Supplementary information

Molecular Iodine Catalysed One-Pot Synthesis of Chromeno[4,3-*b*]quinolin-6-ones under Microwave Irradiation*

Koneni V. Sashidhara* [a], Gopala Reddy Palnati [a, †], L. Ravithej Singh [a, †], Amit Upadhyay [c], Srinivasa Rao Avula [a], Abdhesh Kumar [a], Ruchir Kant [b]

[†]These authors contributed equally.[a]Medicinal and Process Chemistry Division and [b]Molecular and Structural Biology Division, CSIR-Central Drug Research Institute, BS-10/1, Sector 10, Jankipuram extension, Sitapur Road, P.O. Box 173, Lucknow 226031, [c]Medicinal Chemistry, National Institute of Pharmaceutical Education and Research (NIPER), Raebareli 229 010, India.

General Information

Unless otherwise specified all the reagents and catalysts were purchased from Sigma–Aldrich and were used without further any purification. Infrared spectra were recorded with FT-IR as a thin film and are expressed in cm^{-1}. ^{1}H NMR (at 200 or 300 or 400 MHz) and ^{13}C NMR (50 or 75 or 100 MHz) spectra were recorded using DMSO-d_6, TFA-d_1 and $CDCl_3$ as solvents and TMS as internal standard. Chemical shifts are reported in parts per million. Splitting patterns are described as singlet (s), broad singlet (bs), doublet (d), broad doublet (bd), double doublet (dd), triplet (t), quartet (q), and multiplet (m). Mass spectra were obtained on ESI mass spectrometer and HR/ESI mass spectra were obtained on high resolution ESI mass spectrometer. Microwave reactions were performed in a Biotage initiator 2.5 microwave synthesizer (maximum output power 400W, built in magnetic stirrer 300-900 rpm) using normal absorption mode and sealed pressure regulation 2-5 mL MW vial with ‘‘snap-on’’ cap and teflon-coated magnetic stir bar. The temperature in this instrument is determined by a calibrated external infrared sensor (40–250 °C).

A typical general procedure for synthesis of chromeno[4,3-*b*]quinolin-6-one:

To a mixture of aromatic amine (1 mmol.) and aromatic aldehyde (1 mmol.) in acetic acid (1 .0 mL) 4-hydroxy coumarin (1 mmol.) was added, followed by iodine (10 mol%.). The mixture was then stirred at 165°C for 30 mins in a sealed vial under MW irradiation. After completion of the reaction (monitored by TLC), the reaction mixture was treated with 5% aq. $Na_2S_2O_3$ solution (10 mL) and extracted with ethylacetate (3×20 mL). The combined organic layers were dried over anhydrous sodium sulphate, concentrated in vacuum and purified by chromatography on silica gel (100 -200 mesh) using 15-25% EtOAc:Hexane.

(*E*)-N-(4-chlorobenzylidene)-4-methylaniline (intermediate a)

Solid, yield 95% : mp :124-126 °C; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.4 (s, 1H), δ 7.87-7.84 (d, J = 8.48 Hz, 2H), δ 7.47-7.45 (d, J = 8.48 Hz, 2H), δ 7.23-7.21 (d, J = 8.08 Hz, 2H), δ 7.17-7.15 (d, J = 8.08 Hz, 2H) ESI calcd for $C_{14}H_{12}ClN$ [M + H] 230.0 found 230.0

7-(4-chlorophenyl)-9-methyl-6a,7,12,12a-tetrahydro-6*H*-chromeno[4,3-*b*]quinolin-6-one (intermediate g)

Solid, yield 86% : mp 254-256 °C; IR(KBr, cm^{-1}): 3315, 3045, 3010, 3397, 3019, 2400, 1632, 1215, 1070. ^{1}H NMR ($CDCl_3$, 400 MHz): δ (ppm): 9.87 (s, 1H, NH), 8.34-8.32 (dd, J = 7.8 Hz, 1H), 7.66-7.63 (m, 1H,), 7.47-7.43 (m, 1H), 7.38-7.36 (d, j = 8.16 Hz, 1H), 7.29-7.25 (m, 5H), 7.04-7.02 (d, j = 7.8 Hz, 2H), 5.22 (s, 1H), 2.19 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 160.9, 152.7, 146.9, 144.2, 133.4, 132.3, 131.3, 130.0, 129.5, 128.7, 128.7, 124.2, 124.1, 123.2, 117.3, 116.8, 113.8, 96.0, 20.8; ESI calcd for $C_{23}H_{16}ClNO_2$ [M + H] 376.1 found 376.1

9-methyl-7-phenyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8abf):

White solid, yield: 86%; mp: 273-275 ºC; IR (KBr): 3018, 2945, 1725, 1630, 1190 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 8.82 (d, J = 7.5 Hz, 1H), 8.13 (d, J = 8.3 Hz, 1H), 7.68 (d, J = 8.2 Hz, 1H), 7.55-7.52 (m, 4H), 7.41-7.37 (m, 1H), 7.31-7.25 (m, 4H), 2.40 (s, 3H); ^{13}C NMR (TFA-*d*, 100 MHz) δ: 170.4, 160.7, 155.6, 148.5, 145.6, 144.5, 140.4, 140.1, 135.9, 132.3, 131.3, 131.0, 129.1, 128.8, 125.9, 121.7, 120.8, 112.7, 22.3; ESI-MS (*m/z*): 338 $(M+H)^+$; HRMS (ESI) calcd for $C_{23}H_{15}NO_2$ [M + H] 338.1181, found 338.1178.

9-methyl-7-*p*-tolyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8abe):

White solid, yield: 91%; mp: 210-212 ºC; IR (KBr): 3015, 2935, 1735, 1650, 1205 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ: 8.81 (d, J = 7.6 Hz, 1H), 8.12 (d, J = 8.5 Hz, 1H), 7.67 (d, J = 8.4 Hz, 1H), 7.55-7.51 (m, 1H), 7.40-7.36 (m, 3H), 7.30 (d, J = 7.5 Hz, 2H), 7.17 (d, J = 7.60 Hz, 2H), 2.51 (s, 3H), 2.41 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 159.6, 155.0, 152.6, 149.3, 149.0, 137.8, 137.2, 135.2, 134.2, 132.0, 129.3, 129.1, 128.2, 128.0, 126.8, 125.6, 124.5, 120.0, 116.9, 113.3, 21.9, 21.6 ; ESI-MS (*m/z*): 352 $(M+H)^+$; HRMS (ESI) calcd for $C_{24}H_{17}NO_2$ [M + H] 352.1338 found, 352.1336.

7-(4-*iso*propylphenyl)-9-methyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8abd):

Pale yellow solid, yield: 90%; mp: 220-222 ºC; IR (KBr): 3010, 2932, 1705, 1625, 1210 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ: 8.83 (dd, J = 7.8, 1.1 Hz, 1H), 8.13 (d, J = 8.6 Hz, 1H), 7.68 (dd, J = 8.6, 1.6 Hz, 1H), 7.56-7.52 (m, 1H), 7.44-7.37 (m, 3H), 7.31-7.29 (m, 2H), 7.20 (d, J = 8.0 Hz, 2H), 3.10-3.04 (m, 1H), 2.42 (s, 3H), 1.39 (d, J = 6.9 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 159.5, 155.4, 152.6, 149.2, 148.8, 148.7, 137.3, 135.3, 134.3, 132.1, 129.0, 128.2, 128.0, 126.9, 126.4, 125.6, 124.6, 119.8, 116.9, 113.3, 34.0, 24.1, 21.9; ESI-MS (*m/z*): 380 $(M+H)^+$; HRMS (ESI) calcd for $C_{26}H_{21}NO_2$ [M + H] 380.1651, found 380.1644.

7-(4-methoxyphenyl)-9-methyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8abc):

Pale yellow solid, yield: 85%; mp: 246-248 ºC; IR (KBr): 3018, 2925, 1741, 1660, 1215 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ: 8.84 (d, J = 7.8 Hz, 1H), 8.15 (d, J = 8.5 Hz, 1H), 7.71 (d, J = 8.5 Hz, 1H), 7.59-7.54 (m, 1H), 7.44-7.32 (m, 3H), 7.28-7.22 (m, 2H), 7.13 (d, J = 7.8 Hz, 2H), 3.97 (s, 3H), 2.45 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 159.6, 159.5, 154.7, 152.6, 149.2, 149.0, 137.2, 135.2, 132.0, 129.5, 129.3, 129.2, 128.4, 126.8, 125.6, 124.5, 120.0, 116.9, 113.9, 113.4, 55.4, 21.9; ESI-MS (*m/z*): 368 $(M+H)^+$; HRMS (ESI) calcd for $C_{24}H_{17}NO_3$ [M + H] 368.1287, found 368.1281.

7-(3,4-dimethoxyphenyl)-9-methyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8abb):

Pale yellow solid, yield: 88%; mp: 230-232 ºC; IR (KBr): 3020, 2935, 1715, 1610, 1150 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ: 8.82 (dd, J = 7.8, 1.4 Hz, 1H), 8.13 (d, J = 8.6 Hz, 1H), 7.69 (dd, J = 8.6, 1.7 Hz, 1H), 7.57-7.53 (m, 1H), 7.42-7.38 (m, 1H), 7.33-7.30 (m, 2H), 7.07 (d, J = 8.1 Hz, 1H), 6.83 (dd, J = 8.0, 1.8 Hz, 1H), 6.79 (d, J = 1.8 Hz, 1H), 4.02 (s, 3H), 3.87 (s, 3H), 2.43 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 159.5, 154.6, 152.6, 149.3, 149.1, 148.9, 148.9, 137.3, 135.3, 132.0, 129.5, 129.2, 128.4, 126.9, 125.6, 125.6, 120.6, 120.0,

116.9, 113.3, 111.7, 111.0, 56.1, 56.0, 22.0; ESI-MS (*m/z*): 398 $(M+H)^+$; HRMS (ESI) calcd for $C_{25}H_{19}NO_4$ [M + H] 398.1392, found 398.1385.

9-methyl-7-(3,4,5-trimethoxyphenyl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8aba):

White solid, yield: 86%; mp: 282-284 ºC; IR (KBr): 3010, 2935, 1705, 1615, 1250 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ: 8.83 (dd, J = 7.8, 1.4 Hz, 1H), 8.14 (d, J = 8.6 Hz, 1H), 7.71 (dd, J = 8.6, 1.7 Hz, 1H), 7.58-7.54 (m, 1H), 7.43-7.39 (m, 1H), 7.34-7.31 (m, 2H), 6.47 (s, 2H), 4.01 (s, 3H), 3.85 (s, 6H), 2.46 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 159.3, 154.5, 153.3, 152.5, 149.2, 149.0, 137.6, 137.5, 135.4, 132.7, 132.1, 129.2, 128.1, 126.8, 125.6, 124.6, 119.9, 116.9, 113.1, 105.4, 61.2, 56.3, 22.0; ESI-MS (*m/z*): 428 $(M+H)^+$; HRMS (ESI) calcd for $C_{26}H_{21}NO_5$ [M + H] 428.1498, found 428.1492.

7-(4-fluorophenyl)-9-methyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8abg):

White solid, yield: 85%; mp: 235-237 ºC; IR (KBr): 3028, 2935, 1715, 1640, 1180 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ: 8.80 (d, J = 7.8 Hz, 1H), 8.12 (d, J = 8.6 Hz, 1H), 7.68 (d, J = 8.6 Hz, 1H), 7.56-7.52 (m, 1H), 7.41-7.37 (m, 1H), 7.30-7.21 (m, 6H), 2.41 (s, 3H); ^{13}C NMR (TFA-*d*, 100 MHz) δ: 167.1, 165.5, 163.1, 158.6, 153.4, 146.2, 143.6, 142.4, 138.3, 137.9, 129.5, 129.2, 129.0, 129.0, 128.7, 127.0, 123.7, 119.7, 118.5, 116.2, 116.0, 113.2, 110.5, 20.1; ESI-MS (*m/z*): 356 $(M+H)^+$; HRMS (ESI) calcd for $C_{23}H_{14}FNO_2$ [M + H] 356.1087, found 356.1081.

7-(4-chlorophenyl)-9-methyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8abh):

Pale yellow solid, yield: 85%; mp: 245-247 ºC; IR (KBr): 3020, 1738, 1609, 1216 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ: 8.80 (d, J = 7.8 Hz, 1H), 8.13 (d, J = 8.6 Hz, 1H), 7.69 (d, J = 8.6 Hz, 1H), 7.55-7.53 (m, 3H), 7.42-7.38 (m, 1H), 7.30 (d, J = 8.2 Hz, 1H), 7.25-7.20 (m, 3H), 2.42 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 159.6, 153.2, 152.5, 149.2, 149.1, 137.7, 135.6, 135.4, 134.2, 132.2, 129.5, 129.4, 128.7, 127.7, 126.4, 125.5, 124.7, 119.9, 117.0, 113.1, 21.9; ESI-MS (*m/z*): 372 $(M+H)^+$; HRMS (ESI) calcd for $C_{23}H_{14}ClNO_2$ [M + H] 372.0791, found 372.0788.

7-(4-bromophenyl)-9-methyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8abi):

White solid, yield: 88%; mp: 250-252 ºC; IR (KBr): 3020, 2915, 1725, 1605, 1220 cm^{-1}; ^1H NMR ($CDCl_3$, 400 MHz) δ: 8.81 (dd, J = 7.8, 1.3 Hz, 1H), 8.13 (d, J = 8.6 Hz, 1H), 7.71-7.69 (m, 3H), 7.57-7.53 (m, 1H), 7.42-7.39 (m, 1H), 7.31 (d, J = 8.2 Hz, 1H), 7.20-7.16 (m,

3H), 2.42 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 159.6, 153.2, 152.5, 149.2, 149.1, 137.7, 136.1, 135.5, 132.2, 131.6, 129.8, 129.4, 127.7, 126.4, 125.6, 124.7, 122.4, 119.8, 117.0, 113.1, 21.9; ESI-MS (*m/z*): 416 $(M+H)^+$; HRMS (ESI) calcd for $C_{23}H_{14}BrNO_2$ [M + H] 416.0286, found 416.0279.

4-(9-methyl-6-oxo-6*H*-chromeno[4,3-*b*]quinolin-7-yl)benzonitrile (8abj):

Pale yellow solid, yield: 82%; mp: >300 ºC; IR (KBr): 3020, 2915, 1721, 1620, 1215 cm^{-1}; ^{1}H NMR (TFA-*d*, 300 MHz) δ: 8.86 (d, J = 8.1 Hz, 1H), 8.65 (d, J = 8.7 Hz, 1H), 8.39 (d, J = 8.7 Hz, 1H), 8.20 (d, J = 8.0 Hz, 2H), 8.16-8.10 (m, 1H), 7.87-7.82 (m, 1H), 7.73-7.68 (m, 4H), 2.70 (s, 3H); ^{13}C NMR (TFA-*d*, 100 MHz) δ: 164.6, 158.8, 153.9, 146.8, 144.6, 143.2, 140.2, 139.1, 138.6, 133.4, 128.8, 128.3, 127.6, 124.3, 120.4, 113.7, 112.8, 110.8, 20.6; ESI-MS (*m/z*): 363 $(M+H)^+$; HRMS (ESI) calcd for $C_{24}H_{14}N_2O_2$ [M + H] 363.1134, found 363.1128.

9-methyl-7-(4-nitrophenyl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8abk):

Pale yellow solid, yield: 85%; mp: >300 ºC; IR (KBr): 3010, 2925, 1741, 1620, 1205 cm^{-1}; ^{1}H NMR (TFA-*d*, 300 MHz) δ: 8.84 (d, J = 8.0 Hz, 1H), 8.70-8.62(m, 3H), 8.37 (d, J = 8.7 Hz, 1H), 8.13-8.08 (m, 1H), 7.85-7.80 (m, 1H), 7.75-7.66 (m, 4H), 2.67 (s, 3H); ^{13}C NMR (TFA-*d*, 75 MHz) δ: 164.5, 158.8, 154.0, 149.0, 146.9, 144.7, 143.3, 141.8, 139.2, 138.7, 128.9, 128.4, 127.6, 124.7, 124.4, 120.5, 119.2, 113.9, 110.9, 20.7; ESI-MS (*m/z*): 383 $(M+H)^+$; HRMS (ESI) calcd for $C_{23}H_{14}N_2O_4$ [M + H] 383.1032, found 383.1026.

9-methyl-7-(4-(trifluoromethyl)phenyl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8abl):

White solid, yield: 80%; mp: >300 ºC; IR (KBr): 3010, 2915, 1711, 1610, 1205 cm^{-1}; ^{1}H NMR (TFA-*d*, 300 MHz) δ: 8.83 (d, J = 7.7 Hz, 1H), 8.61 (d, J = 8.7 Hz, 1H), 8.36 (d, J = 8.6 Hz, 1H), 8.08-8.06 (m, 3H), 7.85-7.80 (m, 1H), 7.75 (bs, 1H), 7.70-7.61 (m, 3H), 2.68 (s, 3H); ^{13}C NMR (TFA-*d*, 75 MHz) δ: 166.0, 158.6, 153.7, 146.6, 144.1, 142.9, 138.9, 138.7, 138.3, 137.7, 133.3, 132.9, 129.0, 128.6, 127.5, 127.3, 126.1, 126.1, 124.0, 120.0, 118.9, 113.5, 110.7, 20.3; ESI-MS (*m/z*): 406 $(M+H)^+$; HRMS (ESI) calcd for $C_{24}H_{14}F_3NO_2$ [M + H] 406.1055, found 406.1048.

9-methyl-7-(thiophen-3-yl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8abm):

Pale yellow solid, yield: 85%; mp: 248-250 ºC; IR (KBr): 3028, 2925, 1741, 1660, 1215 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 8.79 (d, J = 7.8 Hz, 1H), 8.10 (d, J = 8.6 Hz, 1H), 7.67 (d, J

= 8.6 Hz, 1H), 7.57-7.52 (m, 2H), 7.40-7.36 (m, 2H), 7.30-7.25 (m, 2H), 7.12 (d, *J* = 4.8 Hz, 1H), 2.42 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) *δ*: 159.3, 152.5, 150.2, 149.1, 148.9, 137.4, 136.2, 135.3, 132.0, 129.2, 128.7, 128.3, 126.5, 125.6, 125.5, 124.5, 123.4, 119.9, 116.9, 113.7, 21.9; ESI-MS (*m/z*): 344 $(M+H)^+$; HRMS (ESI) calcd for $C_{21}H_{13}NO_2S$ [M + H] 344.0745, found 344.0742.

2,9-dimethyl-7-p-tolyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8bbe):

White solid, yield: 92%; mp: 250-252 ºC; IR (KBr): 3016, 2935, 1731, 1640, 1205 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) *δ*: 8.61 (bs, 1H), 8.13 (d, *J* = 8.6 Hz, 1H), 7.68 (d, *J* = 8.4 Hz, 1H), 7.37-7.33 (m, 3H), 7.29 (s, 1H), 7.21-7.15 (m, 3H), 2.51 (s, 6H), 2.42 (s, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz) *δ*: 159.8, 155.0, 150.8, 149.4, 149.0, 137.7, 137.1, 135.2, 134.3, 134.2, 133.0, 129.2, 129.1, 128.2, 128.0, 126.9, 125.3, 119.6, 116.7, 113.4, 21.9, 21.6, 21.1; ESI-MS (*m/z*): 366 $(M+H)^+$; HRMS (ESI) calcd for $C_{25}H_{19}NO_2$ [M + H] 366.1494, found 366.1488.

4,9-dimethyl-7-p-tolyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8cbe):

White solid, yield: 90%; mp: 250-252 ºC; IR (KBr): 3018, 2935, 1741, 1650, 1215 cm^{-1}; ^{1}H NMR ($CDCl_3$, 400 MHz) *δ*: 8.66 (d, *J* = 7.8 Hz, 1H), 8.11 (d, *J* = 8.6 Hz, 1H), 7.68-7.66 (m, 1H), 7.39-7.35 (m, 3H), 7.32-7.25 (m, 2H), 7.17 (d, *J* = 7.8 Hz, 2H), 2.51 (s, 3H), 2.43 (s, 3H), 2.41 (s, 3H) ; ^{13}C NMR ($CDCl_3$, 100 MHz) *δ*: 159.7, 154.9, 150.9, 149.6, 149.1, 137.7, 137.1, 135.1, 134.2, 133.3, 129.3, 129.0, 128.0, 126.8, 126.1, 124.0, 123.2, 119.7, 113.1, 21.9, 21.6, 15.7; ESI-MS (*m/z*): 366 $(M+H)^+$; HRMS (ESI) calcd for $C_{25}H_{19}NO_2$ [M + H] 366.1494, found 366.1488.

9-chloro-7-(4-methoxyphenyl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8ahc):

Yellow solid, yield: 86%; mp 222-224 °C; IR(KBr, cm^{-1}): 3389, 1745, 1608, 1546, 1401, 1248, 1168, 1102, 831, 759; ^{1}H NMR ($CDCl_3$, 400 MHz): *δ* 8.84-8.82 (dd, J_1 = 1.4 Hz, J_2 = 7.9 Hz, 1H), 8.20 (d, *J* = 9.0 Hz, 1H), 7.82-7.79 (dd, J_1 = 2.3 Hz, J_2 = 9.0 Hz, 1H), 7.62-7.57 (m, 2H), 7.45-7.41 (m, 1H), 7.34 (d, *J* = 8.2 Hz, 1H), 7.21 (d, *J* = 8.7 Hz, 2H), 7.12 (d, *J* = 8.7 Hz, 2H), 3.96 (s, 3H), δ : ^{13}C NMR ($CDCl_3$, 100 MHz): *δ*159.8, 159.2, 154.8, 152.7, 150.3, 148.7, 133.7, 133.2, 132.5, 131.1, 129.4, 129.0, 128.2, 126.8, 125.7, 124.7, 119.6, 117.0, 114.1, 114.0, 55.4; HRMS (ESI) calcd for $C_{23}H_{14}ClNO_3$ [M + H] 388.0662 found 388.0730.

9-bromo-7-(*p*-tolyl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8age):

Yellow solid, yield: 88%; mp 215-217 °C; IR(KBr, cm^{-1}): 3400, 3021, 1743, 1612, 1553, 1403, 1216, 1103, 763, 670; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.85-8.82 (dd, J_1 = 1.5 Hz, J_2 = 8.0 Hz, 1H), 8.12 (d, J = 9 Hz, 1H), 7.95-7.92 (dd, J_1 = 2.1 Hz, J_2 = 9.0 Hz, 1H), 7.71 (d, J= 2.1 Hz, 1H), 7.61-7.58 (m, 1H), 7.46-7.40 (m, 4H), 7.35 (d, J = 8.2 Hz, 1H), 7.18 (d, J = 8.0 Hz, 2H), 3.96 (s, 3H), δ : : ^{13}C NMR ($CDCl_3$, 100 MHz): δ159.1, 155.1, 152.7, 150.4, 148.8, 138.4, 136.2, 133.2, 132.6, 131.1, 130.2, 129.0, 129.1, 127.9, 125.7, 124.7, 121.4, 119.6, 117.0, 113.9, 21.6; HRMS (ESI) calcd for $C_{23}H_{14}BrNO_2$ [M + H] 416.0286 found 416.0281.

