Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information

Double Allylic Defuorinative Alkylation of 1,1-Bisnucleophiles with (Trifluoromethyl)alkenes: Construction of All-Carbon Quaternary Centers

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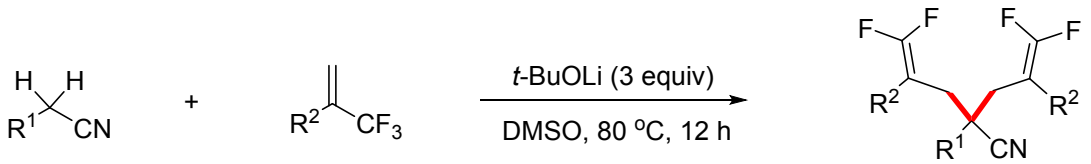
A□ General information

Melting points were measured using a melting point instrument and are uncorrected. Chemical shifts were reported in ppm from the solvent resonance as the internal standard ($CDCl_3$ δ_H = 7.26 ppm, δ_C = 77.16 ppm). Multiplicity was indicated as follows: s (singlet), d (doublet), t (triplet), q (quartet), quint (quintet), m (multiplet). Coupling constants were reported in Hertz (Hz). IR spectra were obtained with an infrared spectrometer on either potassium bromide pellets or liquid films between two potassium bromide pellets. GC−MS data were obtained using electron ionization (Thermo Trace DSQ GC-MS). HRMS was carried out on a high-resolution mass spectrometer (Agilent 6210 ESI/TOF MS or Thermo Q Exactive Plus). TLC was performed using commercially available 100−400 mesh silica gel plates (GF_{254}). X-ray structural analyses were conducted on Bruker APEX-II CCD Diffractometer (T = 210 K).

Materials. Tetrahydrofuran (THF) and toluene were distilled from sodium/benzophenone; 1,2-dichloroethane (DCE) was distilled from calcium hydride; acetonitrile (CH_3CN) was distilled from phosphorus pentoxide. Other commercially available reagents were purchased and used without further purification. Analytical thin-layer chromatography was performed on 0.20 mm silica gel plates (GF_{254}) using UV light as a visualizing agent. Flash column chromatography was carried out using silica gel (200–300 mesh) with the indicated solvent system. All reactions were conducted in oven-dried Schlenk tubes. All the reaction temperatures reported are oil bath temperatures.

B□ General Procedure for the Synthesis of Compound 3

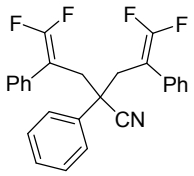


1 **2** **3**

A 25 mL oven-dried Schlenk tube equipped with a magnetic stirring bar, (trifluoromethyl)alkene **2** (0.6 mmol) was added to the mixture of phenylacetonitrile **1** (0.2 mmol), *t*-BuOLi (0.6 mmol) in DMSO (4 mL) under N_2, the reaction mixture was heated at 80℃ and stirred for 12 h. Then the mixture was cooled to room temperature, quenched with H_2O (15 mL), extracted with EtOAc (15 mL × 3). The combined organic layer was dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Further purification by flash column chromatography on silica gel (eluting with petroleum ether/ethyl acetate = 30/1) provided the product **3**.

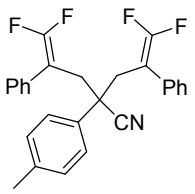
C□ Analysis Data for the Products

2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-2,4-Diphenylpent-4-Enenitrile (3a)



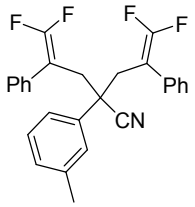
76.6 mg, 91% yield; white solid, mp: 102–103 °C ; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.14–7.22 (m, 8H), 7.08–7.09 (m, 3H), 7.00 (d, J = 6.8 Hz, 4H), 3.08 (d, J = 14.8 Hz, 2H), 2.92 (d, J = 14.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0 (t, $^1J_{F\text{-}C}$ = 289.0 Hz), 136.2, 132.4 (d, $^4J_{F\text{-}C}$ = 2.2 Hz), 132.4 (d, $^4J_{F\text{-}C}$ = 2.3 Hz), 128.8 (t, $^3J_{F\text{-}C}$ = 2.5 Hz), 128.3, 128.0, 127.7, 126.3, 119.7, 89.0 (t, $^2J_{F\text{-}C}$ = 18.5 Hz), 48.1, 39.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.6 (d, J = 33.8 Hz, 2F), -89.0 (d, J = 33.8 Hz, 2F); IR (KBr): 3051, 2934, 2850, 2250, 1727, 1449, 1246, 1129 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{26}H_{19}F_4N$+Na, 444.1346; found, 444.1349.

2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-4-Phenyl-2-(*p*-Tolyl)pent-4-Enenitrile (3b)



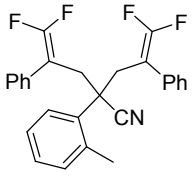
80.1 mg, 92% yield; white solid, mp: 94–95 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17–7.22 (m, 6H), 6.99–7.03 (m, 6H), 6.88 (d, J = 8.0 Hz, 2H), 3.05 (d, J = 14.4 Hz, 2H), 2.89 (d, J = 14.8 Hz, 2H), 2.21 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9 (t, $^1J_{F\text{-}C}$ = 289.5 Hz), 137.7, 133.2, 132.5 (d, $^4J_{F\text{-}C}$ = 2.3 Hz), 132.5 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 128.9, 128.8 (t, $^3J_{F\text{-}C}$ = 2.5 Hz), 128.3, 127.6, 126.2, 119.9, 89.1 (t, $^2J_{F\text{-}C}$ = 18.4 Hz), 47.7, 39.3, 20.8; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.7 (d, J = 33.8 Hz, 2F), -89.1 (d, J = 33.8 Hz, 2F); IR (KBr): 3041, 2927, 2860, 2242, 1728, 1507, 1447, 1313, 1245, 1127 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{27}H_{21}F_4N$+Na, 458.1502; found, 458.1505.

2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-4-Phenyl-2-(*m*-Tolyl)pent-4-Enenitrile (3c)



76.6 mg, 88% yield; white solid, mp: 72–73 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.13–7.21 (m, 6H), 6.97–7.01 (m, 6H), 6.85 (s, 2H), 3.07 (d, J = 14.4 Hz, 2H), 2.90 (d, J = 14.4 Hz, 2H), 2.13 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0 (t, $^1J_{F\text{-}C}$ = 289.5 Hz), 137.9, 136.0, 132.5 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 132.5 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 128.7 (t, $^3J_{F\text{-}C}$ = 2.3 Hz), 128.6, 128.2, 127.6, 127.1, 123.3, 119.9, 89.1 (t, $^2J_{F\text{-}C}$ = 18.5 Hz), 48.2, 39.2, 21.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.6 (d, J = 33.8 Hz, 2F), -89.0 (d, J = 33.8 Hz, 2F); IR (KBr): 3045, 2930, 2859, 2242, 1726, 1447, 1313, 1246, 1130 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{27}H_{21}F_4N$+H, 436.1683; found, 436.1685.

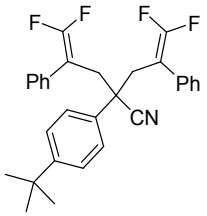
2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-4-Phenyl-2-(*o*-Tolyl)pent-4-Enenitrile (3d)



69.6 mg, 80% yield; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26–7.28 (m, 1H), 7.17–7.19 (m,

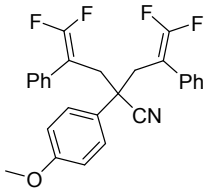
6H), 6.95–6.99 (m, 6H), 6.76–6.78 (m, 1H), 3.12 (d, J = 1.6 Hz, 4H), 2.29 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0 (t, $^1J_{F\text{-}C}$ = 289.0 Hz), 134.9, 133.4, 132.9, 132.4 (d, $^4J_{F\text{-}C}$ = 2.3 Hz), 132.4 (d, $^4J_{F\text{-}C}$ = 2.2 Hz), 128.8 (t, $^3J_{F\text{-}C}$ = 2.2 Hz), 128.2, 128.1, 127.7, 125.9, 121.0, 89.2 (t, $^2J_{F\text{-}C}$ = 18.5 Hz), 49.4, 37.3, 22.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.5 (d, J = 33.8 Hz, 2F), -88.6 (d, J = 33.8 Hz, 2F); IR (KBr): 3057, 2932, 2858, 2239, 1728, 1448, 1246, 1129 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{27}H_{21}F_4N$+Na, 458.1502; found, 458.1509.

2-(4-(*tert*-Butyl)phenyl)-2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-4-Phenylpent-4-Enenitrile (3e)



85.9 mg, 90% yield; white solid, mp: 118–119 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.10–7.17 (m, 6H), 6.96–7.01 (m, 8H), 3.09 (d, J = 14.4 Hz, 2H), 2.89 (d, J = 14.4 Hz, 2H), 1.19 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0 (t, $^1J_{F\text{-}C}$ = 289.5 Hz), 150.6, 133.0, 132.6 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 132.6 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 128.7 (t, $^3J_{F\text{-}C}$ = 2.0 Hz), 128.2, 127.5, 125.9, 125.0, 119.9, 89.1 (t, $^2J_{F\text{-}C}$ = 18.5 Hz), 48.1, 39.2, 34.3, 31,1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.5 (d, J = 33.8 Hz, 2F), -89.0 (d, J = 33.8 Hz, 2F); IR (KBr): 3049, 2955, 2241, 1726, 1504, 1454, 1310, 1247, 1126 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{30}H_{27}F_4N$+H, 478.2152; found, 478.2156.

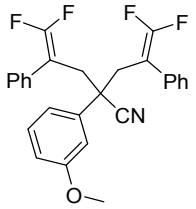
2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-2-(4-Methoxyphenyl)-4-Phenylpent-4-Enenitrile (3f)



65.0 mg, 72% yield; white solid, mp: 107–108 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16–7.22 (m, 6H), 7.04 (d, J = 8.4 Hz, 2H), 7.00 (d, J = 7.2 Hz, 4H), 6.60 (d, J = 8.4 Hz, 2H), 3.72 (s, 3H), 3.06 (d, J = 14.4 Hz, 2H), 2.88 (d, J = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.1, 154.9 (t,

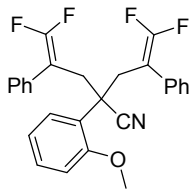
$^{1}J_{F\text{-}C}$ = 289.5 Hz), 132.5 (d, $^{4}J_{F\text{-}C}$ = 2.2 Hz), 132.5 (d, $^{4}J_{F\text{-}C}$ = 2.7 Hz), 128.8 (t, $^{3}J_{F\text{-}C}$ = 2.0 Hz), 128.3, 128.1, 127.6, 127.5, 119.9, 113.6, 89.1 (t, $^{2}J_{F\text{-}C}$ = 18.5 Hz), 55.3, 47.4, 39.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.8 (d, *J* = 33.8 Hz, 2F), -89.0 (d, *J* = 33.8 Hz, 2F); IR (KBr): 3044, 2925, 2241, 1721, 1505, 1449, 1241, 1120 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{27}H_{21}F_4NO$+H, 452.1632; found, 452.1629.

2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-2-(3-Methoxyphenyl)-4-Phenylpent-4-Enenitrile (3g)



82.1 mg, 91% yield; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.15–7.22 (m, 6H), 6.98–7.02 (m, 5H), 6.76 (d, *J* = 7.6 Hz, 1H), 6.59–6.62 (m, 2H), 3.66 (s, 3H), 3.07 (d, *J* = 14.4 Hz, 2H), 2.91 (d, *J* = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.3, 154.9 (t, $^{1}J_{F\text{-}C}$ = 290.5 Hz), 137.7, 132.4 (d, $^{4}J_{F\text{-}C}$ = 2.5 Hz), 132.4 (d, $^{4}J_{F\text{-}C}$ = 2.5 Hz), 129.4, 128.8 (t, $^{3}J_{F\text{-}C}$ = 2.5 Hz), 128.2, 127.7, 119.7, 118.7, 113.4, 112.4, 89.0 (t, $^{2}J_{F\text{-}C}$ = 18.5 Hz), 55.2, 48.2, 39.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.5 (d, *J* = 33.8 Hz, 2F), -88.9 (d, *J* = 30.1 Hz, 2F); IR (KBr): 3057, 2934, 2849, 2242, 1727, 1598, 1447, 1248, 1130, 1041 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{27}H_{21}F_4NO$+H, 452.1632; found, 452.1635.

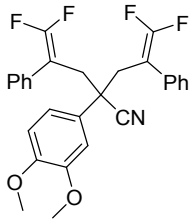
2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-2-(2-Methoxyphenyl)-4-Phenylpent-4-Enenitrile (3h)



67.7 mg, 75% yield; yellow solid, mp: 110–111 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (d, *J* = 7.6 Hz, 1H), 7.05–7.08 (m, 6H), 6.85–6.90 (m, 5H), 6.65 (t, *J* = 7.6 Hz, 1H), 6.08 (d, *J* = 8.0 Hz, 1H), 3.47 (d, *J* = 17.6 Hz, 2H), 3.45 (s, 3H), 3.13 (d, *J* = 14.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.2, 155.0 (t, $^{1}J_{F\text{-}C}$ = 289.0 Hz), 132.8 (d, $^{4}J_{F\text{-}C}$ = 2.3 Hz), 132.8 (d, $^{4}J_{F\text{-}C}$ = 2.3 Hz), 129.8, 128.6

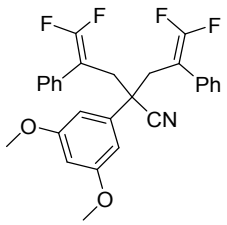
(t, $^{3}J_{F\text{-}C}$ = 2.0 Hz), 127.8, 127.2, 122.0, 121.1, 120.1, 110.2, 89.6 (t, $^{2}J_{F\text{-}C}$ = 18.5 Hz), 54.2, 49.5, 35.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -88.5 (d, *J* = 33.8 Hz, 2F), -89.5 (d, *J* = 33.8 Hz, 2F); IR (KBr): 3073, 2948, 2844, 2241, 1731, 1595, 1451, 1306, 1243 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{27}H_{21}F_4NO$+H, 452.1632; found, 452.1637.

2-(3,3-Difluoro-2-Phenylallyl)-2-(3,4-Dimethoxyphenyl)-5,5-Difluoro-4-Phenylpent-4-Enenitrile (3i)



80.8 mg, 84% yield; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.14–7.18 (m, 6H), 6.98 (d, *J* = 6.4 Hz, 4H), 6.72 (d, *J* = 8.4 Hz, 1H), 6.55 (d, *J* = 8.4 Hz, 1H), 6.48 (s, 1H), 3.77 (s, 3H), 3.68 (s, 3H), 3.09 (d, *J* = 14.4 Hz, 2H), 2.90 (d, *J* = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9 (t, $^{1}J_{F\text{-}C}$ = 289.0 Hz), 148.5, 148.4, 132.5 (d, $^{4}J_{F\text{-}C}$ = 2.3 Hz), 132.5 (d, $^{4}J_{F\text{-}C}$ = 2.3 Hz), 128.8, 128.3, 128.2, 127.7, 120.0, 119.1, 110.8, 109.6, 89.1 (t, $^{2}J_{F\text{-}C}$ = 18.5 Hz), 55.9 (d, *J* = 3.0 Hz), 55.7 (d, *J* = 3.0 Hz), 44.7, 39.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.8 (d, *J* = 33.8 Hz, 2F), -89.1 (d, *J* = 37.6 Hz, 2F); IR (KBr): 3061, 2938, 2843, 2241, 1725, 1513, 1453, 1250, 1142, 1024 cm^{-1} ; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{28}H_{23}F_4NO_2$+H, 482.1738; found, 482.1744.

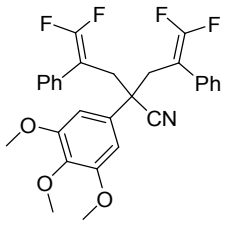
2-(3,3-Difluoro-2-Phenylallyl)-2-(3,5-Dimethoxyphenyl)-5,5-Difluoro-4-Phenylpent-4-Enenitrile (3j)



79.9 mg, 83% yield; yellow solid, mp: 86–87 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.14–7.21 (m, 6H), 7.02 (d, *J* = 6.8 Hz, 4H), 6.26 (s, 2H), 6.12 (s, 1H), 3.63 (s, 6H), 3.06 (d, *J* = 14.4 Hz, 2H), 2.89 (d, *J* = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.6, 155.0 (t, $^{1}J_{F\text{-}C}$ = 289.5 Hz), 138.4, 132.5 (d, $^{3}J_{F\text{-}C}$ = 2.5 Hz), 132.5 (d, $^{3}J_{F\text{-}C}$ = 2.5 Hz), 128.8, 128.2, 127.7, 119.8, 105.0, 99.7,

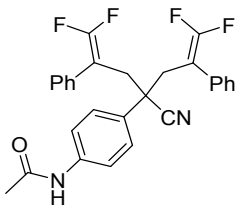
89.1 (t, $^{2}J_{F\text{-}C}$ = 18.5 Hz), 55.3, 48.4, 39.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.5 (d, *J* = 33.8 Hz, 2F), -88.9 (d, *J* = 33.8 Hz, 2F); IR (KBr): 3060, 2942, 2842, 2246, 1723, 1600, 1456, 1319, 1249, 1147, 1051 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{28}H_{23}F_4NO_2$+H, 482.1738; found, 482.1739.

2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-4-Phenyl-2-(3,4,5-Trimethoxyphenyl)pent-4-Enenitrile (3k)



63.4 mg, 62% yield; yellow solid, mp: 103–104 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.12–7.18 (m, 6H), 6.97 (d, *J* = 6.8 Hz, 4H), 6.24 (s, 2H), 3.69 (d, *J* = 8.0 Hz, 9H), 3.13 (d, *J* = 14.4 Hz, 2H), 2.92 (d, *J* = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9 (t, $^{1}J_{F\text{-}C}$ = 289.5 Hz), 152.6, 137.3, 132.5 (d, $^{4}J_{F\text{-}C}$ = 2.4 Hz), 132.5 (d, $^{4}J_{F\text{-}C}$ = 2.5 Hz), 131.2, 128.7, 128.1, 127.7, 119.9, 104.2, 89.0 (t, $^{2}J_{F\text{-}C}$ = 19.0 Hz), 60.6, 56.0, 48.5, 39.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.5 (d, *J* = 33.8 Hz, 2F), -88.8 (d, *J* = 33.8 Hz, 2F); IR (KBr): 3058, 2937, 2844, 2243, 1728, 1593, 1508, 1450, 1247, 1130cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{29}H_{25}F_4NO_3$+H, 512.1843; found, 512.1839.

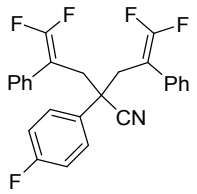
***N*-(4-(4-Cyano-1,1,7,7-Tetrafluoro-2,6-Diphenylhepta-1,6-Dien-4-yl)phenyl)acetamide (3l)**



59.3 mg, 62% yield; white solid, mp: 114–115 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (d, *J* = 10.0 Hz, 1H), 7.35 (d, *J* = 8.0 Hz, 2H), 7.20–7.29 (m, 6H), 7.14 (d, *J* = 8.0 Hz, 2H), 7.05 (d, *J* = 6.8 Hz, 4H), 3.10 (d, *J* = 14.4 Hz, 2H), 2.94 (d, *J* = 14.4 Hz, 2H) 2.17 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.6, 154.9 (t, $^{1}J_{F\text{-}C}$ = 289.5 Hz), 137.9, 132.3 (d, $^{4}J_{F\text{-}C}$ = 2.6 Hz), 132.3 (d, $^{4}J_{F\text{-}C}$ = 2.5 Hz), 131.7, 128.8, 128.4, 127.8, 126.9, 119.8, 119.2, 88.9 (t, $^{2}J_{F\text{-}C}$ = 19.0 Hz), 47.6, 39.2, 24.6; ^{19}F

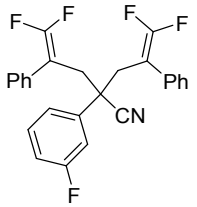
NMR (376 MHz, $CDCl_3$) δ -87.6 (d, J = 24.3 Hz, 2F), -89.0 (d, J = 26.3 Hz, 2F); IR (KBr): 3330, 3052, 2933, 2853, 2245, 1714, 1605, 1524, 1308, 1252, 1127 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{28}H_{22}F_4N_2O$+Na, 501.1560; found, 501.1563.

2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-2-(4-Fluorophenyl)-4-Phenylpent-4-Enenitrile (3m)



79.0 mg, 90% yield; white solid, mp: 100–101 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.19–7.20 (m, 6H), 7.09 (t, J = 6.0 Hz, 2H), 6.98 (d, J = 3.6 Hz, 4H), 6.74 (t, J = 8.0 Hz, 2H), 3.11 (d, J = 14.4 Hz, 2H), 2.91 (d, J = 14.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.1 (d, $^1J_{F\text{-}C}$ = 246.0 Hz), 155.0 (t, $^1J_{F\text{-}C}$ = 289.5 Hz), 132.3 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 132.3 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 131.9 (d, $^3J_{F\text{-}C}$ = 3.0 Hz), 128.7 (t, $^3J_{F\text{-}C}$ = 2.5 Hz), 128.4, 128.2 (d, $^3J_{F\text{-}C}$ = 8.0 Hz), 127.8, 119.6, 115.1 (d, $^2J_{F\text{-}C}$ = 22.0 Hz), 88.9 (t, $^2J_{F\text{-}C}$ = 18.5 Hz), 47.7, 39.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.5 (d, J = 33.1 Hz, 2F), -88.8 (d, J = 33.8 Hz, 2F), -114.3 (m, 1F); IR (KBr): 3055, 2931, 2857, 2243, 1726, 1508, 1447, 1313, 1246, 1131 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{26}H_{18}F_5N$+H, 440.1432; found, 440.1437.

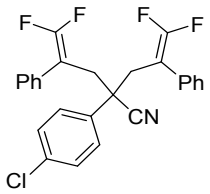
2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-2-(3-Fluorophenyl)-4-Phenylpent-4-Enenitrile (3n)



80.8 mg, 92% yield; white solid, mp: 98–99 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16–7.21 (m, 6H), 7.00–7.07 (m, 5H), 6.94 (d, J = 8.0 Hz, 1H), 6.82 (d, J = 10.0 Hz, 1H), 6.75 (t, J = 8.0 Hz, 1H), 3.10 (d, J = 14.4 Hz, 2H), 2.91 (d, J = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.4 (d, $^1J_{F\text{-}C}$ = 245.0 Hz), 155.0 (t, $^1J_{F\text{-}C}$ = 289.5 Hz), 138.8 (d, $^3J_{F\text{-}C}$ = 7.0 Hz), 132.2 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 132.2 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 129.9 (d, $^3J_{F\text{-}C}$ = 9.0 Hz), 128.7 (t, $^3J_{F\text{-}C}$ = 2.5 Hz), 128.3, 127.8, 122.1

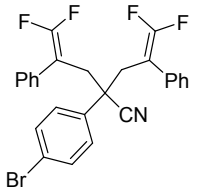
(d, $^{3}J_{F\text{-}C}$ = 3.0 Hz), 119.3, 114.9 (d, $^{2}J_{F\text{-}C}$ = 21.0 Hz), 113.8 (d, $^{2}J_{F\text{-}C}$ = 23.0 Hz), 88.8 (t, $^{2}J_{F\text{-}C}$ = 19.0 Hz), 48.2, 39.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.4 (d, *J* = 33.8 Hz, 2F), -88.6 (d, *J* = 33.8 Hz, 2F) -112.3 (m, 1F); IR (KBr): 3058, 2930, 2858, 2243, 1727, 1597, 1445, 1312, 1247, 1133 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{26}H_{18}F_5N$+Na, 462.1252; found, 462.1257.

2-(4-Chlorophenyl)-2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-4-Phenylpent-4-Enenitrile (3o)



82.8 mg, 91% yield; white solid, mp: 108–109 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.19–7.20 (m, 6H), 6.97–7.05 (m, 8H), 3.10 (d, *J* = 14.4 Hz, 2H), 2.90 (d, *J* = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9 (t, $^{1}J_{F\text{-}C}$ = 289.0 Hz), 134.6, 133.9, 132.2 (d, $^{4}J_{F\text{-}C}$ = 2.3 Hz), 132.2 (d, $^{4}J_{F\text{-}C}$ = 2.4 Hz), 128.7 (t, $^{3}J_{F\text{-}C}$ = 2.0 Hz), 128.4, 128.3, 127.8, 119.4, 88.8 (t, $^{2}J_{F\text{-}C}$ = 18.5 Hz), 47.8, 39.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.4 (d, *J* = 33.8 Hz, 2F), -88.6 (d, *J* = 33.8 Hz, 2F); IR (KBr): 3055, 2932, 2858, 2242, 1727, 1493, 1447, 1312, 1254, 1118 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{26}H_{18}ClF_4N$+Na, 478.0956; found, 478.0959.

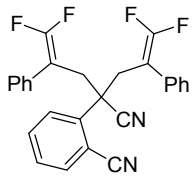
2-(4-Bromophenyl)-2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-4-Phenylpent-4-Enenitrile (3p)



67.9 mg, 68% yield; yellow solid, mp: 93–94 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18–7.22 (m, 6H), 7.14 (d, *J* = 7.6 Hz, 2H), 6.96 (d, *J* = 6.8 Hz, 6H), 3.09 (d, *J* = 14.4 Hz, 2H), 2.89 (d, *J* = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0 (t, $^{1}J_{F\text{-}C}$ = 289.5 Hz), 135.2, 132.2 (d, $^{4}J_{F\text{-}C}$ = 2.5 Hz), 132.2 (d, $^{4}J_{F\text{-}C}$ = 2.4 Hz), 131.3, 128.8 (t, $^{3}J_{F\text{-}C}$ = 2.5 Hz), 128.4, 128.1, 127.8, 122.1, 119.4, 88.8 (t, $^{2}J_{F\text{-}C}$ = 19.0 Hz), 47.9, 39.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.4 (d, *J* = 33.8 Hz, 2F), -88.6 (d, *J* = 33.8 Hz, 2F); IR (KBr): 3054, 2938, 2852, 2245, 1742, 1590, 1485, 1311, 1249, 1126

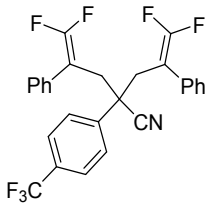
cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{26}H_{18}BrF_4N$+Na, 522.0448; found, 522.0444.

2-(4-Cyano-1,1,7,7-Tetrafluoro-2,6-Diphenylhepta-1,6-Dien-4-yl)benzonitrile (3q)



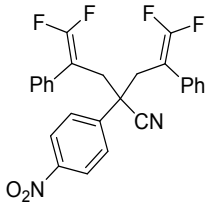
66.0 mg, 74% yield; yellow solid, mp: 103–104 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (d, J = 8.0 Hz, 1H), 7.26 (t, J = 7.6 Hz, 1H), 7.08–7.11 (m, 6H), 6.96–7.04 (m, 6H), 3.58 (d, J = 14.8 Hz, 2H), 3.34 (d, J = 14.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.2 (t, $^1J_{F\text{-}C}$ = 290.5 Hz), 138.0, 135.0, 132.7, 132.0 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 132.0 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 130.1, 128.6 (t, $^3J_{F\text{-}C}$ = 2.0 Hz), 128.3, 128.2, 127.6, 119.1, 118.6, 109.7, 88.8 (t, $^2J_{F\text{-}C}$ = 19.0 Hz), 50.9, 36.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ -86.7 (d, J = 33.8 Hz, 2F), -88.2 (d, J = 33.8 Hz, 2F); IR (KBr): 3058, 2935, 2859, 2225, 1732, 1454, 1312, 1250, 1129 cm^{-1} HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{27}H_{18}F_4N_2$+Na, 469.1298; found, 469.1299.

2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-4-Phenyl-2-(4-(Trifluoromethyl)phenyl)pent-4-Enenitrile (3r)



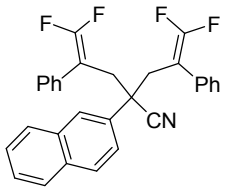
83.2 mg, 85% yield; yellow solid, mp: 92–93 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (dd, J = 15.2 Hz, 8.0 Hz, 4H), 7.13 (d, J = 1.6 Hz, 6H), 6.93 (s, 4H), 3.16 (d, J = 14.8 Hz, 2H), 2.94 (d, J = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0 (t, $^1J_{F\text{-}C}$ = 290.0 Hz), 139.9, 132.1 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 132.1 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 130.1 (q, $^2J_{F\text{-}C}$ = 32.5 Hz), 128.7, 128.4, 127.8, 126.9, 125.1 (q, $^3J_{F\text{-}C}$ = 3.5 Hz), 123.6 (q, $^1J_{F\text{-}C}$ = 270.7 Hz), 119.2, 88.7 (t, $^2J_{F\text{-}C}$ = 19.0 Hz), 48.5, 39.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -63.1 (s, 3F), -87.3 (d, J = 30.1 Hz, 2F), -88.4 (d, J = 33.8 Hz, 2F); IR (KBr): 3058, 2940, 2854, 2243, 1725, 1610, 1434, 1324, 1256, 1146 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{27}H_{18}F_7N$+H, 490.1400; found, 490.1405.

2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-2-(4-Nitrophenyl)-4-Phenylpent-4-Enenitrile (3s)



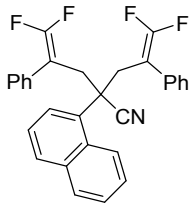
71.8 mg, 77% yield; yellow solid, mp: 138–139 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 8.4 Hz, 2H), 7.26 (d, *J* = 8.4 Hz, 2H), 7.15 (s, 6H), 6.95 (s, 4H), 3.21 (d, *J* = 14.8 Hz, 2H), 2.99 (d, *J* = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0 (t, $^{1}J_{F\text{-}C}$ = 290.5 Hz), 147.2, 143.1, 131.9 (d, $^{4}J_{F\text{-}C}$ = 2.5 Hz), 131.9 (d, $^{4}J_{F\text{-}C}$ = 2.5 Hz), 128.7 (t, $^{3}J_{F\text{-}C}$ = 2.0 Hz), 128.4, 127.9, 127.6, 123.1, 118.9, 88.5 (t, $^{2}J_{F\text{-}C}$ = 19.0 Hz), 48.6, 39.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ -86.9 (d, *J* = 30.1Hz, 2F), -88.1 (d, *J* = 33.8 Hz, 2F); IR (KBr): 3083, 2932, 2858, 2245, 1720, 1517, 1319, 1252, 1126 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{26}H_{18}F_4N_2O_2$+H, 467.1377; found, 467.1381.

2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-2-(Naphthalen-2-yl)-4-Phenylpent-4-Enenitrile (3t)



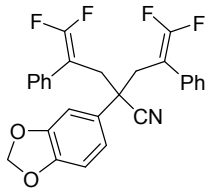
70.7mg, 75% yield; yellow solid, mp: 138–139 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (s, 3H), 7.59 (d, *J* = 8.8 Hz, 1H), 7.51 (t, *J* = 3.2 Hz, 2H), 7.22 (d, *J* = 8.8 Hz, 1H), 7.09–7.17 (m, 6H), 7.03 (d, *J* = 7.2 Hz, 4H), 3.24 (d, *J* = 14.4 Hz, 2H), 3.08 (d, *J* = 14.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9 (t, $^{1}J_{F\text{-}C}$ = 289.5 Hz), 133.3, 132.7, 132.6, 132.3 (d, $^{4}J_{F\text{-}C}$ = 2.3 Hz), 132.3 (d, $^{4}J_{F\text{-}C}$ = 2.4 Hz), 128.8, 128.3, 128.2, 128.1, 127.6, 127.3, 126.6, 126.5, 126.4, 122.8, 119.9, 89.0 (t, $^{2}J_{F\text{-}C}$ = 18.5 Hz), 48.4, 39.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.6 (d, *J* = 33.8 Hz, 2F), -88.8 (d, *J* = 30.0 Hz, 2F); IR (KBr): 3054, 2930, 2856, 2241, 1727, 1445, 1245, 1129 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{30}H_{21}F_4N$+H, 472.1683; found, 472.1689.

2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-2-(Naphthalen-1-yl)-4-Phenylpent-4-Enenitrile (3u)



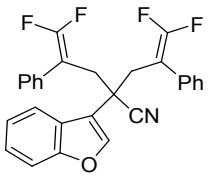
54.7 mg, 58% yield; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (s, 1H), 7.68 (d, J = 8.0 Hz, 1H), 7.48–7.60 (m, 3H), 7.42 (t, J = 7.2 Hz, 1H), 7.12 (t, J = 7.6 Hz, 1H), 7.01 (s, 6H), 6.89 (d, J = 6.0 Hz, 4H), 3.63 (d, J = 14.4 Hz, 2H), 3.50 (d, J = 14.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0 (t, $^{1}J_{F\text{-}C}$ = 290.0 Hz), 135.6, 134.6, 131.8 (t, $^{3}J_{F\text{-}C}$ = 1.5 Hz), 130.6, 129.9, 129.5 (d, $^{4}J_{F\text{-}C}$ = 1.0 Hz), 129.5 (d, $^{4}J_{F\text{-}C}$ = 1.5 Hz), 128.5, 128.2, 127.7, 127.3, 125.7, 125,1, 124.5, 123.9, 121.1, 89.5 (t, $^{2}J_{F\text{-}C}$ = 18.5 Hz), 36.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.3 (d, J = 30.1 Hz, 2F), -88,8 (d, J = 30.1 Hz, 2F); IR (KBr): 3053, 2940, 2854, 2239, 1726, 1506, 1446, 1246, 1131 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{30}H_{21}F_4N$+Na, 494.1502; found, 494.1503.

2-(Benzo[*d*][1,3]dioxol-5-yl)-2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-4-Phenylpent-4-Enenitrile (3v)



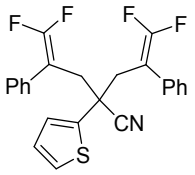
76.3 mg, 82% yield; white solid, mp: 109–110 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20–7.28 (m, 6H), 7.06 (d, J = 7.2 Hz, 4H), 6.71 (d, J = 8.0 Hz, 1H), 6.54 (s, 1H), 6.53 (d, J = 9.2 Hz, 1H), 5.86 (s, 2H), 3.10 (d, J = 14.4 Hz, 2H), 2.90 (d, J = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0 (t, $^{1}J_{F\text{-}C}$ = 289.5 Hz), 147.5, 147.1, 132.5 (d, $^{4}J_{F\text{-}C}$ = 2.5 Hz), 132.5 (d, $^{4}J_{F\text{-}C}$ = 2.5 Hz), 129.8, 128.8 (t, $^{3}J_{F\text{-}C}$ = 2.0 Hz), 128.2, 127.6, 120.3, 119.8, 107.7, 106.7, 101.3, 88.9 (t, $^{2}J_{F\text{-}C}$ = 19.0 Hz), 48.0, 39.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.6 (d, J = 33.8 Hz, 2F), -88.8 (d, J = 33.8 Hz, 2F); IR (KBr): 3055, 2908, 2781, 2243, 1724, 1495, 1247, 1126, 1036 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{27}H_{19}F_4NO_2$+Na, 488.1244; found, 488.1249.

2-(Benzofuran-3-yl)-2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-4-Phenylpent-4-Enenitrile (3w)



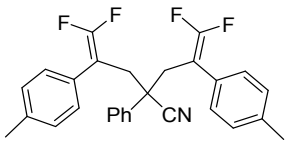
71.9 mg, 78% yield; light yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 (d, J = 7.2 Hz, 1H), 7.25 (s, 1H), 7.17 (s, 2H), 7.14 (t, J = 3.6 Hz, 1H), 7.03 (s, 2H), 7.02 (d, J = 15.2 Hz, 8H), 3.22 (d, J = 14.4 Hz, 2H), 3.11 (d, J = 14.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.9, 155.1 (t, $^{1}J_{F\text{-}C}$ = 290.0 Hz), 143.3, 131.9 (d, $^{4}J_{F\text{-}C}$ = 2.6 Hz), 131.9 (d, $^{4}J_{F\text{-}C}$ = 2.6 Hz), 128.5 (t, $^{3}J_{F\text{-}C}$ = 2.0 Hz), 128.0, 127.6, 124.6, 124.0, 122.6, 120.1, 119.3, 117.6, 112.0, 89.0 (t, $^{2}J_{F\text{-}C}$ = 18.5 Hz), 42.1, 36.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.2 (d, J = 33.8 Hz, 2F), -88.4 (d, J = 33.8 Hz, 2F); IR (KBr): 3056, 2940, 2856, 2241, 1722, 1593, 1456, 1256, 1123, 1005 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{28}H_{19}F_4NO$+H, 462.1474 found, 462.1472.

2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-4-Phenyl-2-(Thiophen-2-yl)pent-4-Enenitrile (3x)



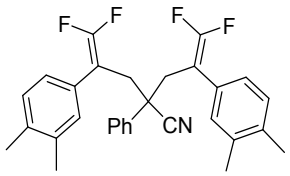
54.7 mg, 64% yield; yellow solid, mp: 84–85 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18–7.26 (m, 6H), 7.09 (d, J = 7.2 Hz, 4H), 7.01 (d, J = 5.2 Hz, 1H), 6.81 (d, J = 3.2 Hz, 1H), 6.64 (t, J = 4.4 Hz, 1H), 3.08 (d, J = 14.4 Hz, 2H), 2.89 (d, J = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.2 (t, $^{1}J_{F\text{-}C}$ = 290.0 Hz), 140.9, 132.4 (d, $^{4}J_{F\text{-}C}$ = 2.6 Hz), 132.4 (d, $^{4}J_{F\text{-}C}$ = 2.6 Hz), 128.8 (t, $^{3}J_{F\text{-}C}$ = 2.5 Hz), 128.4, 127.8, 126.7, 126.4, 125.6, 119.2, 88.9 (t, $^{2}J_{F\text{-}C}$ = 19.0 Hz), 45.4, 40.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ -86.9 (d, J = 33.8 Hz, 2F), -88.3 (d, J = 33.8 Hz, 2F); IR (KBr): 3053, 2933, 2853, 2248, 1726, 1443, 1316, 1246, 1134 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{24}H_{17}F_4NS$+Na, 450.0910; found, 450.0916.

2-(3,3-Difluoro-2-(*p*-Tolyl)allyl)-5,5-Difluoro-2-Phenyl-4-(*p*-Tolyl)pent-4-Enenitrile (3aa)



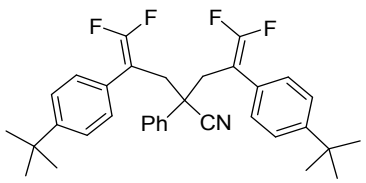
67.4 mg, 75% yield; yellow solid, mp: 144–145 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.09 (s, 2H), 7.04 (s, 3H), 6.93 (d, J = 7.6 Hz, 4H), 6.82 (d, J = 7.2 Hz, 4H), 2.96 (d, J = 14.4 Hz, 2H), 2.80 (d, J = 14.4 Hz, 2H), 2.19 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9 (t, $^1J_{F\text{-}C}$ = 231.5 Hz), 137.5, 136.5, 129.4 (d, $^4J_{F\text{-}C}$ = 2.3 Hz), 129.4 (d, $^4J_{F\text{-}C}$ = 2.3 Hz), 129.1, 128.6 (t, $^3J_{F\text{-}C}$ = 2.0 Hz), 128.3, 127.8, 126.3, 119.8, 88.8 (t, $^2J_{F\text{-}C}$ = 15.0 Hz), 48.0, 39.2, 21.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -88.0 (d, J = 30.1 Hz, 2F), -89.4 (d, J = 26.3 Hz, 2F); IR (KBr): 3039, 2929, 2863, 2240, 1724, 1509, 1441, 1235, 1116, 1022 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{28}H_{23}F_4N$+Na, 472.1657; found, 472.1655.

4-(3,4-Dimethylphenyl)-2-(2-(3,4-Dimethylphenyl)-3,3-Difluoroallyl)-5,5-Difluoro-2-Phenylpent-4-Enenitrile (3ab)



66.8 mg, 70% yield; yellow solid, mp: 92–93 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22–7.25 (m, 2H), 7.17 (t, J = 3.2 Hz, 3H), 7.05 (d, J = 7.6 Hz, 2H), 6.85 (d, J = 7.6 Hz, 2H), 6.80 (s, 2H), 3.11 (d, J = 14.8 Hz, 2H), 2.93 (d, J = 14.4 Hz, 2H), 2.25 (s, 6H), 2.22 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9 (t, $^1J_{F\text{-}C}$ = 289.0 Hz), 136.7, 136.4, 136.1, 130.0, 129.8 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 129.8 (d, $^4J_{F\text{-}C}$ = 2.2 Hz), 129.6, 128.1, 127.6, 126.3, 126.2 (t, $^3J_{F\text{-}C}$ = 2.0 Hz), 119.8, 88.9 (t, $^2J_{F\text{-}C}$ = 19.0 Hz), 48.2, 39.2, 19.7, 19.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ -88.2 (d, J = 33.8 Hz, 2F), -89.4 (d, J = 37.6 Hz, 2F); IR (KBr): 3031, 2937, 2871, 2241, 1727, 1501, 1449, 1250, 1120 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{30}H_{27}F_4N$+H, 478.2152; found, 478.2157.

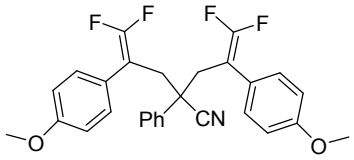
4-(4-(*tert*-Butyl)phenyl)-2-(2-(4-(*tert*-Butyl)phenyl)-3,3-Difluoroallyl)-5,5-Difluoro-2-Phenylpent-4-Enenitrile (3ac)



75.7 mg, 71% yield; white solid, mp: 135–136 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16 (dd, J = 6.8

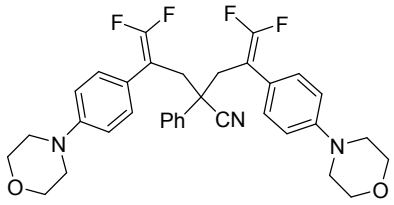
Hz, 1.2 Hz, 4H), 7.06–7.07 (m, 2H), 6.95–6.97 (m, 3H), 6.89 (d, J = 6.4 Hz, 4H), 3.09 (d, J = 11.6 Hz, 2H), 2.90 (d, J = 11.6 Hz, 2H), 1.26 (d, J = 1.2 Hz, 18H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.0 (t, $^1J_{F\text{-}C}$ = 231.5 Hz), 150.4, 136.3, 129.4 (t, $^3J_{F\text{-}C}$ = 2.0 Hz), 128.4, 128.1, 127.6, 126.3, 125.1, 119.9, 88.9 (t, $^2J_{F\text{-}C}$ = 15.0 Hz), 48.6, 39.3, 34.5, 31.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.8 (d, J = 26.3 Hz, 2F), -89.2 (d, J = 30.1 Hz, 2F); IR (KBr): 3045, 2959, 2241, 1727, 1504, 1460, 1250, 1116 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{34}H_{35}F_4N$+Na, 556.2593; found, 556.2595.

2-(3,3-Difluoro-2-(4-Methoxyphenyl)allyl)-5,5-Difluoro-4-(4-Methoxyphenyl)-2-Phenylpent-4-Enenitrile (3ad)



67.4 mg, 70% yield; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.13–7.15 (m, 5H), 6.92 (d, J = 8.4 Hz, 4H), 6.73 (d, J = 8.4 Hz, 4H), 3.74 (s, 6H), 3.04 (d, J = 14.4 Hz, 2H), 2.89 (d, J = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.1, 154.9 (t, $^1J_{F\text{-}C}$ = 289.0 Hz), 136.5, 130.0, 128.3, 127.8, 126.3, 124.4 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 124.4 (d, $^4J_{F\text{-}C}$ = 2.4 Hz), 119.8, 113.8, 88.6 (t, $^2J_{F\text{-}C}$ = 19.0 Hz), 55.2, 48.0, 39.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ -88.4 (d, J = 33.8 Hz, 2F), -89.8 (d, J = 33.8 Hz, 2F); IR (KBr): 3047, 2940, 2845, 2240, 1726, 1604, 1510, 1453, 1250, 1121, 1030 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{28}H_{23}F_4NO_2$+Na, 504.1557; found, 504.1556.

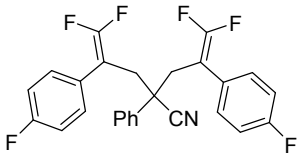
2-(3,3-Difluoro-2-(4-Morpholinophenyl)allyl)-5,5-Difluoro-4-(4-Morpholinophenyl)-2-Phenylpent-4-Enenitrile (3ae)



91.1 mg, 77% yield; white solid, mp: 124–125 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.13–7.23 (m, 5H), 6.96 (d, J = 8.0 Hz, 4H), 6.77 (d, J = 8.8 Hz, 4H), 3.86 (t, J = 4.8 Hz, 8H), 3.15 (t, J = 4.8 Hz, 8H), 3.08 (d, J = 14.4 Hz, 2H), 2.92 (d, J = 14.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.8 (t, $^1J_{F\text{-}C}$ = 288.5 Hz), 150.5, 136.8, 129.6, 128.3, 127.8, 126.3, 123.3 (d, $^4J_{F\text{-}C}$ = 2.4 Hz),

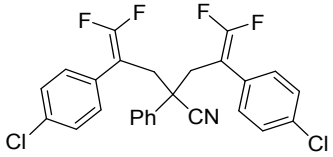
123.3 (d, $^{4}J_{F\text{-}C}$ = 2.4 Hz), 119.9, 115.1, 88.6 (t, $^{2}J_{F\text{-}C}$ = 18.5 Hz), 66.8, 48.9, 48.0, 39.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -88.4 (d, *J* = 37.6 Hz, 2F), -90.1 (d, *J* = 33.8 Hz, 2F); IR (KBr): 3049, 2963, 2842, 1726, 1610, 1516, 1449, 1239, 1121 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{34}H_{33}F_4N_3O_2$+H, 592.2582; found, 592.2586.

2-(3,3-Difluoro-2-(4-Fluorophenyl)allyl)-5,5-Difluoro-4-(4-Fluorophenyl)-2-Phenylpent-4-Enenitrile (3af)



64.9 mg, 71% yield; white solid, mp: 132–133 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.14 (s, 5H), 6.98 (dd, *J* = 8.4 Hz, 5.2Hz, 4H), 6.90 (t, *J* = 8.4 Hz, 4H), 3.14 (d, *J* = 14.8 Hz, 2H), 2.98 (d, *J* = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.1 (d, $^{1}J_{F\text{-}C}$ = 246.0 Hz), 155.0 (t, $^{1}J_{F\text{-}C}$ = 289.5 Hz), 135.8, 130.5 (t, $^{3}J_{F\text{-}C}$ = 2.3 Hz), 130.5 (t, $^{3}J_{F\text{-}C}$ = 2.4 Hz), 128.4, 128.1, 128.0, 126.2, 119.7, 115.3 (d, $^{2}J_{F\text{-}C}$ = 21.0 Hz), 88.2 (t, $^{2}J_{F\text{-}C}$ = 19.0 Hz), 47.9, 39.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.5 (d, *J* = 33.8 Hz, 2F), -88.7 (d, *J* = 33.8 Hz, 2F), -113.8 (s, 1F); IR (KBr): 3055, 2936, 2858, 2238, 1730, 1508, 1238, 1132 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{26}H_{17}F_6N$+Na, 480.1157; found, 480.1161.

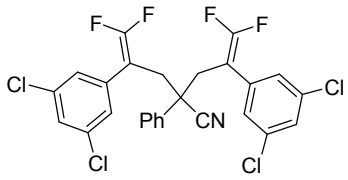
4-(4-Chlorophenyl)-2-(2-(4-Chlorophenyl)-3,3-Difluoroallyl)-5,5-Difluoro-2-Phenylpent-4-Enenitrile (3ag)



61.6 mg, 63% yield; yellow solid, mp: 116–117 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.14 (d, *J* = 6.8 Hz, 4H), 7.09–7.12 (m, 5H), 6.90 (d, *J* = 6.4 Hz, 4H), 3.09 (d, *J* = 11.6 Hz, 2H), 2.92 (d, *J* = 11.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9 (t, $^{1}J_{F\text{-}C}$ = 232.0 Hz), 135.7, 133.6, 130.7 (d, $^{4}J_{F\text{-}C}$ = 2.2 Hz), 130.7 (d, $^{4}J_{F\text{-}C}$ = 2.2 Hz), 130.1 (t, $^{3}J_{F\text{-}C}$ = 1.5 Hz), 128.5, 128.4, 128.1, 126.2, 119.6, 88.2 (t, $^{2}J_{F\text{-}C}$ = 15.0 Hz), 48.0, 39.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -86.6 (d, *J* = 26.3 Hz, 2F), -88.0 (d, *J* = 22.6 Hz, 2F); IR (KBr): 3054, 2938, 2860, 2240, 1726, 1493, 1313, 1252, 1101 cm^{-1}; HRMS

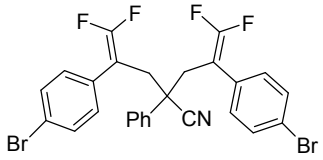
(ESI, m/z): $[M+H]^+$ Calcd. for $C_{26}H_{17}Cl_2F_4N+H$, 490.0747; found, 490.0751.

4-(3,5-Dichlorophenyl)-2-(2-(3,5-Dichlorophenyl)-3,3-Difluoroallyl)-5,5-Difluoro-2-Phenylpent-4-Enenitrile (3ah)



66.8 mg, 60% yield; white solid, mp: 111–112 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.12 (t, J = 1.6 Hz, 2H), 7.10 (s, 5H), 6.81 (s, 4H), 3.18 (dd, J = 14.8 Hz, 1.6Hz, 2H), 2.96 (dt, J = 14.4 Hz, 2.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.2 (t, $^1J_{F\text{-}C}$ = 292.0 Hz), 135.2 (d, $^4J_{F\text{-}C}$ = 2.5 Hz), 135.2 (d, $^4J_{F\text{-}C}$ = 2.5 Hz), 134.7, 134.5, 128.7, 128.2, 127.8, 127.2 (t, $^3J_{F\text{-}C}$ = 2.5 Hz), 126.2, 119.4, 87.5 (t, $^2J_{F\text{-}C}$ = 19.5 Hz), 48.4, 39.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -85.1 (d, J = 26.3 Hz, 2F), -85.8 (d, J = 26.3 Hz, 2F); IR (KBr): 3077, 2935, 2855, 2244, 1727, 1574, 1433, 1310, 1254, 1132 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{26}H_{17}F_6N+Na$, 579.9784; found, 579.9780.

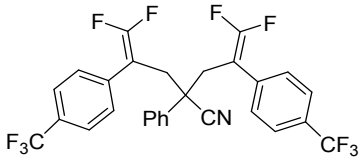
4-(4-Bromophenyl)-2-(2-(4-Bromophenyl)-3,3-Difluoroallyl)-5,5-Difluoro-2-Phenylpent-4-Enenitrile (3ai)



76.6 mg, 66% yield; yellow solid, mp: 116–117 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 (d, J = 6.8 Hz, 4H), 7.11–7.14 (m, 1H), 7.09 (d, J = 3.6 Hz, 4H), 6.84 (d, J = 6.8 Hz, 4H), 3.09 (d, J = 11.6 Hz, 2H), 2.92 (d, J = 11.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9 (t, $^1J_{F\text{-}C}$ = 232.0 Hz), 135.7, 131.5, 131.2 (d, $^4J_{F\text{-}C}$ = 2.2 Hz), 131.2 (d, $^4J_{F\text{-}C}$ = 2.2 Hz), 130.4 (t, $^3J_{F\text{-}C}$ = 2.0 Hz), 128.5, 128.1, 126.2, 121.8, 119.6, 88.2 (t, $^2J_{F\text{-}C}$ = 15.5 Hz), 48.1, 39.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -86.5 (d, J = 22.6 Hz, 2F), -87.9 (d, J = 26.3 Hz, 2F); IR (KBr): 3056, 2943, 2855, 2240, 1725, 1490, 1312, 1252, 1109 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{26}H_{17}Br_2F_4N+H$, 579.9716; found, 579.9722.

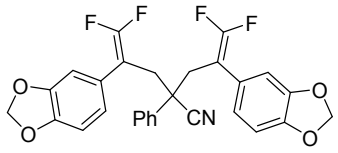
2-(3,3-Difluoro-2-(4-(Trifluoromethyl)phenyl)allyl)-5,5-Difluoro-2-Phenyl-4-(4-

(Trifluoromethyl)phenyl)pent-4-Enenitrile (3aj)



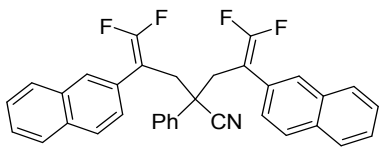
82.5 mg, 74% yield; white solid, mp: 138–139 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 (d, J = 8.0 Hz, 4H), 7.10 (d, J = 8.0 Hz, 4H), 7.00–7.07 (m, 5H), 3.22 (d, J = 14.8 Hz, 2H), 3.03 (d, J = 14.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.2 (t, $^{1}J_{F\text{-}C}$ = 291.0 Hz), 136.1 (t, $^{4}J_{F\text{-}C}$ = 1.5 Hz), 135.1, 129.7 (q, $^{2}J_{F\text{-}C}$ = 32.4 Hz), 129.1 (t, $^{3}J_{F\text{-}C}$ = 2.4 Hz), 128.4, 128.2, 126.2, 125.1 (q, $^{3}J_{F\text{-}C}$ = 3.8 Hz), 123.9 (q, $^{1}J_{F\text{-}C}$ = 269.9 Hz), 119.5, 88.3 (t, $^{2}J_{F\text{-}C}$ = 19.5 Hz), 48.3, 39.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.9 (s, 6F), -85.7 (d, J = 26.3 Hz, 2F), -87.2 (d, J = 26.3 Hz, 2F); IR (KBr): 3061, 2929, 2855, 2236, 1734, 1326, 1247, 1160, 1078 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{28}H_{17}F_{10}N$+H, 558.1274; found, 558.1276.

4-(Benzo[*d*][1,3]dioxol-5-yl)-2-(2-(Benzo[*d*][1,3]dioxol-5-yl)-3,3-Difluoroallyl)-5,5-Difluoro-2-Phenylpent-4-Enenitrile (3ak)



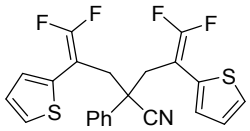
63.1 mg, 62% yield; yellow solid, mp: 111–112 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16 (s, 5H), 6.64 (d, J = 8.0 Hz, 2H), 6.49 (d, J = 8.0 Hz, 2H), 6.44 (s, 2H), 5.88 (s, 4H), 3.03 (d, J = 14.4 Hz, 2H), 2.88 (d, J = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9 (t, $^{1}J_{F\text{-}C}$ = 289.0 Hz), 147.5, 147.1, 136.3, 128.3, 127.9, 126.3, 125.8 (d, $^{3}J_{F\text{-}C}$ = 2.0 Hz), 125.8 (d, $^{3}J_{F\text{-}C}$ = 2.0 Hz), 122.6, 119.7, 109.2, 109.2, 101.1, 88.7 (t, $^{2}J_{F\text{-}C}$ = 19.0 Hz), 47.9, 39.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ -88.1 (d, J = 26.3 Hz, 2F), -89.0 (d, J =26.3 Hz, 2F); IR (KBr): 3061, 2900, 2778, 2241, 1728, 1495, 1447, 1337, 1248, 1111, 1036 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{28}H_{19}F_4NO_4$+Na, 532.1142; found, 532.1138.

2-(3,3-Difluoro-2-(Naphthalen-2-yl)allyl)-5,5-Difluoro-4-(Naphthalen-2-yl)-2-Phenylpent-4-Enenitrile (3al)



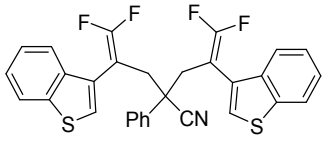
76.1 mg, 73% yield; white solid, mp: 127–128 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (dd, J = 5.2 Hz, 2.8 Hz, 2H), 7.62–7.64 (m, 4H), 7.38–7.40 (m, 6H), 7.13 (dd, J = 6.0 Hz, 1.2 Hz, 2H), 7.09 (dd, J = 6.8 Hz, 0.8 Hz, 2H), 6.90 (t, J = 6.0 Hz, 2H), 6.82 (t, J = 5.6 Hz, 1H), 3.16 (dd, J = 11.6 Hz, 1.6 Hz, 2H), 2.97 (d, J = 11.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.2 (t, $^1J_{F\text{-}C}$ = 232.0 Hz), 136.3, 133.1, 132.6, 129.9 (t, $^3J_{F\text{-}C}$ = 2.5 Hz), 128.3, 128.2, 128.1, 128.0, 127.9, 127.7, 126.4, 126.3, 126.3, 126.3, 119.9, 89.2 (t, $^2J_{F\text{-}C}$ = 15.0 Hz), 48.5, 39.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ -86.8 (d, J = 22.6 Hz, 2F), -88.4 (d, J = 26.3 Hz, 2F); IR (KBr): 3055, 2934, 2854, 2240, 1724, 1500, 1445, 1360, 1251, 1122 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{34}H_{23}F_4N$+Na, 544.1659; found, 544.1661.

2-(3,3-Difluoro-2-(Thiophen-2-yl)allyl)-5,5-Difluoro-2-Phenyl-4-(Thiophen-2-yl)pent-4-Enenitrile (3am)



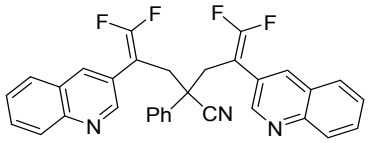
45.0 mg, 52% yield; yellow solid, mp: 115–116 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26–7.29 (m, 2H), 7.22–7.24 (m, 5H), 6.99 (d, J = 1.6 Hz, 2H), 6.90 (d, J = 5.2 Hz, 2H), 3.14 (d, J = 14.4 Hz, 2H), 2.98 (d, J = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.1 (t, $^1J_{F\text{-}C}$ = 290.5 Hz), 136.6, 132.3 (t, $^3J_{F\text{-}C}$ = 3.5 Hz), 128.5, 128.1, 127.2 (t, $^3J_{F\text{-}C}$ = 3.0 Hz), 126.2, 125.6, 123.6 (t, $^3J_{F\text{-}C}$ = 3.5 Hz), 119.7, 84.9 (t, $^2J_{F\text{-}C}$ = 19.5 Hz), 48.2, 39.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -86.1 (d, J = 33.8 Hz, 2F), -86.8 (d, J = 33.8 Hz, 2F); IR (KBr): 3094, 2933, 2862, 2240, 1724, 1455, 1385, 1260, 1111 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{22}H_{15}F_4NS_2$+H, 434.0653; found, 434.0651.

