Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

Convenient synthesis of functionalized spiro[indoline-3,2'-pyrrolizines] or spiro[indoline-3,3'-pyrrolidines] via multicomponent reactions of α-amino acids, dialkyl acetylenedicarboxylates and 3-methyleneoxindoles

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Supporting Information

X-Ray Crystallographic Data: CIF in separate file.

Crystallographic data **1a** (CCDC 1035527), **1a'** (CCDC 1035528), **2a** (CCDC 1035529), **2f** (CCDC 1035530), **2k** (CCDC 1035531), **3b** (CCDC 1051423), **3c** (CCDC 1051424), **4a** (CCDC 1051425), **4e** (CCDC 1051426), and **4i** (CCDC 1051427) have been deposited at the Cambridge Crystallographic Database Centre and is available on request from the Director, CCDC, 12 Union Road, Cambridge, CB2 1EZ, UK (http//www.ccdc.cam.ac.uk).

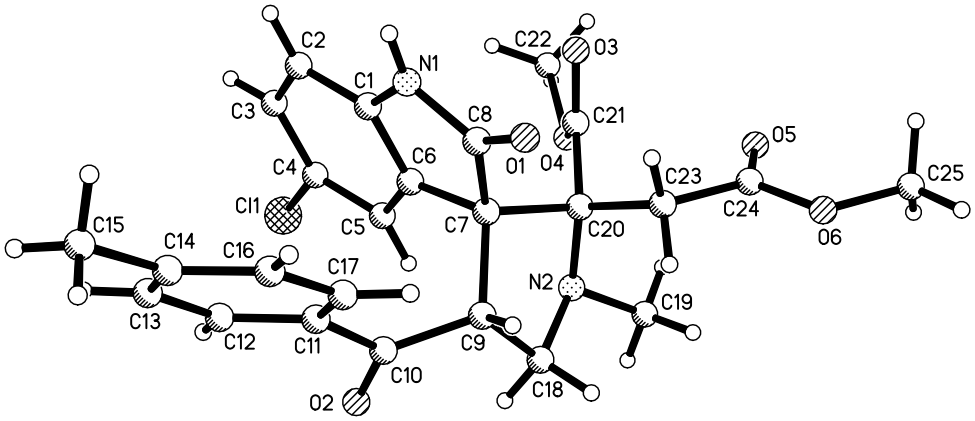


Fig. s1 Molecular structure of **2f**

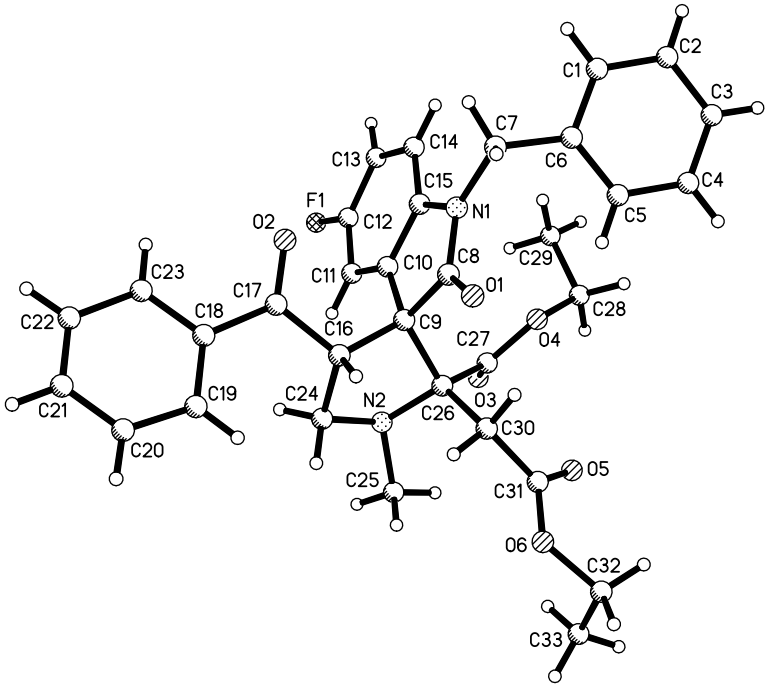


Fig. s2 Molecular structure of **2k**

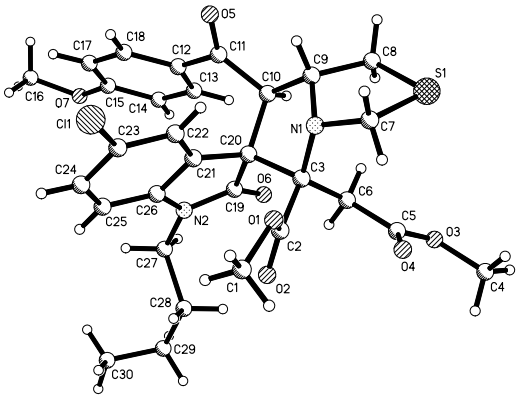


Fig. s3 Molecular structure of compound **3c**

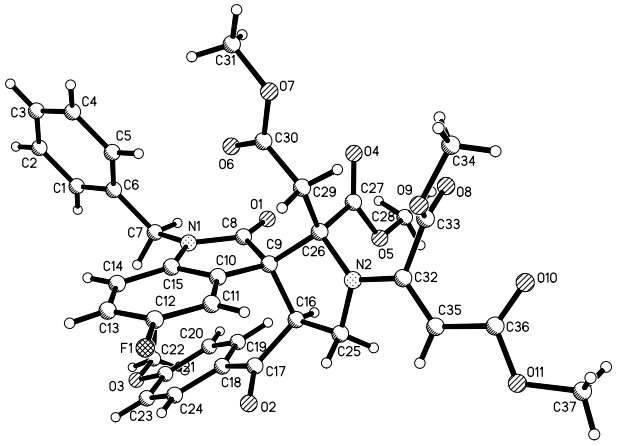


Fig. s4 Molecular structure of compound **4a**

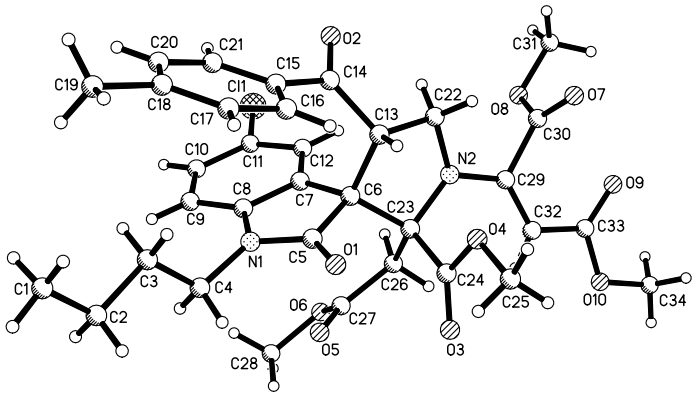


Fig. s5 Molecular structure of compound **4e**

1. General procedure for the preparation of functionalized spiro[indoline-3,3'-pyrrolidines] 1a-n and 2a-l from three-component reaction: A mixture of L-proline (sarcosine, thiazolidine-4-carboxylic acid) (1.2 mmol) dialkyl acetylenedicarboxylate (1.2 mmol) in ethanol (15.0 mL) was stirred at room temperature for about twenty minutes. Then, 3-phenacylideneoxindole (1.0 mmol) was added. The mixture was refluxed for about six hours. The solvent was removed at reduced pressure by rotator evaporation, the residue was subjected to preparative thin-layer chromatography (20 x 30 cm^2 Silicon gel GF254) with a mixture of light petroleum and ethyl acetate (V/V = 2:1) as developing reagent to give the pure product.

Methyl 1-benzyl-5-chloro-3'-(2-methoxy-2-oxoethyl)-1'-(4-methylbenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1a): white solid, 72%, m.p. 198-200℃; ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.41 (d, *J* = 7.8Hz, 2H, ArH), 7.35 (s, 1H, ArH), 7.22-7.19 (m, 3H, ArH), 7.06 (d, *J* = 7.8Hz, 2H, ArH), 7.01-7.00 (m, 3H, ArH), 6.29 (d, *J* = 8.4Hz, 1H, ArH), 4.85-4.82 (m, 1H, CH), 4.78 (d, *J* = 15.6Hz, 1H, CH), 4.32 (d, *J* = 15.6Hz, 1H, CH), 4.27 (d, *J* = 9.0Hz, 1H, CH), 3.70 (s, 3H, OCH_3), 3.48-3.45 (m, 1H, CH), 3.31 (s, 3H, OCH_3), 3.27-3.12 (m, 3H, CH), 2.34 (s, 3H, CH_3), 2.30-2.16 (m, 3H, CH), 1.68 (brs, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.3, 175.1, 171.3, 171.1, 143.9, 140.4, 134.9, 134.8, 128.9, 128.7, 128.6, 128.2, 127.9, 127.6, 127.0, 126.9, 109.3, 67.6, 66.3, 57.9, 52.2, 52.0, 47.3, 44.1, 38.4, 30.9, 27.1, 21.6; IR (KBr) υ: 3057, 3031, 2949, 2873, 1738, 1722, 1693, 1653, 1608, 1558, 1541, 1483, 1456, 1432, 1399, 1351, 1295, 1252, 1209, 1186, 1171, 1105, 1076, 1033, 1006, 933, 881, 820, 765, 738 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{34}H_{34}ClN_2O_6$ ($[M+H]^+$): 601.2100. Found: 601.2109.

Methyl 1-benzyl-5-chloro-3'-(2-methoxy-2-oxoethyl)-1'-(4-methylbenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1a'): white solid, 13%, m.p. 200-202℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.72 (d, *J* = 7.6Hz, 2H, ArH), 7.52-7.50 (m, 2H, ArH), 7.39-7.36 (m, 2H, ArH), 7.32-7.28 (m, 1H, ArH), 7.23-7.21 (m, 2H, ArH), 7.09 (dd, J_1 = 8.4Hz, J_2 = 2.0Hz, 1H, ArH), 6.93 (d, *J* = 2.0Hz, 1H, ArH), 6.63 (d, *J* = 8.4Hz, 1H, ArH), 5.52 (d, *J* = 15.6Hz, 1H, CH), 4.88 (d, *J* = 15.6Hz, 1H, CH), 4.73 (d, *J* = 9.6Hz, 1H, CH), 4.32 (brs, 1H, CH), 3.64 (s, 3H, OCH_3), 3.54 (s, 3H, OCH_3), 3.20-3.06 (m, 2H, CH), 2.82 (brs, 1H, CH), 2.63-2.59 (m, 1H, CH), 2.39 (s, 3H, CH_3), 2.21-2.19 (m, 2H, CH), 2.02-1.80 (m, 2H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.8, 175.9, 172.1, 171.3, 144.4, 142.5, 135.8, 134.0, 129.1, 129.0, 128.9, 128.8, 127.8, 127.7, 127.1, 126.7, 123.6, 110.1, 73.6, 66.7, 65.5, 58.0, 51.4, 48.5, 44.5, 39.2, 32.6, 30.1, 21.6; (KBr) υ: 3062, 2994, 2974, 2947, 2889, 1746, 1731, 1715, 1668, 1608, 1559, 1541, 1489, 1456, 1436, 1401, 1362, 1330, 1281, 1240, 1209, 1171, 1081, 1010, 954, 876, 822, 782, 742, 704 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{34}H_{34}ClN_2O_6$ ($[M+H]^+$): 601.2100. Found: 601.2103.

Methyl 1-benzyl-3'-(2-methoxy-2-oxoethyl)-5-methyl-1'-(4-methylbenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1b): white solid, 71%, m.p. 190-192℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.34 (d, *J* = 7.6Hz, 2H, ArH), 7.20 (brs, 3H, ArH), 7.13 (s, 1H, ArH), 7.03-7.01 (m, 4H, ArH), 6.79 (d, *J* = 7.6Hz, 1H, ArH), 6.22 (d, *J* = 7.6Hz, 1H, ArH), 4.86 (brs, 1H, CH), 4.77 (d, *J* = 16.0Hz, 1H, CH), 4.24-4.20 (m, 2H, CH), 3.68 (s, 3H, OCH_3), 3.42 (d, *J* = 17.2Hz, 1H, CH), 3.30 (d, *J* = 17.2Hz, 1H, CH), 3.18 (s, 4H, OCH_3, CH), 3.04 (brs, 1H, CH), 2.32 (s, 3H, CH_3), 2.27 (s, 4H, CH_3, CH), 2.13 (brs, 2H, CH), 1.64 (brs, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 197.1, 175.6, 171.5, 171.3, 143.4, 139.3, 135.4, 135.2, 131.8, 128.8, 128.7, 128.6, 128.1, 127.4, 127.2, 127.0, 126.4, 108.0, 67.5, 66.5, 58.4, 52.0, 51.6, 47.2, 43.9, 35.8, 30.5, 26.7, 21.5, 21.1; IR (KBr) υ: 3027, 2917, 2864, 1736, 1680, 1607, 1495, 1434, 1353, 1294, 1231, 1204, 1157, 1078, 1034, 993, 880, 824, 739 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{35}H_{37}N_2O_6$ ($[M+H]^+$): 581.2646. Found: 581.2661.

Methyl 1-benzyl-3'-(2-methoxy-2-oxoethyl)-1'-(4-methoxybenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1c): white solid, 76%, m.p. 196-198℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.51 (d, *J* = 8.4Hz, 2H, ArH), 7.38 (d, *J* = 7.2Hz, 1H, ArH), 7.20-7.19 (m, 3H, ArH), 7.03-

7.00 (m, 3H, ArH), 6.97-6.94 (m, 1H, ArH), 6.73 (d, J = 8.4Hz, 2H, ArH), 6.38 (d, J = 7.2Hz, 1H, ArH), 4.87 (brs, 1H, CH), 4.80 (d, J = 15.6Hz, 1H, CH), 4.38 (d, J = 15.6Hz, 1H, CH), 4.25 (d, J = 10.0Hz, 1H, CH), 3.80 (s, 3H, OCH_3), 3.69 (s, 3H, OCH_3), 3.48 (d, J = 17.2Hz, 1H, CH), 3.29 (d, J = 17.2Hz, 1H, CH), 3.17 (s, 3H, OCH_3), 3.07 (brs, 1H, CH), 2.26 (brs, 1H, CH), 2.14 (brs, 2H, CH), 1.63 (brs, 2H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 195.3, 175.6, 171.3, 163.4, 141.7, 135.3, 130.5, 130.4, 128.6, 127.4, 127.0, 126.8, 126.4, 122.4, 113.4, 108.4, 67.7, 66.6, 57.6, 55.4, 52.0, 51.7, 47.2, 43.9, 38.5, 30.7, 27.0; IR (KBr) υ: 3028, 2944, 1739, 1698, 1664, 1603, 1575, 1488, 1467, 1434, 1347, 1262, 1221, 1187, 1153, 1080, 1024, 989, 944, 851, 782, 759, 732, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{34}H_{35}N_2O_7$ ([M+H]$^+$): 583.2439. Found: 583.2448.

Methyl 1-benzyl-1'-(4-chlorobenzoyl)-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1d): white solid, 80%, m.p. 212-214℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.36-7.33 (m, 2H, ArH), 7.30 (d, J = 7.2Hz, 1H, ArH), 7.25-7.23 (m, 3H, ArH), 7.18-7.16 (m, 2H, ArH), 7.08-7.06 (m, 2H, ArH), 7.03-7.01 (m, 1H, ArH), 6.96-6.93 (m, 1H, ArH), 6.40 (d, J = 8.0Hz, 1H, ArH), 4.87-4.81 (brs, 2H, CH), 4.26 (d, J = 15.6Hz, 1H, CH), 4.19 (d, J = 9.6Hz, 1H, CH), 3.68 (s, 3H, OCH_3), 3.40 (d, J = 17.2Hz, 1H, CH), 3.27 (d, J = 17.2Hz, 1H, CH), 3.15 (s, 3H, OCH_3), 3.04 (brs, 1H, CH), 2.31-2.28 (m, 1H, CH), 2.15-2.13 (m, 2H, CH), 1.67-1.63 (m, 2H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.4, 175.7, 171.3, 171.2, 141.7, 139.1, 135.8, 135.1, 129.3, 128.8, 128.7, 128.4, 127.6, 127.1, 126.5, 126.2, 122.5, 108.4, 77.5, 67.4, 66.2, 58.6, 52.1, 51.7, 47.1, 44.0, 38.4, 30.5, 26.7; IR (KBr) υ: 3062, 2905, 2827, 1741, 1697, 1611, 1488, 1454, 1434, 1367, 1350, 1281, 1247, 1227, 1199, 1151, 1086, 1000, 938, 846, 750, 703 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{33}H_{32}ClN_2O_6$ ([M+H]$^+$): 587.1943. Found: 587.1947.

Methyl 1-benzyl-5-fluoro-3'-(2-methoxy-2-oxoethyl)-1'-(3-methoxybenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1e): white solid, 70%, m.p. 166-168℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.35 (brs, 2H, ArH), 7.30 (d, J = 8.0Hz, 1H, ArH), 7.16-7.06 (m, 5H, ArH), 6.84-6.81 (m, 3H, ArH), 6.34 (dd, J_1 = 8.4Hz, J_2 = 4.0Hz, 1H, ArH), 4.98 (d, J = 8.8Hz, 1H, CH), 4.52-4.43 (m, 3H, CH), 3.89 (s, 3H, OCH_3), 3.77 (s, 3H, OCH_3), 3.52 (s, 3H, OCH_3), 2.99-2.97 (m, 2H, CH), 2.53-2.43 (m, 2H, CH), 2.30 (brs, 1H, CH), 2.07 (brs, 2H, CH), 1.90 (brs, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.6, 173.3, 171.7, 170.6, 159.6, 158.9 (d, J = 239.1Hz), 138.8, 138.4, 135.2, 129.4, 128.6, 127.7, 127.6, 127.3, 126.9, 121.3, 120.8, 115.2, 115.3 (d, J = 22.6Hz), 115.0 (d, J = 24.2Hz), 115.1 (d, J = 46.8Hz), 111.7, 109.6 (d, J = 8.0Hz), 75.5, 67.8, 67.1, 55.4, 54.9, 52.2, 51.4, 47.3, 44.3, 40.7, 30.5; IR (KBr) υ: 2981, 2949, 2883, 2837, 1730, 1709, 1677, 1558, 1491, 1472, 1455, 1363, 1346, 1276, 1258, 1201, 1177, 1142, 1034, 996, 870, 820, 787, 742 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{34}H_{34}FN_2O_7$ ([M+H]$^+$): 601.2345. Found: 601.2345.

Methyl 1'-benzoyl-1-benzyl-5-fluoro-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1f): white solid, 73%, m.p. 177-179℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.65 (d, J = 7.2Hz, 2H, ArH), 7.53-7.49 (m, 1H, ArH), 7.40-7.33 (m, 3H, ArH), 7.16-7.07 (m, 3H, ArH), 6.85-6.80 (m, 3H, ArH), 6.32 (dd, J_1 = 8.8Hz, J_2 = 4.0Hz, 1H, ArH), 4.97 (d, J = 8.8Hz, 1H, CH), 4.50-4.48 (m, 2H, CH), 4.28 (d, J = 16.0Hz, 1H, CH), 3.88 (s, 3H, OCH_3), 3.52 (s, 3H, OCH_3), 2.99-2.97 (m, 2H, CH), 2.52-2.43 (m, 2H, CH), 2.32-2.29 (m, 1H, CH), 2.12-2.00 (m, 2H, CH), 1.90-1.87 (m, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 197.0, 173.2, 171.6, 170.6, 158.9 (d, J = 239.7Hz), 138.7, 137.2, 135.2, 133.2, 128.6, 128.4, 128.3, 127.3 (2C), 126.9, 115.2, 115.3 (d, J = 23.8Hz), 115.0 (d, J = 25.0Hz), 109.7 (d, J = 8.0Hz), 75.4, 67.8, 67.0, 55.0, 52.2, 51.4, 47.4, 44.2, 40.8, 30.6, 30.5; IR (KBr) υ: 3067, 2952, 2881, 1753, 1677, 1617, 1492, 1454, 1373, 1345, 1277, 1209, 1175, 1088, 1035, 1003, 972, 904, 874, 823, 773, 734 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{33}H_{32}FN_2O_6$ ([M+H]$^+$): 571.2239. Found: 571.2242.

Methyl 1-butyl-5-fluoro-3'-(2-methoxy-2-oxoethyl)-1'-(4-methylbenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1g): white solid, 69%, m.p. 160-162℃; ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.36-7.34 (m, 2H, ArH), 7.10-7.09 (m, 1H, ArH), 7.06-7.04 (m, 2H, ArH), 6.83-6.81 (m,

1H, ArH), 6.42-6.40 (m, 1H, ArH), 4.78 (brs, 1H, CH), 4.19 (d, J = 9.6Hz, 1H, CH), 3.67 (s, 3H, OCH_3), 3.46-3.43 (m, 1H, CH), 3.40-3.37 (m, 1H, CH), 3.30 (s, 3H, OCH_3), 3.26-3.23 (m, 2H, CH), 3.17-3.14 (m, 1H, CH), 3.02 (brs, 1H, CH), 2.31 (s, 3H, CH_3), 2.26-2.25 (m, 1H, CH), 2.12-2.11 (m, 2H, CH), 1.64-1.62 (m, 1H, CH), 1.31-1.27 (m, 2H, CH_2), 1.24-1.22 (m, 2H, CH_2), 0.87 (t, J = 6.6Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.8, 175.1, 171.3, 171.2, 158.6 (d, J = 239.4Hz), 143.6, 138.1, 138.0, 135.0, 128.8, 128.3, 128.2, 128.0, 114.9 (d, J = 23.4Hz), 114.7 (d, J = 25.8Hz), 107.8 (d, J = 8.1Hz), 77.3, 67.4, 66.4, 58.2, 52.0, 51.7, 47.1, 40.1, 38.2, 30.6, 29.1, 26.7, 21.5, 20.0, 13.7; IR (KBr) υ: 2952, 2873, 1771, 1743, 1678, 1608, 1492, 1454, 1359, 1271, 1223, 1194, 1165, 1134, 1097, 1000, 976, 878, 824, 727 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{31}H_{36}FN_2O_6$ ([M+H]$^+$): 551.2552. Found: 551.2554.

Methyl 1'-benzoyl-1-benzyl-5-chloro-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1h): white solid, 72%, m.p. 192-194℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.66 (d, J = 7.2Hz, 2H, ArH), 7.54-7.50 (m, 2H, ArH), 7.40-7.34 (m, 2H, ArH), 7.14-7.08 (m, 4H, ArH), 6.83 (d, J = 7.2Hz, 2H, ArH), 6.33 (d, J = 8.0Hz, 1H, ArH), 4.98 (d, J = 10.8Hz, 1H, CH), 4.51-4.47 (m, 2H, CH), 4.31 (d, J = 15.6Hz, 1H, CH), 3.88 (s, 3H, OCH_3), 3.52 (s, 3H, OCH_3), 2.99-2.98 (m, 2H, CH), 2.54-2.43 (m, 2H, CH), 2.29 (brs, 1H, CH), 2.08 (brs, 2H, CH), 1.88 (brs, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.9, 173.1, 171.7, 170.5, 141.3, 137.2, 135.1, 133.2, 128.9, 128.7, 128.6, 128.4, 128.2, 127.9, 127.7, 127.3, 127.1, 126.9, 124.9, 110.1, 67.5, 66.9, 55.1, 52.3, 51.4, 47.3, 44.2, 41.3, 40.8, 39.8, 30.5; IR (KBr) υ: 3066, 3023, 2977, 2952, 2882, 1729, 1678, 1653, 1609, 1595, 1577, 1558, 1541, 1483, 1433, 1373, 1343, 1276, 1207, 1178, 1097, 7078, 1049, 1031, 1002, 967, 943, 903, 844, 823, 753, 736 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{33}H_{32}ClN_2O_6$ ([M+H]$^+$): 587.1943. Found: 587.1950.

Methyl 1-benzyl-5-chloro-1'-(4-chlorobenzoyl)-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1i): white solid, 71%, m.p. 202-204℃; ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.74 (d, J = 8.4Hz, 2H, ArH), 7.50-7.49 (m, 2H, ArH), 7.40-7.35 (m, 4H, ArH), 7.30-7.28 (m, 1H, ArH), 7.10 (d, J = 8.4Hz, 1H, ArH), 6.94 (s, 1H, ArH), 6.62 (d, J = 8.4Hz, 1H, ArH), 5.16 (d, J = 15.6Hz, 1H, CH), 4.88 (d, J = 15.6Hz, 1H, CH), 4.68 (d, J = 9.6Hz, 1H, CH), 4.32 (brs, 1H, CH), 3.64 (s, 3H, OCH_3), 3.52 (s, 3H, OCH_3), 3.18-3.17 (m, 1H, CH), 3.07 (brs, 1H, CH), 2.84-2.81 (m, 1H, CH), 2.60 (d, J = 16.8Hz, 1H, CH), 2.24-2.20 (m, 1H, CH), 2.15-2.08 (m, 1H, CH), 2.03-1.99 (m, 1H, CH), 1.77-1.76 (m, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.2, 175.6, 172.0, 171.2, 142.4, 139.9, 135.6, 134.8, 130.1, 129.1, 128.8, 128.7, 127.8, 127.7, 127.2, 126.5, 123.5, 110.2, 73.6, 66.5, 65.4, 58.0, 51.5, 51.4, 48.5, 44.5, 39.0, 32.6, 30.0; IR (KBr) υ: 3085, 3065, 3030, 2975, 2951, 2885, 1727, 1687, 1652, 1611, 1587, 1541, 1488, 1455, 1433, 1399, 1332, 1280, 1255, 1238, 1217, 1199, 1170, 1083, 1037, 1007, 990, 958, 922, 898, 873, 851, 811, 745, 704 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{33}H_{31}Cl_2N_2O_6$ ([M+H]$^+$): 621.1554. Found: 621.1563.

Methyl 1-butyl-5-chloro-3'-(2-methoxy-2-oxoethyl)-1'-(4-methoxybenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1j): white solid, 67%, m.p. 175-176℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.48 (d, J = 8.8Hz, 2H, ArH), 7.31 (brs, 1H, ArH), 7.09 (d, J_1 = 8.0Hz, J_2 = 2.0Hz, 1H, ArH), 6.74 (d, J = 8.8Hz, 2H, ArH), 6.43 (d, J = 8.8Hz, 1H, ArH), 4.80 (brs, 1H, CH), 4.16 (d, J = 10.0Hz, 1H, CH), 3.79 (s, 3H, OCH_3), 3.67 (s, 3H, OCH_3), 3.50-3.44 (m, 1H, CH), 3.34 (s, 4H, OCH_3, CH), 3.30-3.21 (m, 2H, CH), 3.14 (brs, 1H, CH), 3.03 (brs, 1H, CH), 2.25 (brs, 1H, CH), 2.12 (brs, 2H, CH), 1.63 (brs, 1H, CH), 1.35-1.29 (m, 2H, CH_2), 1.24-1.18 (m, 2H, CH_2), 0.86 (t, J = 7.2Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 195.2, 175.1, 171.1, 163.4, 140.6, 130.5, 130.3, 128.5, 127.6, 126.9, 113.3, 108.4, 77.5, 67.7, 66.5, 57.9, 55.4, 52.0, 51.8, 47.1, 40.1, 38.2, 30.5, 29.1, 26.6, 20.0, 13.6; IR (KBr) υ: 3076, 2955, 2873, 1743, 1691, 1666, 1603, 1511, 1486, 1433, 1357, 1244, 1174, 1136, 1094, 1031, 974, 878, 830, 729 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{31}H_{36}ClN_2O_7$ ([M+H]$^+$): 583.2206. Found: 583.2209.

Ethyl 1-benzyl-5-chloro-3'-(2-ethoxy-2-oxoethyl)-1'-(4-methylbenzoyl)-2-oxo-1',3',5',6',7',7a'-

hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1k): white solid, 72%, m.p. 198-200℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.47-7.44 (m, 3H, ArH), 7.18-7.16 (m, 3H, ArH), 7.09-7.08 (m, 2H, ArH), 7.01-6.97 (m, 3H, ArH), 6.27 (d, *J* = 8.4Hz, 1H, ArH), 4.74-4.70 (m, 2H, CH), 4.37 (d, *J* = 16.0Hz, 1H, CH), 4.28 (d, *J* = 9.6Hz, 1H, CH), 4.16-4.13 (m, 2H, CH), 3.78 (brs, 1H, CH), 3.66 (brs, 1H, CH), 3.55-3.51 (m, 1H, CH), 3.21-3.10 (m, 3H, CH), 2.35 (s, 3H, CH_3), 2.22-2.15 (m, 3H, CH), 1.65 (brs, 1H, CH), 1.25 (t, *J* = 7.2Hz, 3H, CH_3), 0.79 (brs, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.3, 175.0, 170.7, 170.6, 143.9, 140.5, 134.9, 134.8, 129.0, 128.7, 128.5, 128.2, 127.8, 127.6, 127.2, 126.9, 109.2, 76.9, 67.4, 66.4, 60.9, 60.8, 57.7, 47.1, 44.0, 38.7, 31.0, 27.4, 21.6, 14.1, 13.4; IR (KBr) υ: 3066, 2978, 2869, 1700, 1679, 1609, 1484, 1432, 1347, 1292, 1190, 1154, 1097, 1029, 903, 851, 829, 736, 710 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{36}H_{38}ClN_2O_6$ ($[M+H]^+$): 629.2413. Found: 629.2420.

1'-Ethyl 3'-methyl 1-benzyl-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-1',3'-dicarboxylate (1l): white solid, 68%, m.p. 188-190℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.41 (brs, 3H, ArH), 7.34 (brs, 2H, ArH), 7.29-7.27 (m, 1H, ArH), 7.14 (brs, 1H, ArH), 6.95 (brs, 1H, ArH), 6.69-6.68 (m, 1H, ArH), 5.12 (d, *J* = 15.2Hz, 1H, CH), 4.76 (d, *J* = 15.2Hz, 1H, CH), 4.42 (brs, 1H, CH), 3.78-3.75 (m, 1H, CH), 3.67 (s, 3H, OCH_3), 3.64-3.60 (m, 2H, CH), 3.42 (d, *J* = 8.4Hz, 1H, CH), 3.09 (s, 3H, OCH_3), 3.02-2.93 (m, 2H, CH), 2.29 (brs, 1H, CH), 2.14 (brs, 2H, CH), 1.63 (brs, 2H, CH), 0.62 (brs, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 175.2, 171.6, 171.4, 169.1, 142.8, 135.8, 128.8, 128.7, 127.7, 127.6, 127.1, 125.6, 122.4, 108.3, 75.2, 66.1, 64.6, 60.5, 55.6, 52.0, 51.6, 46.9, 44.3, 38.3, 32.0, 28.3, 13.4; IR (KBr) υ: 2945, 2877, 1764, 1728, 1697, 1612, 1487, 1443, 1374, 1348, 1275, 1213, 1185, 1149, 1081, 1022, 997, 958, 913, 850, 820, 751, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{29}H_{33}N_2O_7$ ($[M+H]^+$): 521.2282. Found: 521.2290.

1'-Ethyl 3'-methyl 1-butyl-5-fluoro-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-1',3'-dicarboxylate (1m): white solid, 66%, m.p. 172-174℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.24-7.22 (m, 1H, ArH), 6.97-6.93 (m, 1H, ArH), 6.71-6.69 (m, 1H, ArH), 4.34 (brs, 1H, CH), 3.86-3.81 (m, 2H, CH), 3.74-3.69 (m, 1H, CH), 3.65 (s, 3H, OCH_3), 3.62-3.57 (m, 2H, CH), 3.38-3.34 (m, 1H, CH), 3.25 (s, 3H, OCH_3), 3.04 (brs, 1H, CH), 2.97-2.88 (m, 2H, CH), 2.28 (brs, 1H, CH), 2.13 (brs, 2H, CH), 1.67-1.60 (m, 3H, CH_2, CH), 1.47-1.42 (m, 2H, CH_2), 0.99 (t, *J* = 7.2Hz, 3H, CH_3), 0.79 (t, *J* = 7.2Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 174.4, 171.5, 168.9, 158.6 (d, *J* = 239.6Hz), 139.3, 139.2, 128.9, 115.1 (d, *J* = 23.6Hz), 114.0 (d, *J* = 25.5Hz), 107.7 (d, *J* = 7.8Hz), 74.9, 65.9, 64.7, 60.6, 55.2, 52.0, 51.7, 46.8, 40.3, 38.0, 32.1, 29.4, 28.4, 20.1, 13.7, 13.6; IR (KBr) υ: 2955, 2872, 1764, 1732, 1700, 1621, 1492, 1453, 1348, 1282, 1225, 1194, 1155, 1079, 1023, 973, 923, 870, 823, 724 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{26}H_{34}FN_2O_7$ ($[M+H]^+$): 505.2345. Found: 505.2353.

1'-Ethyl 3'-methyl 1-benzyl-5-chloro-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-1',3'-dicarboxylate (1n): white solid, 70%, m.p. 194-196℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.44-7.43 (m, 1H, ArH), 7.39-7.37 (m, 2H, ArH), 7.35-7.32 (m, 2H, ArH), 7.30-7.28 (m, 1H, ArH), 7.12 (dd, J_1 = 8.4Hz, J_2 = 2.0Hz, 1H, ArH), 6.58 (d, *J* = 8.4Hz, 1H, ArH), 5.10 (d, *J* = 15.6Hz, 1H, CH), 4.75 (d, *J* = 15.6Hz, 1H, CH), 4.35 (brs, 1H, CH), 3.85-3.79 (m, 1H, CH), 3.70-3.65 (m, 4H, OCH_3, CH), 3.61 (d, *J* = 17.2Hz, 1H, CH), 3.42 (d, *J* = 10.0Hz, 1H, CH), 3.20 (s, 3H, OCH_3), 3.06-3.04 (m, 1H, CH), 3.02-2.97 (m, 1H, CH), 2.93-2.89 (m, 1H, CH), 2.32-2.26 (m, 1H, CH), 2.16-2.12 (m, 2H, CH), 1.65-1.60 (m, 1H, CH), 0.72 (t, *J* = 6.8Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 174.1, 171.5, 171.4, 168.8, 141.5, 135.3, 129.0, 128.8, 128.7, 127.8, 127.7, 127.5, 125.9, 109.2, 75.1, 66.0, 64.7, 60.7, 55.6, 52.0, 51.8, 46.9, 44.4, 38.2, 32.1, 28.4, 13.6; IR (KBr) υ: 2973, 2946, 2869, 1767, 1735, 1698, 1609, 1482, 1433, 1342, 1197, 1163, 1079, 1019, 959, 873, 824, 745, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{29}H_{32}ClN_2O_7$ ($[M+H]^+$): 555.1893. Found: 555.1894.

Methyl 1-benzyl-5-chloro-4'-(4-chlorobenzoyl)-2'-(2-methoxy-2-oxoethyl)-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2a): white solid, 75%, m.p. 210-212℃; ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.51 (s, 1H, ArH), 7.28-7.27 (m, 2H, ArH), 7.25-7.22 (m, 5H, ArH), 7.11-7.10 (m, 2H, ArH), 6.99 (d, *J* = 8.4Hz, 1H, ArH), 6.20 (d, *J* = 8.4Hz, 1H, ArH), 4.90 (d, *J* = 15.6Hz, 1H, CH), 4.51-4.48 (m, 1H, CH), 4.15-4.12 (m, 1H, CH), 3.88 (d, *J* = 15.6Hz, 1H, CH), 3.68 (s, 3H, OCH_3), 3.61 (d, *J* = 16.8Hz, 1H, CH), 3.10 (d, *J* = 16.8Hz, 1H, CH), 3.06-3.05 (m, 1H, CH), 3.02 (s, 3H, OCH_3), 2.58 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 195.4, 174.7, 171.6, 169.2, 140.6, 139.2, 135.3, 134.8, 129.4, 128.8, 128.7, 128.4, 127.9, 127.8, 127.7, 127.2, 108.7, 76.1, 61.5, 52.1, 51.6, 51.5, 51.2, 44.1, 36.1, 31.0; IR (KBr) υ: 3064, 2946, 2890, 2858, 2795, 1755, 1742, 1686, 1661, 1593 1479, 1433, 1356, 1337, 1283, 1229, 1217, 1191, 1168, 1131, 1095, 1078, 1012, 964, 840, 817, 767, 745 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{31}H_{29}Cl_2N_2O_6$ ([M+H]$^+$): 595.1397. Found: 595.1398.

Methyl 1-butyl-4'-(4-chlorobenzoyl)-2'-(2-methoxy-2-oxoethyl)-1',5-dimethyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2b): white solid, 68%, m.p. 148-150℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.28 (s, 1H, ArH), 7.16-7.14 (m, 2H, ArH), 7.11-7.08 (m, 2H, ArH), 6.88 (d, *J* = 8.0Hz, 1H, ArH), 6.24 (d, *J* = 8.0Hz, 1H, ArH), 4.42 (brs, 1H, CH), 4.22-4.17 (m, 1H, CH), 3.66 (s, 3H, OCH_3), 3.56 (d, *J* = 16.8Hz, 1H, CH), 3.49-3.44 (m, 1H, CH), 3.11 (s, 3H, OCH_3), 3.04-2.98 (m, 2H, CH), 2.89-2.85 (m, 1H, CH), 2.57 (s, 3H, CH_3), 2.30 (s, 3H, CH_3), 1.32-1.26 (m, 4H, CH_2, CH_2), 0.91 (t, *J* = 6.8Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.2, 174.5, 171.9, 169.2, 139.8, 138.5, 135.8, 131.7, 129.1, 129.0, 128.9, 128.0, 126.1, 106.6, 75.9, 61.3, 51.9, 51.3, 51.2, 51.1, 39.8, 36.1, 30.9, 29.3, 21.1, 20.0, 13.7; IR (KBr) υ: 3069, 3034, 2948, 1843, 1786, 1761, 1740, 1702, 1687, 1615, 1593, 1494, 1454, 1434, 1400, 1377, 1349, 1285, 1250, 1230, 1157, 1088, 1051, 1014, 988, 959, 942, 883, 848, 830, 741, 727 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{29}H_{34}ClN_2O_6$ ([M+H]$^+$): 541.2100. Found: 5541.2115.

Methyl 1-benzyl-2'-(2-methoxy-2-oxoethyl)-1'-methyl-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2c): white solid, 74%, m.p. 180-182℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.51 (d, *J* = 7.8Hz, 1H, ArH), 7.22-7.17 (m, 5H, ArH), 7.12-7.11 (m, 2H, ArH), 7.04-7.02 (m, 2H, ArH), 6.99-6.92 (m, 2H, ArH), 6.23 (d, *J* = 7.2Hz, 1H, ArH), 4.90 (d, *J* = 15.6Hz, 1H, CH), 4.55 (brs, 1H, CH), 4.25-4.21 (m, 1H, CH), 3.76 (d, *J* = 15.6Hz, 1H, CH), 3.68 (s, 3H, OCH_3), 3.63 (brs, 1H, CH), 3.16-3.05 (m, 2H, CH), 2.94 (s, 3H, OCH_3), 2.60 (s, 3H, CH_3), 2.35 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.5, 175.2, 172.0, 169.4, 143.2, 142.0, 135.6, 134.7, 128.6, 128.5, 128.2, 128.0, 127.5, 127.4, 127.3, 126.2, 122.5, 107.7, 76.0, 61.5, 52.0, 51.7, 51.3, 51.1, 44.0, 36.1, 31.1, 21.6; IR (KBr) υ: 3027, 2948, 2815, 1767, 1736, 1696, 1609, 1486, 1469, 1434, 1406, 1354, 1287, 1232, 1183, 1170, 1096, 1080, 985, 966, 879, 827, 759, 702 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{32}H_{33}N_2O_6$ ([M+H]$^+$): 541.2333. Found: 541.2339.

Methyl 1-benzyl-5-fluoro-2'-(2-methoxy-2-oxoethyl)-4'-(4-methoxybenzoyl)-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2d): white solid, 73%, m.p. 197-199℃; ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.44-7.40 (m, 2H, ArH), 7.34 (s, 1H, ArH), 7.22 (s, 3H, ArH), 7.06-7.03 (m, 2H, ArH), 6.76-6.75 (m, 2H, ArH), 6.70 (brs, 1H, ArH), 6.18-6.17 (m, 1H, ArH), 4.90 (d, *J* = 15.6Hz, 1H, CH), 4.54 (brs, 1H, CH), 4.15-4.14 (m, 1H, CH), 3.97 (d, *J* = 15.6Hz, 1H, CH), 3.82 (s, 3H, OCH_3), 3.68-3.56 (m, 5H, CH_3, CH), 3.13 (d, *J* = 16.2Hz, 1H, CH), 3.01 (s, 3H, OCH_3), 2.57 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 194.6, 175.0, 171.8, 169.4, 163.3, 158.6 (d, *J* = 239.3Hz), 138.0, 135.2, 130.4, 129.8, 128.6, 128.1, 128.0, 127.6, 127.2, 116.4 (d, *J* = 25.8Hz), 115.0 (d, *J* = 23.7Hz), 113.3, 108.1 (d, *J* = 8.0Hz), 76.0, 62.0, 55.4, 52.0, 51.9, 51.4, 50.5, 44.2, 36.1, 31.0; IR (KBr) υ: 3082, 2838, 2786, 1756, 1731, 1700, 1598, 1488, 1453, 1349, 1238, 1165, 1087, 1027, 998, 943, 829, 742, 701 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{32}H_{32}FN_2O_6$ ([M+H]$^+$): 575.2188. Found: 575.2201.

Methyl 1-benzyl-4'-(4-chlorobenzoyl)-5-fluoro-2'-(2-methoxy-2-oxoethyl)-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2e): white solid, 78%, m.p. 207-209℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.32-7.22 (m, 8H, ArH), 7.13-7.11 (m, 2H, ArH), 6.75-6.71 (m, 1H, ArH), 6.20 (dd, J_1 = 8.4Hz, J_2 = 4.0Hz, 1H, ArH),

4.92 (d, J = 15.6Hz, 1H, CH), 4.51 (dd, J_1 = 9.6Hz, J_2 = 4.0Hz, 1H, CH), 4.16 (dd, J_1 = 9.6Hz, J_2 = 4.0Hz, 1H, CH), 3.82 (d, J = 15.6Hz, 1H, CH), 3.68 (s, 3H, OCH_3), 3.64 (d, J = 16.8Hz, 1H, CH), 3.12 (d, J = 16.8Hz, 1H, CH), 3.07-3.04 (m, 1H, CH), 3.00 (s, 3H, OCH_3), 2.58 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 195.4, 174.9, 171.7, 169.2, 158.7 (d, J = 239.9Hz), 139.2, 138.0, 135.3, 135.0, 129.4, 128.7, 128.3, 127.9, 127.8, 127.7, 127.3, 116.3 (d, J = 25.7Hz), 115.3 (d, J = 23.6Hz), 108.2 (d, J = 7.7Hz), 76.0, 61.7, 52.1, 51.5, 51.2, 44.2, 36.0, 30.9; IR (KBr) υ: 2949, 2834, 2790, 1755, 1734, 1697, 1619, 1589, 1486, 1439, 1400, 1341, 1289, 1237, 1174, 1126, 1087, 1048, 999, 941, 884, 827, 763, 738, 702 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{31}H_{28}ClFN_2NaO_6$ ($[M+Na]^+$): 601.1512. Found: 601.1511.

Methyl 1-benzyl-5-chloro-2'-(2-methoxy-2-oxoethyl)-1'-methyl-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2f): white solid, 72%, m.p. 197-199℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.53 (d, J = 2.0Hz, 1H, ArH), 7.30-7.27 (m, 1H, ArH), 7.25-7.20 (m, 4H, ArH), 7.09-7.06 (m, 4H, ArH), 6.97 (dd, J_1 = 8.4Hz, J_2 = 2.0Hz, 1H, ArH), 6.15 (d, J = 8.4Hz, 1H, ArH), 4.88 (d, J = 16.0Hz, 1H, CH), 4.55-4.51 (m, 1H, CH), 4.16-4.12 (m, 1H, CH), 3.82 (d, J = 16.0Hz, 1H, CH), 3.68 (s, 3H, OCH_3), 3.65-3.60 (m, 1H, CH), 3.13 (d, J = 16.8Hz, 1H, CH), 3.07-3.05 (m, 1H, CH), 3.03 (s, 3H, OCH_3), 2.57 (s, 3H, CH_3), 2.36 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.1, 174.8, 171.8, 169.4, 143.5, 140.7, 135.1, 134.5, 128.7, 128.6 (2C), 128.5, 128.4, 128.3, 128.2, 128.1, 127.8, 127.6, 127.2, 127.1, 108.6, 76.0, 61.6, 52.0, 51.8, 51.5, 51.1, 44.1, 36.1, 31.0, 21.6; IR (KBr) υ: 3067, 2982, 2947, 2847, 2792, 1760, 1737, 1705, 1608, 1559, 1480, 1455, 1435, 1344, 1289, 1225, 1184, 1165, 1079, 1052, 1013, 985, 933, 837, 769, 744 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{32}H_{32}ClN_2O_6$ ($[M+H]^+$): 575.1943. Found: 575.1943.

Methyl 1-benzyl-2'-(2-methoxy-2-oxoethyl)-1',5-dimethyl-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2g): white solid, 74%, m.p. 178-180℃; ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.32 (s, 1H, ArH), 7.21-7.16 (m, 5H, ArH), 7.11-7.10 (m, 2H, ArH), 7.02-7.01 (m, 2H, ArH), 6.77 (d, J = 7.8Hz, 1H, ArH), 6.10 (d, J = 7.8Hz, 1H, ArH), 4.86 (d, J = 15.6Hz, 1H, CH), 4.52-4.50 (m, 1H, CH), 4.19-4.17 (m, 1H, CH), 3.73 (d, J = 15.6Hz, 1H, CH), 3.67 (s, 3H, OCH_3), 3.65 (brs, 1H, CH), 3.13 (d, J = 16.8Hz, 1H, CH), 3.03-3.00 (m, 1H, CH), 2.94 (s, 3H, OCH_3), 2.58 (s, 3H, CH_3), 2.34 (s, 3H, CH_3), 2.26 (s, 3H, OCH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.6, 175.1, 172.0, 169.4, 143.0, 139.6, 135.7, 134.9, 131.8, 128.8 (2C), 128.5, 128.0, 127.4, 127.3, 126.2, 107.3, 76.0, 61.6, 51.9, 51.7, 51.2, 51.1, 43.9, 36.2, 31.1, 21.5, 21.2; IR (KBr) υ: 3076, 2983, 2946, 2847, 2790, 1762, 1738, 1701, 1672, 1613, 1494, 1454, 1435, 1349, 1225, 1184, 1162, 1095, 1052, 879, 831, 741, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{33}H_{35}N_2O_6$ ($[M+H]^+$): 555.2490. Found: 555.2502.

Methyl 1-butyl-5-chloro-2'-(2-methoxy-2-oxoethyl)-4'-(4-methoxybenzoyl)-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2h): white solid, 67%, m.p. 150-152℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.53 (s, 1H, ArH), 7.36-7.31 (m, 2H, ArH), 7.08 (d, J = 8.4Hz, 1H, ArH), 6.72-6.70 (m, 2H, ArH), 6.32 (d, J = 8.4Hz, 1H, ArH), 4.48-4.46 (m, 1H, CH), 4.15-4.11 (m, 1H, CH), 3.79 (s, 3H, OCH_3), 3.67 (s, 3H, OCH_3), 3.58 (d, J = 8.8Hz, 1H, CH), 3.52-3.39 (m, 1H, CH), 3.17 (s, 3H, OCH_3), 3.13-2.98 (m, 3H, CH), 2.57 (s, 3H, CH_3), 1.33-1.25 (m, 4H, CH_2, CH_2), 0.88 (t, J = 7.2Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 194.8, 174.4, 171.8, 163.2, 141.1, 140.9, 130.3, 130.2, 130.0, 128.7, 128.6, 128.5, 128.2, 127.5, 113.2, 107.7, 76.1, 61.7, 55.4, 52.1, 51.5, 50.4, 40.1, 40.0, 36.3, 29.3, 29.2, 20.1, 13.7; IR (KBr) υ: 3111, 3075, 2950, 2869, 2841, 2790, 1761, 1736, 1702, 1603, 1575, 1510, 1483, 1434, 1349, 1305, 1231, 1191, 1173, 1113, 1095, 1081, 1052, 1028, 987, 944, 887, 847, 810, 746, 708 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{29}H_{34}ClN_2O_7$ ($[M+H]^+$): 557.2049. Found: 557.2063.

Methyl 1-butyl-5-chloro-4'-(4-chlorobenzoyl)-2'-(2-methoxy-2-oxoethyl)-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2i): white solid, 66%, m.p. 159-162℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.50-7.49 (m, 1H, ArH), 7.24-7.21 (m, 1H, ArH), 7.19 (s, 3H, ArH), 7.10 (dd, J_1 = 8.4Hz, J_2 = 2.0Hz, 1H, ArH), 6.32 (d, J = 8.4Hz, 1H, ArH), 4.45-4.42 (m, 1H, CH), 4.16-4.12 (m, 1H, CH), 3.67 (s, 3H, OCH_3), 3.55 (d, J = 16.8Hz, 1H, CH), 3.48-3.44 (m, 1H, CH), 3.17 (s, 3H, OCH_3), 3.08-2.91 (m, 3H, CH), 2.58 (s, 3H, CH_3), 1.28-1.24 (m,

4H, CH_2, CH_2), 0.94 (t, J = 6.8Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 195.6, 174.2, 171.6, 169.2, 140.9, 139.0, 135.4, 129.3, 128.8, 128.4, 128.2, 127.9, 127.5, 107.8, 76.0, 61.3, 52.0, 51.4, 51.3, 51.0, 39.9, 36.1, 30.7, 29.2, 20.0, 13.7; IR (KBr) υ: 2951, 2844, 2787, 1764, 1736, 1697, 1606, 1485, 1434, 1398, 1350, 1282, 1229, 1194, 1160, 1086, 1054, 1010, 941, 892, 838, 806, 734 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{28}H_{31}Cl_2N_2O_6$ ($[M+H]^+$): 561.1554. Found: 561.1552.

