Facile aromatic nucleophilic substitution reactions (S_NAr) in ionic liquid: An electrophile-nucleophile dual activation by [Omim]Br for the reaction

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1 Experimental

General procedures for the synthesis of ionic liquids[1]: *N*-Methylimidazole or 1,2-dimethyl-imidazole 40 mmol, 1-haloalkane 48 mmol and ethyl acetate 10 mL were heated under reflux for 24 h. The biphasic system obtained was separated and the upper organic phase discharged. The bottom product phase was washed with ethyl acetate (3 × 10 mL), and dried under vacuum to give 1-octyl-3-methylimidazolium bromide as a colourless liquid. [Omim]OAc and [Omim]HSO_4 are synthesized by exchanging the bromide ion of [Omim]Br with AcO^- or HSO_4^- in acid-base neutralization with NaOAc and $NaHSO_4$ respectively.

Experimental Procedure for IR Studies

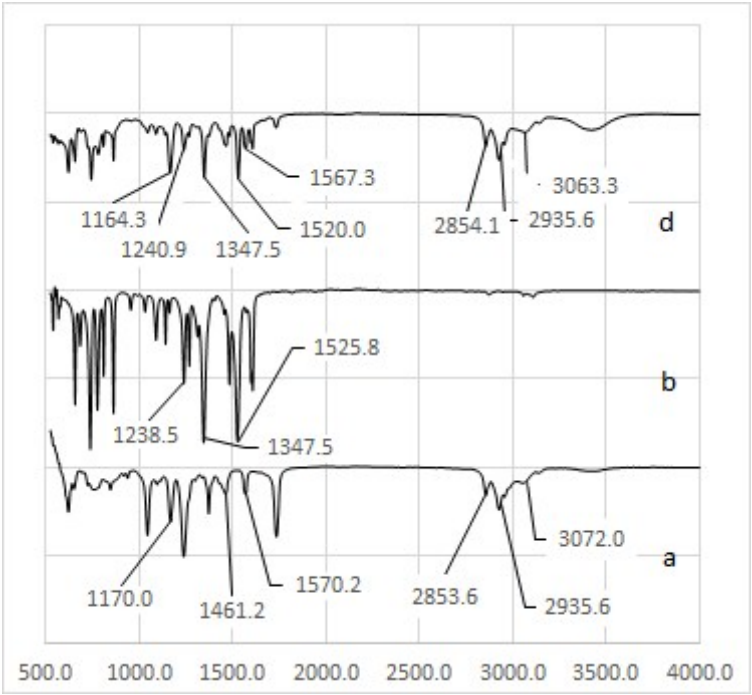


Figure S1 IR spectrum of (a) [Omim]Br, (b) 1-Fluoro-2-nitrobenzene **1a**, (d) the mixing of **1a** and [Omim]Br after 30 min.

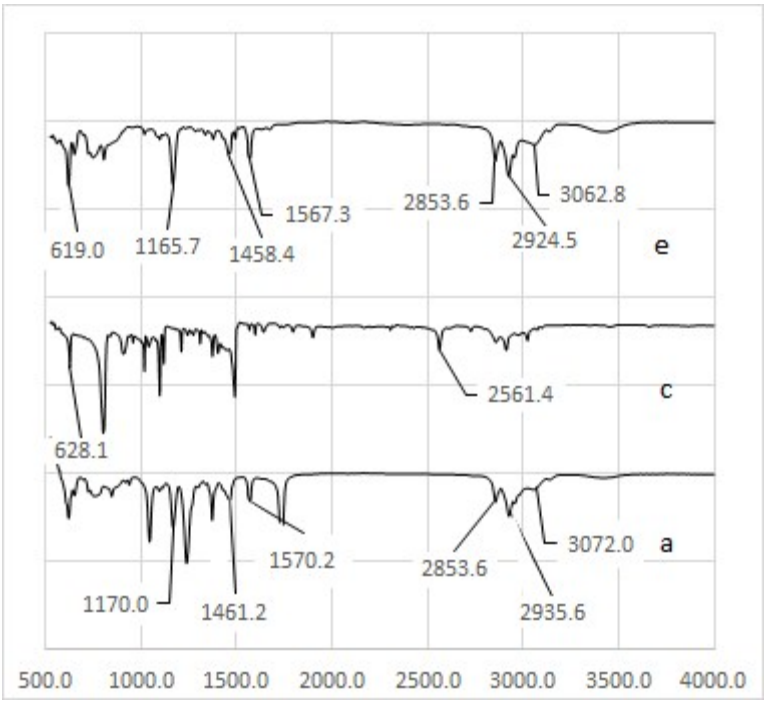


Figure S2 IR spectrum of (a) [Omim]Br, (c) 4-Tolyl mercaptan **2a**, (e) the mixing of **2a** and [Omim]Br after 30 min.

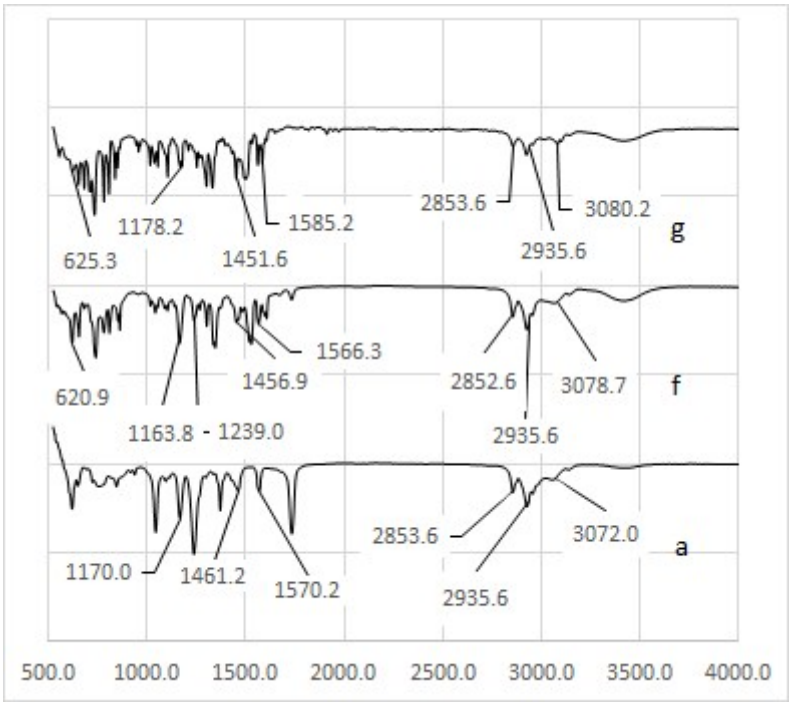


Figure S3 IR spectrum of (a) [Omim]Br. (f) the mixing of **1a** and **2a** in [Omim]Br after 30 min. (g) the mixing of **1a** and **2a** in [Omim]Br after 2 h.

Table S1 The characteristic frequency of compounds in IR

characteristic frequency	chemical bond	compound
1170.0 cm^{-1}	C-N stretching imidazole ring	[Omim]Br
1461.2-1570.2 cm^{-1}	skeleton vibration of imidazole ring	
2853.6-2935.6 cm^{-1}	saturated C-H stretching vibration	
3072.0 cm^{-1}	C-H stretching vibration of imidazole ring	
1238.5 cm^{-1}	C-F stretching vibration of benzene	1-fluoro-2-nitrobenzene
1347.5-1525.8 cm^{-1}	C-NO_2 stretching vibration of benzene	**1a**
628.1 cm^{-1}	C-S stretching vibration of benzene	4-tolyl mercaptan
2561.4 cm^{-1}	S-H stretching vibration	**2a**

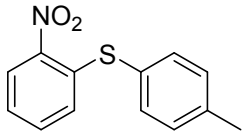
Results and Conclusions:

(1) The formation of HB between the C-2 hydrogen of [Omim]Br and F atom of **1a** is evidenced by the facts that $\nu_{C\text{-}H}$ of imidazole ring in [Omim]Br is shifted from 3072.0 to 3063.3 and $\nu_{C\text{-}F}$ of **1a** is shifted from 1238.5 to 1240.9. (Figure S1)

(2) The interaction between [Omim]Br and **2a** is evidenced by the facts that $\nu_{C\text{-}H}$ of imidazole ring in [Omim]Br is shifted from 3072.0 to 3062.8 and $\nu_{C\text{-}S}$ of **2a** is shifted from 628.1 to 619.0. (Figure S2)

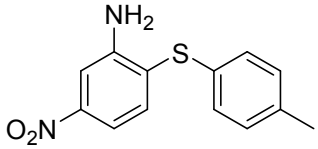
(3) The interaction between [Omim]Br and substrates (**1a** and **2a**) is evidenced by the facts that $\nu_{C\text{-}H}$ of imidazole ring in [Omim]Br is shifted from 3072.0 to 3078.7 (f) and 3080.2 (g). (Figure S3)

2 Characterization Data



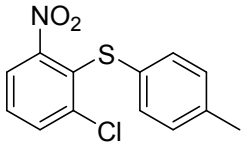
Chemical Formula: $C_{13}H_{11}NO_2S$
Mass: 245

(2-Nitrophenyl)(*p*-tolyl)sulfane **3a**,[2] yellow solid, mp: 87-88 °C (lit. 89-90 °C), yield 94%, 230.3 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.43 (s, 3H), 6.85 (d, J = 8.0 Hz, 1H), 7.19 (t, J = 8.0 Hz, 1H), 7.28-7.34 (m, 3H), 7.46 (d, J = 8.0 Hz, 2H), 8.22 (d, J = 8,5 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.5, 124.8, 125.9, 127.4, 128.3, 131.0, 133.5, 136.1, 140.2, 140.6, 145.0. MS (ESI) *m/z*: 245.



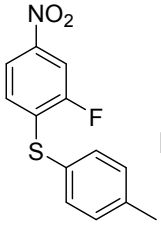
Chemical Formula: $C_{13}H_{12}N_2O_2S$
Mass: 260

5-Nitro-2-(*p*-tolylthio)aniline **3b**,[3] yellow solid, 111-113 °C, yield 84%, 218.4 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.33 (s, 3H), 4.49 (s, 2H), 7.12-7.17 (m, 4H), 7.32 (d, J = 8.5 Hz, 1H), 7.49 (d, J = 8.5 Hz, 1H), 7.55 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.3, 109.3, 113.1, 126.0, 129.5, 130.3, 130.5, 134.3, 137.9, 147.2, 148.6. MS (ESI) *m/z*: 260.



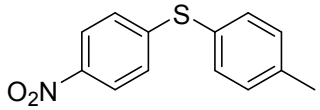
Chemical Formula: $C_{13}H_{10}ClNO_2S$
Mass: 279

(2-Chloro-6-nitrophenyl)(*p*-tolyl)sulfane **3c**,[4] yellow solid, mp: 72-74 °C (lit. 69-70 °C), yield 89%, 248.3 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.30 (s, 3H), 7.07 (d, *J* = 8.5 Hz, 2H), 7.14 (d, *J* = 8.0 Hz, 2H), 7.41 (t, *J* = 8.5 Hz, 1H), 7.58 (d, *J* = 8.0 Hz, 1H), 7.62 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.3, 122.3, 124.5, 127.7, 130.1, 130.3, 133.5, 136.0, 137.7, 141.5, 155.6. MS (ESI) *m/z*: 279.



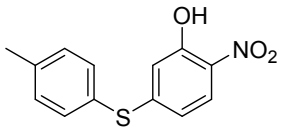
Chemical Formula: $C_{13}H_{10}FNO_2S$
Exact Mass: 263.0416
Elemental Analysis: C, 59.31; H, 3.83; F, 7.22; N, 5.32; O, 12.15; S, 12.18

(2-Fluoro-4-nitrophenyl)(*p*-tolyl)sulfane **3d**, pale yellow solid, mp: 91-93 °C, yield 97%, 255.1 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.28 (s, 3H), 6.97 (t, *J* = 8.0 Hz, 1H), 7.14 (t, *J* = 8.0 Hz, 2H), 7.30 (d, *J* = 8.0 Hz, 2H), 7.67 (d, *J* = 8.5 Hz, 1H), 7.74 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.5, 110.7-111.0 (d, *J* = 26 Hz, 1C), 119.7, 124.6, 127.4, 131.2, 135.6, 137.6, 140.8, 145.8, 156.4-158.4 (d, *J* = 248 Hz, 1C). MS (ESI) *m/z*: 263.0416. Anal. Calcd for $C_{13}H_{10}FNO_2S$: C, 59.31%; H, 3.83%; N, 5.32%. Found: C, 59.17%; H, 4.12; N, 5.04%.



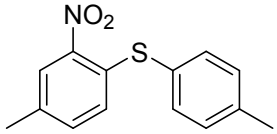
Chemical Formula: $C_{13}H_{11}NO_2S$
Mass: 245

(4-Nitrophenyl)(*p*-tolyl)sulfane **3e**,[2] yellow solid, mp: 78-80 °C (lit. 81.5 °C), yield 90%, 220.5 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.42 (s, 3H), 7.13 (d, *J* = 9.0 Hz, 2H), 7.27 (d, *J* = 8.0 Hz, 2H), 7.44 (d, *J* = 8.0 Hz, 2H), 8.04 (d, *J* = 13.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.5, 124.1, 126.3, 126.6, 131.0, 135.2, 140.4, 145.3, 149.5. MS (ESI) *m/z*: 245.



Chemical Formula: $C_{13}H_{11}NO_3S$
Exact Mass: 261.0460
Elemental Analysis: C, 59.76; H, 4.24; N, 5.36; O, 18.37; S, 12.27

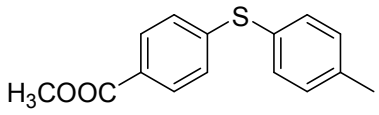
2-Nitro-5-(*p*-tolylthio)phenol **3f**, yellow solid, 118-120 °C, yield 78%, 203.6 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.43 (s, 3H), 6.63-6.67 (m, 2H), 7.28 (d, *J* = 8.0 Hz, 2H), 7.44 (d, *J* = 8.0 Hz, 2H), 7.92 (d, *J* = 8.5 Hz, 1H), 10.76 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.5, 115.0, 117.8, 125.3, 125.6, 130.8, 131.0, 135.5, 140.7, 135.6, 155.5. MS (ESI) *m/z*: 261.0460. Anal. Calcd for $C_{13}H_{11}NO_3S$: C, 59.76%; H, 4.24; N, 5.36%. Found: C, 59.45%; H, 4.62; N, 5.15%.



Chemical Formula: $C_{14}H_{13}NO_2S$
Mass: 259

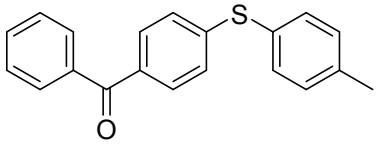
(4-Methyl-2-nitrophenyl)(*p*-tolyl)sulfane **3g**,[5] yellow solid, 105-107 °C, yield 75%, 194.3 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2,27 (s, 3H), 2.34 (s, 3H), 6.66 (d, *J* = 8.5 Hz, 1H), 7.06 (d, *J* = 8.0 Hz,

1H), 7.19 (d, *J* = 7.5 Hz, 2H), 7.36 (d, *J* = 8.0 Hz, 2H), 7.95 (s, 1H).^{13}C NMR (125 MHz, $CDCl_3$) δ 20.6, 21.5, 125.9, 127.8, 128.3, 130.9, 134.7, 135.4, 135.9, 136.6, 140.3, 144.9. MS (ESI) *m/z*: 259.



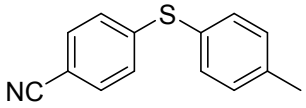
Chemical Formula: $C_{15}H_{14}O_2S$
Mass: 258

Methyl 4-(*p*-tolylthio)benzoate **3h**,[6] white solid, mp: 101-103 °C, yield 51%, 131.6 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.39 (s, 3H), 3.88 (s, 3H),7.14 (d, *J* = 7.0 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 7.40 (d, *J* = 8.5 Hz, 2H),7.87 (d, *J* = 8.0 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.4, 52.2, 126.8, 127.2, 128.3, 130.1, 130.6, 134.5, 139.3, 145.5, 166.9. MS (ESI) *m/z*: 258.



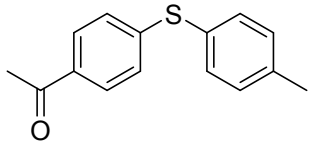
Chemical Formula: $C_{20}H_{16}OS$
Mass: 304

Phenyl(4-(*p*-tolylthio)phenyl)methanone **3i**,[7] pale yellow solid, 123-125 °C, yield 76%, 231.0 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.40 (s, 3H), 7.18 (d, *J* = 8.5 Hz, 2H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.43-7.48 (m, 4H), 7.57 (t, *J* = 8.5 Hz, 1H), 7.67 (d, *J* = 8.0 Hz, 2H), 7.75 (d, *J* = 7.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.3, 126.5, 128.0, 128.3, 129.9, 130.6, 130.8, 132.3, 134.4, 134.5, 137.8, 139.3, 145.3, 195.8. MS (ESI) *m/z*: 304.



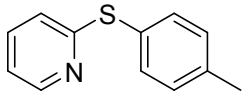
Chemical Formula: $C_{14}H_{11}NS$
Mass: 225

4-(*p*-Tolylthio)benzonitrile **3j**,[8] white solid, mp: 100-102 °C (lit. 102-103 °C), yield 83%, 186.8 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.42 (s, 3H), 7.13 (d, *J* = 8.5 Hz, 2H), 7.27 (d, *J* = 8.0 Hz, 2H), 7.43 (d, *J* = 8.0 Hz, 2H), 7.47 (d, *J* = 8.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.4, 108.3, 118.9, 126.7, 126.8, 130.8, 132.3, 135.0, 140.0, 146.6. MS (ESI) *m/z*: 225.



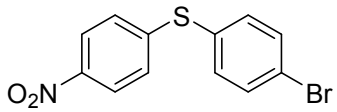
Chemical Formula: $C_{15}H_{14}OS$
Mass: 242

1-(4-(*p*-Tolylthio)phenyl)ethan-1-one **3k**,[9] pale yellow solid, mp: 88-90 °C (lit. 90-92 °C), yield 76%, 183.9 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.40 (s, 3H), 2.54 (s, 3H), 7.15 (d, *J* = 8.5 Hz, 2H), 7.23 (d, *J* = 8.0 Hz, 2H), 7.41 (d, *J* = 8.0 Hz, 2H), 7.79 (d, *J* = 8.0 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.4, 26.6, 126.8, 128.0, 129.0, 130.7, 134.3, 134.6, 139.5, 146.1, 197.3. MS (ESI) *m/z*: 242.



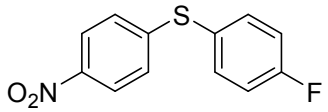
Chemical Formula: $C_{12}H_{11}NS$
Mass: 201

2-(*p*-Tolylthio)pyridine **3l**,[10] pale yellow oil, yield 77%, 154.8 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.40 (s, 3H), 6.83 (d, *J* = 8.0 Hz, 1H), 6.96 (t, *J* = 7.5 Hz, 1H), 7.24 (d, *J* = 8.0 Hz, 2H), 7.41 (t, *J* = 7.0 Hz, 1H), 7.49 (d, *J* = 8.5 Hz, 2H), 8.41 (d, *J* = 5.0 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.5, 119.7, 121.0, 127.4, 130.6, 135.4, 136.7, 139.6, 149.6, 162.3. MS (ESI) *m/z*: 201.



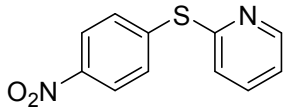
Chemical Formula: $C_{12}H_8BrNO_2S$
Mass: 310

(4-Bromophenyl)(4-nitrophenyl)sulfane **3m**,[11] pale yellow solid, mp: 94-96 °C (lit. 92-94 °C), yield 87%, 269.7 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.19 (d, *J* = 8.5 Hz, 2H), 7.39 (d, *J* = 8.5 Hz, 2H), 7.57 (d, *J* = 8.5 Hz, 2H), 8.07 (d, *J* = 8.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 124.3, 127.2, 130.0, 133.4, 136.1, 145.8, 147.5. MS (ESI) *m/z*: 310.



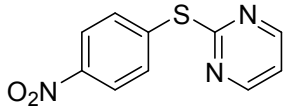
Chemical Formula: $C_{12}H_8FNO_2S$
Mass: 249

(4-Fluorophenyl)(4-nitrophenyl)sulfane **3n**,[9] pale yellow solid, 82-84 °C, yield 93%, 231.6 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.12-7.18 (m, 4H), 7.53-7.56 (m, 2H), 8.06 (d, *J* = 9.0 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 117.6, 124.2, 125.6, 126.4, 137.3, 145.5, 148.6, 162.8-164.8 (d, *J* = 250 Hz, 1C). MS (ESI) *m/z*: 249.



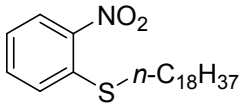
Chemical Formula: $C_{11}H_8N_2O_2S$
Mass: 232

2-((4-Nitrophenyl)thio)pyridine **3o**,[12] pale yellow solid, mp: 84-86 °C (lit. 84-85 °C), yield 77%, 178.6 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.19 (t, *J* = 7.5 Hz, 1H), 7.30 (d, *J* = 8.0 Hz, 1H), 7.59-7.65 (m, 3H), 8.18 (d, *J* = 9.0 Hz, 2H), 8.52 (d, *J* = 7.5 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 122.2, 124.3, 125.0, 132.0, 137.5, 142.5, 147.1, 150.6, 156.7. MS (ESI) *m/z*: 232.



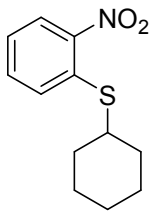
Chemical Formula: $C_{10}H_7N_3O_2S$
Mass: 233

2-((4-Nitrophenyl)thio)pyrimidine **3p**,[13] yellow solid, mp: 108-110 °C (lit. 108-113 °C), yield 83%, 193.4 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.07 (t, *J* = 7.0 Hz, 1H), 7.81 (d, *J* = 8.5 Hz, 2H), 8.24 (d, *J* = 8.5 Hz, 2H), 8.52 (d, *J* = 7.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 118.1, 124.1, 134.9, 138.7, 148.0, 157.9, 170.9. MS (ESI) *m/z*: 233.



Chemical Formula: $C_{24}H_{41}NO_2S$
Mass: 407

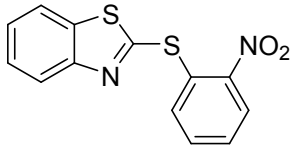
(2-Nitrophenyl)(octadecyl)sulfane **3q**,[14] yellow solid, mp: 52-54 °C (lit. 58-59 °C), yield 91%, 370.4 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.87 (t, *J* = 7.0 Hz, 3H), 1.20-1.33 (m, 28H), 1.45-1.51 (m, 2H), 1.70-1.76 (m, 2H), 2.94 (t, *J* = 7.5 Hz, 2H), 7.23 (t, *J* = 7.5 Hz, 1H), 7.40 (d, *J* = 8.0 Hz, 1H), 7.54 (t, *J* = 8.0 Hz, 1H), 8.19 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 14.3, 22.8, 28.0, 29.3 (2C), 29.5, 29.6, 29.7, 29.8, 32.1, 32.5, 124.3, 126.3, 126.7, 133.5, 138.5, 146.1. MS (ESI) *m/z*: 407.



Chemical Formula: $C_{12}H_{15}NO_2S$
Mass: 237

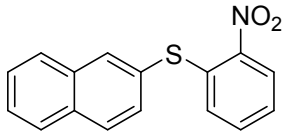
Cyclohexyl(2-nitrophenyl)sulfane **3r**,[15] yellow oil, yield 90%, 213.3 mg. ^{1}H NMR (500 MHz,

$CDCl_3$) δ 1.27-1.47 (m, 5H), 1.66 (d, *J* = 10.0 Hz, 1H), 1.80 (d, *J* = 10.0 Hz, 2H), 2.05 (d, *J* = 11.0 Hz, 2H), 3.27-3.31 (m, 1H), 7.22 (t, *J* = 8.0 Hz, 1H), 7.45-7.52 (m, 2H), 8.07 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, 125 MHz) δ 25.8, 26.1, 32.7, 44.4, 124.9, 126.0, 128.5, 133.1, 136.0, 147.6. MS (ESI) *m/z*: 237.



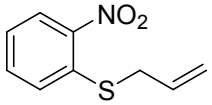
Chemical Formula: $C_{13}H_8N_2O_2S_2$
Mass: 288

2-((2-Nitrophenyl)thio)benzo[d]thiazole **3s**,[16] yellow solid, mp: 104-106 °C (lit. 106 °C), yield 74%, 213.1 mg. ^1H NMR (500 MHz, $CDCl_3$) δ 7.39-7.44 (m, 2H), 7.46-7.51 (m, 2H), 7.55 (t, *J* = 7.0 Hz, 1H), 7.89 (d, *J* = 8.0 Hz, 1H), 8.09 (d, *J* = 8.0 Hz, 1H), 8.23 (d, *J* = 9.0 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 121.6, 123.8, 125.8, 126.4, 126.9, 127.6, 130.8, 133.3, 134.0, 137.7, 146.8, 153.8, 161.0. MS (ESI) *m/z*: 288.



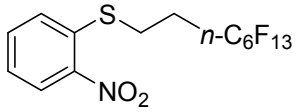
Chemical Formula: $C_{16}H_{11}NO_2S$
Mass: 281

Naphthalen-2-yl(2-nitrophenyl)sulfane **3t**,[17] yellow solid, mp: 92-94 °C (lit. 92-93 °C), yield 82%, 230.4 mg. ^1H NMR (500 MHz, $CDCl_3$) δ 6.95 (d, *J* = 8.5 Hz, 1H), 7.26 (t, *J* = 7.5 Hz, 1H), 7.31-7.36 (m, 1H), 7.57 (d, *J* = 8.5 Hz, 1H), 7.62-7.67 (m, 2H), 7.82-7.98 (m, 3H), 8.22 (s, 1H), 8.29 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 125.2, 125.9, 127.2, 127.8, 128.0, 128.2, 128.3, 128.8, 130.1, 131.7, 133.6, 133.7, 134.1, 136.1, 139.5, 145.2. MS (ESI) *m/z*: 281.



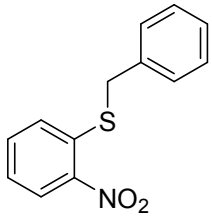
Chemical Formula:$C_9H_9NO_2S$
Mass: 195

Allyl(2-nitrophenyl)sulfane **3u**,[18] light yellow oil, yield 74%, 144,3 mg. ^1H NMR (500 MHz, $CDCl_3$) δ 3.65 (d, *J* = 6.5 Hz, 2H), 5.25 (d, *J* = 10.0 Hz, 1H), 5.37 (d, *J* = 16.5 Hz, 1H)， 5.89-5.94 (m, 1H), 7.27 (d, *J* = 7.0 Hz, 1H), 7.43 (d, *J* = 8.0 Hz, 1H), 7.54 (d, *J* = 7.0 Hz, 1H), 8.20 (t, *J* = 7.5 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 35.6, 119.5, 124.7, 126.0, 127.2, 131.8, 133.3, 137.1, 146.4. MS (ESI) *m/z*: 195.



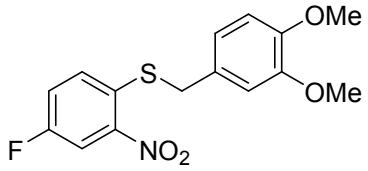
Chemical Formula: $C_{14}H_8F_{13}NO_2S$
Mass: 501

(2-Nitrophenyl)(nonyl)sulfane **3v**,[19] Light yellow oil, yield 71%, 385.8 mg. ^1H NMR (500 MHz, $CDCl_3$) δ 2.44-2.55 (m, 2H), 3.22 (t, *J* = 8.0 Hz, 2H), 7.34 (t, *J* = 7.0 Hz, 1H), 7.40 (d, *J* = 8.0 Hz, 1H), 7.62-7.65 (m, 1H), 8.23-8.25 (m, 1H). ^{13}C NMR ($CDCl_3$, 125 MHz) δ 22.2, 29.3-29.7 (m), 124.6, 125.3, 125.6, 133.0, 134.5, 145.7. ^{19}F NMR ($CDCl_3$, 470 MHz) δ -126.1, -123.3, -122.8, -121.8, -114.2, -80.8. MS (ESI) *m/z*: 501.



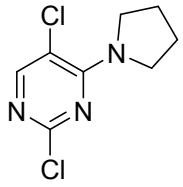
Chemical Formula: $C_{13}H_{11}NO_2S$
Mass: 245

Benzyl(2-nitrophenyl)sulfane **3w**,[20] yellow solid, mp: 82-84 °C (lit. 82-83 °C), yield 98%, 240.1 mg. ^{1}H NMR ($CDCl_3$, 500 MHz) δ 4.20 (s, 2H), 7.25 (t, *J* = 7.0 Hz, 1H), 7.29 (t, *J* = 7.0 Hz, 1H), 7.34 (t, *J* = 7.5 Hz, 2H), 7.42 (d, *J* = 7.5 Hz, 2H), 7.46 (d, *J* = 7.5 Hz, 1H), 7.52 (t, *J* = 8.0 Hz, 1H), 8.20 (t, *J* = 8.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, 125 MHz) δ 37.7, 124.9, 126.2, 127.1, 127.9, 129.0, 129.2, 133.7, 135.1, 137.9, 146.0. MS (ESI) *m/z*: 245.



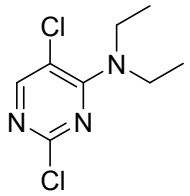
Chemical Formula:$C_{15}H_{14}FNO_4S$
Mass: 323

(3,4-Dimethoxybenzyl)(4-fluoro-2-nitrophenyl)sulfane **3x**,[21] Light yellow solid, mp: 92-94 °C (lit. 92-94 °C), yield 94%, 303.6 mg. ^{1}H NMR ($CDCl_3$, 500 MHz) δ 3.97 (s, 6H), 4.25 (s, 2H), 6.91 (t, *J* = 7.5 Hz, 1H), 7.02 (d, *J* = 8.0 Hz, 2H), 7.36-7.40 (m, 1H), 7.52-7.55 (m, 1H), 7.98-8.01 (m, 1H). ^{13}C NMR ($CDCl_3$, 125 MHz) δ 37.0, 54.9 (2C), 110.3, 111.0, 112.0-112.2 (d, *J* = 26 Hz, 1C), 120.1, 120.2-120.4 (d, *J* = 25 Hz, 1C), 126.1, 128.3, 131.7, 145.7, 147.8, 148.3, 157.4-159.4 (d, *J* = 248 Hz, 1C). MS (ESI) *m/z*: 323.



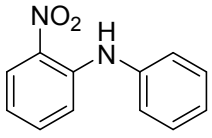
Chemical Formula: $C_8H_9Cl_2N_3$
Mass: 217

2,5-Dichloro-4-(pyrrolidin-1-yl)pyrimidine **4a**,[17] white solid, 78-80 °C, yield 92%, 200.6 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.91 (s, 4H), 3.77 (s, 4H), 7.91 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 25.4, 49.8, 112.4, 156.7, 157.3, 157.6. MS (ESI) *m/z*: 217.



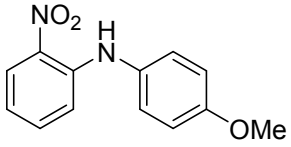
Chemical Formula: $C_8H_{11}Cl_2N_3$
Mass: 219

2,5-Dichloro-*N,N*-diethylpyrimidin-4-amine **4b**,[22] colorless oil, yield 81%, 177.4 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.22 (t, *J* = 8.0 Hz, 6H), 3.61-3.65 (m, 4H), 7.91 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 13.7, 44.5, 112.2, 157.5, 157.9, 158.3. MS (ESI) *m/z*: 219.



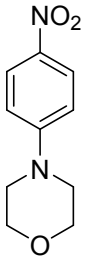
Chemical Formula:$C_{12}H_{10}N_2O_2$
Mass: 214

2-Nitro-*N*-phenylaniline **4c**,[23] red solid, mp: 70-72 °C (lit. 75 °C), yield 85%, 181.9 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.68 (t, *J* = 9.0 Hz, 1H), 7.13-7.20 (m, 4H), 7.28 (t, *J* = 7.5 Hz, 1H), 7.33 (t, *J* = 7.5 Hz, 2H), 8.12 (d, *J* = 9.0 Hz, 1H), 9.41 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 116.2, 117.6, 124.5, 125.8, 126.8, 129.9, 133.4, 135.8, 138.9, 143.2. MS (ESI) *m/z*: 214.



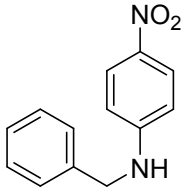
Chemical Formula:$C_{13}H_{12}N_2O_3$
Mass: 244

N-(4-Methoxyphenyl)-2-nitroaniline **4d**,[24] red solid, mp: 88-90 °C (lit. 89 °C), yield 84%, 205.0 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.84 (s, 3H), 6.71 (d, *J* = 7.5 Hz, 1H), 6.95 (d, *J* = 9.0 Hz, 2H), 7.00 (d, *J* = 8.5 Hz, 1H), 7.19 (d, *J* = 9.0 Hz, 2H), 7.32 (t, *J* = 7.0 Hz, 1H), 8.18 (d, *J* = 7.5 Hz, 1H), 9.41 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 55.7, 115.1, 115.9, 116.9, 126.7, 127.2, 131.3, 132.6, 135.9, 144.6, 158.1. MS (ESI) *m/z*: 244.



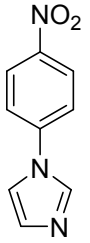
Chemical Formula:$C_{10}H_{12}N_2O_3$
Mass: 208

4-(4-Nitrophenyl)morpholine **4e**,[25] yellow solid, mp: 147-149 °C (lit. 149-150 °C), yield 95%, 197.6 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.36 (t, *J* = 5.0 Hz, 4H), 3.84 (t, *J* = 5.0 Hz, 4H), 6.81 (d, *J* = 9.5 Hz, 2H), 8.10 (d, *J* = 9.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 47.2, 66.5, 112.7, 126.0, 139.1, 155.1. MS (ESI) *m/z*: 208.



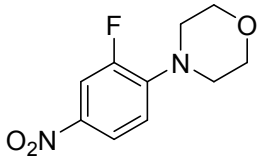
Chemical Formula:$C_{13}H_{12}N_2O_2$
Mass: 228

N-Benzyl-4-nitroaniline **4f**,[26] yellow solid, mp: 144-146 °C (lit. 147 °C), yield 89%, 202.9 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.43 (d, *J* = 5.5 Hz, 2H), 4.94 (s, 1H),6.57 (d, *J* = 9.0 Hz, 2H), 7.30-7.39 (m, 5H), 8.07 (d, *J* = 9.0 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 47.8, 111.5, 126.5, 127.5, 128.0, 129.1, 137.5, 138.4, 153.2. MS (ESI) *m/z*: 228.



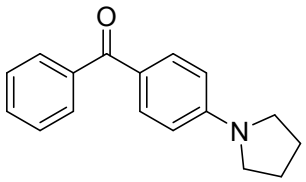
Chemical Formula:$C_9H_7N_3O_2$
Mass: 189

1-(4-Nitrophenyl)-1H-imidazole **4g**,[27] pale yellow solid, mp: 193-195 °C (lit. 195-198 °C), yield 89%, 168.2 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.27 (s, 1H), 7.37 (s, 1H), 7.58 (d, *J* = 9.0 Hz, 2H), 7.98 (s, 1H), 8.37 (d, *J* = 9.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 117.8, 121.2, 125.9, 131.8, 135.5, 142.1, 146.4. MS (ESI) *m/z*: 189.



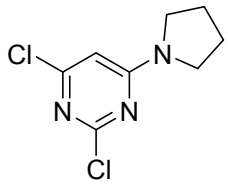
Chemical Formula:$C_{10}H_{11}FN_2O_3$
Mass: 226

4-(2-Fluoro-4-nitrophenyl)morpholin **4h**,[28] yellow solid, mp: 110-112 °C (lit. 112-113 °C), yield 99%, 223.7 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.25 (t, *J* = 9.5 Hz, 4H), 3.84 (t, *J* = 5.0 Hz, 4H), 6.89 (t, *J* = 8.0 Hz, 1H), 7.84 (d, *J* = 10.5 Hz, 1H), 7.93 (d, *J* = 7.5 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 50.0, 66.7, 112.7, 117.0, 121.1, 140.8, 145.6, 152.2-154.2 (d, *J* = 248 Hz, 1C). MS (ESI) *m/z*: 226.



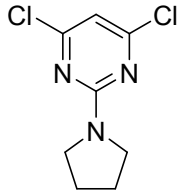
Chemical Formula: $C_{17}H_{17}NO$
Mass: 251

Phenyl(4-(pyrrolidin-1-yl)phenyl)methanone **4i**,[29] pale yellow solid, mp: 134-136 °C (lit. 138 °C), yield 67%, 168.2 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.03 (t, *J* = 6.5 Hz, 4H), 3.37 (t, *J* = 6.5 Hz, 4H), 6.53 (d, *J* = 8.5 Hz, 2H), 7.43 (d, *J* = 7.0 Hz, 2H), 7.51 (d, *J* = 7.5 Hz, 1H), 7.71 (d, *J* = 7.5 Hz, 2H), 7.79 (d, *J* = 8.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 25.6, 47.7, 110.7, 124.3, 128.1, 129.5, 131.1, 133.1, 139.6, 151.0, 195.2. MS (ESI) *m/z*: 251.



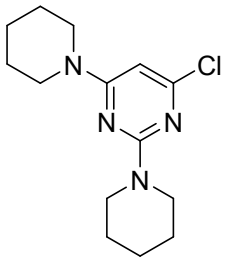
Chemical Formula: $C_8H_9Cl_2N_3$
Mass: 217

2,4-Dichloro-6-(pyrrolidin-1-yl)pyrimidine **4j**,[30] white solid, 84-86 °C, yield 72%, 156.2 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.91-1.97 (m, 2H), 2.01-20.6 (m, 2H), 3.29 (t, *J* = 7.0 Hz, 2H), 3.57 (t, *J* = 6.5 Hz, 2H), 6.15 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 24.8-25.5 (d, *J* = 86 Hz, 1C), 46.9-47.4 (d, *J* = 65 Hz, 1C), 100.5, 159.1, 159.6, 161.4. MS (ESI) *m/z*: 217.



