Ring-Opening Cyclization of Alkylidenecyclopropyl Ketones with Amines. An Efficient Synthesis of 2,3,4-Trisubstituted Pyrroles

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Supporting Information

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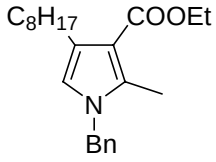
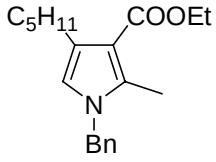
(1) **1-Benzyl-2-methyl-3-(ethoxycarbonyl)-4-octyl-1*H*-pyrrole** (**3aa**)



3aa

3aa: liquid; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.37-7.23 (m, 3 H), 7.00 (d, *J* = 6.9 Hz, 2 H), 6.37 (s, 1 H), 5.00 (s, 2 H), 4.29 (q, *J* = 7.2 Hz, 2 H), 2.68 (t, *J* = 7.8 Hz, 2 H), 2.43 (s, 3 H), 1.63-1.50 (m, 2 H), 1.36 (t, *J* = 7.2 Hz, 3 H), 1.42-1.20 (m, 10 H), 0.90 (t, *J* = 6.6 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.2, 137.2, 136.3, 128.8, 127.5, 126.2, 126.0, 119.0, 110.9, 59.0, 50.1, 31.9, 30.6, 29.7, 29.6, 29.4, 27.0, 22.7, 14.4, 14.1, 11.5; MS (EI) m/z (%): 355 (M^+, 32.53), 257 (100); IR (neat) ν (cm^{-1}): 1697, 1565, 1521, 1454, 1426, 1129, 1082; HRMS calcd for $C_{23}H_{34}NO_2^+$ (MH^+): 356.2584. Found: 356.2584.

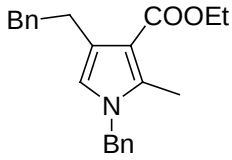
(2) **1-Benzyl-2-methyl-3-(ethoxycarbonyl)-4-pentyl-1*H*-pyrrole** **(3ba)**



3ba

The reaction of **1b** (56 mg, 0.25 mmol), amine **2a** (109 mg, 1 mmol), and anhydrous $MgSO_4$ (16 mg, 0.13 mmol) in 1 mL of CH_3CN afforded 61 mg (78 %) of **3ba**: liquid; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.32-7.15 (m, 3 H), 6.92 (d, *J* = 6.9 Hz, 2 H), 6.29 (s, 1 H), 4.92 (s, 2 H), 4.20 (q, *J* = 7.2 Hz, 2 H), 2.60 (t, *J* = 7.7 Hz, 2 H), 2.34 (s, 3 H), 1.58-1.42 (m, 2 H), 1.27 (t, *J* = 7.2 Hz, 3 H), 1.38-1.15 (m, 4 H), 0.82 (t, *J* = 6.9 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.2, 137.2, 136.3, 128.8, 127.5, 126.2, 126.0, 119.0, 110.9, 59.0, 50.1, 31.9, 30.3, 27.0, 22.6, 14.4, 14.1, 11.5; MS (EI) m/z (%): 313 (M^+, 16.16), 91 (100); IR (neat) ν (cm^{-1}): 1692, 1564, 1520, 1454, 1427, 1278, 1257, 1129, 1081; HRMS calcd for $C_{20}H_{28}NO_2^+$ (MH^+): 314.2115. Found: 314.2107.

(3) **1-Benzyl-2-methyl-3-(ethoxycarbonyl)-4-(2'-phenylethyl)-1*H*-pyrrole** (**3ca**)

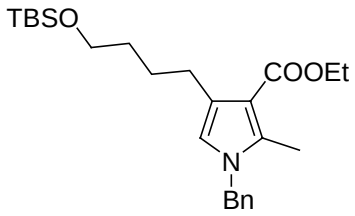


3ca

The reaction of **1c** (65 mg, 0.25 mmol), amine **2a** (109 mg, 1 mmol), and anhydrous $MgSO_4$ (16 mg, 0.13 mmol) in 1 mL of CH_3CN afforded 66 mg (75 %) of **3ca**: liquid; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40-7.18 (m, 8 H), 6.98 (d, *J* = 7.2 Hz, 2 H), 6.31 (s, 1 H), 4.98 (s, 2 H), 4.34 (q, *J* = 7.2 Hz, 2 H), 3.07-3.00 (m, 2 H), 2.96-2.87 (m, 2 H), 2.45 (s, 3 H), 1.39 (t, *J* = 7.2 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.0, 142.6,

137.1, 136.4, 128.7, 128.5, 128.0, 127.5, 126.2, 125.5, 124.7, 119.5, 110.9, 59.1, 50.1, 37.0, 28.9, 14.5, 11.5; MS (EI) m/z (%): 347 (M^+, 29.02), 256 (100), 91 (94.33); IR (neat) ν (cm^{-1}): 1692, 1564, 1520, 1496, 1453, 1428, 1271, 1128, 1084; HRMS calcd for $C_{23}H_{26}NO_2^+$ (MH^+): 348.1958. Found: 348.1961.

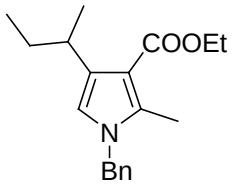
(4) **1-Benzyl-2-methyl-3-(ethoxycarbonyl)-4-(4'-*tert*-butyldimethylsilyloxybutyl) -1*H*-pyrrole** (**3da**)



3da

The reaction of **1d** (87 mg, 0.26 mmol), amine **2a** (109 mg, 1 mmol), and anhydrous $MgSO_4$ (16 mg, 0.13 mmol) in 1 mL of CH_3CN afforded 85 mg (77 %) of **3da**: liquid; ^1H NMR (300 MHz, $CDCl_3$); δ 7.29-7.15 (m, 3 H), 6.92 (d, *J* = 6.9 Hz, 2 H), 6.29 (s, 1 H), 4.91 (s, 2 H), 4.19 (q, *J* = 7.1 Hz, 2 H), 3.56 (t, *J* = 6.2 Hz, 2 H), 2.62 (t, *J* = 7.1 Hz, 2 H), 2.34 (s, 3 H), 1.58-1.49 (m, 4 H), 1.27 (t, *J* = 7.1 Hz, 3 H), 0.82 (s, 9 H), -0.03 (s, 6 H), ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.1, 137.2, 136.4, 128.7, 127.5, 126.2, 125.6, 119.1, 110.9, 63.3, 59.0, 50.1, 32.9, 26.8, 26.6, 25.9, 18.3, 14.4, 11.5, -5.3; MS (EI) m/z (%): 430 (M^++1, 5.47), 429 (M^+, 0.77), 372 (100); IR (neat) ν (cm^{-1}): 1701, 1691, 1565, 1521, 1471, 1429, 1255, 1087; HRMS calcd for $C_{25}H_{39}NO_3SiNa^+$ (MNa^+): 452.2591. Found: 452.2574.

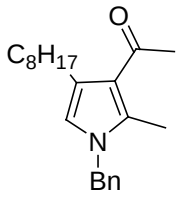
(5) **1-Benzyl-2-methyl-3-(ethoxycarbonyl)-4-(2'-butyl)-1*H*-pyrrole** (**3ea**)



3ea

The reaction of **1e** (115 mg, 0.55 mmol), amine **2a** (219 mg, 2 mmol), and anhydrous $MgSO_4$ (30 mg, 0.25 mmol) in 2 mL of CH_3CN afforded 94 mg (57 %) of **3ea**: liquid; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.32-7.18 (m, 3 H), 6.93 (d, *J* = 6.6 Hz, 2 H), 6.32 (s, 1 H), 4.95 (s, 2 H), 4.23 (q, *J* = 7.2 Hz, 2 H), 3.25-3.10 (m, 1 H), 2.36 (s, 3 H), 1.71-1.58 (m, 1 H), 1.45-1.30 (m, 1 H), 1.30 (t, *J* = 7.2 Hz, 3 H), 1.14 (d, *J* = 7.2 Hz, 3 H), 0.88 (t, *J* = 7.5 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.1, 137.2, 136.0, 131.7, 128.7, 127.4, 126.1, 117.6, 110.7, 59.0, 50.2, 32.0, 30.6, 20.6, 14.3, 11.9, 11.6; MS (EI) m/z (%): 299 (M^+, 30.89), 91 (100); IR (neat) ν (cm^{-1}): 1693, 1516, 1454, 1240; HRMS calcd for $C_{19}H_{26}NO_2^+$ (MH^+): 300.1958. Found: 300.1957.

(6) **1-Benzyl-2-methyl-3-acetyl-4-octyl-1*H*-pyrrole** (**3fa**)

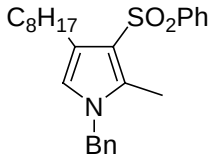


3fa

The reaction of **1f** (59 mg, 0.25 mmol), amine **2a** (109 mg, 1 mmol), and anhydrous $MgSO_4$ (15 mg, 0.125 mmol) in 1 mL of CH_3CN afforded 52 mg (64 %) of **3fa**: liquid; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.25-7.14 (m, 3 H), 6.90 (d, *J* = 6.6 Hz, 2 H), 6.26 (s, 1 H), 4.90 (s, 2 H), 2.57 (t, *J* = 7.8 Hz, 2 H), 2.34 (s, 3 H), 2.29 (s, 3 H), 1.54-1.38 (m, 2 H), 1.33-1.10 (m, 10 H), 0.78 (t, *J* = 6.9 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ

195.7, 137.0, 135.6, 128.8, 127.6, 126.2, 124.9, 121.6, 119.3, 50.1, 31.8, 31.1, 30.3, 29.7, 29.5, 29.3, 27.6, 22.6, 14.1, 12.3; MS (EI) m/z (%): 325 (M^+, 22.94), 91 (100); IR (neat) ν (cm^{-1}): 1645, 1504, 1499, 1454, 1418; HRMS calcd for $C_{22}H_{32}NO^+$ (MH^+): 326.2478. Found: 326.2469.

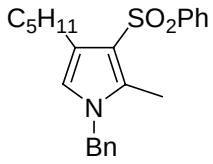
(7) **1-Benzyl-2-methyl-3-(benzenesulfonyl)-4-octyl-1*H*-pyrrole** (**3ga**)



3ga

The reaction of **1g** (84 mg, 0.25 mmol), amine **2a** (111 mg, 1 mmol), and anhydrous $MgSO_4$ (16 mg, 0.13 mmol) in 1 mL of CH_3CN afforded 80 mg (75 %) of **3ga**: liquid; ^1H NMR (300 MHz, $CDCl_3$) δ 7.91-7.82 (m, 2 H), 7.55-7.42 (m, 3 H), 7.37-7.25 (m, 3 H), 6.96 (d, *J* = 6.6 Hz, 2 H), 6.38 (s, 1 H), 4.98 (s, 2 H), 2.61 (t, *J* = 7.7 Hz, 2 H), 2.46 (s, 3 H), 1.52-1.40 (m, 2 H), 1.38-1.17 (m, 10 H), 0.88 (t, *J* = 6.8 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.6, 136.3, 134.2, 131.9, 128.9, 128.7, 127.7, 126.2, 126.1, 124.5, 119.6, 117.1, 50.5, 31.8, 29.7, 29.5, 29.4, 29.2, 25.4, 22.6, 14.1, 10.8; MS (EI) m/z (%): 424 (M^++1, 14.95), 423 (M^+, 1.03), 91 (100); IR (neat) ν (cm^{-1}): 1498, 1454, 1446, 1414, 1302, 1166, 1133; HRMS calcd for $C_{26}H_{33}NO_2SNa^+$ (MNa^+): 446.2124. Found: 446.2114.

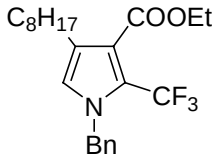
(8) **1-Benzyl-2-methyl-3-(benzenesulfonyl)-4-pentyl-1*H*-pyrrole** (**3ha**)



3ha

The reaction of **1h** (77 mg, 0.26 mmol), amine **2a** (111 mg, 1 mmol), and anhydrous $MgSO_4$ (16 mg, 0.13 mmol) in 1 mL of CH_3CN afforded 82 mg (82 %) of **3ha**: solid, mp: 81-82 ^oC, (petroleum ether/ethyl acetate). ^1H NMR (300 MHz, $CDCl_3$) δ 7.80-7.73 (m, 2 H), 7.43-7.30 (m, 3 H), 7.26-7.15 (m, 3 H), 6.88-6.83 (m, 2 H), 6.29 (s, 1 H), 4.88 (s, 2 H), 2.51 (t, *J* = 7.5 Hz, 2 H), 2.35 (s, 3 H), 1.45-1.30 (m, 2 H), 1.23-1.10 (m, 4 H), 0.76 (t, *J* = 7.2 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.6, 136.3, 134.2, 131.9, 128.8, 128.7, 127.7, 126.2, 126.0, 124.4, 119.6, 117.1, 50.4, 31.6, 29.3, 25.3, 22.4, 14.0, 10.7; MS (EI) m/z (%): 381 (M^+, 14.93), 91 (100); IR (neat) ν (cm^{-1}): 1498, 1453, 1445, 1417, 1310, 1300, 1167, 1136; Anal. Calcd for $C_{23}H_{27}NO_2S$: C 72.40, H 7.13, N 3.67. Found: C 72.12, H 7.02, N 3.53.

