Supporting Information

Copper-Catalyzed Desaturation of Lactones, Lactams and Ketones under pH-Neutral Conditions

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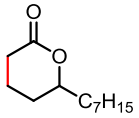
General Information

Unless noted otherwise, all solvents were dried by filtration through a Pure-Solv MD-5 Solvent Purification System (Innovative Technology). Benzene, 1,4-dioxane, and toluene were distilled freshly over sodium, fluorobenzene was distilled freshly over P_2O_5, DCE was distilled freshly over CaH_2 and all carefully freeze-pump-thawed. Sensitive reagents and solvents were transferred under nitrogen into a nitrogen-filled glovebox with standard techniques. Copper(I) thiophene-2-carboxylate (CuTc) was purchased from Oakwood Products, Inc. Copper(I) acetate (CuOAc) was purchased from sigma-aldrich. $CyPPh_2$ was purchased from combi-blocks. $^{i}PrPPh_2$ was purchased from Fisher Scientific and di-^{t}butyl peroxide (DTBP) was purchased from Acros. CuOAc and ligands were stored in the glovebox. DTBP was degassed through freeze-pump-thawe. Analytical thin-layer chromatography (TLC) was carried out using 0.2 mm commercial silica gel plates (silica gel 60, F254, EMD chemical). Vials (15 x 45 mm 1 dram (4 mL) / 17 x 60 mm 3 dram (7.5 mL) with PTFE lined cap attached) were purchased from Qorpak and flame-dried or put in an oven overnight and cooled in a desiccator. Mass spectra were recorded on an Agilent 6530 LC Q-TOF mass spectrometer using electrospray ionization with fragmentation voltage set at 115 V and processed with an Agilent MassHunter Operating System. Infrared spectra were recorded on a Nicolet 380 FTIR using neat thin film technique. Nuclear magnetic resonance spectra (^{1}H NMR and ^{13}C NMR) were recorded with Bruker Model DMX 500 (500 MHz, ^{1}H at 500 MHz, ^{13}C at 126 MHz) or 400 (400 MHz, ^{1}H at 400 MHz, ^{13}C at 101 MHz). Unless otherwise noted, all spectrums were acquired in $CDCl_3$. Chemical shifts are reported in parts per million (ppm, δ), downfield from

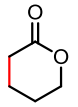
tetramethylsilane (TMS, δ=0.00ppm) and are referenced to residual solvent ($CDCl_3$, δ=7.26 ppm (^1H) and 77.00 ppm (^{13}C)). Coupling constants were reported in Hertz (Hz). Data for ^1H NMR spectra were reported as follows: chemical shift (ppm, referenced to protium, s = singlet, d = doublet, t = triplet, q = quartet, quin = quintet, dd = doublet of doublets, td = triplet of doublets, ddd = doublet of doublet of doublets, m = multiplet, coupling constant (Hz), and integration). All other materials were obtained from Aldrich Chemical Company or Combi-blocks and were used as received.

Syntheses of Lactams, Ketones and lactones

The lactones **1d**[1], **1e**[2], **1g**[3], **1h**[3], **1k**[4], **1l**[5], **1m**[6], **1ai**[7], **3a**[8], **3b**[9], **3d**[10], **3g**[11], **3h**[12] and the lactams **5a**[13], **5b**[12], **5d**[12], **5e**[12], **5f**[14] were prepared according to the previously reported literature. The others are commercially available and were used as received.



1a



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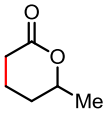

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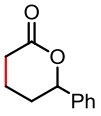
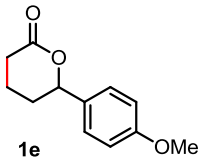


1d



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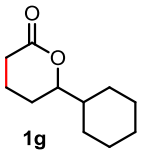
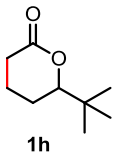
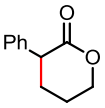


1g



1h



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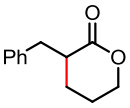
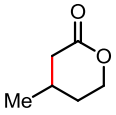


1l



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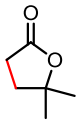
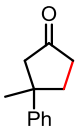
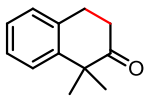


1ai



3a



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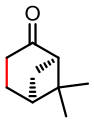

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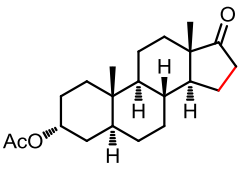

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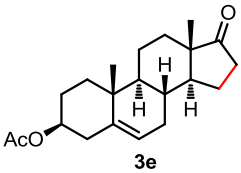

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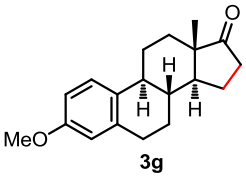

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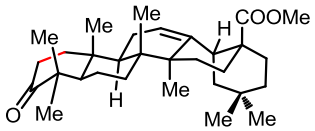

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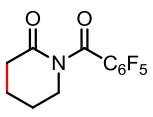
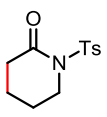
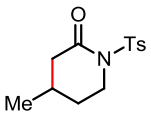


5a



5b



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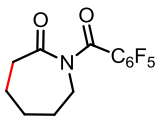

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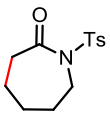
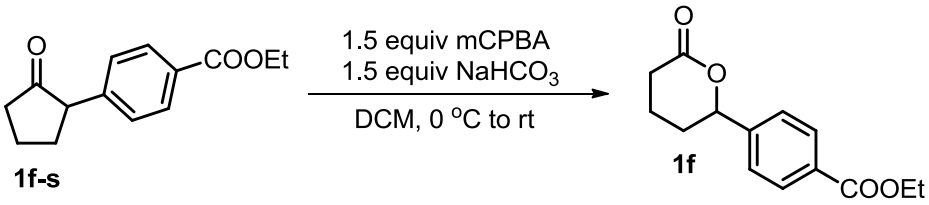


5f

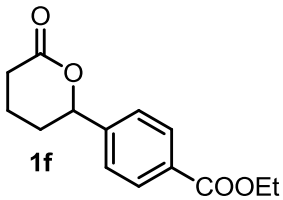
Syntheses of Starting Materials

Method A: For synthesis of the start material 1f, 1n, 1al, 1am and 7.

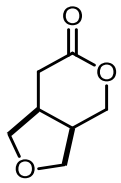
Typical procedure for the synthesise of δ-lactones 1f



A solution of ethyl 4-(2-oxocyclopentyl)benzoate **(1f-s)**[15] (1.16 g, 5.0 mmol), m-CPBA (1.68 g, 7.5 mmol) and $NaHCO_3$ (630 mg, 7.5 mmol) in CH_2CI_2 (30 mL) was stirred at room temperature for 24 h. The resulting solution was quenched with saturated Na_2SO_3 solution, then extracted with DCM and the organic layer was dried over Na_2SO_4 and concentrated. The crude residue was purified by column chromatography on silica gel (eluent: Hexane: Acetone = 4:1) to afford the final δ-lactone **1f** (521 mg, 42% yield) as a light yellow oil.

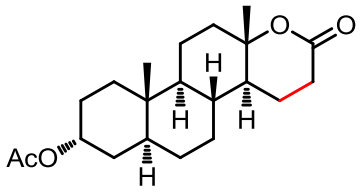


Ethyl 4-(6-oxotetrahydro-2*H*-pyran-2-yl)benzoate (1f). 42% yield as a light yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.05 (d, *J* = 8.4 Hz, 2H), 7.42 (d, *J* = 8.4 Hz, 2H), 5.42 (dd, *J* = 10.4, 3.2 Hz, 1H), 4.38 (q, *J* = 7.2 Hz, 2H), 2.75-2.68 (m, 1H), 2.62-2.54 (m, 1H), 2.21-2.17 (m, 1H), 2.04-1.97 (m, 2H), 1.88-1.80 (m, 1H), 1.40 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 170.80, 165.91, 144.40, 130.10, 129.64, 125.32, 80.78, 60.85, 30.32, 29.24, 18.35, 14.10. **IR (neat):** 2981, 2959, 2940, 2908, 2880, 1718, 1613, 1578, 1464, 1444, 1417, 1367, 1278, 1239, 1181, 1106, 1048, 1021, 966, 934, 854, 769, 706 cm^{-1}. **HRMS (ESI)** clacd for $C_{14}H_{17}O_4$ $[M+H]^+$: 249.1121, found 249.1125.



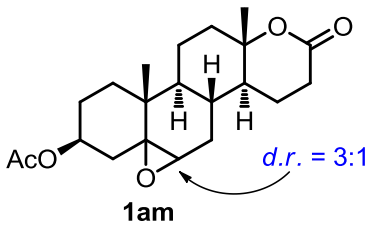
1n

Tetrahydro-1*H*-furo[3,4-*c*]pyran-6(3*H*)-one (1n). 62% yield as a colorless oil. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 4.36 (dd, *J* = 11.6, 4.8 Hz, 1H), 4.13 (dd, *J* = 11.6, 7.2 Hz, 1H), 3.92-3.85 (m, 2H), 3.71 (dd, *J* = 9.6, 3.6 Hz, 1H), 3.58 (dd, *J* = 9.2, 3.6 Hz, 1H), 2.82-2.77 (m, 2H), 2.66 (dd, *J* = 15.2, 6.4 Hz, 1H), 2.46 (dd, *J* = 15.2, 7.2 Hz, 1H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 172.21, 74.08, 70.35, 68.02, 37.14, 35.26, 32.43. **IR (neat):** 2970, 2859, 1747, 1480, 1433, 1393, 1370, 1335, 1303, 1275, 1241, 1165, 1142, 1101, 1076, 1053, 998, 977, 935, 917, 835, 793, 695, 676, 603, 532 cm^{-1}. **HRMS (ESI)** clacd for $C_7H_{11}O_3$ $[M+H]^+$: 143.0703, found 143.0705.



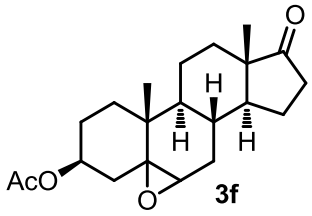
1al

(4aS,4bR,6aS,8R,10aS,10bS,12aS)-10a,12a-Dimethyl-2-oxohexadecahydro-2*H*-naphtho[2,1-*f*]chromen-8-yl acetate (1al). 69% yield as a white solid. M.p. 185-186 °C. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 4.94 (br, 1H), 2.58-2.48 (m, 2H), 1.98 (s, 3H), 1.91-1.86 (m, 2H), 1.82-1.78 (m, 1H), 1.74-1.66 (m, 2H), 1.59-1.53 (m, 2H), 1.46-1.34 (m, 6H), 1.23-1.06 (m, 8H), 0.95-0.87 (m, 2H), 0.69 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.39, 170.38, 83.18, 69.52, 52.67, 46.08, 39.15, 39.07, 37.60, 35.54, 32.38, 32.35, 30.18, 28.42, 27.70, 25.73, 21.36, 21.32, 19.92, 19.50, 10.98. **IR (neat):** 2971, 2941, 2868, 1732, 1454, 1373, 1293, 1250, 1220, 1170, 1148, 1114, 1069, 1026, 987, 964, 944, 871, 760, 748, 592 cm^{-1}. **HRMS (ESI)** clacd for $C_{21}H_{33}O_4$ $[M+H]^+$: 349.2373, found 349.2366.



1am

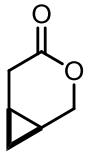
(4aS,6aS,6bR,9S,12aR,12bS)-4a,6b-Dimethyl-3-oxohexadecahydrooxireno[2',3':4,4*a*]naphtho[2,1-*f*]chromen-9-yl acetate (1am). 3e was used as the start material and epoxidation was reacted first then Baeyer-Villiger reaction was occurred. **1n** and **3f** was both obtained. 33% yield as a white solid. M.p. 174-175 ^{o}C. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 4.98-4.72 (m, 1H), 3.15-2.4 (m, 1H), 2.72-2.50 (m, 2H), 2.31-1.90 (m, 10H), 1.74-1.32 (m, 10H), 1.29-1.24 (m, 4H), 1.17-1.08 (m, 1H), 1.06-1.00 (m, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.01, 170.95, 170.20, 169.92, 82.64, 82.46, 70.73, 64.64, 62.91, 62.09, 58.16, 49.53, 46.65, 45.55, 41.37, 38.68, 38.41, 37.36, 36.22, 35.53, 34.98, 34.82, 32.27, 32.15, 31.64, 31.06, 28.51, 28.32, 27.83, 26.82, 26.75, 22.40, 21.13, 21.07, 19.88, 19.69, 19.52, 19.45, 16.78, 15.39. **IR (neat):** 2949, 2872, 1732, 1469, 1440, 1383, 1365, 1287, 1245, 1169, 1106, 1090, 1074, 1032, 999, 973, 872, 767, 734, 698, 609, 510 cm^{-1}. **HRMS (ESI)** clacd for $C_{21}H_{31}O_5$ $[M+H]^+$: 363.2166, found 363.2163.



3f

(3S,6aR,6bS,9aS,11aS,11bR)-9a,11b-Dimethyl-9-oxohexadecahydrocyclopenta[1,2]phenanthro[8a,9-*b*]oxiren-3-yl acetate (3f). 48% yield as a white soild. M.p. 208-209 ^{o}C. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 4.90-4.65 (m, 1H), 3.06-2.85 (m, 1H), 2.41-2.31 (m, 1H), 2.15-1.82 (m, 8H), 1.78-1.05 (m, 13H), 1.03-0.91 (m, 3H), 0.79-0.74 (m, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 220.37, 220.16, 170.22, 169.91, 77.19, 70.89, 64.92, 62.92, 62.31, 58.39, 51.54, 50.87, 47.35, 47.20, 42.47, 37.68, 36.44, 35.82, 35.50, 35.47, 35.03, 34.92, 31.93, 31.20, 31.13, 30.85, 29.25, 29.21, 27.44, 26.94, 26.90, 21.51, 21.46, 21.11, 21.00, 19.72, 16.85, 15.63, 13.35, 13.25. **IR**

(neat): 2946, 2878, 1736, 1471, 1441, 1374, 1243, 1062, 1030, 962, 870, 734, 655, 613 cm^{-1}. **HRMS (ESI)** clacd for $C_{21}H_{31}O_4$ $[M+H]^+$: 347.2217, found 347.2225.

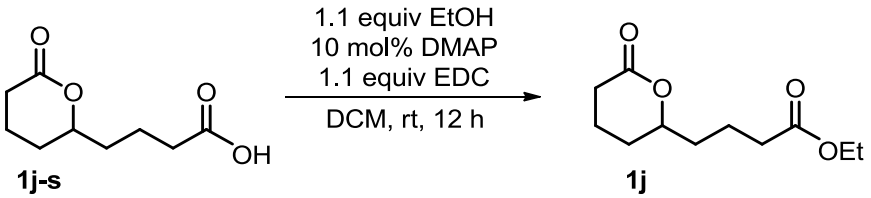


7

3-Oxabicyclo[4.1.0]heptan-4-one (7). 51% yield as a colorless oil; **^{1}H NMR (400 MHz, $CDCl_3$)** δ 4.58 (dd, *J* = 11.6, 2.4 Hz, 1H), 4.38-4.35 (m, 1H), 2.77 (qd, *J* = 16.8, 3.2 Hz, 2H), 1.36-1.31 (m, 2H), 0.83-0.77 (m, 1H), 0.58-0.54 (m, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.00, 67.04, 31.34, 9.25, 7.28, 6.24. **IR (neat):** 3082, 3036, 3006, 2959, 2900, 1740, 1478, 1426, 1395, 1342, 1266, 1232, 1179, 1113, 1083, 1060, 1029, 1006, 988, 918, 843, 825, 773, 757, 720, 607, 518 cm^{-1}. **HRMS (ESI)** clacd for $C_6H_9O_2$ $[M+H]^+$: 113.0597, found 113.0598.

Method B: For synthesis of the start material 1j, 1aj and 1ak.

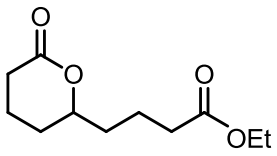
Typical procedure for the synthesise of δ-lactones 1j.



1j-s **1j**

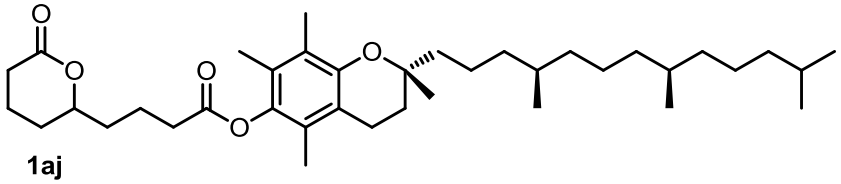
To a solution of 4-(6-oxotetrahydro-2*H*-pyran-2-yl)butanoic acid **(1j-s)** (186.2 mg, 1.0 mmol) in CH_2Cl_2 (5 mL) was added EDC (1-(3-Dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride) (210.9 mg, 1.1 mmol), DMAP (12.2 mg, 0.1 mmol), and EtOH (50.7 mg, 1.1 mmol). The mixture was stirred for 12 h at room temperature. The resulting solution was quenched with water, then extracted with DCM and the organic layer was dried over Na_2SO_4 and concentrated. The crude residue was purified by column chromatography on silica gel (eluent: Hexane: Acetone = 4:1) to

afford the final δ-lactone **1j** (196.2 mg, 92% yield) as a colorless oil.



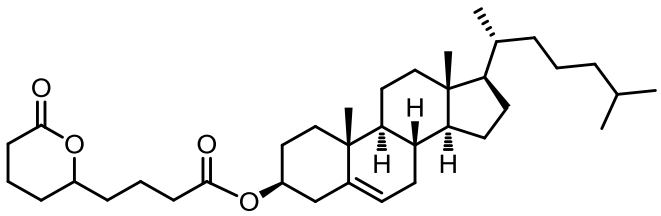
1j

Ethyl 4-(6-oxotetrahydro-2*H*-pyran-2-yl)butanoate (1j). 92% yield as a colorless oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 4.21-4.19 (m, 1H), 4.01 (q, *J* = 7.2 Hz, 2H), 2.50-2.44 (m, 1H), 2.37-2.22 (m, 3H), 1.84-1.70 (m, 4H), 1.65-1.40 (m, 4H), 1.15 (t, *J* = 7.2, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 172.89, 171.46, 79.75, 60.01, 34.77, 33.53, 29.12, 27.41, 20.13, 18.15, 13.94. **IR (neat):** 2955, 2880, 1733, 1466, 1446, 1374, 1342, 1244, 1180, 1097, 1052, 1034, 931, 857, 750, 638, 547 cm^{-1}. **HRMS (ESI)** clacd for $C_{11}H_{19}O_4$ $[M+H]^+$: 215.1278, found 215.1274.



1aj

(R)-2,5,7,8-Tetramethyl-2-((4R,8R)-4,8,12-trimethyltridecyl)chroman-6-yl 4-(6-oxotetrahydro-2H-pyran-2-yl)butanoate (1aj). 88% yield as a colorless oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 4.38-4.32 (m, 1H), 2.67-2.43 (m, 6H), 2.09 (s, 3H), 2.00 (s, 3H), 1.96 (s, 4H), 1.94-1.74 (m, 8H), 1.61-1.49 (m, 4H), 1.44-1.03 (m, 16H), 1.16-1.03 (m, 6H), 0.88-0.84 (m, 12H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.74, 171.60, 149.33, 140.34, 126.50, 124.76, 122.96, 117.32, 79.96, 74.98, 39.31, 37.39, 37.37, 37.36, 37.22, 35.21, 33.51, 32.73, 32.64, 31.04, 29.37, 27.91, 27.72, 24.74, 24.38, 22.67, 22.57, 20.95, 20.54, 20.50, 19.69, 19.60, 18.42, 12.96, 12.12, 11.77. **IR (neat):** 2957, 2927, 2868, 1748, 1461, 1415, 1378, 1334, 1242, 1142, 1103, 1062, 1018, 930, 735 cm^{-1}. **HRMS (ESI)** clacd for $C_{38}H_{63}O_5$ $[M+H]^+$: 599.4670, found 599.4667.

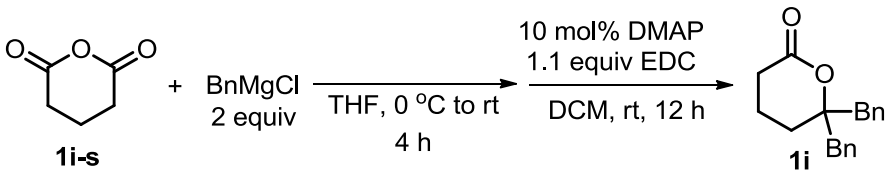


1ak

(3S,8S,9S,10R,13R,14S,17R)-10,13-Dimethyl-17-((R)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[*a*]phenanthren-3-yl 4-(6-oxotetrahydro-2H-pyran-2-yl)butanoate (1ak). 91% yield as a stick colorless oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 5.38-5.37 (m, 1H), 4.65-4.56 (m, 1H), 4.33-4.27 (m, 1H), 2.63-2.55 (m, 1H), 2.48-2.40 (m, 1H), 2.34-2.30 (m, 4H), 2.03-1.80 (m, 10H), 1.75-1.64 (m, 3H), 1.60-1.40 (m, 9H), 1.34-1.33 (m, 2H), 1.30-1.04 (m, 9H), 1.02-0.97 (m, 4H), 0.92 (d, *J* = 6.4 Hz, 3H), 0.87 (d, *J* = 6.8 Hz, 3H), 0.86 (d, *J* = 6.8 Hz, 3H), 0.68 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 172.41, 171.51, 139.44, 122.49, 79.88, 73.78, 56.53, 55.98, 49.86, 42.15, 39.57, 39.37, 37.99, 36.83, 36.43, 36.04, 35.65, 34.95, 34.01, 31.75, 31.69, 29.28, 28.09, 27.85, 27.65, 27.60, 24.14, 23.69, 22.70, 22.44, 20.88, 20.35, 19.17, 18.58, 18.33, 11.72. **IR (neat):** 3054, 2937, 2874, 2851, 1732, 1467, 1376, 1332, 1243, 1173, 1054, 1012, 959, 931, 840, 800, 734, 703, 626, 593, 546 cm^{-1}. **HRMS (ESI)** clacd for $C_{36}H_{59}O_4$ $[M+H]^+$: 555.4408, found 555.4403.

Method C: For synthesis of the start material 1i.

Typical procedure for the synthesis of δ-lactones 1i.

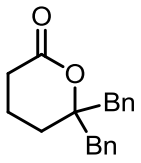


1i-s 1i

To a solution of dihydro-2*H*-pyran-2,6(3*H*)-dione **(1i-s)** (1.14 g, 10.0 mmol) in THF (20 mL) was added BnMgCl (2M in THF) (10 mL, 20.0 mmol) at 0 °C. The reaction mixture was allowed to warm up to room temperature and was stirred for 4 h. The

resulting solution was quenched with saturated NH_4Cl solution, then extracted with ethyl acetate and the organic layer was dried over Na_2SO_4 and concentrated. The crude residue was directly used in the next step.

To a solution of the crude residue in CH_2Cl_2 (30 mL) was added EDC (1-(3-Dimethylaminopropyl)-3- ethylcarbodiimide hydrochloride) (2.1 g, 11 mmol), DMAP (122 mg, 1.0 mmol). The mixture was stirred for 12 h at room temperature. The resulting solution was quenched with water, then extracted with DCM and the organic layer was dried over Na_2SO_4 and concentrated. The crude residue was purified by column chromatography on silica gel (eluent: Hexane: Acetone = 4:1) to afford the product **1i** (916.3 mg, 33%, for the two steps) as a colorless oil.

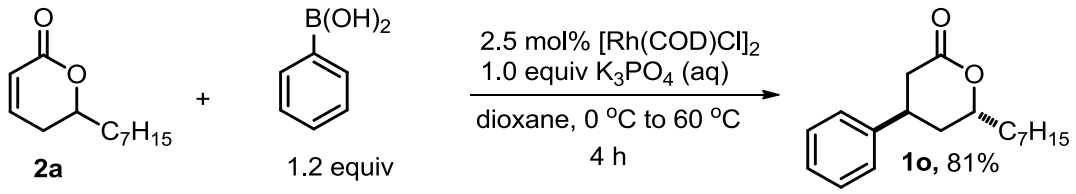


1i

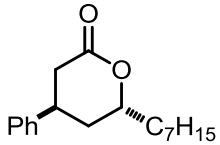
6,6-Dibenzyltetrahydro-2*H*-pyran-2-one (1i). 33% yield as a colorless oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.33-7.24 (m, 10H), 3.11 (d, *J* = 13.6 Hz, 2H), 2.89 (d, *J* = 13.6 Hz, 2H), 2.07 (t, *J* = 6.8 Hz, 2H), 1.72-1.69 (m, 2H), 1.56-1.49 (m, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 170.89, 135.62, 130.53, 128.07, 126.66, 85.33, 46.32, 29.14, 27.41, 16.28. **IR (neat):** 3086, 3061, 3028, 2951, 2922, 1728, 1495, 1454, 1366, 1329, 1263, 1238, 1176, 1080, 1036, 989, 922, 752, 702, 632, 532 cm^{-1}. **HRMS (ESI)** clacd for $C_{19}H_{21}O_2$ $[M+H]^+$: 281.1536, found 281.1537.

Method D: For synthesis of the start material 1o-1ah.

Typical procedure for the synthesise of δ-lactones 1o.

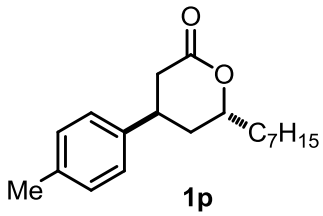


A 20.0 mL vial was charged with **2a** (392.6 mg, 2.0 mmol), phenylboronic acid (292.6 mg, 2.4 mmol), dioxane (10 mL) and K_3PO_4 (aq, 1.5 M) (1.34 mL, 2.0 mmol) at 0 ^oC. The catalyst $[Rh(COD)Cl]_2$ (24.8 mg, 0.05 mmol) was then added. The mixture was stirred at 0 ^oC for 10 min, before the solution was warmed up to 60 ^oC and stirred for 4 h. After completion of the reaction, the mixture was filtered through a thin pad of Na_2SO_4. The filter cake was washed with ethyl acetate, and the combined filtrate was concentrated. The residue was purified by flash column chromatography on silica gel to yield the desired product **1o** (446.5 mg, 81%) as a light yellow oil.



1o

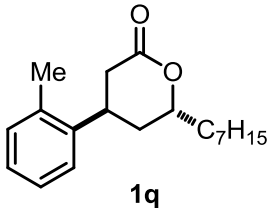
6-Heptyl-4-phenyltetrahydro-2*H*-pyran-2-one (1o). 81% yield as a light yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.37-7.33 (m, 2H), 7.27-7.19 (m, 3H), 4.42-4.36 (m, 1H), 3.37-3.30 (m, 1H), 2.82-2.69 (m, 2H), 2.04 (t, *J* = 6.8 Hz, 2H), 1.79-1.72 (m, 1H), 1.61-1.46 (m, 2H), 1.38-1.27 (m, 9H), 0.87 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.79, 143.09, 128.78, 126.87, 126.44, 77.51, 35.93, 35.29, 34.96, 34.52, 31.55, 29.18, 28.95, 25.01, 22.44, 13.92. **IR (neat):** 3087, 3063, 3029, 2925, 2856, 1732, 1603, 1497, 1455, 1378, 1246, 1162, 1121, 1051, 946, 760, 723, 701, 607, 517 cm^{-1}. **HRMS (ESI)** clacd for $C_{18}H_{27}O_2$ $[M+H]^+$: 275.2006, found 275.2012.



1p

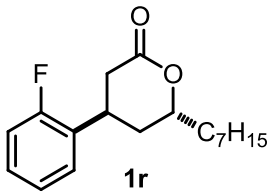
6-Heptyl-4-(*p*-tolyl)tetrahydro-2*H*-pyran-2-one (1p). 87% yield as a yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.17-7.08 (m, 4H), 4.41-4.35 (m, 1H), 3.33-3.26 (m, 1H), 2.73 (qd, *J* = 16.8, 7.2 Hz, 2H), 2.33 (s, 3H), 2.04-2.00 (m, 2H), 1.80-1.71 (m, 1H), 1.61-1.49 (m, 2H), 1.37-1.27 (m, 9H), 0.87 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz,**

$CDCl_3$) δ 171.79, 140.06, 136.45, 129.39, 126.31, 77.48, 36.01, 35.30, 35.06, 34.14, 31.55, 29.18, 28.94, 25.00, 22.44, 20.79, 13.91. **IR (neat):** 3021, 2927, 2856, 1739, 1516, 1465, 1378, 1313, 1290, 1245, 1162, 1119, 1074, 1049, 947, 850, 814, 722, 547, 519 cm^{-1}. **HRMS (ESI)** clacd for $C_{19}H_{29}O_2$ $[M+H]^+$: 289.2162, found 289.2165.



1q

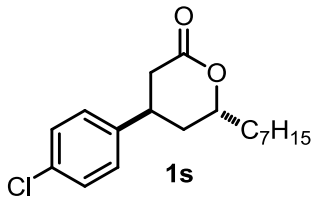
6-Heptyl-4-(*o*-tolyl)tetrahydro-2*H*-pyran-2-one (1q). 85% yield as a light yellow oil. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.25-7.15 (m, 4H), 4.44-4.41 (m, 1H), 3.57-3.43 (m, 1H), 2.89-2.47 (m, 2H), 2.36 (s, 3H), 2.06-1.95 (m, 2H), 1.80-1.76 (m, 1H), 1.62-1.53 (m, 2H), 1.37-1.30 (s, 9H), 0.89 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 172.10, 141.18, 135.12, 130.68, 126.66, 126.47, 124.90, 77.41, 35.39, 35.24, 33.80, 31.52, 30.50, 29.17, 28.92, 24.98, 22.41, 19.14, 13.88. **IR (neat):** 3064, 3021, 2928, 2856, 1736, 1604, 1492, 1463, 1378, 1296, 1248, 1227, 1166, 1113, 1051, 949, 758, 726, 608 cm^{-1}. **HRMS (ESI)** clacd for $C_{19}H_{29}O_2$ $[M+H]^+$: 289.2162, found 289.2163.



1r

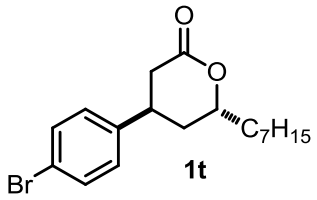
4-(2-Fluorophenyl)-6-heptyltetrahydro-2*H*-pyran-2-one (1r). 65% yield as a yellow oil. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.28-7.06 (m, 4H), 4.44-4.41 (m, 1H), 3.60-3.55 (m, 1H), 2.80-2.79 (m, 2H), 2.08-2.05 (m, 2H), 1.81-1.74 (m, 1H), 1.63-1.49 (m, 2H), 1.38-1.27 (m, 9H), 0.88 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 171.87, 160.58 (d, $^2J_{C\text{-}F}$ = 245.9 Hz), 129.90 (d, $^3J_{C\text{-}F}$ = 13.7 Hz), 128.69 (d, $^3J_{C\text{-}F}$ = 8.5 Hz), 127.87 (d, $^4J_{C\text{-}F}$ = 4.6 Hz), 124.44 (d, $^4J_{C\text{-}F}$ = 3.6 Hz), 115.86 (d, $^2J_{C\text{-}F}$ = 22.1 Hz), 77.62, 35.21, 34.62, 33.57, 31.63, 29.47, 29.46, 29.25, 29.02, 25.04, 22.52,

13.97. **IR (neat):** 3066, 2961, 2928, 2857, 1740, 1585, 1493, 1456, 1378, 1246, 1227, 1190, 1166, 1098, 1073, 1051, 946, 823, 758, 723, 467 cm^{-1}. **HRMS (ESI)** clacd for $C_{18}H_{26}FO_2$ $[M+H]^+$: 293.1911, found 293.1920.



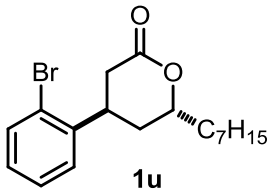
1s

4-(4-Chlorophenyl)-6-heptyltetrahydro-2*H*-pyran-2-one (1s). 83% yield as a yellow oil. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.29 (d, *J* = 8.4 Hz, 2H), 7.12 (d, *J* = 8.4 Hz, 2H), 4.37-4.34 (m, 1H), 3.33-3.27 (m, 1H), 2.78-2.64 (m, 2H), 2.04-1.98 (m, 2H), 1.74-1.72 (m, 1H), 1.57-1.45 (m, 2H), 1.32-1.25 (s, 9H), 0.85 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 171.72, 141.46, 132.70, 128.94, 127.87, 77.60, 35.86, 35.28, 34.83, 34.04, 31.57, 29.19, 28.97, 25.03, 22.48, 13.95. **IR (neat):** 3028, 2957, 2928, 2856, 1733, 1589, 1494, 1466, 1439, 1378, 1305, 1246, 1163, 1094, 1074, 1014, 828, 782, 722, 641, 520 cm^{-1}. **HRMS (ESI)** clacd for $C_{18}H_{26}ClO_2$ $[M+H]^+$: 309.1616, found 309.1626.



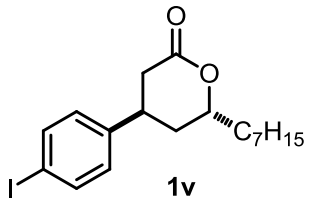
1t

4-(4-Bromophenyl)-6-heptyltetrahydro-2*H*-pyran-2-one (1t). 71% yield as a yellow oil. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.45 (d, *J* = 8.4 Hz, 2H), 7.08 (d, *J* = 8.4 Hz, 2H), 4.39-4.34 (m, 1H), 3.33-3.27 (m, 1H), 2.78-2.65 (m, 2H), 2.07-1.96 (m, 2H), 1.77-1.71 (m, 1H), 1.59-1.46 (m, 2H), 1.34-1.25 (m, 9H), 0.86 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 171.23, 142.05, 131.83, 128.23, 120.65, 77.36, 35.76, 35.26, 34.77, 34.12, 31.54, 29.16, 28.93, 24.99, 22.43, 13.92. **IR (neat):** 3028, 2957, 2927, 2856, 1735, 1490, 1466, 1408, 1377, 1283, 1246, 1162, 1075, 1010, 947, 819, 775, 719, 618, 518 cm^{-1}. **HRMS (ESI)** clacd for $C_{18}H_{26}BrO_2$ $[M+H]^+$: 353.1111, found 353.1118.



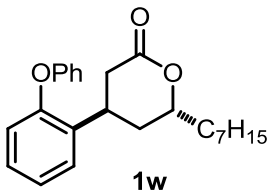
1u

4-(2-Bromophenyl)-6-heptyltetrahydro-2*H*-pyran-2-one (1u). 91% yield as a yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.57 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.34-7.30 (m, 1H), 7.19-7.10 (m, 2H), 4.38-4.32 (m, 1H), 3.78-3.72 (m, 1H), 2.85-2.67 (m, 2H), 2.04 (t, *J* = 6.4 Hz, 2H), 1.81-1.72 (m, 1H), 1.63-1.46 (m, 2H), 1.38-1.25 (m, 9H), 0.85 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.28, 141.49, 133.29, 128.45, 127.87, 126.94, 123.97, 77.44, 35.20, 34.85, 34.02, 33.04, 31.52, 29.15, 28.92, 24.96, 22.42, 13.90. **IR (neat):** 3061, 2955, 2927, 2856, 1735, 1567, 1470, 1438, 1377, 1291, 1245, 1218, 1163, 1122, 1074, 1023, 754, 723, 658 cm^{-1}. **HRMS (ESI)** clacd for $C_{18}H_{25}BrO_2Na$ $[M+Na]^+$: 375.0930, found 375.0932.



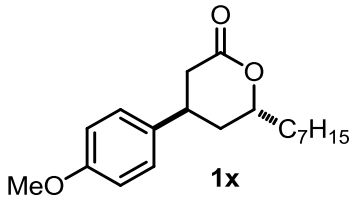
1v

6-Heptyl-4-(4-iodophenyl)tetrahydro-2*H*-pyran-2-one (1v). 69% yield as a yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.68 (d, *J* = 8.4 Hz, 2H), 6.96 (d, *J* = 8.4 Hz, 2H), 4.40-4.33 (m, 1H), 3.33-3.26 (m, 1H), 2.81-2.65 (m, 2H), 2.09-1.95 (m, 2H), 1.80-1.71 (m, 1H), 1.60-1.48 (m, 2H), 1.36-1.27 (m, 9H), 0.87 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.41, 142.80, 137.97, 128.61, 92.23, 77.52, 35.82, 35.40, 34.91, 34.36, 31.68, 29.29, 29.07, 25.12, 22.57, 14.04. **IR (neat):** 2931, 2926, 2855, 1735, 1486, 1465, 1404, 1377, 1283, 1244, 1162, 1064, 1005, 816, 717, 517 cm^{-1}. **HRMS (ESI)** clacd for $C_{18}H_{25}IO_2Na$ $[M+Na]^+$: 423.0791, found 423.0790.



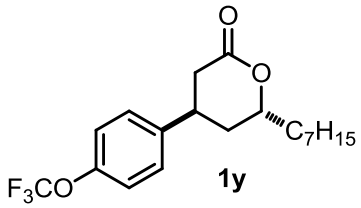
1w

6-Heptyl-4-(2-phenoxyphenyl)tetrahydro-2*H*-pyran-2-one (1w). 88% yield as a colorless oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.33 (t, *J* = 8.2 Hz, 2H), 7.21 (t, *J* = 8.2 Hz, 2H), 7.13-7.08 (m, 2H), 6.95-6.88 (m, 3H), 4.44-4.40 (m, 1H), 3.63-3.56 (m, 1H), 2.88-2.71 (m, 2H), 2.10-1.96 (m, 2H), 1.71-1.69 (m, 1H), 1.52-1.39 (m, 2H), 1.30-1.23 (m, 9H), 0.87 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 172.15, 156.86, 154.18, 133.97, 129.75, 128.17, 127.82, 123.83, 123.16, 119.23, 117.87, 77.67, 35.02, 34.77, 33.50, 31.52, 30.03, 29.13, 28.90, 24.92, 22.42, 13.90. **IR (neat):** 3063, 3038, 2927, 2856, 1739, 1581, 1487, 1453, 1377, 1293, 1235, 1164, 1072, 1048, 870, 801, 752, 692, 495 cm^{-1}. **HRMS (ESI)** clacd for $C_{24}H_{30}O_3Na$ $[M+Na]^+$: 389.2087, found 389.2089.



1x

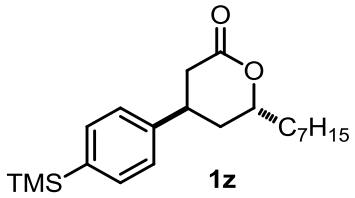
6-Heptyl-4-(4-methoxyphenyl)tetrahydro-2*H*-pyran-2-one (1x). 69% yield as a yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.13 (d, *J* = 8.4 Hz, 2H), 6.89 (d, *J* = 8.4 Hz, 2H), 4.40-4.36 (m, 1H), 3.80 (s, 3H), 3.32-3.28 (m, 1H), 2.79-2.67 (m, 2H), 2.04-2.00 (m, 2H), 1.77-1.74 (m, 1H), 1.59-1.49 (m, 2H), 1.34-1.27 (s, 9H), 0.88 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.84, 158.40, 135.10, 127.46, 114.14, 77.53, 55.16, 36.22, 35.36, 35.20, 33.80, 31.59, 29.23, 28.99, 25.06, 22.49, 13.95. **IR (neat):** 3001, 2928, 2856, 1735, 1612, 1584, 1558, 1514, 1465, 1443, 1377, 1305, 1249, 1181, 1115, 1074, 1035, 830, 808, 724, 692, 536 cm^{-1}. **HRMS (ESI)** clacd for $C_{19}H_{28}O_3Na$ $[M+Na]^+$: 327.1931, found 327.1935.



1y

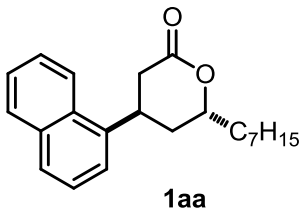
6-Heptyl-4-(4-(trifluoromethoxy)phenyl)tetrahydro-2*H*-pyran-2-one (1y). 78%

yield as a colorless oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.23 (dd, *J* = 19.6, 8.4 Hz, 4H), 4.43-4.38 (m, 1H), 3.41-3.34 (m, 1H), 2.76 (qd, *J* = 17.2, 7.8 Hz, 2H), 2.11-2.01 (m, 2H), 1.81-1.74 (m, 1H), 1.62-1.50 (m, 2H), 1.38-1.28 (m, 9H), 0.88 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.29, 147.96, 141.84, 127.90, 121.31, 120.31 (q, $^1J_{C\text{-}F}$ = 258.4 Hz), 77.44, 35.97, 35.28, 34.85, 34.09, 31.57, 29.18, 28.96, 25.04, 22.45, 13.87. **IR (neat):** 3043, 2930, 2858, 1736, 1595, 1510, 1467, 1379, 1260, 1074, 1019, 922, 852, 811, 724, 672, 612, 542 cm^{-1}. **HRMS (ESI)** clacd for $C_{19}H_{25}F_3O_3Na$ $[M+Na]^+$: 381.1648, found 381.1656.



1z

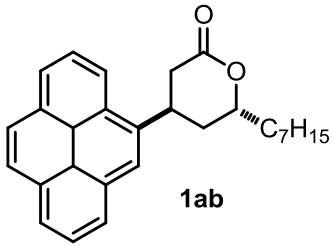
6-Heptyl-4-(4-(trimethylsilyl)phenyl)tetrahydro-2*H*-pyran-2-one (1z). 80% yield as a white solid. M.p. 85-86 °C. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.51 (d, *J* = 8.4 Hz, 2H), 7.20 (d, *J* = 8.0 Hz, 2H), 4.44-4.37 (m, 1H), 3.36-3.29 (m, 1H), 2.82-2.70 (m, 2H), 2.05 (t, *J* = 6.8 Hz, 2H), 1.81-1.72 (m, 1H), 1.62-1.48 (m, 2H), 1.37-1.27 (m, 9H), 0.87 (t, *J* = 6.8 Hz, 3H), 0.27 (s, 9H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.70, 143.65, 139.00, 133.81, 125.92, 77.51, 35.87, 35.32, 34.90, 34.54, 31.58, 29.22, 28.97, 25.04, 22.46, 13.93, -1.29. **IR (neat):** 3069, 3017, 2954, 2924, 2856, 1718, 1600, 1469, 1455, 1377, 1321, 1282, 1248, 1134, 1112, 1081, 1051, 1022, 885, 839, 815, 761, 725, 653, 520 cm^{-1}. **HRMS (ESI)** clacd for $C_{21}H_{35}O_2Si$ $[M+H]^+$: 347.2401, found 347.2410.



1aa

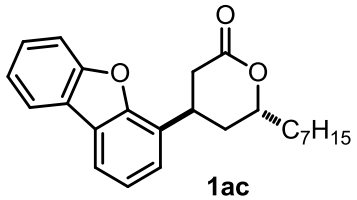
6-Heptyl-4-(naphthalen-1-yl)tetrahydro-2*H*-pyran-2-one (1aa). 83% yield as a light yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.98 (d, *J* = 8.4 Hz, 1H), 7.88 (d, *J* =

8.4 Hz, 1H), 7.77 (d, *J* = 8.4 Hz, 1H), 7.57-7.43 (m, 3H), 7.27 (d, *J* = 7.2 Hz, 1H), 4.33-4.26 (m, 1H), 4.17-4.11 (m, 1H), 2.98-2.87 (m, 2H), 2.21-2.08 (m, 2H), 1.78-1.70 (m, 1H), 1.56-1.45 (m, 2H), 1.31-1.23 (m, 9H), 0.85 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 172.08, 138.42, 133.96, 130.75, 129.12, 127.67, 126.39, 125.77, 125.32, 122.61, 122.57, 77.48, 35.34, 35.30, 34.31, 31.57, 30.32, 29.22, 28.96, 24.95, 22.47, 13.95. **IR (neat):** 3048, 2927, 2855, 1735, 1598, 1510, 1465, 1378, 1240, 1164, 1086, 1072, 1011, 943, 798, 778, 734, 606, 580 cm^{-1}. **HRMS (ESI)** clacd for $C_{44}H_{57}O_4$ $[2M+H]^+$: 649.4251, found 649.4253.



1ab

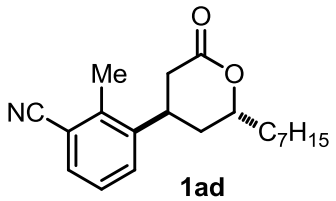
4-(3a1,5a1-Dihydropyren-4-yl)-6-heptyltetrahydro-2*H*-pyran-2-one (1ab). 71% yield as a brown solid. M.p. 108-109 °C. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.10-7.90 (m, 8H), 7.69-7.65 (m, 1H), 4.28-4.20 (m, 2H), 2.95-2.92 (m, 2H), 2.14-2.02 (m, 2H), 1.71-1.61 (m, 1H), 1.48-1.33 (m, 2H), 1.21-1.16 (m, 9H), 0.82 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.98, 135.99, 131.14, 130.35, 130.05, 127.84, 127.72, 127.11, 125.94, 125.25, 124.94, 124.83, 124.54, 122.59, 121.67, 77.44, 35.63, 35.26, 34.80, 31.49, 30.50, 29.13, 28.88, 24.87, 22.40, 13.90. **IR (neat):** 3042, 2955, 2927, 2855, 1731, 1603, 1587, 1465, 1439, 1378, 1306, 1244, 1186, 1073, 1033, 975, 947, 844, 818, 760, 720, 683, 625 cm^{-1}. **HRMS (ESI)** clacd for $C_{28}H_{32}O_2Na$ $[M+Na]^+$: 423.2295, found 423.2285.



1ac

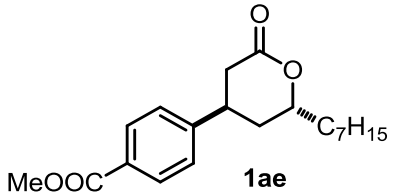
4-(Dibenzo[*b*,*d*]furan-4-yl)-6-heptyltetrahydro-2*H*-pyran-2-one (1ac). 86% yield

as a yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.94 (d, *J* = 7.6 Hz, 1H), 7.85 (d, *J* = 6.8 Hz, 1H), 7.57 (d, *J* = 8.4 Hz, 1H), 7.49-7.45 (m, 1H), 7.36-7.28 (m, 2H), 7.23 (d, *J* = 6.8 Hz, 1H), 4.59-4.53 (m, 1H), 3.86-3.78 (m, 1H), 3.07-2.86 (m, 2H), 2.31-2.26 (m, 1H), 2.18-2.14 (m, 1H), 1.86-1.76 (m, 1H), 1.64-1.45 (m, 2H), 1.40-1.25 (m, 9H), 0.86 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.95, 155.74, 153.51, 127.25, 127.09, 124.77, 124.50, 123.95, 123.01, 122.86, 120.67, 119.41, 111.55, 77.69, 35.18, 34.57, 33.39, 31.59, 30.71, 29.20, 29.00, 25.02, 22.47, 13.95. **IR (neat):** 3058, 2927, 2855, 1736, 1587, 1496, 1475, 1452, 1425, 1377, 1321, 1277, 1247, 1186, 1118, 1085, 1047, 1032, 844, 819, 798, 754, 736, 618, 564 cm^{-1}. **HRMS (ESI)** clacd for $C_{24}H_{28}O_3Na$ $[M+Na]^+$: 387.1931, found 387.1932.



1ad

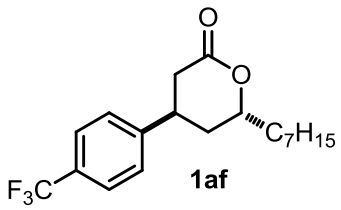
3-(2-Heptyl-6-oxotetrahydro-2*H*-pyran-4-yl)-2-methylbenzonitrile (1ad). 84% yield as a yellow solid. M.p. 73-74 °C. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.55 (d, *J* = 7.5 Hz, 1H), 7.40-7.33 (m, 2H), 4.39-4.34 (m, 1H), 3.65-3.59 (m, 1H), 2.81-2.70 (m, 2H), 2.58 (s, 3H), 2.11-2.05 (m, 1H), 1.97-1.93 (m, 1H), 1.79-1.75 (m, 1H), 1.62-1.51 (m, 2H), 1.35-1.19 (m, 9H), 0.87 (t, *J* = 7.0 Hz, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 171.27, 142.69, 139.09, 131.23, 129.54, 126.99, 118.08, 114.18, 77.26, 35.22, 35.14, 33.57, 31.54, 30.83, 29.15, 28.93, 24.99, 22.43, 17.26, 13.90. **IR (neat):** 2953, 2928, 2856, 1736, 1590, 1466, 1379, 1291, 1250, 1168, 1122, 1077, 1030, 796, 721, 561 cm^{-1}. **HRMS (ESI)** clacd for $C_{20}H_{28}NO_2$ $[M+H]^+$: 314.2115, found 314.2121.



1ae

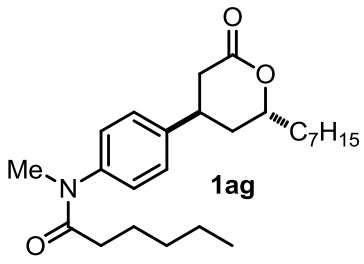
Methyl 4-(2-heptyl-6-oxotetrahydro-2*H*-pyran-4-yl)benzoate (1ae). 90% yield as a

yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.03 (d, *J* = 8.4 Hz, 2H), 7.30 (d, *J* = 8.4 Hz, 2H), 4.43-4.37 (m, 1H), 3.92 (s, 3H), 3.45-3.38 (m, 1H), 2.85-2.72 (m, 2H), 2.14-2.04 (m, 2H), 1.83-1.73 (m, 1H), 1.63-1.45 (m, 2H), 1.40-1.26 (m, 9H), 0.87 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.26, 166.43, 148.22, 130.05, 128.84, 126.54, 77.39, 51.92, 35.56, 35.20, 34.63, 34.60, 31.49, 29.11, 28.88, 24.95, 22.39, 13.86. **IR (neat):** 2953, 2928, 2856, 1736, 1590, 1466, 1379, 1291, 1250, 1168, 1122, 1077, 1030, 796, 721, 561 cm^{-1}. **HRMS (ESI)** clacd for $C_{20}H_{29}O_4$ $[M+H]^+$: 333.2060, found 333.2068.



1af

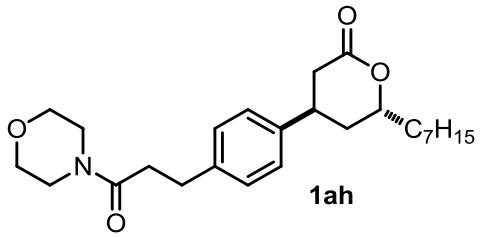
6-Heptyl-4-(4-(trifluoromethyl)phenyl)tetrahydro-2*H*-pyran-2-one (1af). 75% yield as a yellow oil. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.62 (d, *J* = 8.0 Hz, 2H), 7.36 (d, *J* = 8.0 Hz, 2H), 4.44-4.38 (m, 1H), 3.46-3.40 (m, 1H), 2.84-2.72 (m, 2H), 2.12-2.05 (m, 2H), 1.80-1.78 (m, 1H), 1.62-1.51 (m, 2H), 1.37-1.27 (m, 9H), 0.87 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 171.12, 147.16, 129.32 (q, $^2J_{C-F}$ = 32.3 Hz), 126.98, 125.80 (q, $^2J_{C-F}$ = 3.9 Hz), 123.91 (q, $^2J_{C-F}$ = 271.4 Hz), 77.43, 35.69, 35.29, 34.71, 34.59, 31.58, 29.19, 28.97, 25.04, 22.47, 13.90. **IR (neat):** 2930, 2858, 1736, 1620, 1467, 1422, 1379, 1328, 1250, 1223, 1165, 1125, 1070, 1017, 839, 742, 725, 694, 608, 569 cm^{-1}. **HRMS (ESI)** clacd for $C_{38}H_{50}F_6O_4Na$ $[2M+Na]^+$: 707.3506, found 707.3510.



1ag

***N*-(4-(2-heptyl-6-oxo-3,6-dihydro-2*H*-pyran-4-yl)phenyl)-*N*-methylhexanamide**

(1ag). 82% yield as a yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.21 (d, *J* = 8.4 Hz, 2H), 7.12 (d, *J* = 8.0 Hz, 2H), 4.40-4.33 (m, 1H), 3.37-3.29 (m, 1H), 3.19 (s, 3H), 2.80-2.63 (m, 2H), 2.11-2.01 (m, 4H), 1.79-1.67 (m, 1H), 1.58-1.45 (ms, 4H), 1.35-1.06 (m, 13H), 0.83-0.75 (m, 6H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 173.01, 171.32, 142.97, 142.59, 127.77, 127.66, 77.44, 37.09, 35.95, 35.27, 34.82, 34.19, 33.87, 31.54, 31.28, 29.16, 28.93, 25.02, 22.43, 22.20, 13.90, 13.73. **IR (neat):** 2955, 2928, 2857, 1739, 1657, 1607, 1512, 1464, 1418, 1384, 1248, 1162, 1127, 1110, 1049, 846 cm^{-1}. **HRMS (ESI)** clacd for $C_{25}H_{39}NO_3Na$ $[M+Na]^+$: 424.2822, found 424.2823.

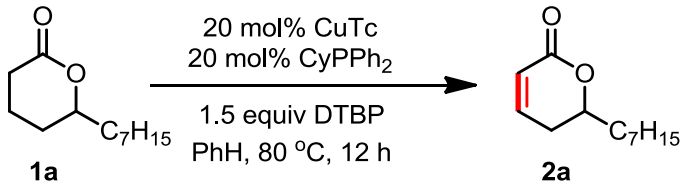


1ah

6-Heptyl-4-(4-(3-morpholino-3-oxopropyl)phenyl)tetrahydro-2*H*-pyran-2-one (1ah). 88% yield as a yellow oil. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.14 (d, *J* = 8.0 Hz, 2H), 7.06 (d, *J* = 8.4 Hz, 2H), 4.35-4.28 (m, 1H), 3.56-3.52 (m, 4H), 3.47-3.45 (m, 2H), 3.33-3.31 (m, 2H), 3.25-3.22 (m, 1H), 2.91-2.87 (m, 2H), 2.71-2.59 (m, 2H), 2.56-2.52 (m, 2H), 1.97-1.94 (m, 2H), 1.72-1.63 (m, 1H), 1.53-1.36 (m, 2H), 1.30-1.15 (m, 9H), 0.79 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.51, 170.31, 140.84, 139.61, 128.67, 126.44, 77.32, 66.49, 66.14, 45.59, 41.61, 35.83, 35.12, 34.80, 34.24, 33.99, 31.37, 30.48, 29.01, 28.77, 24.84, 22.27, 13.77. **IR (neat):** 2955, 2926, 2855, 1735, 1647, 1515, 1462, 1434, 1271, 1244, 1229, 1116, 1070, 1050, 1025, 866, 847, 824, 724, 586 cm^{-1}. **HRMS (ESI)** clacd for $C_{25}H_{38}NO_4$ $[M+H]^+$: 416.2795, found 416.2802.

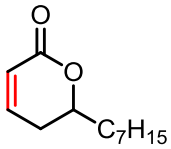
General procedure of the Cu-catalyzed desaturation of δ-lactones, ketones and lactams:

Typical procedure for the synthesis of 6-heptyl-5,6-dihydro-2*H*-pyran-2-one (2a).



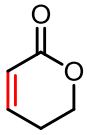
1a 2a

An oven-dried 4.0 mL vial was charged with 6-heptyltetrahydro-2*H*-pyran-2-one **(1a)** (39.7 mg, 0.2 mmol) and CuTc (7.6 mg, 0.04 mmol, 0.2 equiv). It was directly transferred in a nitrogen-filled glovebox with caps. In the glovebox, $CyPPh_2$ (10.7 mg, 0.04 mmol, 0.2 equiv) and 2 mL of degassed benzene were added to the vial. To the resulting solution was added DTBP ($^tBuOO^tBu$) (43.9 mg, 0.3 mmol, 1.5 equiv). The vial was tightly sealed, transferred out of glovebox and stirred on a pie-block at 80 °C for 12 hrs. After completion of the reaction, the solvent was evaporated under the reduced pressure and the residue was purified by column chromatography on silica gel (Hexane: Ethyl Acetate = 4:1) to afford **2a** (31.7 mg, 81%) as a colorless oil.



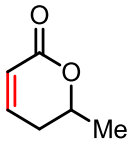
1a

6-Heptyl-5,6-dihydro-2*H*-pyran-2-one (2a). Isolated yield = 81% on 0.2 mmol scale; colorless oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 6.90-6.86 (m, 1H), 6.04-6.00 (m, 1H), 4.45-4.38 (m, 1H), 2.38-2.27 (m, 2H), 1.84-1.76 (m, 1H), 1.68-1.60 (m, 1H), 1.55-1.48 (m, 1H), 1.43-1.37 (m, 1H), 1.30-1.28 (m, 8H), 0.88 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.56, 145.03, 121.35, 77.97, 34.80, 31.67, 29.33, 29.25, 29.05, 24.74, 22.55, 14.01. The spectroscopic data are in agreement with those previously reported[16].



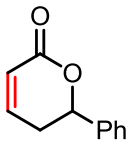
2b

5,6-Dihydro-2*H*-pyran-2-one (2b). Isolated yield = 73% on 0.2 mmol scale; colorless oil; R_f = 0.25 (Hexane: Ethyl acetate = 3:1); **^{1}H NMR (500 MHz, $CDCl_3$)** δ 6.93 (dt, *J* = 9.0, 4.5 Hz, 1H), 6.02 (dt, *J* = 9.5, 2.0 Hz, 1H), 4.41 (t, *J* = 6.5 Hz, 2H), 2.47-2.43 (m, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 163.73, 145.65, 121.60, 66.44, 23.96. The spectroscopic data are in agreement with those previously reported[13].



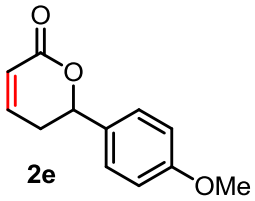
2c

6-Methyl-5,6-dihydro-2*H*-pyran-2-one (2c). Isolated yield = 68% on 0.2 mmol scale; colorless oil; R_f = 0.25 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 6.87 (ddd, *J* = 9.8, 5.7, 2.8 Hz, 1H), 6.02 (ddd, *J* = 9.8, 2.5, 1.2 Hz, 1H), 4.57 (dqd, *J* = 10.9, 6.3, 4.5 Hz, 1H), 2.440-2.30 (m, 2H), 1.44 (d, *J* = 6.0 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.51, 144.89, 121.34, 74.34, 30.99, 20.73. The spectroscopic data are in agreement with those previously reported[17].

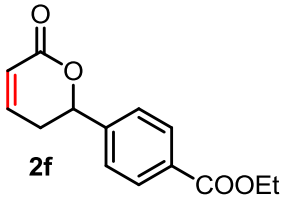


2d

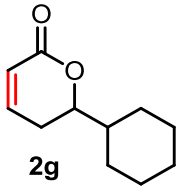
6-Phenyl-5,6-dihydro-2*H*-pyran-2-one (2d). Isolated yield = 71% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: Acetone = 4:1); **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.41-7.33 (m, 5H), 6.98-6.95 (m, 1H), 6.13 (d, *J* = 10.0 Hz, 1H), 5.44 (dd, *J* = 11.0, 5.0 Hz, 1H), 2.69-2.57 (m, 2H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 164.01, 144.89, 138.39, 128.58, 128.54, 125.97, 121.56, 79.16, 31.56. The spectroscopic data are in agreement with those previously reported[18].



6-(4-Methoxyphenyl)-5,6-dihydro-2*H*-pyran-2-one (2e). Isolated yield = 72% on 0.2 mmol scale; colorless oil; R_f = 0.35 (Hexane: Acetone = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.30-7.22 (m, 2H), 6.89 (ddd, *J* = 9.6, 6.4, 2.4 Hz, 1H), 6.86-6.79 (m, 2H), 6.12-5.97 (m, 1H), 5.32 (dd, *J* = 11.6, 4.2 Hz, 1H), 3.74 (s, 3H), 2.72-2.39 (m, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.24, 159.75, 144.99, 130.46, 127.55, 121.58, 113.93, 79.08, 55.27, 31.48. **IR (neat):** 3003, 2961, 2937, 2909, 2838, 1725, 1613, 1517, 1464, 1383, 1305, 1284, 1247, 1178, 1150, 1062, 1028, 913, 816, 781, 692, 665, 556, 539 cm^{-1}. **HRMS (ESI)** clacd for $C_{12}H_{13}O_3$ $[M+H]^+$: 205.0859, found 205.0854.

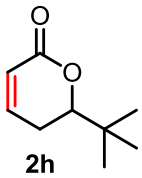


Ethyl 4-(6-oxo-3,6-dihydro-2*H*-pyran-2-yl)benzoate (2f). Isolated yield = 69% on 0.2 mmol scale; colorless oil; R_f = 0.35 (Hexane: Acetone = 4:1); **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.08 (d, *J* = 8.4 Hz, 2H), 7.50 (d, *J* = 8.4 Hz, 2H), 7.07-6.84 (m, 1H), 6.16 (d, *J* = 10.2 Hz, 1H), 5.52 (dd, *J* = 10.2, 5.6 Hz, 1H), 4.39 (q, *J* = 7.2 Hz, 2H), 2.64 (dd, *J* = 10.2, 3.2 Hz, 2H), 1.40 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 166.01, 163.59, 144.66, 143.11, 130.61, 129.87, 125.74, 121.64, 78.50, 61.07, 31.55, 14.26. **IR (neat):** 3063, 2982, 2940, 2905, 1720, 1614, 1416, 1381, 1368, 1278, 1244, 1179, 1151, 1108, 1065, 1020, 914, 855, 816, 769, 704, 660, 532 cm^{-1}. **HRMS (ESI)** clacd for $C_{14}H_{14}O_4Na$ $[M+Na]^+$: 269.0784, found 269.0789.



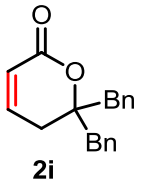
6-Cyclohexyl-5,6-dihydro-2*H*-pyran-2-one (2g). Isolated yield = 78% on 0.2 mmol

scale; colorless oil; R_f = 0.5 (Hexane: Acetone = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 6.91-6.86 (m, 1H), 6.01-5.98 (m, 1H), 4.20-4.15 (m, 1H), 2.40-2.25 (m, 2H), 1.96-1.93 (m, 1H), 1.79-1.59 (m, 4H), 1.36-1.01 (m, 6H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.71, 145.28, 121.33, 81.98, 41.62, 28.17, 26.52, 26.20, 25.85, 25.73. The spectroscopic data are in agreement with those previously reported[19].



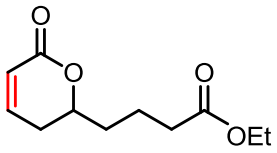
2h

6-(Tert-butyl)-5,6-dihydro-2*H*-pyran-2-one (2h). Isolated yield = 73% on 0.2 mmol scale; colorless oil; R_f = 0.4 (Hexane: Acetone = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 6.99-6.74 (m, 1H), 6.29-5.67 (m, 1H), 4.04 (dd, *J* = 11.6, 4.8 Hz, 1H), 2.42-2.21 (m, 2H), 0.98 (s, 9H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.82, 145.51, 121.09, 85.22, 33.77, 25.41, 24.51. **IR (neat):** 2962, 2910, 2874, 1718, 1481, 1398, 1383, 1367, 1250, 1152, 1084, 1045, 1028, 963, 817, 590. cm^{-1}. **HRMS (ESI)** clacd for $C_9H_{15}O_2$ $[M+H]^+$: 155.1067, found 155.1067.



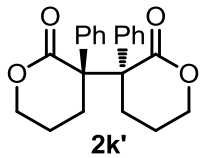
2i

6-(Tert-butyl)-5,6-dihydro-2*H*-pyran-2-one (2i). Isolated yield = 41% on 0.2 mmol scale; colorless oil; R_f = 0.4 (Hexane: Acetone = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.35-7.27 (m, 6H), 7.25-7.18 (m, 4H), 6.79-6.56 (m, 1H), 5.92 (dt, *J* = 9.6, 2.0 Hz, 1H), 3.17 (d, *J* = 14.4 Hz, 2H), 3.00 (d, *J* = 14.4 Hz, 2H), 2.36 (dd, *J* = 4.4, 2.0 Hz, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 163.36, 143.53, 135.73, 130.77, 128.41, 126.99, 120.66, 84.34, 44.95, 29.39. **IR (neat):** 3085, 3061, 3029, 2925, 2853, 1720, 1602, 1495, 1454, 1382, 1273, 1232, 1146, 1078, 1030, 951, 816, 754, 702, 542 cm^{-1}. **HRMS (ESI)** clacd for $C_{19}H_{19}O_2$ $[M+H]^+$: 279.1380, found 279.1388.



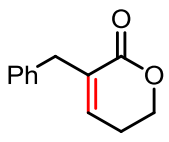
2j

Ethyl 4-(6-oxo-3,6-dihydro-2*H*-pyran-2-yl)butanoate (2j). 20 mol% ^{i}PrPPh$_2$ was used instead of 20 mol% CyPPh$_2$. Isolated yield = 72% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: Acetone = 3:1); **^{1}H NMR (400 MHz, CDCl$_3$)** δ 6.91-6.87 (m, 1H), 6.04-6.01 (m, 1H), 4.48-4.41 (m, 1H), 4.13 (q, *J* = 7.2 Hz, 2H), 2.39-2.33 (m, 4H), 1.88-1.72 (m, 4H), 1.26 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 173.10, 164.26, 144.91, 121.35, 77.44, 60.35, 34.05, 33.70, 29.23, 20.25, 14.19. **IR (neat):** 2983, 2940, 1729, 1462, 1421, 1379, 1301, 1253, 1186, 1147, 1083, 1037, 959, 916, 858, 817, 664, 578, 553 cm^{-1}. **HRMS (ESI)** clacd for $C_{11}H_{17}O_4$ $[M+H]^+$: 213.1121, found 213.1124.



2k'

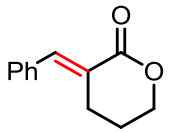
3,3'-Diphenyloctahydro-2*H*,2'*H*-[3,3'-bipyran]-2,2'-dione (2k'). 60% yield as a white soild. M.p. 211-212 ^{o}C. **^{1}H NMR (400 MHz, CDCl$_3$)** δ 7.50-7.31 (m, 4H), 6.81-6.80 (m, 1H), 4.37-4.31 (m, 1H), 4.01-3.97 (m, 1H), 3.06-2.98 (m, 1H), 1.68-1.61 (m, 2H), 1.51-1.44 (m, 1H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 174.41, 135.05, 130.75, 128.40, 128.05, 127.74, 69.29, 57.93, 29.63, 19.92. **IR (neat):** 3056, 2974, 2930, 2902, 1719, 1498, 1477, 1446, 1400, 1255, 1172, 1150, 1127, 1085, 976, 913, 738, 699, 662, 544 cm^{-1}. **HRMS (ESI)** clacd for $C_{22}H_{22}O_4Na$ $[M+Na]^+$: 373.1410, found 373.1415.



2l

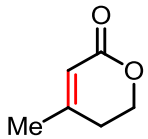
3-Benzyl-5,6-dihydro-2*H*-pyran-2-one (2l). Isolated yield = 25% on 0.2 mmol scale;

colorless oil; R_f = 0.3 (Hexane: Acetone = 5:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.26-7.13 (m, 5H), 6.36 (t, *J* = 4.4 Hz, 1H), 4.28 (t, *J* = 6.4 Hz, 2H), 3.56 (d, *J* = 1.6 Hz, 2H), 2.36-2.32 (m, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.82, 140.02, 138.28, 132.91, 129.26, 128.54, 126.50, 66.35, 36.73, 24.43. The spectroscopic data are in agreement with those previously reported[20].



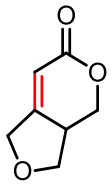
2l'

(*E*)-3-Benzylidenetetrahydro-2*H*-pyran-2-one (2l'). Isolated yield = 9% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: Acetone = 5:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.93 (t, *J* = 2.0 Hz, 1H), 7.46-7.26 (m, 5H), 4.41 (t, J = 5.2 Hz, 2H), 2.89 (td, *J* = 6.6, 2.4 Hz, 2H), 2.00-1.95 (m, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 166.94, 141.63, 134.95, 130.19, 129.16, 128.55, 125.71, 68.68, 25.91, 23.00. The spectroscopic data are in agreement with those previously reported[21].



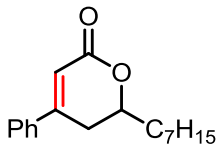
2m

4-Methyl-5,6-dihydro-2*H*-pyran-2-one (2m). 20 mol% ^{i}PrPPh$_2$ was used instead of 20 mol% CyPPh$_2$. Isolated yield = 80% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: Acetone = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 5.80 (d, *J* = 1.2 Hz, 1H), 4.37 (t, *J* = 6.4 Hz, 2H), 2.37 (t, *J* = 6.4 Hz, 2H), 1.99 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.56, 157.76, 116.71, 65.83, 29.13, 22.96. The spectroscopic data are in agreement with those previously reported[22].



