43), 125 (100), 89 (12), 63 (4), 51 (1). This compound was known: Miyazaki, T.; Kasai, S.; Ogiwara, Y.; Sakai, N. *Eur. J. Org. Chem.* **2016**, *5*, 1043.



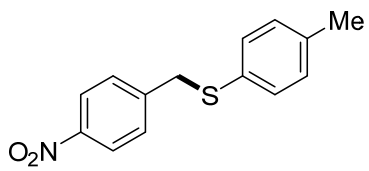

**3-Chlorobenzyl 4-tolyl thioether (4fa).** $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.24 (s, 1H), 7.20-7.18 (m, 4H), 7.12-7.10 (m, 1H), 7.07 (d, *J* = 8.0 Hz, 2H), 4.00 (s, 2H), 2.31 (s, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 140.0, 137.0, 134.2, 131.7, 131.2, 129.7, 129.6, 128.9, 127.2, 127.0, 39.5, 21.1. MS (EI): *m/z* (%) 248 (49), 125 (100), 89 (12), 77 (5), 51 (1). This compound was known: Miyazaki, T.; Kasai, S.; Ogiwara, Y.; Sakai, N. *Eur. J. Org. Chem.* **2016**, *5*, 1043.



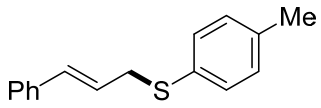

**4-Chlorobenzyl 4-tolyl thioether (4ga).** $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.26 (d, *J* = 8.0 Hz, 2H), 7.21 (dd, *J* = 8.0, 12.0 Hz, 4H), 7.10 (d, *J* = 8.0 Hz, 2H), 4.04 (s, 2H), 2.34 (s, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 137.0, 136.5, 132.8, 131.8, 131.2, 130.1, 129.7, 128.5, 39.3, 21.0. MS (EI): *m/z* (%) 248 (28), 125 (100), 89 (12), 63 (3), 51 (1). This compound was known: Miyazaki, T.; Kasai, S.; Ogiwara, Y.; Sakai, N. *Eur. J. Org. Chem.* **2016**, *5*, 1043.



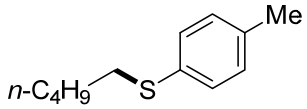

**4-Fluorobenzyl 4-tolyl thioether (4ha).** $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.20-7.18 (m, 4H), 7.06 (d, *J* = 8.0 Hz, 2H), 6.96-6.92 (m, 2H), 4.01 (s, 2H), 2.30 (s, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 161.9 ($J_{C\text{-}F}$ = 244.6 Hz), 136.9, 133.6 ($J_{C\text{-}F}$ = 3.3 Hz), 132.0, 131.1, 130.4 ($J_{C\text{-}F}$ = 8.0 Hz), 129.7, 115.3 ($J_{C\text{-}F}$ = 21.3 Hz), 39.2, 21.1. MS (EI): *m/z* (%) 232 (32), 109 (100), 83 (11), 57 (2). This compound was known: Oderinde, M. S.; Frenette, M.; Robbins, D. W.; Aquila, B.; Johannes, J. W. *J. Am. Chem. Soc.* **2016**, *138*, 1760.



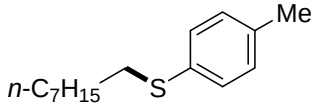
**4-Nitrobenzyl 4-tolyl thioether (4ia).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 8.10 (d, $J$ = 8.0 Hz, 2H), 7.34 (d, $J$ = 8.0 Hz, 2H), 7.17 (d, $J$ = 8.0 Hz, 2H), 7.06 (d, $J$ = 8.0 Hz, 2H), 4.07 (s, 2H), 2.31 (s, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 147.0, 145.9, 137.7, 133.7, 131.9, 129.9, 129.6, 123.6, 39.6, 21.1. MS (EI): *m/z* (%) 259 (100), 213 (23), 136 (27), 123 (29), 90 (28), 78 (20). This compound was known: Santoni, G.; Mba, M.; Bonchio, M.; Nugent, W. A.; Zonta, C.; Licini, G. *Chem. Eur. J.* **2010**, *16*, 645.



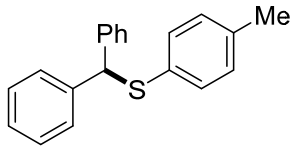

**Cinnamyl 4-tolyl thioether (4ja).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.33-7.26 (m, 6H), 7.23-7.19 (m, 1H), 7.09 (d, $J$ = 8.0 Hz, 2H), 6.38 (d, $J$ = 16.0 Hz, 1H), 6.27-6.21 (m, 1H), 3.66 (dd, $J$ = 7.0, 1.0 Hz, 2H), 2.31 (s, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 136.8, 136.7, 132.6, 132.0, 131.2, 129.6, 128.5, 127.5, 126.3, 125.4, 37.9, 21.1. MS (EI): *m/z* (%) 240 (16), 117 (100), 91 (12), 65 (3), 51 (1). This compound was known: Gholinejad, M. *Eur. J. Org. Chem.* **2015**, *19*, 4162.



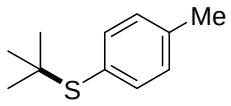

**Pentyl 4-tolyl thioether (4ka).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.24 (d, $J$ = 8.0 Hz, 2H), 7.09 (d, $J$ = 8.0 Hz, 2H), 2.87 (t, $J$ = 7.5 Hz, 2H), 2.31 (s, 3H), 1.65-1.59 (m, 2H), 1.42-1.26 (m, 4H), 0.88 (t, $J$ = 7.5 Hz, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 135.8, 133.2, 129.8, 129.6, 34.4, 31.0, 29.0, 22.2, 21.0, 14.0. MS (EI): *m/z* (%) 194 (54), 137 (25), 124 (100), 91 (43), 77 (5). This compound was known: Sakai, N.; Miyazaki, T.; Sakamoto, T.; Yatsuda, T.; Moriya, T.; Ikeda, R.; Konakahara, T. *Org. Lett.* **2012**, *14*, 4366.



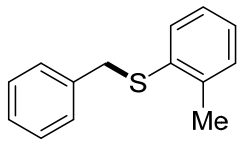

**Octyl 4-tolyl thioether (4la).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.25 (d, $J$ = 8.0 Hz, 2H), 7.10 (d, $J$ = 8.0 Hz, 2H), 2.87 (t, $J$ = 7.5 Hz, 2H), 2.32 (S, 3H), 1.65-1.59 (m, 2H), 1.42-1.38 (m, 2H), 1.31-1.27 (m, 8H), 0.88 (t, $J$ = 7.5 Hz, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 135.8, 133.2, 129.8, 129.6, 34.4, 31.9, 29.3, 29.2, 29.1, 28.8, 22.6, 21.0. MS (EI): *m/z* (%) 236 (59), 137 (21), 124 (100), 91 (26), 57 (7). This compound was known: Oderinde, M. S.; Frenette, M.; Robbins, D. W.; Aquila, B.; Johannes, J. W. *J. Am. Chem. Soc.* **2016**, *138*, 1760.



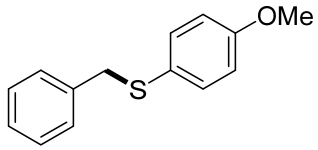
**Benzhydryl 4-tolyl thioether (4ma).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.40 (d, $J$ = 7.5 Hz, 4H), 7.28 (t, $J$ = 7.5 Hz, 4H), 7.21 (dd, $J$ = 16.0, 7.5 Hz, 2H), 7.13 (d, $J$ = 8.0 Hz, 2H), 6.97 (d, $J$ = 8.0 Hz, 2H), 5.46 (s, 1H), 2.25 (s, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 141.2, 136.9, 132.3, 131.4, 129.5, 128.5, 128.4, 127.2, 58.1, 21.1. MS (EI): *m/z* (%) 290 (4), 167 (100), 152 (16), 123 (4). This compound was known: Firouzabadi, H.; Iranpoor, N.; Jafarpour, M. *Tetrahedron Lett.* **2006**, *47*, 93.



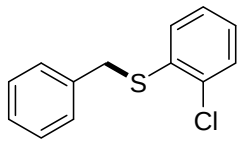

***t*-Butyl 4-tolyl thioether (4pa).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.41 (d, $J$ = 7.5 Hz, 2H), 7.13 (d, $J$ = 7.5 Hz, 2H), 2.36 (s, 3H), 1.27 (s, 9H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 138.7, 137.4, 129.8, 129.2, 45.5, 30.9, 21.2. MS (EI): *m/z* (%) 180 (22), 179 (35), 125 (32), 124 (100), 123 (41), 91 (46). This compound was known: Venkanna, G. T.; Arman, H. D.; Tonzetich, Z. J. *ACS Catal.* **2014***, 4*, 2941.




**Benzyl 2-tolyl thioether (4ab).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.30-7.21 (m, 6H), 7.15-7.07 (m, 3H), 4.07 (s, 2H), 2.31 (s, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 138.0, 137.3, 135.8, 130.1, 129.0, 128.9, 128.5, 127.2, 126.4, 126.1, 38.4, 20.3. MS (EI): *m/z* (%) 214 (38), 91 (100), 65 (12), 51 (2). This compound was known: Sayah, M.; Organ, M. G. *Chem. Eur. J.* **2011**, *17*, 11719.

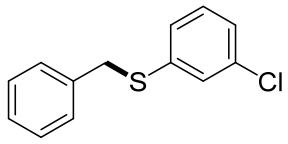



**Benzyl 4-methoxyphenyl thioether (4ac).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.20-7.10 (m, 7H), 6.71 (dt, $J$ = 9.0, 3.0 Hz, 2H), 3.91 (s, 2H), 3.70 (s, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 159.2, 138.2, 134.1, 128.9, 128.4, 127.0, 126.1, 114.4, 55.3, 41.2. MS (EI): *m/z* (%) 230 (41), 91 (100), 65 (10), 51 (1). This compound was known: Miyazaki, T.; Kasai, S.; Ogiwara, Y.; Sakai, N. *Eur. J. Org. Chem.* **2016**, *5*, 1043.

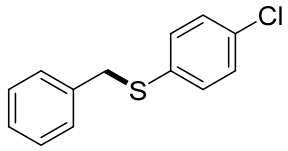



**Benzyl 2-chlorophenyl thioether (4ad).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.36 (s, 1H), 7.34 (d, $J$ = 8.0 Hz, 2H), 7.29 (t, $J$ = 8.0 Hz, 2H), 7.24 (t, $J$ = 7.5 Hz, 2H), 7.16-7.08 (m, 2H), 4.14 (s, 2H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 136.4, 135.8, 133.7, 129.7, 129.3, 128.9, 128.6, 127.4, 127.1, 126.9, 37.5. MS (EI): *m/z* (%) 234 (24), 91 (100), 65 (12), 51 (1). This compound was known: Naso, F.;

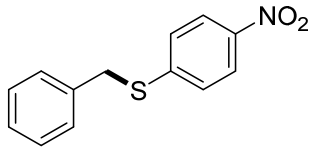
Capozzi, M. A. M.; Bottoni, A.; Calvaresi, M.; Bertolasi, V.; Capitelli, F.; Cardellicchio, C. *Chem. Eur. J.* **2009**, *15*, 13417.



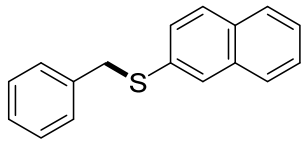

**Benzyl 3-chlorophenyl thioether (4ae).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.30-7.22 (m, 6H), 7.18-7.12 (m, 3H), 4.13 (s, 2H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 138.6, 136.8, 134.6, 129.8, 129.0, 128.8, 128.6, 127.4, 127.4, 126.3, 38.7. MS (EI): *m/z* (%) 234 (23), 91 (100), 65 (12), 51 (1). This compound was known: Li, Y.; Xie, W.; Jiang, X. *Chem. Eur. J.* **2015**, *21*, 16059.



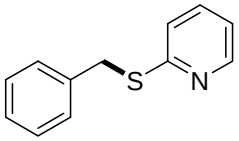

**Benzyl 4-chlorophenyl thioether (4af).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.30-7.20 (m, 9H), 4.07 (s, 2H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 137.1, 134.7, 132.5, 131.4, 129.0, 128.8, 128.6, 127.3, 39.3. MS (EI): *m/z* (%) 234 (23), 91 (100), 65 (13), 51 (1). This compound was known: Miyazaki, T.; Kasai, S.; Ogiwara, Y.; Sakai, N. *Eur. J. Org. Chem.* **2016**, *5*, 1043.



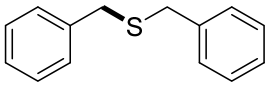

**Benzyl 4-nitrophenyl thioether (4ag).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 8.10 (d, $J$ = 7.5 Hz, 2H), 7.39 (d, $J$ = 7.5 Hz, 2H), 7.35-7.29 (M, 5H), 4.25 (S, 2H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 147.2, 135.5, 128.8, 127.8, 126.8, 123.9, 37.1. MS (EI): *m/z* (%) 245 (11), 91 (100), 92 (8), 65 (10). This compound was known: Naso, F.; Capozzi, M. A. M.; Bottoni, A.; Calvaresi, M.; Bertolasi, V.; Capitelli, F.; Cardellicchio, C. *Chem. Eur. J.* **2009**, *15*, 13417.



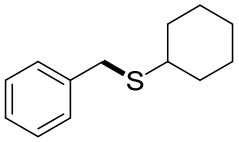

**Benzyl naphthalen-2-yl thioether (4ah).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.77 (d, $J$ = 7.5Hz, 1H), 7.73-7.68 (m, 3H), 7.46-7.38 (m, 3H), 7.33-7.21 (m, 5H), 4.21 (s, 2H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 137.4, 133.9, 133.7, 131.9, 128.9, 128.6, 128.3, 127.8, 127.75, 127.73, 127.2, 127.2, 126.5, 125.8, 39.0. MS (EI): *m/z* (%) 250 (47), 115 (14), 91 (100), 65 (11), 51 (1). This compound was known: Bryliakov, K. P.; Talsi, E. P. *Eur. J. Org. Chem.* **2011**, *24*, 4693.



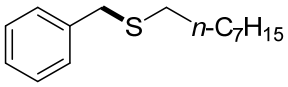
**Benzyl pyridin-2-yl thioether (4ai).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 8.47 (d, $J$ = 5.0 Hz, 1H), 7.51-7.47 (m, 1H), 7.42 (d, $J$ = 7.0 Hz, 2H), 7.31-7.28 (m, 2H), 7.25-7.22 (m, 1H), 7.18 (dd, $J$ = 1.0, 8.0 Hz, 1H), 7.02-7.00 (m, 1H), 4.46 (s, 2H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 158.8, 149.2, 137.8, 136.2, 129.0, 128.5, 127.1, 122.2, 119.6, 34.6. MS (EI): *m/z* (%) 200 (23), 167(92), 124 (20), 91 (100), 79 (27), 65 (30), 51 (10). This compound was known: Rostami, A.; Rostami, A.; Ghaderi, A. *J. Org. Chem.* **2015**, *80*, 8694.



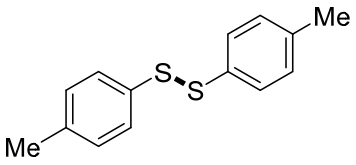
**Dibenzyl thioether (4aj).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.32-7.26 (m, 8H), 7.25-7.22 (m, 2H), 3.59 (s, 4H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 138.2, 129.0, 128.5, 127.0, 35.6. MS (EI): *m/z* (%) 214 (41), 123 (28), 91 (100), 65 (15), 51 (3). This compound was known: Miyazaki, T.; Kasai, S.; Ogiwara, Y.; Sakai, N. *Eur. J. Org. Chem.* **2016**, *5,* 1043.



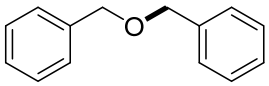
**Benzyl cyclohexyl thioether (4ak).** $^{1}$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.32-7.20 (m, 5H), 3.74 (s, 2H), 2.56 (t, $J$ = 10.0 Hz, 1H), 1.94 (d, $J$ = 12.5Hz, 2H), 1.74 (s, 2H), 1.59 (s, 1H), 1.36-1.23 (m, 6H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 139.0, 128.8, 128.4, 126.8, 43.0, 34.6, 33.4, 26.0, 25.9. MS (EI): *m/z* (%) 206 (33), 124 (20), 115 (26), 91 (100), 81 (17), 67 (15), 65 (10), 55 (17). This compound was known: Bhat, V. T.; Duspara, P. A.; Seo, S.; Binti, N. S.; Bakara, A.; Greaney, M. F. *Chem. Commun.* **2015**, *51*, 4383.



**Benzyl *n*-octyl thioether (4al).** $^{1}$H NMR (500 MHz, $CDCl_3$): 7.31-7.22 (m, 5H), 3.70 (s, 2H), 2.40 (t, $J$ = 7.5 Hz, 2H), 1.58-1.52 (m, 2H), 1.36-1.25 (m, 10H), 0.88 (t, $J$ = 7.0 Hz, 3H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 138.7, 128.8, 128.4, 126.8, 36.3, 31.8, 31.4, 29.3, 29.2, 28.9, 22.6, 14.1. MS (EI): *m/z* (%) 236 (18), 145 (55), 124 (7), 91 (100), 69 (28), 55 (8).This compound was known: Miyazaki, T.; Kasai, S.; Ogiwara, Y.; Sakai, N. *Eur. J. Org. Chem.* **2016**, *5*, 1043.




**Di(*p*-tolyl) disulfide (5a).** $^{1}$H NMR (500 MHz, $CDCl_3$): 7.38 (d, $J$ = 8.5 Hz, 4H), 7.10 (d, $J$ = 8.5 Hz, 4H), 2.32 (s, 6H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 137.4, 134.0, 129.8, 128.6, 21.0. MS (EI): *m/z* (%) 247 (10), 246 (18), 245 (100), 182 (11), 124 (20), 123 (98), 91 (19), 79 (20), 77 (16).This compound was known: Li, X.-B.; Li, Z.-J.; Gao, Y.-J.; Meng, Q.-Y.; Yu, S.; Weiss, R. G.; Tung, C.-H.; Wu, L.-Z. *Angew. Chem. Int. Ed.* **2014**, *53*, 2085.




**Dibenzyl ether (6a).** $^{1}$H NMR (500 MHz, $CDCl_3$): 7.50-7.42 (m, 10H), 4.69 (s, 4H). $^{13}$C NMR (125.4 MHz, $CDCl_3$): $\delta$ 138.5, 128.5, 127.9, 127.8, 72.3. MS (EI): *m/z* (%) 107 (15), 92 (100), 91 (74), 79 (14), 77 (10), 65 (15).This compound was known: Gellert, B. A.; Kahlcke, N.; Feurer, M.; Roth, S. *Chem. Eur. J.* **2011**, *17*, 12203.

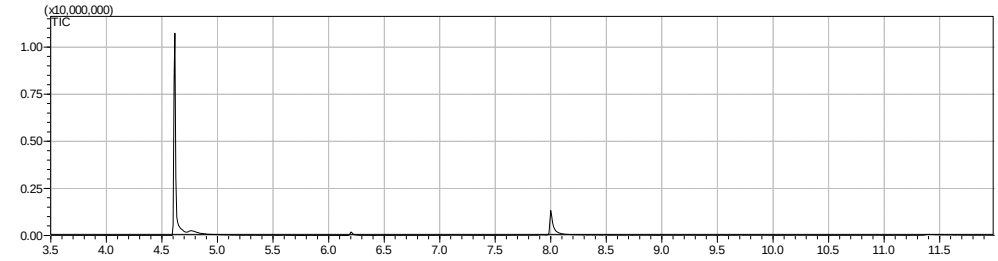
## Control Reactions

### 1. Analysis on the Transformation of Thiols (2) to Didulfides (5)

**1.1 GC-MS Analysis of the Commercial *p*-Tolylthiol (2a):** The commercial *p*-tolylthiol (**2a**) was directly measured by GC-MS without any treatment after purchased.

**Result:** *p*-TolSH/(*p*-TolS)$_2$ = ca. 84/16

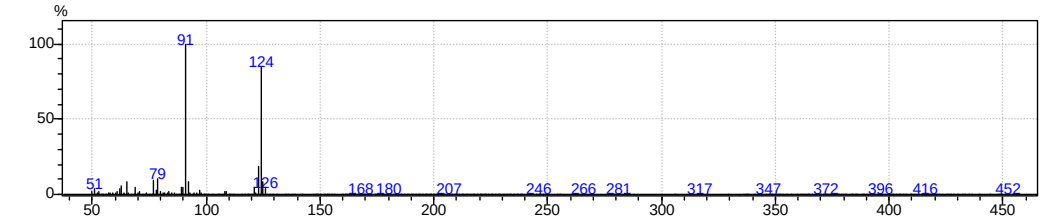
GC spectra:



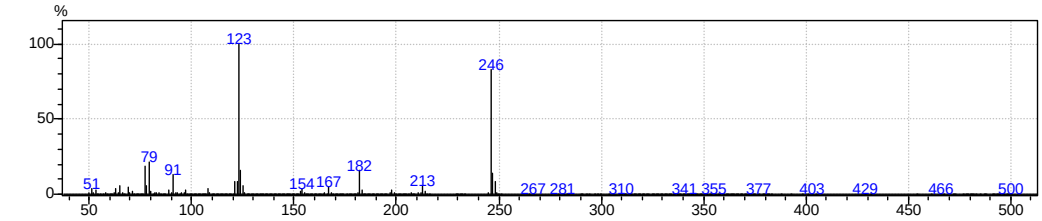

| Peak | Ret.Time | Start Tm | End Tm | m/z | Area | Area% | Height | Height% | A/H | Mark |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.615 | 4.575 | 5.083 | TIC | 15847874 | 84.16 | 10736152 | 89.18 | 1.48 | MI |
| 2 | 8.001 | 7.950 | 8.300 | TIC | 2982631 | 15.84 | 1302903 | 10.82 | 2.29 | MI |

Mass Spectra:

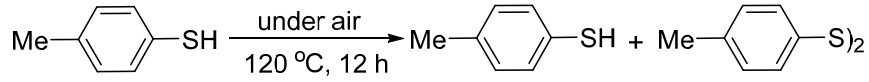
Ret. Time = 4.615, m/z = 124, *p*-TolSH




Ret. Time = 8.001, m/z = 246, (*p*-TolS)$_2$




**1.2 Heating the Commercial *p*-Tolylthiol (2a) in Air under the Standard Conditions:**




commercial **2a**
(contains **5a**, **2a/5a** ca. 84/16$^{GC}$)

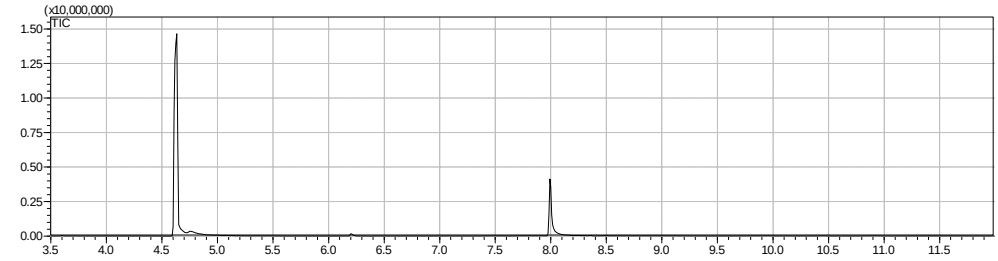
**2a**

**5a**

result: **2a/5a** ca. 82/18$^{GC}$

**Detailed procedure:** The commercial *p*-tolylthiol (**2a**, 0.248 g, 2.0 mmol) was sealed in a 10 mL Schlenk tube under air and then heated at 120 °C for 12 h. The mixture was then dissolved in EtOAc and analyzed by TLC and/or GC-MS.