4-(Benzo[*b*]thiophen-3-yl)-2-(2-(Benzo[*b*]thiophen-3-yl)-3,3-Difluoroallyl)-5,5-Difluoro-2-Phenylpent-4-Enenitrile (3an)



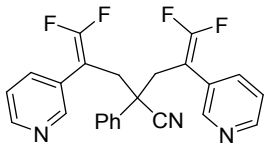
82.1 mg, 77% yield; white solid, mp: 93–94 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78–7.82 (m, 2H), 7.42–7.44 (m, 2H), 7.34–7.38 (m, 4H), 7.05 (d, J = 7.2 Hz, 2H), 7.02 (s, 2H), 6.90–6.98 (m, 3H), 3.21 (d, J = 14.4 Hz, 2H), 3.06 (d, J = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.2 (t, $^1J_{F\text{-}C}$ = 291.0 Hz), 139.8, 137.2, 135.3, 127.9, 127.8, 127.4 (d, $^4J_{F\text{-}C}$ = 1.7 Hz), 127.4 (d, $^4J_{F\text{-}C}$ = 1.7 Hz), 126.4 (d, $^3J_{F\text{-}C}$ = 4.0 Hz), 125.9, 124.5, 124.2, 122.7, 122.5 (d, $^4J_{F\text{-}C}$ = 1.0 Hz), 119.7, 83.2 (t, $^2J_{F\text{-}C}$ = 21.0 Hz), 48.4, 39.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ -82.9 (d, J = 30.1 Hz, 2F), -86.0 (d, J = 30.1 Hz, 2F); IR (KBr): 3070, 2938, 2854, 2242, 1728, 1438, 1271, 1110 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{30}H_{19}F_4NS_2$+Na, 556.0787; found, 556.0782.

2-(3,3-Difluoro-2-(Quinolin-3-yl)allyl)-5,5-Difluoro-2-Phenyl-4-(Quinolin-3-yl)pent-4-Enenitrile (3ao)



64.9 mg, 62% yield; yellow solid, mp: 153–154 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.49 (s, 2H), 7.99 (d, J = 8.4 Hz, 2H), 7.61–7.68 (m, 6H), 7.49 (t, J = 7.2 Hz, 2H), 7.06 (d, J = 7.6 Hz, 2H), 6.82 (t, J = 7.6 Hz, 2H), 6.68 (t, J = 7.2 Hz, 1H), 3.34 (d, J = 14.4 Hz, 2H), 3.13 (d, J = 14.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6 (t, $^1J_{F\text{-}C}$ = 291.5 Hz), 149.9, 146.9, 135.8 (t, $^3J_{F\text{-}C}$ = 2.5 Hz), 134.9, 129.8, 129.1, 128.4, 128.1, 127.6, 127.1, 127.0, 126.1, 125.4 (t, $^3J_{F\text{-}C}$ = 3.0 Hz), 119.8, 86.5 (t, $^2J_{F\text{-}C}$ = 19.5 Hz), 48.4, 39.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -84.8 (d, J = 26.3 Hz, 2F), -86.9 (d, J = 30.1 Hz, 2F); IR (KBr): 3058, 2934, 2856, 2240, 1726, 1491, 1449, 1359, 1264, 1122 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{32}H_{21}F_4N_3$+H, 524.1744; found, 524.1748.

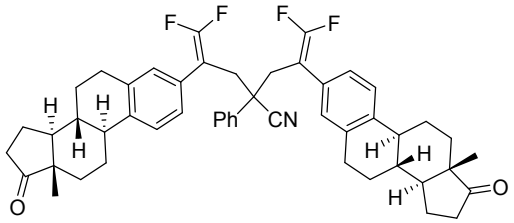
2-(3,3-Difluoro-2-(Pyridin-3-yl)allyl)-5,5-Difluoro-2-Phenyl-4-(Pyridin-3-yl)pent-4-Enenitrile (3ap)



53.3 mg, 63% yield; white solid, mp: 135–136 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37 (d, J = 4.4 Hz, 2H), 8.21 (s, 2H), 7.26 (d, J = 8.0 Hz, 2H), 7.07 (t, J = 5.6 Hz, 7H), 3.22 (d, J = 14.4 Hz, 2H),

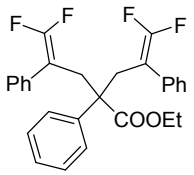
3.03 (d, J = 14.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.3 (t, $^1J_{F\text{-}C}$ = 291.0 Hz), 149.5 (t, $^3J_{F\text{-}C}$ = 3.0 Hz), 148.7, 136.1 (t, $^3J_{F\text{-}C}$ = 2.0 Hz), 134.8, 128.6, 128.4, 128.4 (d, $^4J_{F\text{-}C}$ = 3.1 Hz), 128.4 (d, $^4J_{F\text{-}C}$ = 2.8 Hz), 126.2, 123.0, 119.6, 86.2 (t, $^2J_{F\text{-}C}$ = 19.5 Hz), 48.1, 39.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -85.2 (d, J = 30.1 Hz, 2F), -87.2 (d, J = 30.1 Hz, 2F); IR (KBr): 3042, 2925, 2855, 2242, 1727, 1470, 1253, 1128 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{24}H_{17}F_4N_3$+H, 424.1431; found, 424.1434.

2-(3,3-Difluoro-2-((8*R*,9*S*,13*S*,14*S*)-13-Methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-Decahydro-6*H*-Cyclopenta[*a*]phenanthren-3-yl)allyl)-5,5-Difluoro-4-((8*R*,9*S*,13*S*,14*S*)-13-Methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-Decahydro-6*H*-Cyclopenta[*a*]phenanthren-3-yl)-2-Phenylpent-4-Enenitrile (3aq)



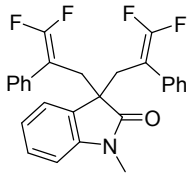
94.4 mg, 61% yield; white solid, mp: 113–114 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.14 (d, J = 7.2 Hz, 4H), 7.09 (d, J = 3.2 Hz, 3H), 6.85 (t, J = 7.6 Hz, 2H), 6.69 (d, J = 6.8 Hz, 2H), 3.10 (d, J = 14.4 Hz, 2H), 2.91 (d, J = 14.4 Hz, 2H), 2.78 (d, J = 3.2 Hz, 4H), 2.53 (dd, J = 18.4 Hz, 8.4 Hz, 2H), 2.38 (s, 2H), 1.97–2.19 (m, 8H), 1.36–1.65 (m, 13H), 1.30 (d, J = 11.2 Hz, 1H), 0.94 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 154.9 (t, $^1J_{F\text{-}C}$ = 289.0 Hz), 139.2, 136.6, 136.3 (d, J = 1.0 Hz), 129.7 (t, $^3J_{F\text{-}C}$ = 2.0 Hz), 129.6 (t, $^3J_{F\text{-}C}$ = 2.0 Hz), 129.5, 129.4, 127.9, 127.4, 126.3, 126.0 (t, $^3J_{F\text{-}C}$ = 3.5 Hz), 125.2, 119.8, 88.8 (t, $^2J_{F\text{-}C}$ = 18.3 Hz), 88.8 (t, $^2J_{F\text{-}C}$ = 18.4 Hz), 60.4, 50.5, 48.3, 48.0, 44.3, 44.3, 39.2, 39.1, 38.0, 35.9, 31.6, 29.2, 26.4, 25.6, 21.6, 21.1, 14.2, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ -87.9 (t, J = 30.1 Hz, 2F), -89.0 (d, J = 37.6 Hz, 2F); IR (KBr): 3053, 2929, 2864, 2241, 1730, 1452, 1248, 1117 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{50}H_{51}F_4NO_2$+Na, 796.3748; found, 796.3757.

Ethyl 2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-2,4-Diphenylpent-4-Enoate (5g)



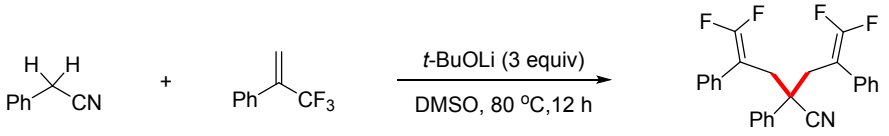
41.2 mg, 44% yield; white solid, mp: 75–76 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.12–7.19 (m, 6H), 7.01–7.05 (m, 7H), 6.94–6.96 (m, 2H), 3.35 (q, *J* = 5.6 Hz, 2H), 3.20 (d, *J* = 11.6 Hz, 2H), 3.09 (d, *J* = 12.0 Hz, 2H), 0.86 (t, *J* = 5.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.9, 154.3 (t, $^{1}J_{F\text{-}C}$ = 229.5 Hz), 141.2, 132.9, 129.2, 127.9, 127.7, 127.2, 126.6, 89.6 (t, $^{2}J_{F\text{-}C}$ = 14.5 Hz), 60.7, 34.5, 29.8, 13.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -90.0 (d, *J* = 37.6 Hz, 2F), -90.7 (d, *J* = 37.6 Hz, 2F); IR (KBr): 3058, 2932, 2856, 2257, 1726, 1596, 1452, 1305, 1230, 1118, 1076 cm^{-1}; HRMS (ESI, m/z): $[M+H]^+$ Calcd. for $C_{28}H_{24}F_4O_2$+H, 469.1785; found, 465.1789.

Ethyl 2-(3,3-Difluoro-2-Phenylallyl)-5,5-Difluoro-2,4-Diphenylpent-4-Enoate (5h)



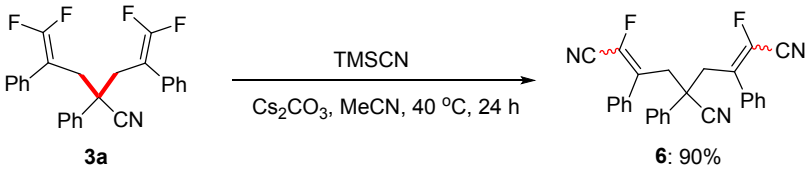
63.1 mg, 70% yield; white solid, mp: 98–99 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22 (t, *J* = 7.6 Hz, 1H), 7.09–7.15 (m, 7H), 6.99 (t, *J* = 7.6 Hz, 1H), 6.79 (d, *J* = 6.4 Hz, 4H), 6.48 (d, *J* = 8.0 Hz, 1H), 3.09 (d, *J* = 14.4 Hz, 2H), 2.95 (d, *J* = 14.0 Hz, 2H), 2.15 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.1, 154.0 (t, $^{1}J_{F\text{-}C}$ = 287.0 Hz), 143.9, 131.8 (d, $^{4}J_{F\text{-}C}$ = 2.5 Hz), 131.7 (d, $^{4}J_{F\text{-}C}$ = 2.6 Hz), 129.2, 128.6, 128.2, 127.7, 127.4, 123.9, 122.1 107.4, 89.5 (t, $^{2}J_{F\text{-}C}$ = 18.5 Hz), 52.1, 35.2, 25.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -89.6 (d, *J* = 37.6 Hz, 2F), -91.9 (d, *J* = 37.6 Hz, 2F); IR (KBr): 3053, 2932, 2852, 1723, 1612, 1475, 1241, 1125 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{27}H_{21}F_4NO$+Na, 474.1451; found, 474.1456.

D□ Procedure for the Gram-Scale Synthesis and Transformation of the Products



A 250 mL round-bottom flask equipped with a magnetic stirring bar, oxime phenylacetonitrile **1a** (0.585 g, 5 mmol), 2-trifluoromethyl-1-alkene **2a** (2.58 g, 15 mmol), *t*-BuOLi (1.2 g, 15 mmol), and DMSO (100 mL) was vigorously stirred at 80 °C for 12 h under N_2. Then the mixture was cooled to room temperature, added water (150 mL), extracted with EtOAc (150 mL × 3). The combined organic phases were washed with brine (150 mL × 3), dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Further purification by flash column chromatography on silica gel (eluting with petroleum ether/ethyl acetate = 30/1) provided the product **3a** in 65% isolated yield (1.368 g).

Synthesis of product 6



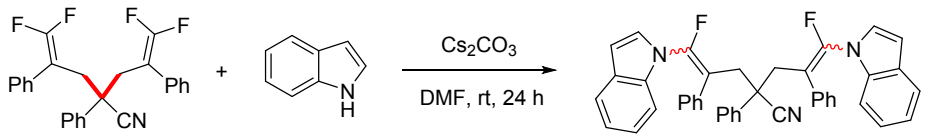
An oven-dried 25mL Schlenk tube equipped with a magnetic stirring bar was added Cs_2CO_3 (13.0 mg, 0.04 mmol), TMSCN (99.2 mg, 1.0 mmol), MeCN (2 mL) and **3a** (84.2 mg, 0.2 mmol) at room temperature. The mixture was stirred at 40 °C for 48 h under N_2. Then added distilled water (15 mL), and extracted with EtOAc (15 mL × 3). The combined organic layers were dried over Na_2SO_4, and concentrated *in vacuo*. The residue was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 8:1) to give the product **6** in 90% isolated yield.

1,7-Difluoro-2,4,6-Triphenylhepta-1,6-Diene-1,4,7-Tricarbonitrile (6)

78.3 mg, 90% yield; colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (t, J = 7.2 Hz, 2H), 7.30 (t, J = 7.2 Hz, 4H), 7.17–7.23 (m, 3H), 7.12 (d, J = 7.2 Hz, 2H), 7.06 (d, J = 7.6 Hz, 4H), 3.32 (s, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 134.4, 133.8 (d, $^1J_{F\text{-}C}$ = 149.3 Hz), 131.3 (d, $^3J_{F\text{-}C}$ = 3.0 Hz), 130.6, 130.3, 128.9, 128.8, 128.7, 128.5 (d, $^3J_{F\text{-}C}$ = 3.0 Hz), 125.9, 118.3, 111.5 (d, $^2J_{F\text{-}C}$ = 47.0 Hz), 46.2, 40.7; ^{19}F NMR (376 MHz, $CDCl_3$) δ -117.2 (s, 2F); IR (KBr): 3057, 2932, 2860, 2231,

1648, 1493, 1445, 1268, 1199 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{28}H_{19}F_2N_3$+Na, 458.1437; found, 458.1434.

Synthesis of product 7



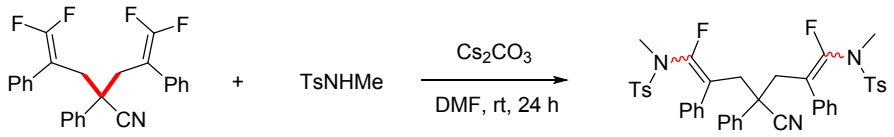
3a **7**: 81%

To a 25 mL oven-dried Schlenk tube equipped with a magnetic stirring bar was added Cs_2CO_3 (234.6 mg, 0.72 mmol), indole (58.6 mg, 0.5 mmol), DMF (2 mL) and **3a** (101.0 mg, 0.24 mmol). The mixture was stirred at room temperature for 24 h. Then added distilled water (15 mL), and extracted with EtOAc (15 mL × 3). The combined organic layers were dried over Na_2SO_4, and concentrated *in vacuo*. The residue was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 15:1) to give the product **7** in 81% isolated yield.

5-Fluoro-2-(3-Fluoro-3-(1*H*-Indol-1-yl)-2-Phenylallyl)-5-(1*H*-Indol-1-yl)-2,4-Diphenylpent-4-Enenitrile (7)

99.7 mg, 81% yield; white solid, mp: 173–174 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (d, J = 8.0 Hz, 2H), 7.41–7.43 (m, 2H), 7.16–7.28 (m, 9H), 7.04–7.13 (m, 6H), 6.80 (d, J = 7.2 Hz, 4H), 6.57 (d, J = 3.2 Hz, 2H), 6.35 (d, J = 3.2 Hz, 2H), 3.52 (dd, J = 22.0 Hz, 14.0 Hz, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.3 (d, $^1J_{F\text{-}C}$ = 265.0 Hz), 136.5, 136.1 (d, $^3J_{F\text{-}C}$ = 3.0 Hz), 134.6 (d, $^3J_{F\text{-}C}$ = 4.0 Hz), 128.4, 128.4, 128.3, 128.2, 128.2, 127.9, 127.7, 127.4, 127.4, 126.9, 123.2, 121.4, 120.8, 119.9, 111.5, 111.5, 111.3 (d, $^2J_{F\text{-}C}$ = 26.2 Hz), 105.1, 48.2, 41.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -85.0 (s, 2F); IR (KBr): 3052, 2923, 2852, 2242, 1693, 1598, 1457, 1328, 1222, 1137 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{42}H_{31}F_2N_3$+Na, 638.2378; found, 638.2371.

Synthesis of product 8



3a **8**: 96%

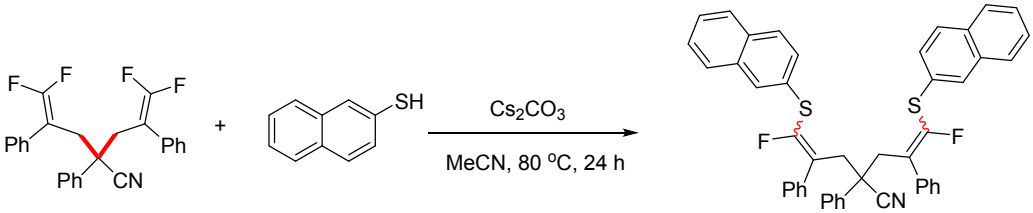
An oven-dried 25mL Schlenk tube equipped with a magnetic stirring bar was added Cs_2CO_3

(195.5 mg, 0.6 mmol), *N,* 4-dimethylbenzenesulfonamide (111.1 mg, 0.6 mmol), DMF (2 mL) and **3a** (84.2 mg, 0.2 mmol). The mixture was stirred at the room temperature for 24 h. Then added distilled water (15 mL), and extracted with EtOAc (15 mL × 3). The combined organic layers were dried over Na_2SO_4, and concentrated *in vacuo*. The residue was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to give the product **8** in 96% isolated yield.

***N,N'*-(4-Cyano-1,7-Difluoro-2,4,6-Triphenylhepta-1,6-Diene-1,7-diyl)bis(*N*,4-Dimethylbenzenesulfonamide) (8)**

144.8 mg, 96% yield; white solid, mp: 156–157 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (d, J = 7.6 Hz, 4H), 7.16–7.23 (m, 15H), 7.00 (d, J = 5.2 Hz, 4H), 3.29 (d, J = 13.6 Hz, 2H), 3.18 (d, J = 14.0 Hz, 2H), 2.70 (s, 6H), 2.40 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.7 ($^1J_{F\text{-}C}$ = 279.0 Hz), 144.1, 143.5, 136.4, 135.2 (d, $^3J_{F\text{-}C}$ = 3.0 Hz), 134.8, 129.7, 129.5, 128.6 (d, $^3J_{F\text{-}C}$ = 2.0 Hz), 128.2, 128.1, 128.0, 127.7, 127.3, 126.6, 119.7, 117.3 (d, $^2J_{F\text{-}C}$ = 30.0 Hz), 47.1, 41.4, 36.0, 21.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ -89.8 (s, 2F); IR (KBr): 3055, 2935, 2242, 1686, 1447, 1349, 1164, 1097, 1030 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{42}H_{31}F_2N_3$+Na, 774.2242; found, 774.2240.

Synthesis of product 9



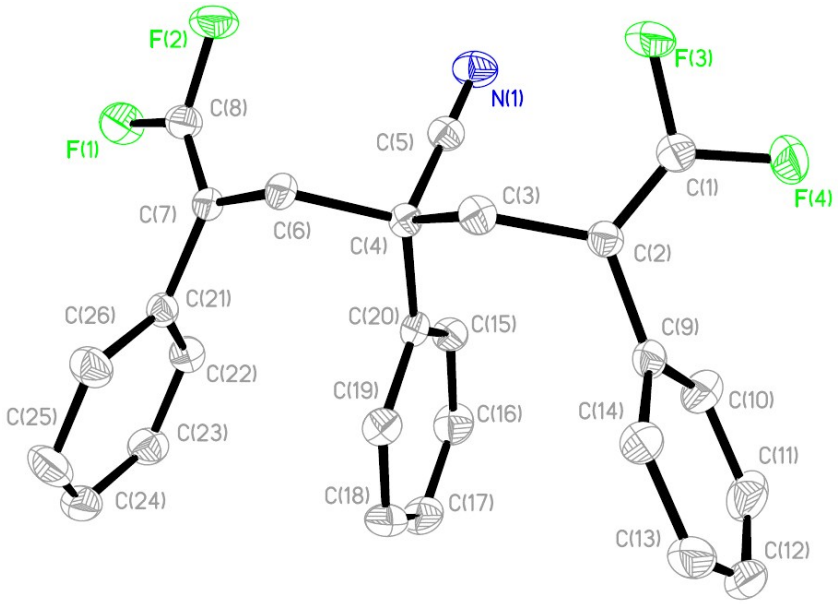
To a 25 mL oven-dried Schlenk tube equipped with a magnetic stirring bar was added Cs_2CO_3 (195.5 mg, 0.6 mmol), 2-naphthalenethiol (96.1 mg, 0.6 mmol), MeCN (3 mL) and **3a** (84.2 mg, 0.2 mmol) at room temperature. The mixture was stirred at 80 °C for 24 h under N_2. Then added distilled water (15 mL), and extracted with EtOAc (15 mL × 3). The combined organic layers were dried over Na_2SO_4, and concentrated *in vacuo*. The residue was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 30:1) to give the product **9** in 91 % isolated yield.

5-Fluoro-2-((3-Fluoro-3-(Naphthalen-2-ylthio)-2-Phenylallyl)-5-(Naphthalen-2-ylthio)-2,4-Diphenylpent-4-Enenitrile (9)

127.6 mg, 91% yield; yellow solid, mp: 73–74 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77–7.86 (m, 8H), 7.53 (t, *J* = 4.0 Hz, 4H), 7.37 (d, *J* = 7.6 Hz, 2H), 7.21–7.32 (m, 11H), 7.12 (d, *J* = 6.8 Hz, 4H), 3.43 (dd, *J* = 18.4 Hz, 14.8 Hz, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.0 (d, $^{1}J_{F\text{-}C}$ = 300.0 Hz), 136.6, 136.4 (d, $^{3}J_{F\text{-}C}$ = 3.0 Hz), 133.8, 132.2, 129.7 (d, $^{3}J_{F\text{-}C}$ = 2.0 Hz), 129.1 (d, $^{3}J_{F\text{-}C}$ = 2.0 Hz), 129.0, 128.5, 128.2, 127.9, 127.8, 127.7, 127.5, 126.8, 126.7, 126.7, 126.5, 126.4, 126.3, 120.0, 47.2, 42.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ -85.3 (s, 2F); IR (KBr): 3053, 2931, 2856, 2243, 1618, 1496, 1443, 1270, 1117, 1026, 743 cm^{-1}; HRMS (ESI, m/z): $[M+Na]^+$ Calcd. for $C_{46}H_{33}F_2NS_2$+Na, 724.1915; found, 724.1922.

E□X-ray Crystallographic Data

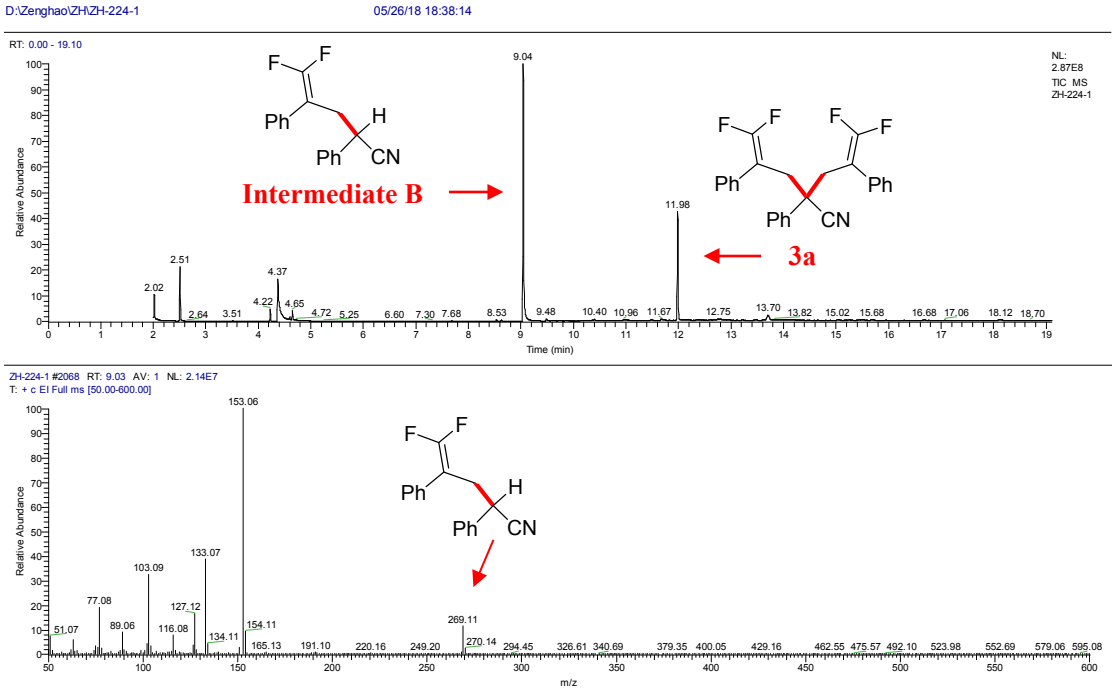
The X-ray crystallographic structures for **3a**. ORTEP representation with 50% probability thermal ellipsoids. Solvent and hydrogen are omitted for clarity. Crystal data have been deposited to CCDC, number 1974572.



Empirical formula	$C_{26}H_{19}F_4N$
Formula weight	421.42
Temperature	210 K
Crystal system, Space group	Orthorhombic, $P2_12_12_1$
Unit cell dimensions	a = 14.572(2) Å α = 90 deg. b = 6.7351(12) Å beta = 90 deg. c = 21.402(4) Å gamma = 90 deg.
Volume	2100.5(6) $Å^3$
Z	4
ρ_{calc}g/cm3	1.333
μ/mm 1	0.102 mm^{-1}
F(000)	872.0
Crystal size	0.28 × 0.15 × 0.12 mm^3
Radiation	MoK\a (λ = 0.71073)
Theta range for data collection	3.806 to 52.932 deg.
Index ranges	-16 ≤ h ≤ 17, -8 ≤ k ≤ 8, -26 ≤ l ≤ 26

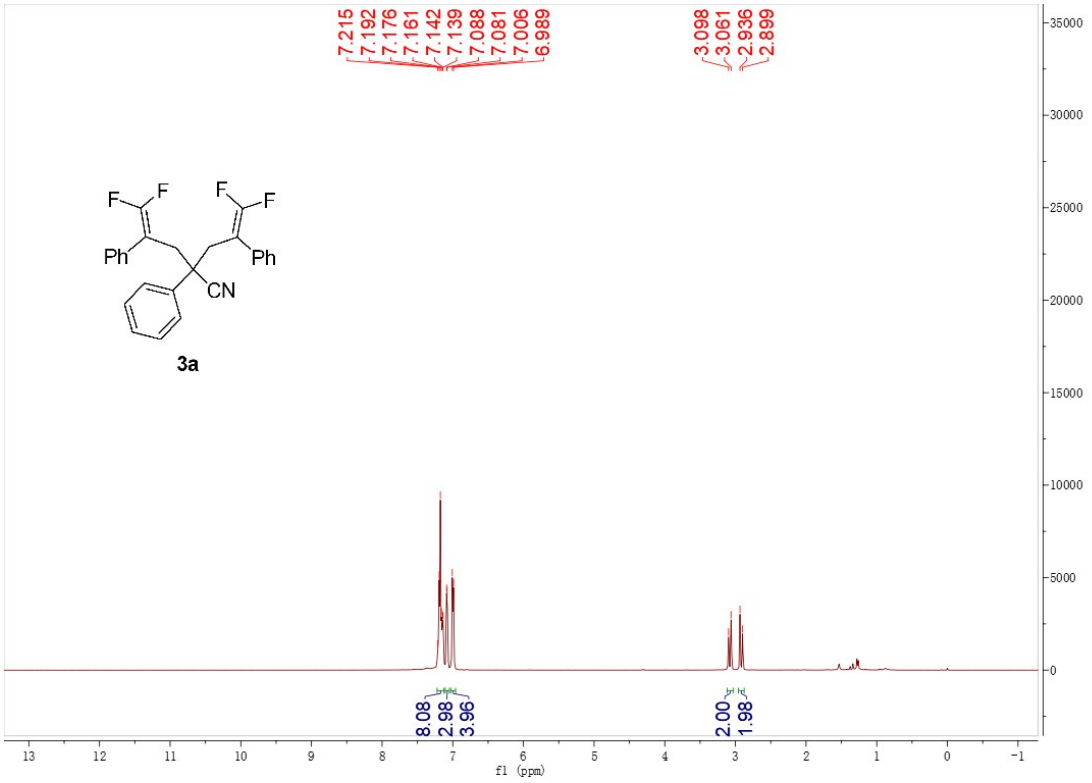
Reflections collected	12001
Independent reflections	4245 [R_{int} = 0.0950, R_{sigma} = 0.1180]
Data/restraints/parameters	4245/0/281
Goodness-of-fit on F^2	0.958
Final R indexes [I>=2σ (I)]	R_1 = 0.0579, wR_2 = 0.1106
Final R indexes [all data]	R_1 = 0.1075, wR_2 = 0.1323

F GC-MS Data of Intermediate B

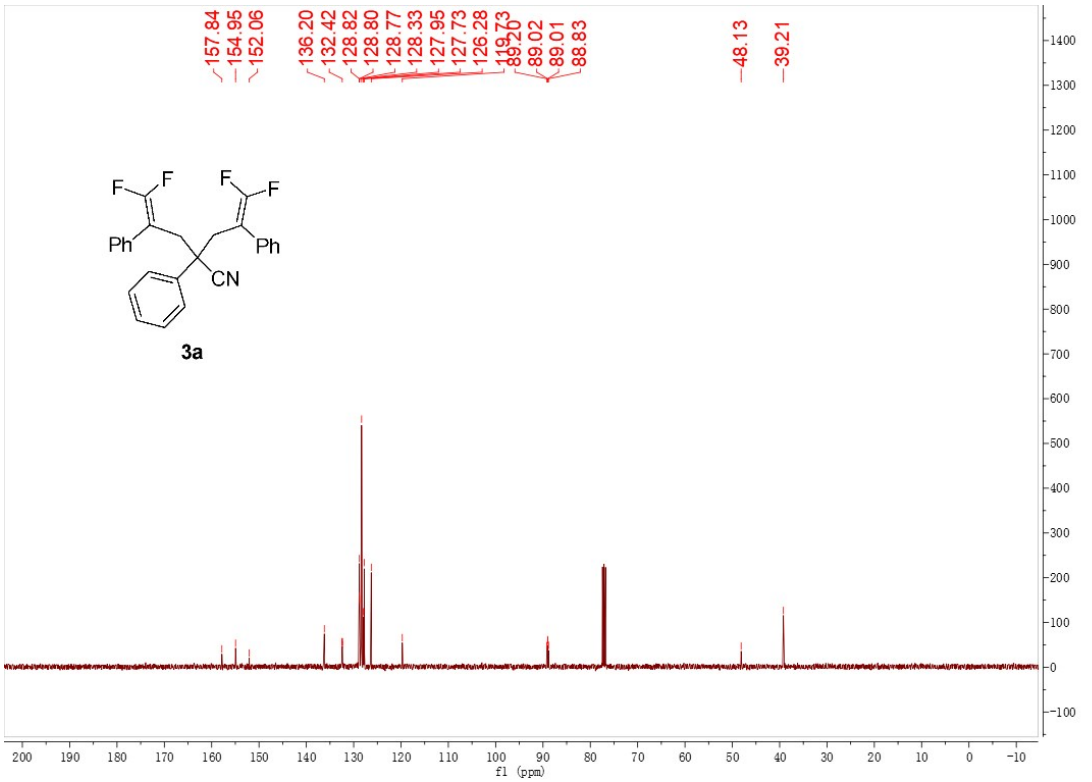


G□ NMR Spectra of New Compounds

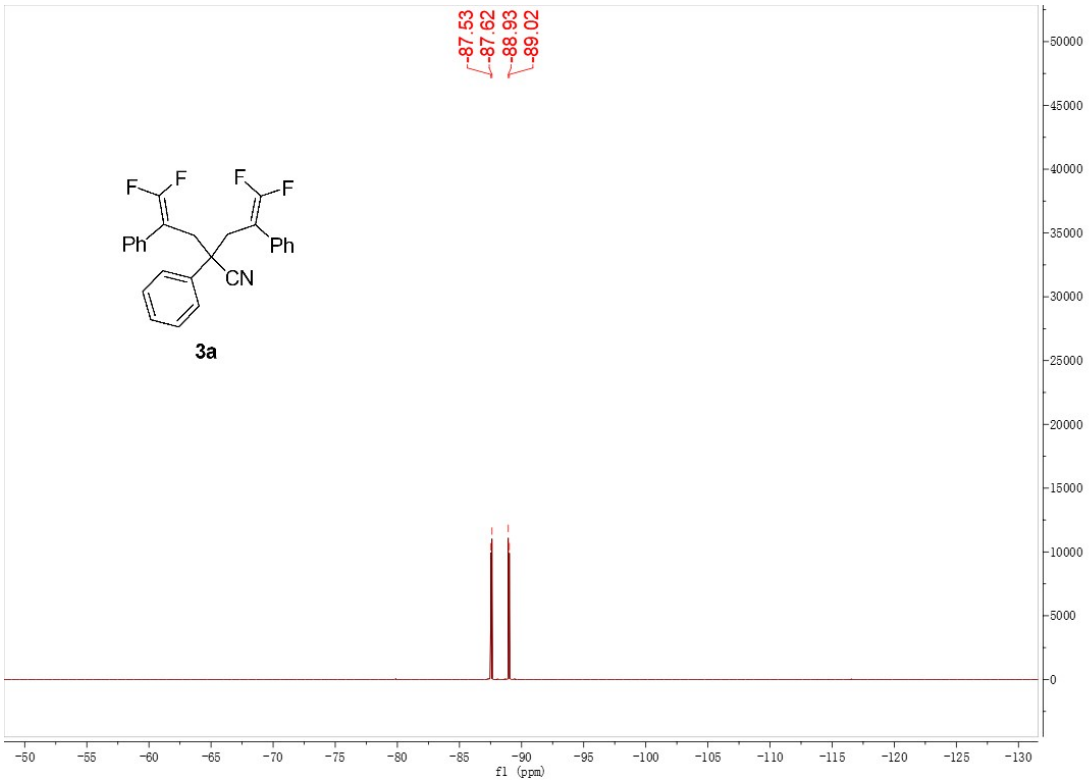
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3a



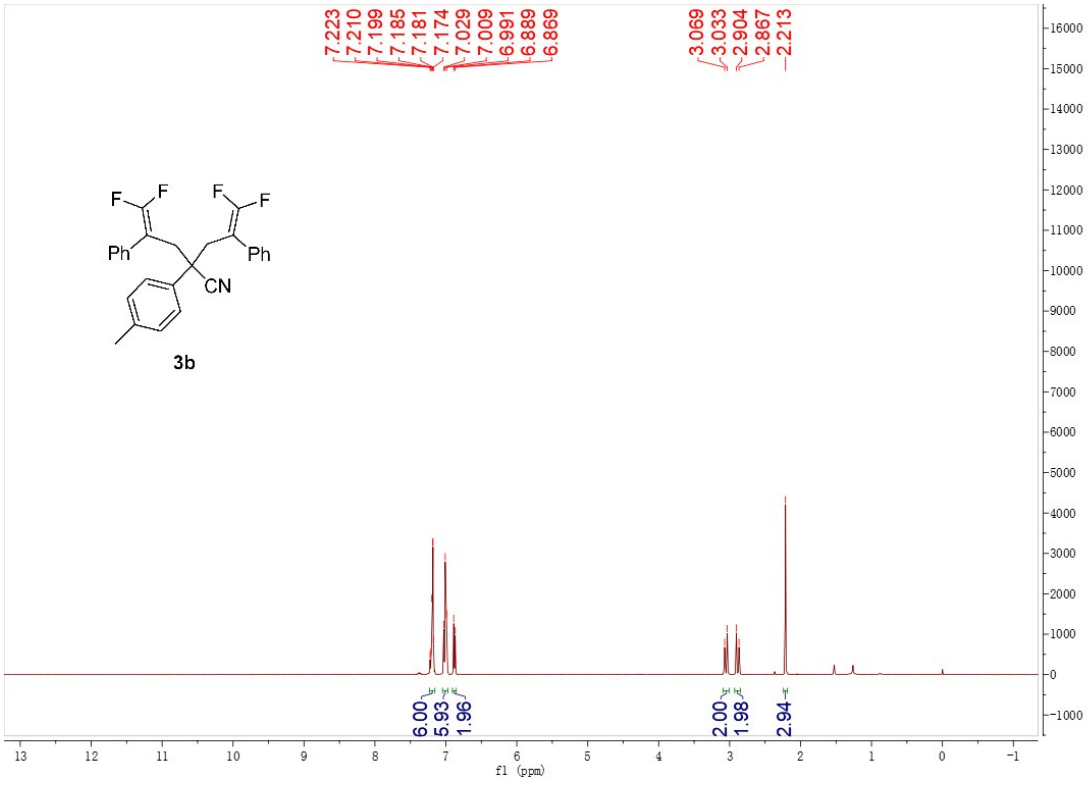
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3a



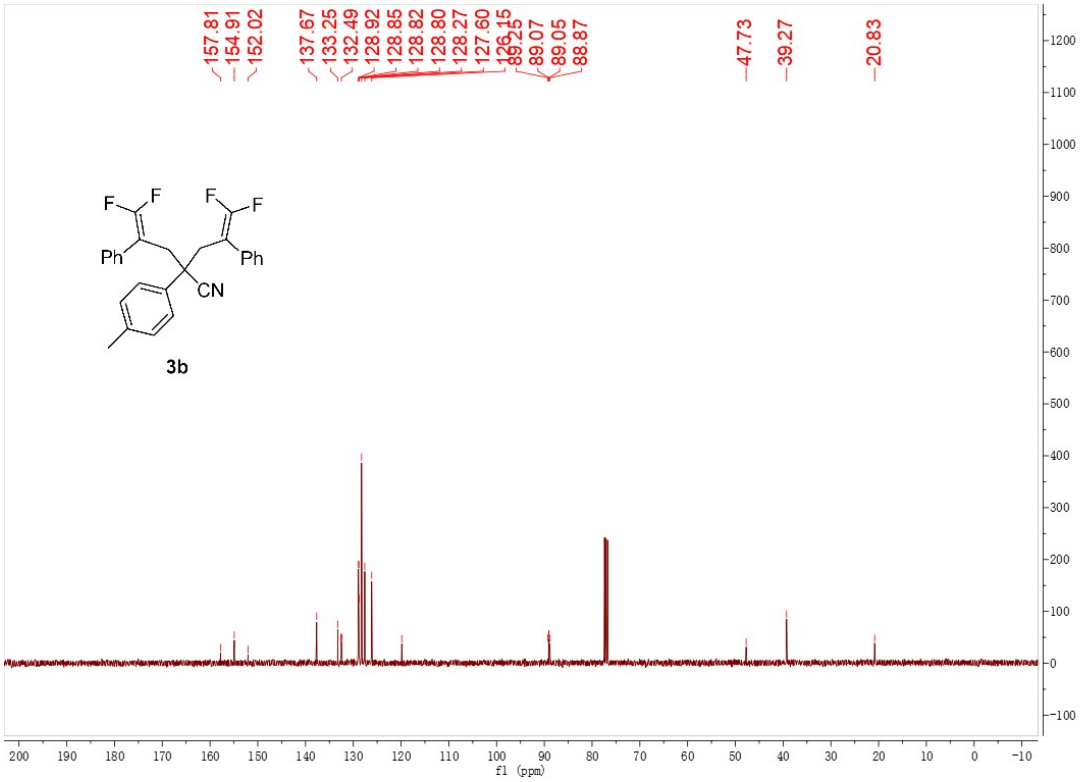
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3a



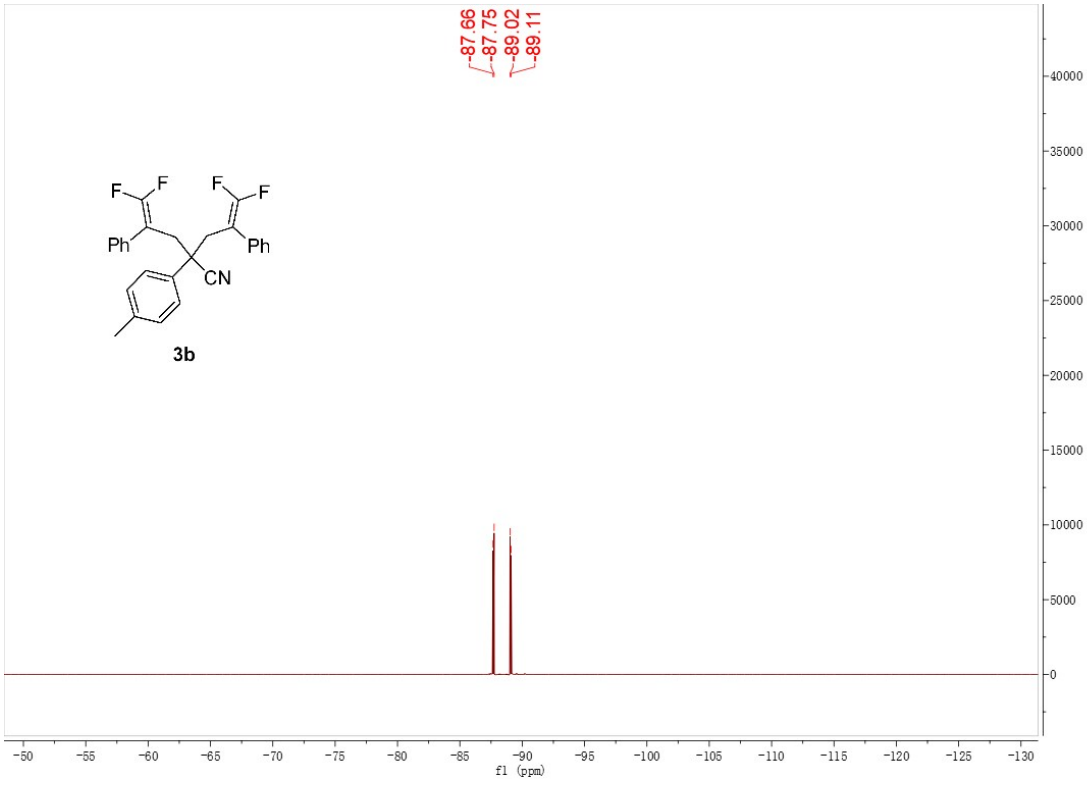
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3b



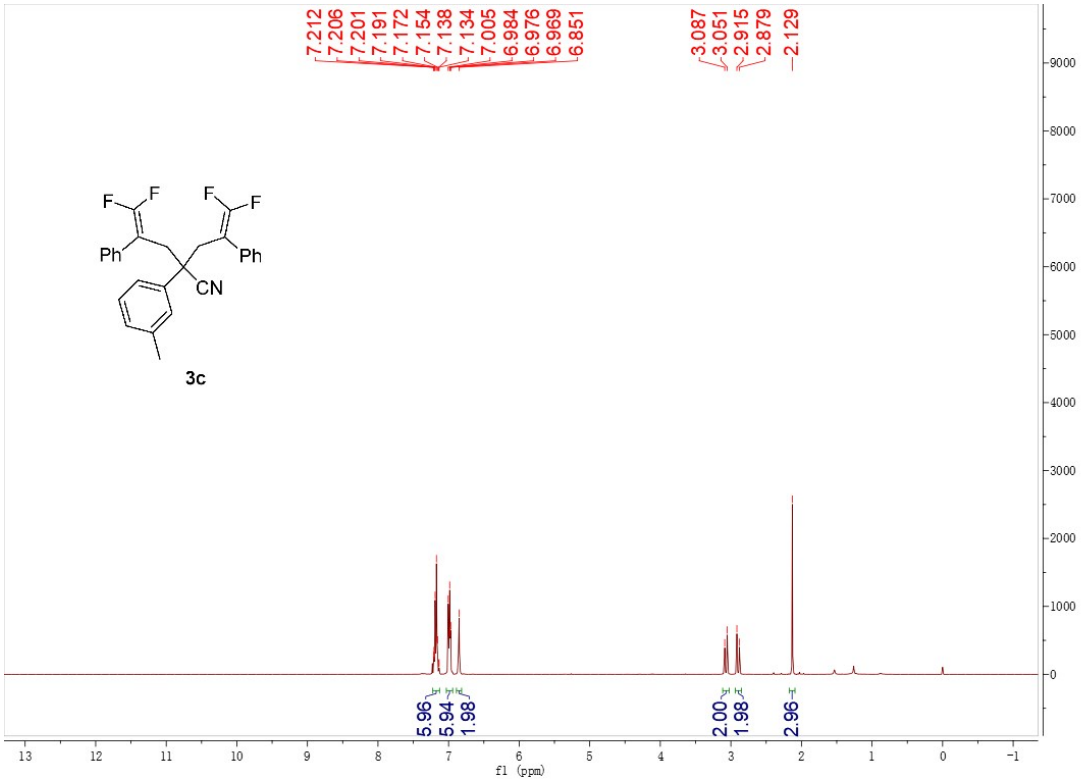
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3b



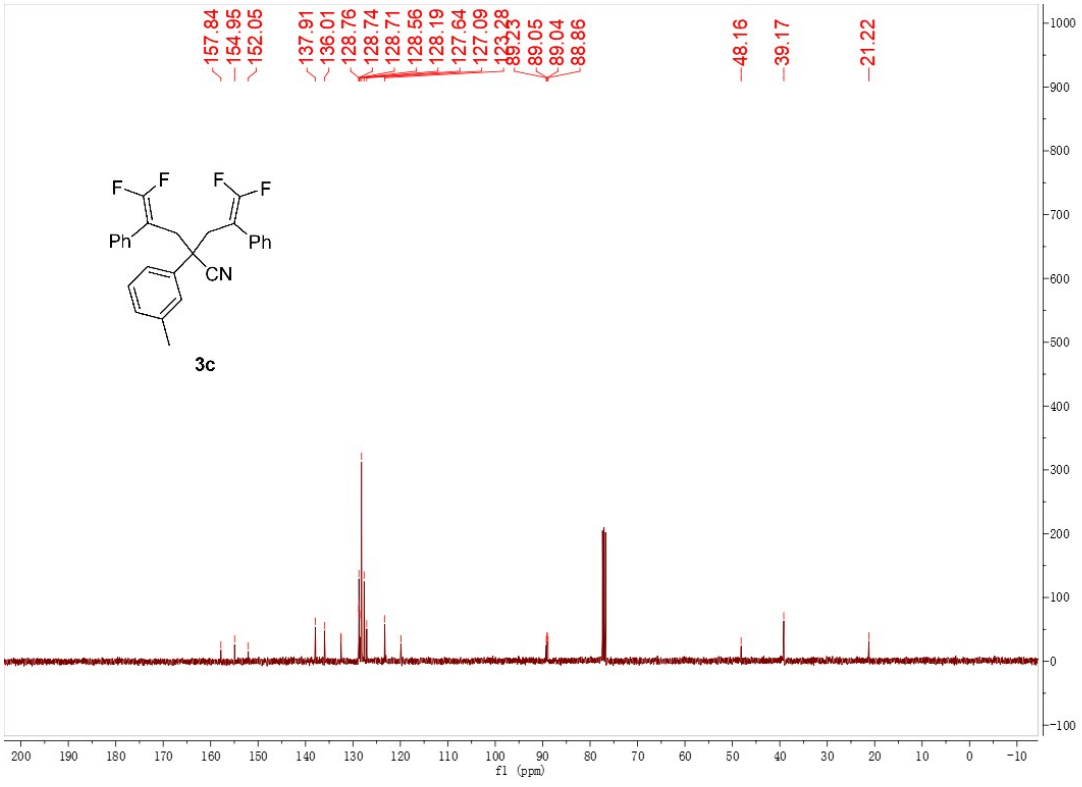
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3b



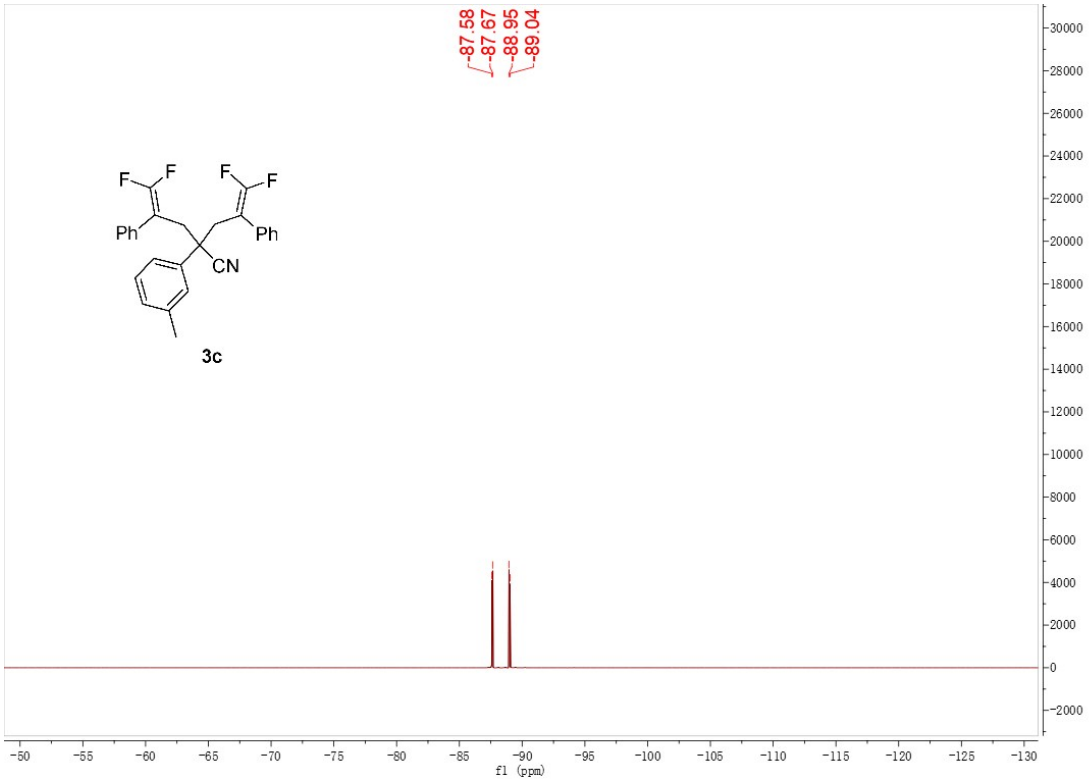
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3c



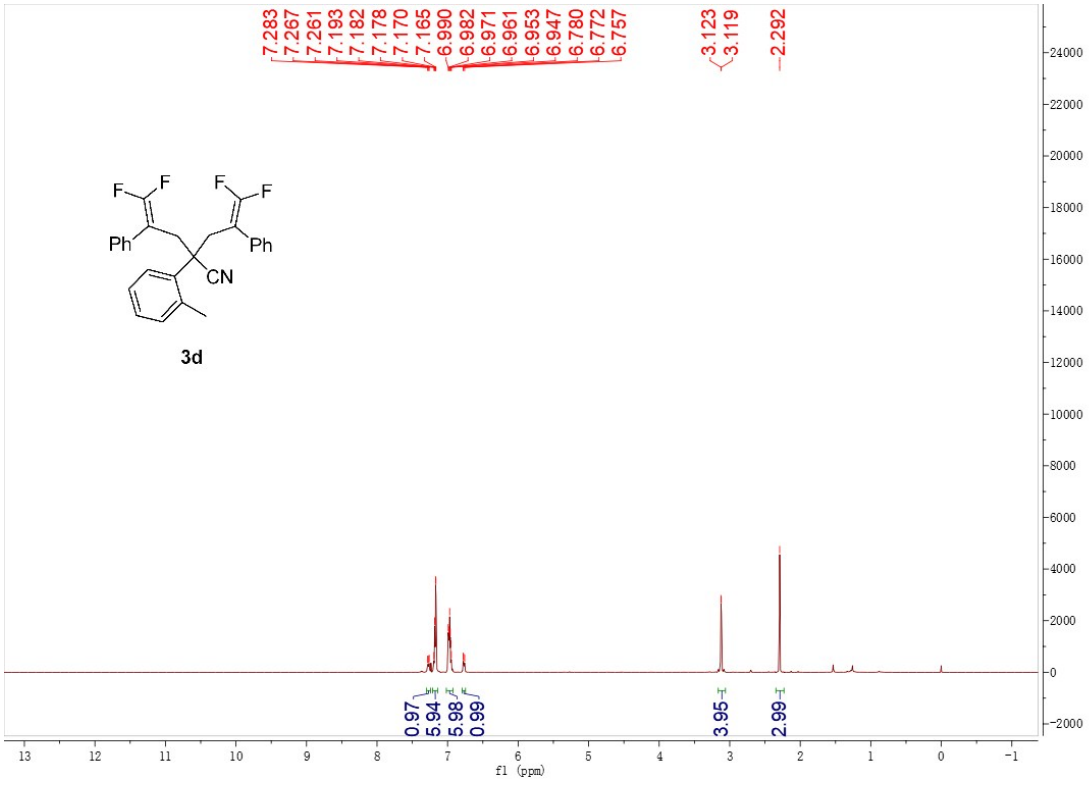
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3c



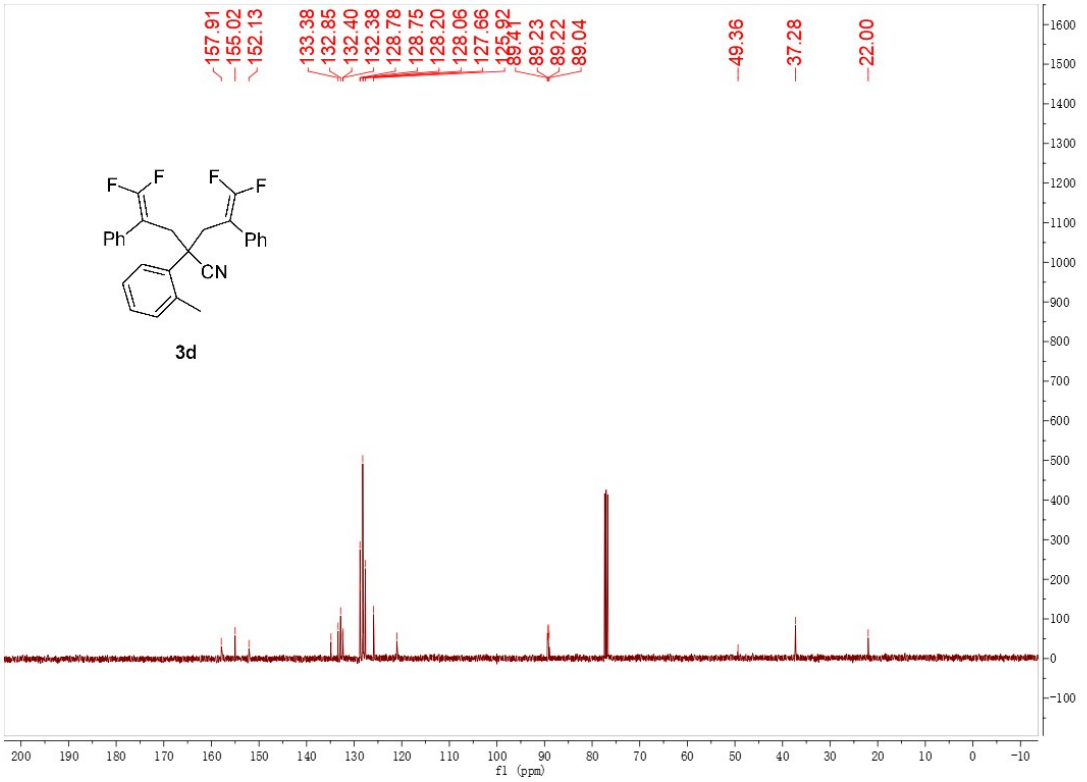
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3c



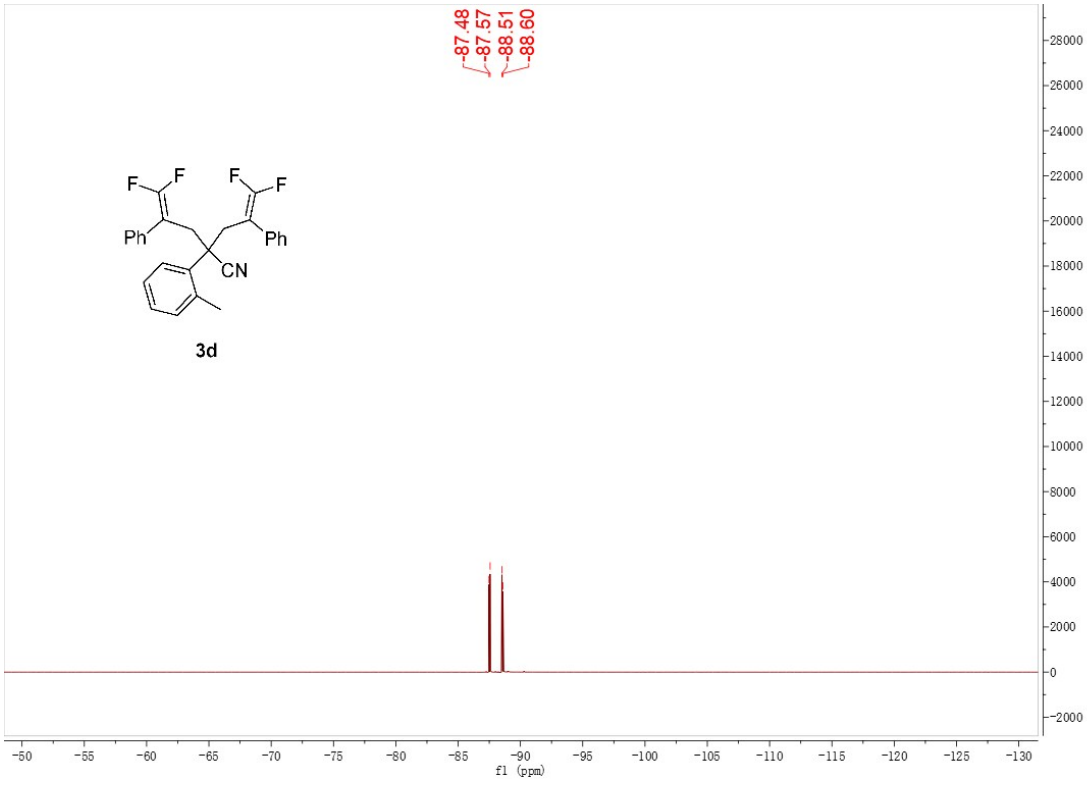
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3d