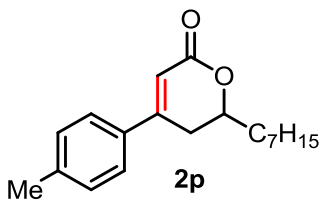
2n

3a,4-Dihydro-1*H*-furo[3,4-*c*]pyran-6(3*H*)-one (2n). Isolated yield = 51% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: Acetone = 3:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 5.90 (d, *J* = 2.0 Hz, 1H), 4.69-4.53 (m, 2H), 4.47 (d, *J* = 16.4 Hz, 1H), 4.28 (t, *J* = 8.4 Hz, 1H), 4.13 (dd, *J* = 12.4, 10.4 Hz, 1H), 3.46-3.38 (m, 1H), 3.32 (s, 1H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.16, 163.32, 110.50, 69.57, 68.89, 68.68, 39.43. **IR (neat):** 2997, 2949, 2890, 2851, 1723, 1397, 1376, 1296, 1239, 1212, 1063, 1042, 1016, 913, 850, 790, 669 cm^{-1}. **HRMS (ESI)** clacd for $C_7H_9O_3$ $[M+H]^+$: 141.0546, found 141.0547.



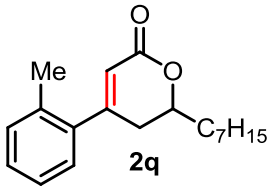
2o

6-Heptyl-4-phenyl-5,6-dihydro-2*H*-pyran-2-one (2o). Isolated yield = 60% on 0.2 mmol scale; light yellow oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.55-7.52 (m, 2H), 7.46-7.43 (m, 3H), 6.36 (d, *J* = 2.0 Hz, 1H), 4.53-4.49 (m, 1H), 2.81-2.66 (m, 2H), 1.94-1.85 (m, 1H), 1.78-1.69 (m, 1H), 1.61-1.53 (m, 1H), 1.50-1.43 (m, 1H), 1.33-1.29 (m, 8H), 0.88 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.71, 154.67, 136.21, 130.52, 128.92, 125.91, 114.91, 77.41, 34.85, 31.70, 29.31, 29.09, 24.88, 22.58, 14.04. **IR (neat):** 3060, 3030, 2927, 2856, 1711, 1618, 1577, 1496, 1448, 1387, 1257, 1192, 1162, 1125, 1042, 873, 765, 722, 699 cm^{-1}. **HRMS (ESI)** clacd for $C_{18}H_{25}O_2$ $[M+H]^+$: 273.1849, found 273.1853.



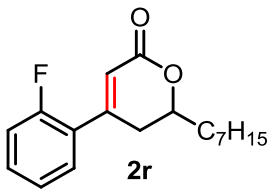
2p

6-Heptyl-4-(p-tolyl)-5,6-dihydro-2*H*-pyran-2-one (2p). Isolated yield = 57% on 0.2 mmol scale; colorless oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.44 (d, *J* = 8.5 Hz, 2H), 7.24 (d, *J* = 7.5 Hz, 2H), 6.32 (s, 1H), 4.50-4.48 (m, 1H), 2.79-2.64 (m, 2H), 2.39 (s, 3H), 1.89-1.87 (m, 1H), 1.75-1.71 (m, 1H), 1.58-1.56 (m, 1H), 1.48-1.46 (m, 1H), 1.32-1.29 (m, 8H), 0.89 (t, *J* = 7.0 Hz, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 165.96, 154.57, 141.05, 133.29, 129.65, 125.89, 113.94, 77.36, 34.89, 31.72, 31.63, 29.34, 29.11, 24.90, 22.60, 21.32, 14.04. **IR (neat):** 2952, 2923, 2855, 1687, 1611, 1516, 1468, 1387, 1274, 1251, 1135, 1043, 1022, 992, 905, 868, 836, 812, 726, 655, 567 cm^{-1}. **HRMS (ESI)** clacd for $C_{19}H_{27}O_2$ $[M+H]^+$: 287.2006, found 287.2000.



2q

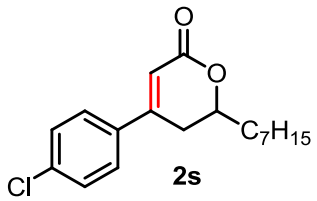
6-Heptyl-4-(o-tolyl)-5,6-dihydro-2*H*-pyran-2-one (2q). Isolated yield = 50% on 0.2 mmol scale; colorless oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.30-7.22 (m, 3H), 7.13 (d, *J* = 7.5 Hz, 1H), 5.98 (s, 1H), 4.55-4.54 (m, 1H), 2.71-2.65 (m, 1H), 2.54-2.50 (m, 1H), 2.34 (s, 3H), 1.88-1.85 (m, 1H), 1.72-1.67 (m, 1H), 1.58-1.56 (m, 1H), 1.44-1.43 (m, 1H), 1.31-1.28 (m, 8H), 0.89 (t, *J* = 7.0 Hz, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 165.24, 157.94, 138.32, 134.35, 130.93, 128.95, 127.14, 126.14, 118.85, 77.83, 34.81, 34.75, 31.70, 29.32, 29.10, 24.87, 22.60, 20.29, 14.04. **IR (neat):** 3061, 3019, 2955, 2927, 2856, 1717, 1628, 1488, 1458, 1384, 1271, 1249, 1235, 1195, 1119, 1073, 1037, 983, 949, 760, 729, 615, 589 cm^{-1}. **HRMS (ESI)** clacd for $C_{19}H_{27}O_2$ $[M+H]^+$: 287.2006, found 287.2009.



2r

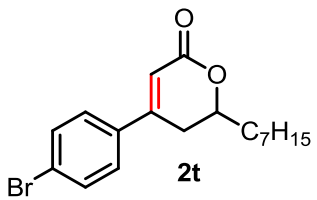
4-(2-Fluorophenyl)-6-heptyl-5,6-dihydro-2*H*-pyran-2-one (2r). Isolated yield = 51%

on 0.2 mmol scale; colorless oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.41-7.36 (m, 2H), 7.21 (t, *J* = 7.6 Hz, 1H), 7.16-7.11 (m, 1H), 6.30 (d, *J* = 2.0 Hz, 1H), 4.56-4.49 (m, 1H), 2.83-2.68 (m, 2H), 1.92-1.83 (m, 1H), 1.76-1.67 (m, 1H), 1.62-1.52 (m, 1H), 1.49-1.41 (m, 1H), 1.32-1.29 (m, 8H), 0.89 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.16, 160.15 (d, $^1J_{C\text{-}F}$ = 252.0 Hz), 151.68, 131.64 (d, $^3J_{C\text{-}F}$ = 8.9 Hz), 128.63 (d, $^4J_{C\text{-}F}$ = 3.1 Hz), 125.25 (d, $^2J_{C\text{-}F}$ = 12.0 Hz), 124.64 (d, $^4J_{C\text{-}F}$ = 3.5 Hz), 118.82 (d, $^3J_{C\text{-}F}$ = 5.2 Hz), 116.56 (d, $^2J_{C\text{-}F}$ = 22.4 Hz), 77.73, 34.75, 33.14, 33.10, 31.72, 29.32, 29.11, 24.86, 22.60, 14.06. **IR (neat):** 2957, 2928, 2856, 1715, 1611, 1491, 1452, 1389, 1379, 1255, 1208, 1110, 1079, 1040, 983, 881, 841, 760, 724, 586 cm^{-1}. **HRMS (ESI)** clacd for $C_{36}H_{47}F_2O_4$ $[2M+H]^+$: 581.3437, found 581.3433.



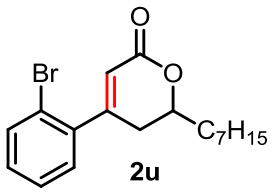
2s

4-(4-Chlorophenyl)-6-heptyl-5,6-dihydro-2*H*-pyran-2-one (2s). Isolated yield = 55% on 0.2 mmol scale; colorless oil; R_f = 0.35 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.48-7.40 (m, 4H), 6.33 (s, 1H), 4.53-4.48 (m, 1H), 2.76-2.63 (m, 2H), 1.92-1.84 (m, 1H), 1.78-1.68 (m, 1H), 1.60-1.52 (m, 1H), 1.50-1.42 (m, 1H), 1.33-1.29 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.45, 153.31, 136.68, 134.66, 129.24, 127.22, 115.34, 77.38, 34.85, 31.72, 31.64, 29.33, 29.11, 24.89, 22.60, 14.06. **IR (neat):** 2957, 2924, 2854, 1686, 1616, 1592, 1494, 1468, 1408, 1384, 1267, 1239, 1190, 1134, 1095, 1040, 1011, 939, 870, 833, 740, 722, 570, 540 cm^{-1}. **HRMS (ESI)** clacd for $C_{18}H_{23}ClO_2Na$ $[M+Na]^+$: 329.1279, found 329.1284.



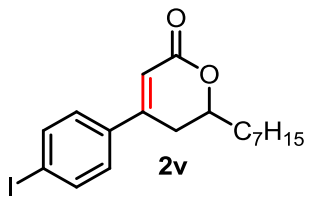
2t

4-(4-Bromophenyl)-6-heptyl-5,6-dihydro-2*H*-pyran-2-one (2t). Isolated yield = 53% on 0.2 mmol scale; light yellow oil; R_f = 0.35 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.59-7.56 (m, 2H), 7.41-7.38 (m, 2H), 6.34 (d, *J* = 1.2 Hz, 1H), 4.54-4.47 (m, 1H), 2.72-2.68 (m, 2H), 1.93-1.84 (m, 1H), 1.78-1.69 (m, 1H), 1.58-1.54 (m, 1H), 1.49-1.43 (m, 1H), 1.38-1.26 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.44, 153.40, 135.14, 132.22, 127.44, 125.01, 115.40, 77.39, 34.86, 31.73, 31.61, 29.34, 29.12, 24.90, 22.62, 14.07. **IR (neat):** 2955, 2923, 2854, 1687, 1616, 1585, 1491, 1468, 1405, 1385, 1279, 1241, 1135, 1075, 1043, 1008, 871, 830, 817, 722, 568 cm^{-1}. **HRMS (ESI)** clacd for $C_{36}H_{47}Br_2O_4$ $[2M+H]^+$: 701.1836, found 701.1830.



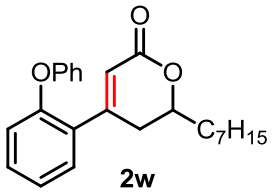
2u

4-(2-Bromophenyl)-6-heptyl-5,6-dihydro-2*H*-pyran-2-one (2u). Isolated yield = 57% on 0.2 mmol scale; light yellow oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.62 (dd, *J* = 7.6, 1.2 Hz, 1H), 7.36 (td, *J* = 7.6, 1.2 Hz, 1H), 7.27-7.23 (m, 1H), 7.19 (dd, *J* = 7.6, 1.6 Hz, 1H), 6.02 (t, *J* = 1.2 Hz, 1H), 4.64-4.57 (m, 1H), 2.70-2.67 (m, 2H), 1.92-1.82 (m, 1H), 1.75-1.66 (m, 1H), 1.59-1.51 (s, 1H), 1.48-1.41 (m, 1H), 1.35-1.21 (m, 8H), 0.88 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.01, 157.36, 139.53, 133.31, 130.39, 129.14, 127.74, 120.74, 119.75, 78.14, 34.73, 34.07, 31.71, 29.31, 29.11, 24.82, 22.60, 14.06. **IR (neat):** 3061, 2927, 2856, 1720, 1635, 1567, 1560, 1467, 1433, 1385, 1281, 1250, 1228, 1188, 1119, 1056, 1025, 982, 880, 758, 730, 681, 606, 582, 556 cm^{-1}. **HRMS (ESI)** clacd for $C_{18}H_{23}BrO_2Na$ $[M+Na]^+$: 373.0774, found 373.0779.



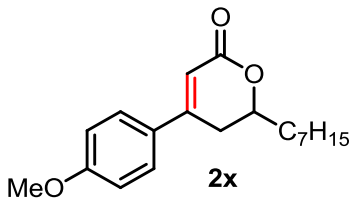
2v

6-Heptyl-4-(4-iodophenyl)-5,6-dihydro-2*H*-pyran-2-one (2v). Isolated yield = 49% on 0.2 mmol scale; light yellow oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.78 (d, *J* = 8.4 Hz, 2H), 7.25 (d, *J* = 8.8 Hz, 2H), 6.34 (s, 1H), 4.52-4.48 (m, 1H), 2.70-2.68 (m, 2H), 1.89-1.85 (m, 1H), 1.76-1.70 (m, 1H), 1.59-1.55 (m, 1H), 1.48-1.45 (m, 1H), 1.33-1.29 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.40, 153.53, 138.17, 135.71, 127.48, 115.38, 96.95, 77.38, 34.84, 31.71, 31.50, 29.32, 29.11, 24.88, 22.60, 14.06. **IR (neat):** 2954, 2922, 2854, 1687, 1616, 1580, 1487, 1468, 1403, 1387, 1280, 1239, 1136, 1064, 1045, 1004, 871, 829, 813, 735, 694, 564 cm^{-1}. **HRMS (ESI)** clacd for $C_{18}H_{23}IO_2Na$ $[M+Na]^+$: 421.0635, found 421.0631.



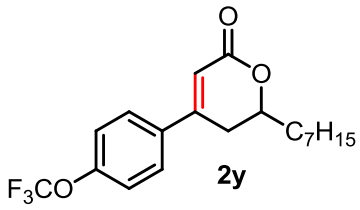
2w

6-Heptyl-4-(2-phenoxyphenyl)-5,6-dihydro-2*H*-pyran-2-one (2w). Isolated yield = 61% on 0.2 mmol scale; light yellow oil; R_f = 0.35 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.37-7.32 (m, 4H), 7.19-7.10 (m, 2H), 6.95-6.92 (m, 3H), 6.22 (d, *J* = 2.0 Hz, 1H), 4.40-4.33 (m, 1H), 2.79-2.72 (m, 2H), 1.84-1.75 (m, 1H), 1.66-1.58 (m, 1H), 1.51-1.42 (m, 1H), 1.39-1.31 (m, 1H), 1.36-1.26 (m, 8H), 0.88 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.44, 156.60, 154.80, 154.22, 131.05, 129.94, 129.74, 129.13, 123.97, 123.62, 119.67, 118.52, 118.29, 77.91, 34.64, 33.51, 31.70, 29.27, 29.09, 24.85, 22.60, 14.06. **IR (neat):** 3063, 3040, 2928, 2856, 1716, 1624, 1589, 1579, 1485, 1448, 1386, 1240, 1163, 1110, 1073, 1041, 983, 950, 873,797, 753, 692, 589 cm^{-1}. **HRMS (ESI)** clacd for $C_{24}H_{29}O_3$ $[M+H]^+$: 365.2111, found 365.2103.



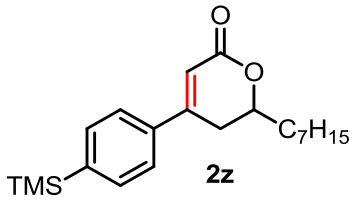
2x

6-Heptyl-4-(4-methoxyphenyl)-5,6-dihydro-2*H*-pyran-2-one (2x). Isolated yield = 52% on 0.2 mmol scale; colorless oil; R_f = 0.2 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.51 (d, *J* = 8.8 Hz, 2H), 6.95 (d, *J* = 8.8 Hz, 2H), 6.28 (d, *J* = 2.0 Hz, 1H), 4.51-4.44 (m, 1H), 3.86 (s, 3H), 2.79-2.61 (m, 2H), 1.93-1.83 (m, 1H), 1.77-1.68 (m, 1H), 1.61-1.53 (m, 1H), 1.50-1.41 (m, 1H), 1.33-1.29 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 166.15, 161.59, 154.06, 128.32, 127.54, 114.31, 112.69, 77.31, 55.41, 34.90, 31.72, 31.55, 29.34, 29.11, 24.92, 22.60, 14.05. **IR (neat):** 3067, 2955, 2922, 2856, 1685, 1605, 1574, 1515, 1489, 1423, 1391, 1344, 1274, 1256, 1237, 1186, 1136, 1044, 1031, 868, 831, 782, 575, 533 cm^{-1}. **HRMS (ESI)** clacd for $C_{19}H_{27}O_3$ $[M+H]^+$: 303.1955, found 303.1959.



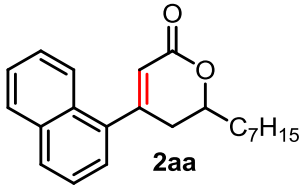
2y

6-Heptyl-4-(4-(trifluoromethoxy)phenyl)-5,6-dihydro-2*H*-pyran-2-one (2y). Isolated yield = 58% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.59-7.55 (m, 2H), 7.30-7.28 (m, 2H), 6.34 (d, *J* = 1.2 Hz, 1H), 4.54-4.49 (m, 1H), 2.78-2.66 (m, 2H), 1.91-1.86 (m, 1H), 1.77-1.71 (m, 1H), 1.59-1.55 (m, 1H), 1.49-1.45 (m, 1H), 1.33-1.29 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.33, 153.10, 150.65, 134.81, 127.58, 121.14, 120.30 (q, $^1J_{C-F}$ = 259.2 Hz), 115.69, 77.39, 34.83, 31.73, 31.70, 29.31, 29.10, 24.88, 22.59, 14.03. **IR (neat):** 3056, 2954, 2923, 2855, 1689, 1618, 1609, 1585, 1513, 1470, 1421, 1385, 1277, 1212, 1161, 1042, 1016, 989, 939, 926, 841, 827, 740, 725, 670, 619, 566 cm^{-1}. **HRMS (ESI)** clacd for $C_{19}H_{23}F_3O_3Na$ $[M+Na]^+$: 379.1492, found 379.1496.



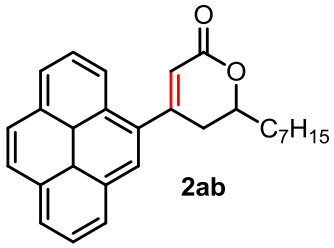
2z

6-Heptyl-4-(4-(trimethylsilyl)phenyl)-5,6-dihydro-2*H*-pyran-2-one (2z). Isolated yield = 62% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.59 (d, *J* = 7.5 Hz, 2H), 7.50 (d, *J* = 8.0 Hz, 2H), 6.37 (s, 1H), 4.51-4.50 (m, 1H), 2.80-2.70 (m, 2H), 1.89-1.87 (m, 1H), 1.76-1.72 (m, 1H), 1.60-1.58 (m, 1H), 1.48-1.47 (m, 1H), 1.32-1.29 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H), 0.29 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 165.77, 154.73, 144.06, 136.45, 133.88, 125.08, 114.95, 77.46, 34.89, 31.73, 31.65, 29.35, 29.12, 24.93, 22.61, 14.06, -1.30. **IR (neat):** 3068, 3021, 2954, 2926, 2856, 1698, 1613, 1466, 1401, 1382, 1370, 1251, 1110, 1078, 1038, 1018, 881, 838, 761, 736, 705, 628 cm^{-1}. **HRMS (ESI)** clacd for $C_{21}H_{32}O_2SiNa$ $[M+Na]^+$: 367.2064, found 364.2070.



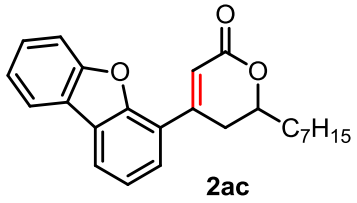
2aa

6-Heptyl-4-(naphthalen-1-yl)-5,6-dihydro-2*H*-pyran-2-one (2aa). Isolated yield = 64% on 0.2 mmol scale; yellow oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.92-7.87 (m, 3H), 7.56-7.49 (m, 3H), 7.35 (dd, *J* = 7.2, 1.2 Hz, 1H), 6.20 (d, *J* = 2.0 Hz, 1H), 4.73-4.66 (m, 1H), 2.88-2.68 (m, 2H), 1.96-1.87 (m, 1H), 1.78-1.70 (m, 1H), 1.63-1.54 (m, 1H), 1.51-1.40 (m, 1H), 1.38-1.23 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.18, 156.95, 136.55, 133.75, 129.70, 129.53, 128.79, 126.89, 126.36, 125.16, 124.73, 124.59, 119.89, 78.01, 35.48, 34.83, 31.71, 29.34, 29.12, 24.88, 22.60, 14.06. **IR (neat):** 3058, 2959, 2927, 2855, 1716, 1629, 1590, 1508, 1465, 1441, 1387, 1271, 1249, 1180, 1126, 1102, 1069, 1034, 1020, 942, 880, 802, 777, 724, 585 cm^{-1}. **HRMS (ESI)** clacd for $C_{22}H_{27}O_2$ $[M+H]^+$: 323.2006, found 323.1999.



2ab

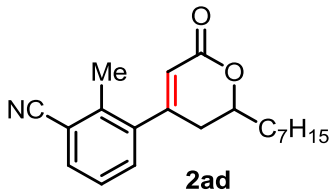
4-(3a1,5a1-Dihydropyren-4-yl)-6-heptyl-5,6-dihydro-2*H*-pyran-2-one (2ab). Isolated yield = 42% on 0.2 mmol scale; light yellow oil; R_f = 0.5 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.24-8.03 (m, 8H), 7.85 (d, *J* = 8.0 Hz, 1H), 6.33 (d, *J* = 2.0 Hz, 1H), 4.81-4.75 (m, 1H), 3.03-2.83 (m, 2H), 2.01-1.92 (m, 1H), 1.83-1.75 (m, 1H), 1.67-1.57 (m, 1H), 1.52-1.50 (m, 1H), 1.40-1.25 (m, 8H), 0.89 (d, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.24, 157.08, 133.42, 131.80, 131.30, 130.67, 128.61, 128.45, 127.56, 127.17, 126.44, 125.92, 125.64, 124.95, 124.65, 124.57, 123.75, 120.57, 78.10, 35.88, 34.90, 31.74, 29.38, 29.15, 24.94, 22.63, 14.08. **IR (neat):** 3043, 2955, 2927, 2855, 1712, 1600, 1466, 1389, 1277, 1244, 1187, 1074, 1036, 882, 846, 821, 760, 719, 682 cm^{-1}. **HRMS (ESI)** clacd for $C_{28}H_{30}O_2$ $[M]^+$: 398.2240, found 398.2237.



2ac

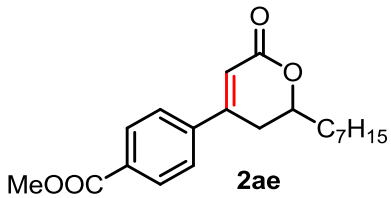
4-(Dibenzo[*b*,*d*]furan-4-yl)-6-heptyl-5,6-dihydro-2*H*-pyran-2-one (2ac). 20 mol% ^{i}PrPPh$_2$ was used instead of 20 mol% CyPPh$_2$. Isolated yield = 53% on 0.2 mmol scale; light yellow oil; R_f = 0.35 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.99 (dd, *J* = 14.4, 7.6 Hz, 2H), 7.63 (d, *J* = 8.4 Hz, 1H), 7.54-7.49 (m, 2H), 7.42-7.38 (m, 2H), 6.99 (d, *J* = 2.0 Hz, 1H), 4.64-4.58 (m, 1H), 3.04-2.88 (m, 2H), 1.99-1.90 (m, 1H), 1.83-1.75 (m, 1H), 1.66-1.60 (m, 1H), 1.55-1.46 (m, 1H), 1.36-1.26 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.95, 155.97, 153.47, 150.78, 127.84, 125.46, 125.27, 123.32, 123.25, 123.06, 122.61, 121.43, 120.72, 118.47, 111.92, 77.57, 34.92, 32.17, 31.74, 29.36, 29.14, 24.95, 22.62,

14.06. **IR (neat):** 3060, 2927, 2855, 1709, 1611, 1583, 1493, 1475, 1451, 1418, 1388, 1270, 1221, 1188, 1124, 1098, 1065, 1040, 879, 846, 830, 799, 753, 595, 578, 563 cm^{-1}. **HRMS (ESI)** clacd for $C_{24}H_{27}O_3$ $[M+H]^+$: 363.1955, found 363.1962.



2ad

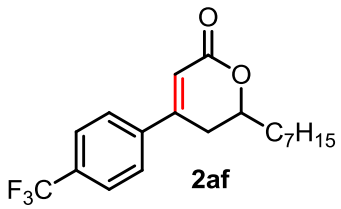
3-(2-Heptyl-6-oxo-3,6-dihydro-2*H*-pyran-4-yl)-2-methylbenzonitrile (2ad). 20 mol% $^{i}PrPPh_2$ was used instead of 20 mol% $CyPPh_2$. Isolated yield = 44% on 0.2 mmol scale; colorless oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.66-7.64 (m, 1H), 7.36-7.35 (m, 2H), 5.99 (d, *J* = 2.4 Hz, 1H), 4.61-4.54 (m, 1H), 2.68 (dd, *J* = 15.6, 11.6 Hz, 1H), 2.53 (s, 3H), 2.46 (dd, *J* = 17.8, 3.6 Hz, 1H), 1.92-1.84 (m, 1H), 1.75-1.66 (m, 1H), 1.60-1.49 (m, 1H), 1.46-1.39 (s, 1H), 1.32-1.21 (m, 8H), 0.88 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 164.41, 155.79, 139.78, 138.21, 133.14, 131.42, 126.86, 120.28, 117.56, 114.55, 34.75, 34.58, 31.69, 29.29, 29.09, 24.82, 22.59, 18.65, 14.05. **IR (neat):** 2959, 2928, 2856, 1719, 1632, 1585, 1466, 1387, 1281, 1248, 1197, 1125, 1084, 1053, 947, 881, 800, 720 cm^{-1}. **HRMS (ESI)** clacd for $C_{40}H_{50}N_2O_4Na$ $[2M+Na]^+$: 645.3663, found 645.3662.



2ae

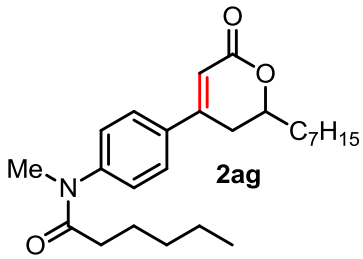
Methyl 4-(2-heptyl-6-oxo-3,6-dihydro-2*H*-pyran-4-yl)benzoate (2ae). Isolated yield = 50% on 0.2 mmol scale; light yellow oil; R_f = 0.3 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.10 (d, *J* = 8.4 Hz, 2H), 7.59 (d, *J* = 8.4 Hz, 2H), 6.41 (s, 1H), 4.55-4.51 (m, 1H), 3.95 (s, 4H), 2.77-2.74 (m, 2H), 1.92-1.84 (m, 1H), 1.79-1.71 (m, 1H), 1.62-1.55 (m, 1H), 1.50-1.43 (s, 1H), 1.32-1.22 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 166.22, 165.22, 153.46, 140.50, 131.72, 130.13, 125.92, 116.77, 77.48, 52.37, 34.85, 31.72, 29.33, 29.11, 24.88, 22.61,

14.06. **IR (neat):** 2954, 2924, 2854, 1726, 1699, 1608, 1469, 1435, 1415, 1388, 1285, 1246, 1192, 1110, 1044, 1017, 989, 941, 850, 774, 765, 748, 688 cm^{-1}. **HRMS (ESI)** clacd for $C_{20}H_{26}O_4Na$ $[M+Na]^+$: 353.1723, found 353.1726.



2af

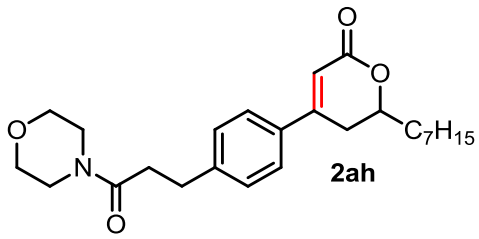
6-Heptyl-4-(4-(trifluoromethyl)phenyl)-5,6-dihydro-2*H*-pyran-2-one (2af). Isolated yield = 58% on 0.2 mmol scale; colorless oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.70 (d, *J* = 8.0 Hz, 2H), 7.64 (d, *J* = 8.4 Hz, 2H), 6.40 (s, 1H), 4.57-4.50 (m, 1H), 2.76-2.74 (m, 2H), 1.95-1.86 (m, 1H), 1.80-1.71 (m, 1H), 1.64-1.57 (m, 1H), 1.51-1.44 (m, 1H), 1.38-1.29 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 165.05, 153.11, 139.82, 132.14 (q, $^2J_{C-F}$ = 32.9 Hz), 126.31, 125.93 (q, $^4J_{C-F}$ = 3.8 Hz), 123.64 (q, $^1J_{C-F}$ = 272.2 Hz), 116.98, 77.48, 34.82, 31.74, 31.70, 29.31, 29.09, 24.86, 22.59, 14.03. **IR (neat):** 3081, 2925, 2956, 1692, 1619, 1469, 1415, 1382, 1320, 1277, 1261, 1168, 1130, 1072, 1041, 1014, 940, 844, 768, 750, 600, 559 cm^{-1}. **HRMS (ESI)** clacd for $C_{19}H_{23}F_3O_2$ $[M]^+$: 340.1645, found 340.1646.



2ag

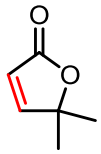
***N*-(4-(2-Heptyl-6-oxo-3,6-dihydro-2*H*-pyran-4-yl)phenyl)-*N*-methylhexanamide (2ag).** Isolated yield = 62% on 0.2 mmol scale; light yellow oil; R_f = 0.3 (Hexane: Acetone = 3:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.61-7.59 (m, 2H), 7.27 (d, *J* = 8.8 Hz, 2H), 6.38 (d, *J* = 1.6 Hz, 1H), 4.57-4.50 (m, 1H), 3.29 (s, 3H), 2.82-2.68 (m, 2H), 2.12 (br, 2H), 1.96-1.86 (m, 1H), 1.80-1.71 (m, 1H), 1.64-1.56 (m, 3H), 1.51-1.43 (m,

1H), 1.35-1.19 (m, 12H), 0.90 (t, *J* = 7.2 Hz, 3H), 0.84 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 172.93, 165.40, 153.34, 146.16, 127.67, 127.25, 115.55, 77.38, 37.21, 34.83, 34.15, 31.68, 31.39, 29.29, 29.08, 25.12, 24.86, 22.57, 22.33, 14.02, 13.84. **IR (neat):** 3041, 2928, 2857, 1713, 1660, 1603, 1512, 1466, 1416, 1383, 1297, 1249, 1190, 1128, 1046, 981, 877, 847, 760, 723, 589, 541 cm^{-1}. **HRMS (ESI)** clacd for $C_{25}H_{38}NO_3$ $[M+H]^+$: 400.2846, found 400.2850.



2ah

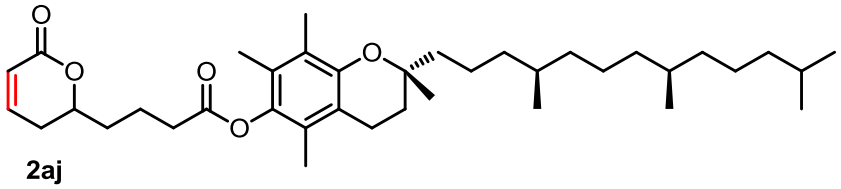
6-Heptyl-4-(4-(3-morpholino-3-oxopropyl)phenyl)-5,6-dihydro-2*H*-pyran-2-one (2ah). Isolated yield = 58% on 0.2 mmol scale; colorless oil; R_f = 0.25 (Hexane: Acetone = 2:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.46 (d, *J* = 8.4 Hz, 2H), 7.29 (d, *J* = 8.4 Hz, 2H), 6.32 (d, *J* = 2.0 Hz, 1H), 4.52-4.45 (m, 1H), 3.64-3.57 (m, 6H), 3.39 (t, *J* = 4.8 Hz, 2H), 3.02 (t, *J* = 7.6 Hz, 2H), 2.77-2.61 (m, 4H), 1.92-1.83 (m, 1H), 1.76-1.68 (m, 1H), 1.61-1.53 (m, 1H), 1.48-1.41 (m, 1H), 1.32-1.25 (m, 8H), 0.88 (t, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 170.30, 165.83, 154.34, 144.20, 134.15, 129.09, 126.14, 114.36, 77.38, 66.84, 66.45, 45.83, 41.95, 34.87, 34.28, 31.71, 31.63, 30.88, 29.33, 29.11, 24.90, 22.60, 14.05. **IR (neat):** 3035, 2926, 2857, 1699, 1632, 1457, 1436, 1376, 1298, 1285, 1270, 1242, 1119, 1069, 1019, 997, 980, 870, 826, 771, 748, 567 cm^{-1}. **HRMS (ESI)** clacd for $C_{25}H_{36}NO_4$ $[M+H]^+$: 414.2639, found 414.2645.



2ai

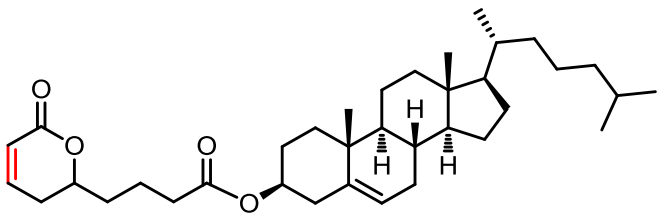
5,5-dimethylfuran-2(5*H*)-one (2ai). Isolated as a inseparable mixture with 10% of the starting material **1ai**. The yield of **2ai** was determined to be 54% on 0.2 mmol

scale; colorless oil; R_f = 0.3 (Hexane: Acetone = 4:1) and 10% of **1ai**; **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.40 (d, *J* = 5.6 Hz, 1H), 5.99 (d, *J* = 6.0 Hz, 1H), 1.49 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 172.46, 161.25, 119.85, 86.59, 25.32. The spectroscopic data are in agreement with those previously reported[23].



2aj

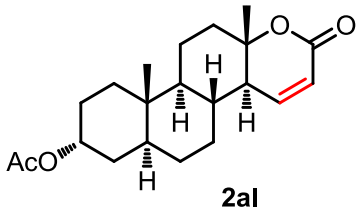
(R)-2,5,7,8-Tetramethyl-2-((4R,8R)-4,8,12-trimethyltridecyl)chroman-6-yl 4-(6-oxo-3,6-dihydro-2*H*-pyran-2-yl)butanoate (2aj). Isolated yield = 43% on 0.2 mmol scale; colorless oil; R_f = 0.35 (Hexane: Acetone = 5:1) **^{1}H NMR (400 MHz, $CDCl_3$)** δ 6.91-6.87 (m, 1H), 6.06-6.03 (m, 1H), 4.51-4.48 (s, 1H), 2.67 (d, *J* = 6.8 Hz, 2H), 2.59 (d, *J* = 6.8 Hz, 2H), 2.39-2.36 (m, 2H), 2.09 (s, 3H), 2.00 (s, 3H), 1.96 (s, 3H), 1.93-1.74 (m, 5H), 1.58-1.48 (m, 4H), 1.45-1.32 (m, 5H), 1.28-1.23 (m, 10H), 1.17-1.03 (m, 6H), 0.87-0.84 (m, 12H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.74, 164.26, 149.39, 144.88, 140.36, 126.52, 124.78, 123.03, 121.45, 117.37, 77.44, 75.03, 40.40, 39.69, 39.34, 37.42, 37.26, 34.25, 33.45, 32.77, 32.68, 30.98, 29.27, 27.95, 24.78, 24.42, 24.07, 23.71, 22.70, 22.61, 21.00, 20.57, 20.40, 19.72, 19.63, 13.01, 12.16, 11.80. **IR (neat):** 2955, 2927, 2868, 1751, 1724, 1461, 1416, 1378, 1334, 1249, 1140, 1105, 1083, 1064, 959, 917, 816, 737, 553 cm^{-1}. **HRMS (ESI)** clacd for $C_{38}H_{61}O_5$ $[M+H]^+$: 597.4514, found 597.4519.



2ak

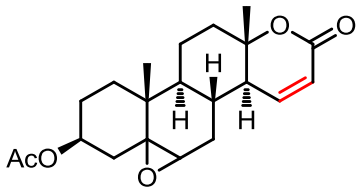
(3S,8S,9S,10R,13R,14S,17R)-10,13-Dimethyl-17-((*R*)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1*H*-cyclopenta[*a*]phenanthren-3-yl 4-(6-oxo-3,6-dihydro-2*H*-pyran-2-yl)butanoate (2ak). Isolated yield = 56% on 0.2

mmol scale; colorless oil; R_f = 0.35 (Hexane: Acetone = 5:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 6.91-6.86 (m, 1H), 6.03 (dt, *J* = 9.8, 1.8 Hz, 1H), 5.37 (d, *J* = 5.2 Hz, 1H), 4.66-4.58 (m, 1H), 4.48-4.41 (m, 1H), 2.37-2.30 (m, 6H), 2.04-1.94 (m, 2H), 1.90-1.72 (m, 7H), 1.61-1.48 (m, 8H), 1.36-1.10 (m, 11H), 1.02-0.98 (m, 5H), 0.91 (d, *J* = 6.4 Hz, 3H), 0.86 (dd, *J* = 6.4, 1.6 Hz, 6H), 0.68 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 172.51, 164.27, 144.88, 139.55, 122.65, 121.41, 77.46, 73.98, 56.64, 56.08, 49.97, 42.27, 39.68, 39.47, 38.10, 36.93, 36.55, 36.14, 35.75, 34.07, 31.86, 31.81, 29.26, 28.19, 27.98, 27.76, 24.24, 23.78, 22.79, 22.53, 20.99, 20.33, 19.28, 18.68, 11.82. **IR (neat):** 2945, 2904, 2869, 2850, 1730, 1467, 1439, 1381, 1366, 1253, 1177, 1144, 1085, 1030, 959, 815, 736 cm^{-1}. **HRMS (ESI)** clacd for $C_{36}H_{57}O_4$ $[M+H]^+$: 575.4070, found 575.4080.



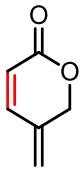
2al

(4aS,4bR,6aS,8R,10aS,10bS,12aS)-10a,12a-Dimethyl-2-oxo-4a,4b,5,6,6a,7,8,9,10, 10a,10b,11,12,12a-tetradecahydro-2*H*-naphtho[2,1-*f*]chromen-8-yl acetate (2al). 20 mol% ^{i}PrPPh$_2$ was used instead of 20 mol% CyPPh$_2$. Isolated yield = 75% on 0.2 mmol scale; white solid. M.p. 197-198 ^{o}C; R_f = 0.35 (Hexane: Acetone = 3:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 6.82 (d, *J* = 9.6 Hz, 1H), 6.03 (dd, *J* = 9.6, 3.2 Hz, 1H), 5.02 (s, 1H), 2.31 (d, *J* = 11.6 Hz, 1H), 2.14-1.95 (m, 5H), 1.88-1.71 (m, 3H), 1.66 (d, *J* = 13.6 Hz, 1H), 1.48 (d, *J* = 15.4 Hz, 4H), 1.36-1.11 (m, 8H), 1.04 (d, *J* = 12.0 Hz, 2H), 0.78 (s, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 170.51, 163.91, 145.32, 121.68, 83.35, 69.63, 53.61, 48.47, 39.63, 38.20, 35.87, 35.05, 32.54, 30.17, 27.75, 25.93, 21.45, 21.39, 18.45, 11.16. **IR (neat):** 2953, 2883, 2858, 1726, 1375, 1271, 1238, 1196, 1186, 1128, 1114, 1050, 1018, 974, 856, 833, 810, 736, 612 cm^{-1}. **HRMS (ESI)** clacd for $C_{21}H_{30}O_4Na$ $[M+Na]^+$: 369.2036, found 369.2035.



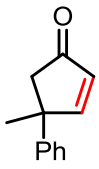
2am

(4aS,6aS,6bR,9S,12aR,12bS)-4a,6b-Dimethyl-3-oxo-3,4a,5,6,6a,6b,7,8,9,10,11a,12,12a,12b-tetradecahydrooxireno[2',3':4,4a]naphtho[2,1-*f*]chromen-9-yl acetate (2am). 20 mol% ^{i}PrPPh$_2$ was used instead of 20 mol% CyPPh$_2$. Isolated yield = 64% on 0.2 mmol scale; white solid. M.p. 148-149 ^{o}C; R_f = 0.3 (Hexane: Acetone = 3:1); **^{1}H NMR (400 MHz, CDCl$_3$)** δ 6.68 (d, *J* = 9.8 Hz, 1H), 6.04 (dd, *J* = 9.8, 3.2 Hz, 1H), 4.95 (s, 1H), 2.98 (d, *J* = 4.4, 1H), 2.36-2.33 (m, 1H), 2.30-2.23 (s, 1H), 2.19-2.13 (m, 1H), 2.02 (s, 3H), 1.98-1.94 (m, 1H), 1.79-1.61 (m, 6H), 1.51-1.37 (m, 3H), 1.29-1.25 (m, 5H), 1.07 (s, 3H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 170.17, 163.66, 144.90, 122.33, 82.83, 70.88, 64.91, 58.06, 49.08, 42.00, 37.69, 35.73, 35.13, 31.84, 29.67, 27.61, 27.04, 21.30, 18.25, 15.66. **IR (neat):** 2950, 2874, 1732, 1468, 1440, 1382, 1366, 1284, 1246, 1122, 1098, 1036, 1001, 972, 929, 873, 817, 735, 711, 619, 510 cm^{-1}. **HRMS (ESI)** clacd for $C_{21}H_{28}O_5Na$ $[M+Na]^+$: 383.1829, found 383.1832.



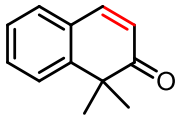
8

5-Methylene-5,6-dihydro-2*H*-pyran-2-one (8). Isolated as a inseparable mixture with 62% of the starting material. The yield of **8** was determined to be 21% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: Acetone = 4:1) and 62% of **8**; **^{1}H NMR (400 MHz, CDCl$_3$)** δ 7.07 (d, *J* = 8.0 Hz, 1H), 5.98 (d, *J* = 8.0 Hz, 1H), 5.38 (d, *J* = 4.8 Hz, 2H), 5.01 (t, *J* = 1.2 Hz, 2H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 163.13, 143.34, 134.86, 119.72, 118.48, 69.82. The spectroscopic data are in agreement with those previously reported[24].



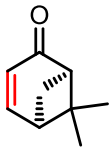
4a

4-Methyl-4-phenylcyclopent-2-enone (4a). Isolated yield = 52% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: Ethyl acetate = 10:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.69 (d, *J* = 5.6 Hz, 1H), 7.37-7.33 (m, 2H), 7.28-7.25 (m, 3H), 6.21 (d, *J* = 5.6 Hz, 1H), 2.61 (q, *J* = 18.6 Hz, 2H), 1.64 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 209.77, 171.34, 145.23, 131.67, 128.73, 126.77, 125.66, 51.87, 48.24, 27.15. The spectroscopic data are in agreement with those previously reported[25].



4b

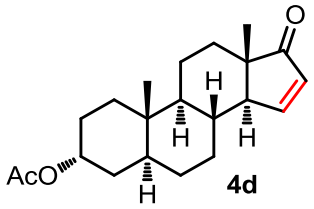
1,1-Dimethylnaphthalen-2(1*H*)-one (4b). Isolated yield = 60% on 0.2 mmol scale; colorless oil; R_f = 0.35 (Hexane: Ethyl acetate = 10:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.47-7.41 (m, 3H), 7.33-7.26 (m, 2H), 6.17 (d, *J* = 9.6 Hz, 1H), 1.47 (s, 6H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 204.55, 147.66, 144.79, 130.05, 129.44, 128.68, 126.67, 126.23, 124.51, 47.43, 27.84. The spectroscopic data are in agreement with those previously reported[26].



4c

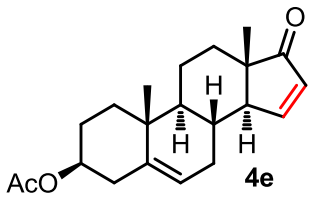
(1R,5R)-6,6-Dimethylbicyclo[3.1.1]hept-3-en-2-one (4c). Isolated yield = 57% on 0.2 mmol scale; colorless oil; R_f = 0.5 (Hexane: Ethyl acetate = 10:1); **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.55-7.51 (m, 1H), 5.96 (d, *J* = 9.0 Hz, 1H), 2.87-2.83 (m, 1H), 2.72 (t, *J* = 5.5 Hz, 1H), 2.62-2.60 (m, 1H), 2.14 (d, *J* = 9.5 Hz, 1H), 1.52 (s, 3H), 1.04 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 204.35, 157.13, 125.90, 58.84, 55.18, 44.01, 42.15, 26.69, 22.45. The spectroscopic data are in agreement with those previously

reported[27].



4d

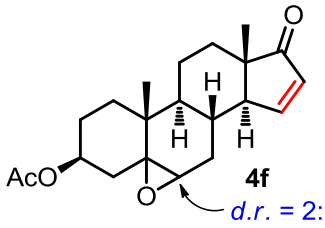
(3R,5S,8R,9S,10S,13S,14S)-10,13-Dimethyl-17-oxo-2,3,4,5,6,7,8,9,10,11,12,13,14,17-tetradecahydro-1*H*-cyclopenta[*a*]phenanthren-3-yl acetate (4d). 20 mol% ^{i}PrPPh$_2$ was used instead of 20 mol% CyPPh$_2$. Isolated yield = 62% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, CDCl$_3$)** δ 7.54 (d, *J* = 5.2 Hz, 1H), 6.04 (dd, *J* = 5.8, 3.2 Hz, 1H), 5.04 (s, 1H), 2.31 (d, *J* = 11.6 Hz, 1H), 2.07 (s, 3H), 2.03-1.99 (m, 1H), 1.89-1.67 (m, 5H), 1.58-1.50 (m, 5H), 1.34-1.27 (m, 3H), 1.17-1.13 (m, 1H), 1.08 (s, 3H), 0.97-0.83 (m, 5H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 213.30, 170.62, 158.59, 131.64, 69.82, 56.99, 55.54, 51.13, 40.25, 36.16, 32.76, 32.56, 32.30, 30.65, 29.11, 27.86, 25.99, 21.52, 20.71, 19.77, 11.37. **IR (neat):** 2933, 2858, 1733, 1712, 1448, 1367, 1259, 1243, 1161, 1069, 1026, 976, 902, 853, 817, 735, 707, 618, 558. cm^{-1}. **HRMS (ESI)** clacd for $C_{21}H_{31}O_3$ $[M+H]^+$: 331.2268, found 331.2264.



4e

(3S,8R,9S,10R,13S,14S)-10,13-Dimethyl-17-oxo-2,3,4,7,8,9,10,11,12,13,14,17-dodecahydro-1*H*-cyclopenta[*a*]phenanthren-3-yl acetate (4e). Isolated yield = 55% on 0.2 mmol scale; colorless oil; R_f = 0.45 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, CDCl$_3$)** δ 7.50 (d, *J* = 5.6 Hz, 1H), 6.05 (dd, *J* = 5.6, 3.2 Hz, 1H), 5.44-5.43 (m, 1H), 4.66-4.58 (m, 1H), 2.38-2.26 (m, 4H), 2.04 (s, 3H), 1.92-1.84 (m, 4H), 1.79-1.56 (m, 5H), 1.21-1.12 (m, 2H), 1.10 (s, 3H), 1.09 (s, 3H). **^{13}C NMR (101 MHz, CDCl$_3$)** δ 213.02, 170.50, 158.46, 140.45, 131.92, 121.30, 73.59, 57.21, 51.17, 50.68, 38.07,

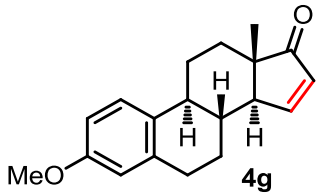
36.91, 36.74, 30.60, 29.02, 28.80, 27.63, 21.40, 20.11, 19.95, 19.28. The spectroscopic data are in agreement with those previously reported[28].



4f

d.r. = 2:1 from **3f**

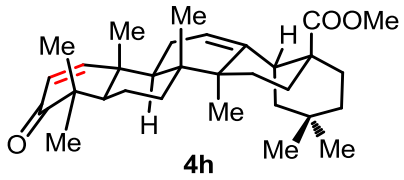
(3S,6aR,6bS,9aS,11aS,11bR)-9a,11b-Dimethyl-9-oxo-1,2,3,4,5a,6,6a,6b,9,9a,10,11, 11a,11b-tetradecahydrocyclopenta[1,2]phenanthro[8a,9-*b*]oxiren-3-yl acetate (4f). Isolated yield = 55% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: Ethyl acetate = 3:1); **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.51-7.45 (m, 1H), 6.05-6.04 (m, 1H), 4.98-4.76 (m, 1H), 3.19-2.98 (m, 1H), 2.40-2.29 (m, 1H), 2.24-2.12 (m, 2H), 2.04-2.03 (m, 4H), 1.93-1.67 (m, 5H), 1.63-1.60 (m, 1H), 1.56-1.33 (m, 5H), 1.15-1.08 (m, 3H), 1.04-1.02 (m, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 212.66, 212.55, 170.51, 170.19, 158.02, 157.81, 132.11, 131.92, 71.03, 71.01, 65.27, 62.91, 62.69, 58.31, 57.29, 56.51, 52.35, 50.80, 50.72, 43.39, 37.90, 36.62, 35.96, 35.48, 35.39, 31.89, 31.38, 29.03, 28.67, 27.65, 27.13, 27.08, 26.85, 26.82, 21.30, 21.28, 20.62, 20.28, 19.94, 19.70, 17.05, 15.92. **IR (neat):** 2944, 2871, 1731, 1711, 1440, 1368, 1244, 1075, 1034, 971, 909, 870, 817, 735, 700, 609, 527 cm^{-1}. **HRMS (ESI)** clacd for $C_{21}H_{28}O_4Na$ $[M+Na]^+$: 367.1879, found 367.1879.



4g

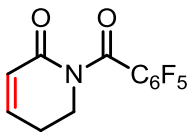
(8R,9S,13S,14S)-3-methoxy-13-methyl-7,8,9,11,12,13-hexahydro-6*H*-cyclopenta[*a*]phenanthren-17(14*H*)-one (4g). Isolated yield = 41% on 0.2 mmol scale; light yellow solid; R_f = 0.4 (Hexane: Ethyl acetate = 5:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.63 (d, *J* = 4.8 Hz, 1H), 7.21 (d, *J* = 8.8 Hz, 1H), 6.73 (dd, *J* = 8.4, 2.8 Hz, 1H), 6.67 (d, *J* = 2.4 Hz, 1H), 6.09 (dd, *J* = 6.4, 3.2 Hz, 1H), 3.79 (s, 3H), 2.97-2.95 (m, 2H),

2.53-2.33 (m, 3H), 2.22-2.17 (m, 1H), 2.03-2.00 (m, 1H), 1.84-1.68 (m, 3H), 1.59-1.54 (m, 1H), 1.11 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 213.00, 158.16, 157.69, 137.47, 131.94, 131.88, 126.04, 113.95, 111.54, 56.11, 55.22, 51.48, 45.12, 35.59, 29.29, 29.22, 26.70, 25.45, 20.96. The spectroscopic data are in agreement with those previously reported[27].



4h

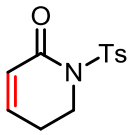
(4aS,6aS,6bR,8aR,12aR,12bR,14bS)-Methyl 2,2,6a,6b,9,9,12a-heptamethyl-10-oxo-1,2,3,4,4a,5,6,6a,6b,7,8,8a,9,10,12a,12b,13,14*b*-octadecahydropicene-4a-carboxylate (4h). Isolated yield = 45% on 0.2 mmol scale; white solid; R_f = 0.4 (Hexane: Ethyl acetate = 5:1); **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.04 (d, *J* = 10.0 Hz, 1H), 5.80 (d, *J* = 10.0 Hz, 1H), 5.36 (s, 1H), 3.64 (s, 3H), 2.91-2.88 (m, 1H), 2.12-2.09 (m, 2H), 1.99-1.96 (m, 2H), 1.86-1.84 (m, 1H), 1.71-1.62 (m, 4H), 1.57-1.51 (m, 4H), 1.39-1.31 (m, 3H), 1.21-1.16 (m, 2H), 1.16-1.15 (m, 9H), 1.09 (s, 3H), 0.94 (s, 3H), 0.91 (s, 3H), 0.82 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 205.31, 178.18, 159.07, 144.27, 125.03, 121.65, 53.38, 51.57, 46.76, 45.63, 44.52, 41.98, 41.72, 41.49, 40.02, 39.44, 33.82, 33.08, 32.42, 32.26, 30.68, 27.74, 27.63, 25.79, 23.58, 23.29, 22.98, 21.61, 18.86, 18.62, 17.31. The spectroscopic data are in agreement with those previously reported[27].



6a

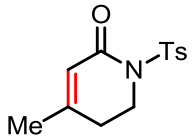
1-(Perfluorobenzoyl)-5,6-dihydropyridin-2(1*H*)-one (6a). 20 mol% ^{i}PrPPh$_2$ was used instead of 20 mol% CyPPh$_2$. Isolated yield = 48% on 0.2 mmol scale; colorless oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (500 MHz, $CDCl_3$)** δ 6.98 (dt, *J* = 10.0, 4.5 Hz, 1H), 5.90 (dt, *J* = 9.5, 2.0 Hz, 1H), 4.07 (t, *J* = 6.5 Hz, 2H), 2.54-2.50

(m, 2H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 163.93, 159.44, 147.08, 144.07-143.85 (m), 143.15-142.81 (m), 142.05-141.79 (m), 141.11-140.78 (m), 138.59-138.31 (m), 136.58-136.31 (m), 124.46, 113.77-113.43 (m), 41.74, 24.58. The spectroscopic data are in agreement with those previously reported[13].



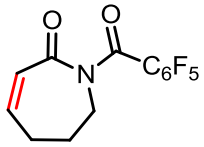
6b

1-Tosyl-5,6-dihydropyridin-2(1*H*)-one (6b). 20 mol% ^{i}PrPPh$_2$ was used instead of 20 mol% CyPPh$_2$. Isolated yield = 62% on 0.2 mmol scale; white solid; R_f = 0.25 (Hexane: Acetone = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.96-7.93 (m, 2H), 7.34-7.32 (m, 2H), 6.82 (dt, *J* = 9.6, 4.4 Hz, 1H), 5.86 (dt, *J* = 9.6, 2.0 Hz, 1H), 4.07 (t, *J* = 6.4 Hz, 2H), 2.58-2.54 (m, 2H), 2.44 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 162.94, 144.71, 144.56, 135.78, 129.33, 128.45, 125.01, 43.97, 25.28, 21.59. The spectroscopic data are in agreement with those previously reported[13].



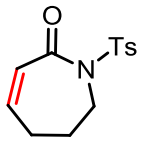
6d

4-Methyl-1-tosyl-5,6-dihydropyridin-2(1*H*)-one (6d). 20 mol% ^{i}PrPPh$_2$ was used instead of 20 mol% CyPPh$_2$. Isolated yield = 59% on 0.2 mmol scale; white solid; M.p. 120-121 ^{o}C; R_f = 0.25 (Hexane: Acetone = 5:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.91 (d, *J* = 8.4 Hz, 2H), 7.30 (d, *J* = 8.4 Hz, 2H), 5.63 (t, *J* = 1.2 Hz, 1H), 4.03 (t, *J* = 6.4 Hz, 2H), 2.47 (t, *J* = 6.4 Hz, 2H), 2.42 (s, 3H), 1.94 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 163.25, 156.85, 144.51, 135.93, 129.26, 128.37, 120.40, 43.74, 30.26, 22.87, 21.55. The spectroscopic data are in agreement with those previously reported[13].



6e

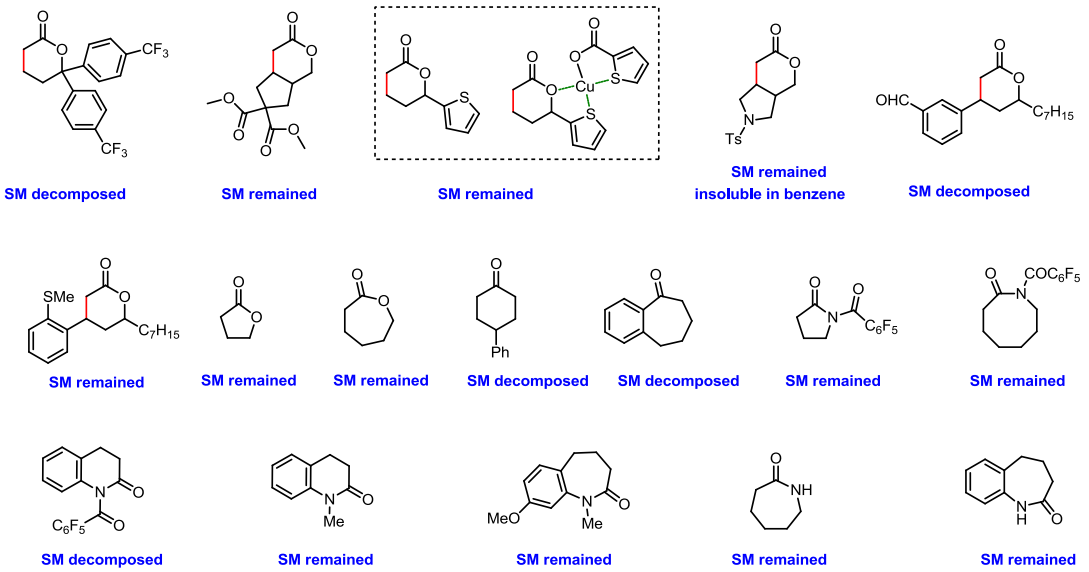
1-(Perfluorobenzoyl)-6,7-dihydro-1*H*-azepin-2(5*H*)-one (6e). 20 mol% ^{i}PrPPh$_2$ was used instead of 20 mol% CyPPh$_2$ and 100 ^{o}C was employed. Isolated yield = 48% on 0.2 mmol scale; colorless oil; R_f = 0.4 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (500 MHz, CDCl$_3$)** δ 6.65 (dt, *J* = 11.5, 6.5 Hz, 1H), 6.01 (dt, *J* = 12.0, 1.0 Hz, 1H), 4.06 (t, *J* = 6.0 Hz, 5.5, 2H), 2.54-2.50 (m, 2H), 2.11-2.05 (m, 2H). **^{13}C NMR (125 MHz, CDCl$_3$)** δ 169.90, 158.88, 144.38, 143.92-143.67 (m), 143.05-142.76 (m), 141.91-141.68 (m), 141.11-140.72 (m), 138.63-138.36 (m), 136.63-136.35 (m), 126.43, 113.46-113.16 (m), 41.54, 25.64, 25.37. The spectroscopic data are in agreement with those previously reported[13].



6f

1-Tosyl-6,7-dihydro-1*H*-azepin-2(5*H*)-one (6f). 20 mol% ^{i}PrPPh$_2$ was used instead of 20 mol% CyPPh$_2$ and 100 ^{o}C was employed. Isolated yield = 42% on 0.2 mmol scale; colorless oil; R_f = 0.3 (Hexane: acetone = 3:1); **^{1}H NMR (500 MHz, CDCl$_3$)** δ 7.92 (d, *J* = 8.0 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 6.44-6.39 (m, 1H), 5.87 (d, *J* = 11.5 Hz, 1H), 3.95-3.92 (m, 2H), 2.44-2.40 (m, 5H), 2.12-2.07 (m, 2H). **^{13}C NMR (125 MHz, CDCl$_3$)** δ 168.12, 144.58, 141.96, 136.31, 129.29, 128.49, 126.52, 44.63, 28.08, 26.05, 21.60. The spectroscopic data are in agreement with those previously reported[29].

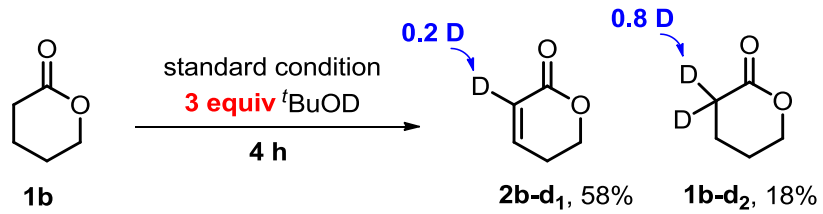
Unsuccessful Examples



SM: starting material

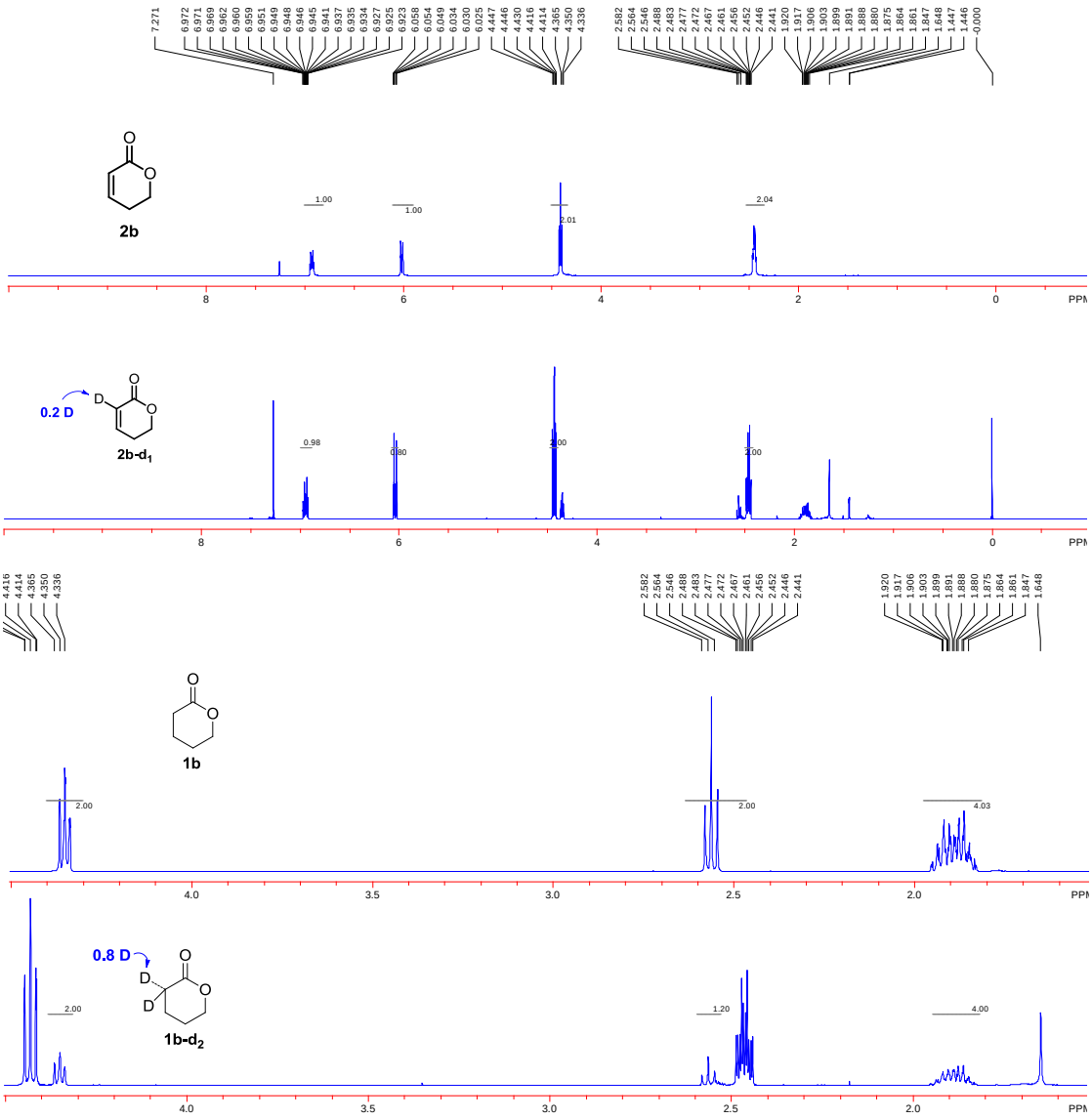
Experimental Procedures for Mechanistic Studies

Typical procedure for the deuterium-transfer experiment.

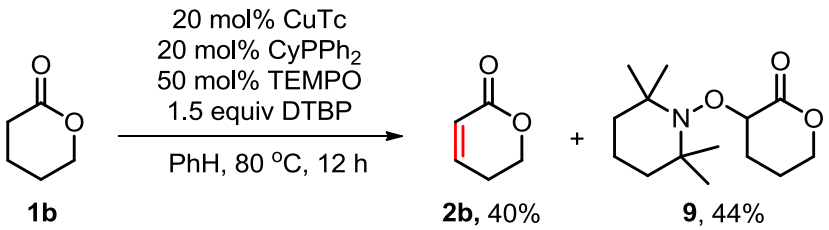


An oven-dried 4.0 mL vial was charged with tetrahydro-2*H*-pyran-2-one **(1b)** (20 mg, 0.2 mmol) and CuTc (7.6 mg, 0.04 mmol, 0.2 equiv). It was directly transferred in a nitrogen-filled glovebox with caps. In the glovebox, $CyPPh_2$ (10.7 mg, 0.04 mmol, 0.2 equiv), ^{t}BuOD (45 mg, 0.6 mmol, 3 equiv) and 2 mL of degassed benzene were added to the vial. To the resulting solution was added DTBP (^{t}BuO^{t}Bu) (43.9 mg, 0.3 mmol, 1.5 equiv). The vial was tightly sealed, transferred out of glovebox and stirred on a pie-block at 80 ^{o}C for 4 hrs. After completion of the reaction, the solvent was evaporated under the reduced pressure and the residue was purified by column

chromatography on silica gel (hexane: Acetone = 3:1) to afford the mixture of **2b-d$_1$** and **1b-d$_2$** (15.23 mg) as a colorless oil.

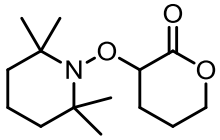


Typical procedure for the synthesis of 9.



An oven-dried 4.0 mL vial was charged with tetrahydro-2*H*-pyran-2-one **(1b)** (20 mg,

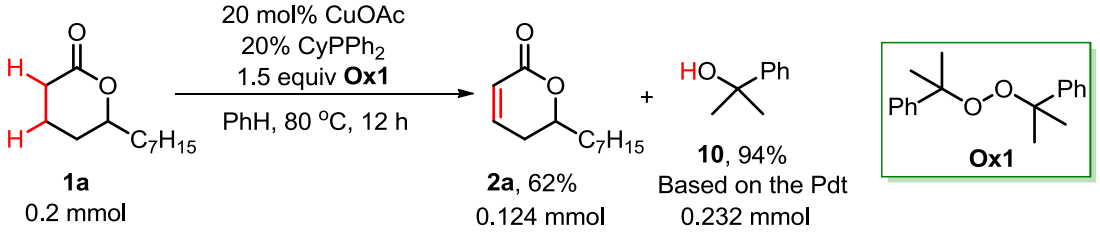
0.2 mmol) and CuTc (7.6 mg, 0.04 mmol, 0.2 equiv) and TEMPO (15.6 mg, 0.1 mmol, 0.5 equiv). It was directly transferred in a nitrogen-filled glovebox with caps. In the glovebox, $CyPPh_2$ (10.7 mg, 0.04 mmol, 0.2 equiv) and 2 mL of degassed benzene were added to the vial. To the resulting solution was added DTBP ($^tBuOO^tBu$) (43.9 mg, 0.3 mmol, 1.5 equiv). The vial was tightly sealed, transferred out of glovebox and stirred on a pie-block at 80 ^oC for 12 hrs. After completion of the reaction, the solvent was evaporated under the reduced pressure and the residue was purified by column chromatography on silica gel (hexane: Acetone = 3:1) to afford **9** (22.6 mg, 44%) as a colorless oil and **2b** as a colorless oil (7.8 mg, 40%).



9

3-((2,2,6,6-Tetramethylpiperidin-1-yl)oxy)tetrahydro-2*H*-pyran-2-one (9). Isolated yield = 44% on 0.2 mmol scale (50 mol% TEMPO was used); colorless oil; R_f = 0.4 (Hexane: Acetone = 3:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 4.56-4.50 (m, 1H), 4.43-4.40 (m, 1H), 4.29-4.24 (m, 1H), 2.19-2.11 (m, 2H), 1.95-1.90 (m, 2H), 1.46-1.10 (m, 18H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 171.33, 80.57, 66.74, 60.26, 59.95, 40.02, 33.79, 33.14, 25.08, 20.59, 20.08, 19.87, 17.02. **IR (neat):** 2974, 2932, 2878, 1754, 1471, 1458, 1376, 1362, 1289, 1245, 1134, 1086, 1053, 971, 922, 834, 702 cm^{-1}. **HRMS (ESI)** clacd for $C_{14}H_{25}NO_3Na$ $[M+Na]^+$: 278.1726, found 278.1735.

Typical procedure for the synthesis of 10.

