A Dual Catalysis Approach to the Asymmetric Steglich Rearrangement and Catalytic Enantioselective Addition of *O*-Acylated Azlactones to Isoquinolines

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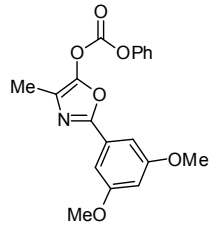
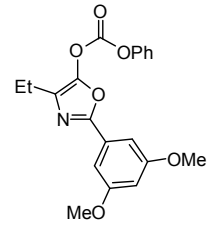
Supporting Information

General Information: Reagents and solvents were purchased from commercial sources and were used as received. Toluene was freshly distilled from sodium under nitrogen prior to use. Reactions were run under a nitrogen atmosphere. Purification of reaction products was carried out by flash chromatography using Sorbent Technologies Standard Grade silica gel (60 Å, 230–400 mesh). Analytical thin layer chromatography was performed on EM Reagent 0.25 mm silica gel 60 F_{254} plates. Visualization was accomplished with UV light and Dragendorff-Munier stain, followed by heating. Melting points were recorded on a Thomas Hoover capillary melting point apparatus and are uncorrected. Infrared spectra were recorded on an ATI Mattson Genesis Series FT-Infrared spectrophotometer. Proton nuclear magnetic resonance spectra (^{1}H-NMR) were recorded on a Varian VNMRS–500 MHz instrument and are reported in ppm using solvent as an internal standard ($CDCl_3$ at 7.26 ppm. Data are reported as app = apparent, s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, comp = complex; br = broad; integration; coupling constant(s) in Hz. Proton-decoupled carbon nuclear magnetic resonance spectra (^{13}C-NMR) spectra were recorded on a Varian VNMRS–500 MHz instrument and are reported in ppm using solvent as an internal standard ($CDCl_3$ at 77.0 ppm). Mass spectra were recorded on a Finnigan LCQ-DUO mass spectrometer or on a Finnigan 2001 Fourier Transform Ion Cyclotron Resonance Mass Spectrometer. HPLC analysis was carried out on an Agilent 1100 series instrument with auto sampler and multiple wavelength detectors. Optical rotations were measured using a 1 mL cell with a 1 dm path length on a Jasco P–2000 polarimeter at 589 nm and at 20 °C. *O*-acylated azlactones were prepared according to literature methods.[1,2]

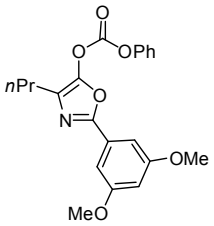
Selected Characterization Data of *O*-Acylated Azlactones



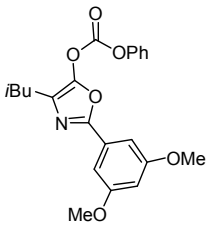
2-(3,5-dimethoxyphenyl)-4-methyloxazol-5-yl phenyl carbonate (1a): mp = 104–106 ºC; IR (KBr) 2962, 2924, 1786, 1602, 1555, 1225, 1209, 1195, 1052, 732 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.49–7.42 (m, 2H), 7.35–7.28 (comp, 3H), 7.12 (d, *J* = 2.3 Hz, 2H), 6.54 (t, *J* = 2.3 Hz, 1H), 3.85 (s, 6H), 2.21(s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.0, 154.8, 150.7, 150.0, 145.7, 129.8, 128.6, 126.9, 120.7, 120.5, 103.63, 103.55, 55.6, 10.4; *m/z* (ESI-MS) 355.9 $[M+H]^+$.



2-(3,5-dimethoxyphenyl)-4-ethyloxazol-5-yl phenyl carbonate (1b): mp = 125–127 ºC; IR (KBr) 2971, 2939, 2839, 1800, 1599, 1555, 1207, 1157, 1065, 733 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.53–7.38 (m, 2H), 7.38–7.25 (comp, 3H), 7.14 (d, *J* = 2.2 Hz, 2H), 6.54 (t, *J* = 2.2 Hz, 1H), 3.84 (s, 6H), 2.60 (q, *J* = 7.6 Hz, 2H), 1.31 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.0, 154.8, 150.7, 150.2, 155.0, 129.8, 128.7, 126.8, 126.0, 120.4, 103.64, 103.61, 55.55, 55.49, 18.4, 12.3; *m/z* (ESI-MS) 370.9 $[M+H]^+$.



2-(3,5-dimethoxyphenyl)-4-propyloxazol-5-yl phenyl carbonate (1c): mp = 71–73 ºC; IR (KBr) 2963, 2927, 2841, 1789, 1599, 1552, 1231, 1158, 732 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.47–7.37 (m, 2H), 7.35–7.27 (comp, 3H), 7.13 (d, *J* = 2.4 Hz, 2H), 6.54 (t, *J* = 2.4 Hz, 1H), 3.85 (s, 6H), 2.53 (t, *J* = 7.5 Hz, 2H), 1.80–1.68 (m, 2H), 1.01 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.0, 154.9, 150.7, 150.2, 145.5, 129.8, 128.8, 126.8, 124.8, 120.5, 103.7, 103.4, 55.6, 26.9, 21.2, 13.7; *m/z* (ESI-MS) 383.9 $[M]^+$.

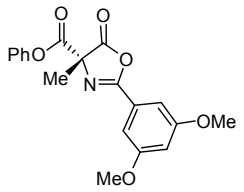


2-(3,5-dimethoxyphenyl)-4-isobutyloxazol-5-yl phenyl carbonate (1d): mp = 69–71 ºC; IR (KBr) 2965, 2934, 1782, 1597, 1552, 1232, 1155, 1044, 732 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.49–7.41 (m, 2H), 7.35–7.27 (comp, 3H), 7.13 (d, *J* = 2.3 Hz, 2H), 6.54 (t, *J* = 2.3 Hz, 1H), 3.85 (s, 6H), 2.42 (d, *J* = 7.2 Hz, 2H), 2.11 (app sept, *J* = 6.7 Hz, 1H), 0.99 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.0, 154.9, 150.7, 150.2, 146.1, 129.8, 128.8, 126.8, 124.1, 120.5, 103.7, 103.4, 55.6, 33.9, 27.6, 22.3; *m/z* (ESI-MS) 398.0 $[M+H]^+$.

General Procedure for the Rearrangements of *O*-Acylated Azlactones:

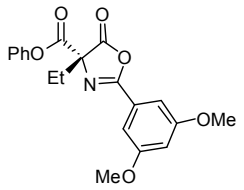
A flame dried 2 dram sample vial was charged with azlactone (0.20 mmol, 1 equiv), HB-catalyst (0.04 mmol, 0.2 equiv) and 4Å MS (50 mg). Anhydrous toluene (2.2 mL) was added and the reaction mixture was stirred at room temperature for 5 min. It was then cooled to –78 ºC over 15 min, a solution of DMAP (0.04 mmol) in 1.1 mL of toluene was added and the reaction mixture was stirred at –78 ºC. The reaction was monitored by TLC and, upon completion, allowed to warm to rt. The crude reaction mixture was purified directly by flash chromatography.

(*R*)-phenyl 2-(3,5-dimethoxyphenyl)-4-methyl-5-oxo-4,5-dihydrooxazole-4-carboxylate (2a):



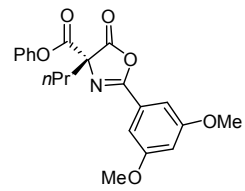
Following the general procedure, compound **2a** was obtained as colorless oil in 49% yield. Rf = 0.18 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ +5.4 (c 1.0, $CHCl_3$, 87% ee); IR (neat) 2938, 1819, 1768, 1647, 1596, 1492, 1458, 1428, 1360, 1343, 1206, 1159, 1103, 1065, 1023, 916, 842 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.46– 7.32 (m, 2H), 7.30–7.22 (m, 1H), 7.21 (d, *J* = 2.3 Hz, 2H), 7.15–7.07 (comp, 2H), 6.70 (t, *J* = 2.4 Hz, 1H), 3.86 (s, 6H), 1.89 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 174.7, 164.5, 163.6, 161.0, 150.2, 129.5, 126.7, 126.5, 121.0, 120.9, 106.5, 105.9, 73.0, 55.7, 20.4; *m/z* (ESI-MS) 355.9 $[M+H]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 95/5, Flow rate = 1 mL/min, UV = 280 nm, t_R = 7.8 min (major) and t_R = 8.8 min (minor).

(*R*)-phenyl 2-(3,5-dimethoxyphenyl)-4-ethyl-5-oxo-4,5-dihydrooxazole-4-carboxylate (2b):



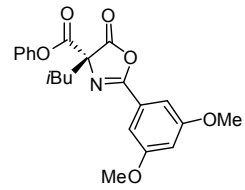
Following the general procedure, compound **2b** was obtained as colorless oil in 65% yield. Rf = 0.36 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ +37.3 (c 1.0, $CHCl_3$, 91% ee); IR (neat) 2971, 2939, 1817, 1765, 1650, 1696, 1492, 1458, 1428, 1360, 1344, 1315, 1206, 1159, 1064, 1034, 913, 846, 743, 727 cm^{-1}; ^1H NMR δ 7.45–7.33 (m, 2H), 7.31–7.24 (m, 1H), 7.23 (d, *J* = 2.4 Hz, 2H), 6.70 (t, *J* = 2.4 Hz, 1H), 3.86 (s, 6H), 2.46 (dq, *J* = 14.4, 7.5 Hz, 1H), 2.37 (dq, *J* = 14.8, 7.4 Hz, 1H), 1.01 (t, *J* = 7.5 Hz); ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.9, 164.3, 163.5, 161.0, 150.2, 129.5, 126.7, 126.5, 121.1, 106.8, 106.6, 106.14, 106.11, 56.0, 55.91, 27.3, 7.7; *m/z* (ESI-MS) 369.9 $[M+H]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 95/5, Flow rate = 1 mL/min, UV = 280 nm, t_R = 7.1 min (major) and t_R = 8.9 min (minor).

(*R*)-phenyl 2-(3,5-dimethoxyphenyl)-5-oxo-4-propyl-4,5-dihydrooxazole-4-carboxylate (2c):



Following the general procedure, compound **2c** was obtained as colorless oil in 52% yield. Rf = 0.42 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ +138.8 (c 1.0, $CHCl_3$, 91% ee); IR (neat) 2965, 2936, 2876, 2842, 1819, 1766, 1649, 1595, 1492, 1458, 1427, 1360, 1343, 1315, 1206, 1159, 1110, 1065, 1036, 969, 914, 845, 743 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.40–7.34 (m, 2H), 7.27–7.23 (m, 1H), 7.22 (d, *J* = 2.4 Hz, 2H), 6.70 (t, *J* = 2.4 Hz, 1H), 3.85 (s, 6H), 2.41 (ddd, *J* = 17.0, 12.0, 4.9 Hz, 1H), 2.29 (ddd, *J* = 16.8, 11.7, 5.1 Hz, 1H), 1.55–1.23 (comp, 2H), 1.00 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 174.0, 164.3, 163.4, 161.0, 150.2, 129.5, 126.7, 126.5, 121.0, 106.4, 105.8, 76.9, 36.3, 16.8, 13.7; *m/z* (ESI-MS) 383.9 $[M+H]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 95/5, Flow rate = 1 mL/min, UV = 280 nm, t_R = 6.5 min (major) and t_R = 7.9 min (minor).

(*R*)-phenyl 2-(3,5-dimethoxyphenyl)-4-isobutyl-5-oxo-4,5-dihydrooxazole-4-carboxylate (2d):

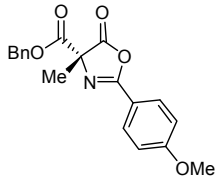


Following the general procedure, compound **2d** was obtained as colorless oil in 51% yield. Rf = 0.45 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ +3.6 (c 1.0, $CHCl_3$, 90% ee); IR (neat) 2961, 1818, 1771, 1650, 1595, 1492, 1459, 1427, 1361, 1343, 1316, 1206, 1159, 1121, 1066, 1041 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.40–7.33 (m, 2H), δ 7.28–7.25 (m, 1H), 7.24 (d, *J* = 2.3 Hz, 2H), 7.14–7.08 (comp, 2H), 6.71 (t, *J* = 2.3 Hz, 1H), 3.86 (s, 6H), 2.52 (dd, *J* = 14.4, 5.5 Hz, 1H), 2.19 (dd, *J* = 14.4, 7.4 Hz, 1H), 1.82 (app sept, *J* = 6.7 Hz, 1H), 1.01 (d, *J* = 6.7 Hz, 3H), 0.97 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 174.5, 164.5, 163.1, 161.0, 150.2, 129.5, 129.0, 128.2, 126.8, 126.5, 121.0, 106.3, 105.9, 76.5, 55.7, 42.7, 24.6, 23.8, 23.0; *m/z* (ESI-MS) 398.0 $[M+H]^+$; HPLC: Daicel Chiralpak

OD-H, *n*-hexane/*i*-PrOH = 95/5, Flow rate = 1 mL/min, UV = 280 nm, t_R = 6.1 min (major) and t_R = 7.2 min (minor).

Determination of the absolute configuration of the rearrangement products:

(*R*)-benzyl 2-(4-methoxyphenyl)-4-methyl-5-oxo-4,5-dihydrooxazole-4-carboxylate (2e):



Following the general procedure, with the exception that the reaction was performed at –60 ºC, compound **2e** was obtained as colorless oil in 52% yield. All spectral data matched what was reported previously.[1] The absolute configuration of compound (*R*)-**2e** ($[\alpha]_D^{20}$ +27.6 (c 1.0, $CHCl_3$, 60% ee) was assigned by comparison with the (*S*)-enantiomer reported in the literature[1] ($[\alpha]_D^{20}$ –55 (c 0.95, $CHCl_3$, 90.6% ee).

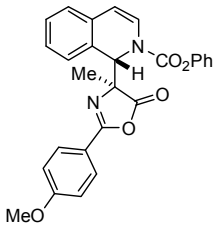
The absolute configuration of the products (**2a**–**2d**) was assigned by analogy.

General Procedure for the Reaction of Azlactones with Isoquinolines:

A flame dried 2 dram sample vial was charged with azlactone (0.20 mmol, 1 equiv), catalyst (0.02 mmol, 0.1 equiv) and 4Å MS (50 mg). Anhydrous pentane (2.2 mL) was added and the reaction mixture was stirred at room temperature for 5 min. It was then cooled to –25 ºC over 15 min and a solution of isoquinoline (0.24 mmol) in 1.1 mL of mesitylene was added. The reaction mixture was stirred at –25 ºC and monitored by TLC. Upon consumption of starting material, the reaction was quenched by addition of 0.2 mL of a 0.1 M solution of DMAP in CH_2Cl_2. Stirring was continued at –25 ºC for another 10 minutes. The reaction mixture was then allowed to warm to rt and purified directly by flash chromatography.

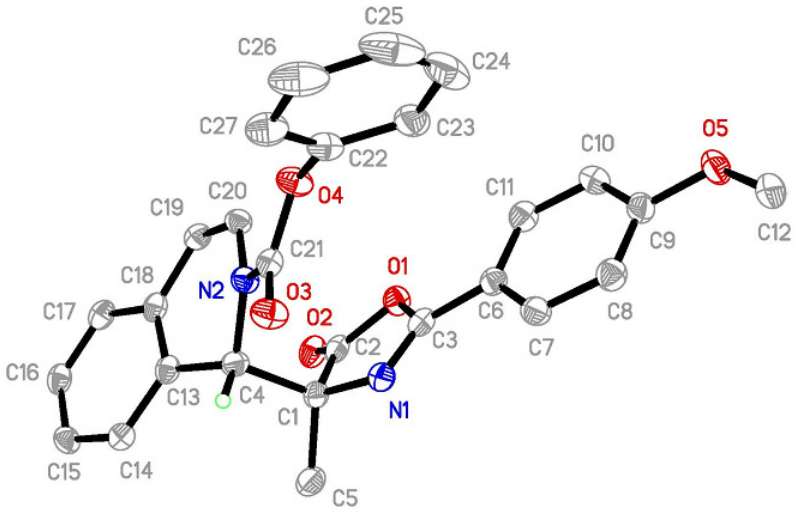
Characterization Data of Products

(*S*)-phenyl 1-((*S*)-2-(4-methoxyphenyl)-4-methyl-5-oxo-4,5-dihydrooxazol-4-yl)isoquinoline-2(1*H*)-carboxylate (7a):



Following the general procedure, compound **7a** was obtained as a white solid in 85% yield. mp = 69–71 ºC; Rf = 0.50 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –175.69 (c 1.0, $CHCl_3$, 93% ee); dr = 96:04; IR (KBr) 3063, 2935, 1814, 1728, 1648, 1512, 1321, 1197, 1016, 740 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): the compound exists as a 2:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer), δ 7.86–7.80 (m, 2H), 7.80–7.77 (m, 2H*), 7.46–7.40 (comp, 2H*), 7.40–7.34 (comp, 2H), 7.33–7.21 (comp, 5H, 5H*), 7.19 (app dd *J* = 7.7, 1.1 Hz, 1H), 7.13 (app dd *J* = 7.7, 1.1 Hz, 1H*), 7.12–7.07 (comp, 2H, 2H*), 6.96–6.89 (comp, 2H, 2H*), 6.10 (d, *J* = 7.7 Hz, 1H*), 6.03 (d, *J* = 7.7 Hz, 1H), 5.91 (s, 1H*), 5.87 (s, 1H), 3.86 (s, 3H), 3.85 (s, 3H*), 1.60 (s, 3H*), 1.53 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.9, 178.8, 163.2, 163.1, 160.2, 160.0, 152.3, 152.0, 150.9, 150.6, 137.7, 131.9, 131.5, 129.7, 129.7, 129.5, 129.4, 129.0, 128.8, 127.8, 127.5, 127.4, 127.2, 126.9, 126.0, 126.0, 125.9, 128.9, 125.6, 125.0, 124.9, 124.8, 121.5, 121.5, 117.9, 117.8, 114.0, 114.1, 111.9, 111.2, 73.7, 73.4, 61.2, 60.1, 55.4, 55.4, 21.2, 20.3, 19.9; *m/z* (ESI-MS) 476.8 $[M+Na]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 90/10, Flow rate = 0.5 mL/min, UV = 280 nm, major diastereomer: t_R = 20.4 min (minor) and t_R = 27.6 min (major), minor diastereomer: t_R = 22.5 min (minor) and t_R = 25.7 min (major).

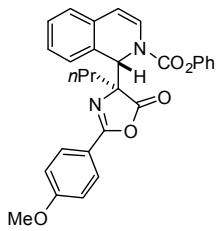
The enantioenriched product **7a** was recrystallized from EtOAc/hexanes and the absolute configuration was assigned by X-ray crystallography.



The requisite CIF has been submitted to the journal.

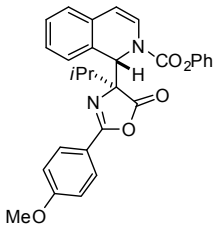
(*S*)-phenyl 1-((*S*)-4-ethyl-2-(4-methoxyphenyl)-5-oxo-4,5-dihydrooxazol-4-yl)isoquinoline-2(1*H*)-carboxylate (7b): Following the general procedure, compound **7b** was obtained as a white solid in 94% yield. mp = 63–65 ºC; R_f = 0.56 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –183.5 (c 1.0, $CHCl_3$, 92% ee); dr = 93:07; IR (KBr) 2967, 2935, 1810, 1729, 1650, 1512, 1323, 1197, 1025, 741 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): the compound exists as a 2:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer), δ 7.89–7.79 (comp, 2H, 2H*), 7.46–7.40 (comp, 2H*), 7.40–7.34 (comp, 2H), 7.33–7.20 (comp, 5H, 5H*), 7.17 (d, *J* = 7.7 Hz, 1H), 7.14–7.05 (comp, 1H*, 2H, 2H*), 6.98–6.90 (comp, 2H, 2H*), 6.09 (d, *J* = 7.7 Hz, 1H*), 6.03 (d, *J* = 7.7 Hz, 1H), 5.95 (s, 1H*), 5.92 (s, 1H), 3.86 (s, 3H), 3.85 (s, 3H*), 2.28–2.10 (comp, 1H, 1H*), 2.09–1.92 (comp, 1H, 1H*), 0.77 (t, *J* = 7.4 Hz, 3H*), 0.73 (t, *J* = 7.4, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.2, 178.1, 163.2, 163.1, 160.6, 160.4, 152.2, 152.0, 150.9, 150.7, 132.0, 131.5, 129.7, 129.4, 129.4, 129.4, 128.9, 128.8, 127.8, 127.5, 127.4, 127.2, 126.1, 126.0, 126.0, 125.8, 125.6, 125.0, 124.9, 124.7, 121.5, 121.5, 117.8, 117.7, 114.1, 114.1, 112.1, 111.4, 78.9, 78.2, 77.2, 61.1, 60.2, 55.4, 26.5, 26.1, 8.1, 8.0; *m/z* (ESI-MS) 468.7 $[M]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 99/1, Flow rate = 0.5 mL/min, UV = 280 nm, major diastereomer: t_R = 49.7 min (minor) and t_R = 99.6 min (major), minor diastereomer: t_R = 54.6 min and t_R = 92.6 min. Due to peak overlap of one of the enantiomers of the minor diastereomer with the major enantiomer of the major diastereomer, the ee was calculated by using the product dr obtained via ^1H NMR.

The absolute configuration was assigned by analogy.

(*S*)-phenyl 1-((*S*)-4-propyl-2-(4-methoxyphenyl)-5-oxo-4,5-dihydrooxazol-4-yl)isoquinoline-2(1*H*)-carboxylate (7c): 

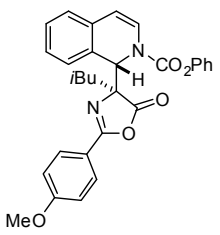
Following the general procedure compound **7c** was obtained as a white solid in 93% yield. mp = 56–58ºC; R_f = 0.63 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –177.6 (c 1.0, $CHCl_3$, 91% ee); dr = 92:08; IR (KBr) 2960, 2932, 1811, 1731, 1650, 1511, 1320, 1197, 1026, 742 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) the compound exists as a 1.7:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer), δ 7.87–7.81 (m, 2H), 7.80–7.77 (m, 2H*), 7.43 (app t, *J* = 7.7 Hz, 2H*), 7.37 (app t, *J* =7.7 Hz, 2H), 7.33–7.20 (comp, 5H, 5H*), 7.17 (d, *J* = 7.7 Hz, 1H), 7.12 (d, *J* = 7.7 Hz, 1H*), 7.11–7.06 (comp, 2H, 2H*), 6.99–6.90 (comp, 2H, 2H*), 6.10 (d, *J* = 7.7 Hz, 1H*), 6.04 (d, *J* = 7.7 Hz, 1H), 5.97 (s, 1H*), 5.92 (s, 1H), 3.85 (s, 3H), 3.84 (s, 3H*), 2.19–2.03 (comp, 1H, 1H*), 2.01 (dt, *J* = 12.6, 4.4 Hz, 1H*), 1.92 (dt, *J* = 12.6, 4.5 Hz, 1H), 1.25–0.94 (comp, 2H, 2H*), 0.90 (t, *J* = 7.3 Hz, 3H*), 0.86 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.4, 178.3, 163.2, 163.1, 160.4, 160.2, 152.2, 152.1, 150.9, 150.7, 137.7, 132.0, 131.6, 129.7, 129.7, 129.5, 129.4, 128.9, 128.8, 127.8, 127.4, 127.2, 126.9, 126.0, 126.0, 126.0, 125.8, 125.6, 125.0, 124.9, 124.8, 121.6, 121.5, 117.8, 117.7, 114.1, 114.1, 112.1, 111.5, 78.3, 78.0, 61.3, 60.3, 55.4, 35.5, 34.9, 21.2, 17.3, 17.2, 13.9, 13.8; *m/z* (ESI-MS) 482.8 $[M]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 90/10, Flow rate = 0.5 mL/min, UV = 280 nm, major diastereomer: t_R = 14.1 min (minor) and t_R = 21.2 min (major), minor diastereomer: t_R = 15.7 min (minor) and t_R = 19.3 min (major).

The absolute configuration was assigned by analogy.

(*S*)-phenyl 1-((*S*)-4-isopropyl-2-(4-methoxyphenyl)-5-oxo-4,5-dihydrooxazol-4-yl)isoquinoline-2(1*H*)-carboxylate (7d): 

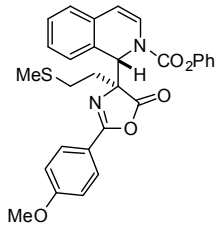
Following the general procedure, except that the reaction was performed in mesitylene/pentane (1:4) at –35 ºC, compound **7d** was obtained as a white solid in 94% yield. mp = 63–65 ºC; Rf = 0.70 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –122.6 (c 1.0, $CHCl_3$, 87% ee); dr = 87:13; IR (KBr) 2957, 1811, 1731, 1650, 1511, 1320, 1197, 1053, 741 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): the compound exists as a 1.4:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer), δ 7.98–7.90 (m, 2H), 7.90–7.86 (m, 2H*), 7.49–7.27 (comp, 6H, 6H*), 7.25–7.10 (comp, 2H, 2H*), 7.01–6.85 (comp, 4H, 4H*), 6.31 (s, 1H*), 6.24 (s, 1H), 6.06–5.96 (comp, 1H, 1H*), 3.89 (s, 3H), 3.85 (s, 3H*), 2.37–2.25 (comp, 1H, 1H*), 1.43 (d, *J* = 6.7 Hz, 3H*), 1.30 (d, *J* = 6.7 Hz, 3H), 0.90 (d, *J* = 6.7 Hz, 3H), 0.78 (d, *J* = 6.7 Hz, 3H*); ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.5, 177.5, 163.2, 163.2, 161.7, 160.6, 152.1, 151.7, 151.0, 150.8, 137.7, 132.3, 131.8, 129.9, 129.8, 129.7, 129.7, 129.6, 129.4, 129.3, 129.0, 128.9, 128.5, 128.3, 127.4, 127.4, 127.1, 127.1, 126.9, 125.8, 125.8, 125.8, 125.0, 124.9, 124.8, 124.7, 124.3, 121.7, 121.5, 118.2, 118.1, 114.2, 114.1, 114.1, 114.0, 112.6, 112.4, 79.2, 77.7, 58.5, 57.4, 55.5, 55.5, 55.4, 55.4, 31.3, 31.2, 31.0, 26.9, 21.2, 17.6, 17.5, 17.4, 17.4, 17.3; *m/z* (ESI-MS) 482.9 $[M]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 90/10, Flow rate = 0.2 mL/min, UV = 280 nm, major diastereomer: t_R = 38.9 min (minor) and t_R = 48.8 min (major), minor diastereomer: t_R = 37.9 min (minor) and t_R = 51.7 min (major).

The absolute configuration was assigned by analogy.

(*S*)-phenyl 1-((*S*)-4-isobutyl-2-(4-methoxyphenyl)-5-oxo-4,5-dihydrooxazol-4-yl)isoquinoline-2(1*H*)-carboxylate (7e): 

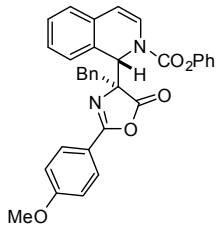
Following the general procedure, except that the reaction was performed at –30 ºC, compound **7e** was obtained as a white solid in 95% yield. mp = 59–61 ºC; Rf = 0.66 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –176.43 (c 1.0, $CHCl_3$, 90% ee); dr = 92:08; IR (KBr) 2957, 1810, 1731, 1649, 1607, 1511, 1455, 1353, 1320, 1258, 1197, 1053, 777, 741 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): the compound exists as a 1.4:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer r), δ 7.88–7.82 (m, 2H), 7.81–7.76 (m, 2H*), 7.46–7.40 (comp, 2H*), 7.39–7.33 (comp, 2H), 7.33–7.19 (comp, 5H, 5H*), 7.17–7.02 (comp, 3H, 3H*), 7.00–6.89 (comp, 2H, 2H*), 6.09 (d, *J* = 7.7, 1H*), 6.03 (d, *J* = 7.7 Hz, 1H), 5.93 (s, 1H*), 5.88 (s, 1H), 3.87 (s, 3H), 3.85 (s, 3H*), 2.10–1.96 (comp, 2H, 2H*), 1.60–1.44 (comp, 1H, 1H*), 0.89 (d, *J* = 6.7 Hz, 3H*), 0.85 (d, *J* = 6.6 Hz, 3H), 0.82 (d, *J* = 6.7 Hz, 3H*), 0.78 (d, *J* = 6.6 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 179.0, 178.8, 163.1, 160.0, 159.8, 152.2, 150.9, 150.7, 137.7, 132.1, 131.6, 129.7, 129.6, 129.5, 129.4, 129.3128.9, 128.8, 127.9, 127.5, 127.4, 127.1, 126.9, 126.0, 125.8, 125.7, 125.6, 124.9, 124.9, 124.7, 121.6, 121.4, 118.0, 117.9, 114.1, 114.1, 112.2, 111.7, 77.5, 77.4, 62.1, 61.1, 55.4, 55.4, 41.9, 41.3, 25.0, 24.1, 23.2, 23.1, 21.2; *m/z* (ESI-MS) 519.0 $[M+Na]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 90/10, Flow rate = 0.5 mL/min, UV = 280 nm, major diastereomer: t_R = 13.2 min (minor) and t_R = 19.3 min (major), minor diastereomer: t_R = 14.3 min (minor) and t_R = 16.8 min (major).

The absolute configuration was assigned by analogy.

