

Catalytic Regioselective Synthesis of Structurally Diverse Indene Derivatives from *N*-Benzylid Sulfonamides and Disubstituted Alkynes

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Supporting Information

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General Information

¹H and ¹³C NMR spectra were recorded on a Bruker AC-300 FT spectrometer (300 MHz and 75 MHz, respectively) or on a Bruker AC-400 FT spectrometer (400 MHz and 100 MHz, respectively) using tetramethylsilane as an internal reference. Chemical shifts (δ) and coupling constants (J) were expressed in ppm and Hz, respectively. 2D NOESY spectra were recorded on a Bruker AC-400 FT spectrometer (400 MHz). IR spectra were recorded on a Perkin-Elmer 2000 FTIR spectrometer. High resolution mass spectra were recorded on a LC-TOF spectrometer (Micromass). High pressure liquid chromatography (HPLC) analyses were performed on a Hewlett-Packard 1200 Series instrument equipped with an isostatic pump and a Daicel Chiralpak AD column (250 x 4.6 mm), and the UV detection was monitored at 254 nm. Melting points were uncorrected.

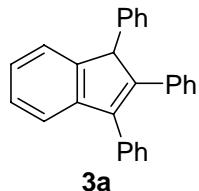
Sulfonamides **1a**, **1e**, (**R**)-**1e**, and **1l** were prepared by treatment of the corresponding amines with *p*-toluenesulfonyl chloride and triethylamine in dichloromethane at room temperature, and the rest of sulfonamides were prepared from the corresponding alcohols and *p*-toluenesulfonamide according to a literature procedure.¹ Alkynes **2b-c**, **2g**, and **2i-n** were prepared according to literature procedures.² The rest of chemicals were purchased from the Sinopharm Chemical Reagent Co., Meryer, Acros, and Alfa Aesar, and used as received. Solvents were dried over magnesium sulfate before use.

General Procedure for the FeCl₃-Catalyzed Regioselective Synthesis of Indene Derivatives from *N*-Benzylidene Sulfonamides and Disubstituted Alkynes (Tables 1 and 2)

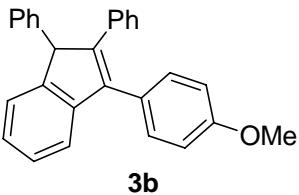
To a solution of *N*-benzylidene sulfonamide **1** (0.20 mmol) in dry nitromethane (2.0 mL) were added alkyne **2** (0.24 mmol) and FeCl₃ (3.3 mg, 0.020 mmol). The resulting mixture was stirred at 80 °C until no further transformation was detected by thin layer chromatography (TLC) analysis. The mixture was cooled to room temperature, and purified by silica gel column chromatography, eluting with petroleum ether/ethyl acetate (100:0 to 5:1), to give indene derivative **3**.

Except for the reaction of sulfonamide **1j** with alkyne **2a** (Table 2, entry 14), no regioisomer of indene derivative **3** was identified by ¹H NMR analysis of the CH group at the C-1 position. The regiochemistry of products **3c**, **3e**, **3i**, **3l**, **3p**, **3y**, and **3z** was determined by 2D NOESY analysis (*vide infra*), and the regiochemistry of the rest of new products shown in Tables 1 and 2 was determined by analogy.

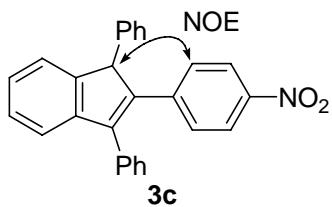
Analytical Data for the Products Shown in Tables 1 and 2



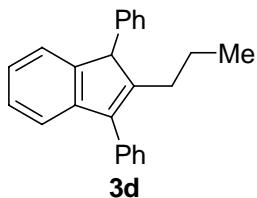
3a,³ white solid, m.p. 133-135 °C; ¹H NMR (400 MHz, CDCl₃): δ 7.48-7.39 (m, 5H), 7.35-7.08 (m, 14H), 5.16 (s, 1H); ¹³C NMR (75 MHz, CDCl₃): δ 148.3, 145.7, 145.1, 139.9, 135.7, 129.7, 129.4, 128.8, 128.3, 128.0, 127.6, 127.0, 126.8, 125.8, 124.0, 120.6, 58.2.



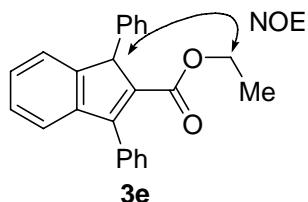
3b,⁴ colorless oil; ¹H NMR (400 MHz, CDCl₃): δ 7.34 (d, *J* = 8.8 Hz, 2H), 7.45-7.16 (m, 14H), 7.01 (d, *J* = 8.8 Hz, 2H), 5.07 (s, 1H), 3.83 (s, 3H); ¹³C NMR (75 MHz, CDCl₃): δ 159.1, 148.4, 145.2, 140.0, 135.9, 130.8, 129.4, 128.8, 128.3, 128.0, 127.0, 126.7, 125.8, 124.0, 120.6, 114.3, 58.1, 55.4.



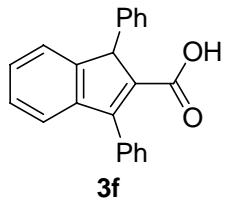
3c, yellow solid, m.p. 161-163 °C; ¹H NMR (400 MHz, CDCl₃): δ 7.84 (d, *J* = 9.2 Hz, 2H), 7.39-7.30 (m, 5H), 7.25-7.04 (m, 11H), 5.07 (s, 1H); ¹³C NMR (75 MHz, CDCl₃): δ 148.5, 146.2, 144.4, 138.9, 134.8, 129.9, 129.4, 129.3, 129.1, 128.4, 128.2, 127.4, 127.3, 127.0, 124.2, 123.4, 121.5, 58.0; IR (film): ν 3063, 3026, 2926, 1594, 1513, 1495, 1452 cm⁻¹; HRMS (EI) Calcd for C₂₇H₁₉NO₂ (M): 389.1416. Found: 389.1410.



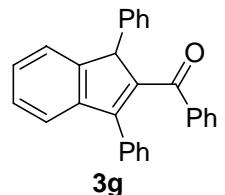
3d,³ colorless oil; ¹H NMR (400 MHz, CDCl₃): δ 7.55-7.42 (m, 4H), 7.41-7.38 (m, 1H), 7.33-7.24 (m, 6H), 7.21-7.09 (m, 3H), 4.60 (s, 1H), 2.50-2.40 (m, 1H), 2.10-2.00 (m, 1H), 1.55-1.37 (m, 2H), 0.82 (t, *J* = 7.4 Hz, 3H); ¹³C NMR (75 MHz, CDCl₃): δ 149.2, 148.2, 140.2, 135.5, 130.5, 129.8, 129.4, 129.0, 128.9, 128.6, 128.5, 127.3, 126.9, 126.8, 124.9, 124.0, 119.7, 57.2, 29.2, 23.4, 14.2.



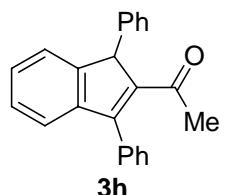
3e, colorless oil; ¹H NMR (400 MHz, CDCl₃): δ 7.53-7.41 (m, 5H), 7.30-7.15 (m, 9H), 5.04 (s, 1H), 4.07-3.97 (m, 1H), 3.95-3.85 (m, 1H), 0.92 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 164.5, 153.0, 149.0, 143.5, 139.0, 134.1, 128.9, 128.6, 128.3, 128.2, 128.0, 127.2, 126.9, 124.4, 122.8, 60.0, 56.5, 13.7; IR (film): ν 3062, 3027, 2980, 2928, 1709, 1595, 1574, 1494, 1453 cm⁻¹; HRMS (EI) Calcd for C₂₄H₂₀O₂ (M): 340.1463. Found: 340.1467.



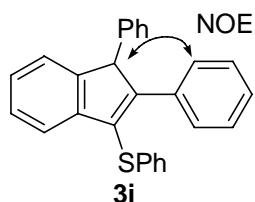
3f,⁵ white solid, m.p. 199-201 °C; ¹H NMR (400 MHz, CDCl₃): δ 7.48-7.42 (m, 5H), 7.29-7.20 (m, 7H), 7.16-7.12 (m, 2H), 4.99 (s, 1H); ¹³C NMR (100 MHz, CDCl₃): δ 169.0, 155.4, 149.5, 143.3, 138.8, 134.7, 133.8, 129.0, 128.9, 128.8, 128.6, 128.3, 128.0, 127.4, 127.1, 124.5, 123.3, 56.5.



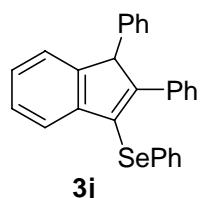
3g,⁶ white solid, m.p. 148-150 °C; ¹H NMR (400 MHz, CDCl₃): δ 7.53-7.47 (m, 3H), 7.38-7.30 (m, 5H), 7.22-7.15 (m, 9H), 7.07-7.00 (m, 2H), 5.37 (s, 1H); ¹³C NMR (100 MHz, CDCl₃): δ 194.9, 149.0, 148.8, 145.5, 143.2, 138.2, 137.9, 133.7, 132.0, 129.4, 129.3, 128.7, 128.3, 128.2, 128.1, 127.7, 127.5, 127.1, 124.8, 122.6, 57.7.



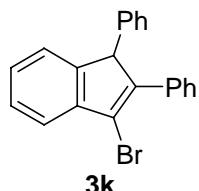
3h,⁶ white solid, m.p. 95-97 °C; ¹H NMR (400 MHz, CDCl₃): δ 7.56-7.45 (m, 5H), 7.30-7.14 (m, 9H), 5.11 (s, 1H), 1.89 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 197.2, 151.6, 149.0, 145.9, 144.0, 139.1, 134.8, 128.9, 128.8, 128.7, 128.4, 128.3, 127.9, 127.4, 127.0, 124.6, 123.1, 56.4, 30.6.



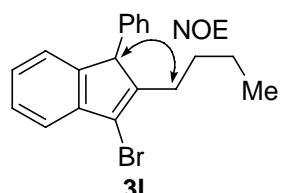
3i, colorless oil; ¹H NMR (400 MHz, CDCl₃): δ 7.41 (d, *J* = 7.2 Hz, 2H), 7.39-7.26 (m, 3H), 7.25-7.10 (m, 12H), 7.05 (d, *J* = 8.4 Hz, 2H), 5.16 (s, 1H); ¹³C NMR (100 MHz, CDCl₃): δ 143.6, 130.7, 130.3, 129.5, 129.2, 128.7, 128.5, 127.9, 127.7, 127.4, 127.3, 126.6, 56.6; IR (film): ν 3060, 3025, 2925, 1600, 1577, 1492, 1457 cm⁻¹; HRMS (EI) Calcd for C₂₇H₂₀S (M): 376.1286. Found: 376.1305.



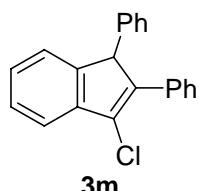
3j, white solid, m.p. 103-105 °C; ¹H NMR (400 MHz, CDCl₃): δ 7.50 (d, *J* = 7.2 Hz, 2H), 7.41-7.37 (m, 2H), 7.30-7.18 (m, 10H), 7.10-7.04 (m, 5H), 5.50 (s, 1H); ¹³C NMR (100 MHz, CDCl₃): δ 156.3, 147.3, 144.7, 139.0, 135.5, 131.1, 130.2, 129.3, 129.2, 128.7, 128.2, 127.9, 127.8, 127.2, 126.9, 126.2, 126.1, 123.8, 122.2, 59.3; IR (film): ν 3059, 3025, 2924, 1598, 1580, 1490, 1450 cm⁻¹; HRMS (EI) Calcd for C₂₇H₂₀Se (M): 424.0730. Found: 424.0712.



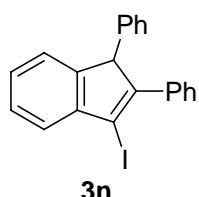
3k,⁷ white solid, m.p. 74-76 °C; ¹H NMR (300 MHz, CDCl₃): δ 7.68 (d, *J* = 6.9 Hz, 2H), 7.65-7.45 (m, 3H), 7.42-7.18 (m, 9H), 4.78 (s, 1H); ¹³C NMR (75 MHz, CDCl₃): δ 147.4, 138.2, 133.5, 129.2, 129.0, 128.7, 128.4, 127.6, 127.2, 126.0, 124.2, 120.2, 61.1.



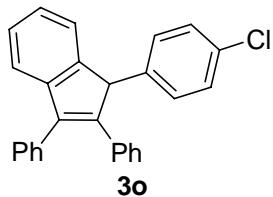
3l, colorless oil; ¹H NMR (400 MHz, CDCl₃): δ 7.39-7.23 (m, 5H), 7.17-7.09 (m, 2H), 7.04-6.98 (m, 2H), 4.46 (s, 1H), 2.64-2.50 (m, 1H), 2.10-2.03 (m, 1H), 1.42-1.24 (m, 4H), 0.87 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 150.2, 146.4, 143.1, 138.8, 129.1, 128.9, 127.3, 127.2, 126.0, 123.7, 119.7, 118.2, 57.3, 31.0, 28.0, 22.6, 14.0; IR (film): ν 3062, 3026, 2926, 1604, 1493, 1459 cm⁻¹; HRMS (EI) Calcd for C₁₉H₁₉Br (M): 326.0670. Found: 326.0667.



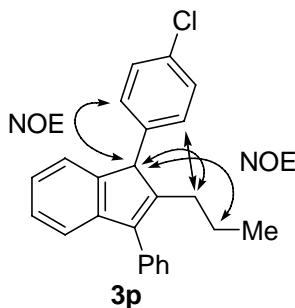
3m,⁸ white solid, m.p. 84-85 °C; ¹H NMR (400 MHz, CDCl₃): δ 7.62 (d, *J* = 7.2 Hz, 2H), 7.53-7.48 (m, 2H), 7.45-7.41 (m, 1H), 7.36-7.32 (m, 9H), 4.69 (s, 1H); ¹³C NMR (100 MHz, CDCl₃): δ 145.8, 142.7, 139.0, 137.7, 137.0, 132.5, 128.9, 128.5, 128.3, 127.2, 125.9, 124.0, 120.1, 59.4.



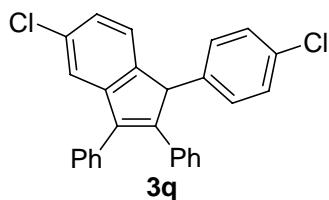
3n,⁹ white solid, m.p. 103-105 °C; ¹H NMR (400 MHz, CDCl₃): δ 7.58-7.43 (m, 5H), 7.36-7.10 (m, 9H), 4.69 (s, 1H); ¹³C NMR (100 MHz, CDCl₃): δ 149.4, 149.2, 143.4, 138.7, 135.2, 129.1, 128.8, 128.7, 128.5, 128.3, 127.4, 127.0, 125.7, 124.2, 120.0, 105.4, 63.9.



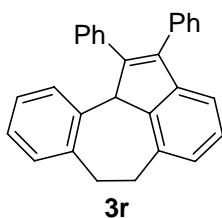
3o, colorless oil; ^1H NMR (400 MHz, CDCl_3): δ 7.45-7.33 (m, 4H), 7.30-7.00 (m, 14H), 5.07 (s, 1H); ^{13}C NMR (75 MHz, CDCl_3): δ 147.8, 138.5, 135.3, 129.6, 129.5, 128.9, 128.8, 128.1, 128.0, 127.8, 127.7, 127.2, 127.1, 126.9, 125.9, 125.7, 125.0, 123.9, 120.7, 57.3; IR (film): ν 3060, 3026, 2926, 1600, 1489, 1458, 1443 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{27}\text{H}_{19}\text{Cl}$ (M): 378.1175. Found: 378.1180.



3p, colorless oil; ^1H NMR (400 MHz, CDCl_3): δ 7.50-7.30 (m, 5H), 7.24 (d, $J = 8.4$ Hz, 2H), 7.23-7.05 (m, 4H), 7.02 (d, $J = 8.4$ Hz, 2H), 4.54 (s, 1H), 2.50-2.38 (m, 1H), 2.04-1.90 (m, 1H), 1.52-1.31 (m, 2H), 0.81 (t, $J = 7.4$ Hz, 3H); ^{13}C NMR (75 MHz, CDCl_3): δ 148.7, 147.8, 138.8, 129.8, 129.3, 129.1, 128.8, 128.6, 128.4, 127.5, 127.0, 125.1, 124.9, 124.8, 123.9, 119.9, 56.8, 29.3, 23.4, 14.2; IR (film): ν 3062, 3025, 2958, 1598, 1489, 1462 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{24}\text{H}_{21}\text{Cl}$ (M): 344.1332. Found: 344.1328.

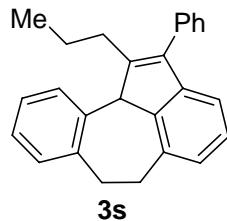


3q, colorless oil; ^1H NMR (300 MHz, CDCl_3): δ 7.48-7.40 (m, 5H), 7.31-7.06 (m, 12H), 5.10 (s, 1H); ^{13}C NMR (75 MHz, CDCl_3): δ 147.0, 146.8, 146.0, 137.8, 134.8, 132.7, 131.0, 129.6, 128.9, 128.1, 127.3, 125.8, 124.9, 124.4, 121.6, 120.9, 56.9; IR (film): ν 3058, 3025, 2926, 1597, 1575, 1489, 1460 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{27}\text{H}_{18}\text{Cl}_2$ (M): 412.0786. Found: 412.0781.

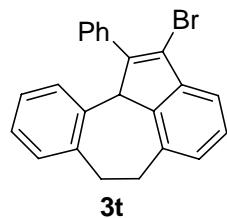


3r, white solid, m.p. 161-163 °C; ^1H NMR (300 MHz, CDCl_3): δ 7.49-7.41 (m, 4H), 7.33-7.08 (m, 9H), 7.00-6.90 (m, 3H), 6.75 (d, $J = 7.5$ Hz, 1H), 5.88 (s, 1H), 4.03-3.90 (m, 1H), 3.50-3.42 (m, 1H), 3.10-3.00 (m, 2H); ^{13}C NMR (75 MHz, CDCl_3): δ 145.1, 141.9, 141.6, 139.6, 136.1, 134.9, 130.5,

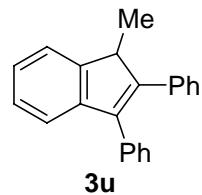
129.6, 128.3, 127.6, 127.3, 127.2, 126.9, 126.7, 126.4, 126.1, 118.2, 52.1, 31.9, 31.7; IR (film): ν 3058, 2926, 1597, 1487, 1440 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{29}\text{H}_{22}$ (M): 370.1722. Found: 370.1718.



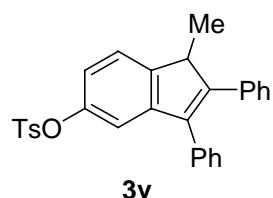
3s, colorless oil; ^1H NMR (300 MHz, CDCl_3): δ 7.60-7.42 (m, 5H), 7.40-7.34 (m, 1H), 7.29-7.12 (m, 4H), 7.10 (d, $J = 7.2$ Hz, 1H), 6.91 (d, $J = 7.8$ Hz, 1H), 5.29 (s, 1H), 4.00-3.83 (m, 1H), 3.50-3.40 (m, 1H), 3.10-2.68 (m, 3H), 2.69-2.62 (m, 1H), 1.67-1.41 (m, 2H), 0.90 (t, $J = 7.5$ Hz, 3H); ^{13}C NMR (75 MHz, CDCl_3): δ 145.4, 144.7, 142.3, 141.7, 140.2, 135.8, 134.6, 129.4, 128.8, 128.6, 127.3, 127.0, 126.9, 126.6, 124.3, 117.2, 51.7, 31.7, 30.7, 29.8, 23.8, 14.4; IR (film): ν 3017, 2929, 1592, 1485, 1456, 1439 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{26}\text{H}_{24}$ (M): 336.1878. Found: 336.1873.



3t, colorless oil; ^1H NMR (400 MHz, CDCl_3): δ 7.60 (d, $J = 8.4$ Hz, 2H), 7.59-7.36 (m, 4H), 7.29-7.16 (m, 3H), 7.14-7.08 (m, 1H), 7.03 (d, $J = 7.6$ Hz, 1H), 6.90 (d, $J = 7.6$ Hz, 1H), 5.38 (s, 1H), 3.80-3.68 (m, 1H), 3.40-3.32 (m, 1H), 3.00-2.87 (m, 2H); ^{13}C NMR (100 MHz, CDCl_3): δ 145.0, 142.3, 141.7, 141.2, 137.9, 134.9, 133.7, 129.2, 128.7, 128.5, 128.3, 127.3, 127.2, 126.6, 124.8, 123.4, 117.7, 55.8, 31.4; IR (film): ν 3061, 3026, 2924, 1592, 1493, 1451 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{23}\text{H}_{17}\text{Br}$ (M): 372.0514. Found: 372.0508.

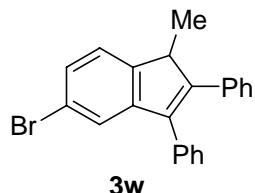


3u,³ white solid, m.p. 104-106 °C; ^1H NMR (400 MHz, CDCl_3): δ 7.52-7.47 (m, 1H), 7.34-7.13 (m, 13H), 4.02 (q, $J = 7.6$ Hz, 1H), 1.29 (d, $J = 7.6$ Hz, 3H); ^{13}C NMR (75 MHz, CDCl_3): δ 129.7, 129.5, 128.7, 128.2, 127.3, 126.8, 125.2, 122.9, 120.5, 46.1, 16.7.

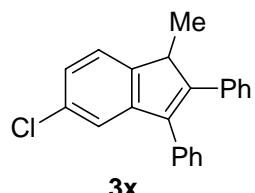


3v, white solid, m.p. 157-159 °C; ^1H NMR (400 MHz, CDCl_3): δ 7.72 (d, $J = 8.4$ Hz, 2H), 7.39 (d, J

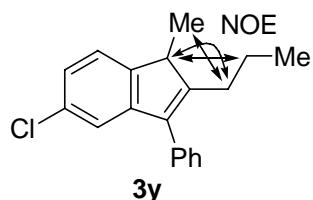
= 8.0 Hz, 1H), 7.30-7.24 (m, 5H), 7.21-7.16 (m, 3H), 7.15-7.10 (m, 4H), 6.92 (d, J = 8.4 Hz, 1H), 6.70 (s, 1H), 3.98 (q, J = 7.6 Hz, 1H), 2.45 (s, 3H), 1.26 (d, J = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3): δ 149.6, 149.0, 147.0, 146.3, 145.1, 137.5, 135.2, 134.7, 132.7, 129.4, 129.3, 128.7, 128.7, 128.6, 128.2, 127.4, 127.1, 123.5, 119.1, 114.4, 45.7, 21.7, 16.4; IR (film): ν 3057, 3029, 2927, 1605, 1492, 1466, 1444 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{29}\text{H}_{24}\text{O}_3\text{S}$ (M): 452.1446. Found: 452.1452.



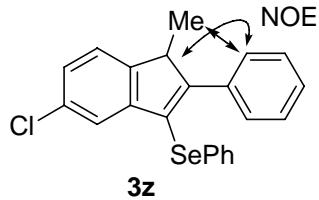
3w, white solid, m.p. 120-122 °C; ^1H NMR (400 MHz, CDCl_3): δ 7.42-7.25 (m, 8H), 7.22-7.11 (m, 5H), 3.99 (q, J = 7.6 Hz, 1H), 1.28 (d, J = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3): δ 149.7, 147.6, 147.5, 135.6, 135.4, 129.8, 129.2, 128.6, 128.3, 127.9, 127.5, 124.6, 123.9, 121.2, 46.1, 16.9; IR (film): ν 3056, 3024, 2967, 1595, 1574, 1488, 1460 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{22}\text{H}_{17}\text{Br}$ (M): 360.0514. Found: 360.0509.



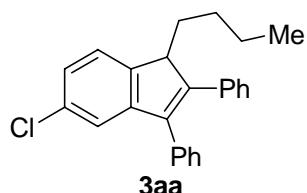
3x, white solid, m.p. 97-100 °C; ^1H NMR (300 MHz, CDCl_3): δ 7.48-7.32 (m, 6H), 7.31-7.18 (m, 7H), 4.05 (q, J = 7.5 Hz, 1H), 1.33 (d, J = 7.5 Hz, 3H); ^{13}C NMR (75 MHz, CDCl_3): δ 146.9, 137.8, 135.4, 135.2, 132.9, 129.6, 129.0, 128.4, 127.7, 127.3, 125.2, 124.0, 120.7, 120.2, 45.8, 16.8; IR (film): ν 3057, 3025, 2927, 1600, 1487, 1460, 1444 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{22}\text{H}_{17}\text{Cl}$ (M): 316.1019. Found: 316.1013.



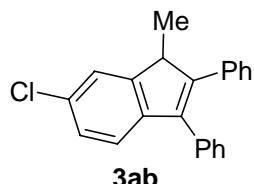
3y, colorless oil; ^1H NMR (400 MHz, CDCl_3): δ 7.48-7.40 (m, 3H), 7.39-7.31 (m, 3H), 7.22-7.12 (m, 2H), 3.50 (q, J = 7.6 Hz, 1H), 2.57-2.47 (m, 1H), 2.36-2.28 (m, 1H), 1.75-1.58 (m, 1H), 1.50-1.40 (m, 1H), 1.38 (d, J = 7.6 Hz, 3H), 0.89 (t, J = 7.4 Hz, 3H); ^{13}C NMR (75 MHz, CDCl_3): δ 152.1, 146.8, 129.2, 128.6, 127.4, 124.1, 123.5, 119.8, 44.5, 29.0, 23.2, 15.9, 14.3; IR (film): ν 3058, 3028, 2961, 2930, 1598, 1575, 1493, 1464 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{19}\text{H}_{19}\text{Cl}$ (M): 282.1175. Found: 282.1167.



