Supporting Information for

Selective transannular ring transformations in azirino-fused eight- membered O,N- or S,N-heterocycles

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General methods. Melting points were determined on a hot stage microscope (Boetius) and are uncorrected. IR spectra were recorded on a Carl-Zeiss UR 20 spectrometer. ^{1}H NMR spectra were recorded on a Bruker DPX 300 spectrometer at 300 MHz with internal standard TMS (δ = 0) and ^{13}C NMR spectra – at 75 MHz with internal standard $CDCl_3$ (δ = 77). Mass spectra were measured with Varian MAT 731, MAT CH 7 spectrometers (70 eV). Elemental analysis was performed on a Hewlett-Packard 185B CHN-analyser. Methylene chloride was dried by distillation over phosphorus pentoxide. Silica gel LS 5/40 (Chemapol) was used for column chromatography. Compounds **1a**,**b** were prepared by the reported procedure.[1] Anhydrous $ZnCl_2$ was prepared according to the reported procedure.[2]

1,1-Dichloro-1a-phenyl-1a,2,3,4-tetrahydro-1*H*-azirino[2,1-*e*][1,6]benzoxazocine (2a). Pellets of KOH (2.4 g, 42.8 mmol) were added to a solution of benzoxazocine **1a** (1.2 g, 5.06 mmol) and benzyltriethylammonium chloride (TEBA) (0.2 g, 0.879 mmol) in chloroform (20 mL) and the mixture was vigorously stirred at 21-23°C for 0.5 h. After addition of hexane (10 mL) the reaction mixture was stirred for 0.5 h, then passed through a short silica plug, which was subsequently washed with hexane (30 mL). The solvent was removed under reduced pressure, and crystallization of the residue from diethyl ether yielded 1.42 g (88%) of azirinobenzoxazocine **2a**. White solid; mp 148-150 °C (Et_2O). ^{1}H NMR ($CDCl_3$): δ 1.45-1.60 (m, 1H), 1.70-1.85 (m, 2H), 2.60-2.68 (m, 1H), 3.61-3.69 (m, 1H), 4.58-4.63 (m, 1H), 7.10–7.30 (m, 4H), 7.40-7.50 (m, 3H), 7.55-7.65 (m, 2H). ^{13}C NMR ($CDCl_3$): δ 26.4 (CH_2), 28.9 (CH_2), 60.2 (CPh), 78.8 (CCl_2), 79.0 (OCH_2), 121.9, 123.3, 124.19, 124.21, 127.8, 128.27, 128.33, 135.4, 137.6, 151.8. Anal. Calcd. for $C_{17}H_{15}Cl_2NO$, %: C 63.77, H 4.72, N 4.37. Found, %: C 63.79, H 4.83, N 4.35.

1,1-Dichloro-1a-phenyl-1a,2,3,4-tetrahydro-1*H*-azirino[2,1-*e*][1,6]benzothiazocine (2b). Pellets of KOH (4 g, 71 mmol) were added to a solution of benzothiazocine **1b** (2 g, 7.91 mmol) and benzyltriethylammonium chloride (TEBA) (0.4 g, 1.758 mmol) in chloroform (25 mL) and the mixture was vigorously stirred at 21-23°C for 2 h. After addition of hexane (20 mL) the reaction mixture was stirred for 0.5 h, then passed through a basic alumina plug, which was subsequently washed with hexane

(1) Press, J. B.; Eudy, N. H. *J. Org. Chem*. **1984**, *49*, 116-122.
(2) Weberg, R. T.; Haltiwanger, R. C.; Laurie, J. C. V.; Dubois, M. R. *J. Am. Chem. Soc*. **1986**, *108*, 6442-6450.

(30 mL). The solvent was removed under reduced pressure, and crystallization of the residue from diethyl ether yielded 1.25 g (48%) of azirinobenzotiazocine **2b.** White solid; mp 144-146 °C (Et_2O). ^1H NMR ($CDCl_3$): 1.46-1.59 (m, 1H), 1.60-1.77 (m, 1H), 1.85-1.95 (m, 1H), 2.40-2.53 (m, 1H), 2.75-2.85 (m, 1H), 3.03-3.12 (m, 1H), 7.06–7.14 (m, 1H), 7.33-7.51 (m, 5H), 7.63-7.71 (m, 3H). ^{13}C NMR ($CDCl_3$): δ 26.6 (CH_2), 30.3 (CH_2), 40.8 (SCH_2), 61.3 (CPh), 78.3 (CCl_2), 121.5, 123.6, 124.5, 127.7, 128.0, 129.1, 129.8, 137.3, 138.9, 146.3. Anal. Calcd. for $C_{17}H_{15}Cl_2NS$, %: C 60.72, H 4.50, N 4.17. Found, %: C 60.72, H 4.76, N 3.90.

1-Chloro-1-fluoro-1a-phenyl-1a,2,3,4-tetrahydro-1*H*-azirino[2,1-*e*][1,6]benzoxazocine (2c). Dichlorofluoromethane was bubbled through a vigorously stirred mixture of benzoxazocine **1a** (1 g, 4.2 mmol), powdery KOH (2.5 g, 44.6 mmol), and TEBA (0.2 g, 0.879 mmol) in CH_2Cl_2 (10 mL) at 8-11°C for 40 min. The reaction mixture was passed through a short silica plug, which was subsequently washed with hexane (30 mL). The solvent was removed under reduced pressure, and crystallization of the residue from diethyl ether yielded 0.851 g (66%) of azirinobenzoxazocine **2c** as a single stereoisomer**.** White solid; mp 118-119 °C (Et_2O). ^1H NMR ($CDCl_3$): δ 1.42-1.54 (m, 1H), 1.56-1.70 (m, 1H), 1.74-1.92 (m, 1H), 2.57-2.63 (m, 1H), 3.63-3.73 (m, 1H), 4.60-4.65 (m, 1H), 7.11-7.24 (m, 4H), 7.34-7.50 (m, 3H), 7.60-7.66 (m, 2H). ^{13}C NMR ($CDCl_3$): δ 25.6 (d, J_{HF} 2 Hz), 28.6 (d, J_{HF} 4 Hz), 60.1 (d, J_{HF} 13 Hz, CPh), 78.9 (OCH_2), 98.9 (d, J_{HF} 294 Hz, CFCl), 122.1, 123.4, 124.1, 124.4, 127.8, 128.3, 128.4, 135.2, 135.9 (d, J_{HF} 4 Hz), 152.1 (d, J_{HF} 3 Hz). Anal. Calcd. for $C_{17}H_{15}ClFNO$, %: C 67.22, H 4.98, N 4.61. Found, %: C 67.41, H 4.94, N 4.48.

1-Chloro-1-fluoro-1a-phenyl-1a,2,3,4-tetrahydro-1*H*-azirino[2,1-*e*][1,6]benzothiazocine (2d). Sodium dichlorofluoroacetate (16 g, 94.7 mmol) was added by small portions to a gently refluxed and vigorously stirred solution of benzothiazocine **1b** (1.2 g, 4.74 mmol) and TEBA (0.2 g, 0.879 mmol) in dichloroethane (100 mL) over 3 h. Then the solvent was evaporated under reduced pressure, CH_2Cl_2 (50 mL) was added to the residue and the mixture was filtered through a short silica plug, which was subsequently washed with hexane (30 mL). The solvent was removed under reduced pressure, and crystallization of the residue from diethyl ether yielded 0.482 g (32%) of azirinobenzothiazocine **2d** as a single stereoisomer. White solid; mp 123-125 °C (Et_2O). ^1H NMR ($CDCl_3$): δ 1.38-1.85 (m, 3H), 2.42-2.53 (m, 1H), 2.65-2.77 (m, 1H), 3.05-3.11 (m, 1H), 7.08-7.14 (m, 1H), 7.28-7.49 (m, 5H), 7.62-7.75 (m, 3H). ^{13}C NMR ($CDCl_3$): δ 25.8 (d, J_{HF} 1 Hz), 29.8 (d, J_{HF} 3 Hz), 40.8 (CH_2S), 61.3 (d, J_{HF} 13 Hz, CPh), 98.2 (d, J_{HF} 294 Hz, CFCl), 121.6, 123.8, 123.9, 127.6, 128.1, 128.9, 129.7, 135.5 (d, J_{HF} 4 Hz), 139.0, 146.2. Anal. Calcd. for $C_{17}H_{15}ClFNS$, %: C 63.84, H 4.73, N 4.38. Found, %: C 63.89, H 4.75, N 4.23.

Procedure for Reaction of benzoxazocine 2a with Methanol. A solution of azirinobenzoxazocine **2a** (0.13 g, 0.406 mmol) in methanol (2 mL) was refluxed for 1.4 h. The solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give compounds **3b** (0.081 g, 24%), **3a** (0.162 g, 50%), **4b** (0.021 g, 6%), and **4a** (0.021 g, 6%).

3-Methoxy-2-(3-methoxypropyl)-2-phenyl-2*H*-1,4-benzoxazine (3a). White solid; mp 69-70 °C (hexane-Et_2O). ^1H NMR ($CDCl_3$): δ 1.36-1.50 (m, 1H), 1.51-1.65 (m, 1H), 2.46-2.58 (m, 1H), 2.72-2.84 (m, 1H), 3.30 (s, 6H, OCH_3), 3.34-3.40 (m, 2H), 7.22-7.34 (m, 5H), 7.46–7.53 (m, 3H), 7.77-7.82 (m, 1H). ^{13}C NMR ($CDCl_3$): δ 22.6 (CH_2), 31.9 (CH_2), 51.6 (OCH_3), 58.4 (OCH_3), 72.3 (OCH_2), 80.8 (CPh), 110.9, 120.3, 124.3, 125.3, 126.0, 127.7, 128.2, 140.4, 140.6, 150.8, 167.0 (C=N). Anal. Calcd. for $C_{19}H_{21}NO_3$, %: C 73.29, H 6.80, N 4.50. Found, %: C 73.39, H 6.93, N 4.67.

2-(3-Chloropropyl)-3-methoxy-2-phenyl-2*H*-1,4-benzoxazine (3b). White solid; mp 75-76 °C (hexane-Et_2O). ^1H NMR ($CDCl_3$): δ 1.56-1.71 (m, 1H), 1.72-1.86 (m, 1H), 2.53-2.65 (m, 1H), 2.82-2.94 (m, 1H), 3.33 (s, 3H, OCH_3), 3.52-3.60 (m, 2H), 7.30-7.42 (m, 5H), 7.47–7.52 (m, 3H), 7.79-7.83 (m, 1H). ^{13}C NMR ($CDCl_3$): δ 25.9 (CH_2), 32.7 (CH_2), 44.9 (CH_2), 51.8 (OCH_3), 80.5 (CPh), 111.0, 120.3,

124.4, 125.4, 125.9, 127.9, 128.4, 140.1, 140.5, 150.9, 166.6 (C=N). Anal. Calcd. for $C_{18}H_{18}ClNO_2$, %: C 68.46, H 5.74, N 4.44. Found, %: C 68.47, H 5.86, N 4.45.

2-(3-Methoxypropyl)-2-phenyl-2*H*-1,4-benzoxazin-3(4*H*)-one (4a). White solid; mp 138-140 °C (Et_2O). ^{1}H NMR ($CDCl_3$): δ 1.76-1.96 (m, 2H), 2.15-2.27 (m, 1H), 2.38-2.51 (m, 1H), 3.32 (s, 3H, OCH_3), 3.39-3.47 (m, 2H), 6.65-6.73 (m, 1H), 6.85-6.93 (m, 1H), 6.95-7.03 (m, 1H), 7.09-7.15 (m, 1H), 7.20-7.30 (m, 3H), 7.48-7.53 (m, 2H), 8.38 (s, 1H, NH). ^{13}C NMR ($CDCl_3$): δ 24.0 (CH_2), 36.8 (CH_2), 58.4 (OCH_3), 72.5 (OCH_2), 84.3 (CPh), 115.4, 117.3, 122.3, 124.0, 125.4, 126.2, 127.9, 128.3, 139.0, 143.2, 167.7 (C=O). IR ν (cm^{-1}): 1700 (C=O), 3400 (NH). Anal. Calcd. for $C_{18}H_{19}NO_3$, %: C 72.71, H 6.44, N 4.71. Found, %: C 73.02, H 6.42, N 4.73.

2-(3-Chloropropyl)-2-phenyl-2*H*-1,4-benzoxazin-3(4*H*)-one (4b). White solid; mp 126-128 °C (hexane-Et_2O). ^{1}H NMR ($CDCl_3$): δ 2.00-2.12 (m, 2H), 2.24-2.34 (m, 1H), 2.49-2.54 (m, 1H), 3.55-3.62 (m, 2H), 6.77-6.80 (m, 1H), 6.89–6.95 (m, 1H), 6.98-7.04 (m, 1H), 7.13-7.15 (m, 1H), 7.22-7.32 (m, 3H), 7.50-7.52 (m, 2H), 9.47 (s, 1H, NH). ^{13}C NMR ($CDCl_3$): δ 27.3 (CH_2), 37.6 (CH_2), 45.0 (CH_2), 84.1 (CPh), 115.6, 117.4, 122.5, 124.2, 125.4, 126.1, 128.2, 128.5, 138.6, 143.0, 167.7 (C=O). IR ν (cm^{-1}): 1700 (C=O), 3390 (NH). Anal. Calcd. for $C_{17}H_{16}ClNO_2$, %: C 67.66, H 5.34, N 4.64. Found, %: C 67.71, H 5.30, N 4.52.

