Supporting Information

Pd-catalyzed cross-coupling synthesis of 4-aryl-3-formylcoumarins

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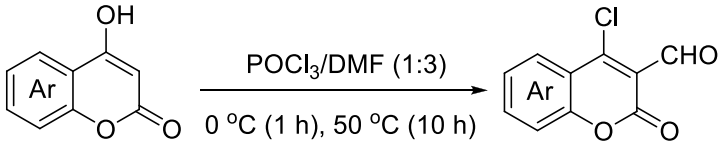
General Information:

The coupling reactions were done in dry Schlenk tubes under N_2 atmosphere conditions. All solvents used in coupling reactions were dried following the standard procedures. These solvents after distillation were stored over oven-dried molecular sieves (4Å) in Schlenk bottles under N_2 atmosphere. Column chromatography was done with 100-200 mesh (Souvenier Chemicals) or 230-400 mesh silica gel (Merck) using EtOAc/hexane as eluent. The instruments of JEOL ECS 400 (400 MHz) and JEOL ECX 500 (500 MHz) were used to measure ^{1}H and ^{13}C NMR spectra. Agilent 6230 LC/TOF analyzer for atmospheric-pressure chemical ionization (APCI) and Agilent 6546 LC/Q-TOF analyzer for Electrospray Ionization (ESI) were used to measure high-resolution mass spectra (HRMS). The Perkin Elmer FT-IR machine was used for recording IR spectra. Chemical shifts in parts per million (ppm) were reported with reference to residual $CHCl_3$ (δ = 7.26 ppm) for^{1}H NMR and δ = 77.16 ppm for $CDCl_3$ in ^{13}C NMR spectrum. Coupling constant (J) values were reported in Hertz (Hz). The JSGW melting point apparatus was used to measure the melting points of the products and are reported uncorrected.

Experimental procedures:

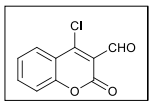
The synthesis of 4-hydroxy coumarins was carried out from corresponding 2-hydroxy acetophenone derivatives using the known procedure.[1] These compounds were further transformed into 4-chloro-3-formyl coumarin using $POCl_3$ and DMF conditions.[2]

General procedure for preparation of 4-chloro -3-formylcoumarin derivatives (**1a-1d**):

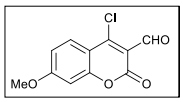


In an oven-dried round-bottomed flask, DMF (10 mL) was taken and cooled to 0 °C. To this, the $POCl_3$ (5 mL) was added dropwise with stirring. To this mixture, 4-hydroxycoumarin (3 g, 1 equiv.) in DMF (5 mL) added dropwise. After the complete addition, the mixture was stirred at 50 ^{o}C for 10 h. Then, the mixture was cooled to rt and poured into ice-cold water. The resulted solid product was filtered off and dried under reduced pressure. The crudewas further purified by silica gel column chromatography using 100-200 silic and ethyl acetate/hexane as an eluent to obtain 4-chloro-3-formylcoumarin.

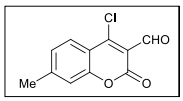
4-chloro-2-oxo-2*H*-chromene-3-carbaldehyde (1a): Yellow solid (2.9 g, 75%); m.p. 122-124 ^{o}C, ^{1}H NMR (396 MHz, Chloroform-*d*) δ = 10.36 (s, 1H), 8.12 (dd, *J* = 8.1, 1.5 Hz, 1H), 7.76 – 7.71 (m, 1H), 7.47 – 7.42 (m, 1H), 7.40 – 7.37 (m, 1H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ = 186.94, 158.53, 153.70, 153.35, 135.85, 127.75, 125.71, 118.46, 118.26, 117.30. IR (neat, cm^{-1}): 2875, 1702, 1602, 1540, 1300, 966, 751. APCI (m/z) calcd. for $C_{10}H_6ClO_3$ $[M+H]^+$ 209.0005;found 209.0019.



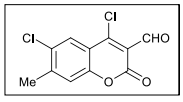
4-chloro-7-methoxy-2-oxo-2*H*-chromene-3-carbaldehyde (1b): Yellow solid (2.6 g, 70%); m.p. 176-178 ^{o}C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 10.33 (s, 1H), 8.00 (d, *J* = 9.0 Hz, 1H), 6.97 (dd, *J* = 9.1, 2.4 Hz, 1H), 6.81 (d, *J* = 2.4 Hz, 1H), 3.94 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 186.94, 166.29, 159.00, 155.78, 154.16, 129.22, 115.12, 114.61, 112.05, 100.63, 56.43. IR (neat, cm^{-1}): 1722, 1691, 1608, 1527, 1292, 1129, 844, 753. APCI (m/z) calcd. for $C_{11}H_8ClO_4$ $[M+H]^+$ 239.0106;found 239.0107.



4-chloro-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (1c): Yellow solid (2.8 g, 74%); m.p. 142-144 ^{o}C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ 10.32 (s, 1H), 7.96 (d, *J* = 8.2 Hz, 1H), 7.23 (d, *J* = 8.8 Hz, 1H), 7.16 (s, 1H), 2.50 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 186.93, 158.75, 153.80, 153.45, 148.25, 127.46, 127.05, 117.30, 117.24, 116.16, 22.13. IR (neat, cm^{-1}): 2868, 1755, 1610, 1534, 1324, 1157, 844, 723. APCI (m/z) calcd. for $C_{11}H_8ClO_3$ $[M+H]^+$ 223.0162;found 223.0166.



4,6-dichloro-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (1d): Yellow solid (2.5 g, 68%); m.p. 130-132 ^{o}C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 10.32 (s, 1H), 8.04 (s, 1H), 7.25 (s, 1H), 2.51 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 186.63, 158.29, 152.18, 151.53, 145.77, 132.02, 127.13, 119.16, 118.01, 117.54, 21.09. IR (neat, cm^{-1}): 2924, 1730, 1701, 1534, 1300, 1034, 889, 797. APCI (m/z) calcd. for $C_{11}H_7Cl_2O_3$ $[M+H]^+$ 256.9767; found 256.9767.



General procedure for synthesis of 4-aryl-3-formylcoumarins (2.1 - 2.11, 3.1 - 3.14, Table 2 and Table 3):

The cross-coupling reaction was carried out in an oven-dried Schlenk tube under a nitrogen atmosphere with 4-chloro-3-formylcoumarin derivative (0.825 mmol, 3.3 equiv.), $BiAr_3$ (0.25 mmol, 1 equiv.), K_3PO_4 (1 mmol, 4 equiv.), $Pd_2(dba)_3$ (0.0125 mmol, 0.05 equiv.), PPh_3 (0.025 mmol, 0.1 equiv.) in THF (3 mL). The mixture was heated in an oil bath at 60 ^{o}C for 4 h. It was then brought to rt and extracted with ethyl acetate (30 mL). The organic extract was washed with water, brine, dried over anhydrous $MgSO_4$, and concentrated. The crude was purified by silica gel column chromatography using ethyl acetate/hexane as an eluent. The cross-coupled product yield was calculated considering 0.75 mmol as 100% yield.

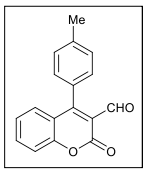
Procedure for one-pot synthesis of Wittig modified 3, 4-disubstituted couamrins (4.1 – 4.6, Table 4):

Step 1: The cross-coupling reaction was carried out in an oven-dried Schlenk tube under a nitrogen atmosphere with 4-chloro-3-formylcoumarin (0.825 mmol, 3.3 equiv.), $BiAr_3$ (0.25 mmol, 1 equiv.), K_3PO_4 (1 mmol, 4 equiv.), $Pd_2(dba)_3$ (0.0125 mmol, 0.05 equiv.), PPh_3 (0.025 mmol, 0.1 equiv.) in THF (3 mL). The mixture was heated in an oil bath at 60 ^oC for 4 h.

Step 2: The product mixture obtained in Schlenk tube from step 1 was cooled to rt. To this, Wittig salt (0.75 mmol, 3 equiv.), NaOMe (0.75 mmol, 3 equiv.) and THF (1 mL) were added under the nitrogen atmosphere. The mixture was heated at 60 ^oC for 6 h. It was then brought to rt, extracted with ethyl acetate (30 mL). The organic extract was washed with water, brine, dried over anhydrous $MgSO_4$, and concentrated. The crude was subjected to silica gel column chromatography using ethyl acetate/hexane as an eluent to obtain Wittig modified 3, 4-disubstituted couamrin product. The overall yield was calculated considering 0. 75 mmol product as 100% yield.

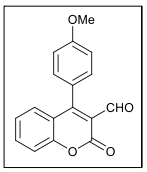
Spectral data of products:

2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (2.1): Yellow solid (166 mg, 84%); m.p. 134-136 ^oC, ^1H



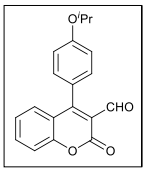
NMR (400 MHz, Chloroform-*d*) δ = 9.92 (s, 1H), 7.68 – 7.62 (m, 1H), 7.40 (d, *J* = 8.3 Hz, 1H), 7.36 (d, *J* = 7.9 Hz, 2H), 7.28 (dd, *J* = 7.9, 1.3 Hz, 1H), 7.24 (d, *J* = 7.1 Hz, 1H), 7.20 (d, *J* = 7.8 Hz, 2H), 2.48 (s, 3H).^{13}C NMR (101 MHz, Chloroform-*d*) δ = 188.53, 161.89, 158.27, 154.65, 140.34, 134.80, 129.57, 129.49, 128.76, 128.50, 124.86, 119.97, 119.14, 117.29, 21.60. IR (neat, cm^{-1}): 2862, 1753, 1722, 1605, 1548, 1365, 1041, 815, 759. APCI (m/z) calcd. for $C_{17}H_{13}O_3$ $[M+H]^+$ 265.0859;found 265.0858.

4-(4-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.2): Yellow solid (176 mg, 84%); m.p.



156-158 ^oC, ^1H NMR (400 MHz, Chloroform-*d*) δ = 9.94 (s, 1H), 7.68 (t, *J* = 7.1 Hz, 1H), 7.43 (d, *J* = 8.2 Hz, 1H), 7.37 (d, *J* = 7.9 Hz, 1H), 7.32 – 7.29 (m, 3H), 7.10 (d, *J* = 8.7 Hz, 2H), 3.94 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.55, 161.41, 161.16, 158.29, 154.70, 134.70, 130.67, 129.45, 124.84, 123.36, 120.06, 119.29, 117.34, 114.38, 55.59. IR (neat, cm^{-1}): 2924, 1753, 1719, 1606, 1543, 1256, 1017, 835, 761. APCI (m/z) calcd. for $C_{17}H_{13}O_4$ $[M+H]^+$ 281.0808;found 281.0825.

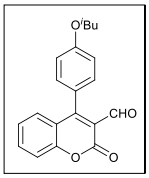
4-(4-isopropoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.3): Yellow solid (179 mg, 77%); m.p.



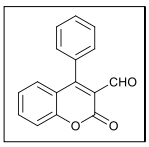
128-130 ^oC, ^1H NMR (400 MHz, Chloroform-*d*) δ = 9.87 (s, 1H), 7.64 (td, *J* = 8.0, 7.4, 1.5 Hz, 1H), 7.40 – 7.34 (m, 2H), 7.26 – 7.21 (m, 3H), 7.05 – 6.99 (m, 2H), 4.64 (hept, *J* = 6.0 Hz, 1H), 1.39 (d, *J* = 6.0 Hz, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ = 188.58, 161.78, 159.68, 158.07, 154.70, 134.70, 130.84, 129.42, 124.80, 122.74, 119.98, 119.26, 117.33, 115.79, 70.32,

22.11. IR (neat, cm^{-1}): 2978, 1754, 1722, 1605, 1546, 1249, 1106, 953, 758. APCI (m/z) calcd. for $C_{19}H_{17}O_4$ $[M+H]^+$ 309.1121;found 309.1129.

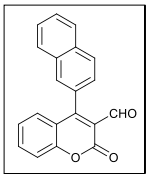
4-(4-isobutoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.4): Yellow solid (195 mg, 80%); m.p. 108-110 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 9.89 (s, 1H), 7.67 – 7.62 (m, 1H), 7.39 (d, *J* = 8.2 Hz, 1H), 7.36 (dd, *J* = 8.0, 1.3 Hz, 1H), 7.26– 7.22 (m, 3H), 7.06 (d, *J* = 8.7 Hz, 2H), 3.81 (d, *J* = 6.4 Hz, 2H), 2.19 –2.09 (m, 1H), 1.06 (d, *J* = 6.7 Hz, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.56, 161.63, 160.90, 158.20, 154.70, 134.67, 130.70, 129.45, 124.80, 123.00, 120.05, 119.26, 117.32, 114.85, 74.72, 28.38, 19.36. IR (neat, cm^{-1}): 2960, 1754, 1721, 1605, 1547, 1366, 1027, 758. APCI (m/z) calcd. for $C_{20}H_{19}O_4$ $[M+H]^+$ 323.1278;found 323.1275.



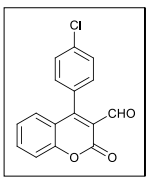
2-oxo-4-phenyl-2*H*-chromene-3-carbaldehyde (2.5): Yellow solid (121 mg, 64%); m.p. 140-142 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 9.95 (s, 1H), 7.68 – 7.64(m, 1H), 7.57 –7.53 (m, 3H), 7.41 (d, *J* = 8.2 Hz, 1H), 7.31 (dd, *J* = 6.5, 3.1 Hz, 2H), 7.24 –7.21 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.38, 161.31, 158.41, 154.68, 134.86, 131.74, 129.97, 129.51, 128.88, 128.58, 124.95, 119.95, 119.13, 117.31. IR (neat, cm^{-1}): 2767, 1748, 1676, 1604, 1548, 1372, 893, 762. APCI (m/z) calcd. for $C_{16}H_{11}O_3$ $[M+H]^+$ 251.0703;found 251.0713.



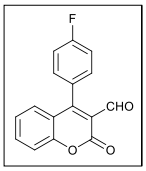
4-(naphthalen-2-yl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.6): Yellow solid (204 mg, 90%); m.p. 122-124 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 9.98 (s, 1H), 8.03 (d, *J* = 8.3 Hz, 1H), 7.93 (dd, *J* = 28.7, 7.4 Hz, 2H), 7.80 (s, 1H), 7.68 – 7.61 (m, 3H), 7.42 (dd, *J* = 15.0, 8.3 Hz, 2H), 7.24 (dd, *J* = 13.6, 6.2 Hz, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.34, 161.27, 158.46, 154.70, 134.85, 133.63, 132.76, 129.65, 129.16, 128.75, 128.46, 128.44, 128.15, 127.70, 127.43, 125.70, 124.97, 120.06, 119.36, 117.35. IR (neat, cm^{-1}): 2924, 1752, 1721, 1602, 1547, 1324, 821, 754. APCI (m/z) calcd. for $C_{20}H_{13}O_3$ $[M+H]^+$ 301.0859;found 301.0850.



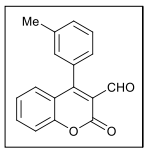
4-(4-chlorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.7): Yellow solid (157 mg, 74%); m.p. 174-176 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 10.06 (s, 1H), 7.69 – 7.65 (m, 1H), 7.54 (d, *J* = 8.3 Hz, 2H), 7.42 (d, *J* = 8.4 Hz, 1H), 7.27 – 7.22 (m, 3H), 7.19 (dd, *J* = 8.0, 1.5 Hz, 1H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.32, 159.12, 159.02, 154.67, 136.13, 134.98, 130.46, 129.79, 129.41, 129.22, 125.13, 119.83, 119.07, 117.44. IR (neat, cm^{-1}): 2924, 1749, 1705, 1596, 1541, 1362, 1089, 762. APCI (m/z) calcd. for $C_{16}H_{10}ClO_3$ $[M+H]^+$ 285.0313;found 285.0313.



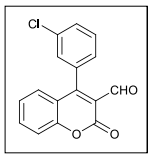
4-(4-fluorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.8): Yellow solid (117 mg, 58%); m.p. 144-146 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 10.03 (s, 1H), 7.69 – 7.65 (m, 1H), 7.42 (d, *J* = 8.4 Hz, 1H), 7.31 – 7.19 (m, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.36, 163.57 (d, $J_{C\text{-}F}$ = 249.25 Hz), 159.55, 158.89, 154.66, 134.92, 130.55 (d, $J_{C\text{-}F}$ = 8.33 Hz), 129.41, 127.81, 125.08, 120.00, 119.28, 117.42, 116.20 (d, $J_{C\text{-}F}$ = 21.81 Hz). IR (neat, cm^{-1}): 2867, 1752, 1725, 1604, 1548, 1223, 836, 760. APCI (m/z) calcd. for $C_{16}H_{10}FO_3$ $[M+H]^+$ 269.0608;found 269.0608.



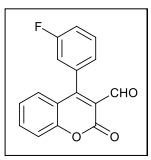
2-oxo-4-*m*-tolyl-2*H*-chromene-3-carbaldehyde (2.9): Yellow solid (160 mg, 81%); m.p. 114-116 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 9.91 (s, 1H), 7.68 – 7.64 (m, 1H), 7.41 (dq, *J* = 13.8, 7.7 Hz, 3H), 7.26 – 7.24 (m, 2H), 7.12 (s, 2H), 2.44 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ = 188.49, 162.05, 158.14, 154.65, 138.85, 134.88, 131.49, 130.82, 129.52, 129.15, 128.80, 125.80, 124.91, 119.92, 119.07, 117.29, 21.62. IR (neat, cm^{-1}): 2861, 1755, 1721, 1604, 1548, 1364, 998, 758. APCI (m/z) calcd. for $C_{17}H_{13}O_3$ $[M+H]^+$ 265.0859;found 265.0857.



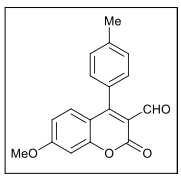
4-(3-chlorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.10): Yellow solid (147 mg, 70%); m.p. 118-120 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 10.06 (d, *J* = 0.9 Hz, 1H), 7.70 – 7.66 (m, 1H), 7.55 – 7.48 (m, 2H), 7.42 (d, *J* = 8.4 Hz, 1H), 7.28 – 7.22 (m, 2H), 7.19 – 7.16 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.16, 158.93, 158.57, 154.65, 135.08, 135.04, 133.89, 130.23, 129.94, 129.42, 128.18, 126.52, 125.19, 119.71, 119.02, 117.40. IR (neat, cm^{-1}): 2864, 1755, 1724, 1602, 1550, 1347, 1192, 758. APCI (m/z) calcd. for $C_{16}H_{10}ClO_3$ $[M+H]^+$ 285.0313;found 285.0313.



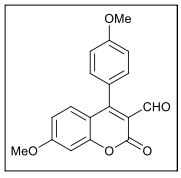
4-(3-fluorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.11): Yellow solid (143 mg, 71%); m.p. 136-138 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 10.05 (s, 1H), 7.70 – 7.66 (m, 1H), 7.54 (td, *J* = 8.0, 5.8 Hz, 1H), 7.43 (d, *J* = 8.3 Hz, 1H), 7.29 – 7.24 (m, 2H), 7.19 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.07 (d, *J* = 7.7 Hz, 1H), 7.02 (dt, *J* = 8.5, 1.8 Hz, 1H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.15, 162.77 (d, J_{C-F} = 247.68 Hz), 158.88, 158.76, 154.67, 135.02, 134.13 (d, J_{C-F} = 7.86 Hz), 130.81 (d, J_{C-F} = 8.31 Hz), 129.39, 125.16, 124.14, 124.12, 119.70, 119.04, 117.41, 116.86 (d, J_{C-F} = 20.68 Hz), 115.68 (d, J_{C-F} = 23.11 Hz). IR (neat, cm^{-1}): 2888, 1728, 1703, 1606, 1586, 1347, 1149, 760. APCI (m/z) calcd. for $C_{16}H_{10}FO_3$ $[M+H]^+$ 269.0608;found 269.0608.



7-methoxy-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.1): Yellow solid (148 mg, 67%); m.p. 146-148 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 9.87 (d, *J* = 1.4 Hz, 1H), 7.34 (d, *J* = 7.8 Hz, 2H), 7.19 – 7.15 (m, 3H), 6.85 (s, 1H), 6.78 (dd, *J* = 9.0, 2.4 Hz, 1H), 3.91 (s, 3H), 2.46 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.47, 165.48, 162.43, 158.65, 157.01, 140.09, 130.84, 129.48, 129.00, 128.64, 116.10, 113.65, 113.51, 100.71, 56.22, 21.56. IR (neat, cm^{-1}): 2924, 1755, 1725, 1614, 1584, 1370, 1287, 771. APCI (m/z) calcd. for $C_{18}H_{15}O_4$ $[M+H]^+$ 295.0965;found 295.0965.



7-methoxy-4-(4-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.2): Yellow solid (196 mg, 84%); m.p. 144-146 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 9.86 (d, *J* = 4.1 Hz, 1H), 7.26 – 7.20 (m, 3H), 7.07 – 7.05 (m, 2H), 6.85 (t, *J* = 2.8 Hz, 1H), 6.81 – 6.78 (m, 1H), 3.91 – 3.90 (m, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.52, 165.42, 162.13, 160.97, 158.59, 156.99, 130.78, 130.52, 123.75, 116.15, 114.25, 113.59, 113.51, 100.74, 56.20, 55.55. IR (neat, cm^{-1}): 2845, 1752, 1719, 1611, 1507, 1287, 1116, 836. APCI (m/z) calcd. for $C_{18}H_{15}O_5$ $[M+H]^+$ 311.0914;found 311.0913.



7-methoxy-4-(3-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.3): Yellow solid (150 mg, 65%); m.p. 154-156 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 9.87 (s, 1H), 7.44 (t, *J* = 7.9 Hz, 1H), 7.14 (d, *J* = 9.0 Hz, 1H), 7.06 (dd, *J* = 8.4, 2.4 Hz, 1H), 6.87 – 6.84 (m, 2H), 6.81 – 6.80 (m, 1H), 6.78 (dd, *J* = 9.1, 2.4 Hz, 1H), 3.90 (s, 3H), 3.84 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.25, 165.59, 161.96, 159.78, 158.46, 157.01, 133.34, 130.79, 130.07, 120.80, 115.96, 115.15, 114.28, 113.73, 113.29, 100.71, 56.22, 55.53. IR (neat, cm^{-1}): 2845, 1755, 1721, 1614, 1535, 1288, 1164, 770. APCI (m/z) calcd. for $C_{18}H_{15}O_5$ $[M+H]^+$ 311.0914;found 311.0919.

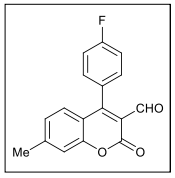
4-(3-chlorophenyl)-7-methoxy-2-oxo-2*H*-chromene-3-carbaldehyde (3.4): Yellow solid (145 mg, 62%); m.p. 108-110 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 10.00 (s, 1H), 7.52 – 7.46 (m, 3H), 7.15 (d, *J* = 7.4 Hz, 1H), 7.05 (d, *J* = 8.9 Hz, 1H), 6.87 (d, *J* = 2.6 Hz, 1H), 6.80 (dd, *J* = 9.0, 2.4 Hz, 1H), 3.91 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.11, 165.69, 159.34, 159.20, 157.06, 134.98, 134.36, 130.74, 130.15, 129.77, 129.14, 128.11, 126.44, 115.79, 113.98, 113.20, 100.90, 56.29. IR (neat, cm^{-1}): 2962, 1756, 1724, 1614, 1536, 1298, 1141, 741. APCI (m/z) calcd. for $C_{17}H_{12}ClO_4$ $[M+H]^+$ 315.0424;found 315.0423.

7-methyl-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.5): Yellow solid (156 mg, 75%); m.p. 136-138 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 9.89 (s, 1H), 7.34 (d, *J* = 7.9 Hz, 2H), 7.18 (d, *J* = 7.9 Hz, 3H), 7.14 (d, *J* = 8.2 Hz, 1H), 7.03 (d, *J* = 7.2 Hz, 1H), 2.46 (s, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.53, 162.05, 158.50, 154.77, 146.91, 140.15, 129.47, 129.21, 128.69, 126.19, 118.09, 117.57, 117.33, 22.06, 21.55. IR (neat, cm^{-1}): 2861, 1755, 1722, 1619, 1538, 1369, 1262, 1137, 773. APCI (m/z) calcd. for $C_{18}H_{15}O_3$ $[M+H]^+$ 279.1016;found 279.1017.

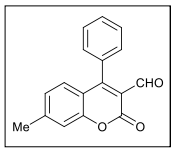
4-(4-methoxyphenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.6): Yellow solid (171 mg, 77%); m.p. 140-142 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 9.88 (s, 1H), 7.24 (d, *J* = 8.6 Hz, 2H), 7.20 (d, *J* = 8.5 Hz, 2H), 7.06 – 7.04 (m, 3H), 3.89 (s, 3H), 2.47 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.62, 161.73, 161.03, 158.50, 154.79, 146.84, 130.61, 129.17, 126.18, 123.52, 118.18, 117.62, 117.39, 114.27, 55.56, 22.05. IR (neat, cm^{-1}): 2841, 1753, 1719, 1608, 1509, 1370, 1252, 1178, 631. APCI (m/z) calcd. for $C_{18}H_{15}O_4$ $[M+H]^+$ 295.0965;found 295.0965.

4-(4-chlorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.7): Yellow solid (147 mg, 66%); m.p. 158-160 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 10.03 (s, 1H), 7.53 – 7.50 (m, 2H), 7.23 – 7.20 (m, 3H), 7.05 (s, 2H), 2.48 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.37, 159.39, 159.25, 154.77, 147.23, 135.94, 130.65, 129.74, 129.11, 126.46, 117.93, 117.49, 117.41, 22.11. IR (neat, cm^{-1}): 2862, 1755, 1724, 1620, 1537, 1369, 1261, 1091, 736. APCI (m/z) calcd. for $C_{17}H_{12}ClO_3$ $[M+H]^+$ 299.0469;found 299.0469.

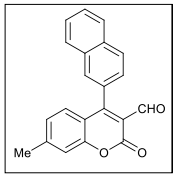
4-(4-fluorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.8): Yellow solid (145 mg, 69%); m.p. 124-126 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 10.00 (s, 1H), 7.28 – 7.21 (m, 5H), 7.08 – 7.04 (m, 2H), 2.47 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.42, 163.46 (d, $J_{C\text{-}F}$ = 248.75 Hz), 159.86, 159.11, 154.76, 147.17, 130.49 (d, $J_{C\text{-}F}$ = 8.31 Hz), 129.13, 127.98 (d, $J_{C\text{-}F}$ = 3.03 Hz), 126.42, 118.14, 117.57, 117.46, 116.09 (d, $J_{C\text{-}F}$ = 21.76 Hz), 22.09. IR (neat, cm^{-1}): 2856, 1753, 1720, 1619, 1537, 1369, 1230, 1015, 673. APCI (m/z) calcd. for $C_{17}H_{12}FO_3$ $[M+H]^+$ 283.0765;found 283.0765.



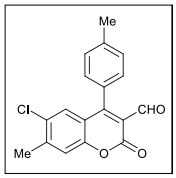
7-methyl-2-oxo-4-phenyl-2*H*-chromene-3-carbaldehyde (3.9): Yellow solid (136 mg, 69%); m.p. 146-148 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 9.93 (s, 1H), 7.56 – 7.53 (m, 3H), 7.29 (dd, *J* = 6.6, 2.8 Hz, 2H), 7.21 (s, 1H), 7.09 (d, *J* = 8.2 Hz, 1H), 7.04 (d, *J* = 8.4 Hz, 1H), 2.48 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.45, 161.52, 158.69, 154.85, 147.03, 132.00, 129.85, 129.25, 128.82, 128.55, 126.30, 118.11, 117.59, 117.42, 22.11. IR (neat, cm^{-1}): 2859, 1754, 1722, 1618, 1537, 1370, 1261, 1076, 755. APCI (m/z) calcd. for $C_{17}H_{13}O_3$ $[M+H]^+$ 265.0859; found 265.0858.



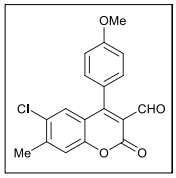
7-methyl-4-(naphthalen-2-yl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.10): Yellow solid (168 mg, 71%); m.p. 148-150 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 9.97 (s, 1H), 8.01 (d, *J* = 8.4 Hz, 1H), 7.96 (d, *J* = 7.4 Hz, 1H), 7.89 – 7.87 (m, 1H), 7.78 (s, 1H), 7.63 – 7.58 (m, 2H), 7.38 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.24 (s, 1H), 7.12 (d, *J* = 8.2 Hz, 1H), 7.02 (d, *J* = 8.3 Hz, 1H), 2.48 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.40, 161.47, 158.73, 154.84, 147.03, 133.58, 132.74, 129.39, 128.65, 128.41, 128.36, 128.13, 127.60, 127.35, 126.32, 125.75, 118.31, 117.68, 117.43, 22.10. IR (neat, cm^{-1}): 2861, 1753, 1721, 1620, 1537, 1384, 1263, 1045, 749. APCI (m/z) calcd. for $C_{21}H_{15}O_3$ $[M+H]^+$ 315.1016; found 315.1016.



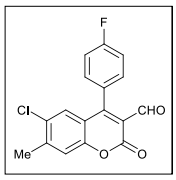
6-chloro-7-methyl-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.11): Yellow solid (176 mg, 75%); m.p. 180-182 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 9.89 (s, 1H), 7.37 (d, *J* = 7.9 Hz, 2H), 7.28 (s, 1H), 7.21 (s, 1H), 7.18 (d, *J* = 8.0 Hz, 2H), 2.48 (s, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.21, 160.61, 158.02, 152.93, 144.35, 140.61, 131.05, 129.75, 128.72, 128.65, 128.11, 119.19, 119.12, 118.97, 21.62, 21.01. IR (neat, cm^{-1}): 2854, 1760, 1726, 1612, 1537, 1366, 1160, 919, 730. APCI (m/z) calcd. for $C_{18}H_{14}ClO_3$ $[M+H]^+$ 313.0626; found 313.0626.



6-chloro-4-(4-methoxyphenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.12): Yellow solid (175 mg, 71%); m.p. 178-180 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 9.89 (s, 1H), 7.28 (s, 1H), 7.26 – 7.23 (m, 3H), 7.10 – 7.07 (m, 2H), 3.91 (s, 3H), 2.48 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.29, 161.32, 160.28, 158.02, 152.95, 144.29, 131.03, 130.59, 128.69, 122.89, 119.24, 119.17, 119.04, 114.56, 55.61, 20.99. IR (neat, cm^{-1}): 2841, 1758, 1723, 1607, 1533, 1366, 1253, 1021, 890. APCI (m/z) calcd. for $C_{18}H_{14}ClO_4$ $[M+H]^+$ 329.0575;found 329.0575.

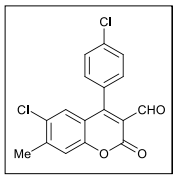


6-chloro-4-(4-fluorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.13): Yellow solid



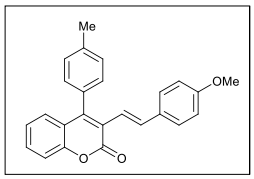
(155 mg, 65%); m.p. 184-186 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 10.00 (s, 1H), 7.30 (s, 1H), 7.27 (s, 2H), 7.26 (s, 2H), 7.12 (s, 1H), 2.49 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.08, 163.66 (d, $J_{C\text{-}F}$ = 249.45 Hz), 158.61, 158.43, 152.89, 144.62, 131.27, 130.48 (d, $J_{C\text{-}F}$ = 8.34 Hz), 128.62, 127.33 (d, $J_{C\text{-}F}$ = 3.36 Hz), 119.30, 119.07, 119.04, 116.40 (d, $J_{C\text{-}F}$ = 22.11 Hz), 21.04. IR (neat, cm^{-1}): 2859, 1758, 1726, 1605, 1536, 1365, 1160, 1021, 889. APCI (m/z) calcd. for $C_{17}H_{11}ClFO_3$ $[M+H]^+$ 317.0375;found 317.0378.

6-chloro-4-(4-chlorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.14): Yellow



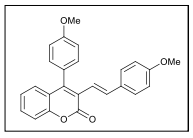
solid (151 mg, 60%); m.p. 138-140 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 10.03 (s, 1H), 7.56 – 7.53 (m, 2H), 7.30 (s, 1H), 7.22 – 7.20 (m, 2H), 7.10 (s, 1H), 2.49 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 188.03, 158.71, 158.00, 152.88, 144.69, 136.36, 131.32, 129.96, 129.69, 129.38, 128.58, 119.30, 118.89, 118.83, 21.04. IR (neat, cm^{-1}): 2863, 1759, 1727, 1613, 1534, 1366, 1160, 1015, 889. APCI (m/z) calcd. for $C_{17}H_{11}Cl_2O_3$ $[M+H]^+$ 333.0080;found 333.0084.

(*E*)-3-(4-methoxystyryl)-4-*p*-tolyl-2*H*-chromen-2-one (4.1): Yellow solid (154 mg, 56%); m.p. 146-148



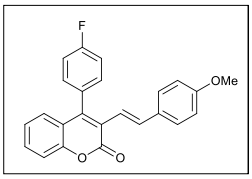
°C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 7.92 (d, *J* = 16.2 Hz, 1H), 7.45 (td, *J* = 7.8, 7.2, 1.5 Hz, 1H), 7.37 (dd, *J* = 8.0, 2.4 Hz, 3H), 7.21 (dd, *J* = 12.0, 8.3 Hz, 4H), 7.15 – 7.11 (m, 1H), 7.08 (dd, *J* = 8.0, 1.5 Hz, 1H), 6.80 (d, *J* = 8.7 Hz, 2H), 6.61 (d, *J* = 16.2 Hz, 1H), 3.78 (s, 3H), 2.50 (s, 3H).^{13}C NMR (126 MHz, Chloroform-*d*) δ = 160.20, 159.77, 152.20, 149.77, 138.81, 135.19, 131.83, 130.82, 130.71, 129.67, 129.18, 128.30, 127.53, 124.12, 121.78, 121.27, 119.99, 116.46, 114.14, 55.40, 21.59. IR (neat, cm^{-1}): 2834, 1723, 1605, 1511, 1249, 1074, 755. APCI (m/z) calcd. for $C_{25}H_{21}O_3$ $[M+H]^+$ 369.1485;found 369.1481.

(*E*)-4-(4-methoxyphenyl)-3-(4-methoxystyryl)-2*H*-chromen-2-one (4.2): Yellow solid (150 mg,



52%); m.p. 122-124 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.93 (d, *J* = 16.2 Hz, 1H), 7.49 – 7.43 (m, 1H), 7.37 (d, *J* = 8.3 Hz, 1H), 7.24 (dd, *J* = 8.7, 2.4 Hz, 4H), 7.17 – 7.06 (m, 4H), 6.81 (d, *J* = 8.7 Hz, 2H), 6.63 (d, *J* = 16.2 Hz, 1H), 3.93 (s, 3H), 3.79 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ = 160.21, 159.99, 159.78, 152.21, 149.47, 135.17, 130.83, 130.73, 128.30, 127.50, 126.89, 124.14, 121.96, 121.38, 120.01, 116.50, 114.40, 114.17, 55.54, 55.41. IR (neat, cm^{-1}): 2926, 1722, 1605, 1511, 1249, 1174, 1074, 755. APCI (m/z) calcd. for $C_{25}H_{21}O_4$ $[M+H]^+$ 385.1434; found 385.1433.

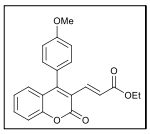
(*E*)-4-(4-fluorophenyl)-3-(4-methoxystyryl)-2*H*-chromen-2-one (4.3): Yellow solid (106 mg, 38%);



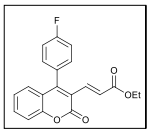
m.p. 118-120 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 7.92 (d, *J* = 16.2 Hz, 1H), 7.47 (td, *J* = 8.0, 7.5, 1.5 Hz, 1H), 7.38 – 7.36 (m, 1H), 7.30 (dd, *J* = 6.9, 4.7 Hz, 4H), 7.21 (d, *J* = 8.7 Hz, 2H), 7.17 – 7.14 (m, 1H), 7.02 (dd, *J* = 8.0, 1.1 Hz, 1H), 6.81 (d, *J* = 8.8 Hz, 2H), 6.53 (d, *J* = 16.2 Hz, 1H), 3.79 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ = 162.96 (d, $J_{C\text{-}F}$ = 247.68 Hz), 159.95, 152.15, 148.26, 135.79, 131.21 (d, $J_{C\text{-}F}$ = 8.10 Hz), 131.02, 130.81, 130.42, 128.32, 127.14, 124.29, 122.24, 121.04, 119.43,

116.59, 116.30 (d, $J_{C\text{-}F}$ = 21.53 Hz), 114.22, 55.41. IR (neat, cm^{-1}): 2836, 1724, 1604, 1511, 1249, 1075, 755. APCI (m/z) calcd. for $C_{24}H_{18}FO_3$ $[M+H]^+$ 373.1234; found 373.1234.

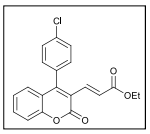
(*E*)-ethyl 3-(4-(4-methoxyphenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.4): White solid (121 mg, 46%); m.p. 146-148 °C, ^{1}H NMR (400 MHz, Chloroform-*d*) δ = 7.57 (ddd, *J* = 8.5, 5.8, 2.9 Hz, 1H), 7.42 – 7.36 (m, 1H), 7.34 – 7.28 (m, 2H), 7.25 – 7.17 (m, 4H), 7.12 – 7.07 (m, 2H), 4.19 (q, *J* = 7.1 Hz, 2H), 3.93 (s, 3H), 1.28 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ = 167.65, 160.59, 159.38, 155.97, 153.05, 136.86, 132.69, 130.62, 128.57, 125.42, 124.45, 120.62, 119.49, 116.82, 114.52, 60.57, 55.52, 14.34. IR (neat, cm^{-1}): 2923, 1726, 1634, 1510, 1277, 1170, 750. APCI (m/z) calcd. for $C_{21}H_{19}O_5$ $[M+H]^+$ 351.1227; found 351.1229.



(*E*)-ethyl 3-(4-(4-fluorophenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.5): White solid (102 mg, 40%); m.p. 140-142 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 7.60 (ddd, *J* = 8.5, 7.3, 1.5 Hz, 1H), 7.42 (d, *J* = 8.9 Hz, 1H), 7.33 – 7.27 (m, 6H), 7.24 – 7.20 (m, 1H), 7.11 (dd, *J* = 8.1, 1.4 Hz, 1H), 4.19 (q, *J* = 7.1 Hz, 2H), 1.29 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ = 167.44, 163.39 (d, $J_{C\text{-}F}$ = 248.72 Hz), 159.10, 154.80, 153.02, 136.16, 132.95, 131.04 (d, $J_{C\text{-}F}$ = 8.15 Hz), 129.40 (d, $J_{C\text{-}F}$ = 3.26 Hz), 128.23, 125.31, 124.65, 120.34, 119.88, 116.95, 116.48 (d, $J_{C\text{-}F}$ = 21.78 Hz), 60.70, 14.33. IR (neat, cm^{-1}): 2985, 1729, 1706, 1604, 1508, 1278, 1187, 762. APCI (m/z) calcd. for $C_{20}H_{16}FO_4$ $[M+H]^+$ 339.1027; found 339.1022.



(*E*)-ethyl 3-(4-(4-chlorophenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.6): White solid (120 mg, 45%); m.p. 138-140 °C, ^{1}H NMR (500 MHz, Chloroform-*d*) δ = 7.59 – 7.54 (m, 3H), 7.41 – 7.38 (m, 1H), 7.31 – 7.26 (m, 2H), 7.24 – 7.17 (m, 3H), 7.08 (dd, *J* = 8.1, 1.4 Hz, 1H), 4.17 (q, *J* = 7.1 Hz, 2H), 1.27 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ = 167.44, 159.01, 154.54, 153.03, 136.03, 133.02, 131.87, 130.44, 129.57, 128.17, 125.46, 124.69, 120.13, 119.75, 116.99, 60.74, 14.35. IR (neat, cm^{-1}): 2980, 1724, 1643, 1496, 1276, 1189, 758. APCI (m/z) calcd. for $C_{20}H_{16}ClO_4$ $[M+H]^+$ 355.0737; found 355.0743.

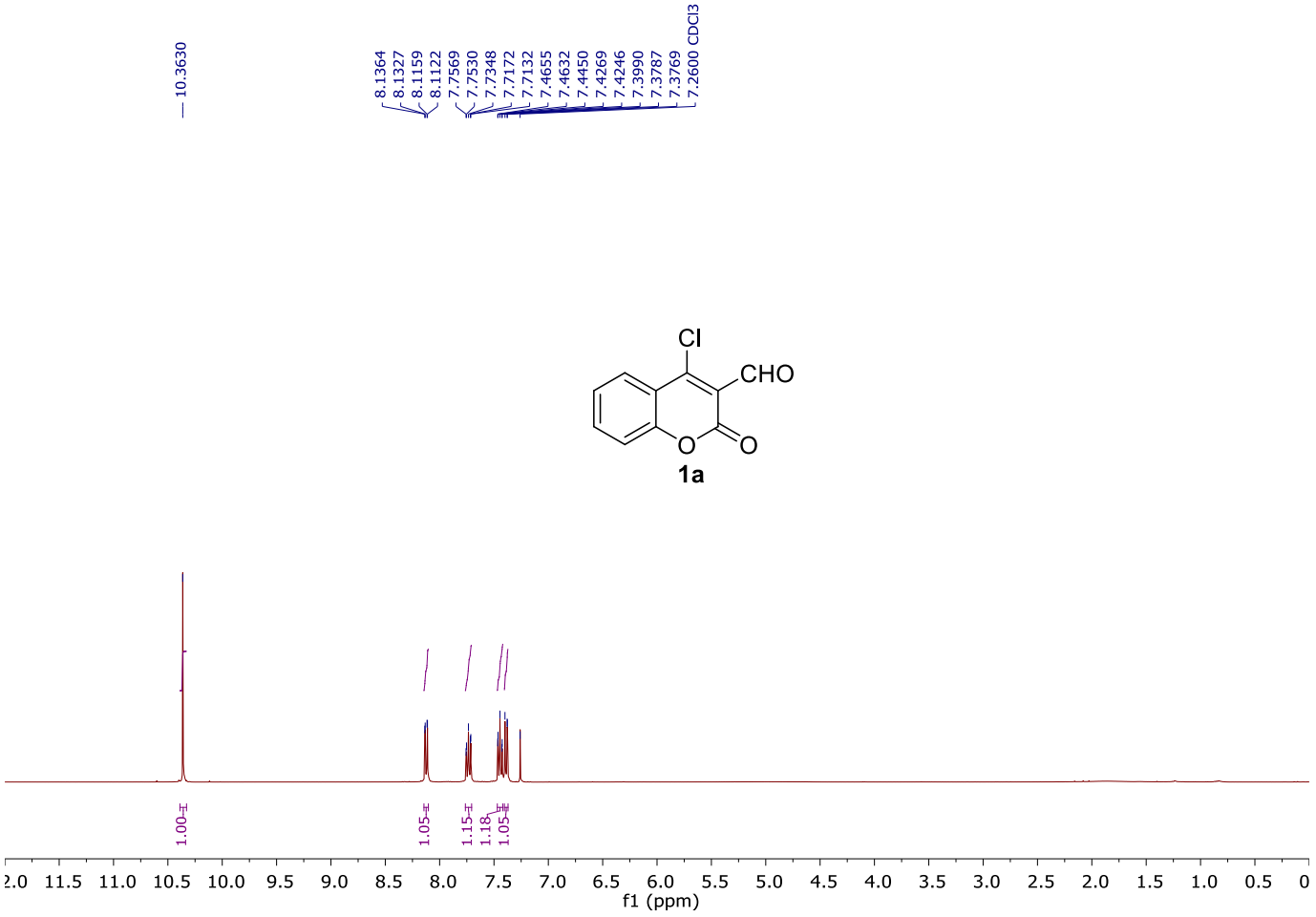


References:

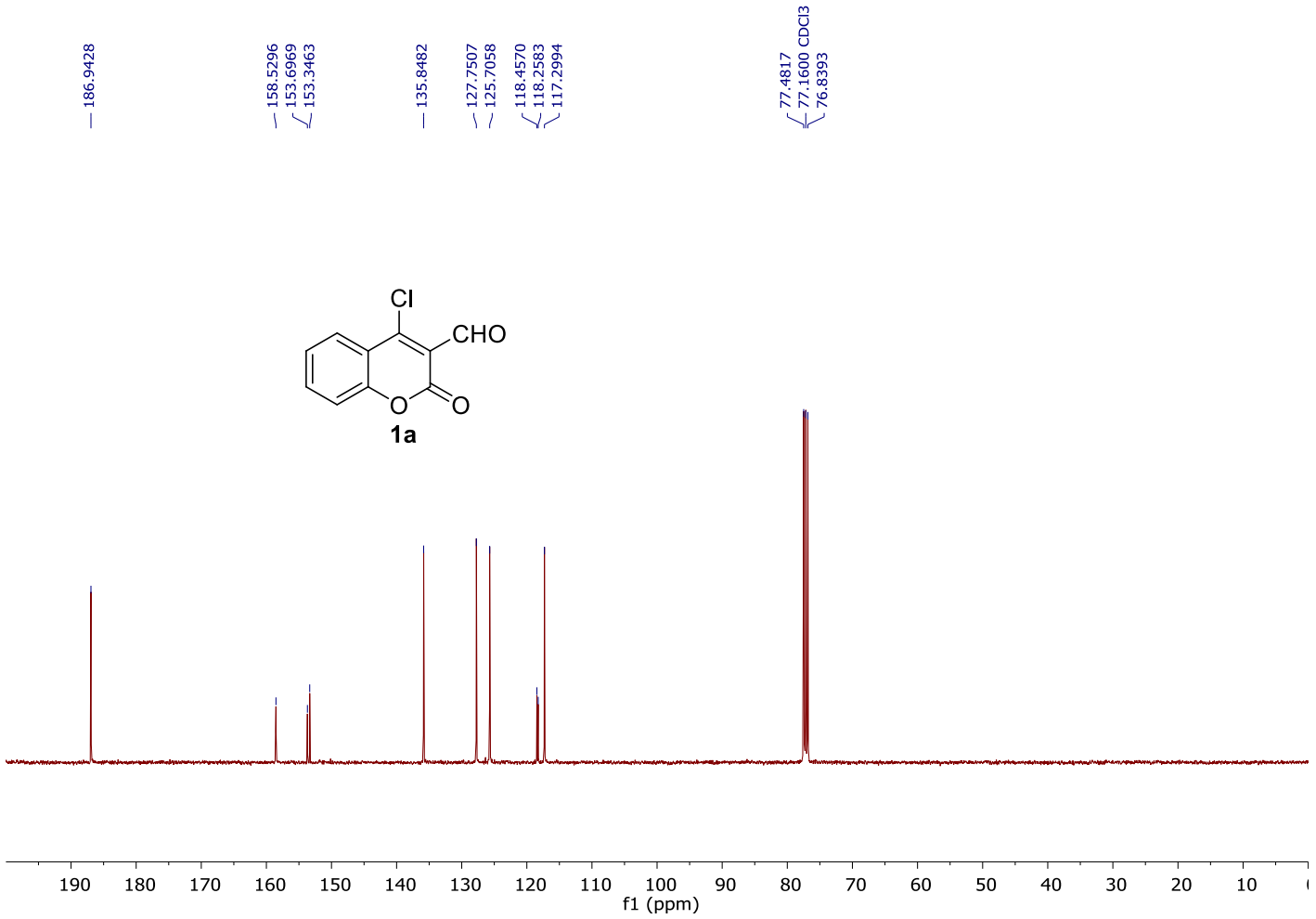
(1) J. Liu, Y.Q. Sun, Y. Huo, H. Zhang, L. Wang, P. Zhang, D. Song, Y. Shi and W. Guo, *J. Am. Chem. Soc*., 2014, **136**, 574-577.

(2) U. R. Saeed, H. C. Zahid, G. Farzana and T. S. Claudius, *J. Enzyme Inhib. Med. Chem.* 2005, **20**, 333.