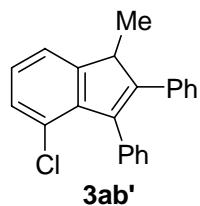
3z, colorless oil; ^1H NMR (400 MHz, CDCl_3): δ 7.49 (d, $J = 7.2$ Hz, 2H), 7.43-7.35 (m, 4H), 7.29-7.24 (m, 2H), 7.21-7.02 (m, 5H), 4.08 (q, $J = 7.6$ Hz, 1H), 1.27 (d, $J = 7.6$ Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3): δ 160.3, 146.6, 145.8, 136.3, 135.1, 133.0, 132.1, 130.8, 130.0, 129.3, 128.2, 127.4, 126.3, 125.6, 123.6, 122.2, 47.2, 16.8; IR (film): ν 3055, 3025, 2964, 2925, 1599, 1577, 1489, 1475, 1455, 1438 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{22}\text{H}_{17}\text{ClSe}$ (M): 396.0184. Found: 396.0174.



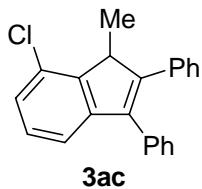
3aa, colorless oil; ^1H NMR (400 MHz, CDCl_3): δ 7.45-7.12 (m, 13H), 4.10-4.00 (m, 1H), 2.00-1.87 (m, 1H), 1.70-1.50 (m, 1H), 1.30-0.90 (m, 4H), 0.70 (t, $J = 7.0$ Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3): δ 148.2, 147.7, 145.3, 138.6, 135.6, 135.1, 132.7, 129.6, 129.5, 128.3, 127.6, 127.2, 124.9, 124.1, 120.6, 50.6, 30.2, 26.6, 22.9, 13.9; IR (film): ν 3056, 3025, 2956, 2929, 1598, 1574, 1487, 1458, 1443 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{25}\text{H}_{23}\text{Cl}$ (M): 358.1488. Found: 358.1483.



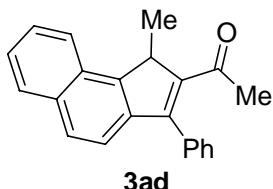
3ab, white solid, m.p. 93-94 °C; ^1H NMR (400 MHz, CDCl_3): δ 7.48 (s, 1H), 7.38-7.34 (m, 5H), 7.33-7.16 (m, 7H), 4.02 (q, $J = 7.6$ Hz, 1H), 1.29 (d, $J = 7.6$ Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3): δ 150.1, 148.0, 143.4, 137.7, 135.3, 135.2, 131.1, 129.5, 129.3, 128.7, 128.1, 127.4, 127.0, 126.8, 123.3, 121.2, 45.9, 16.5; IR (film): ν 3056, 3025, 2961, 2926, 1595, 1574, 1488, 1459, 1443 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{22}\text{H}_{17}\text{Cl}$ (M): 316.1019. Found: 316.1013.



3ab', colorless oil; ^1H NMR (400 MHz, CDCl_3): δ 7.56-7.53 (m, 1H), 7.45-7.38 (m, 2H), 7.33-7.27 (m, 1H), 7.22-7.18 (m, 6H), 7.16-7.12 (m, 2H), 7.11-7.00 (m, 1H), 4.03 (q, $J = 7.6$ Hz, 1H), 1.30 (d, $J = 7.6$ Hz, 3H); ^{13}C NMR (100 MHz, CDCl_3): δ 150.9, 150.1, 140.6, 138.3, 136.7, 135.2, 129.3, 128.9, 128.0, 127.4, 127.1, 126.9, 126.0, 121.3, 46.0, 16.9; IR (film): ν 3058, 3029, 2965, 2927, 1599, 1566, 1489, 1454, 1422 cm^{-1} ; HRMS (EI) Calcd for $\text{C}_{22}\text{H}_{17}\text{Cl}$ (M): 316.1019. Found:



3ac, white solid, m.p. 109-111 °C; ¹H NMR (400 MHz, CDCl₃): δ 7.46-7.42 (m, 1H), 7.31-7.20 (m, 6H), 7.18-7.04 (m, 6H), 4.10 (q, *J* = 7.6 Hz, 1H), 1.31 (d, *J* = 7.6 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 149.0, 147.3, 145.0, 137.7, 135.3, 135.1, 131.7, 130.1, 129.6, 128.7, 128.4, 127.5, 127.3, 125.8, 119.1, 46.5, 14.7; IR (film): ν 3058, 2931, 1597, 1572, 1492, 1446 cm⁻¹; HRMS (EI) Calcd for C₂₂H₁₇Cl (M): 316.1019. Found: 316.1016.

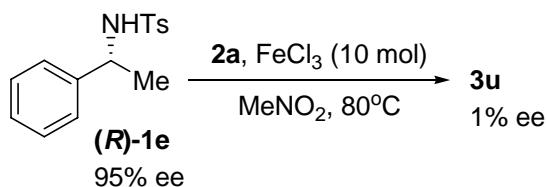


3ad, white solid, m.p. 129-131 °C; ¹H NMR (400 MHz, CDCl₃): δ 8.04 (d, *J* = 8.4 Hz, 1H), 7.83 (d, *J* = 8.0 Hz, 1H), 7.69 (d, *J* = 8.4 Hz, 1H), 7.52-7.42 (m, 4H), 7.38-7.34 (m, 2H), 7.19-7.12 (m, 2H), 4.36 (q, *J* = 7.2 Hz, 1H), 1.92 (s, 3H), 1.56 (d, *J* = 7.2 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 195.5, 150.9, 146.6, 146.2, 139.8, 134.5, 132.6, 128.1, 128.0, 127.8, 127.7, 127.6, 127.1, 125.6, 125.1, 123.5, 119.9, 43.7, 29.4, 17.5; IR (film): ν 3052, 2964, 2925, 1636, 1582, 1552, 1515, 1484, 1441 cm⁻¹; HRMS (EI) Calcd for C₂₂H₁₈O (M): 298.1358. Found: 298.1364.

Gram-Scale Synthesis of Indene Derivative 3a

To a solution of sulfonamide **1a** (3.37 g, 10.0 mmol) in dry nitromethane (100 mL) were added alkyne **2a** (2.14 g, 12.0 mmol) and FeCl₃ (163 mg, 1.00 mmol). The resulting mixture was stirred at 80 °C until no further transformation was detected by TLC analysis. The mixture was cooled to room temperature, and purified by silica gel column chromatography, eluting with petroleum ether, to give indene derivative **3a** (2.34 g, 68%) as a white solid.

Reaction of Sulfonamide (*R*)-**1e** with Alkyne **2a**



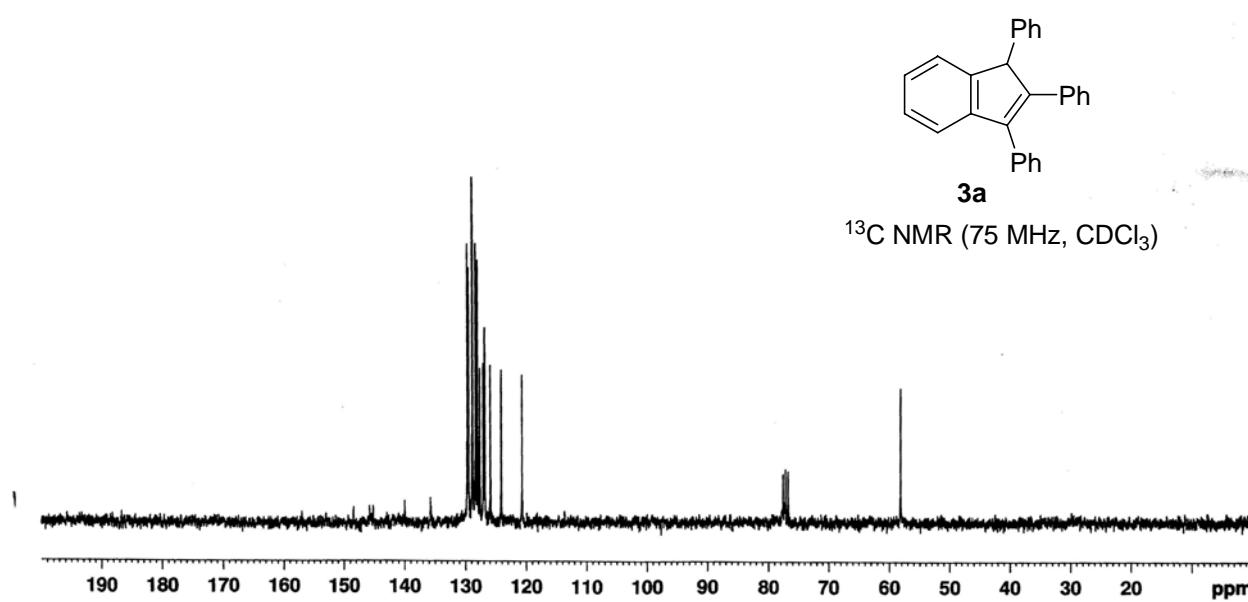
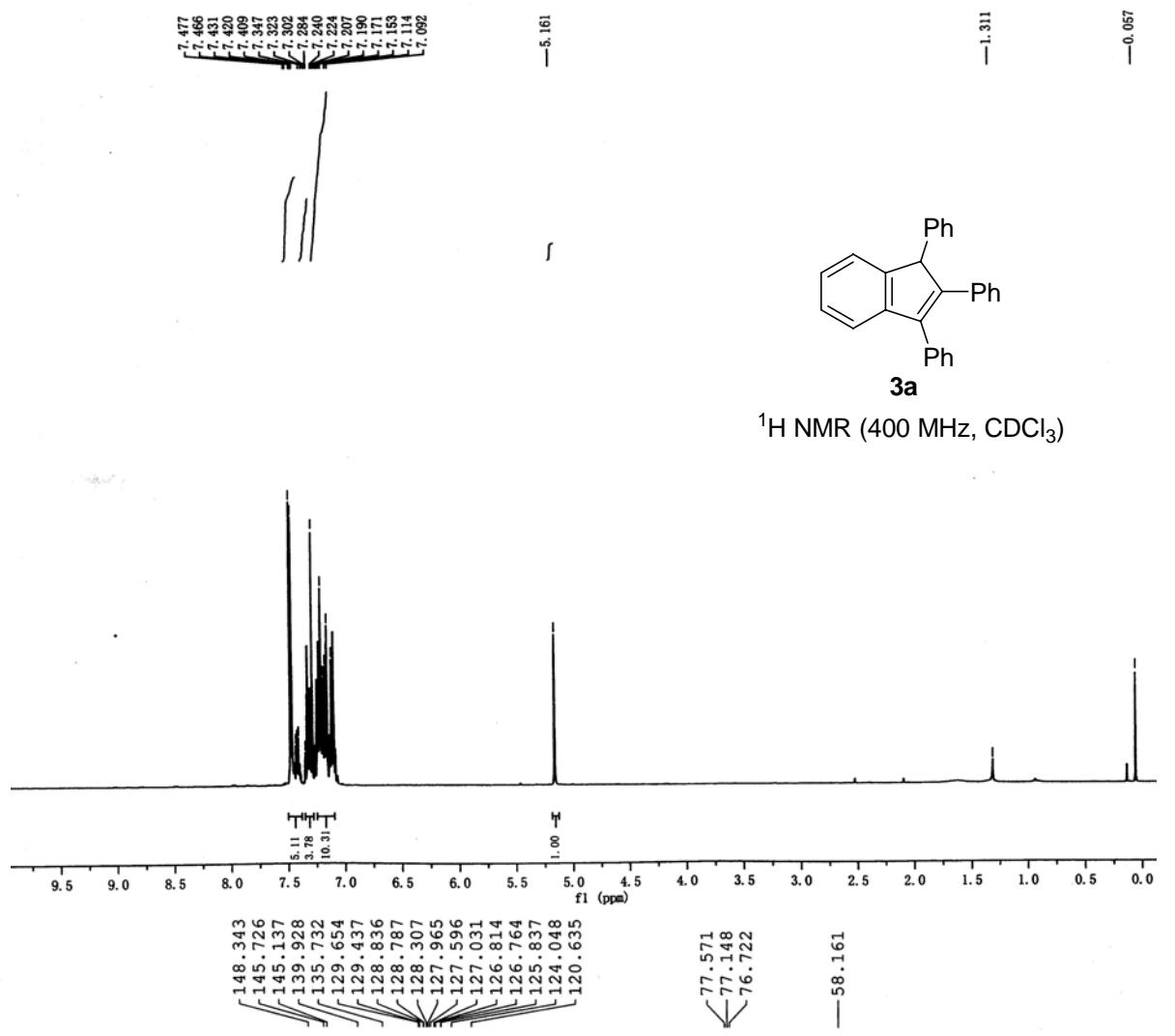
This reaction was performed according to the general procedure for the FeCl₃-catalyzed regioselective synthesis of indene derivatives from *N*-benzylic sulfonamides and disubstituted alkynes. Product **3u** was obtained in 51% yield. The ee of product **3u** was determined to be 1% by HPLC analysis (Chiralpak AD column, IPA/*n*-Hex = 1:99, flow rate = 1.0 mL/min, t_{minor} = 3.87 min, t_{major} = 4.28 min).

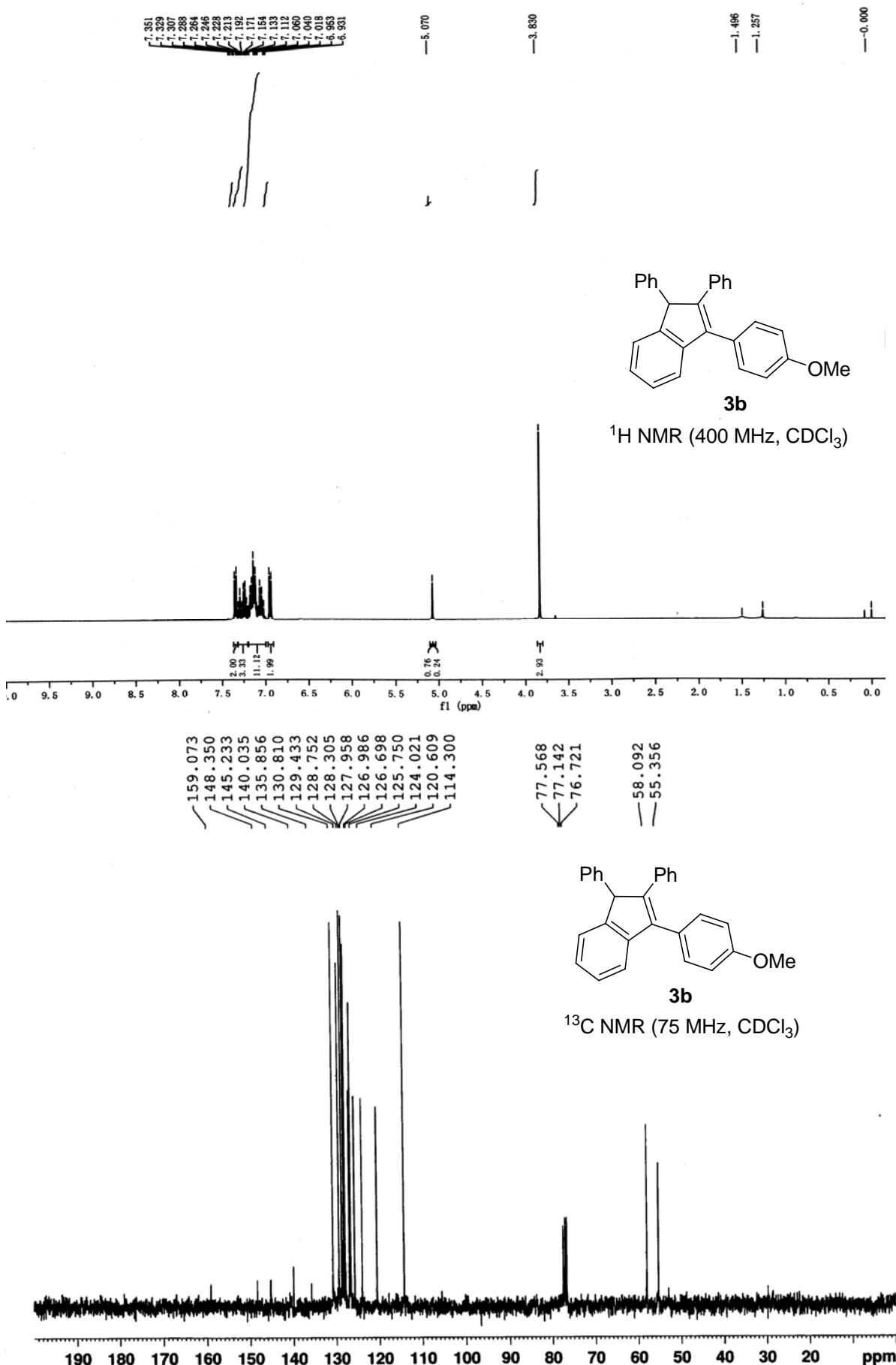
Reaction of Sulfonamide **1a with Alkyne **2o** (Scheme 2)**

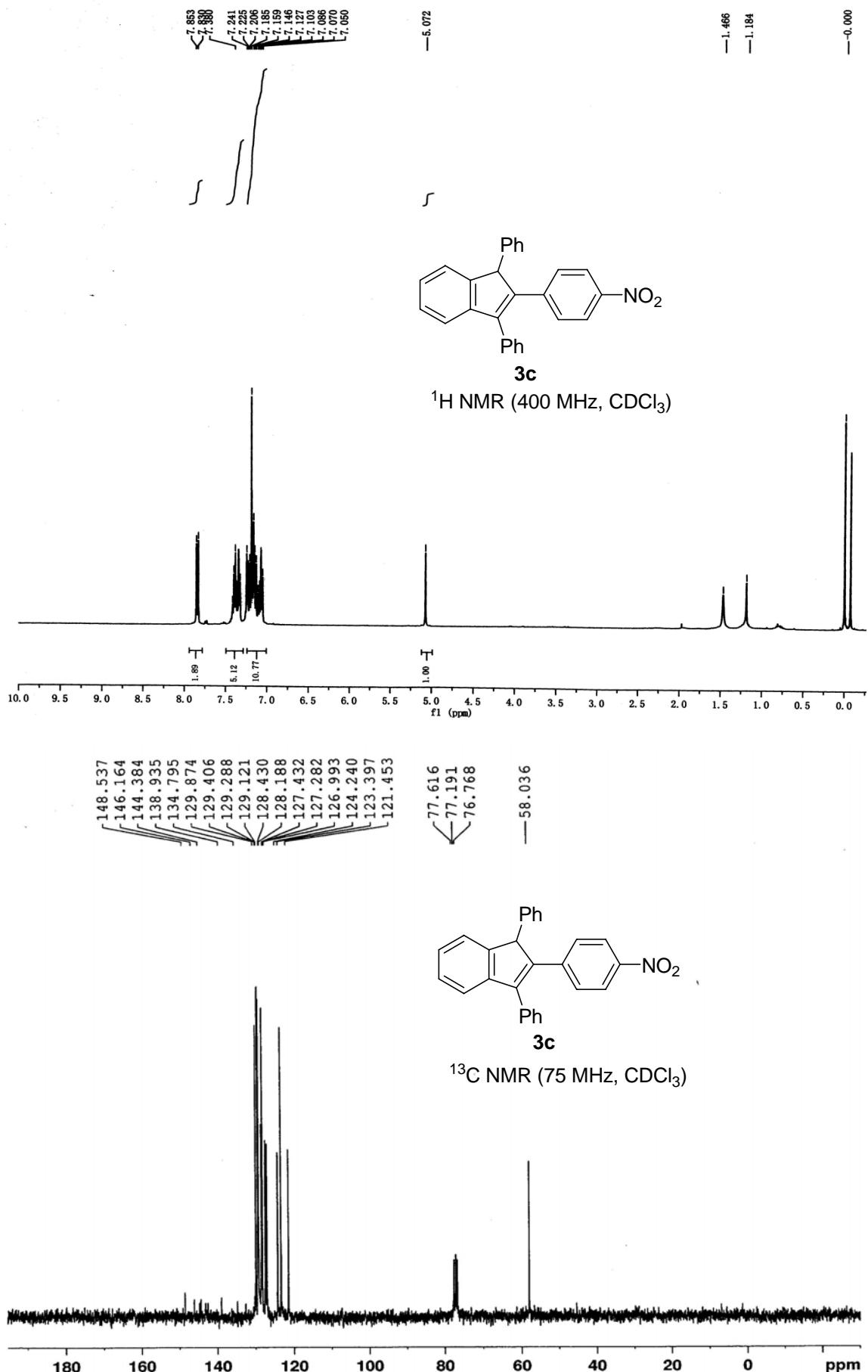
To a solution of sulfonamide **1a** (67.4 mg, 0.20 mmol) in dry nitromethane (2.0 mL) were added alkyne **2o** (41.8 mg, 42.7 μ L, 0.24 mmol) and FeCl₃ (3.3 mg, 0.020 mmol). The resulting mixture was stirred at 80 °C for 12 h. The mixture was cooled to room temperature, and purified by silica gel column chromatography, eluting with petroleum ether, to give alkyne **7** (27.8 mg, 52%) as a white solid.¹⁰ m.p. 77-79 °C; ¹H NMR (400 MHz, CDCl₃): δ 7.43-7.35 (m, 6H), 7.29-7.20 (m, 6H), 7.19-7.13 (m, 3H), 5.14 (s, 1H); ¹³C NMR (75 MHz, CDCl₃): δ 141.8, 131.7, 128.6, 128.2, 128.0, 127.9, 126.9, 90.2, 84.9, 43.8.