(*S*)-phenyl 1-((*S*)-2-(4-methoxyphenyl)-4-(2-(methylthio)ethyl)-5-oxo-4,5-dihydrooxazol-4-yl)isoquinoline-2(1*H*)-carboxylate (7f): 

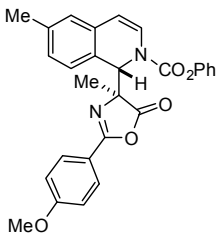
Following the general procedure, except that the reaction was performed at –30 ºC, compound **7f** was obtained as a white solid in 95% yield. mp = 52–55ºC; Rf = 0.86 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –175.35 (c 1.0, $CHCl_3$, 92% ee); dr = 90:10; IR (KBr) 2917, 1812, 1729, 1646, 1511, 1321, 1197, 1171, 742 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): the compound exists as a 1.8:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer), δ 7.86–7.77 (m, 2H, 2H*), 7.46–7.40 (comp, 2H*), 7.40–7.34 (comp, 2H), 7.33–7.20 (comp, 4H, 4H*), 7.18–7.04 (comp, 4H, 4H*), 7.00–6.90 (comp, 2H, 2H*), 6.10 (d, *J* = 7.6 Hz, 1H*), 6.05 (d, *J* = 7.6 Hz, 1H), 5.94 (s, 1H*), 5.90 (s, 1H), 3.87 (s, 3H), 3.85 (s, 3H*), 2.55–2.31 (comp, 3H, 3H*), 2.30–2.20 (comp, 1H, 1H*), 2.02 (s, 3H*), 2.00 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.0, 178.0, 163.3, 163.2, 160.9, 160.8, 152.2, 152.0, 150.8, 150.6, 137.7, 131.9, 131.5, 129.9, 129.8, 129.5, 129.4, 129.1, 128.9, 128.6, 128.1, 127.9, 127.6, 127.5, 127.3, 126.8, 128.1, 127.9, 127.6, 127.5, 127.3, 126.8, 126.0, 125.9, 125.6, 125.5, 125.0, 124.9, 124.8, 121.5, 121.4, 117.7, 117.6, 114.1, 114.1, 112.1, 111.5, 71.2, 61.4, 60.4, 55.4, 32.6, 32.0, 28.7, 27.0, 21.1, 15.3, 15.2; *m/z* (ESI-MS) 514.6 $[M]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 90/10, Flow rate = 0.5 mL/min, UV = 280 nm, major diastereomer: t_R = 24.5 min (minor) and t_R = 31.7 min (major), minor diastereomer: t_R = 21.9 min (minor) and t_R = 27.9 min (major).

The absolute configuration was assigned by analogy.

(*S*)-phenyl 1-((*S*)-4-benzyl-2-(4-methoxyphenyl)-5-oxo-4,5-dihydrooxazol-4-yl)isoquinoline-2(1*H*)-carboxylate (7g): 

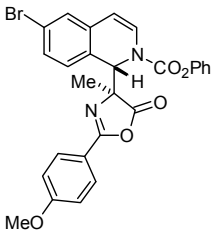
Following the general procedure, except that the reaction was performed at 0.1 M concentration and at –35 ºC, compound **7g** was obtained as a white solid in 95% yield. mp = 49–51 ºC; Rf = 0.73 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –269.38 (c 1.0, $CHCl_3$, 90% ee); dr = 90:10; IR (KBr) 3030, 2932,1813, 1728, 1649, 1512, 1321, 1197, 977, 740 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): the compound exists as a 2:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer), δ 7.74–7.62 (comp, 2H, 2H*), 7.50–7.36 (comp, 4H, 4H*), 7.34–7.25 (comp, 3H, 3H*), 7.25–7.05 (comp, 9H, 9H*), 6.92–6.82 (comp, 2H, 2H*), 6.21–6.07 (comp, 2H, 2H*), 3.81 (s, 3H), 3.81 (s, 3H*), 3.50 (d, *J* = 13.0 Hz, 1H*), 3.48 (d, *J* = 13.0 Hz, 1H), 3.31 (d, *J* = 13.0 Hz, 1H*), 3.24 (d, *J* = 13.0 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.4, 177.3, 162.9, 162.9, 160.0, 159.9, 152.3, 152.1, 150.9, 150.6, 133.8, 133.6, 131.9, 131.5, 130.4, 130.3, 129.5, 129.4, 129.4, 129.0, 128.8, 127.9, 127.9, 127.8, 127.7, 127.5, 127.2, 127.1, 126.9, 126.1, 126.0, 126.0, 125.9, 125.7, 125.0, 124.9, 124.8, 121.5, 121.4, 121.4, 117.7, 117.6, 113.9, 113.9, 112.1, 111.5, 79.1, 78.5, 77.2, 61.0, 60.2, 55.3, 39.3, 38.8; *m/z* (ESI-MS) 552.9 $[M+Na]^+$; HPLC: Daicel Chiralpak AS-H, *n*-hexane/*i*-PrOH = 95/5, Flow rate = 1 mL/min, UV = 280 nm, major diastereomer: t_R = 20.5 min (minor) and t_R = 35.3 min (major), minor diastereomer: t_R = 16.2 min (minor) and t_R = 27.6 min (major).

The absolute configuration was assigned by analogy.

(*S*)-phenyl 1-((*S*)-2-(4-methoxyphenyl)-4-methyl-5-oxo-4,5-dihydrooxazol-4-yl)-6-methyl-isoquinoline-2(1*H*)-carboxylate (7h): 

Following the general procedure, except that the reaction was performed at –30 ºC, compound **7h** was obtained as a white solid in 94% yield. mp = 61–63 ºC; Rf = 0.50 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –108.71 (c 1.0, $CHCl_3$, 88% ee); dr = 90:10; IR (KBr) 2933, 1816, 1729, 1605, 1512, 1321, 1200, 1016, 743 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): the compound exists as a 1.9:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer), δ 7.67–7.80 (comp, 2H, 2H*), 7.44–7.39 (comp, 2H*), 7.39–7.34 (comp, 2H), 7.25–7.13 (comp, 3H, 3H*), 7.12–7.05 (comp, 3H, 3H*), 6.98–6.89 (comp, 3H, 3H*), 6.05 (d, *J* = 8.1 Hz, 1H*), 5.98 (d, *J* = 8.1 Hz, 1H), 5.86 (s, 1H*), 5.82 (s, 1H), 3.86 (s, 3H), 3.85 (s, 3H*), 2.31 (s, 3H*), 2.30 (s, 3H), 1.58 (s, 3H*), 1.51 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.8, 178.8, 163.2, 163.1, 160.2, 160.0, 152.2, 152.0, 150.9, 150.7, 138.8, 138.6, 131.8, 131.3, 129.8, 129.8, 129.4, 129.4, 129.4, 128.2, 127.9, 127.8, 127.5, 127.0, 125.9, 125.8, 125.6, 125.5, 124.8, 123.1, 123.0, 121.6, 121.5, 118.0, 117.9, 114.1, 114.1, 112.0, 111.3, 73.5, 73.2, 61.0, 60.0, 55.4, 21.2, 21.1, 20.4, 19.9; *m/z* (ESI-MS) 468.8 $[M]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 90/10, Flow rate = 0.5 mL/min, UV = 280 nm, major diastereomer: t_R = 19.6 min (minor) and t_R = 26.3 min (major), minor diastereomer: t_R = 21.6 min (minor) and t_R = 23.0 min (major).

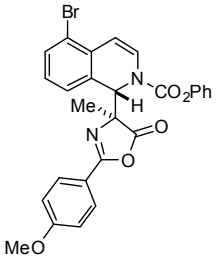
The absolute configuration was assigned by analogy.

(*S*)-phenyl 6-bromo-1-((*S*)-2-(4-methoxyphenyl)-4-methyl-5-oxo-4,5-dihydrooxazol-4-yl)-isoquinoline-2(1*H*)-carboxylate (7i): 

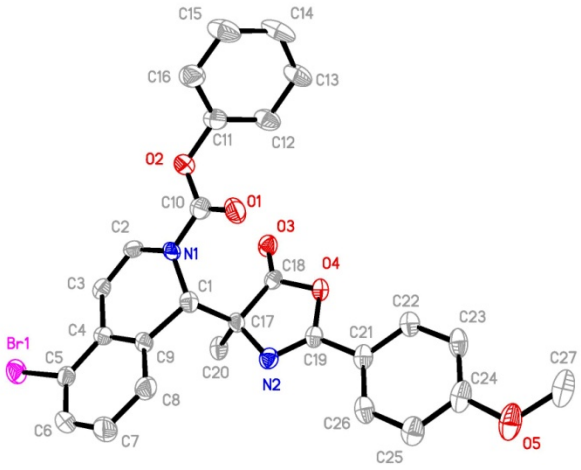
Following the general procedure, except that the reaction was performed at –15 ºC, compound **7i** was obtained as a white solid in 95% yield. mp = 57–59 ºC; Rf = 0.53 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –134.771 (c 1.0, $CHCl_3$, 90% ee); dr = 91:09; IR (KBr) 2966, 1817, 1730, 1648, 1512, 1349, 1197, 1016, 742 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): the compound exists as a 2:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer), δ 7.88–7.80 (comp, 2H, 2H*), 7.45–7.35 (comp, 4H, 4H*), 7.31–7.21 (comp, 2H, 6H*), 7.18 (d, *J* = 8.2 Hz, 2H), 7.10 (d, *J* = 8.2 Hz, 2H), 6.98–6.92 (m, 2H, 2H*), 6.01 (d, *J* = 7.6 Hz, 1H*), 5.95 (d, *J* = 7.7 Hz, 1H), 3.87 (s, 3H), 3.86 (s, 3H*), 1.57 (s, 3H*), 1.50 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.6, 163.3, 160.4, 160.2, 152.1, 150.8, 150.5, 133.9, 133.5, 130.2, 129.9, 129.8, 129.5, 129.5, 129.4, 129.2, 127.6, 127.5, 126.9, 126.2, 126.1, 126.0, 124.8, 124.7, 123.0, 122.8, 121.5, 121.4, 117.7, 117.6, 114.2, 114.2, 110.5, 109.8, 77.2, 73.3, 73.0, 60.7, 59.6, 55.5, 20.2, 19.8; *m/z* (ESI-MS) 533.2 $[M+H]^+$; HPLC: Daicel Chiralpak AS-H, *n*-hexane/*i*-PrOH = 90/10, Flow rate = 1.0 mL/min, UV = 280 nm, major diastereomer: t_R = 12.9 min (minor) and t_R = 37.6 min (major), minor diastereomer: t_R = 16.1 min (minor) and t_R = 27.9 min (major).

The absolute configuration was assigned by analogy.

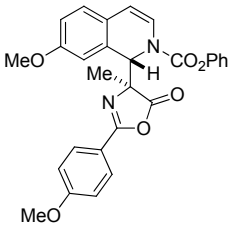
(*S*)-phenyl 5-bromo-1-((*S*)-2-(4-methoxyphenyl)-4-methyl-5-oxo-4,5-dihydrooxazol-4-yl)-isoquinoline-2(1*H*)-carboxylate (7j): Following the general procedure, except that the reaction was performed at 0.1 M concentration and at –15 ºC, compound **7j** was obtained as a white solid in 81% yield. mp = 62–64 ºC; Rf = 0.56 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –162.0 (c 1.0, $CHCl_3$, 93% ee); dr = 93:07; IR (KBr) 2935, 1815, 1724, 1643, 1511, 1353, 1197, 1016, 741 cm^{-1};. ^1H NMR (500 MHz, $CDCl_3$): the compound exists as a 2:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer), δ 7.83–7.78 (m, 2H), 7.78–7.74 (m, 2H*), 7.51–7.45 (comp, 1H, 1H*), 7.44–7.35 (comp, 2H, 2H*), 7.32–7.20 (comp, 4H, 4H*), 7.12 (d, *J* = 8.9 Hz, 2H), 7.07 (d, *J* = 8.9 Hz, 2H*), 6.97–6.88 (comp, 2H, 2H*), 6.48 (d, *J* = 8.0 Hz, 1H*), 6.42 (d, *J* = 8.0 Hz, 1H), 5.87 (s, 1H*), 5.83 (s, 1H), 3.87 (s, 3H), 3.86 (s, 3H*), 1.59 (s, 3H*), 1.52 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.6, 163.2, 160.2, 152.1, 150.8, 150.5, 133.1, 132.9, 131.6, 131.2, 129.8, 129.5, 129.4, 128.3, 128.0, 127.9, 127.8, 127.3, 127.0, 126.7, 126.6, 126.2, 126.0, 121.5, 121.4, 120.4, 117.7, 114.2, 114.1, 110.5, 109.8, 73.7, 61.1, 60.2, 61.2, 55.5, 20.2, 19.8; *m/z* (ESI-MS) 532.5 $[M]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 90/10, Flow rate = 0.5 mL/min, UV = 280 nm, major diastereomer: t_R = 22.6 min (minor) and t_R = 28.0 min (major), minor diastereomer: t_R = 25.0 min (minor) and t_R = 26.8 min (major).



The enantioenriched product **7j** was recrystallized from EtOAc/hexanes and the absolute configuration was assigned by X-ray crystallography.

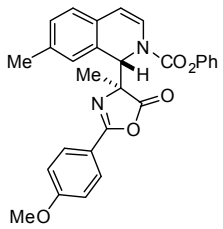


The requisite CIF has been submitted to the journal.



(*S*)-phenyl 7-methoxy-1-((*S*)-2-(4-methoxyphenyl)-4-methyl-5-oxo-4,5-dihydrooxazol-4-yl)-isoquinoline-2(1*H*)-carboxylate (7k): Following the general procedure, except that the reaction was run at –30 ºC, compound **7k** was obtained as a white solid in 95% yield. mp = 59–61 ºC; Rf = 0.43 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –102.50 (c 1.0, $CHCl_3$, 93% ee); dr = 93:07; IR (KBr) 2935, 1816, 1726, 1648, 1511, 1257, 1199, 1016, 742 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): the compound exists as a 2.3:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer), δ 7.87–7.80 (comp, 2H, 2H*), 7.50–7.34 (comp, 2H*, 2H), 7.25–7.20 (comp, 2H, 2H*), 7.16–7.06 (comp, 2H, 2H*), 7.05–7.00 (comp, 1H, 1H*), 6.98–6.90 (comp, 2H, 2H*), 6.90–6.85 (comp, 1H, 1H*), 6.84–6.76 (comp, 1H, 1H*), 6.06 (d, *J* = 7.7 Hz, 1H*), 6.00 (d, *J* = 7.5 Hz, 1H), 5.85 (s, 1H*), 5.81 (s, 1H), 3.85 (s, 3H), 3.84 (s, 3H*), 3.82 (s, 3H, 3H*), 1.59 (s, 3H*), 1.52 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.9, 178.8, 163.2, 163.1, 160.2, 160.0, 159.9, 158.8, 152.4, 152.0, 150.9, 150.6, 129.7, 129.7, 129.4, 129.4, 129.4, 127.5, 127.4, 126.1, 126.0, 125.9, 125.8, 125.0, 124.6, 123.5, 122.8, 121.5, 121.5, 121.4, 117.9, 117.8, 114.5, 114.4, 114.1, 114.1, 113.5, 113.4, 111.7, 110.9, 77.2, 73.5, 73.2, 61.2, 60.3, 55.4, 55.4, 53.4, 20.3, 19.8; *m/z* (ESI-MS) 484.6 $[M]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 90/10, Flow rate = 0.5 mL/min, UV = 280 nm, major diastereomer: t_R = 23.9 min (minor) and t_R = 29.5 min (major), minor diastereomer: t_R = 27.2 min and t_R = 29.5 min. Due to peak overlap of one of the enantiomers of the minor diastereomer with the major enantiomer of the major diastereomer, the ee was calculated by using the product dr obtained via ^1H NMR.

The absolute configuration was assigned by analogy.

(*S*)-phenyl 1-((*S*)-2-(4-methoxyphenyl)-4-methyl-5-oxo-4,5-dihydrooxazol-4-yl)-7-methyl-isoquinoline-2(1*H*)-carboxylate (7l): 

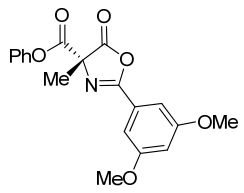
Following the general procedure, except that the reaction was run at –30 ºC, compound **7l** was obtained as a white solid in 95% yield. mp = 60–62 ºC; Rf = 0.56 (CH_2Cl_2/Et_2O 50:1 v/v); $[\alpha]_D^{20}$ –123.25 (c 1.0, $CHCl_3$, 92% ee); dr = 93:07; IR (KBr) 2940, 1815, 1728, 1650, 1512, 1352, 1200, 1016, 743 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$): the compound exists as a 1.9:1 mixture of carbamate rotamers (* denotes the proton(s) corresponding to the minor rotamer), δ 7.86–7.82 (m, 2H), 7.82–7.78 (m, 2H*), 7.44–7.39 (comp, 2H*), 7.39–7.34 (comp, 2H), 7.24–7.20 (comp, 2H), 7.15–7.04 (comp, 4H, 4H*), 7.01–6.97 (comp, 1H, 1H*), 6.97–6.90 (comp, 2H, 2H*), 6.08 (d, *J* = 7.5 Hz, 1H*), 6.01 (d, *J* = 7.5 Hz, 1H), 5.86 (s, 1H*), 5.82 (s, 1H), 3.86 (s, 3H), 3.85 (s, 3H*), 2.37 (s, 3H*), 2.36 (s, 3H), 1.60 (s, 3H*), 1.53 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.8, 178.8, 163.2, 163.1, 160.2, 160.0, 152.3, 152.0, 150.9, 150.7, 137.4, 137.1, 129.8, 129.7, 129.7, 129.5, 129.4, 129.3, 128.8, 128.4, 128.2, 126.0, 125.9, 125.9, 125.8, 124.9, 124.7, 124.6, 124.0, 121.5, 121.5, 118.0, 117.8, 114.1, 114.0, 112.0, 11.3, 77.2, 73.6, 73.2, 61.2, 60.2, 55.4, 21.4, 21.4, 20.4, 20.0; *m/z* (ESI-MS) 468.8 $[M]^+$; HPLC: Daicel Chiralpak OD-H, *n*-hexane/*i*-PrOH = 90/10, Flow rate = 0.5 mL/min, UV = 280 nm, major diastereomer: t_R = 18.4 min (minor) and t_R = 27.9 min (major), minor diastereomer: t_R = 20.7 min (minor) and t_R = 26.0 min (major).

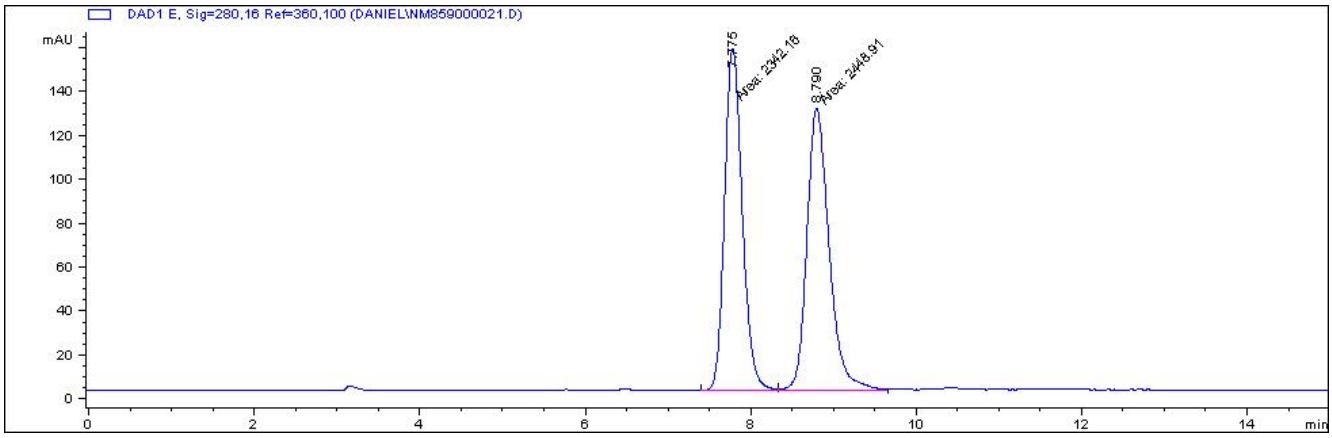
The absolute configuration was assigned by analogy.

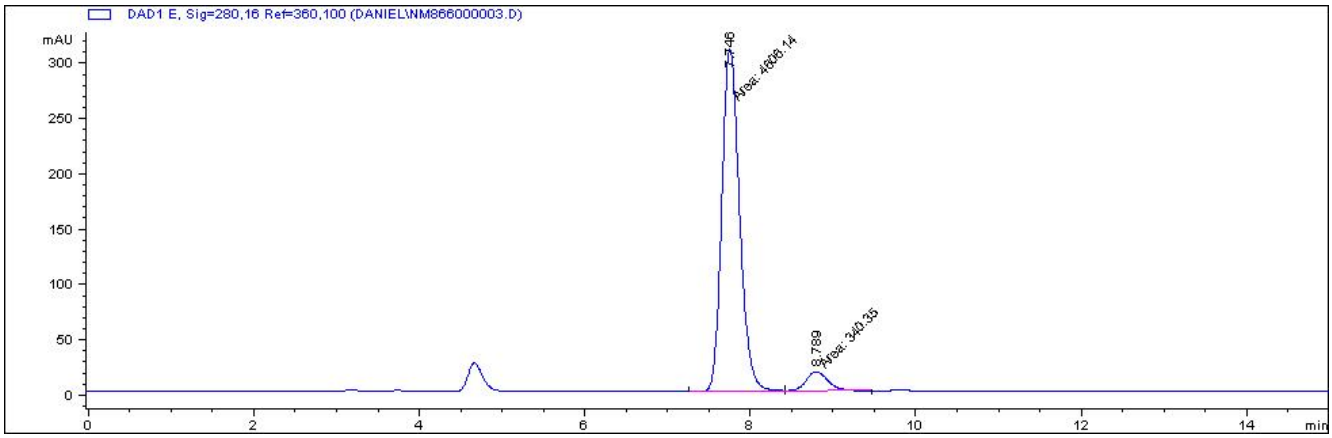
References

1. Ruble, J. C.; Fu, G. C. *J. Am. Chem. Soc.* **1998**, *120*, 11532.
2. Shaw, S. A.; Aleman, P.; Vedejs, E. *J. Am. Chem. Soc.* **2003**, *125*, 13368.