Methyl 5-chloro-2'-(2-methoxy-2-oxoethyl)-1'-methyl-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2j): white solid, 47%, m.p. 210-212℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.66 (s, 1H, NH), 7.48 (s, 1H, ArH), 7.30 (d, J = 8.0Hz, 2H, ArH), 7.06-7.04 (m, 3H, ArH), 6.41 (d, J = 8.0Hz, 1H, ArH), 4.50-4.46 (m, 1H, CH), 4.10-4.06 (m, 1H, CH), 3.67 (s, 3H, OCH_3), 3.58 (d, J = 16.8Hz, 1H, CH), 3.24 (s, 3H, OCH_3), 3.07-3.04 (m, 2H, CH), 2.57 (s, 3H, CH_3), 2.30 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 165.8, 163.4, 159.9, 159.6, 145.2, 138.4, 129.5, 129.4, 129.3, 128.9, 121.6, 116.6, 114.6, 113.2, 106.8, 55.3, 52.7, 52.0, 51.7, 47.5, 32.7; IR (KBr) υ: 3297, 3033, 2952, 2845, 2786, 1718, 1671, 1617, 1473, 1434, 1406, 1363, 1301, 1251, 1196, 1164, 1098, 1008, 934, 882, 829, 785, 745, 718 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{25}H_{26}ClN_2O_6$ ($[M+H]^+$): 485.1474. Found: 485.1486.

Ethyl 4'-benzoyl-1-benzyl-2'-(2-ethoxy-2-oxoethyl)-5-fluoro-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2k): white solid, 75%, m.p. 193-194℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.45 (t, J = 7.2Hz, 1H, ArH), 7.35-7.32 (m, 3H, ArH), 7.28-7.26 (m, 2H, ArH), 7.24-7.21 (m, 3H, ArH), 7.11-7.09 (m, 2H, ArH), 6.69 (td, J_1 = 8.8Hz, J_2 = 2.0Hz, 1H, ArH), 6.11 (dd, J_1 = 8.8Hz, J_2 = 4.0Hz, 1H, ArH), 4.88 (d, J = 15.6Hz, 1H, CH), 4.60-4.56 (m, 1H, CH), 4.19-4.11 (m, 3H, CH), 3.74 (d, J = 15.6Hz, 1H, CH), 3.68-3.64 (m, 1H, CH), 3.61-3.55 (m, 2H, CH), 3.18-3.10 (m, 2H, CH), 2.63 (s, 3H, CH_3), 1.27 (t, J = 7.2Hz, 3H, CH_3), 0.54 (t, J = 7.2Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.8, 175.0, 171.2, 169.0, 158.7 (d, J = 239.5Hz), 138.4, 138.3, 137.2, 135.2, 132.7, 128.6, 128.2, 128.1, 127.9, 127.6, 127.3, 116.3 (d, J = 25.8Hz), 115.0 (d, J = 23.6Hz), 108.2 (d, J = 8.0Hz), 75.8, 61.7, 61.6, 60.8, 60.7, 51.6, 51.3, 44.2, 36.3, 31.5, 14.0, 13.1; IR (KBr) υ: 3066, 2982, 2848, 1755, 1734, 1694, 1622, 1487, 1452, 1372, 1344, 1297, 1265, 1230, 1175, 1158, 1084, 1053, 1026, 968, 934, 904, 859, 828, 790, 773, 738, 701 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{33}H_{34}FN_2O_6$ ($[M+H]^+$): 573.2395. Found: 573.2399.

Ethyl 1-benzyl-4'-(4-chlorobenzoyl)-2'-(2-ethoxy-2-oxoethyl)-5-fluoro-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2l): white solid, 80%, m.p. 201-202℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.35-7.29 (m, 3H, ArH), 7.24-7.22 (m, 5H, ArH), 7.11-7.09 (m, 2H, ArH), 6.72 (td, J_1 = 8.8Hz, J_2 = 2.4Hz, 1H, ArH), 6.18 (dd, J_1 = 8.8Hz, J_2 = 4.0Hz, 1H, ArH), 4.87 (d, J = 15.6Hz, 1H, CH), 4.55-4.52 (m, 1H, CH), 4.16-4.11 (m, 3H, CH), 3.93 (d, J = 15.6Hz, 1H, CH), 3.66-3.62 (m, 1H, CH), 3.61-3.57 (m, 2H, CH), 3.14-3.04 (m, 2H, CH), 2.61 (s, 3H, CH_3), 1.27 (t, J = 7.2Hz, 3H, CH_3), 0.56 (t, J = 7.2Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 195.4, 174.9, 171.1, 168.9, 158.7 (d, J = 239.8Hz), 139.3, 138.3, 138.2, 135.3, 134.9, 129.4, 128.6, 128.4, 127.9, 127.8, 127.7, 127.3, 116.4 (d, J = 25.8Hz), 115.1 (d, J = 23.6Hz), 108.3 (d, J = 8.0Hz), 75.9, 61.8, 61.7, 60.9, 60.8, 51.7, 51.1, 44.3, 36.3, 31.5, 14.0, 13.2; IR (KBr) υ: 3075, 2940, 2845, 1755, 1697, 1620, 1590, 1488, 1452, 1398, 1368, 1340, 1273, 1227, 1171, 1125, 1089, 1050, 1022, 978, 945, 862, 834, 800, 740, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{33}H_{33}ClFN_2O_6$ ($[M+H]^+$): 607.2006. Found: 607.2006.

Methyl 1-benzyl-5'-(2-methoxy-2-oxoethyl)-7'-(4-methoxybenzoyl)-5-methyl-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5'-carboxylate (3a): white solid, 72%, m.p. 182-184℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.48-7.45 (m, 3H, ArH), 7.18-7.16 (m, 3H, ArH), 6.97-6.95 (m, 2H, ArH), 6.83 (d, J = 8.0Hz, 1H, ArH), 6.79-6.77 (m, 2H, ArH), 6.18 (d, J = 8.0Hz, 1H, ArH), 4.90-4.85 (m, 1H, CH), 4.79 (d, J = 11.2Hz, 1H, CH), 4.73 (d, J = 15.6Hz, 1H, CH), 4.51-4.48 (m, 2H, CH_2), 4.01 (d, J = 15.6Hz, 1H, CH), 3.88 (d, J = 18.0Hz, 1H, CH), 3.83 (s, 3H, OCH_3), 3.70 (s, 3H, OCH_3), 3.42-3.38 (m, 1H, CH), 3.23 (d, J = 17.6Hz, 1H, CH), 3.04 (s, 3H, OCH_3), 2.91-2.87 (m, 1H, CH), 2.30 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 193.9,

173.5, 171.8, 170.0, 163.5, 139.4, 135.3, 131.9, 130.7, 129.6, 129.4, 128.5, 128.4, 127.4, 126.9, 125.2, 113.3, 107.8, 75.4, 67.0, 64.8, 57.2, 55.5, 54.4, 51.8, 51.7, 43.8, 40.2, 37.0, 21.2; IR(KBr) υ: 3035, 3001, 2940, 2871, 2845, 1764, 1730, 1680, 1599, 1509, 1483, 1433, 1384, 1351, 1296, 1262, 1231, 1202, 1172, 1117, 1094, 1049, 1024, 1007, 991, 961, 928, 882, 846, 804, 776, 745, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{34}H_{34}N_2NaO_7S$ ($[M+Na]^+$): 637.1979, found: 637.1989.

Methyl 1-benzyl-5'-(2-methoxy-2-oxoethyl)-7'-(4-methoxybenzoyl)-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5'-carboxylate (3b): white solid, 76%, m.p. 147-149℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.64 (d, *J* = 7.6Hz, 1H, ArH), 7.47 (d, *J* = 8.8Hz, 2H, ArH), 7.18-7.17 (m, 3H, ArH), 7.06-7.02 (m, 1H, ArH), 7.00-6.97 (m, 3H, ArH), 6.78 (d, *J* = 8.8Hz, 2H, ArH), 6.31 (d, *J* = 7.6Hz, 1H, ArH), 4.92-4.86 (m, 1H, CH), 4.81-4.74 (m, 2H, CH_2), 4.52-4.48 (m, 2H, CH_2), 4.05 (d, *J* = 16Hz, 1H, CH), 3.88 (d, *J* = 17.6Hz, 1H, CH), 3.83 (s, 3H, OCH_3), 3.71 (s, 3H, OCH_3), 3.43-3.39 (m, 1H, CH), 3.24 (d, *J* = 18.0Hz, 1H, CH), 3.04 (s, 3H, OCH_3), 2.92-2.88 (m, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 193.8, 173.6, 171.7, 170.0, 163.6, 141.8, 135.2, 130.7, 129.5, 129.1, 128.5, 127.9, 127.4, 126.9, 125.2, 122.5, 113.4, 108.1, 75.4, 67.1, 64.7, 57.1, 55.5, 54.4, 51.9, 51.8, 43.9, 40.3, 37.0; IR(KBr) υ: 3063, 3029, 3004, 2951, 2875, 2841, 1764, 1730, 1677, 1603, 1575, 1494, 1437, 1352, 1311, 1261, 1233, 1179, 1116, 1090, 1028, 996, 969, 947, 929, 907, 883, 866, 841, 803, 778, 737 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{33}H_{32}N_2NaO_7S$ ($[M+Na]^+$): 623.1822, found: 623.1840.

Methyl 1-butyl-5-chloro-5'-(2-methoxy-2-oxoethyl)-7'-(4-methoxybenzoyl)-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5'-carboxylate (**3c**): white solid, 69%, m.p. 181-183℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.63 (d, *J* = 2Hz, 1H, ArH), 7.45-7.43 (m, 2H, ArH), 7.15-7.13 (m, 1H, ArH), 6.78-6.74 (m, 2H, ArH), 6.38 (d, *J* = 8.4Hz, 1H, ArH), 4.83-4.80 (m, 1H, CH), 4.78-4.76 (m, 1H, CH), 4.48-4.43 (m, 2H, CH_2), 3.82-3.78 (m, 4H, OCH_3, CH), 3.69 (s, 3H, OCH_3), 3.40-3.34 (m, 2H, CH_2), 3.23 (s, 3H, OCH_3), 3.15 (d, *J* = 17.6Hz, 1H, CH), 3.10-3.04 (m, 1H, CH), 2.89-2.85 (m, 1H, CH), 1.26-1.13 (m, 4H, CH_2, CH_2), 0.82 (t, *J* = 7.2Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 193.6, 172.7, 171.6, 170.0, 163.6, 140.8, 130.6, 129.4, 129.1, 128.1, 127.4, 127.2, 113.3, 108.2, 75.3, 66.9, 64.7, 56.9, 55.4, 54.3, 51.9, 40.1, 39.9, 36.8, 29.0, 19.9, 13.6; IR(KBr) υ: 3088, 3028, 2955, 2919, 2850, 1733, 1711, 1699, 1601, 1485, 1435, 1377, 1350, 1294, 1233, 1210, 1173, 1125, 1107, 1058, 1027, 1006, 973, 954, 886, 819, 770, 730 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{30}H_{33}ClN_2NaO_7S$ ($[M+Na]^+$): 623.6153, found: 623.6161.

Methyl 7'-benzoyl-1-benzyl-5'-(2-methoxy-2-oxoethyl)-5-methyl-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5'-carboxylate (3d): white solid, 74%, m.p. 192-194℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.50-7.45 (m, 1H, ArH), 7.40 (s, 1H, ArH), 7.31-7.28 (m, 4H, ArH), 7.23-7.19 (m, 3H, ArH), 7.05-7.03 (m, 2H, ArH), 6.84-6.82 (m, 1H, ArH), 6.12 (d, *J* = 7.6Hz, 1H, ArH), 4.92-4.87 (m, 1H, CH), 4.79 (d, *J* = 10.8Hz, 1H, CH), 4.75 (d, *J* = 15.6Hz, 1H, CH), 4.52 (d, *J* = 11.2Hz, 1H, CH), 4.48 (d, *J* = 5.6Hz, 1H, CH), 3.85 (d, *J* = 18.0Hz, 1H, CH), 3.71 (s, 3H, OCH_3), 3.61 (d, *J* = 15.6Hz, 1H, CH), 3.47-3.42 (m, 1H, CH), 3.22 (d, *J* = 18.0Hz, 1H, CH), 3.02 (s, 3H, OCH_3), 2.94-2.89 (m, 1H, CH), 2.29 (s, 3H, CH_3) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.5, 173.5, 171.7, 169.8, 139.5, 137.1, 135.4, 132.8, 132.0, 129.5, 128.5, 128.2, 128.1, 128.0, 127.4, 127.0, 125.3, 110.0, 107.8, 75.1, 66.5, 64.4, 58.4, 54.4, 51.8, 51.7, 43.8, 40.3, 37.1, 21.2; IR(KBr) υ: 3062, 3027, 2996, 2950, 2924, 2882, 1733, 1698, 1677, 1617, 1599, 1494, 1434, 1396, 1351, 1292, 1253, 1227, 1191, 1091, 1030, 991, 928, 881, 829, 793, 762, 732, 701 cm^{-1} ; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{33}H_{32}N_2NaO_6S$ ($[M+Na]^+$): 607.1873, found: 607.1879.

Methyl 1-benzyl-5-fluoro-5'-(2-methoxy-2-oxoethyl)-7'-(4-methylbenzoyl)-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5'-carboxylate (3e): white solid, 71%, m.p. 136-138℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.43-7.40 (m, 1H, ArH), 7.36 (d, *J* = 8.0Hz, 2H, ArH), 7.19-7.18 (m, 3H, ArH), 7.14-7.12 (m, 2H, ArH), 6.97-6.96 (m, 2H, ArH), 6.78-6.73 (m, 1H, ArH), 6.18 (q, *J* = 4.4Hz, 1H, ArH), 4.84-4.81 (m, 1H, CH), 4.79-4.78 (m, 1H, CH), 4.74 (d, *J* = 15.6Hz, 1H, CH), 4.53-4.46 (m, 2H, CH_2), 3.91-3.83 (m,

2H, CH_2), 3.71 (s, 3H, OCH_3), 3.44-3.39 (m, 1H, CH), 3.20 (d, *J* = 18.0Hz, 1H, CH), 3.11 (s, 3H, OCH_3), 2.93-2.88 (m, 1H, CH), 2.42-2.38 (m, 3H, CH_3) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ: 195.0, 173.2, 171.6, 169.8, 158.6 (d, *J* = 239.7Hz), 144.1, 137.9, 134.8, 134.1, 128.9, 128.6, 128.4, 127.5, 126.9, 115.8 (d, *J* = 25.0Hz), 115.6 (d, *J* = 23.1Hz), 108.6 (d, *J* = 8.1Hz), 75.2, 66.8, 64.8, 64.7, 57.5, 54.2, 51.9, 51.8, 43.9, 40.2, 37.0, 21.6; IR(KBr) υ: 3057, 3021, 2993, 2944, 2878, 2840, 1768, 1731, 1697, 1604, 1512, 1485, 1461, 1439, 1353, 1308, 1261, 1232, 1175, 1125, 1083, 1022, 990, 962, 934, 868, 835, 787, 758 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{33}H_{31}FN_2NaO_6S$ ($[M+Na]^+$): 625.1779, found: 625.1780.

7'-ethyl 5'-methyl 5-fluoro-5'-(2-methoxy-2-oxoethyl)-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5',7'-dicarboxylate (**3f**): white solid, 68%, m.p. 205-207℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.67 (s, 1H, NH), 7.34(d, *J* = 8.0Hz, 1H, ArH), 6.96-6.92 (m, 1H, ArH), 6.75-6.72 (m, 1H, ArH), 4.73 (d, *J* = 11.2Hz, 1H, CH), 4.47-4.42 (m, 1H, CH), 4.37 (d, *J* = 11.2Hz, 1H, CH), 3.92-3.86 (m, 1H, CH), 3.82-3.74 (m, 2H, CH_2), 3.68 (s, 3H, OCH_3), 3.59 (d, *J* = 6.8Hz, 1H, CH), 3.45 (t, *J* = 9.2Hz, 1H, CH), 3.31 (s, 3H, OCH_3), 3.00 (d, *J* = 18.0Hz, 1H, CH), 2.87-2.83 (m, 1H, CH), 0.83 (t, *J* = 6.8Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 175.4, 171.6, 170.2, 168.4, 158.5 (d, *J* = 239.6Hz), 137.0 (d, *J* = 1.8Hz), 128.5 (d, *J* = 8.2Hz), 115.9 (d, *J* = 23.6Hz), 114.4 (d, *J* = 25.8Hz), 109.5 (d, *J* = 7.8Hz), 74.3, 66.9, 64.0, 61.3, 55.5, 54.1, 52.1, 51.9, 40.2, 36.5, 13.4; IR(KBr) υ: 3323, 3174, 3123, 3090, 2980, 2950, 2880, 2850, 1724, 1630, 1607, 1486, 1456, 1395, 1363, 1309, 1238, 1189, 1118, 1091, 1057, 1014, 987, 963, 932, 878, 829, 764, 738 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{21}H_{23}FN_2NaO_7S$ ($[M+Na]^+$): 489.1102, found: 489.1106.

2. General procedure for the preparation of functionalized spiro[indoline-3,3'-pyrrolidines] 4a-4j from three-component reaction: A mixture of A mixture of glycine (alanine, phenylalanine) (1.2 mmol) and dialkyl acetylenedicarboxylate (3.0 mmol) in ethanol (15.0 mL) was stirred at room temperature for about twenty minutes. Then, 3-phenacylideneoxindole (1.0 mmol) was added. The mixture was refluxed for about six hours. The solvent was removed at reduced pressure by rotator evaporation, the residue was subjected to preparative thin-layer chromatography (20 x 30 cm^2 Silicon gel GF254) with a mixture of light petroleum and ethyl acetate (V/V = 2:1) as developing reagent to give the pure product.

Dimethyl 2-(1-benzyl-5-fluoro-2'-(2-methoxy-2-oxoethyl)-4'-(4-methoxybenzoyl)-2'-(methoxycarbonyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4a): white solid, 70%, m.p. 190-192℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.72 (d, *J* = 9.2Hz, 2H, ArH), 7.14-7.10 (m, 1H, ArH), 7.05-6.98 (m, 3H, ArH), 6.87-6.80 (m, 3H, ArH), 6.70 (d, *J* = 7.2Hz, 2H, ArH), 6.28-6.24 (m, 1H, ArH), 5.25-5.21 (m, 1H, CH), 4.77 (s, 1H, CH), 4.59 (d, *J* = 16.0Hz, 1H, CH), 4.45-4.33 (m, 2H, CH_2), 4.05 (s, 3H, OCH_3), 3.97 (s, 3H, OCH_3), 3.92-3.88 (m, 1H, CH), 3.81 (s, 3H, OCH_3), 3.67 (s, 3H, OCH_3), 3.50 (d, *J* = 16.8Hz, 1H, CH), 3.37 (s, 3H, OCH_3), 2.54 (d, *J* = 17.2Hz, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 191.7, 173.7, 169.9, 168.8, 166.9, 165.3, 164.4, 158.4 (d, *J* = 240.8Hz), 149.2, 139.5, 134.9, 131.0, 129.2, 128.4, 127.1, 126.9, 125.7 (d, *J* = 8.0Hz), 115.9 (d, *J* = 23.2Hz), 114.3 (d, *J* = 25.1Hz), 114.0, 110.3 (d, *J* = 7.9Hz), 92.9, 73.5, 63.2, 63.1, 55.5, 53.6, 53.3, 51.6, 51.2, 48.4, 45.1, 36.0; IR(KBr) υ: 3077, 3008, 2952, 2901, 2843, 1749, 1724, 1700, 1672, 1599, 1572, 1492, 1440, 1406, 1377, 1262, 1218, 1174, 1120, 1054, 1025, 950, 877, 841, 815, 782, 738, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{37}H_{35}FN_2NaO_{11}$ ($[M+Na]^+$): 725.2117, found: 725.2120.

Dimethyl 2-(1-butyl-2'-(2-methoxy-2-oxoethyl)-4'-(4-methoxybenzoyl)-2'-(methoxycarbonyl)-5-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4b): white solid, 67%, m.p. 162-164℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.54 (d, *J* = 8.8Hz, 2H, ArH), 7.00 (d, *J* = 8.0Hz, 1H, ArH), 6.96 (s, 1H, ArH), 6.82 (d, *J* = 8.8Hz, 2H, ArH), 6.42 (d, *J* = 8.0Hz, 1H, ArH), 5.07 (t, *J* = 9.2Hz, 1H, CH), 4.76 (s, 1H, CH), 4.48 (t, *J* = 10.4Hz, 1H, CH), 4.02 (s, 3H, OCH_3), 3.97 (s, 3H, OCH_3), 3.86-3.81 (m, 4H, OCH_3, CH), 3.66 (s, 3H, OCH_3), 3.41 (d, *J* = 16.8Hz, 1H, CH), 3.30 (s, 3H, OCH_3), 3.20-3.14 (m, 1H, CH), 3.09-3.03 (m, 1H, CH), 2.55 (d, *J* = 14.8Hz, 1H, CH), 2.36 (s, 3H, CH_3), 1.26-1.06 (m, 4H, CH_2, CH_2), 0.75 (t, *J* = 7.2Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 192.7,

172.8, 170.0, 168.4, 167.1, 165.4, 163.9, 149.5, 141.0, 131.5, 130.6, 129.8, 129.7, 127.0, 124.3, 113.5, 108.2, 92.1, 73.3, 62.9, 55.4, 53.4, 53.2, 51.3, 51.2, 51.1, 49.2, 40.2, 36.0, 28.6, 21.3, 20.3, 13.6; IR(KBr) υ: 3067, 2954, 2843, 1744, 1708, 1680, 1585, 1496, 1437, 1363, 1233, 1203, 1172, 1098, 1022, 956, 850, 816, 747 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{35}H_{40}N_2NaO_{11}$ ($[M+Na]^+$): 687.2524, found: 687.2540.

Dimethyl 2-(1-benzyl-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4c): white solid, 75%, m.p. 195-197℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.57 (d, *J* = 8.4Hz, 2H, ArH), 7.22-7.17 (m, 3H, ArH), 7.14-7.08 (m, 2H, ArH), 7.06-7.01 (m, 3H, ArH), 6.84-6.75 (m, 2H, ArH), 6.30 (d, *J* = 7.6Hz, 1H, ArH), 5.22 (t, *J* = 9.2Hz, 1H, CH), 4.77 (s, 1H, CH), 4.49 (t, *J* = 10.0Hz, 1H, CH), 4.42-4.32 (m, 2H, CH_2), 4.06 (s, 3H, OCH_3), 3.97 (s, 3H, OCH_3), 3.90 (d, *J* = 9.6Hz, 1H, CH), 3.71-3.65 (m, 3H, OCH_3), 3.50-3.46 (m, 1H, CH), 3.31-3.25 (m, 3H, OCH_3), 2.56 (d, *J* = 16.8Hz, 1H, CH), 2.37-2.33 (m, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 193.5, 173.7, 170.0, 168.8, 167.0, 165.4, 149.4, 144.8, 143.3, 135.1, 133.8, 129.3, 128.6, 128.2, 127.0, 126.2, 124.1, 122.3, 110.0, 109.9, 92.3, 73.5, 62.9, 53.6, 53.2, 51.5, 51.2, 49.1, 44.8, 36.0, 21.7; IR(KBr) υ: 3032, 2955, 2873, 2820, 1729, 1604, 1487, 1436, 1406, 1373, 1292, 1234, 1208, 1179, 1154, 1109, 1087, 1055, 1003, 970, 950, 883, 829, 812, 785, 745 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{37}H_{36}N_2NaO_{10}$($[M+Na]^+$): 691.2262, found: 691.2277.

Dimethyl 2-(1-benzyl-5-chloro-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4d): white solid, 73%, m.p. 200-202℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.60 (d, *J* = 8.0Hz, 2H, ArH), 7.21-7.18 (m, 3H, ArH), 7.13 (t, *J* = 7.2Hz, 1H, ArH), 7.06-7.02 (m, 3H, ArH), 6.73 (d, *J* = 7.6Hz, 2H, ArH), 6.22 (d, *J* = 8.4Hz, 1H, ArH), 5.23 (t, *J* = 9.2Hz, 1H, CH), 4.79 (s, 1H, CH), 4.42 (d, *J* = 10.0Hz, 1H, CH), 4.37 (s, 2H, CH_2), 4.05 (s, 3H, OCH_3), 3.98 (s, 3H, OCH_3), 3.92-3.89 (m, 1H, CH), 3.68 (s, 3H, OCH_3), 3.48 (d, *J* = 17.2Hz, 1H, CH), 3.38 (s, 3H, OCH_3), 2.53 (d, *J* = 17.2Hz, 1H, CH), 2.38 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 193.2, 173.4, 169.8, 168.8, 166.9, 165.3, 149.1, 145.1, 142.0, 134.7, 133.7, 129.4, 128.6, 128.3, 127.7, 127.2, 127.0, 126.3, 126.0, 110.8, 93.0, 73.4, 62.9, 53.6, 53.3, 51.7, 51.5, 51.3, 48.9, 44.8, 35.9, 31.9, 29.7, 22.6, 21.7, 14.1; IR(KBr) υ: 3063, 3031, 3004, 2950, 2896, 2843, 1749, 1701, 1676, 1606, 1570, 1488, 1465, 1438, 1404, 1362, 1308, 1263, 1229, 1210, 1179, 1156, 1100, 1047, 1020, 977, 952, 887, 850, 833, 807, 758, 732, 700 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{37}H_{35}ClN_2NaO_{10}$ ($[M+Na]^+$): 725.1872, found: 725.1884.

Dimethyl 2-(1-butyl-5-chloro-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4e): white solid, 62%, m.p. 176-178℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.43 (d, *J* = 8.0Hz, 2H, ArH), 7.21-7.19 (m, 1H, ArH), 7.17-7.13 (m, 2H, ArH), 7.08 (d, *J* = 8.0Hz, 1H, ArH), 6.45 (d, *J* = 8.4Hz, 1H, ArH), 5.09 (t, *J* = 9.2Hz, 1H, CH), 4.77 (s, 1H, CH), 4.43-4.38 (m, 2H, CH_2), 4.20-4.11 (m, 1H, CH), 4.02 (s, 3H, OCH_3), 3.98 (s, 3H, OCH_3), 3.92-3.91 (m, 1H, CH), 3.67-3.65 (m, 4H, OCH_3, CH), 3.43 (d, *J* = 16.4Hz, 1H, CH), 3.35 (s, 3H, OCH_3), 3.16 (s, 1H, CH), 2.50 (d, *J* = 16.8Hz, 1H, CH), 2.36 (s, 3H, CH_3), 1.19-1.06 (m, 4H, CH_2, CH_2), 0.76 (t, *J* = 6.8Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 193.8, 172.5, 169.8, 168.5, 166.9, 165.3, 149.2, 144.6, 142.1, 134.1, 129.3, 129.1, 128.9, 128.3, 127.3, 126.3, 126.0, 109.4, 92.9, 73.2, 62.6, 53.5, 53.3, 51.5, 51.2, 51.1, 49.4, 40.2, 35.8, 28.3, 21.6, 20.2, 19.8, 13.7; IR(KBr) υ: 3032, 2955, 2873, 1730, 1603, 1487, 1436, 1406, 1373, 1292, 1234, 1208, 1179, 1154, 1109, 1087, 1055, 1003, 970, 950, 883, 829, 812, 785, 744 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{34}H_{37}ClN_2NaO_{10}$ ($[M+Na]^+$): 691.2029, found: 691.2046.

Dimethyl 2-(1-benzyl-5-chloro-4'-(4-chlorobenzoyl)-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4f): white solid, 71%, m.p. 202-204℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.62 (d, *J* = 8.8Hz, 2H, ArH), 7.34 (d, *J* = 8.4Hz, 2H, ArH), 7.18-7.15 (m, 2H, ArH), 7.10-7.06 (m, 3H, ArH), 6.78 (d, *J* = 7.2Hz, 2H, ArH), 6.31 (d, *J* = 8.4Hz, 1H, ArH), 5.21-5.17 (m, 1H, CH), 4.79 (s, 1H, CH), 4.42-4.41 (m, 2H, CH_2), 4.38 (d, *J* = 10.0Hz, 1H, CH), 4.04 (s, 3H, OCH_3), 3.98 (s, 3H, OCH_3), 3.92-3.89

(m, 1H, CH), 3.68 (s, 3H, OCH_3), 3.48 (d, *J* = 16.8Hz, 1H, CH), 3.39 (s, 3H, OCH_3), 2.52 (d, *J* = 16.8Hz, 1H, CH); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 192.6, 173.3, 169.7, 168.8, 166.8, 165.2, 149.0, 142.0, 140.7, 134.5, 134.3, 129.9, 129.6, 129.1, 128.4, 127.8, 127.4, 127.0, 126.4, 125.8, 110.8, 93.4, 73.5, 62.8, 53.7, 53.3, 51.7, 51.4, 51.3, 49.0, 45.0, 35.8; IR(KBr) υ: 3089, 3028, 3008, 2953, 2905, 2847, 1732, 1685, 1599, 1486, 1436, 1377, 1342, 1293, 1269, 1232, 1209, 1158, 1091, 1057, 1010, 972, 955, 886, 849, 819, 777, 741 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{36}H_{32}Cl_2N_2NaO_{10}$([M+Na]$^+$): 745.1326, found: 745.1334.

Dimethyl 2-(1-benzyl-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-5'-methyl-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4g): white solid, 74%, m.p. 120-122℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.62 (d, *J* = 7.6Hz, 2H, ArH), 7.41-7.40 (m, 1H, ArH), 7.19 (d, *J* = 7.6Hz, 2H, ArH), 7.12-7.06 (m, 3H, ArH), 7.02-6.98 (m, 2H, ArH), 6.70 (d, *J* = 7.6Hz, 2H, ArH), 6.29-6.28 (m, 1H, ArH), 4.94-4.93 (m, 2H, CH_2), 4.86-4.82 (m, 1H, CH), 4.42-4.29 (m, 2H, CH_2), 4.07 (s, 3H, OCH_3), 3.95 (s, 3H, OCH_3), 3.69 (s, 3H, OCH_3), 3.53 (d, *J* = 17.2Hz, 1H, CH), 3.28 (s, 3H, OCH_3), 2.78 (s, 1H, CH), 2.37 (s, 3H, CH_3), 1.42 (d, *J* = 5.6Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 193.6, 174.0, 170.9, 169.0, 166.5, 165.1, 147.2, 144.8, 143.2, 135.3, 134.3, 129.6, 129.3, 129.2, 128.7, 128.2, 127.2, 127.0, 126.9, 126.3, 124.3, 122.4, 109.7, 101.1, 74.3, 62.1, 58.2, 57.5, 53.4, 53.1, 51.4, 51.3, 44.7, 36.6, 21.6, 19.3; IR(KBr) υ: 3063, 3027, 2951, 2846, 1739, 1711, 1675, 1597, 1490, 1468, 1455, 1435, 1409, 1364, 1317, 1296, 1273, 1233, 1207, 1176, 1158, 1101, 1061, 1032, 1011, 979, 950, 931, 901, 878, 839, 813, 783, 760, 740cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{38}H_{38}N_2NaO_{10}$ ([M+Na]$^+$): 705.2419, found: 705.2424.

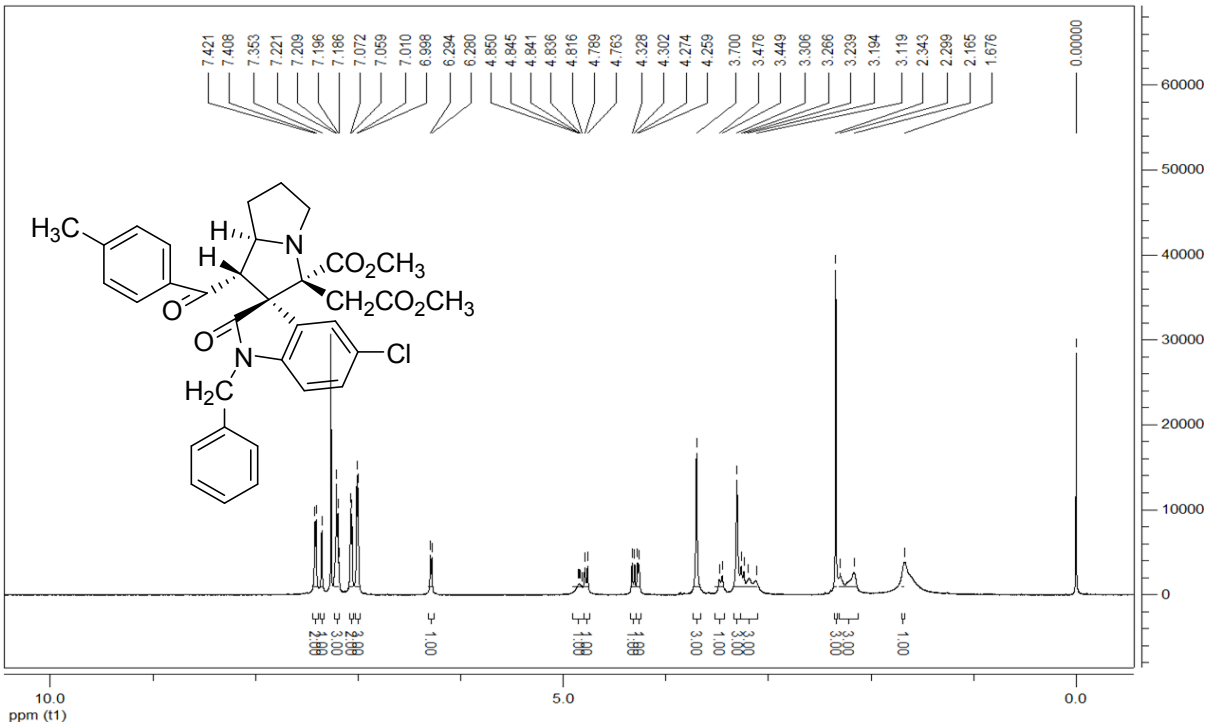
Dimethyl 2-(1-benzyl-5-chloro-4'-(4-chlorobenzoyl)-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-5'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4h): white solid, 70%, m.p. 138-140℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.66 (d, *J* = 8.8Hz, 2H, ArH), 7.44 (s, 1H, ArH), 7.36 (d, *J* = 8.4Hz, 2H, ArH), 7.17-7.13 (m, 1H, ArH), 7.10-7.03 (m, 3H, ArH), 6.73 (d, *J* = 7.6Hz, 2H, ArH), 6.30 (d, *J* = 8.4Hz, 1H, ArH), 4.93-4.88 (m, 2H, CH_2), 4.75-4.68 (m, 1H, CH), 4.47-4.31 (m, 2H, CH_2), 4.06 (s, 3H, OCH_3), 4.00 (s, 3H, OCH_3), 3.70 (s, 3H, OCH_3), 3.56 (d, *J* = 17.2Hz, 1H, CH), 3.77 (s, 3H, OCH_3), 2.42 (d, *J* = 16.8Hz, 1H, CH), 1.42 (d, *J* = 16.0Hz, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 192.8, 173.6, 170.6, 169.1, 166.3, 164.8, 146.8, 141.8, 140.8, 134.8, 134.6, 129.9, 129.3, 129.0, 128.4, 127.9, 127.4, 127.0, 126.5, 125.9, 110.5, 102.3, 74.1, 62.0, 58.1, 57.4, 53.6, 53.2, 51.6, 51.5, 44.9, 36.2, 19.4; IR(KBr) υ: 3021, 2953, 2850, 1744, 1682, 1597, 1484, 1434, 1404, 1361, 1270, 1210, 1156, 1097, 1060, 1011, 975, 906, 817, 744 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{37}H_{34}Cl_2NaN_2O_{10}$([M+Na]$^+$): 760.1014, found: 760.1020.

Dimethyl 2-(1,5'-dibenzyl-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4i): white solid, 65%, m.p. 194-196℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.48-7.46 (m, 1H, ArH), 7.32 (d, *J* = 8.4Hz, 2H, ArH), 7.07-7.04 (m, 2H, ArH), 7.03-7.00 (m, 3H, ArH), 6.97-6.96 (m, 1H, ArH), 6.93 (t, *J* = 7.6Hz, 3H, ArH), 6.88-6.83 (m, 3H, ArH), 6.60 (d, *J* = 7.6Hz, 2H, ArH), 6.23-6.21 (m, 1H, ArH), 5.09-5.05 (m, 2H, CH_2), 5.01-4.95 (m, 1H, CH), 4.50 (d, *J* = 16.0Hz, 1H, CH), 4.23 (d, *J* = 16.4Hz, 1H, CH), 4.07 (s, 3H, OCH_3), 4.03 (s, 3H, OCH_3), 3.72 (s, 3H, OCH_3), 3.58-3.48 (m, 2H, CH_2), 3.26 (s, 3H, OCH_3), 3.22-3.16 (m, 1H, CH), 2.51 (d, *J* = 16.8Hz, 1H, CH), 2.32 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 192.0, 174.1, 170.9, 169.0, 166.4, 165.3, 147.1, 144.0, 143.1, 136.0, 135.2, 133.4, 129.7, 129.0, 128.8, 128.4, 128.1, 128.0, 126.9, 126.8, 126.7, 126.5, 124.4, 122.3, 109.5, 102.3, 74.3, 64.4, 62.4, 55.3, 53.4, 53.2, 51.5, 51.4, 44.7, 36.9, 21.6; IR(KBr) υ: 3025, 2951, 2896, 2820, 1739, 1718, 1680, 1601, 1491, 1465, 1435, 1368, 1270, 1207, 1167, 1085, 1051, 1013, 950, 831, 812, 758 cm^{-1}; MS (*m*/*z*): HRMS (ESI) Calcd. for $C_{44}H_{42}N_2NaO_{10}$ ([M+Na]$^+$): 781.2732, found: 781.2743.

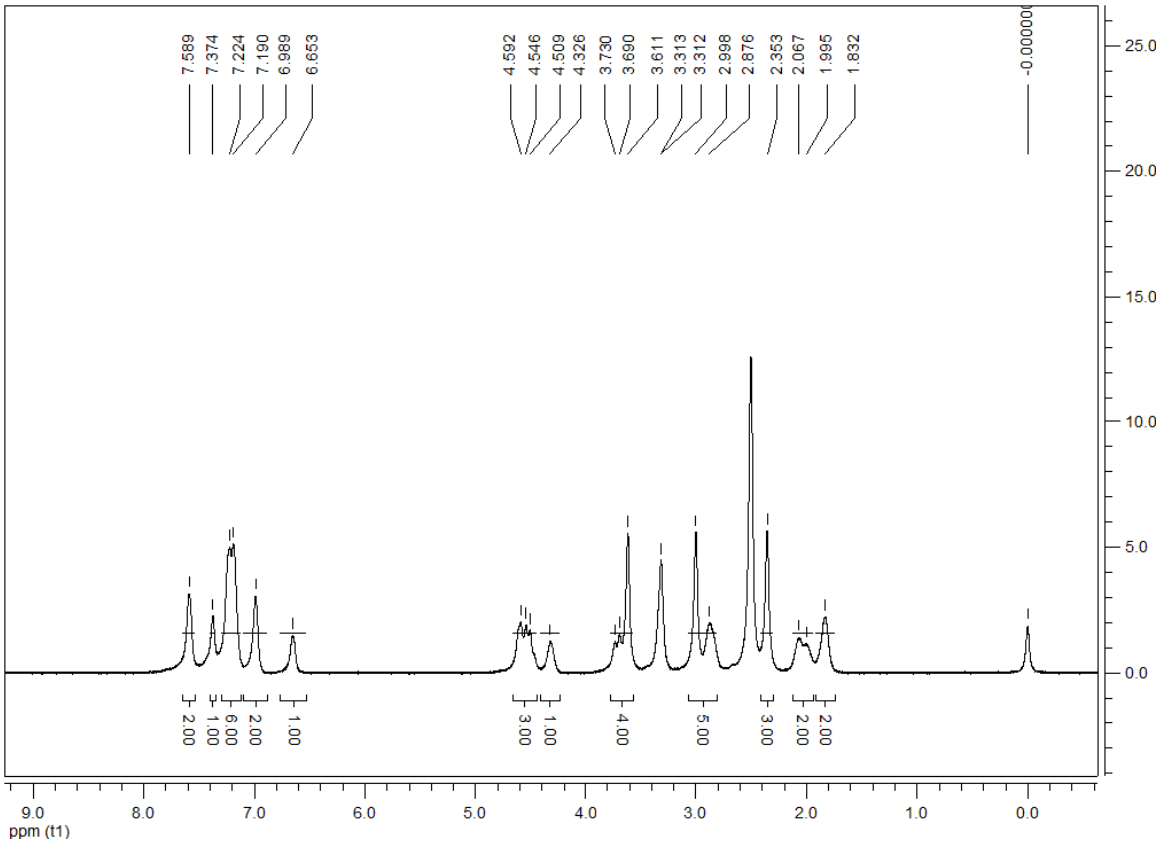
Dimethyl 2-(1,5'-dibenzyl-5-fluoro-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4j): white solid, 71%, m.p. 208-210℃; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.34 (d, *J* = 8.0Hz, 2H, ArH), 7.30-7.28 (m, 1H, ArH), 7.07-7.05 (m, 3H, ArH), 6.96-6.94 (m,

2H, ArH), 6.93-6.91 (m, 2H, ArH), 6.88-6.83 (m, 3H, ArH), 6.74-6.69 (m, 1H, ArH), 6.57 (d, *J* = 7.6Hz, 2H, ArH), 6.15-6.12 (m, 1H, ArH), 5.09-5.04 (m, 2H, CH_2), 4.92-4.86 (m, 1H, CH), 4.51 (d, *J* = 16.0Hz, 1H, CH), 4.21 (d, *J* = 16.0Hz, 1H, CH), 4.08 (s, 3H, OCH_3), 4.06 (s, 3H, OCH_3), 3.73 (s, 3H, OCH_3), 3.60 (d, *J* = 17.2Hz, 1H, CH), 3.52-3.48 (m, 1H, CH), 3.32 (s, 3H, OCH_3), 3.23-3.17 (m, 1H, CH), 2.49 (d, *J* = 16.8Hz, 1H, CH), 2.33 (s, 3H, CH_3); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 191.8, 173.9, 170.7, 169.0, 166.2, 165.2, 157.2, 146.9, 144.2, 139.2, 136.0, 135.0, 133.3, 129.7, 129.0, 128.4, 128.2, 128.1, 127.0, 126.8, 126.6, 115.5 (d, *J* = 23.7Hz), 114.9 (d, *J* = 25.5Hz), 110.0 (d, *J* = 8.1Hz), 103.0, 74.1, 64.5, 62.6, 55.1, 53.5, 53.3, 51.6, 51.5, 44.9, 40.8, 36.7, 21.6; IR(KBr) υ: 3029, 2954, 2876, 2820, 1730, 1681, 1595, 1493, 1453, 1437, 1359, 1234, 1215, 1181, 1162, 1078, 1051, 1016, 968, 890, 853, 812, 755, 700 cm^{-1}; MS (*m/z*): HRMS (ESI) Calcd. for $C_{44}H_{41}FN_2NaO_{10}$ ($[M+Na]^+$): 799.2637, found: 799.2649.

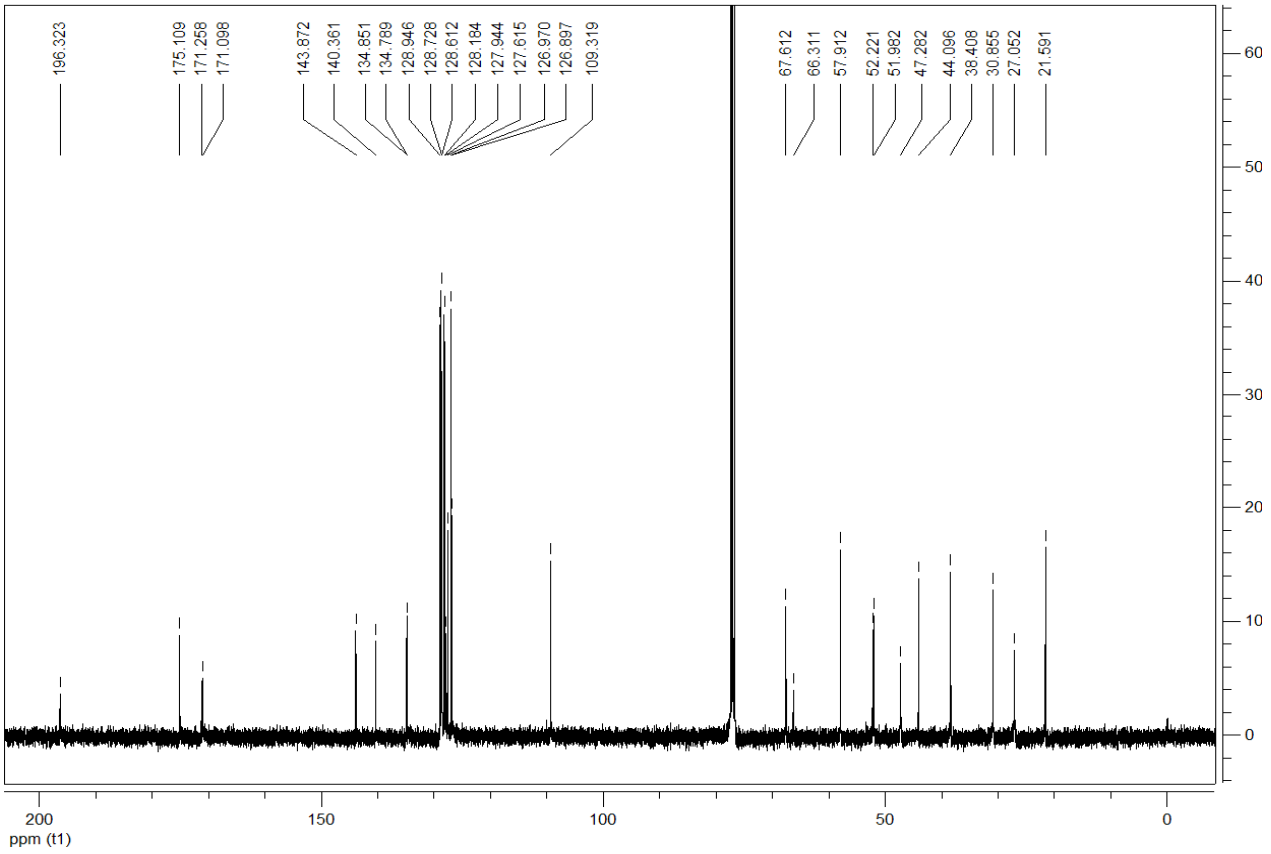
Methyl 1-benzyl-5-chloro-3'-(2-methoxy-2-oxoethyl)-1'-(4-methylbenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1a):