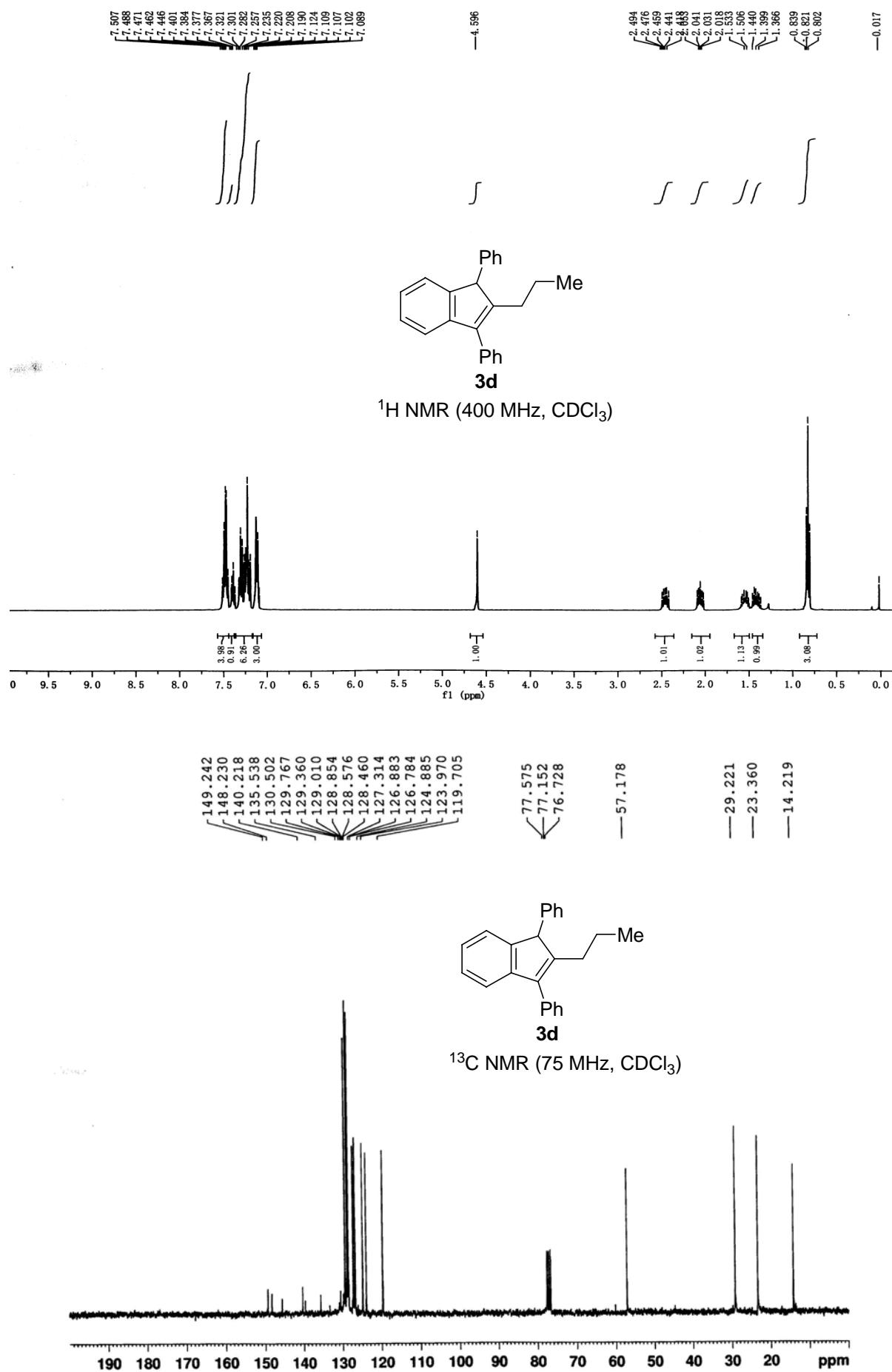
References

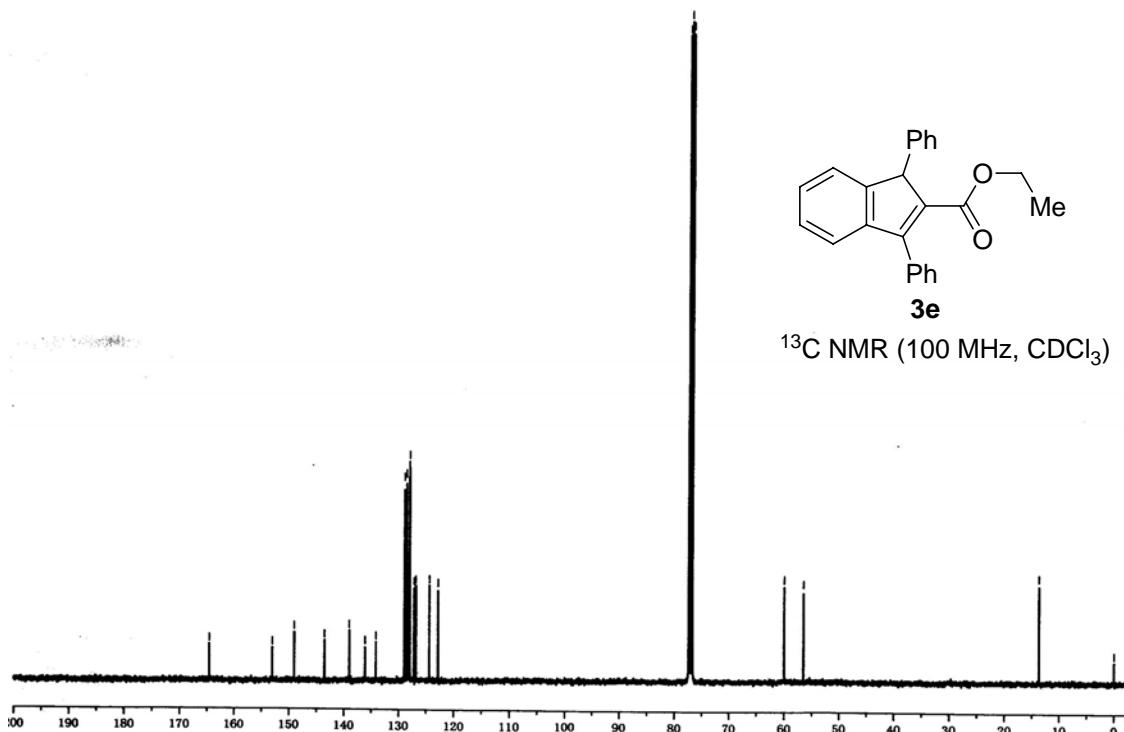
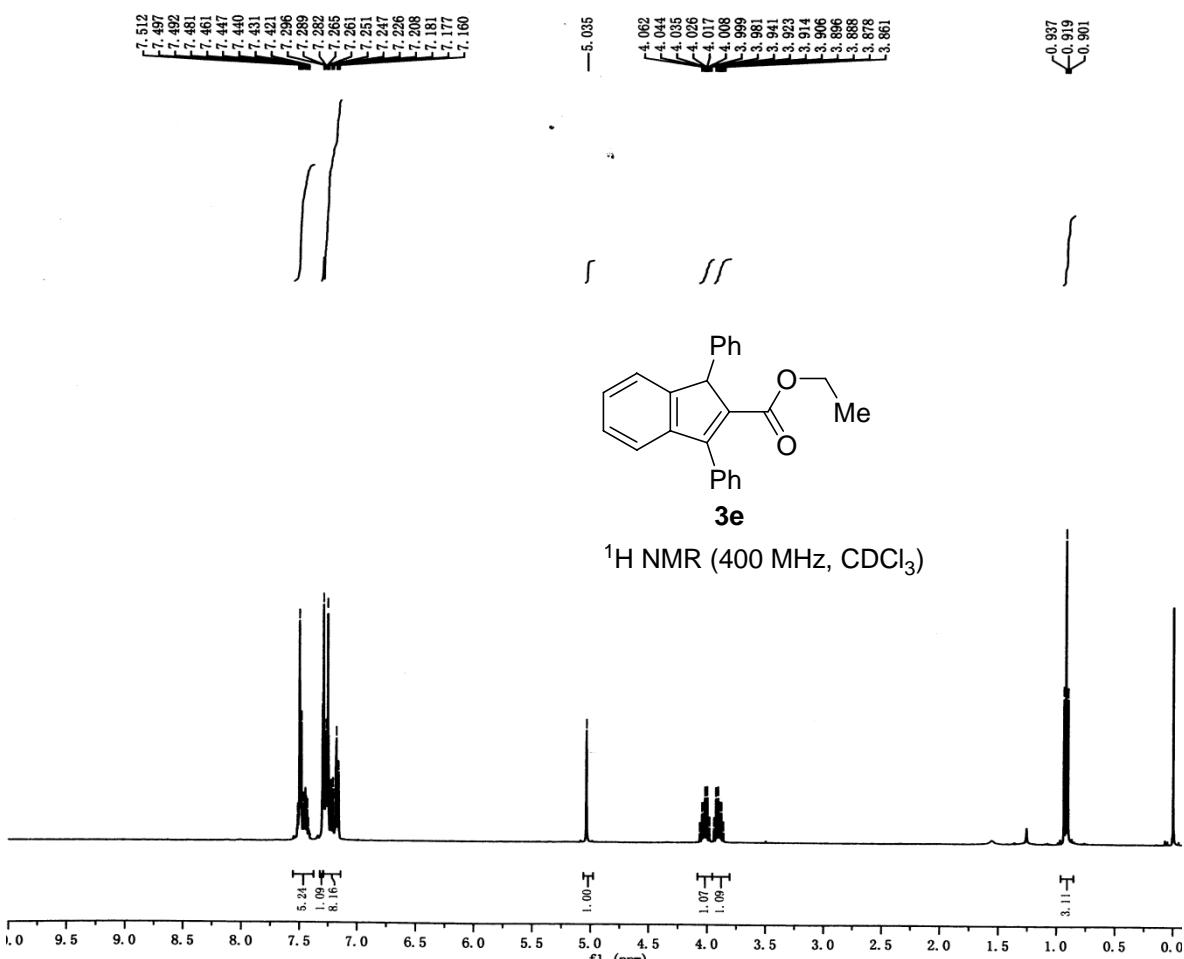
- (1) Zhan, Z.-P.; Yu, J.-L.; Liu, H.-J.; Cui, Y.-Y.; Yang, R.-F.; Yang, W.-Z.; Li, J.-P. *J. Org. Chem.* **2006**, *71*, 8298.
- (2) For the preparation of alkynes **2b-c**, see: (a) Liang, B.; Dai, M; Chen, J.; Yang, Z. *J. Org. Chem.* **2005**, *70*, 391. For the preparation of alkyne **2g**, see: (b) Waldo, J. P.; Larock, R. C. *J. Org. Chem.* **2007**, *72*, 9643. For the preparation of alkynes **2i-j**, see: (c) Bieber, L. W.; da Silva, M. F.; Menezes, P. H. *Tetrahedron Lett.* **2004**, *45*, 2735. For the preparation of alkynes **2k-n**, see: (d) Li, L.-S.; Wu, Y.-L. *Tetrahedron Lett.* **2002**, *43*, 2427.
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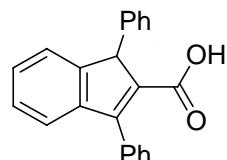
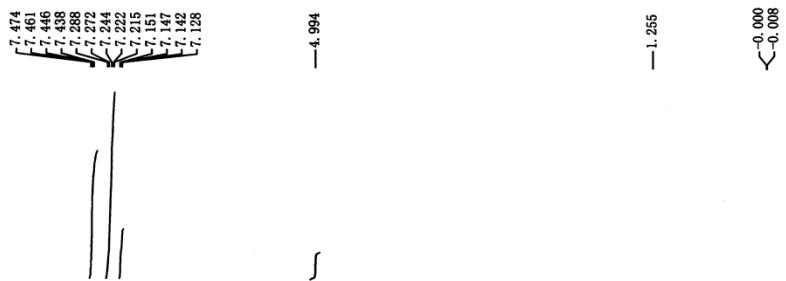




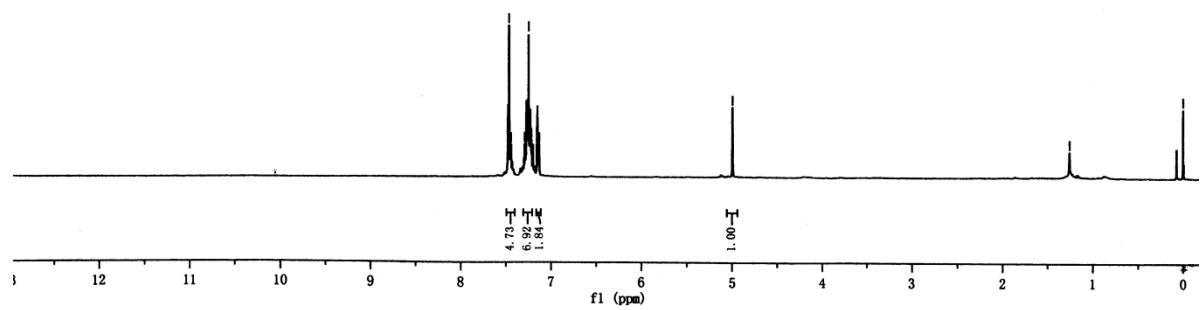






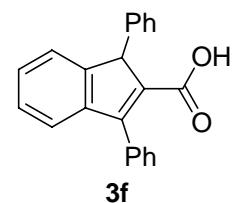


¹H NMR (400 MHz, CDCl₃)

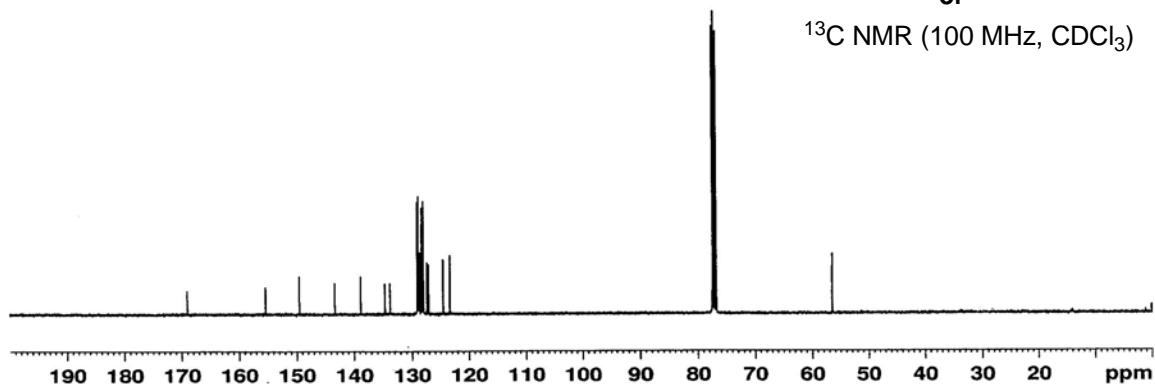


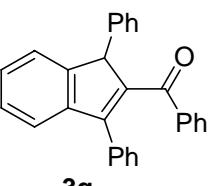
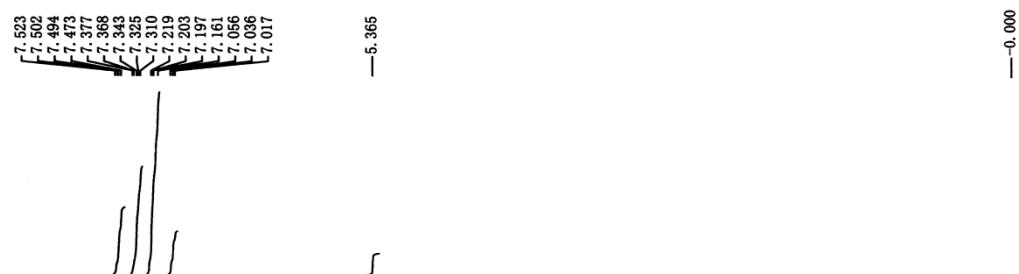
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76.826

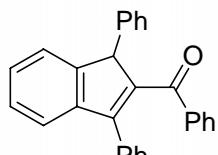
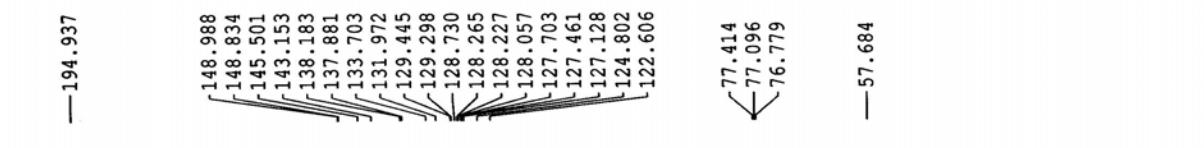
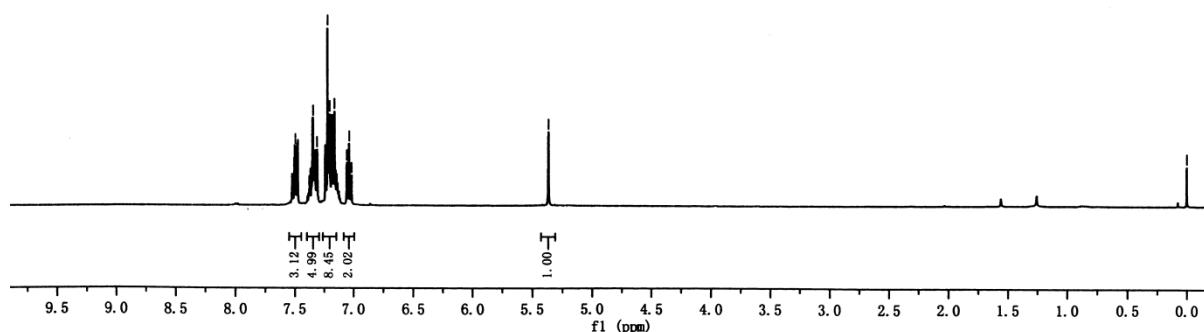


¹³C NMR (100 MHz, CDCl₃)

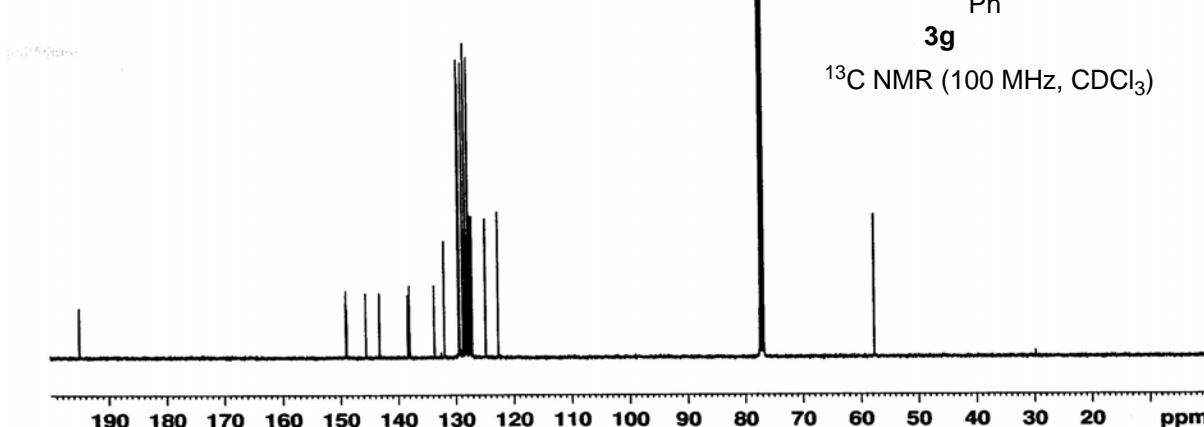


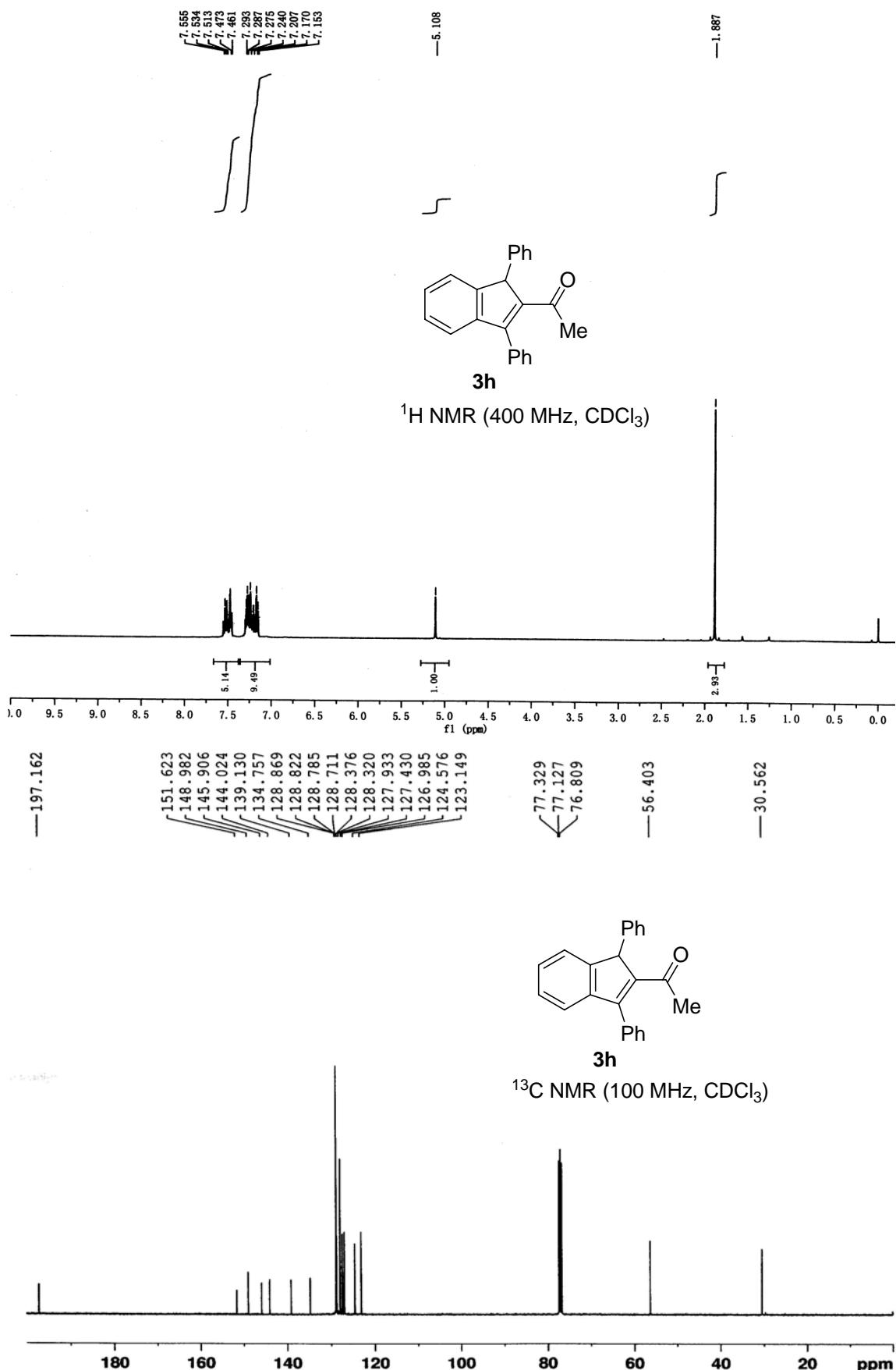


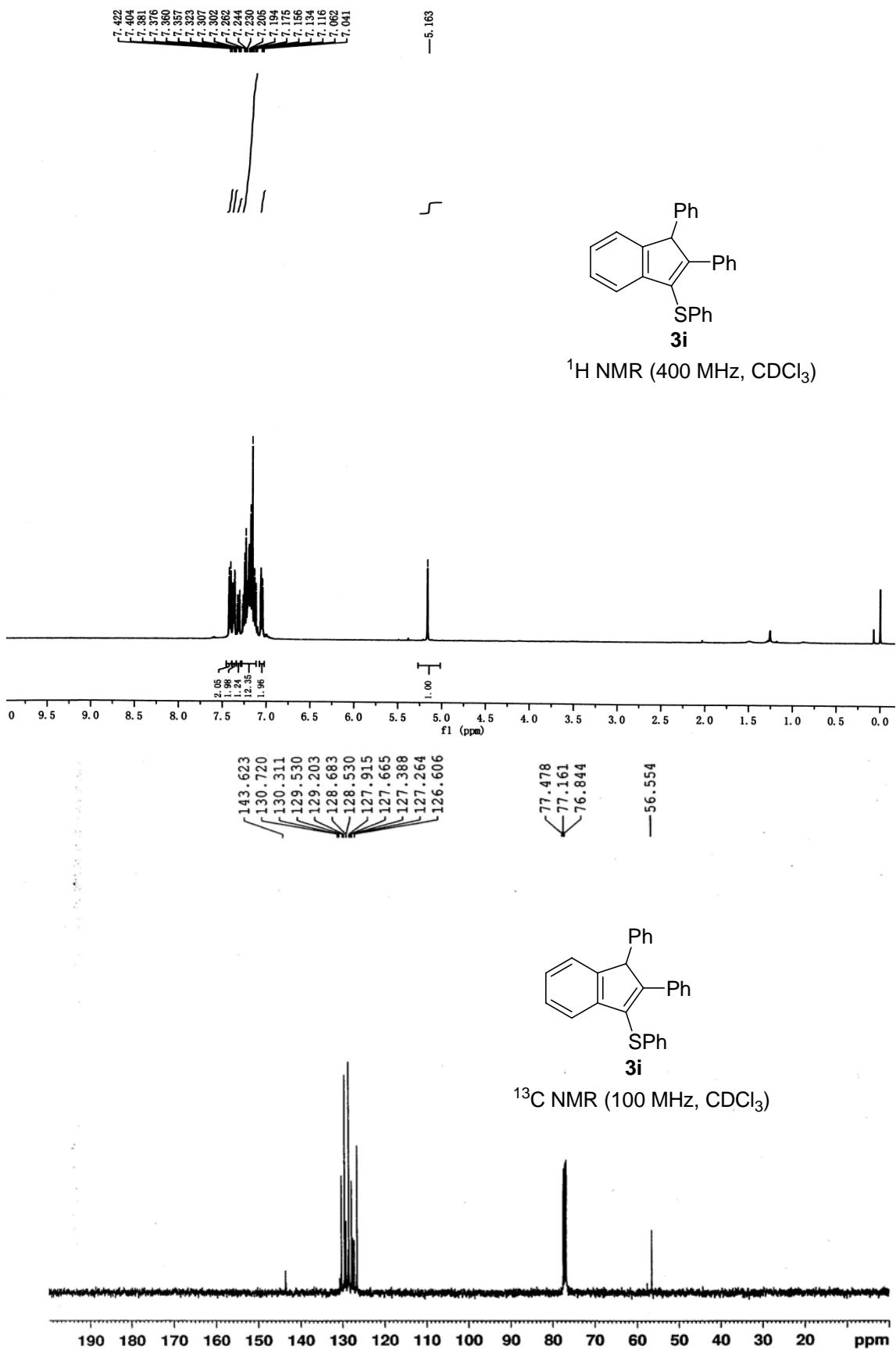
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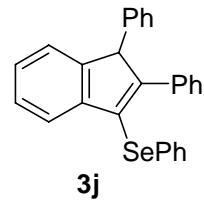
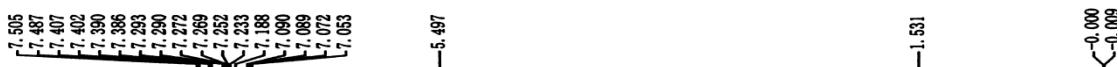


¹³C NMR (100 MHz, CDCl₃)

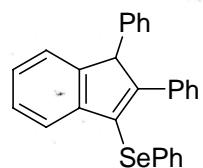
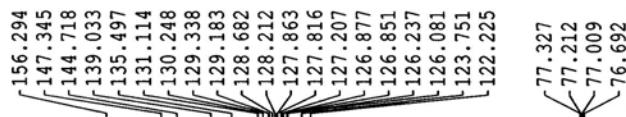
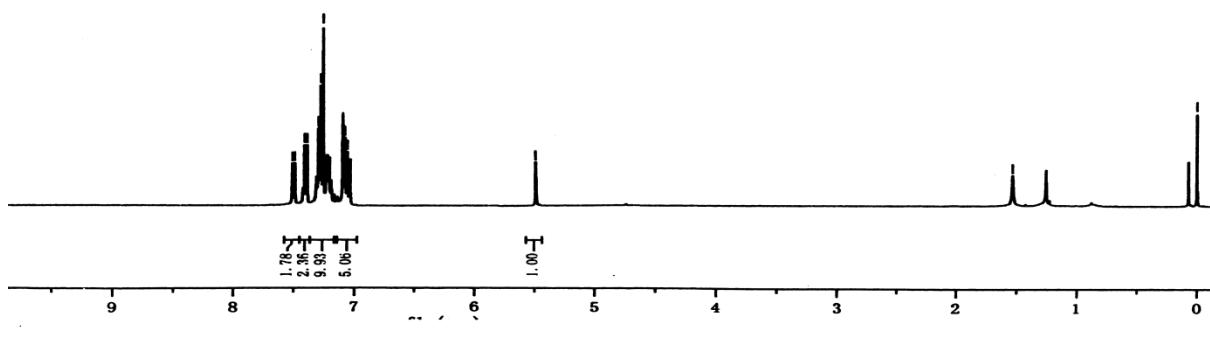