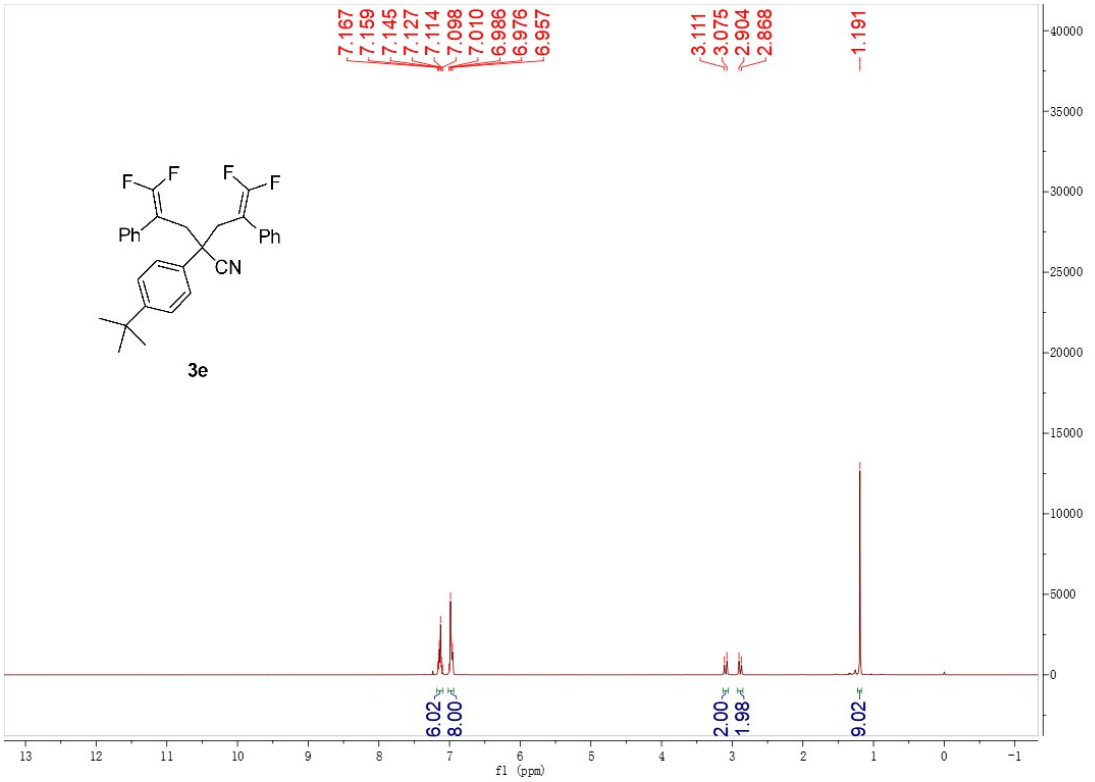
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3d



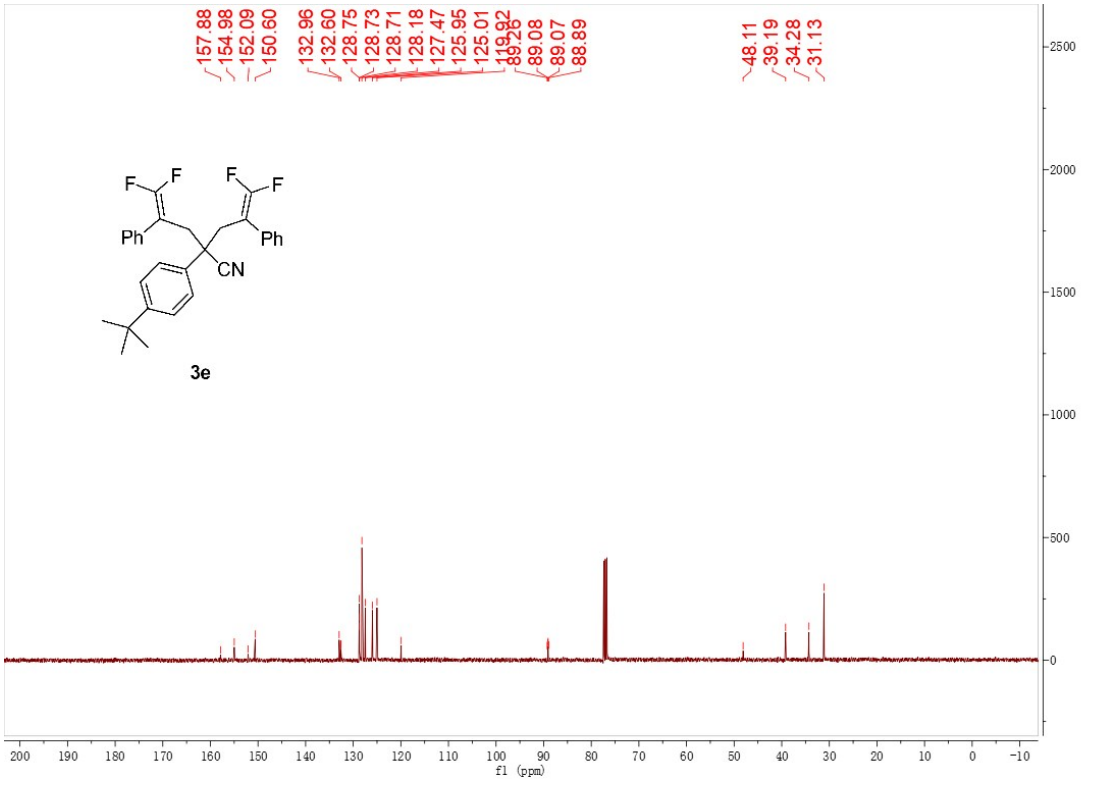
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3d



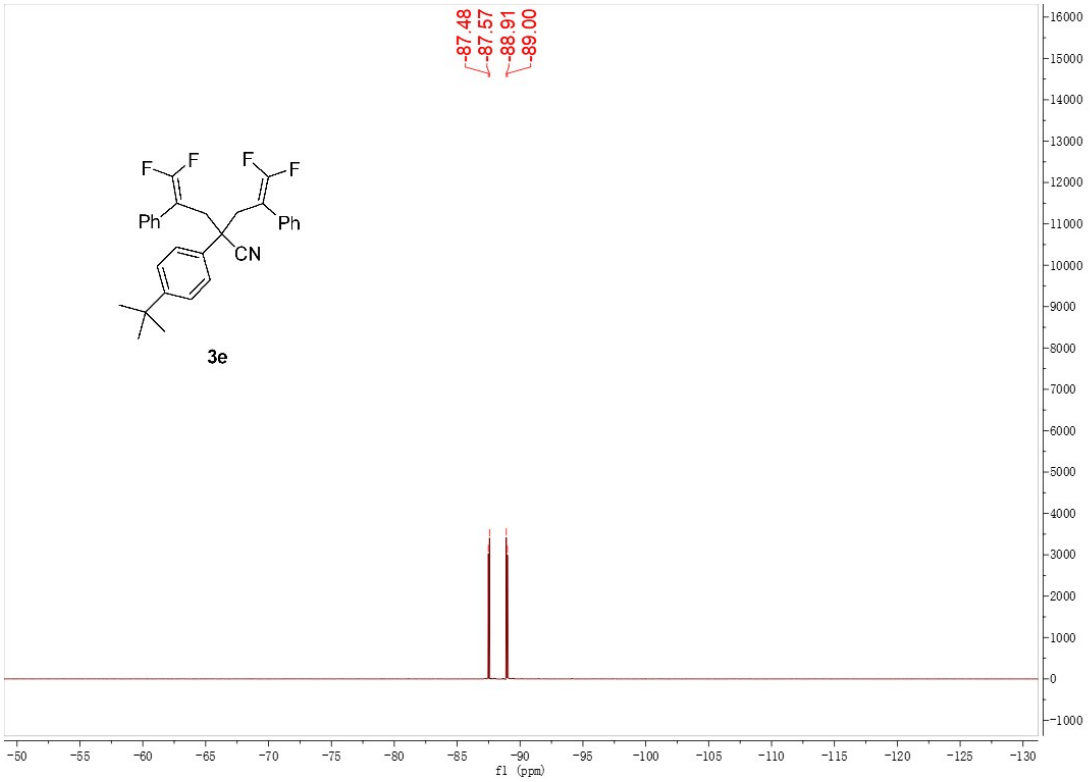
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3e



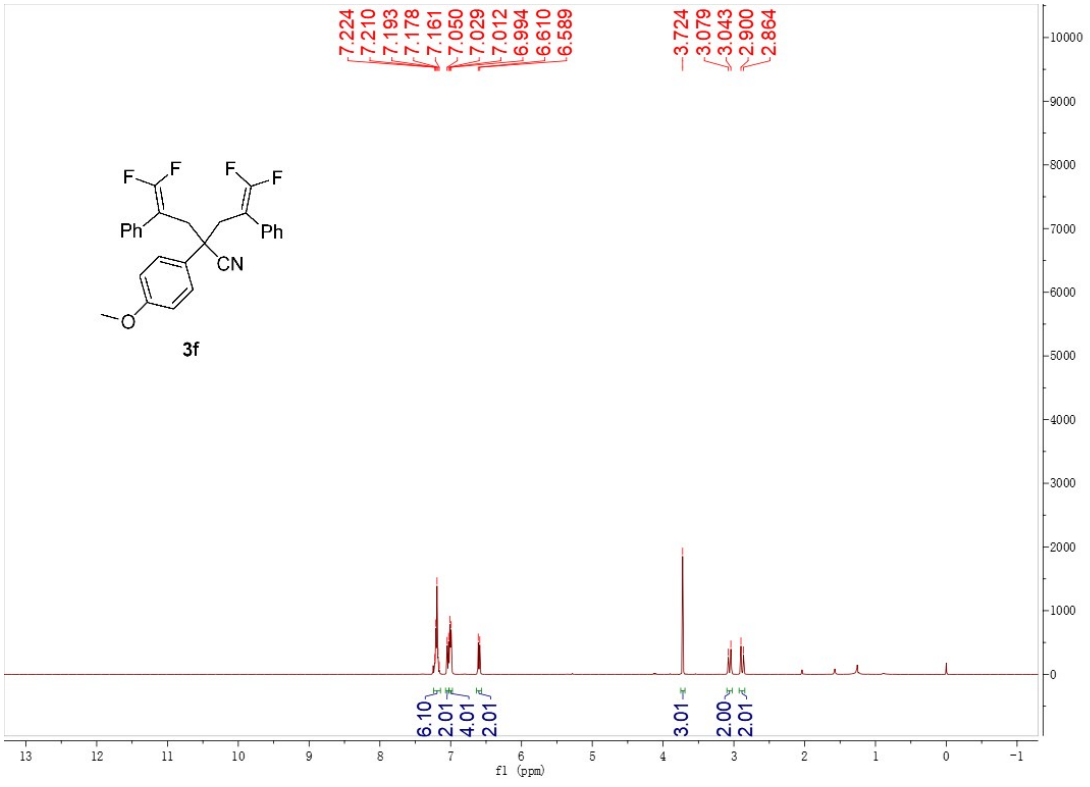
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3e



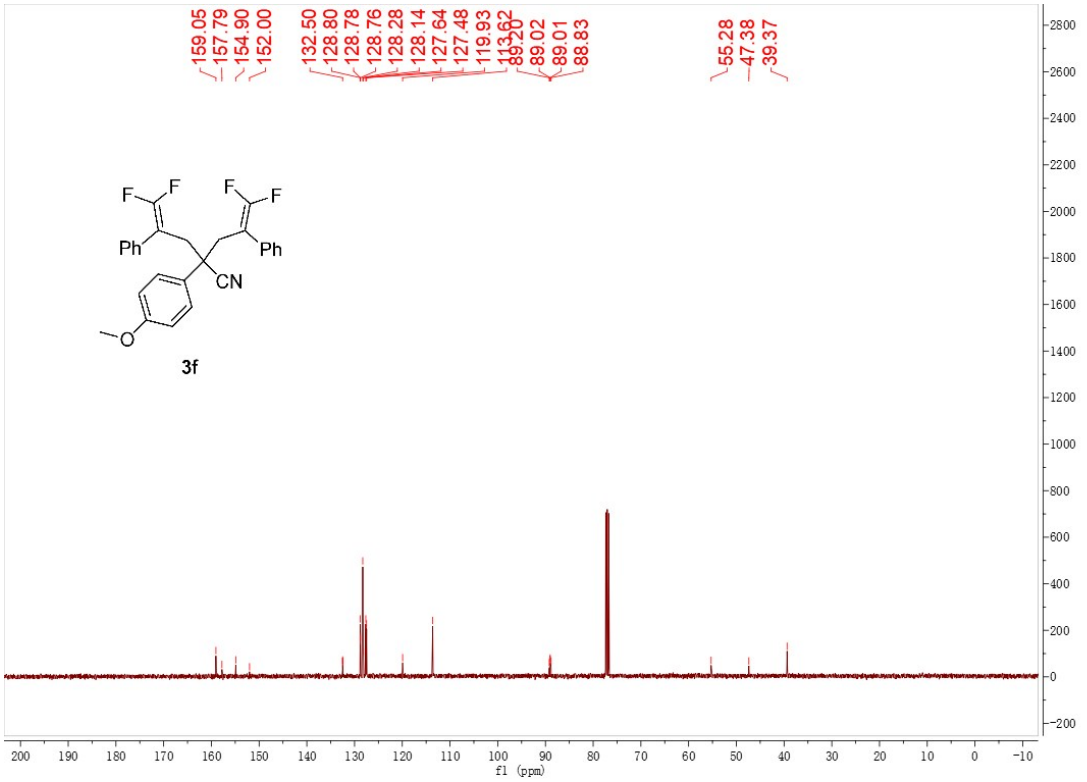
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3e



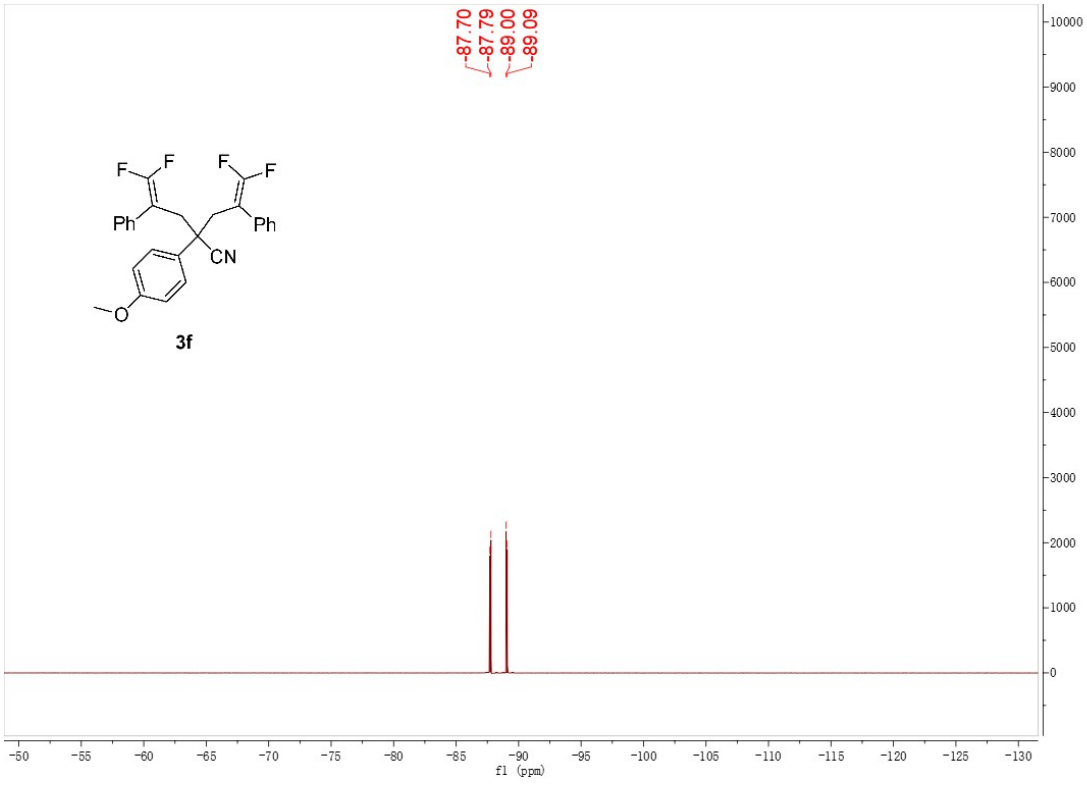
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3f



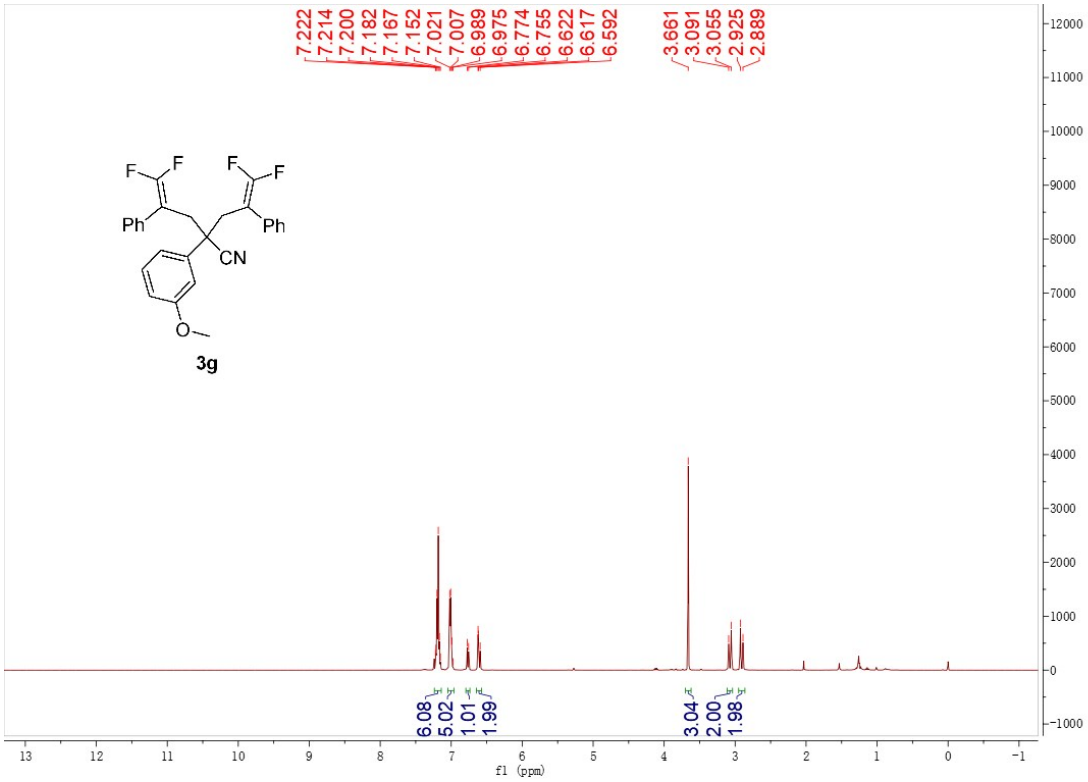
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3f



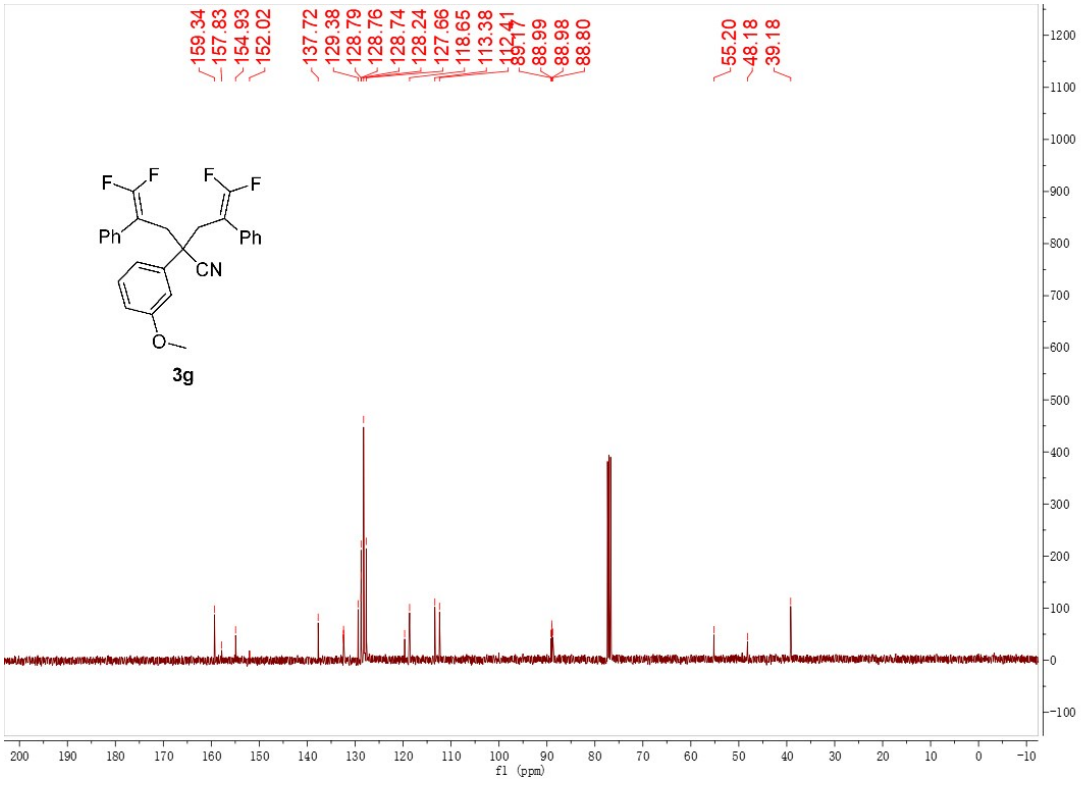
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3f



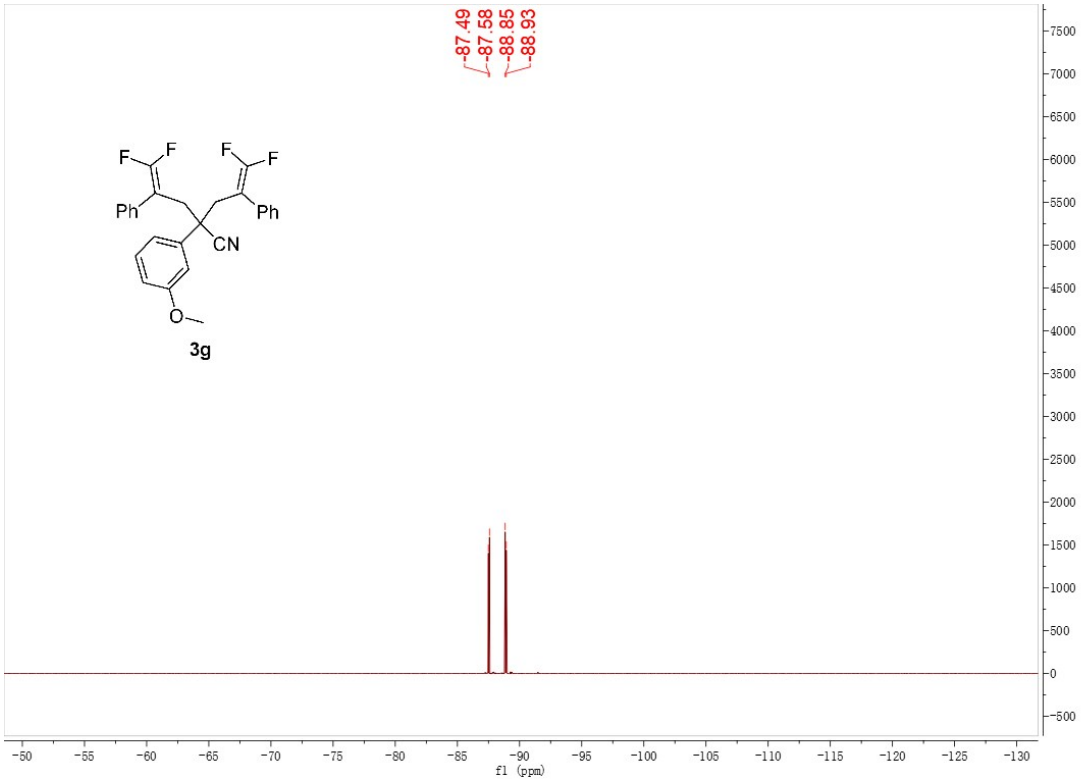
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3g



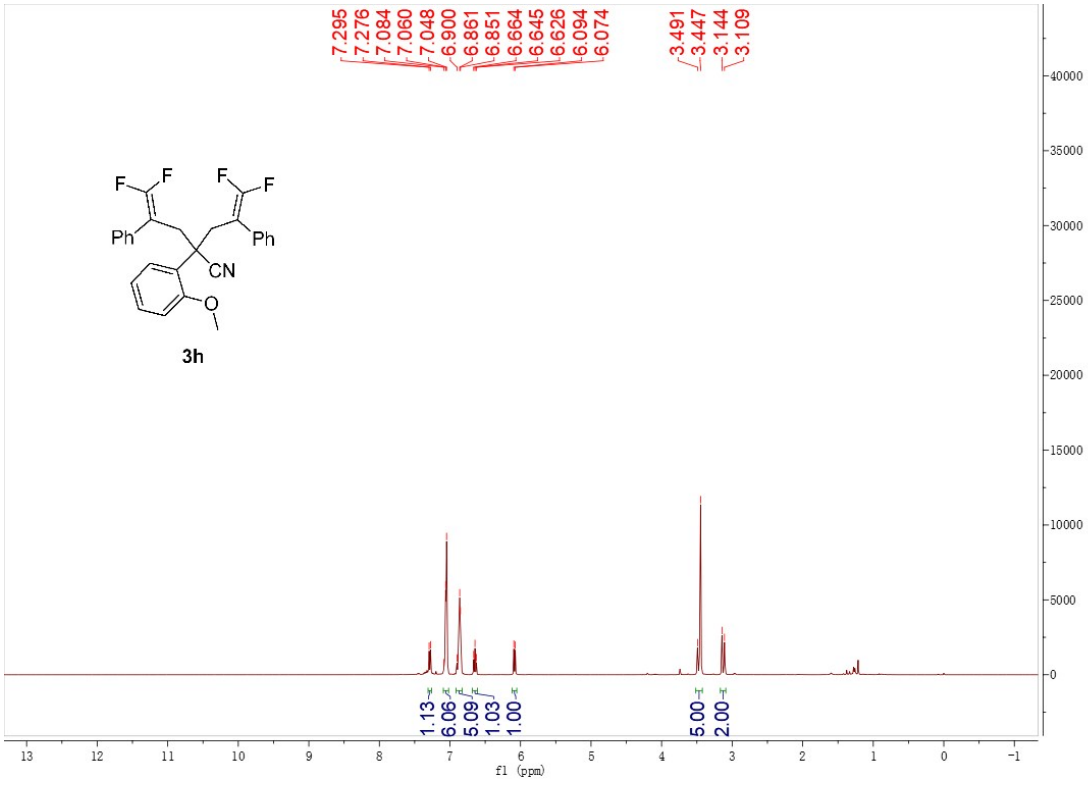
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3g



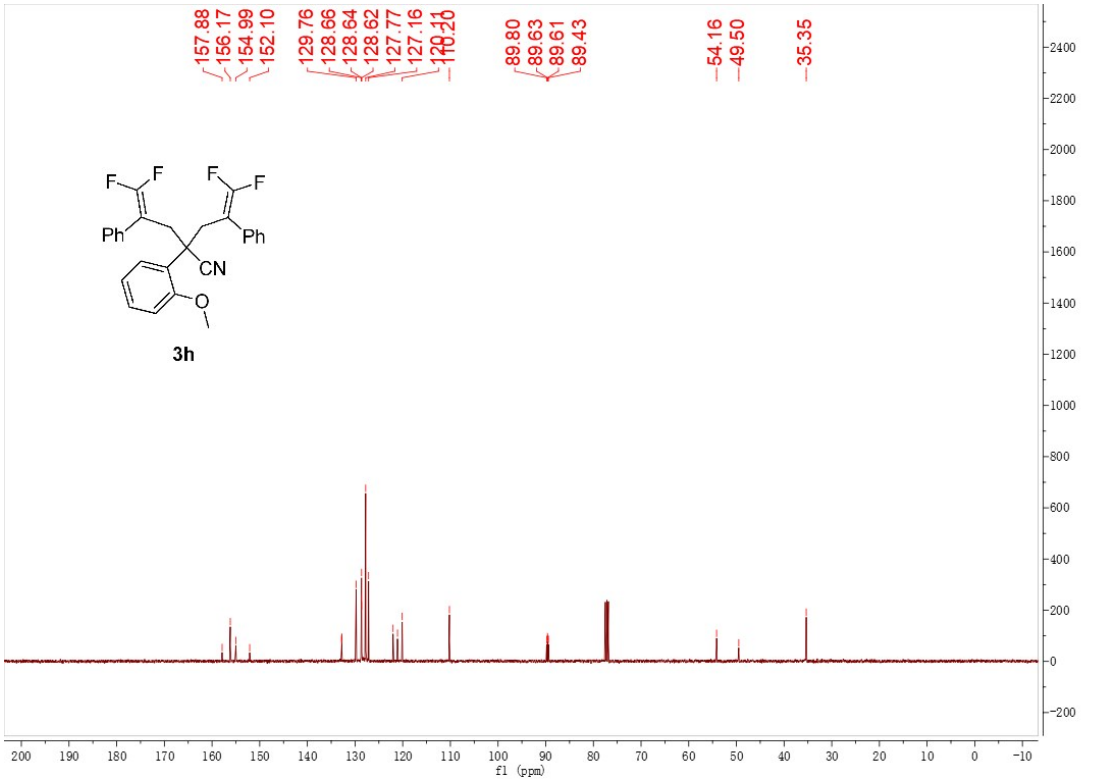
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3g



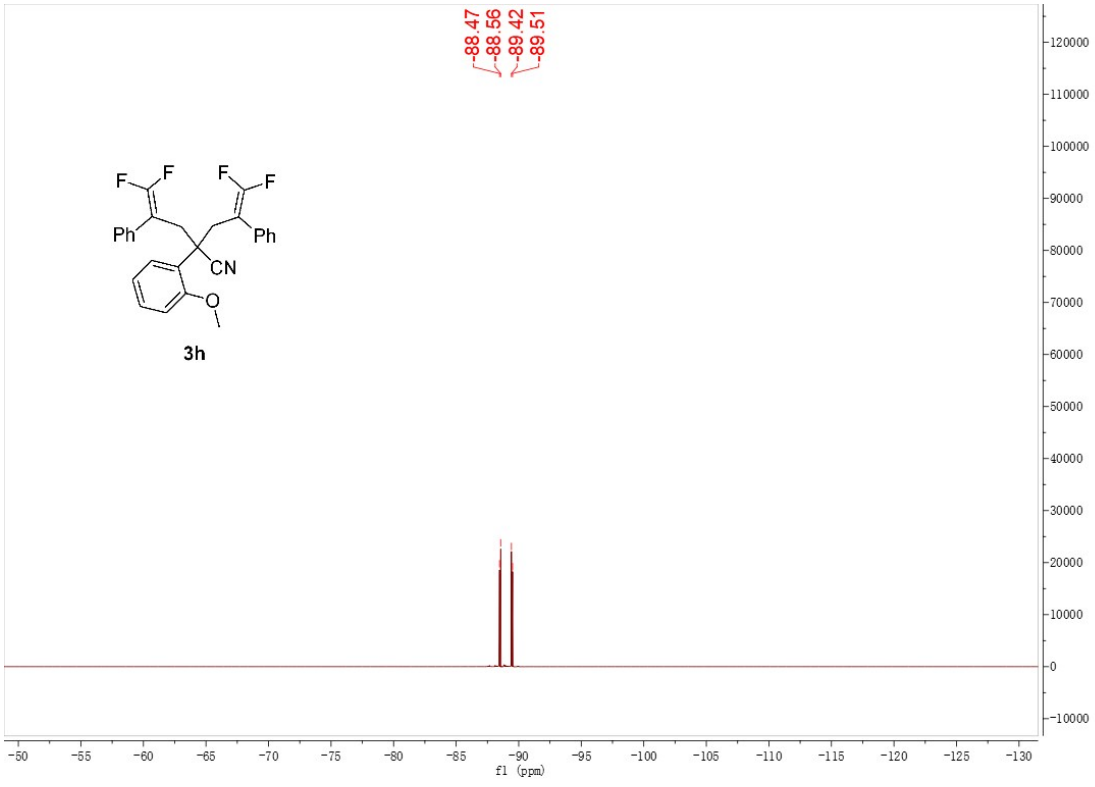
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3h



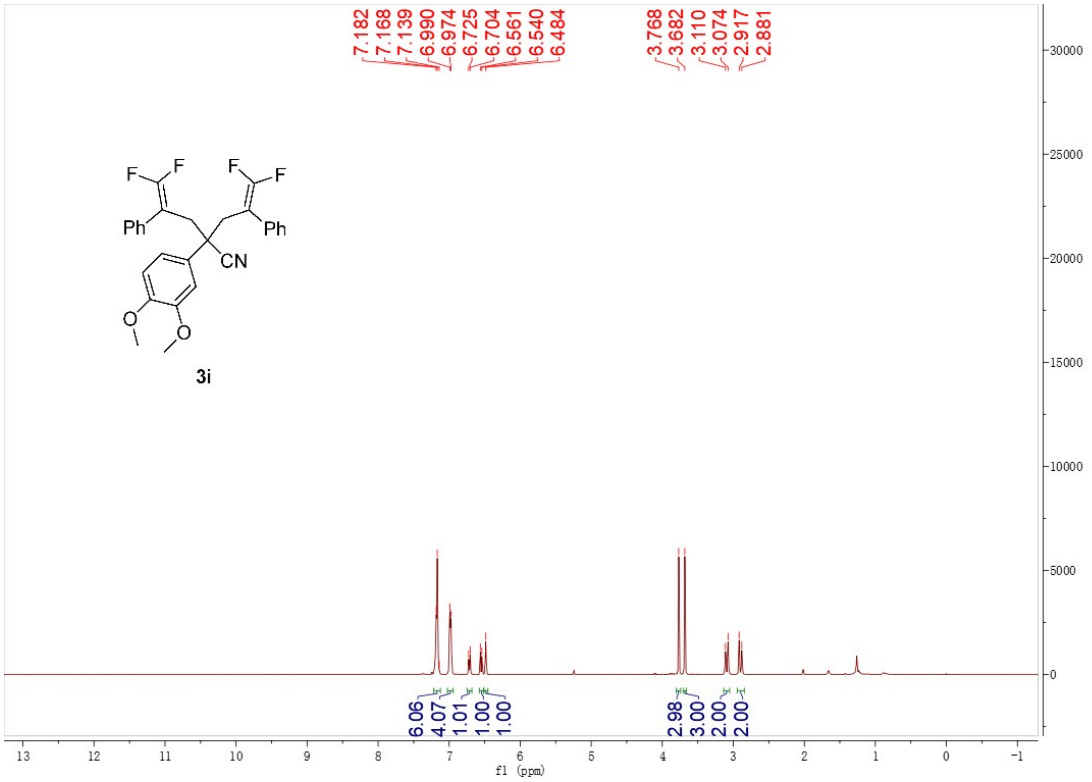
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3h



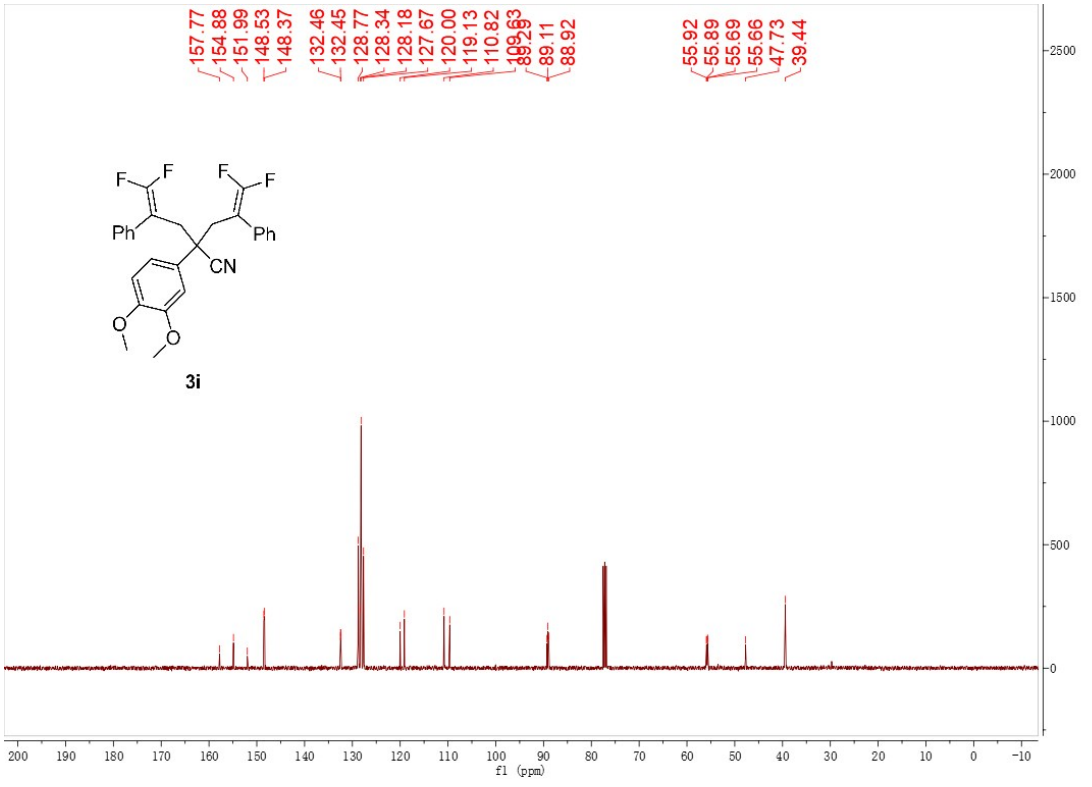
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3h



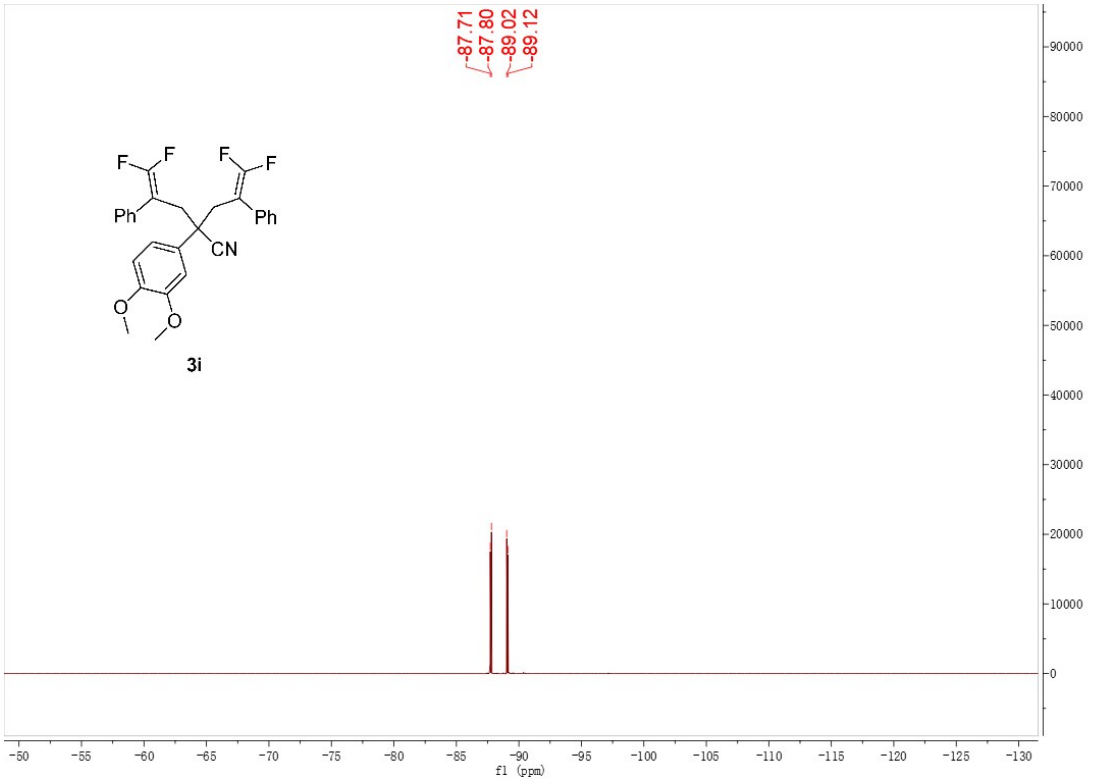
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3i



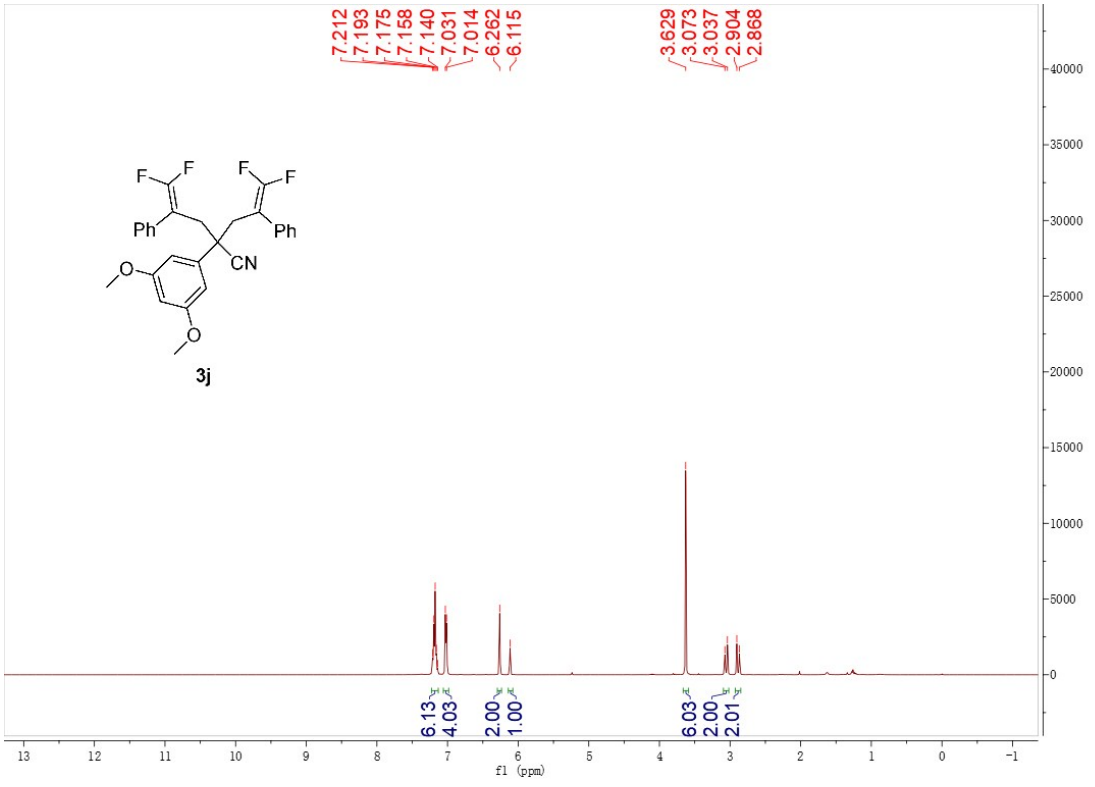
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3i



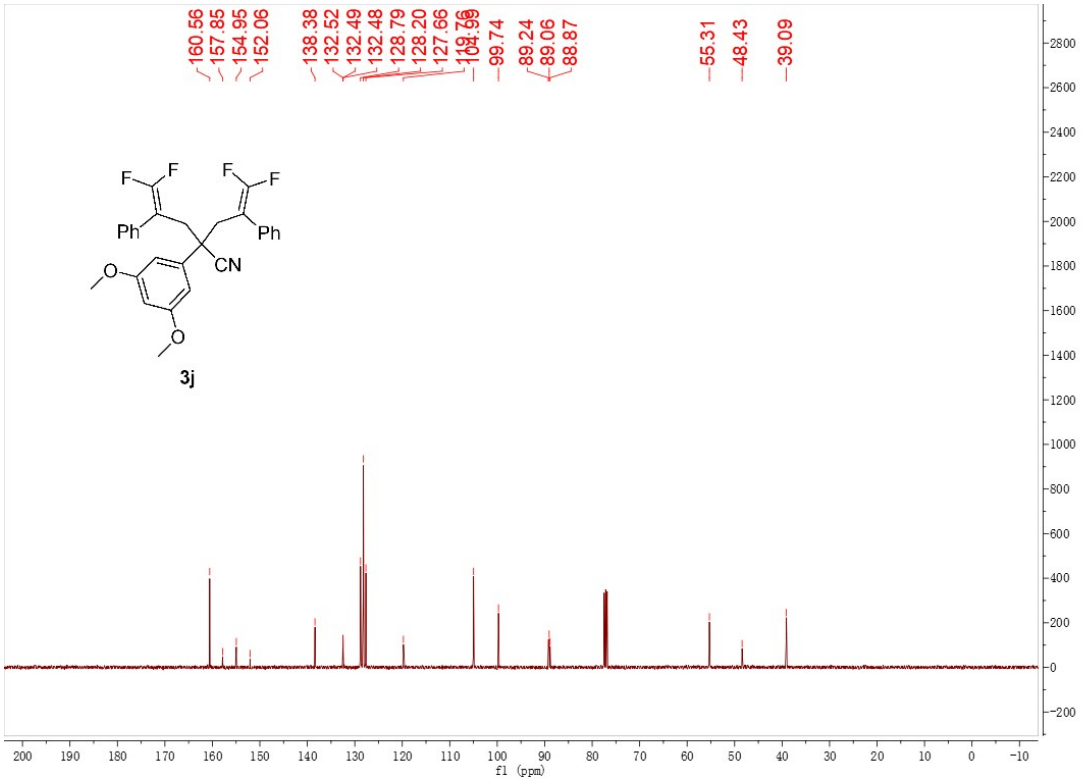
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3i



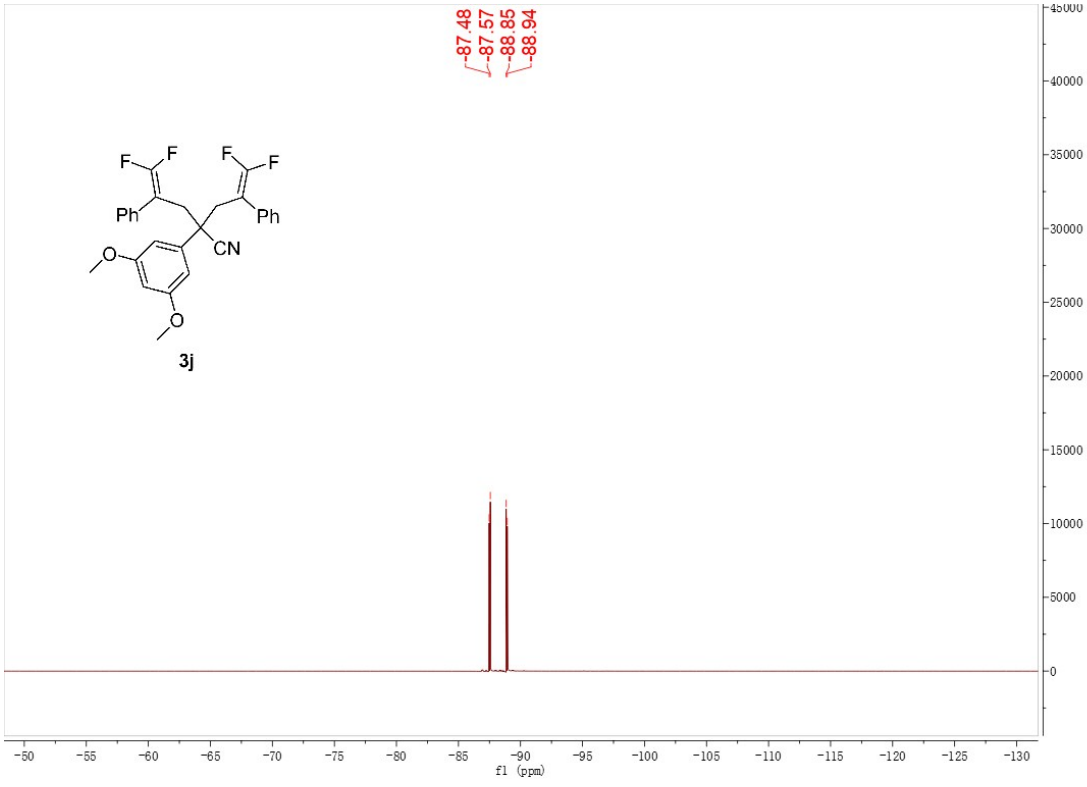
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3j



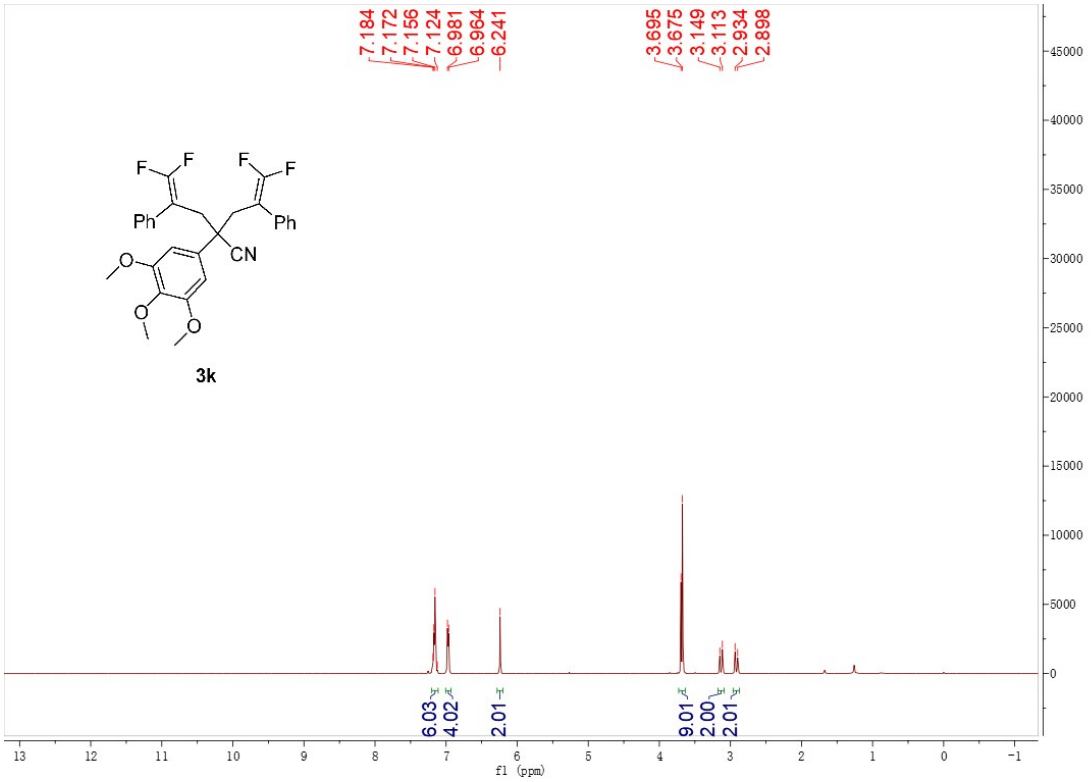
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3j



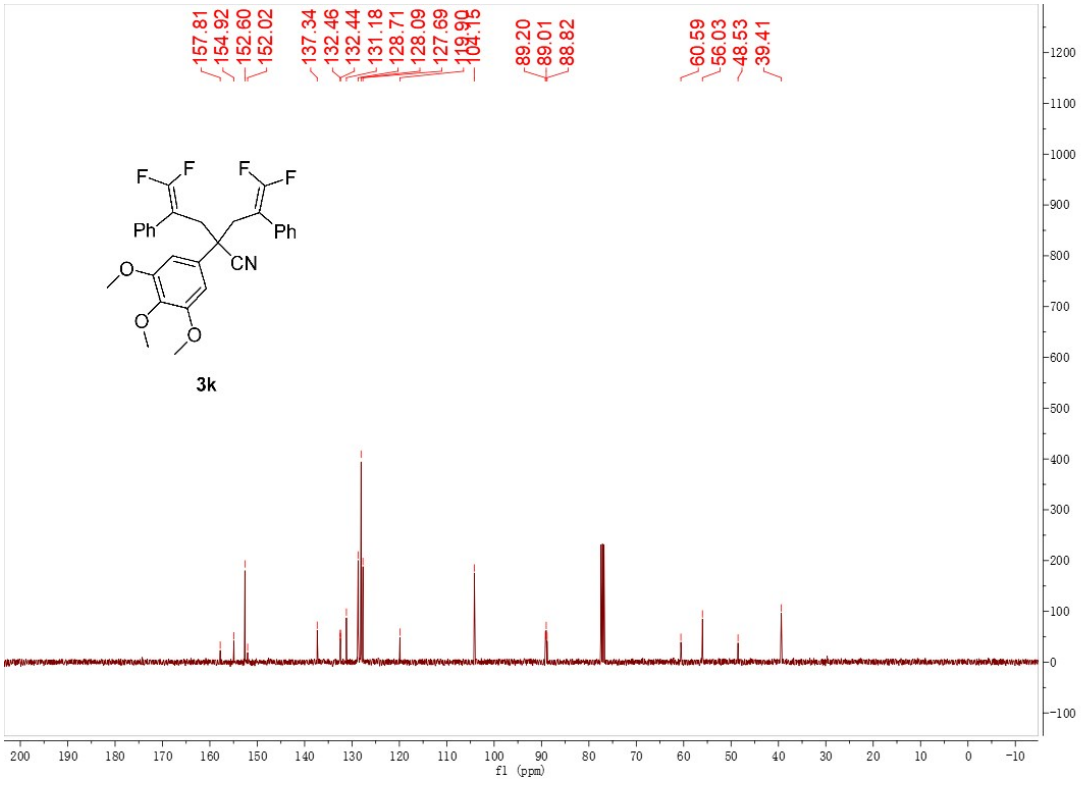
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3j



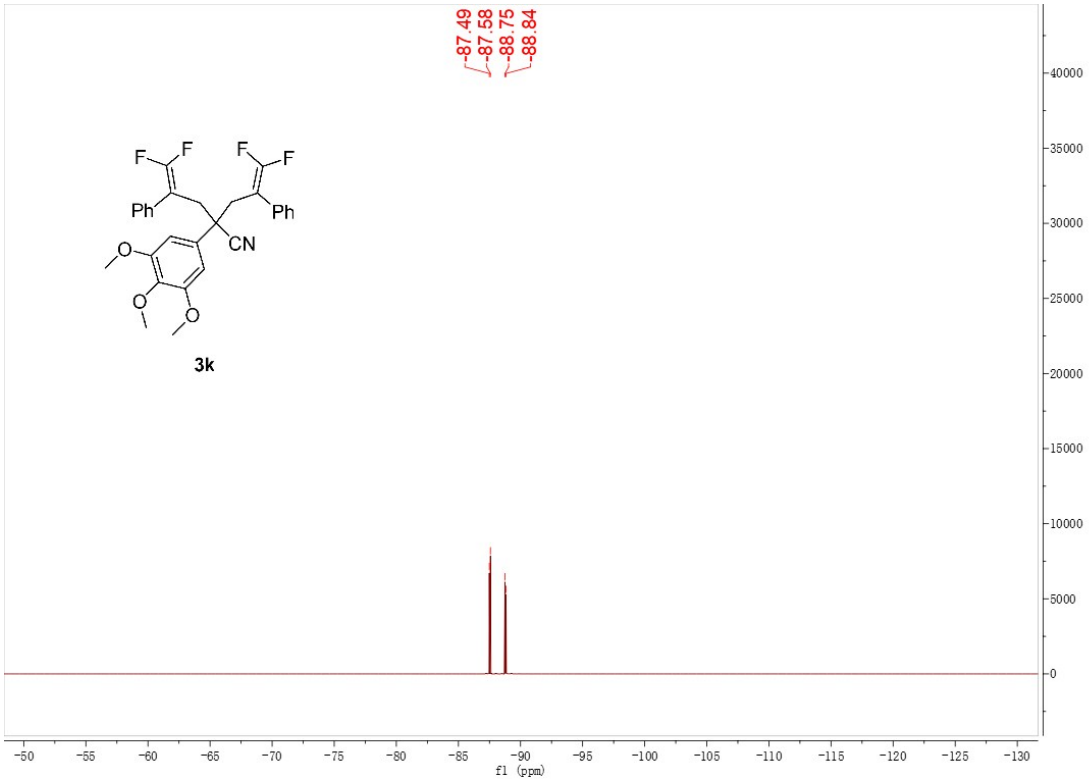
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3k