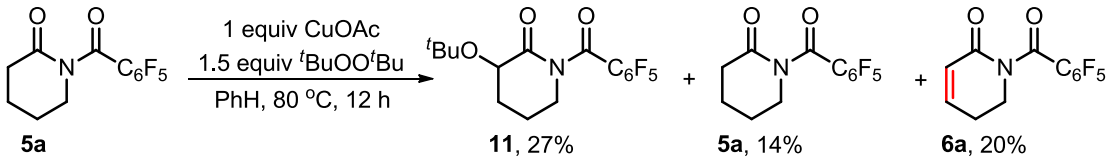


An oven-dried 4.0 mL vial was charged with 6-heptyltetrahydro-2*H*-pyran-2-one **(1a)** (39.6 mg, 0.2 mmol), CuOAc (4.8 mg, 0.04 mmol, 0.2 equiv). It was directly

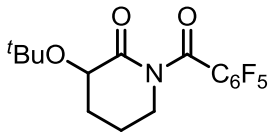
transferred in a nitrogen-filled glovebox with caps. In the glovebox, $CyPPh_2$ (10.7 mg, 0.04 mmol, 0.2 equiv) and 2 mL of benzene were added to the vial. Then, the oxidant DCP (dicumyl peroxide) (81.1 mg, 0.3 mmol, 1.5 equiv) was added to the vial. The vial was tightly sealed, transferred out of glovebox and stirred on a pie-block at 80 ^oC for 12 hrs. After completion of the reaction, the solvent was evaporated under the reduced pressure and the residue was purified by column chromatography on silica gel (hexane: Acetone = 3:1) to afford **10** (31.6 mg, 94% based on **2a**) as a colorless oil and **2a** as a colorless oil (24.5 mg, 62%).

2-phenylpropan-2-ol (10). Isolated yield = 94% on 0.2 mmol scale; light yellow oil; R_f = 0.3 (Hexane: Ethyl acetate = 5:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.50-7.47 (m, 2H), 7.36-7.32(m, 2H), 7.26-7.21 (m, 1H), 1.88 (s, 1H), 1.58 (s, 6H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 149.07, 128.17, 126.63, 124.34, 72.47, 31.69. The spectroscopic data are in agreement with those previously reported[30].

Typical procedure for the synthesis of 11.



An oven-dried 4.0 mL vial was charged with 1-(perfluorobenzoyl)piperidin-2-one **(5a)** (58.6 mg, 0.2 mmol) and CuOAc (24 mg, 0.2 mmol, 1.0 equiv). It was directly transferred in a nitrogen-filled glovebox with caps. In the glovebox, 2 mL of benzene were added to the vial. To the resulting solution was added DTBP (^{t}BuOO^{t}Bu) (43.9 mg, 0.3 mmol, 1.5 equiv). The vial was tightly sealed, transferred out of glovebox and stirred on a pie-block at 80 ^oC for 12 hrs. After completion of the reaction, the solvent was evaporated under the reduced pressure and the residue was purified by column chromatography on silica gel (hexane: Ethyl acetate = 4:1) to afford **11** (20 mg, 27%) as a colorless oil , **5a** as a light yellow oil (8.4 mg, 14%) and **6a** as a colorless oil (11.5 mg, 20%).



11

3-(Tert-butoxy)-1-(perfluorobenzoyl)piperidin-2-one (11). Isolated yield = 27% on 0.2 mmol scale; light yellow oil; R_f = 0.3 (Hexane: Ethyl acetate = 4:1); **^{1}H NMR (400 MHz, $CDCl_3$)** δ 4.16-4.13 (m, 1H), 3.96-3.91 (m, 2H), 2.12-2.06 (m, 2H), 1.97-1.92 (m, 2H), 1.20 (s, 9H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 174.08, 159.81, 75.92, 69.95, 43.74, 29.76, 27.80, 19.74. **IR (neat):** 2977, 2942, 2882, 1729, 1690, 1656, 1507, 1429, 1369, 1333, 1293, 1245, 1157, 1085, 1026, 994, 962, 912, 819, 768, 724, 696, 650, 581 cm^{-1}. **HRMS (ESI)** clacd for $C_{16}H_{16}F_5NO_3Na$ $[M+Na]^+$: 388.0942, found 388.0947.

Determination of the Kinetic Dependence of Reaction Components by Initial Rate Methods Using 1b as the Model Substrate

General Methods: The reactions were conducted for specific times and then cooled down and immediately filtered by short column on silica gel and concentrated. Then CH_2Br_2 as an internal standard was added to the reaction mixture and the mixture was analyzed by ^{1}H NMR. The initial rate was determined from the data points of approximately first 20% conversion of the limiting reagents.

Kinetic Dependence on CuL (CuTc-$CyPPh_2$): Reactions were performed with tetrahydro-2*H*-pyran-2-one **(1b)** (20 mg, 0.2 mmol), CuTc (5.7-11.4 mg, 0.03-0.06 mmol, 0.15-0.3 equiv), $CyPPh_2$ (8-16.1 mg, 0.03-0.06 mmol, 0.15-0.3 equiv), 2 mL of degassed benzene and the oxidant DTBP (^{t}BuOO^{t}Bu) (43.9 mg, 0.3 mmol, 1.5 equiv) following the general procedure of the Cu-catalyzed desaturation reaction.

[CuTc+CyPPh$_2$] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.015	20	0.003	0.00027
	30	0.006	
	40	0.008	
	50	0.011	
	60	0.014	

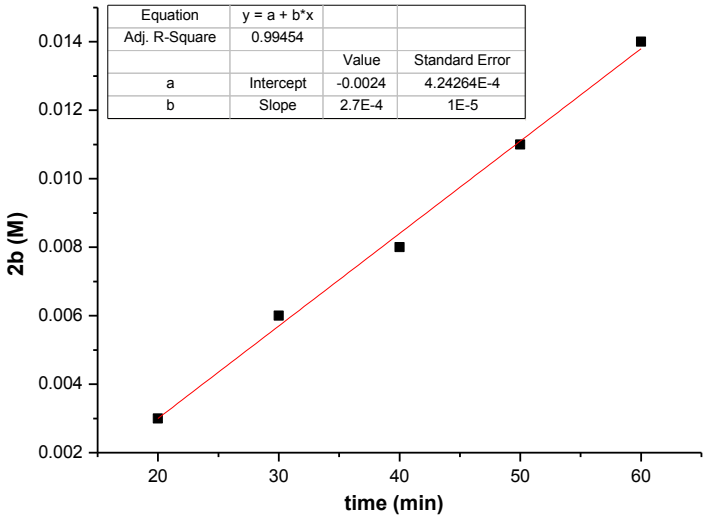


Figure S1. Initial rate data for the desaturation of **1b** to **2b** at CuL (0.015M).

[CuTc+CyPPh$_2$] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.02	20	0.004	0.00033
	30	0.007	
	40	0.01	
	50	0.014	
	60	0.017	

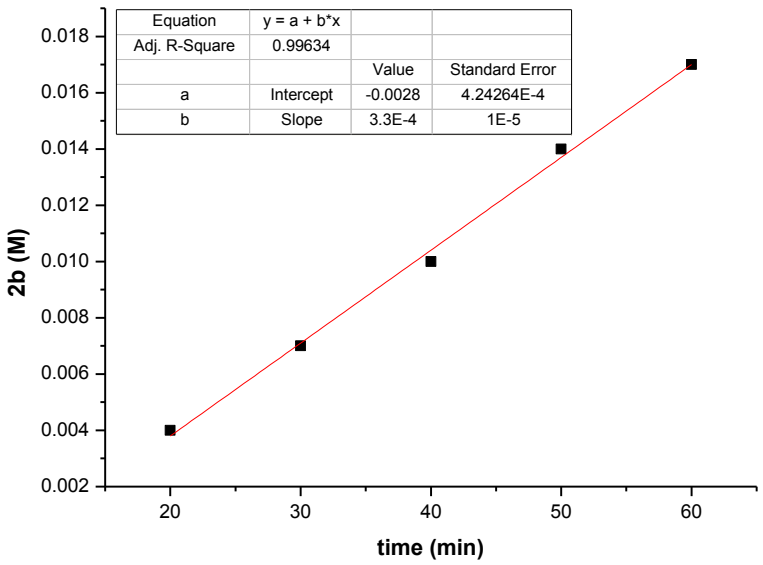


Figure S2. Initial rate data for the desaturation of **1b** to **2b** at CuL (0.02 M).

[CuTc+CyPPh$_2$] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.025	20	0.006	0.00041
	30	0.009	
	40	0.014	
	50	0.018	

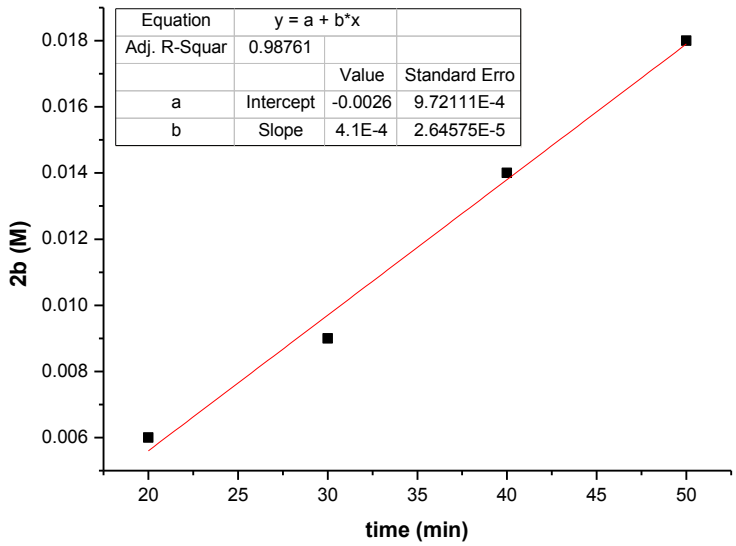


Figure S3. Initial rate data for the desaturation of **1b** to **2b** at CuL (0.025M).

[CuTc+CyPPh$_2$] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.03	20	0.008	0.00048
	30	0.012	
	40	0.018	
	50	0.022	

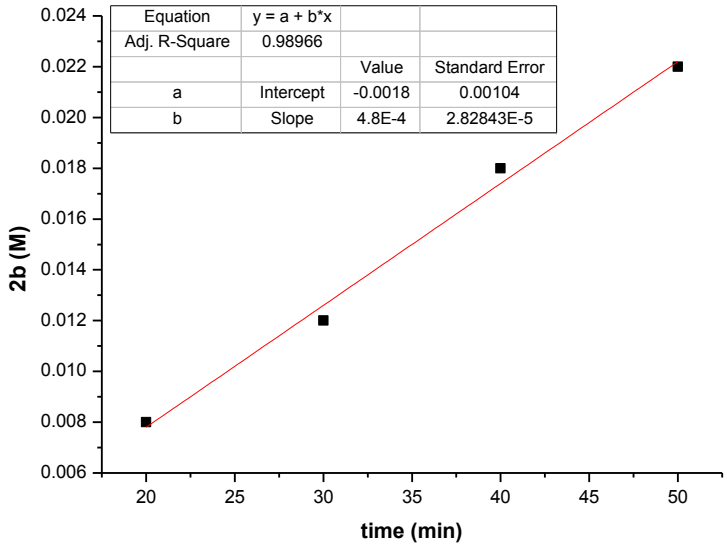


Figure S4. Initial rate data for the desaturation of **1b** to **2b** at CuL (0.03M).

[CuTc-CyPPh$_2$] (M)	initial rate (M/min)
0.015	0.00027
0.02	0.00033
0.025	0.00041
0.03	0.00048

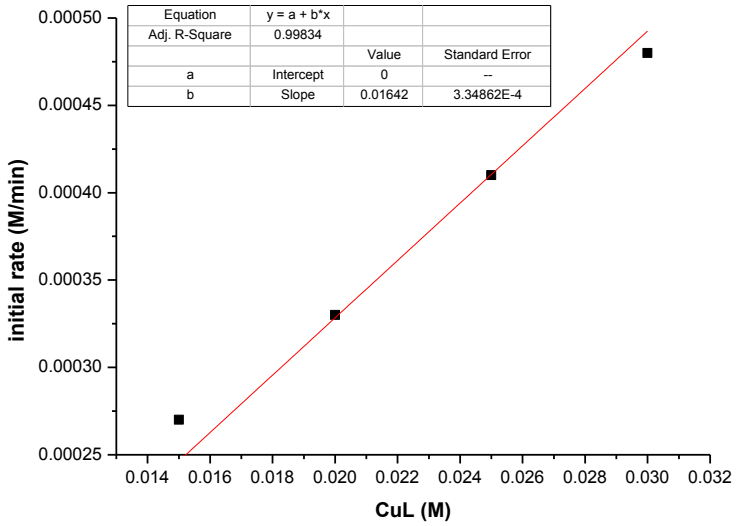
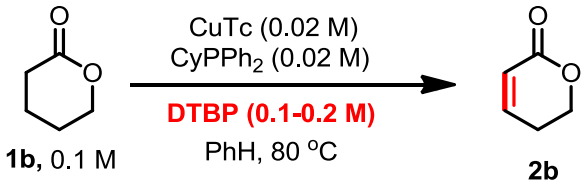


Figure S5. Plot of initial rate of δ-lactone desaturation at varying concentrations of **CuL**.

Kinetic Dependence on di-^{t}butyl peroxide (DTBP): Reactions were performed with tetrahydro-2*H*-pyran-2-one **(1b)** (20 mg, 0.2 mmol), CuTc (7.6 mg, 0.04 mmol, 0.2 equiv), $CyPPh_2$ (10.7 mg, 0.04 mmol, 0.2 equiv), 2 mL of degassed benzene and the oxidant DTBP (^{t}BuOO^{t}Bu) (29.2-58.5 mg, 0.2-0.4 mmol, 1.0-2.0 equiv) following the general procedure of the Cu-catalyzed desaturation reaction.



[DTBP] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.1	20	0	0.000235
	40	0.004	
	60	0.009	
	80	0.013	
	100	0.019	

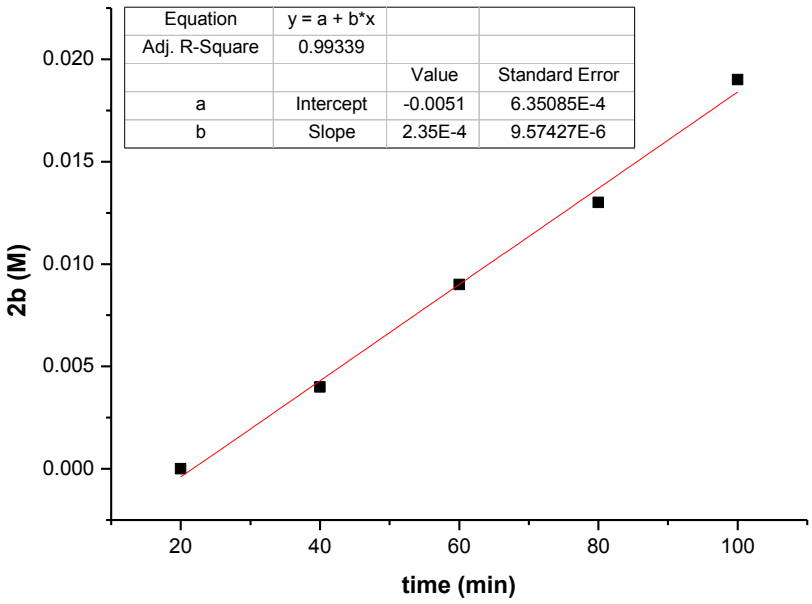


Figure S6. Initial rate data for the desaturation of **1b** to **2b** at DTBP (0.1M).

[DTBP] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.15	20	0.004	0.00033
	30	0.007	
	40	0.01	
	50	0.014	
	60	0.017	

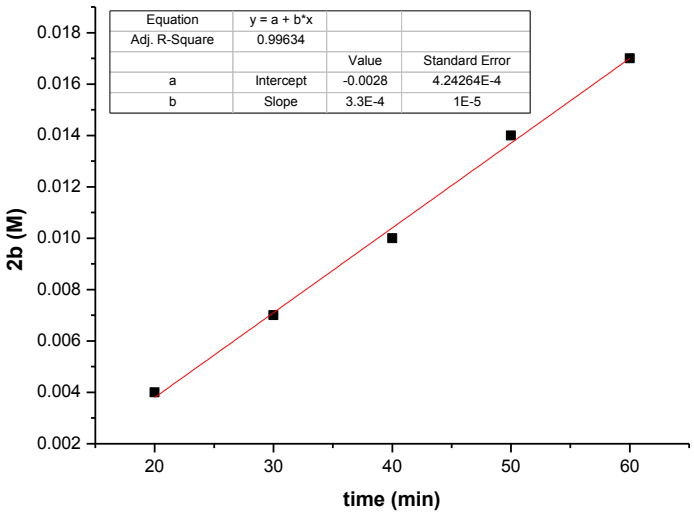


Figure S7. Initial rate data for the desaturation of **1b** to **2b** at DTBP (0.15M).

[DTBP] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.175	20	0.006	0.000390576
	35	0.011	
	45	0.015	
	50	0.018	

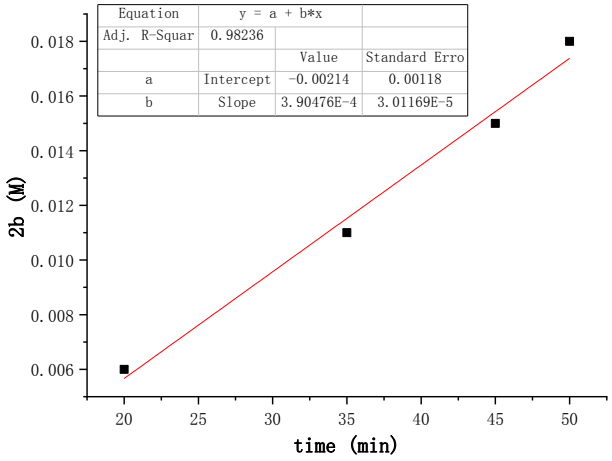


Figure S8. Initial rate data for the desaturation of **1b** to **2b** at DTBP (0.175M).

[DTBP] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.2	10	0.002	0.00044
	20	0.008	
	30	0.012	
	50	0.02	

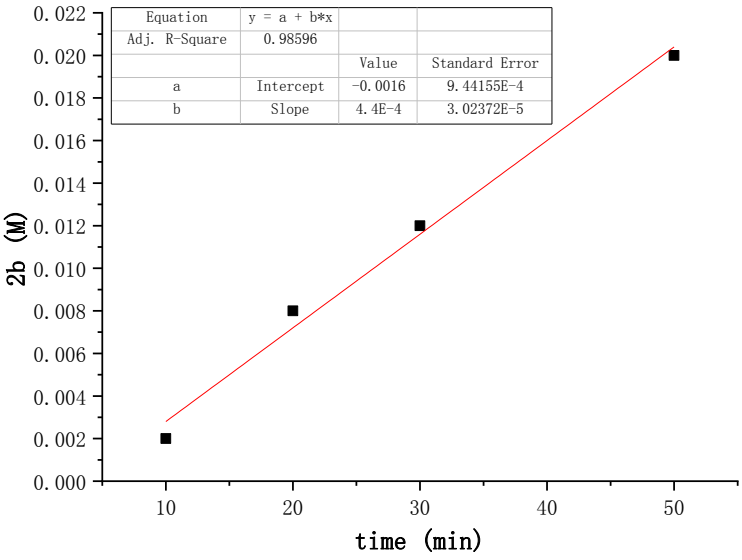


Figure S9. Initial rate data for the desaturation of **1b** to **2b** at DTBP (0.2M).

[DTBP] (M)	initial rate (M/min)
0.1	0.000235
0.15	0.00033
0.175	0.0003906
0.2	0.00044

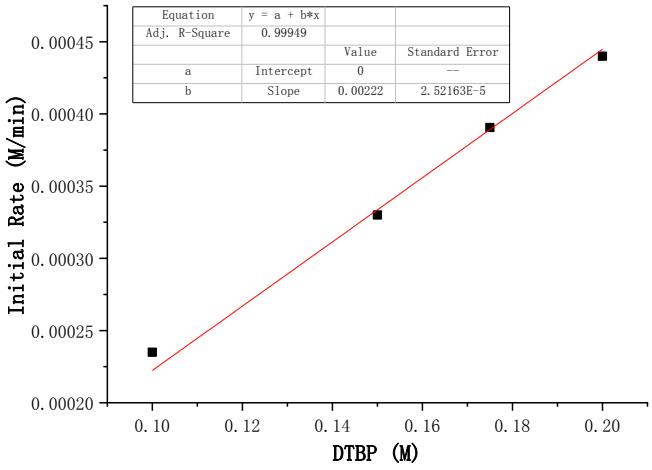
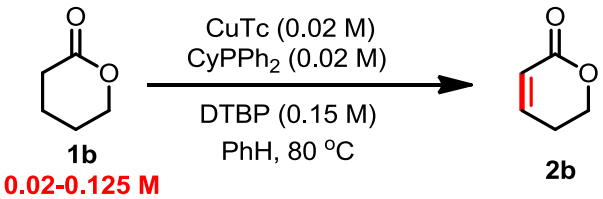


Figure S10. Plot of initial rate of δ-lactone desaturation at varying concentrations of DTBP

Kinetic Dependence on tetrahydro-2*H*-pyran-2-one (1b): Reactions were performed with tetrahydro-2*H*-pyran-2-one **(1b)** (4-25 mg, 0.1-0.25 mmol), CuTc (7.6 mg, 0.04 mmol, 0.2 equiv), $CyPPh_2$ (10.7 mg, 0.04 mmol, 0.2 equiv), 2 mL of degassed benzene and the oxidant DTBP ($^tBuOO^tBu$) (43.8 mg, 0.3 mmol, 1.5 equiv) following the general procedure of the Cu-catalyzed desaturation reaction.



[**2b**] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.02	10	0.00155	0.00017522
	15	0.002265	
	20	0.003181	
	25	0.004098	
	30	0.005014	

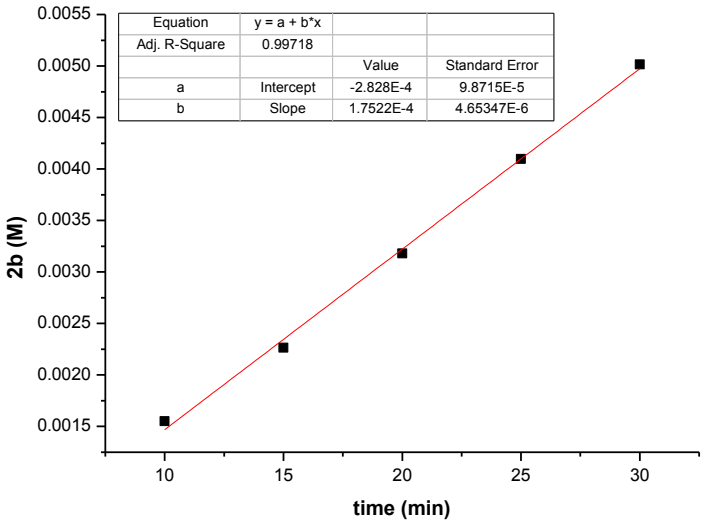


Figure S11. Initial rate data for the desaturation of **1b** to **2b** at **1b** (0.02M).

[**2b**] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.025	10	0.000825	0.000185
	20	0.002675	
	25	0.0036	
	35	0.00545	
	40	0.006375	

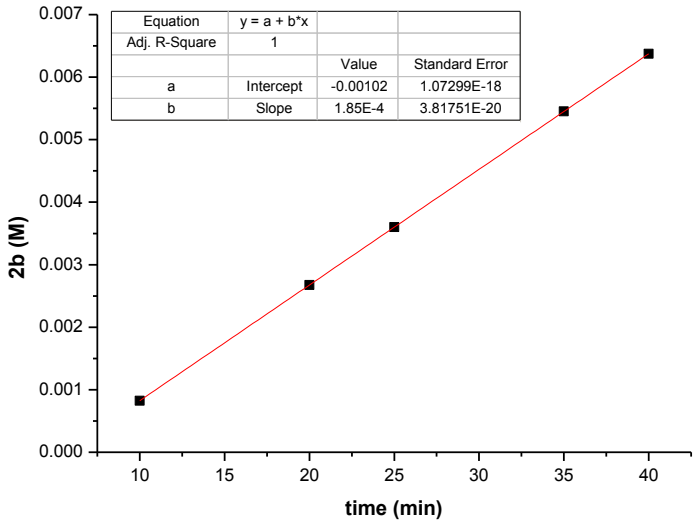


Figure S12. Initial rate data for the desaturation of **1b** to **2b** at **1b** (0.025M).

[**2b**] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.0333	10	0.002	0.000246838
	20	0.004	
	25	0.00533	
	30	0.007	
	35	0.008	

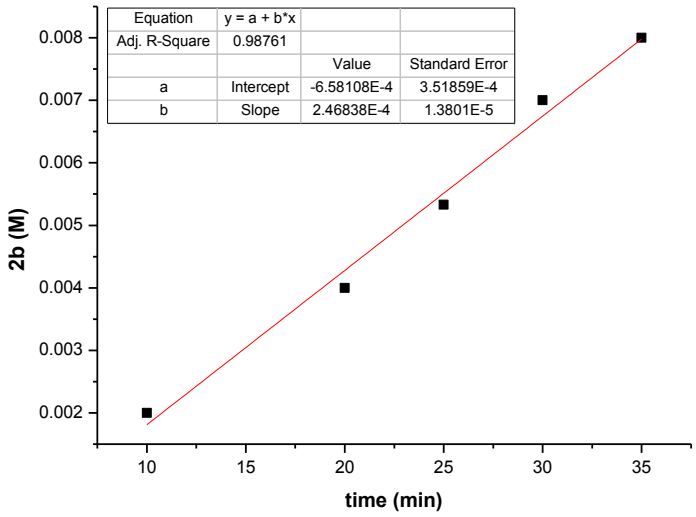


Figure S13. Initial rate data for the desaturation of **1b** to **2b** at **1b** (0.0333M).

[**2b**] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.05	20	0.0015	0.000255
	30	0.004	
	40	0.007	
	50	0.009	

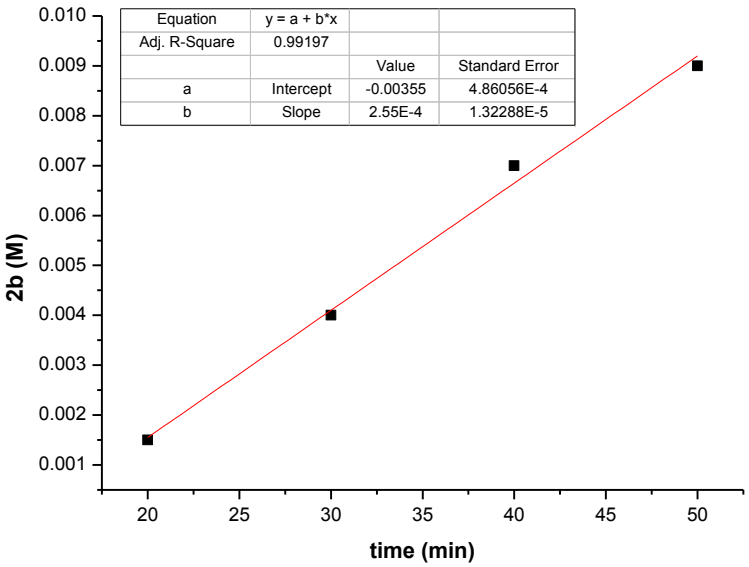


Figure S14. Initial rate data for the desaturation of **1b** to **2b** at **1b** (0.05M).

[**2b**] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.075	30	0.0045	0.0002475
	40	0.0075	
	50	0.00975	
	60	0.012	

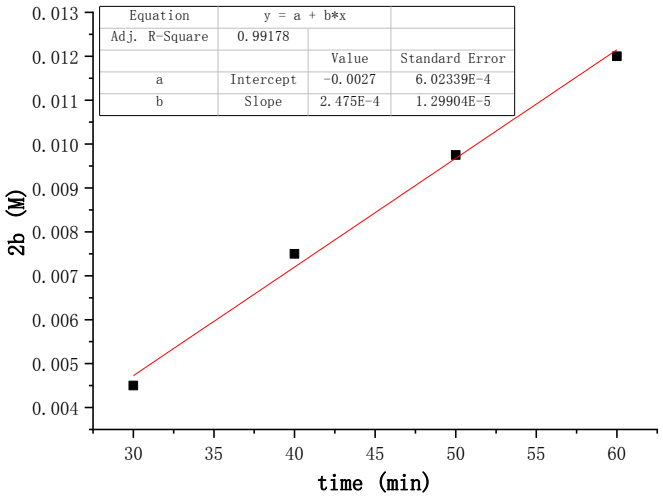


Figure S15. Initial rate data for the desaturation of **1b** to **2b** at **1b** (0.075M).

[**2b**] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.1	20	0.004	0.00033
	30	0.007	
	40	0.01	
	50	0.014	
	60	0.017	

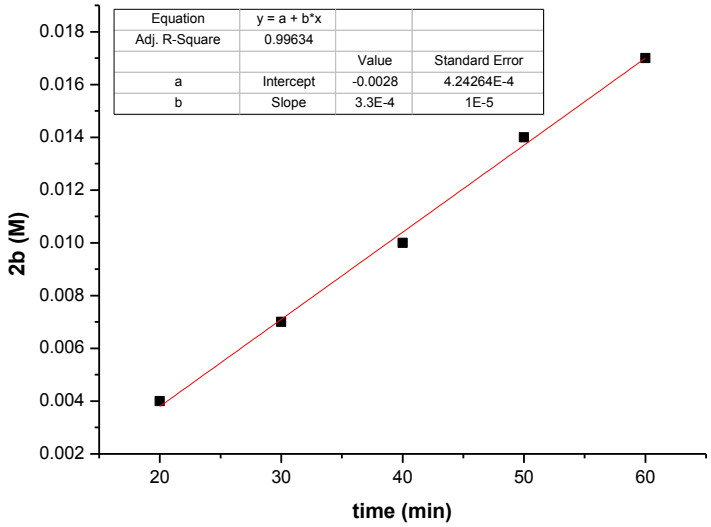


Figure S16. Initial rate data for the desaturation of **1b** to **2b** at **1b** (0.1M).

[**2b**] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.125	20	0.0025	0.000220339
	30	0.005	
	50	0.00875	
	70	0.01375	

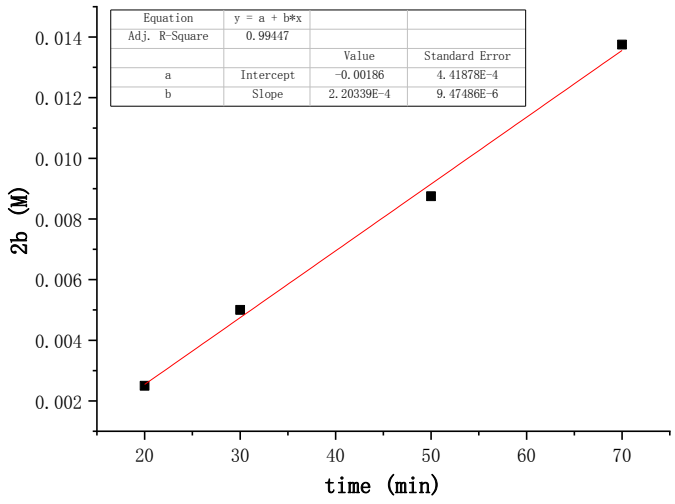


Figure S17. Initial rate data for the desaturation of **1b** to **2b** at **1b** (0.125M).

[**2b**] (M)	initial rate (M/min)
0.02	0.00017522
0.025	0.000185
0.03333	0.000246838
0.05	0.000255
0.075	0.0002475
0.1	0.00033
0.125	0.000220339

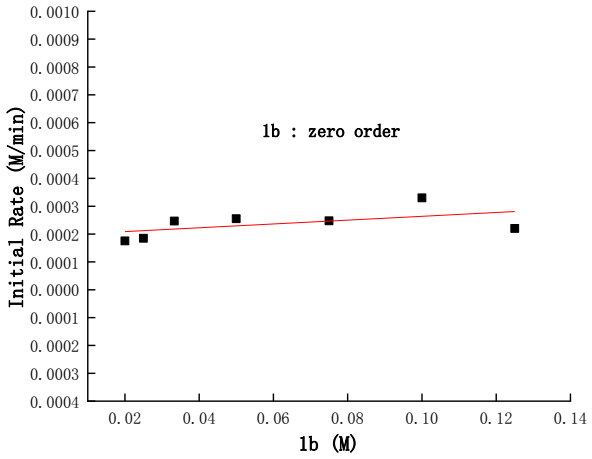
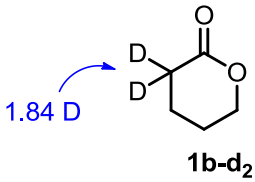


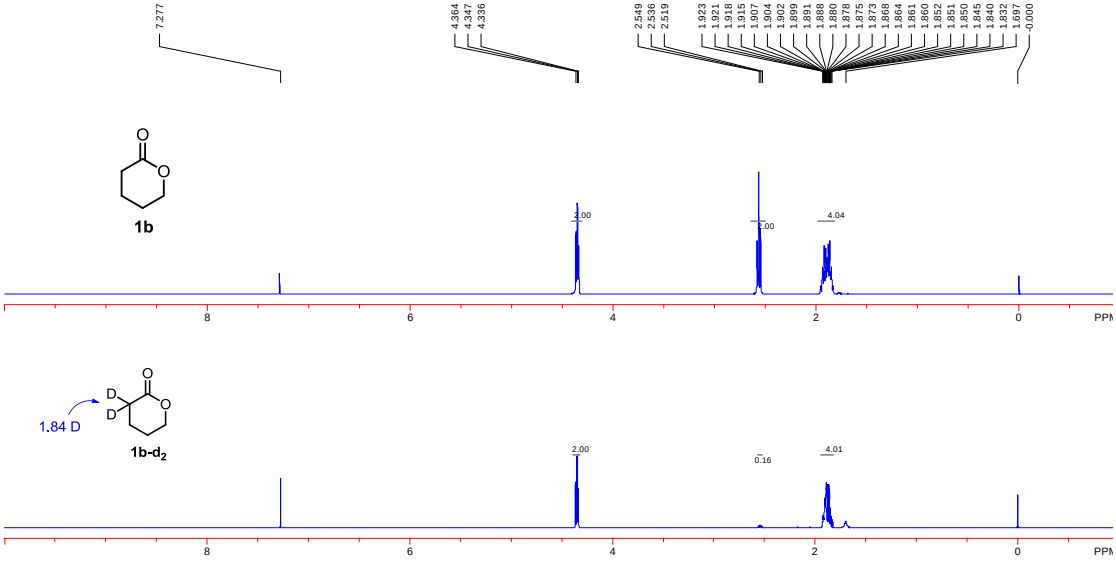
Figure S18. Plot of initial rate of δ-lactone desaturation at varying concentrations of **1b**.

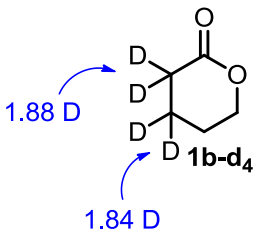
The synthesis of 1a-d_2 and 1a-d_4 and Kinetic Isotope Effect Studies



1b-d_2

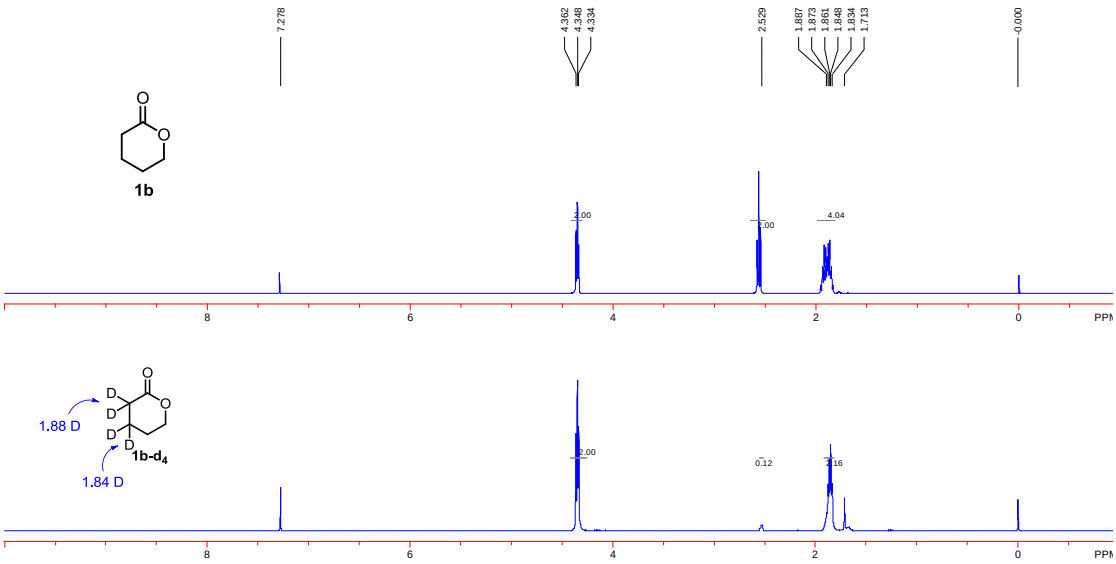
1,1-diduteriumtetrahydro-2*H*-pyran-2-one (1b-d_2) was synthesized by known method[31]. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 4.36-4.34 (m, 2H), 2.57-2.52 (m, 0.16H), 1.92-1.70 (m, 4H). The spectroscopic data are in agreement with those previously reported.



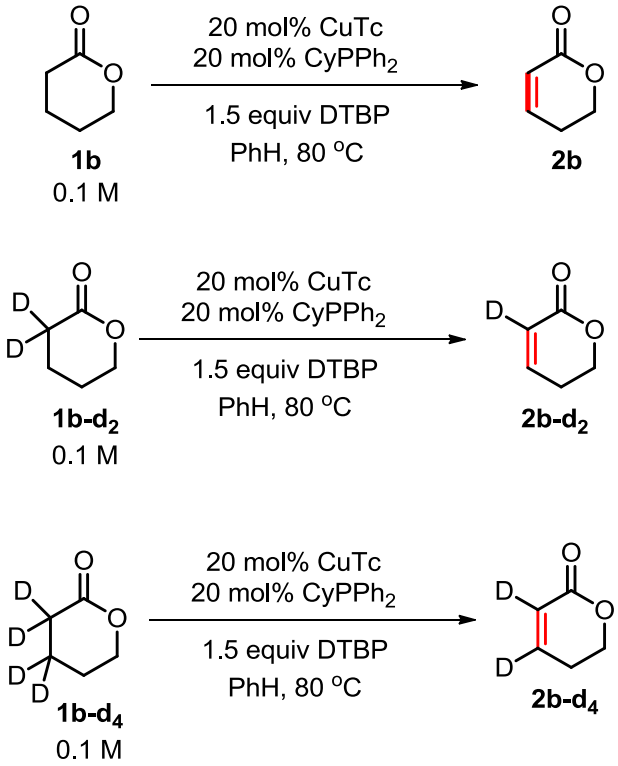


1b-d_4

1,1,2,2-tetraduteriumtetrahydro-2*H*-pyran-2-one (1b-d_4) was synthesized by known method[32]. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 4.36-4.33 (m, 2H), 2.56-2.51 (m, 0.12H), 1.87-1.83 (m, 2.16H). The spectroscopic data are in agreement with those previously reported.



Intermolecular parallel KIE experiments with tetrahydro-2*H*-pyran-2-one **(1b)**, 1,1-diduteriumtetrahydro-2*H*-pyran-2-one **(1b-d_2)** and 1,1,2,2-tetraduteriumtetrahydro -2*H*-pyran-2-one **(1b-d_4).**



Reactions were performed with tetrahydro-2*H*-pyran-2-one **(1b)** (20 mg, 0.2 mmol), or 1,1-diduteriumtetrahydro-2*H*-pyran-2-one **(1b-d_2)** (20.4 mg, 0.2 mmol), or

1,1,2,2-tetraduteriumtetrahydro -2*H*-pyran-2-one **(1b-d_4)** (20.8 mg, 0.2 mmol), CuTc (7.6 mg, 0.04 mmol, 0.2 equiv), $CyPPh_2$ (10.7 mg, 0.04 mmol, 0.2 equiv), 2 mL of degassed benzene and the oxidant DTBP ($^tBuOO^tBu$) (43.8 mg, 0.3 mmol, 1.5 equiv) following the general procedure of the Cu-catalyzed desaturation reaction.

[**2b-d_2**] (M)	time (min)	**2b-d_2** (M)	initial rate (M/min)
0.1	40	0.006	0.000280769
	60	0.012	
	70	0.015	
	90	0.02	

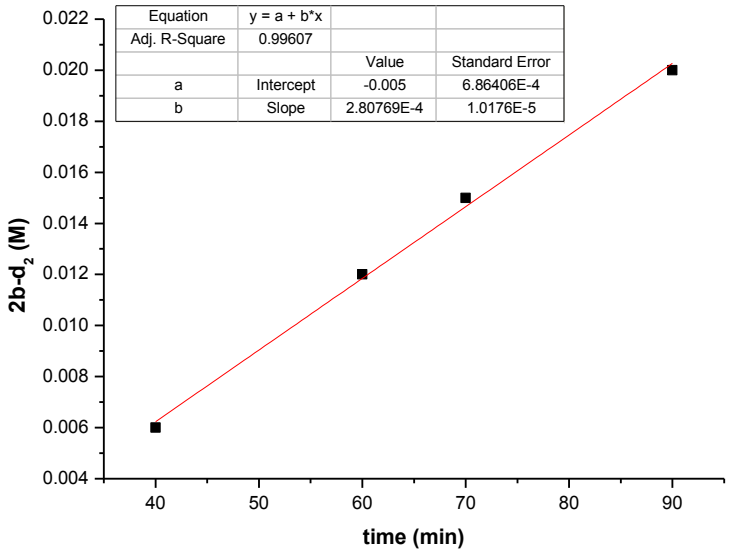


Figure S19. Initial rate data for the desaturation of **1b-d_2** to **2b-d_2** at **1b-d_2** (0.1 M).

[1b-d_4] (M)	time (min)	**2b-d_4** (M)	initial rate (M/min)
0.1	20	0	0.000296262
	40	0.008	
	60	0.014	
	90	0.021	

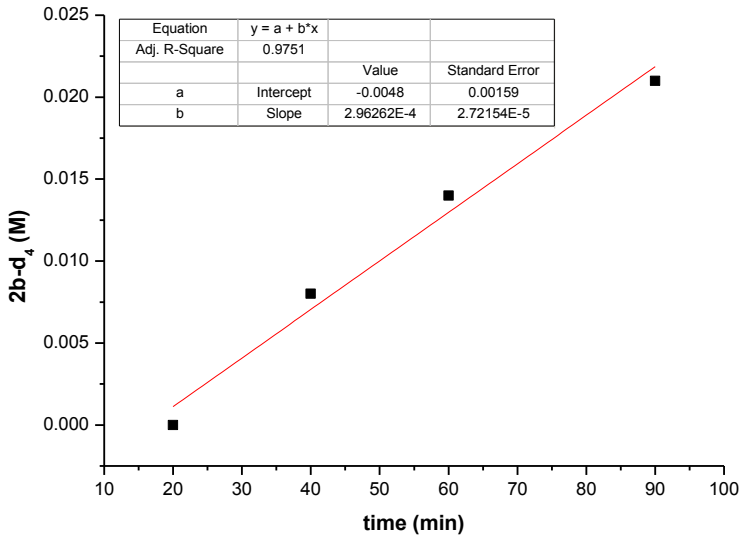
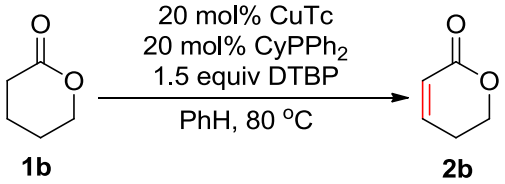


Figure S20. Initial rate data for the desaturation of **1b-d$_4$** to **2b-d$_4$** at **1b-d$_4$** (0.1 M).

The KIE between **1b** and **1b-d$_2$**: 0.00033/0.000280769= 1.2;

The KIE between **1b-d$_2$** and **1b-d$_4$**: 0.000288356/0.000296262= 0.97.

The Induction Period Studies.



An oven-dried 4.0 mL vial was charged with CuTc (7.6 mg, 0.04 mmol, 0.2 equiv). It was directly transferred in a nitrogen-filled glovebox with caps. In the glovebox, $CyPPh_2$ (10.7 mg, 0.04 mmol, 0.2 equiv) and 1 mL of degassed benzene were added to the vial. To the resulting solution was added DTBP (^{t}BuOO^{t}Bu) (43.9 mg, 0.3 mmol, 1.5 equiv). The vial was tightly sealed, transferred out of glovebox and stirred on a pie-block at 80 ^{o}C for 30 min. Then the reaction was added tetrahydro-2*H*-pyran-2-one **(1b)** (20 mg, 0.2 mmol) with 1 mL PhH in the glovebox. Then it was transferred out of glovebox and stirred on a pie-block at 80 ^{o}C for the appointed time.

[**2b**] (M)	time (min)	**2b** (M)	initial rate (M/min)
0.1	10	0.003	0.00033
	20	0.007	
	30	0.01	
	40	0.013	

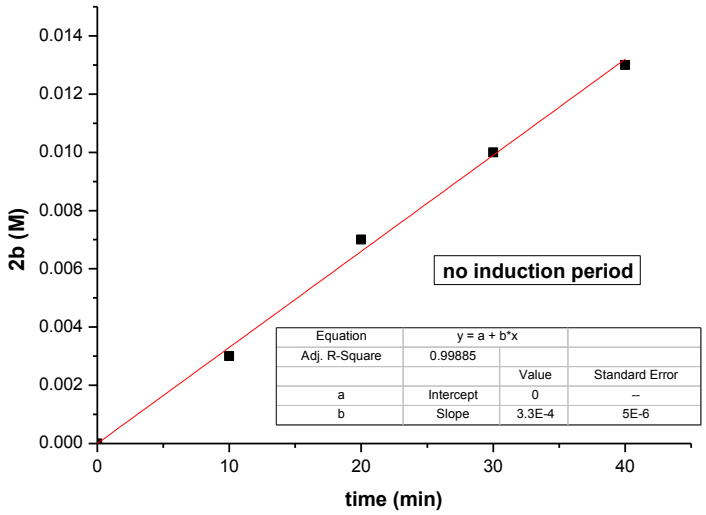
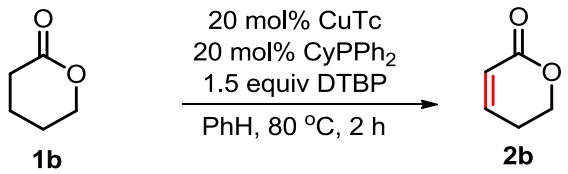


Figure S21. Induction period studies

Investigation of Copper Species by EPR.



An oven-dried 4.0 mL vial was charged with tetrahydro-2*H*-pyran-2-one **(1a)** (20 mg, 0.2 mmol) and CuTc (7.6 mg, 0.04 mmol, 0.2 equiv). It was directly transferred in a nitrogen-filled glovebox with caps. In the glovebox, $CyPPh_2$ (10.7 mg, 0.04 mmol, 0.2 equiv) and 2 mL of degassed benzene were added to the vial. To the resulting solution was added DTBP (^{t}BuOO^{t}Bu) (43.9 mg, 0.3 mmol, 1.5 equiv). The vial was tightly sealed, transferred out of glovebox and stirred on a pie-block at 80 ^{o}C for 2 hrs. Then the reaction solution (0.4 mL) were added to quartz tubes in glove box and subject to EPR analysis at room temperature under N_2 protection in room temperature (Instrument: Bruker-BioSpin: E500). The field values observed here match the

reported data for Cu(II) species.[33]

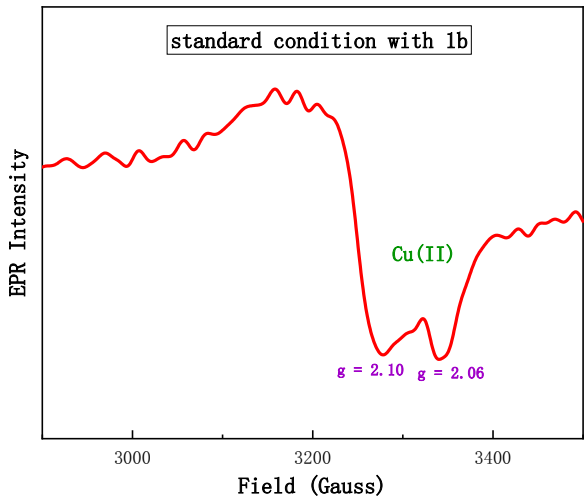
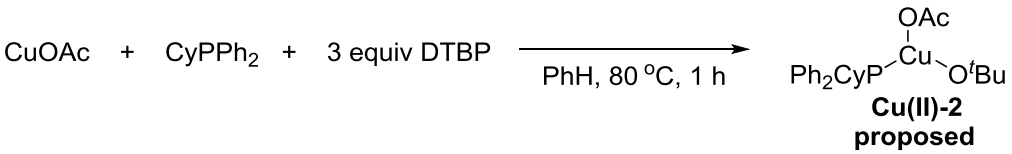


Figure S22. EPR spectra of Cu species for reaction in standard condition



An oven-dried 4.0 mL vial was directly transferred in a nitrogen-filled glovebox with caps. In the glovebox, $CyPPh_2$ (26.8 mg, 0.1 mmol, 1 equiv), CuOAc (12.2 mg, 0.1 mmol, 1 equiv) and 2 mL of degassed benzene were added to the vial. To the resulting solution was added DTBP (^{t}BuOO^{t}Bu) (43.9 mg, 0.3 mmol, 1.5 equiv). The vial was tightly sealed, transferred out of glovebox and stirred on a pie-block at 80 ^{o}C for 1 hour. Then the reaction solution (0.4 mL) were added to quartz tubes in glove box and subject to EPR analysis at room temperature under N_2 protection in room temperature (Instrument: Bruker-BioSpin: E500).

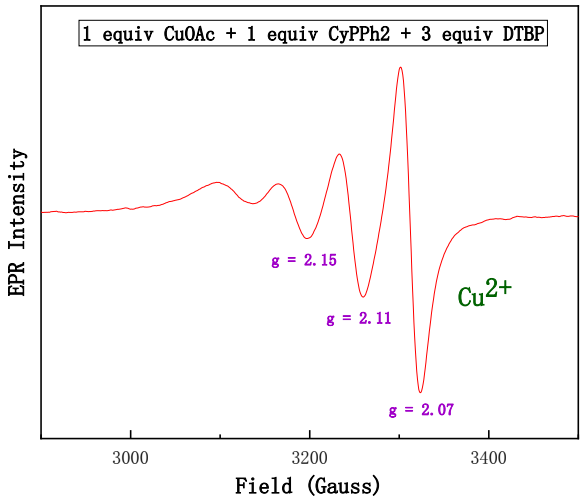
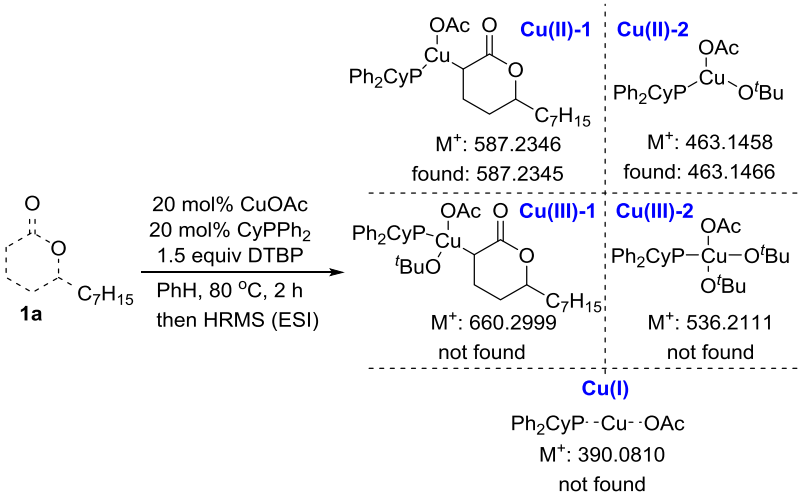


Figure S23. EPR spectra of Cu species.

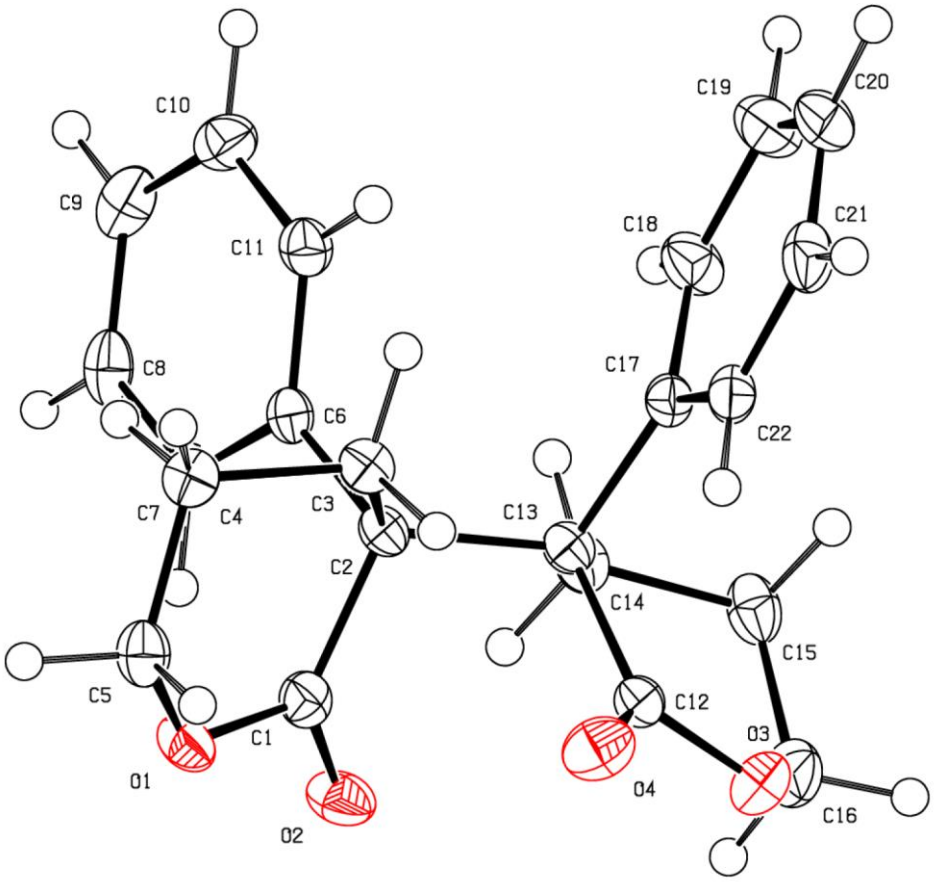
Investigation of Copper Species by HRMS Studies.



An oven-dried 4.0 mL vial was charged with 6-heptyltetrahydro-2*H*-pyran-2-one **(1a)** (39.7 mg, 0.2 mmol) and CuOAc (4.8 mg, 0.04 mmol, 0.2 equiv). It was directly transferred in a nitrogen-filled glovebox with caps. In the glovebox, $CyPPh_2$ (10.7 mg, 0.04 mmol, 0.2 equiv) and 2 mL of degassed benzene were added to the vial. To the resulting solution was added DTBP (^{t}BuO^{t}Bu) (43.9 mg, 0.3 mmol, 1.5 equiv). The vial was tightly sealed, transferred out of glovebox and stirred on a pie-block at 80 ^{o}C

for 2 hrs. Then the reaction solution (0.2 mL) was transferred to a MS-vial with 1 mL ethyl acetate added in glove box. The sample was then subjected to HRMS analysis at room temperature under N_2 protection in room temperature. Both Cu(II) species were found from HRMS, but Cu(I) and Cu(III) species were not observed.

The Crystal data and structure refinement for 2k'



X-ray of 2k'

Table S1 Crystal data and structure refinement for 2k'.

Identification code	Ming-lactone
Empirical formula	$C_{22}H_{22}O_4$
Formula weight	350.39
Temperature/K	100(2)
Crystal system	orthorhombic
Space group	$Pna2_1$
a/Å	13.4604(14)
b/Å	11.9775(12)

c/Å	10.6350(11)
α/°	90
β/°	90
γ/°	90
Volume/Å^3	1714.6(3)
Z	4
ρ_{calc}g/cm^3	1.357
μ/mm^{-1}	0.093
F(000)	744.0
Crystal size/mm^3	0.1 × 0.1 × 0.05
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	4.552 to 52.696
Index ranges	-16 ≤ h ≤ 16, -13 ≤ k ≤ 14, -13 ≤ l ≤ 13
Reflections collected	12571
Independent reflections	3485 [R_{int} = 0.0506, R_{sigma} = 0.0479]
Data/restraints/parameters	3485/1/235
Goodness-of-fit on F^2	1.021
Final R indexes [I>=2σ (I)]	R_1 = 0.0388, wR_2 = 0.0706
Final R indexes [all data]	R_1 = 0.0580, wR_2 = 0.0772
Largest diff. peak/hole / e Å^{-3}	0.21/-0.16
Flack parameter	-0.2(5)

Table S2 Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for Ming-lactone. U_{eq} is defined as 1/3 of of the trace of the orthogonalised U_{IJ} tensor.

Atom	*x*	*y*	*z*	U(eq)
O1	6674.0(14)	7222.9(16)	1713.6(17)	24.1(5)
O3	6002.3(15)	10365.5(15)	4499(2)	28.4(5)
O2	5438.0(14)	8115.7(18)	2549.3(18)	27.7(5)
O4	7203.0(15)	9518.9(16)	3515(2)	30.1(5)
C22	7885.7(19)	8768(2)	6175(3)	21.1(6)
C1	6202.2(19)	7601(2)	2736(3)	21.0(6)
C12	6516(2)	9434(2)	4249(3)	21.3(6)
C6	6057.5(19)	6250(2)	4510(3)	17.9(6)
C7	5193.4(19)	5854(2)	3956(3)	21.3(6)
C13	6280(2)	8348(2)	4959(3)	18.2(6)
C3	7713.2(18)	7114(2)	3993(3)	19.2(6)
C4	7940(2)	6260(2)	2980(3)	21.4(6)
C8	4737(2)	4885(2)	4379(3)	24.9(7)
C17	6928.3(19)	8324(2)	6160(3)	19.3(6)
C14	5168.3(19)	8328(2)	5310(3)	21.0(7)

C2	6577.2(18)	7329(2)	4059(2)	17.4(6)
C21	8495(2)	8654(2)	7207(3)	27.5(7)
C11	6448(2)	5648(2)	5519(3)	21.8(6)
C5	7663(2)	6740(3)	1731(3)	23.9(7)
C10	5988(2)	4694(2)	5948(3)	26.0(7)
C18	6602(2)	7803(3)	7253(3)	27.9(7)
C15	4872(2)	9407(2)	5960(3)	26.6(7)
C9	5129(2)	4308(2)	5379(3)	28.6(7)
C16	5016(2)	10358(2)	5065(3)	29.5(7)
C20	8168(2)	8096(3)	8264(3)	34.0(8)
C19	7209(2)	7688(3)	8283(3)	35.3(8)

Table S3 Anisotropic Displacement Parameters ($Å^2 \times 10^3$) for Ming-lactone. The Anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U_{11}+2hka^*b^*U_{12}+\ldots]$.

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
O1	25.7(11)	30.7(12)	15.9(10)	-1.5(9)	0.0(9)	2.0(9)
O3	32.1(11)	19.6(10)	33.6(13)	-0.1(10)	0.4(10)	2.3(9)
O2	24.5(11)	36.4(13)	22.2(12)	2.7(10)	-3.1(9)	7.7(10)
O4	27.8(11)	27.9(12)	34.5(12)	7.0(11)	6.2(10)	-3.0(9)
C22	22.2(14)	18.6(14)	22.4(15)	-4.5(14)	-1.5(14)	0.1(12)
C1	21.4(14)	20.2(15)	21.3(16)	-0.3(13)	-0.1(13)	-5.2(12)
C12	23.7(15)	19.4(16)	20.9(16)	-1.2(12)	-7.1(13)	-0.3(12)
C6	17.8(13)	19.7(14)	16.4(14)	-3.8(12)	4.3(13)	2.4(12)
C7	18.7(14)	23.5(15)	21.5(15)	-4.9(13)	1.2(12)	2.4(12)
C13	15.5(13)	21.2(15)	17.9(15)	-0.6(12)	-1.1(11)	-0.6(11)
C3	13.8(12)	23.1(15)	20.7(14)	0.0(13)	-0.5(12)	-1.8(12)
C4	17.0(13)	22.8(15)	24.3(15)	-0.6(13)	1.7(13)	0.5(11)
C8	20.4(14)	24.7(16)	29.5(17)	-9.9(14)	7.6(14)	-5.2(12)
C17	21.2(14)	18.2(14)	18.6(15)	-3.0(13)	-1.4(12)	2.2(12)
C14	14.6(14)	25.6(15)	22.8(17)	-3.2(13)	-1.1(12)	-1.2(11)
C2	14.7(12)	21.1(15)	16.4(14)	-1.0(12)	-1.6(12)	-1.2(11)
C21	22.9(15)	25.8(17)	33.9(18)	-10.8(14)	-7.1(14)	1.2(13)
C11	22.4(14)	23.3(15)	19.7(16)	-2.2(13)	2.9(13)	0.6(12)
C5	22.2(15)	25.2(16)	24.4(16)	-5.1(14)	5.0(13)	-0.2(13)
C10	30.4(16)	24.3(16)	23.5(16)	3.5(14)	7.1(14)	5.0(13)
C18	27.7(16)	32.7(17)	23.3(16)	-0.4(14)	-4.7(14)	-8.0(14)
C15	20.7(14)	32.3(18)	26.9(17)	-9.8(15)	-0.3(13)	3.6(13)
C9	32.7(17)	20.9(15)	32.2(18)	-0.9(14)	18.2(16)	-2.2(13)
C16	28.9(16)	28.3(18)	31.3(18)	-6.9(15)	-0.6(14)	7.8(14)

C20	40.6(18)	32.7(18)	28.8(18)	-4.8(15)	-19.0(15)	3.2(15)
C19	46(2)	36.7(19)	22.8(17)	3.2(16)	-6.8(16)	-9.7(16)

Table S4 Bond Lengths for Ming-lactone.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
O1	C1	1.338(3)	C13	C14	1.543(4)
O1	C5	1.451(3)	C13	C2	1.602(4)
O3	C12	1.340(3)	C3	C4	1.517(4)
O3	C16	1.458(4)	C3	C2	1.552(3)
O2	C1	1.216(3)	C4	C5	1.495(4)
O4	C12	1.214(3)	C8	C9	1.374(4)
C22	C17	1.394(4)	C17	C18	1.390(4)
C22	C21	1.377(4)	C14	C15	1.519(4)
C1	C2	1.530(4)	C21	C20	1.380(5)
C12	C13	1.536(4)	C11	C10	1.377(4)
C6	C7	1.388(4)	C10	C9	1.385(4)
C6	C2	1.546(4)	C18	C19	1.373(4)
C6	C11	1.395(4)	C15	C16	1.496(4)
C7	C8	1.387(4)	C20	C19	1.381(5)
C13	C17	1.547(4)			

Table S5 Bond Angles for Ming-lactone.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
C1	O1	C5	124.0(2)	C9	C8	C7	120.1(3)
C12	O3	C16	123.2(2)	C22	C17	C13	121.6(3)
C21	C22	C17	121.5(3)	C18	C17	C22	116.9(3)
O1	C1	C2	121.3(2)	C18	C17	C13	121.4(2)
O2	C1	O1	116.1(2)	C15	C14	C13	110.6(2)
O2	C1	C2	122.5(2)	C1	C2	C6	108.3(2)
O3	C12	C13	120.1(2)	C1	C2	C13	107.7(2)
O4	C12	O3	116.8(2)	C1	C2	C3	108.6(2)
O4	C12	C13	123.0(2)	C6	C2	C13	109.8(2)
C7	C6	C2	122.2(2)	C6	C2	C3	108.7(2)
C7	C6	C11	117.8(3)	C3	C2	C13	113.5(2)
C11	C6	C2	120.0(2)	C22	C21	C20	120.4(3)
C8	C7	C6	121.3(3)	C10	C11	C6	120.9(3)
C12	C13	C17	107.8(2)	O1	C5	C4	113.1(2)

C12	C13	C14	109.4(2)	C11	C10	C9	120.5(3)
C12	C13	C2	107.5(2)	C19	C18	C17	121.6(3)
C17	C13	C2	109.8(2)	C16	C15	C14	108.9(2)
C14	C13	C17	110.3(2)	C8	C9	C10	119.4(3)
C14	C13	C2	112.0(2)	O3	C16	C15	112.7(2)
C4	C3	C2	110.0(2)	C21	C20	C19	118.8(3)
C5	C4	C3	108.8(2)	C18	C19	C20	120.6(3)

Table S6 Hydrogen Atom Coordinates (Å×10^4) and Isotropic Displacement Parameters (Å^2×10^3) for Ming-lactone.