(9) **1-Benzyl-2-(trifluoromethyl)-3-(ethoxycarbonyl)-4-octyl-1*H*-pyrrole** (**3ia**)

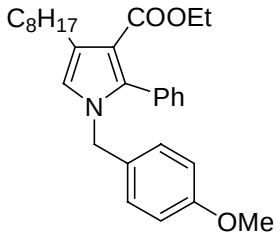


3ia

The reaction of **1i** (80 mg, 0.25 mmol), amine **2a** (110 mg, 1 mmol), and anhydrous $MgSO_4$ (15 mg, 0.125 mmol) in 1 mL of CH_3CN afforded 41 mg (40 %) of **3ia**: liquid; ^1H NMR (300 MHz, $CDCl_3$) δ 7.30-7.18 (m, 3 H), 7.05-6.95 (m, 2 H), 6.41 (s, 1 H), 5.10 (s, 2 H), 4.24 (q, *J* = 7.2 Hz, 2 H), 2.49 (t, *J* = 7.5 Hz, 2 H), 1.50-1.37 (m, 2 H),

1.27 (t, J = 7.2 Hz, 3 H), 1.30-1.08 (m, 10 H), 0.80 (t, J = 6.9 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 164.4, 136.4, 128.7, 127.9, 126.6, 126.0, 123.6 (q, $^4J_{C\text{-}F}$ = 1.7 Hz), 120.9 (q, $^1J_{C\text{-}F}$ = 267.4 Hz), 120.6 (q, $^2J_{C\text{-}F}$ = 38.0 Hz), 117.8 (q, $^3J_{C\text{-}F}$ = 2.3 Hz), 60.7, 52.5 (q, $^4J_{C\text{-}F}$ = 3.3 Hz), 31.8, 30.4, 29.41, 29.38, 29.2, 25.6, 22.6, 14.1, 14.0; ^{19}F NMR (91 MHz, $CDCl_3$) δ –55.1; MS (EI) m/z (%): 409 (M^+, 0.57), 91 (100); MS (MALDI): 432.2 (M^++Na), 410.2 (M^++1); IR (neat) ν (cm^{-1}): 1720, 1512, 1457, 1463, 1435, 1236, 1157, 1110; HRMS calcd for $C_{23}H_{31}NO_2F_3^+$ (MH^+): 410.2301. Found: 410.2303.

(10) **1-(4'-Methoxybenzyl)-2-phenyl-3-(ethoxycarbonyl)-4-octyl-1*H*-pyrrole (3jb)**

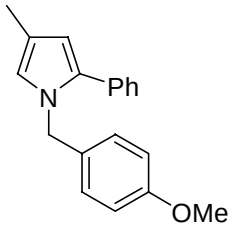


3jb

The reaction of **1j** (83 mg, 0.25 mmol), amine **2b** (140 mg, 1 mmol), and anhydrous $MgSO_4$ (15 mg, 0.125 mmol) in 1 mL of CH_3CN afforded 76 mg (67 %) of **3jb**: liquid; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40-7.33 (m, 3 H), 7.29-7.22 (m, 2 H), 6.87 (d, J = 8.8 Hz, 2 H), 6.79 (d, J = 8.8 Hz, 2 H), 6.46 (s, 1 H), 4.77 (s, 2 H), 4.04 (q, J = 7.2 Hz, 2 H), 3.78 (s, 3 H), 2.73 (t, J = 7.8 Hz, 2 H), 1.67-1.55 (m, 2 H), 1.43-1.20 (m, 10 H), 1.01 (t, J = 7.2 Hz, 3 H), 0.89 (t, J = 6.8 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.4, 158.9, 139.1, 132.7, 130.6, 129.7, 128.1, 128.0, 127.7, 126.7, 119.3, 113.9, 111.9, 58.9, 55.2, 49.9, 31.9, 30.4, 29.8, 29.5, 29.4, 26.8, 22.7, 14.1, 13.8; MS (EI) m/z (%): 448 (M^++1, 10.65), 121 (100); IR (neat) ν (cm^{-1}): 1700, 1613, 1514, 1481,

1249, 1175, 1082; HRMS calcd for $C_{29}H_{38}NO_3^+$ (MH^+): 448.2846. Found: 448.2832.

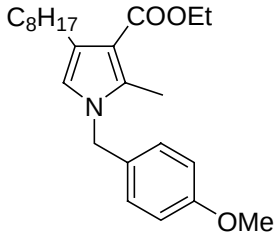
(11) **1-(4'-Methoxybenzyl)-2-phenyl-4-methyl-1*H*-pyrrole (3kb)**



3kb

The reaction of **1k** (40 mg, 0.25 mmol), amine **2b** (140 mg, 1 mmol), and anhydrous $MgSO_4$ (15 mg, 0.125 mmol) in 1 mL of CH_3CN afforded 25 mg (36%) of **3kb**. **1k** (20 mg, 50%) was recovered. **3kb**: liquid; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.42-7.23 (m, 5 H), 7.00 (d, *J* = 8.8 Hz, 2 H), 6.86 (d, *J* = 8.8 Hz, 2 H), 6.55-6.50 (m, 1 H), 6.17-6.13 (m, 1H), 5.04 (s, 2 H), 3.81 (s, 3 H), 2.17 (s, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.7, 134.7, 133.4, 130.9, 128.7, 128.3, 127.8, 126.7, 120.7, 118.9, 113.9, 110.1, 55.2, 49.8, 11.9; MS (EI) m/z (%): 277 (M^+, 19.98), 121 (100); IR (neat) ν (cm^{-1}): 1699, 1613, 1586, 1513, 1464, 1443, 1249, 1175, 1035; HRMS calcd for $C_{19}H_{20}NO^+$ (MH^+): 278.1539. Found: 278.1536.

(12) **1-(4'-Methoxybenzyl)-2-methyl-3-(ethoxycarbonyl)-4-octyl-1*H*-pyrrole (3ab)**

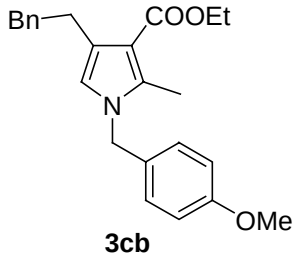


3ab

The reaction of **1a** (67 mg, 0.25 mmol), amine **2b** (135 mg, 1 mmol), and anhydrous

$MgSO_4$ (15 mg, 0.125 mmol) in 1 mL of CH_3CN afforded 83 mg (86 %) of **3ab**: solid, mp 48-50 ^oC (petroleum ether/Et_2O). ^1H NMR (300 MHz, $CDCl_3$) δ 6.93 (d, *J* = 8.5 Hz, 2 H), 6.83 (d, *J* = 8.5 Hz, 2 H), 6.32 (s, 1 H), 4.91 (s, 2 H), 4.26 (q, *J* = 7.0 Hz, 2 H), 3.78 (s, 3 H), 2.64 (t, *J* = 7.8 Hz, 2 H), 2.42 (s, 3 H), 1.60-1.45 (m, 2 H), 1.34 (t, *J* = 7.0 Hz, 3 H), 1.36-1.20 (m, 10 H), 0.87 (t, *J* = 6.8 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.2, 158.9, 136.1, 129.1, 127.6, 125.8, 118.8, 114.1, 110.8, 58.9, 55.2, 49.6, 31.8, 30.6, 29.7, 29.5, 29.3, 27.0, 22.6, 14.4, 14.1, 11.5; MS (EI) m/z (%): 385 (M^+, 10.44), 121 (100); IR (neat) ν (cm^{-1}): 1675, 1515, 1467, 1277, 1135; Anal. Calcd for $C_{24}H_{35}NO_3$: C 74.77, H 9.15, N 3.63. Found: C 74.62, H 9.15, N 3.29.

(13) **1-(4'-Methoxybenzyl)-2-methyl-3-(ethoxycarbonyl)-4-(2'-phenylethyl)-1*H*-pyrrole (3cb)**

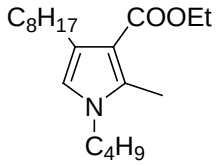


3cb

The reaction of **1c** (67 mg, 0.26 mmol), amine **2b** (133 mg, 1 mmol), and anhydrous $MgSO_4$ (15 mg, 0.125 mmol) in 1 mL of CH_3CN afforded 75 mg (77 %) of **3cb**: liquid; ^1H NMR (300 MHz, $CDCl_3$) δ 7.34-7.15 (m, 5 H), 6.92 (d, *J* = 8.7 Hz, 2 H), 6.85 (d, *J* = 8.7 Hz, 2 H), 6.29 (s, 1 H), 4.91 (s, 2 H), 4.33 (t, *J* = 7.2 Hz, 2 H), 3.81 (s, 3 H), 3.05-2.98 (m, 2 H), 2.95-2.87 (m, 2 H), 2.46 (s, 3 H), 1.38 (t, *J* = 7.2 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.1, 158.9, 142.7, 136.3, 129.0, 128.5, 128.1, 127.7, 125.5, 124.6, 119.3, 114.1, 110.8, 59.0, 55.2, 49.7, 37.1, 28.9, 14.5, 11.6; MS (EI) m/z

(%): 377 (M^+, 11.65), 121 (100); IR (neat) ν (cm^{-1}): 1690, 1613, 1514, 1454, 1428, 1249, 1082; HRMS calcd for $C_{24}H_{28}NO_3^+$ (MH^+): 378.2064. Found: 378.2070.

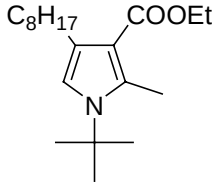
(14) **1-(*n*-Butyl)-2-methyl-3-(ethoxycarbonyl)-4-octyl-1*H*-pyrrole (3ac)**



3ac

The reaction of **1a** (68 mg, 0.26 mmol), amine **2c** (72 mg, 1 mmol), and anhydrous $MgSO_4$ (15 mg, 0.125 mmol) in 1 mL of CH_3CN afforded 41 mg (50 %) of **3ac**: liquid; ^1H NMR (300 MHz, $CDCl_3$) δ 6.28 (s, 1 H), 4.25 (q, *J* = 7.2 Hz, 2 H), 3.74 (t, *J* = 7.4 Hz, 2 H), 2.63 (t, *J* = 7.4 Hz, 2 H), 2.47 (s, 3 H), 1.70-1.58 (m, 2 H), 1.58-1.40 (m, 2 H), 1.36 (t, *J* = 7.2 Hz, 3 H), 1.40-1.10 (m, 12 H), 0.93 (t, *J* = 7.4 Hz, 3 H), 0.88 (t, *J* = 7.2 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.2, 135.7, 125.5, 118.1, 110.2, 58.9, 46.2, 32.9, 31.9, 30.7, 29.7, 29.6, 29.3, 27.0, 22.6, 19.9, 14.4, 14.1, 13.6, 11.4; MS (EI) m/z (%): 321 (M^+, 24.34), 223 (100); IR (neat) ν (cm^{-1}): 1694, 1519, 1465, 1429, 1259, 1097; HRMS calcd for $C_{20}H_{36}NO_2^+$ (MH^+): 322.2741. Found: 322.2728.

(15) **1-(*t*-Butyl)-2-methyl-3-(ethoxycarbonyl)-4-octyl-1*H*-pyrrole (3ad)**

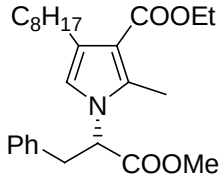


3ad

The reaction of **1a** (68 mg, 0.25 mmol), amine **2d** (78 mg, 1.1 mmol), and anhydrous

$MgSO_4$ (16 mg, 0.13 mmol) in 1 mL of CH_3CN afforded 41 mg (50 %) of **3ad**: liquid; ^1H NMR (300 MHz, $CDCl_3$) δ 6.49 (s, 1 H), 4.25 (q, *J* = 7.2 Hz, 2 H), 2.70 (s, 3 H), 2.59 (t, *J* = 7.8 Hz, 2 H), 1.59 (s, 9 H), 1.60-1.45 (m, 2 H), 1.33 (t, *J* = 7.2 Hz, 3 H), 1.38-1.20 (m, 10 H), 0.87 (t, *J* = 6.6 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.6, 136.3, 123.7, 115.9, 112.3, 58.9, 56.4, 31.9, 30.9, 30.6, 29.8, 29.6, 29.3, 27.4, 22.7, 14.8, 14.4, 14.1; MS (EI) m/z (%): 321 (M^+, 22.58), 167 (100); IR (neat) ν (cm^{-1}): 1694, 1563, 1512, 1254, 1215, 1101; HRMS calcd for $C_{20}H_{36}NO_2^+$ (MH^+): 322.2741. Found: 322.2741.