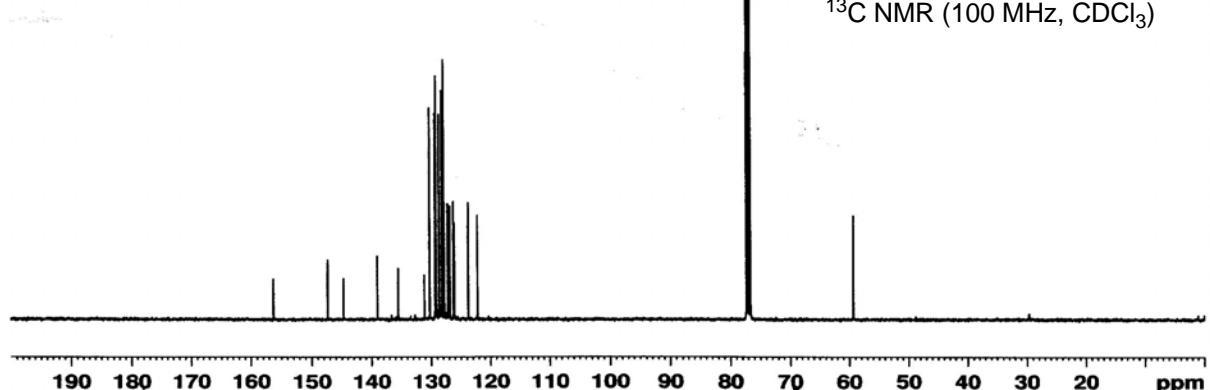


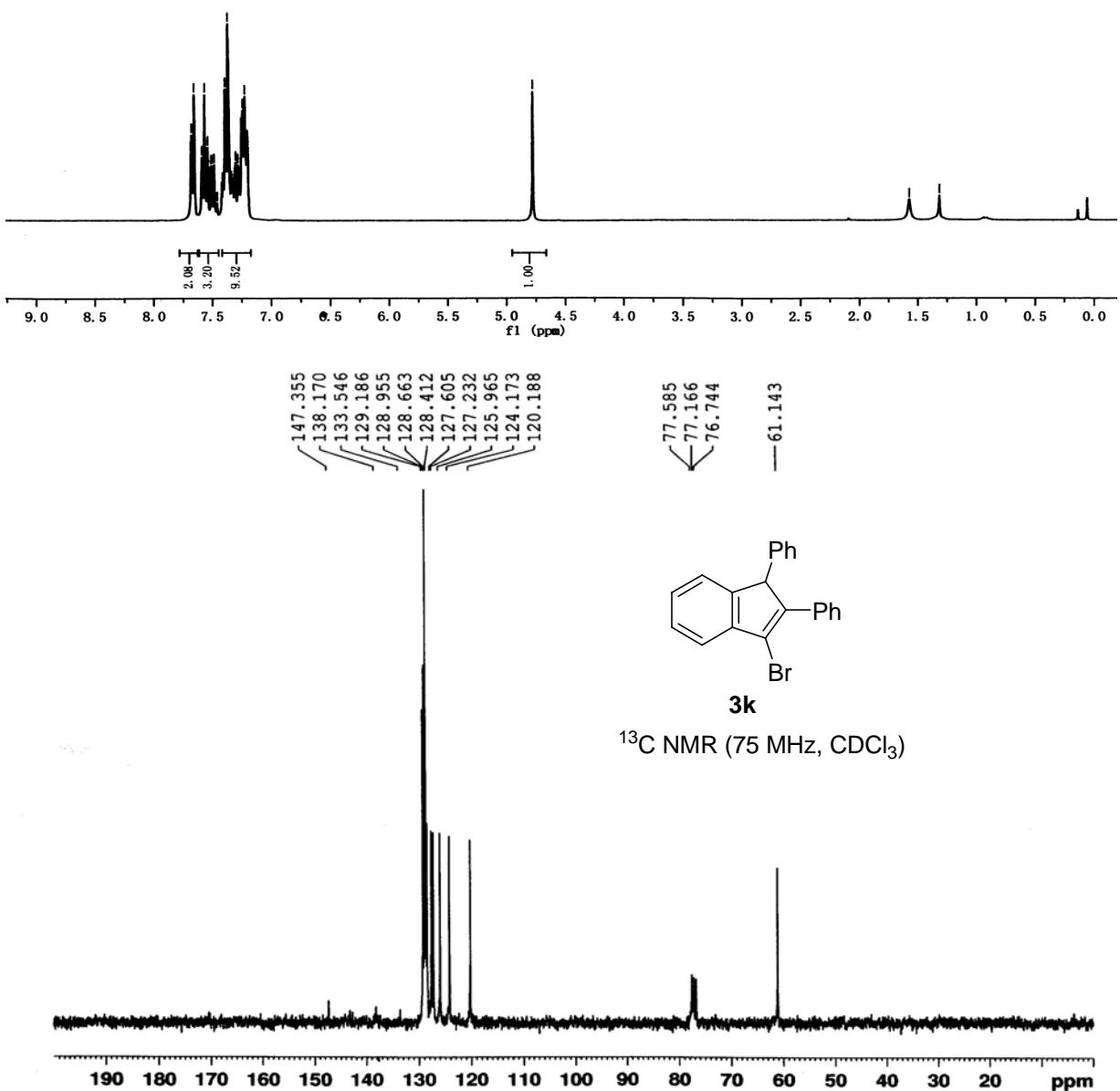
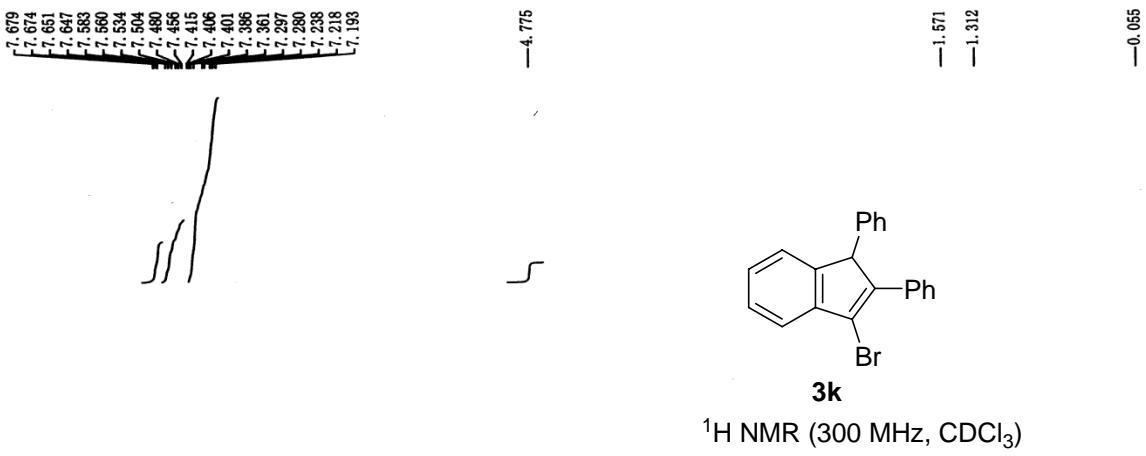


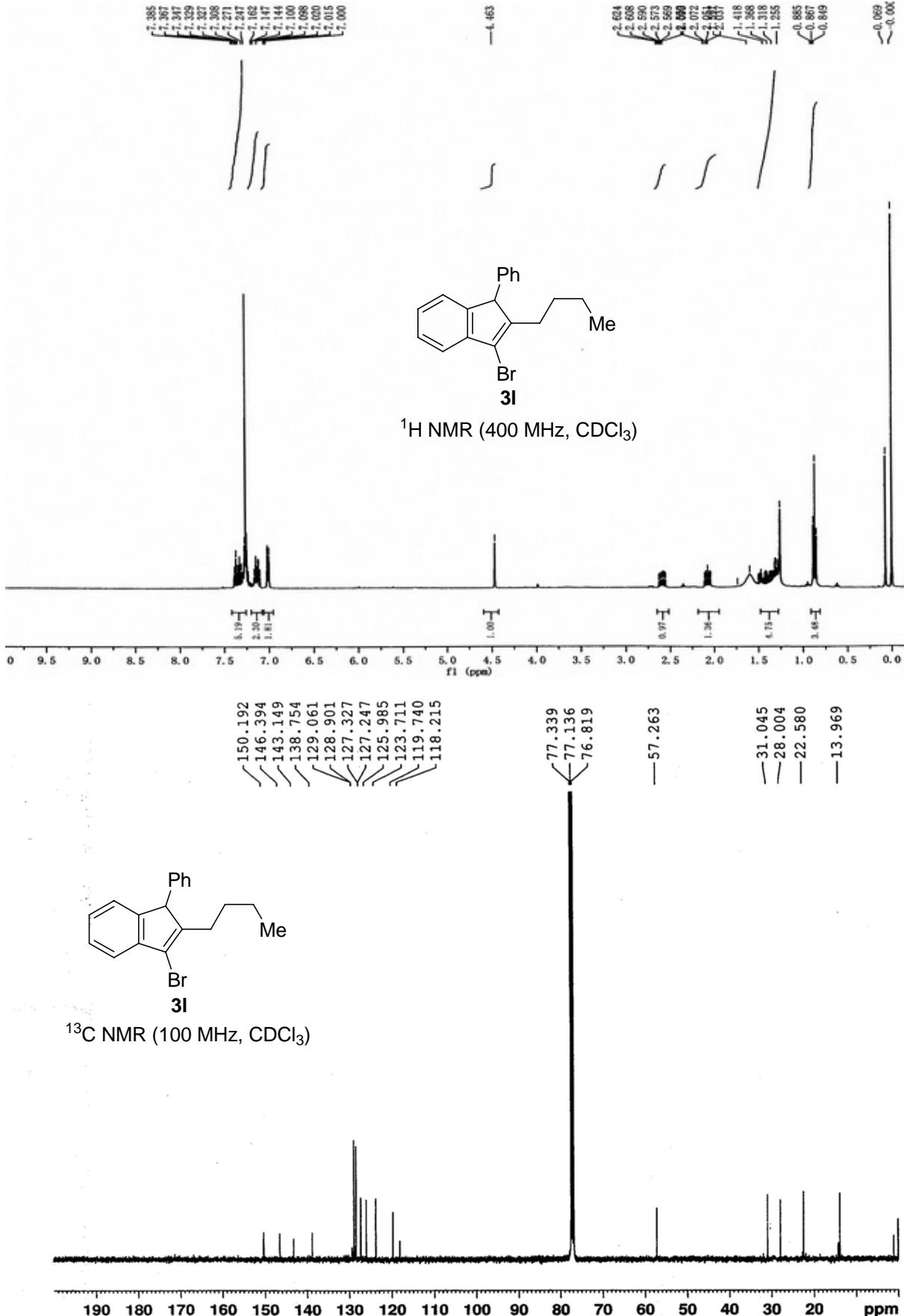
¹H NMR (400 MHz, CDCl₃)

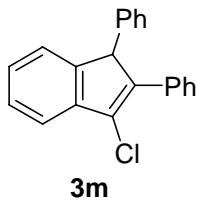


¹³C NMR (100 MHz, CDCl₃)

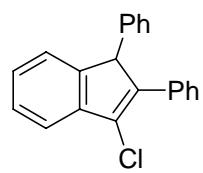
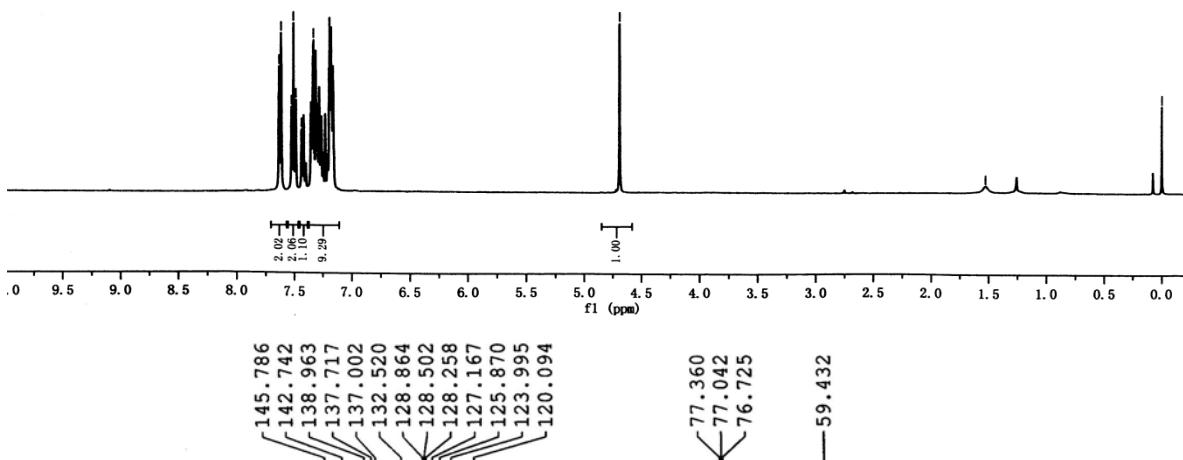




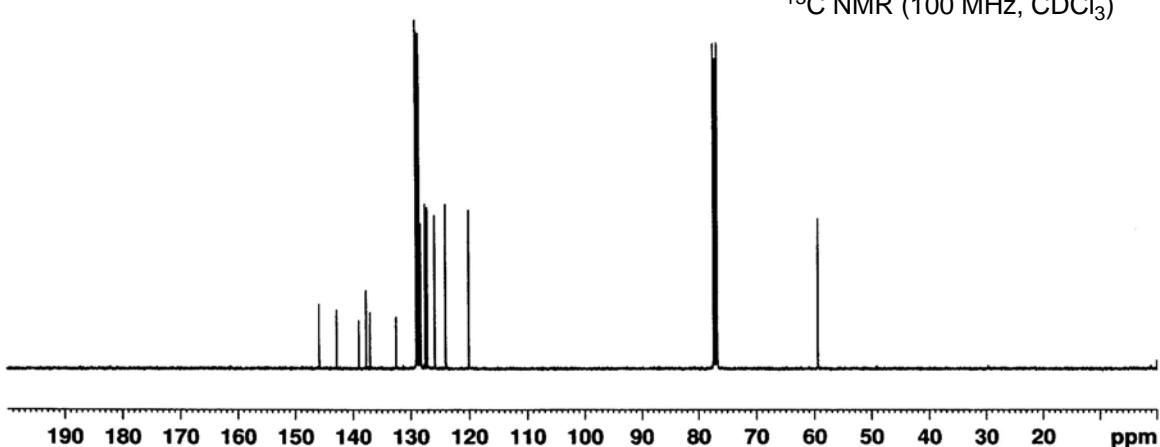




¹H NMR (400 MHz, CDCl₃)

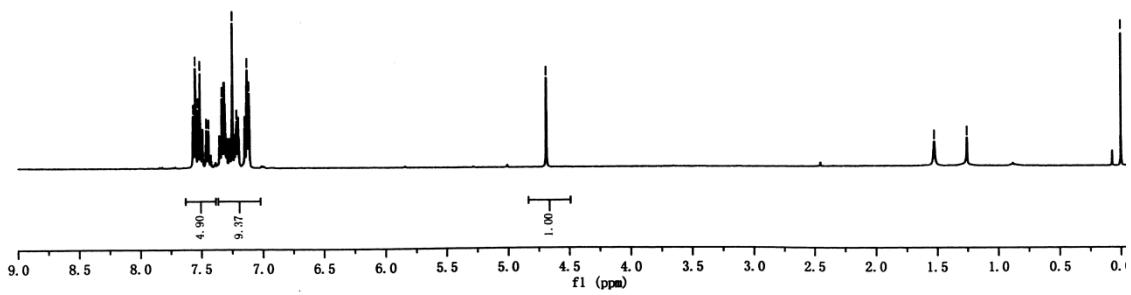


¹³C NMR (100 MHz, CDCl₃)



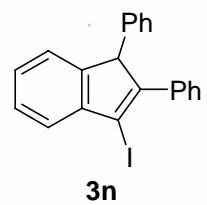


¹H NMR (400 MHz, CDCl₃)

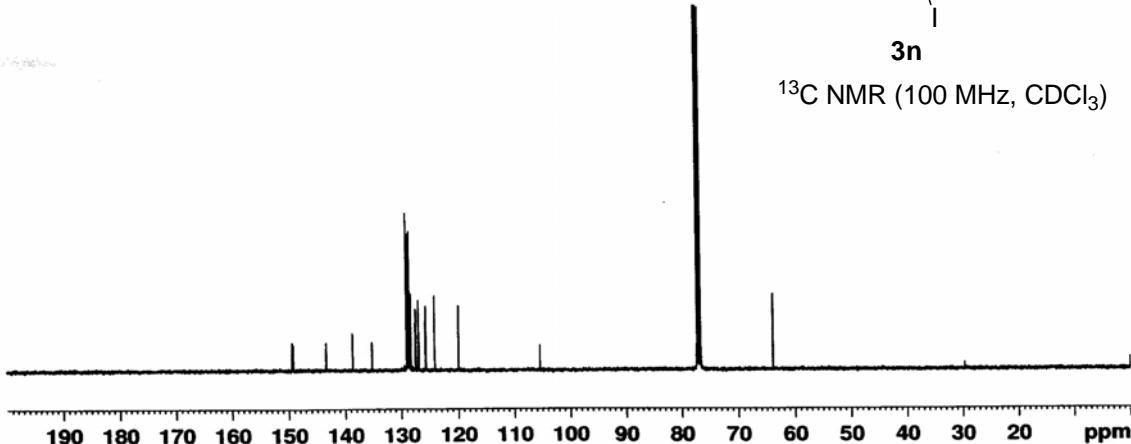


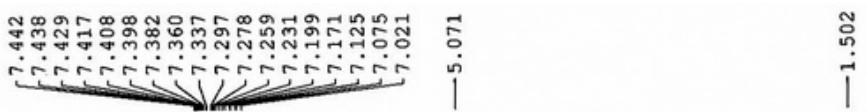
149.427
149.242
143.386
138.655
135.191
129.053
128.802
128.667
128.526
128.294
127.438
126.932
125.715
124.152
119.966
105.409

77.213
77.009
76.692
63.891

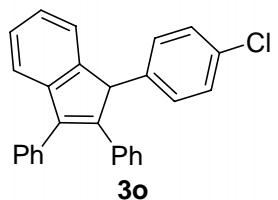
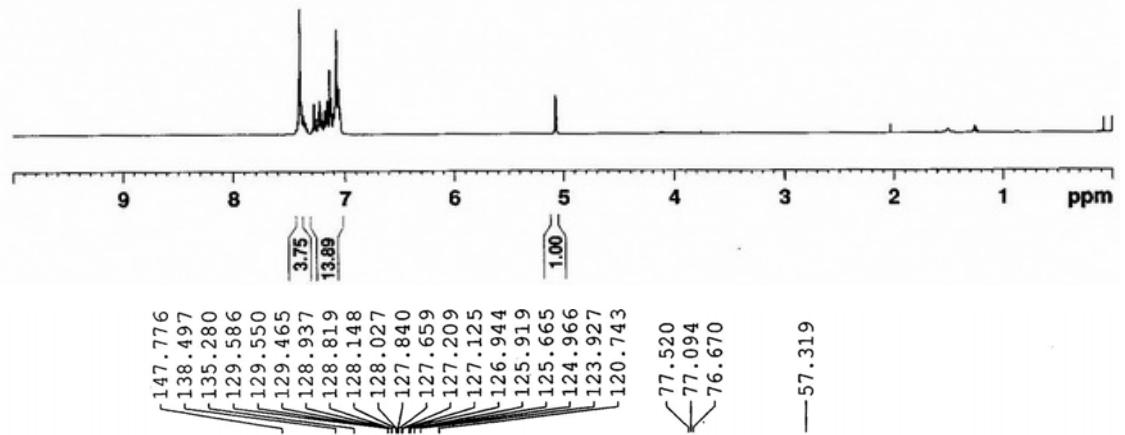


¹³C NMR (100 MHz, CDCl₃)

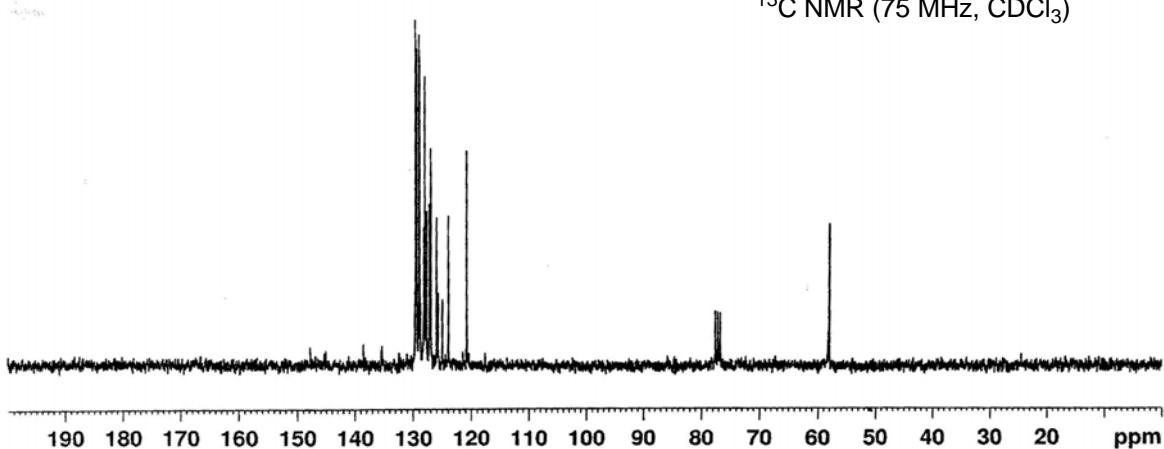


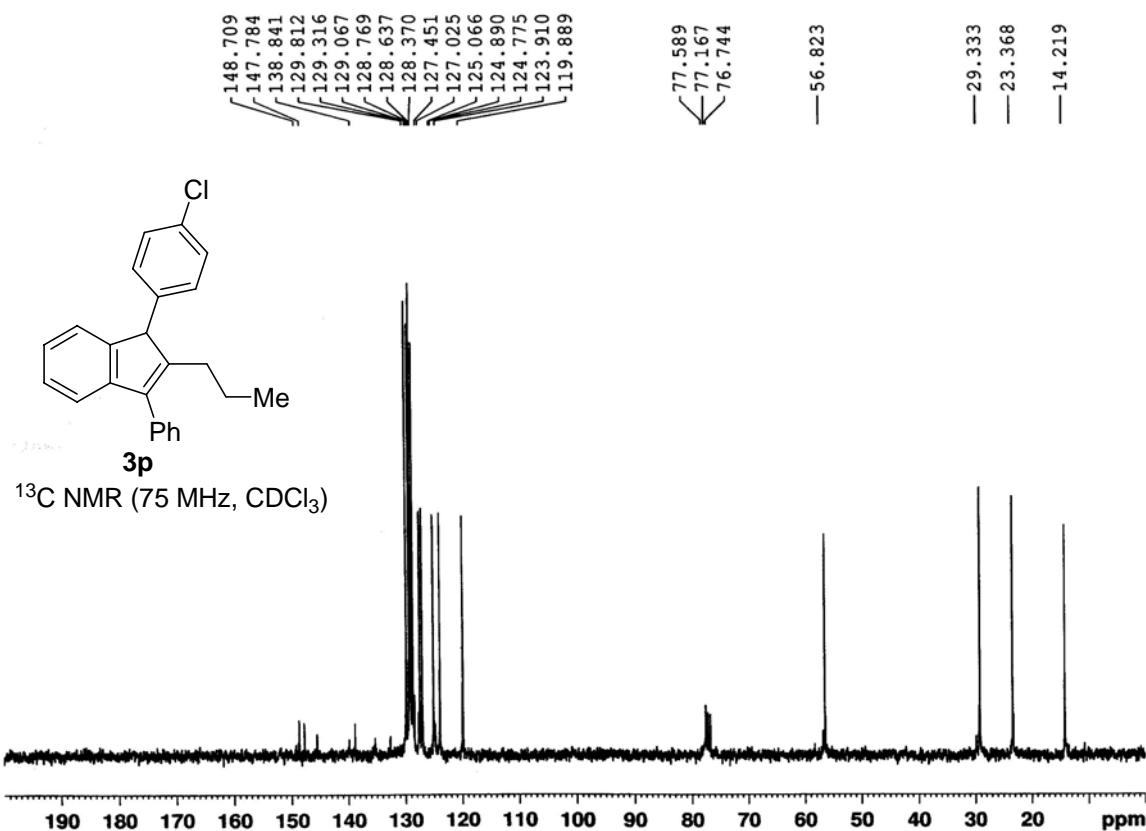
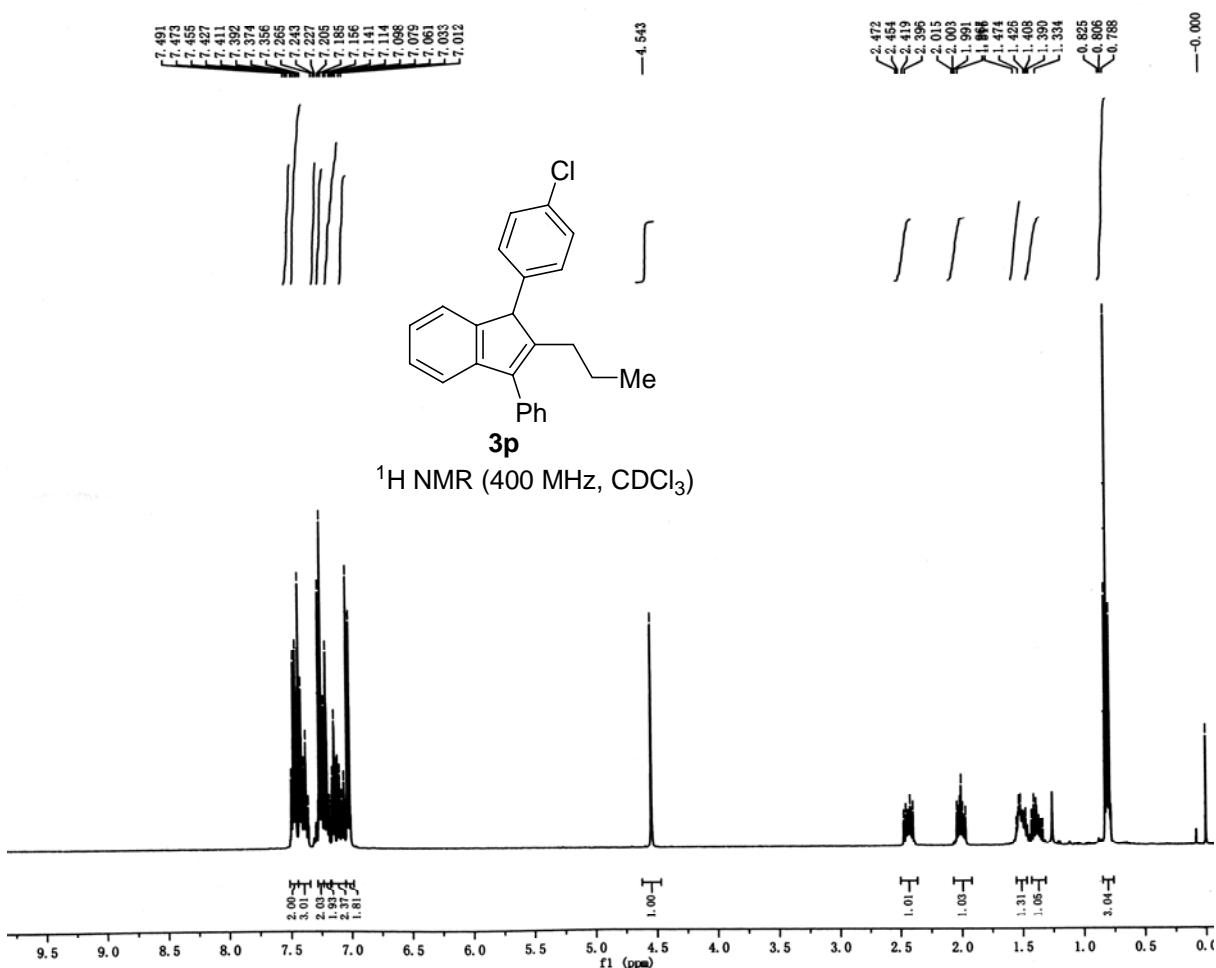