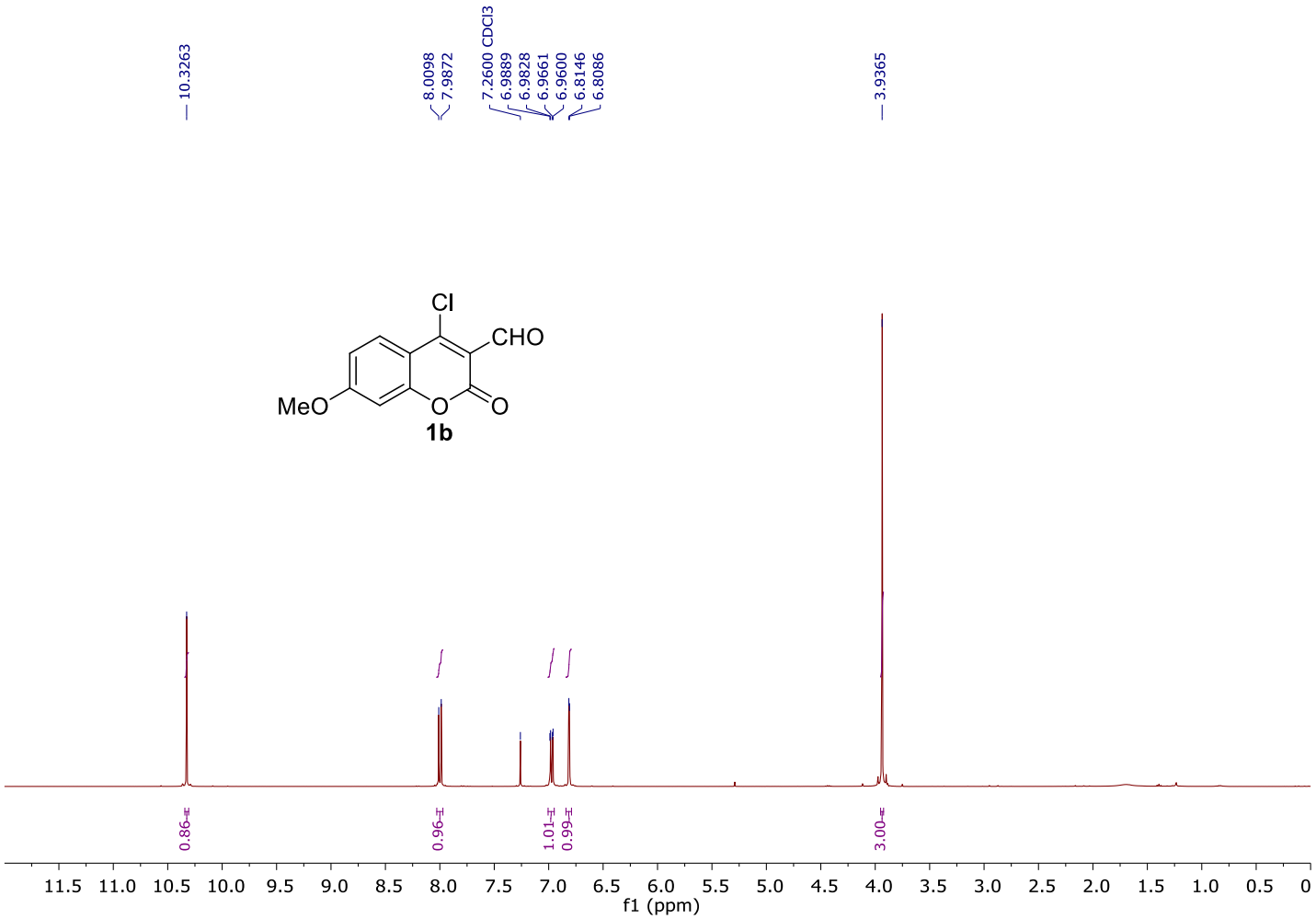
^{1}H, ^{13}C NMR, HRMS spectra:



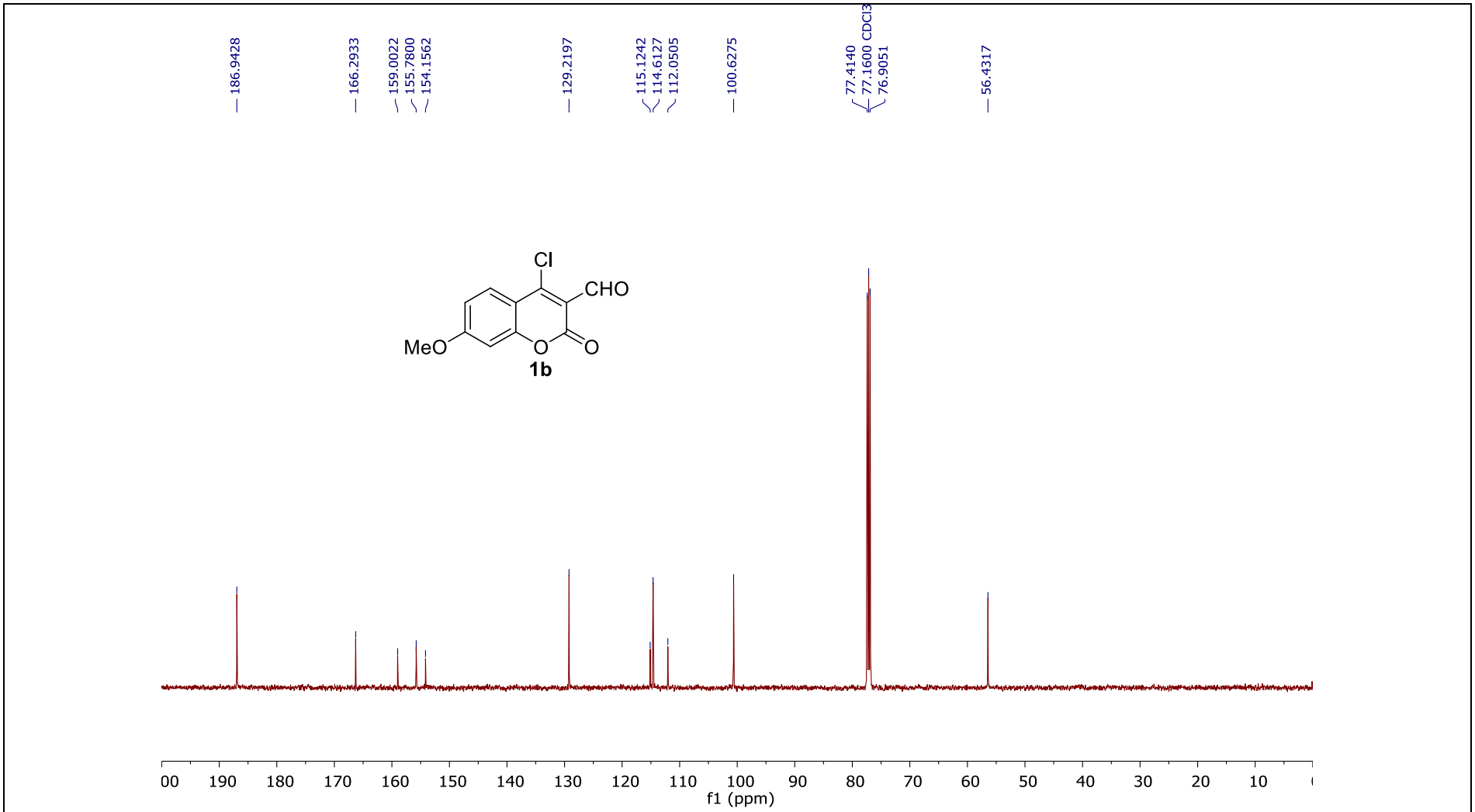
^{1}H Spectrum of 4-chloro-2-oxo-2*H*-chromene-3-carbaldehyde (1a)



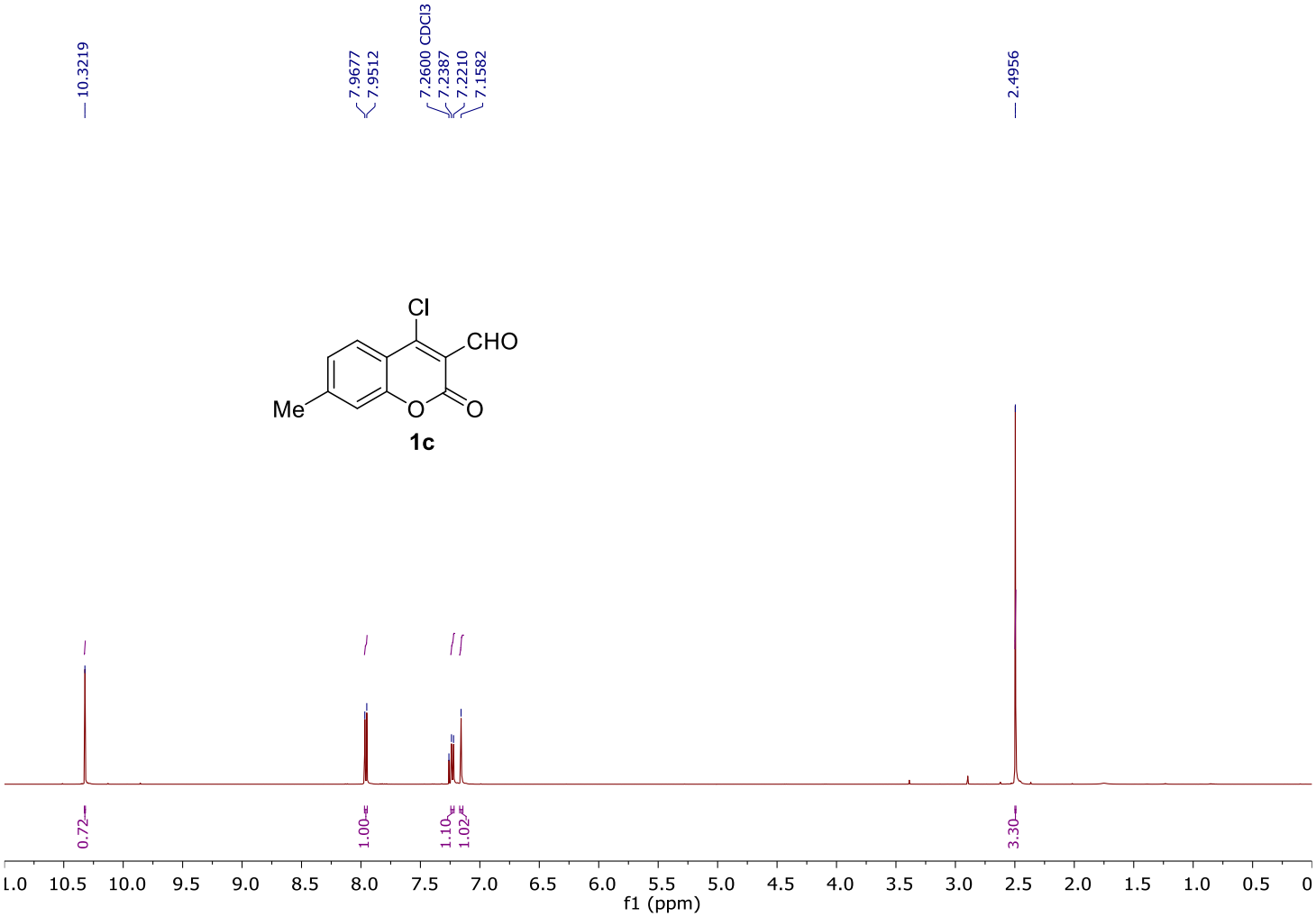
^{13}C Spectrum of 4-chloro-2-oxo-2*H*-chromene-3-carbaldehyde (1a)



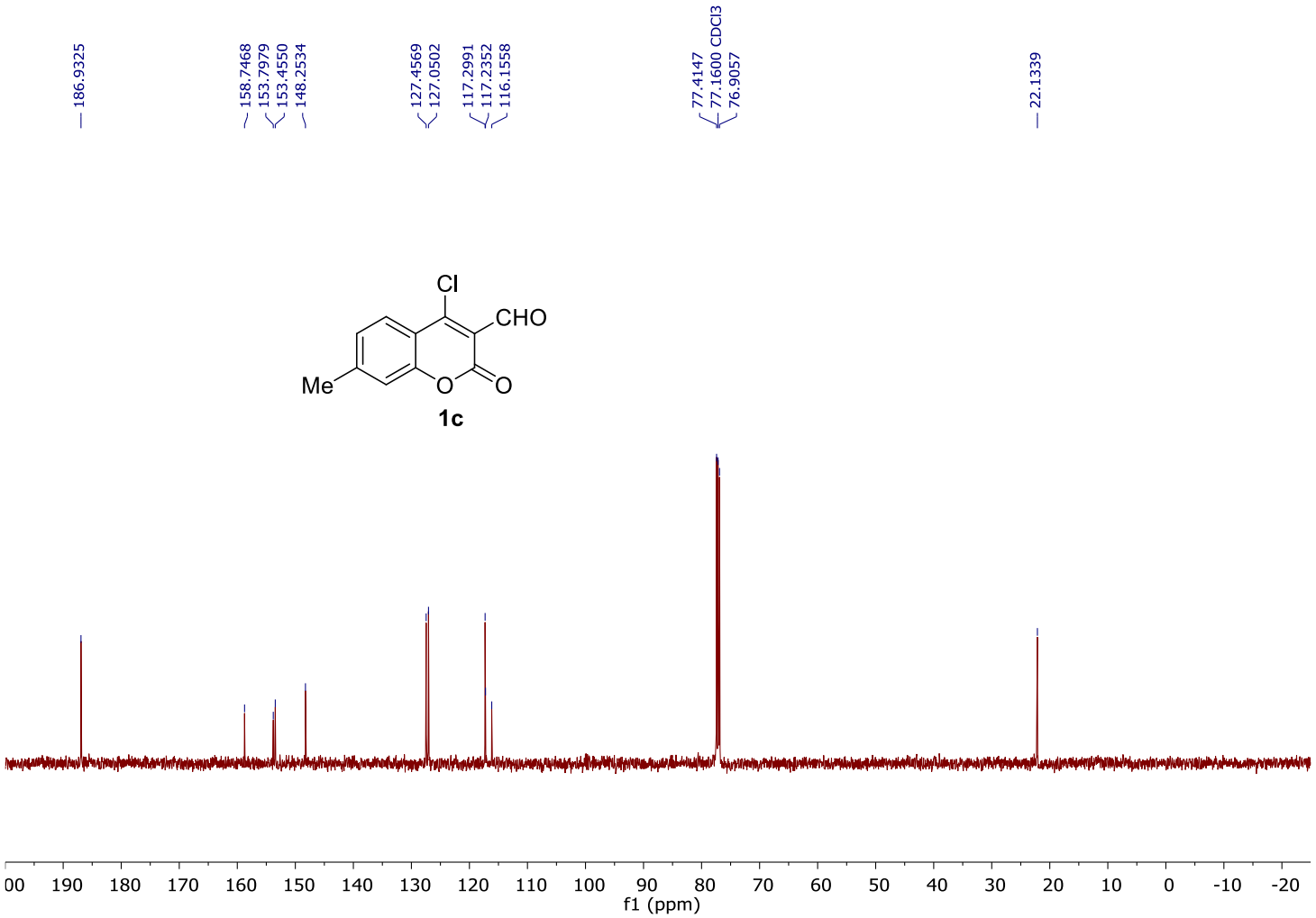
^{1}H Spectrum of 4-chloro-7-methoxy-2-oxo-2*H*-chromene-3-carbaldehyde (1b)



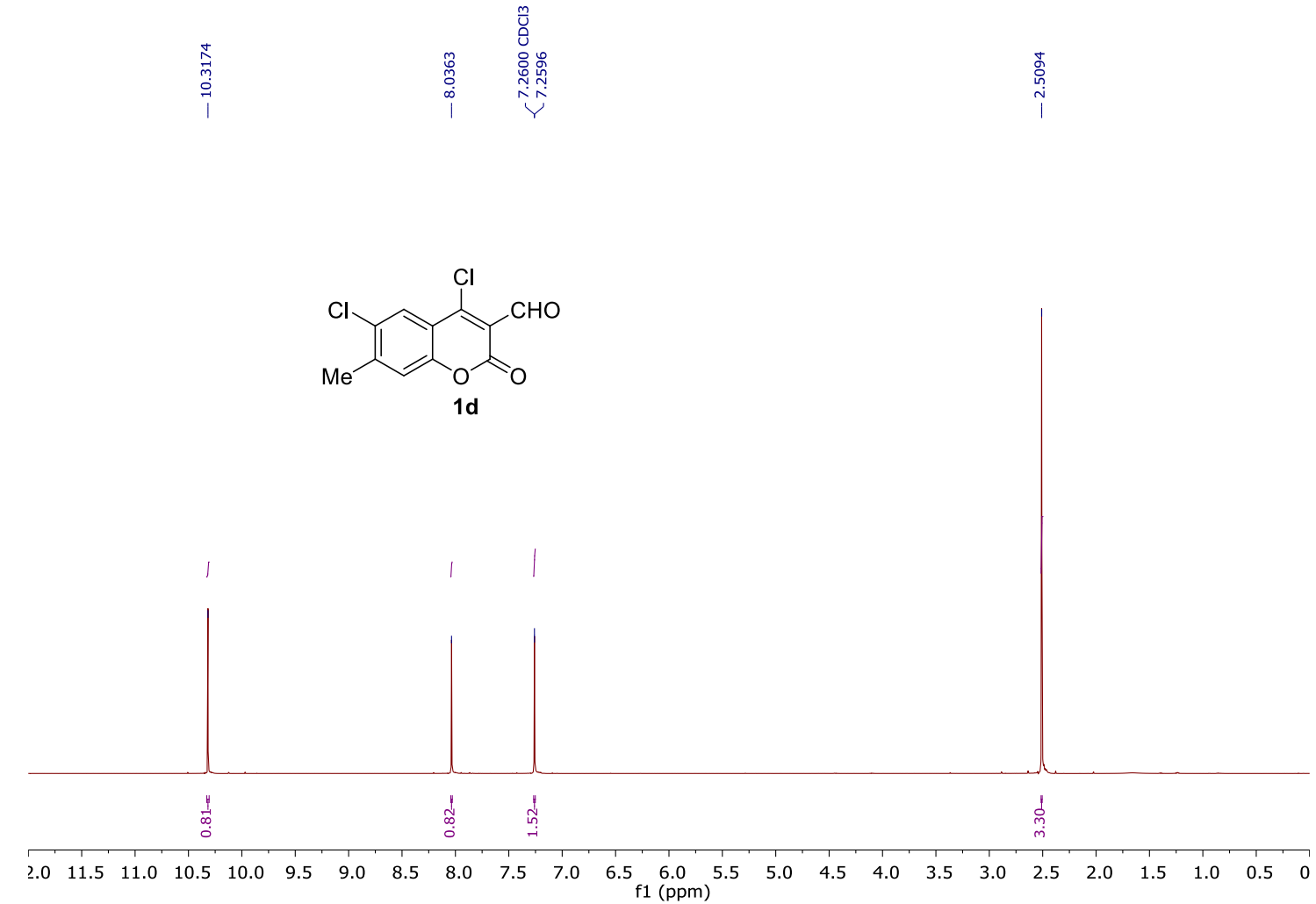
^{13}C Spectrum of 4-chloro-7-methoxy-2-oxo-2*H*-chromene-3-carbaldehyde (1b)



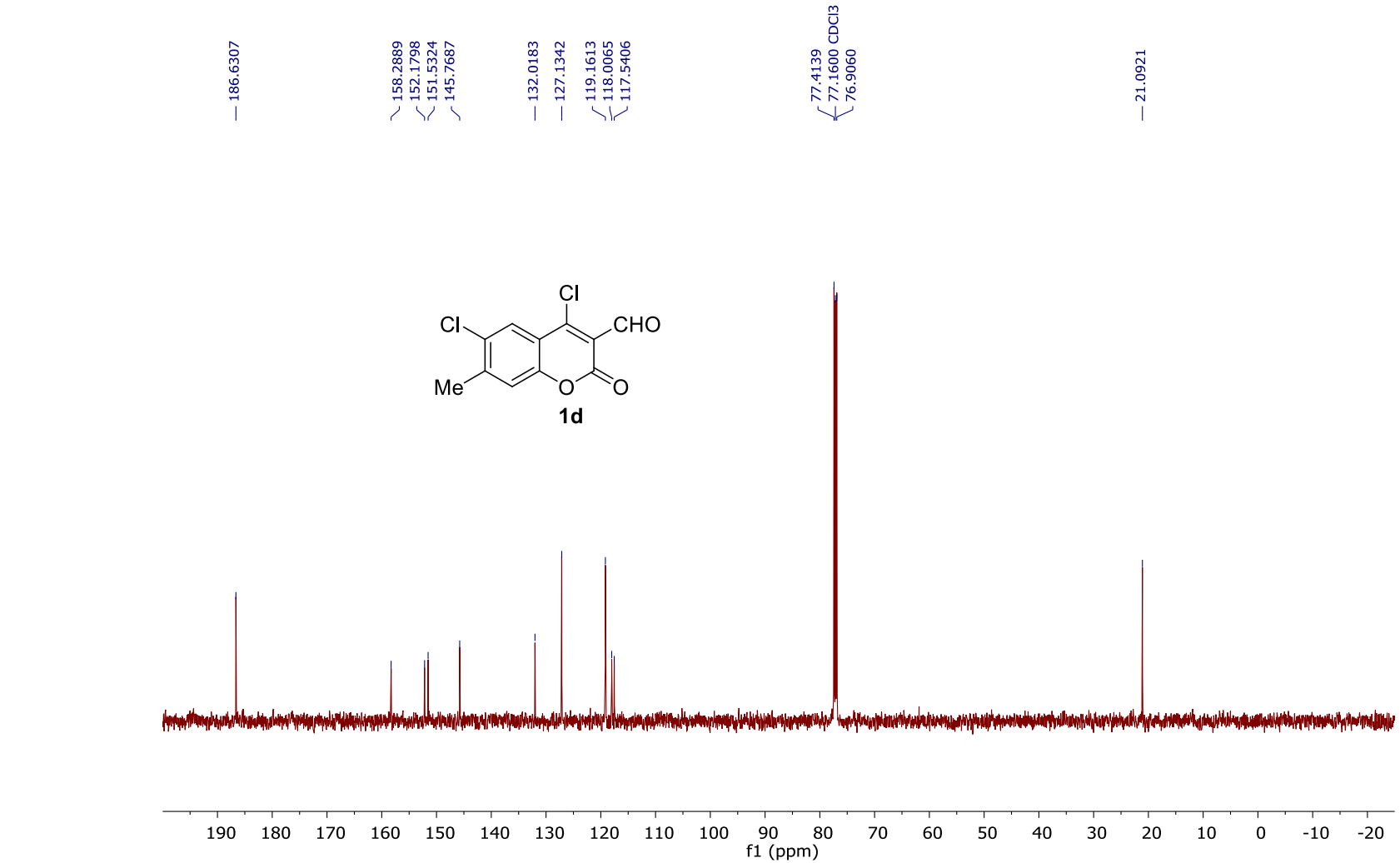
^{1}H Spectrum of 4-chloro-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (1c)



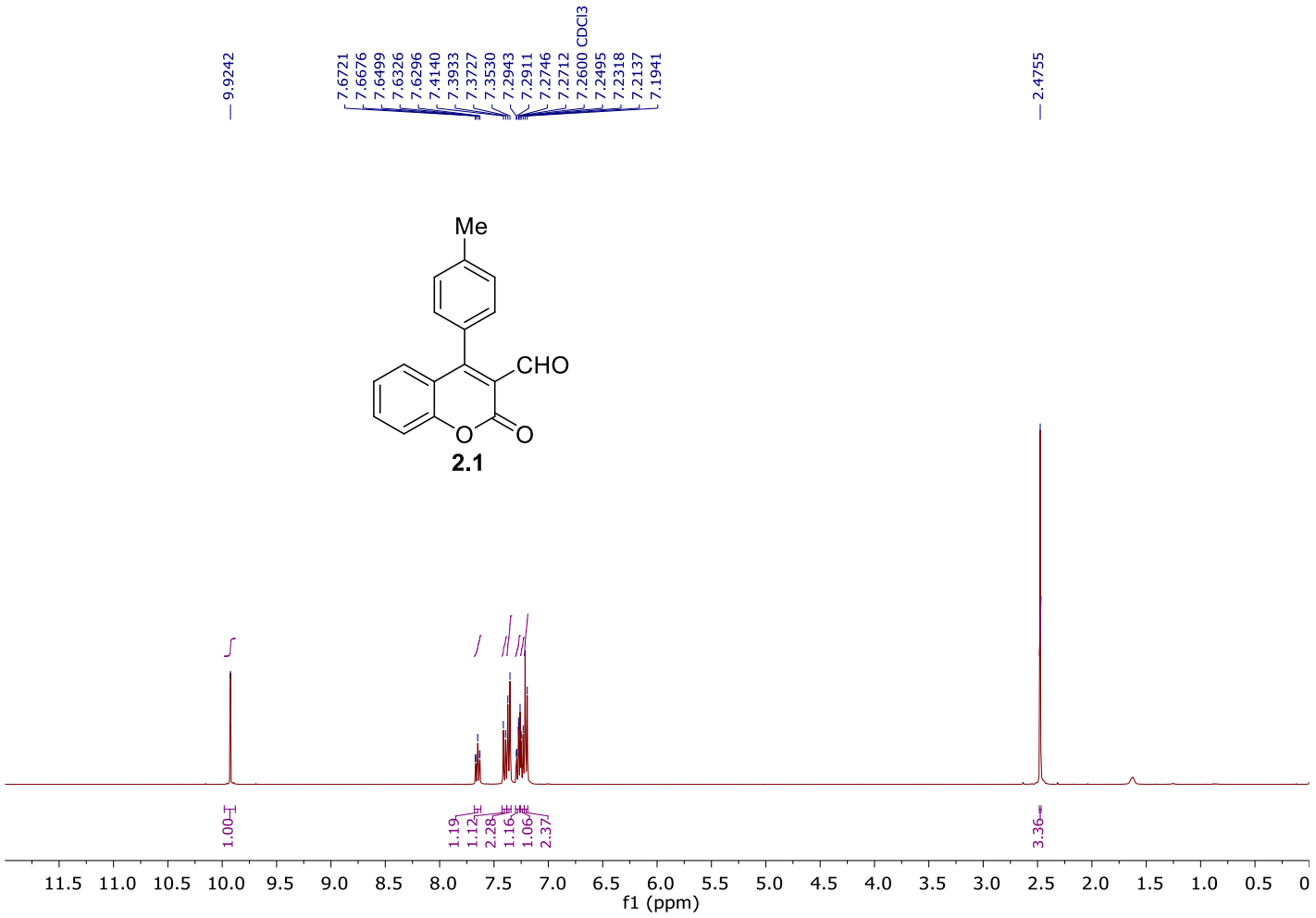
^{13}C Spectrum of 4-chloro-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (1c)



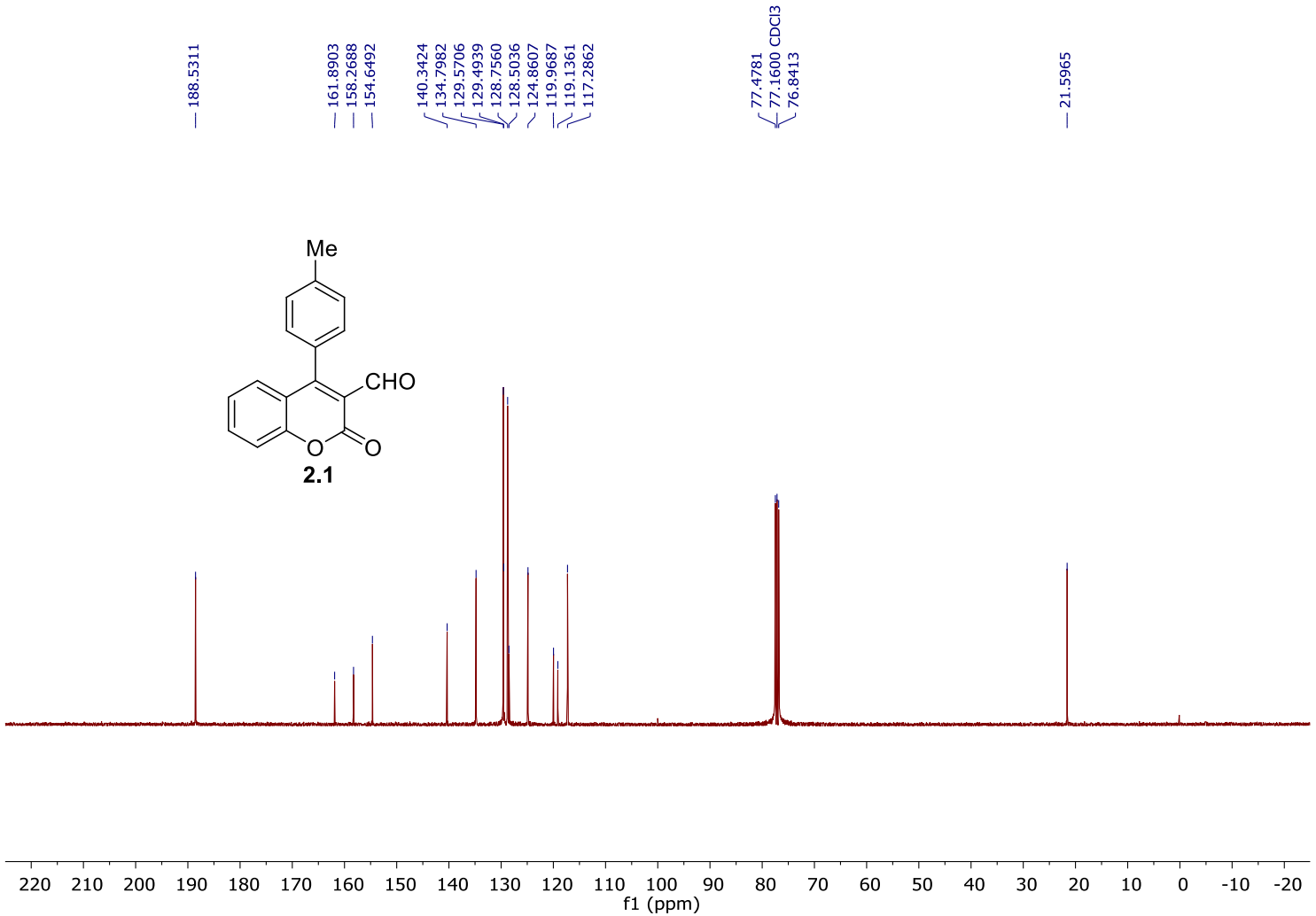
^{1}H Spectrum of 4,6-dichloro-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (1d)



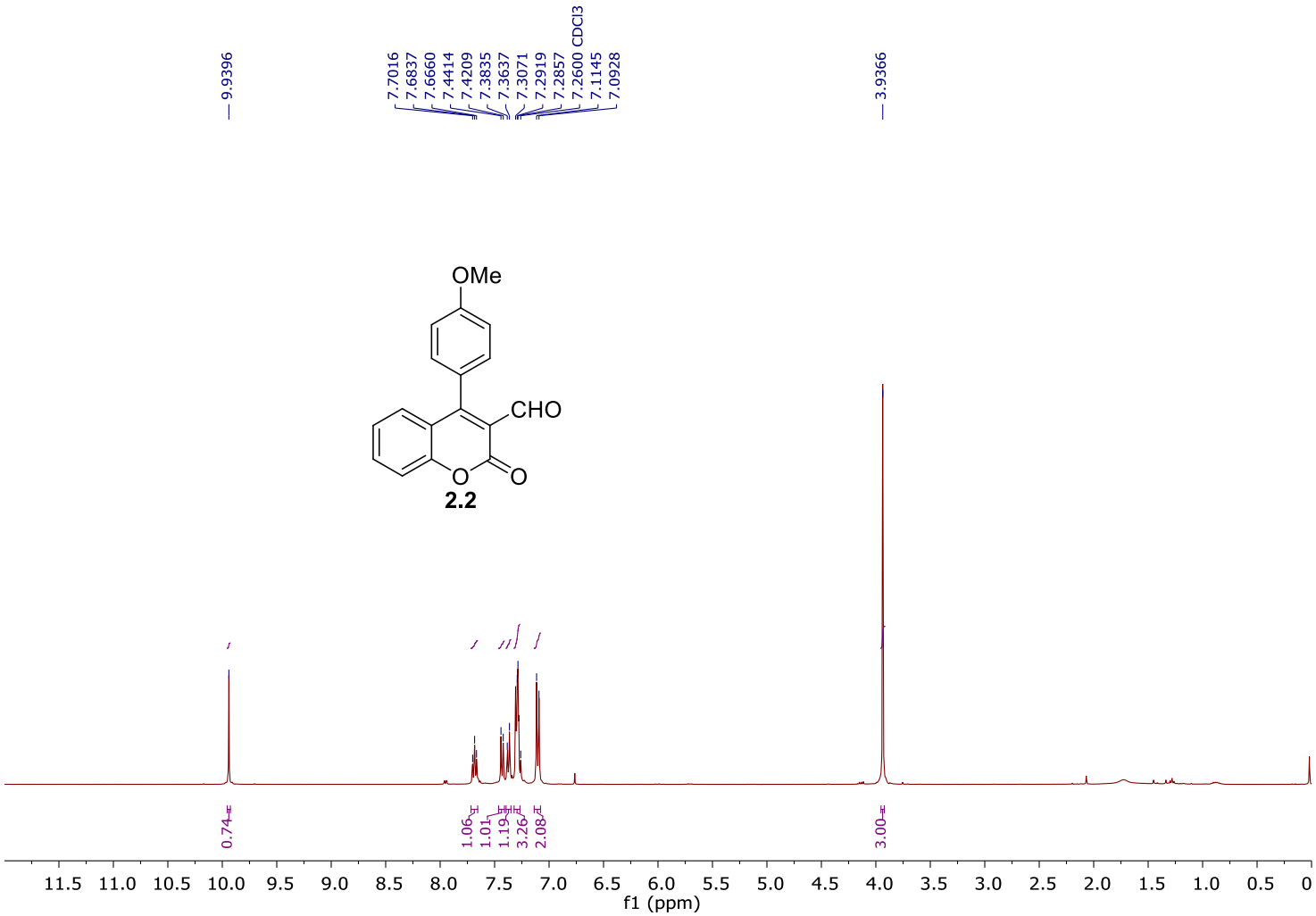
^{13}C Spectrum of 4,6-dichloro-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (1d)



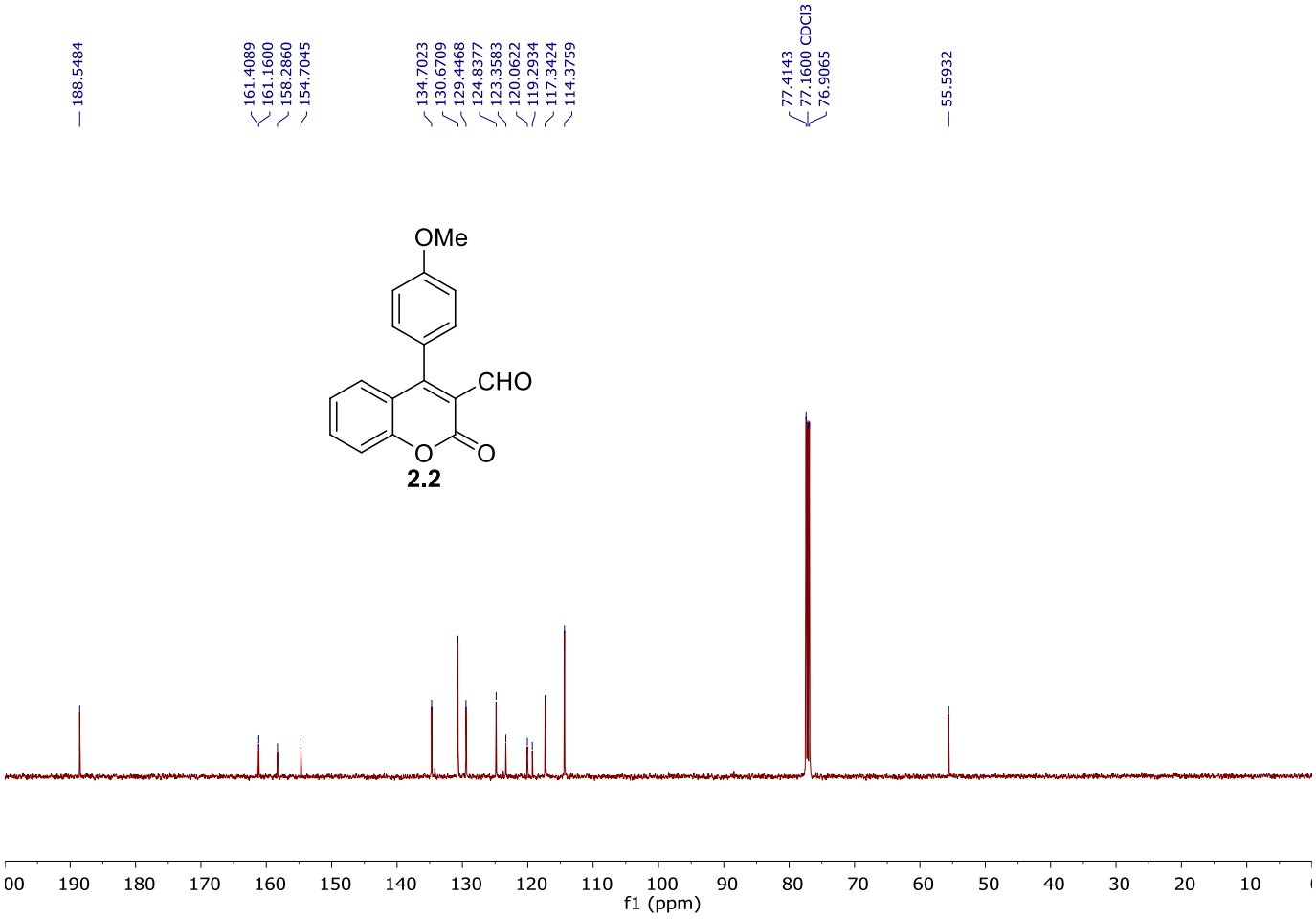
^{1}H Spectrum of 2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (2.1)



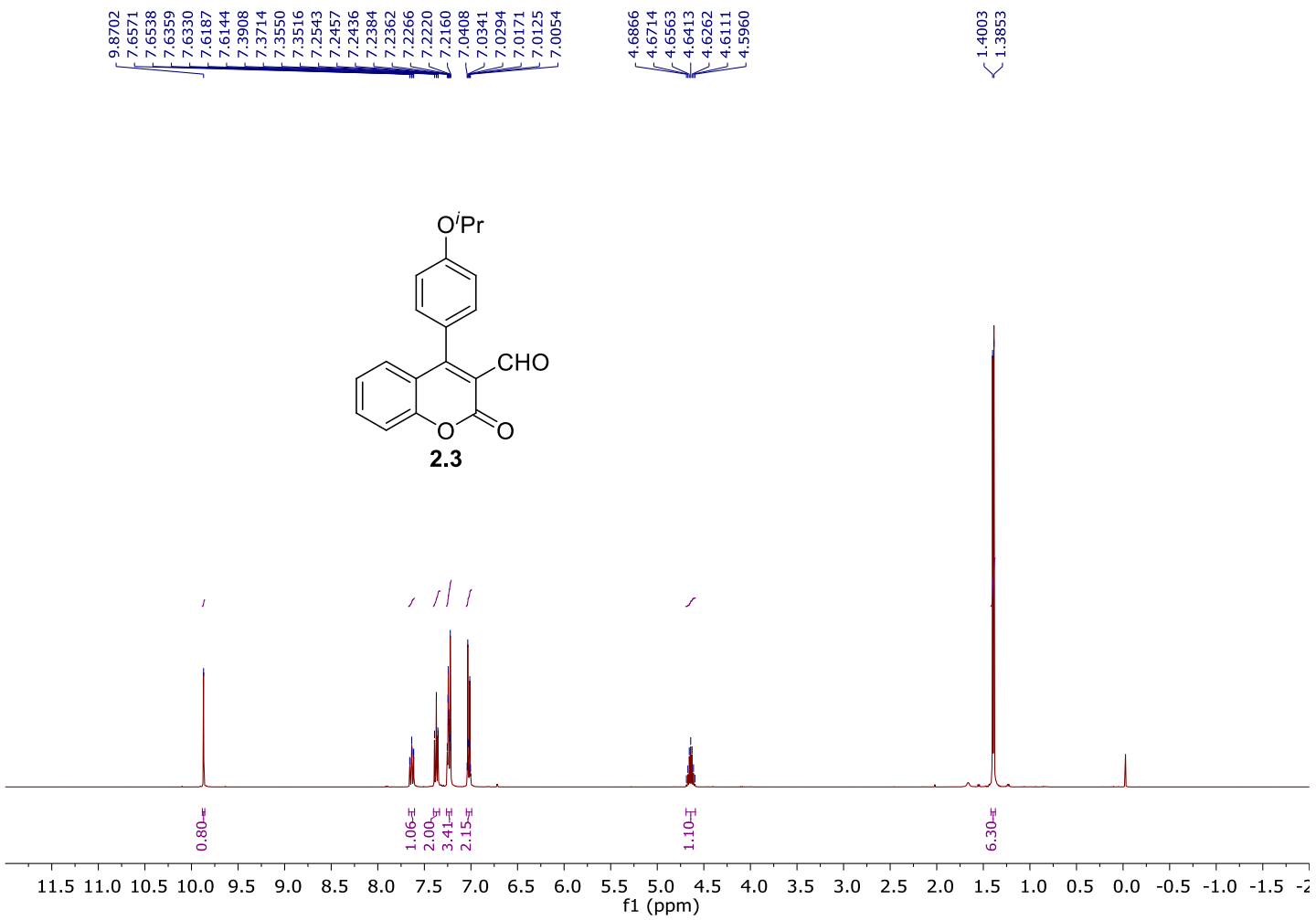
^{13}C Spectrum 2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (2.1)



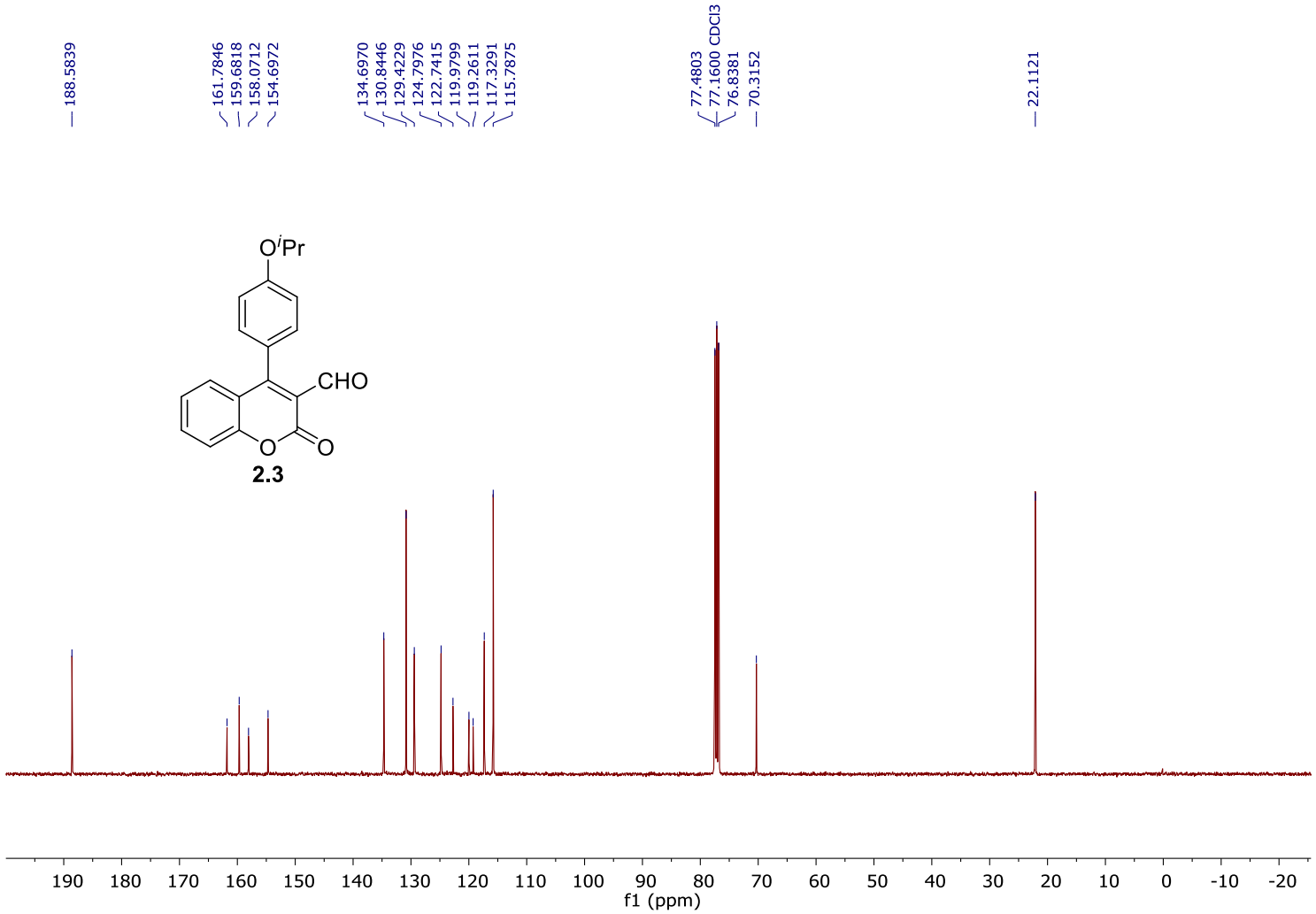
^{1}H Spectrum of 4-(4-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.2)



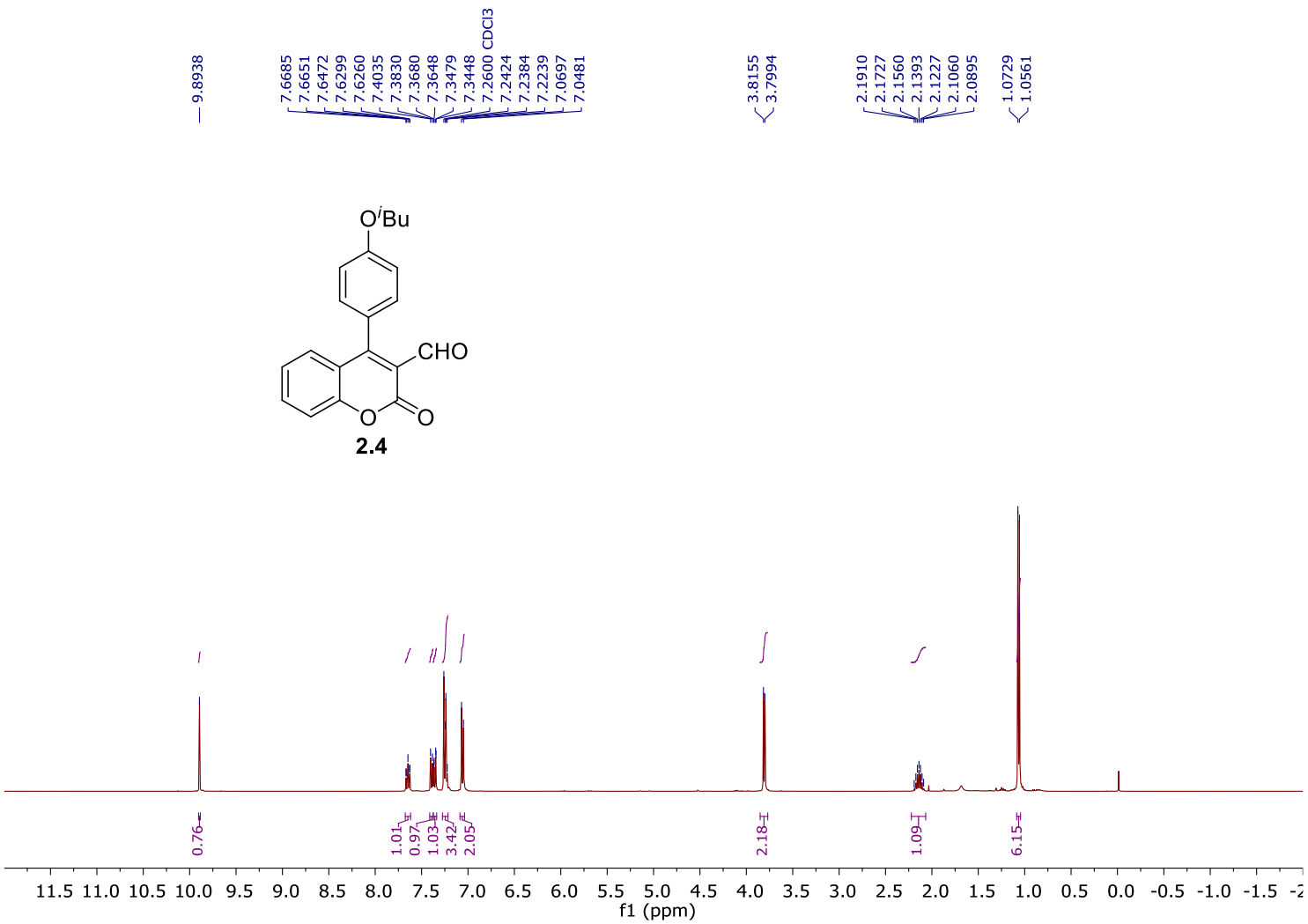
^{13}C Spectrum of 4-(4-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.2)



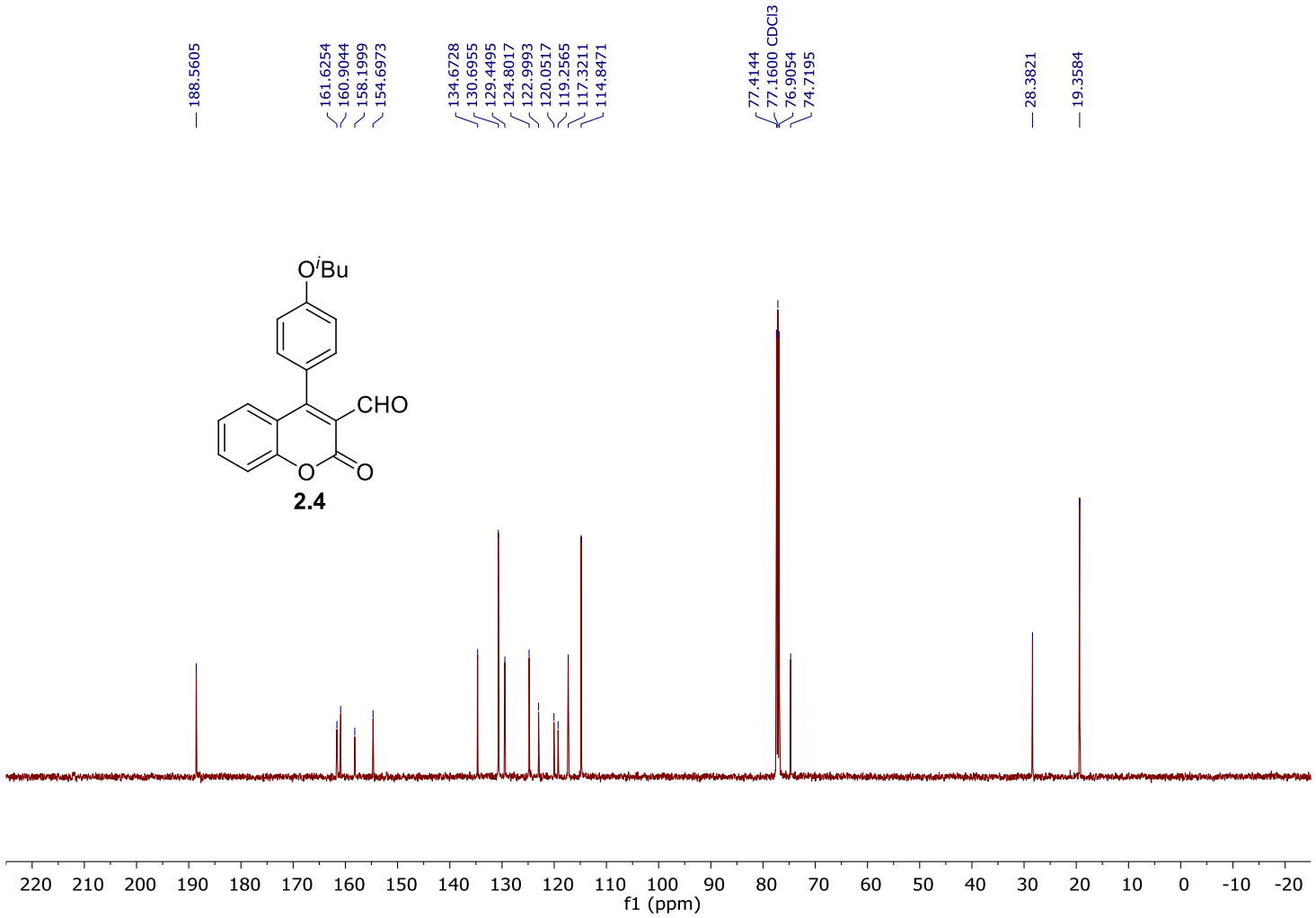
^{1}H Spectrum of 4-(4-isopropoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.3)



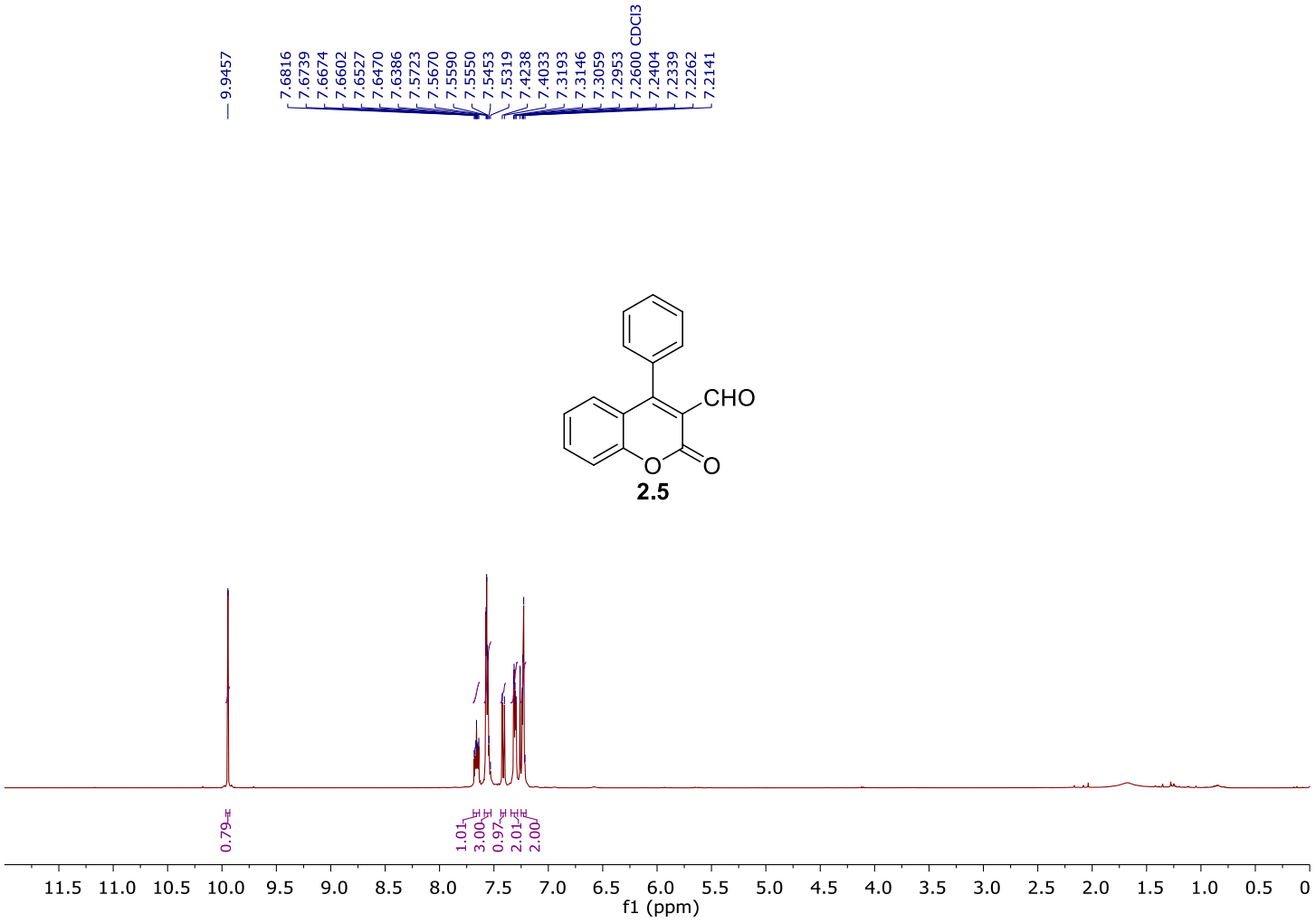
^{13}C Spectrum of 4-(4-isopropoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.3)



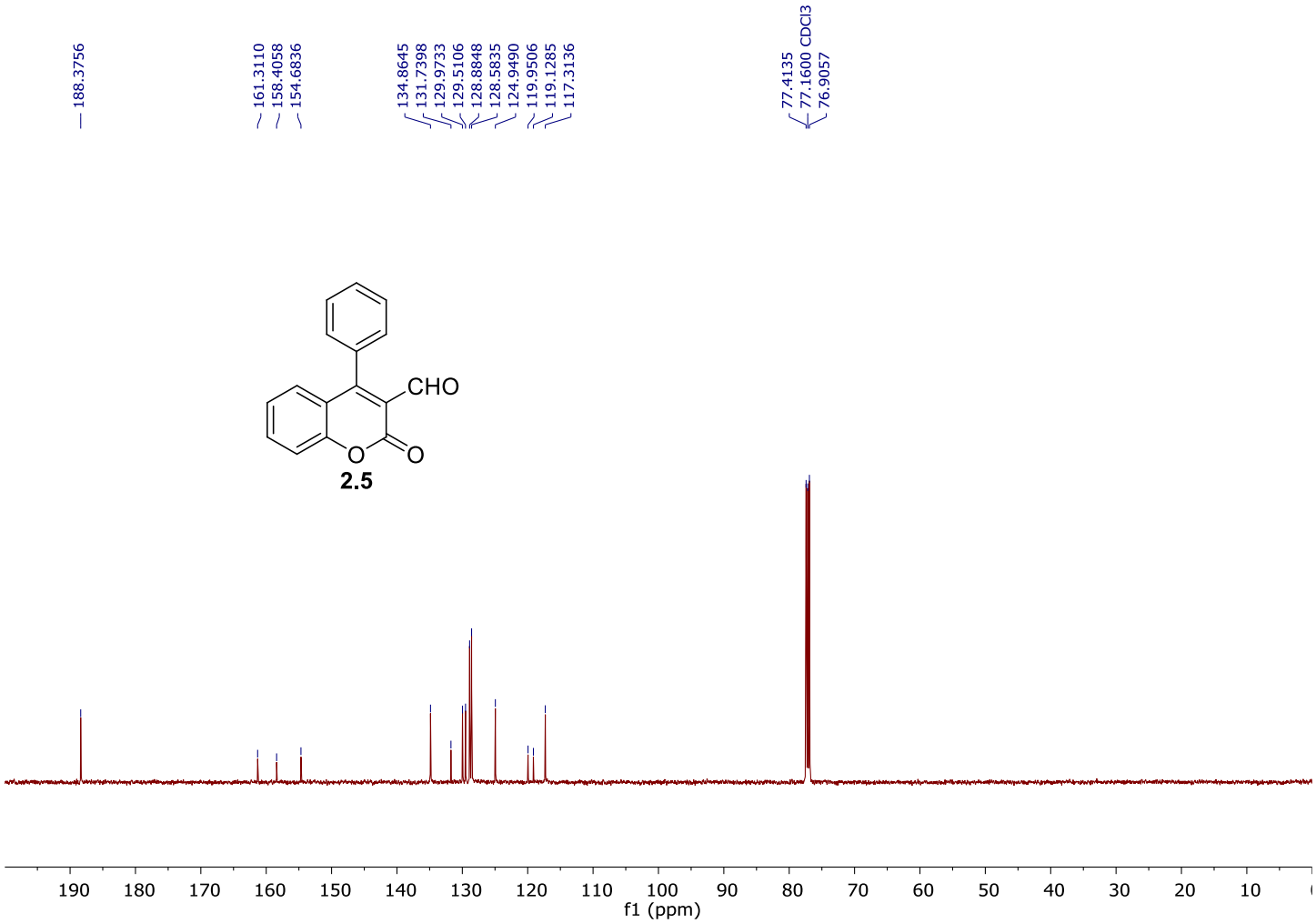
^{1}H Spectrum of 4-(4-isobutoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.4)