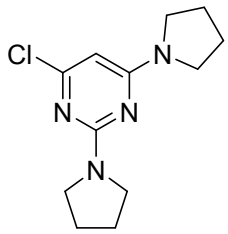
Chemical Formula: $C_8H_9Cl_2N_3$
Mass: 217

4,6-Dichloro-2-(pyrrolidin-1-yl)pyrimidine **4j'**,[31] white solid, 87-89 °C, yield 15%, 32.6 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.96-1.98 (m, 4H), 3.56 (t, *J* = 7.0 Hz, 4H), 6.49 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 25.4, 47.2, 107.2, 159.4, 161.4. MS (ESI) *m/z*: 217.



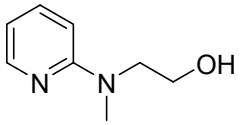
Chemical Formula: $C_{14}H_{21}ClN_4$
Mass: 280

4-Chloro-2,6-di(piperidin-1-yl)pyrimidine **4k**,[32] pale yellow solid, mp: 93-95 °C (lit. 95-96 °C), yield 78%, 218.4 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.52-1.58 (m, 8H), 1.59-1.64 (m, 4H), 3.50 (t, *J* = 5.0 Hz, 4H), 3.69 (t, *J* = 5.0 Hz, 4H), 5.79 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 24.8-25.0 (d, *J* = 23 Hz, 1C), 25.6-25.9 (d, *J* = 35 Hz, 1C), 44.9-45.3 (d, *J* = 51 Hz, 1C), 90.2, 160.4, 161.1, 163.2. MS (ESI) *m/z*: 280.



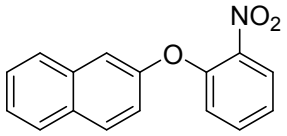
Chemical Formula: $C_{12}H_{17}ClN_4$
Mass: 252

4-Chloro-2,6-di(pyrrolidin-1-yl)pyrimidine **4l,**[32] pale yellow solid, mp: 78-80 °C (lit. 79-82 °C), yield 81%, 204.1 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.88-1.94 (m, 8H), 3.52 (t, *J* = 7.0 Hz, 8H), 5.63 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 25.6, 46.3-46.6 (d, *J* = 41 Hz, 1C), 90.7, 159.0, 159.9, 161.4. MS (ESI) *m/z*: 252.



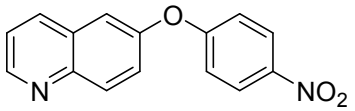
Chemical Formula: $C_8H_{12}N_2O$
Mass: 152

2-(Methyl(pyridin-2-yl)amino)ethan-1-ol **4m**,[33] pale yellow oil, yield 94%, 142.9 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.05 (s, 3H), 3.69 (t, *J* = 5.5 Hz, 2H), 3.83 (t, *J* = 5.0 Hz, 2H), 6.52 (d, *J* = 8.5 Hz, 1H), 6.56 (t, *J* = 7.0 Hz, 1H), 7.46 (t, *J* = 8.5 Hz, 1H), 8.03 (d, *J* = 6.5 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 38.0, 54.5, 63.1, 106.5, 112.4, 137.9, 147.2, 159.4. MS (ESI) *m/z*: 152.



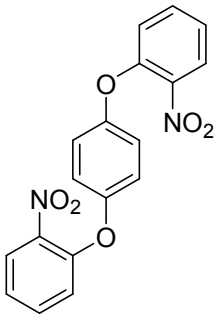
Chemical Formula:$C_{16}H_{11}NO_3$
Mass: 265

2-(2-Nitrophenoxy)naphthalene **5a**,[34] brown solid, mp: 55-57 °C (lit. 58 °C), yield 80%, 212 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.10 (d, *J* = 8.5 Hz, 1H), 7.25-7.33 (m, 2H), 7.42 (s, 1H), 7.47-7.56 (m, 3H), 7.77 (d, *J* = 8.0 Hz, 1H), 7.88-7.93 (m, 2H), 8.03 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 115.2, 119.8, 120.9, 123.5, 125.5, 126.0, 127.0, 127.4, 128.0, 130.5, 130.9, 134.3, 134.4, 141.6, 150.8, 153.7. MS (ESI) *m/z*: 265.



Chemical Formula: $C_{15}H_{10}N_2O_3$
Mass: 266

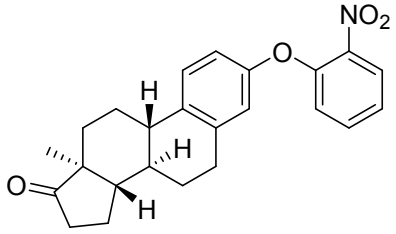
6-(4-Nitrophenoxy)quinoline **5b**,[35] red solid, 69-71 °C, yield 78%, 207.5 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.08 (d, *J* = 9.0 Hz, 2H), 7.42-7.49 (m, 3H), 8.09 (d, *J* = 9.0 Hz, 1H), 8.17 (d, *J* = 9.0 Hz, 2H), 8.22 (d, *J* = 9.0 Hz, 1H), 8.90 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 116.4, 117.9, 122.1, 123.8, 126.2, 129.2, 132.3, 135.6, 143.3, 146.0, 150.3, 152.9, 162.9. MS (ESI) *m/z*: 266.



Chemical Formula:$C_{18}H_{12}N_2O_6$
Mass: 352

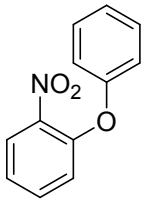
1,4-Bis(2-nitrophenoxy)benzene **5c**,[36] brown solid, mp: 158-160 °C (lit. 159-160 °C), yield 71%, 249.9 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.03 (d, *J* = 8.0 Hz, 2H), 7.08 (s, 4H), 7.22 (t, *J* = 7.5 Hz,

2H), 7.53 (t, *J* = 8.0 Hz, 2H), 7.96 (d, *J* = 8.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 120.4, 120.9, 123.5, 125.9, 134.4, 141.4, 150.8, 152.4. MS (ESI) *m/z*: 352.



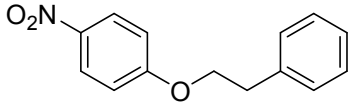
Chemical Formula: $C_{24}H_{25}NO_4$
Mass: 391

(8*R*,9*S*,13*S*,14*S*)-13-Methyl-3-(2-nitrophenoxy)-6,7,8,9,11,12,13,14,15,16-decahydro-17*H*-cyclopenta[a]phenanthren-17-one **5d**,[37] yellow solid, >250 °C, yield 77%, 301.1 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.93 (s, 3H), 1.49-1.64 (m, 7H), 1.96-2.17 (m, 3H), 2.27-2.31 (m, 1H), 2.39-2.42 (m, 1H), 2.49-2.54 (m, 1H), 2.88-2.90 (m, 2H), 6.79 (s, 1H), 6.82 (d, *J* = 8.5 Hz, 1H), 7.03 (d, *J* = 8.5 Hz, 1H), 7.17 (d, *J* = 8.0 Hz, 1H), 7.27 (d, *J* = 8.5 Hz, 1H), 7.48 (t, *J* = 8.5 Hz, 1H), 7.94 (d, *J* = 8.5 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 14.0, 21.7, 26.0, 26.5, 29.6, 31.7, 36.0, 38.3, 44.2, 48.1, 50.6, 60.5, 116.6, 119.4, 120.5, 122.9, 125.8, 127.0, 134.1, 136.3, 138.8, 141.4, 151.1, 153.8. MS (ESI) *m/z*: 391.



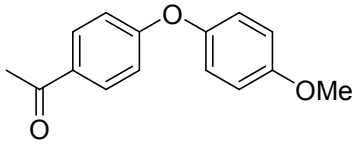
Chemical Formula: $C_{12}H_9NO_3$
Mass: 215

1-Nitro-2-(*p*-tolyloxy)benzene **5e**,[38] yellow oil, yield 92%, 197.8 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.01 (d, *J* = 8.0 Hz, 1H), 7.04 (d, *J* = 7.5 Hz, 2H), 7.16-7.20 (m, 2H), 7.38 (t, *J* = 7.5 Hz, 2H), 7.49 (d, *J* = 8.5 Hz, 1H), 7.94 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 119.9, 120.6, 123.3, 124.7, 125.9, 130.2, 134.3, 141.5, 150.9, 155.9. MS (ESI) *m/z*: 215.



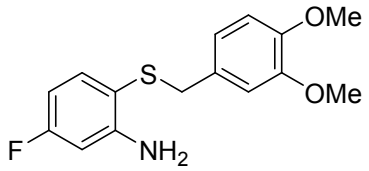
Chemical Formula:$C_{14}H_{13}NO_3$
Mass: 243

1-Nitro-4-phenethoxybenzene **5f**,[39] pale yellow solid, mp: 54-56 °C (lit. 56-57 °C), yield 79%, 192.0 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.15 (t, *J* = 7.0 Hz, 2H), 4.26-4.30 (m, 2H), 6.94 (d, *J* = 9.0 Hz, 2H), 7.22-7.36 (m, 5H), 8.18 (d, *J* = 9.5 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 35.6, 69.6, 114.6, 126.0, 126.9, 128.8, 129.1, 137.6, 141.6, 164.0. MS (ESI) *m/z*: 243.



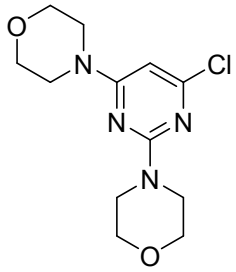
Chemical Formula:$C_{15}H_{14}O_3$
Mass: 242

1-(4-(4-Methoxyphenoxy)phenyl)ethan-1-one **5g**,[38] pale yellow solid, mp: 60-62 °C (lit. 60-61 °C), yield 76%, 183.9 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.55(s, 3H), 3.82 (s, 3H), 6.92 (t, *J* = 7.5 Hz, 4H), 7.01 (d, *J* = 9.0 Hz, 2H), 7.91 (d, *J* = 9.0 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 26.5, 55.8, 115.2, 116.5, 121.8, 130.7, 131.5, 148.6, 156.8, 163.1, 196.9. MS (ESI) *m/z*: 242.



Chemical Formula: $C_{15}H_{16}FNO_2S$
Mass: 293

2-((3,4-Dimethoxybenzyl)thio)-5-fluoroaniline **6**,[40] light yellow oil, yield 92%, 269.6 mg. ^{1}H NMR ($CDCl_3$, 500 MHz) δ 3.72 (s, 3H), 3.74 (s, 2H), 3.79 (s, 3H), 4.44 (s, 2H), 6.27-6.34 (m, 1H), 6.35-6.36 (m, 1H), 6.53 (d, *J* = 1.5 Hz, 1H), 6.61-6.62 (m, 1H), 6.69 (d, *J* = 8.0 Hz, 1H), 7.07-7.10 (m, 1H). ^{13}C NMR ($CDCl_3$, 125 MHz) δ 38.2, 54.3, 54.5, 99.8-100.0 (d, *J* = 25 Hz, 1C), 103.7-103.8 (d, *J* = 22 Hz, 1C), 109.8, 110.8-110.9 (d, *J* = 22 Hz, 1C), 119.8, 129.5, 137.3, 137.4, 146.8-147.3 (d, *J* = 65 Hz, 1C), 149.3-149.4 (d, *J* = 11 Hz, 1C), 162.0, 164.0. MS (ESI) *m/z*: 293.



Chemical Formula: $C_{12}H_{17}ClN_4O_2$
Mass: 284

4,4'-(6-Chloropyrimidine-2,4-diyl)dimorpholine **7**,[30] white solid, mp: 139-141 °C (lit. 139-142 °C), yield 83%, 235.7 mg. ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.50 (s, 4H), 3.68-3.72 (m, 12H), 5.82 (s, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 44.4, 66.6-66.9 (d, *J* = 39 Hz, 1C), 91.2, 160.6, 160.9, 163.9. MS (ESI) *m/z*: 284.

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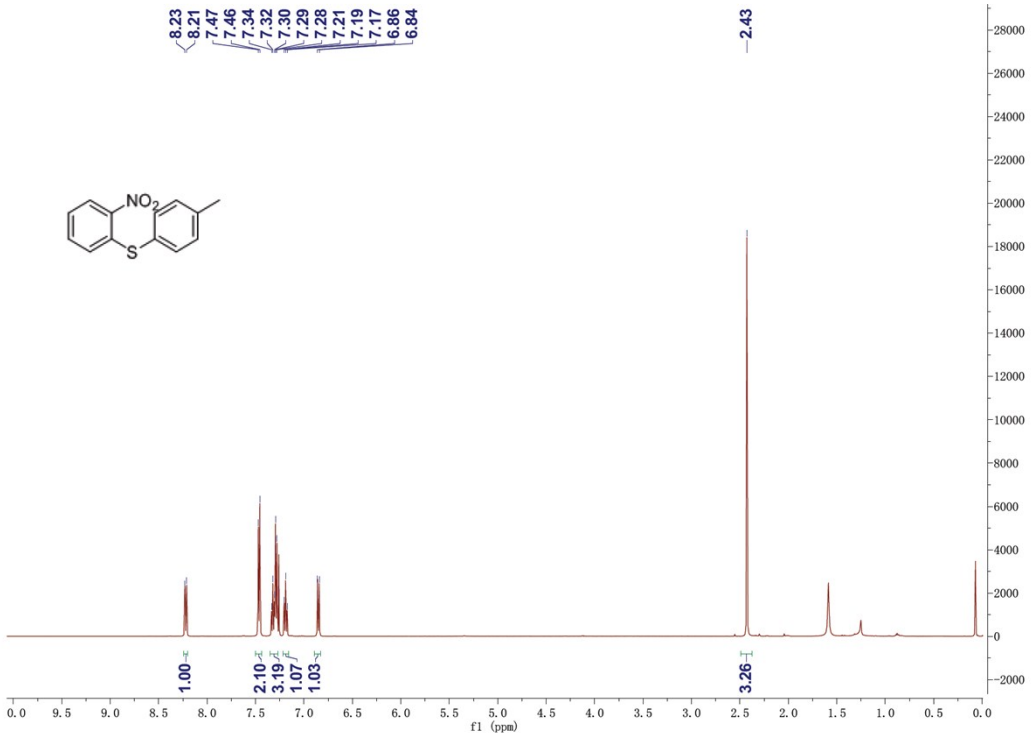
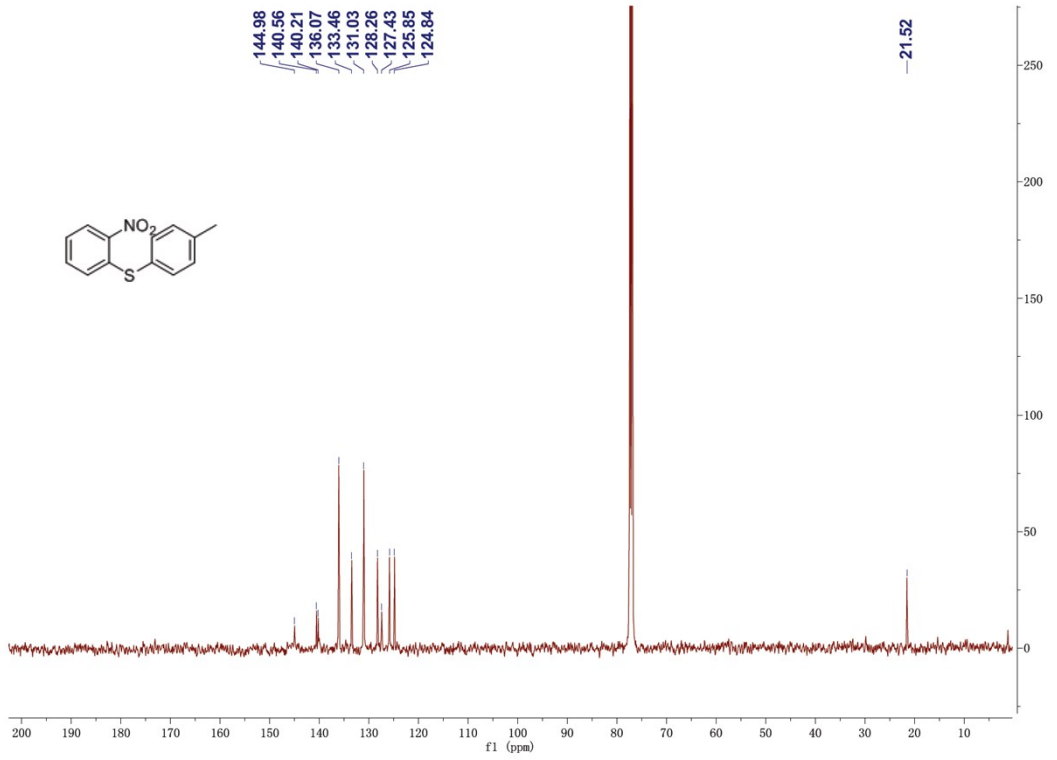
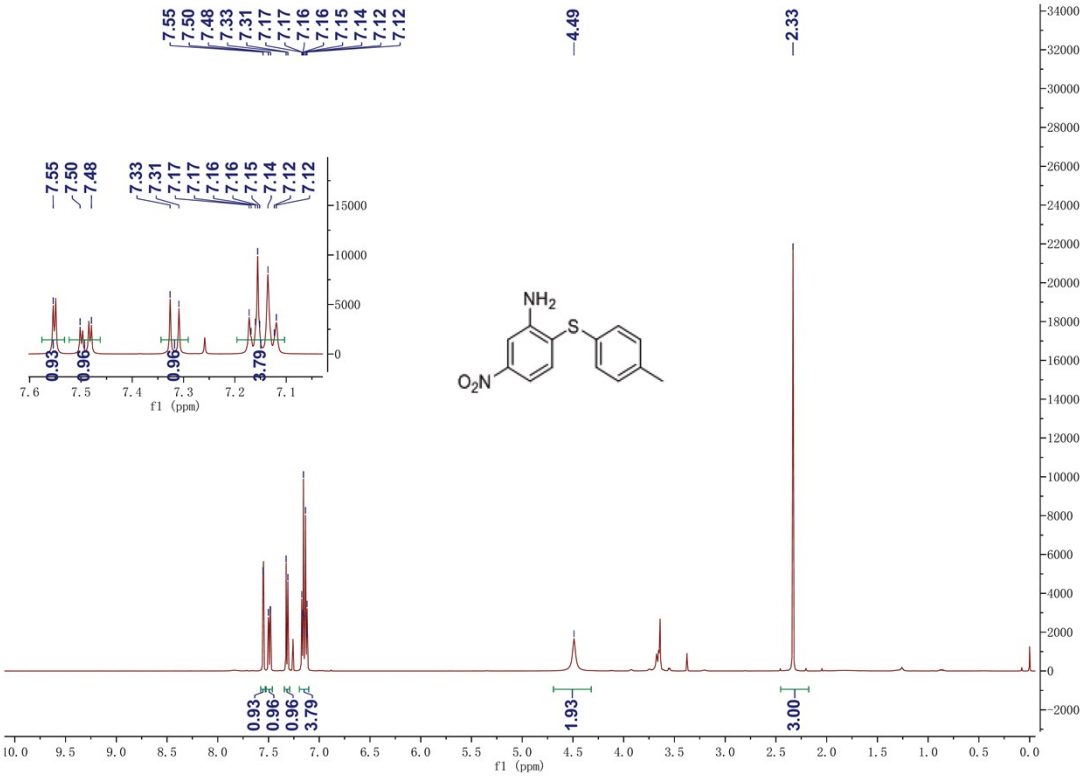
3 NMR Spectra of All Products



^{1}H NMR of 3a



^{13}C NMR of 3a



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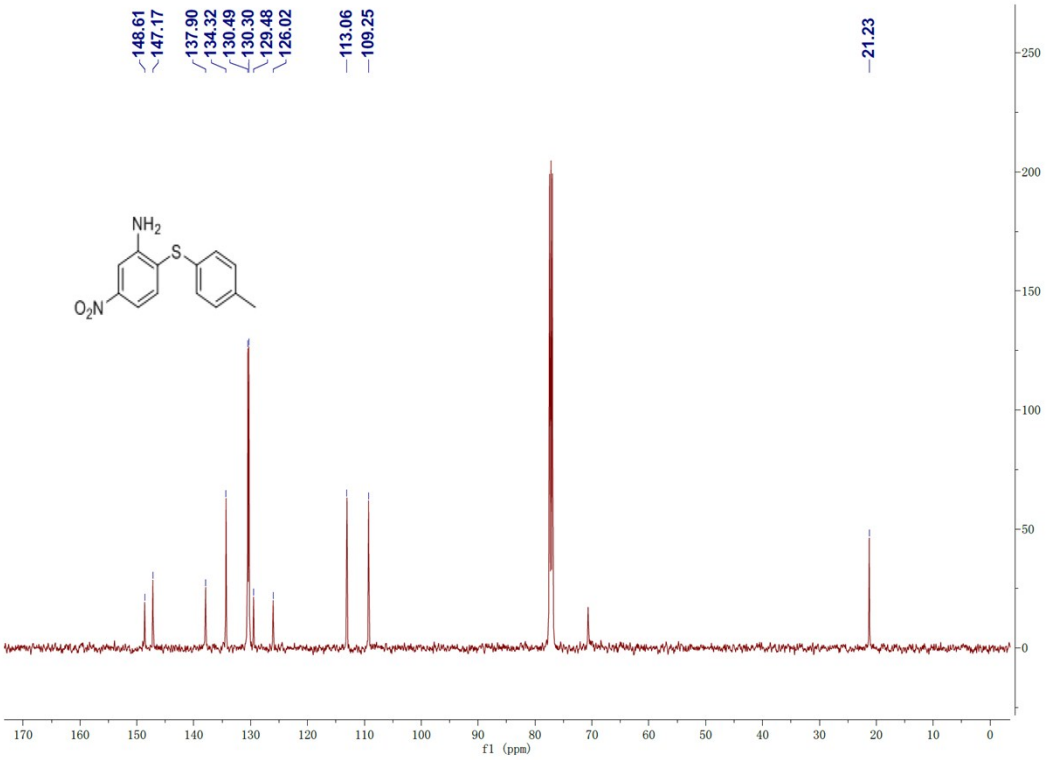

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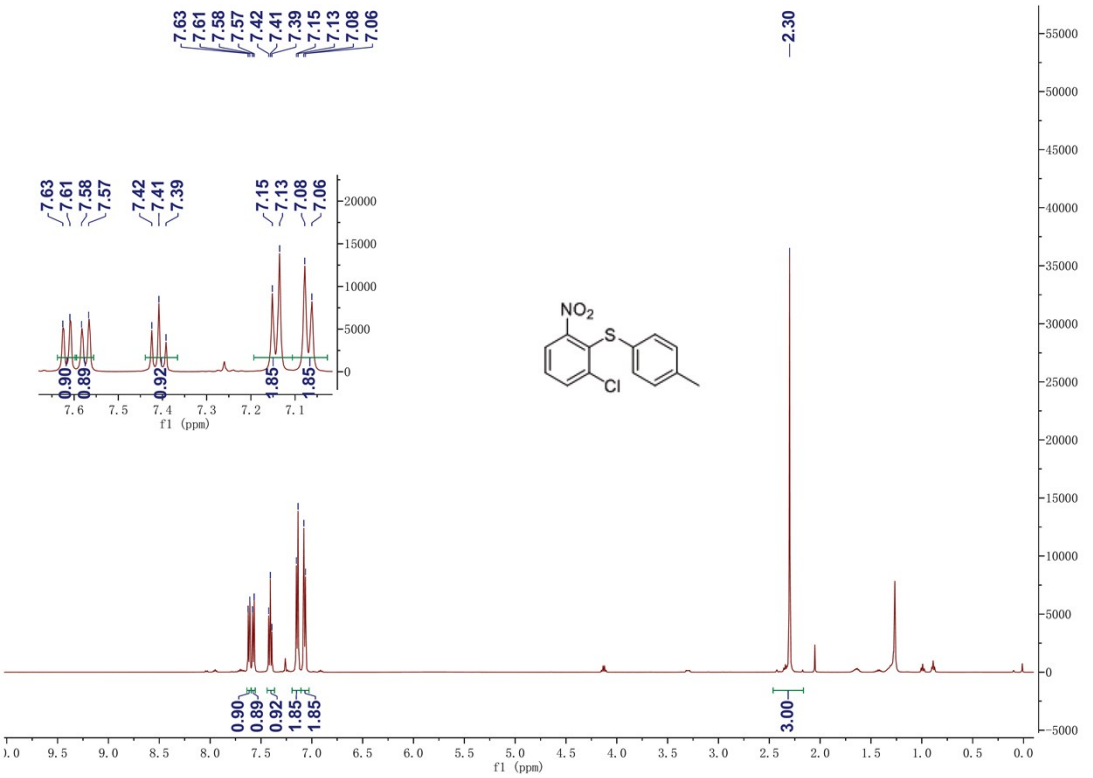

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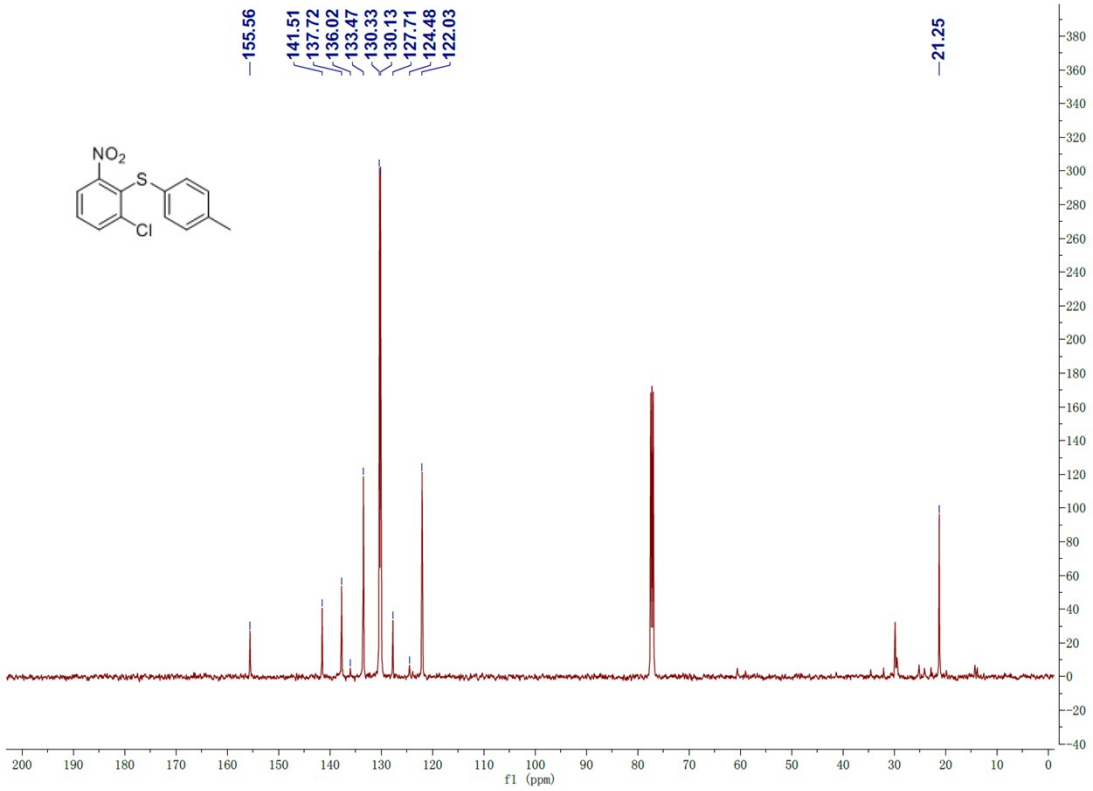

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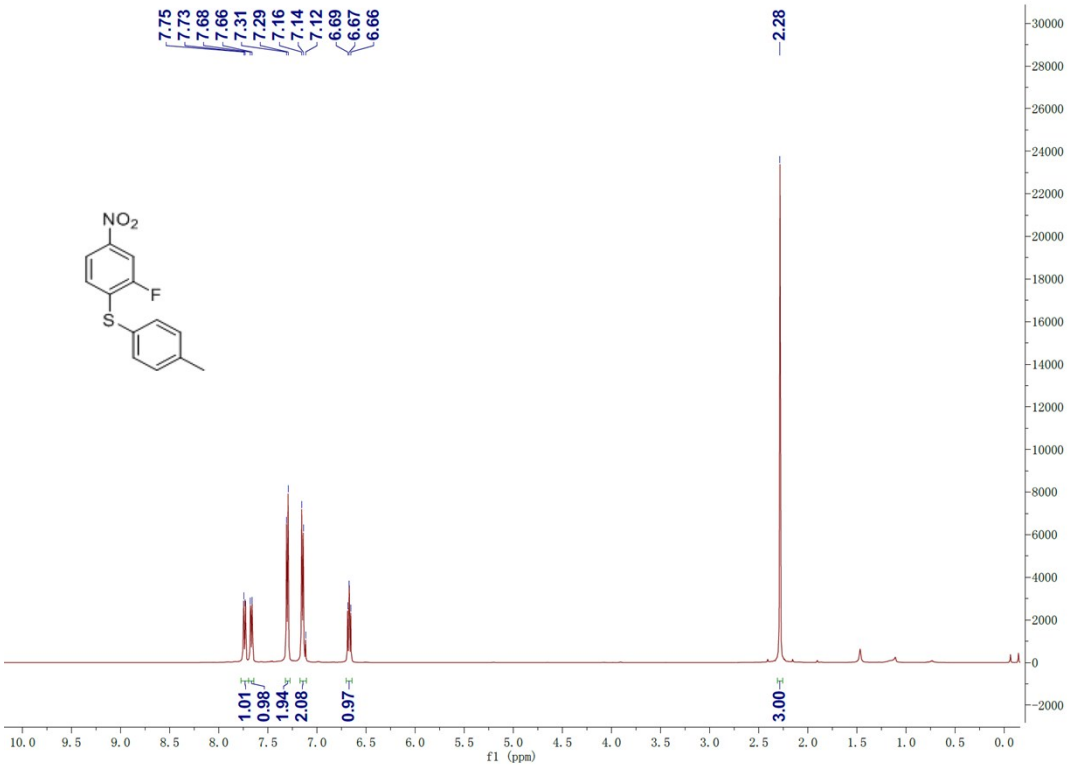

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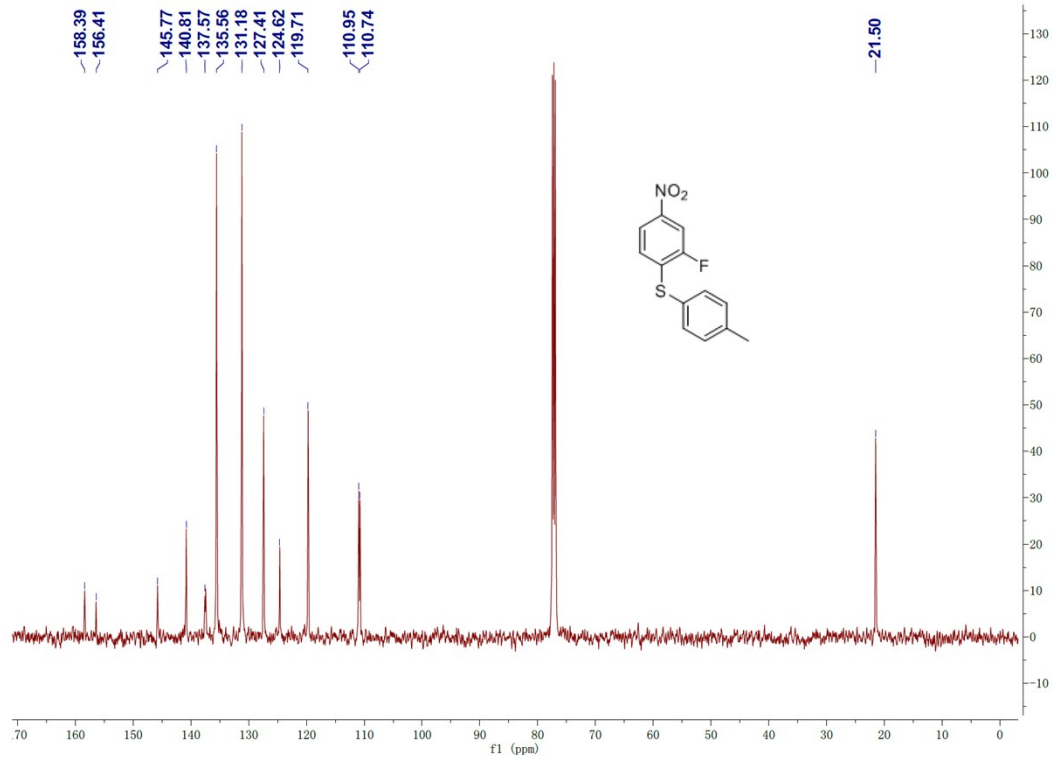
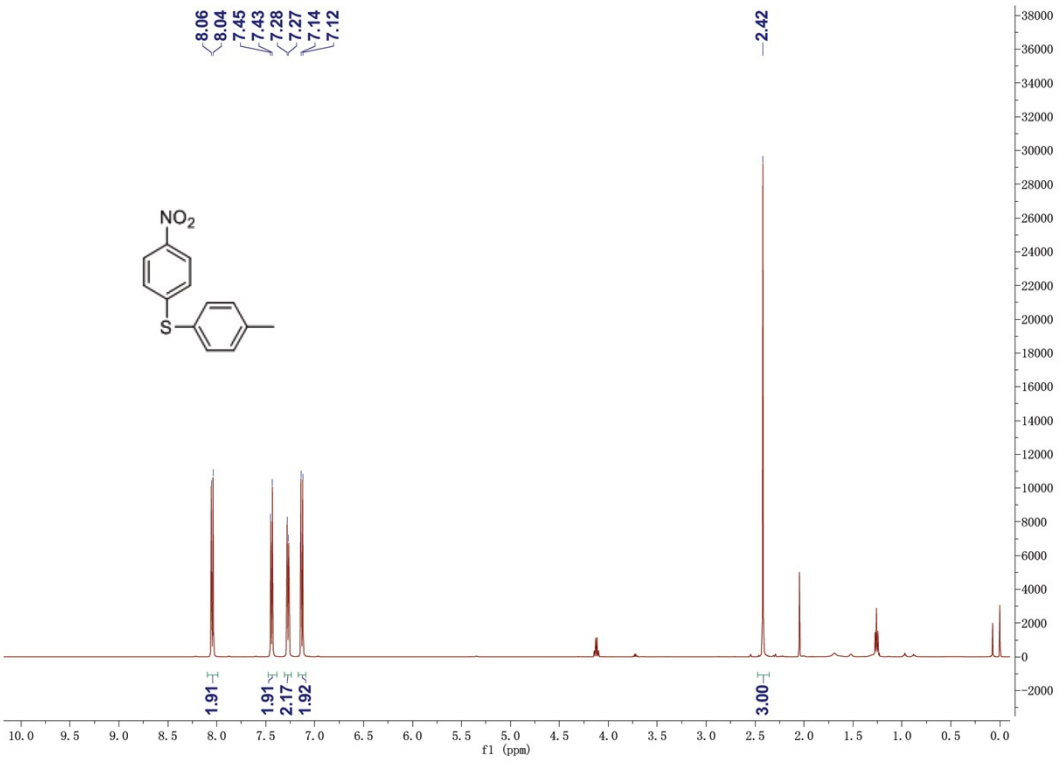
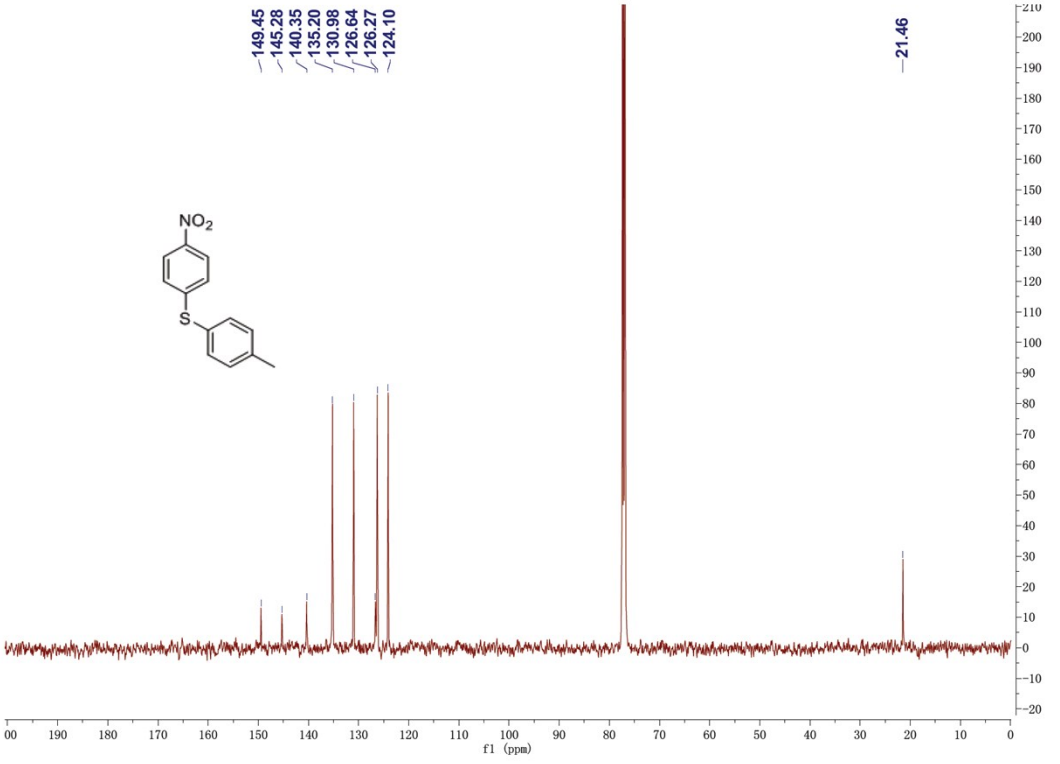