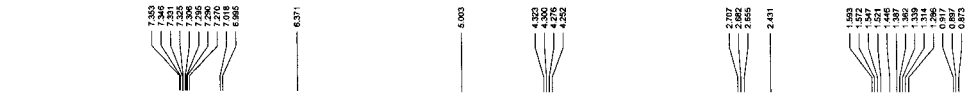
(16) **1-(1'-(Methoxycarbonyl)-2'-phenylethyl)-2-methyl-3-(ethoxycarbonyl)-4-octyl-1*H*-pyrrole (3ae)**

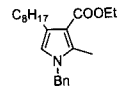


3ae

The reaction of **1a** (65 mg, 0.24 mmol), amine **2e** (179 mg, 1.0 mmol), and anhydrous $MgSO_4$ (15 mg, 0.125 mmol) in 1 mL of CH_3CN afforded 61 mg (60 %) of **3ae**. The reaction of **1a** (134 mg, 0.5 mmol), amine (*S*)-**2e** (359 mg, 2.0 mmol), and anhydrous $MgSO_4$ (30 mg, 0.25 mmol) in 2 mL of CH_3CN afforded 158 mg (74 %) of (*S*)-**3ae** with 96 ee% as determined by HPLC analysis (Chiralpak AD-H, hexane: *i*-PrOH = 90:10, 230 nm), t_r = 4.3 (minor), 4.7 (major), $[\alpha]^{20}_D$ -92.6° (*c* 1.3, $CHCl_3$); oil, ^1H NMR (300 MHz, $CDCl_3$) δ 7.27-7.15 (m, 3 H), 7.03-6.93 (m, 2 H), 6.55 (s, 1 H), 4.81 (dd, *J* = 9.6, 5.7 Hz, 1 H), 4.23 (q, *J* = 7.2 Hz, 2 H), 3.71 (s, 3 H), 3.42 (dd, *J* = 13.8,

5.7 Hz, 1 H), 3.18 (dd, *J* = 13.8, 9.6 Hz, 1 H), 2.80-2.50 (m, 2 H), 2.19 (s, 3 H), 1.62-1.50 (m, 2 H), 1.42-1.19 (m, 10 H), 1.32 (t, *J* = 6.9 Hz, 3 H), 0.89 (t, *J* = 7.2 Hz, 3 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.1, 166.0, 136.6, 136.0, 128.8, 128.5, 127.1, 126.5, 115.5, 110.5, 59.2, 58.9, 52.6, 38.7, 31.8, 30.4, 29.6, 29.5, 29.3, 27.1, 22.6, 14.3, 14.0, 10.9; MS (ESI) m/z: 428 [M^++1]; IR (neat) ν (cm^{-1}): 1748, 1695, 1521, 1426, 1256, 1087; HRMS calcd for $C_{26}H_{38}NO_4^+$ (MH^+): 428.2795. Found: 428.2782.

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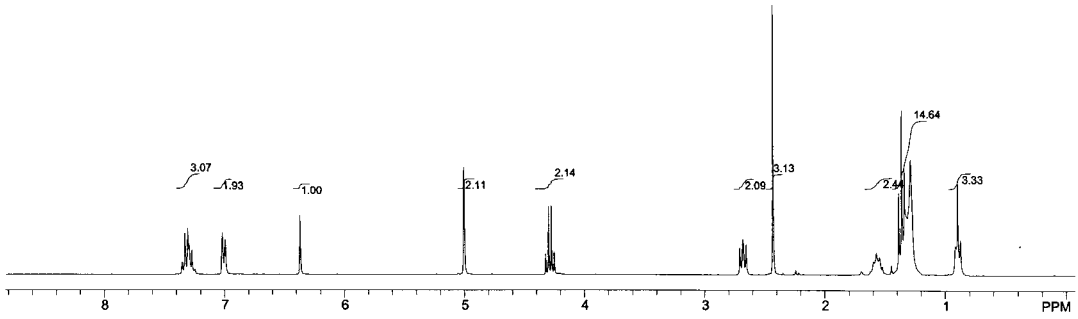
N
Bn

3aa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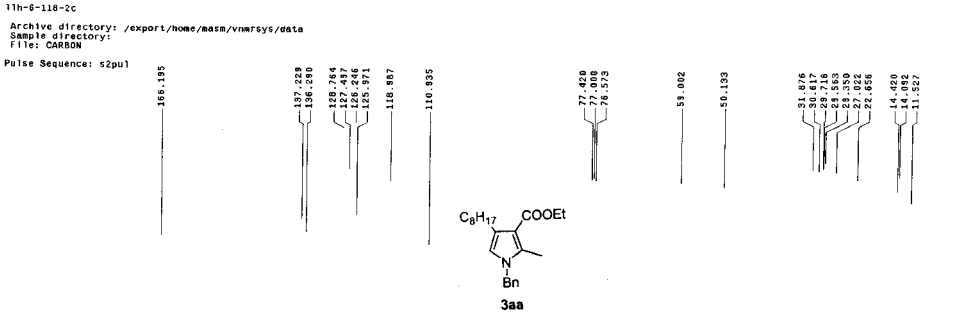
4
3
2
1
PPM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30.617
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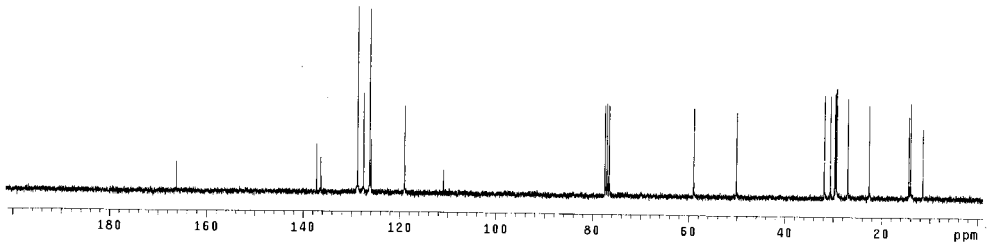
COOEt
N
Bn

3aa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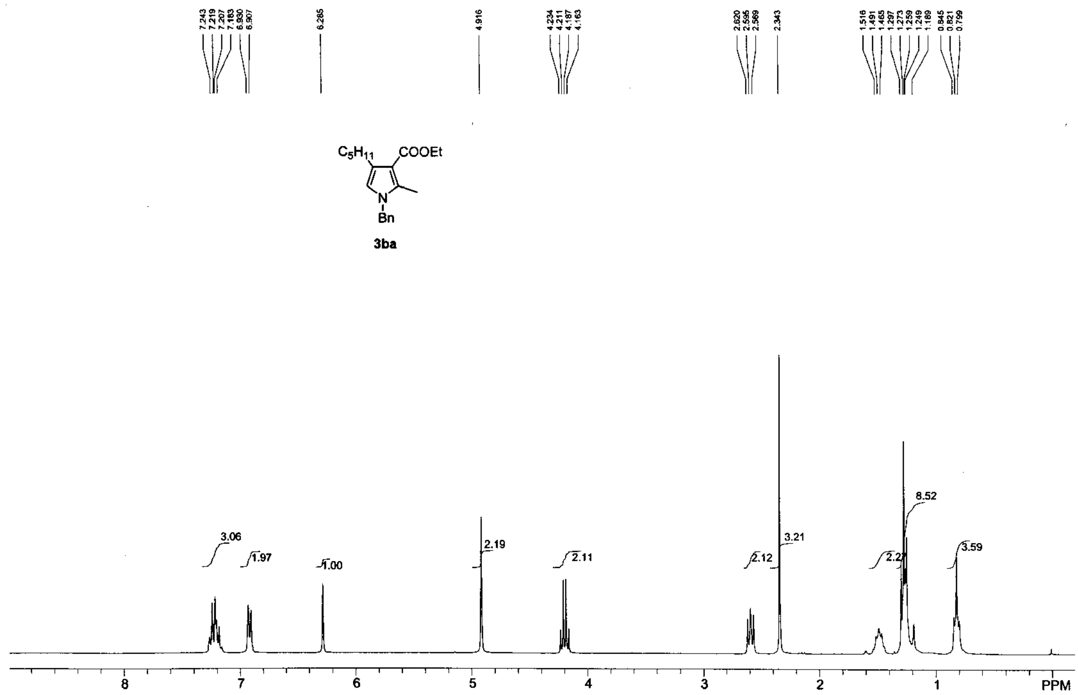

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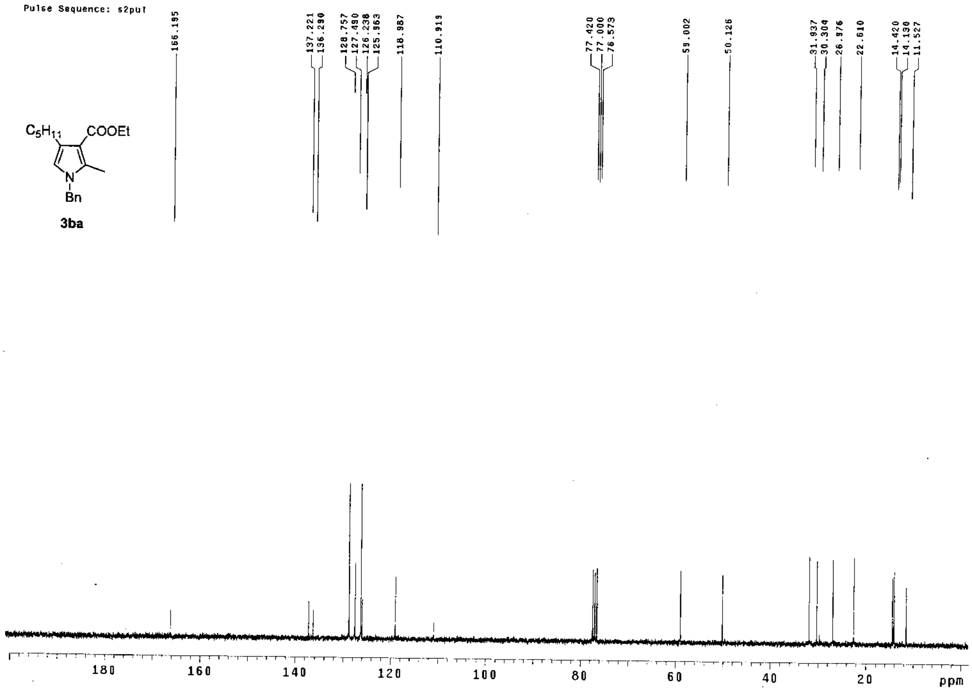

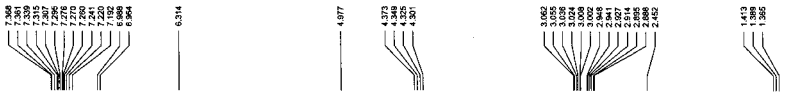

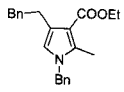
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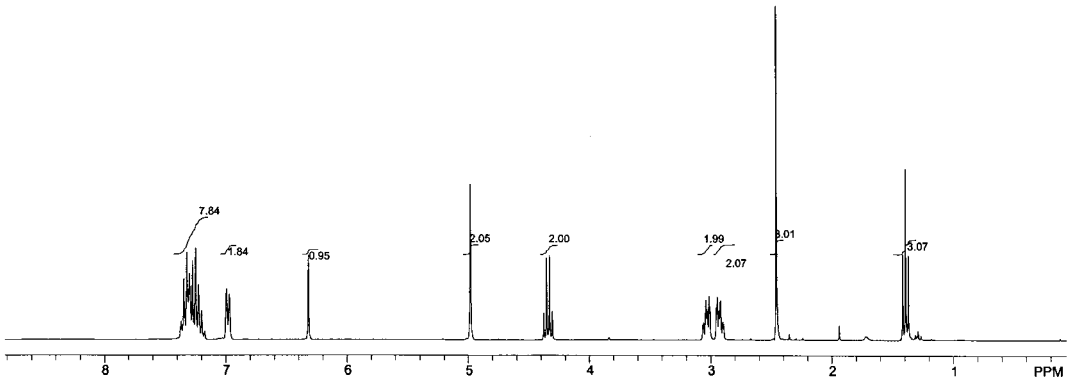
N
Bn

3ca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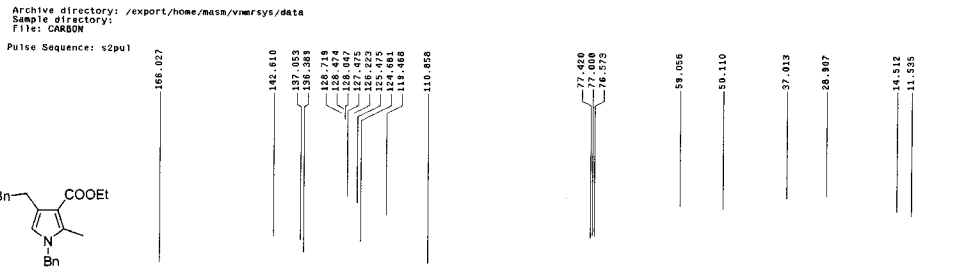
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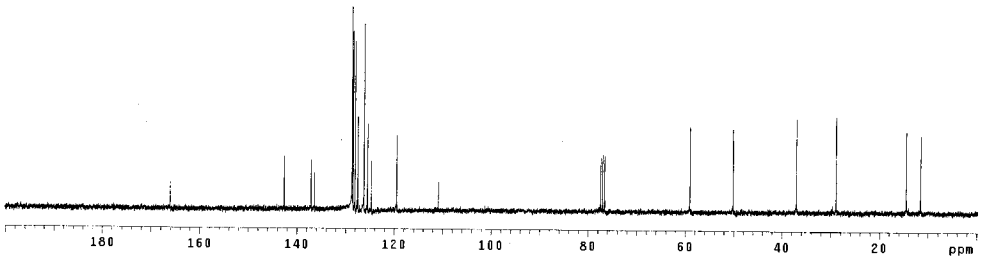
COOEt
N
Bn