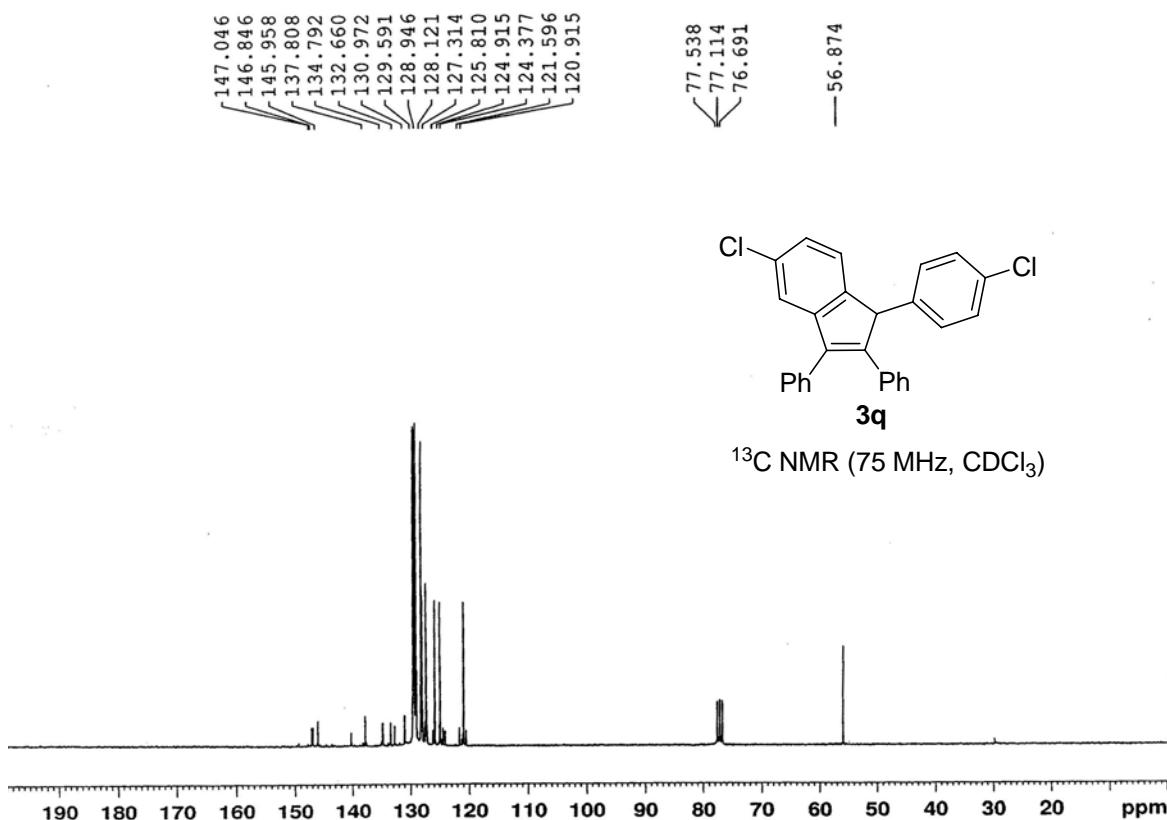
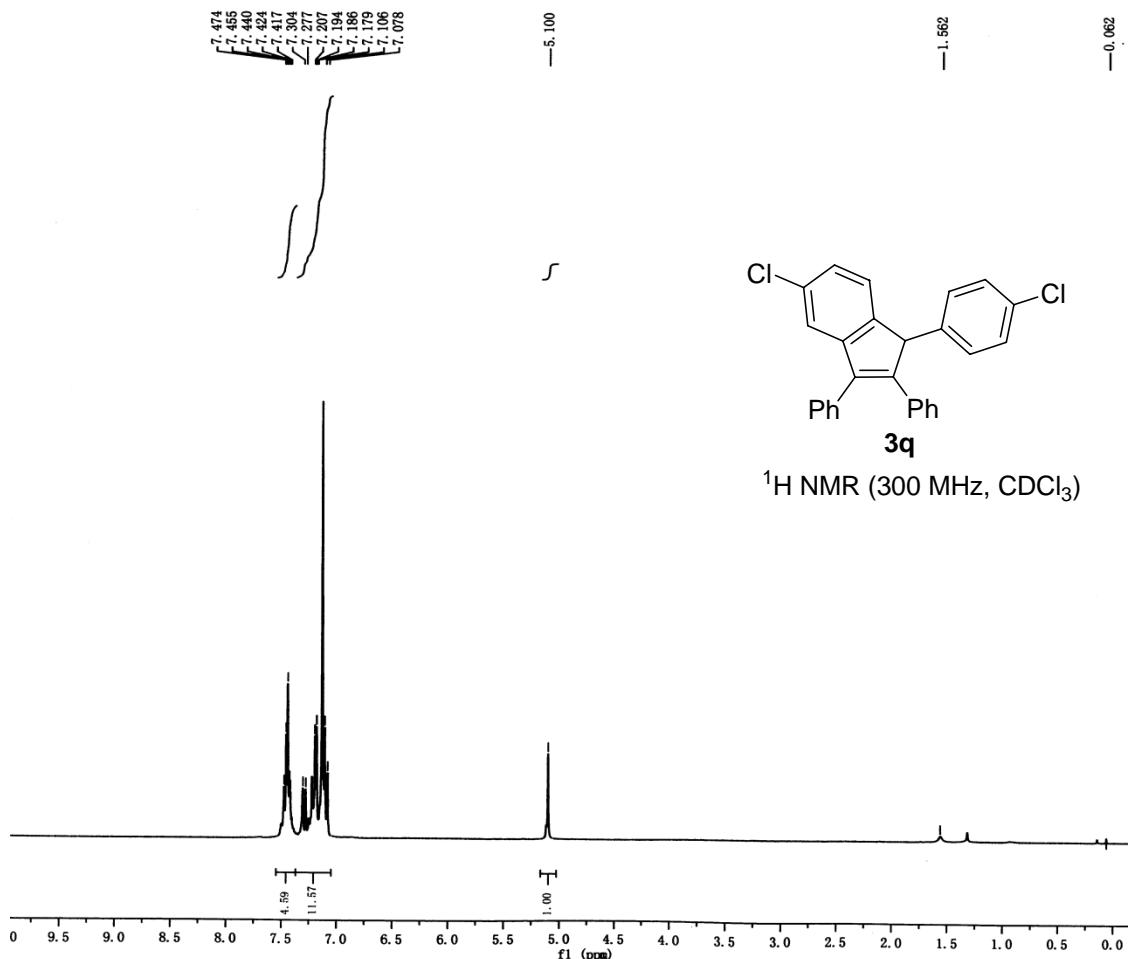
¹H NMR (400 MHz, CDCl₃)



¹³C NMR (75 MHz, CDCl₃)



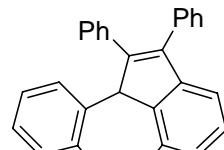




7.477
 7.468
 7.424
 7.420
 7.316
 7.293
 7.270
 7.191
 7.175
 7.167
 7.123
 7.099
 6.992
 6.970
 6.912
 6.887
 6.759
 6.734

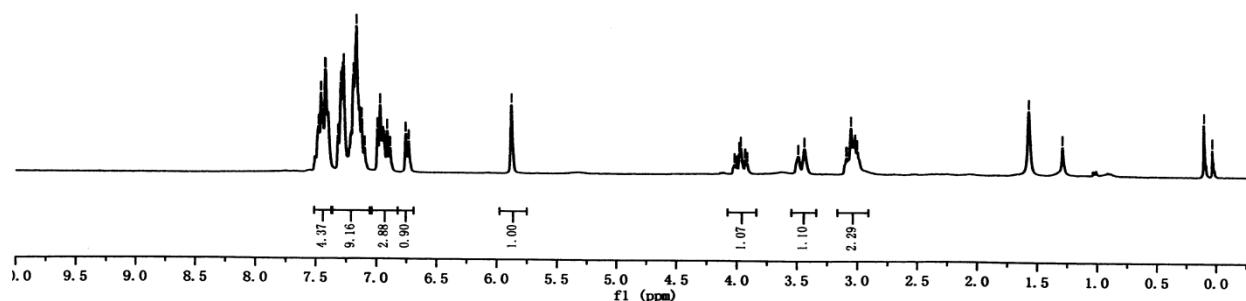
4.022
 4.004
 3.982
 3.968
 3.933
 3.917
 3.489
 3.439
 3.091
 3.055
 3.020
 3.003

-1.576
 -1.293
 -0.111
 -0.038



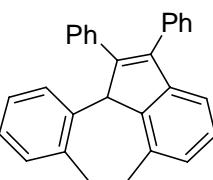
3r

¹H NMR (300 MHz, CDCl₃)



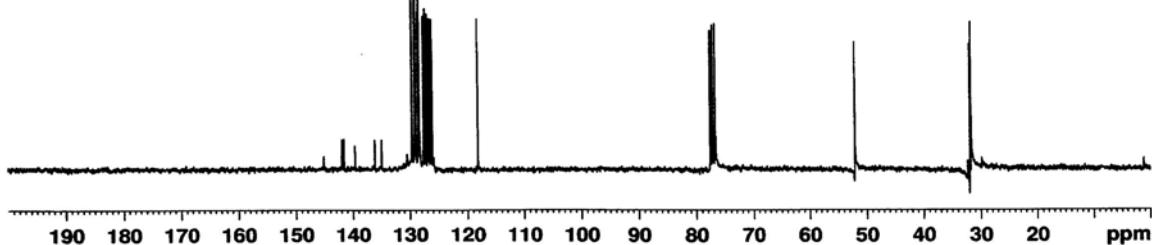
145.124
 141.906
 141.561
 139.616
 136.149
 134.523
 130.476
 129.604
 128.345
 127.624
 127.308
 127.242
 126.902
 126.741
 126.424
 126.134
 118.182

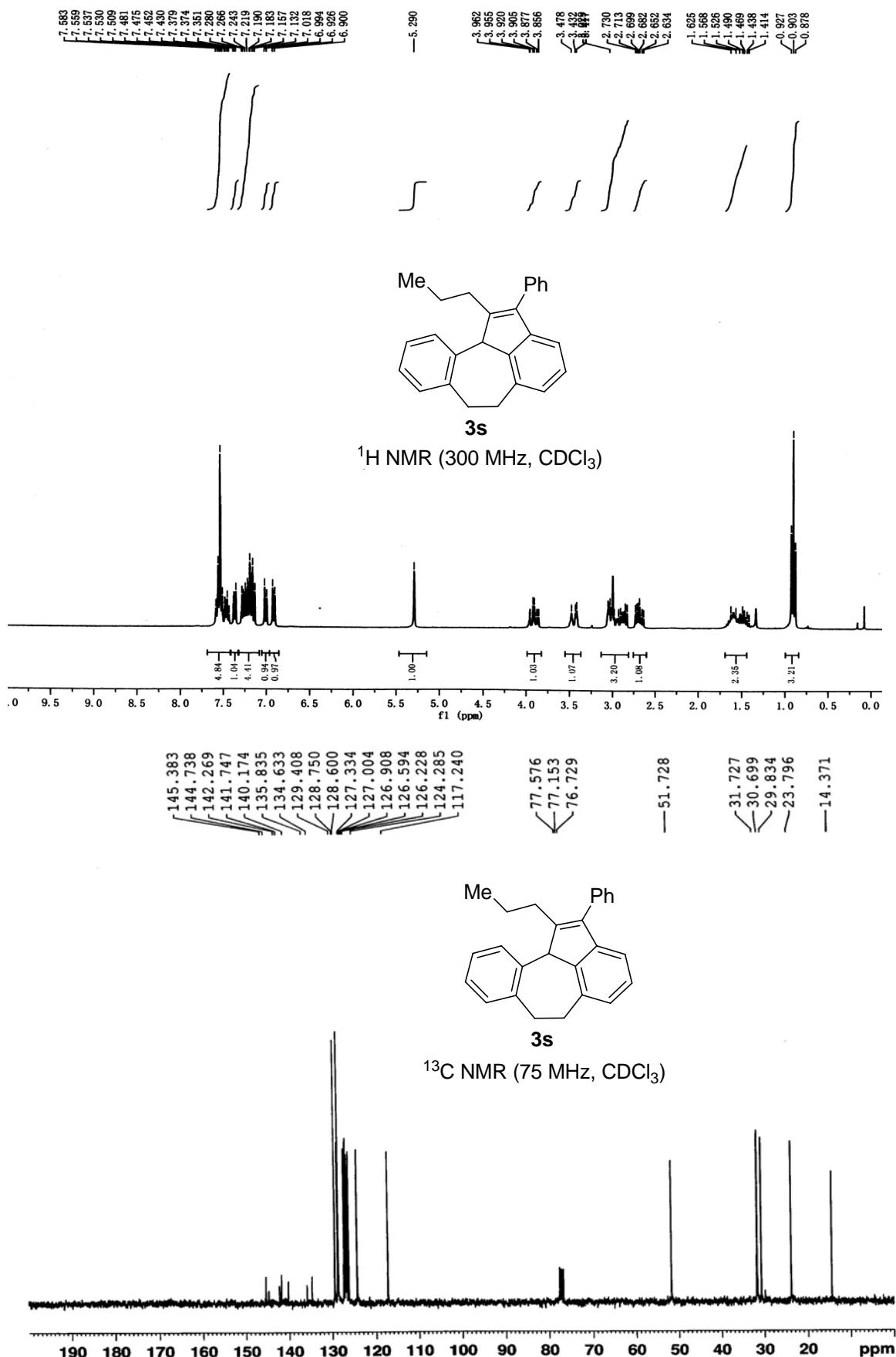
77.579
 77.156
 76.733
 -52.079

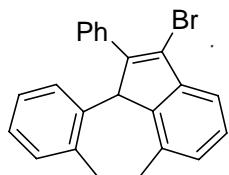
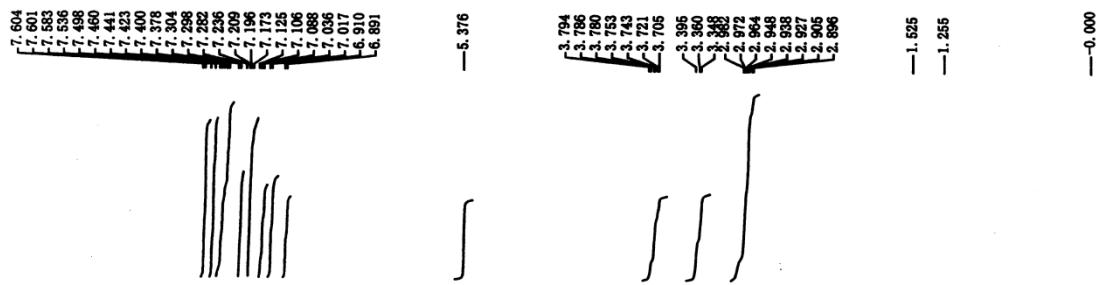


3r

¹³C NMR (75 MHz, CDCl₃)

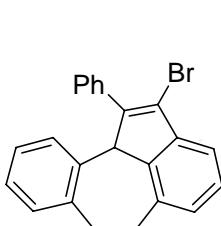
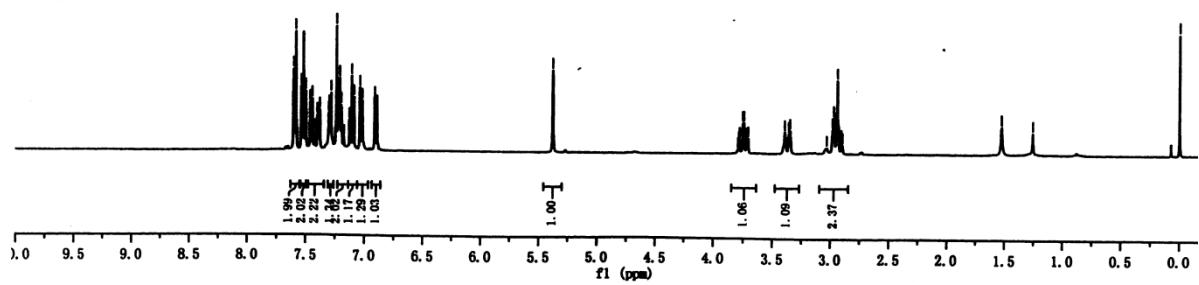






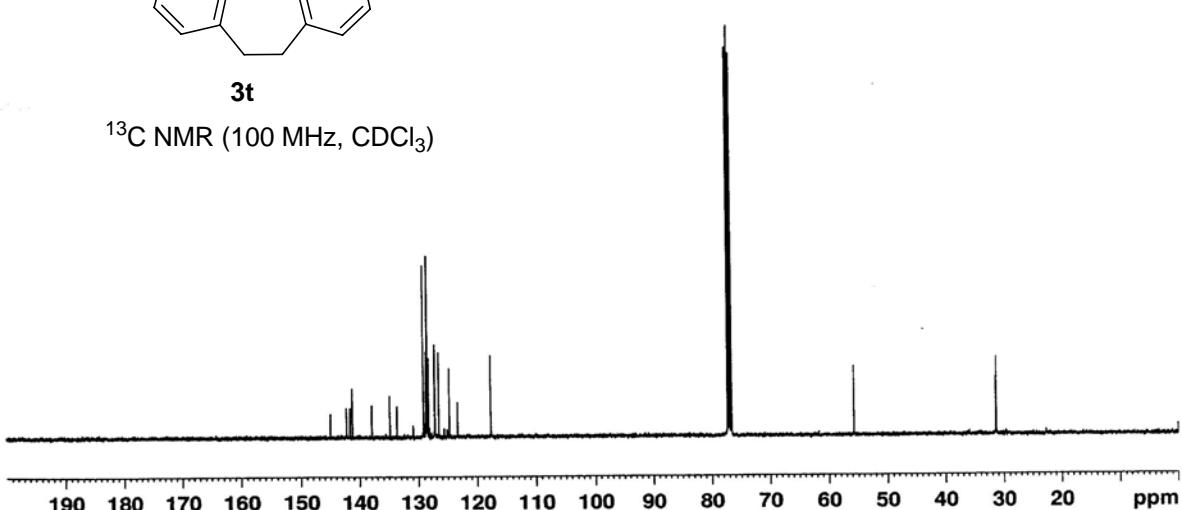
3t

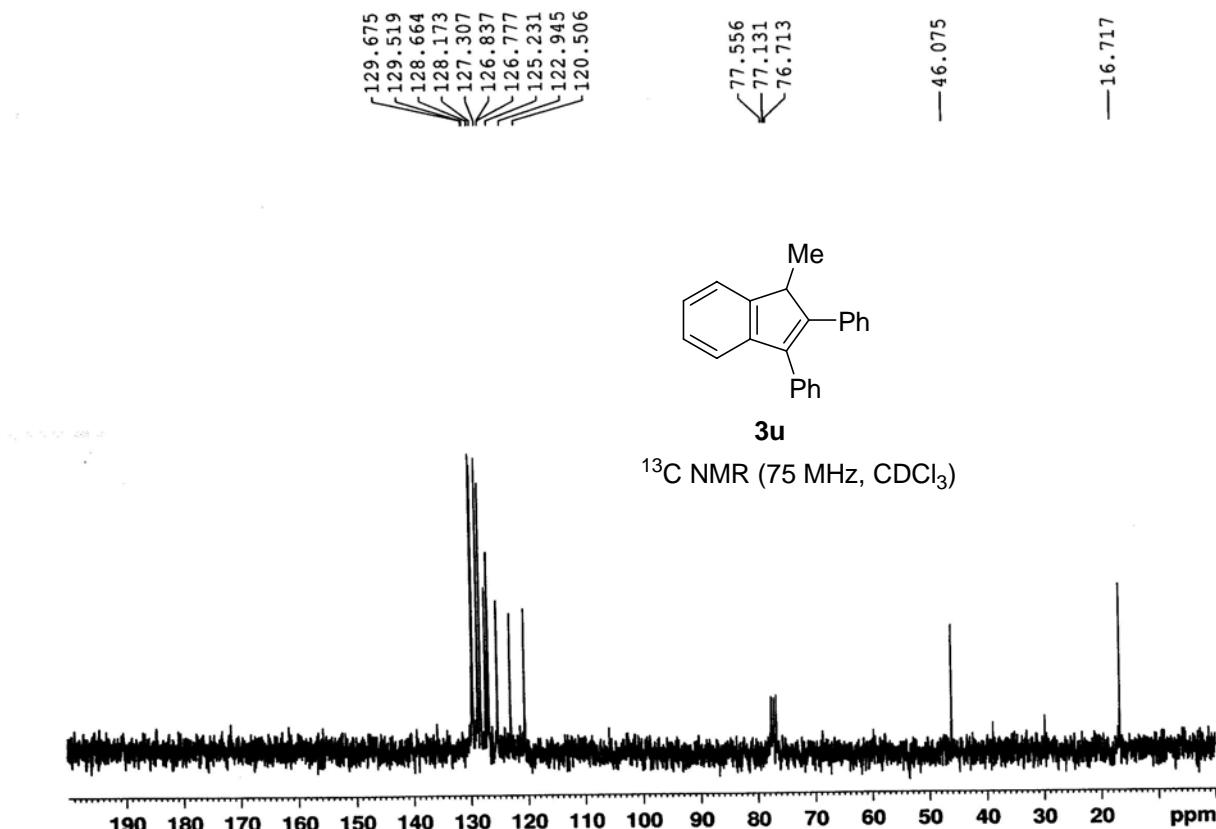
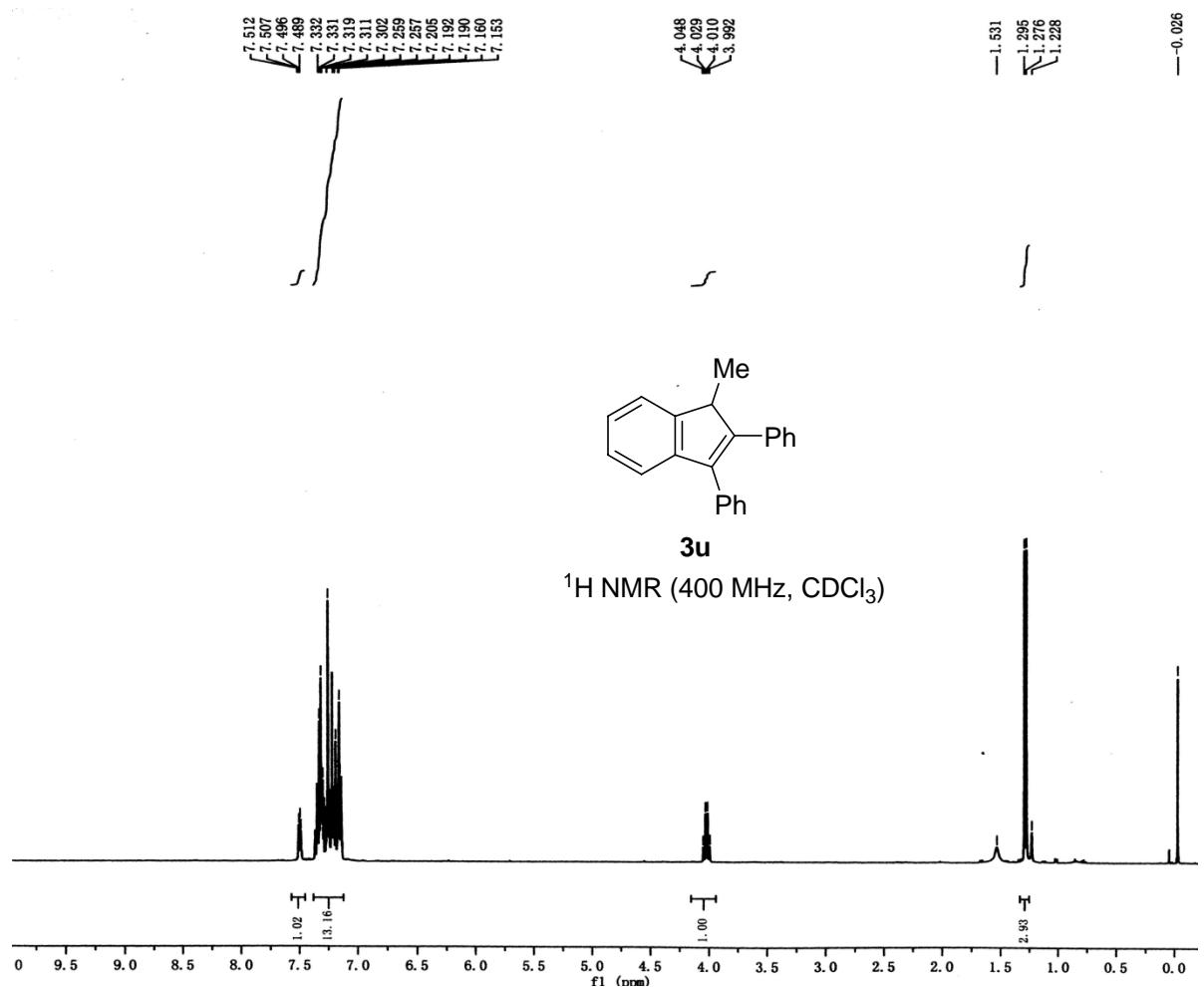
¹H NMR (400 MHz, CDCl₃)