9-chloro-7-(4-fluorophenyl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8ahg):

Yellow solid, yield: 82%; mp 265-267 °C; IR(KBr, cm^{-1}): 3418, 3019, 1403, 1215, 758, 669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.86-8.83 (dd, J_1 = 1.4 Hz, J_2 = 8.0 Hz, 1H), 8.23 (d, J = 9.0 Hz, 1H), 7.84-7.82 (dd, J_1 = 2.2 Hz, J_2 = 9.0 Hz, 1H), 7.64-7.59 (m, 1H), 7.49 (d, J = 2.1 Hz, 1H), 7.47-7.43 (t, J = 15.1, 1H), 7.36 (d, J = 8.2 Hz, 1H), 7.31-7.26 (m, 4H), δ : ^{13}C NMR ($CDCl_3$, 100 MHz): δ164.2, 159.2, 153.7, 152.7, 150.3, 148.8, 133.9, 133.5, 132.7, 131.2, 129.9, 128.7, 126.5, 125.7, 124.9, 119.5, 117.1, 116.0, 115.8, 114.0; HRMS (ESI) calcd for $C_{22}H_{11}ClFNO_2$ [M + H] 376.0541 found 376.0536.

9-bromo-7-(4-methoxyphenyl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8agc):

Brown solid, yield: 86%; mp 212-214 °C; IR(KBr, cm^{-1}): 3412, 3020, 2925, 1745, 1607, 1549, 1513, 1478, 1406, 1215, 1172, 1103, 1032, 760, 670;^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.85-8.82 (dd, J_1 = 1.4 Hz, J_2 = 8.1 Hz, 1H), 8.13 (d, J = 9.0 Hz, 1H), 7.95-7.92 (dd, J_1 = 2.0 Hz, J_2 = 8.9 Hz, 1H), 7.76 (d, J = 2.0 Hz, 1H), 7.62-7.59 (m, 1H), 7.44 (s, 1H), 7.35 (d, J = 8.2 Hz, 1H), 7.22 (d, J = 8.6 Hz, 2H) , 7.13 (d, J = 8.6 Hz, 2H), 3.97 (s, 3H) δ : : ^{13}C NMR ($CDCl_3$, 100 MHz): δ159.8, 159.1, 154.8, 152.7, 150.4, 148.8, 136.2, 132.6, 132.1, 131.2, 130.2, 129.4, 128.1, 125.7, 124.7, 124.1, 121.4, 119.6, 117.0, 114.1, 55.4; HRMS (ESI) calcd for $C_{23}H_{14}BrNO_3$ [M + H] 432.0235 found 432.0212.

7-(4-methoxyphenyl)-9-nitro-6*H*-chromeno[4,3-*b*]quinolin-6-one (8ajc):

Green solid, yield: 84%; mp 226-228 °C; IR(KBr, cm^{-1}): 3399, 3019, 2925, 1744, 1610, 1552, 1485, 1403, 1342, 1215, 1083, 757, 669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.89-8.87(dd, J_1 = 1.6 Hz, J_2 = 8.0 Hz, 1H), 8.64-8.60 (m, 2H), 8.38 (d, J = 9.6 Hz, 1H), 7.69-7.65 (m, 1H), 7.50-7.46 (m, 1H), 7.38 (d, J = 8.9, 1H), 7.26 (d, J = 2.1 Hz, 2H), 7.16 (d, J = 8.7 Hz, 2H), 3.98 (s, 3H) δ : : ^{13}C NMR ($CDCl_3$, 100 MHz): δ160.4, 158.6, 158.4, 153.3, 153.0, 152.1,

145.8, 133.7, 131.4, 129.6, 127.5, 127.2, 126.3, 125.9, 125.4, 125.0, 119.3, 117.2, 114.9, 114.4, 55.5; HRMS (ESI) calcd for $C_{23}H_{14}N_2O_5$ [M + H] 399.0981 found 399.0968.

9-methoxy-7-(*p*-tolyl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8aae):

Yellow solid, yield: 88%; mp 214-216 °C; IR(KBr, cm^{-1}): 3402, 3020, 2925, 1740, 1620, 1549, 1497, 1410, 1216, 1174, 1101, 760, 669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.85-8.82 (dd, J_1 = 1.5 Hz, J_2 = 7.9 Hz, 1H), 8.18 (d, J = 9.2 Hz, 1H), 7.58-7.53 (m, 2H), 7.43 (d, J = 8.0, 1H), 7.41-7.38 (m, 1H), 7.35-7.33 (dd, J_1 = 0.8 Hz, J_2 = 8.3, 2H), 7.20 (d, J = 8.0 Hz, 2H), 6.81 (d, J = 2.7 Hz, 1H), 3.73 (s, 3H), 2.53 (s, 3H) δ : : ^{13}C NMR ($CDCl_3$, 100 MHz): δ158.1, 153.8, 152.4, 148.0, 146.9, 137.8, 134.3, 131.7, 131.0, 129.4, 129.2, 127.9, 126.0, 125.3, 124.5, 120.1, 116.9, 113.4, 105.3, 55.5, 21.6; HRMS (ESI) calcd for $C_{24}H_{17}NO_3$ [M + H] 368.1287 found 368.1283.

7-(4-methoxyphenyl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8afc):

Brown solid, yield: 91%; mp 227-229 °C; IR(KBr, cm^{-1}): 3848, 3745, 3670, 3398, 3019, 1742, 1610, 1551, 1515, 1492, 1464, 1402, 1242, 1215, 1175, 1147, 1109, 1031, 757, 669 ; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.90-8.87(dd, J_1 = 1.0 Hz, J_2 = 7.9 Hz,1H), 8.27 (d, J =8.0 Hz, 1H), 7.91-7.87 (m, 1H), 7.66-7.63 (dd, J_1 = 0.9 Hz, J_2 = 8.6 Hz, 1H), 7.61 (d, J = 8.2 Hz, 1H), 7.58 (d, J = 8.2, 1H), 7.53-7.42 (m, 1H), 7.37-7.34 (dd, J_1 = 0.9 Hz, J_2 = 8.3 Hz, 1H), 7.24 (d, J = 8.7 Hz, 2H), 7.12 (d, J = 8.7 Hz, 2H), 3.95 (s, 3H) δ : : ^{13}C NMR ($CDCl_3$, 100 MHz): δ159.6, 155.8, 152.8, 150.4, 150.2, 133.5, 132.8, 132.3, 129.6, 129.5, 129.0, 128.4, 127.1, 125.8, 124.6, 120.0, 117.5, 117.0, 11.9, 113.5, 55.4; HRMS (ESI) calcd for $C_{23}H_{15}NO_3$ [M + H] 354.1130 found 354.1134.

9-fluoro-7-(4-methoxyphenyl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8aic):

White solid, yield: 88%; mp 224-226 °C; IR(KBr, cm^{-1}): 3405, 3021, 1744, 1615, 1553, 1495, 1402, 1216, 1175, 1096, 761, 669; ^{1}H NMR ($CDCl_3$, 400 MHz):δ 8.85-8.83(dd, J = 1.5 Hz, J_2 = 7.9 Hz, 1H), 8.29-8.25 (dd, J_1 = 5.4 Hz, J_2 = 9.3 Hz, 1H), 7.69-7.64 (m, 1H), 7.62-7.57 (m ,1H), 7.46-7.42 (m, 1H), 7.35 (d, J = 8.1, 1H), 7.26-7.21 (m, 3H), 7.13 (d, J = 8.7 Hz, 2H), 3.96 (s, 3H), δ : : ^{13}C NMR ($CDCl_3$, 100 MHz): δ161.9, 159.8, 159.3, 155.0, 152.6, 149.6, 147.5, 132.3, 132.2, 132.1, 129.4, 128.5, 125.6, 124.7, 123.5, 123.2, 119.7, 117.0, 114.1, 111.3, 55.4; HRMS (ESI) calcd for $C_{23}H_{14}FNO_3$ [M + H] 372.1036 found 372.1017.

7-(3,4-dimethoxyphenyl)-9-*iso*propyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8adb):

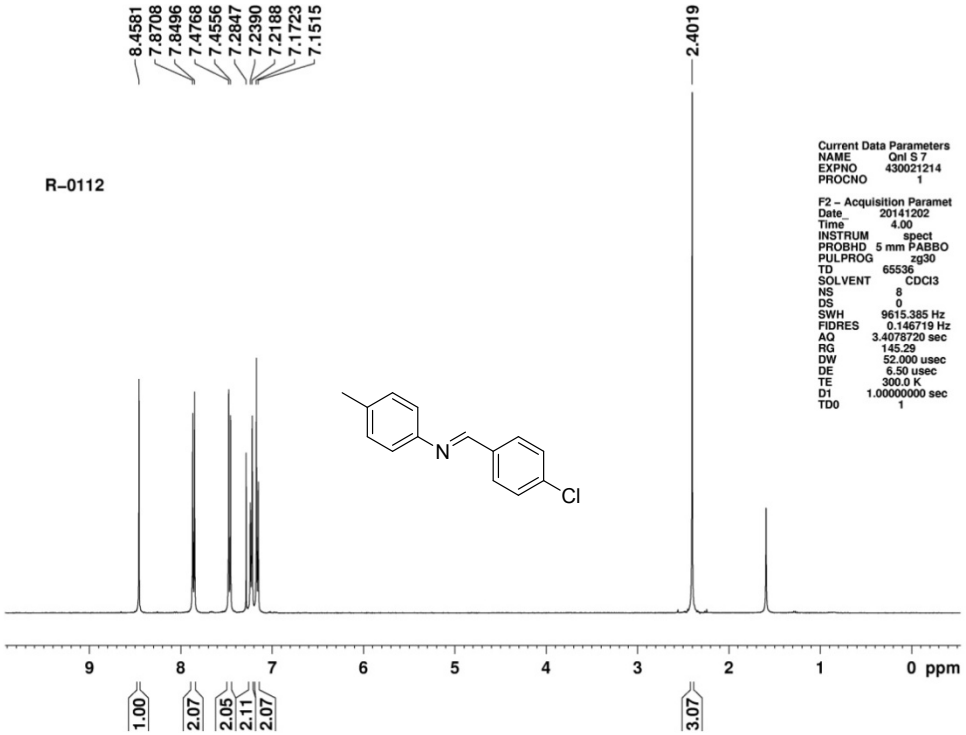
yellow solid, yield: 91%; mp 223-225 °C; IR(KBr, cm^{-1}): 3848, 3745, 3671, 3399, 3019, 1650, 1403, 1215, 1070, 768, 669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.94-8.91(dd, J_1 = 1.5 Hz, J_2 = 7.9 Hz, 1H), 8.28 (d, J = 8.7 Hz, 1H), 7.85-7.82 (dd, J_1 = 2.0 Hz, J_2 = 8.8 Hz, 1H), 7.62-7.57 (m, 1H), 7.46-7.42 (m, 2H), 7.36-7.34 (dd, J_1 = 0.9 Hz, J_2 = 8.1, 1H), 7.09 (d, J = 8.1 Hz, 1H), 6.88-6.82 (m, 1H), 4.04 (s, 3H), 3.89 (s, 3H), 3.04-2.99 (m, 1H), 1.28 (d, J = 8.1 Hz, 3H), 1.26 (d, J = 8.1 Hz, 3H) δ : : ^{13}C NMR ($CDCl_3$, 100 MHz): δ159.5, 154.8, 152.5, 149.4, 148.8, 147.8, 132.5, 131.9, 129.45, 129.41, 128.3, 125.5, 124.5, 124.3, 120.6, 119.9, 116.8, 113.1, 111.7, 110.9, 56.0, 55.8, 34.30, 23.72, 23.62; HRMS (ESI) calcd for $C_{27}H_{23}NO_4$ [M + H] 426.1705 found 426.1663 $(M+H)^+$.

7-(3,4-dimethoxyphenyl)-9-ethyl-6*H*-chromeno[4,3-*b*]quinolin-6-one (8acb):

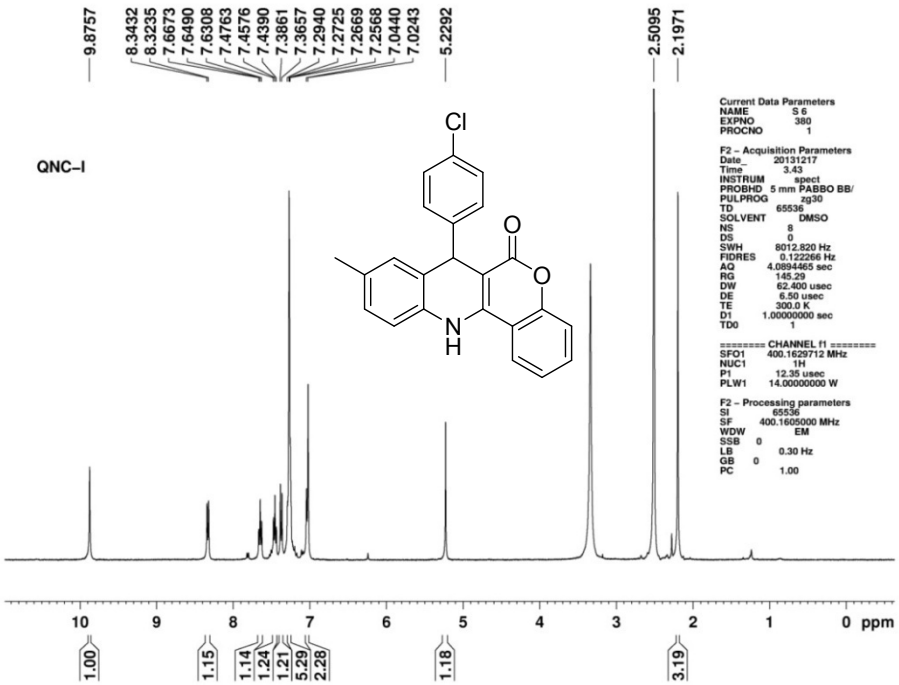
yellow solid, yield: 92%; mp 215-217 °C; IR(KBr, cm^{-1}): 3851, 3745, 3671, 3397, 3019, 12400, 1632, 1404, 1215, 1070, 757, 669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.96-8.94(dd, J_1 = 1.2, J_2 = 8.0 Hz, 1H), 8.30 (d, J = 8.6 Hz, 1H), 7.81-7.78 (dd, J_1 = 1.9 Hz, J_2 = 8.7 Hz, 1H), 7.62-7.57 (m, 1H), 7.47-7.43 (m, 1H), 7.41 (d, J = 1.2, 1H), 7.36-7.34 (dd, J_1 = 0.9 Hz, J_2 = 8.2 Hz, 1H), 7.09 (d, J = 8.1 Hz, 1H), 6.87-6.85 (dd, J_1= 1.9 Hz, J_2 = 8.0 Hz, 1H), 6.81 (d, J = 1.9 Hz, 1H), 4.04 (s, 3H), 3.89 (s, 3H), 2.79-2.74 (q, J = 7.5 Hz, 2H), 1.28-1.24 (t, J = 7.5 Hz, 3H) δ : : ^{13}C NMR ($CDCl_3$, 100 MHz): δ154.7, 152.5, 149.2, 149.2, 148.9, 148.8, 143.4, 134.1, 131.9, 129.3, 128.35, 125.64, 125.53, 124.49, 120.62, 119.96, 116.84, 113.21, 111.75, 110.96, 56.01, 55.90, 29.09, 15.31; HRMS (ESI) calcd for $C_{26}H_{21}NO_4$ [M + H] 412.1549 found 412.1528.

9-(*tert*-butyl)-7-(3,4-dimethoxyphenyl)-6*H*-chromeno[4,3-*b*]quinolin-6-one (8aeb):

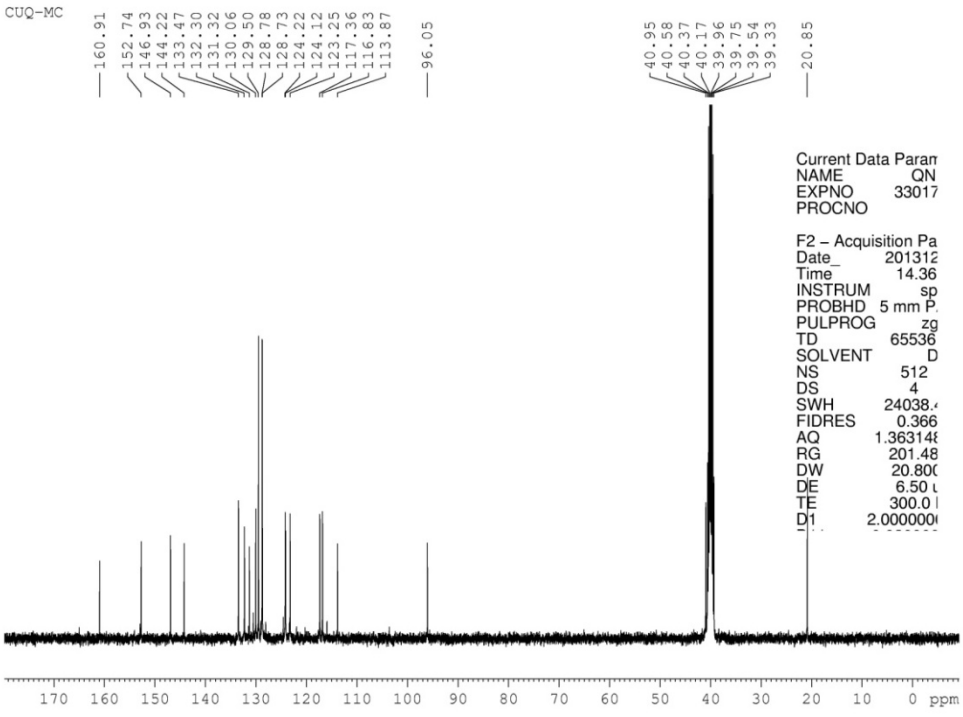
yellow solid, yield: 94%; mp 229-231 °C; IR(KBr, cm^{-1}): 3851, 3745, 3671, 3397, 3019, 2400, 1632, 1404, 1215, 1070, 757, 669; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.94-8.91(dd, J_1 = 1.3 Hz, J_2 = 7.9 Hz, 1H), 8.28 (d, J = 8.9 Hz, 1H), 8.02-8.00 (dd, J_1 = 2.2 Hz, J_2 = 9.0 Hz, 1H), 7.61-7.57 (m, 1H), 7.59-7.57 (m, 1H), 7.46-7.42 (m, 1H), 7.37-7.34 (dd, J_1 = 0.8 Hz, J_2 = 8.1 Hz, 1H), 7.09 (d, J = 8.1 Hz, 1H), 6.89-6.86 (dd, J_1 = 1.9 Hz, J_2 = 8.1 Hz, 1H), 6.83 (d, J = 1.9 Hz,1H), 4.04 (s, 3H), 3.89 (s, 3H), 1.32 (s, 9 H) δ : : ^{13}C NMR ($CDCl_3$, 100 MHz): δ159.5, 155.2, 152.5, 150.0, 149.5, 149.0, 148.9, 148.8, 132.0, 131.9, 129.6, 129.0, 127.9, 125.6, 124.5, 123.0, 120.7, 119.9, 116.8, 113.1, 111.8, 110.9, 56.0, 55.9, 35.1, 30.9; HRMS (ESI) calcd for $C_{28}H_{25}NO_4$ [M + H] 440.1862 found 440.1837.