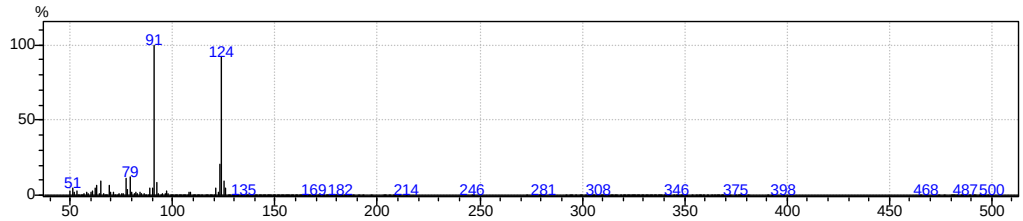
GC spectra:



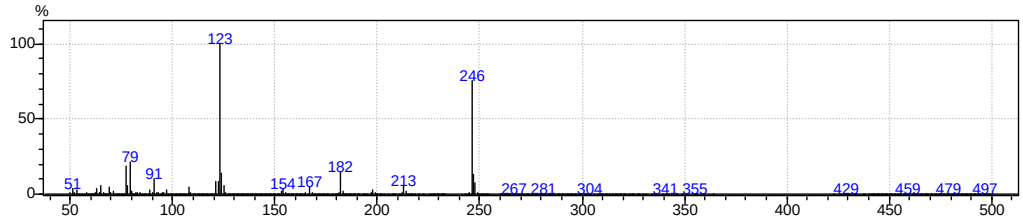

| Peak | Ret.Time | Start Tm | End Tm | m/z | Area | Area% | Height | Height% | A/H | Mark |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.630 | 4.575 | 5.083 | TIC | 33957309 | 82.40 | 14646061 | 78.11 | 2.32 | MI |
| 2 | 7.994 | 7.950 | 8.242 | TIC | 7253830 | 17.60 | 4104330 | 21.89 | 1.77 | MI |

Mass Spectra:

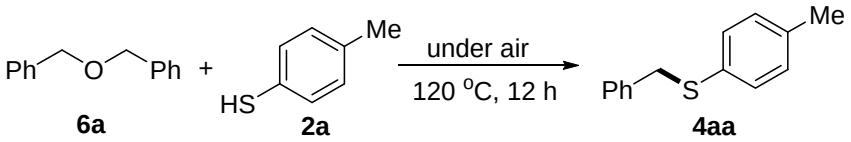
Ret. Time = 4.630, m/z = 124, *p*-TolSH




Ret. Time = 7.994, m/z = 246, $(p\text{-TolS})_2$




## 2. S-Alkylation of *p*-Tolylthiol (2a) with Dibenzyl Ether (6a) with or without $PhCH_2Br$ (3a) Catalysis

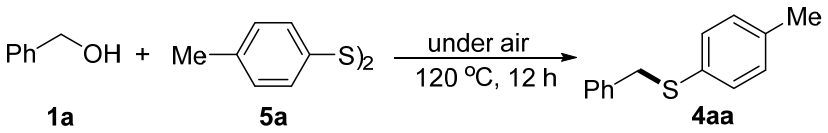



**6a** **2a** **4aa**

(1) $PhCH_2Br$ (**3a**, 20 mol%): 66%
(2) blank: trace (<5%)

**Detailed procedure :** The mixture of benzyl ether (**6a**, 0.4752 g, 2.4 mmol), *p*-tolylthiol (**2a**, 0.2480 g, 2.0 mmol), and benzyl bromide (**3a**, 0.0684 g, 20 mol%) was sealed in a 10 mL Schlenk tube under air and heated at 120 °C for 12 h. The mixture was then dissolved in EtOAc and analyzed by TLC and/or GC-MS. The solvent was evaporated under vacuum and the residue purified by flash column chromatography on silica gel using petroleum ether as the eluent, giving 66% isolated yield of **4aa**. Only trace **4aa** could be observed in another control reaction without addition of benzyl bromide (**3a**) (entry 2).

## 3. S-Alkylation of Disulfide (5a) with Benzyl Alcohol (1a) with or without $PhCH_2Br$ (3a) Catalysis

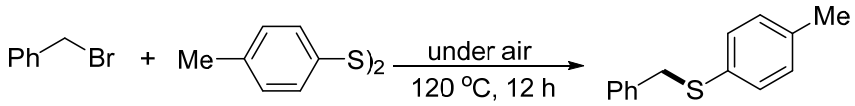



**1a** **5a** **4aa**

(1) $PhCH_2Br$ (**3a**, 20 mol%): 35%
(2) blank: trace (<5%)

**Detailed procedure :** The mixture of benzyl alcohol (**1a**, 0.2160 g, 2 mmol), di(*p*-tolyl) disulfide (**5a**, 0.5904 g, 2.4 mmol) and benzyl bromide (**3a**, 0.0684 g, 20 mol%) was sealed in a 10 mL Schlenk tube under air and heated at 120 °C for 12 h. The mixture was then dissolved in EtOAc and analyzed by TLC and/or GC-MS. The solvent was evaporated under vacuum and the residue purified by flash column chromatography on silica gel using petroleum ether as the eluent, giving 35% isolated yield of **4aa** (entry 1). Only trace **4aa** could be observed in another control reaction without addition of benzyl bromide (**3a**) (entry 2).

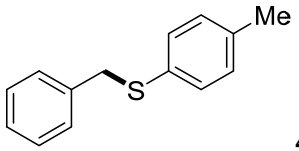
**4. S-Alkylation of Disulfide with Benzyl bromide**




**3a** **5a** **4aa**, 23%

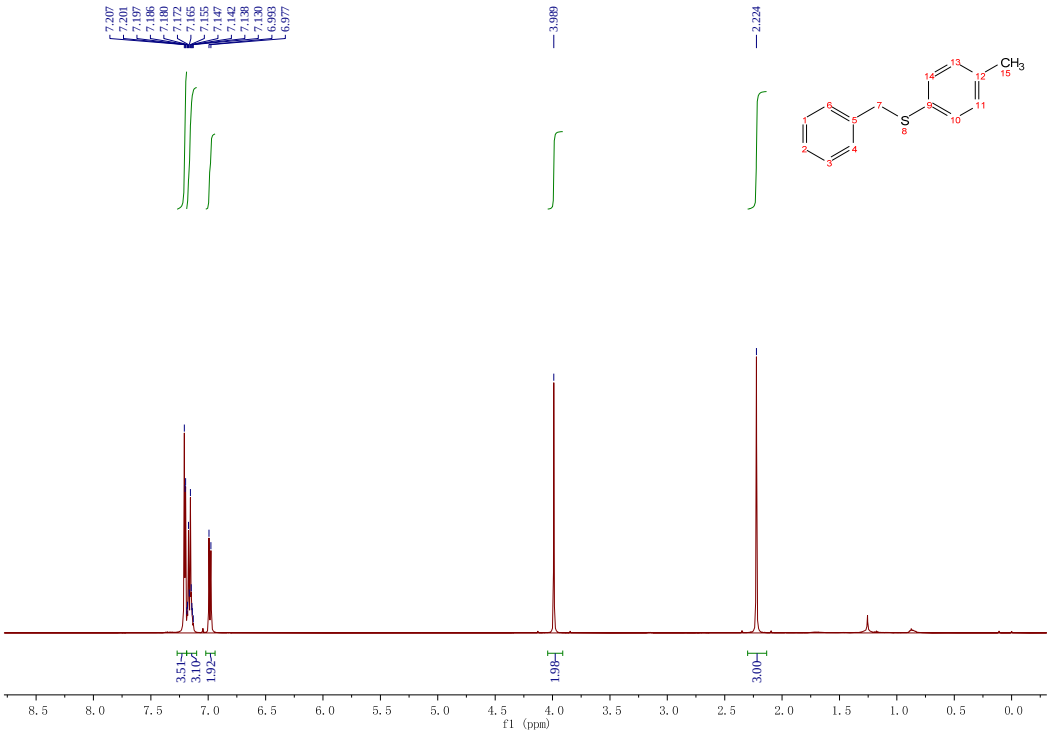
**Detailed procedure:** The mixture of benzyl bromide (**3a**, 0.4104 g, 2.4 mmol) and di(*p*-tolyl) disulfide (**5a**, 0.2460 g, 1 mmol) was sealed in a 10 mL Schlenk tube under air and heated at 120 °C for 12 h. The mixture was then dissolved in EtOAc and analyzed by TLC and/or GC-MS. The solvent was evaporated under vacuum and the residue purified by flash column chromatography on silica gel using petroleum ether as the eluent, giving 23% isolated yield of **4aa**.