Atom	***x***	***y***	***z***	**U(eq)**
H22	8122.94	9156.89	5457.18	25
H7	4908.72	6253.35	3273.86	26
H3A	8063.5	7820.73	3803.97	23
H3B	7952.64	6836.28	4816.14	23
H4A	8655.78	6071.63	2990.61	26
H4B	7556.67	5567.88	3135.42	26
H8	4152.87	4620.9	3975.83	30
H14A	4764.54	8229.46	4539.69	25
H14B	5035.31	7688.99	5875.09	25
H21	9145.25	8962.97	7191.45	33
H11	7039.24	5900.08	5915.31	26
H5A	8151.23	7323.32	1501.29	29
H5B	7699.61	6144.29	1086.9	29
H10	6263.23	4297.52	6638.61	31
H18	5943.36	7520.78	7288.94	33
H15A	4167.73	9368.33	6223.87	32
H15B	5286	9521.01	6718.58	32
H9	4813.06	3650.23	5678.24	34
H16A	4511	10309.32	4391.34	35
H16B	4911.29	11069.6	5519.85	35
H20	8595.18	7994.13	8965.55	41
H19	6966.44	7323.63	9014.95	42

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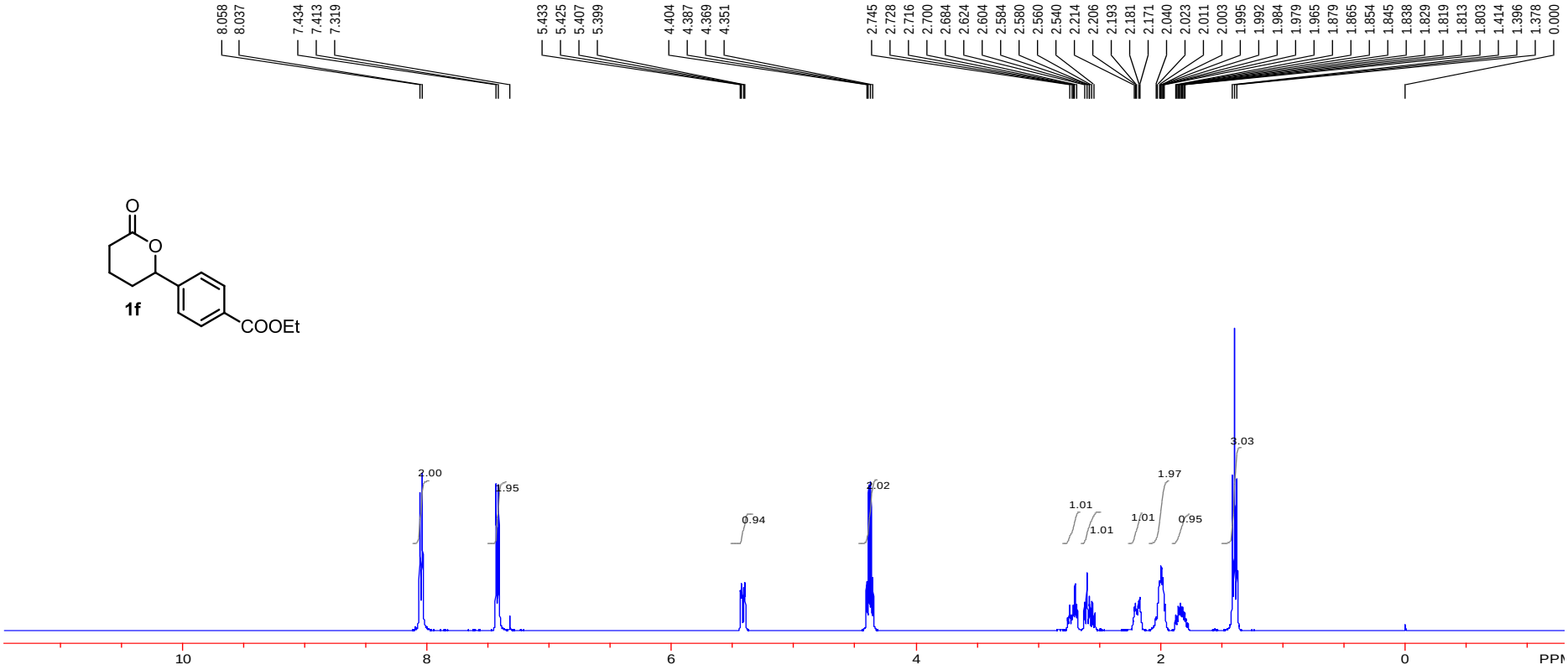
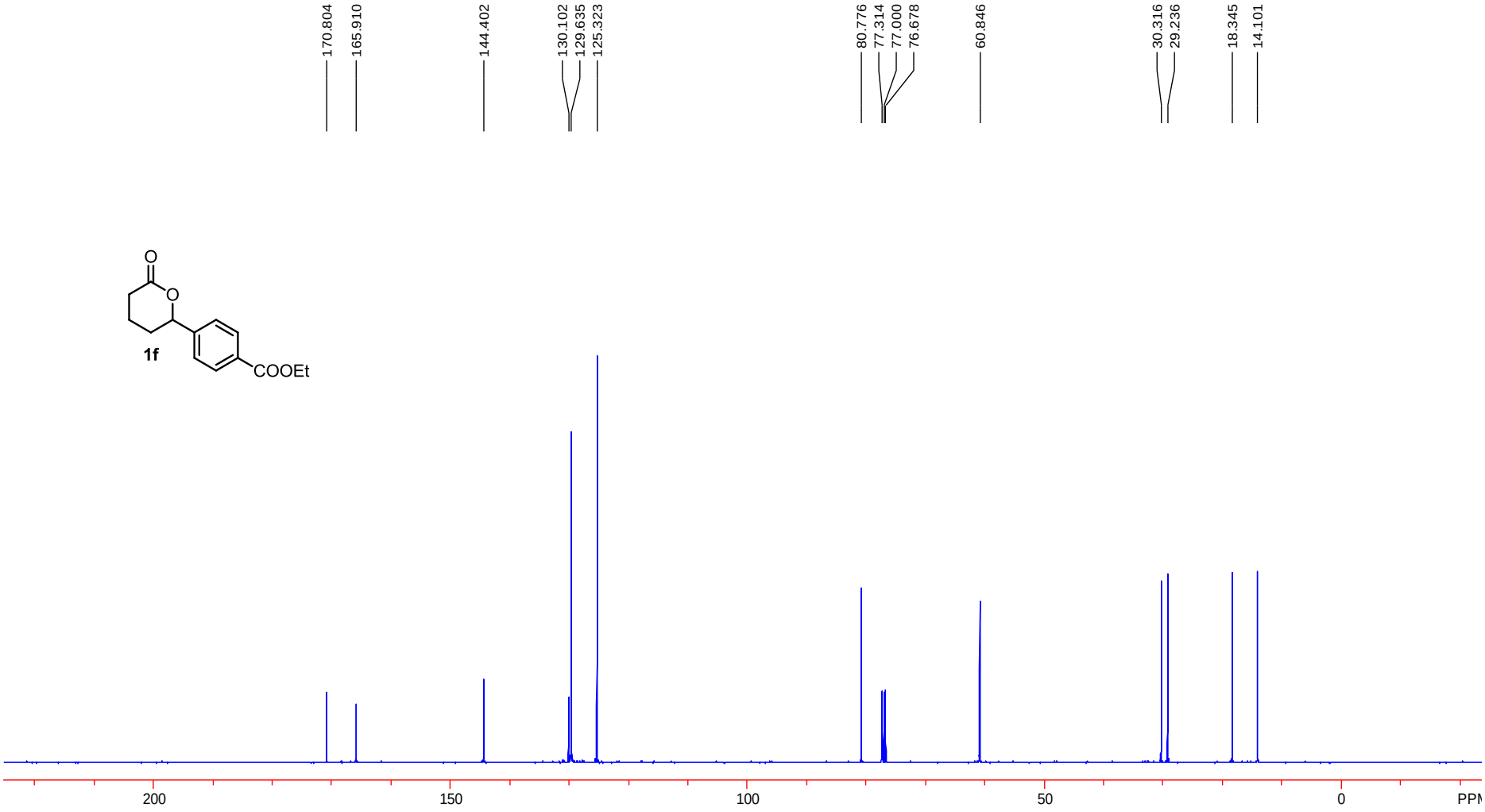
Spectra

^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)



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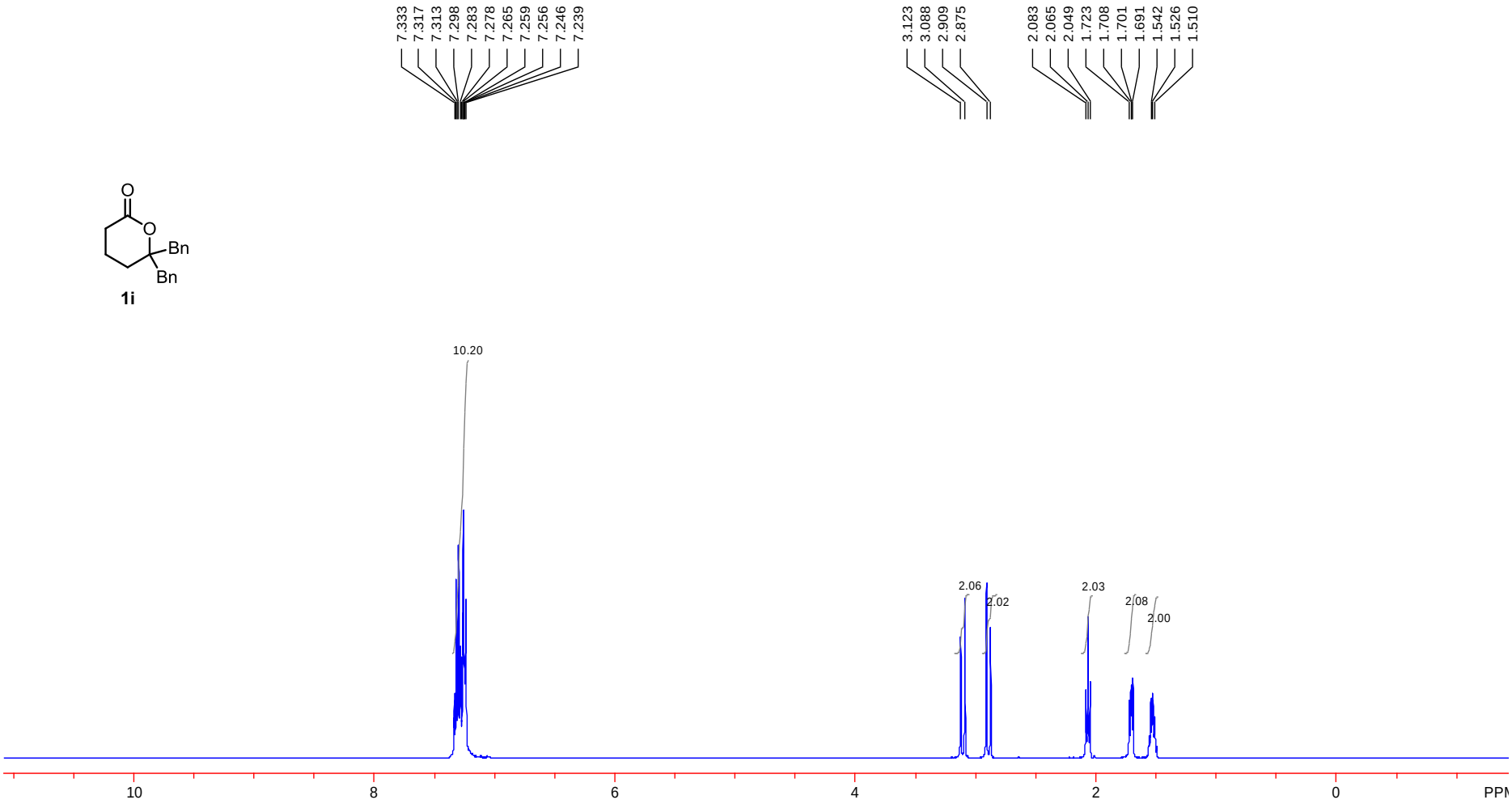

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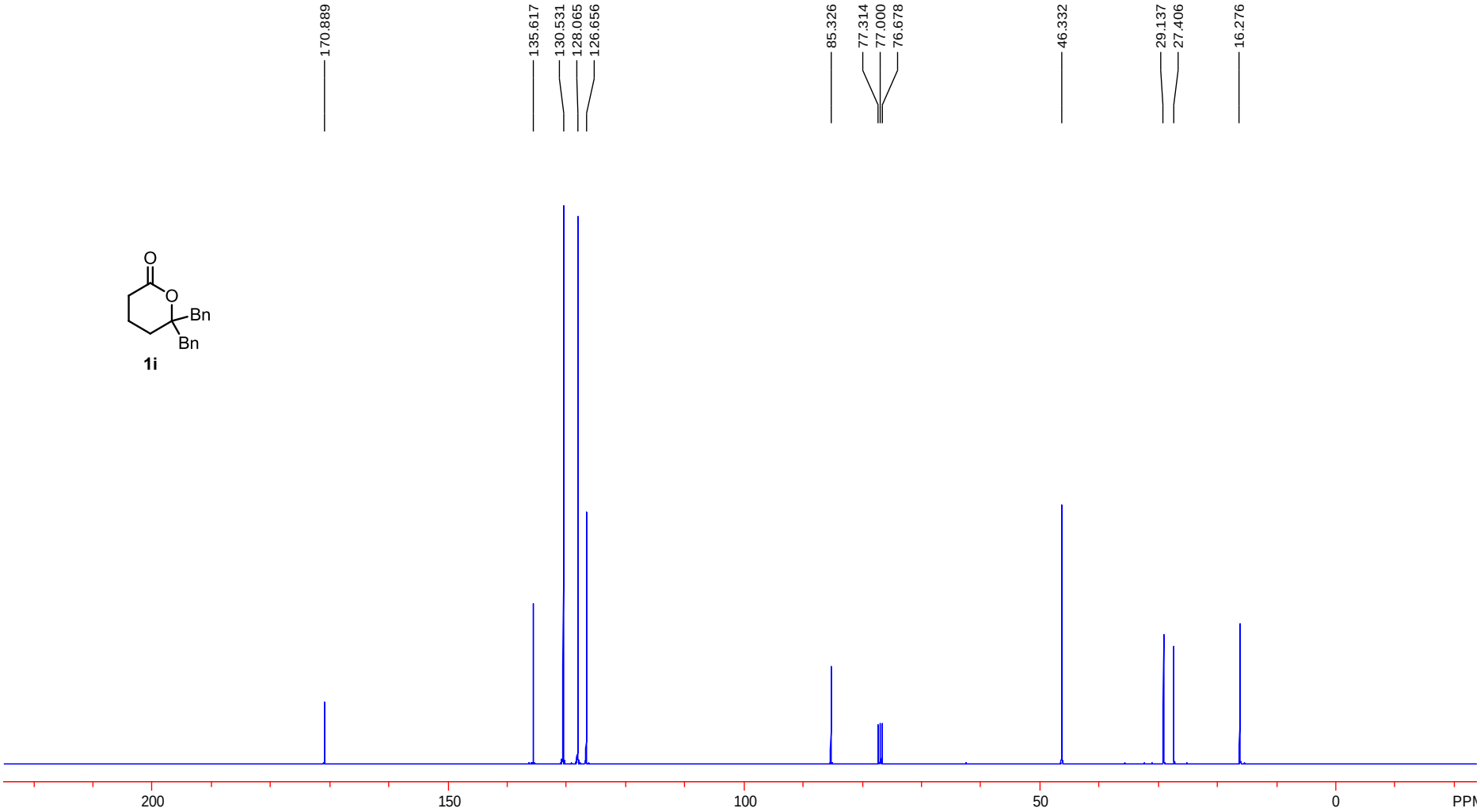

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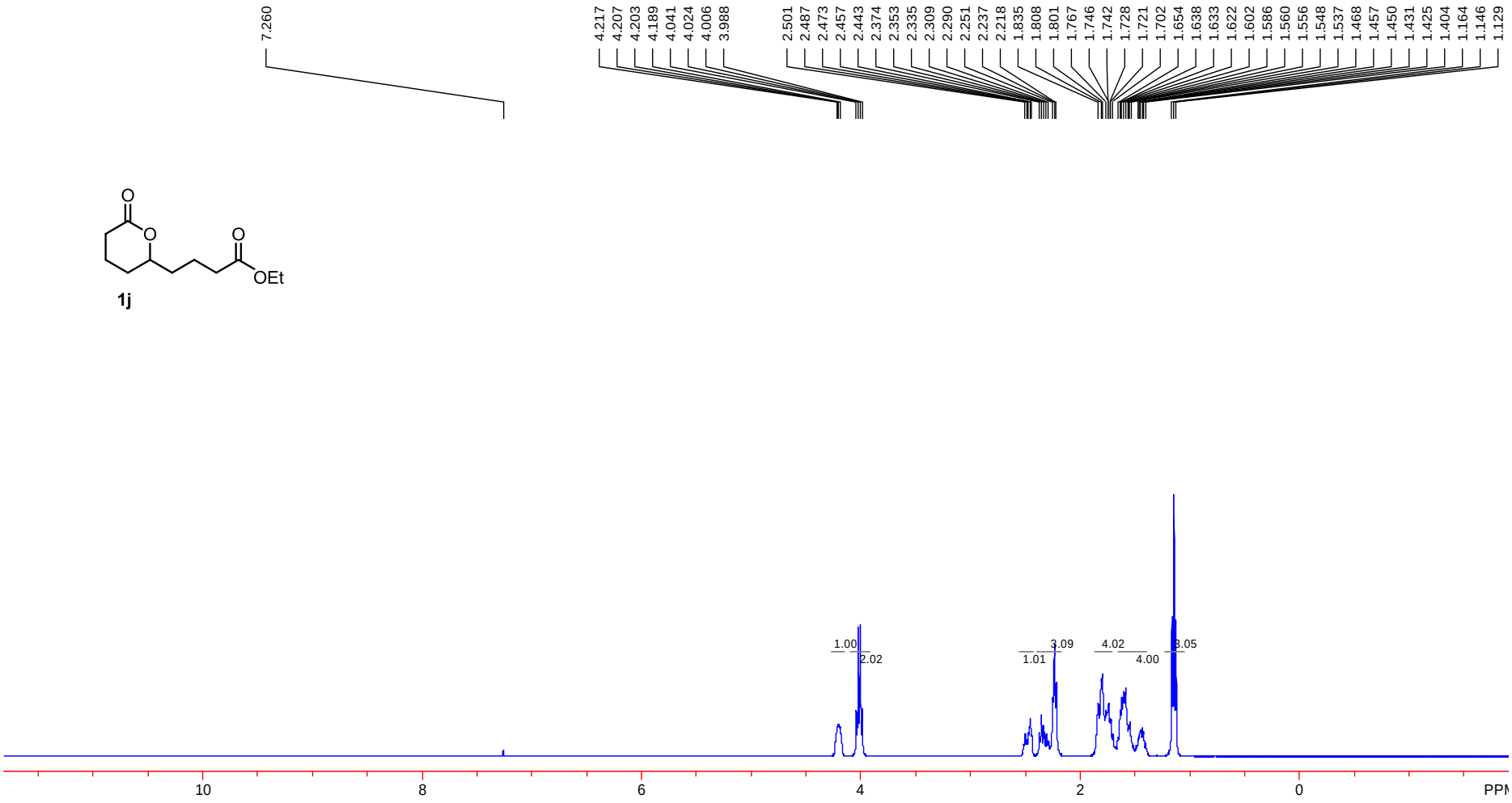

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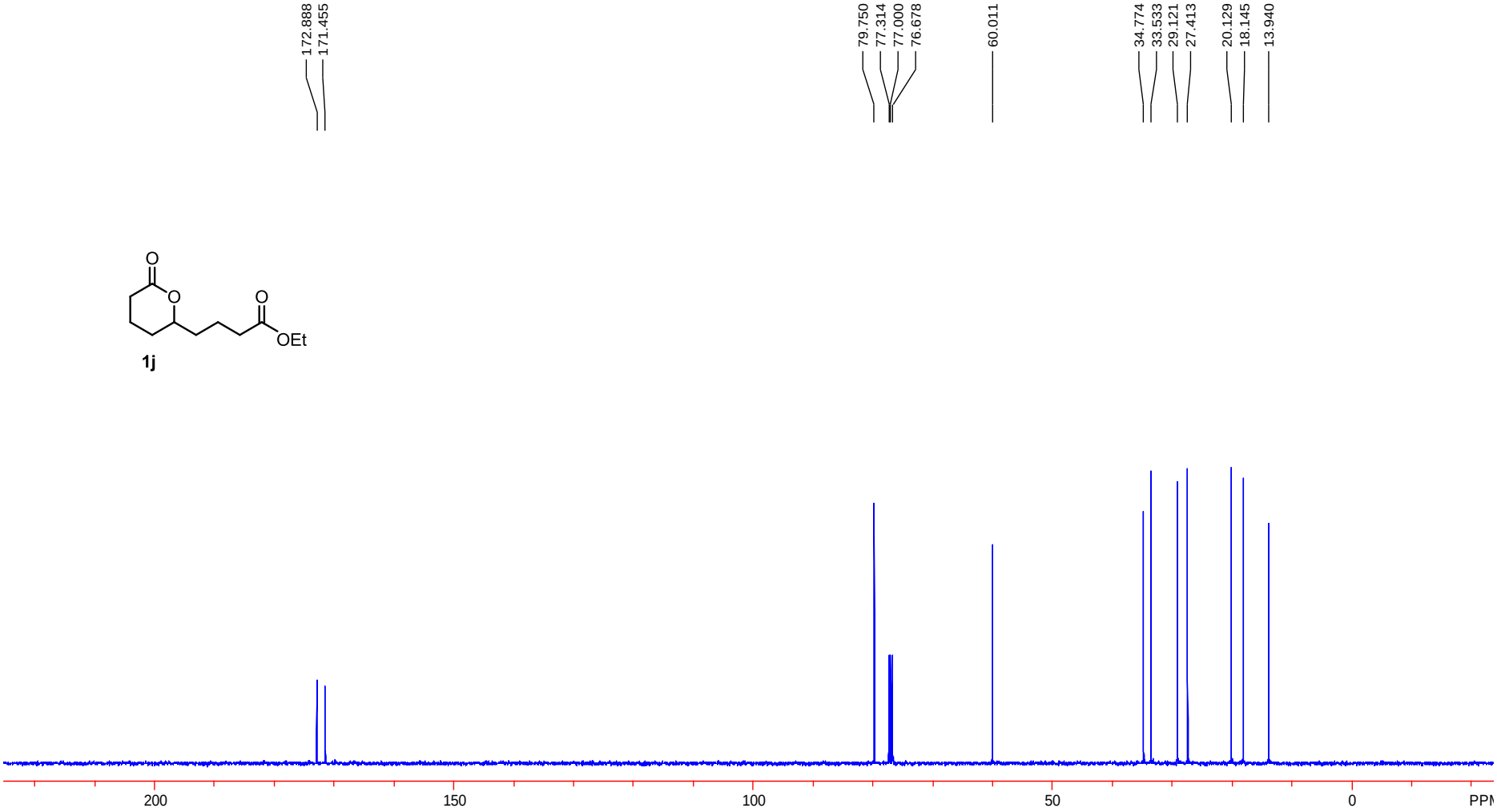

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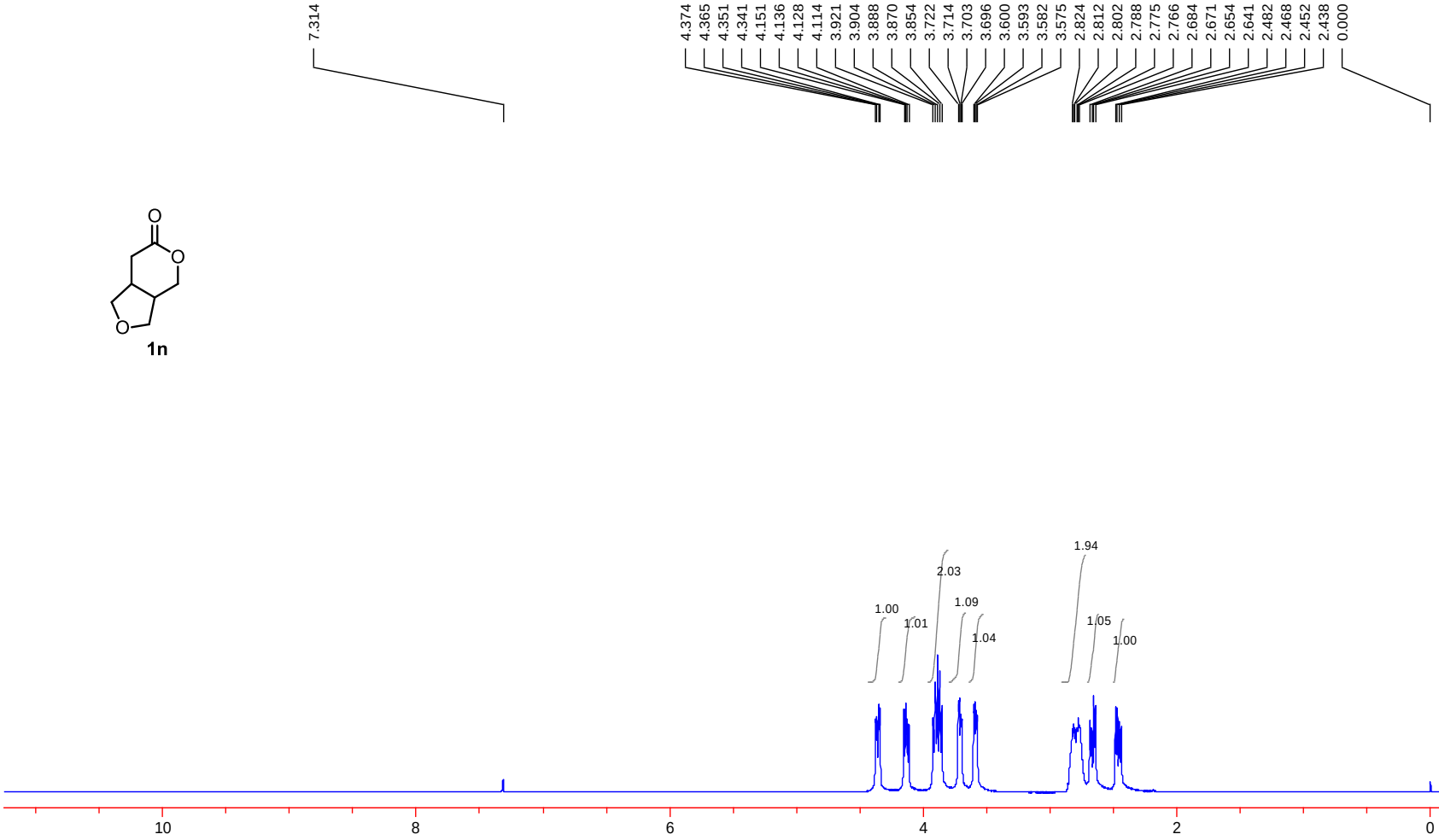

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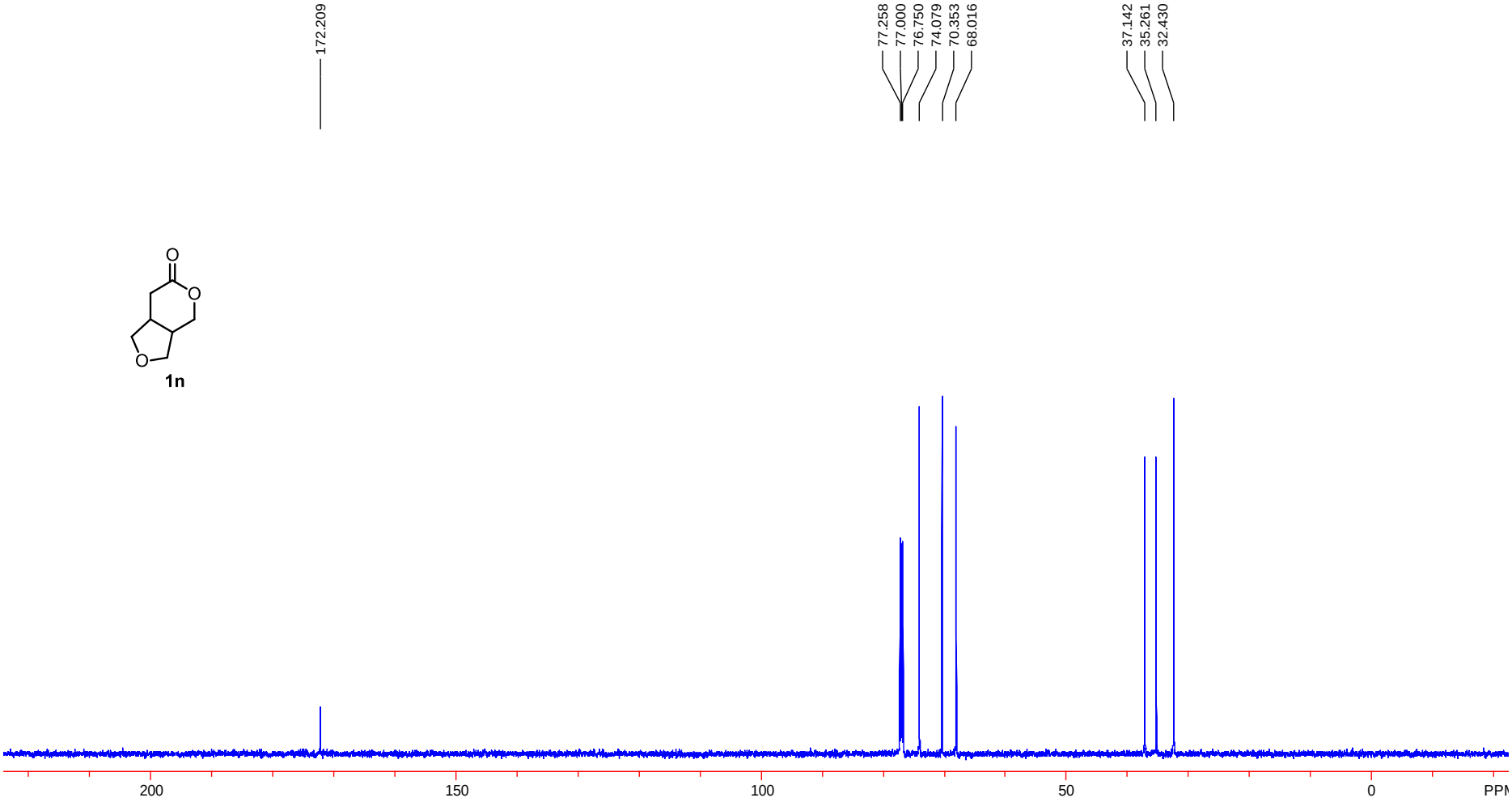

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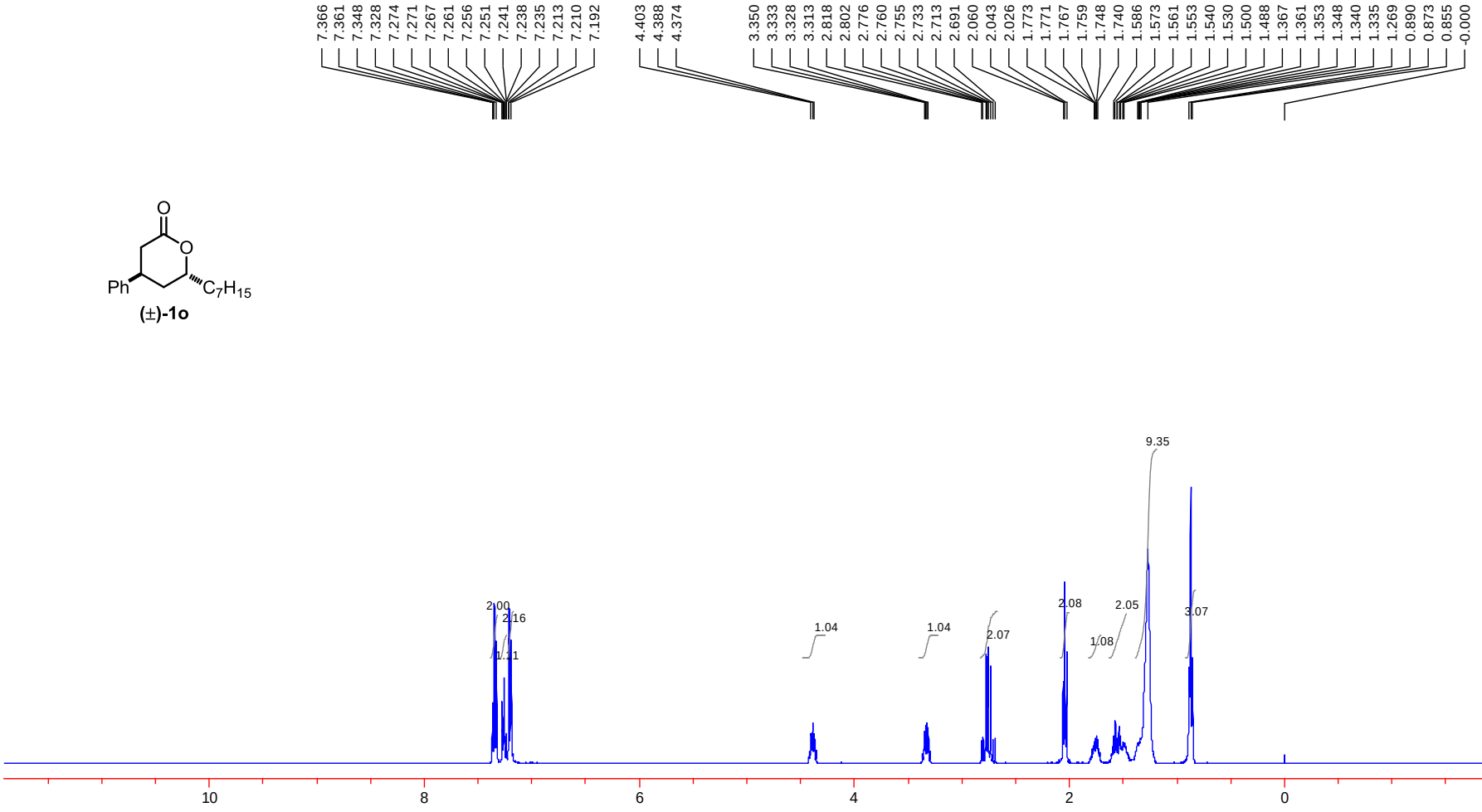

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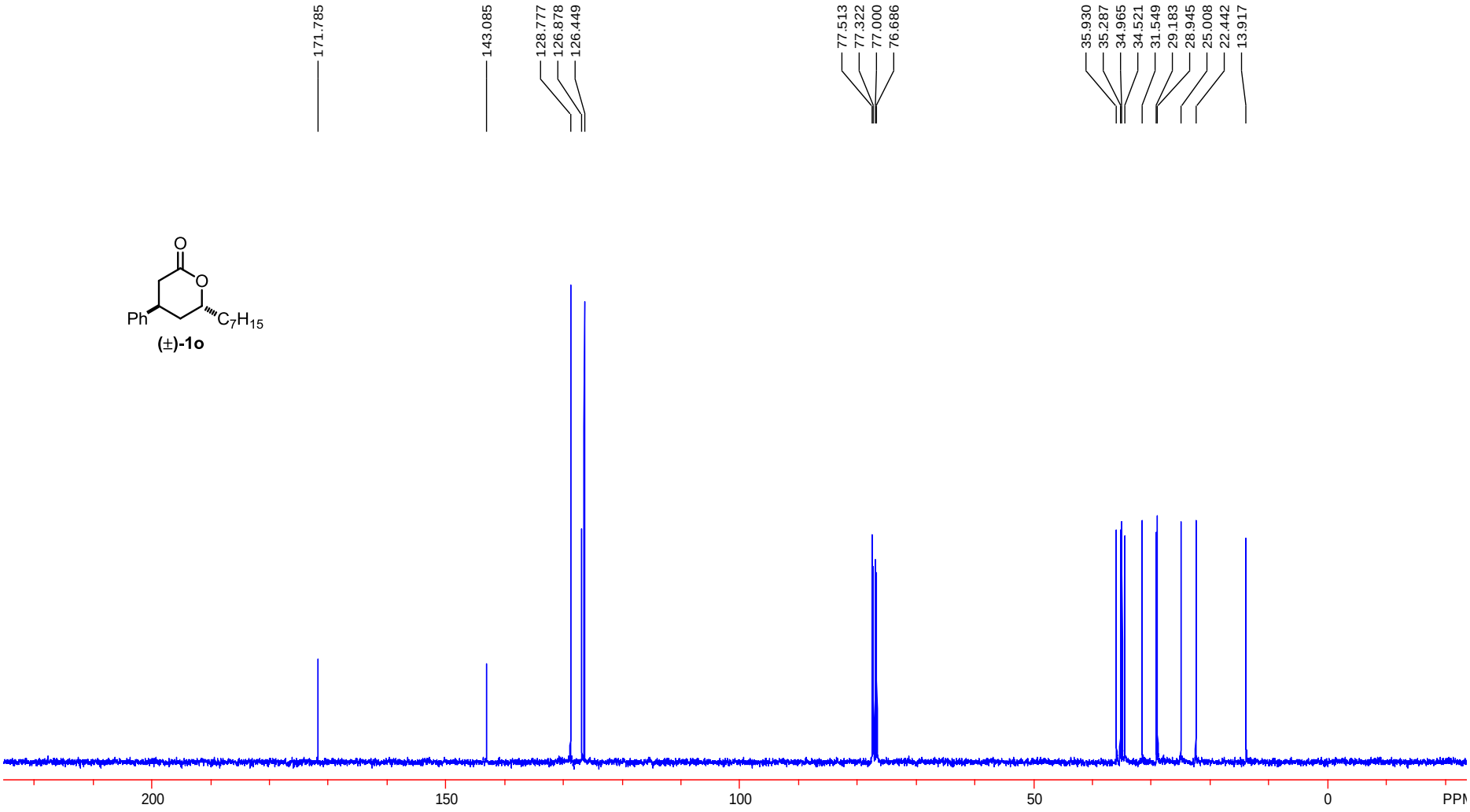

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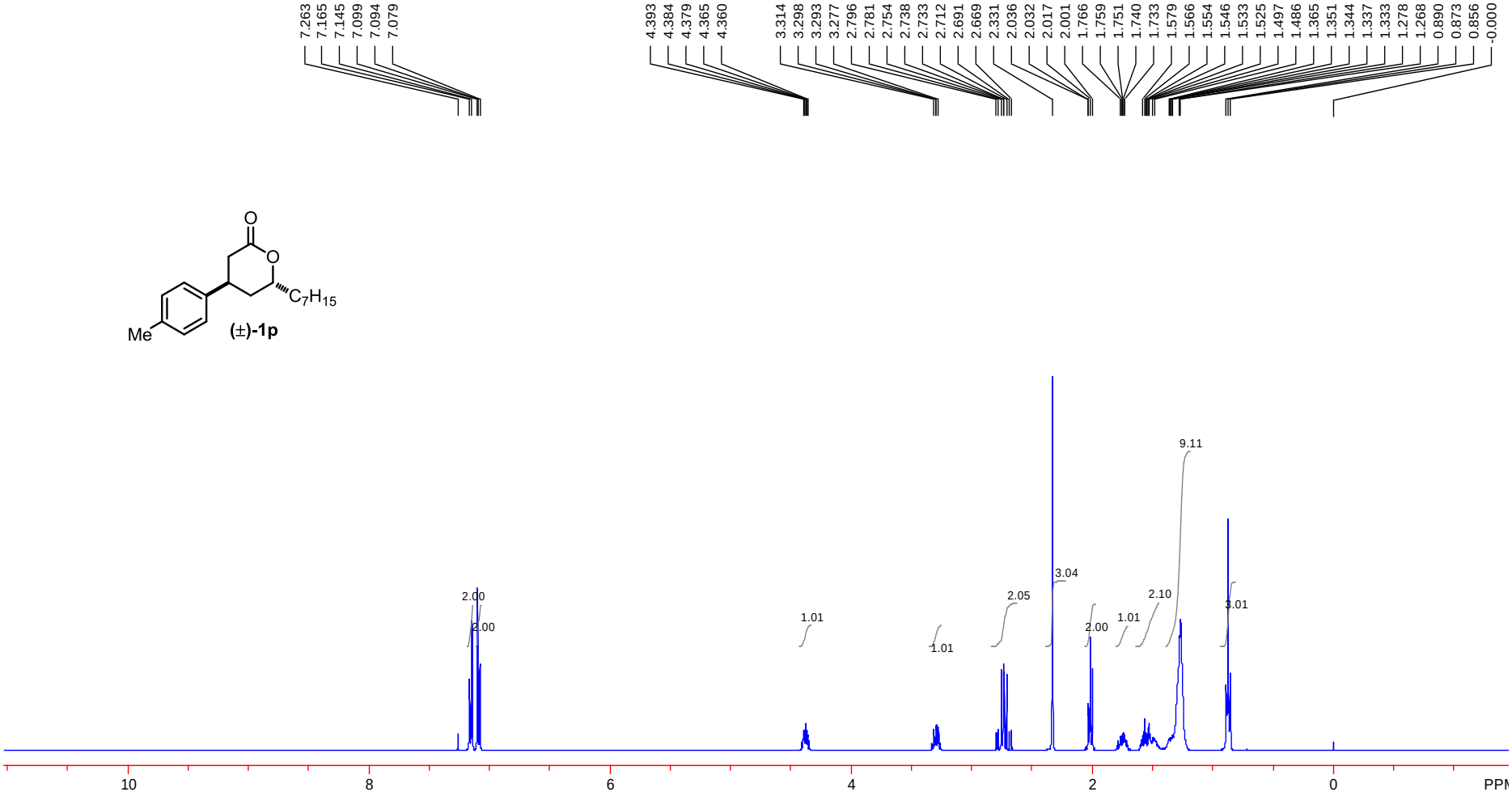

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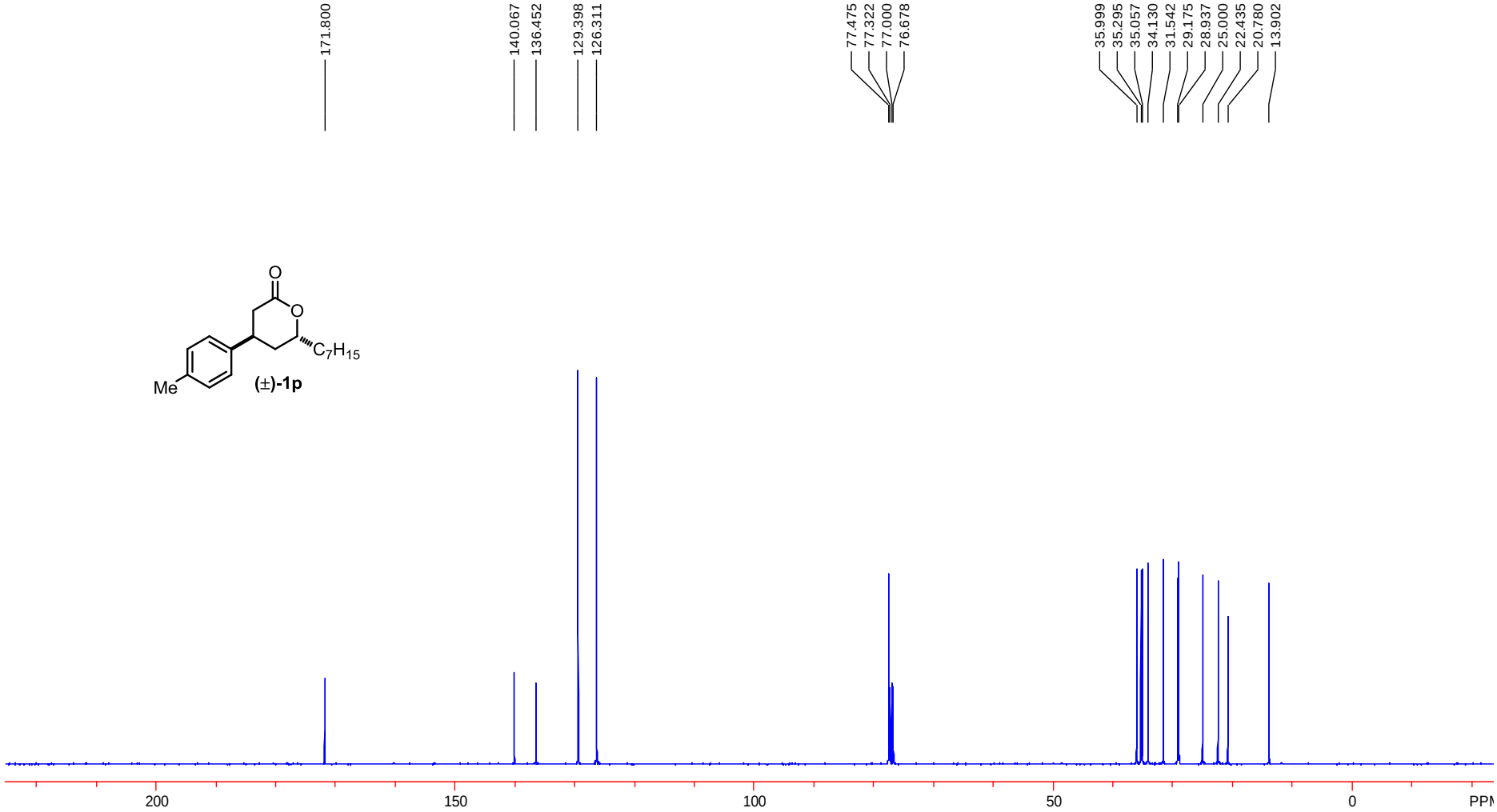

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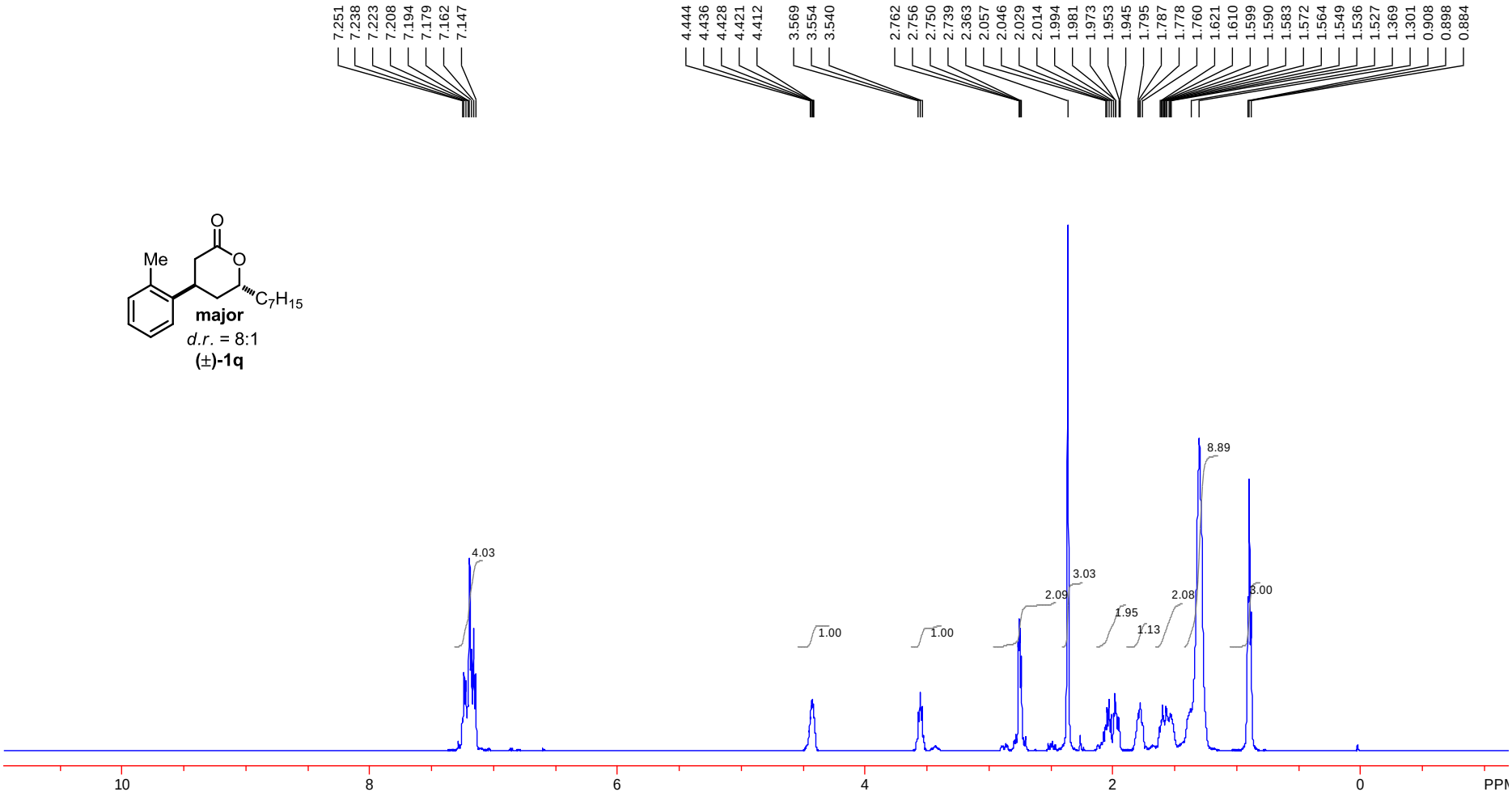

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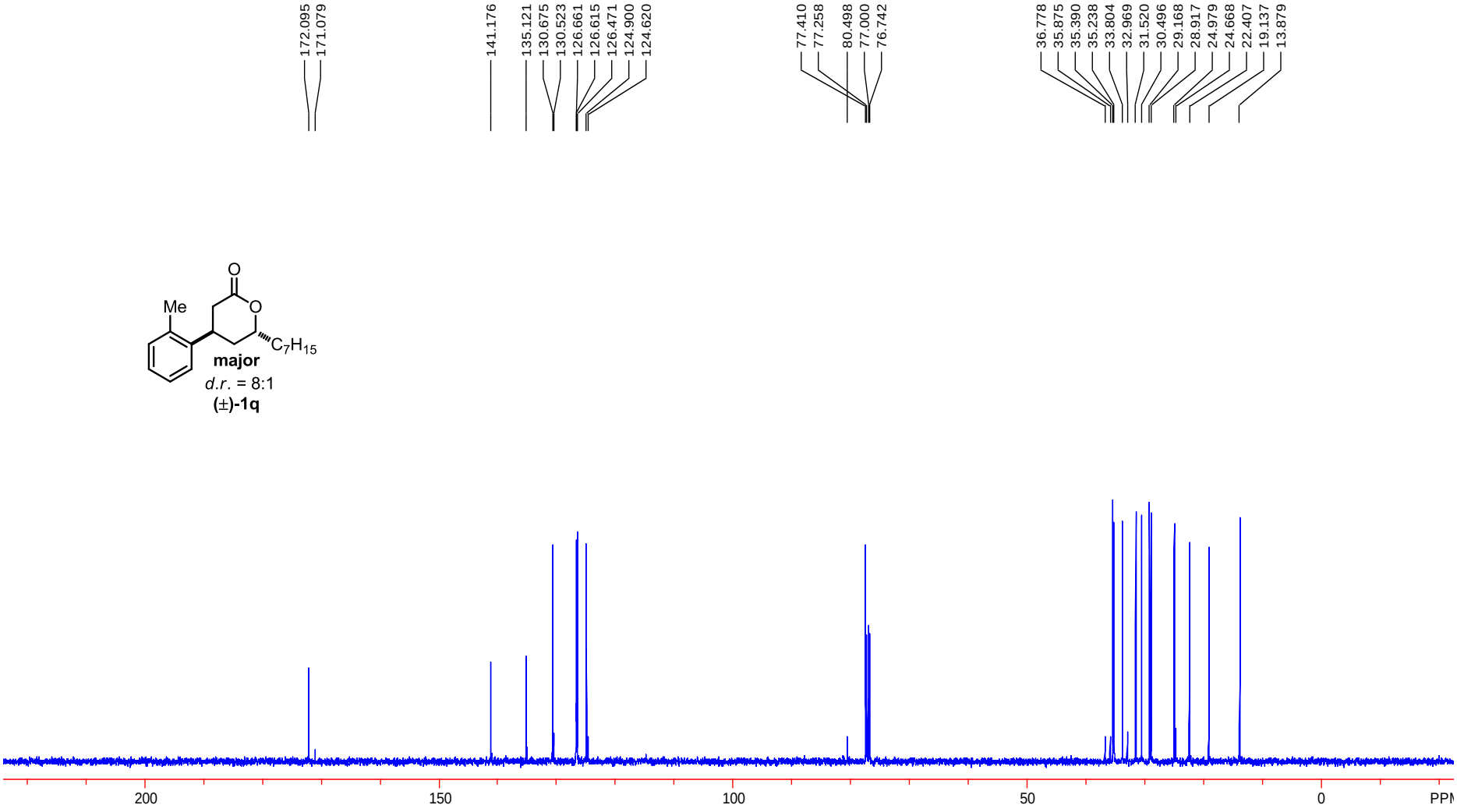

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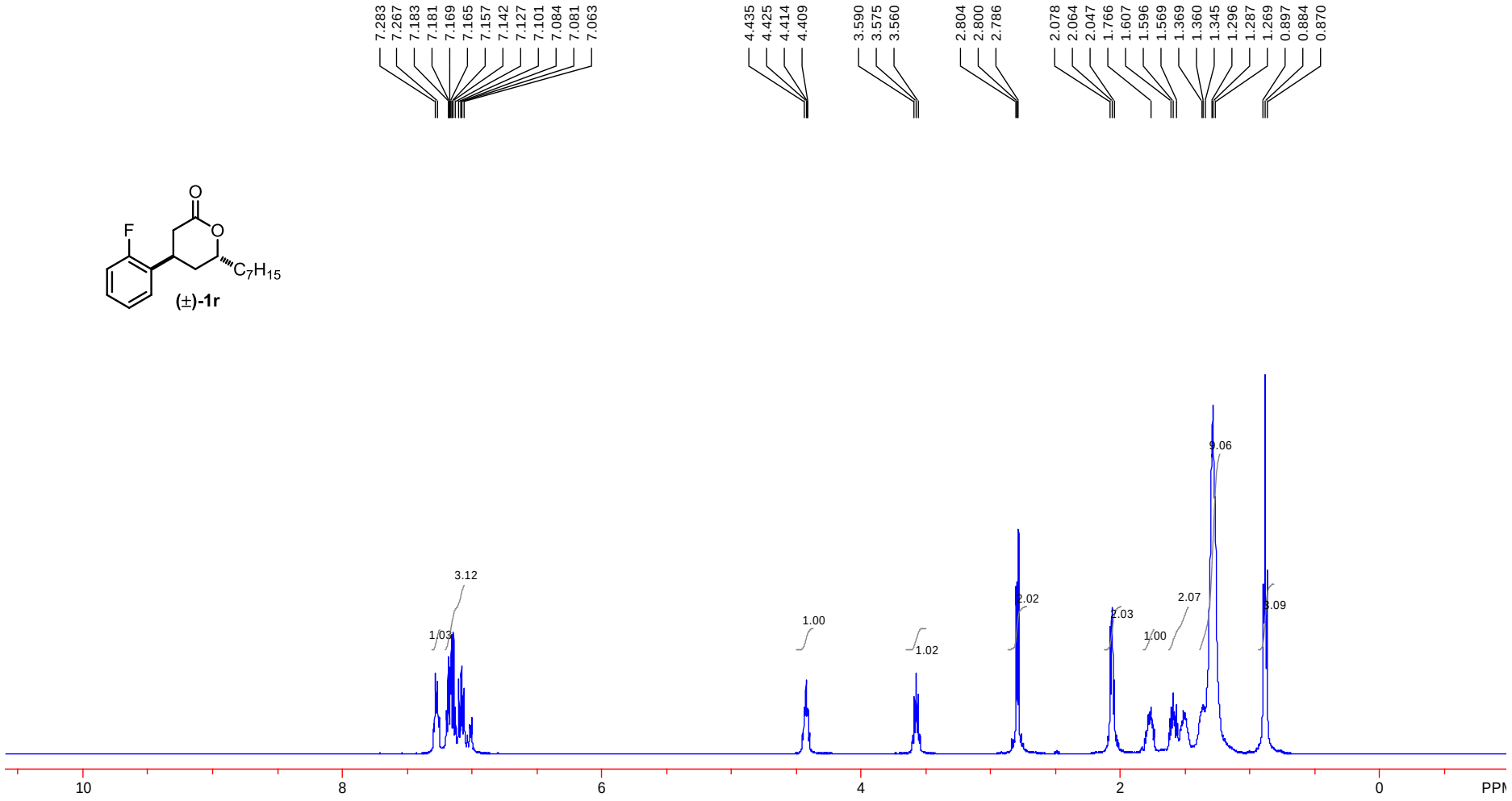

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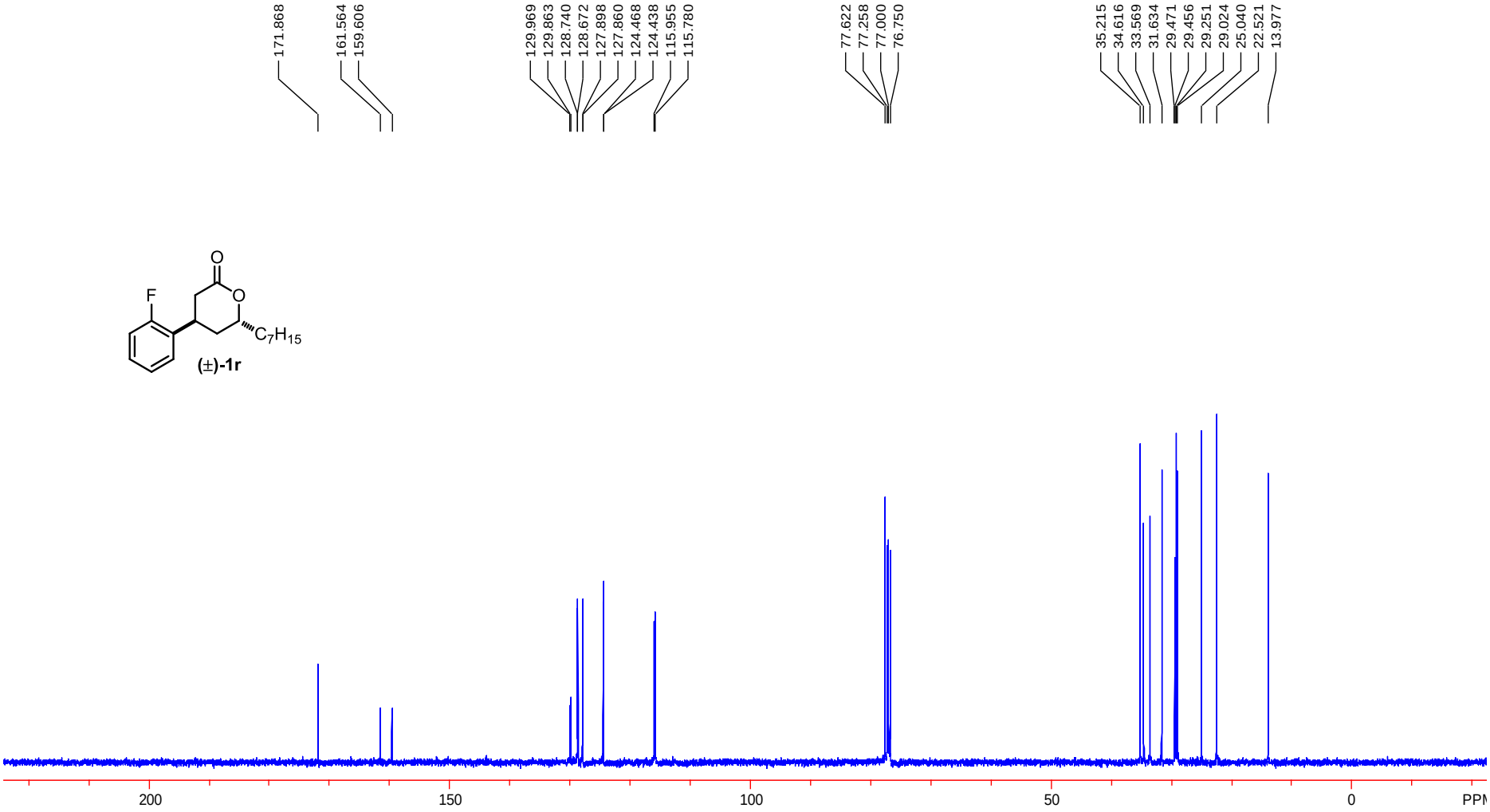

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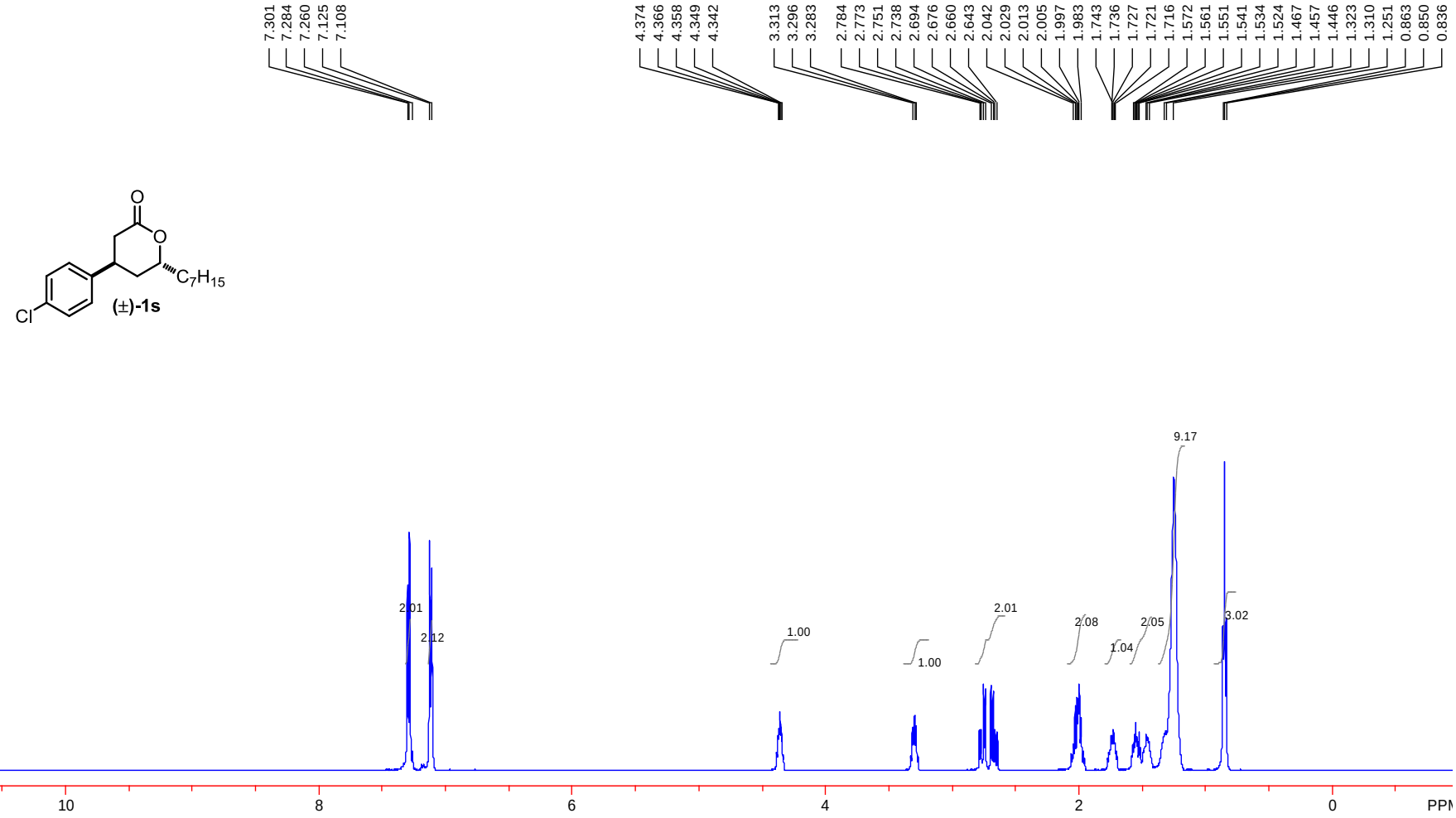

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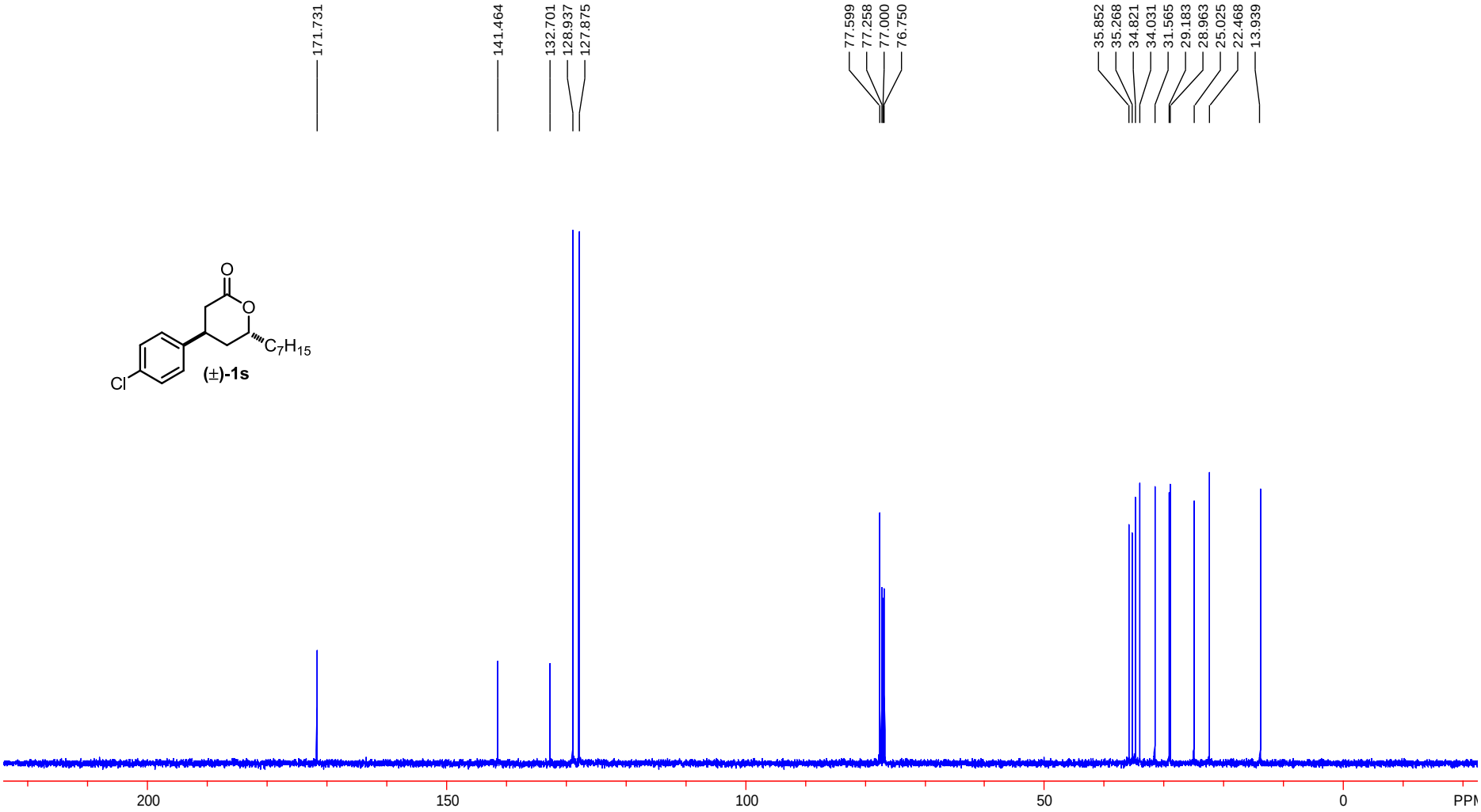

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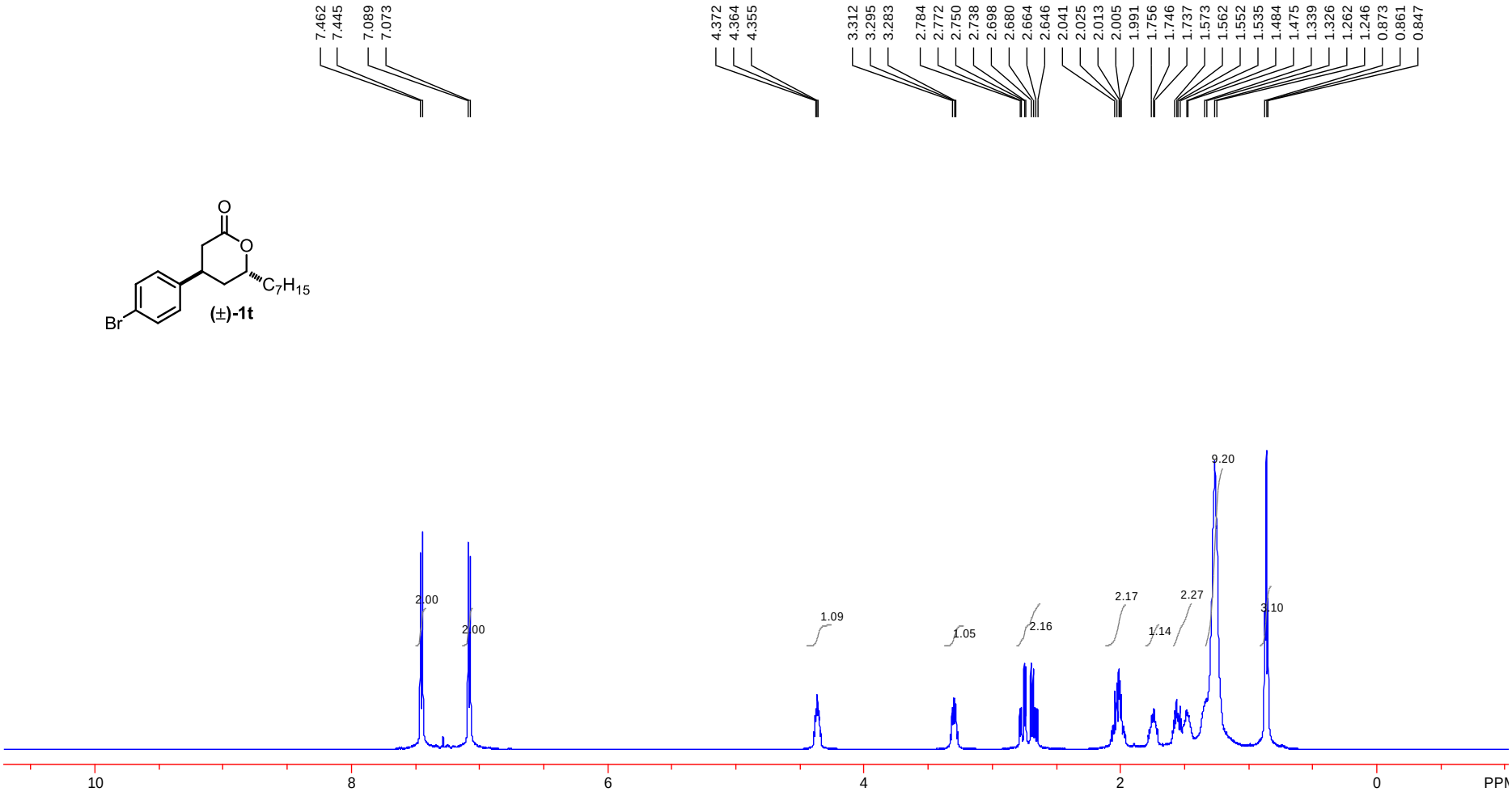