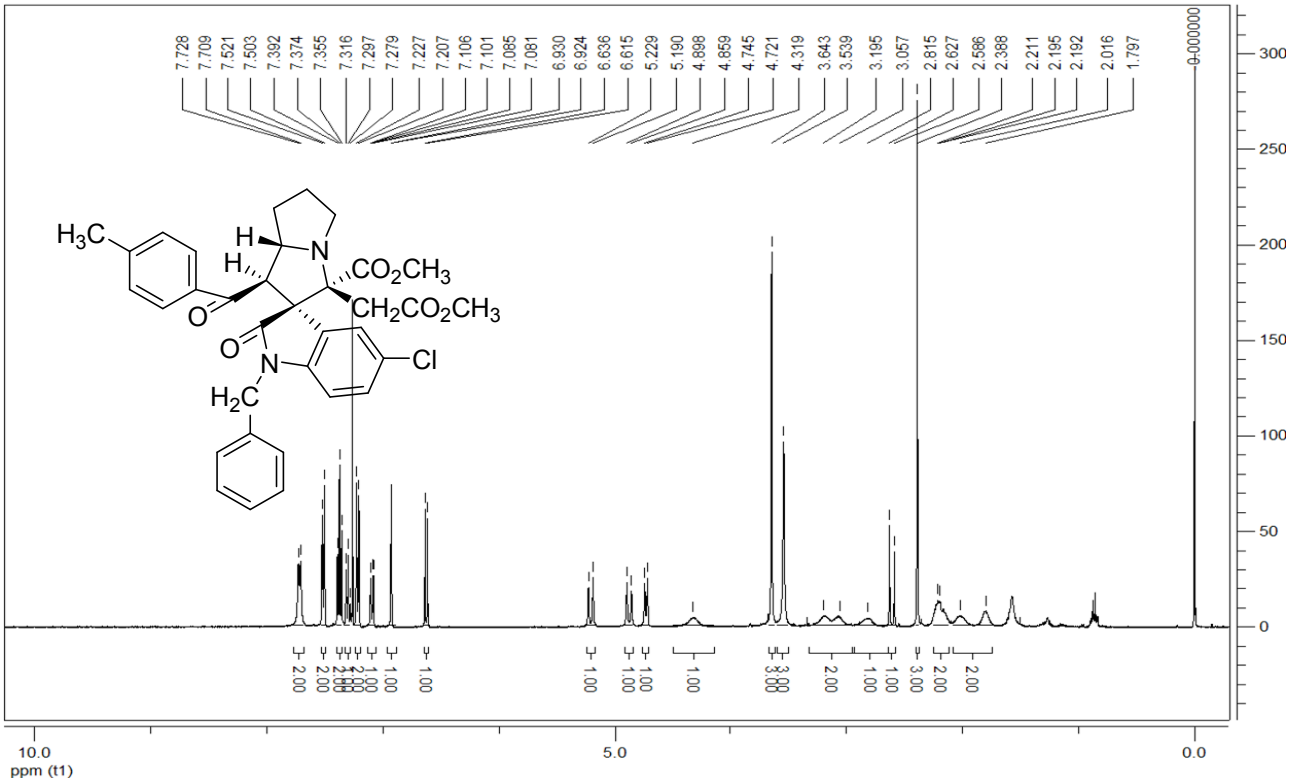
^1H NMR in $CDCl_3$

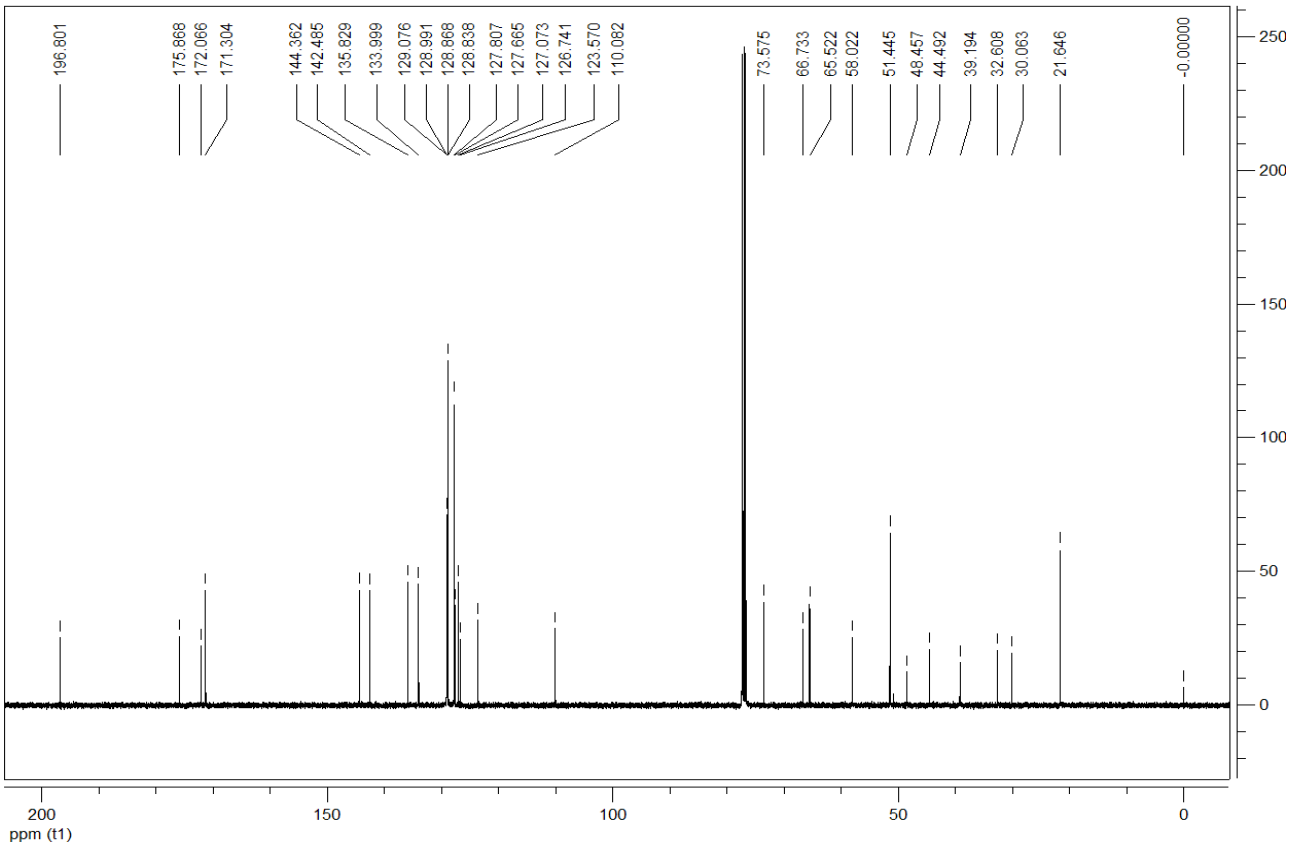


^{1}H NMR in DMSO-d_6

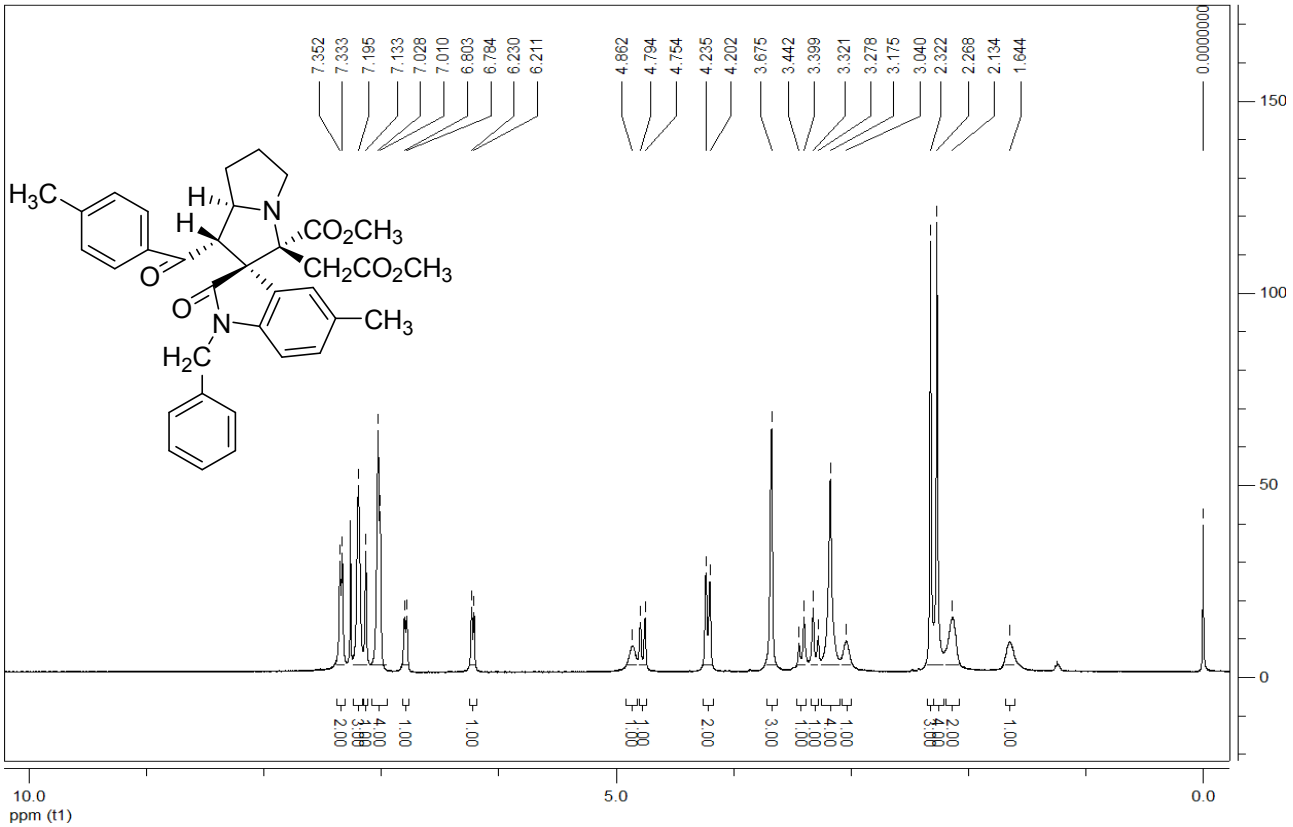


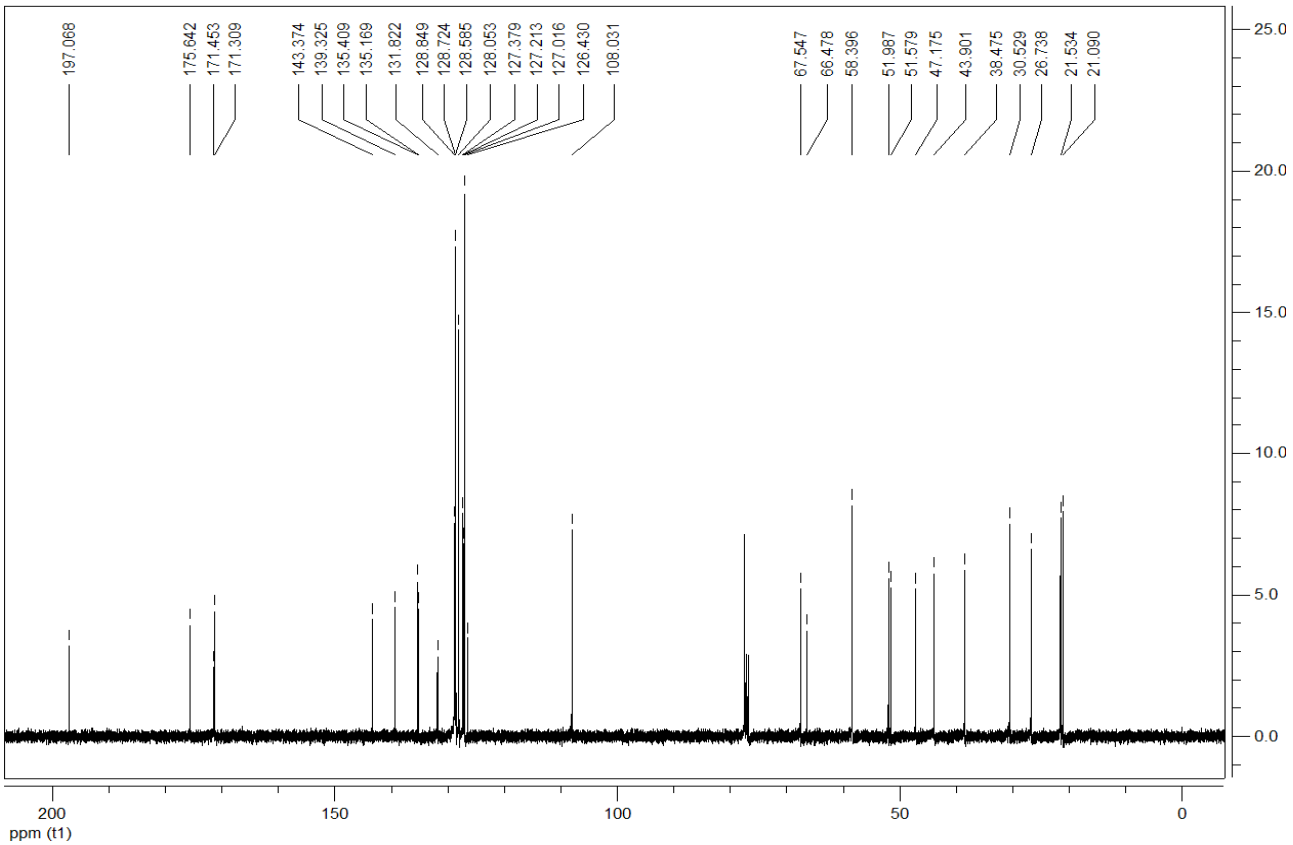
Methyl 1-benzyl-5-chloro-3'-(2-methoxy-2-oxoethyl)-1'-(4-methylbenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1a')



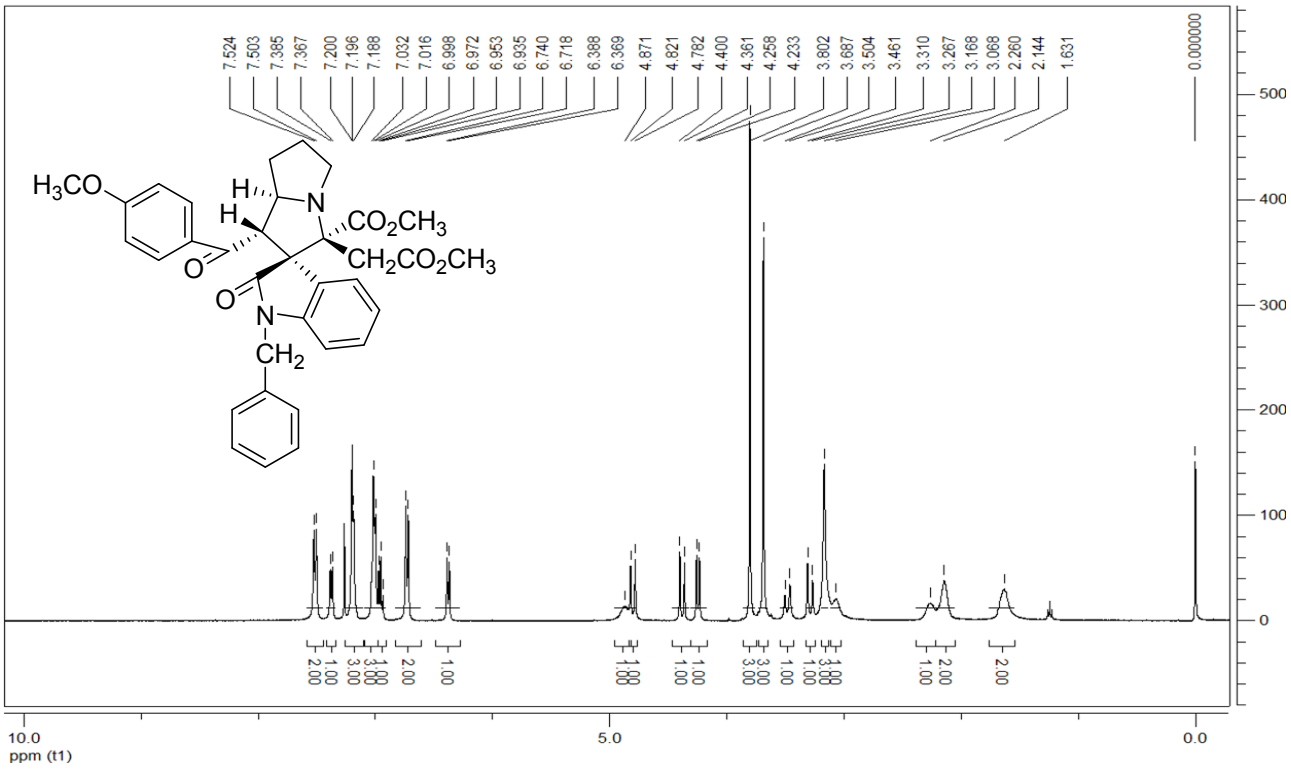


Methyl 1-benzyl-3'-(2-methoxy-2-oxoethyl)-5-methyl-1'-(4-methylbenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1b):

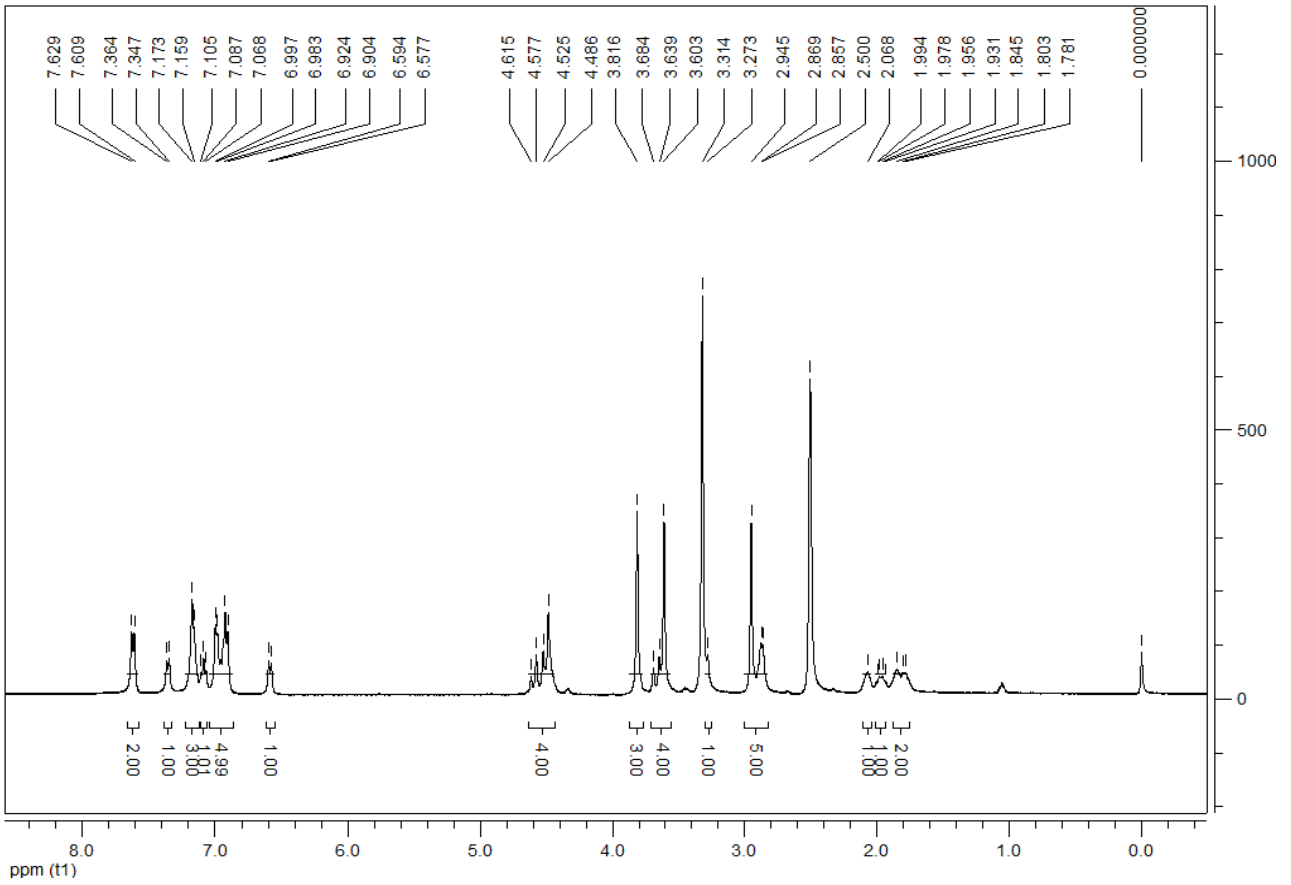




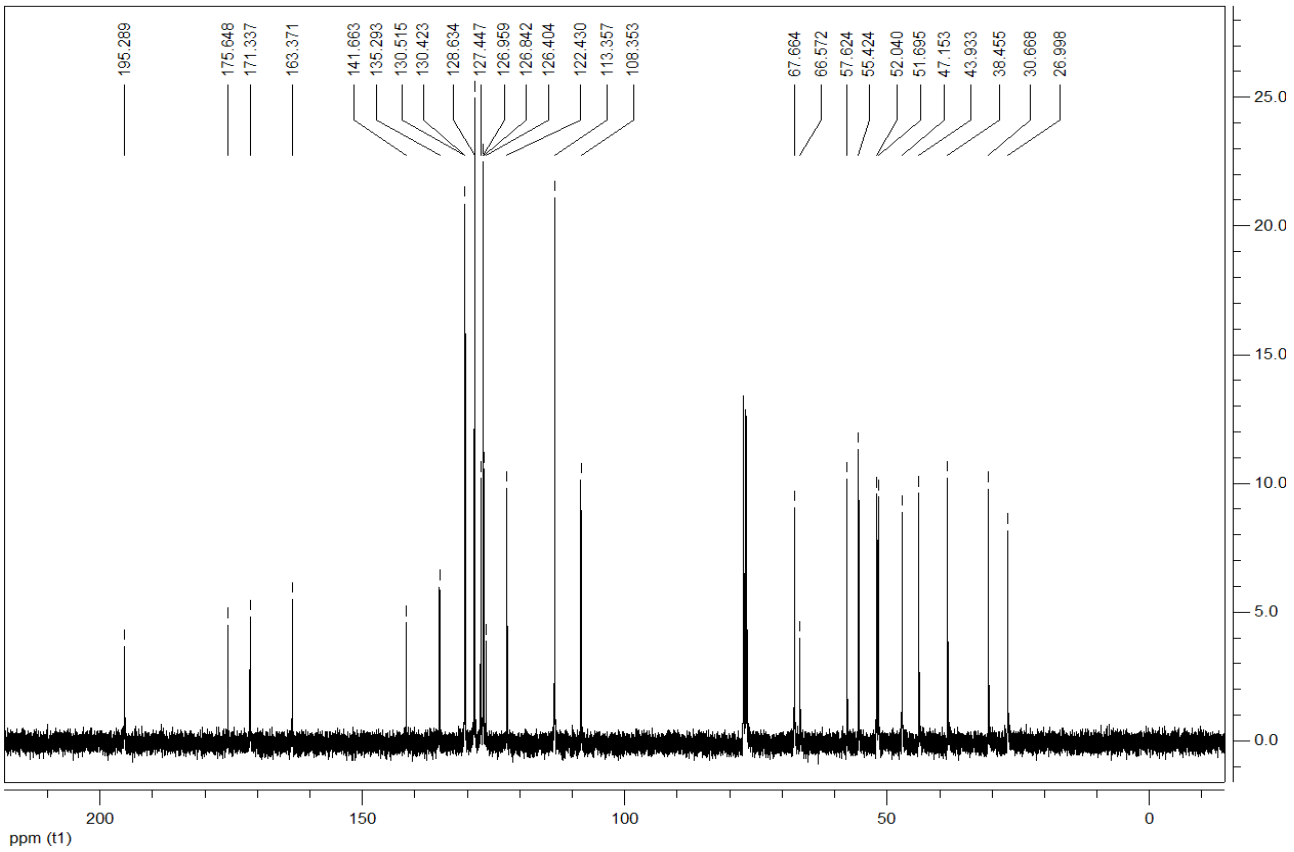
Methyl 1-benzyl-3'-(2-methoxy-2-oxoethyl)-1'-(4-methoxybenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1c):



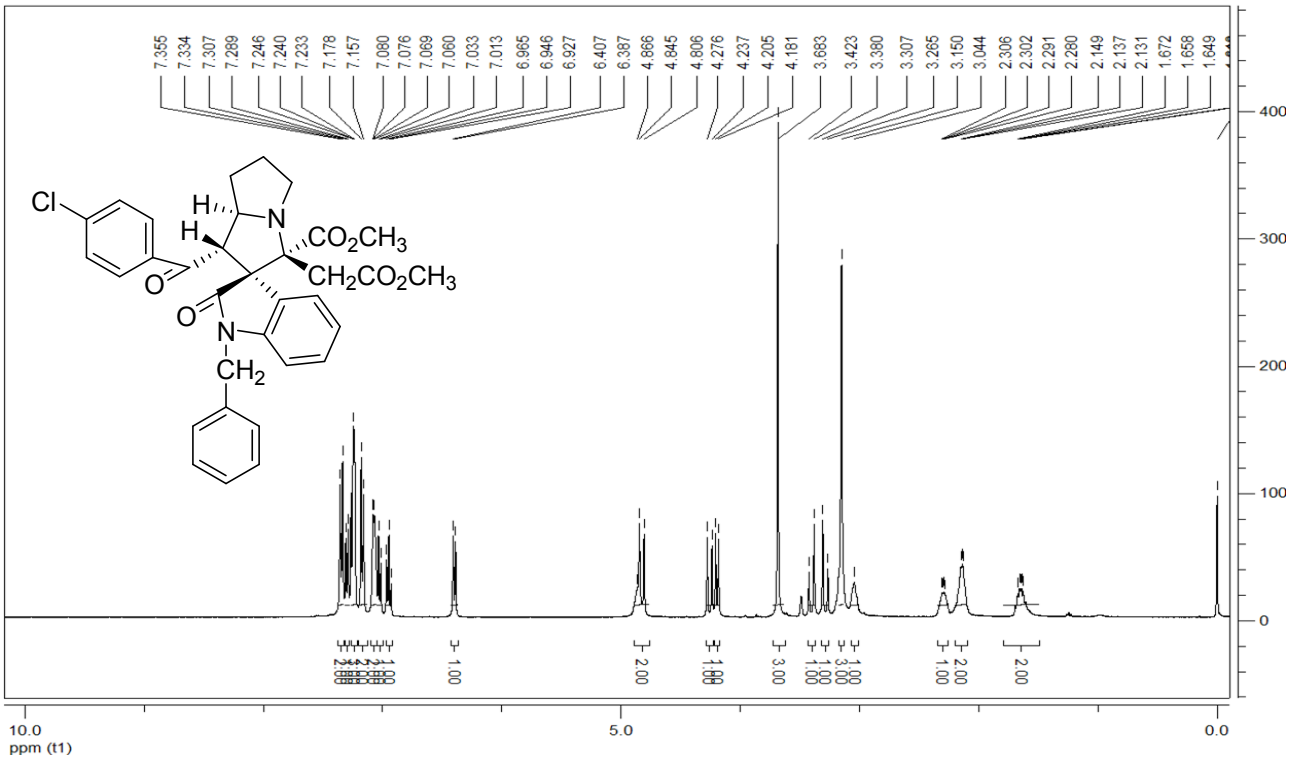
^{1}H NMR in $CDCl_3$

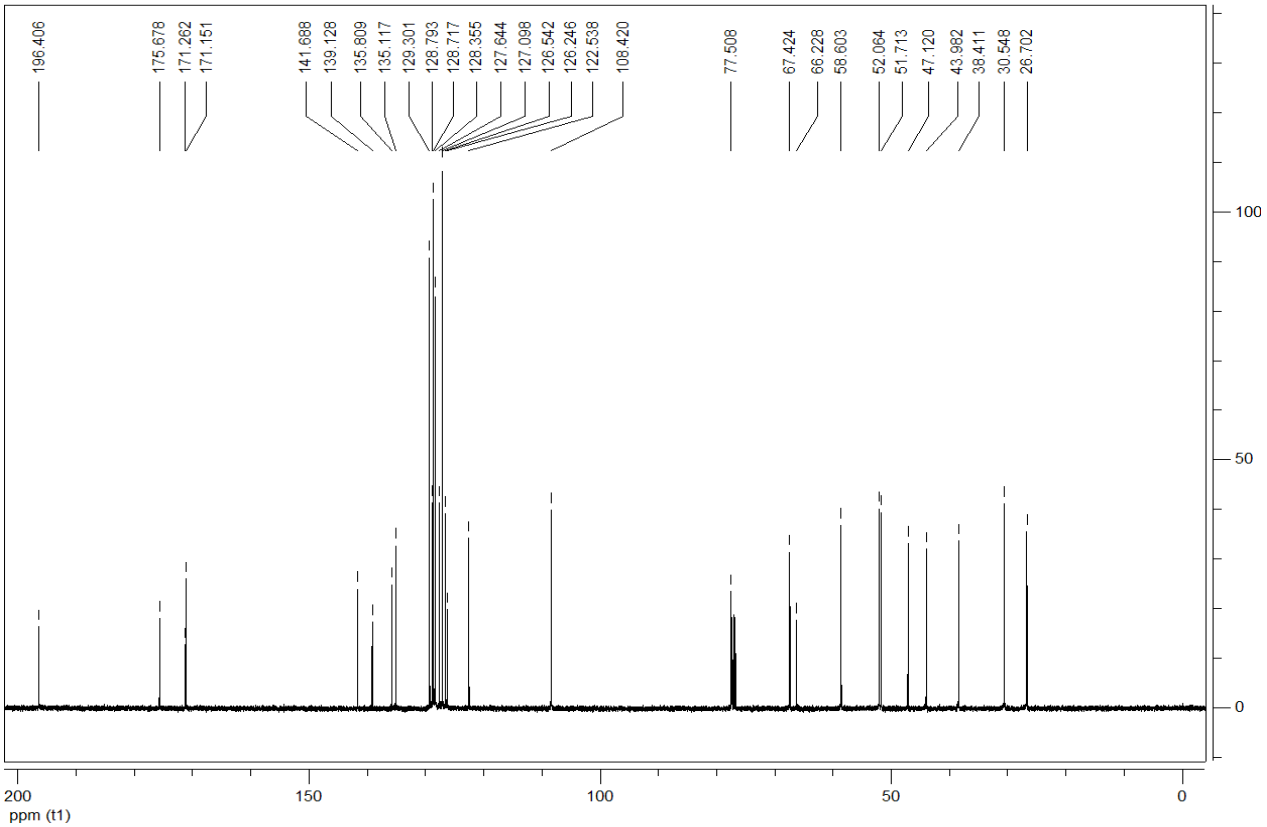


^{1}H NMR in DMSO-d_6

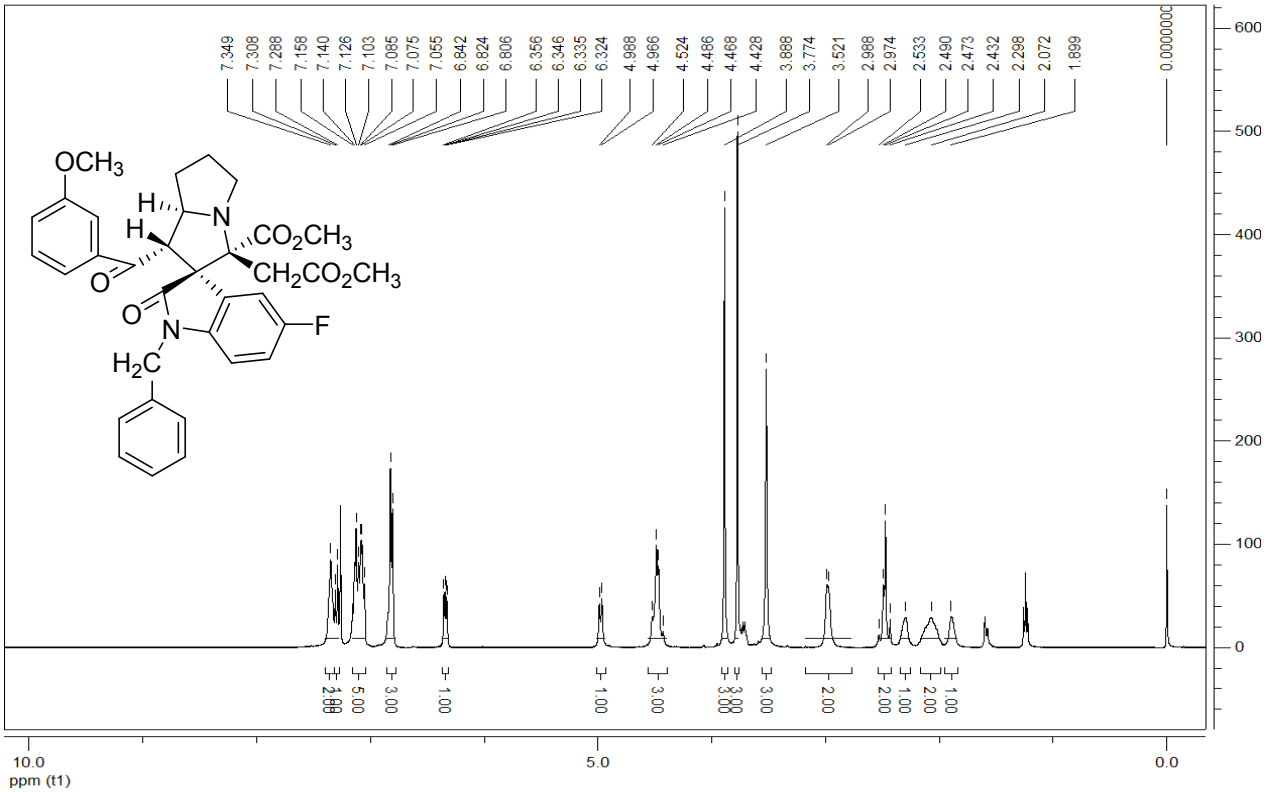


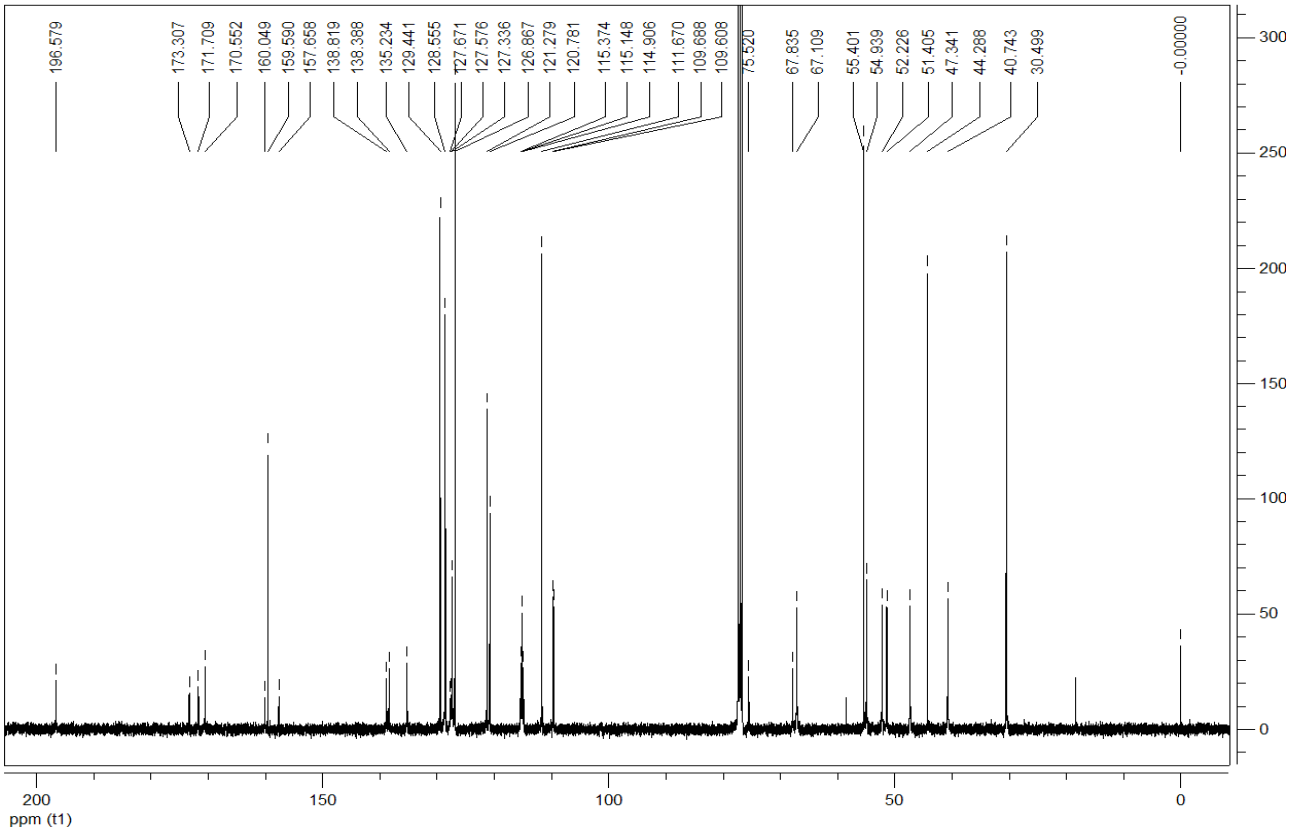
Methyl 1-benzyl-1'-(4-chlorobenzoyl)-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline- 3,2'-pyrrolizine]-3'-carboxylate (1d):



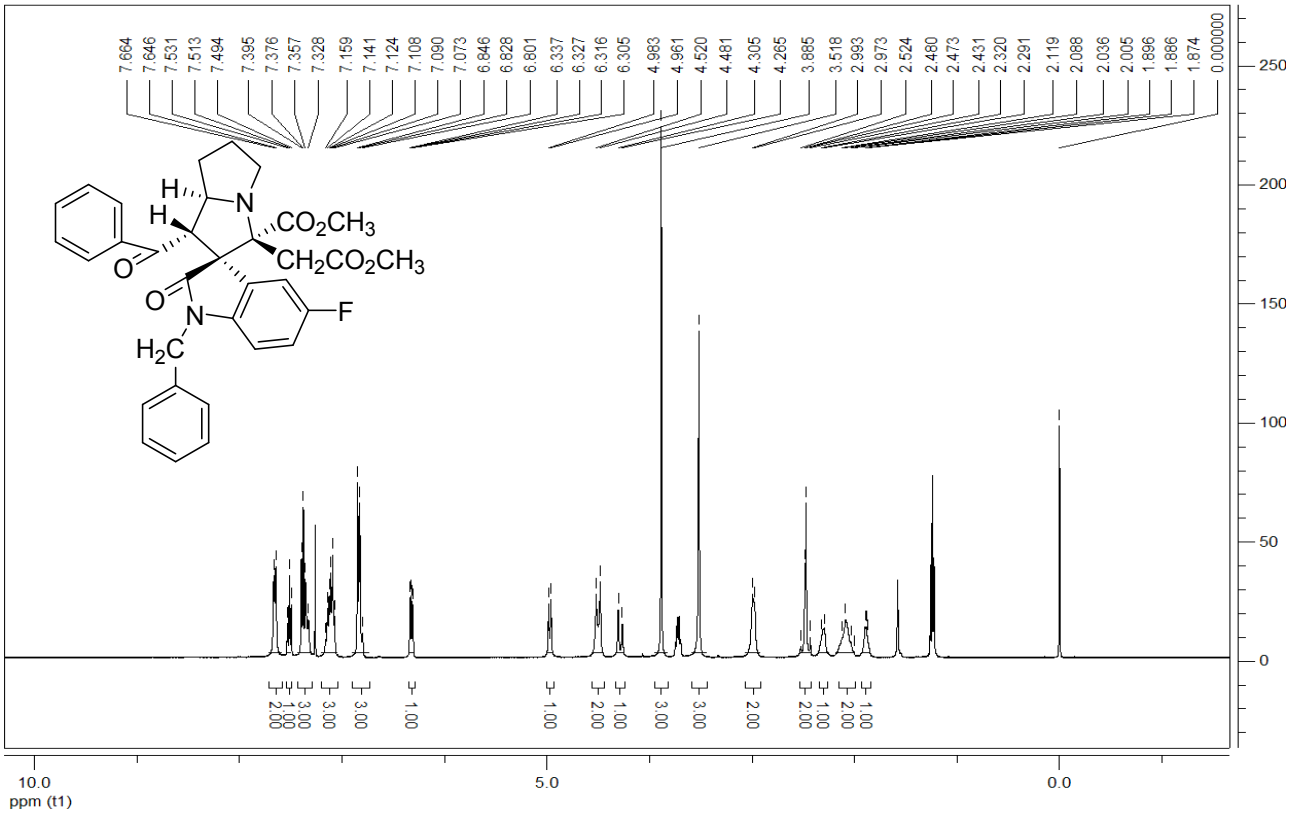


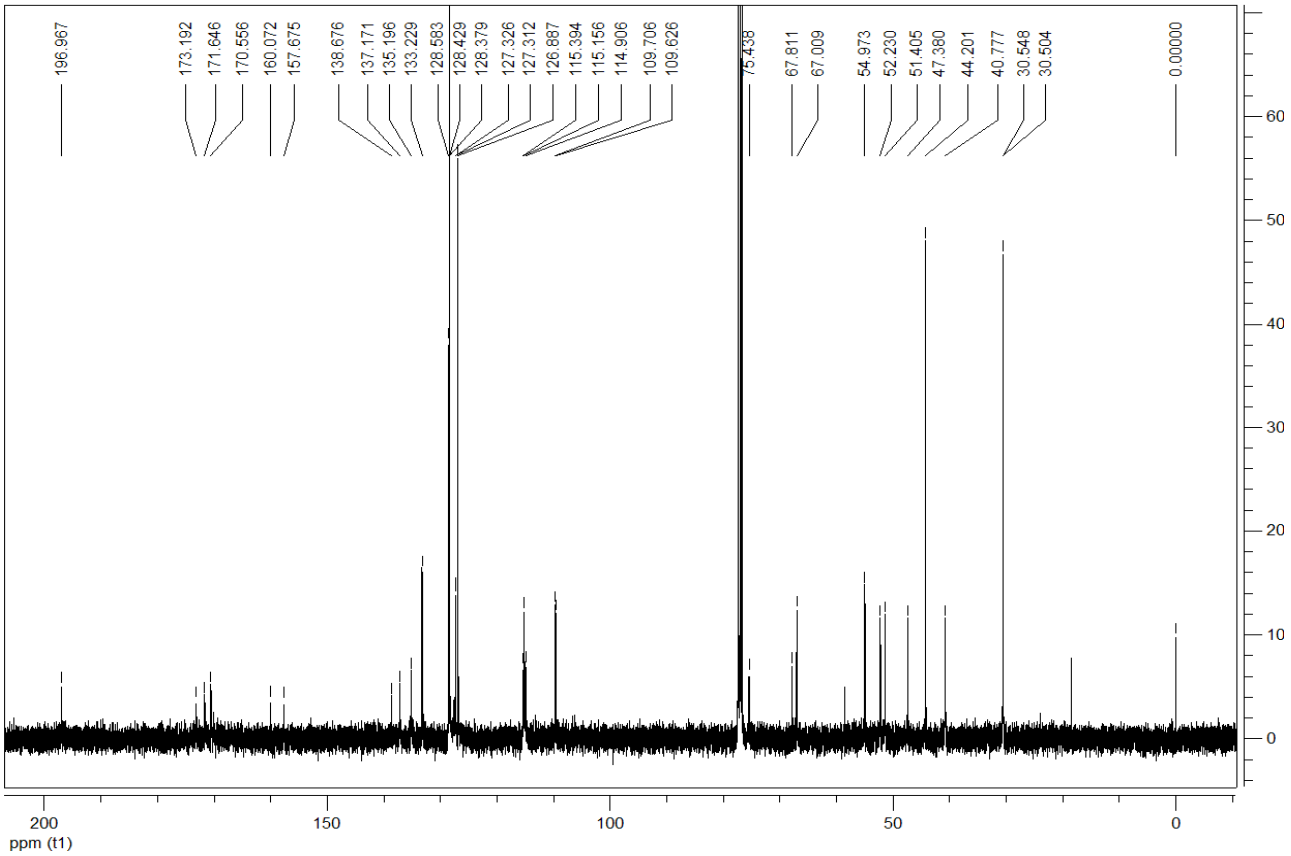
Methyl 1-benzyl-5-fluoro-3'-(2-methoxy-2-oxoethyl)-1'-(3-methoxybenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1e):



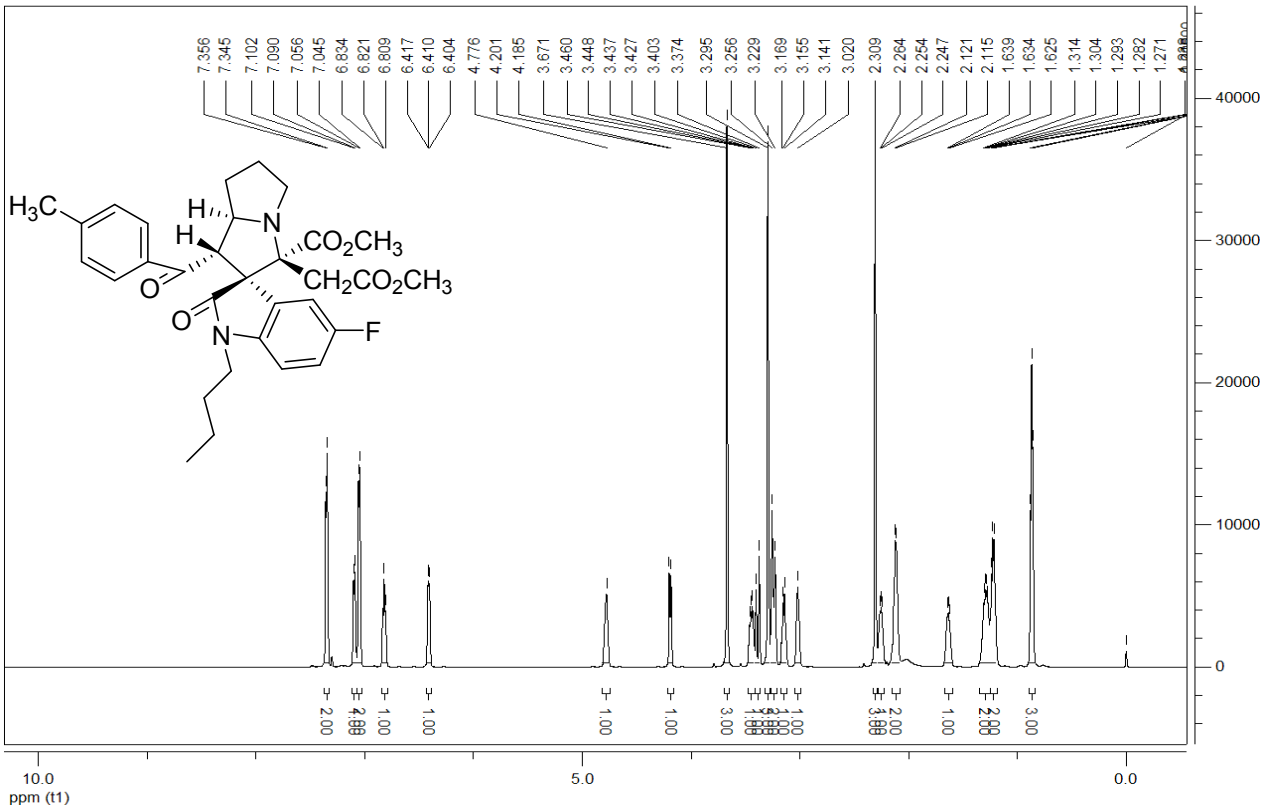


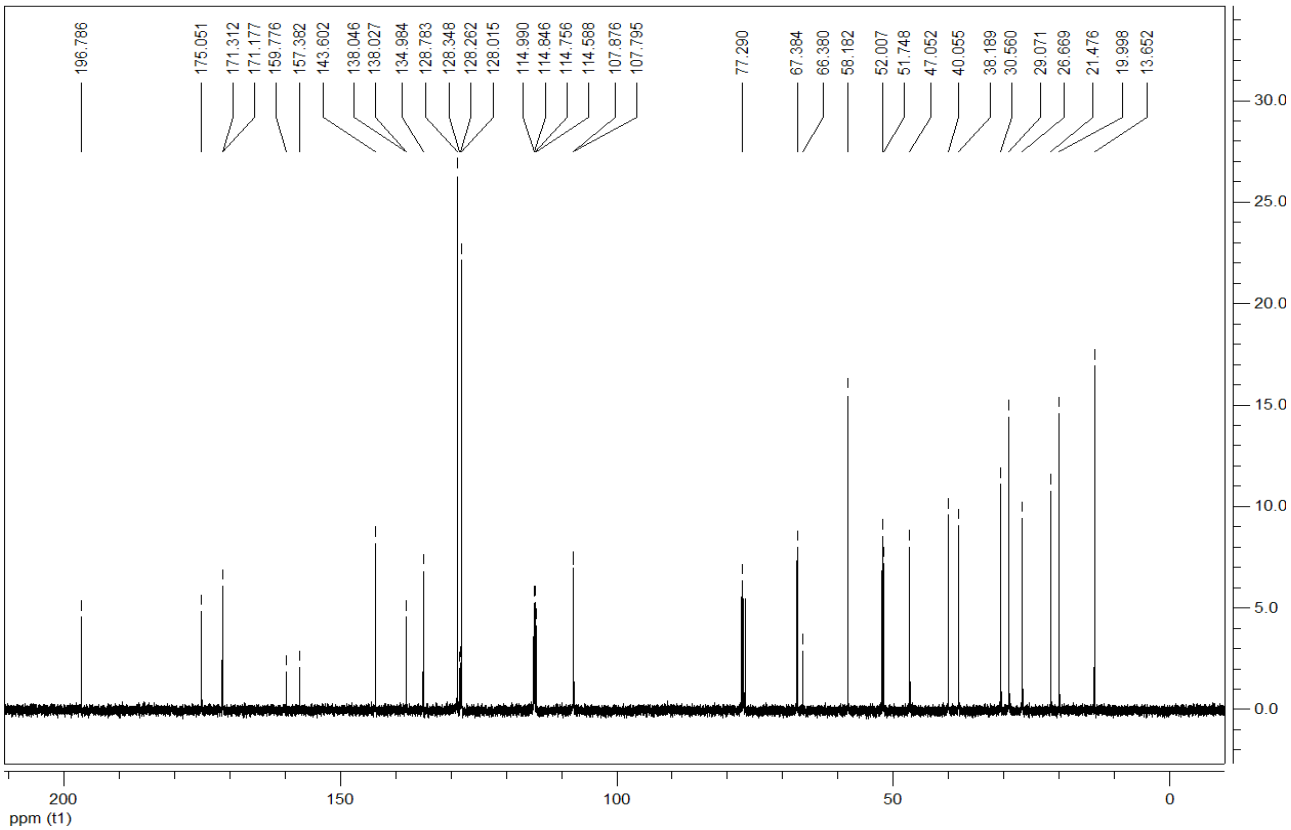
Methyl 1'-benzoyl-1-benzyl-5-fluoro-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1f):