# $^{1}$H and $^{13}$C NMR Spectra of All Products

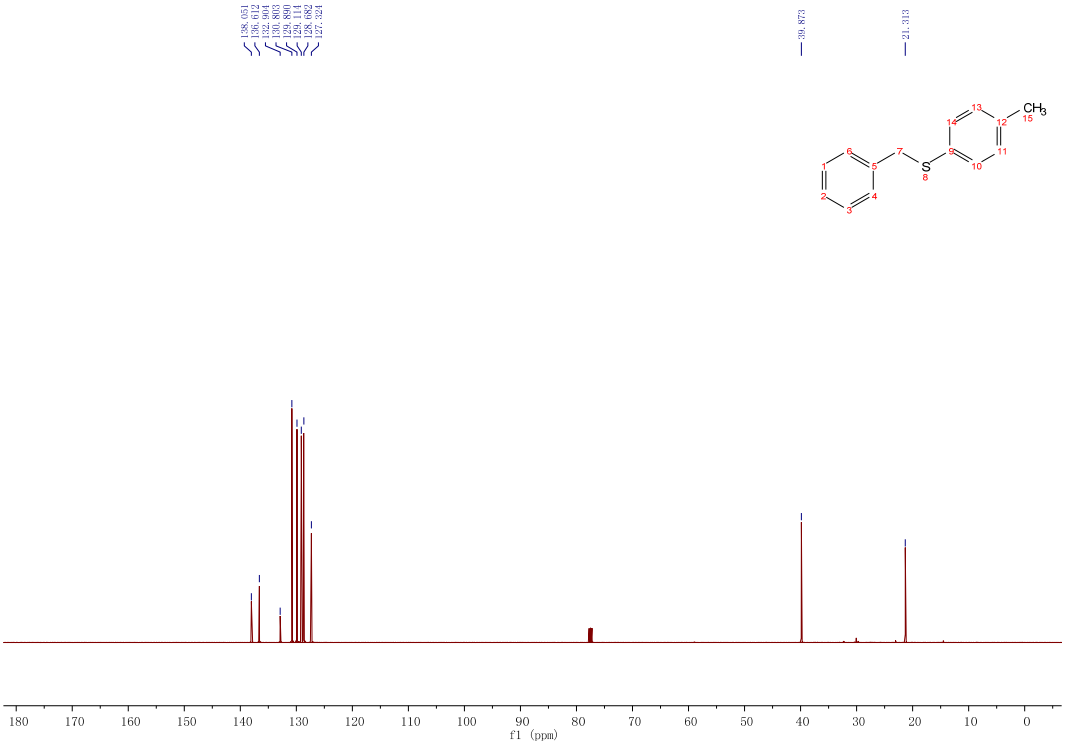


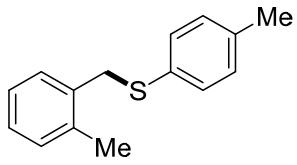

**4aa**

## $^{1}$H NMR



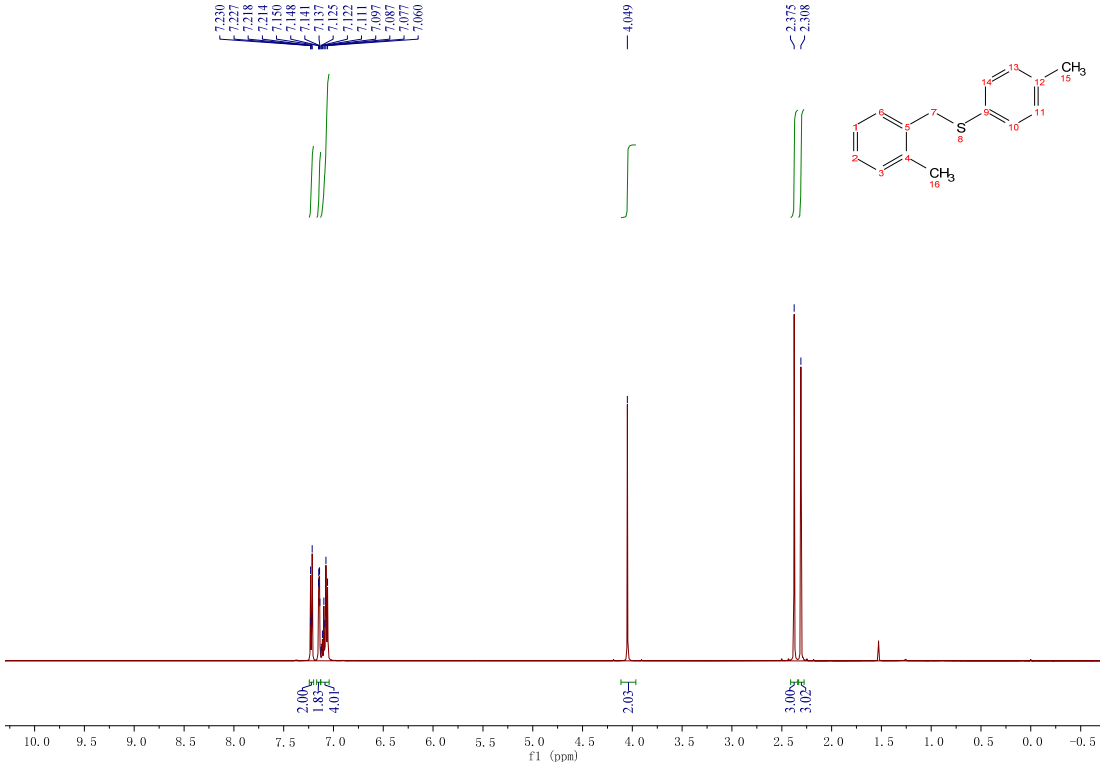

## $^{13}$C NMR



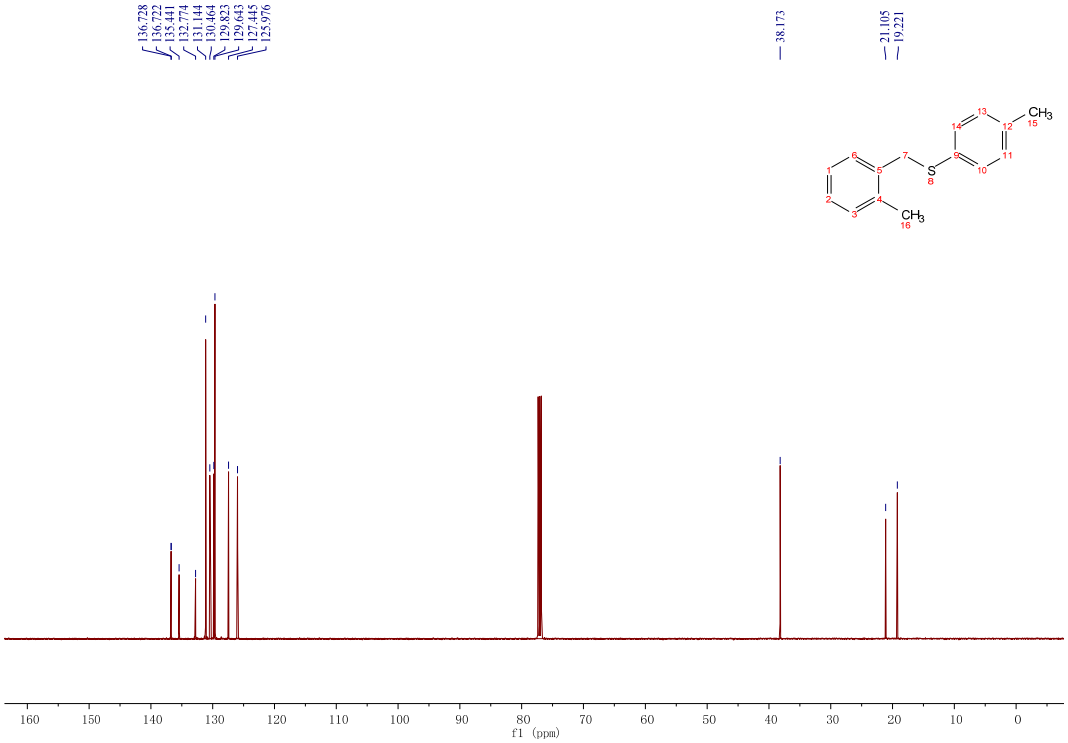


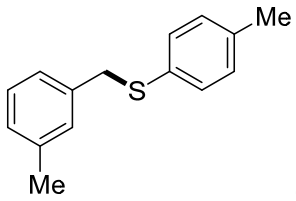

**4ba**

**$^{1}$H NMR**



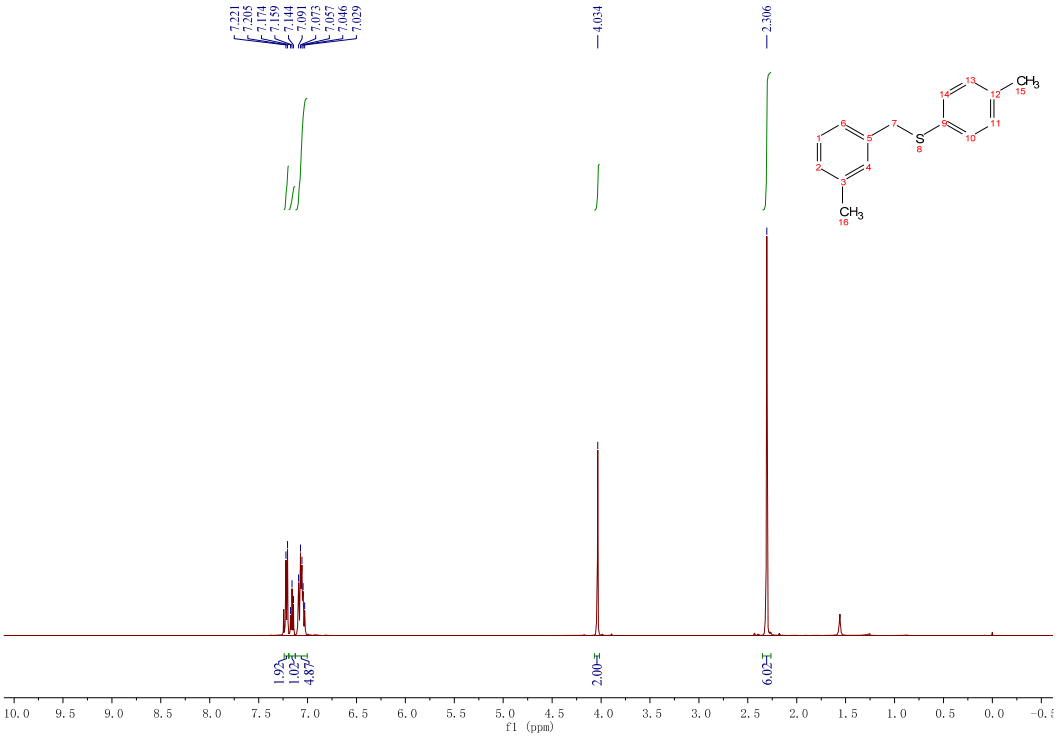

**$^{13}$C NMR**



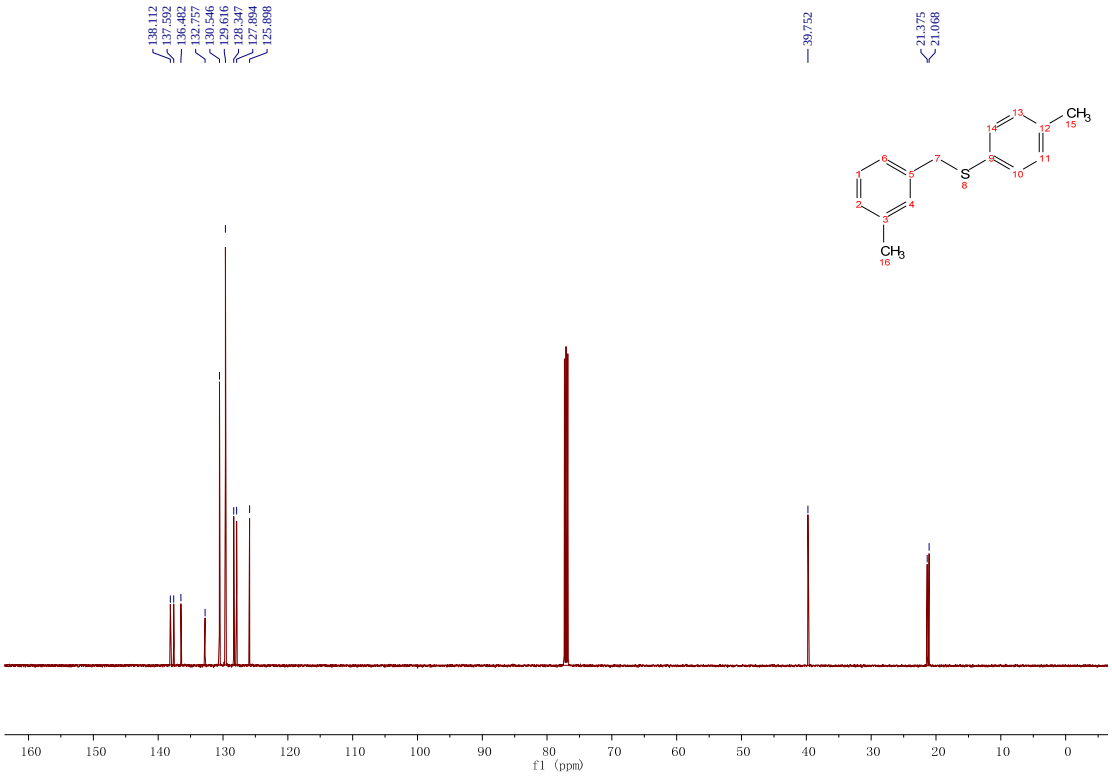


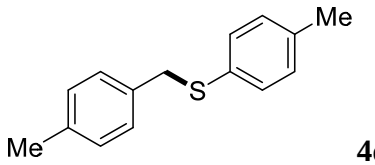

**4ca**

**$^{1}$H NMR**



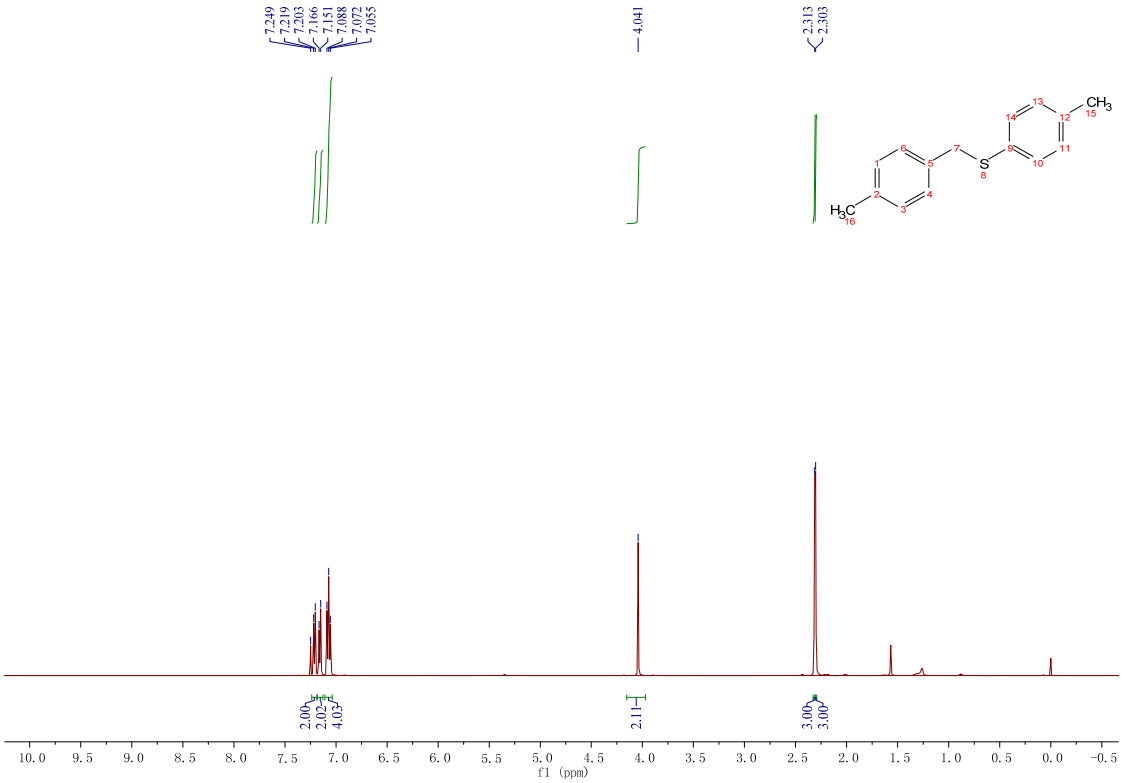

**$^{13}$C NMR**



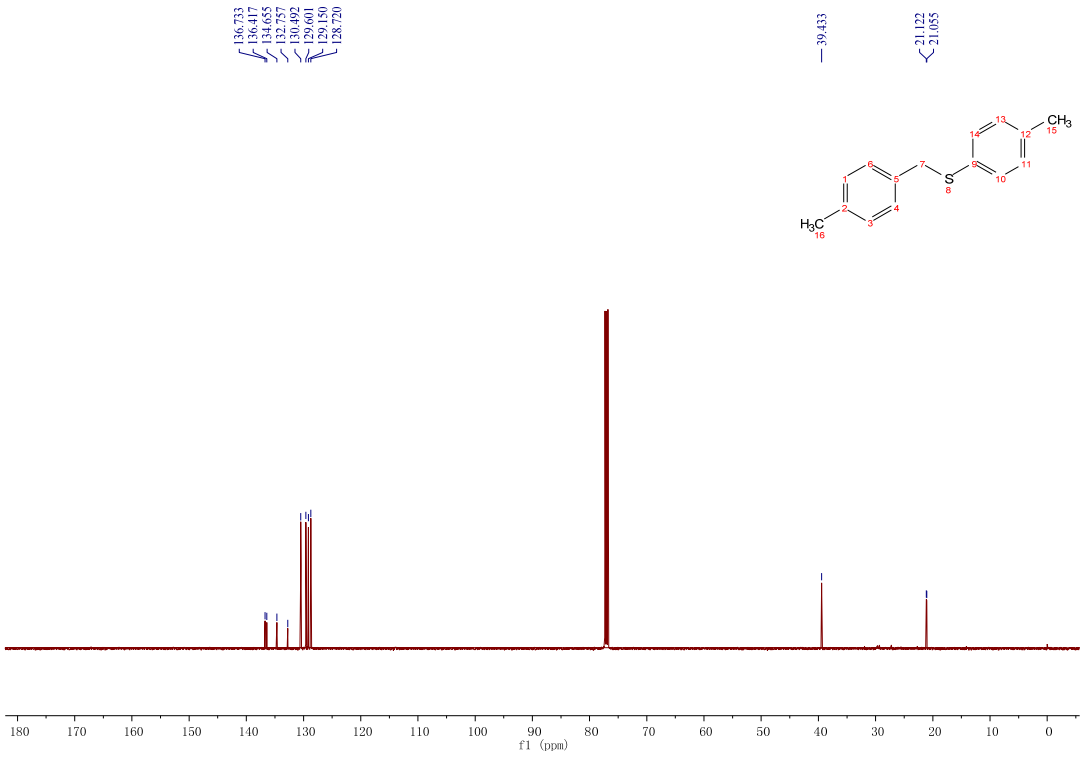


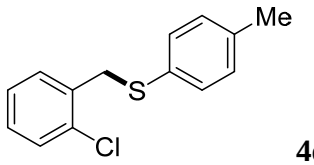

**4da**

**$^{1}$H NMR**



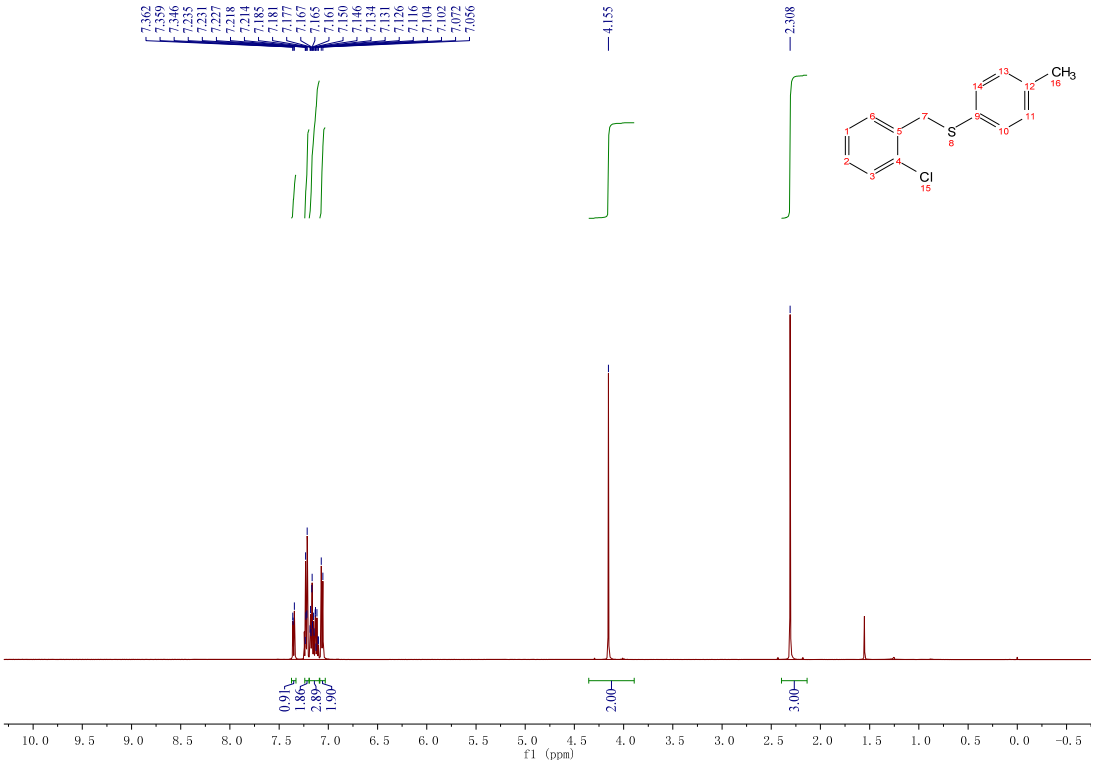

**$^{13}$C NMR**



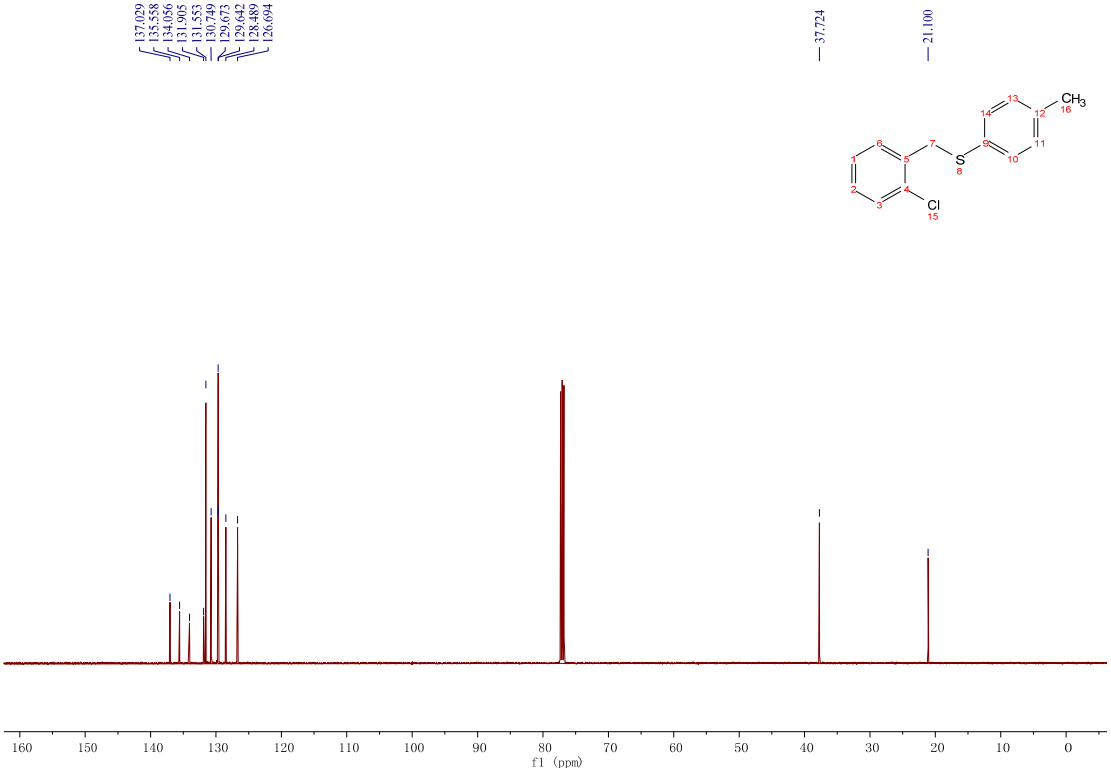


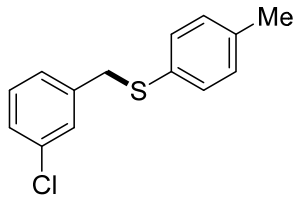

**4ea**

**$^{1}$H NMR**



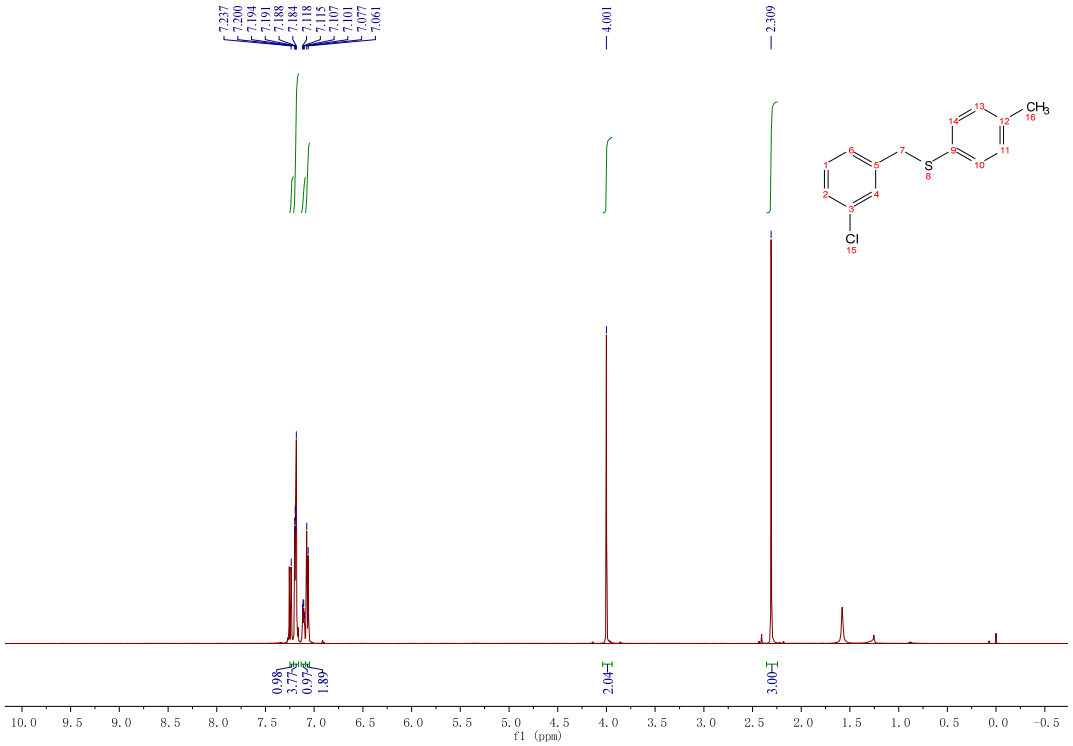