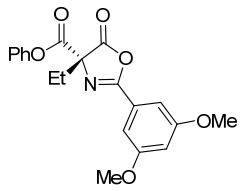
HPLC Profile of 2a

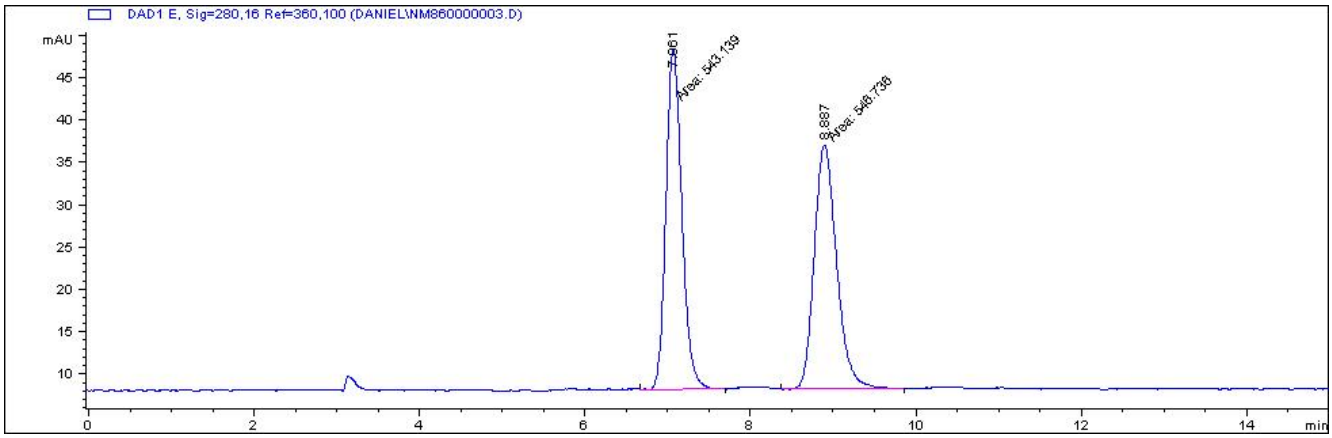


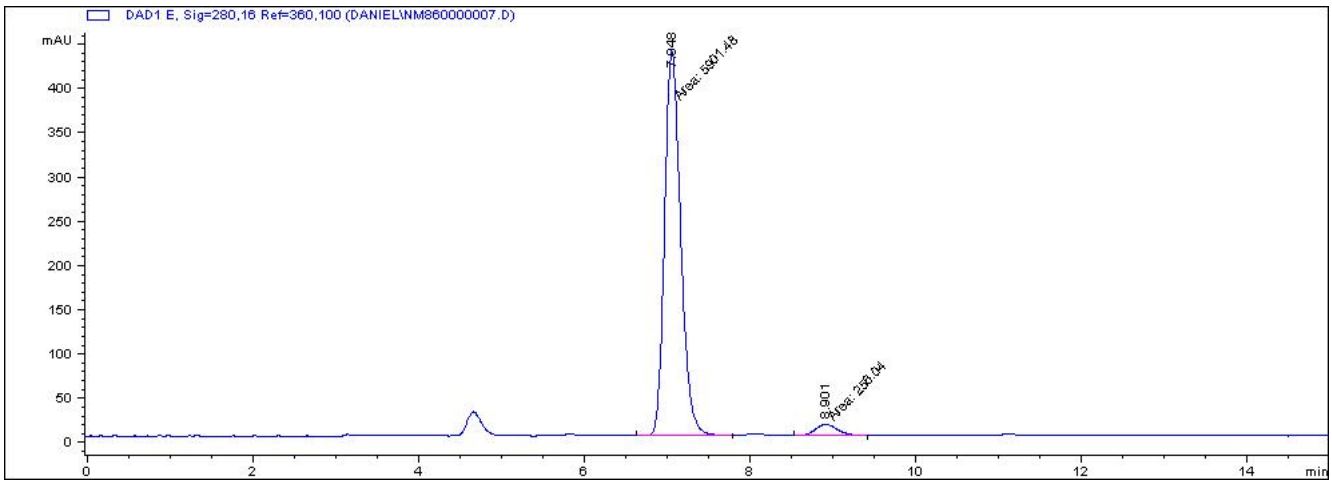




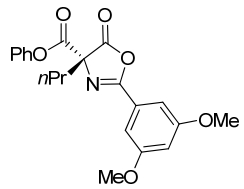
HPLC Profile of 2b

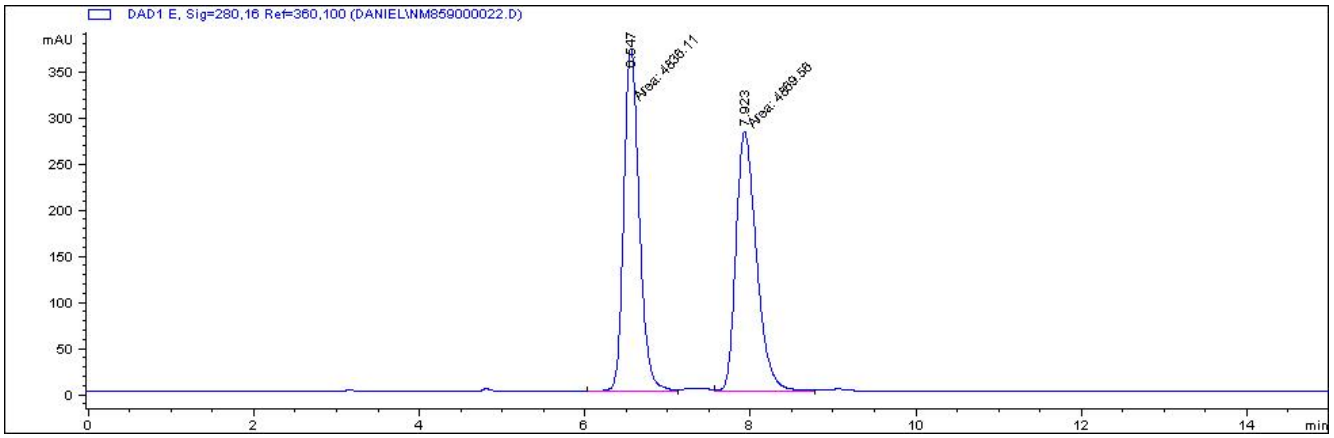


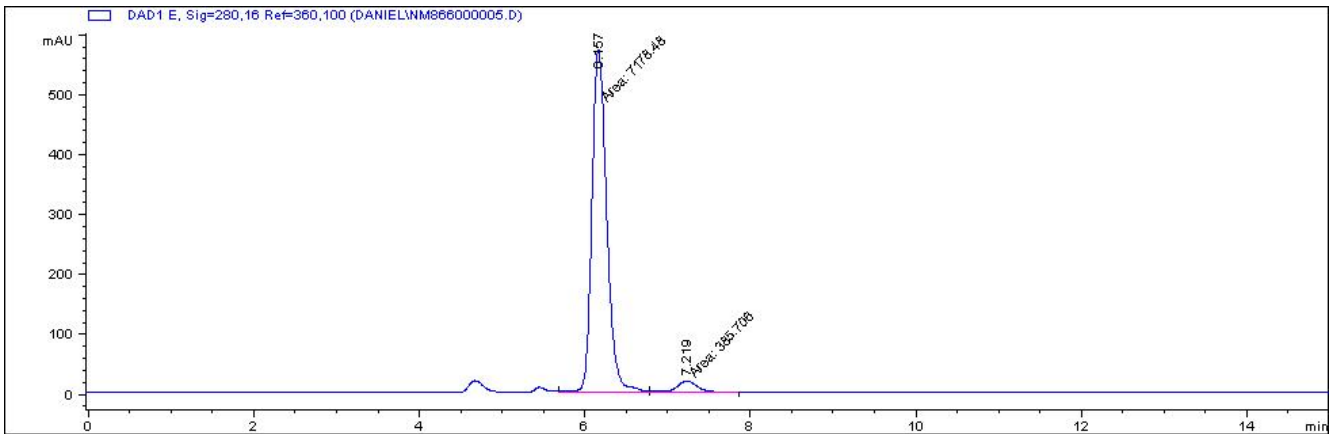




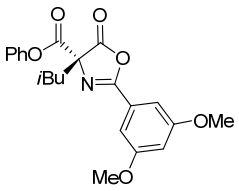
HPLC Profile of 2c

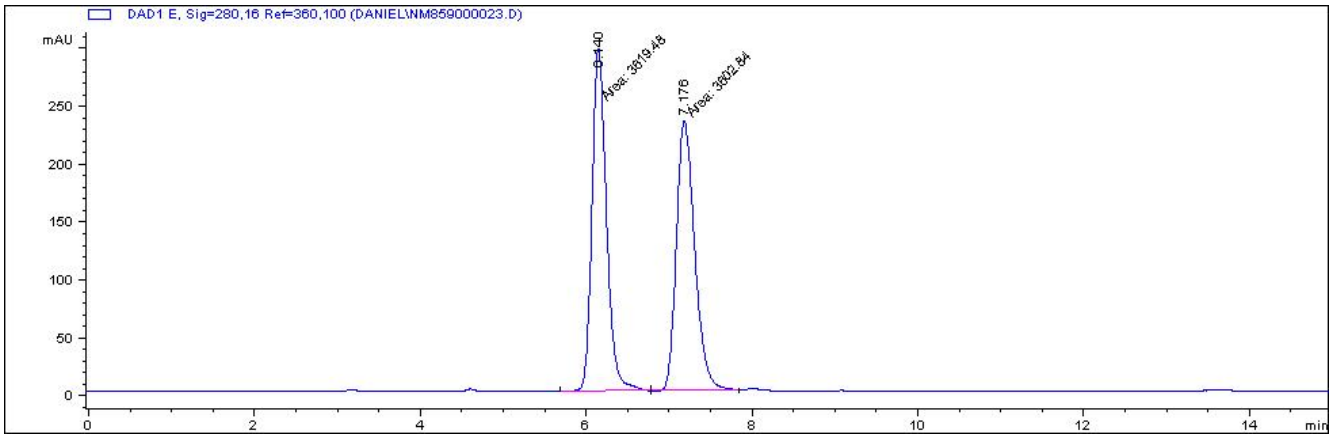


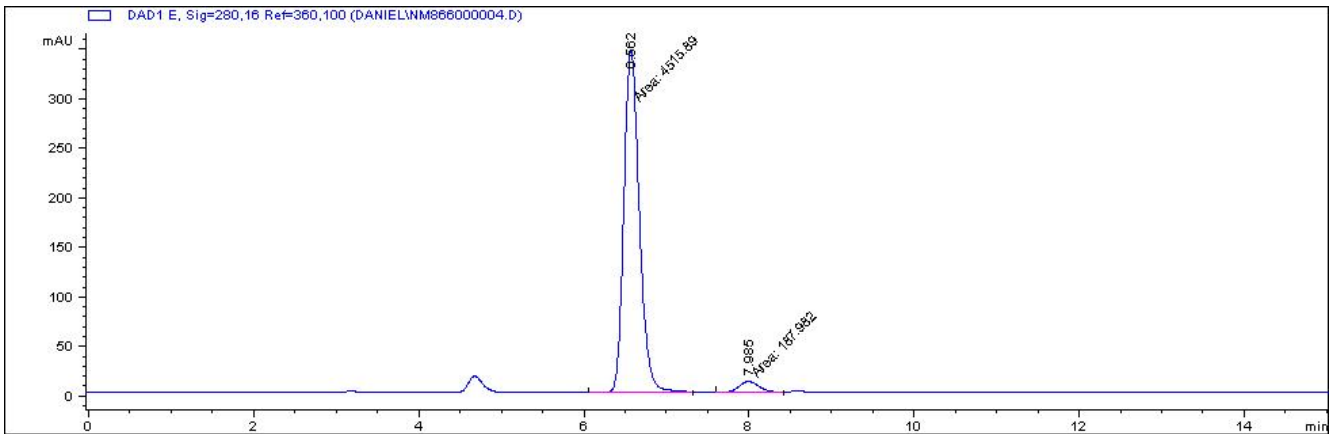




HPLC Profile of 2d







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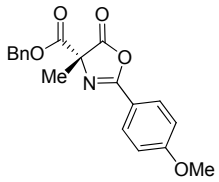
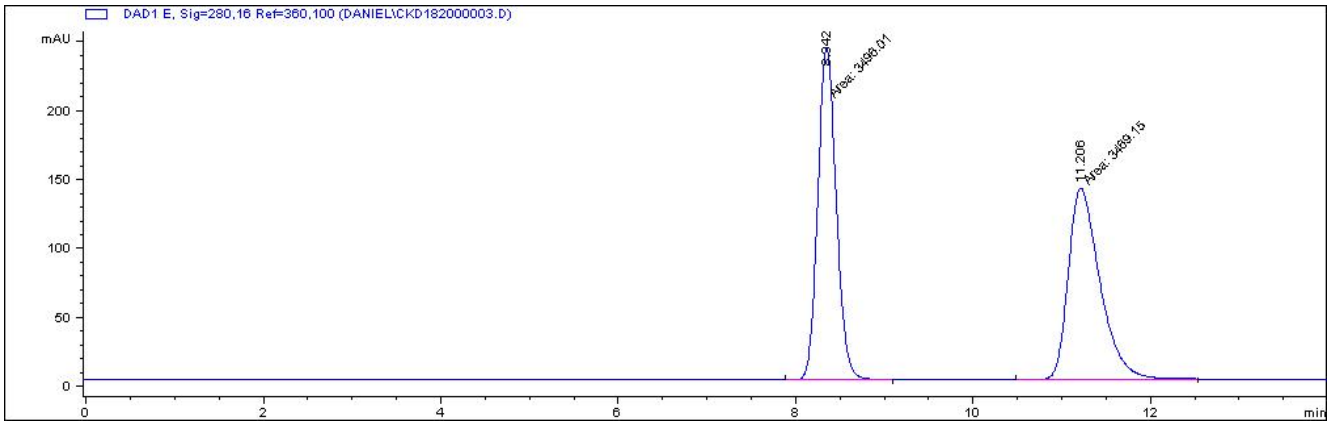
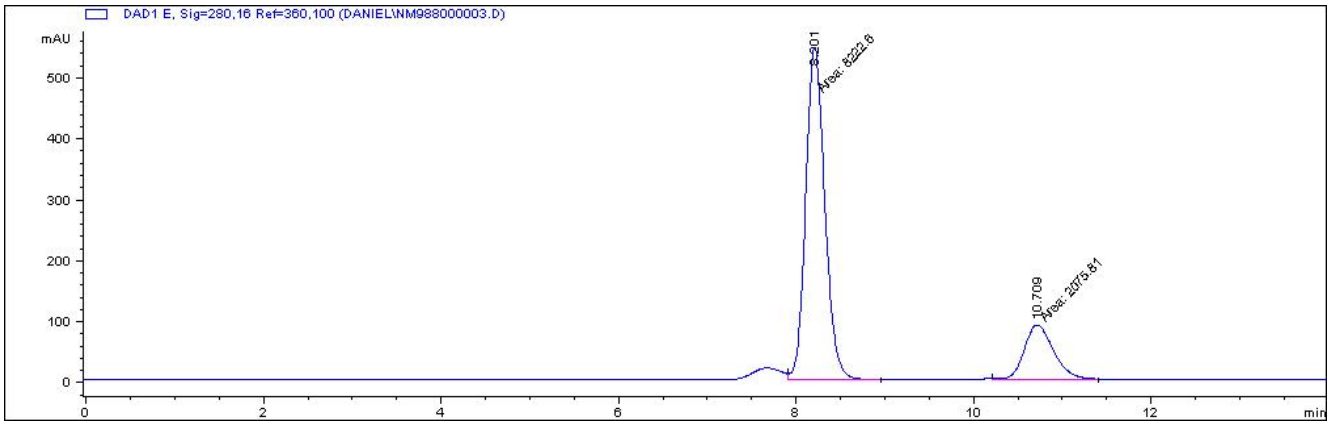
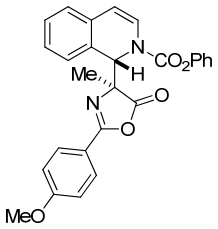
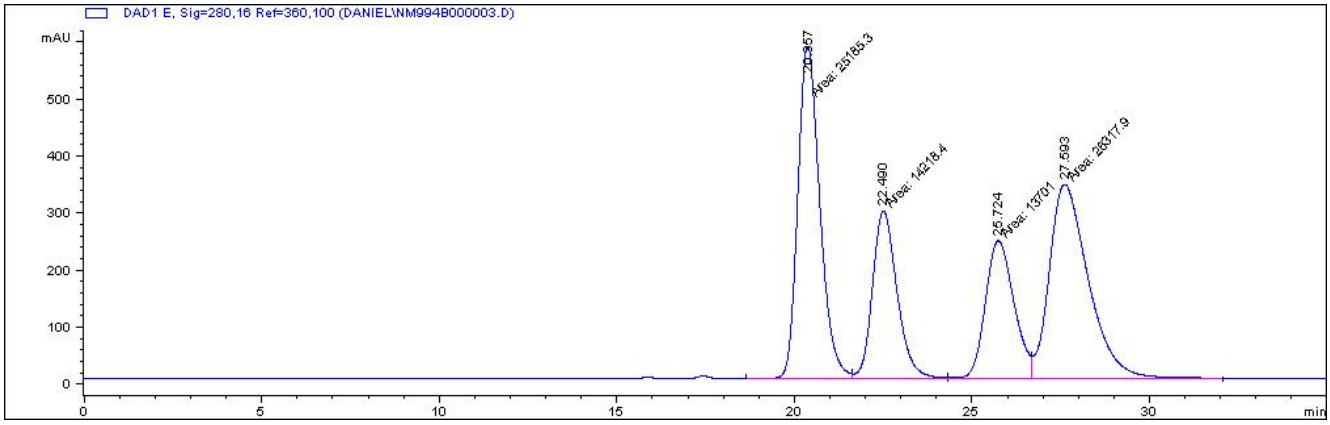


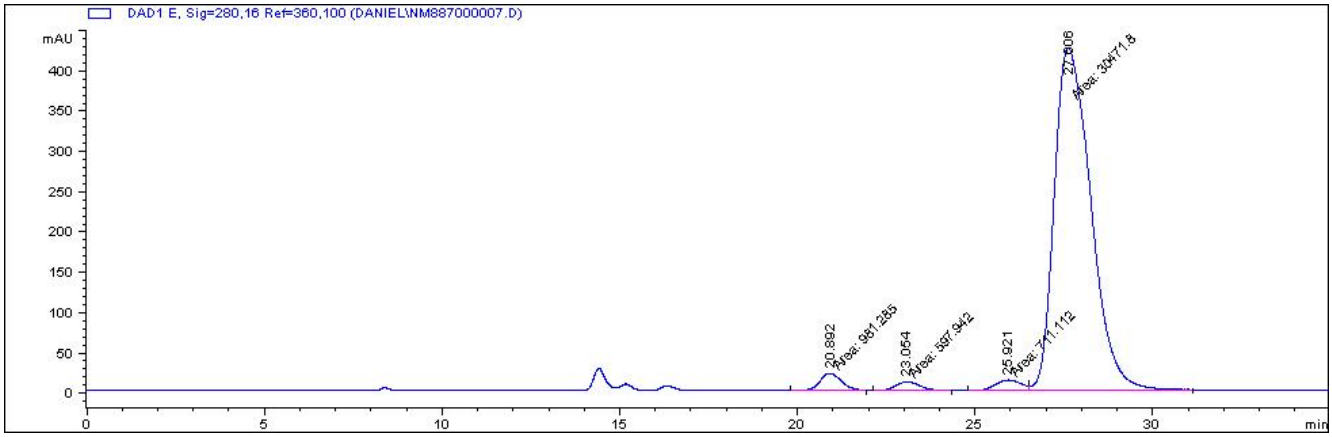




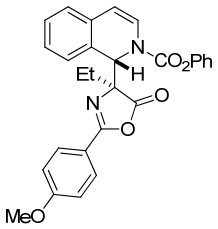
HPLC Profile of 7a

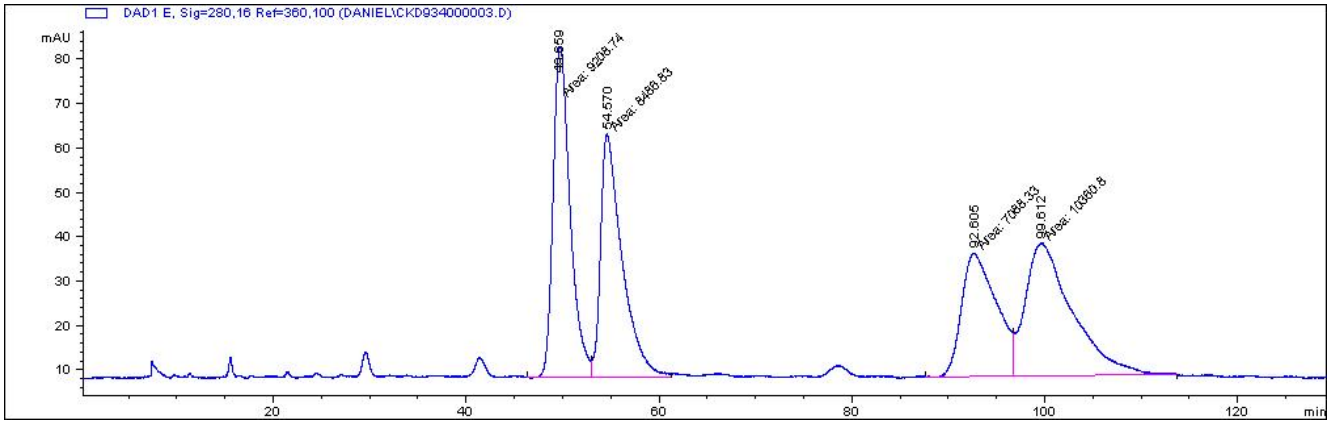


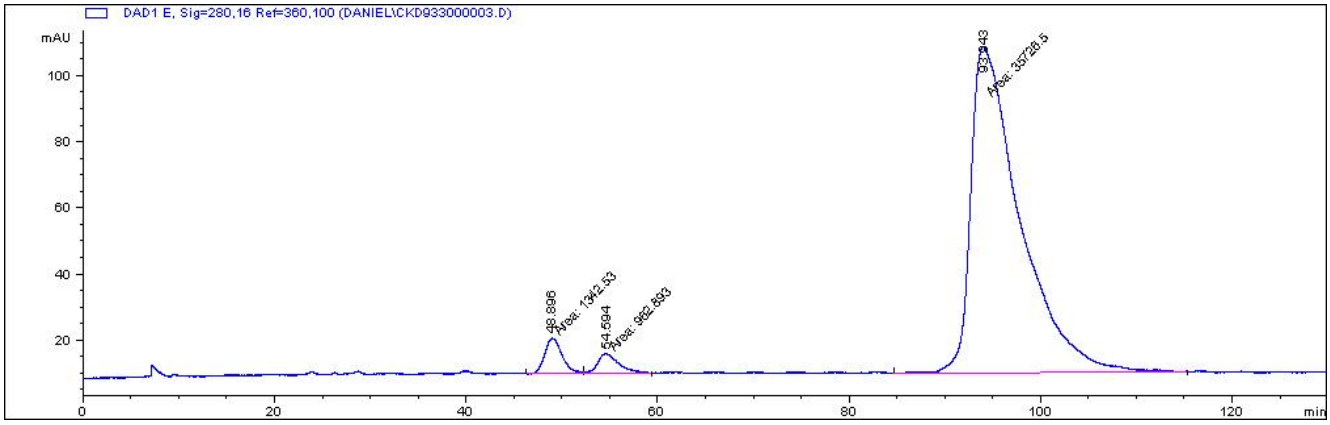




HPLC Profile of 7b







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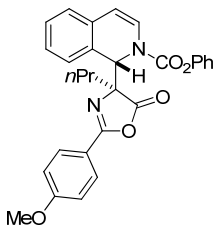

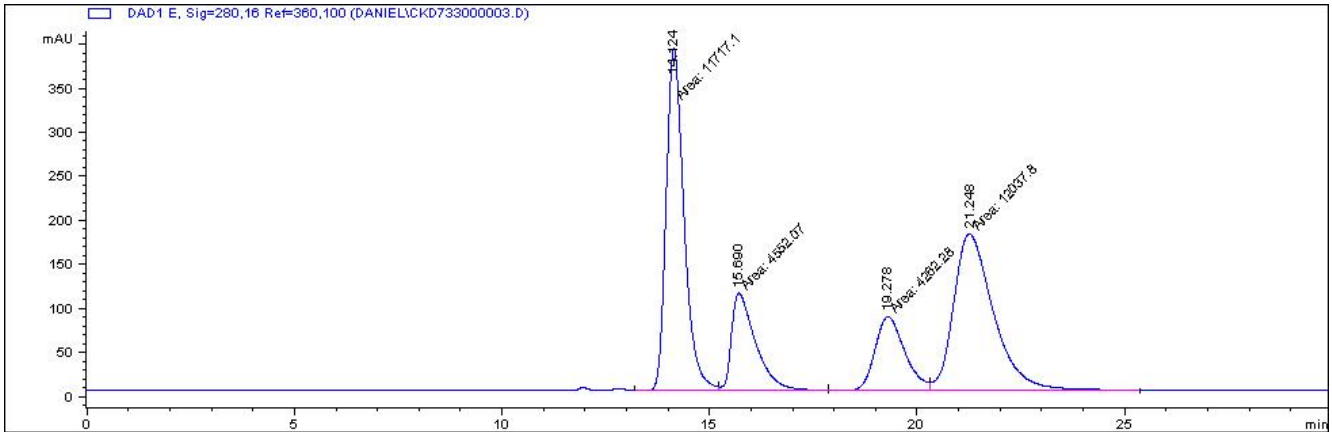

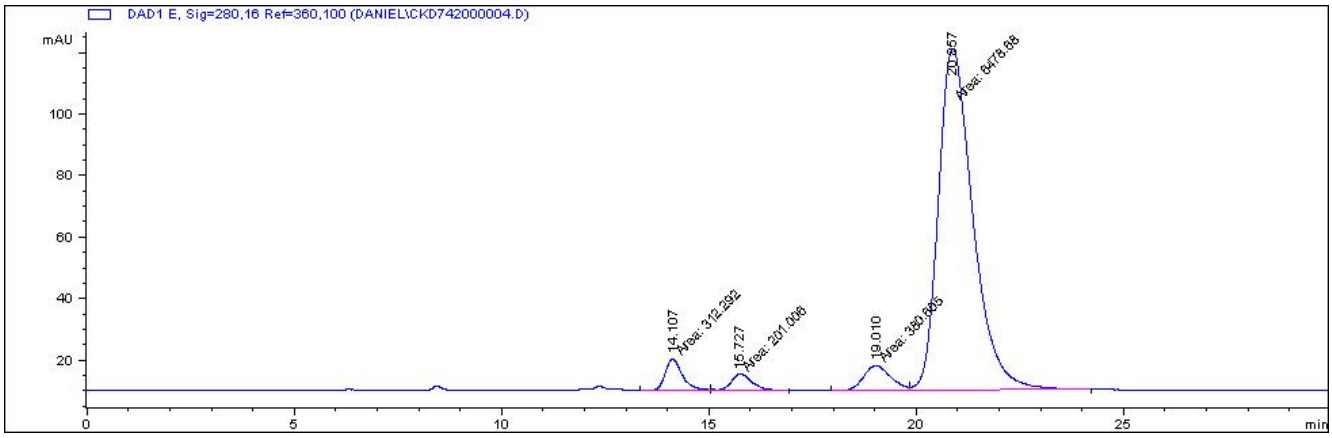

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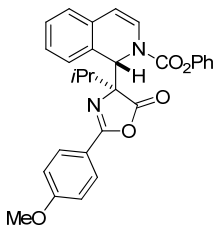

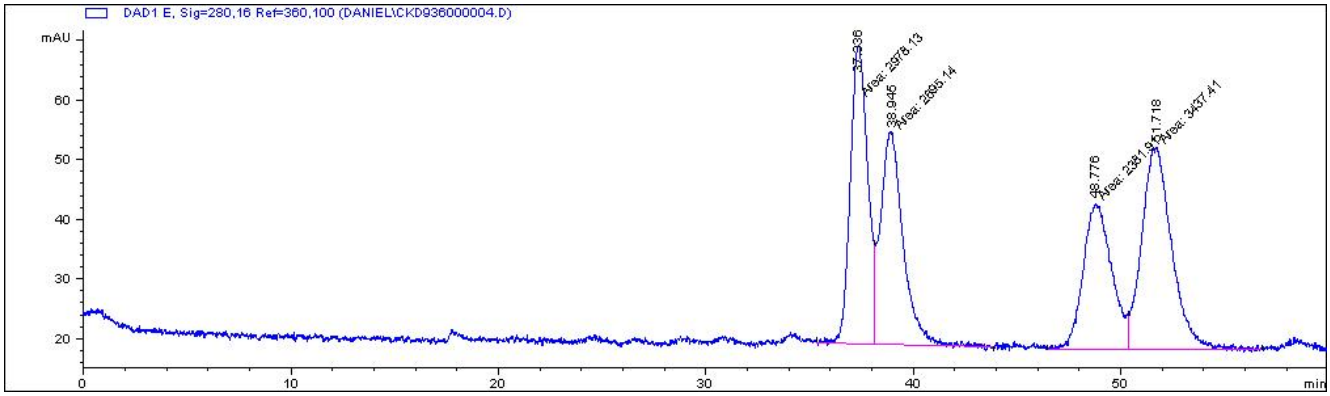

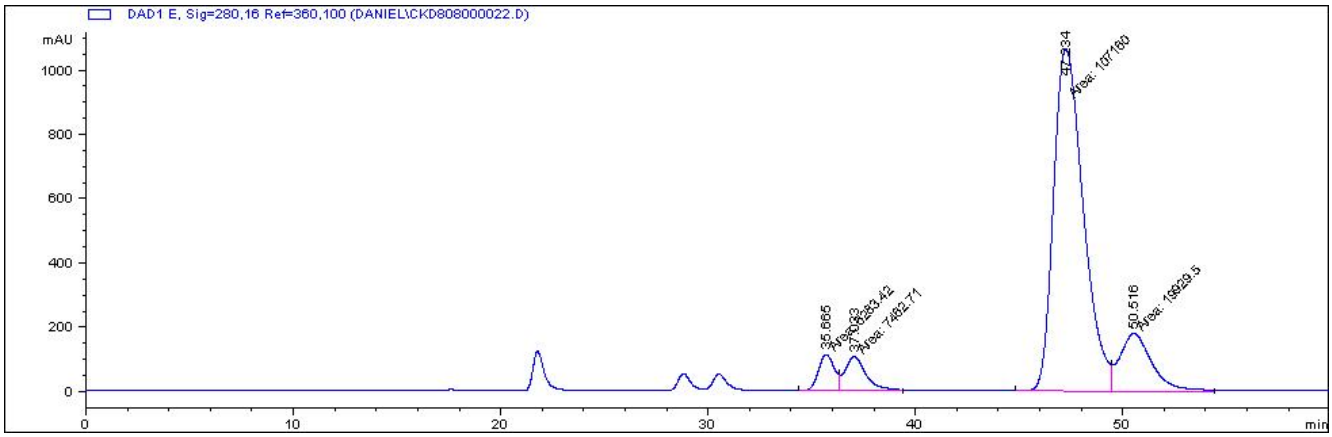

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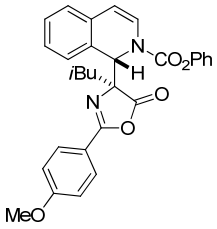
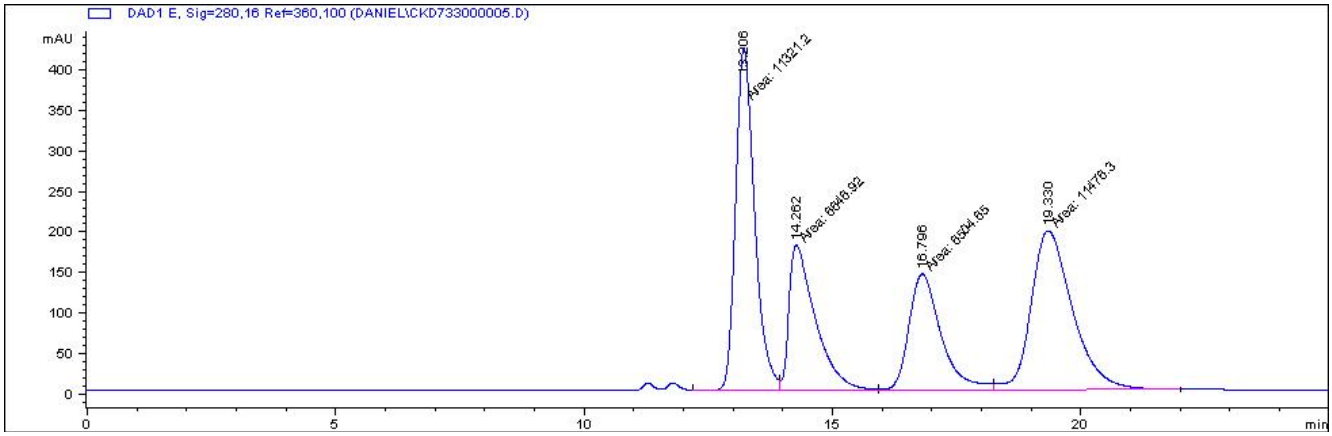
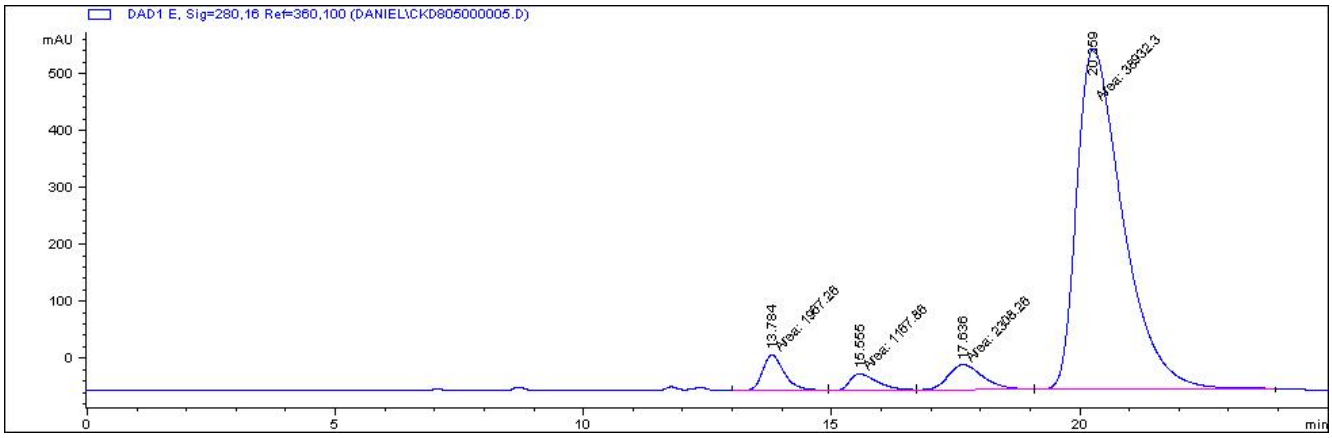
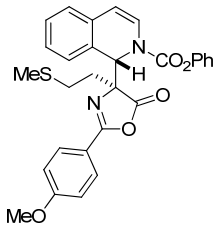
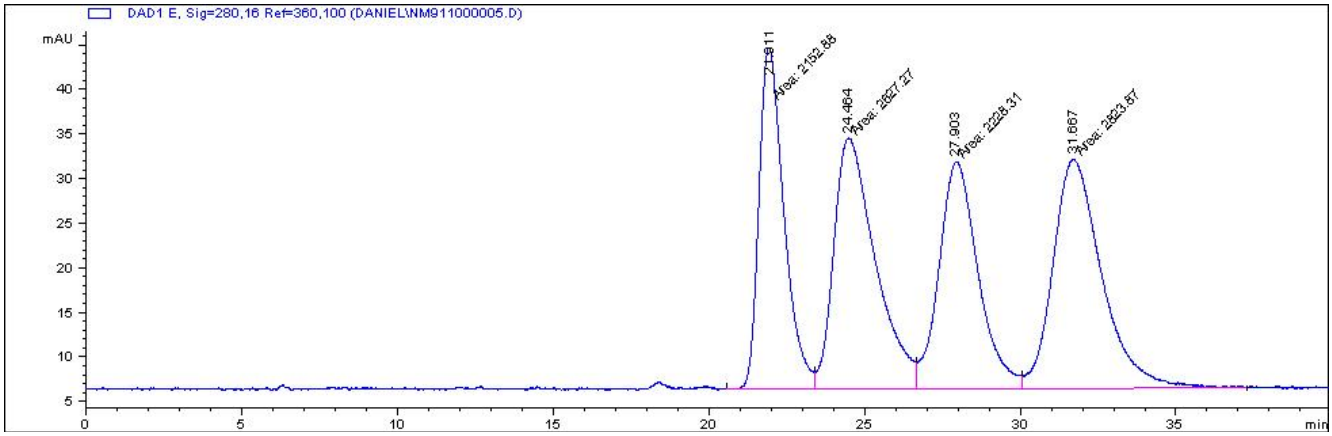