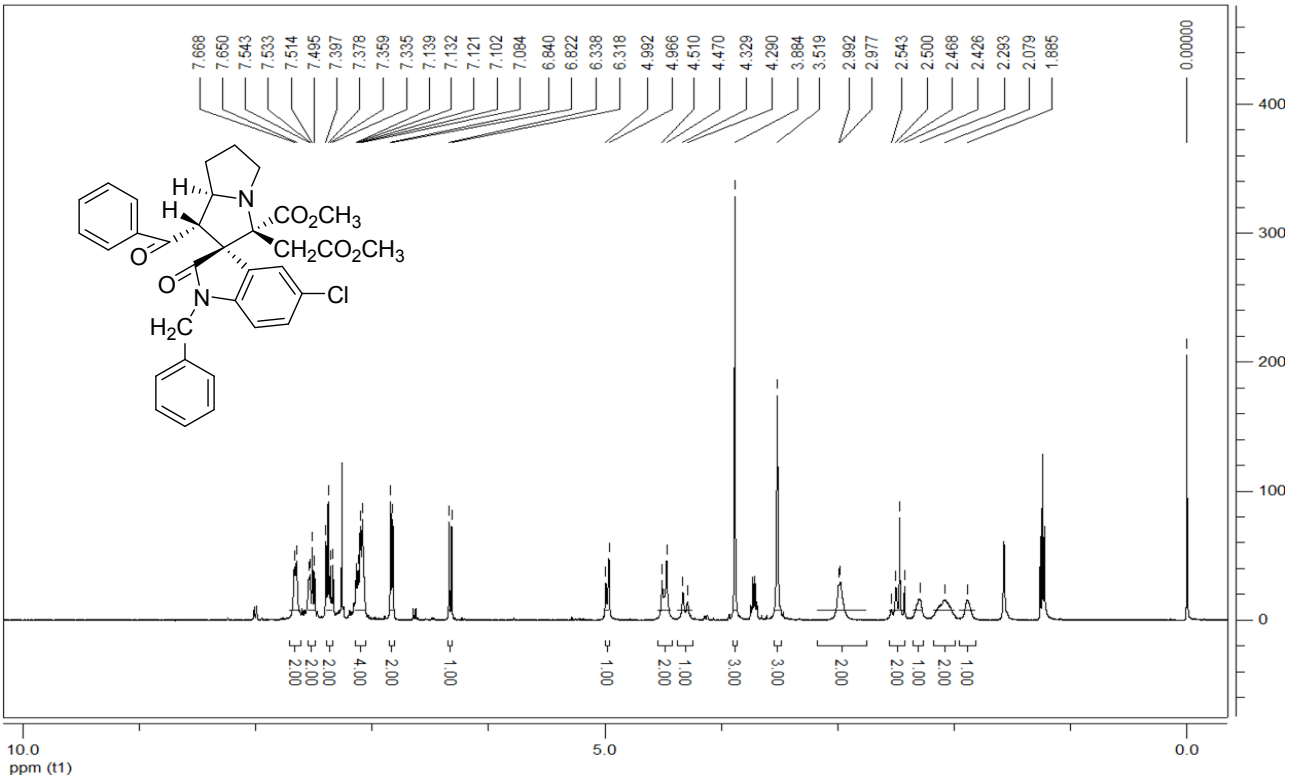


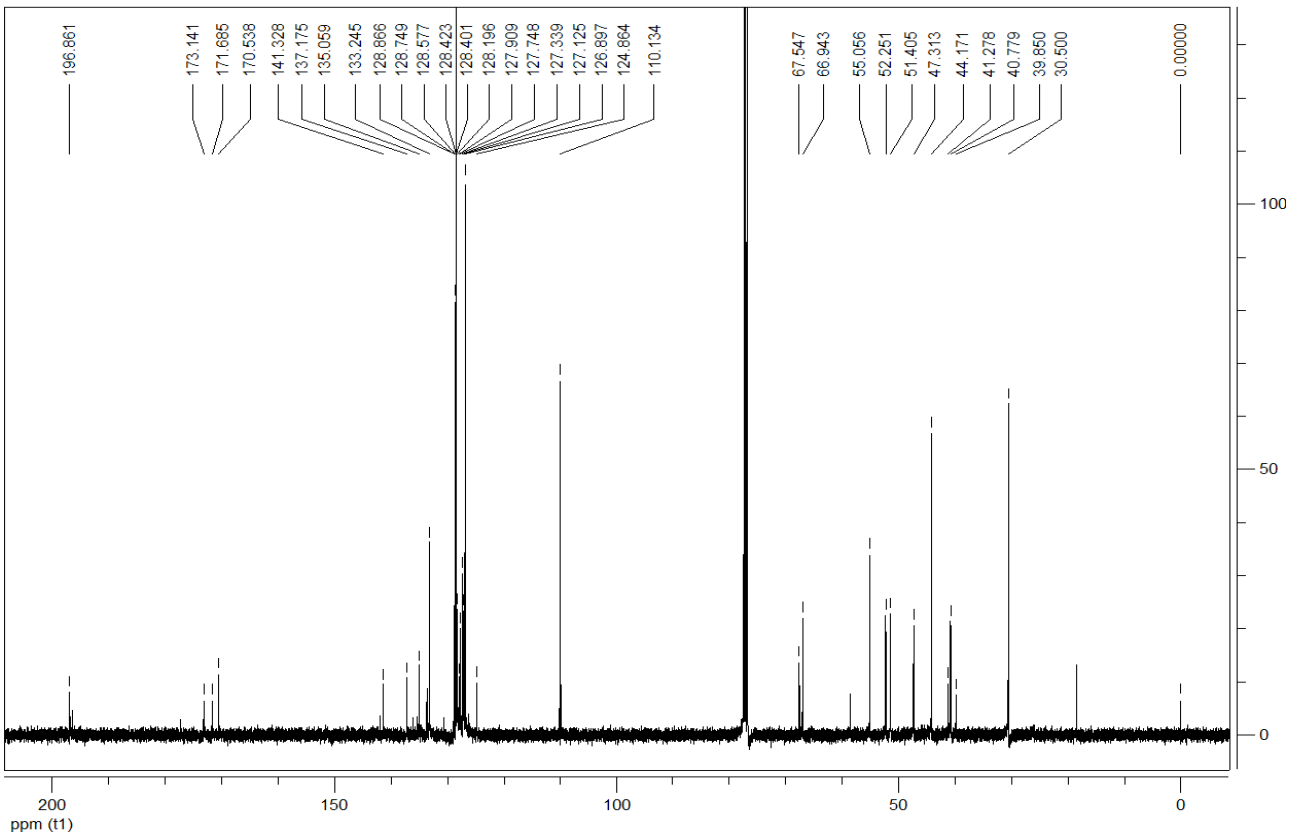
Methyl 1-butyl-5-fluoro-3'-(2-methoxy-2-oxoethyl)-1'-(4-methylbenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1g):



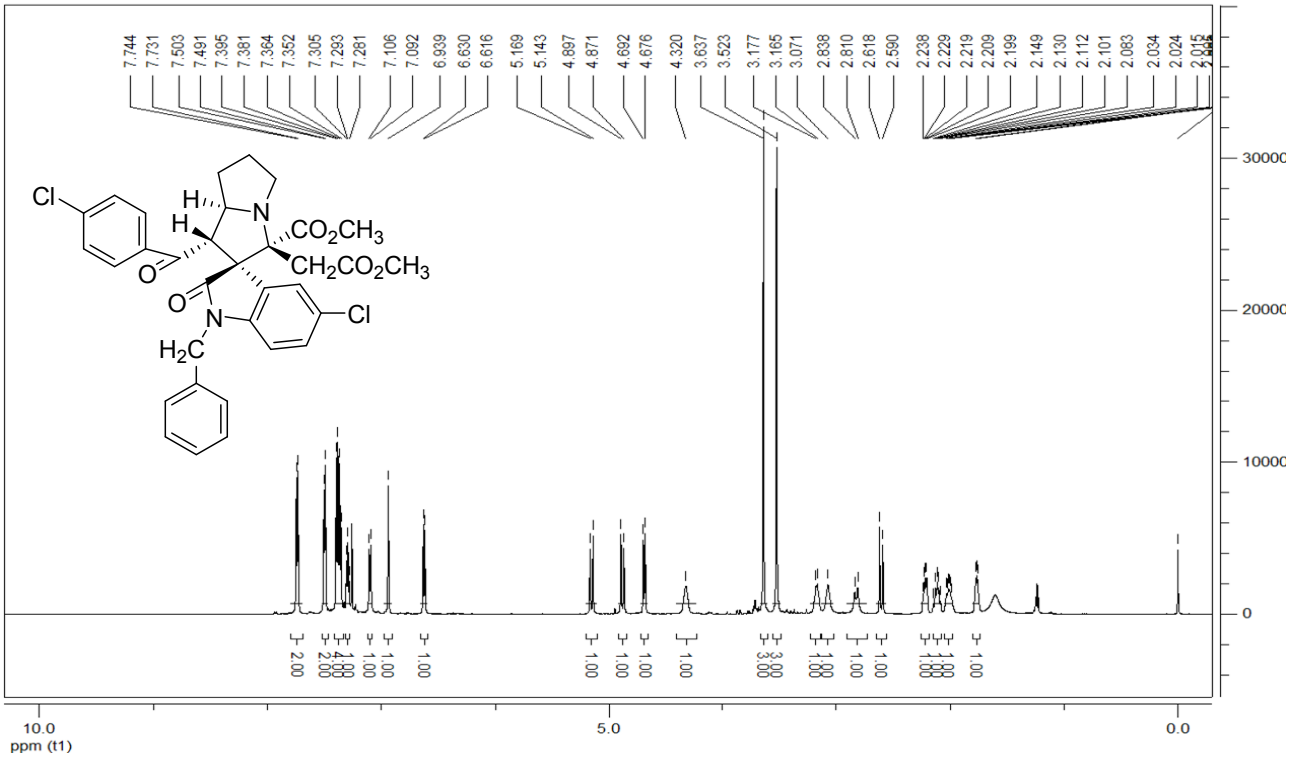


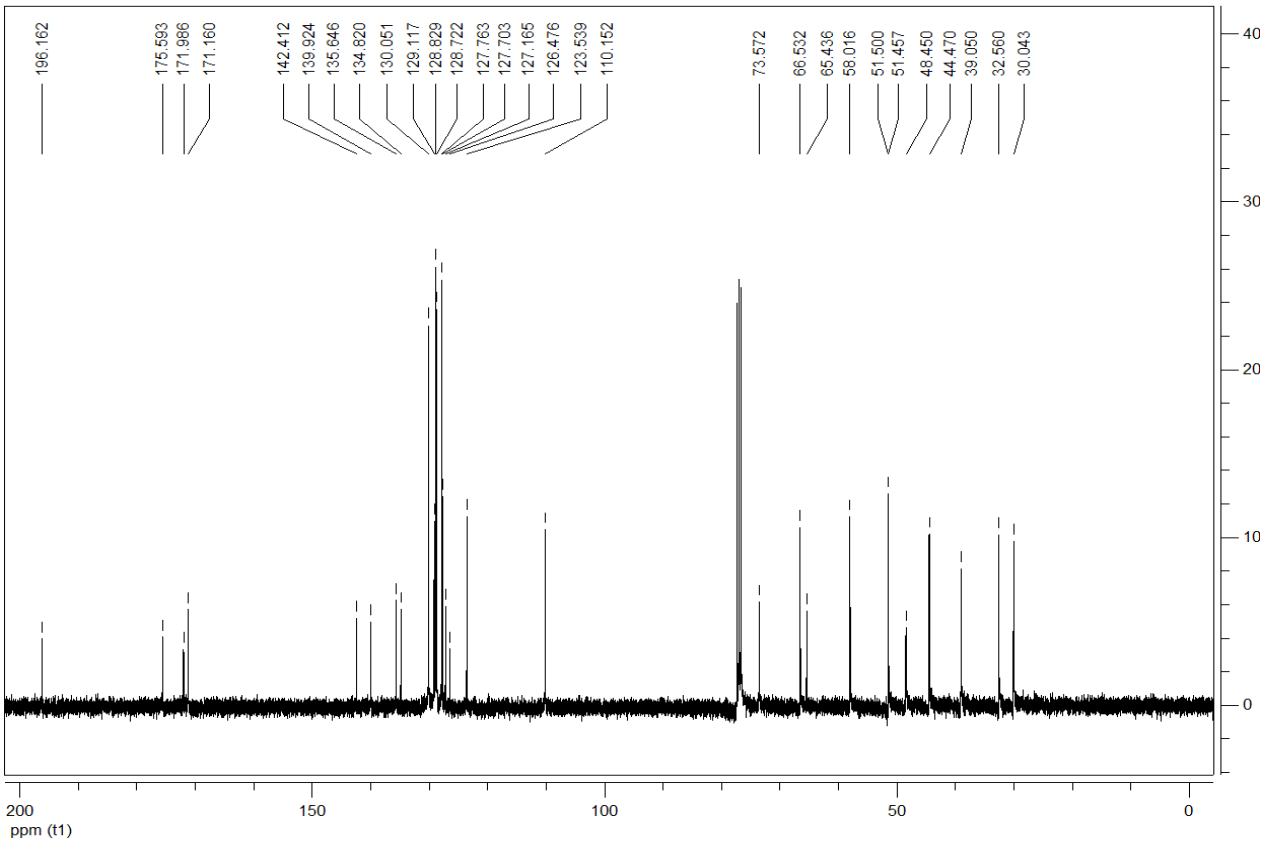
Methyl 1'-benzoyl-1-benzyl-5-chloro-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1h):



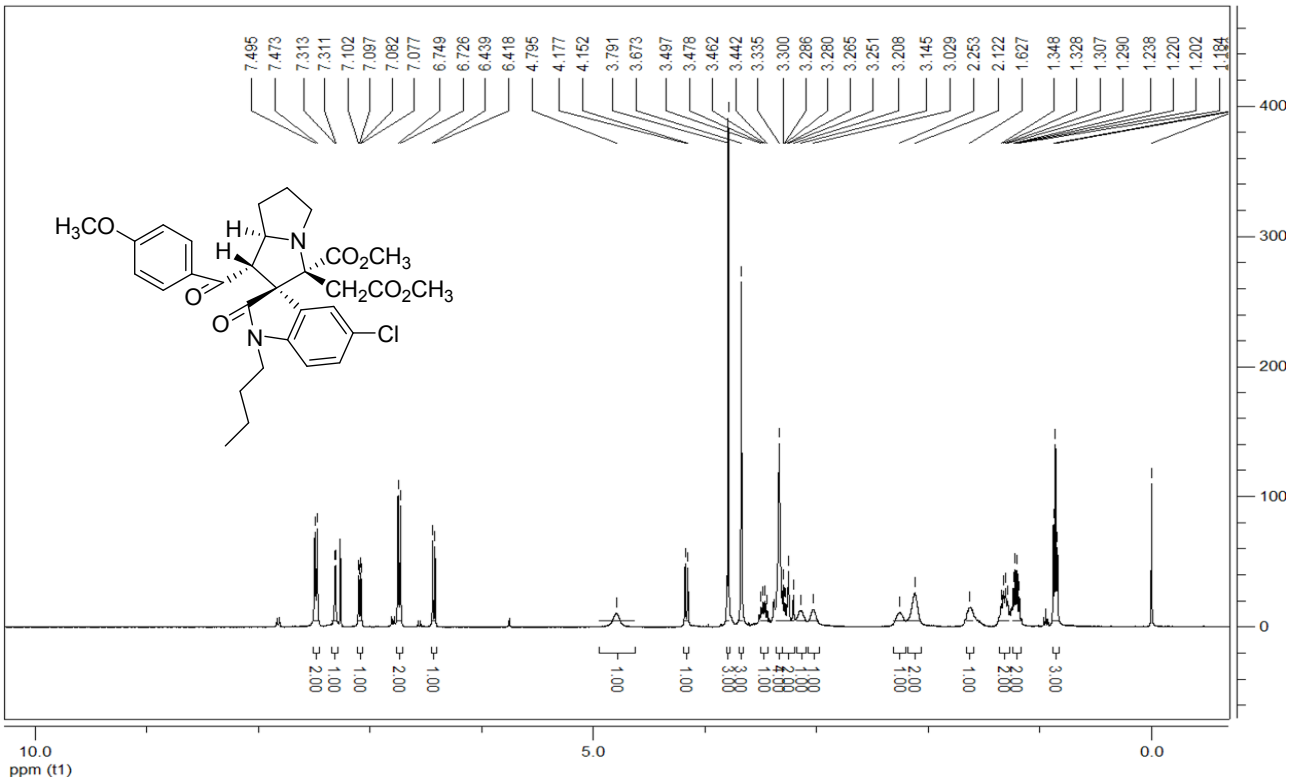


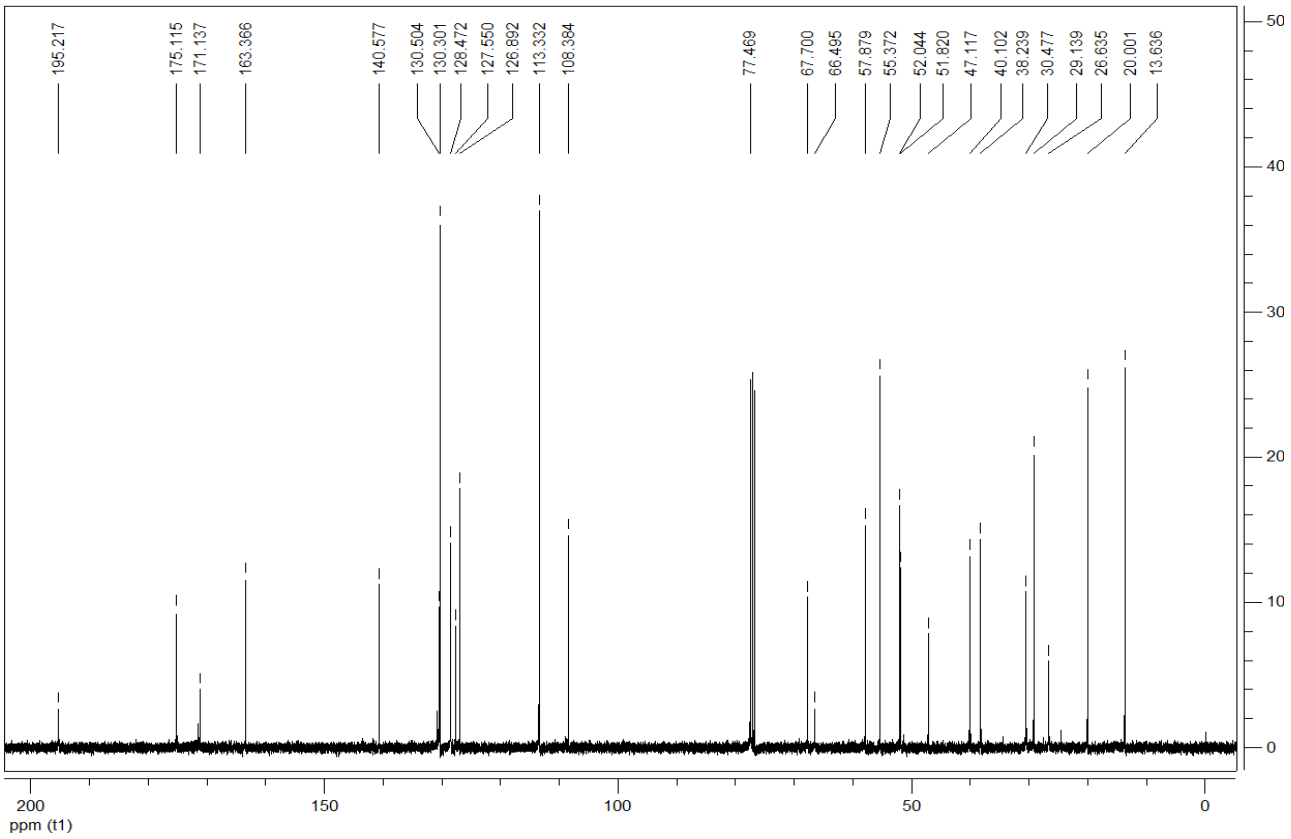
Methyl 1-benzyl-5-chloro-1'-(4-chlorobenzoyl)-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1i):



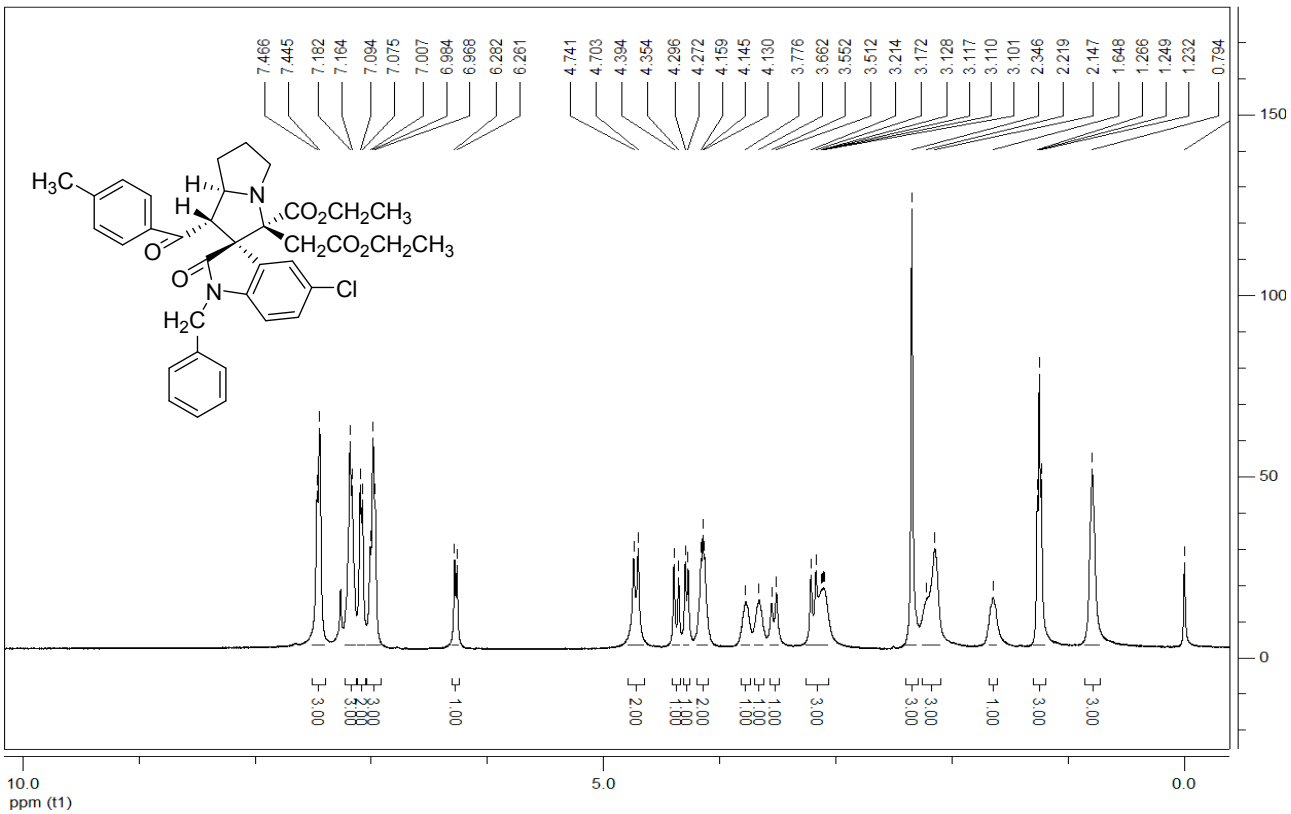


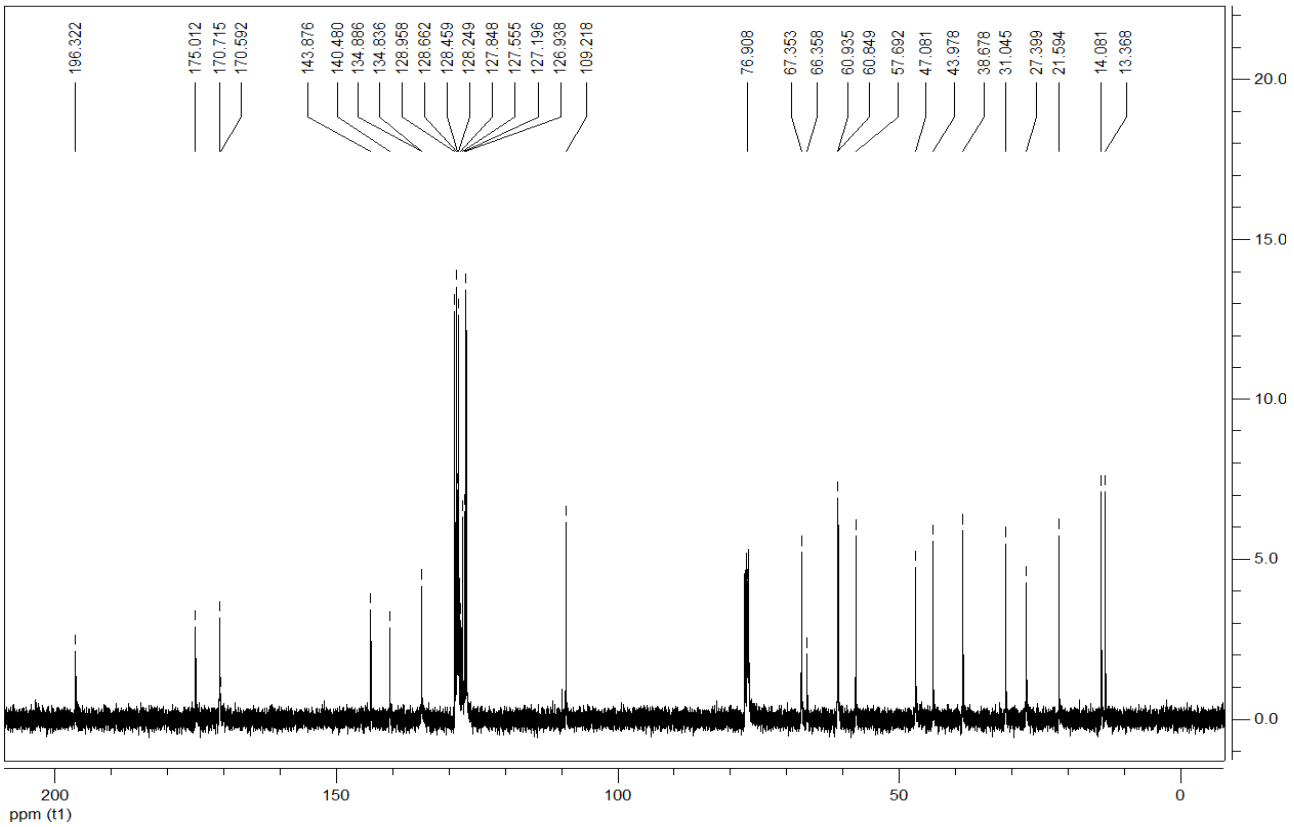
Methyl 1-butyl-5-chloro-3'-(2-methoxy-2-oxoethyl)-1'-(4-methoxybenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1j):



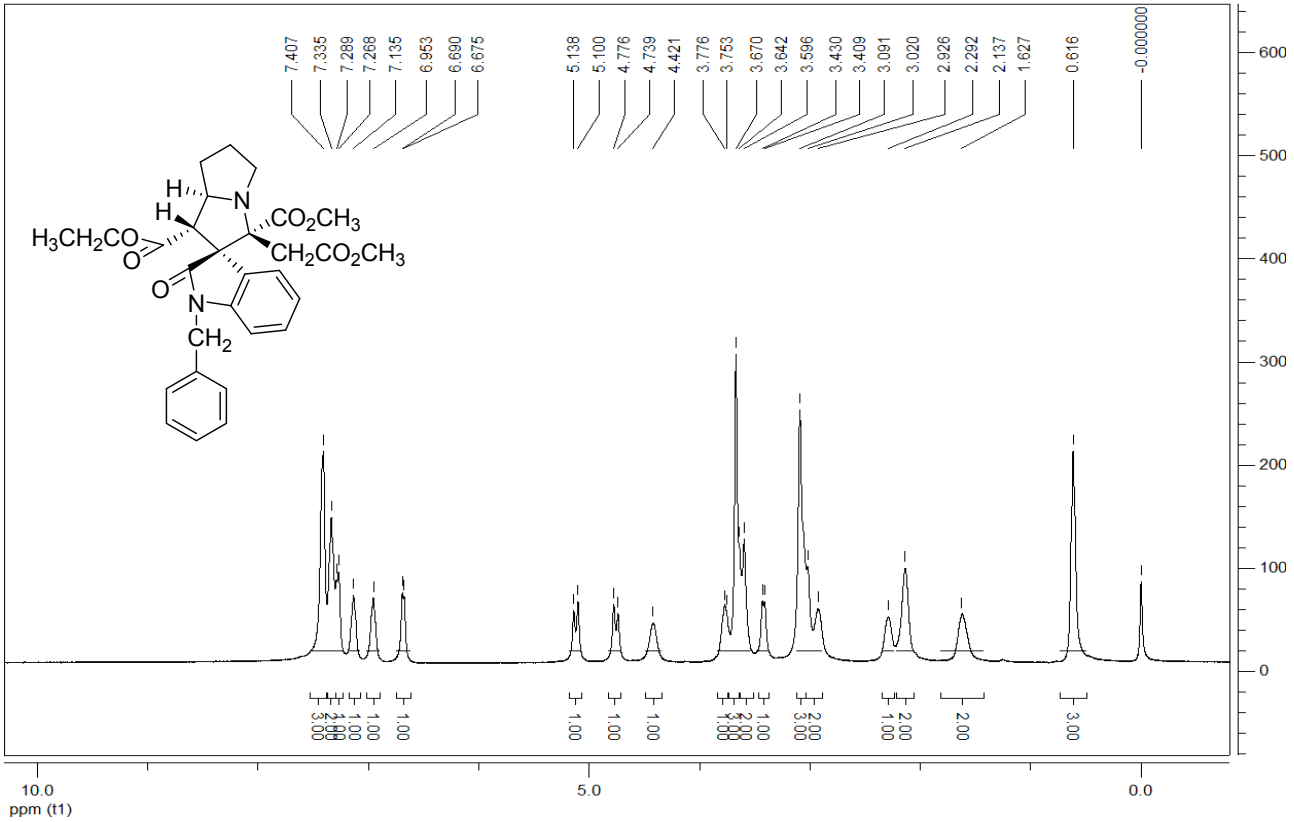


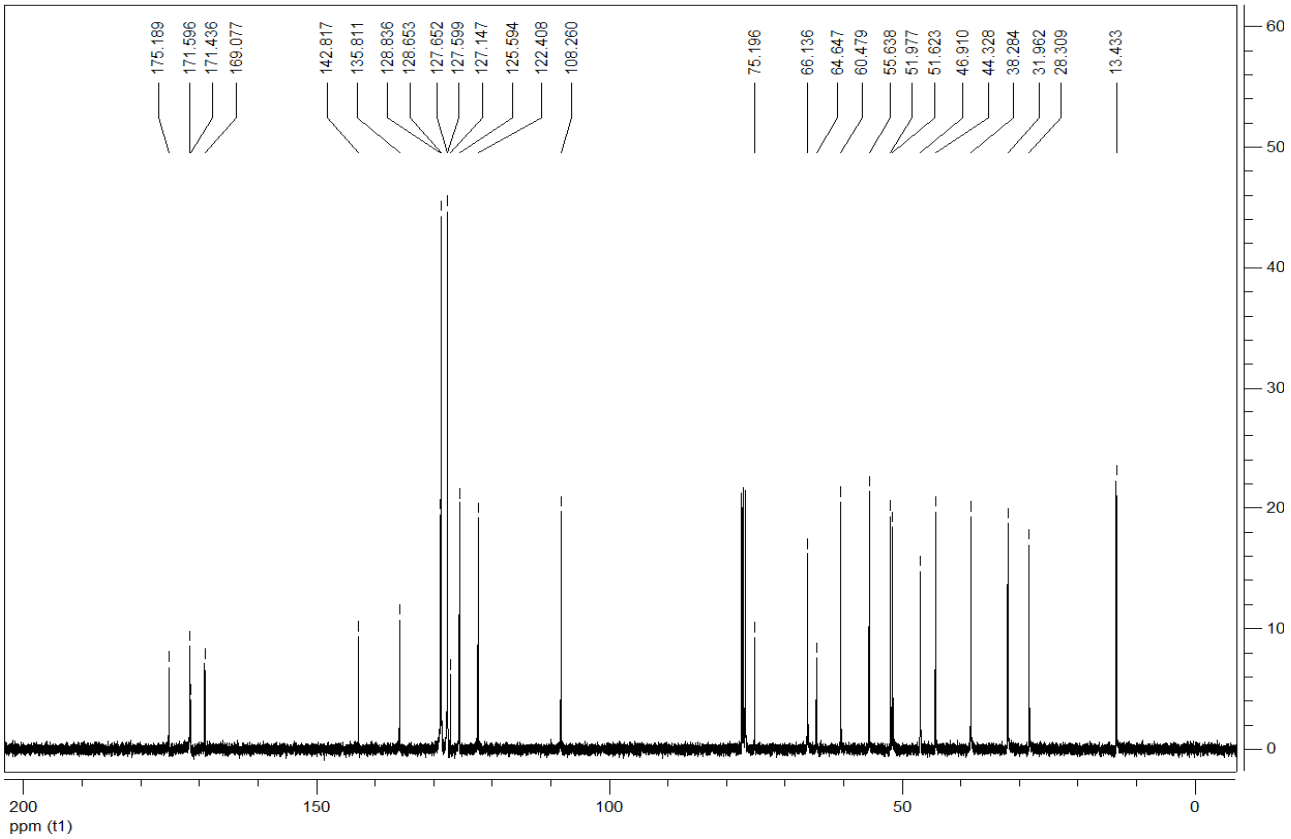
Ethyl 1-benzyl-5-chloro-3'-(2-ethoxy-2-oxoethyl)-1'-(4-methylbenzoyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-3'-carboxylate (1k):



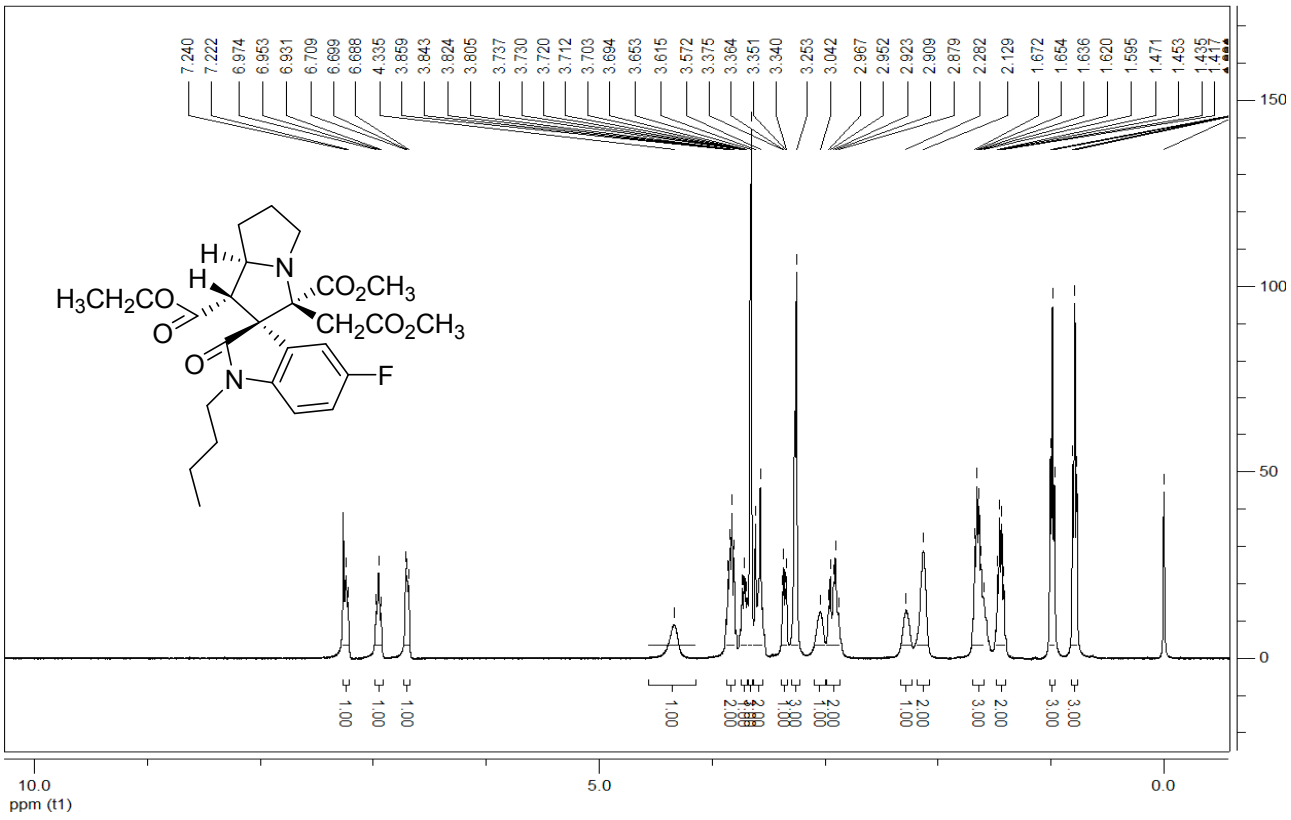


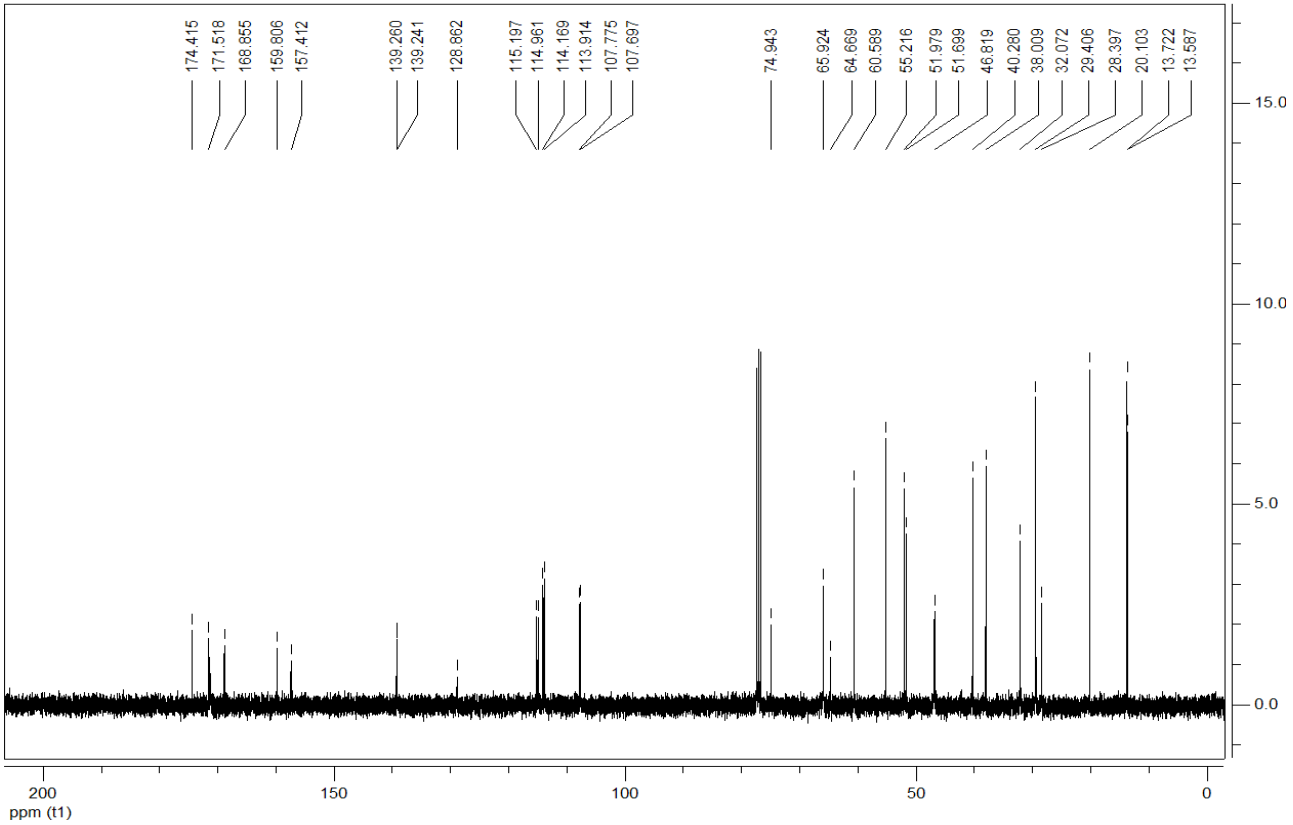
1'-Ethyl 3'-methyl 1-benzyl-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-1',3'-dicarboxylate (1l):



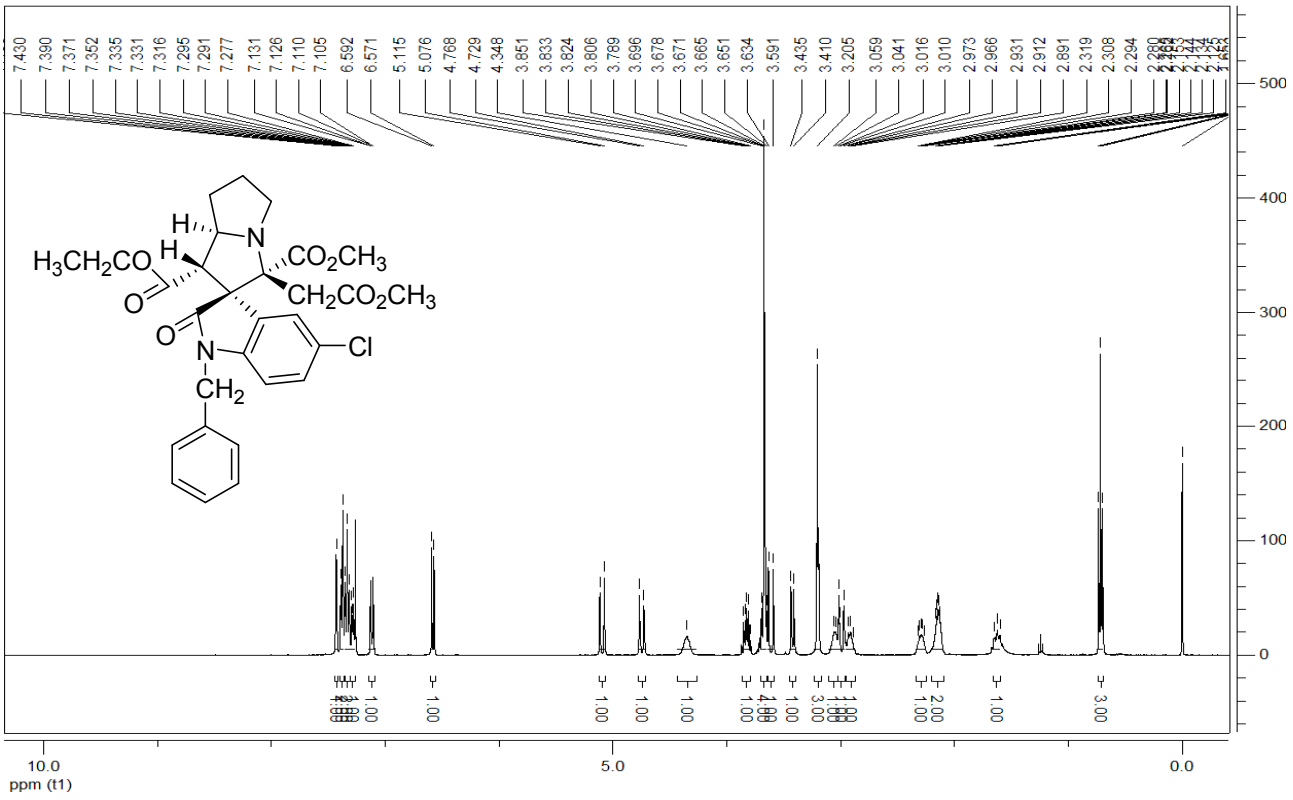


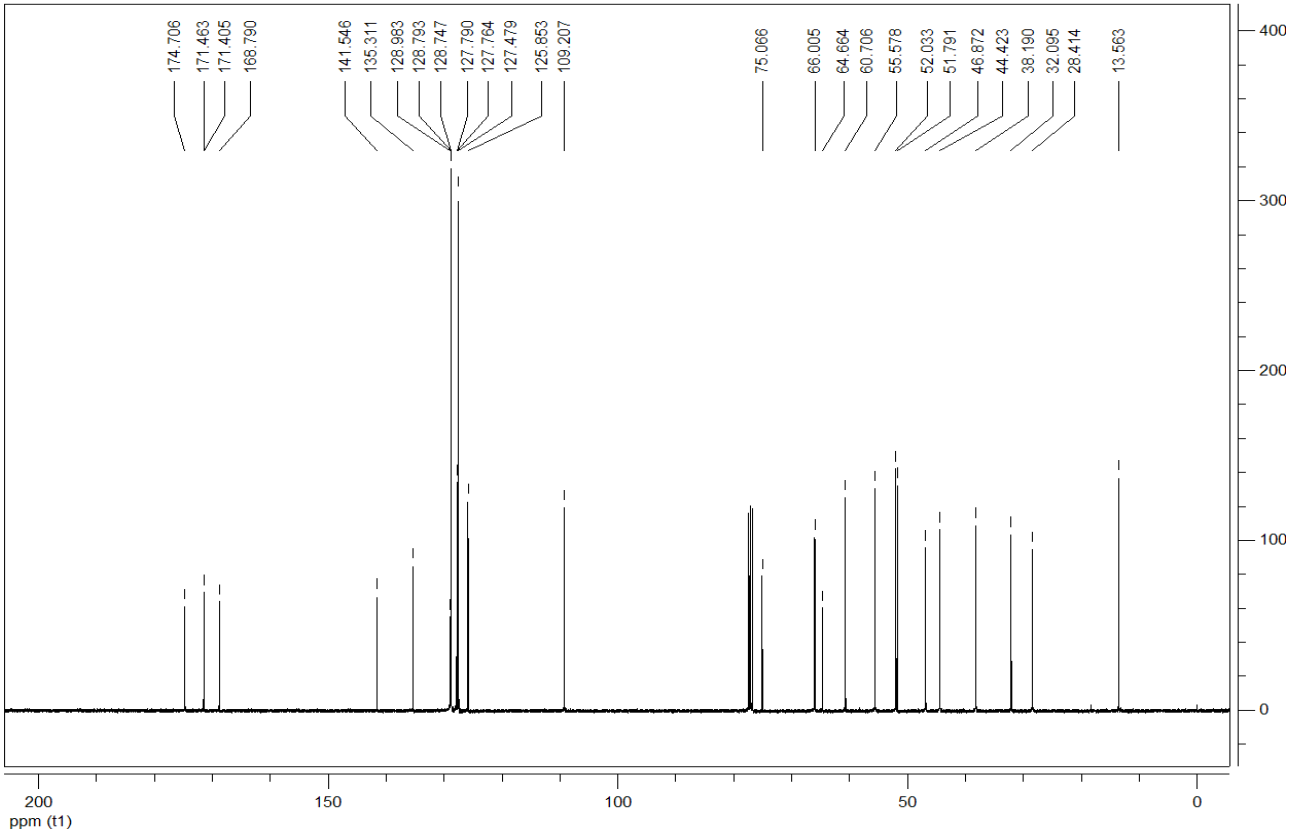
1'-Ethyl 3'-methyl 1-butyl-5-fluoro-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-1',3'-dicarboxylate (1m):



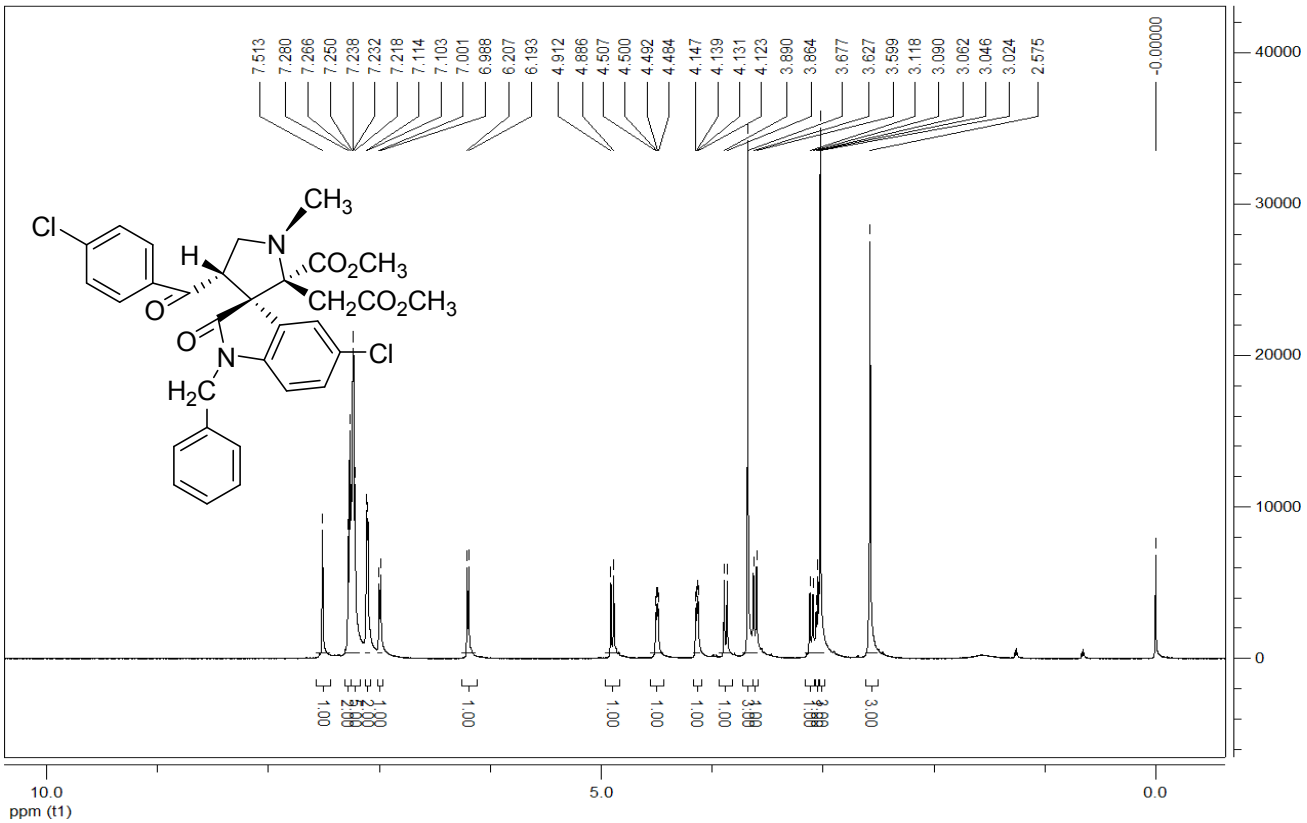


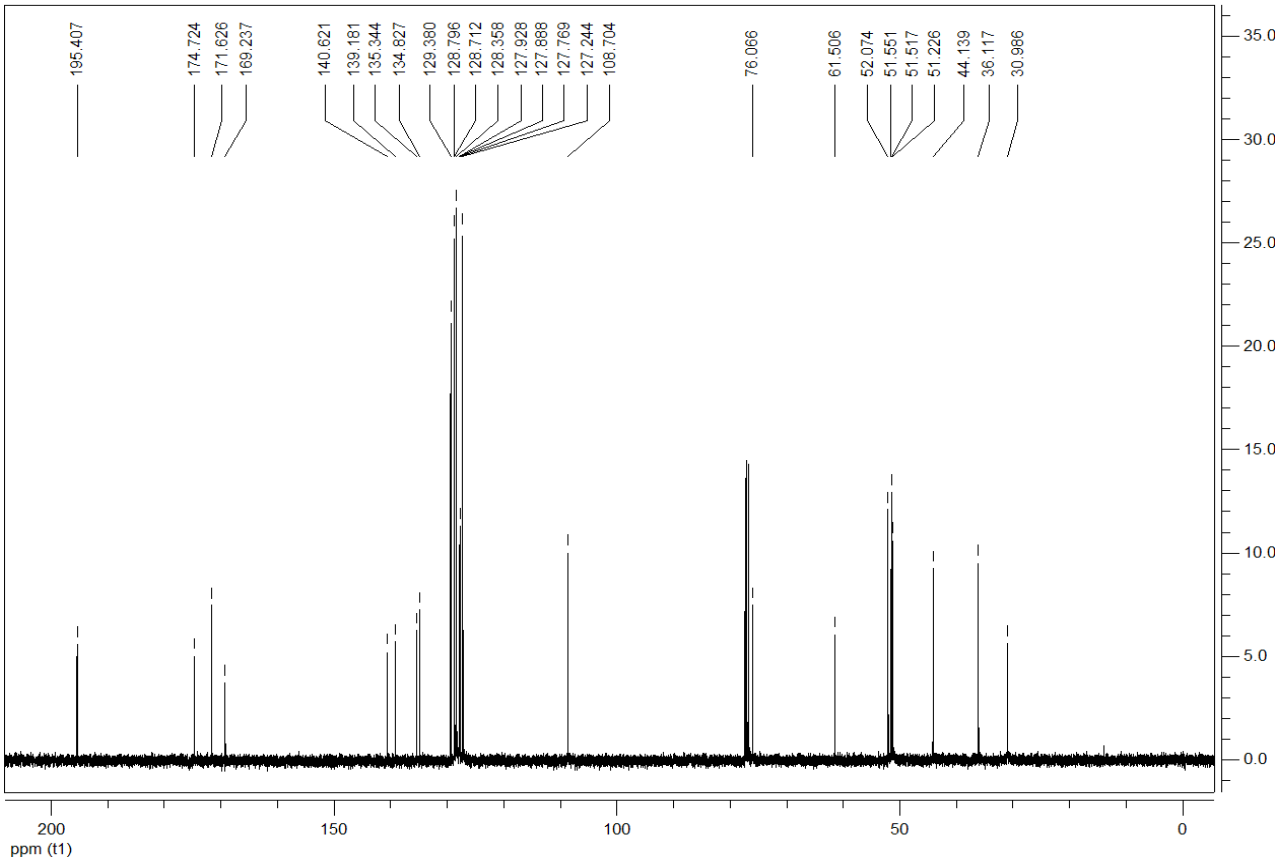
1'-Ethyl 3'-methyl 1-benzyl-5-chloro-3'-(2-methoxy-2-oxoethyl)-2-oxo-1',3',5',6',7',7a'-hexahydrospiro[indoline-3,2'-pyrrolizine]-1',3'-dicarboxylate (1n):