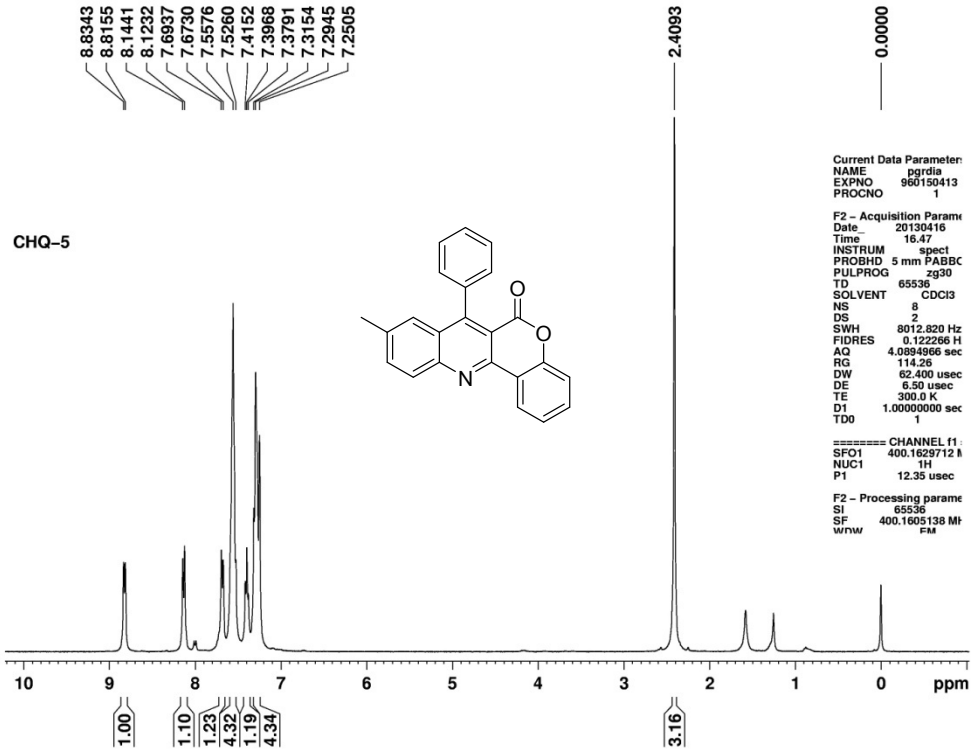
^{1}H NMR of intermediate **a** at 400 MHz ($CDCl_3$)



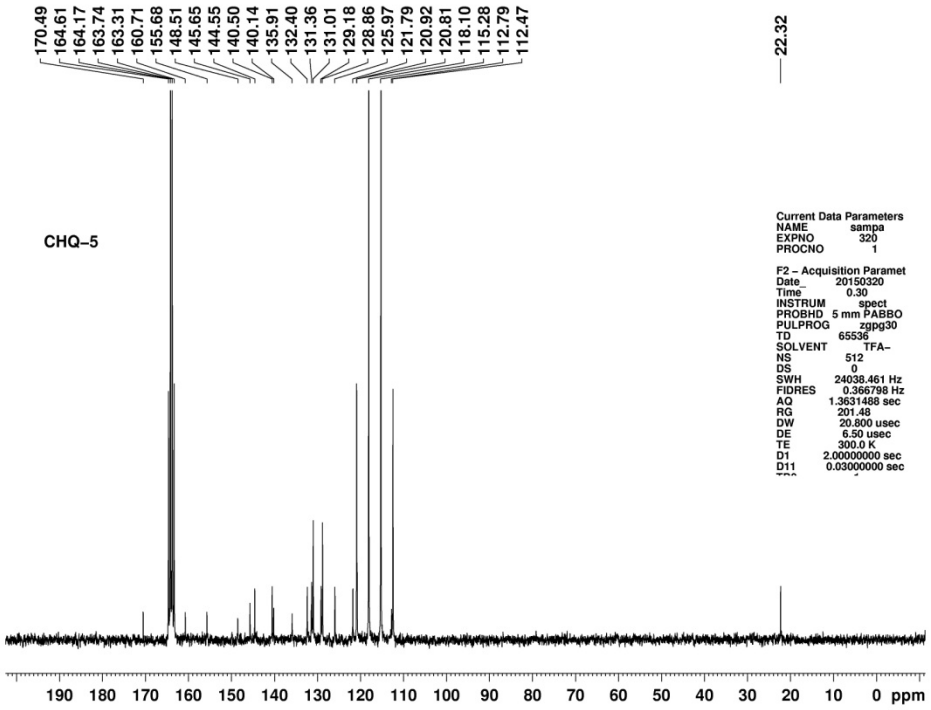
^{1}H NMR of intermediate **g** at 400 MHz (DMSO-d_6)



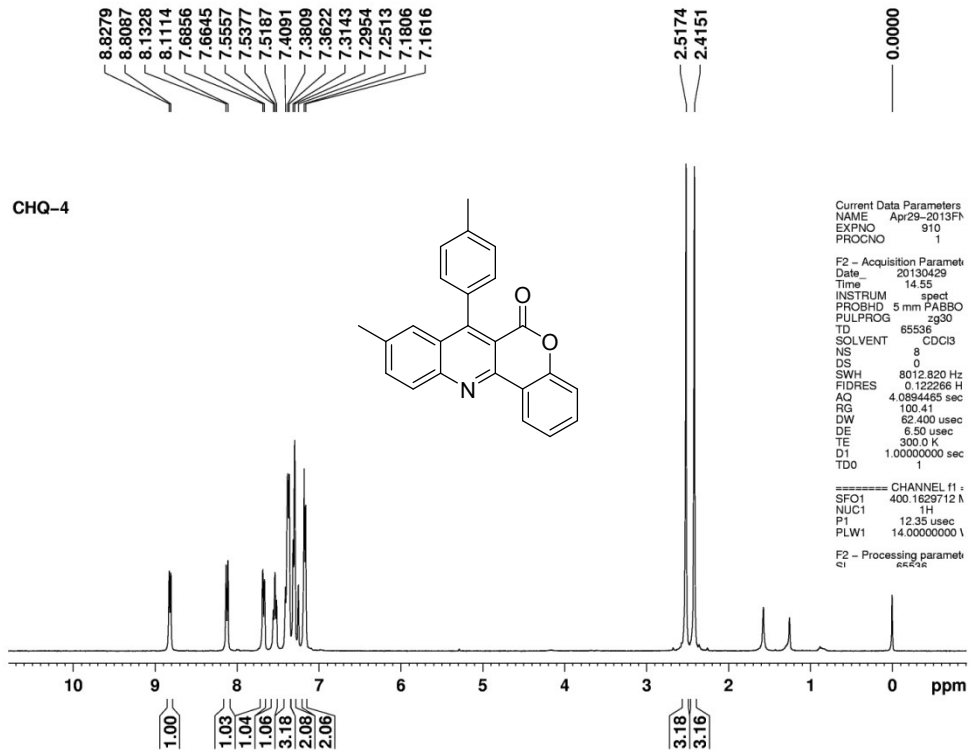
^{13}C NMR of intermediate **g** at 100 MHz (DMSO-d_6)



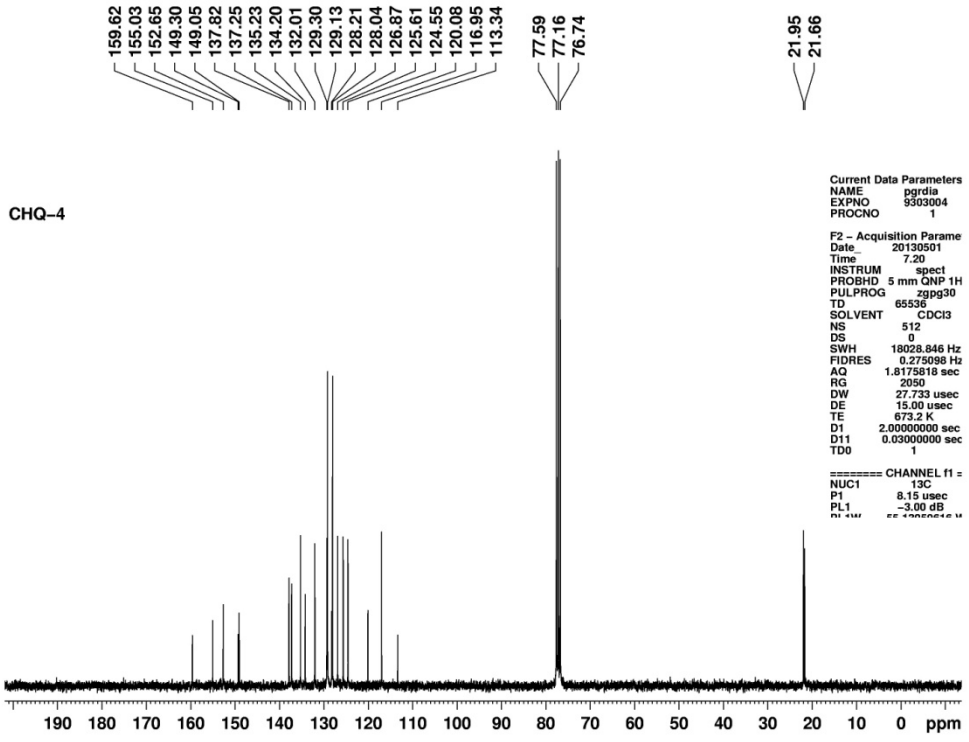
^{1}H NMR of compound **8abf** at 400 MHz ($CDCl_3$)



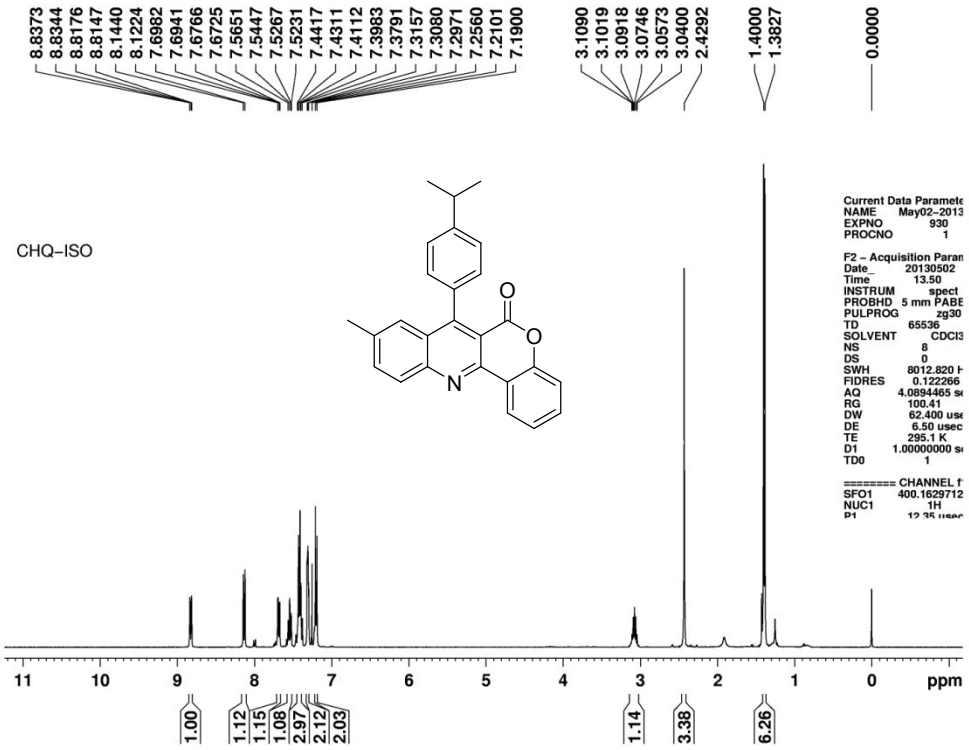
^{13}C NMR of compound **8abf** at 100 MHz (TFA-*d*)



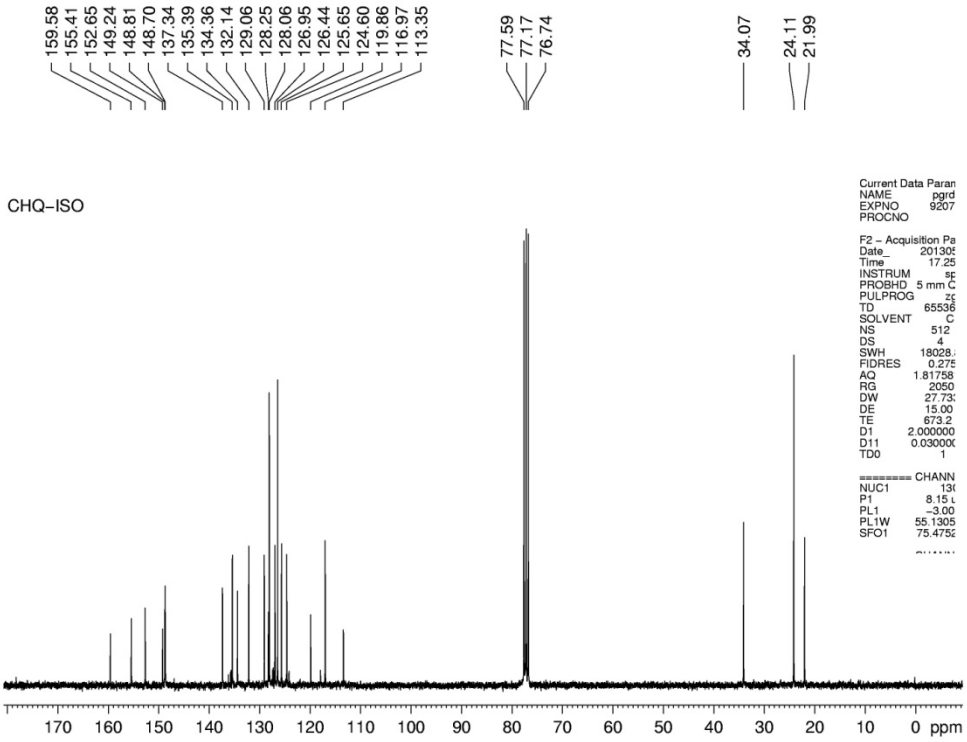
^{1}H NMR of compound **8abe** at 400 MHz ($CDCl_3$)



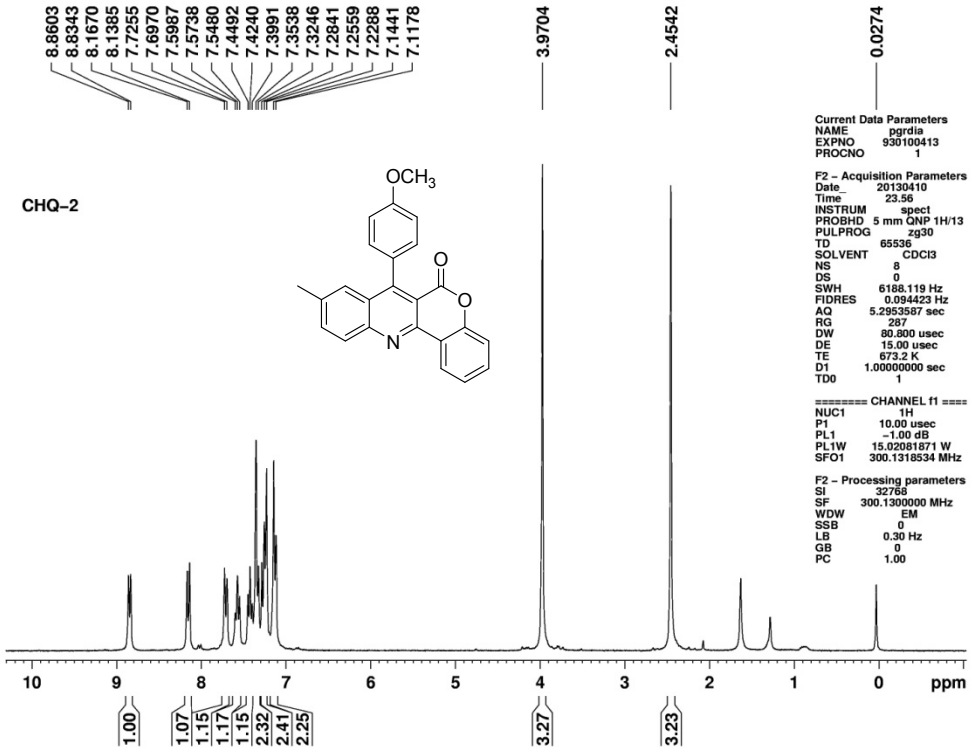
^{13}C NMR of compound **8abe** at 100 MHz ($CDCl_3$)



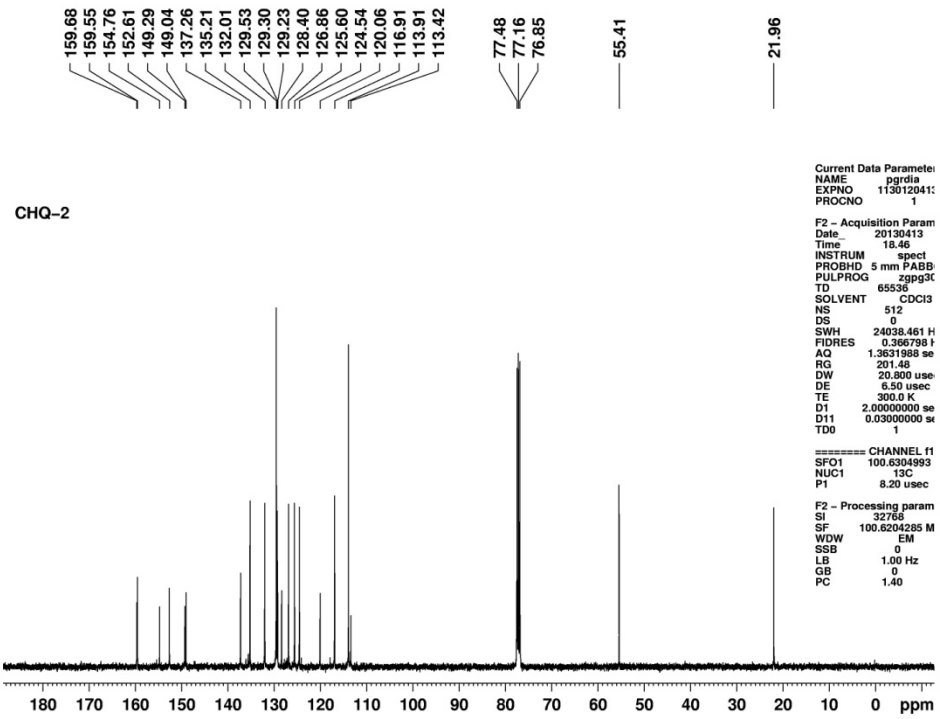
^{1}H NMR of compound **8abd** at 400 MHz ($CDCl_3$)



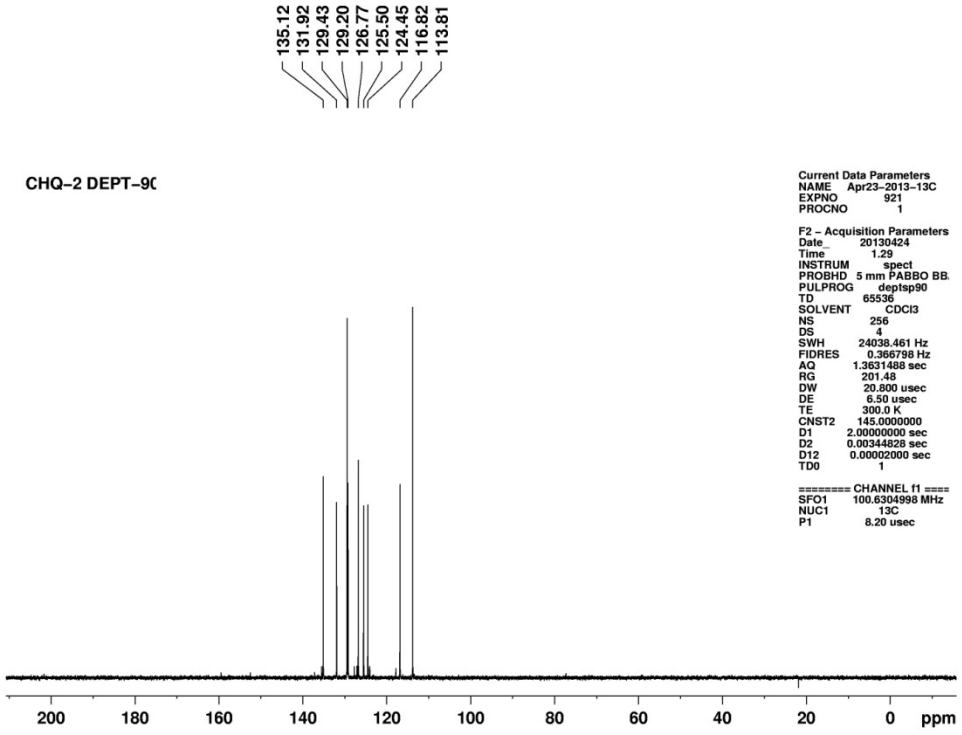
^{13}C NMR of compound **8abd** at 100 MHz ($CDCl_3$)



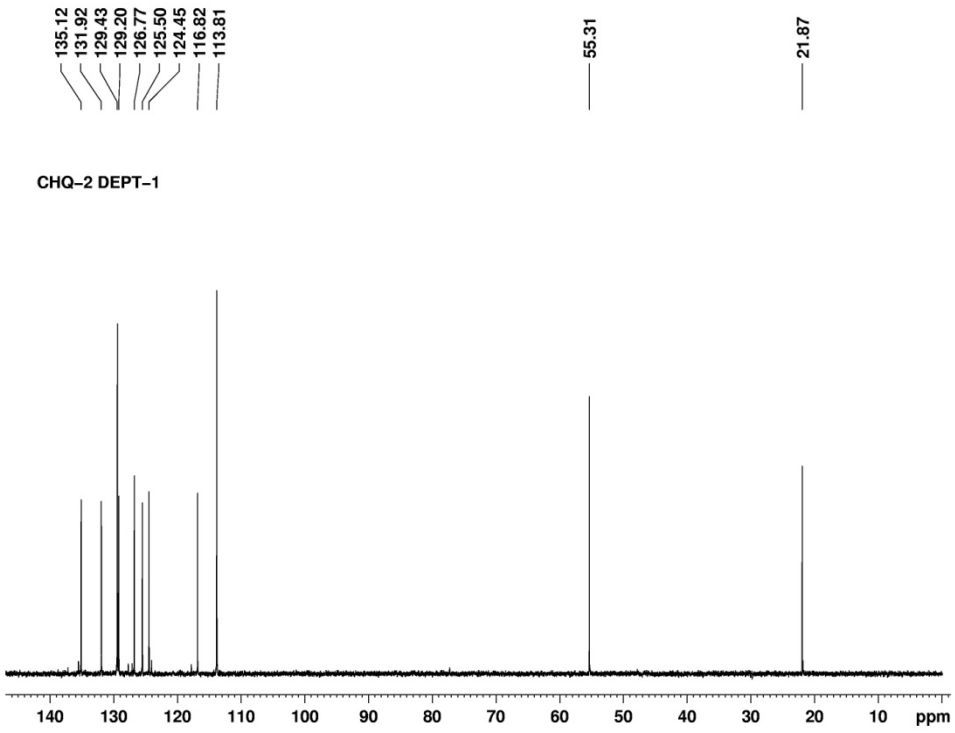
^{1}H NMR of compound **8abc** at 400 MHz ($CDCl_3$)



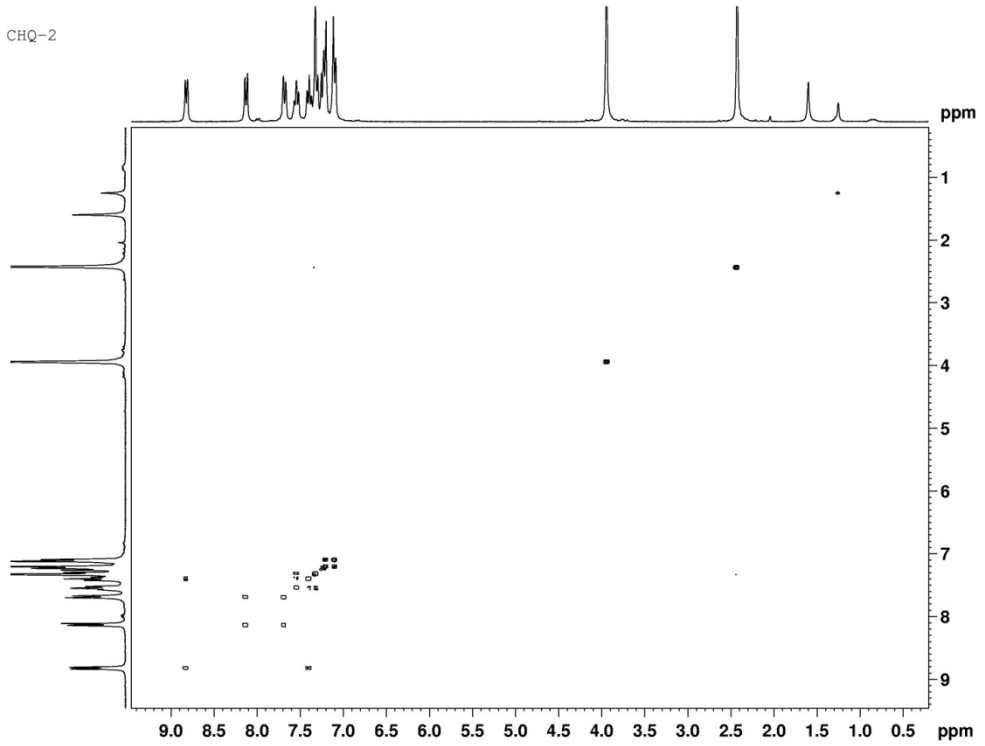
^{13}C NMR of compound **8abc** at 100 MHz ($CDCl_3$)