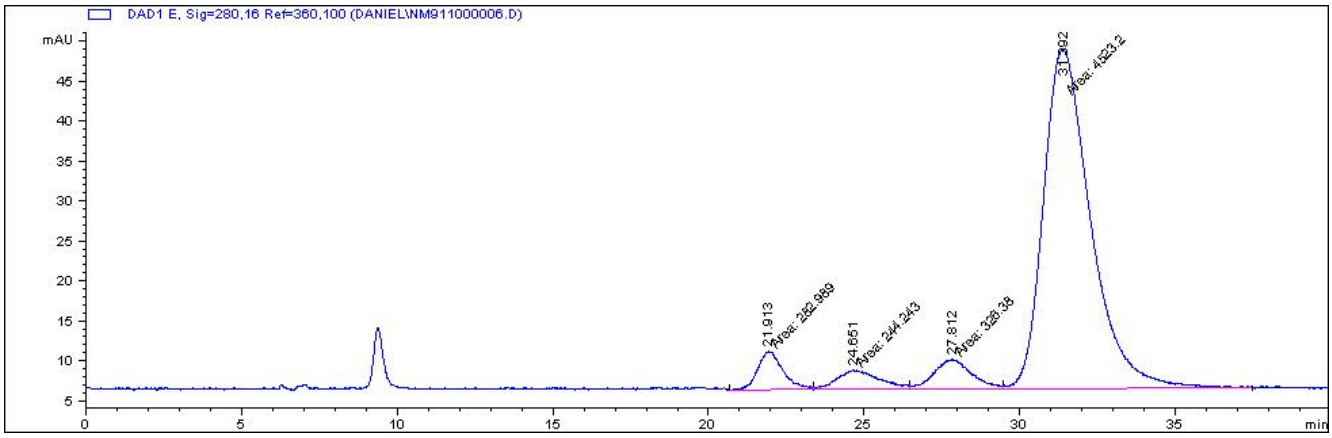




HPLC Profile of 7f







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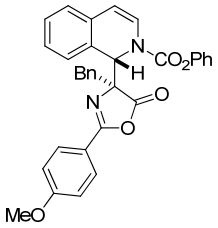
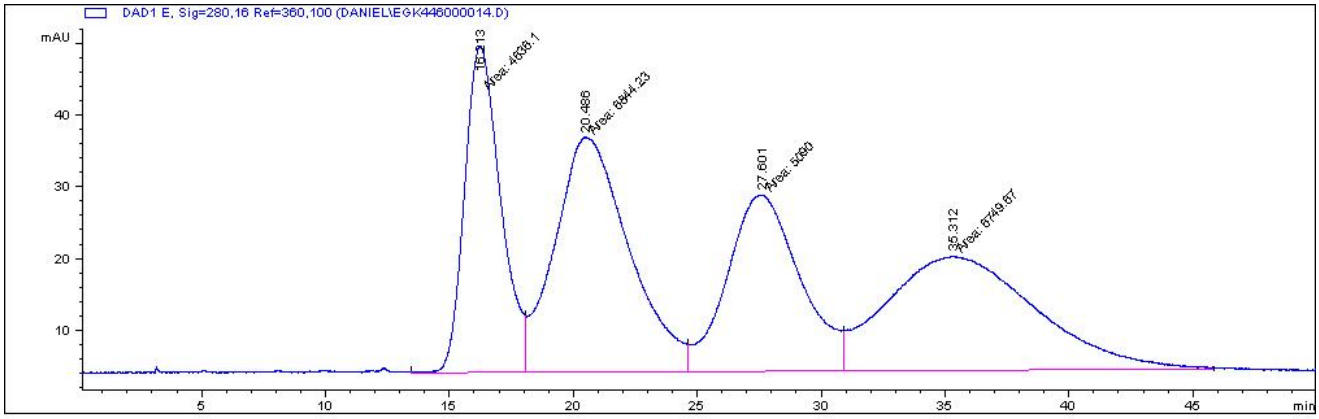
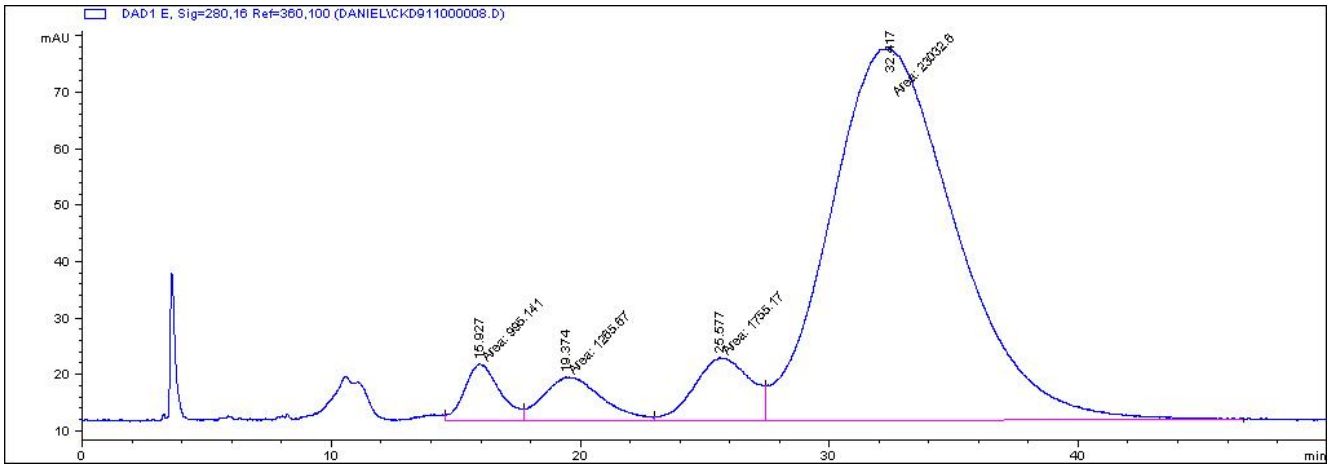
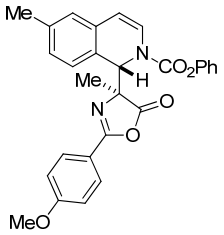
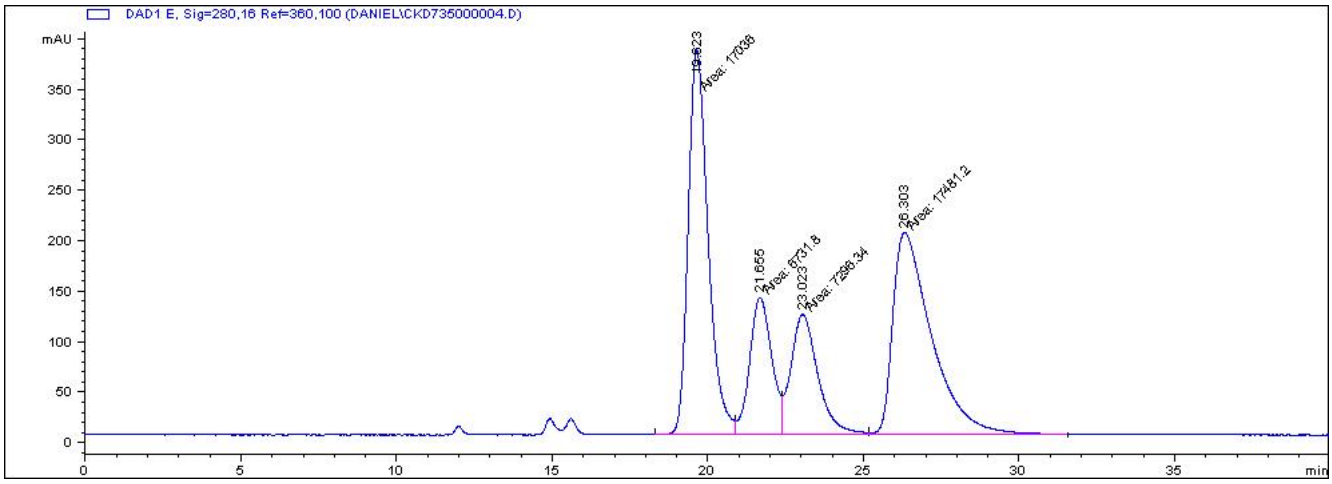


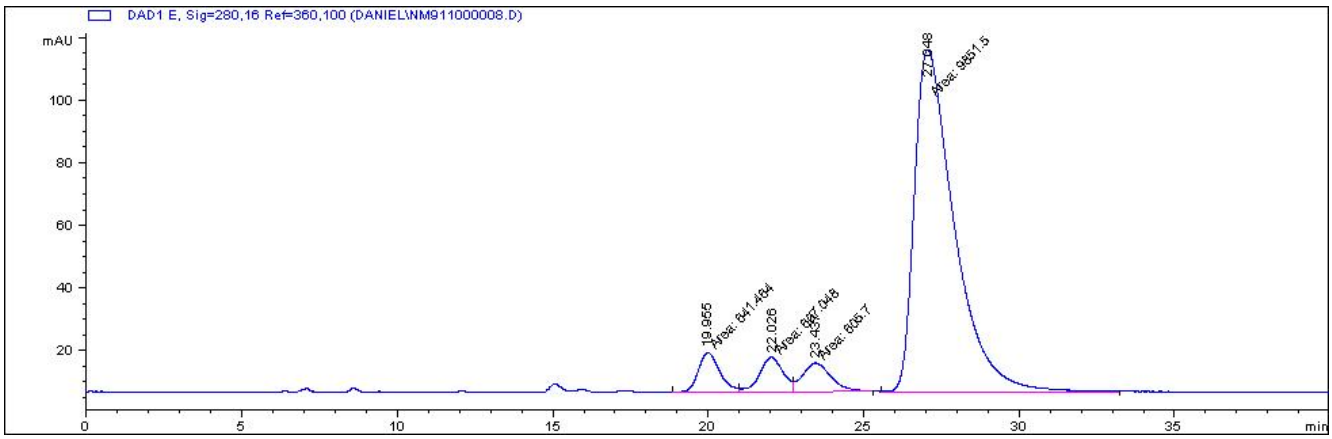




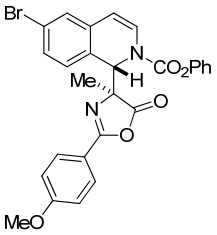
HPLC Profile of 7h

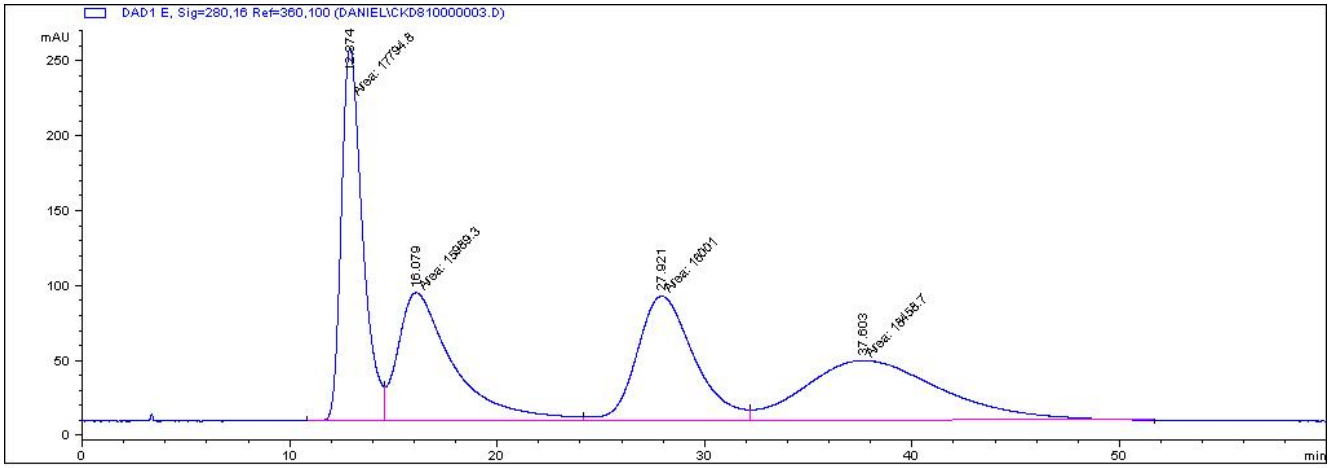


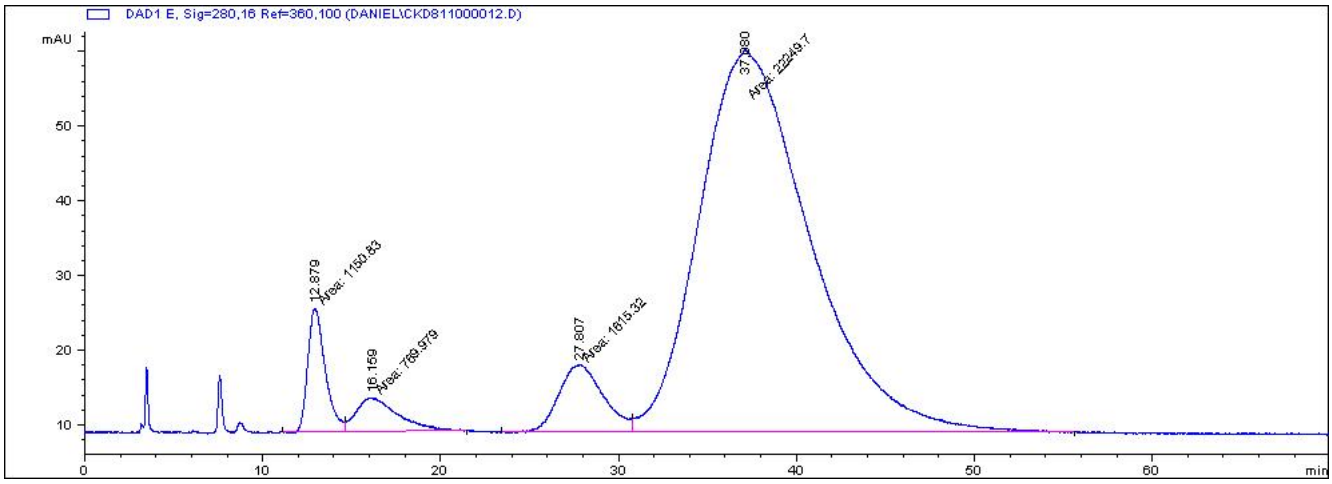




HPLC Profile of 7i







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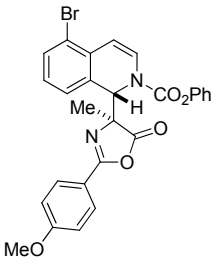
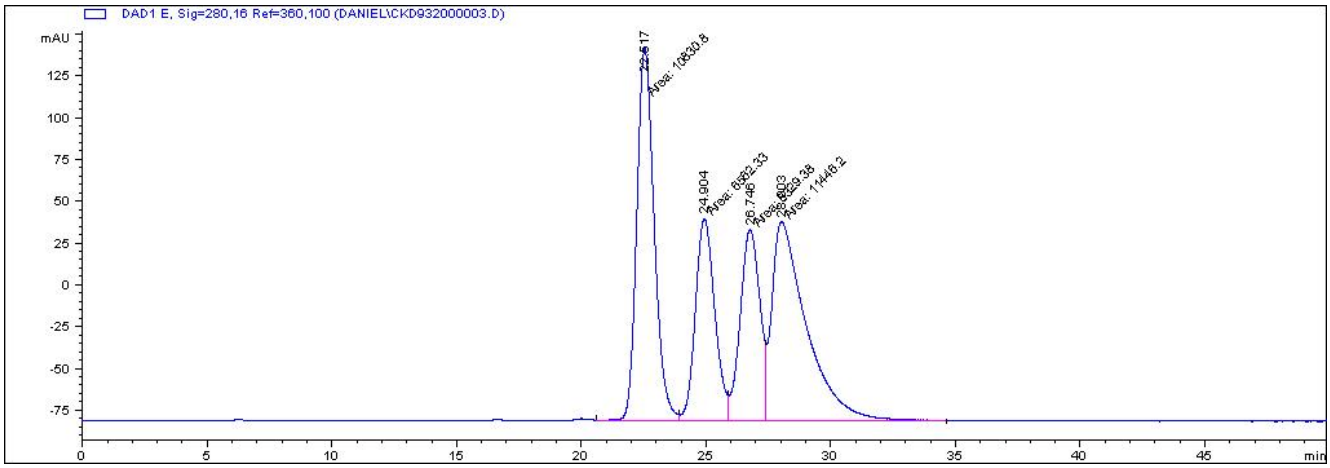
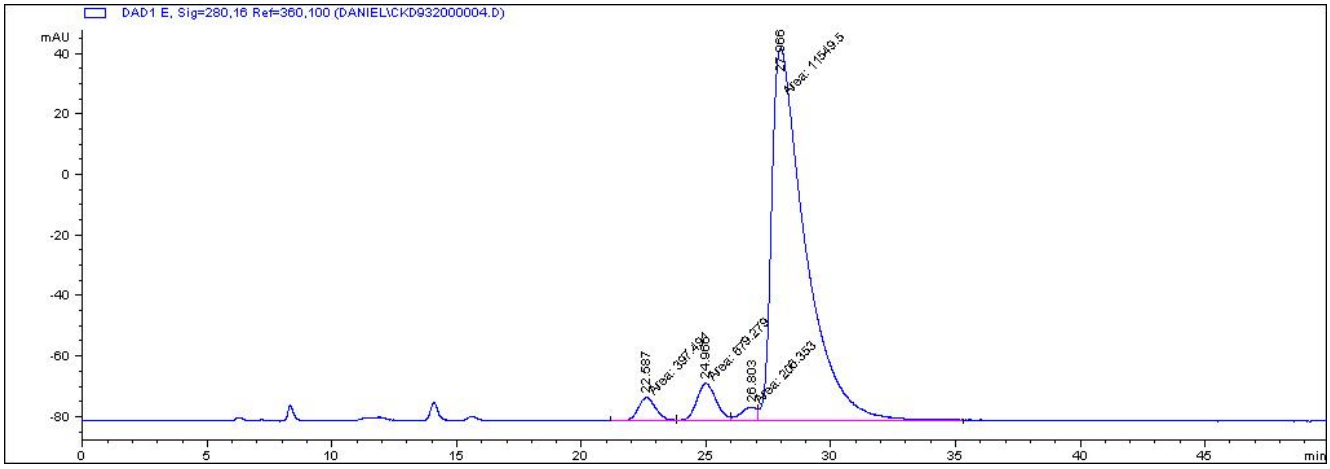
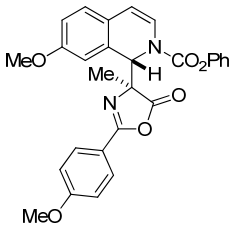
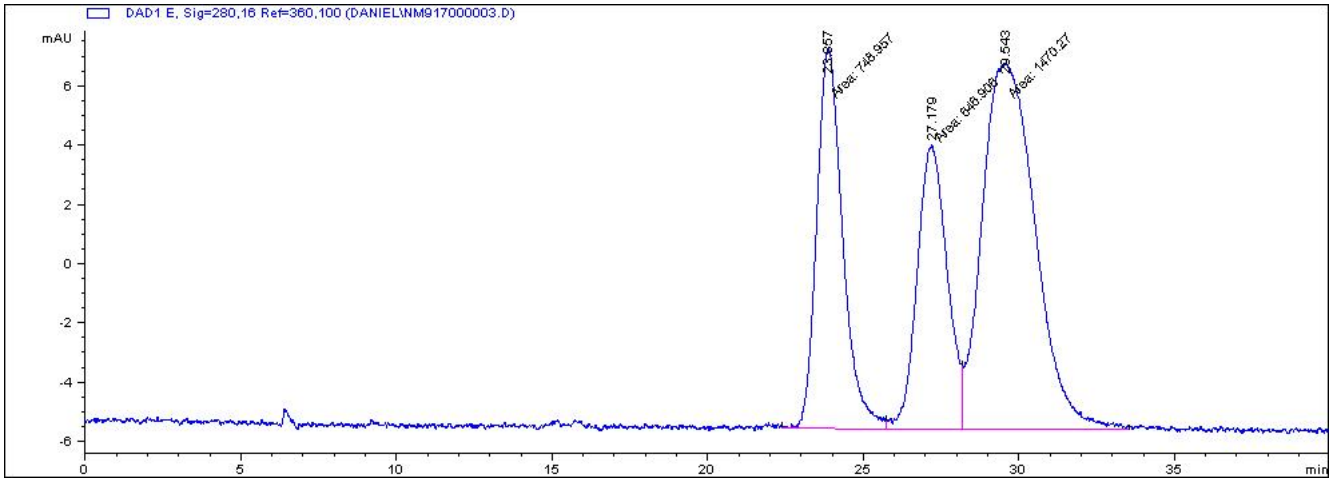


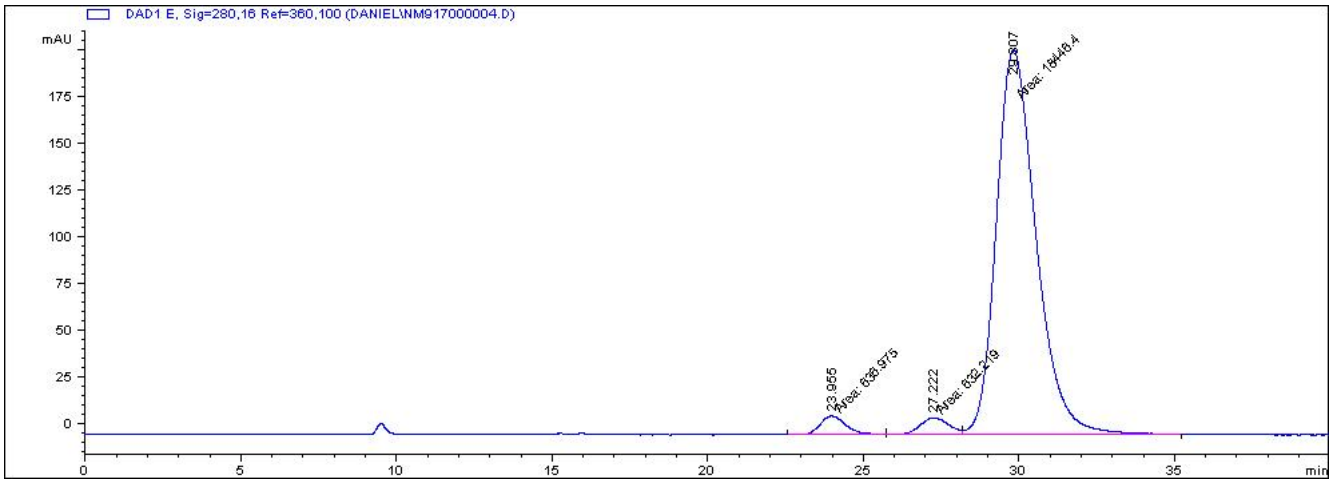




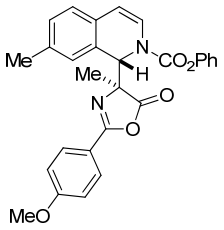
HPLC Profile of 7k

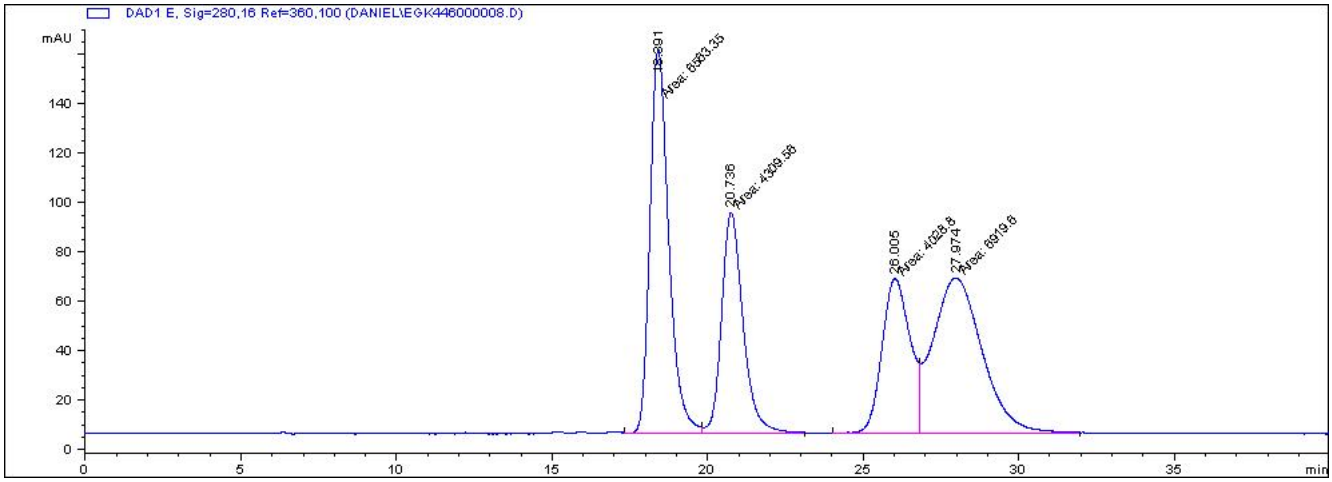


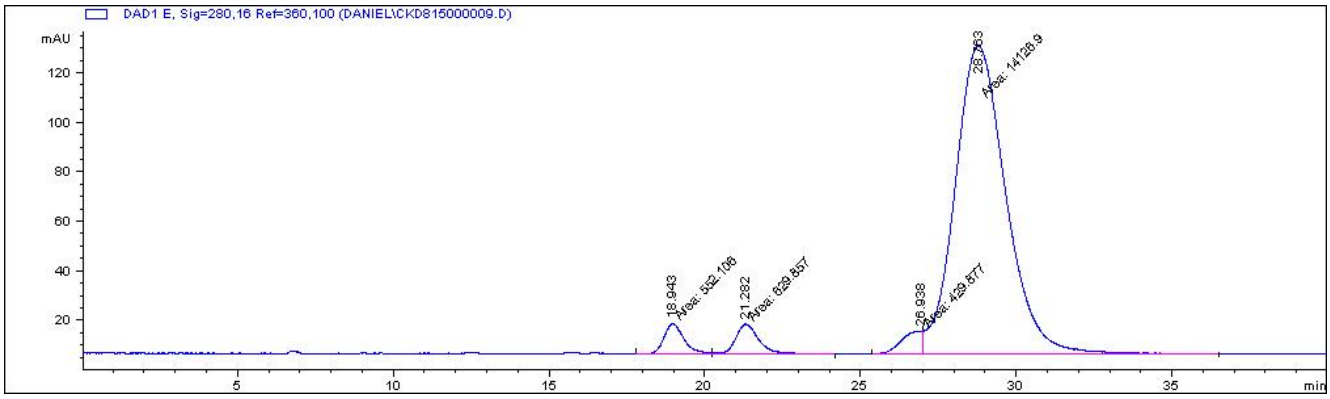




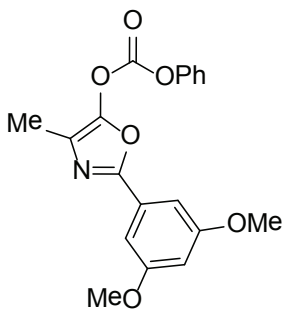
HPLC Profile of 7l

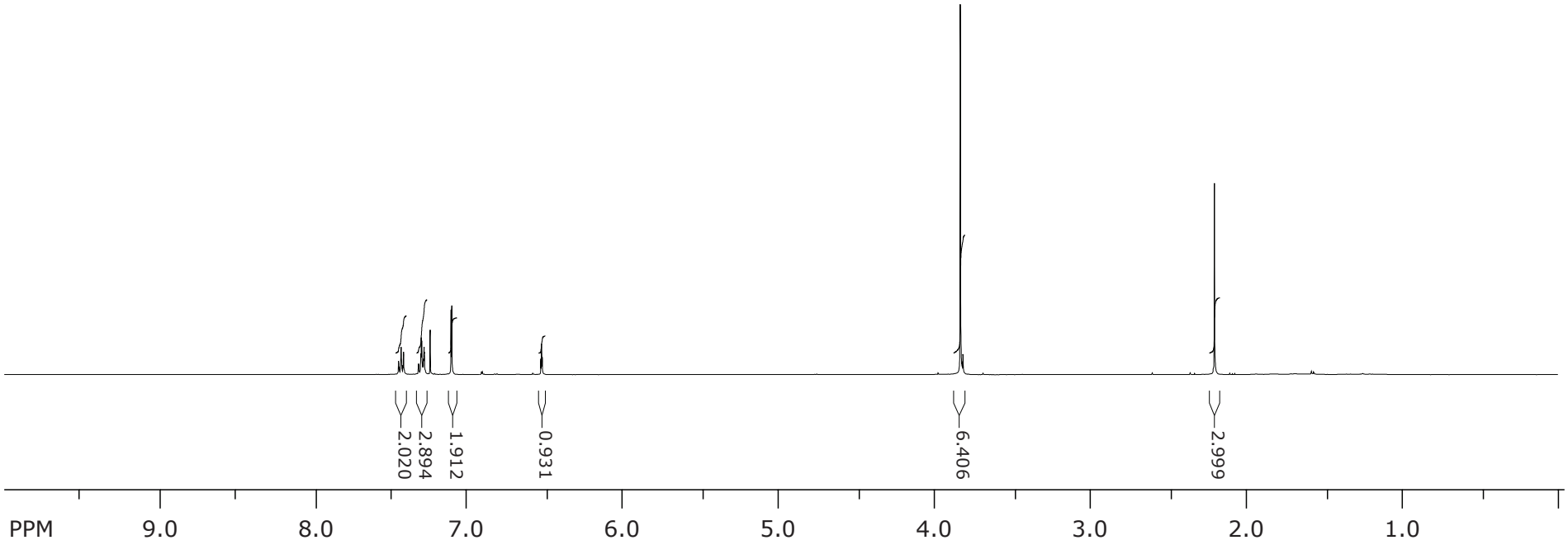




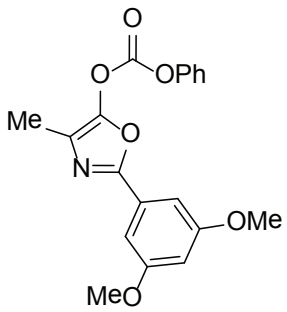


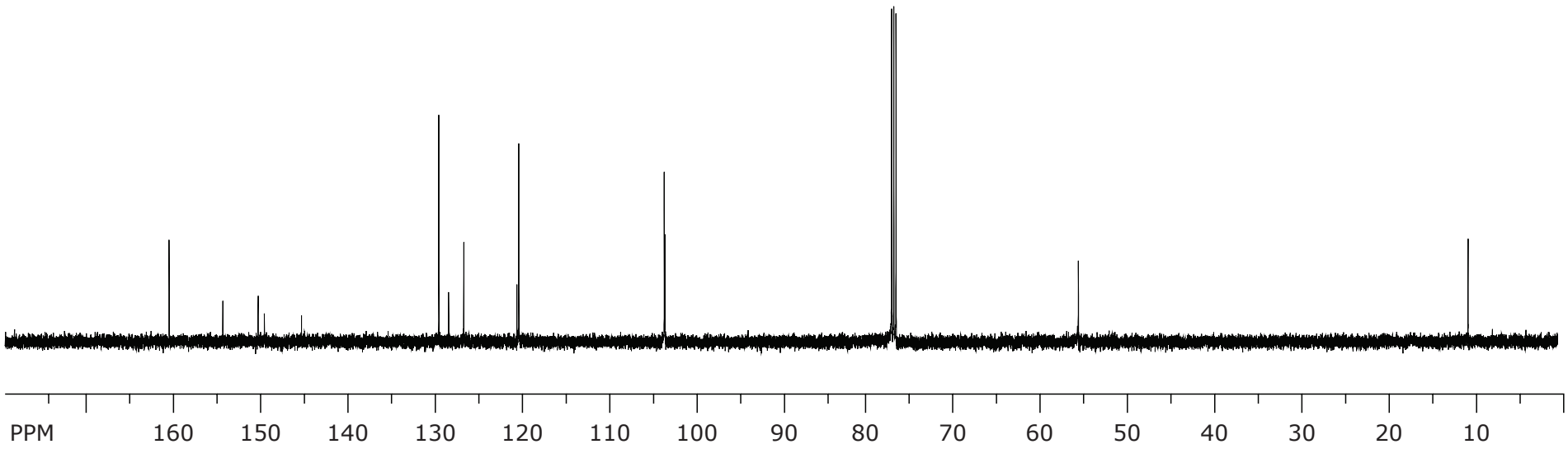
^{1}H NMR of **1a**


O
O
OPh
Me
O
N
OMe
MeO

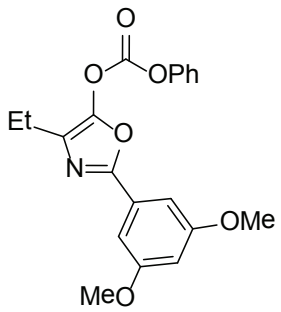

2.020
2.894
1.912
0.931
6.406
2.999
PPM
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0