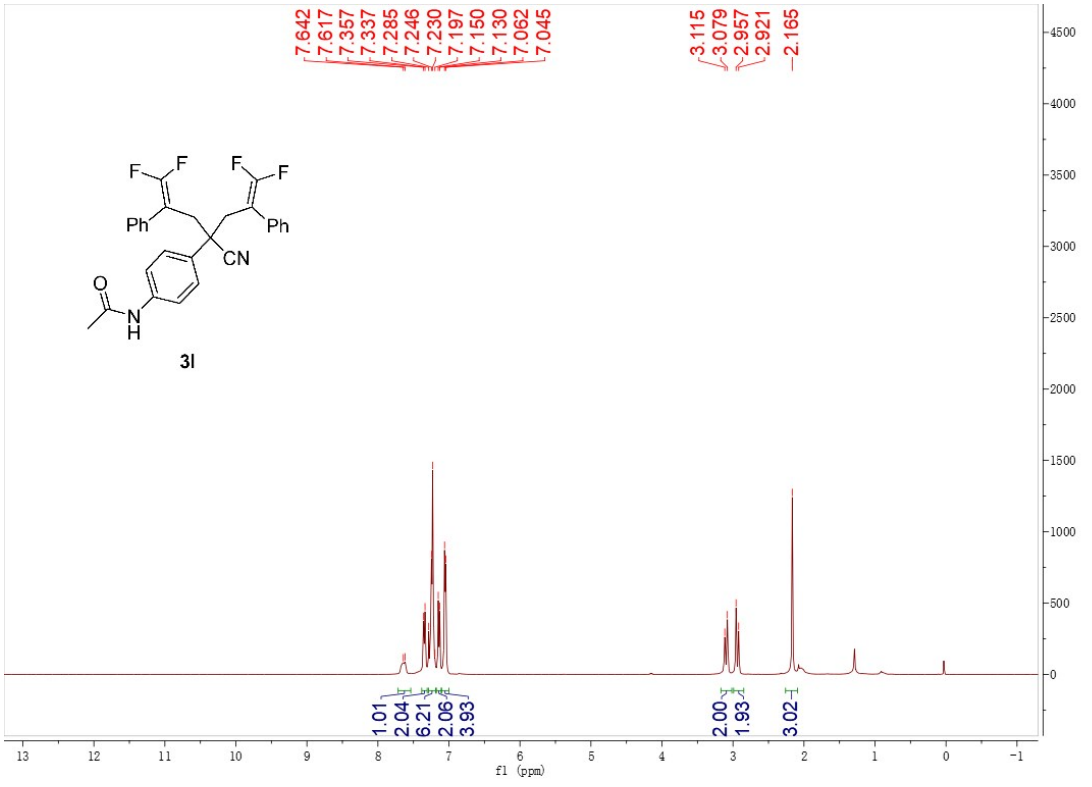
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3k



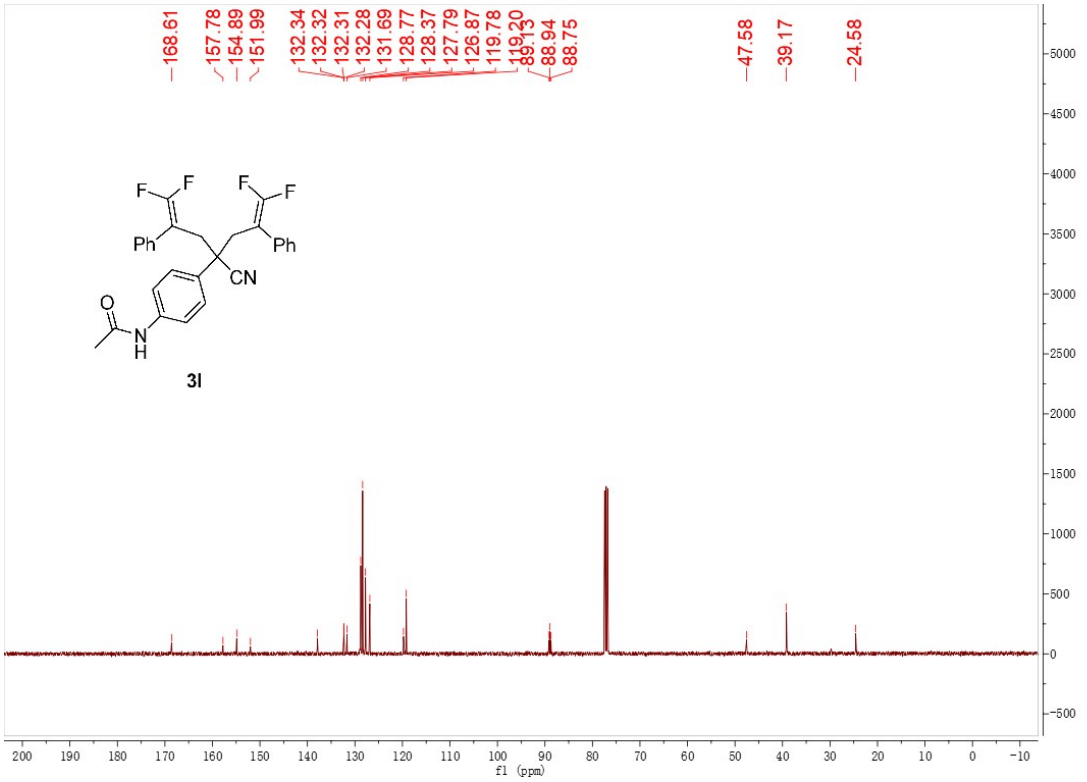
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3k



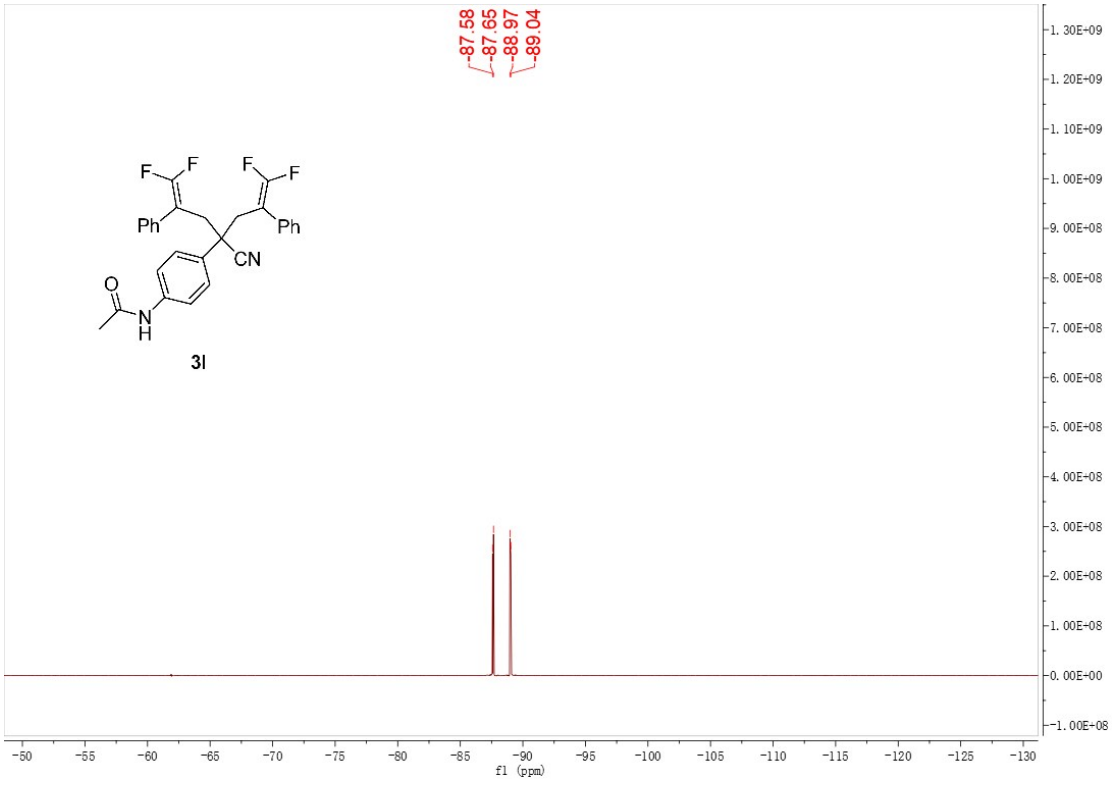
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3l



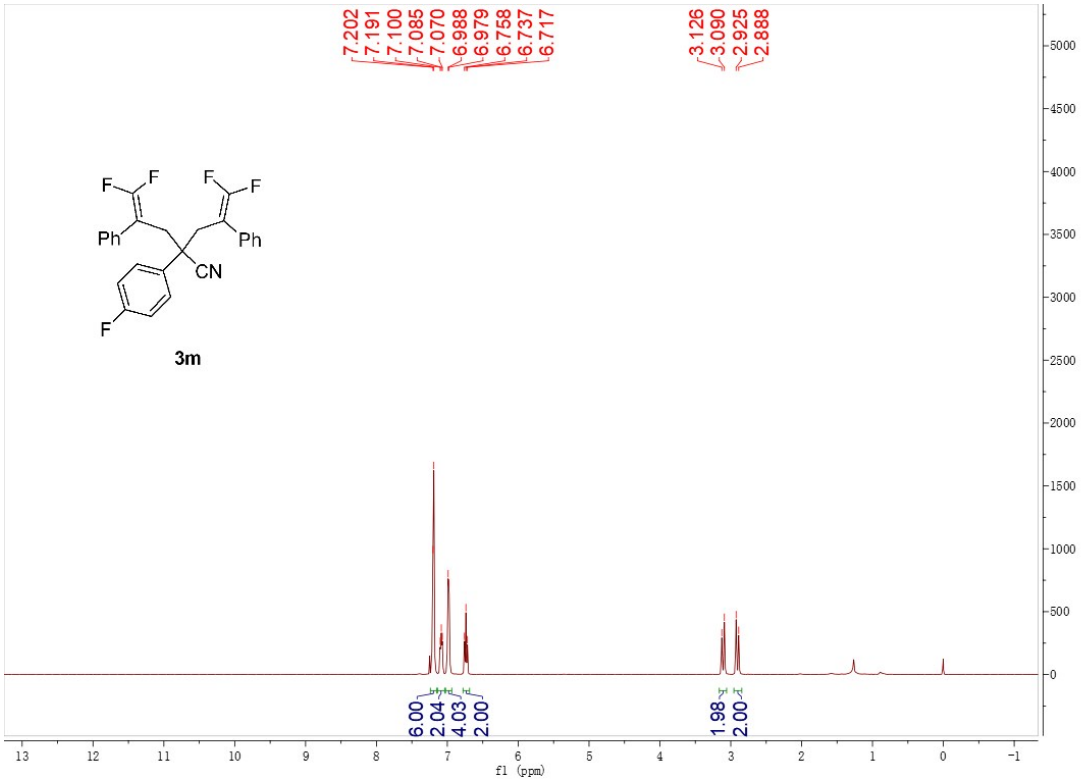
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3l



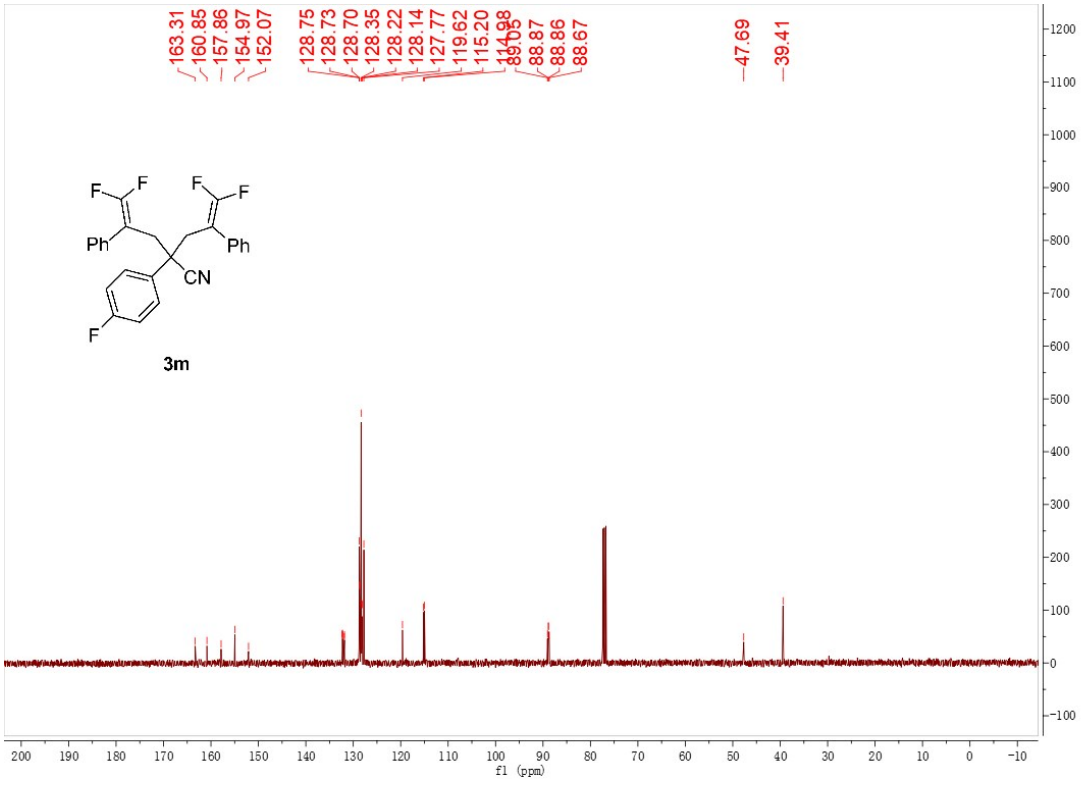
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3l



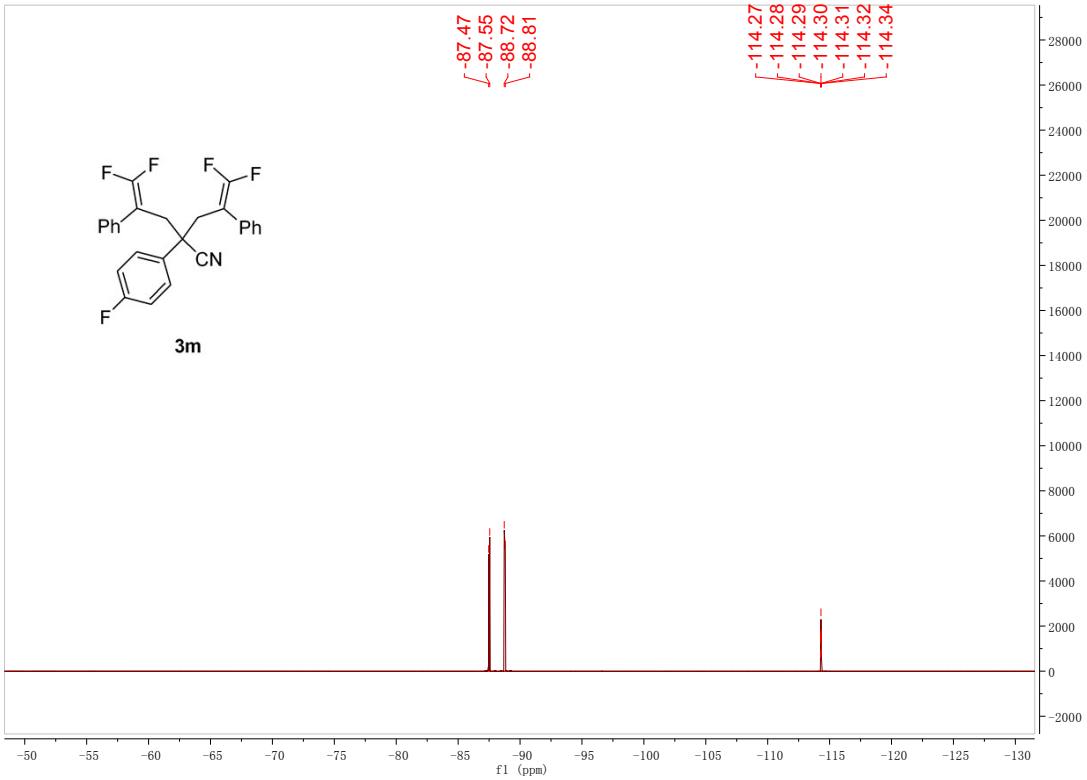
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3m



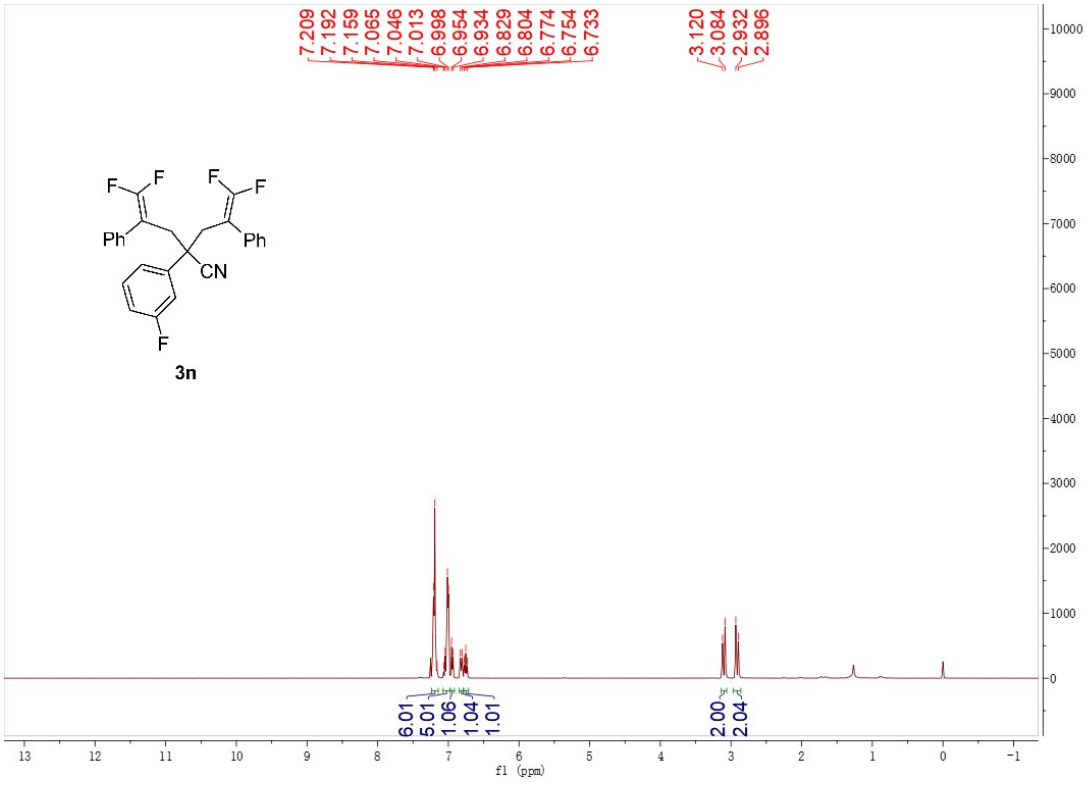
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3m



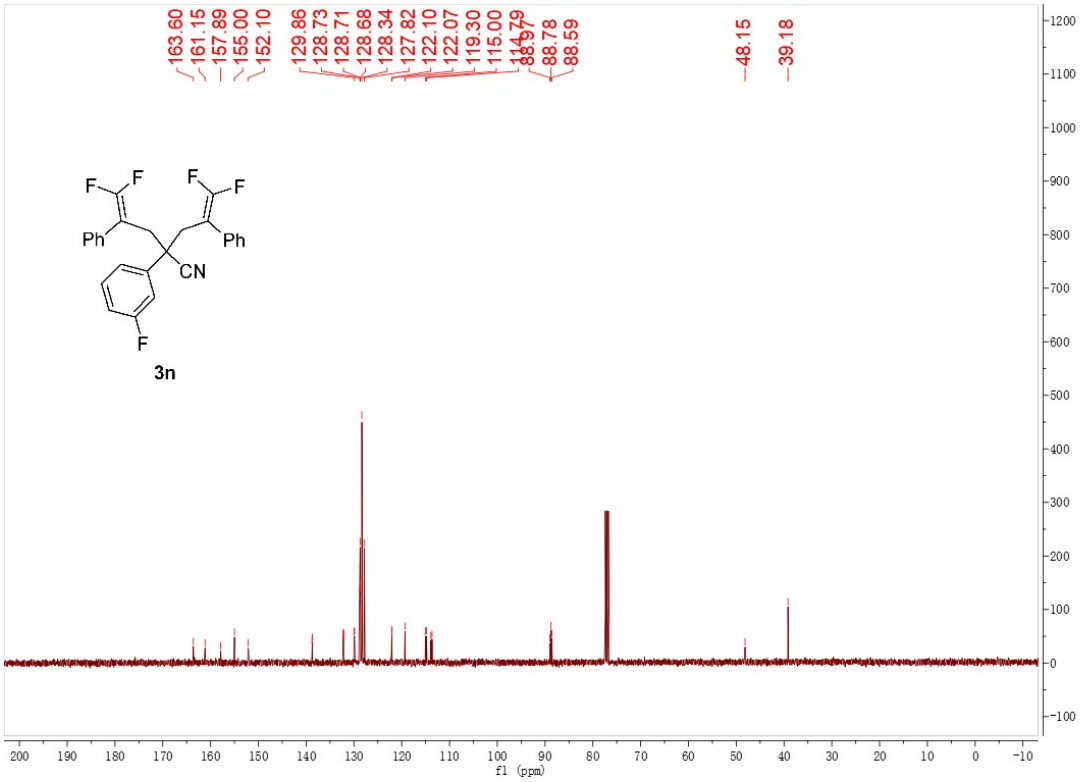
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3m



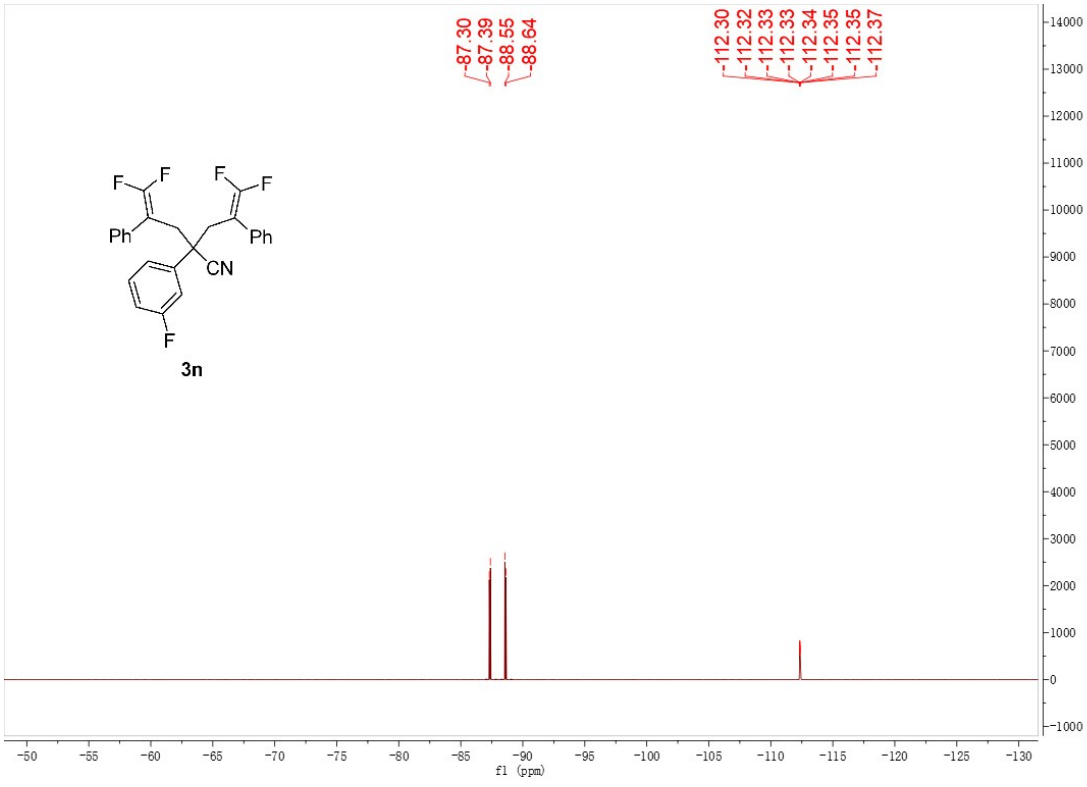
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3n



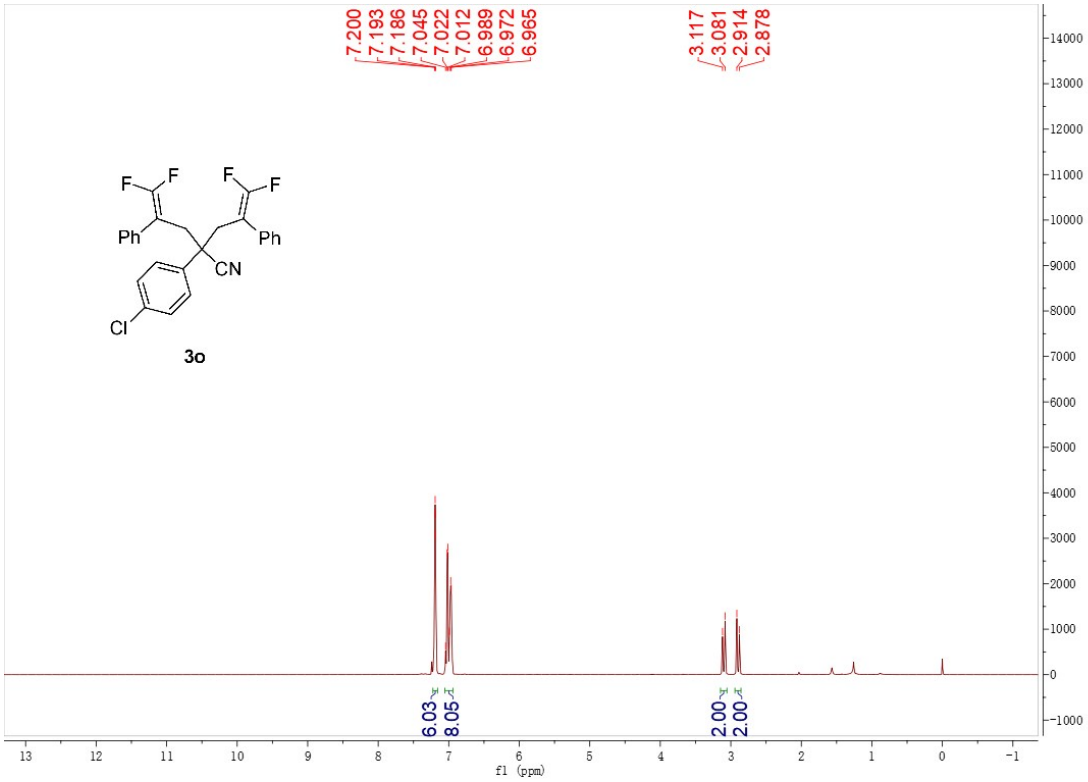
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3n



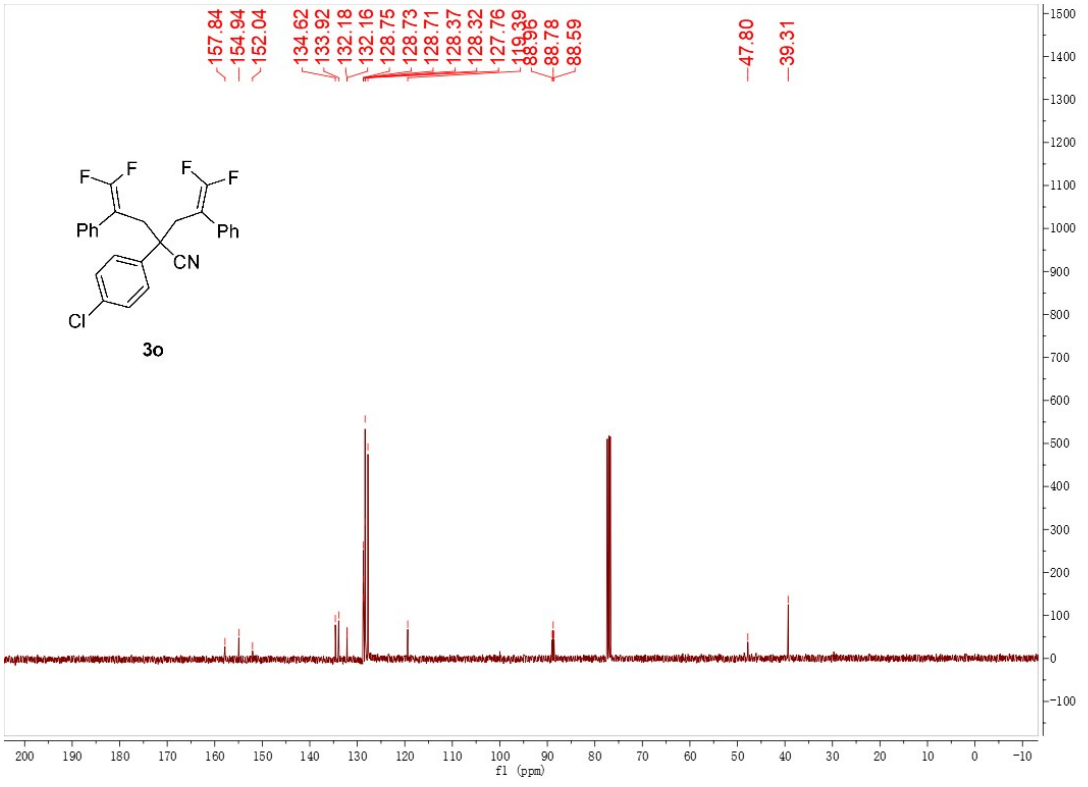
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3n



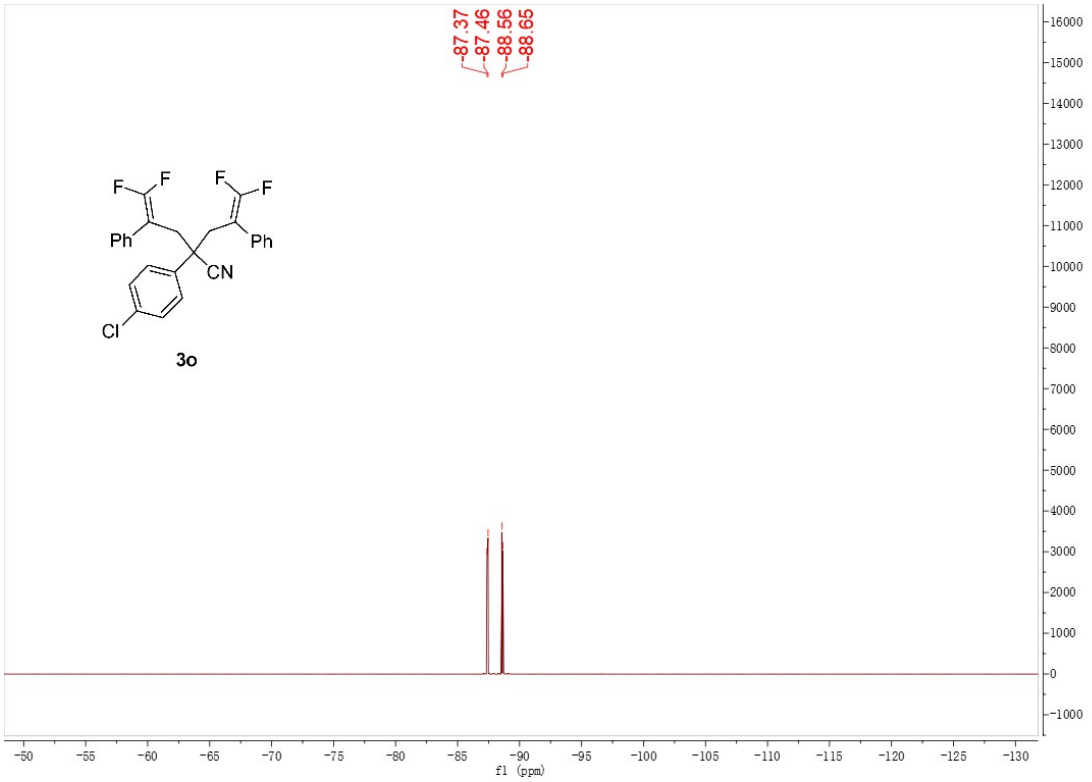
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3o



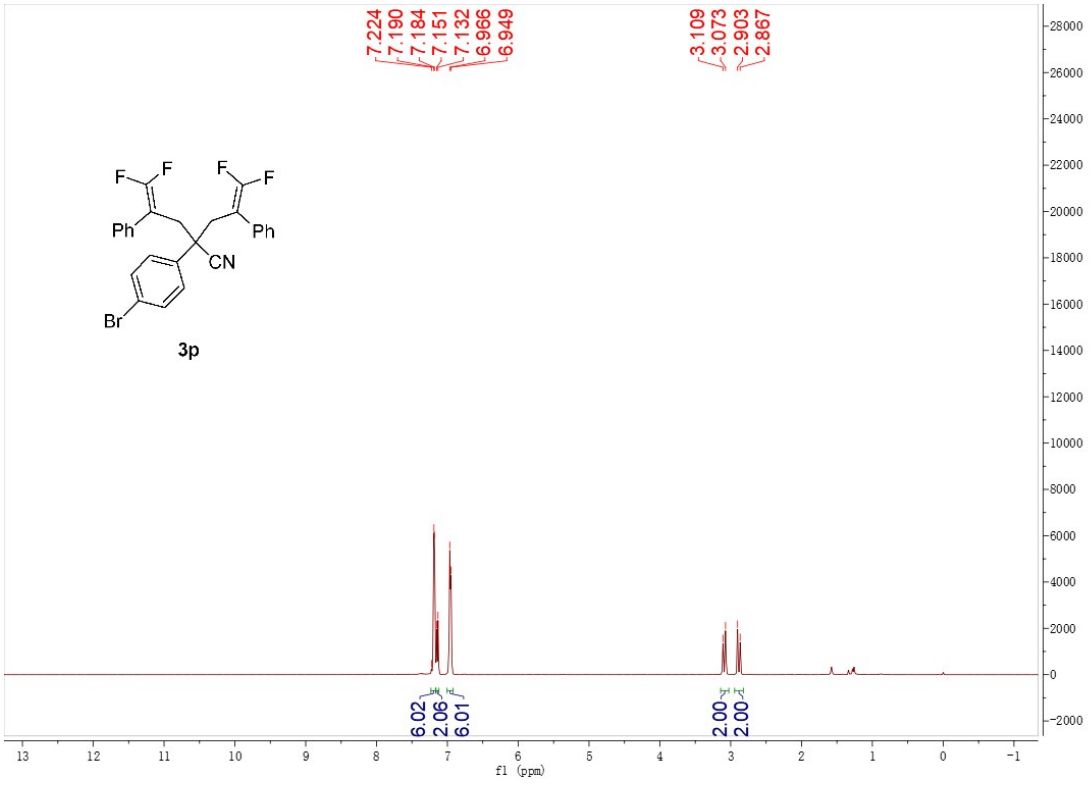
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3o



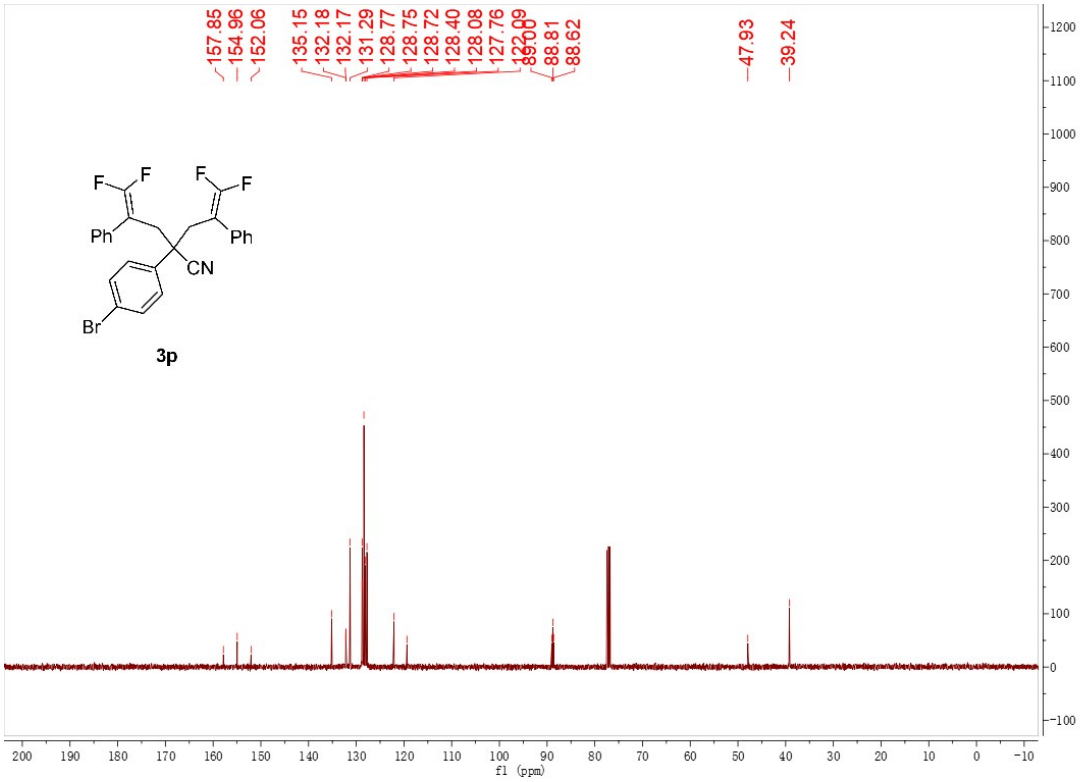
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3o



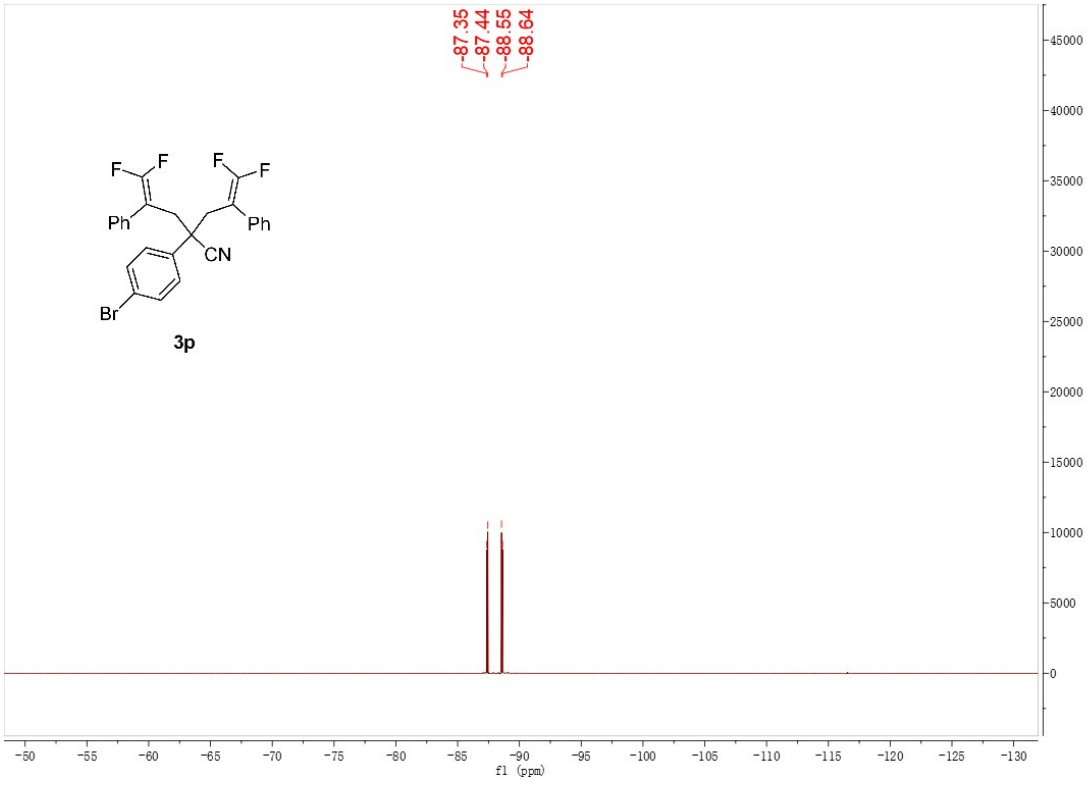
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3p



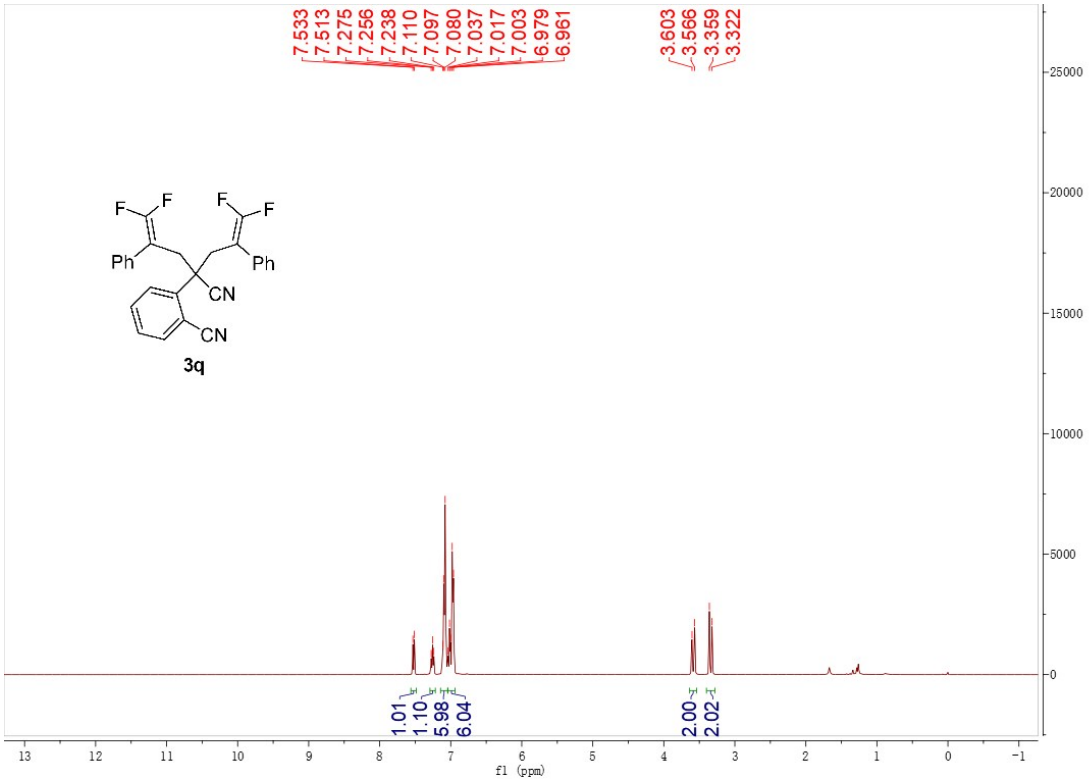
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3p



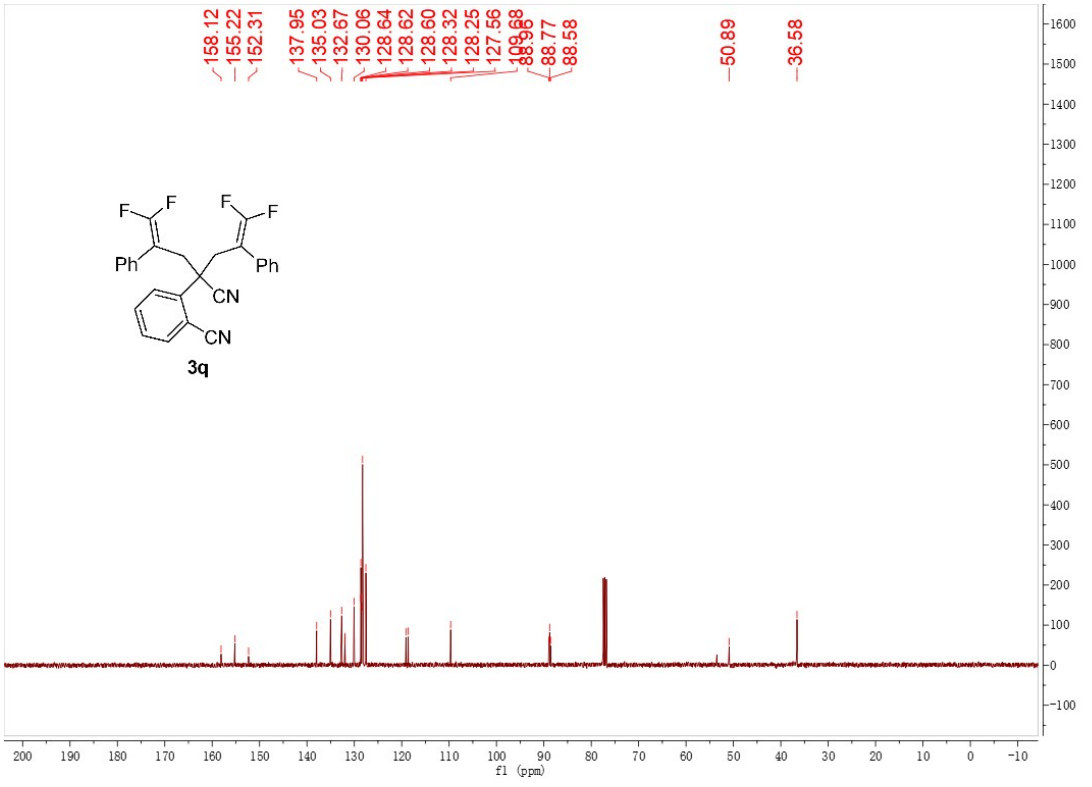
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3p



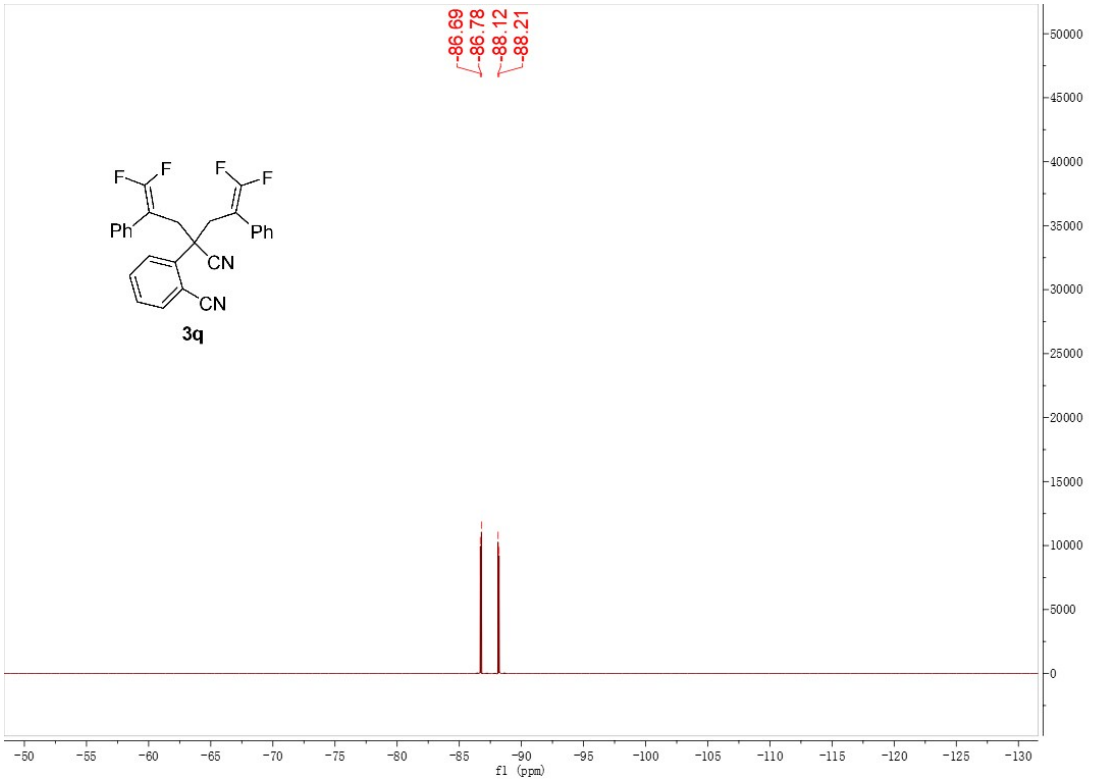
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3q



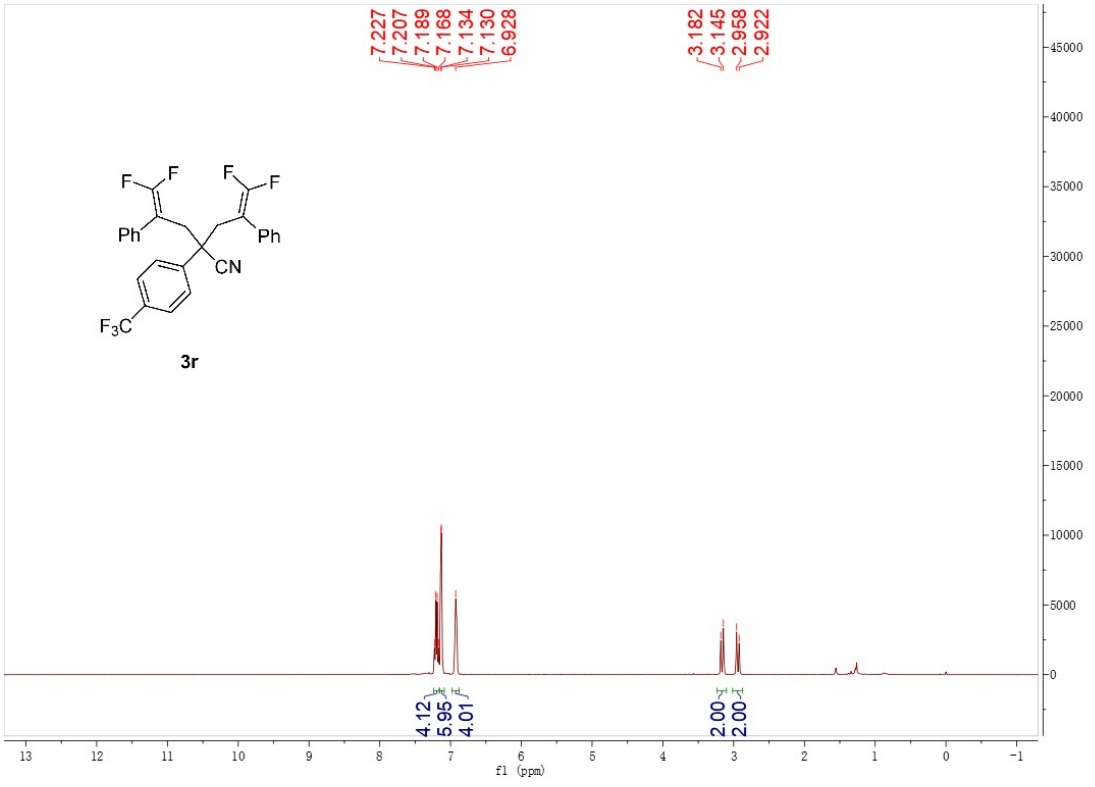
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3q



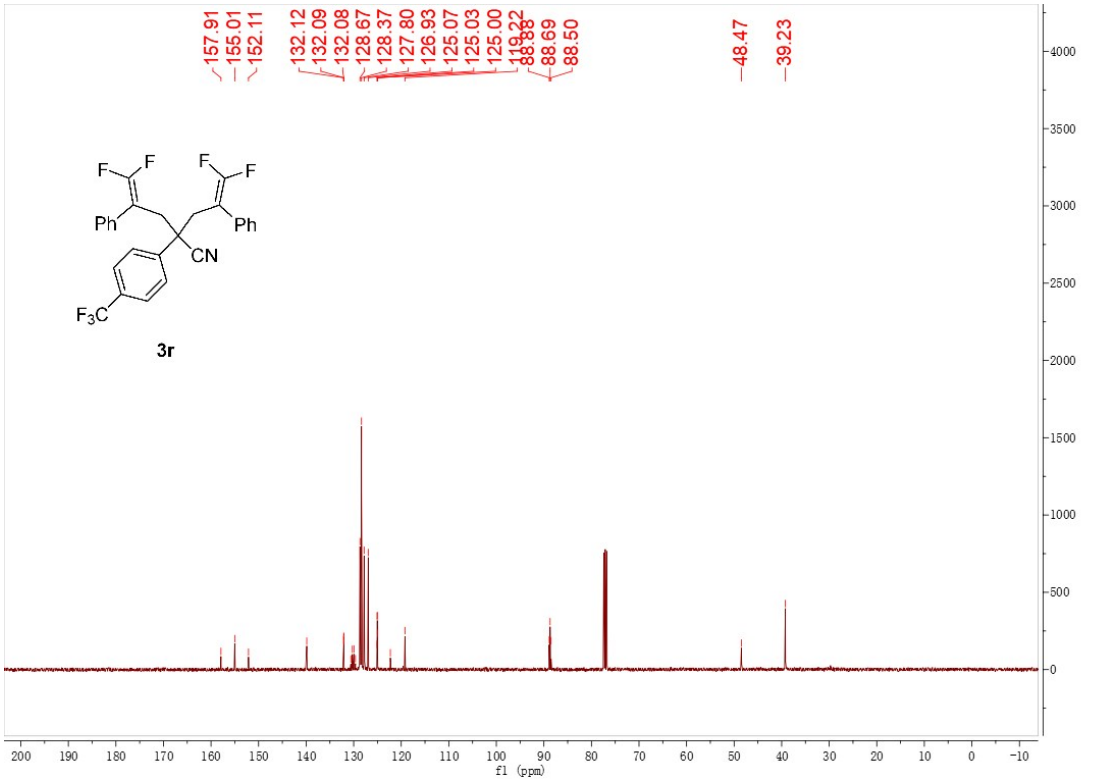
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3q



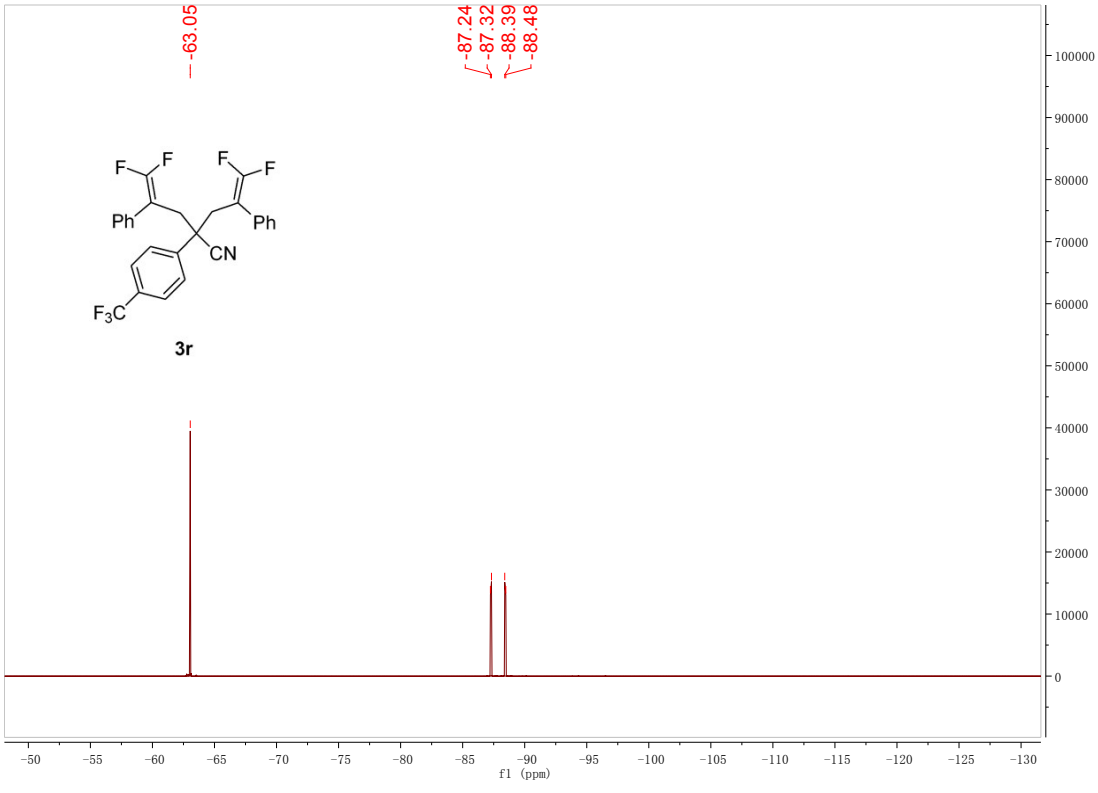
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3r