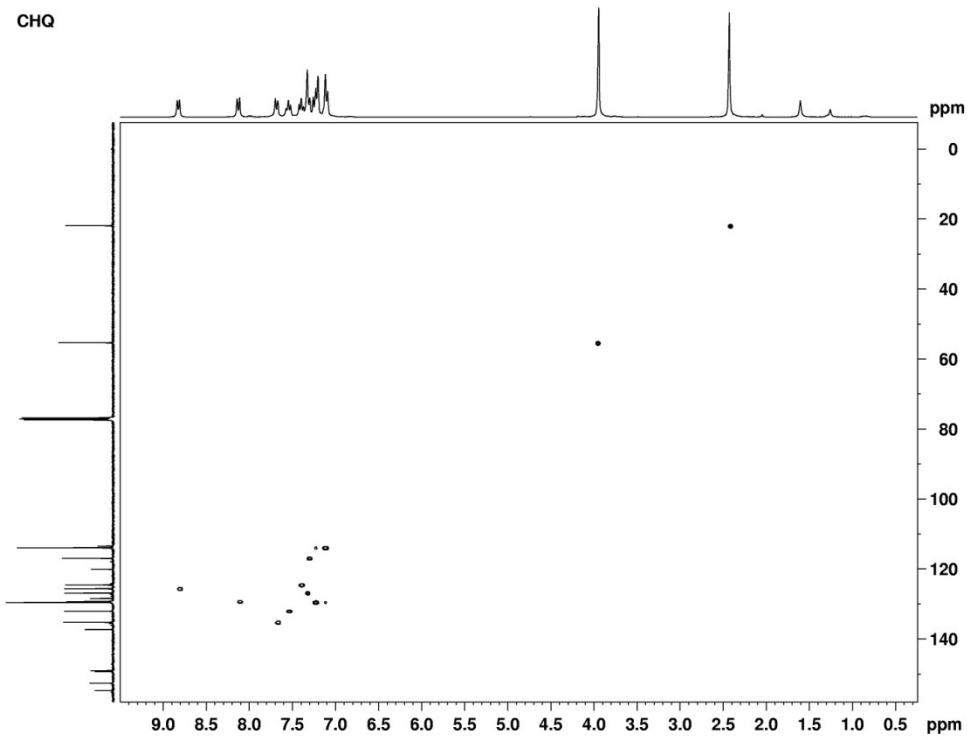
DEPT-90 of compound **8abc** at 100 MHz ($CDCl_3$)



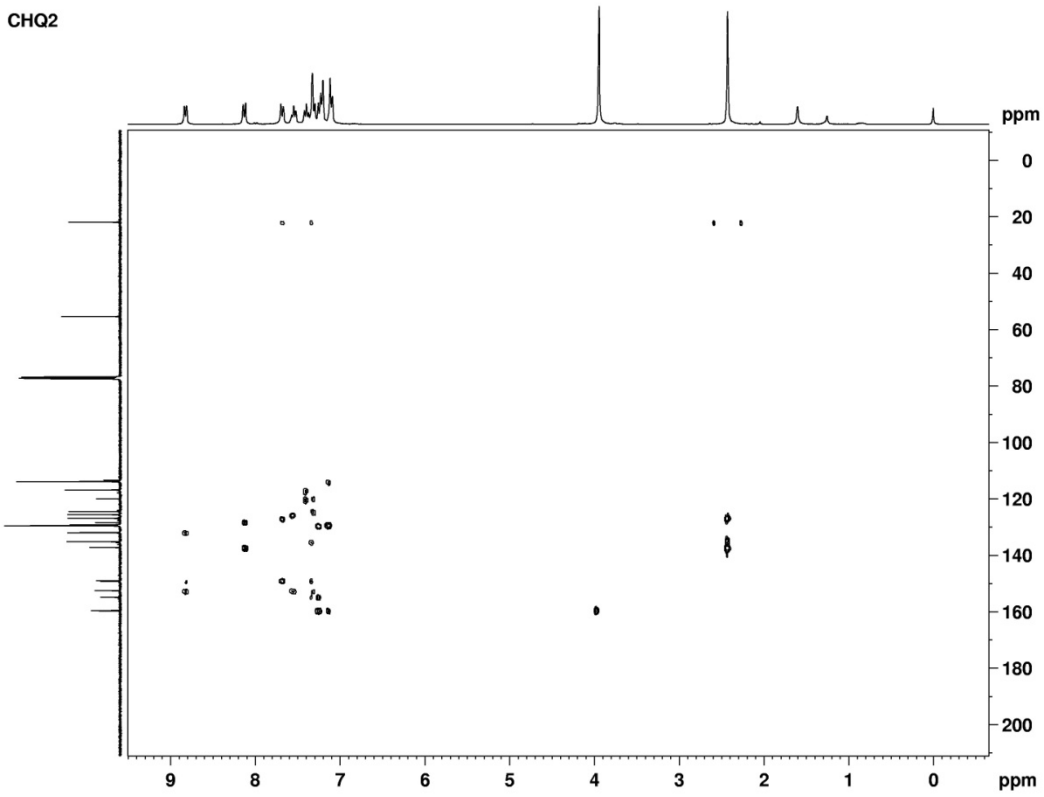
DEPT-135 of compound **8abc** at 100 MHz ($CDCl_3$)



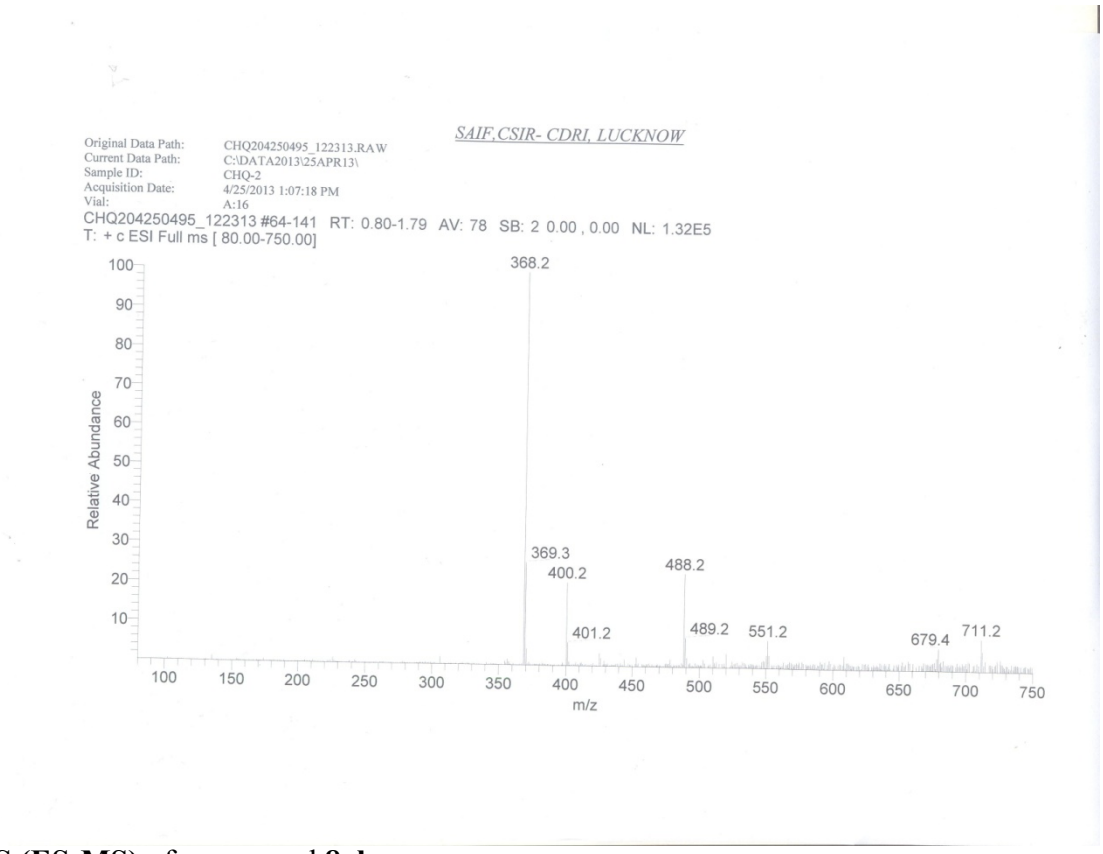
COSY of compound **8abc** at 400 MHz ($CDCl_3$)



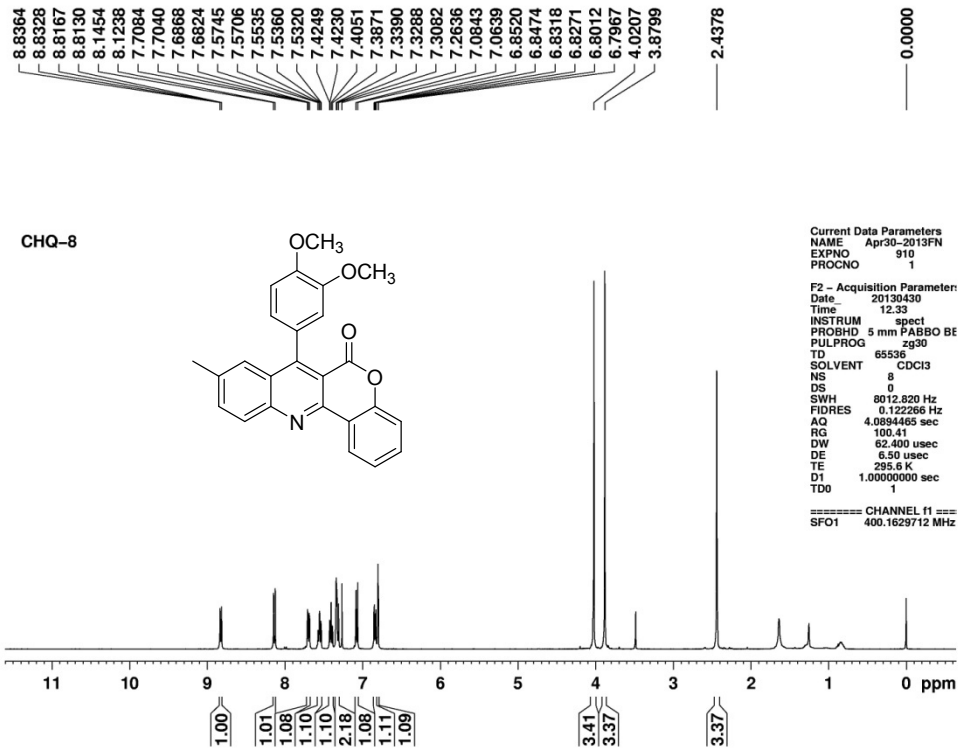
HSQC of compound **8abc** at 400 MHz ($CDCl_3$)



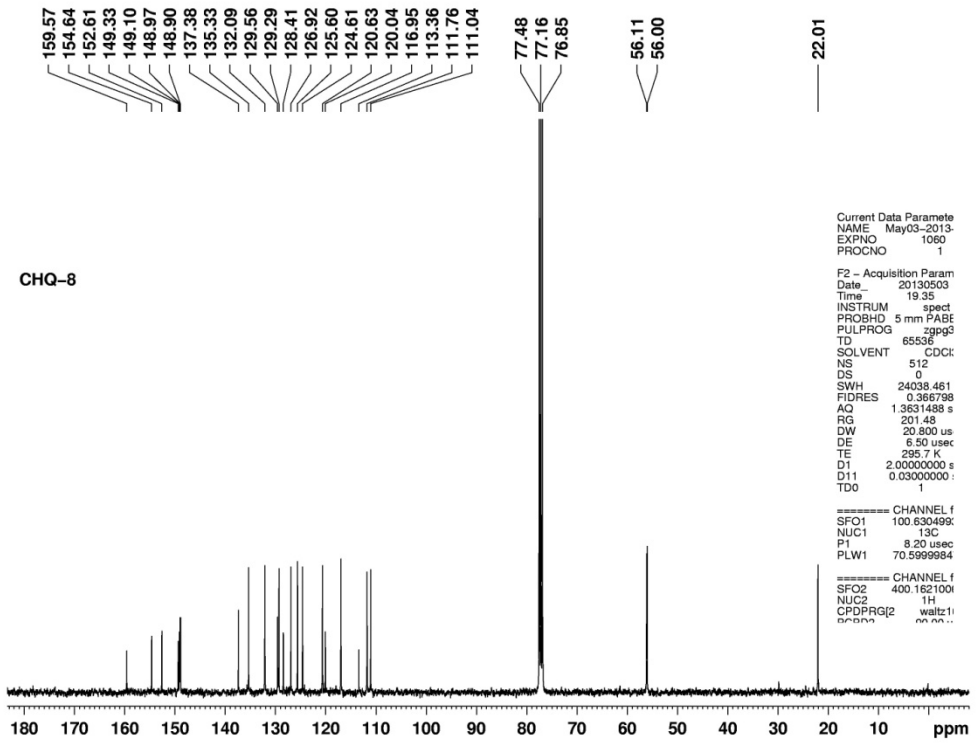
HMBC of compound **8abc** at 400 MHz ($CDCl_3$)



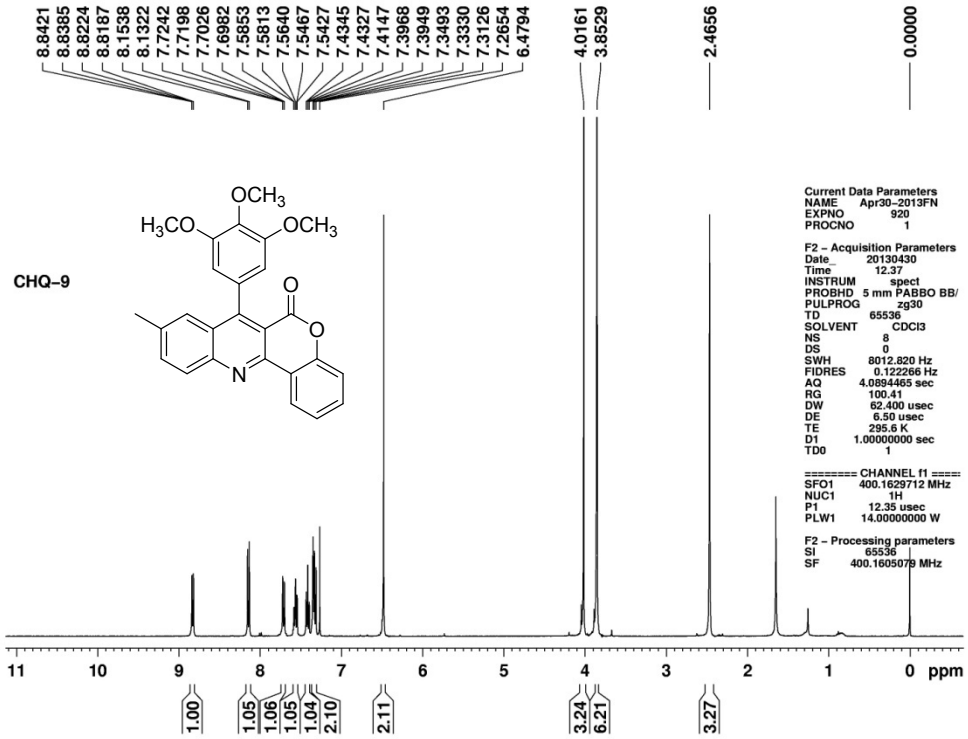
MASS (ES-MS) of compound **8abc**



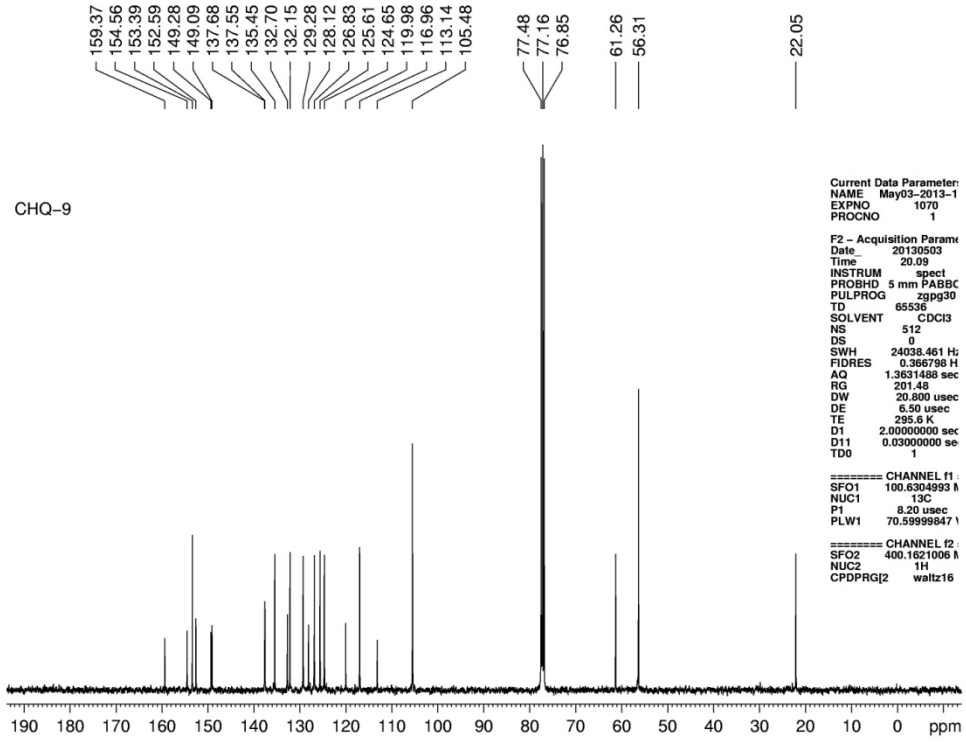
^{1}H NMR of compound **8abb** at 400 MHz ($CDCl_3$)



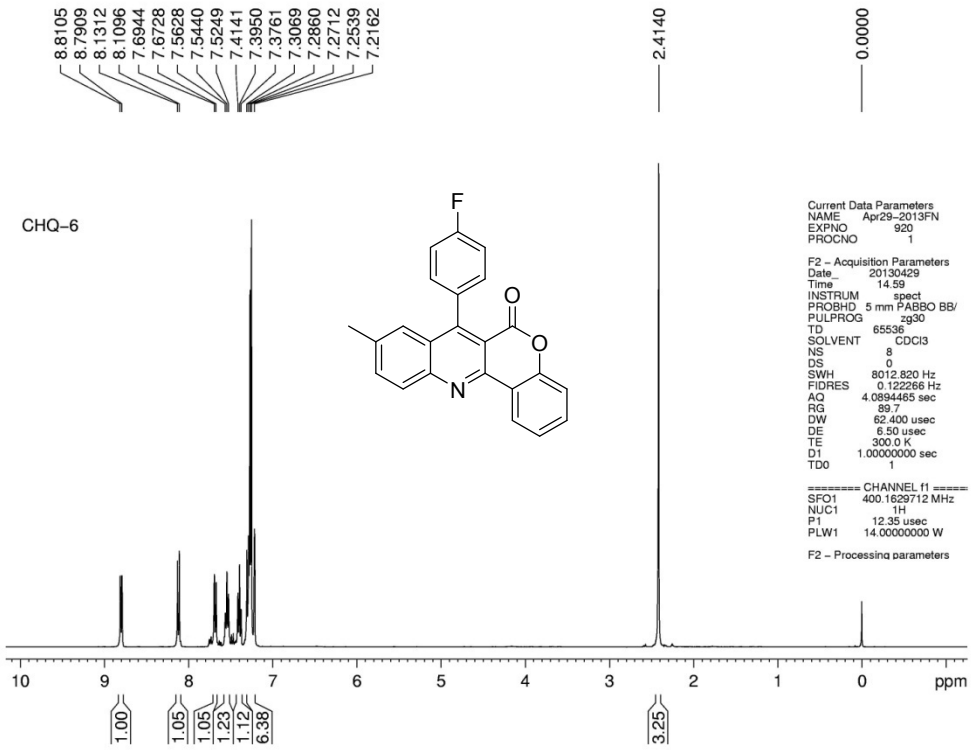
^{13}C NMR of compound **8abb** at 100 MHz ($CDCl_3$)



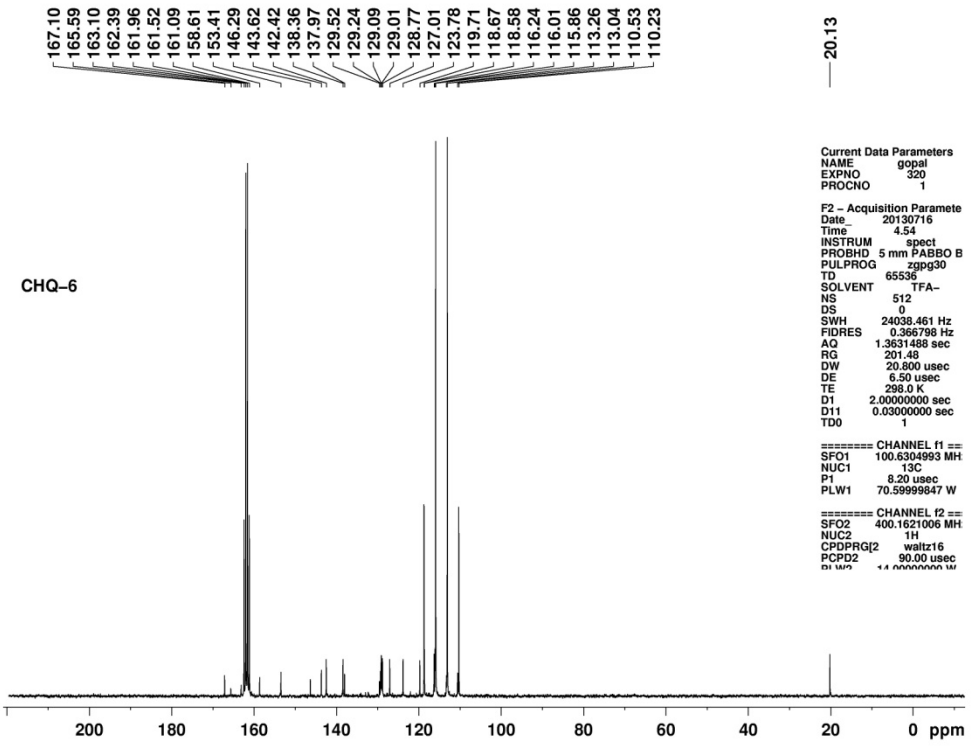
^{1}H NMR of compound **8aba** at 400 MHz ($CDCl_3$)



