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Lewis acid catalyzed spiro annulation of (*Z*)-3-amino-acrylates with 2-amino arylbenzamides: One-pot synthesis of pyrrole-quinazoline hybrids

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Supporting Information

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Supporting Information

Melting points of all the compounds were recorded on Veego programmable melting point apparatus and are uncorrected. IR spectra were recorded on a PerkinElmer FT-IR 240-C spectrophotometer using KBr optics. ^{1}H and ^{13}C NMR spectra were recorded on Bruker AV 400 MHz in $CDCl_3$ and DMSO-d_6 using TMS as internal standard. high resolution mass spectra (HRMS) [ESI^+] were obtain using either a TOF or a double focusing spectrometer, micro mass VG 70–70H or LC/MSD trap SL spectrometer operating at 70 eV using direct inlet system. All the reactions were monitored by thin layer chromatography (TLC) on percolated silica gel 60 F254 (mesh); spots were visualized with UV light. Merck silica gel (60-120 mesh) was used for column chromatography.

General procedure for synthesis of ethyl 2,4'-dioxo-5-phenyl-3'-(alkyl/aryl)-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylates (3a-s)

Ethyl (*Z*)-3-amino-3-phenylacrylates (**1a-d,** 1 equiv.) and oxalyl chloride (1 equiv.) were reacted in 2 mL of CH_3CN:1,4-dioxane (5:1) at reflux for 2 h. After confirming the formation of intermediate **A** by TLC, then 2-amino *N*-aryl/alkyl benzamides (**2a-p,** 1 equiv.) and $Bi(OTf)_3$ (10 mol%) were added and stirred for 2-4 h under reflux. Upon the completion of the reaction (monitored by TLC), the reaction mixture was concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel using EtOAc/hexane as an eluent to afford the corresponding ethyl 2,4'-dioxo-5-phenyl-3'-(alkyl/aryl)-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylates (**3a-s**) in 72-90% yields.

Ethyl 2,4'-dioxo-3',5-diphenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3a)

Wheatish solid; (yield: 84%), m.p.: 245-247 ºC; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.94 (1H, s), 7.89 (1H, d, J = 7.8 Hz), 7.40-7.36 (1H, m), 7.31-7.26 (6H, m), 7.18-7.16 (2H, m), 7.10 (1H, s), 7.08 (1H, d, J = 1.3 Hz), 6.87 (1H, t, J = 7.1 Hz), 6.65 (1H, d, J = 7.8 Hz), 5.11 (1H, s), 4.0 (2H, q, J = 7.0, 5.2 Hz), 0.94 (3H, t, J = 7.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 181.17, 168.26, 167.29, 160.30, 150.56, 142.53, 138.32, 135.55, 134.42, 134.14, 133.56, 133.30, 133.08, 132.63, 122.42, 119.00, 118.70, 112.14, 83.83, 64.45, 18.58; FT-IR (KBr): υ 3282, 3062, 2926,

2855, 1751, 1694, 1639, 1492, 1106, 755 cm^{-1}; ESI-MS: m/z 440 $[M+H]^+$; ESI-HRMS: calcd for $C_{26}H_{22}N_3O_4$ $[M+H]^+$ 440.16048; found: 440.15943.

Ethyl 2,4'-dioxo-5-phenyl-3'-(*p*-tolyl)-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3b)

Brown solid; (yield: 86%), m.p.: 262-266 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.34 (1H, s), 7.78 (1 H, d, J = 6.8 Hz), 7.40 (1H, d, J = 7.2 Hz), 7.34 (2H, t, J = 7.4 Hz), 7.24 (3H, d, J = 7.1 Hz), 7.14-7.11 (4H, m), 6.85 (1H, s), 6.72-6.65 (2H, m), 3.98 (2H, q, J = 13.2, 6.0 Hz), 2.33 (3H, s), 0.91 (3H, t, J = 9.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 181.34, 168.24, 167.26, 160.19, 150.91, 142.71, 139.91, 138.40, 135.61, 134.28, 134.20, 133.46, 132.72, 132.58, 132.40, 121.98, 118.69, 118.22, 112.30, 83.93, 64.37, 26.01, 18.67; FT-IR (KBr): υ 3278, 3022, 2992, 2856, 1750, 1689, 1639, 1515, 1369, 1104, 752 cm^{-1}; ESI-MS: m/z 454 $[M+H]^+$; ESI-HRMS: calcd for $C_{27}H_{24}N_3O_4$ $[M+H]^+$ 454.17613; found: 454.17504.

Ethyl 3'-(4-methoxyphenyl)-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3c)

Wheatish solid; (yield: 90%), m.p.: 252-254 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.29 (1H, s), 7.80 (1H, d, J = 7.6 Hz), 7.41 (1H, d, J = 7.0 Hz), 7.35 (2H, t, J = 6.9 Hz), 7.28-7.22 (3H, m), 7.16 (2H, d, J = 7.7 Hz), 6.85 (2H, d, J = 7.5 Hz), 6.73-6.64 (3H, m), 3.99 (2H, q, J = 12.7, 5.5 Hz), 3.78 (3H, s), 0.91 (3H, t, J = 7.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 181.20, 168.41, 167.38, 163.90, 159.99, 150.62, 138.25, 135.54, 134.95, 134.48, 134.16, 133.39, 132.82, 132.64, 122.21, 118.98, 118.73, 118.49, 112.40, 84.07, 64.43, 60.21, 18.56; FT-IR (KBr): υ 3391, 3191, 3010, 2921, 2851, 1752, 1680, 1645, 1510, 1070, 751 cm^{-1}; ESI-MS: m/z 470 $[M+H]^+$; ESI-HRMS: calcd for $C_{27}H_{24}N_3O_5$ $[M+H]^+$ 470.17105; found: 470.17083.

Ethyl 3'-(3,4-dimethoxyphenyl)-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3d)

Orange solid; (yield: 87%), m.p.: 274-276 ºC; ^1H NMR (400 MHz, $CDCl_3$): δ 7.97 (1H, s), 7.79 (1H, d, J = 6.6 Hz), 7.32 (1H, t, J = 7.4 Hz), 7.21 (3H, t, J = 6.7 Hz), 7.08 (2H, d, J = 7.5 Hz), 6.76 (1H, t, J = 7.5 Hz), 6.67 (1H, d, J = 1.3 Hz), 6.62 (2H, s), 6.57 (1H, d, J = 8.0 Hz), 5.09 (1H, s), 3.92 (2H, q, J = 7.0 Hz), 3.72 (3H, s), 3.61 (3H, s), 0.86 (3H, t, J = 7.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): δ 175.54, 164.01, 162.66, 148.86, 144.29, 133.69, 131.24, 130.07, 129.76, 129.67 129.29, 128.53, 128.46, 128.38, 128.32, 128.12, 119.69, 115.82, 115.54, 112.68, 111.04, 78.94,

60.27, 55.91, 55.84, 13.77; FT-IR (KBr): υ 3020, 1752, 1641, 1514, 1372, 1327, 1214, 1104, 749 cm^{-1}; ESI-MS: m/z 500 $[M+H]^+$; ESI-HRMS: calcd for $C_{28}H_{26}N_3O_6$ $[M+H]^+$ 500.18161; found: 500.18022.

Ethyl 2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3e)

white solid; (yield: 72%), m.p.: 231-233 ºC; ^1H NMR (400 MHz, $CDCl_3$): δ 12.36 (1H, s), 9.71 (1H, s), 8.19 (1H, d, J = 6.8 Hz), 7.83 (1H, d, J = 8.0 Hz), 7.70 (1H, t, J = 7.5 Hz), 7.45 (1H, t, J = 7.0 Hz), 7.31-7.29 (1H, m), 7.27 (3H, s), 7.09 (1H, s), 5.37 (1H, s), 4.16 (2H, q, J = 7.1 Hz), 1.20 (3H, t, J = 7.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.72, 160.56, 157.42, 151.53, 147.15, 143.28, 135.00, 130.03, 129.09, 128.97, 128.29, 127.31, 126.99, 123.08, 105.15, 77.25, 60.73, 14.36; FT-IR (KBr): υ 3214, 2922, 2853, 1685, 1515, 1474, 1295, 1215, 1184, 758 cm^{-1}; ESI-MS: m/z 364 $[M+H]^+$; ESI-HRMS: calcd for $C_{20}H_{18}N_3O_4$ $[M+H]^+$ 364.12918; found: 364.12824.

Ethyl 3'-(4-fluorophenyl)-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3f)

Pale yellow solid; (yield: 75%), m.p.: 244-246 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.34 (1H, s), 7.81 (1H, d, J = 7.7 Hz), 7.42 (1H, t, J = 7.2 Hz), 7.35 (2H, t, J = 7.5 Hz), 7.26 (5H, d, J = 6.6 Hz), 7.04 (2H, t, J = 8.5 Hz), 6.75-6.67 (3H, m), 4.00 (2H, q, J = 13.3, 6.0 Hz), 0.91 (3H, t, J = 7.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 181.17, 168.48, 167.97, 167.29, 165.51, 160.42, 150.71, 138.57, 138.45, 136.33, 135.72, 134.02, 133.36, 132.75, 132.63, 122.29, 120.57, 120.35, 118.88, 118.11, 111.96, 83.99, 64.54, 18.58; FT-IR (KBr): υ 3280, 3020, 2928, 2857, 1751, 1689, 1642, 1508, 1369, 1216, 1104, 754 cm^{-1}; ESI-MS: m/z 458 $[M+H]^+$; ESI-HRMS: calcd for $C_{26}H_{21}FN_3O_4$ $[M+H]^+$ 458.15106; found: 458.14993.

Ethyl 3'-(4-bromophenyl)-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3g)

Pale brown solid; (yield: 76%), m.p.: 251-253 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.37 (1H, s), 7.81 (1H, d, J = 7.7 Hz), 7.47 (3H, d, J = 8.6 Hz), 7.43 (1H, d, J = 7.4 Hz), 7.37 (2H, t, J = 7.5 Hz), 7.28 (3H, d, J = 7.4 Hz), 7.15 (2H, d, J = 8.6 Hz), 6.74 (1H, t, J = 7.5 Hz), 6.68 (2H, d, J = 10.4 Hz), 3.99 (2H, q, J = 12.6, 5.3 Hz), 0.92 (3H, t, J = 7.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 181.09, 168.16, 167.17, 160.46, 150.87, 141.83, 138.64, 136.69, 136.44, 135.78, 134.06, 133.43, 132.79, 132.57, 126.73, 122.14, 118.80, 117.91, 111.85, 83.83,

64.49, 18.64; FT-IR (KBr): υ 3021, 2926, 1751, 1641, 1488, 1418, 1366, 1214, 747 cm^{-1}; ESI-MS: m/z 518 $[M+H]^+$; ESI-HRMS: calcd for $C_{26}H_{21}BrN_3O_4$ $[M+H]^+$ 518.07100; found: 518.06969.

Ethyl 3'-benzyl-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3h)

Pale yellow solid; (yield: 82%), m.p.: 284-286 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.28 (1H, s), 7.89 (1H, d, J = 7.8 Hz), 7.46-7.39 (5H, m), 7.31 (2H, d, J = 4.9 Hz), 7.22-7.18 (4H, m), 6.76 (1H, t, J = 7.7 Hz), 6.62 (1H, d, J = 8.0 Hz), 6.30 (1H, s), 4.70 (1H, s), 3.87-3.82 (2H, q, J = 6.9, 4.4 Hz), 0.91 (3H, t, J = 6.9 Hz); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 175.82, 163.83, 162.23, 155.68, 144.88, 137.56, 133.14, 130.92, 128.91, 128.85, 128.32, 128.10, 127.88, 127.70, 127.02, 118.07, 114.53, 114.27, 106.32, 77.67, 59.57, 46.39, 13.59; FT-IR (KBr): υ 3300, 3018, 2923, 2854, 1749, 1694, 1620, 1491, 1215, 1092, 748 cm^{-1}; ESI-MS: m/z 454 $[M+H]^+$; ESI-HRMS: calcd for $C_{27}H_{24}N_3O_4$ $[M+H]^+$ 454.17613; found: 454.17506.

Ethyl 3'-(4-methoxybenzyl)-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3i)

Pale orange solid; (yield: 86%), m.p.: 262-264 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.28 (1H, s), 7.89 (1H, d, J = 7.6 Hz), 7.51-7.43 (5H, m), 7.26-7.20 (3H, m), 6.77-6.71 (3H, m), 6.61 (1H, d, J = 8.0 Hz), 6.35 (1H, s), 4.81 (1H, d, J = 15.1 Hz), 4.53 (1H, d, J = 15.2 Hz), 3.89 (2H, q, J = 9.0, 3.4 Hz), 3.74 (3H, s), 0.94 (3H, t, J = 7.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 175.83, 163.82, 162.31, 158.55, 155.69, 144.78, 133.11, 130.95, 129.82, 129.51, 128.95, 128.87, 127.93, 127.73, 118.11, 114.70, 114.27, 113.26, 106.19, 77.35, 59.63, 55.06, 45.72, 13.63; FT-IR (KBr): υ 3279, 2926, 2854, 1752, 1697, 1622, 1512, 1244, 1095, 753 cm^{-1}; ESI-MS: m/z 484 $[M+H]^+$; ESI-HRMS: calcd for $C_{28}H_{26}N_3O_5$ $[M+H]^+$ 484.18670; found: 484.18471.

Ethyl 3'-(tert-butyl)-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3j)

Brown solid; (yield: 83%), m.p.: 214-216 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.12 (1H, s), 8.49 (1H, s), 7.58 (2H, d, J = 7.9 Hz), 7.46 (1H, d, J = 7.3), 7.32-7.27 (3H, m), 7.06 (2H, t, J = 7.5 Hz), 6.75 (1H, s), 4.03 (2H, q, J = 13.5, 5.6 Hz), 1.45 (9H, s), 1.06 (3H, t, J = 7.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 167.46, 165.30, 162.55, 142.34, 139.53, 137.49,

129.27, 127.27, 126.94, 126.40, 125.64, 125.52, 122.52, 122.38, 110.59, 90.20, 59.46, 49.31, 28.23, 13.40; FT-IR (KBr): υ 3308, 3067, 2966, 2926, 2855, 1718, 1616, 1527, 1453, 1185, 762 cm^{-1}; ESI-MS: m/z 420 $[M+H]^+$; ESI-HRMS: calcd for $C_{24}H_{26}N_3O_4$ $[M+H]^+$ 420.19178; found: 420.19091.

Ethyl 3'-ethyl-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3k)

Pale yellow solid; (yield: 80%), m.p.: 202-204 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.62 (1H, s), 7.76 (1H, d, J = 4.9 Hz), 7.65 (2H, d, J = 4.4 Hz), 7.47 (3H, d, J = 7.6 Hz), 7.18 (1H, s), 6.7-6.66 (2H, m), 6.58 (1H, d, J = 7.3 Hz), 3.94-3.88 (2H, m), 3.30 (2H, q, J = 13.3, 6.8 Hz), 1.18 (3H, s), 0.87 (3H, t, J = 5.4 Hz); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 175.82, 162.31, 161.88, 154.53, 144.36, 132.30, 130.38, 128.45, 128.25, 127.27, 126.69, 116.78, 113.17, 112.88, 107.07, 77.66, 59.03, 38.04, 12.93, 12.89; FT-IR (KBr): υ 3276, 2928, 2856, 1754, 1695, 1624, 1524, 1491, 1102, 753 cm^{-1}; ESI-MS: m/z 392 $[M+H]^+$; ESI-HRMS: calcd for $C_{22}H_{22}N_3O_4$ $[M+H]^+$ 392.16048; found: 392.15959.

Ethyl 3'-cyclopropyl-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'H-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3l)

Yellow solid; (yield: 82%), m.p.: 189-191 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.58 (1H, s), 7.76 (1H, s), 7.65-7.63 (2H, m), 7.50-7.48 (3H, m), 7.18 (1H, d, J = 3.7 Hz), 6.68 (1H, d, J = 4.2 Hz), 6.60 (2H, s), 3.97 (2H, q, J = 13.7, 6.9 Hz), 2.48-2.48 (1H, m), 0.93 (3H, t, J = 6.6 Hz), 0.91 (2H, d, J = 6.4 Hz), 0.81 (1H, d, J = 3.8 Hz), 0.67 (1H, s); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 176.40, 164.14, 161.87, 154.16, 144.21, 135.25, 130.14, 128.69, 128.09, 127.19, 126.78, 116.68, 113.68, 112.80, 107.60, 77.88, 58.97, 25.38, 12.93, 6.61, 5.05; FT-IR (KBr): υ 3275, 3018, 2928, 2856, 1752, 1691, 1637, 1515, 1449, 1350, 1104, 756 cm^{-1}; ESI-MS: m/z 404 $[M+H]^+$; ESI-HRMS: calcd for $C_{23}H_{22}N_3O_4$ $[M+H]^+$ 404.16048; found: 404.15963.

Ethyl 6'-chloro-2,4'-dioxo-3',5-diphenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3m)

Pale orange solid; (yield: 85%), m.p.: 242-244 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.55 (1H, s), 7.89 (1H, s), 7.55-7.42 (6H, m), 7.38-7.34 (5H, m), 7.19 (1H, s), 6.82 (1H, t, J = 10.3 Hz), 4.16 (2H, q, J = 14.2, 7.5 Hz), 1.10 (3H, t, J = 6.7 Hz); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 175.32, 161.68, 161.56, 154.98, 143.57, 136.52, 132.42, 130.01, 128.56, 128.34,

128.02, 127.65, 127.02, 126.37, 121.29, 115.05, 114.15, 106.17, 78.08, 58.90, 12.98; FT-IR (KBr): υ 3277, 2928, 2856, 1751, 1643, 1492, 1450, 1106, 757 cm^{-1}; ESI-MS: m/z 474 $[M+H]^+$; ESI-HRMS: calcd for $C_{26}H_{21}ClN_3O_4$ $[M+H]^+$ 474.12151; found: 474.12052.

Ethyl 3'-benzyl-6'-chloro-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3n)

Orange solid; (yield: 80%), m.p.: 268-270 ºC; ^1H NMR (500 MHz, $CDCl_3$): δ 7.93 (1H, d, J = 2.5 Hz), 7.73 (1H, s), 7.43 (1H, t, J = 6.8 Hz), 7.35 (3H, t, J = 7.7 Hz), 7.30 (2H, d, J = 7.0 Hz), 7.18 (1H, s), 7.17 (1H, d, J = 2.4 Hz), 7.16 (1H, d, J = 2.5 Hz), 7.13-7.10 (3H, m), 6.54 (1H, d, J = 8.5 Hz), 4.92 (1H, d, J = 15.5 Hz), 4.41 (1H, d, J = 15.5 Hz), 3.88 (2H, q, J = 7.1 Hz), 0.95 (3H, t J = 7.2 Hz); ^{13}C NMR (125 MHz, $CDCl_3$): δ 174.66, 163.07, 162.38, 155.24, 141.88, 136.90, 133.19, 131.71, 128.62, 128.40, 128.30, 128.20, 127.93, 127.52, 125.78, 118.70, 117.82, 105.43, 60.48, 46.70, 13.84; FT-IR (KBr): υ 3281, 3022, 2929, 1747, 1693, 1620, 1530, 1248, 1216, 1096, 754 cm^{-1}; ESI-MS: m/z 488 $[M+H]^+$; ESI-HRMS: calcd for $C_{27}H_{23}ClN_3O_4$ $[M+H]^+$ 488.13716; found: 488.13561.

Ethyl 6'-chloro-3'-(4-methoxybenzyl)-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3o)

Orange solid; (yield: 82%), m.p.: 262-264 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.28 (1H, s), 7.85 (1H, d, J = 1.8 Hz), 7.50-7.41 (6H, m), 7.24 (2H, d, J = 8.4 Hz), 7.15 (1H, d, J = 6.5 Hz), 6.71 (2H, d, J = 8.5 Hz), 6.54 (1H, s), 4.85 (1H, d, J = 15.0 Hz), 4.49 (1H, d, J = 15.1 Hz), 3.92 (2H, q, J = 5.3, 1.6 Hz), 3.73 (3H, s), 0.97 (3H, t, J = 7.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 175.64, 162.82, 162.22, 158.65, 156.03, 143.49, 132.80, 131.07, 129.88, 129.21, 128.87, 127.74, 127.43, 126.73, 122.68, 115.85, 115.83, 113.30, 105.76, 77.13, 59.68, 55.06, 45.80, 13.70; FT-IR (KBr): υ 3210, 3017, 2924, 2853, 1750, 1619, 1511, 1245, 1096, 750 cm^{-1}; ESI-MS: m/z 518 $[M+H]^+$; ESI-HRMS: calcd for $C_{28}H_{25}ClN_3O_5$ $[M+H]^+$ 518.14773; found: 518.14645.

Ethyl 3'-butyl-6'-chloro-2,4'-dioxo-5-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3p)

Yellow solid; (yield: 79%), m.p.: 216-218 ºC; ^1H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.65 (1H, s), 7.68 (3H, d, J = 38.1 Hz), 7.48 (3H, d, J = 4.0 Hz), 7.12 (1H, d, J = 2.2 Hz), 6.84 (1H, s), 6.58-6.56 (1H, m), 3.98 (2H, q, J = 6.5, 4.2 Hz), 1.58 (2H, s), 1.27 (4H, d, J = 4.8 Hz), 0.95-0.88

(6H, m); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 175.61, 161.76, 161.45, 154.97, 143.05, 131.99, 130.49, 128.39, 128.20, 127.33, 126.20, 121.31, 114.54, 114.38, 106.56, 77.45, 59.10, 43.16, 29.48, 19.71, 13.08, 13.03; FT-IR (KBr): υ 3268, 2960, 2929, 2864, 1753, 1693, 1627, 1492, 1419, 1321, 1104, 1031, 757 cm^{-1}; ESI-MS: m/z 454 $[M+H]^+$; ESI-HRMS: calcd for $C_{24}H_{25}ClN_3O_4$ $[M+H]^+$ 454.15281; found: 454.15181.

Ethyl 5-(4-fluorophenyl)-2,4'-dioxo-3'-phenyl-1,2,3',4'-tetrahydro-1'H-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3q)

Pale brown solid; (yield: 73%), m.p.: 226-228 ºC; ^{1}H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.47 (s, 1H), 7.76 (s, 1H), 7.42 (d, J = 5.7 Hz, 1H), 7.36 (s, 2H), 7.25 (s, 5H), 7.07 (d, J = 7.5 Hz, 3H), 6.69 (t, J = 6.2 Hz, 2H), 3.97 (q, J = 5.9, 6.4 Hz, 2H), 0.91 (t, J = 3.9 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 175.16, 162.40, 161.99, 161.28, 159.53, 154.34, 144.75, 132.51, 130.46, 130.38, 129.71, 128.11, 127.37, 126.74, 126.64, 116.27, 114.54, 114.32, 112.87, 112.20, 106.04, 78.02, 58.51, 12.61; FT-IR (KBr): υ 3391, 1746, 1649, 1508, 1369, 1222, 1106, 995, 763 cm^{-1}; ESI-MS: m/z 458 $[M+H]^+$; ESI-HRMS: calcd for $C_{26}H_{21}FN_3O_4$ $[M+H]^+$ 458.15106; found: 458.14863.

Ethyl 2,4'-dioxo-3'-phenyl-5-(*p*-tolyl)-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3r)

Pale yellow solid; (yield: 85%), m.p.: 243-245 ºC; ^{1}H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.50 (s, 1H), 7.71 (t, J = 7.1 Hz, 1H), 7.41 (d, J = 7.1 Hz, 1H), 7.35 (t, J = 7.2 Hz, 2H), 7.28 (s, 1H), 7.22 (d, J = 7.1 Hz, 3H), 7.15 (d, J = 7.9 Hz, 2H), 7.08 (d, J = 7.9 Hz, 2H), 6.66 (t, J = 11.5, Hz, 2H), 3.96 (q, J = 8.7, 7.0 Hz, 2H), 2.33 (s, 3H), 0.90 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 176.05, 163.04, 162.08, 154.92, 145.63, 145.52, 137.49, 134.65, 133.09, 130.35, 128.96, 128.19, 127.46, 127.40, 116.98, 116.86, 113.54, 113.16, 107.12, 78.70, 59.17, 20.79, 13.41; FT-IR (KBr): υ 3401, 2991, 1747, 1649, 1519, 1450, 998, 756 cm^{-1}; ESI-MS: m/z 454 $[M+H]^+$; ESI-HRMS: calcd for $C_{27}H_{24}N_3O_4$ $[M+H]^+$ 454.17613; found: 454.17561.

Ethyl 5-(4-methoxyphenyl)-2,4'-dioxo-3'-phenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (3s)

White solid; (yield: 88%), m.p.: 272-274 ºC; ^{1}H NMR (400 MHz, $CDCl_3$ + DMSO-d_6): δ 10.46 (s, 1H), 7.74 (d, J = 7.7 Hz, 1H), 7.45-7.41 (m, 1H), 7.38-7.34 (m, 2H), 7.27-7.22 (m, 4H), 7.13 (d, J = 6.7 Hz, 2H), 6.86 (d, J = 5.2 Hz, 2H), 6.67 (t, J = 3.8 Hz, 2H), 3.97 (q, J = 7.6, 2.6 Hz,

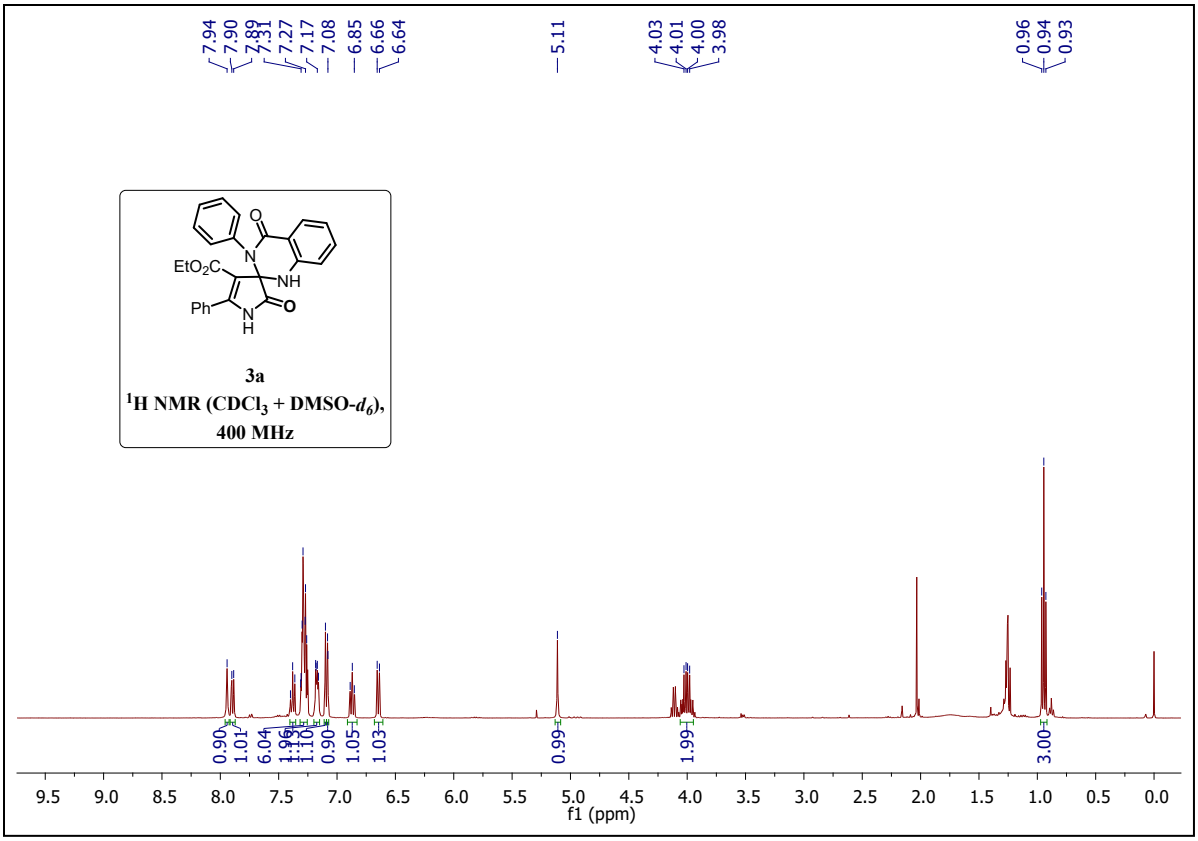
2H), 3.78 (s, 3H), 0.91 (t, J = 4.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$ + DMSO-d_6): δ 175.47, 162.74, 161.73, 158.21, 154.31, 144.83, 132.52, 129.87, 129.82, 129.62, 129.25, 128.77, 128.43, 127.68, 126.4, 116.67, 113.20, 113.05, 106.70, 78.35, 58.79, 54.50, 12.85; FT-IR (KBr): υ 3403, 1652, 1216, 988, 754 cm^{-1}; ESI-MS: m/z 470 $[M+H]^+$; ESI-HRMS: calcd for $C_{27}H_{24}N_3O_5$ $[M+H]^+$ 470.17105; found: 470.17060.

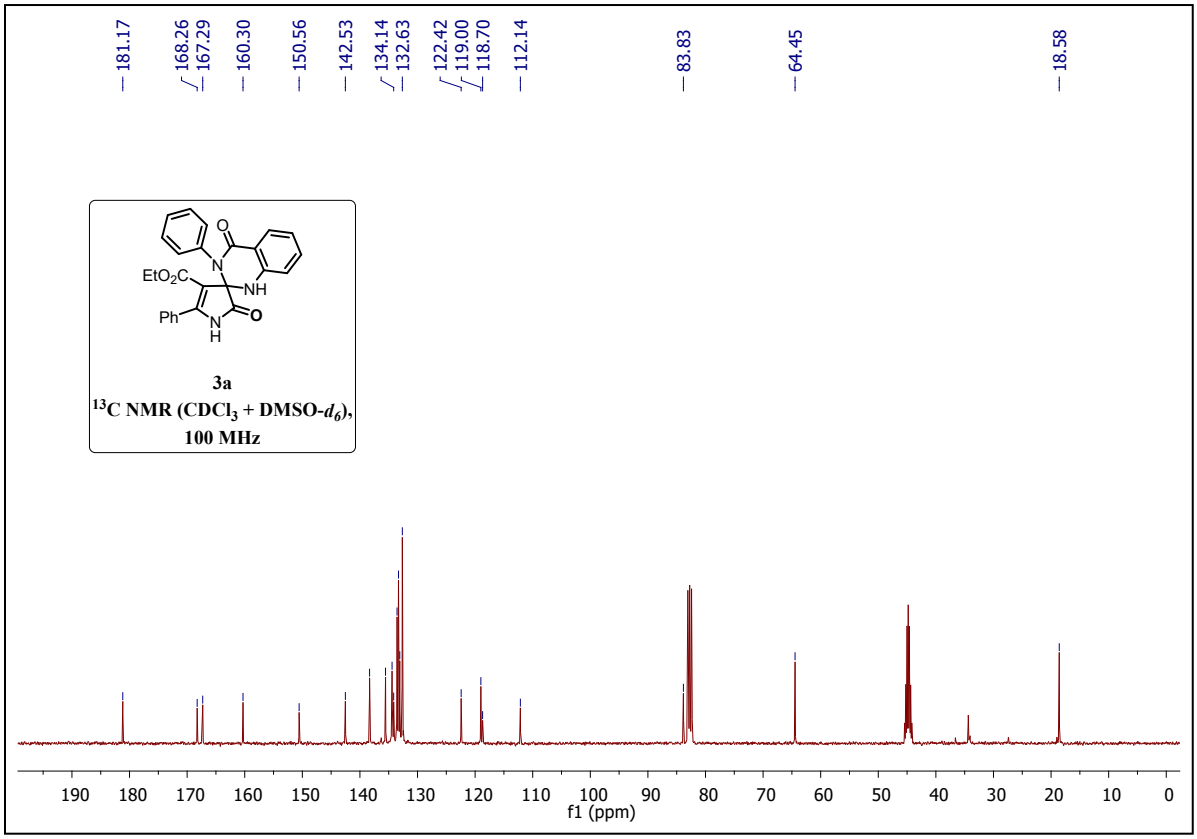
Ethyl 3'-butyl-2,4'-dioxo-5,6'-diphenyl-1,2,3',4'-tetrahydro-1'*H*-spiro[pyrrole-3,2'-quinazoline]-4-carboxylate (5)

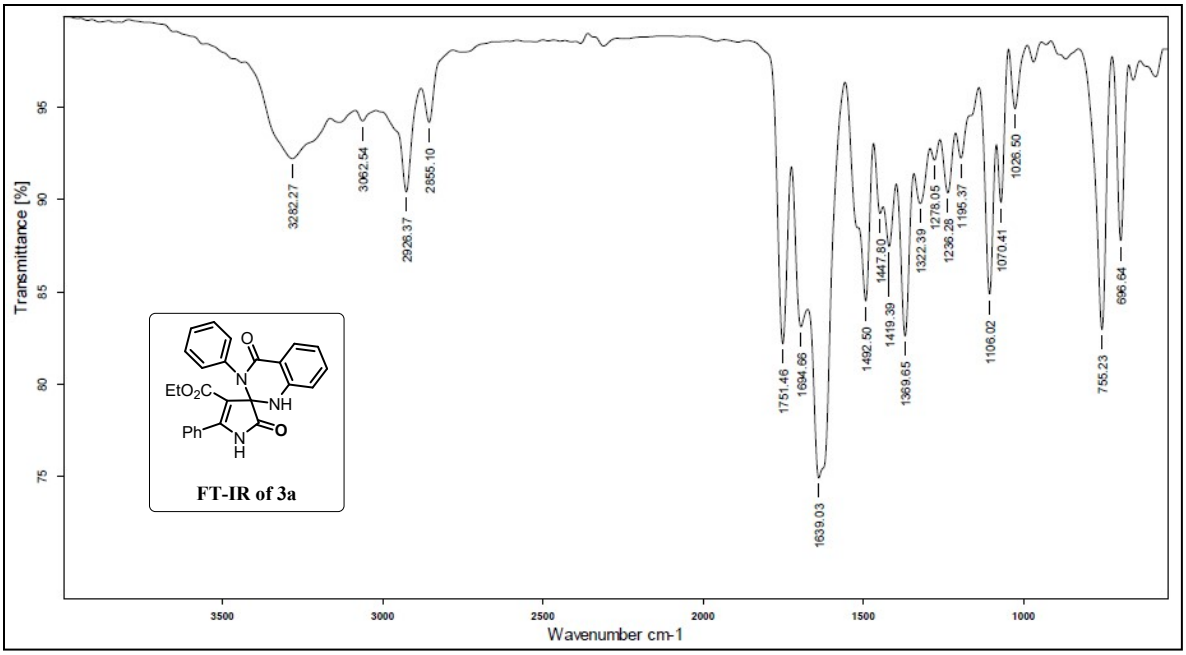
White solid; (yield: 82%), m.p.: 252-254 ºC; ^{1}H NMR (400 MHz, $CDCl_3$): δ 12.32 (1H, s), 8.55 (1H, d, J = 1.4 Hz), 8.07 (1H, d, J = 6.5 Hz), 7.96 (1H, d, J = 8.4 Hz), 7.72 (2H, d, J = 7.4 Hz), 7.51-7.40 (8H, m), 5.51 (1H, s), 4.47 (2H, t, J = 6.9 Hz), 4.31 (2H, q, J = 7.1 Hz), 1.74-1.68 (2H, m), 1.38-1.32 (5H, m), 0.92 (3H, t, J = 7.3 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.81, 162.03, 159.04, 152.25, 146.36, 144.61, 141.60, 139.43, 135.46, 133.36, 129.84, 129.09, 128.75, 128.29, 128.19, 127.32, 127.12, 124.91, 122.23, 104.51, 60.56, 44.20, 31.87, 20.14, 14.38, 13.76; FT-IR (KBr): υ 3223, 3063, 2962, 1715, 1684, 1621, 1478, 1288, 1180, 769 cm^{-1}; ESI-MS: m/z 496. $[M+H]^+$; ESI-HRMS: calcd for $C_{30}H_{30}N_3O_4$ $[M+H]^+$ 496.22308; found: 496.22392.

Ethyl 2-phenyl-1*H*-pyrrolo[2,3-*b*]quinoxaline-3-carboxylate (7)

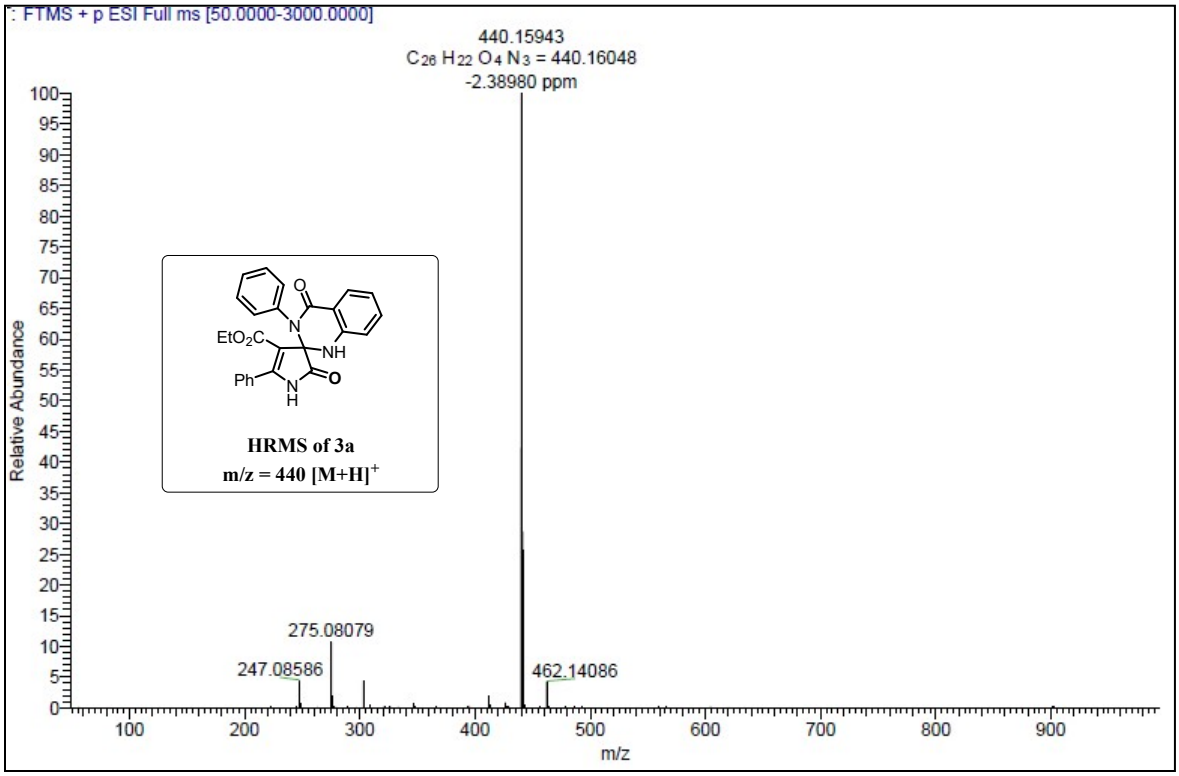
Pale brown; (yield: 88%), m.p.: 232-234 ºC; ^{1}H NMR (400 MHz, $CDCl_3$): δ 12.54 (1H, s), 8.21 (1H, d, J = 7.8 Hz), 7.71 (2H, d, J = 7.1 Hz), 7.55-7.49 (3H, m), 7.43 (2H, t, J = 7.5 Hz), 7.32-7.28 (1H, m), 7.00 (1H, d, J = 7.9 Hz), 4.28 (2H, q, J = 7.1 Hz), 1.18 (3H, t, J = 7.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$): δ 163.37, 154.75, 142.16, 142.07, 141.65, 138.20, 131.22, 130.54, 129.94, 129.88, 128.53, 128.41, 127.38, 126.99, 103.54, 60.49, 14.17; FT-IR (KBr): υ 3193, 3063, 2925, 1726, 1694, 1611, 1254, 760 cm^{-1}; ESI-MS: m/z 318 $[M+H]^+$; ESI-HRMS: calcd for $C_{19}H_{16}N_2O_3$ $[M+H]^+$ 318.12370; found: 318.12292.