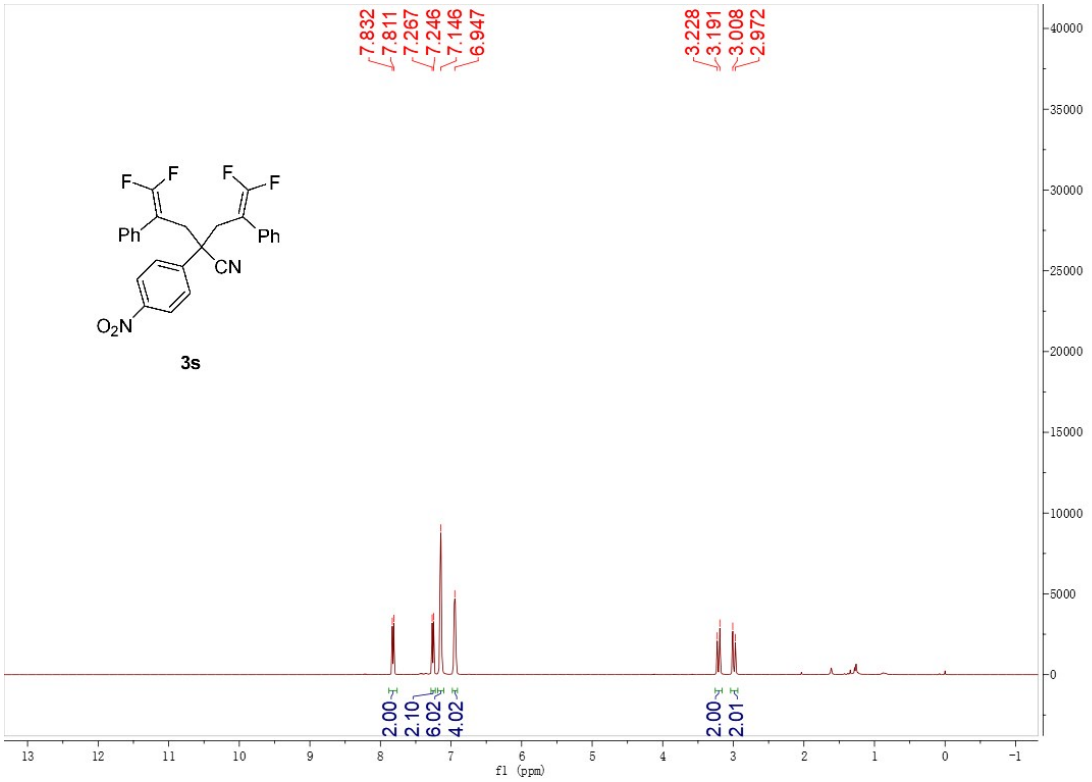
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3r



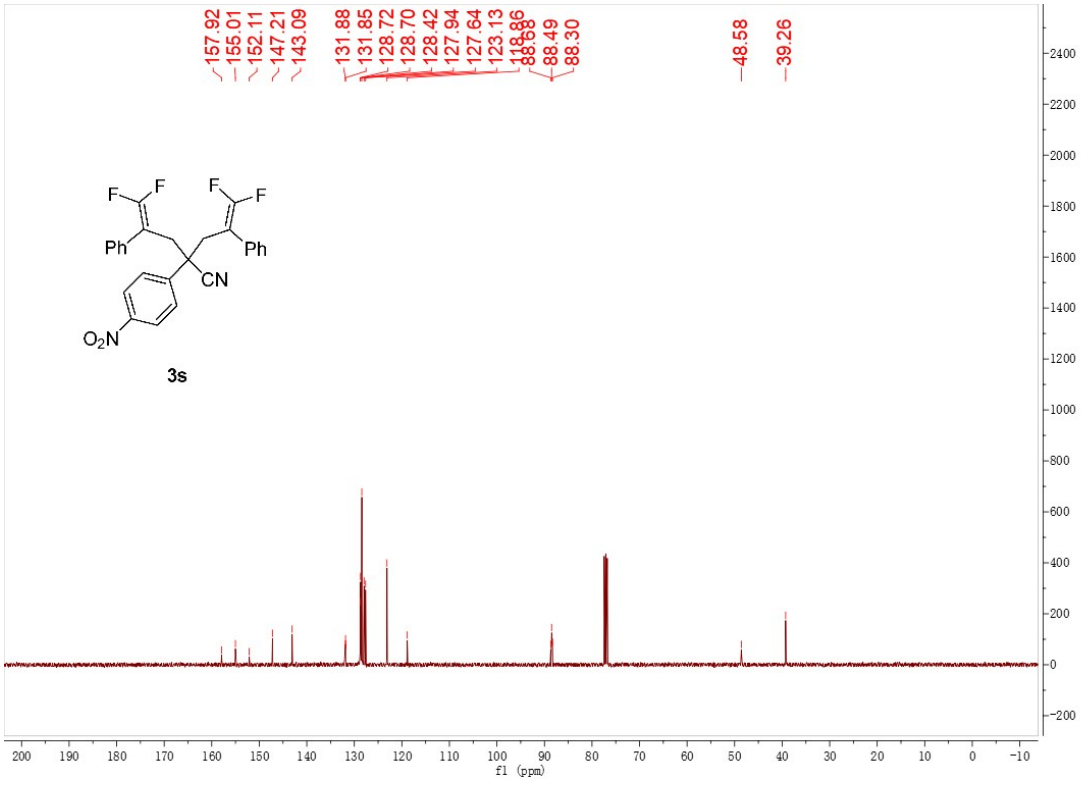
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3r



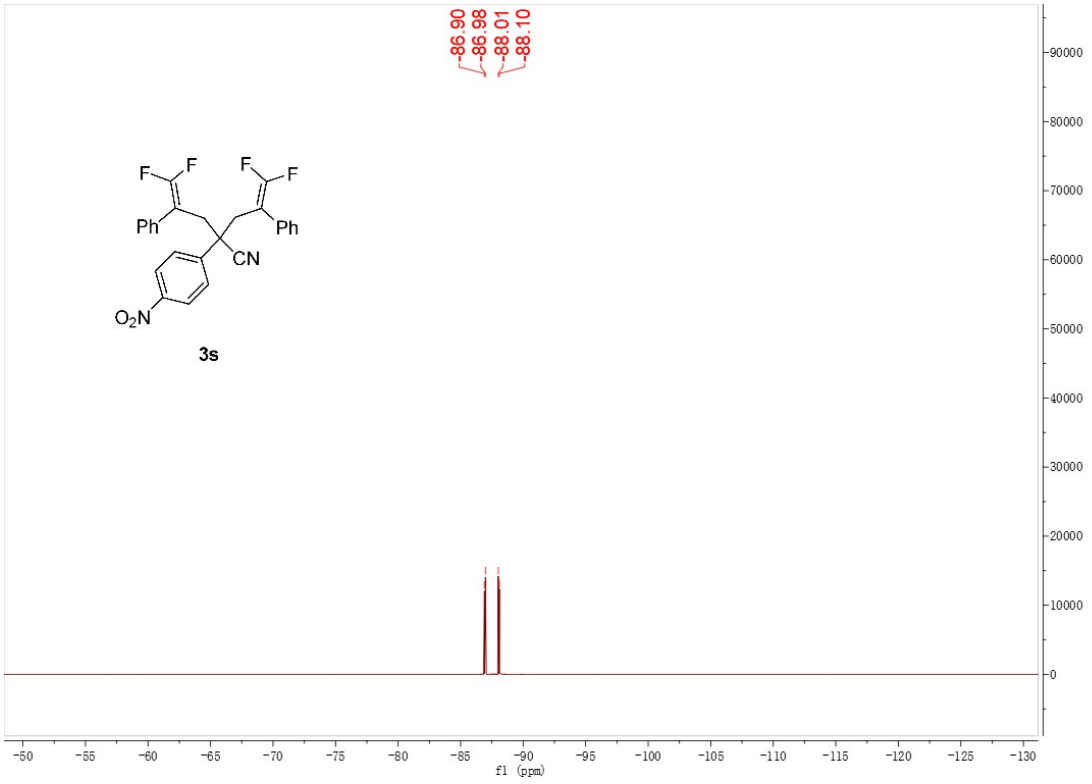
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3s



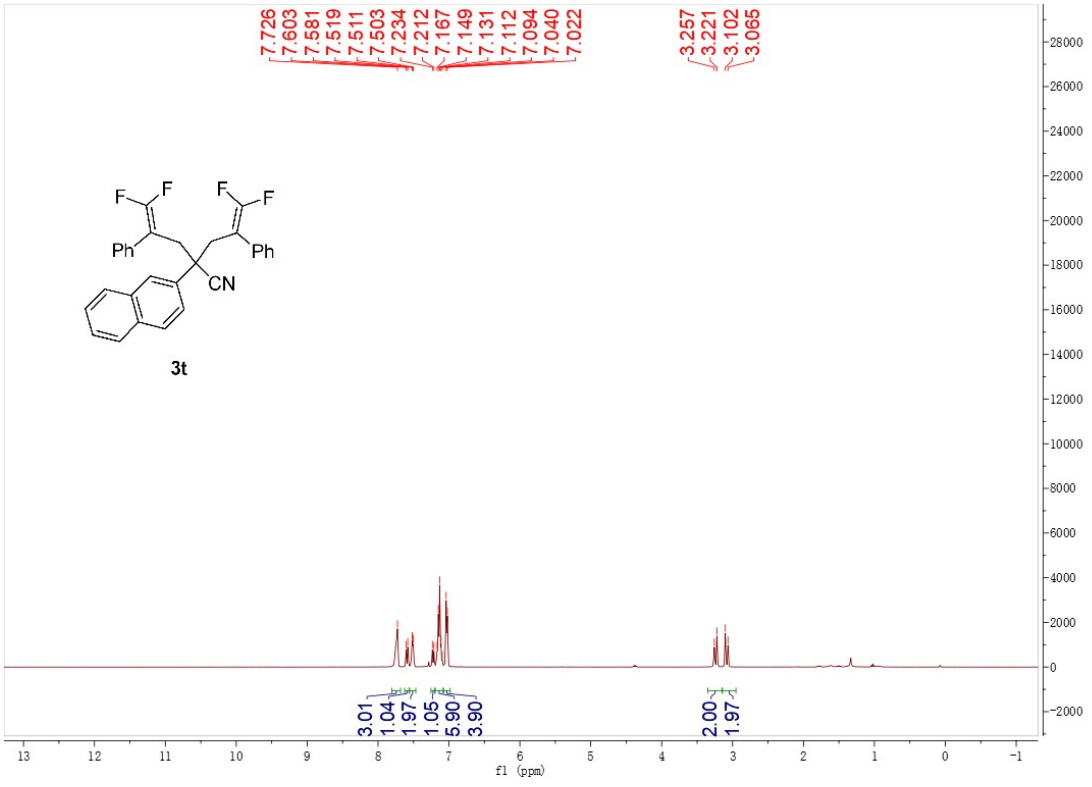
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3s



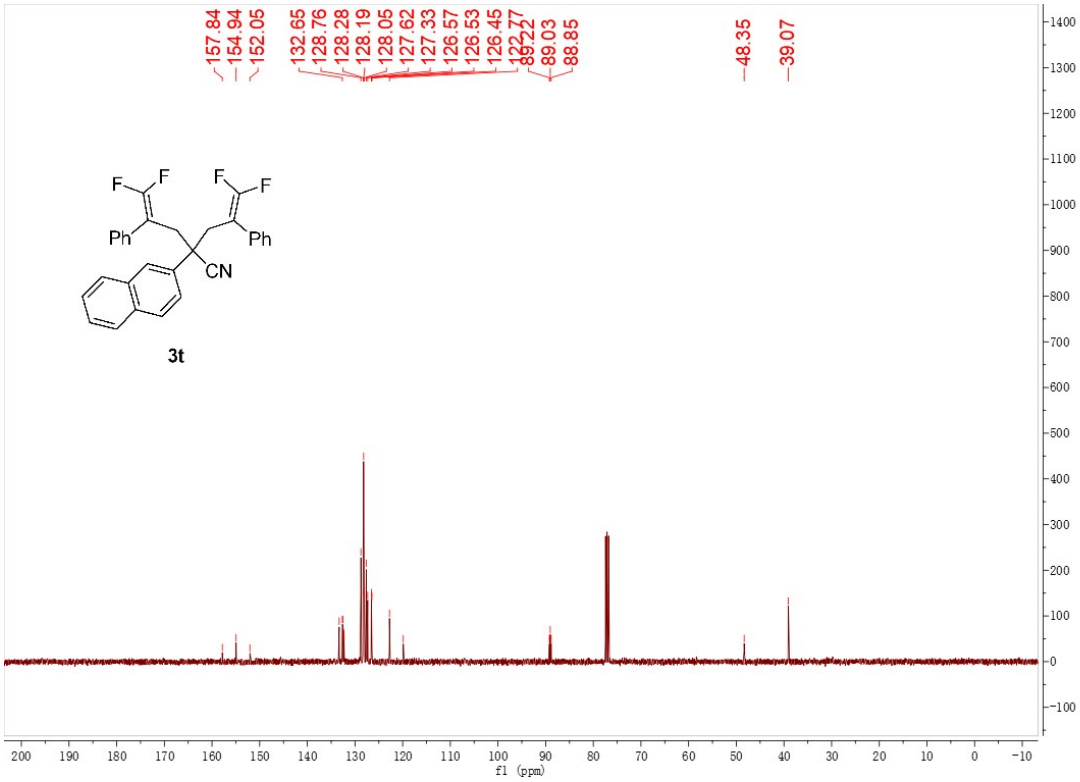
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3s



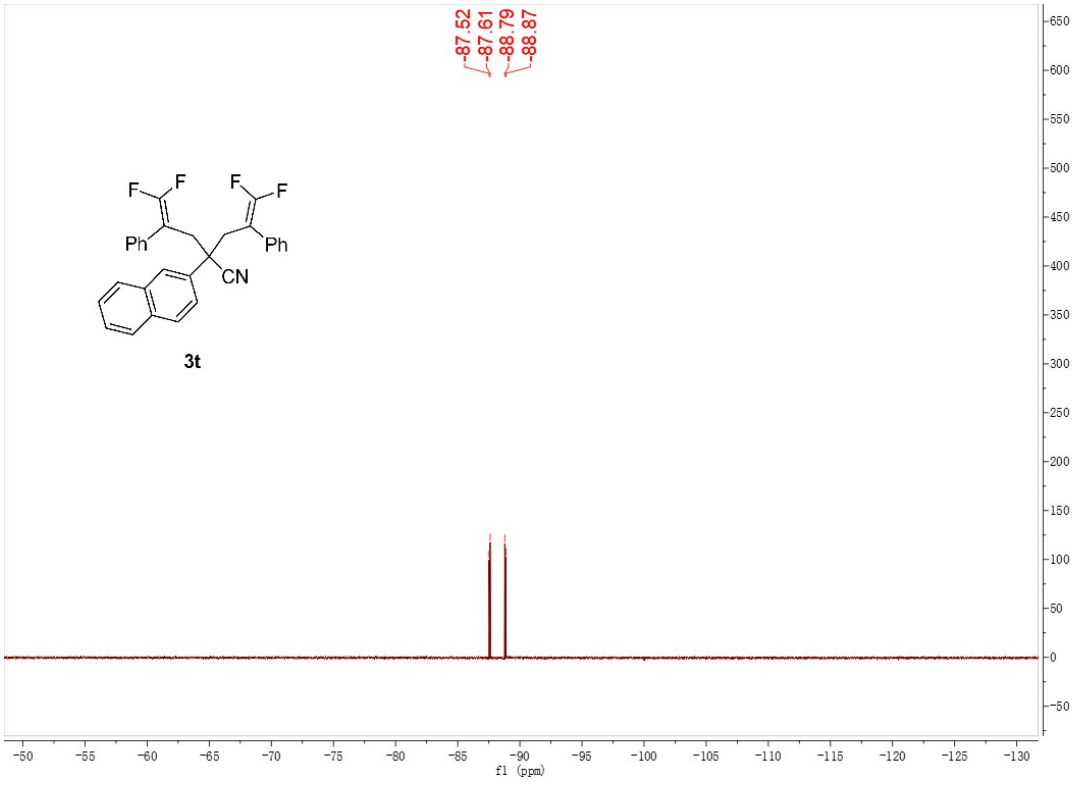
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3t



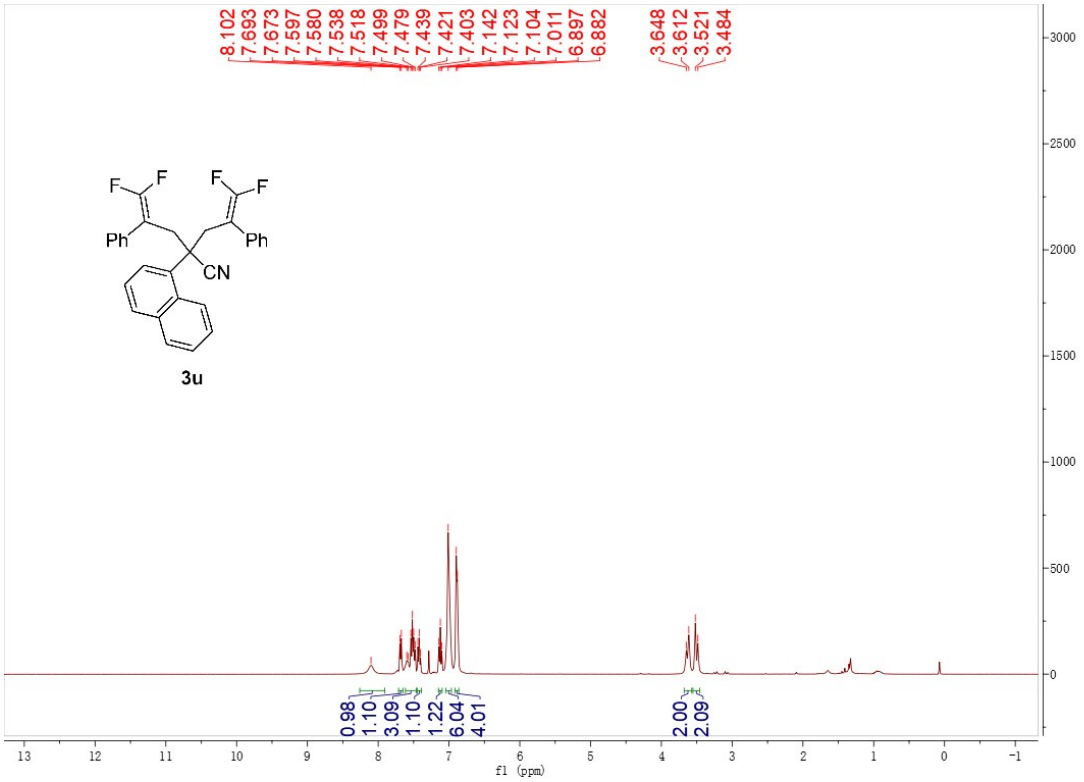
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3t



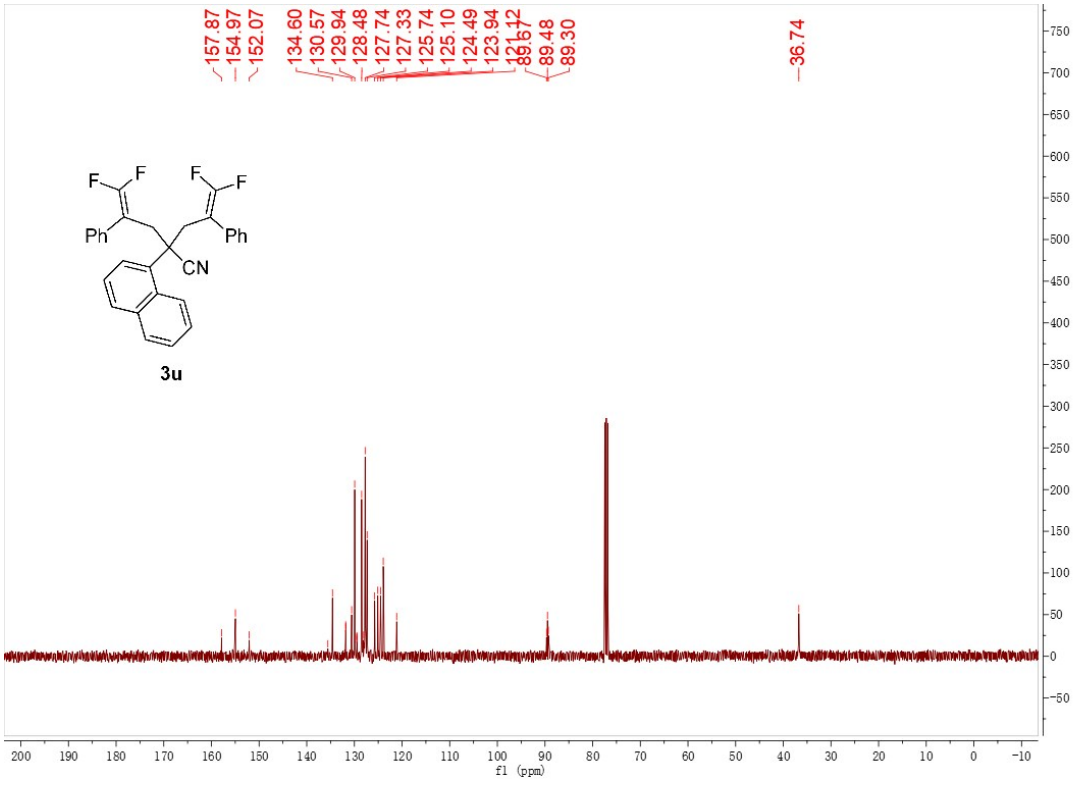
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3t



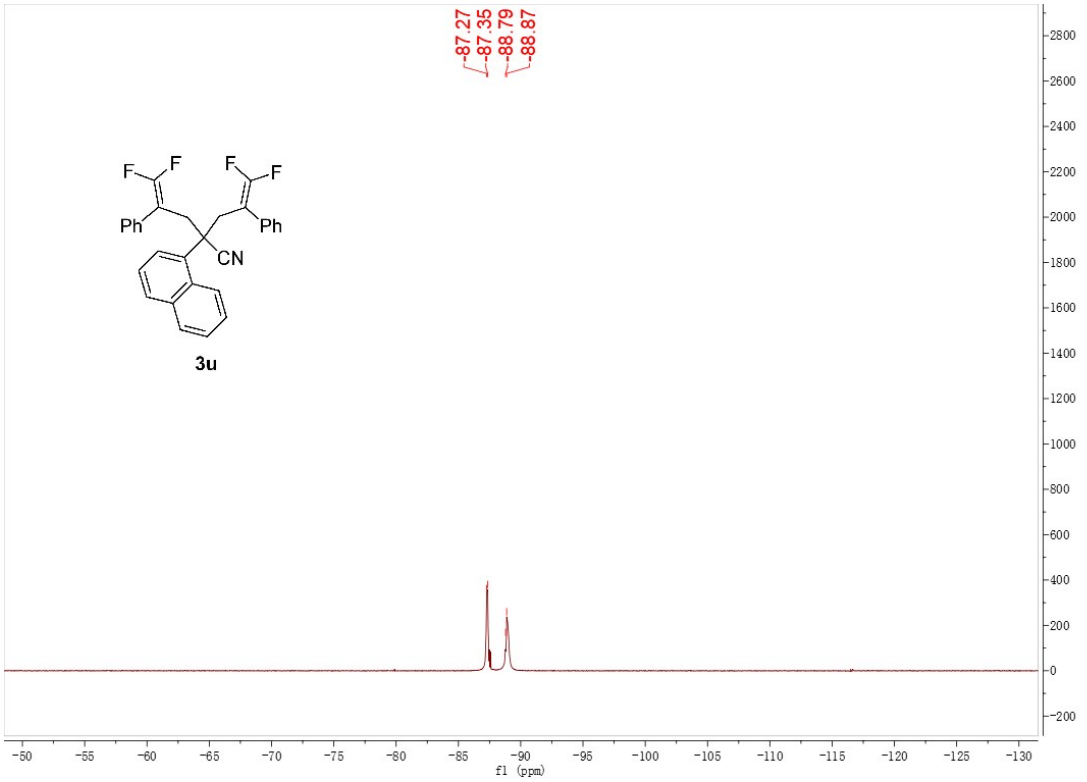
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3u



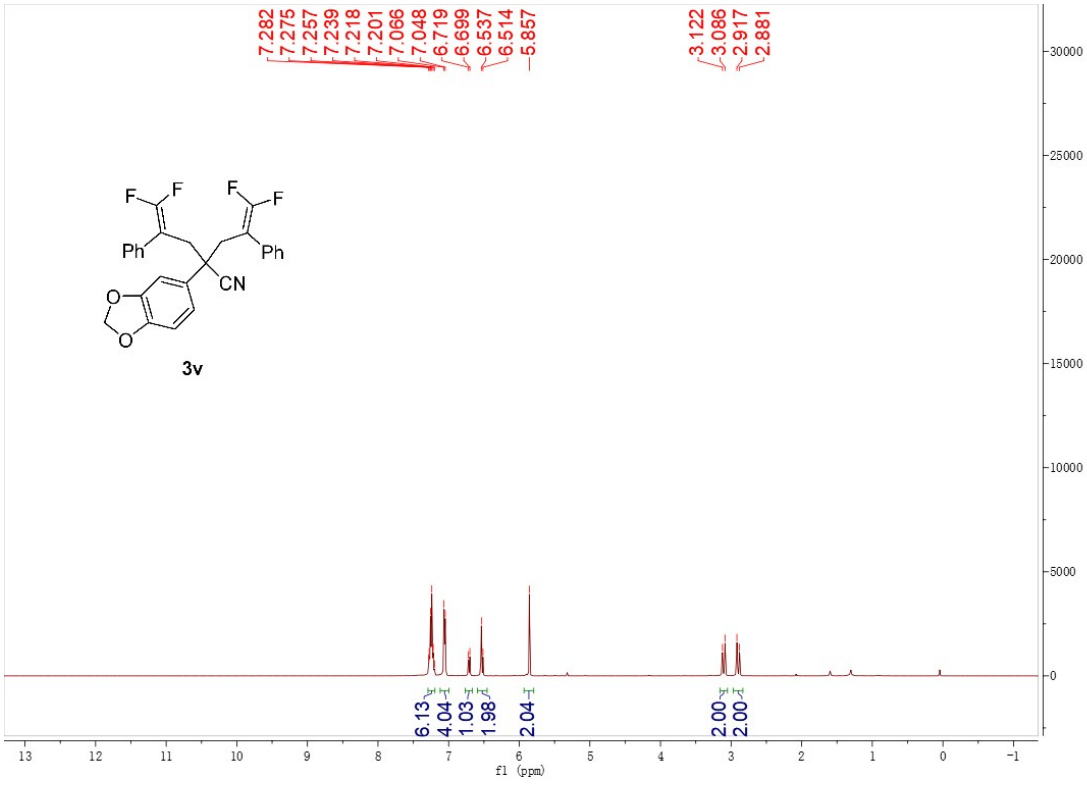
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3u



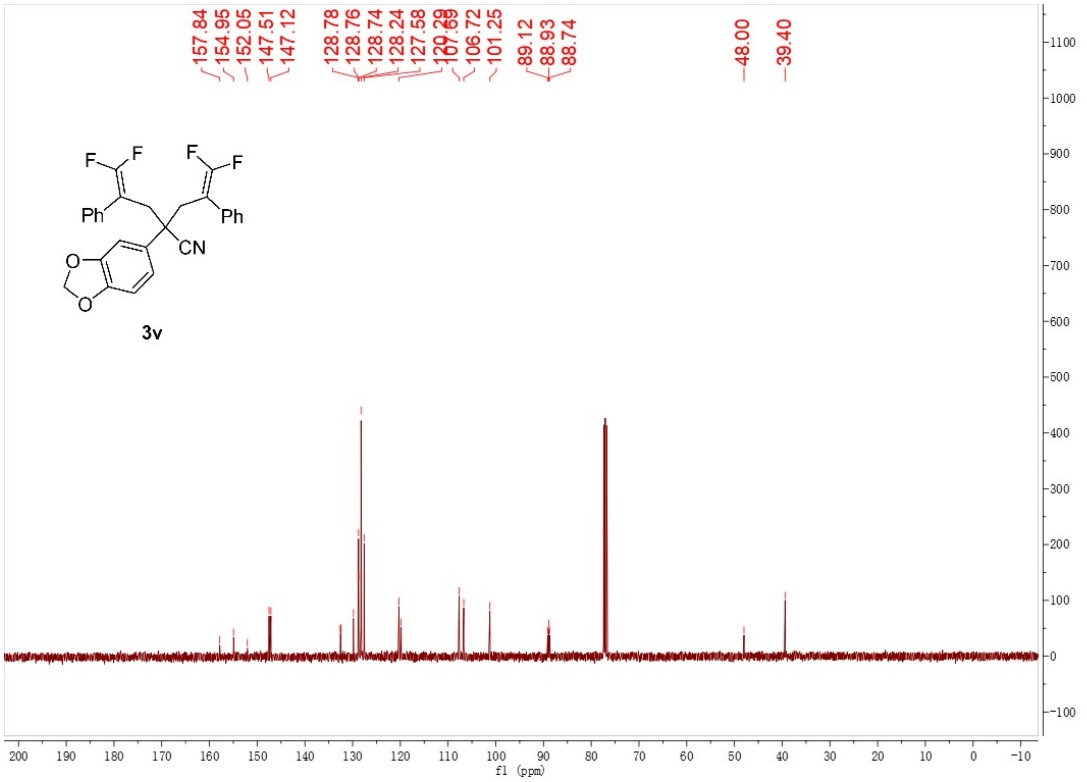
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3u



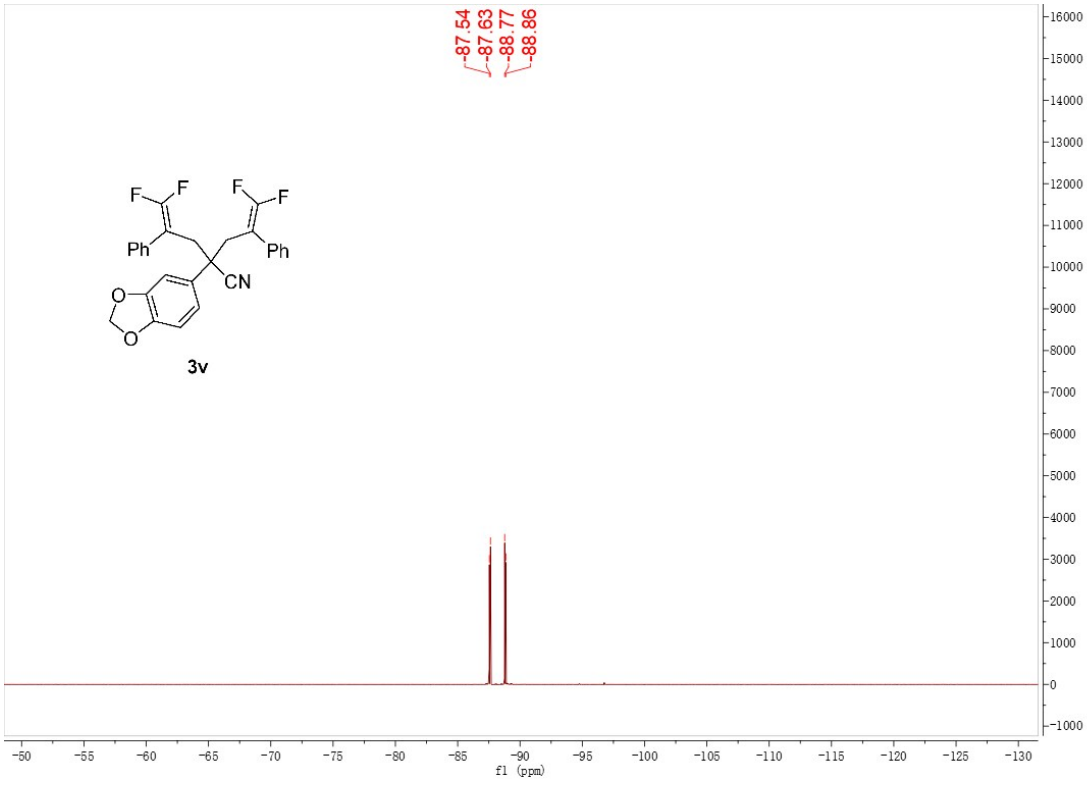
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3v



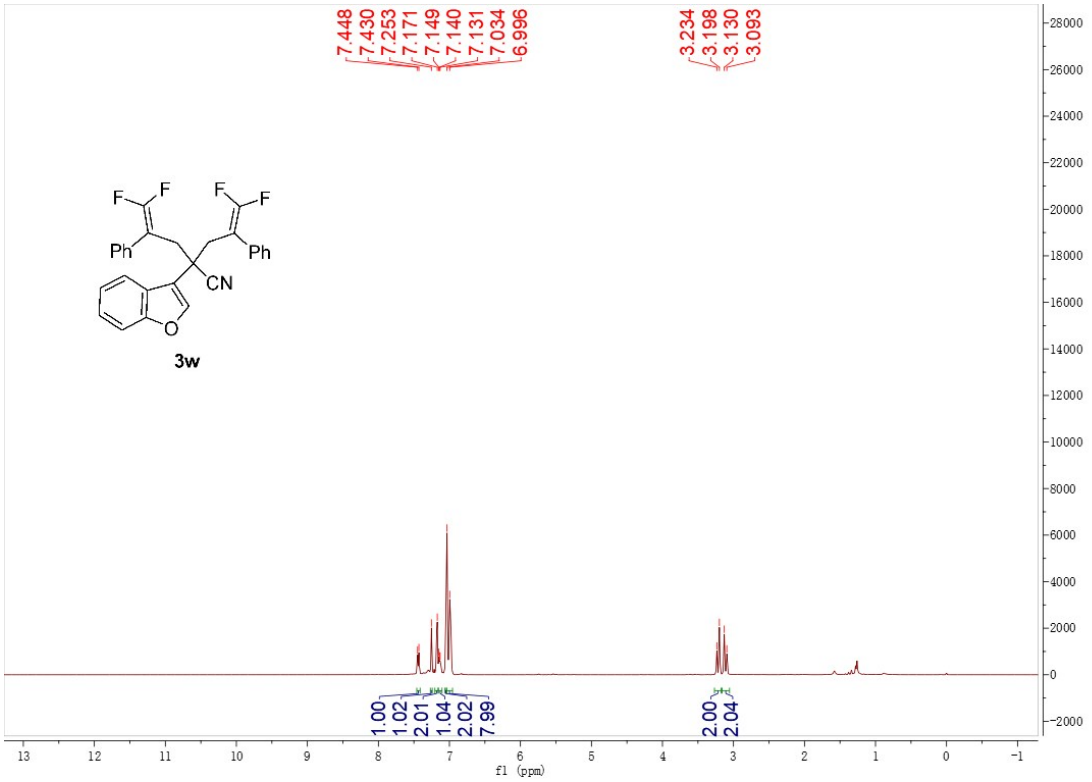
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3v



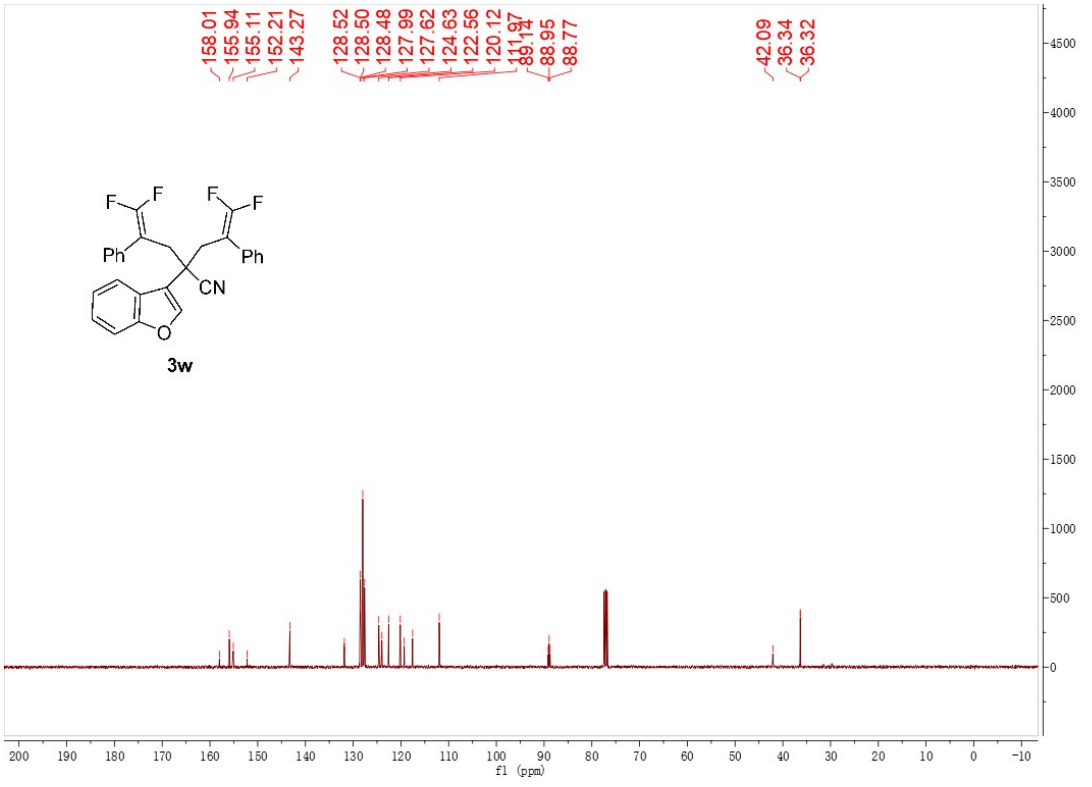
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3v



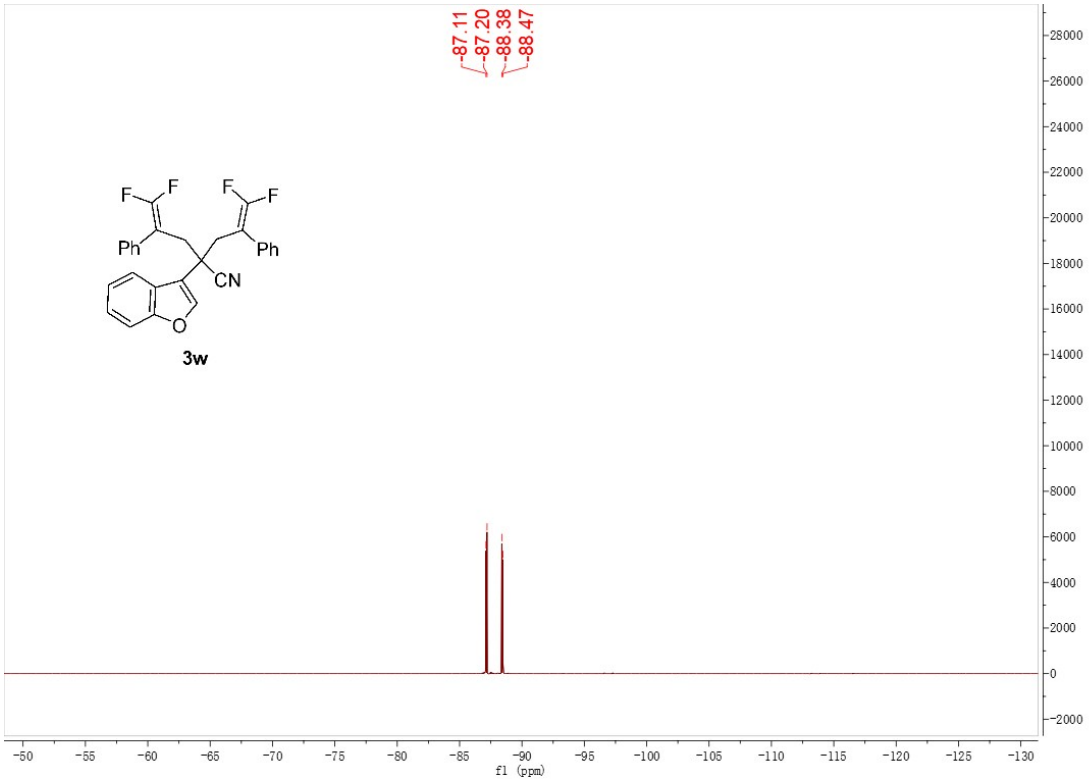
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3w



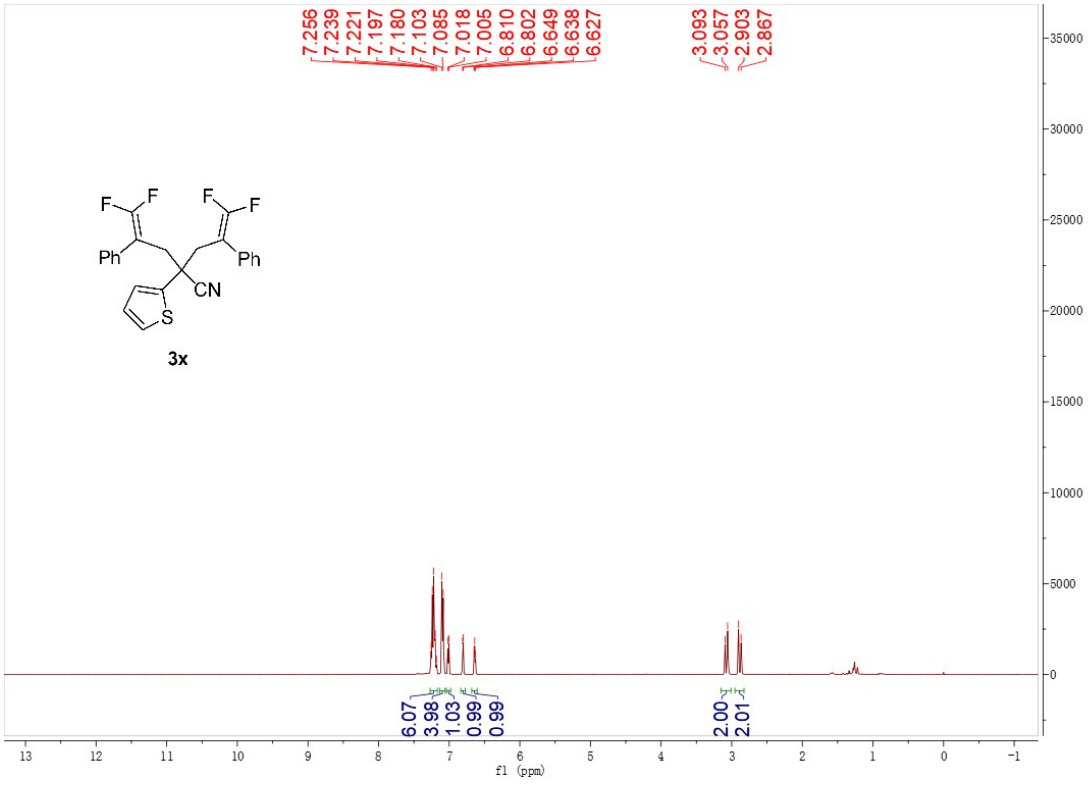
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3w



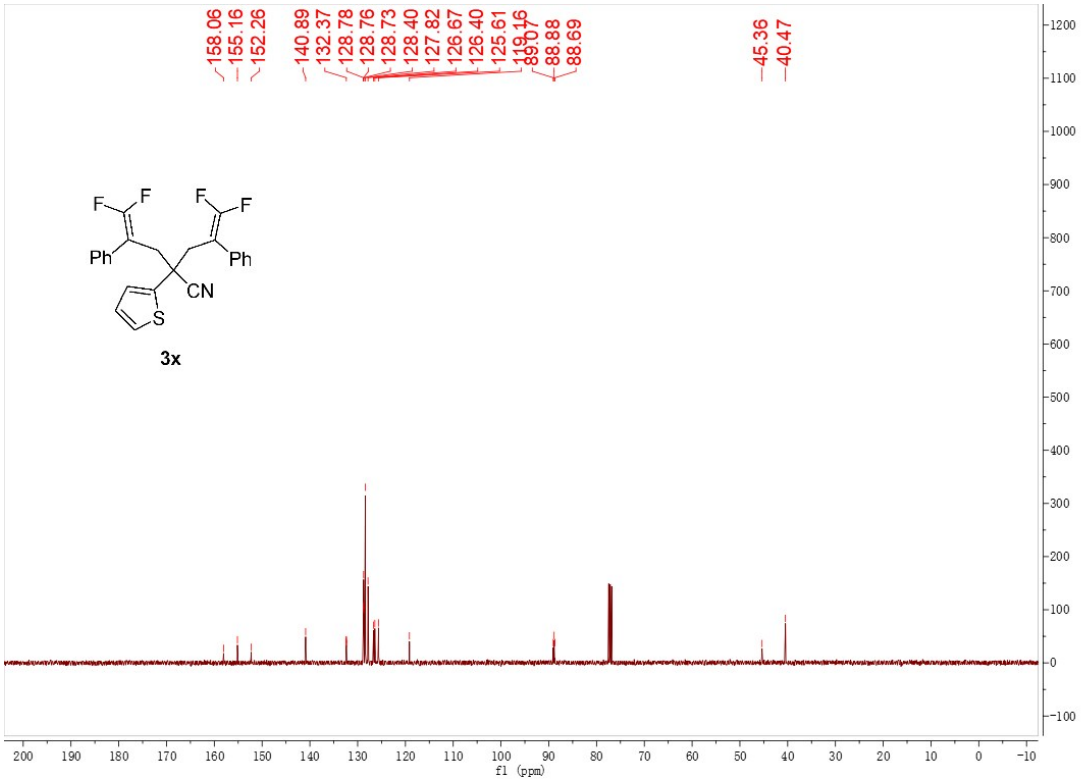
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3w



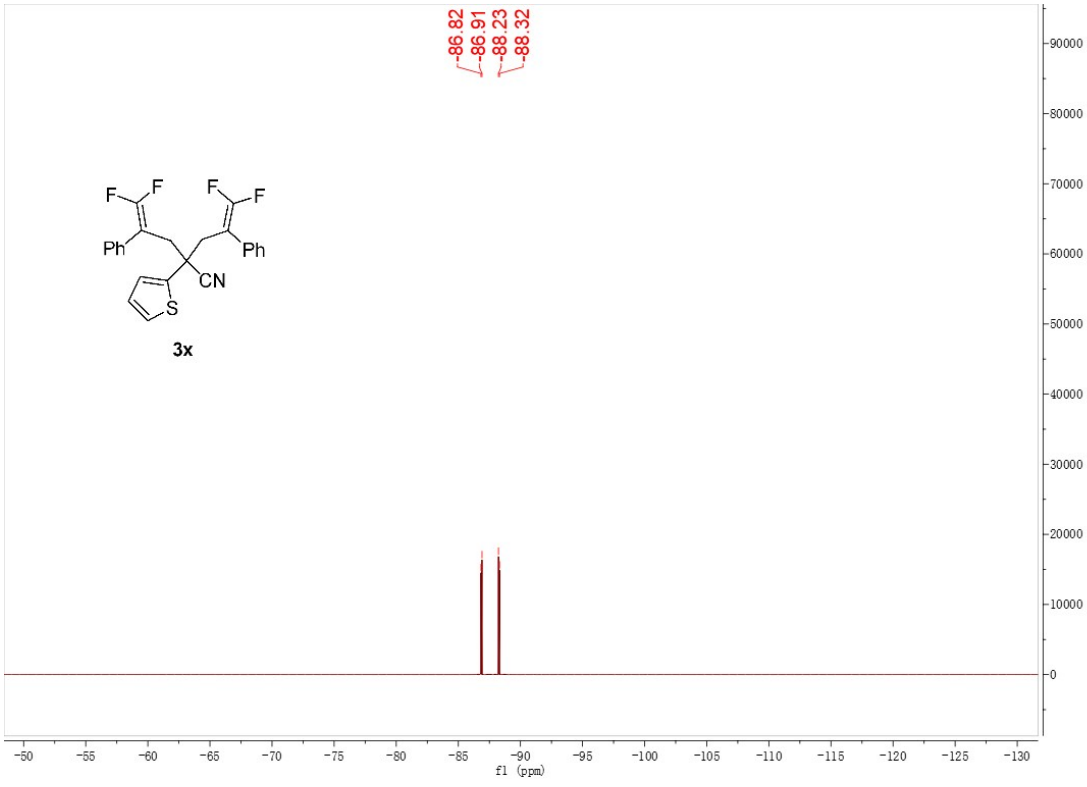
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3x



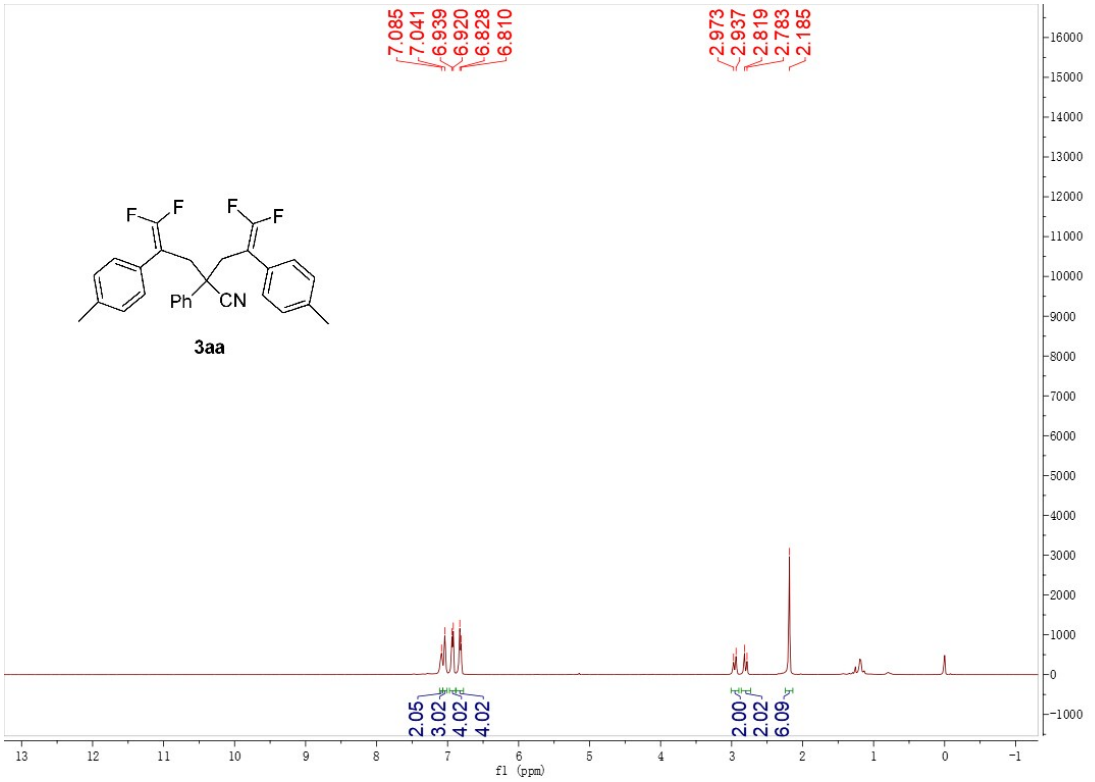
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3x



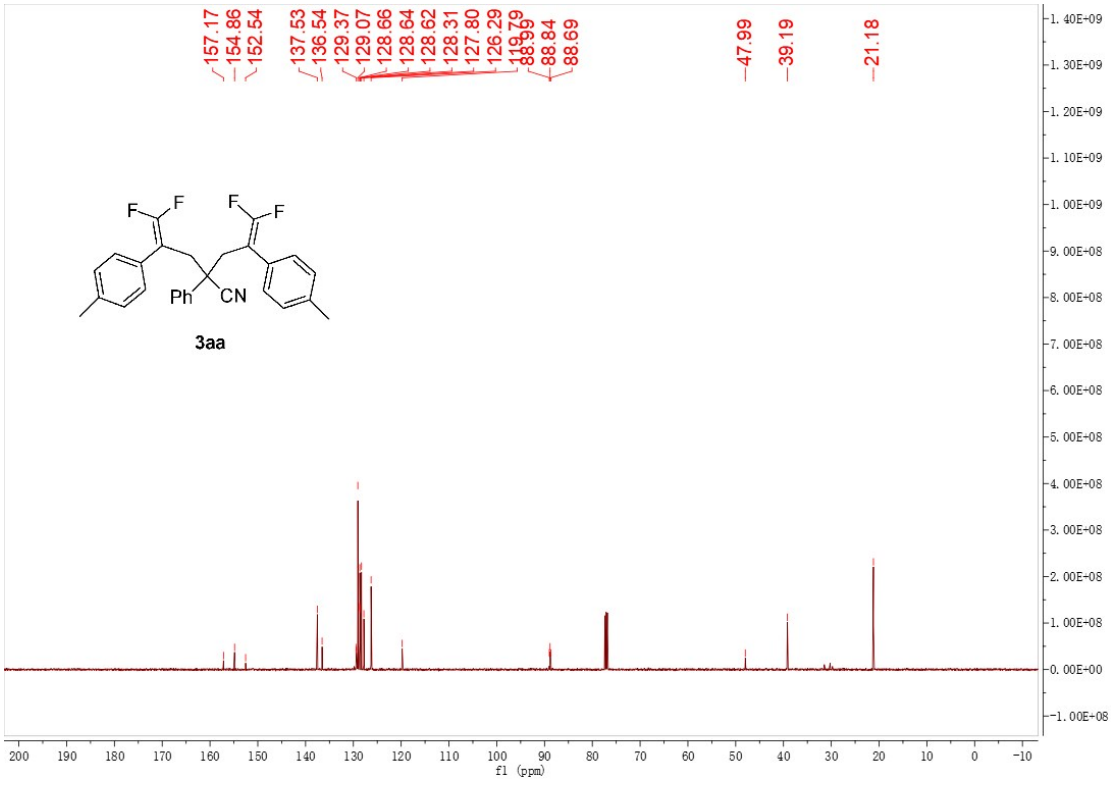
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3x



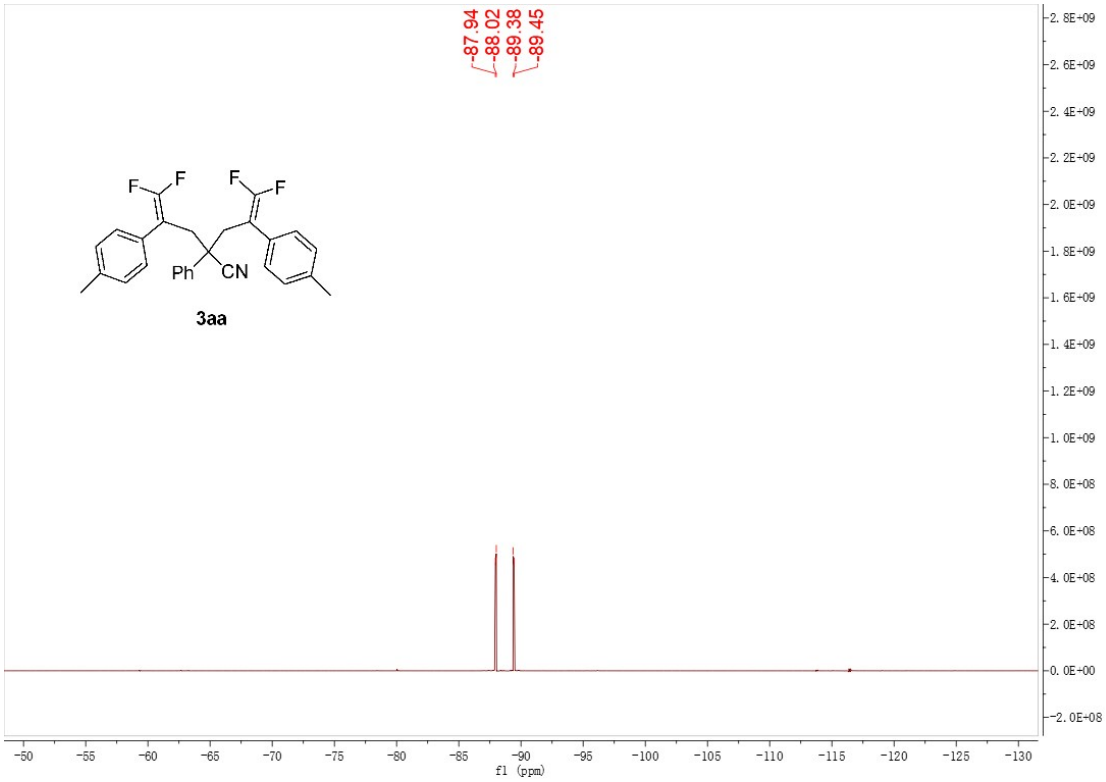
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3aa



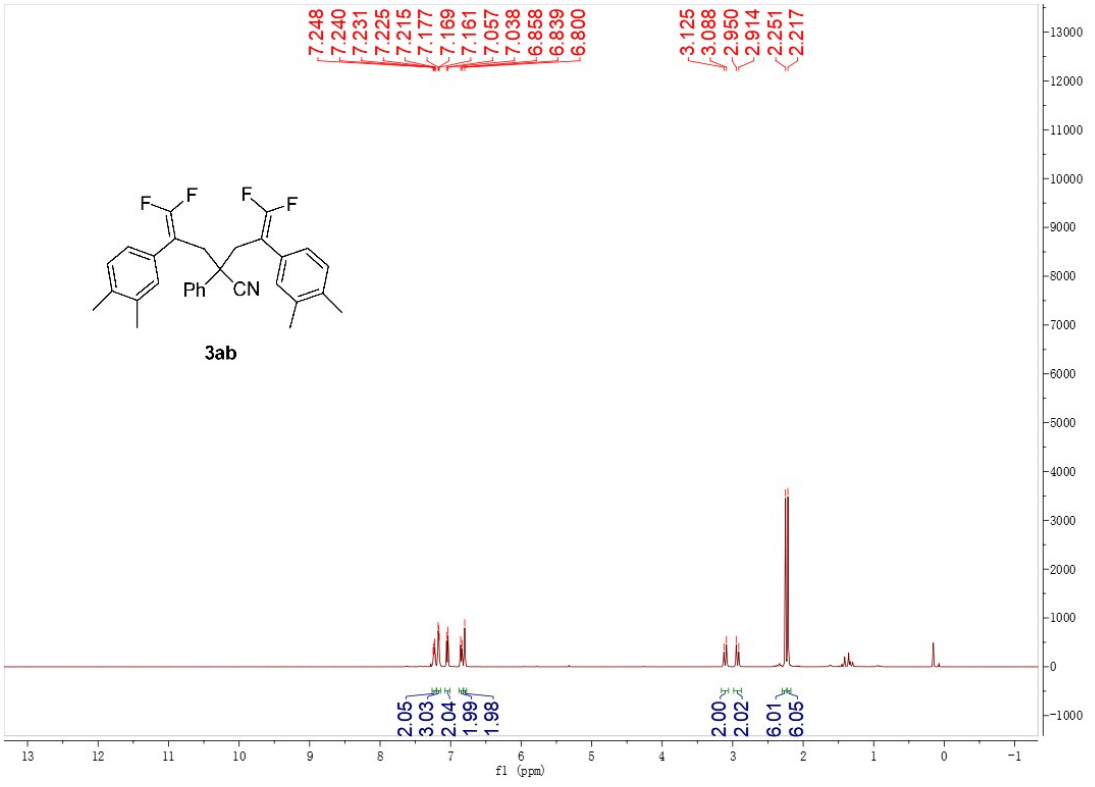
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3aa