Procedure for Reaction of benzoxazocine 2a in trifluoroacetic acid. A solution of azirinobenzoxazocine **2a** (0.2 g, 0.625 mmol) in CF_3CO_2H (2 mL) was stirred at room temperature for 2 h. The solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give compound **4b** (0.160 g, 85%).

1-Benzyl-4a-phenyl-2,3,4,4a-tetrahydro-1*H*-pyrido[3,2-*b*][1,4]benzoxazine (5). A solution of azirinobenzoxazocine **2a** (0.2 g, 0.625 mmol) and benzylamine (0.2 g, 1.87 mmol) in DMSO (2 mL) was heated in an oil bath at 100 °C for 2 h, and then allowed to cool to ambient temperature. The reaction mixture was poured into water, and extracted with ethyl acetate. The extract was washed with brine and dried over Na_2SO_4. The solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give compound **5** (0.080 g, 36%). White solid; mp 155-157 °C (hexane-Et_2O). ^{1}H NMR ($CDCl_3$): δ 1.53-1.83 (m, 2H), 2.30-2.47 (m, 2H), 3.22-3.40 (m, 2H), 4.99 and 5.14 (AB, *J* =14.5 Hz, 2H, CH_2Ph), 6.77-6.88 (m, 3H), 7.00–7.05 (m, 1H), 7.18-7.53 (m, 10H). ^{13}C NMR ($CDCl_3$): δ 18.9 (CH_2), 35.6 (CH_2), 47.2 (CH_2), 51.2 (CH_2), 76.0 (OCPh), 115.7, 122.3, 122.7, 123.4, 127.0, 127.3, 127.98, 128.04, 128.6, 128.7, 136.5, 137.7, 140.3, 144.8, 155.9 (C=N). Anal. Calcd. for $C_{24}H_{22}N_2O$, %: C 81.33, H 6.26, N 7.90. Found, %: C 81.27, H 6.10, N 7.90.

2-(1,4-Dichloro-1-phenylbutyl)-1,3-benzoxazole (6). A mixture of $ZnCl_2$x1.5H_2O (0.1 g, 0.613 mmol), azirinobenzoxazocine **2a** (0.2 g, 0.625 mmol), and CH_2Cl_2 (5 mL) was stirred under argon atmosphere at room temperature for 1h. Then $ZnCl_2$ was filtered, the solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give compound **6** (0.135 g, 68%). Pale-yellow oil. ^{1}H NMR ($CDCl_3$): δ 1.82-1.96 (m, 1H), 2.06-2.20 (m, 1H), 2.84-3.03 (m, 2H), 3.58-3.63 (m, 2H), 7.37-7.43 (m, 5H), 7.47-7.53 (m, 3H), 7.81-7.84 (m, 1H). ^{13}C NMR ($CDCl_3$): δ 27.8 (CH_2), 40.7 (CH_2), 44.5 (CH_2), 70.5 (CPh), 111.0, 120.7, 124.7, 125.9, 126.4, 128.5, 128.6, 139.4, 140.4, 151.0, 165.5 (C=N). MS (EI) *m/z* (%): 323 $[M + 4]^+$ (1), 321 $[M + 2]^+$ (8), 319 $[M]^+$ (12), 286 $[M + 2 – Cl]^+$ (33), 284 $[M – Cl]^+$ (100), 248 (22), 242 (7), 233 (5), 220 (20), 207 (30), 180 (3), 149 (3), 146 (3), 133 (11), 129 (17), 115 (18), 103 (19), 91 (13), 77 (20).

2-(1,4-Dichloro-1-phenylbutyl)-1,3-benzothiazole (7). A mixture of $ZnCl_2$x1.5H_2O (0.1 g, 0.613 mmol), azirinobenzoxazocine **2b** (0.2 g, 0.595 mmol), and CH_2Cl_2 (5 mL) was vigorously stirred under argon atmosphere at room temperature for 1h. Then $ZnCl_2$ was filtered, the solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give compound **(7)** (0.141 g, 70%). Pale-

yellow oil. ^{1}H NMR ($CDCl_3$): δ 1.88-2.16 (m, 2H), 2.90-3.11 (m, 2H), 3.59-3.64 (m, 2H), 7.34–7.61 (m, 7H), 7.86 (d, *J* = 8.0 Hz, 1H), 8.07 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR ($CDCl_3$): δ 28.3 (CH_2), 41.5 (CH_2), 44.6(CH_2), 76.1 (CPh), 121.5, 123.7, 125.6, 126.2, 126.6, 128.38, 128.40, 136.0, 141.8, 152.7, 175.0 (C=N). MS (DCI, NH_3) *m/z* (%):MS (DCI, NH_3) *m/z* (%): 340 $[M + 4 + H]^+$ (11), 338 $[M + 2 + H]^+$ (65), 337 $[M + 2]^+$ (22), 336 $[M + H]^+$ (100), 304 (14), 302 (40), 300 (9).

2-(4-Chloro-1-methoxy-1-phenylbutyl)-1,3-benzothiazole (8). A solution of azirinobenzothiazocine **2b** (0.1 g, 0.297 mmol) in methanol (1 mL) was refluxed for 0.5 h. The solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give compound **8**, (0.055 g, 55%).White solid; mp 144-146 °C (hexane-Et_2O). ^{1}H NMR ($CDCl_3$): δ 1.68-1.80 (m, 2H), 2.66-2.78 (m, 1H), 2.88-3.00 (m, 1H), 3.35 (s, 3H, OCH_3), 3.56-3.62 (m, 2H), 7.25–7.40 (m, 4H), 7.44-7.50 (m, 1H), 7.54-7.60 (m, 2H), 7.84-7.88 (m, 1H), 8.01-8.05 (m, 1H). ^{13}C NMR ($CDCl_3$): δ 26.3 (CH_2), 32.0 (CH_2), 45.1 (CH_2), 51.0 (OCH_3), 83.2 (CPh), 121.6, 123.2, 125.0, 125.7, 126.2, 127.7, 128.4, 135.7, 141.9, 152.9, 177.1 (C=N). Anal. Calcd. for $C_{18}H_{18}ClNOS$, %: C 65.15, H 5.47, N 4.22. Found, %: C 65.22, H 5.44, N 4.07

2-(3-Hydroxypropyl)-2-phenyl-2*H*-1,4-benzothiazin-3(4*H*)-one (9). A solution of azirinobenzothiazocine **2b** (0.2 g, 0.595 mmol) in CF_3CO_2H (2 mL) was stirred at room temperature for 2 h. The solvent was evaporated, a solution of KOH (0.13 g, 2.32 mmol) in methanol (5 mL) was added to the residue and the mixture was refluxed for 2 h. The solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give compound **9**, (0.131 g, 73%). White solid; mp 142-143 °C (hexane-Et_2O). ^{1}H NMR ($CDCl_3$): δ 1.53-1.81 (m, 3H, CH_2, OH), 2.22-2.42 (m, 2H), 3.61-3.63 (m, 2H), 6.67–6.70 (m, 1H), 6.92-6.97 (m, 1H), 7.03-7.09 (m, 1H), 7.14-7.25 (m, 3H), 7.33-7.36 (m, 1H), 7.51-7.54 (m, 2H), 8.24 (s, 1H, NH). ^{13}C NMR ($CDCl_3$): δ 28.3 (CH_2), 34.7 (CH_2), 55.1 (CPh), 62.5 (CH_2OH), 116.4, 119.8, 123.7, 126.6, 127.2, 127.6, 127.8, 128.3, 135.9, 137.9, 169.1 (C=O). IR ν (cm^{-1}): 1700 (C=O), 3390 (NH), 3630 (OH). Anal. Calcd. for $C_{17}H_{17}NO_2S$, %: C 68.20, H 5.72, N 4.68. Found, %: C 68.33, H 5.77, N 4.67.

Procedures for Reactions of Fluorinated Aziridines 2c,d.

(1) A mixture of azirinobenzoxazocine **2c** (0.108 g, 0.355 mmol), $ZnCl_2 \cdot 1.5H_2O$ (0.1 g, 0.613 mmol), and CH_2Cl_2 (5 mL) was stirred at room temperature for 1h. The salt was filtered, the solvent was removed and the residue was crystallized from a mixture of hexane-EtOAc to give compound **4b** (0.101 g, 93%).

(2) A solution of azirinobenzoxazocine **2c** (0.095 g, 0.313 mmol) in MeOH (2 mL) was refluxed for 2 h. The solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give compounds **4a** (0.050 g, 53%) and **4b** (0.030 g, 32%).

(3) A mixture of anhydrous $ZnCl_2$ (0.1 g, 0.735 mmol), azirinobenzoxazocine **2c** (0.1 g, 0.329 mmol), and CH_2Cl_2 (5 mL) was stirred under argon atmosphere at room temperature for 0.5 h. After evaporation of methylene chloride anhydrous DMSO (5 mL) and a solution of benzylamine (0.18 g, 1.68 mmol) in anhydrous DMSO (5 mL) were subsequently added. The reaction mixture was heated at 100 °C for 0.5 h, and then allowed to cool to ambient temperature. The mixture was poured into saturated aqueous Na_2CO_3 and extracted with ethyl acetate. The extract was washed with water and dried over Na_2SO_4. The solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give compounds **5** (0.081 g, 68%) and **4b** (0.025 g, 25%).

(4) A mixture of anhydrous $ZnCl_2$ (0.1 g, 0.735 mmol), azirinobenzothiazocine **2d** (0.1 g, 0.313 mmol), and CH_2Cl_2 (5 mL) was stirred under argon atmosphere at room temperature for 0.75 h. After evaporation of methylene chloride anhydrous DMSO (5 mL) and a solution of isobutylamine (0.12 g, 1.64 mmol) in anhydrous DMSO (5 mL) were subsequently added. The reaction mixture was heated at

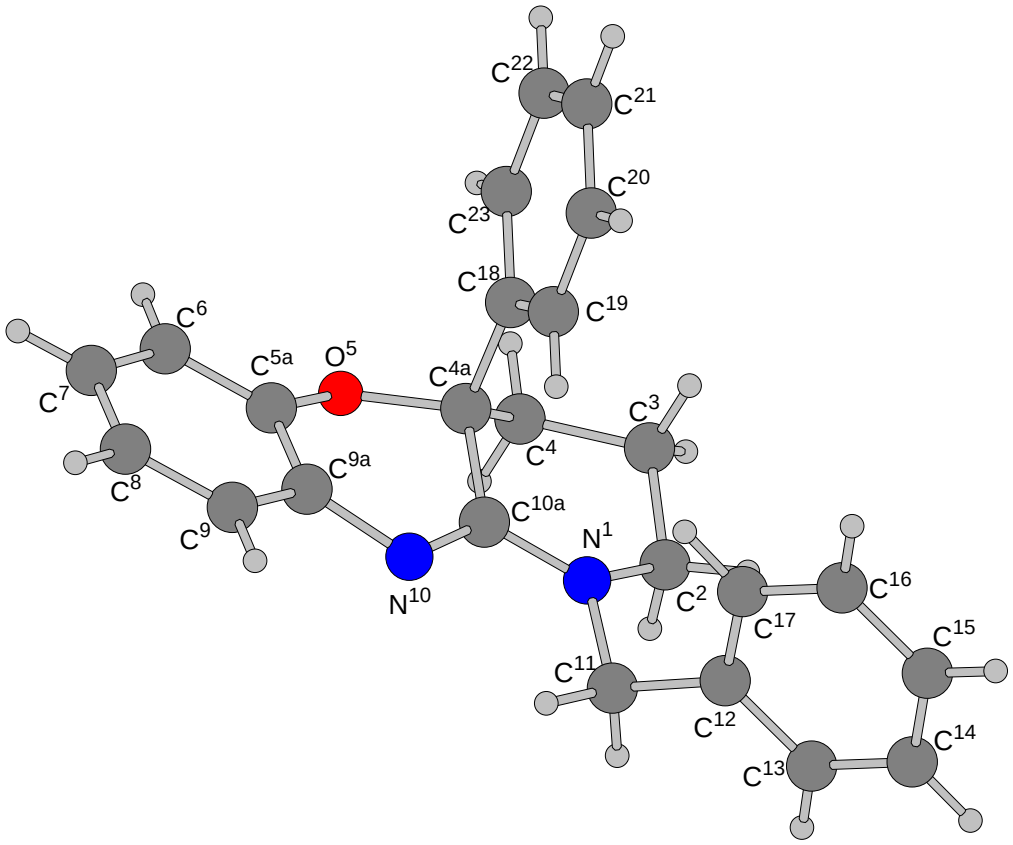
100 °C for 0.25 h, and then allowed to cool to ambient temperature. The mixture was poured into saturated aqueous Na_2CO_3 and extracted with ethyl acetate. The extract was washed with water and dried over Na_2SO_4. The solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give **1-isobutyl-4a-phenyl-2,3,4,4a-tetrahydro-1*H*-pyrido[3,2-*b*][1,4]benzothiazine (10)** (0.055 g, 52%). Pale-yellow oil. ^{1}H NMR ($CDCl_3$): δ 1.04 (d, *J* = 6.7 Hz, 3H, CH_3), 1.07 (d, *J* = 6.7 Hz, 3H, CH_3), 1.65-1.74 (m, 2H), 2.15-2.25 (m, 1H), 2.36-2.50 (m, 2H), 3.45-3.51 (m, 3H), 3.67-3.74 (m, 1H), 6.64-6.69 (m, 1H), 6.97–7.18 (m, 6H), 7.41 (d, *J* = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$): δ 19.6 (CH_2), 20.4 (CH_3), 20.6 (CH_3), 26.4 (CH), 36.1 (CH_2), 46.2 (CPh), 49.8 (CH_2), 57.0 (CH_2), 119.4, 120.9, 123.6, 126.3, 126.5, 127.0, 127.5, 127.6, 141.2, 145.2, 154.6 (C=N). MS (EI) *m/z* (%): 336 $[M]^+$ (11), 281 (5), 280 (30), 236 (5), 223 (5), 203 (6), 149 (13), 133 (17), 121 (19), 119 (83), 117 (72), 105 (26), 97 (18), 91 (26), 71 (49), 69 (32), 57 (94), 55 (45), 43 (100), 41 (75).