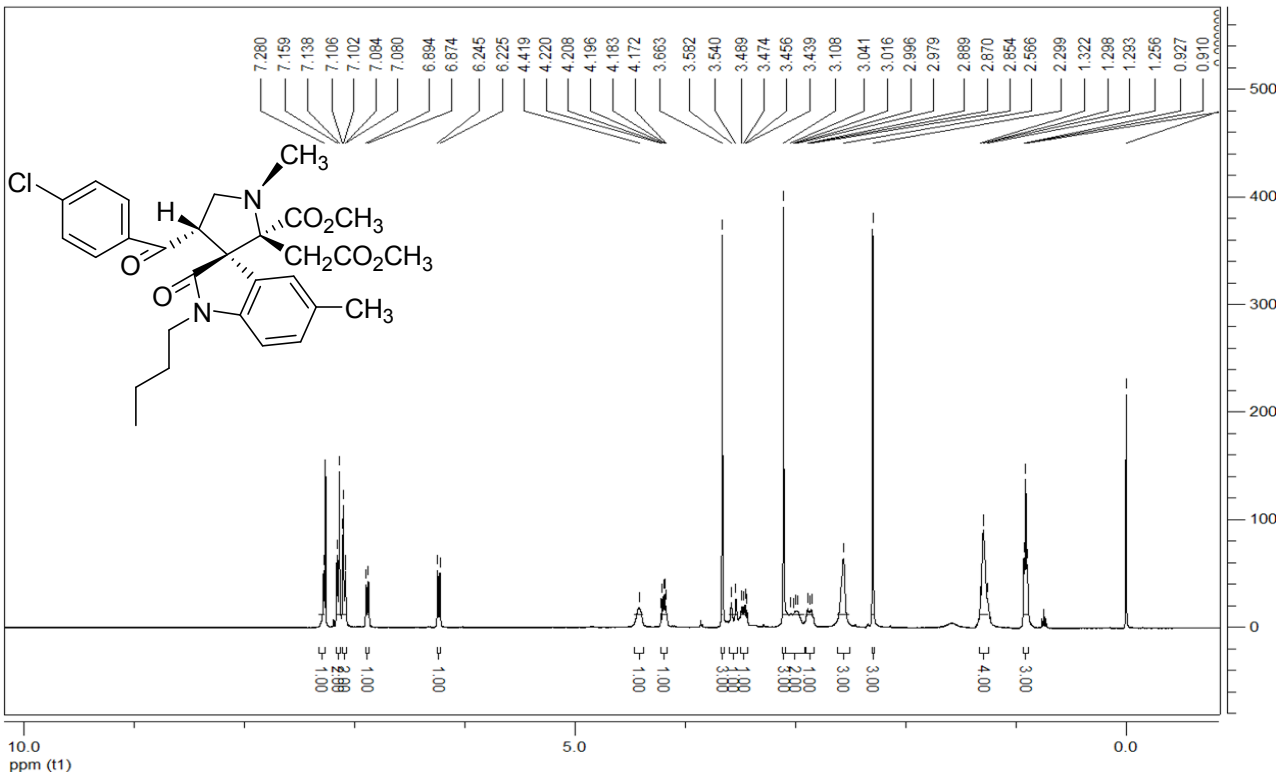


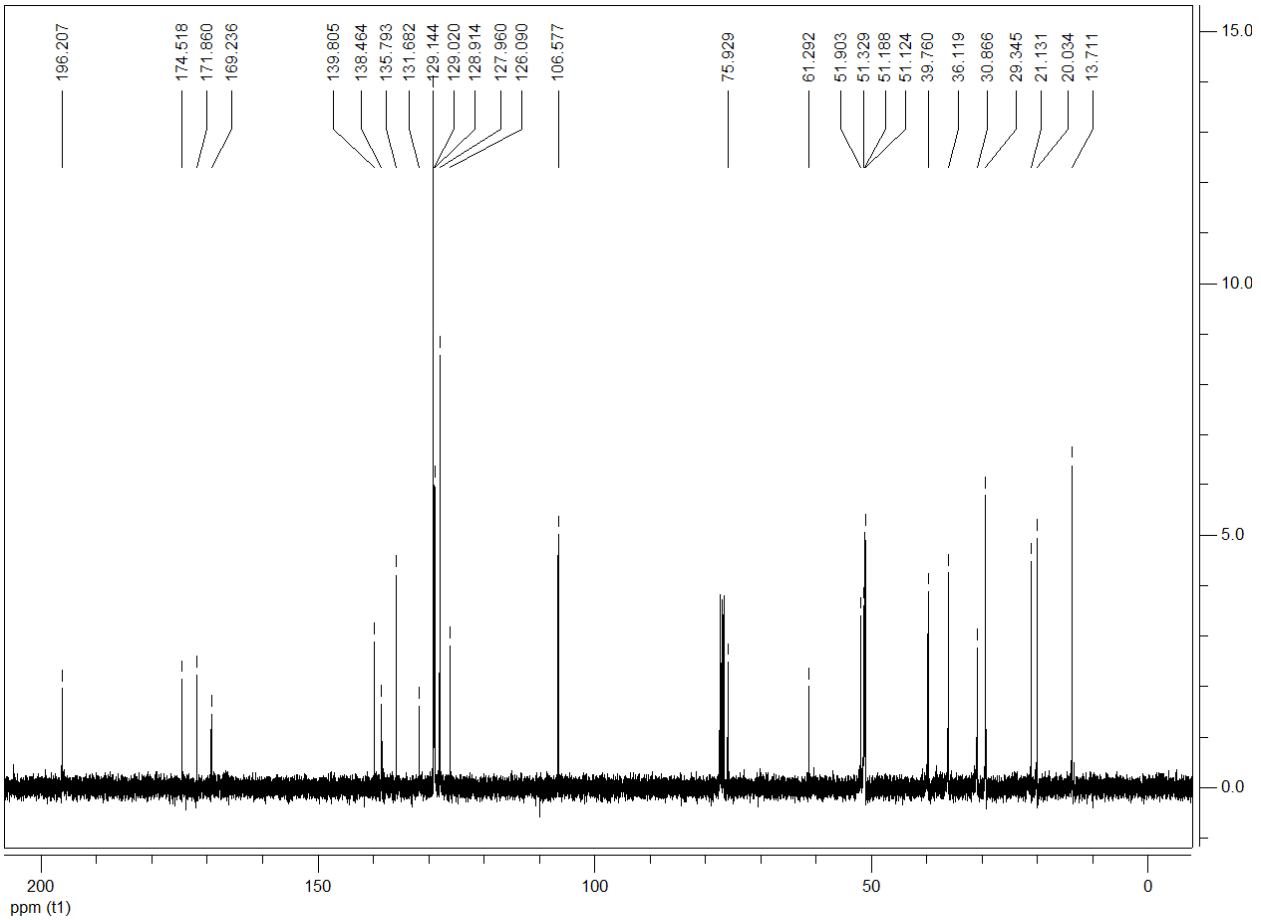
Methyl 1-benzyl-5-chloro-4'-(4-chlorobenzoyl)-2'-(2-methoxy-2-oxoethyl)-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2a):



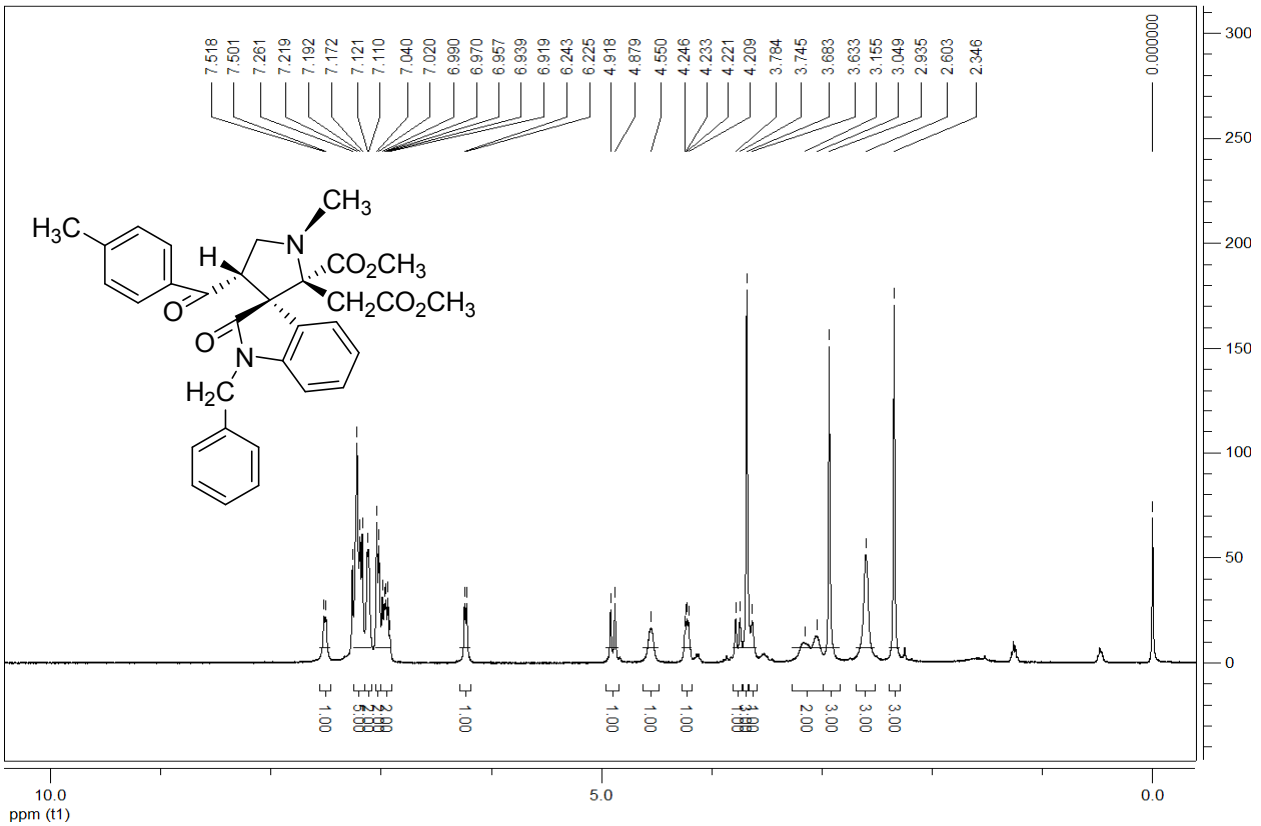


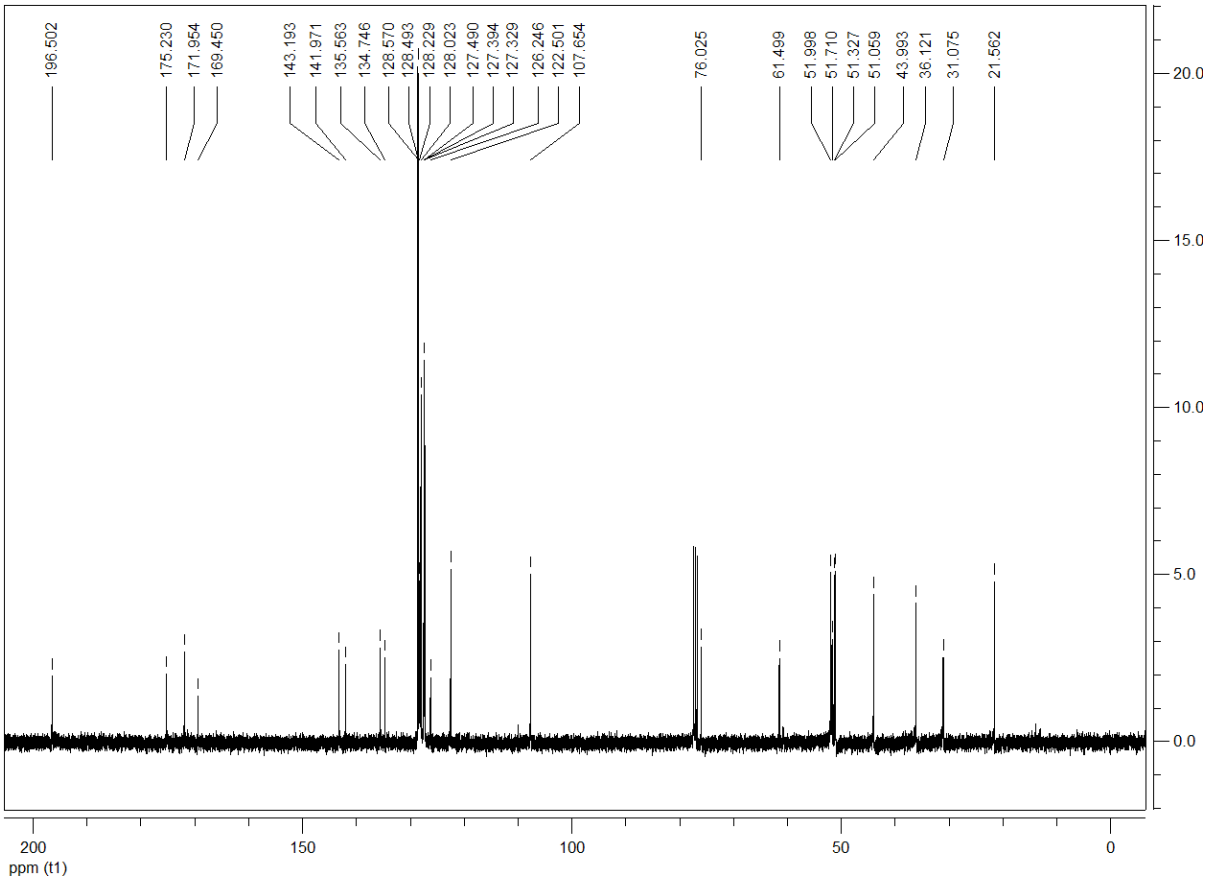
Methyl 1-butyl-4'-(4-chlorobenzoyl)-2'-(2-methoxy-2-oxoethyl)-1',5-dimethyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2b):



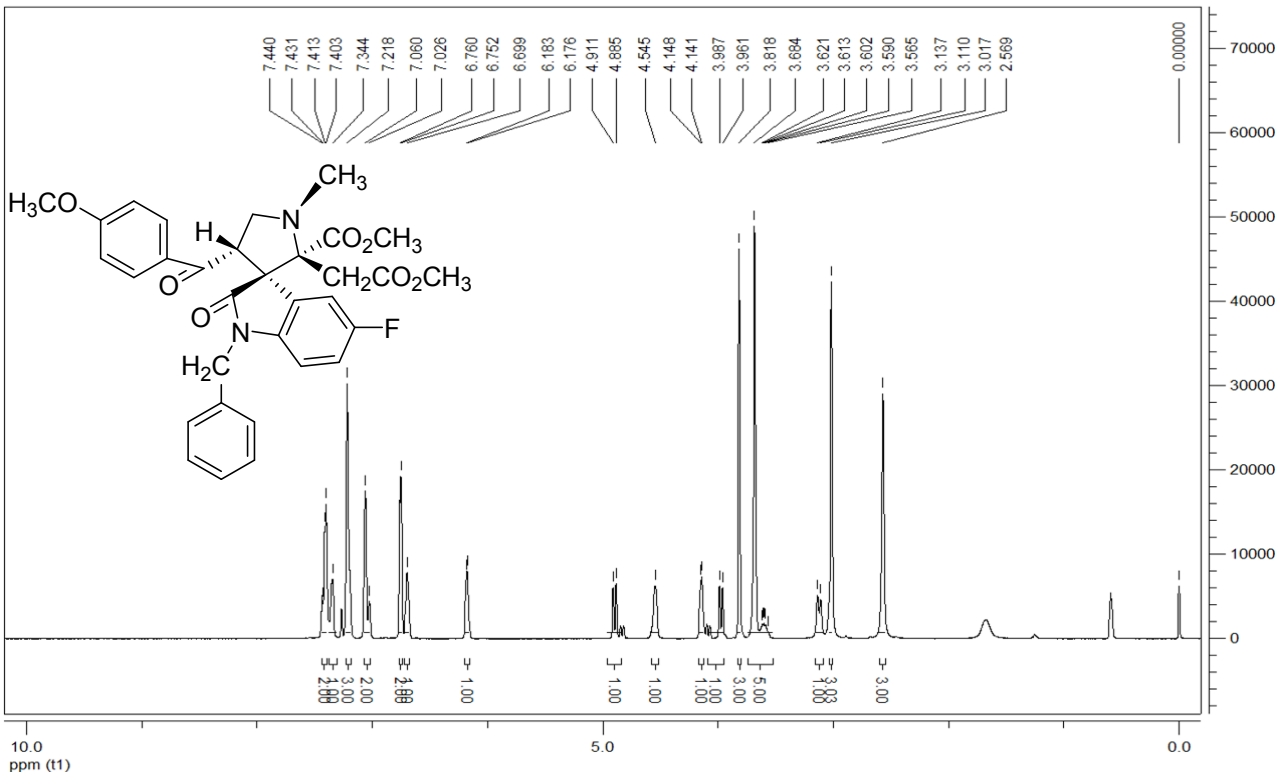


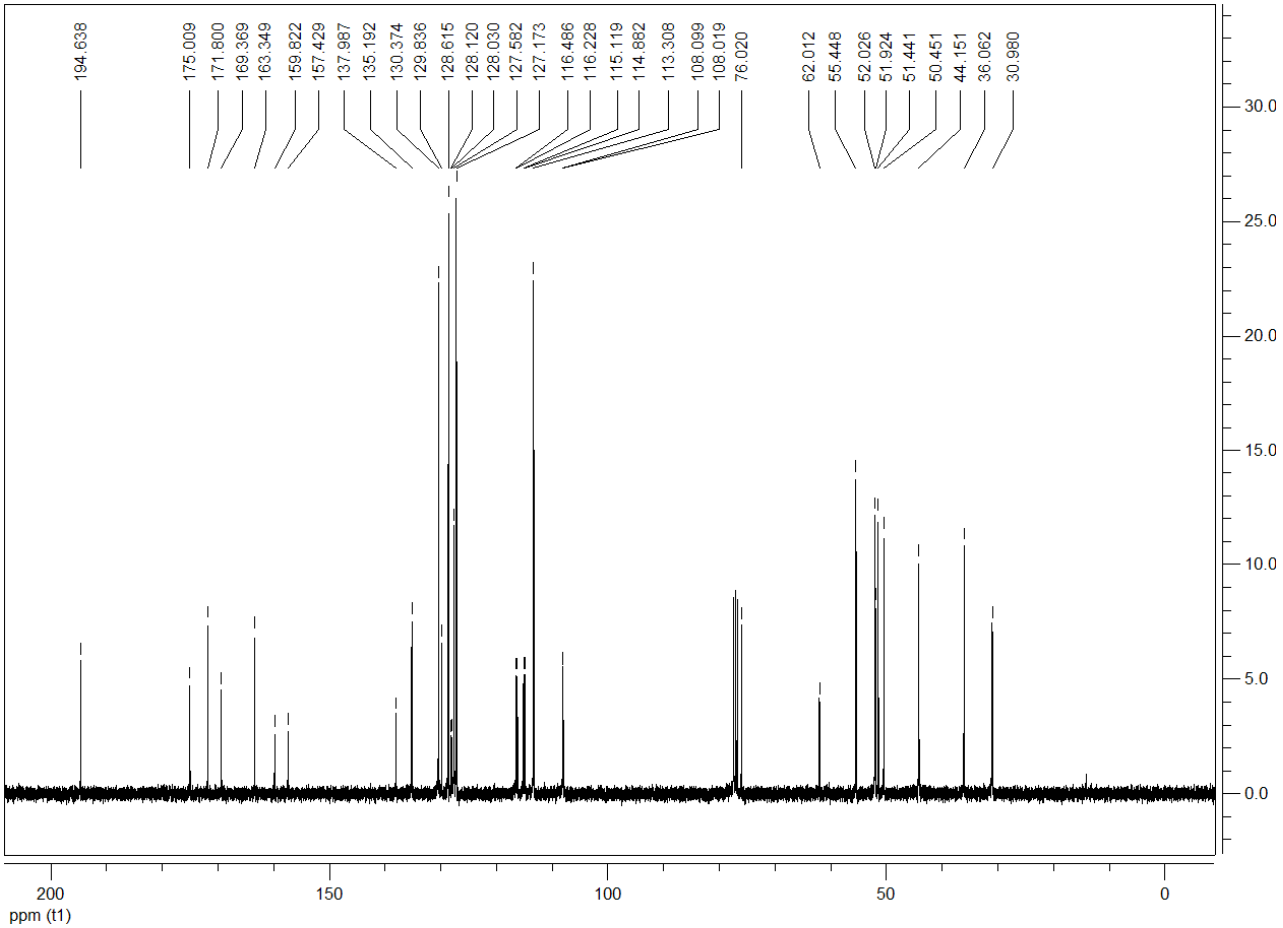
Methyl 1-benzyl-2'-(2-methoxy-2-oxoethyl)-1'-methyl-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2c):



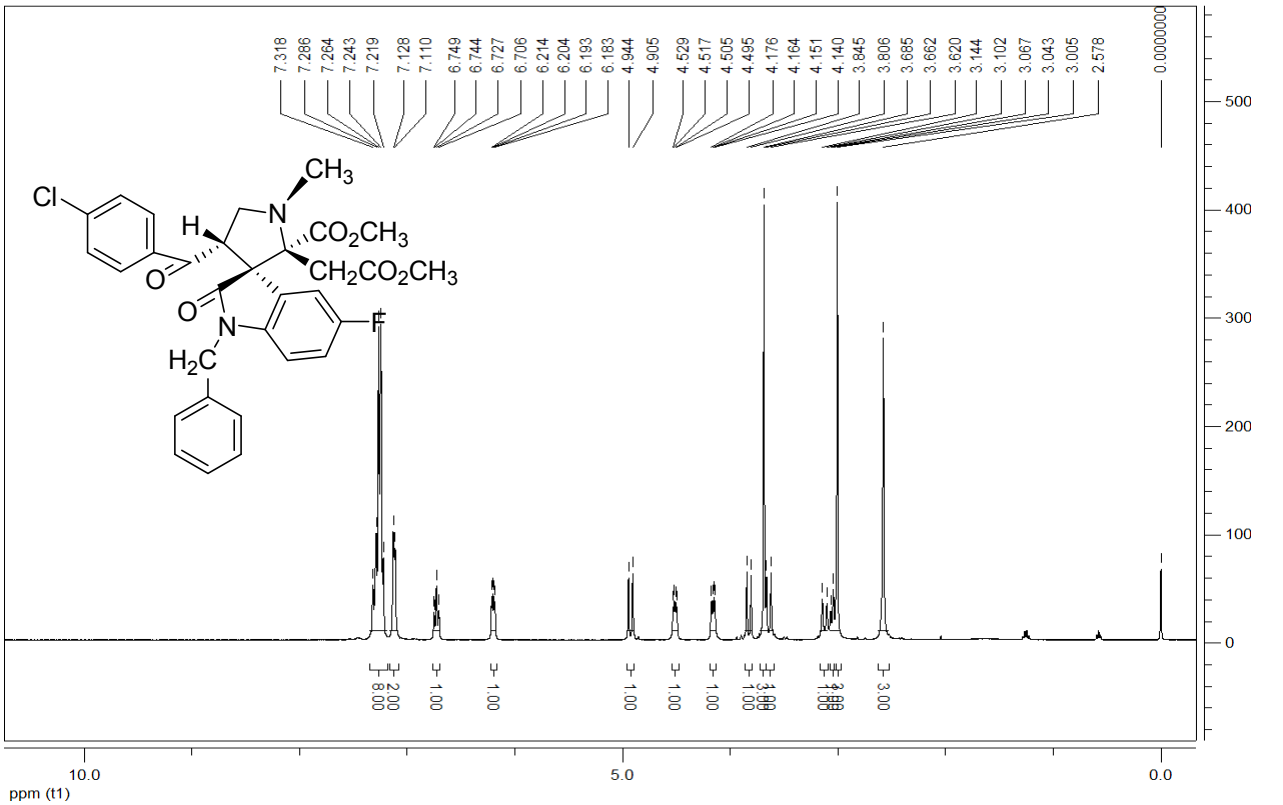


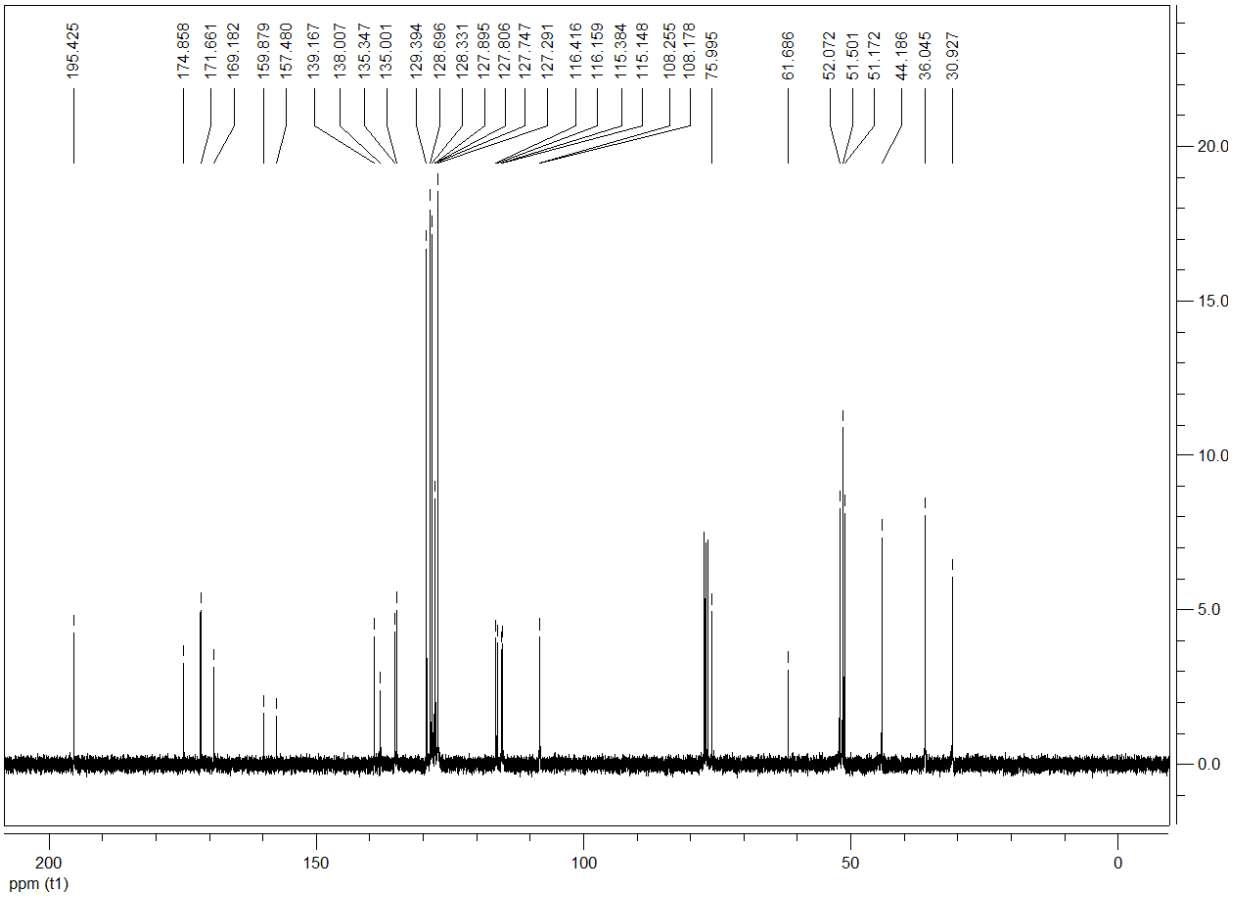
Methyl 1-benzyl-5-fluoro-2'-(2-methoxy-2-oxoethyl)-4'-(4-methoxybenzoyl)-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2d):



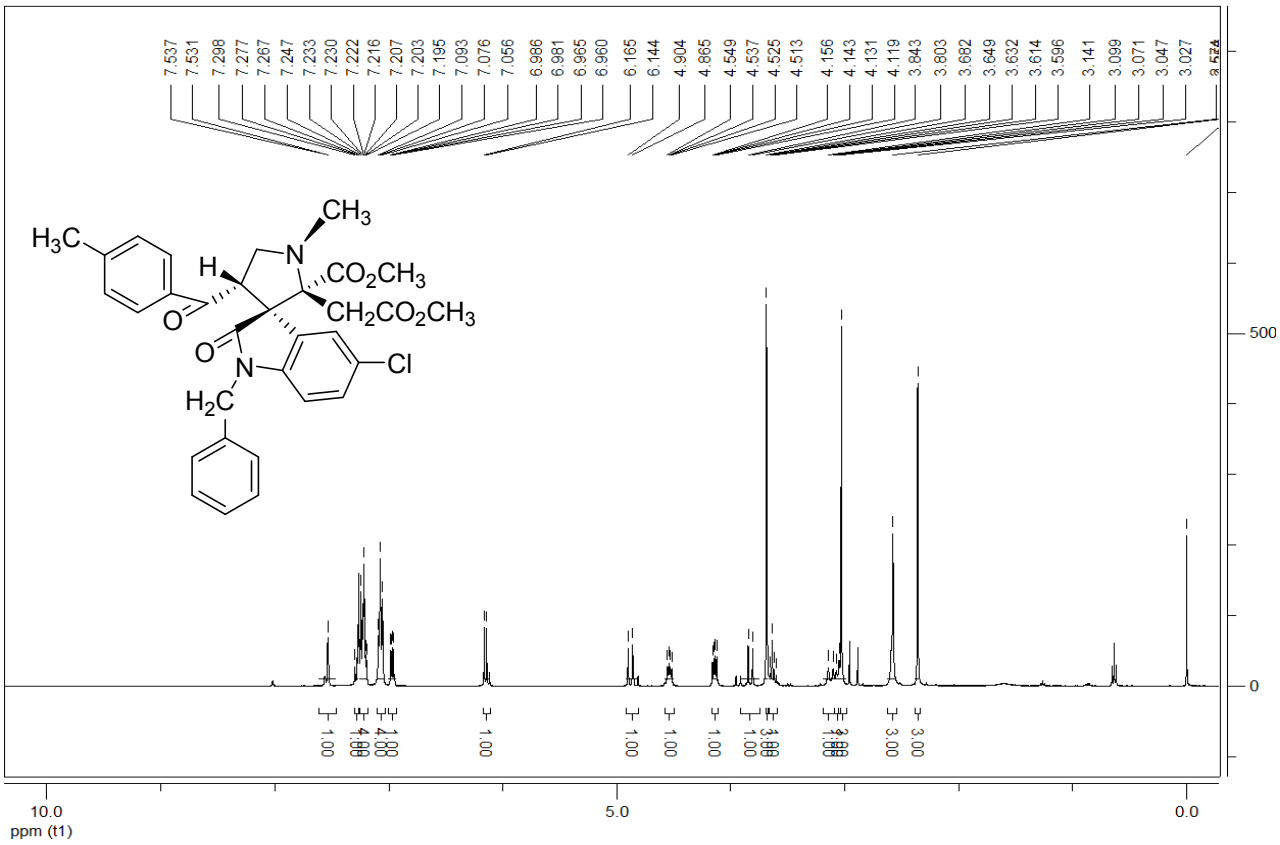


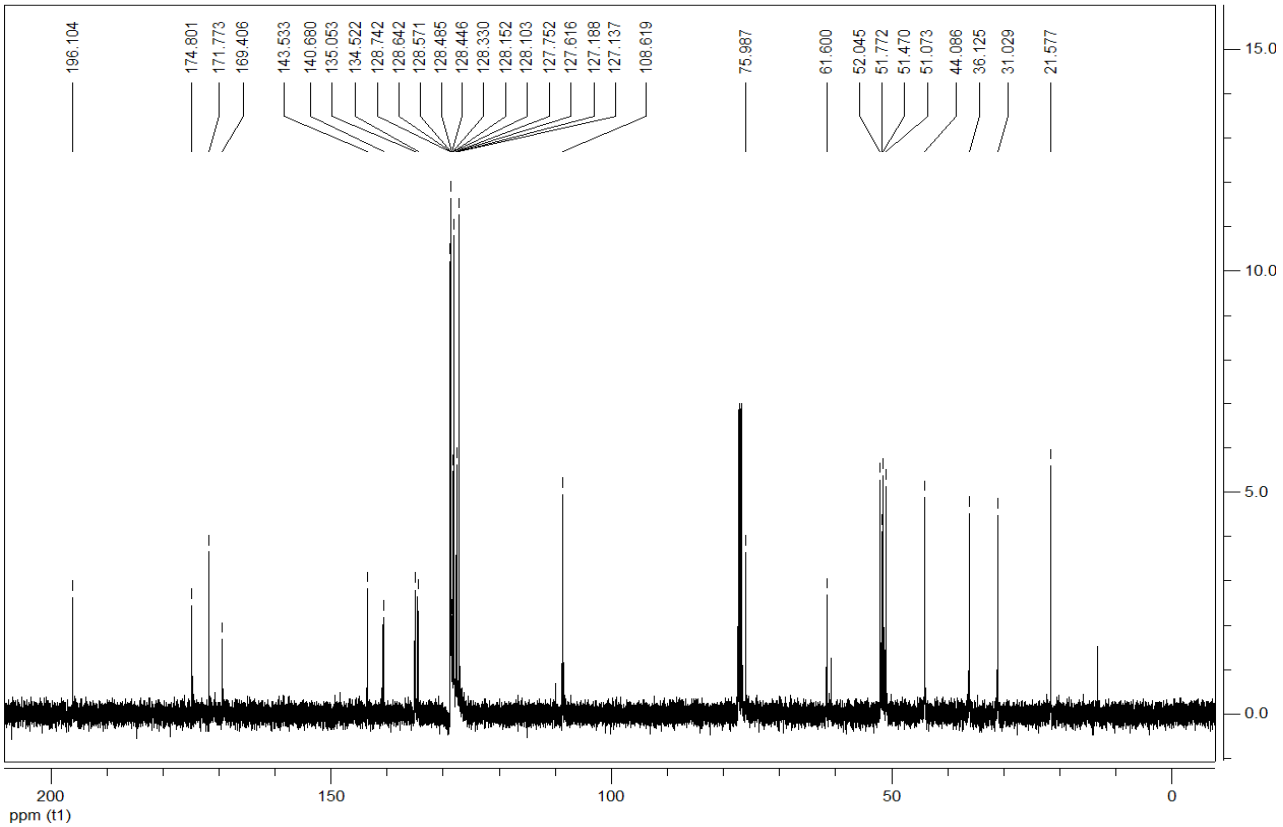
Methyl 1-benzyl-4'-(4-chlorobenzoyl)-5-fluoro-2'-(2-methoxy-2-oxoethyl)-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2e):



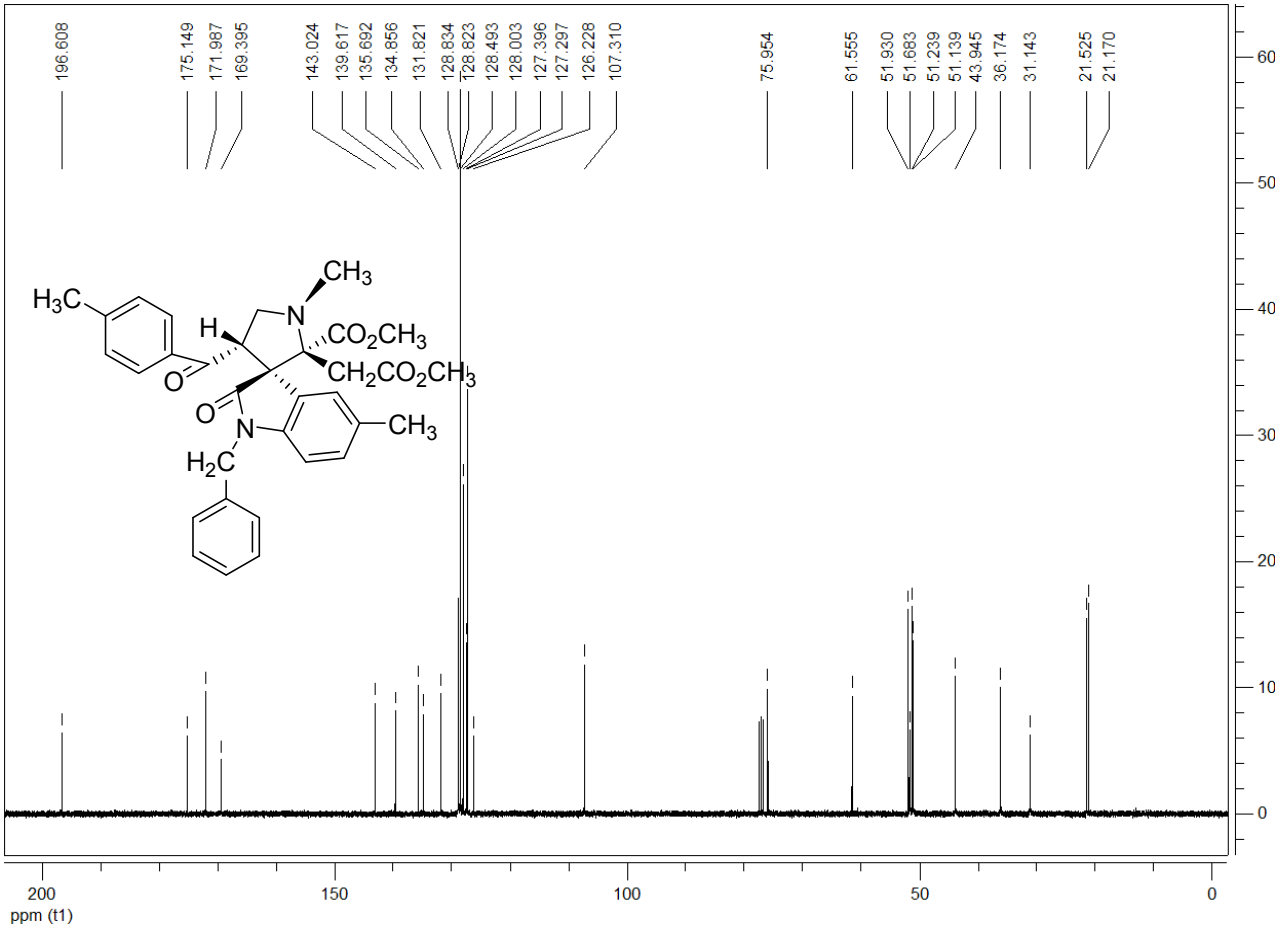


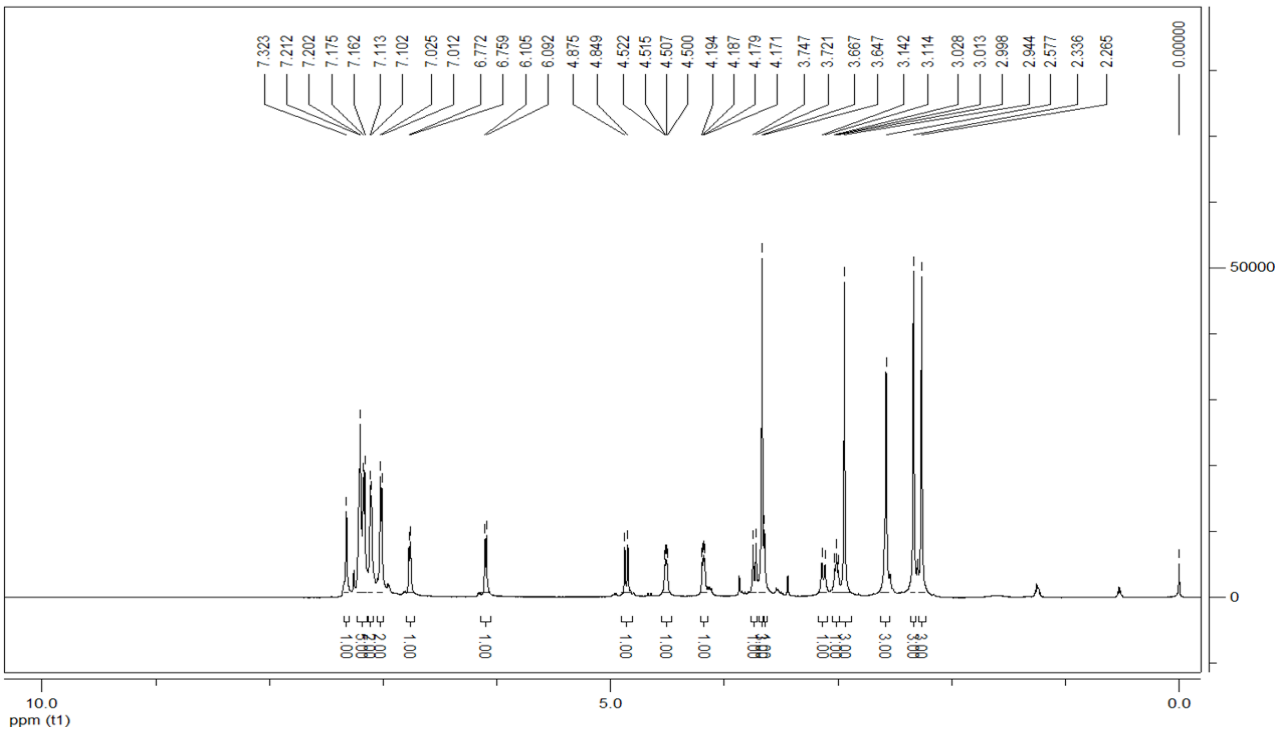
Methyl 1-benzyl-5-chloro-2'-(2-methoxy-2-oxoethyl)-1'-methyl-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2f):



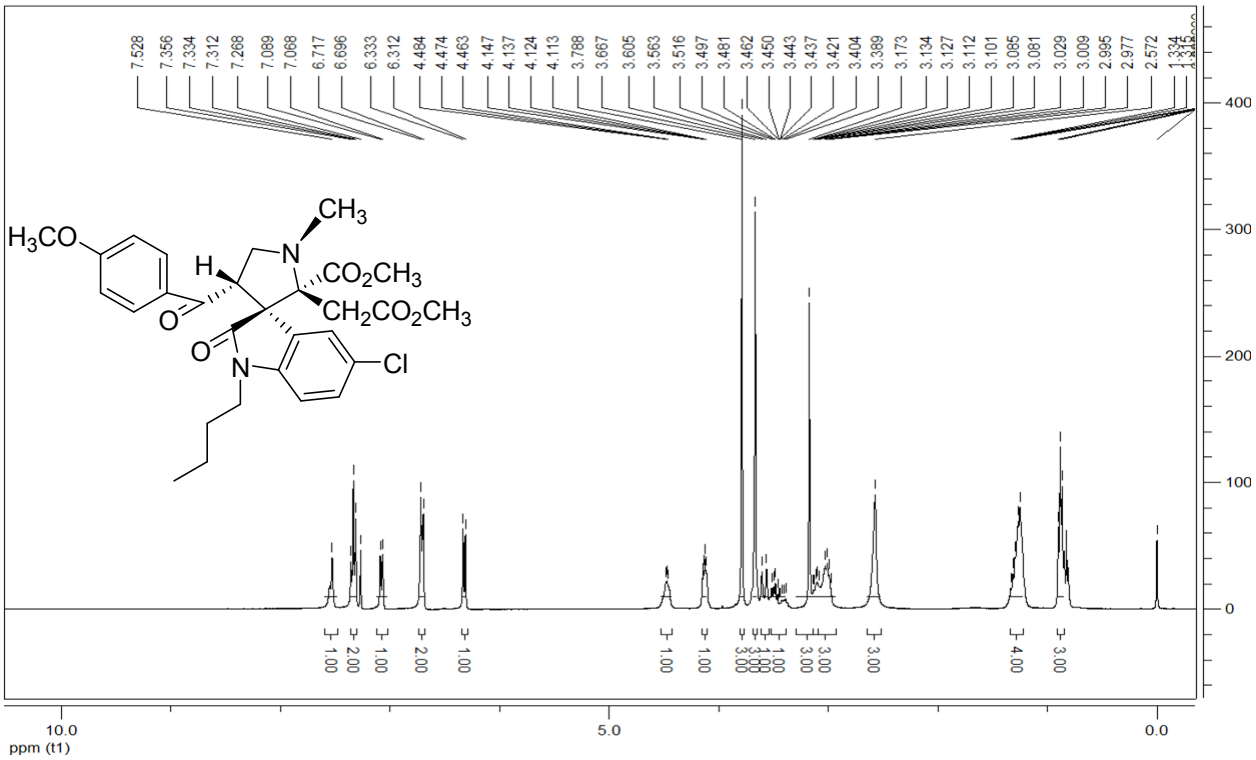


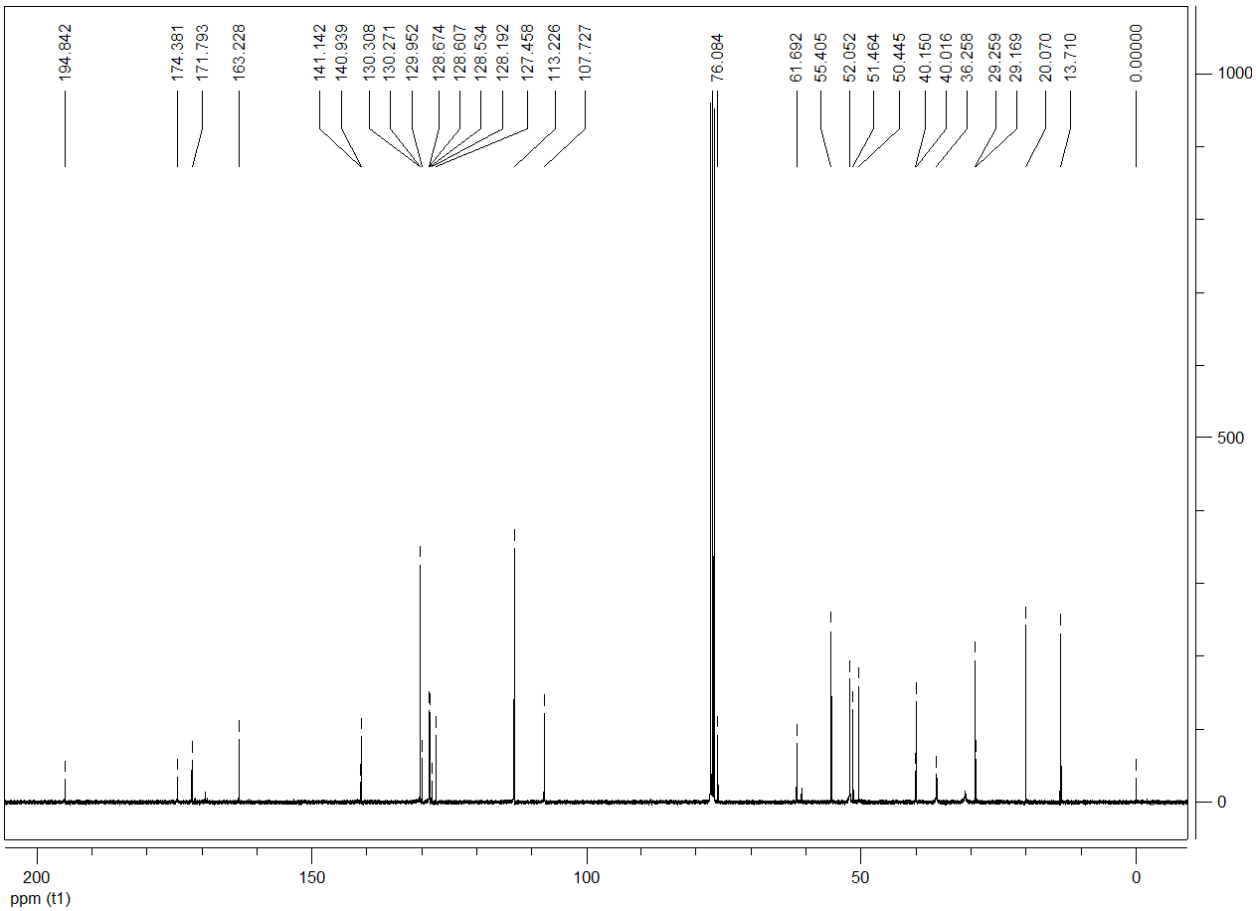
Methyl 1-benzyl-2'-(2-methoxy-2-oxoethyl)-1',5-dimethyl-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2g):