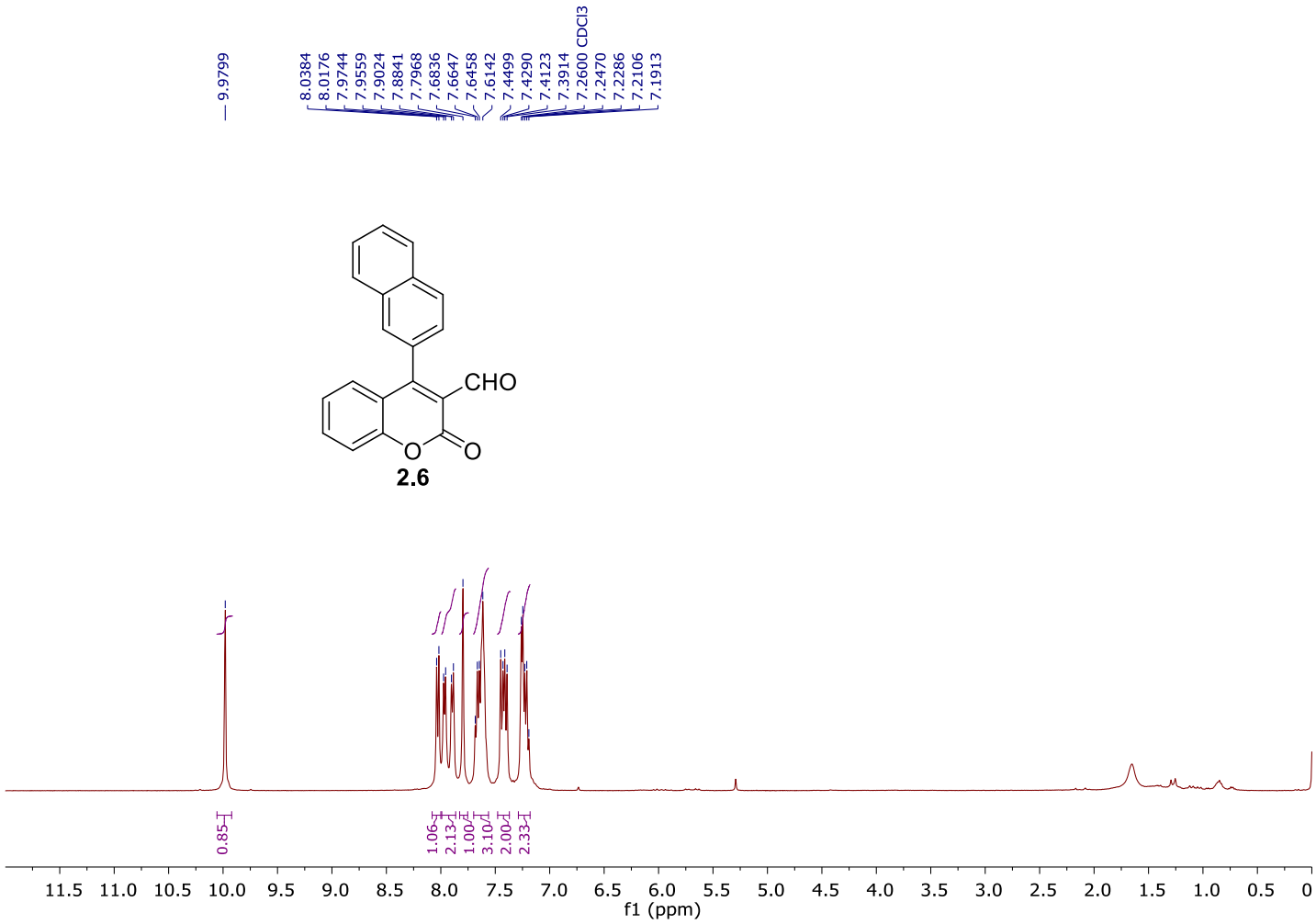
^{13}C Spectrum of 4-(4-isobutoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.4)



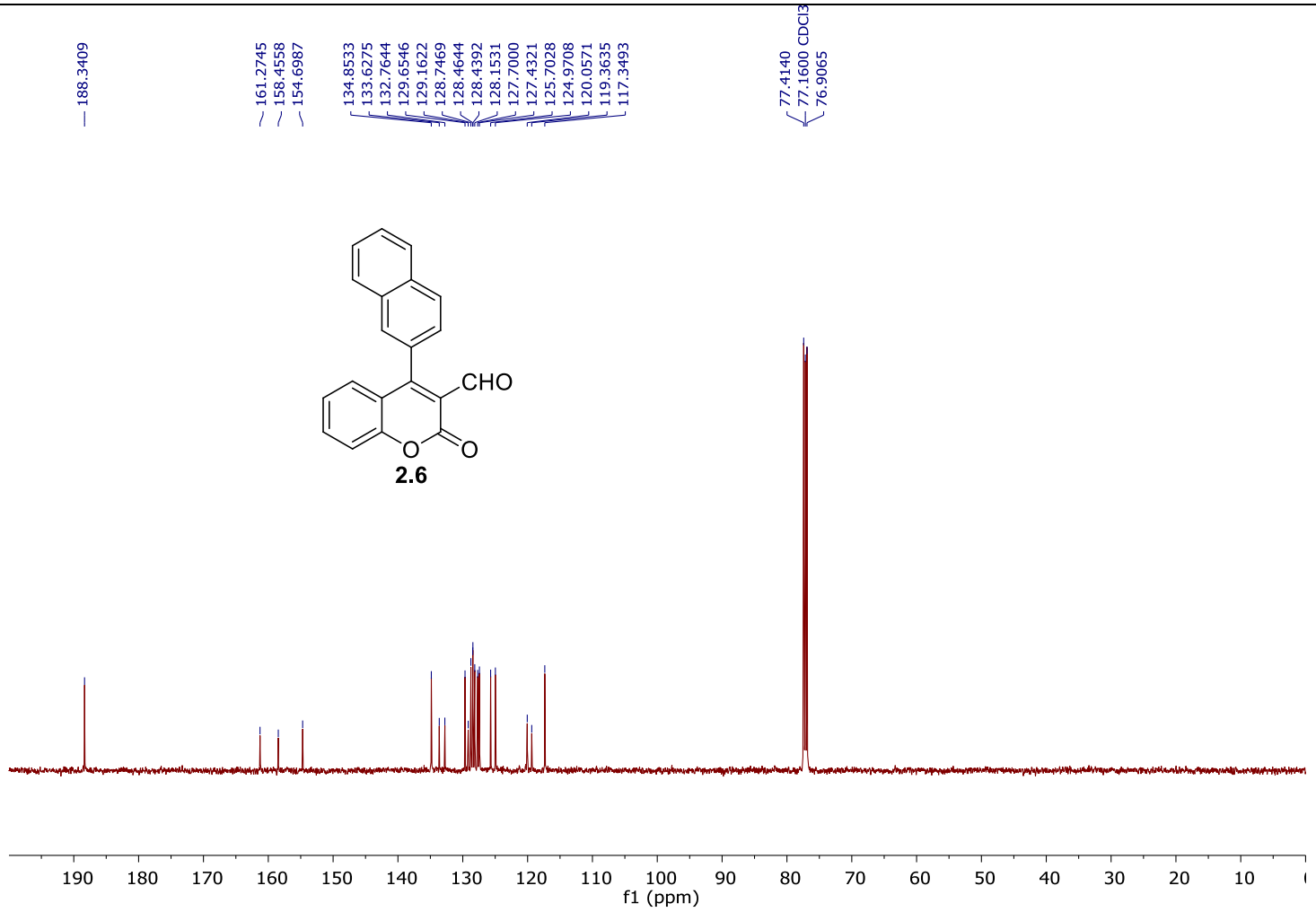
^{1}H Spectrum of 2-oxo-4-phenyl-2*H*-chromene-3-carbaldehyde (2.5)



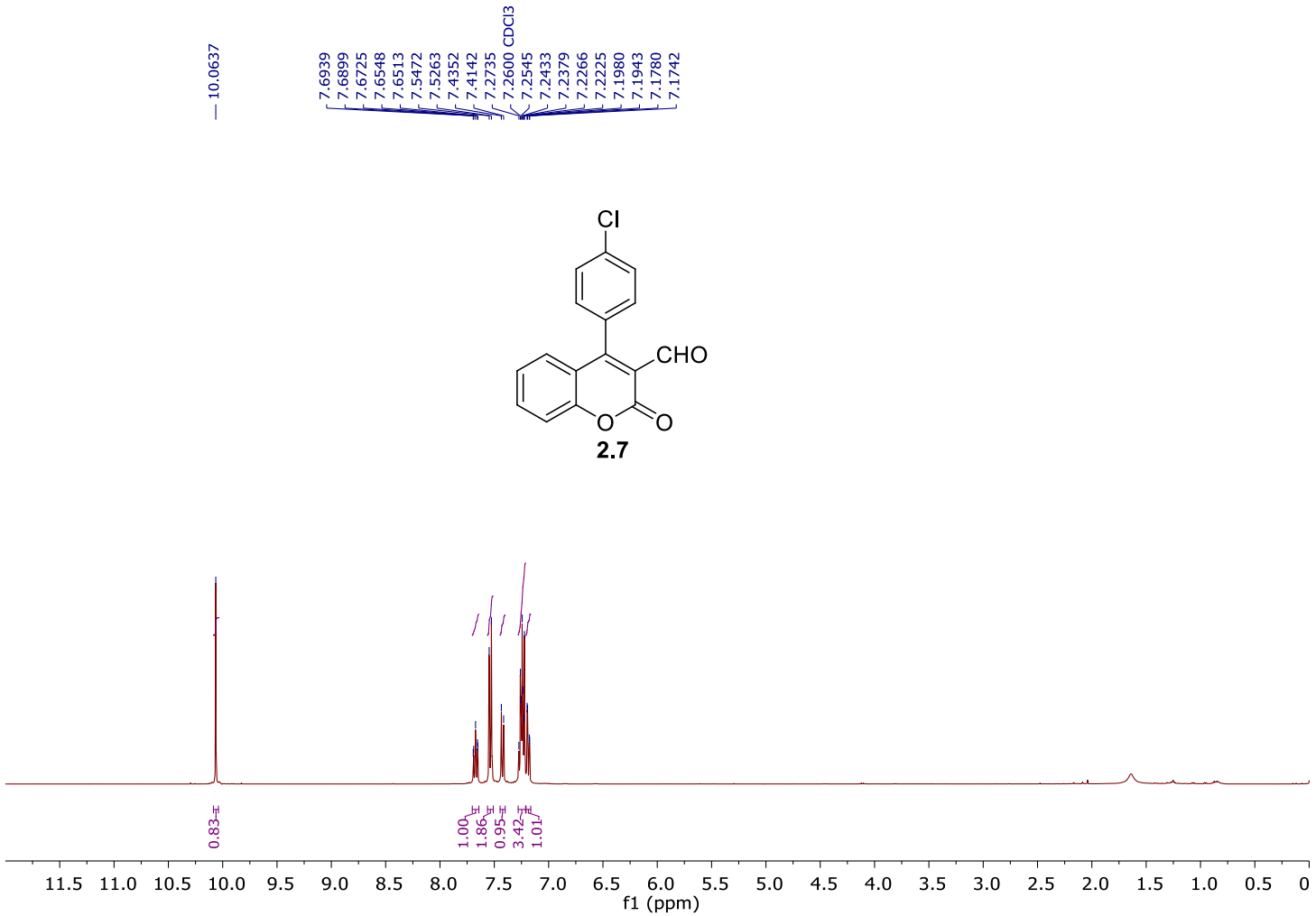
^{13}C Spectrum of 2-oxo-4-phenyl-2*H*-chromene-3-carbaldehyde (2.5)



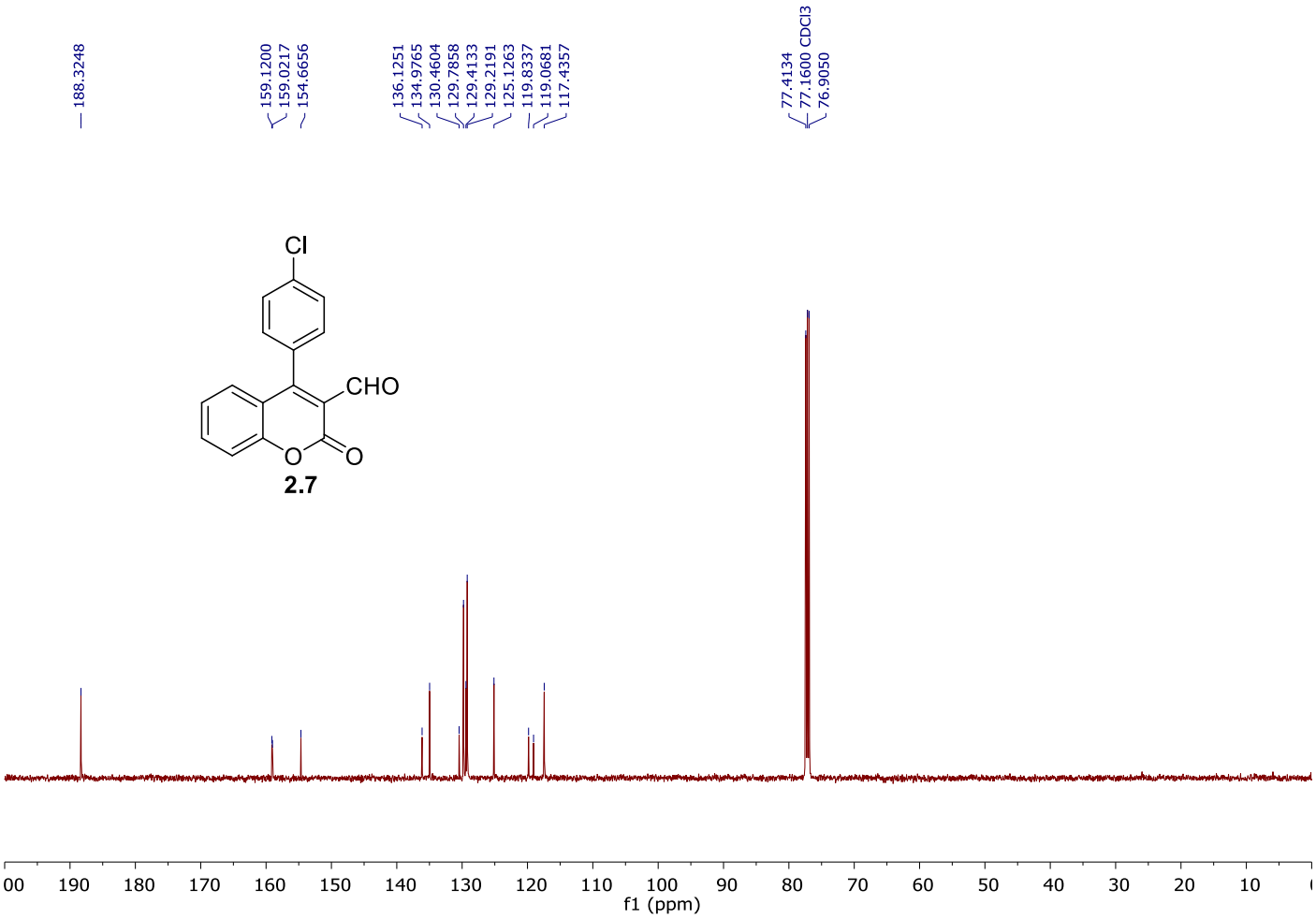
^{1}H Spectrum of 4-(naphthalen-2-yl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.6)



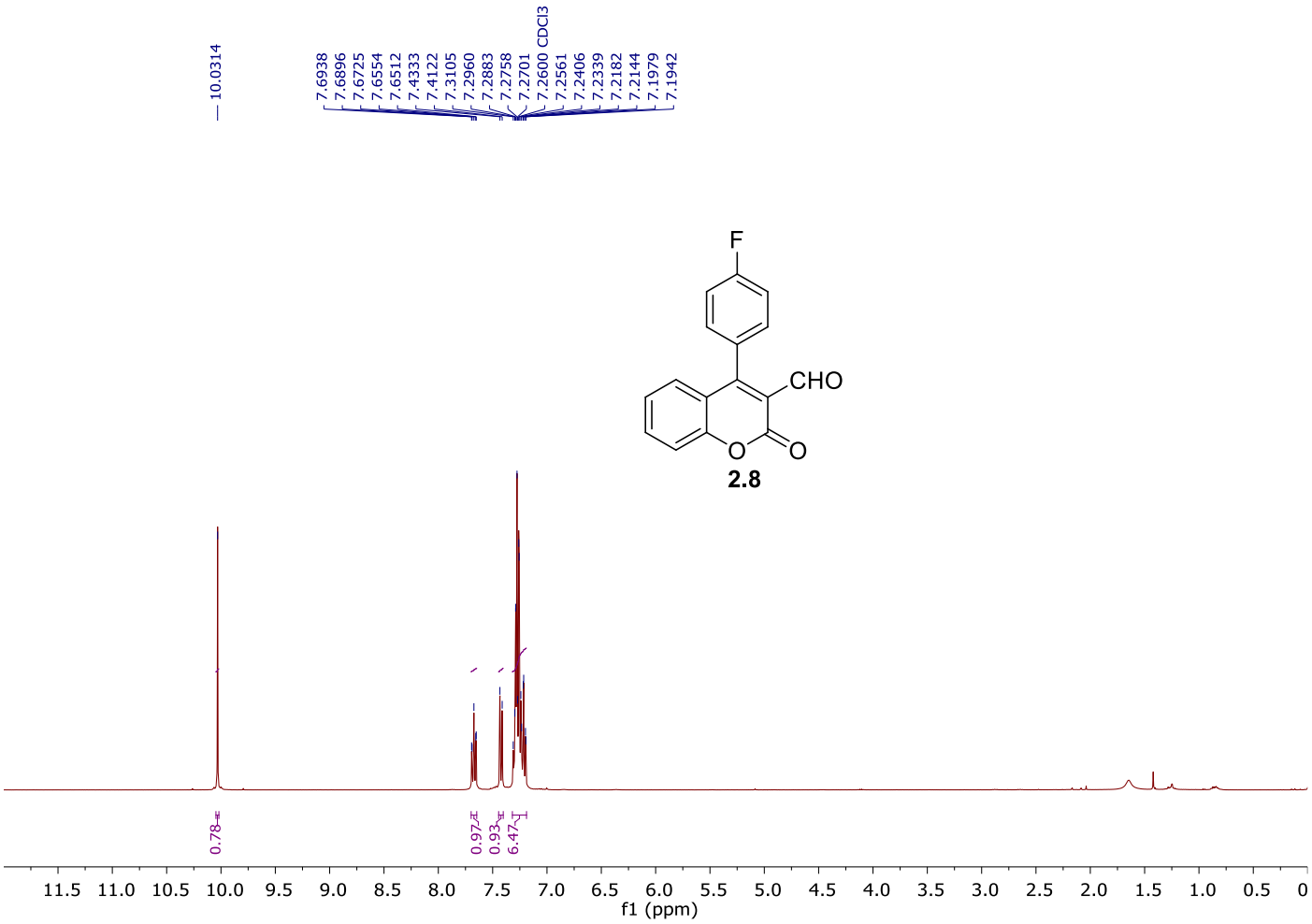
^{13}C Spectrum of 4-(naphthalen-2-yl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.6)



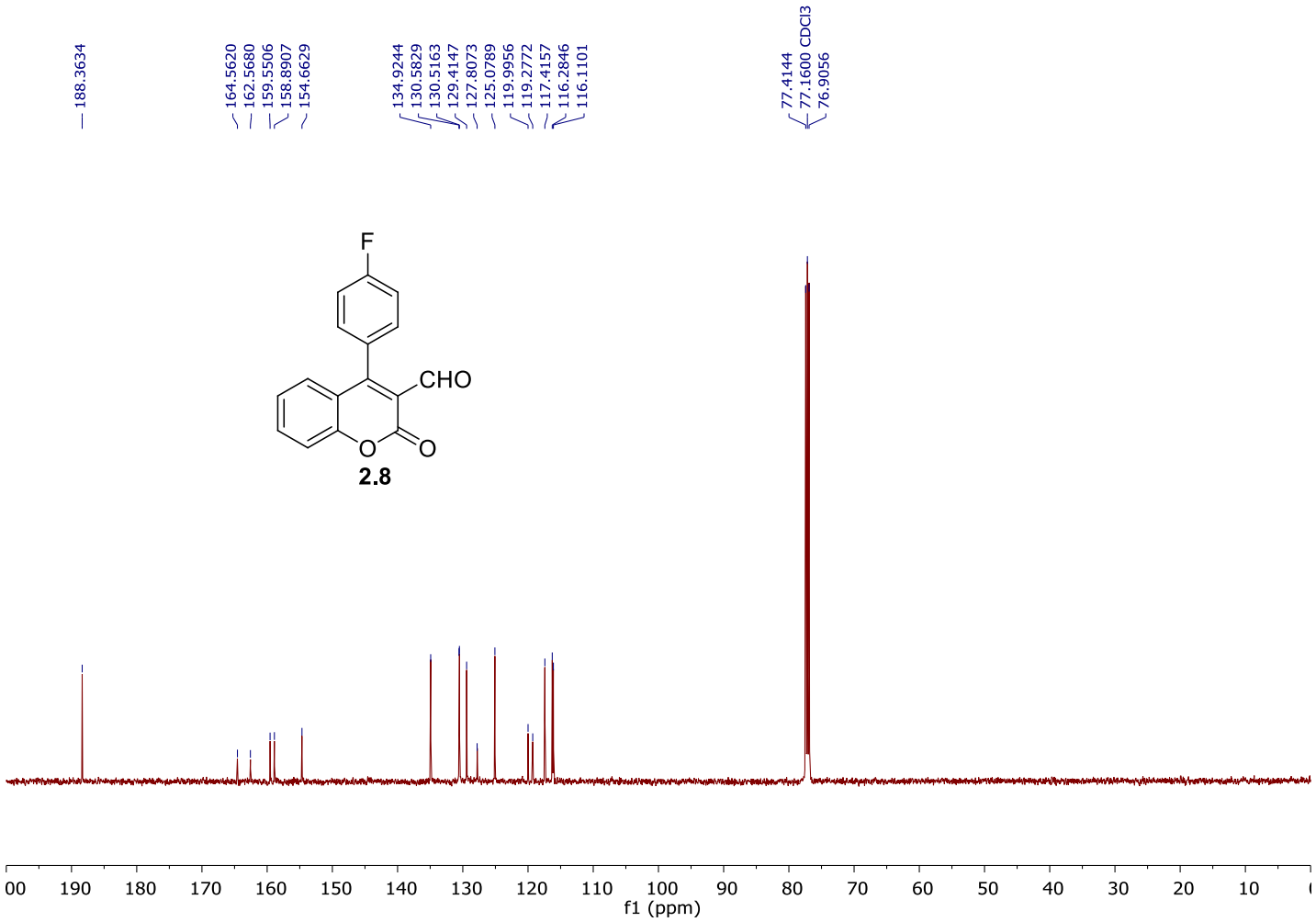
^{1}H Spectrum of 4-(4-chlorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.7)



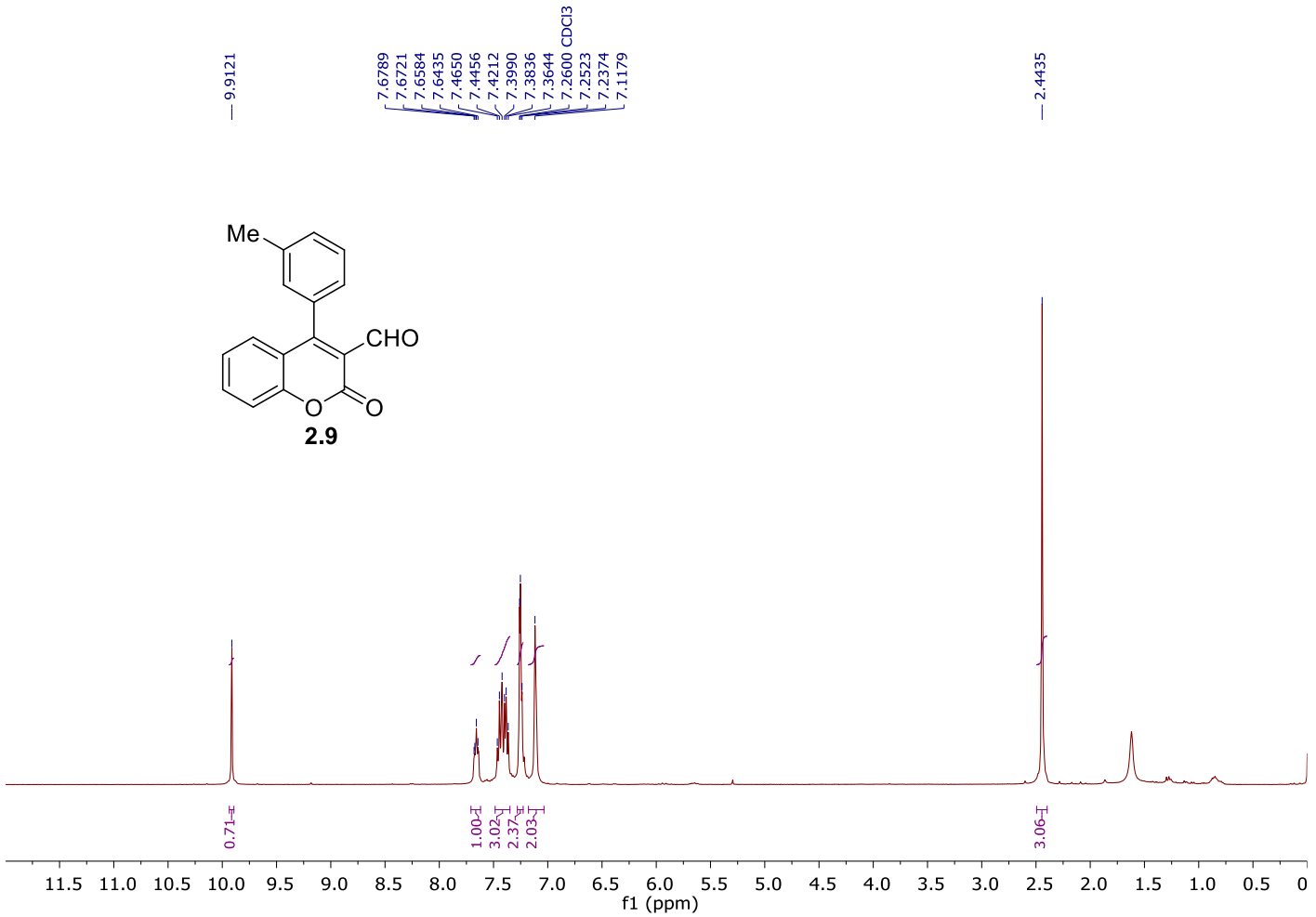
^{13}C Spectrum of 4-(4-chlorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.7)



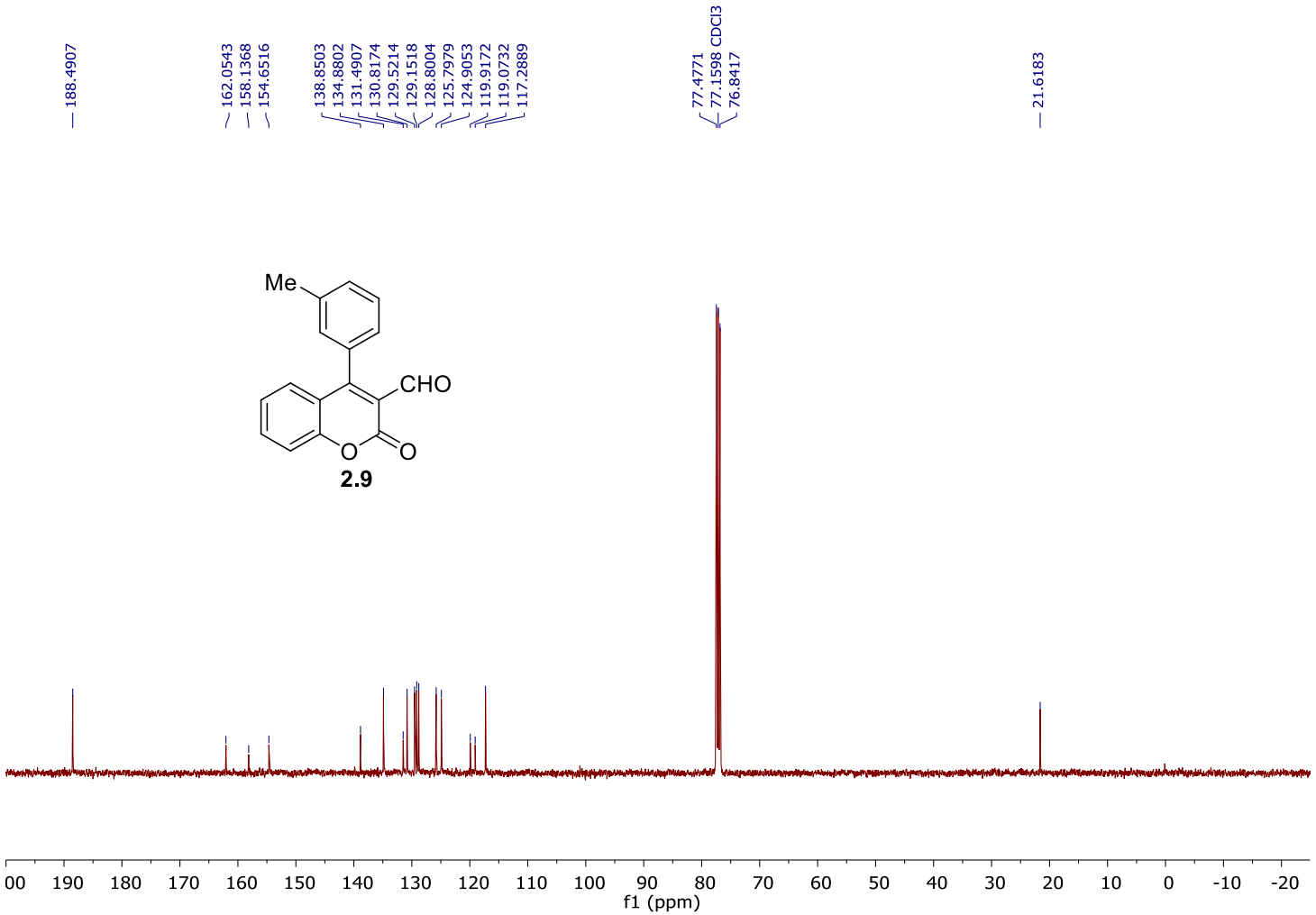
^{1}H Spectrum of 4-(4-fluorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.8)



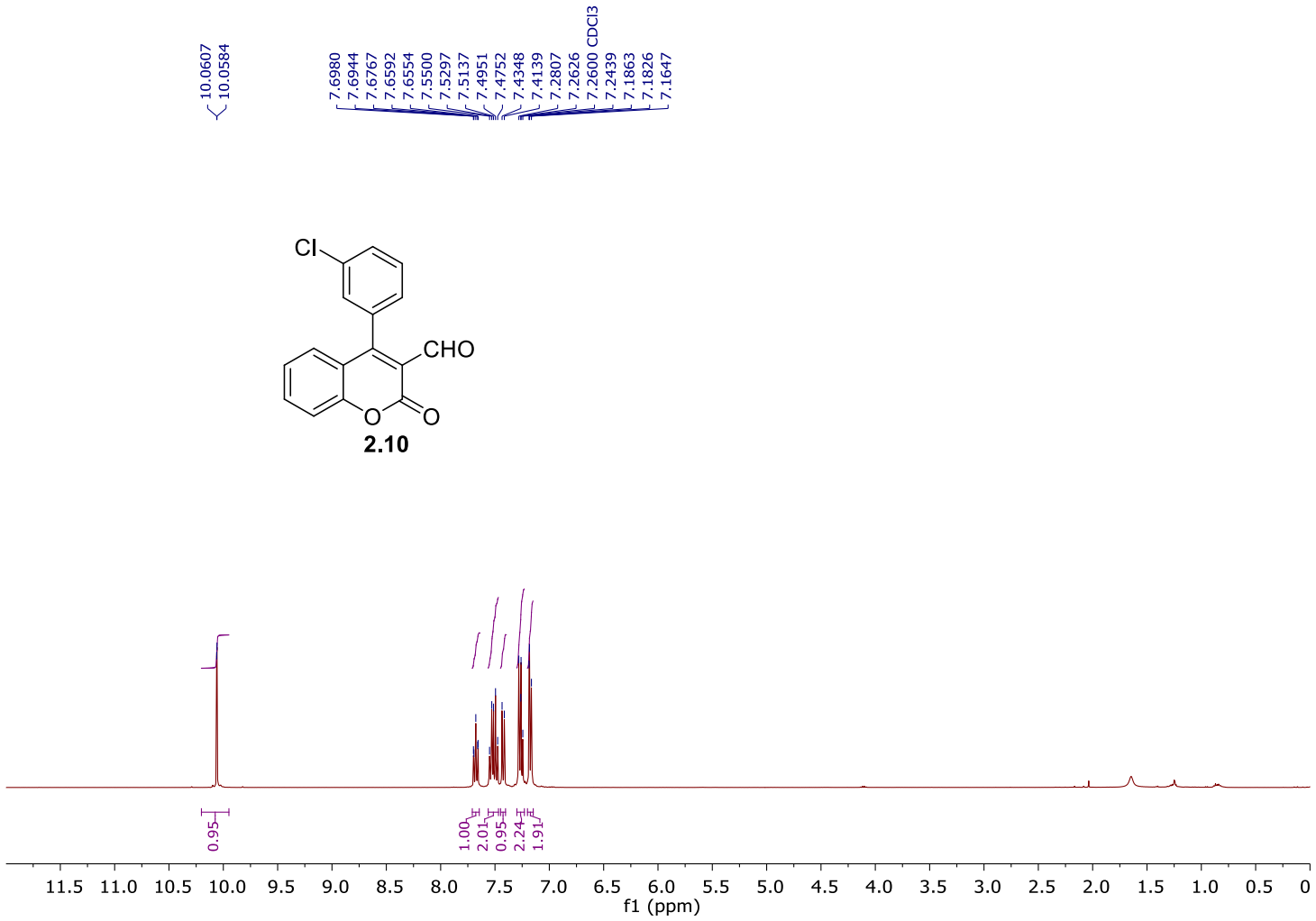
^{13}C Spectrum of 4-(4-fluorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.8)



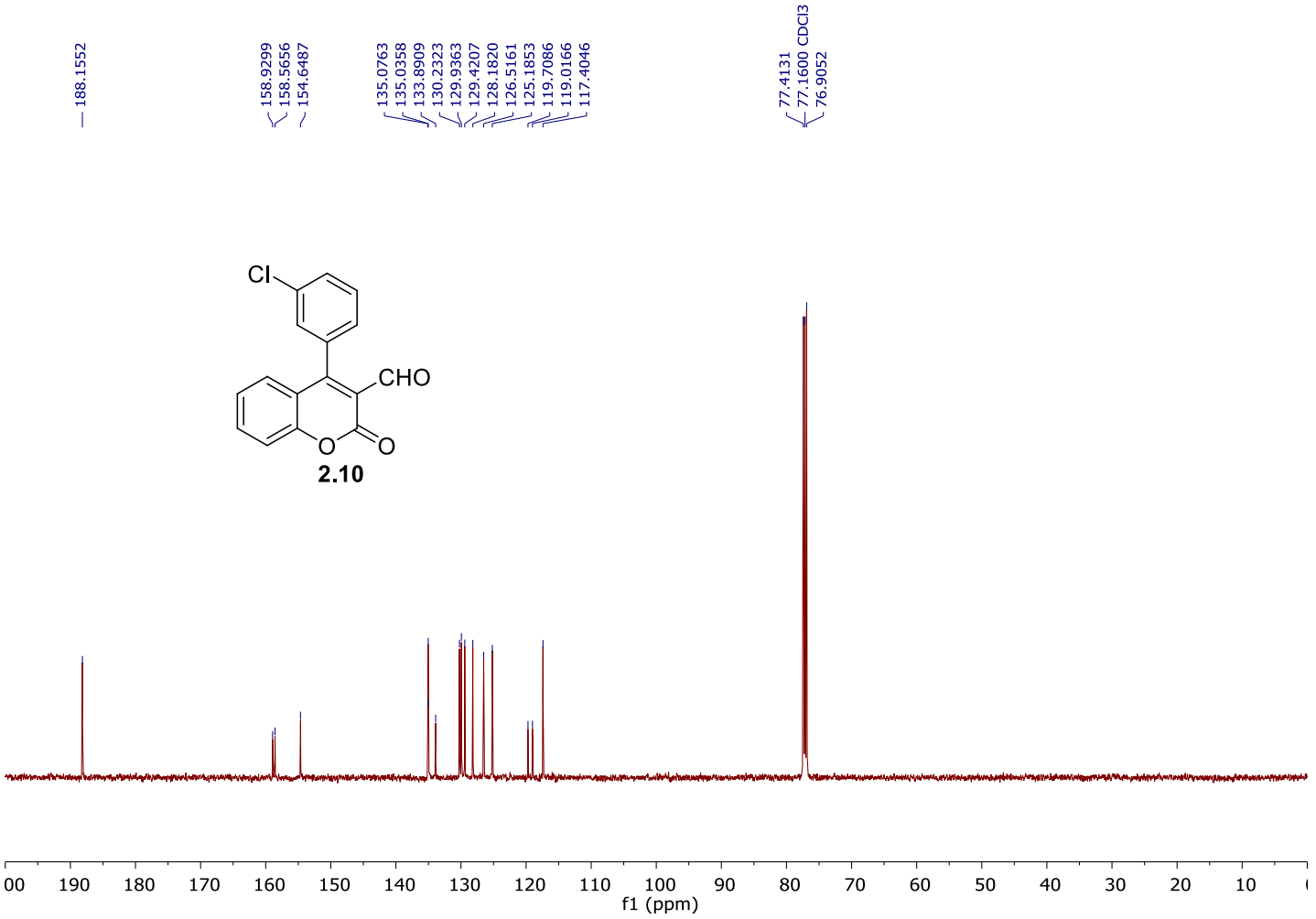
^{1}H Spectrum of 2-oxo-4-*m*-tolyl-2*H*-chromene-3-carbaldehyde (2.9)



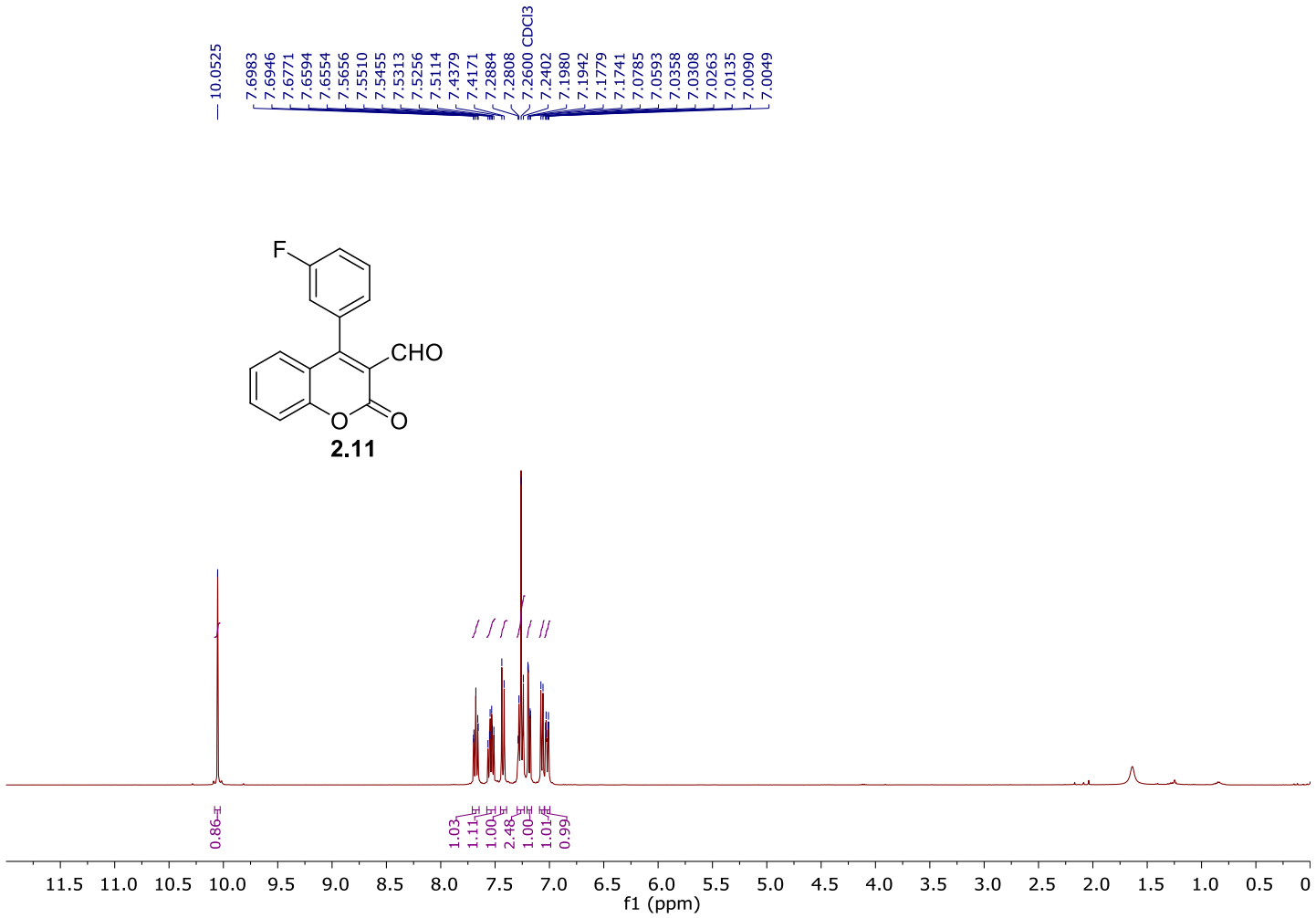
^{13}C Spectrum of 2-oxo-4-*m*-tolyl-2*H*-chromene-3-carbaldehyde (2.9)



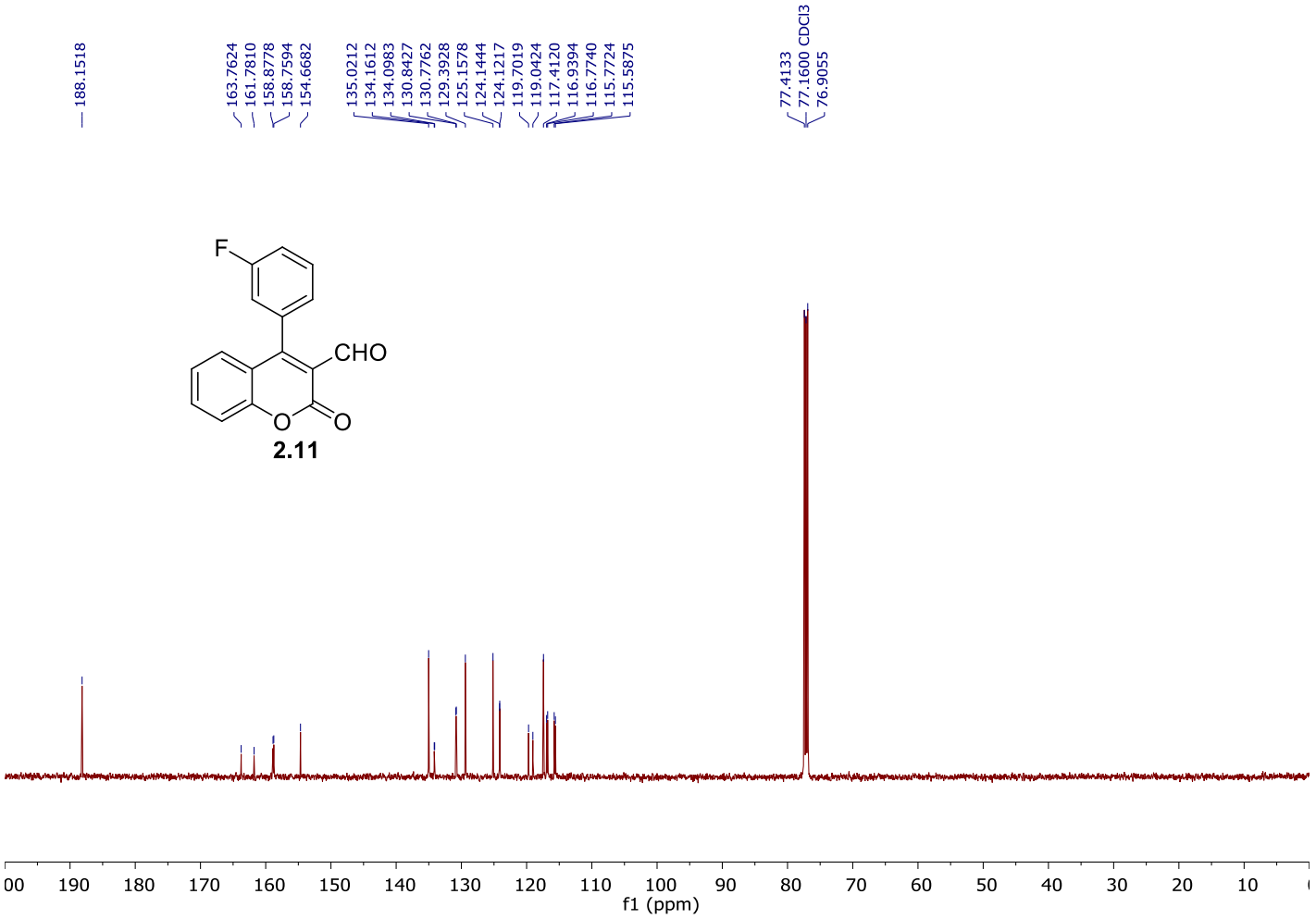
^{1}H Spectrum of 4-(3-chlorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.10)



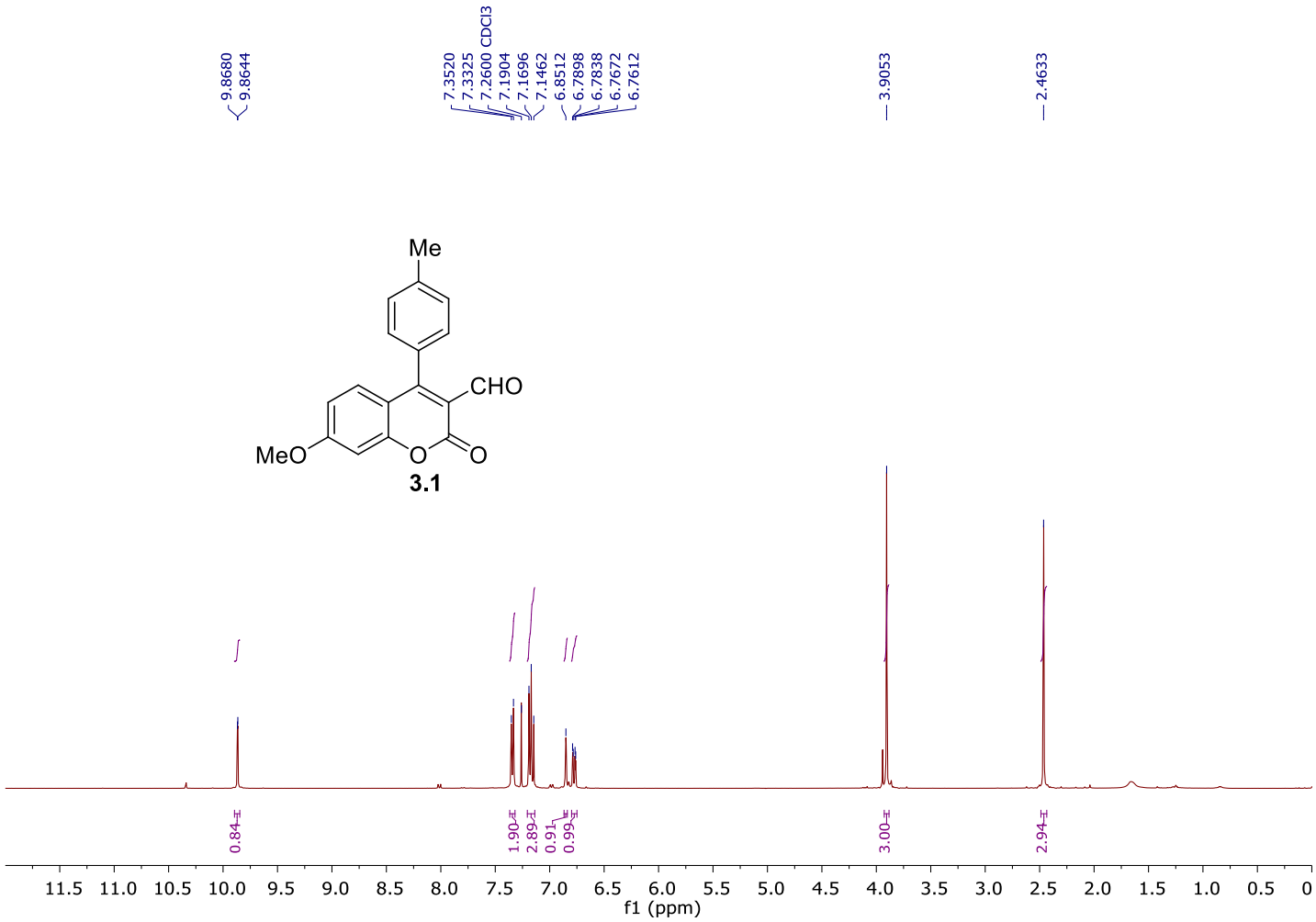
^{13}C Spectrum of 4-(3-chlorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.10)



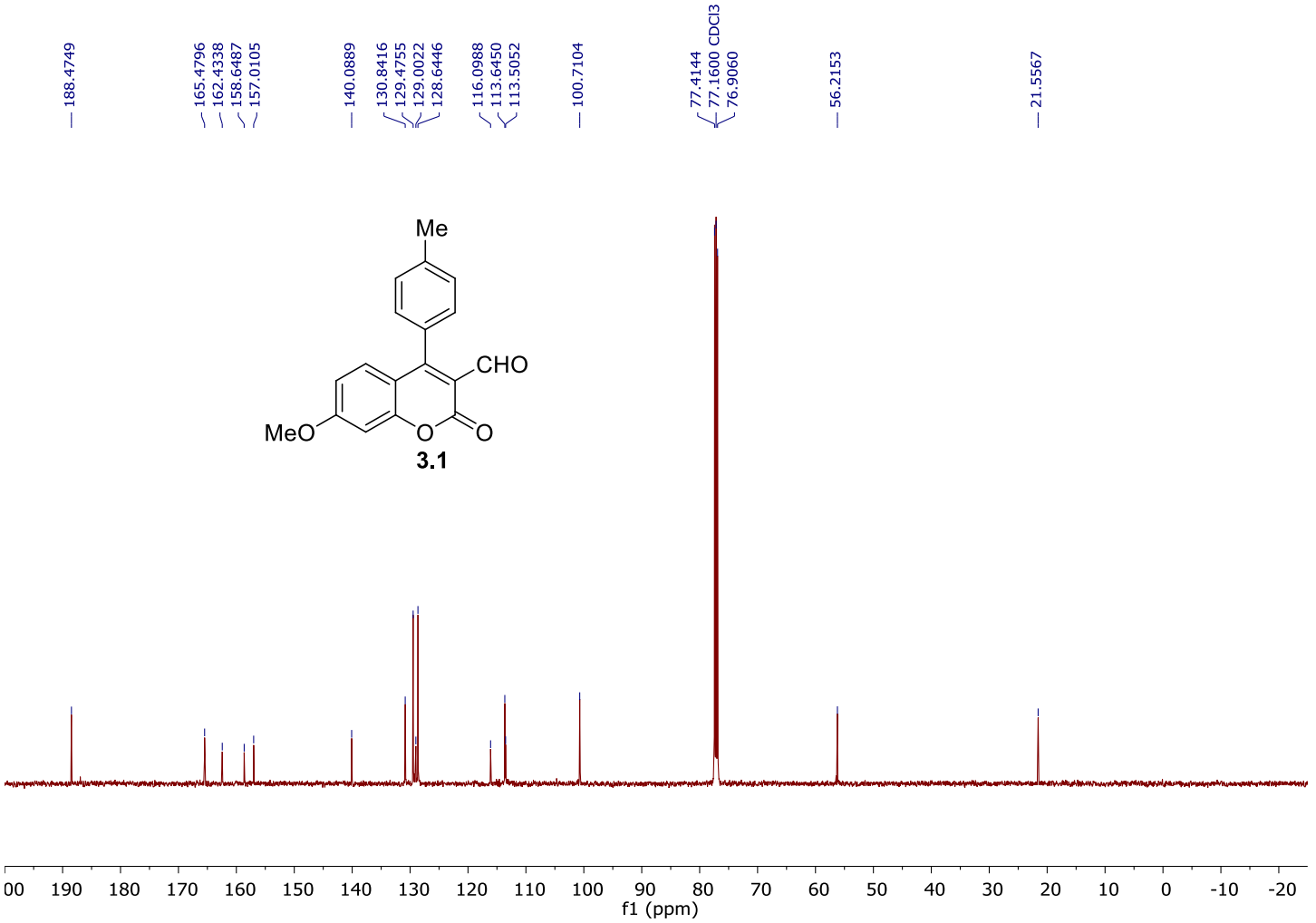
^{1}H Spectrum of 4-(3-fluorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.11)



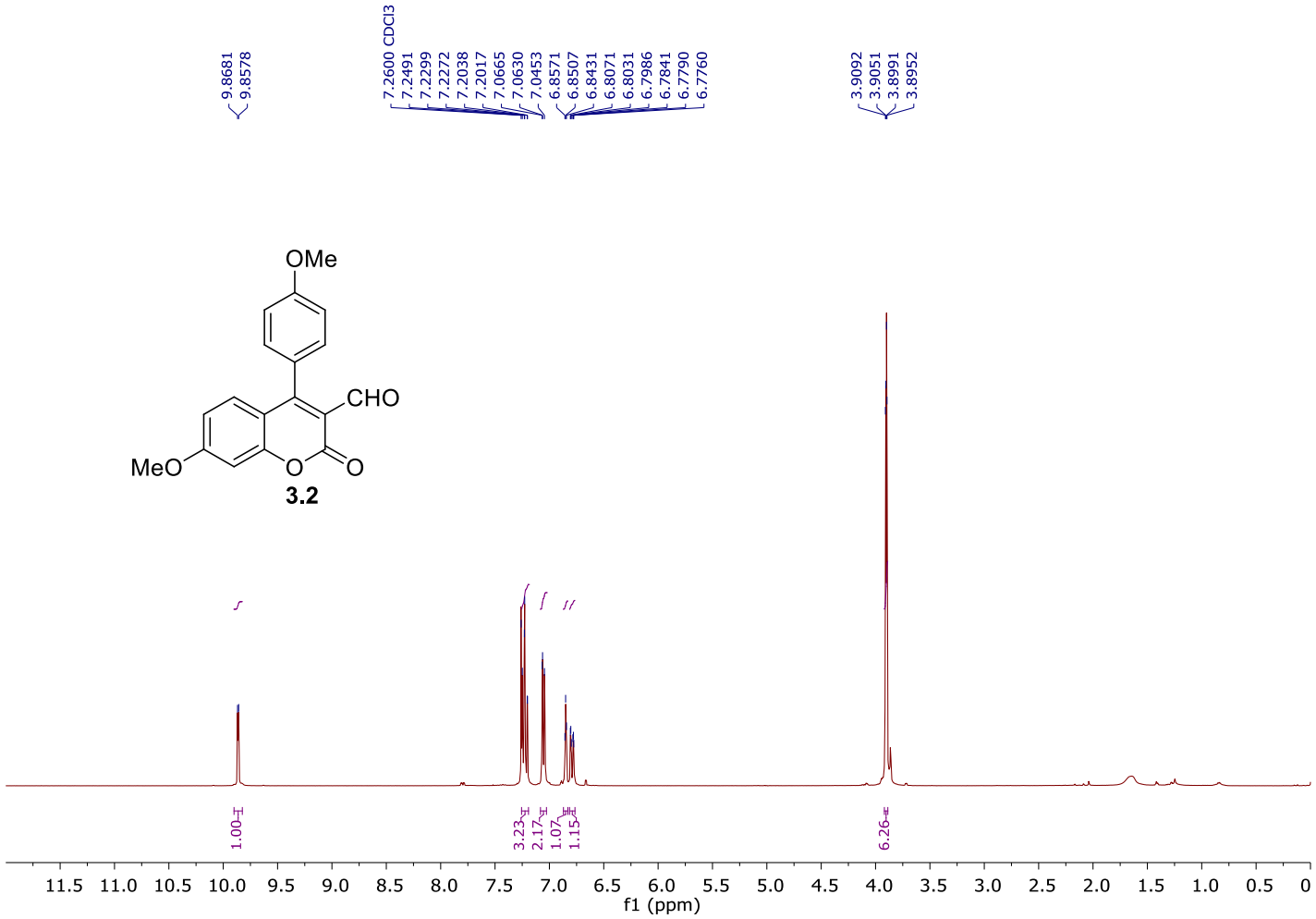
^{13}C Spectrum of 4-(3-fluorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.11)