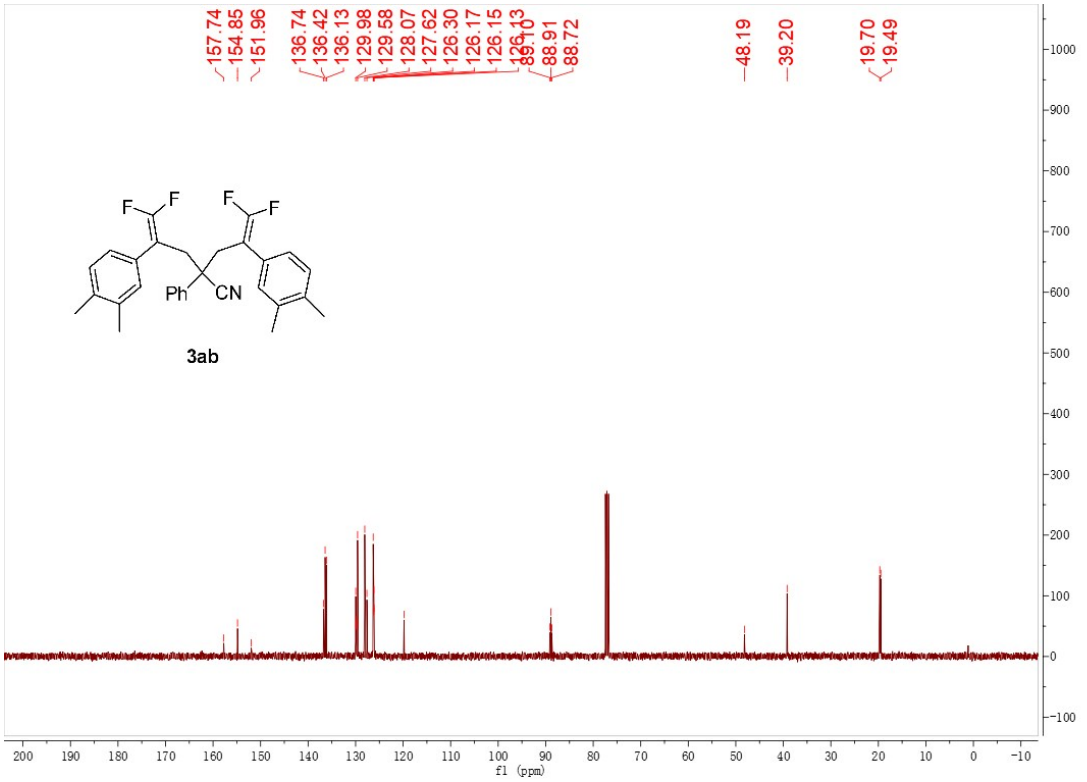
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3aa



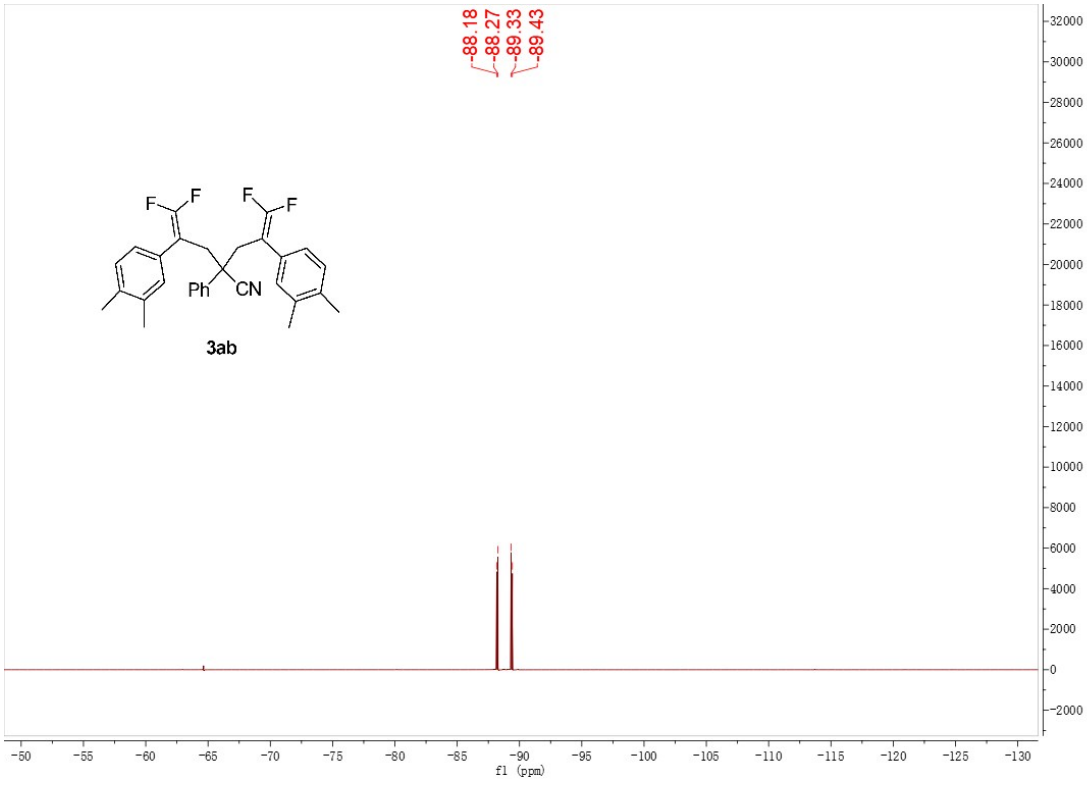
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3ab



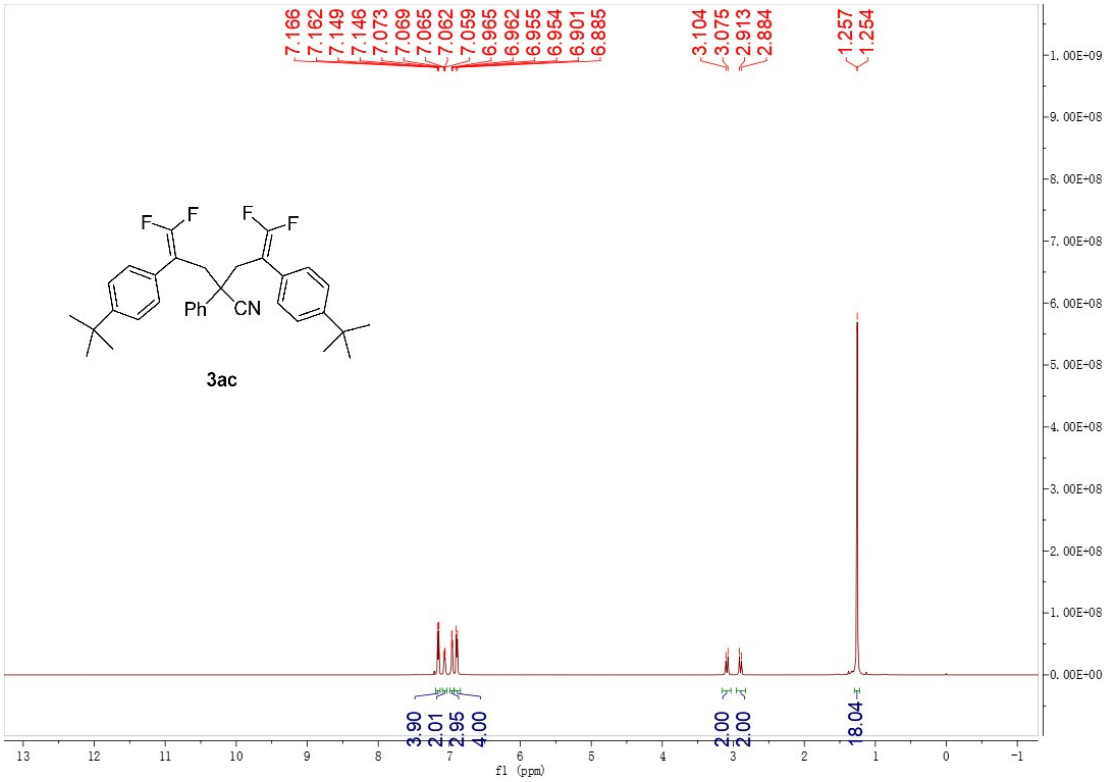
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3ab



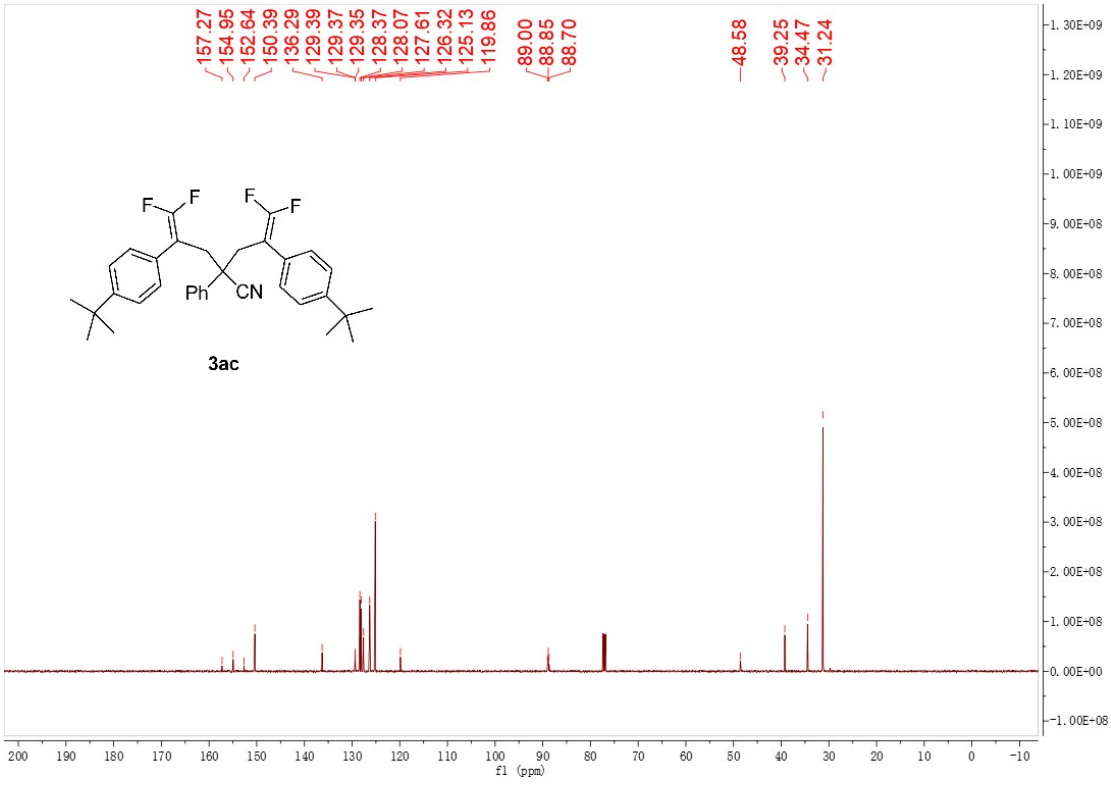
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3ab



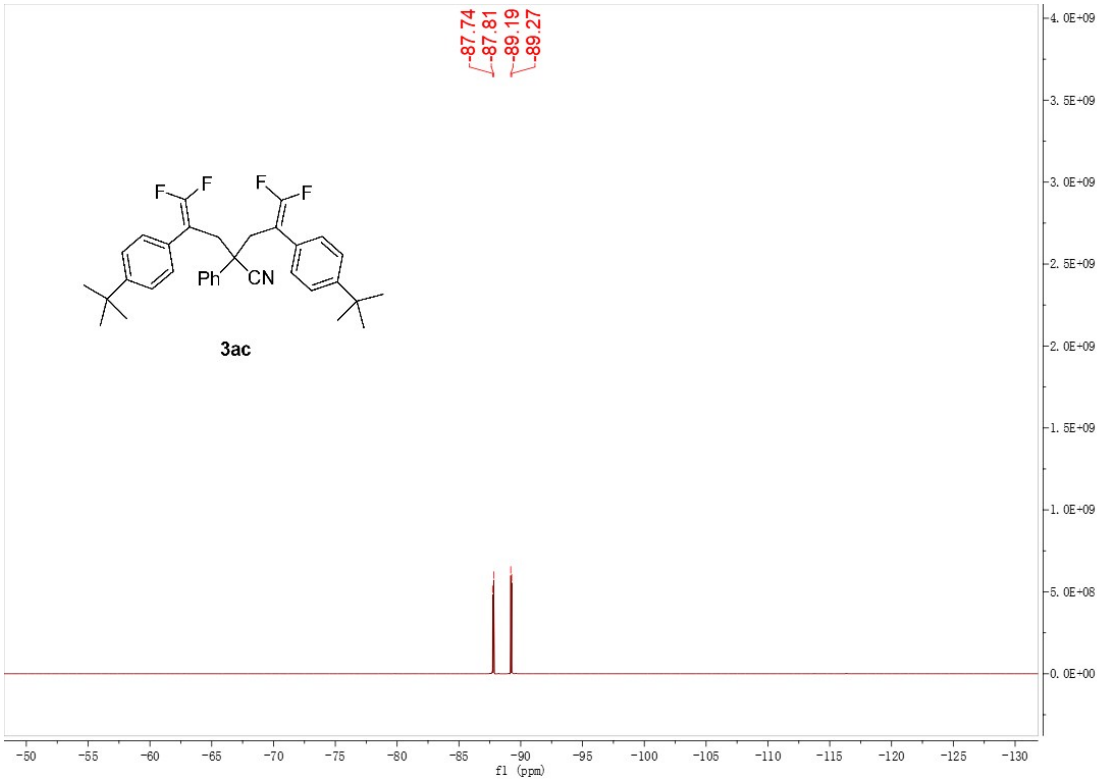
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3ac



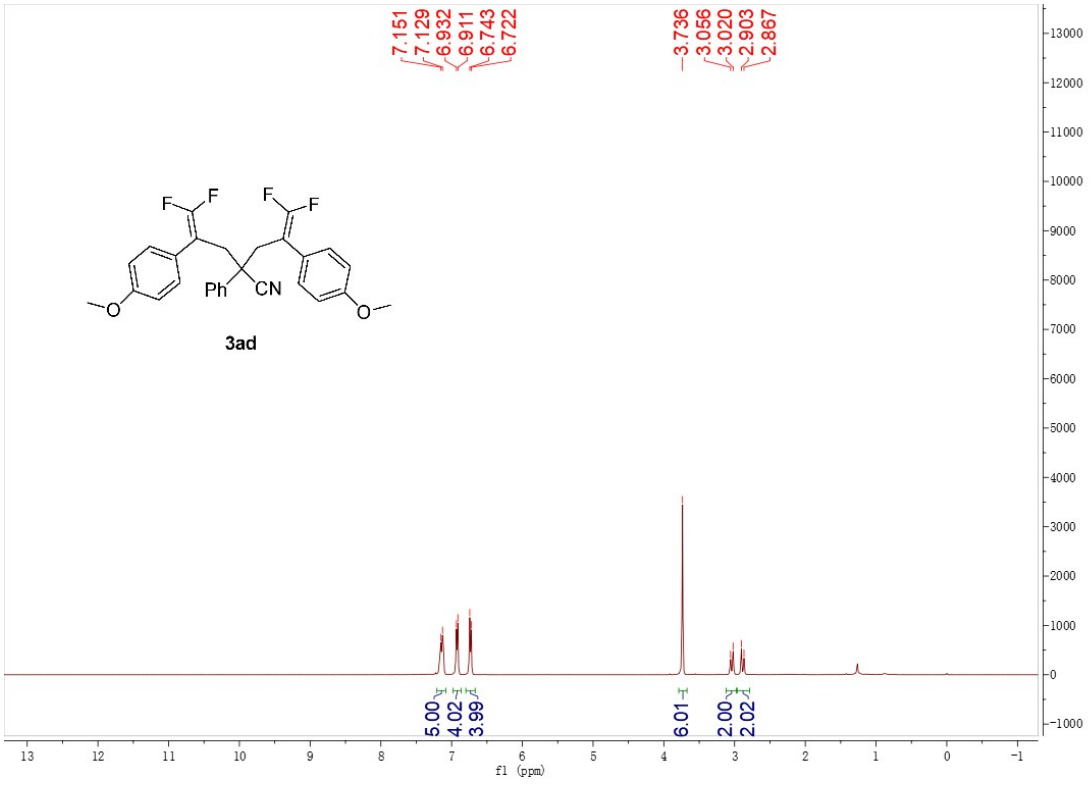
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3ac



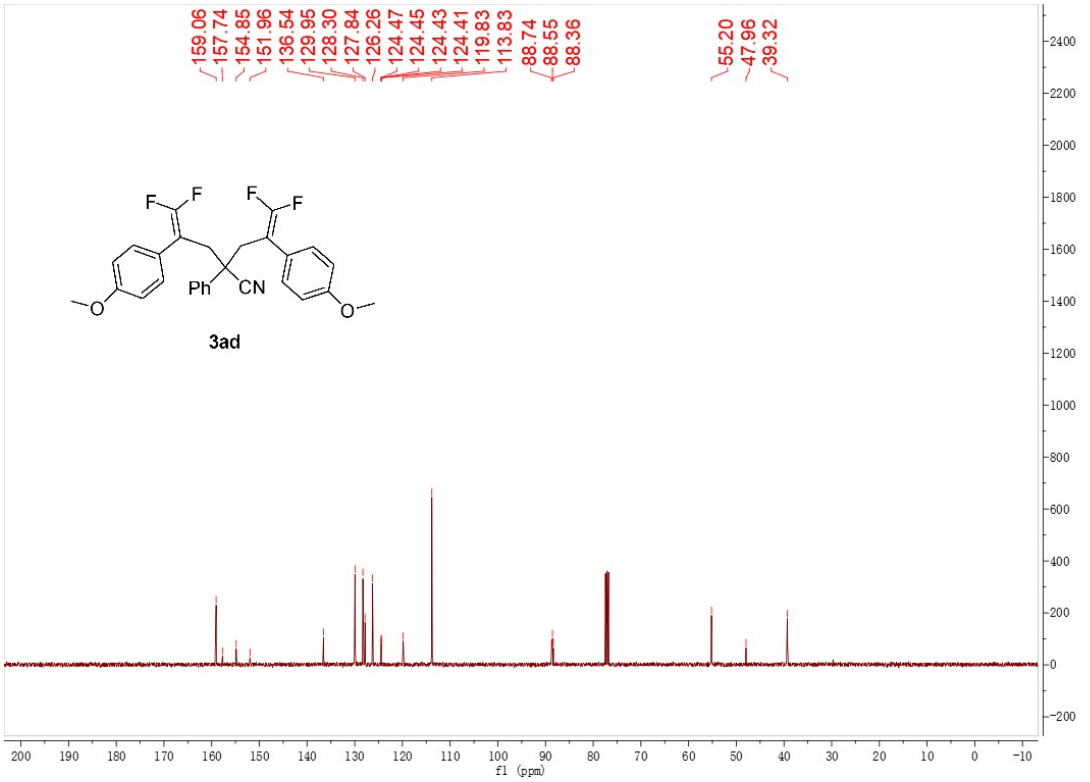
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3ac



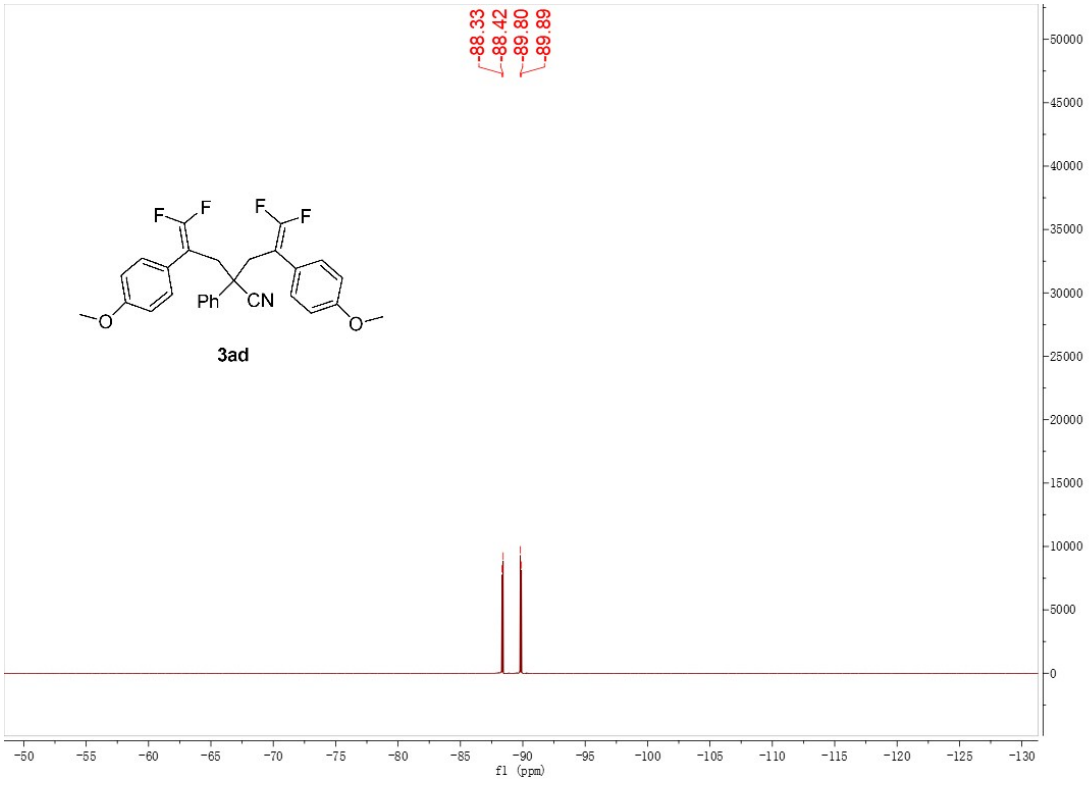
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3ad



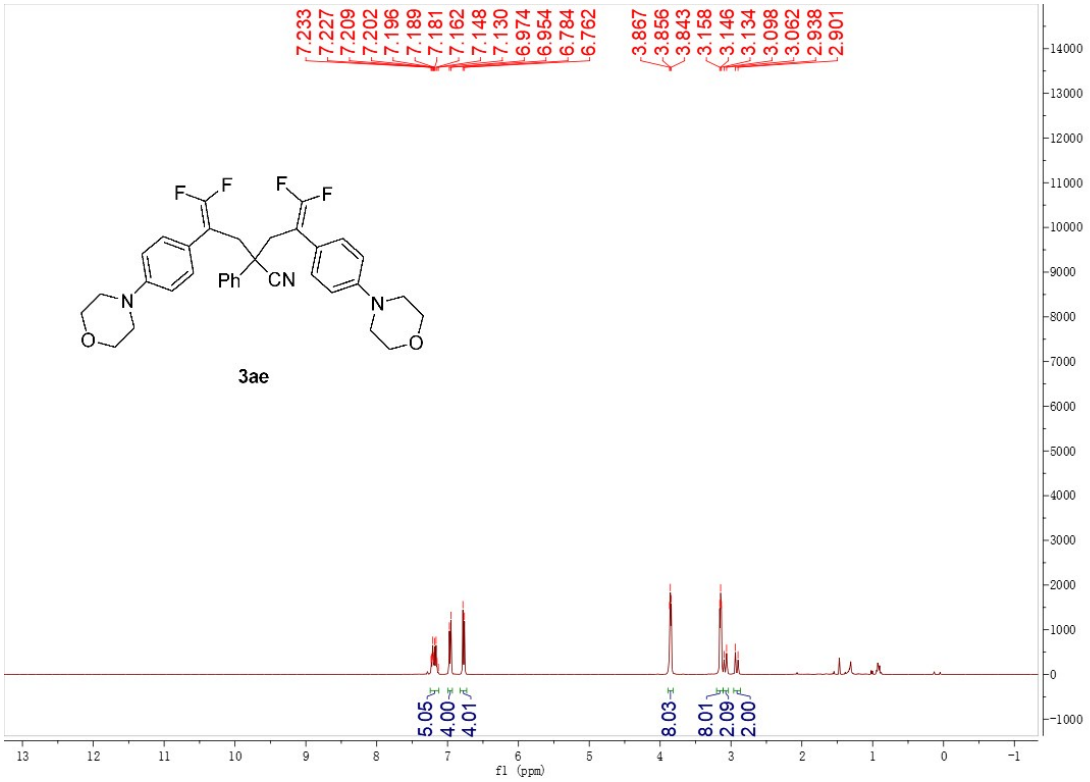
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3ad



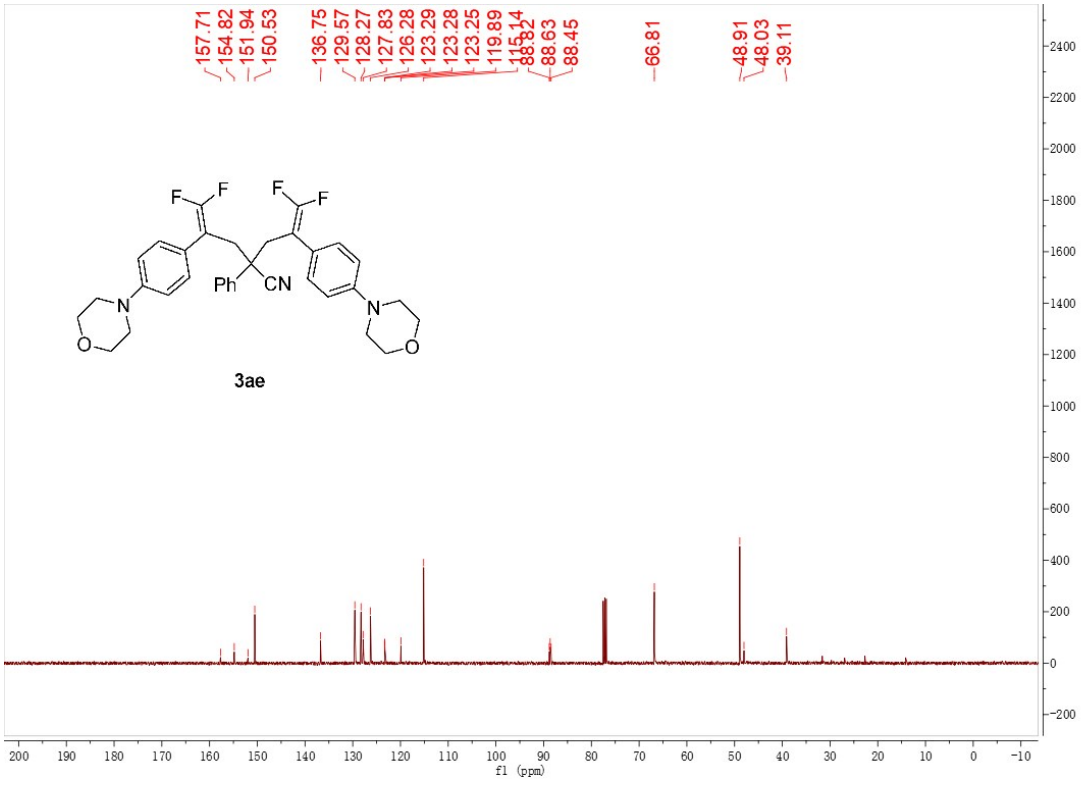
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3ad



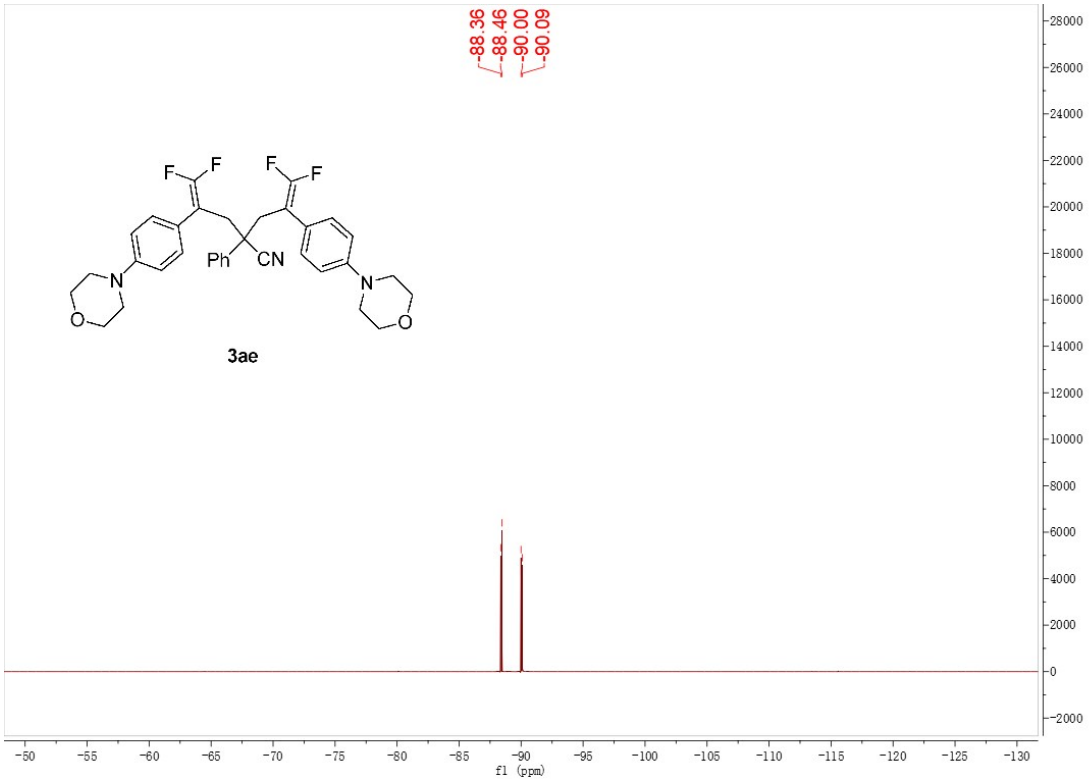
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3ae



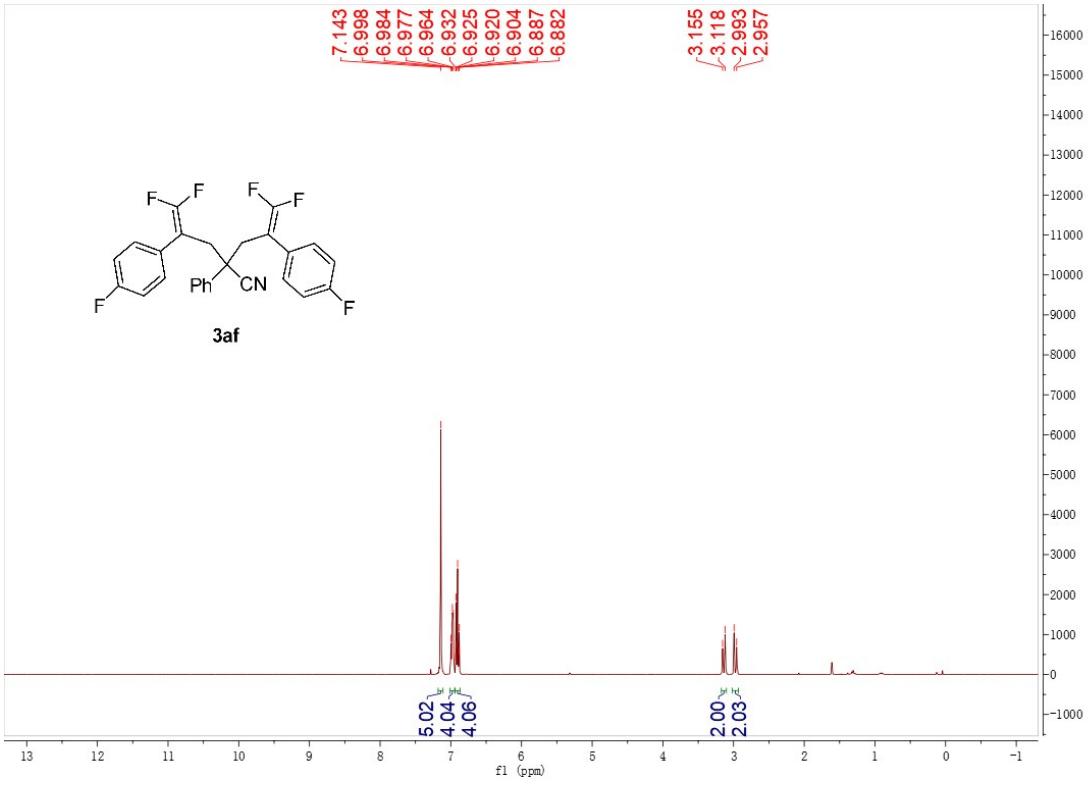
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3ae



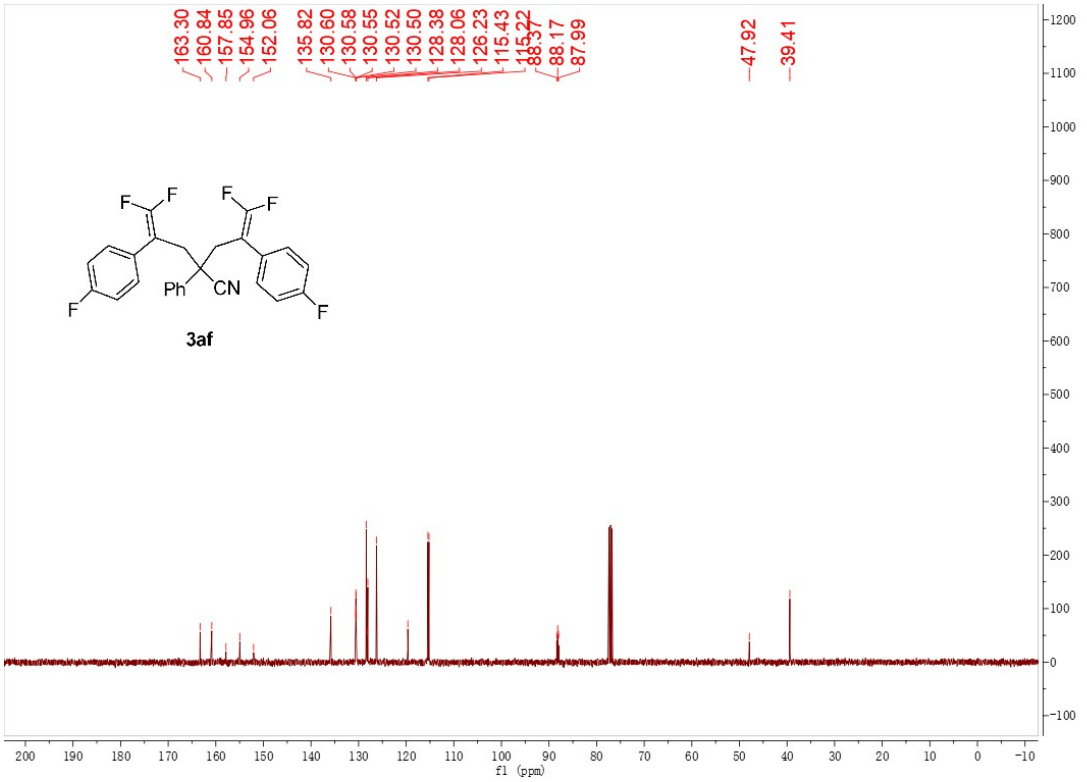
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3ae



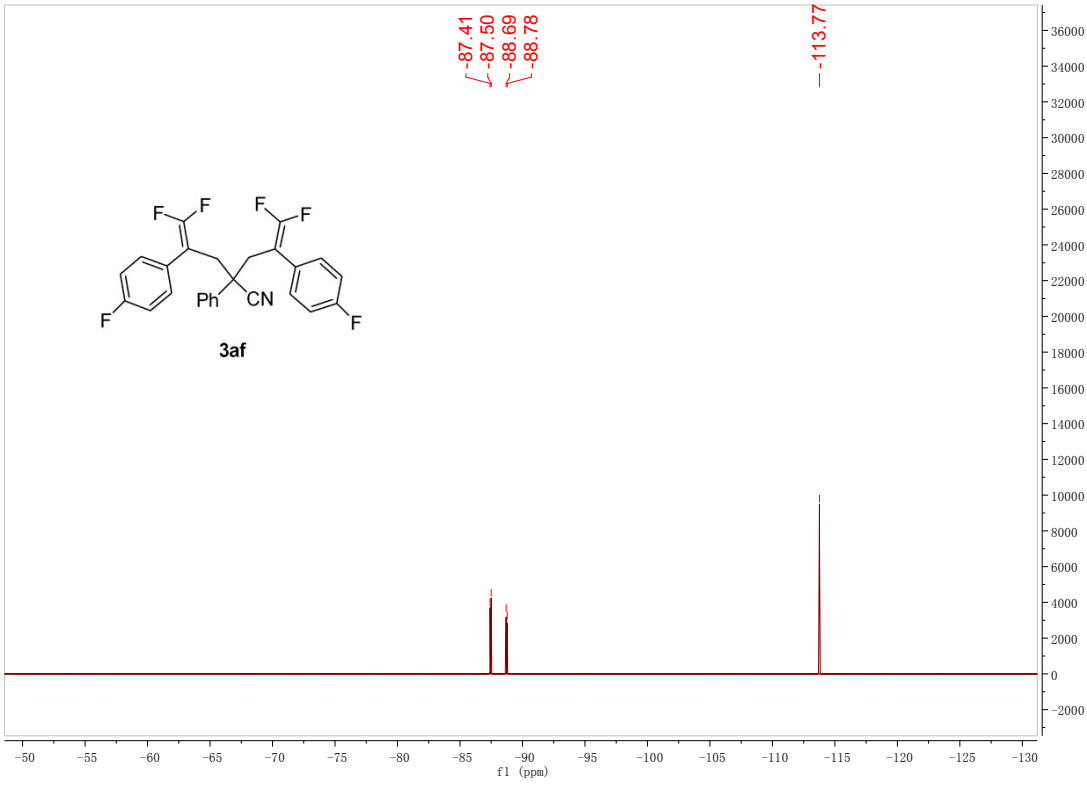
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3af



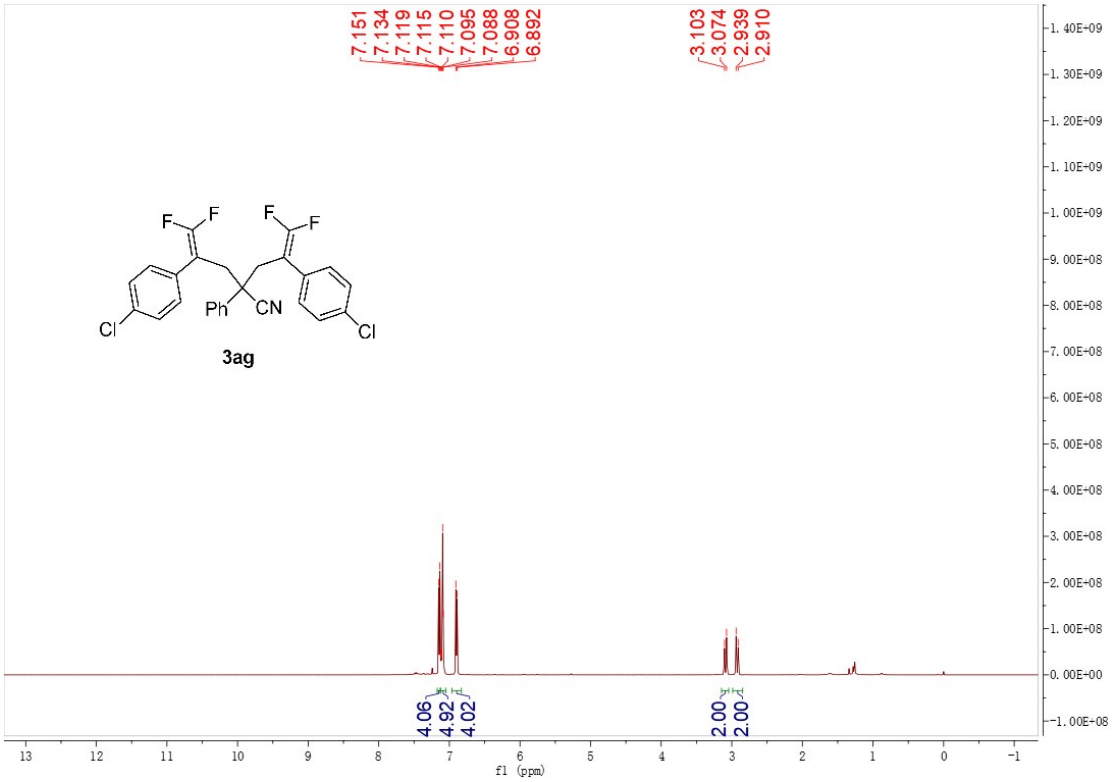
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3af



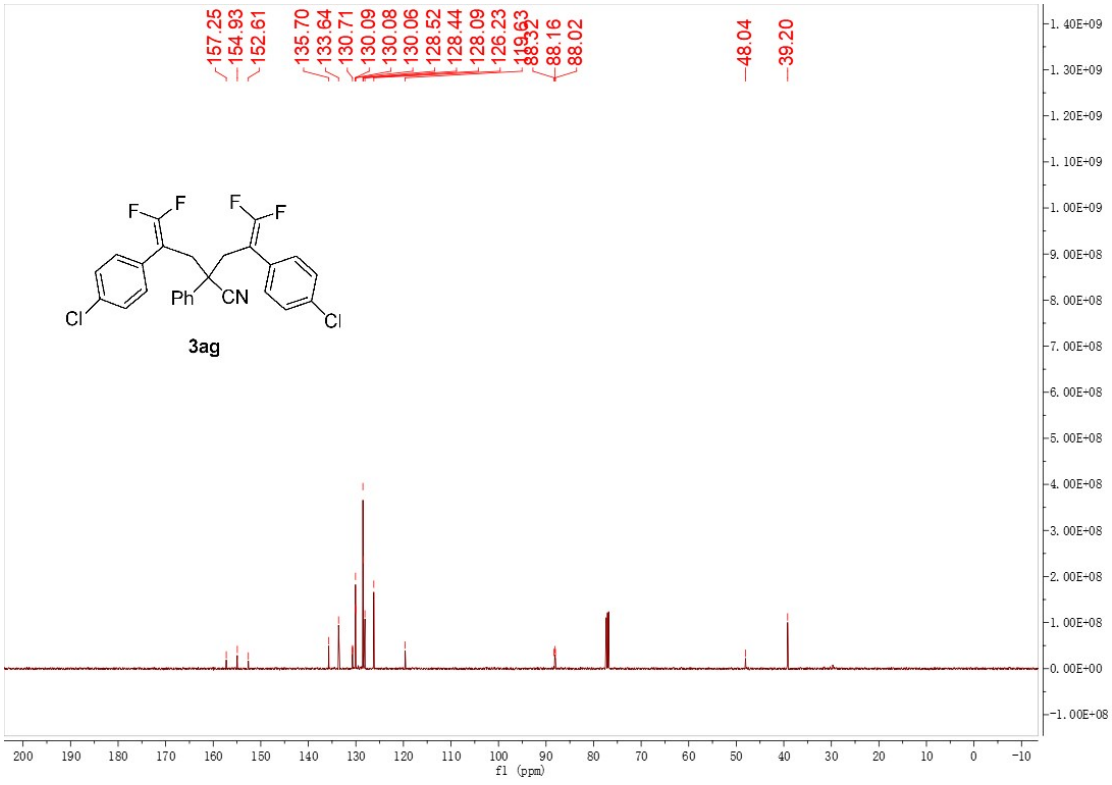
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3af



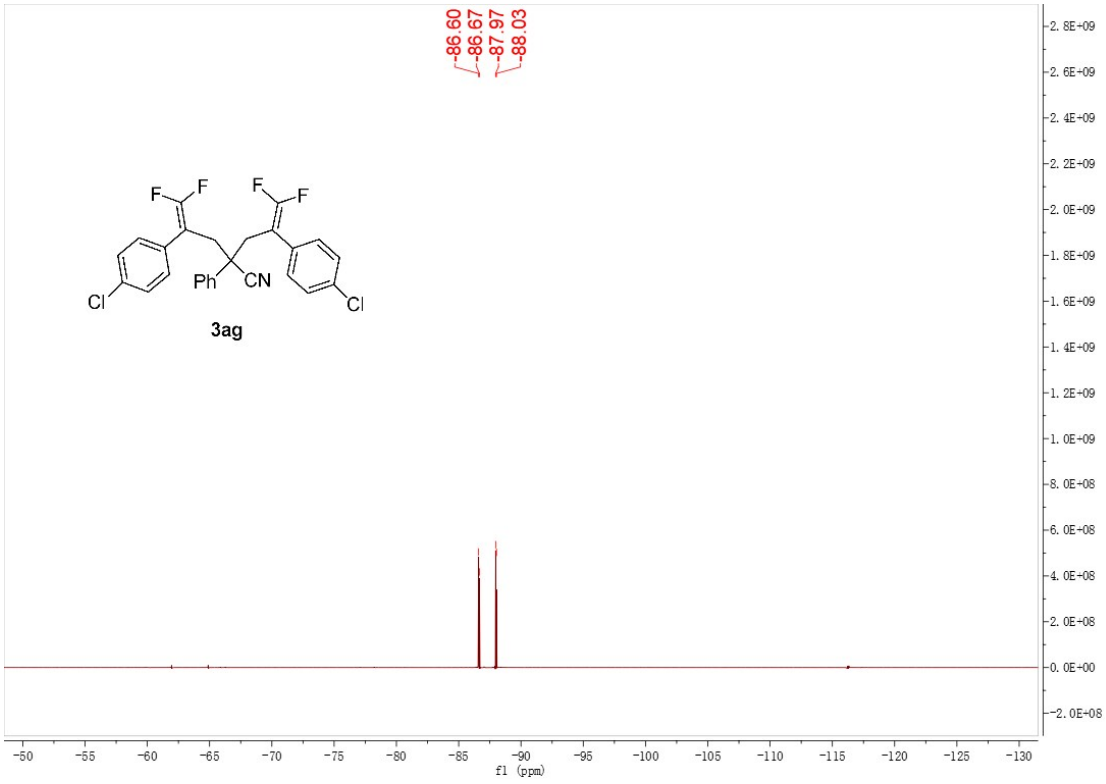
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3ag



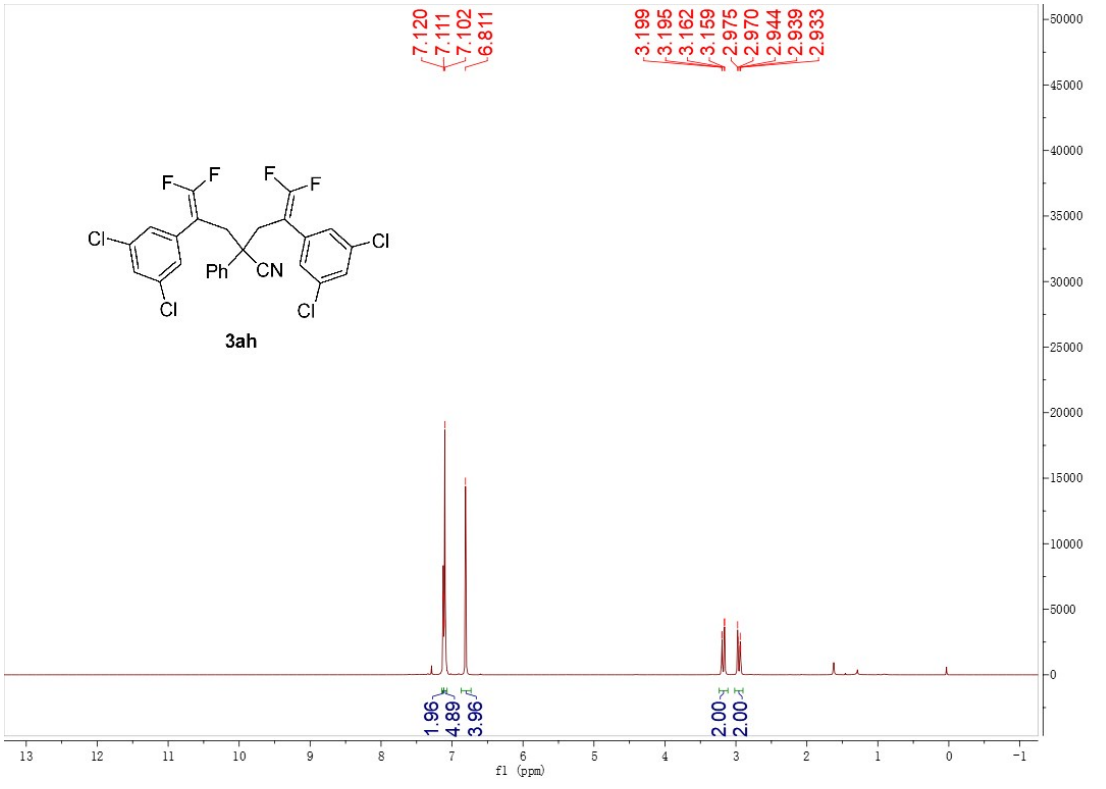
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3ag



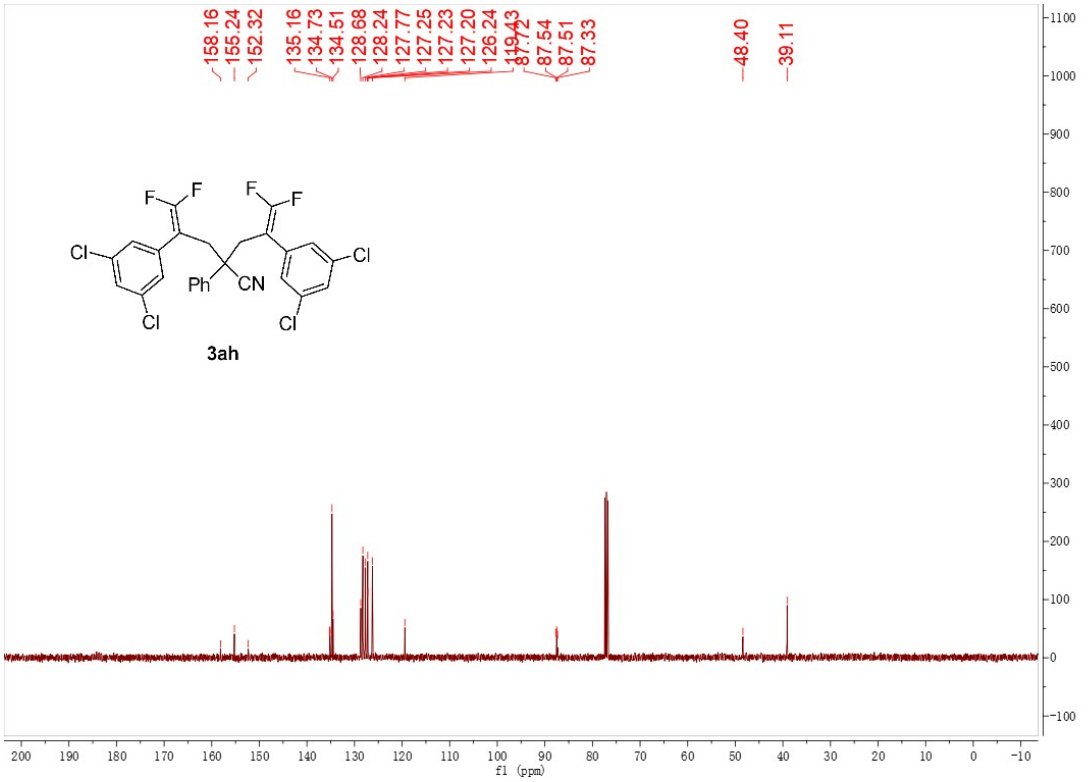
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3ag



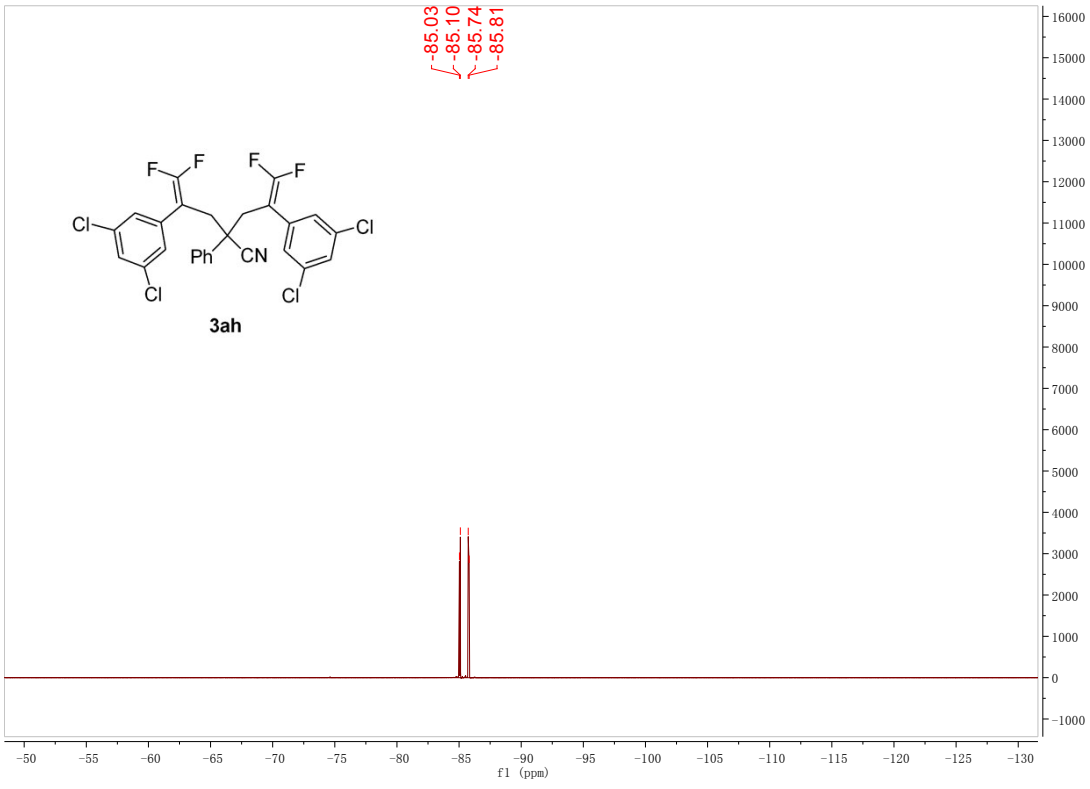
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3ah



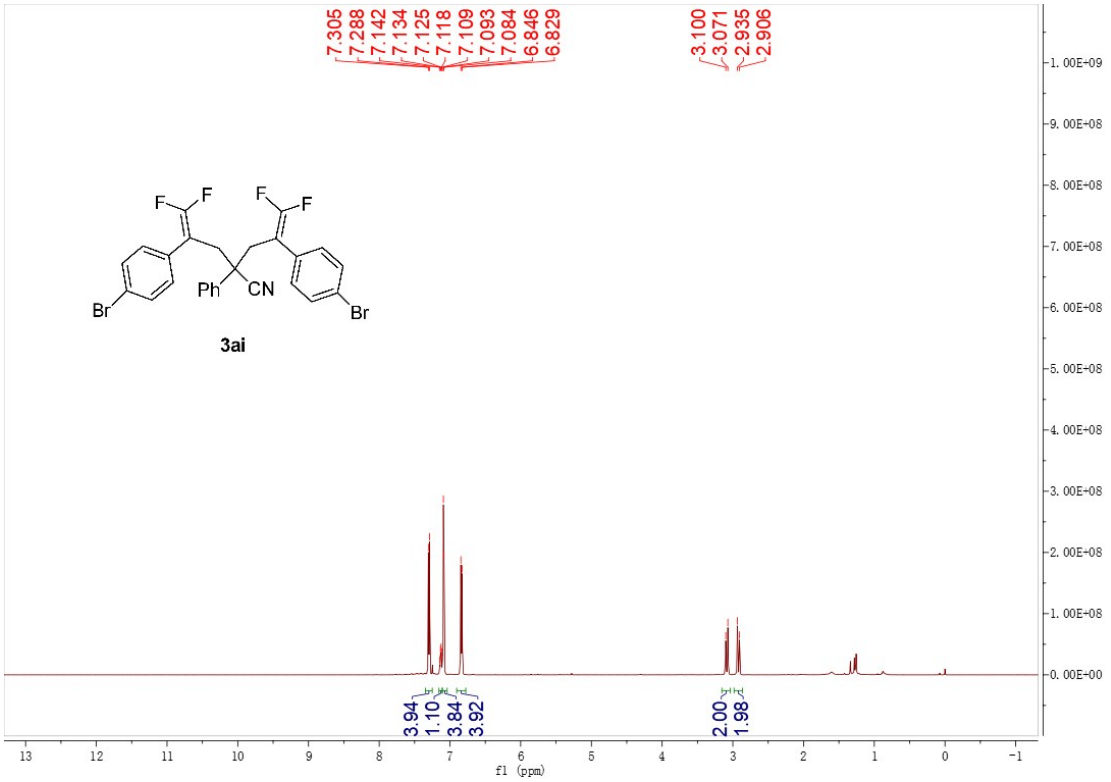
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3ah