7.94
7.90
7.89
7.31
7.27
7.17
7.08
6.85
6.66
6.64
5.11
4.03
4.01
4.00
3.98
0.96
0.94
0.93
EtO2C
NH
Ph
N
H
O
3a
1H NMR (CDCl3 + DMSO-d6),
400 MHz
0.90
1.01
6.04
1.96
1.10
0.90
1.05
1.03
0.99
1.99
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


181.17
168.26
167.29
160.30
150.56
142.53
134.14
132.63
122.42
119.00
118.70
112.14
83.83
64.45
18.58
EtO2C
NH
Ph
N
H
O
3a
13C NMR (CDCl3 + DMSO-d6),
100 MHz
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

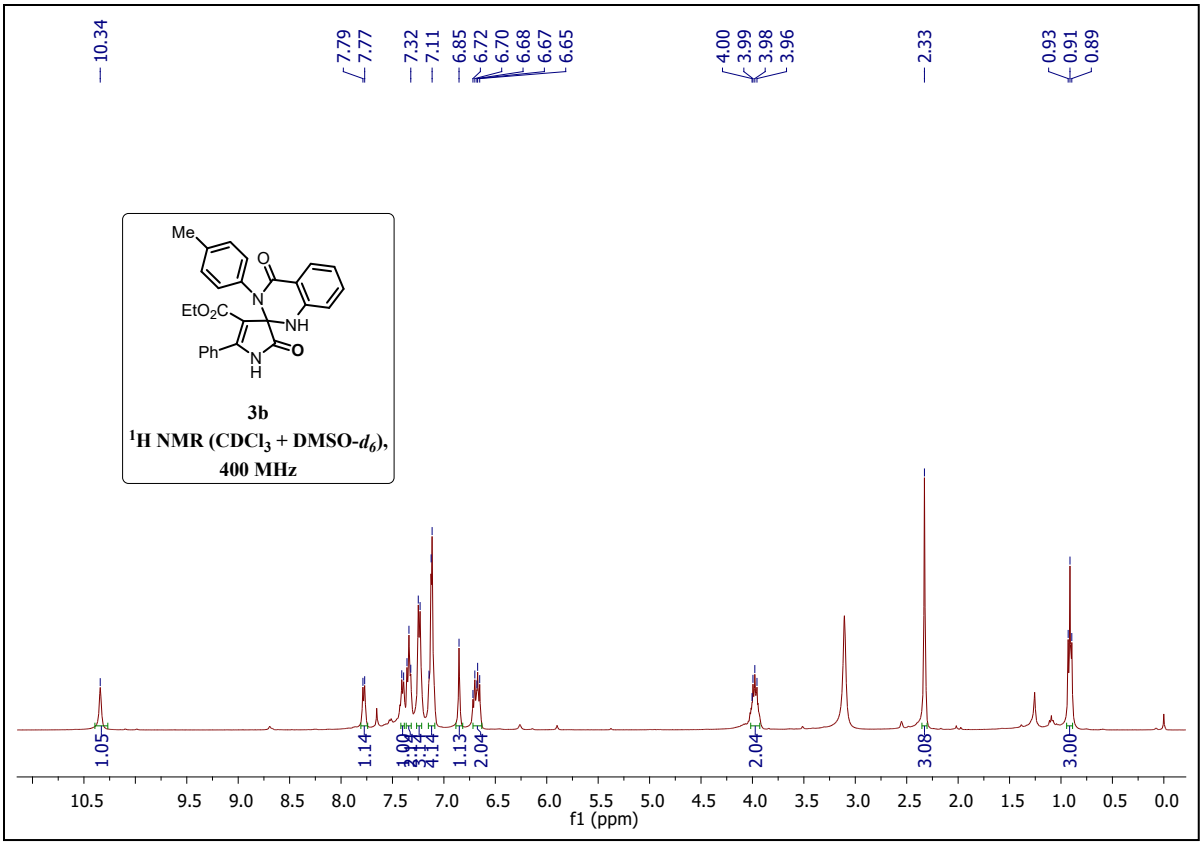


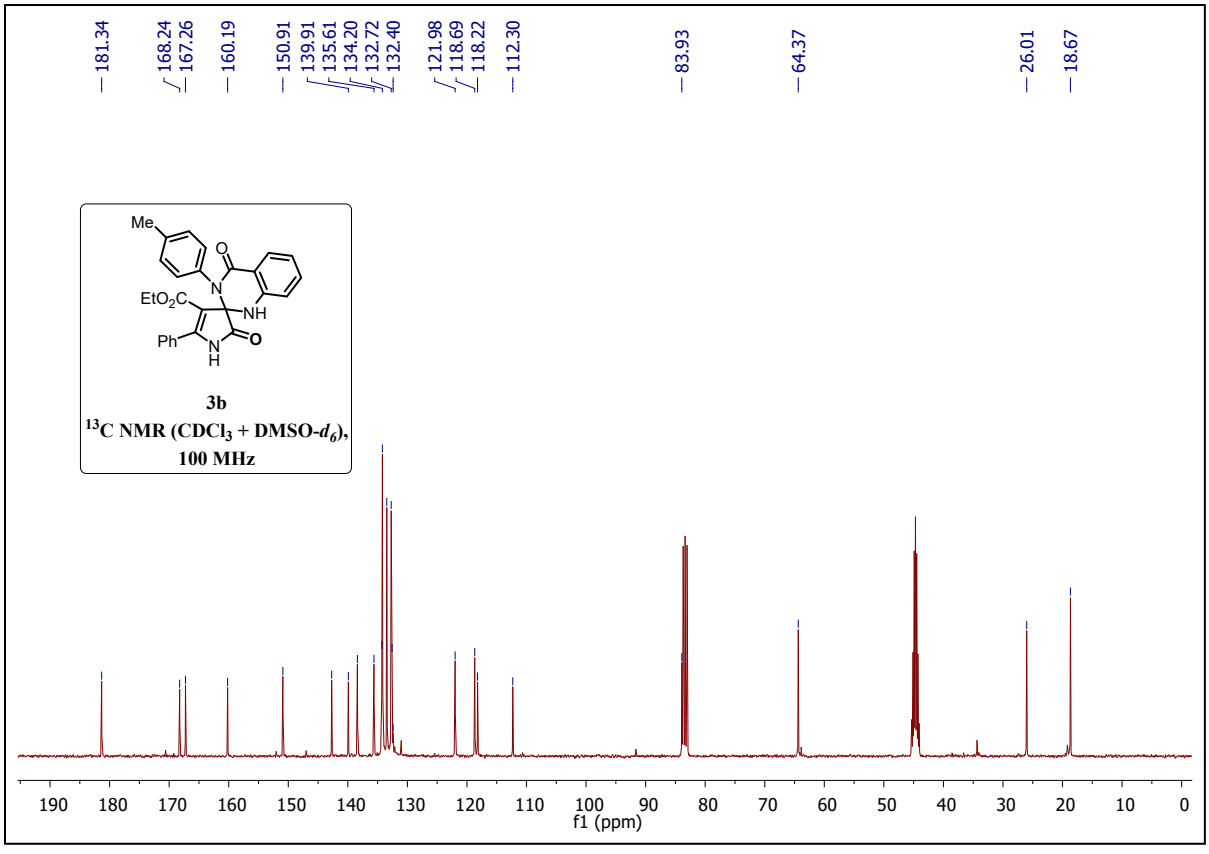
FT-IR of 3a

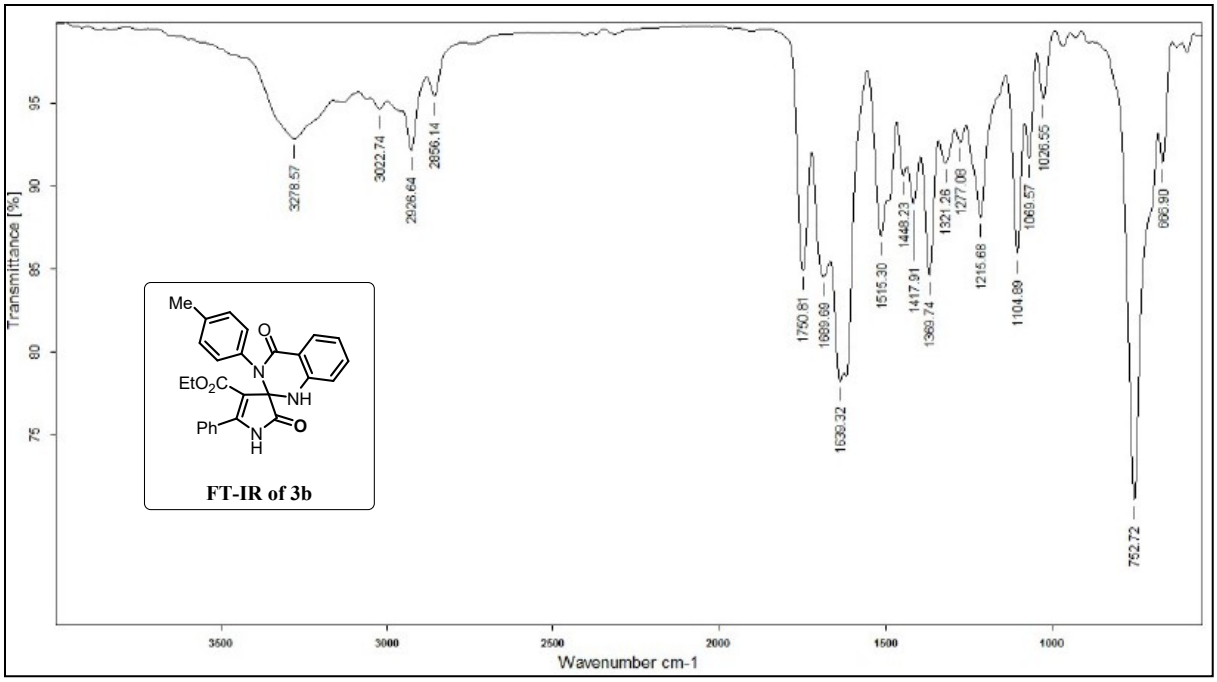


HRMS of 3a

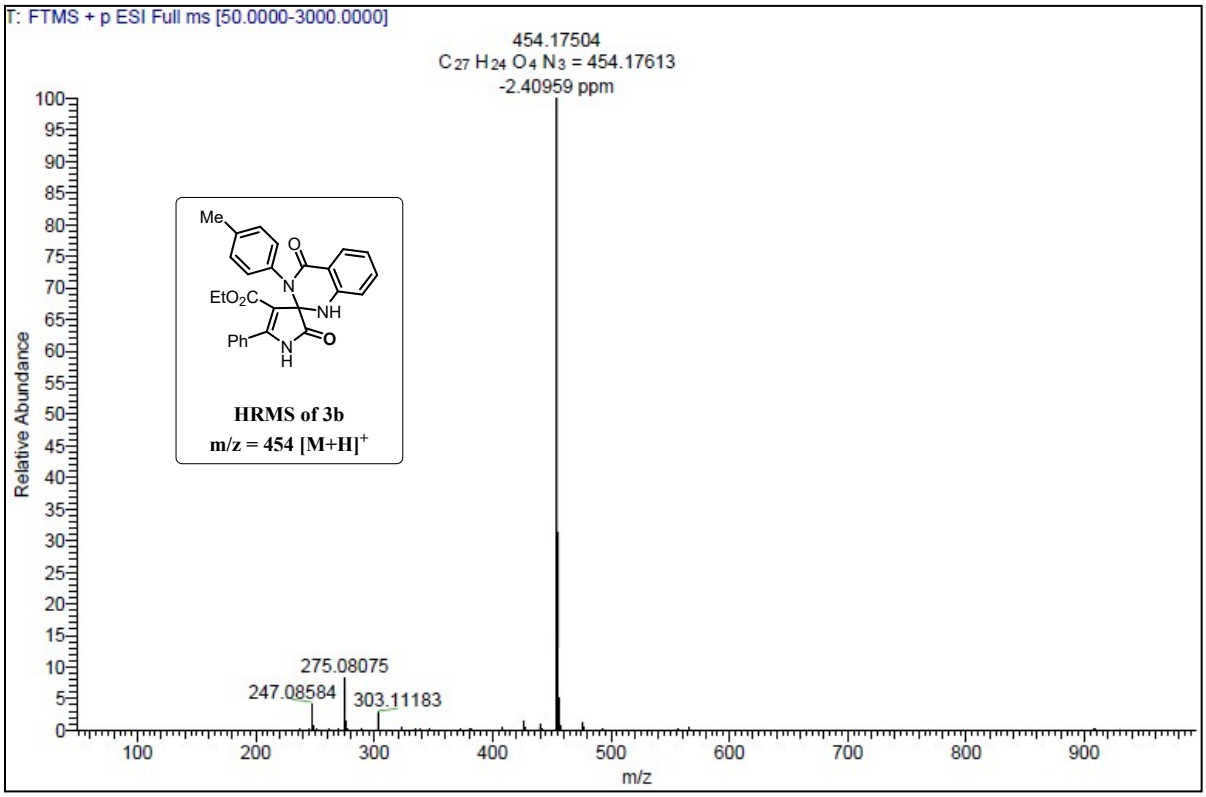
m/z = 440 $[M+H]^+$


10.34
7.79
7.77
7.32
7.11
6.85
6.72
6.70
6.68
6.67
6.65
4.00
3.99
3.98
3.96
2.33
0.93
0.91
0.89
Me
O
N
EtO2C
NH
Ph
N
H
O
3b
1H NMR (CDCl3 + DMSO-d6),
400 MHz
1.05
1.14
1.09
3.12
4.14
1.13
2.04
2.04
3.08
3.00
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


181.34
168.24
167.26
160.19
150.91
139.91
135.61
134.20
132.72
132.40
121.98
118.69
118.22
112.30
83.93
64.37
26.01
18.67
Me
O
N
EtO2C
NH
Ph
N
H
O
3b
13C NMR (CDCl3 + DMSO-d6),
100 MHz
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

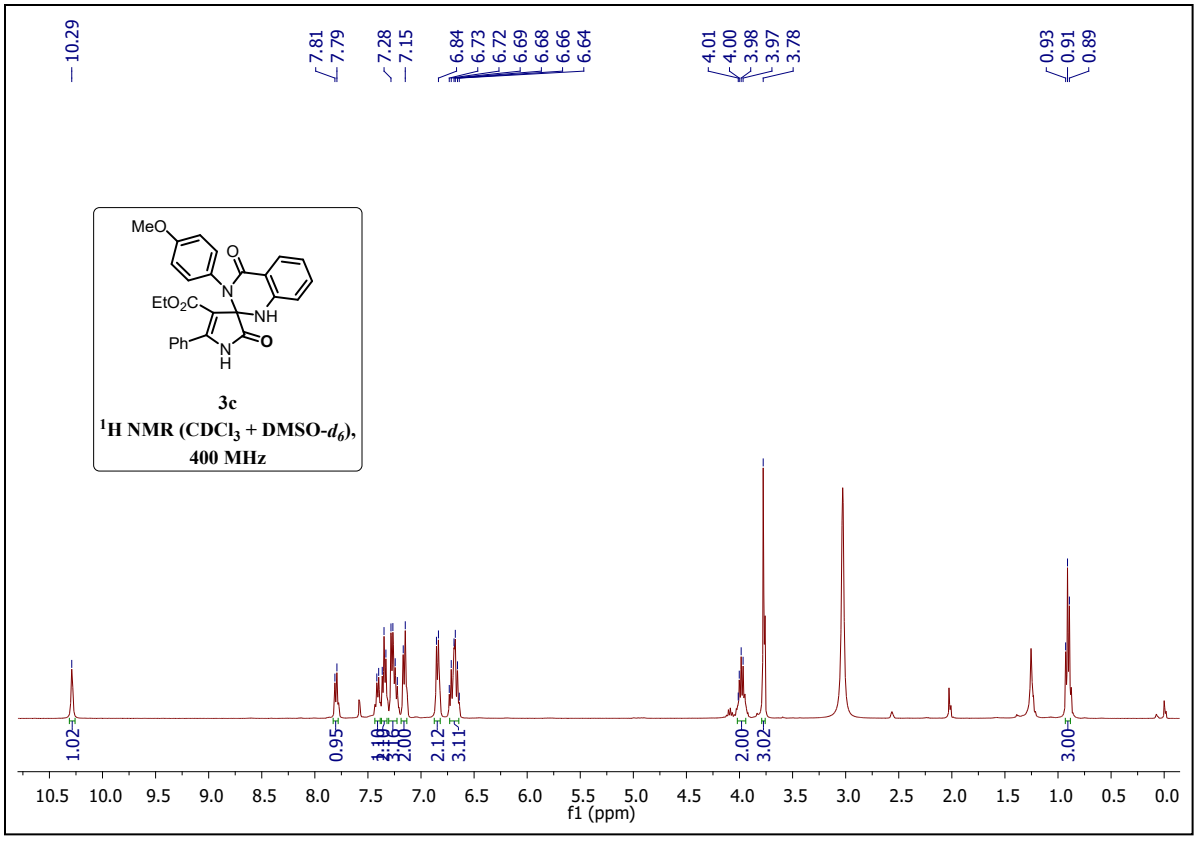


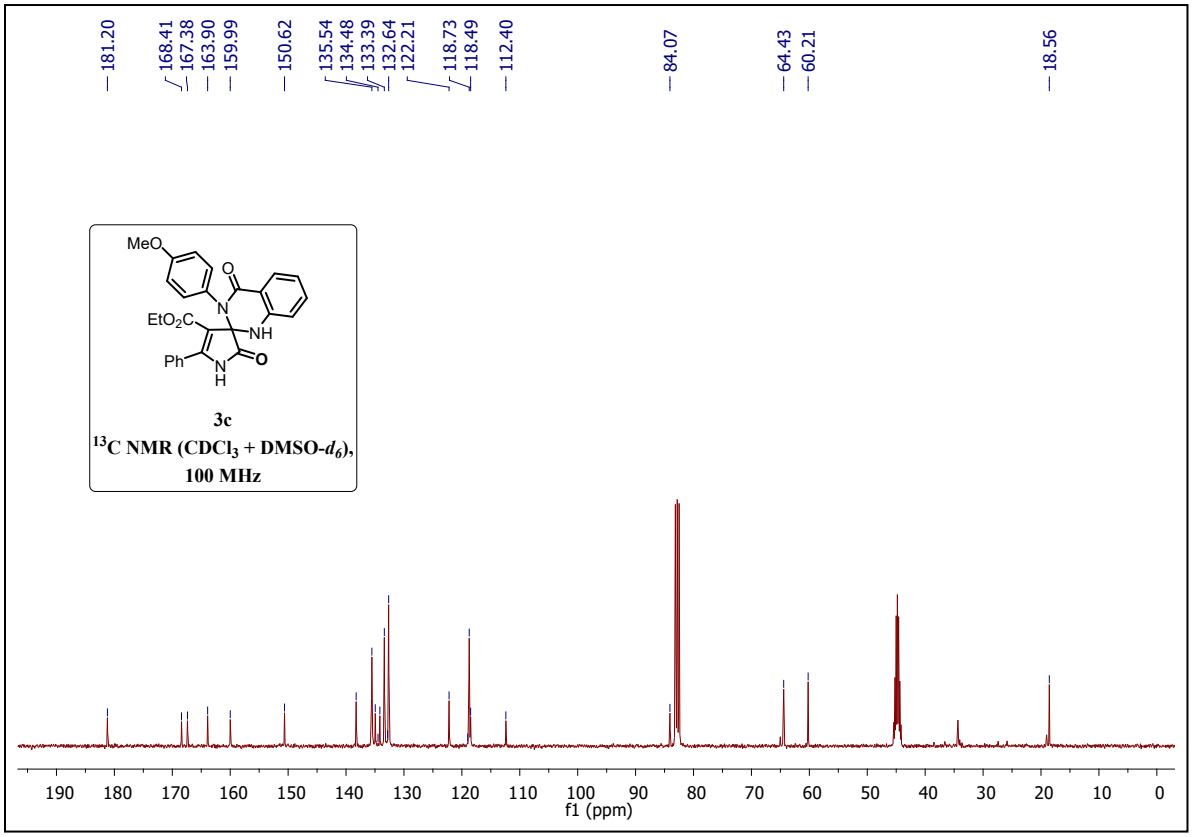
FT-IR of 3b

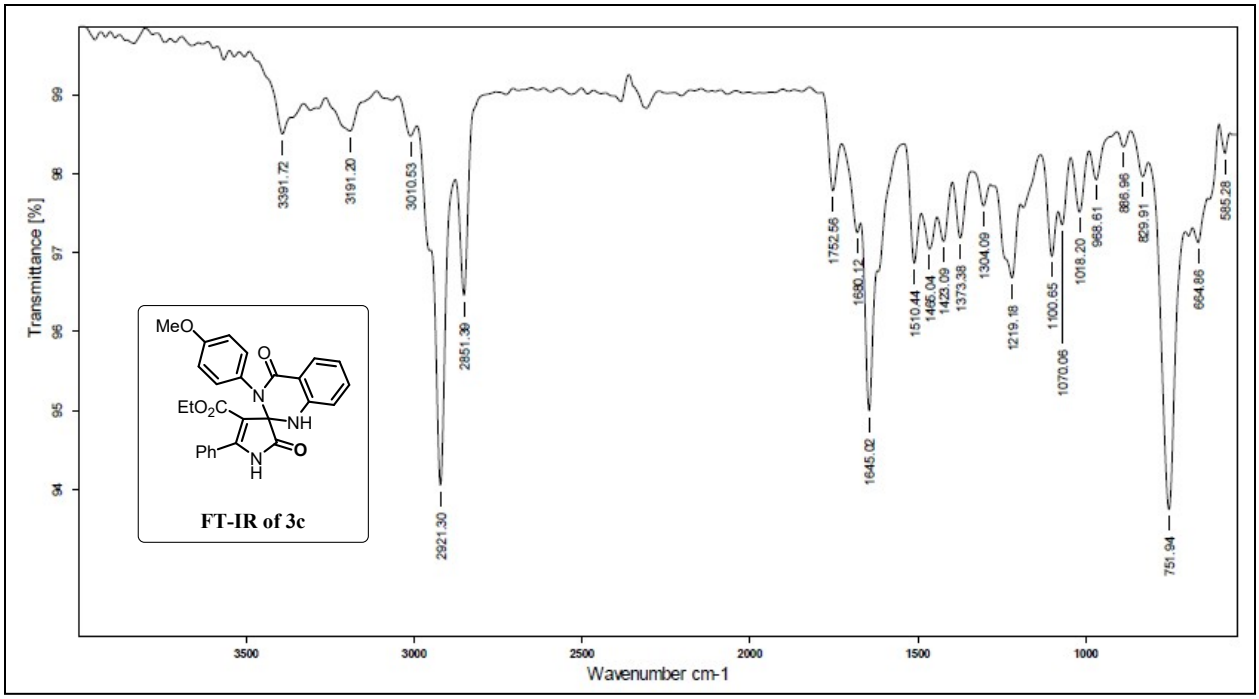


HRMS of 3b

m/z = 454 $[M+H]^+$


10.29
7.81
7.79
7.28
7.15
6.84
6.73
6.72
6.69
6.68
6.66
6.64
4.01
4.00
3.98
3.97
3.78
0.93
0.91
0.89
MeO
O
N
EtO2C
NH
Ph
N
H
O
3c
1H NMR (CDCl3 + DMSO-d6),
400 MHz
1.02
0.95
2.00
2.12
3.11
2.00
3.02
3.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


181.20
168.41
167.38
163.90
159.99
150.62
135.54
134.48
133.39
132.64
122.21
118.73
118.49
112.40
84.07
64.43
60.21
18.56
MeO
O
N
EtO2C
NH
Ph
N
H
O
3c
13C NMR (CDCl3 + DMSO-d6),
100 MHz
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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3010.53
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1680.12
1645.02
1510.44
1485.04
1423.09
1373.38
1304.09
1219.18
1100.65
1070.06
1018.20
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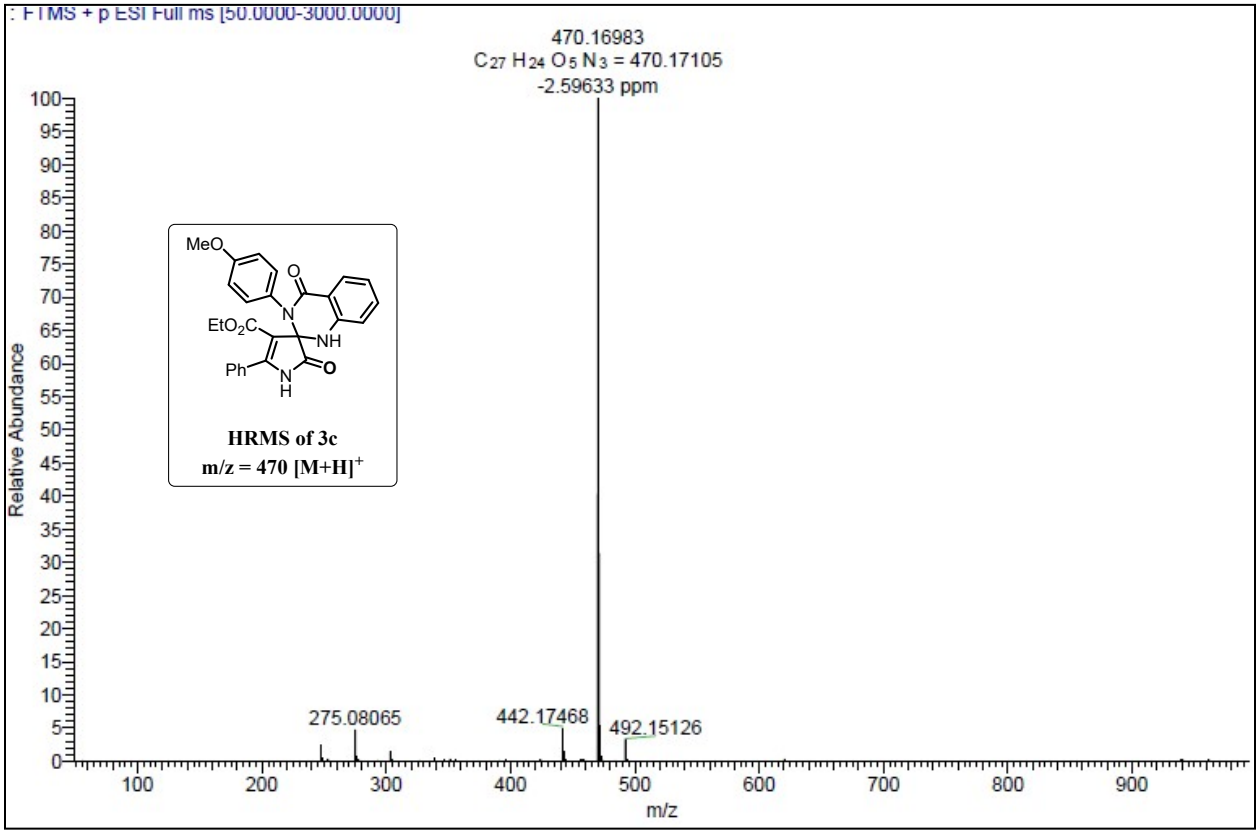
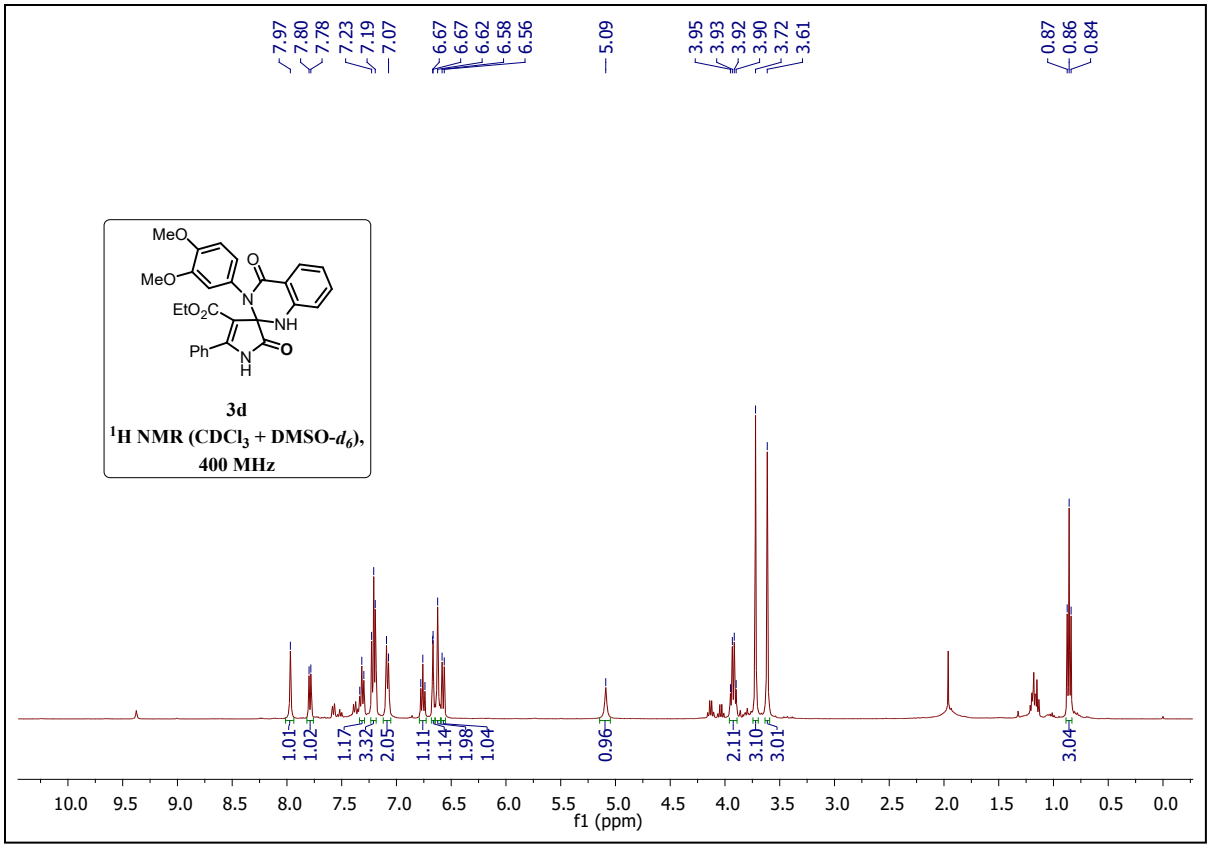
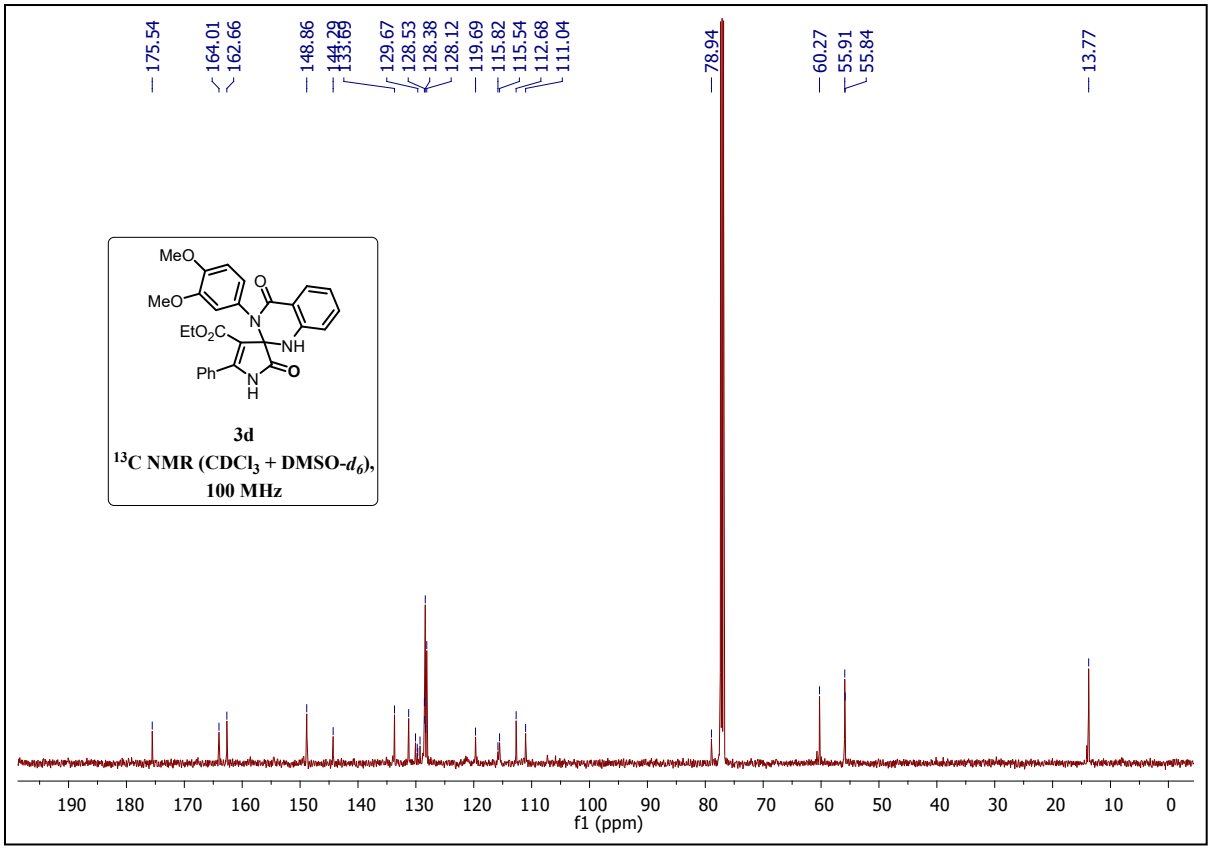
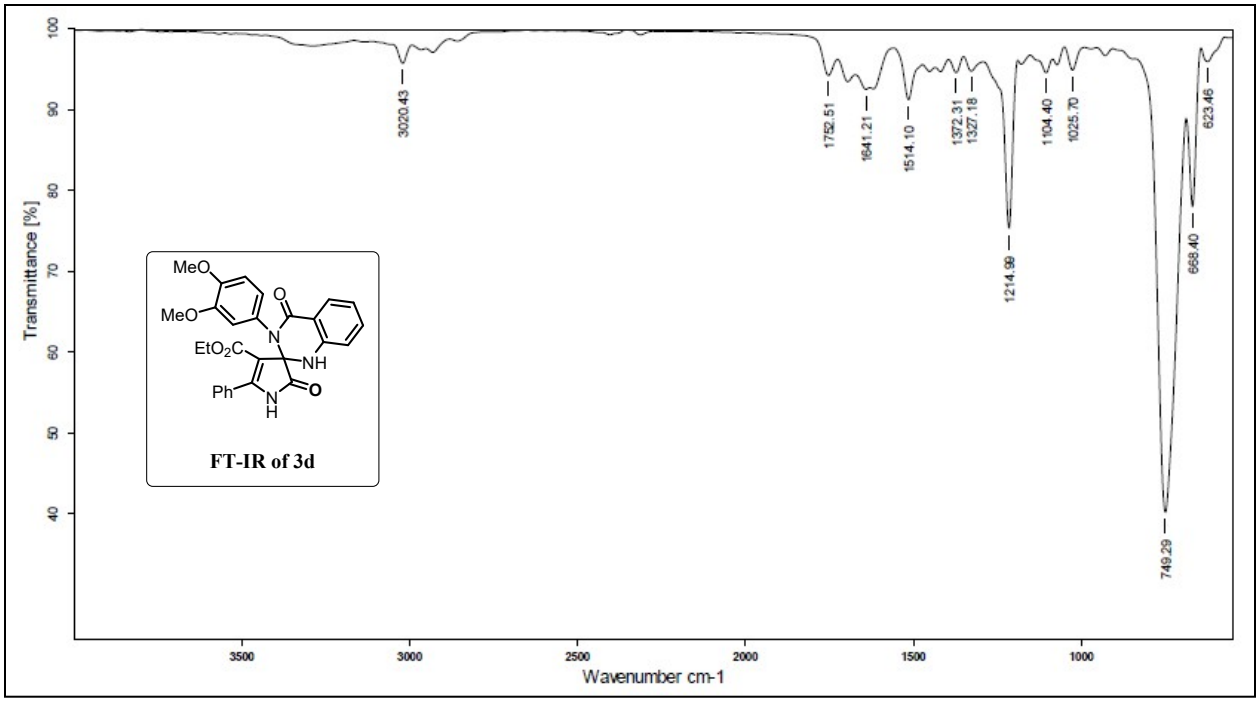
829.91
751.94
664.86
585.28
MeO
EtO2C
Ph
NH
FT-IR of 3c