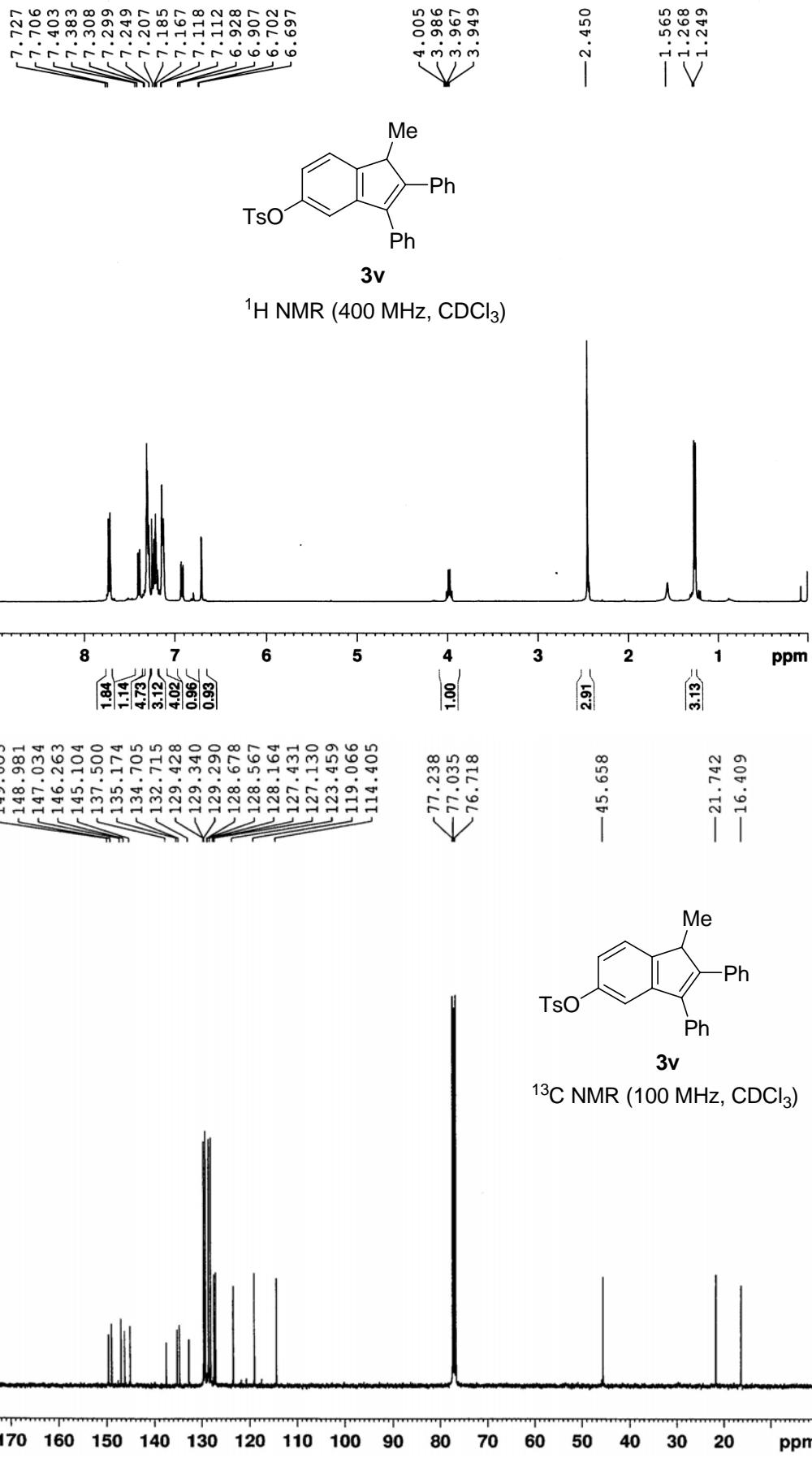


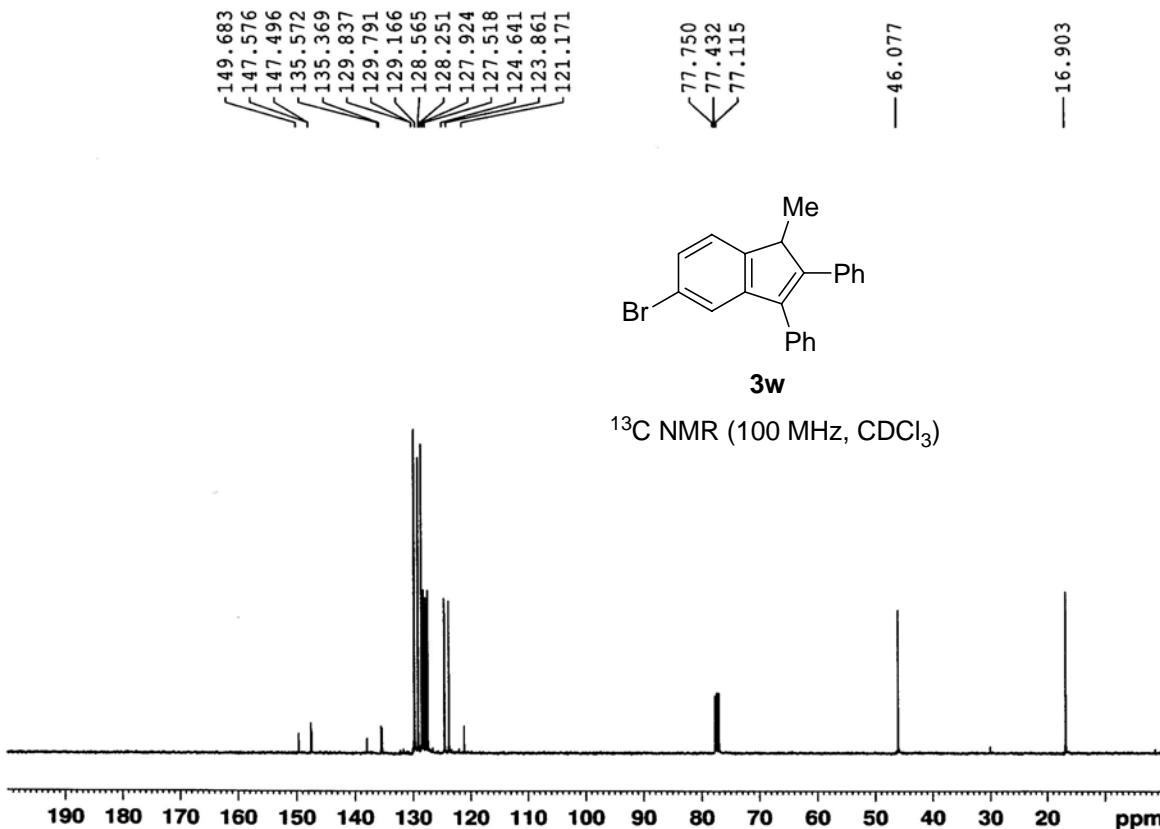
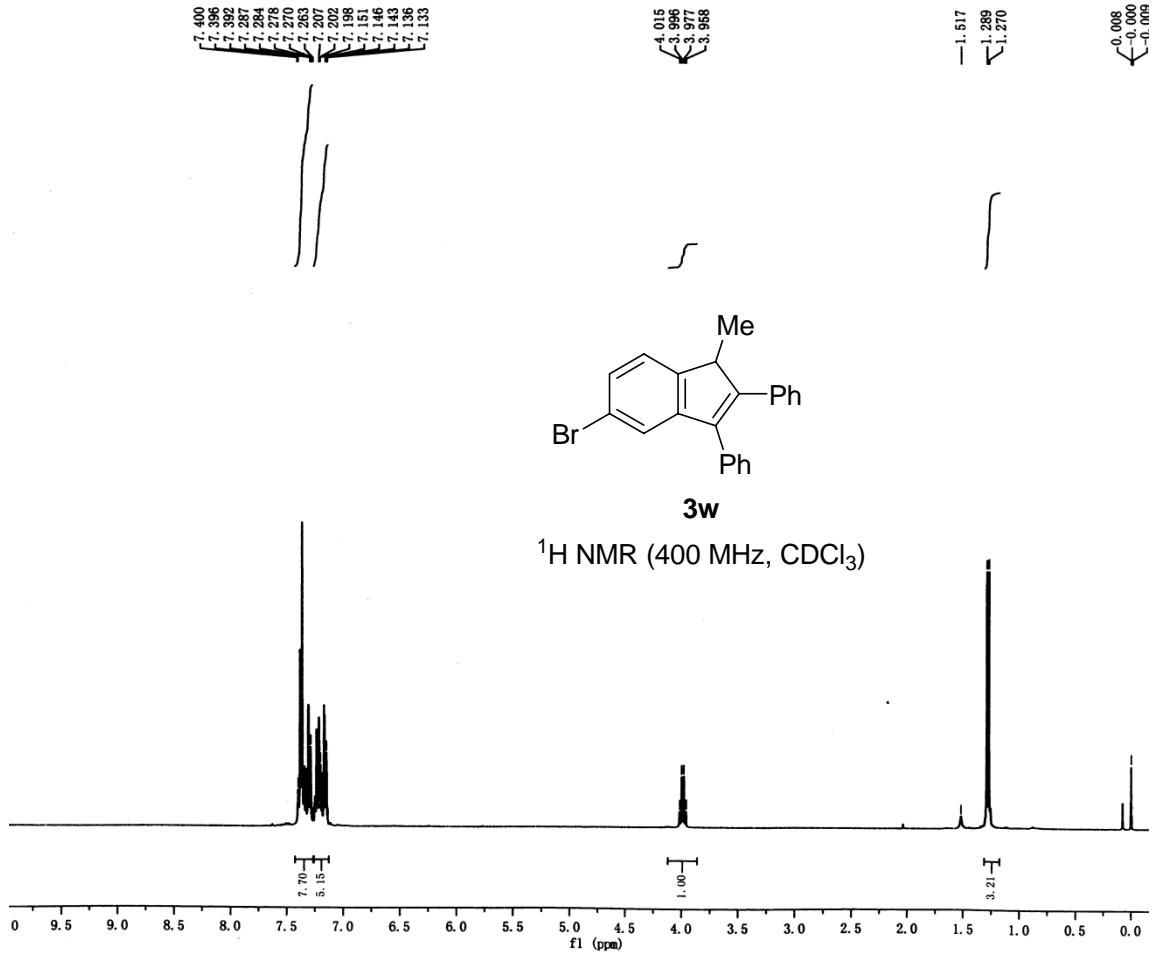
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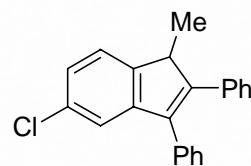
¹³C NMR (100 MHz, CDCl₃)



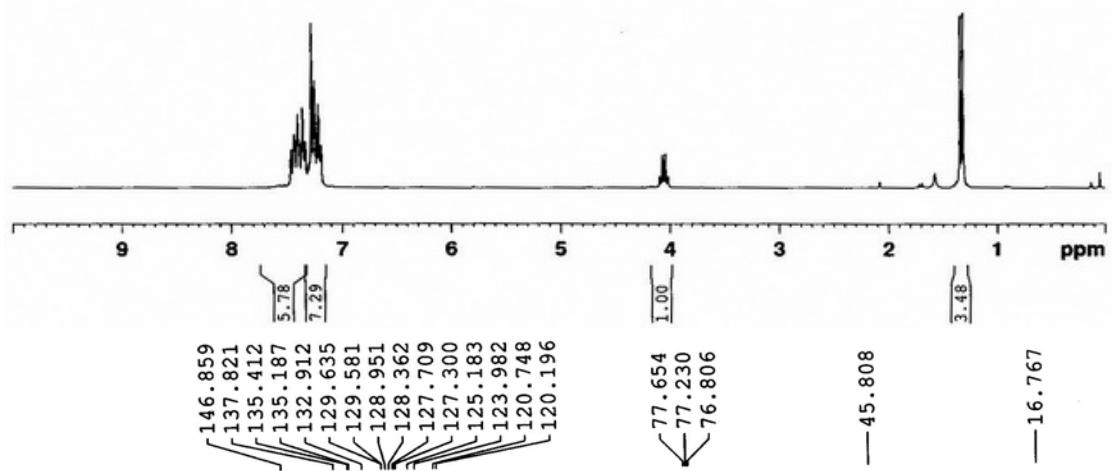




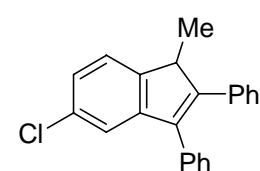




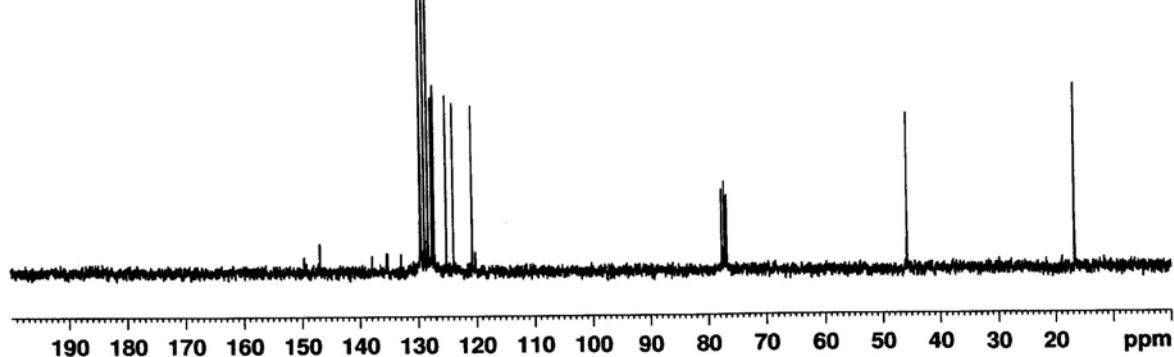
¹H NMR (300 MHz, CDCl₃)

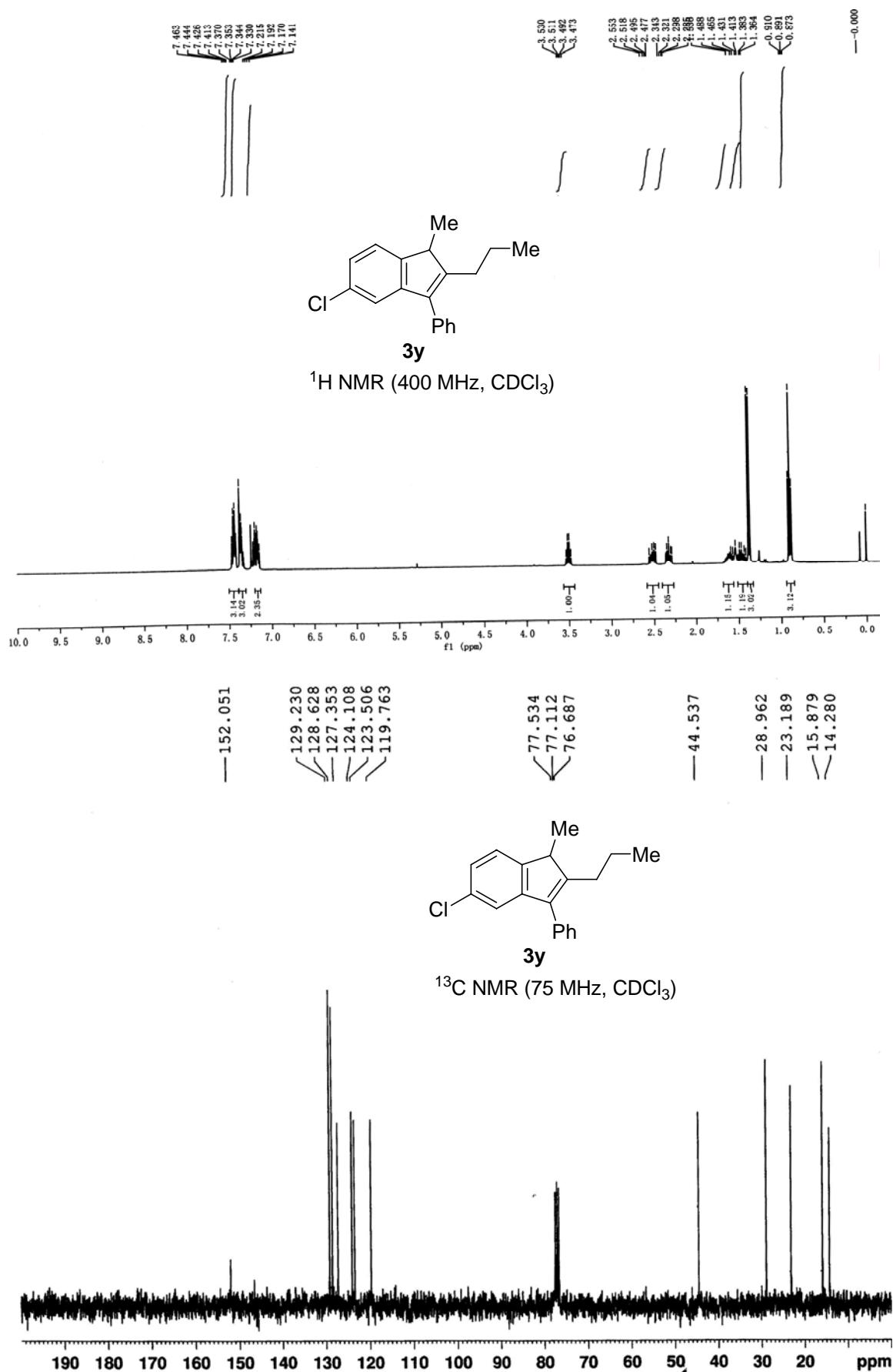


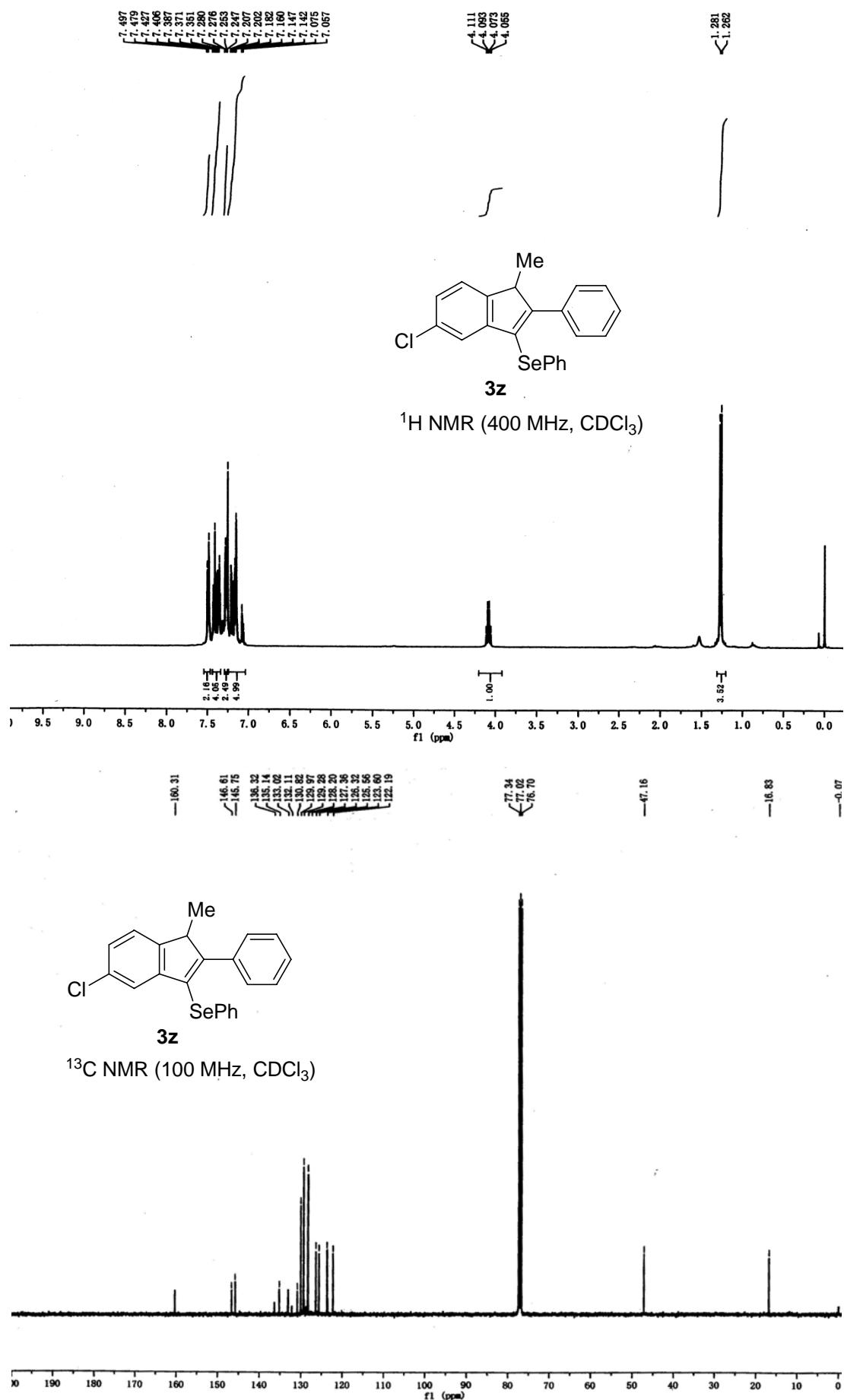
146.859
137.821
135.412
135.187
132.912
129.635
129.581
128.951
128.362
127.709
127.300
125.183
123.982
120.748
120.196