**$^{13}$C NMR**



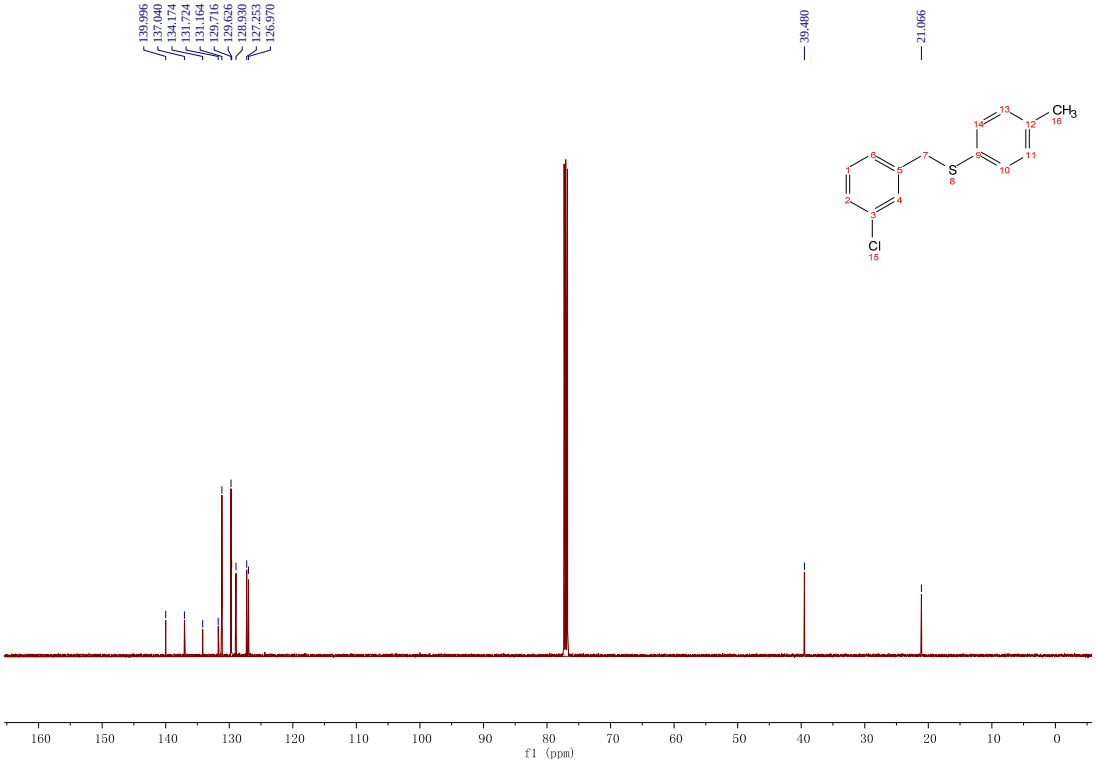


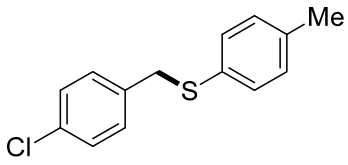

**4fa**

**$^{1}$H NMR**



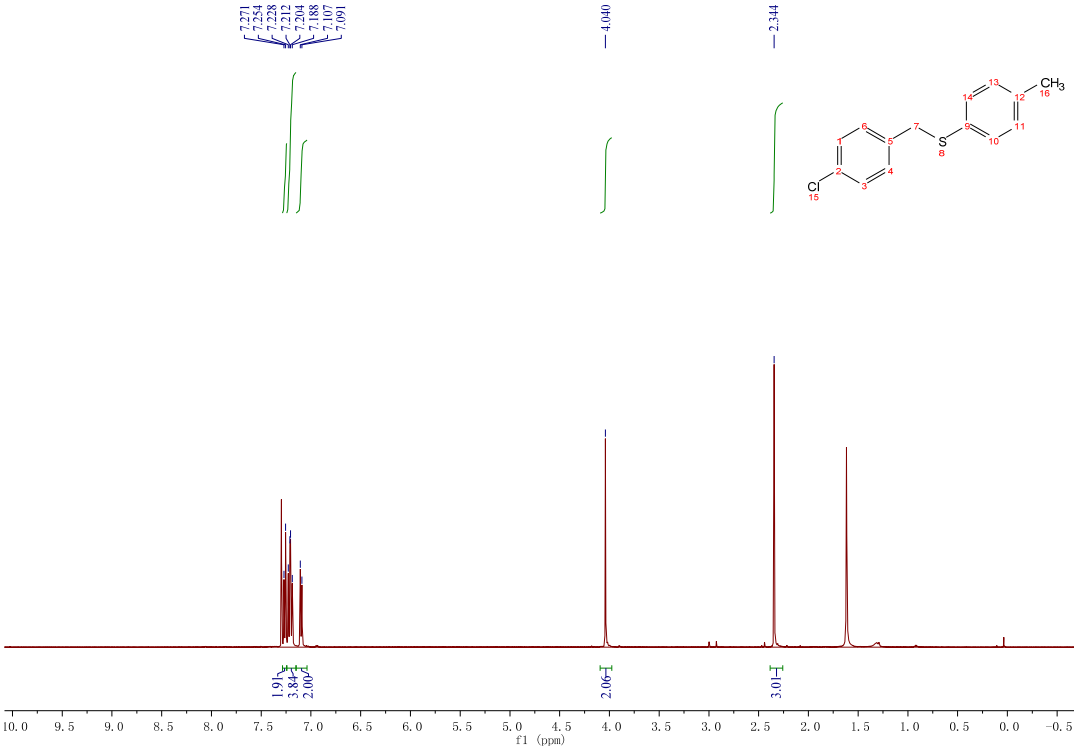

**$^{13}$C NMR**



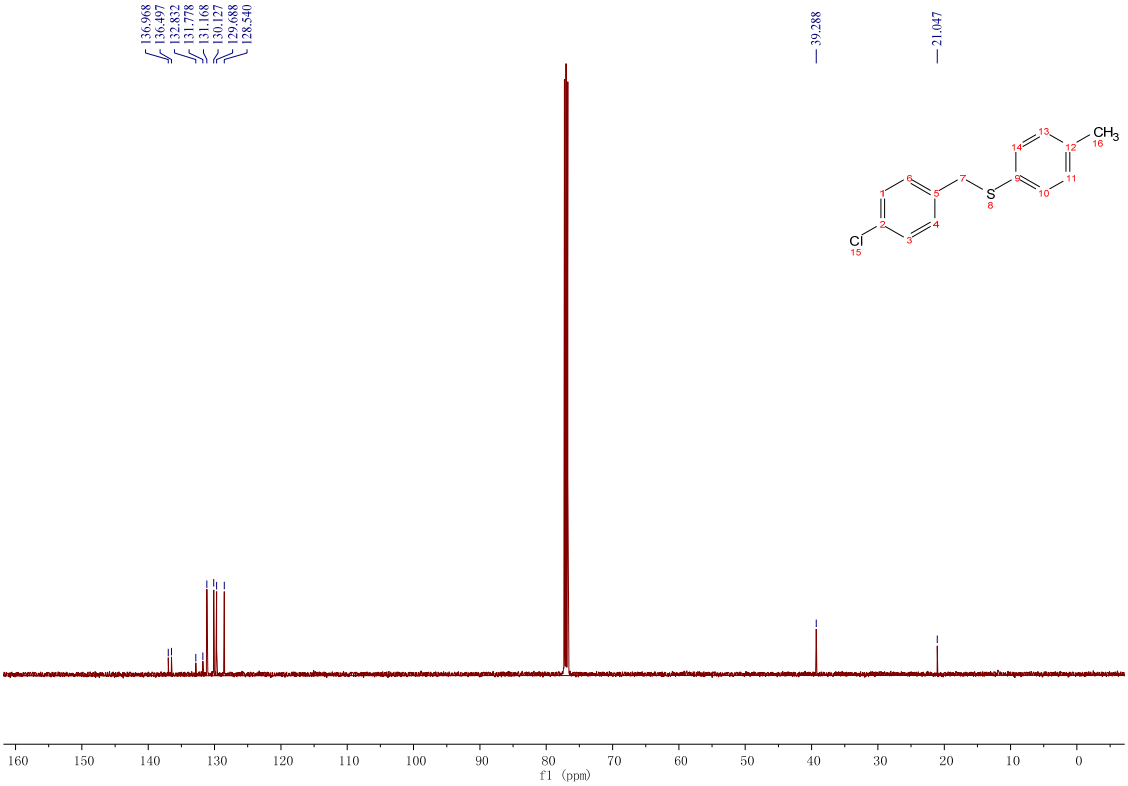


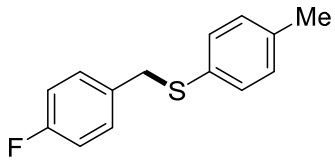

**4ga**

**$^{1}$H NMR**



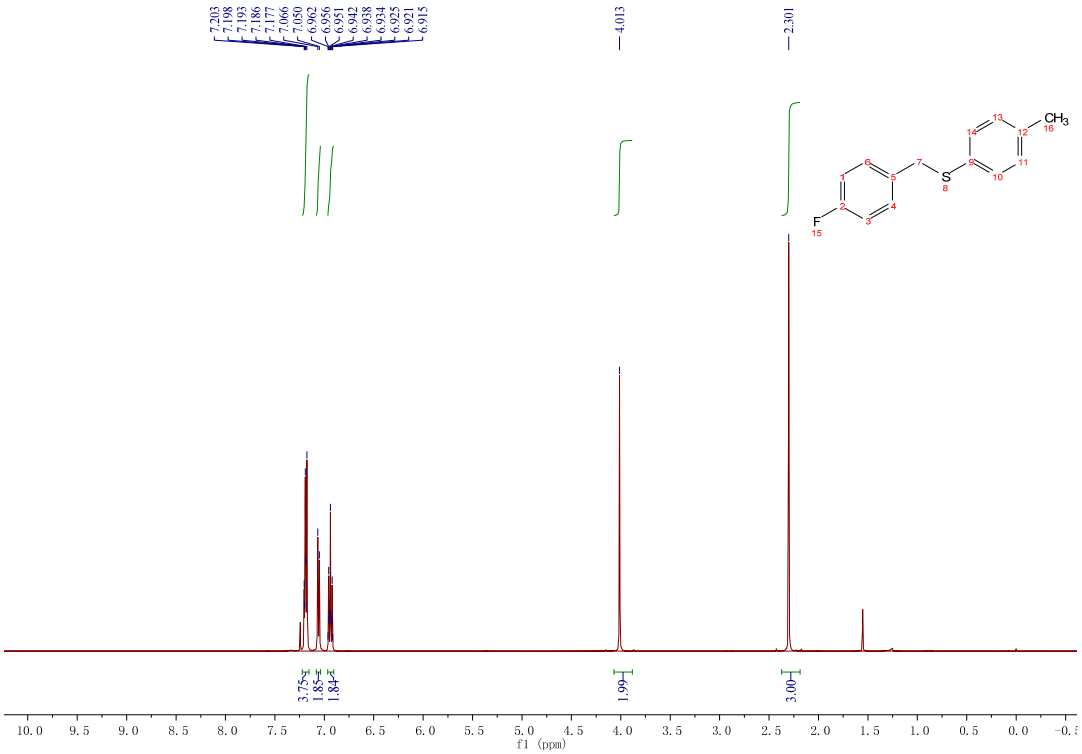

**$^{13}$C NMR**



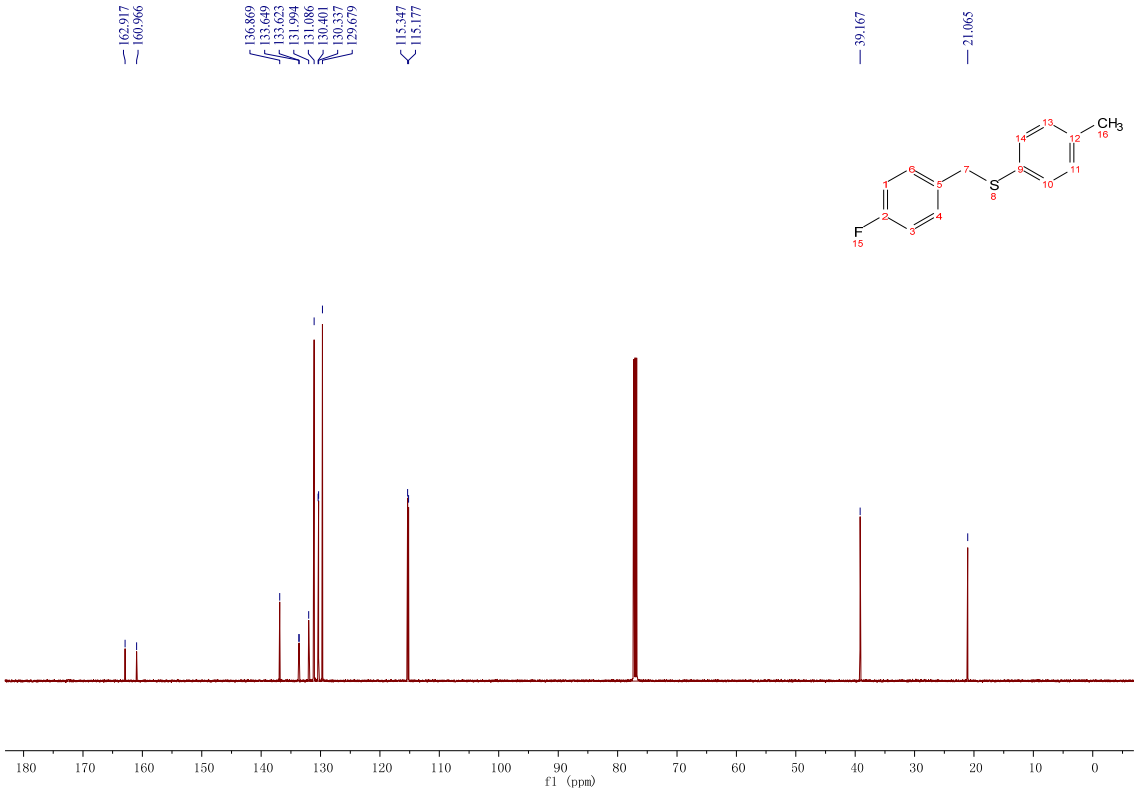


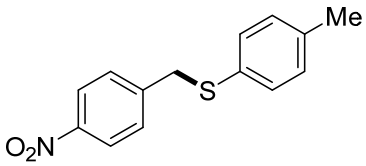

**4ha**

**$^{1}$H NMR**



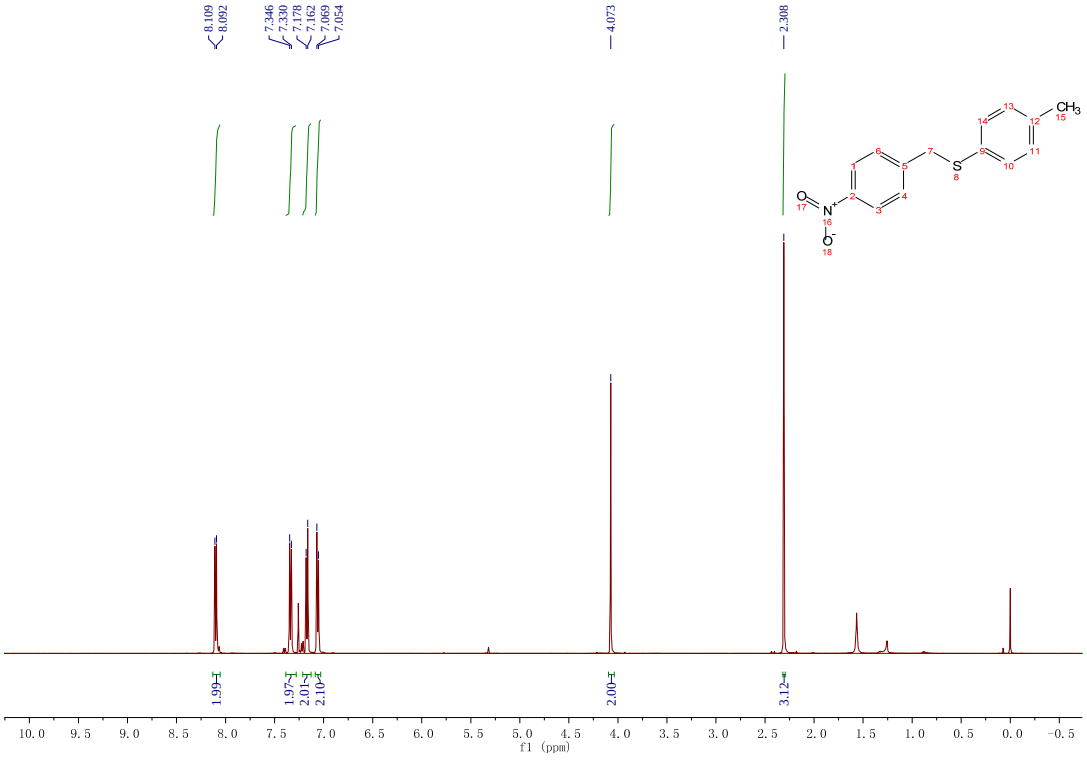

**$^{13}$C NMR**



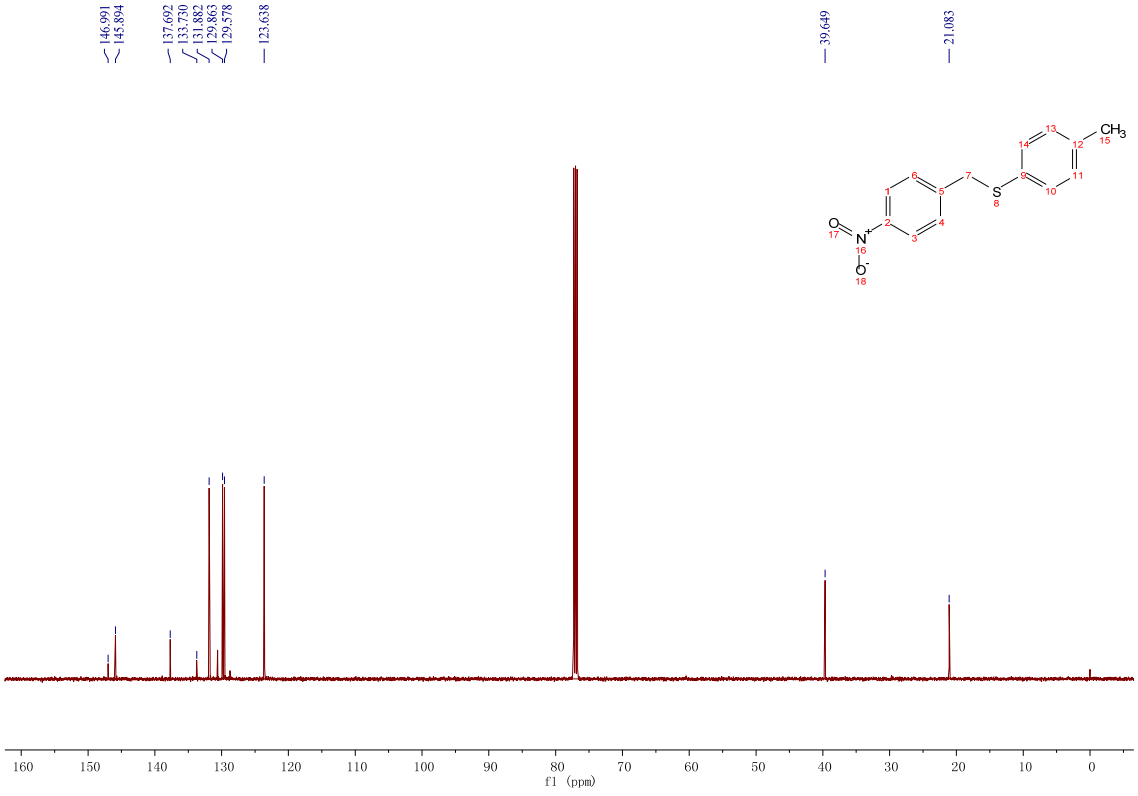


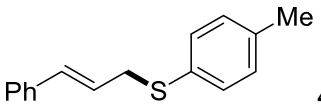

**4ia**

**$^{1}$H NMR**



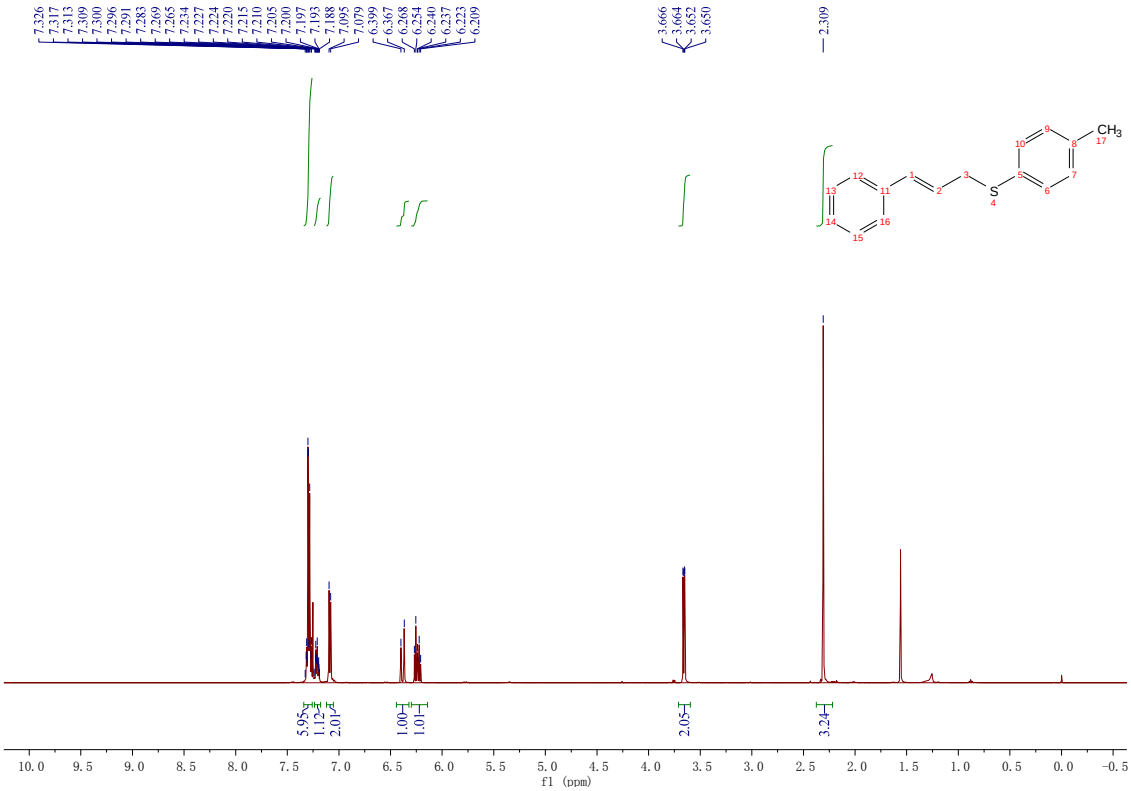

**$^{13}$C NMR**



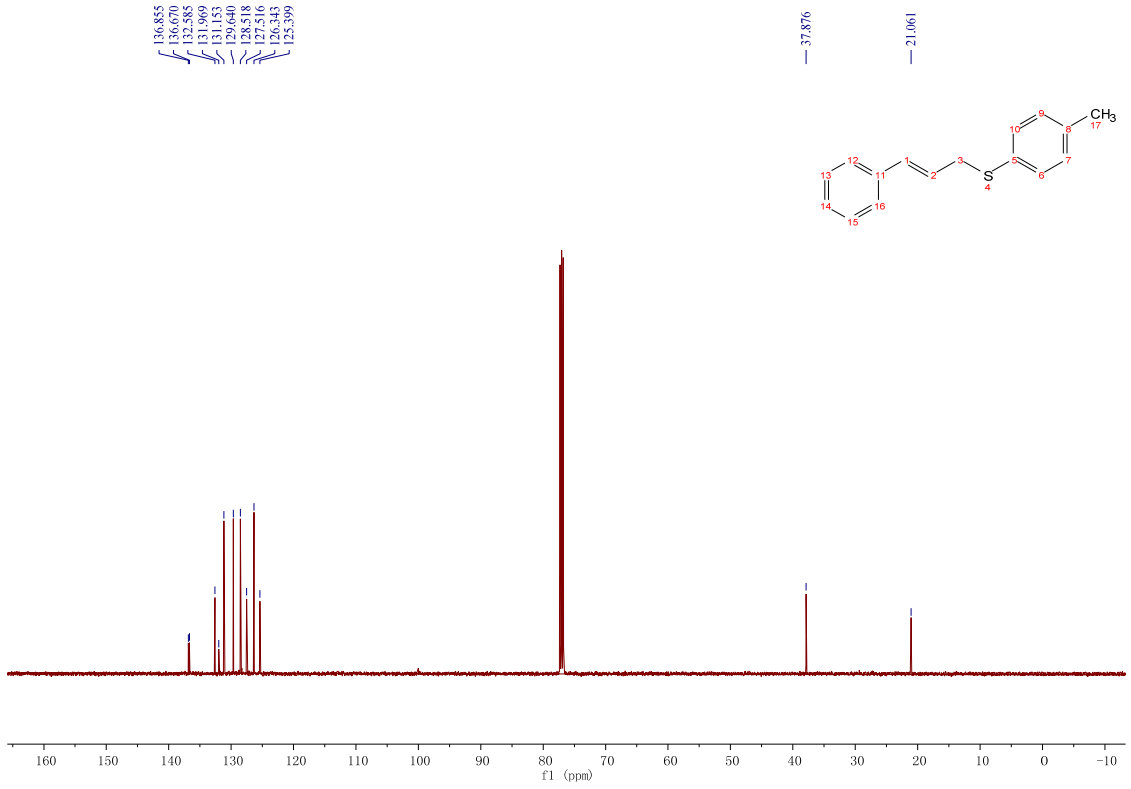


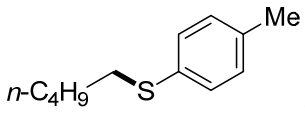

**4ja**

**$^{1}$H NMR**



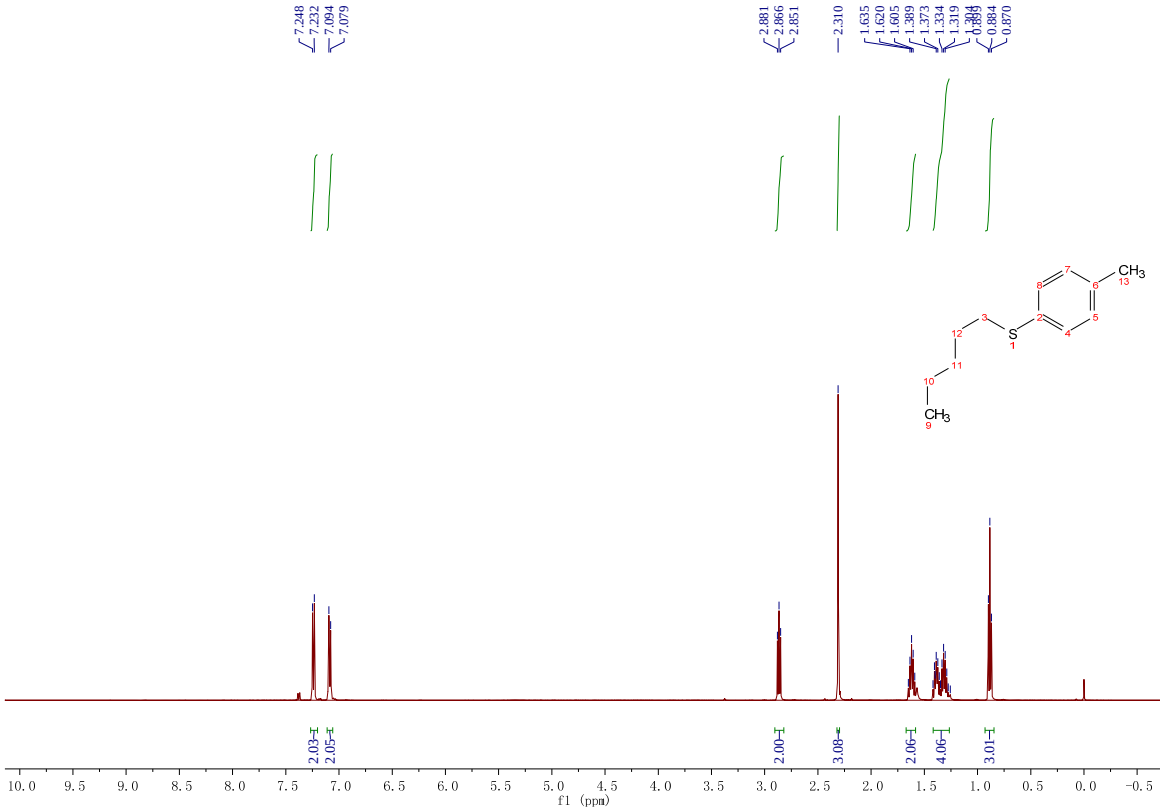

**$^{13}$C NMR**



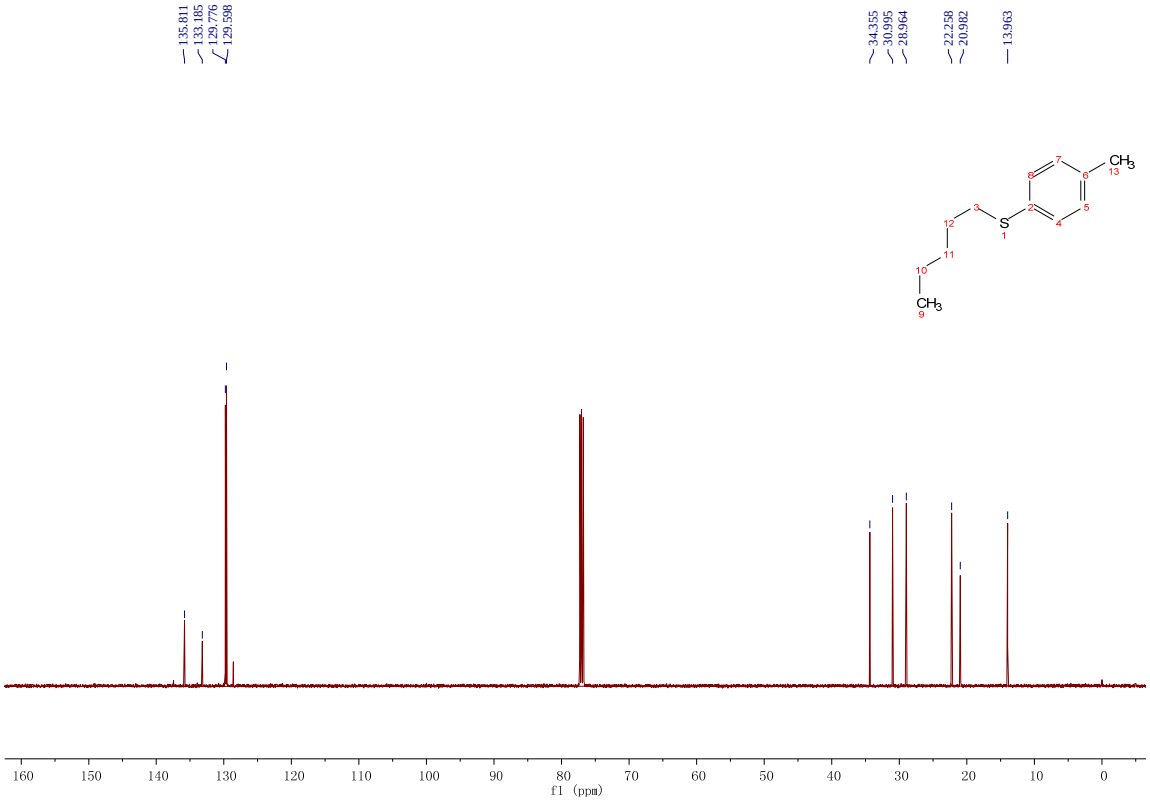