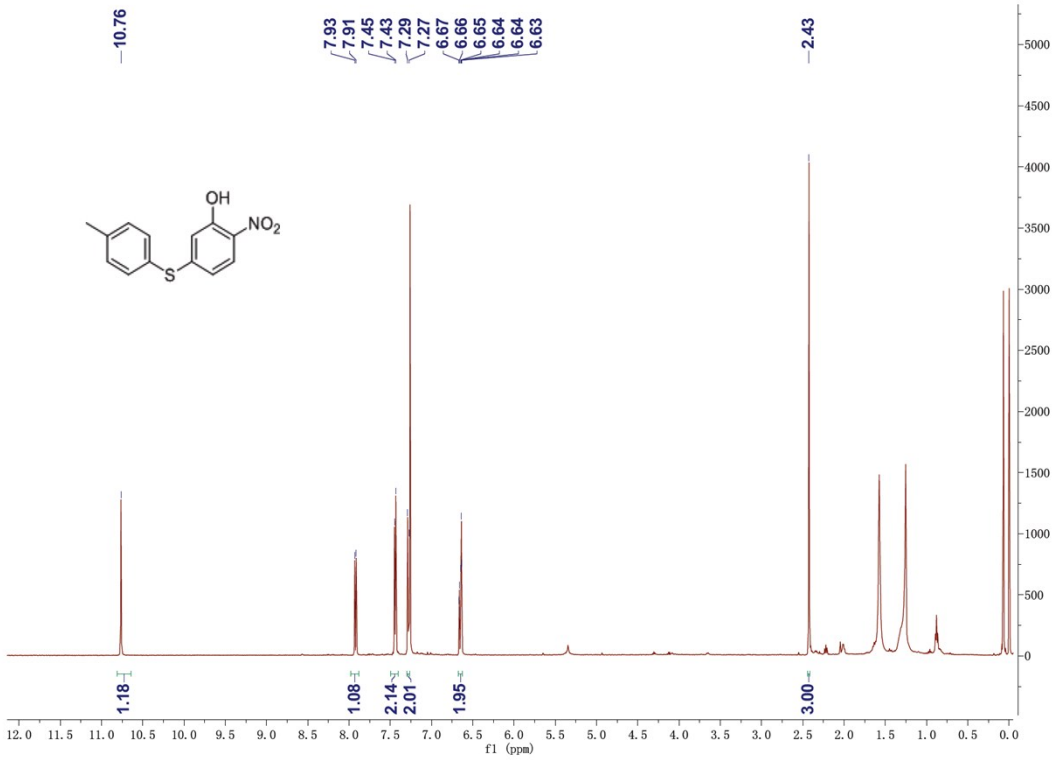
^{13}C NMR of 3d



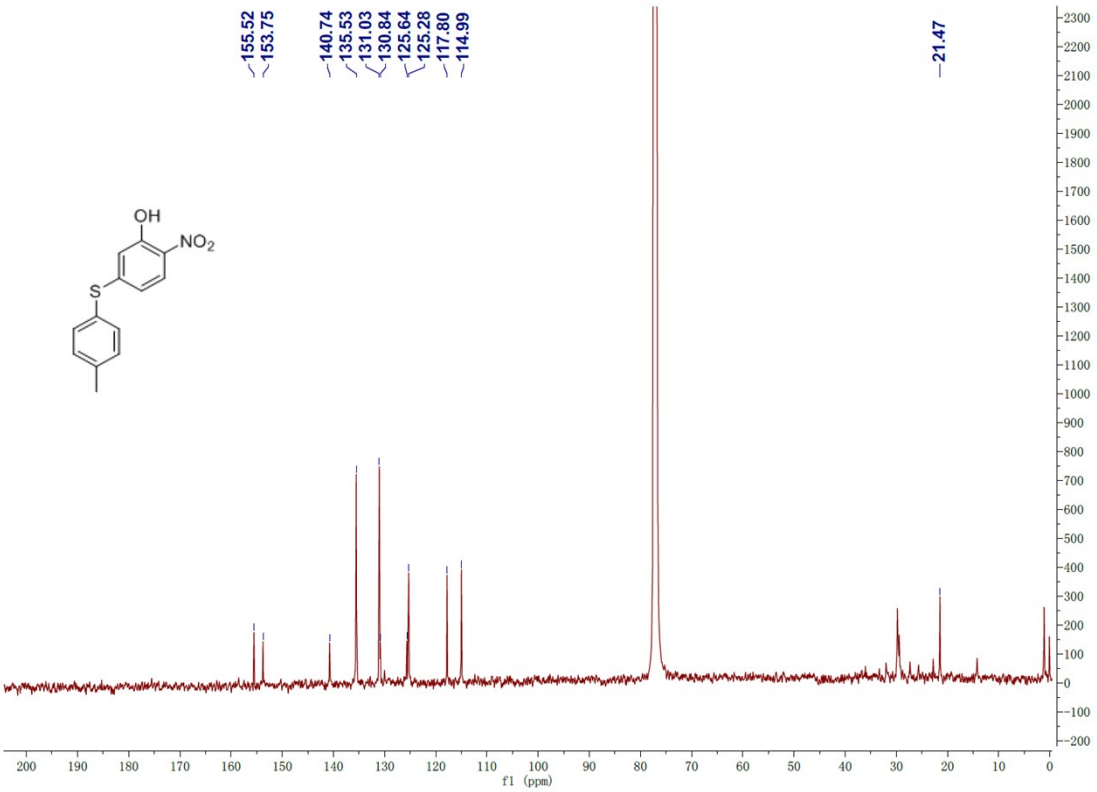
^{1}H NMR of 3e



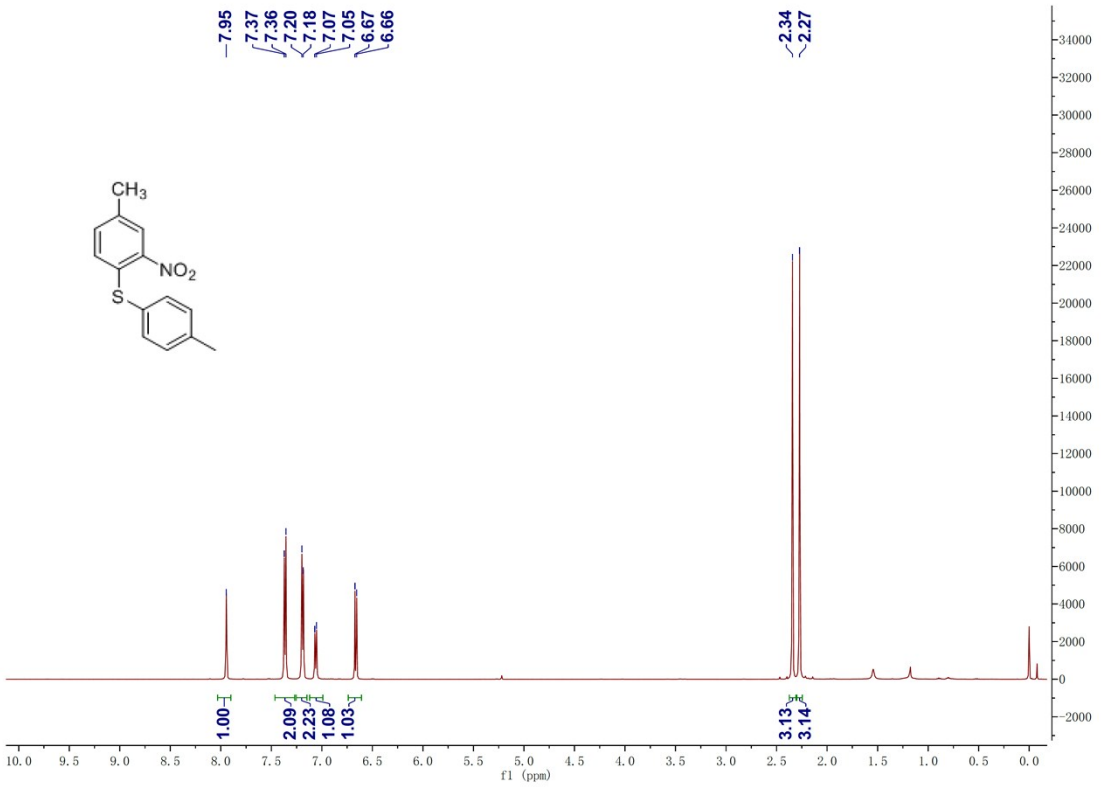
^{13}C NMR of 3e



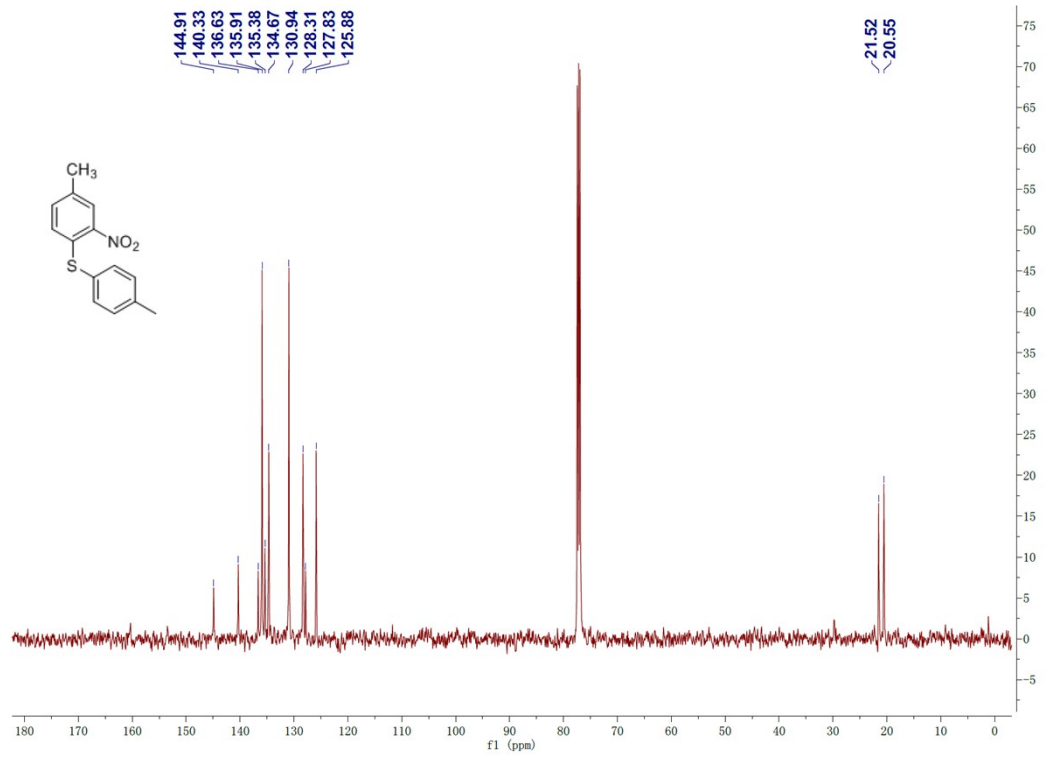
^{1}H NMR of 3f



^{13}C NMR of 3f



^{1}H NMR of 3g



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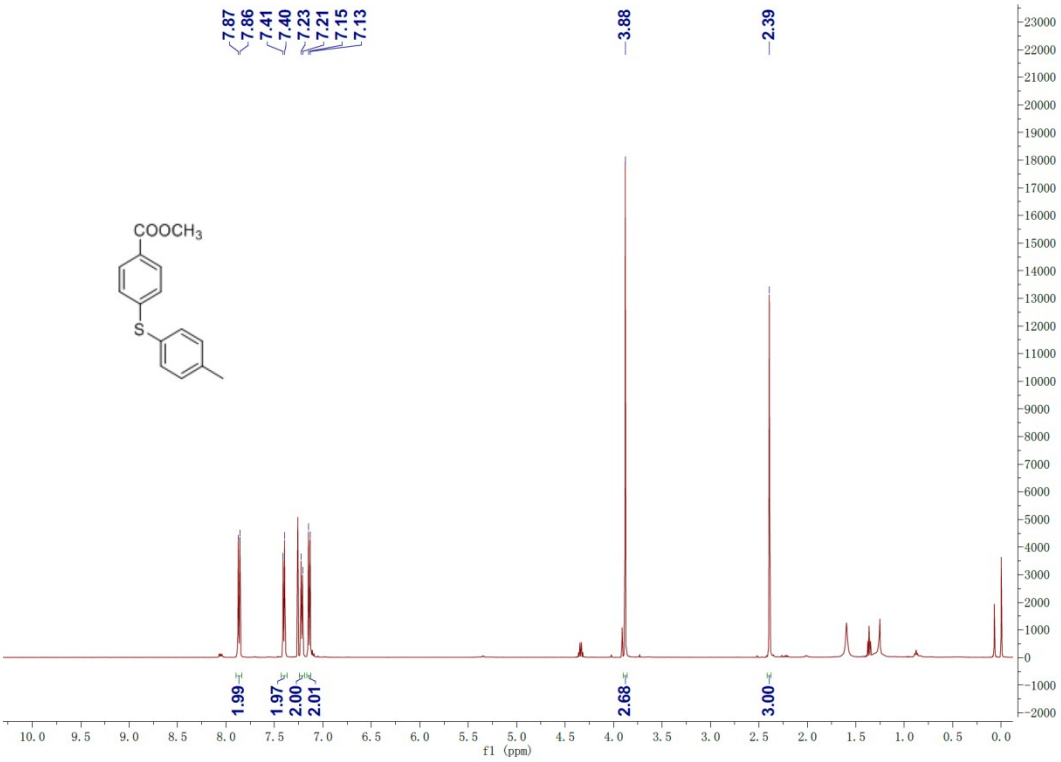

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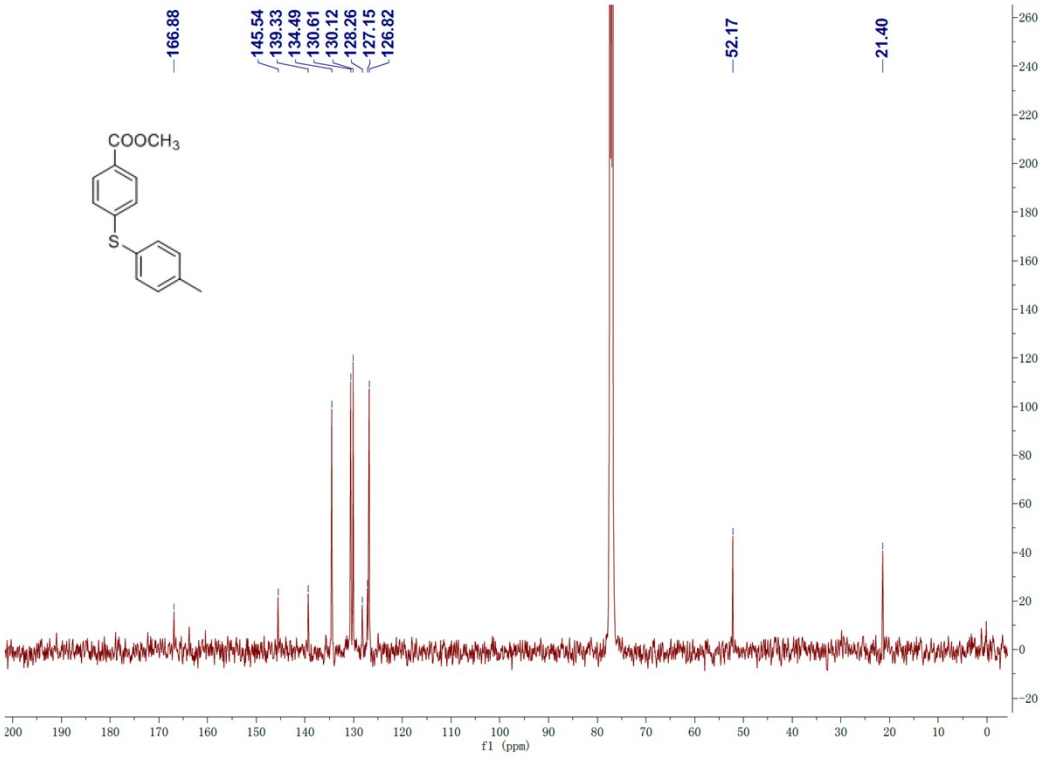
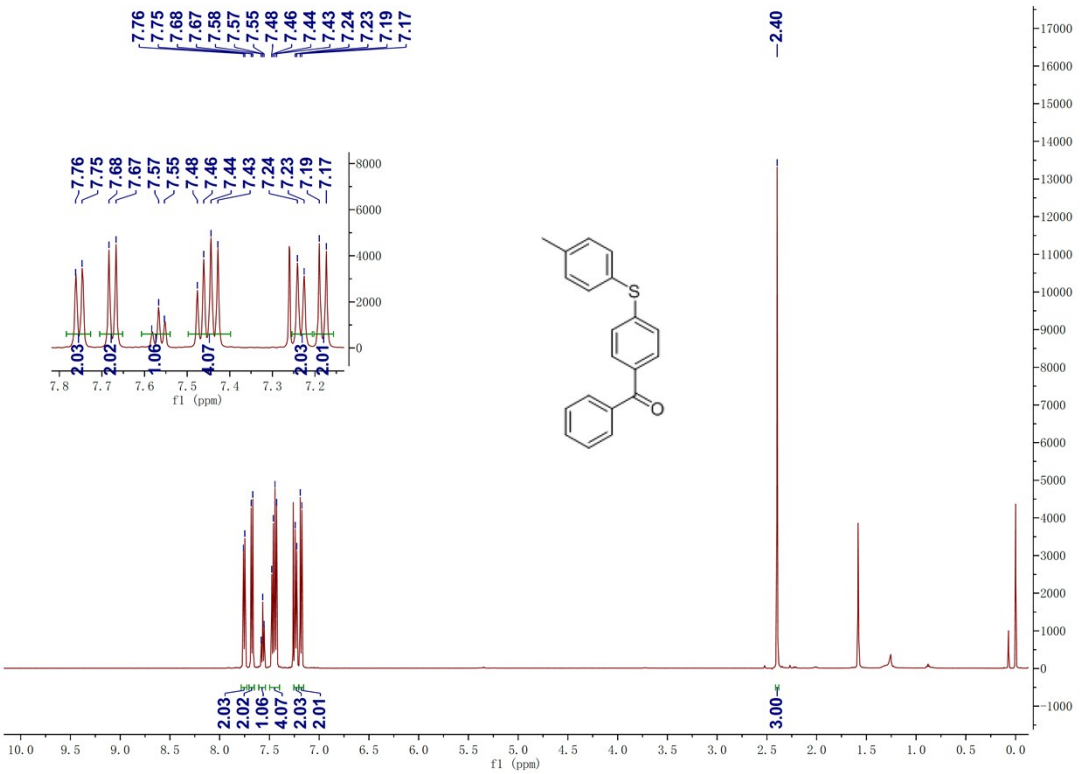
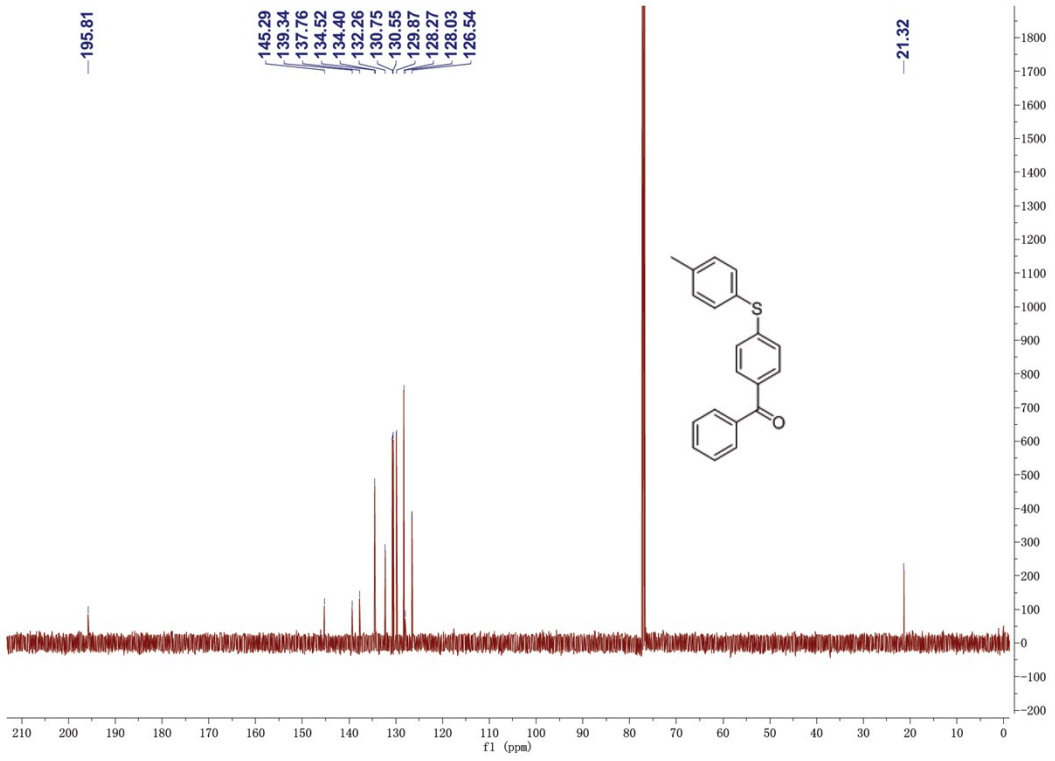


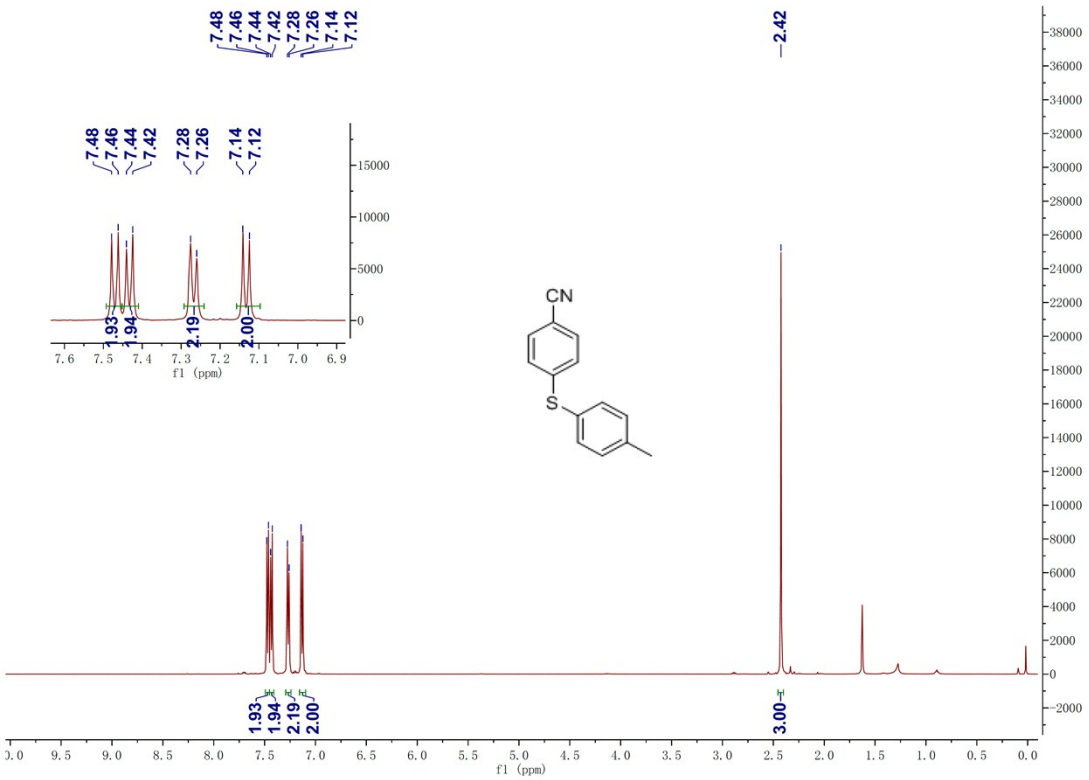
^{13}C NMR of 3h



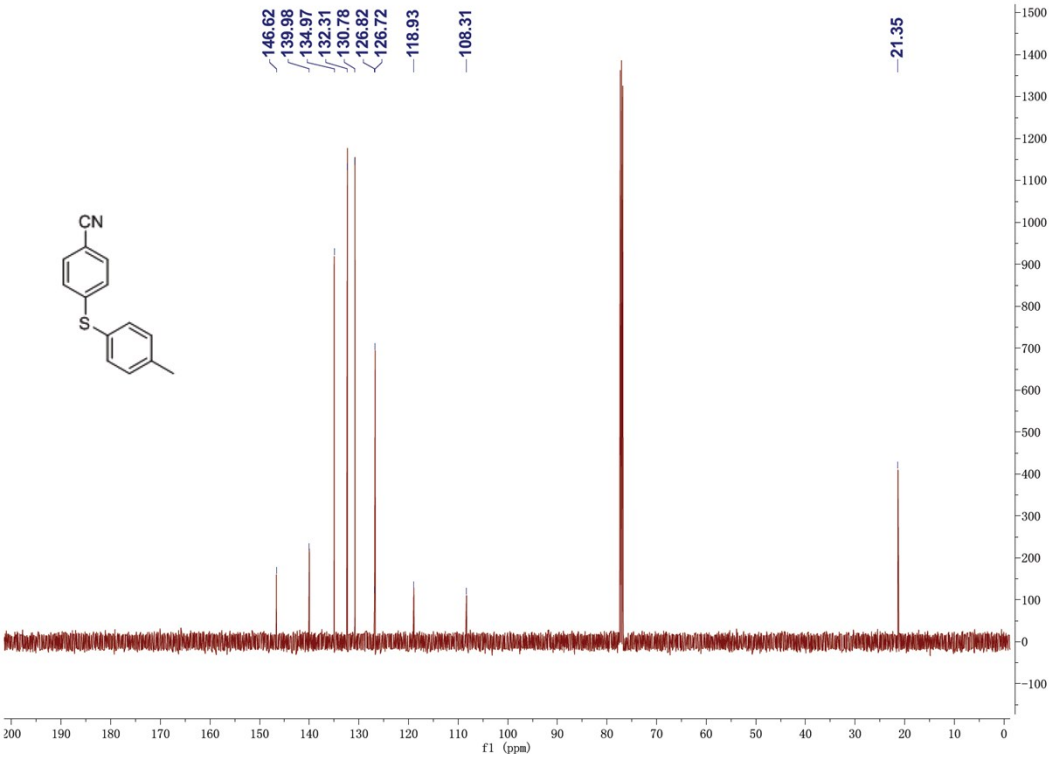
^{1}H NMR of 3i



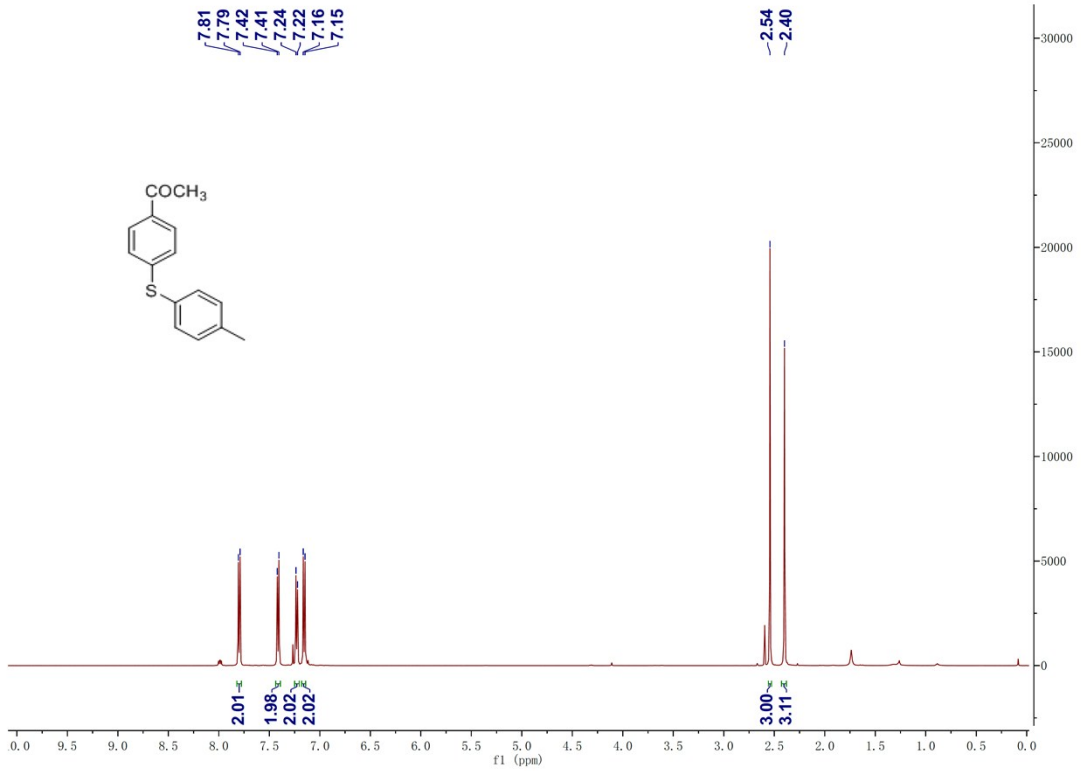
^{13}C NMR of 3i



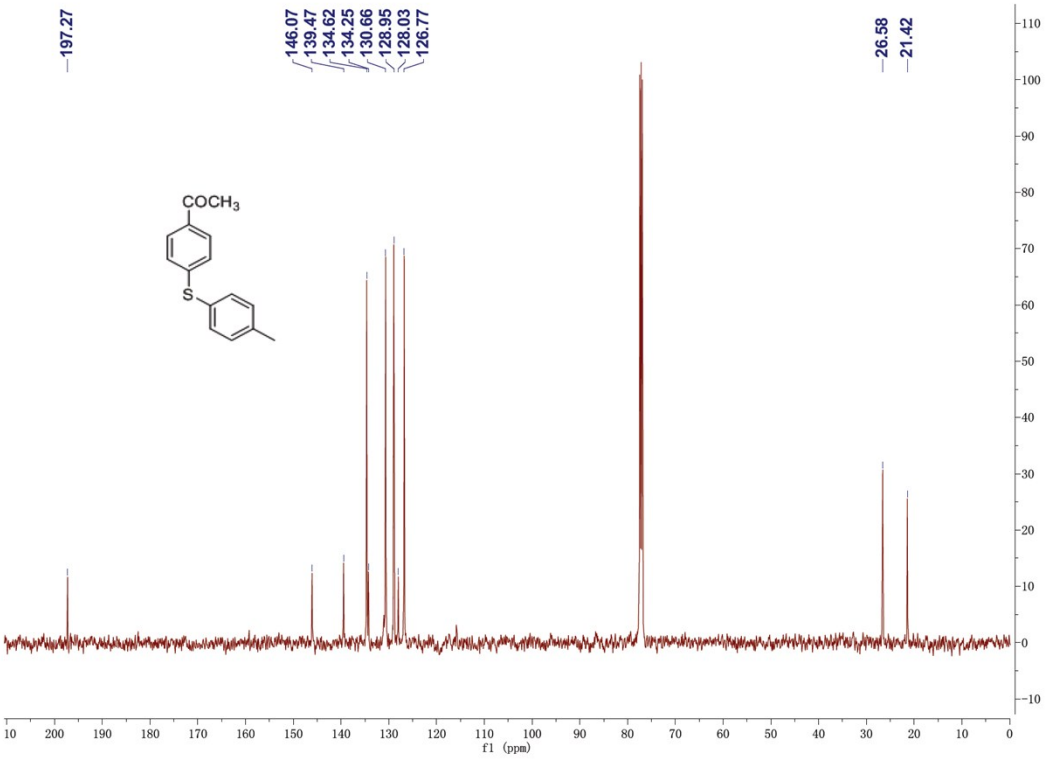
^{1}H NMR of 3j



^{13}C NMR of 3j



^{1}H NMR of 3k



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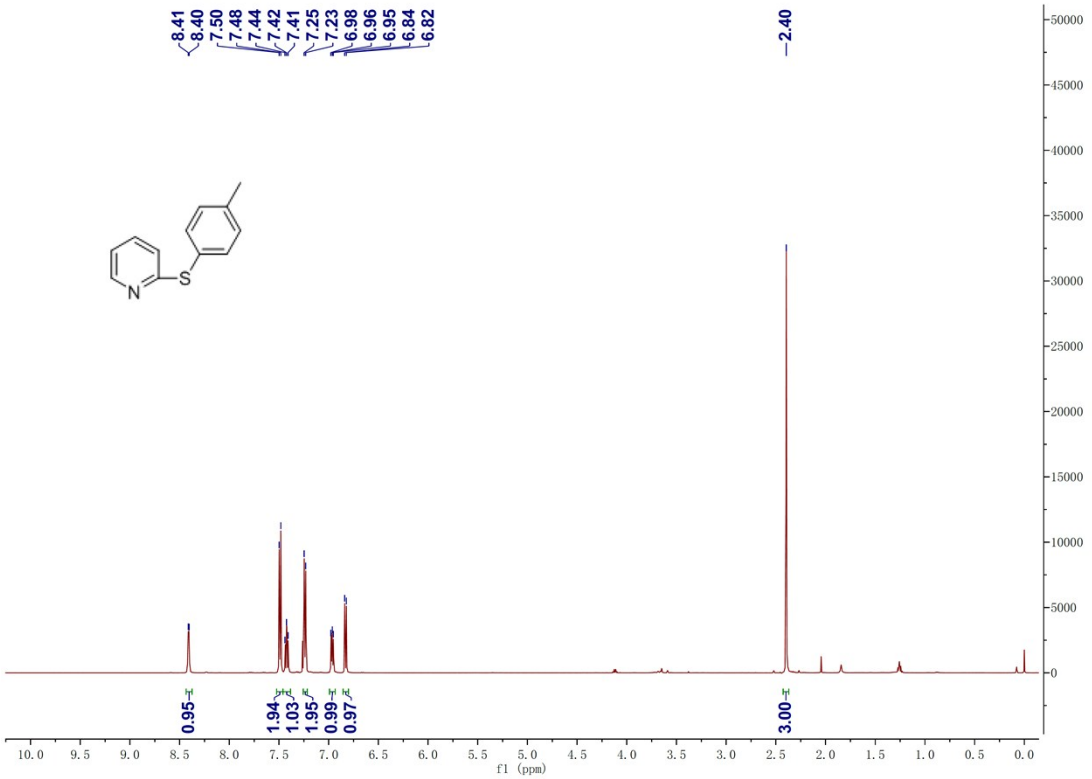
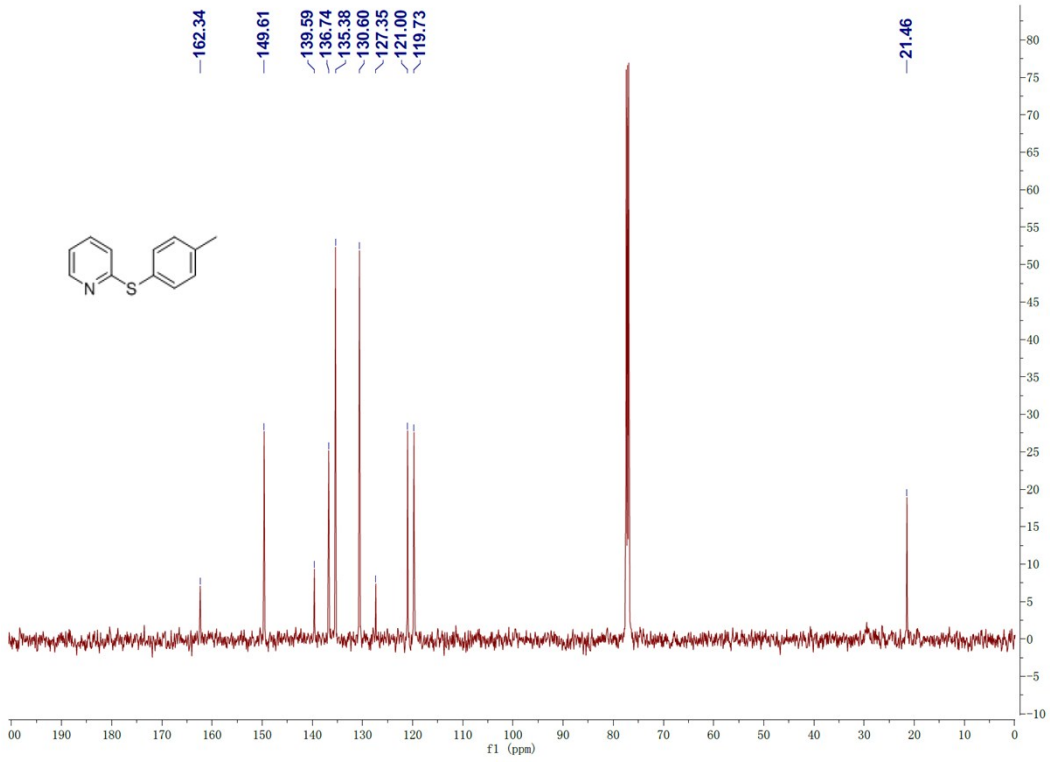
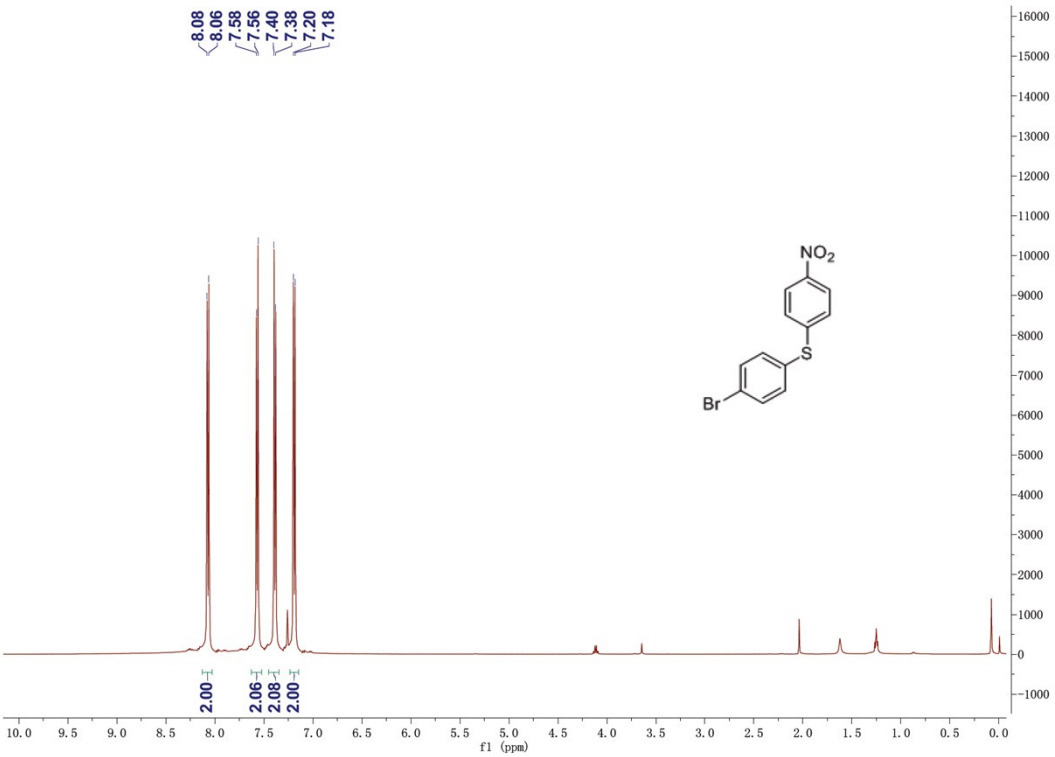