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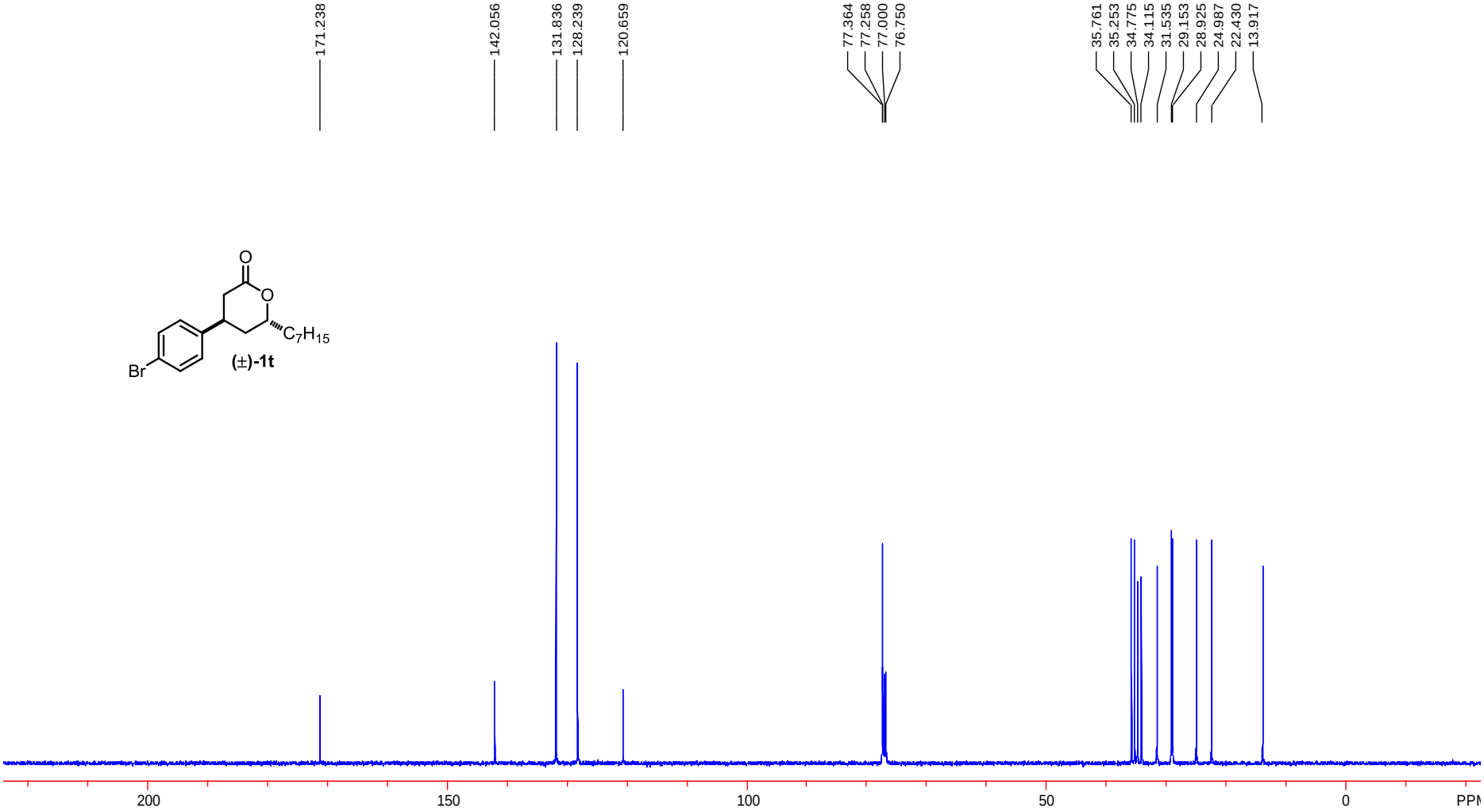

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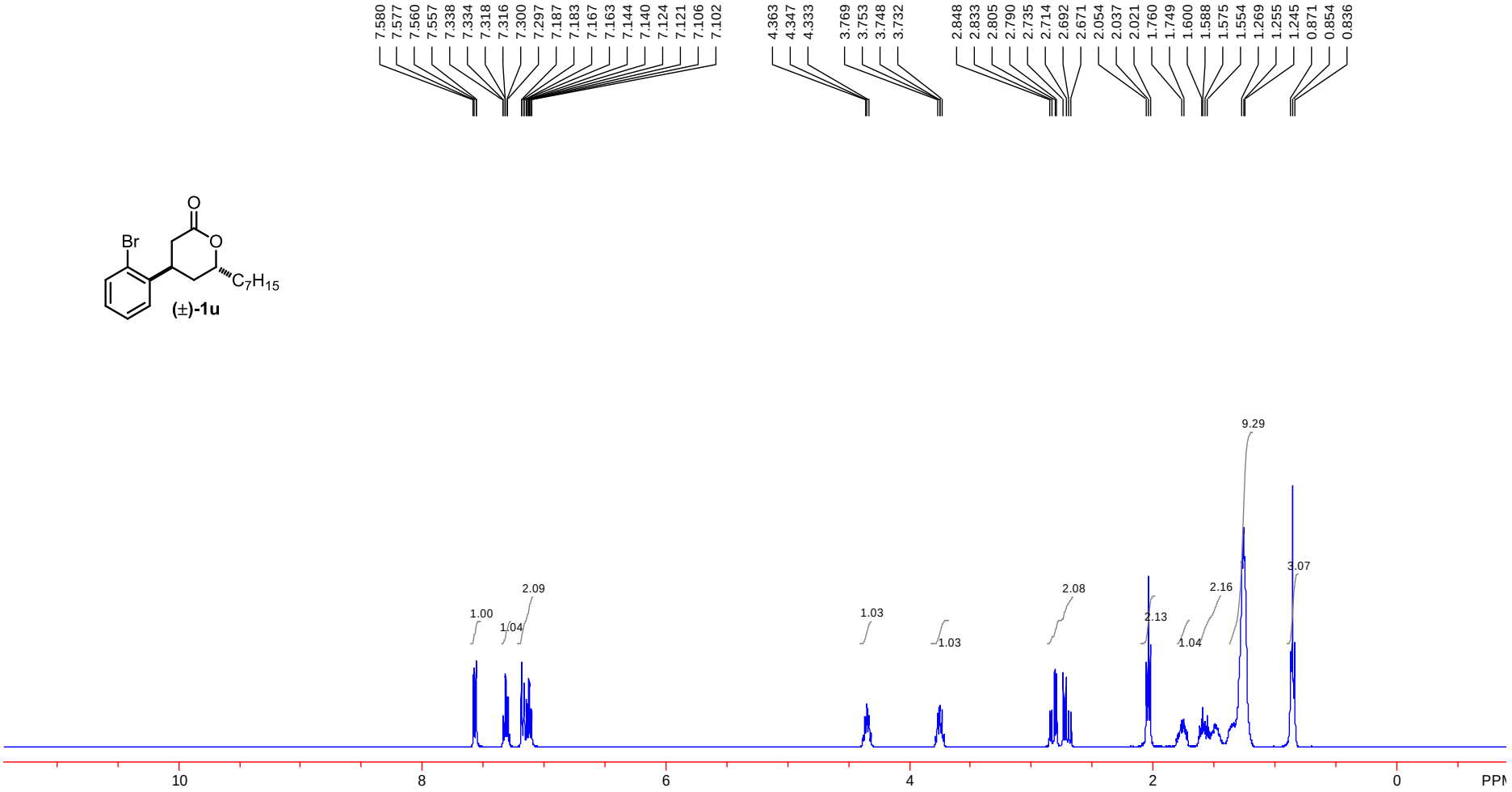

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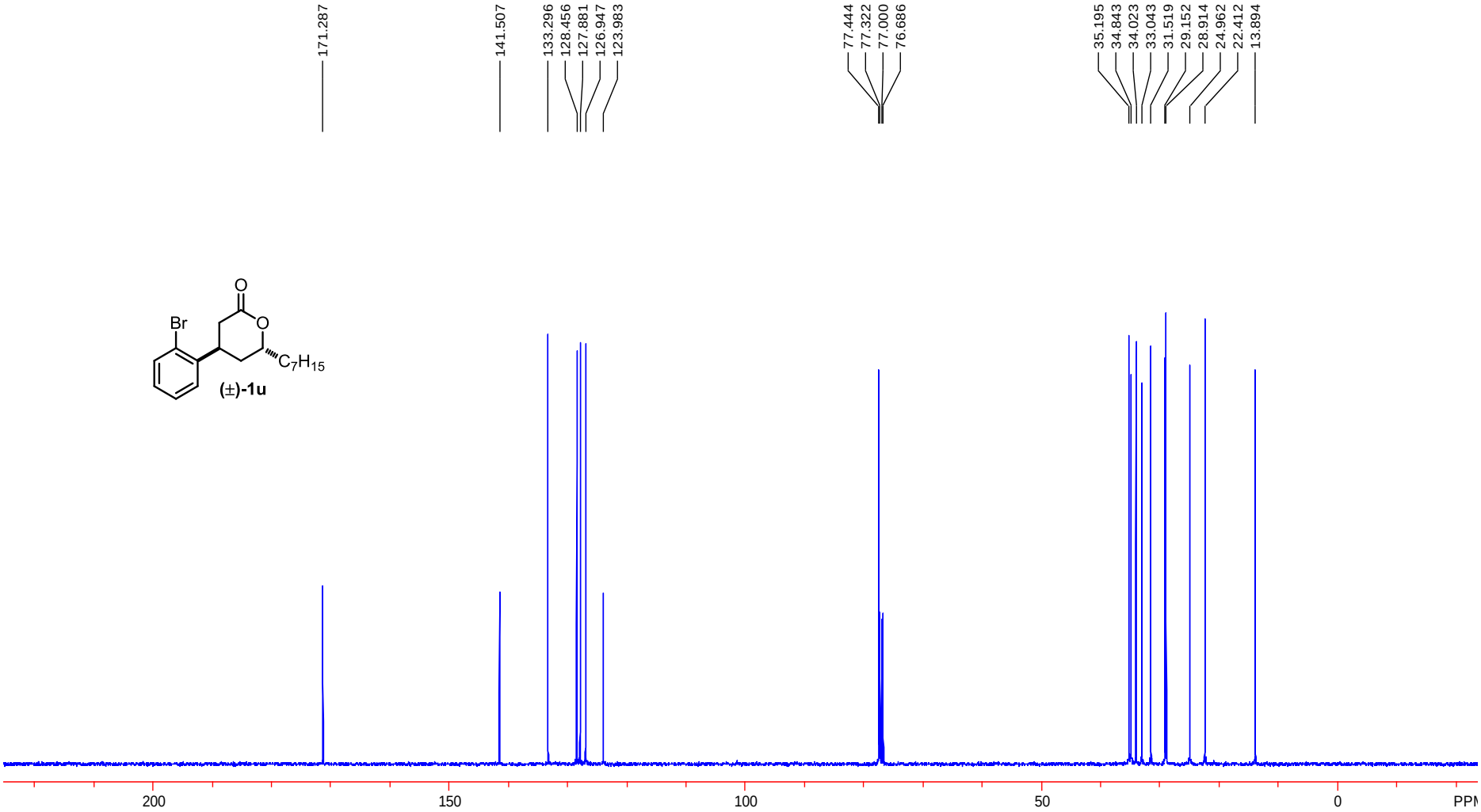

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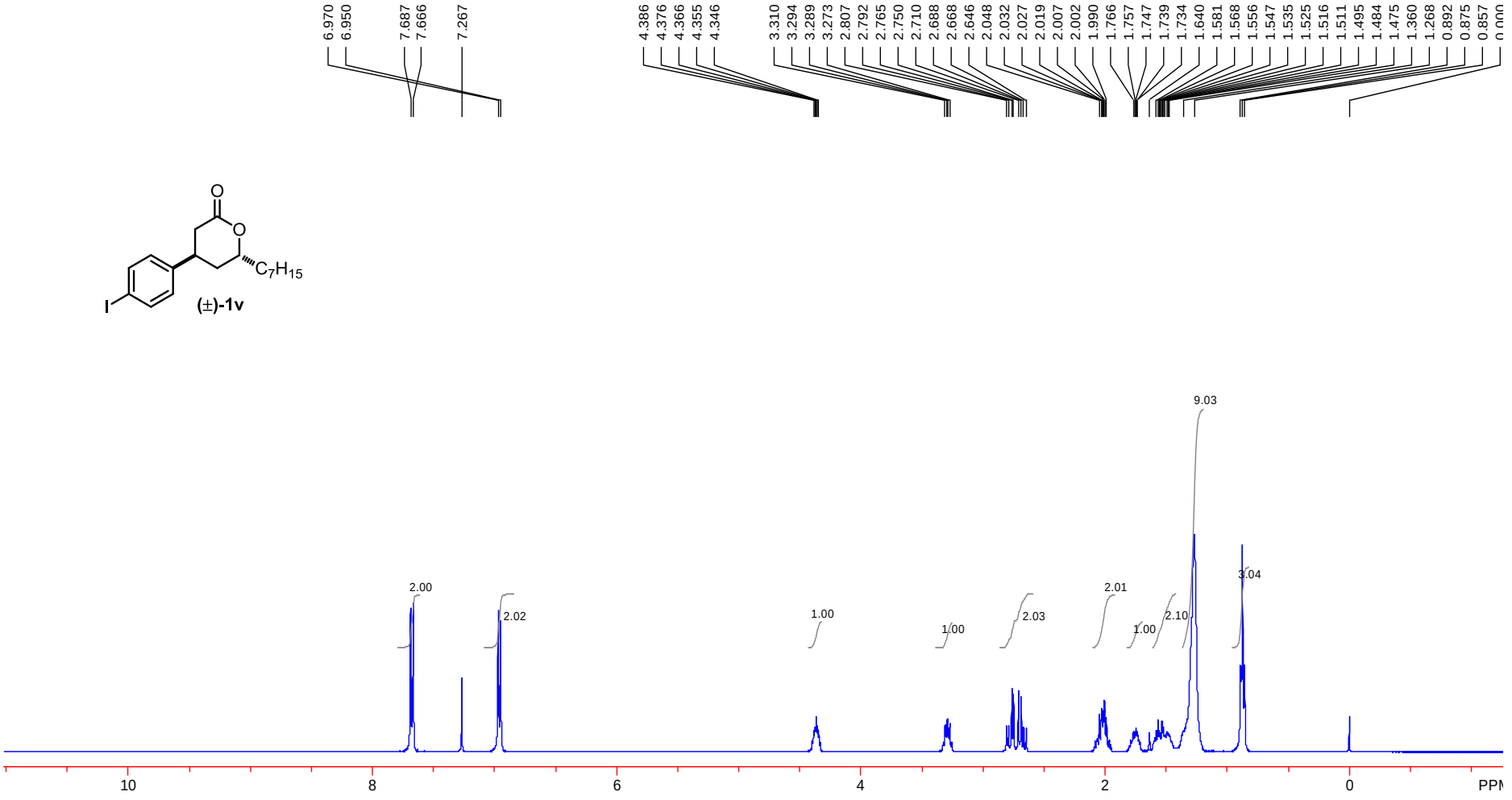

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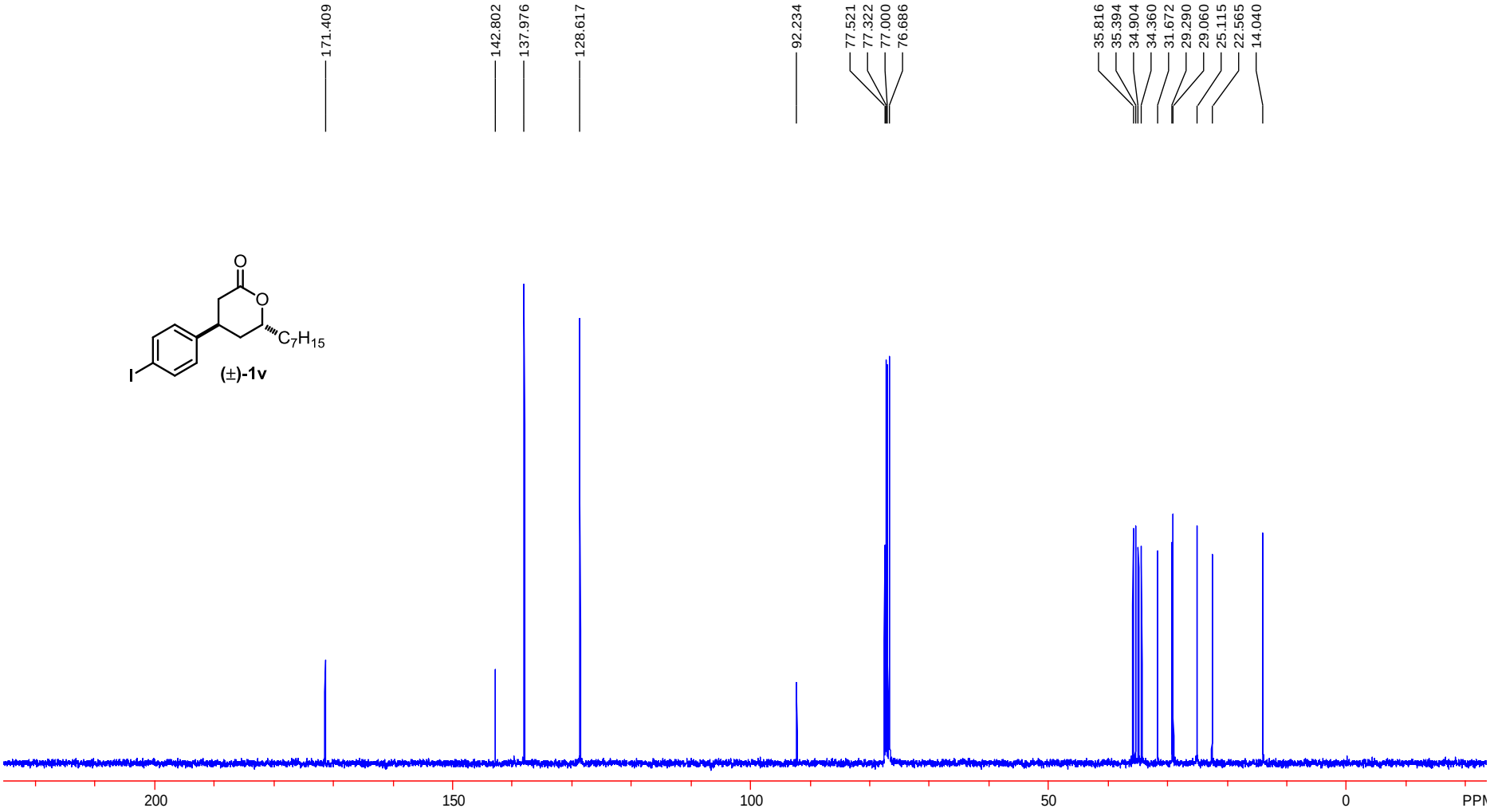

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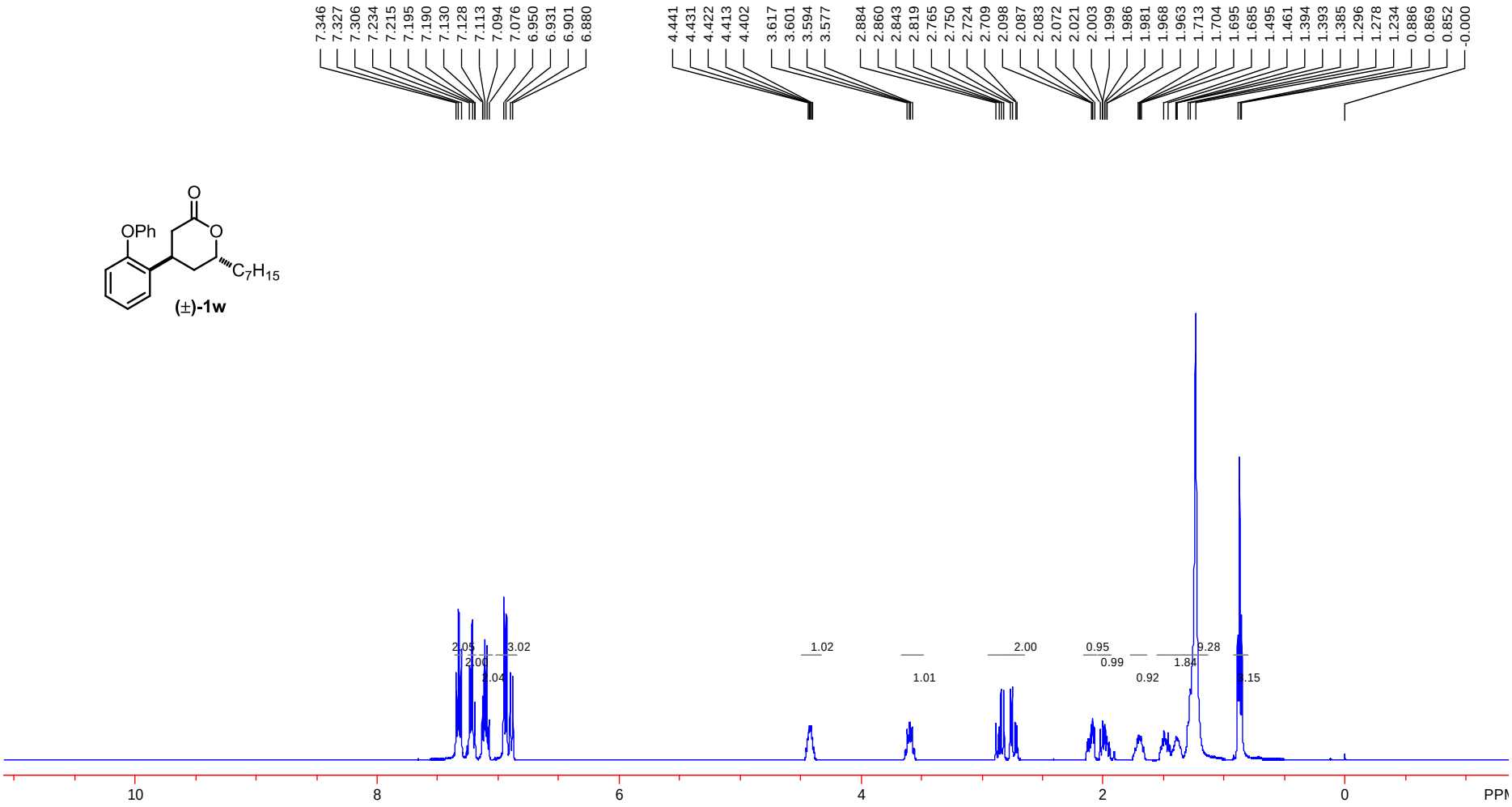

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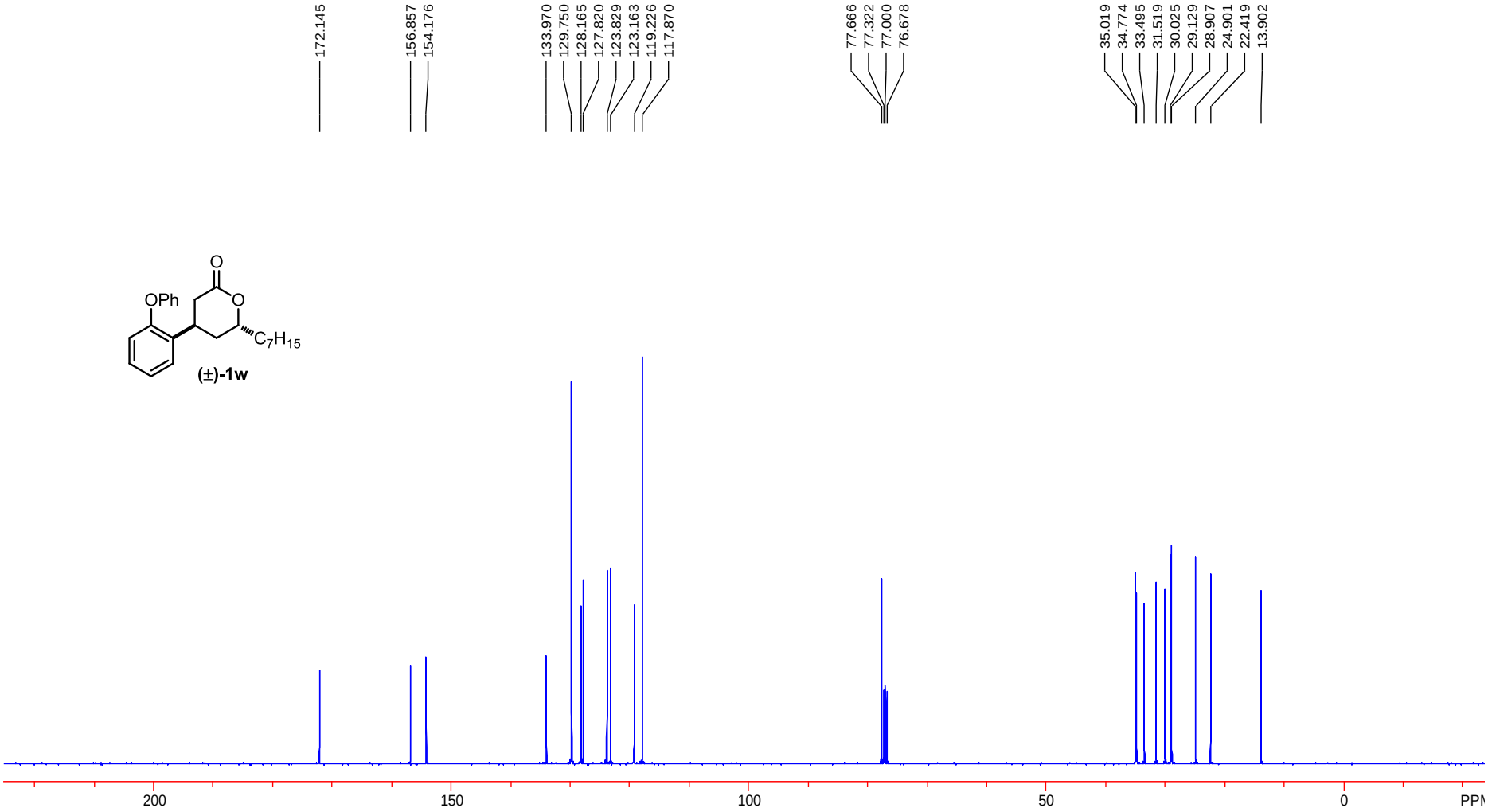

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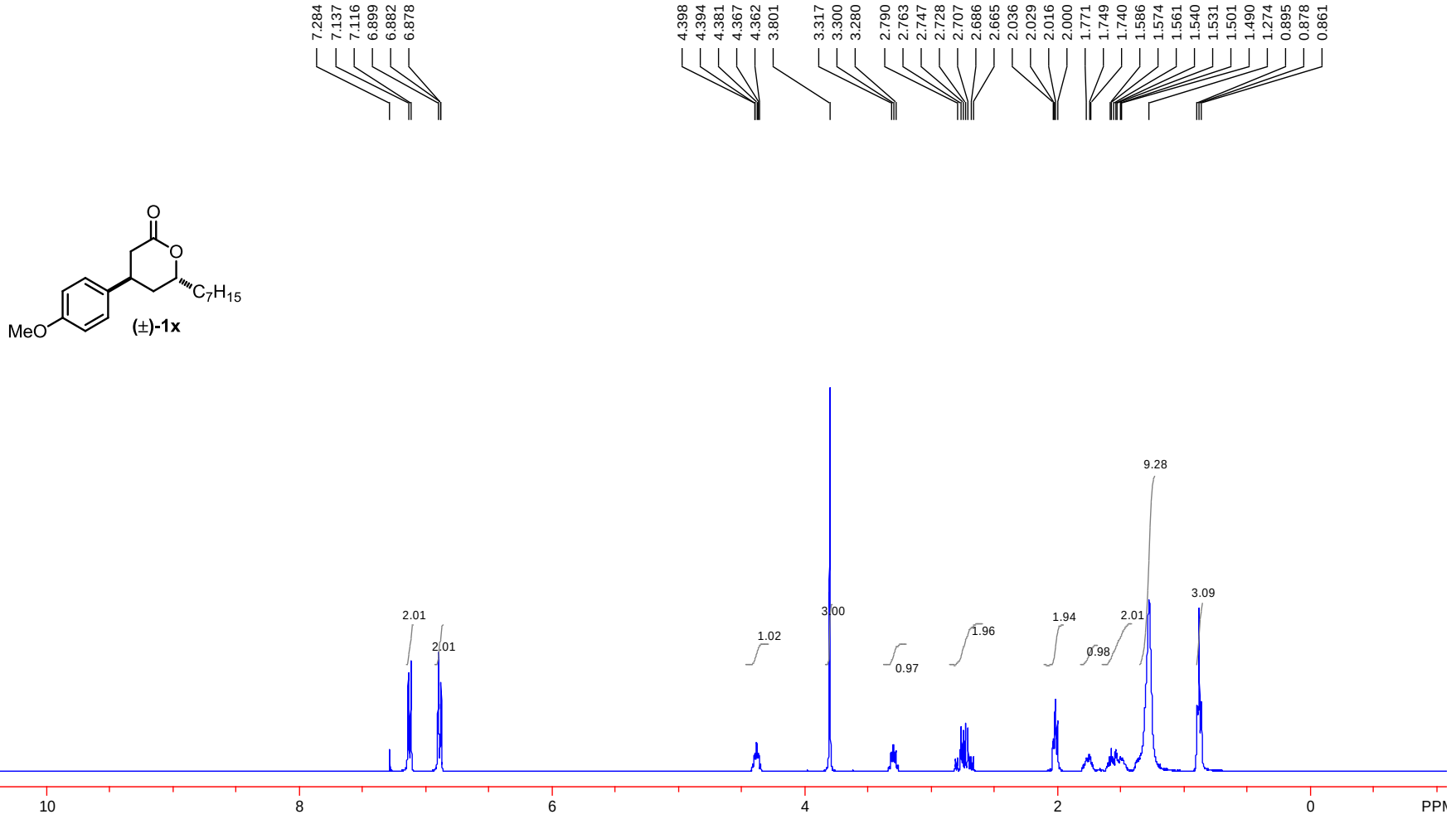

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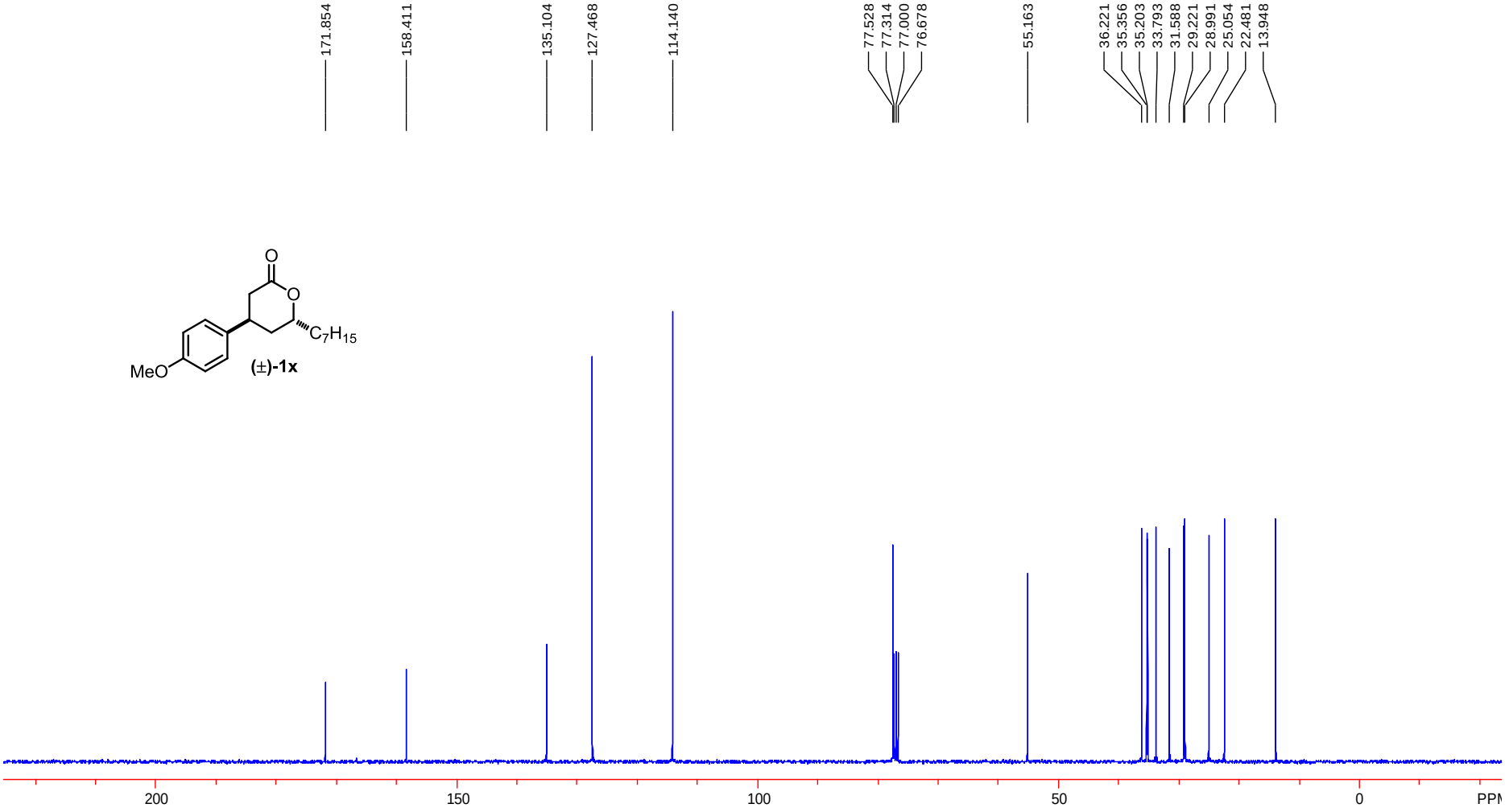

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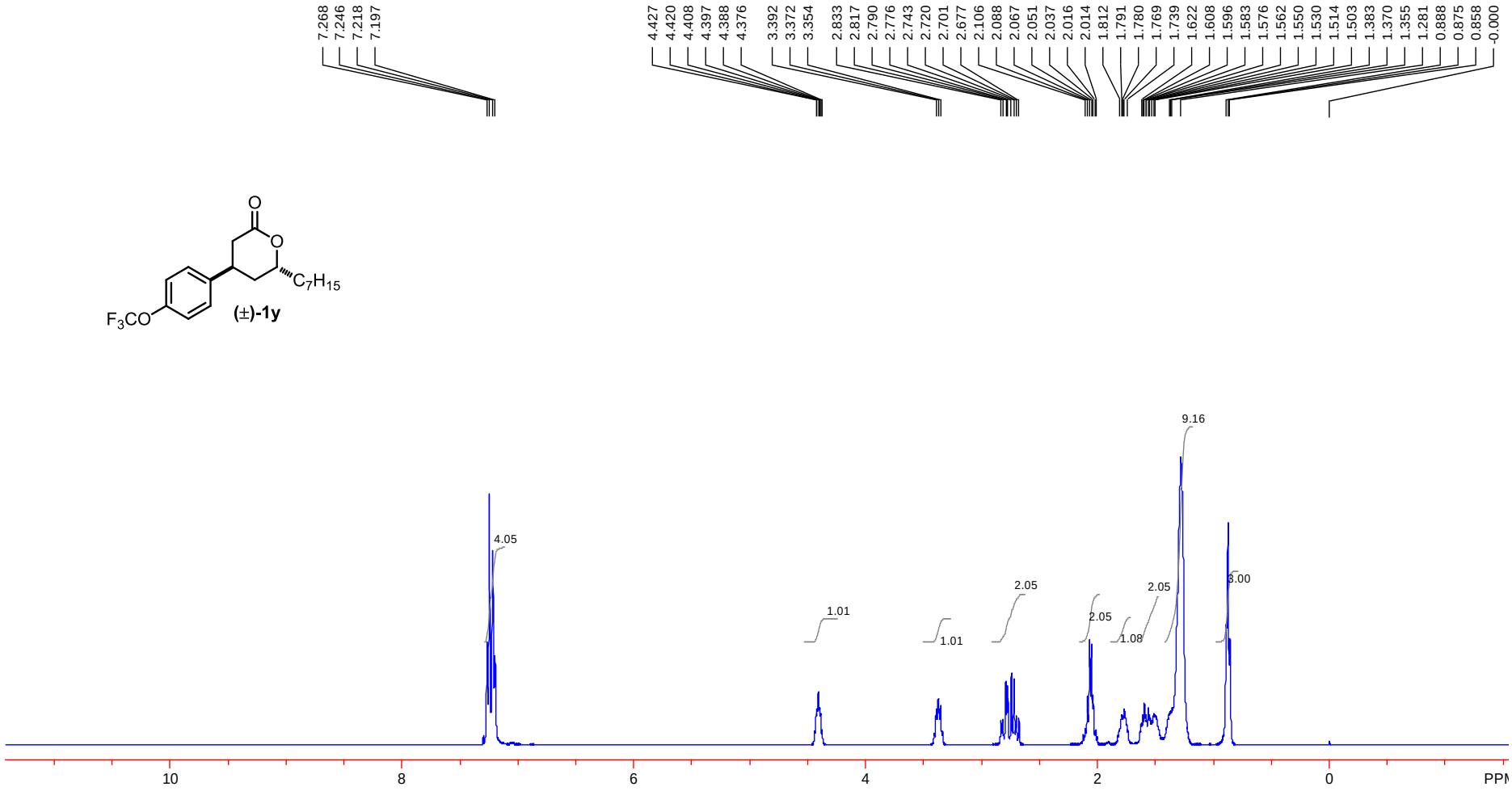

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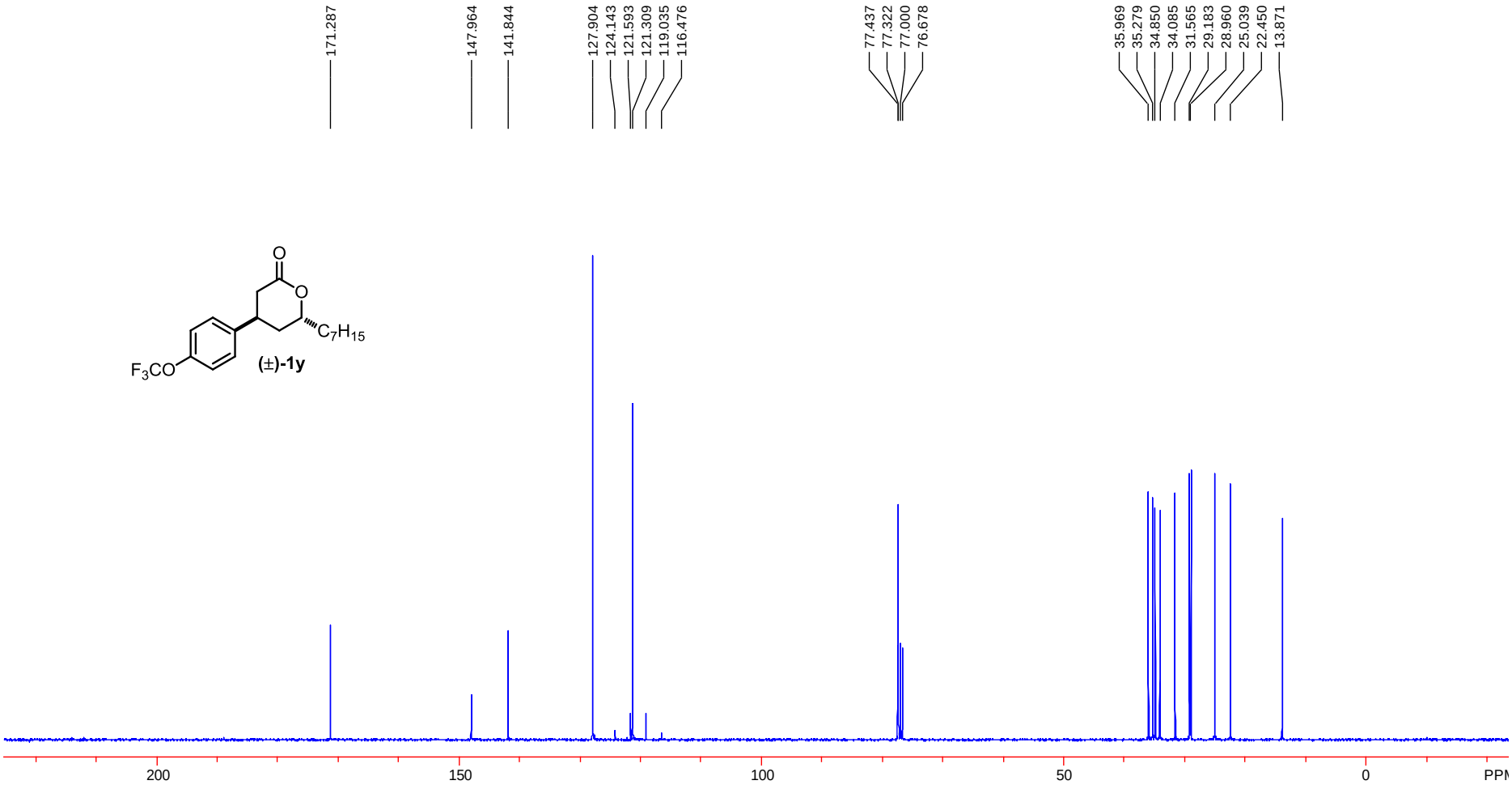

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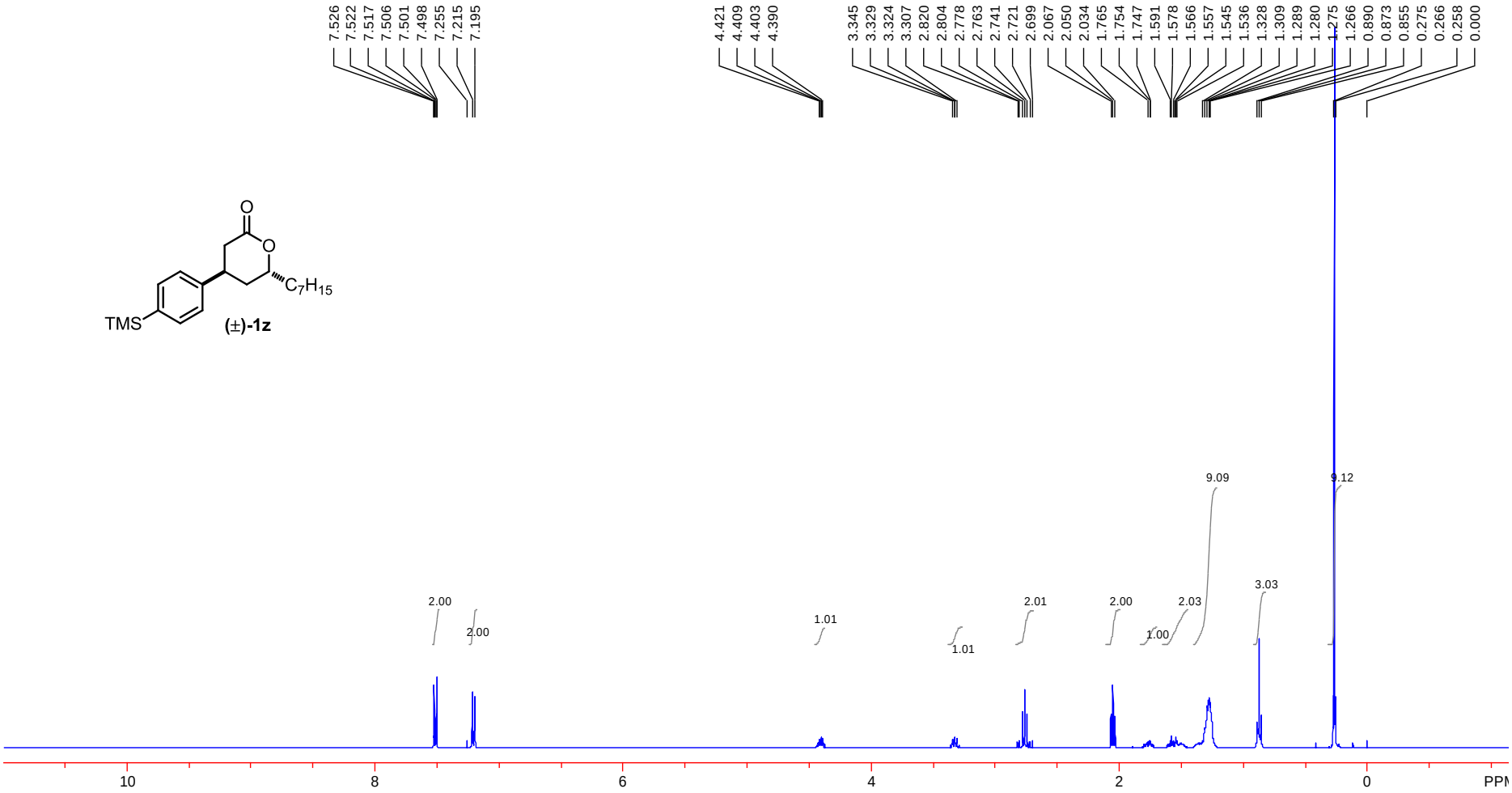

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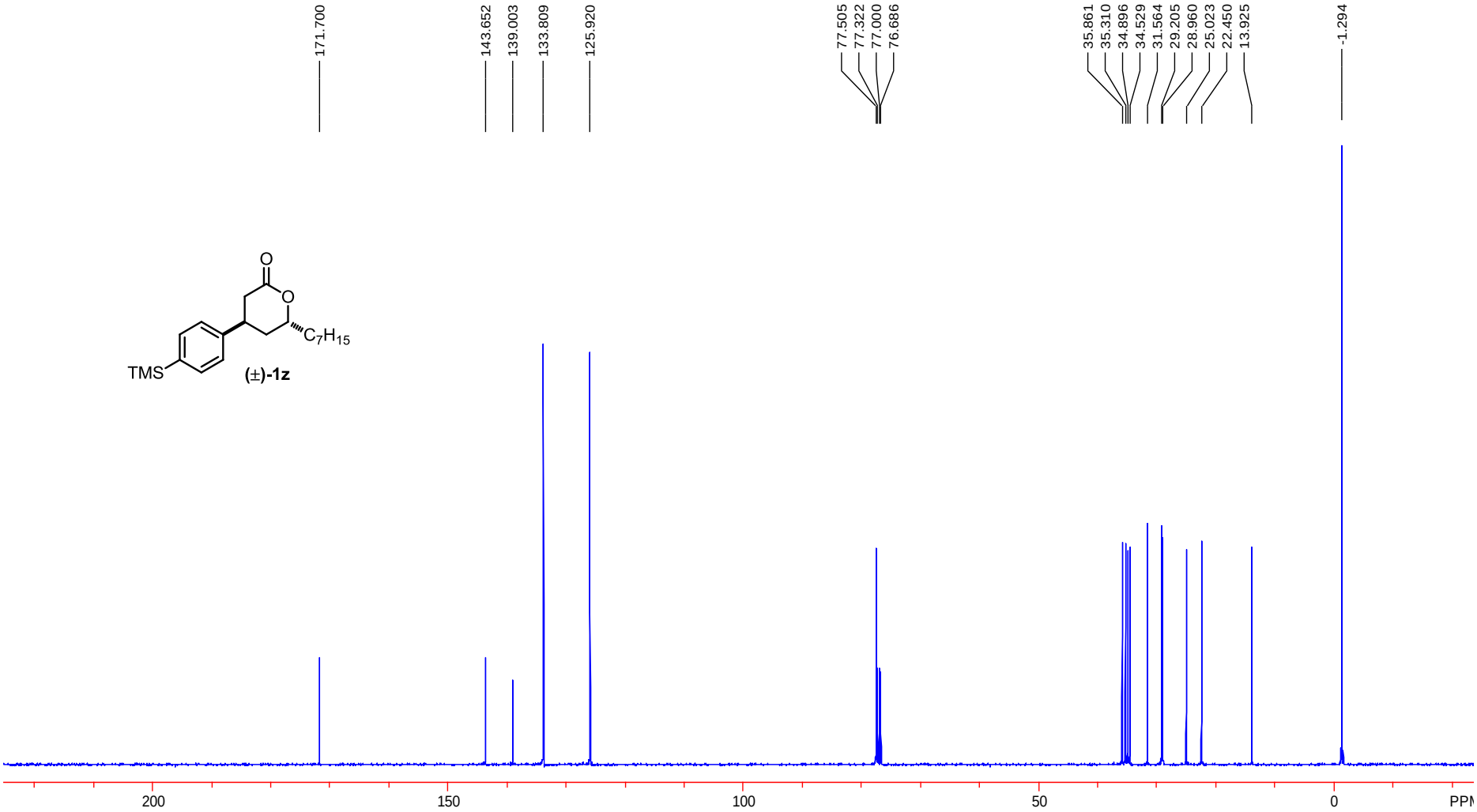

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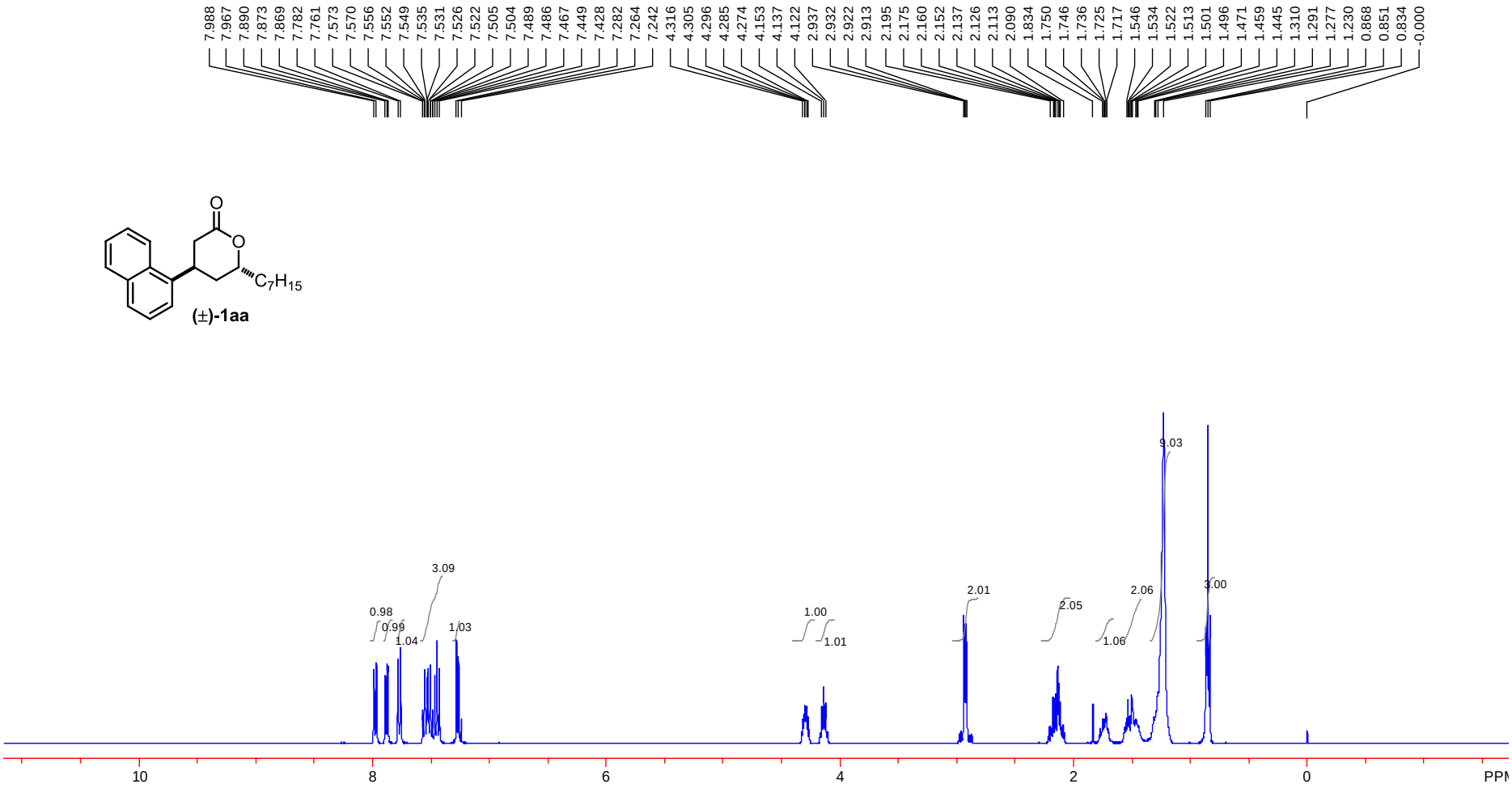

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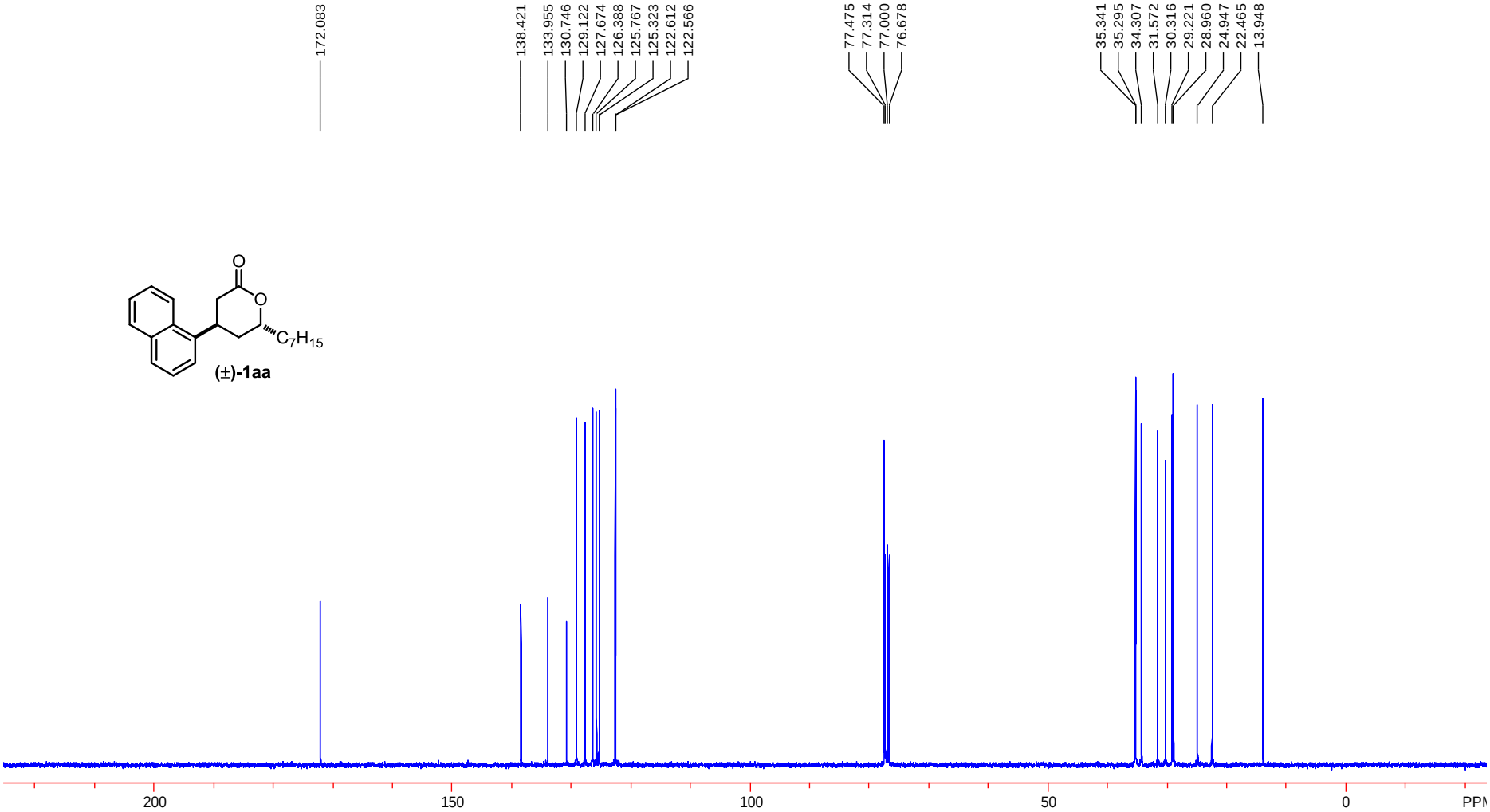

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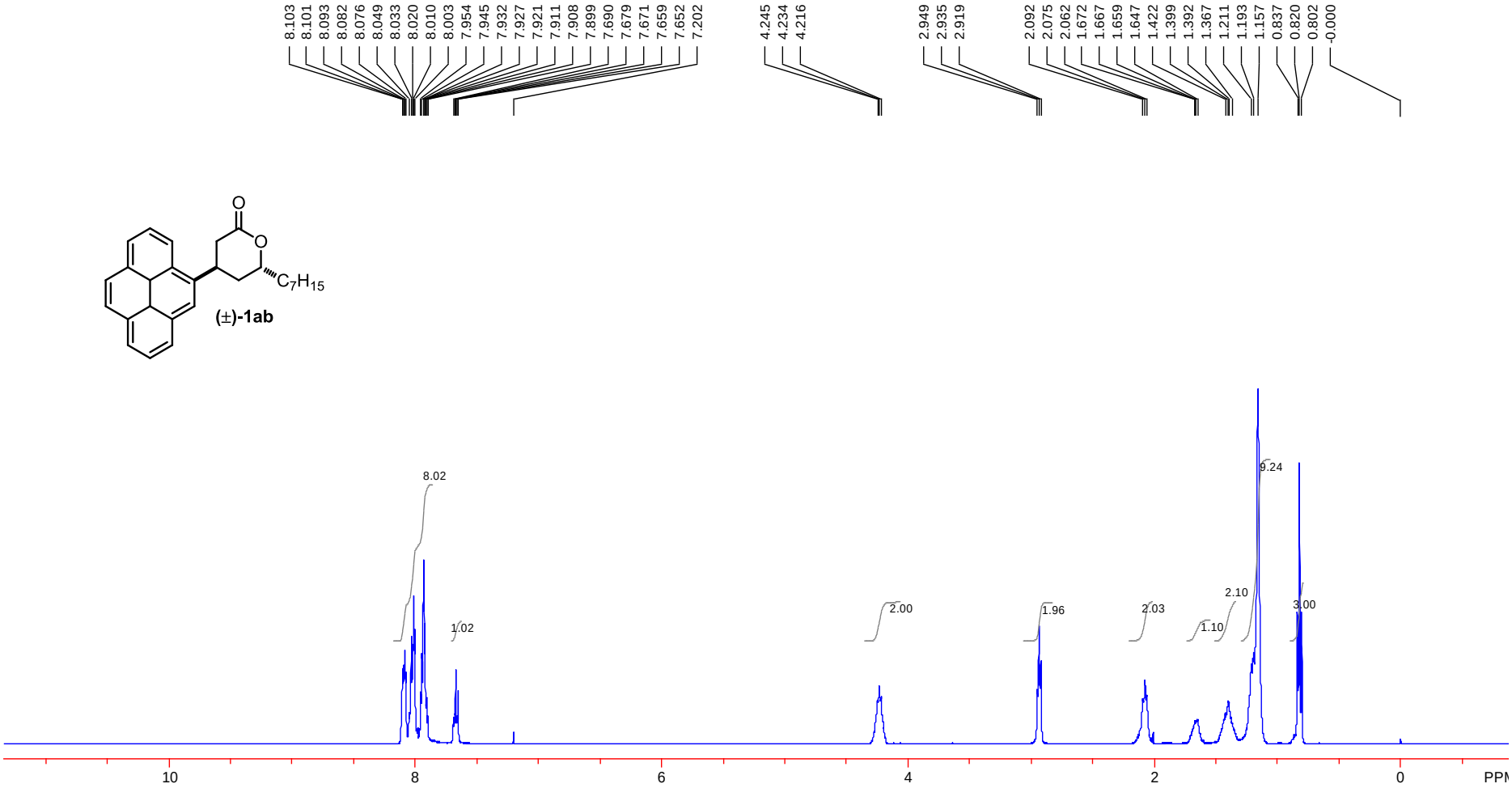

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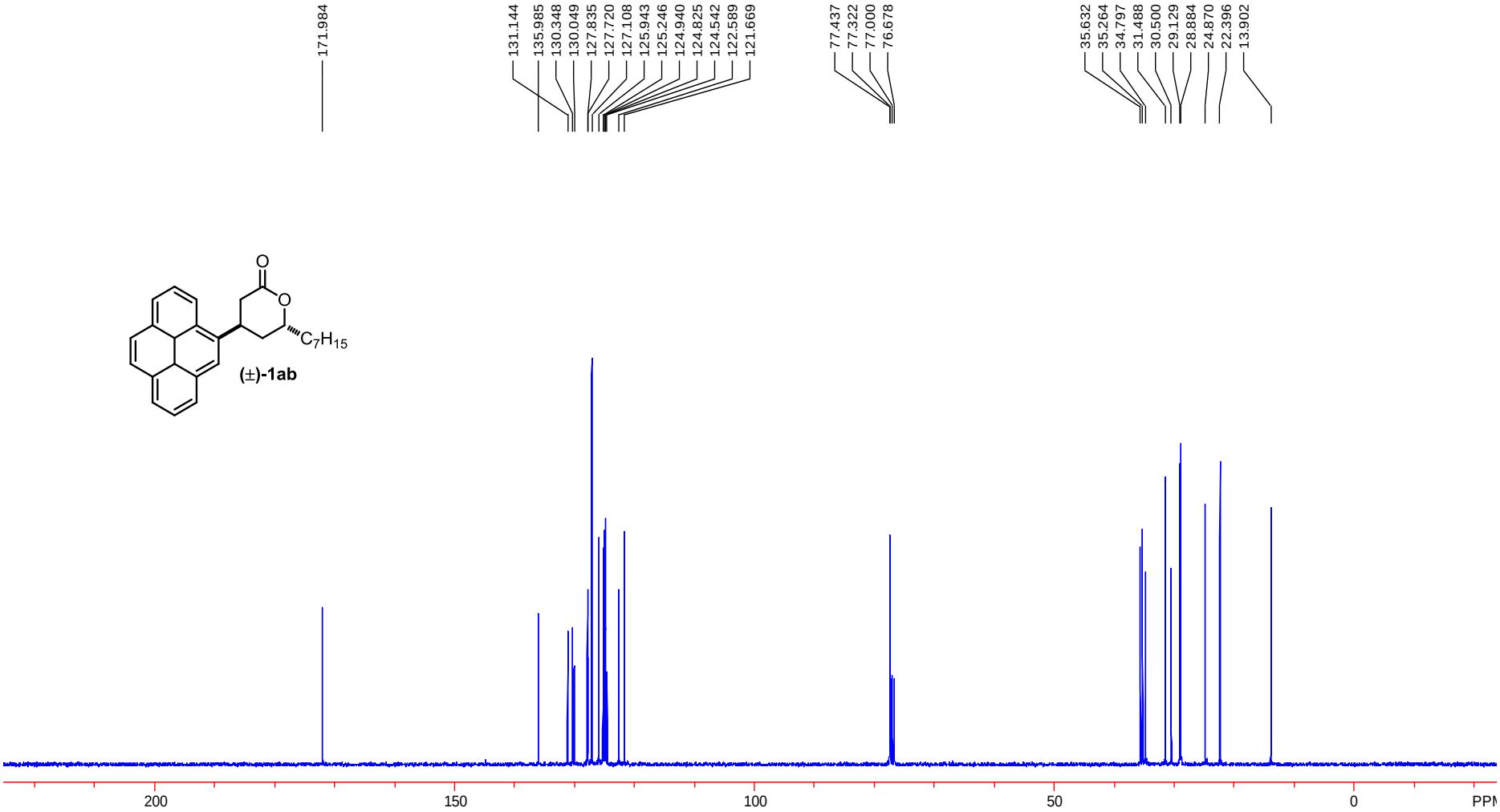

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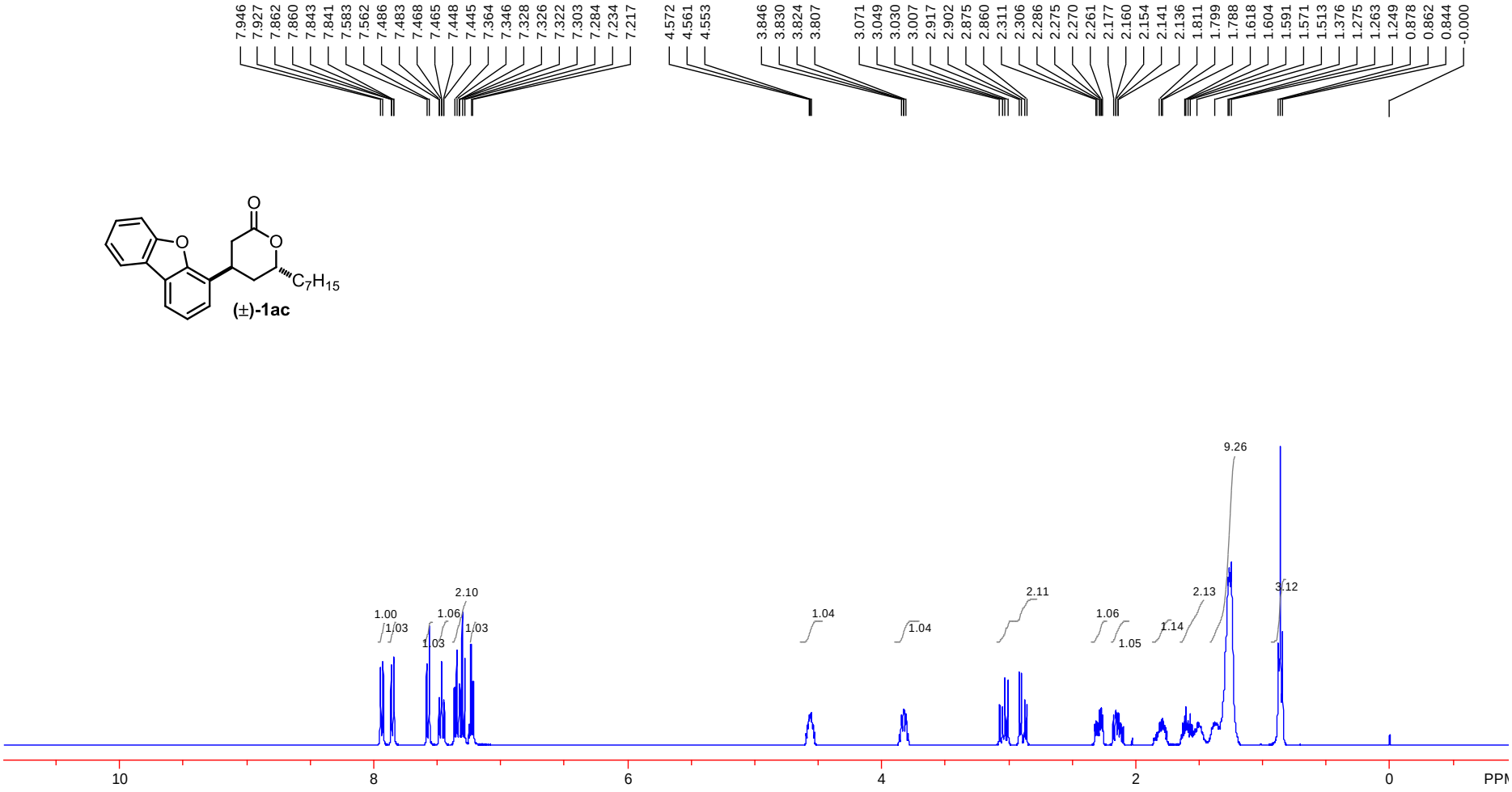

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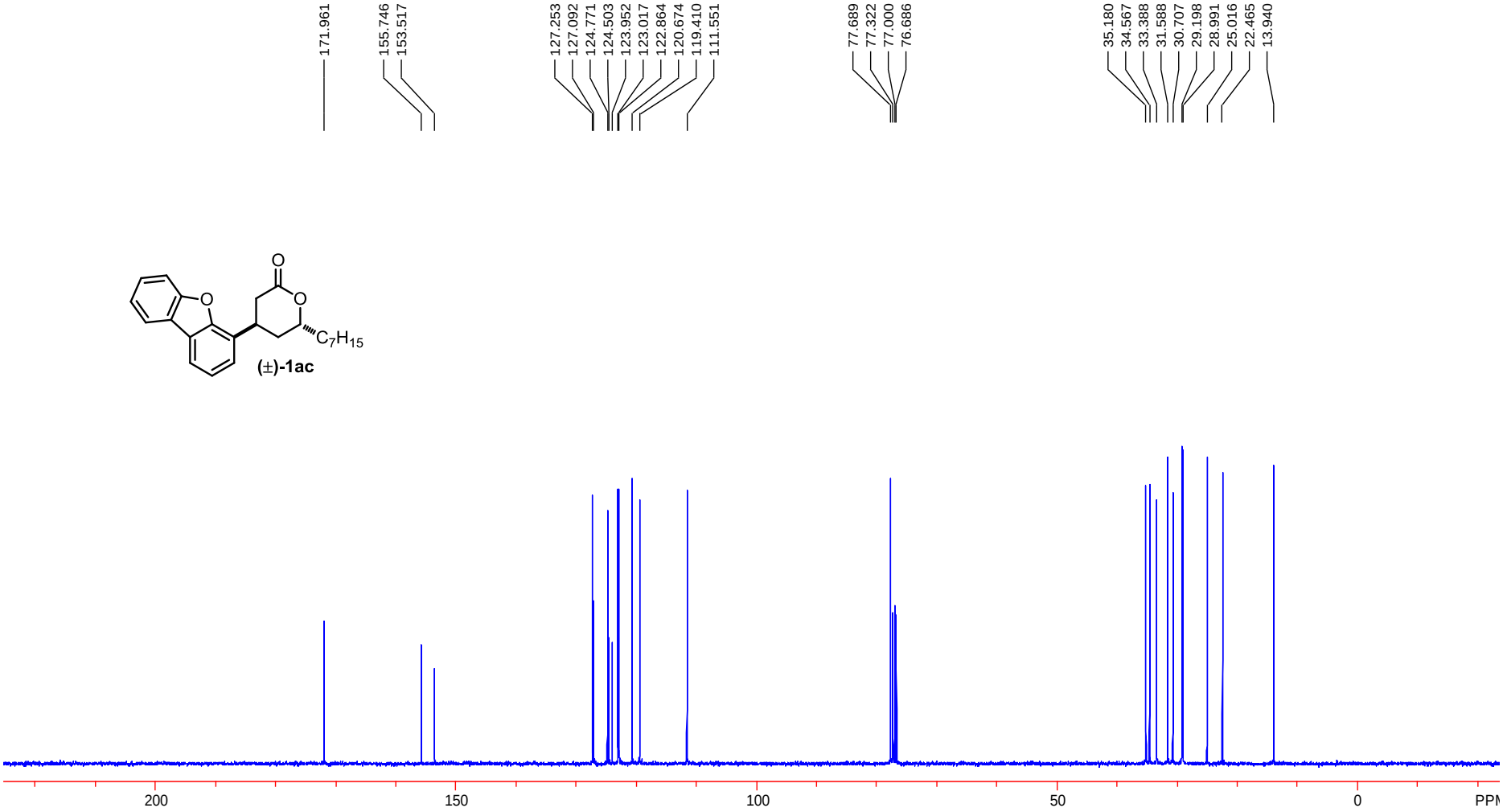