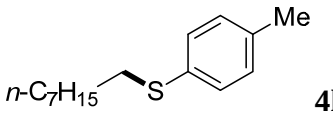

**4ka**

**$^{1}$H NMR**



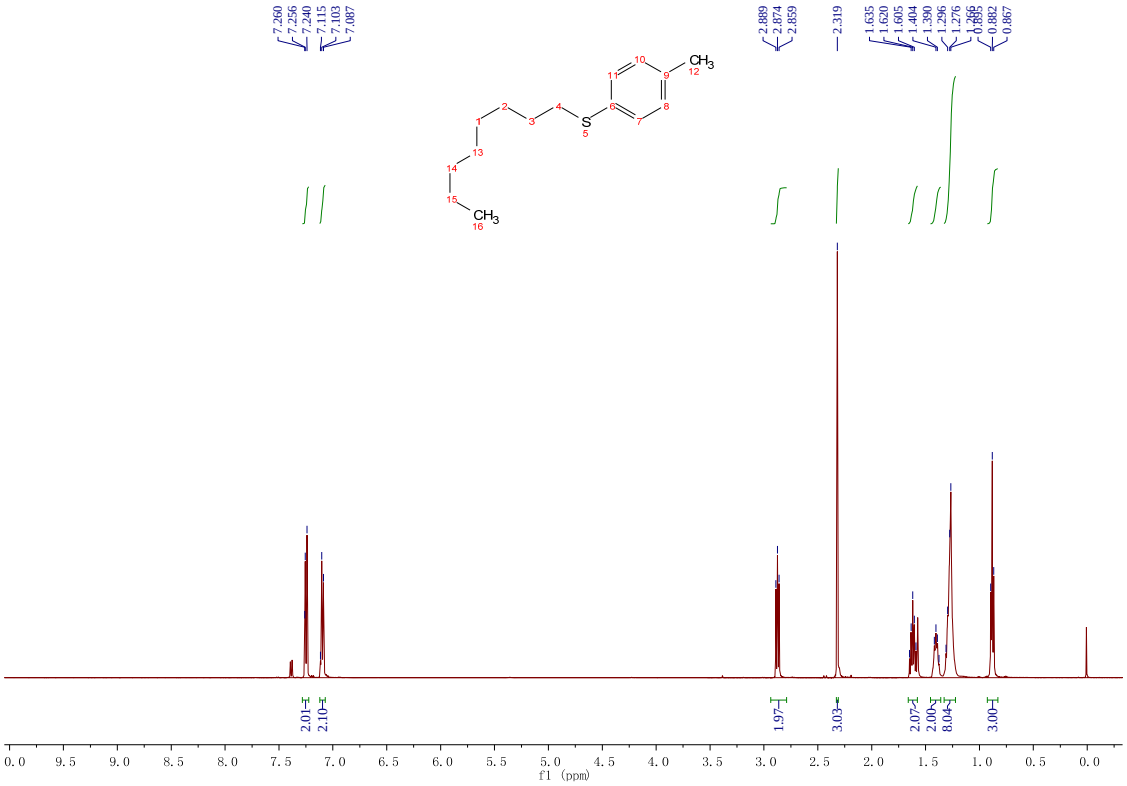

**$^{13}$C NMR**



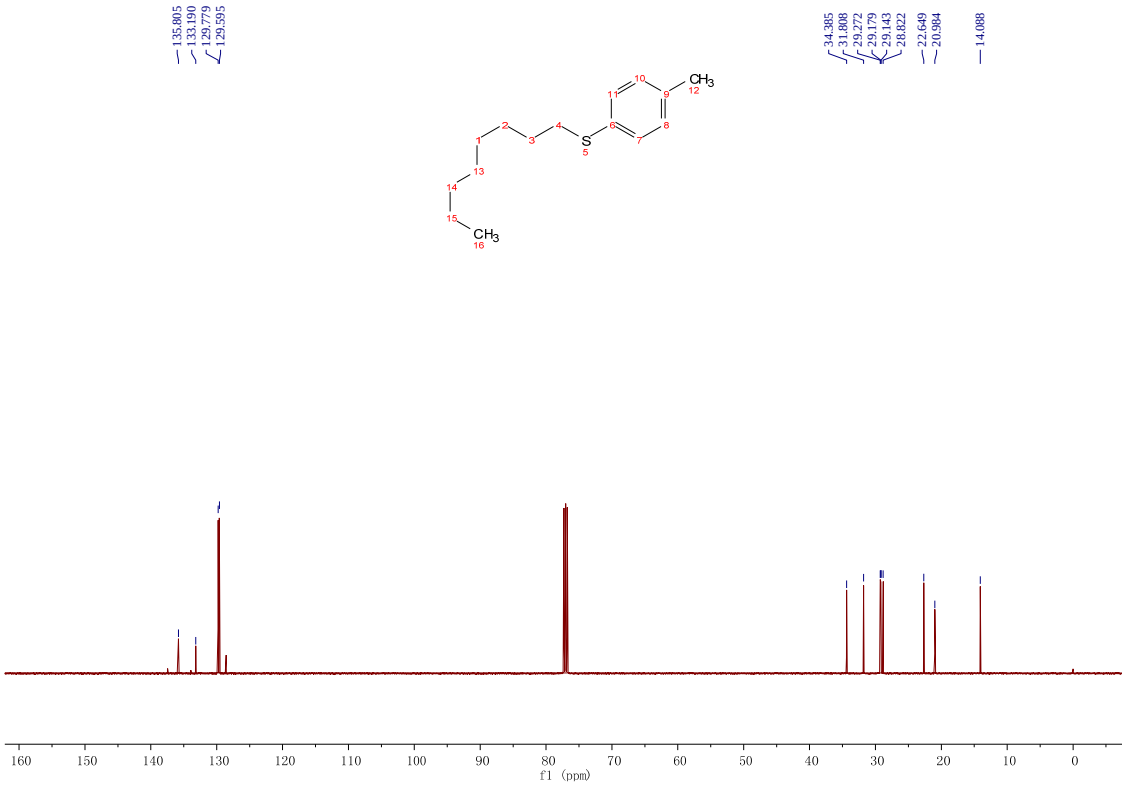


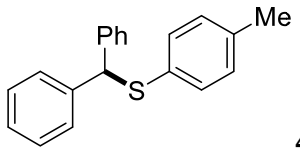

**4la**

**$^{1}$H NMR**



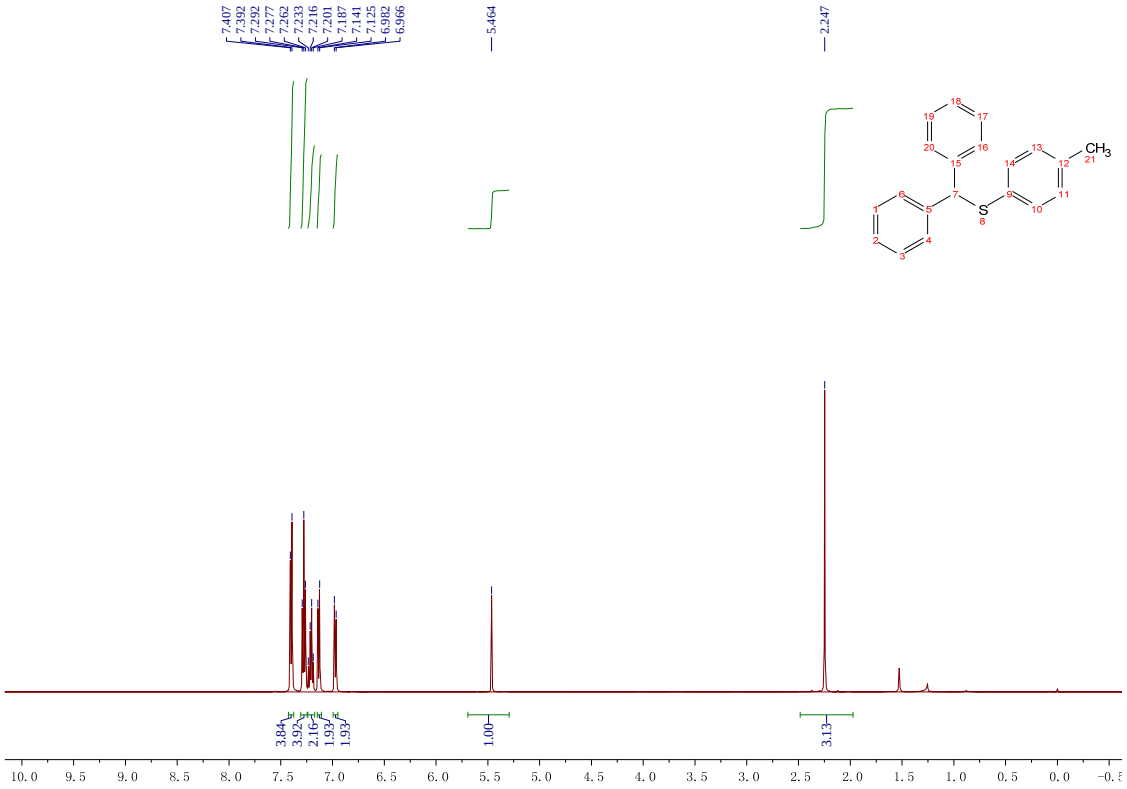

**$^{13}$C NMR**



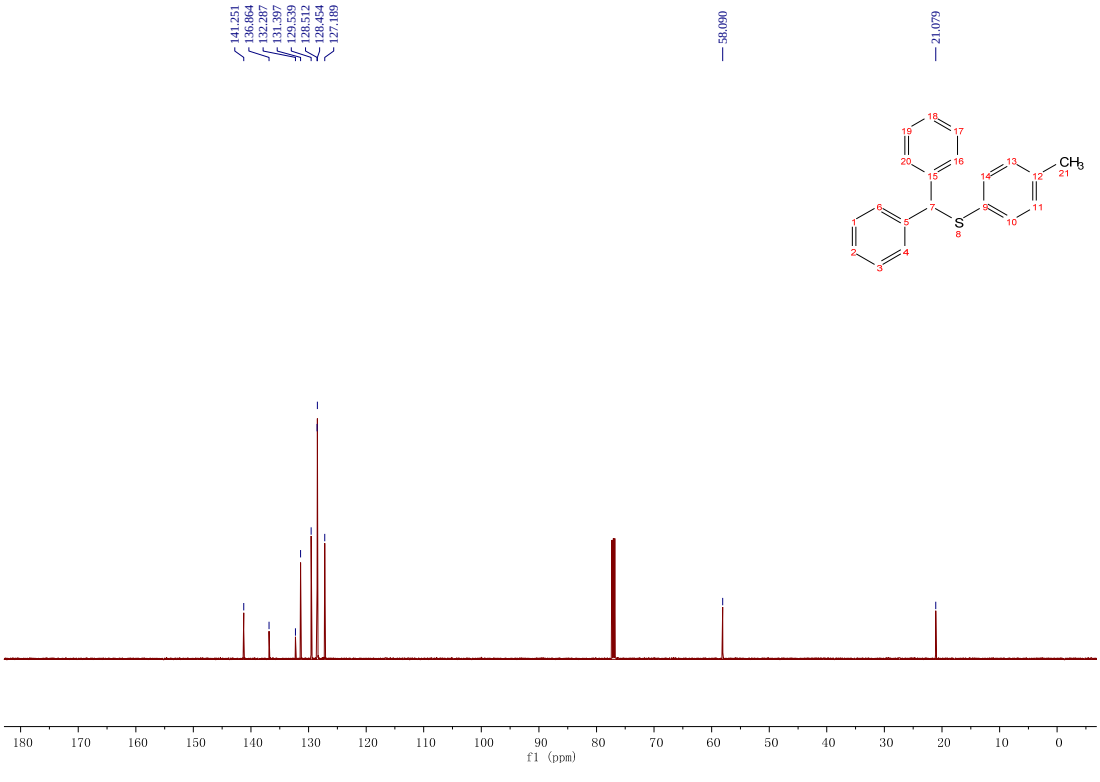


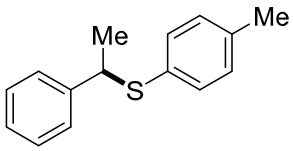

**4ma**

**$^{1}$H NMR**



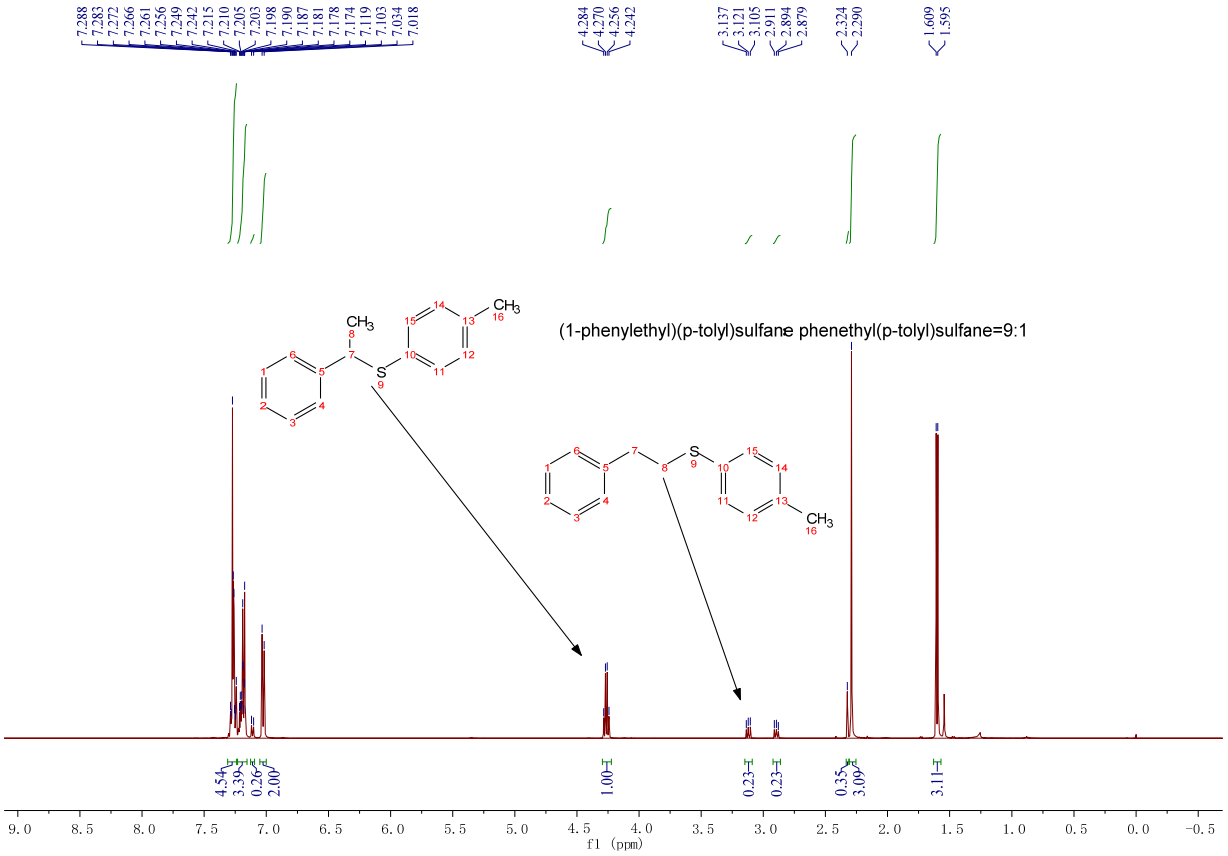

**$^{13}$C NMR**

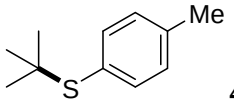



Me
Me
S

**4na**

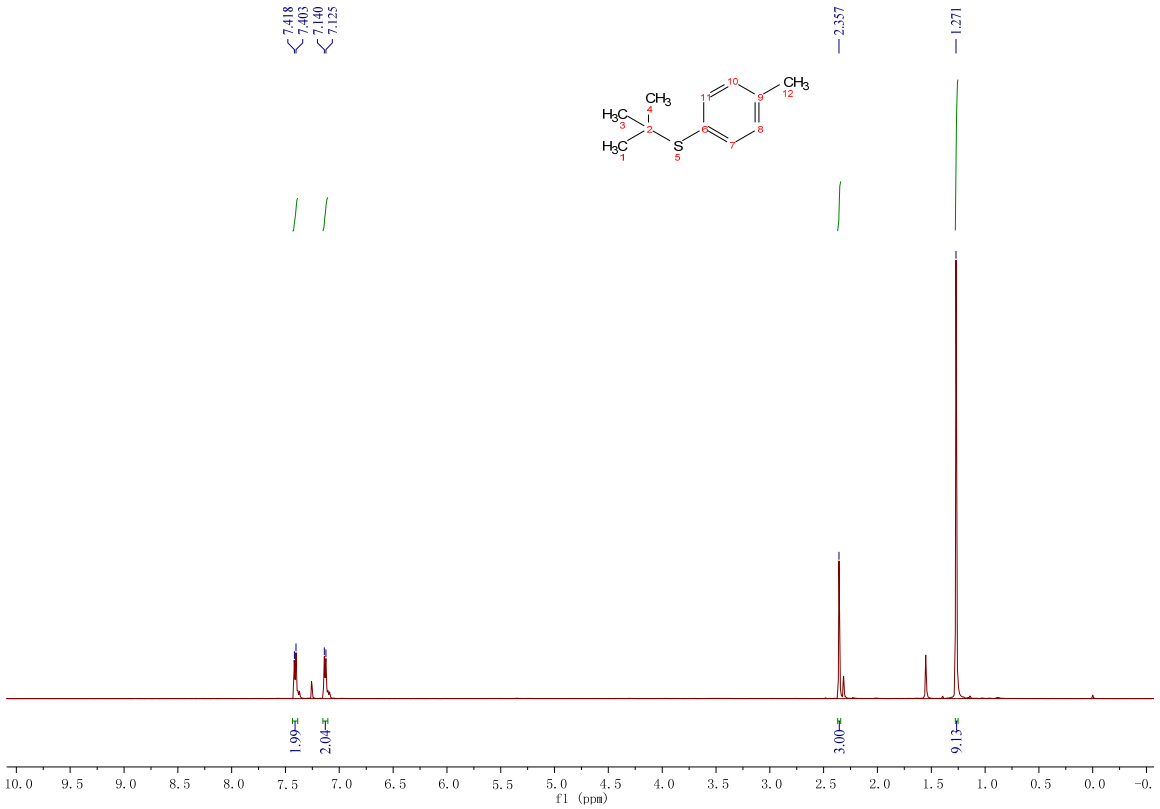
**$^{1}$H NMR**


7.288
7.283
7.272
7.266
7.261
7.256
7.249
7.242
7.215
7.210
7.205
7.203
7.198
7.190
7.187
7.181
7.178
7.174
7.119
7.103
7.034
7.018
4.284
4.270
4.256
4.242
3.137
3.121
3.105
2.911
2.894
2.879
2.324
2.290
1.609
1.595
(1-phenylethyl)(p-tolyl)sulfane phenethyl(p-tolyl)sulfane=9:1
4.54
3.39
0.26
2.00
1.00
0.23
0.23
0.35
3.09
3.11
f1 (ppm)