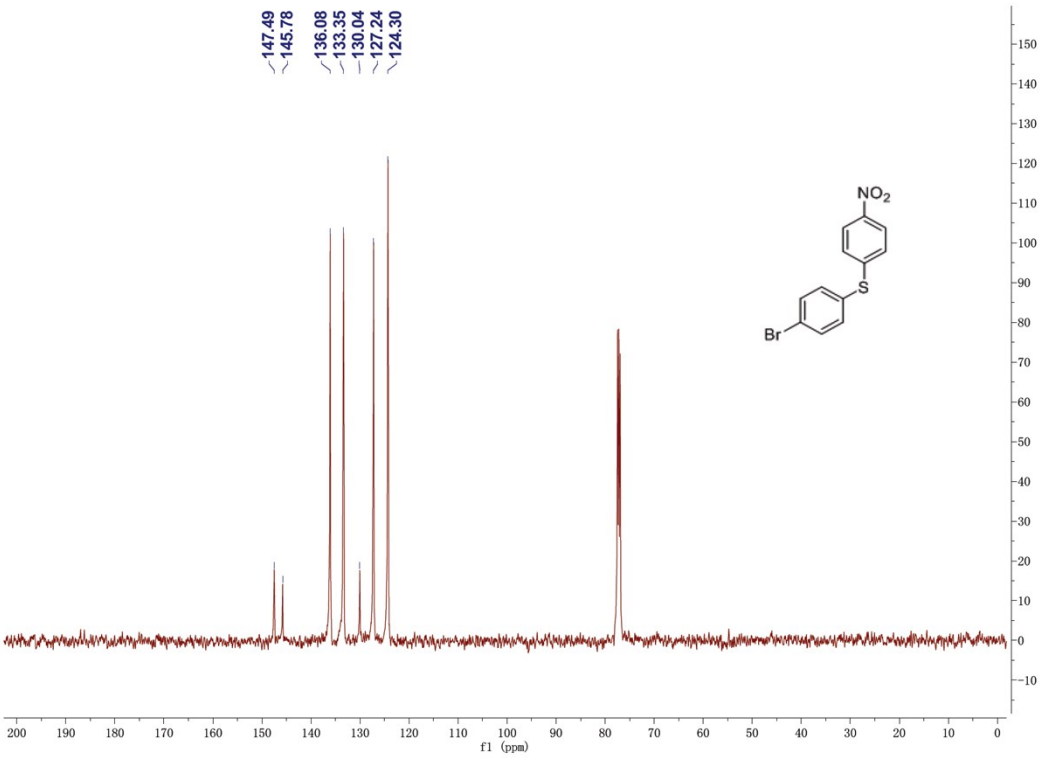
^{1}H NMR of 3l



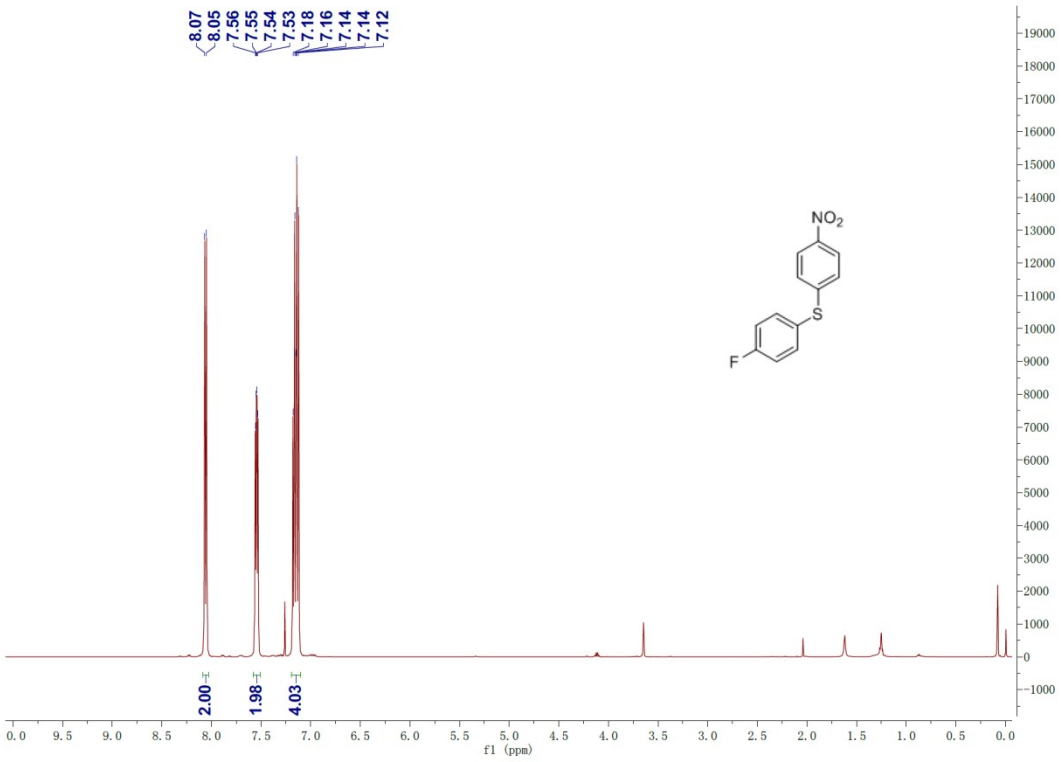
^{13}C NMR of 3l



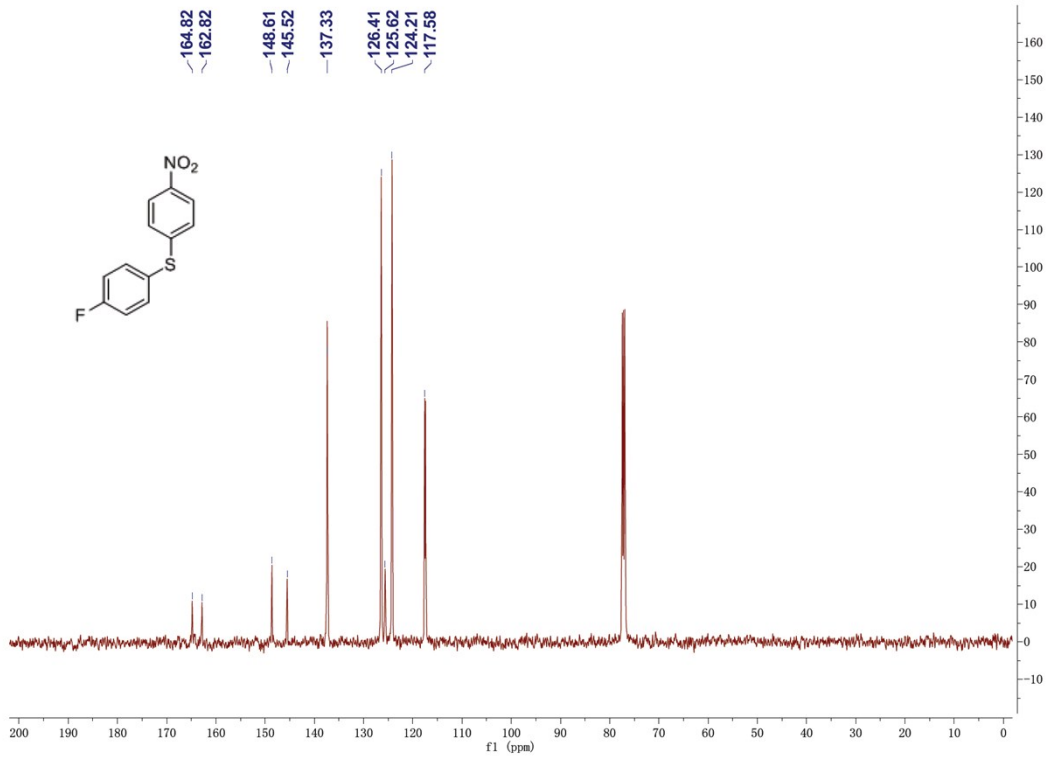
^{1}H NMR of 3m



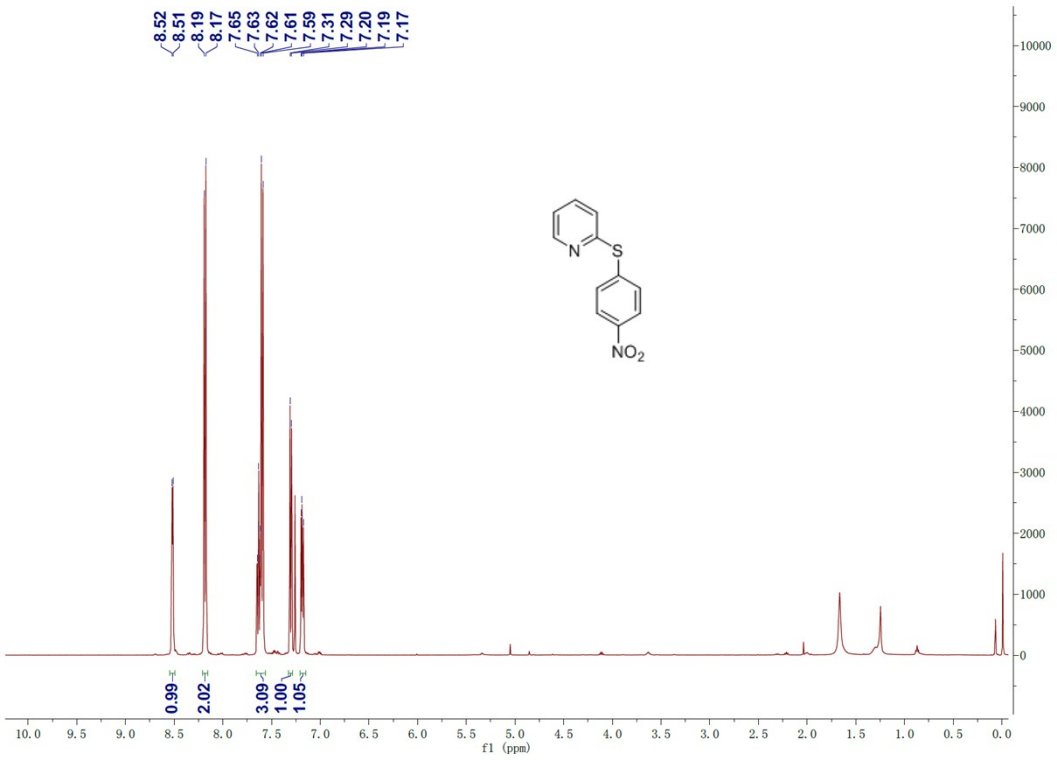
^{13}C NMR of 3m



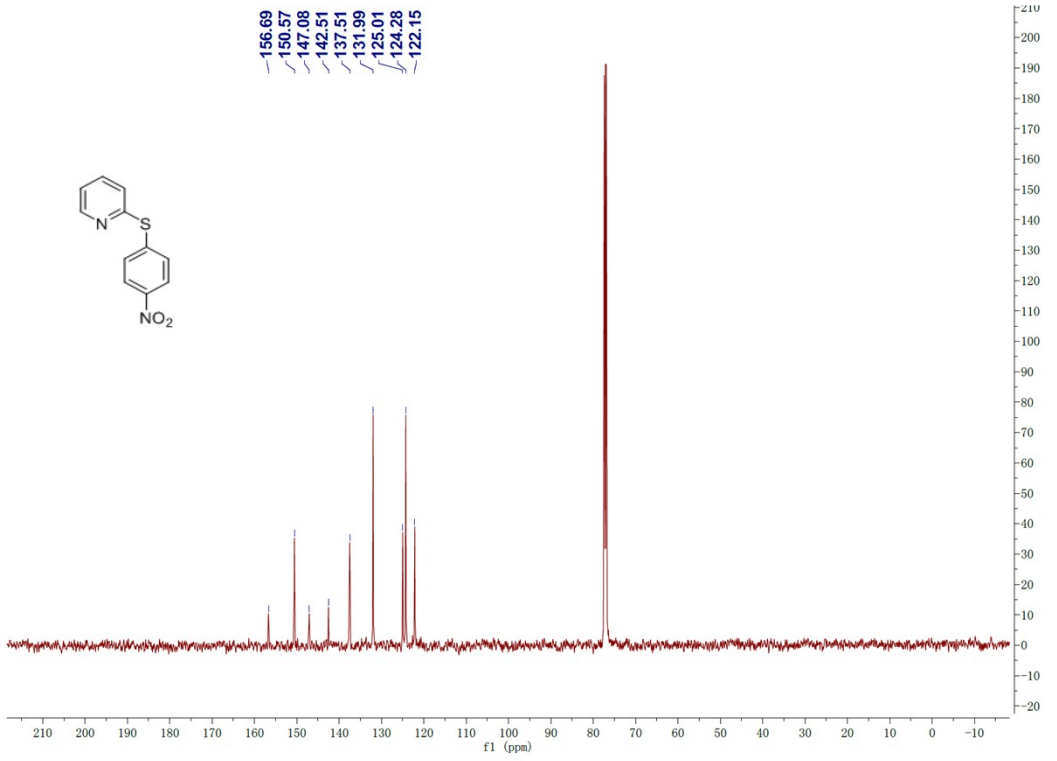
^{1}H NMR of 3n



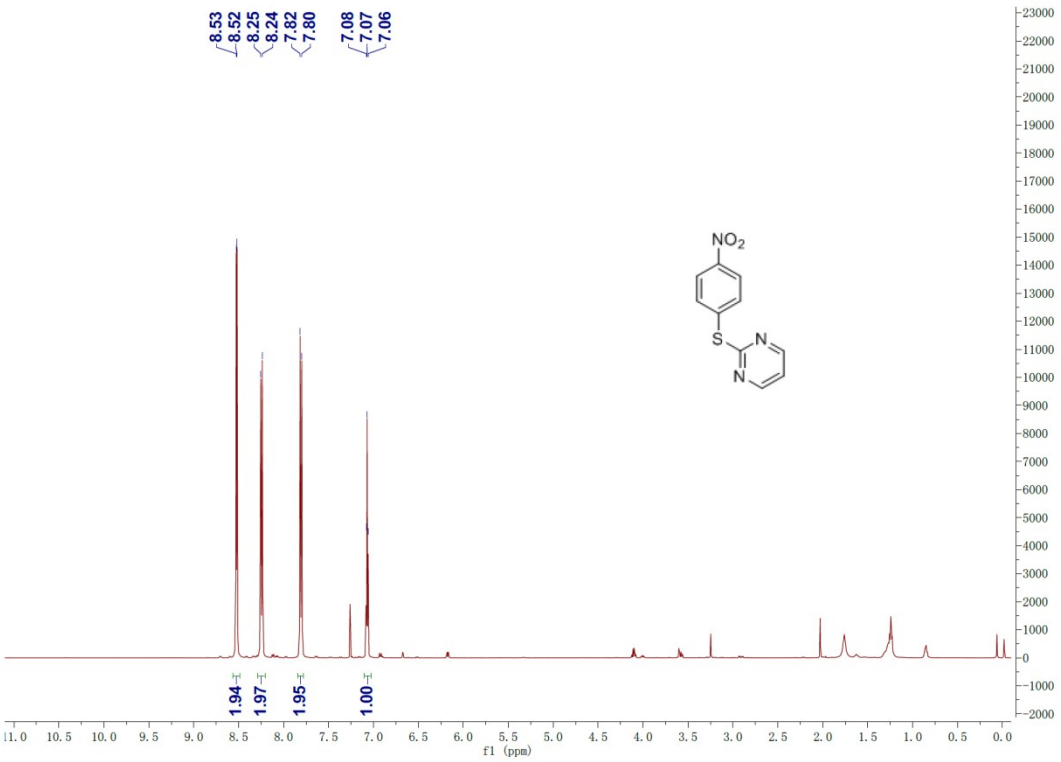
^{13}C NMR of 3n



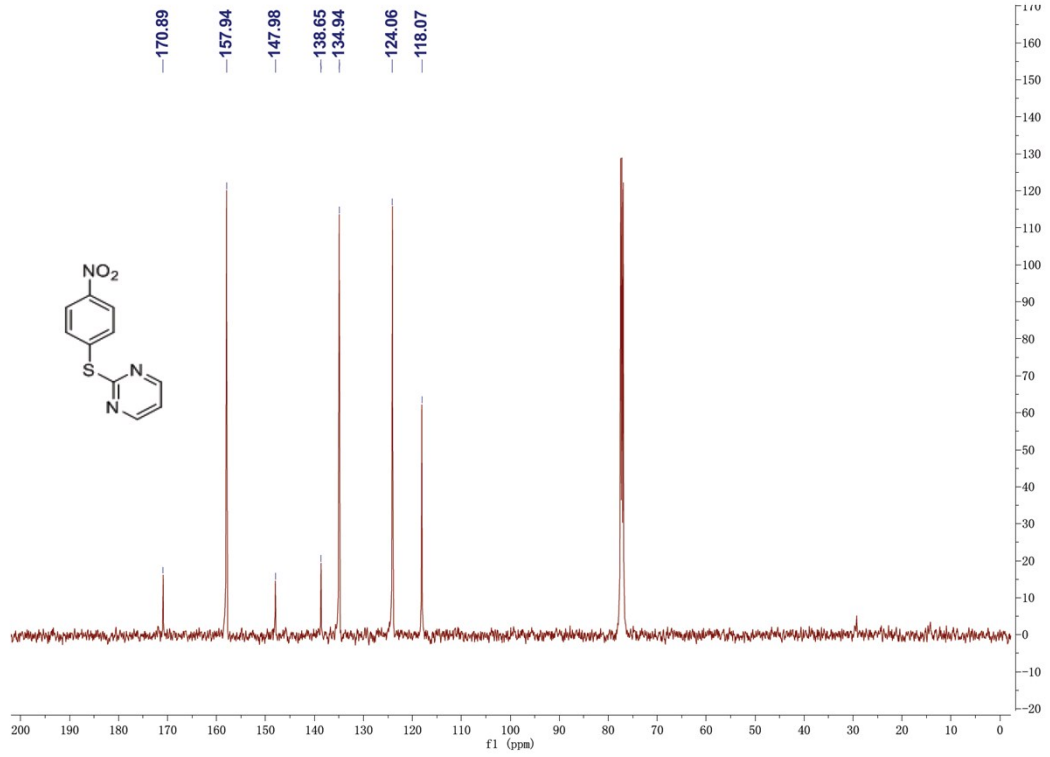
^{1}H NMR of 3o



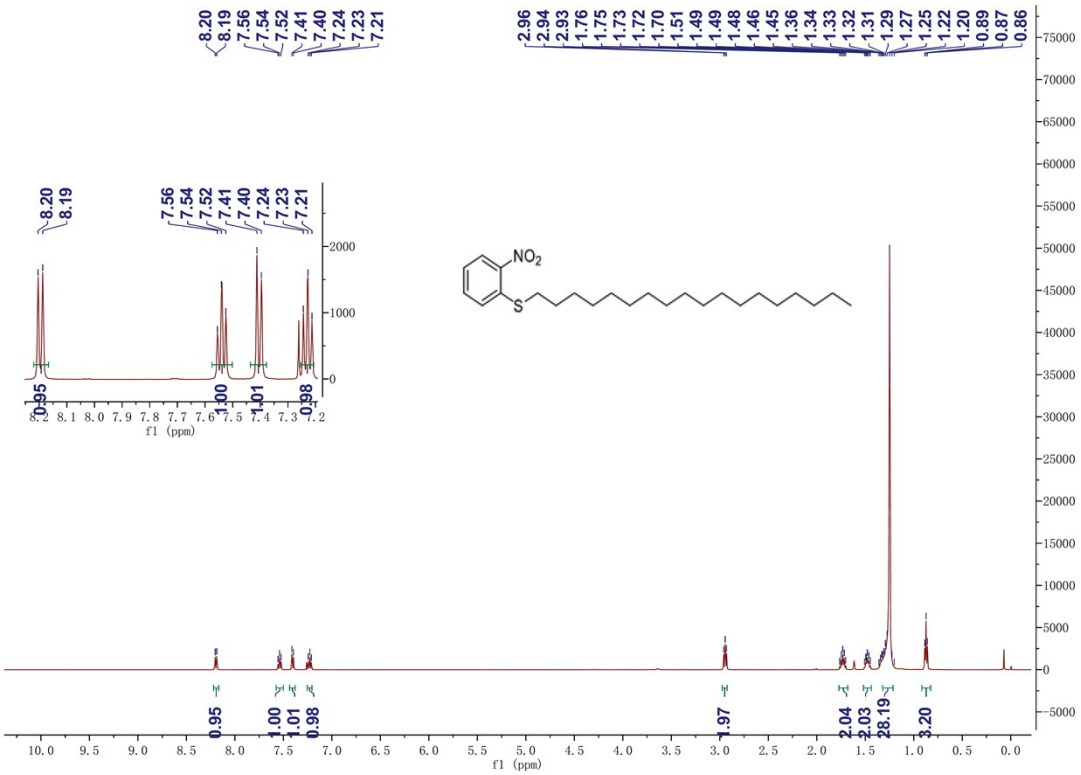
^{13}C NMR of 3o



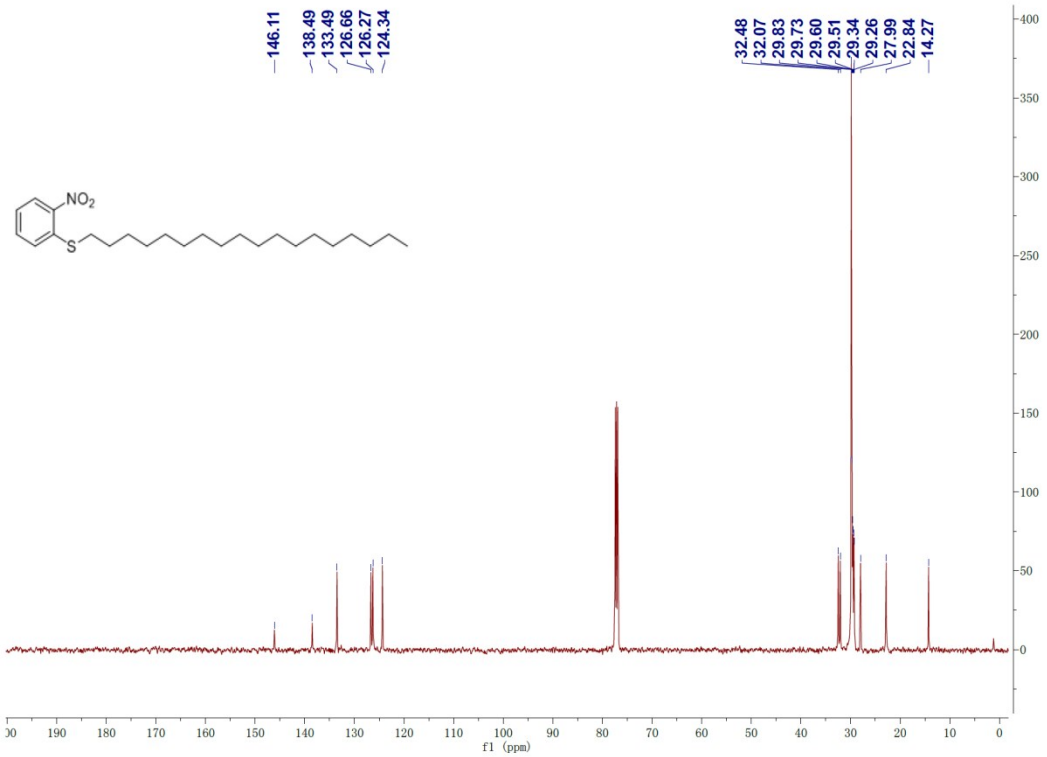
^{1}H NMR of 3p



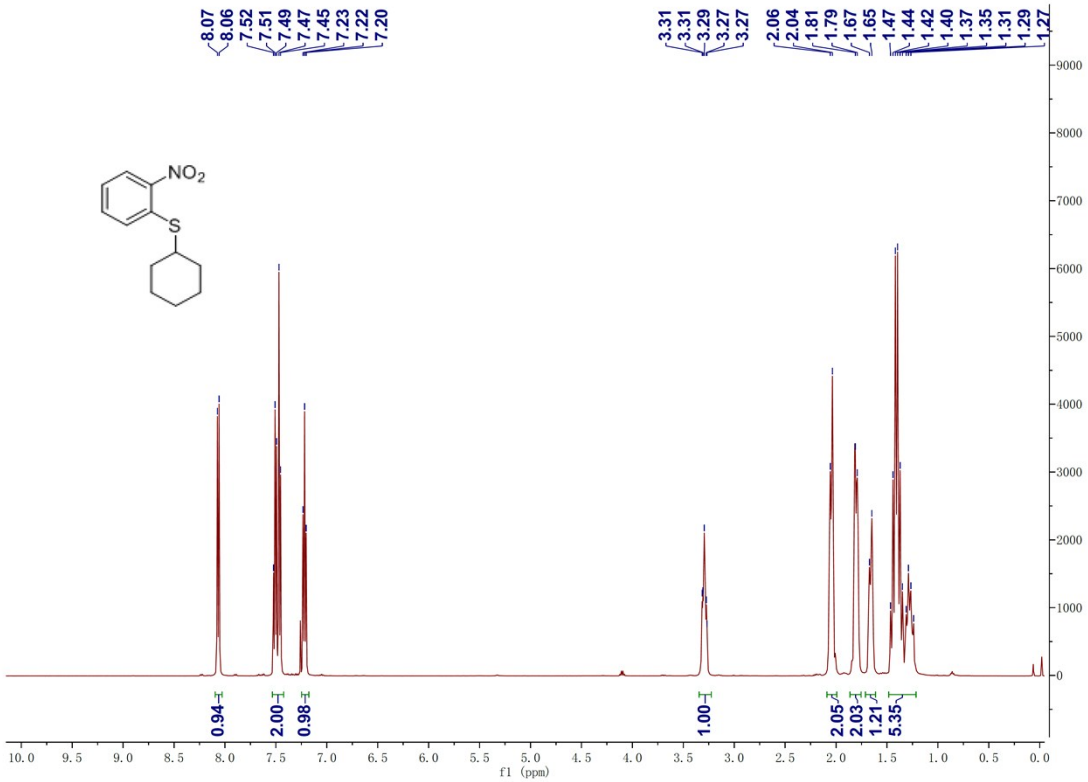
^{13}C NMR of 3p



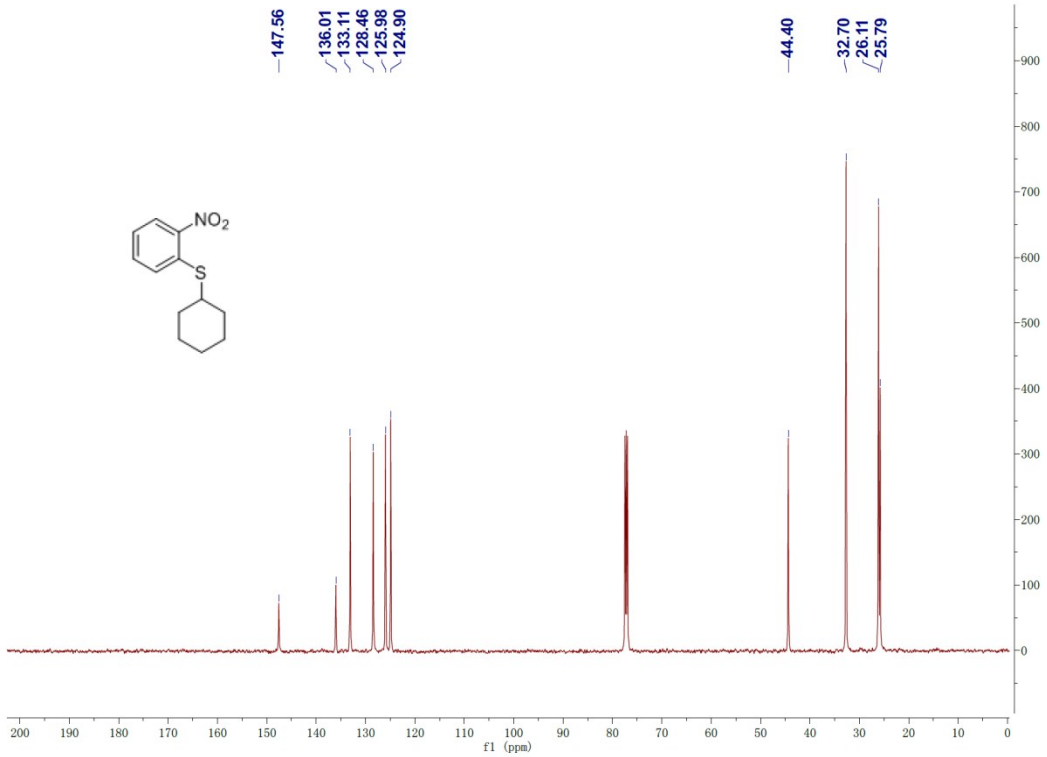
^{1}H NMR of 3q



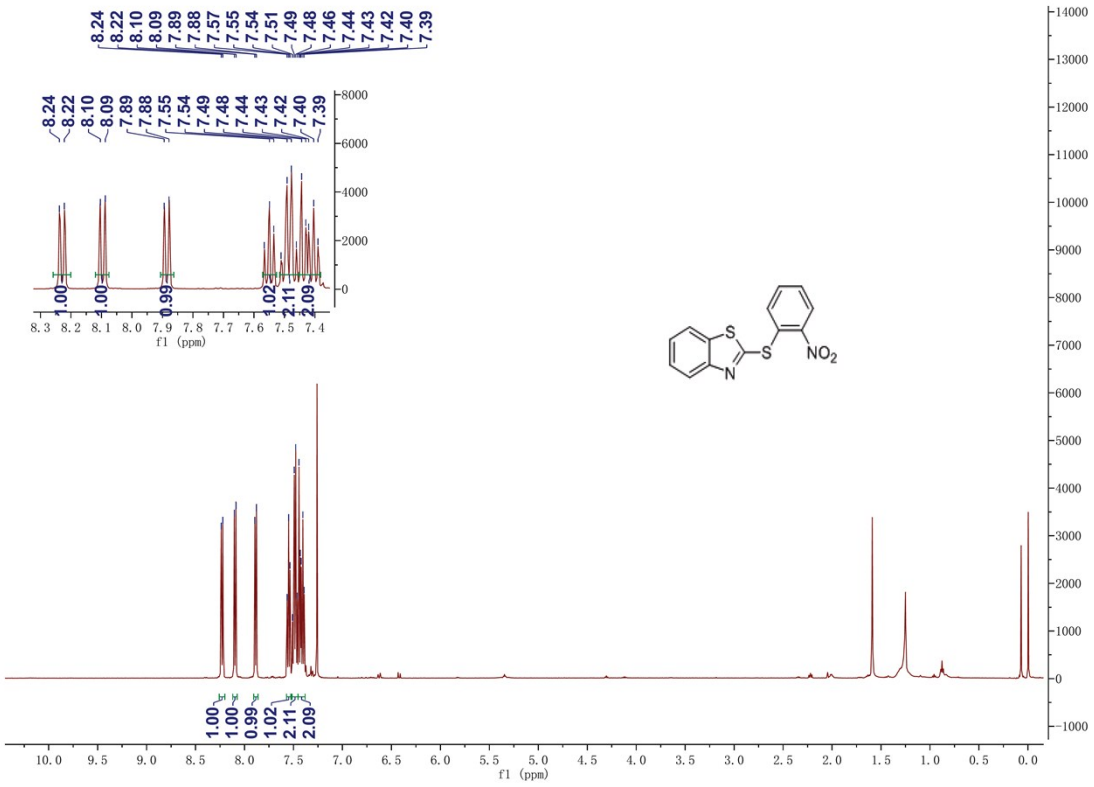
^{13}C NMR of 3q



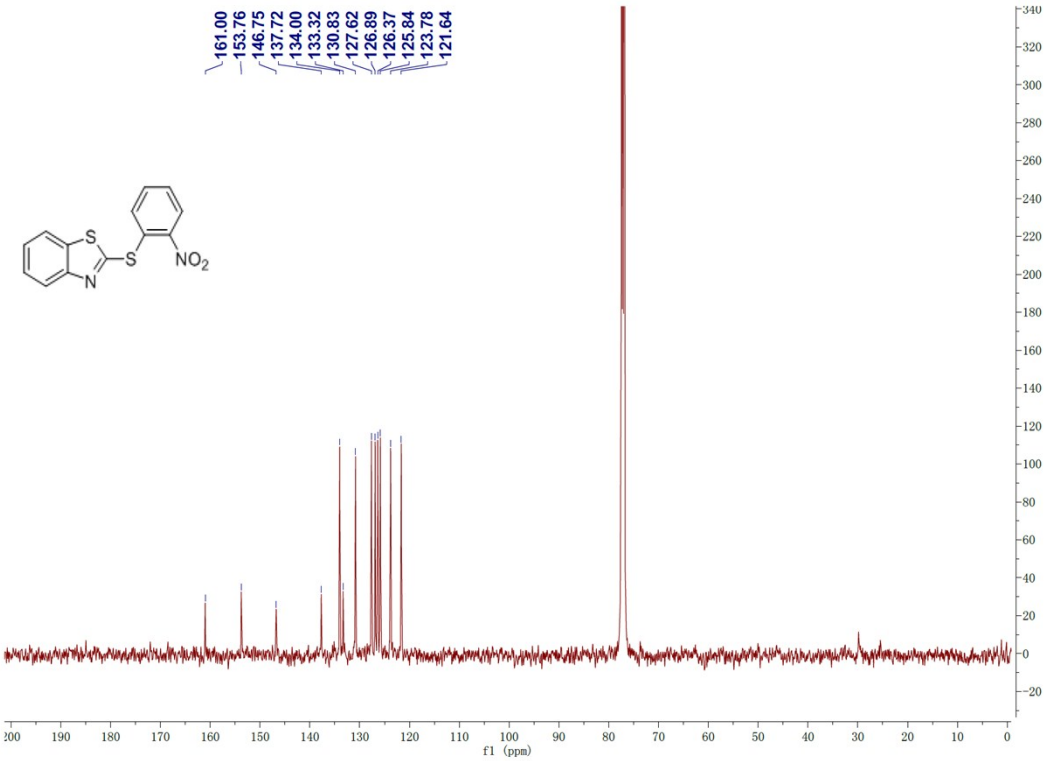
^{1}H NMR of 3r



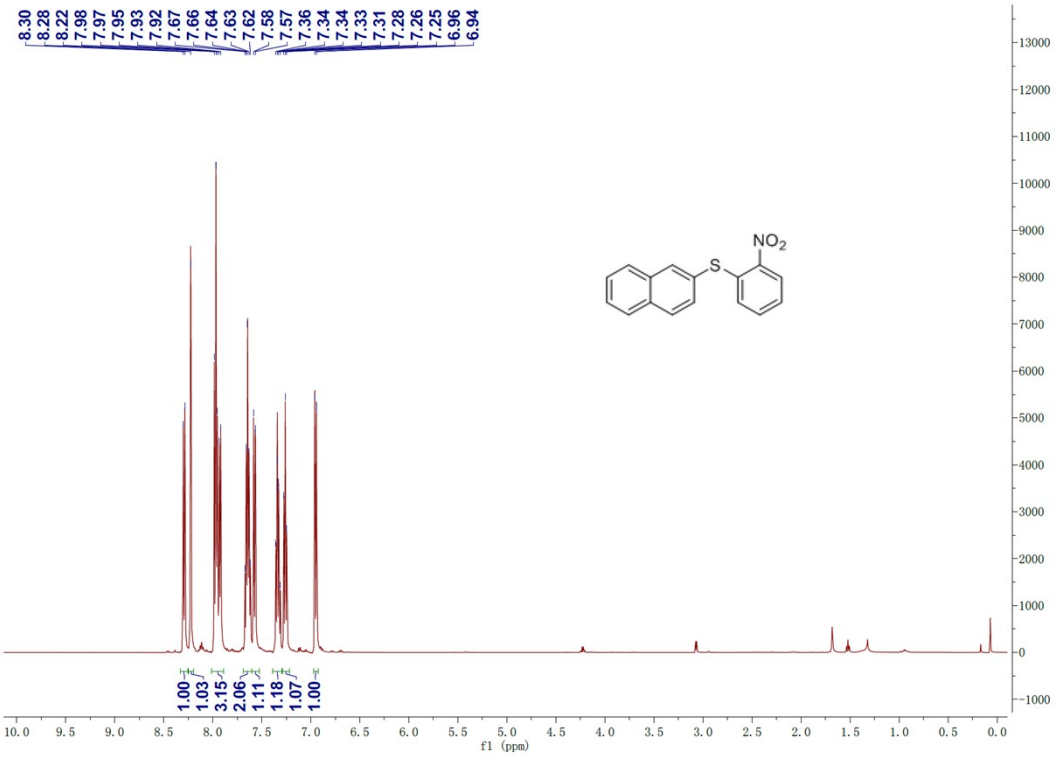