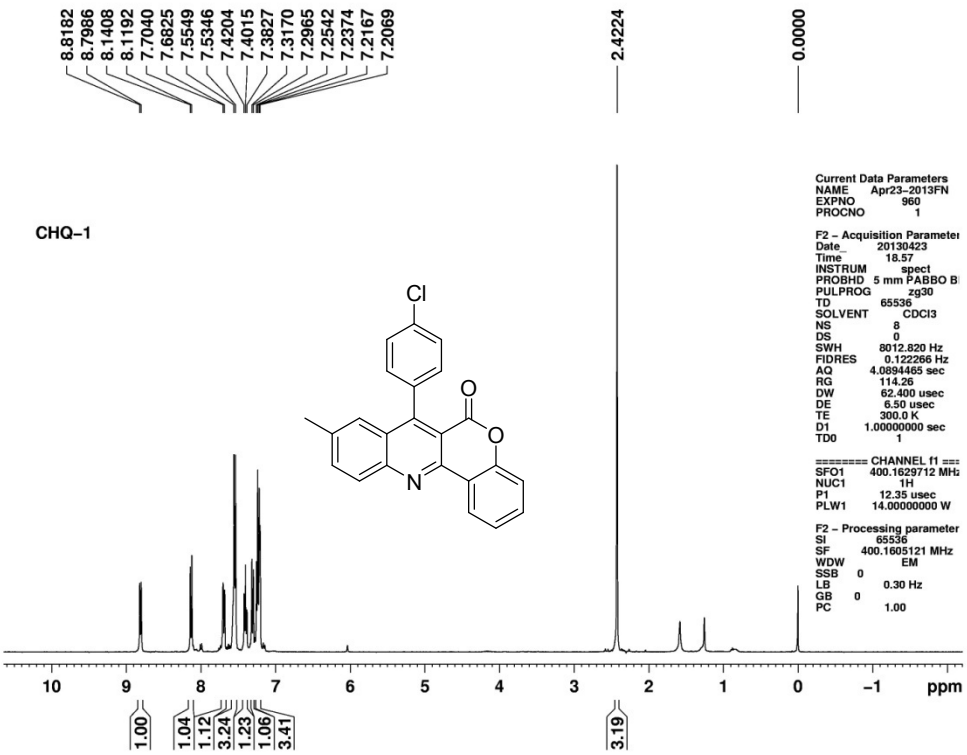
^{13}C NMR of compound **8aba** at 100 MHz ($CDCl_3$)



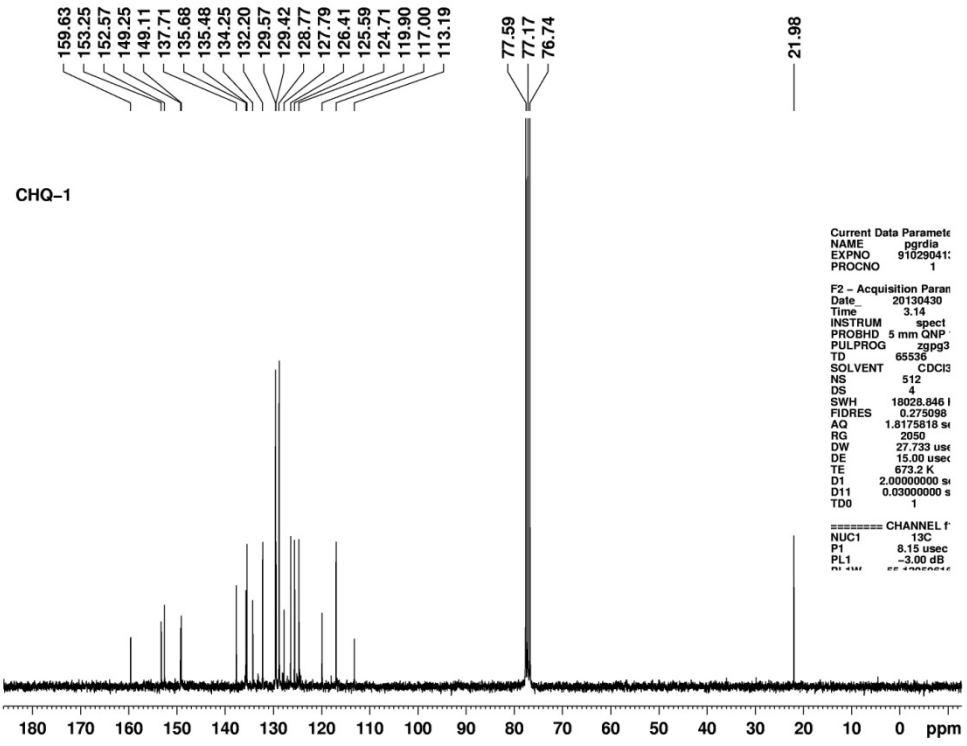
^{1}H NMR of compound **8abg** at 400 MHz ($CDCl_3$)



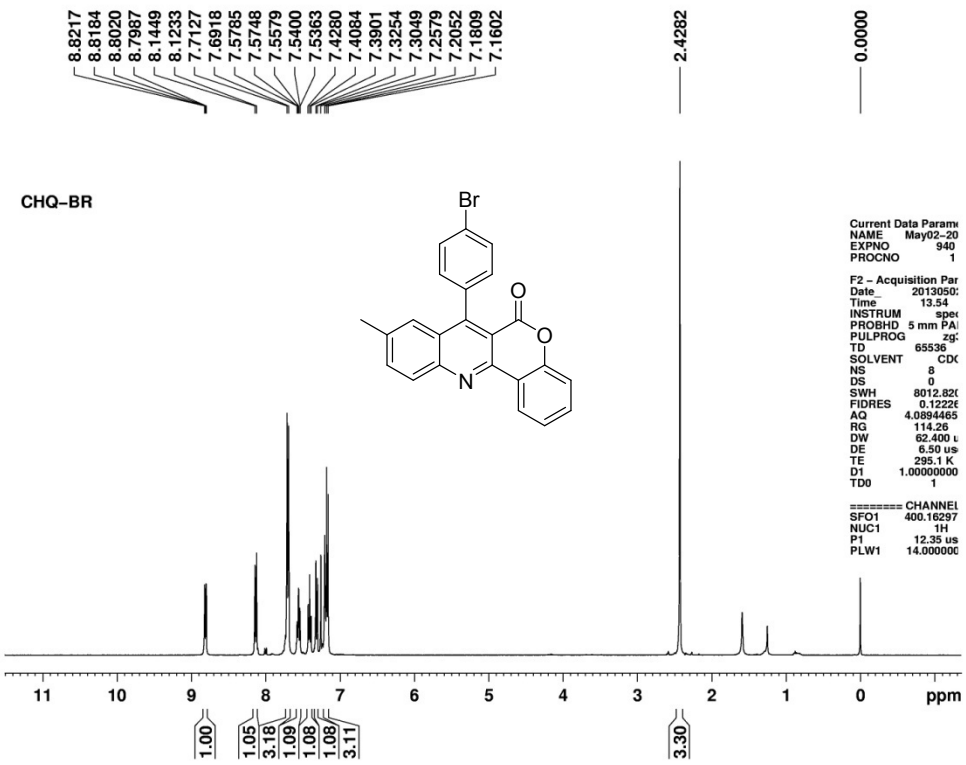
^{13}C NMR of compound **8abg** at 100 MHz (TFA-*d*)



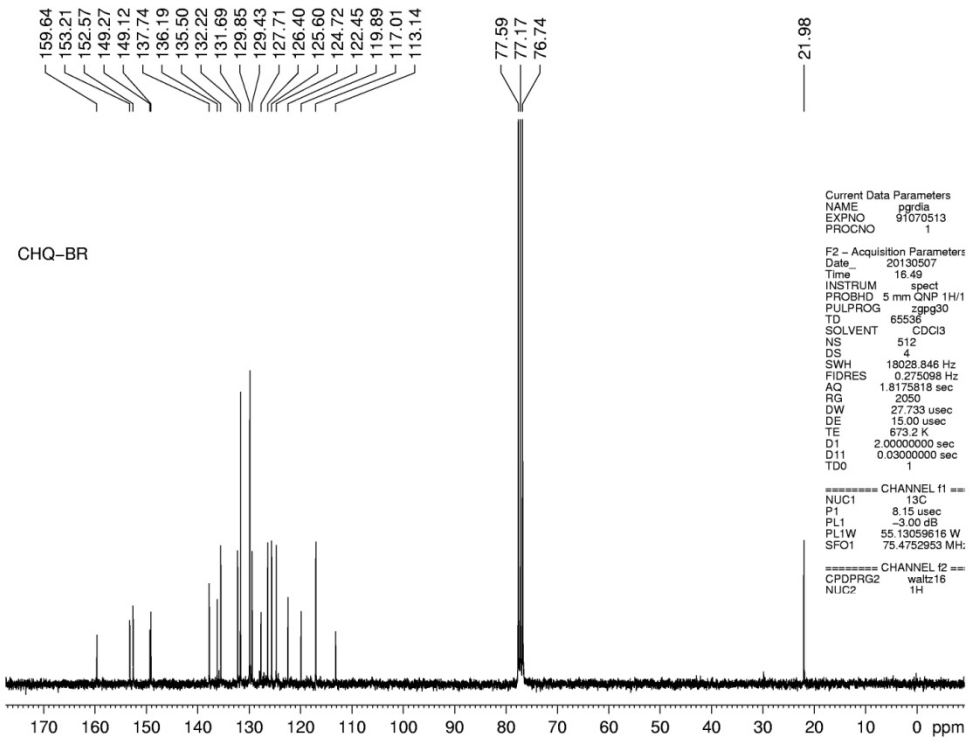
^{1}H NMR of compound **8abh** at 400 MHz ($CDCl_3$)



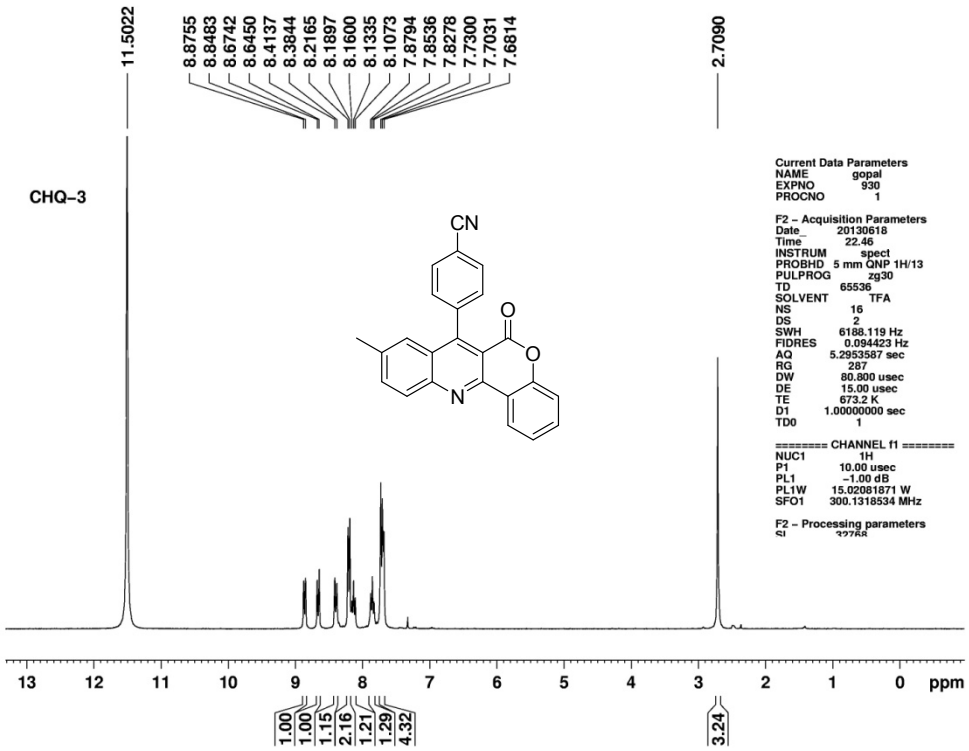
^{13}C NMR of compound **8abh** at 100 MHz ($CDCl_3$)



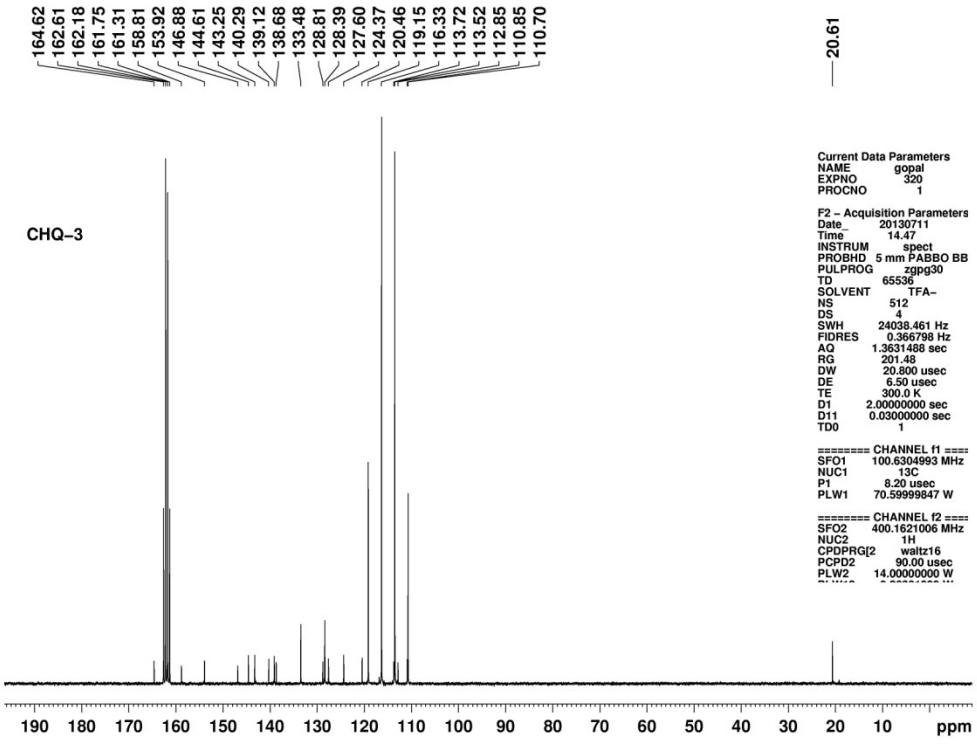
^{1}H NMR of compound **8abi** at 400 MHz ($CDCl_3$)



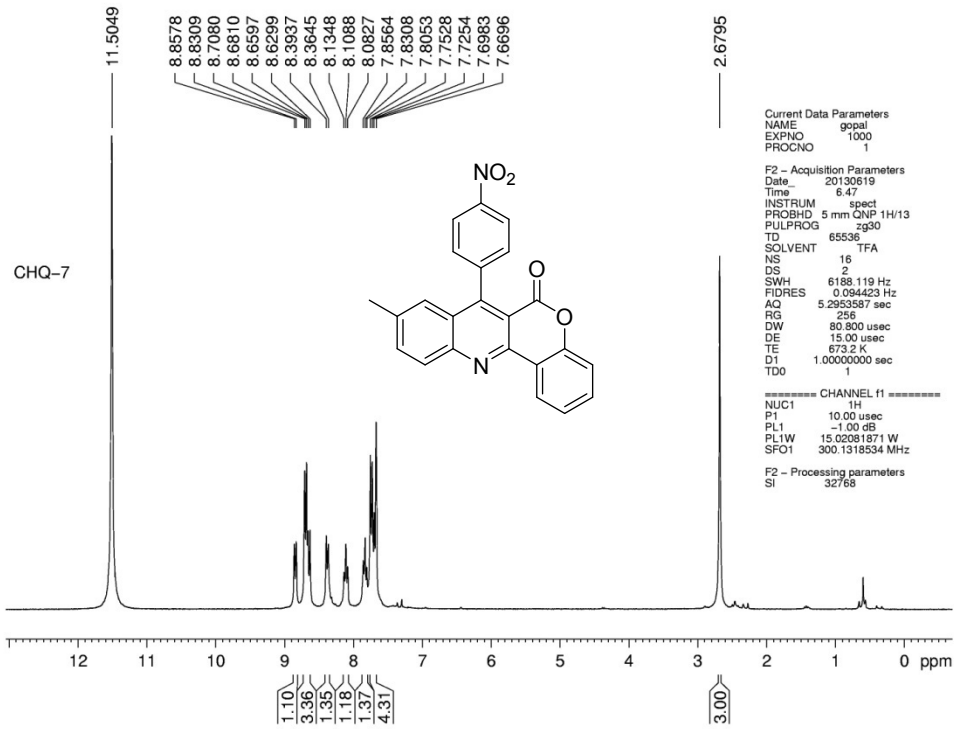
^{13}C NMR of compound **8abi** at 100 MHz ($CDCl_3$)



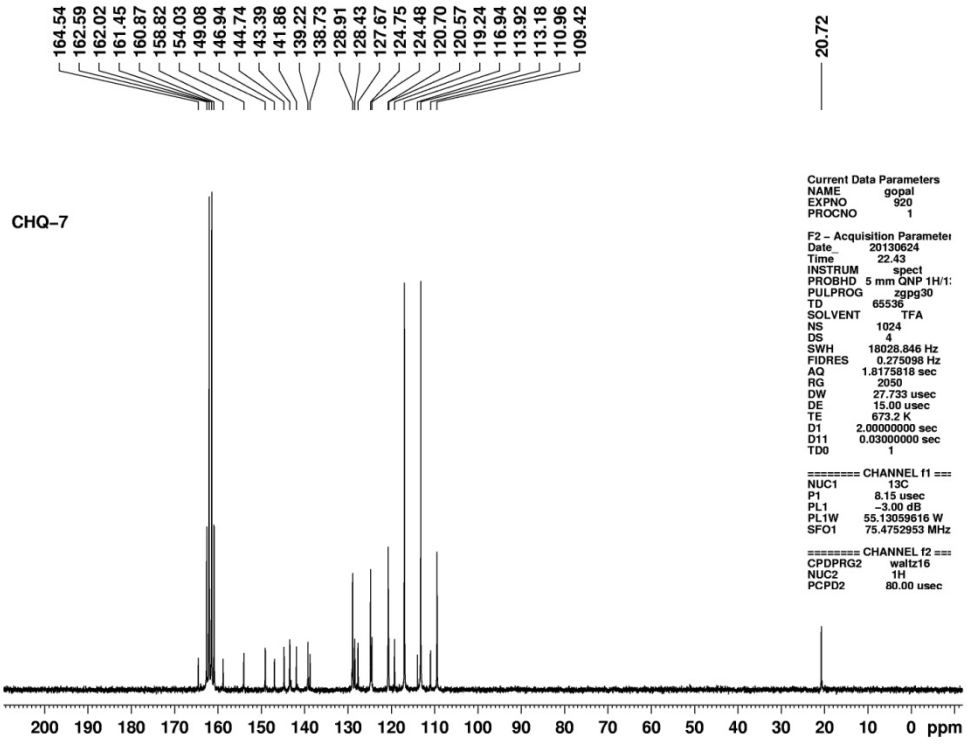
^{1}H NMR of compound **8abj** at 400 MHz (TFA-*d*)



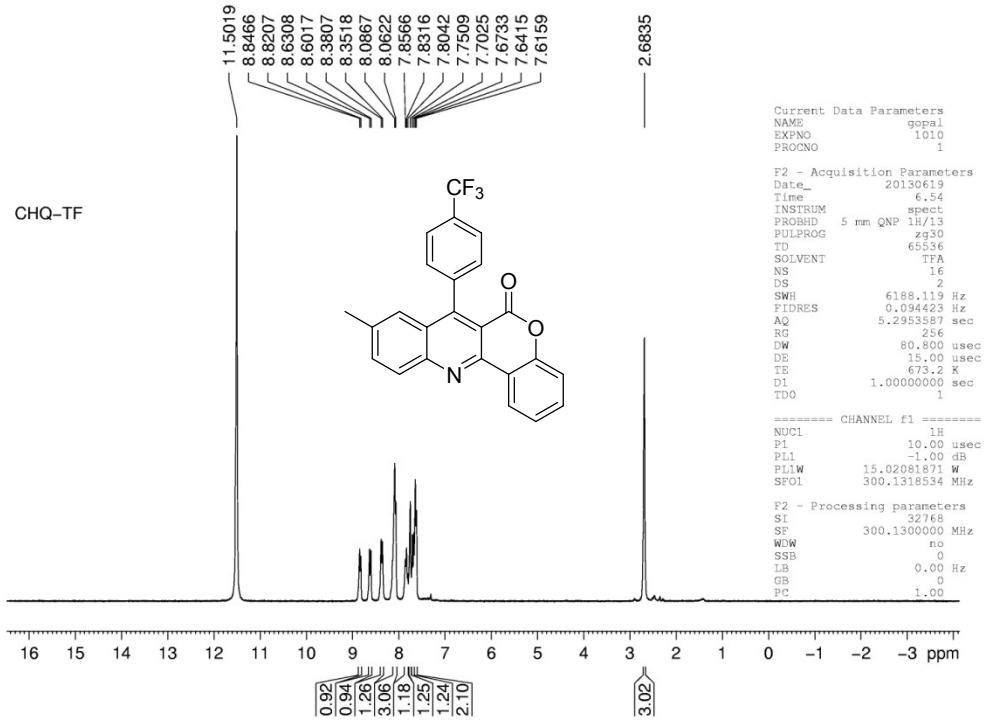
^{13}C NMR of compound **8abj** at 100 MHz (TFA-*d*)



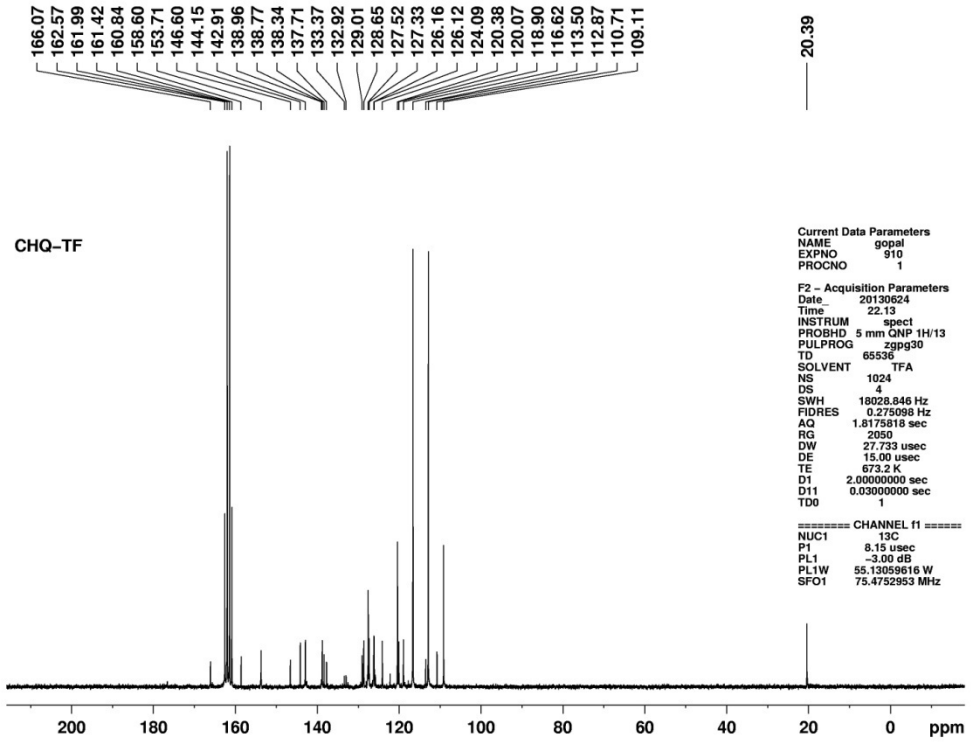
^{1}H NMR of compound **8abk** at 300 MHz (TFA-*d*)