3ca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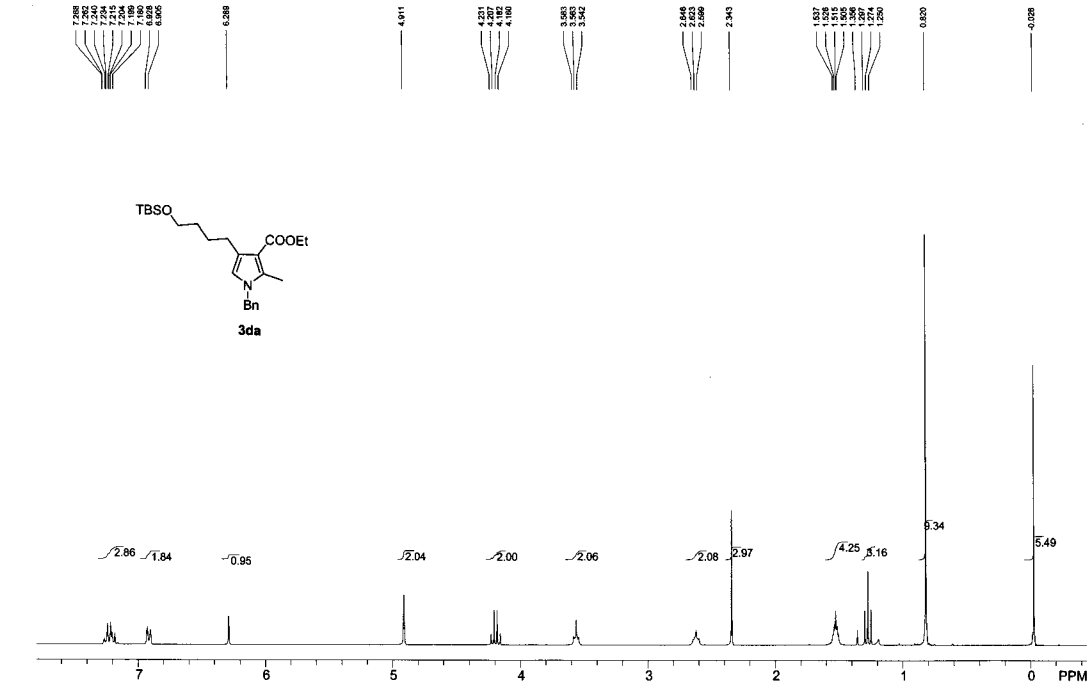
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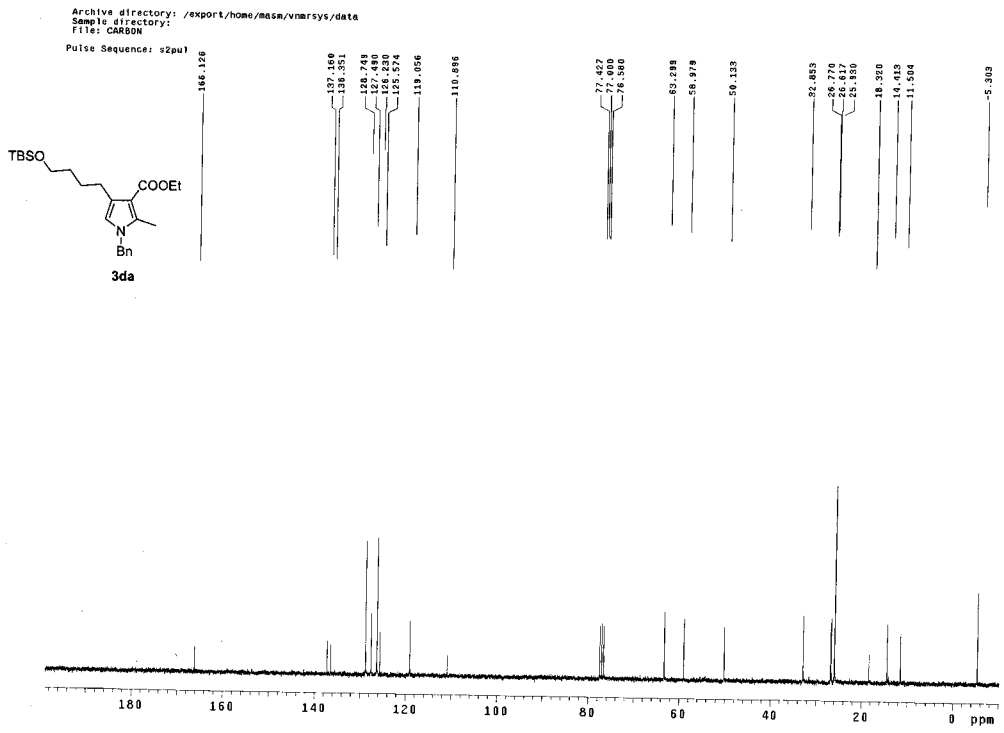
COOEt
N
Bn
3da
PPM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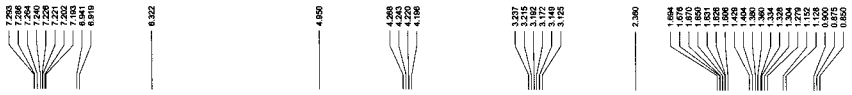
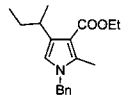
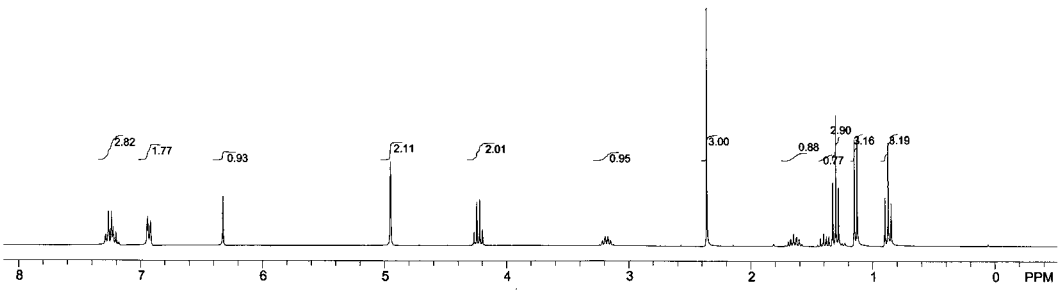
COOEt
N
Bn
3da
ppm




COOEt
N
Bn

3ea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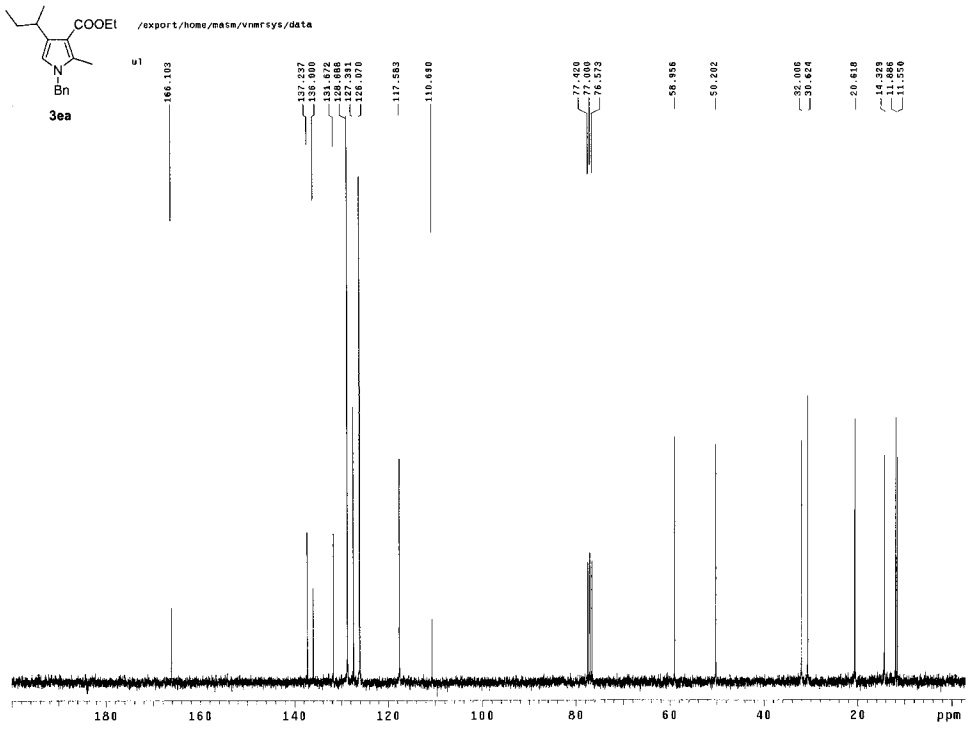
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77.000
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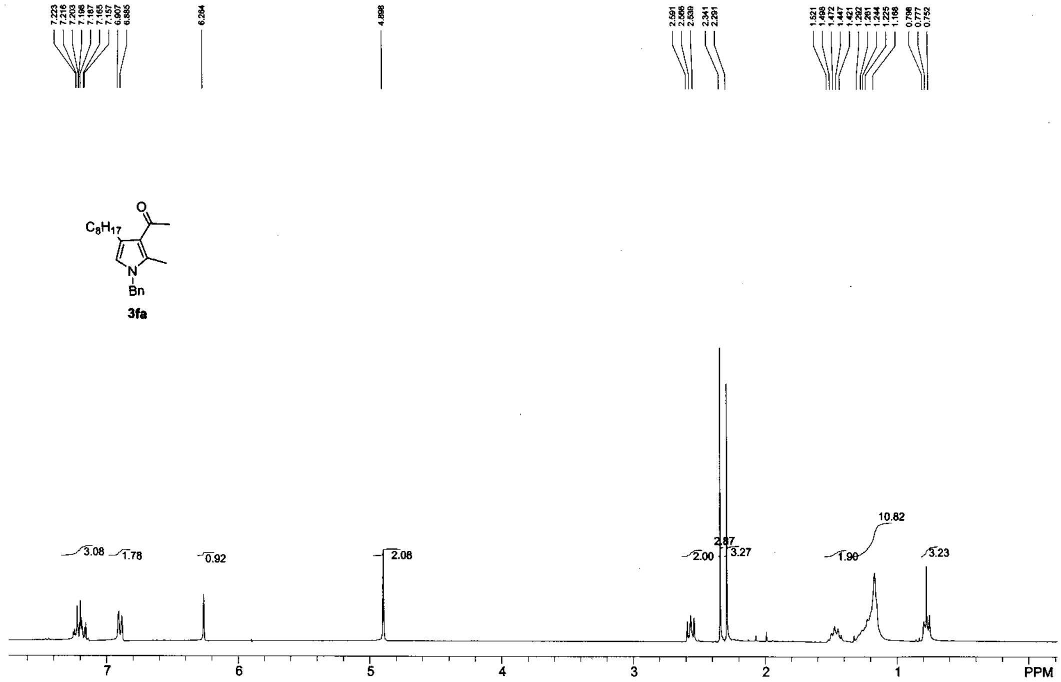
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0.798 0.777 0.752
C_8H_{17}
O
N
Bn
3fa
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1.78
0.92
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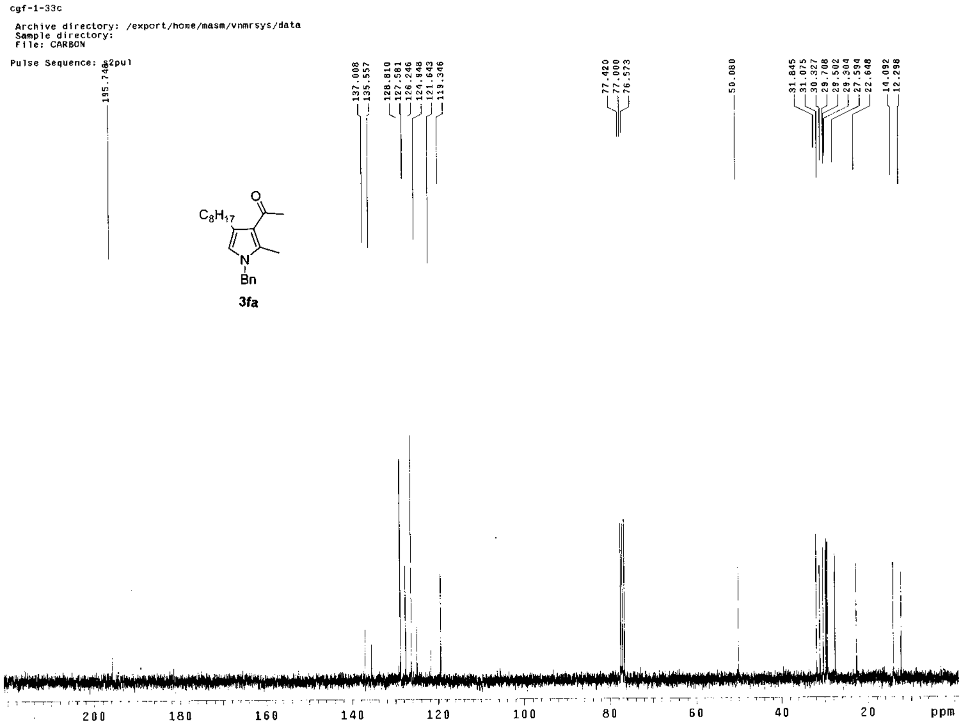
7
6
5
4
3
2
1
PPM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50.080
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14.092 12.298
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N
Bn
3fa
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60
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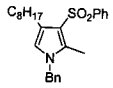
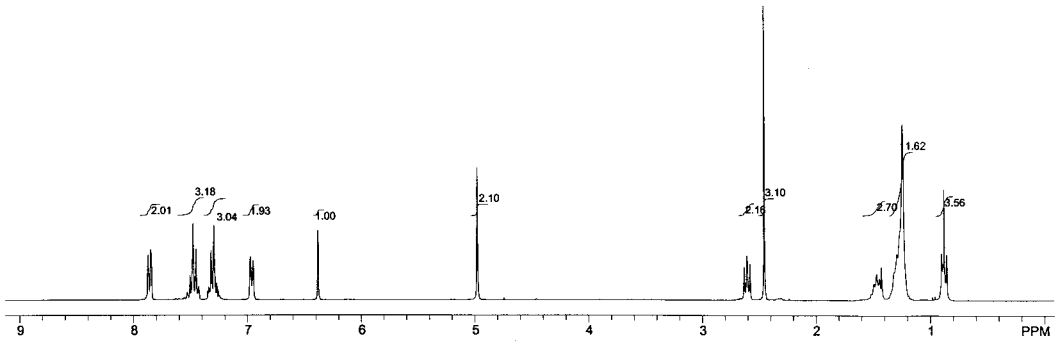
20
ppm