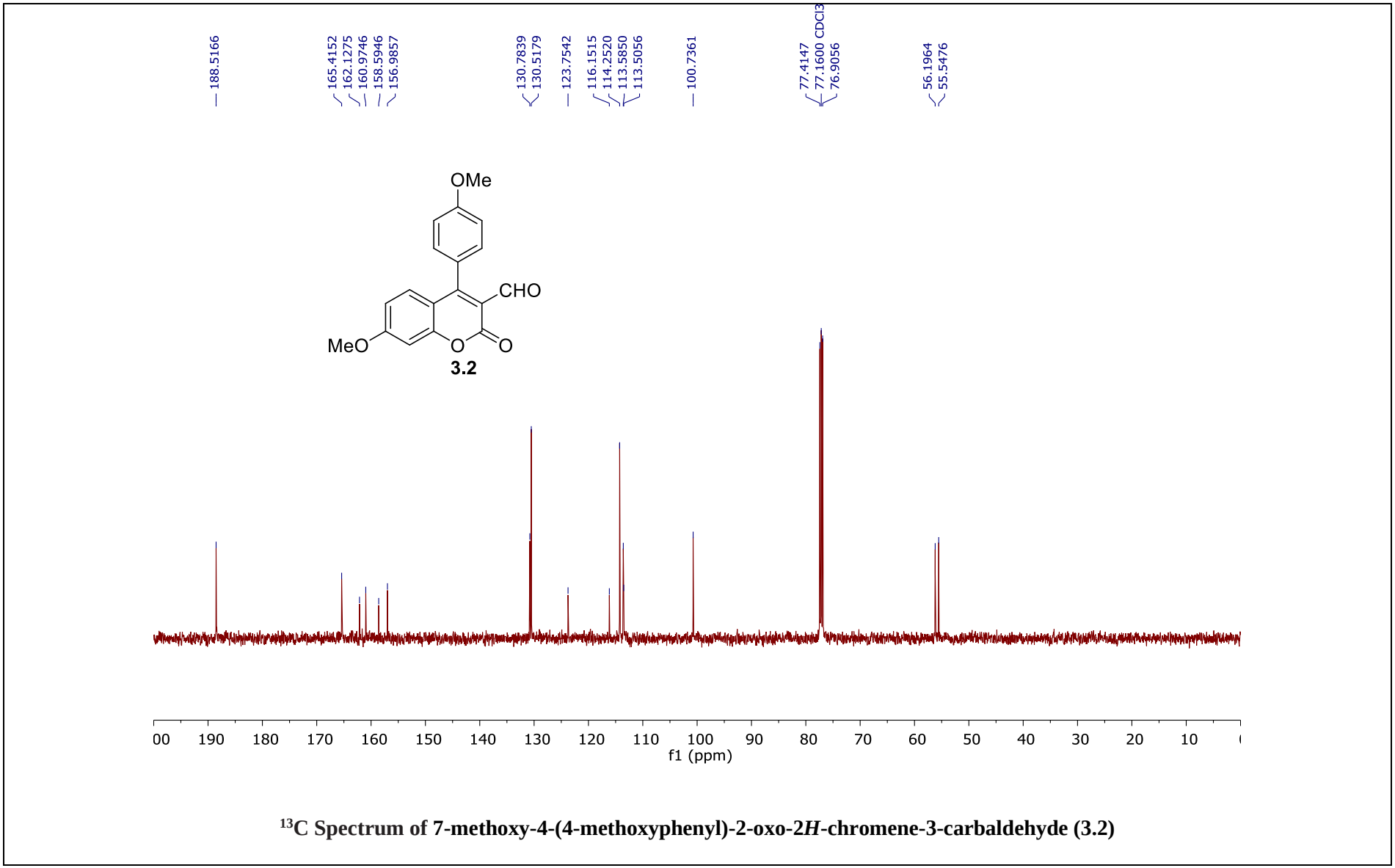
^{1}H Spectrum of 7-methoxy-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.1)



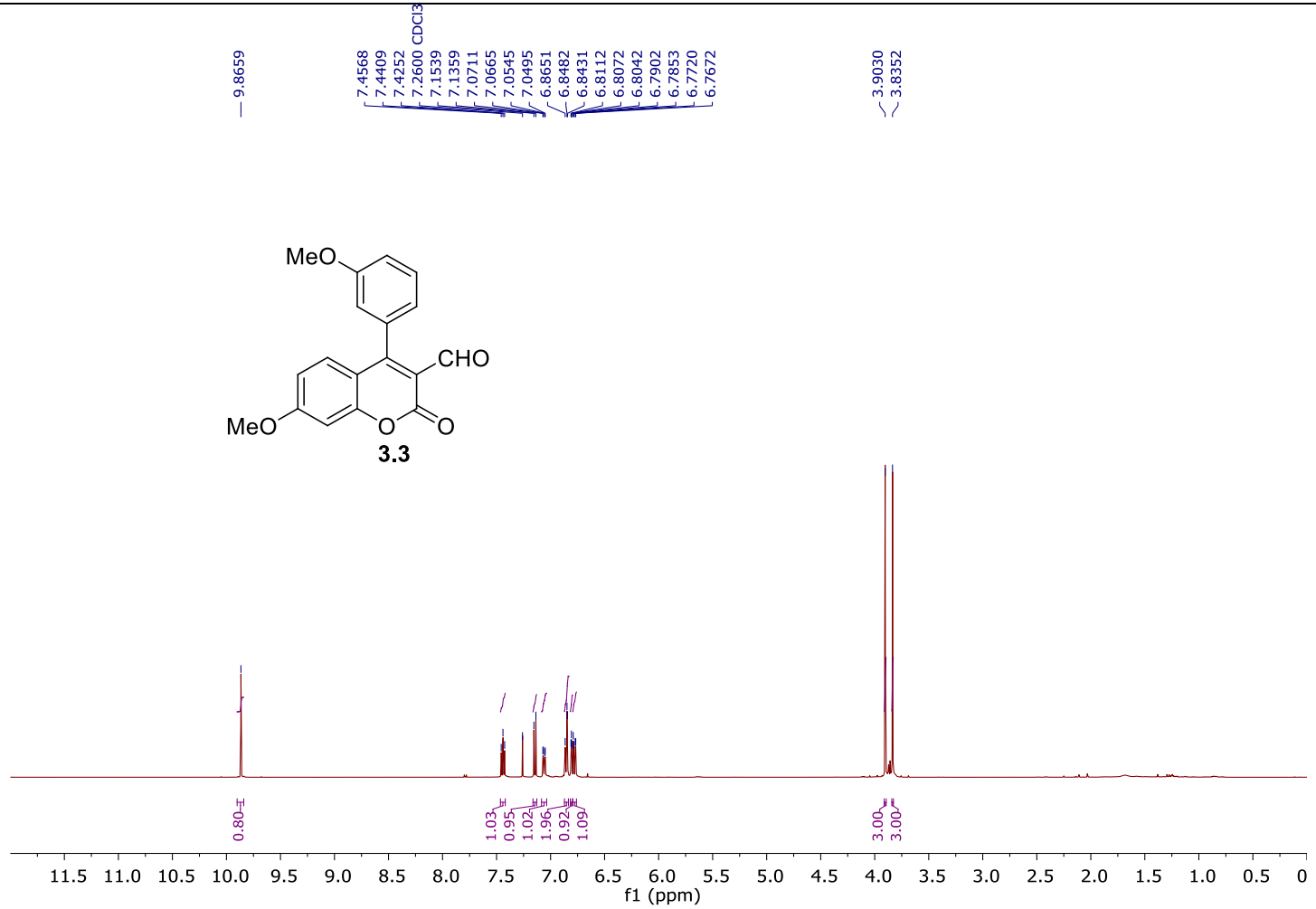
^{13}C Spectrum of 7-methoxy-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.1)



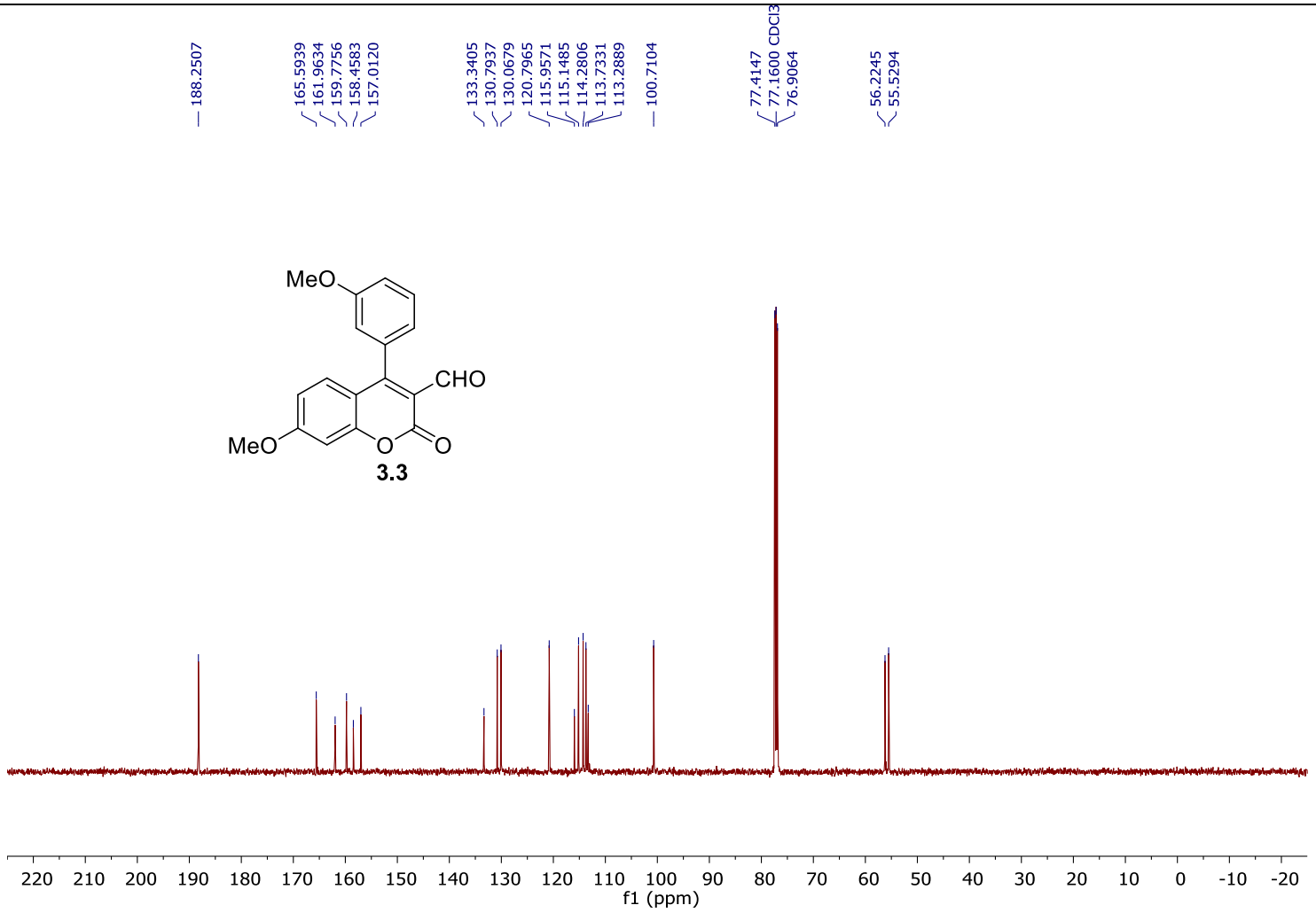
^{1}H Spectrum of 7-methoxy-4-(4-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.2)



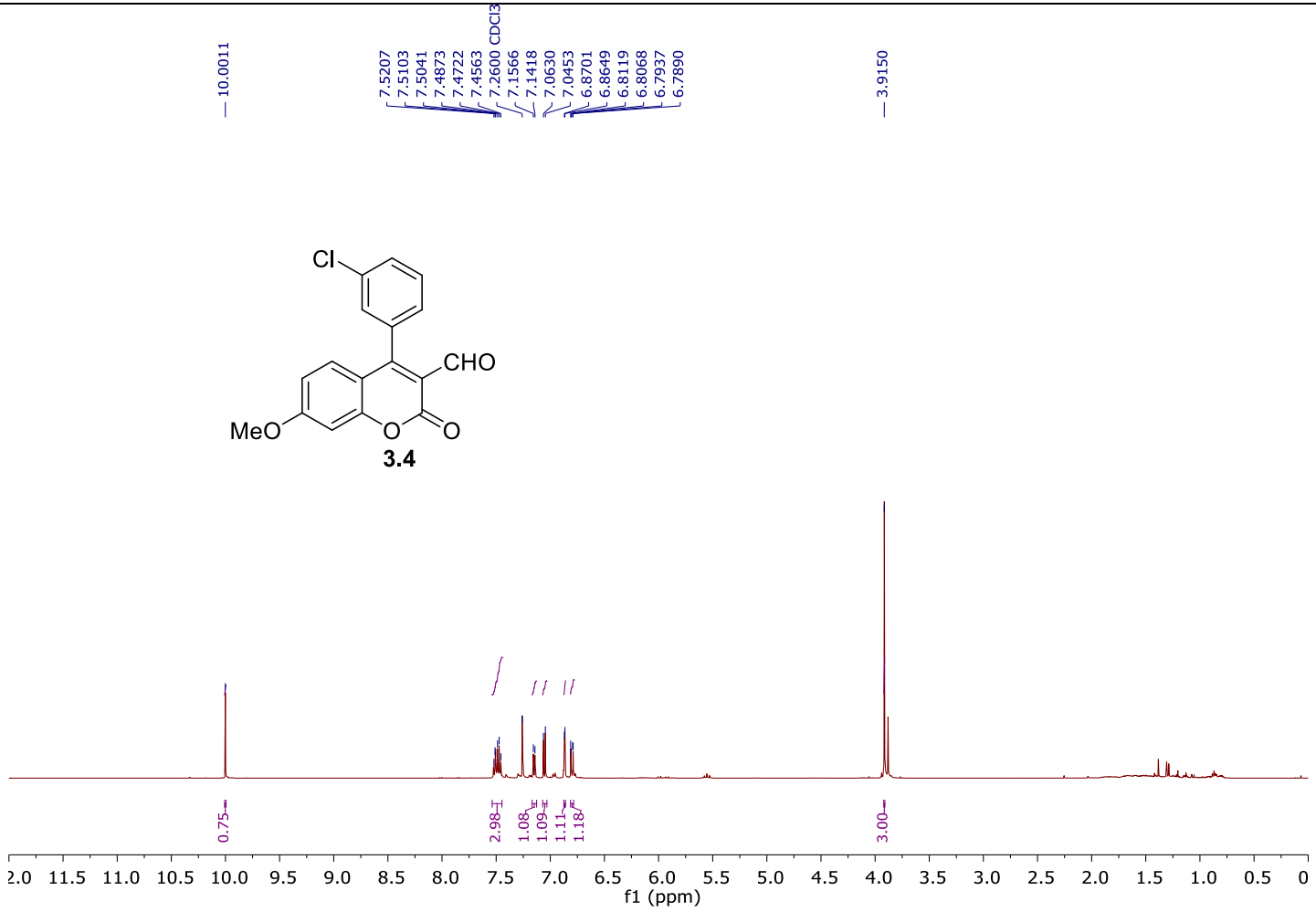
^{13}C Spectrum of 7-methoxy-4-(4-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.2)



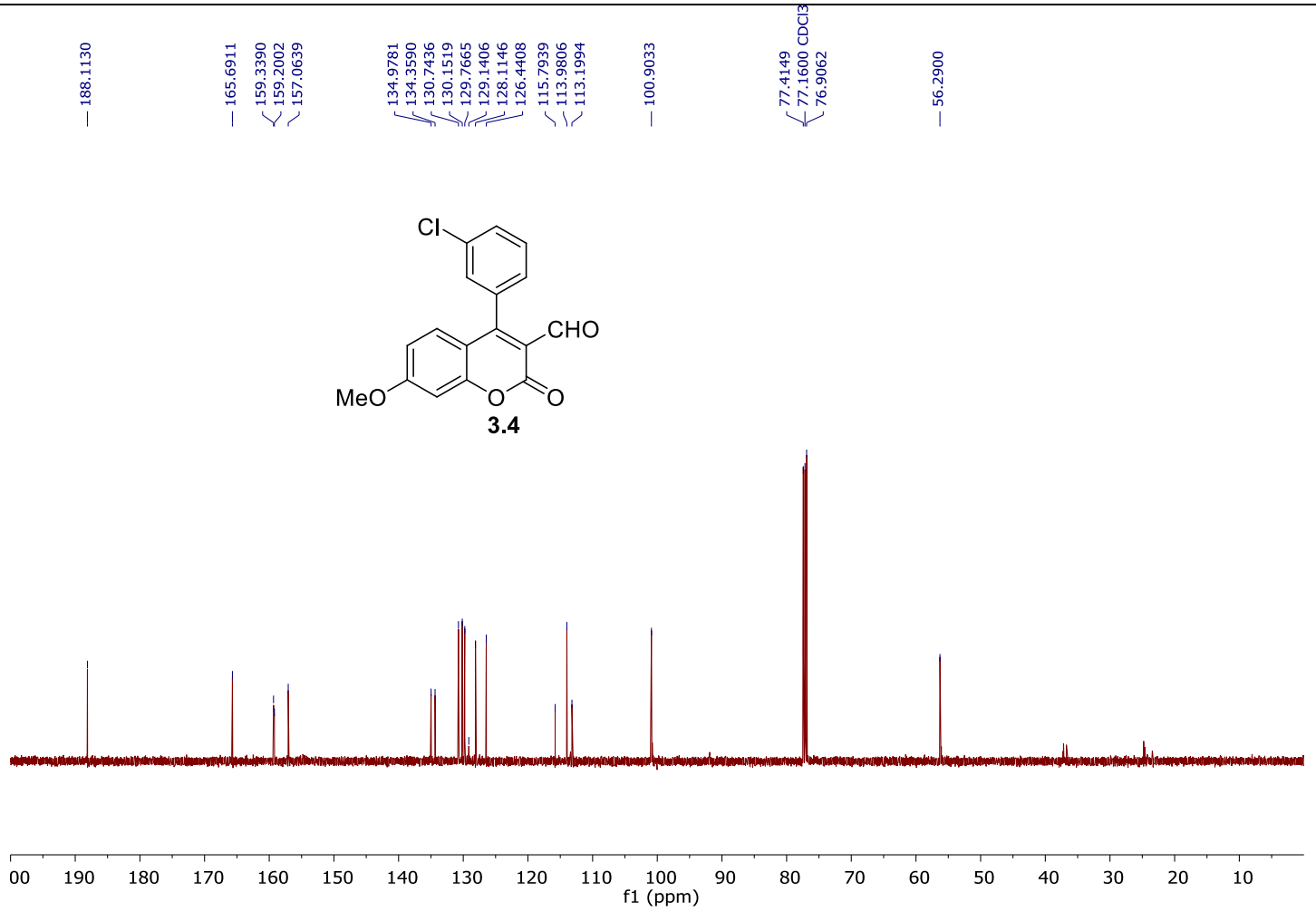
^{1}H Spectrum of 7-methoxy-4-(3-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.3)



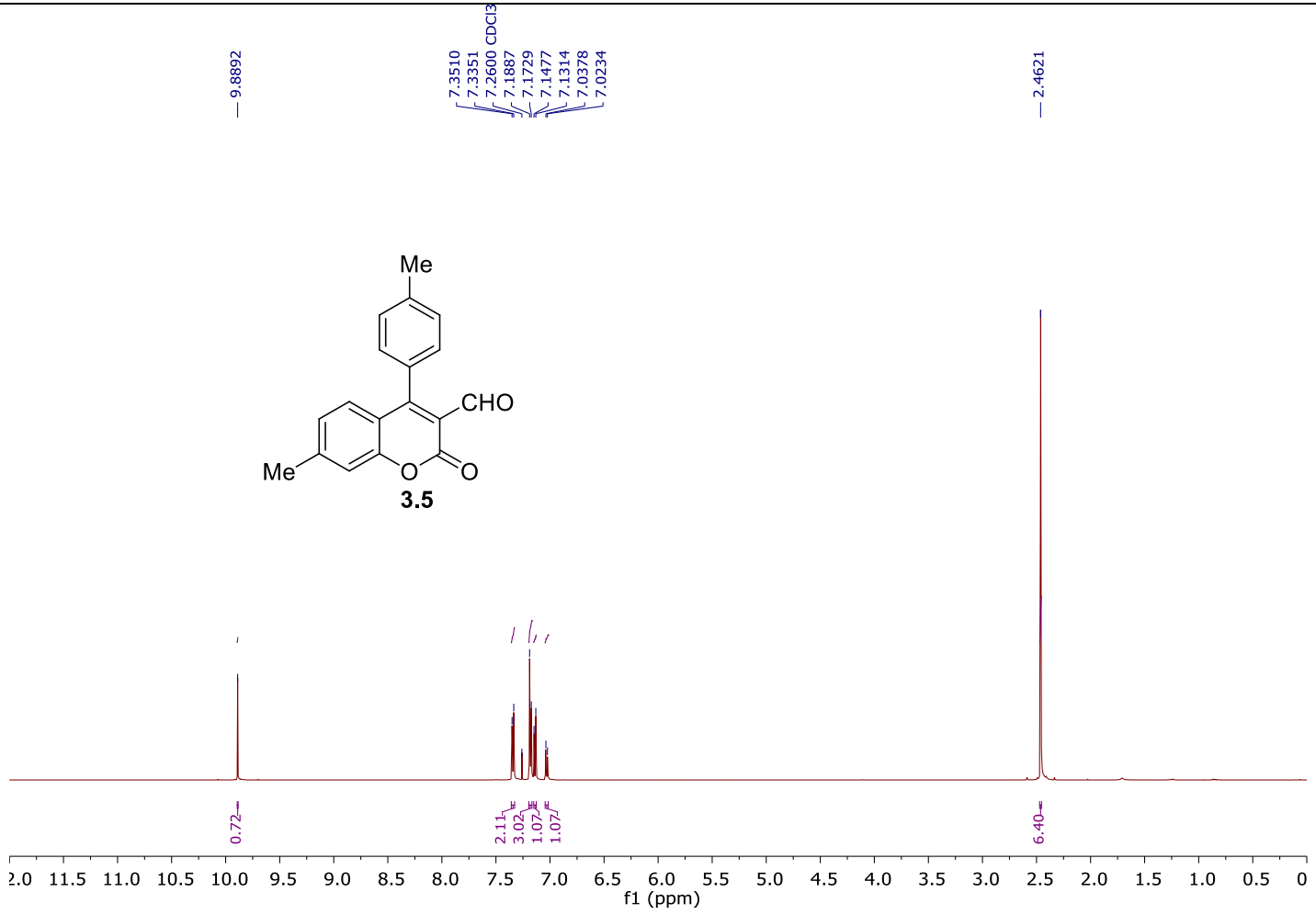
^{13}C Spectrum of 7-methoxy-4-(3-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.3)



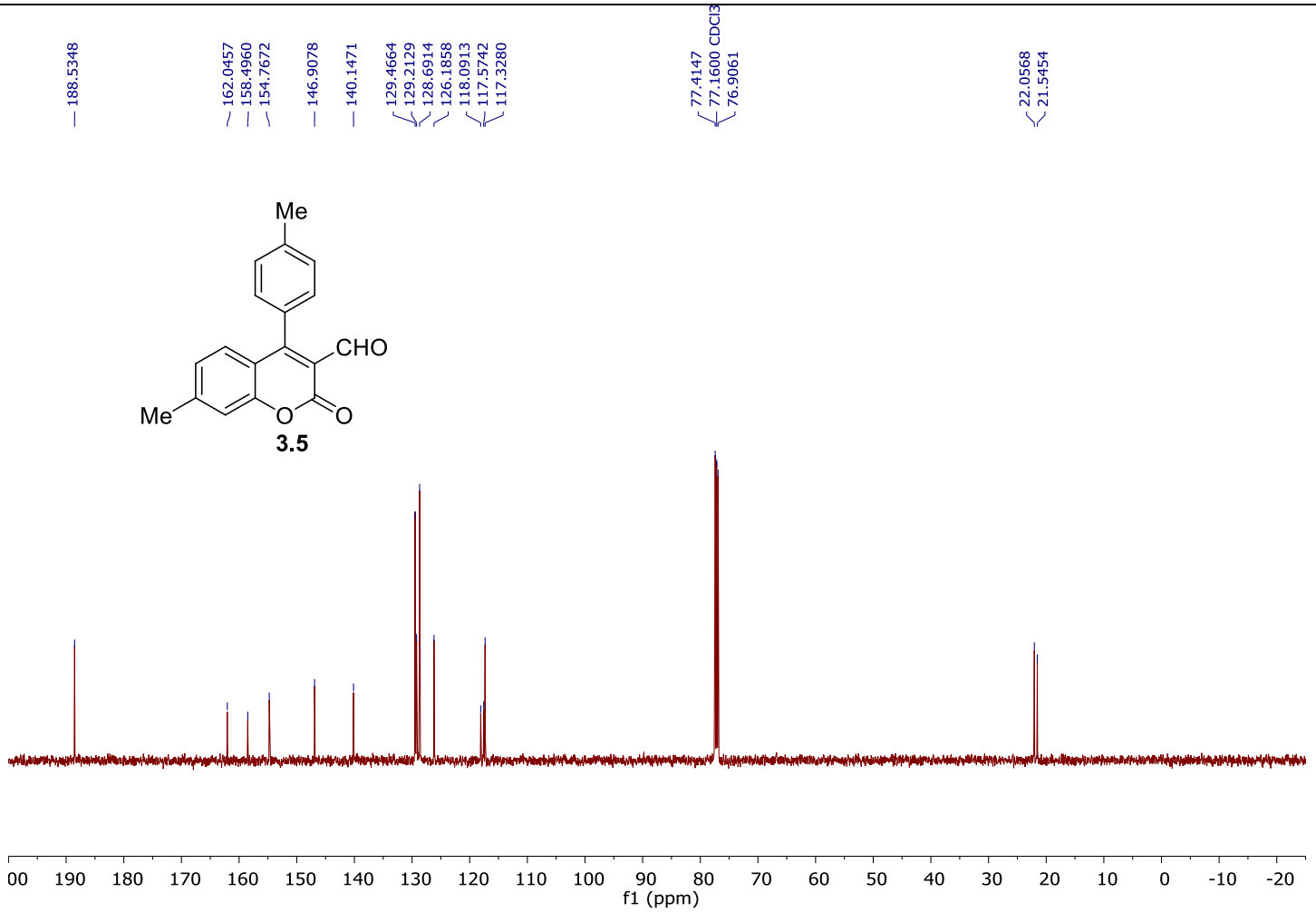
[1]H Spectrum of 4-(3-chlorophenyl)-7-methoxy-2-oxo-2*H*-chromene-3-carbaldehyde (3.4)



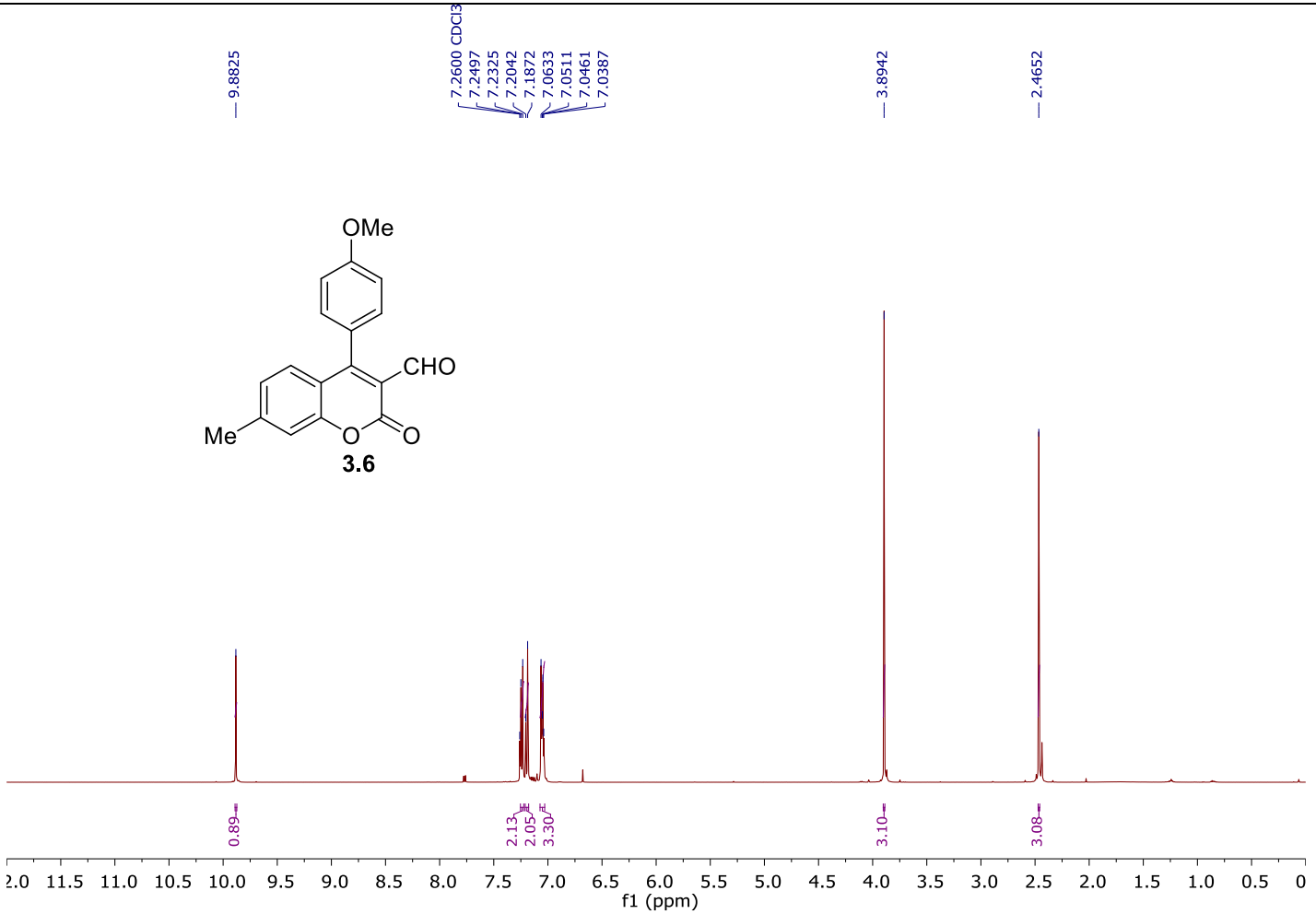
^{13}C Spectrum of 4-(3-chlorophenyl)-7-methoxy-2-oxo-2*H*-chromene-3-carbaldehyde (3.4)



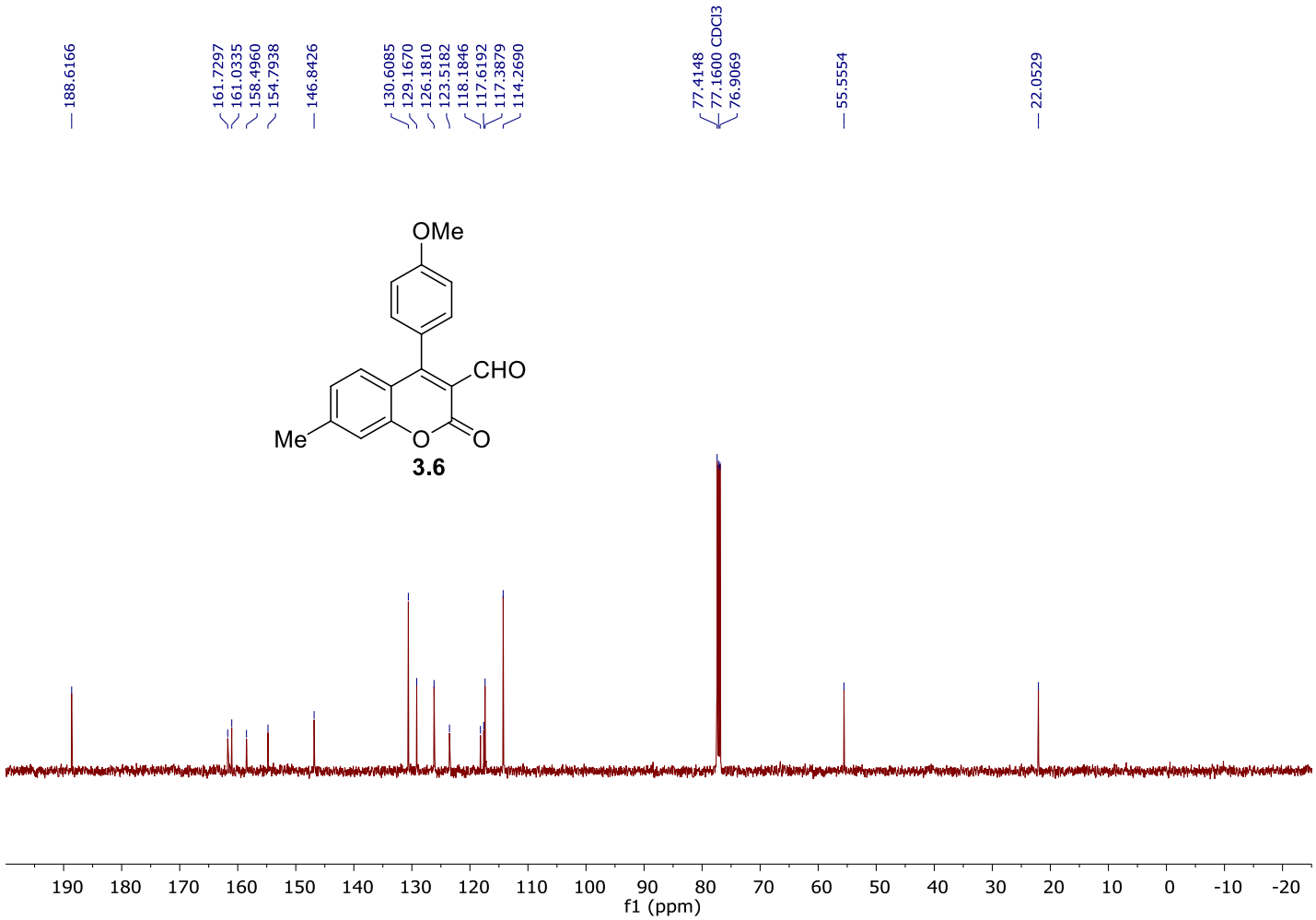
^{1}H Spectrum of 7-methyl-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.5)



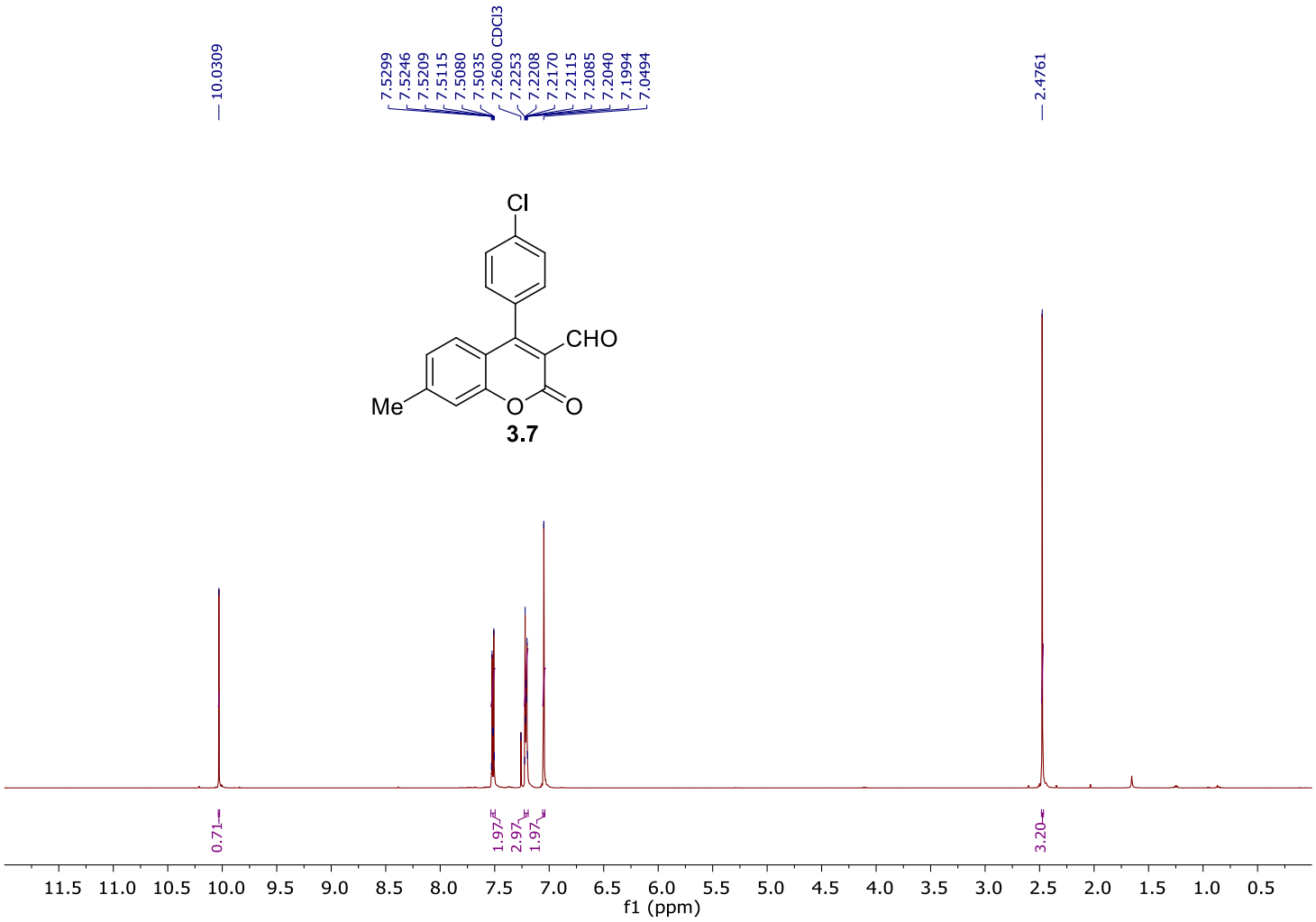
^{13}C Spectrum of 7-methyl-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.5)



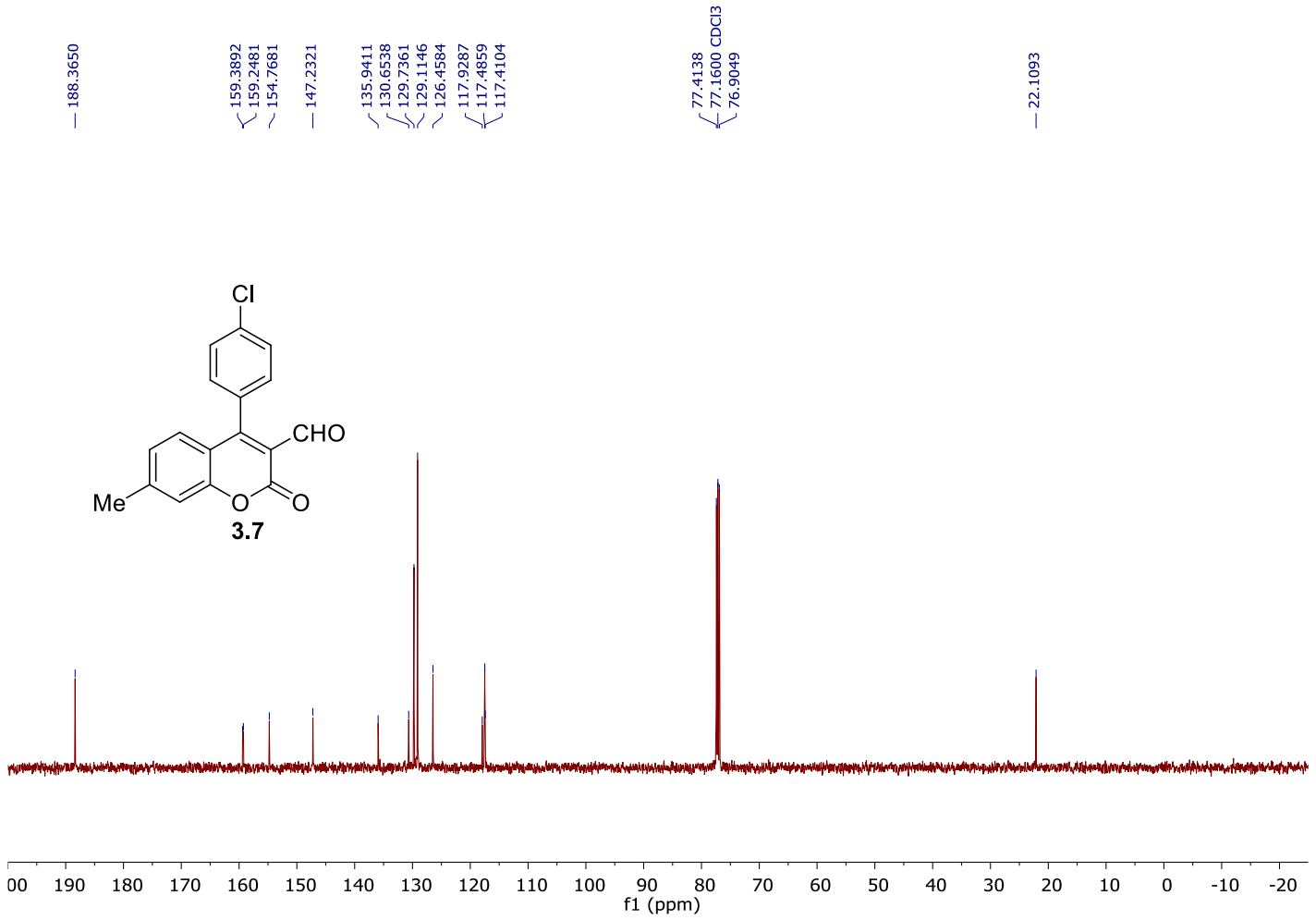
[1]H Spectrum of 4-(4-methoxyphenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.6)



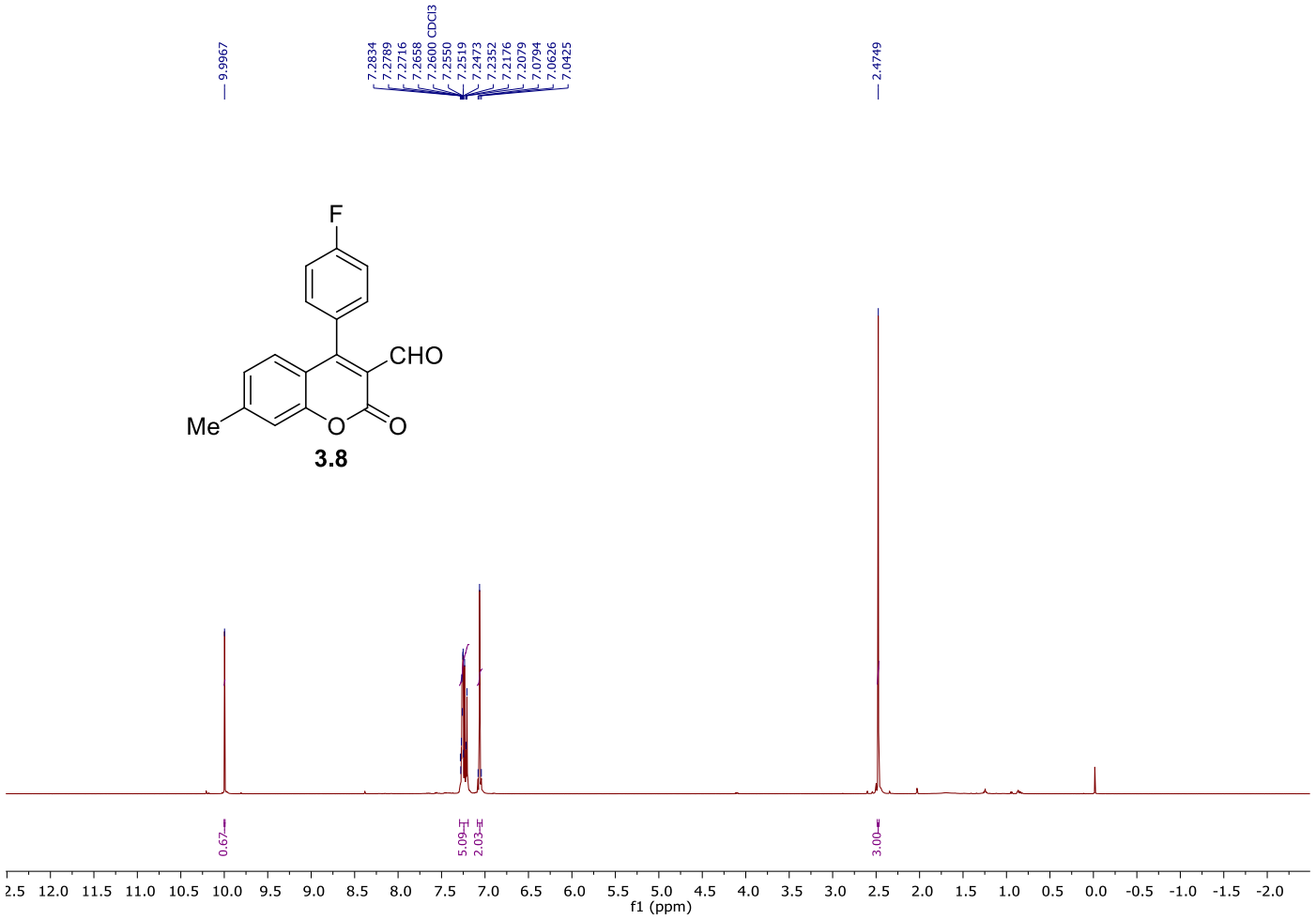
^{13}C Spectrum of 4-(4-methoxyphenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.6)



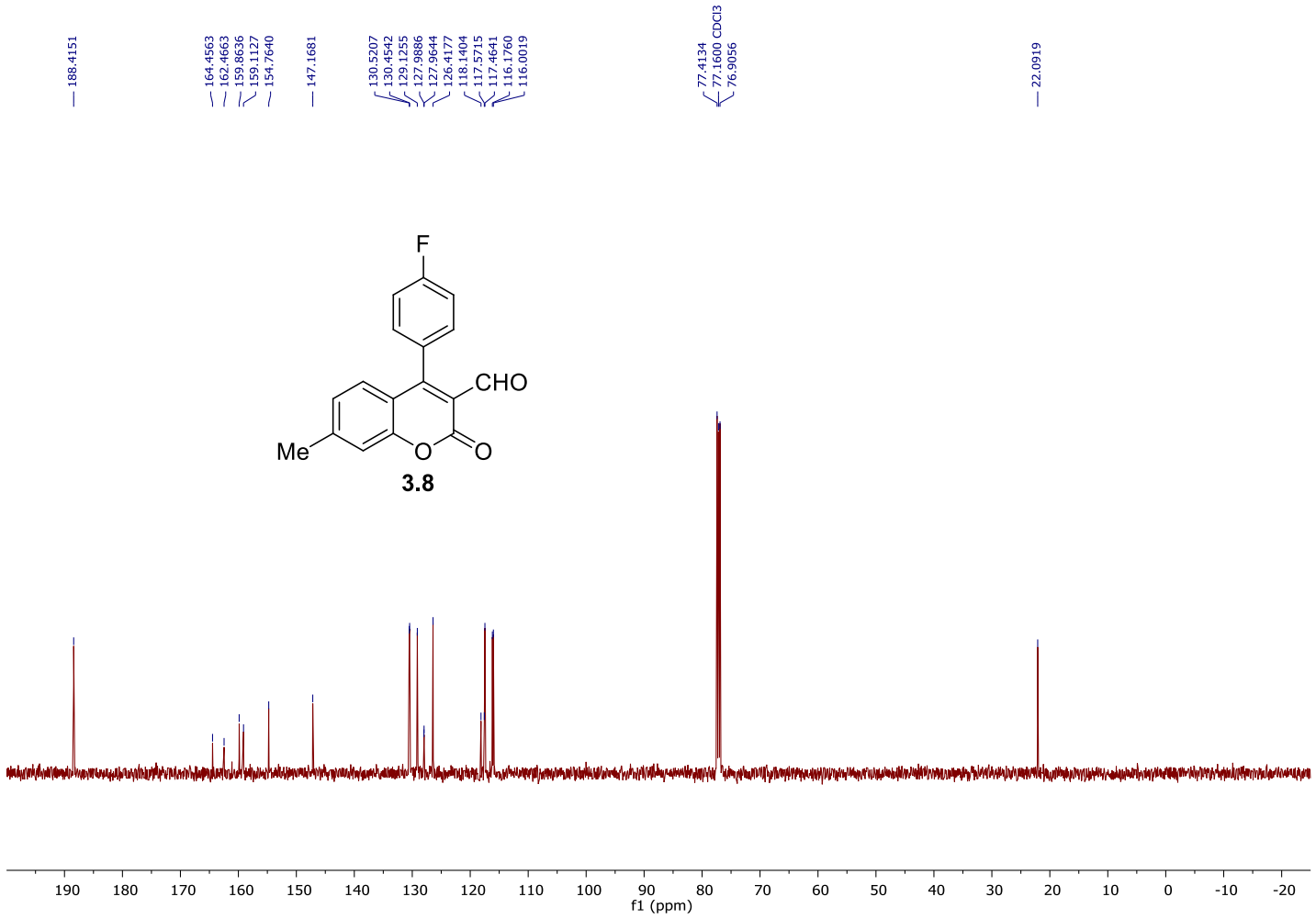
^{1}H Spectrum of 4-(4-chlorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.7)



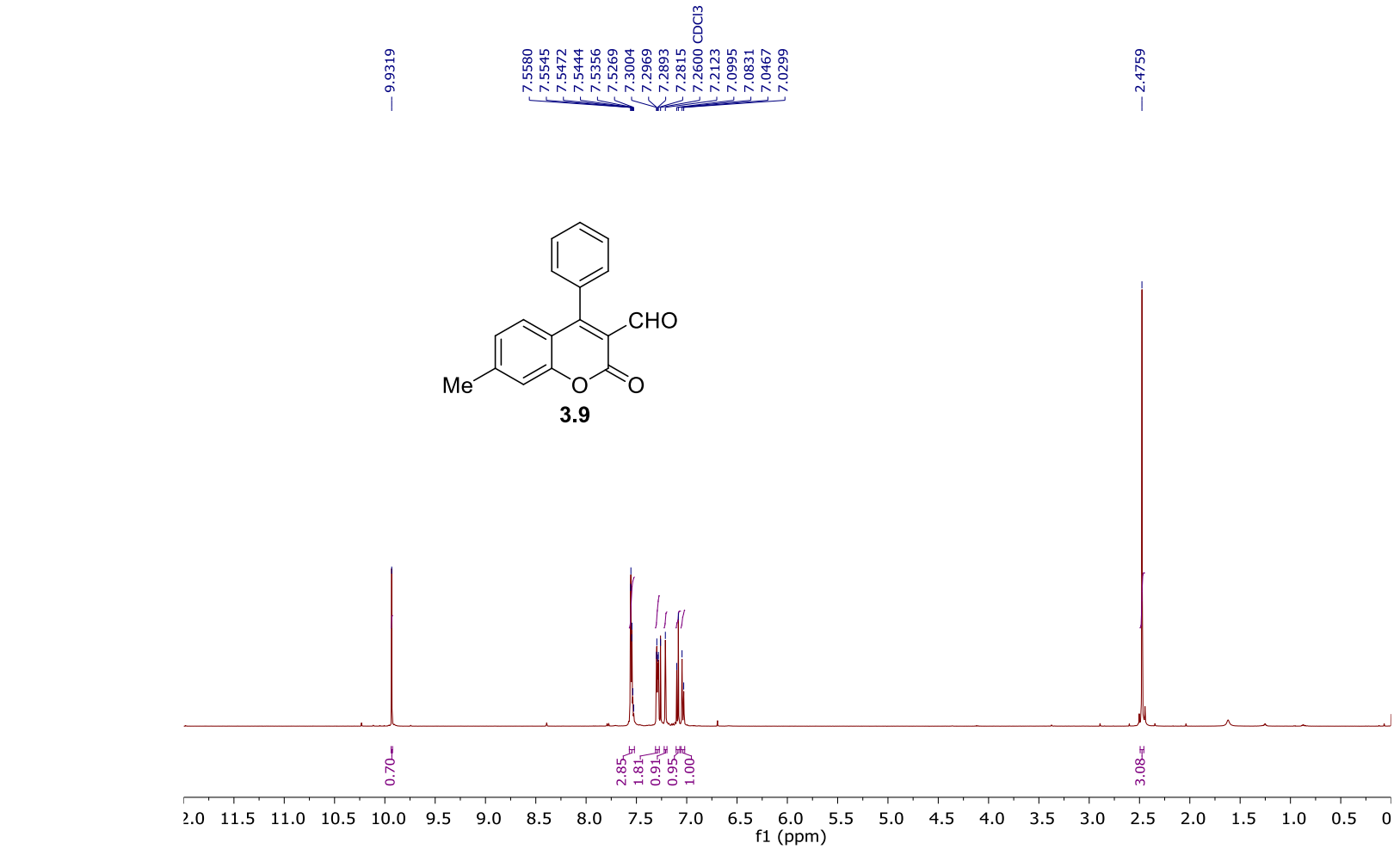
^{13}C Spectrum of 4-(4-chlorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.7)