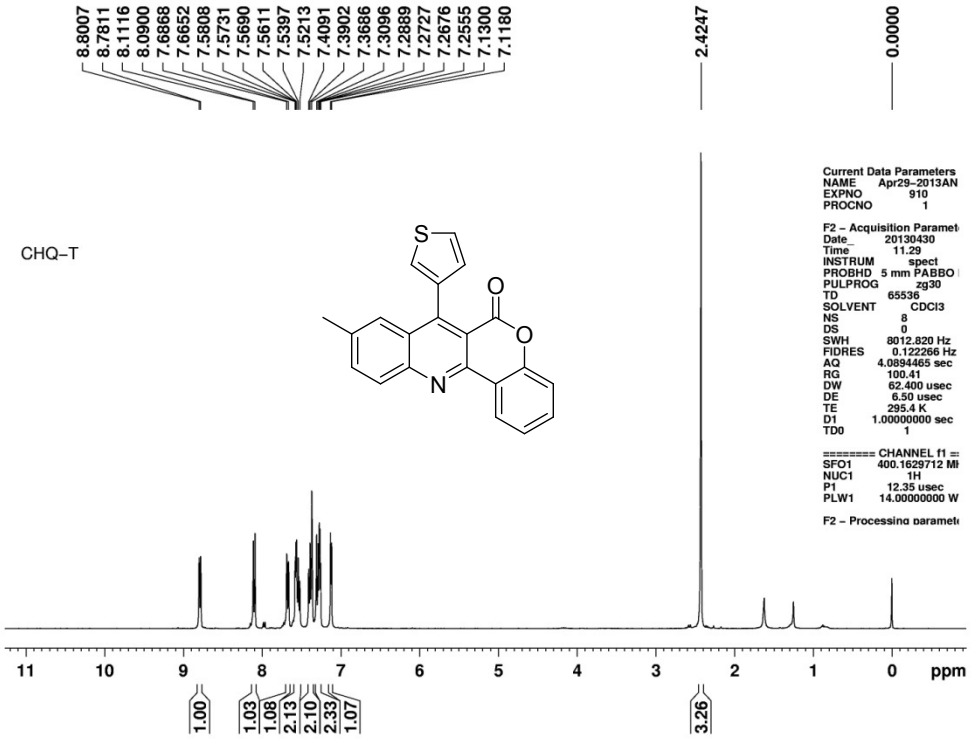
^{13}C NMR of compound **8abk** at 75 MHz (TFA-*d*)



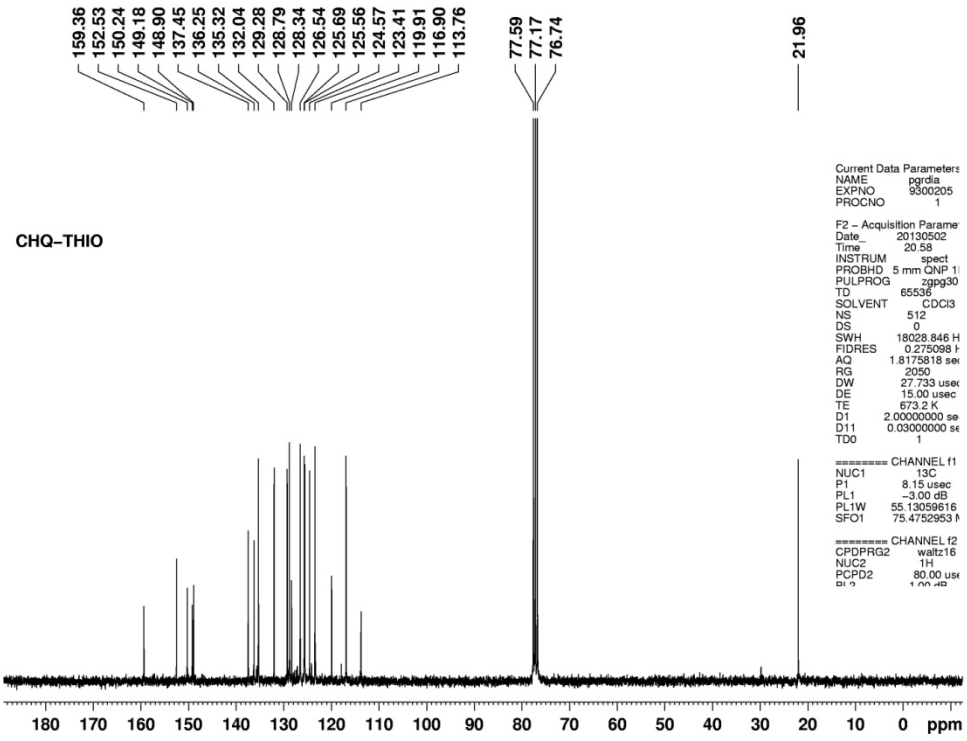
^{1}H NMR of compound **8abl** at 300 MHz (TFA-*d*)



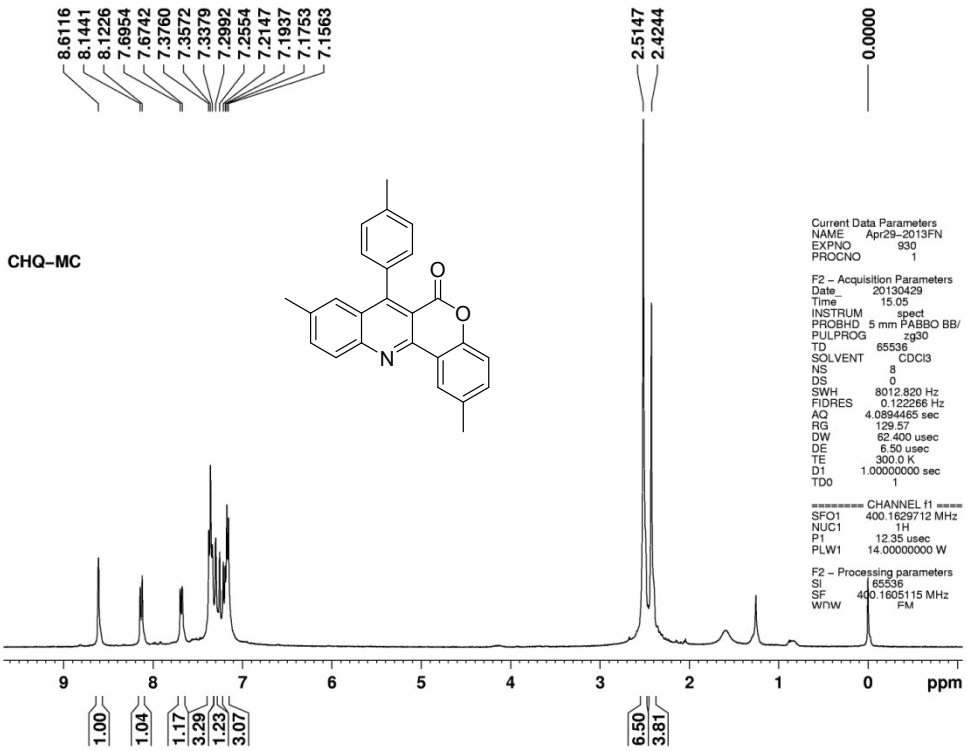
^{13}C NMR of compound **8abl** at 75 MHz (TFA-*d*)



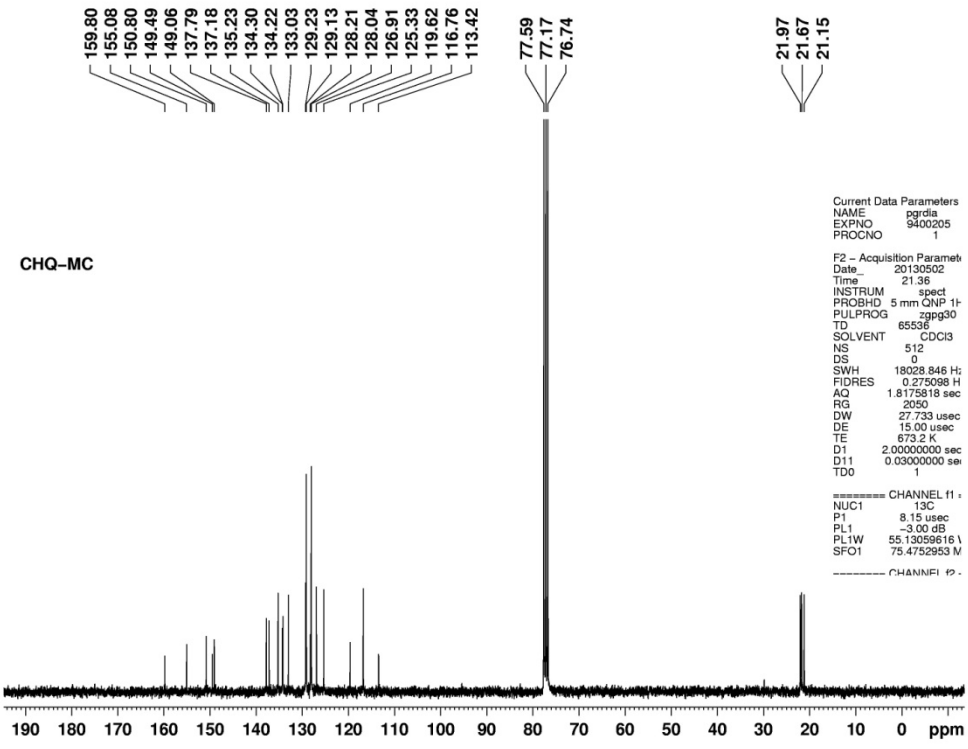
^{1}H NMR of compound **8abm** at 400 MHz ($CDCl_3$)



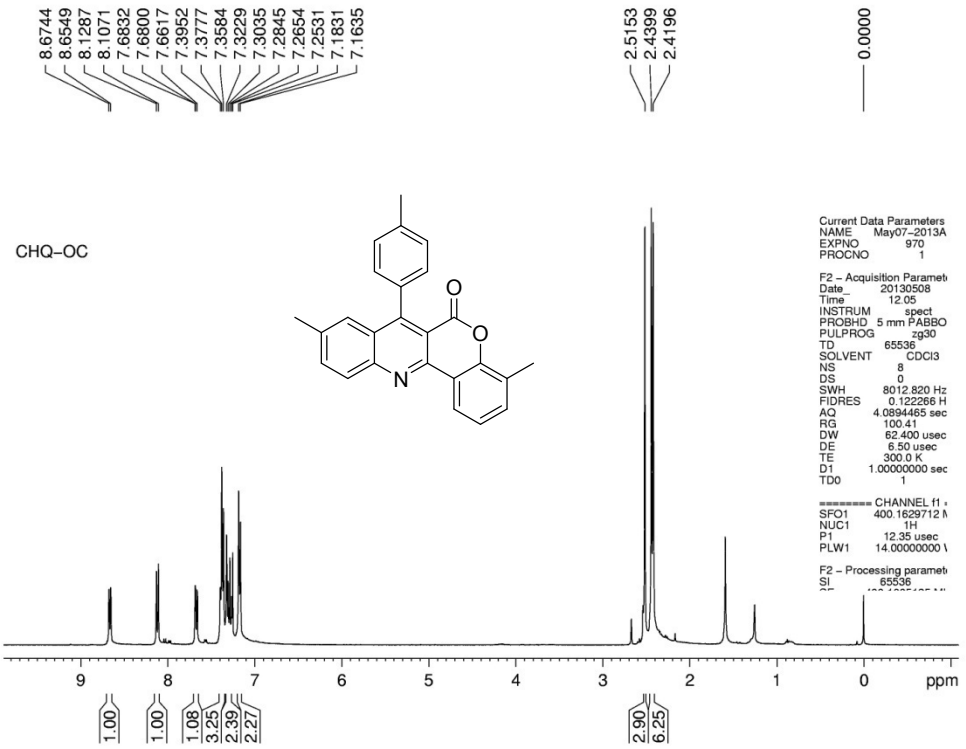
^{13}C NMR of compound **8abm** at 75 MHz ($CDCl_3$)



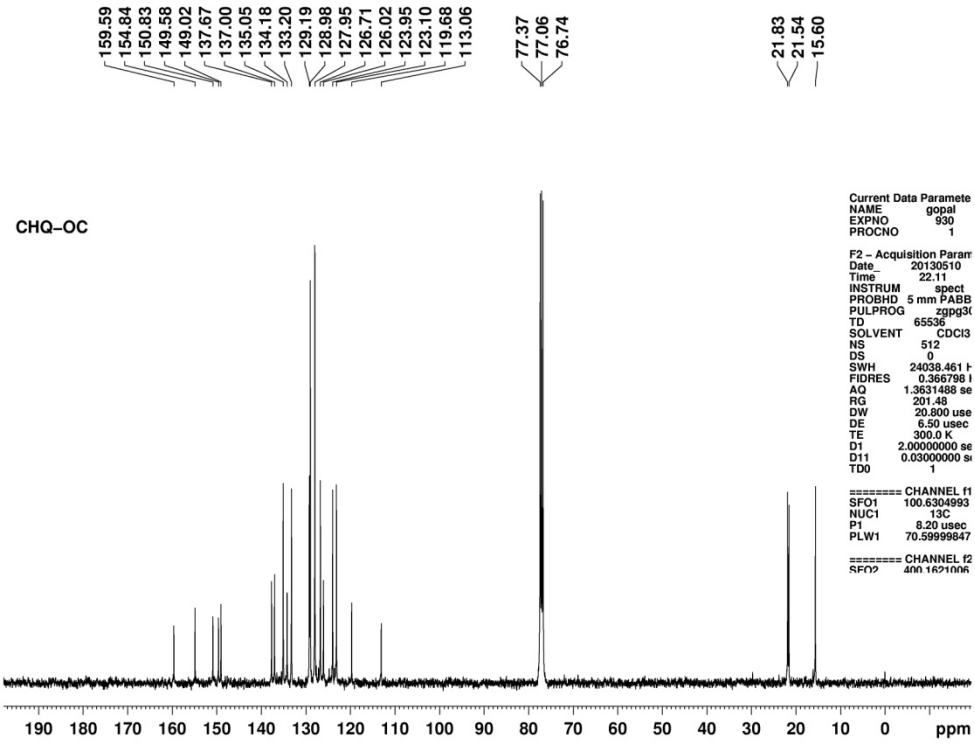
^{1}H NMR of compound **8bbe** at 400 MHz ($CDCl_3$)



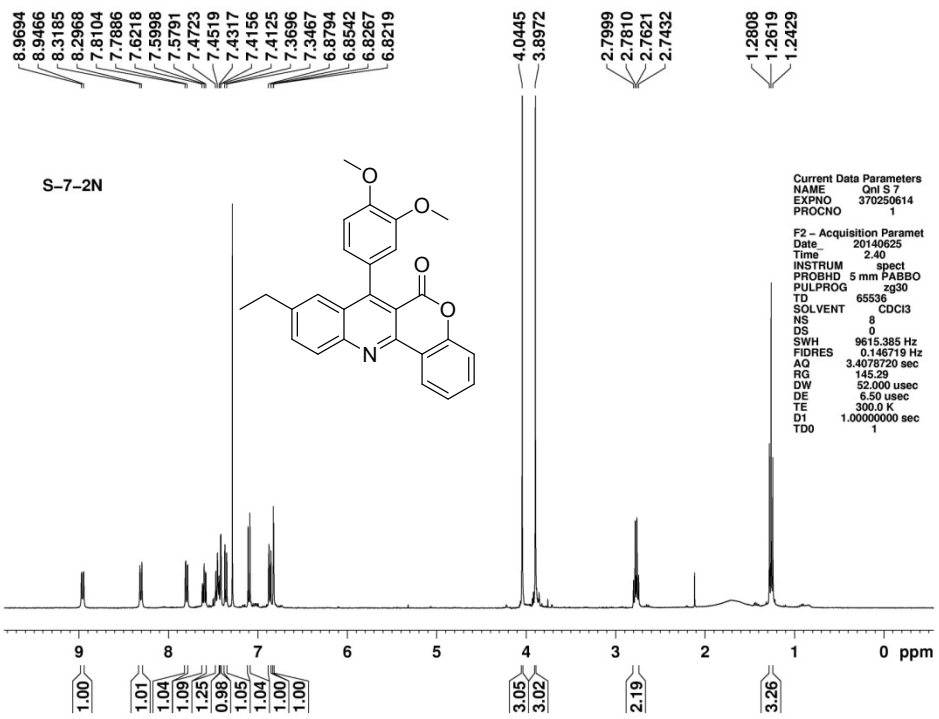
^{13}C NMR of compound **8bbe** at 100 MHz ($CDCl_3$)



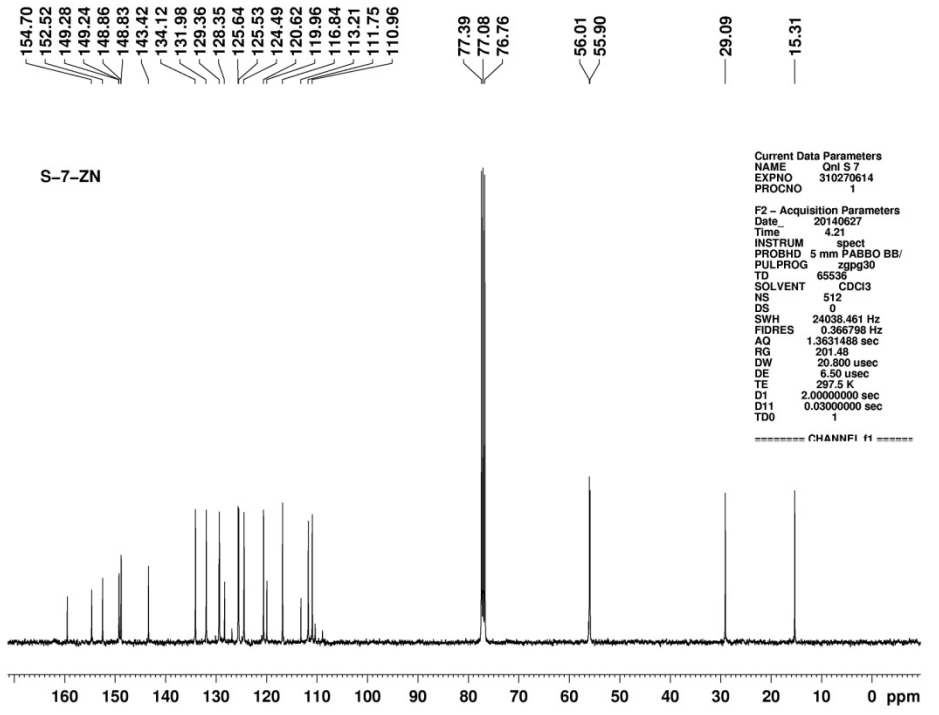
^{1}H NMR of compound **8cbe** at 400 MHz ($CDCl_3$)



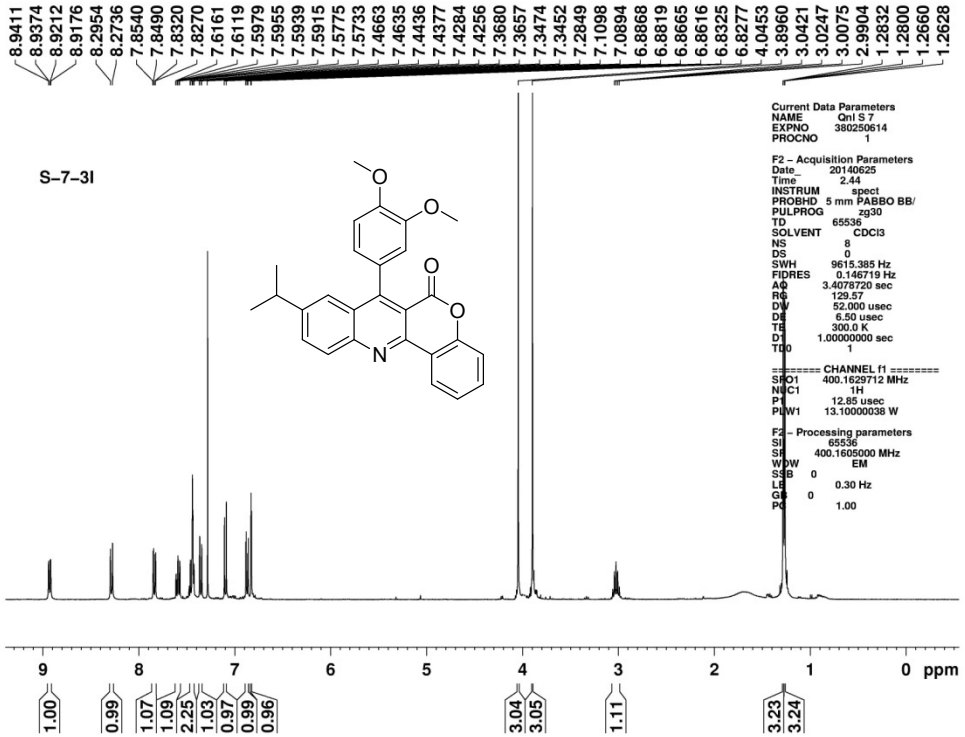
^{13}C NMR of compound **8cbe** at 100 MHz ($CDCl_3$)



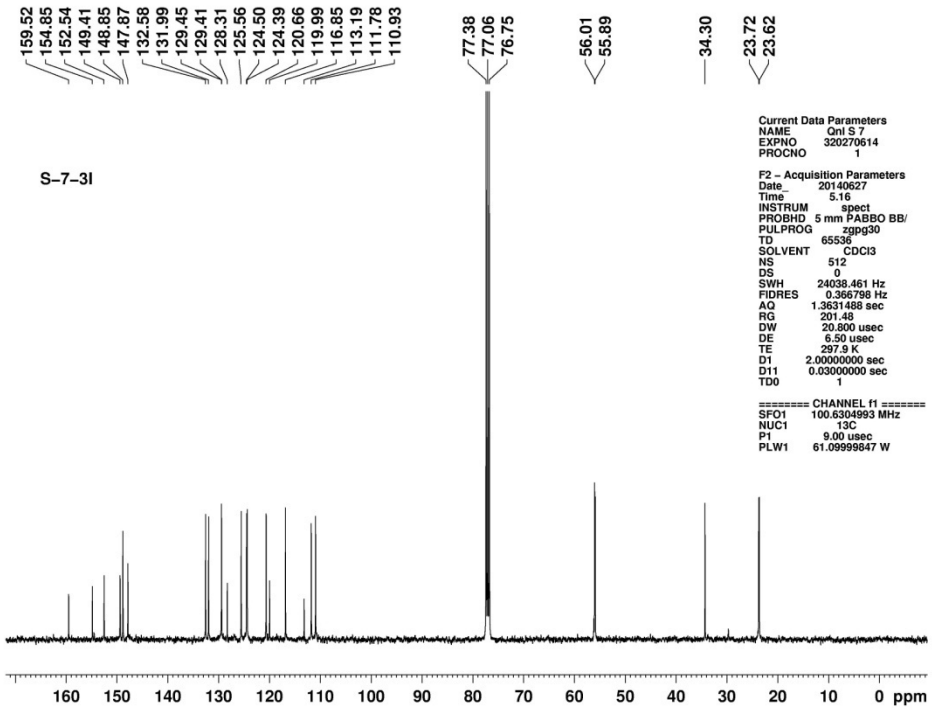
^{1}H NMR of compound **8acb** at 400 MHz ($CDCl_3$)