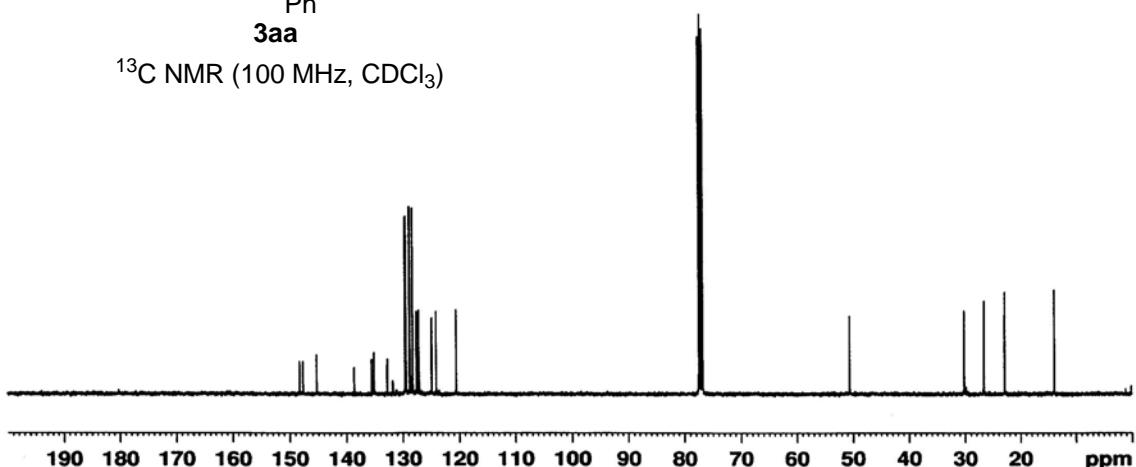
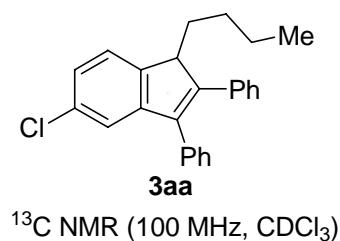
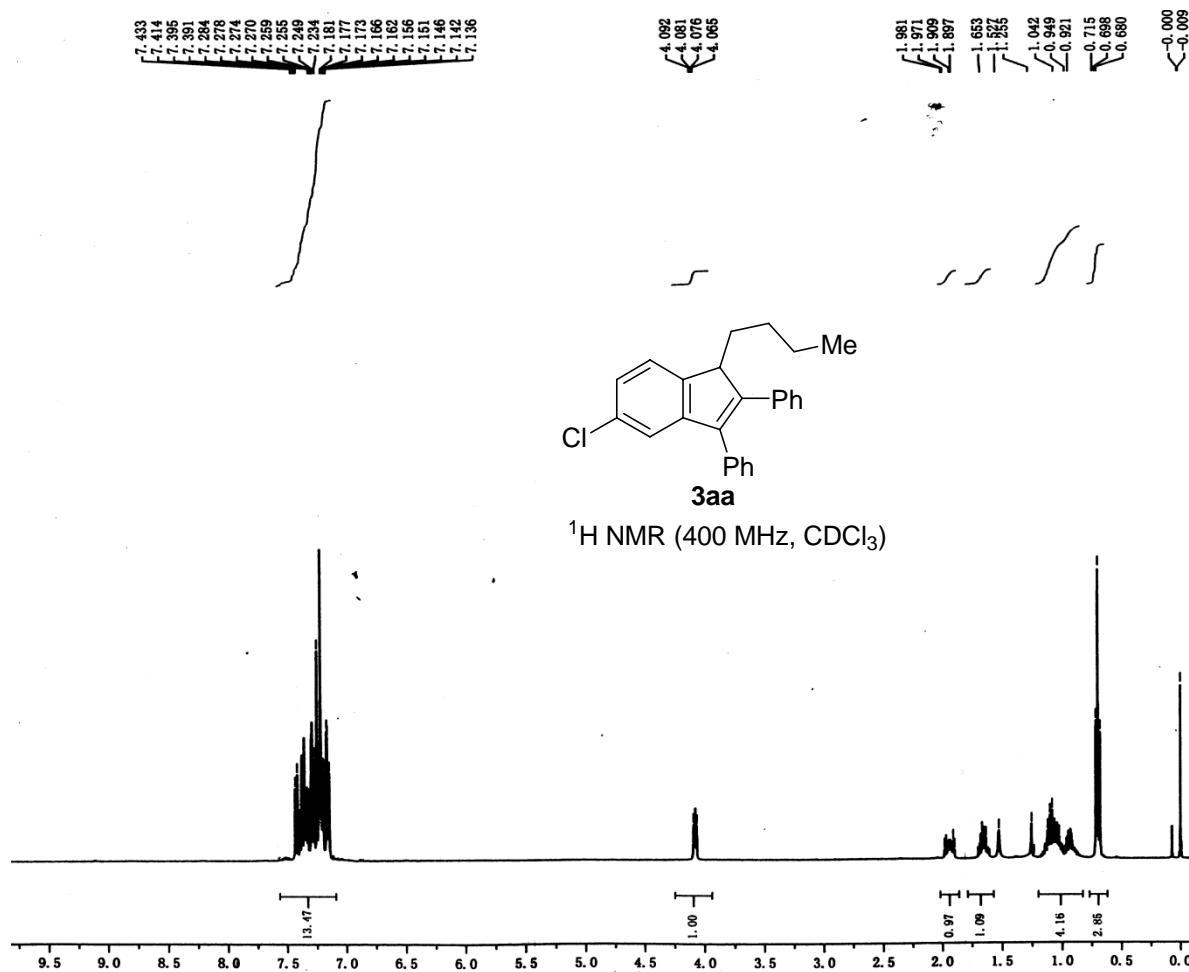


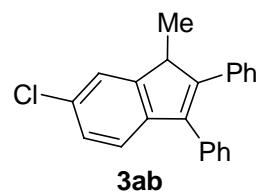
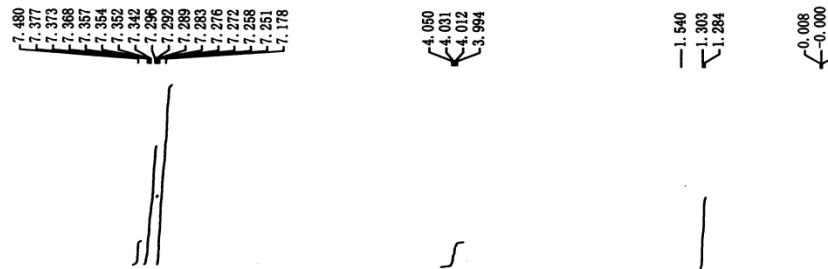
¹³C NMR (75 MHz, CDCl₃)



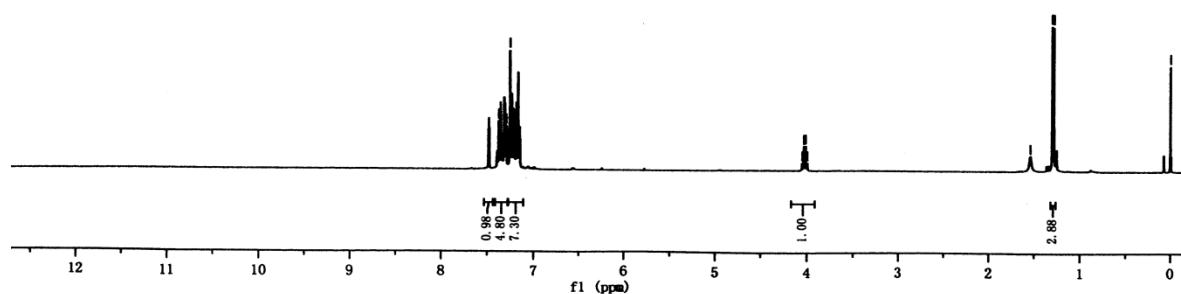




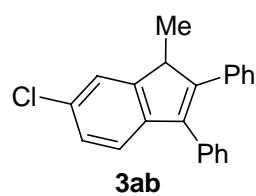




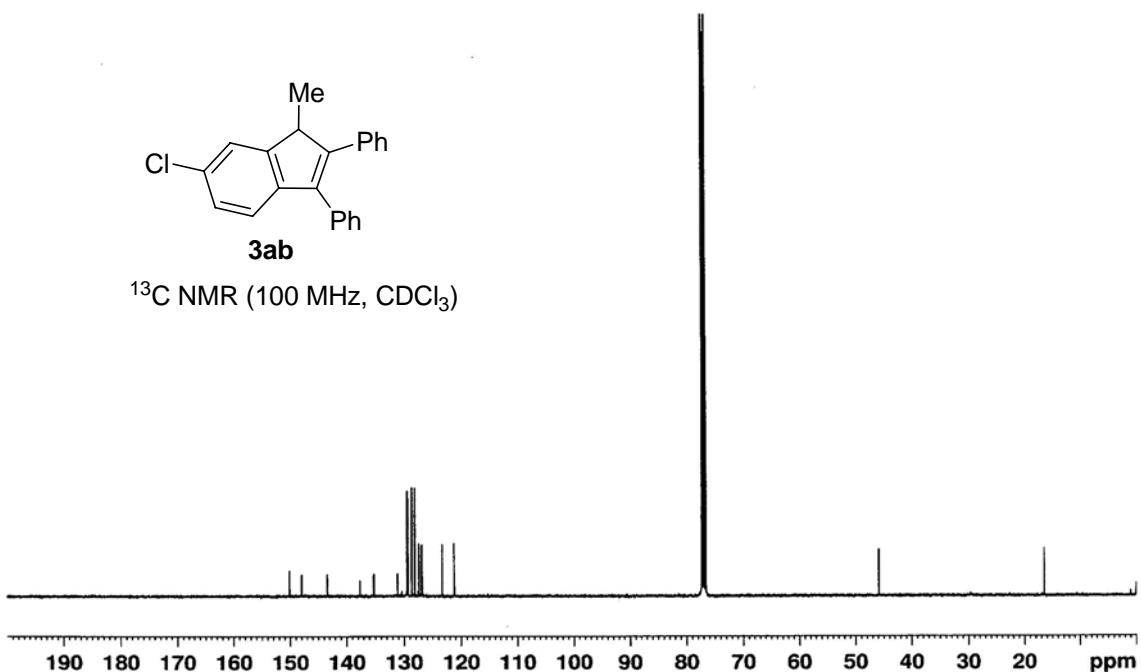
¹H NMR (400 MHz, CDCl₃)

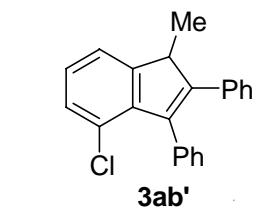


150.121
147.999
143.427
137.688
135.278
135.202
131.097
129.450
129.335
128.662
128.145
127.423
126.977
126.840
123.346
121.218

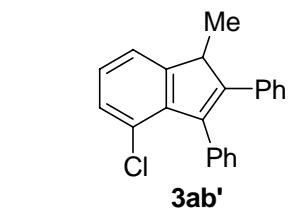
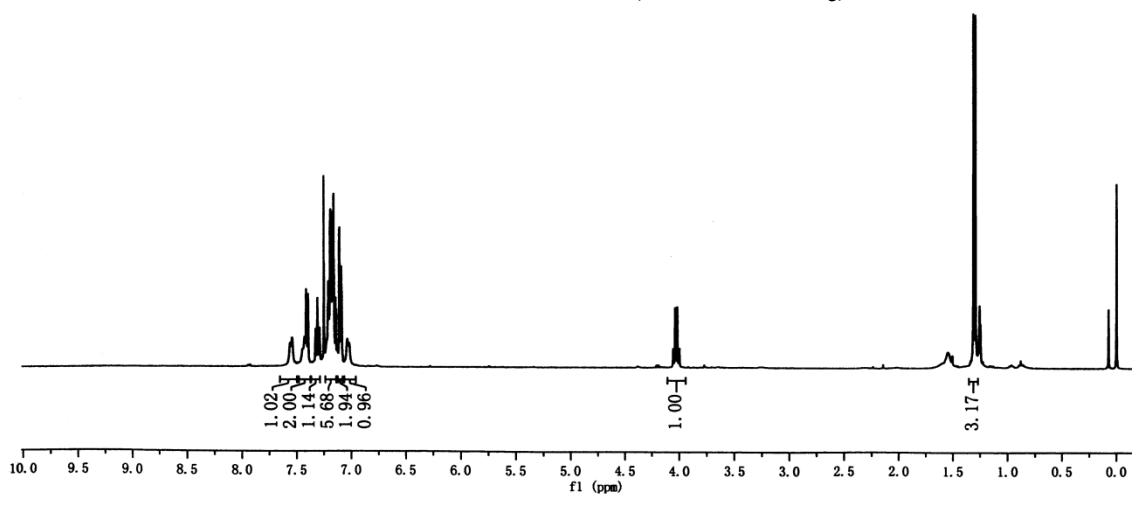


¹³C NMR (100 MHz, CDCl₃)

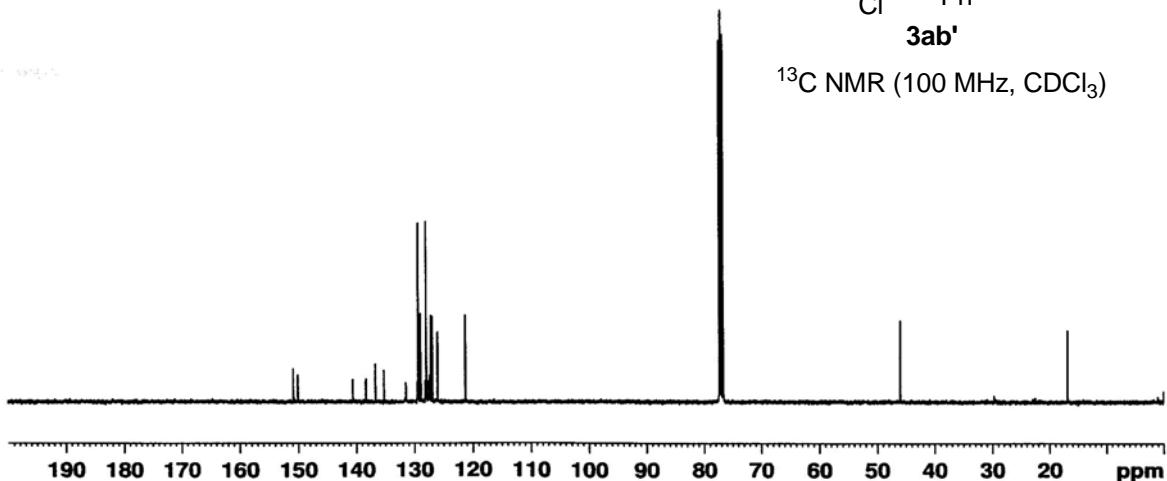


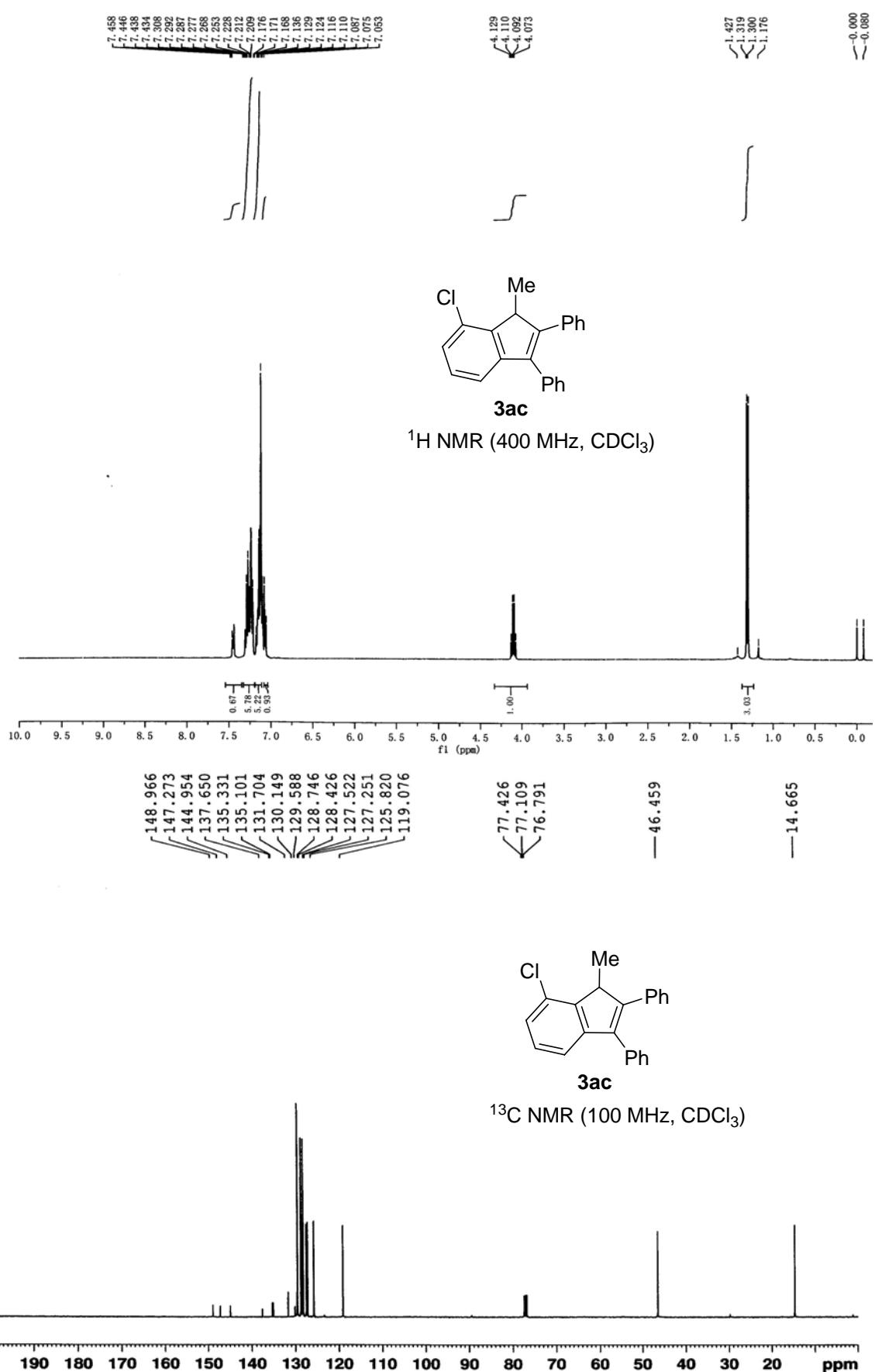


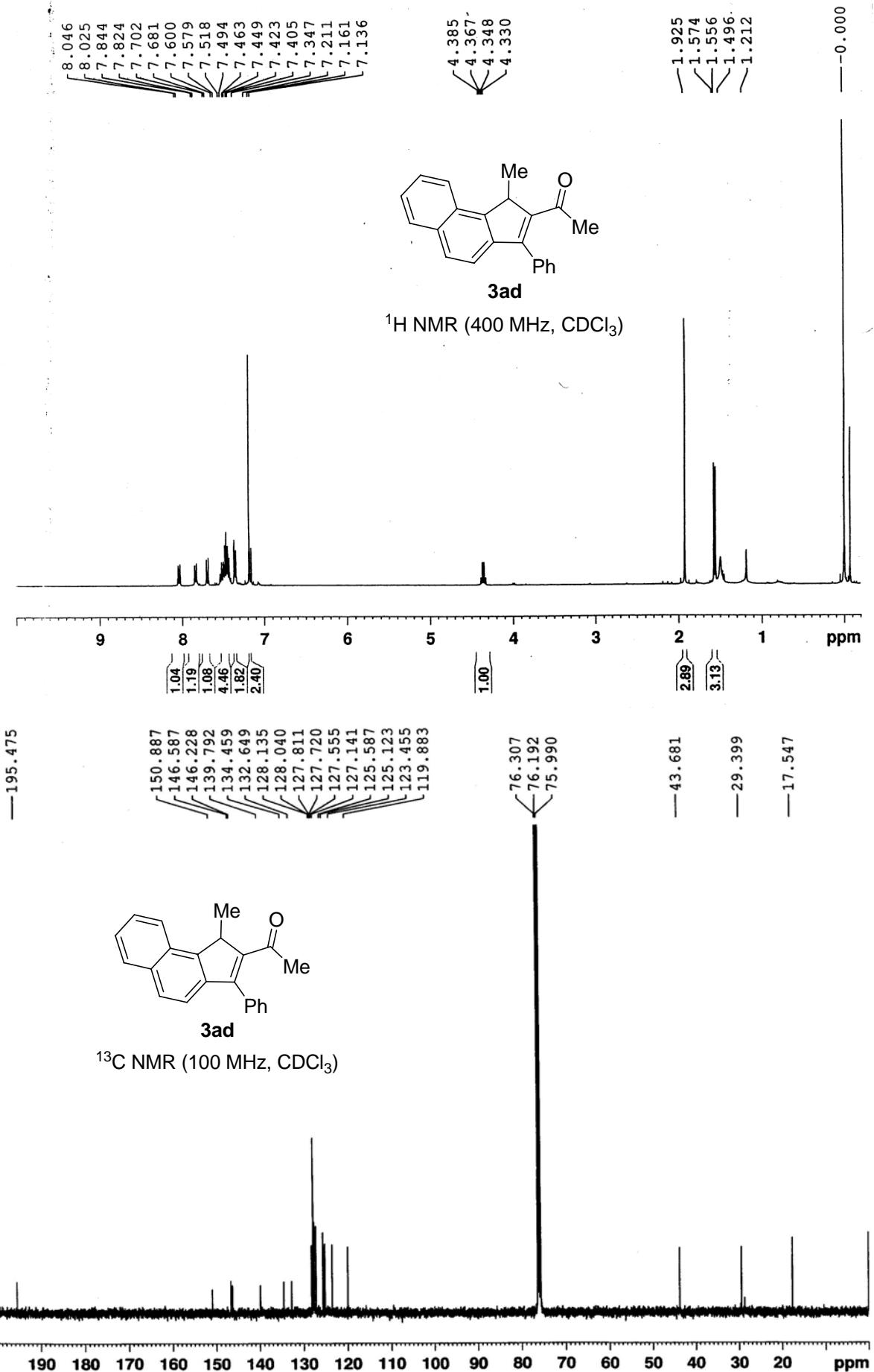
¹H NMR (400 MHz, CDCl₃)

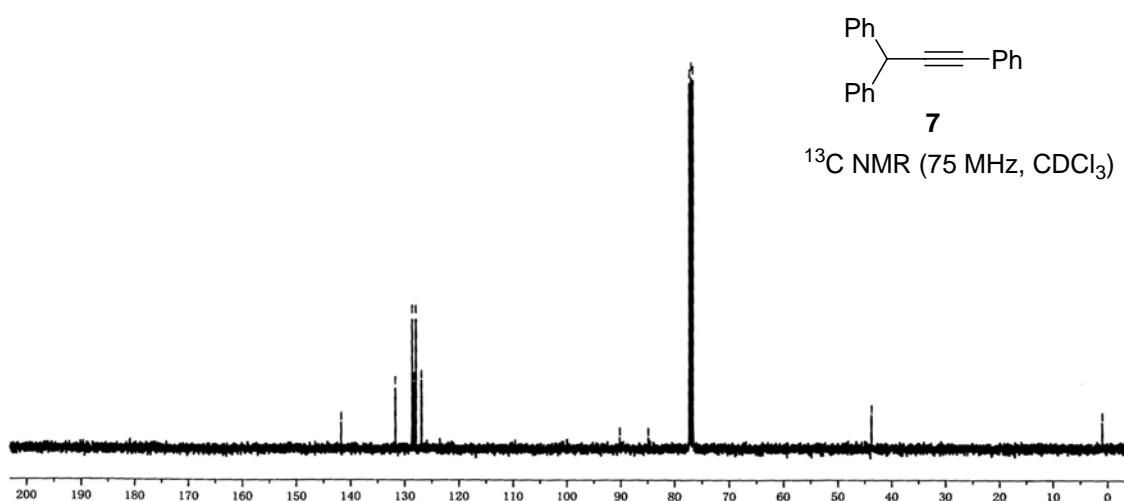
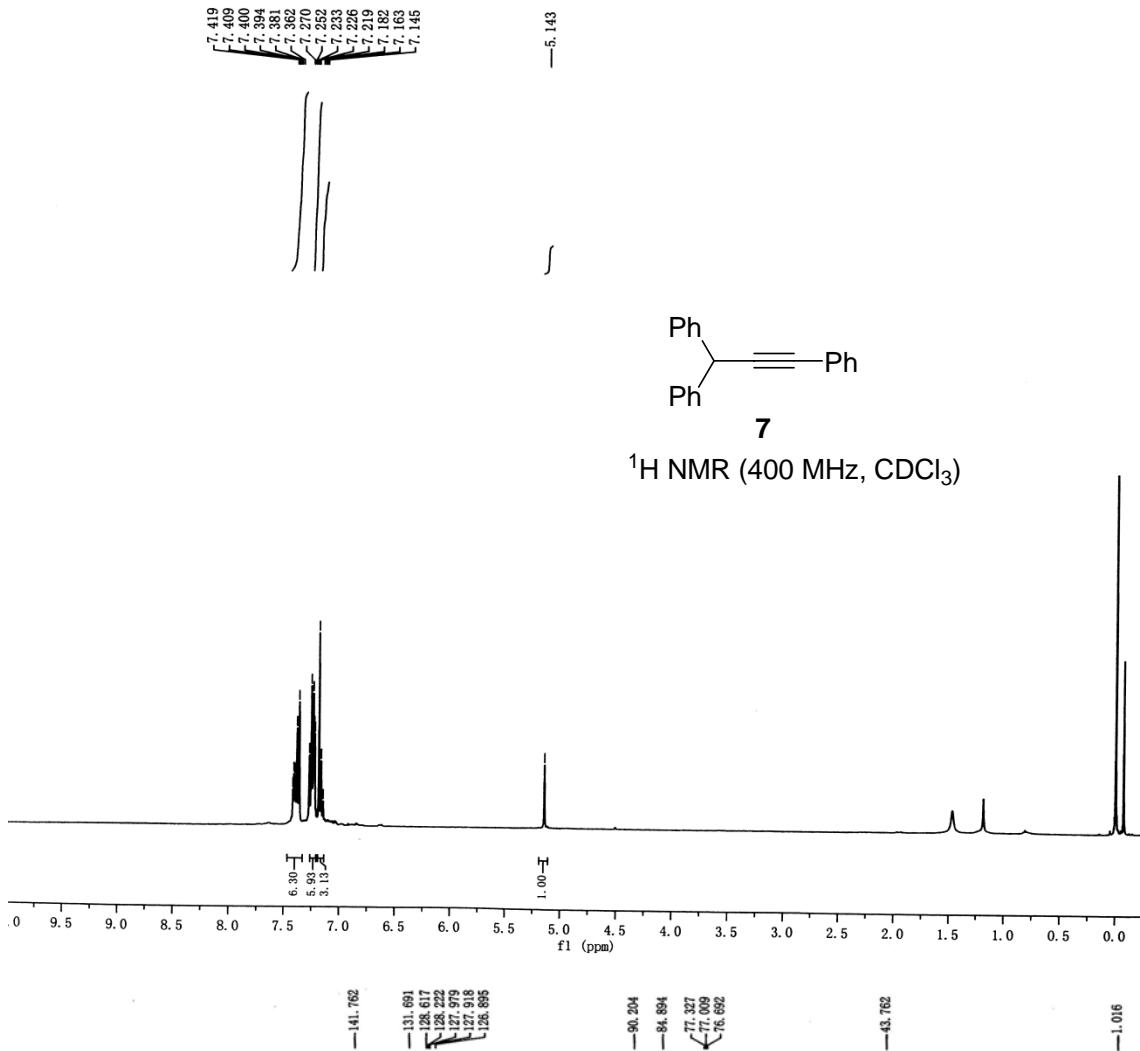