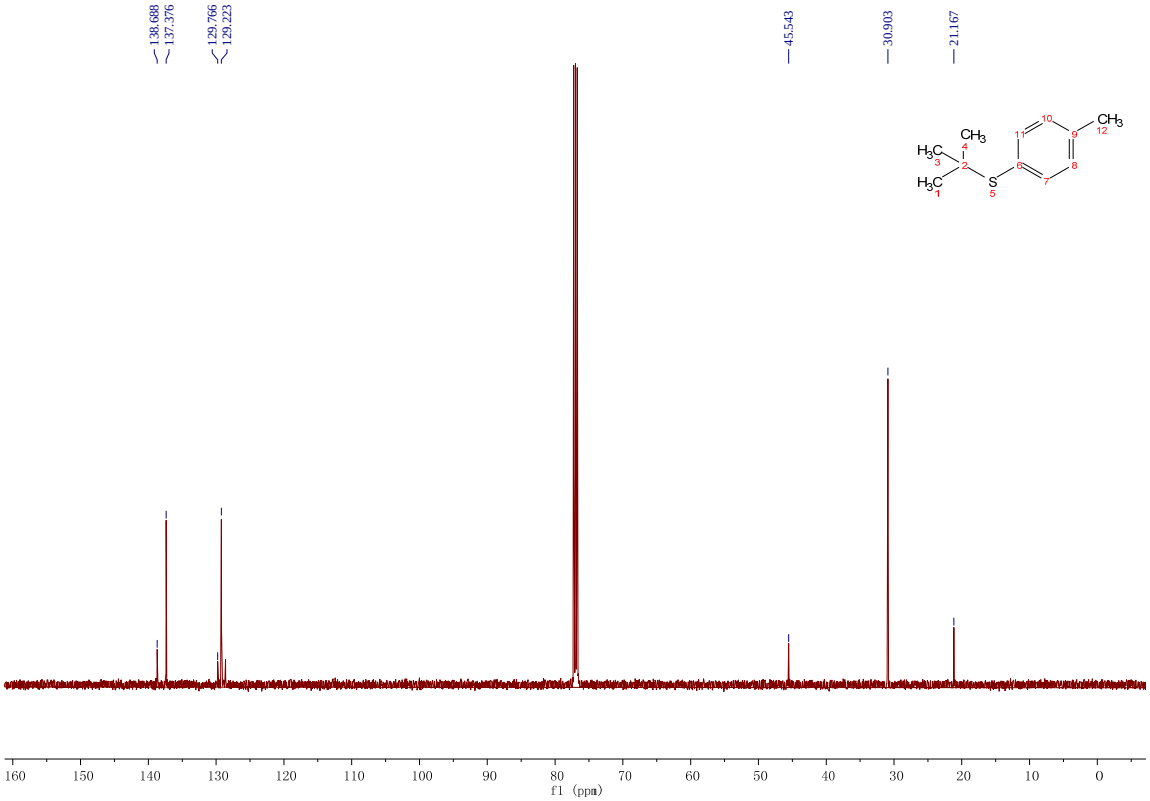


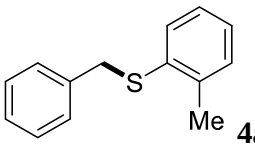

**4pa**

**$^{1}$H NMR**



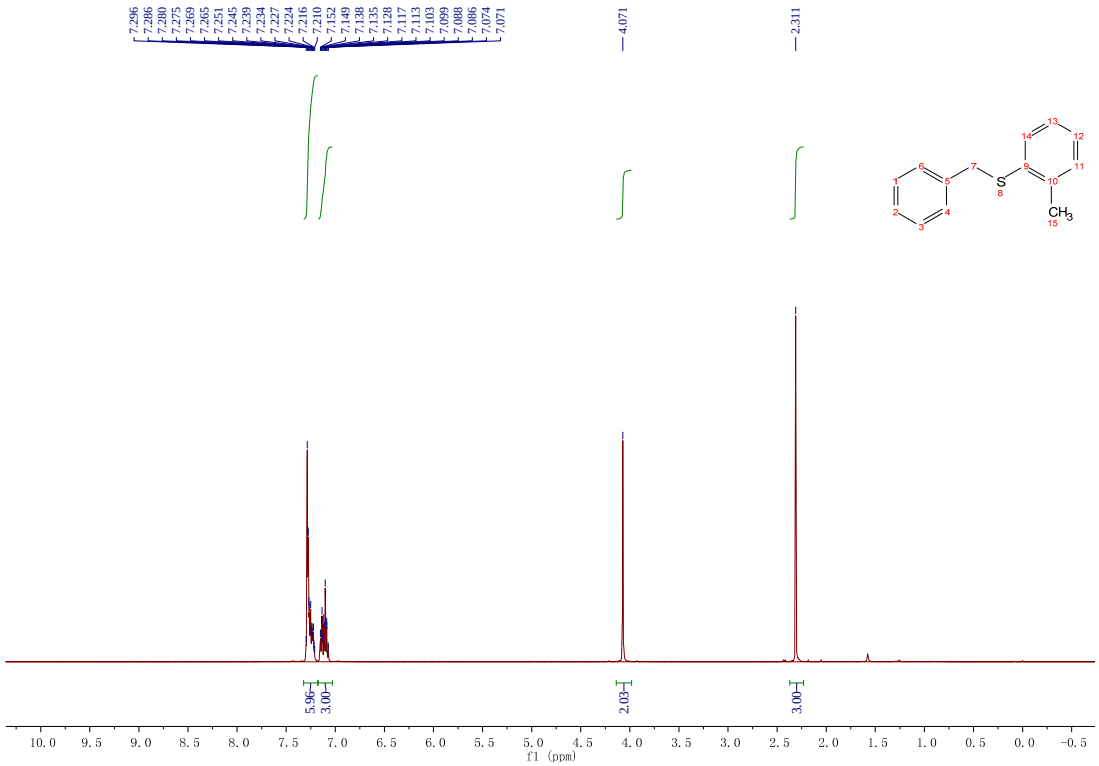

**$^{13}$C NMR**



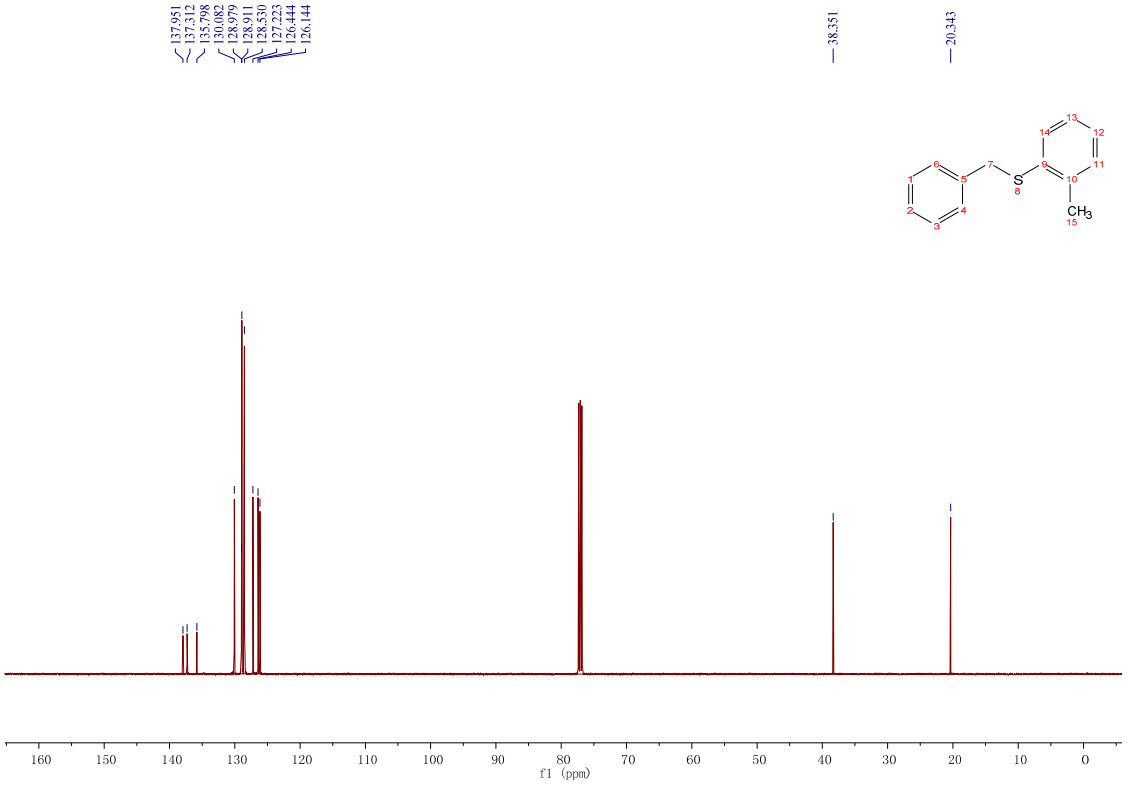


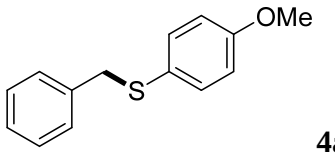

**4ab**

**$^{1}$H NMR**



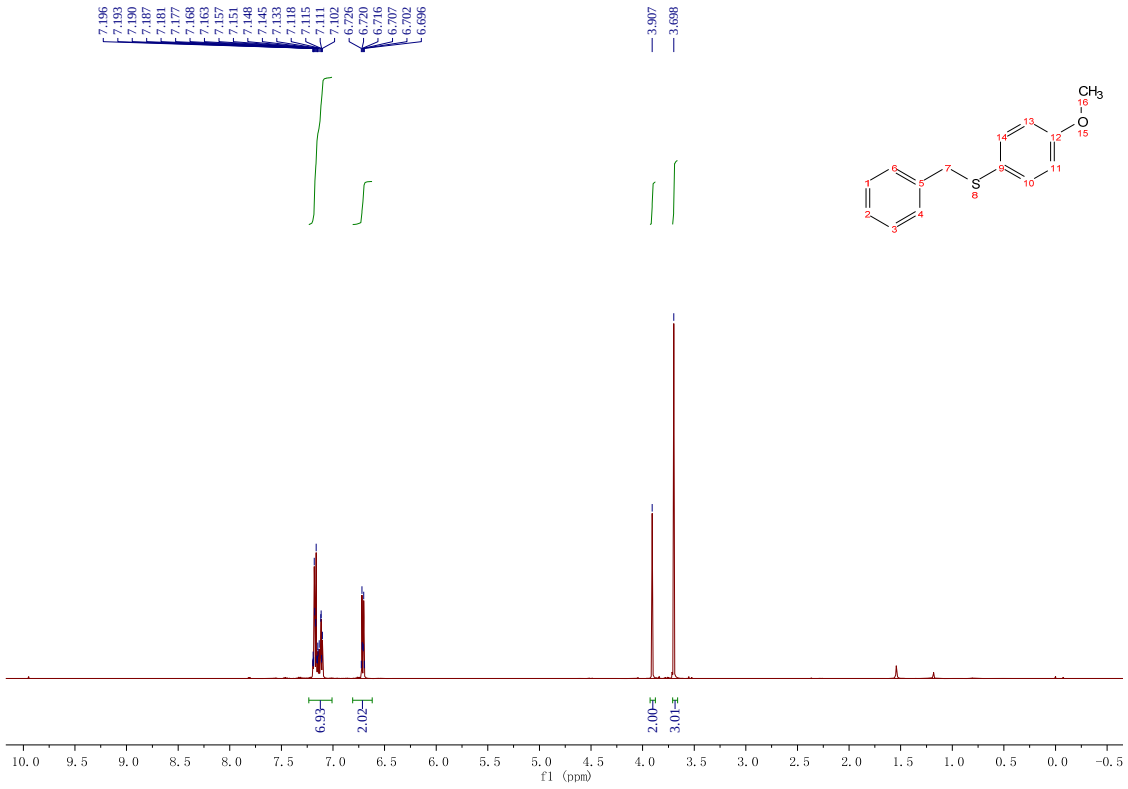

**$^{13}$C NMR**



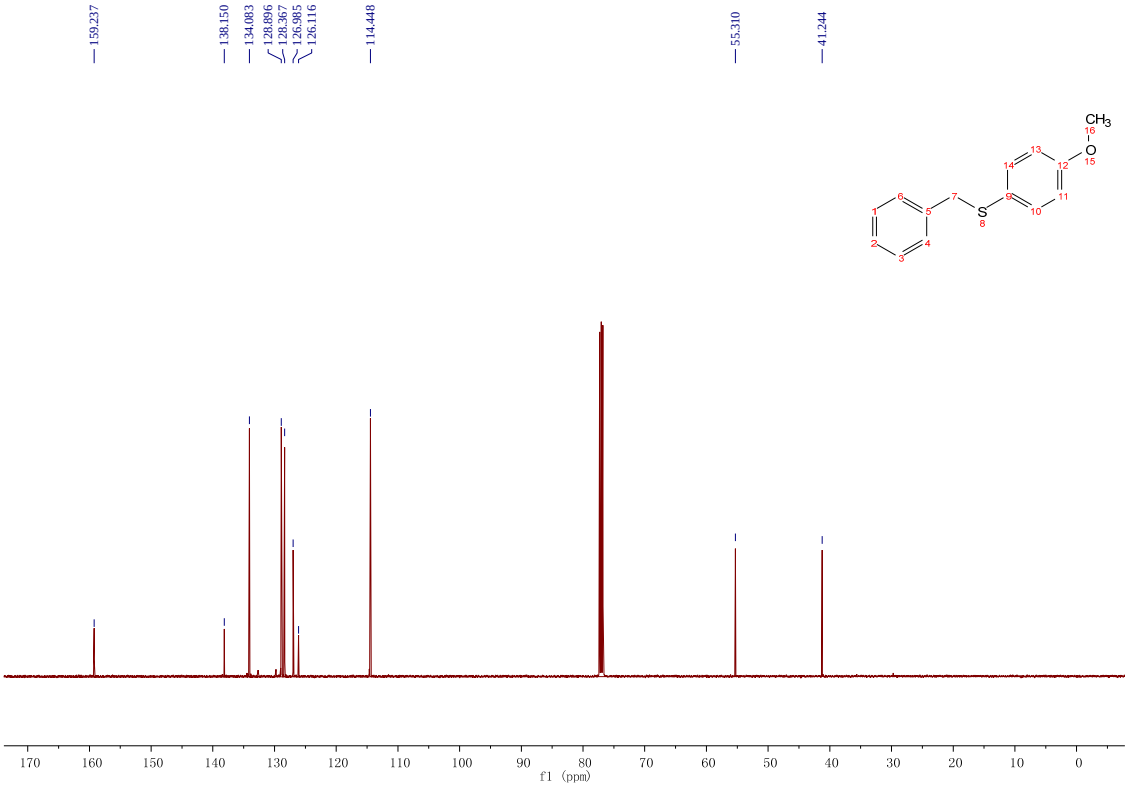


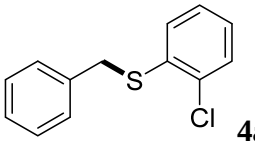

**4ac**

**$^{1}$H NMR**



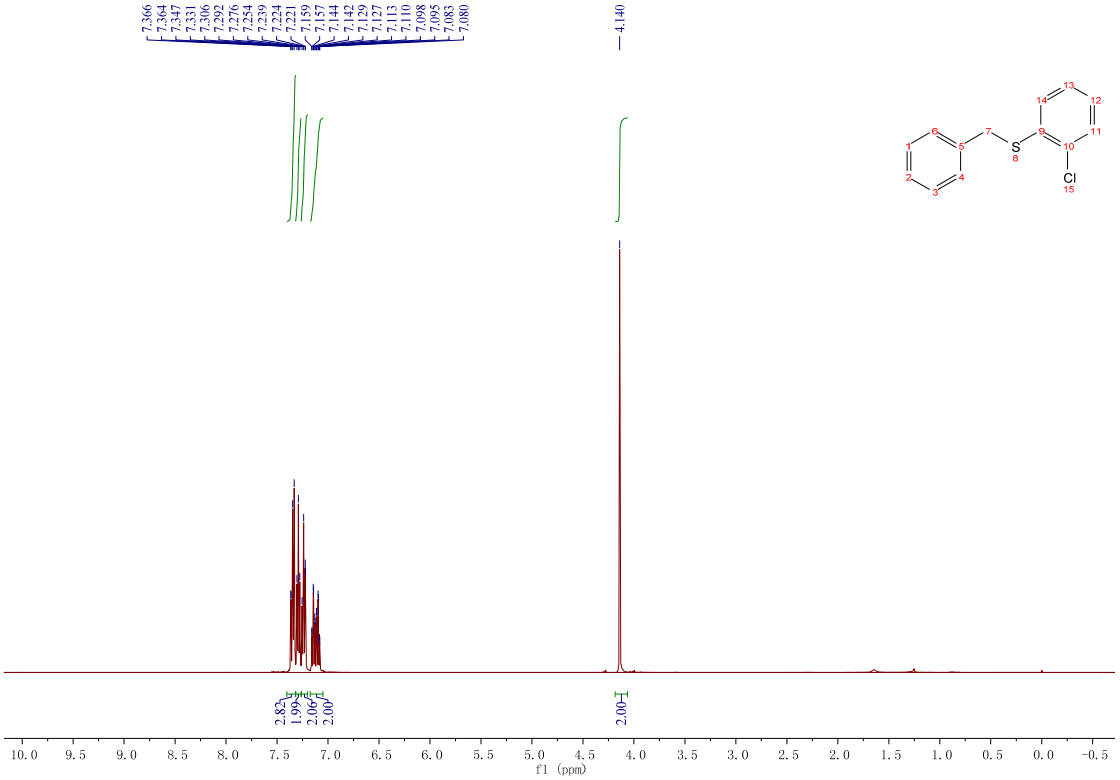

**$^{13}$C NMR**



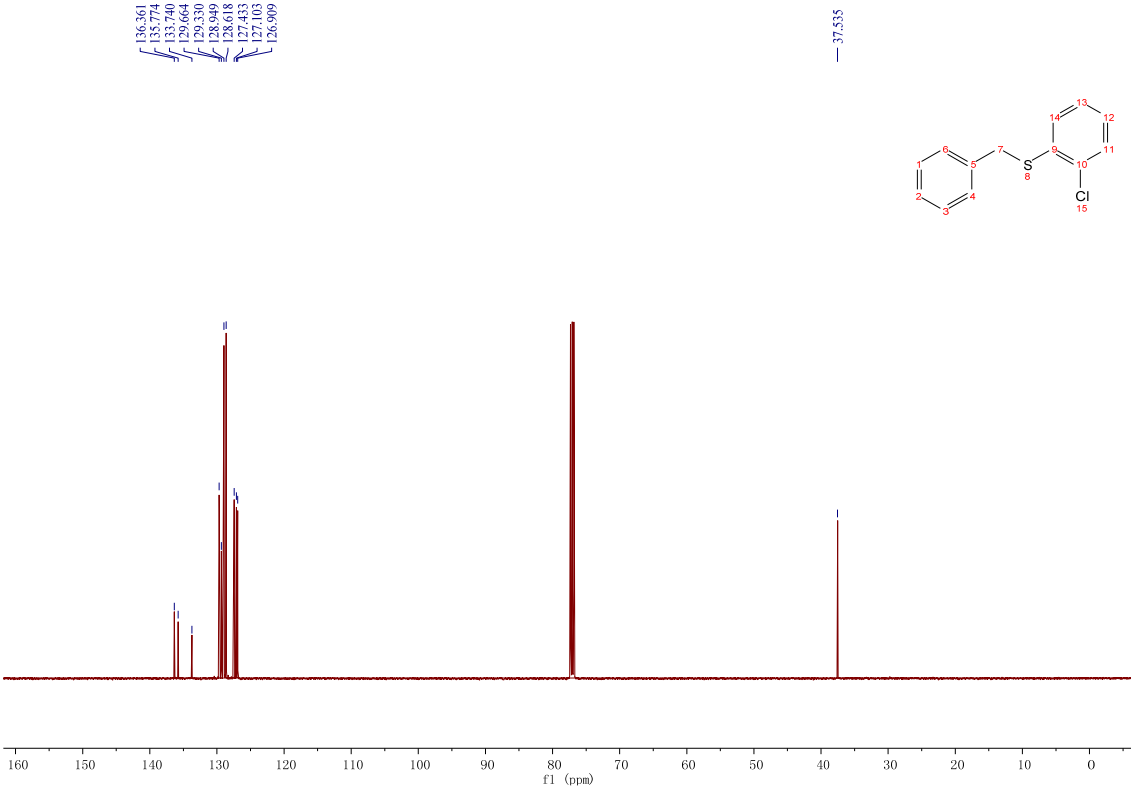


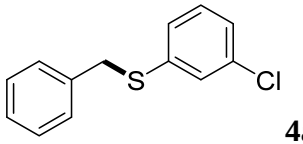

**4ad**

**$^{1}$H NMR**



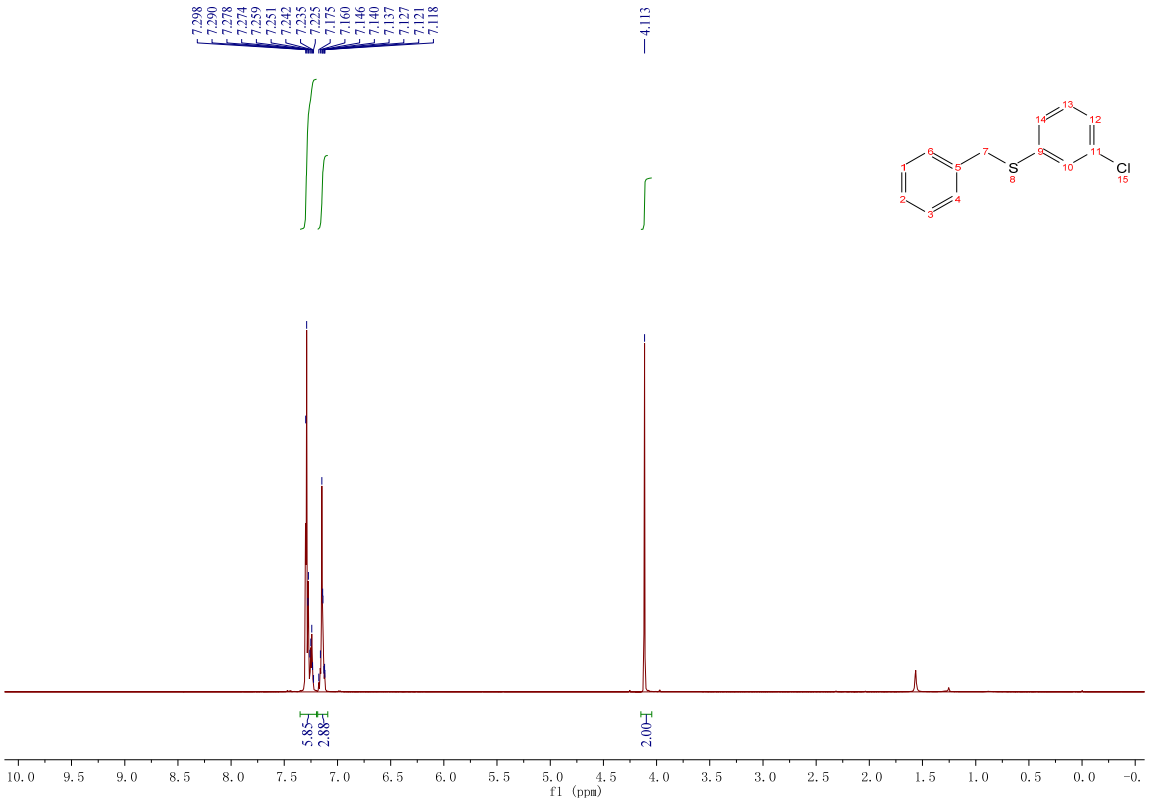

**$^{13}$C NMR**



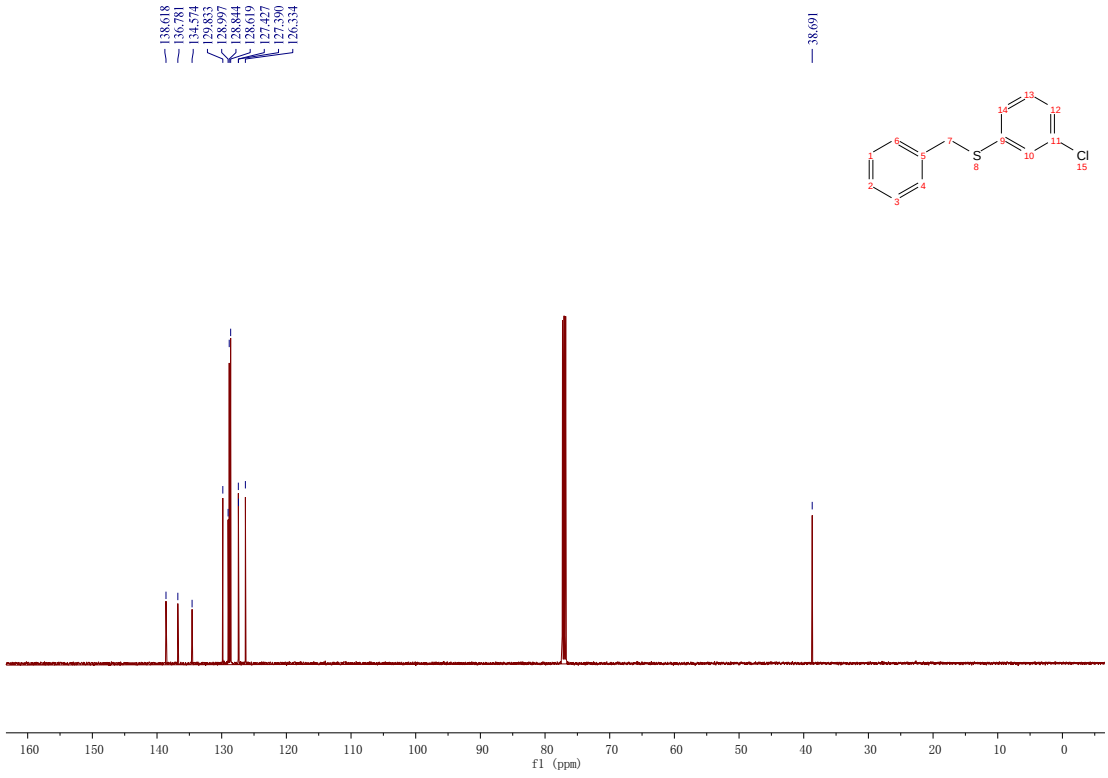


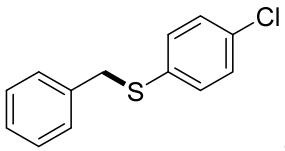