Procedures for preparation of 2-pyrrol-2-yl derivatives of 1,3-benzoxazole and 1,3-benzothiazole.

2-(1-Benzyl-2-phenylpyrrolidin-2-yl)-1,3-benzoxazole (11a). A solution of dichloride **6** (0.14 g, 0.437 mmol) and benzylamine (0.14 g, 1.31 mmol) in DMSO (5 mL) was heated in an oil bath at 100 °C for 2 h, and then allowed to cool to ambient temperature. The reaction mixture was poured into water and extracted with ethyl acetate. The extract was washed with brine and dried over Na_2SO_4. The solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give **11a** (0.131 g, 83%). Pale-yellow oil. ^{1}H NMR ($CDCl_3$): δ 1.95-2.25 (m, 3H), 2.38-2.48 (m, 1H), 3.13-3.25 (m, 3H, CH_2, CHPh), 4.29 (m, 1H, CHPh), 7.29-7.59 (m, 13H), 7.84-7.86 (m, 1H). ^{13}C NMR ($CDCl_3$): δ 21.7, 41.4, 50.3, 54.3, 71.7 (CPh), 110.9, 120.3, 124.3, 124.9, 126.6, 126.7, 127.4, 128.1, 128.3, 128.4, 139.9, 140.7, 142.8, 150.8, 167.2 (C=N). MS (EI) *m/z* (%): 354 $[M]^+$ (33), 235 (19), 156 (30), 104 (23), 91 (100), 81 (31).

2-[1-Phenethyl-2-phenylpyrrolidin-2-yl]-1,3-benzoxazole (11b) A mixture of azirinobenzoxazocine **2a** (0.2 g, 0.625 mmol), $ZnCl_2$ (0.1 g, 0.735 mmol), and CH_2Cl_2 (5 mL) was stirred at room temperature for 1h. The salt was filtered, the solvent was removed and a solution of phenethylamine (0.16 g, 1.322 mmol) in DMSO (5 mL) was added to the residue. The solution was heated in an oil bath at 100 °C for 2 h, and then allowed to cool to ambient temperature. The reaction mixture was poored to water, and extracted with ethyl acetate. The extract was washed with brine and dried over Na_2SO_4. The solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give compound **11b** (0.112 g, 48%). Pale-yellow oil. ^{1}H NMR ($CDCl_3$): δ 2.00-2.10 (m, 2H), 2.22-2.42 (m, 2H), 2.54-2.60 (m, 1H), 2.83-2.88 (m, 2H), 3.05-3.10 (m, 1H), 3.15-3.25 (m, 1H), 3.54-3.62 (m, 1H), 7.17-7.35 (m, 12H), 7.45-7.50 (m, 1H), 7.75-7.85 (m, 1H). ^{13}C NMR ($CDCl_3$): δ 21.9, 35.9, 41.5, 50.4, 52.2, 71.8 (CPh), 110.8, 120.1, 124.2, 124.8, 125.9, 126.5, 127.1, 128.2, 128.3, 129.0, 140.4, 140.6, 142.9, 150.7, 167.4 (C=N). MS (EI) *m/z* (%): 368 $[M]^+$ (6), 284 (3), 279 (10), 278 (20), 277 (100), 248 (33), 234 (5), 208 (5), 167 (16), 149 (35), 105 (12), 91 (14), 77 (10).

2-(1-Benzyl-2-phenylpyrrolidin-2-yl)-1,3-benzothiazole (12). A solution of dichloride **7** (0.14 g, 0.416 mmol) and benzylamine (0.22 g, 2.06 mmol) in DMSO (2 mL) was heated in an oil bath at 100 °C for 5 h, and then allowed to cool to ambient temperature. The reaction mixture was poored to water, and extracted with ethyl acetate. The extract was washed with brine and dried over Na_2SO_4. The solvent was evaporated and the residue was chromatographed on silica (EtOAc/hexane) to give compound **12** (0.051 g, 32%). Pale-yellow oil. ^{1}H NMR ($CDCl_3$): δ 2.03-2.18 (m, 2H), 2.68-2.99 (m, 4H), 3.28 and 3.69 (AB, 1+1H *J* = 13.4 Hz, CH_2Ph), 7.31-7.53 (m, 12H), 7.95 (d, *J* = 8.0 Hz, 1H), 8.07 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR ($CDCl_3$): δ 22.6 (CH_2), 42.5 (CH_2), 51.2 (CH_2), 55.4 (CH_2), 74.2 (CPh), 121.5, 123.1, 124.7, 125.7, 126.8, 127.4, 128.0, 128.1, 128.2, 128.3, 135.4, 139.7, 141.5, 154.0, 179.7 (C=N). MS (DCI, NH_3) *m/z* (%): 372 $[M + 2]^+$ (28), 371 $[M + H]^+$, (100).



Structure of 1-Benzyl-4a-phenyl-2,3,4,4a-tetrahydro-1*H*-pyrido[3,2-*b*][1,4]benzoxazine (5)

Bibliographic data

Creation method
SHELXL-97

Crystal data

Formula sum	$C_{24}\ H_{22}\ N_2\ O$
Formula weight	354.44
Crystal system	triclinic
Space group	*P* -1 (no. 2)
Unit cell dimensions	*a* = 9.4130(19) E
	b = 10.281(2) E
	c = 11.618(2) E
	α = 101.32(3) °
	β = 109.63(3) °
	γ = 112.28(3) °
Cell volume	909.85(30) E^3
Z	2
Density, calculated	1.294 g/cm^3
R_{All}	0.062
Pearson code	aP98
Formula type	NO2P22Q24
Wyckoff sequence	i^{49}

Atomic coordinates and isotropic displacement parameters (in E ^{2})

Atom	Wyck.	x	y	z	U
O5	2*i*	0.05277(14)	0.46571(12)	0.73788(11)	
N1	2*i*	-0.10673(18)		0.21741(15)	0.40426(13)
N10	2*i*	-0.23241(17)		0.33697(15)	0.49096(13)
C2	2*i*	0.0409(2)	0.19538(19)	0.41170(18)	
H2A	2*i*	0.11050	0.26960	0.38360	0.0430
H2B	2*i*	-0.00220	0.09290	0.34920	0.0430
C3	2*i*	0.1554(2)	0.21259(19)	0.54719(18)	
H3A	2*i*	0.26750	0.22610	0.55220	0.0430
H3B	2*i*	0.10120	0.11990	0.56420	0.0430
C4	2*i*	0.1839(2)	0.34808(18)	0.65039(17)	
H4A	2*i*	0.23750	0.44090	0.63340	0.0390
H4B	2*i*	0.26260	0.36110	0.73870	0.0390
C4A	2*i*	0.0122(2)	0.32372(17)	0.64586(16)	
C5A	2*i*	-0.0888(2)	0.48158(17)	0.72844(16)	
C6	2*i*	-0.0817(2)	0.57026(18)	0.83845(17)	
H6A	2*i*	0.01690	0.61420	0.92130	0.0410
C7	2*i*	-0.2211(2)	0.59421(19)	0.82619(18)	
H7A	2*i*	-0.21760	0.65580	0.90070	0.0450
C8	2*i*	-0.3651(2)	0.52812(19)	0.70511(19)	
H8A	2*i*	-0.46060	0.54380	0.69710	0.0450
C9A	2*i*	-0.2317(2)	0.41539(17)	0.60482(16)	
C9	2*i*	-0.3702(2)	0.43926(18)	0.59581(18)	
H9A	2*i*	-0.46980	0.39400	0.51350	0.0420
C10A	2*i*	-0.1141(2)	0.29662(17)	0.50859(16)	
C11	2*i*	-0.2287(2)	0.18278(19)	0.26931(17)	
H11A	2*i*	-0.16400	0.23510	0.22590	0.0460
H11B	2*i*	-0.30810	0.22290	0.27320	0.0460
C12	2*i*	-0.3327(2)	0.01554(18)	0.18743(16)	
C13	2*i*	-0.3388(2)	-0.0412(2)	0.06627(18)	
H13A	2*i*	-0.27140	0.02520	0.03640	0.0490
C14	2*i*	-0.4423(2)	-0.1940(2)	-0.01174(19)	
H14A	2*i*	-0.44500	-0.23130	-0.09440	0.0560
C15	2*i*	-0.5409(3)	-0.2917(2)	0.0297(2)	
H15A	2*i*	-0.61230	-0.39610	-0.02400	0.0640
C17	2*i*	-0.4319(3)	-0.0848(2)	0.22785(19)	
H17A	2*i*	-0.42870	-0.04850	0.31090	0.0570
C18	2*i*	-0.0687(2)	0.19545(17)	0.69044(15)	
C19	2*i*	-0.2374(2)	0.07990(18)	0.61693(17)	
H19A	2*i*	-0.30660	0.07780	0.53460	0.0400
C20	2*i*	-0.3070(2)	-0.03294(19)		0.66164(18)
H20A	2*i*	-0.42270	-0.11150	0.60980	0.0440
C21	2*i*	-0.2085(2)	-0.03080(19)		0.78072(18)
H21A	2*i*	-0.25560	-0.10770	0.81160	0.0470
C22	2*i*	-0.0407(3)	0.0839(2)	0.85522(19)	
H22A	2*i*	0.02770	0.08570	0.93770	0.0560
C23	2*i*	0.0290(2)	0.1965(2)	0.81079(18)	
H23A	2*i*	0.14460	0.27490	0.86320	0.0500
C16	2*i*	-0.5351(3)	-0.2364(2)	0.1502(2)	
H16A	2*i*	-0.60260	-0.30310	0.17990	0.0740

Anisotropic displacement parameters (in E ^{2})

Atom	U_{11}	U_{22}	U_{33}	U_{12}	U_{13}	U_{23}
O5	0.0267(6)	0.0254(6)	0.0337(6)	0.0114(5)	0.0109(5)	0.0067(5)
N1	0.0342(8)	0.0293(7)	0.0308(8)	0.0146(6)	0.0153(6)	0.0098(6)
N10	0.0301(7)	0.0283(7)	0.0321(7)	0.0137(6)	0.0128(6)	0.0124(6)
C2	0.0379(10)	0.0300(9)	0.0438(10)	0.0148(8)	0.0244(9)	0.0123(8)
C3	0.0319(9)	0.0316(9)	0.0461(11)	0.0153(8)	0.0208(8)	0.0126(8)
C4	0.0268(9)	0.0289(8)	0.0385(10)	0.0119(7)	0.0140(7)	0.0107(7)
C4A	0.0291(9)	0.0233(8)	0.0305(9)	0.0121(7)	0.0127(7)	0.0070(7)
C5A	0.0271(8)	0.0243(8)	0.0360(9)	0.0122(7)	0.0148(7)	0.0130(7)
C6	0.0360(9)	0.0271(8)	0.0354(9)	0.0123(7)	0.0162(8)	0.0104(7)
C7	0.0414(10)	0.0307(9)	0.0447(10)	0.0168(8)	0.0257(9)	0.0124(8)
C8	0.0339(9)	0.0330(9)	0.0524(11)	0.0174(8)	0.0236(9)	0.0165(8)
C9A	0.0308(9)	0.0248(8)	0.0352(9)	0.0134(7)	0.0155(7)	0.0132(7)
C9	0.0305(9)	0.0321(9)	0.0434(10)	0.0151(7)	0.0163(8)	0.0173(8)
C10A	0.0281(8)	0.0230(8)	0.0306(9)	0.0087(7)	0.0131(7)	0.0100(7)
C11	0.0494(11)	0.0327(9)	0.0290(9)	0.0182(8)	0.0159(8)	0.0124(7)
C12	0.0326(9)	0.0314(9)	0.0321(9)	0.0153(7)	0.0133(7)	0.0116(7)
C13	0.0394(10)	0.0399(10)	0.0379(10)	0.0149(8)	0.0196(8)	0.0096(8)
C14	0.0427(11)	0.0448(11)	0.0385(10)	0.0219(9)	0.0111(9)	0.0009(9)
C15	0.0472(12)	0.0323(10)	0.0501(13)	0.0121(9)	0.0018(10)	0.0070(9)
C17	0.0488(12)	0.0440(11)	0.0379(11)	0.0110(9)	0.0202(9)	0.0151(9)
C18	0.0297(8)	0.0263(8)	0.0301(9)	0.0152(7)	0.0135(7)	0.0091(7)
C19	0.0295(9)	0.0326(9)	0.0339(9)	0.0138(7)	0.0121(7)	0.0126(7)
C20	0.0347(10)	0.0307(9)	0.043(1)	0.0127(8)	0.0188(8)	0.0132(8)
C21	0.0478(11)	0.0310(9)	0.0434(11)	0.0173(8)	0.0248(9)	0.0178(8)
C22	0.0507(12)	0.0434(11)	0.0352(10)	0.0166(9)	0.0118(9)	0.0203(9)
C23	0.0365(10)	0.0379(10)	0.0349(10)	0.0103(8)	0.0083(8)	0.0140(8)
C16	0.0579(14)	0.0439(12)	0.0543(14)	0.0024(10)	0.0176(11)	0.0212(11)