3ga



cgf-1-31c

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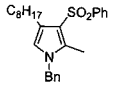
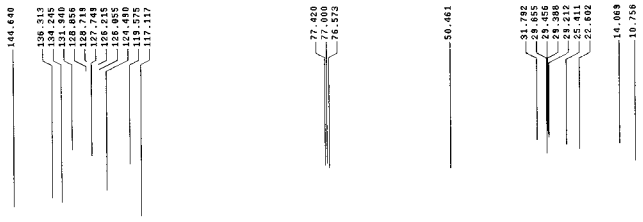
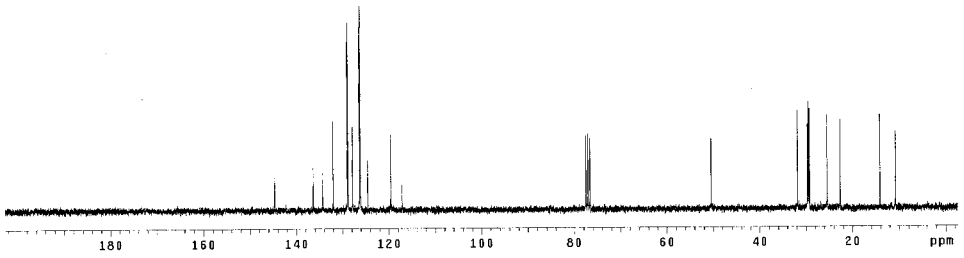
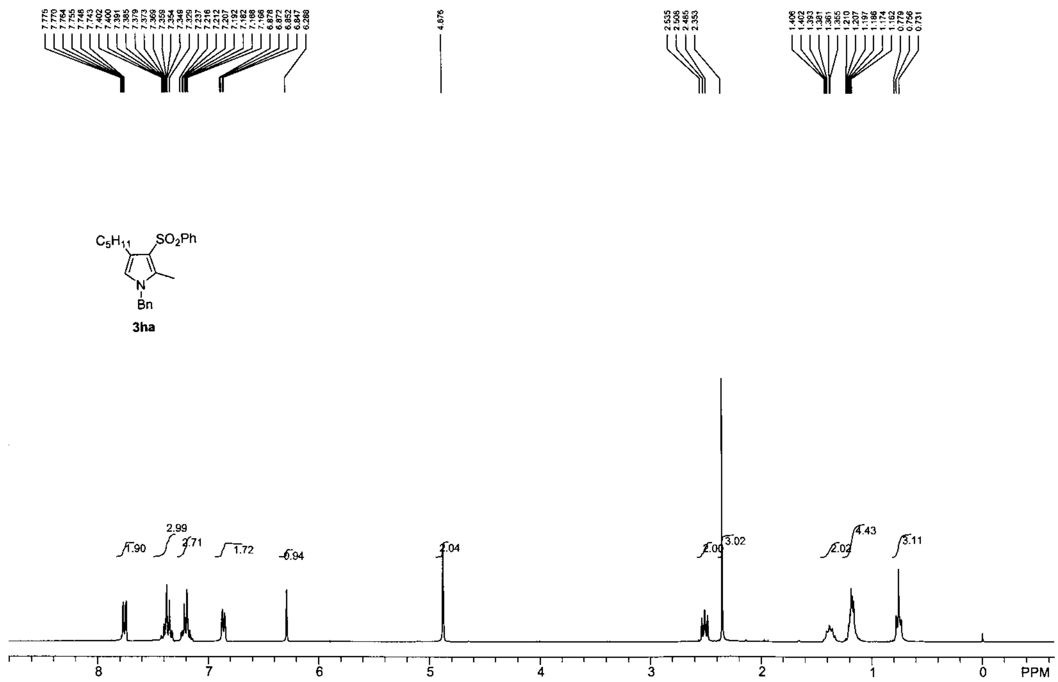


3ga







cgf-1-36c
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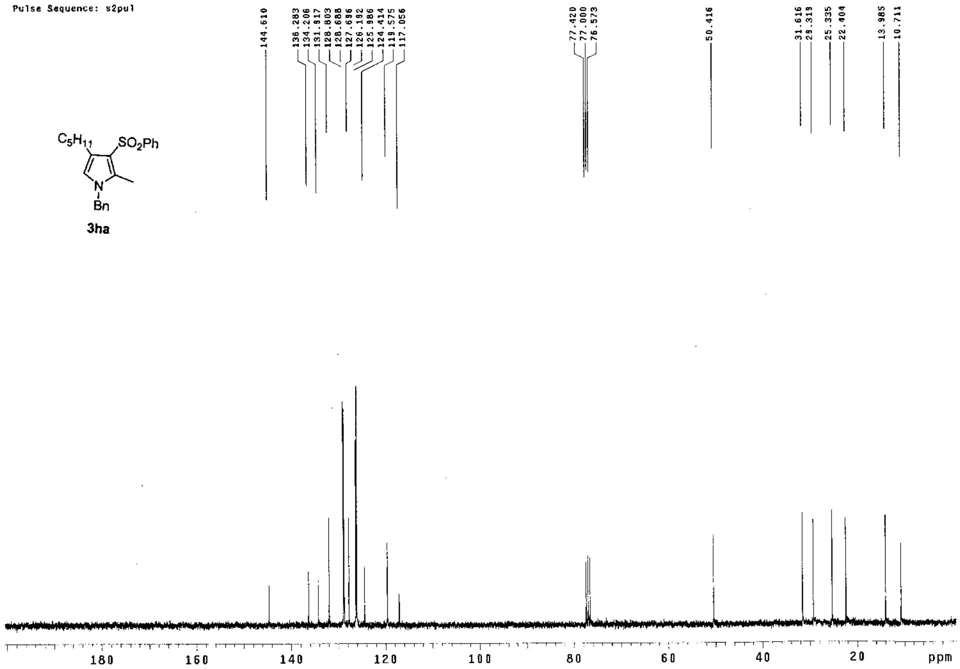