**4ae**

**$^{1}$H NMR**



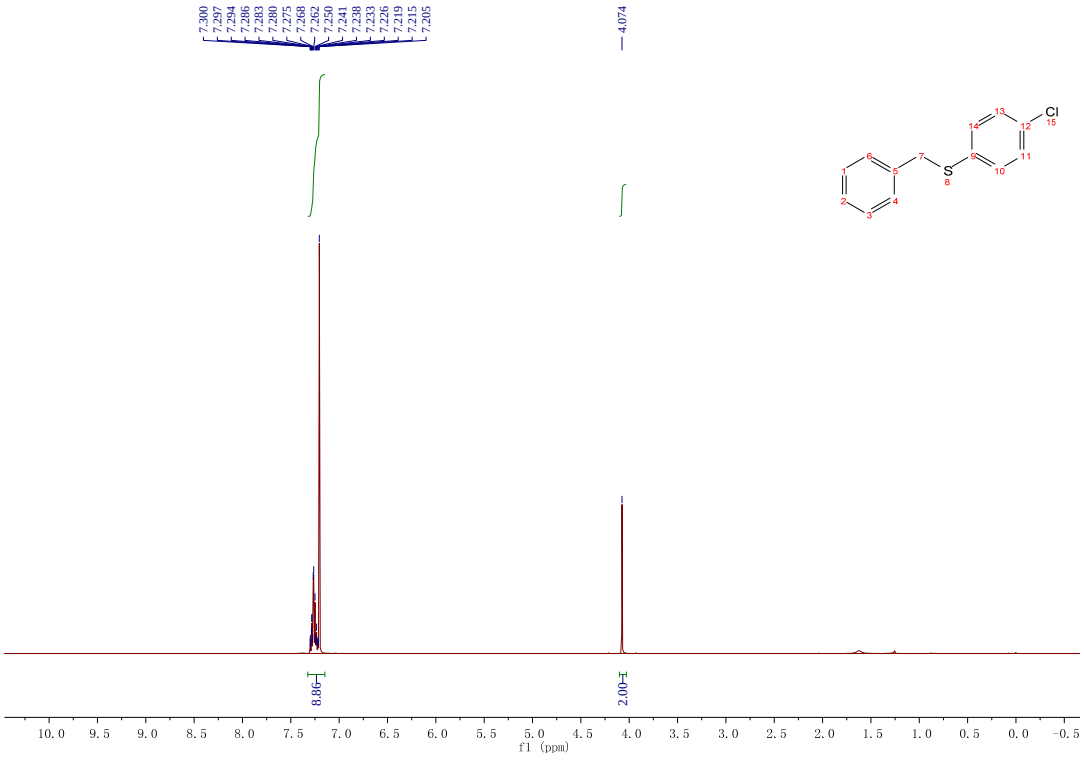

**$^{13}$C NMR**



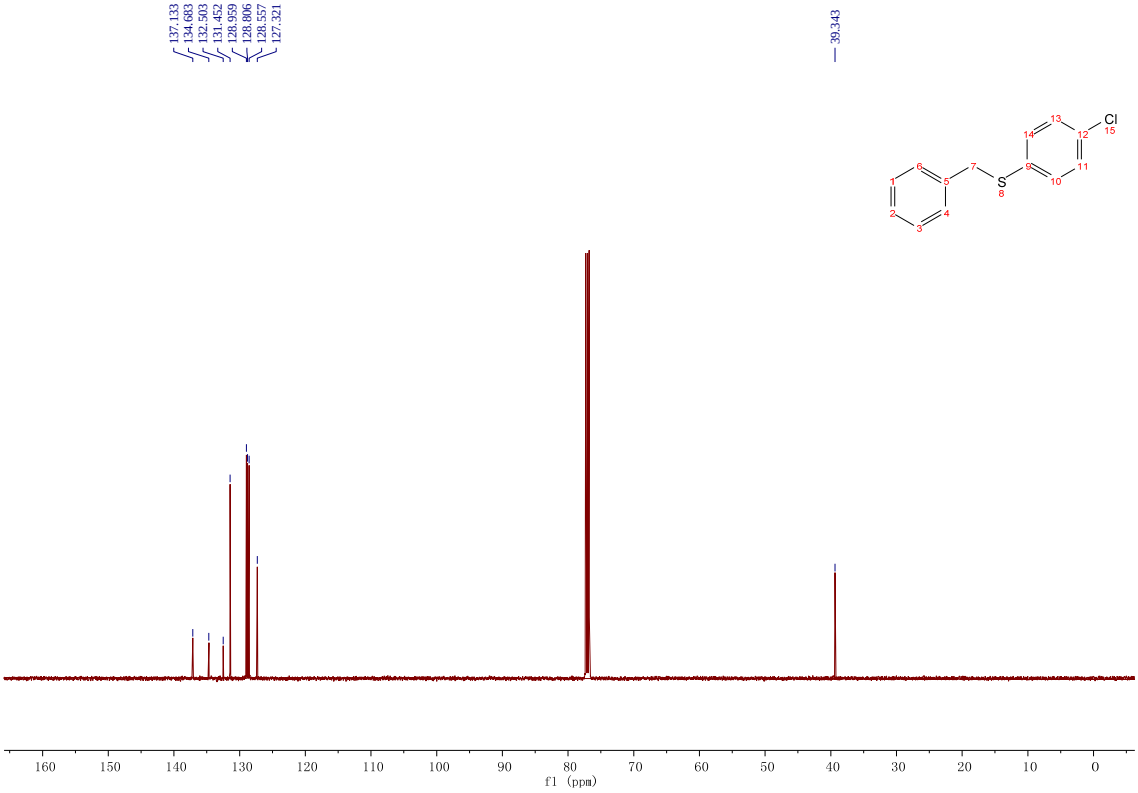


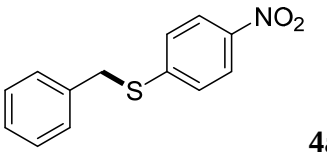

**4af**

**$^{1}$H NMR**



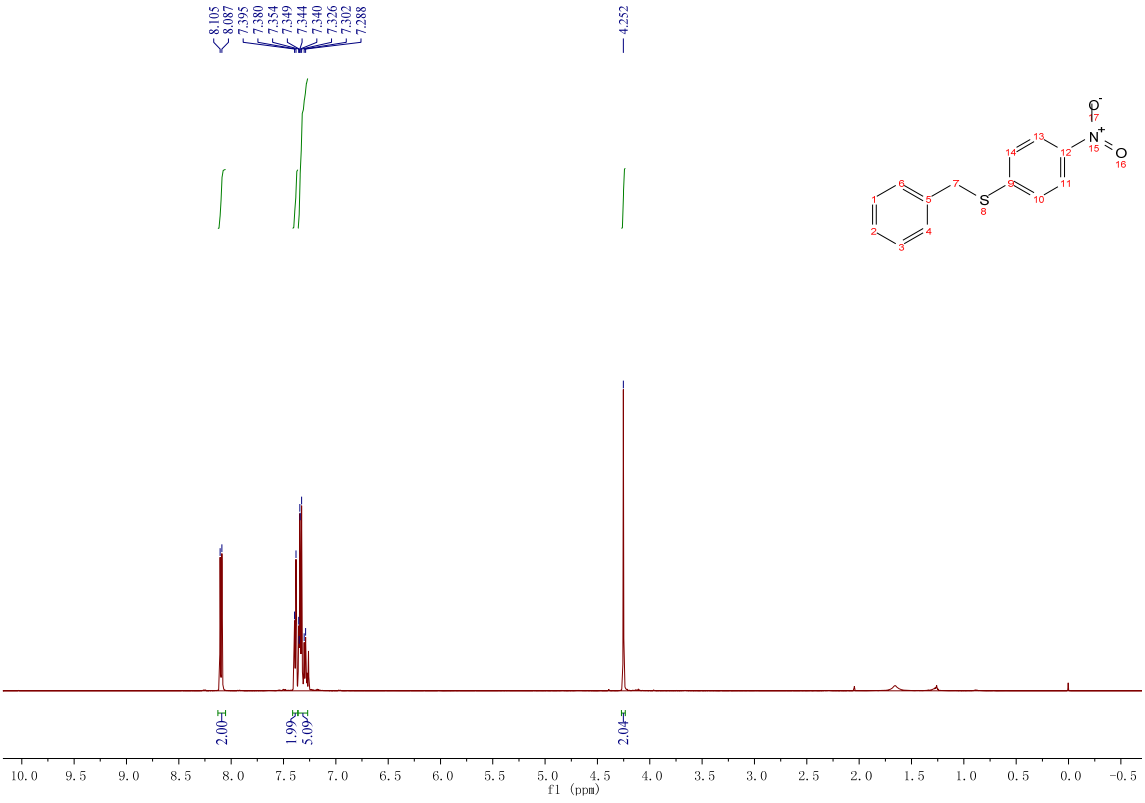

**$^{13}$C NMR**



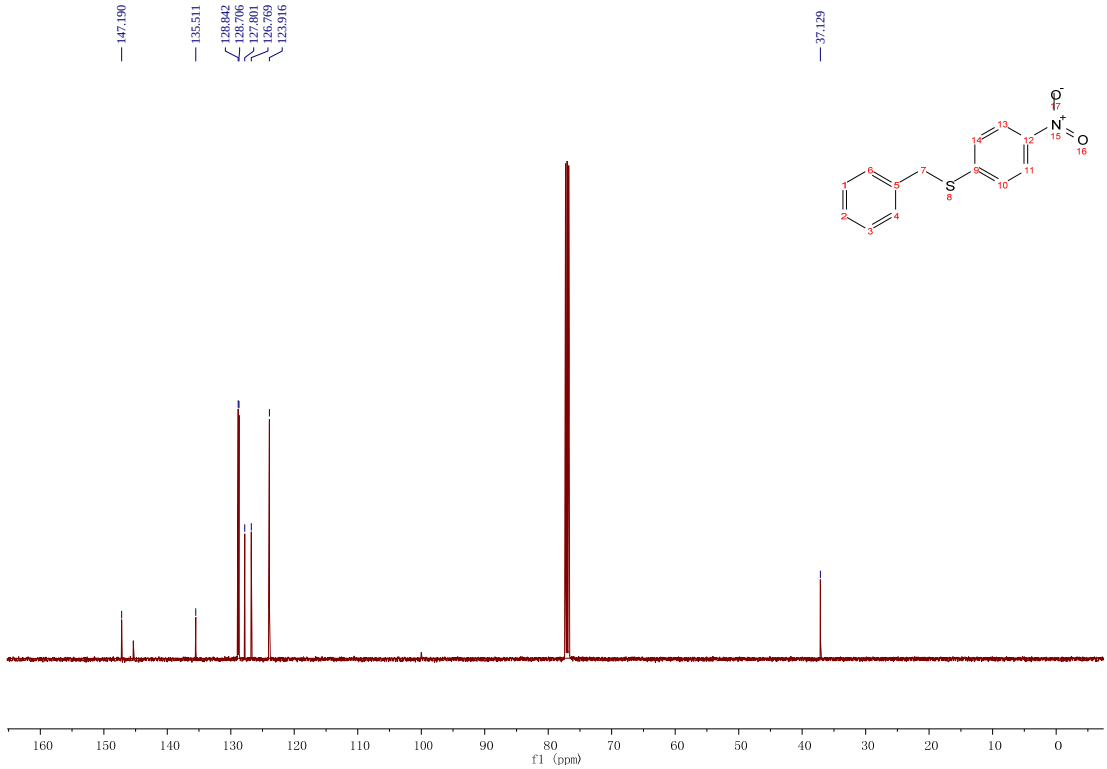


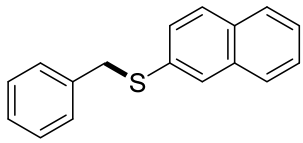

**4ag**

**$^{1}$H NMR**



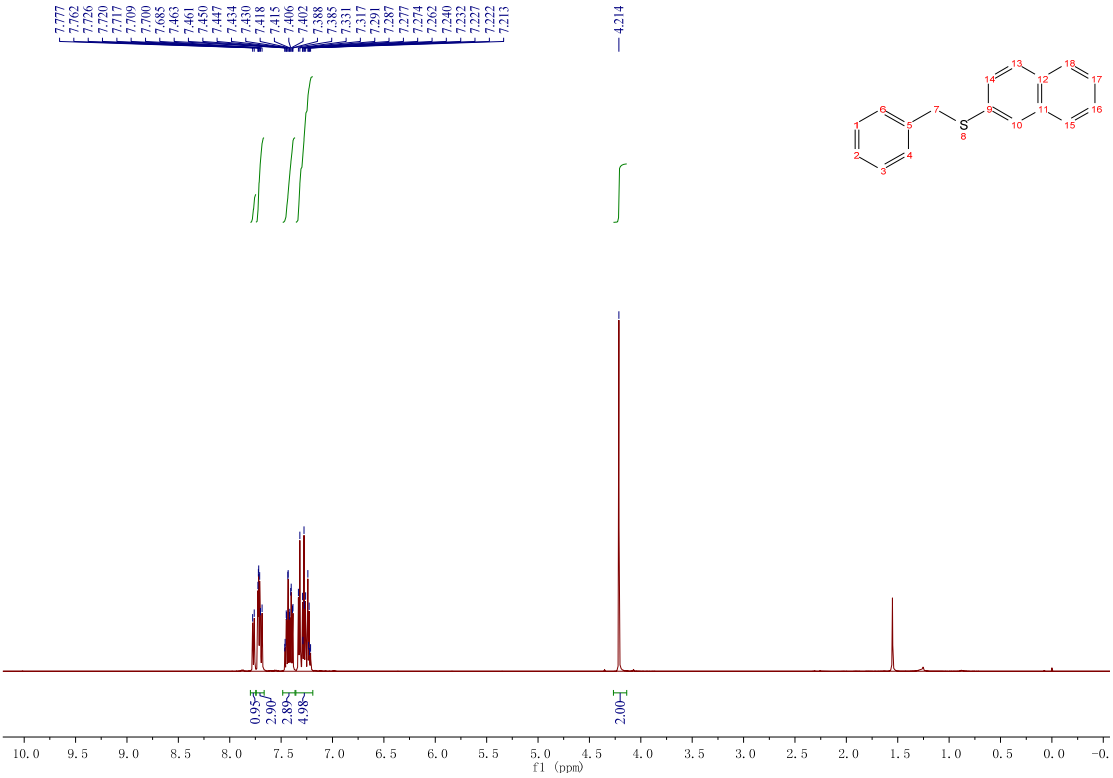

**$^{13}$C NMR**



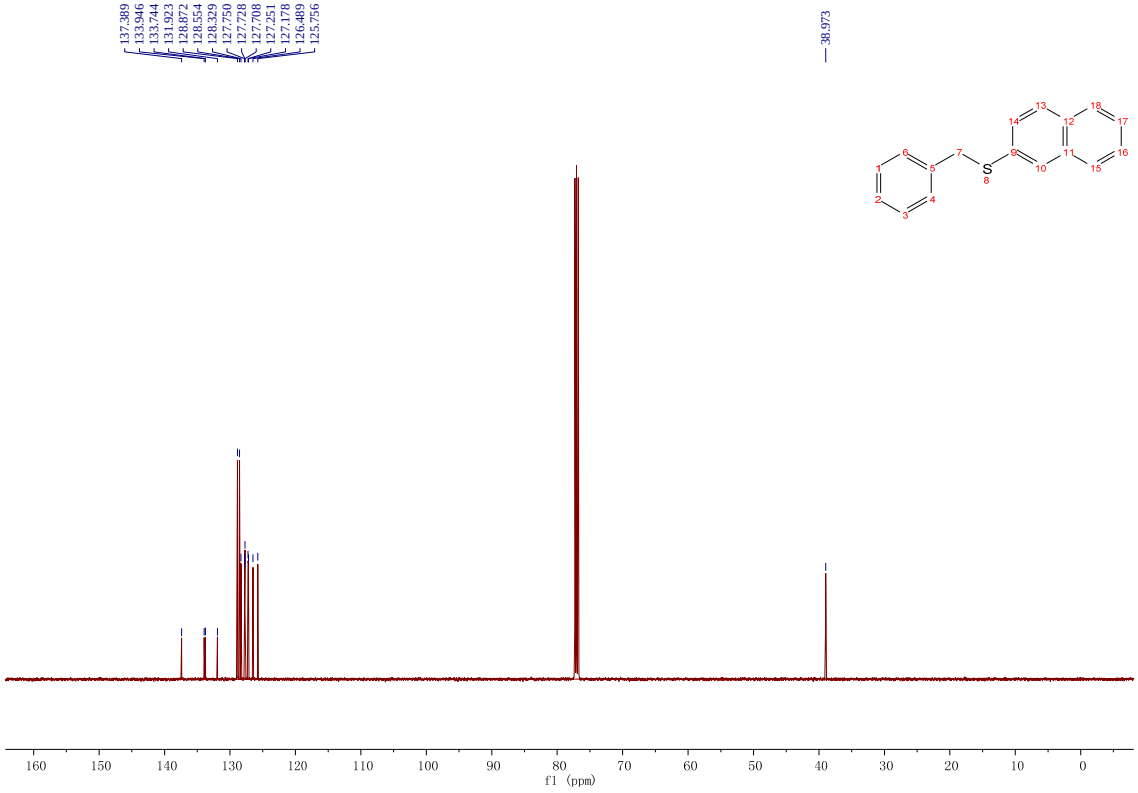


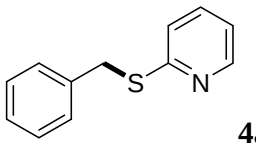
**4ah**

**$^{1}$H NMR**



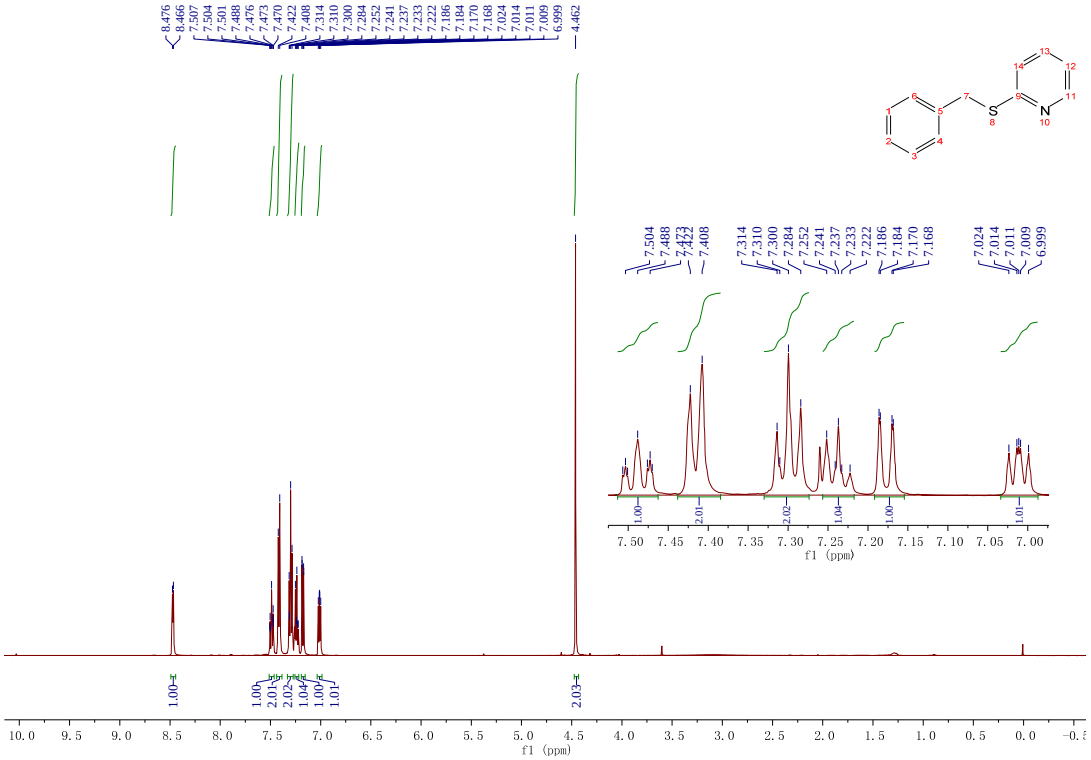

**$^{13}$C NMR**



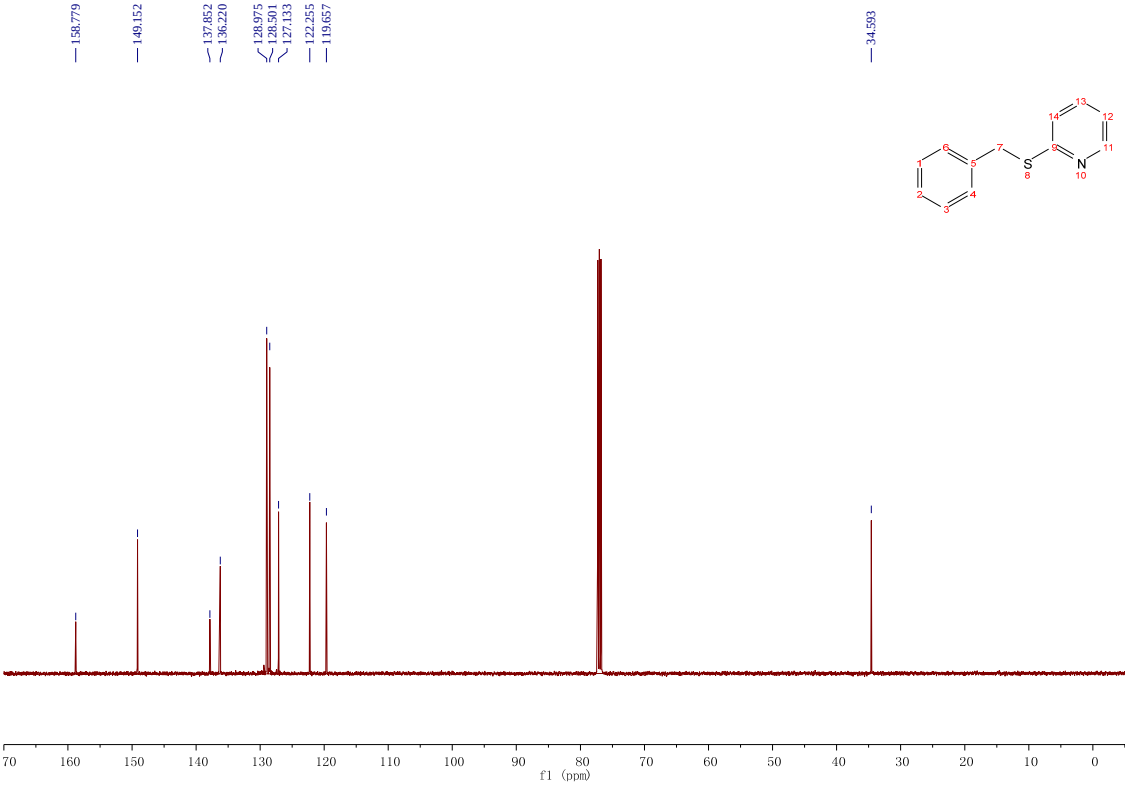


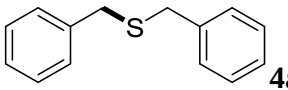
**4ai**

**$^{1}$H NMR**



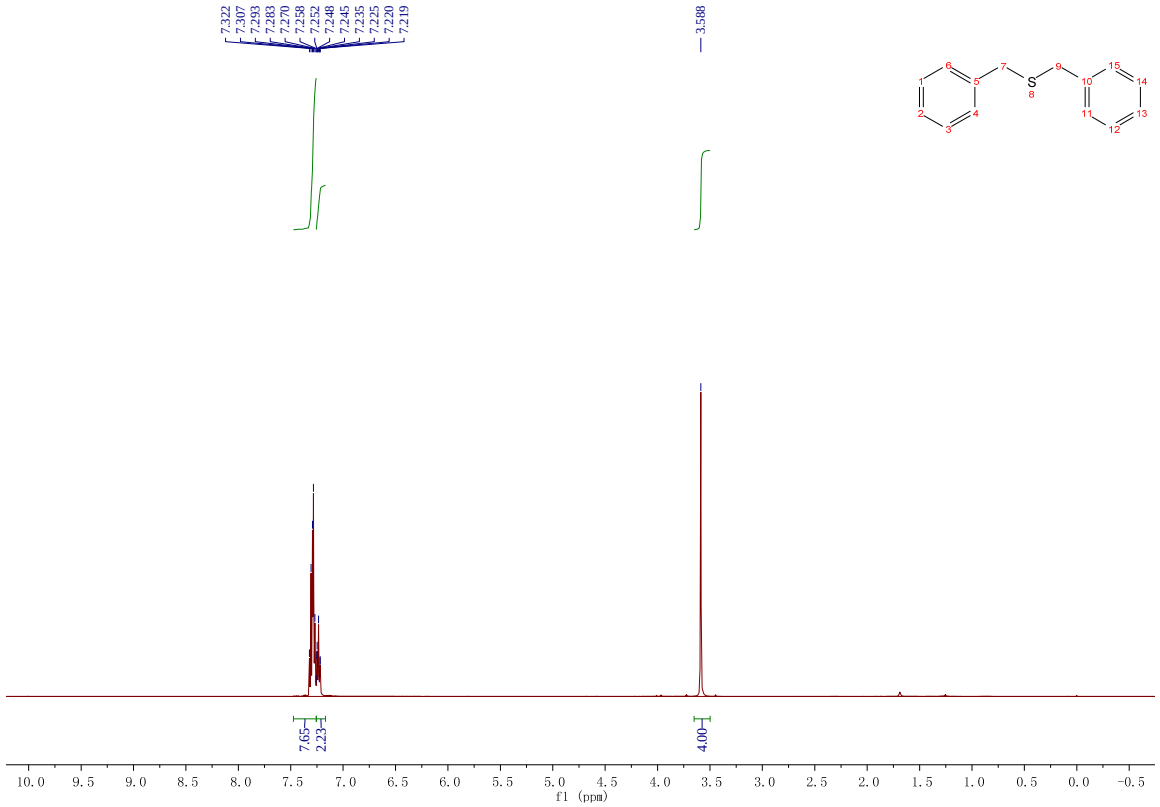