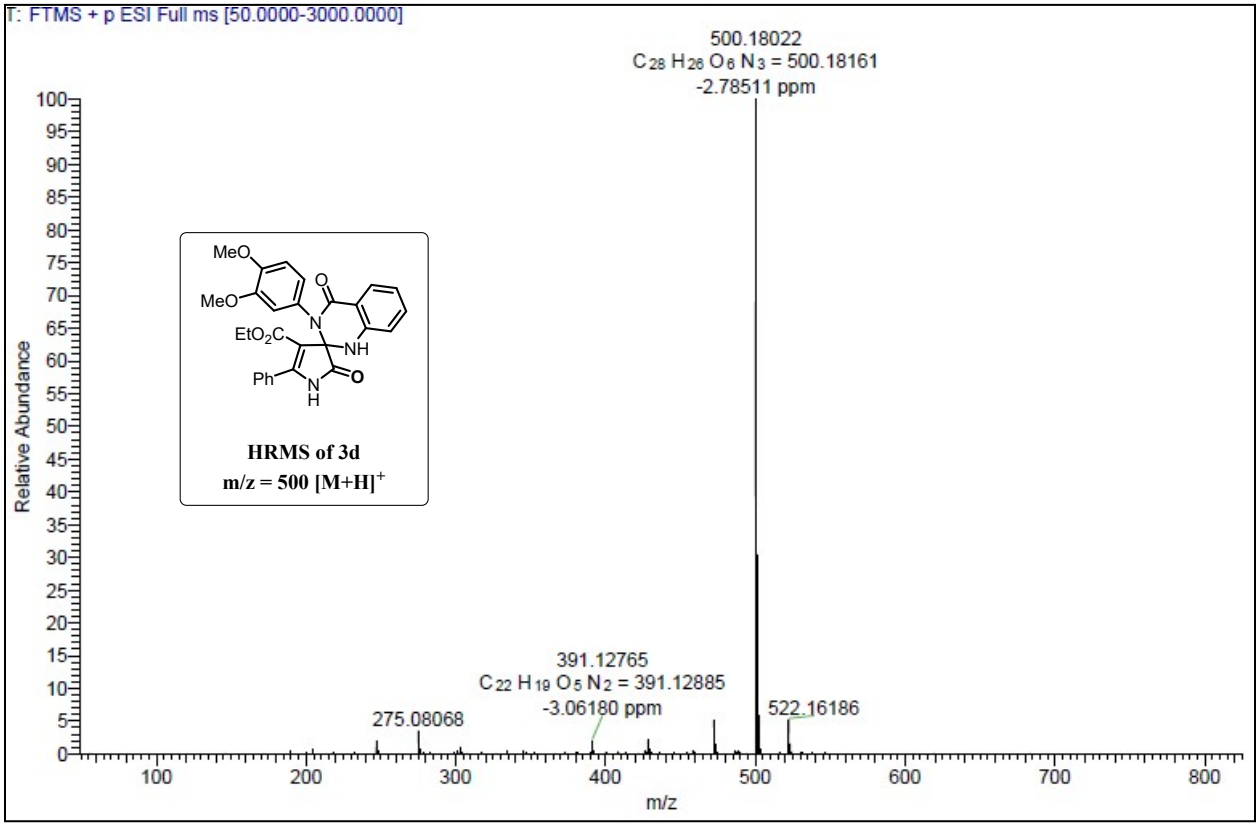

: FTMS + p ESI Full ms [50.0000-3000.0000]
470.16983
C27 H24 O5 N3 = 470.17105
-2.59633 ppm
Relative Abundance
m/z
275.08065
442.17468
492.15126
MeO
EtO2C
Ph
NH
HRMS of 3c
m/z = 470 [M+H]+


7.97
7.80
7.78
7.23
7.19
7.07
6.67
6.67
6.62
6.58
6.56
5.09
3.95
3.93
3.92
3.90
3.72
3.61
0.87
0.86
0.84
MeO
MeO
EtO2C
Ph
O
N
NH
N
H
O
3d
1H NMR (CDCl3 + DMSO-d6),
400 MHz
1.01
1.02
1.17
3.32
2.05
1.11
1.14
1.98
1.04
0.96
2.11
3.10
3.01
3.04
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


175.54
164.01
162.66
148.86
144.29
133.65
129.67
128.53
128.38
128.12
119.69
115.82
115.54
112.68
111.04
78.94
60.27
55.91
55.84
13.77
MeO
MeO
EtO2C
Ph
O
N
NH
N
H
O
3d
13C NMR (CDCl3 + DMSO-d6),
100 MHz
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

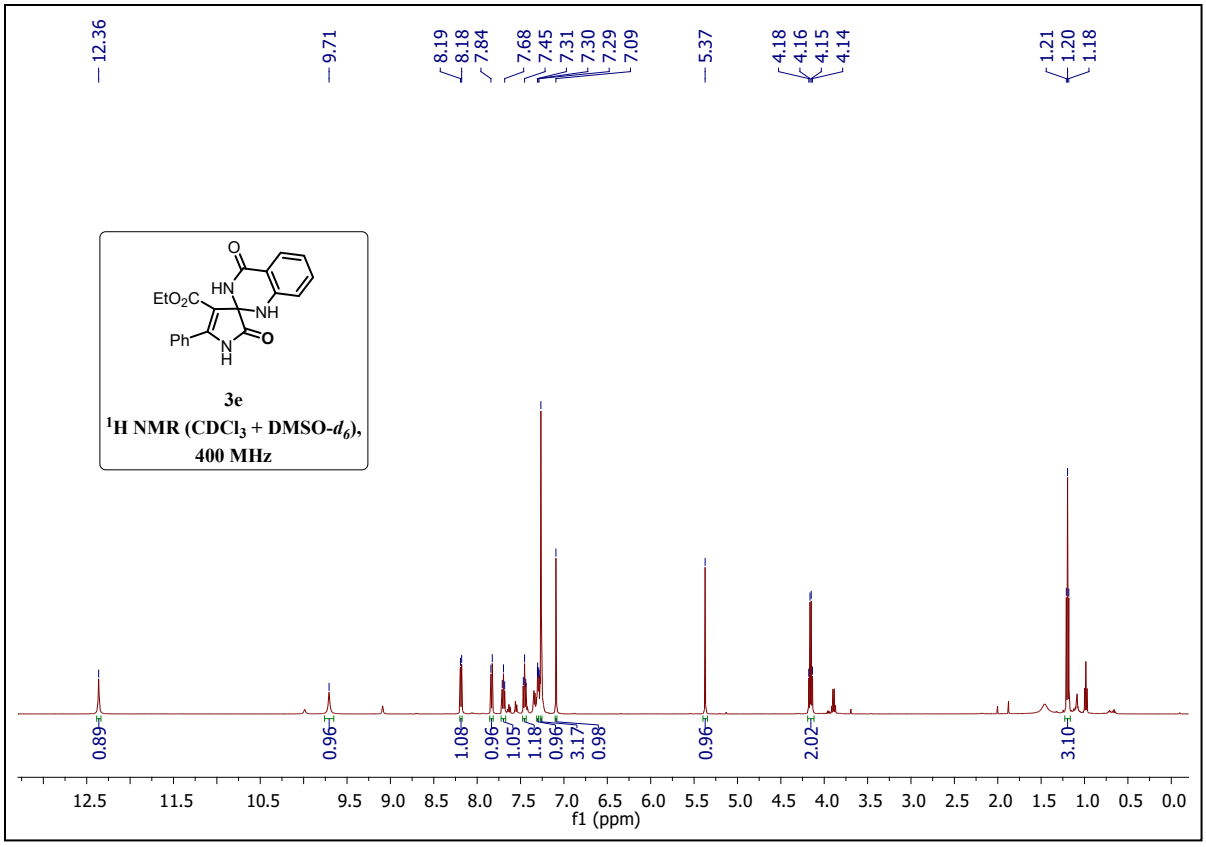


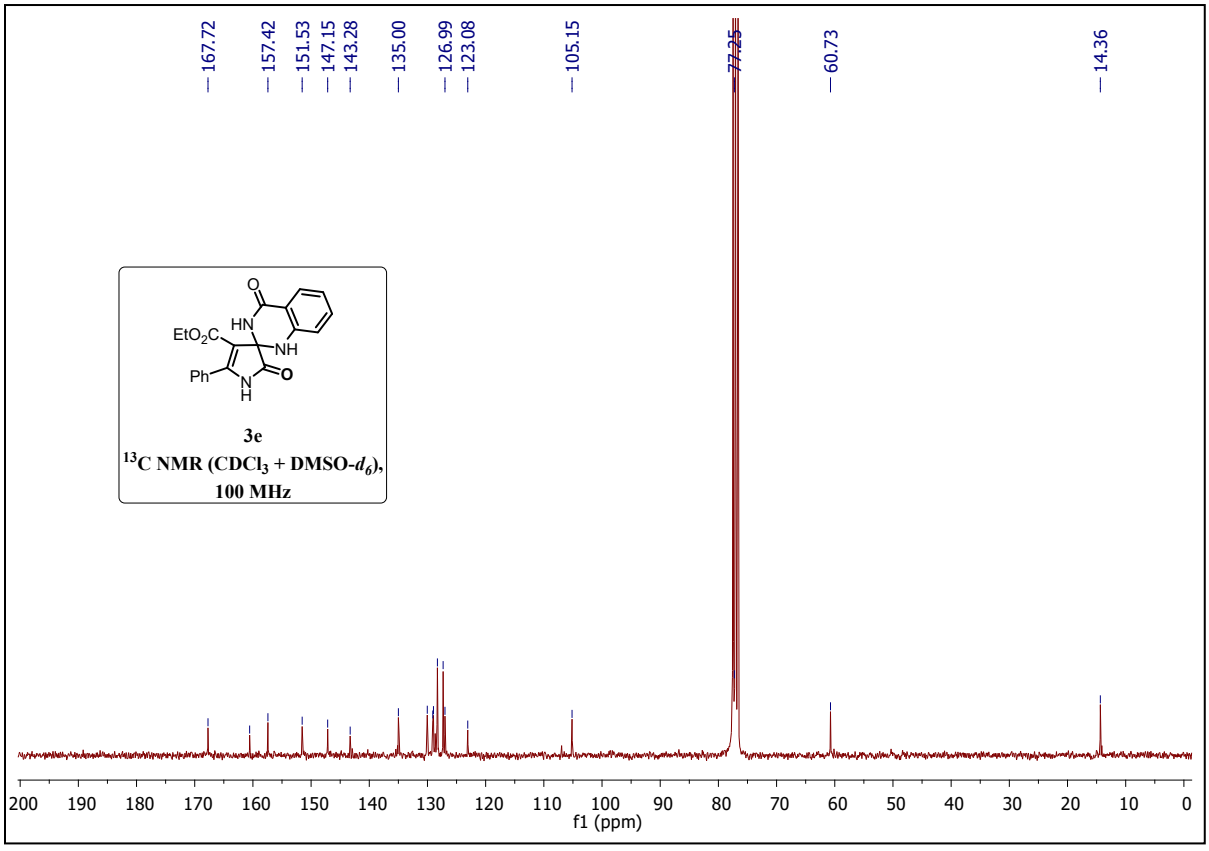
FT-IR of 3d

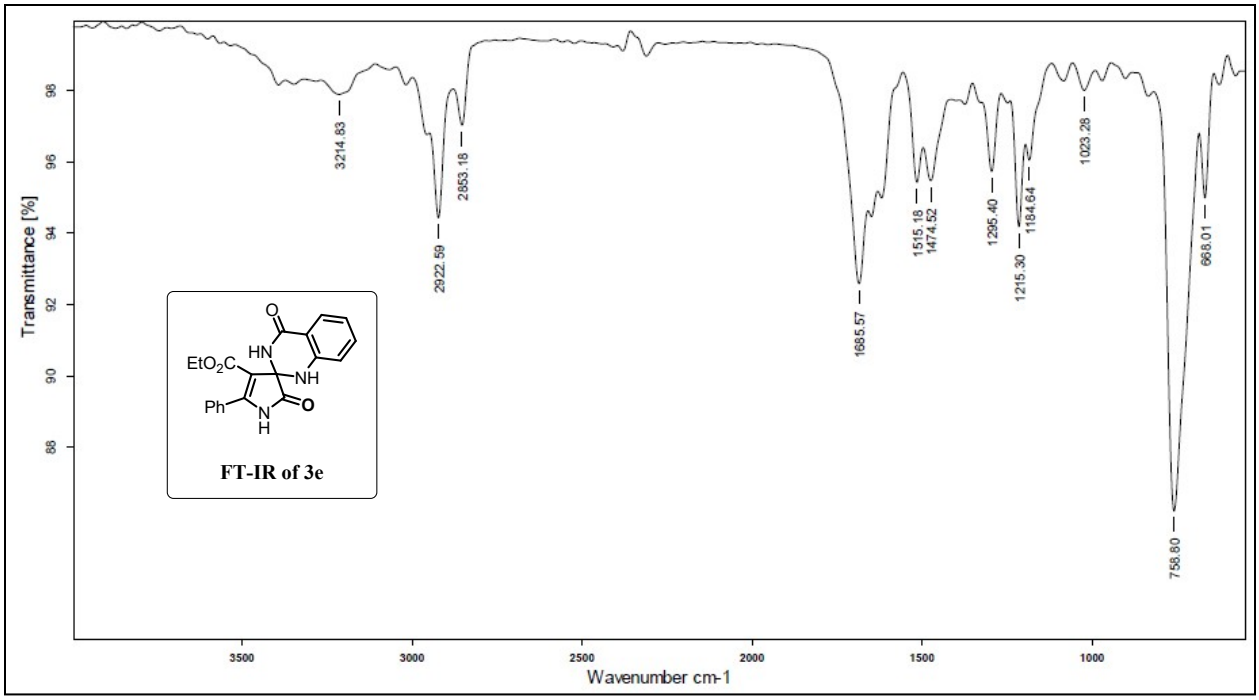


HRMS of 3d

m/z = 500 $[M+H]^+$


12.36
9.71
8.19
8.18
7.84
7.68
7.45
7.31
7.30
7.29
7.09
5.37
4.18
4.16
4.15
4.14
1.21
1.20
1.18
0.89
0.96
1.08
0.96
1.05
1.18
0.96
3.17
0.98
0.96
2.02
3.10
12.5 11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
3e
1H NMR (CDCl3 + DMSO-d6),
400 MHz


167.72
157.42
151.53
147.15
143.28
135.00
126.99
123.08
105.15
77.35
60.73
14.36
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)
3e
13C NMR (CDCl3 + DMSO-d6),
100 MHz


Transmittance [%]
Wavenumber cm-1
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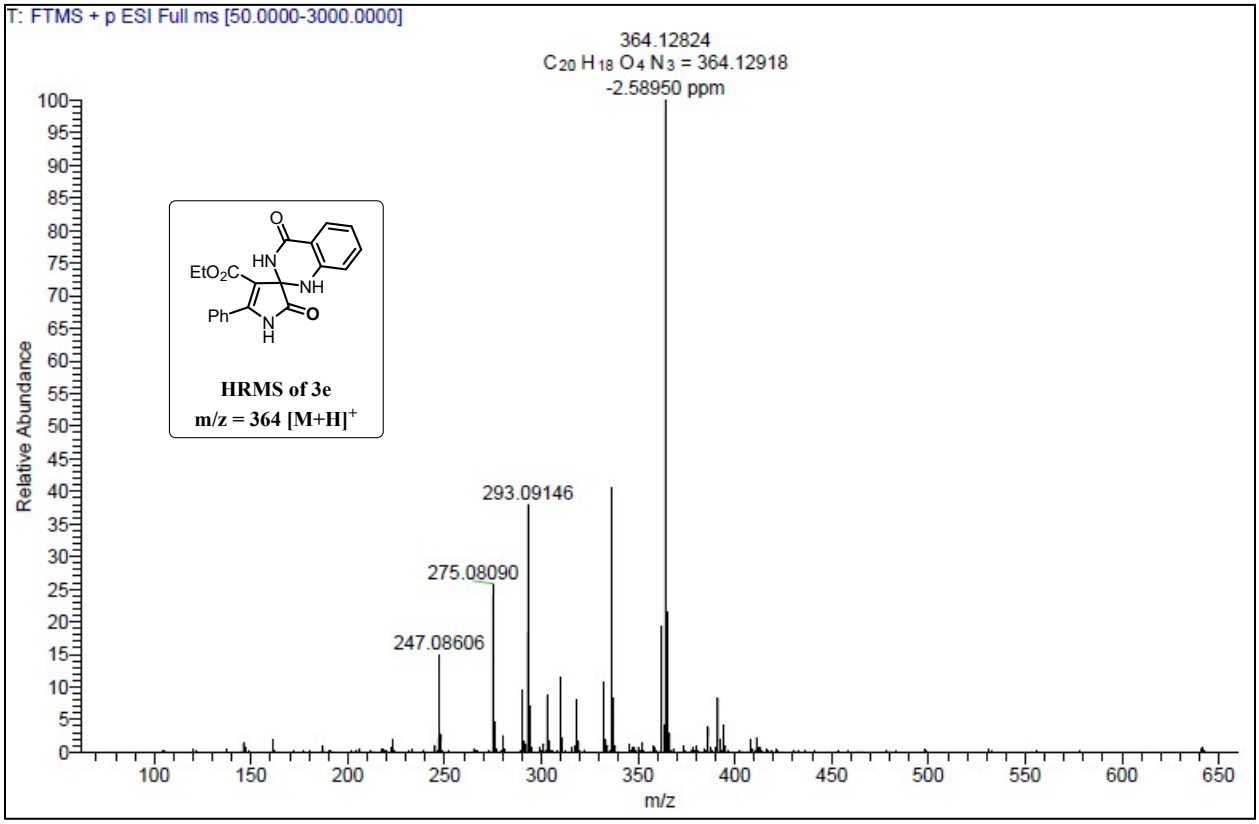
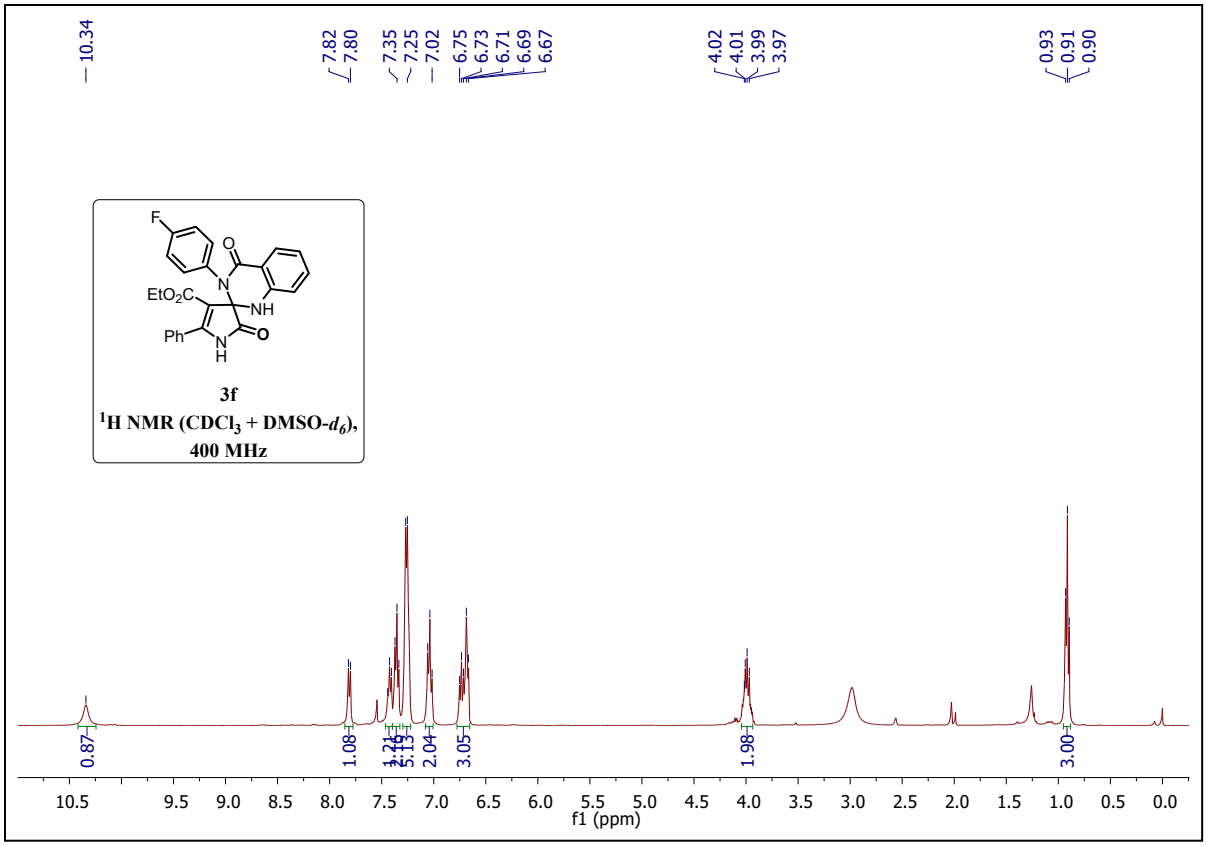
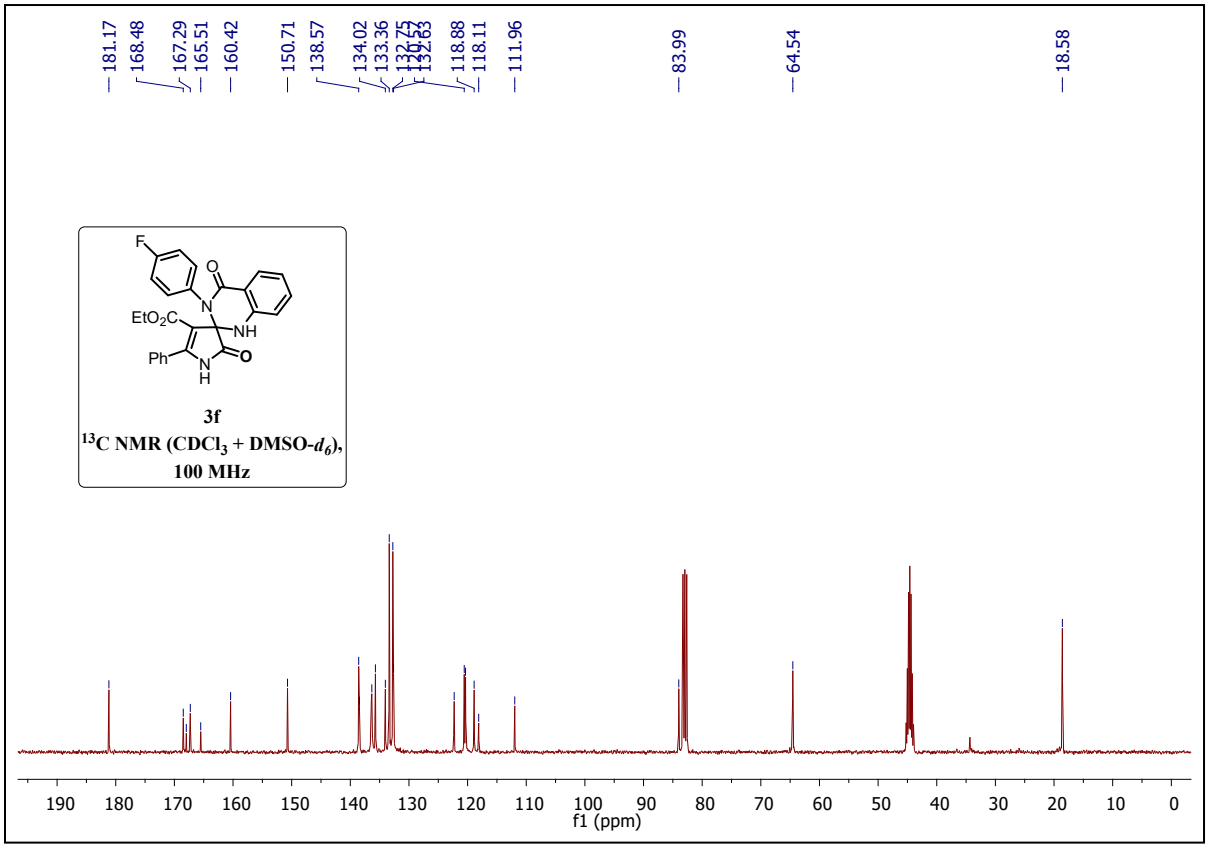
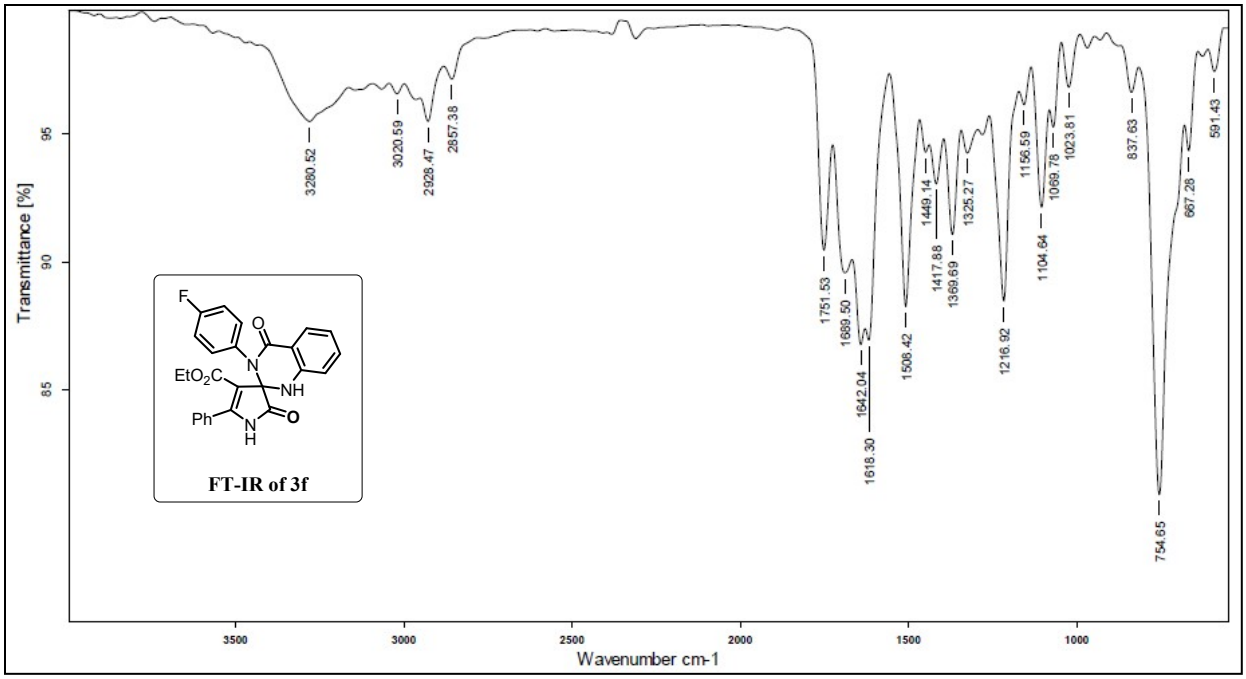
2853.18
1685.57
1515.18
1474.52
1295.40
1215.30
1184.64
1023.28
758.80
668.01
FT-IR of 3e

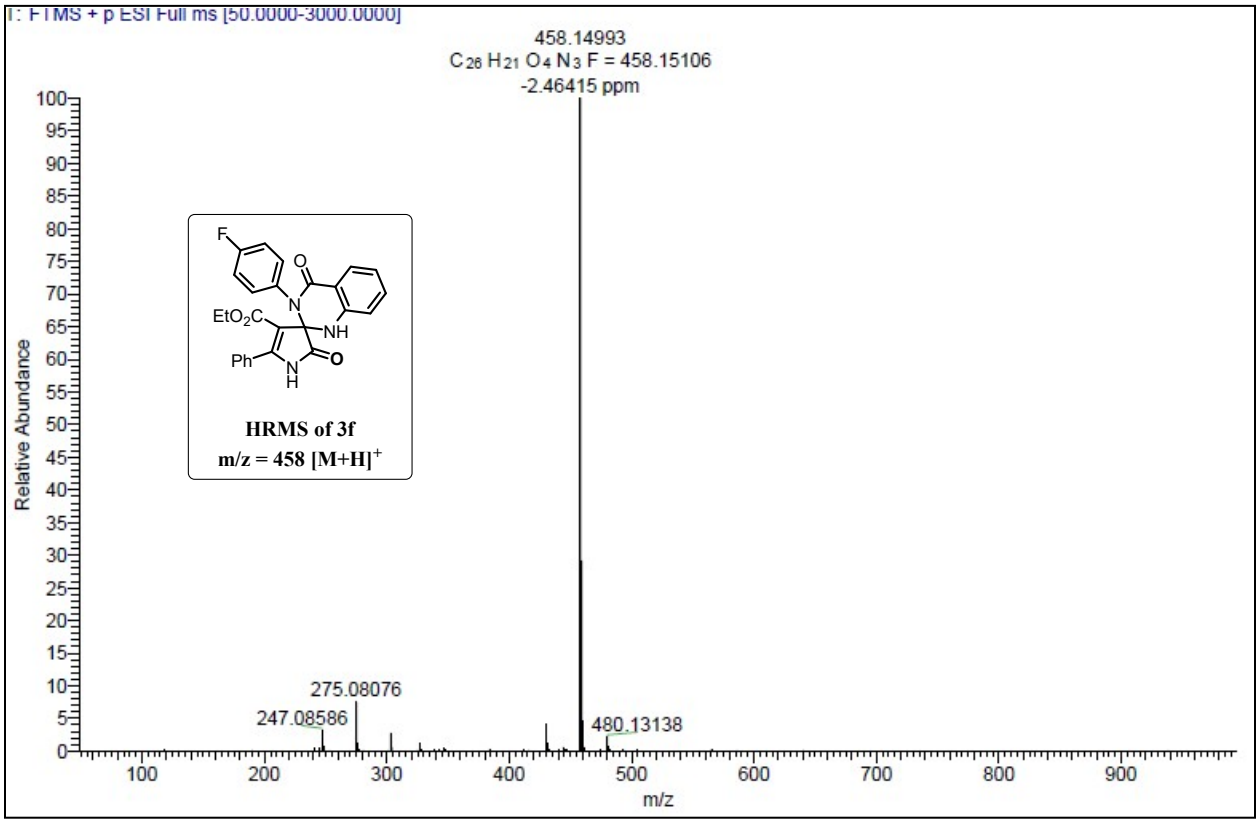

T: FTMS + p ESI Full ms [50.0000-3000.0000]
364.12824
C20 H18 O4 N3 = 364.12918
-2.58950 ppm
293.09146
275.08090
247.08606
Relative Abundance
m/z
HRMS of 3e
m/z = 364 [M+H]+


10.34
7.82
7.80
7.35
7.25
7.02
6.75
6.73
6.71
6.69
6.67
4.02
4.01
3.99
3.97
0.93
0.91
0.90
F
O
N
EtO2C
NH
Ph
N
H
O
3f
1H NMR (CDCl3 + DMSO-d6),
400 MHz
0.87
1.08
1.21
1.16
5.13
2.04
3.05
1.98
3.00
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

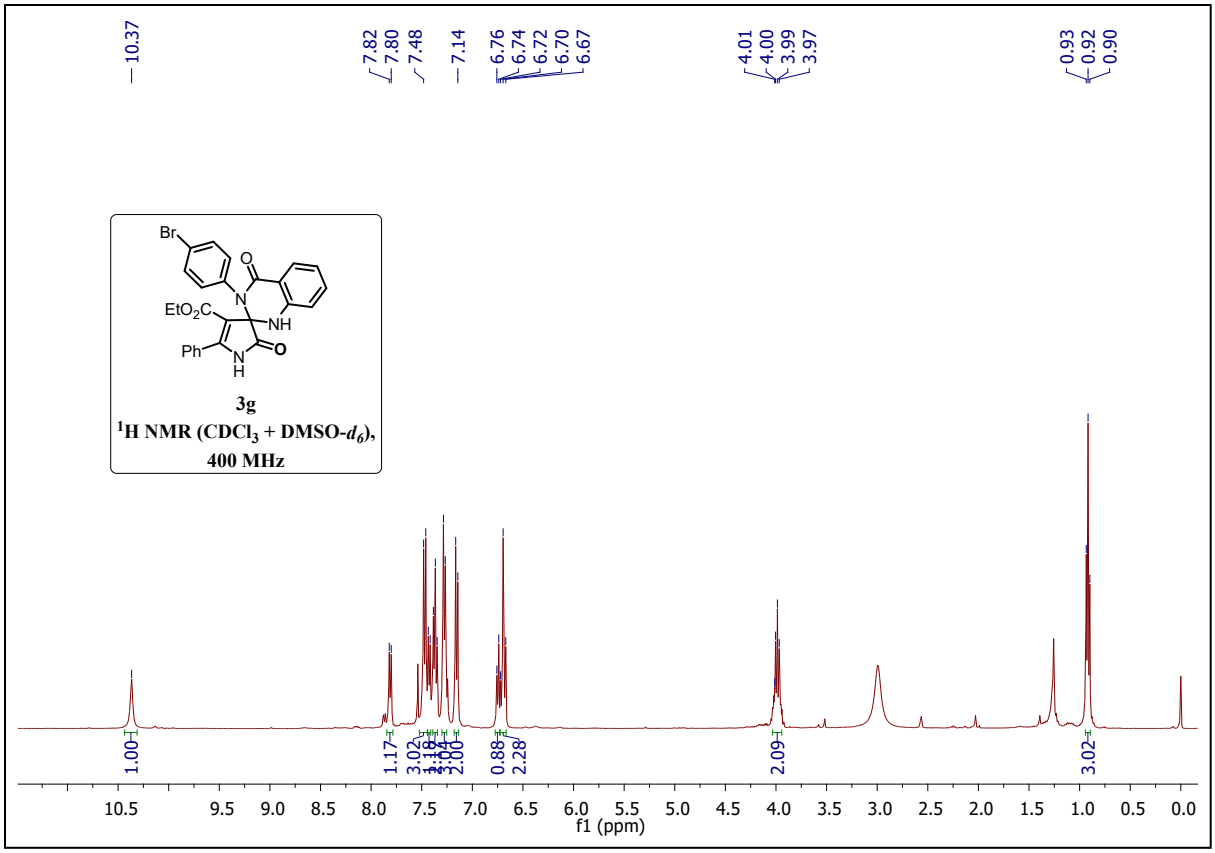

181.17
168.48
167.29
165.51
160.42
150.71
138.57
134.02
133.36
132.75
132.57
132.63
118.88
118.11
111.96
83.99
64.54
18.58
F
O
N
EtO2C
NH
Ph
N
H
O
3f
13C NMR (CDCl3 + DMSO-d6),
100 MHz
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