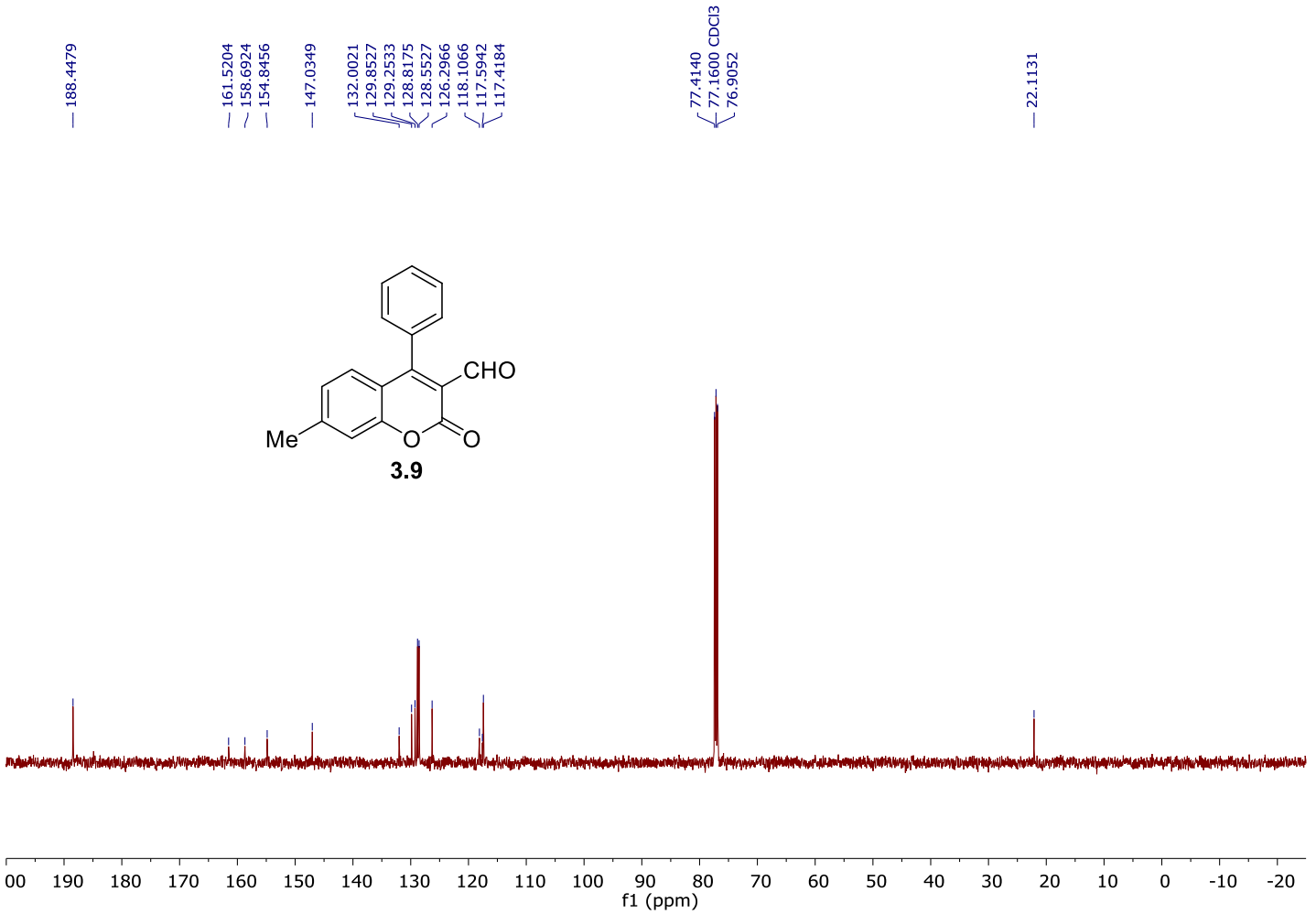
^{1}H Spectrum of 4-(4-fluorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.8)



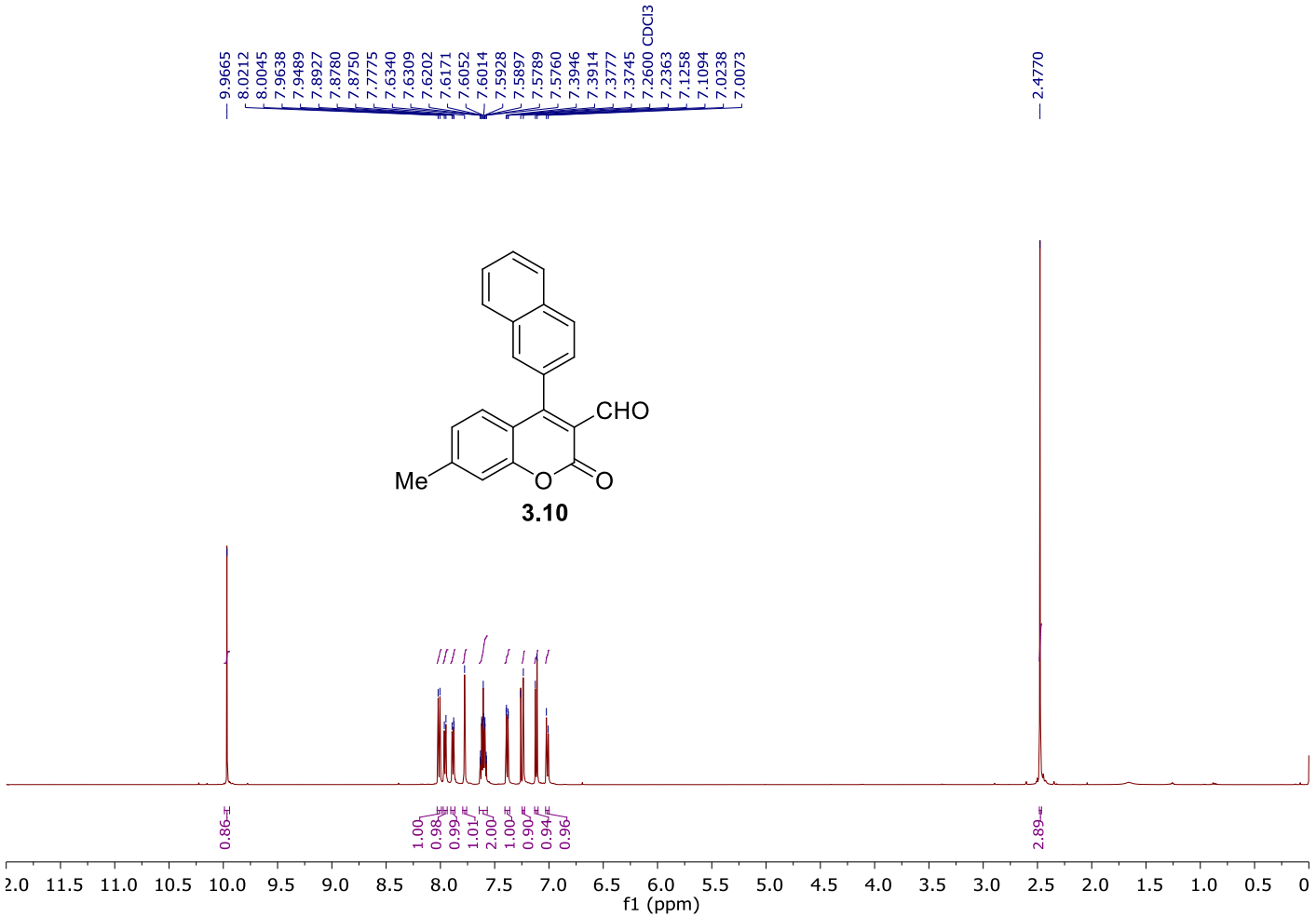
^{13}C Spectrum of 4-(4-fluorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.8)



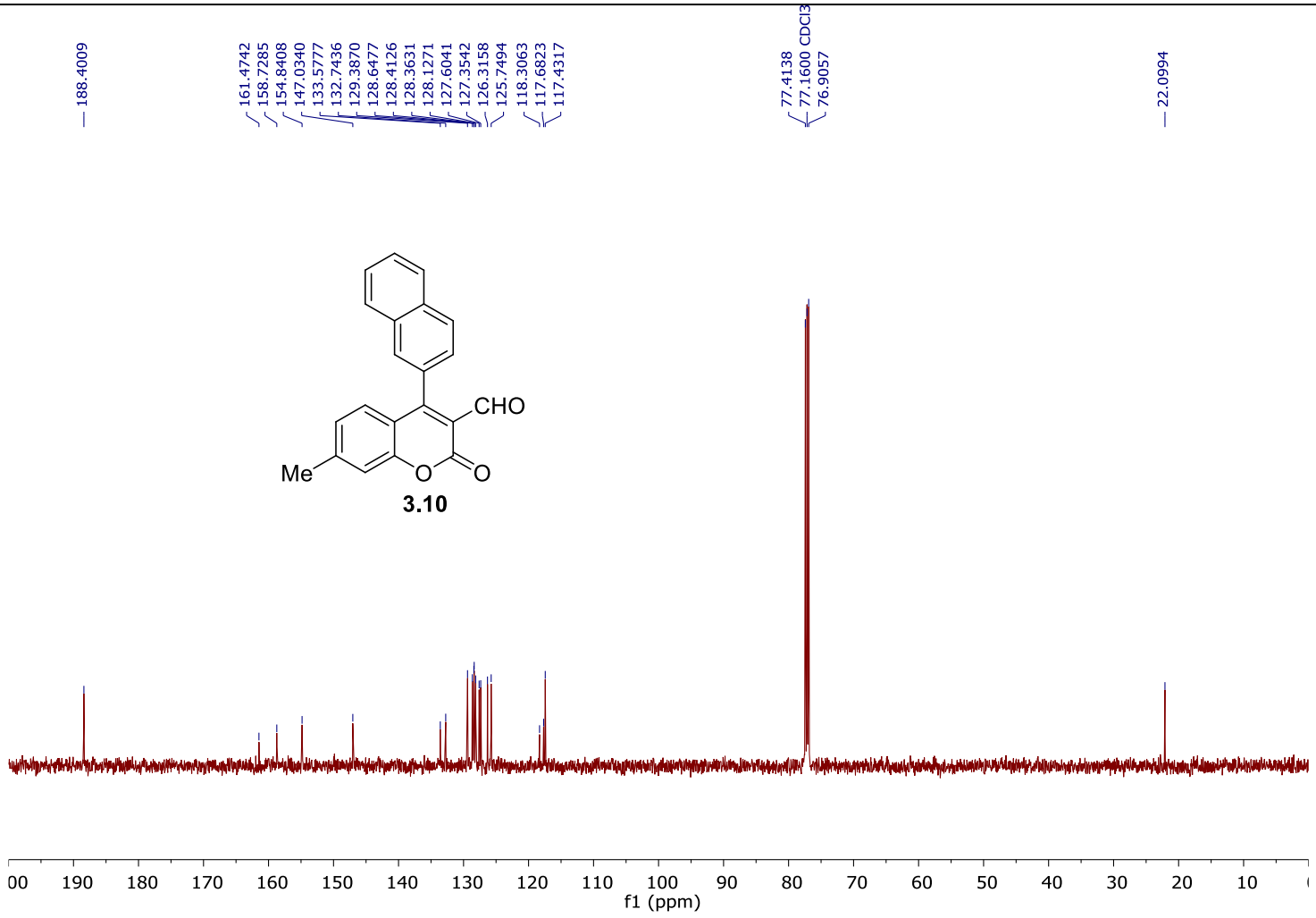
^{1}H Spectrum of 7-methyl-2-oxo-4-phenyl-2*H*-chromene-3-carbaldehyde (3.9)



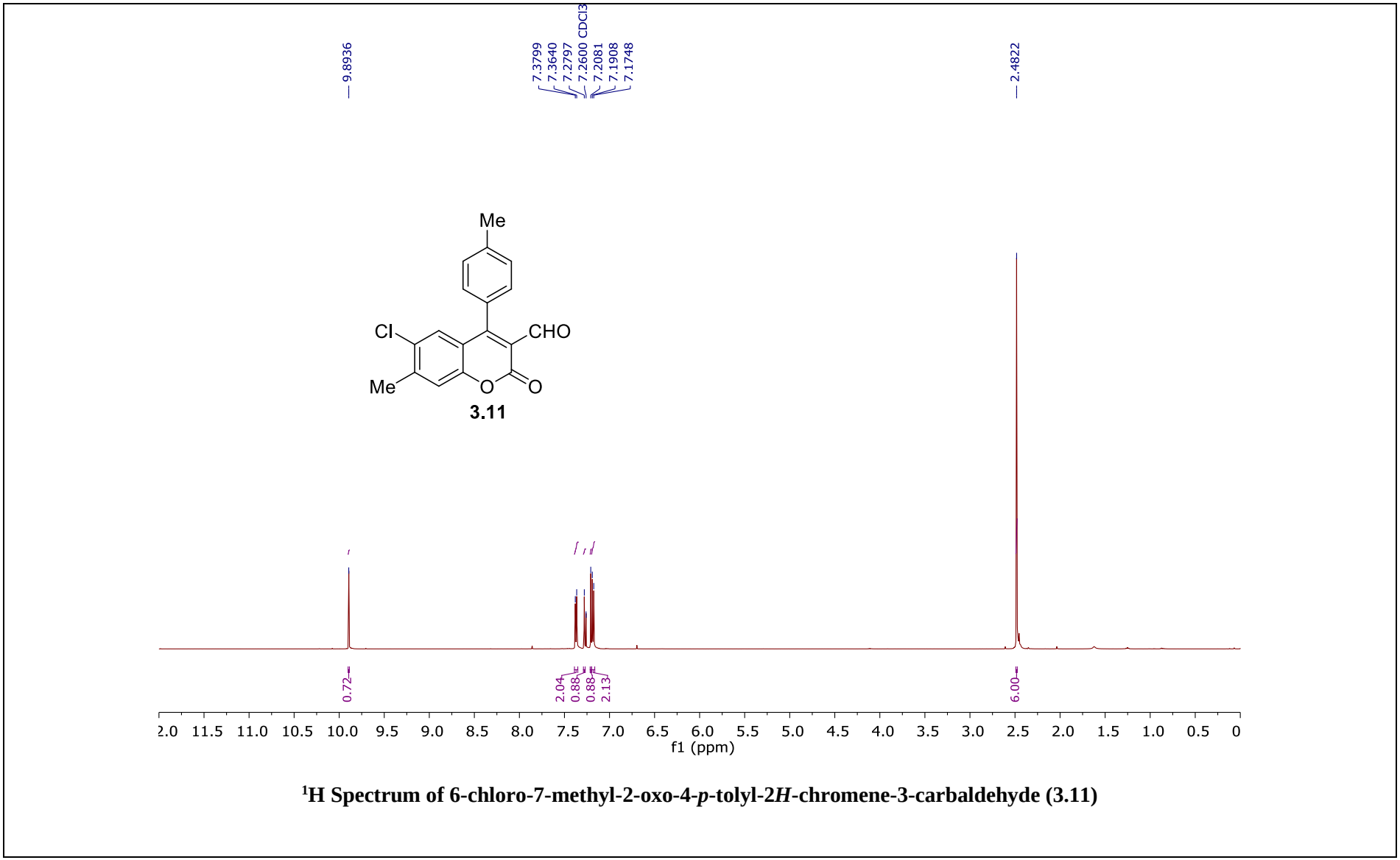
^{13}C Spectrum of 7-methyl-2-oxo-4-phenyl-2*H*-chromene-3-carbaldehyde (3.9)



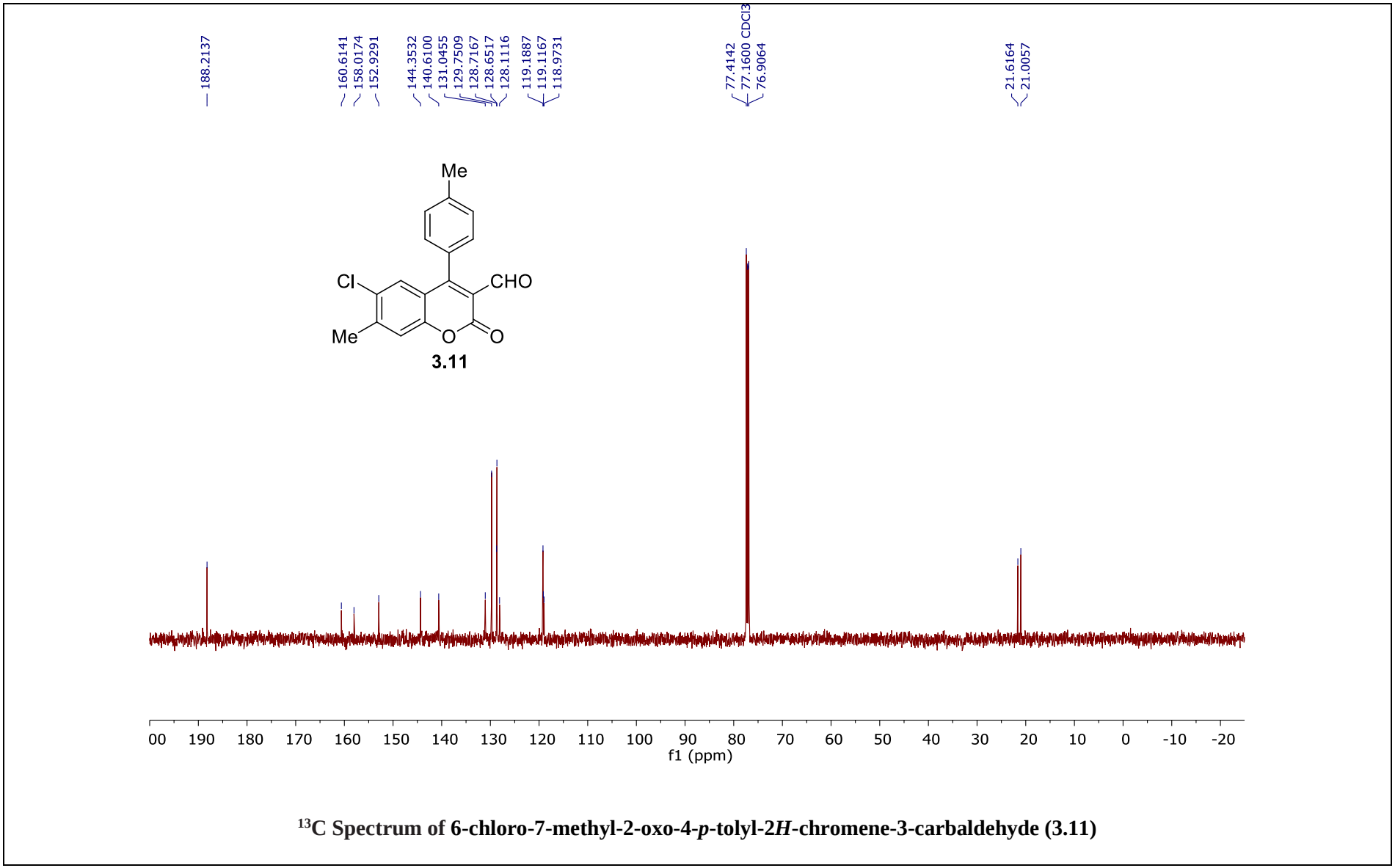
[1]H Spectrum of 7-methyl-4-(naphthalen-2-yl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.10)



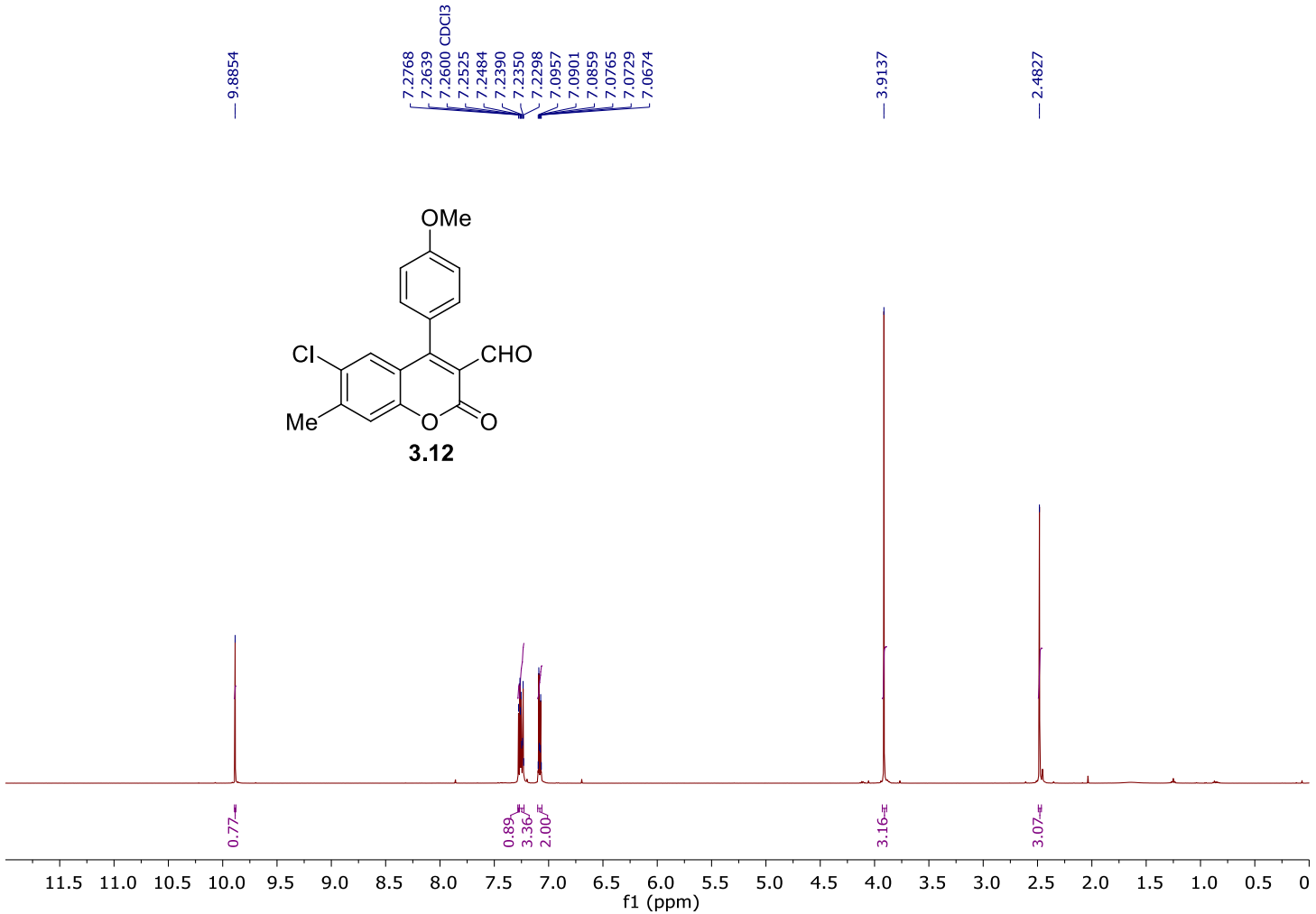
^{13}C Spectrum of 7-methyl-4-(naphthalen-2-yl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.10)



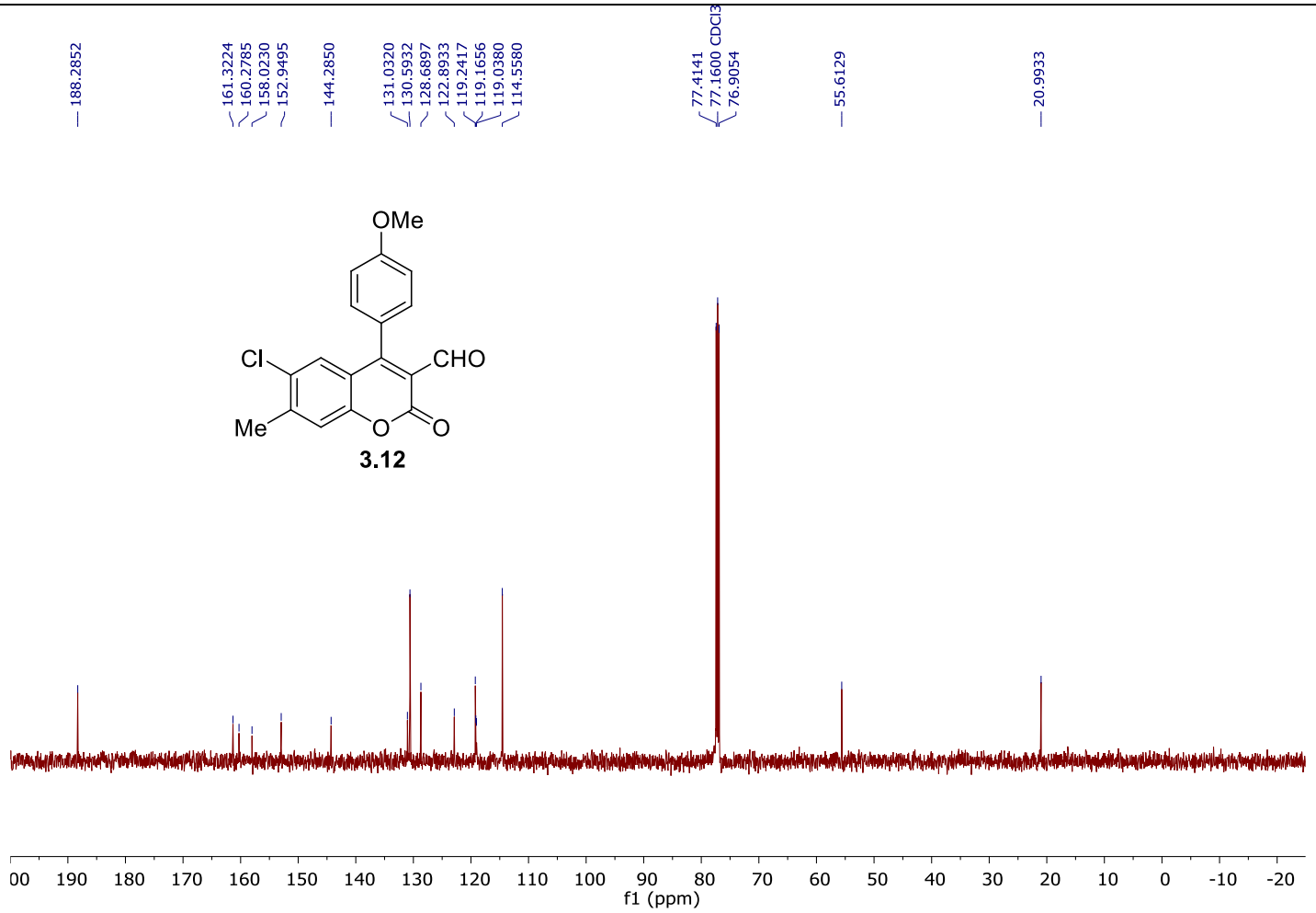
^{1}H Spectrum of 6-chloro-7-methyl-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.11)



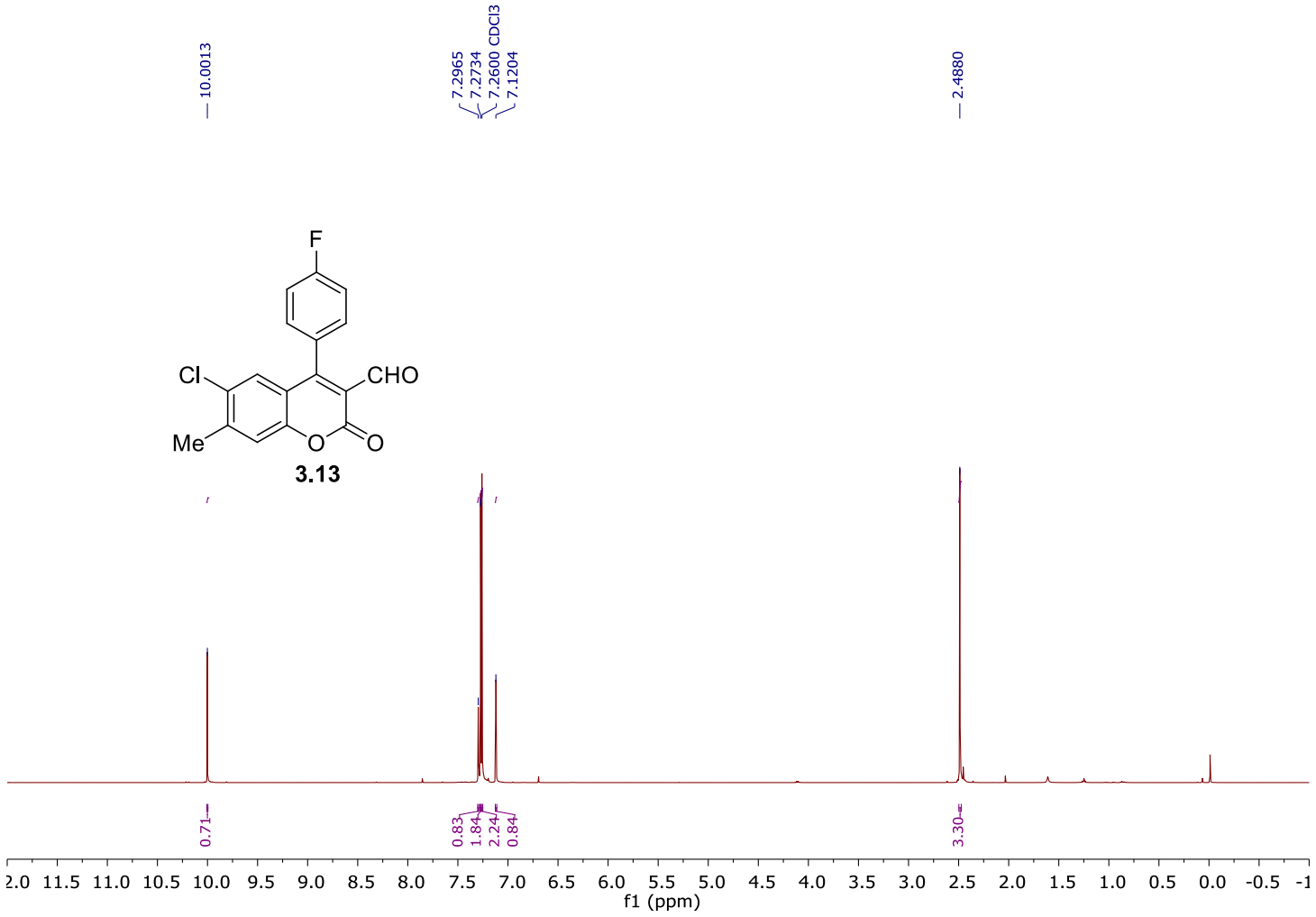
^{13}C Spectrum of 6-chloro-7-methyl-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.11)



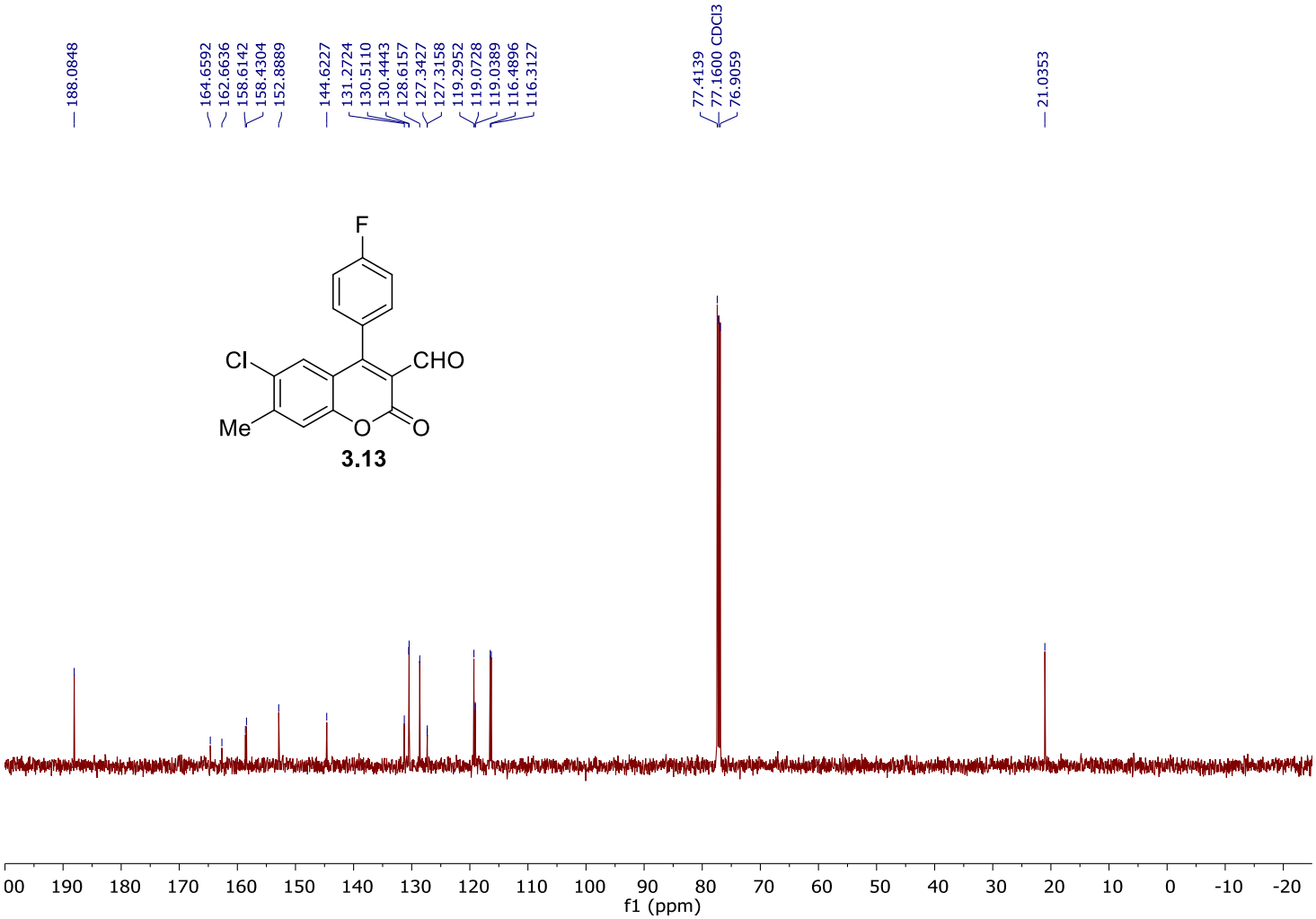
^{1}H Spectrum of 6-chloro-4-(4-methoxyphenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.12)



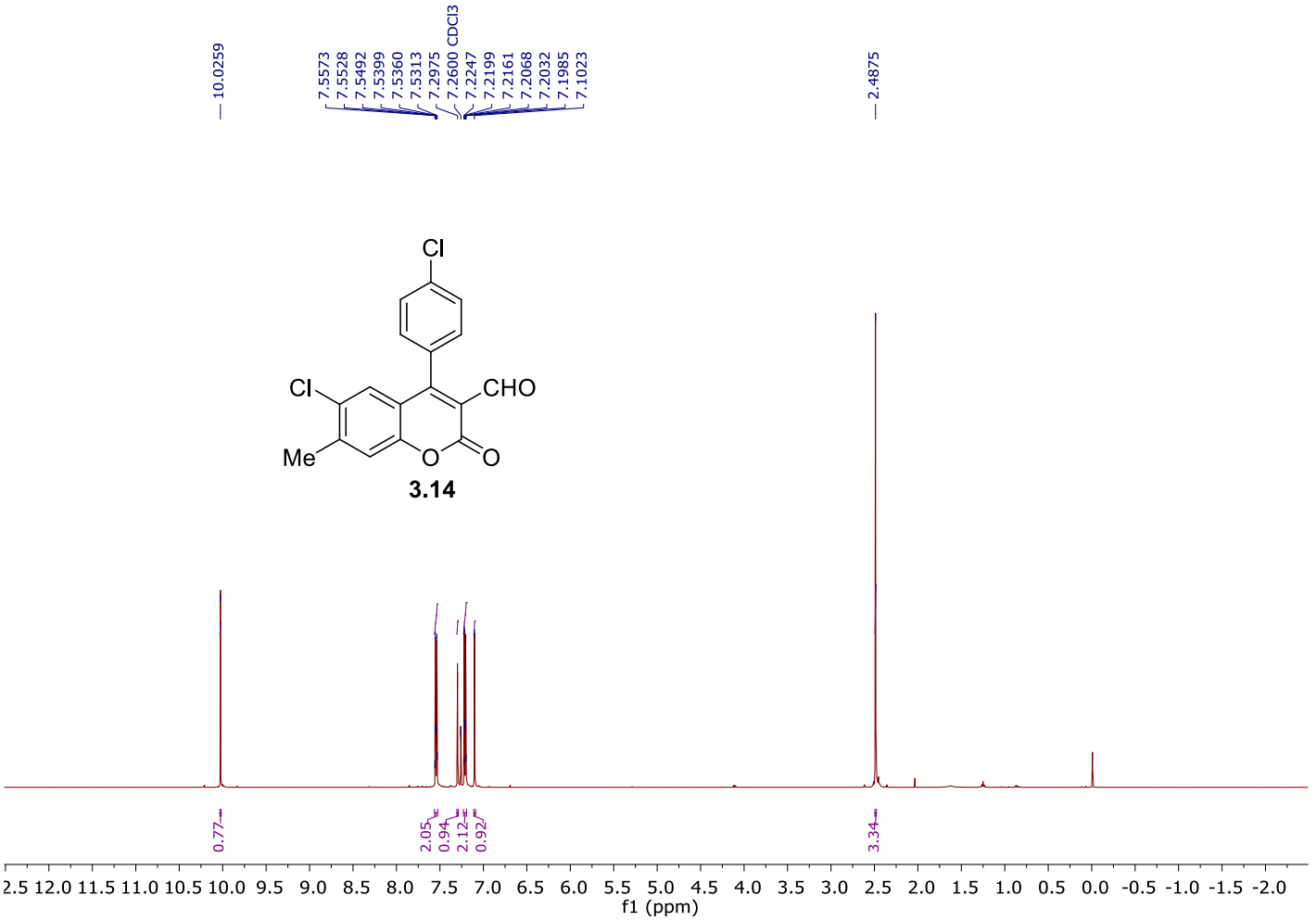
^{13}C Spectrum of 6-chloro-4-(4-methoxyphenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.12)



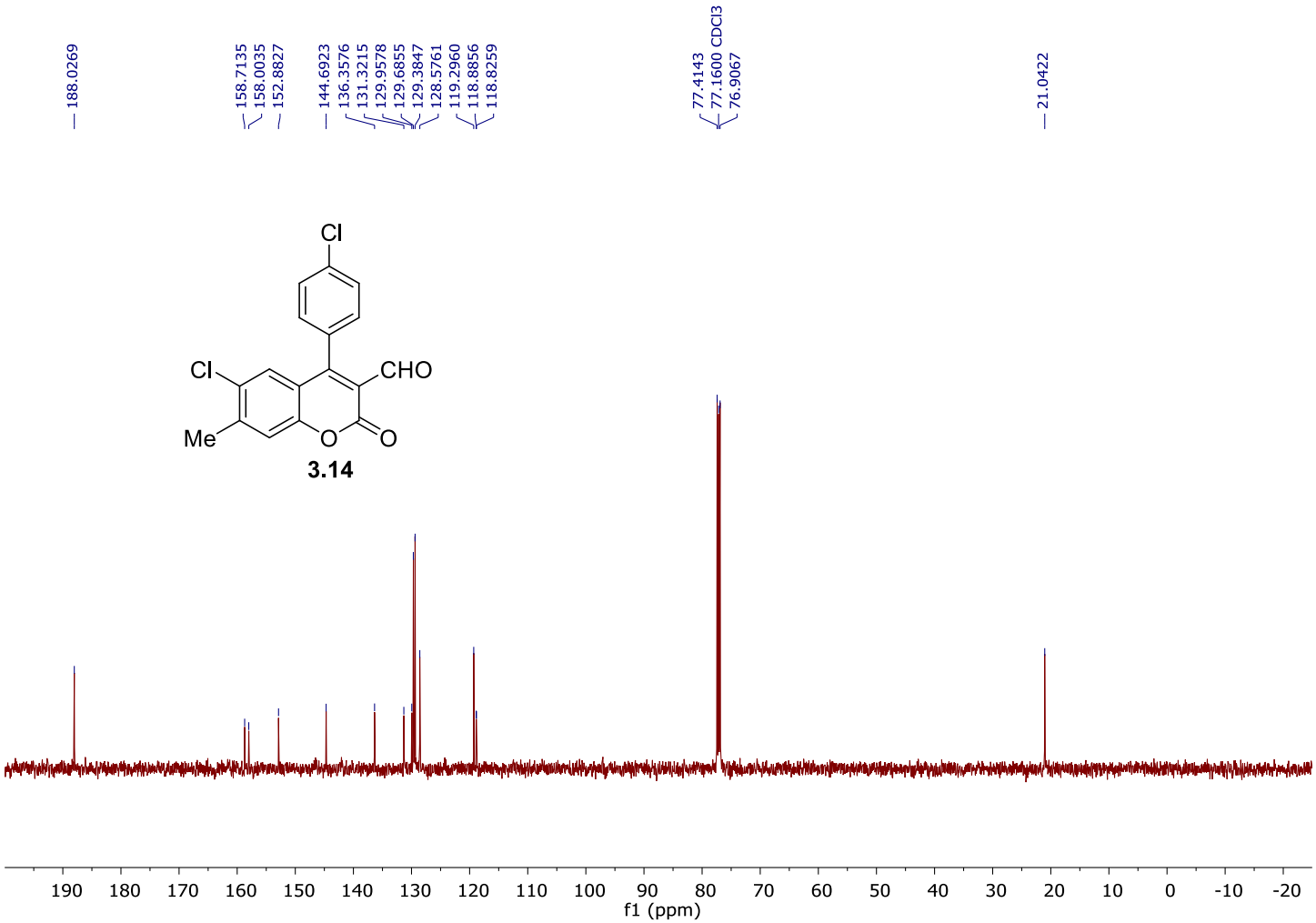
^{1}H Spectrum of 6-chloro-4-(4-fluorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.13)



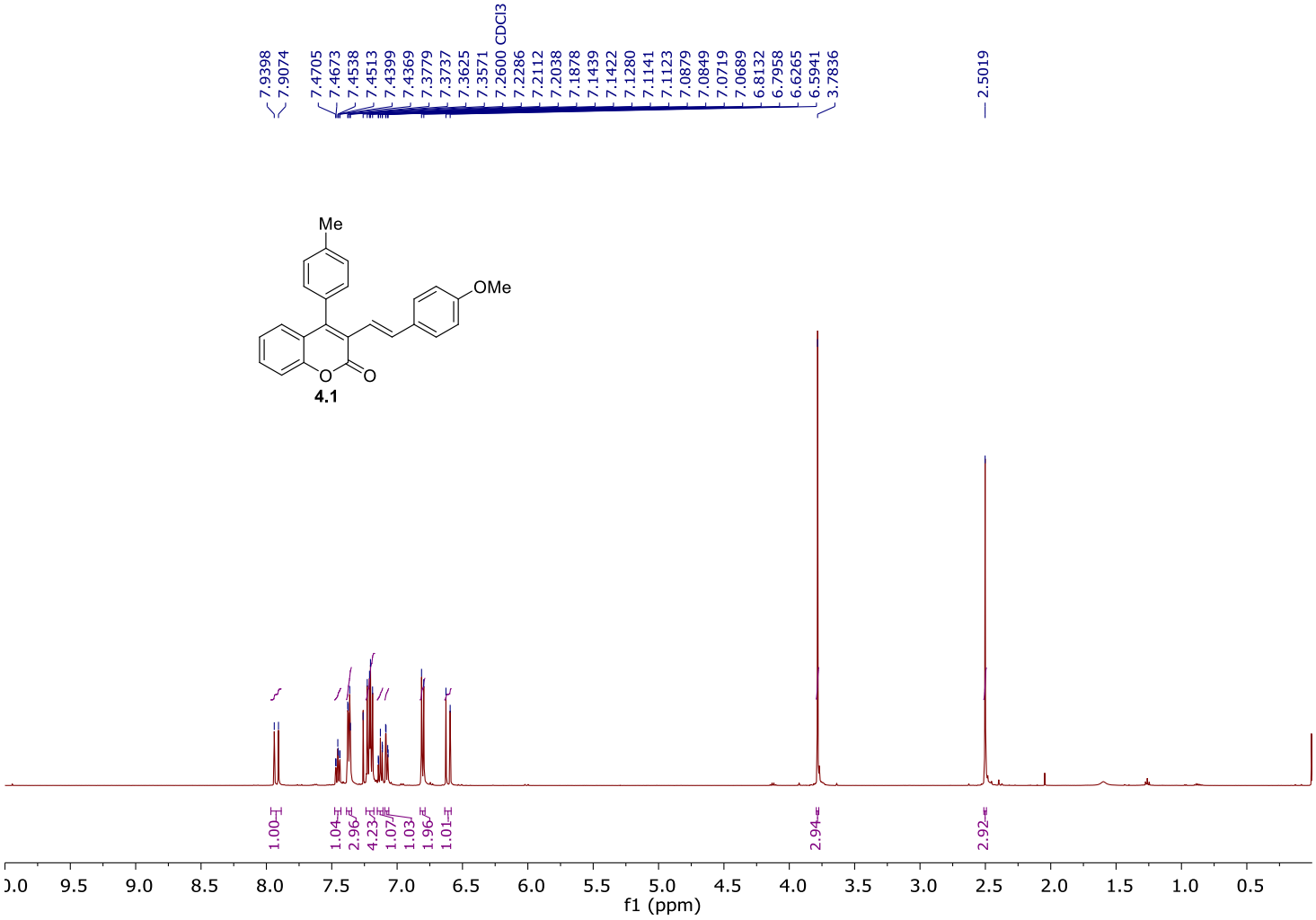
^{13}C Spectrum of 6-chloro-4-(4-fluorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.13)



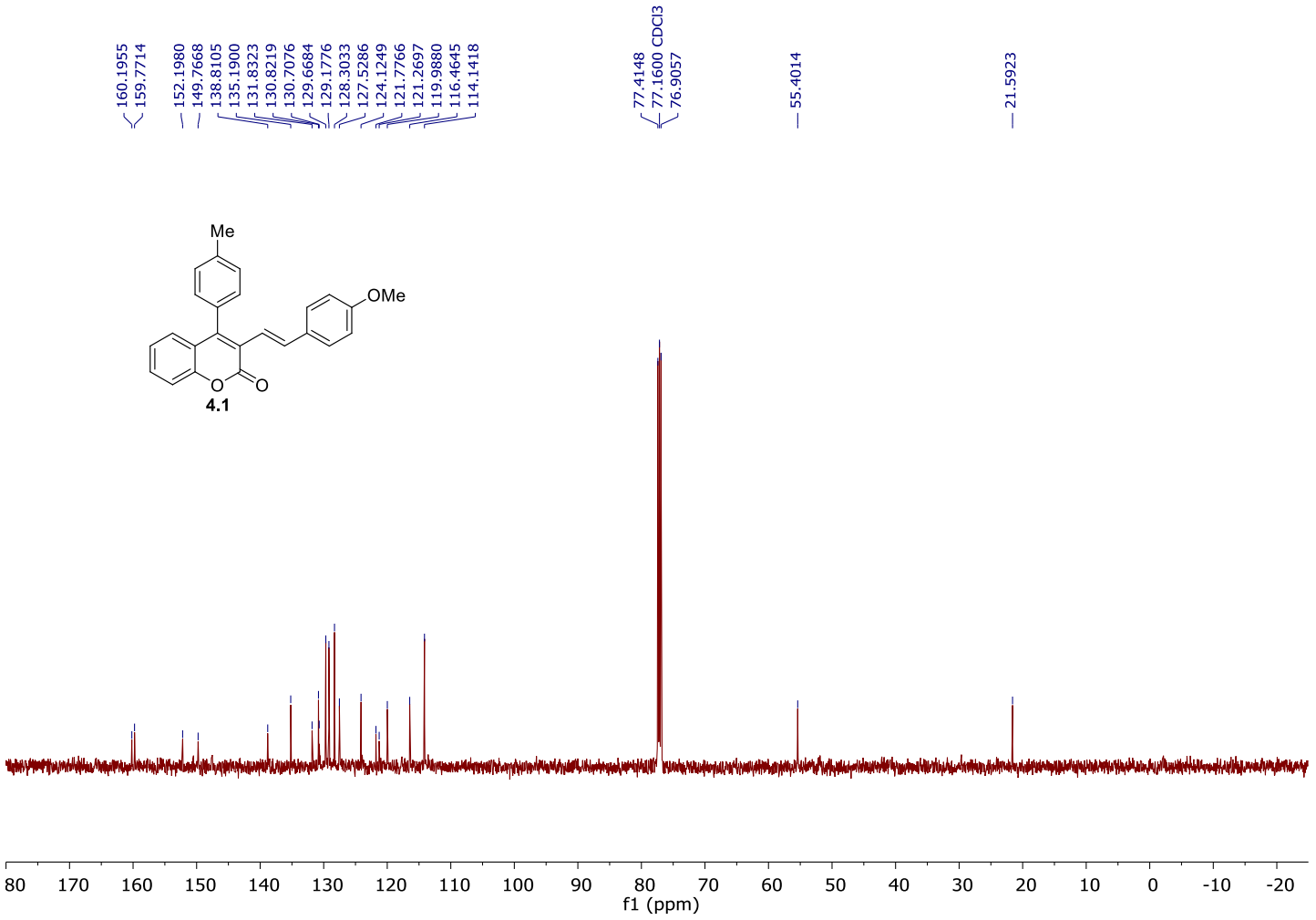
^{1}H Spectrum of 6-chloro-4-(4-chlorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.14)



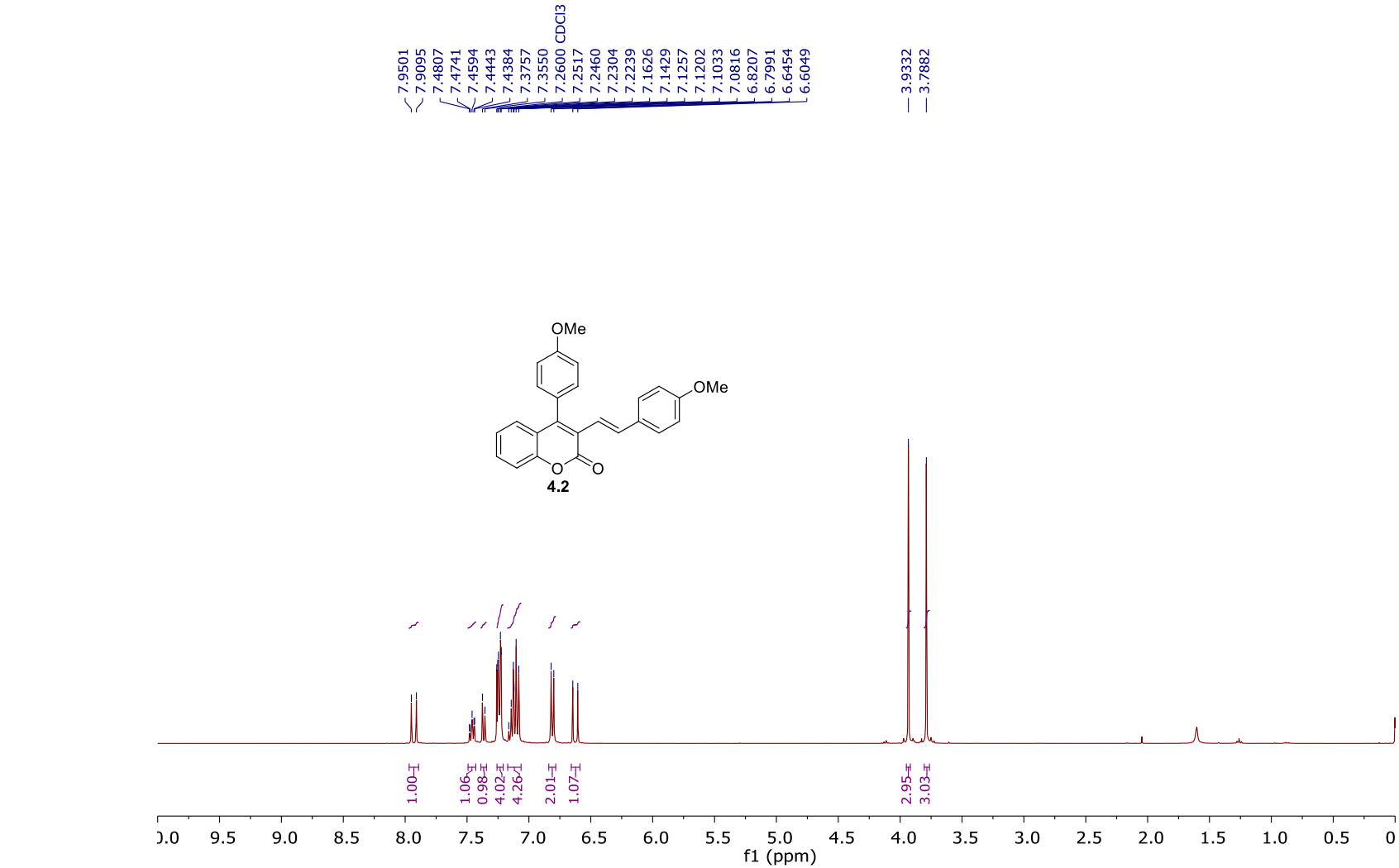
^{13}C Spectrum of 6-chloro-4-(4-chlorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.14)



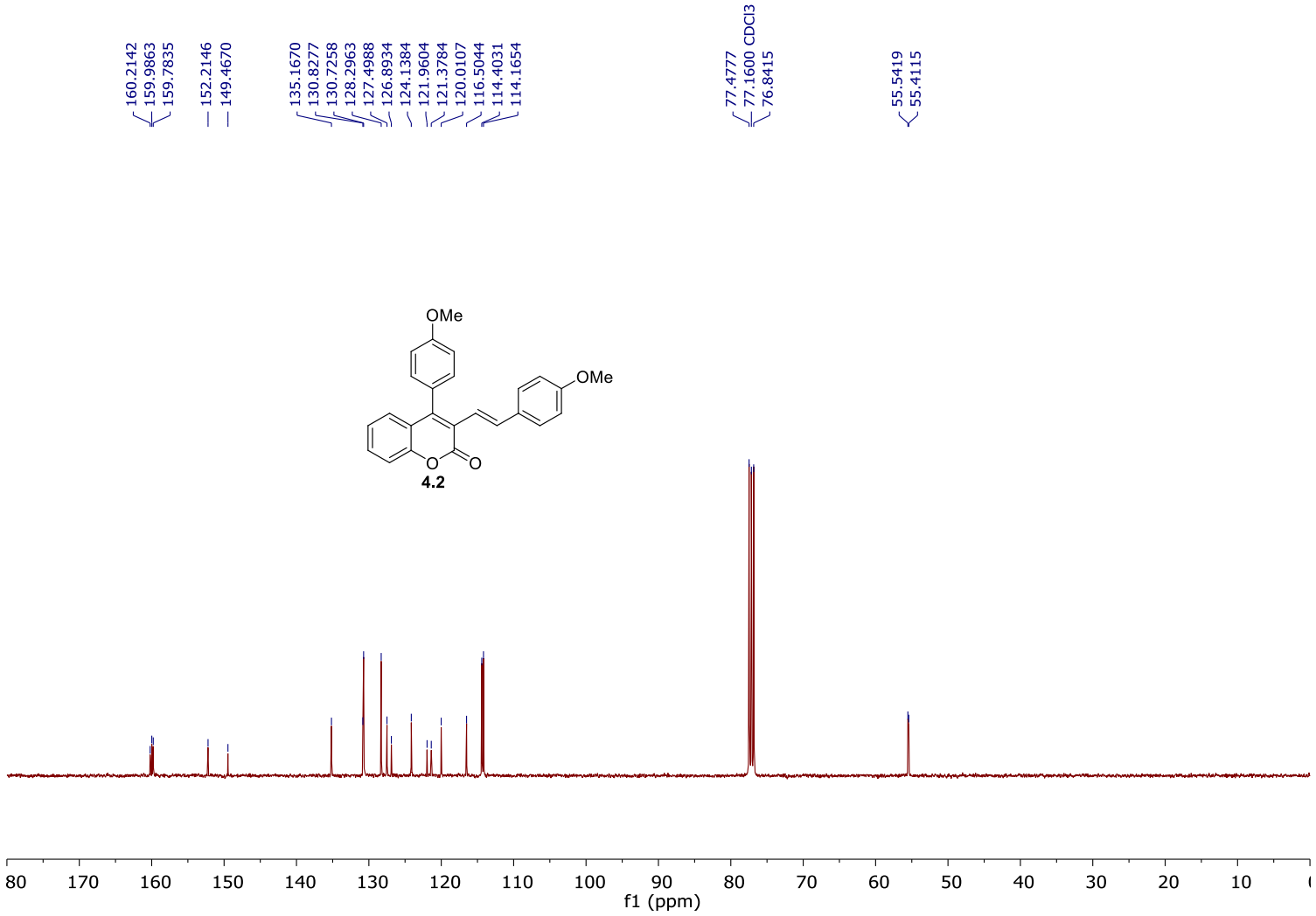
^{1}H Spectrum of (*E*)-3-(4-methoxystyryl)-4-*p*-tolyl-2*H*-chromen-2-one (4.1)