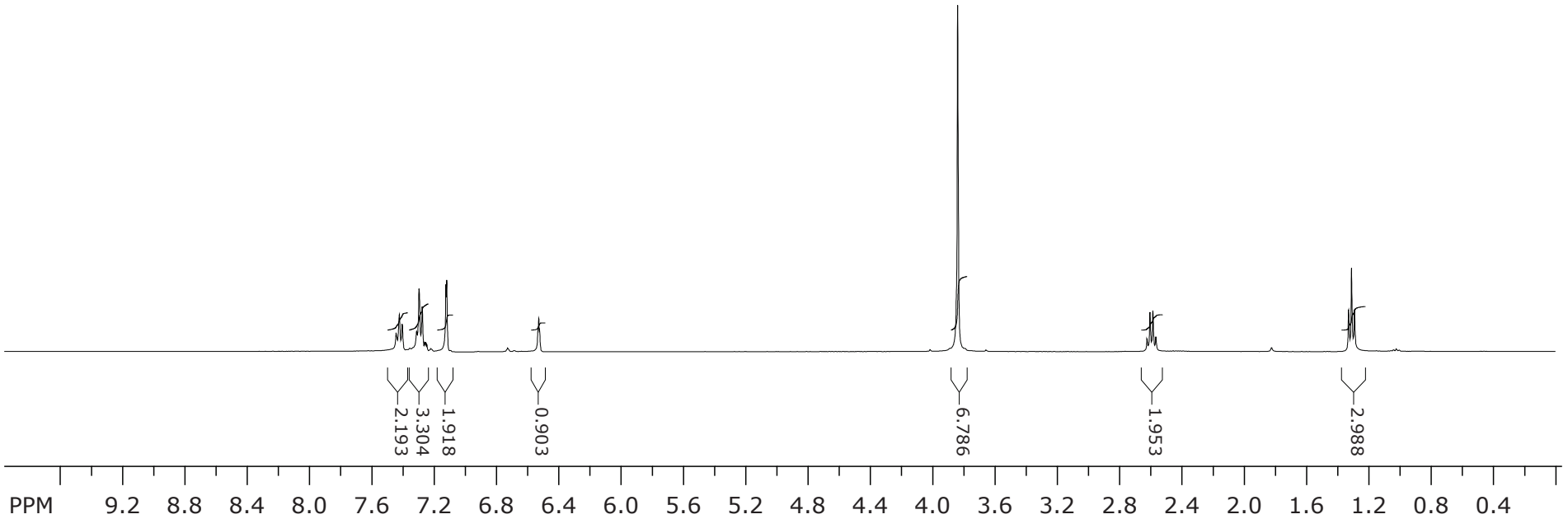
^{13}C NMR of **1a**


O
O
OPh
Me
O
N
OMe
MeO

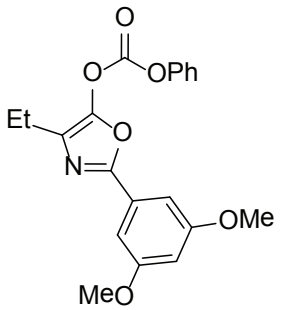

PPM
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

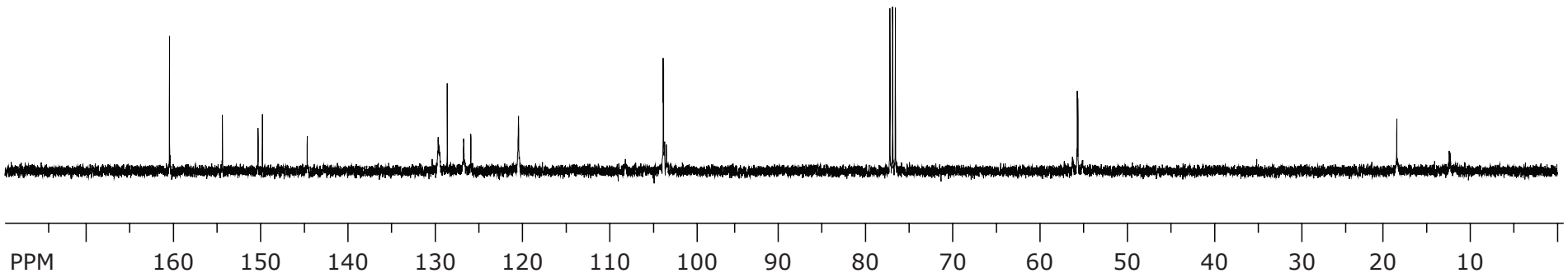
^{1}H NMR of **1b**


O
O
OPh
Et
O
N
OMe
MeO

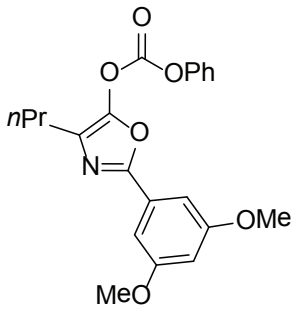

2.193
3.304
1.918
0.903
6.786
1.953
2.988
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

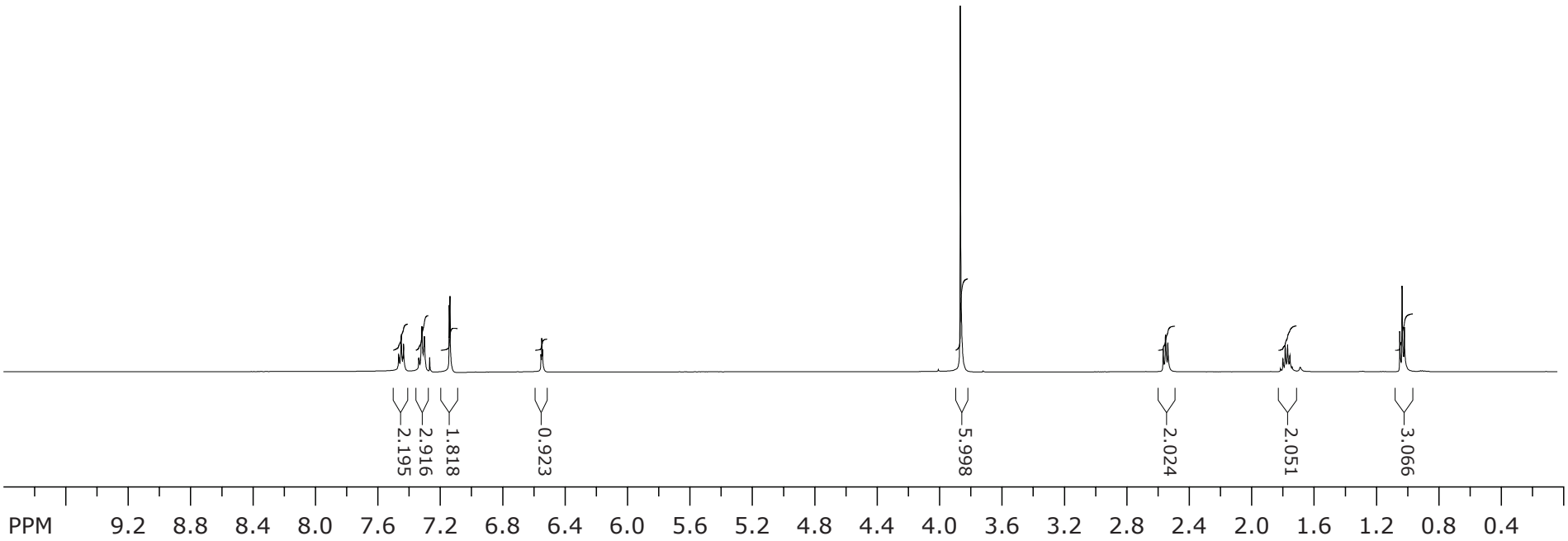
^{13}C NMR of **1b**


O
O
OPh
Et
O
N
OMe
MeO

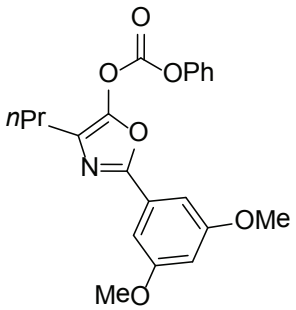

PPM
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

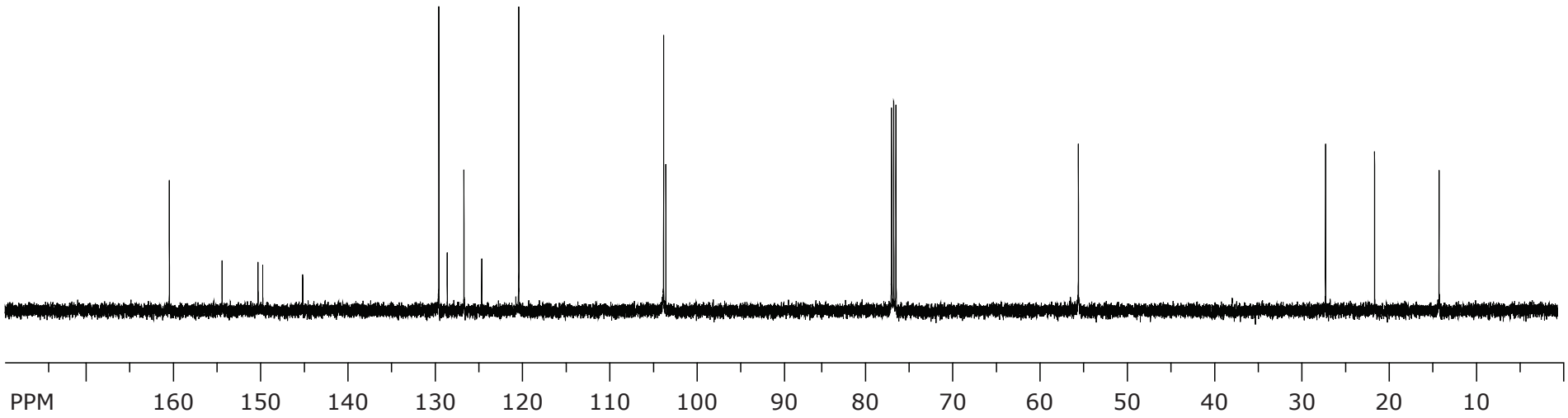
^{1}H NMR of **1c**


O
O
OPh
nPr
O
N
OMe
MeO

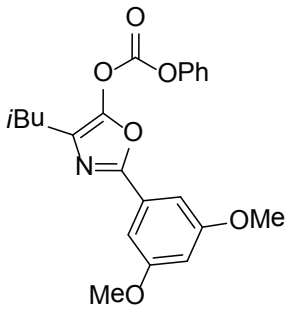

2.195
2.916
1.818
0.923
5.998
2.024
2.051
3.066
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

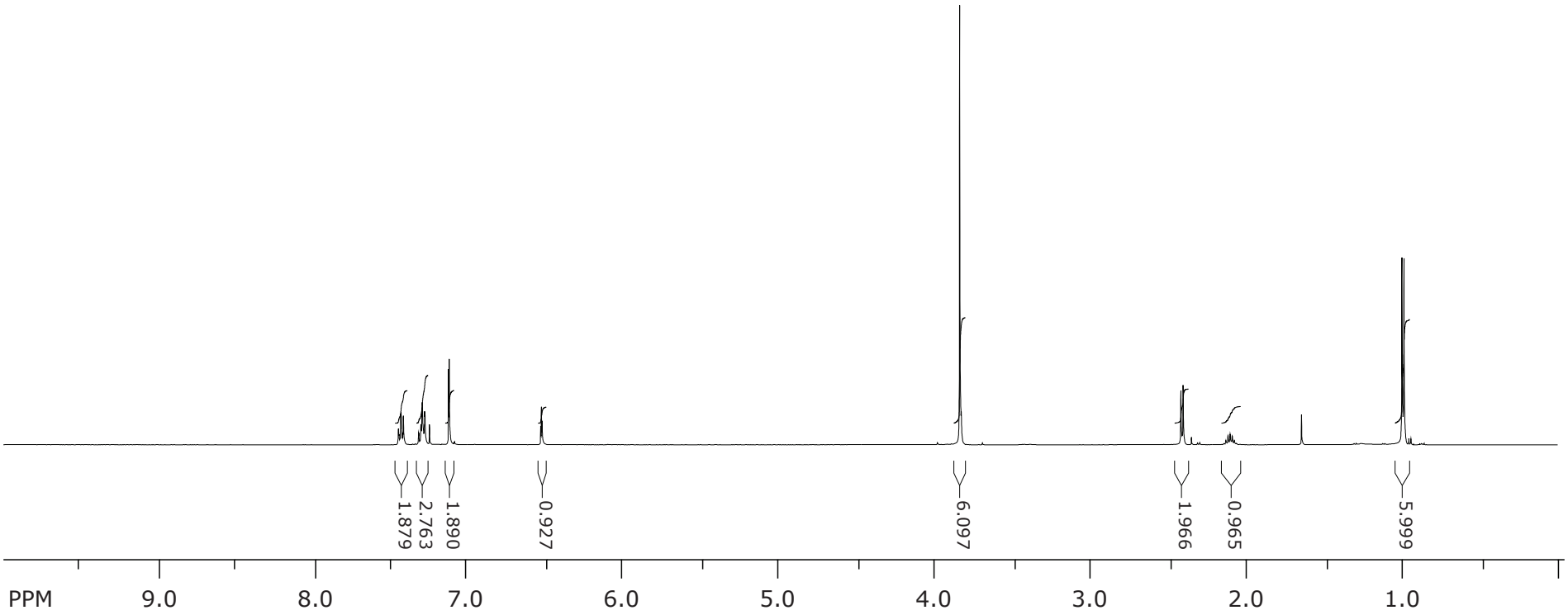
^{13}C NMR of **1c**


O
O
OPh
nPr
O
N
OMe
MeO

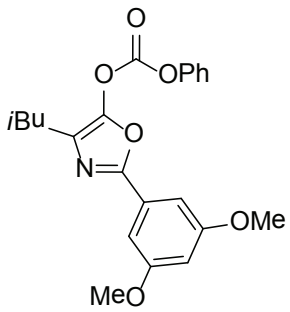

PPM
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

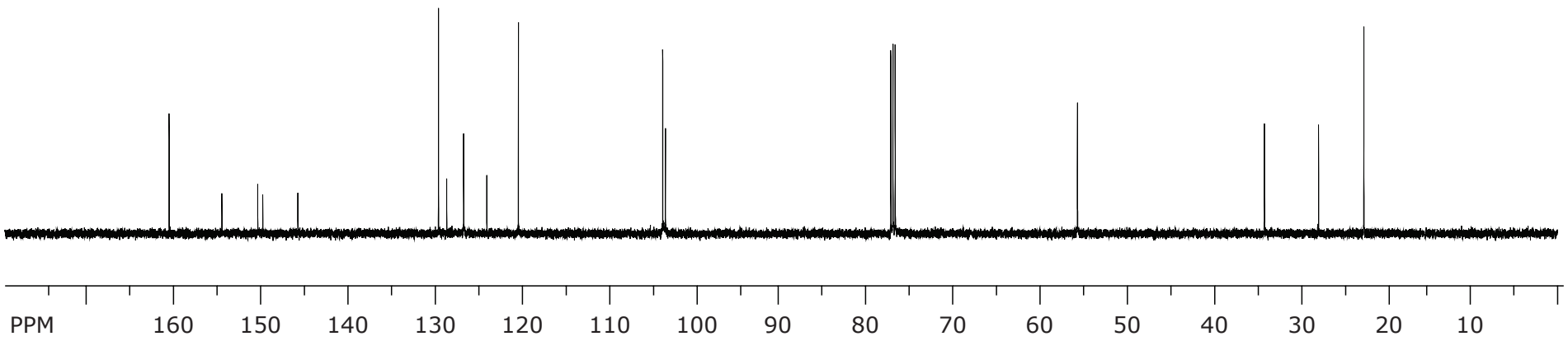
^{1}H NMR of **1d**


O
O
OPh
iBu
O
N
OMe
MeO

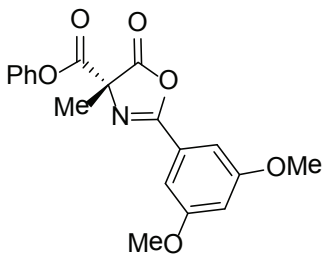

1.879
2.763
1.890
0.927
6.097
1.966
0.965
5.999
PPM
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0

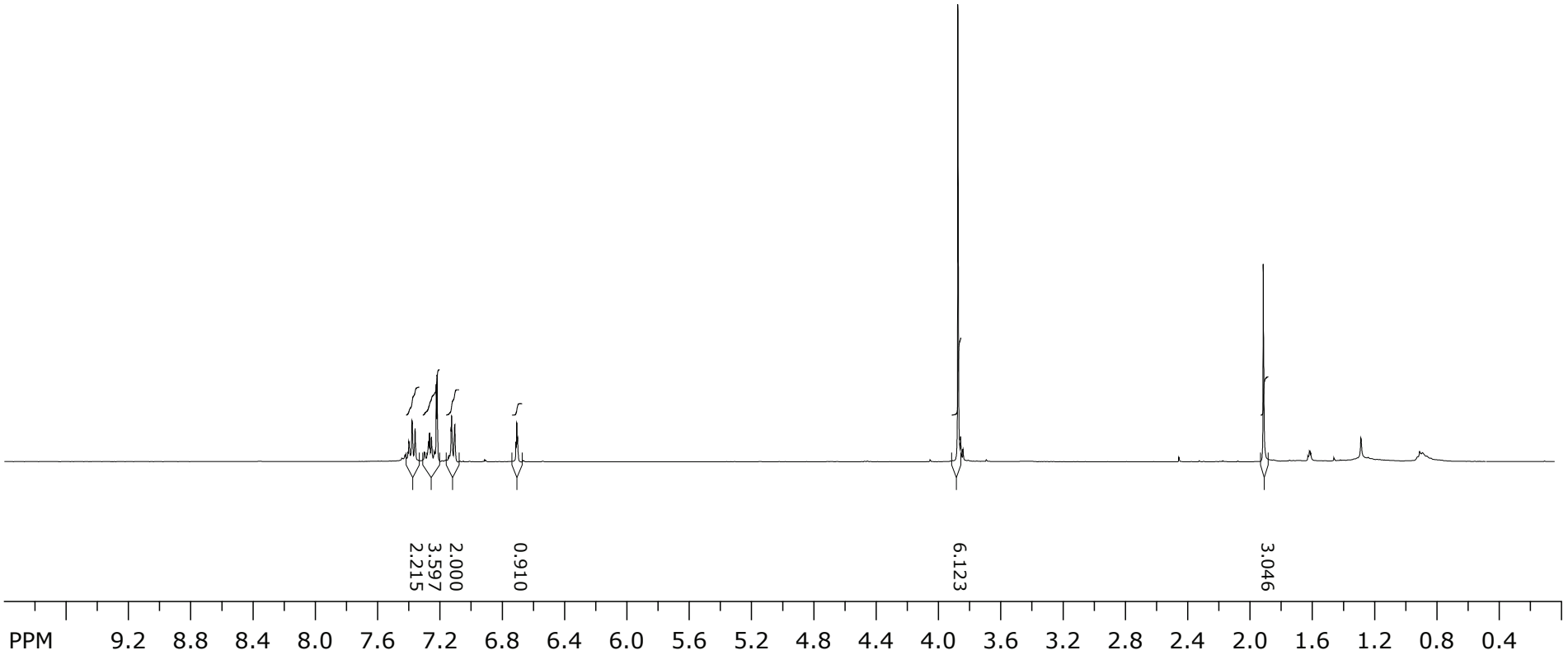
^{13}C NMR of **1d**


O
O
OPh
iBu
O
N
OMe
MeO

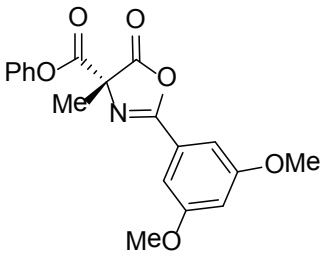

PPM
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

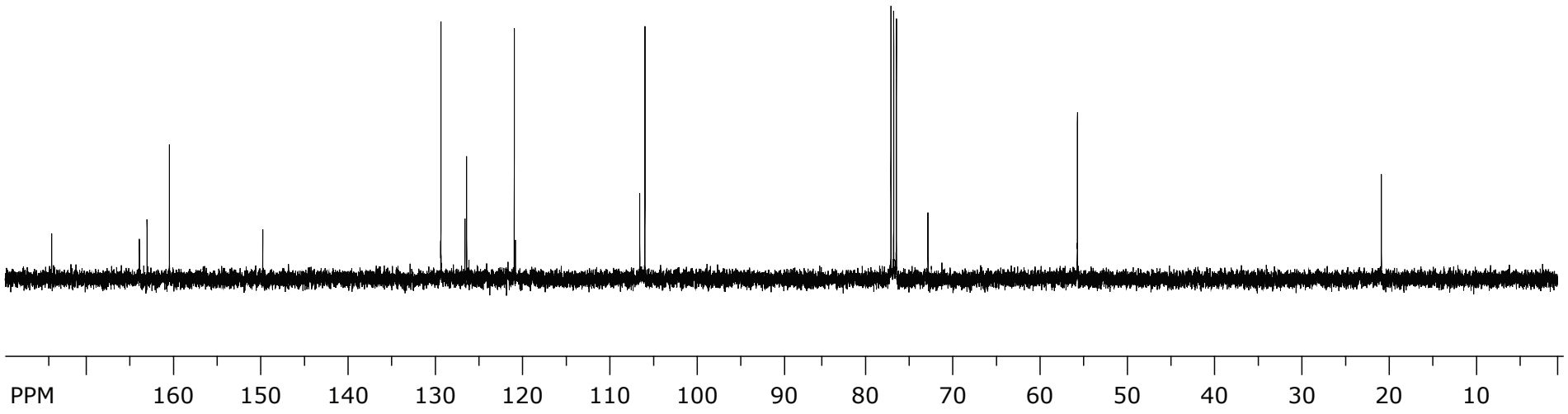
^{1}H NMR of **2a**


O
O
PhO
O
Me
N
OMe
MeO

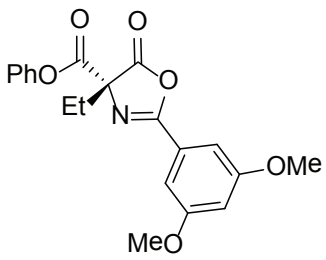

2.215
3.597
2.000
0.910
6.123
3.046
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

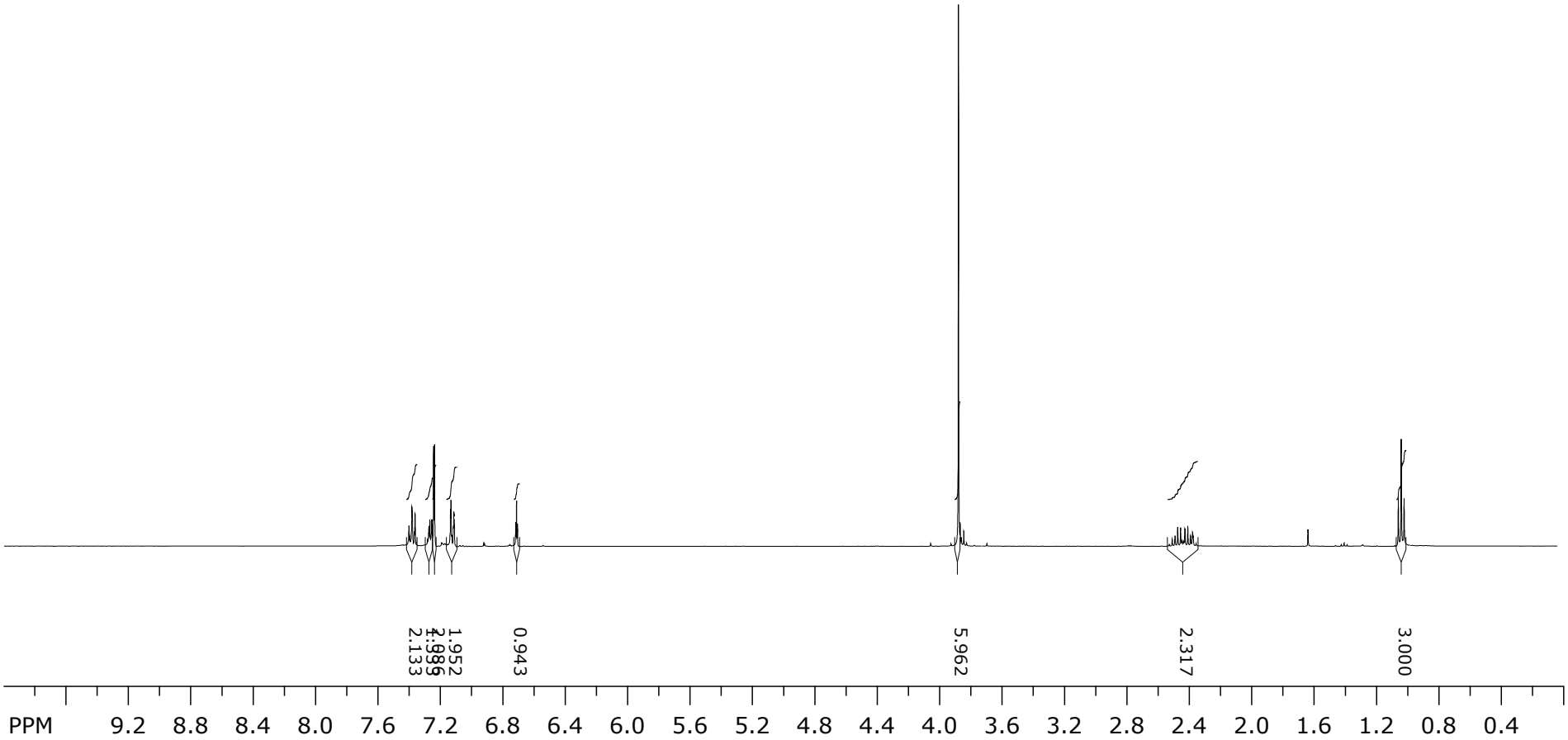
^{13}C NMR of **2a**


O
O
PhO
O
Me
N
OMe
MeO

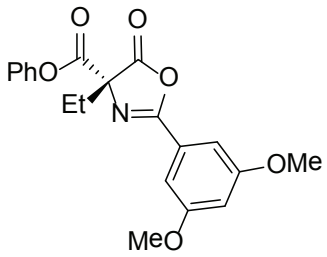

PPM
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

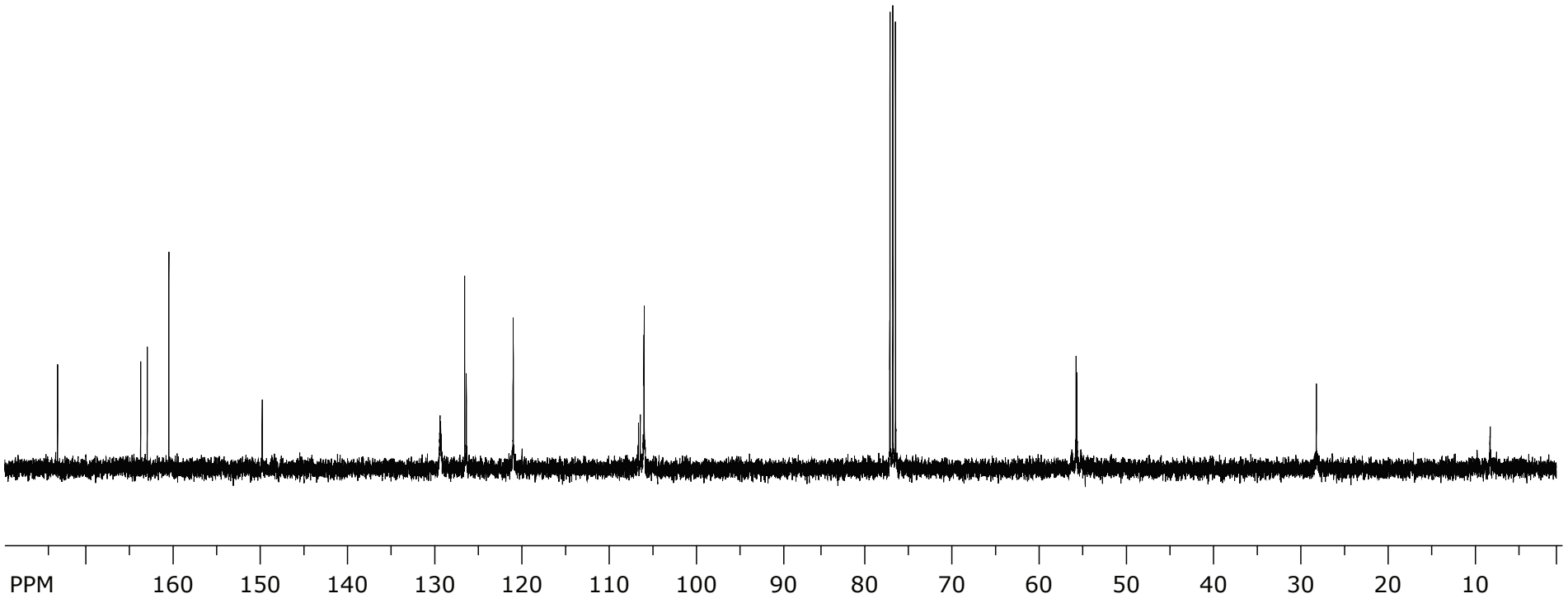
^{1}H NMR of **2b**


O
O
PhO
O
Et
N
OMe
MeO

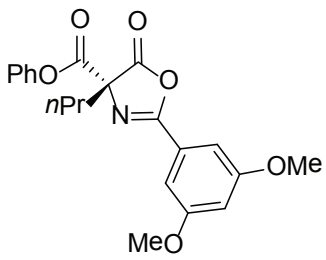

2.133
1.952
0.943
5.962
2.317
3.000
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