^{13}C NMR of 3r



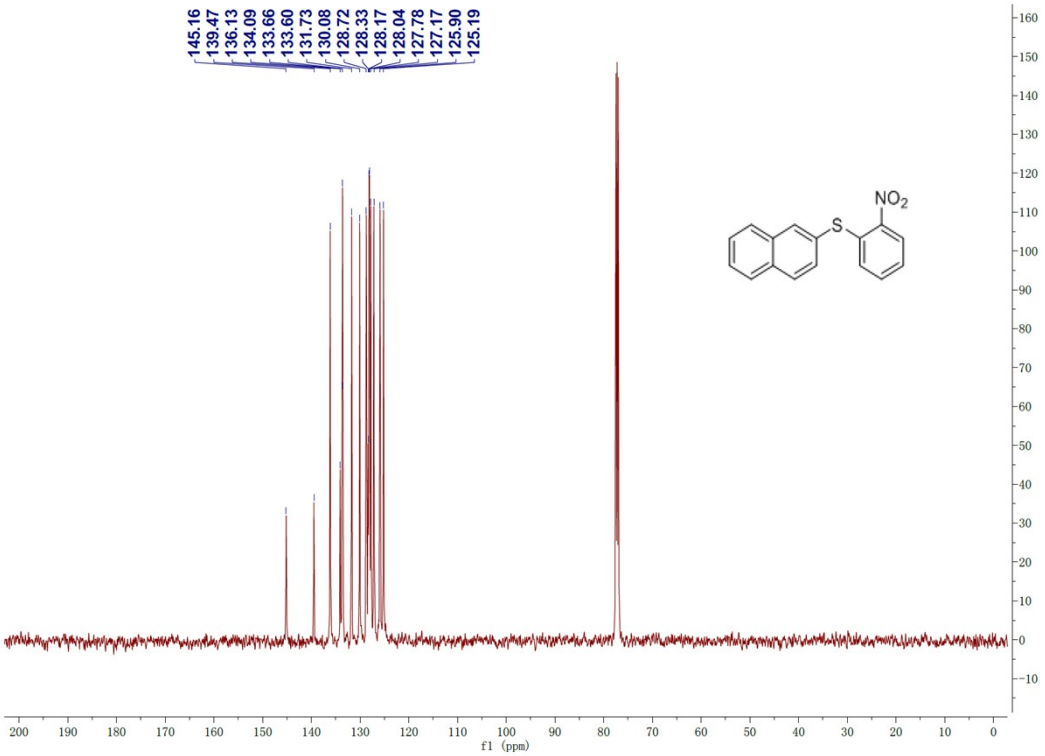
^{1}H NMR of 3s



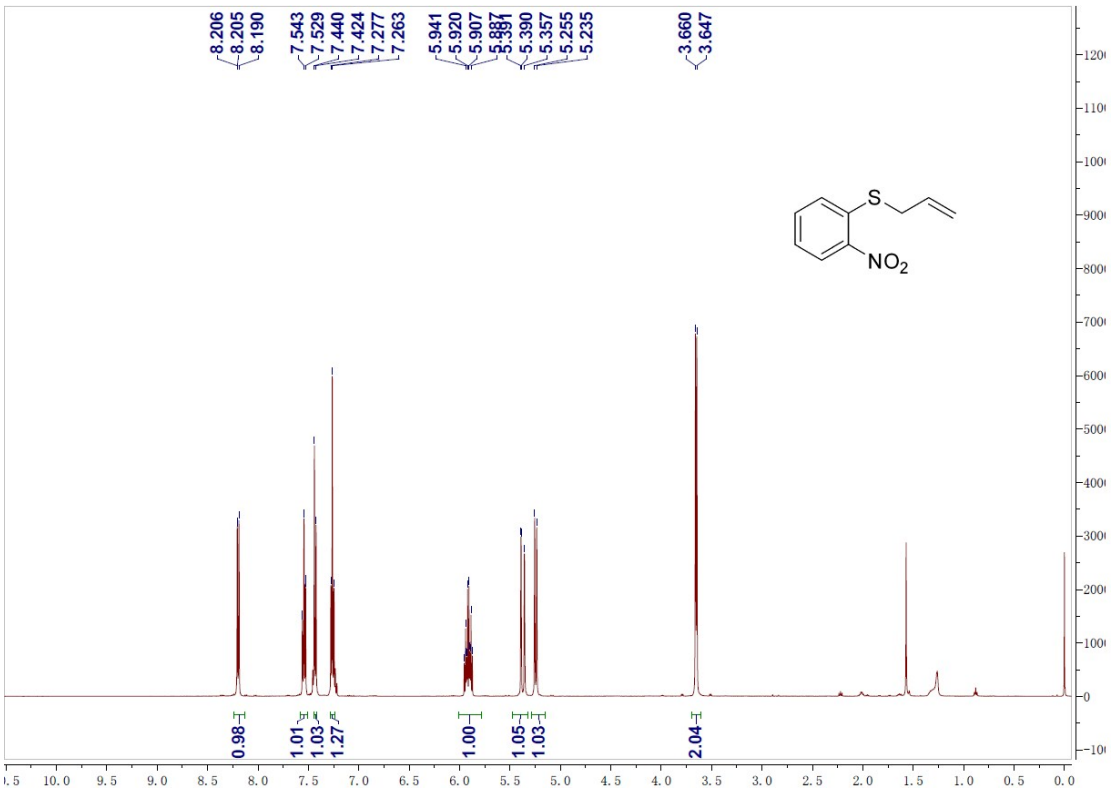
^{13}C NMR of 3s



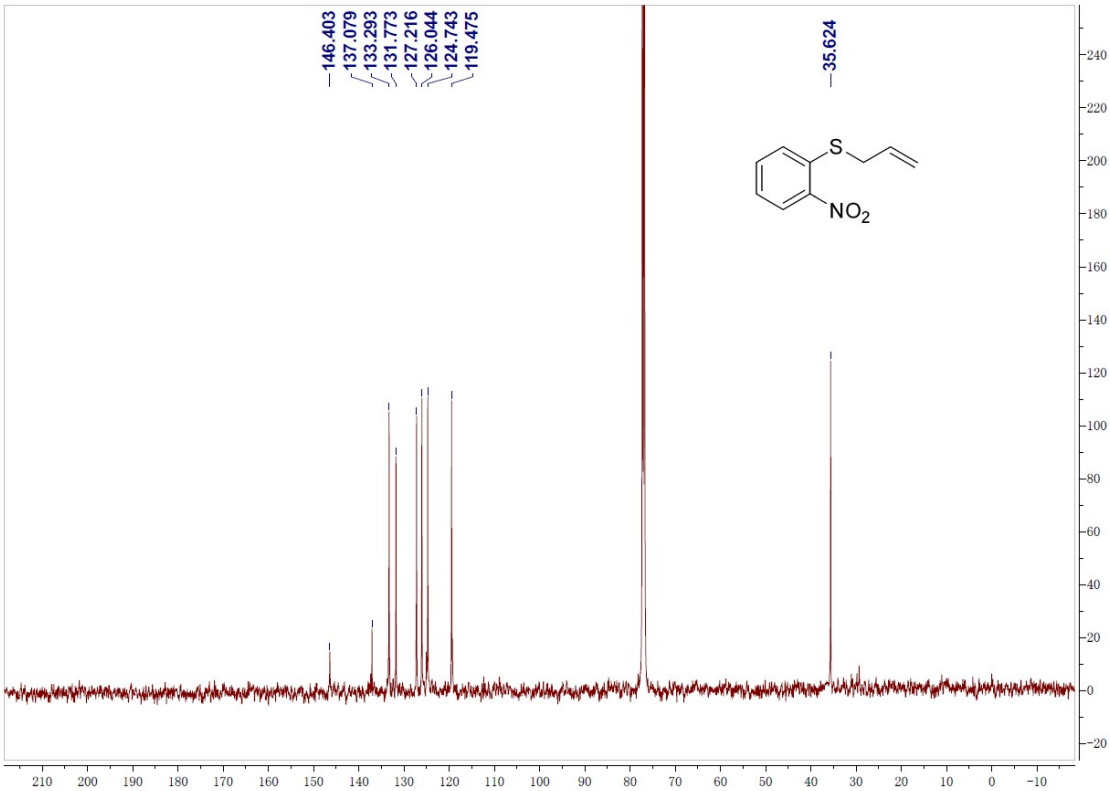
^{1}H NMR of 3t



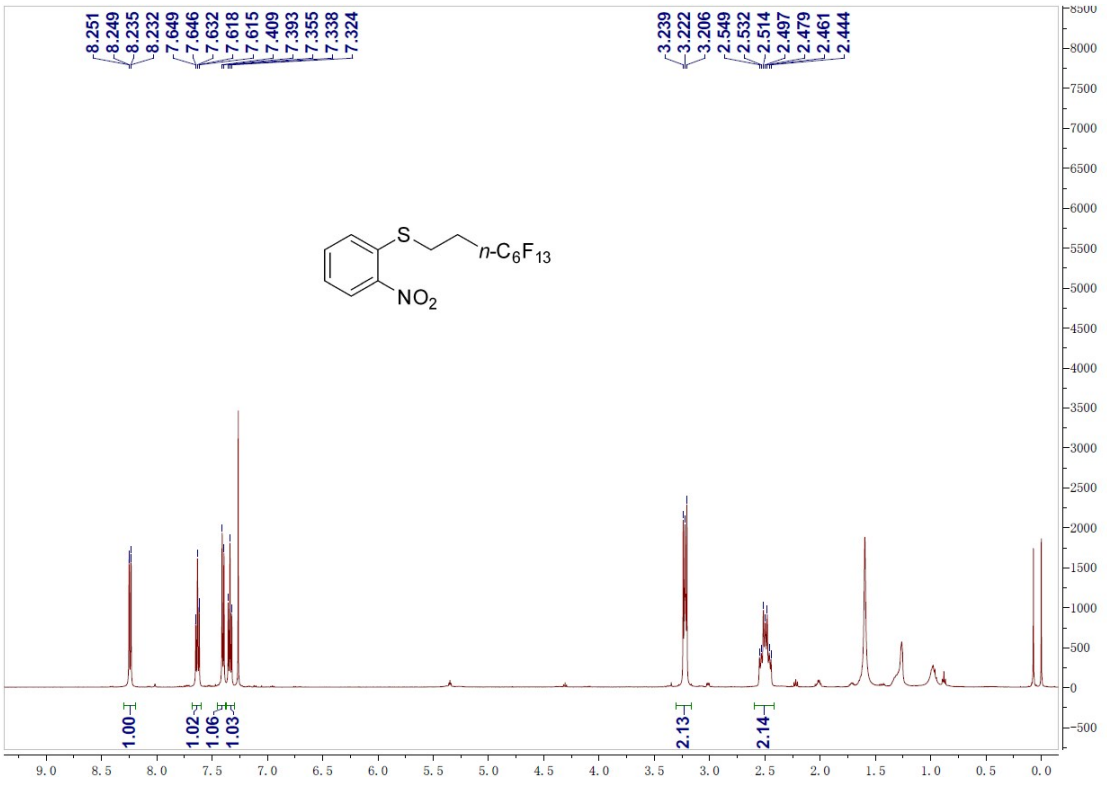
^{13}C NMR of 3t



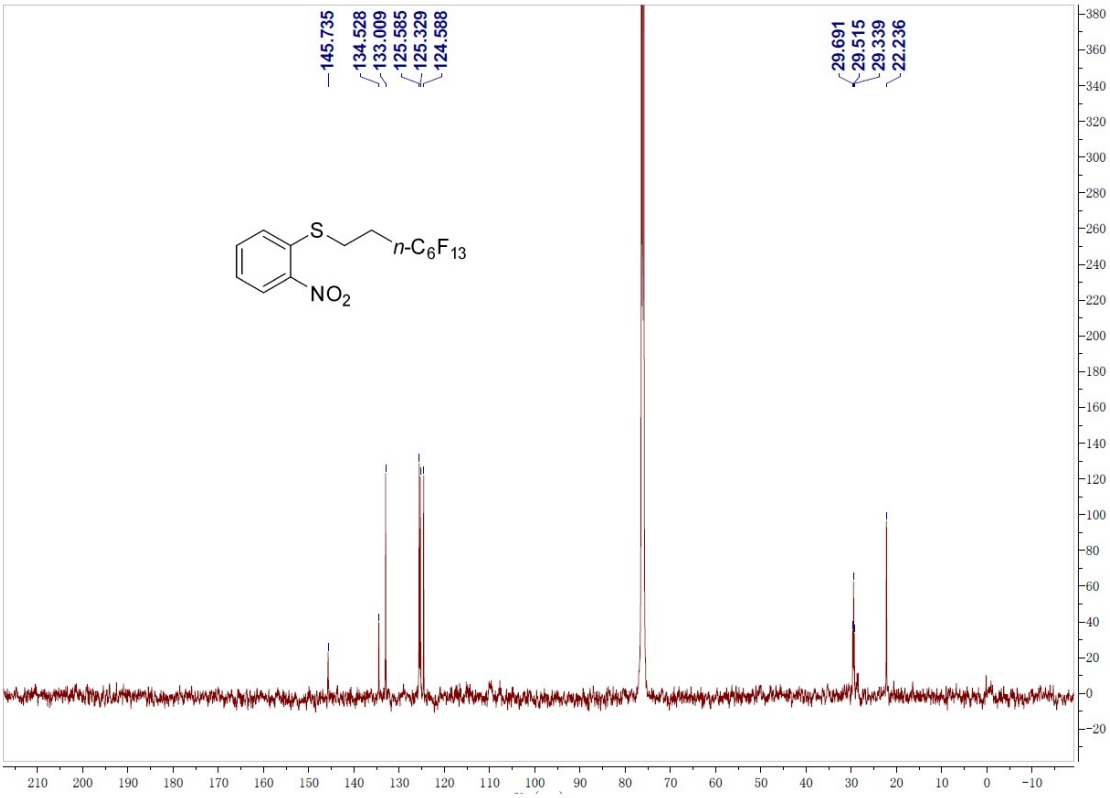
^{1}H NMR of 3u



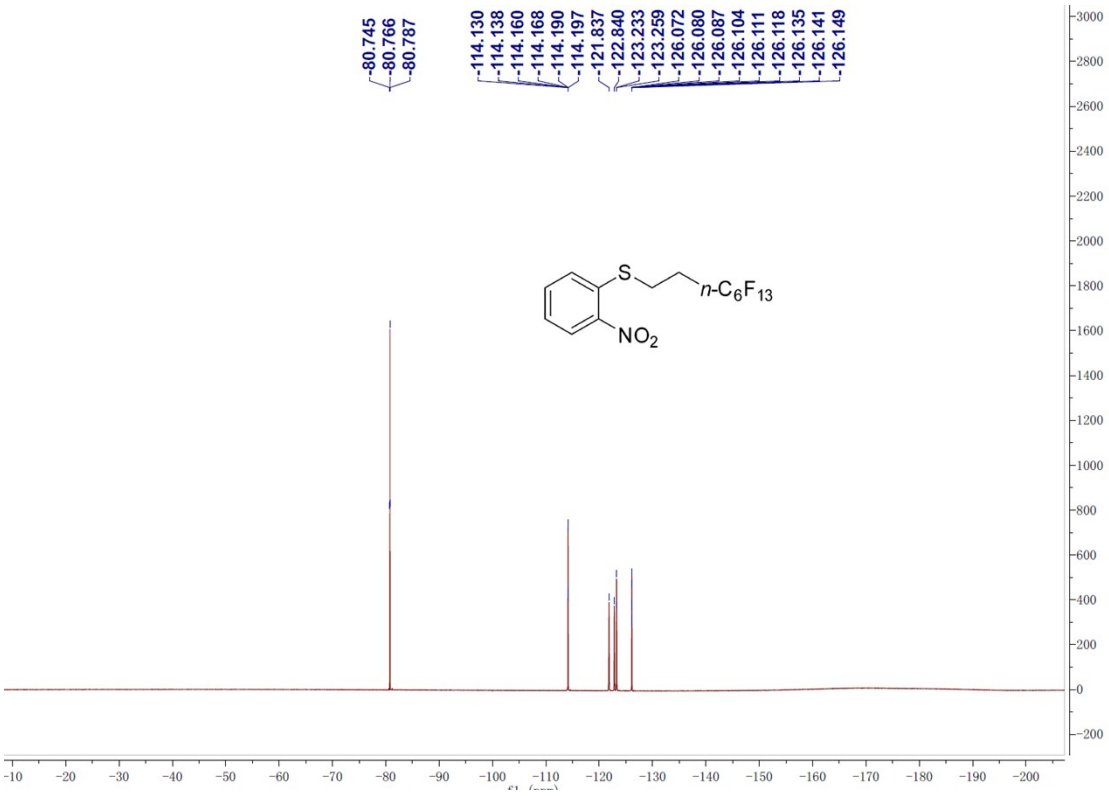
^{13}C NMR of 3u



^{1}H NMR of 3v



^{13}C NMR of 3v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-80.787
-114.130
-114.138
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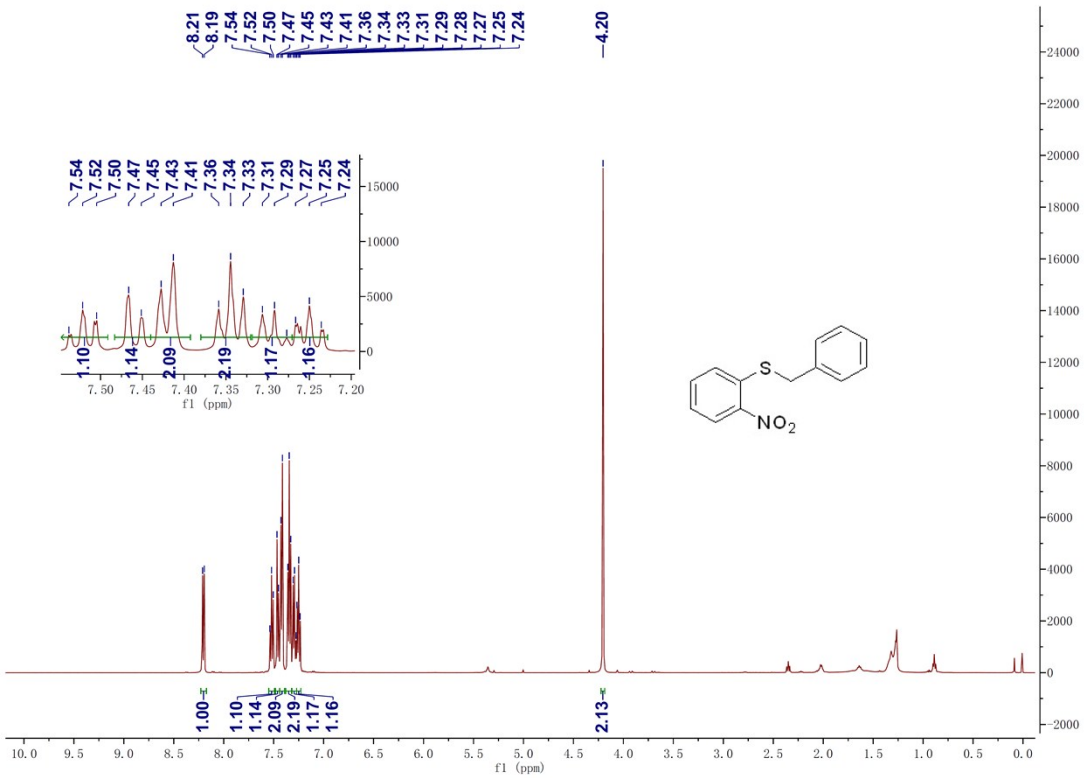
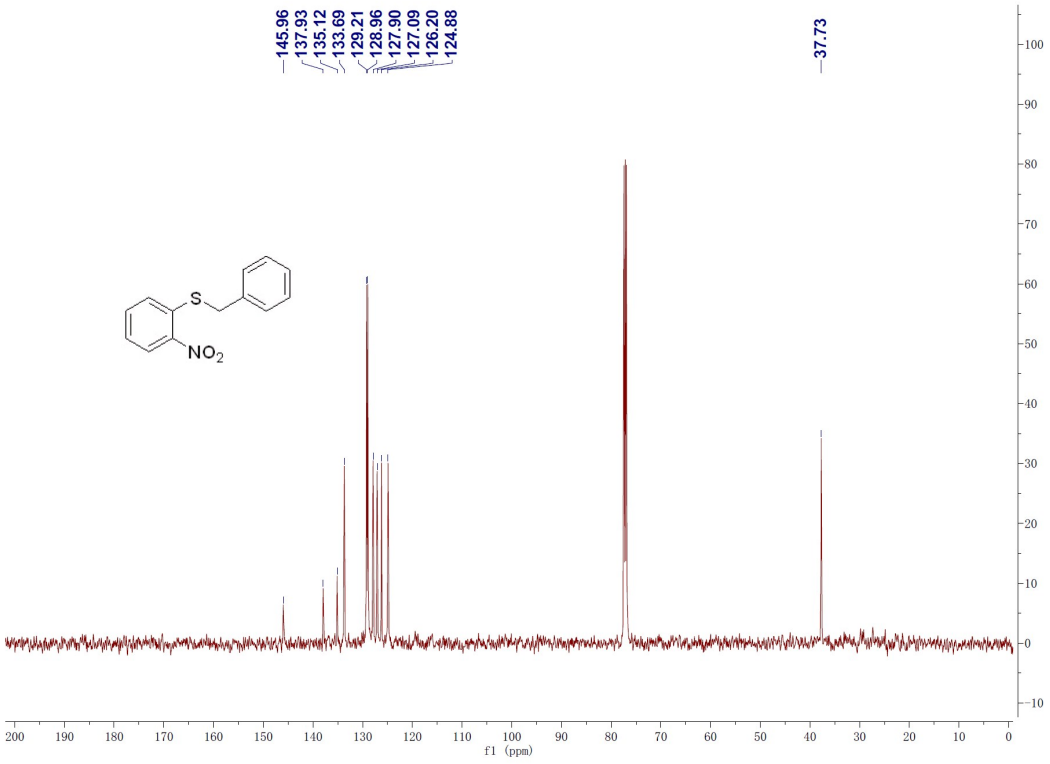
-114.168
-114.190
-114.197
-121.837
-122.840
-123.233
-123.259
-126.072
-126.080
-126.087
-126.104
-126.111
-126.118
-126.135
-126.141
-126.149
S
n-C6F13
NO2