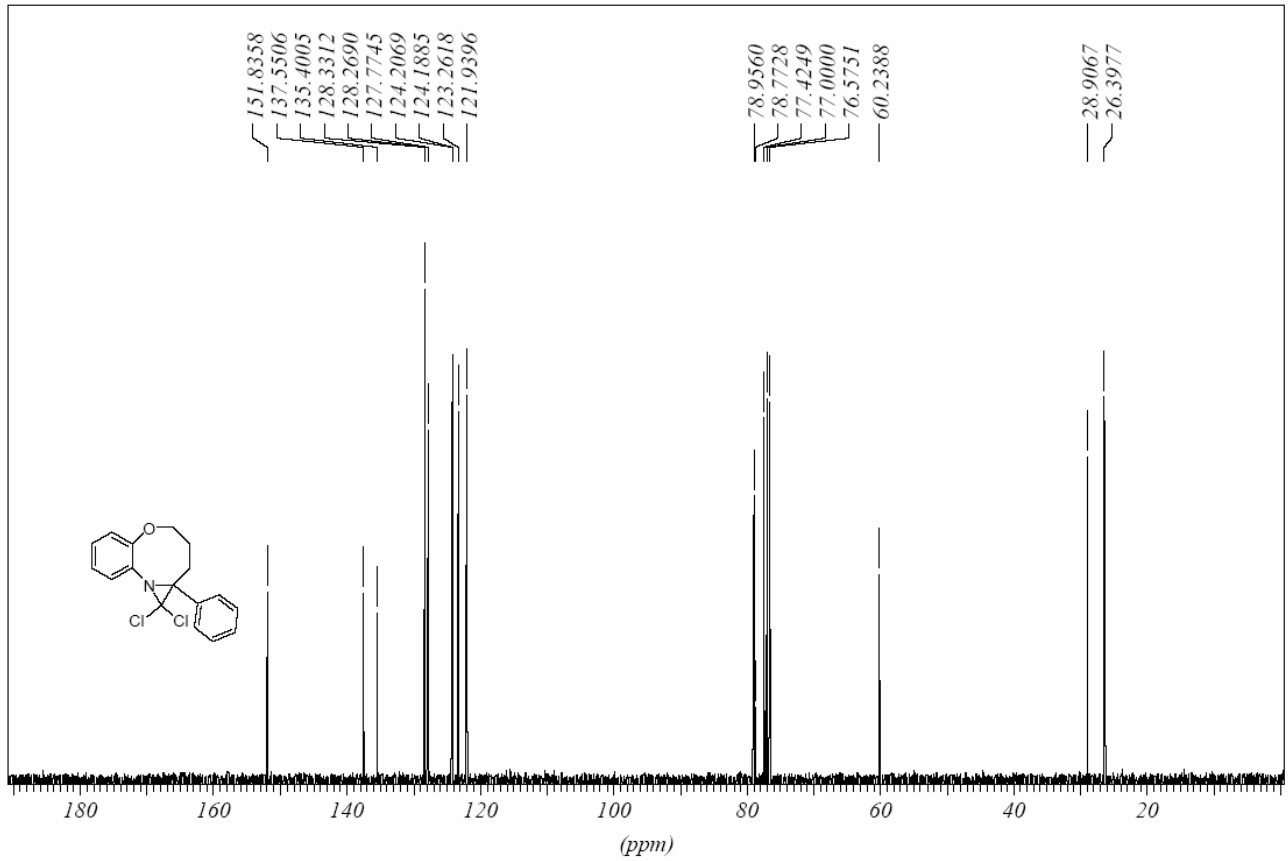
Selected geometric parameters (E, °)

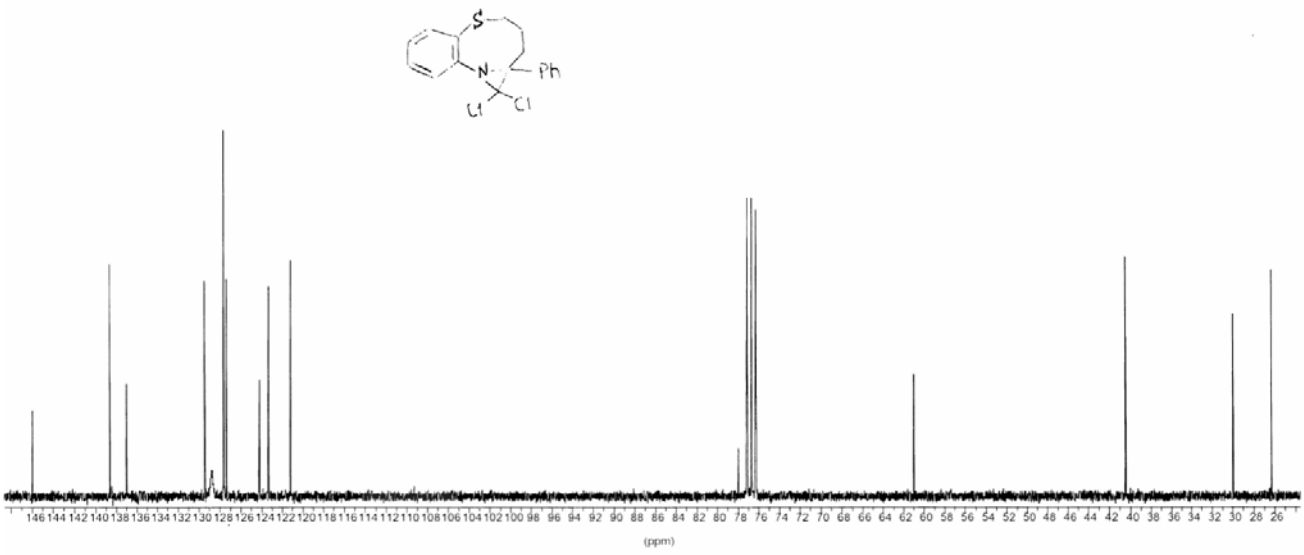
O5—C5A	1.374(6)	C8—C9	1.386(25)
O5—C4A	1.453(34)	C9A—C9	1.390(8)
N1—C10A	1.360(22)	C11—C12	1.508(48)
N1—C2	1.468(7)	C12—C17	1.382(24)
N1—C11	1.471(37)	C12—C13	1.387(18)
N10—C10A	1.298(12)	C13—C14	1.388(47)
N10—C9A	1.404(22)	C14—C15	1.373(24)
C2—C3	1.509(33)	C15—C16	1.378(17)
C3—C4	1.515(34)	C17—C16	1.378(46)
C4—C4A	1.519(8)	C18—C19	1.386(52)
C4A—C10A	1.528(37)	C18—C23	1.387(26)
C4A—C18	1.536(24)	C19—C20	1.391(21)
C5A—C6	1.381(25)	C20—C21	1.373(27)
C5A—C9A	1.400(48)	C21—C22	1.379(52)
C6—C7	1.391(8)	C22—C23	1.387(21)
C7—C8	1.387(48)		

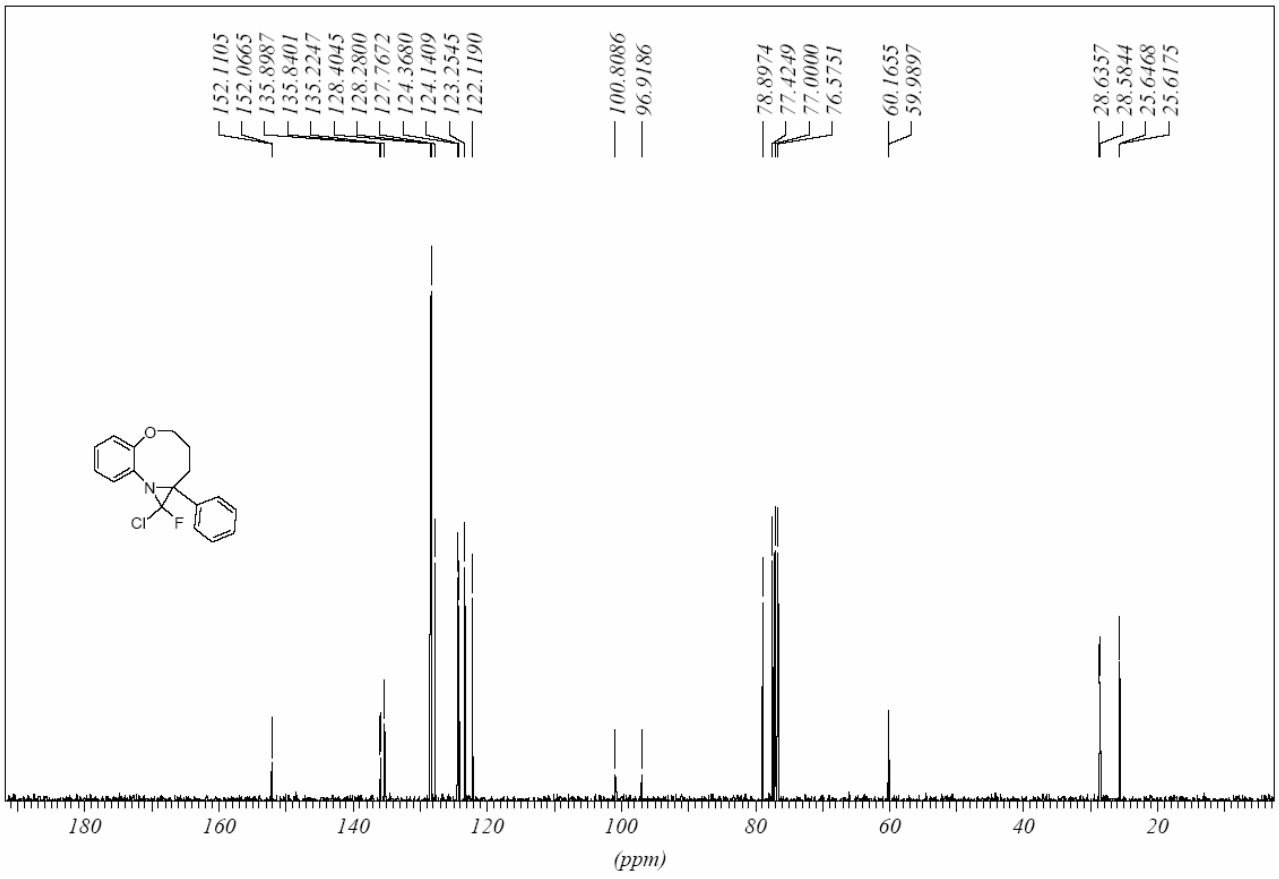
C5A—O5—C4A	114.12(15)	C5A—C9A—N10	121.94(15)
C10A—N1—C2	124.64(17)	C8—C9—C9A	120.98(19)
C10A—N1—C11	119.97(14)	N10—C10A—N1	120.82(18)
C2—N1—C11	113.45(15)	N10—C10A—C4A	121.78(17)
C10A—N10—C9A	116.58(17)	N1—C10A—C4A	117.19(14)
N1—C2—C3	113.80(16)	N1—C11—C12	113.05(14)
C2—C3—C4	110.16(15)	C17—C12—C13	117.95(18)
C3—C4—C4A	109.35(17)	C17—C12—C11	120.92(18)
O5—C4A—C4	104.34(15)	C13—C12—C11	121.05(16)