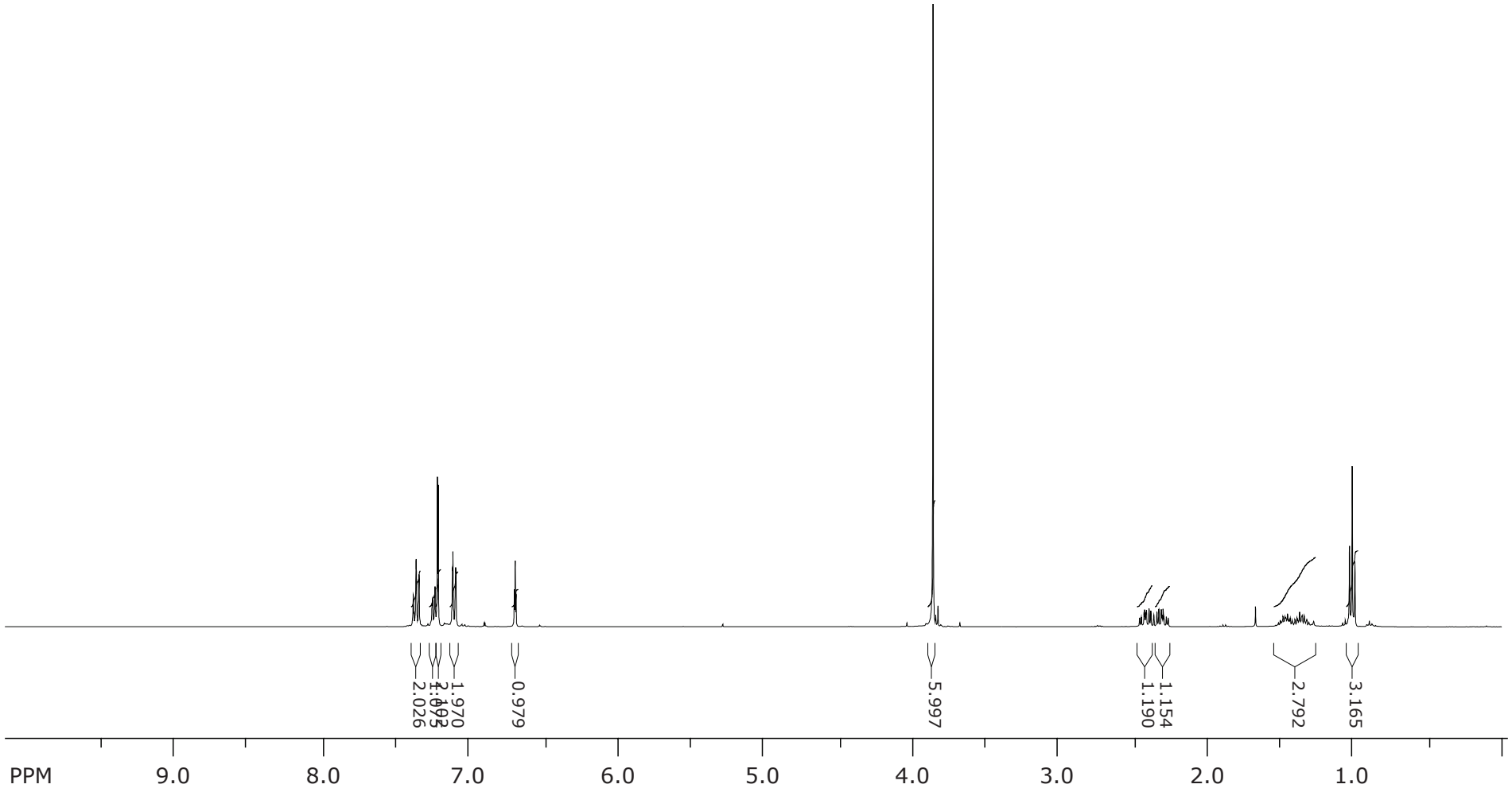
^{13}C NMR of **2b**


O
O
PhO
O
Et
N
OMe
MeO

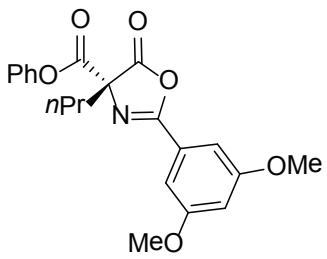

PPM
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

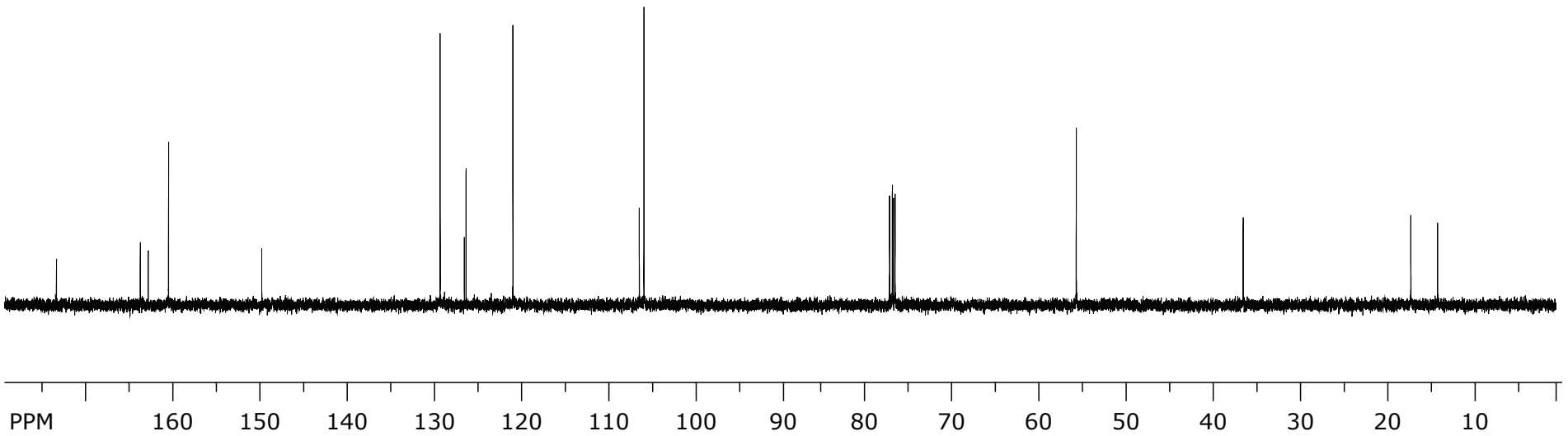
^{1}H NMR of **2c**


O
O
PhO
O
nPr
N
OMe
MeO

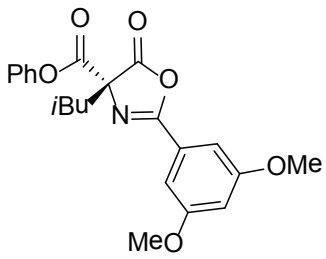

2.026
1.970
0.979
5.997
1.190
1.154
2.792
3.165
PPM
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0

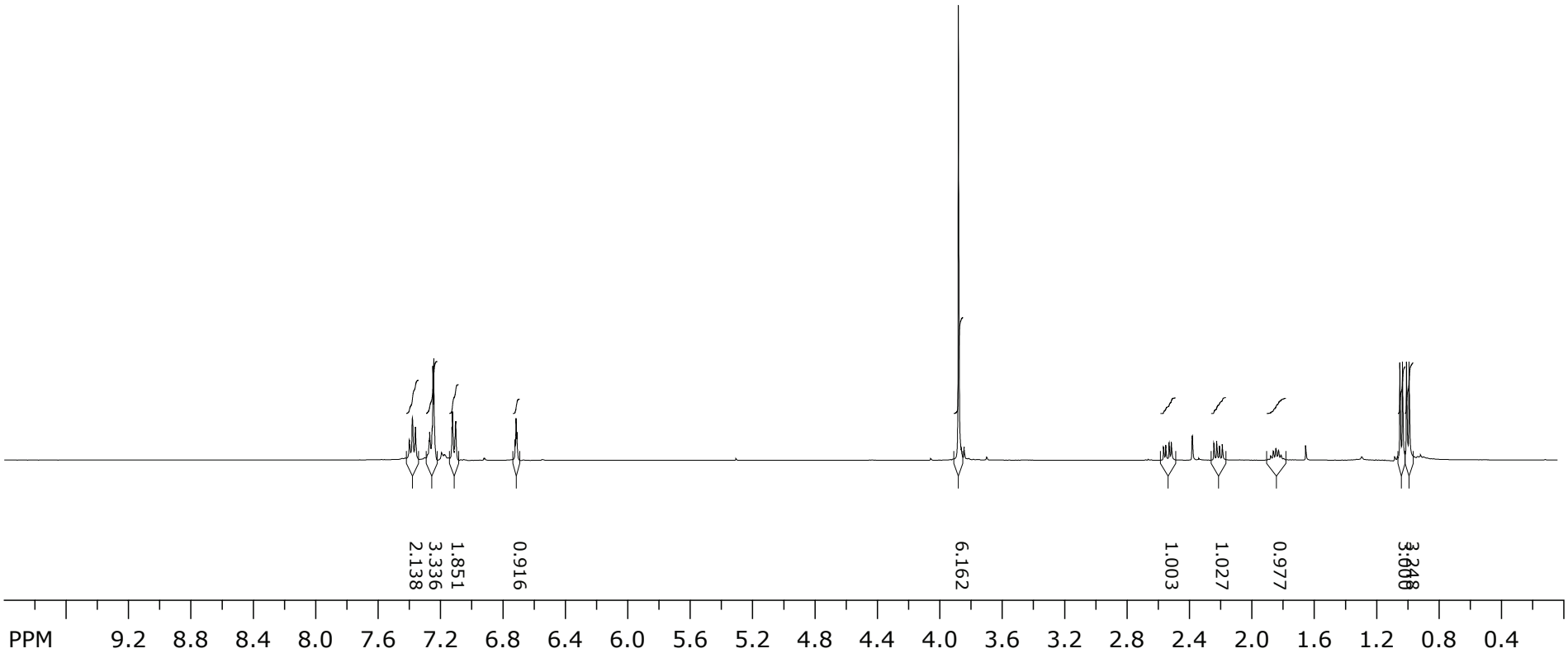
^{13}C NMR of **2c**


O
O
PhO
O
nPr
N
OMe
MeO

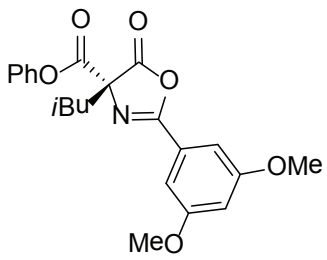

PPM
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

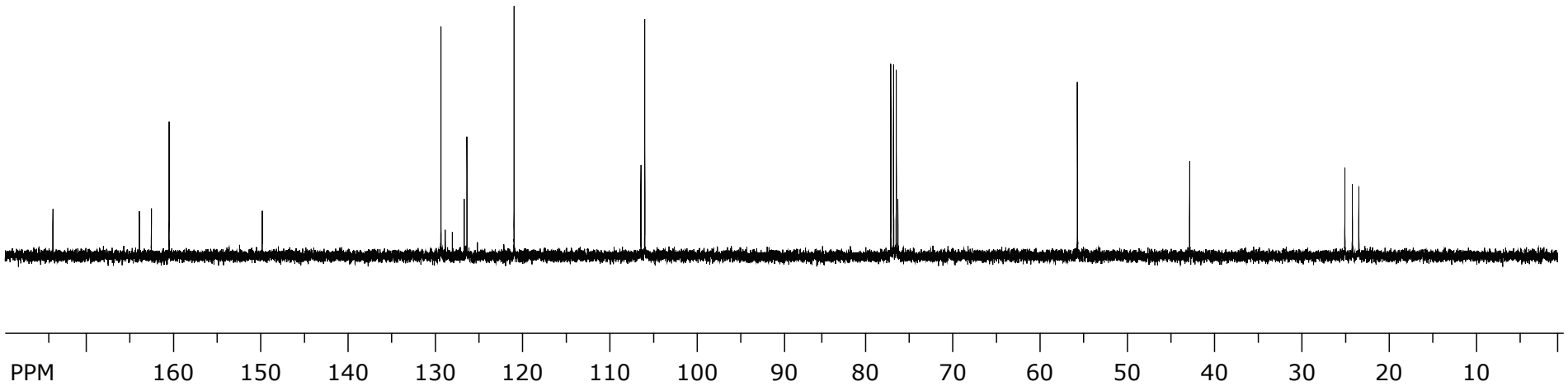
^{1}H NMR of **2d**


O
O
PhO
O
*i*Bu
N
OMe
MeO

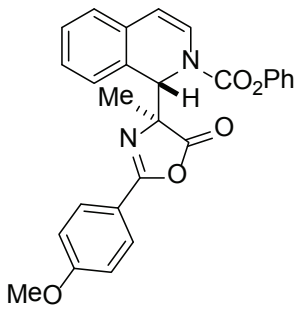

2.138
3.336
1.851
0.916
6.162
1.003
1.027
0.977
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

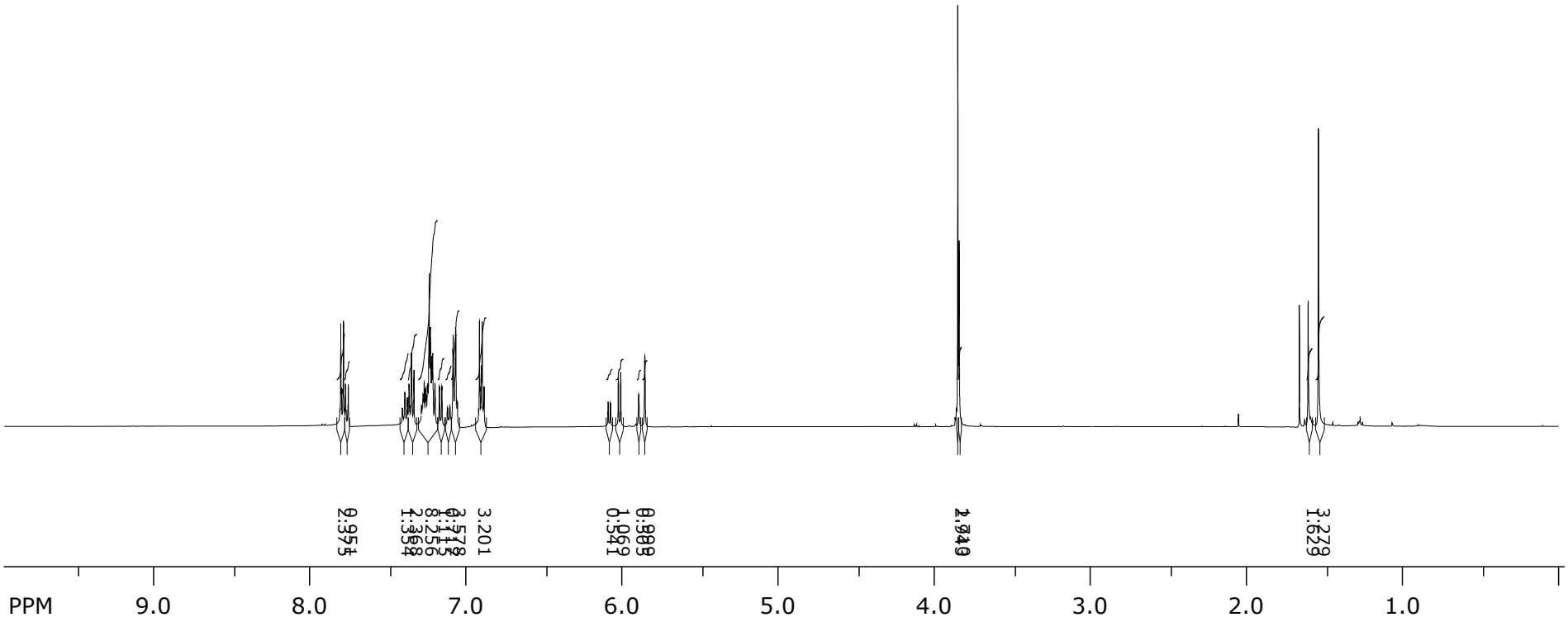
^{13}C NMR of **2d**


O
O
PhO
O
iBu
N
OMe
MeO

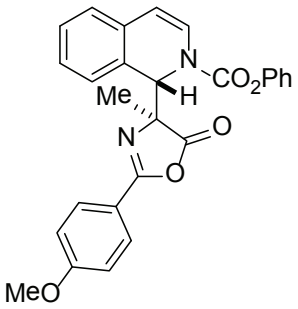

PPM
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

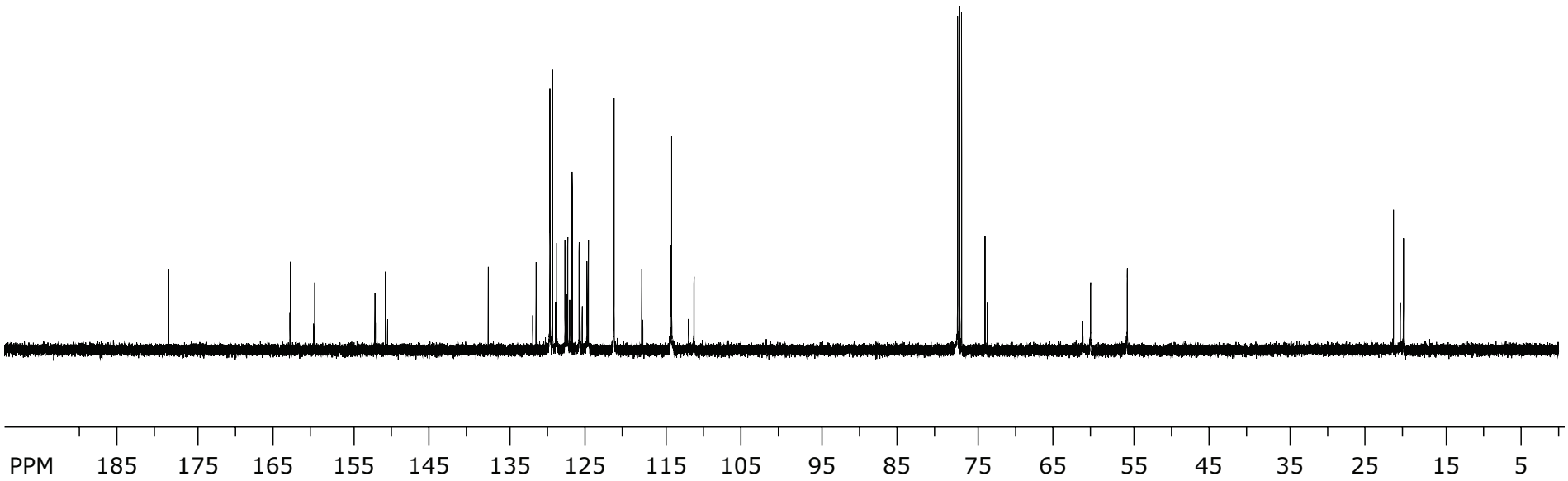
^{1}H NMR of **7a**


N
CO2Ph
Me
H
N
O
O
MeO

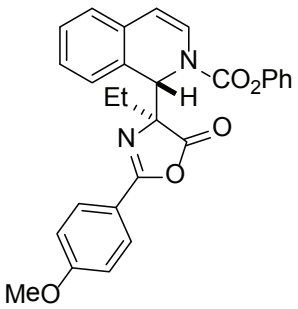

9.951
1.354
8.256
3.201
0.541
1.629
PPM
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0

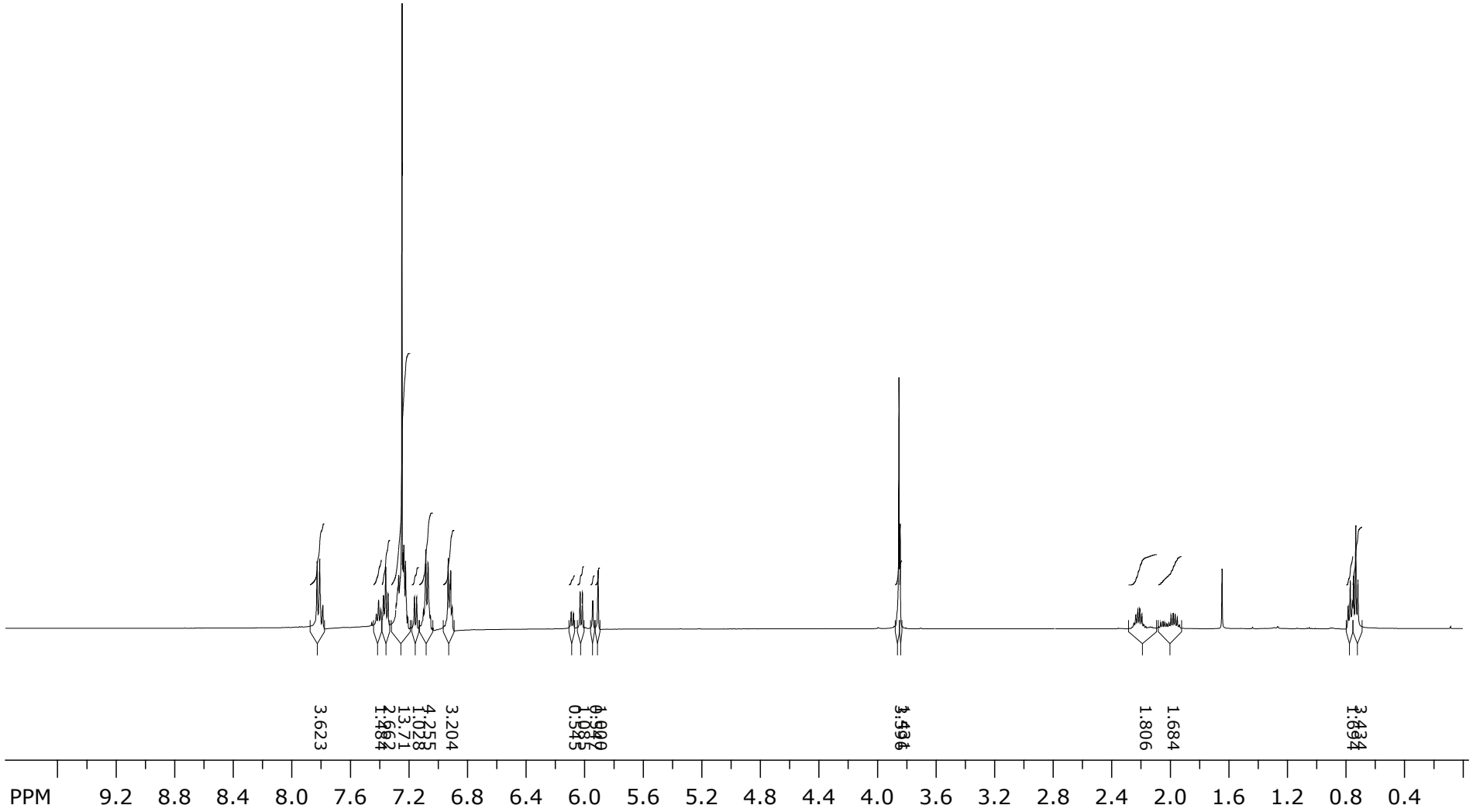
^{13}C NMR of **7a**


N
CO2Ph
Me
H
N
O
O
MeO

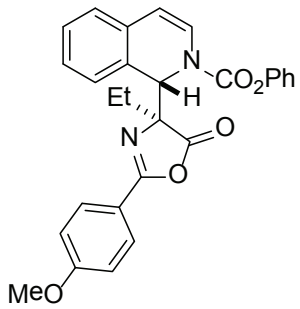

PPM
185
175
165
155
145
135
125
115
105
95
85
75
65
55
45
35
25
15
5

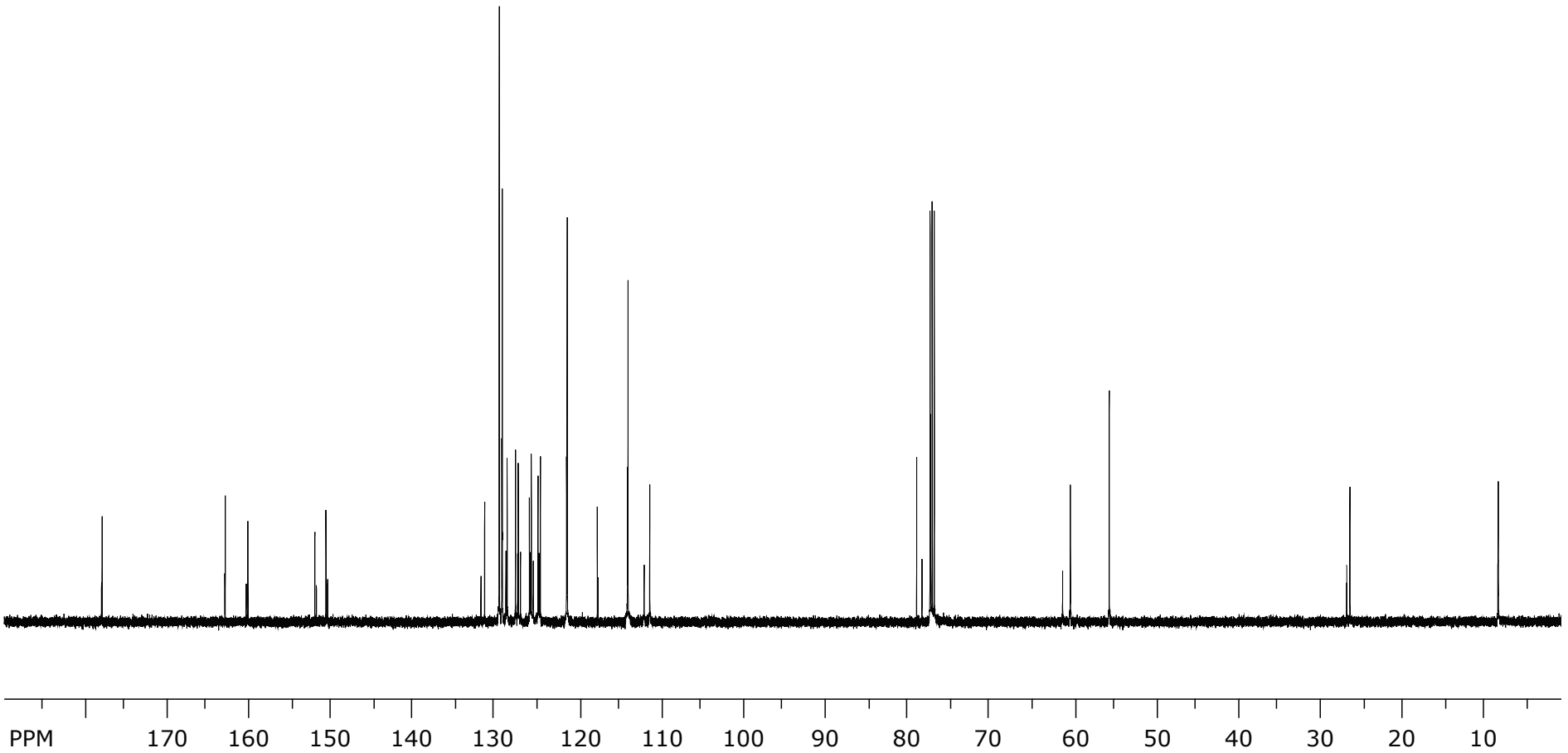
^{1}H NMR of **7b**


N
CO2Ph
Et
H
N
O
O
MeO

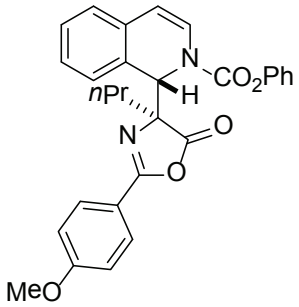

3.623
2.484
2.464
13.71
4.255
3.204
0.545
1.806
1.684
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

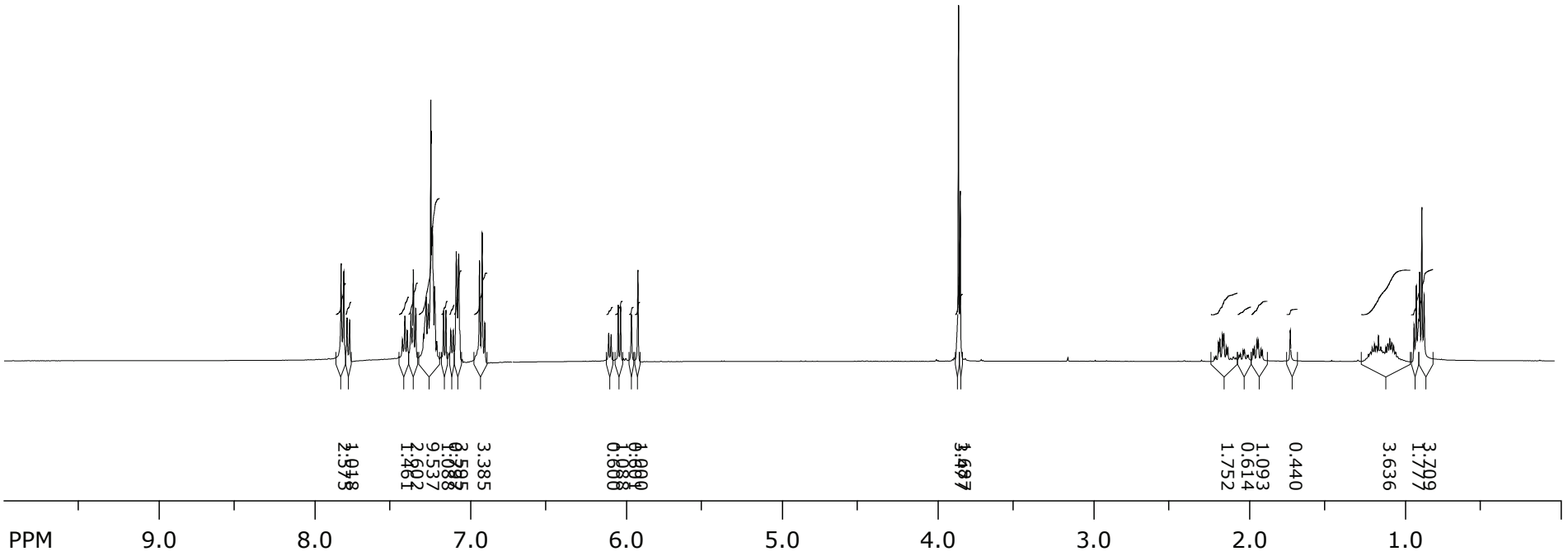
^{13}C NMR of **7b**


N
CO2Ph
Et
H
N
O
O
MeO

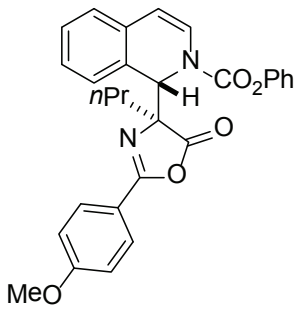

PPM
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

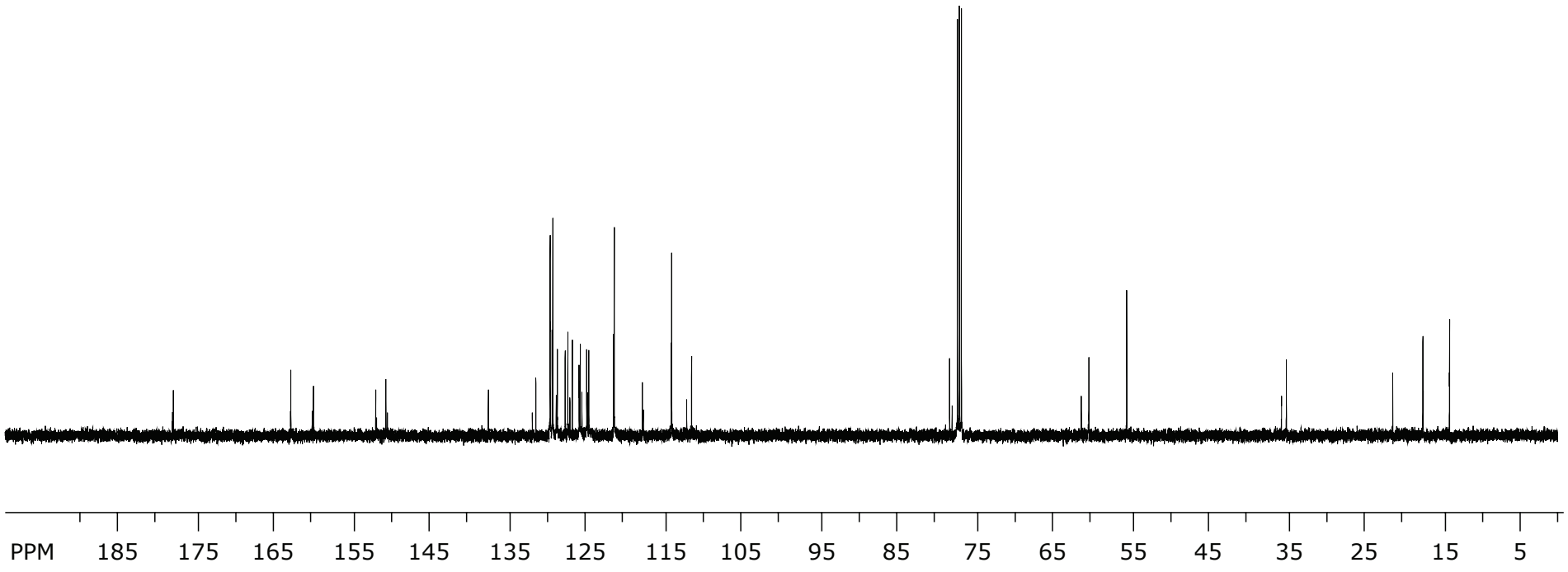
^{1}H NMR of **7c**


N
CO2Ph
H
nPr
N
O
O
MeO

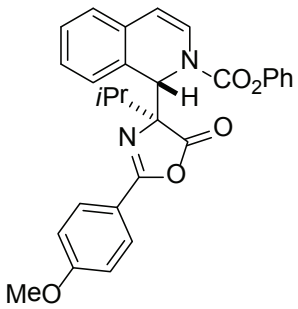

2.918
1.461
9.537
3.385
0.800
3.687
1.752
1.093
0.614
0.440
3.636
3.799
PPM
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0