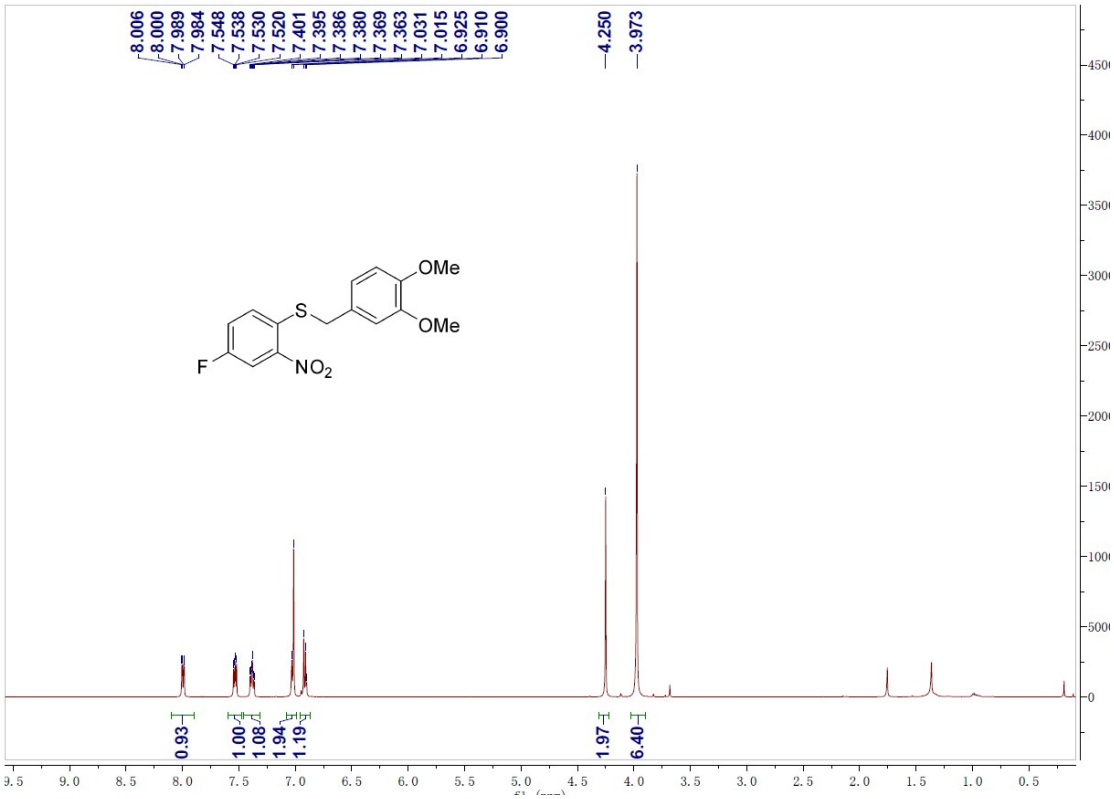
^{19}F NMR of 3v



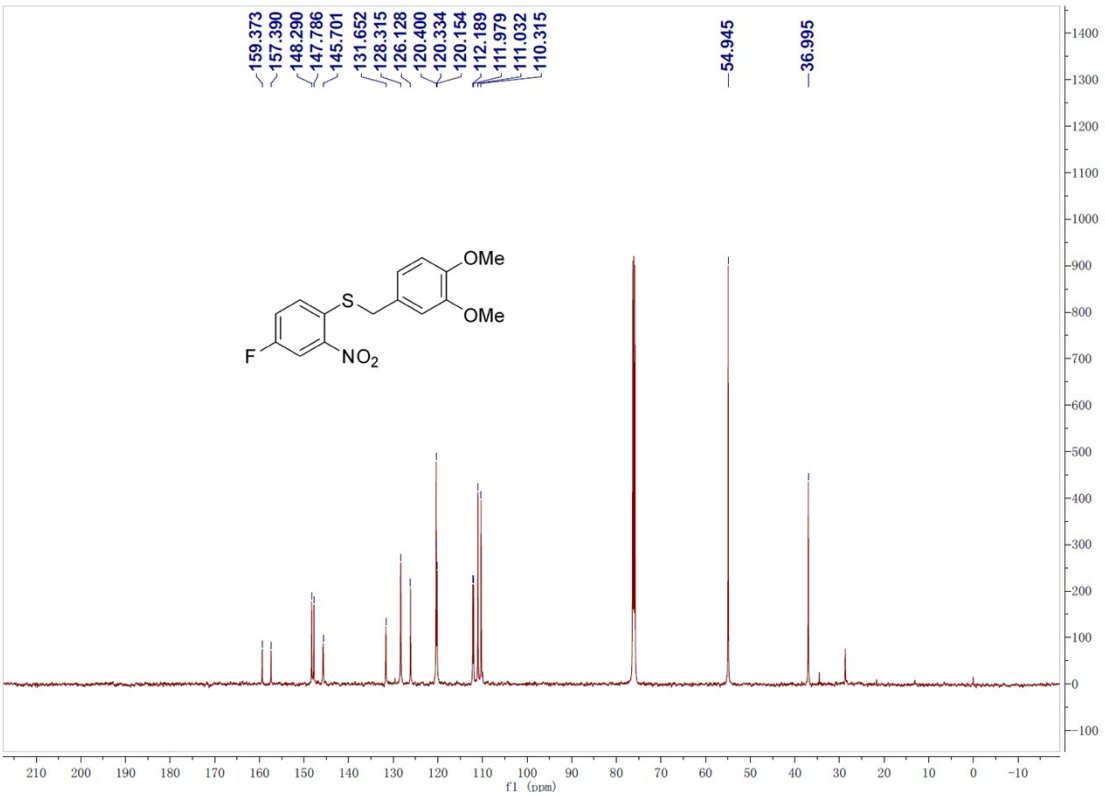
^{1}H NMR of 3w



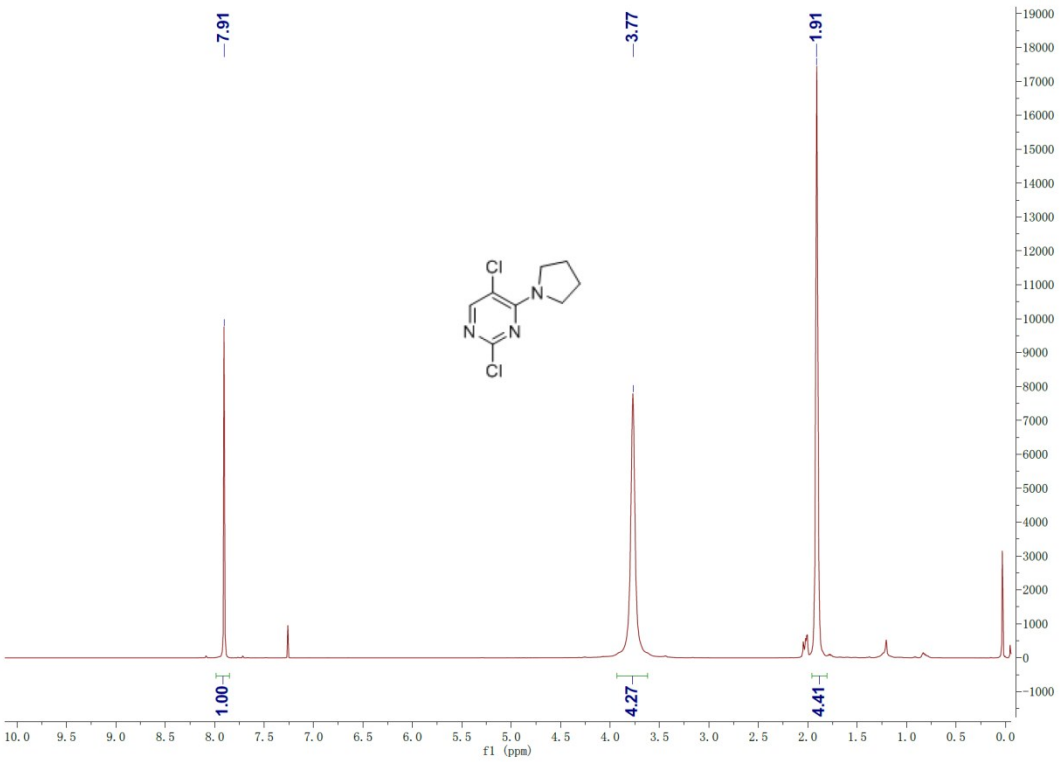
^{13}C NMR of 3w



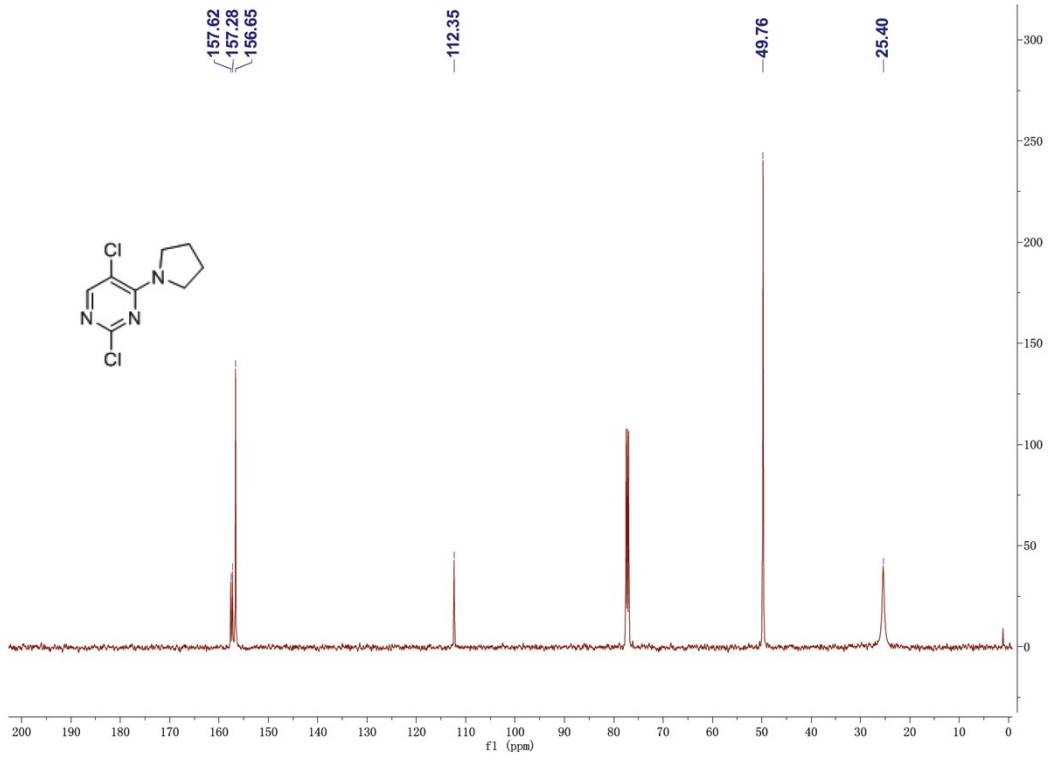
^{1}H NMR of 3x



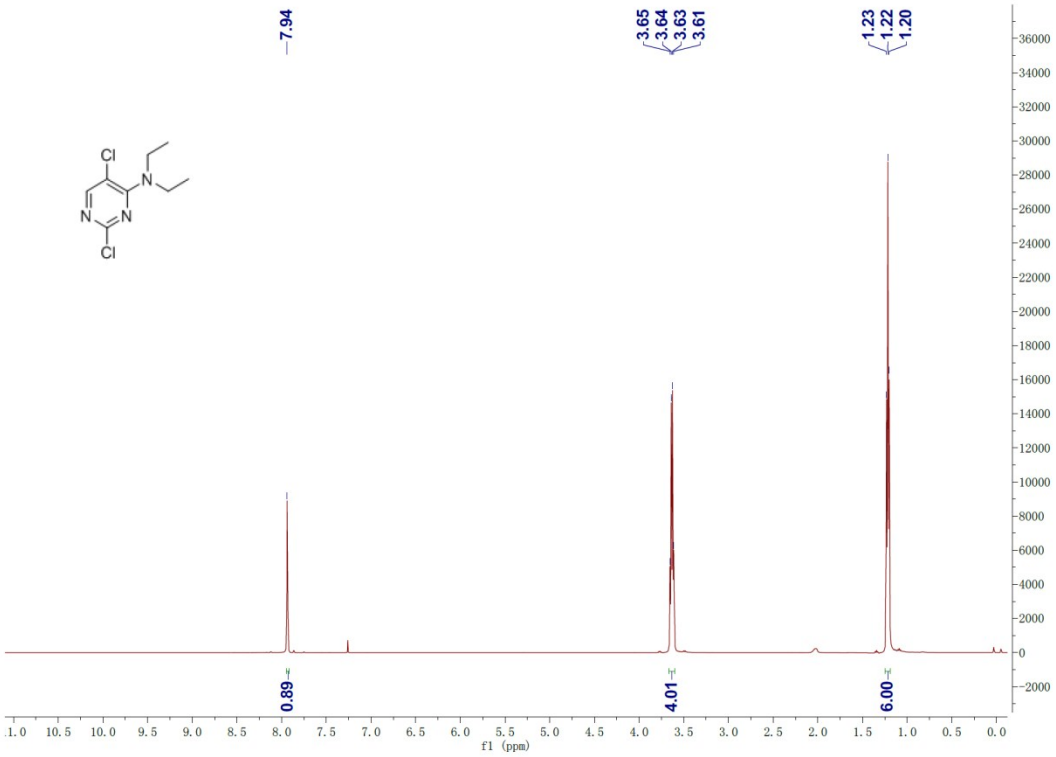
^{13}C NMR of 3x



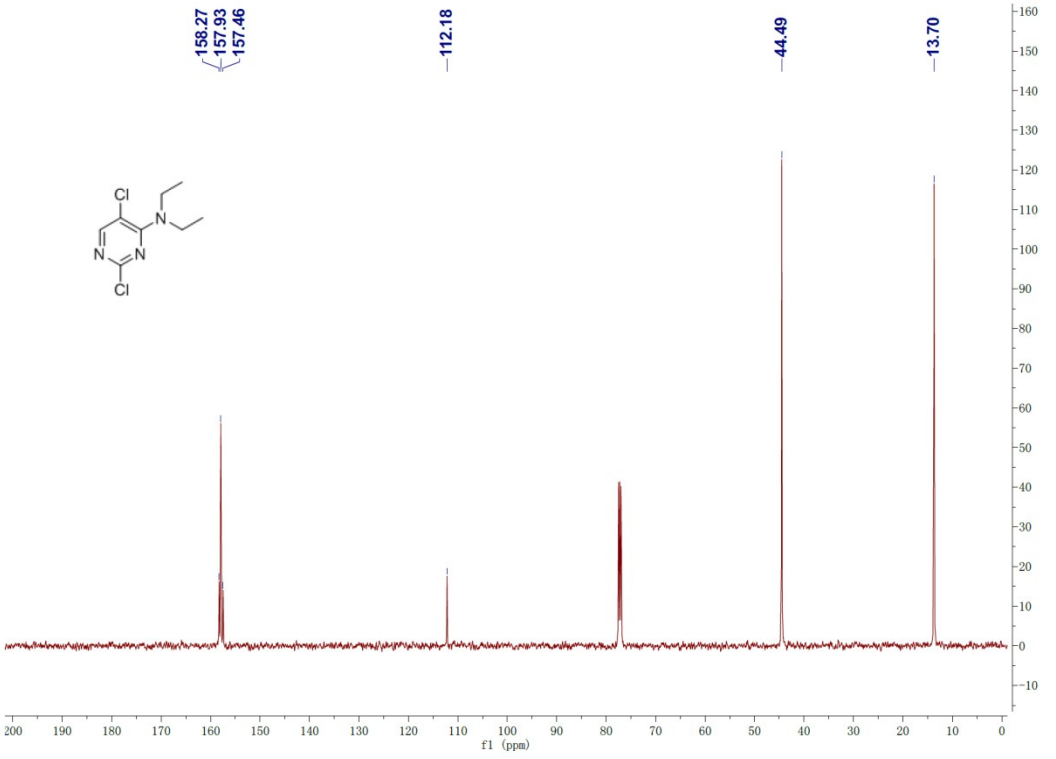
^{1}H NMR of 4a



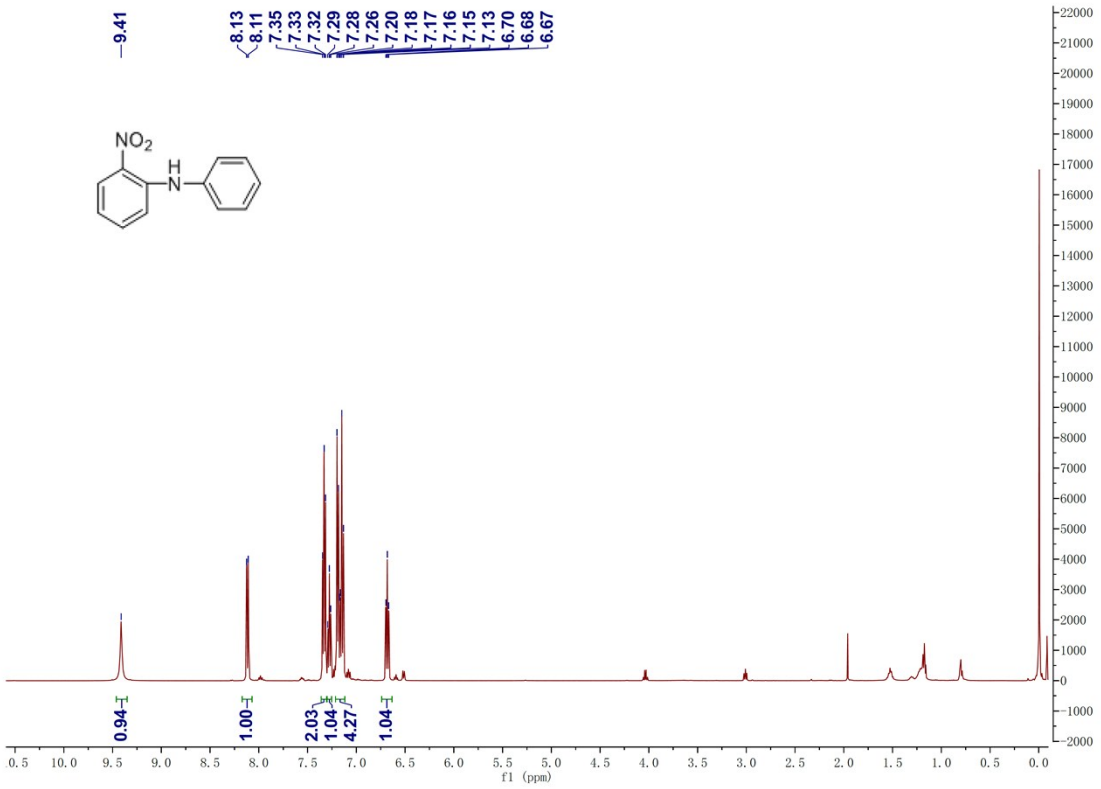
^{13}C NMR of 4a



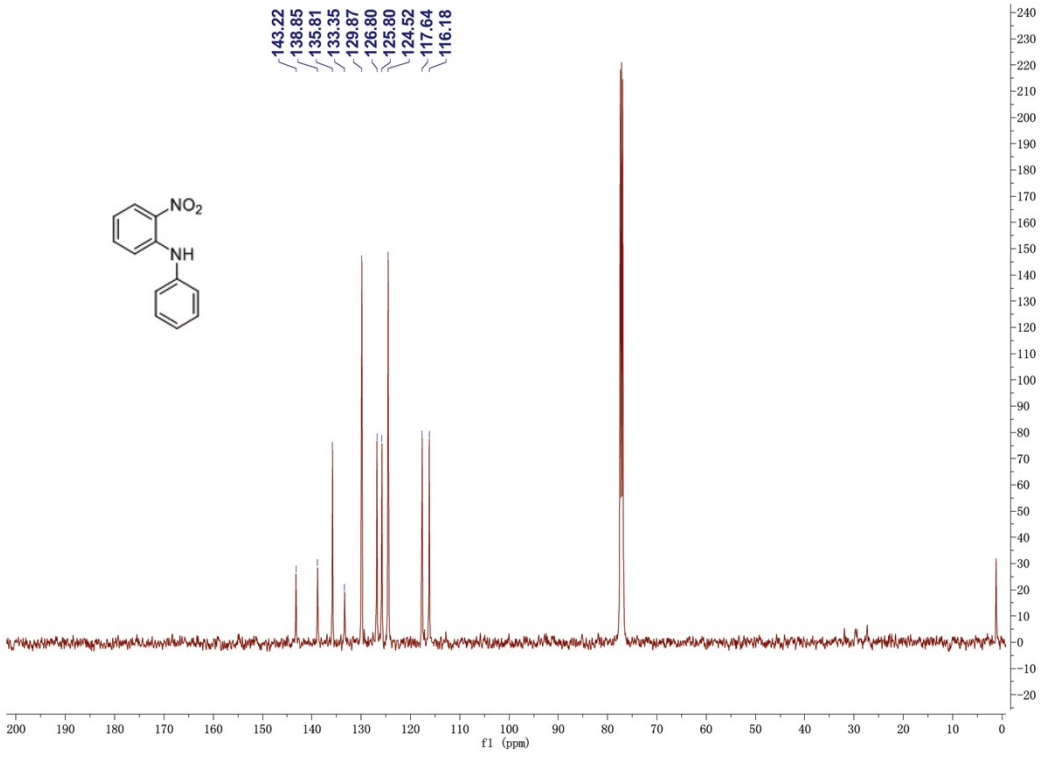
^{1}H NMR of 4b



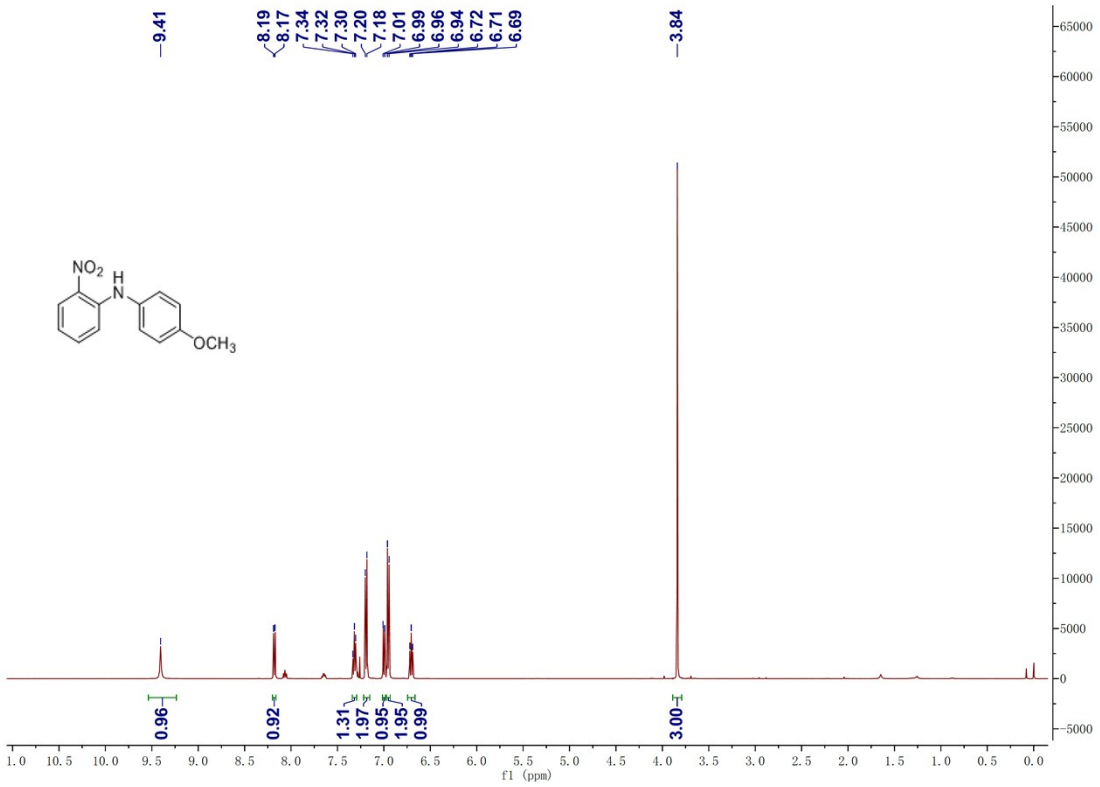
^{13}C NMR of 4b



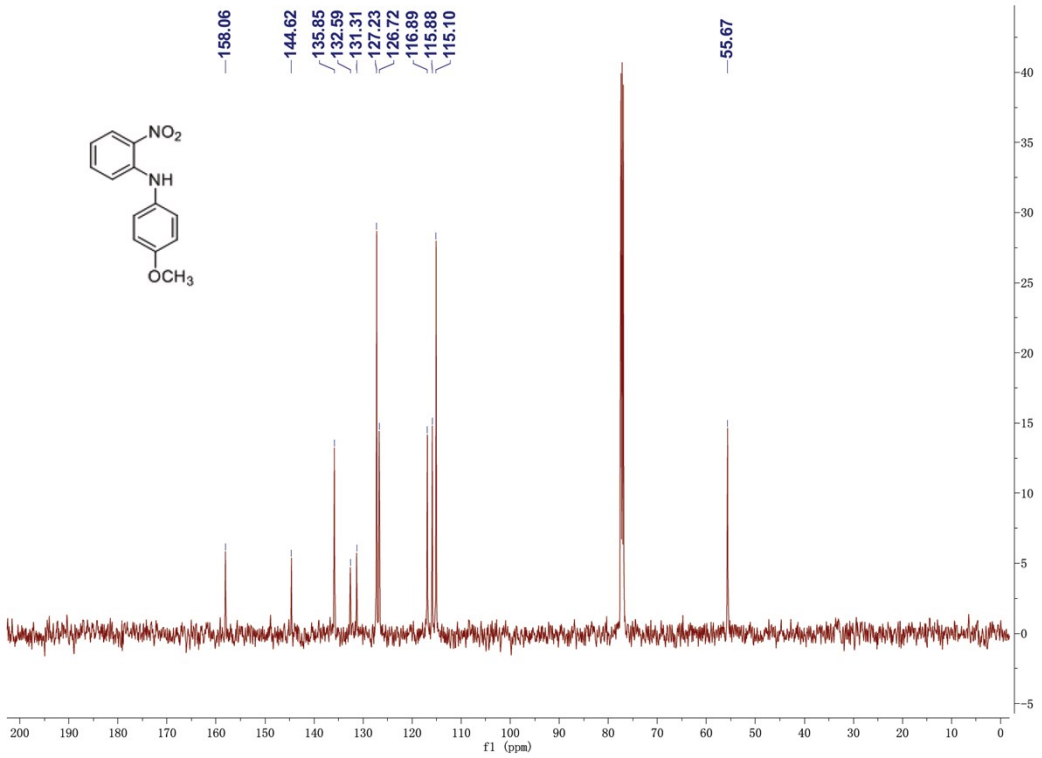
^{1}H NMR of 4c



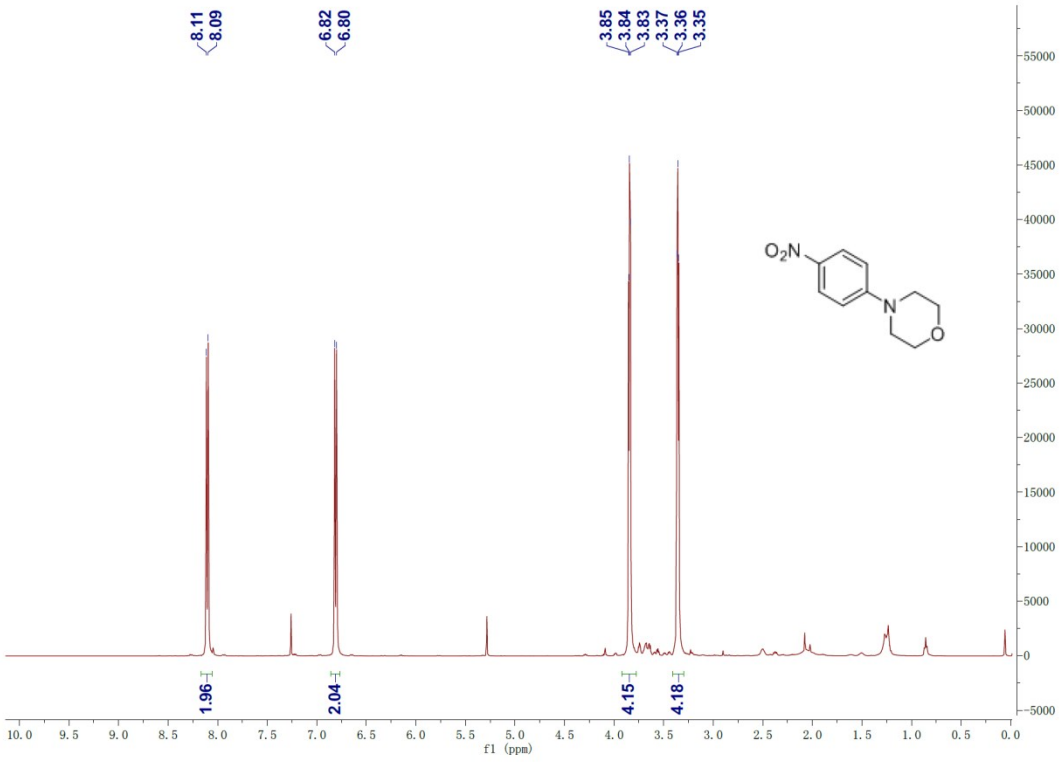
^{13}C NMR of 4c



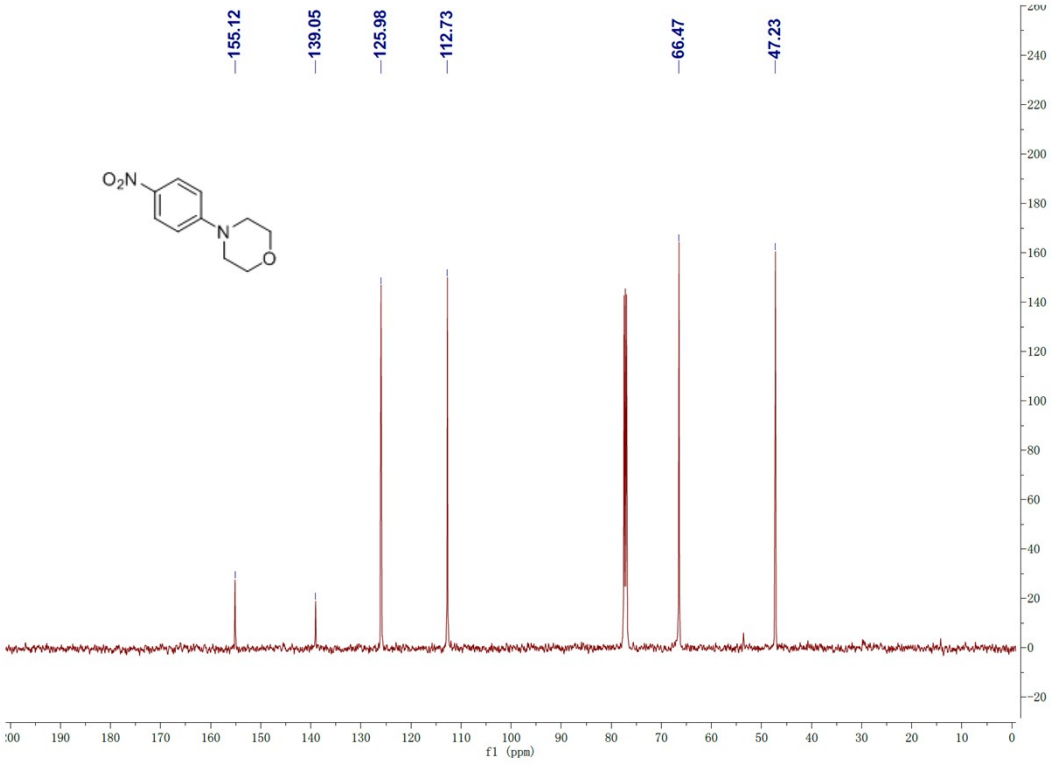
^{1}H NMR of 4d



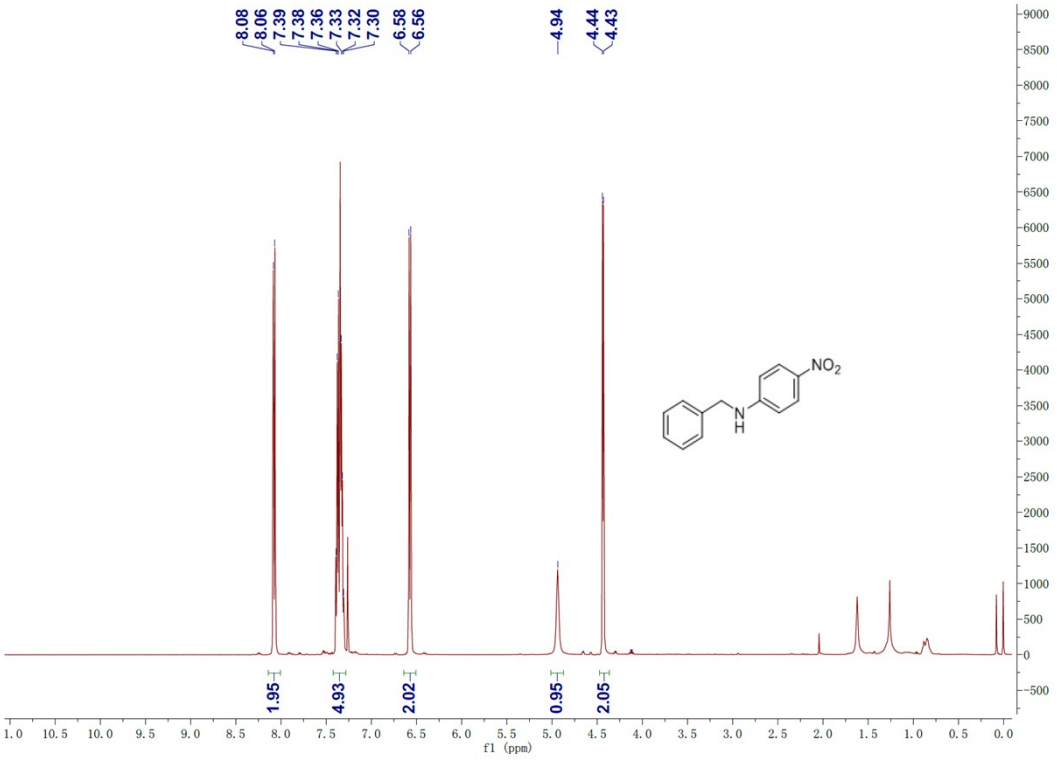
^{13}C NMR of 4d



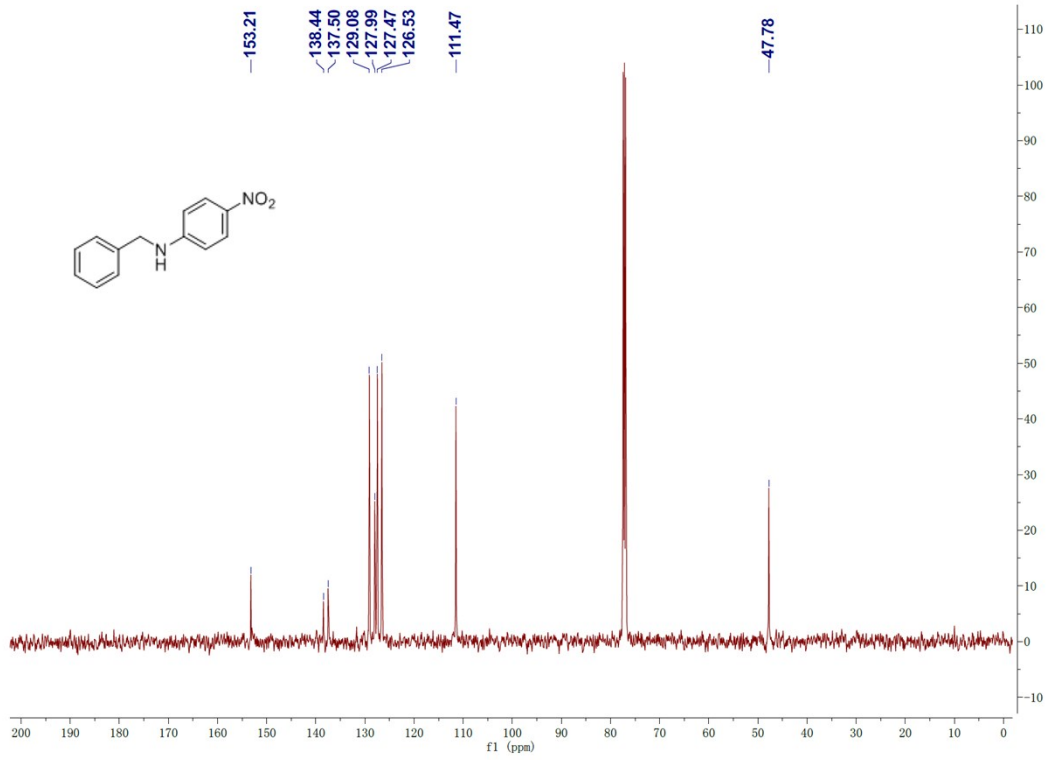