O5—C4A—C10A	108.94(13)	C12—C13—C14	120.70(18)
C4—C4A—C10A	110.77(16)	C15—C14—C13	120.49(20)
O5—C4A—C18	108.68(14)	C14—C15—C16	119.20(21)
C4—C4A—C18	113.57(16)	C16—C17—C12	121.35(20)
C10A—C4A—C18	110.29(14)	C19—C18—C23	118.21(16)
O5—C5A—C6	119.31(18)	C19—C18—C4A	122.82(17)
O5—C5A—C9A	118.48(17)	C23—C18—C4A	118.95(15)
C6—C5A—C9A	122.05(16)	C18—C19—C20	121.14(18)
C5A—C6—C7	119.02(19)	C21—C20—C19	119.99(18)
C8—C7—C6	119.98(19)	C20—C21—C22	119.50(18)
C9—C8—C7	120.24(18)	C21—C22—C23	120.61(20)
C9—C9A—C5A	117.71(18)	C22—C23—C18	120.55(18)
C9—C9A—N10	120.18(18)	C17—C16—C15	120.31(19)

^{13}C NMR spectra of compounds **2a-d**, **3a**,**b**, **4a**,**b**, **5-10**, **11a**,**b**, **12.**



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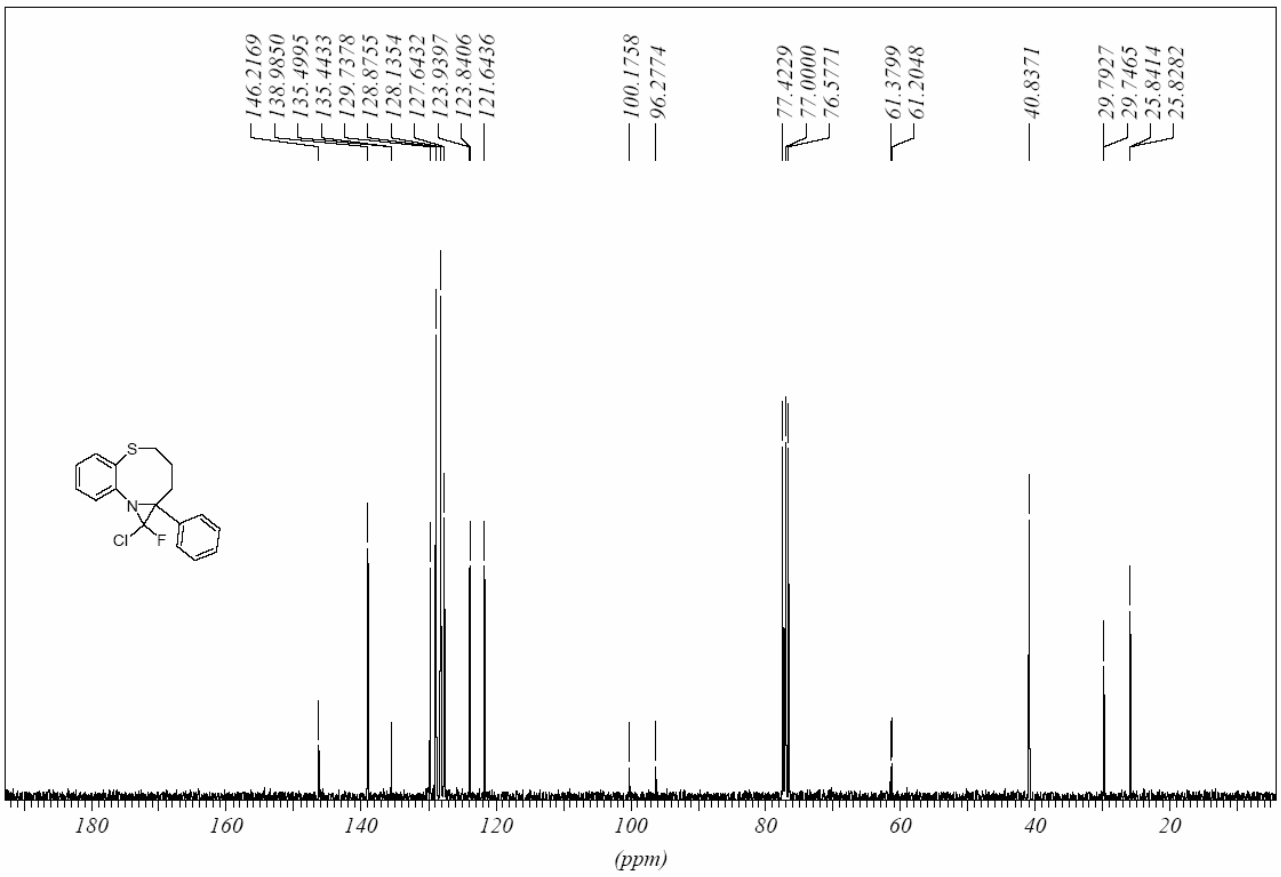
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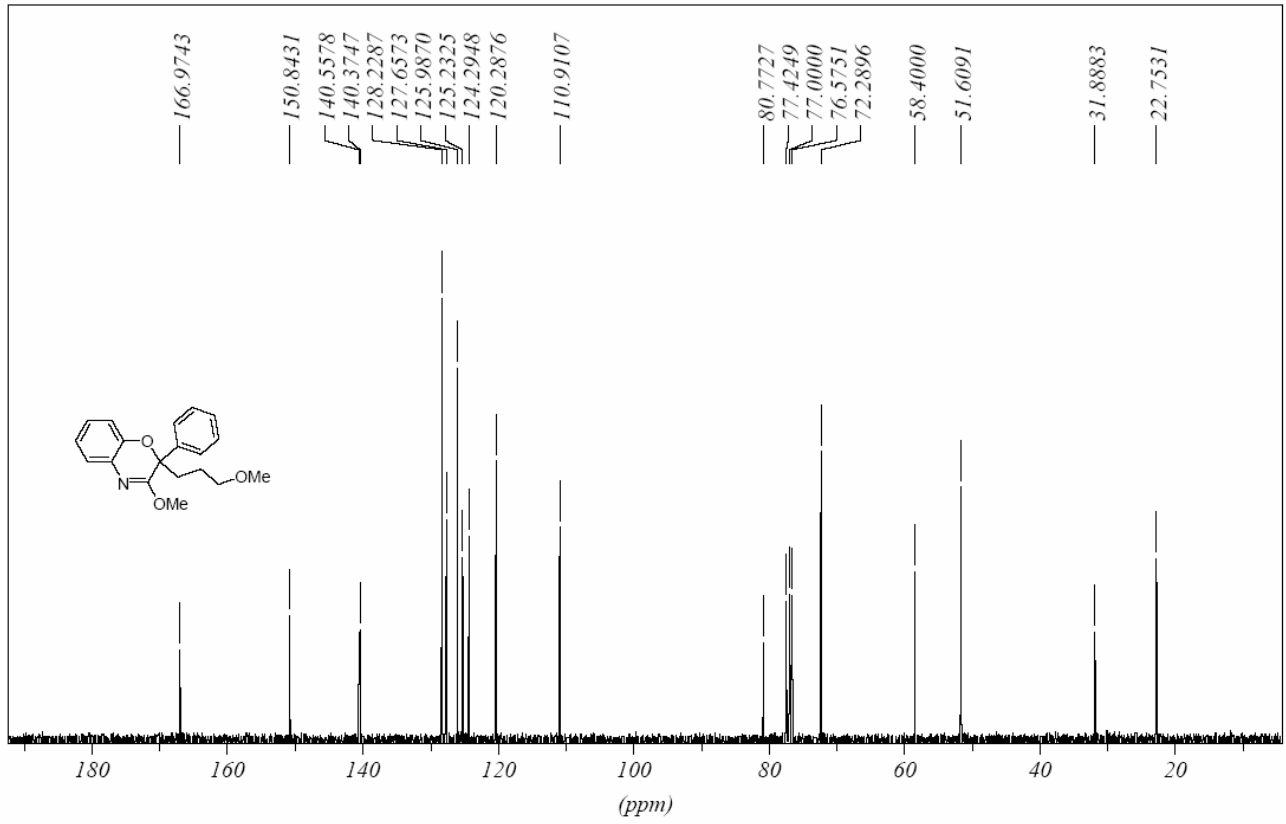
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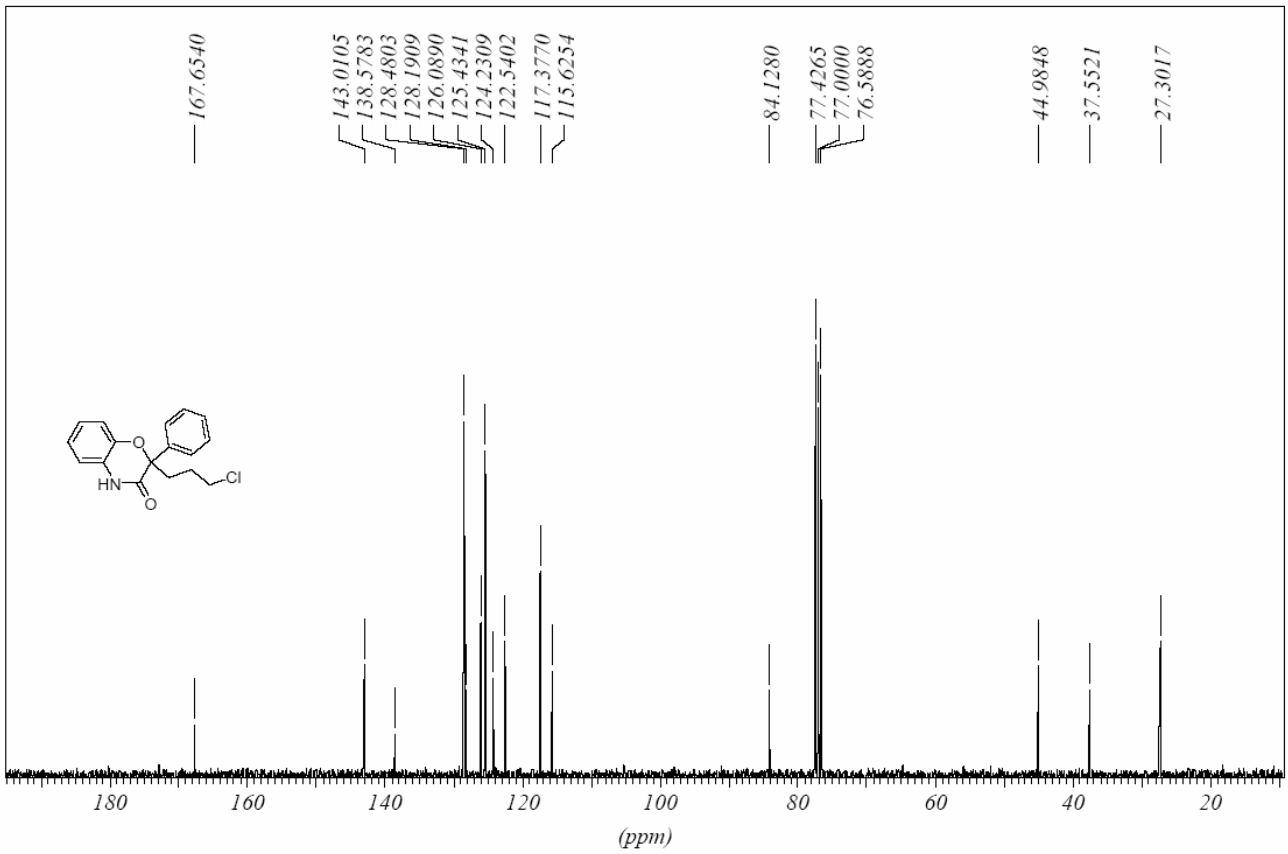
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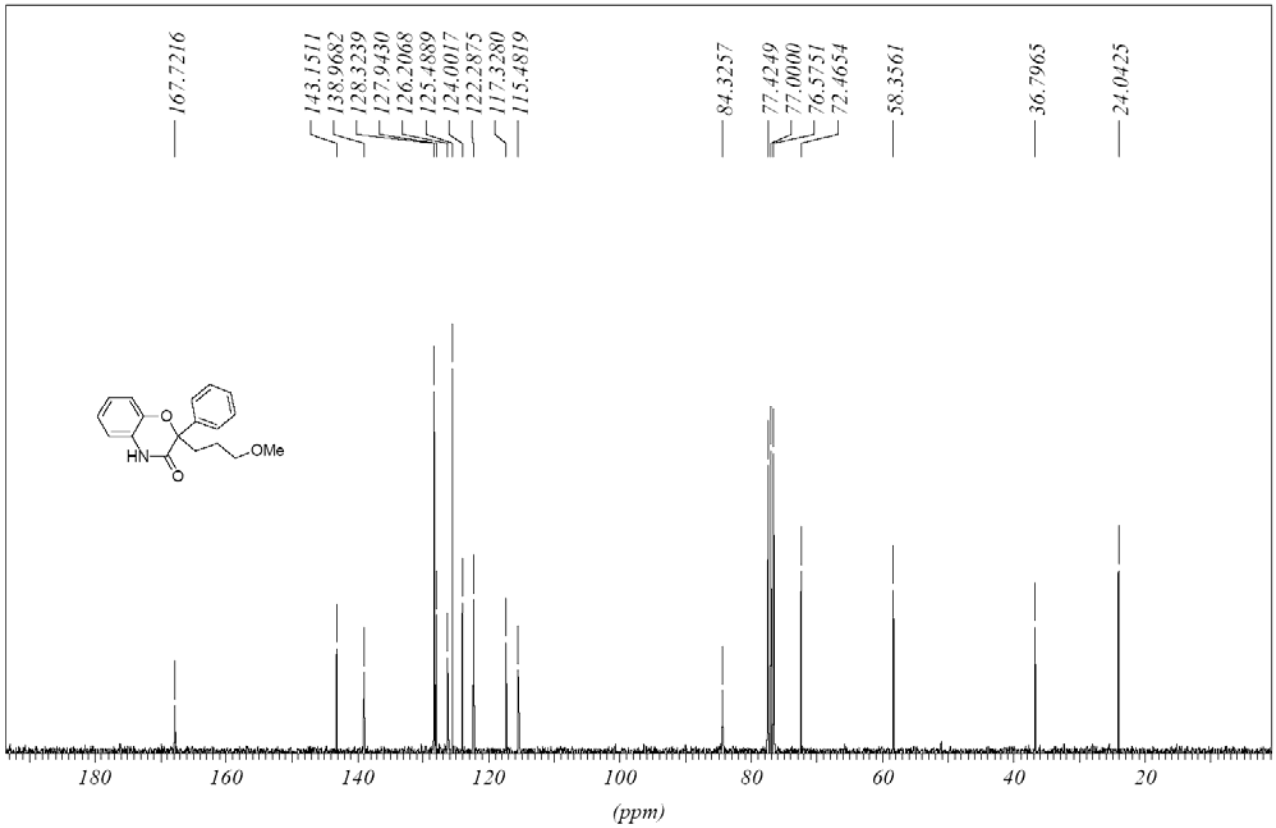