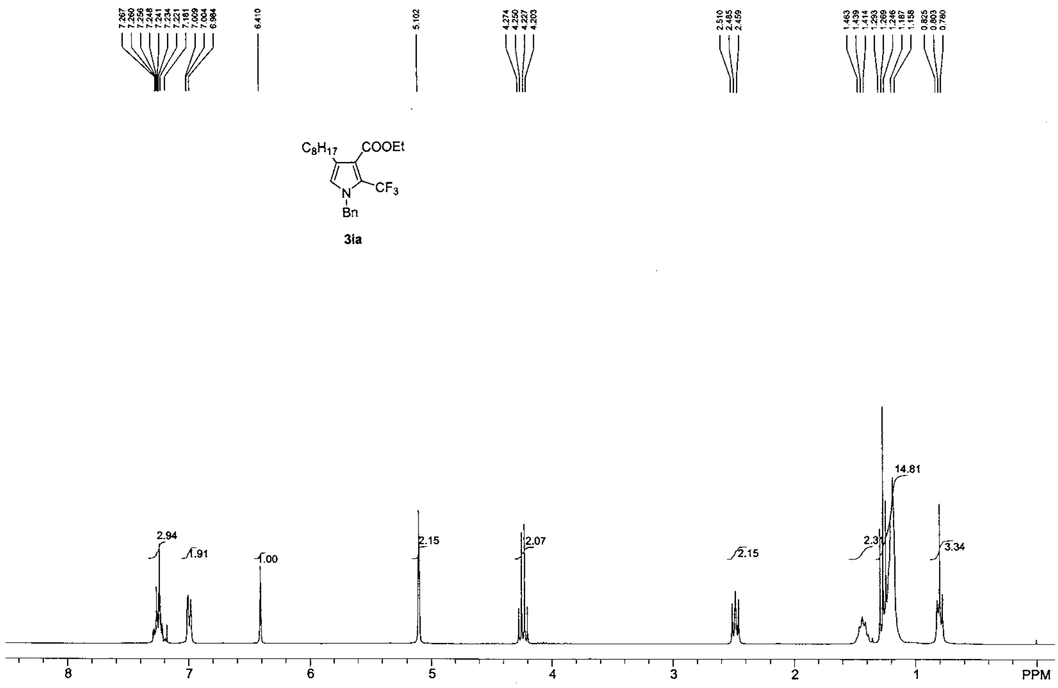

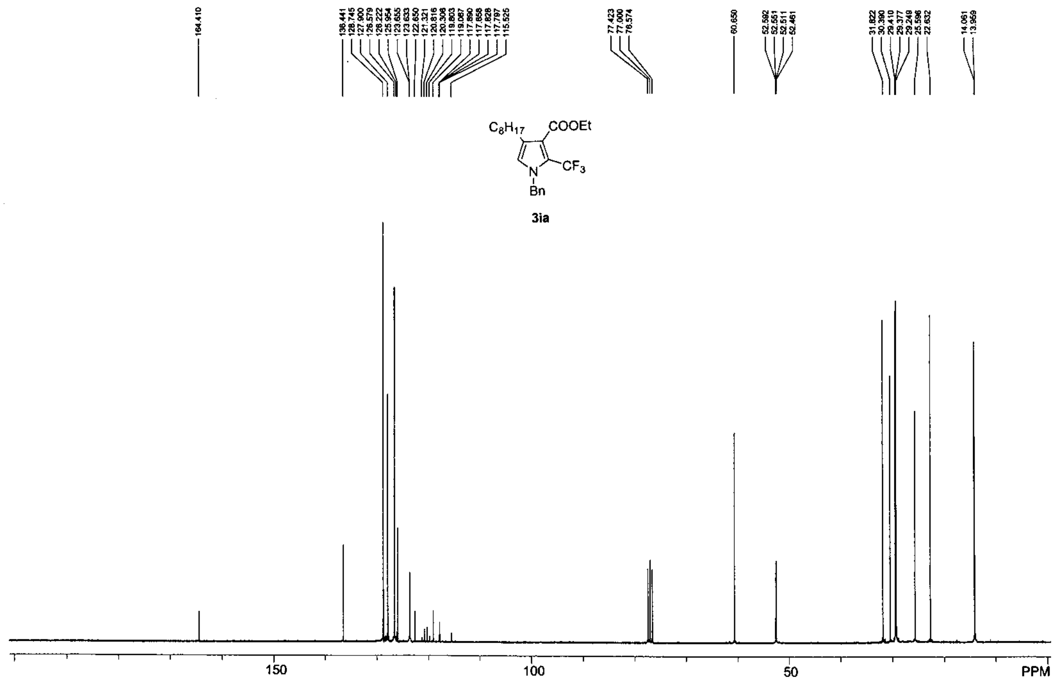

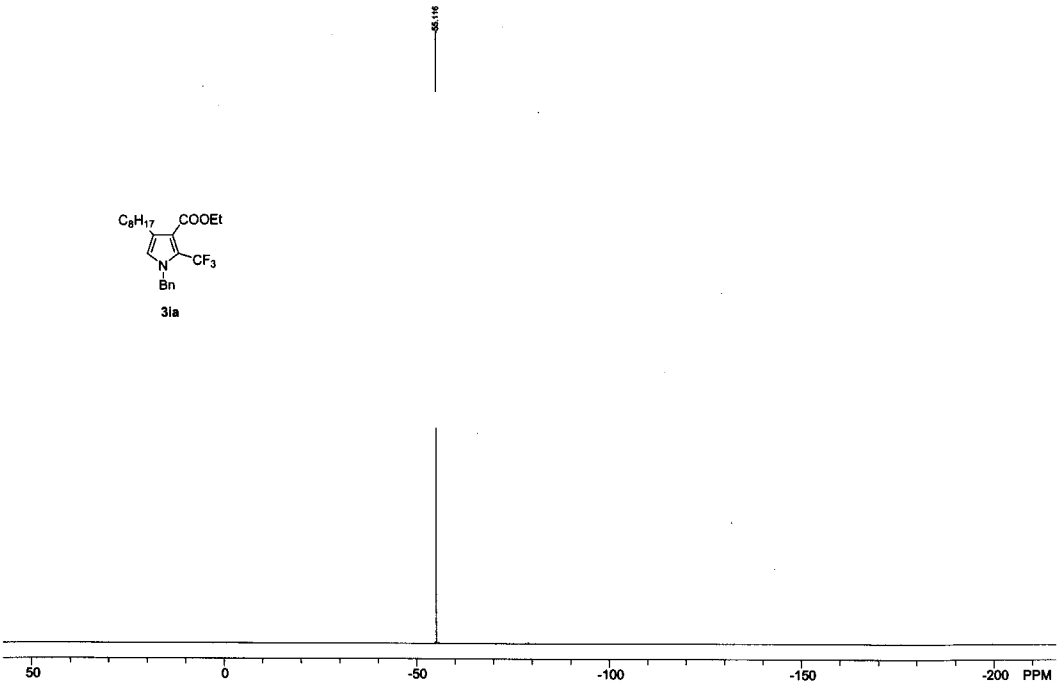
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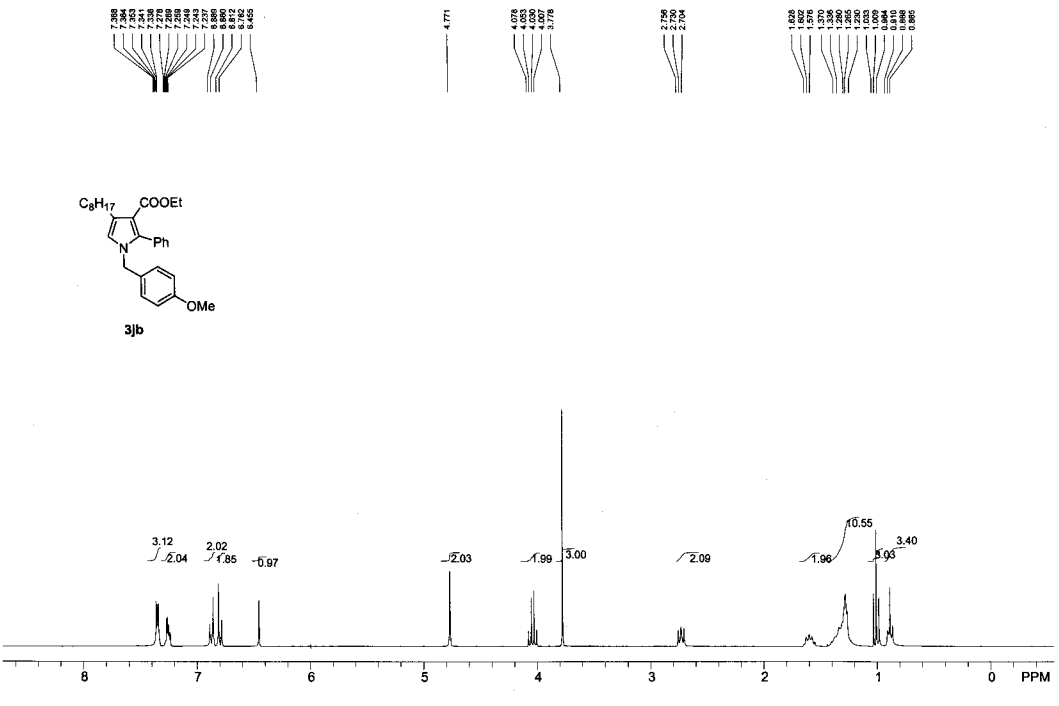
PPM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COOEt
Ph
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OMe
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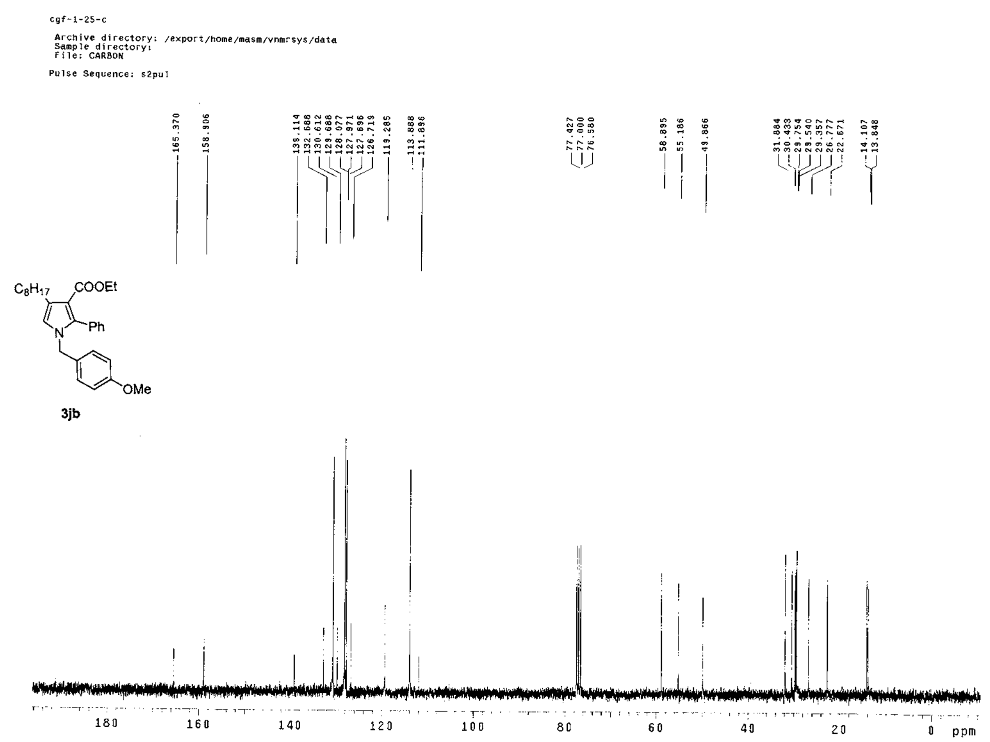
PPM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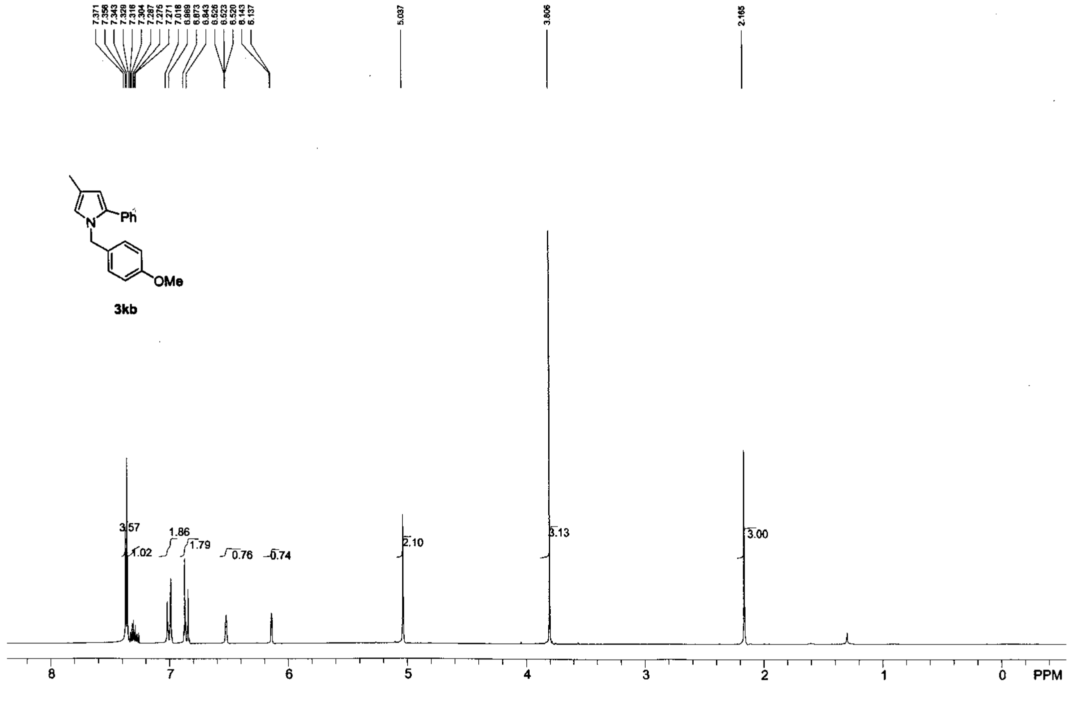
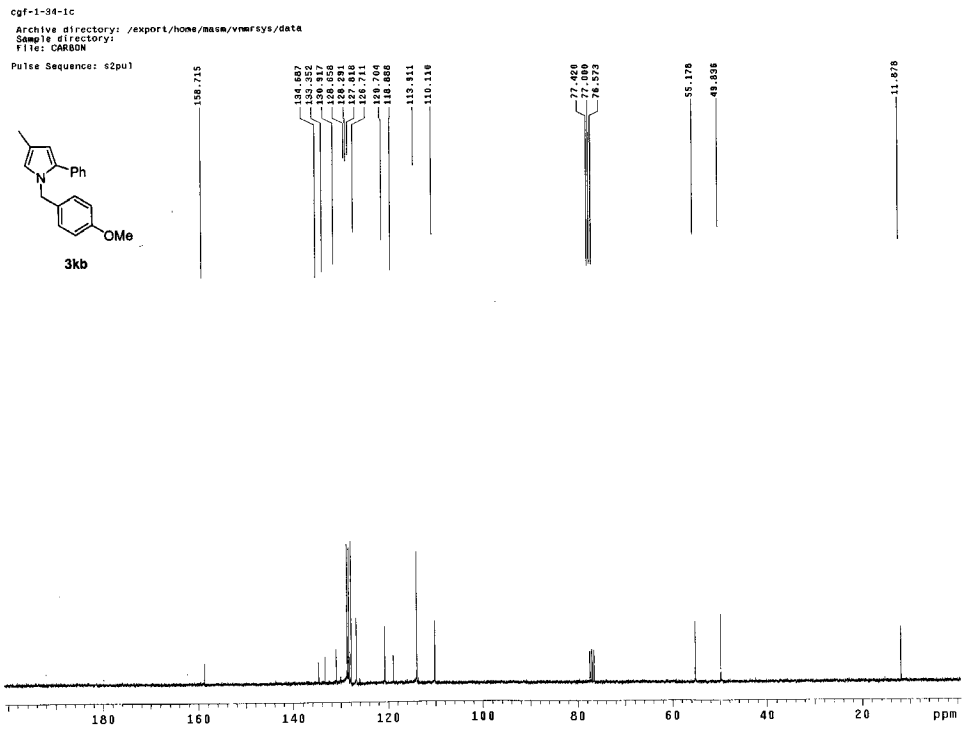
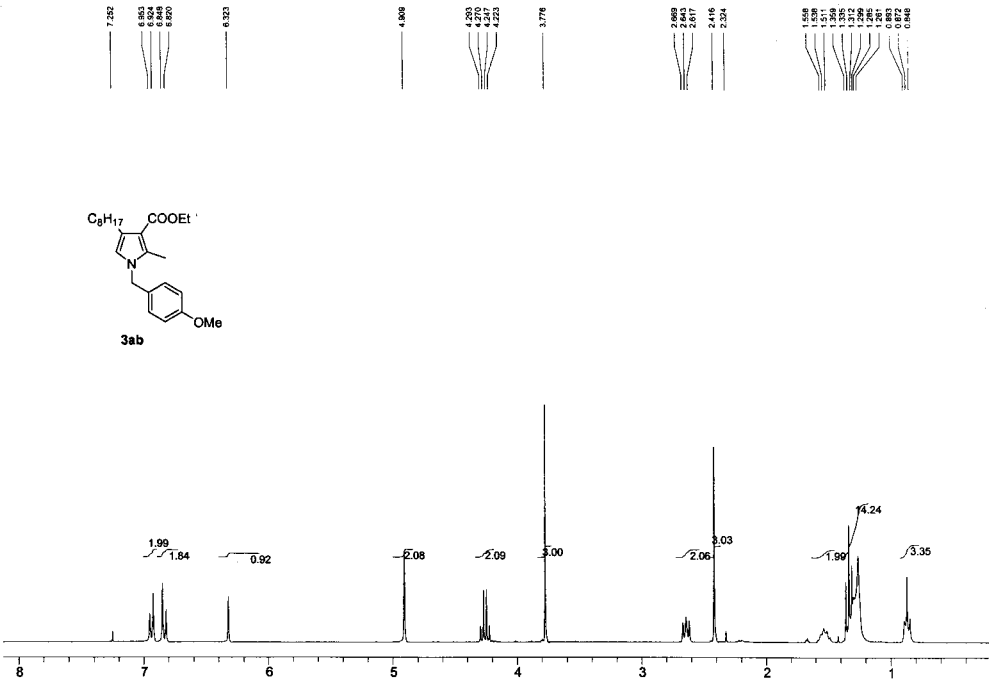
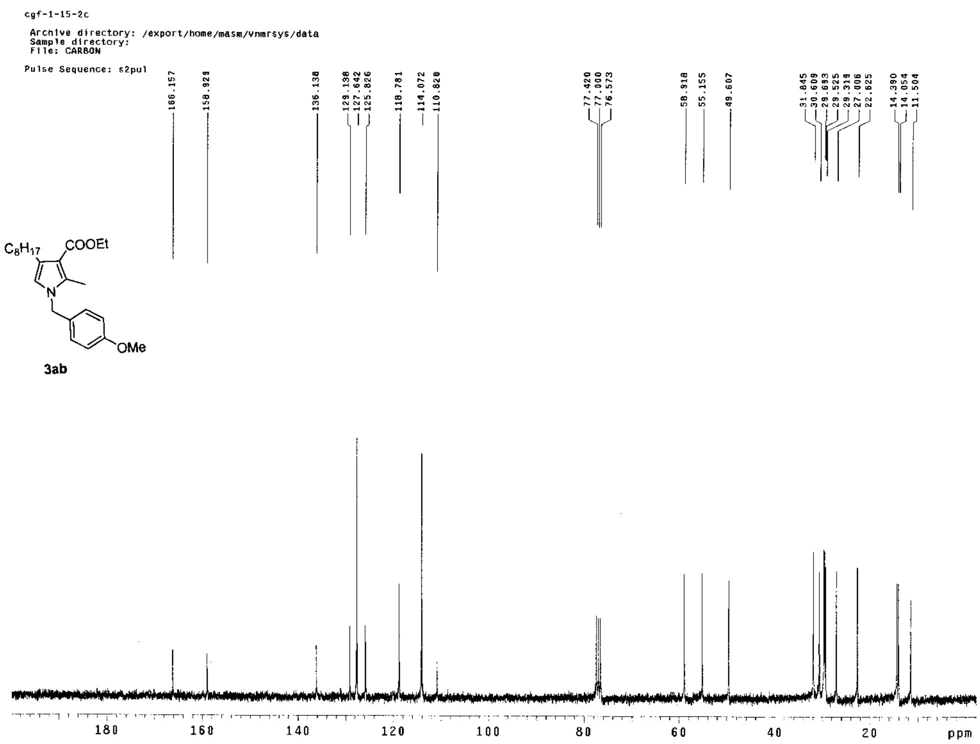
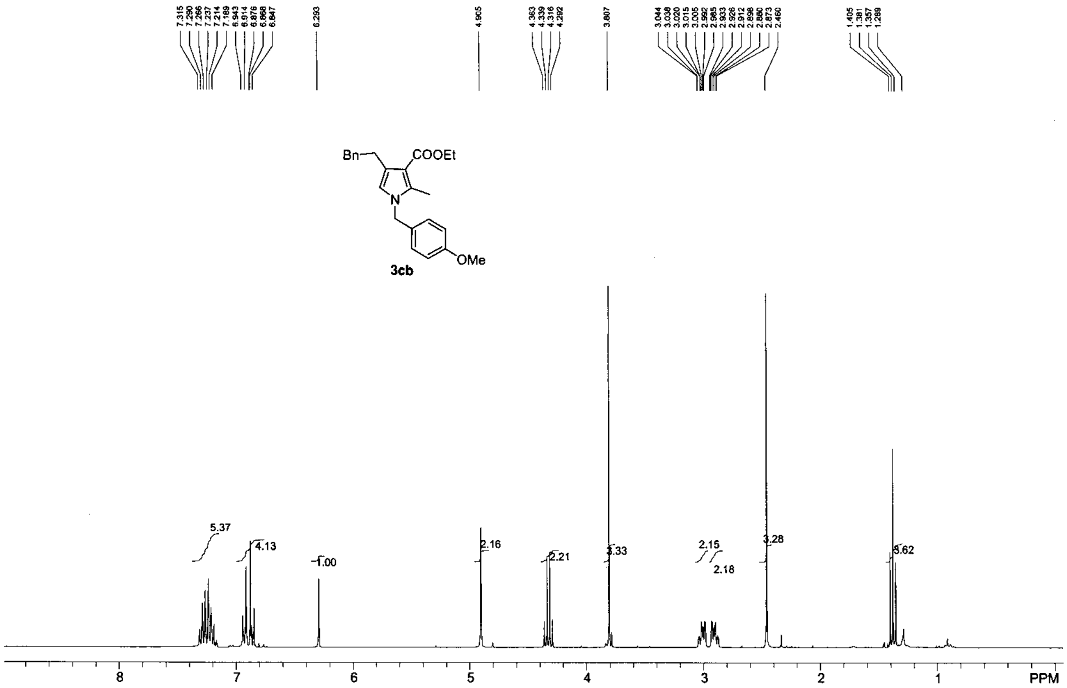
Ph
OMe
3jb
ppm