^{1}H NMR of 4e



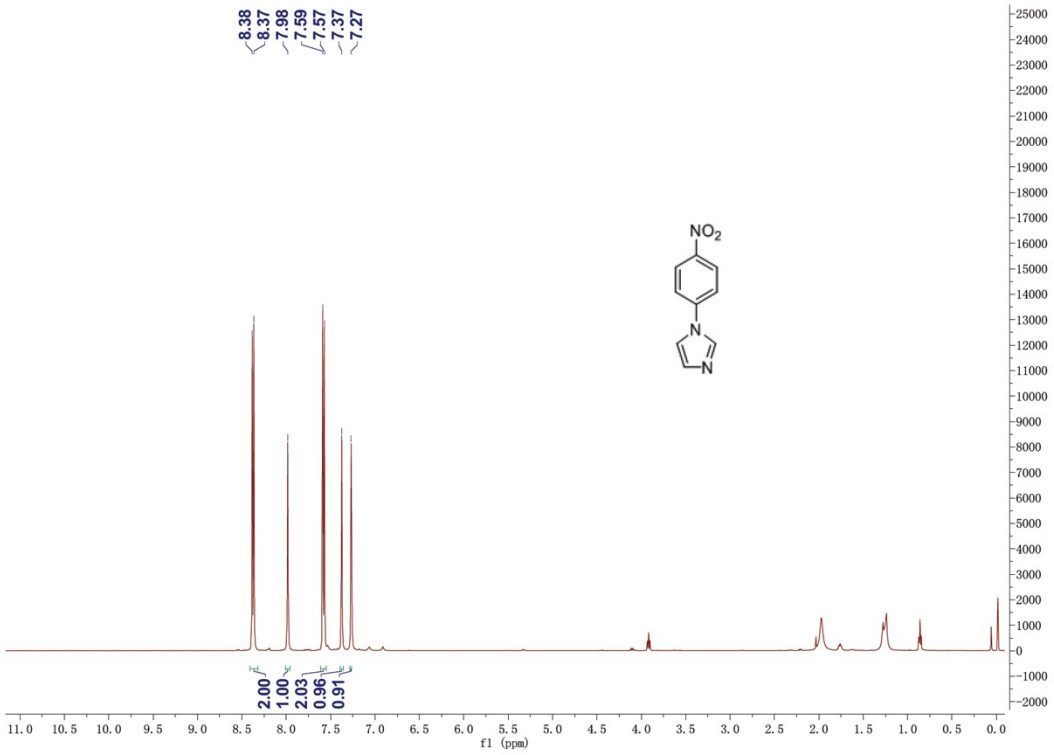
^{13}C NMR of 4e



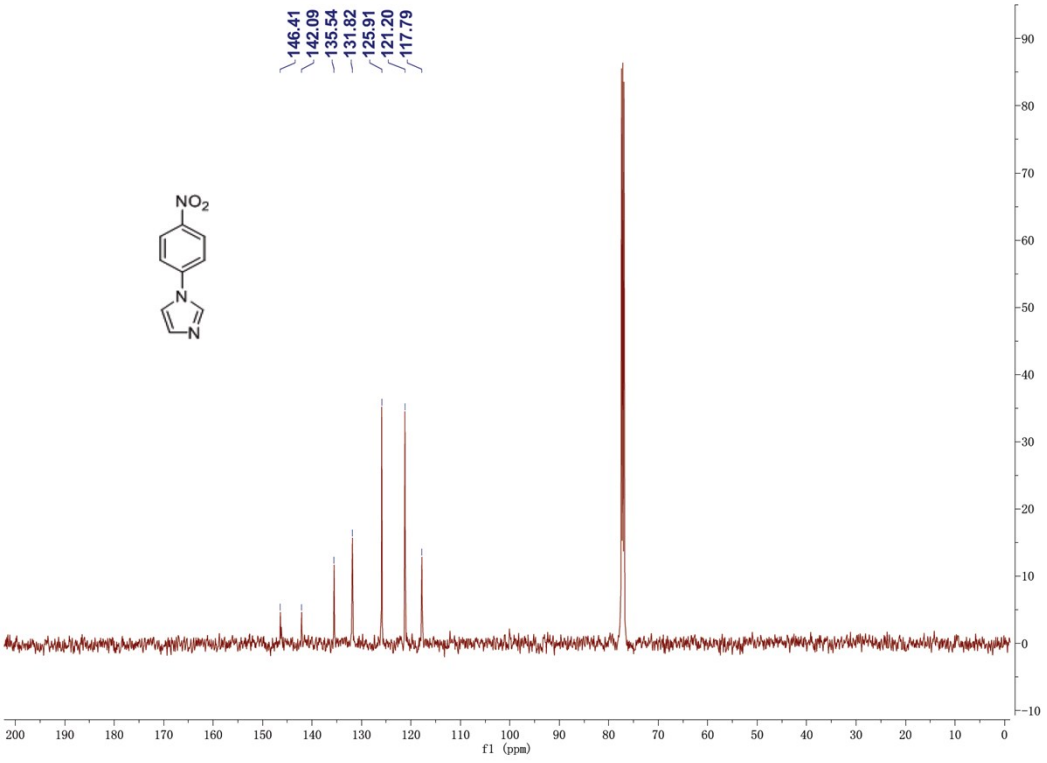
^{1}H NMR of 4f



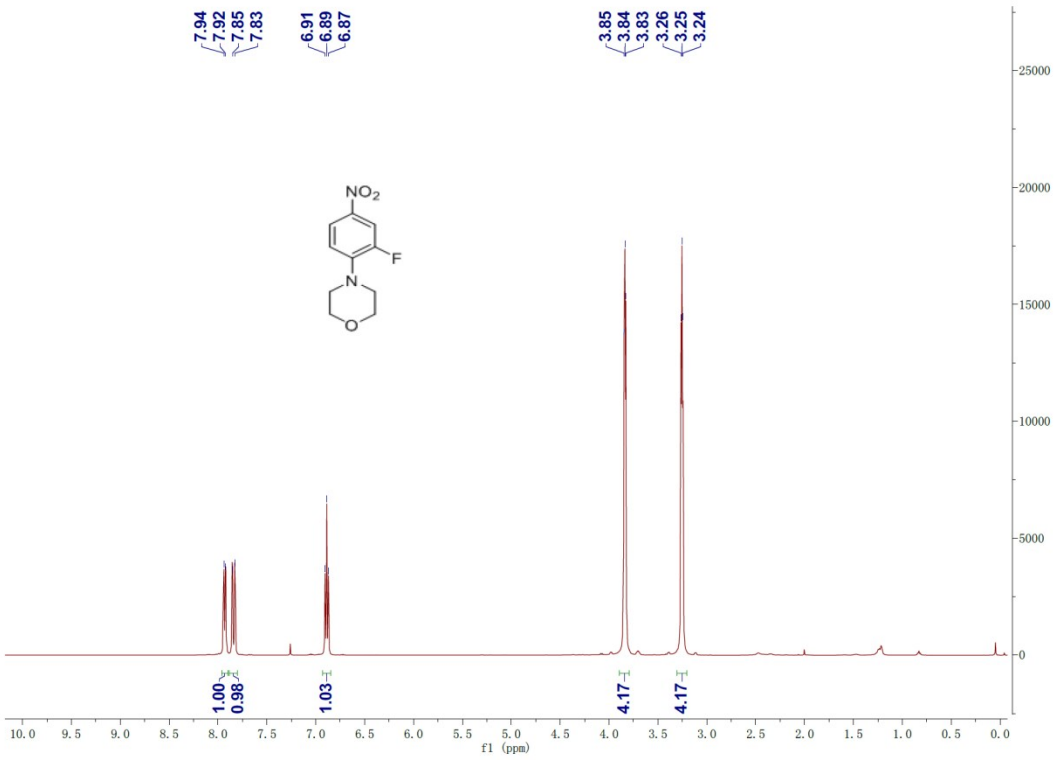
^{13}C NMR of 4f



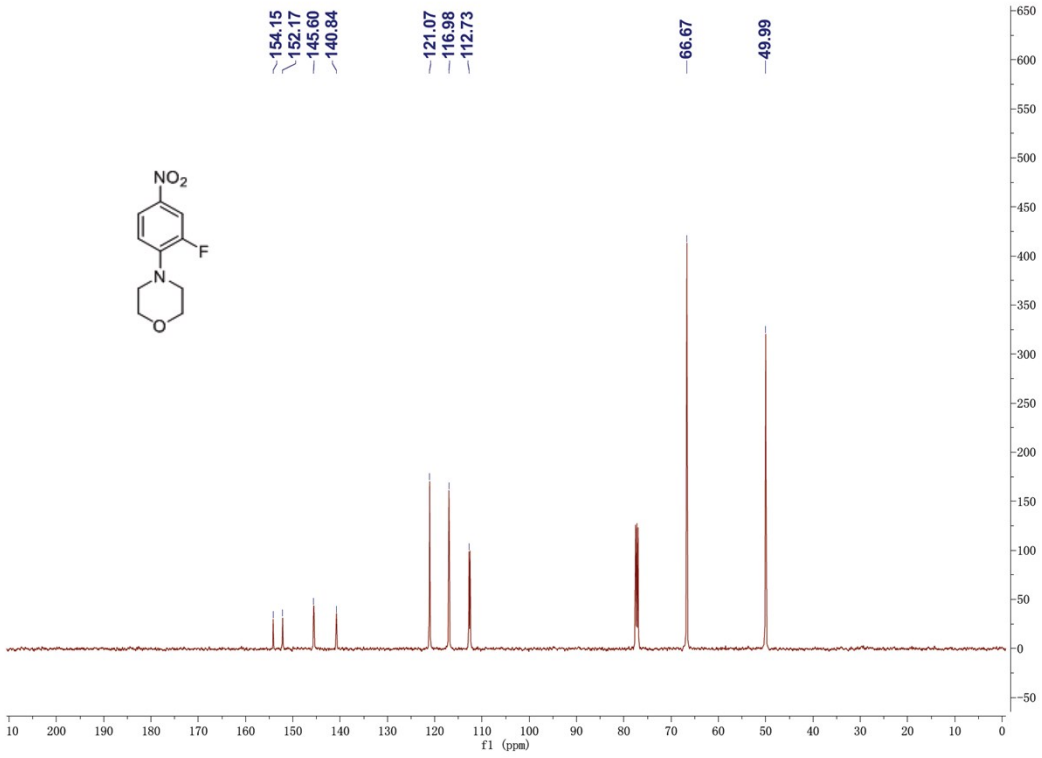
^{1}H NMR of 4g



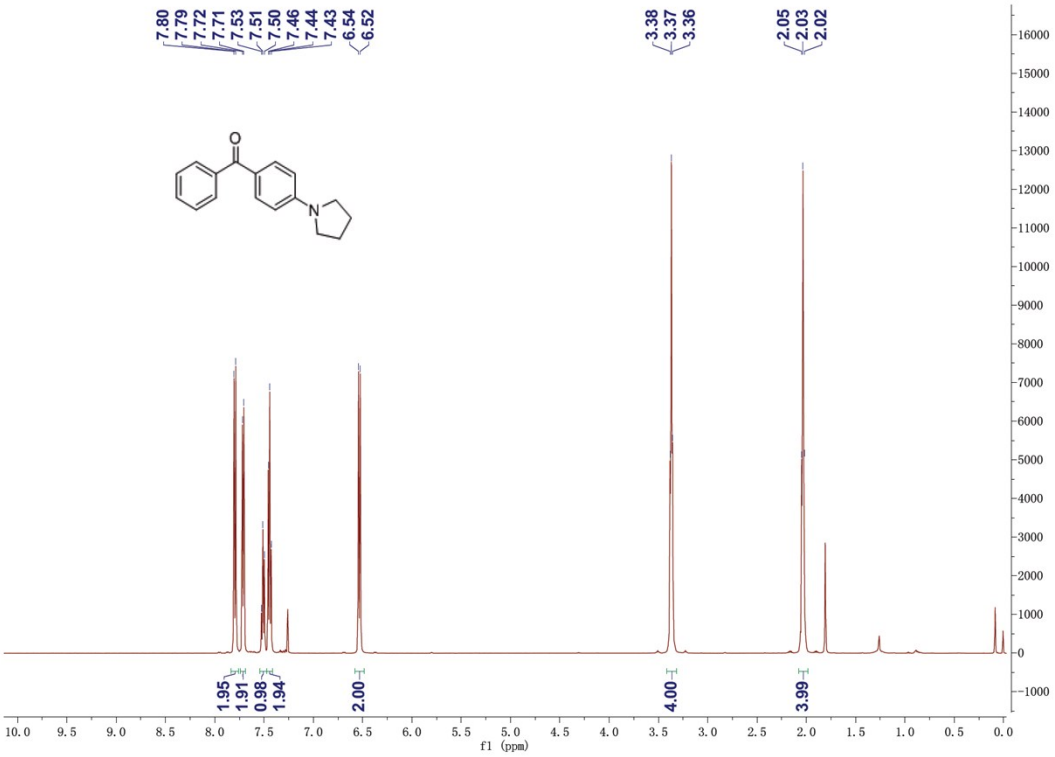
^{13}C NMR of 4g



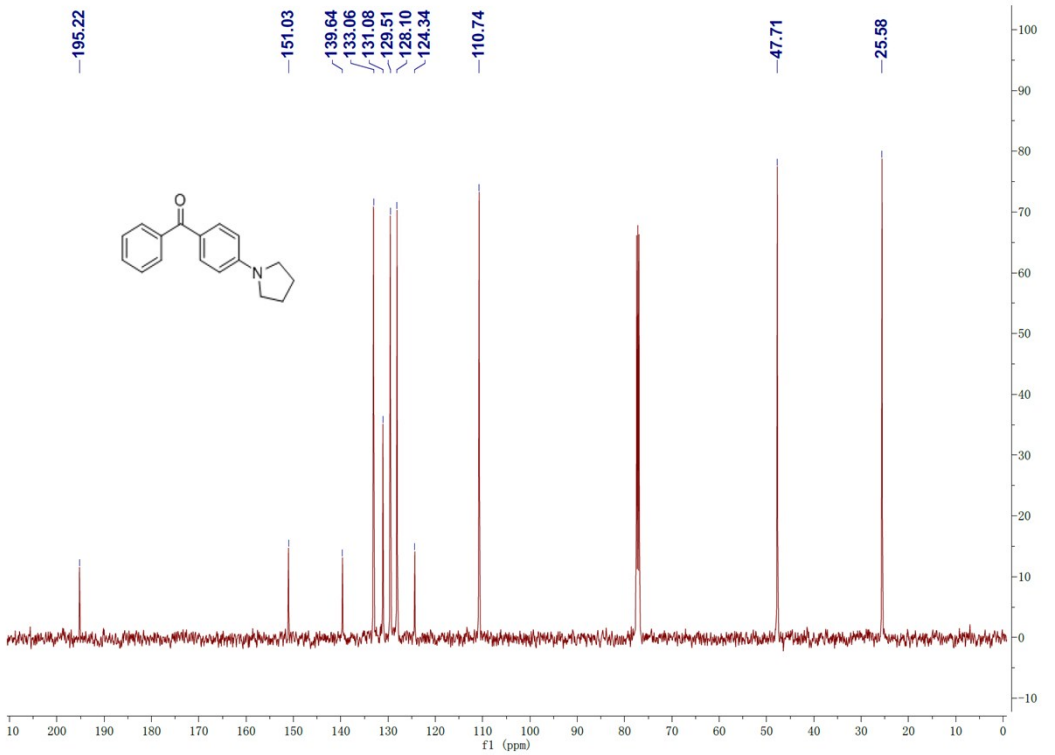
^{1}H NMR of 4h



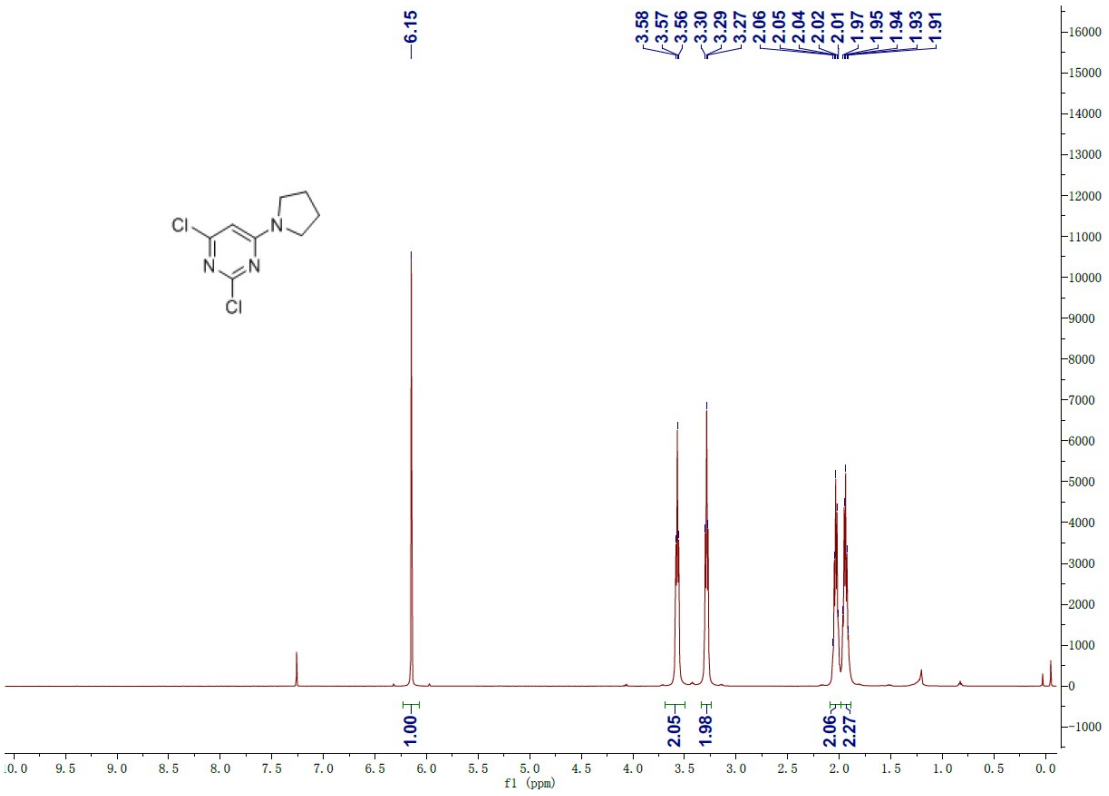
^{13}C NMR of 4h



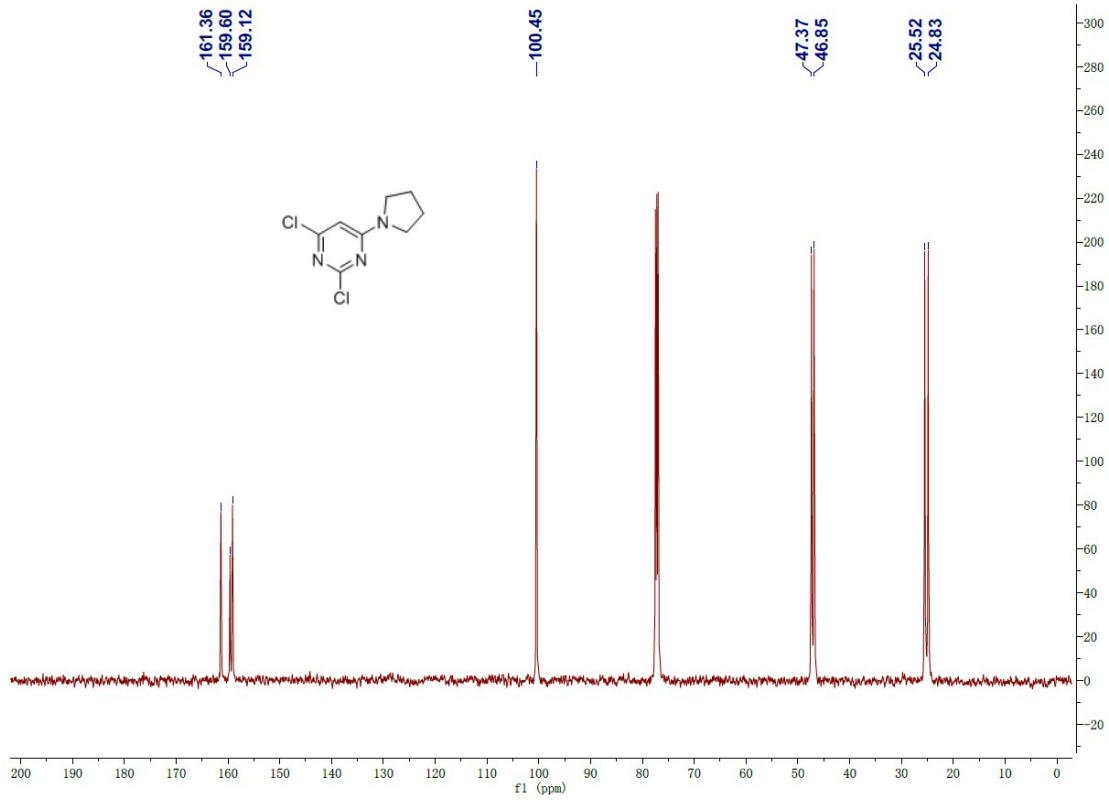
^{1}H NMR of 4i



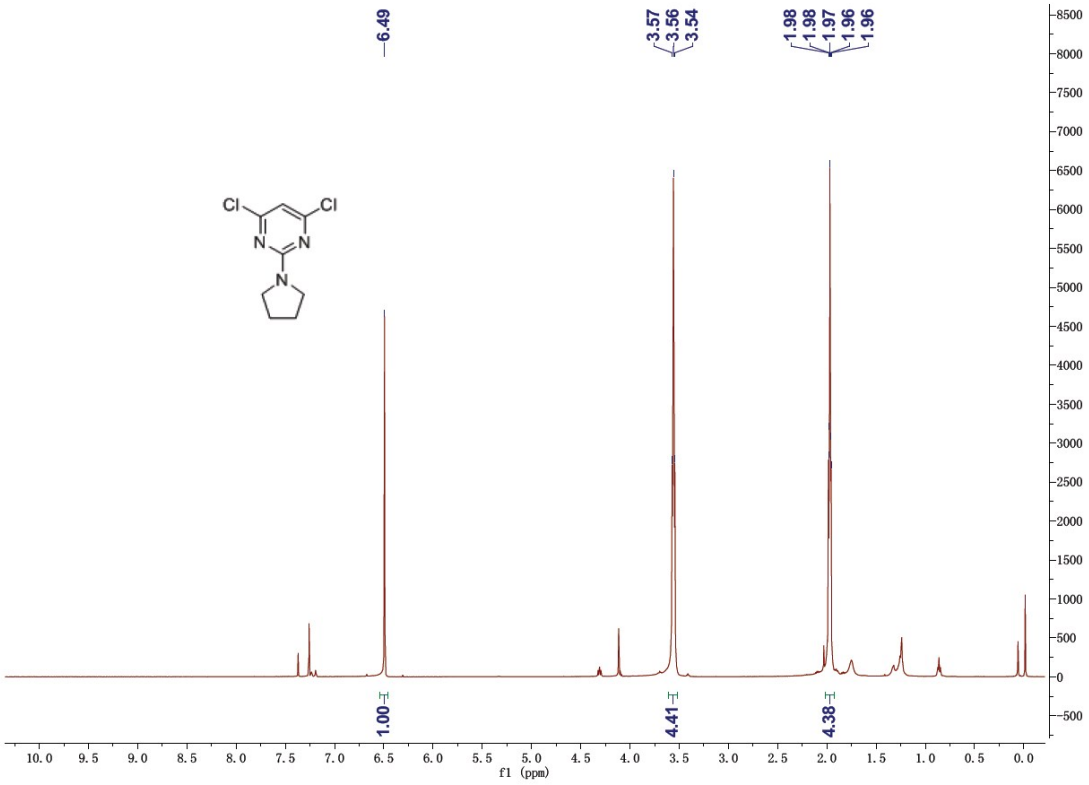
^{13}C NMR of 4i



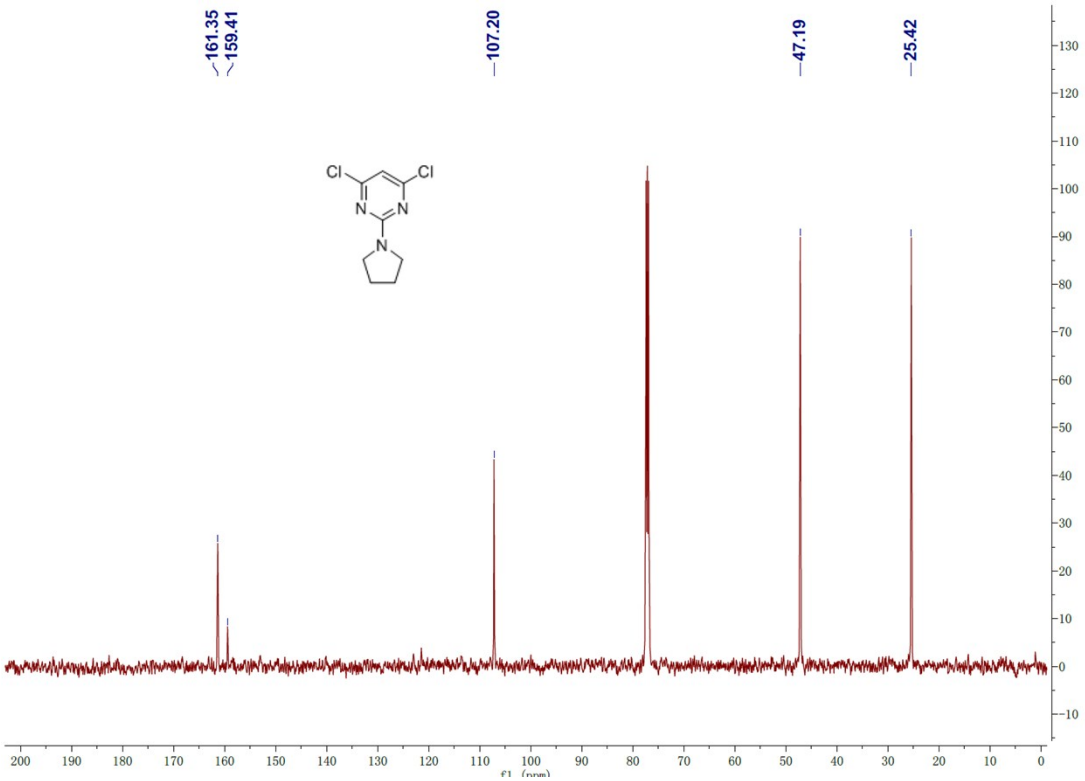
^{1}H NMR of 4j



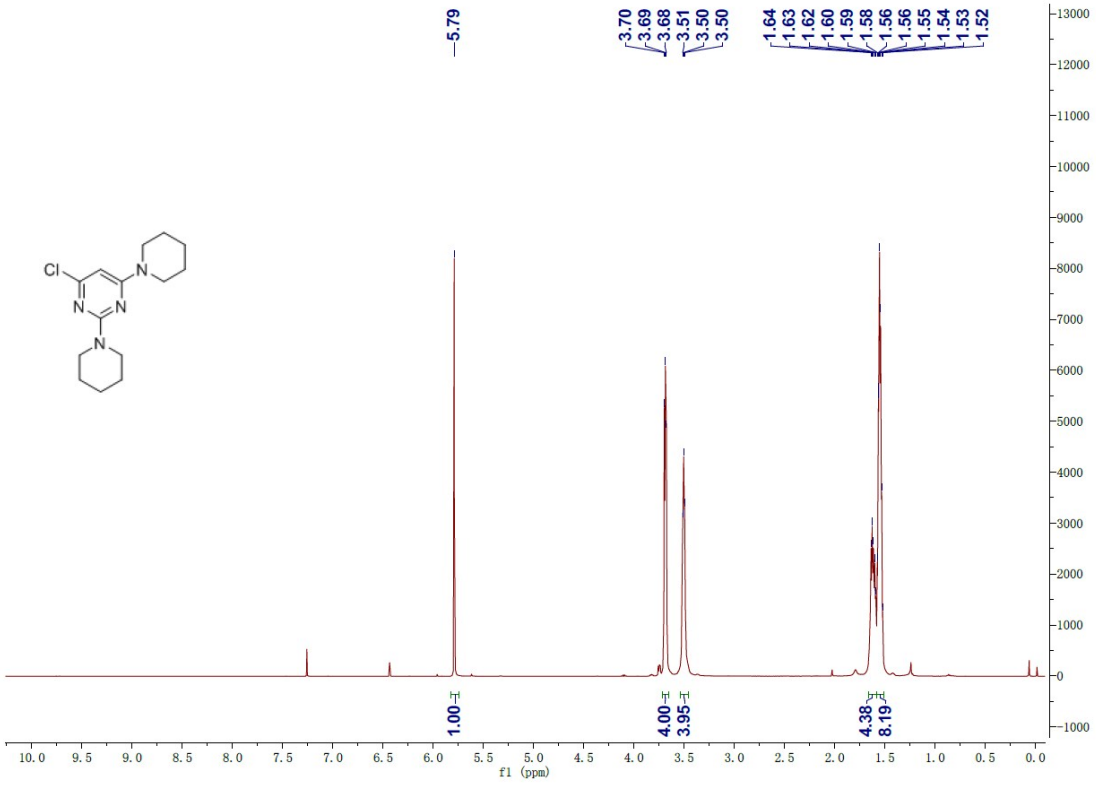
^{13}C NMR of 4j



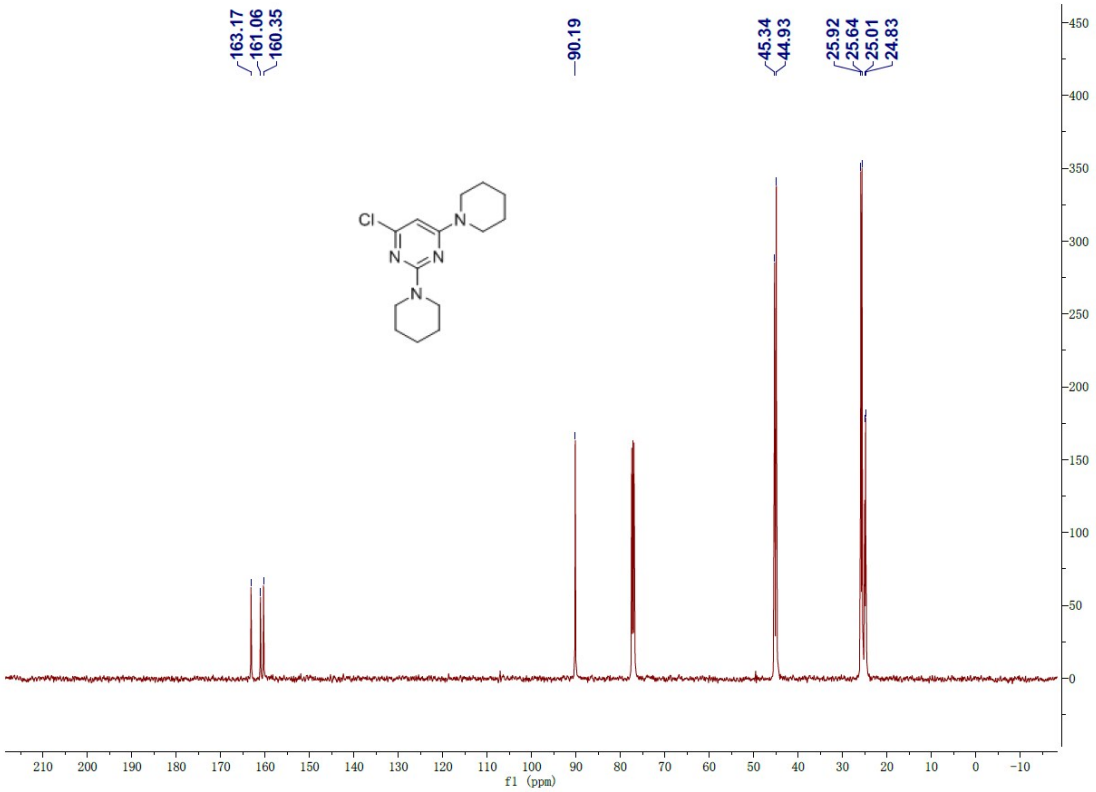
^{1}H NMR of 4j'



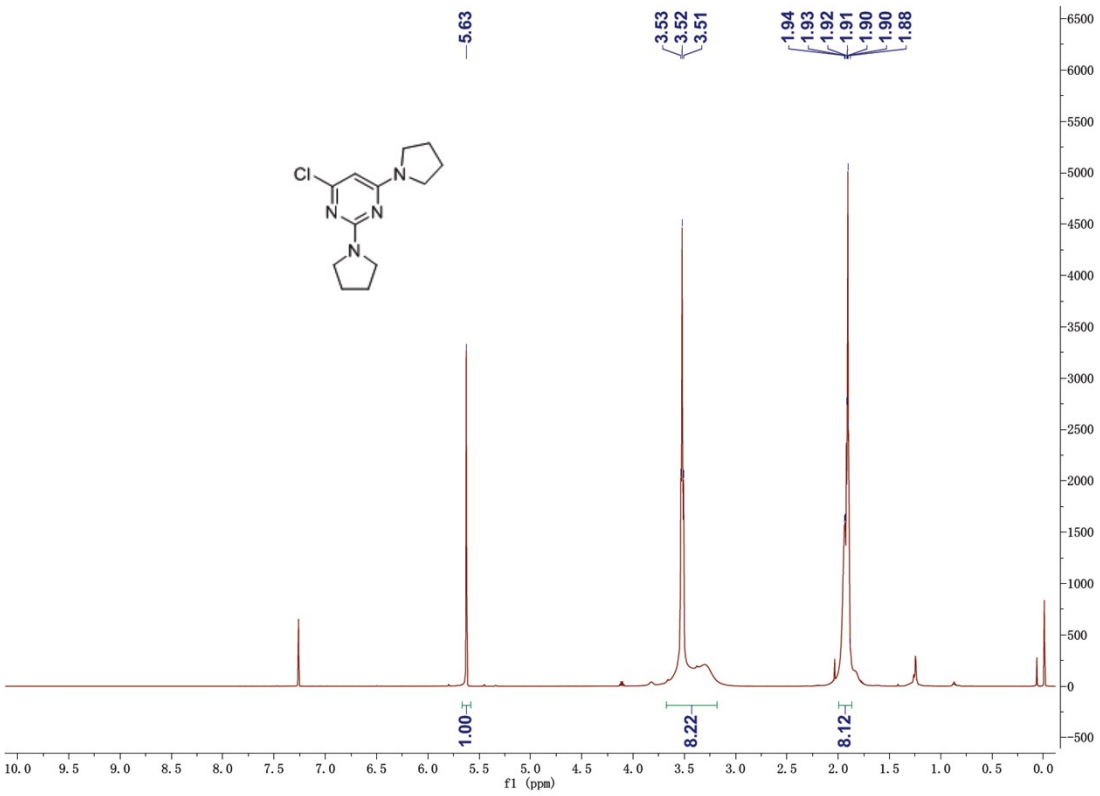
^{13}C NMR of 4j'