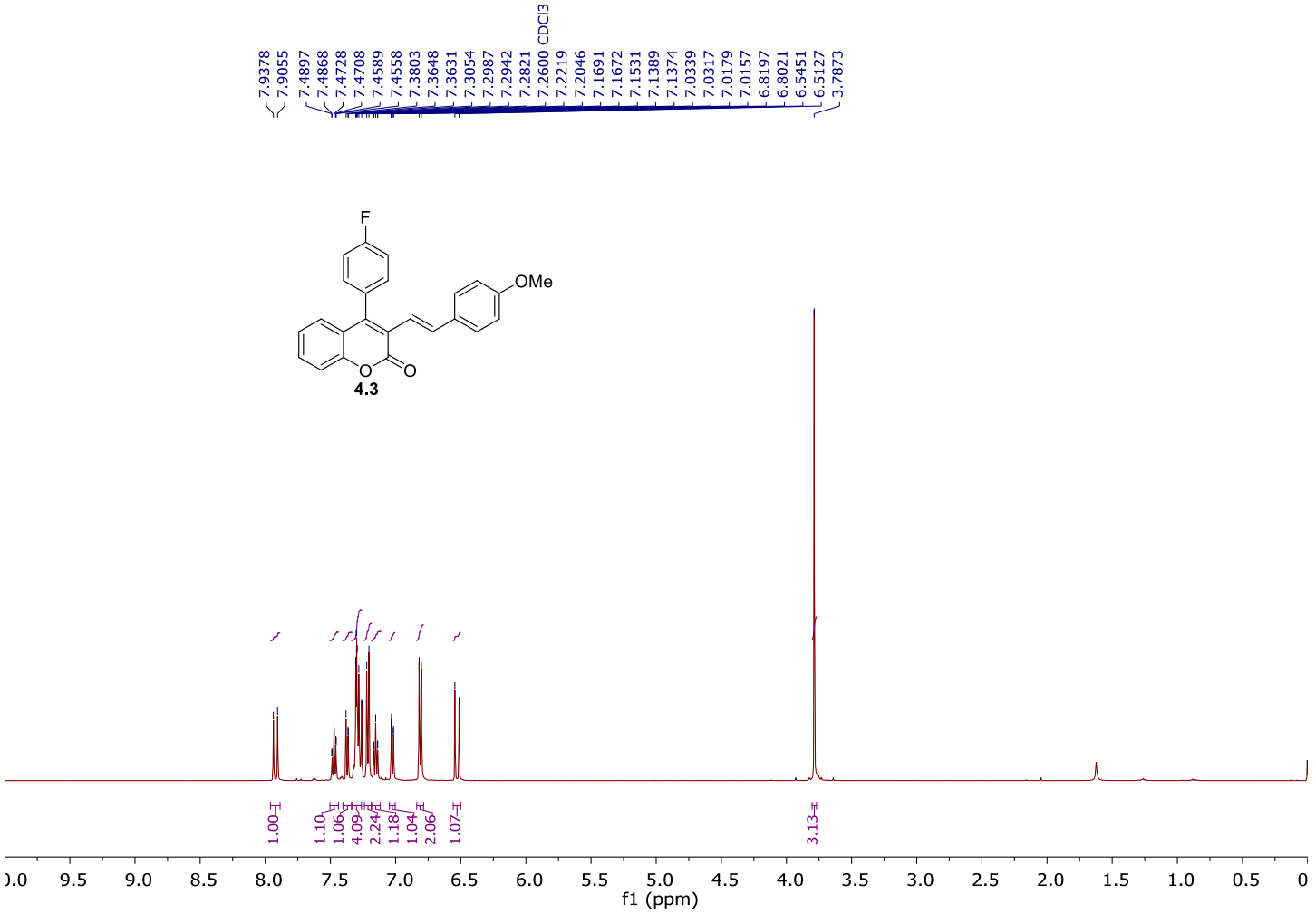
^{13}C Spectrum of (*E*)-3-(4-methoxystyryl)-4-*p*-tolyl-2*H*-chromen-2-one (4.1)



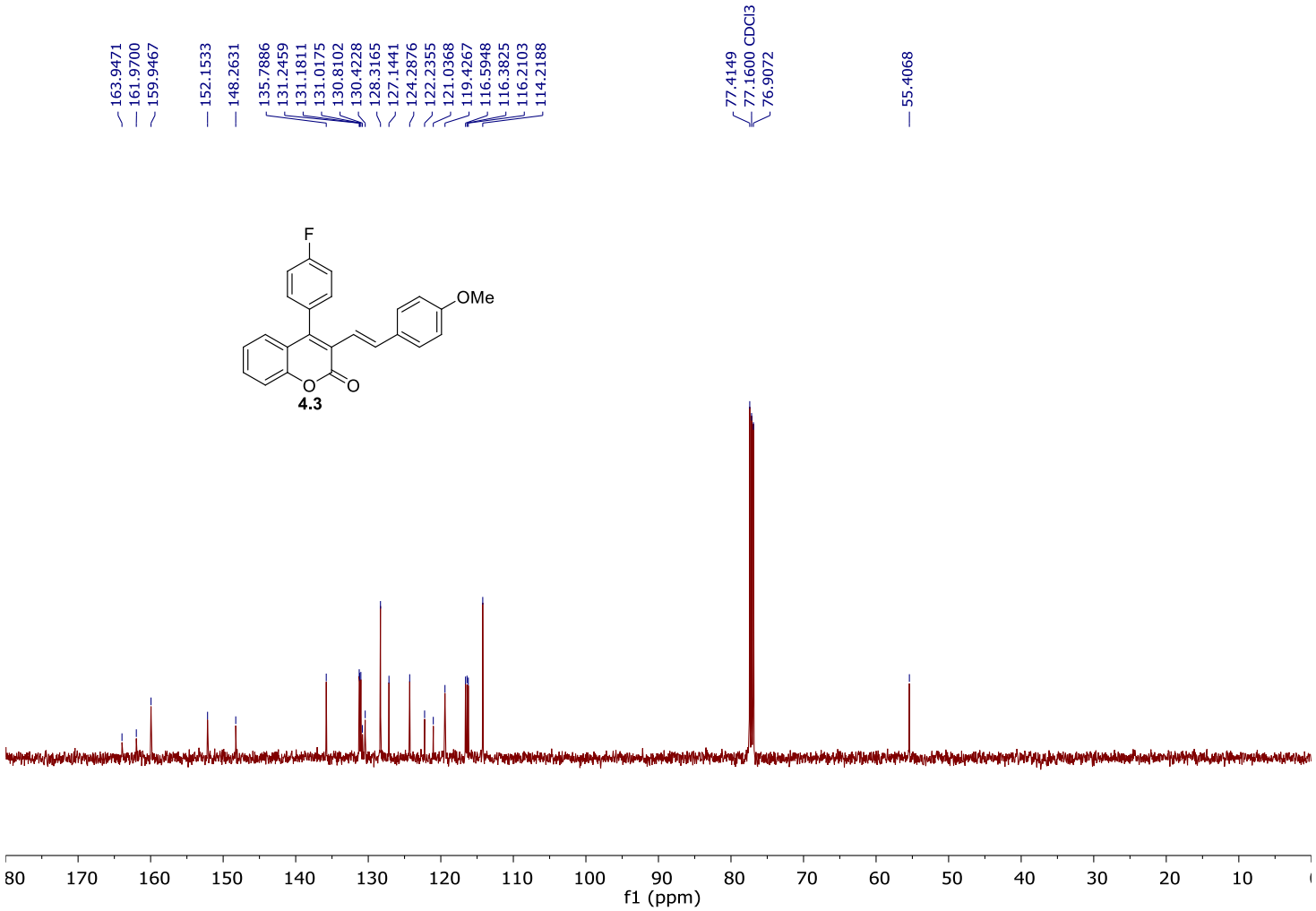
^{1}H Spectrum of (*E*)-4-(4-methoxyphenyl)-3-(4-methoxystyryl)-2*H*-chromen-2-one (4.2)



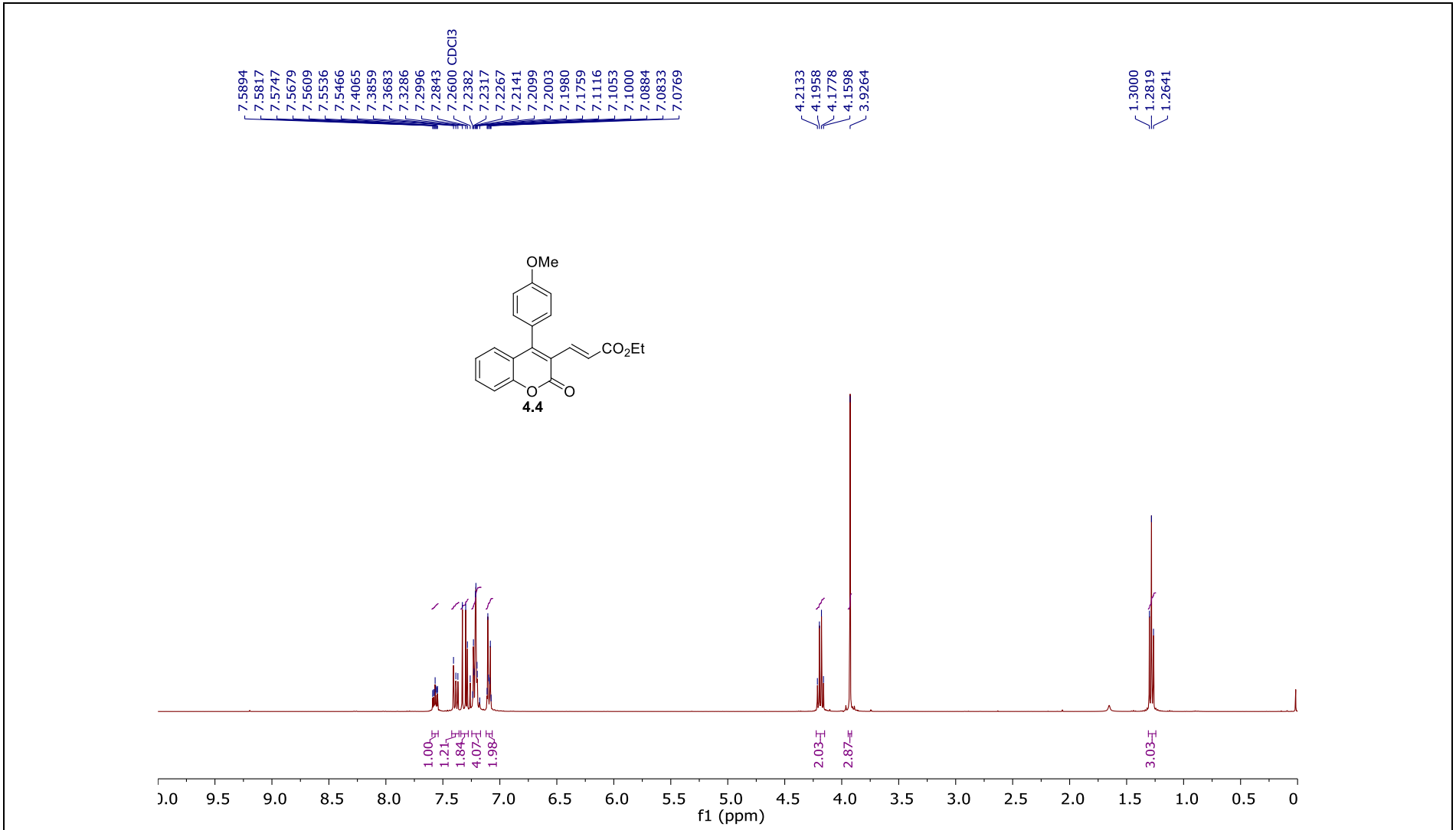
^{13}C Spectrum of (*E*)-4-(4-methoxyphenyl)-3-(4-methoxystyryl)-2*H*-chromen-2-one (4.2)



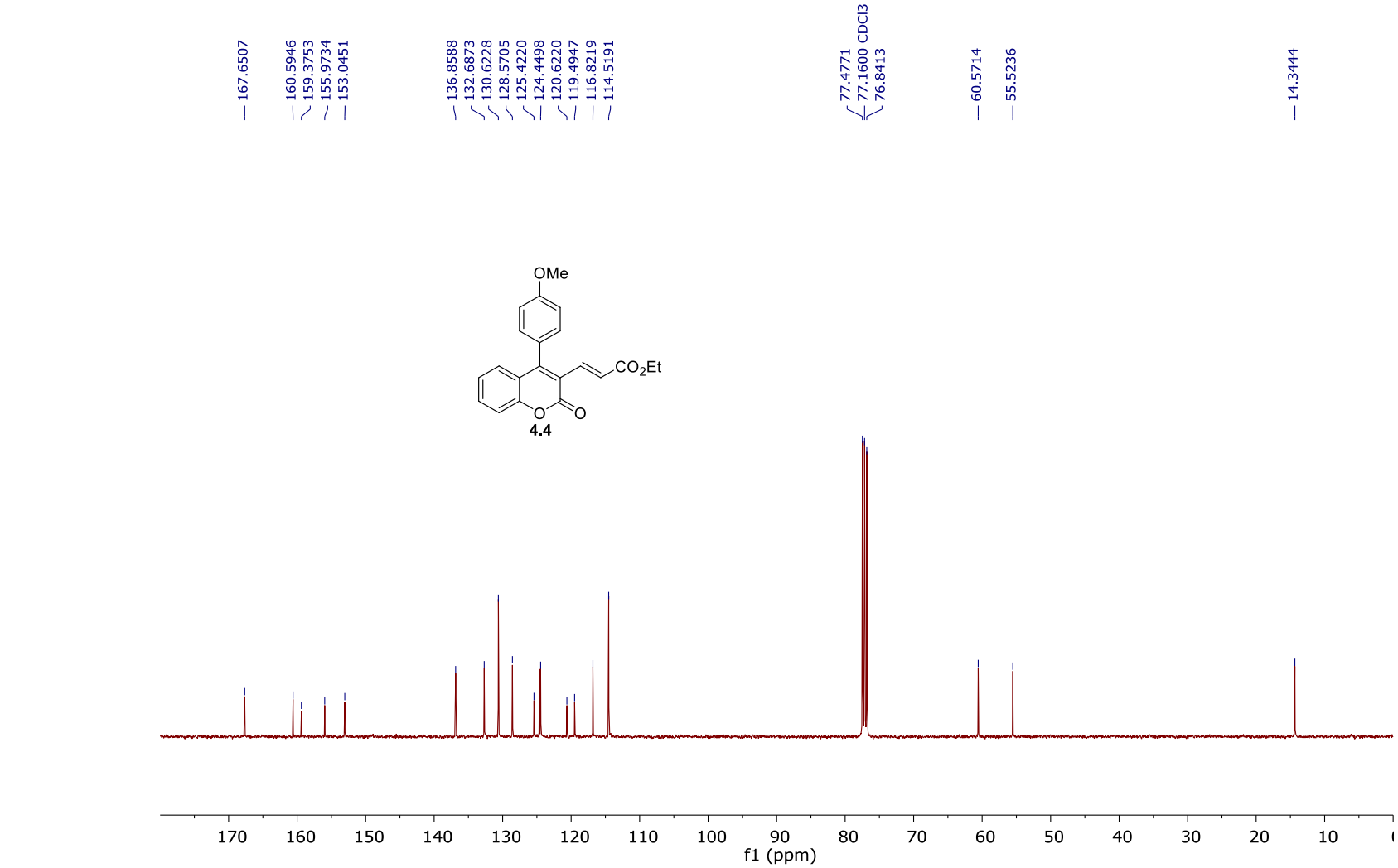
^{1}H Spectrum of (*E*)-4-(4-fluorophenyl)-3-(4-methoxystyryl)-2*H*-chromen-2-one (4.3)



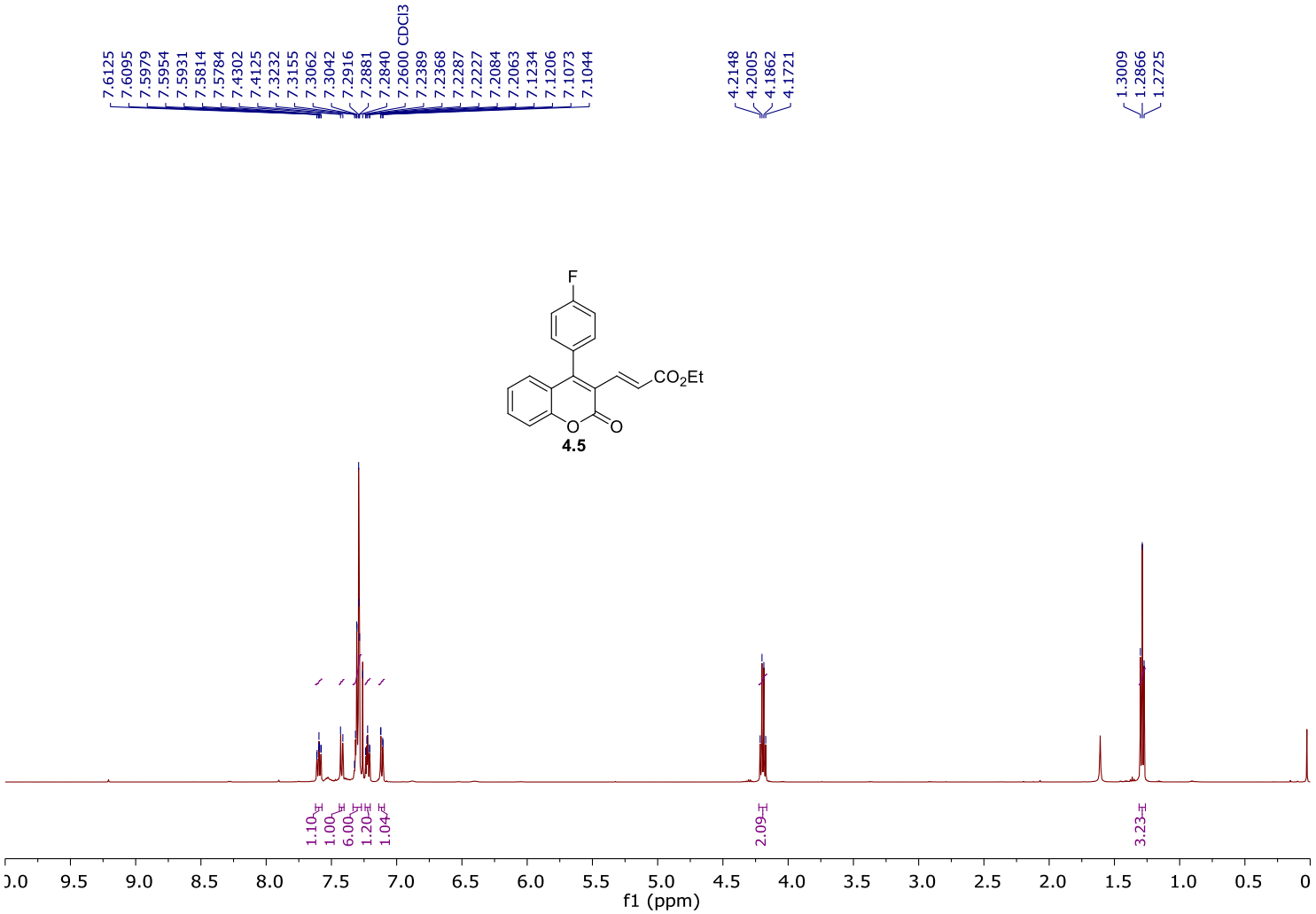
^{13}C Spectrum of (*E*)-4-(4-fluorophenyl)-3-(4-methoxystyryl)-2*H*-chromen-2-one (4.3)



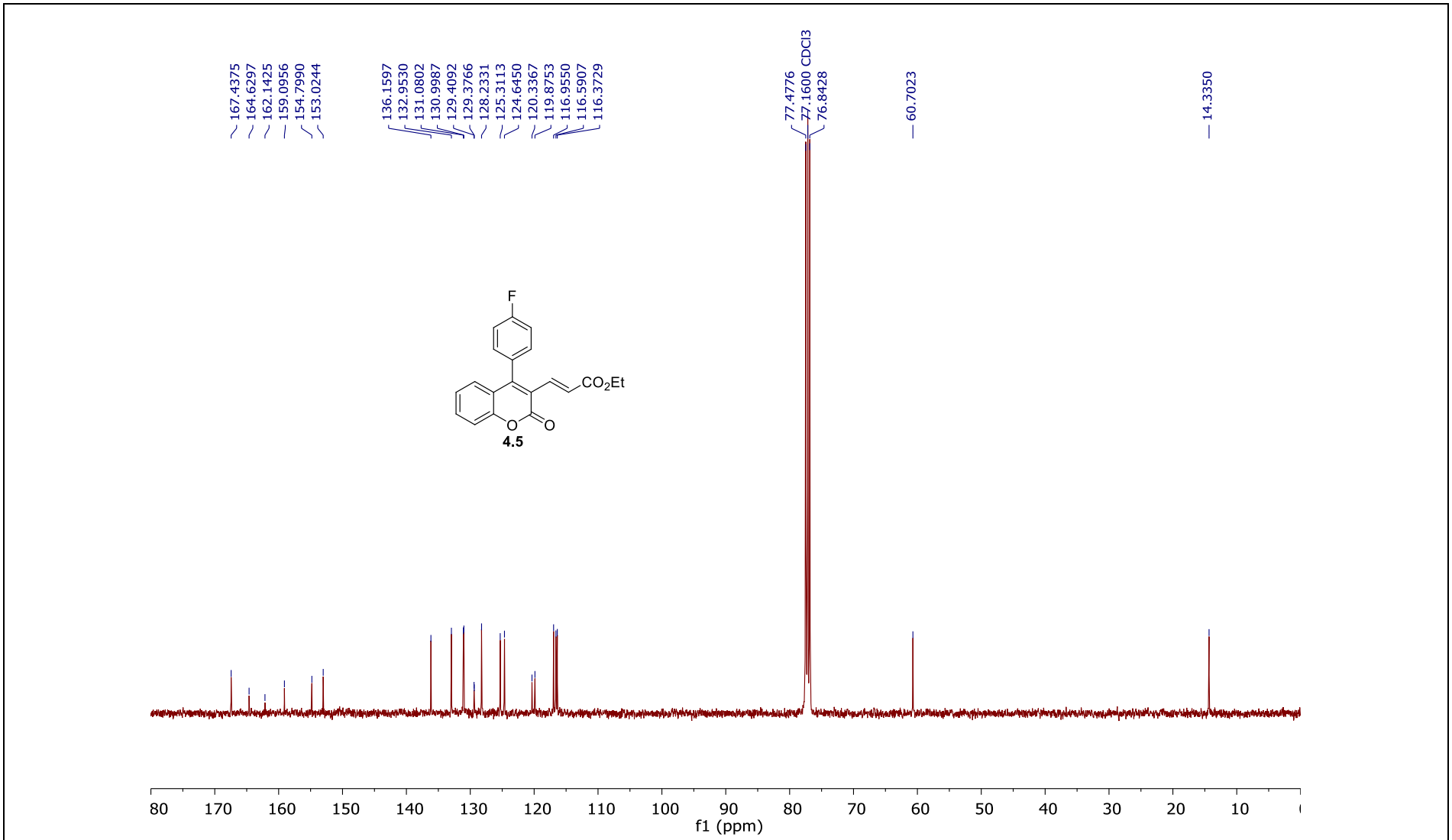
^{1}H Spectrum of (*E*)-ethyl 3-(4-(4-methoxyphenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.4)



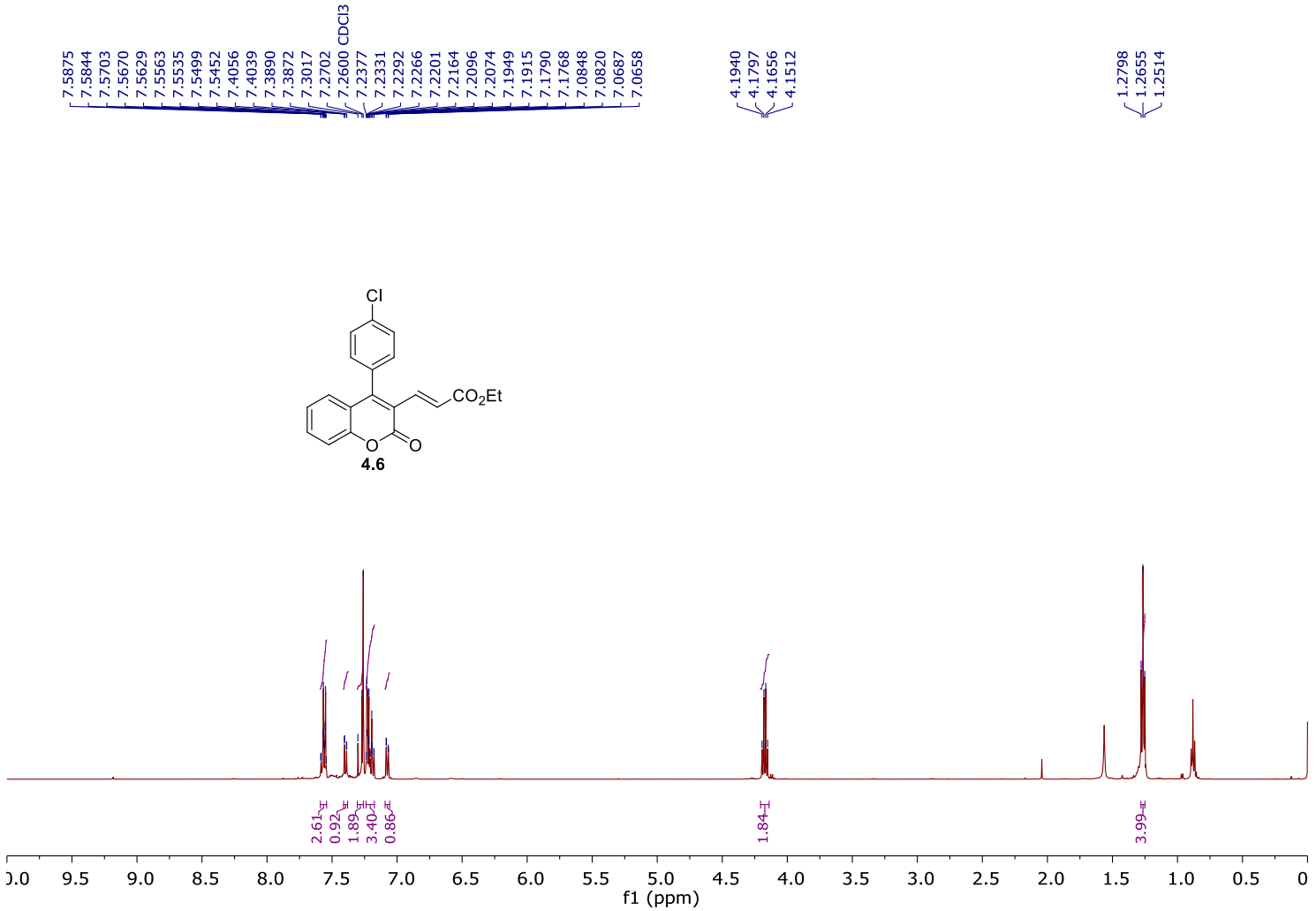
^{13}C Spectrum of (*E*)-ethyl 3-(4-(4-methoxyphenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.4)



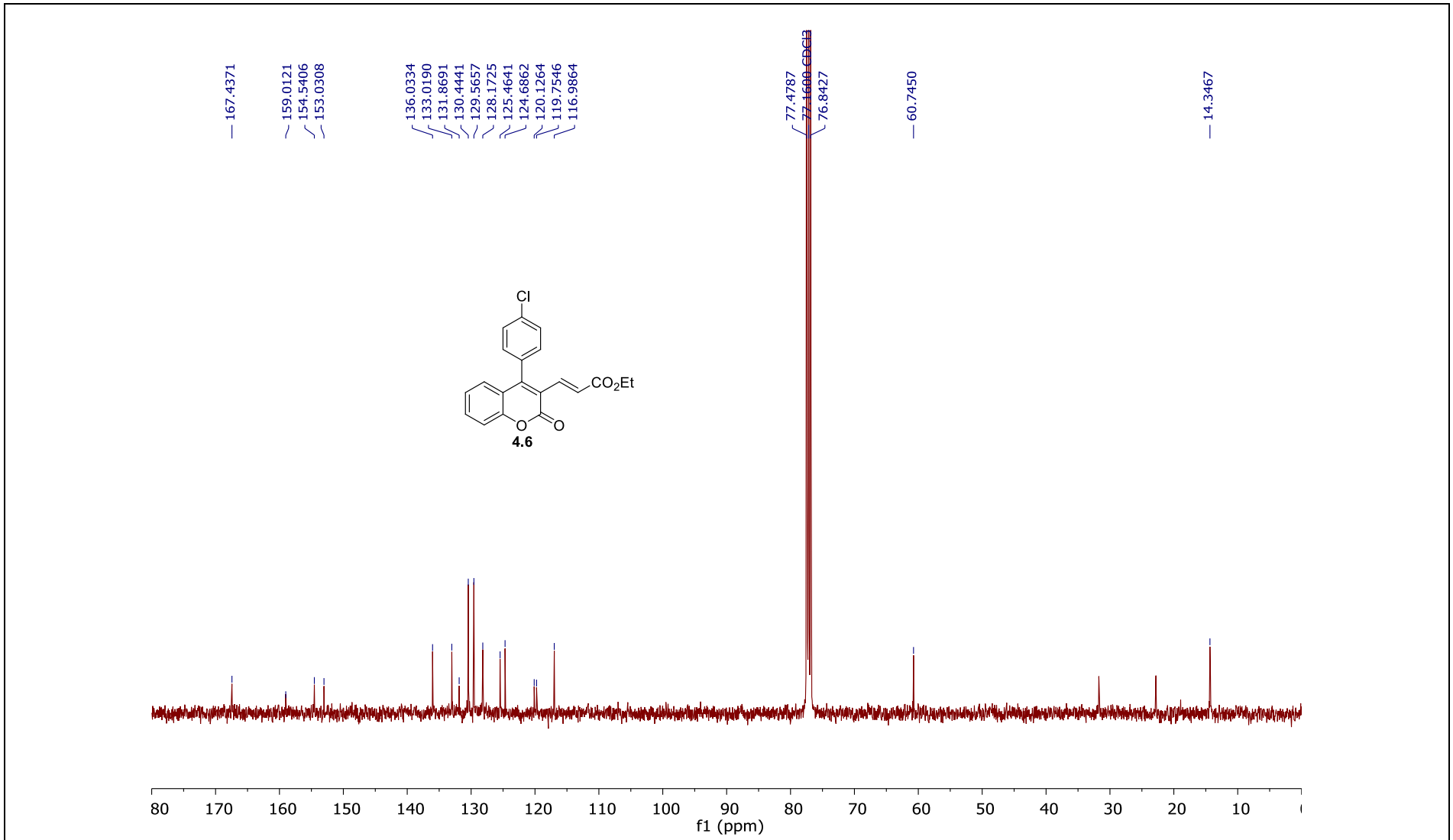
^{1}H Spectrum of (*E*)-ethyl 3-(4-(4-fluorophenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.5)



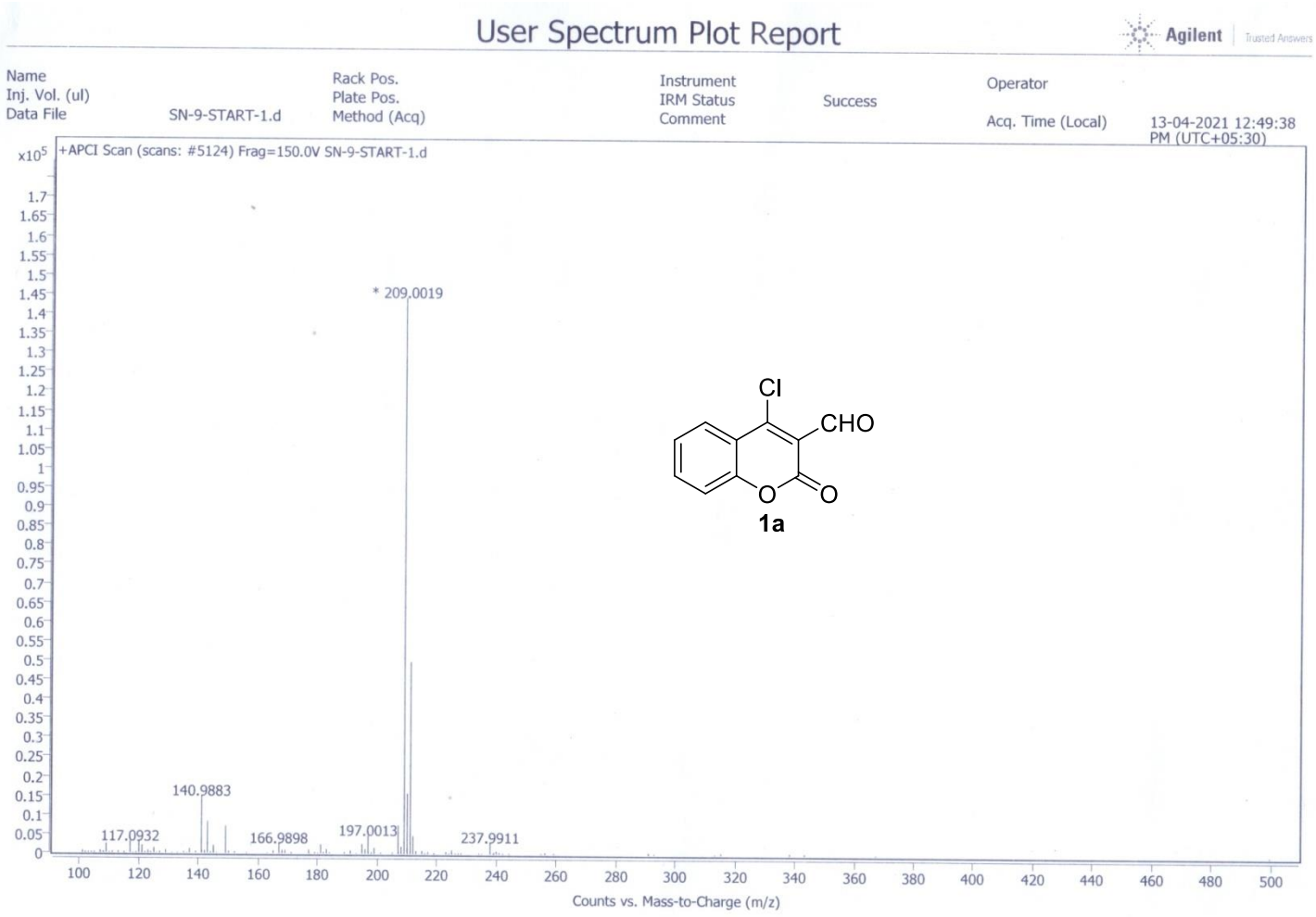
^{13}C Spectrum of (*E*)-ethyl 3-(4-(4-fluorophenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.5)



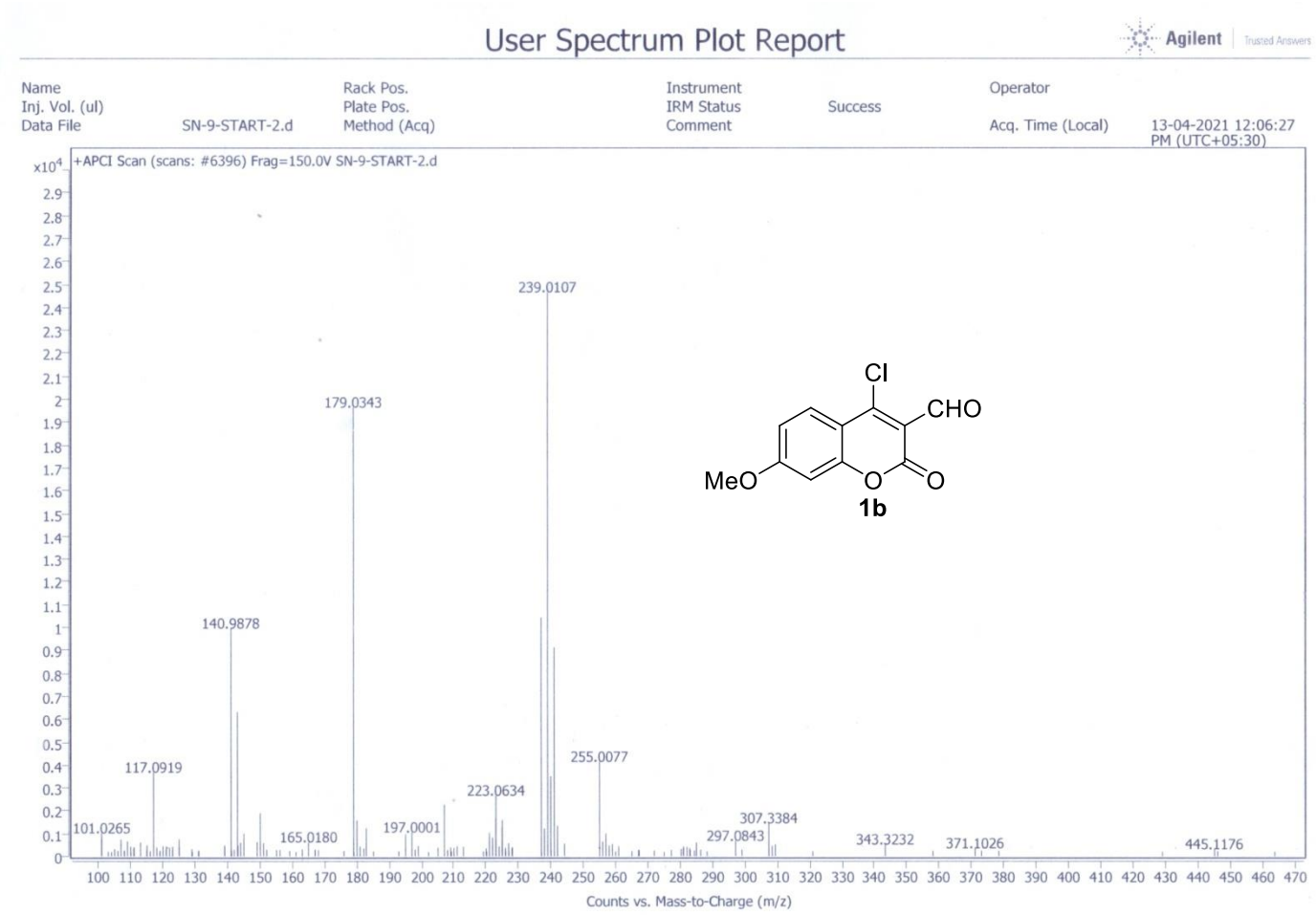
^{1}H Spectrum of (*E*)-ethyl 3-(4-(4-chlorophenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.6)



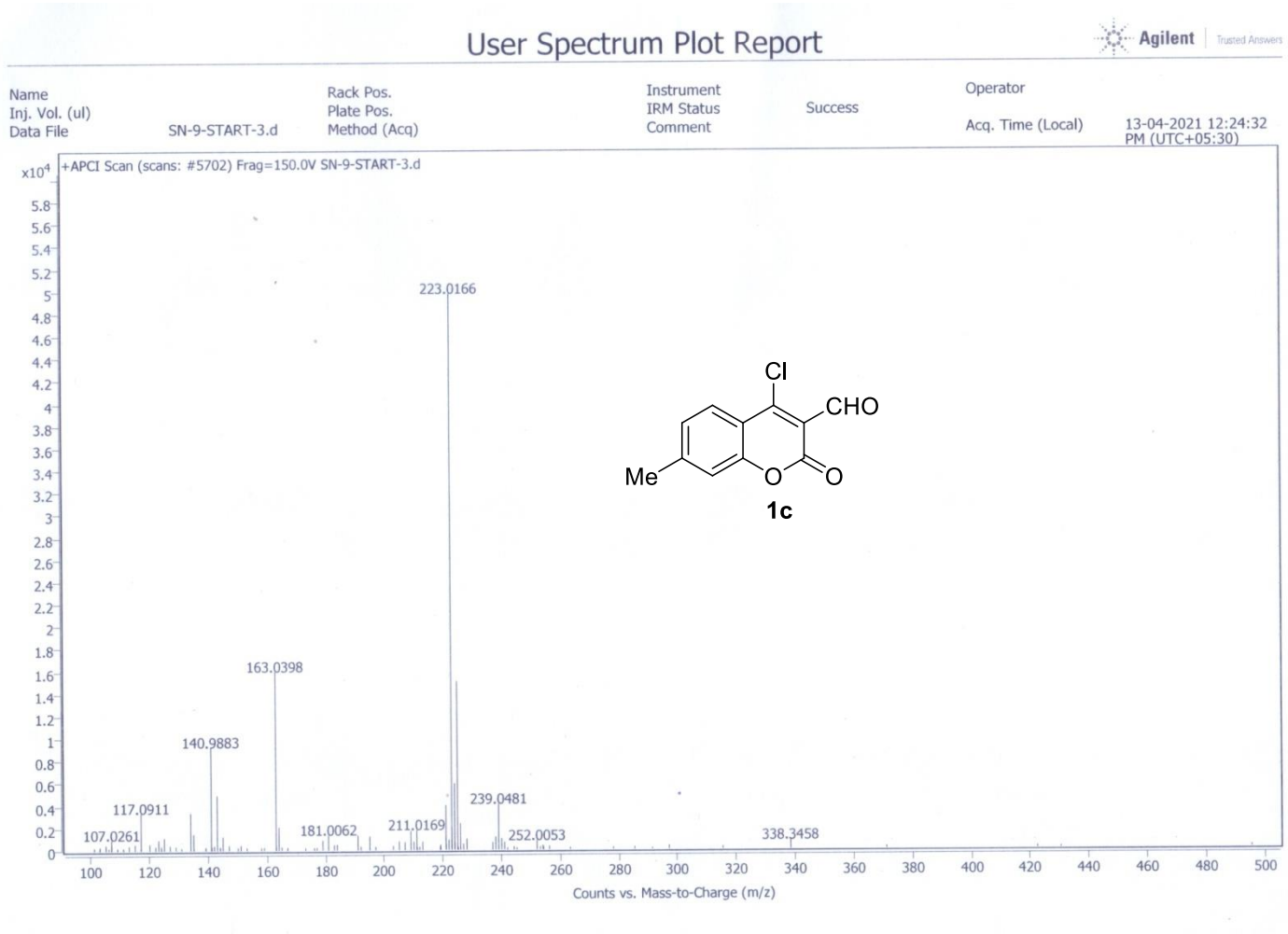
^{13}C Spectrum of (*E*)-ethyl 3-(4-(4-chlorophenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.6)



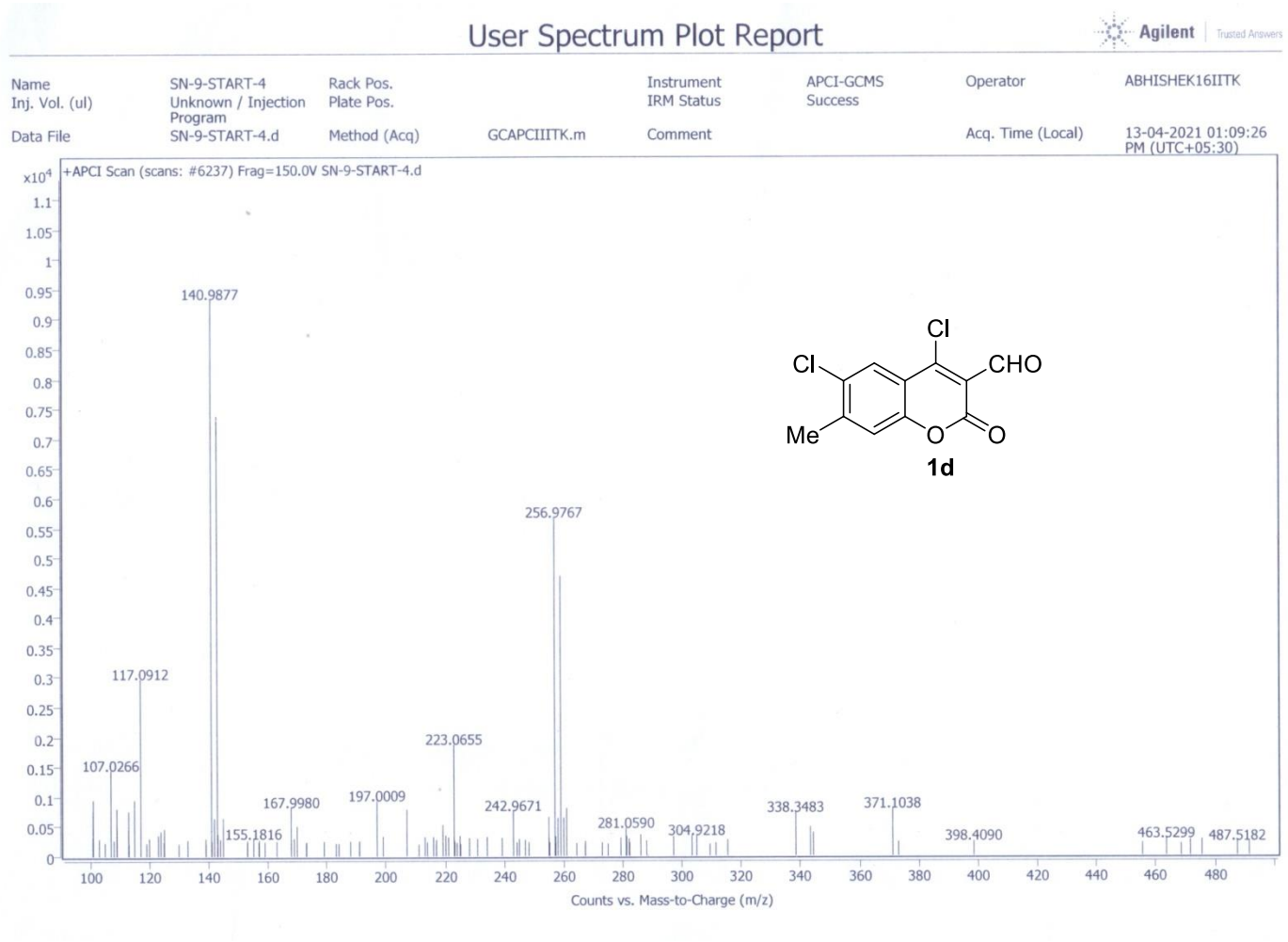
Mass Spectrum of 4-chloro-2-oxo-2*H*-chromene-3-carbaldehyde (1a)



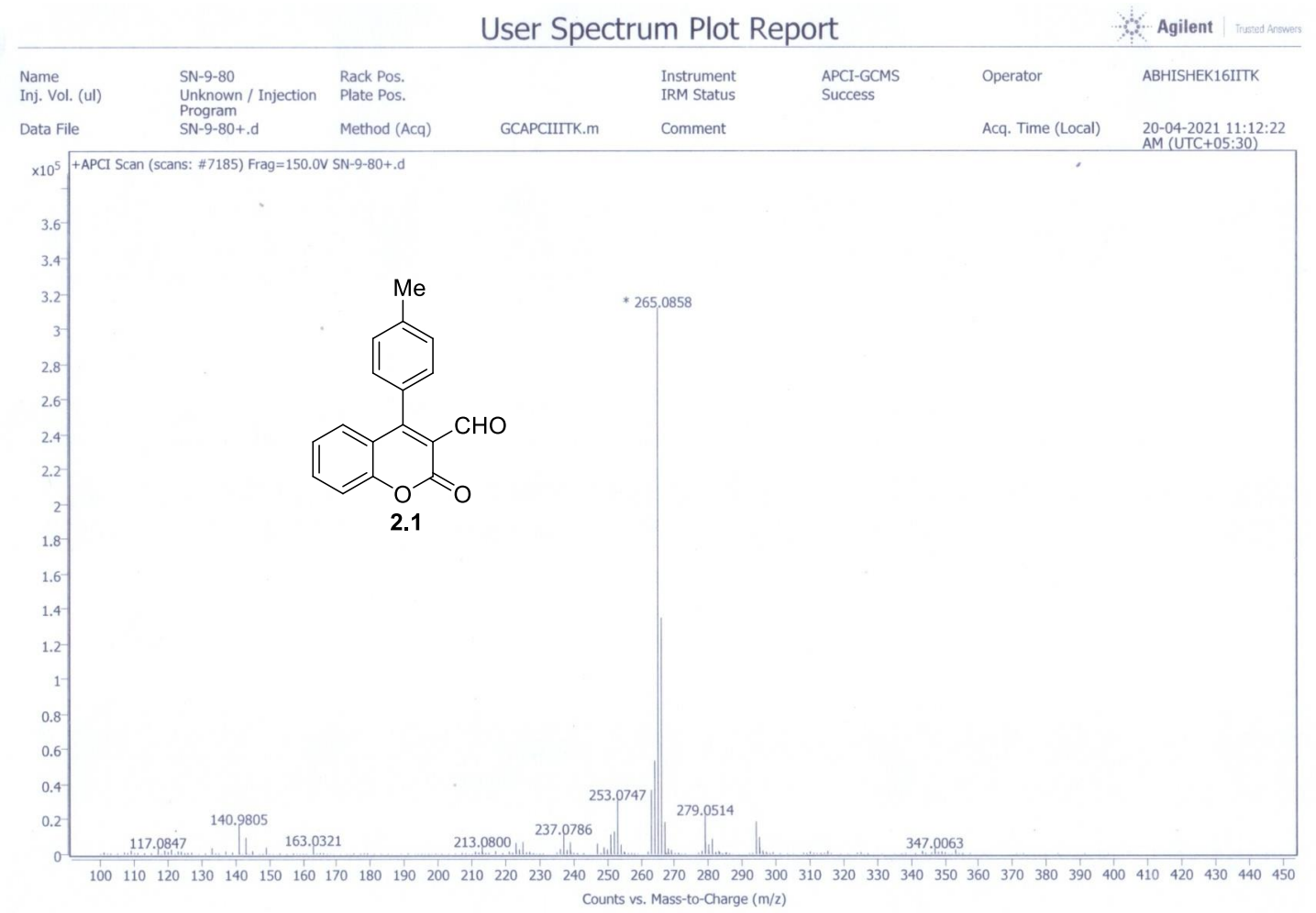
Mass Spectrum of 4-chloro-7-methoxy-2-oxo-2*H*-chromene-3-carbaldehyde (1b)



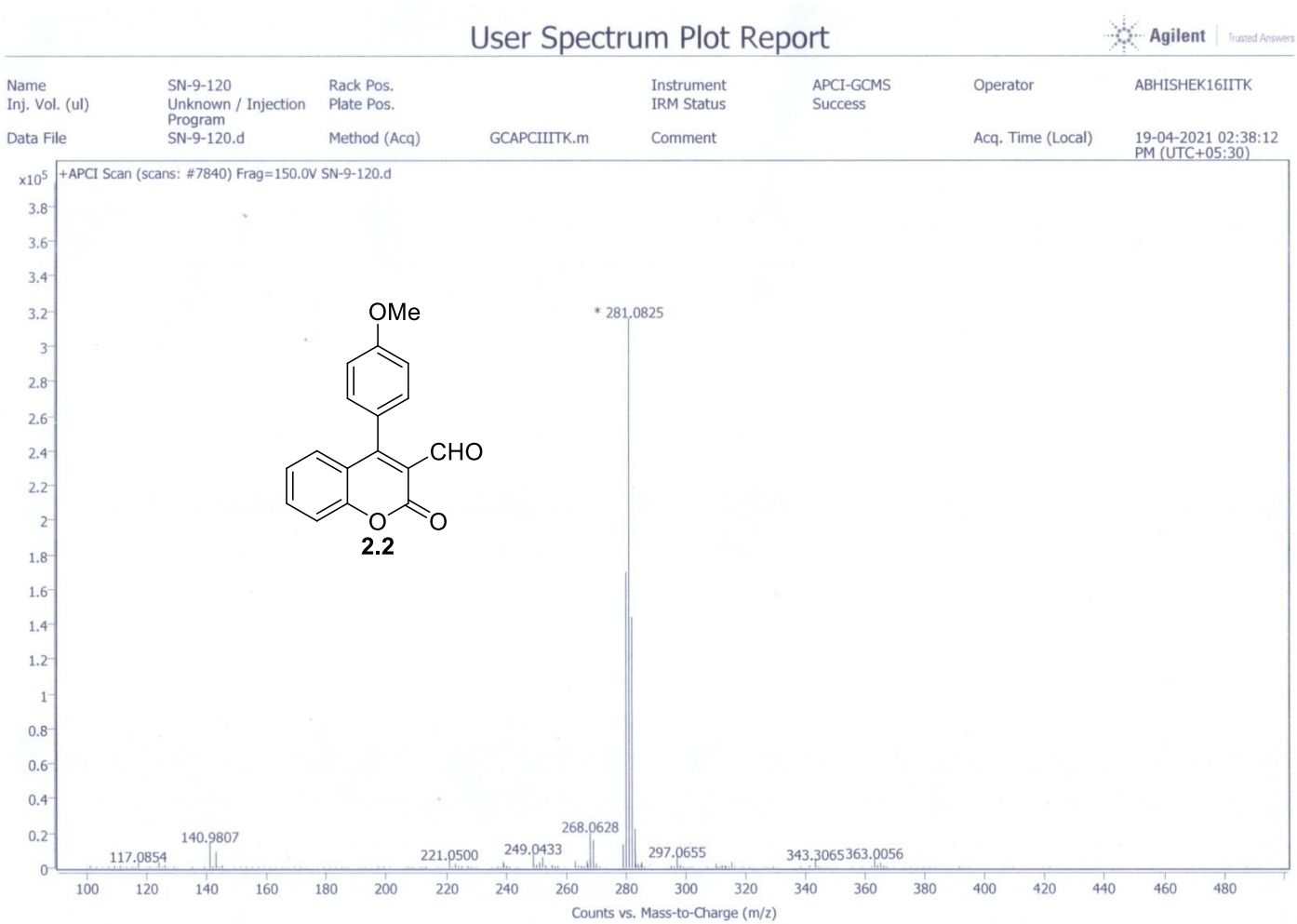
Mass Spectrum of 4-chloro-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (1c)