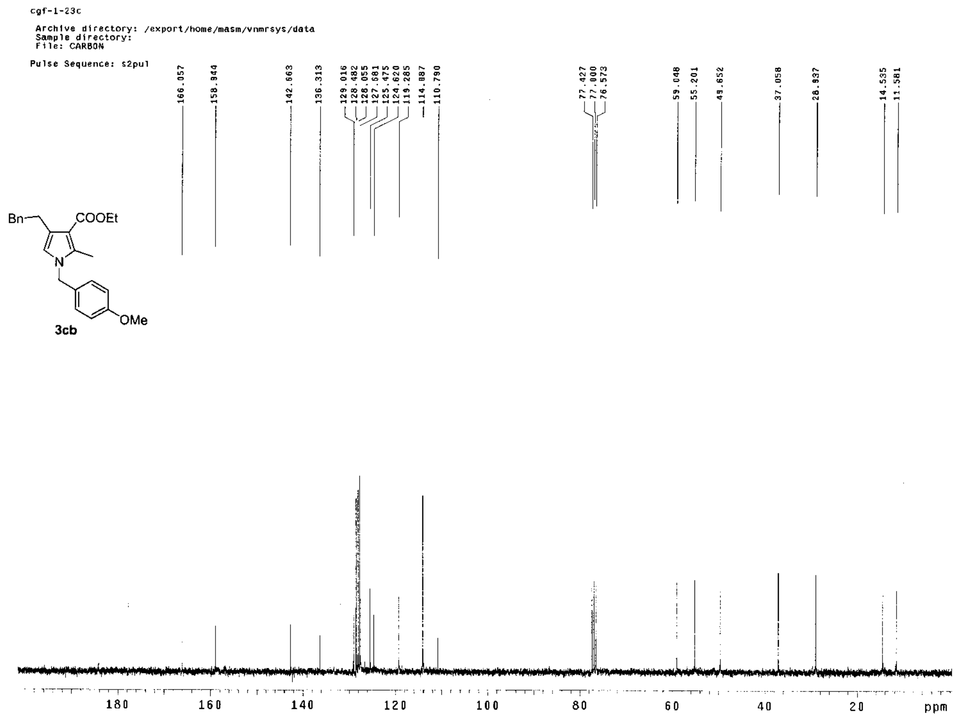

Ph
OMe
3kb
PPM


cgf-1-34-1c
Archive directory: /export/home/masm/vnmrsys/data
Sample directory:
File: CARBON
Pulse Sequence: s2pul
158.715
134.687
133.352
130.817
128.858
128.291
127.818
126.711
120.706
118.688
113.911
110.110
77.420
77.000
76.573
55.176
49.838
11.878
Ph
N
OMe
3kb
180
160
140
120
100
80
60
40
20
ppm

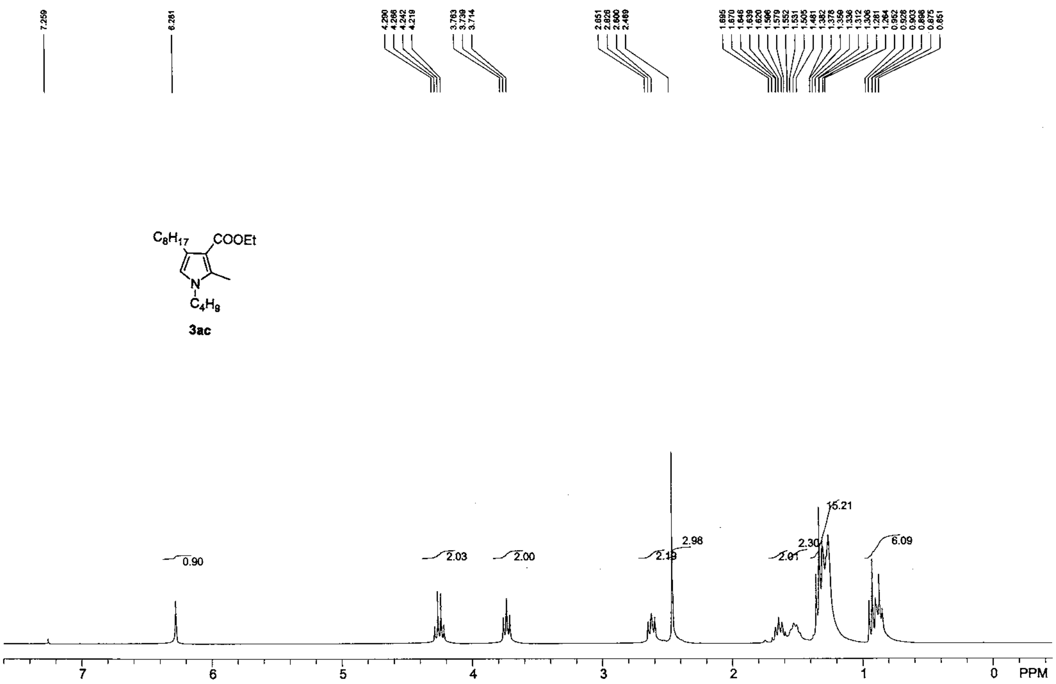

7.252
6.951
6.924
6.848
6.820
6.323
4.809
4.233
4.220
4.217
4.203
3.778
2.968
2.943
2.617
2.416
2.324
1.558
1.538
1.517
1.359
1.335
1.312
1.299
1.284
1.261
0.893
0.873
0.848
C8H17
COOEt
N
OMe
3ab
1.99
1.84
0.92
2.08
2.09
3.00
2.06
3.03
1.99
14.24
3.35
8
7
6
5
4
3
2
1
0PPM


cgf-1-15-2c
Archive directory: /export/home/masm/vnmrsys/data
Sample directory:
File: CARBON
Pulse Sequence: s2pul
C_8H_{17}
COOEt
N
OMe
3ab
ppm