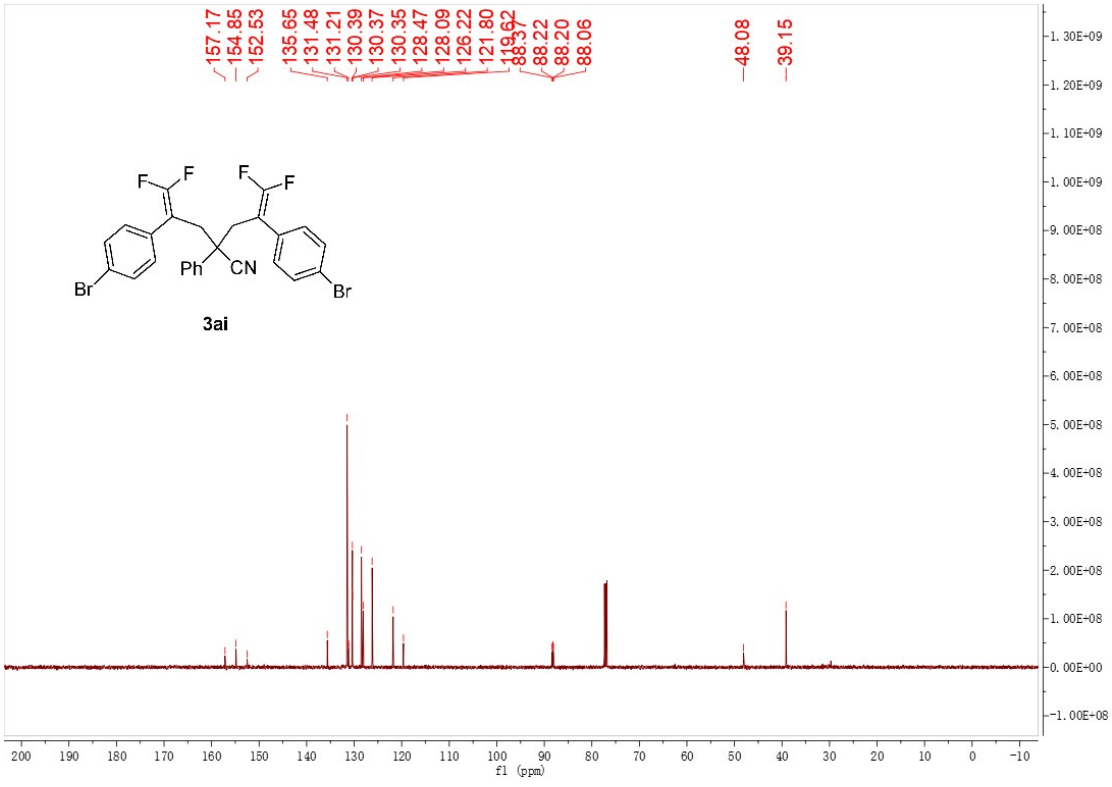
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3ah



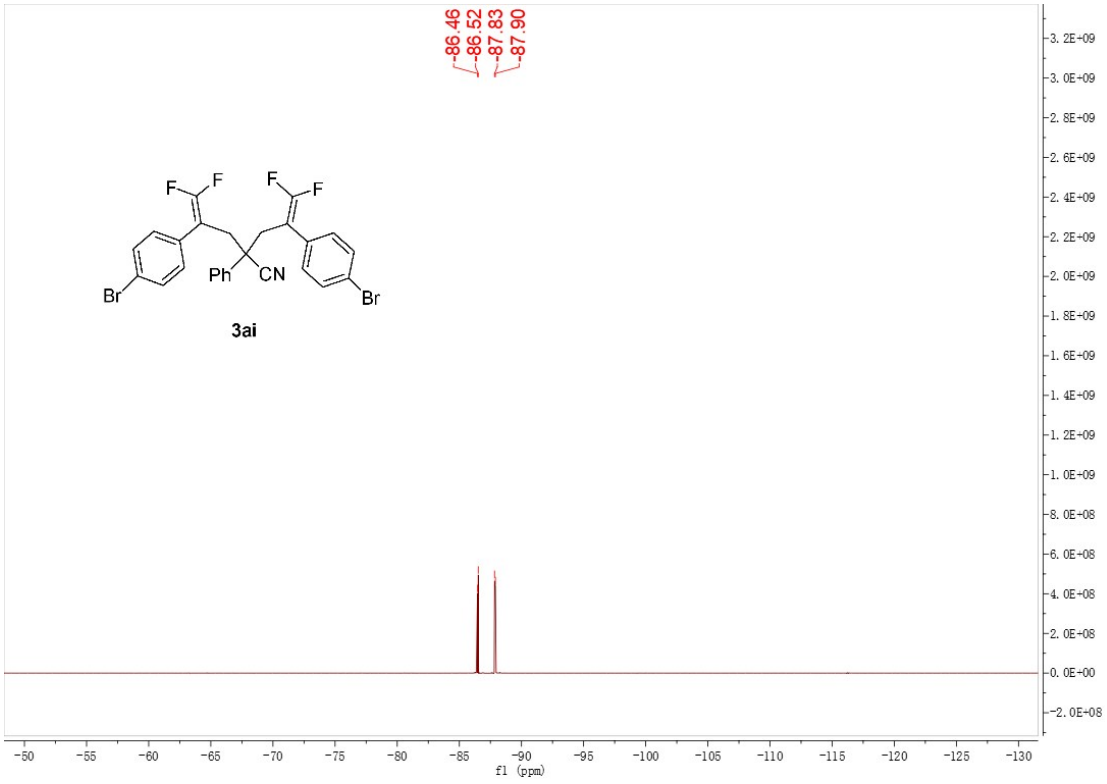
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3ai



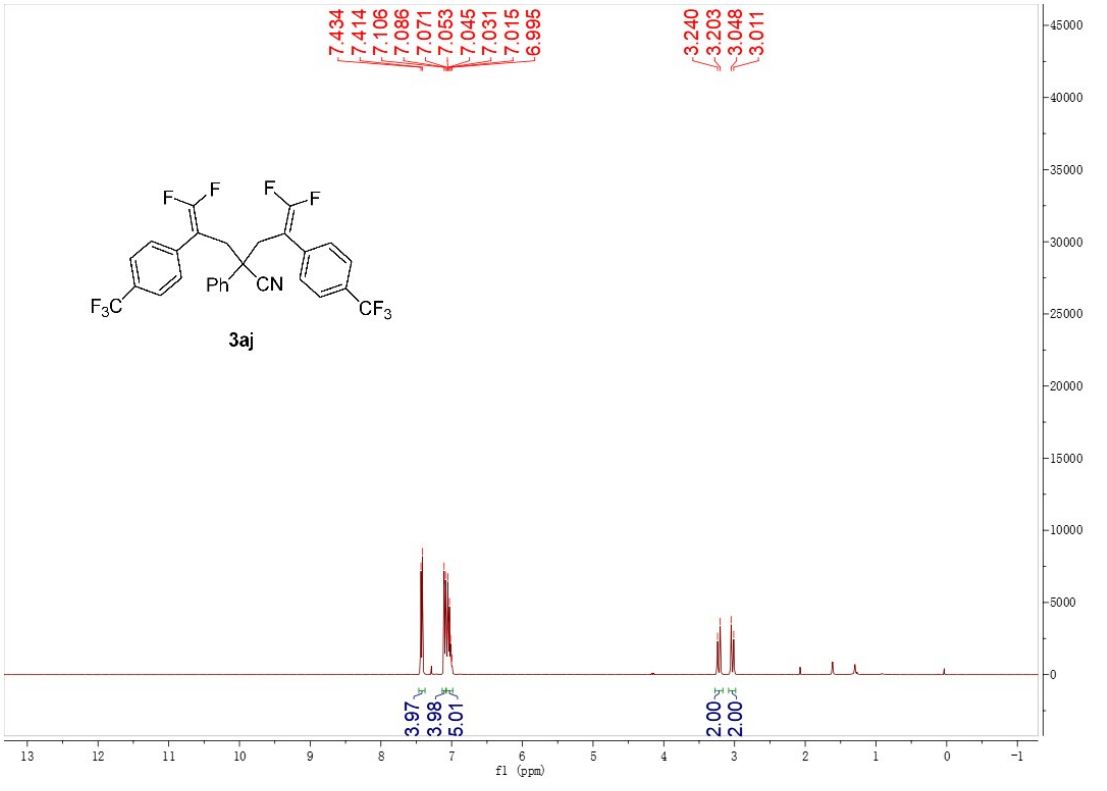
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3ai



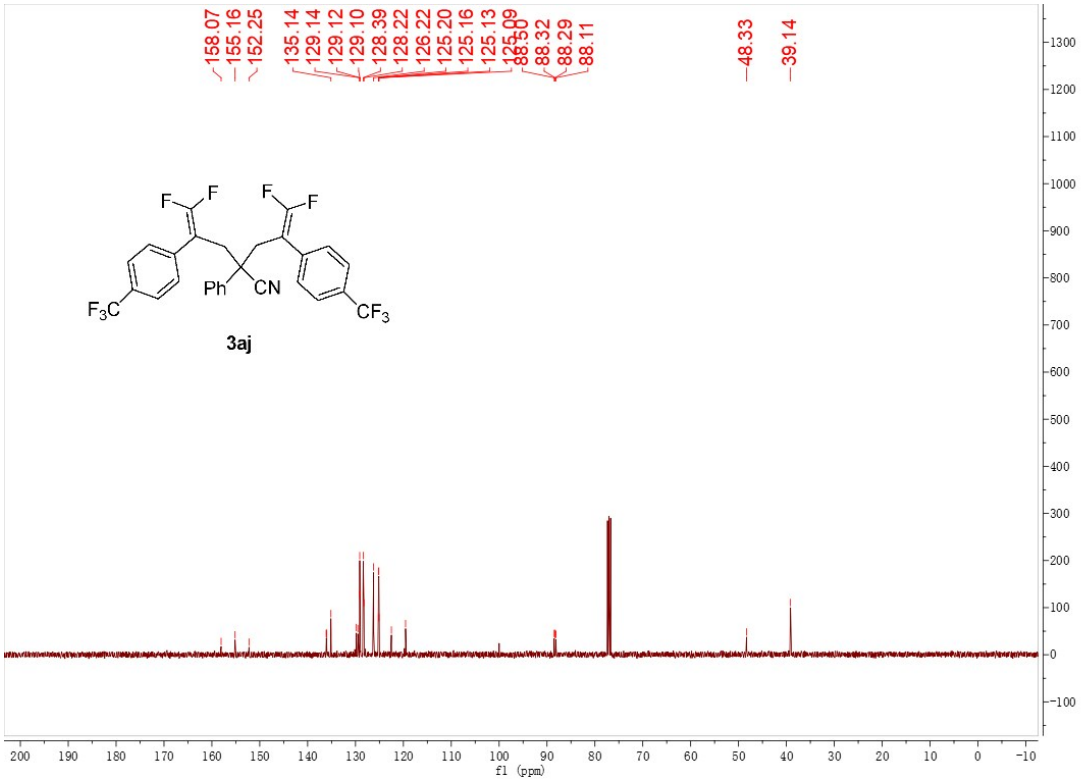
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3ai



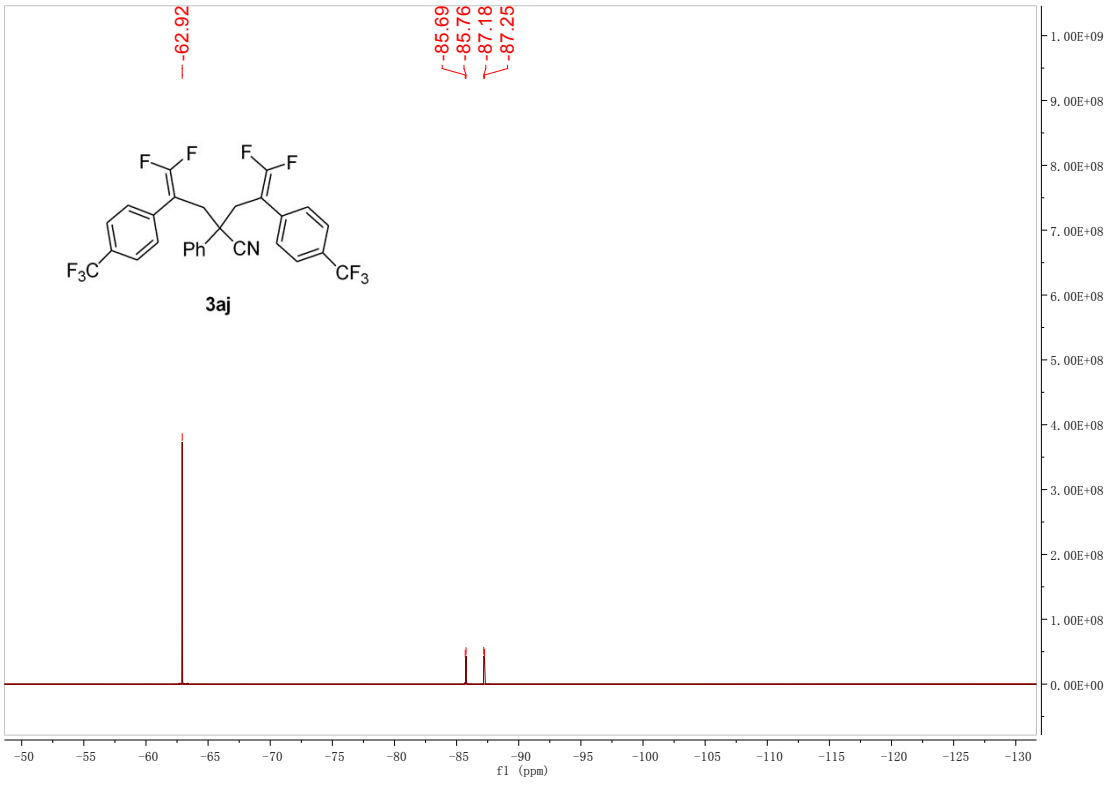
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3aj



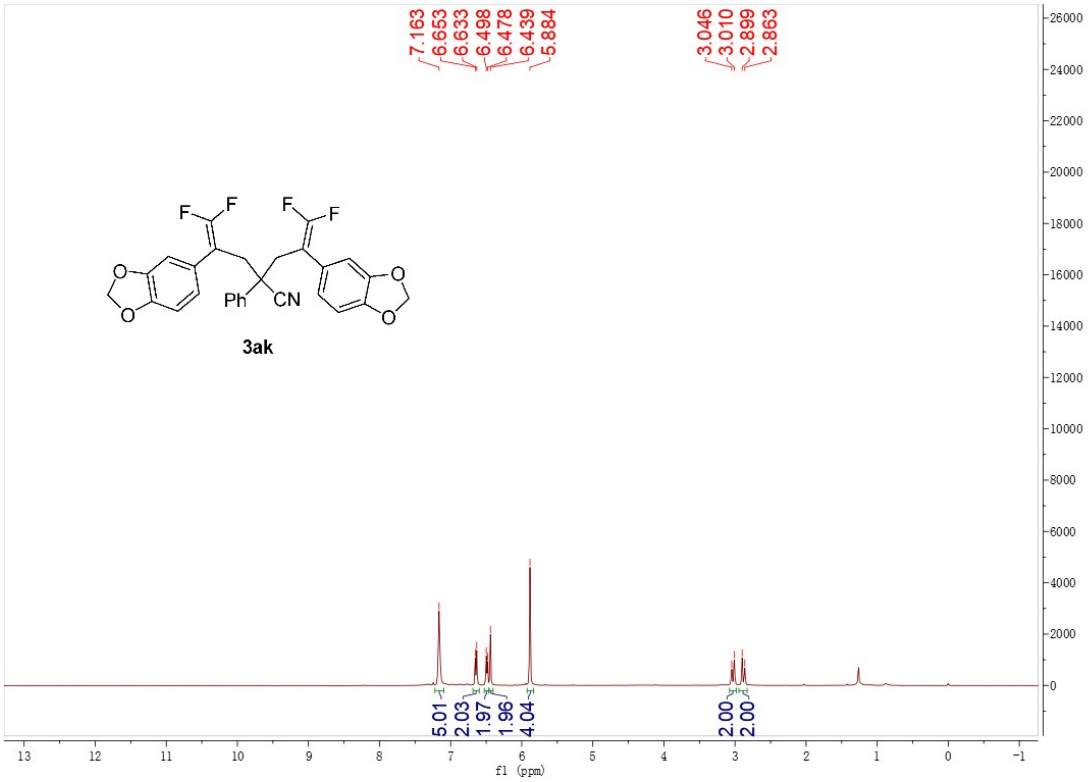
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3aj



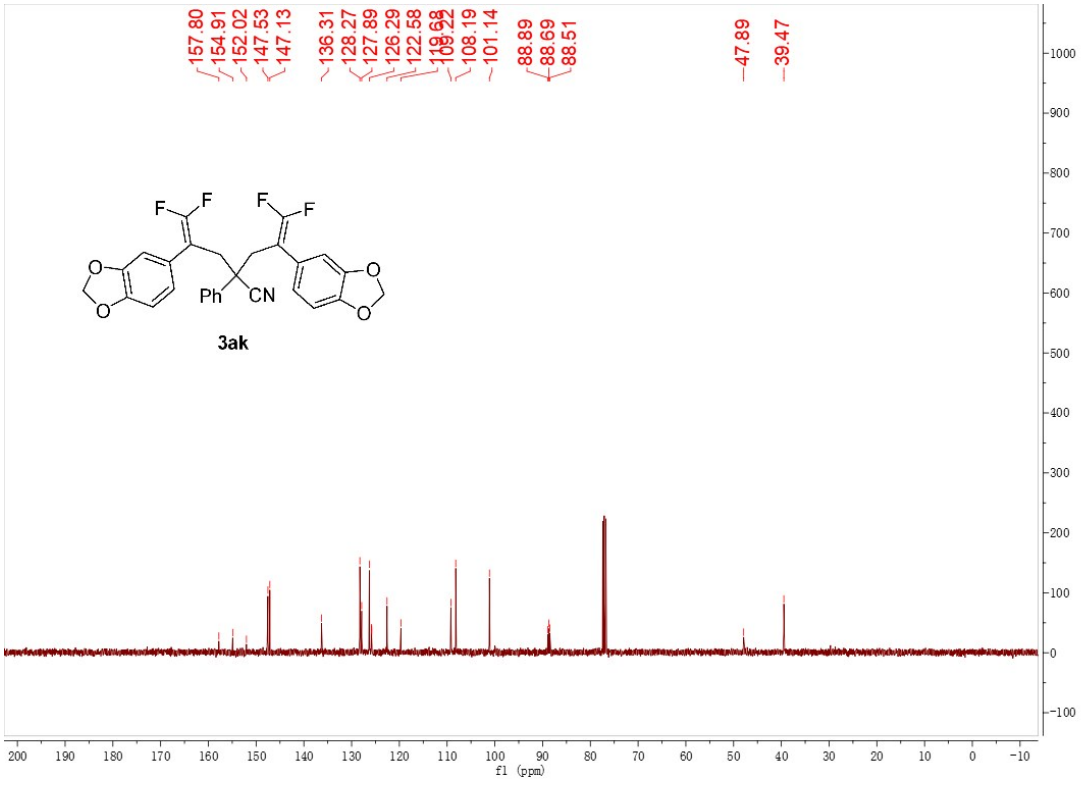
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3aj



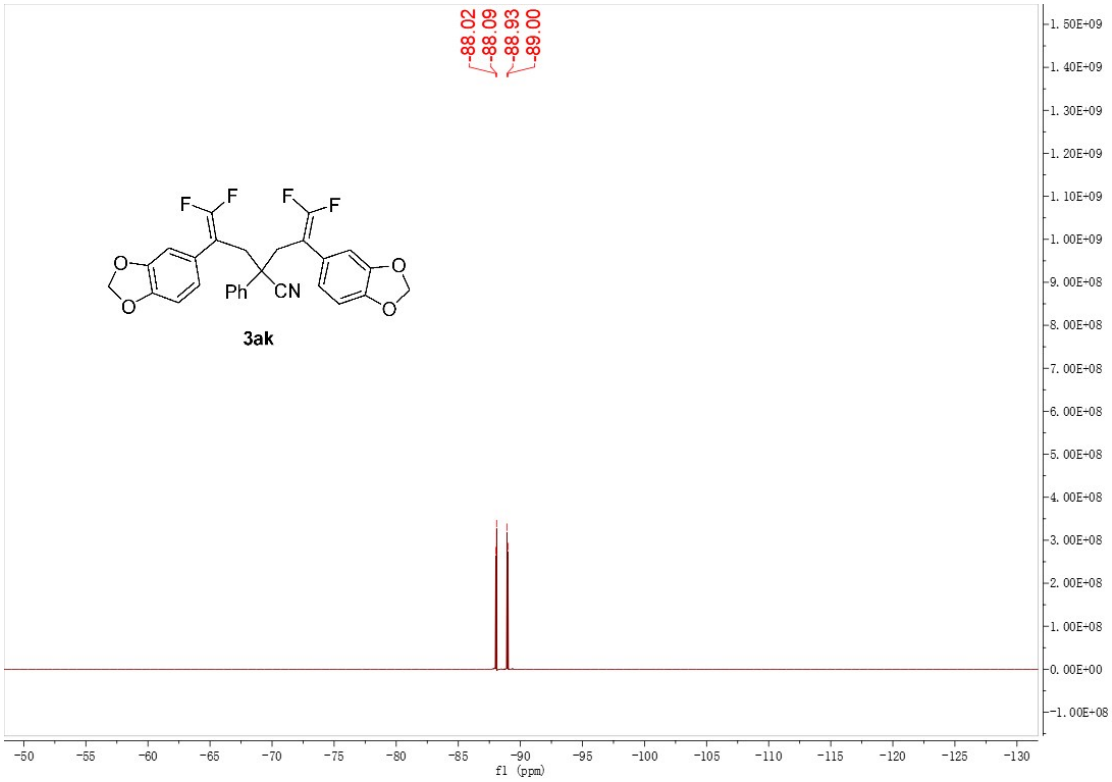
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3ak



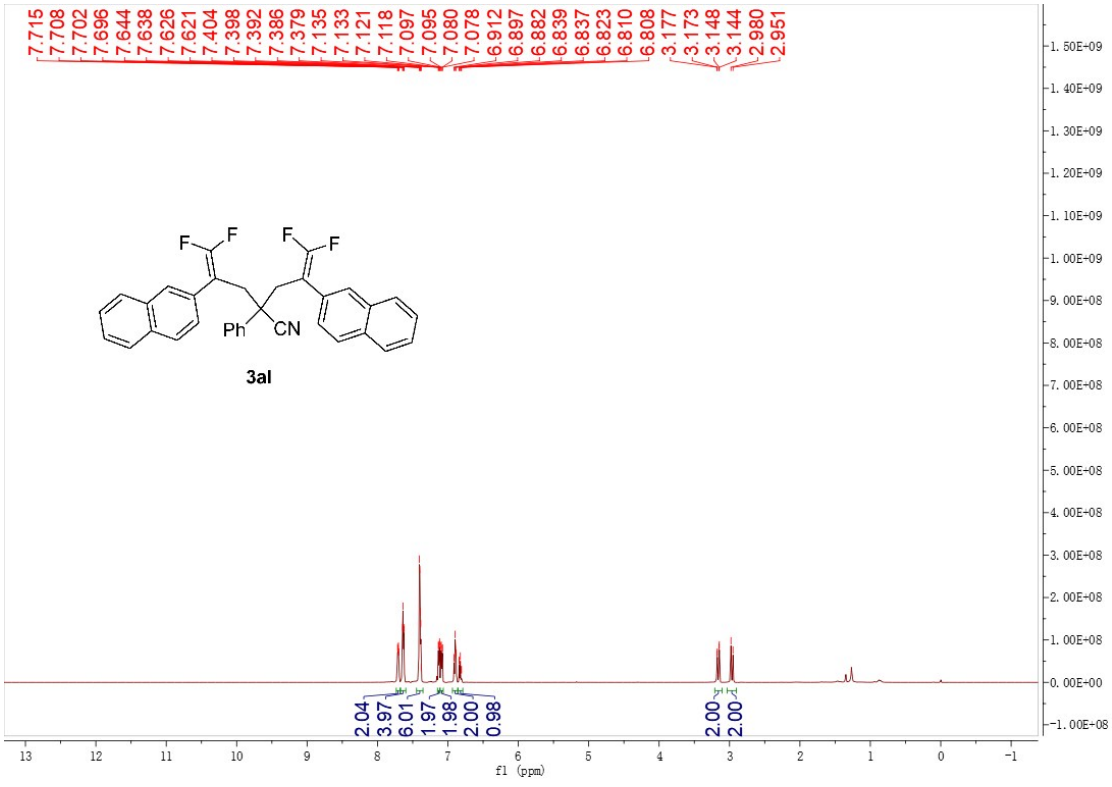
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3ak



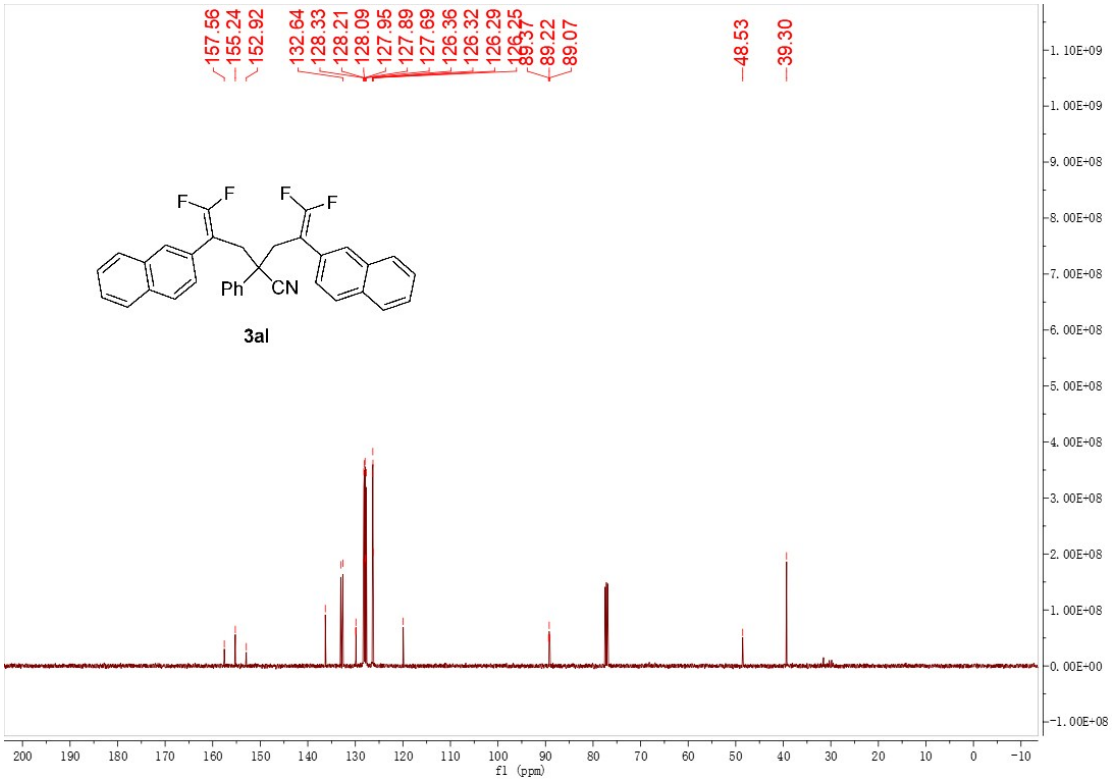
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3ak



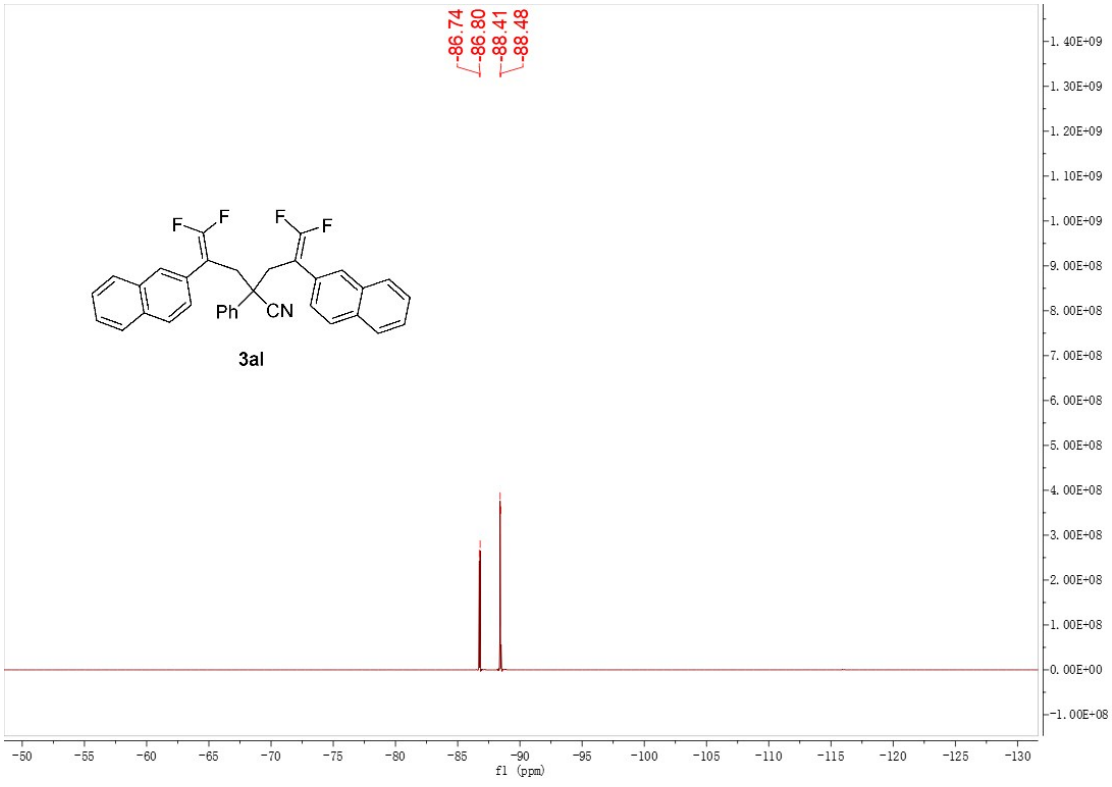
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3al



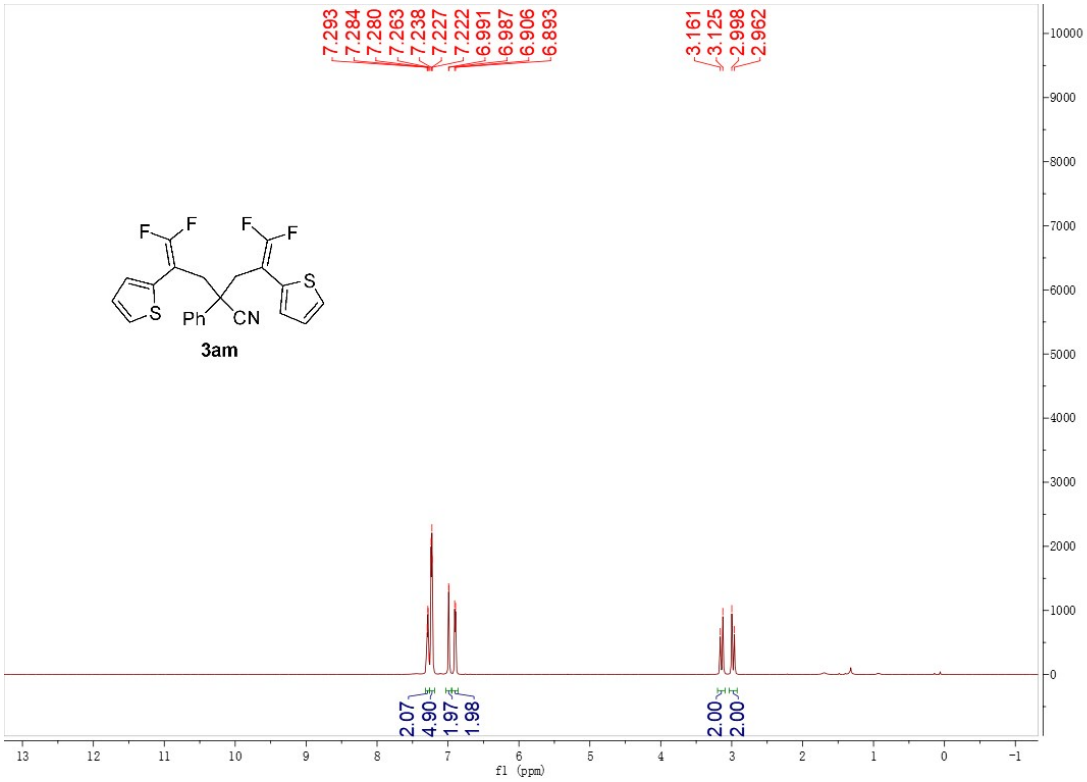
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3al



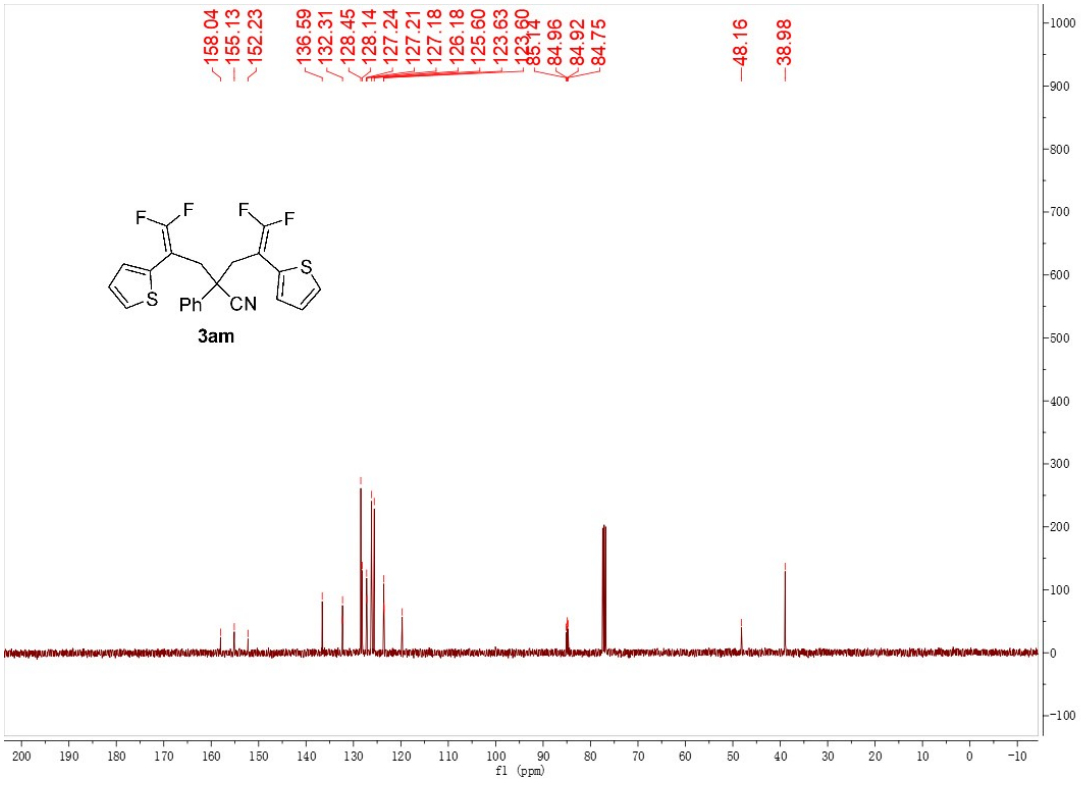
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3al



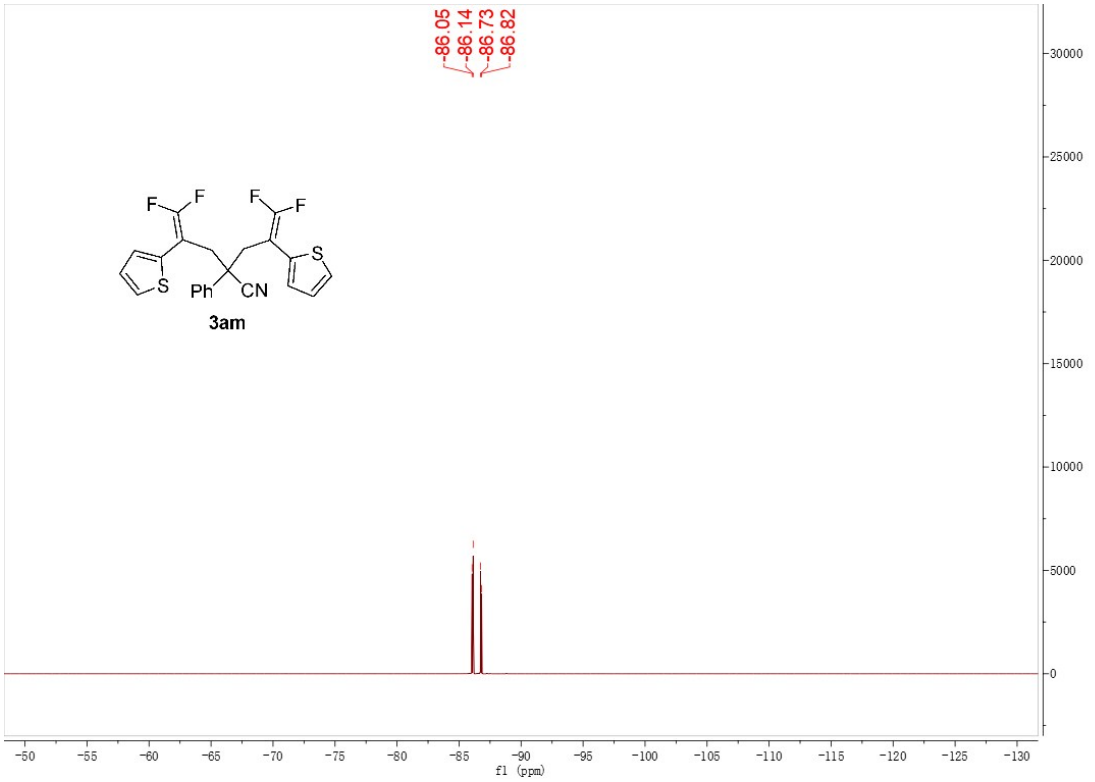
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3am



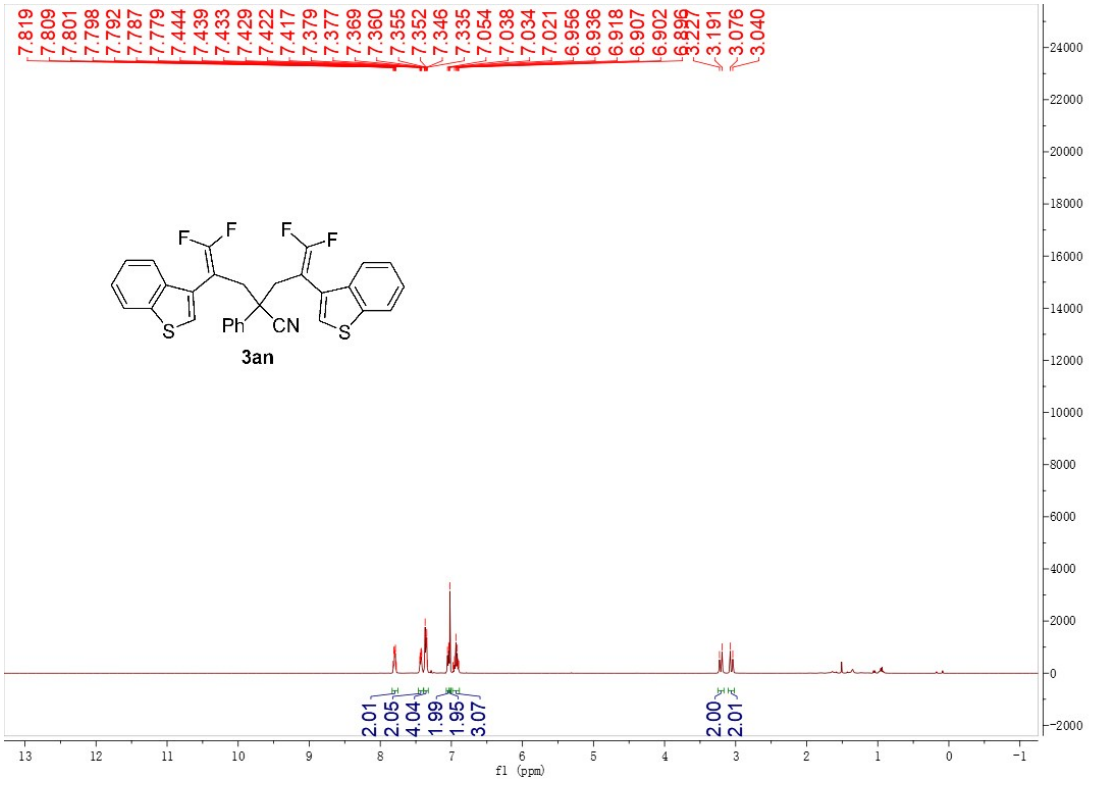
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3am



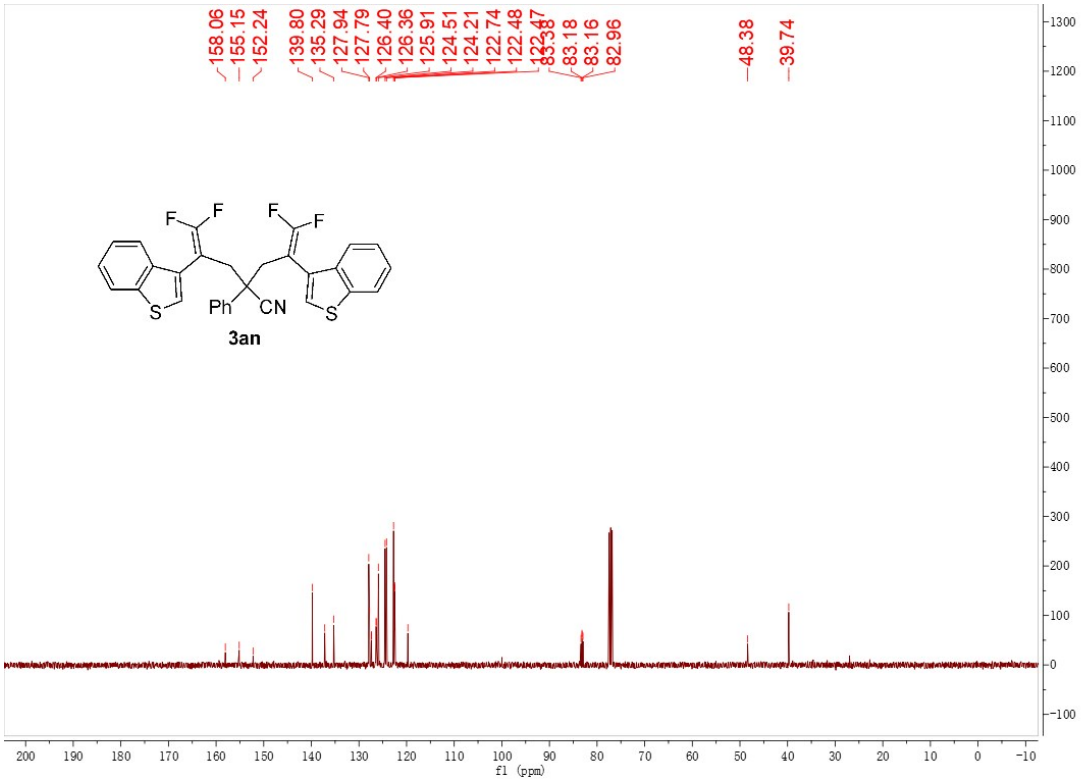
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3am



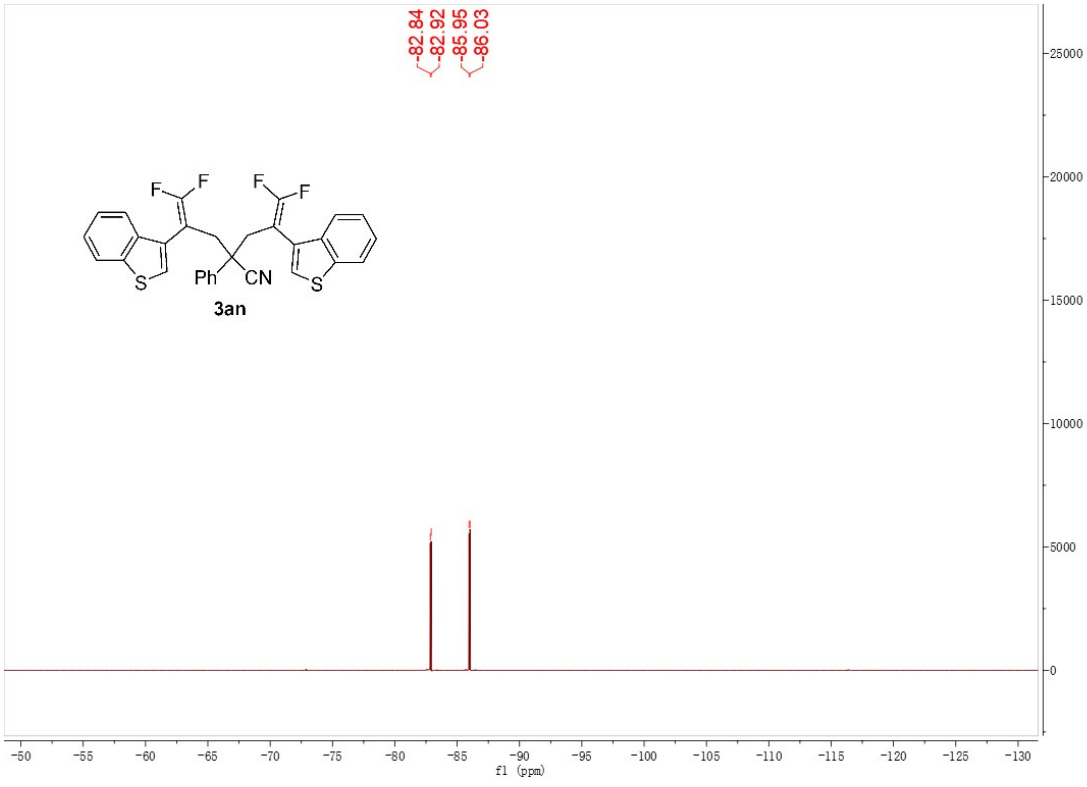
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3an



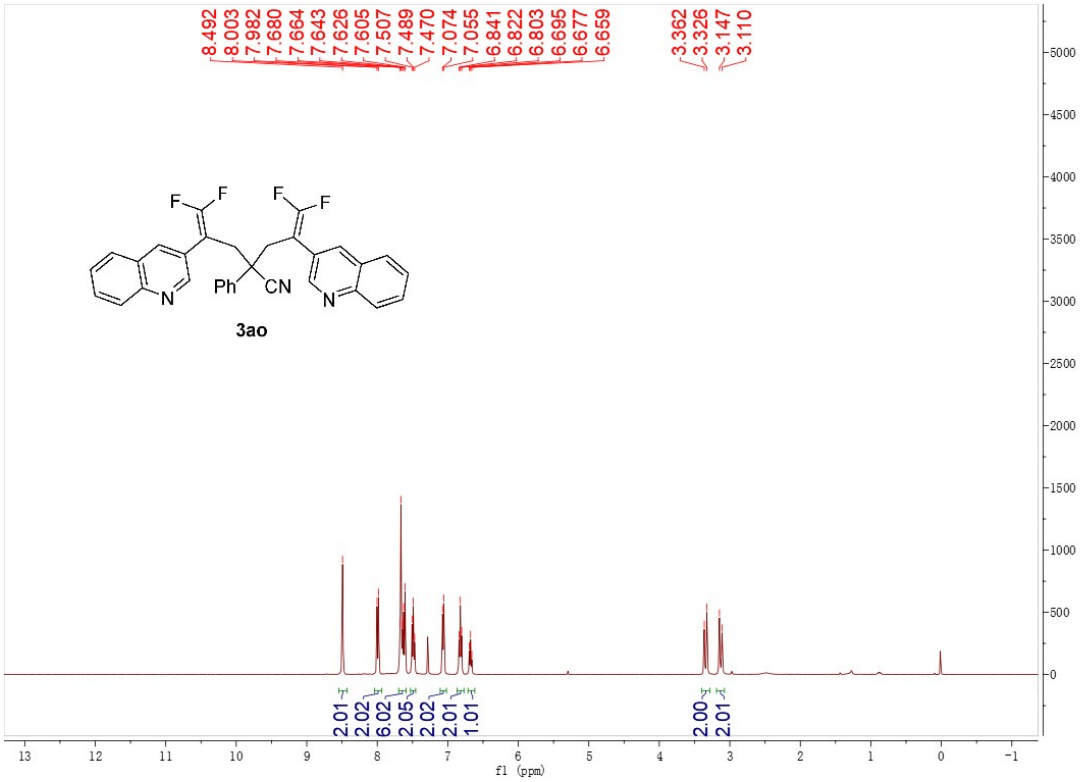
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3an



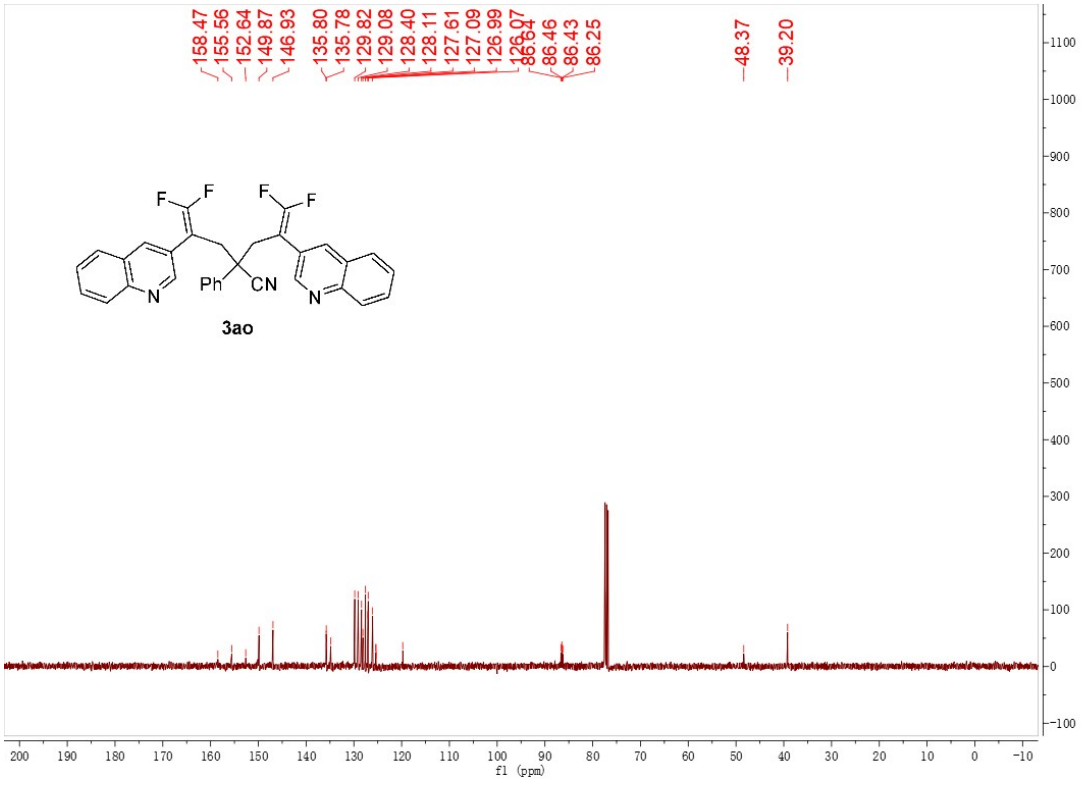
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3an



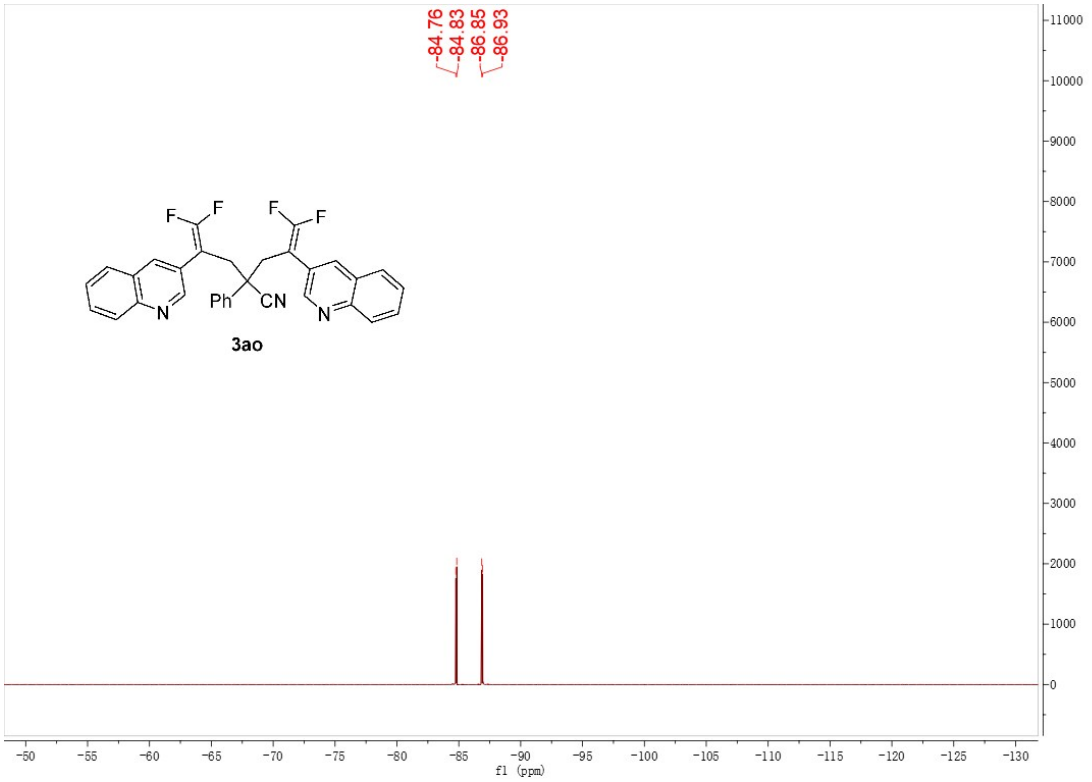
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3ao



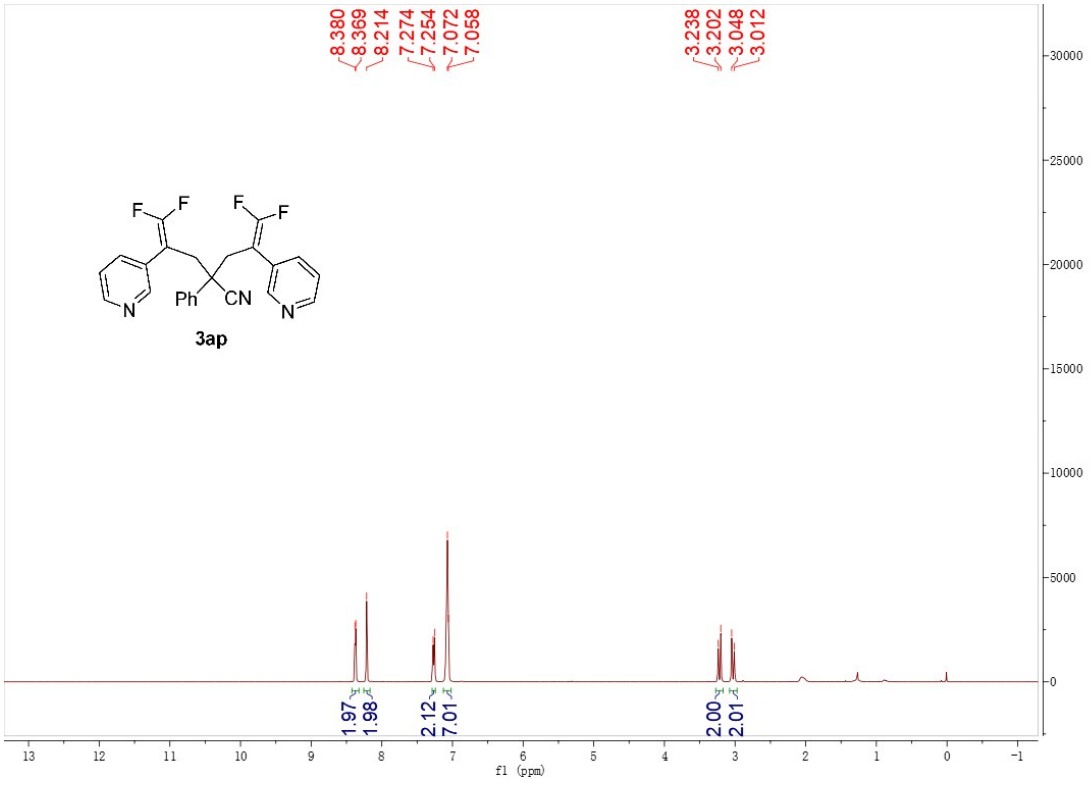
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3ao



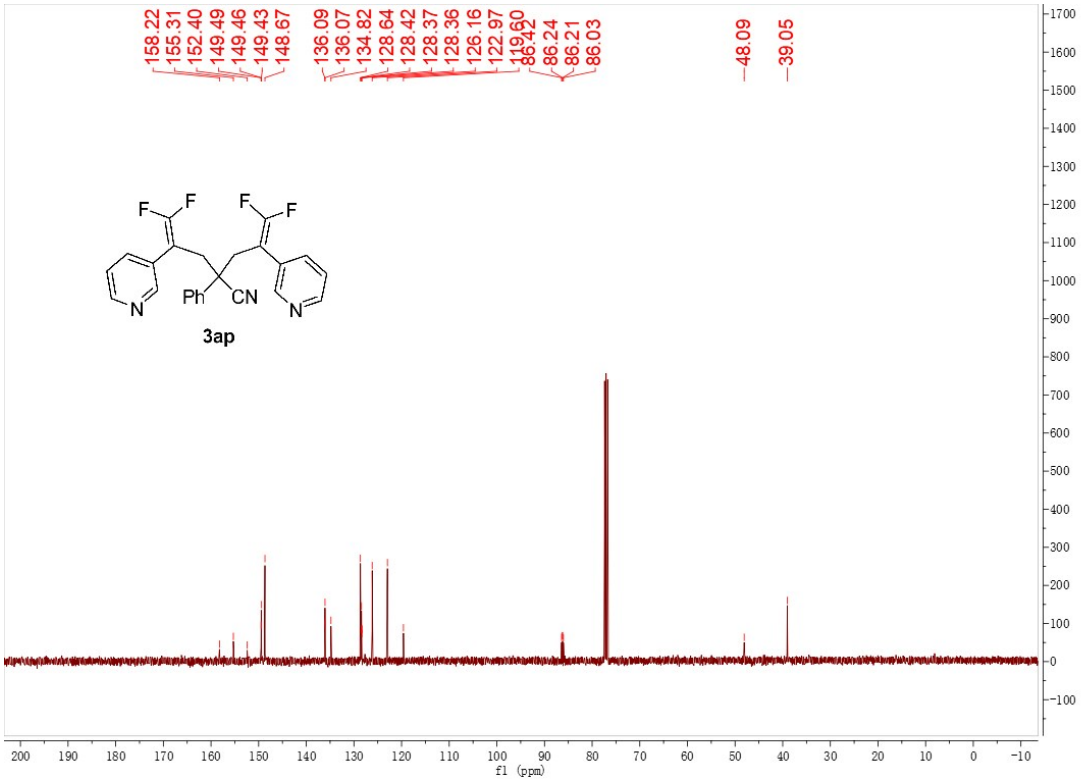
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3ao