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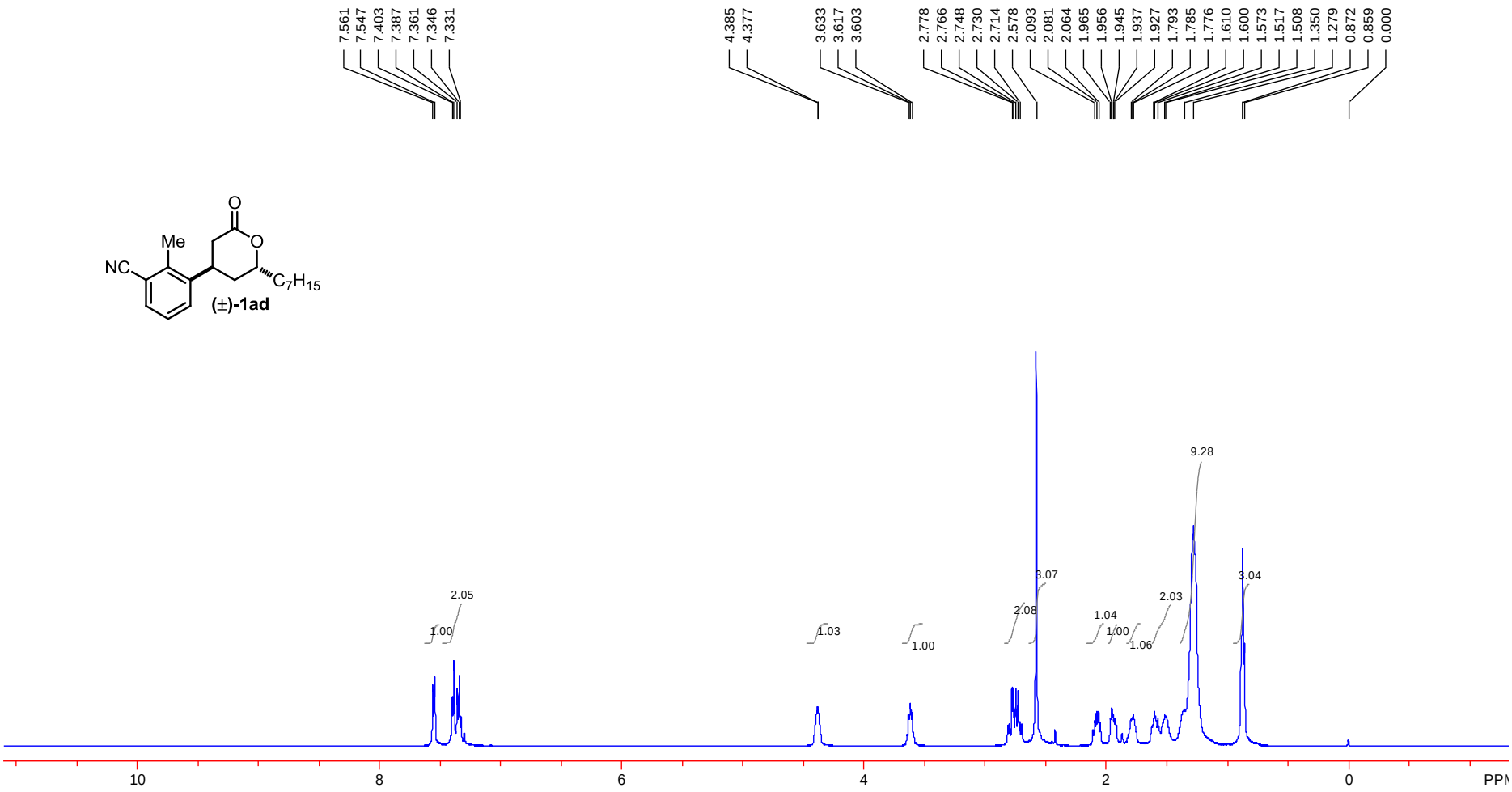

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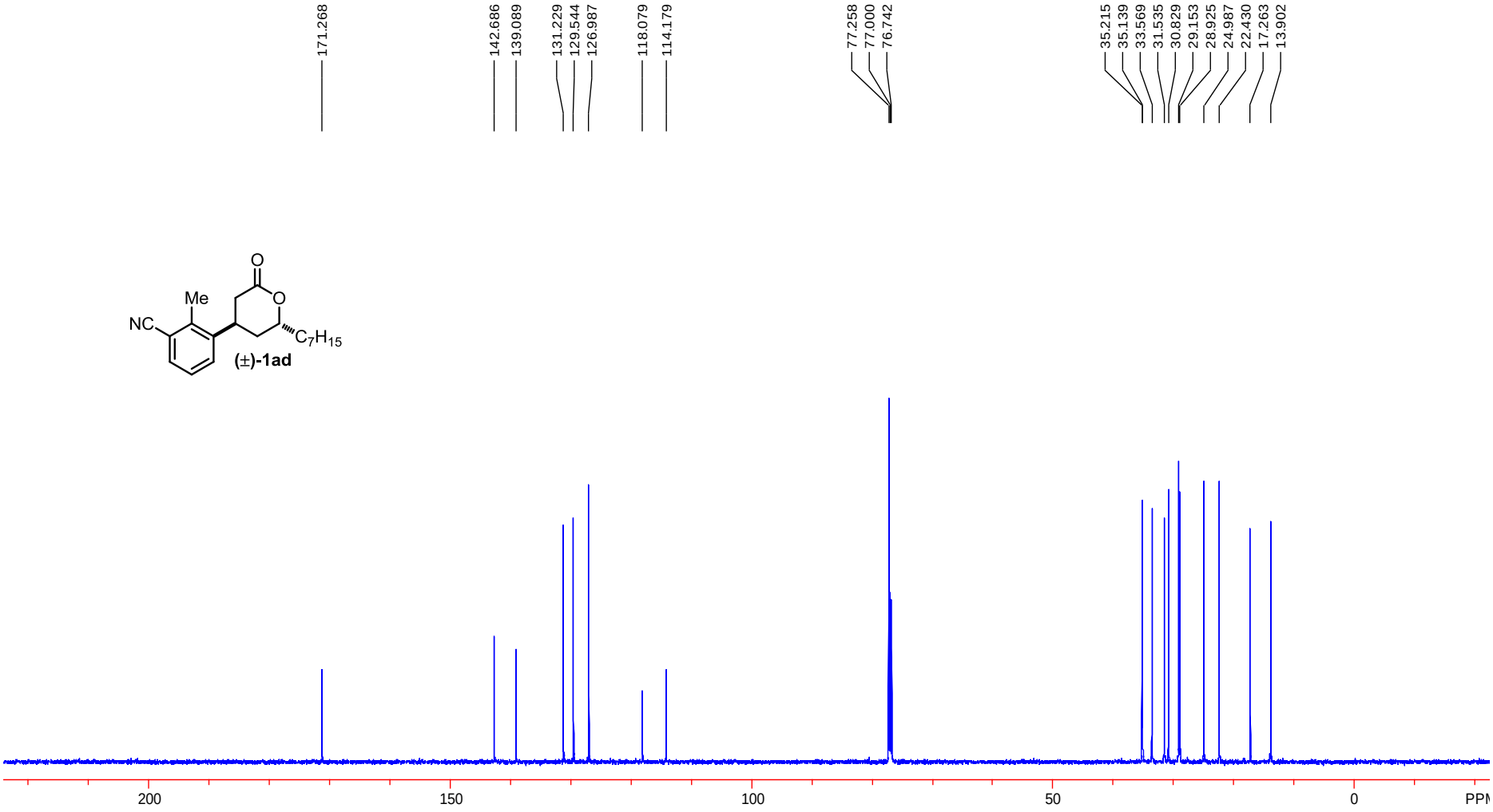

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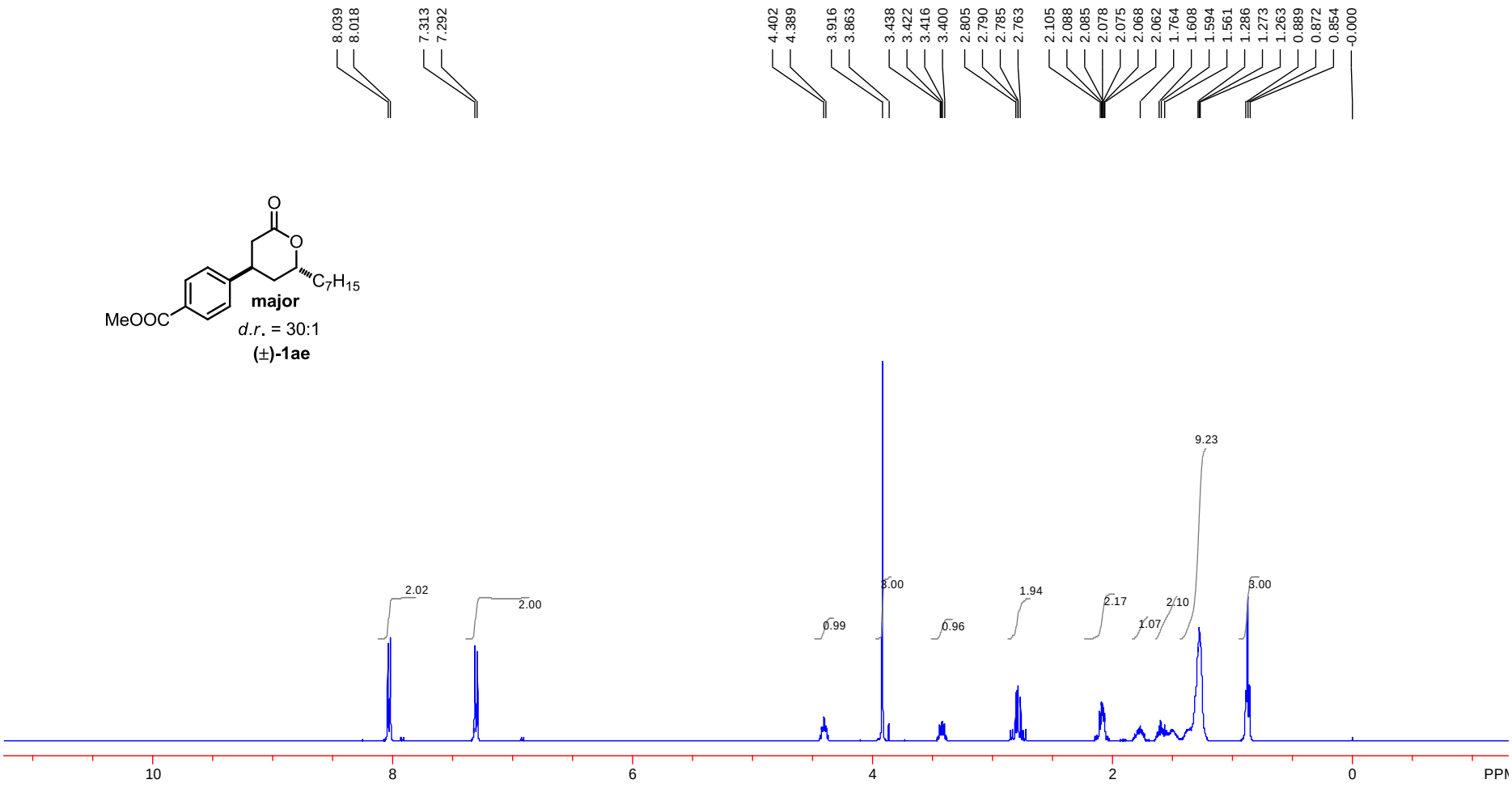

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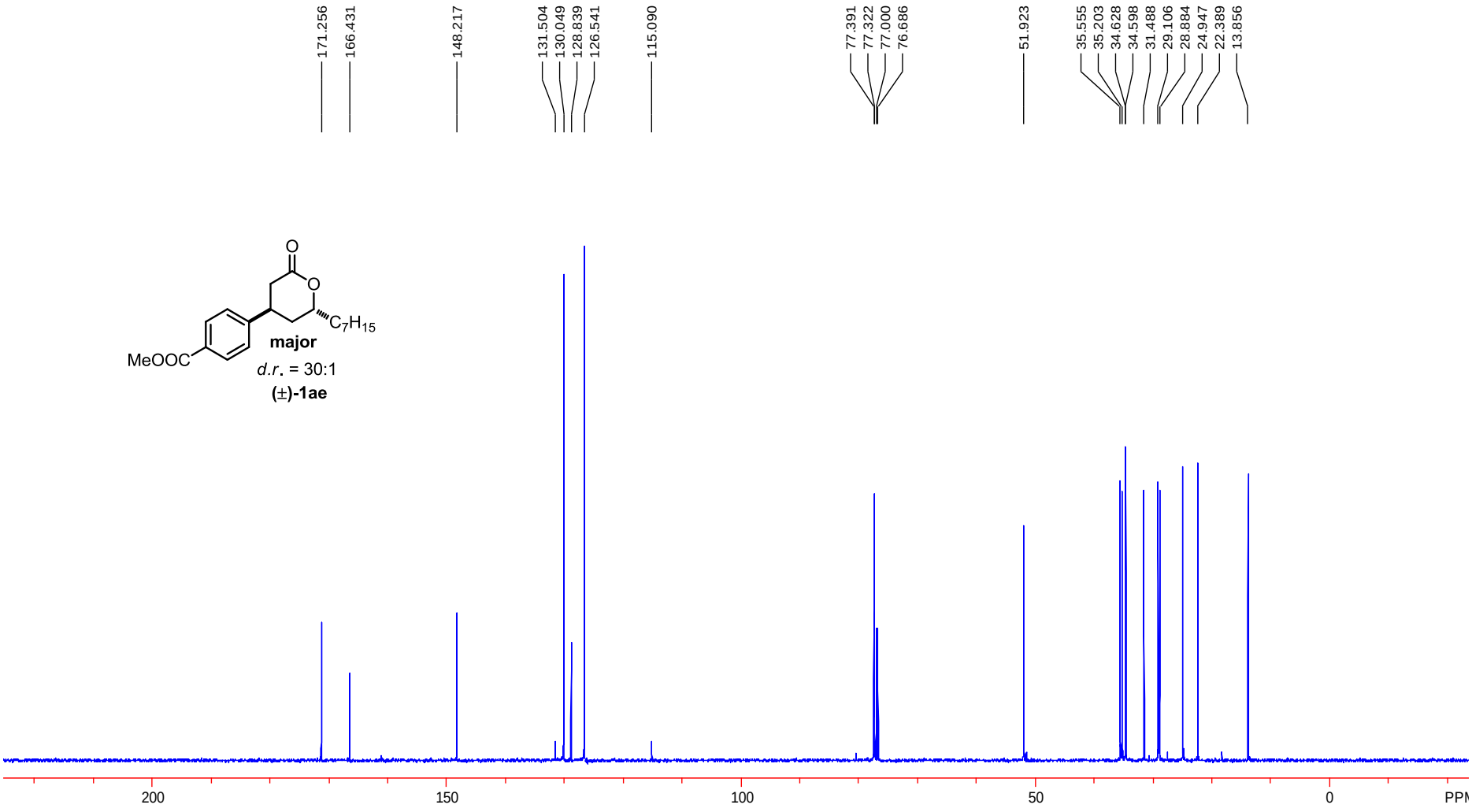

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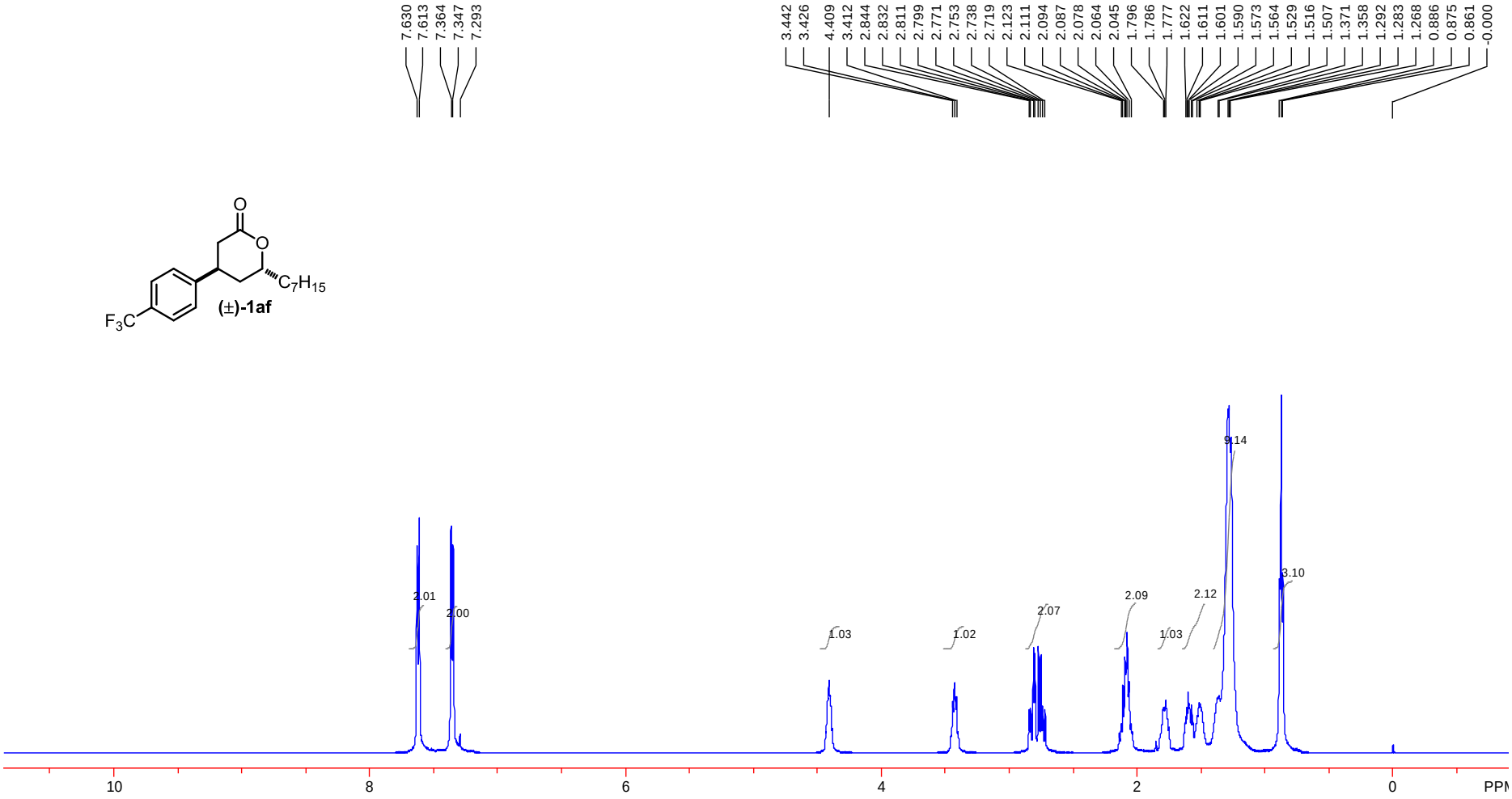

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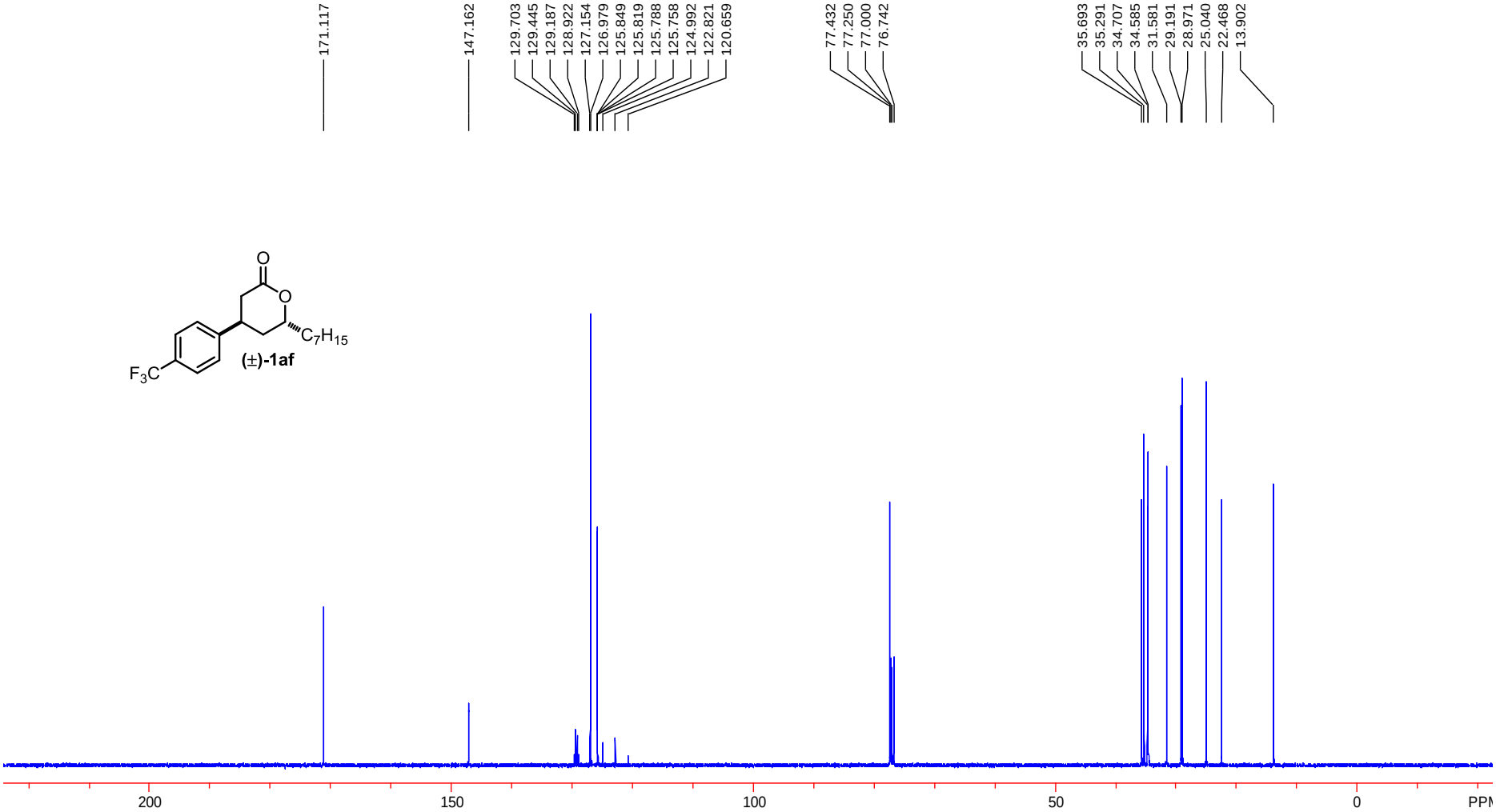

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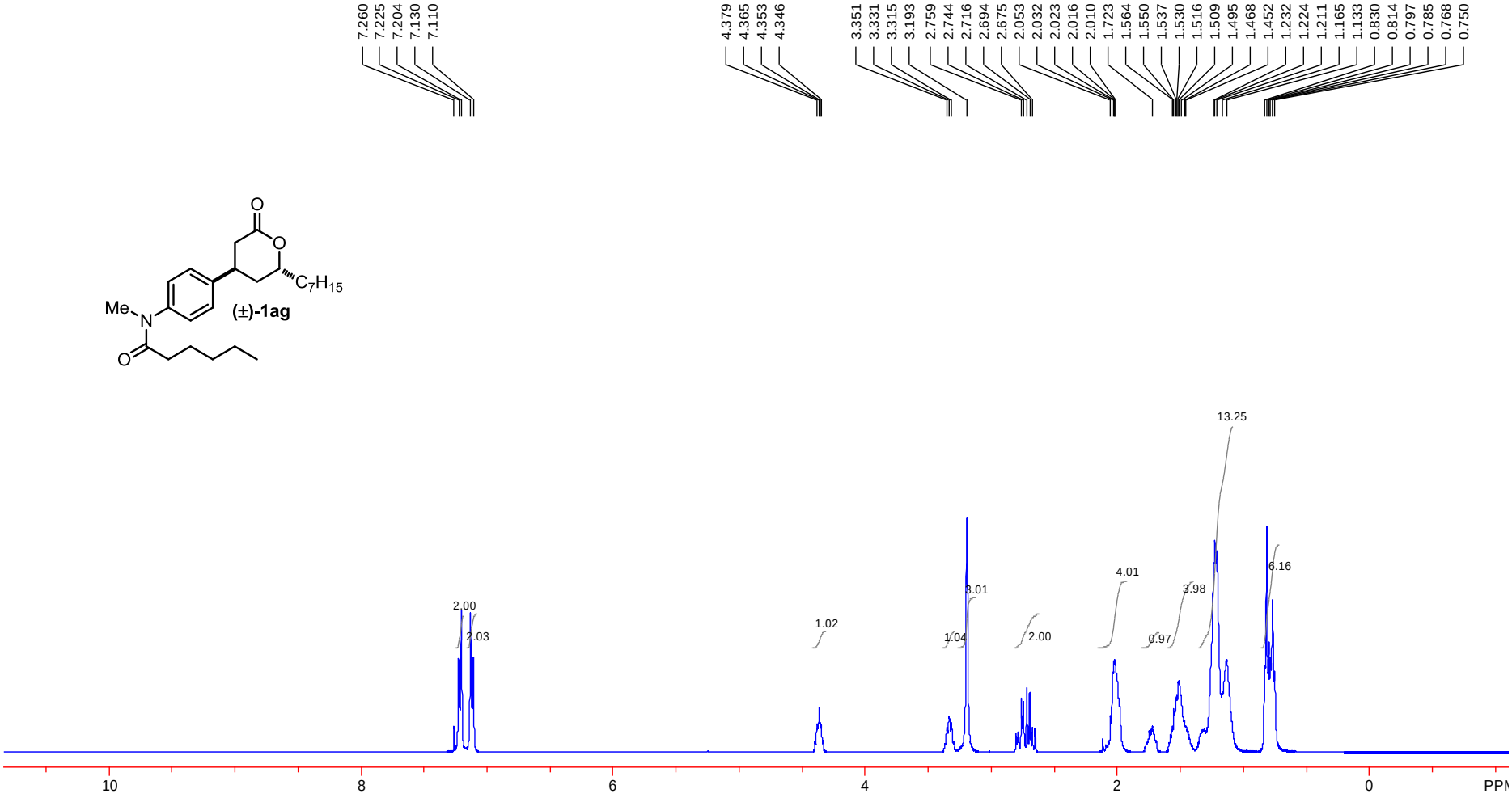

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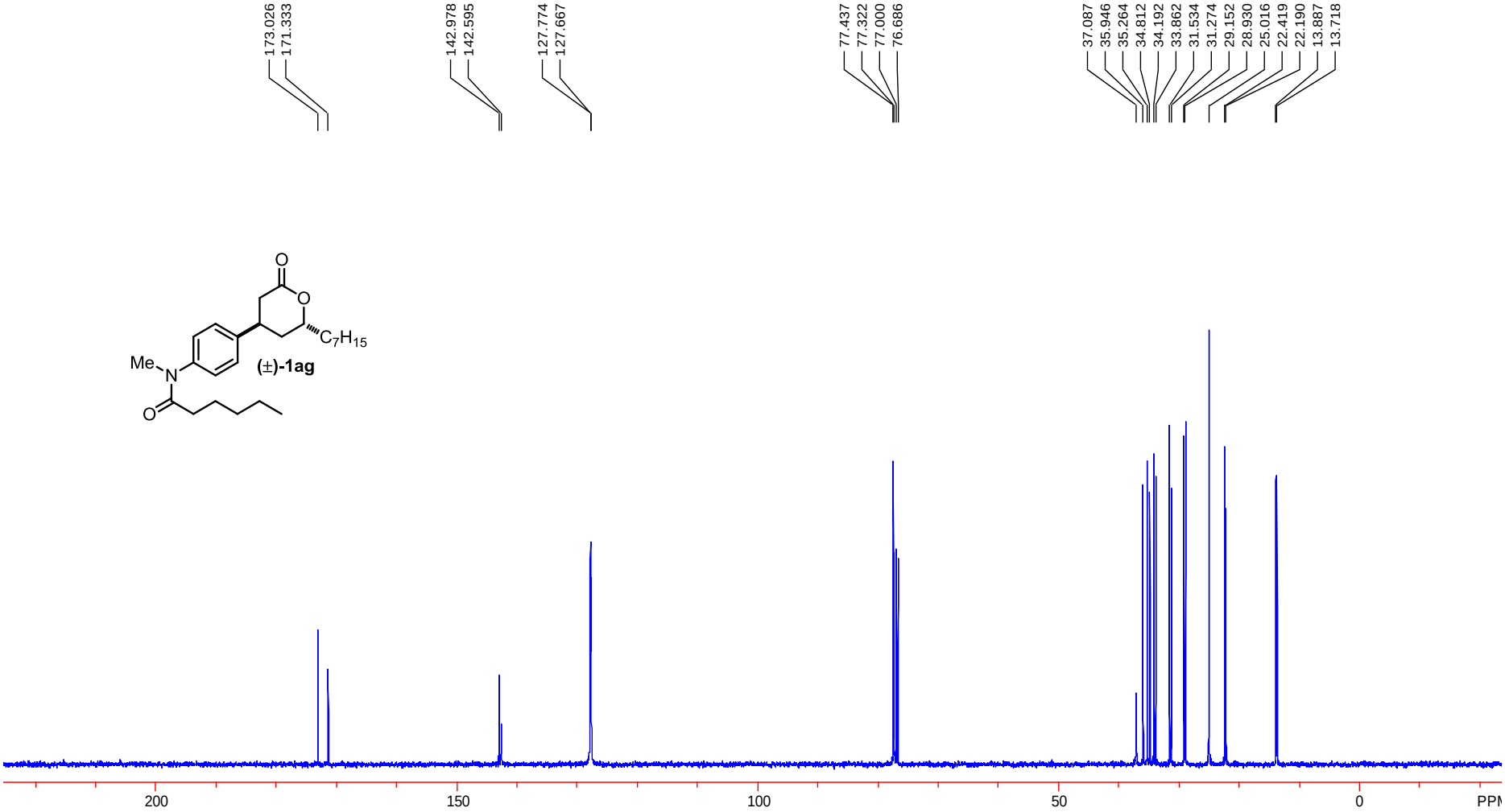

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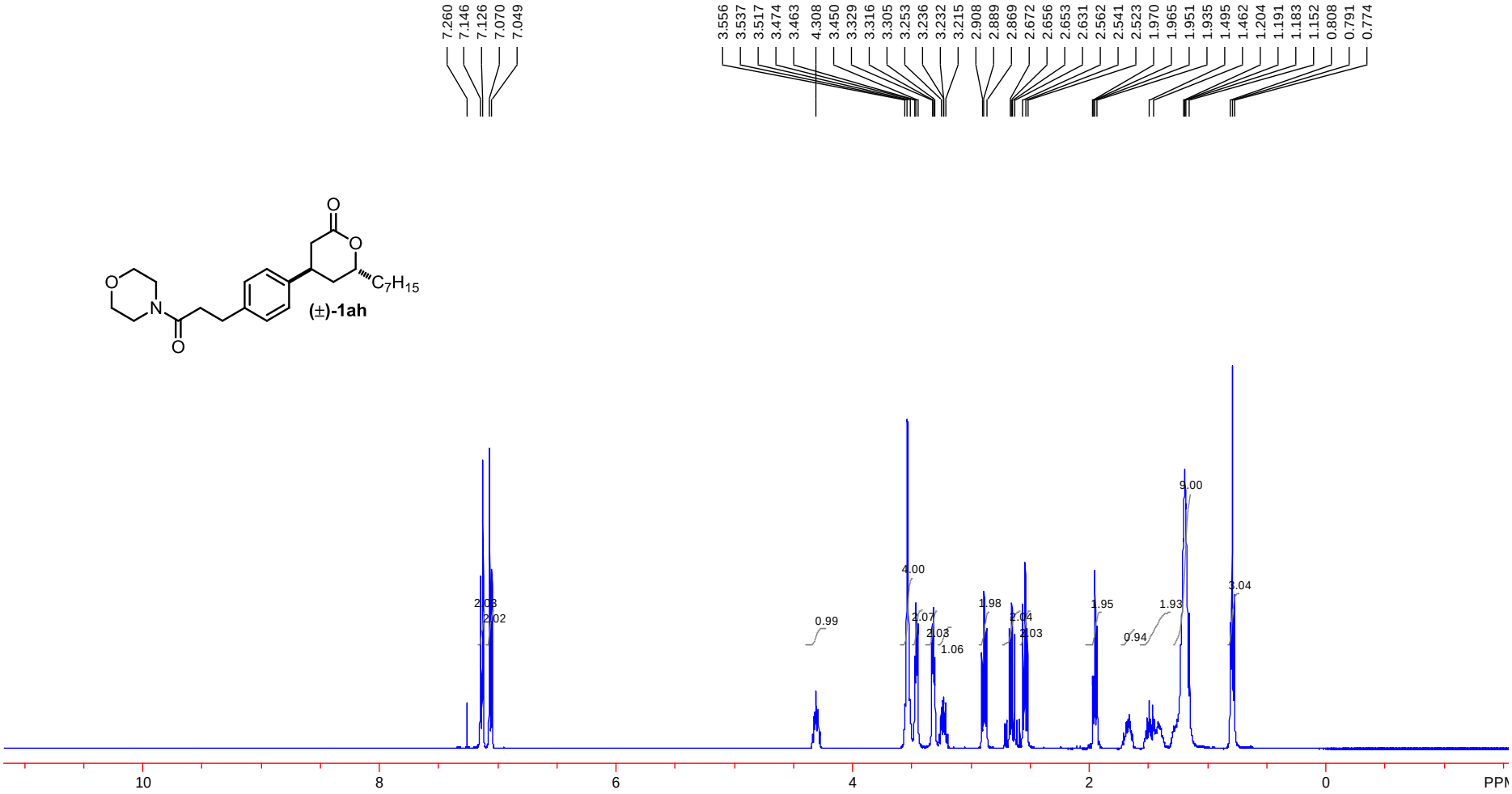

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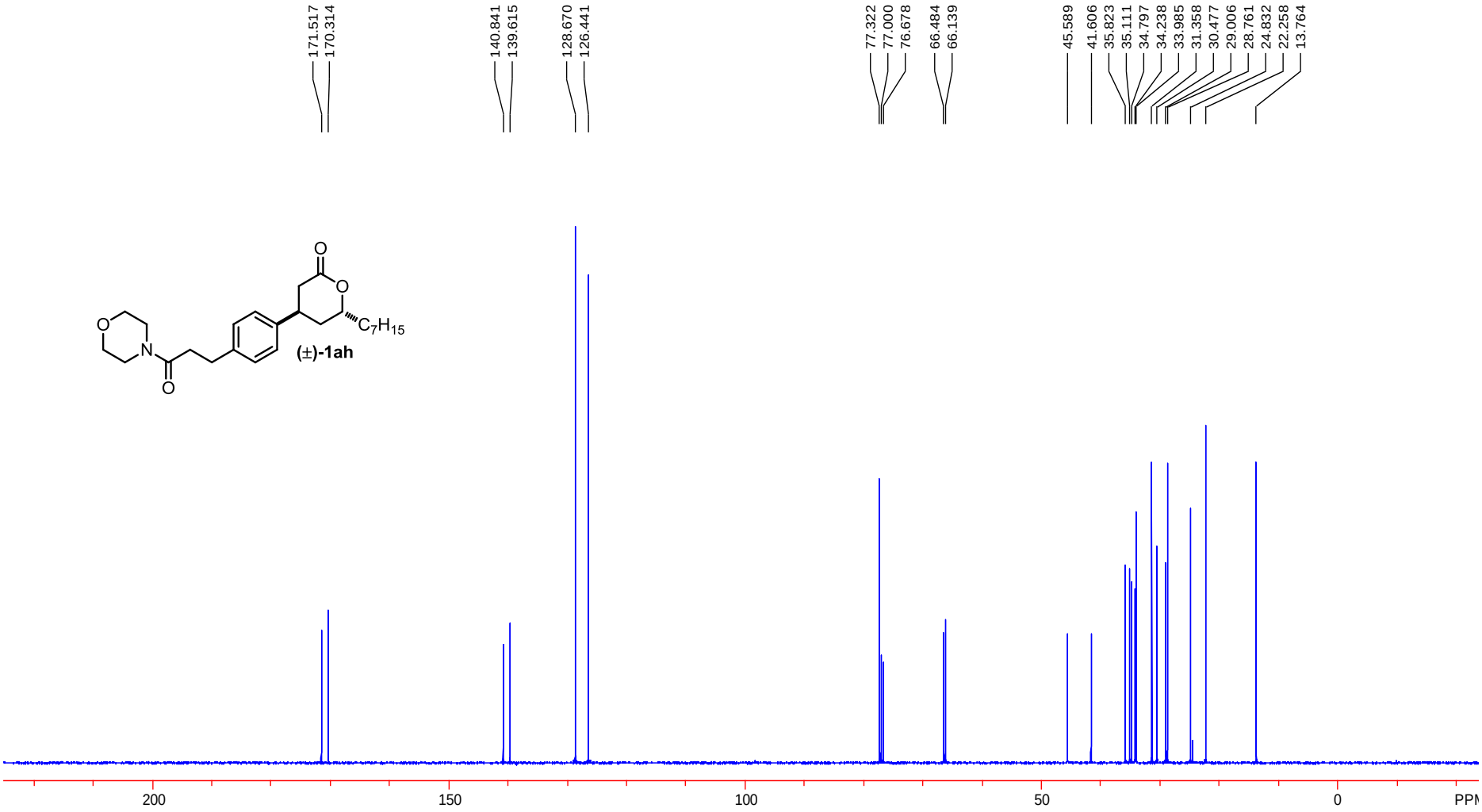

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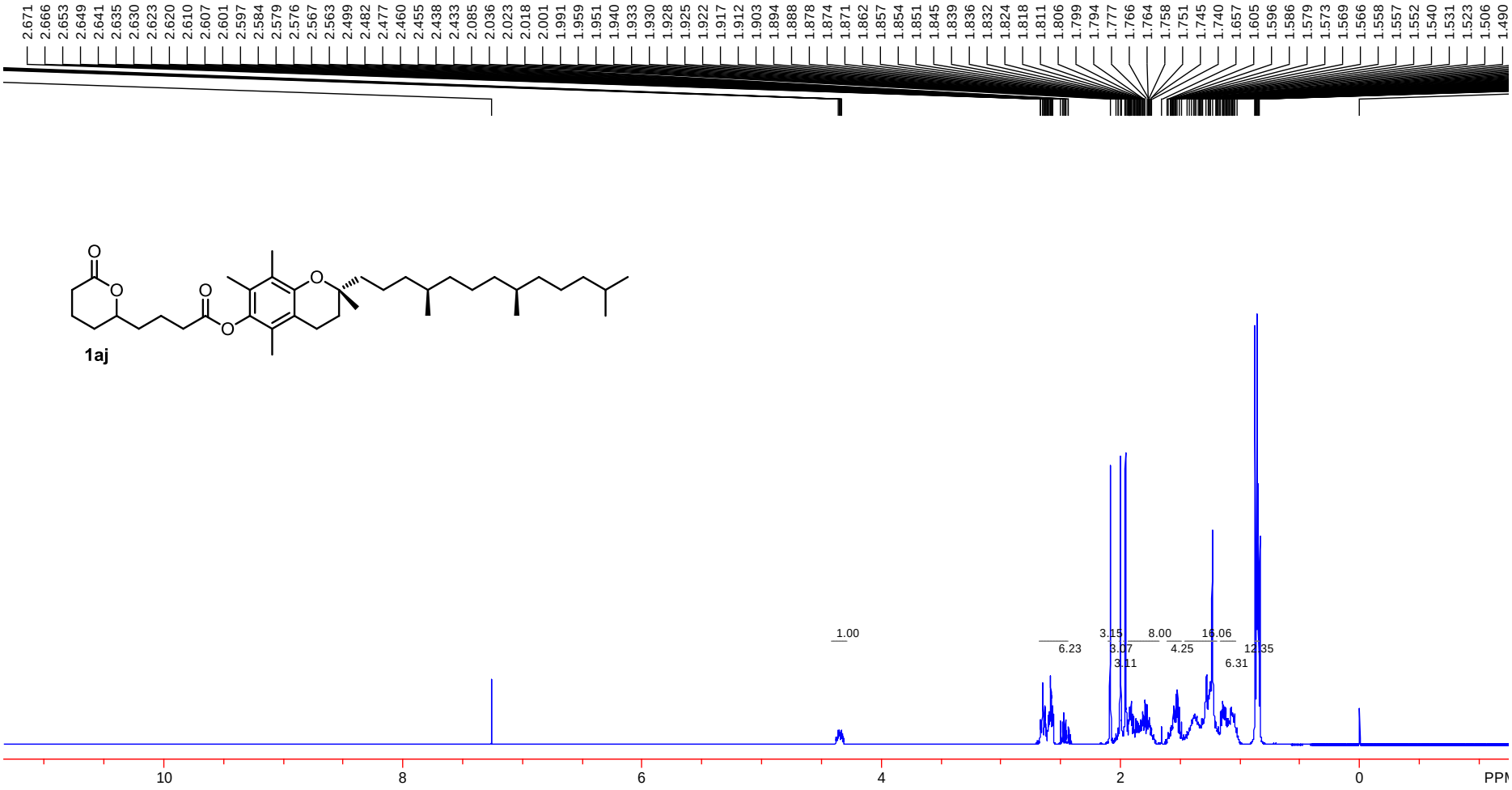

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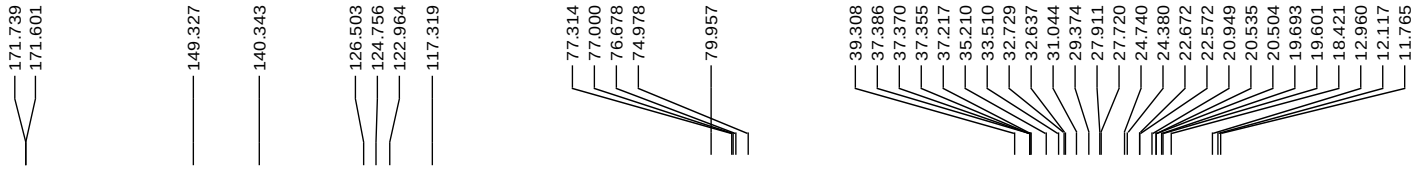
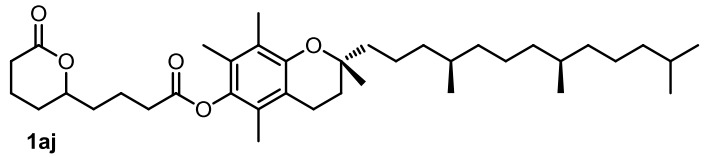
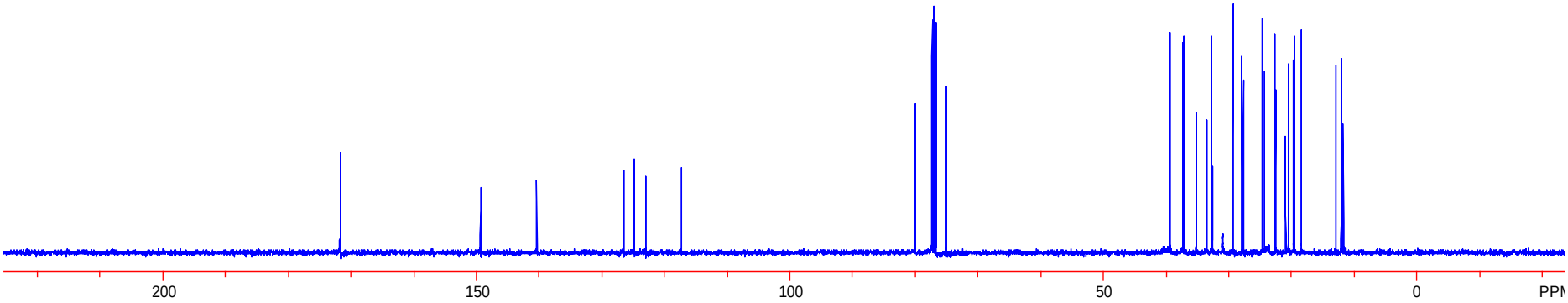
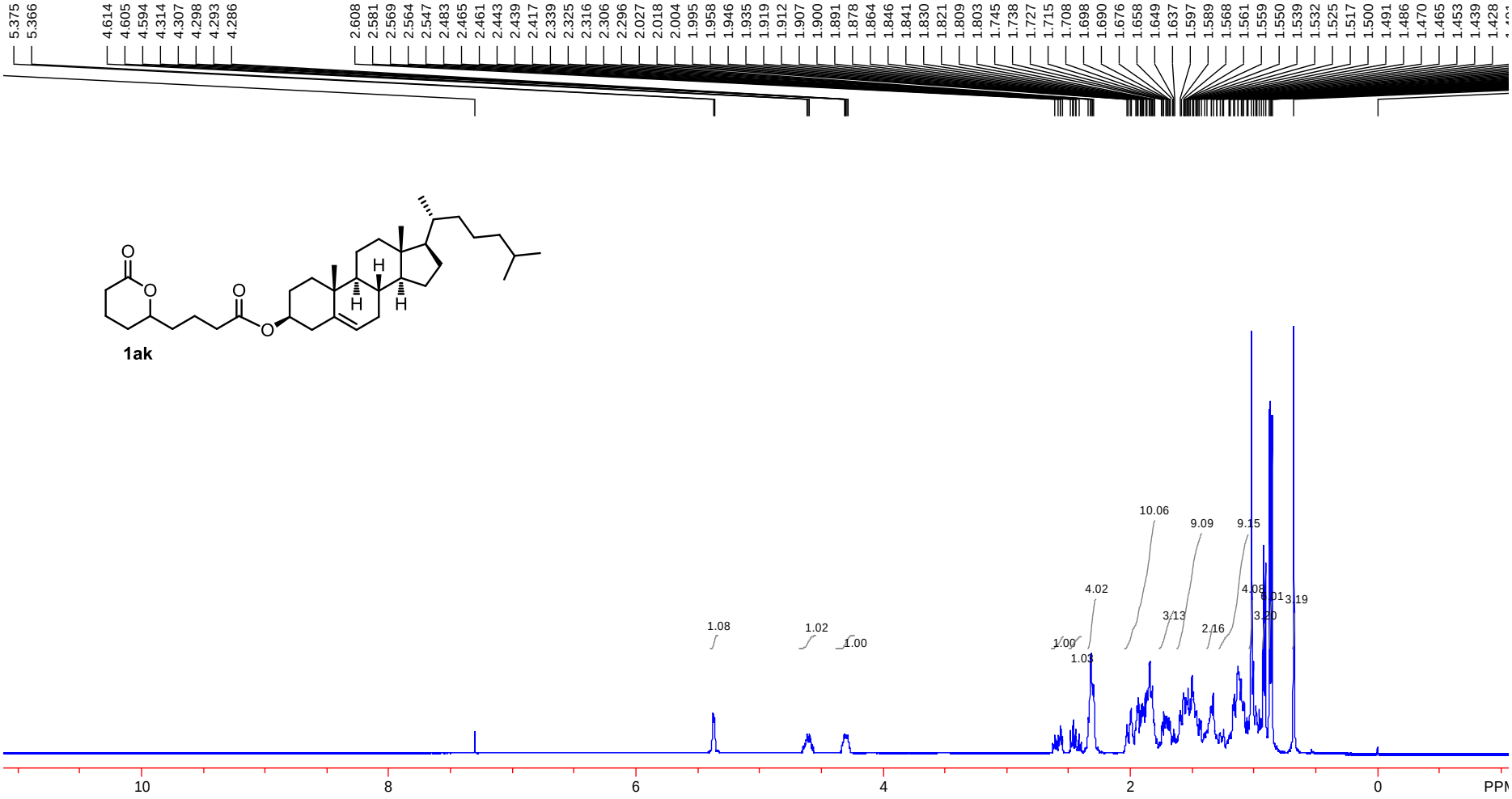




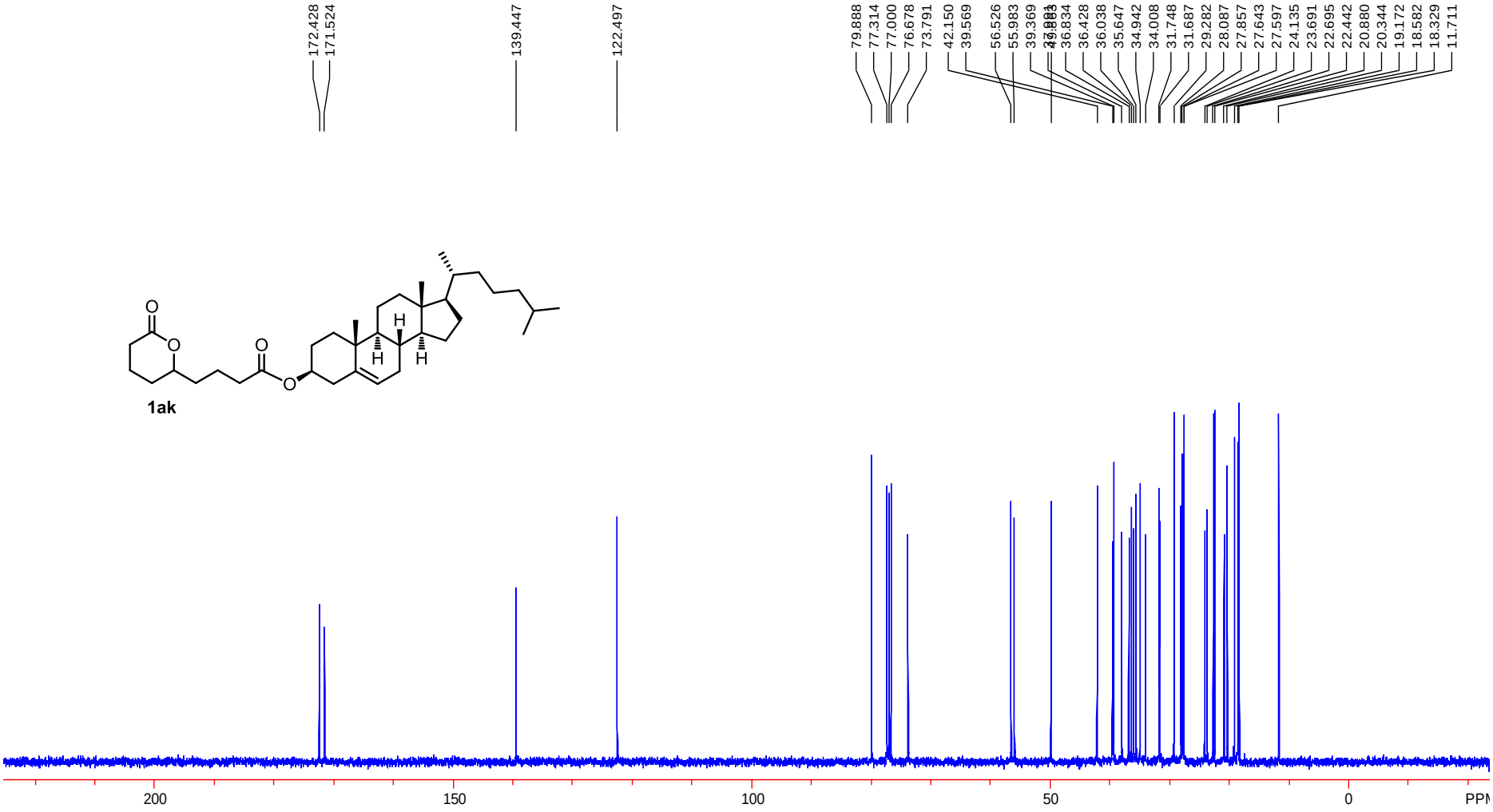
1aj



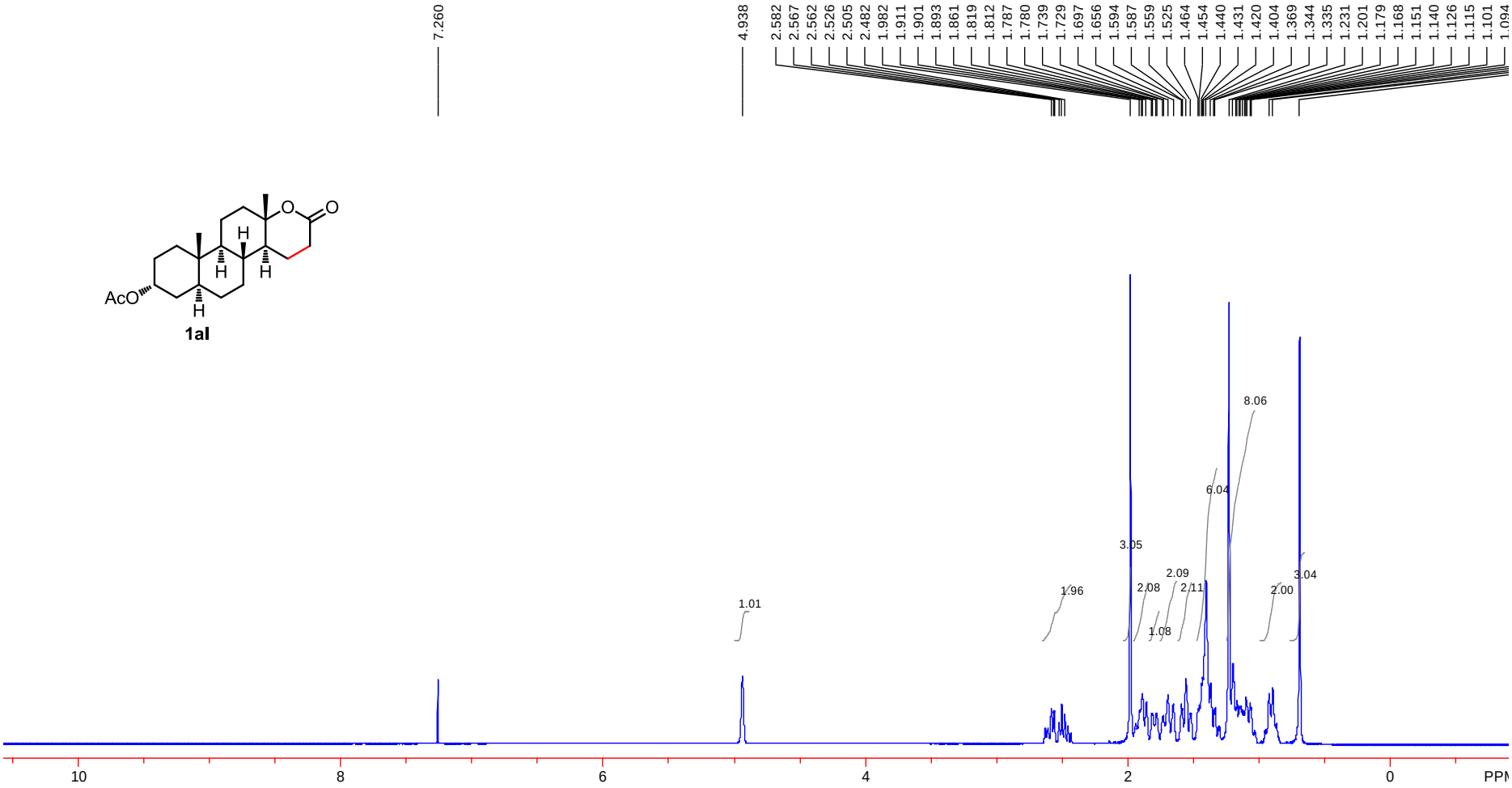
^{1}H NMR (400 MHz, $CDCl_3$)



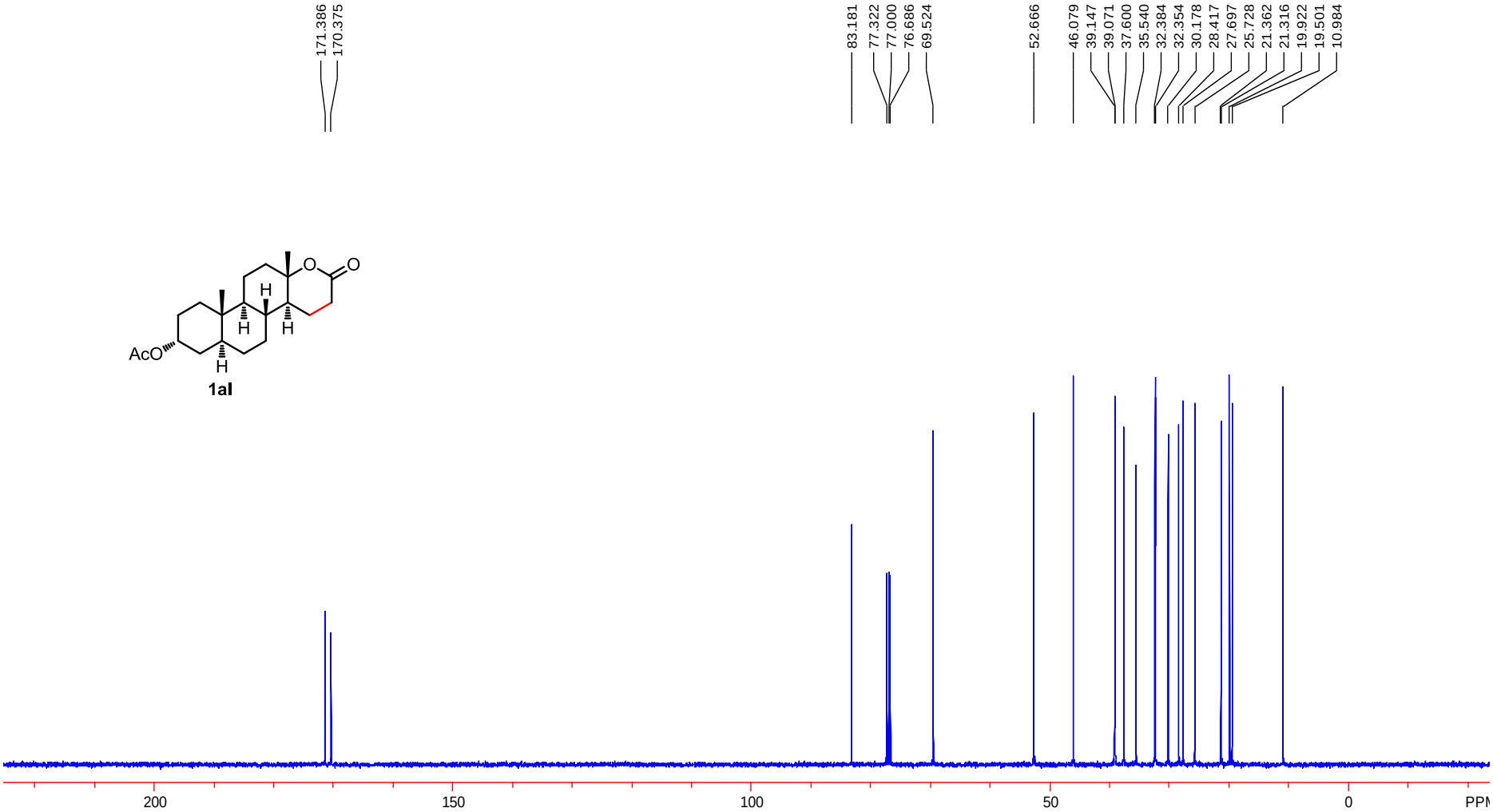
^{13}C NMR (101 MHz, $CDCl_3$)



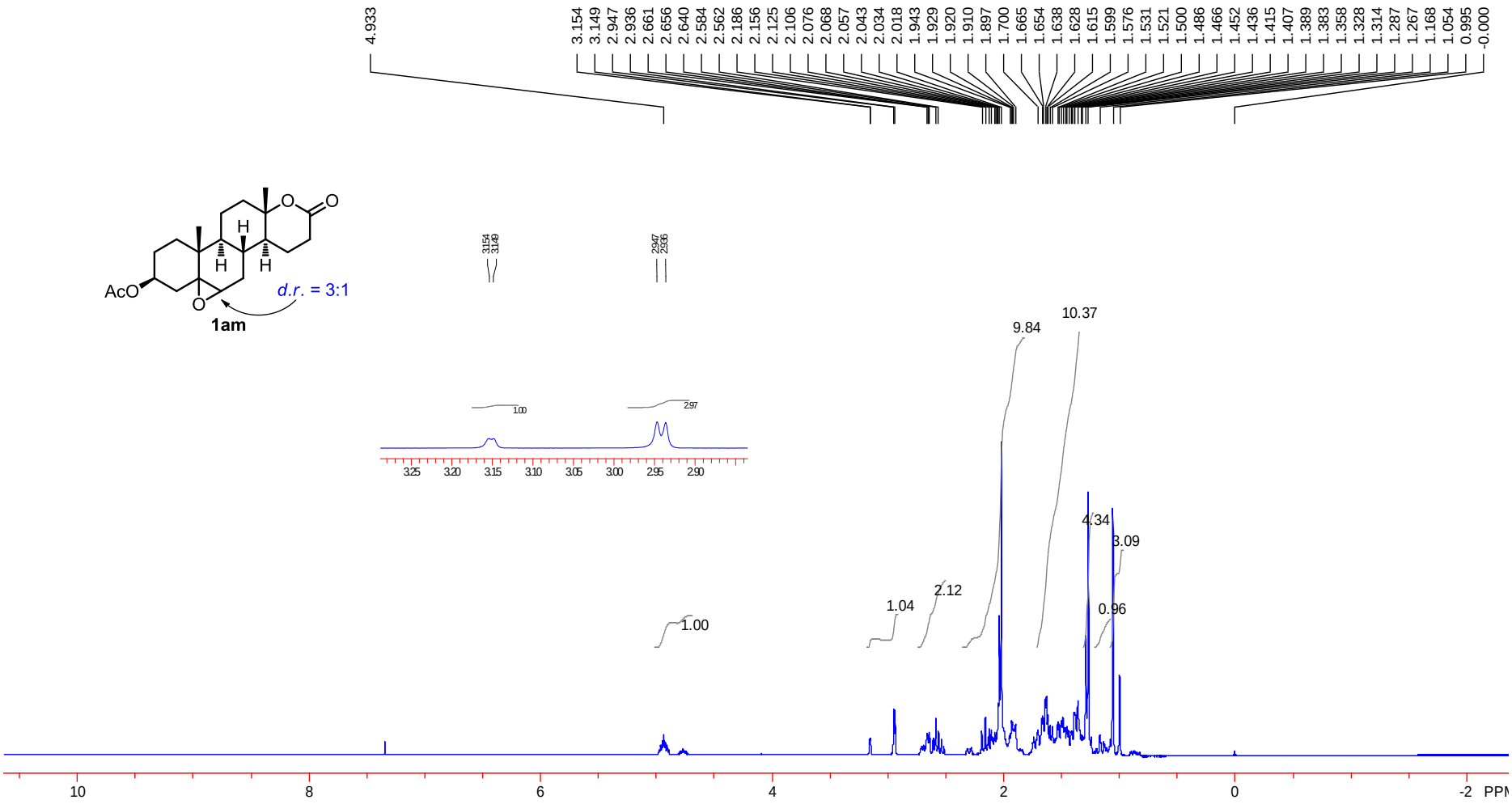
^{1}H NMR (400 MHz, $CDCl_3$)



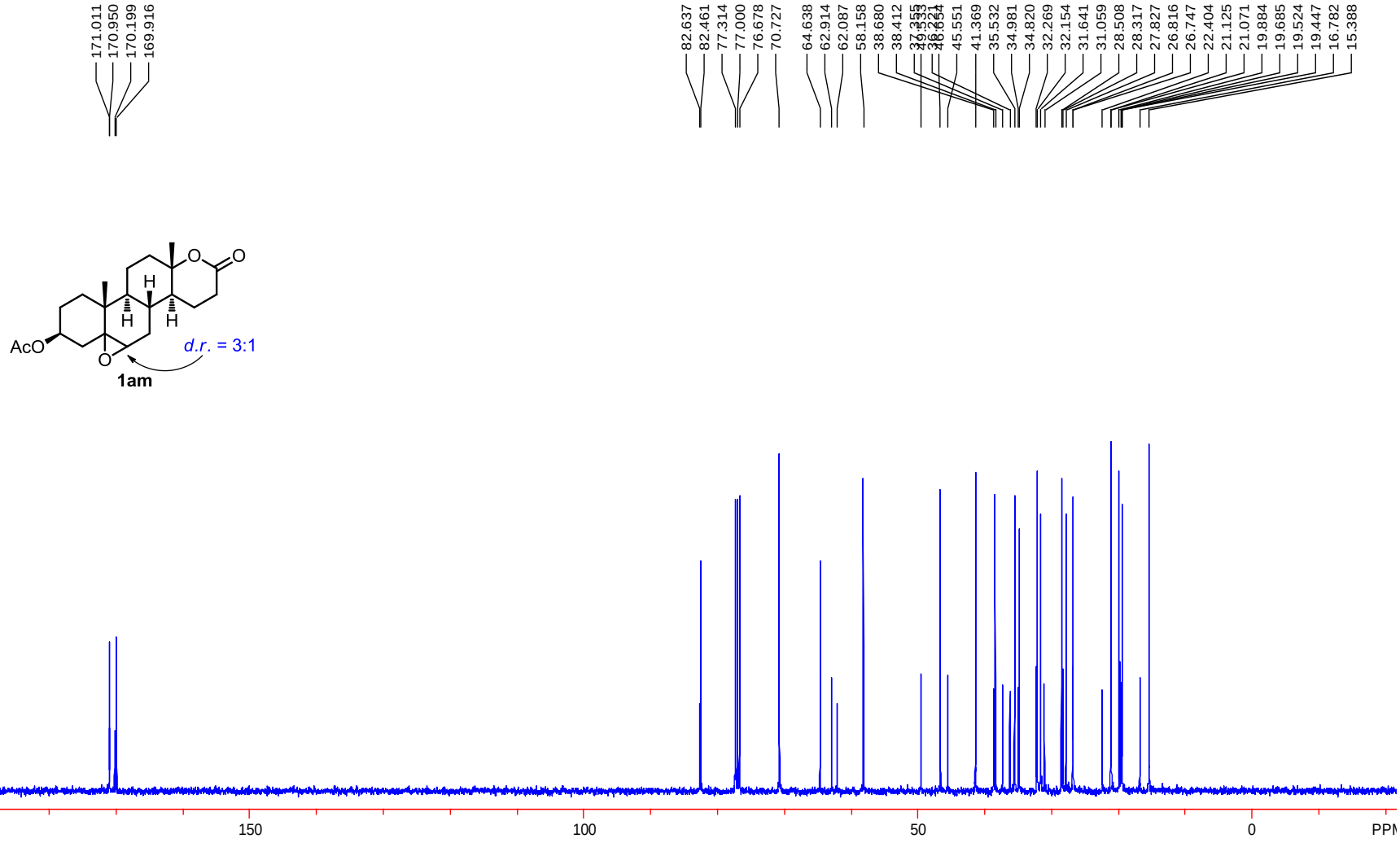
^{13}C NMR (101 MHz, $CDCl_3$)