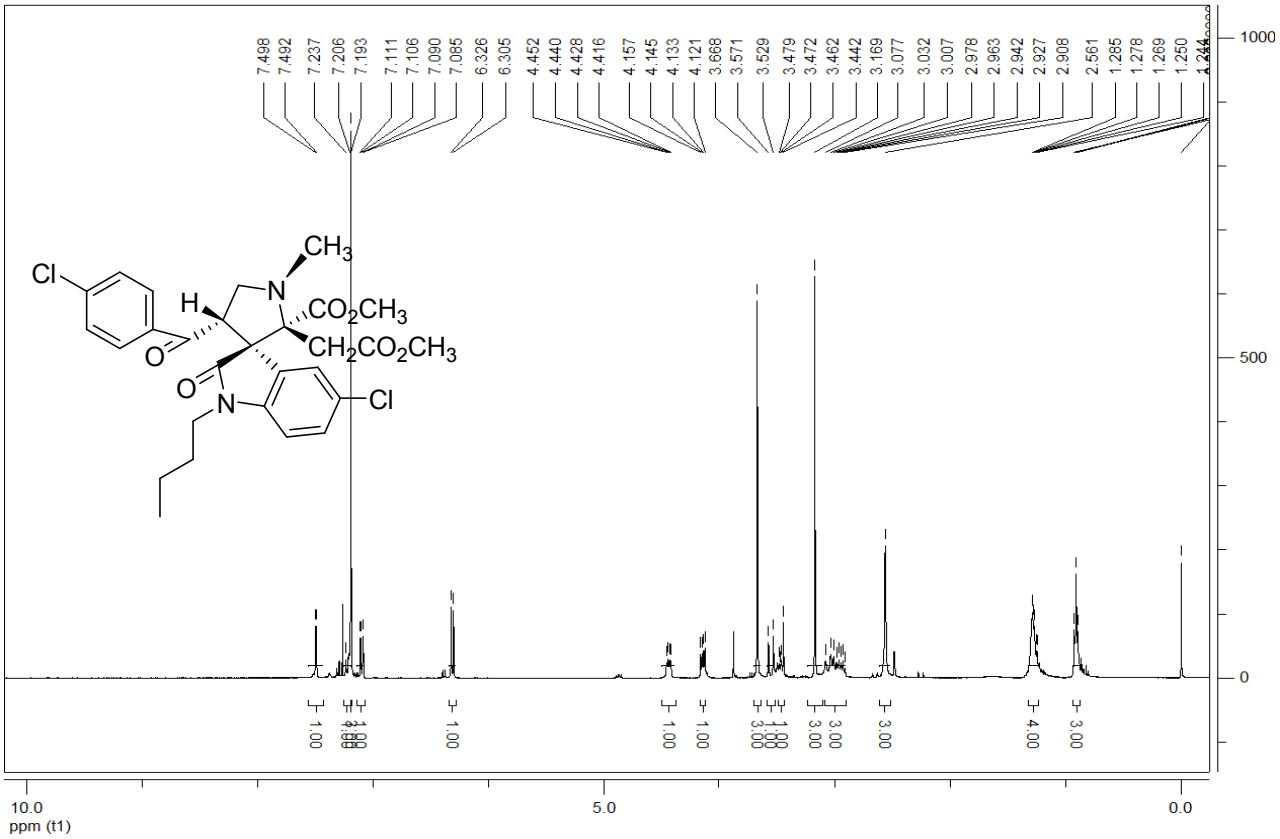


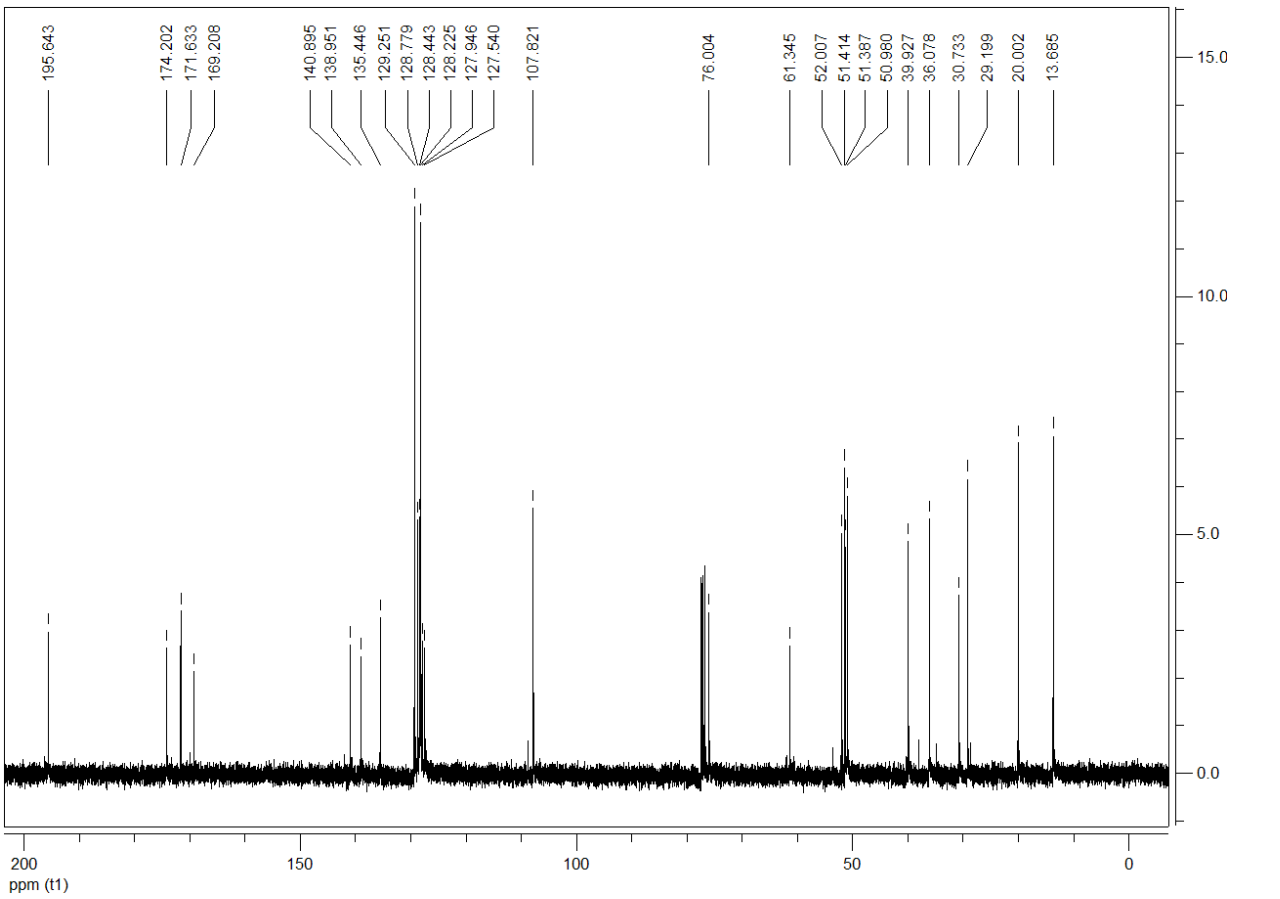
Methyl 1-butyl-5-chloro-2'-(2-methoxy-2-oxoethyl)-4'-(4-methoxybenzoyl)-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2h):



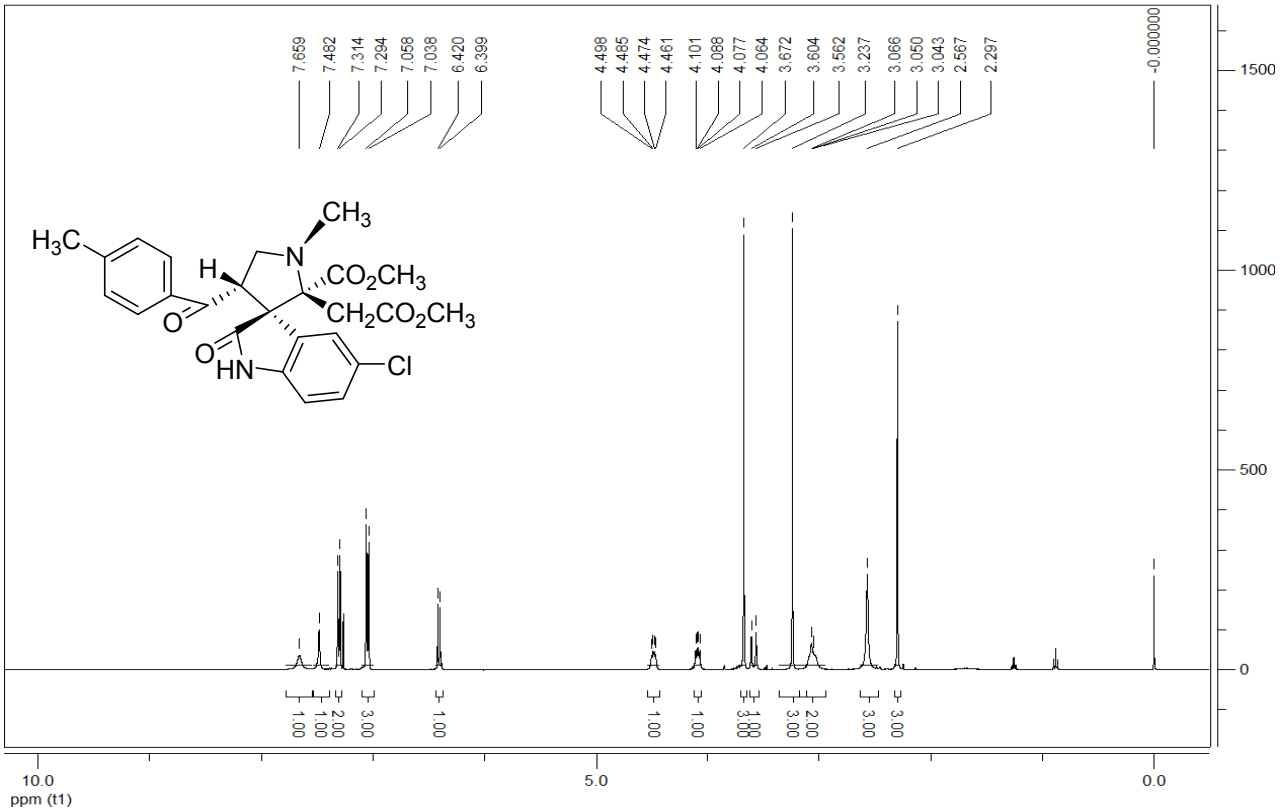


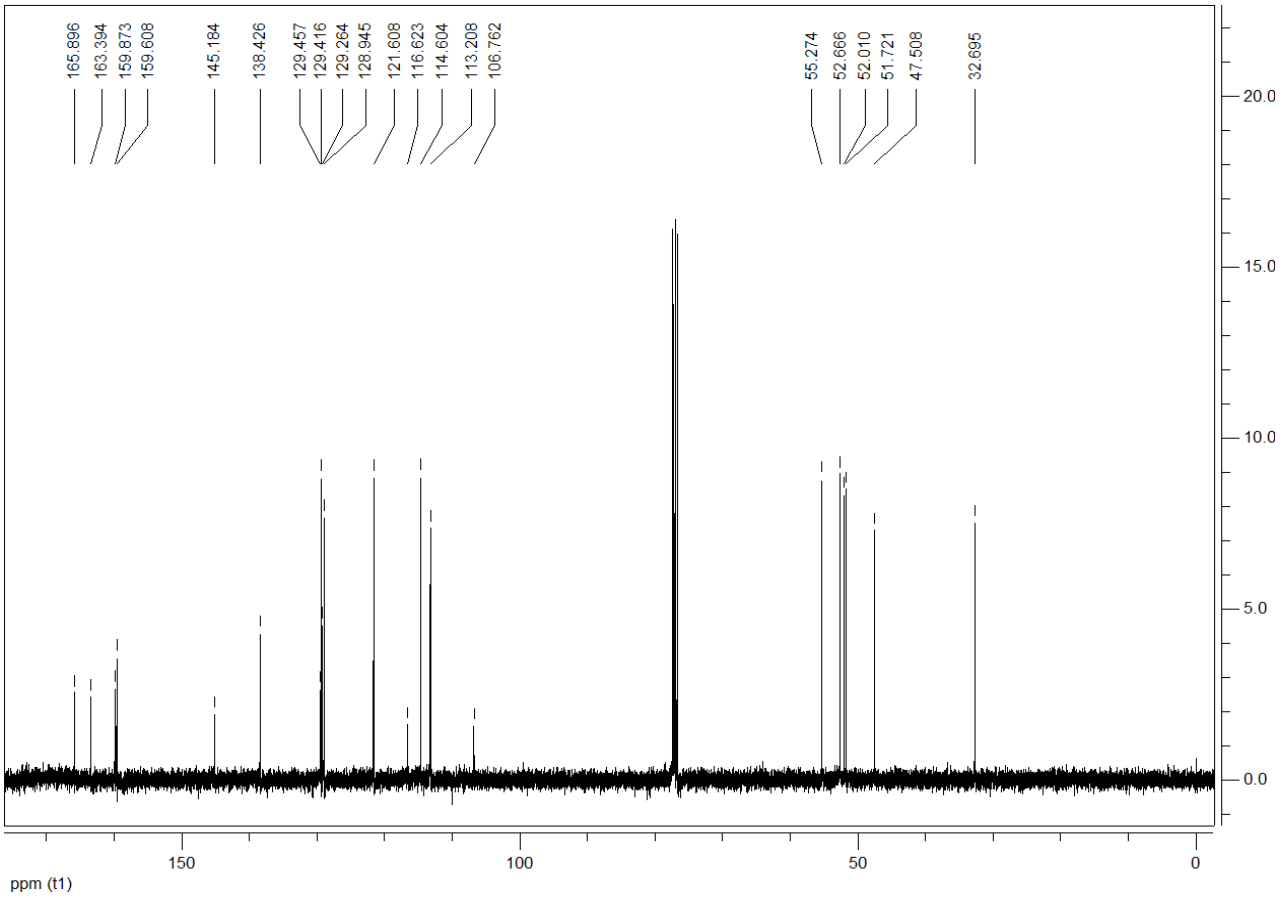
Methyl 1-butyl-5-chloro-4'-(4-chlorobenzoyl)-2'-(2-methoxy-2-oxoethyl)-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2i):



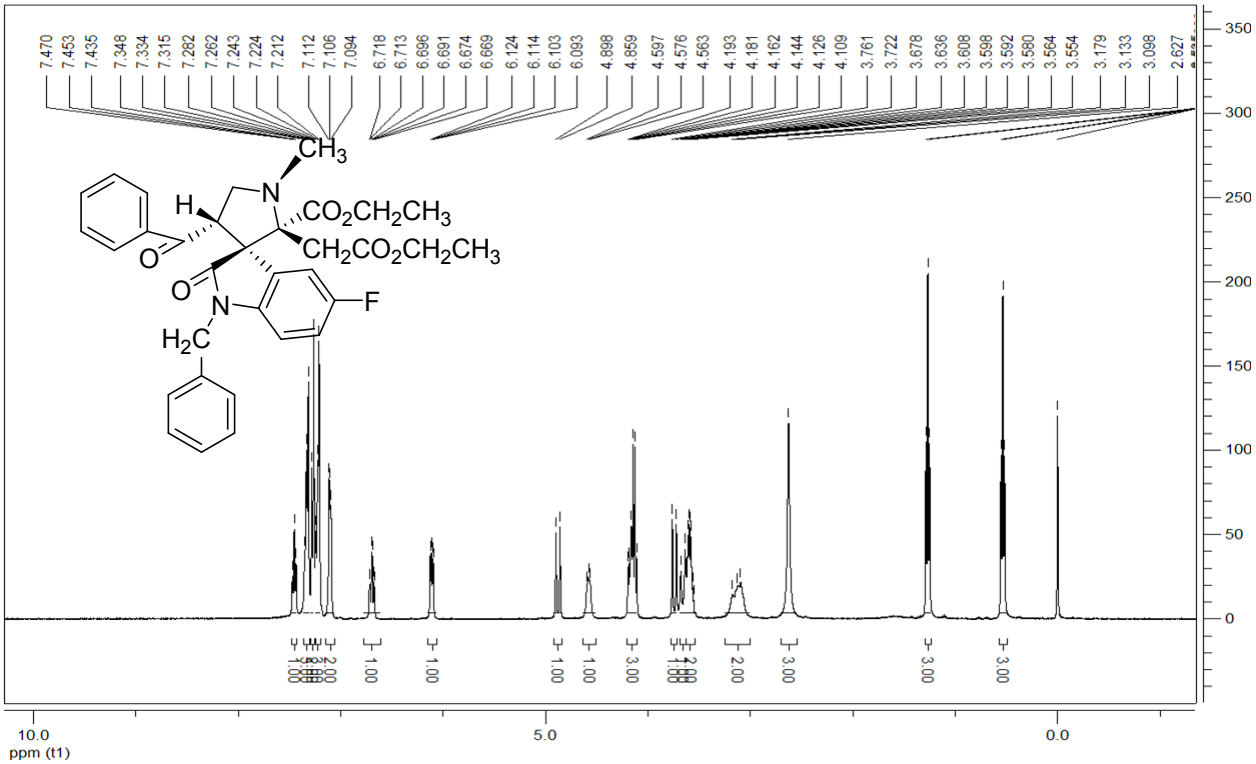


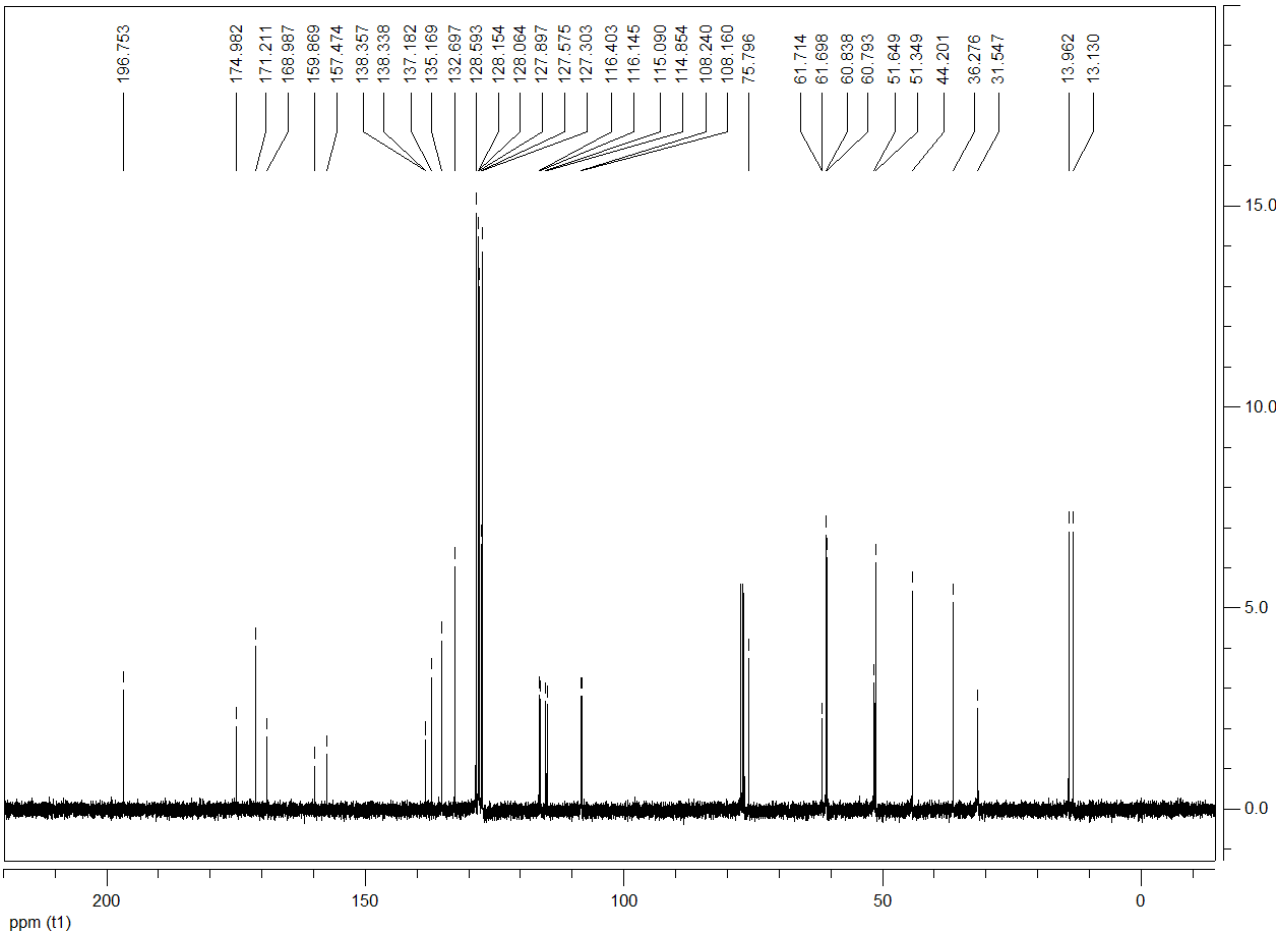
Methyl 5-chloro-2'-(2-methoxy-2-oxoethyl)-1'-methyl-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2j):



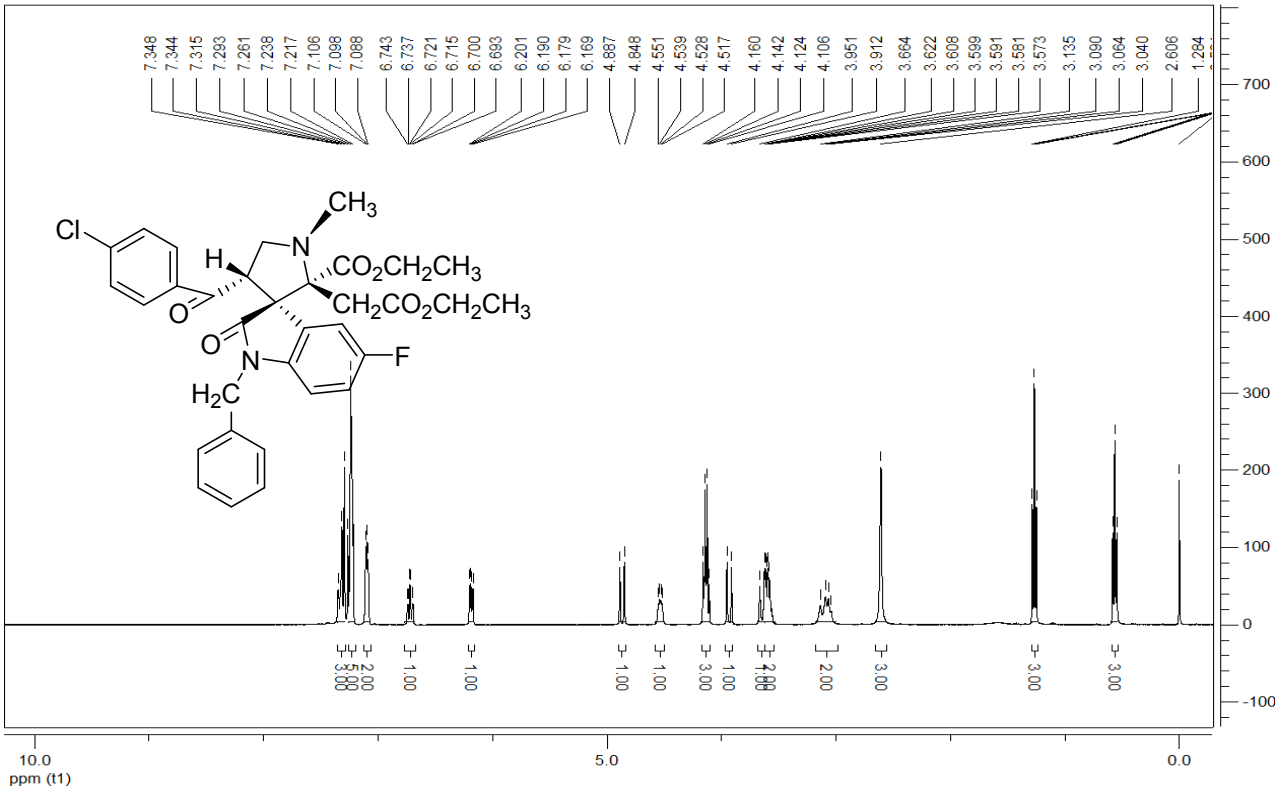


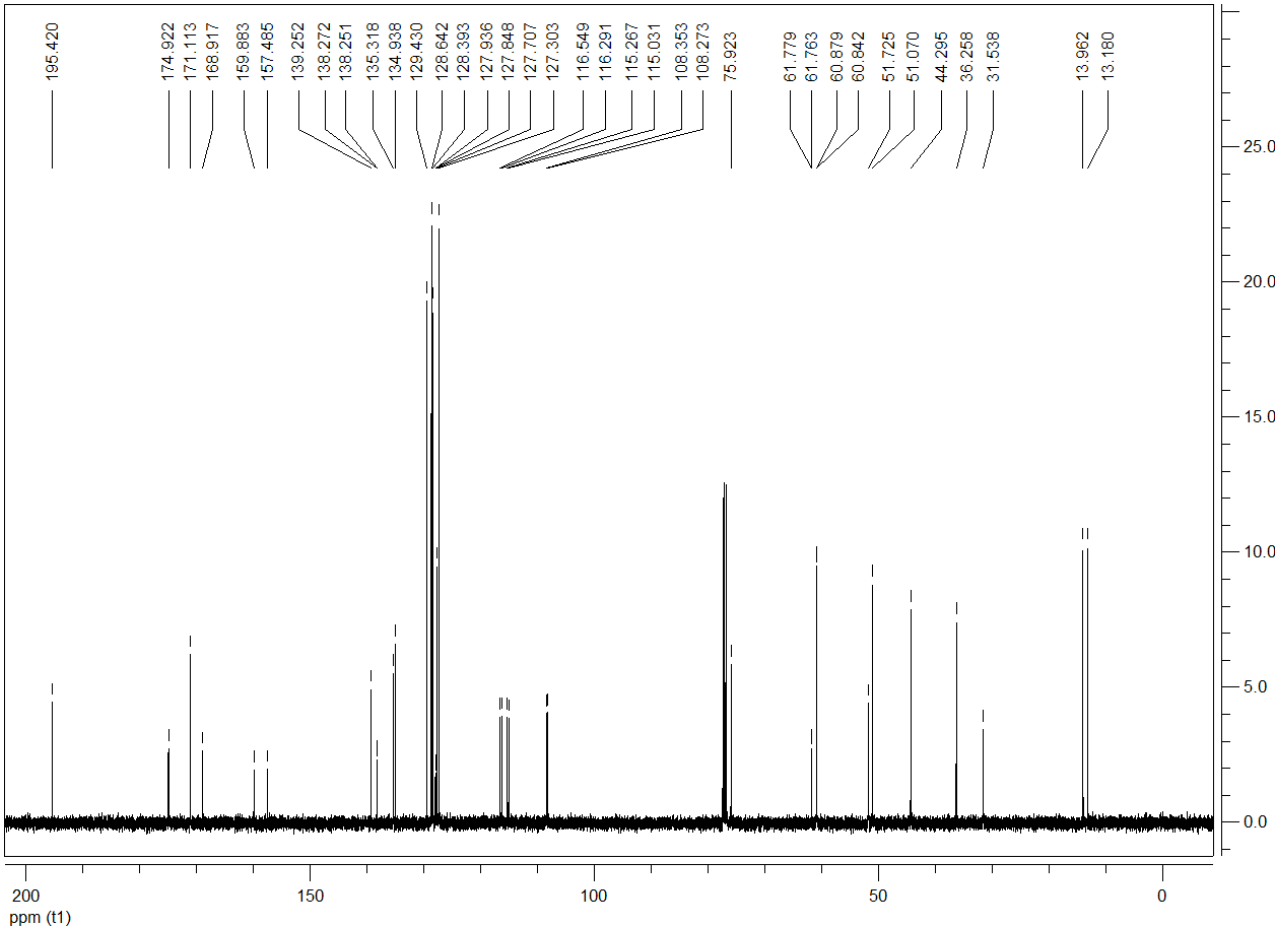
Ethyl 4'-benzoyl-1-benzyl-2'-(2-ethoxy-2-oxoethyl)-5-fluoro-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2k):



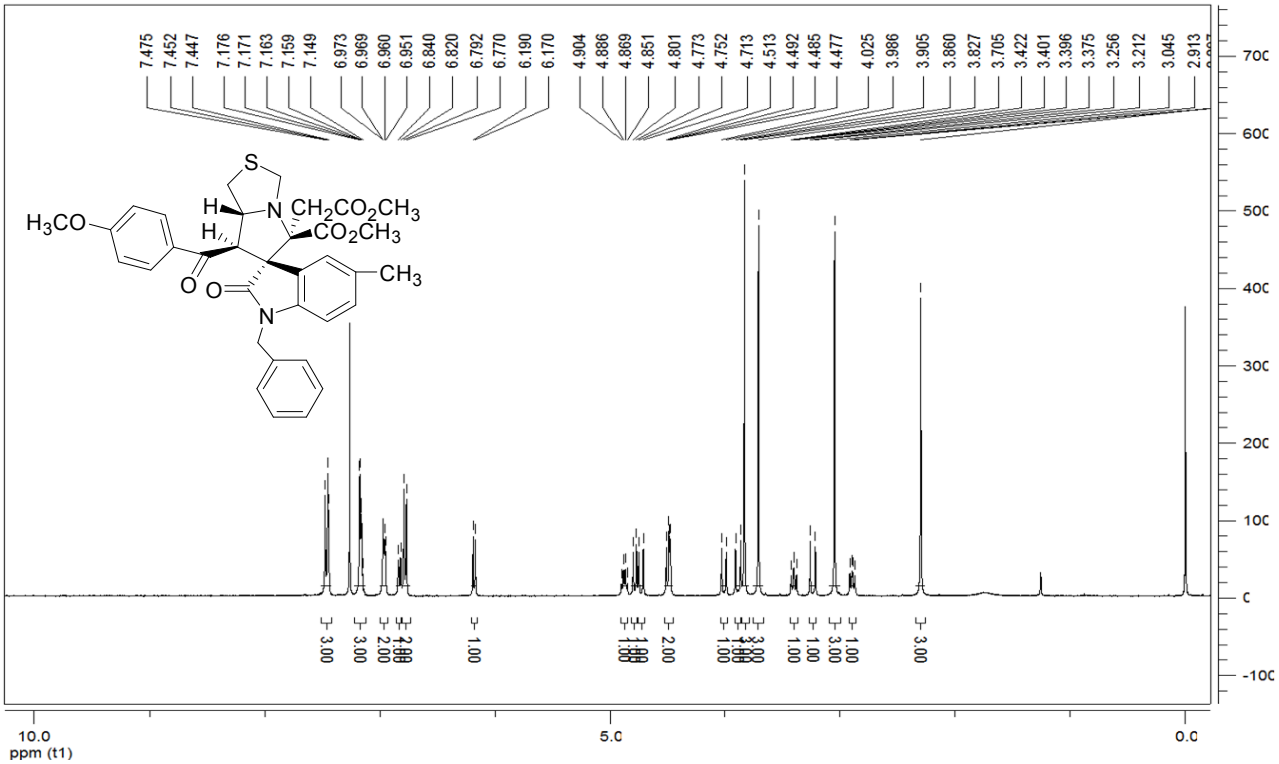


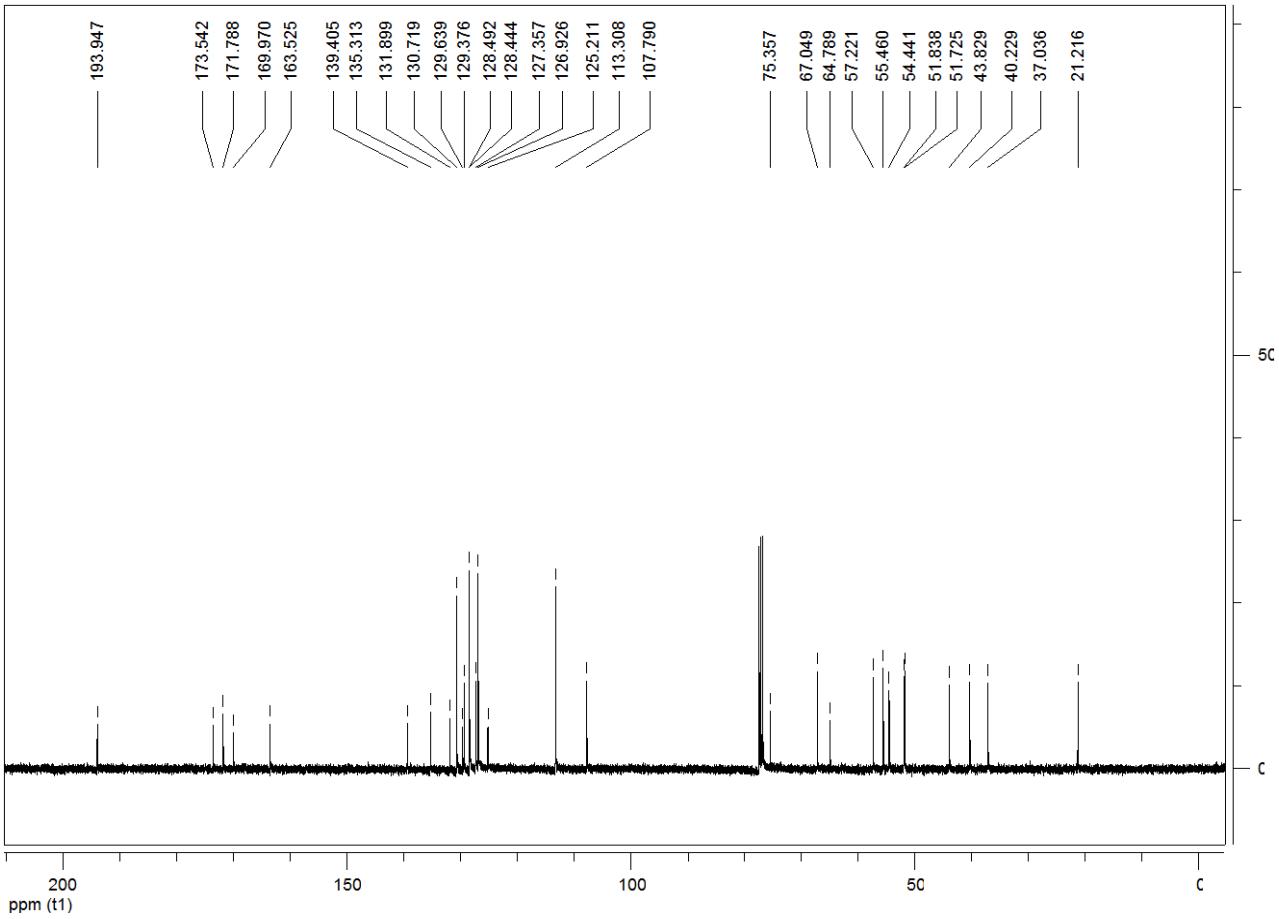
Ethyl 1-benzyl-4'-(4-chlorobenzoyl)-2'-(2-ethoxy-2-oxoethyl)-5-fluoro-1'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-2'-carboxylate (2l):



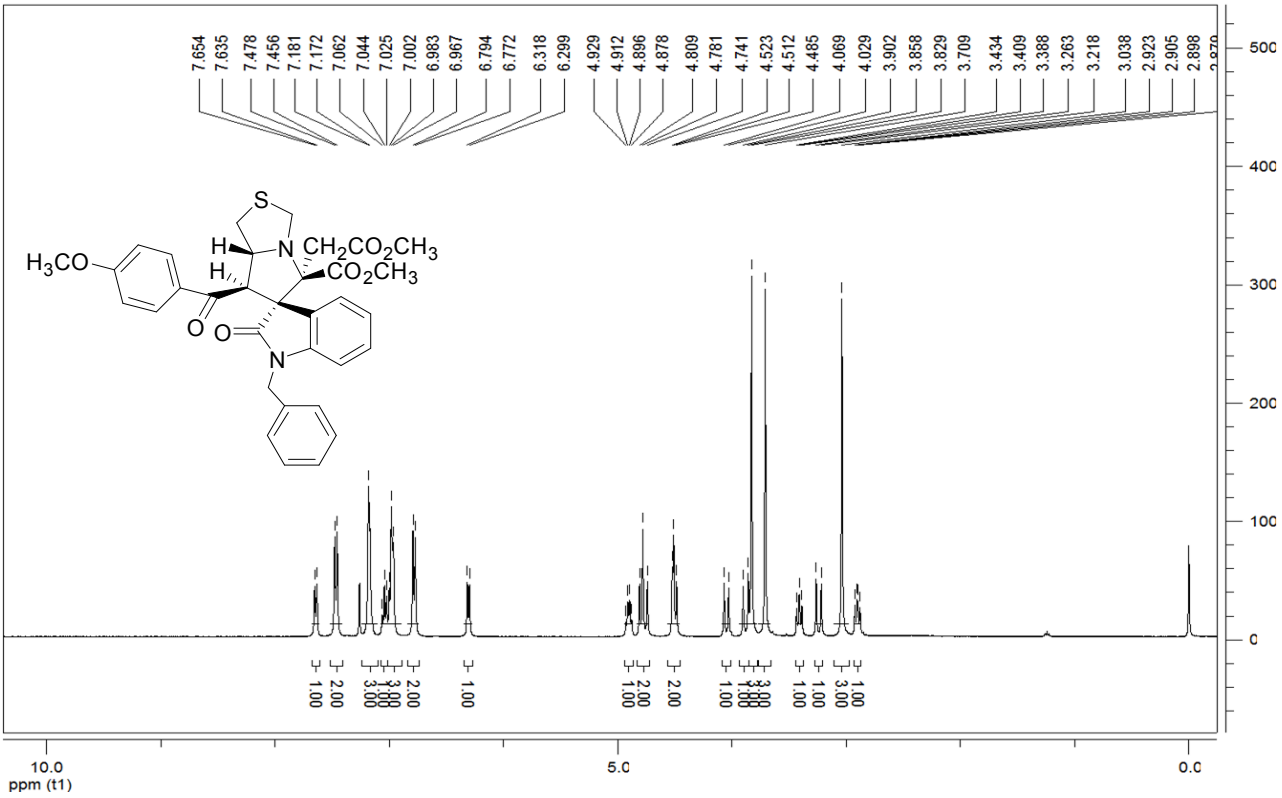


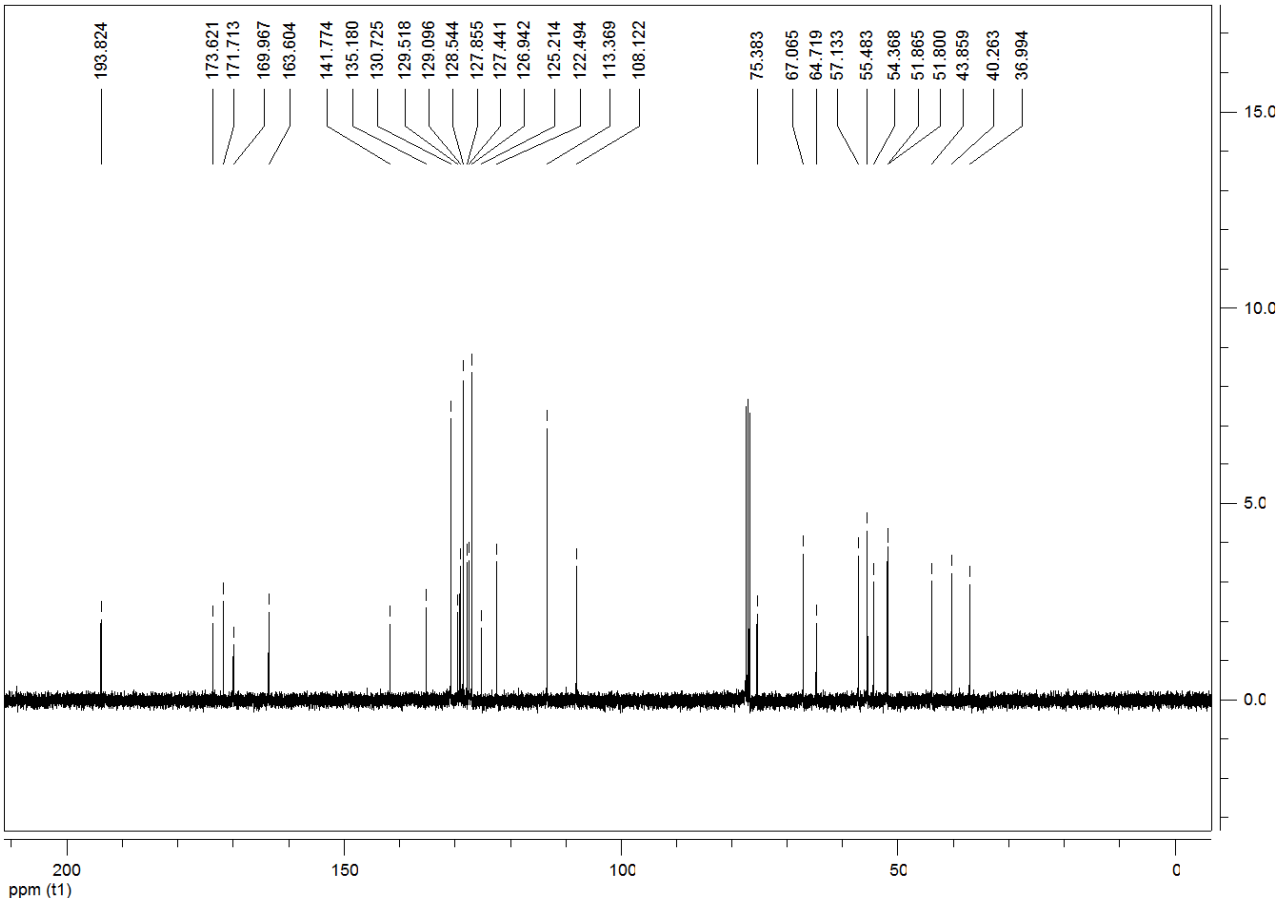
Methyl 1-benzyl-5'-(2-methoxy-2-oxoethyl)-7'-(4-methoxybenzoyl)-5-methyl-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5'-carboxylate (3a)



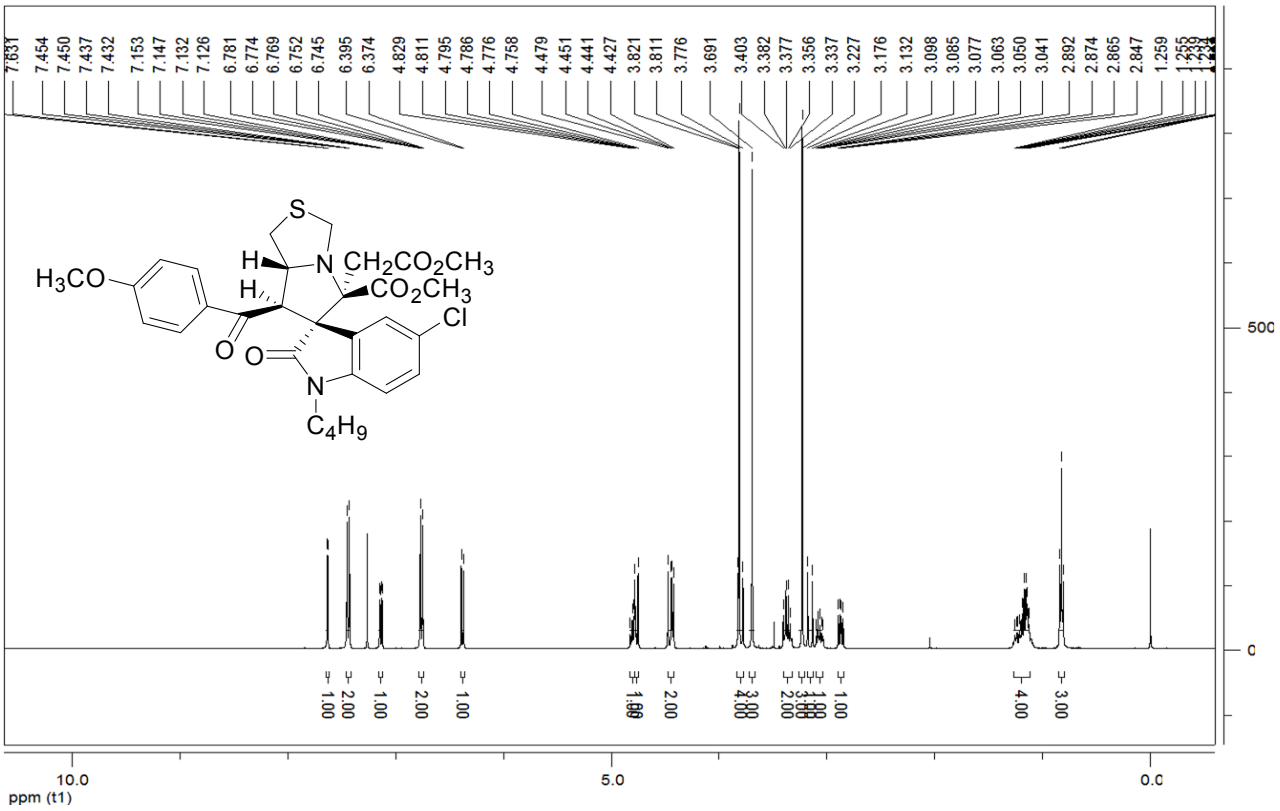


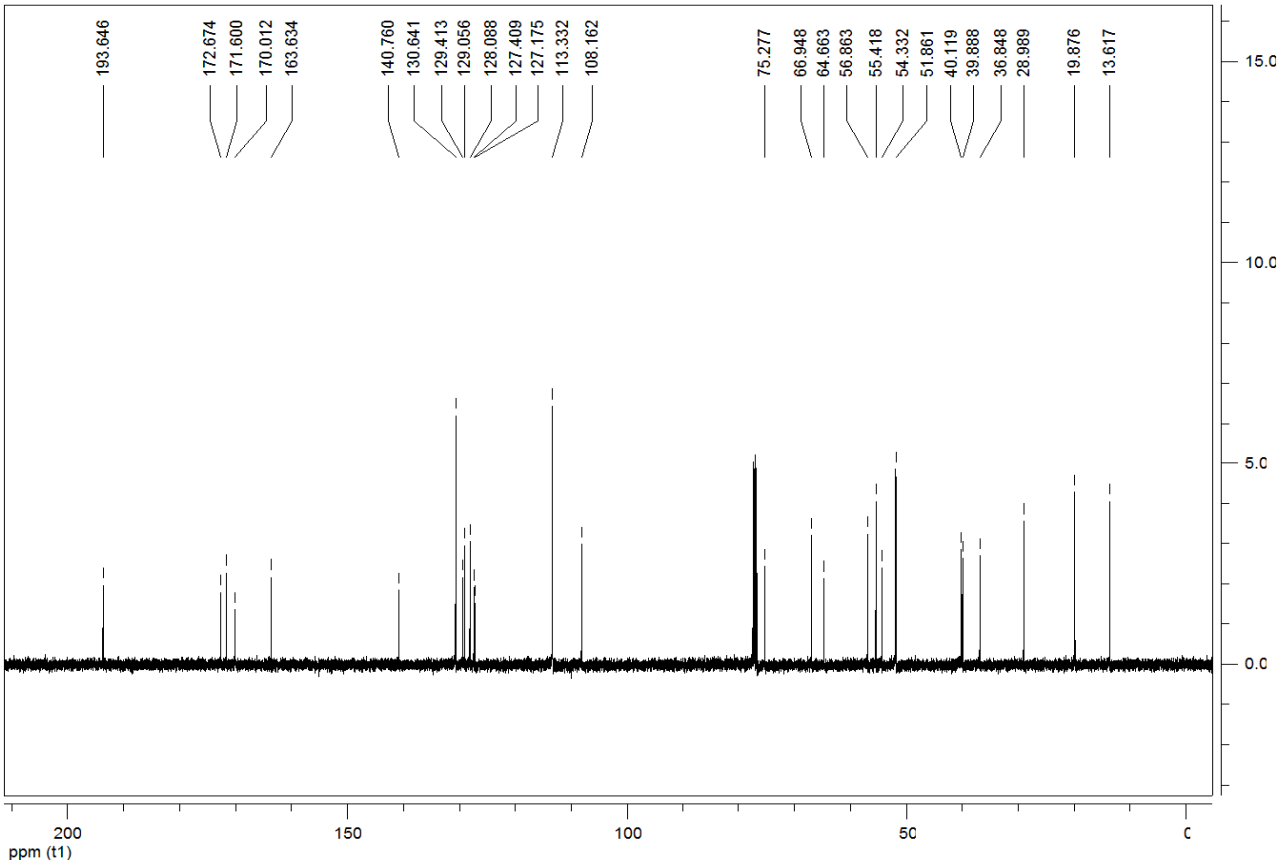
Methyl 1-benzyl-5'-(2-methoxy-2-oxoethyl)-7'-(4-methoxybenzoyl)-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5'-carboxylate (3b):