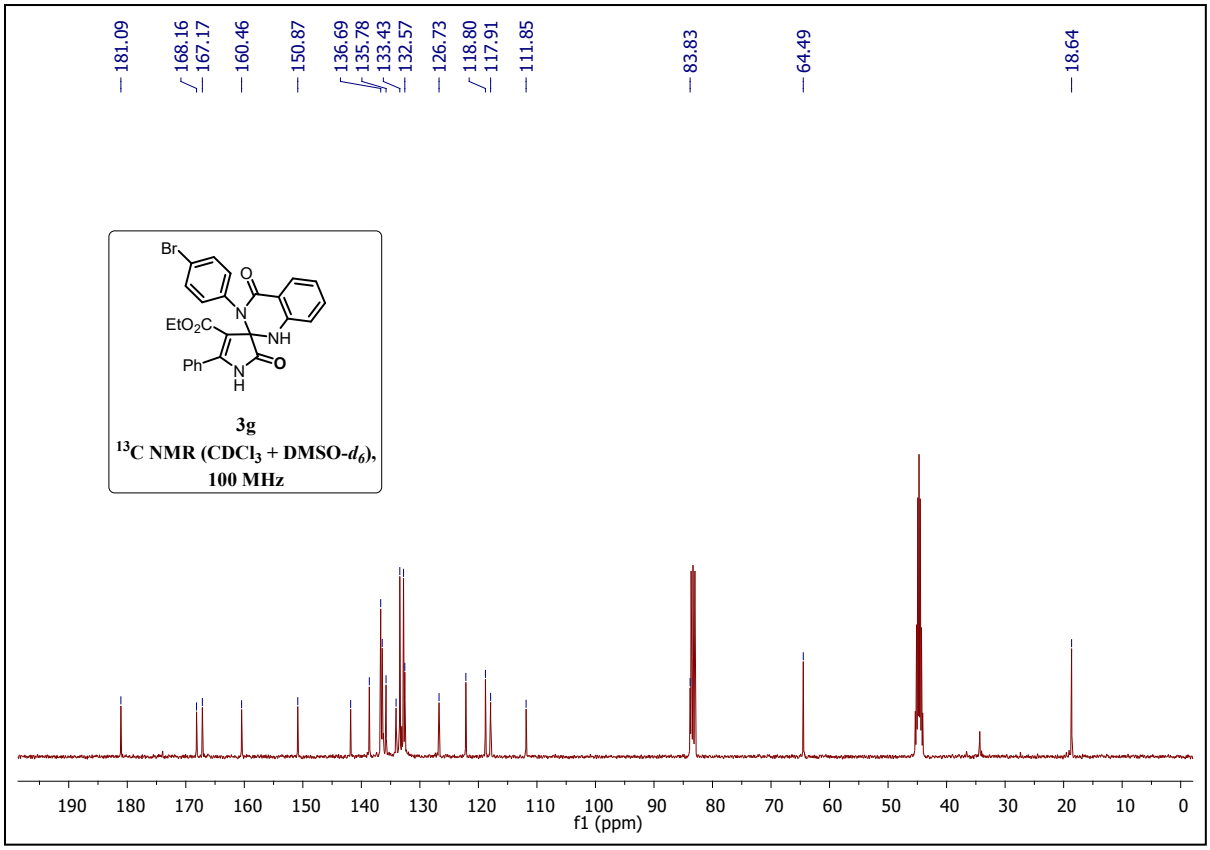


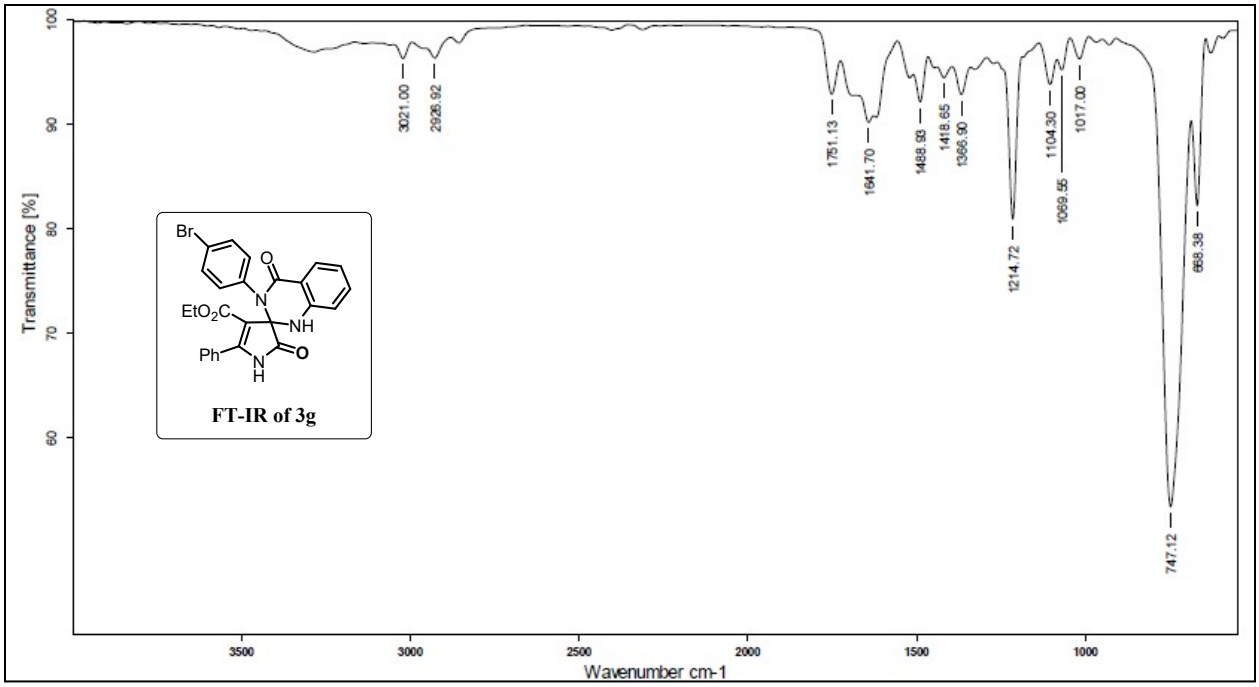
FT-IR of 3f

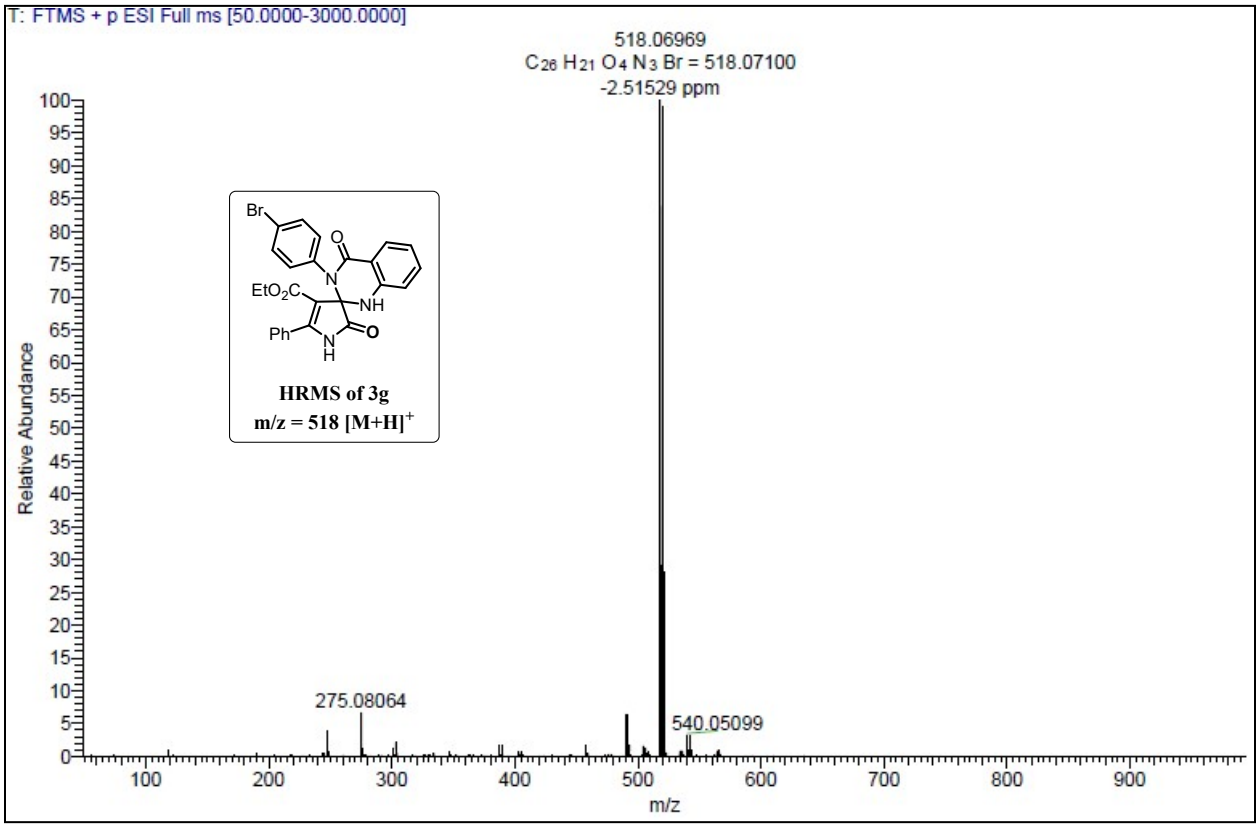


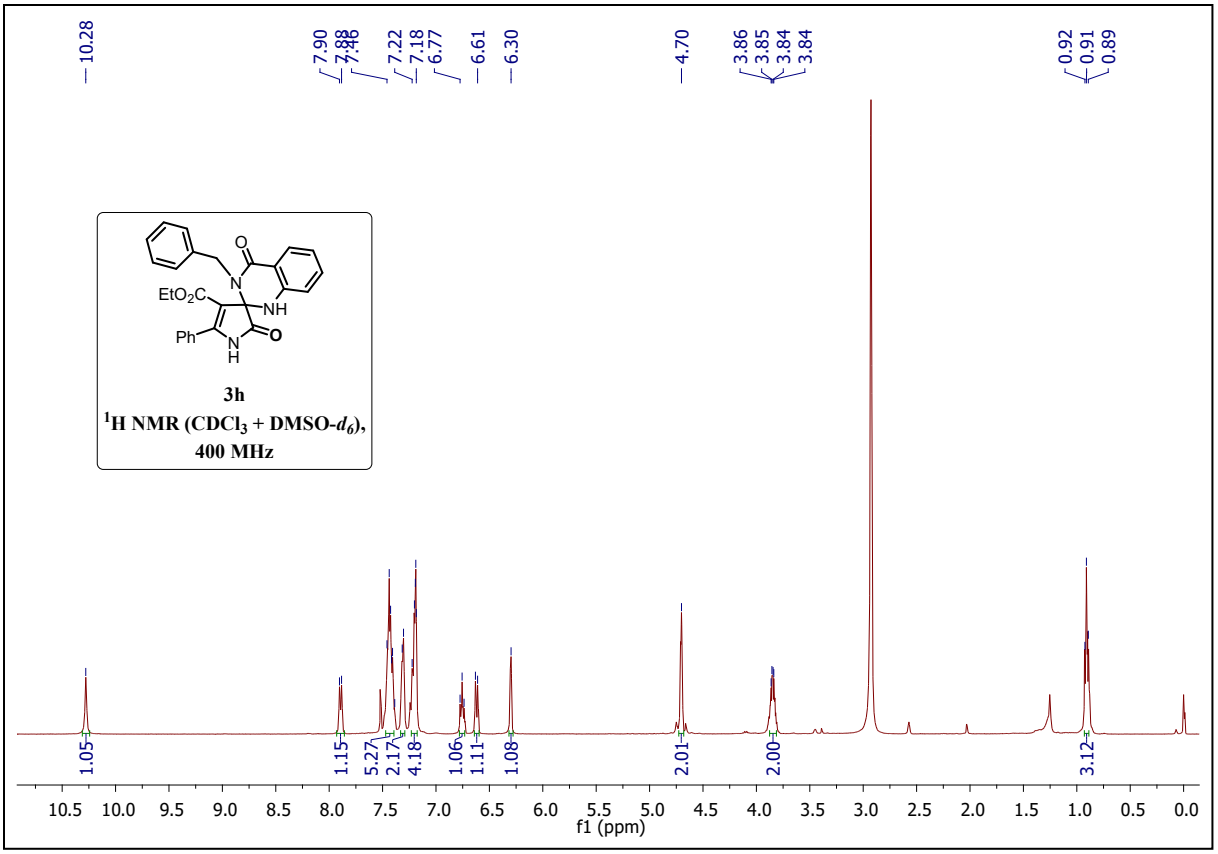
HRMS of 3f
m/z = 458 $[M+H]^+$

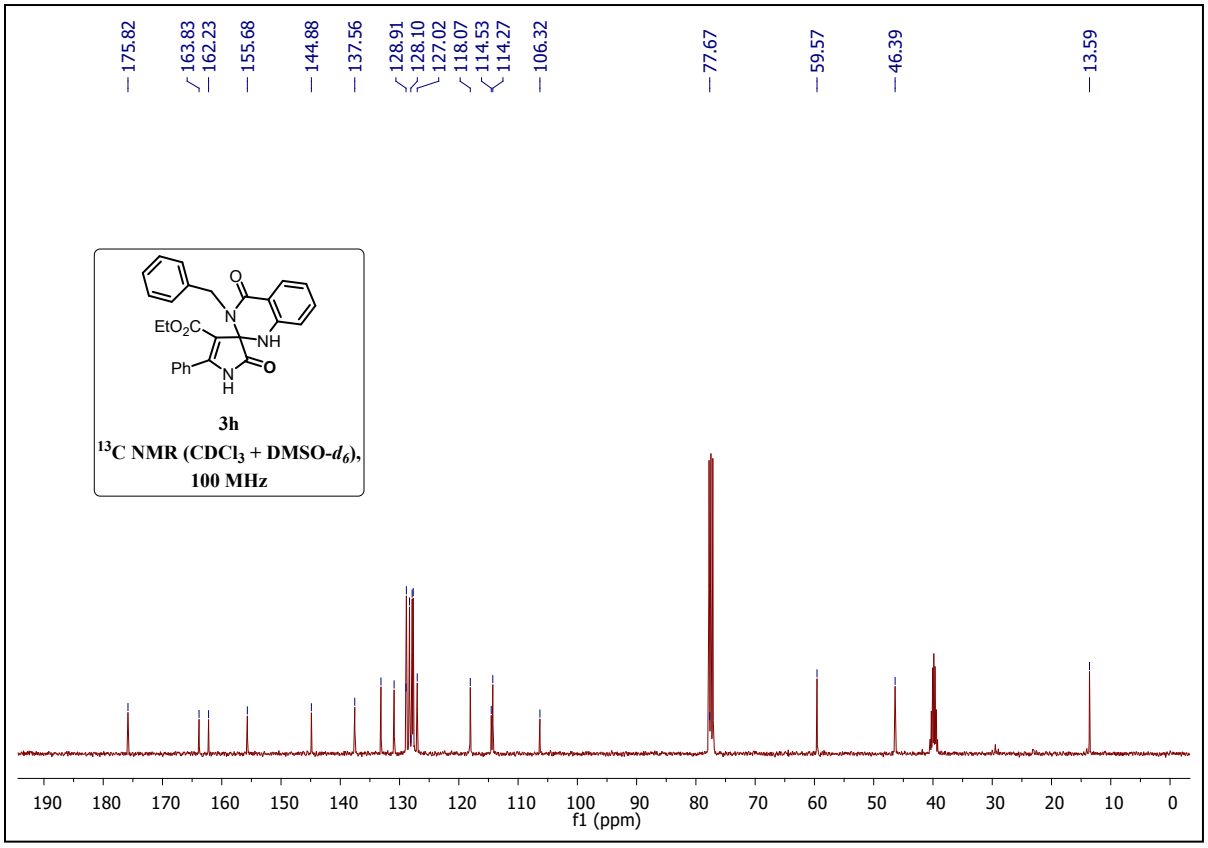

10.37
7.82
7.80
7.48
7.14
6.76
6.74
6.72
6.70
6.67
4.01
4.00
3.99
3.97
0.93
0.92
0.90
Br
O
N
EtO2C
NH
Ph
N
H
O
3g
1H NMR (CDCl3 + DMSO-d6),
400 MHz
1.00
1.17
3.02
3.10
3.04
2.00
0.88
2.28
2.09
3.02
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

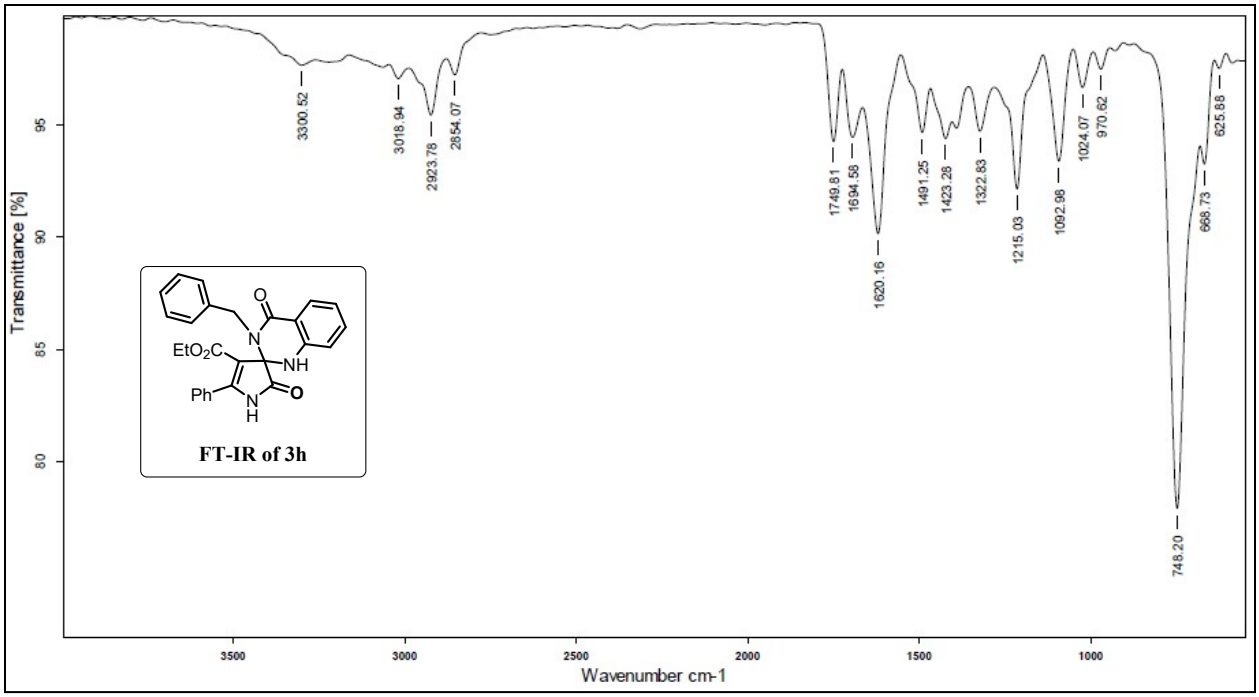

181.09
168.16
167.17
160.46
150.87
136.69
135.78
133.43
132.57
126.73
118.80
117.91
111.85
83.83
64.49
18.64
Br
O
N
EtO2C
NH
Ph
N
H
O
3g
13C NMR (CDCl3 + DMSO-d6),
100 MHz
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


Transmittance [%]
Wavenumber cm-1
3021.00
2926.92
1751.13
1641.70
1488.93
1418.65
1366.90
1214.72
1104.30
1069.55
1017.00
868.38
747.12
FT-IR of 3g

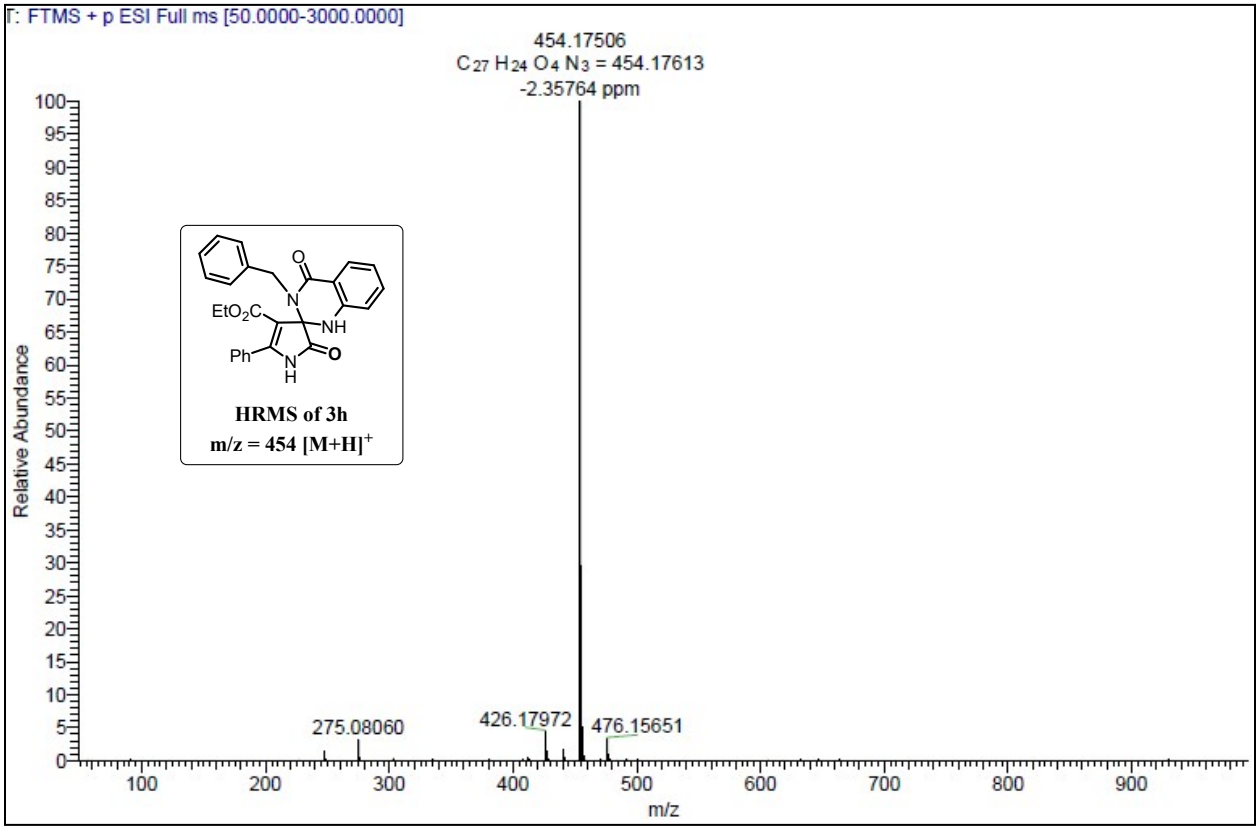

T: FTMS + p ESI Full ms [50.0000-3000.0000]
518.06969
C26 H21 O4 N3 Br = 518.07100
-2.51529 ppm
Relative Abundance
m/z
275.08064
540.05099
HRMS of 3g
m/z = 518 [M+H]+


10.28
7.90
7.88
7.46
7.22
7.18
6.77
6.61
6.30
4.70
3.86
3.85
3.84
3.84
0.92
0.91
0.89
1.05
1.15
5.27
2.17
4.18
1.06
1.11
1.08
2.01
2.00
3.12
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
EtO2C
Ph
NH
O
N
H
3h
1H NMR (CDCl3 + DMSO-d6),
400 MHz

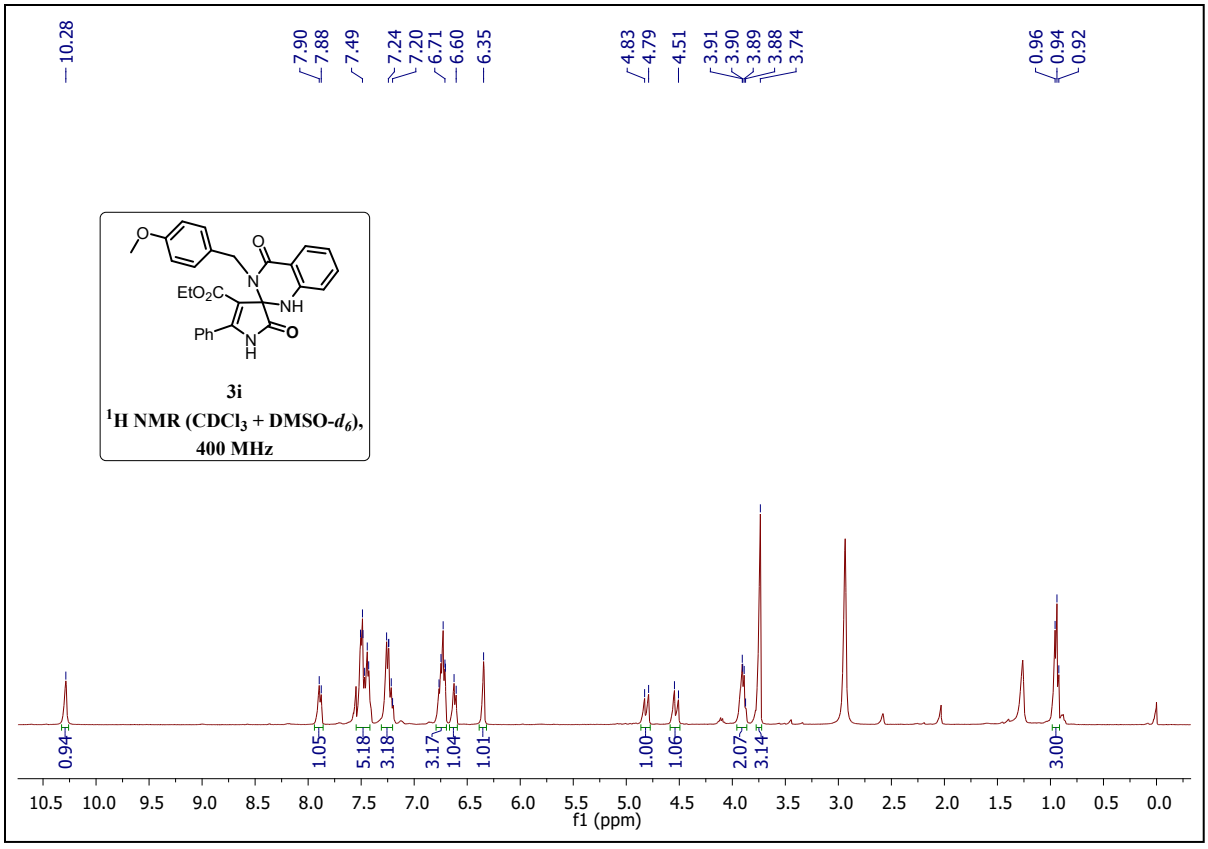

175.82
163.83
162.23
155.68
144.88
137.56
128.91
128.10
127.02
118.07
114.53
114.27
106.32
77.67
59.57
46.39
13.59
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)
EtO2C
Ph
NH
O
N
H
3h
13C NMR (CDCl3 + DMSO-d6),
100 MHz

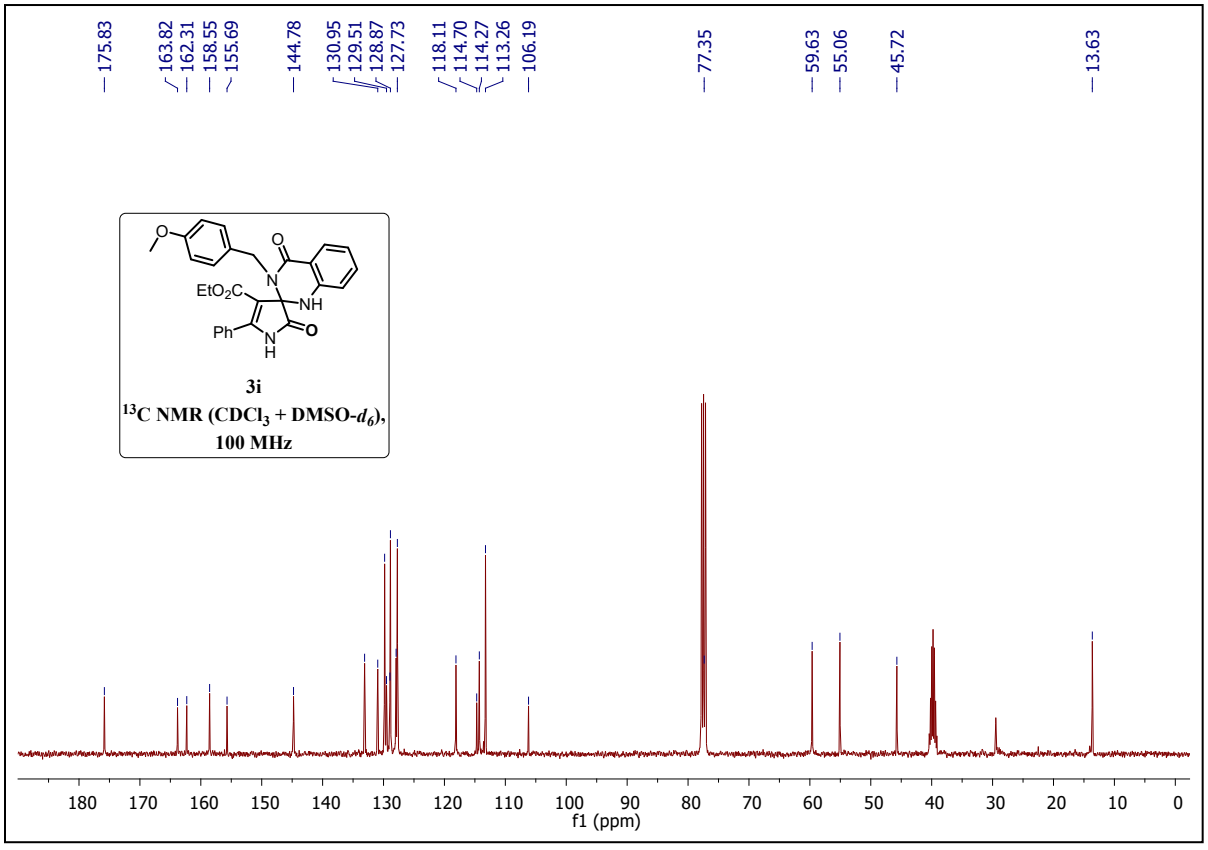


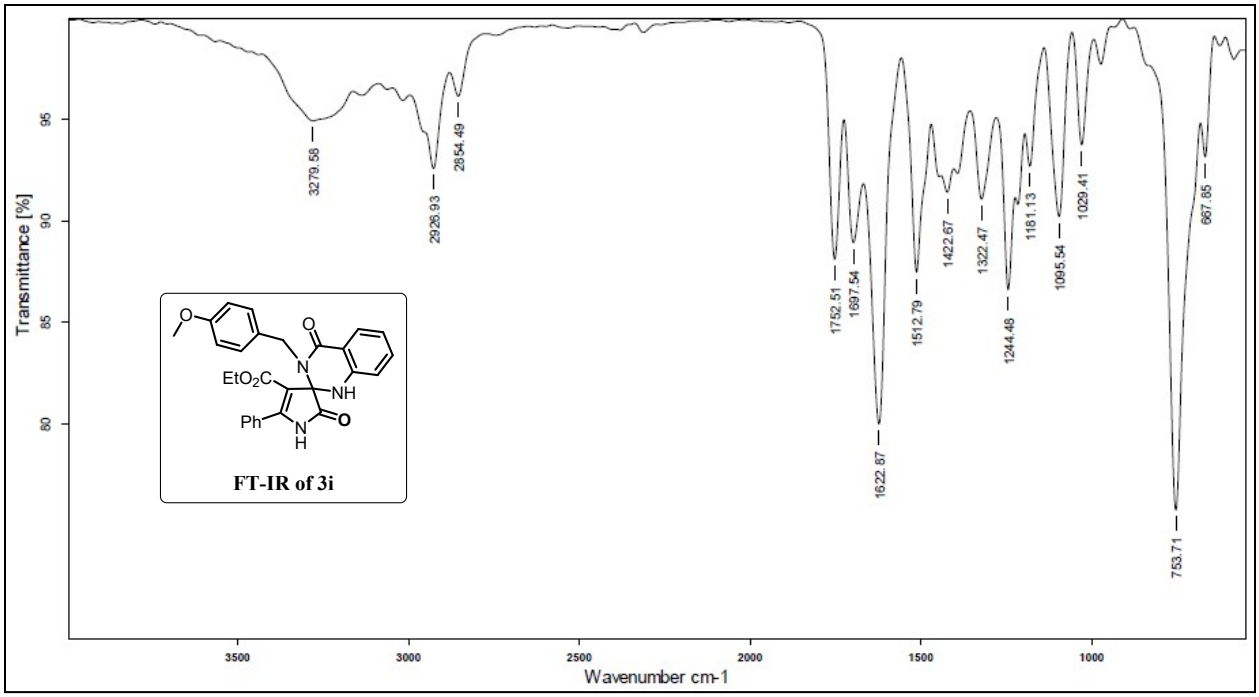
FT-IR of 3h

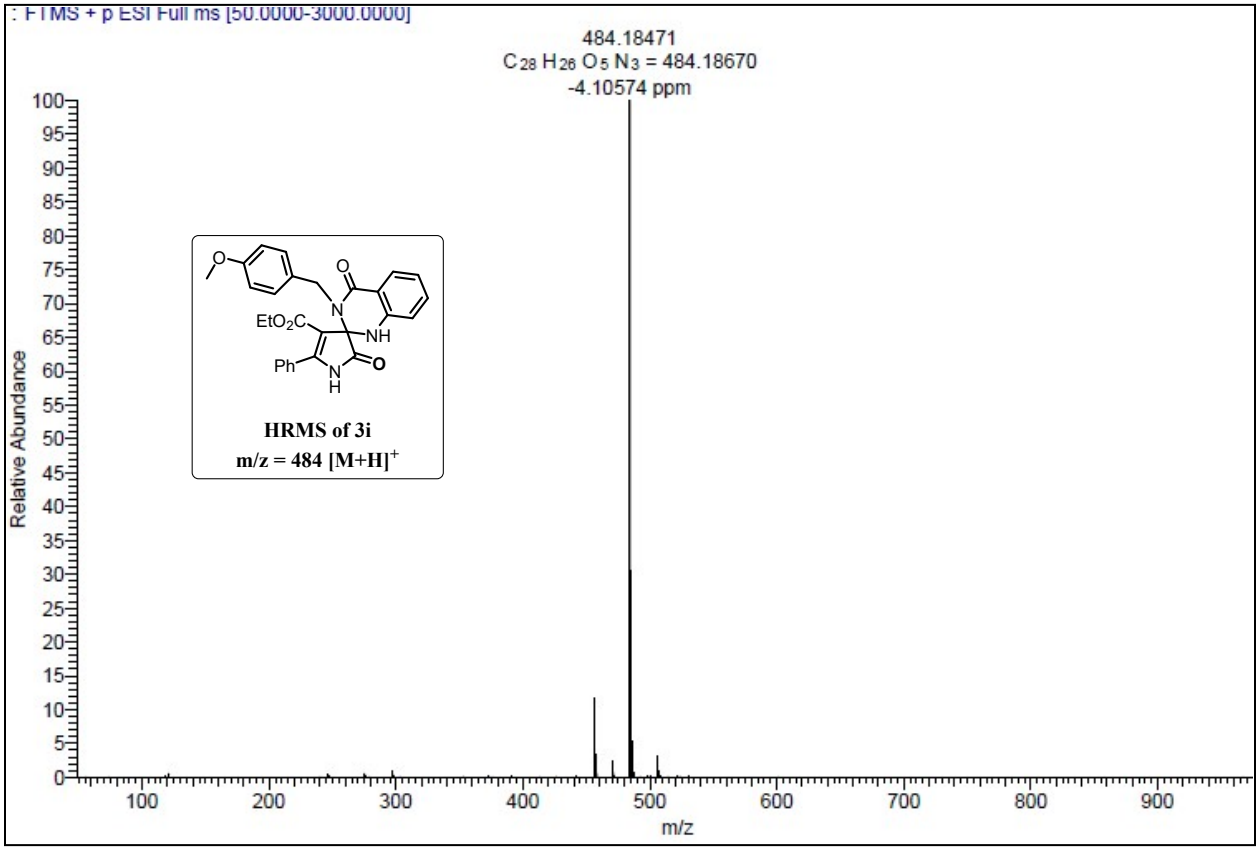


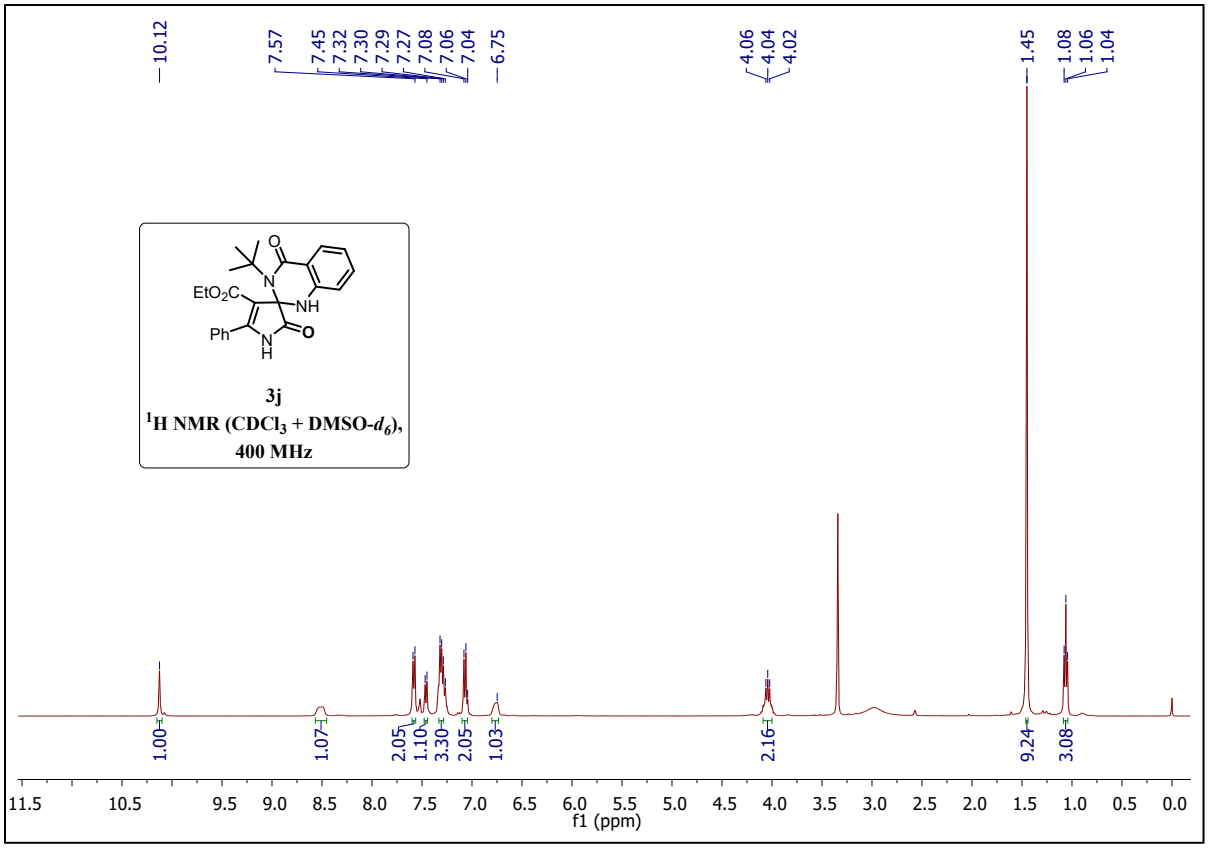
HRMS of 3h
m/z = 454 $[M+H]^+$

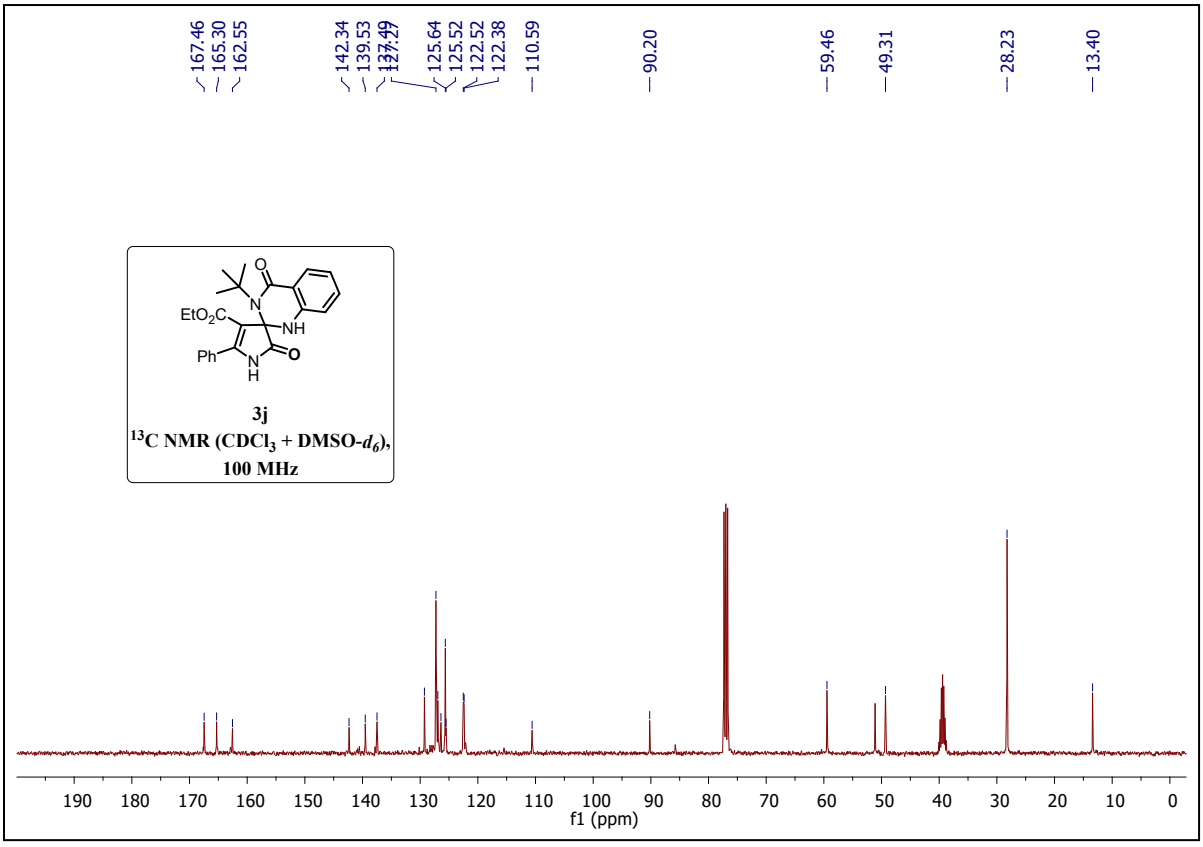

10.28
7.90
7.88
7.49
7.24
7.20
6.71
6.60
6.35
4.83
4.79
4.51
3.91
3.90
3.89
3.88
3.74
0.96
0.94
0.92
EtO2C
NH
Ph
N
H
O
3i
1H NMR (CDCl3 + DMSO-d6),
400 MHz
0.94
1.05
5.18
3.18
3.17
1.04
1.01
1.00
1.06
2.07
3.14
3.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