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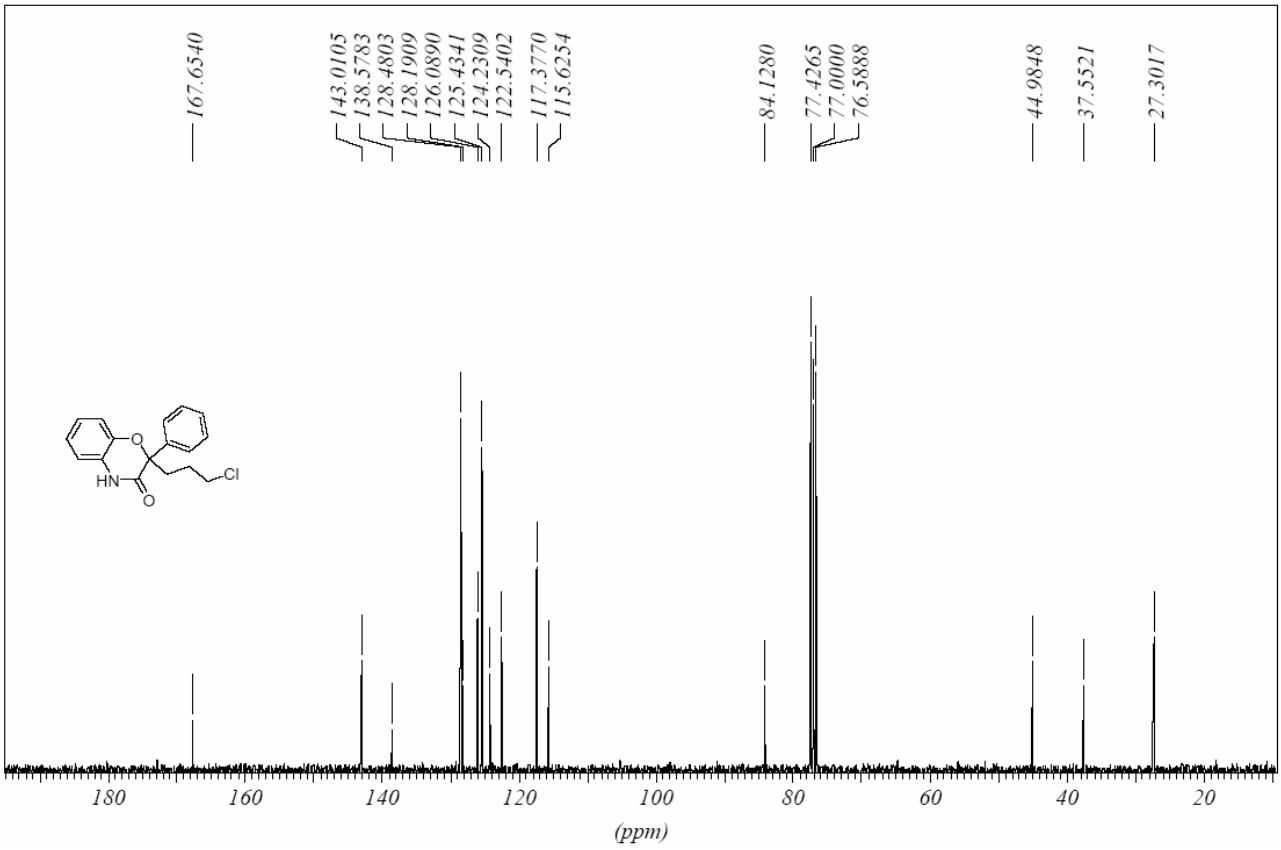
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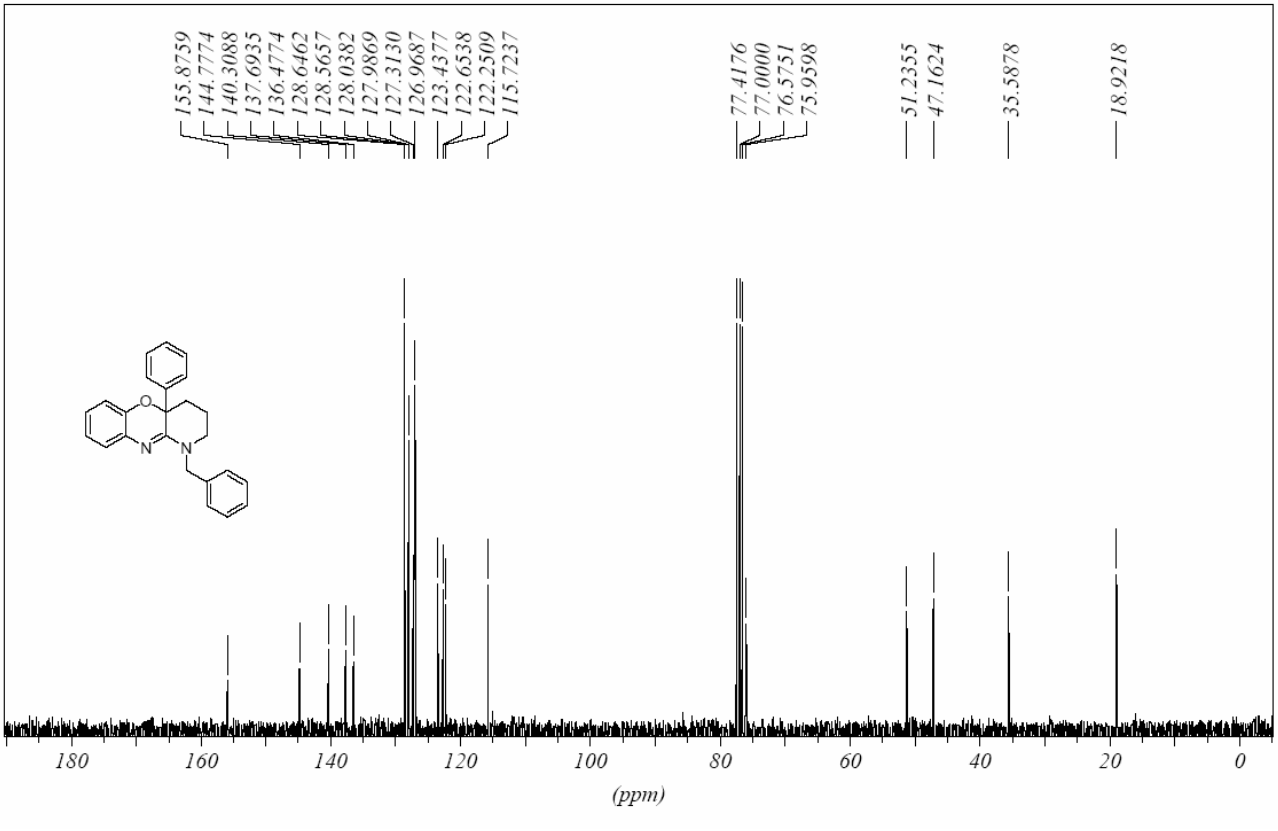
160
140
120
100
80
60
40
20
(ppm)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136.4774
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128.5657
128.0382
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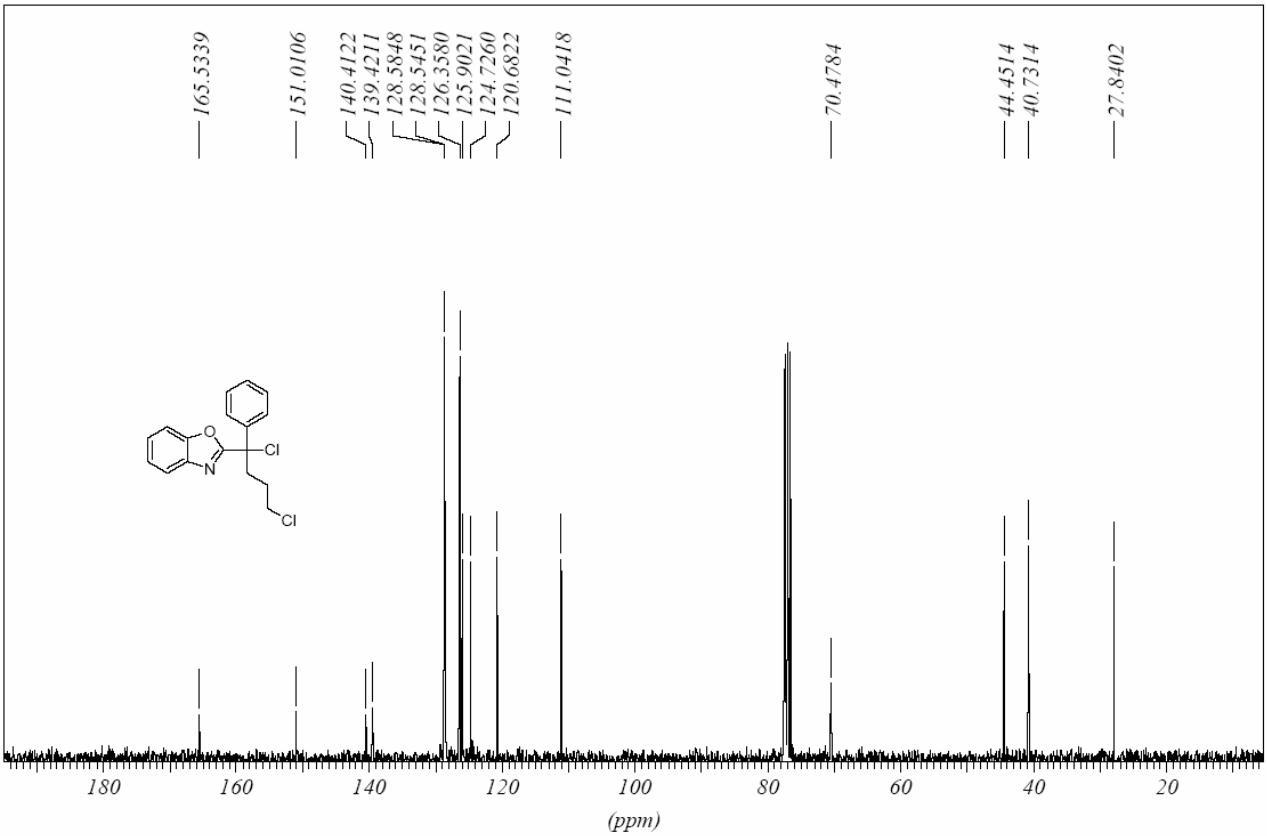
127.3130
126.9687
123.4377
122.6538
122.2509
115.7237
77.4176
77.0000
76.5751
75.9598
51.2355
47.1624
35.5878
18.9218
O
N
N
180
160
140
120
100
80
60
40
20
0
(ppm)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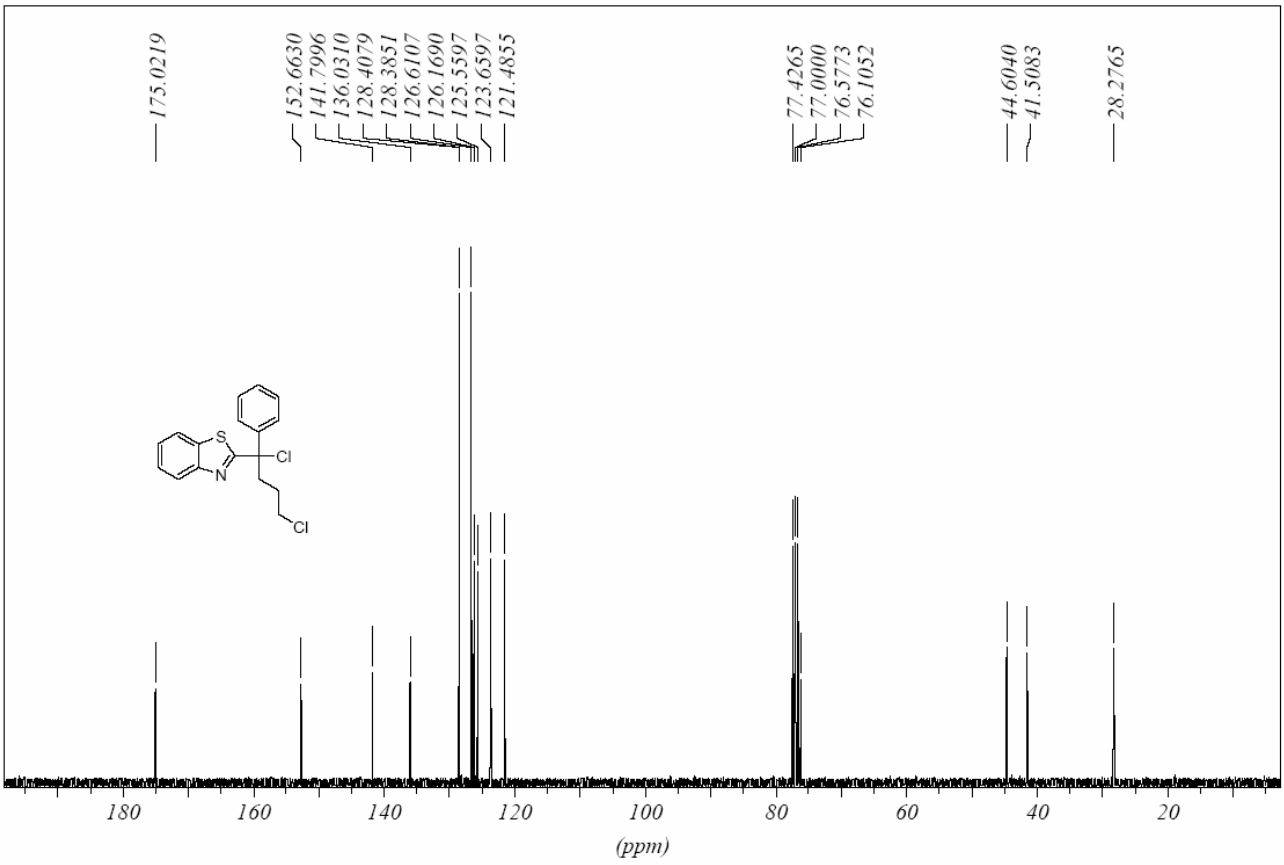
111.0418
70.4784
44.4514
40.7314
27.8402
O
N
Cl
Cl
180
160
140
120
100
80
60
40
20
(ppm)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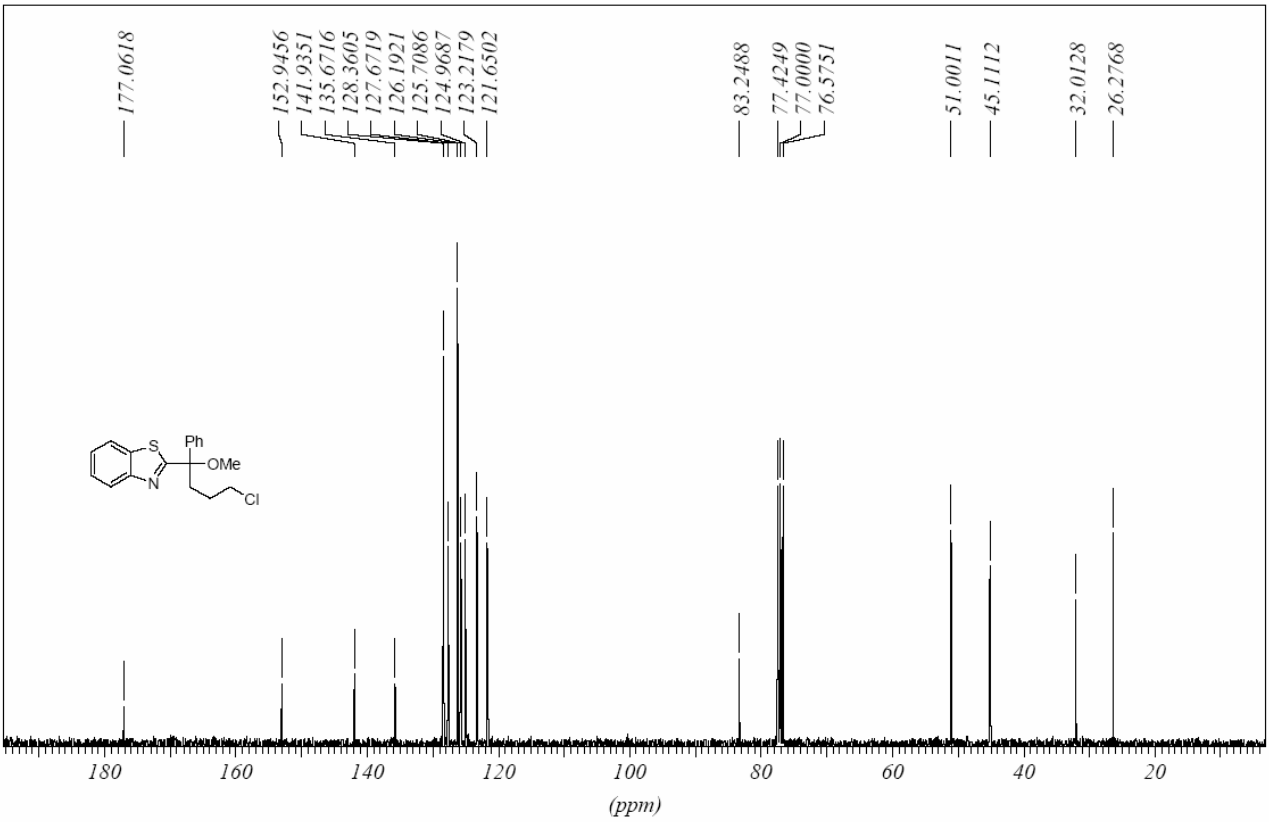
152.6630
141.7996
136.0310
128.4079
128.3851
126.6107
126.1690
125.5597
123.6597
121.4855
77.4265
77.0000
76.5773
76.1052
44.6040
41.5083
28.2765
S
N
Cl
Cl
180
160
140
120
100
80
60
40