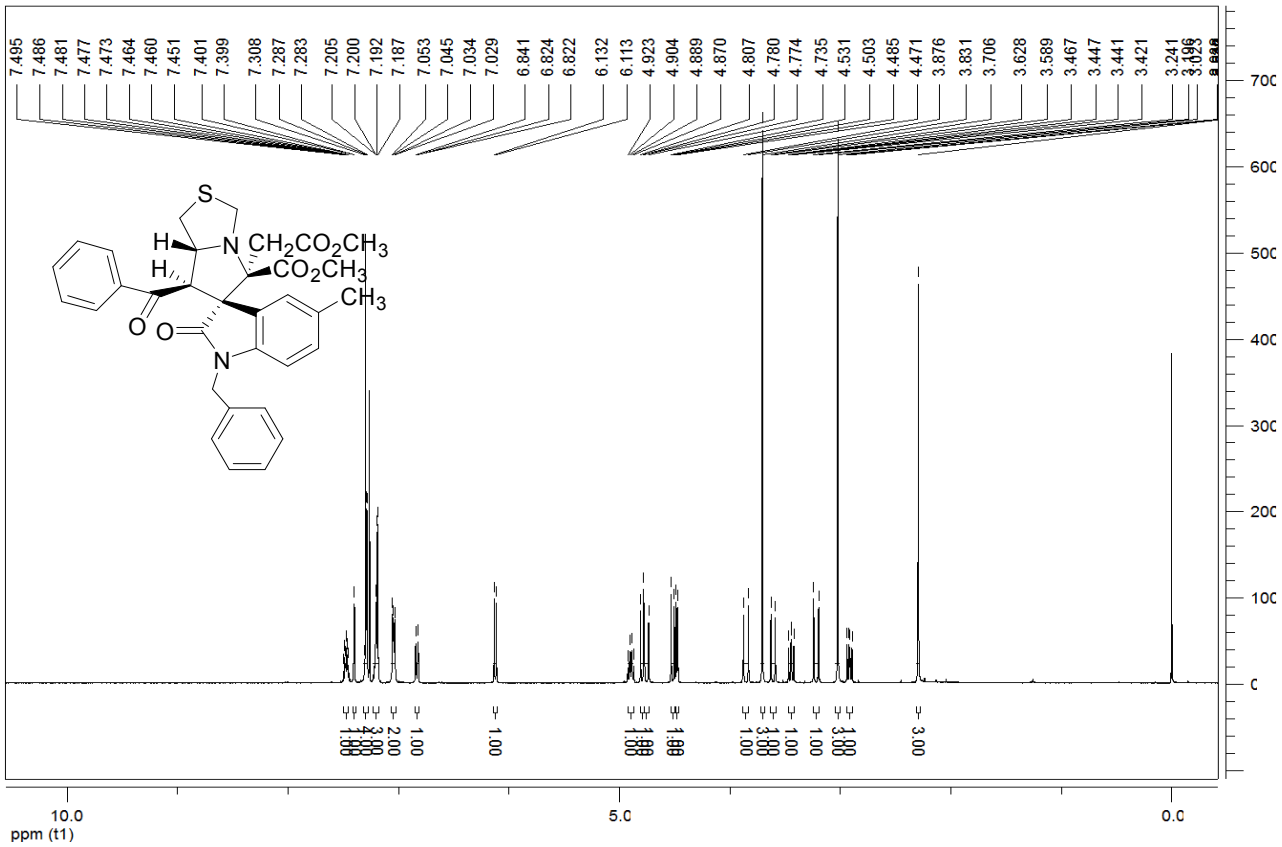


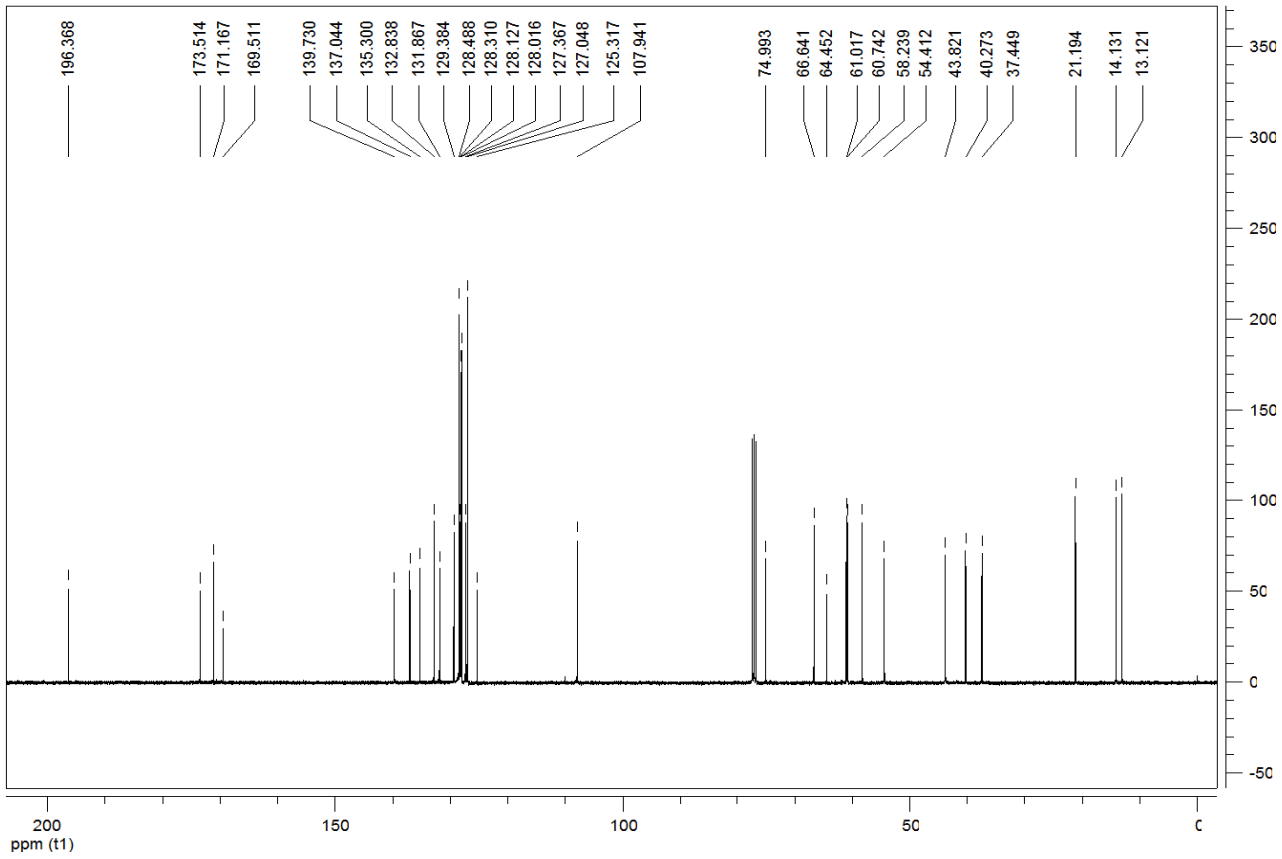
Methyl 1-butyl-5-chloro-5'-(2-methoxy-2-oxoethyl)-7'-(4-methoxybenzoyl)-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5'-carboxylate (**3c**):



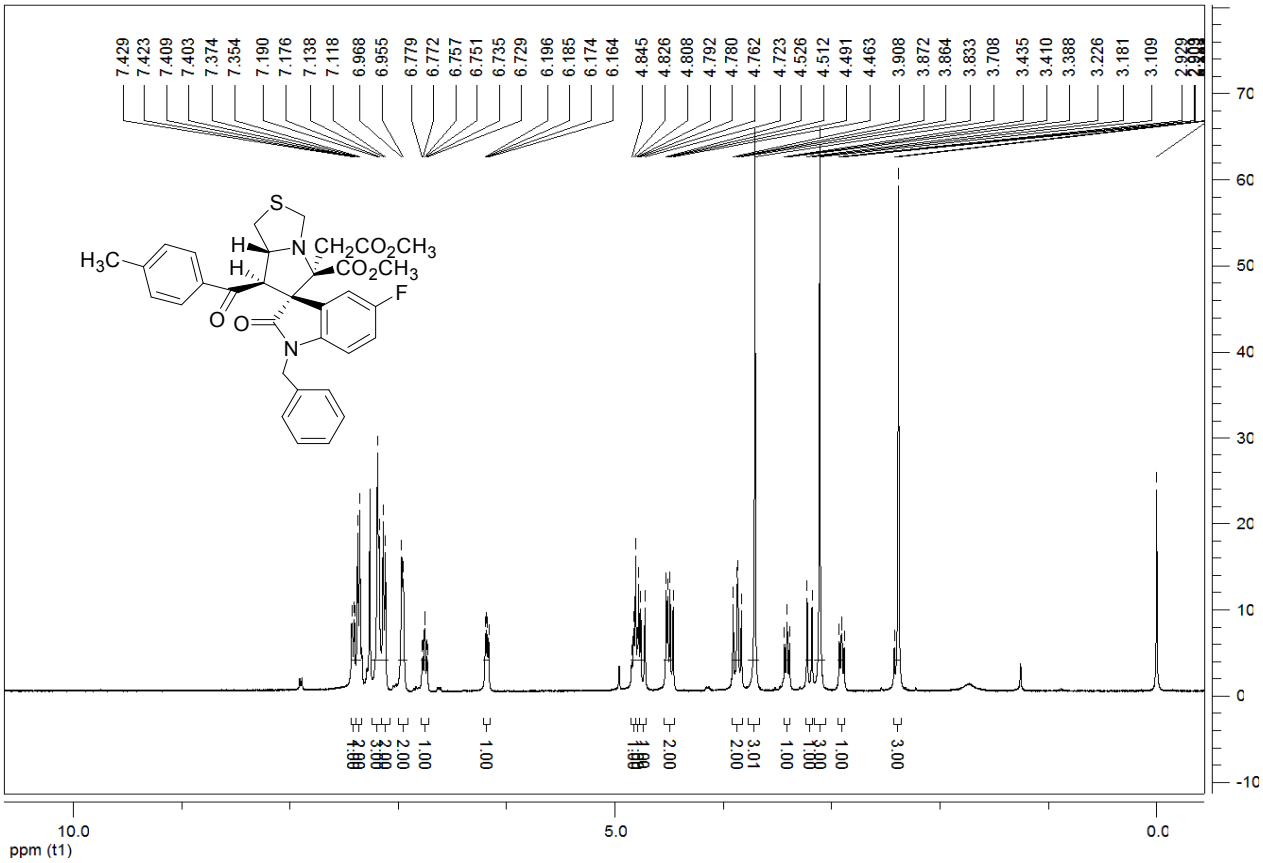


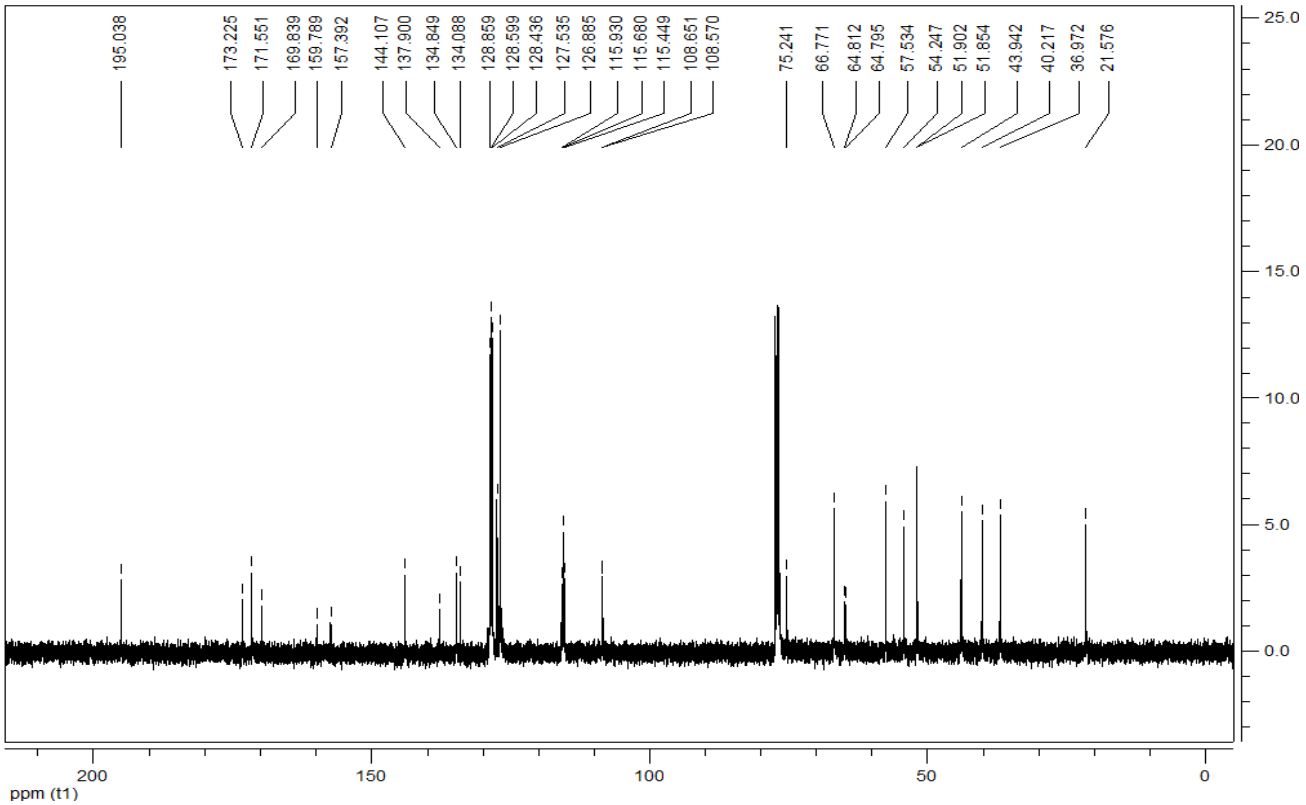
Methyl 7'-benzoyl-1-benzyl-5'-(2-methoxy-2-oxoethyl)-5-methyl-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5'-carboxylate (3d):



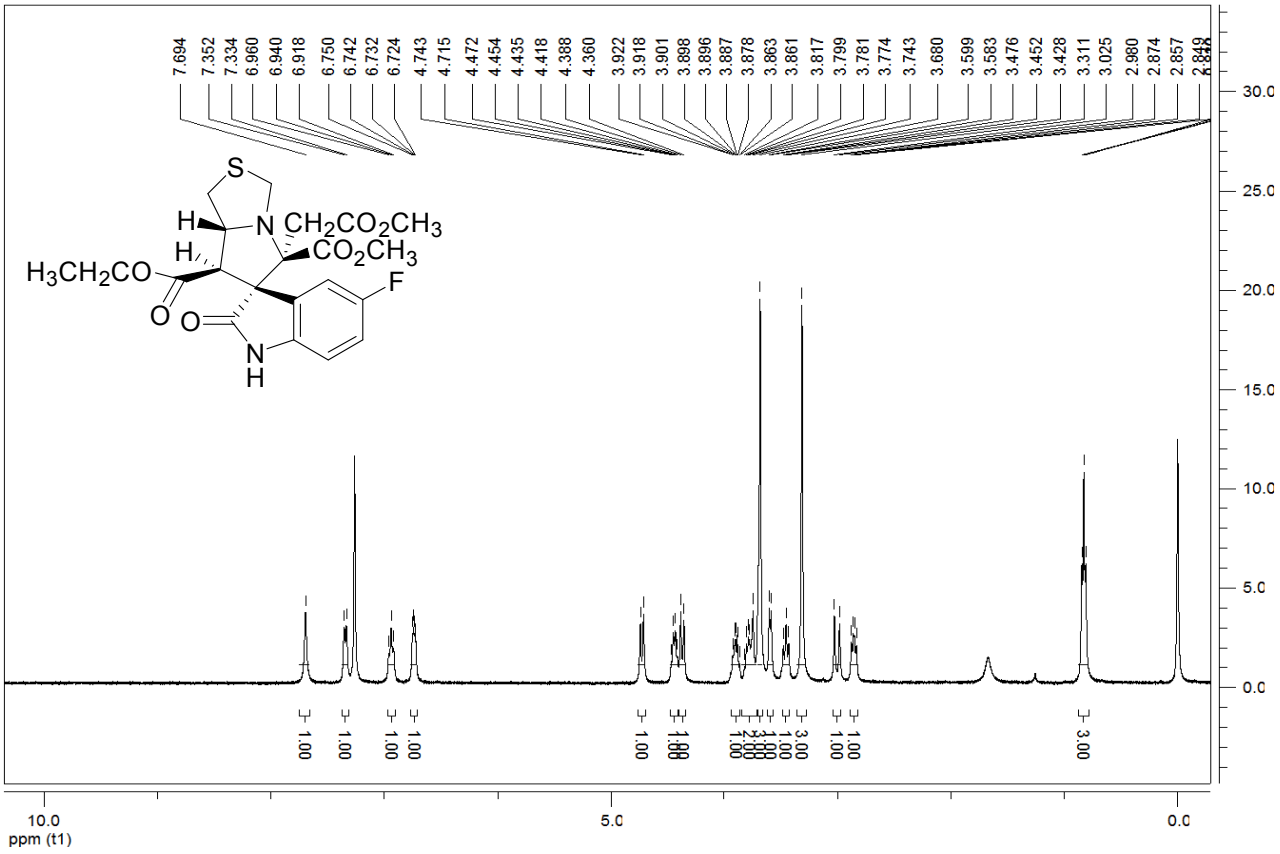


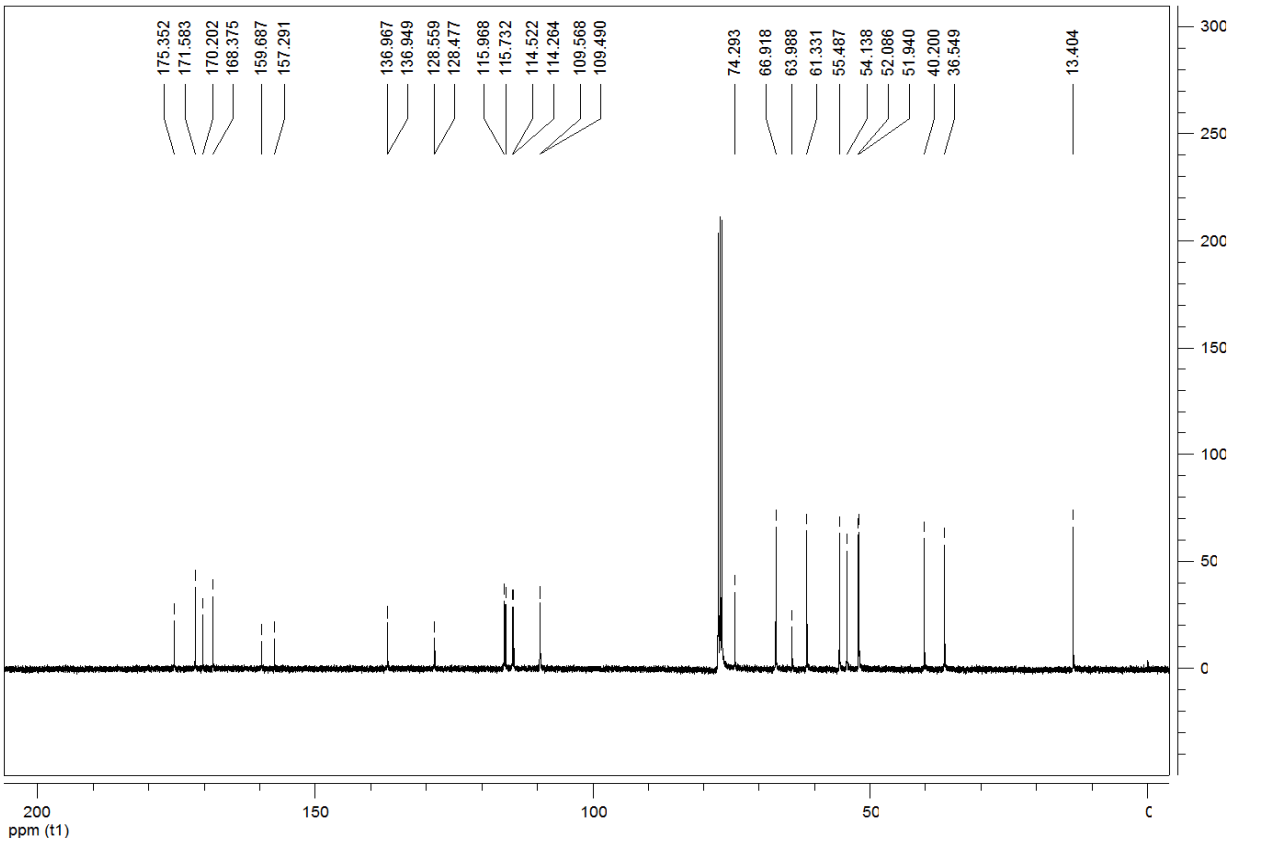
Methyl 1-benzyl-5-fluoro-5'-(2-methoxy-2-oxoethyl)-7'-(4-methylbenzoyl)-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5'-carboxylate (3e):



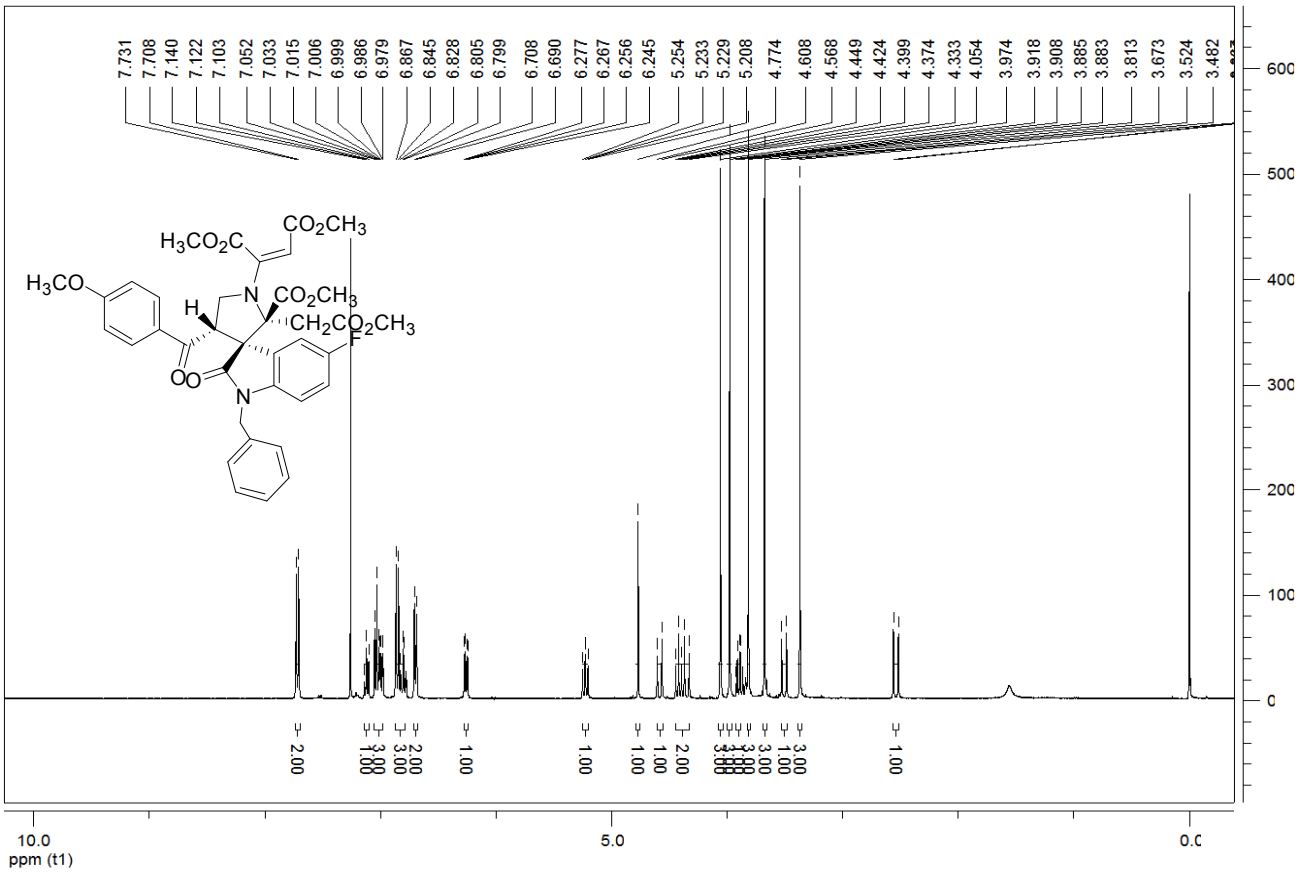


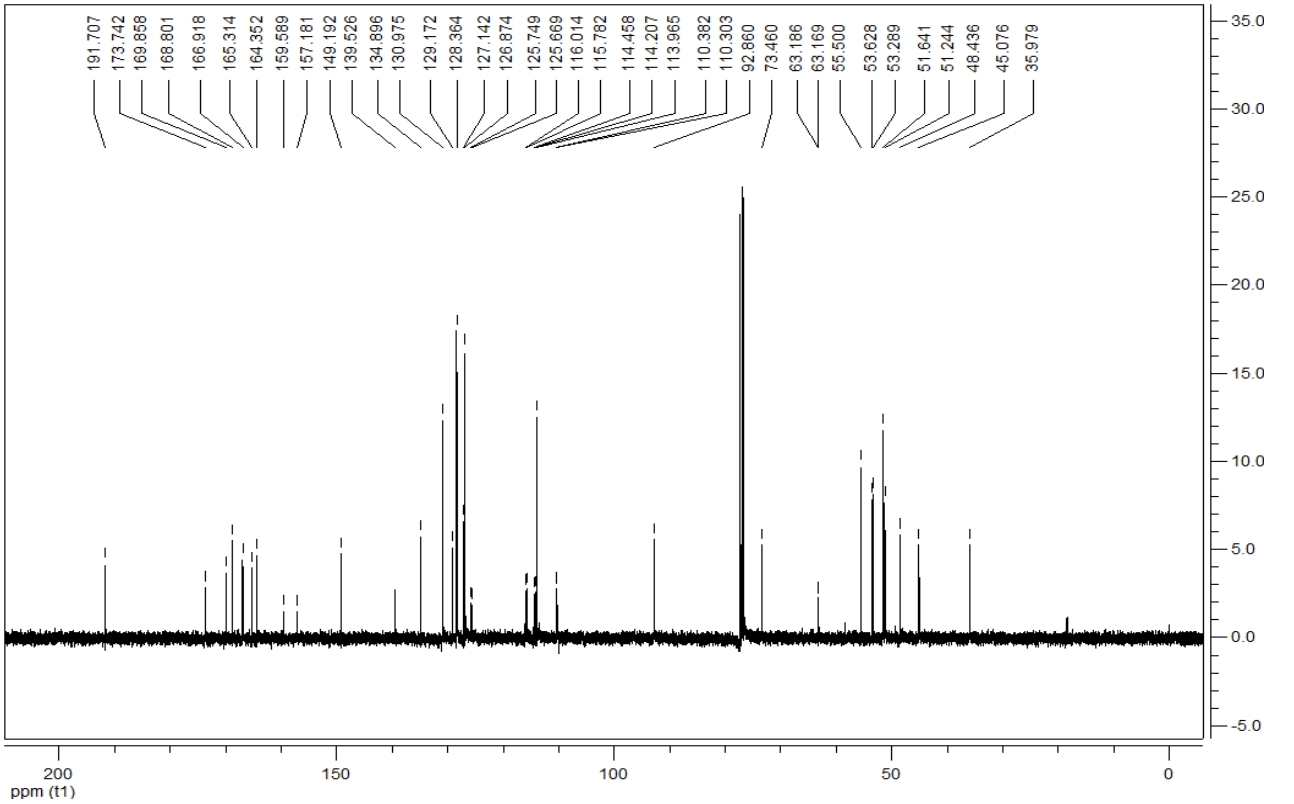
7'-ethyl 5'-methyl 5-fluoro-5'-(2-methoxy-2-oxoethyl)-2-oxo-3',5',7',7a'-tetrahydro-1'H-spiro[indoline-3,6'-pyrrolo[1,2-c]thiazole]-5',7'-dicarboxylate (3f):



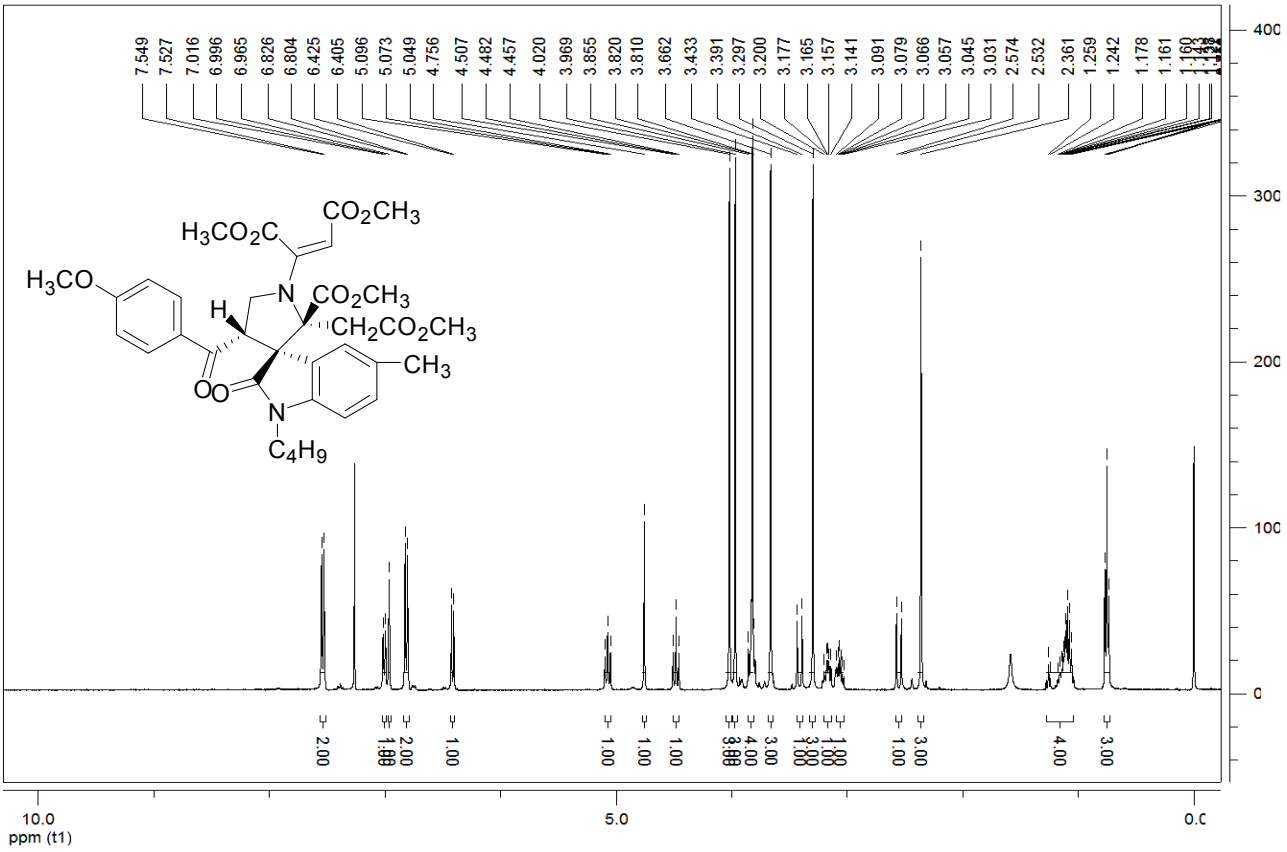


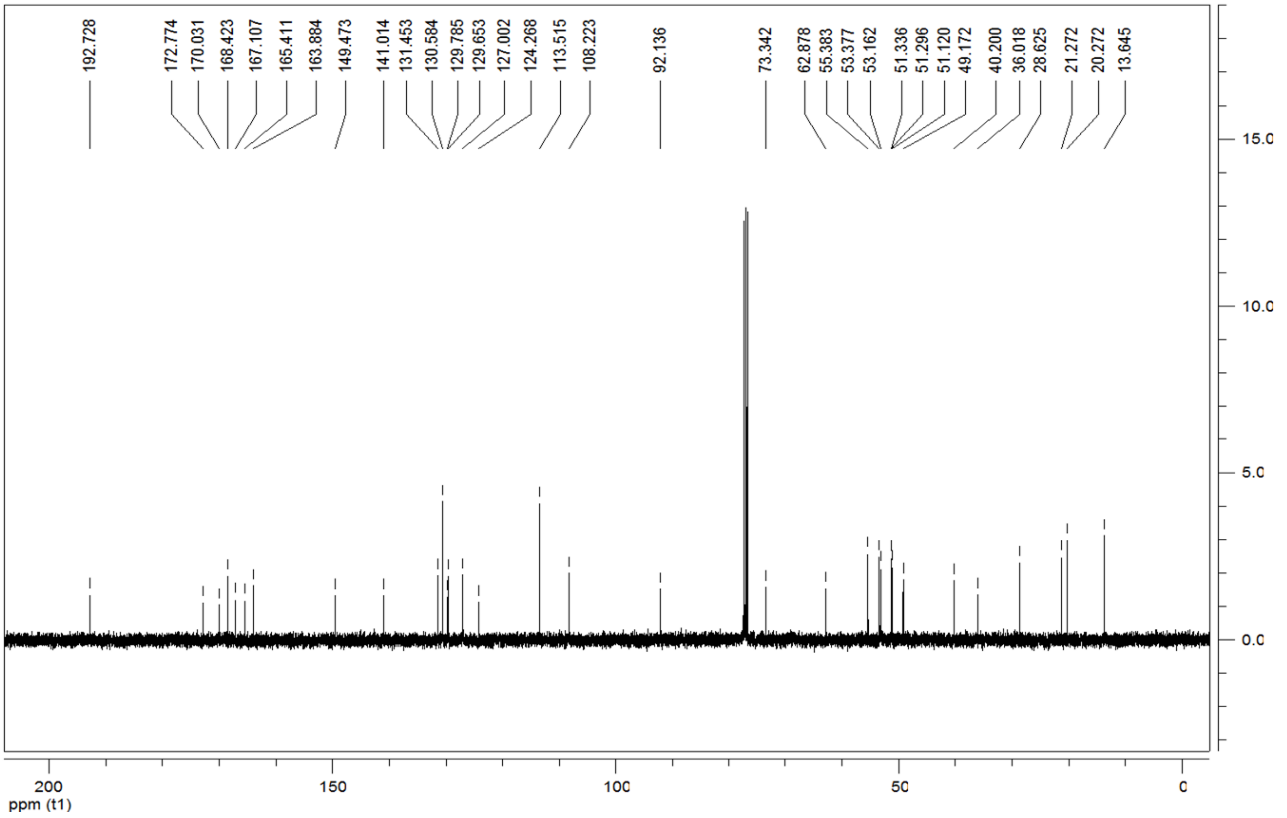
Dimethyl 2-(1-benzyl-5-fluoro-2'-(2-methoxy-2-oxoethyl)-4'-(4-methoxybenzoyl)-2'-(methoxycarbonyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4a):



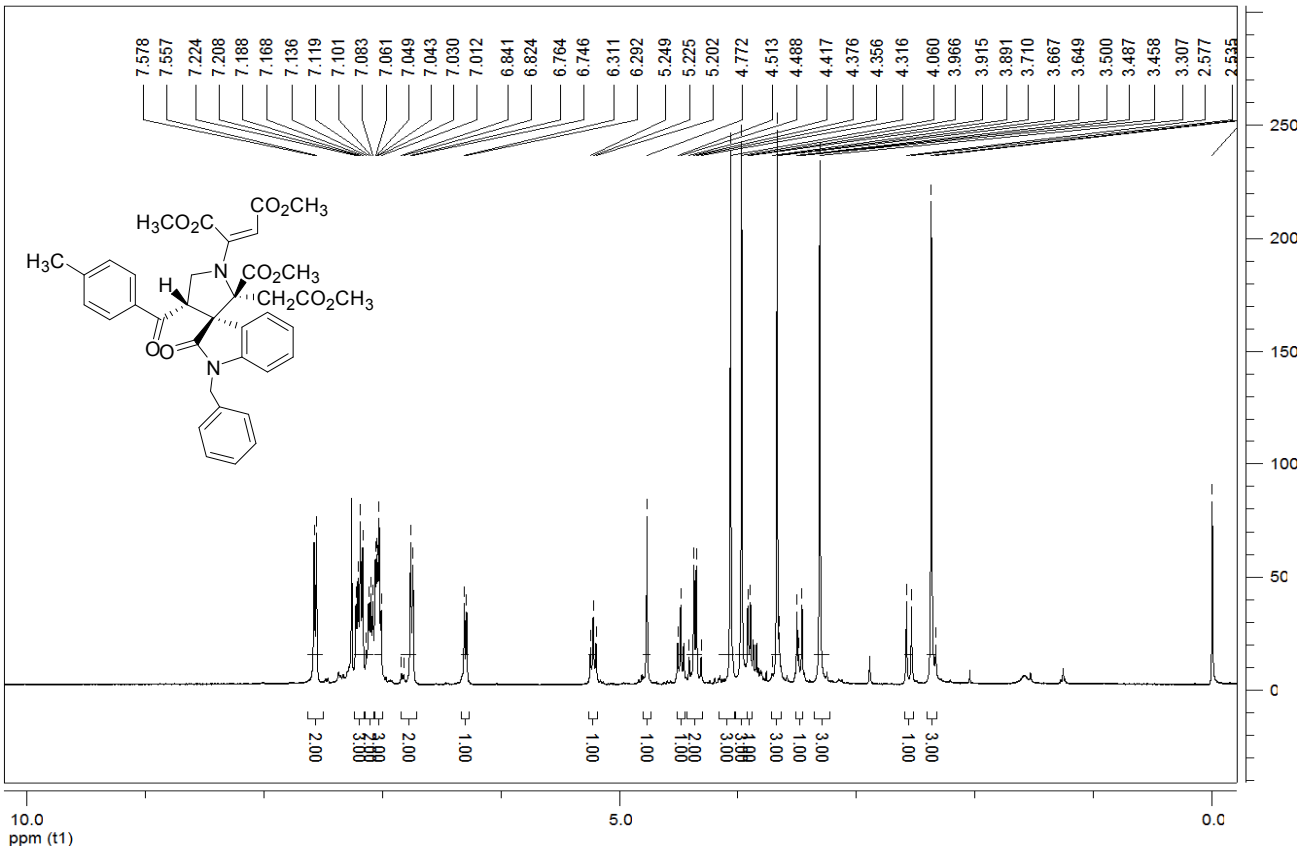


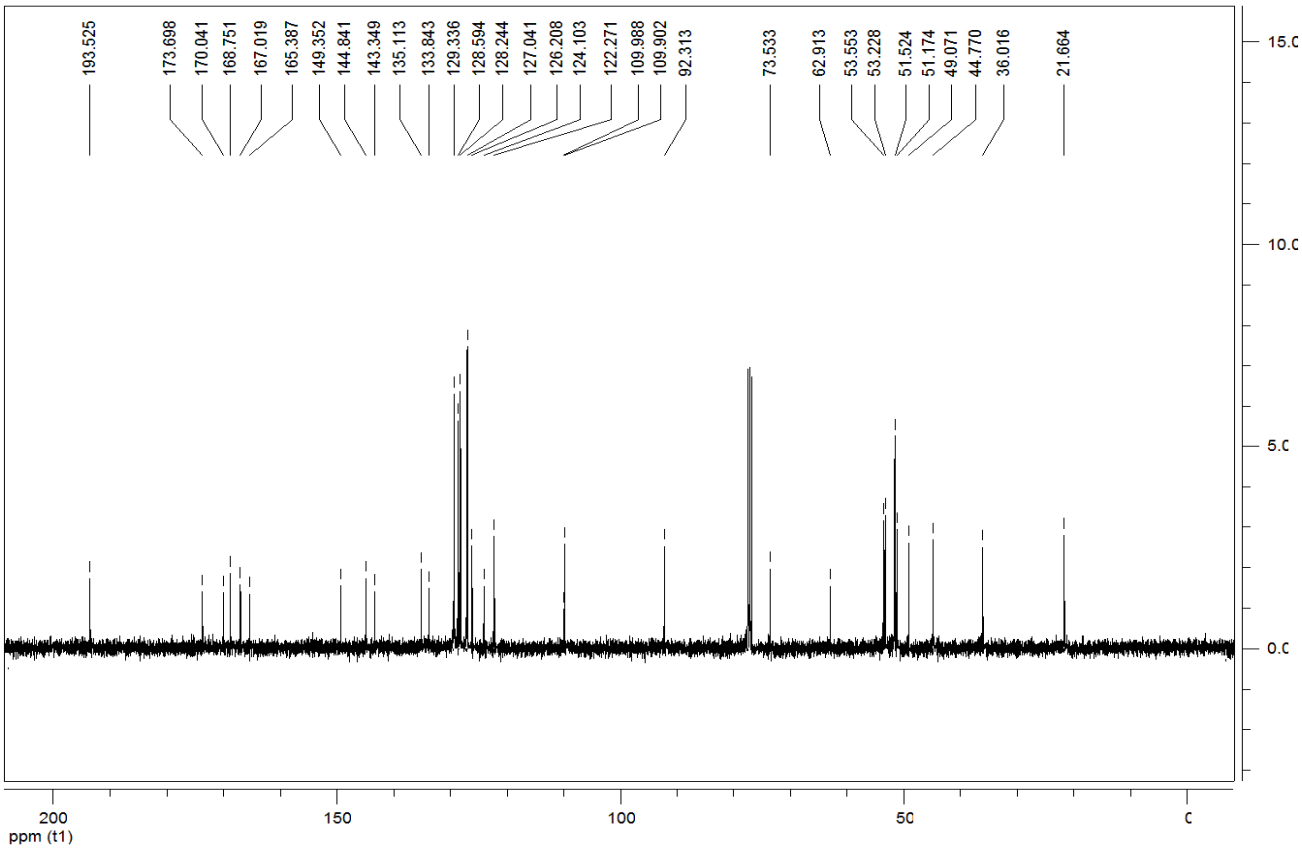
Dimethyl 2-((2'S,3S,4'R)-1-butyl-2'-(2-methoxy-2-oxoethyl)-4'-(4-methoxybenzoyl)-2'-(methoxycarbonyl)-5-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4b):



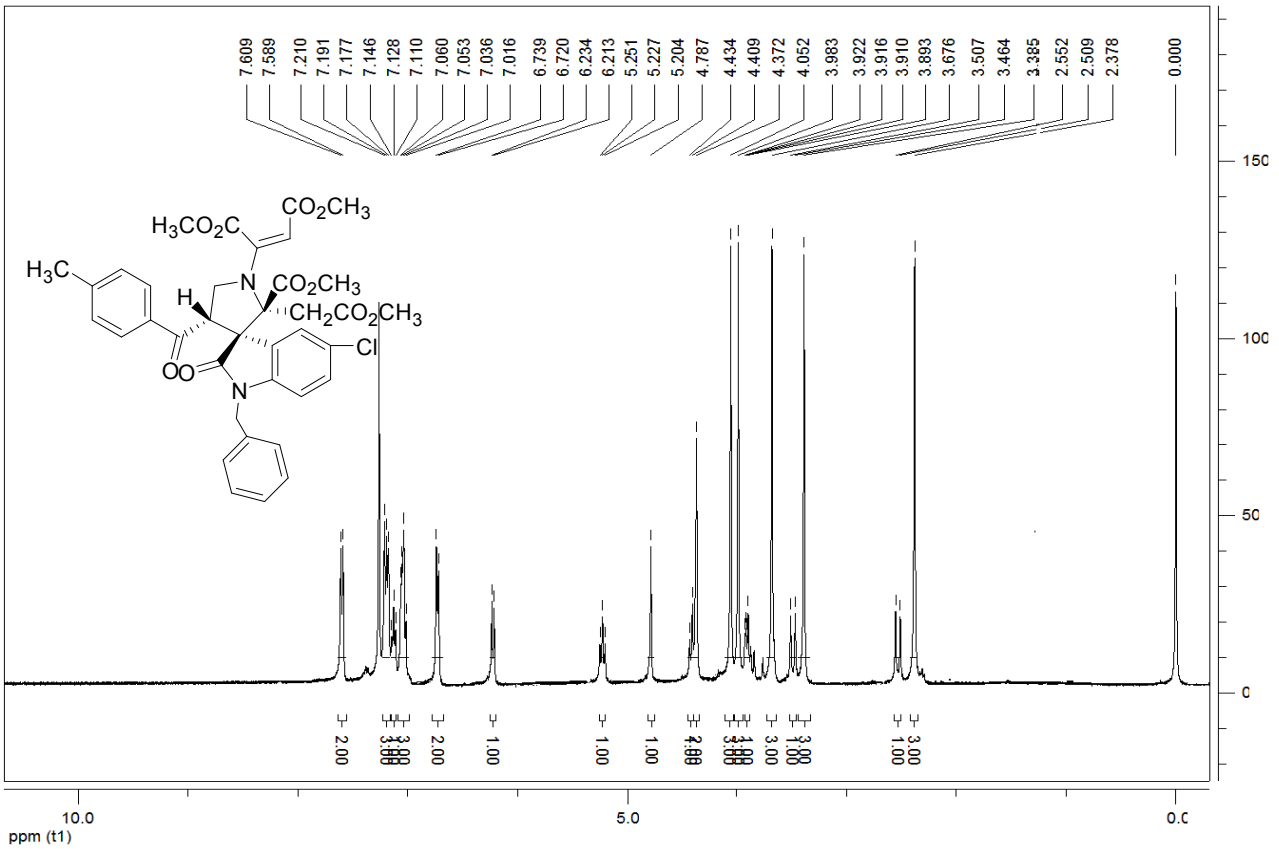


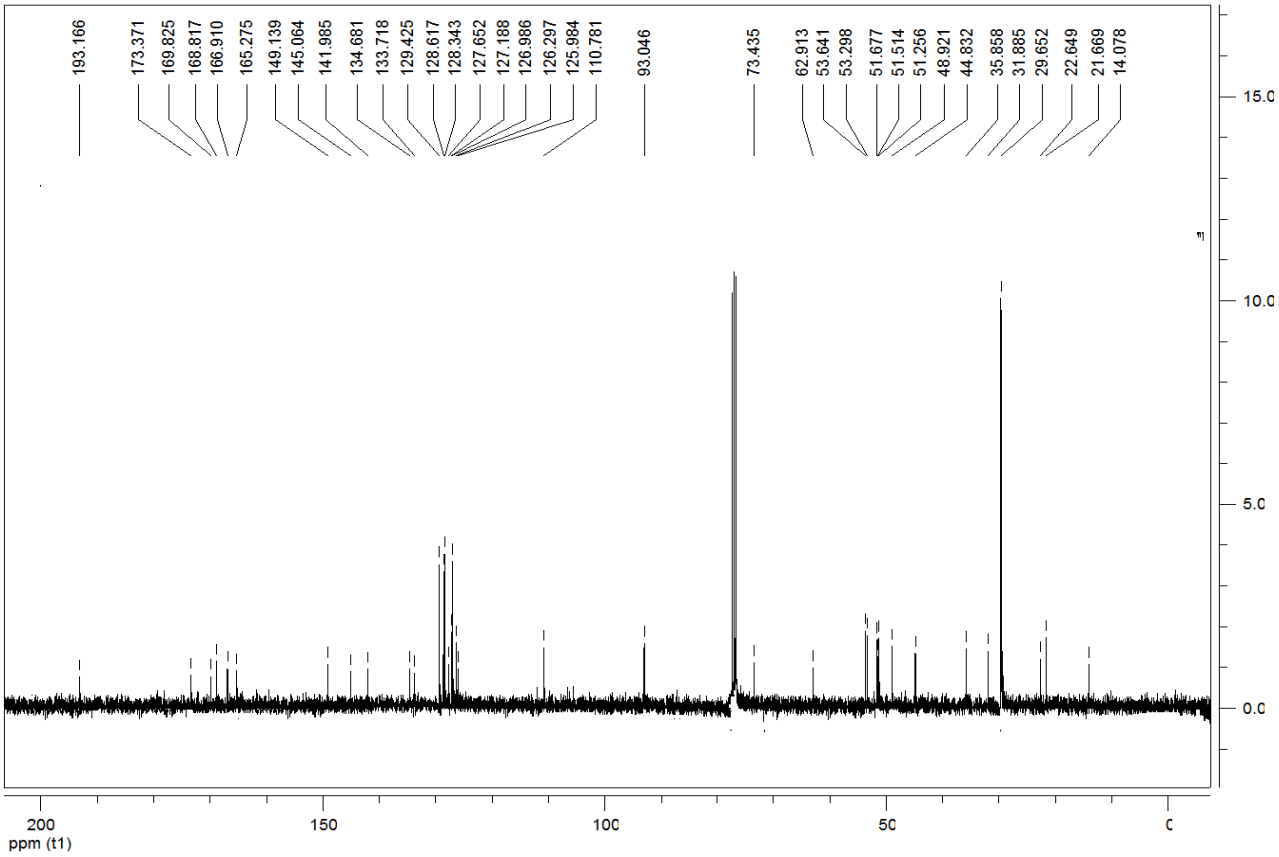
Dimethyl 2-(1-benzyl-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4c):



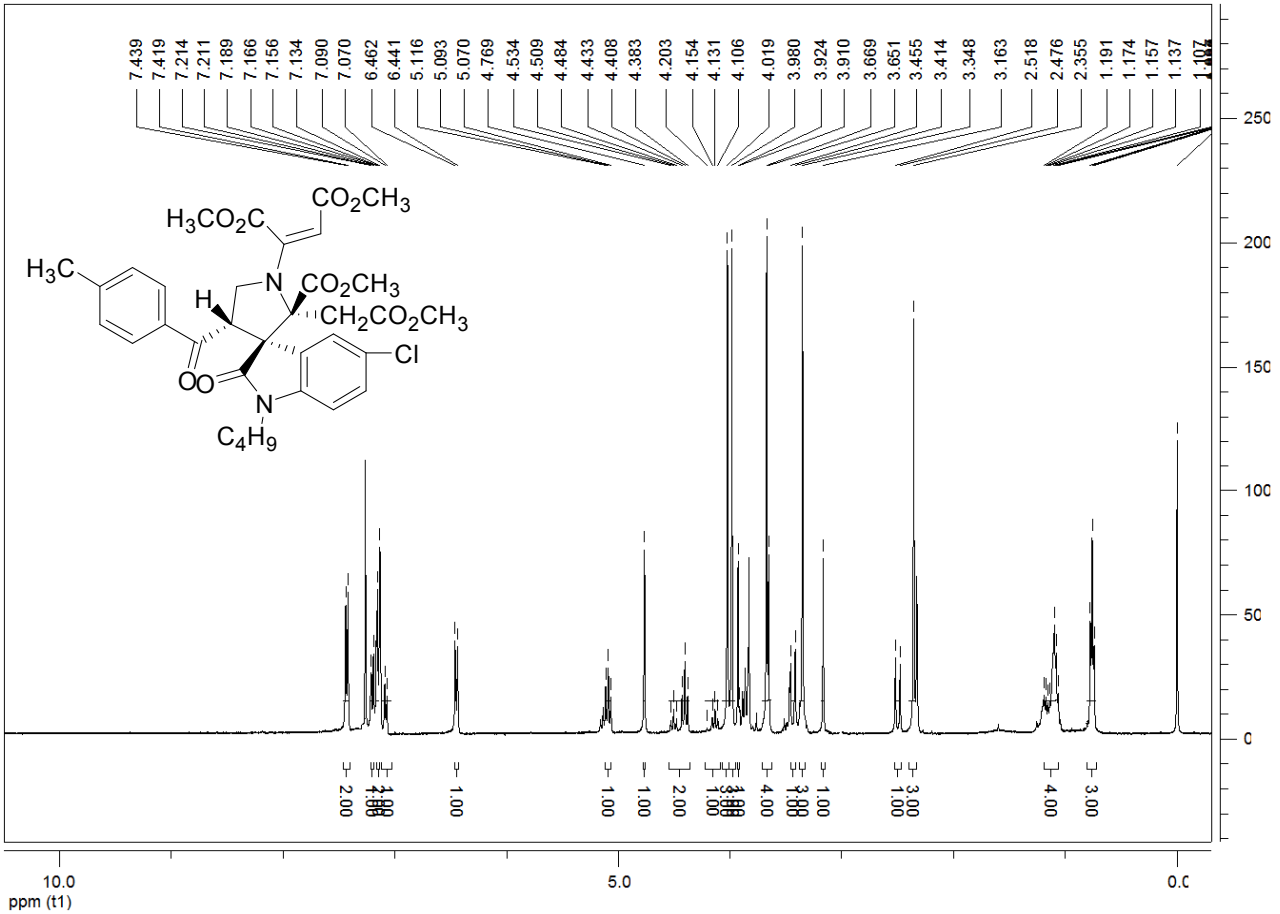


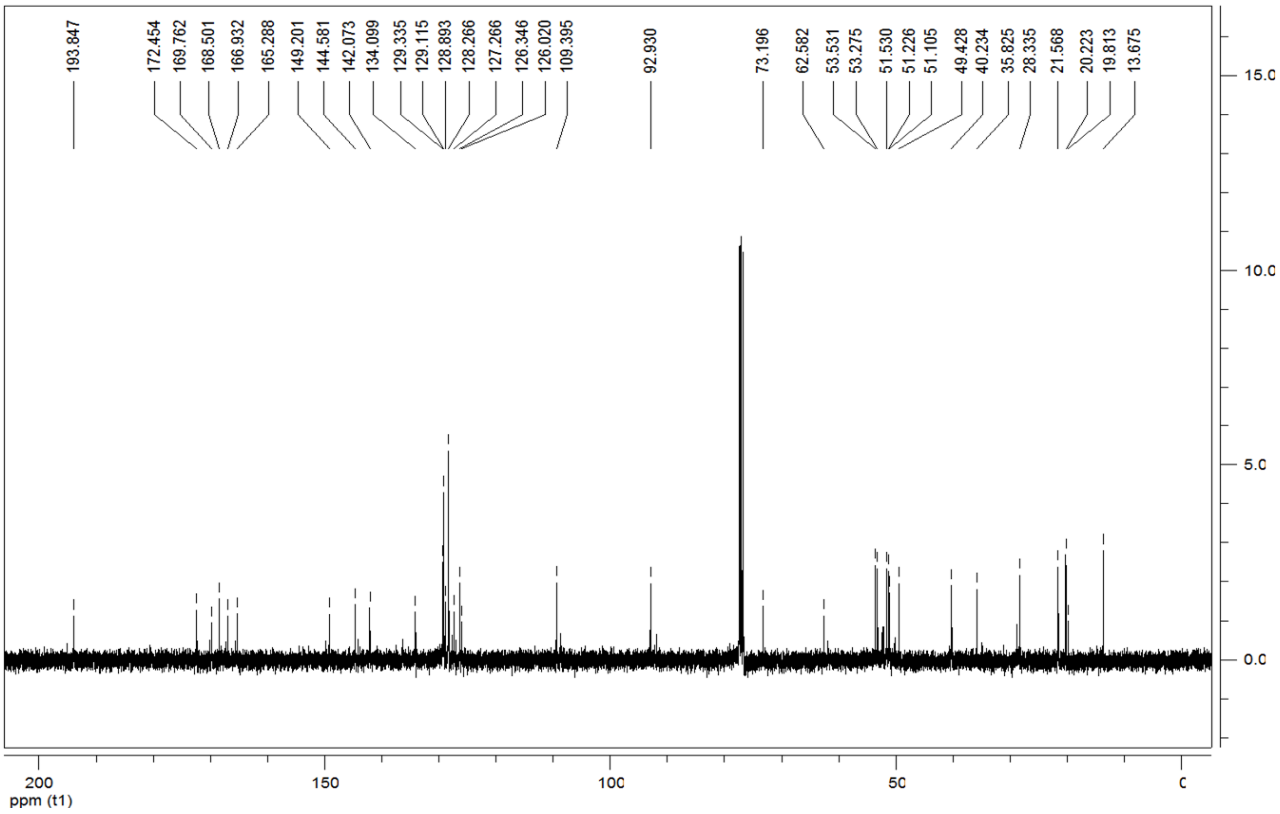
Dimethyl 2-((2'S,3S,4'R)-1-benzyl-5-chloro-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4d):