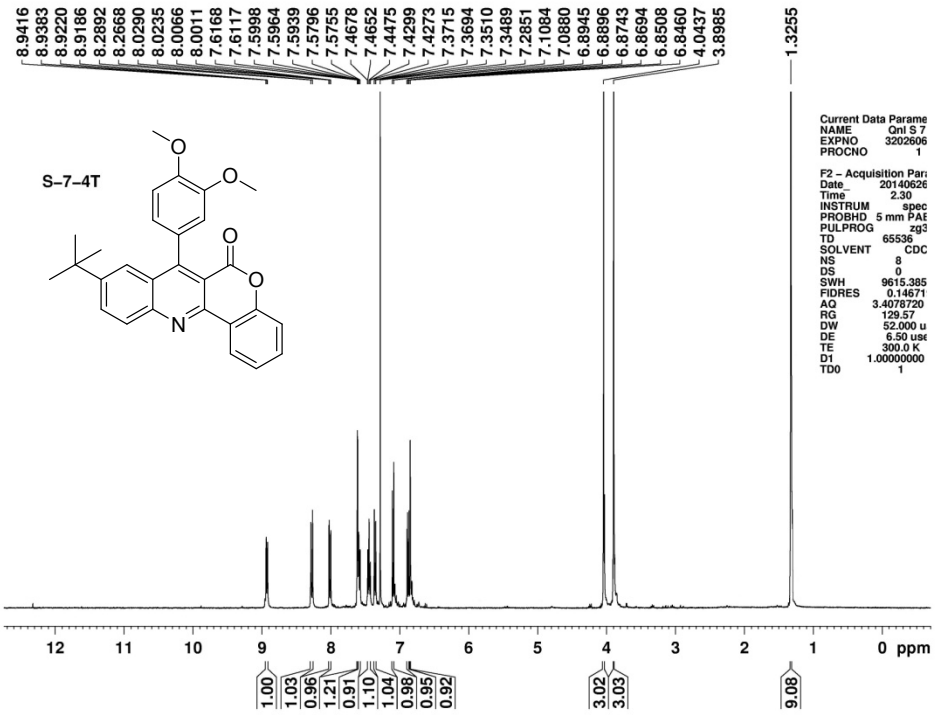
^{13}C NMR of compound **8acb** at 100 MHz ($CDCl_3$)



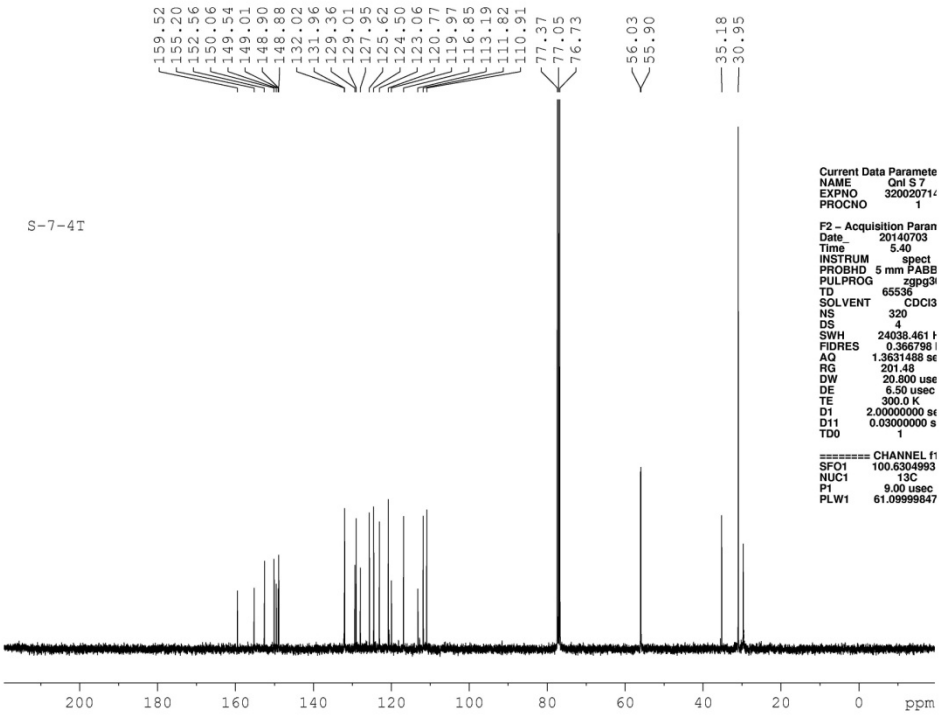
^{1}H NMR of compound **8adb** at 400 MHz ($CDCl_3$)



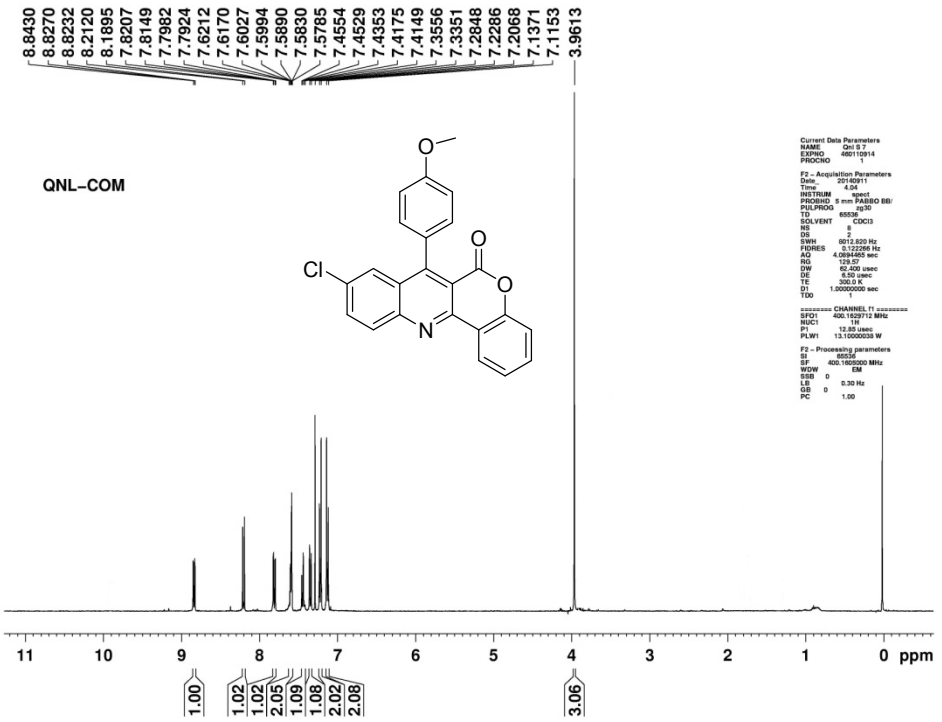
^{13}C NMR of compound **8adb** at 100 MHz ($CDCl_3$)



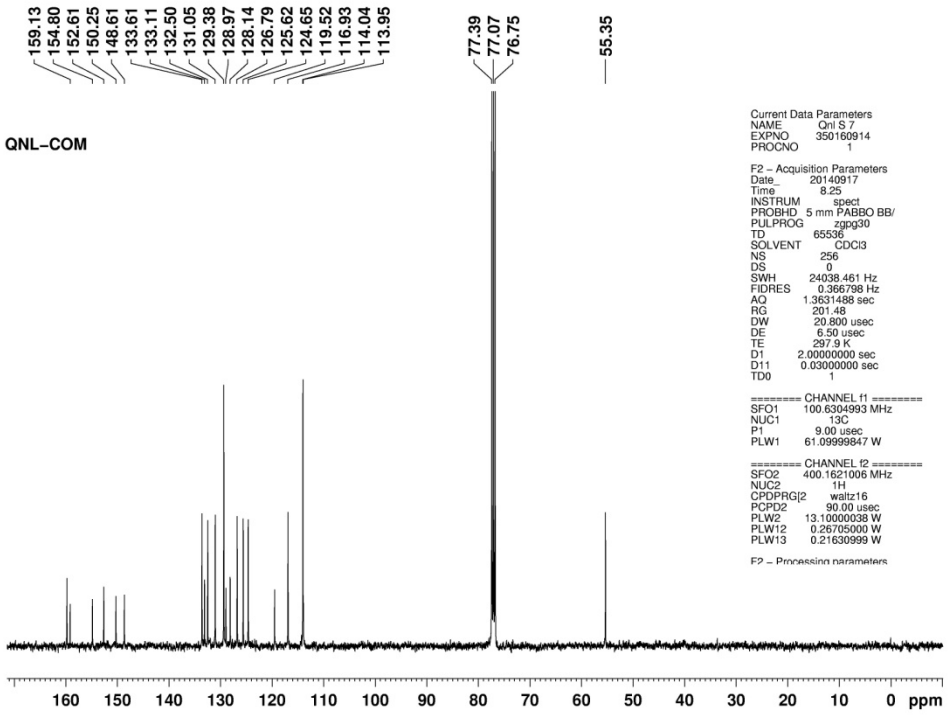
^{1}H NMR of compound **8aeb** at 400 MHz ($CDCl_3$)



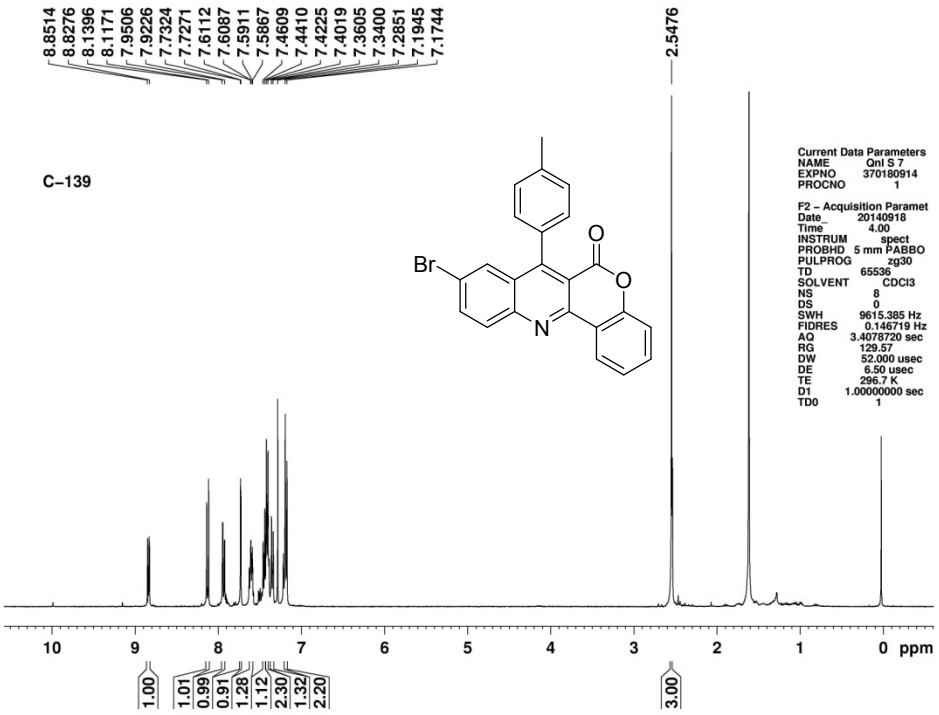
^{13}C NMR of compound **8aeb** at 100 MHz ($CDCl_3$)



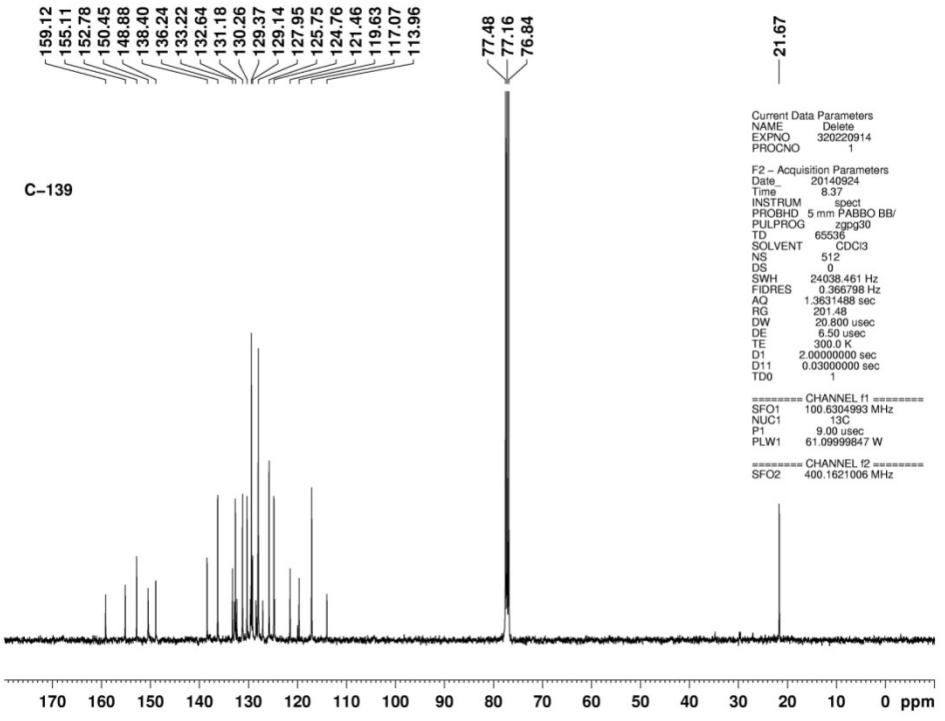
^{1}H NMR of compound **8ahc** at 400 MHz ($CDCl_3$)



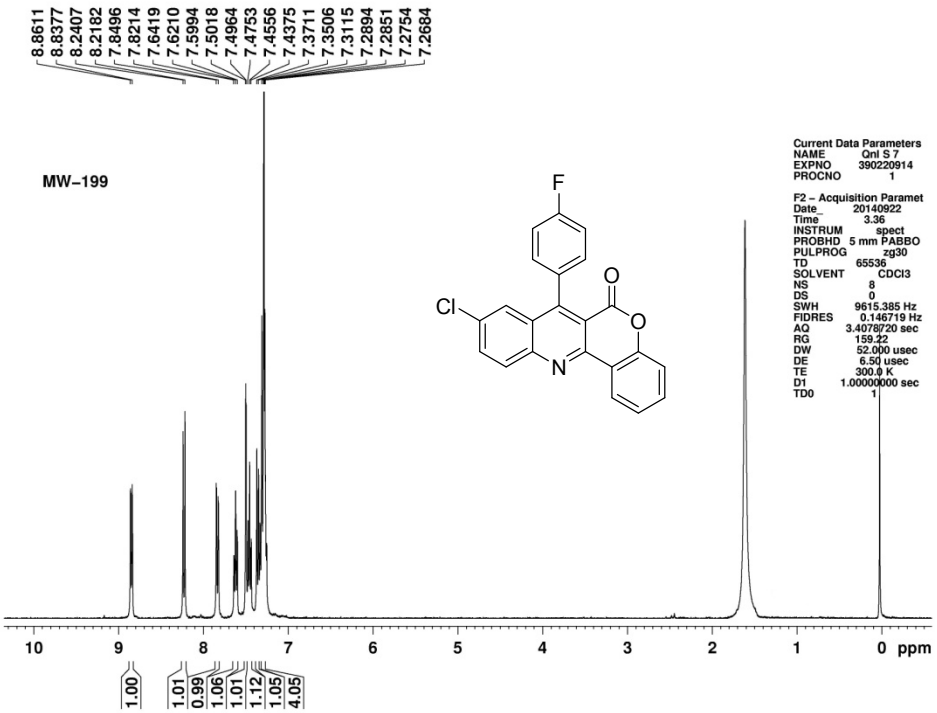
^{13}C NMR of compound **8ahc** at 100 MHz ($CDCl_3$)



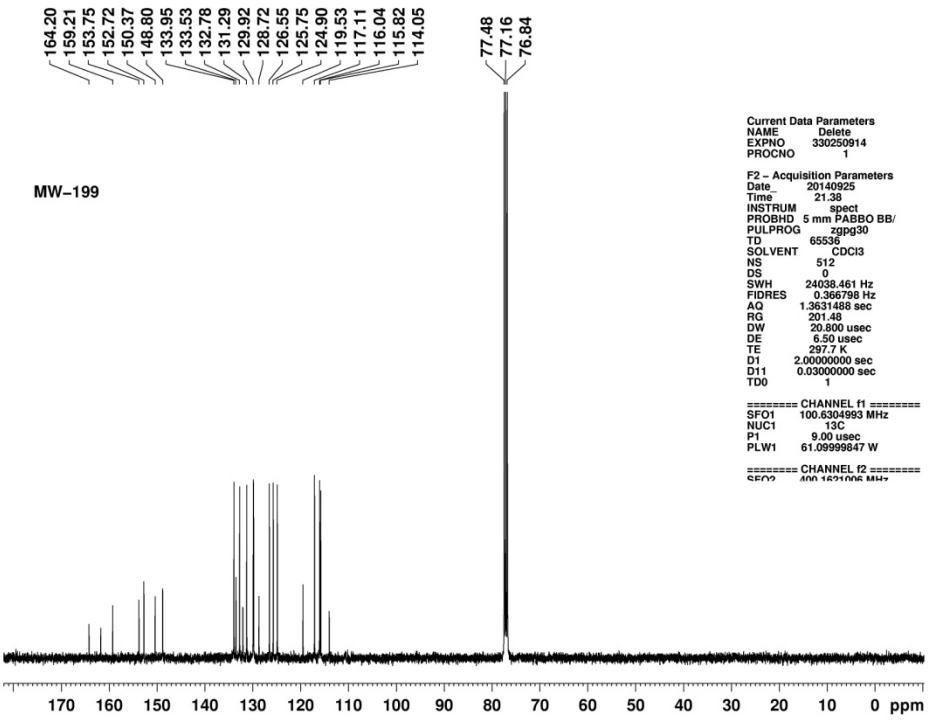
^{1}H NMR of compound **8age** at 400 MHz ($CDCl_3$)



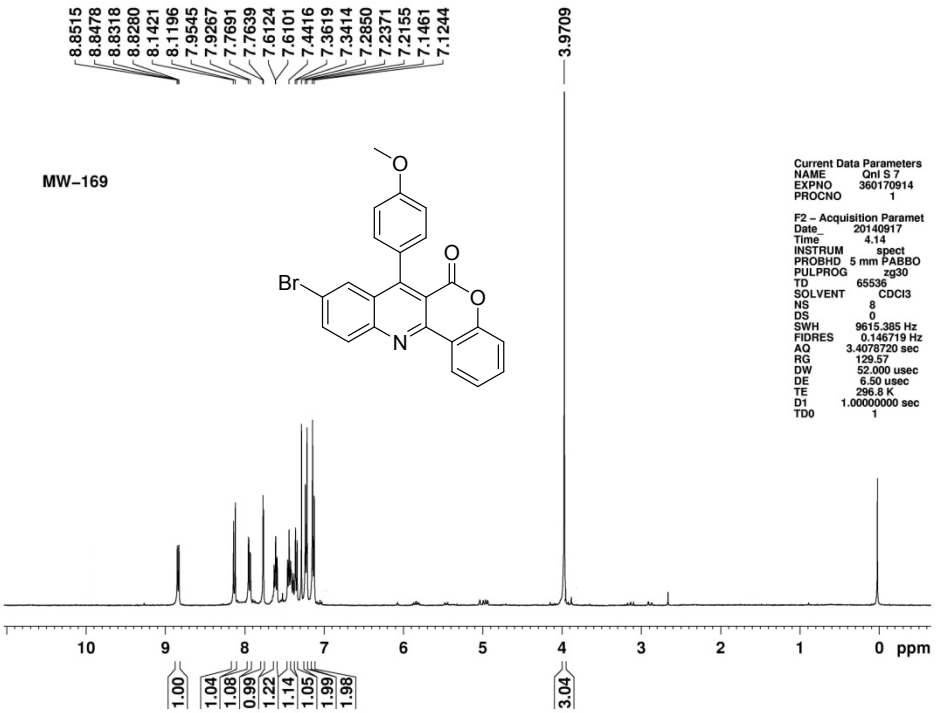
^{13}C NMR of compound **8age** at 100 MHz ($CDCl_3$)



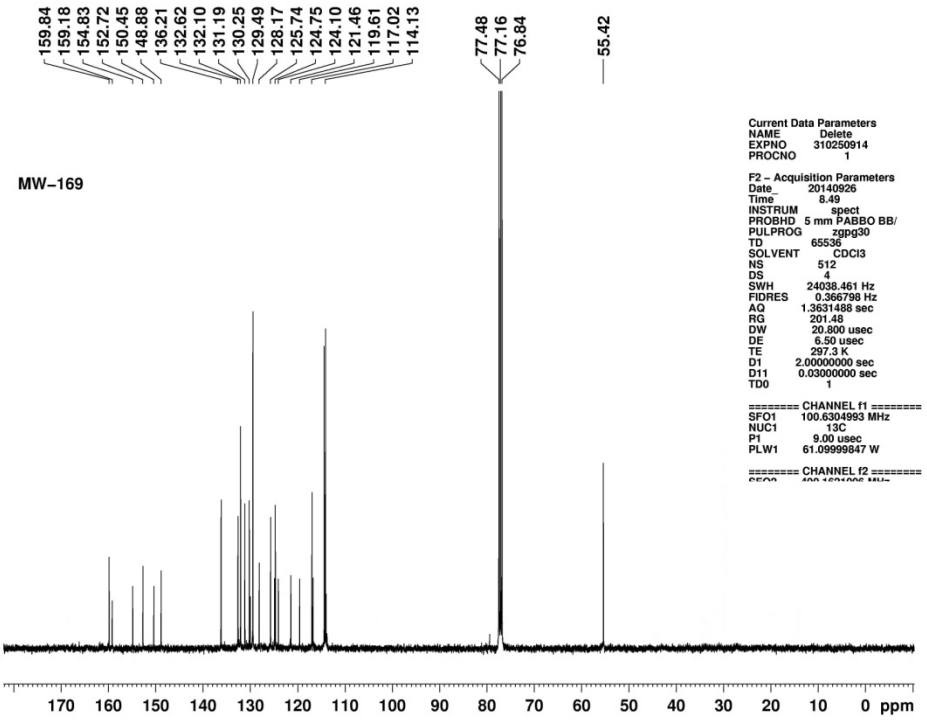
^{1}H NMR of compound **8ahg** at 400 MHz ($CDCl_3$)