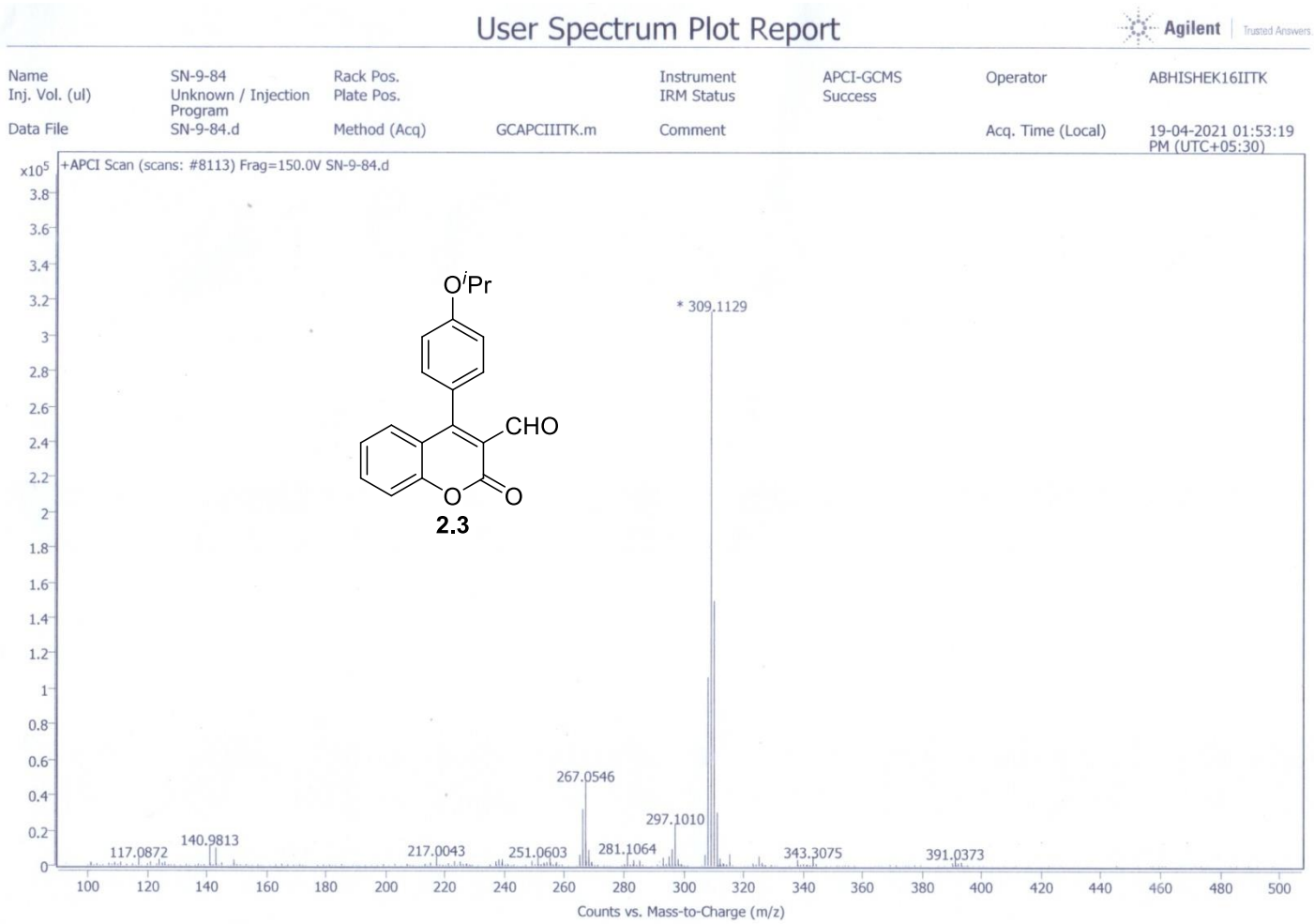
Mass Spectrum of 4,6-dichloro-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (1d)



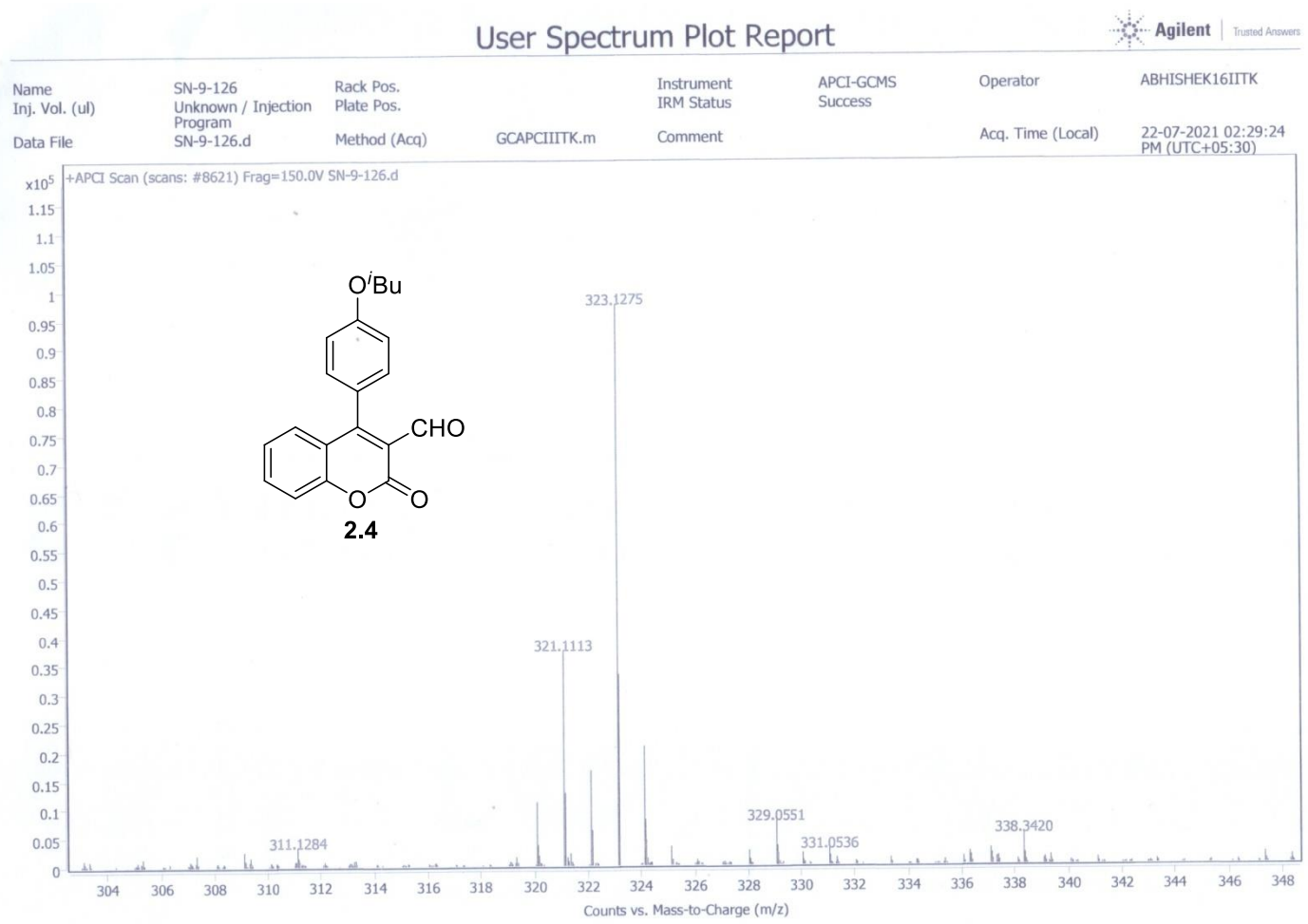
Mass Spectrum of 2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (2.1)



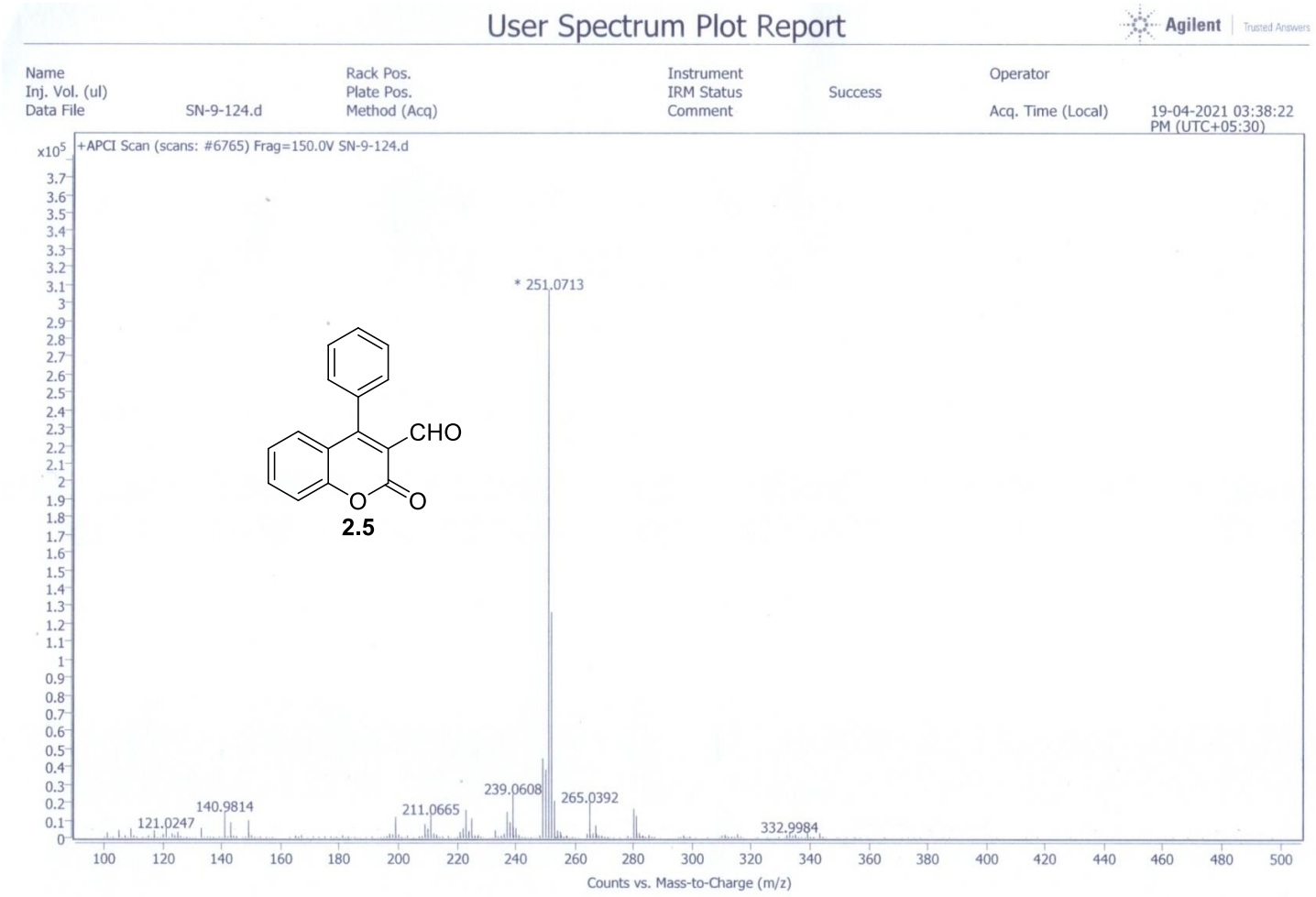
Mass Spectrum of 4-(4-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.2)



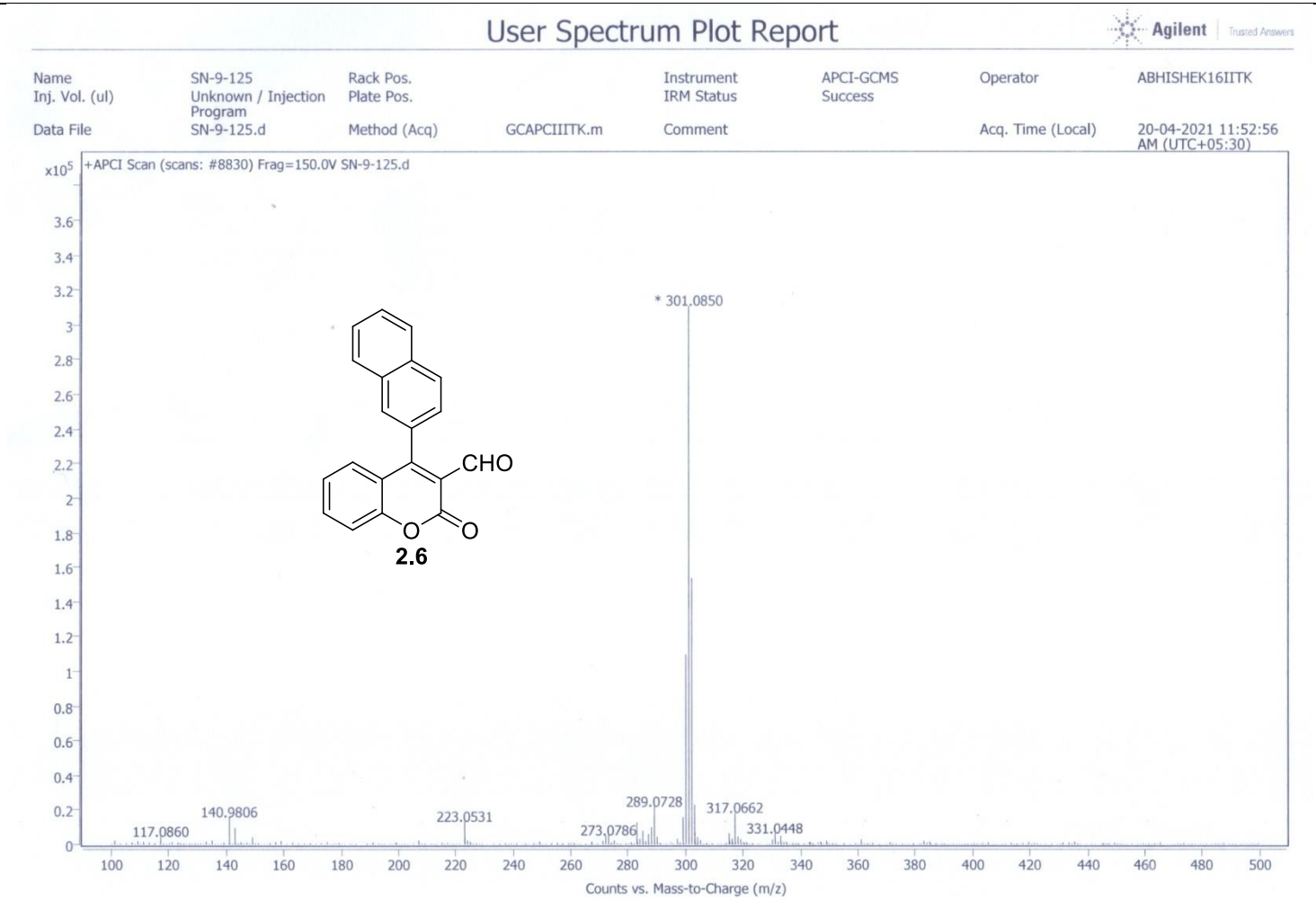
Mass Spectrum of 4-(4-isopropoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.3)



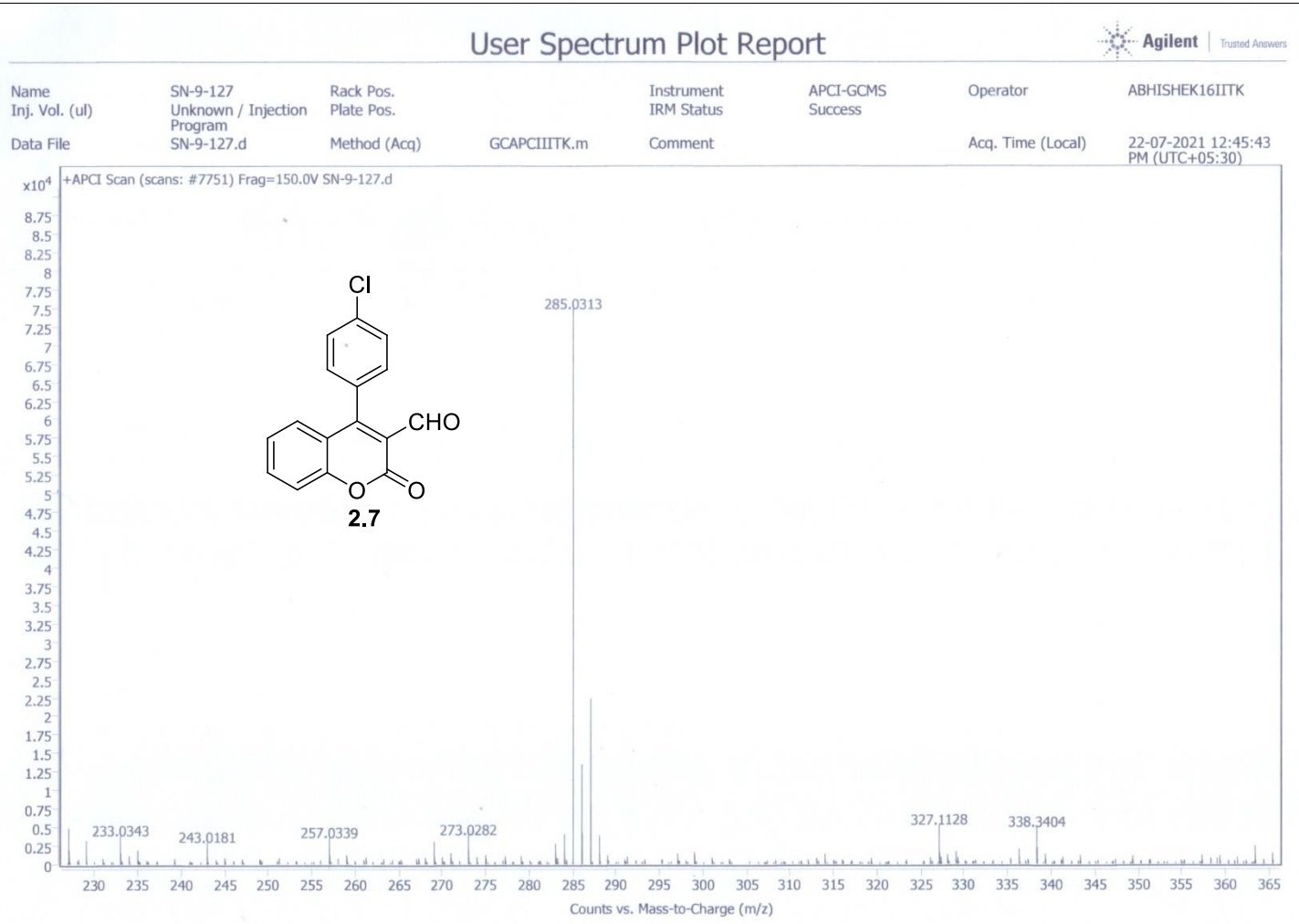
Mass Spectrum of 4-(4-isobutoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.4)



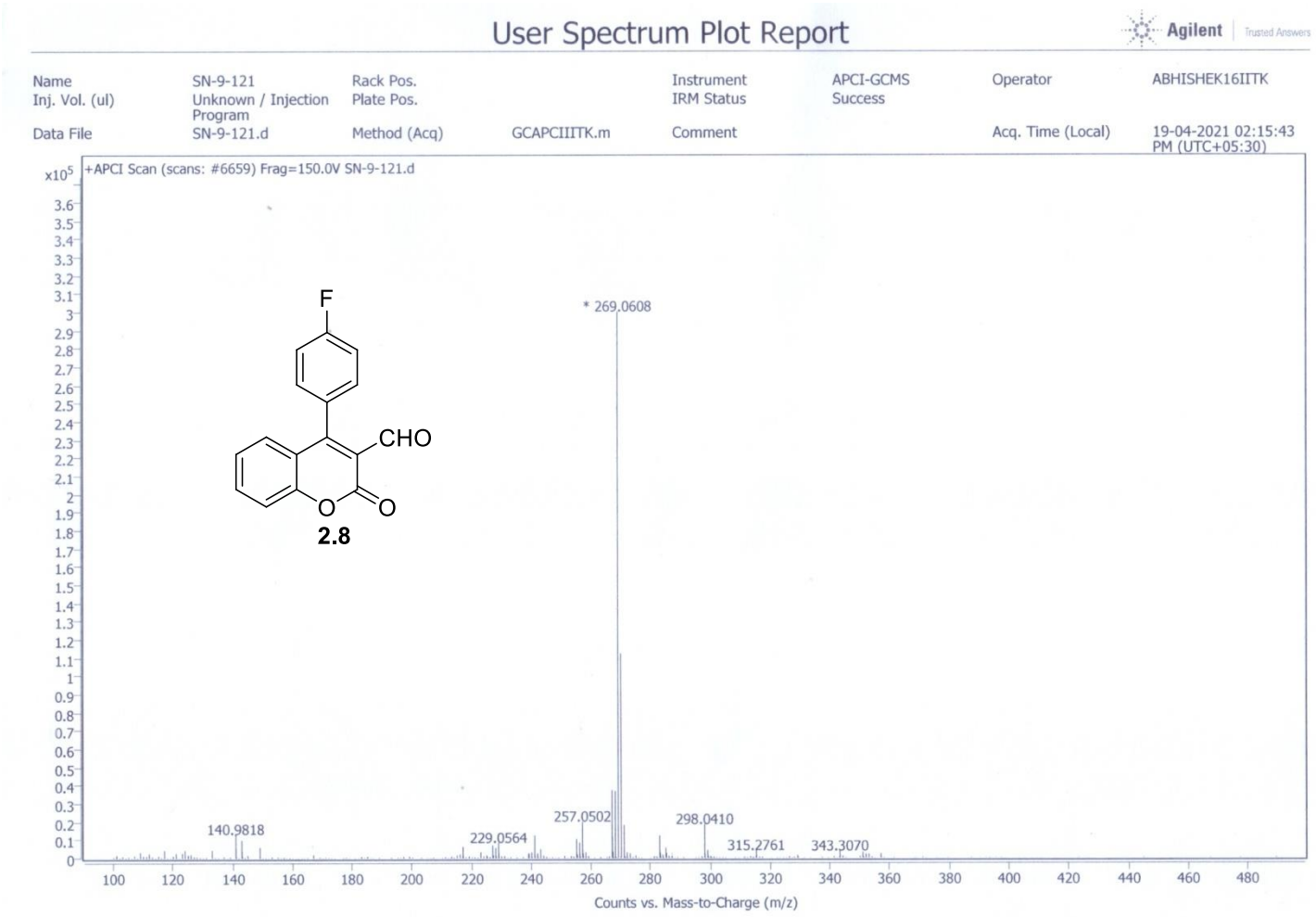
Mass Spectrum of 2-oxo-4-phenyl-2*H*-chromene-3-carbaldehyde (2.5)



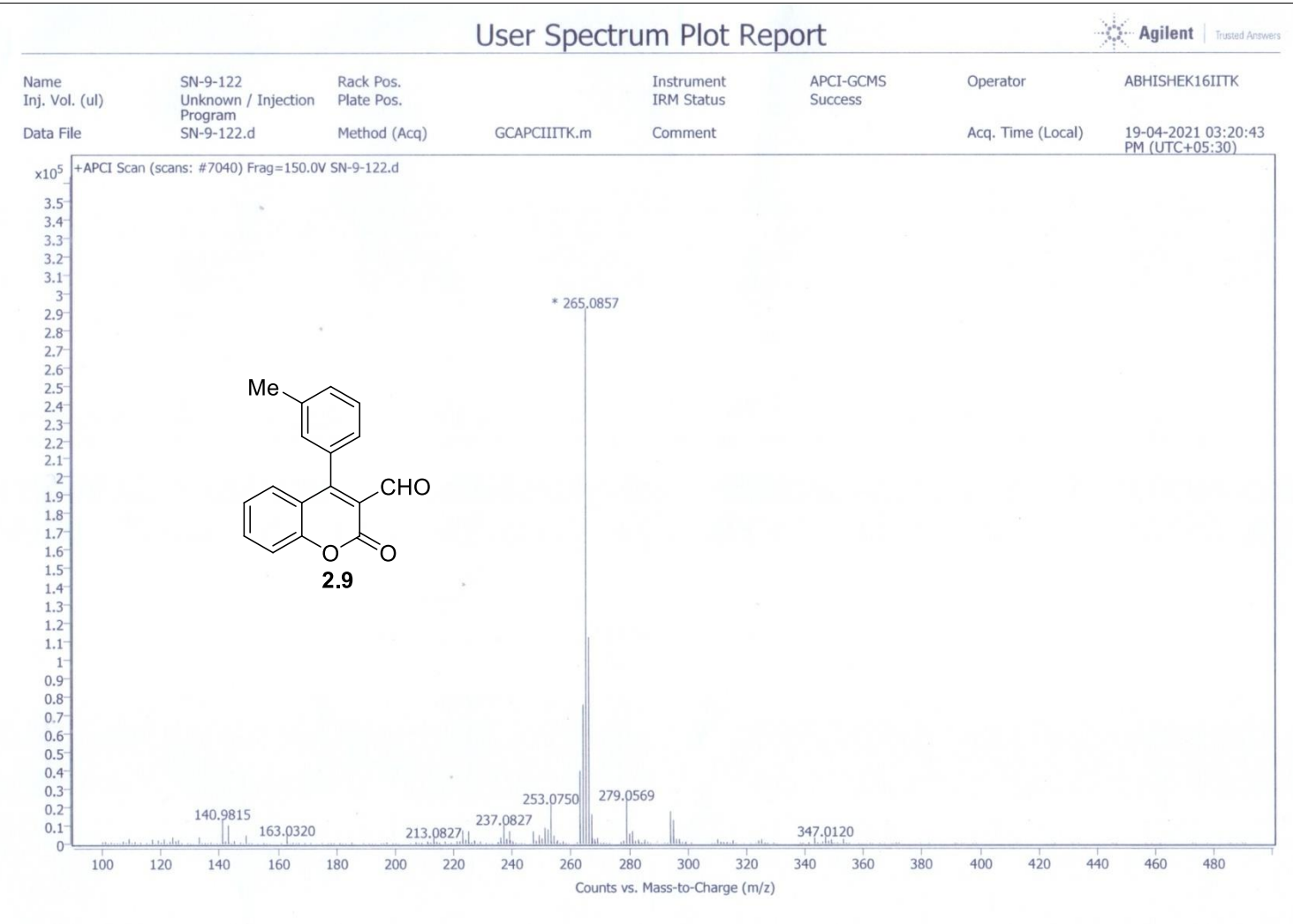
Mass Spectrum of 4-(naphthalen-2-yl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.6)



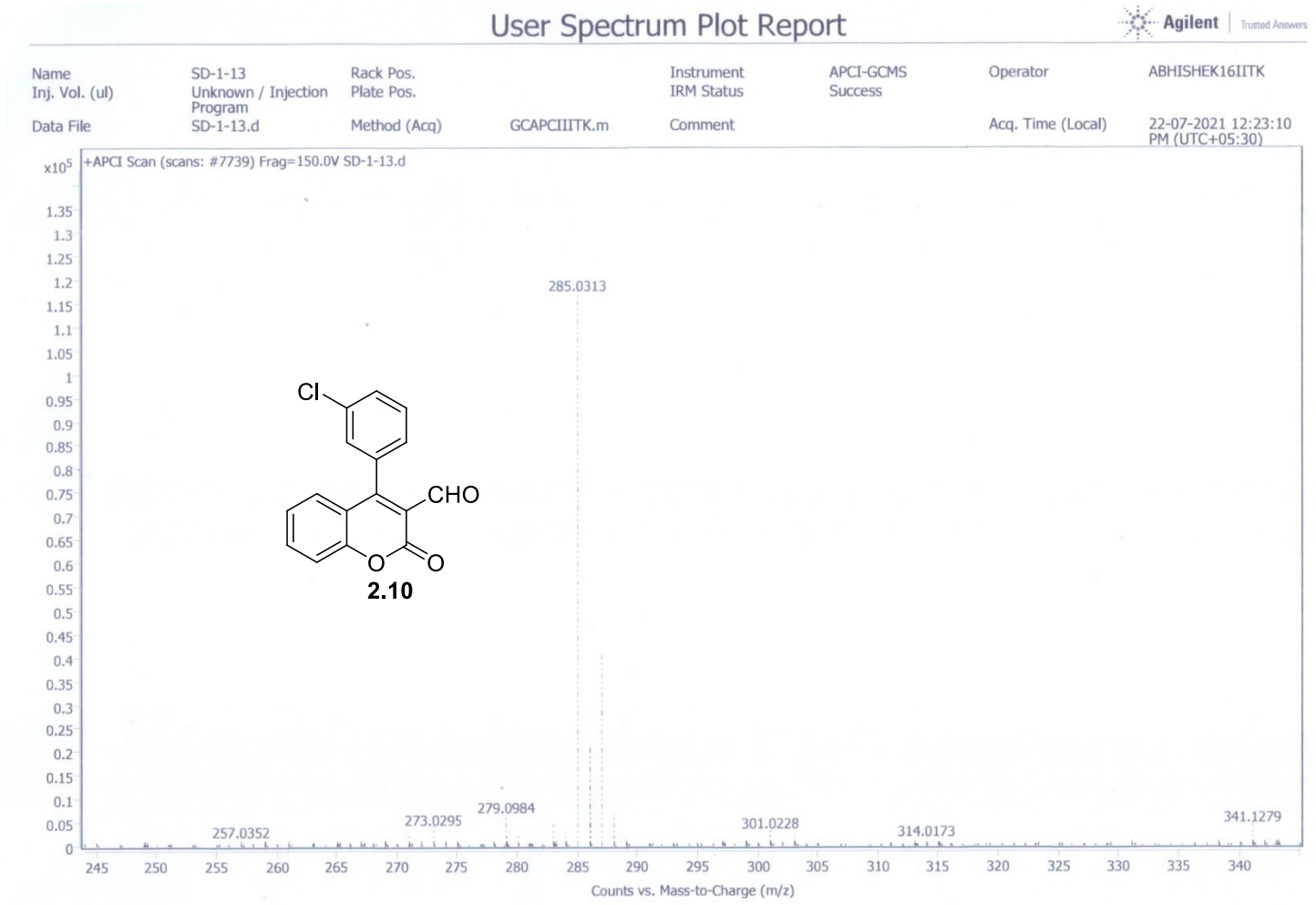
Mass Spectrum of 4-(4-chlorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.7)



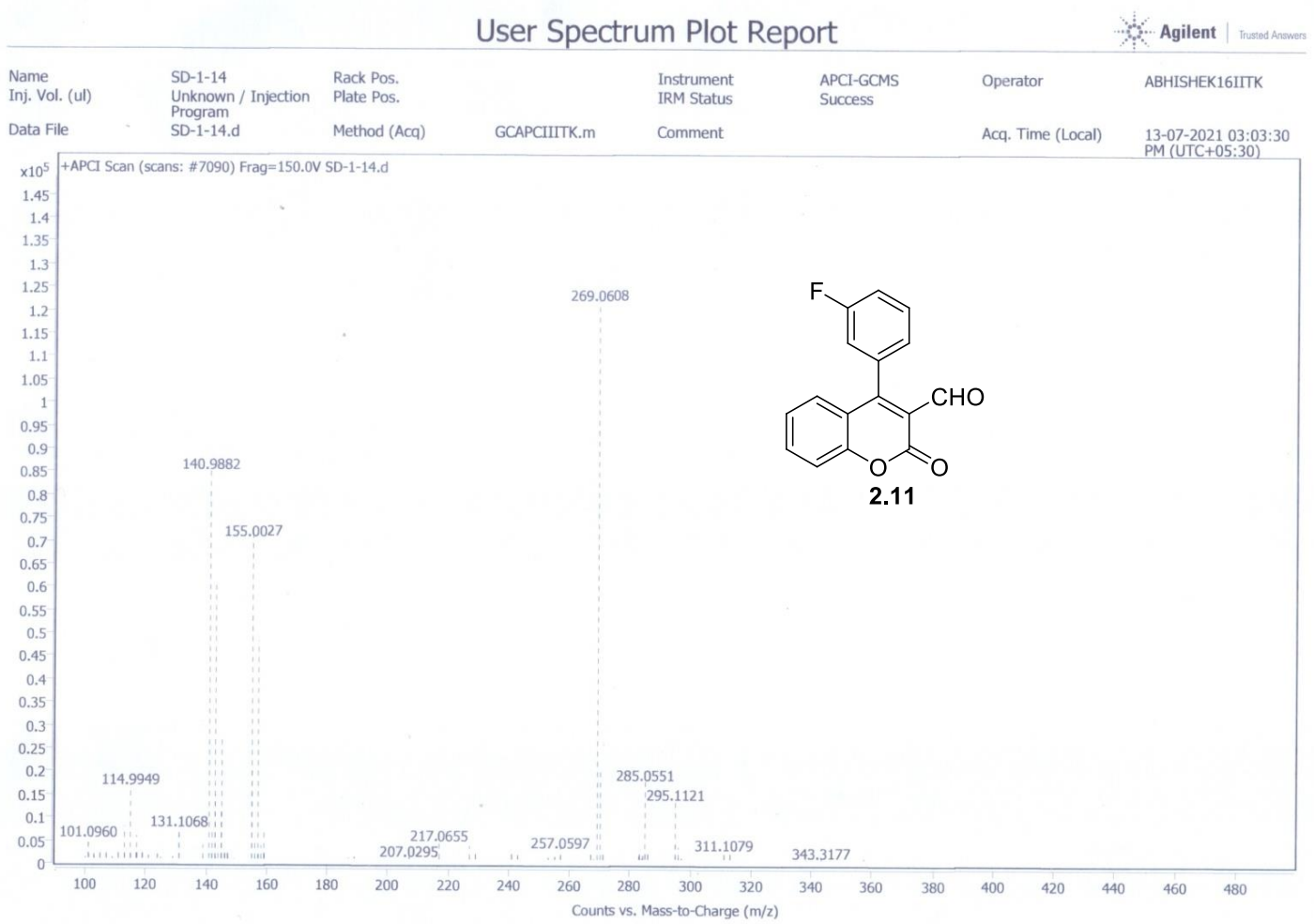
Mass Spectrum of 4-(4-fluorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.8)



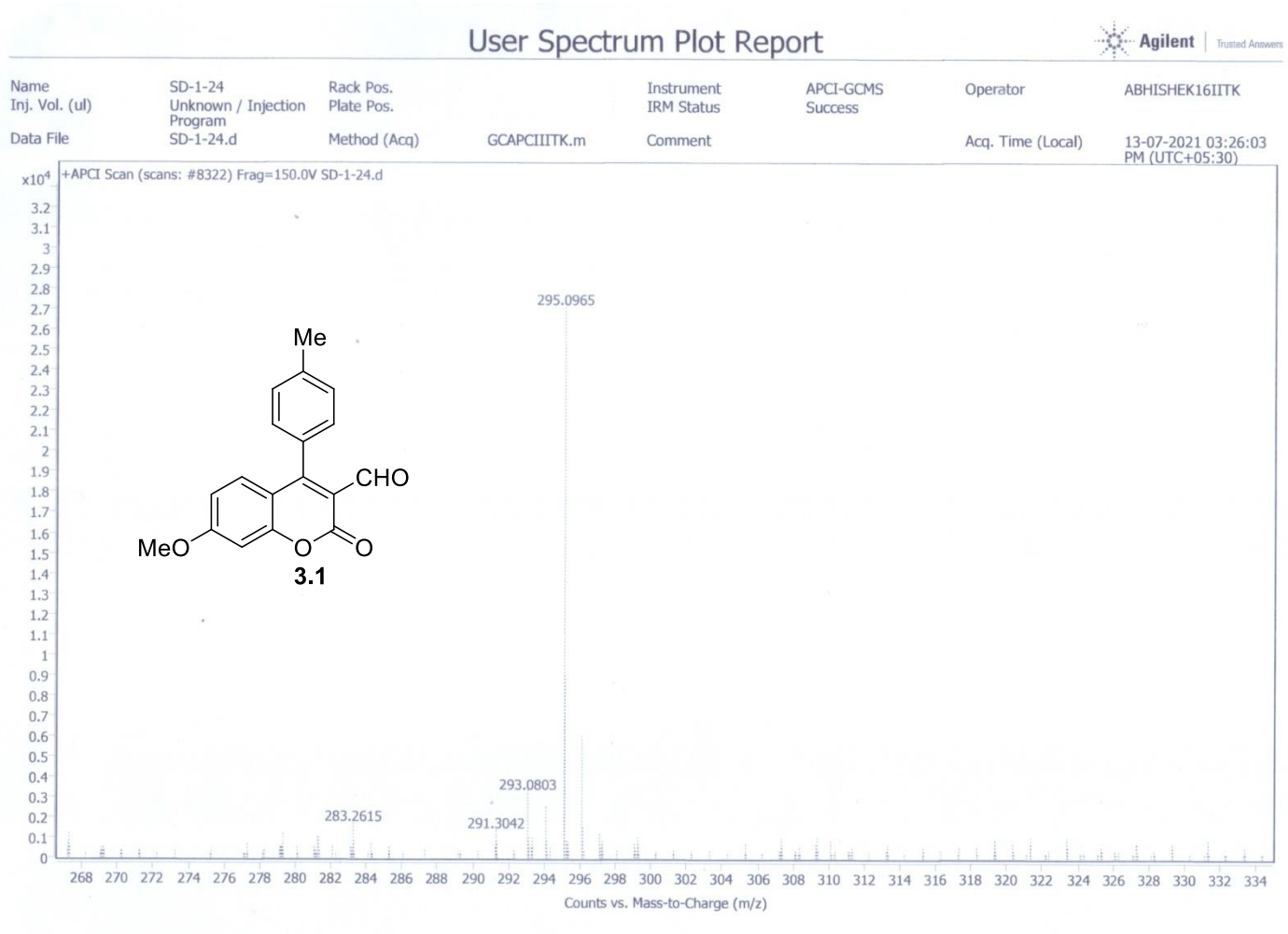
Mass Spectrum of 2-oxo-4-*m*-tolyl-2*H*-chromene-3-carbaldehyde (2.9)



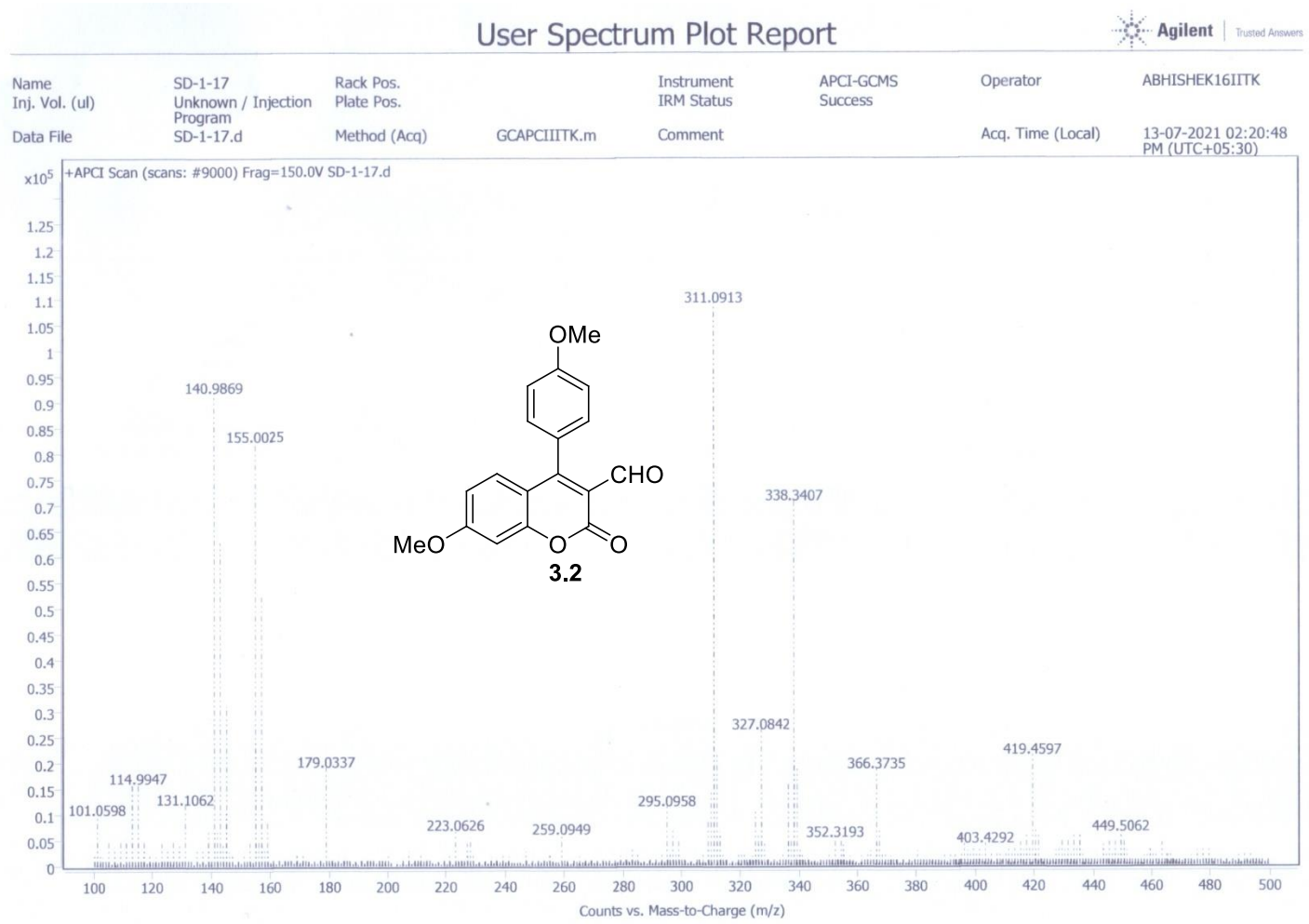
Mass Spectrum of 4-(3-chlorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.10)



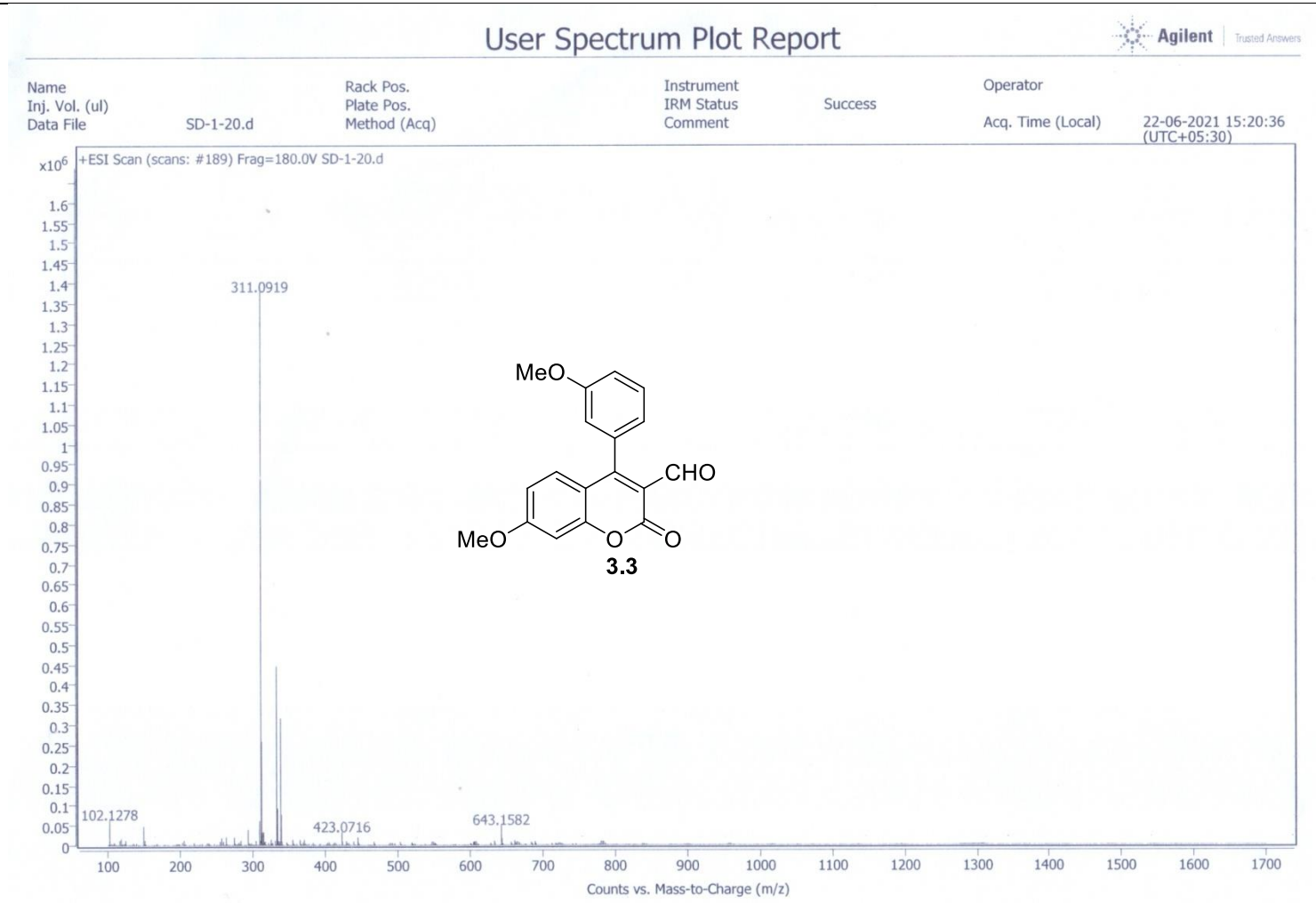
Mass Spectrum of 4-(3-fluorophenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (2.11)



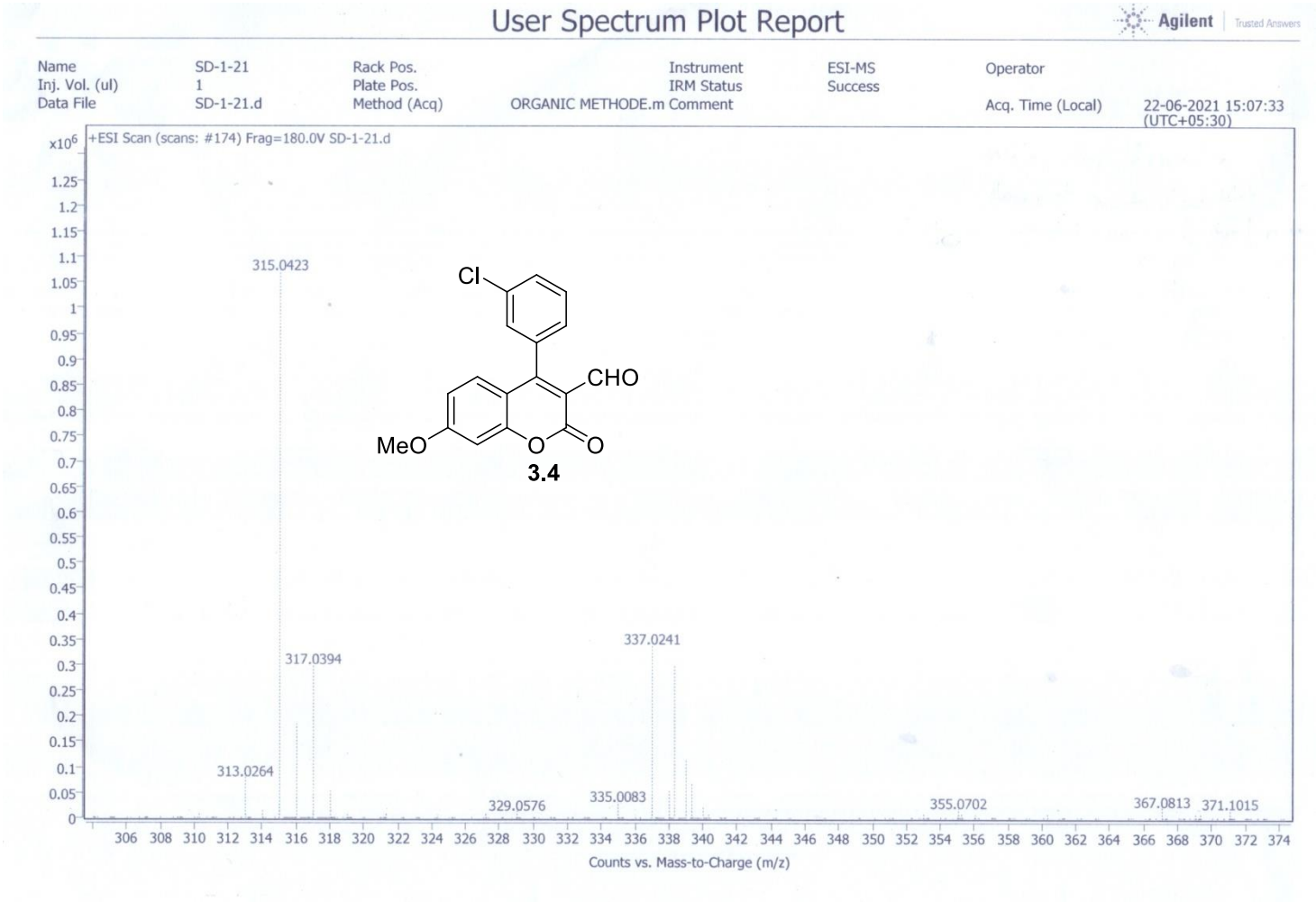
Mass Spectrum of 7-methoxy-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.1)



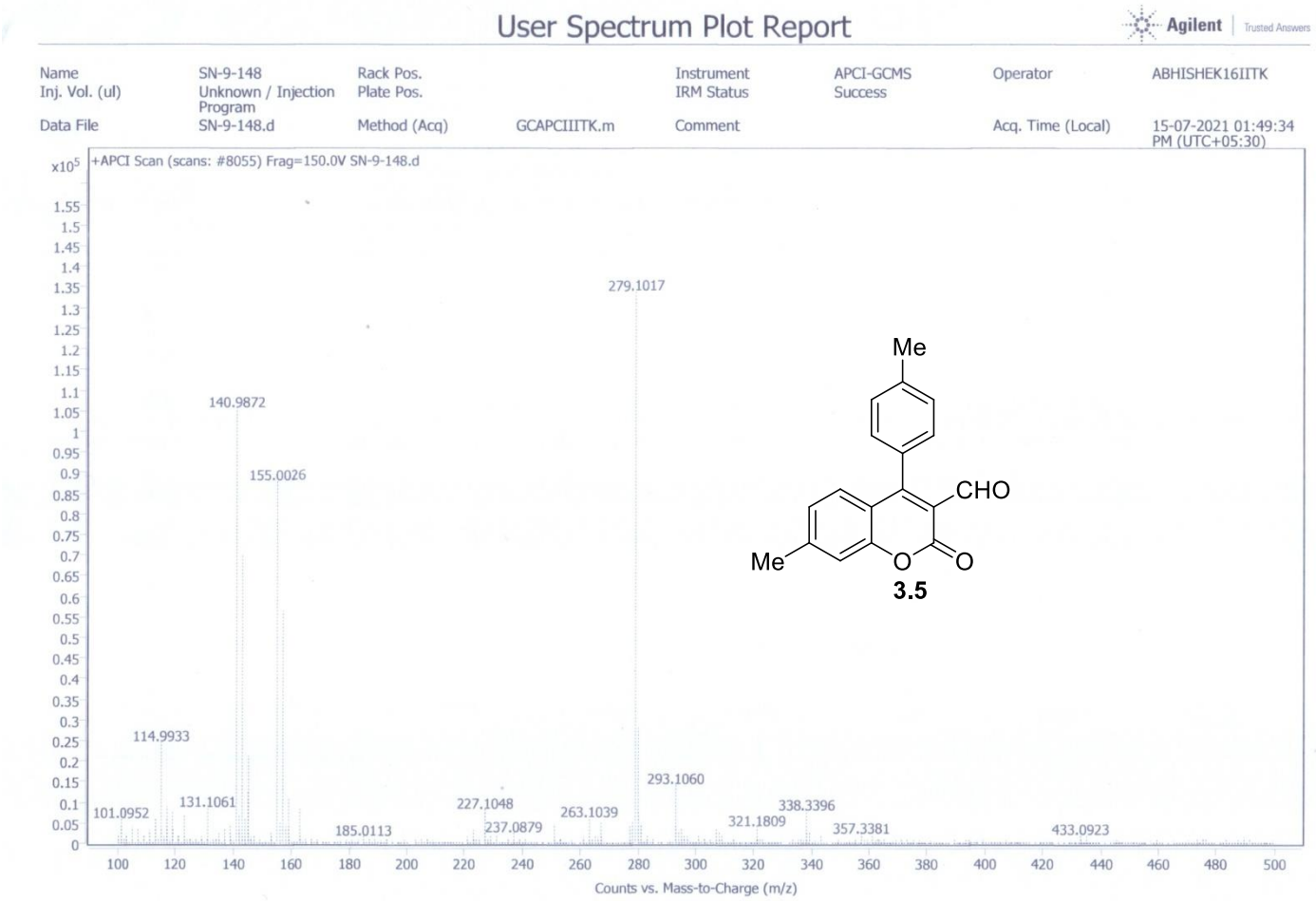
Mass Spectrum of 7-methoxy-4-(4-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.2)



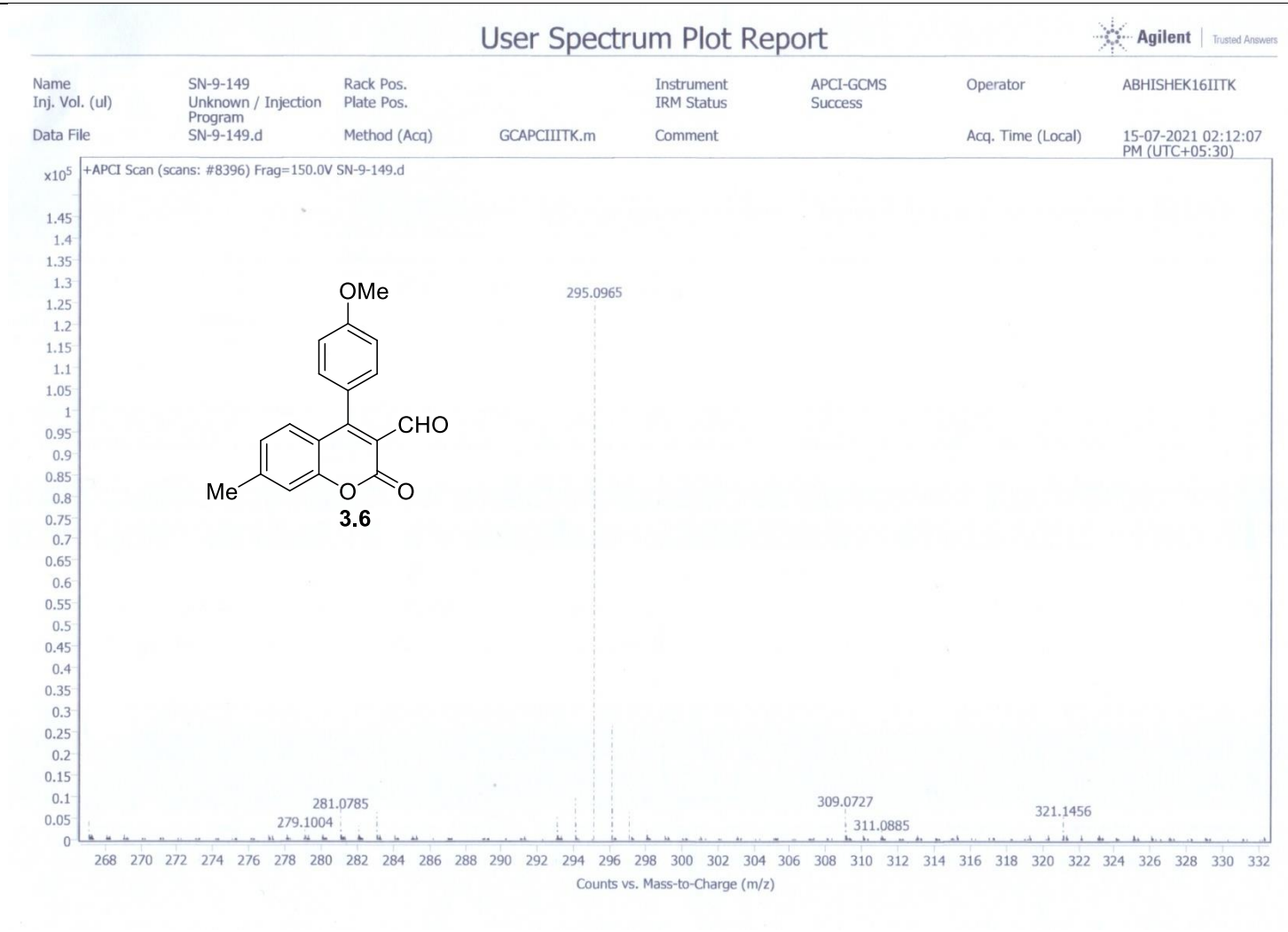
Mass Spectrum of 7-methoxy-4-(3-methoxyphenyl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.3)