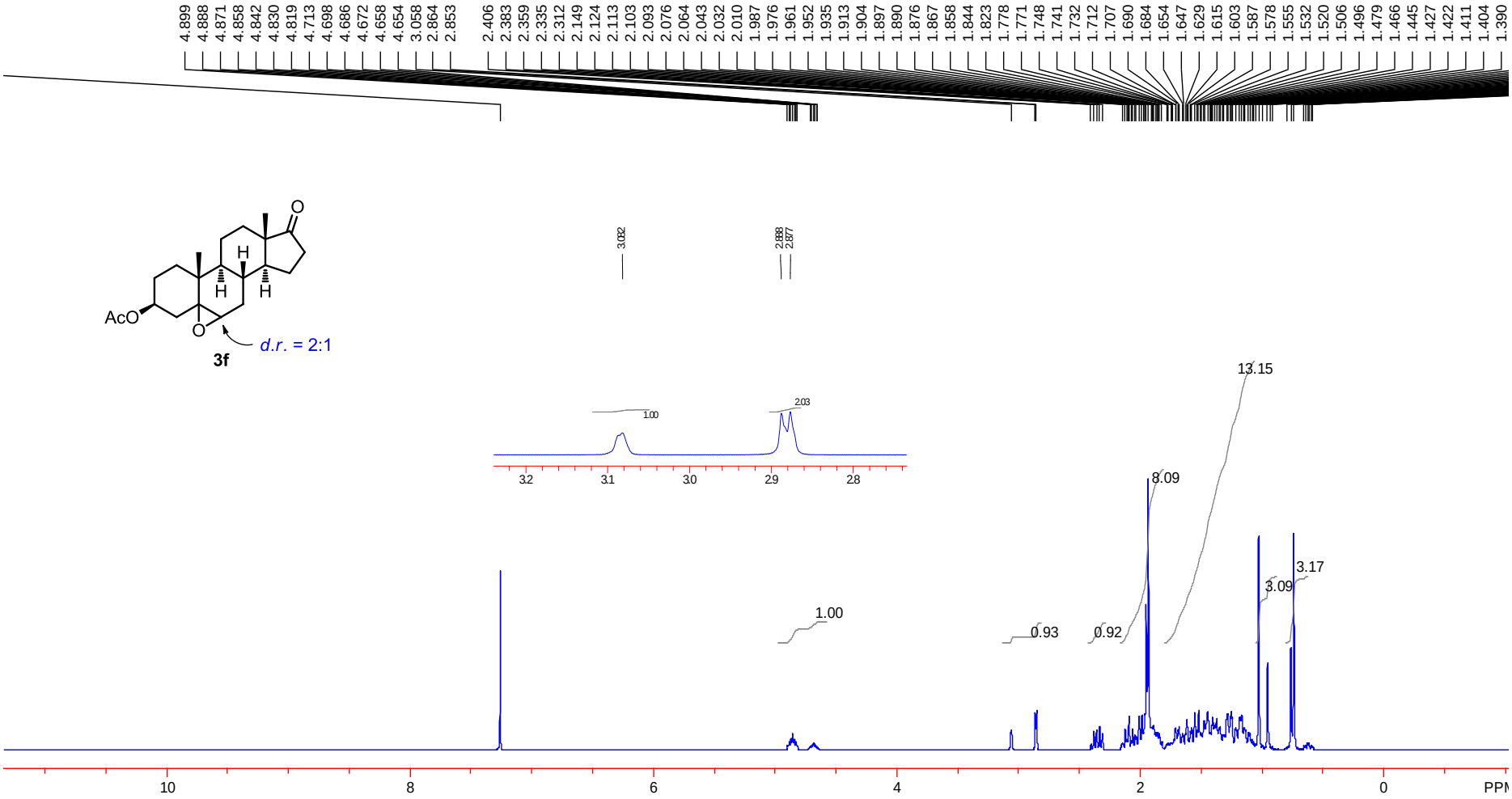
^{1}H NMR (400 MHz, $CDCl_3$)



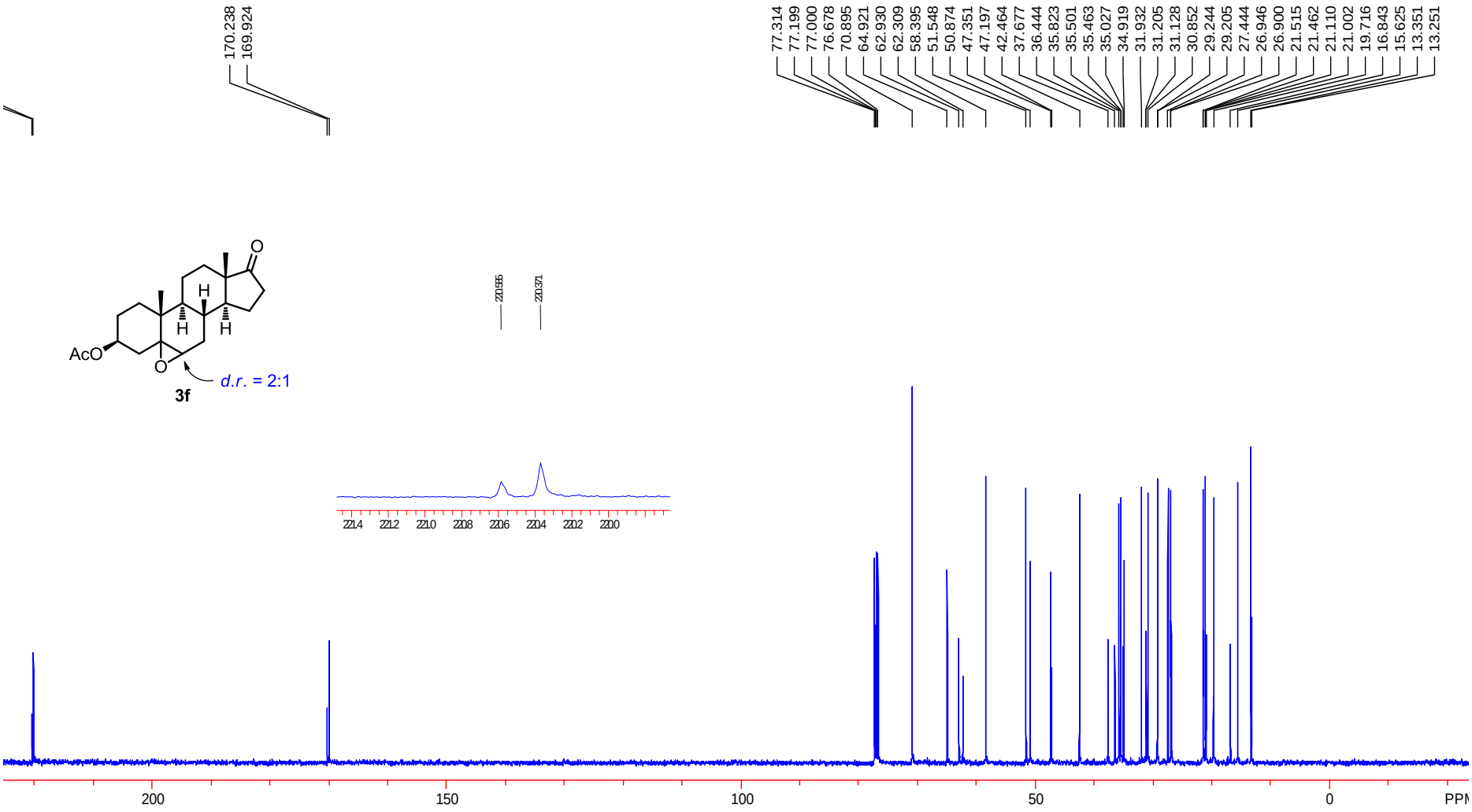
^{13}C NMR (101 MHz, $CDCl_3$)



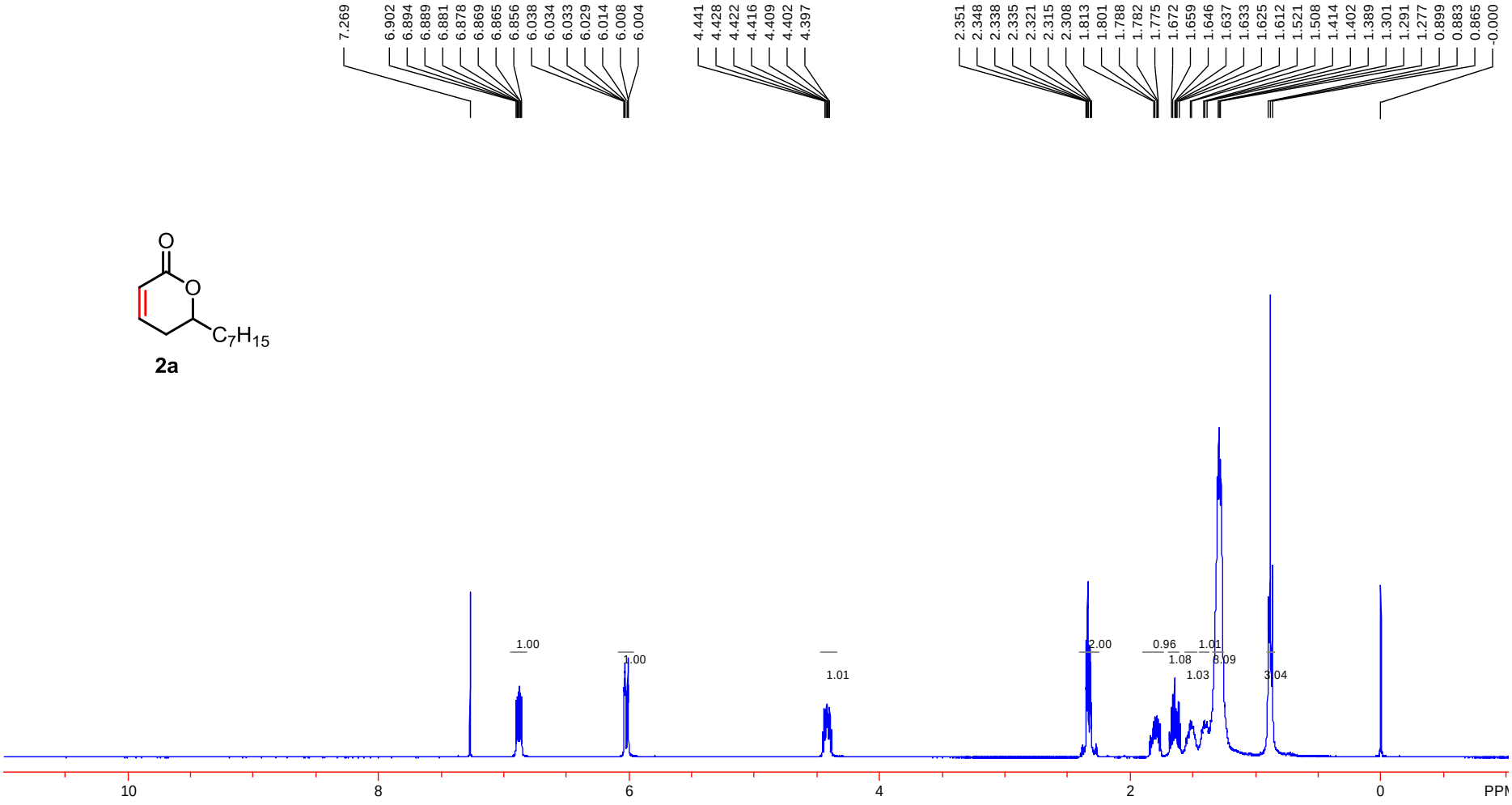
^{1}H NMR (400 MHz, $CDCl_3$)



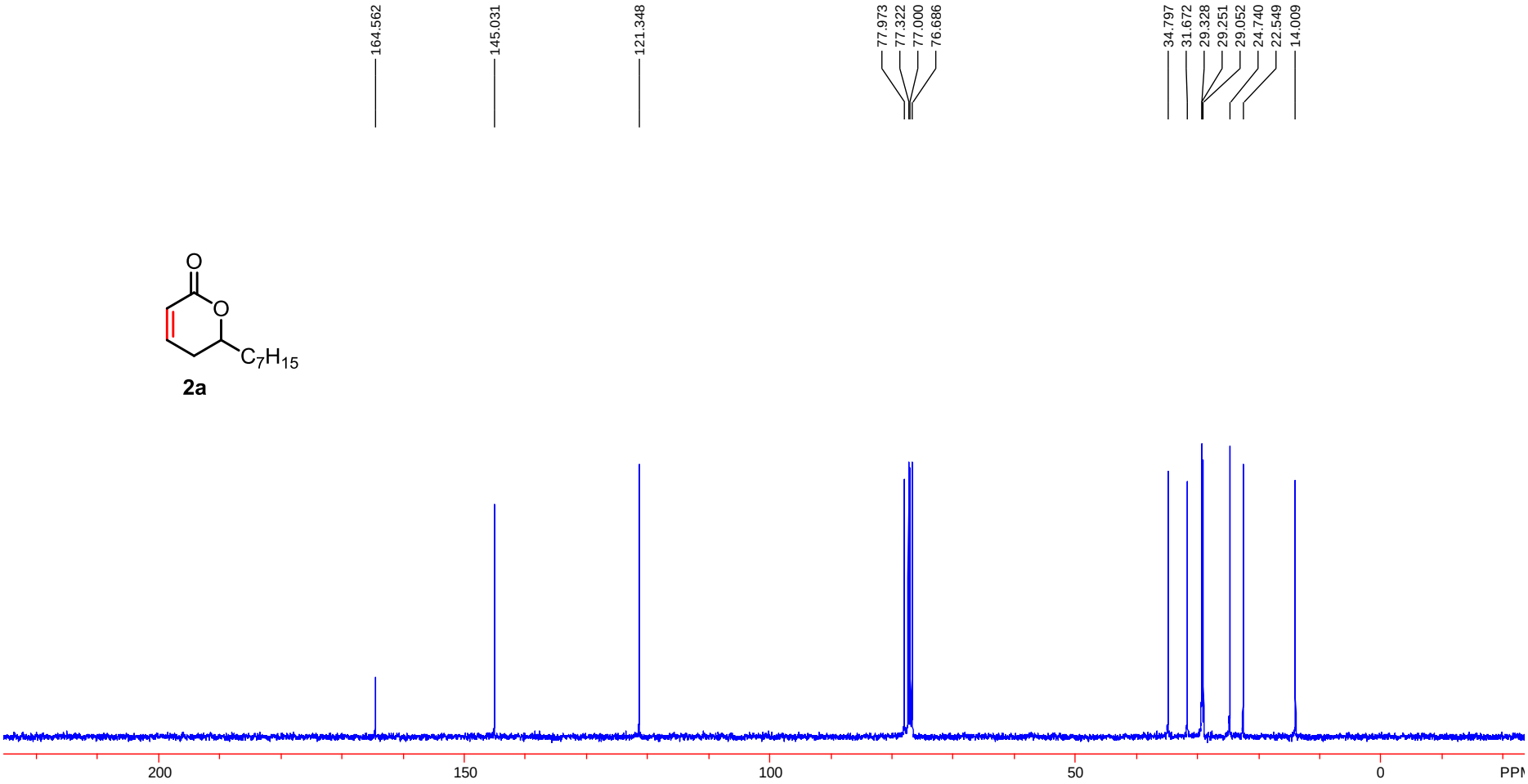
^{13}C NMR (101 MHz, $CDCl_3$)



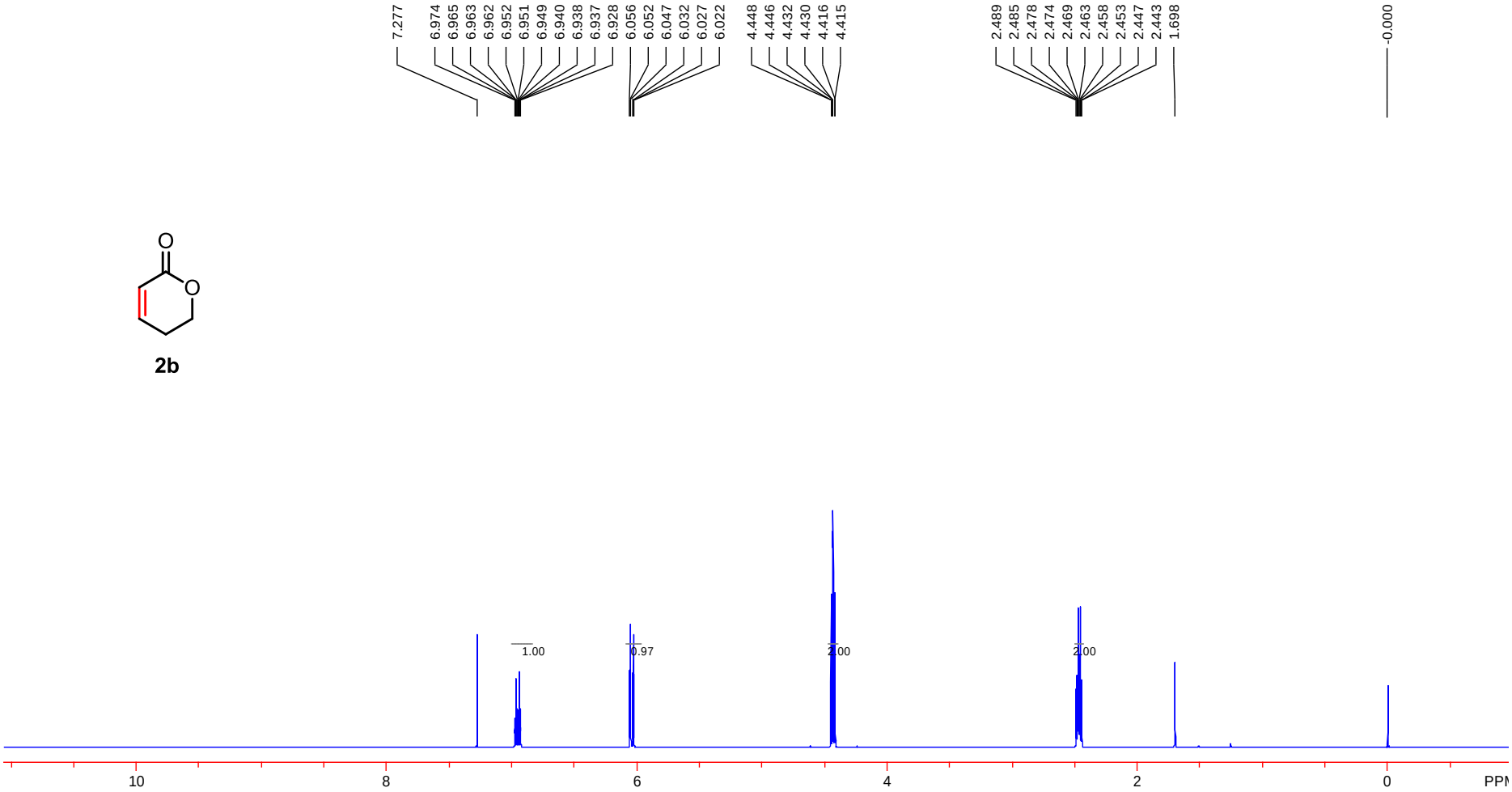
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)

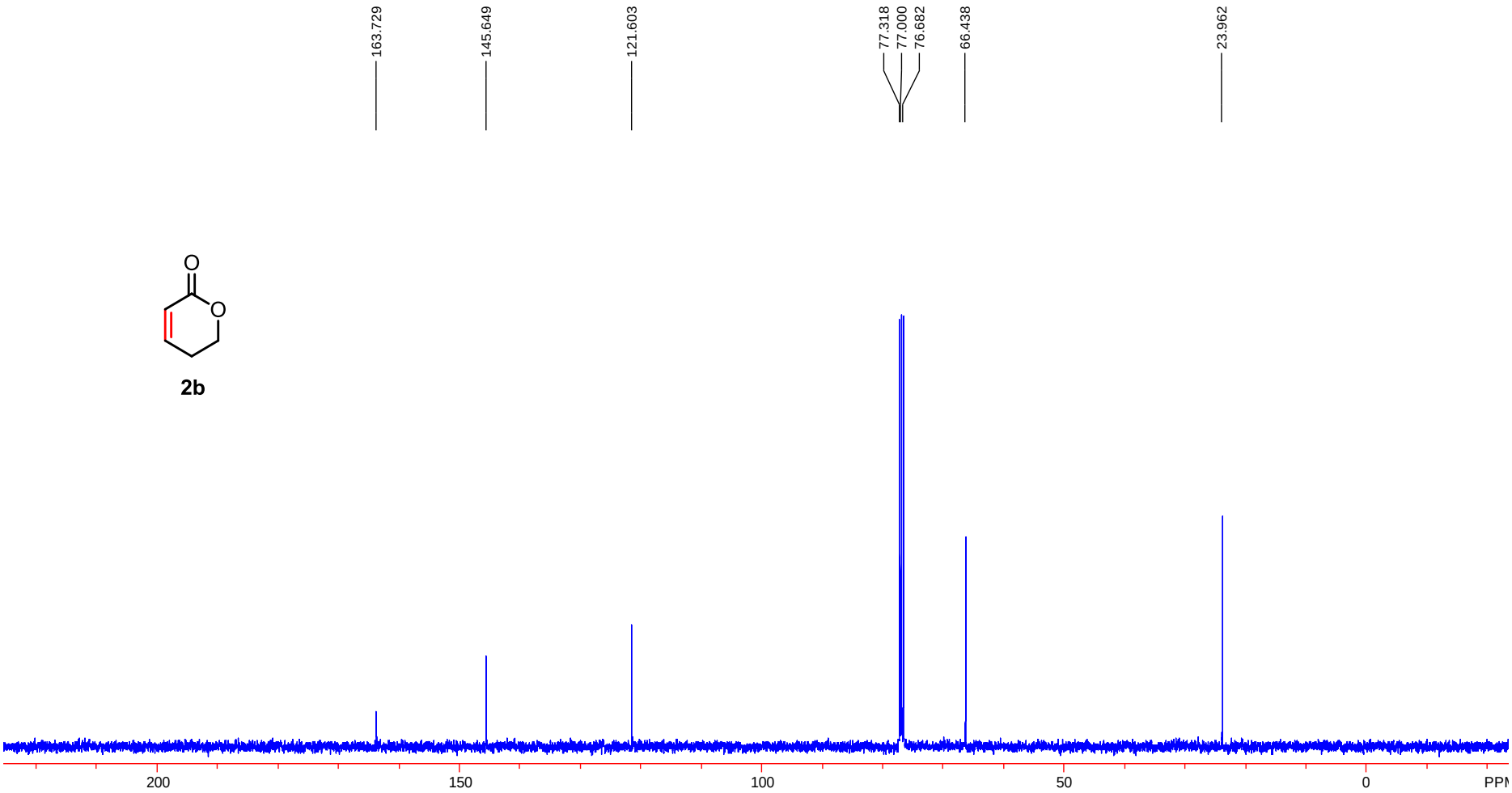


^{1}H NMR (500 MHz, $CDCl_3$)

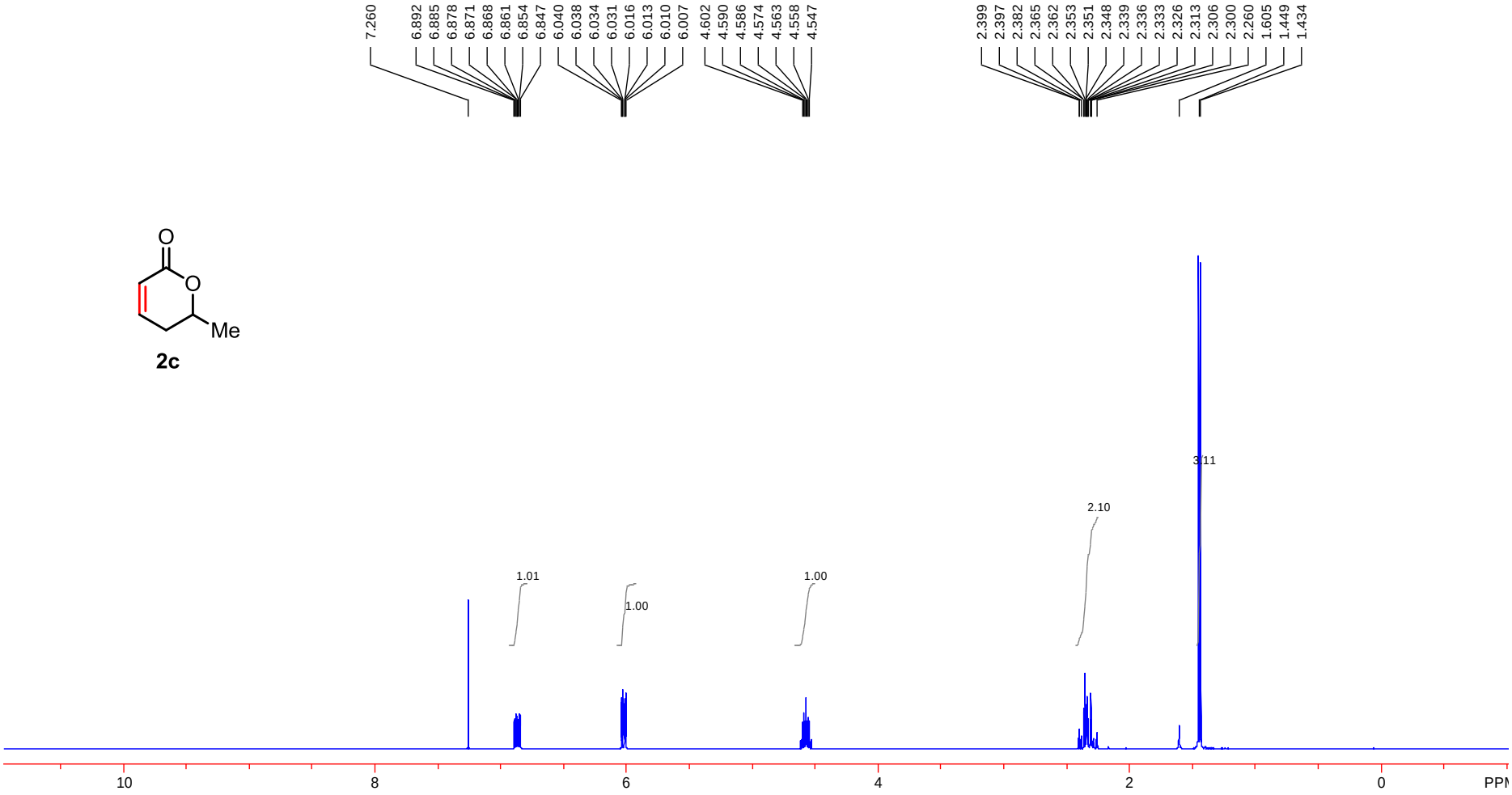


2b

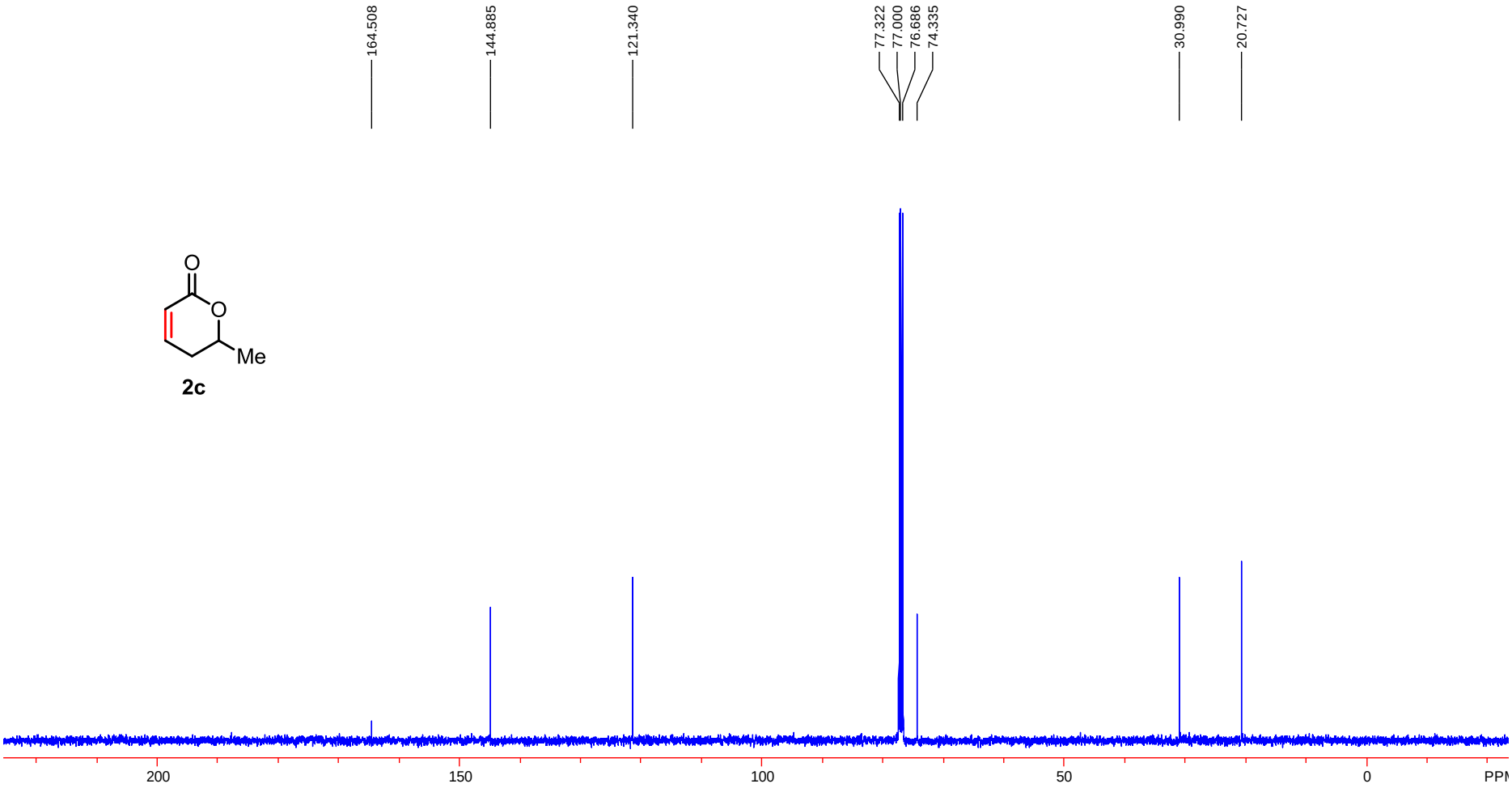
^{13}C NMR (101 MHz, $CDCl_3$)



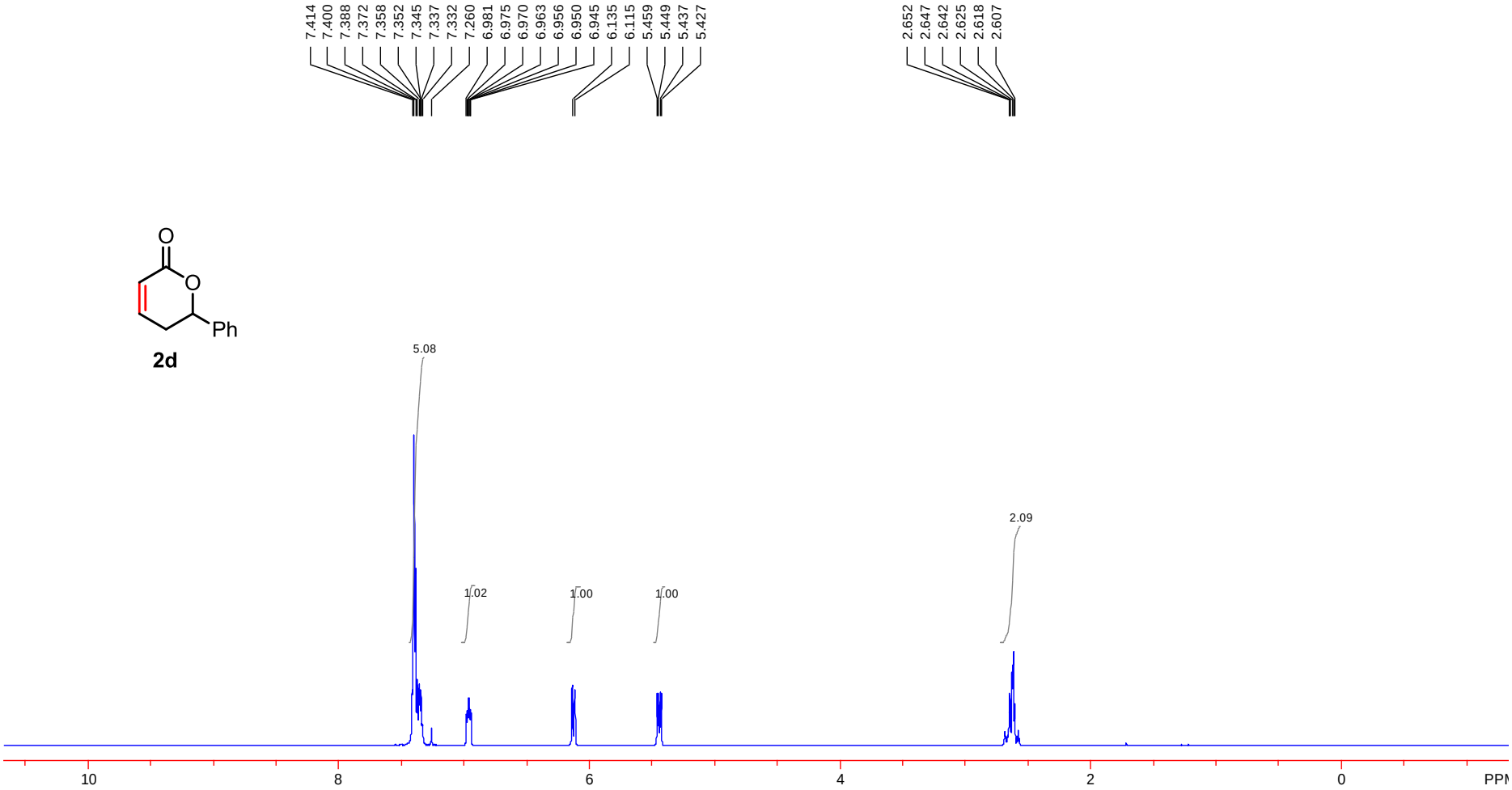
^{1}H NMR (400 MHz, $CDCl_3$)



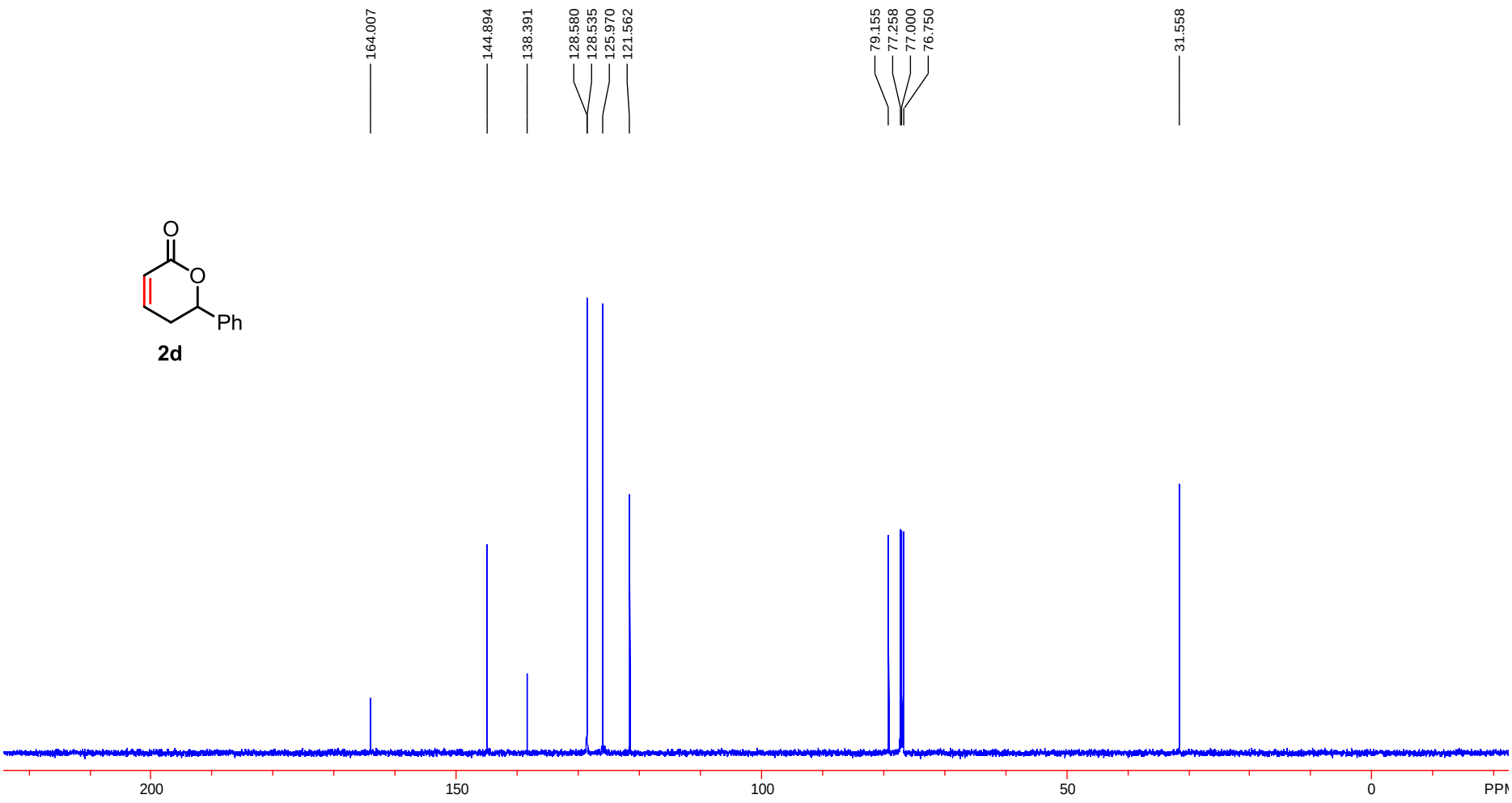
^{13}C NMR (101 MHz, $CDCl_3$)



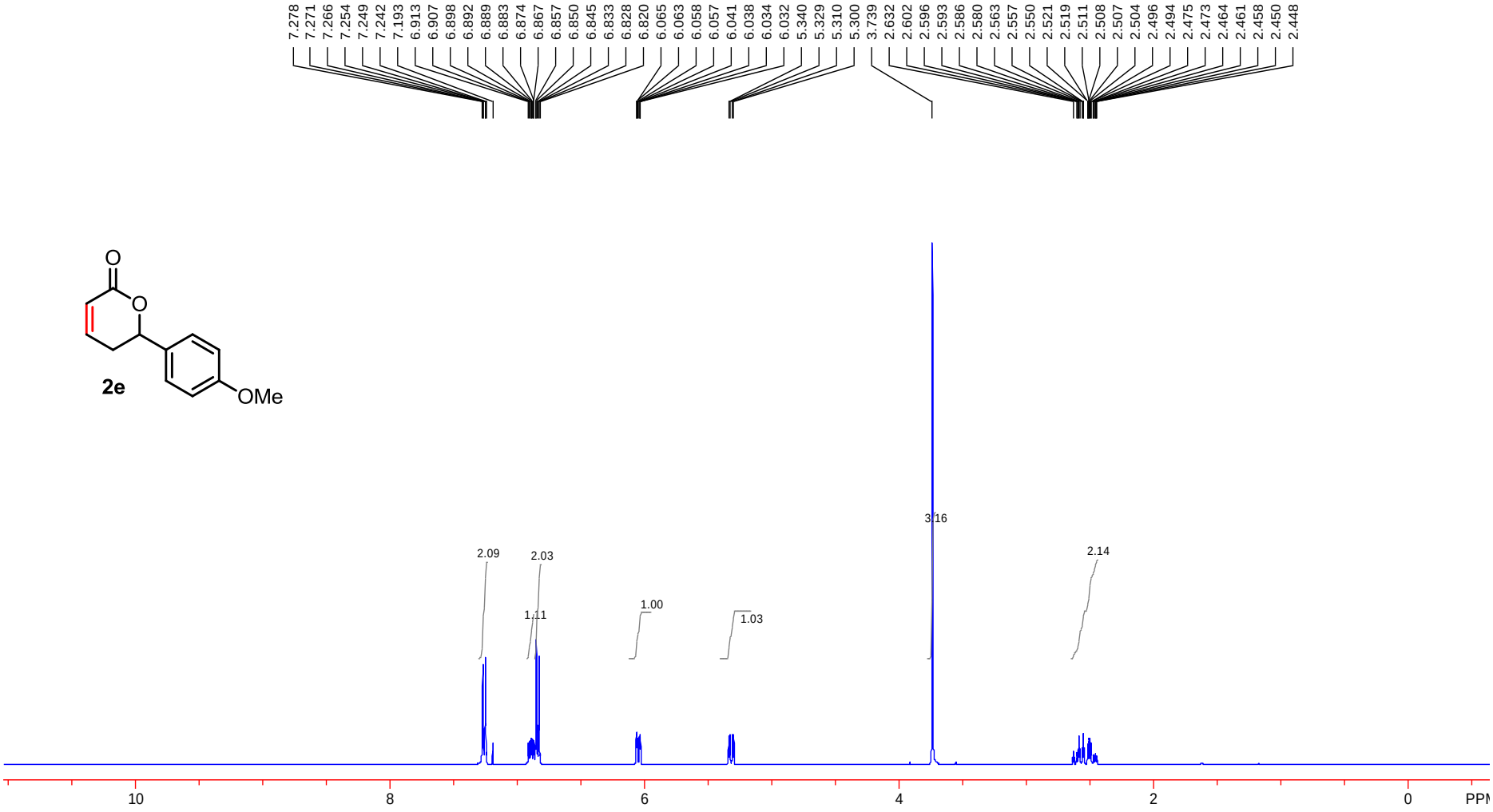
^{1}H NMR (500 MHz, $CDCl_3$)



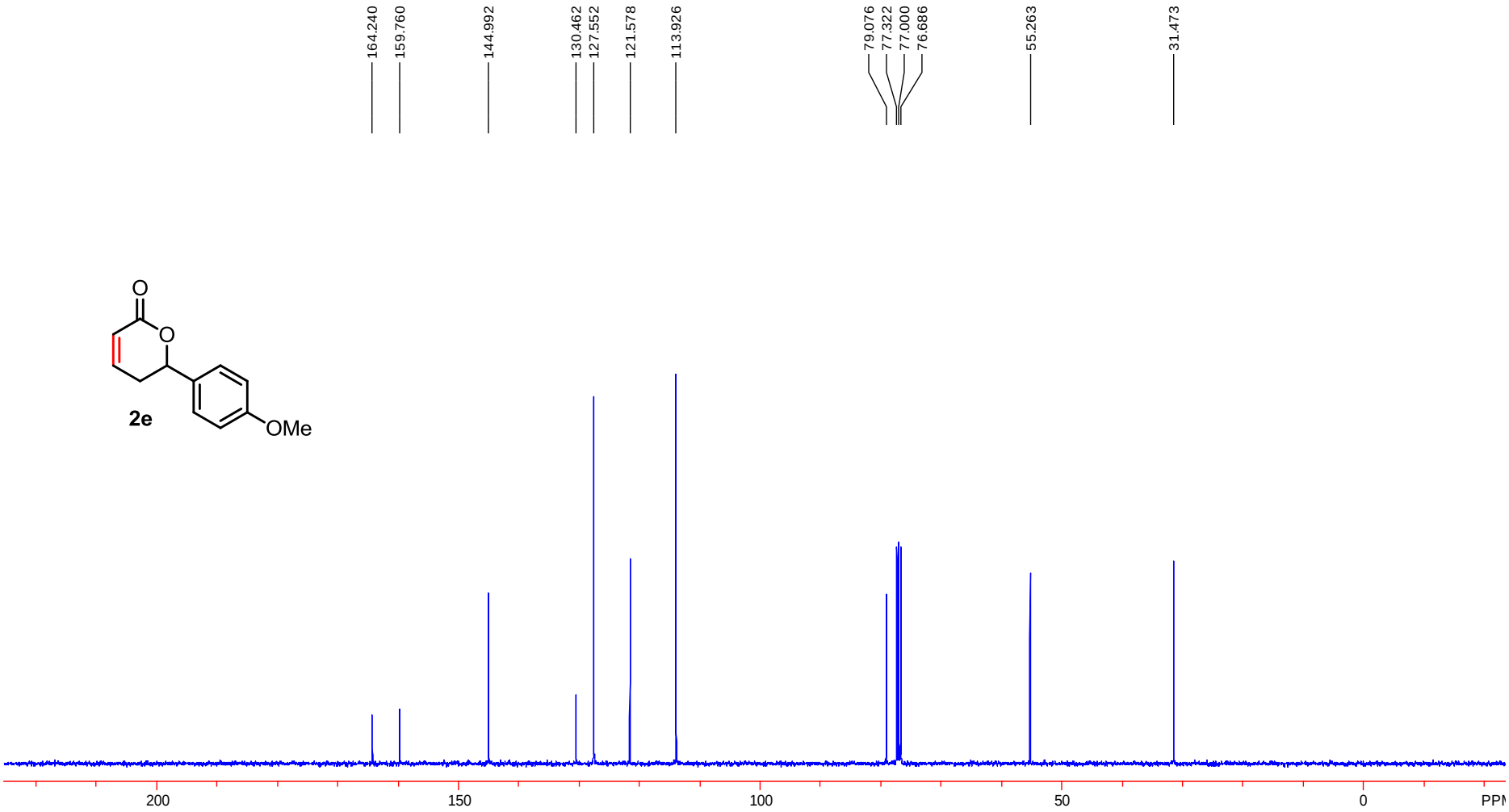
^{13}C NMR (125 MHz, $CDCl_3$)



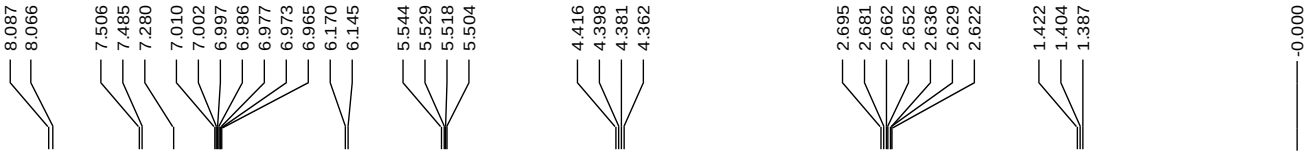
^{1}H NMR (400 MHz, $CDCl_3$)

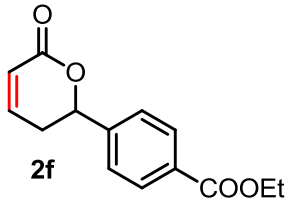


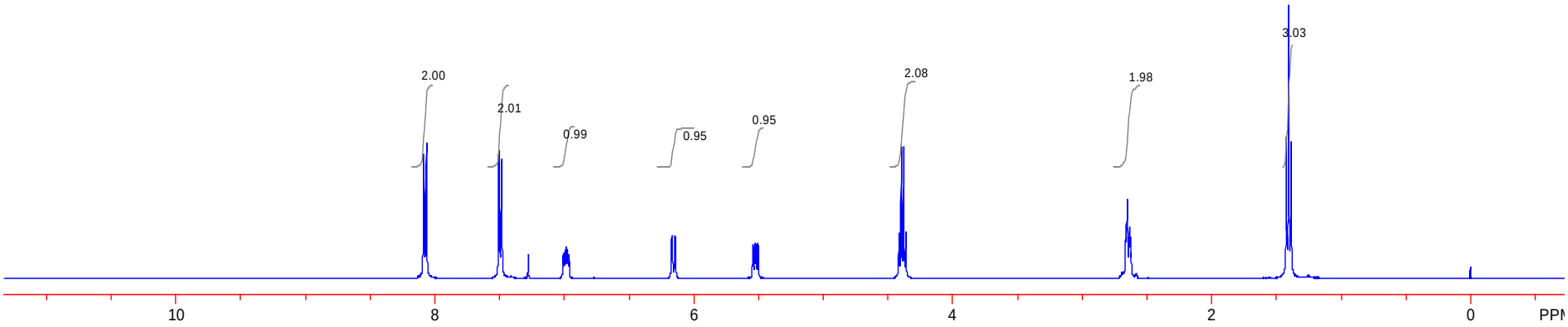
^{13}C NMR (101 MHz, $CDCl_3$)



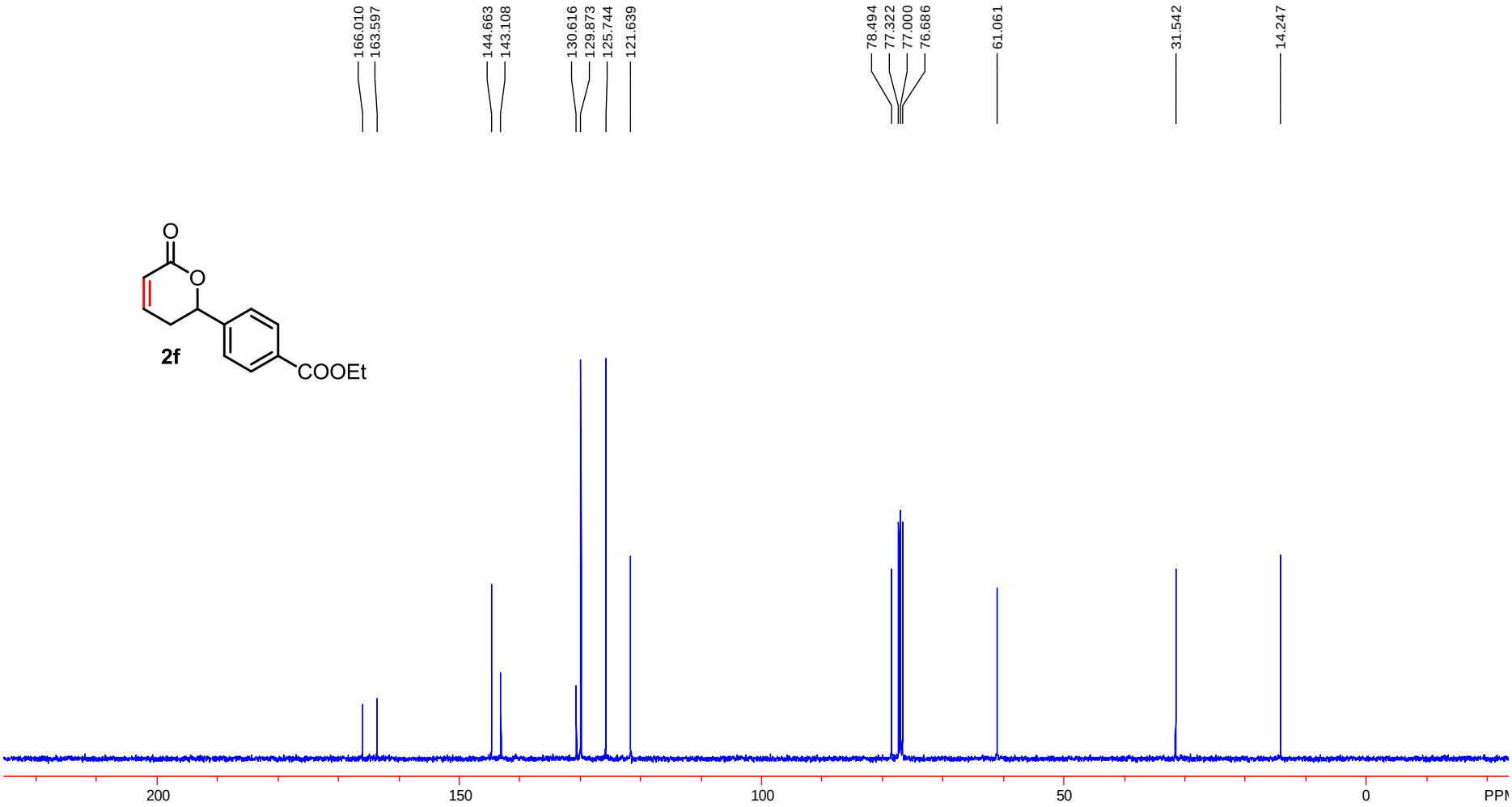
^{1}H NMR (400 MHz, $CDCl_3$)



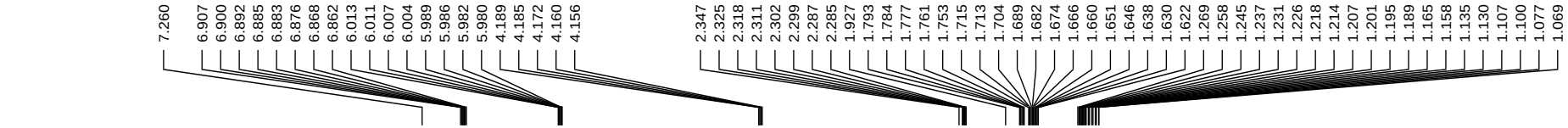


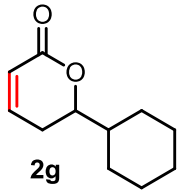


^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (400 MHz, $CDCl_3$)





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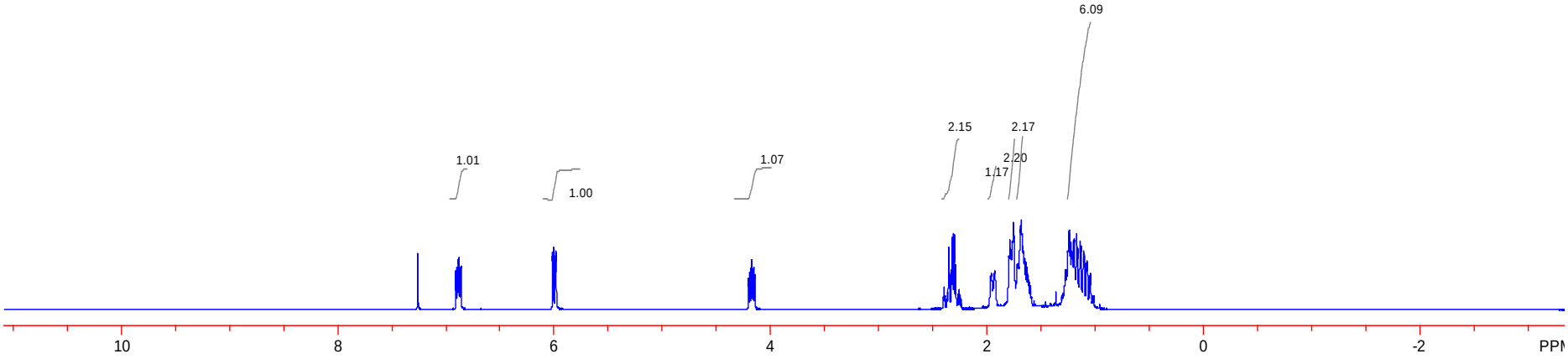
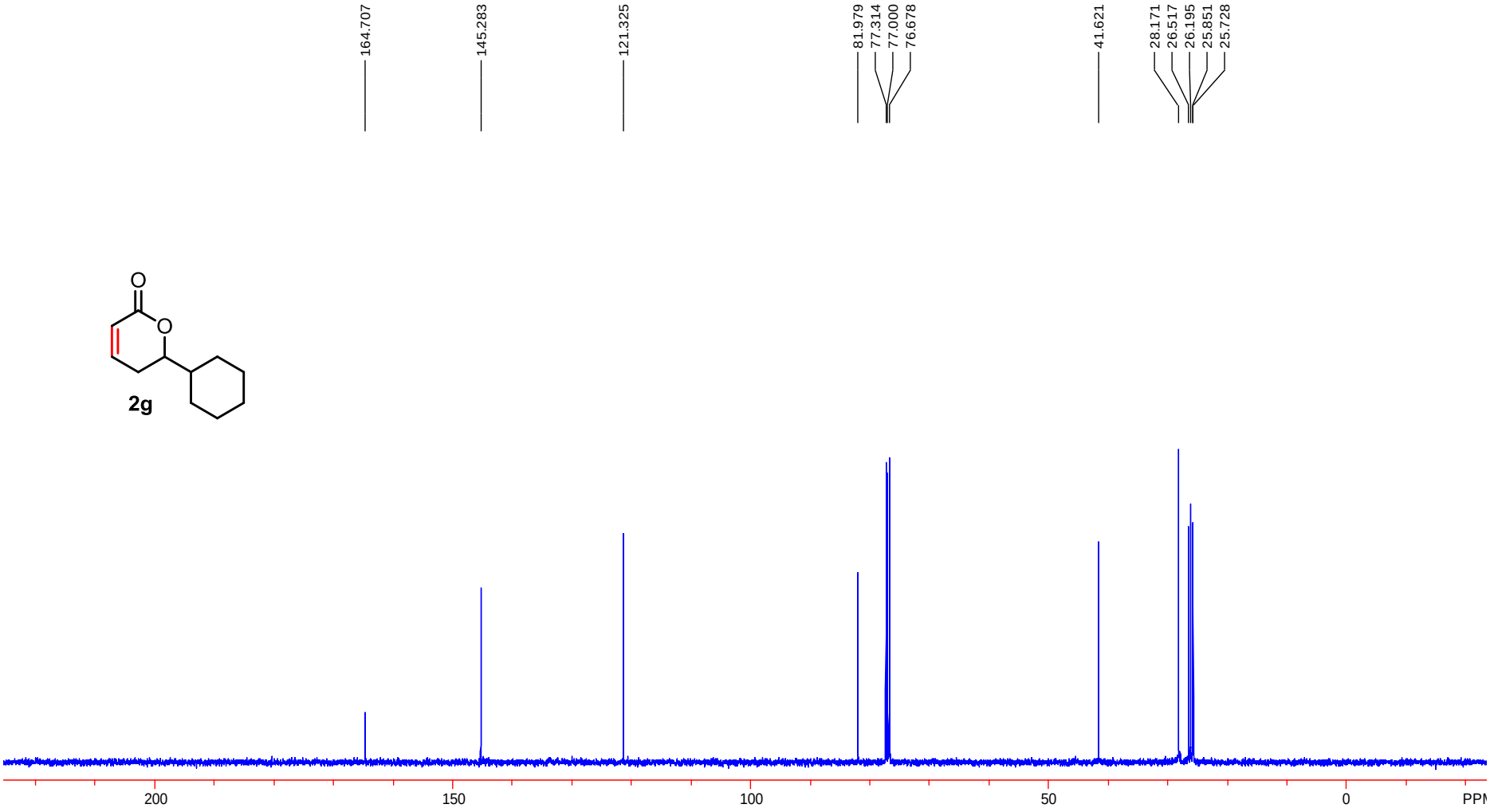
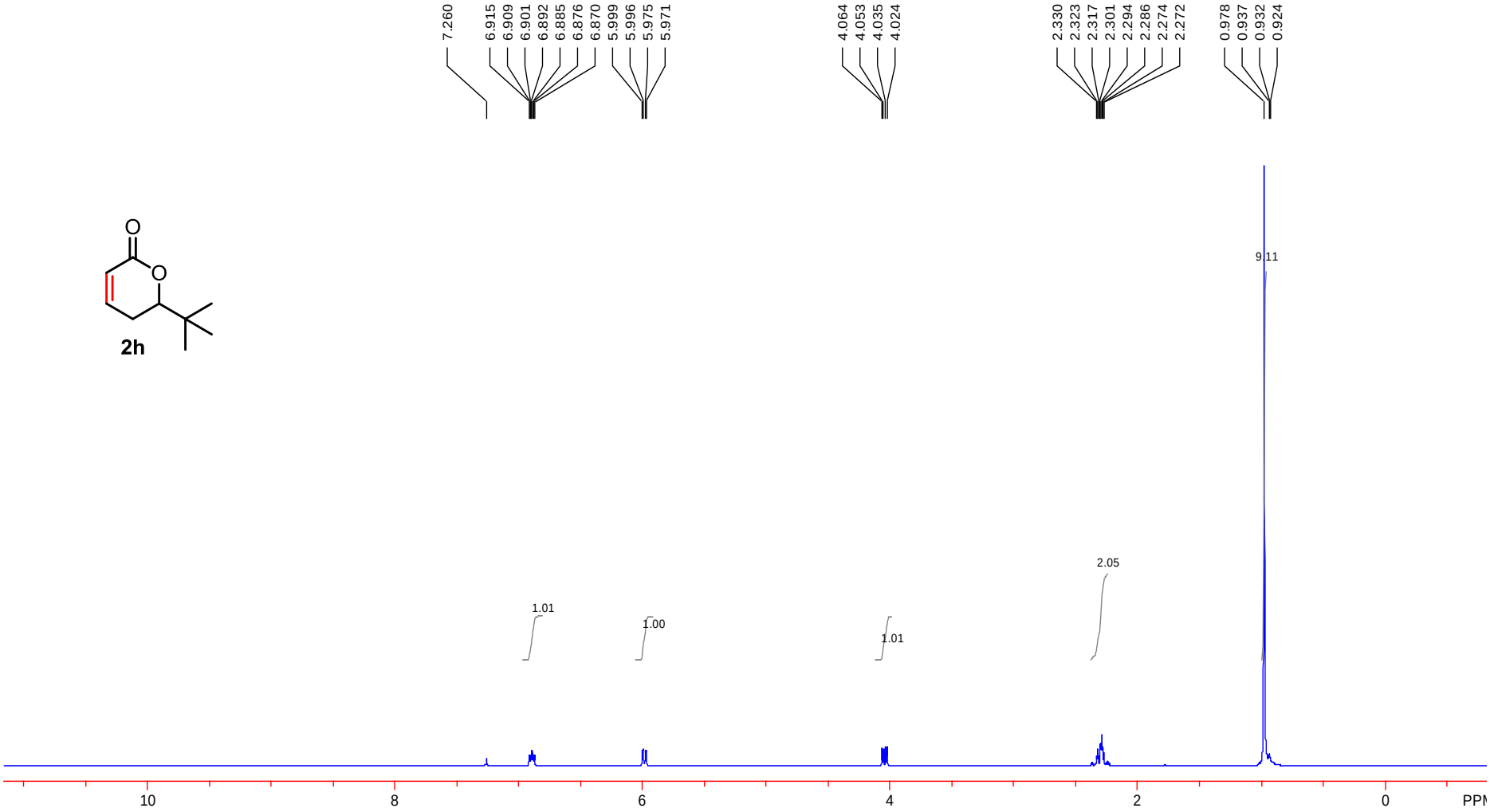


^{13}C NMR (101 MHz, $CDCl_3$)

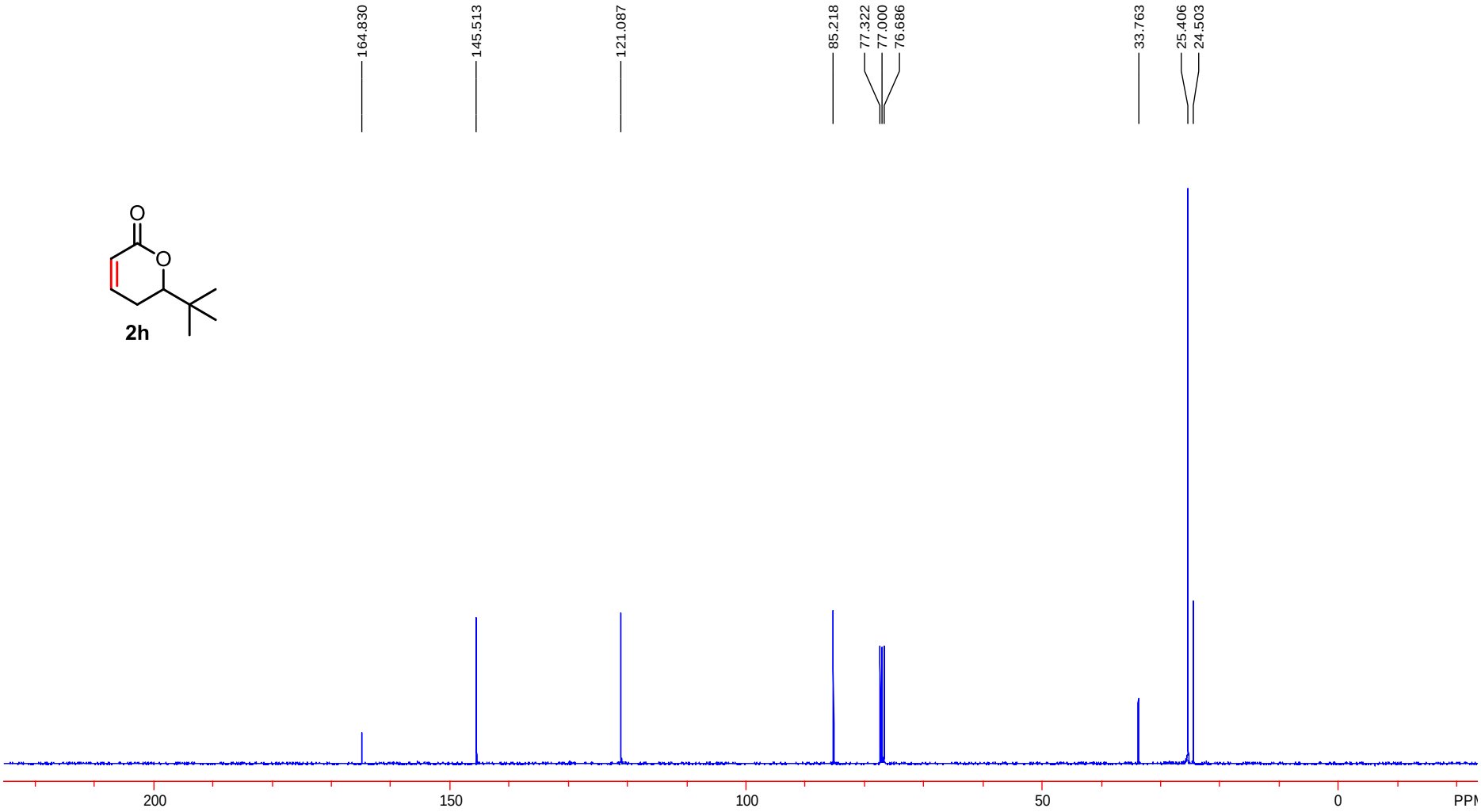


^{1}H NMR (400 MHz, $CDCl_3$)

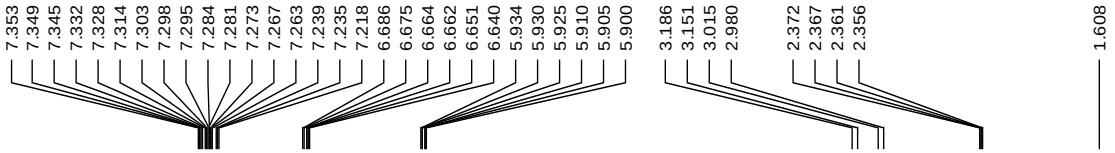


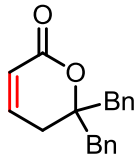
2h

^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (400 MHz, $CDCl_3$)





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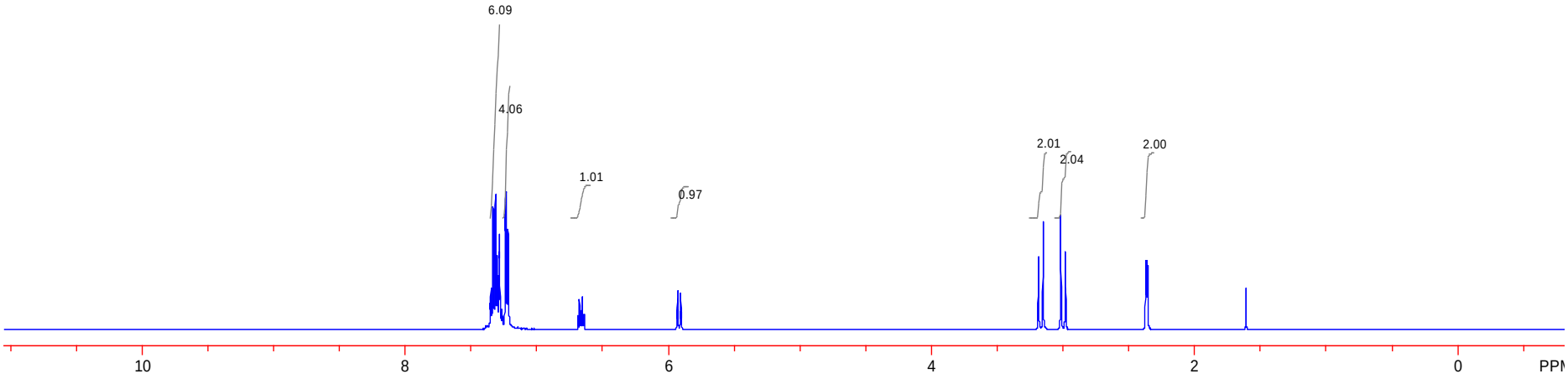
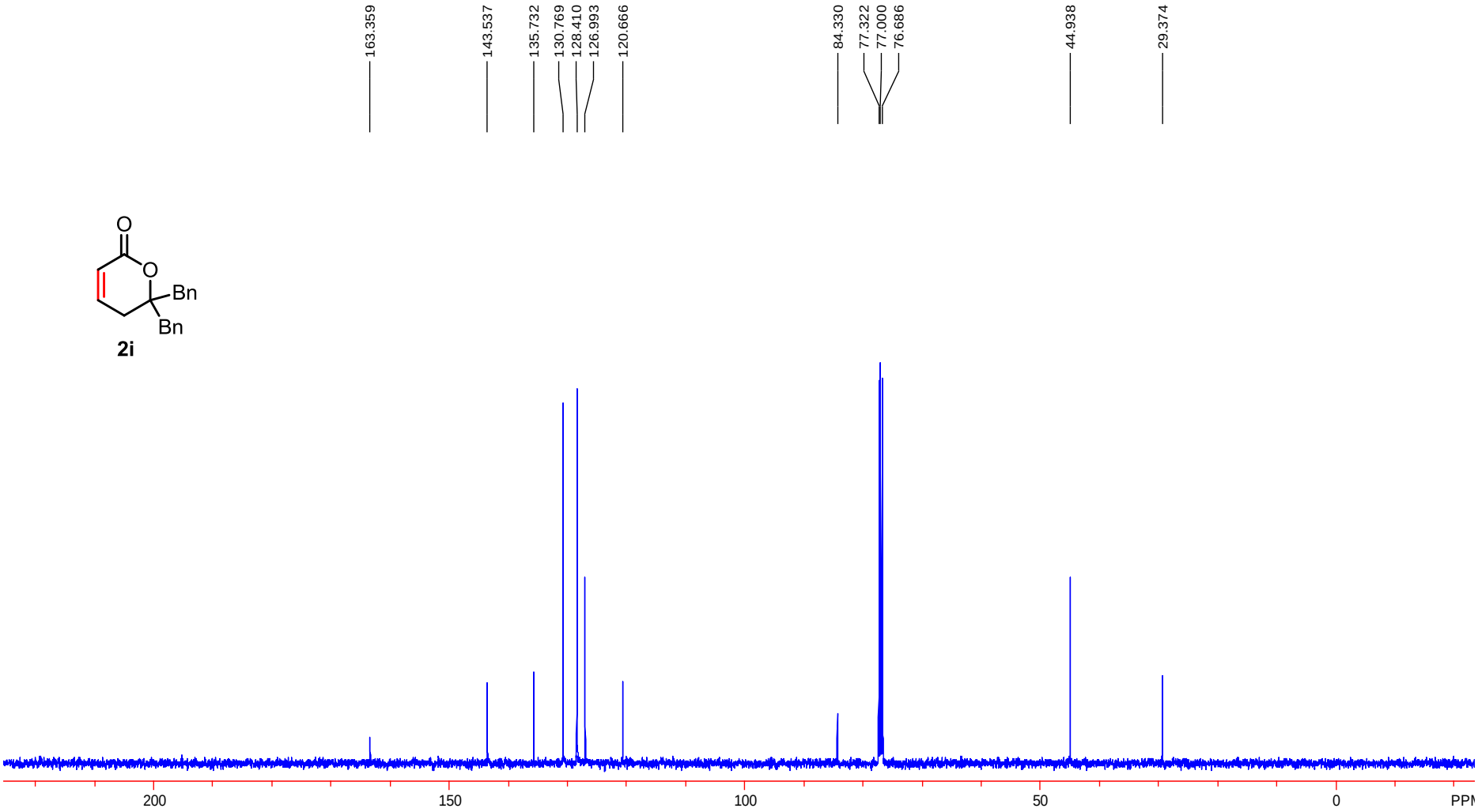