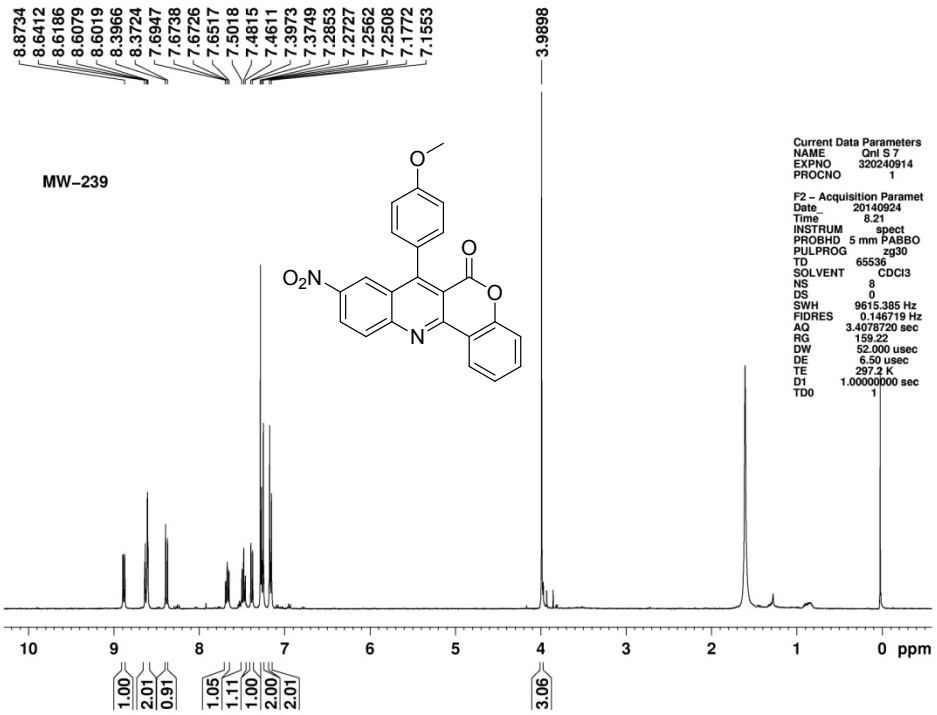
^{13}C NMR of compound **8ahg** at 100 MHz ($CDCl_3$)



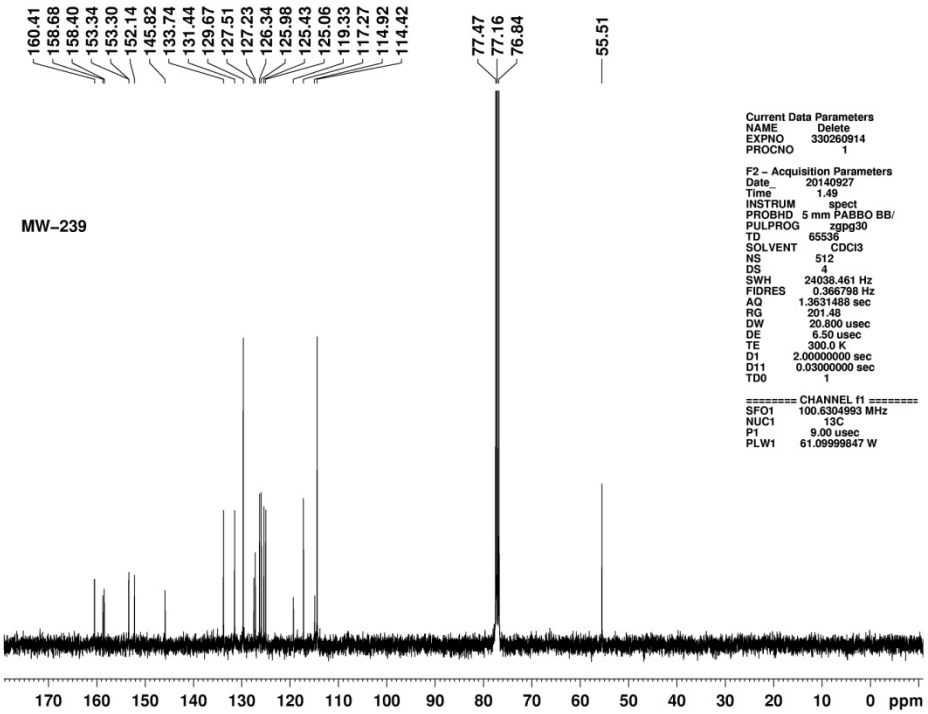
^{1}H NMR of compound **8agc** at 400 MHz ($CDCl_3$)



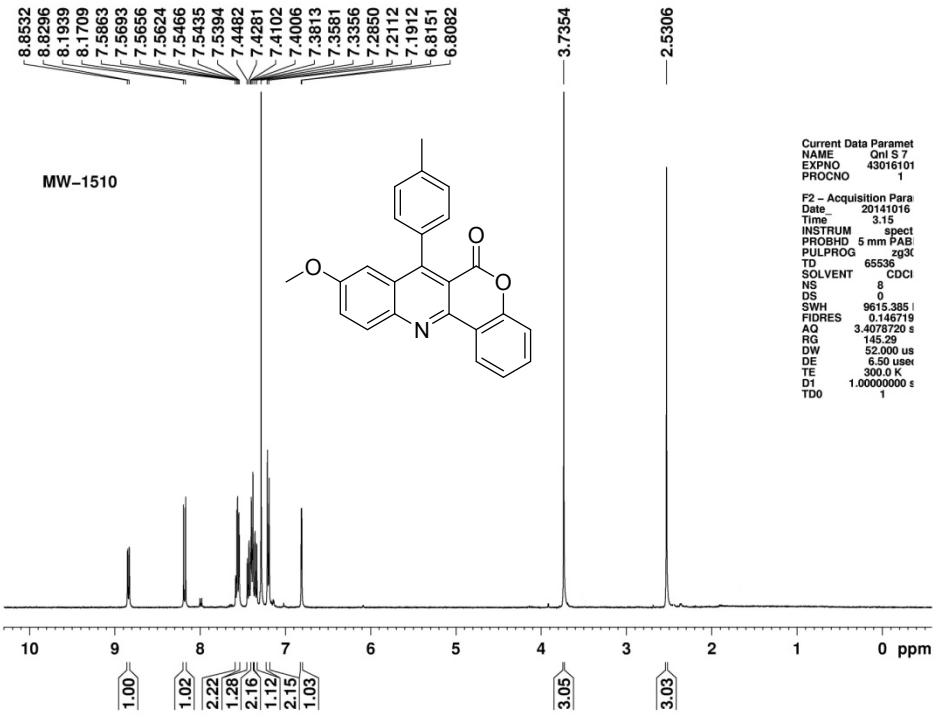
^{13}C NMR of compound **8agc** at 100 MHz ($CDCl_3$)



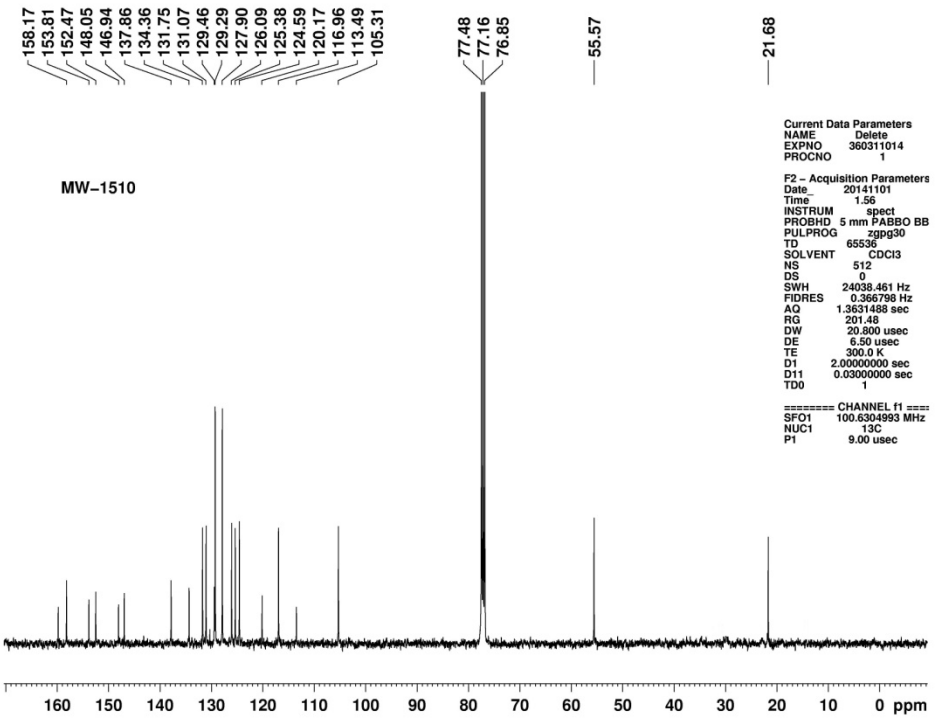
^{1}H NMR of compound **8ajc** at 400 MHz ($CDCl_3$)



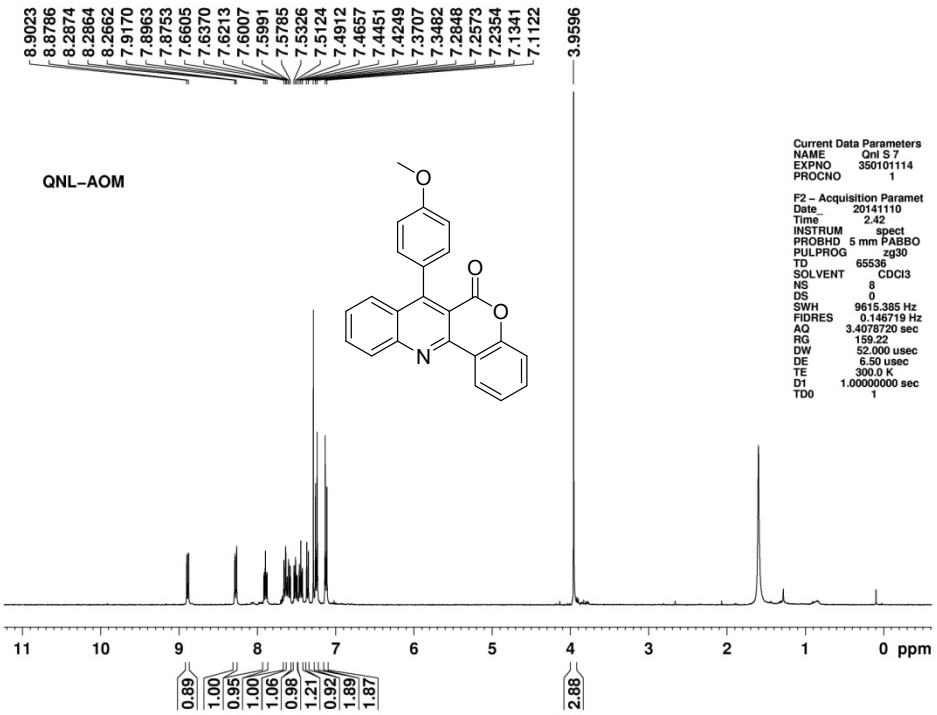
^{13}C NMR of compound **8ajc** at 100 MHz ($CDCl_3$)



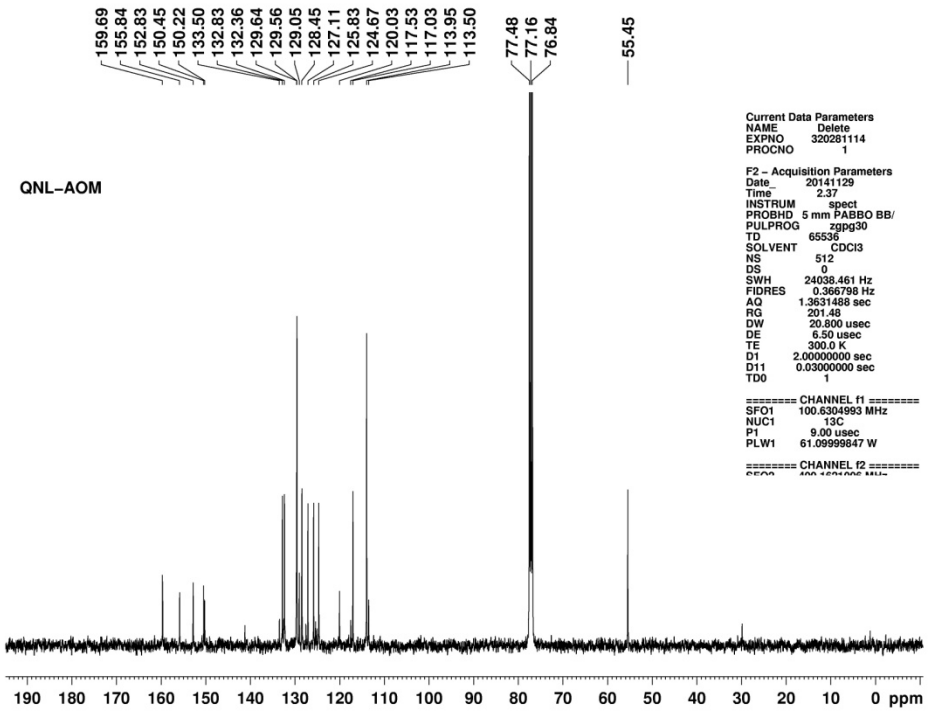
^{1}H NMR of compound **8aae** at 400 MHz ($CDCl_3$)



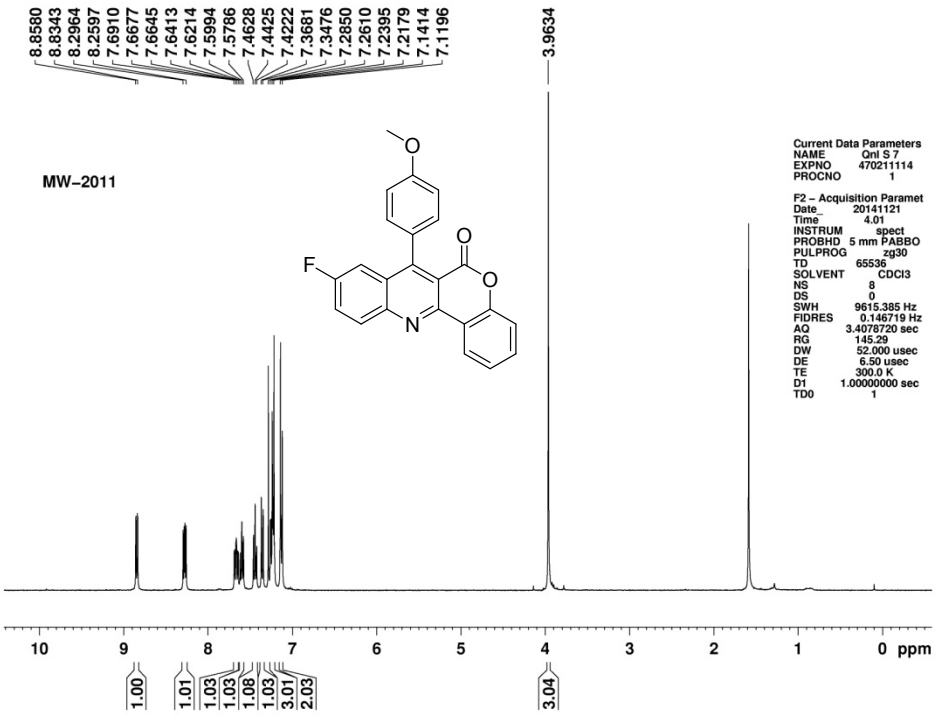
^{13}C NMR of compound **8aae** at 100 MHz ($CDCl_3$)



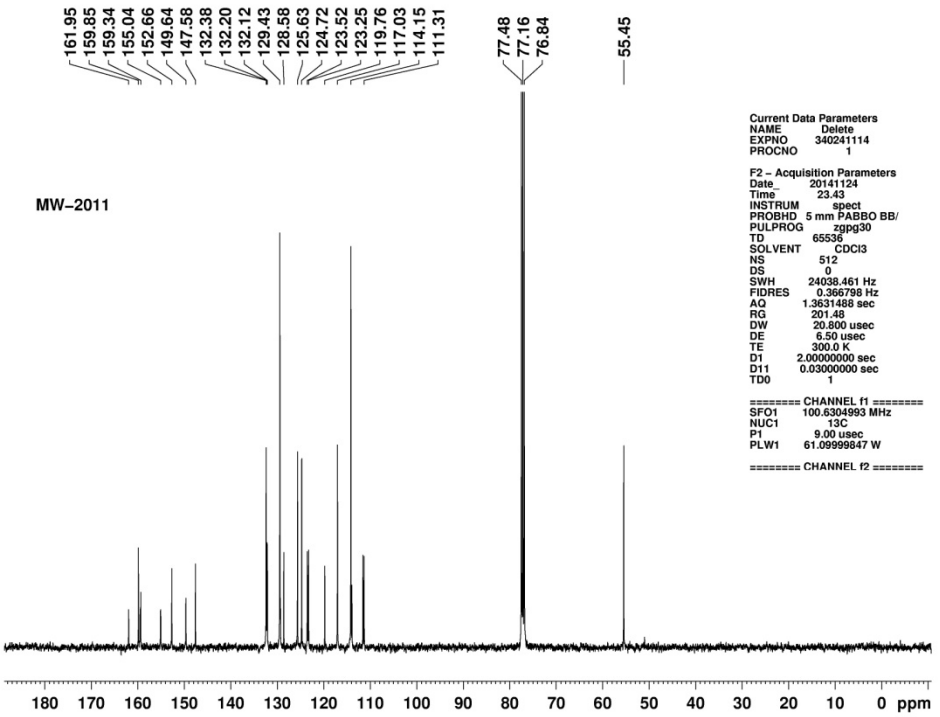
^{1}H NMR of compound **8afc** at 400 MHz ($CDCl_3$)



^{13}C NMR of compound **8afc** at 100 MHz ($CDCl_3$)



^{1}H NMR of compound **8aic** at 400 MHz ($CDCl_3$)



^{13}C NMR of compound **8aic** at 100 MHz ($CDCl_3$)

X-Ray Data Collection and Structure Refinement Details of compound 8abh.

A good quality single crystal of size 0.30 x 0.18 x 0.16 mm, was selected under a polarizing microscope and was mounted on a glass fiber for data collection. Single crystal X-ray data for compound **8abh** were collected on the Rigaku Kappa 3 circle diffractometer equipped with the AFC12 goniometer and enhanced sensitivity (HG) Saturn724+ CCD detector in the 4x4 bin mode using the monochromated Mo-Kα radiation generated from the microfocus sealed tube MicroMax-003 X-ray generator equipped with specially designed confocal multilayer optics. Data collection was performed using ω-scans of 0.5° steps at 293(2) K. Cell determination, data collection and data reduction was performed using the Rigaku CrystalClear-SM Expert 2.1 b24[1] software. Structure solution and refinement were performed by using SHELX-97[2]. Refinement of coordinates and anisotropic thermal parameters of non-hydrogen atoms were carried out by the full-matrix least-squares method. The hydrogen atoms attached to carbon atoms were generated with idealized geometries and isotropically refined using a riding model.[3]

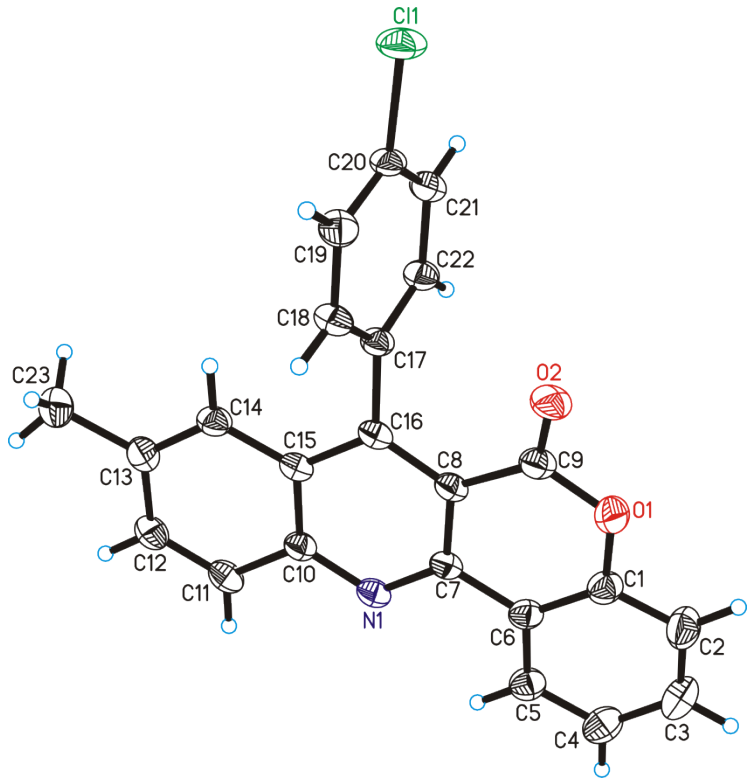


Figure 1 ORTEP diagram drawn with 30% ellipsoid probability for non-H atoms of the crystal structure of compound **8abh** determined at 293 K. Crystals of compound **8abh** were grown from the chloroform by slow evaporation method.

Table 1 Crystal data and structure refinement details for compound **8abh**.

Compound	**8abh**
Empirical formula	C_{23} H_{14} Cl N O_2
Formula weight	371.80
Crystal System	Triclinc
Space group	*P*-1
a (Å)	8.686(6)
b (Å)	10.371(8)
c (Å)	11.293(8)
α (°)	109.138(7)
β (°)	111.662(9)
γ (°)	92.379(9)
V (Å^3)	877.8(11)
Z	2
D_c (g/cm^3)	1.407
F_{000}	384
μ (mm^{-1})	0.24
θ_{max} (°)	25.35
Total reflections	6884
Unique reflections	3137
Reflections [$I > 2\sigma(I)$]	1706
Parameters	244
R_{int}	0.0397
Goodness-of-fit	0.914
R [$F^2 > 2\sigma(F^2)$]	0.0505
wR (F^2, all data)	0.1463
CCDC No.	963785

References:

1. CrystalClear 2.1, Rigaku Corporation, Tokyo, Japan
2. Sheldrick, G. M. *Acta Crystallogr., Sect. A* 2008, **64**, 112–122.
3. Farrugia, L. J., Wingx suite for small-molecule single-crystal crystallography. *J. Appl. Crystallogr.*, 1999, **32**, 837–838.