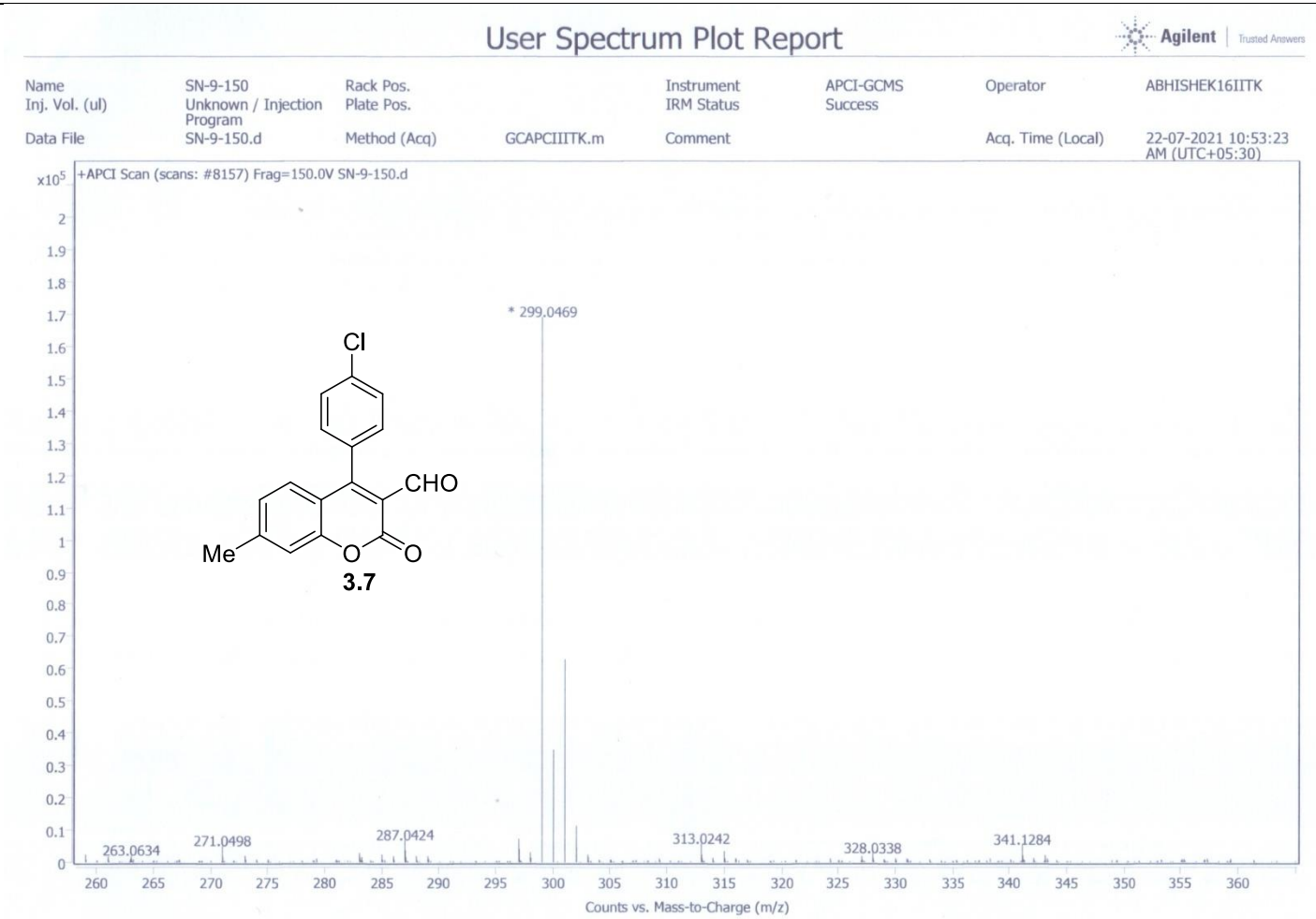
Mass Spectrum of 4-(3-chlorophenyl)-7-methoxy-2-oxo-2*H*-chromene-3-carbaldehyde (3.4)



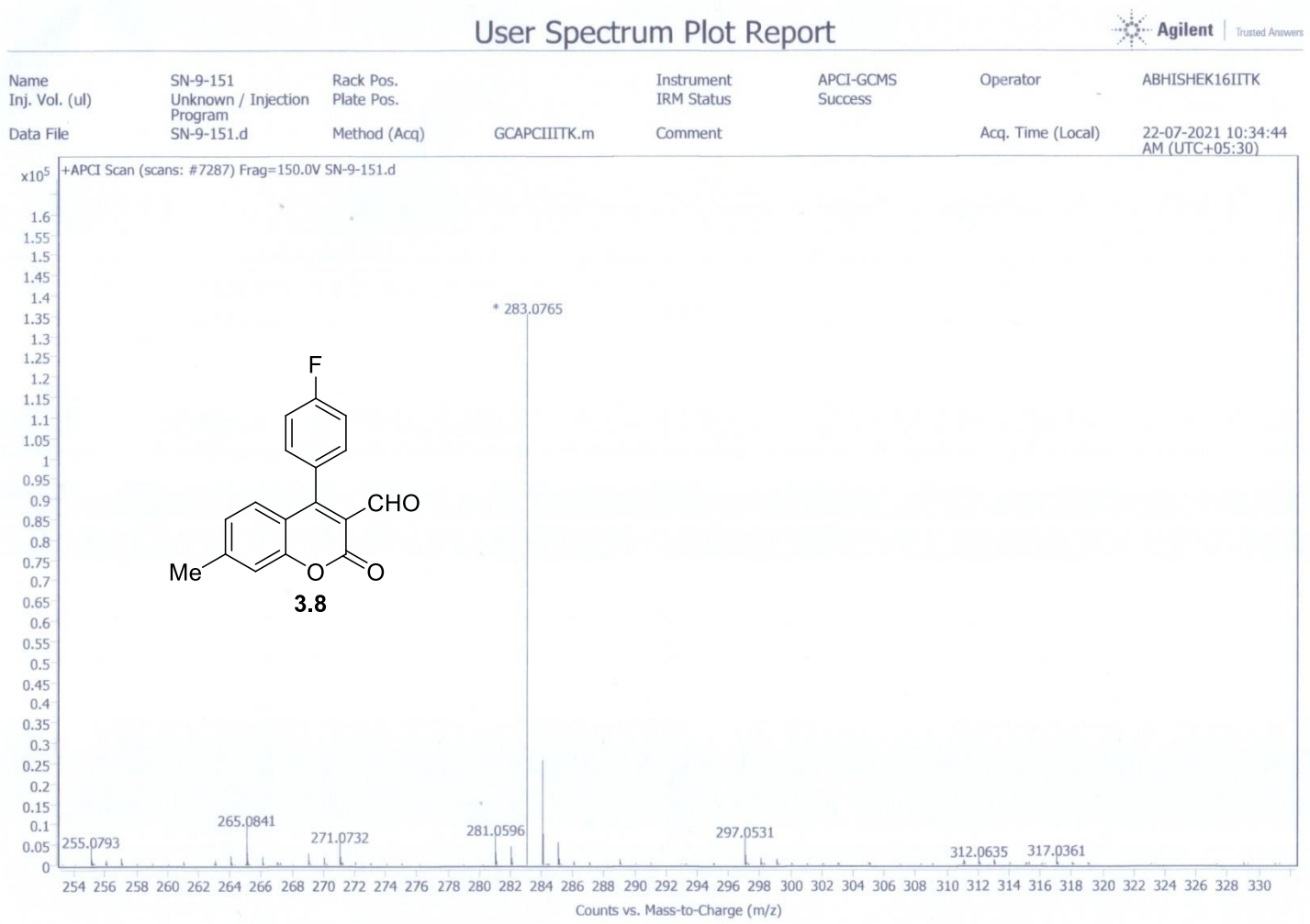
Mass Spectrum of 7-methyl-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.5)



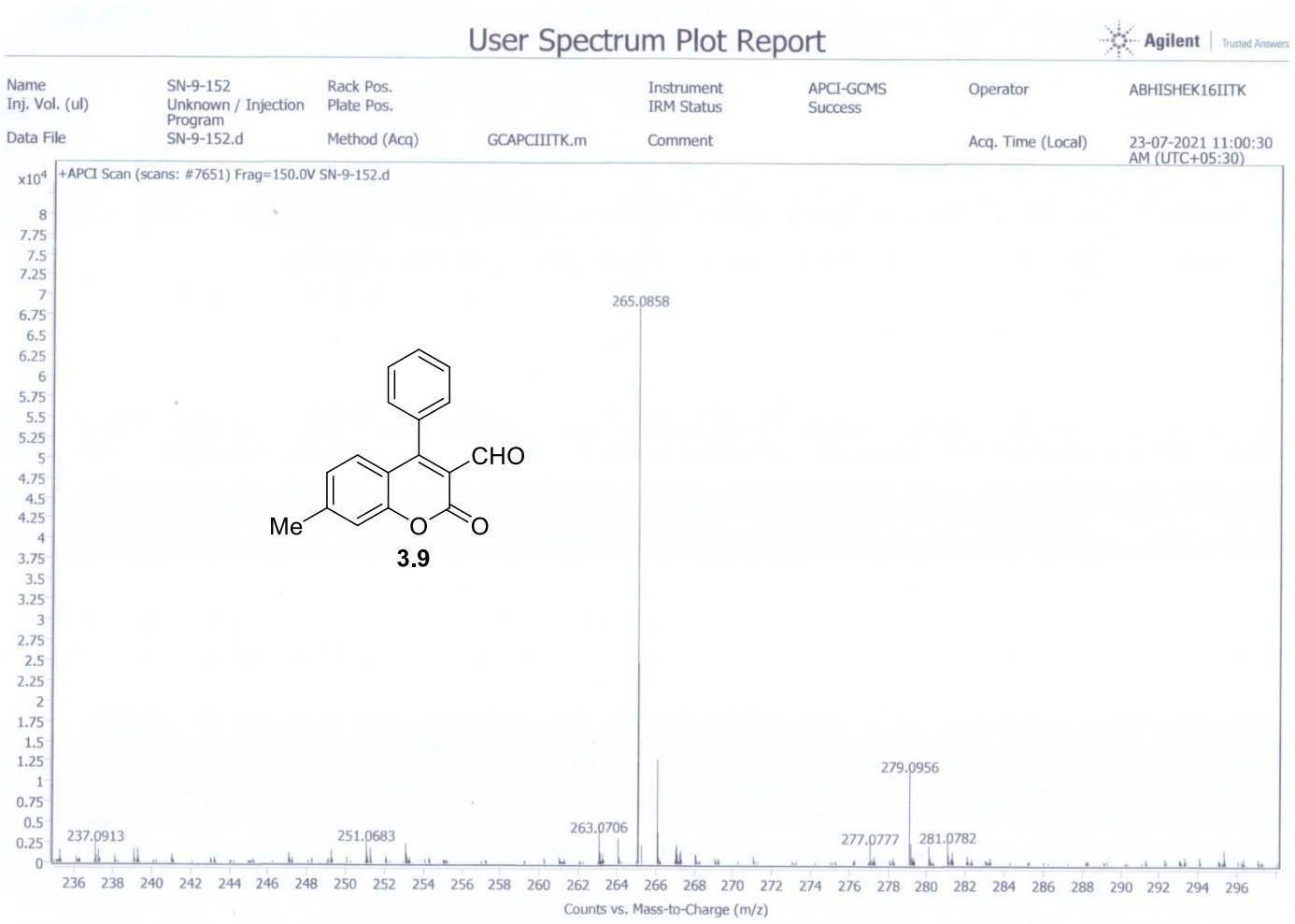
Mass Spectrum of 4-(4-methoxyphenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.6)



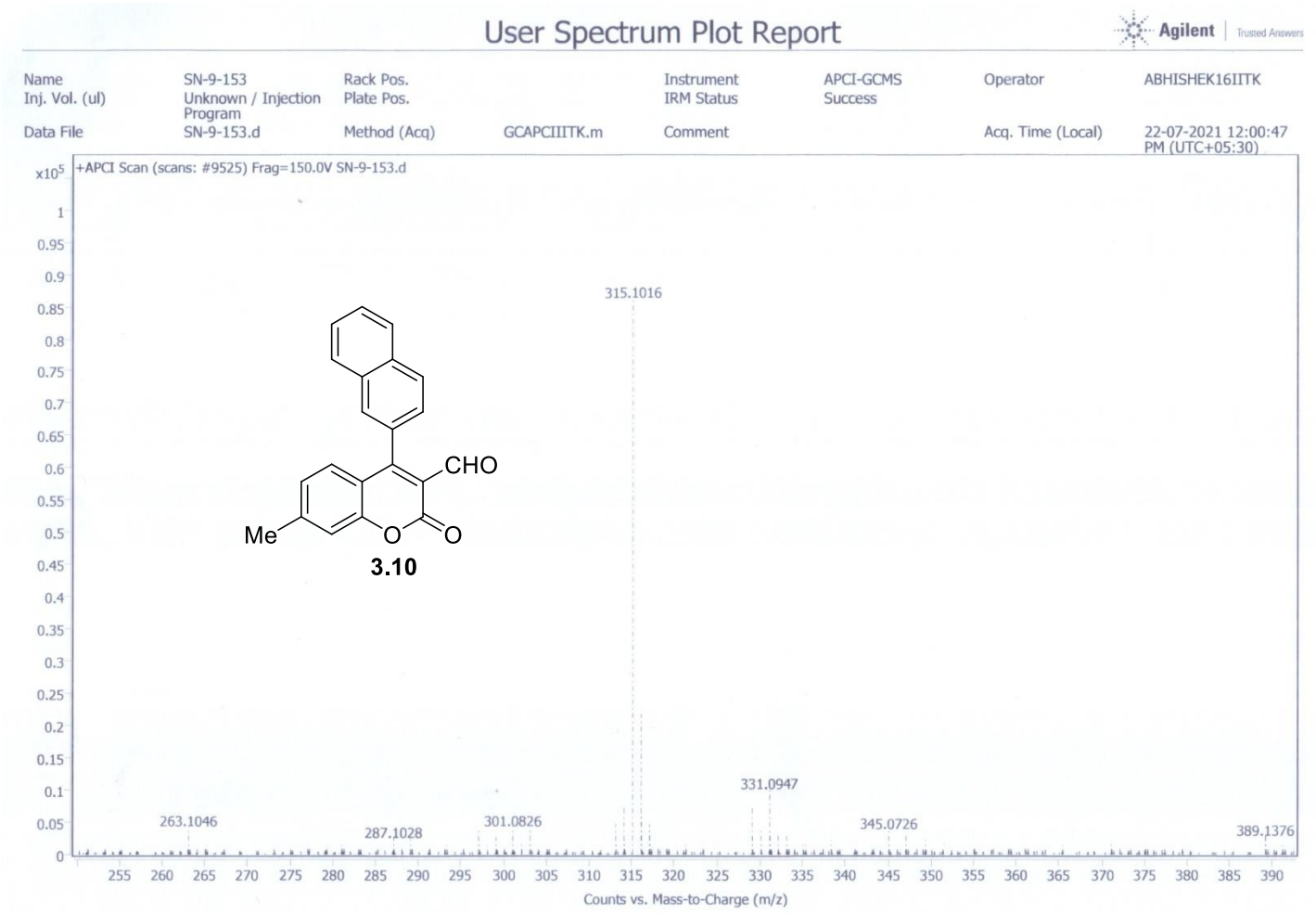
Mass Spectrum of 4-(4-chlorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.7)



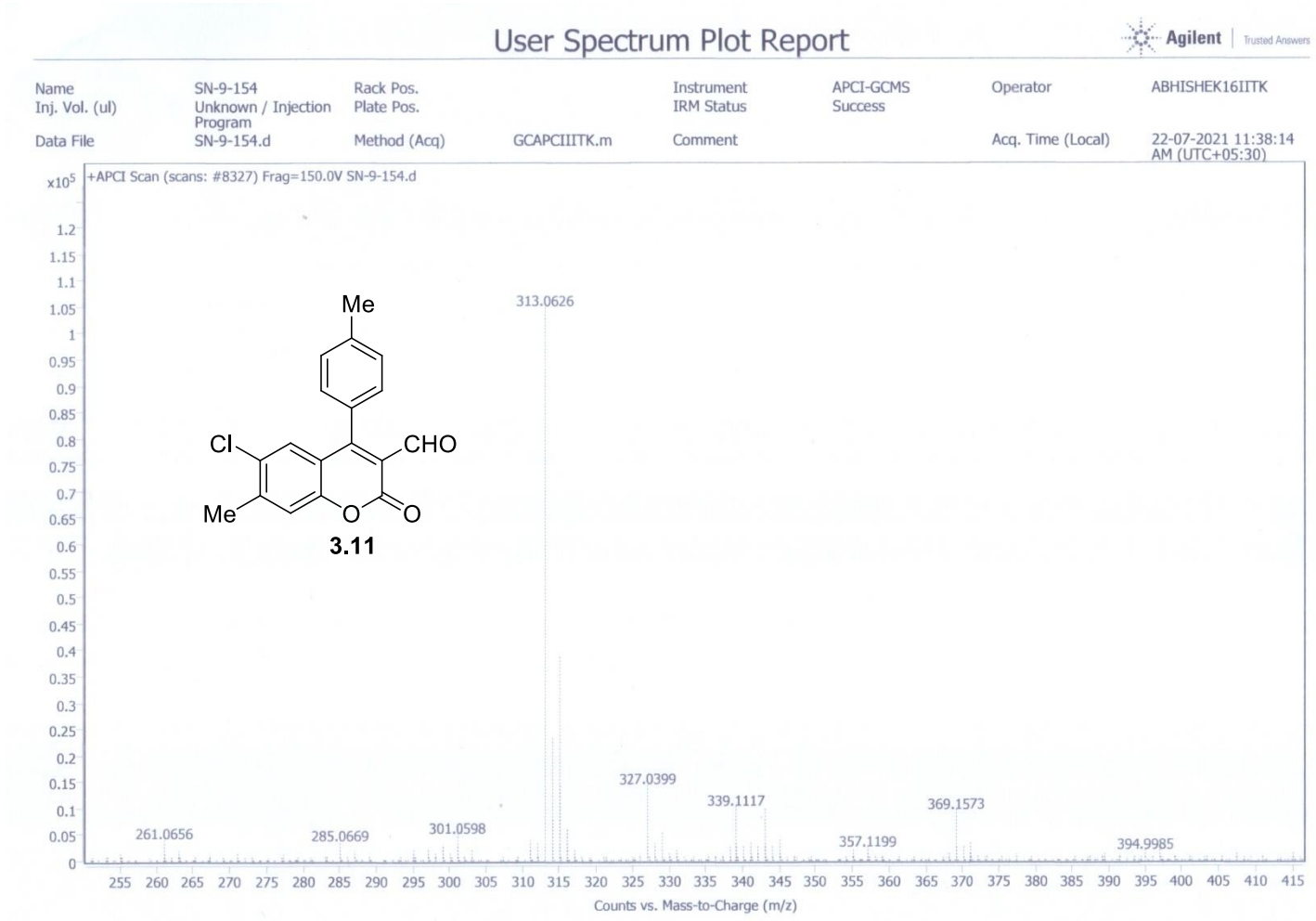
Mass Spectrum of 4-(4-fluorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.8)



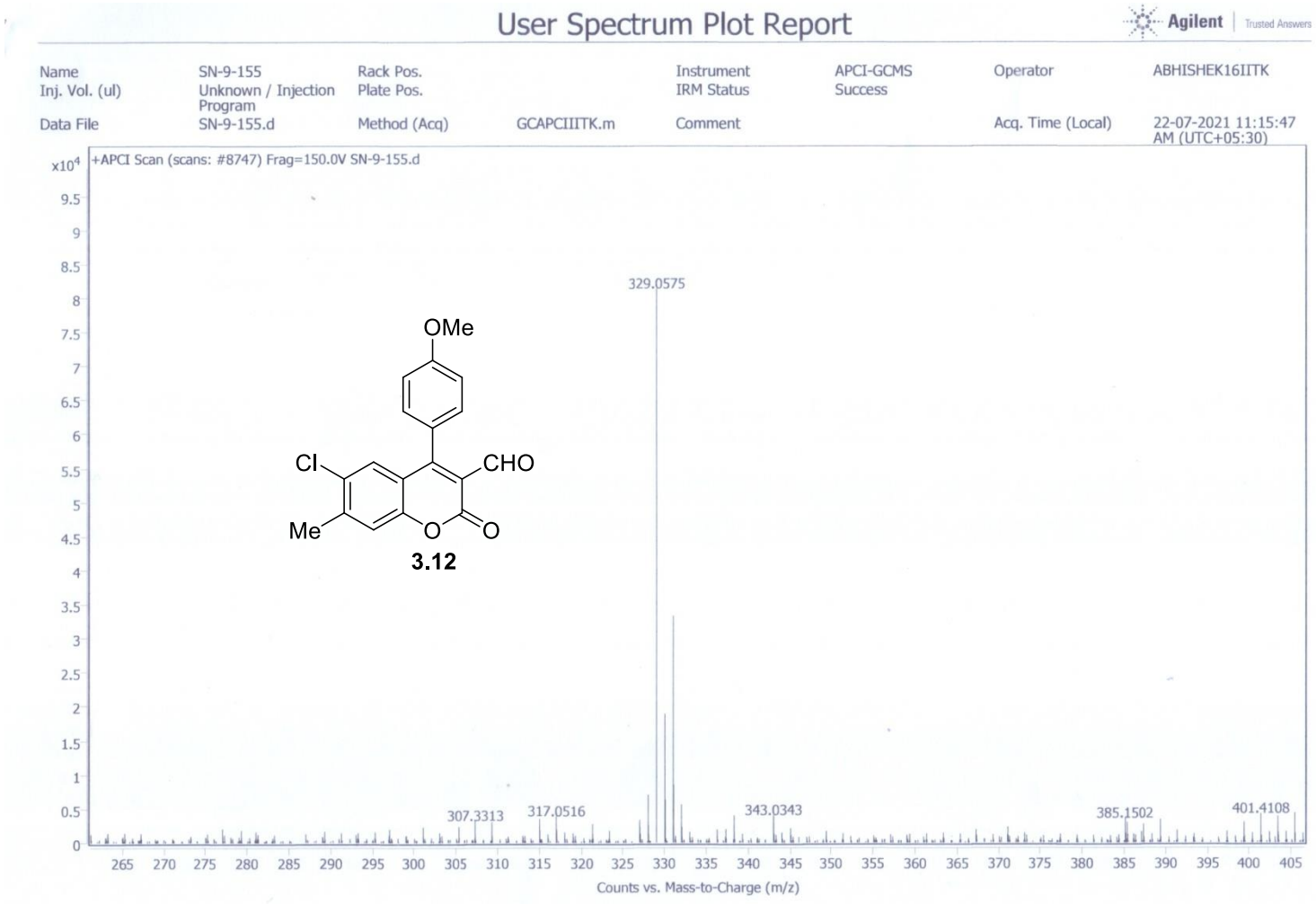
Mass Spectrum of 7-methyl-2-oxo-4-phenyl-2*H*-chromene-3-carbaldehyde (3.9)



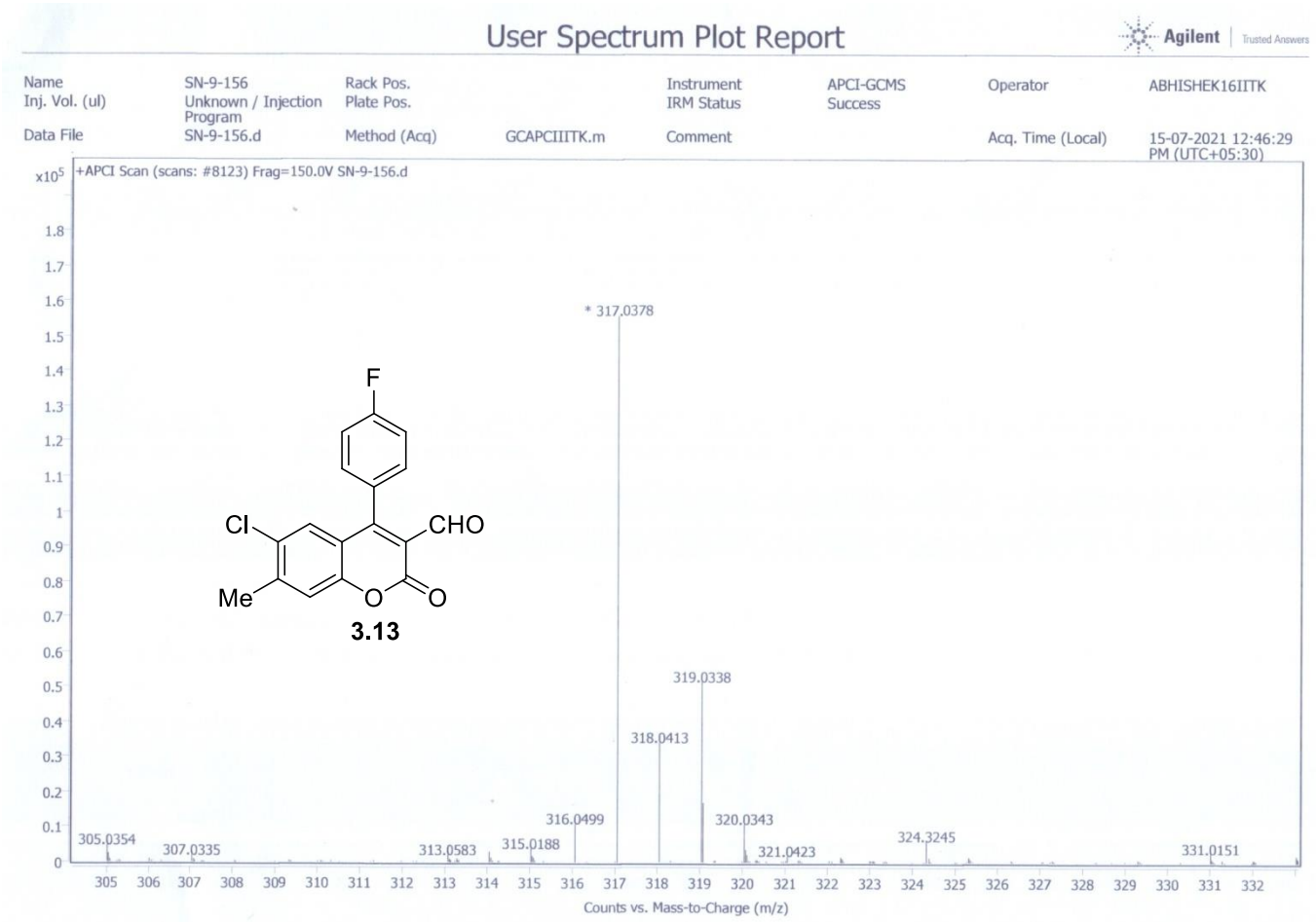
Mass Spectrum of 7-methyl-4-(naphthalen-2-yl)-2-oxo-2*H*-chromene-3-carbaldehyde (3.10)



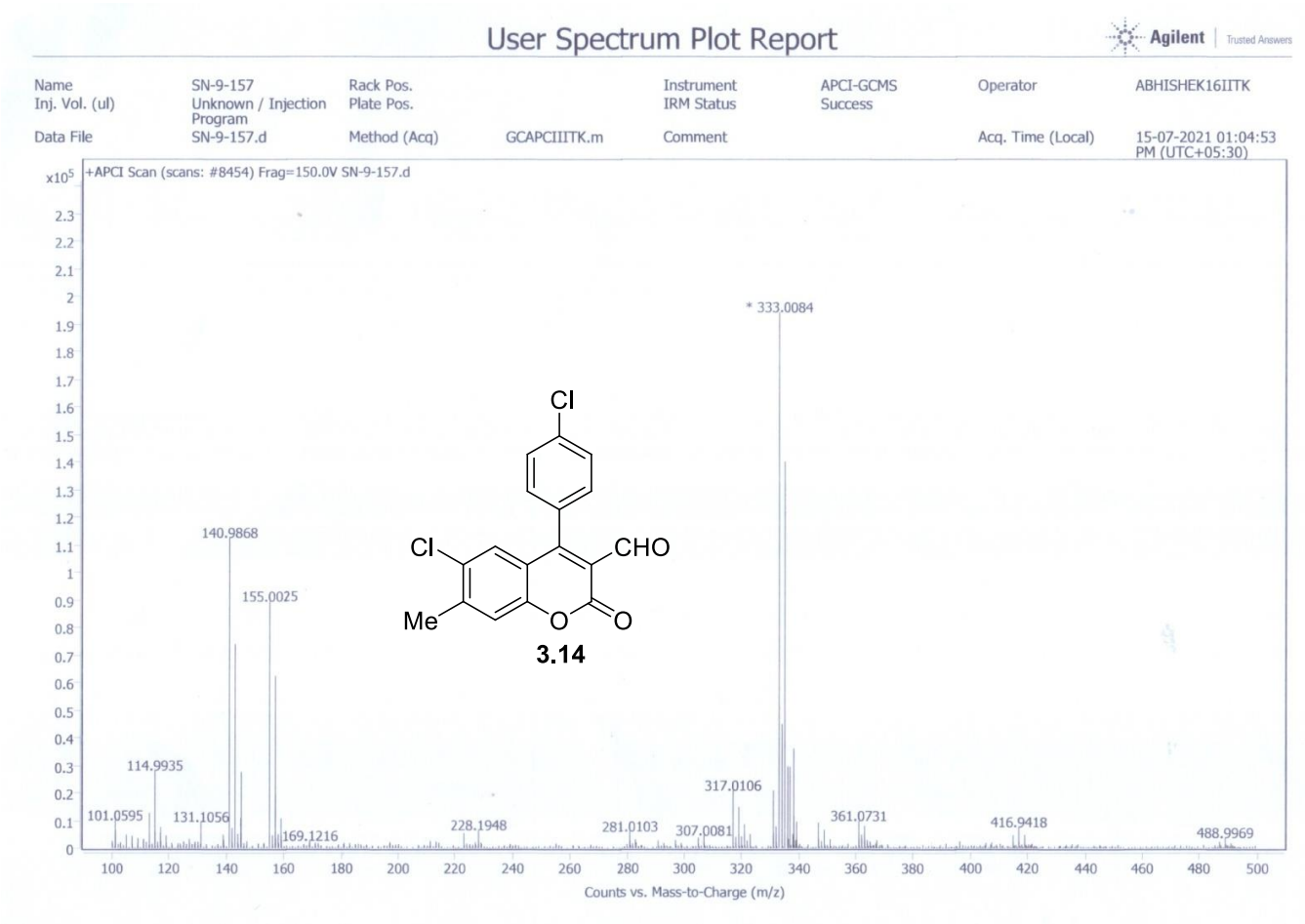
Mass Spectrum of 6-chloro-7-methyl-2-oxo-4-*p*-tolyl-2*H*-chromene-3-carbaldehyde (3.11)



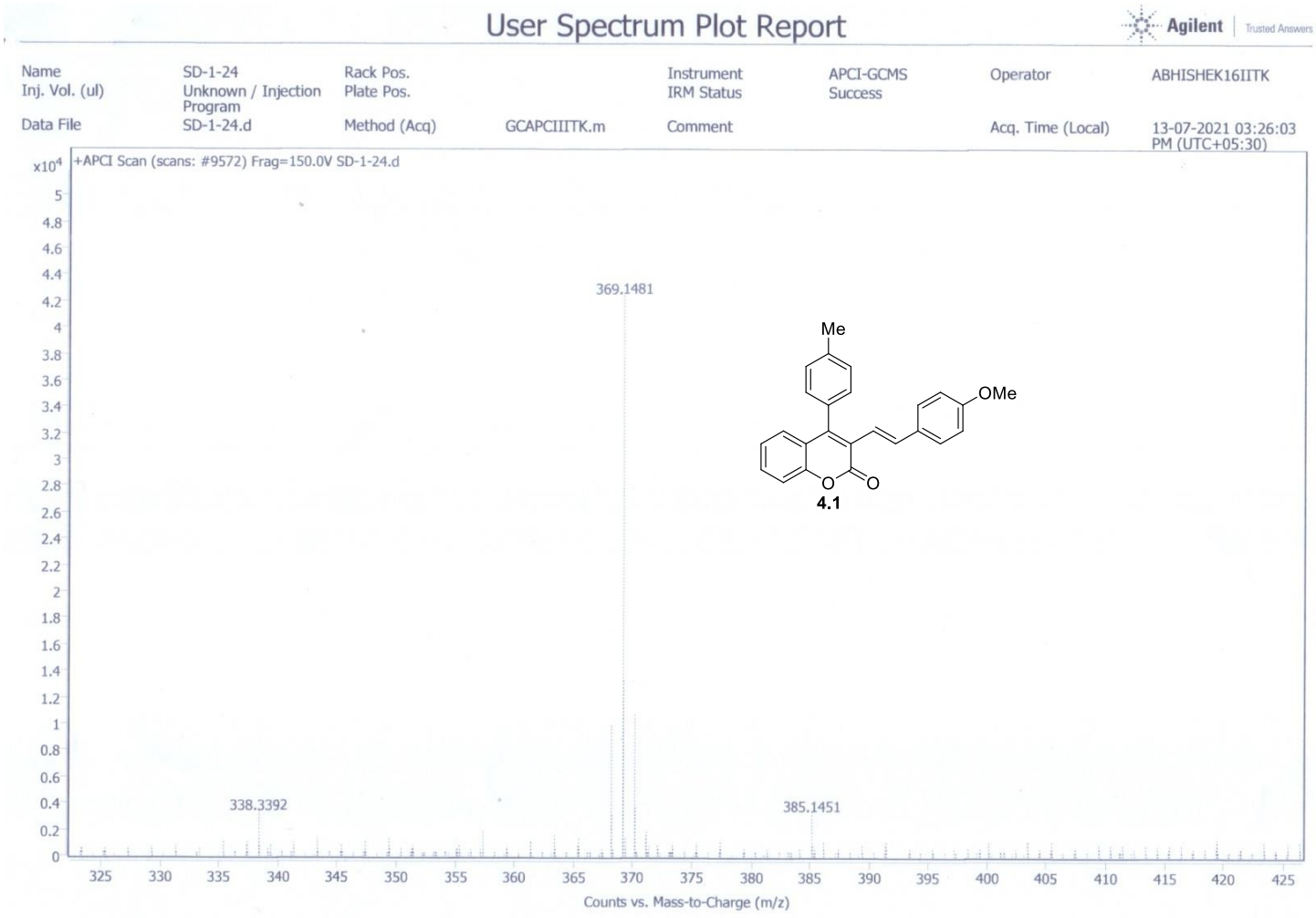
Mass Spectrum of 6-chloro-4-(4-methoxyphenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.12)



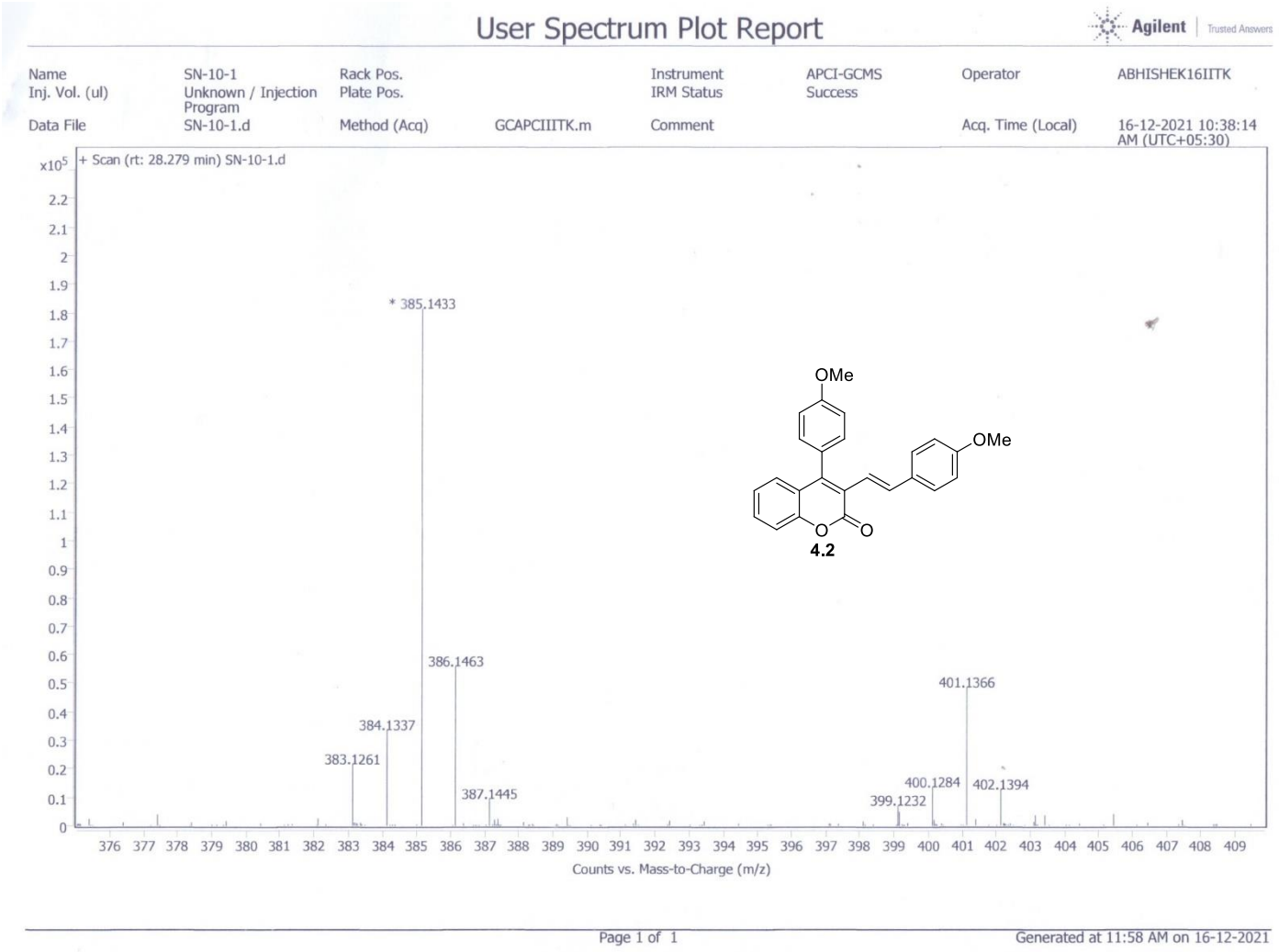
Mass Spectrum of 6-chloro-4-(4-fluorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.13)



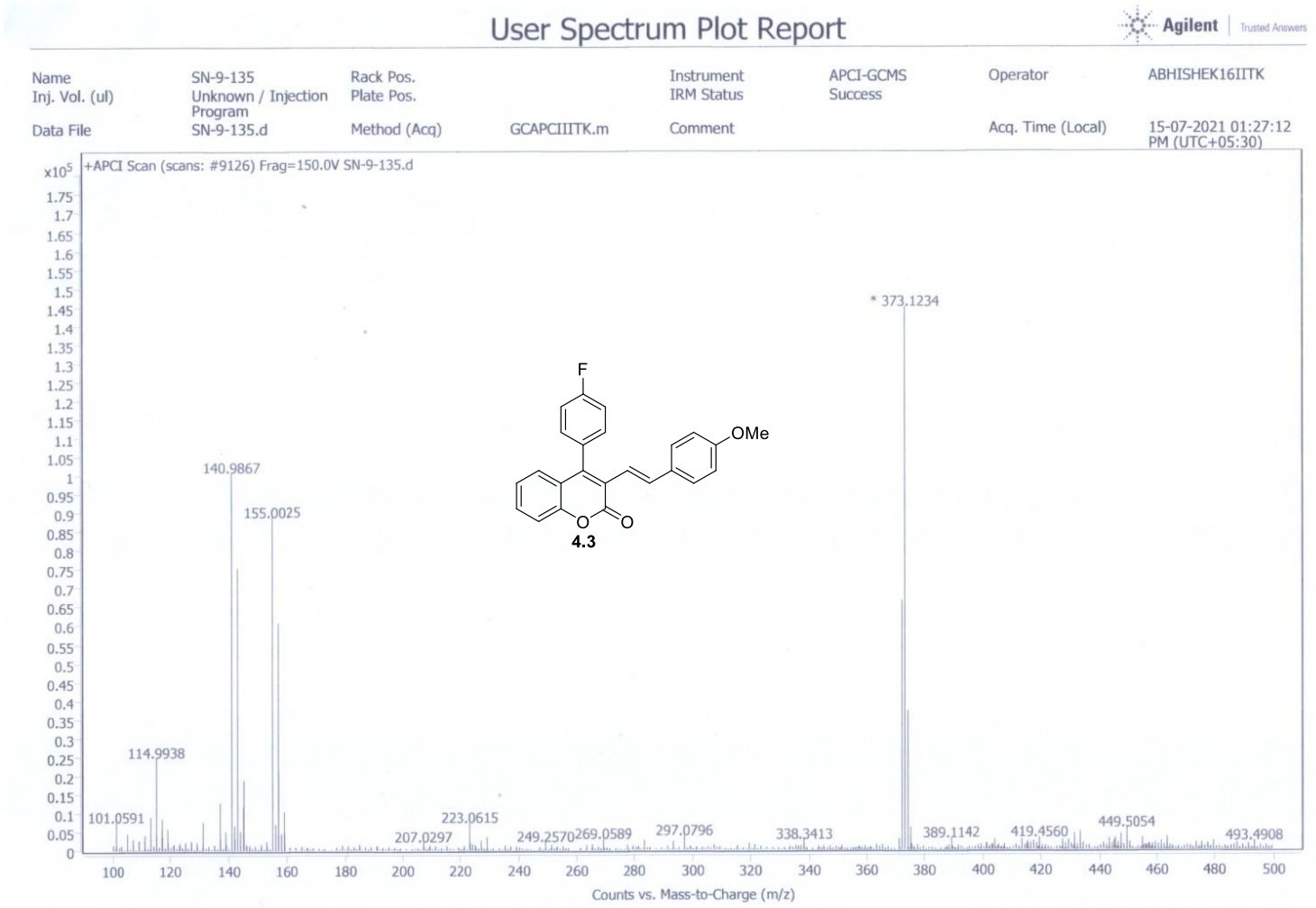
Mass Spectrum of 6-chloro-4-(4-chlorophenyl)-7-methyl-2-oxo-2*H*-chromene-3-carbaldehyde (3.14)



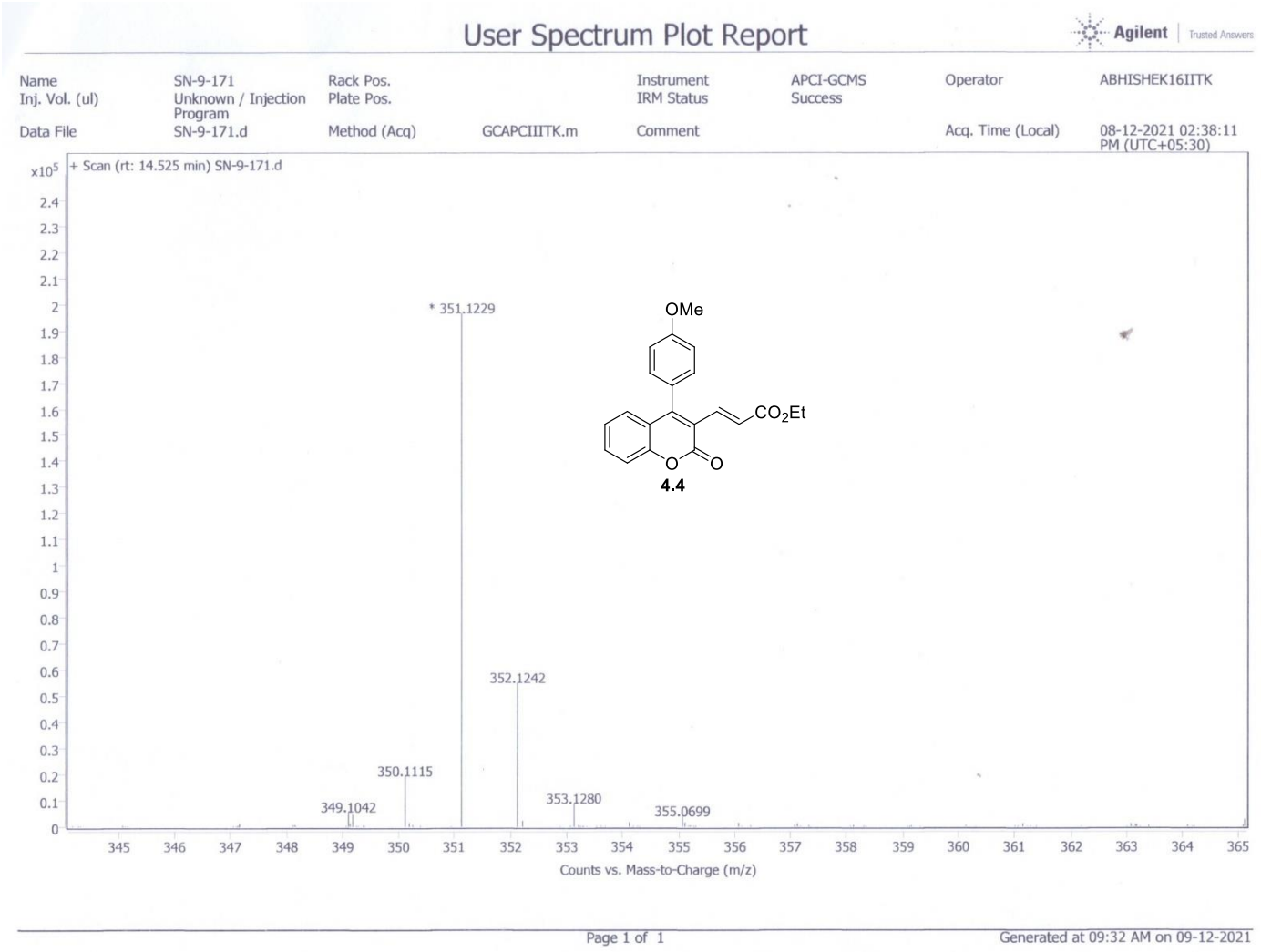
Mass Spectrum of (*E*)-3-(4-methoxystyryl)-4-*p*-tolyl-2*H*-chromen-2-one (4.1)



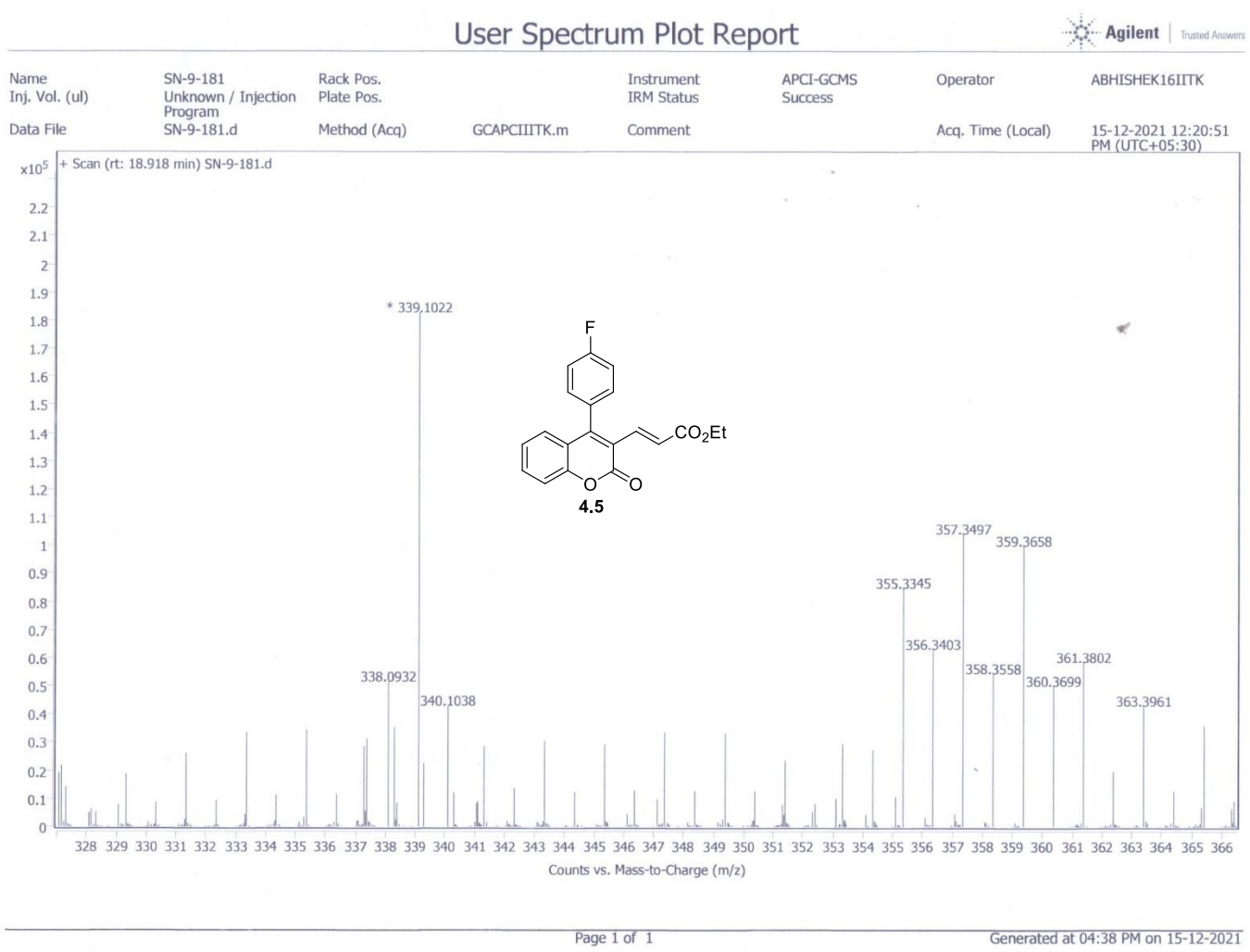
Mass Spectrum of (*E*)-4-(4-methoxyphenyl)-3-(4-methoxystyryl)-2*H*-chromen-2-one (4.2)



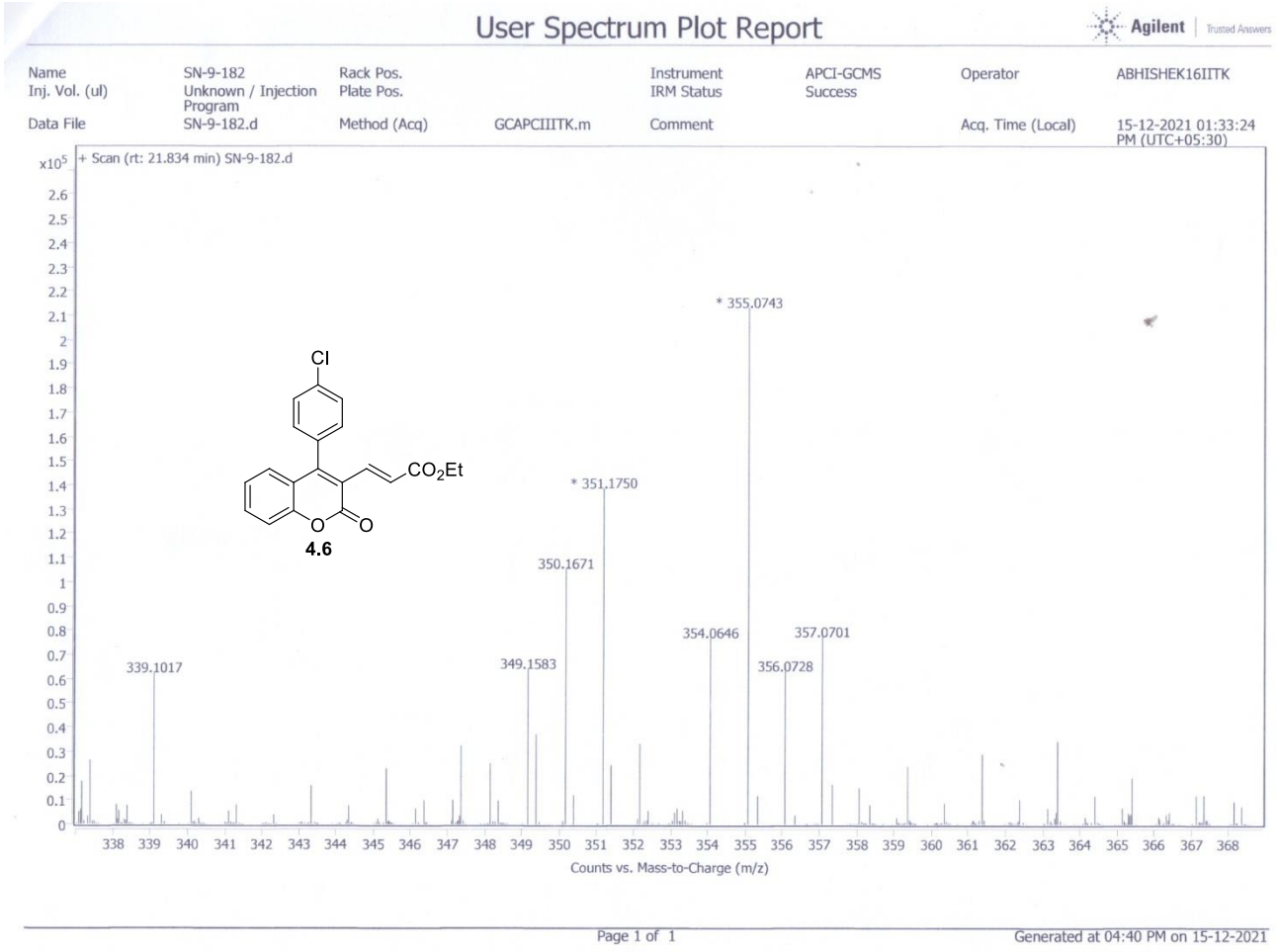
Mass Spectrum of (*E*)-4-(4-fluorophenyl)-3-(4-methoxystyryl)-2*H*-chromen-2-one (4.3)



Mass Spectrum of (*E*)-ethyl 3-(4-(4-methoxyphenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.4)



Mass Spectrum of (*E*)-ethyl 3-(4-(4-fluorophenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.5)



Mass Spectrum of (*E*)-ethyl 3-(4-(4-chlorophenyl)-2-oxo-2*H*-chromen-3-yl)acrylate (4.6)