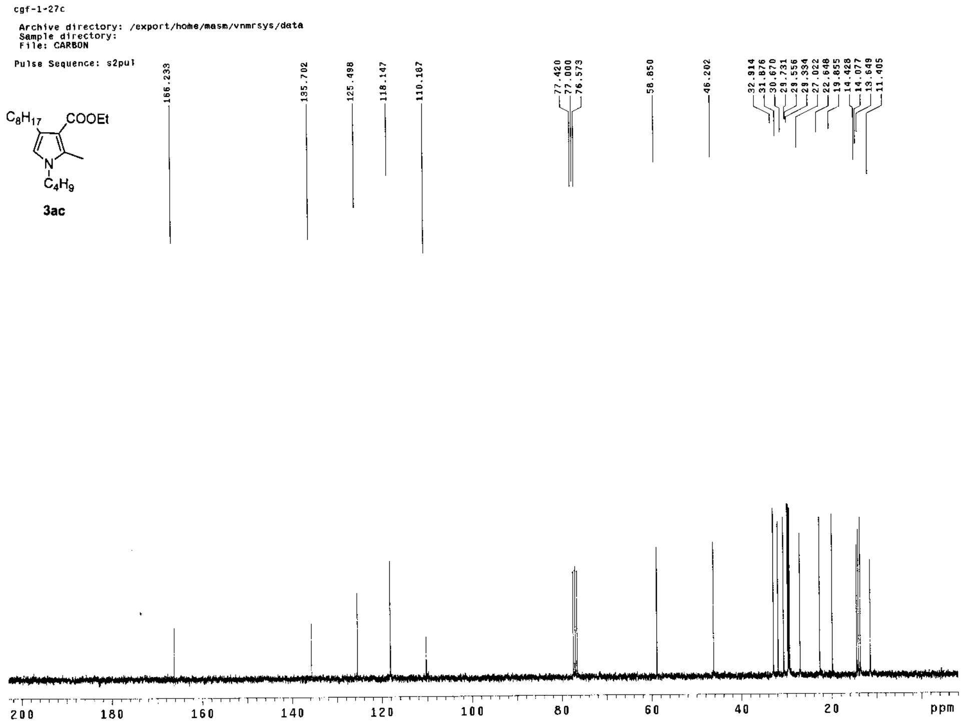

Bn
COOEt
N
OMe
3cb
PPM

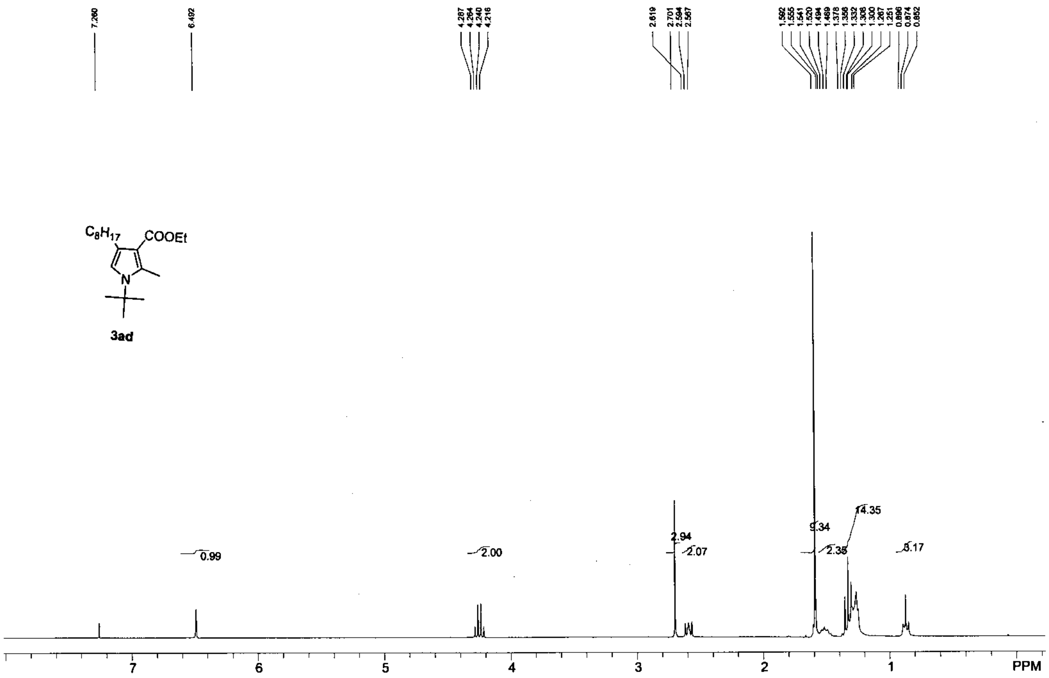

cgf-1-23c
Archive directory: /export/home/masm/vnmrsys/data
Sample directory:
File: CARBON
Pulse Sequence: s2pul
166.057
158.844
142.663
136.313
129.016
128.482
128.055
127.581
125.475
124.620
119.285
114.887
110.790
77.427
77.000
76.573
59.048
55.201
49.652
37.058
28.937
14.535
11.581
Bn
COOEt
N
OMe
180
160
140
120
100
80
60
40
20
ppm

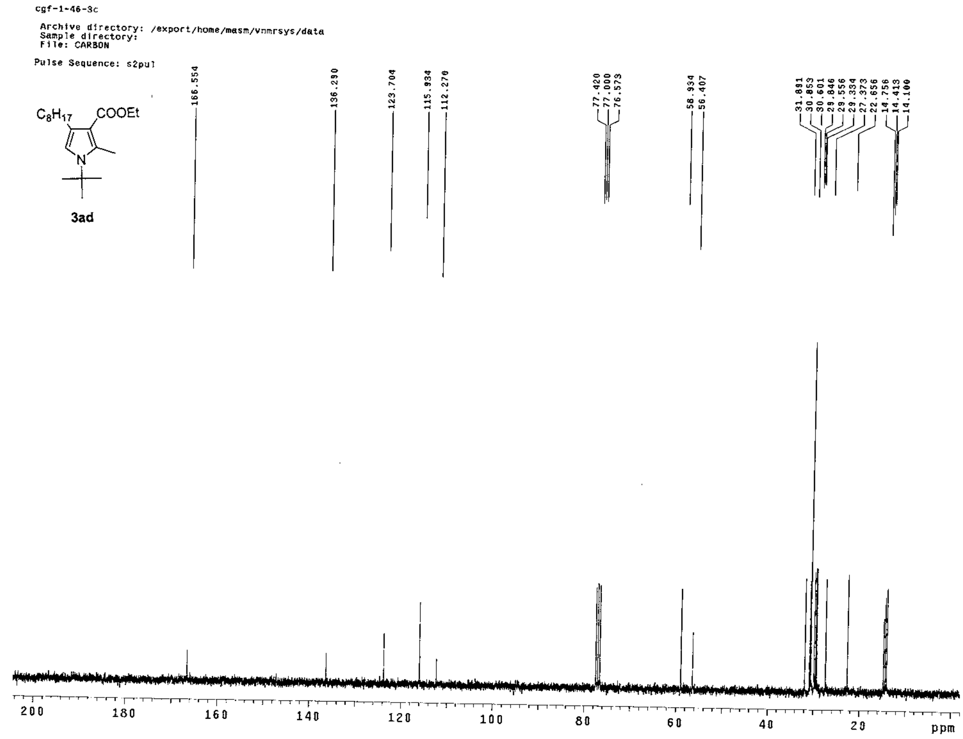
3cb

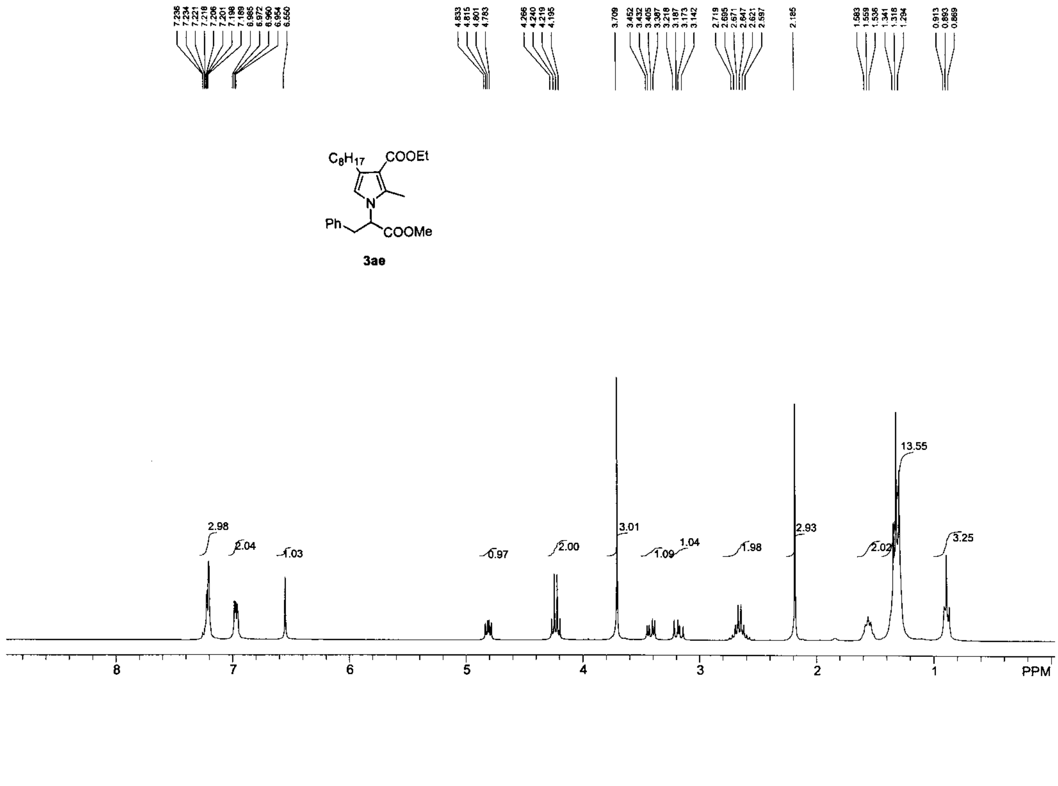

C8H17
COOEt
N
C4H9
0.90
2.03
2.00
2.19
2.98
2.01
2.30
15.21
6.09
7
6
5
4
3
2
1
0
PPM

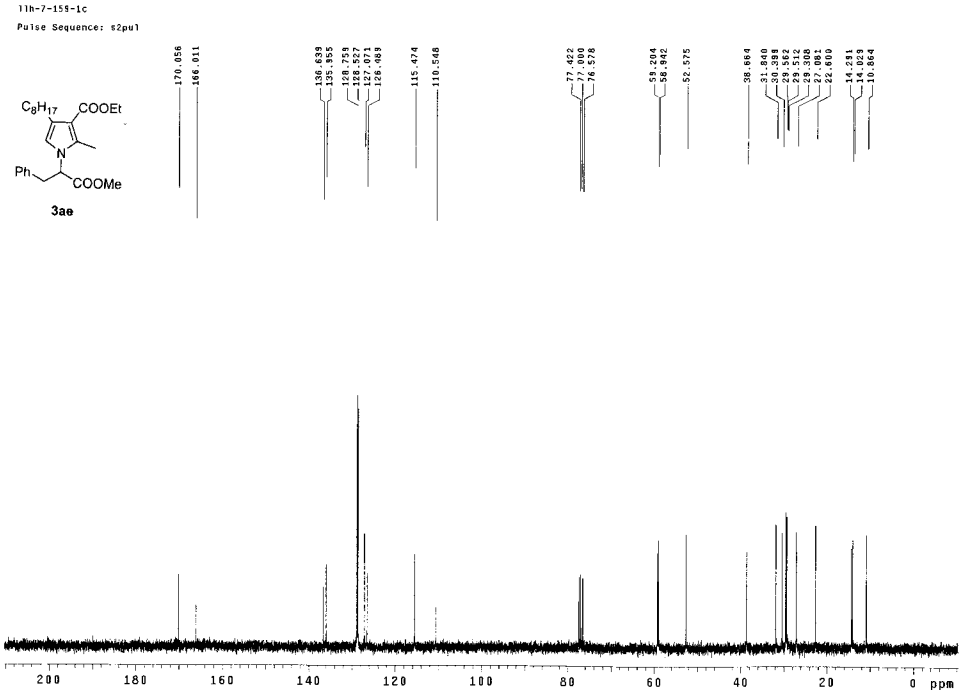
3ac


cgf-1-27c
Archive directory: /export/home/masm/vnmrsys/data
Sample directory:
File: CARBON
Pulse Sequence: s2pul
C_8H_{17}
COOEt
N
C_4H_9
3ac
166.233
135.702
125.498
118.147
110.167
77.420
77.000
76.573
58.850
46.202
32.914
31.876
30.670
29.731
29.556
28.334
27.022
22.648
19.855
14.428
14.077
13.649
11.405
200 180 160 140 120 100 80 60 40 20 ppm


C_8H_{17}
COOEt
N
3ad
7.260
6.492
0.99
2.00
2.94
2.07
9.34
2.35
14.35
3.17
7 6 5 4 3 2 1 PPM


cgf-1-46-3c
Archive directory: /export/home/masm/vnmrsys/data
Sample directory:
File: CARBON
Pulse Sequence: s2pul
C8H17
COOEt
N
3ad
166.554
136.290
123.704
115.934
112.270
77.420
77.000
76.573
58.934
56.407
31.881
30.853
30.601
29.846
29.556
29.334
27.373
22.656
14.735
14.413
14.100
200
180
160
140
120
100
80
60
40
20
ppm


C8H17
COOEt
N
Ph
COOMe
3ae
2.98
2.04
1.03
0.97
2.00
3.01
1.09
1.04
1.98
2.93
2.02
13.55
3.25
8
7
6
5
4
3
2
1
PPM


11h-7-155-1c
Pulse Sequence: s2pul
170.056
166.011
136.639
135.955
128.759
128.527
127.071
126.489
115.474
110.548
77.422
77.000
76.578
59.204
58.942
52.575
38.664
31.840
30.388
29.562
29.513
29.306
27.081
22.600
14.231
14.029
10.864
C8H17
COOEt
N
Ph
COOMe
3ae
200
180
160
140
120
100
80
60
40
20
0
ppm