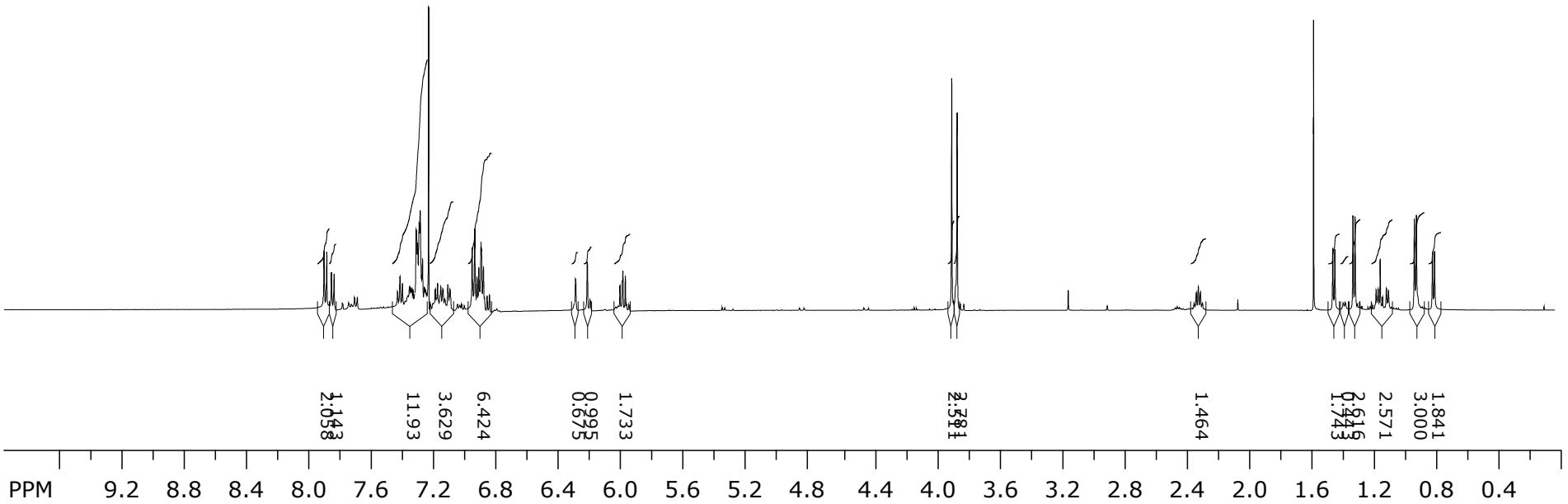
^{13}C NMR of **7c**


N
CO2Ph
H
nPr
N
O
O
MeO

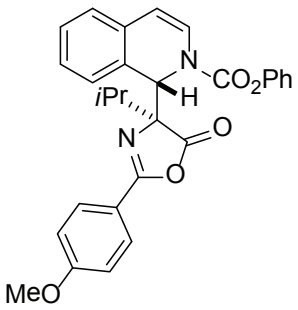

PPM
185
175
165
155
145
135
125
115
105
95
85
75
65
55
45
35
25
15
5

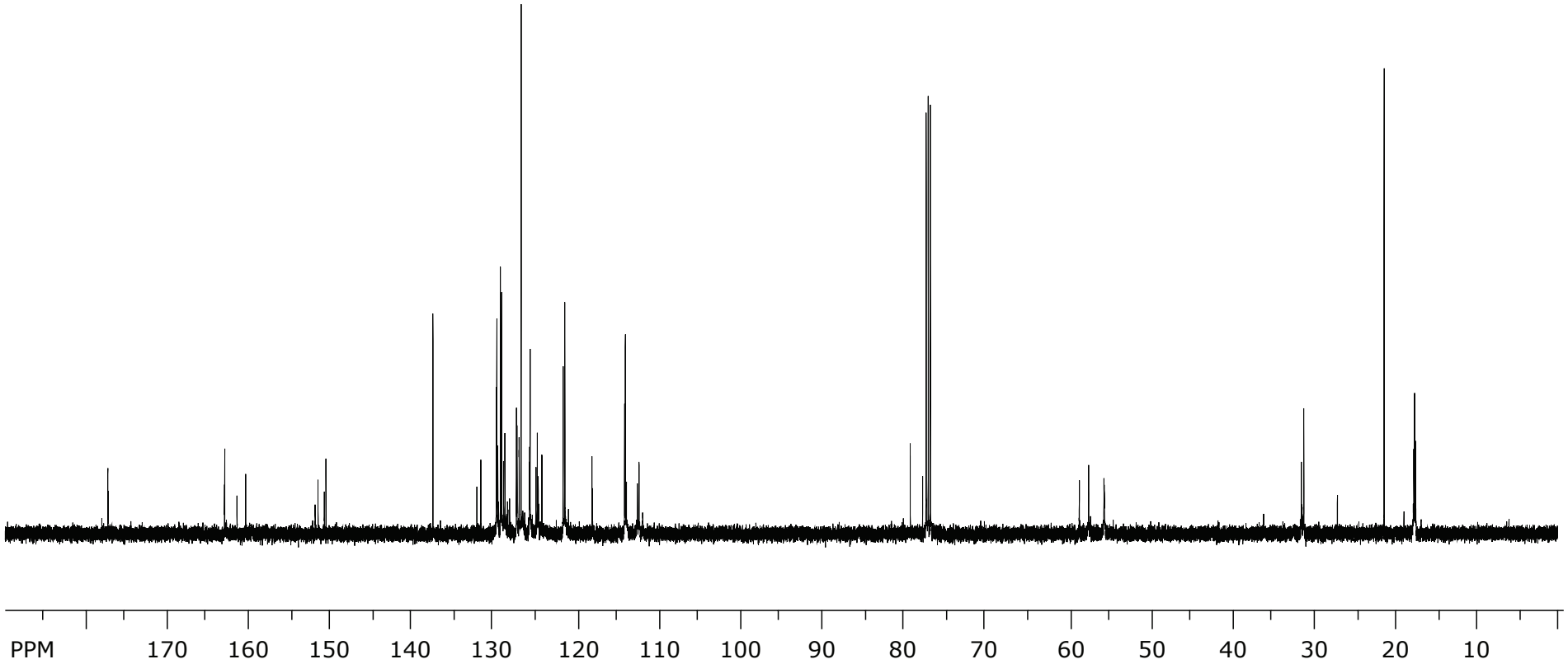
^{1}H NMR of **7d**


N
CO2Ph
iPr
H
N
O
O
MeO

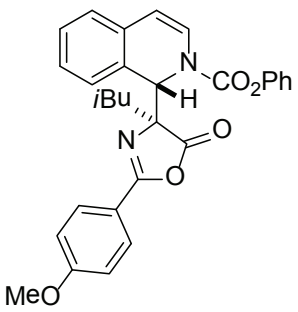

2.058
1.143
11.93
3.629
6.424
0.675
0.995
1.733
2.581
2.511
1.464
1.743
0.616
2.571
3.000
1.841
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

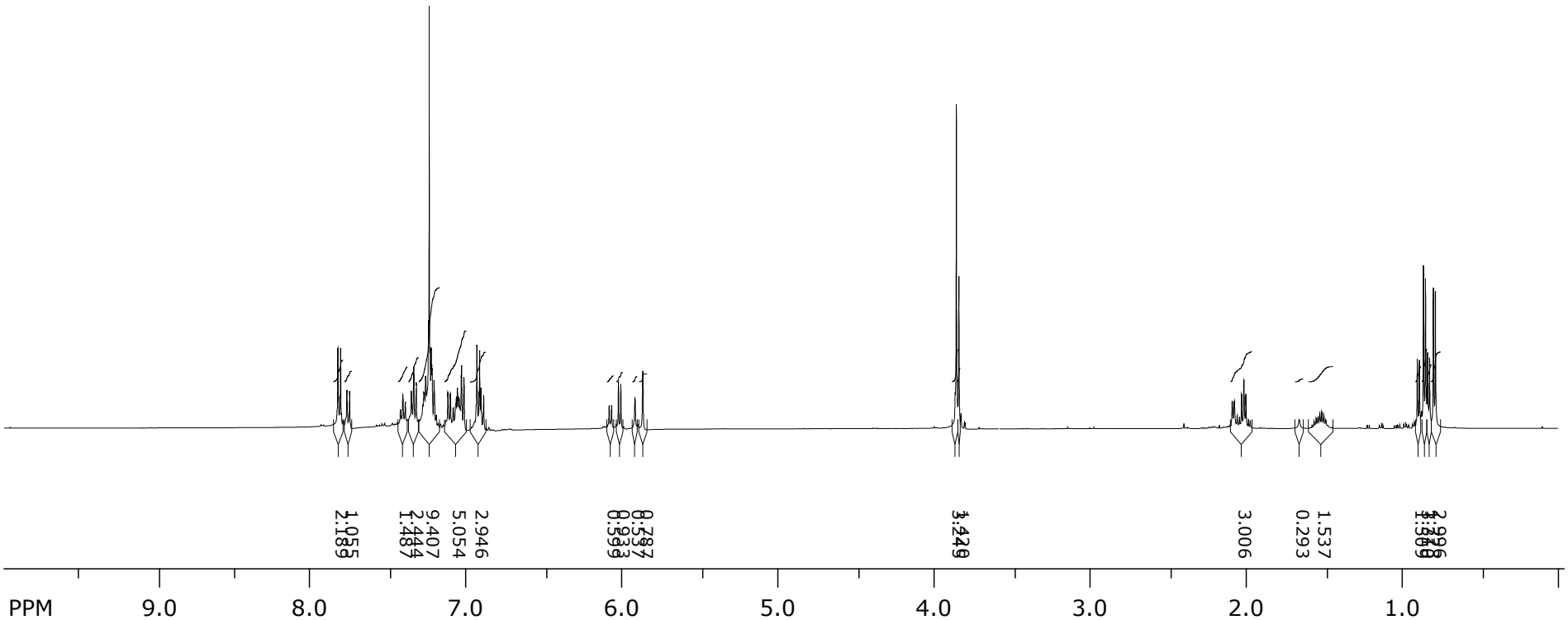
^{13}C NMR of **7d**


N
CO2Ph
H
iPr
N
O
O
MeO

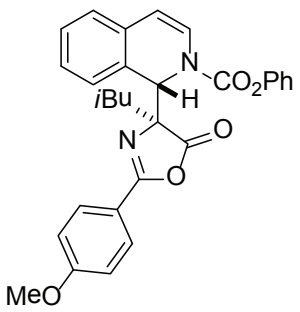

PPM
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

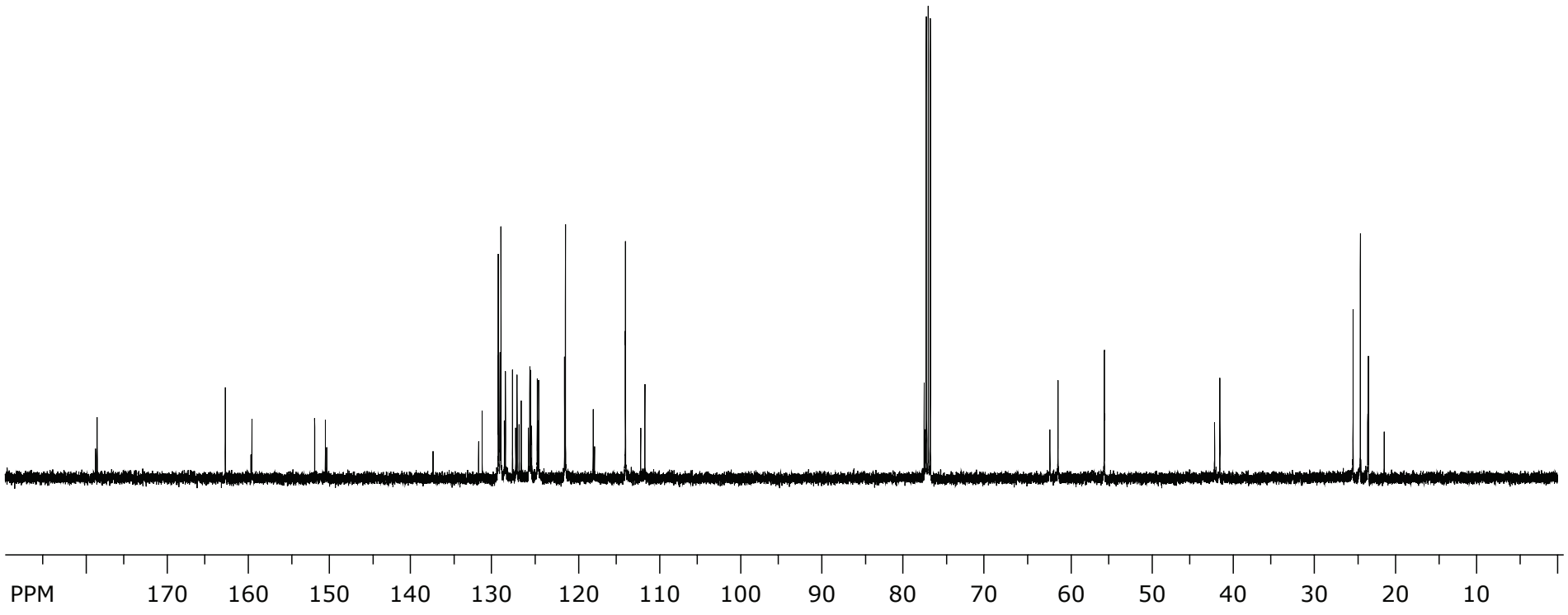
^{1}H NMR of **7e**


N
CO2Ph
iBu
H
N
O
O
MeO

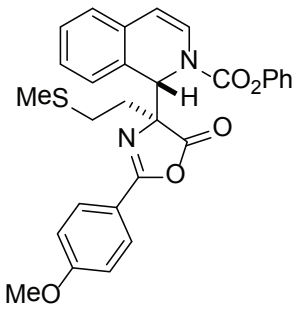

2.185
1.055
1.487
1.444
9.407
5.054
2.946
0.933
0.599
0.537
0.787
3.429
3.006
0.293
1.537
PPM
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0

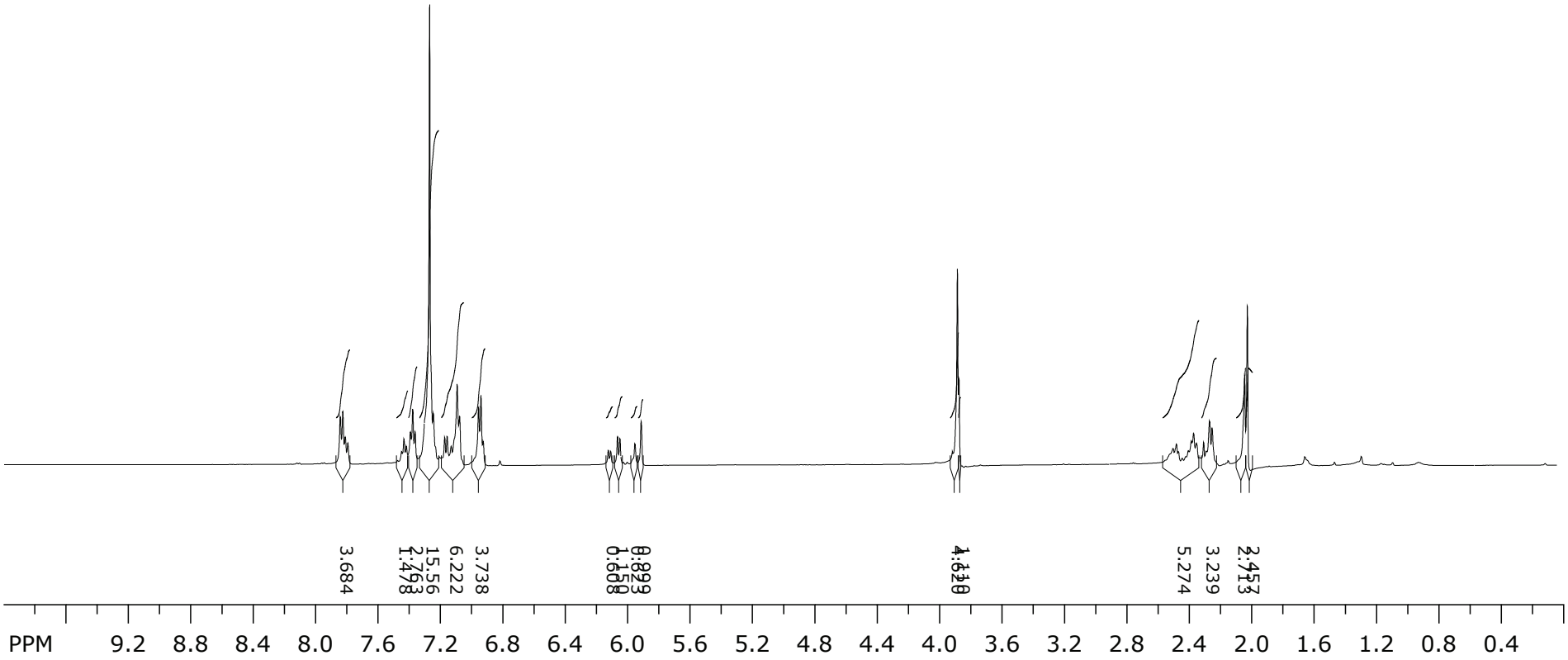
^{13}C NMR of **7e**


N
CO2Ph
H
iBu
N
O
O
MeO

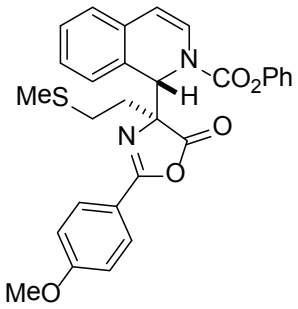

PPM
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

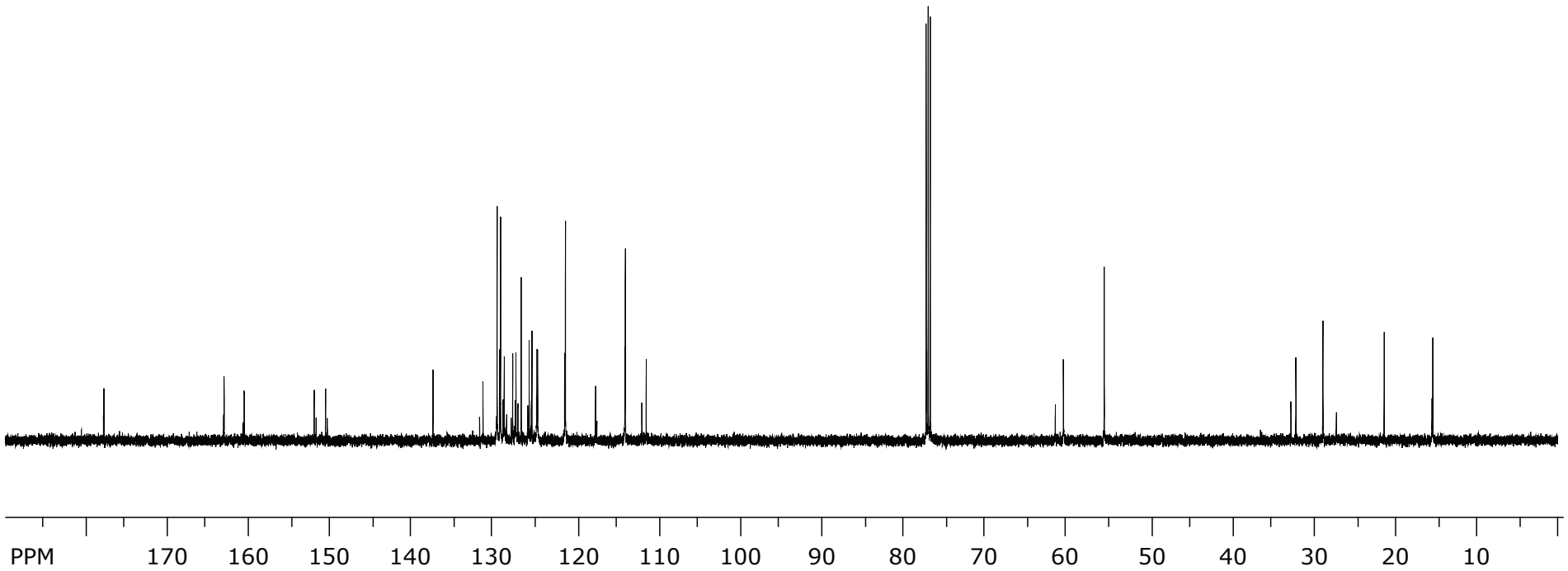
^{1}H NMR of **7f**


N
CO2Ph
H
MeS
N
O
O
MeO

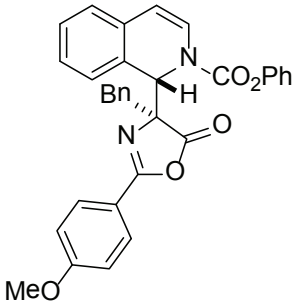

3.684
1.478
15.56
6.222
3.738
0.829
4.610
5.274
3.239
2.457
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

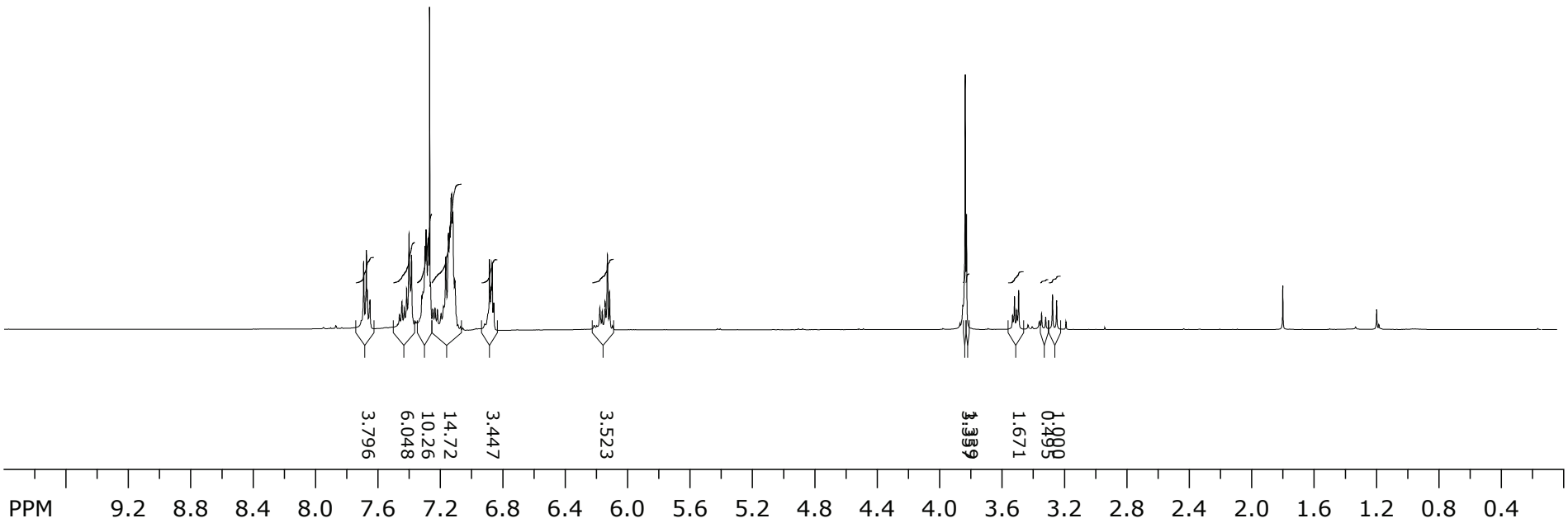
^{13}C NMR of **7f**


N
CO2Ph
H
MeS
N
O
O
MeO

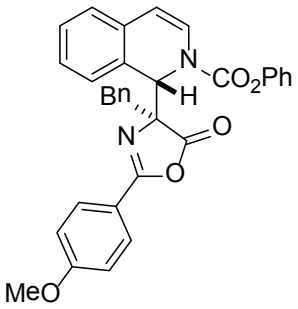

PPM
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

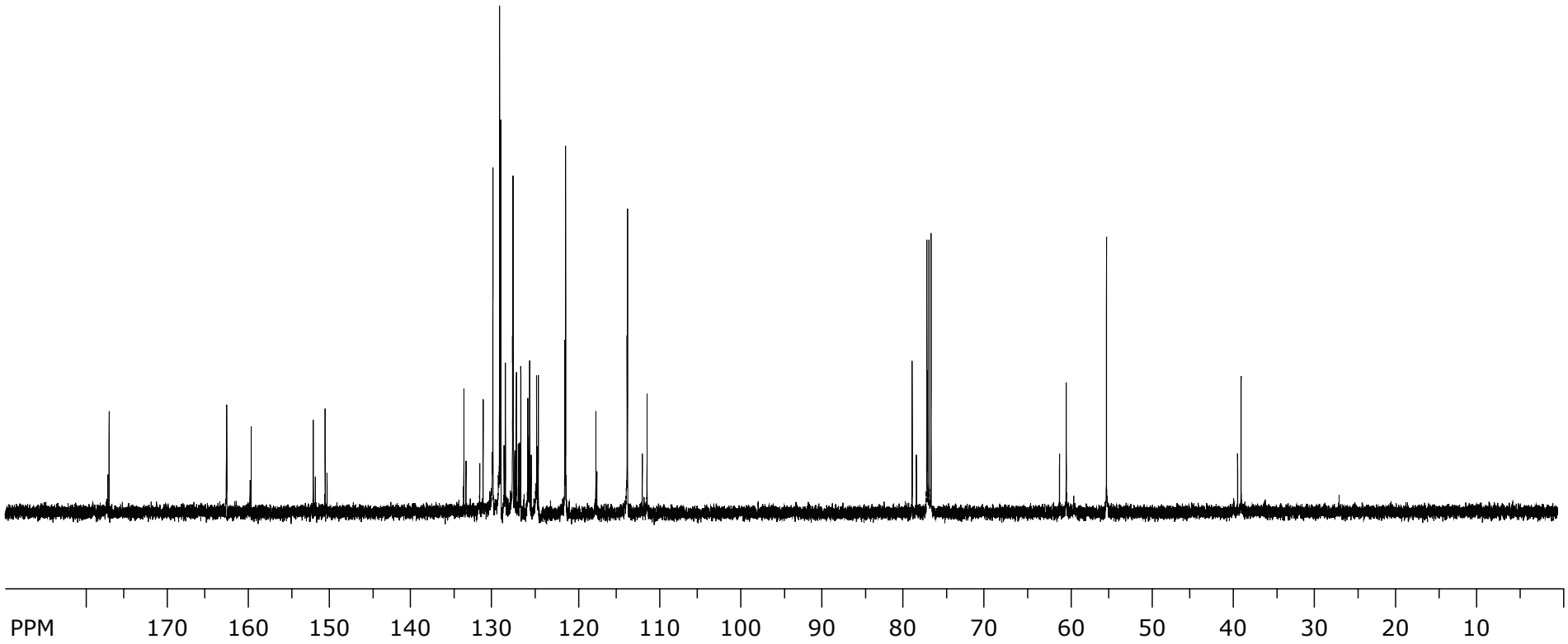
^{1}H NMR of **7g**


N
CO2Ph
Bn
H
N
O
O
MeO

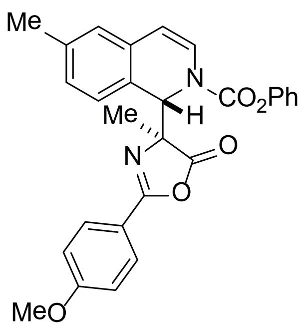

3.796
6.048
10.26
14.72
3.447
3.523
1.671
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