20
(ppm)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141.9351
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124.9687
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121.6502
83.2488
77.4249
77.0000
76.5751
51.0011
45.1112
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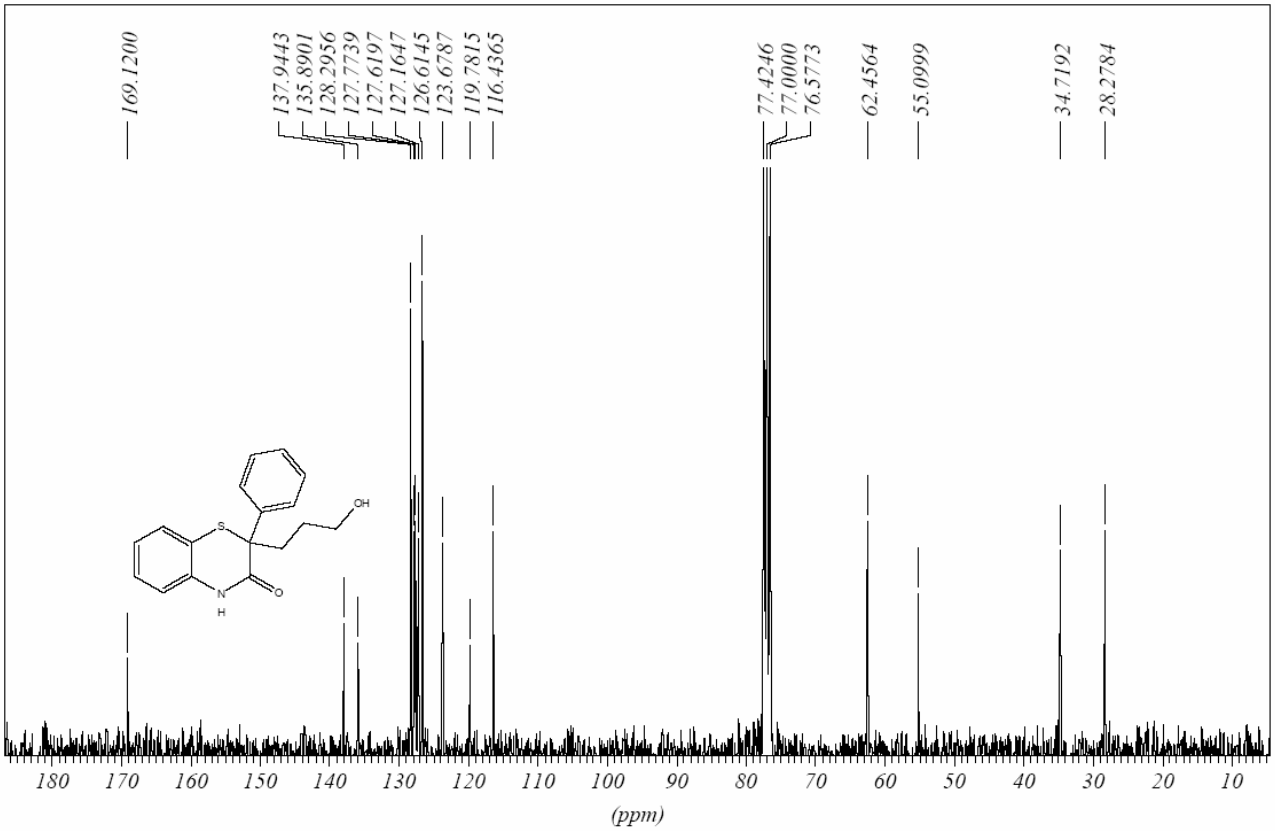
S
N
Ph
OMe
Cl
180
160
140
120
100
80
60
40
20
(ppm)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123.6787
119.7815
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77.4246
77.0000
76.5773
62.4564
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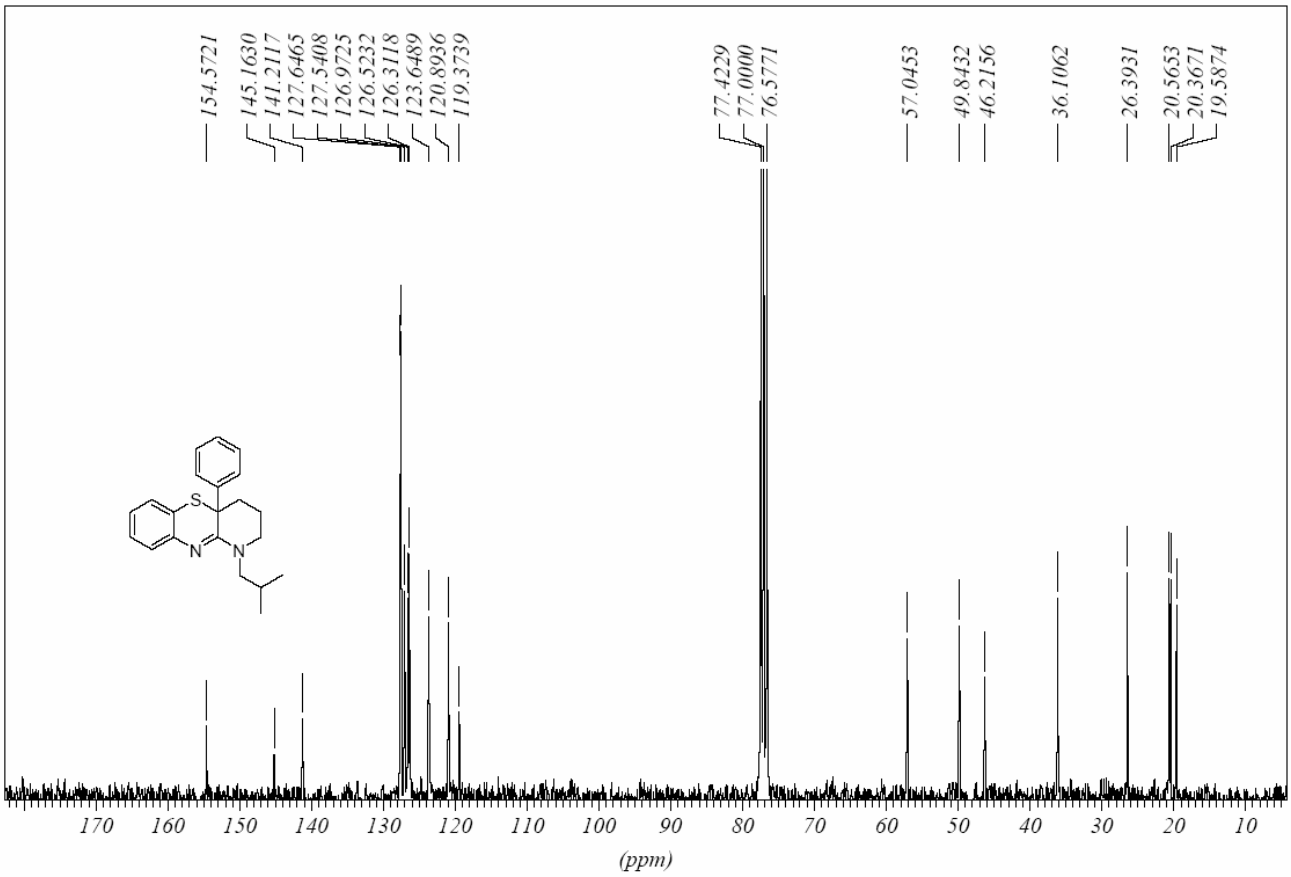
28.2784
OH
S
N
H
O
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
(ppm)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141.2117
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77.4229
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49.8432
46.2156
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S
N
N
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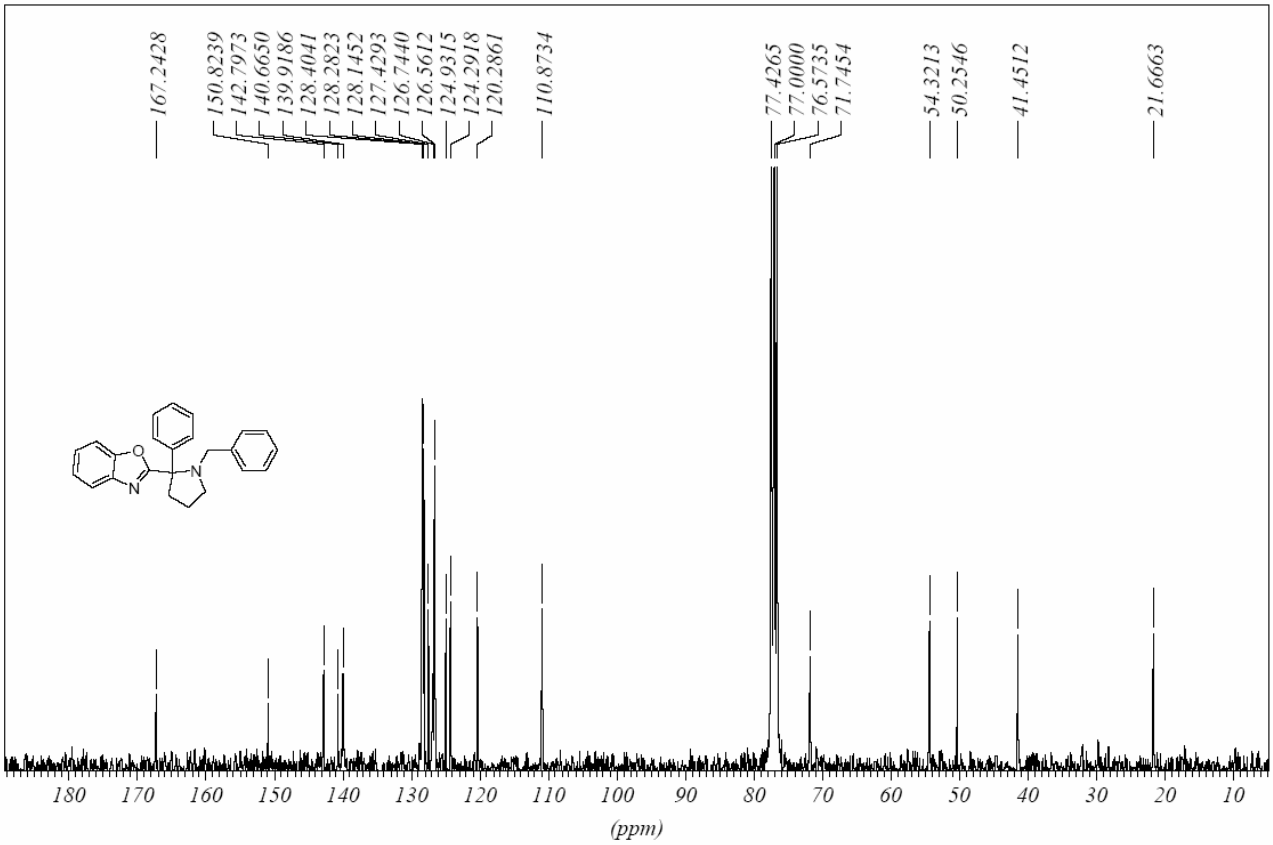