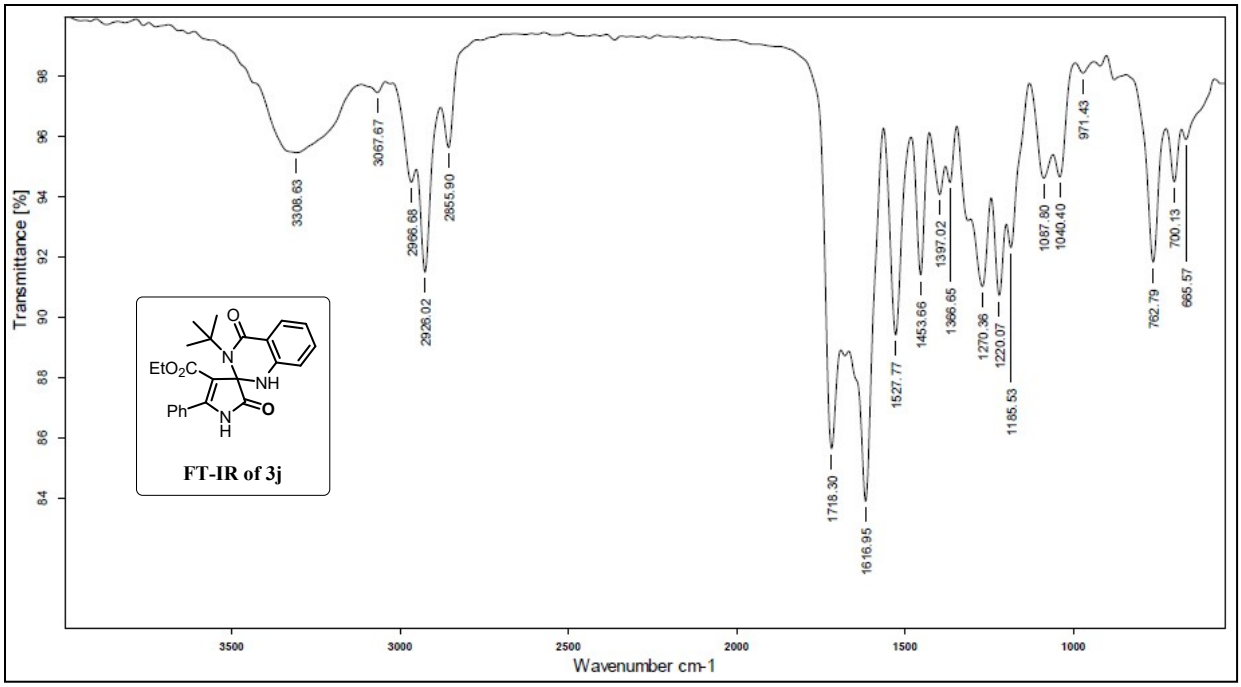

175.83
163.82
162.31
158.55
155.69
144.78
130.95
129.51
128.87
127.73
118.11
114.70
114.27
113.26
106.19
77.35
59.63
55.06
45.72
13.63
EtO2C
NH
Ph
N
H
O
3i
13C NMR (CDCl3 + DMSO-d6),
100 MHz
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


Transmittance [%]
Wavenumber cm-1
3279.58
2926.93
2854.49
1752.51
1697.54
1622.87
1512.79
1422.67
1322.47
1244.48
1181.13
1095.54
1029.41
753.71
667.85
FT-IR of 3i

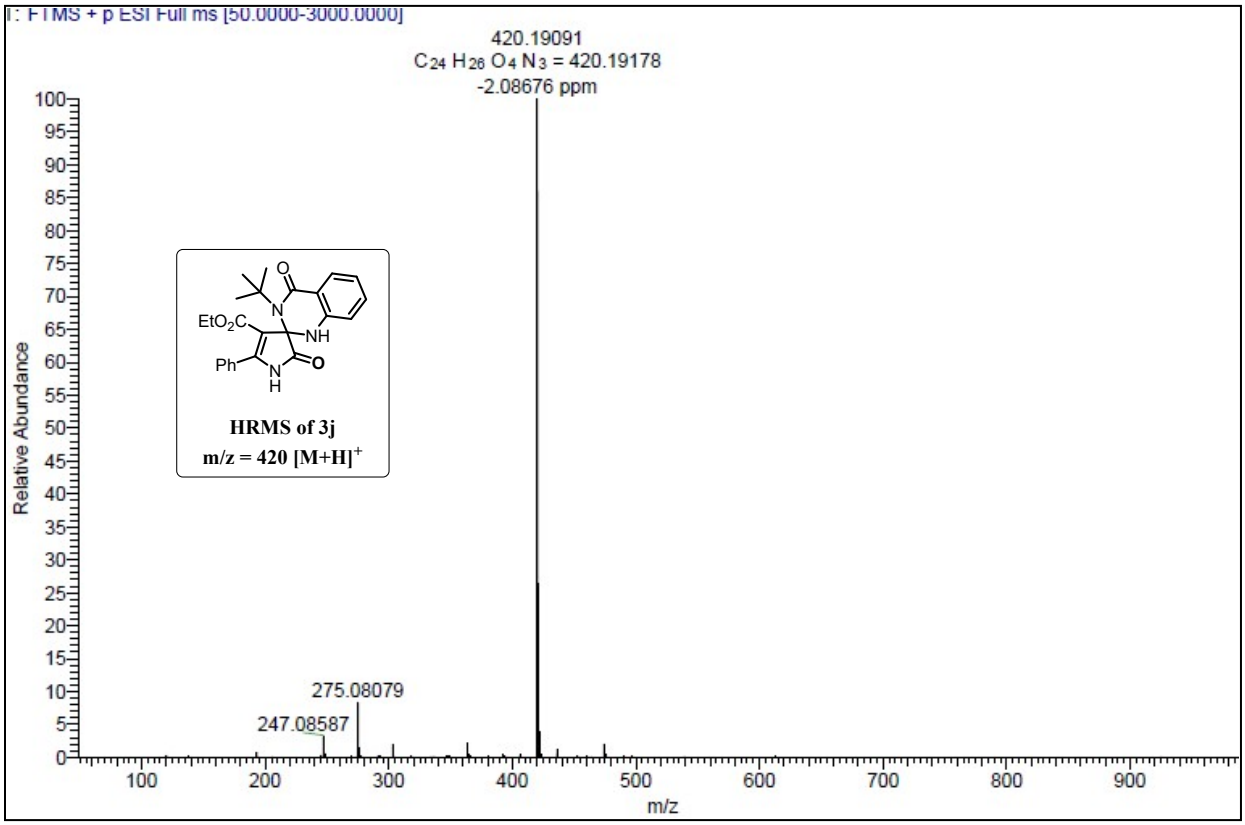

484.18471
C28 H26 O5 N3 = 484.18670
-4.10574 ppm
Relative Abundance
m/z
HRMS of 3i
m/z = 484 [M+H]+


10.12
7.57
7.45
7.32
7.30
7.29
7.27
7.08
7.06
7.04
6.75
4.06
4.04
4.02
1.45
1.08
1.06
1.04
1.00
1.07
2.05
1.10
3.30
2.05
1.03
2.16
9.24
3.08
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
EtO2C
Ph
NH
O
N
H
3j
1H NMR (CDCl3 + DMSO-d6),
400 MHz


167.46
165.30
162.55
142.34
139.53
137.49
137.27
125.64
125.52
122.52
122.38
110.59
90.20
59.46
49.31
28.23
13.40
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)
EtO2C
Ph
NH
O
N
H
3j
13C NMR (CDCl3 + DMSO-d6),
100 MHz

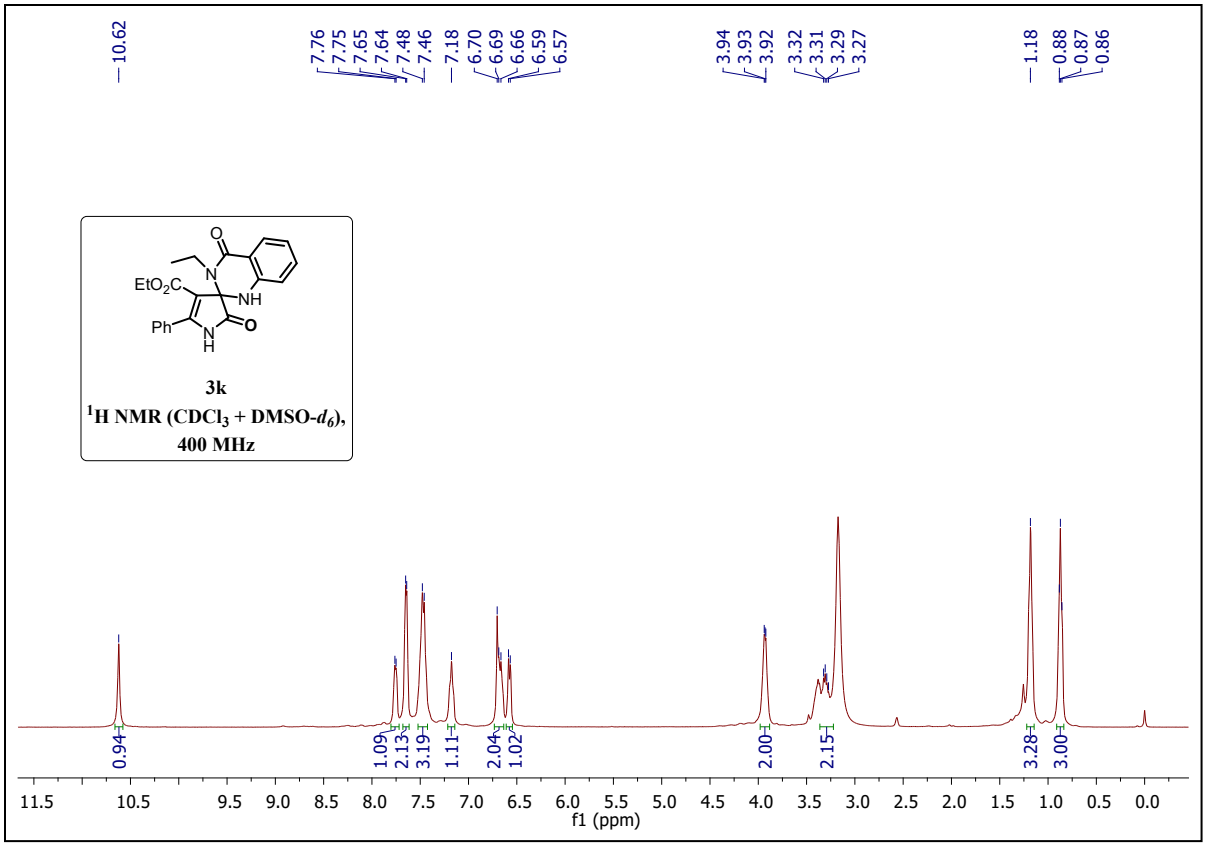


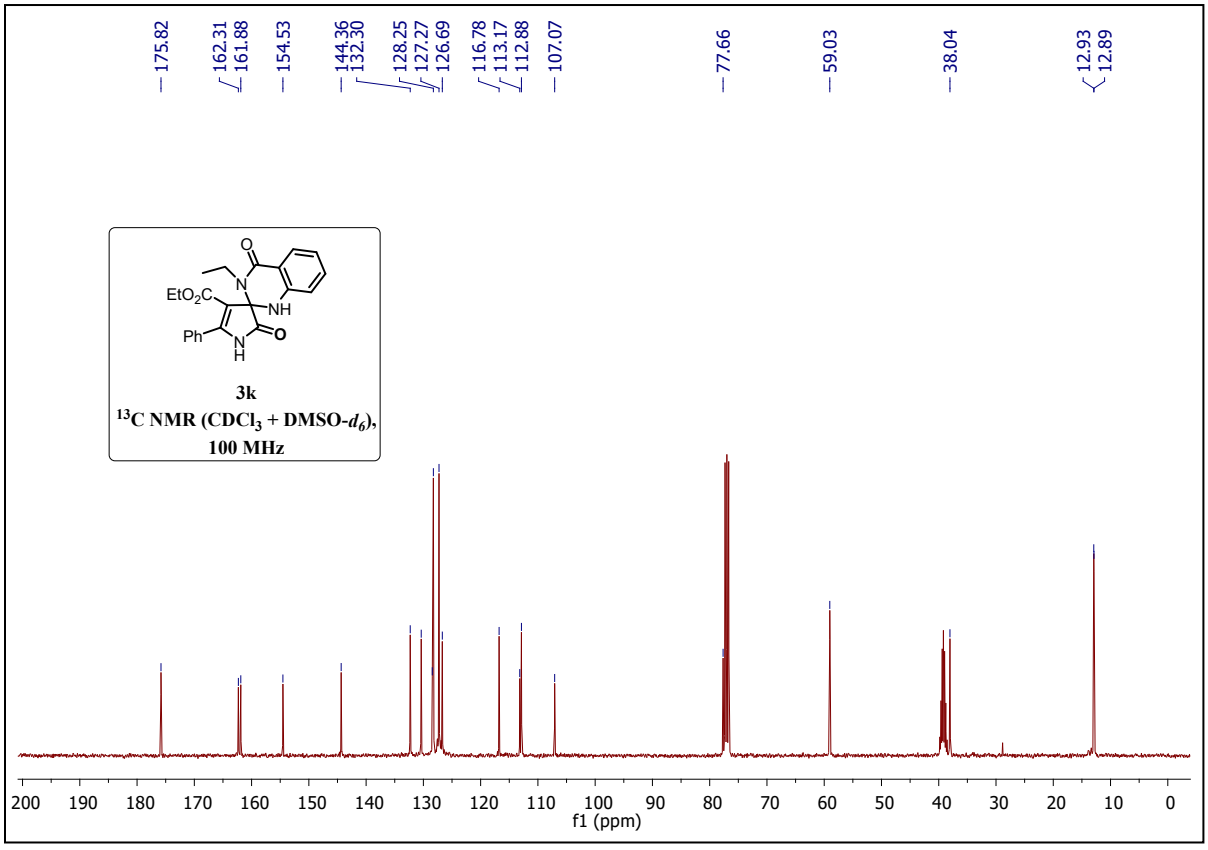
FT-IR of 3j

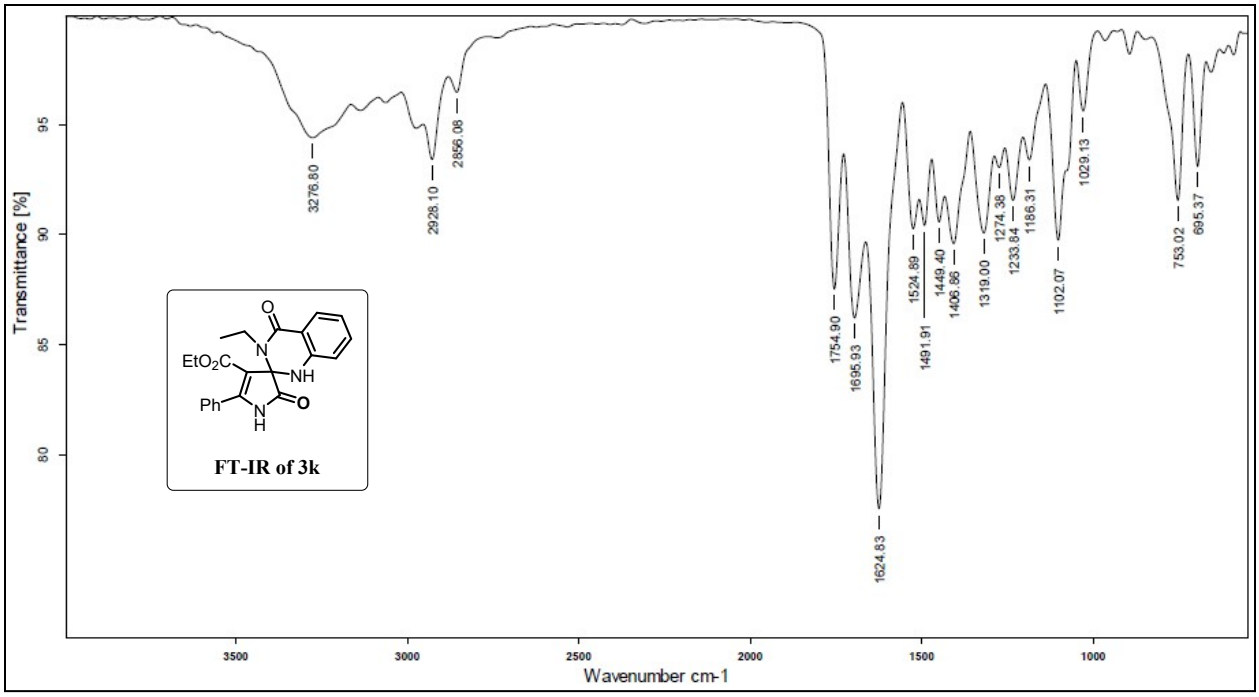


HRMS of 3j

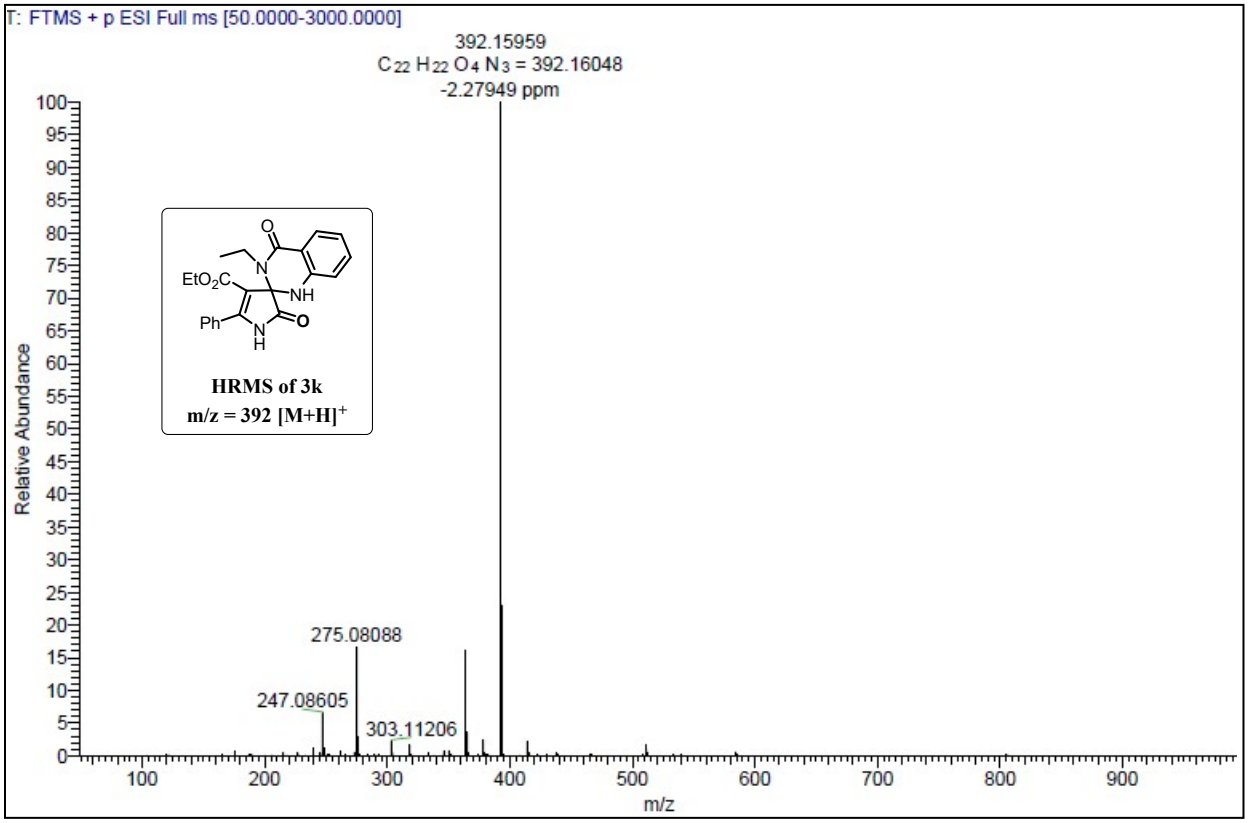
m/z = 420 $[M+H]^+$


10.62
7.76
7.75
7.65
7.64
7.48
7.46
7.18
6.70
6.69
6.66
6.59
6.57
3.94
3.93
3.92
3.32
3.31
3.29
3.27
1.18
0.88
0.87
0.86
EtO2C
NH
Ph
N
H
O
3k
1H NMR (CDCl3 + DMSO-d6),
400 MHz
0.94
1.09
2.13
3.19
1.11
2.04
1.02
2.00
2.15
3.28
3.00
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

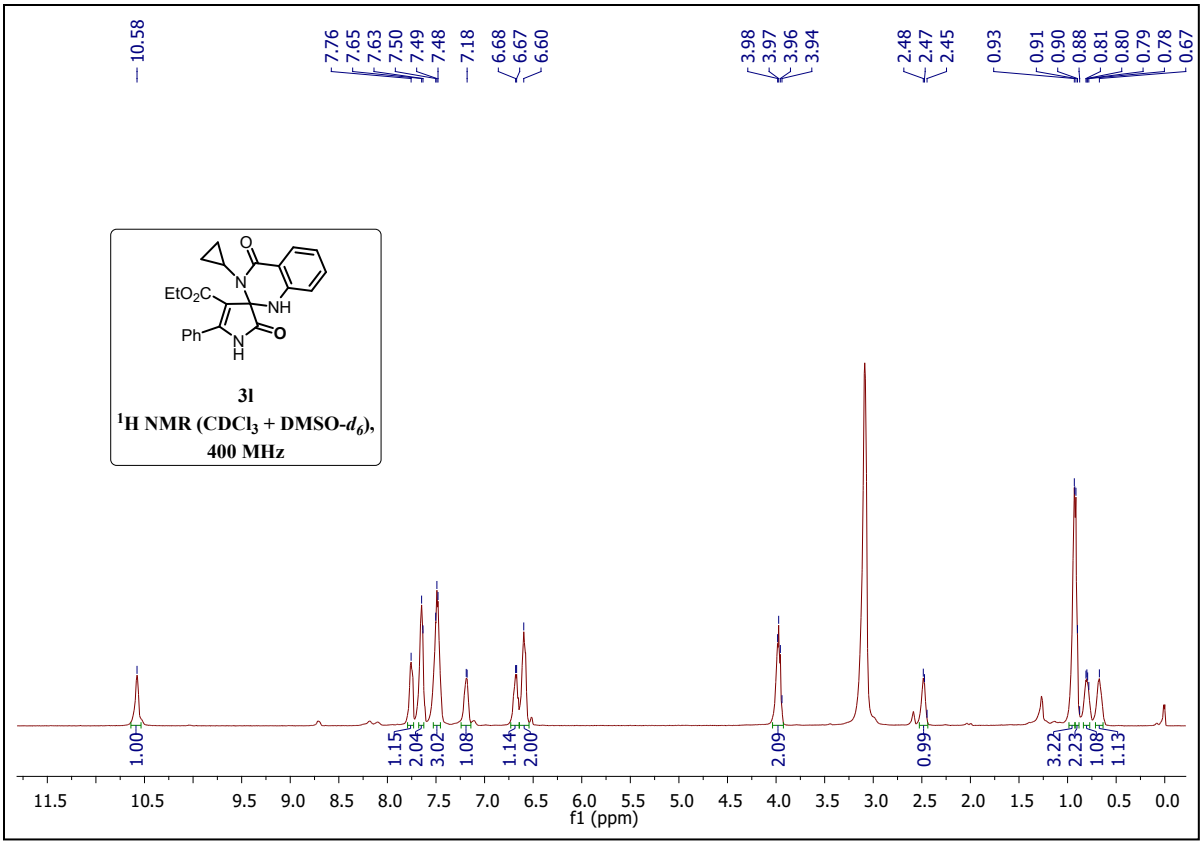

175.82
162.31
161.88
154.53
144.36
132.30
128.25
127.27
126.69
116.78
113.17
112.88
107.07
77.66
59.03
38.04
12.93
12.89
EtO2C
NH
Ph
N
H
O
3k
13C NMR (CDCl3 + DMSO-d6),
100 MHz
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

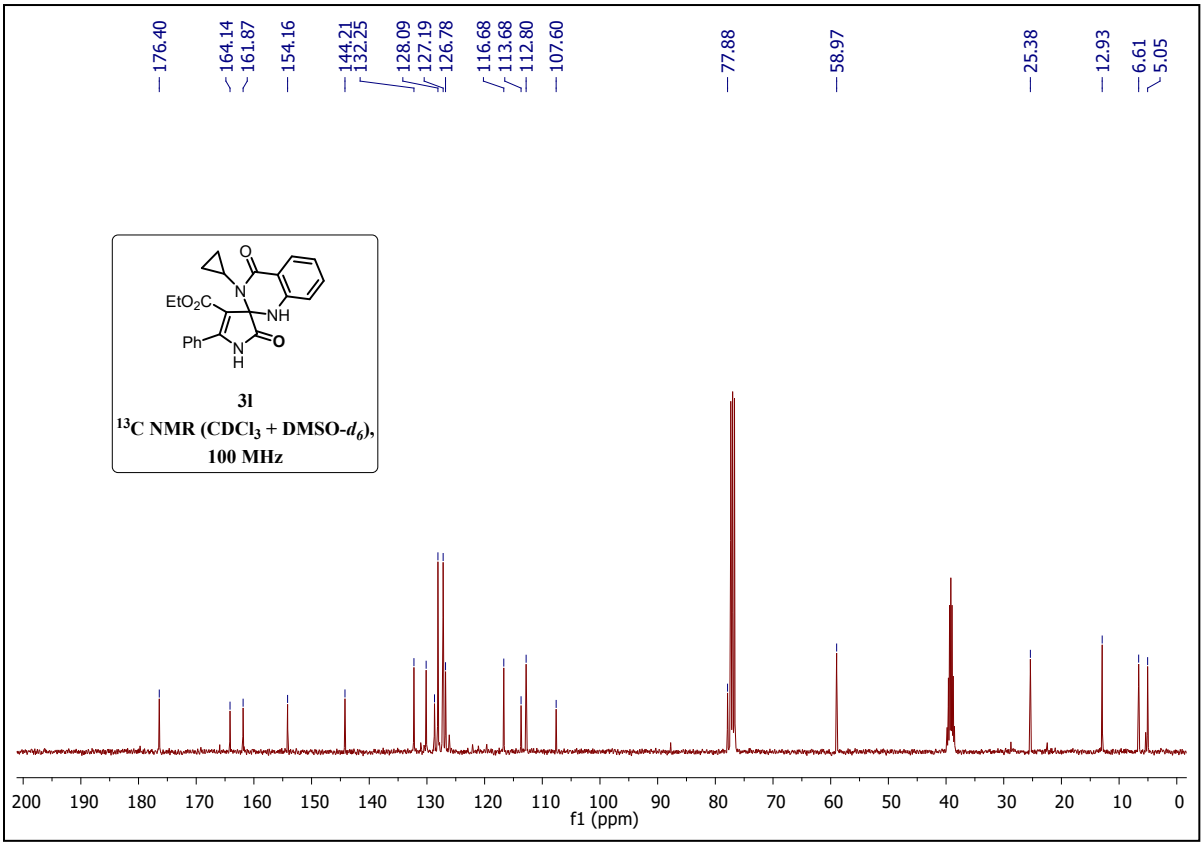


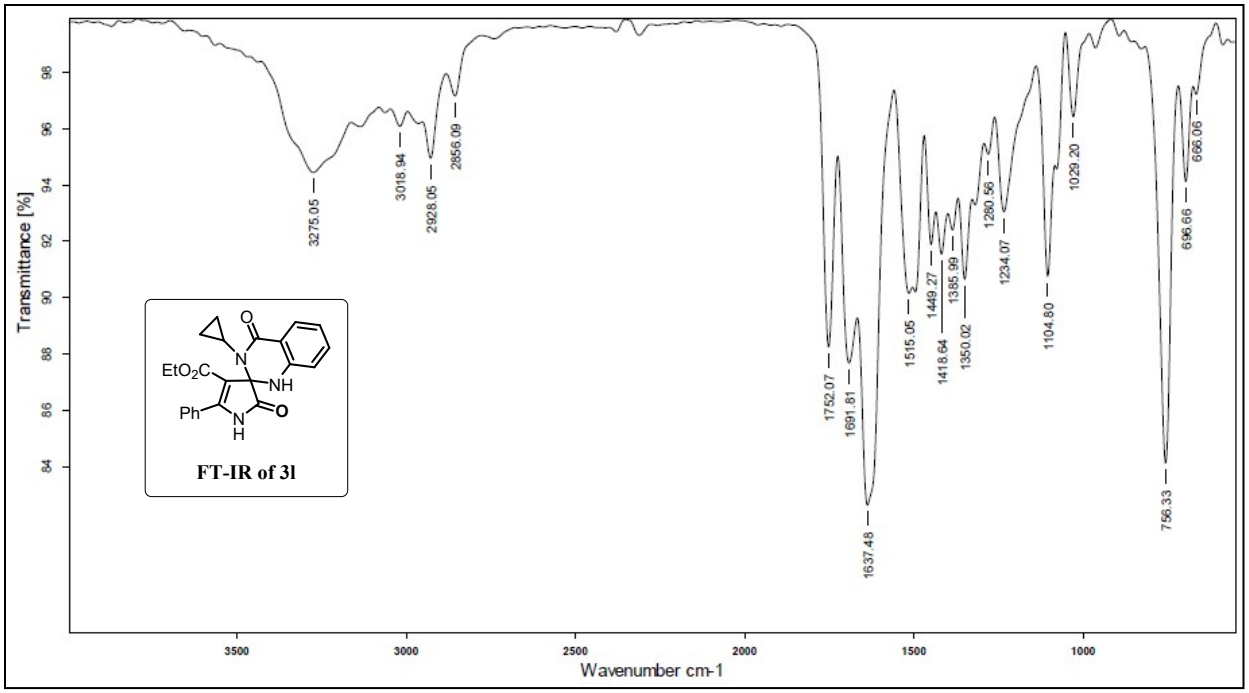
FT-IR of 3k

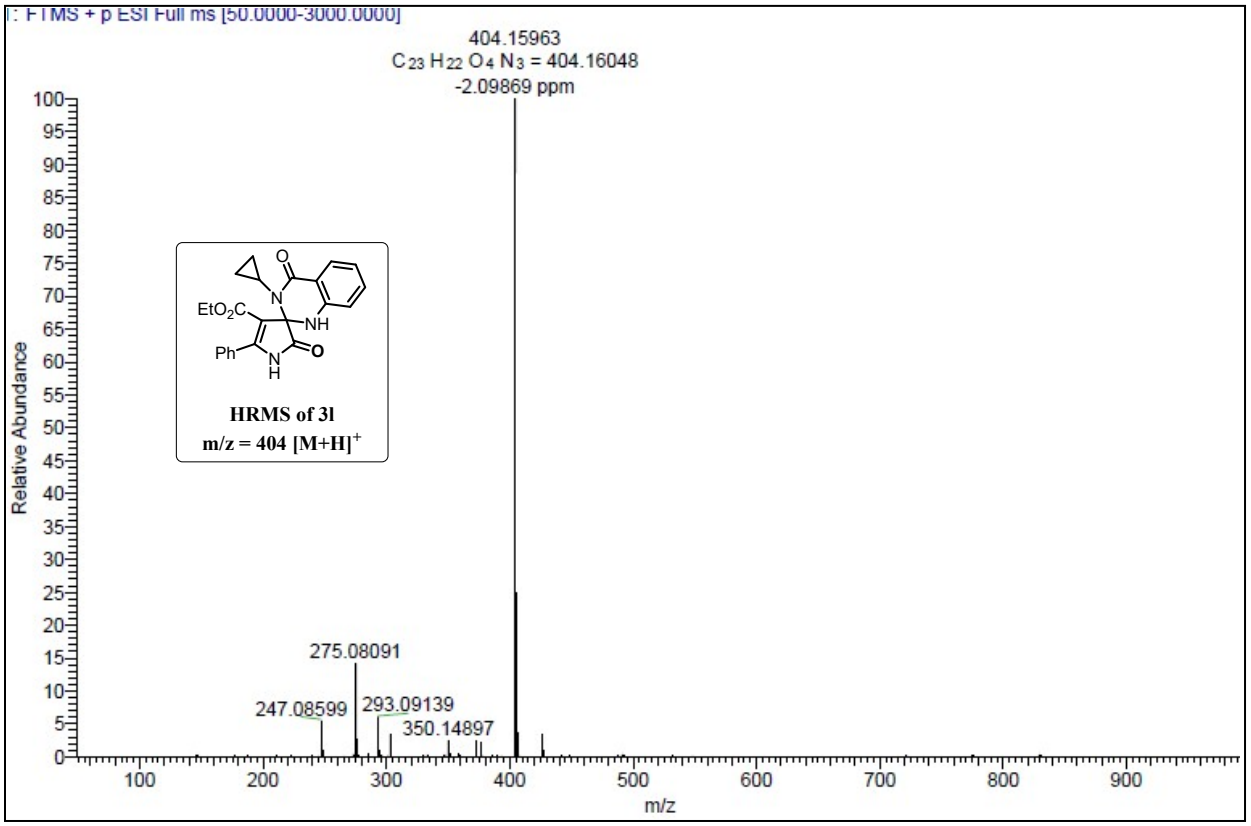


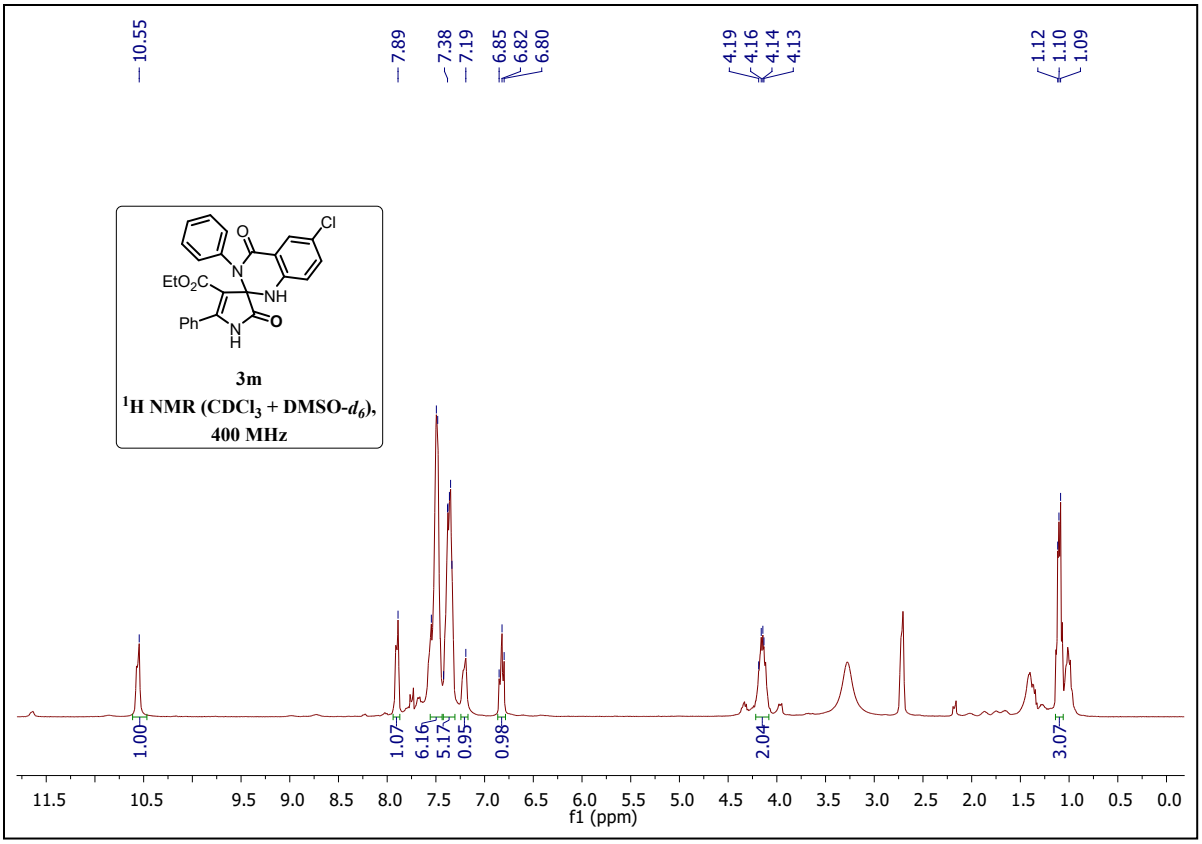
HRMS of 3k
m/z = 392 $[M+H]^+$

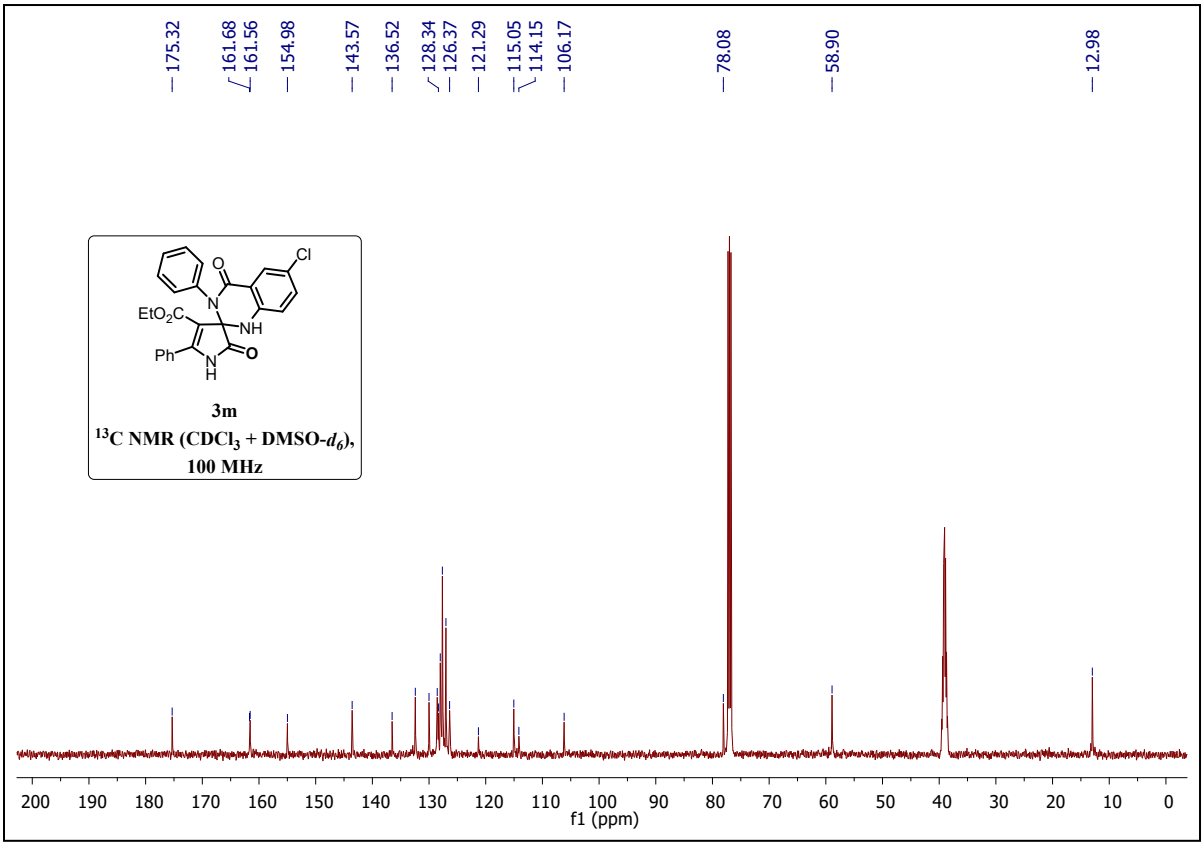

10.58
7.76
7.65
7.63
7.50
7.49
7.48
7.18
6.68
6.67
6.60
3.98
3.97
3.96
3.94
2.48
2.47
2.45
0.93
0.91
0.90
0.88
0.81
0.80
0.79
0.78
0.67
EtO2C
NH
Ph
N
H
O
3l
1H NMR (CDCl3 + DMSO-d6),
400 MHz
1.00
1.15
2.04
3.02
1.08
1.14
2.00
2.09
0.99
3.22
2.23
1.08
1.13
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