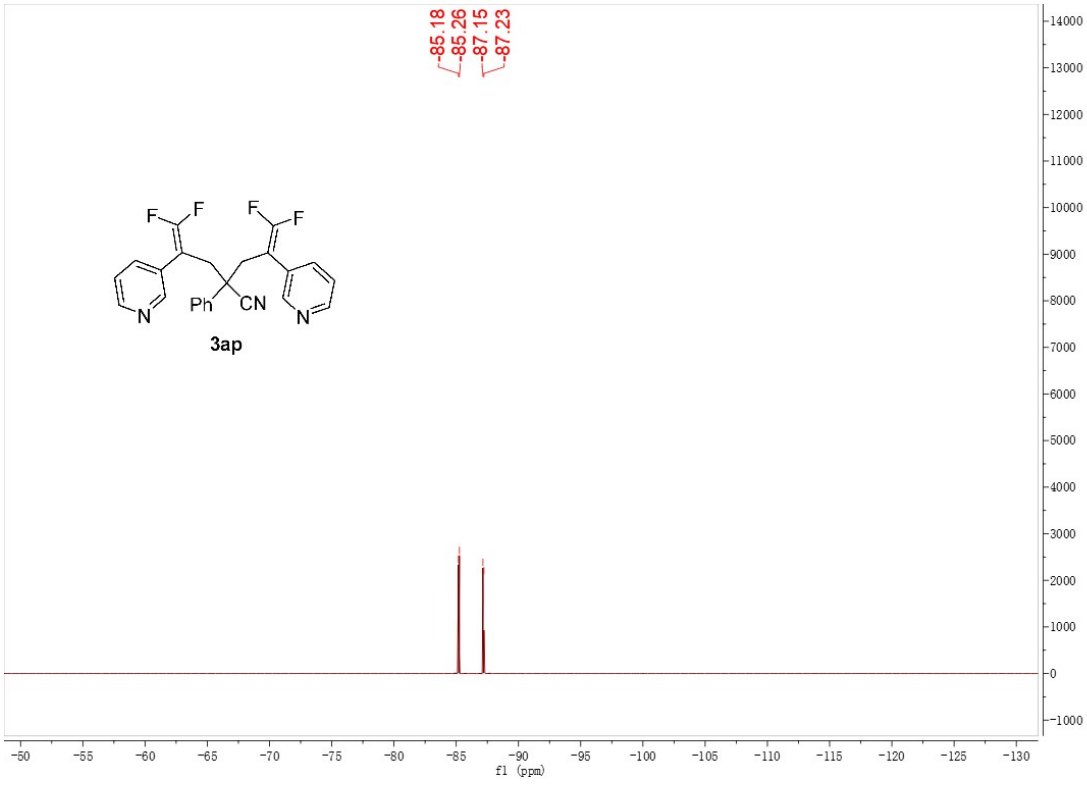
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3ap



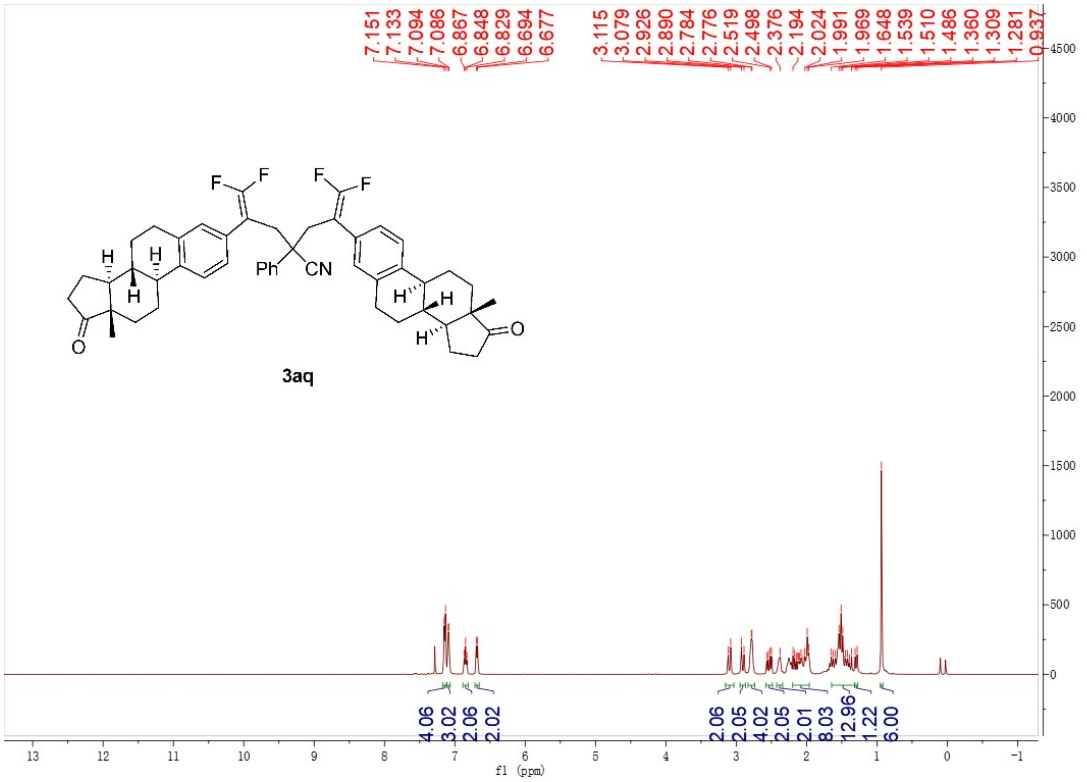
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3ap



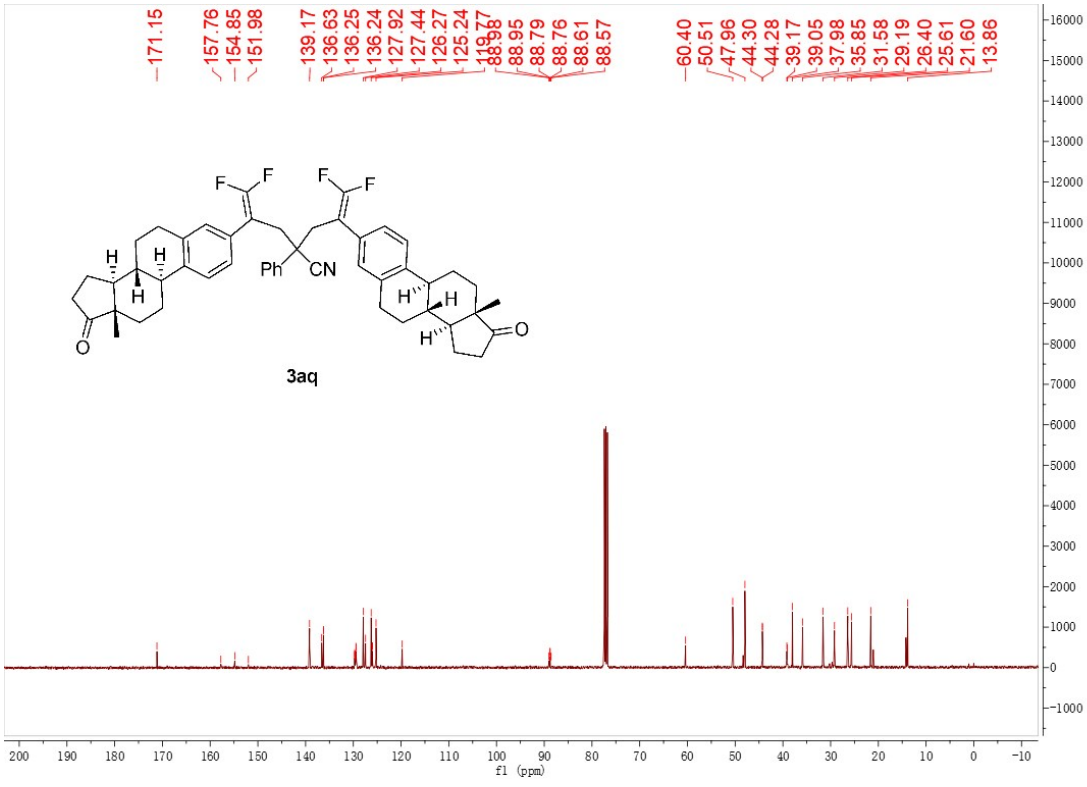
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3ap



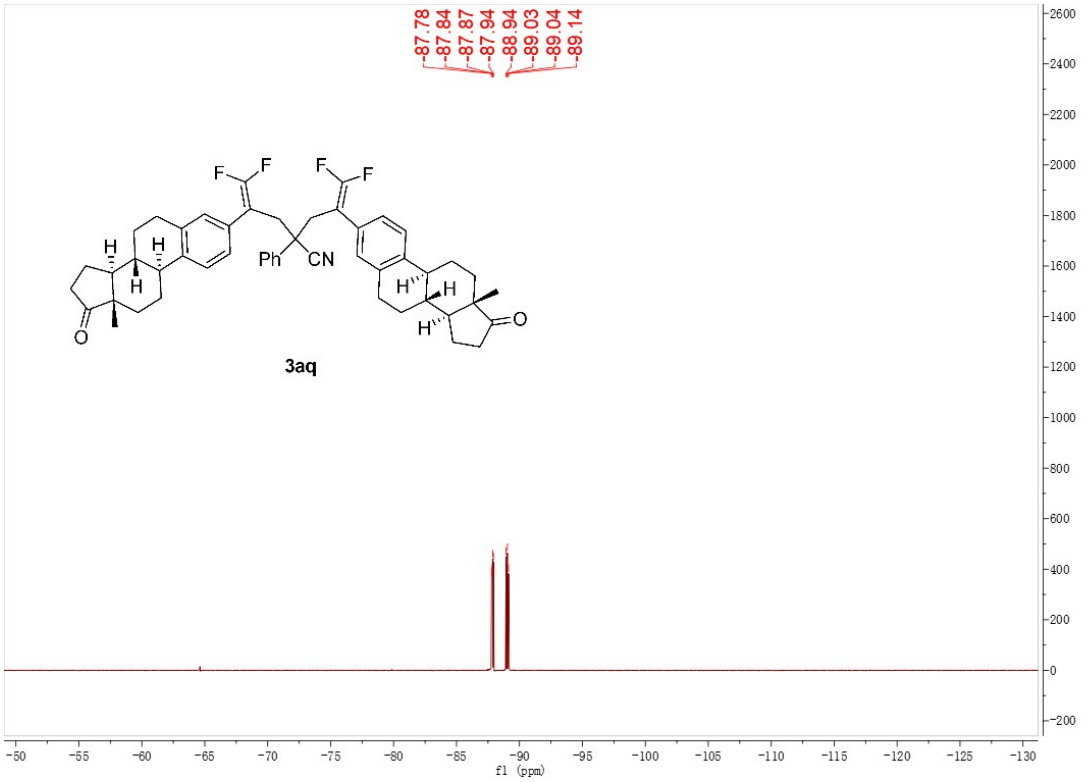
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 3aq



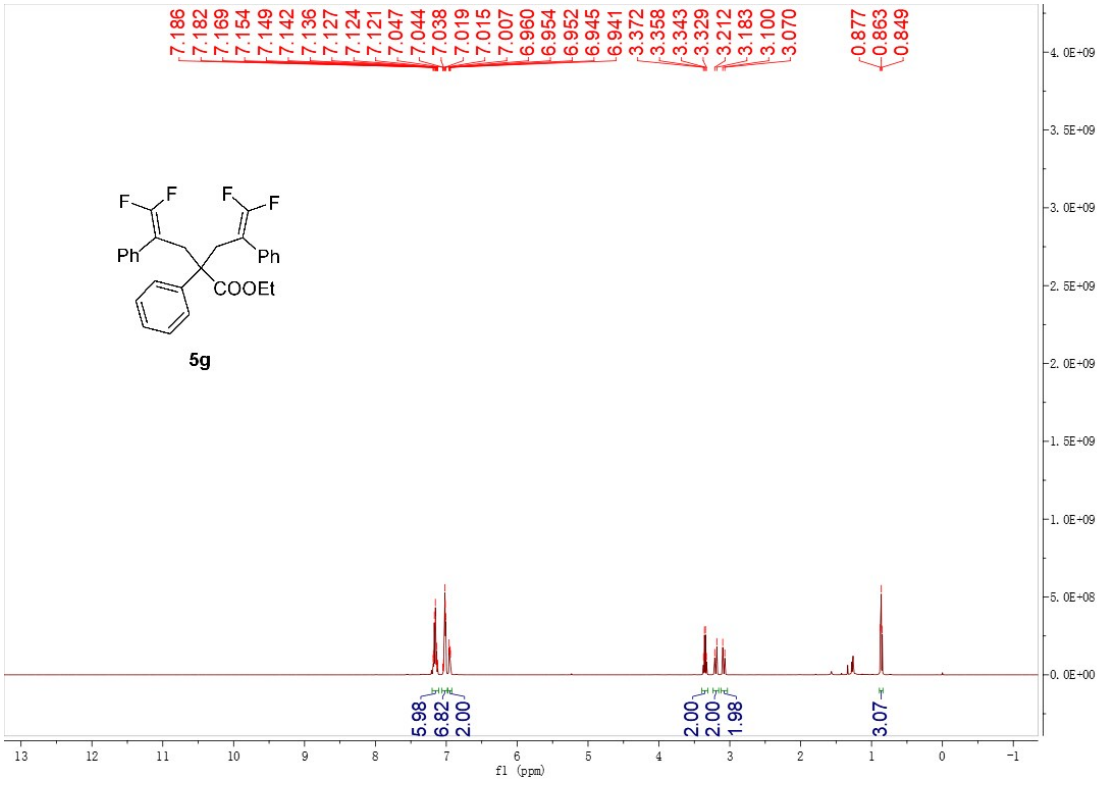
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 3aq



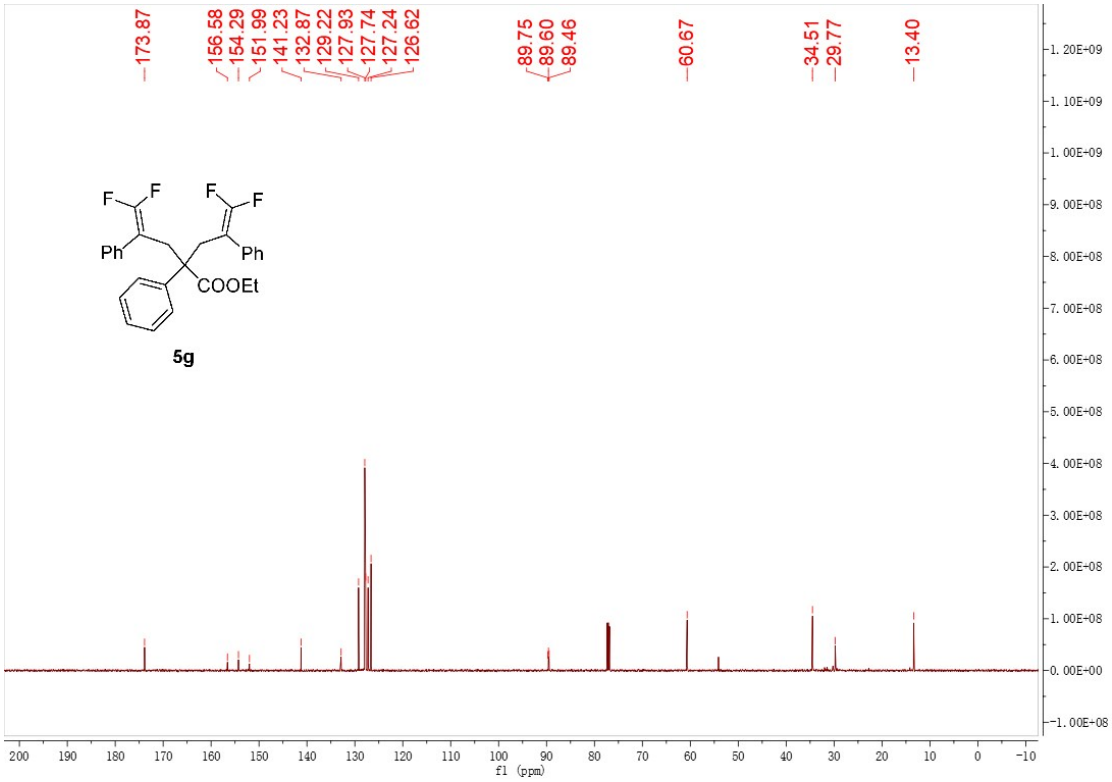
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 3aq



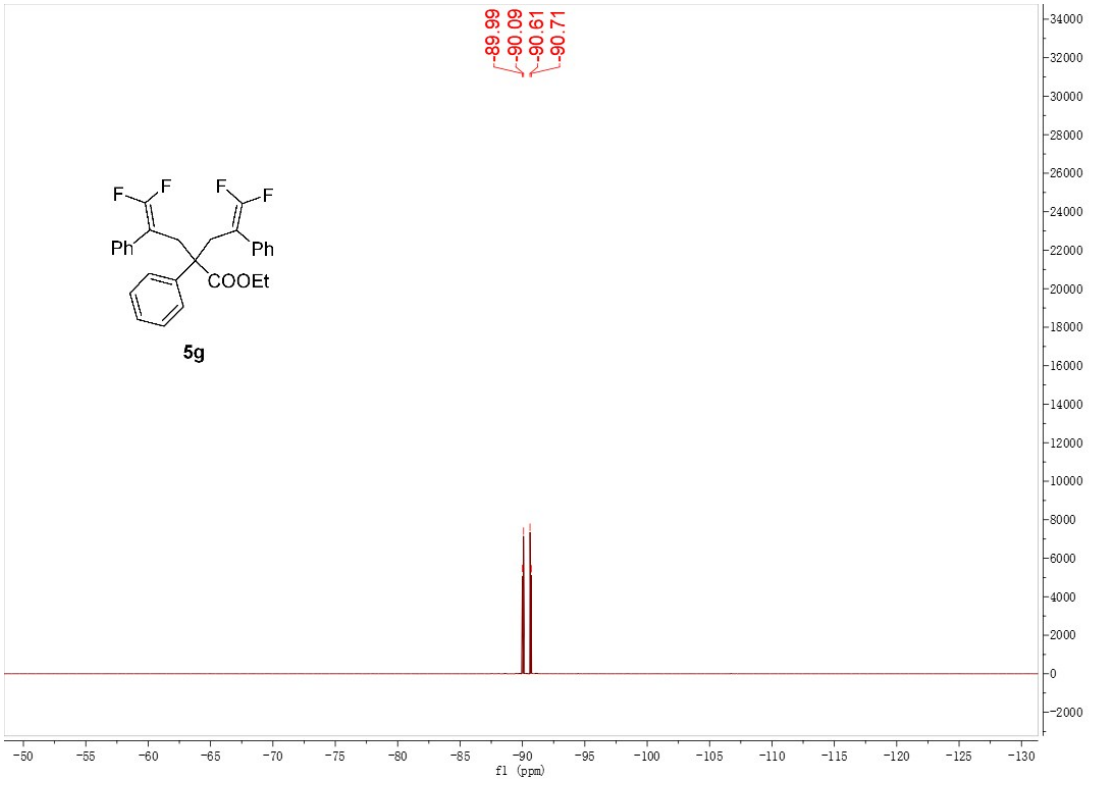
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 5g



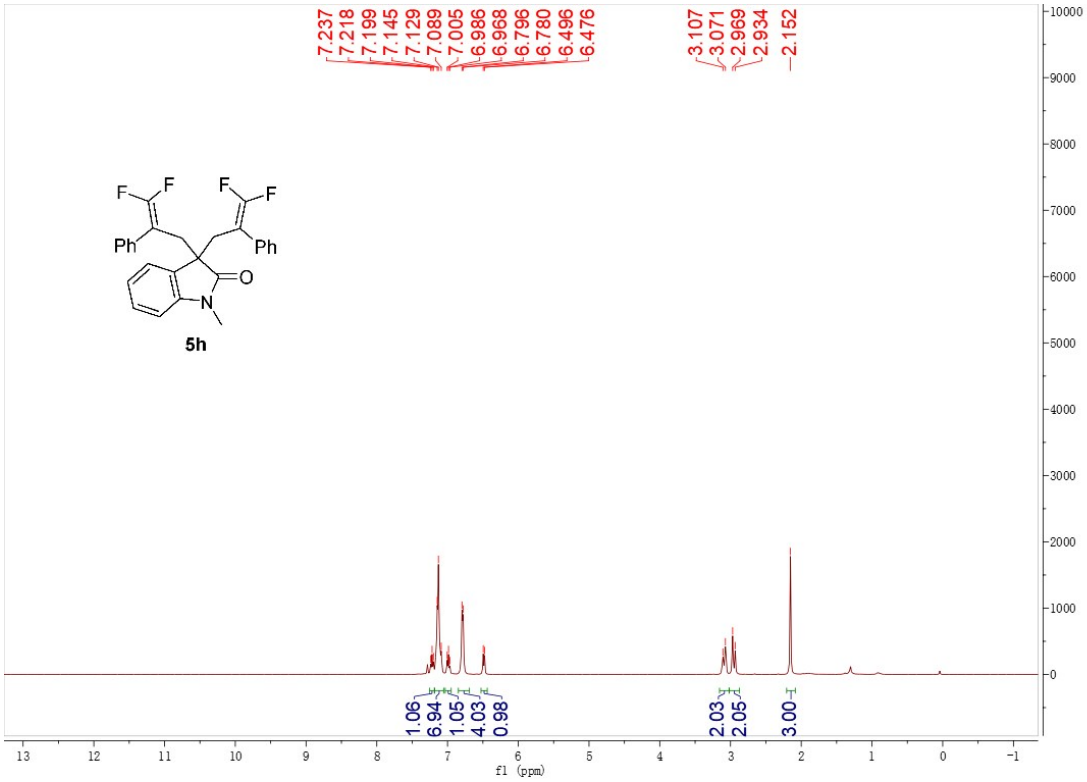
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 5g



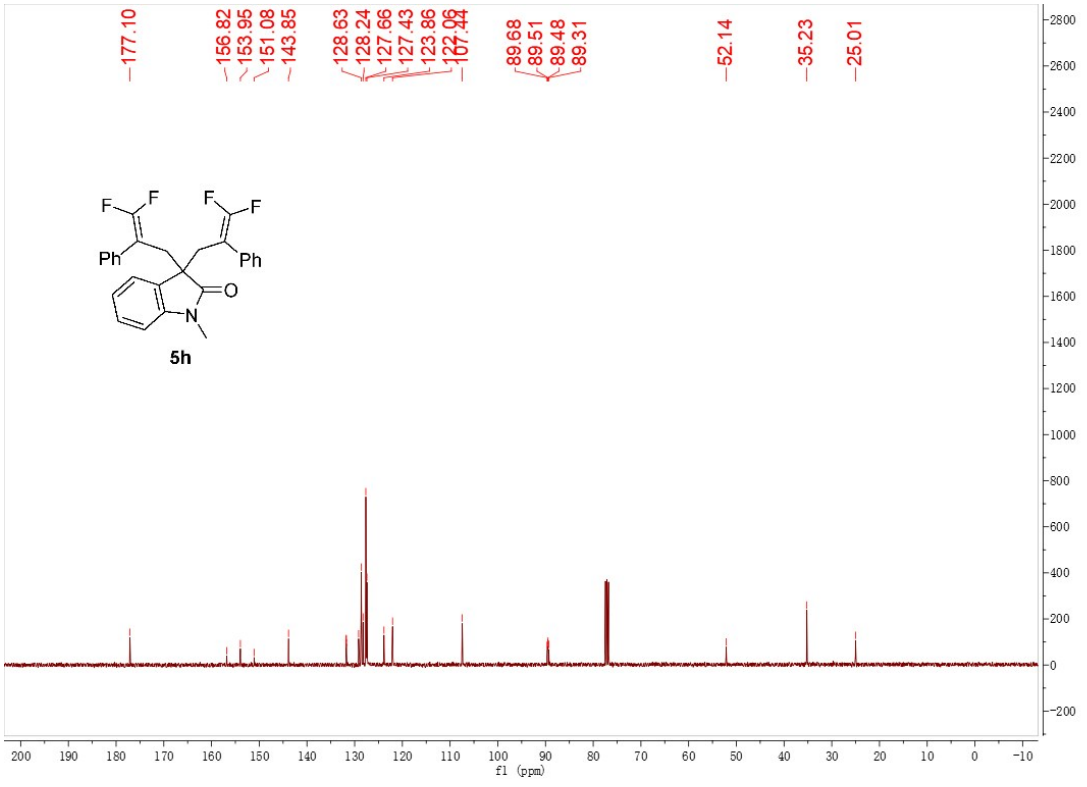
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 5g



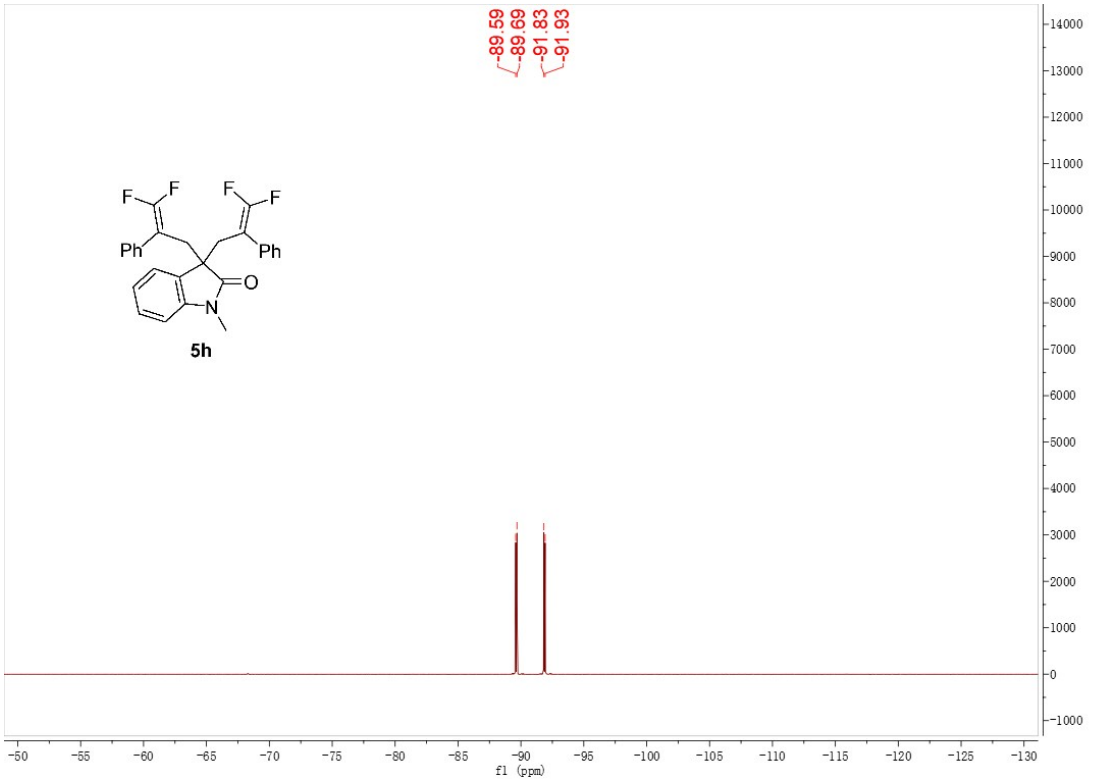
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 5h



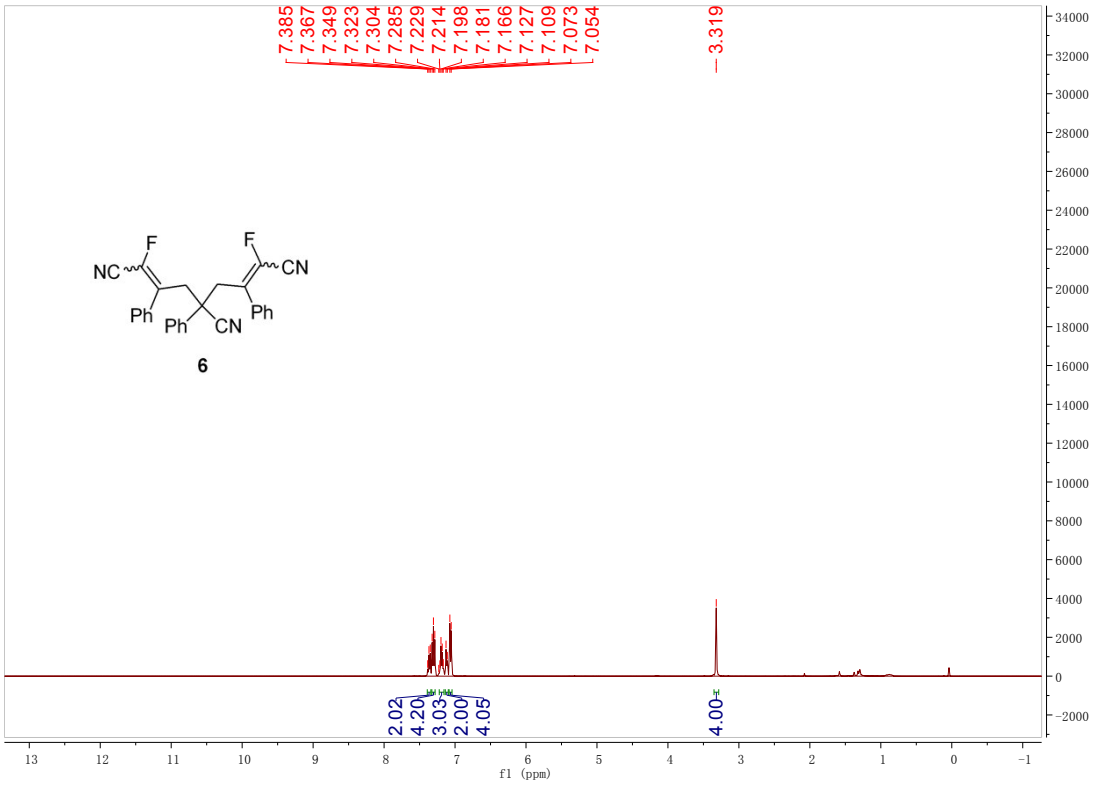
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 5h



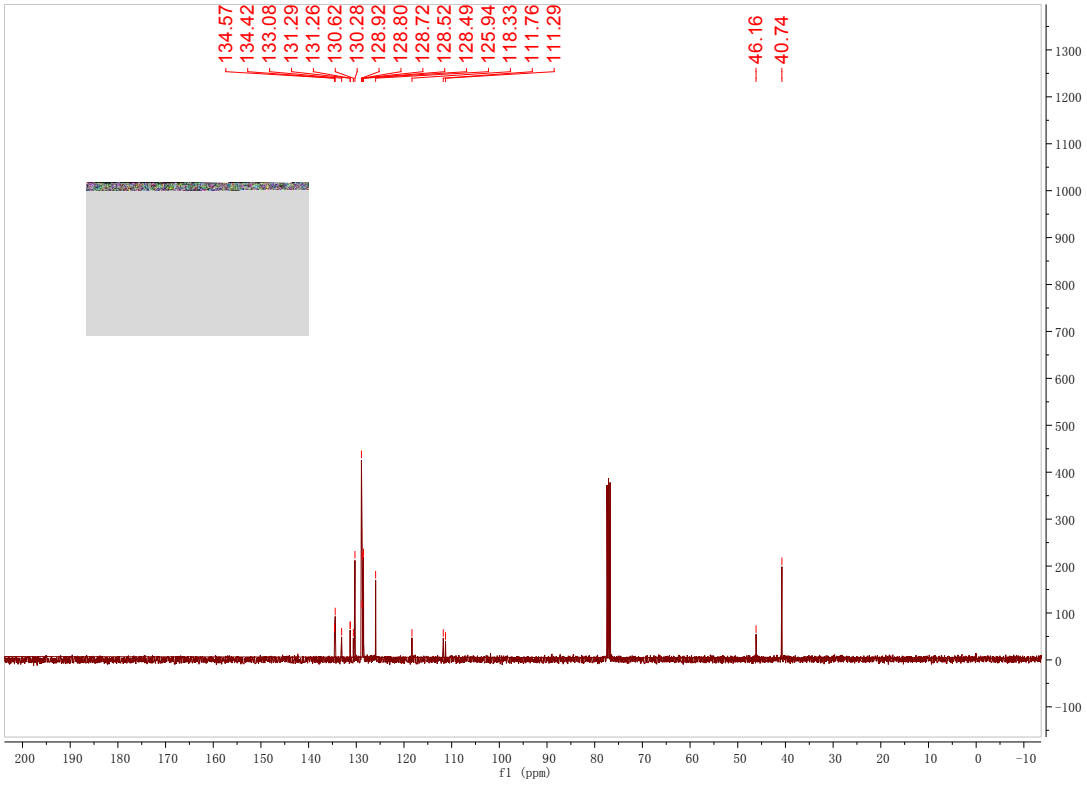
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 5h



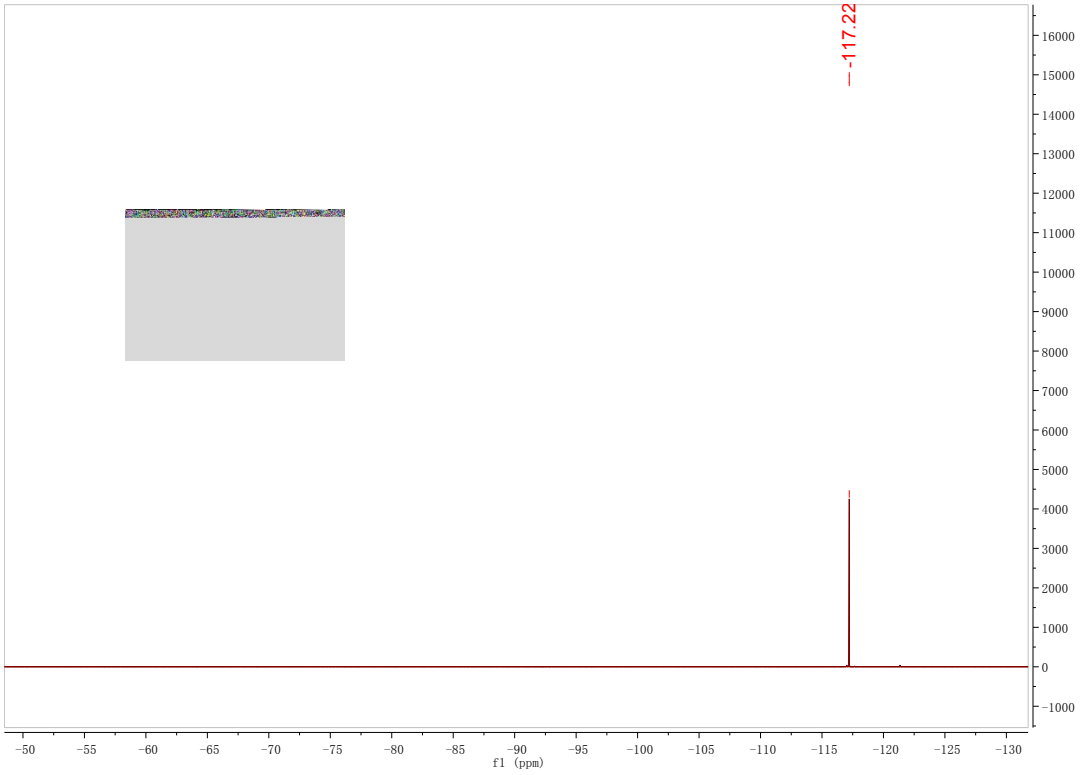
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 6



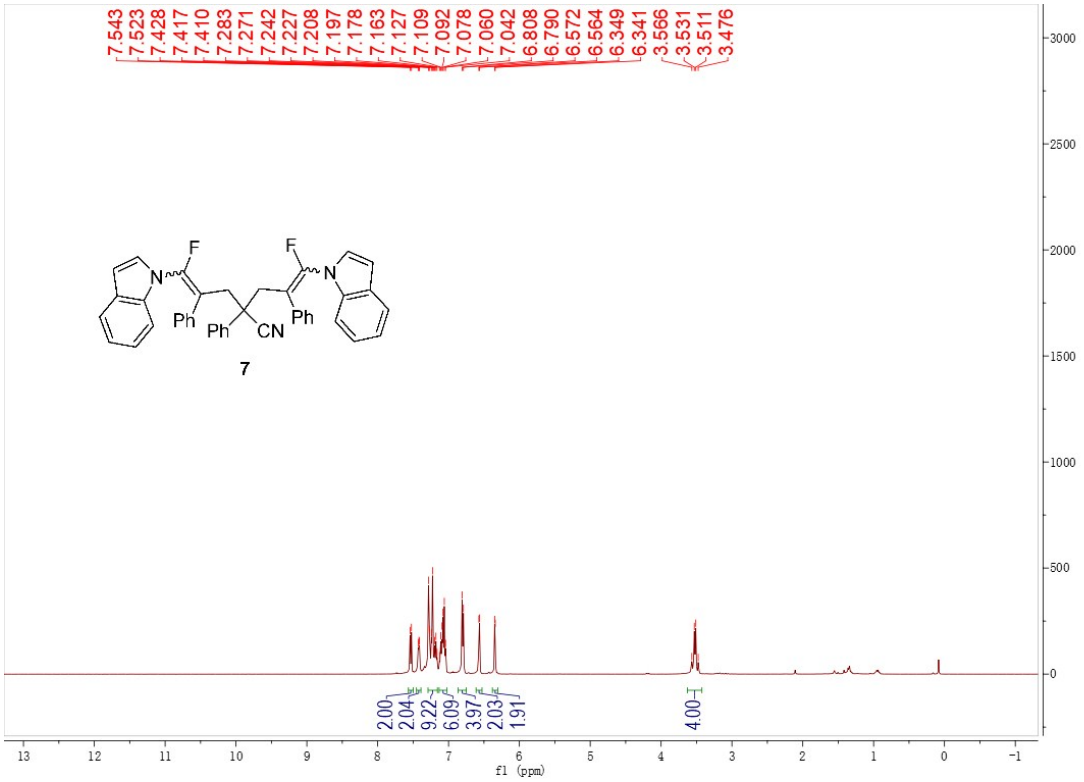
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 6



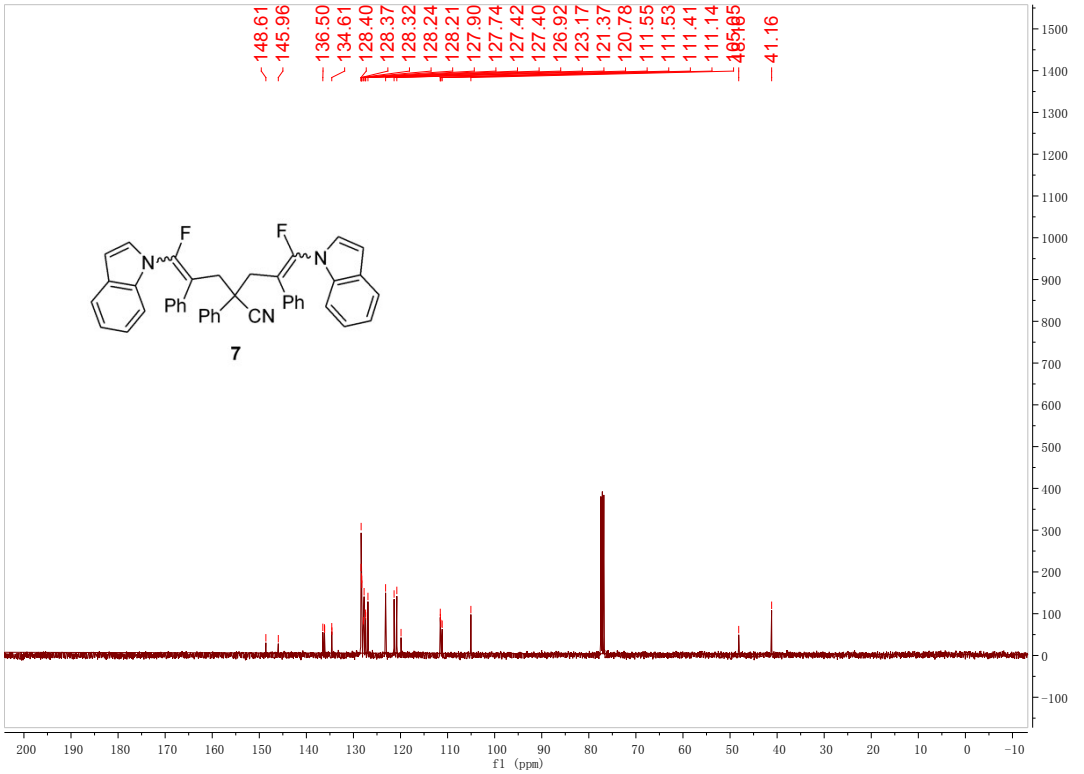
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 6



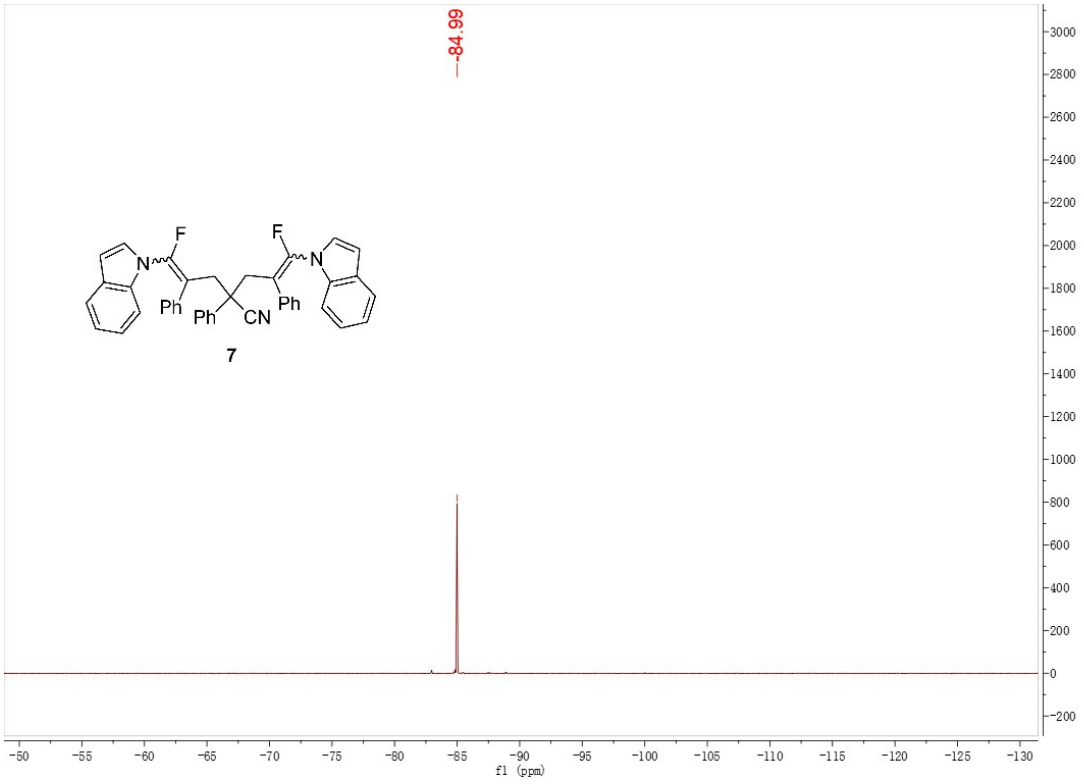
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 7



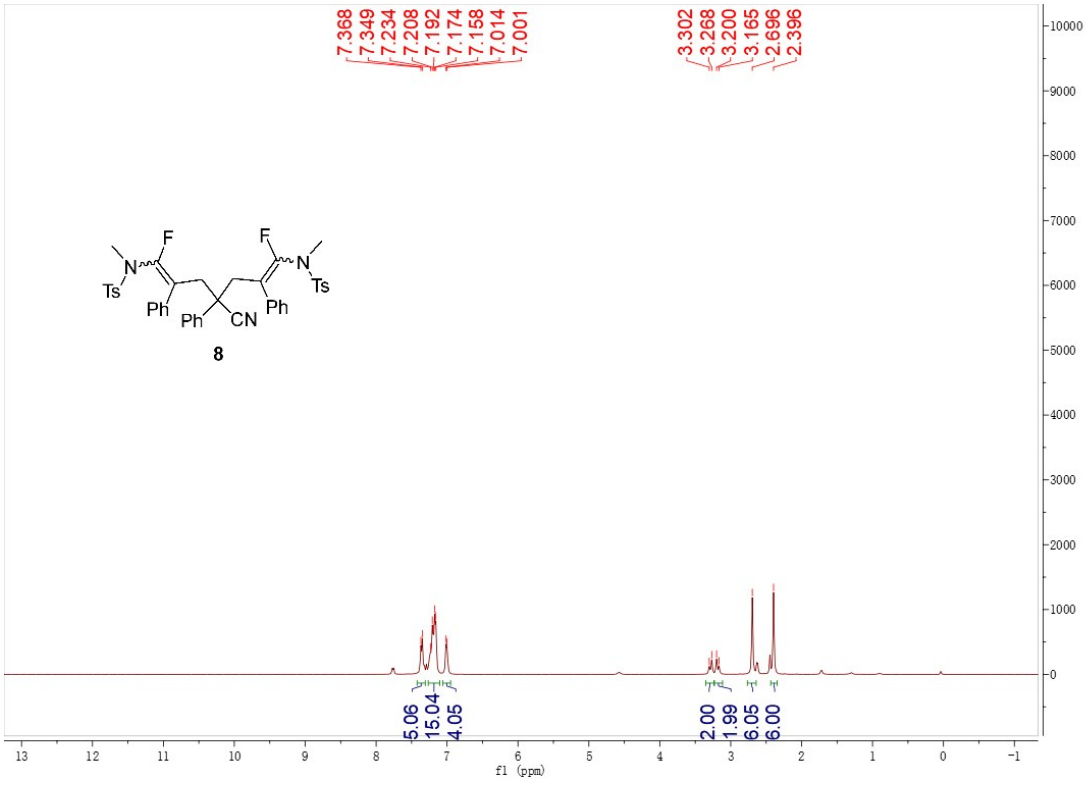
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 7



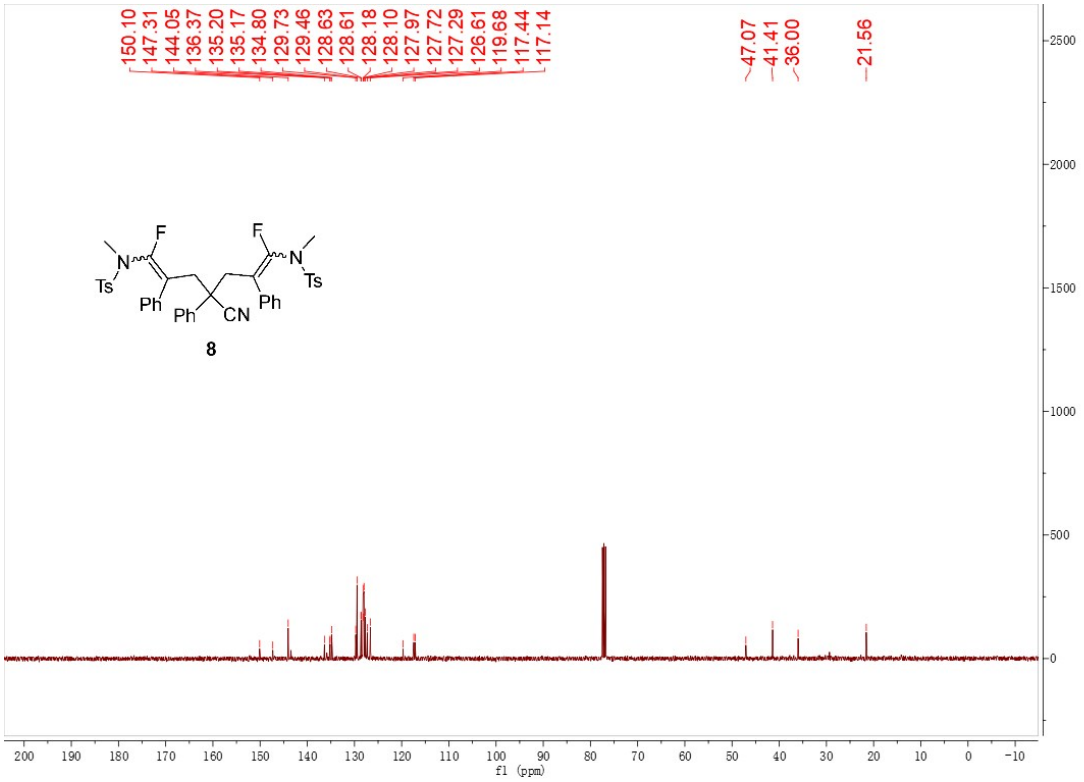
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 7



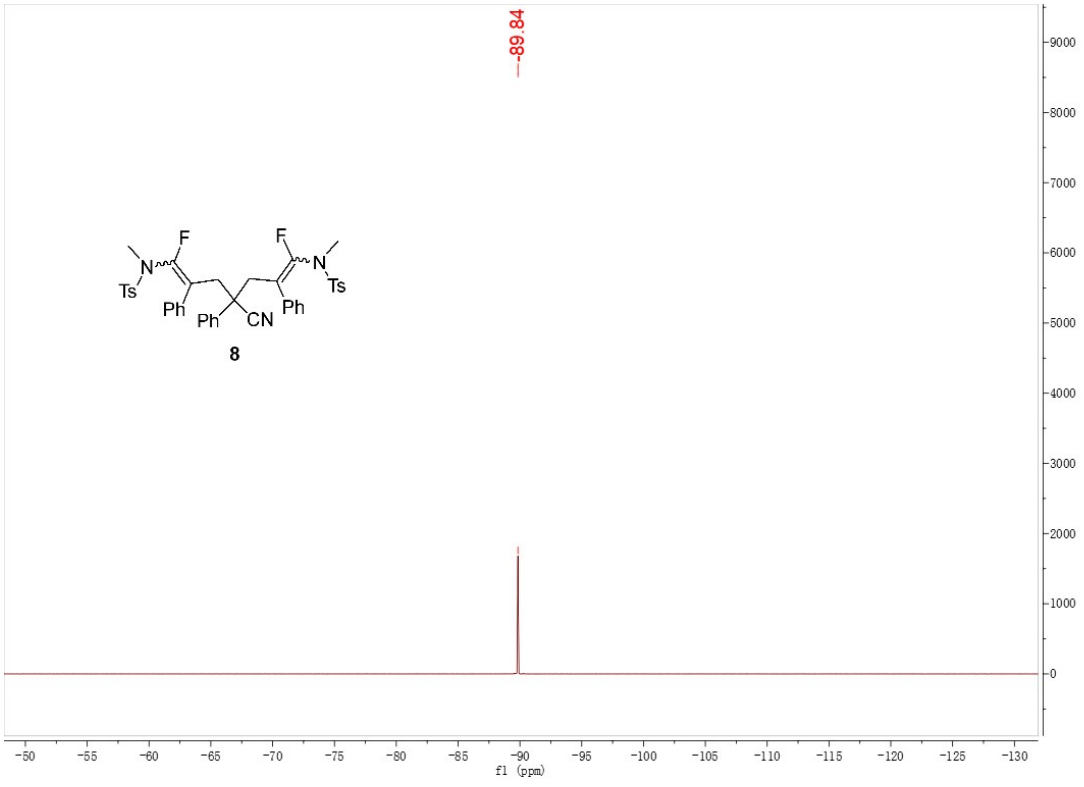
^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 8



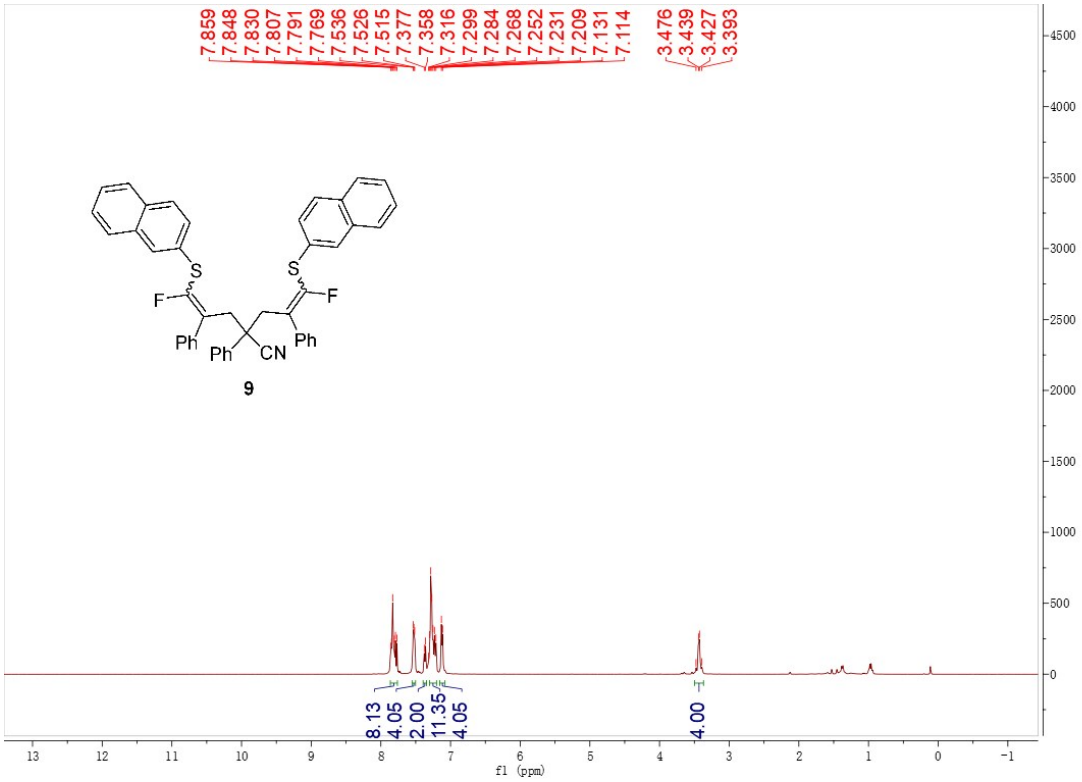
^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 8



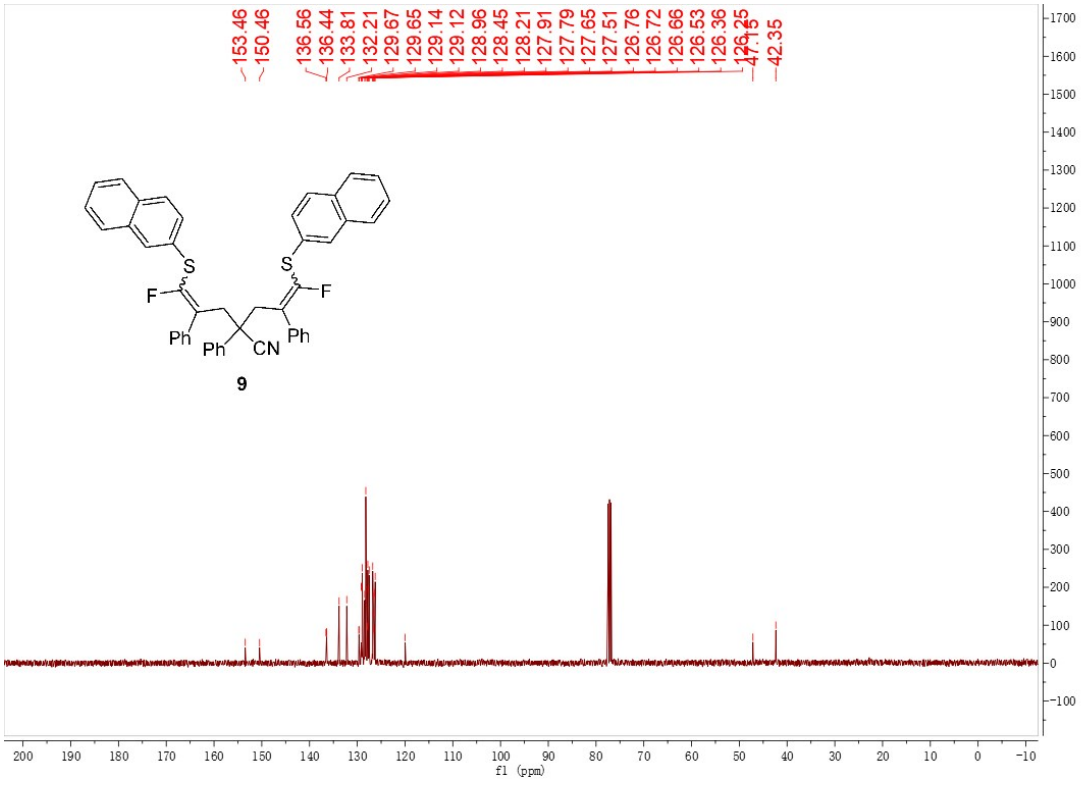
^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 8



^{1}H NMR (400 MHz, $CDCl_3$) spectrum for 9



^{13}C NMR (100 MHz, $CDCl_3$) spectrum for 9



^{19}F NMR (376 MHz, $CDCl_3$) spectrum for 9