(ppm)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142.7973
140.6650
139.9186
128.4041
128.2823
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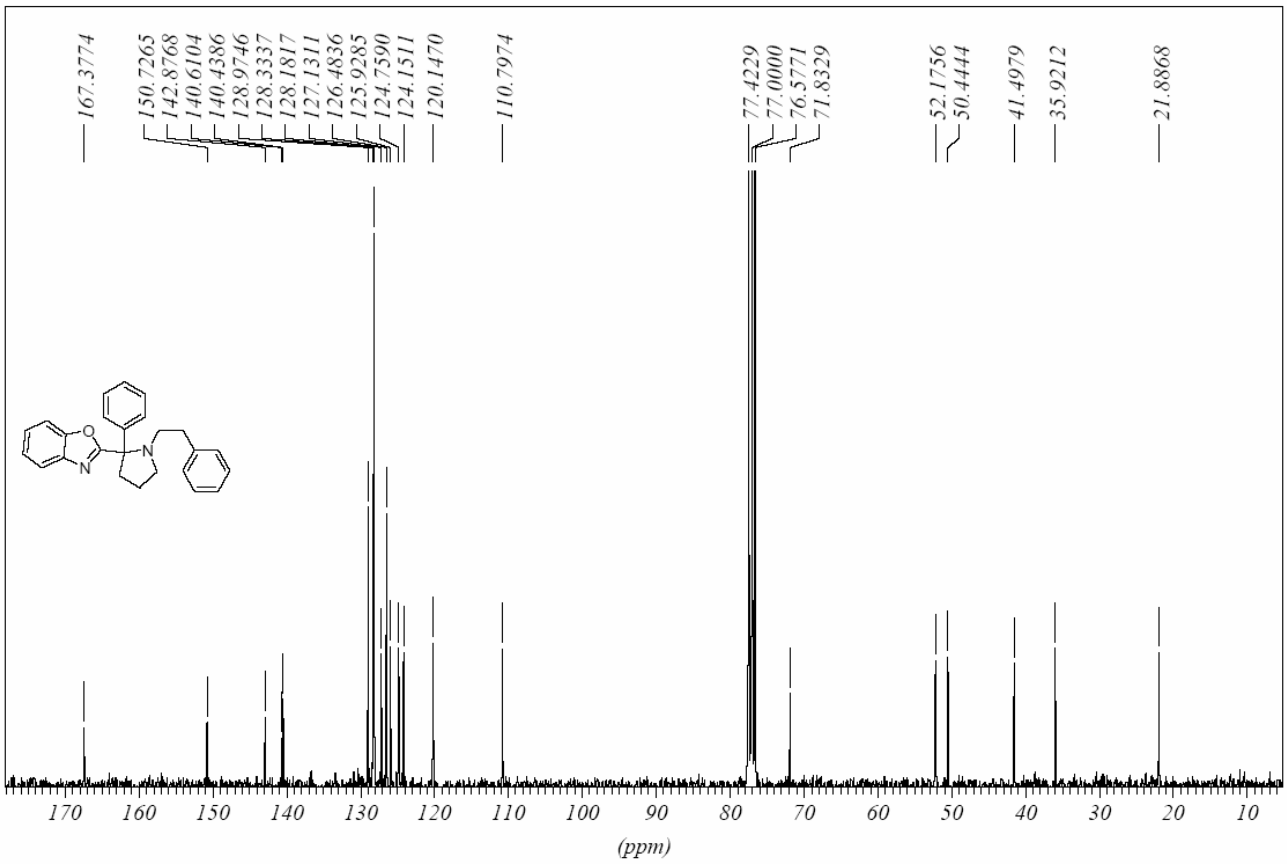
127.4293
126.7440
126.5612
124.9315
124.2918
120.2861
110.8734
77.4265
77.0000
76.5735
71.7454
54.3213
50.2546
41.4512
21.6663
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
(ppm)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150.7265
142.8768
140.6104
140.4386
128.9746
128.3337
128.1817
127.1311
126.4836
125.9285
124.7590
124.1511
120.1470
110.7974
77.4229
77.0000
76.5771
71.8329
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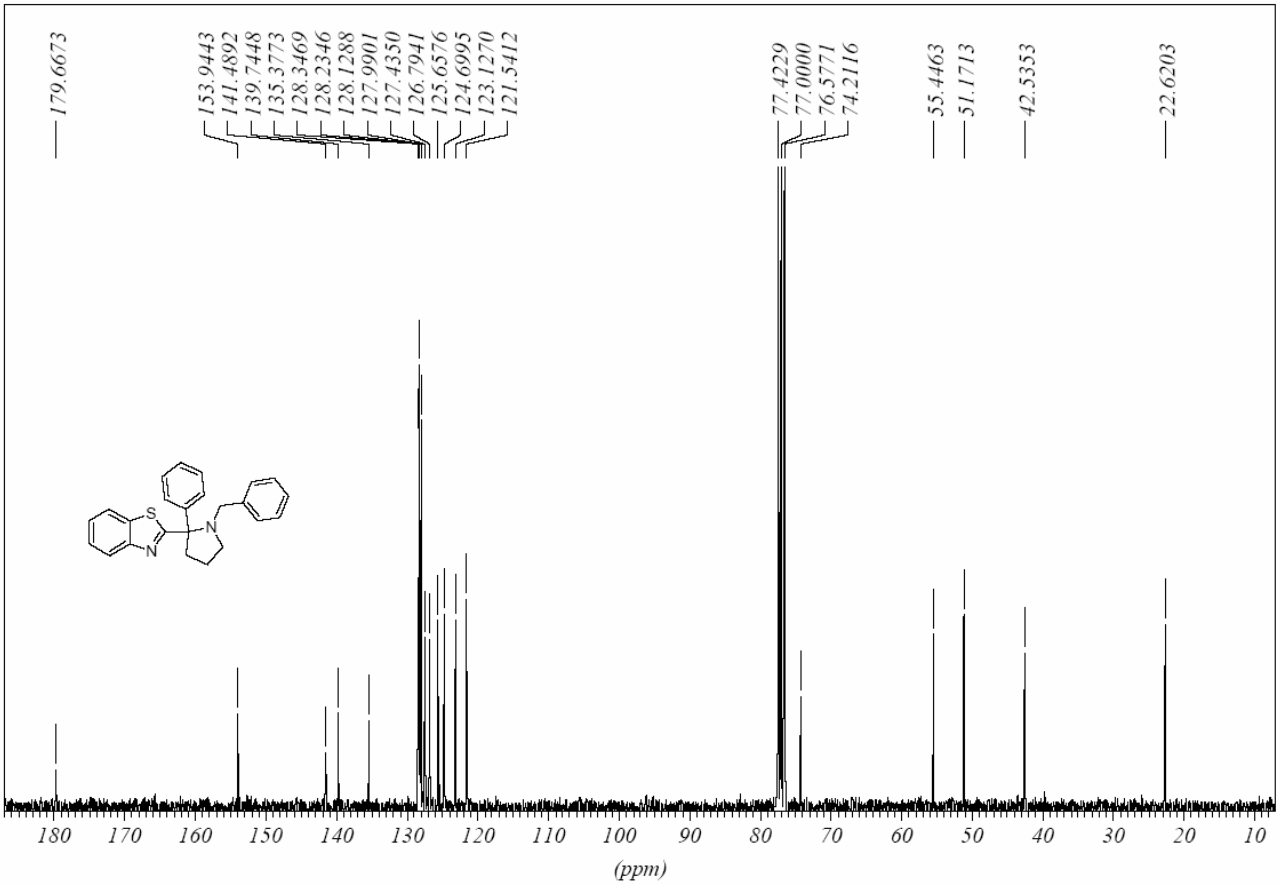
50.4444
41.4979
35.9212
21.8868
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
(ppm)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141.4892
139.7448
135.3773
128.3469
128.2346
128.1288
127.9901
127.4350
126.7941
125.6576
124.6995
123.1270
121.5412
77.4229
77.0000
76.5771
74.2116
55.4463
51.1713
42.5353
22.6203
S
N
N
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
(ppm)