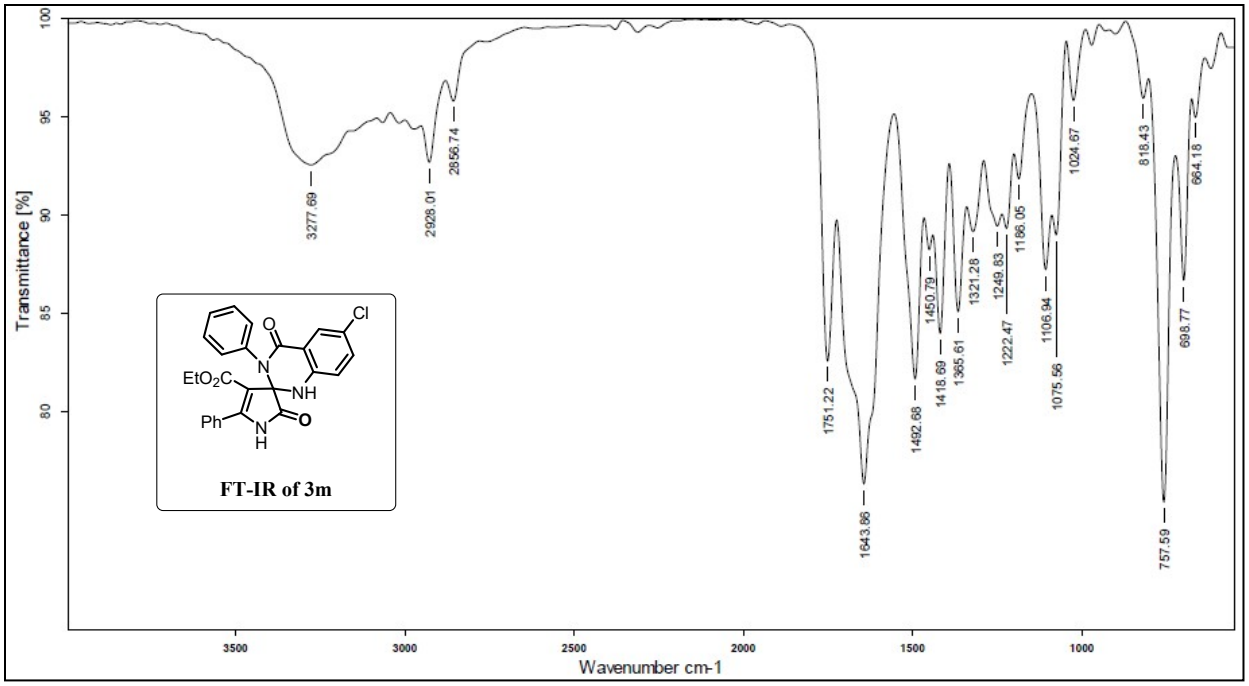

176.40
164.14
161.87
154.16
144.21
132.25
128.09
127.19
126.78
116.68
113.68
112.80
107.60
77.88
58.97
25.38
12.93
6.61
5.05
EtO2C
NH
Ph
N
H
O
3l
13C NMR (CDCl3 + DMSO-d6),
100 MHz
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


Transmittance [%]
Wavenumber cm-1
3275.05
3018.94
2928.05
2856.09
1752.07
1691.81
1637.48
1515.05
1449.27
1418.64
1385.99
1350.02
1280.56
1234.07
1104.80
1029.20
756.33
699.66
666.06
EtO2C
NH
Ph
N
H
O
FT-IR of 3l

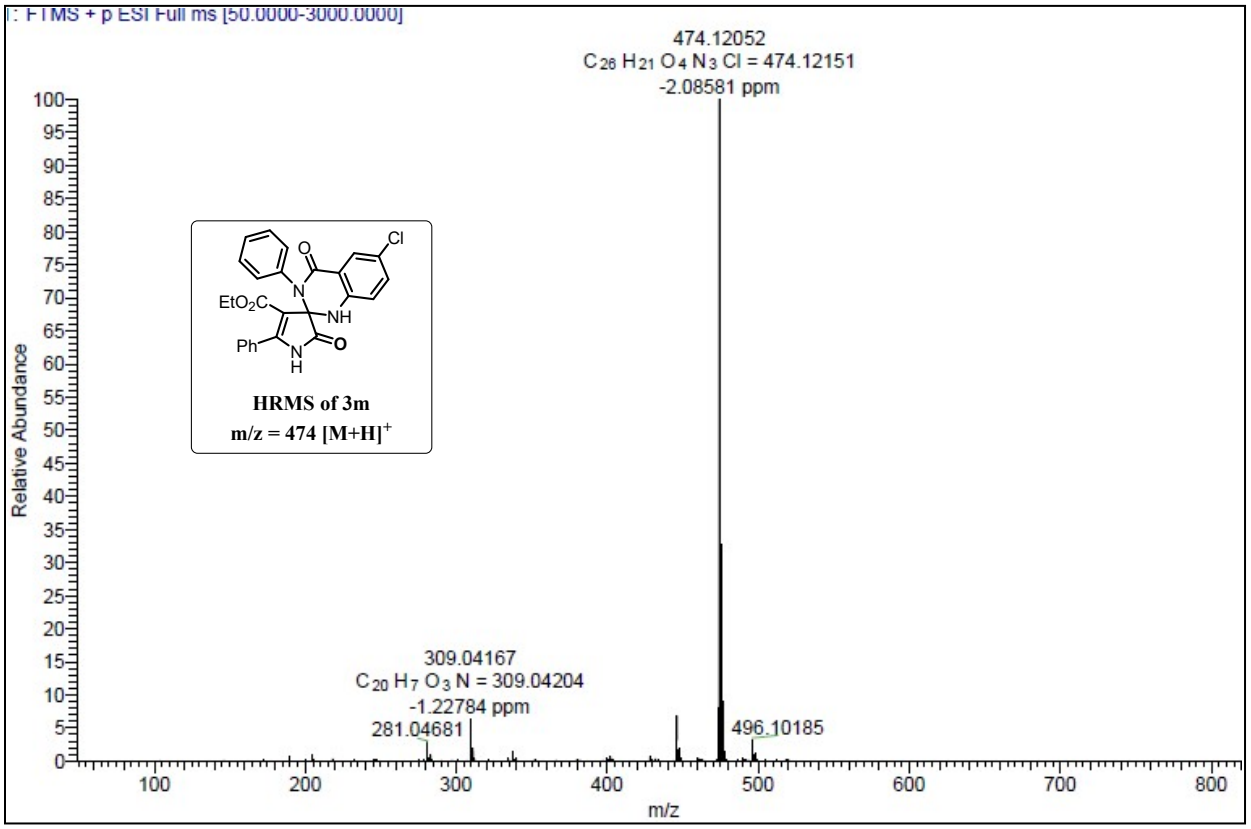

404.15963
C23 H22 O4 N3 = 404.16048
-2.09869 ppm
Relative Abundance
m/z
275.08091
247.08599
293.09139
350.14897
EtO2C
NH
Ph
N
H
O
HRMS of 3l
m/z = 404 [M+H]+


10.55
7.89
7.38
7.19
6.85
6.82
6.80
4.19
4.16
4.14
4.13
1.12
1.10
1.09
3m
^{1}H NMR (CDCl$_3$ + DMSO-d_6),
400 MHz
1.00
1.07
6.16
5.17
0.95
0.98
2.04
3.07
f1 (ppm)


175.32
161.68
161.56
154.98
143.57
136.52
128.34
126.37
121.29
115.05
114.15
106.17
78.08
58.90
12.98
3m
^{13}C NMR (CDCl$_3$ + DMSO-d_6),
100 MHz
f1 (ppm)

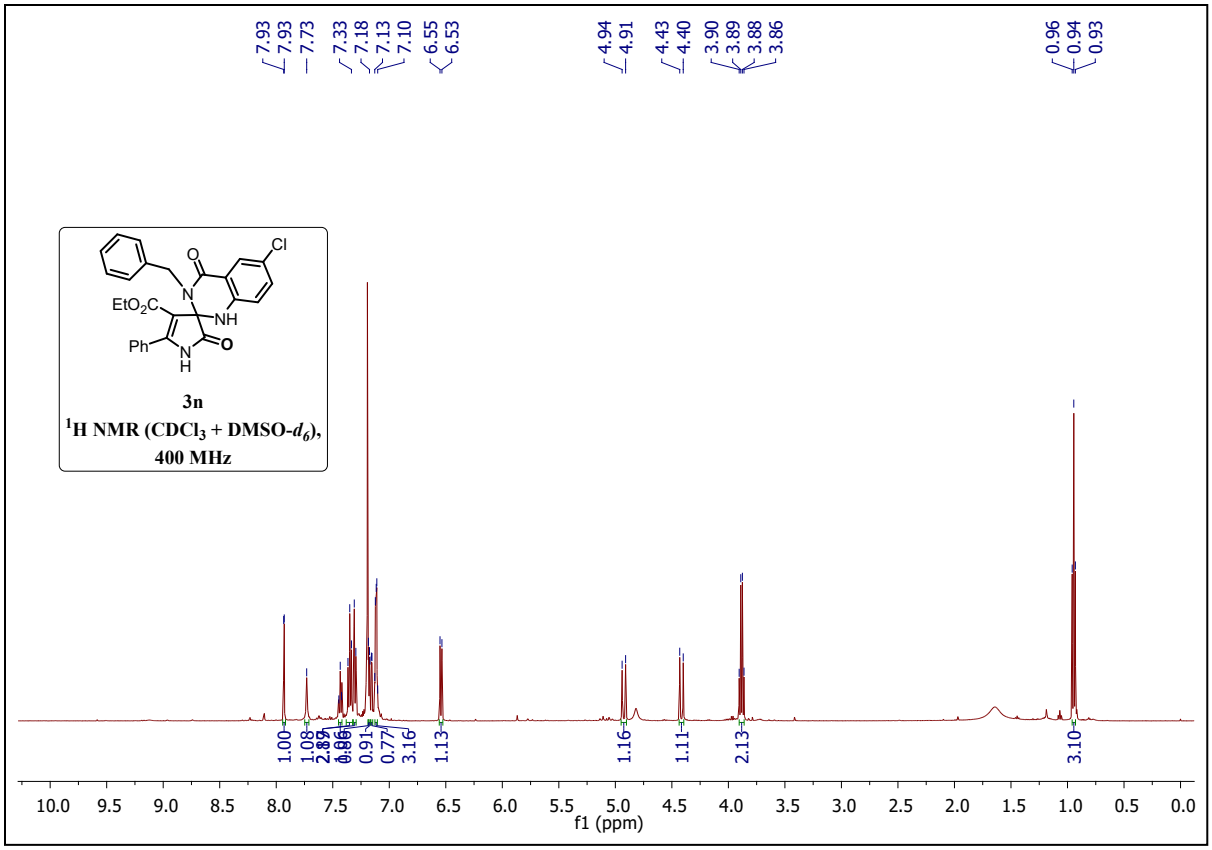


FT-IR of 3m



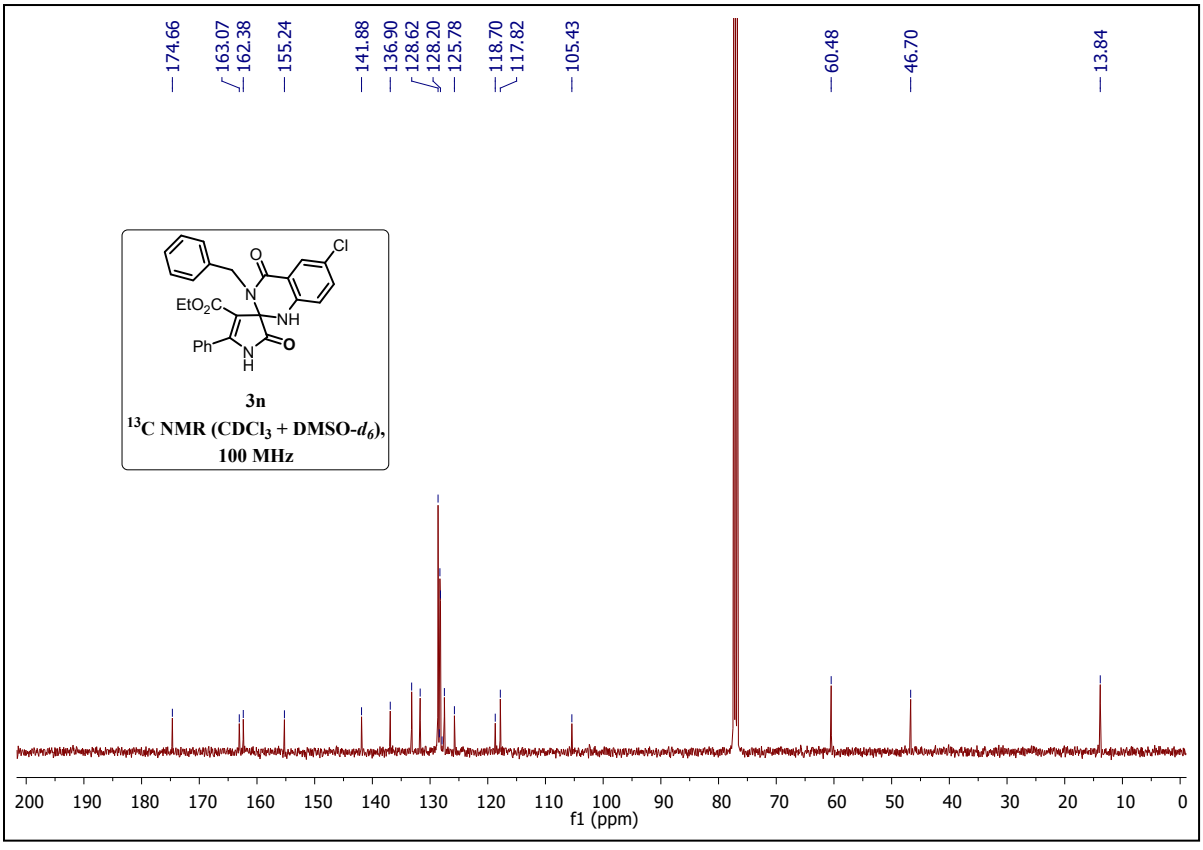
HRMS of 3m

m/z = 474 $[M+H]^+$



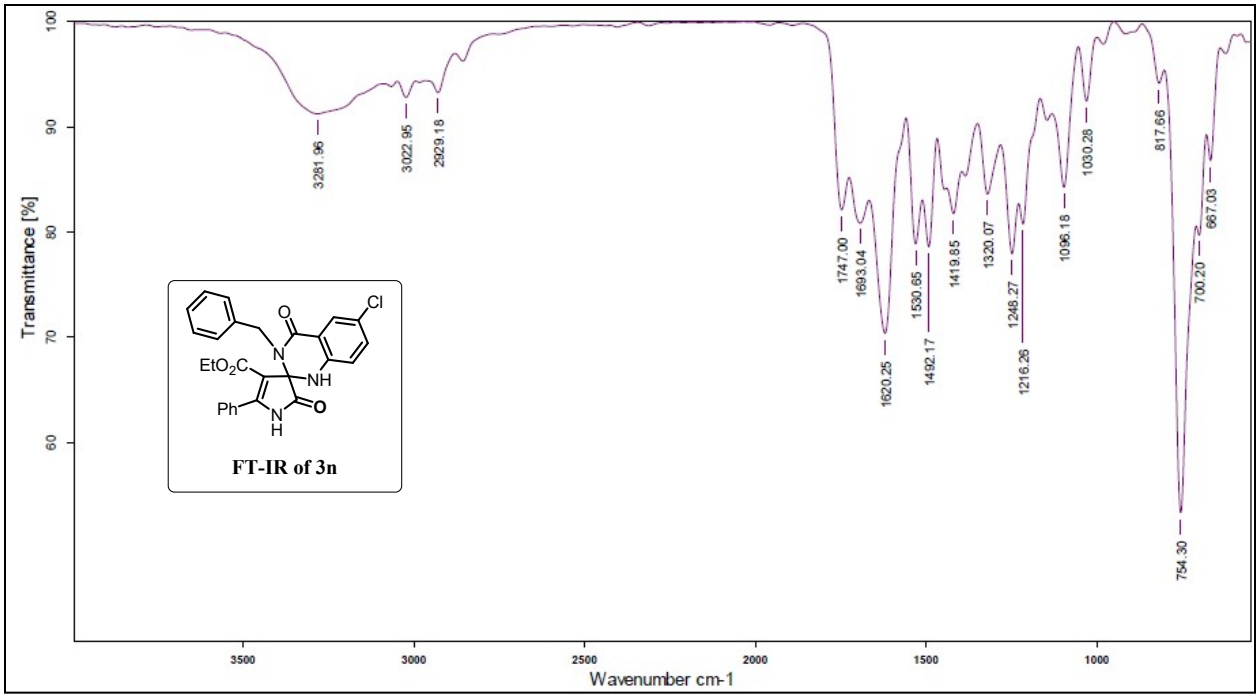
3n

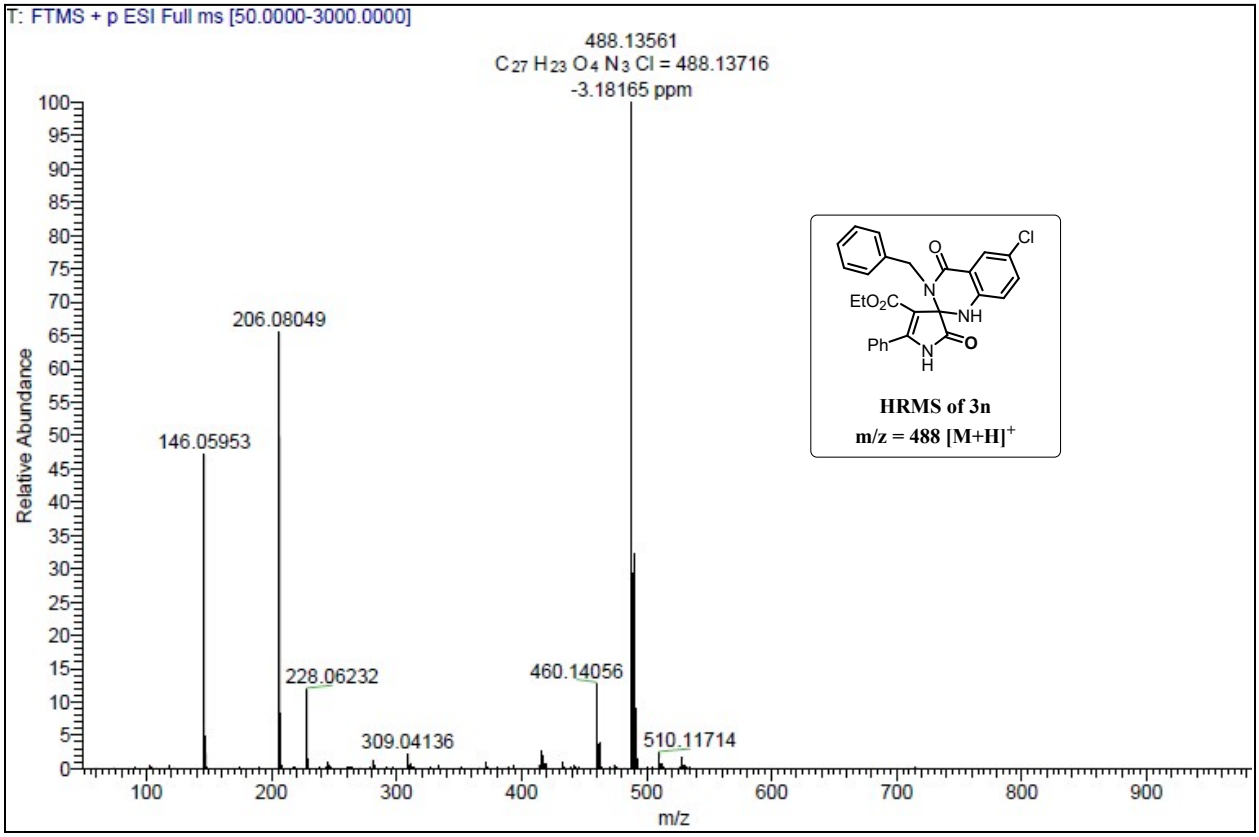
^{1}H NMR ($CDCl_3$ + DMSO-d_6), 400 MHz

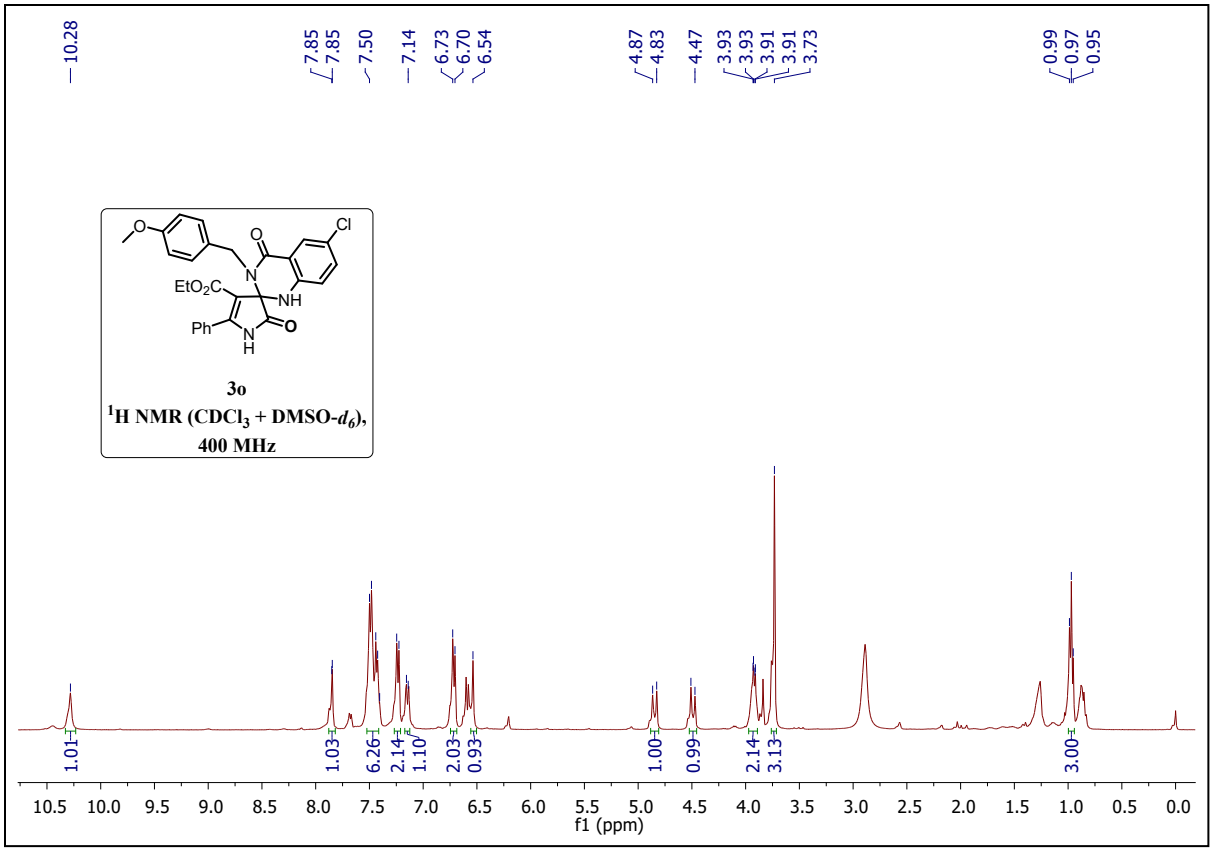


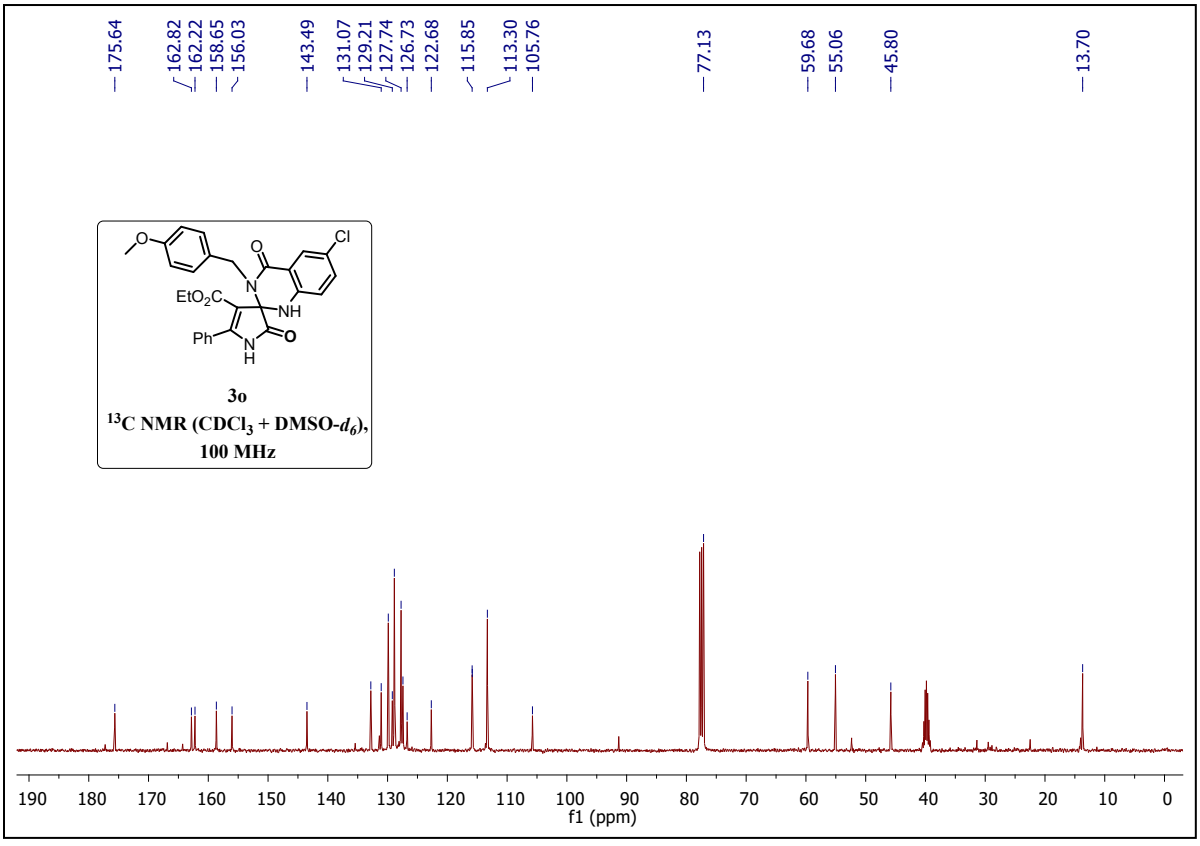
3n

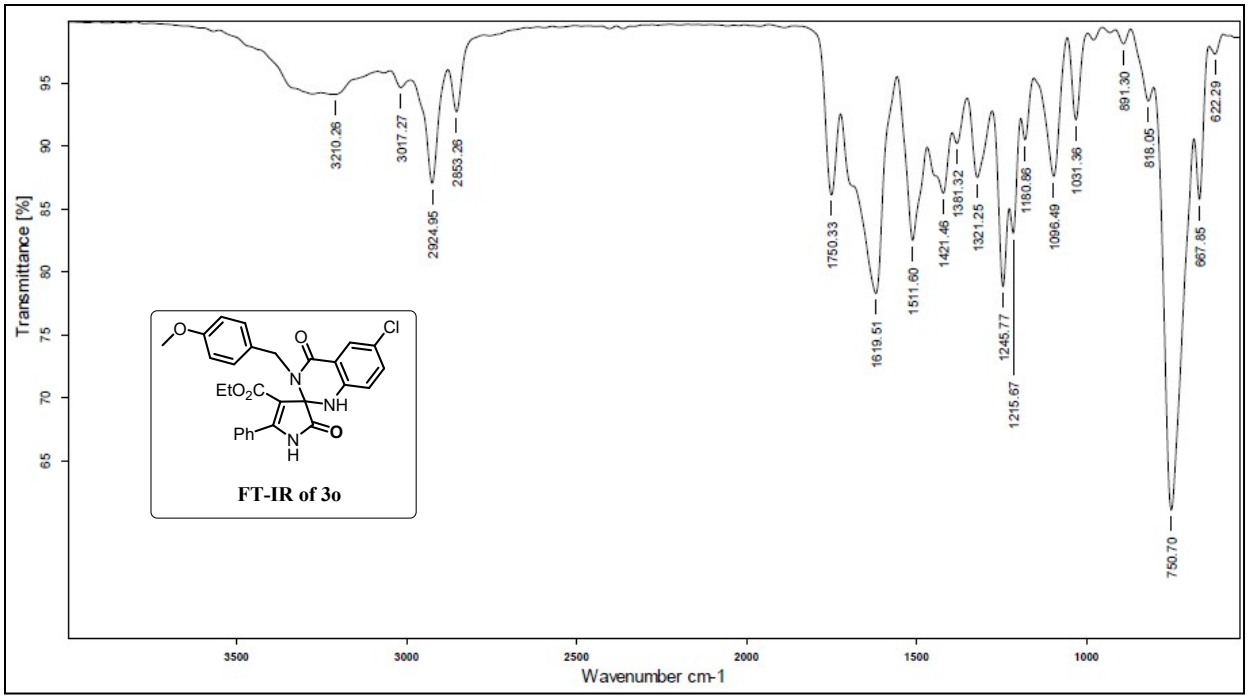
^{13}C NMR ($CDCl_3$ + DMSO-d_6), 100 MHz

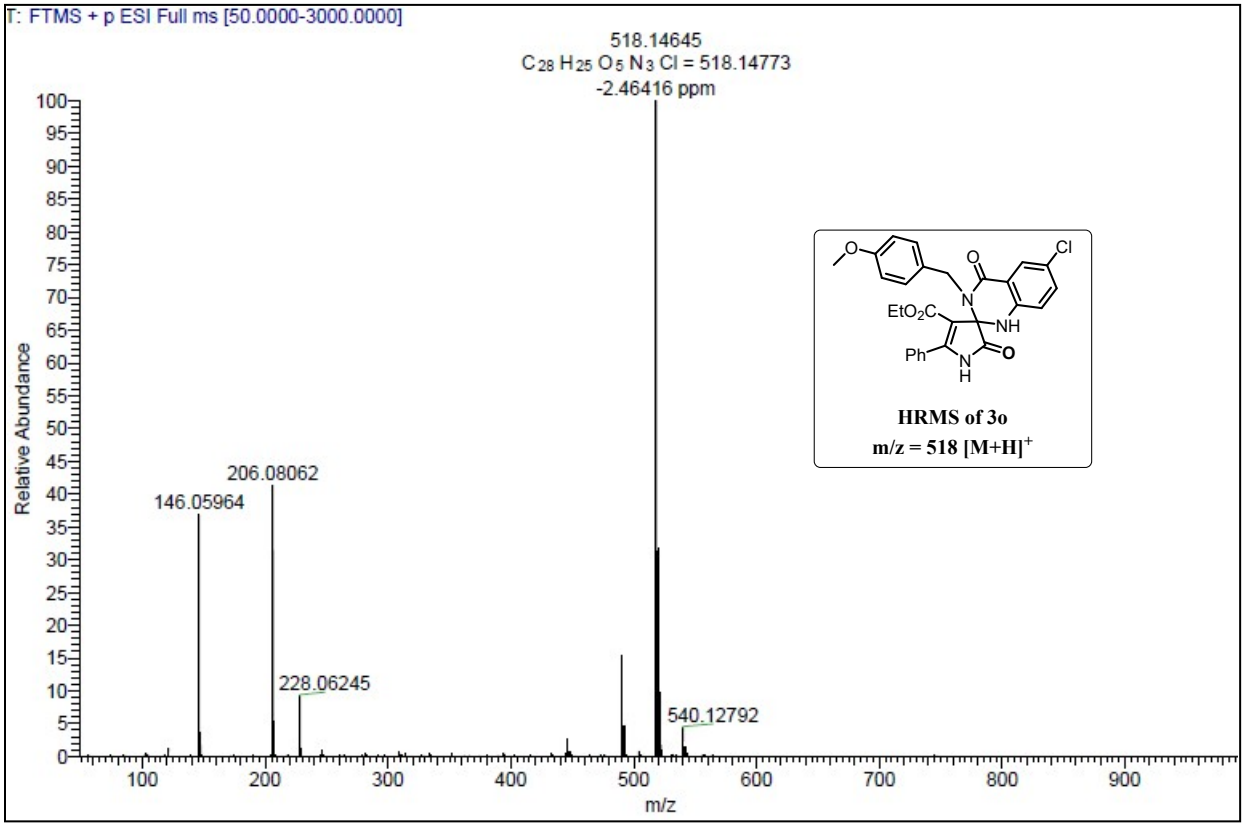

Transmittance [%]
Wavenumber cm-1
3281.96
3022.95
2929.18
1747.00
1693.04
1620.25
1530.65
1492.17
1419.85
1320.07
1248.27
1216.26
1096.18
1030.28
817.66
754.30
700.20
667.03
FT-IR of 3n

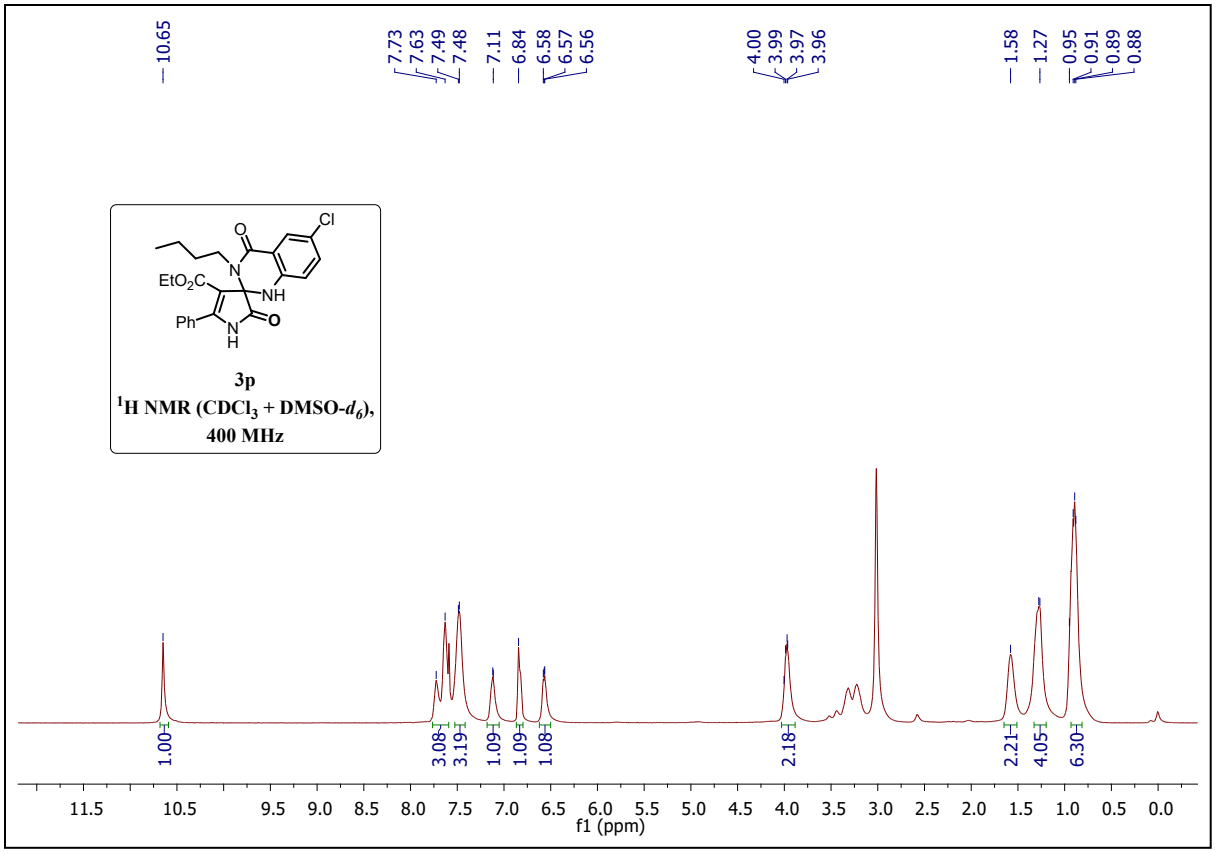

T: FTMS + p ESI Full ms [50.0000-3000.0000]
488.13561
C27 H23 O4 N3 Cl = 488.13716
-3.18165 ppm
206.08049
146.05953
228.06232
460.14056
309.04136
510.11714
Relative Abundance
m/z
HRMS of 3n
m/z = 488 [M+H]+

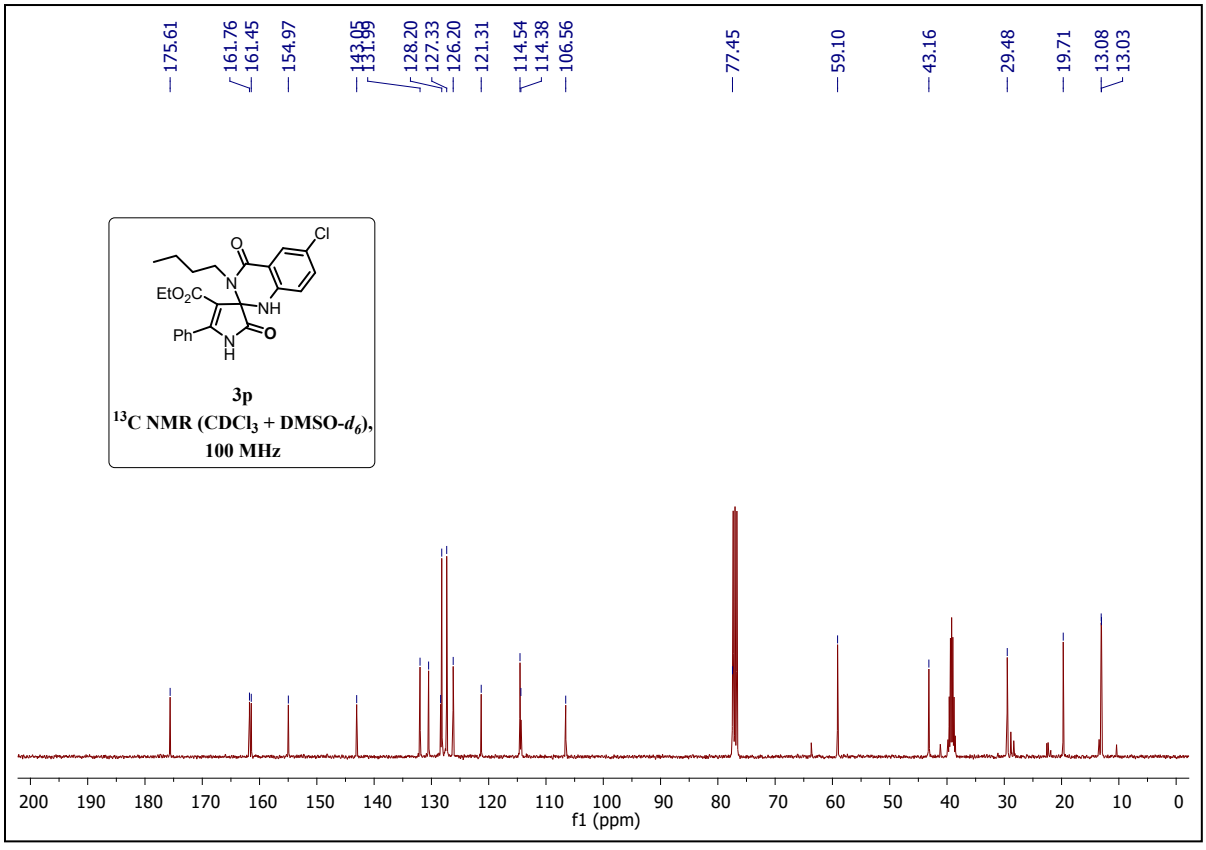

10.28
7.85
7.85
7.50
7.14
6.73
6.70
6.54
4.87
4.83
4.47
3.93
3.93
3.91
3.91
3.73
0.99
0.97
0.95
3o
1H NMR (CDCl3 + DMSO-d6),
400 MHz
1.01
1.03
6.26
2.14
1.10
2.03
0.93
1.00
0.99
2.14
3.13
3.00
f1 (ppm)