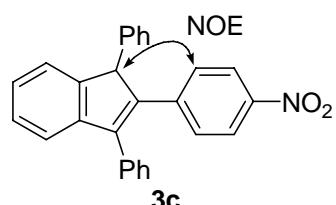
¹³C NMR (100 MHz, CDCl₃)



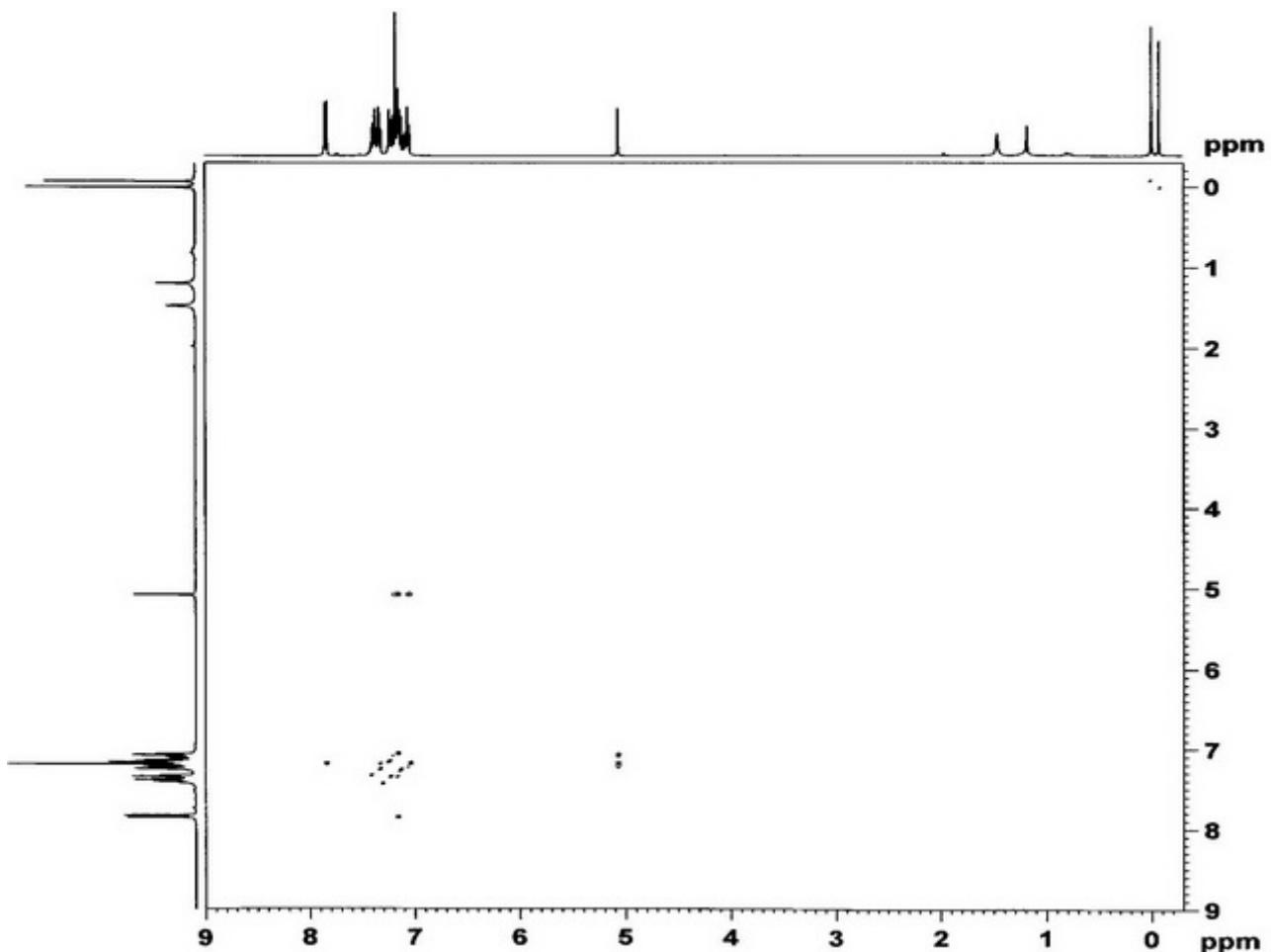


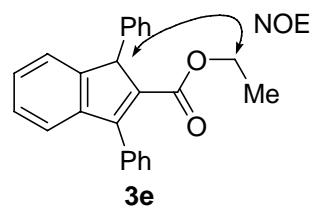




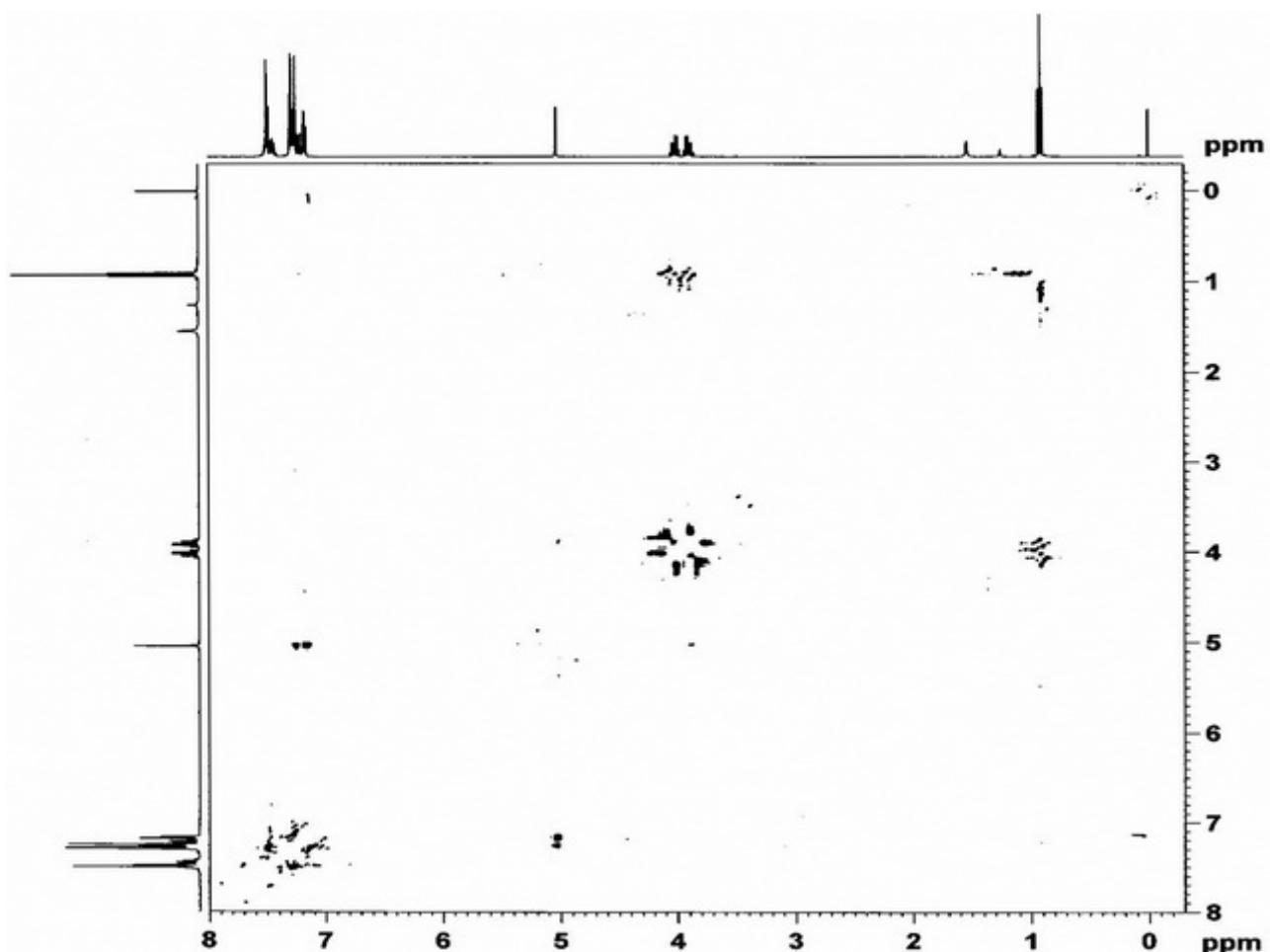


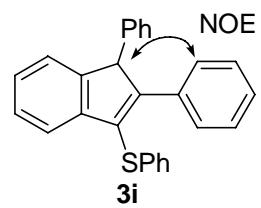
2D NOESY (400 MHz, CDCl₃)



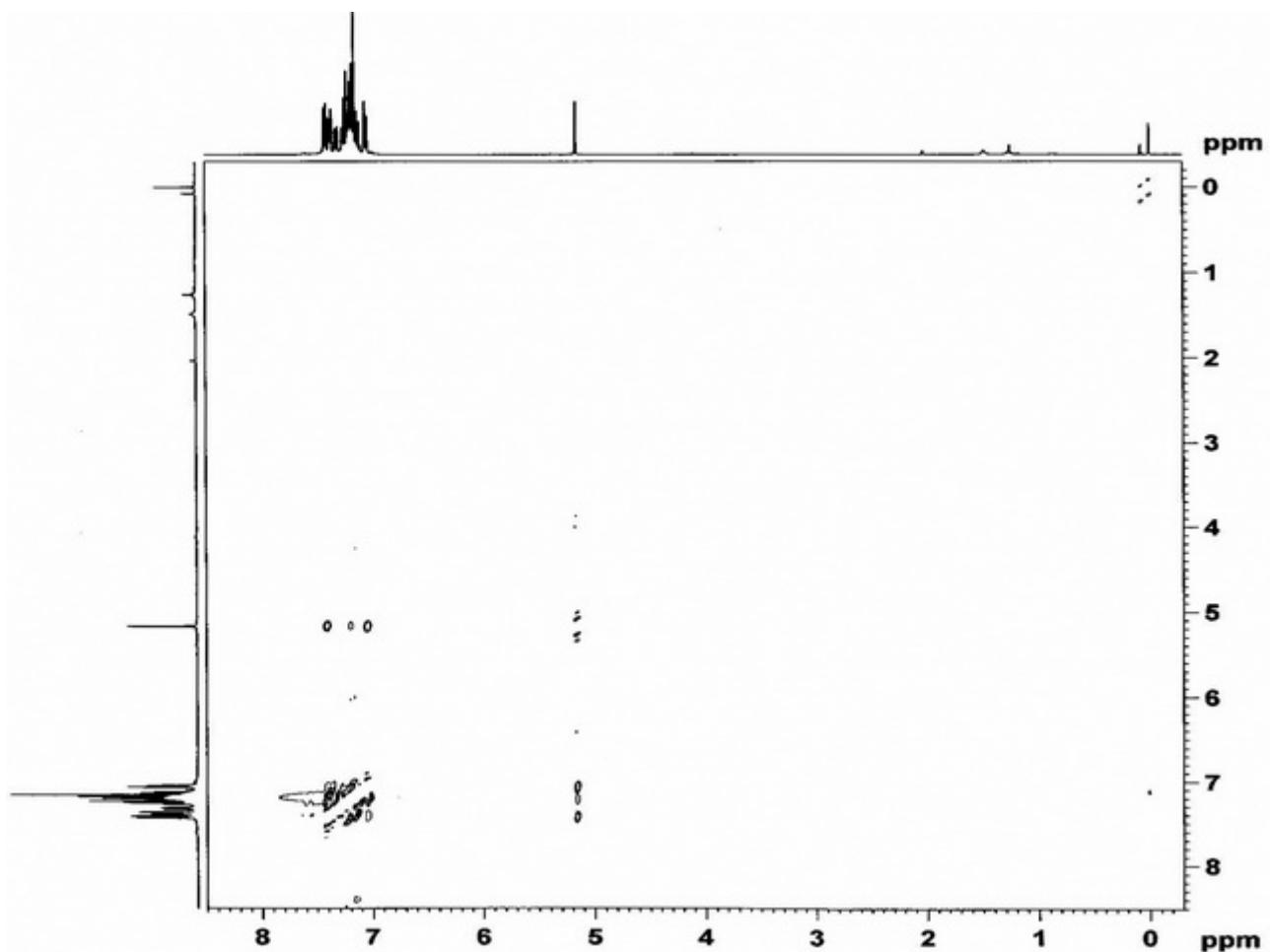


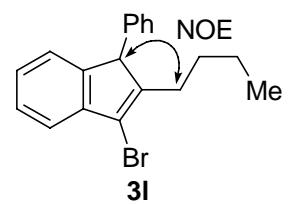
2D NOESY (400 MHz, CDCl_3)



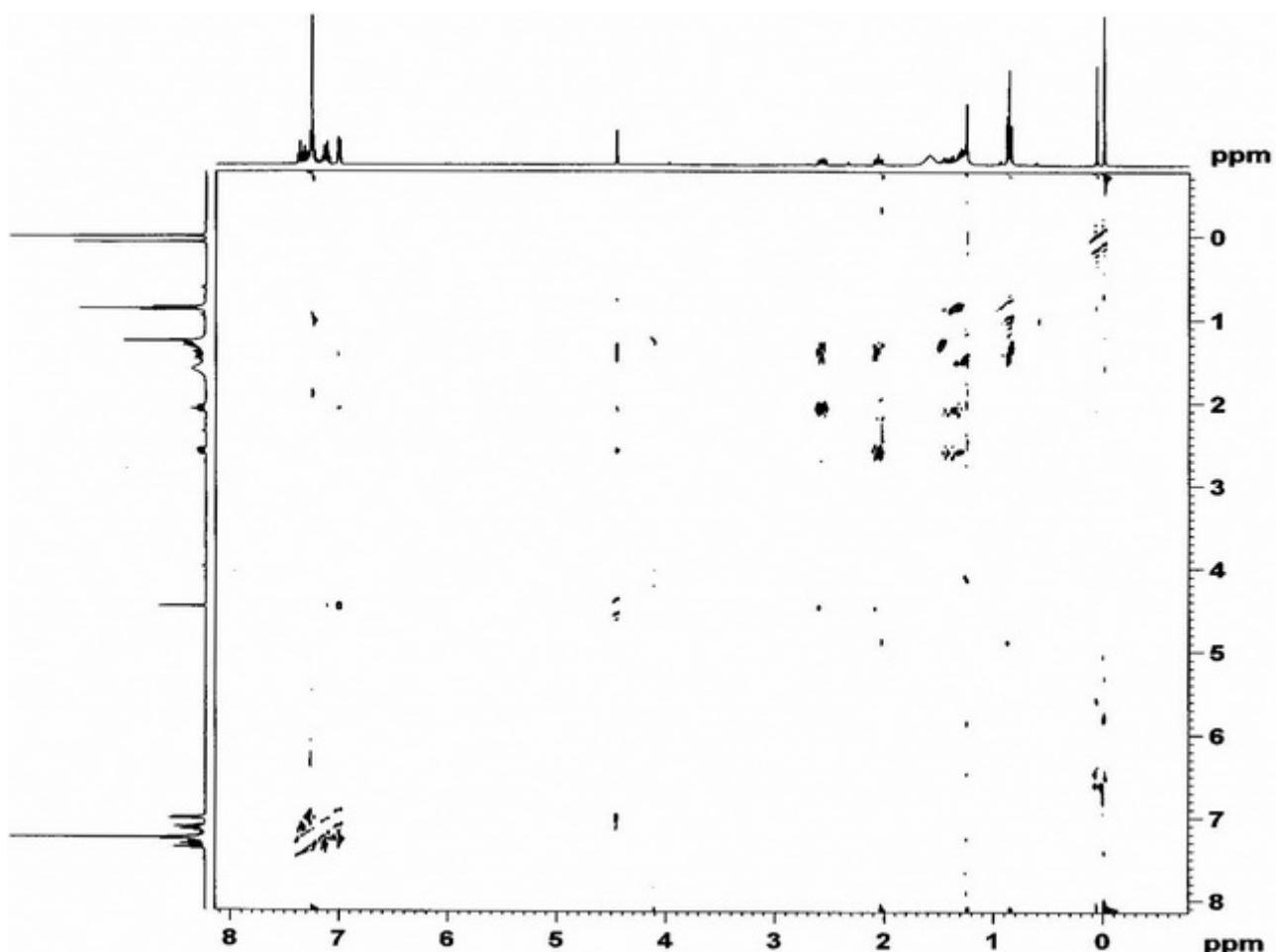


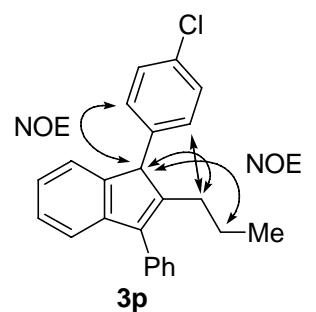
2D NOESY (400 MHz, CDCl₃)



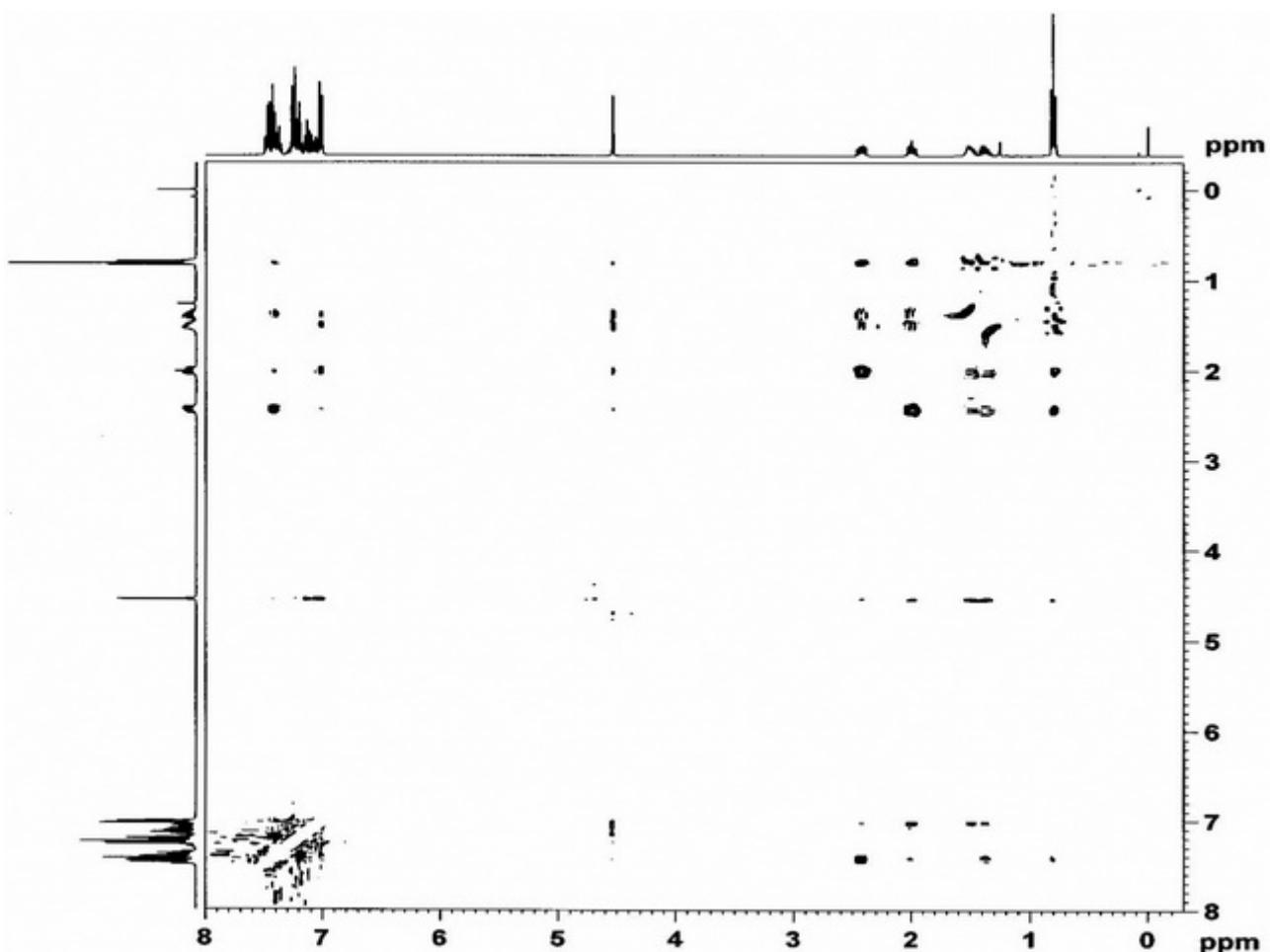


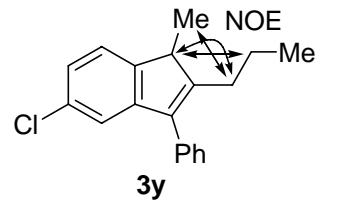
2D NOESY (400 MHz, CDCl₃)



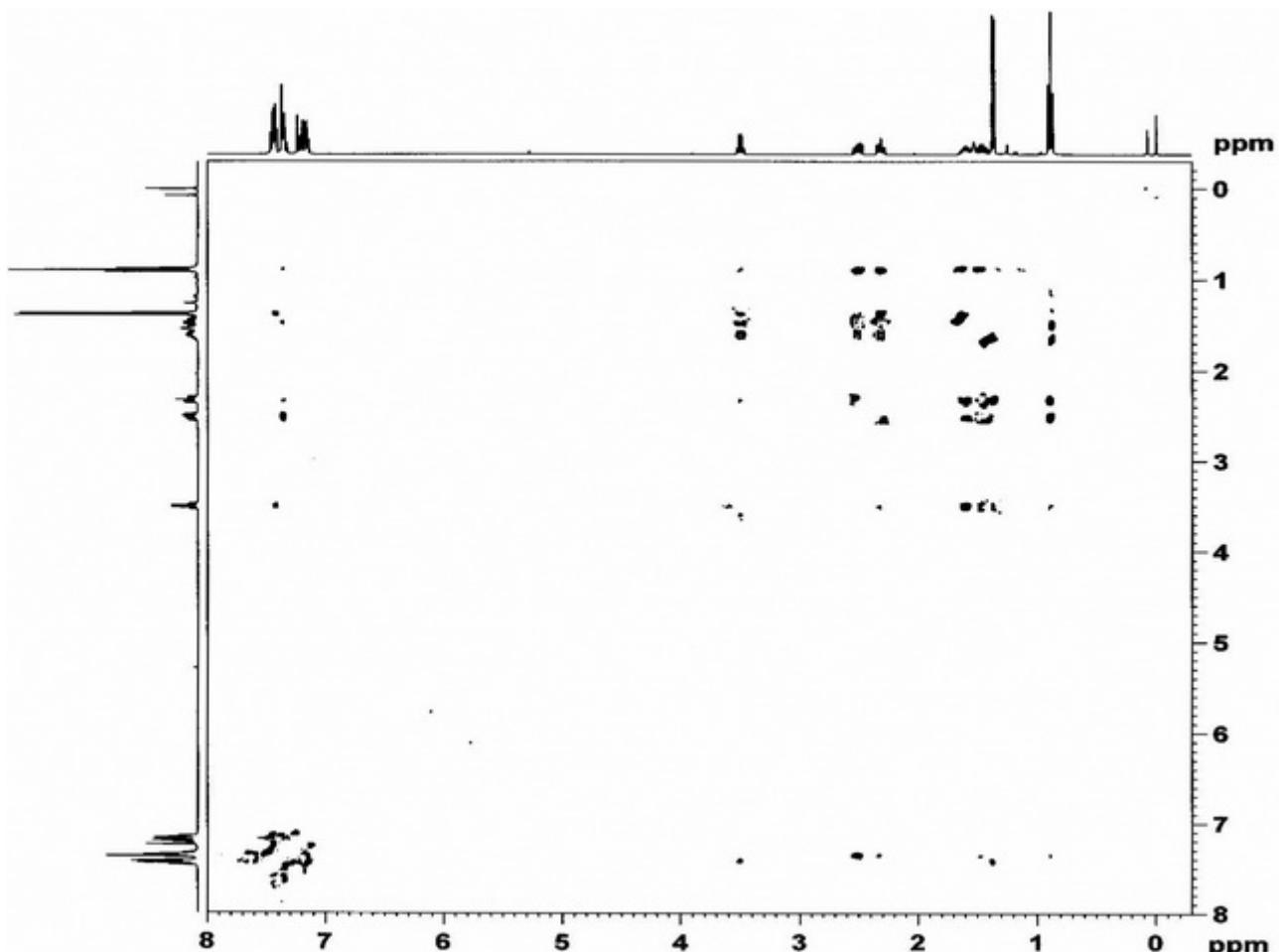


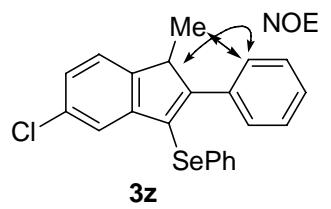
2D NOESY (400 MHz, CDCl₃)





2D NOESY (400 MHz, CDCl₃)





3z
2D NOESY (400 MHz, CDCl₃)