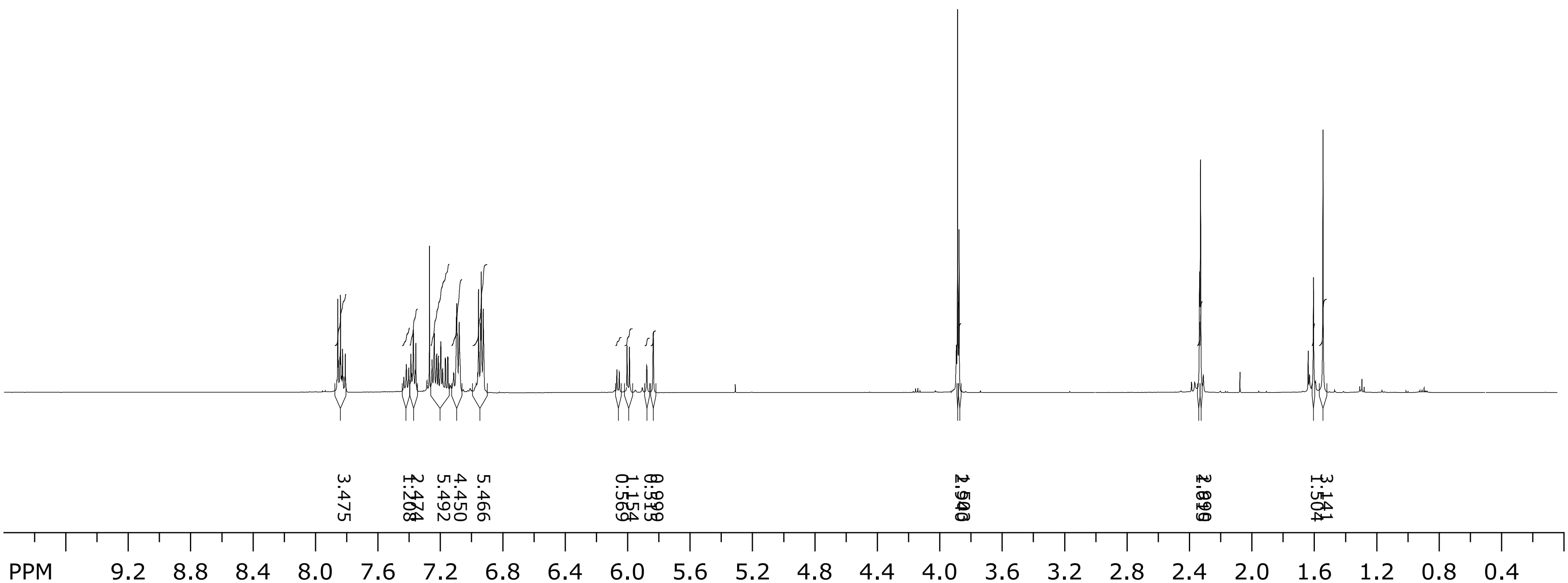
^{13}C NMR of **7g**


N
CO2Ph
Bn
H
N
O
O
MeO

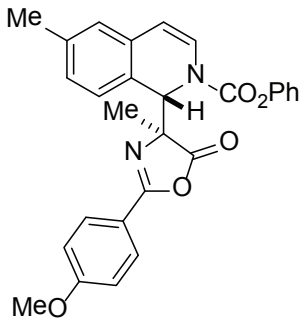

PPM
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

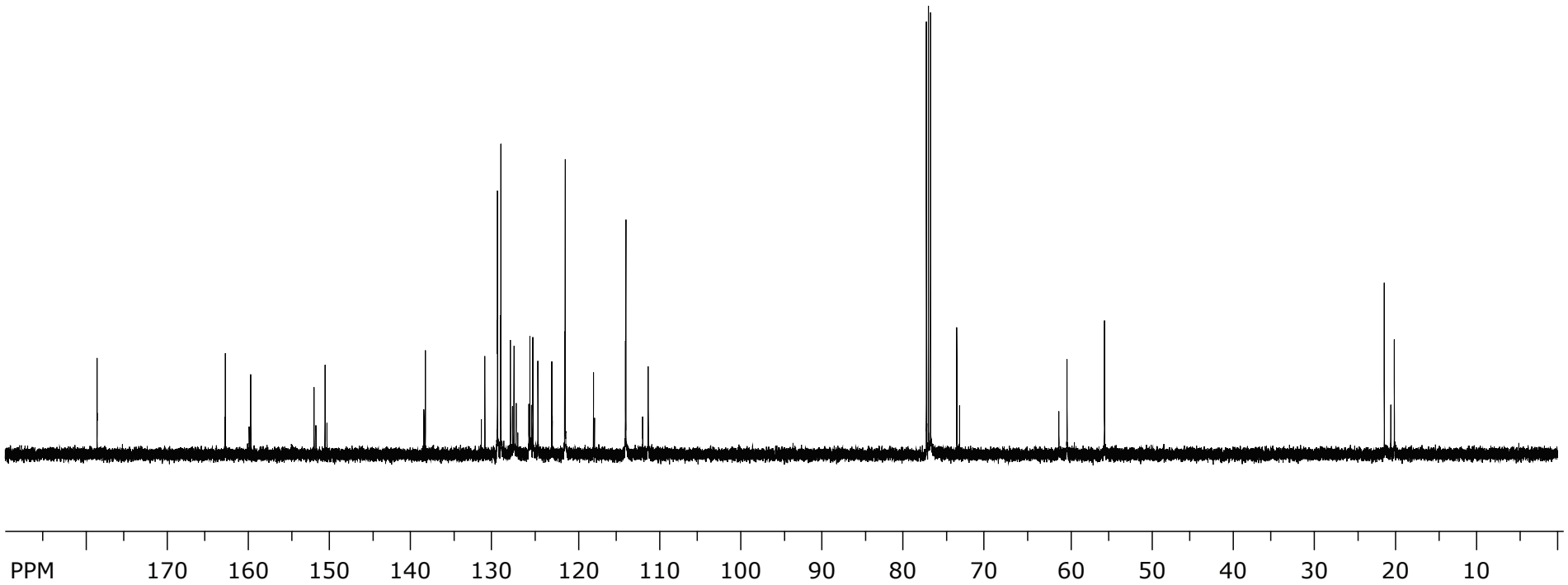
^{1}H NMR of **7h**


Me
N
CO2Ph
Me
H
N
O
O
MeO

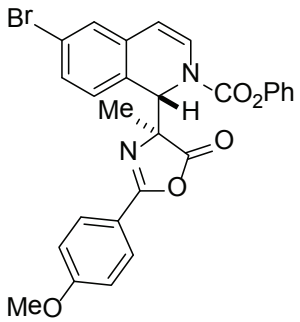

3.475
5.466
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

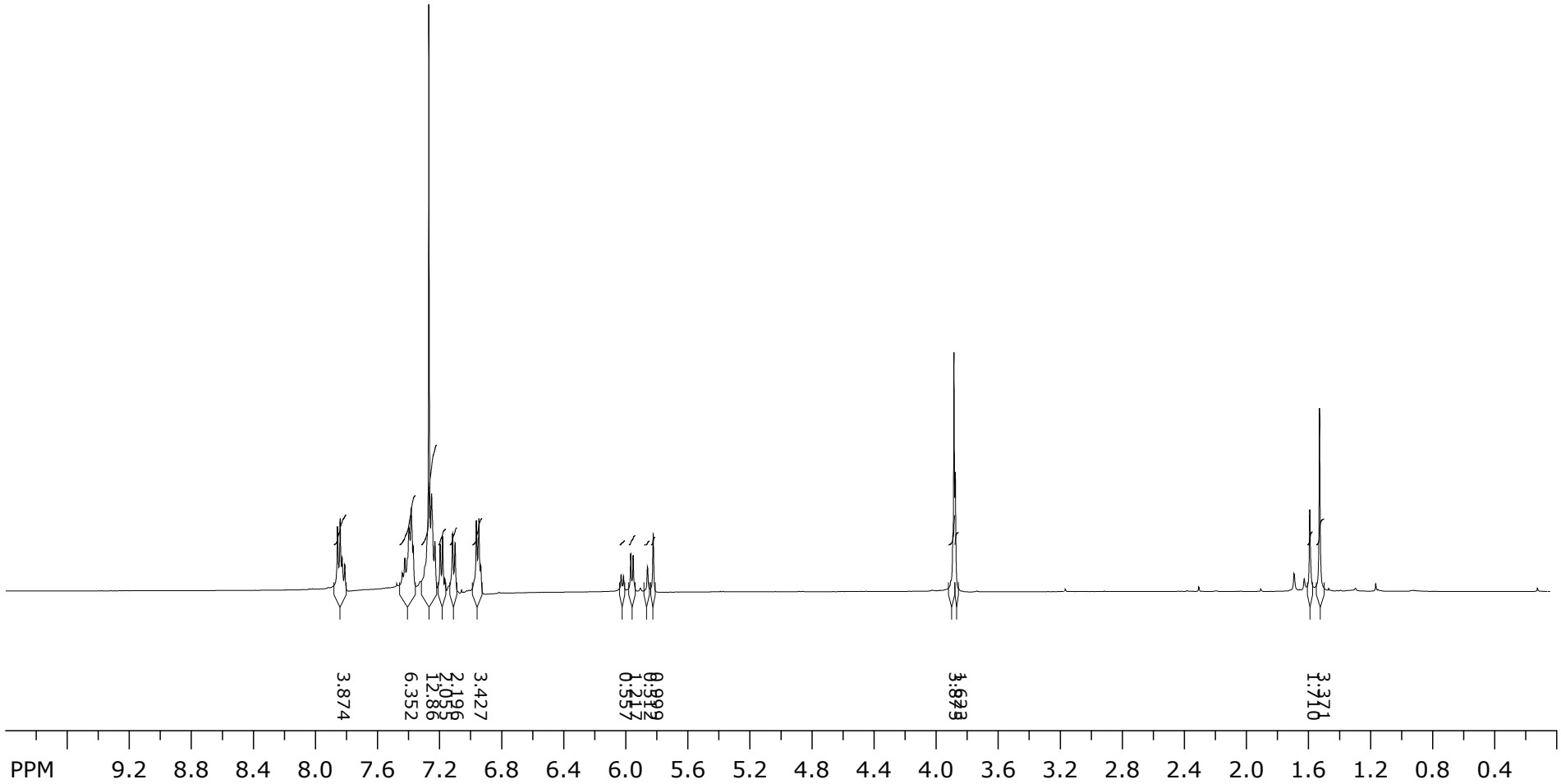
^{13}C NMR of **7h**


Me
N
CO2Ph
Me
H
N
O
O
MeO

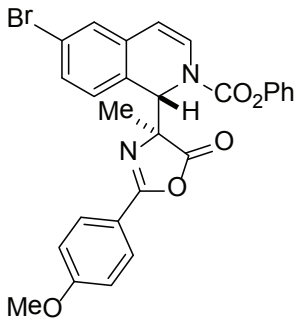

PPM
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

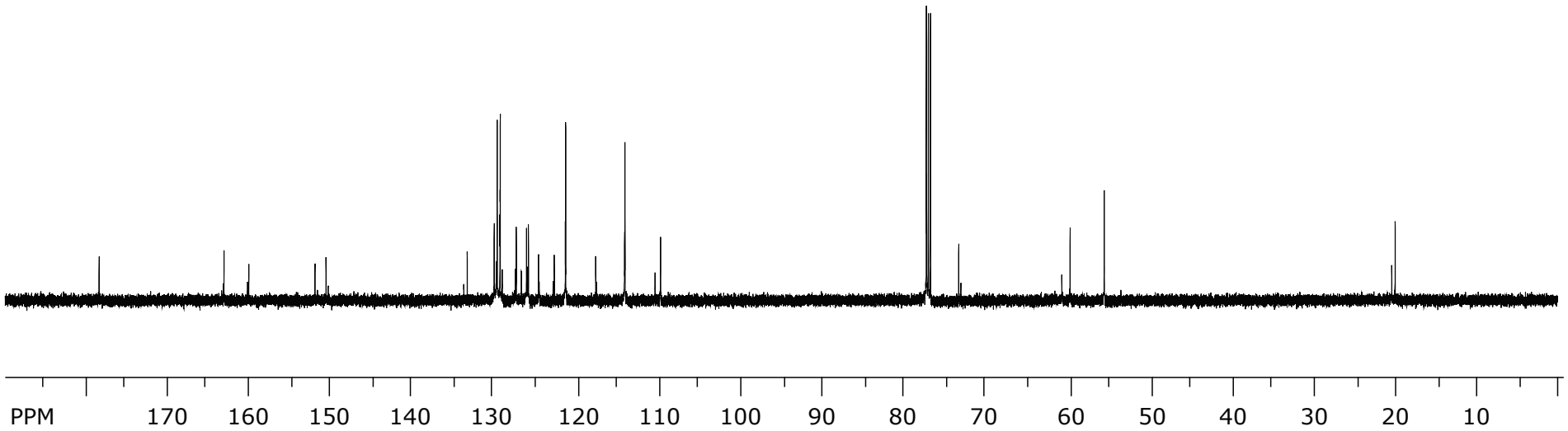
^{1}H NMR of **7i**


Br
N
CO2Ph
Me
H
N
O
O
MeO

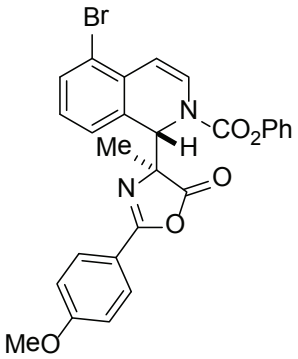

3.874
6.352
12.86
2.196
2.055
3.427
0.557
1.517
0.999
3.623
3.710
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

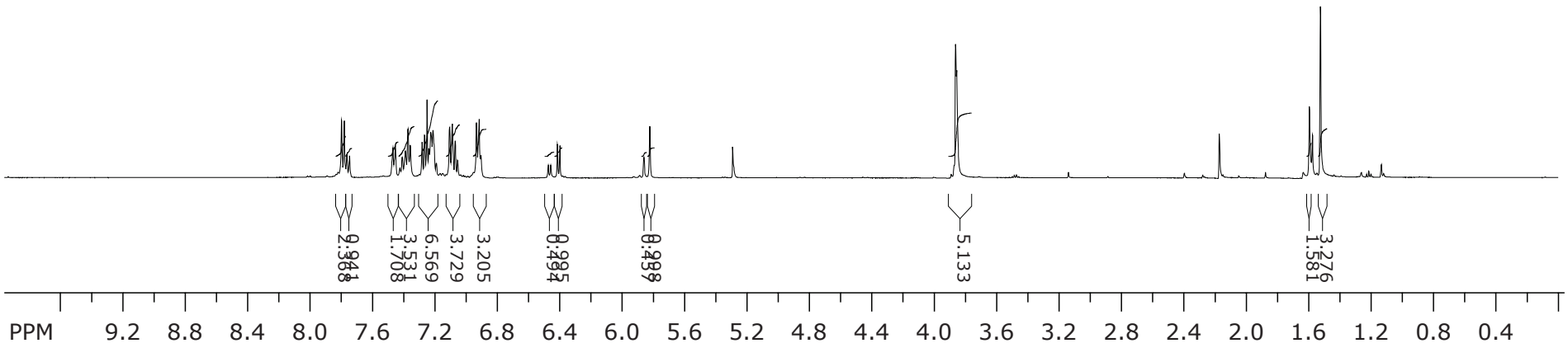
^{13}C NMR of **7i**


Br
N
CO2Ph
Me
H
N
O
O
MeO

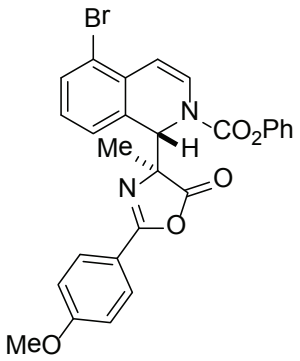

PPM
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

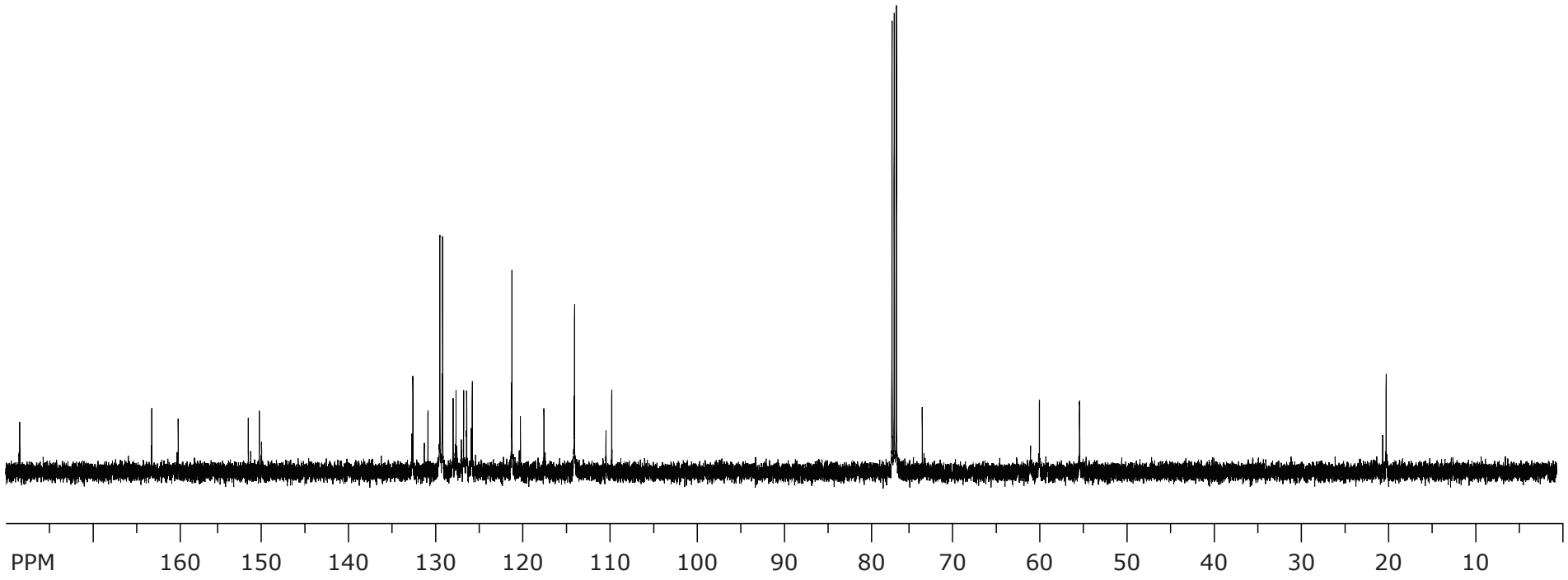
^{1}H NMR of **7j**


Br
N
CO2Ph
Me
H
N
O
O
MeO

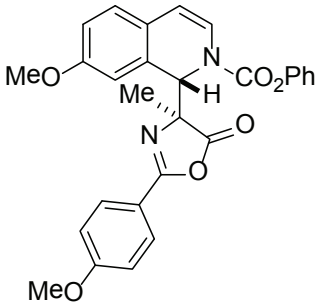

2.368
1.708
3.531
6.569
3.729
3.205
0.995
0.997
5.133
1.581
3.276
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

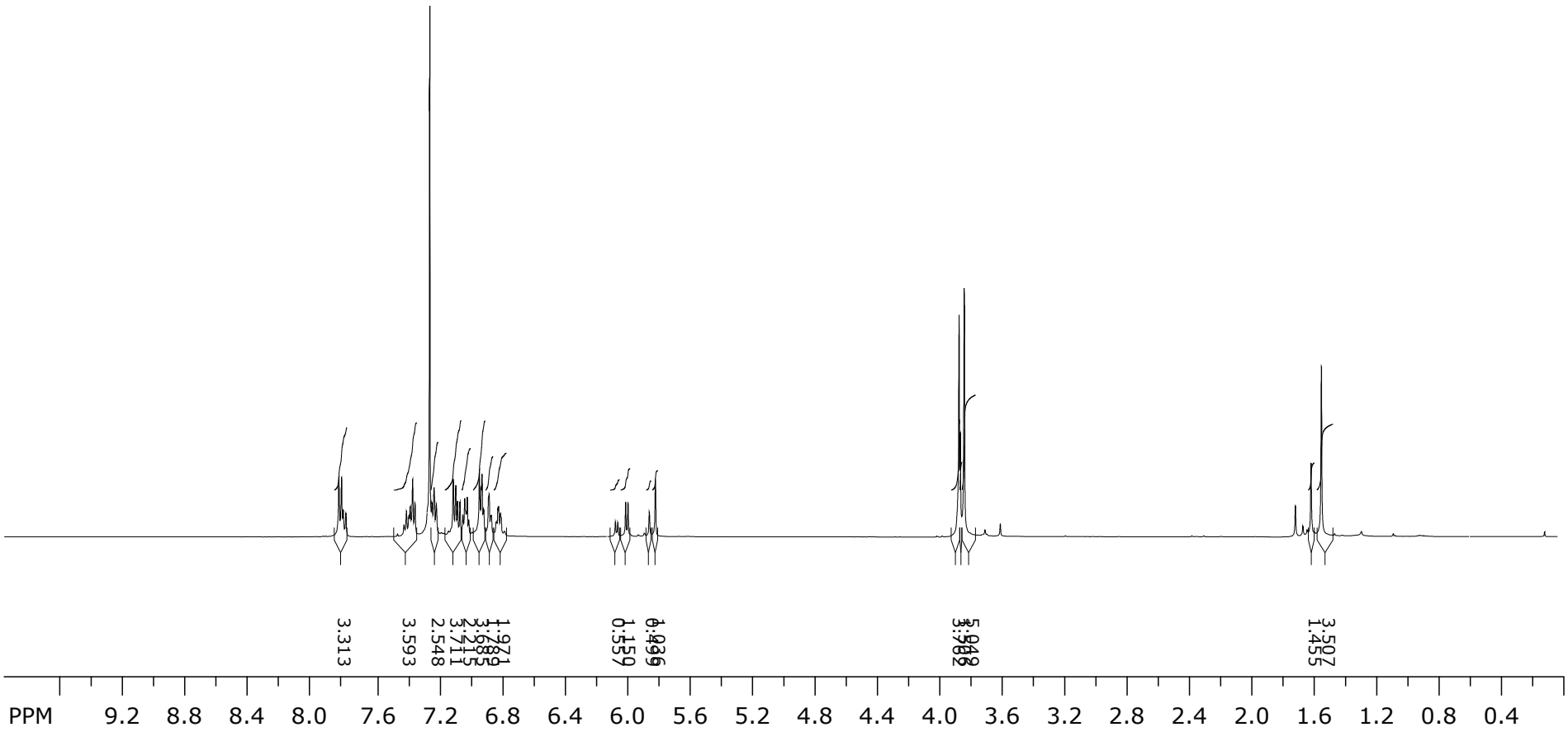
^{13}C NMR of **7j**


Br
N
CO2Ph
Me
H
N
O
O
MeO

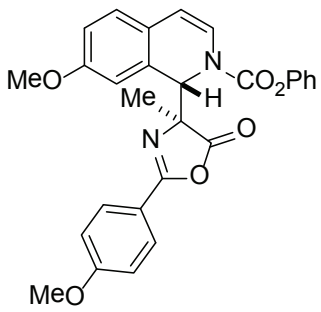

PPM
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

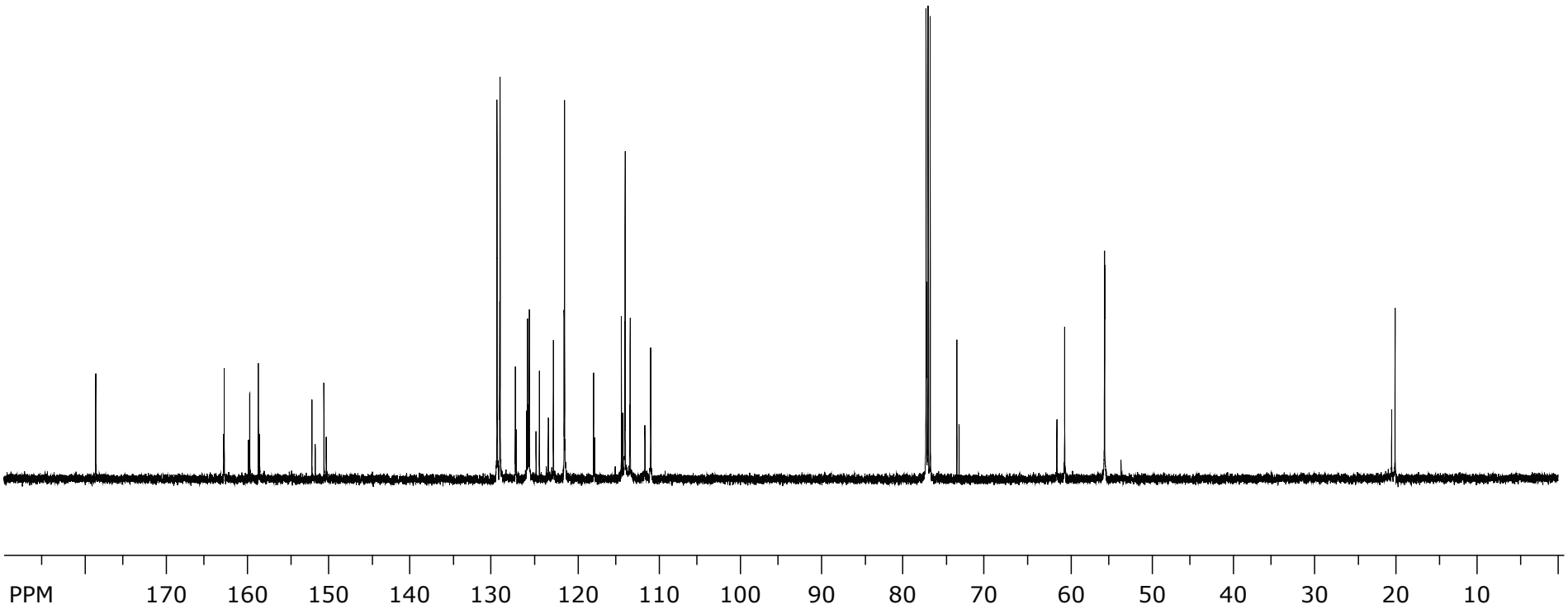
^{1}H NMR of **7k**


MeO
Me
N
H
CO2Ph
N
O
O
MeO

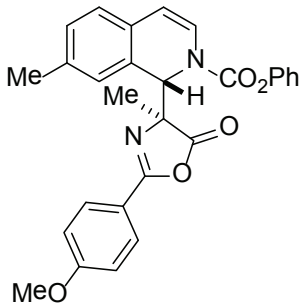

3.313
3.593
2.548
3.711
3.215
3.685
1.971
0.559
1.159
3.902
3.948
1.455
3.507
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

^{13}C NMR of **7k**


MeO
N
CO2Ph
Me
H
N
O
O
MeO

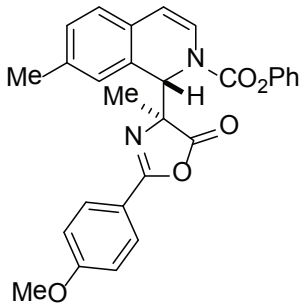

PPM
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

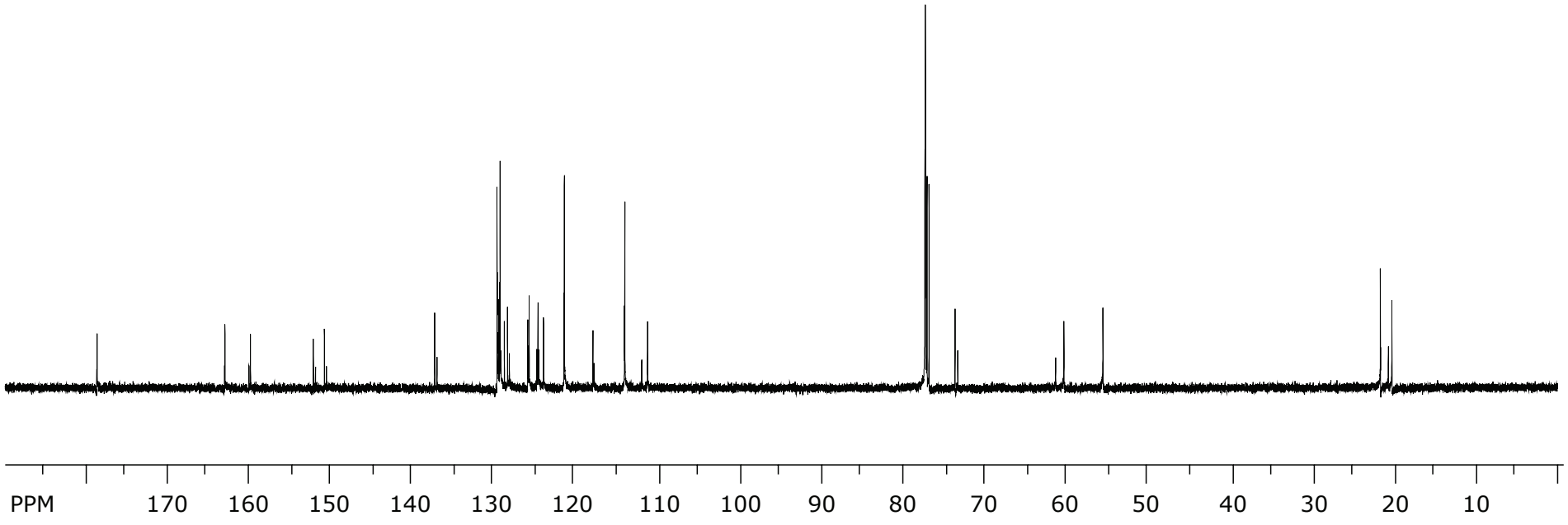
^{1}H NMR of **7l**


Me
N
CO2Ph
Me
H
N
O
O
O
MeO

2.996
1.385
2.293
7.316
3.463
1.034
0.949
3.000
2.957
3.085
PPM
9.2
8.8
8.4
8.0
7.6
7.2
6.8
6.4
6.0
5.6
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4

^{13}C NMR of **7l**


Me
N
CO2Ph
Me
H
N
O
O
O
MeO


PPM
170
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90
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10