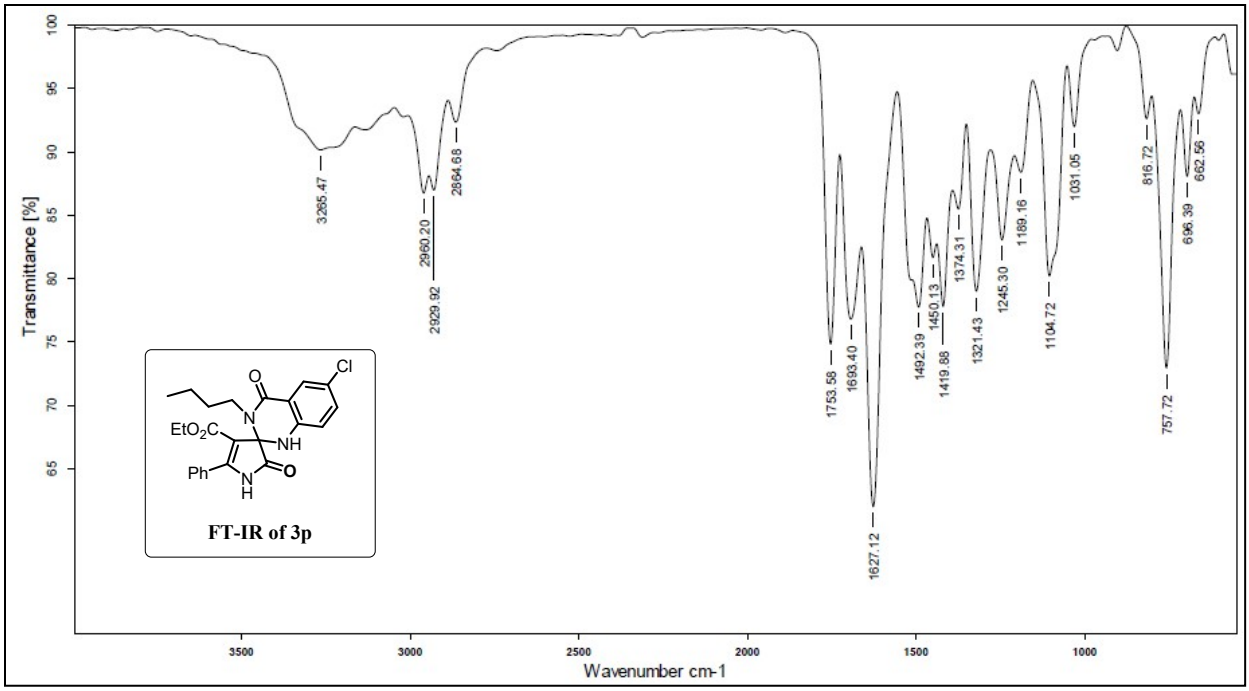

175.64
162.82
162.22
158.65
156.03
143.49
131.07
129.21
127.74
126.73
122.68
115.85
113.30
105.76
77.13
59.68
55.06
45.80
13.70
3o
13C NMR (CDCl3 + DMSO-d6),
100 MHz
f1 (ppm)

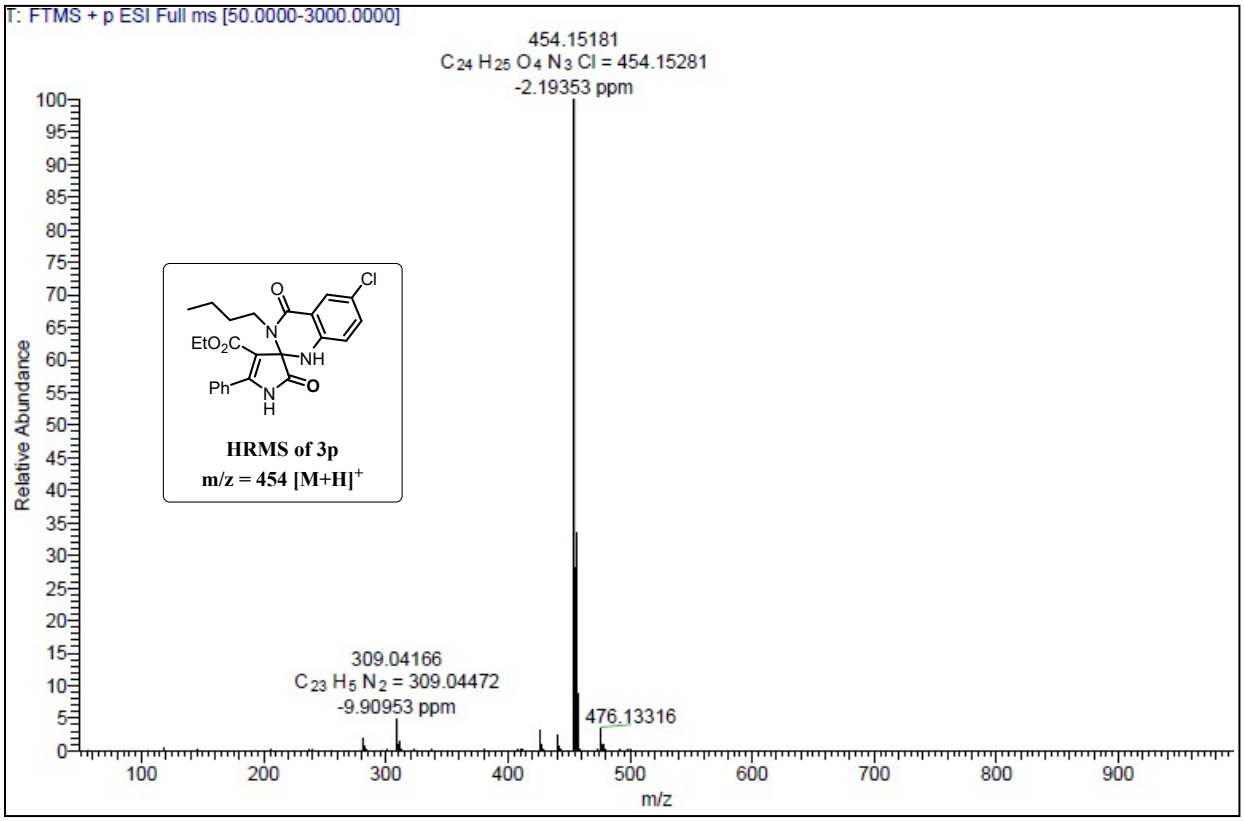

Transmittance [%]
Wavenumber cm-1
3210.26
3017.27
2924.95
2853.28
1750.33
1619.51
1511.60
1421.46
1381.32
1321.25
1245.77
1215.67
1180.86
1096.49
1031.36
891.30
818.05
750.70
667.85
622.29
FT-IR of 3o

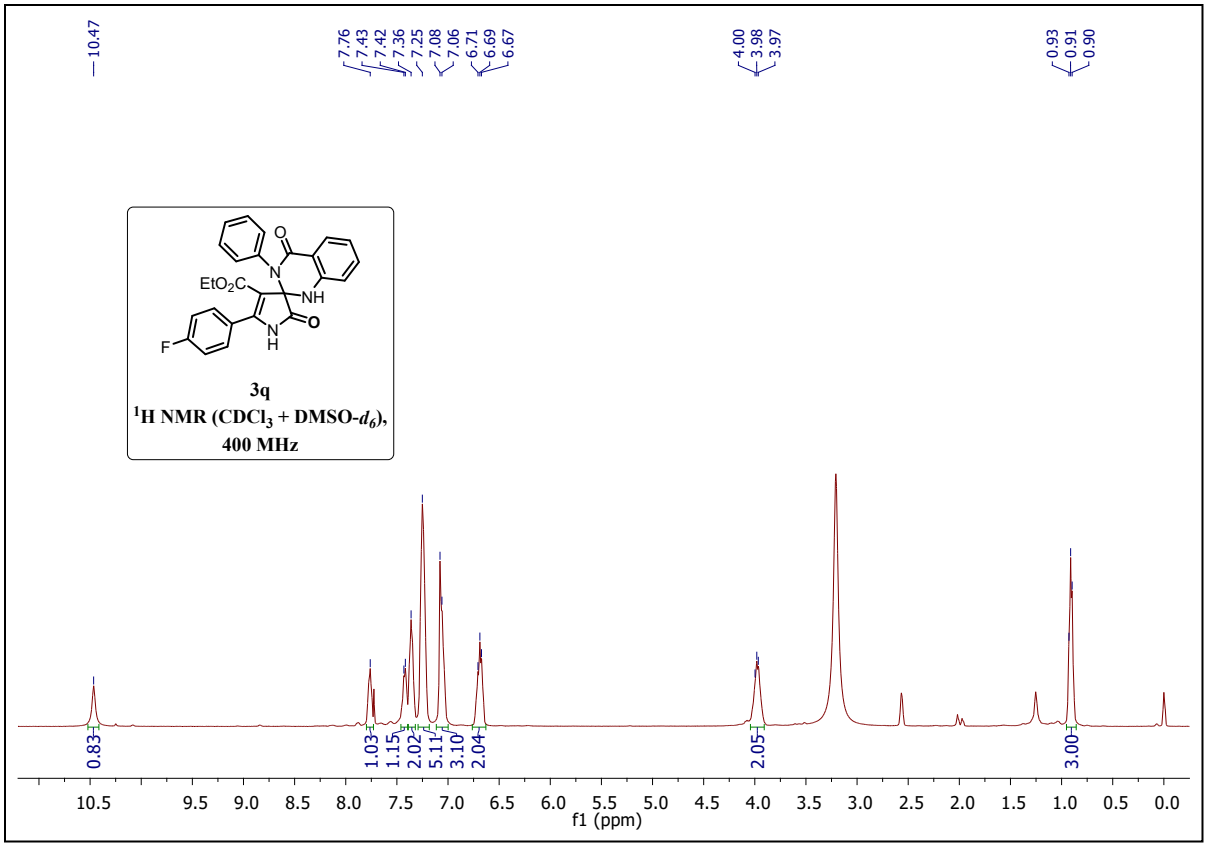

T: FTMS + p ESI Full ms [50.0000-3000.0000]
518.14645
C28 H25 O5 N3 Cl = 518.14773
-2.46416 ppm
Relative Abundance
m/z
206.08062
146.05964
228.06245
540.12792
HRMS of 3o
m/z = 518 [M+H]+

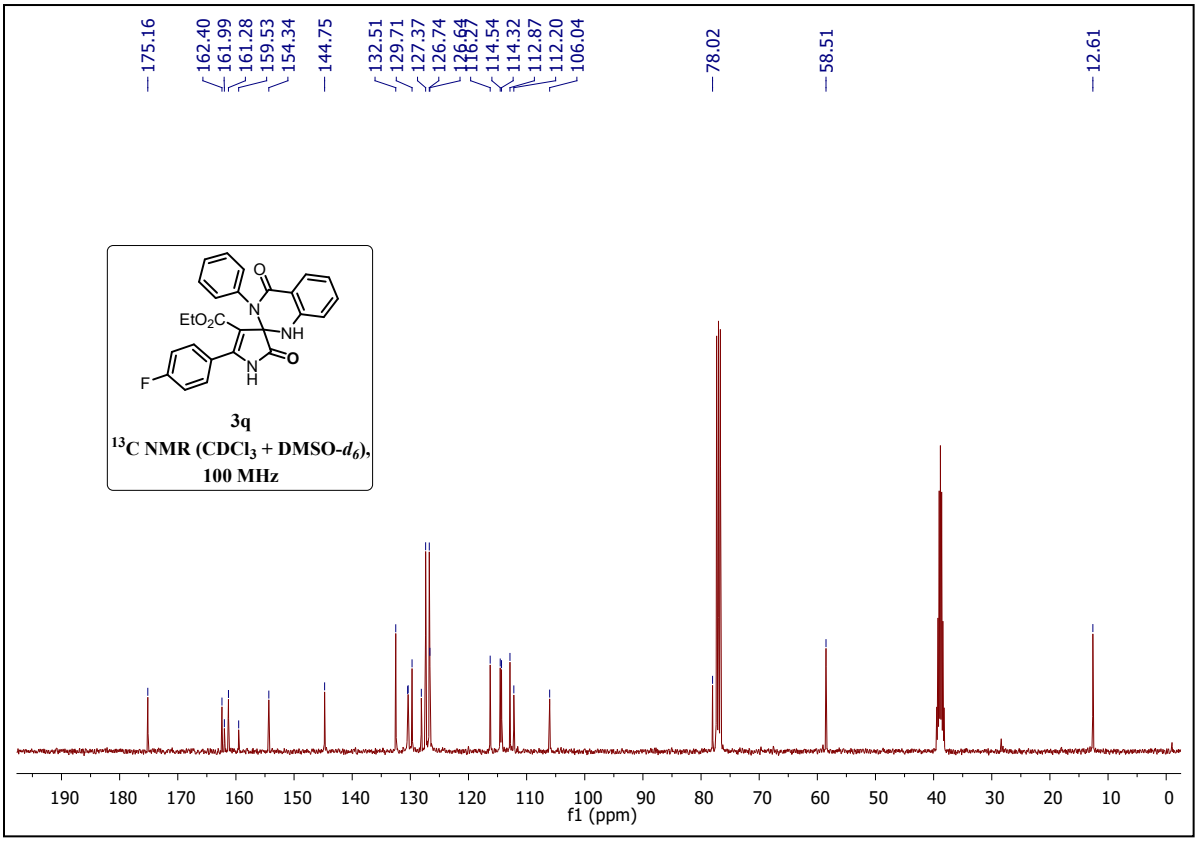

10.65
7.73
7.63
7.49
7.48
7.11
6.84
6.58
6.57
6.56
4.00
3.99
3.97
3.96
1.58
1.27
0.95
0.91
0.89
0.88
Cl
O
N
EtO2C
NH
Ph
N
H
O
3p
1H NMR (CDCl3 + DMSO-d6),
400 MHz
1.00
3.08
3.19
1.09
1.09
1.08
2.18
2.21
4.05
6.30
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

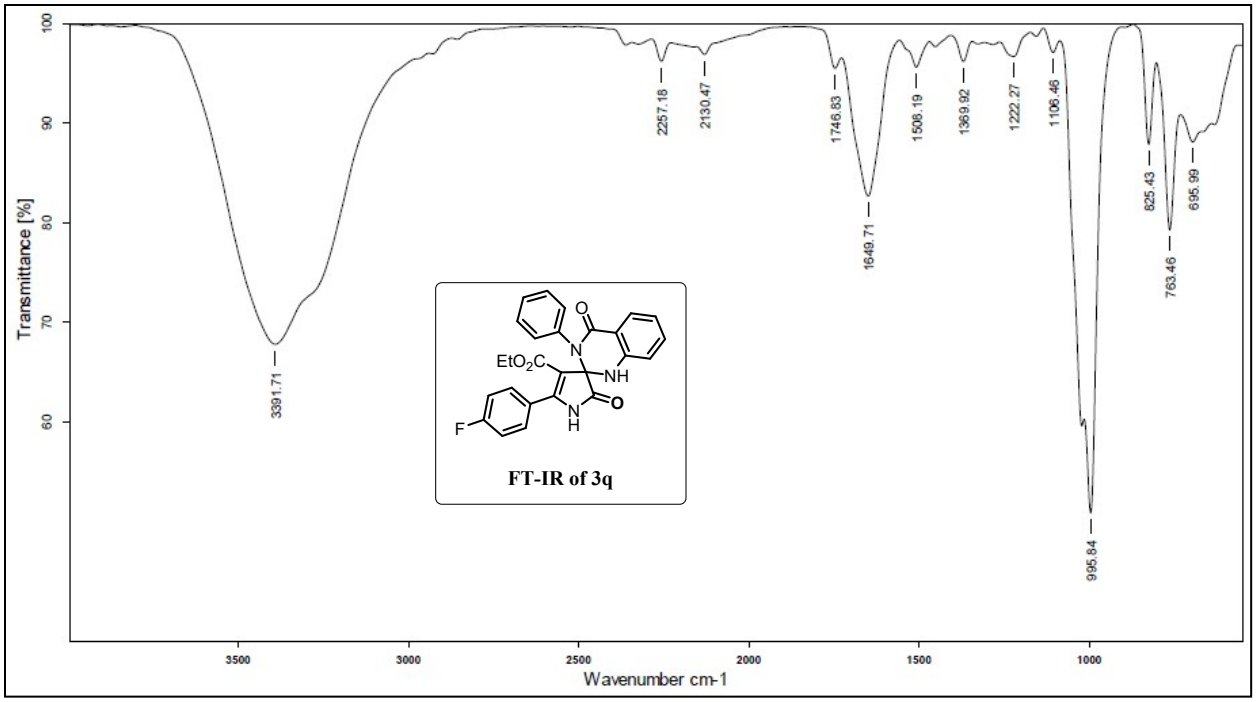

175.61
161.76
161.45
154.97
143.05
131.99
128.20
127.33
126.20
121.31
114.54
114.38
106.56
77.45
59.10
43.16
29.48
19.71
13.08
13.03
Cl
O
N
EtO2C
NH
Ph
N
H
O
3p
13C NMR (CDCl3 + DMSO-d6),
100 MHz
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

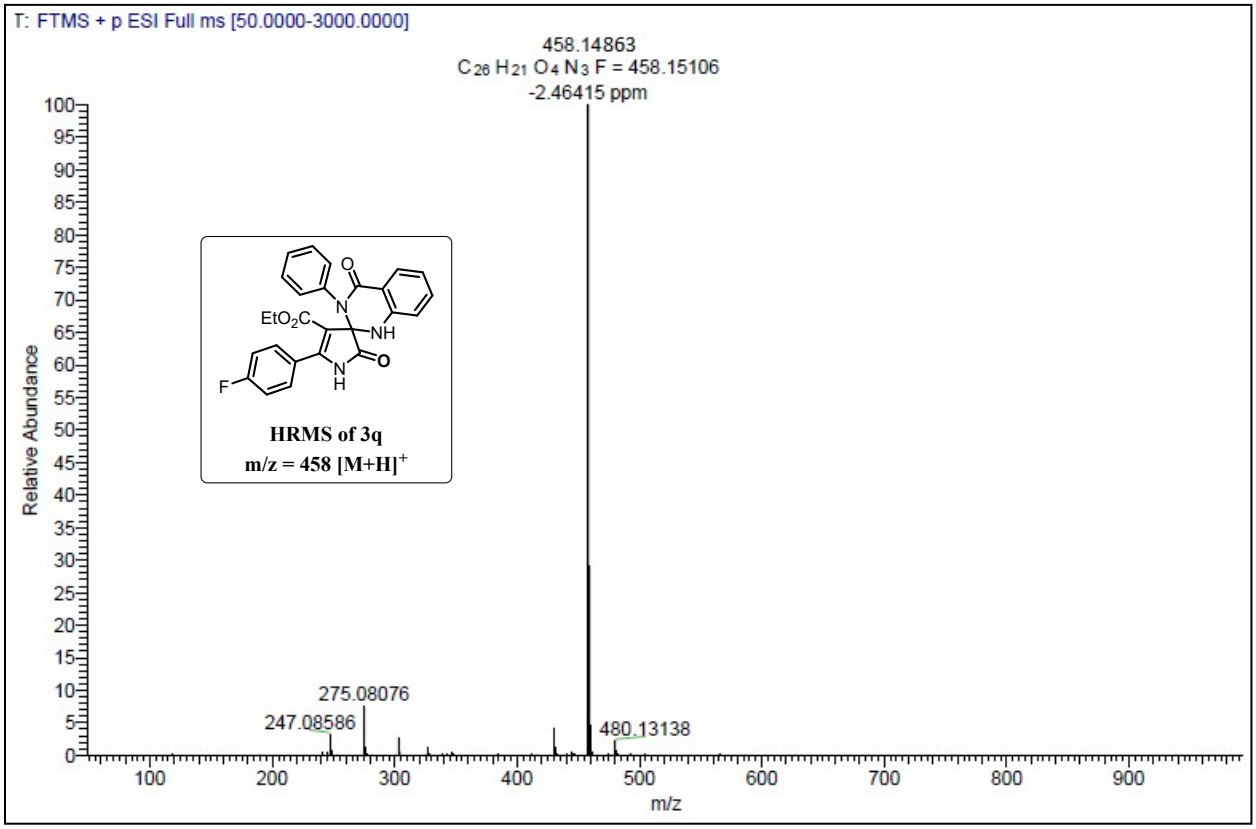

Transmittance [%]
Wavenumber cm-1
3265.47
2960.20
2929.92
2864.68
1753.58
1693.40
1627.12
1492.39
1450.13
1419.88
1374.31
1321.43
1245.30
1189.16
1104.72
1031.05
816.72
757.72
696.39
662.56
FT-IR of 3p

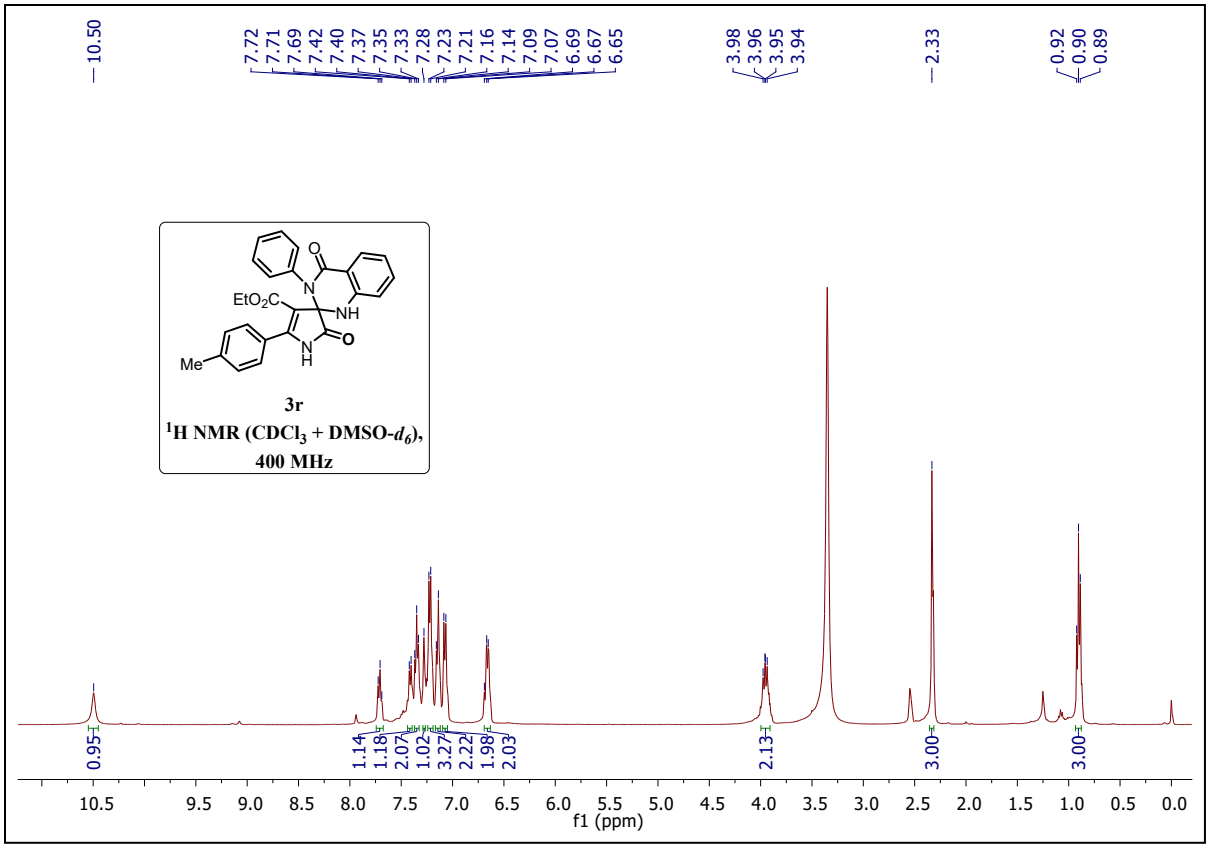

T: FTMS + p ESI Full ms [50.0000-3000.0000]
454.15181
C24 H25 O4 N3 Cl = 454.15281
-2.19353 ppm
309.04166
C23 H5 N2 = 309.04472
-9.90953 ppm
476.13316
Relative Abundance
m/z
HRMS of 3p
m/z = 454 [M+H]+

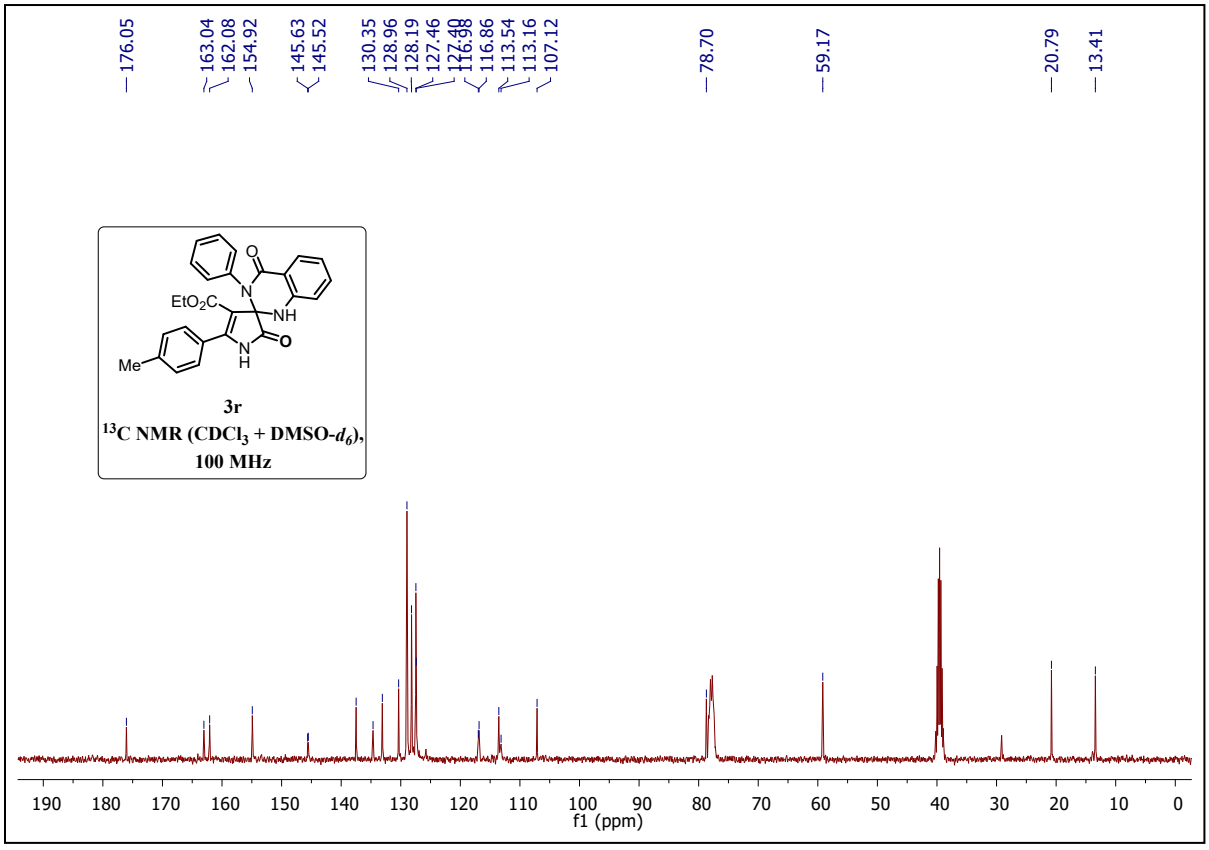

10.47
7.76
7.43
7.42
7.36
7.25
7.08
7.06
6.71
6.69
6.67
4.00
3.98
3.97
0.93
0.91
0.90
EtO2C
NH
O
N
H
F
3q
1H NMR (CDCl3 + DMSO-d6),
400 MHz
0.83
1.03
1.15
2.02
5.11
3.10
2.04
2.05
3.00
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

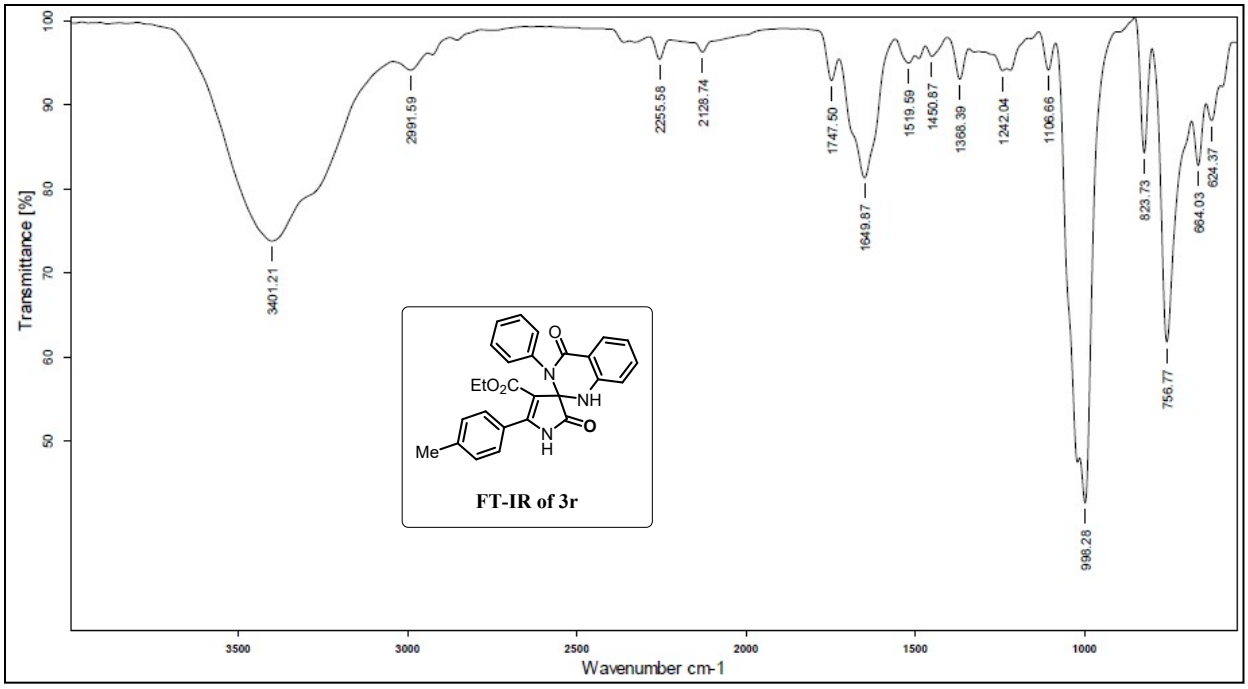

175.16
162.40
161.99
161.28
159.53
154.34
144.75
132.51
129.71
127.37
126.74
114.54
114.32
112.87
112.20
106.04
78.02
58.51
12.61
EtO2C
NH
O
N
H
F
3q
13C NMR (CDCl3 + DMSO-d6),
100 MHz
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

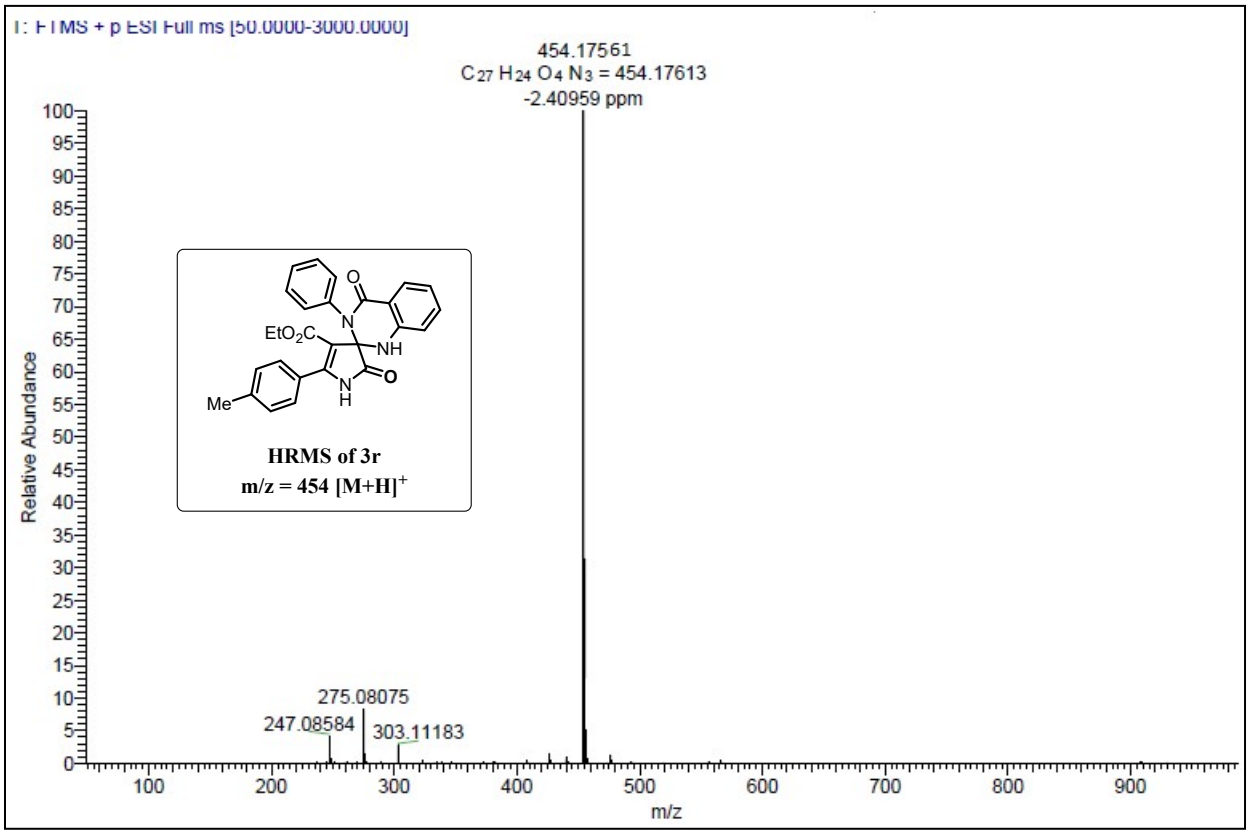

Transmittance [%]
Wavenumber cm-1
3391.71
2257.18
2130.47
1746.83
1649.71
1508.19
1369.92
1222.27
1106.46
995.84
825.43
763.46
695.99
EtO2C
NH
O
N
H
F
FT-IR of 3q

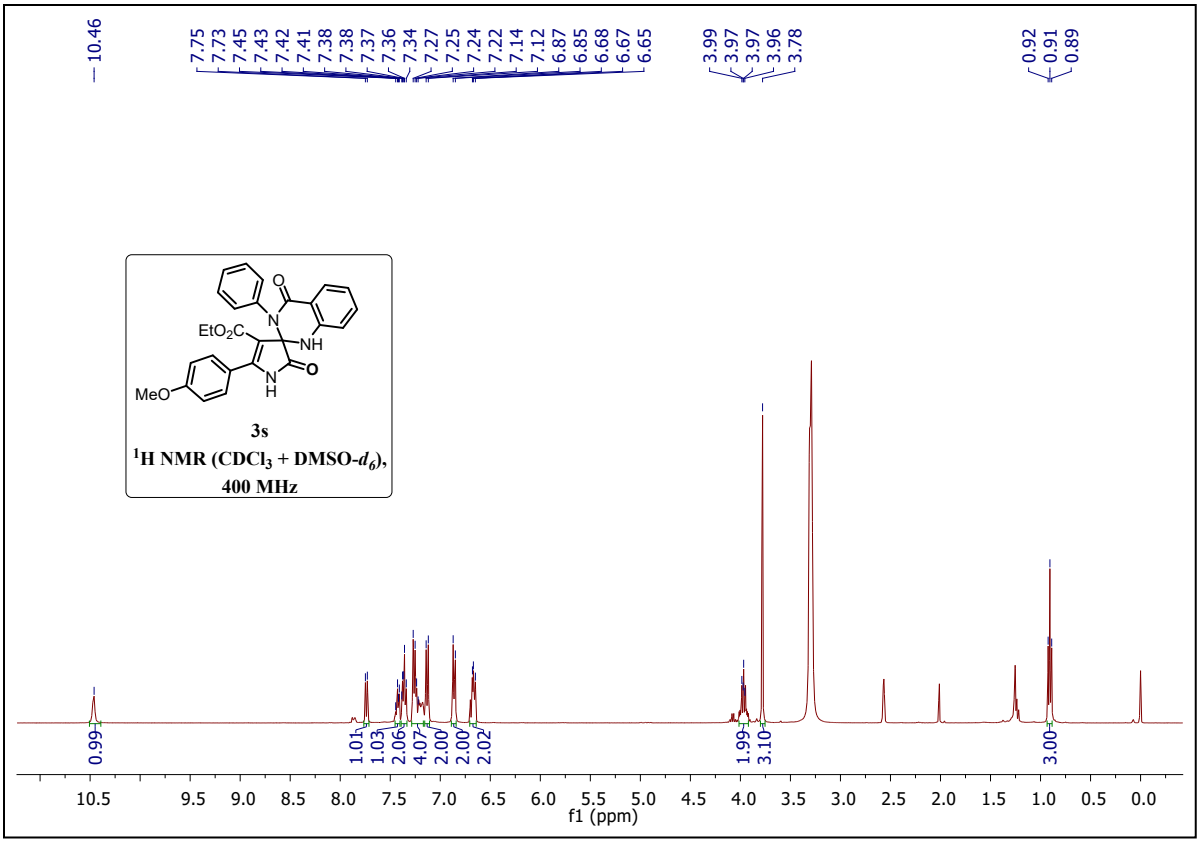

T: FTMS + p ESI Full ms [50.0000-3000.0000]
458.14863
C26 H21 O4 N3 F = 458.15106
-2.46415 ppm
Relative Abundance
m/z
275.08076
247.08586
480.13138
EtO2C
NH
O
N
H
F
HRMS of 3q
m/z = 458 [M+H]+