**$^{13}$C NMR**



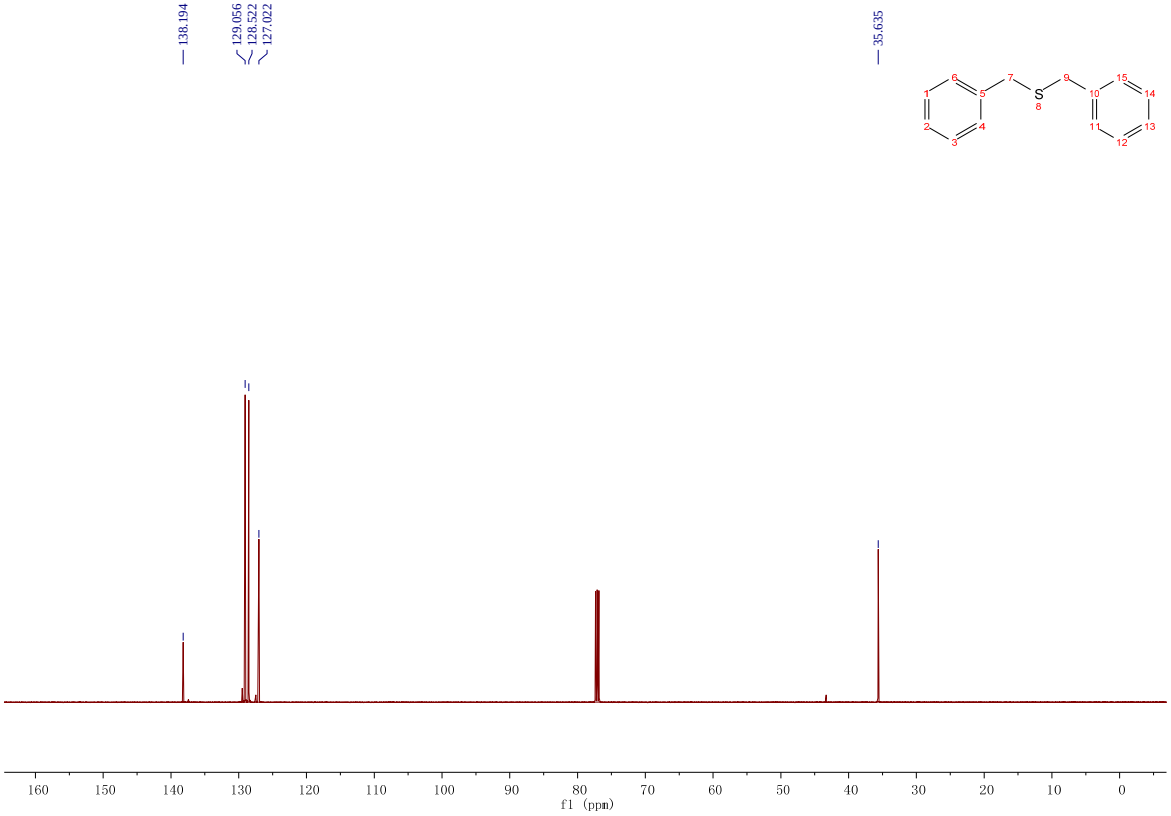


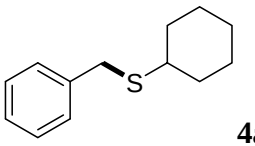
**4aj**

**$^{1}$H NMR**



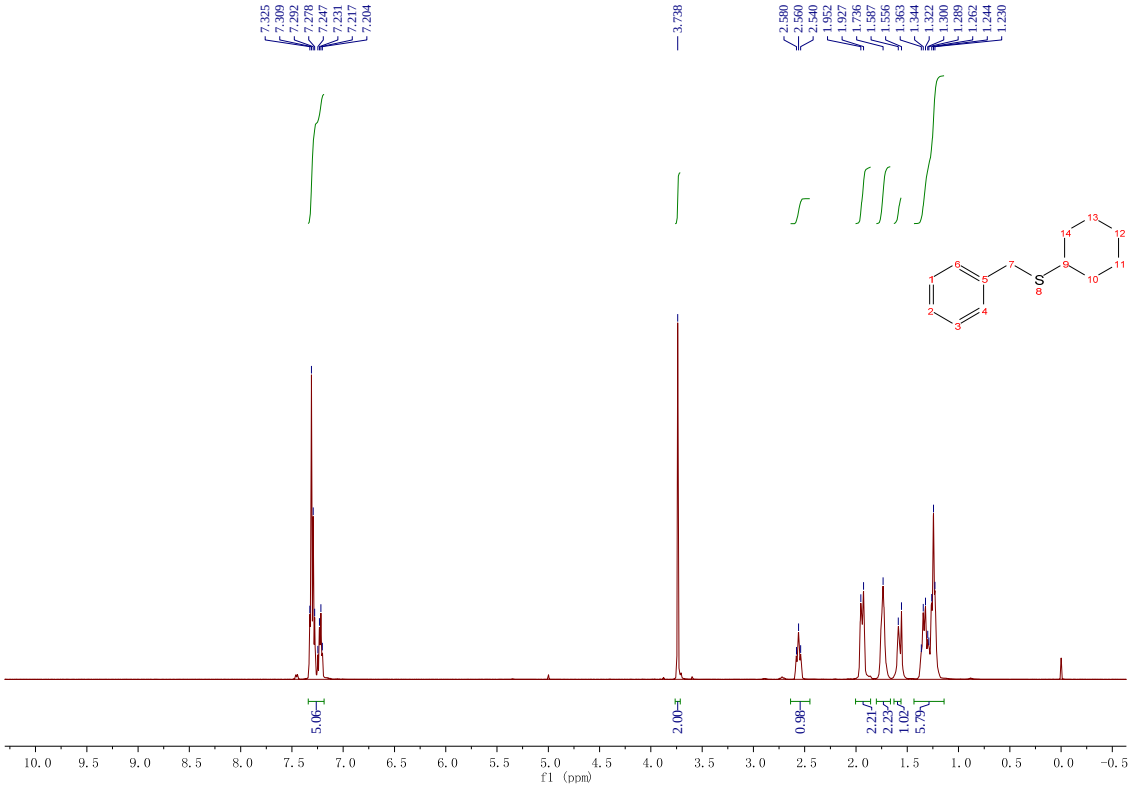

**$^{13}$C NMR**



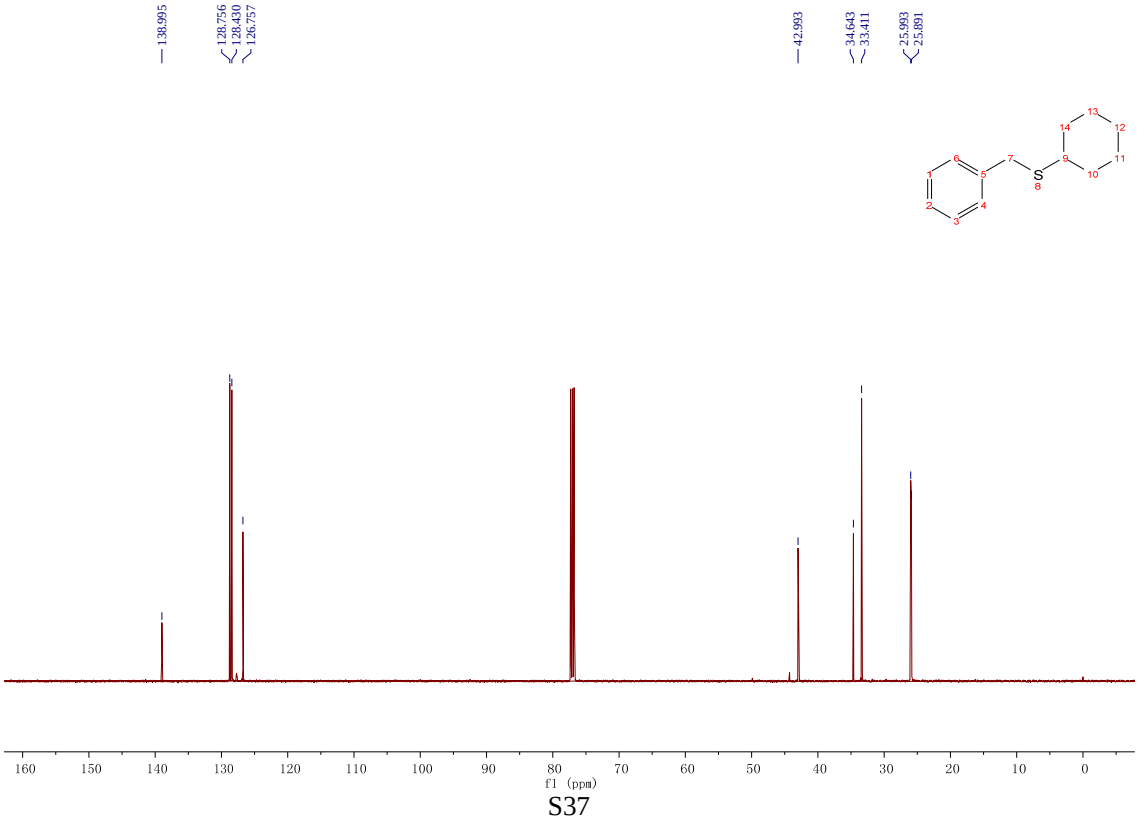


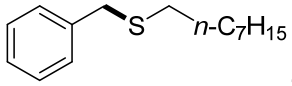
**4ak**

**$^{1}$H NMR**



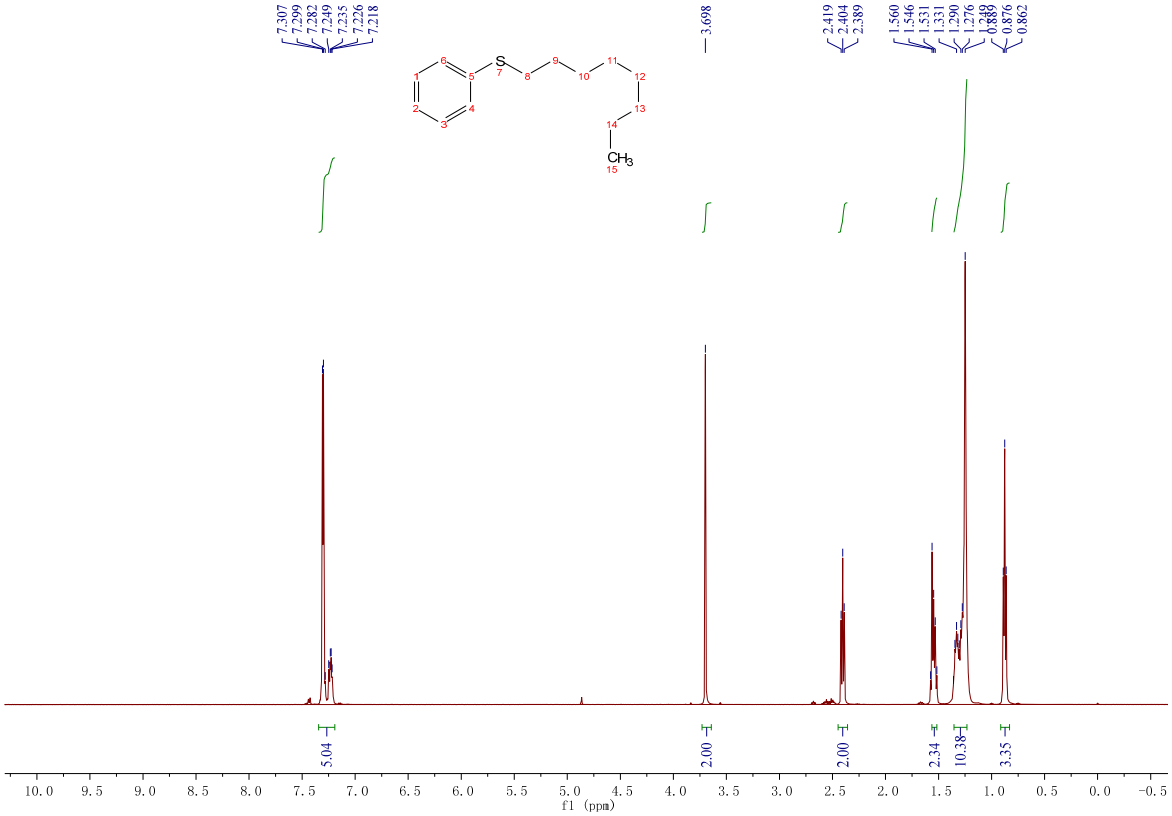

**$^{13}$C NMR**



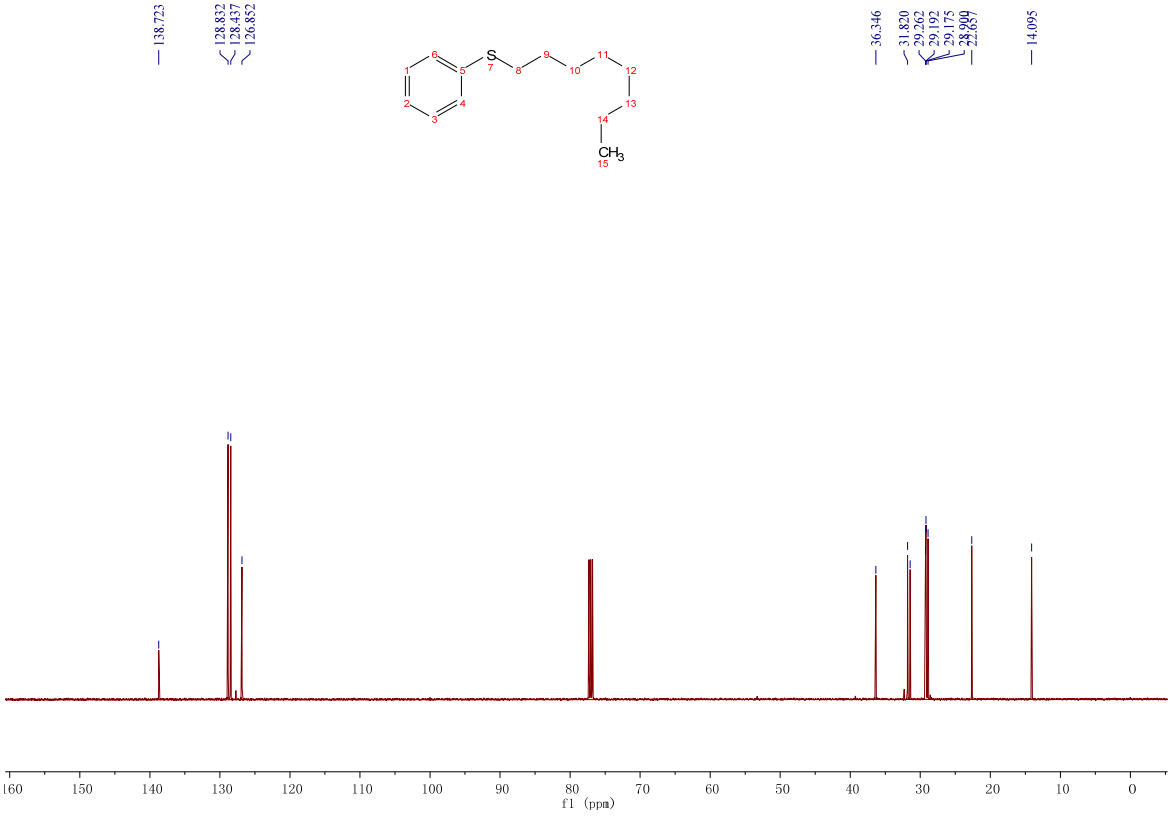


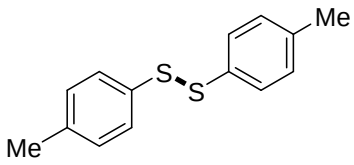

**4al**

**$^{1}$H NMR**



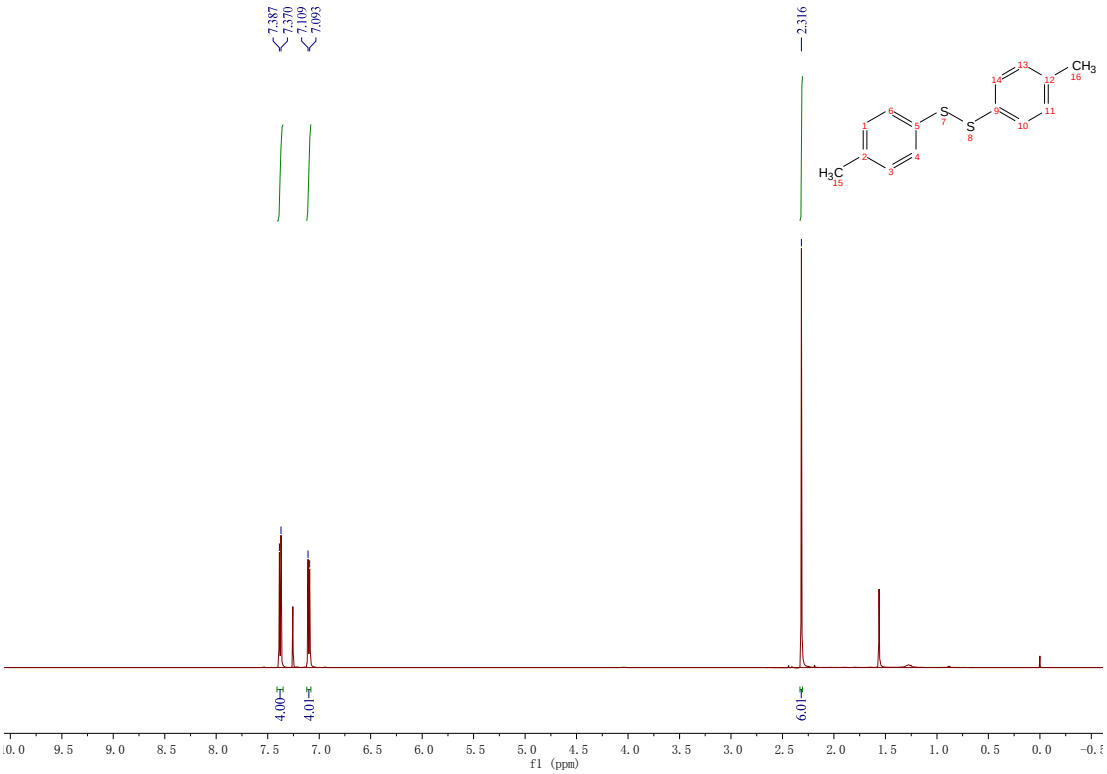

**$^{13}$C NMR**



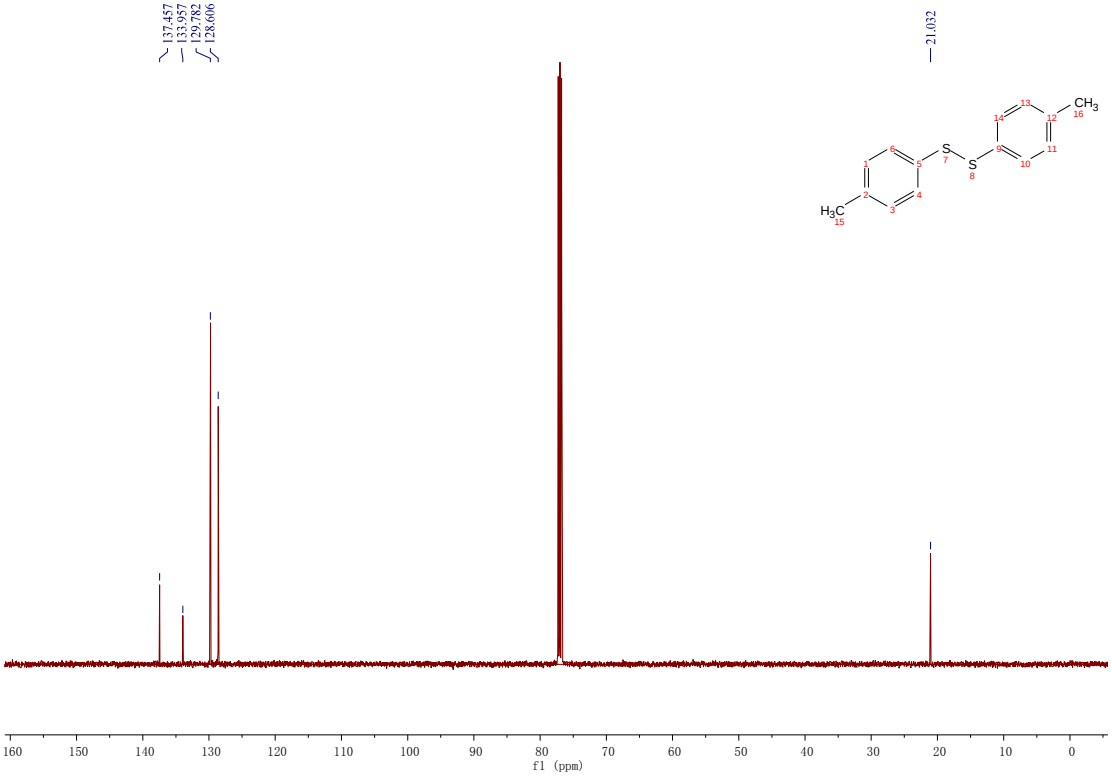


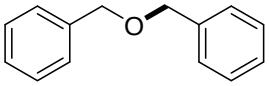

**5a**

**$^{1}$H NMR**



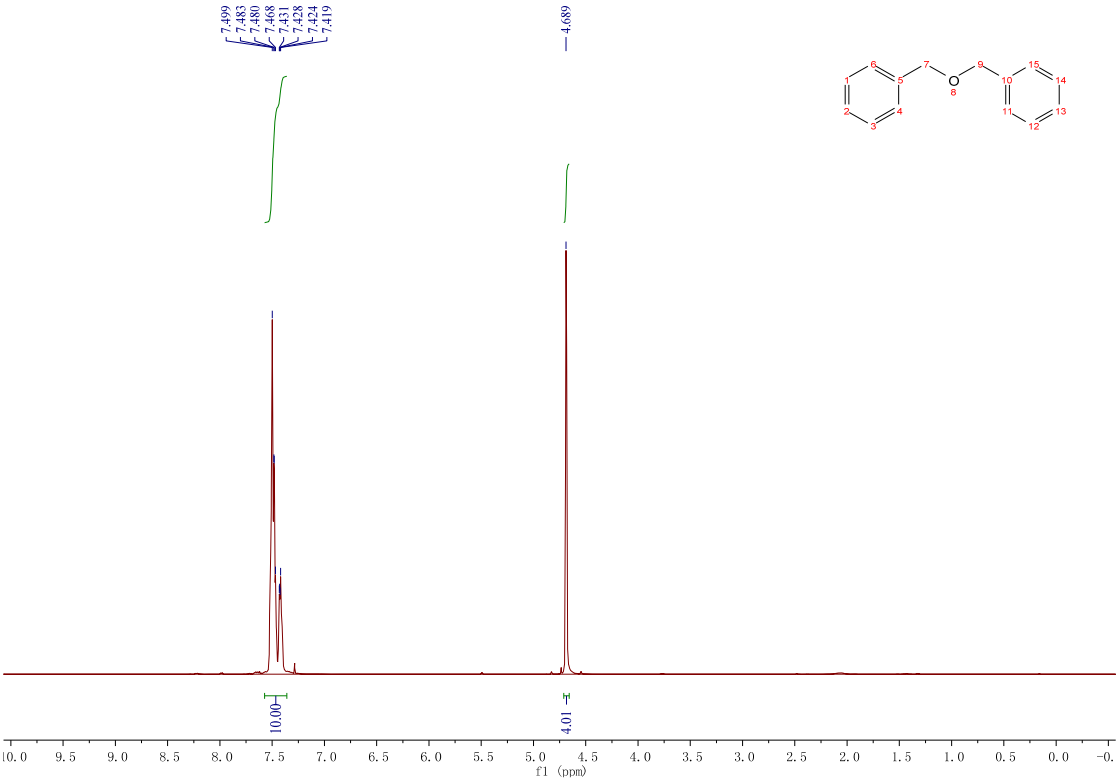

**$^{13}$C NMR**





**6a**

**$^{1}$H NMR**




**$^{13}$C NMR**