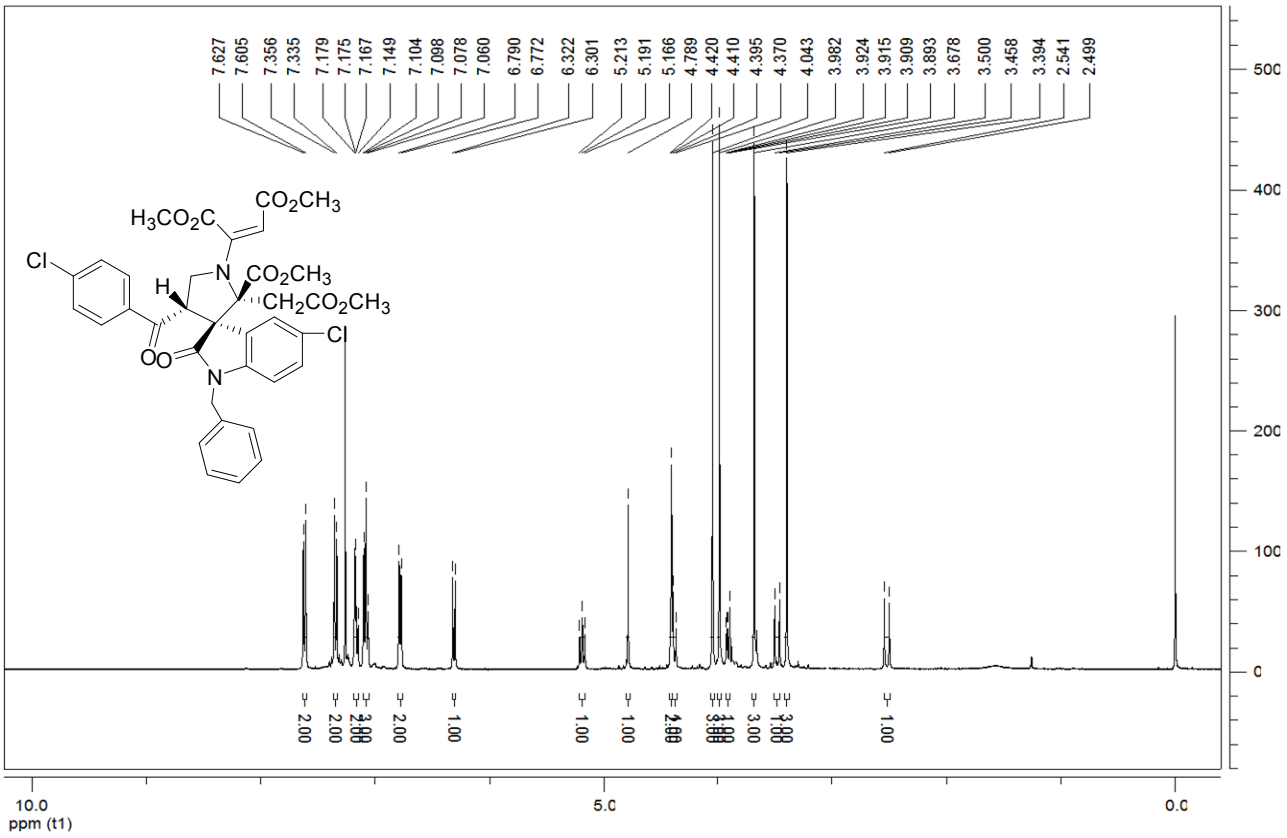


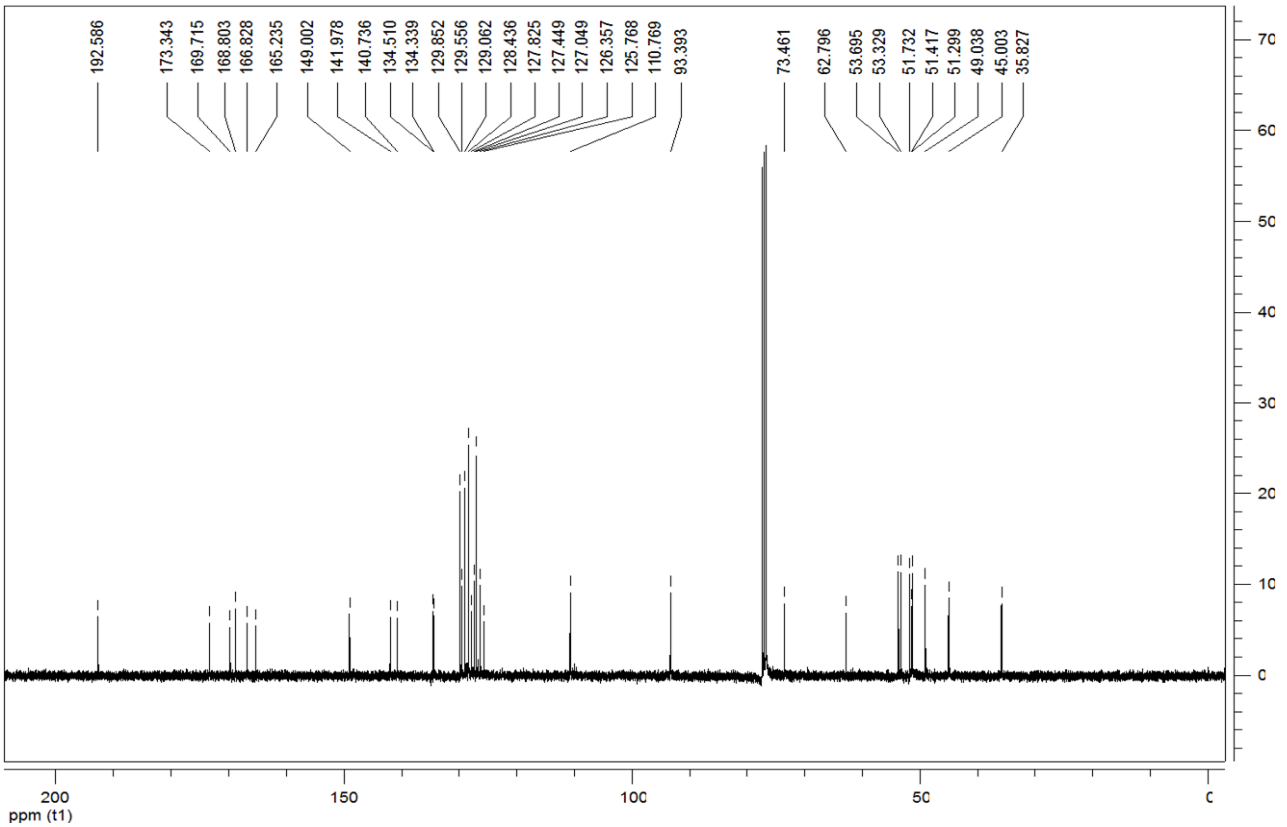
Dimethyl 2-(1-butyl-5-chloro-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4e):



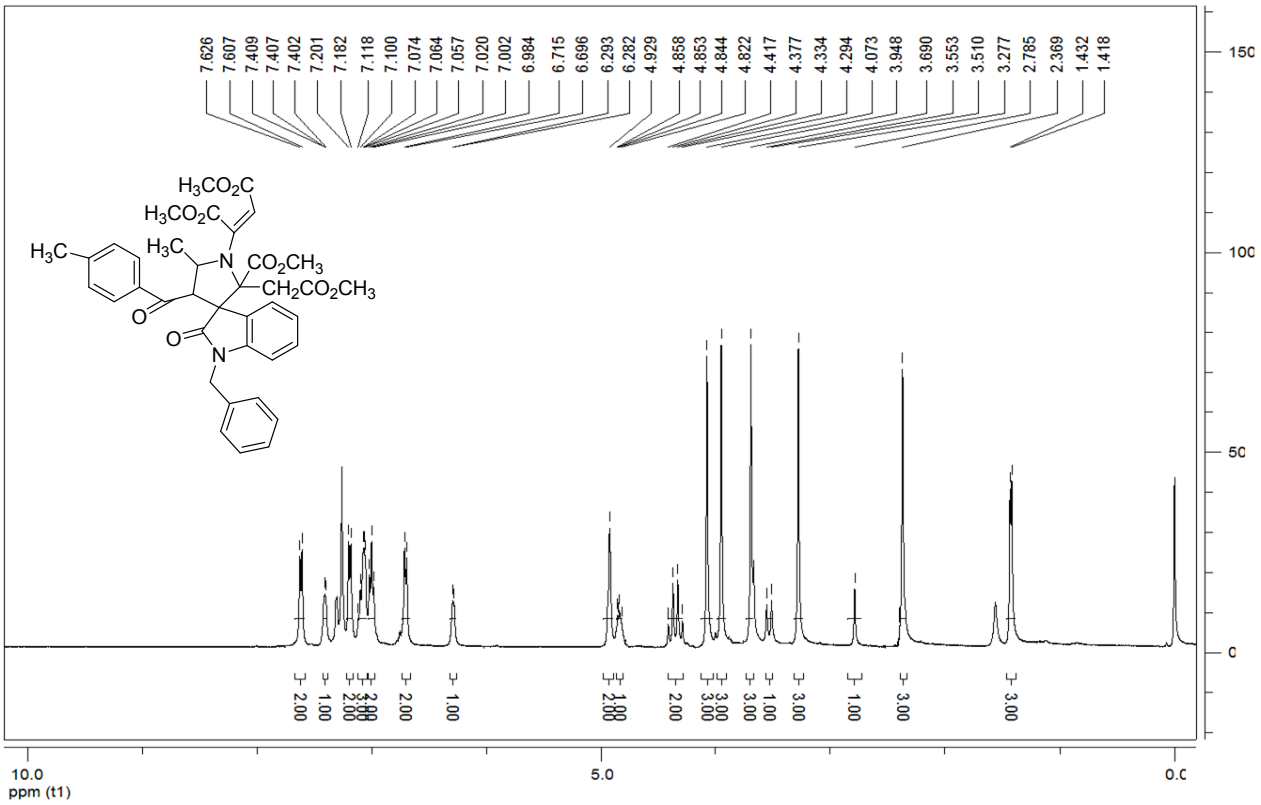


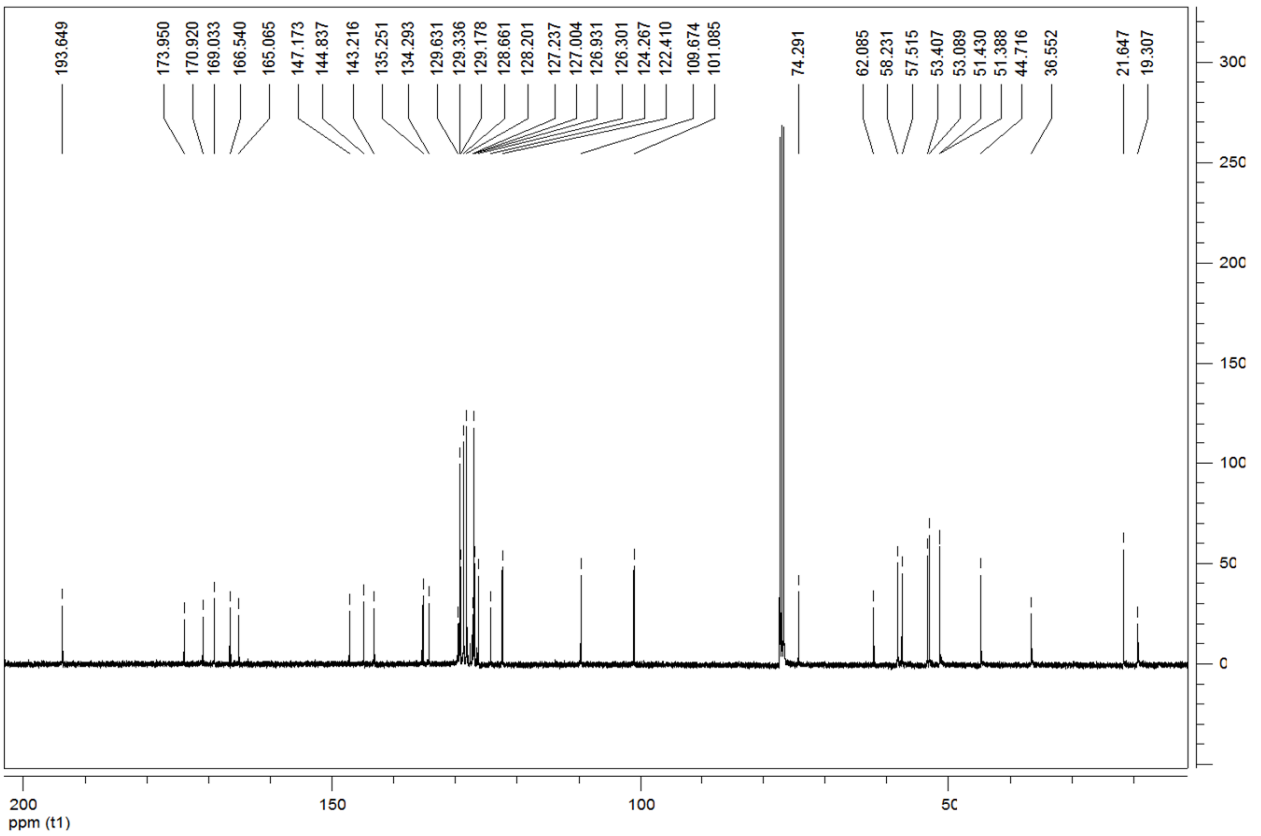
Dimethyl 2-(1-benzyl-5-chloro-4'-(4-chlorobenzoyl)-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4f):



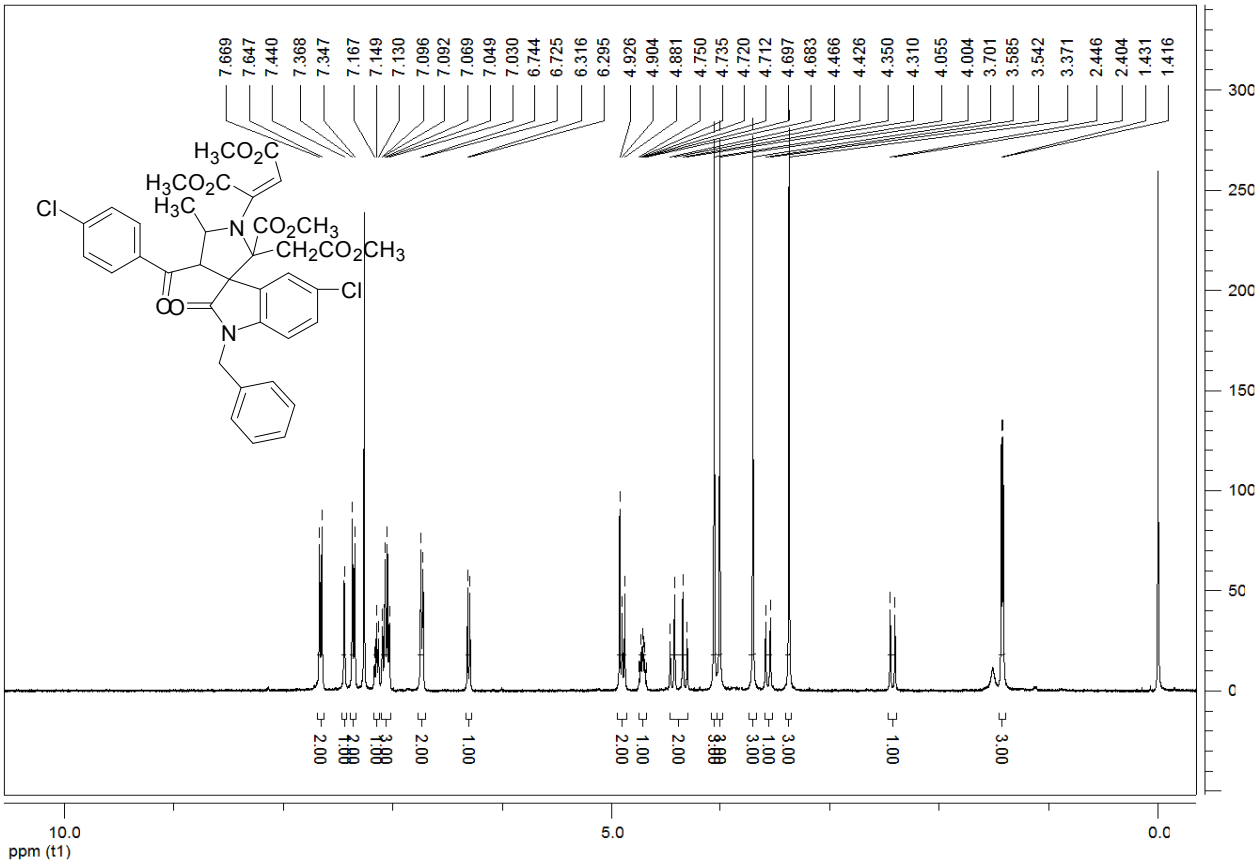


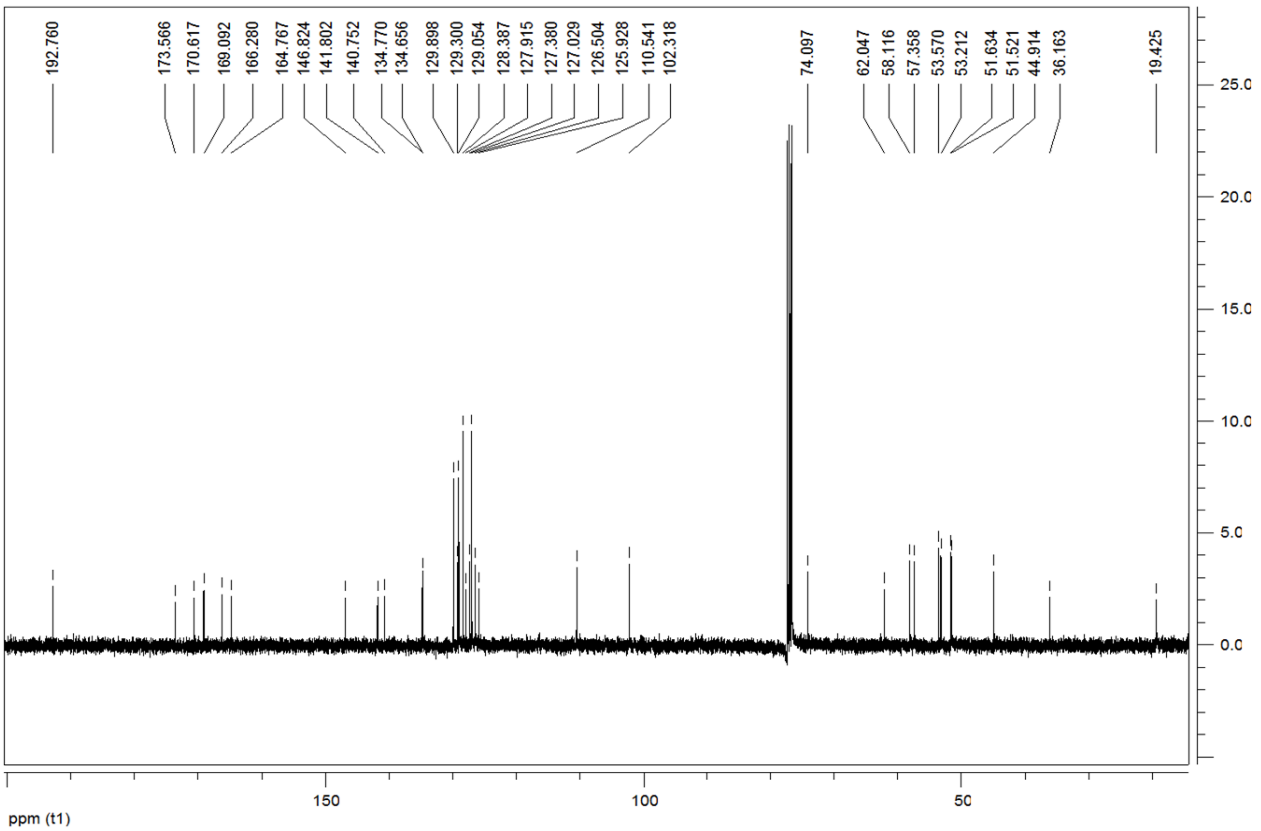
Dimethyl 2-(1-benzyl-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-5'-methyl-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4g):



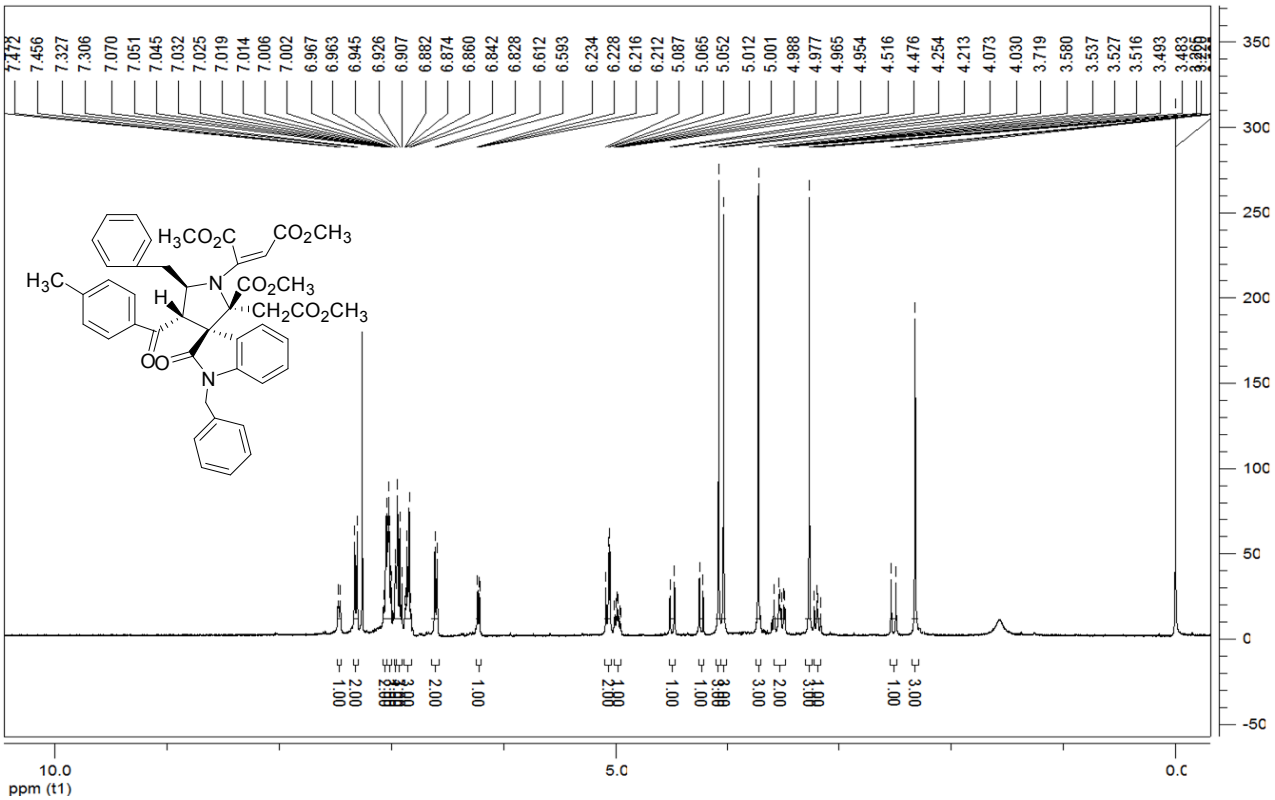


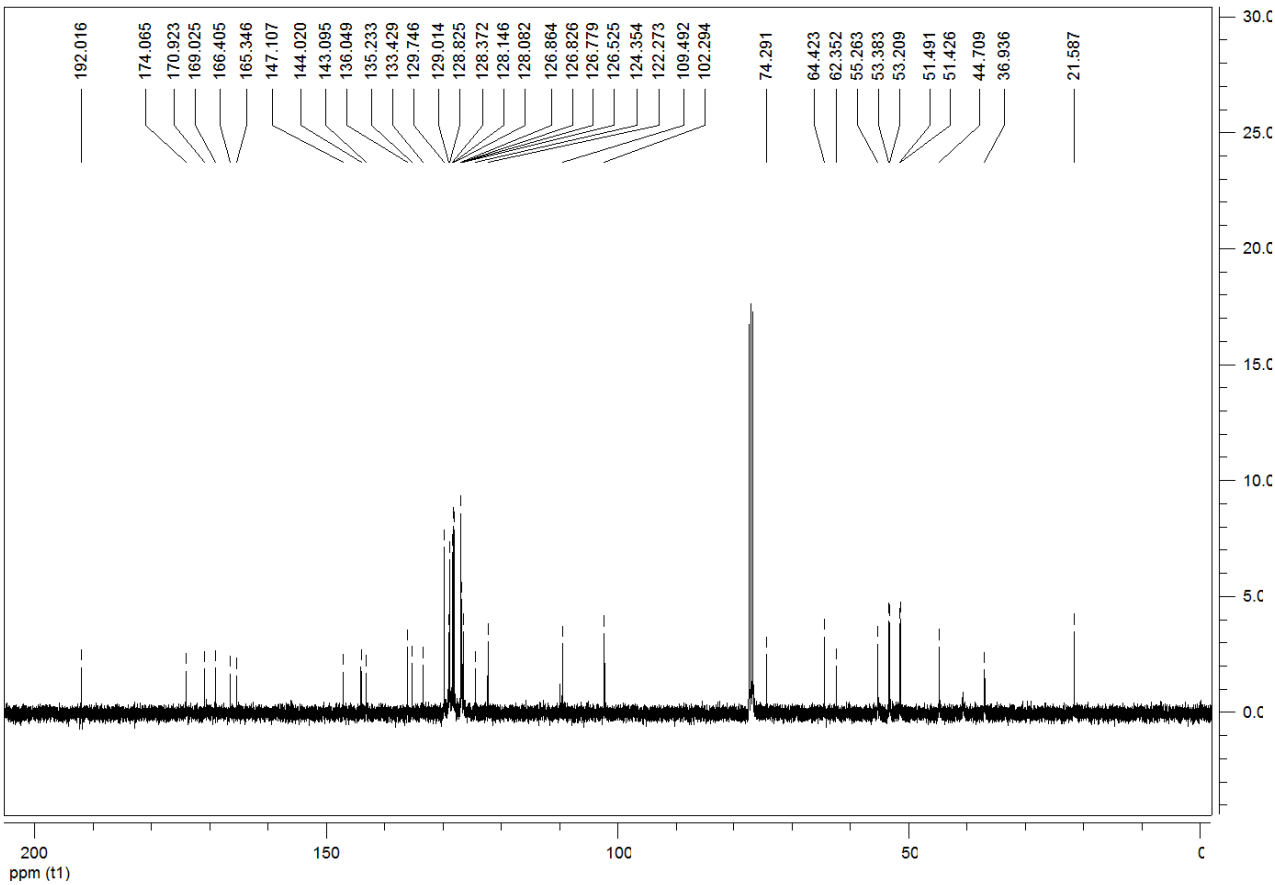
Dimethyl 2-(1-benzyl-5-chloro-4'-(4-chlorobenzoyl)-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-5'-methyl-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4h):



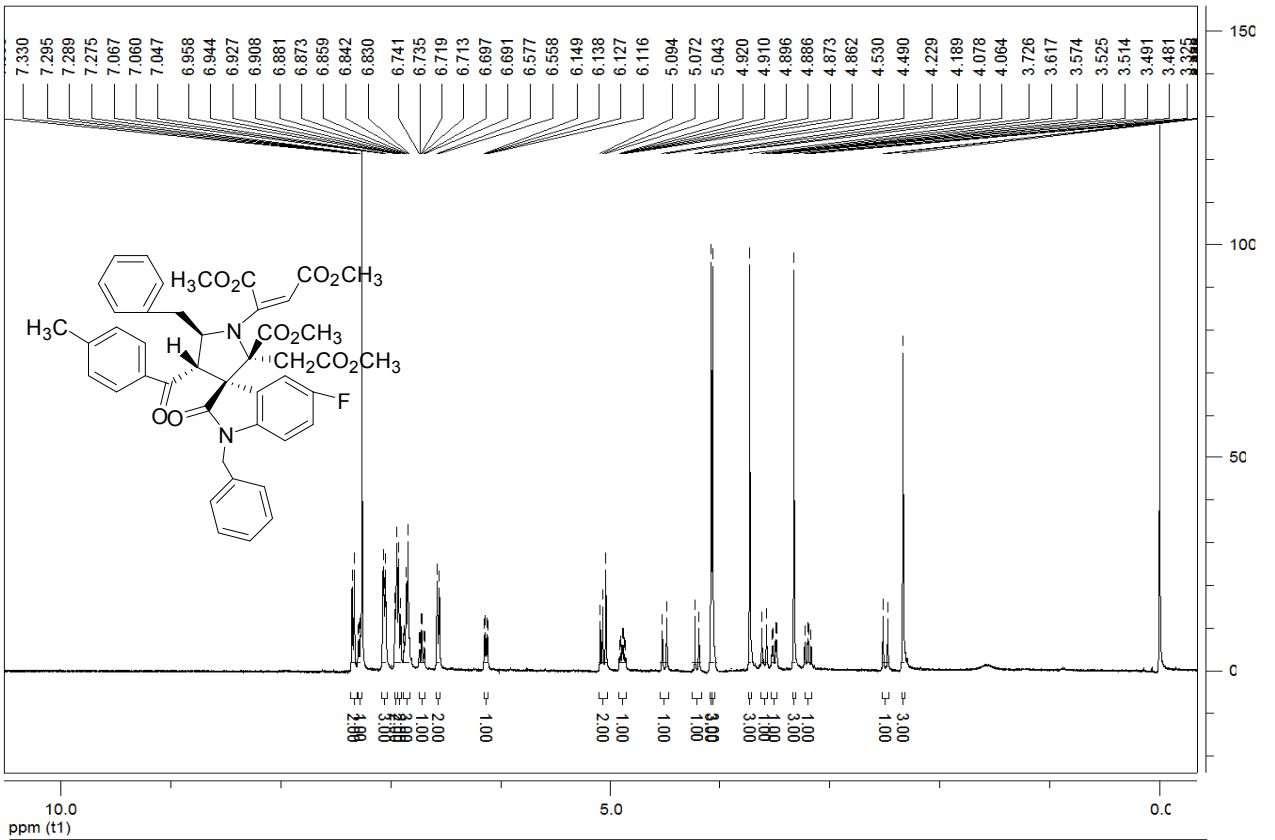


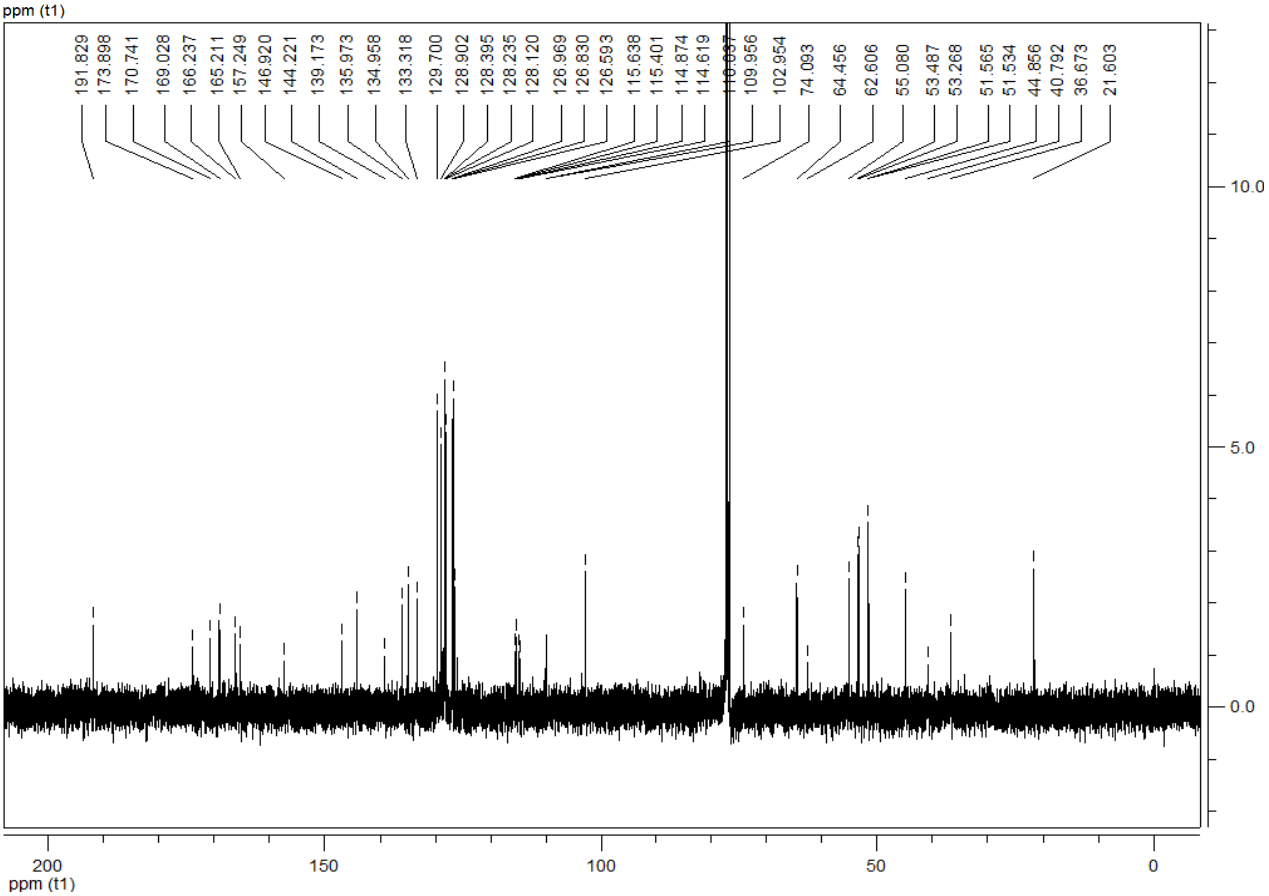
dimethyl 2-(1,5'-dibenzyl-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (4i):

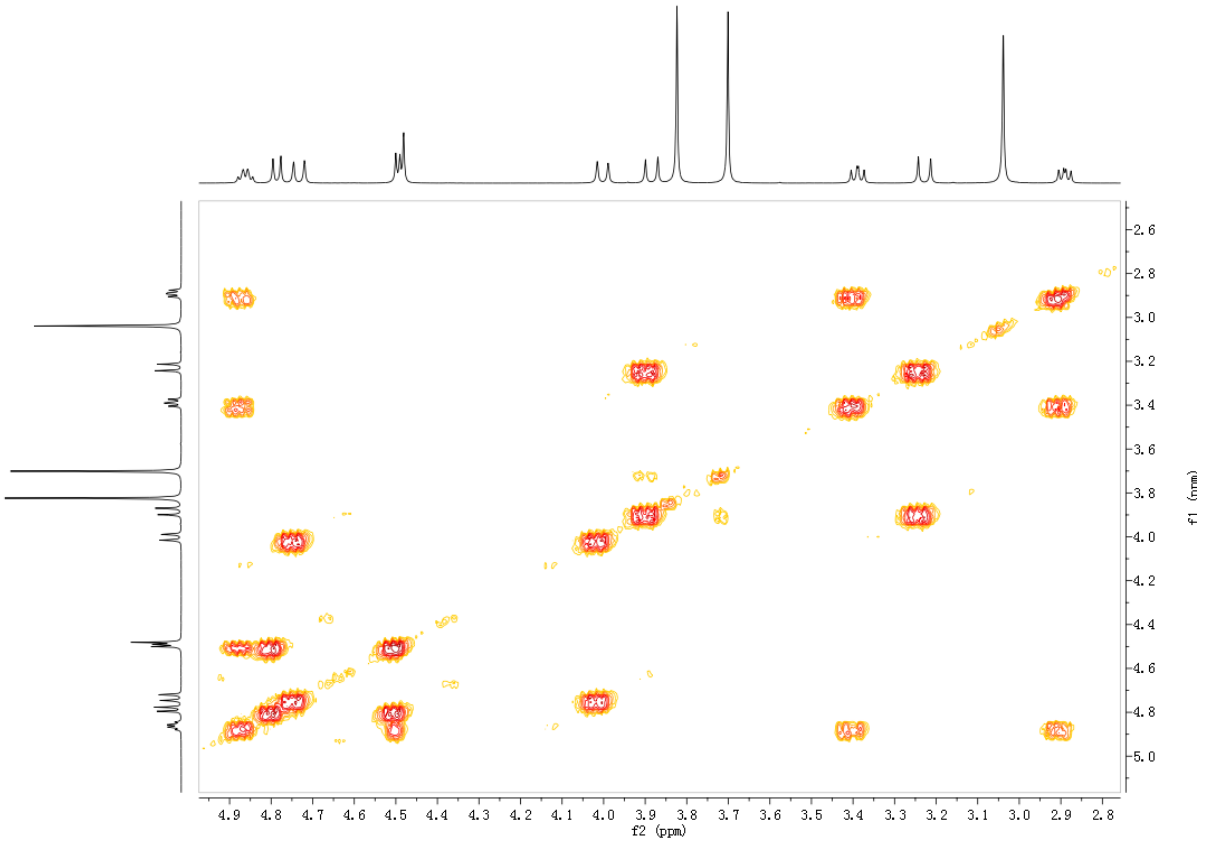




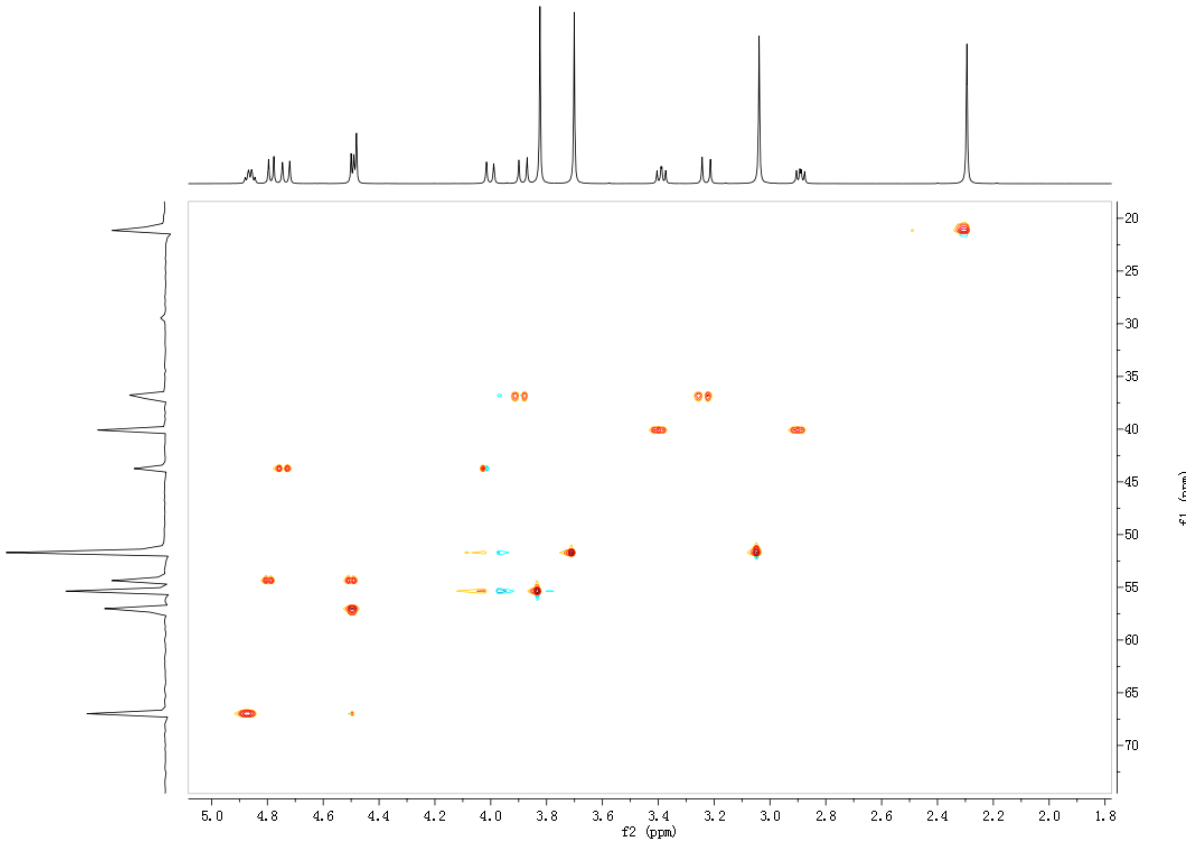
Dimethyl 2-(1,5'-dibenzyl-5-fluoro-2'-(2-methoxy-2-oxoethyl)-2'-(methoxycarbonyl)-4'-(4-methylbenzoyl)-2-oxospiro[indoline-3,3'-pyrrolidine]-1'-yl)maleate (3j):


7.330
7.295
7.289
7.275
7.067
7.060
7.047
6.958
6.944
6.927
6.908
6.881
6.873
6.859
6.842
6.830
6.741
6.735
6.719
6.713
6.697
6.691
6.577
6.558
6.149
6.138
6.127
6.116
5.094
5.072
5.043
4.920
4.910
4.896
4.886
4.873
4.862
4.530
4.490
4.229
4.189
4.078
4.064
3.726
3.617
3.574
3.525
3.514
3.491
3.481
H3CO2C
CO2CH3
H3C
N
CO2CH3
H
CH2CO2CH3
F
O
O
N
2.00
1.00
2.00
1.00
1.00
3.00
3.00
1.00
3.00
10.0
5.0
ppm (t1)

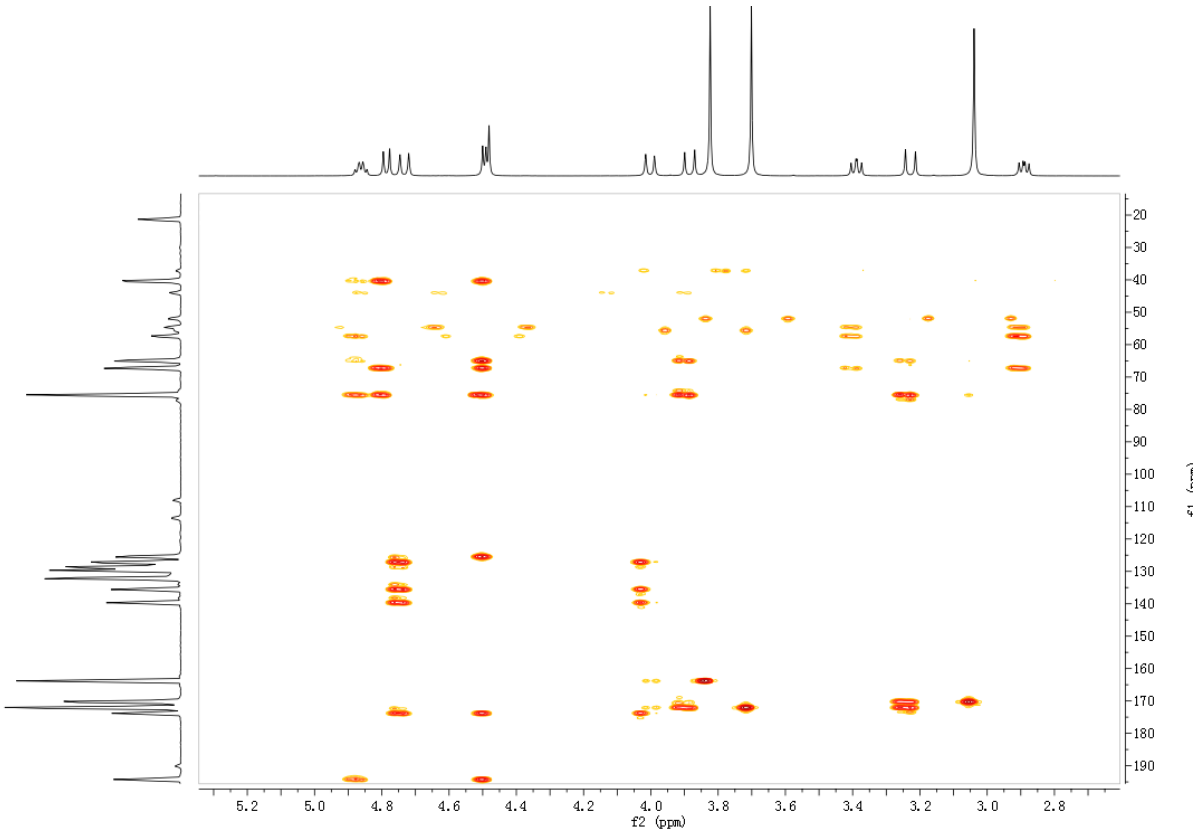

191.829
173.898
170.741
169.028
166.237
165.211
157.249
146.920
144.221
139.173
135.973
134.958
133.318
129.700
128.902
128.395
128.235
128.120
126.969
126.830
126.593
115.638
115.401
114.874
114.619
109.956
102.954
74.093
64.456
62.606
55.080
53.487
53.268
51.565
51.534
44.856
40.792
36.673
21.603
200
150
100
50
0
ppm (t1)



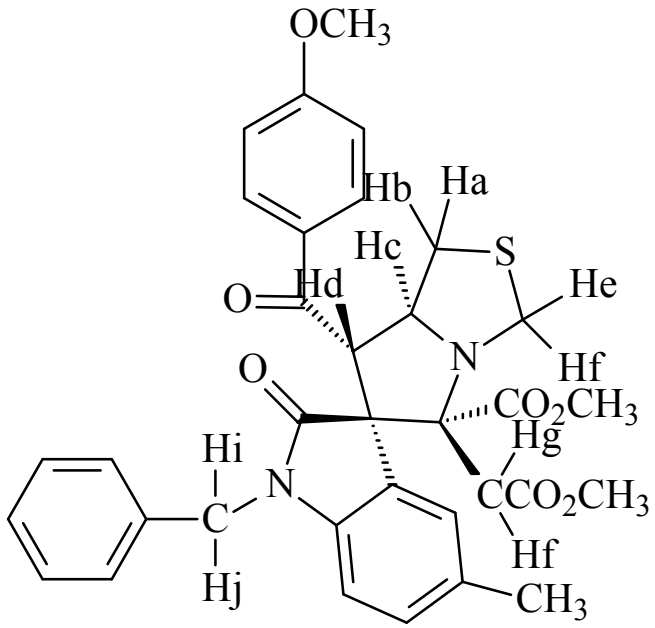
H-H COSY 谱图



H-C COSY 谱图



Long-range COSY 谱图



By using the H-H COSY, H-C COSY and long-range COSY 2D spectra, the signs of ten protons of CH, CH2 units in the spiro compound **3a** were clearly elucidated as Ha, Hb, 3.39 ppm, 2.89 ppm; Hc 4.87 ppm; Hd 4.50 ppm; He, Hf 4.49 ppm, 4.79 ppm; Hg, Hh 3.88 ppm, 3.22 ppm; and Hi, Hj 4.73 ppm、4.00 ppm.