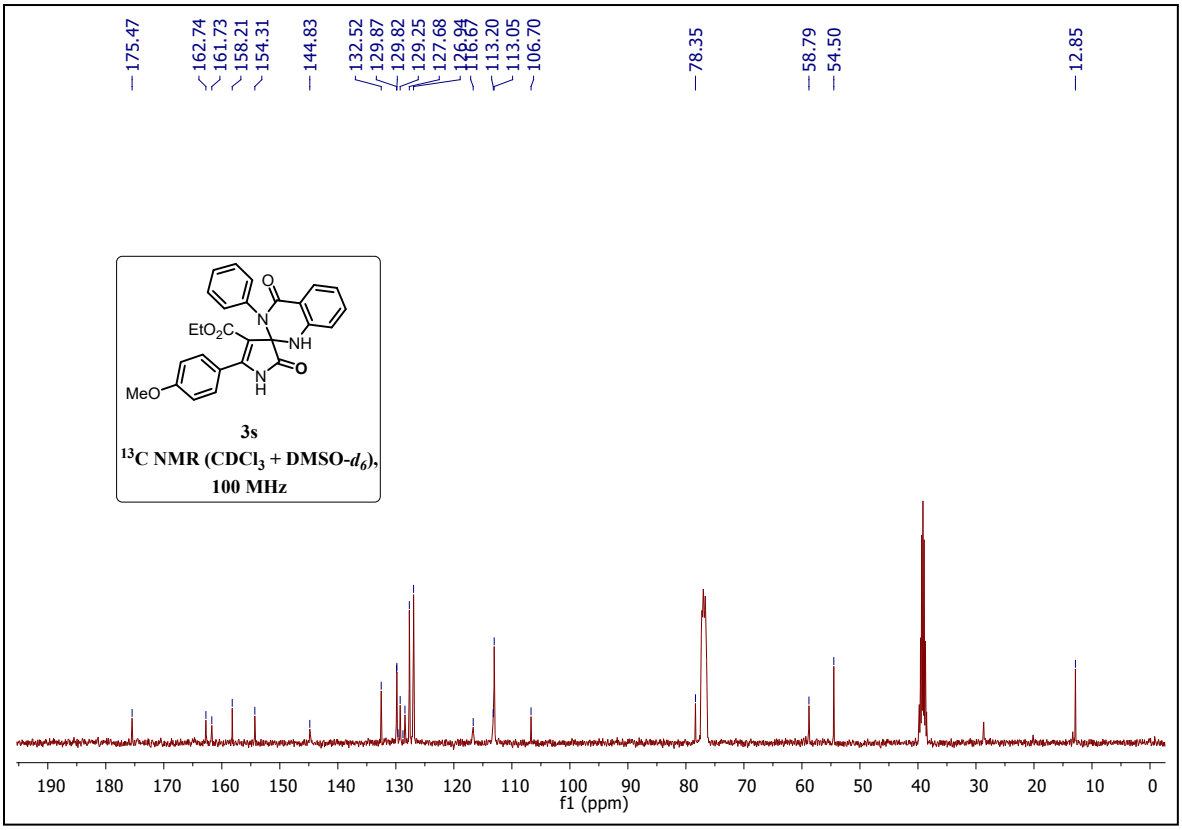

10.50
7.72
7.71
7.69
7.42
7.40
7.37
7.35
7.33
7.28
7.23
7.21
7.16
7.14
7.09
7.07
6.69
6.67
6.65
3.98
3.96
3.95
3.94
2.33
0.92
0.90
0.89
EtO2C
NH
O
N
H
Me
3r
1H NMR (CDCl3 + DMSO-d6),
400 MHz
0.95
1.14
1.18
2.07
1.02
3.27
2.22
1.98
2.03
2.13
3.00
3.00
f1 (ppm)

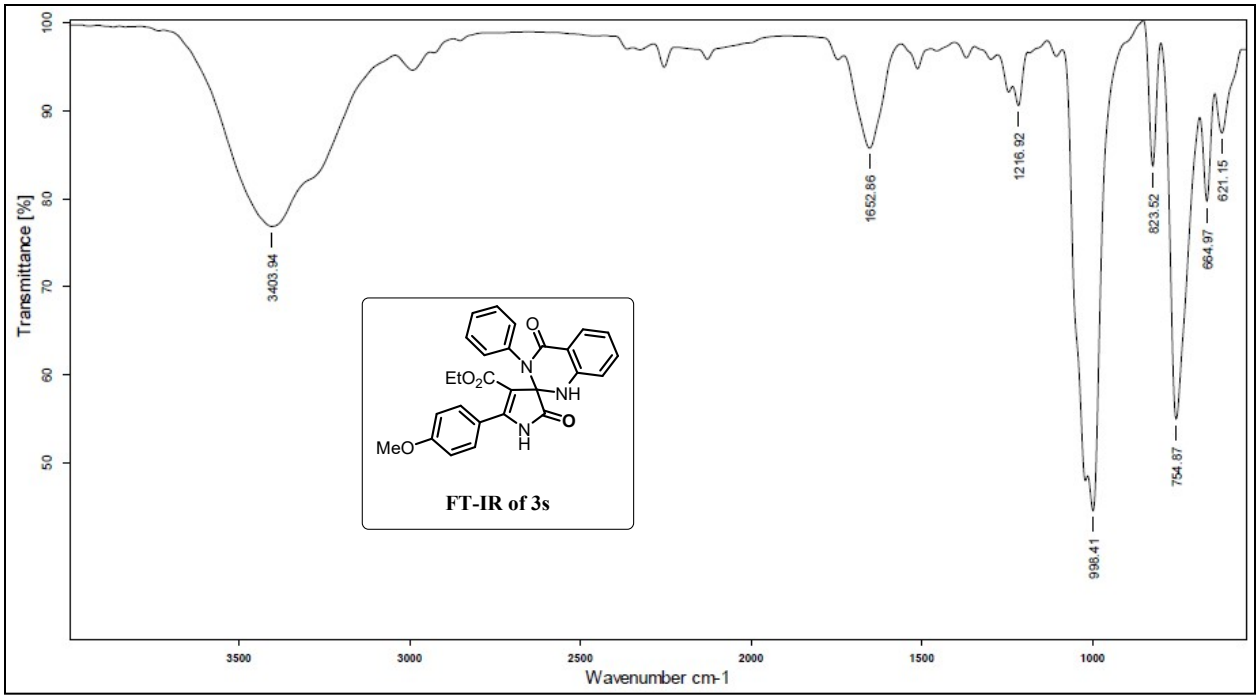

176.05
163.04
162.08
154.92
145.63
145.52
130.35
128.96
128.19
127.46
116.98
116.86
113.54
113.16
107.12
78.70
59.17
20.79
13.41
EtO2C
NH
O
N
H
Me
3r
13C NMR (CDCl3 + DMSO-d6),
100 MHz
f1 (ppm)

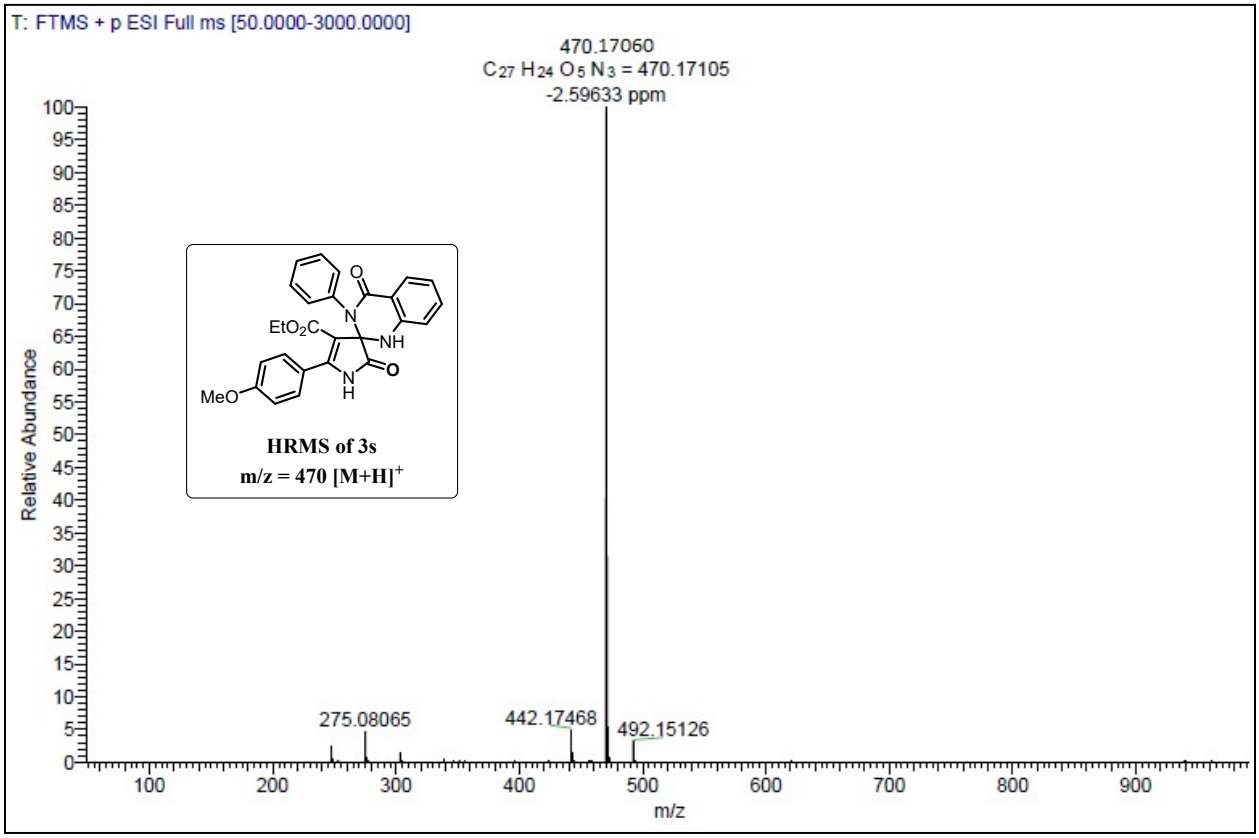

Transmittance [%]
Wavenumber cm-1
3401.21
2991.59
2255.58
2128.74
1747.50
1649.87
1519.59
1450.87
1368.39
1242.04
1106.66
998.28
823.73
756.77
664.03
624.37
EtO2C
NH
O
N
H
Me
FT-IR of 3r

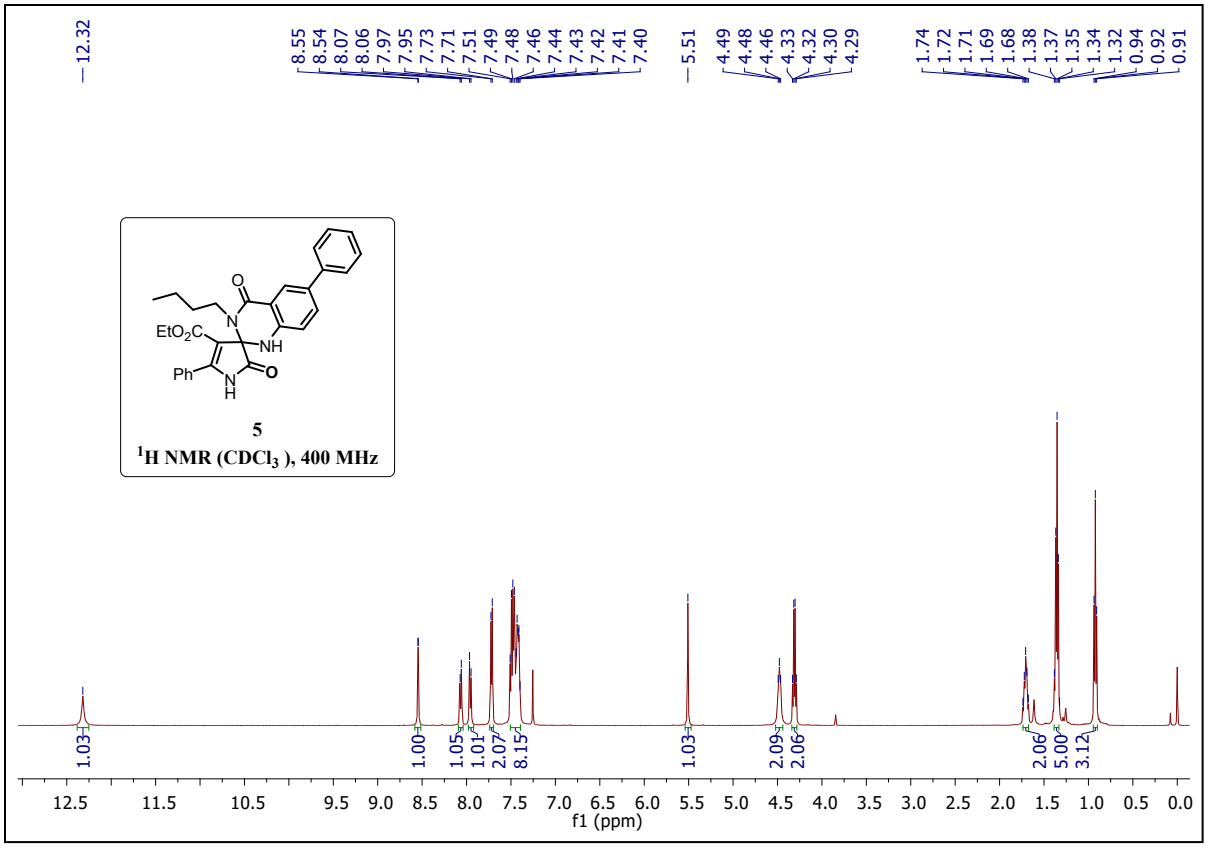

454.17561
C27 H24 O4 N3 = 454.17613
-2.40959 ppm
Relative Abundance
m/z
275.08075
247.08584
303.11183
EtO2C
NH
O
N
H
Me
HRMS of 3r
m/z = 454 [M+H]+

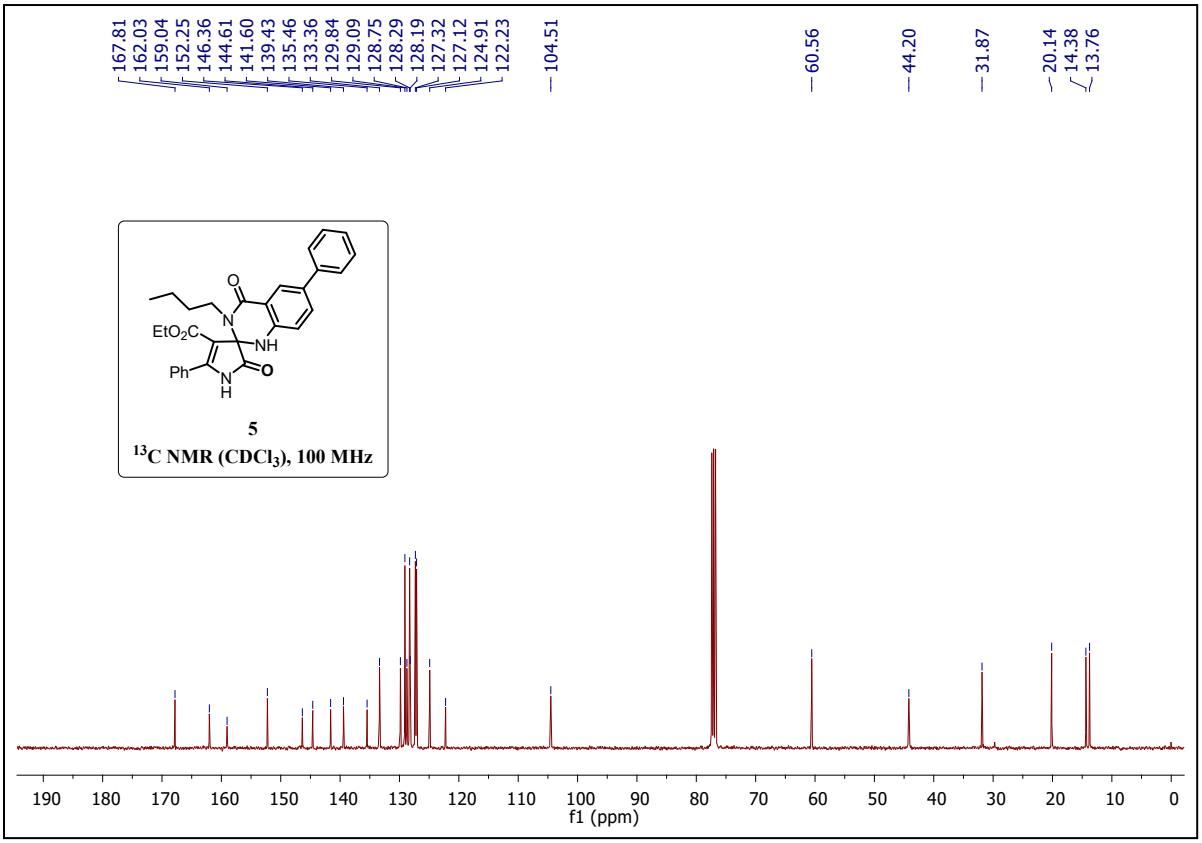

10.46
7.75
7.73
7.45
7.43
7.42
7.41
7.38
7.38
7.37
7.36
7.34
7.27
7.25
7.24
7.22
7.14
7.12
6.87
6.85
6.68
6.67
6.65
3.99
3.97
3.97
3.96
3.78
0.92
0.91
0.89
EtO2C
NH
O
N
H
MeO
3s
1H NMR (CDCl3 + DMSO-d6),
400 MHz
0.99
1.01
1.03
2.06
4.07
2.00
2.00
2.02
1.99
3.10
3.00
f1 (ppm)

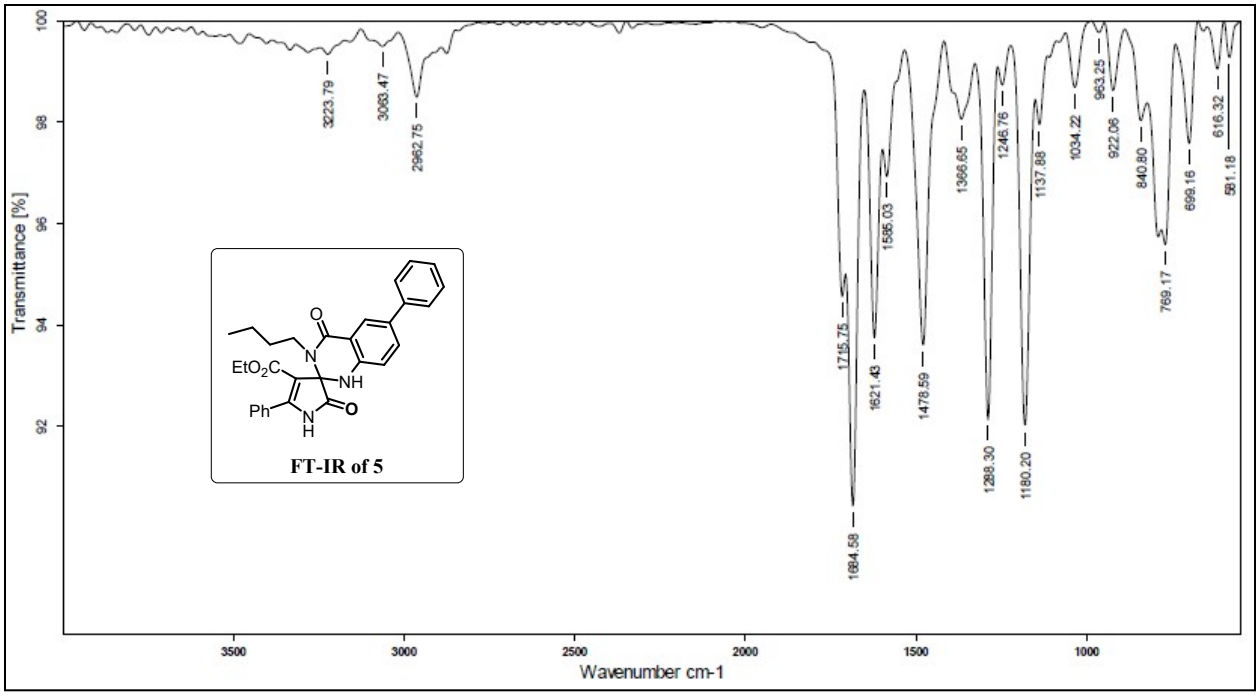

175.47
162.74
161.73
158.21
154.31
144.83
132.52
129.87
129.82
129.25
127.68
113.20
113.05
106.70
78.35
58.79
54.50
12.85
EtO2C
NH
O
N
H
MeO
3s
13C NMR (CDCl3 + DMSO-d6),
100 MHz
f1 (ppm)


Transmittance [%]
Wavenumber cm-1
3403.94
1652.86
1216.92
998.41
823.52
754.87
664.97
621.15
EtO2C
MeO
NH
O
N
H
FT-IR of 3s

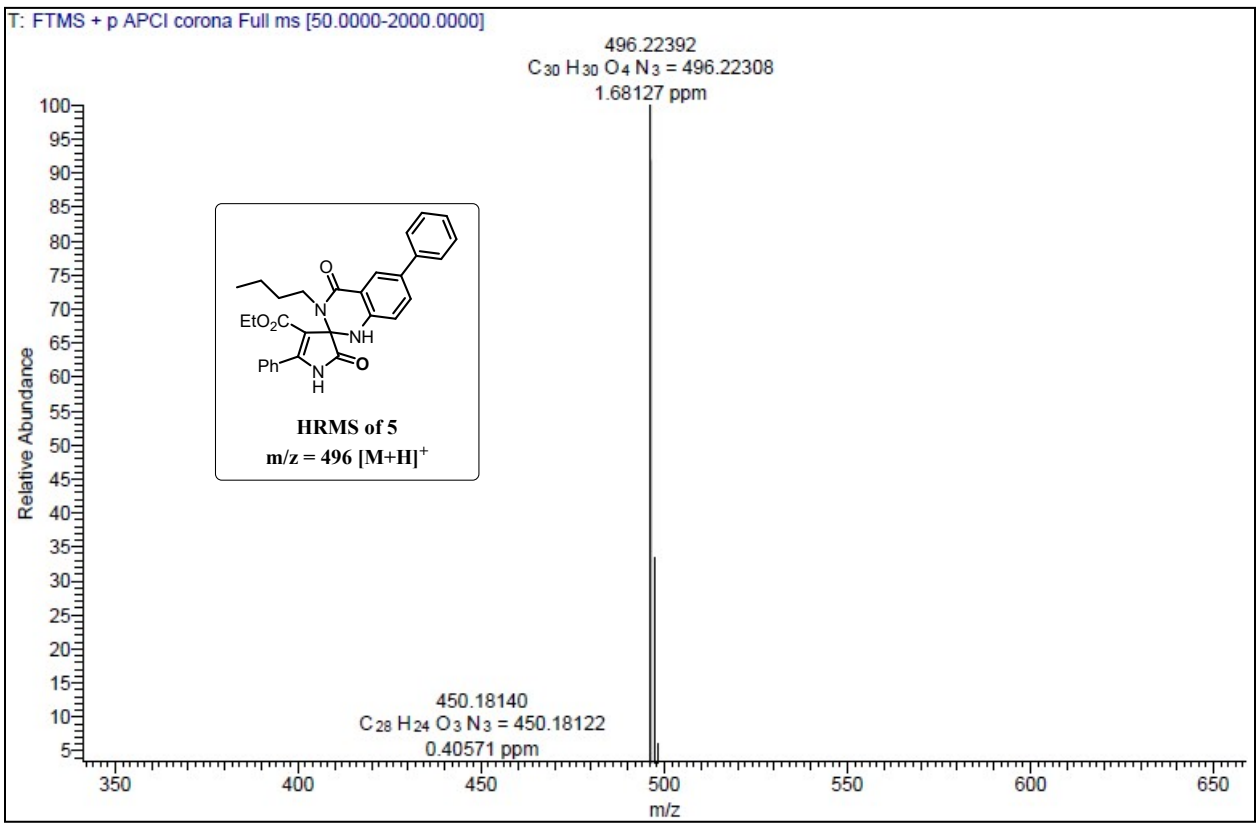

T: FTMS + p ESI Full ms [50.0000-3000.0000]
470.17060
C27 H24 O5 N3 = 470.17105
-2.59633 ppm
Relative Abundance
m/z
275.08065
442.17468
492.15126
EtO2C
MeO
NH
O
N
H
HRMS of 3s
m/z = 470 [M+H]+


12.32
8.55
8.54
8.07
8.06
7.97
7.95
7.73
7.71
7.51
7.49
7.48
7.46
7.44
7.43
7.42
7.41
7.40
5.51
4.49
4.48
4.46
4.33
4.32
4.30
4.29
1.74
1.72
1.71
1.69
1.68
1.38
1.37
1.35
1.34
1.32
0.94
0.92
0.91
EtO2C
NH
Ph
N
H
O
5
1H NMR (CDCl3), 400 MHz
1.03
1.00
1.05
1.01
2.07
8.15
1.03
2.09
2.06
2.06
5.00
3.12
f1 (ppm)


167.81
162.03
159.04
152.25
146.36
144.61
141.60
139.43
135.46
133.36
129.84
129.09
128.75
128.29
128.19
127.32
127.12
124.91
122.23
104.51
60.56
44.20
31.87
20.14
14.38
13.76
EtO2C
NH
Ph
N
H
O
5
13C NMR (CDCl3), 100 MHz
f1 (ppm)

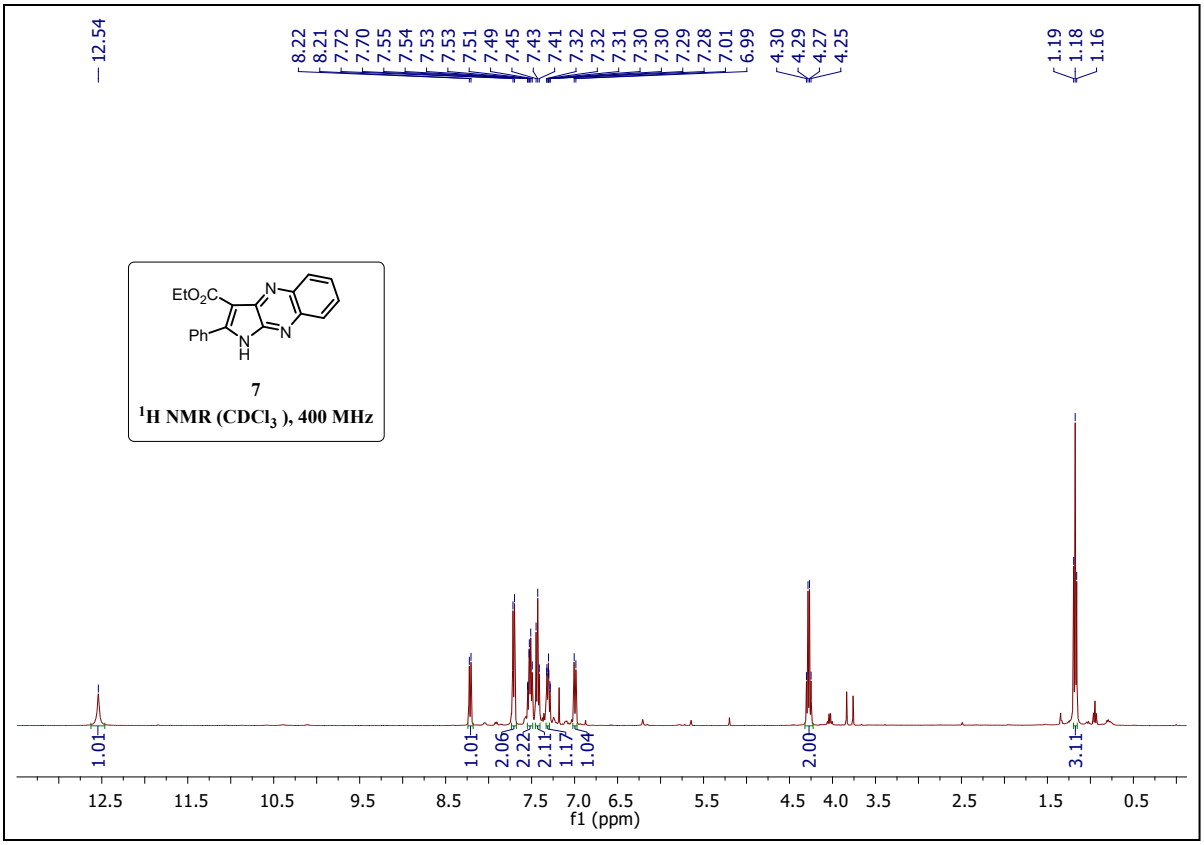


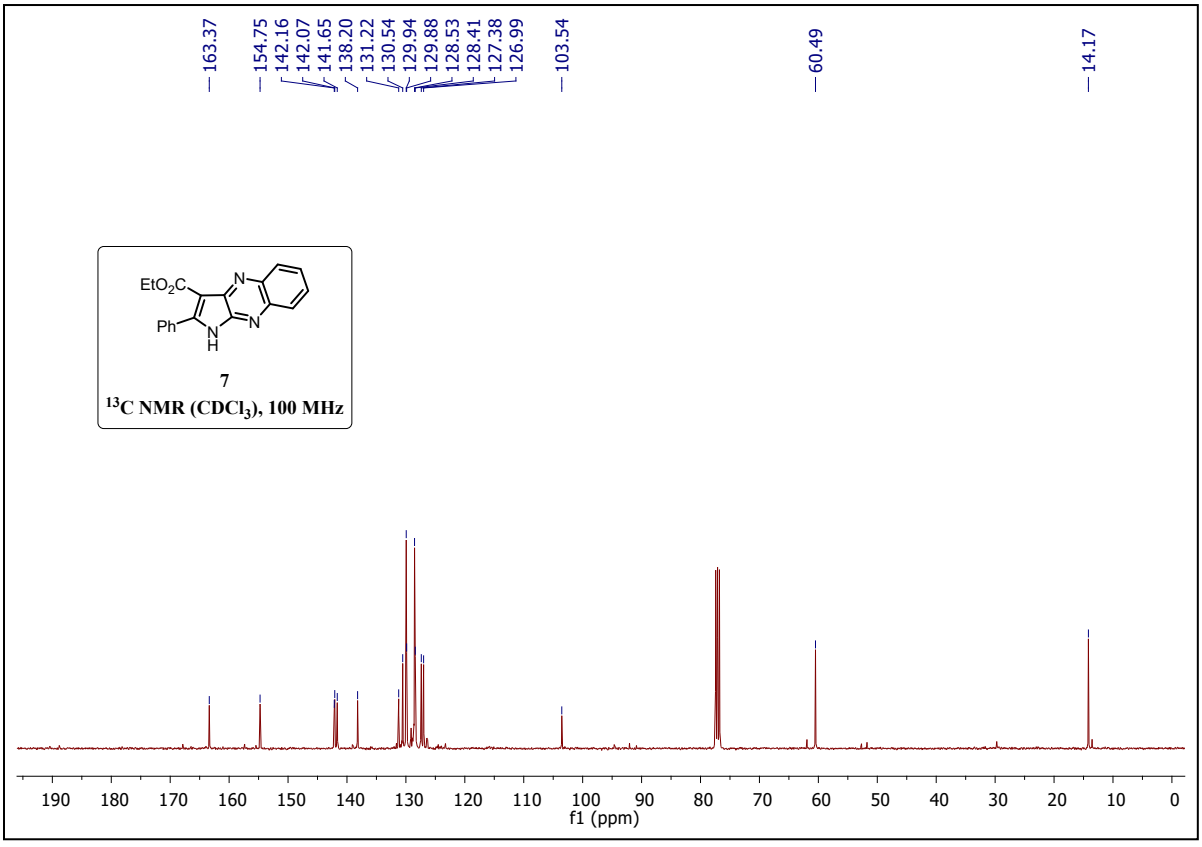
FT-IR of 5

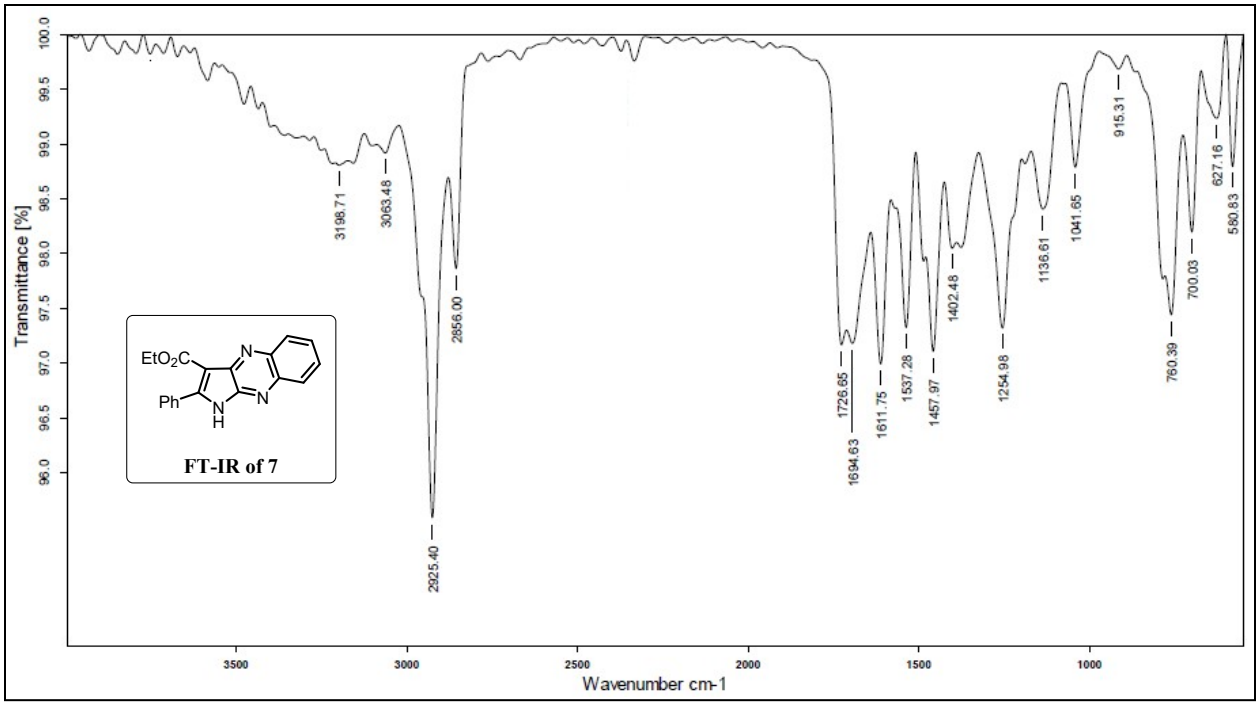


HRMS of 5

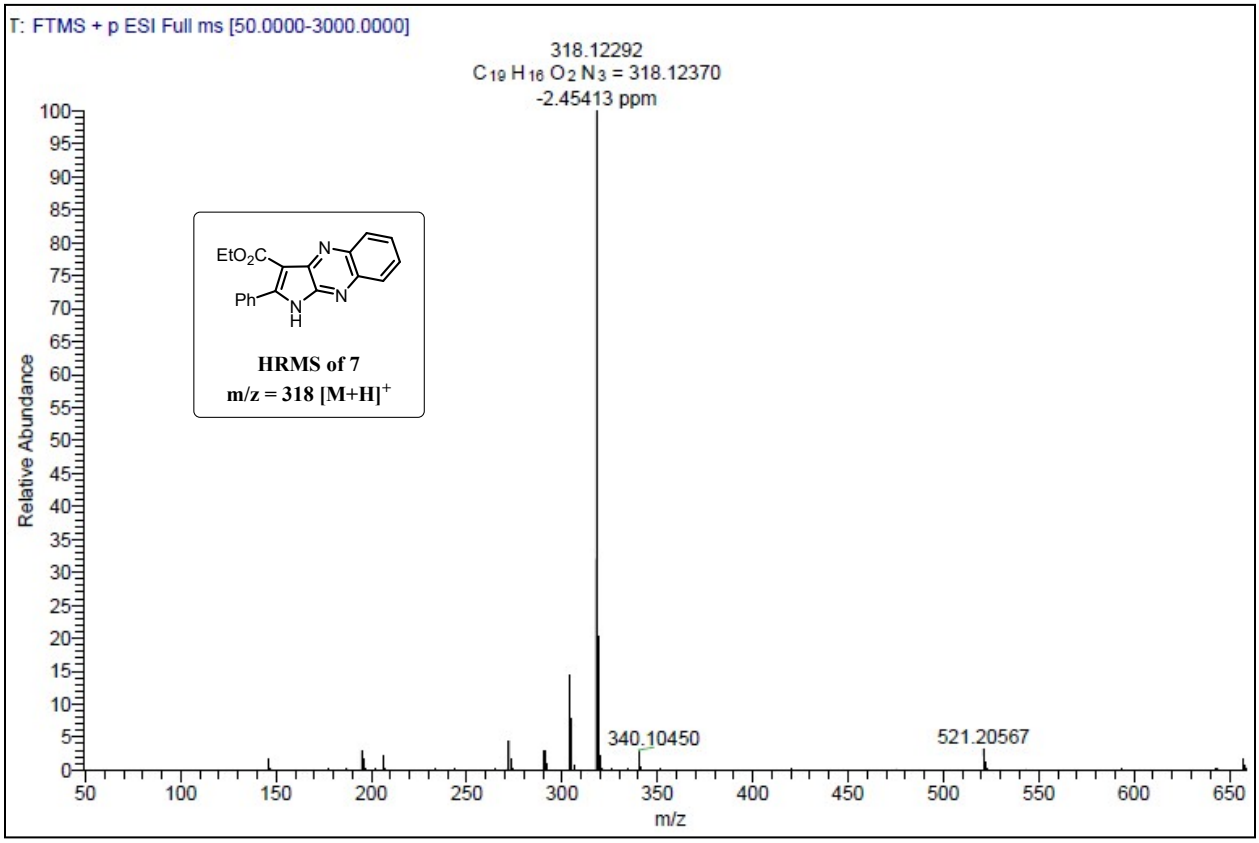
m/z = 496 $[M+H]^+$


12.54
8.22
8.21
7.72
7.70
7.55
7.54
7.53
7.53
7.51
7.49
7.45
7.43
7.41
7.32
7.32
7.31
7.30
7.30
7.29
7.28
7.01
6.99
4.30
4.29
4.27
4.25
1.19
1.18
1.16
EtO2C
Ph
N
H
7
1H NMR (CDCl3), 400 MHz
1.01
1.01
2.06
2.22
2.11
1.17
1.04
2.00
3.11
12.5
11.5
10.5
9.5
8.5
7.5
7.0
6.5
5.5
4.5
4.0
3.5
2.5
1.5
0.5
f1 (ppm)


163.37
154.75
142.16
142.07
141.65
138.20
131.22
130.54
129.94
129.88
128.53
128.41
127.38
126.99
103.54
60.49
14.17
EtO2C
Ph
N
H
7
13C NMR (CDCl3), 100 MHz
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



FT-IR of 7



HRMS of 7

m/z = 318 $[M+H]^+$