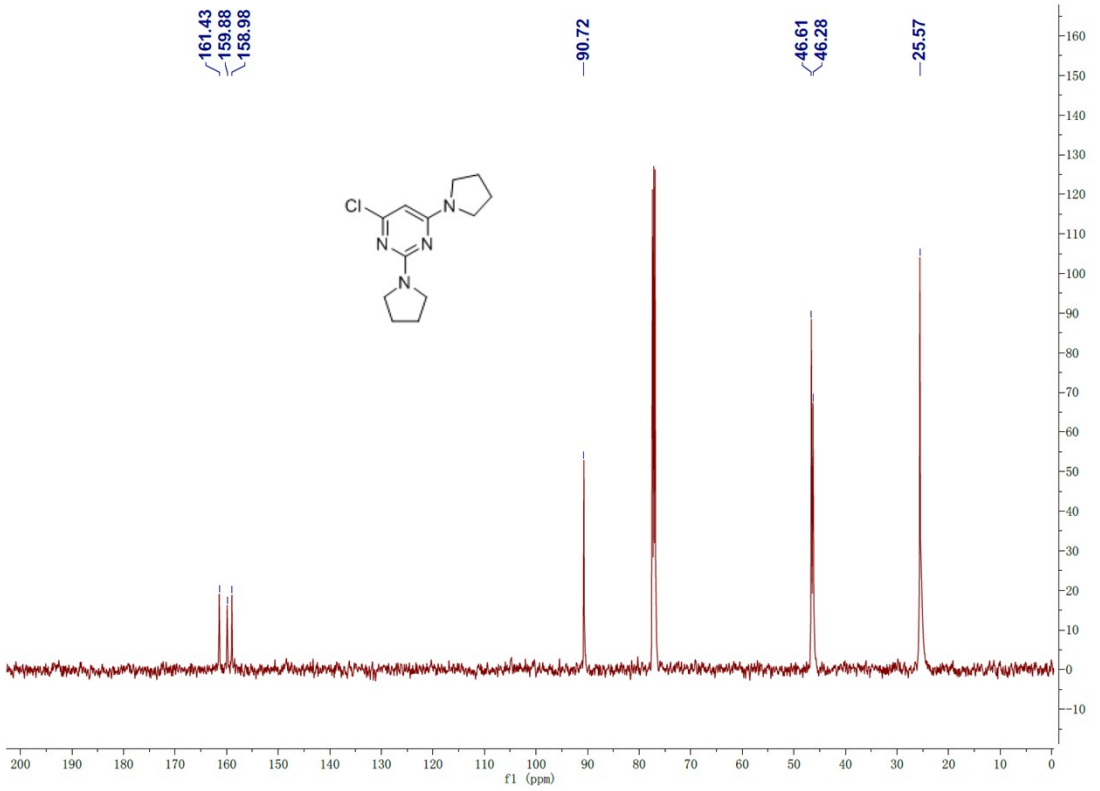
^{1}H NMR of 4k



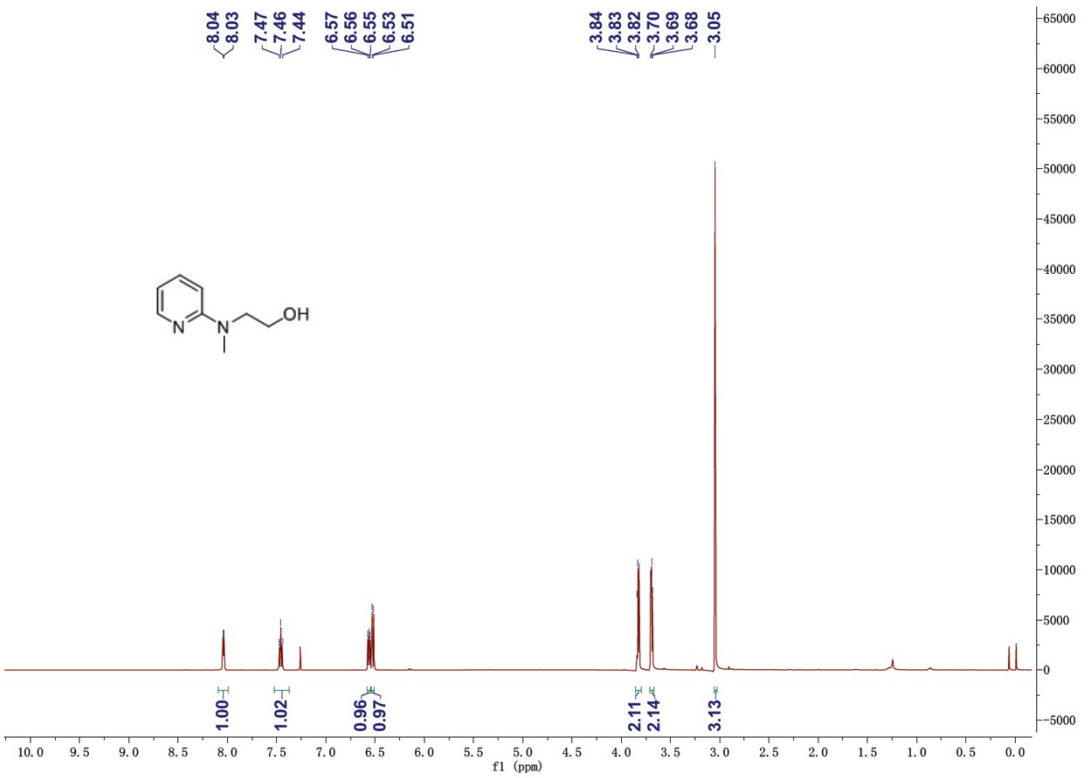
^{13}C NMR of 4k



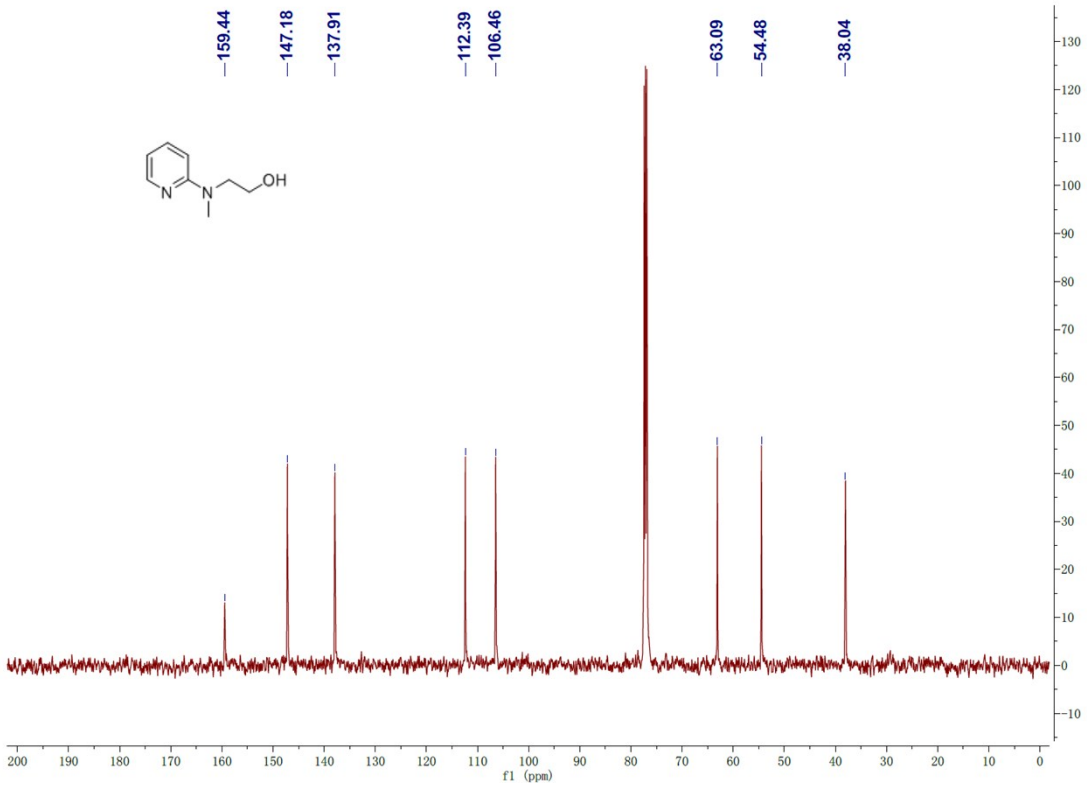
^{1}H NMR of 4l



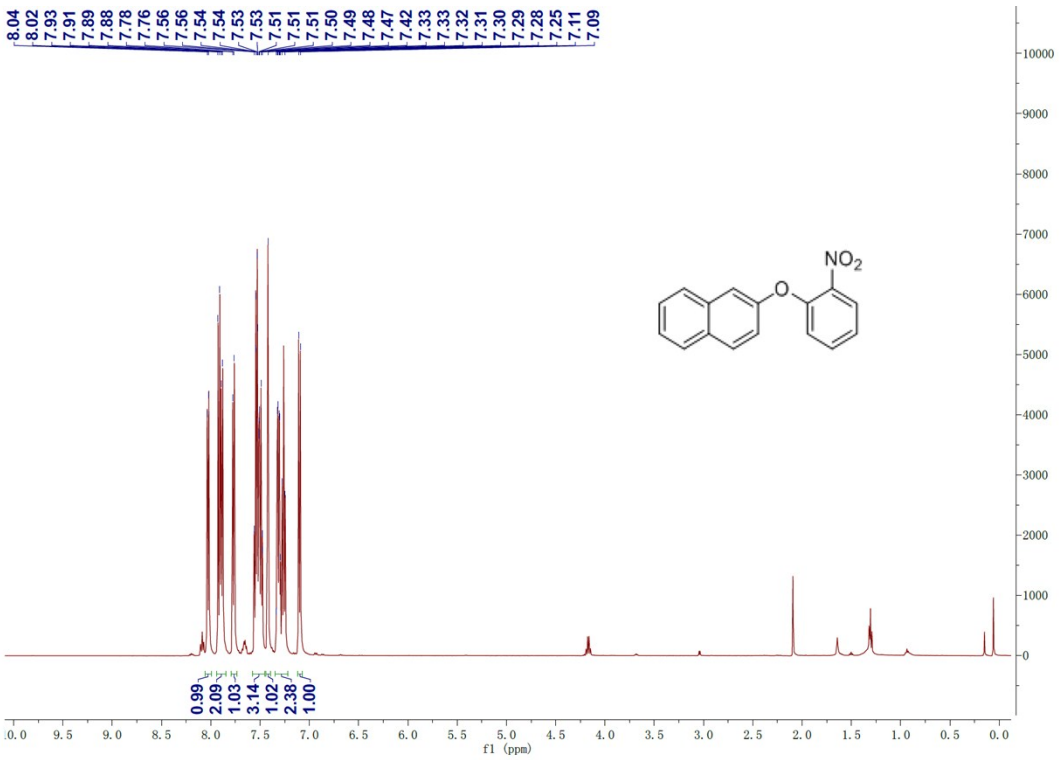
^{13}C NMR of 4l



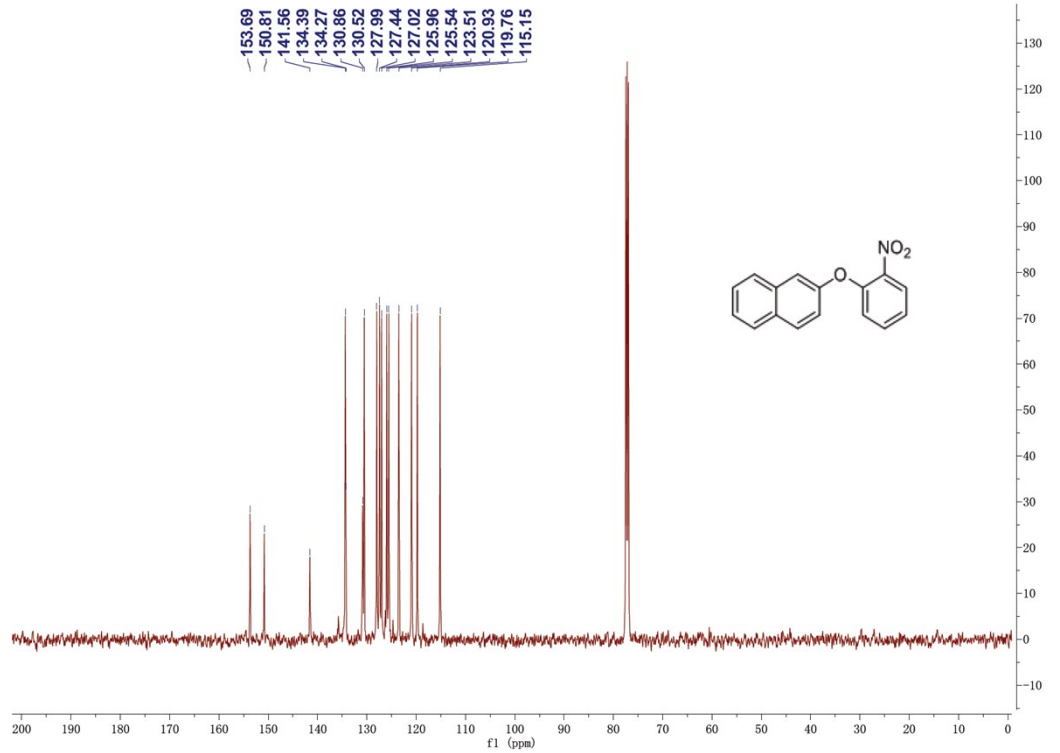
^{1}H NMR of 4m



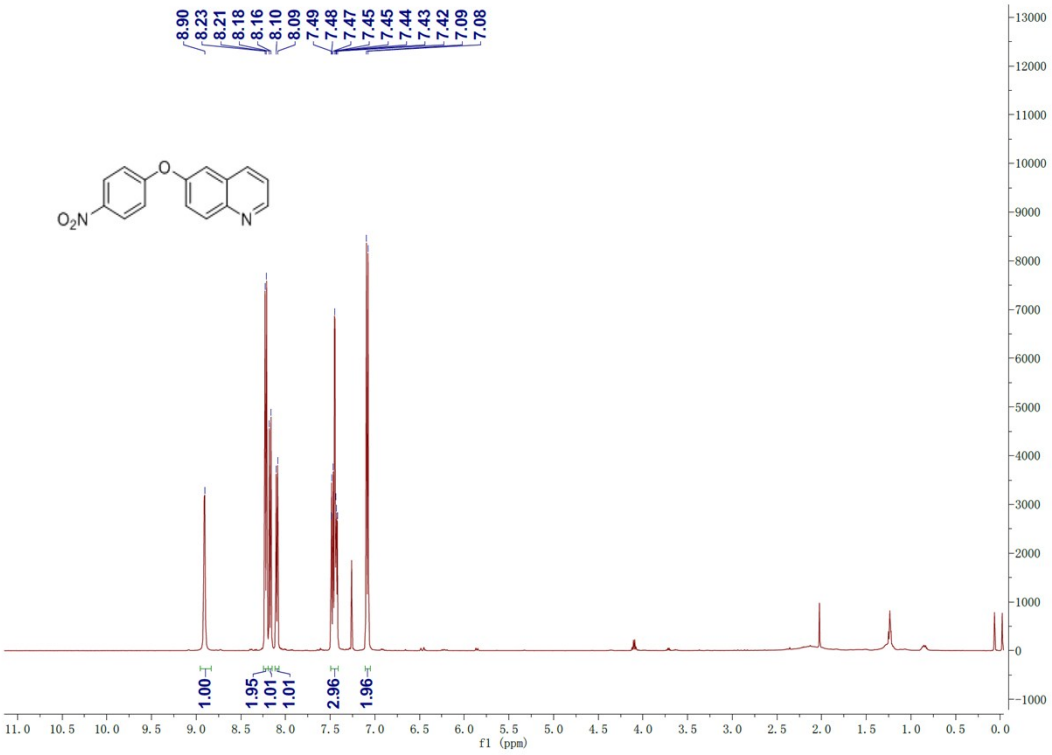
^{13}C NMR of 4m



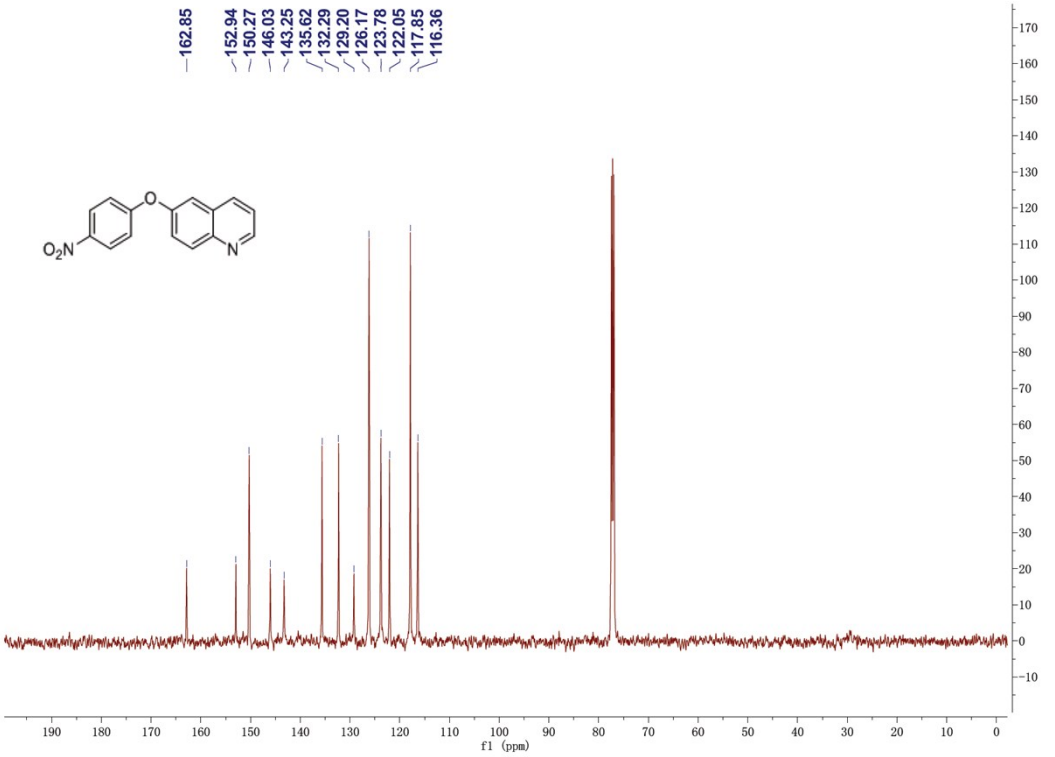
^{1}H NMR of 5a



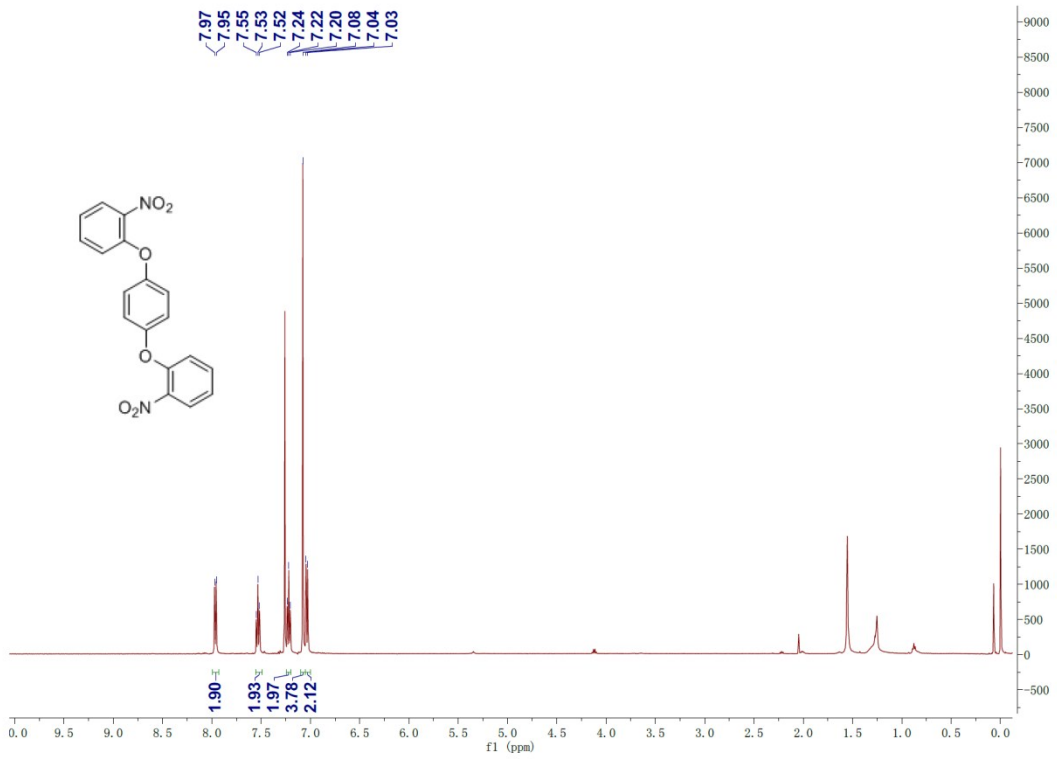
^{13}C NMR of 5a



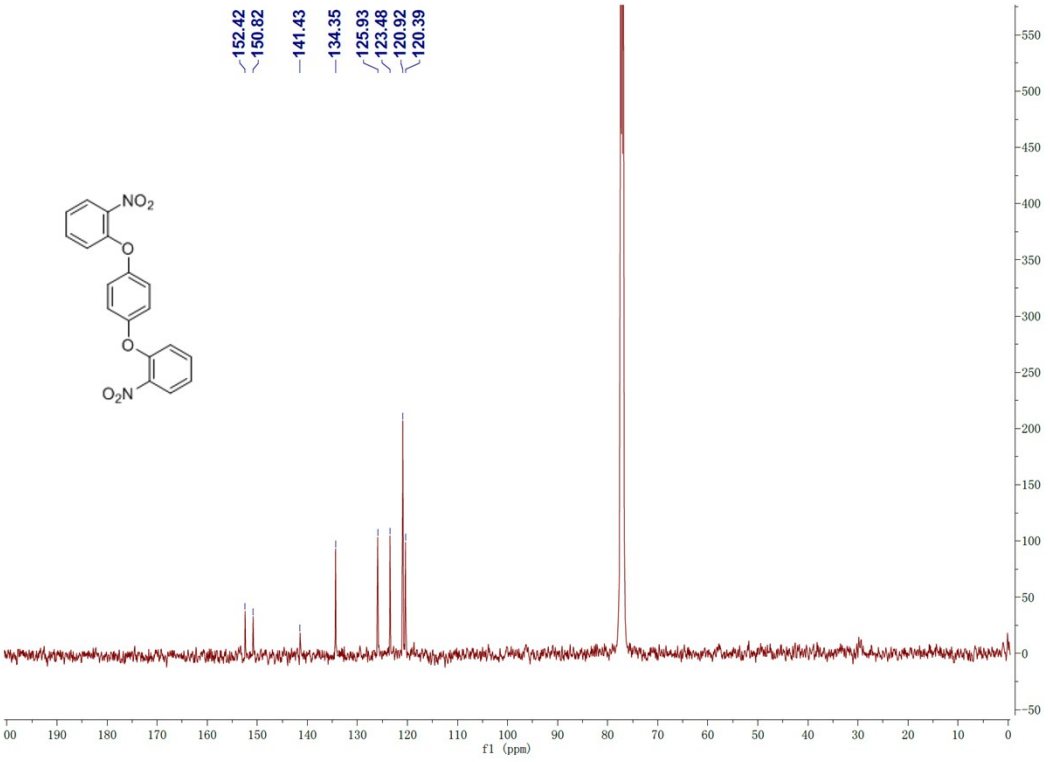
^{1}H NMR of 5b



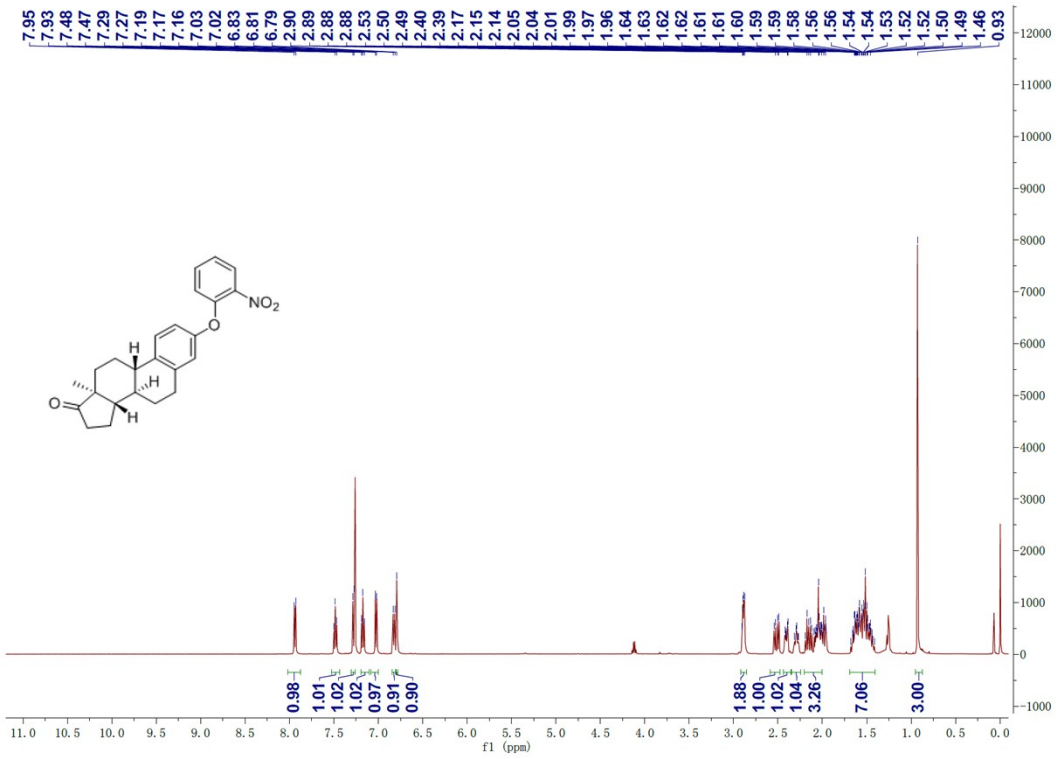
^{13}C NMR of 5b



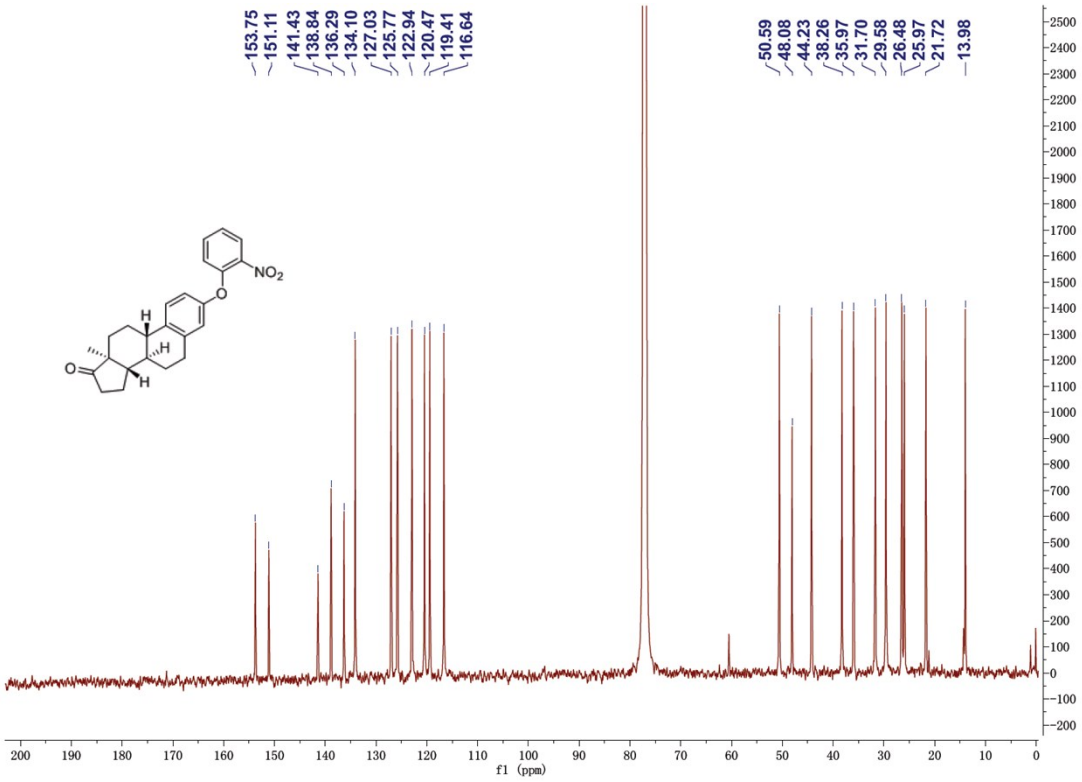
^{1}H NMR of 5c



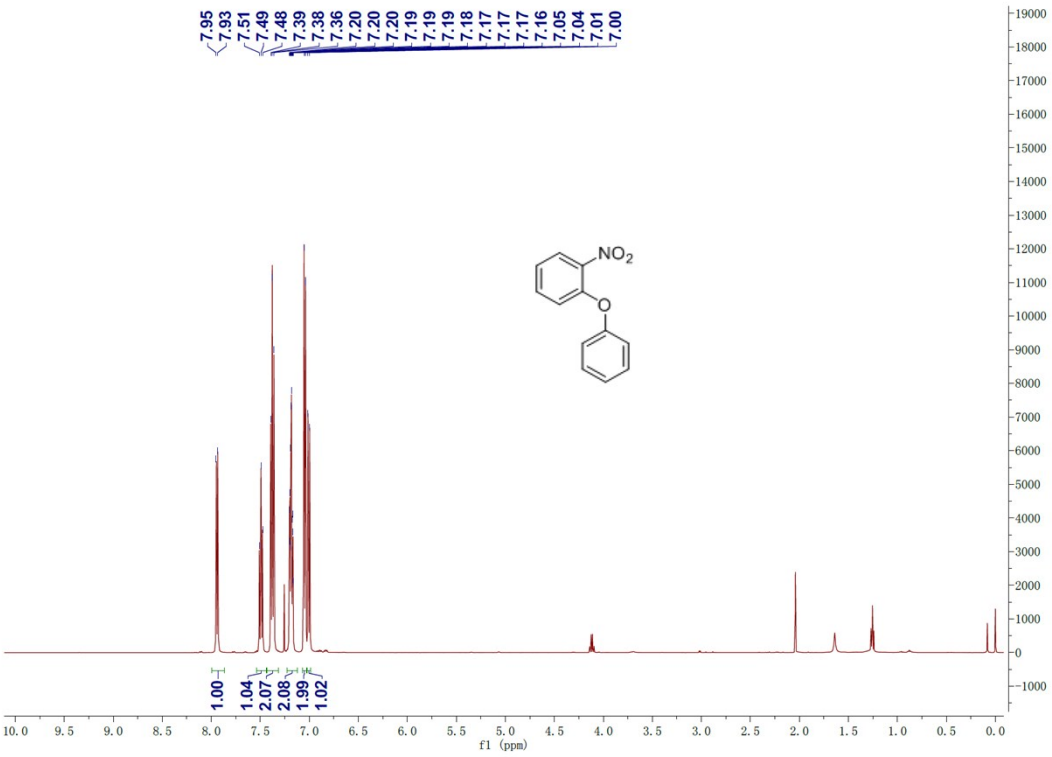
^{13}C NMR of 5c



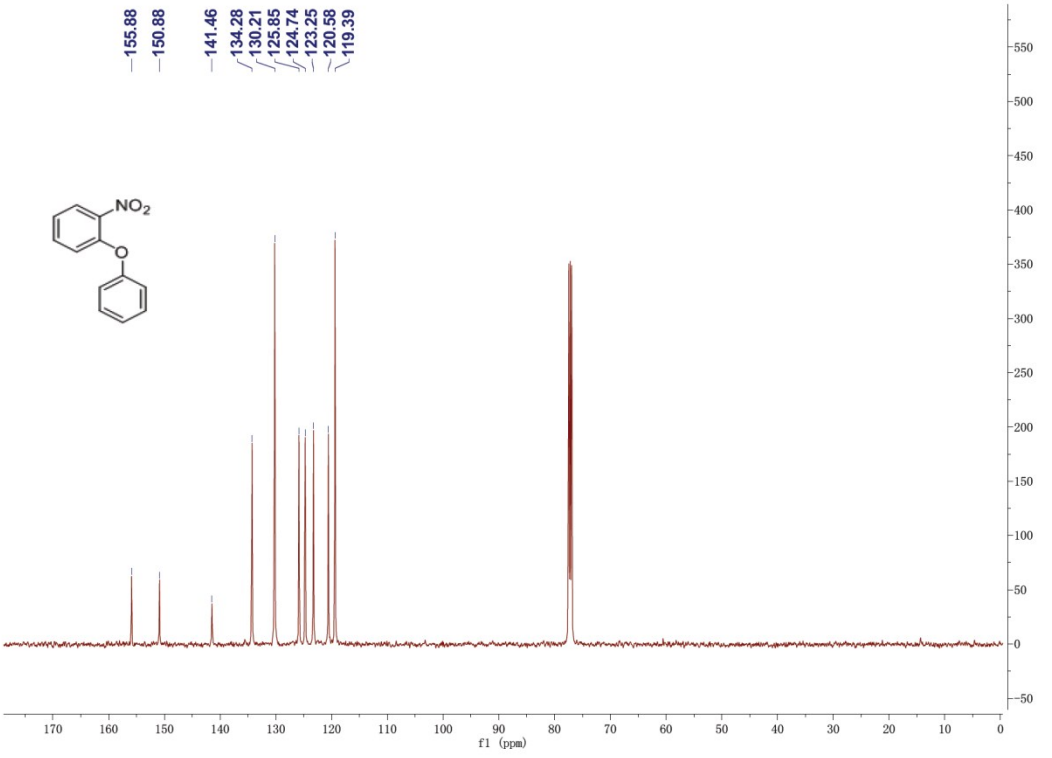
^{1}H NMR of 5d



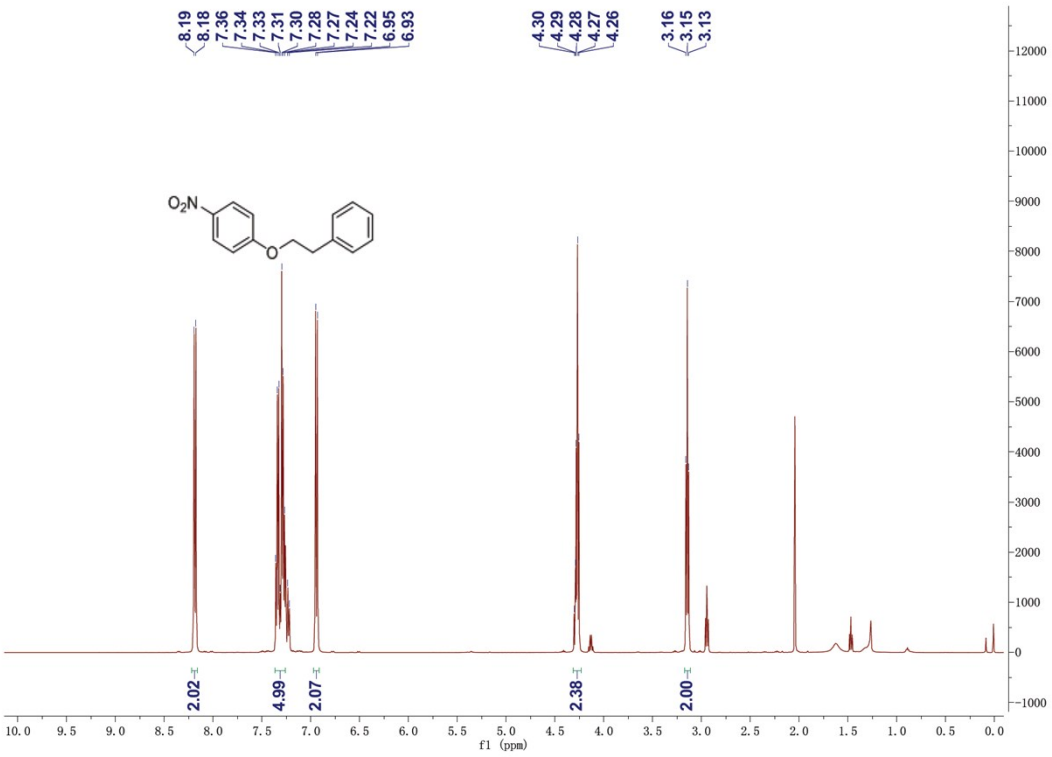
^{13}C NMR of 5d



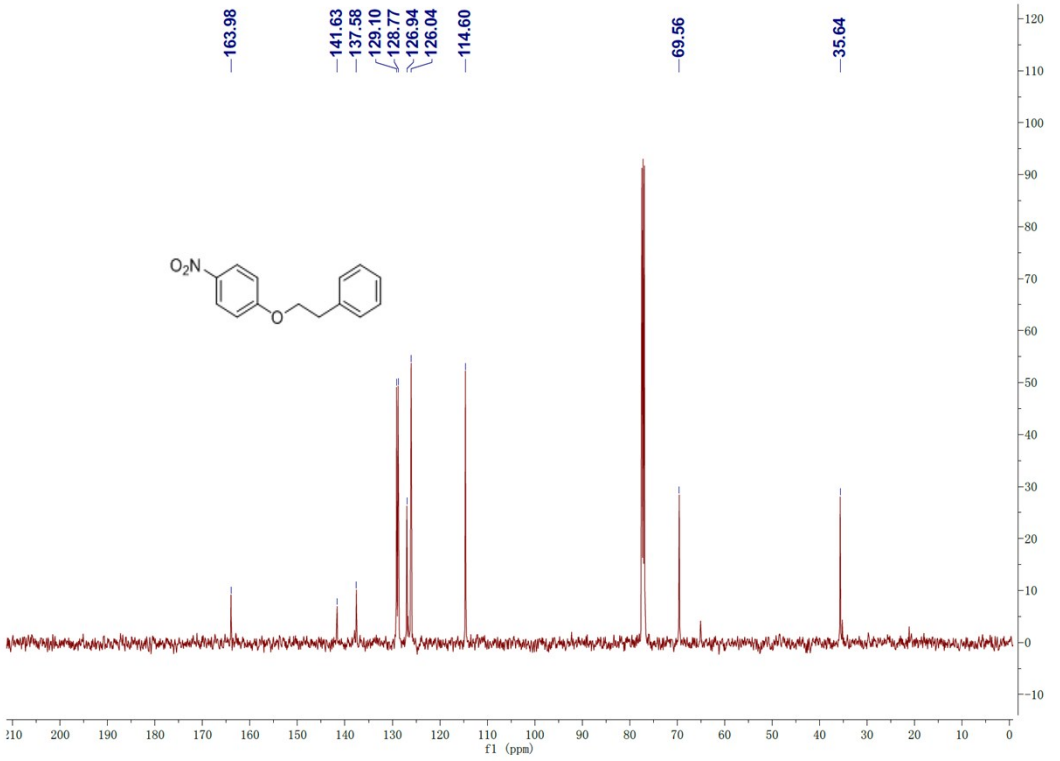
^{1}H NMR of 5e



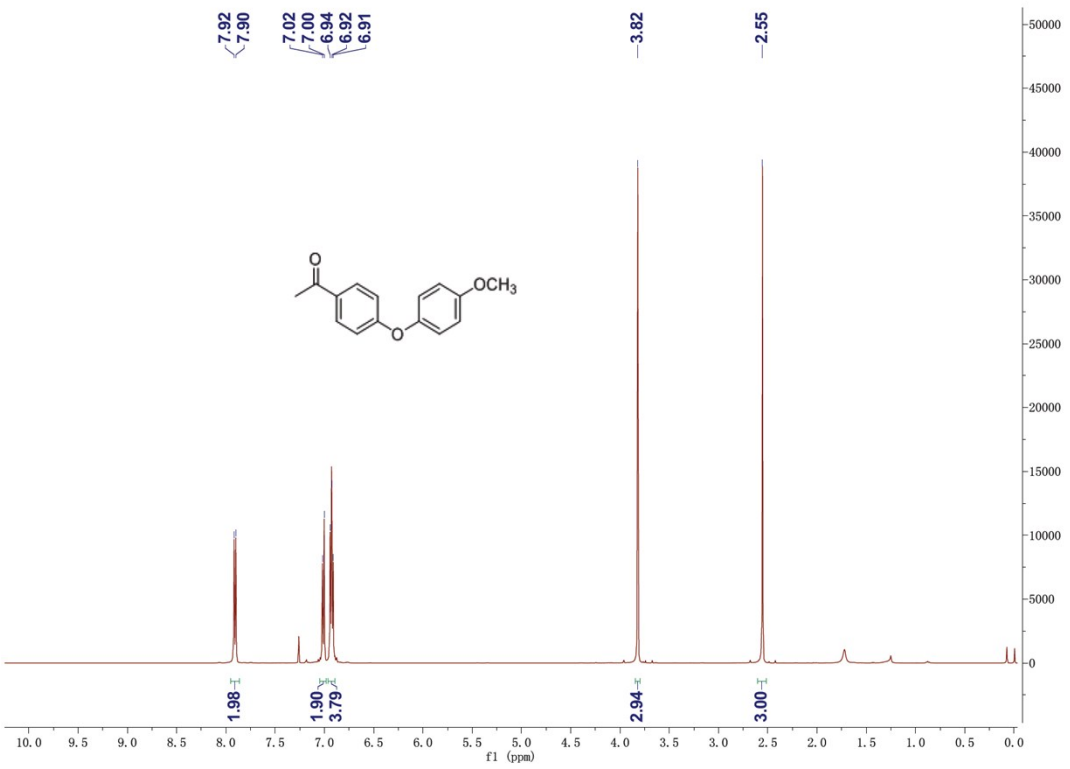
^{13}C NMR of 5e



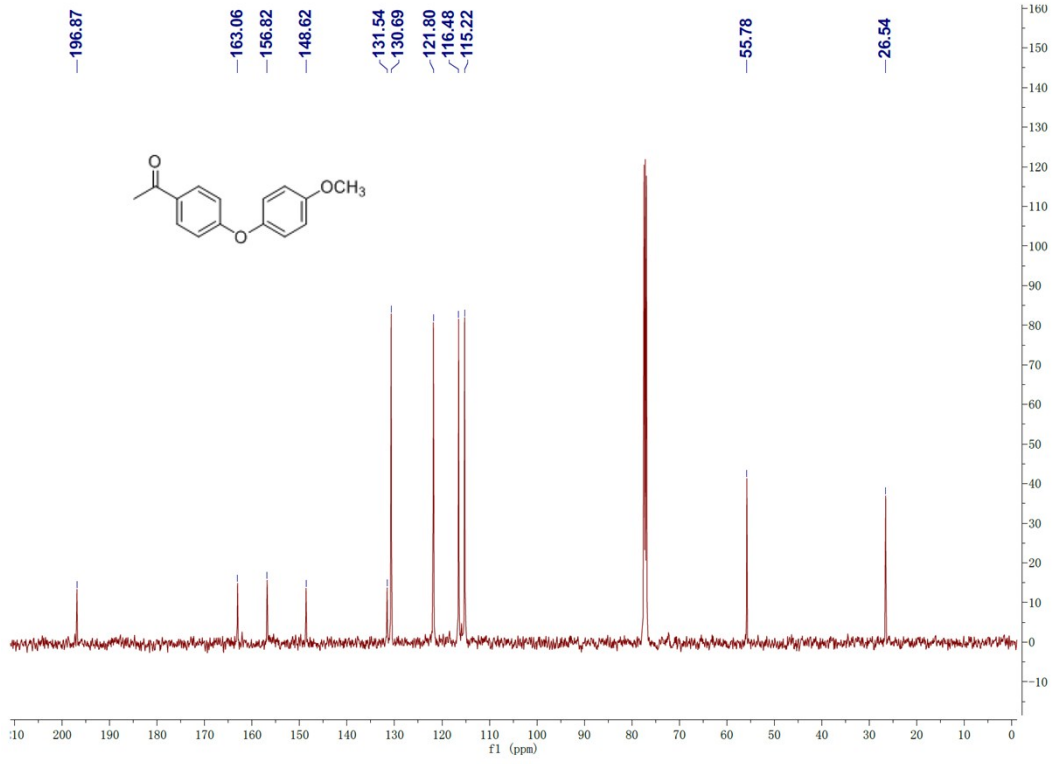
^{1}H NMR of 5f



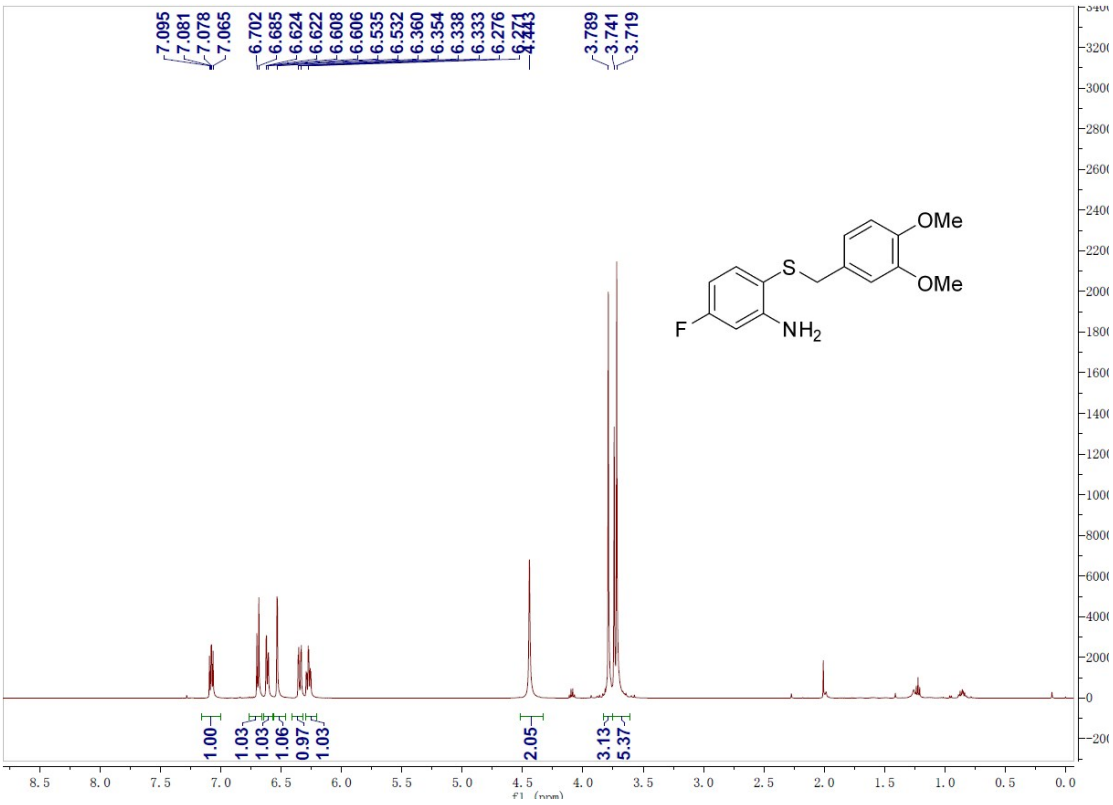
^{13}C NMR of 5f



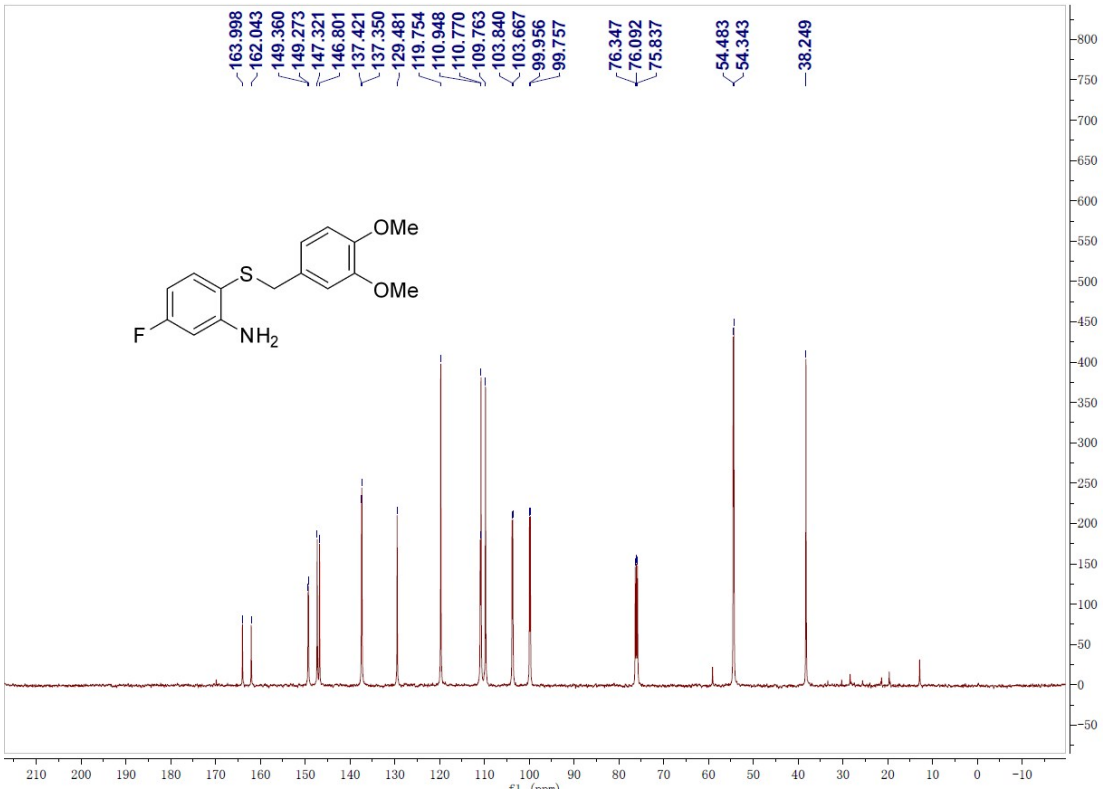
^{1}H NMR of 5g



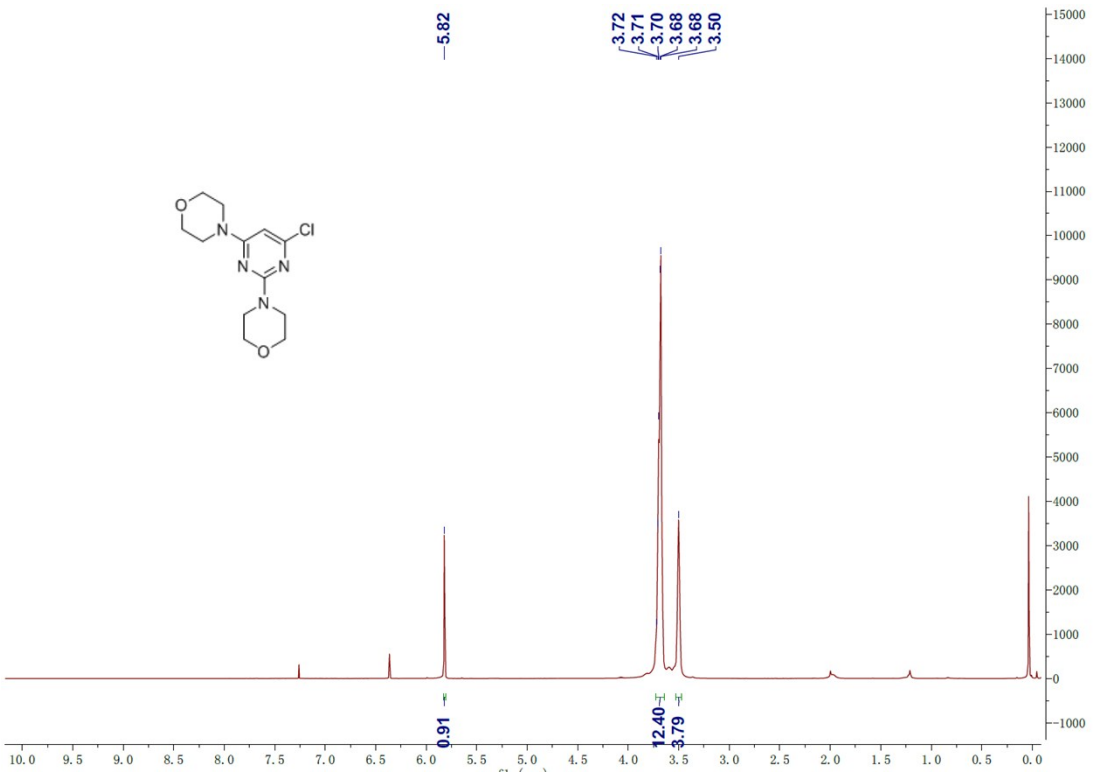
^{13}C NMR of 5g



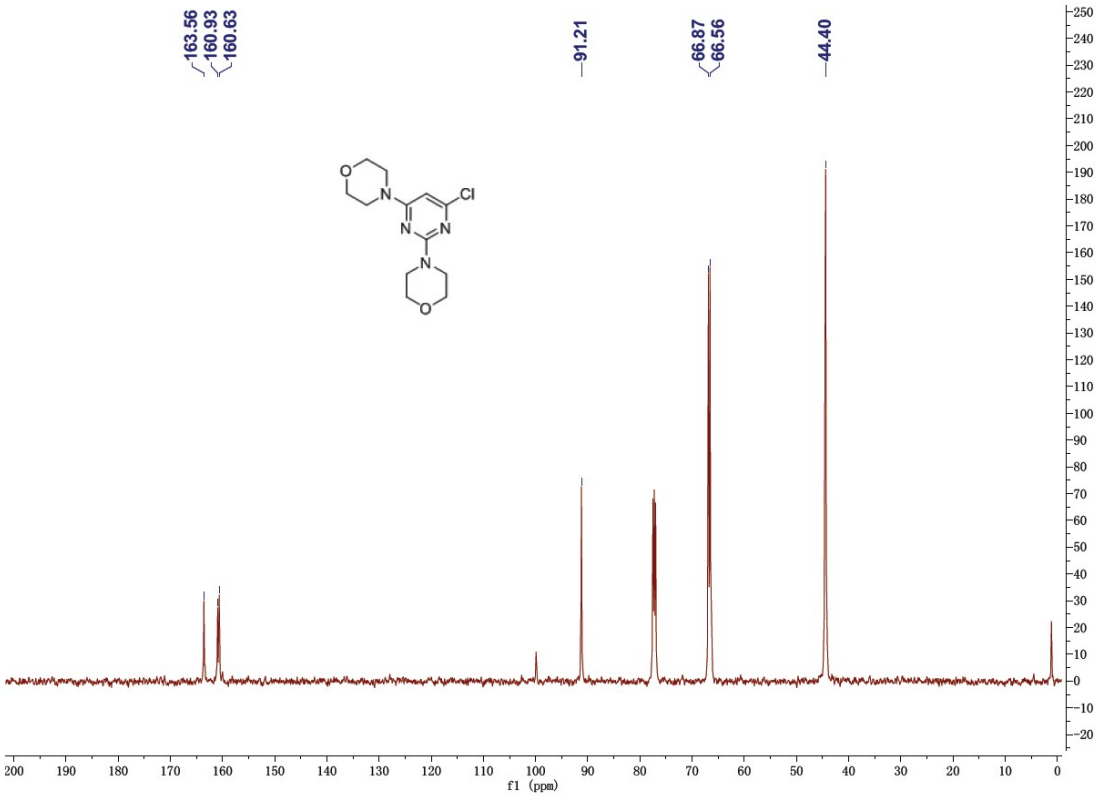
^{1}H NMR of 6



^{13}C NMR of 6



^{1}H NMR of 7



^{13}C NMR of 7