^{13}C NMR (101 MHz, $CDCl_3$)



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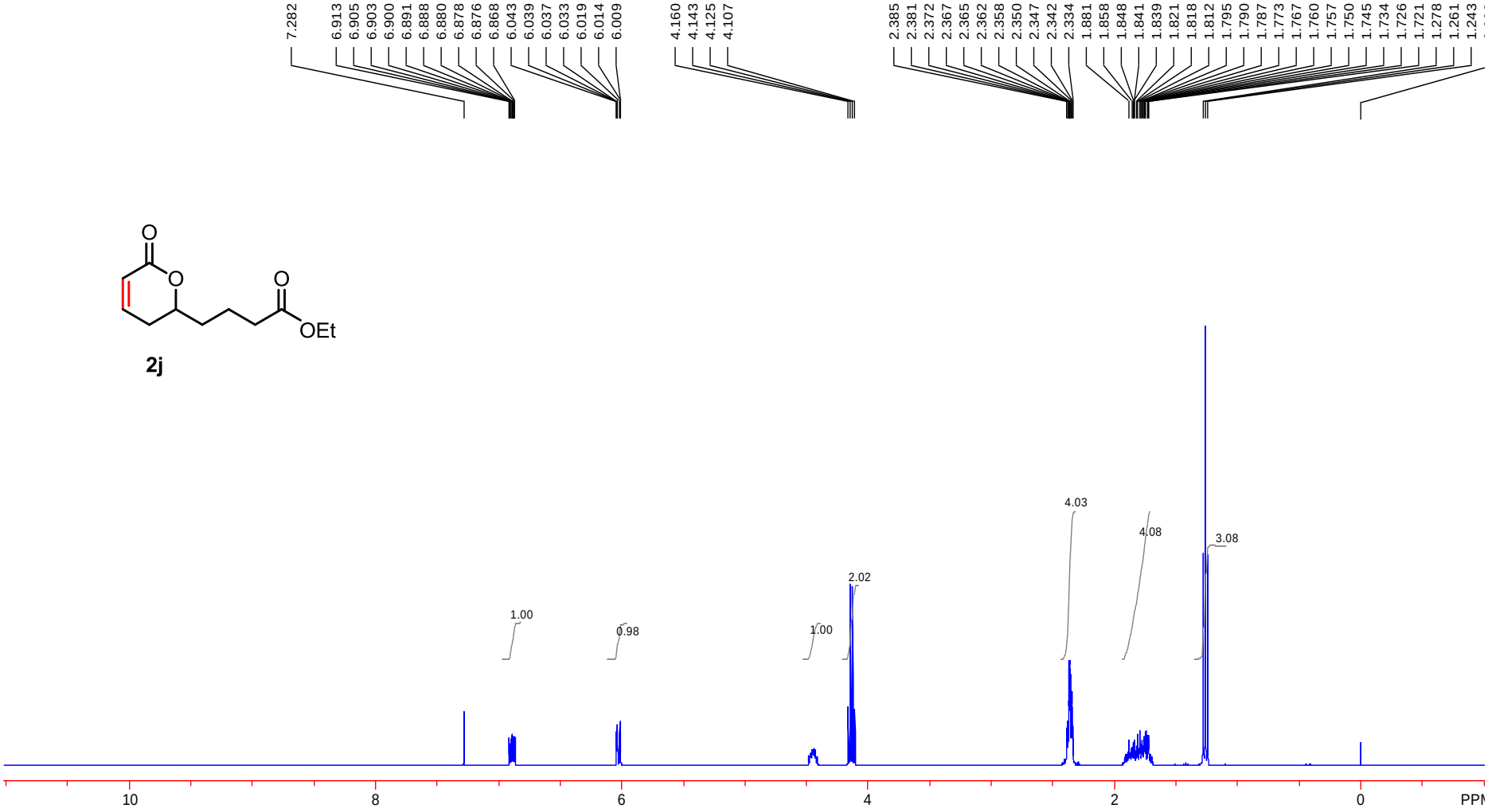
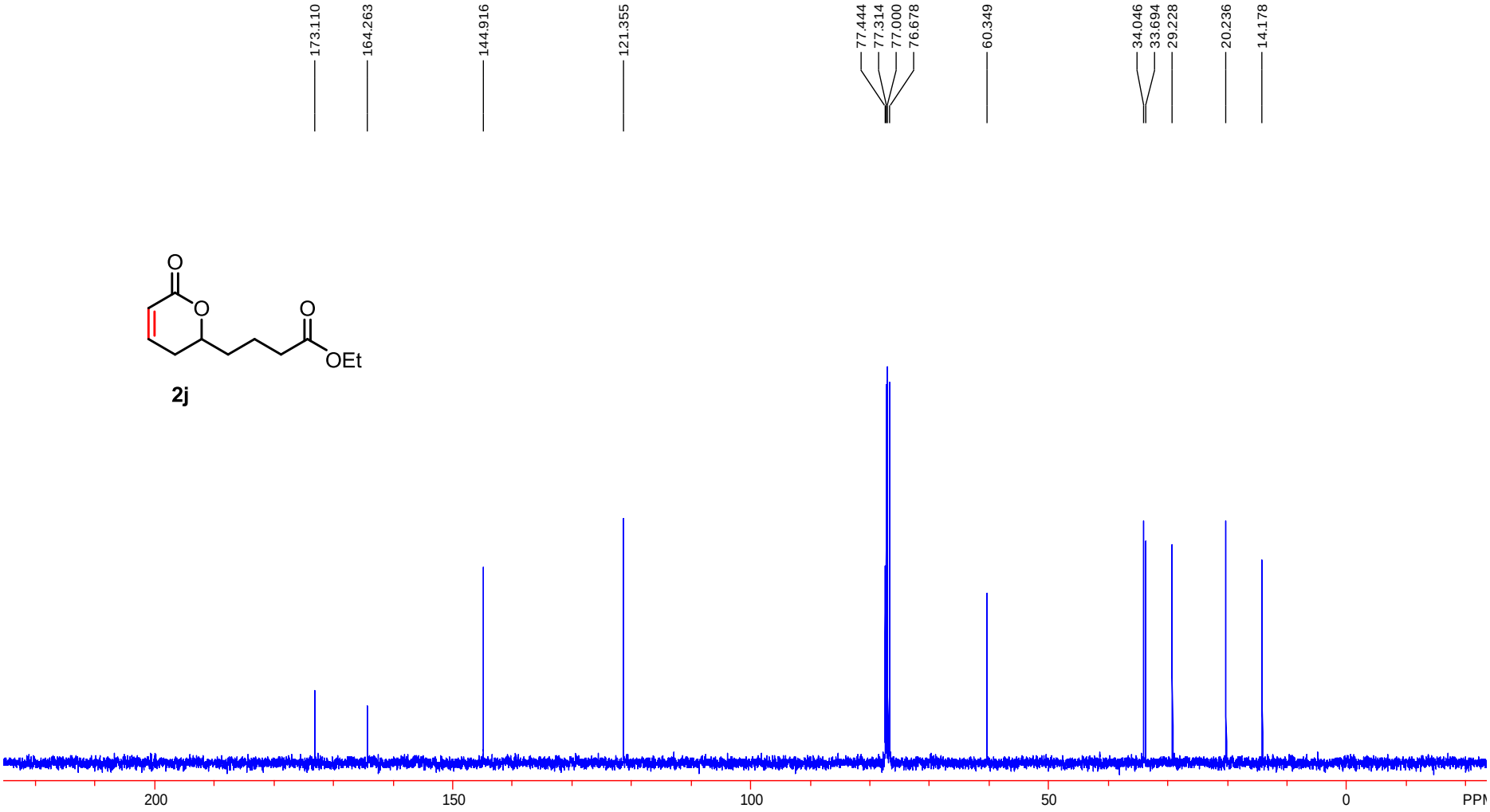
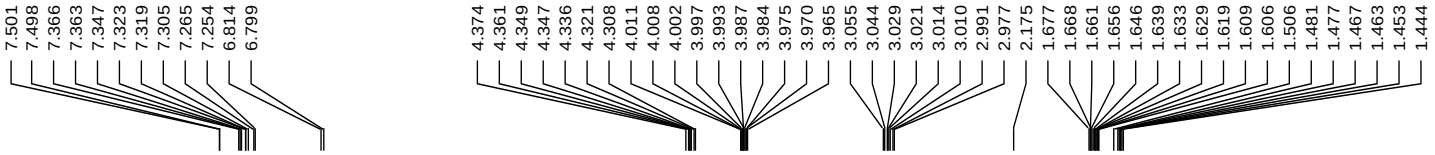
^{1}H NMR (400 MHz, $CDCl_3$)

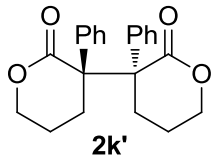


^{13}C NMR (101 MHz, $CDCl_3$)

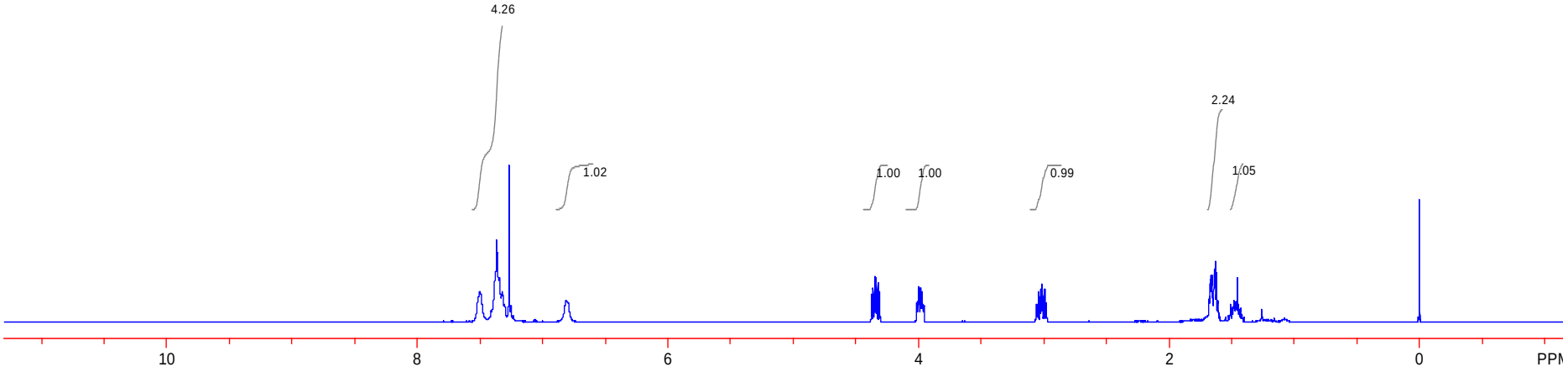


^{1}H NMR (400 MHz, $CDCl_3$)

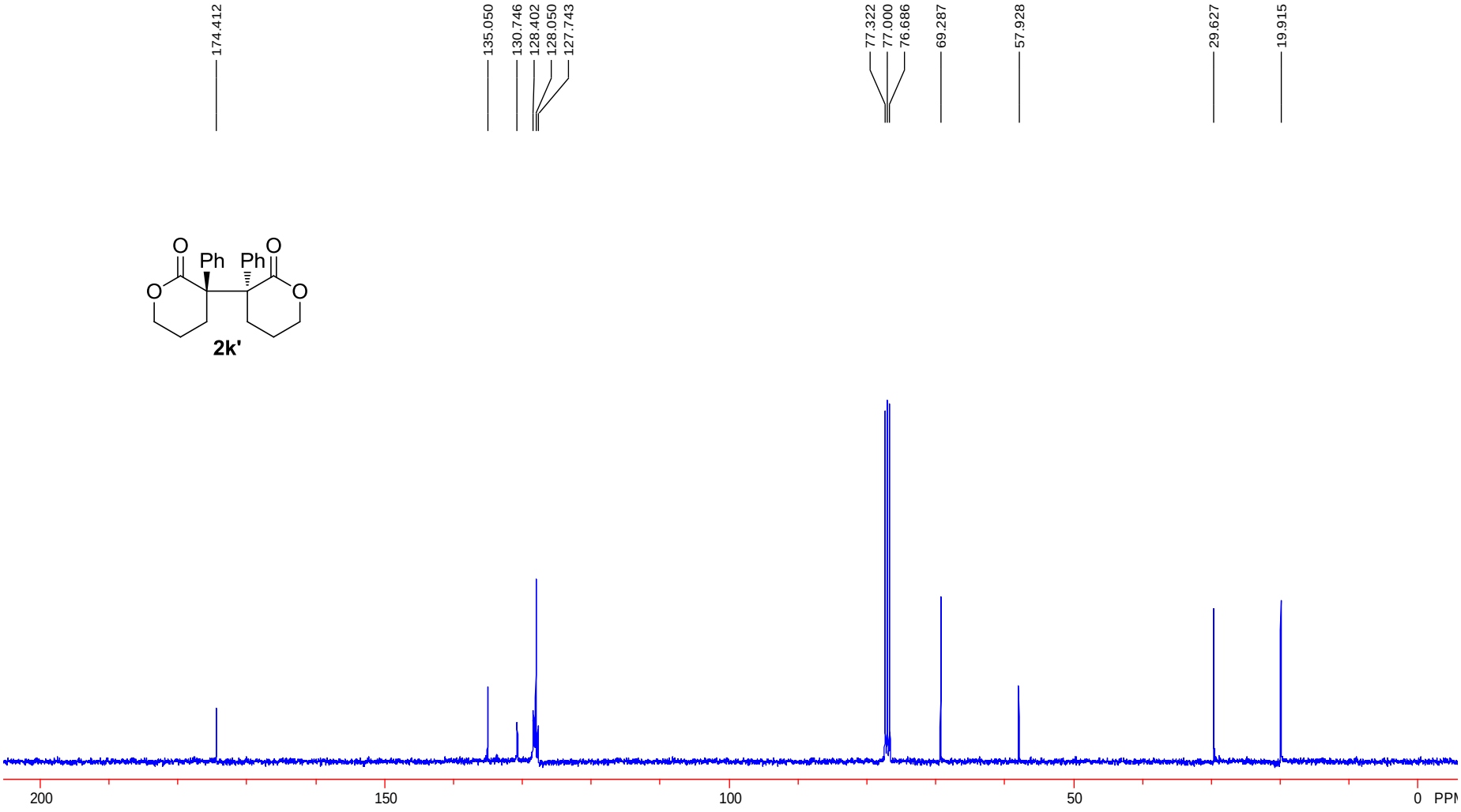




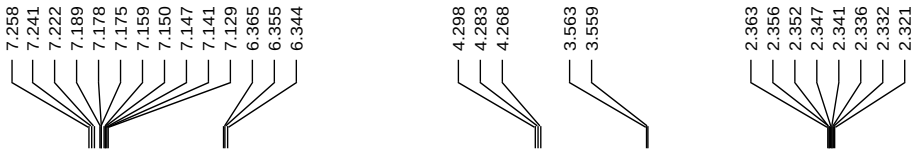
2k'

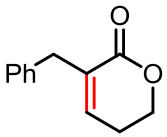


^{13}C NMR (101 MHz, $CDCl_3$)

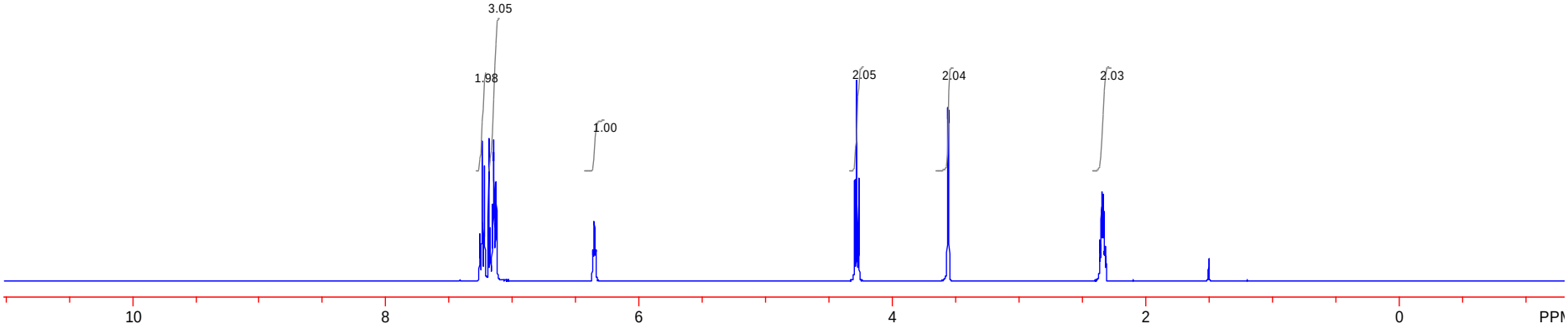


^{1}H NMR (400 MHz, $CDCl_3$)

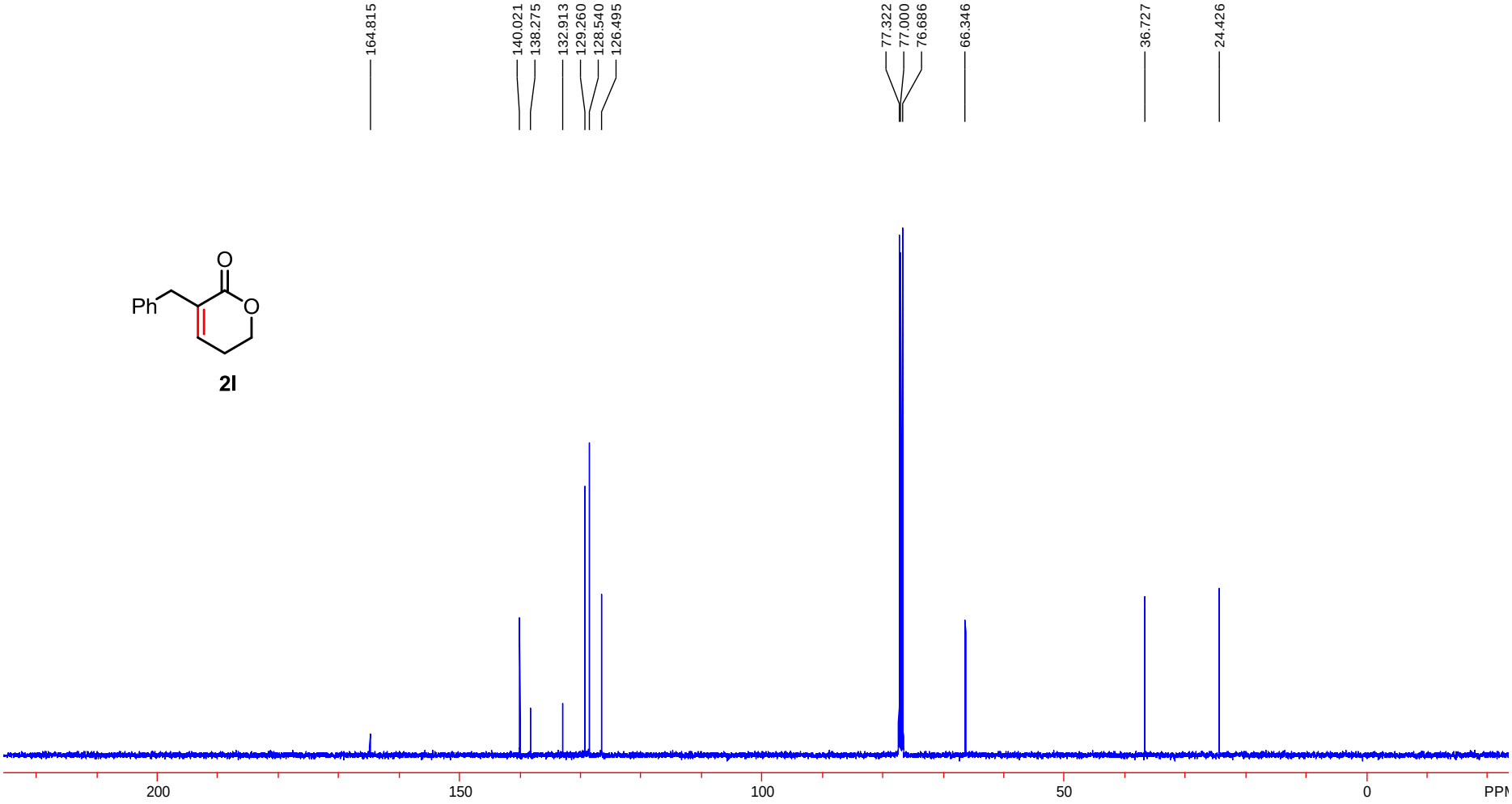




2l



^{13}C NMR (101 MHz, $CDCl_3$)



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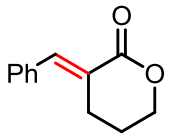

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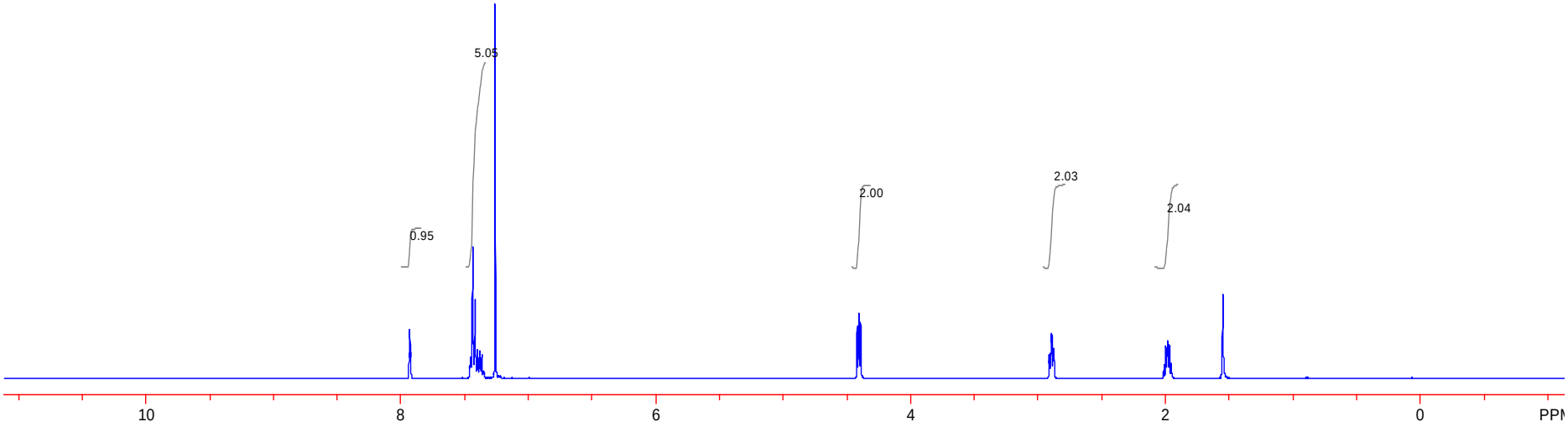
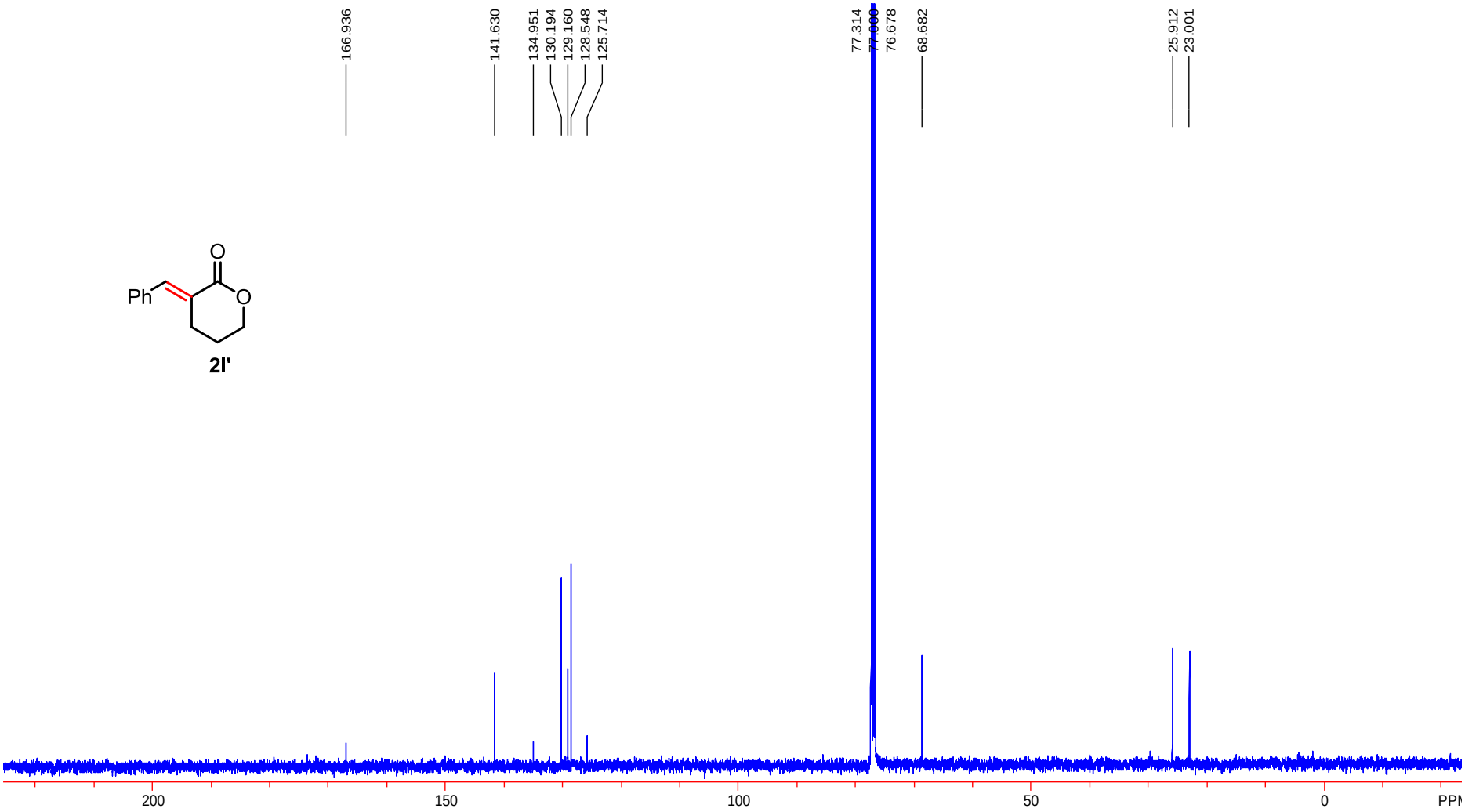


^{13}C NMR (101 MHz, $CDCl_3$)



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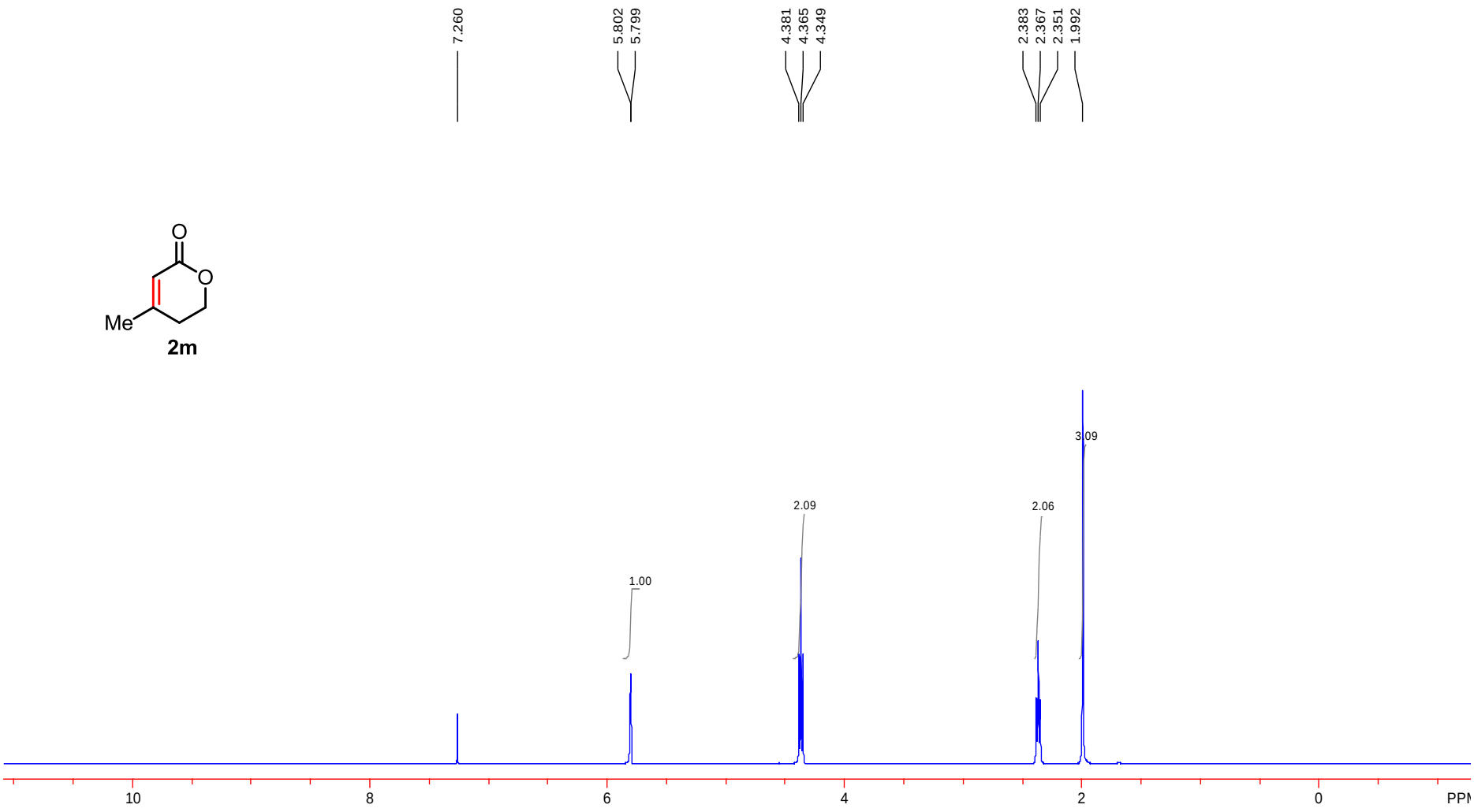
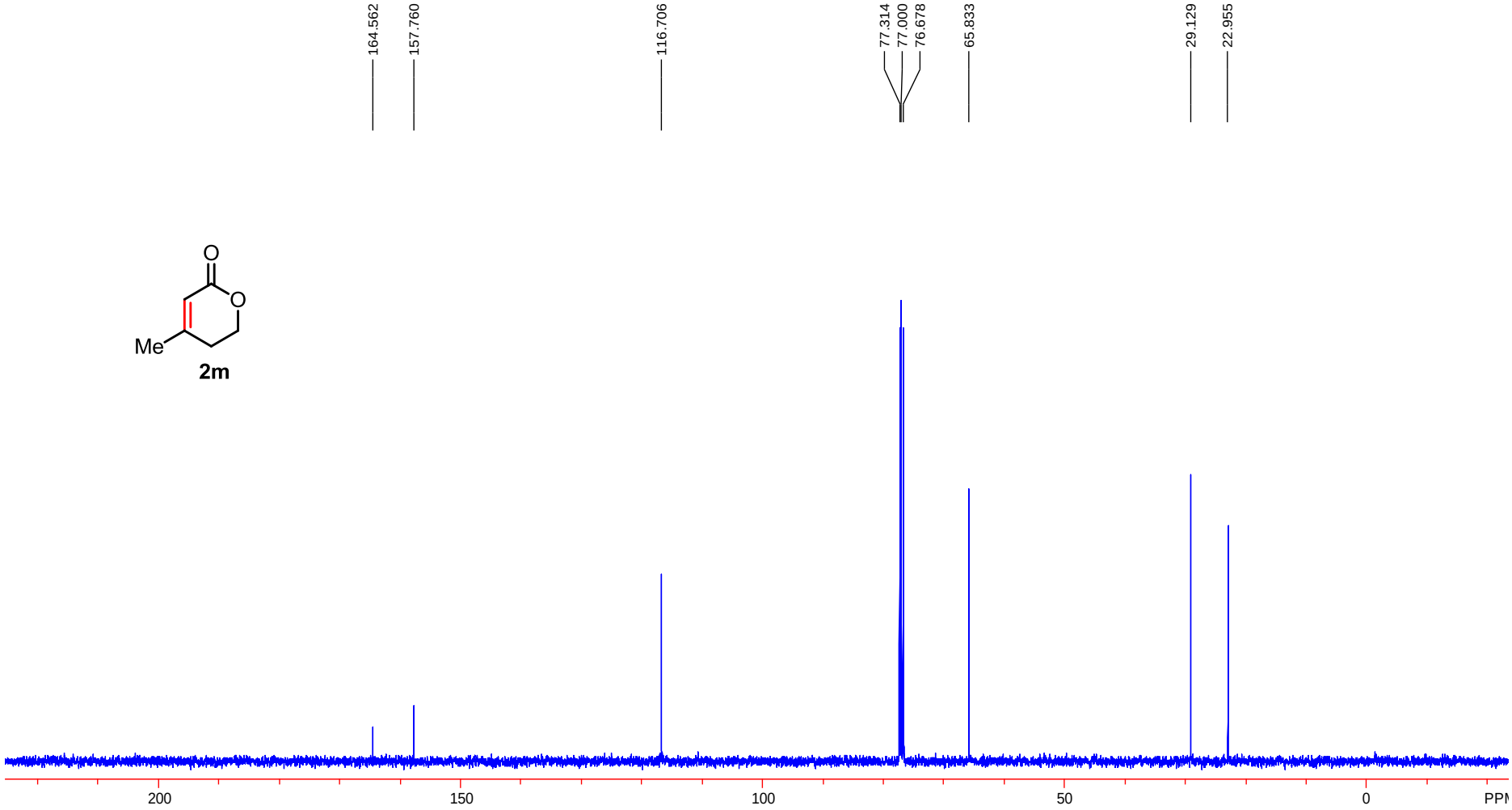
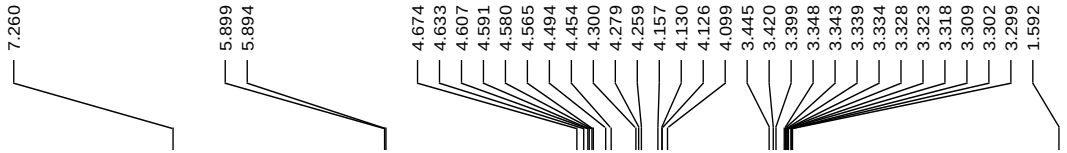
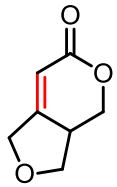


^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (400 MHz, $CDCl_3$)





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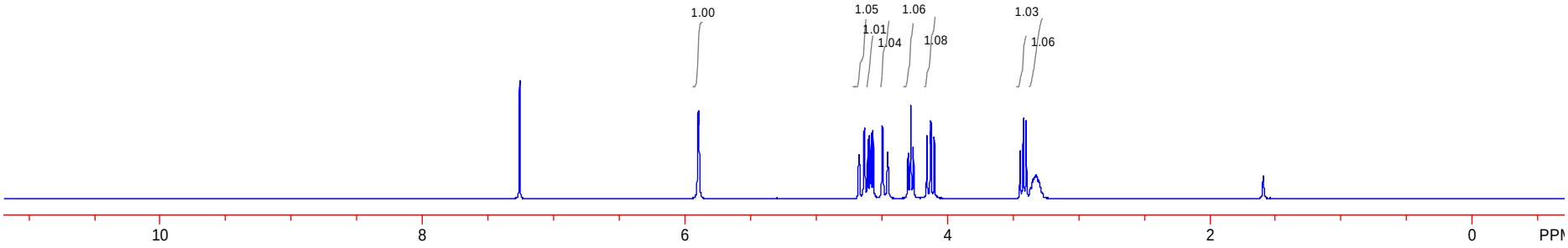
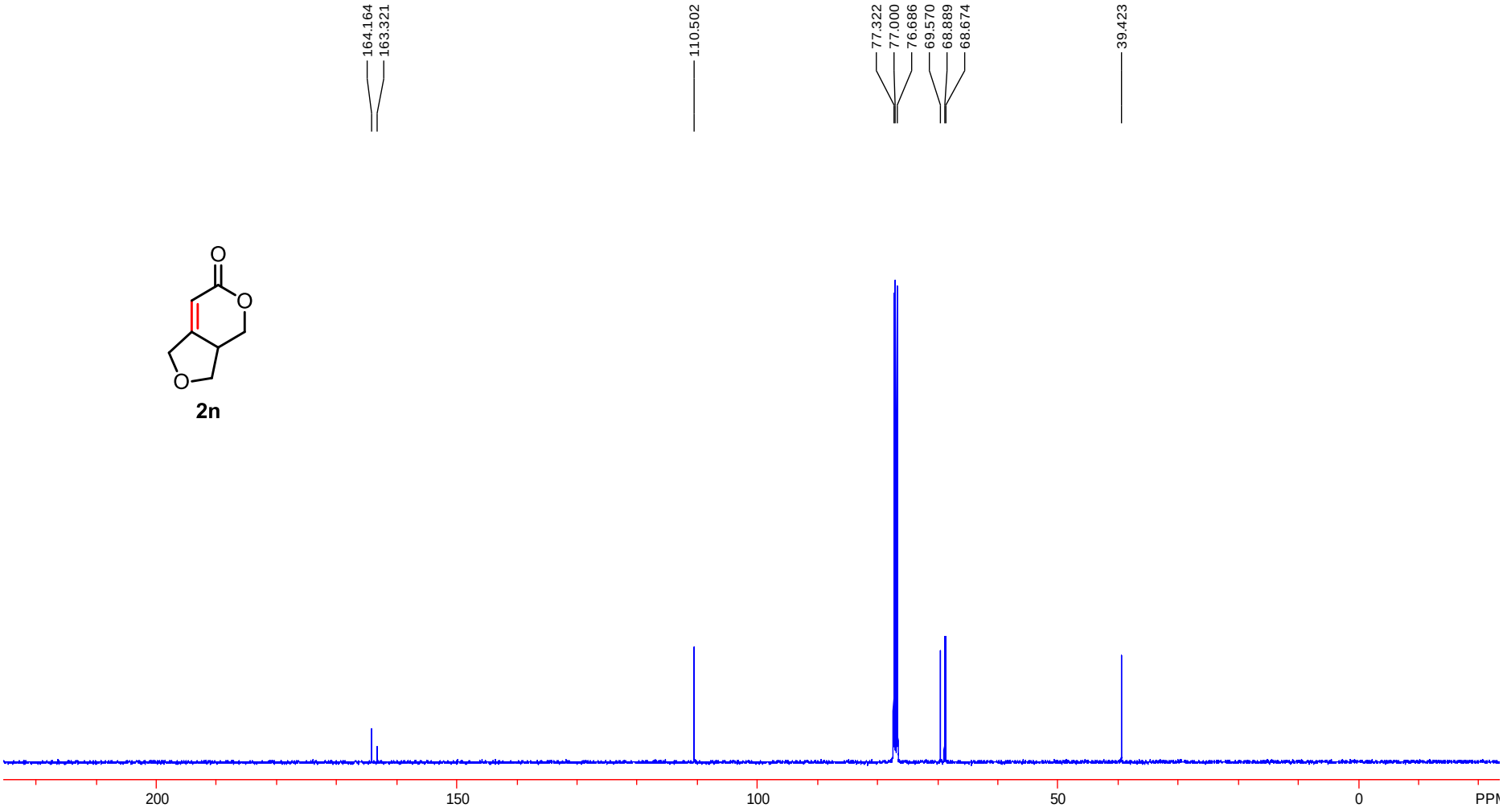


^{13}C NMR (101 MHz, $CDCl_3$)



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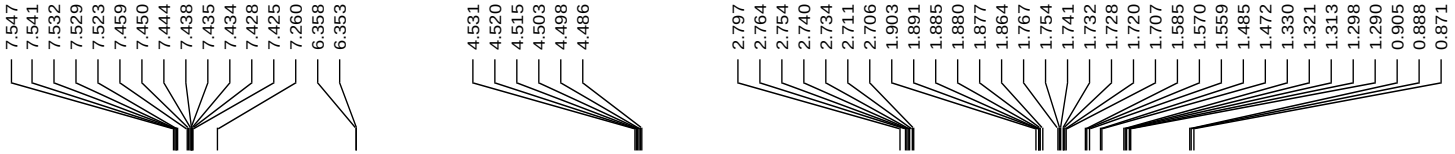
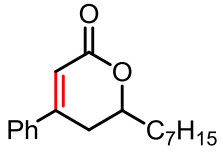
^{1}H NMR (400 MHz, $CDCl_3$)





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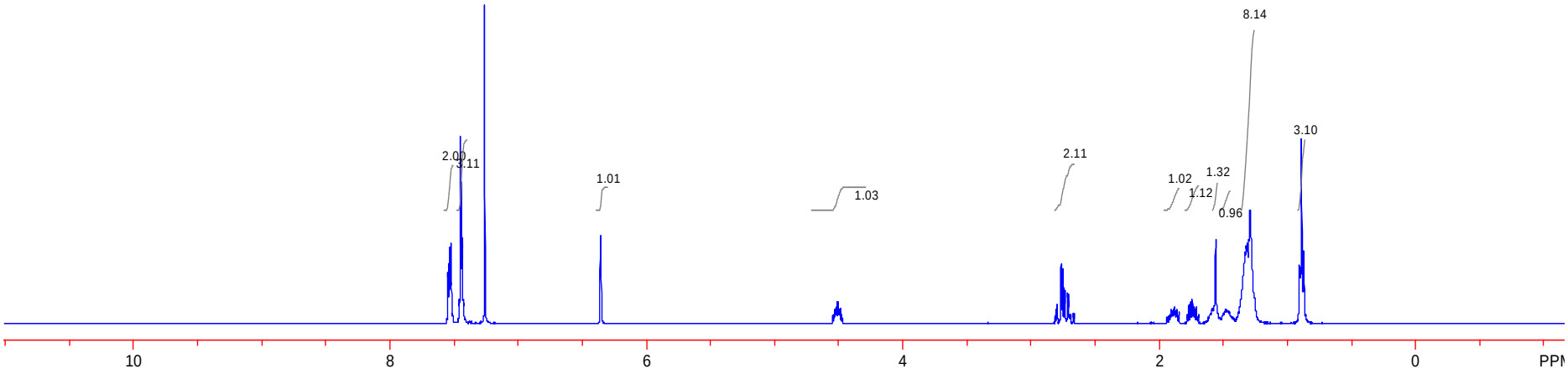
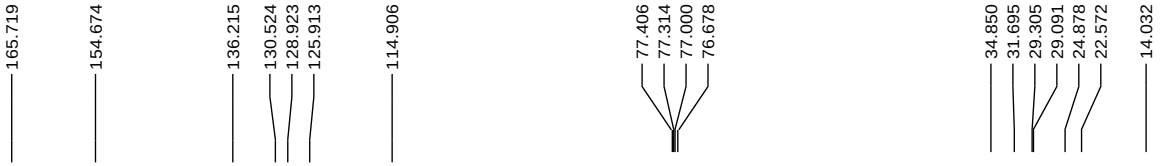
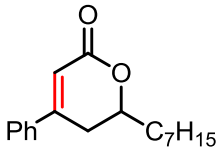


^{13}C NMR (101 MHz, $CDCl_3$)





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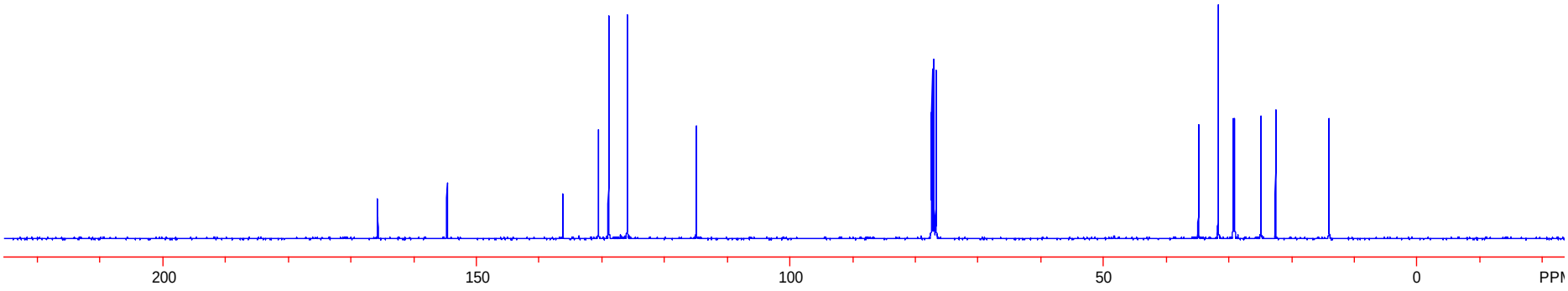
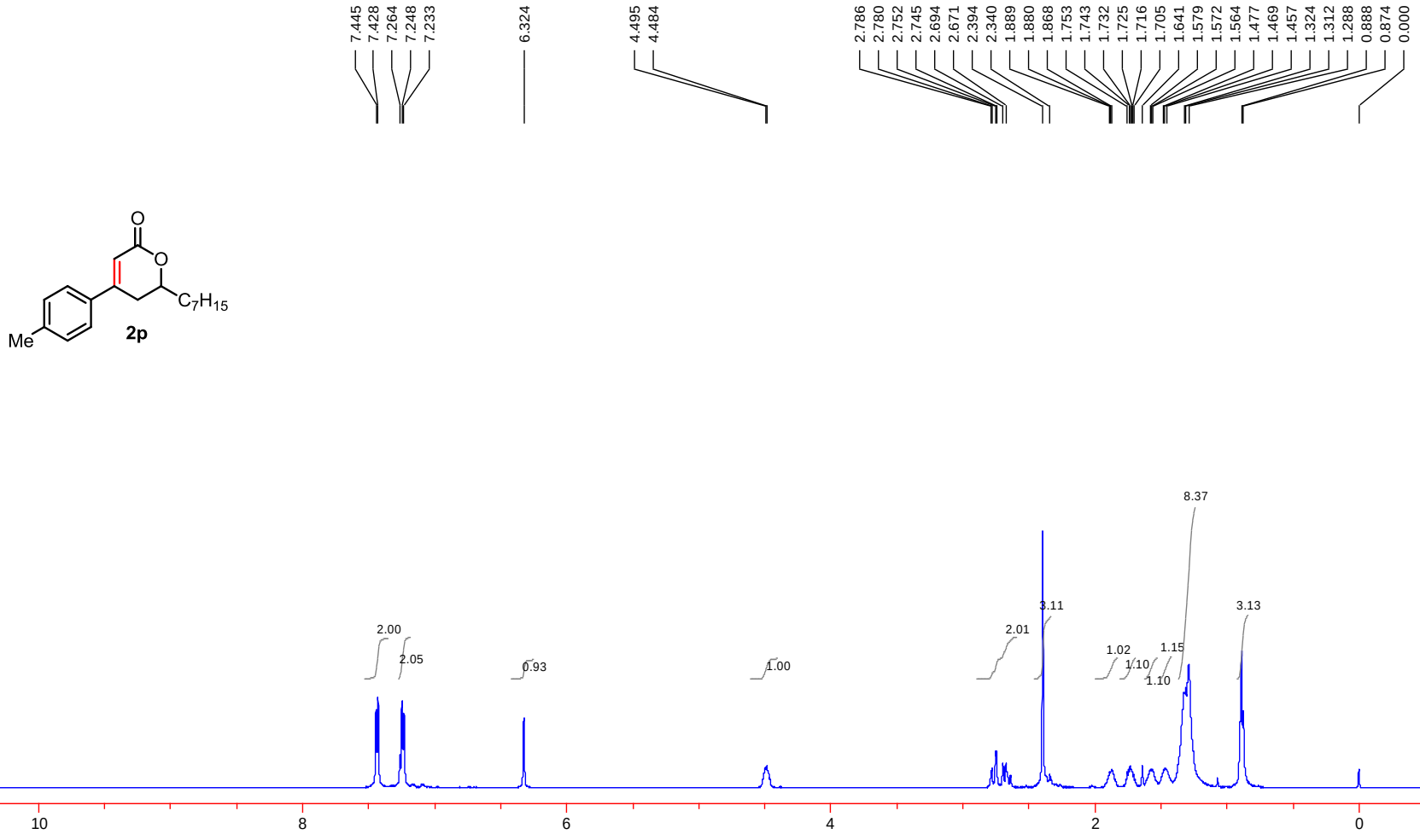
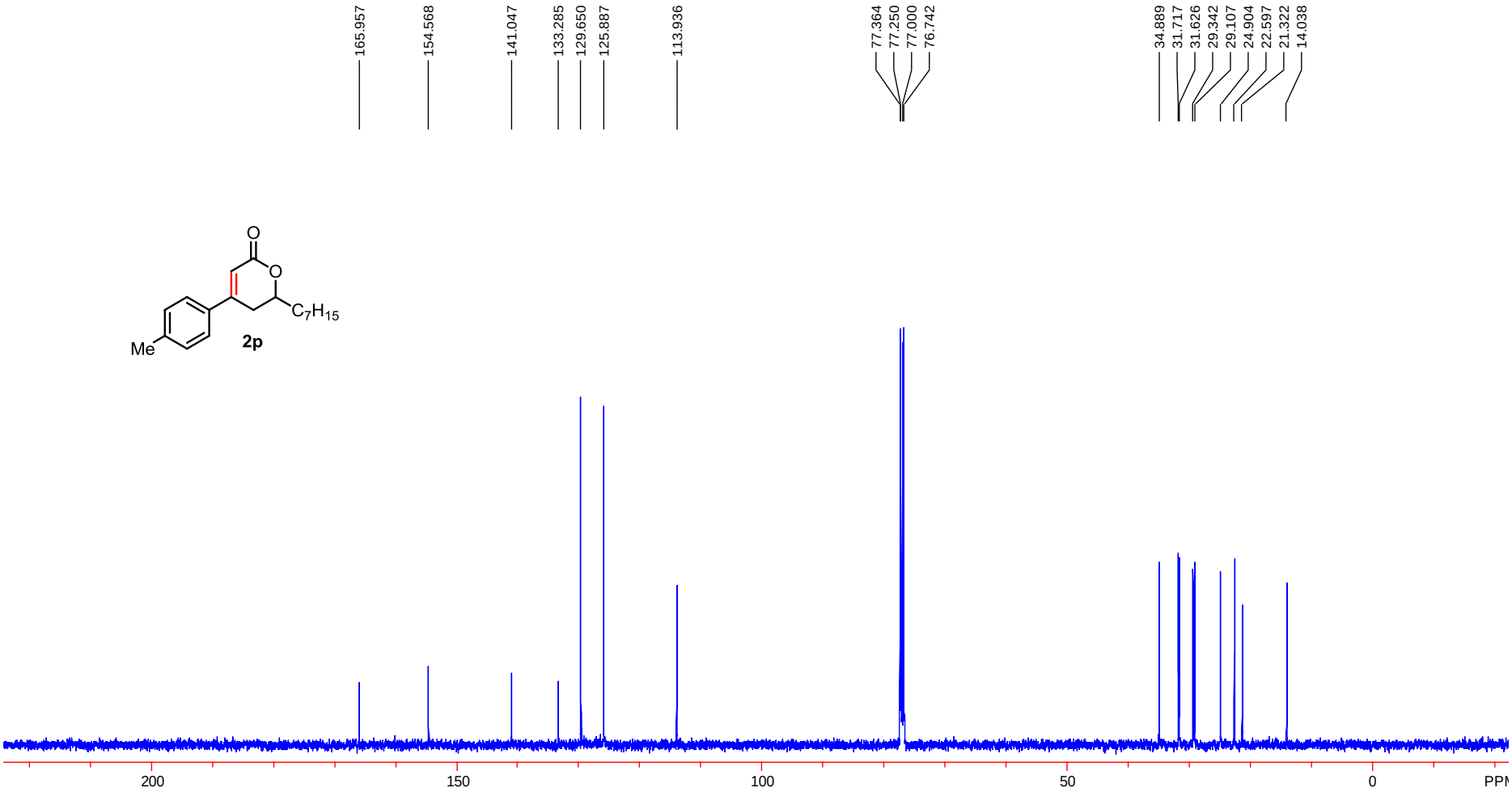


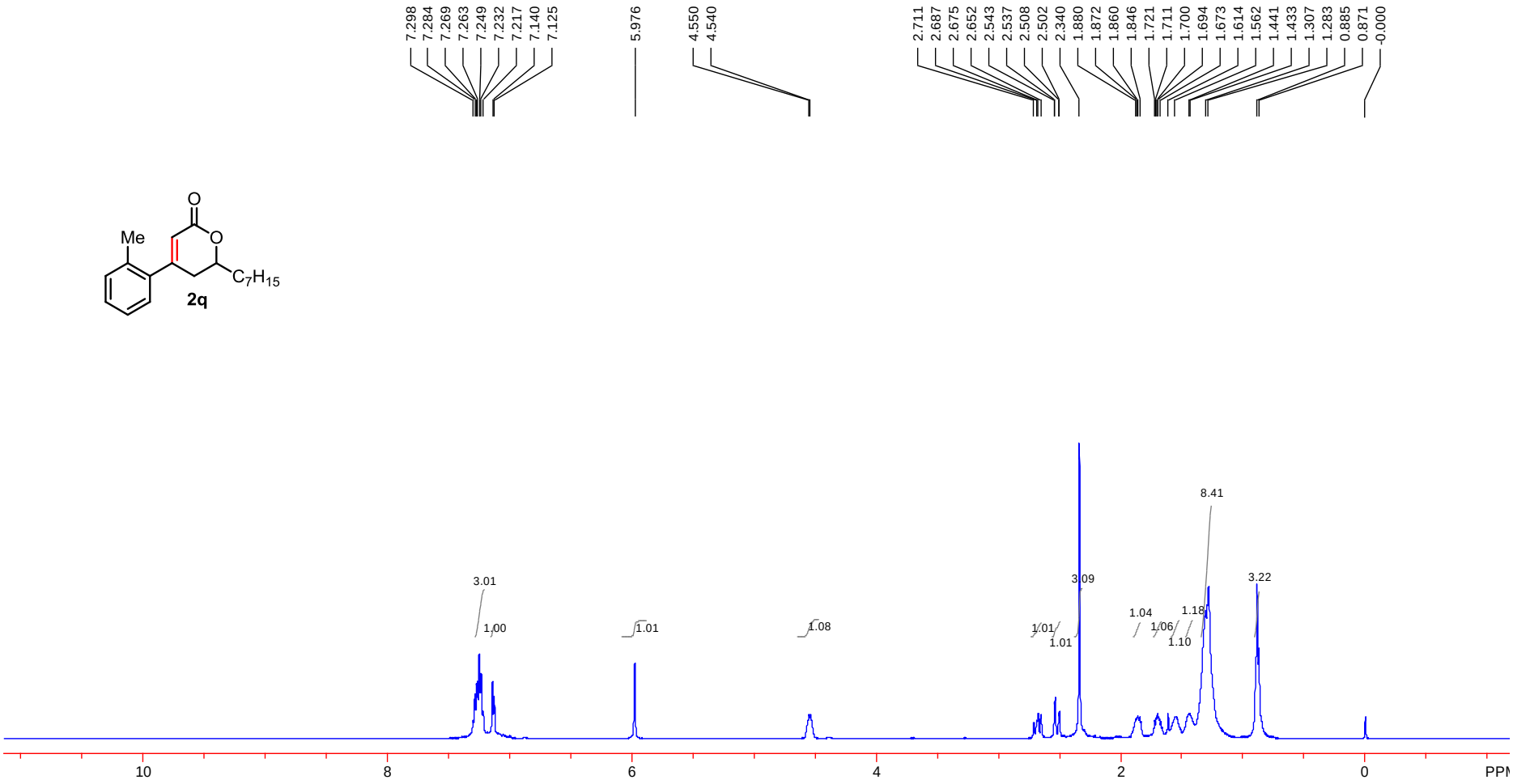
^{1}H NMR (500 MHz, $CDCl_3$)



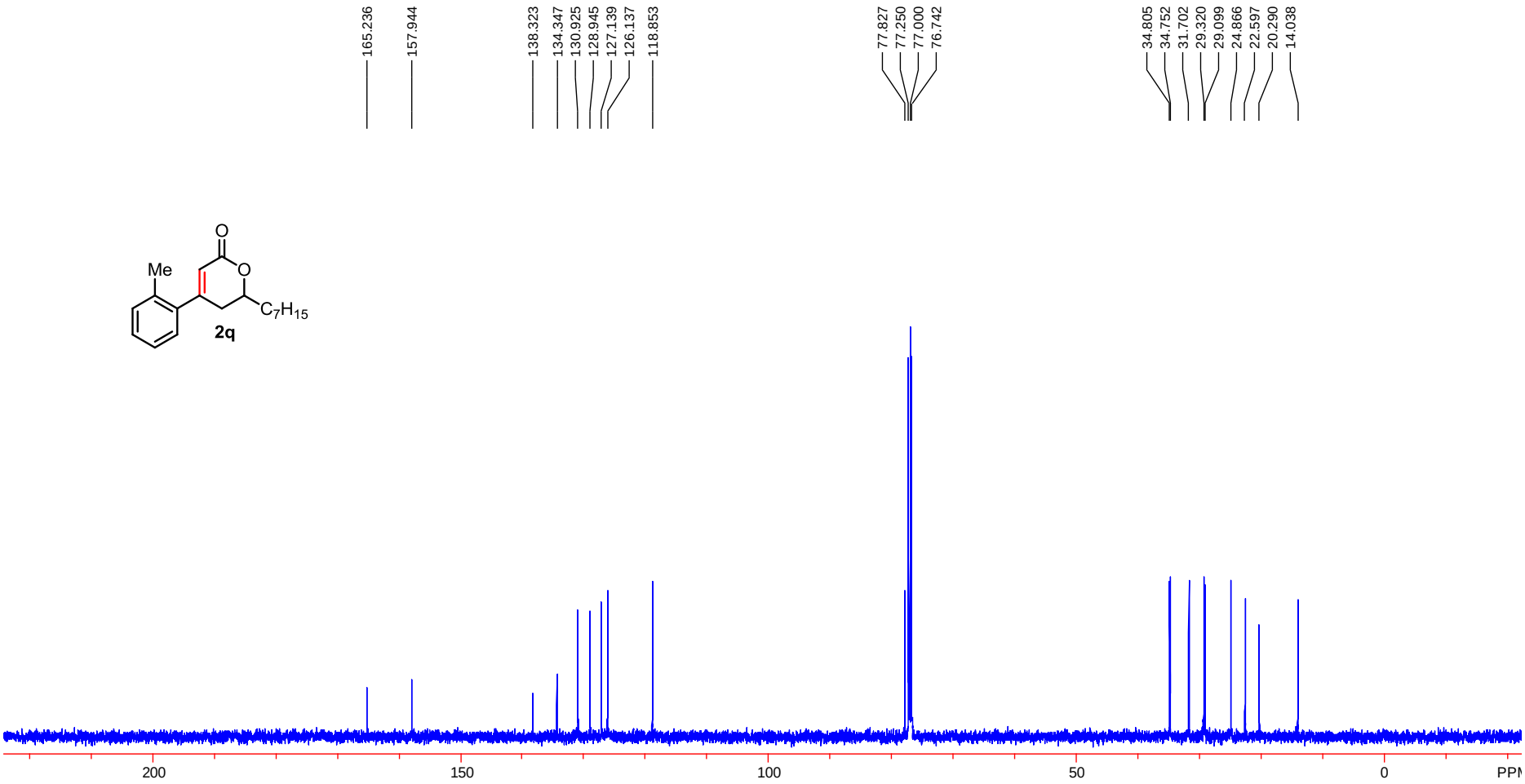
^{13}C NMR (125 MHz, $CDCl_3$)



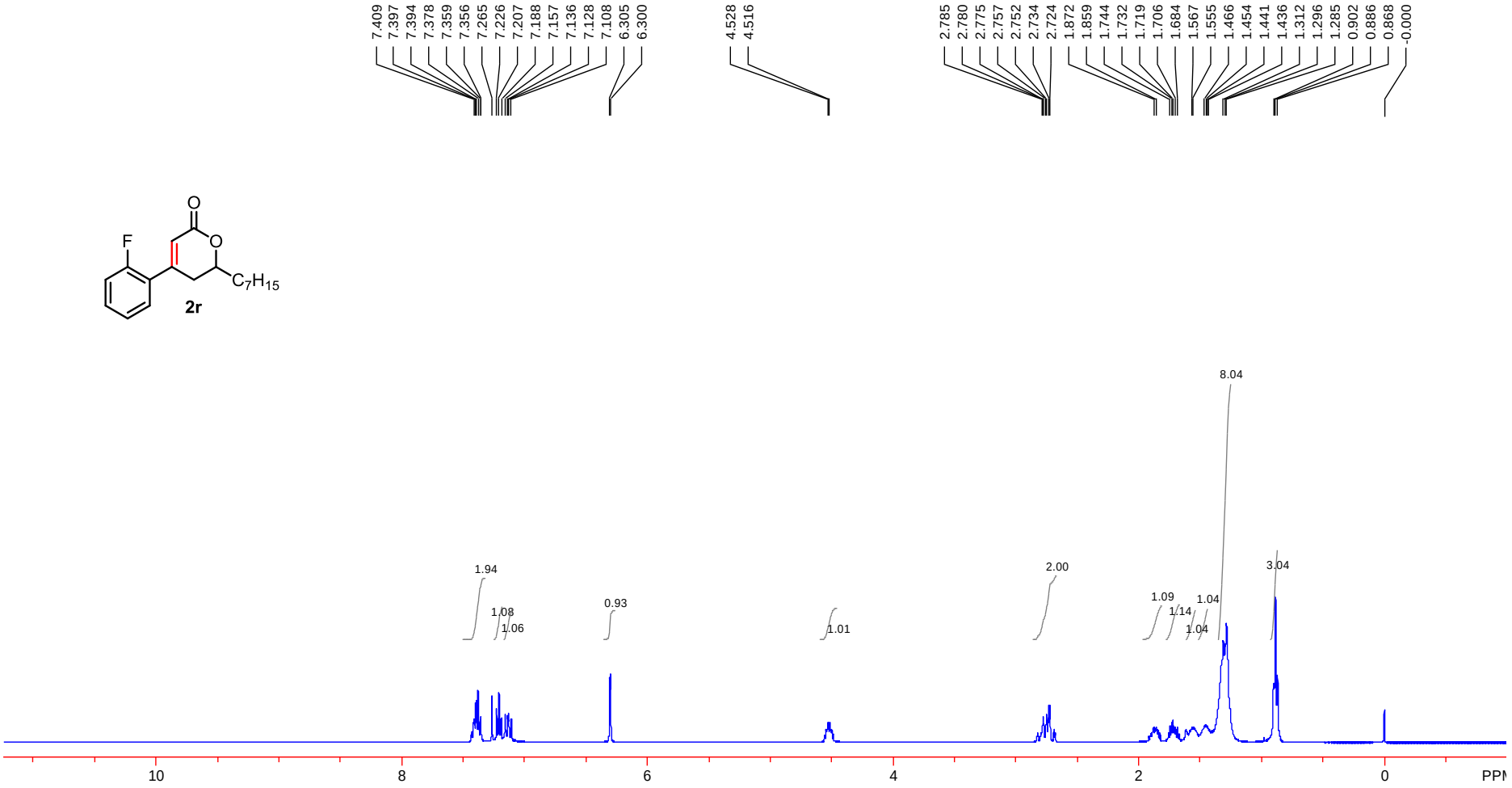
^{1}H NMR (500 MHz, $CDCl_3$)



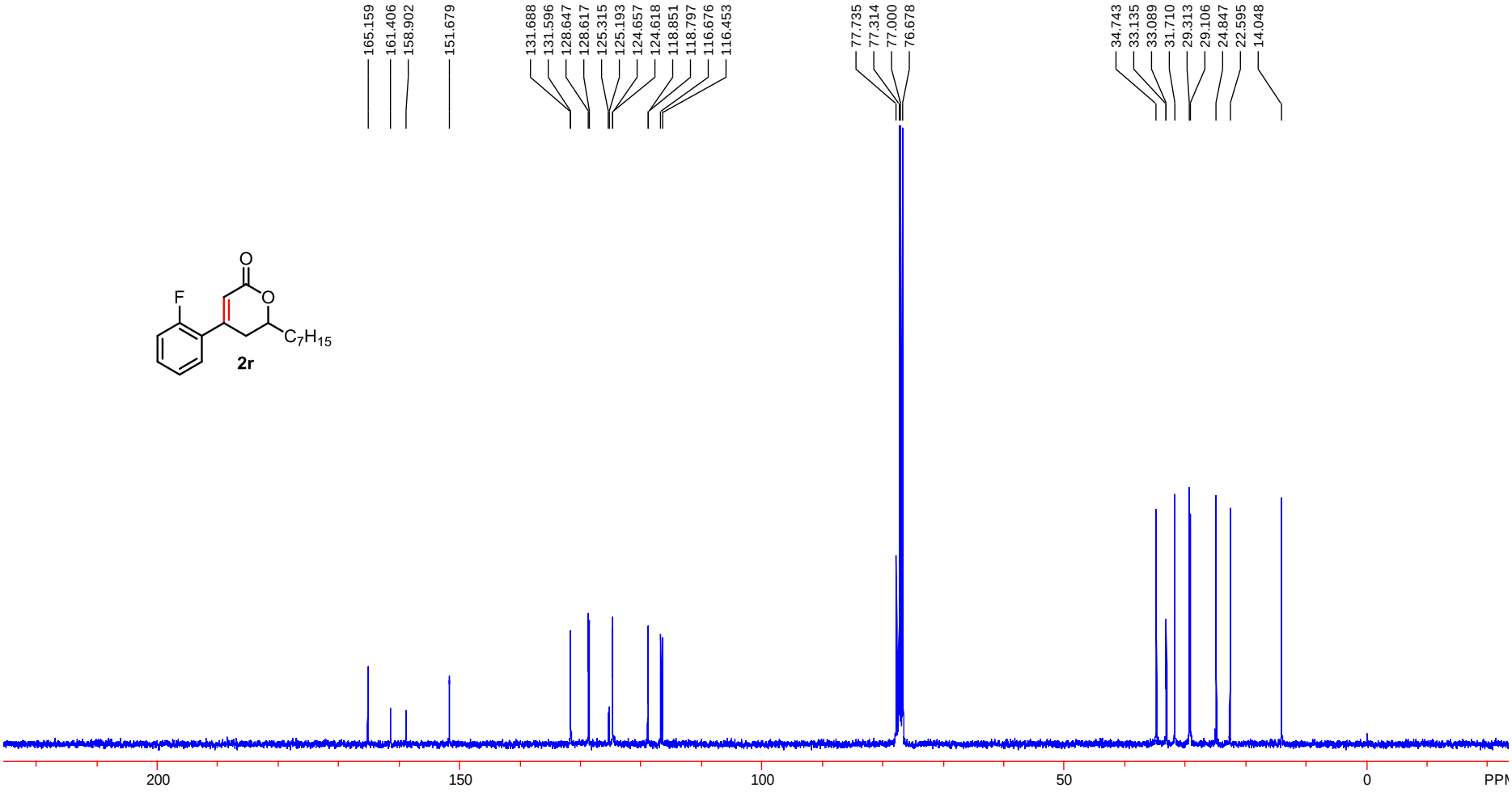
^{13}C NMR (125 MHz, $CDCl_3$)



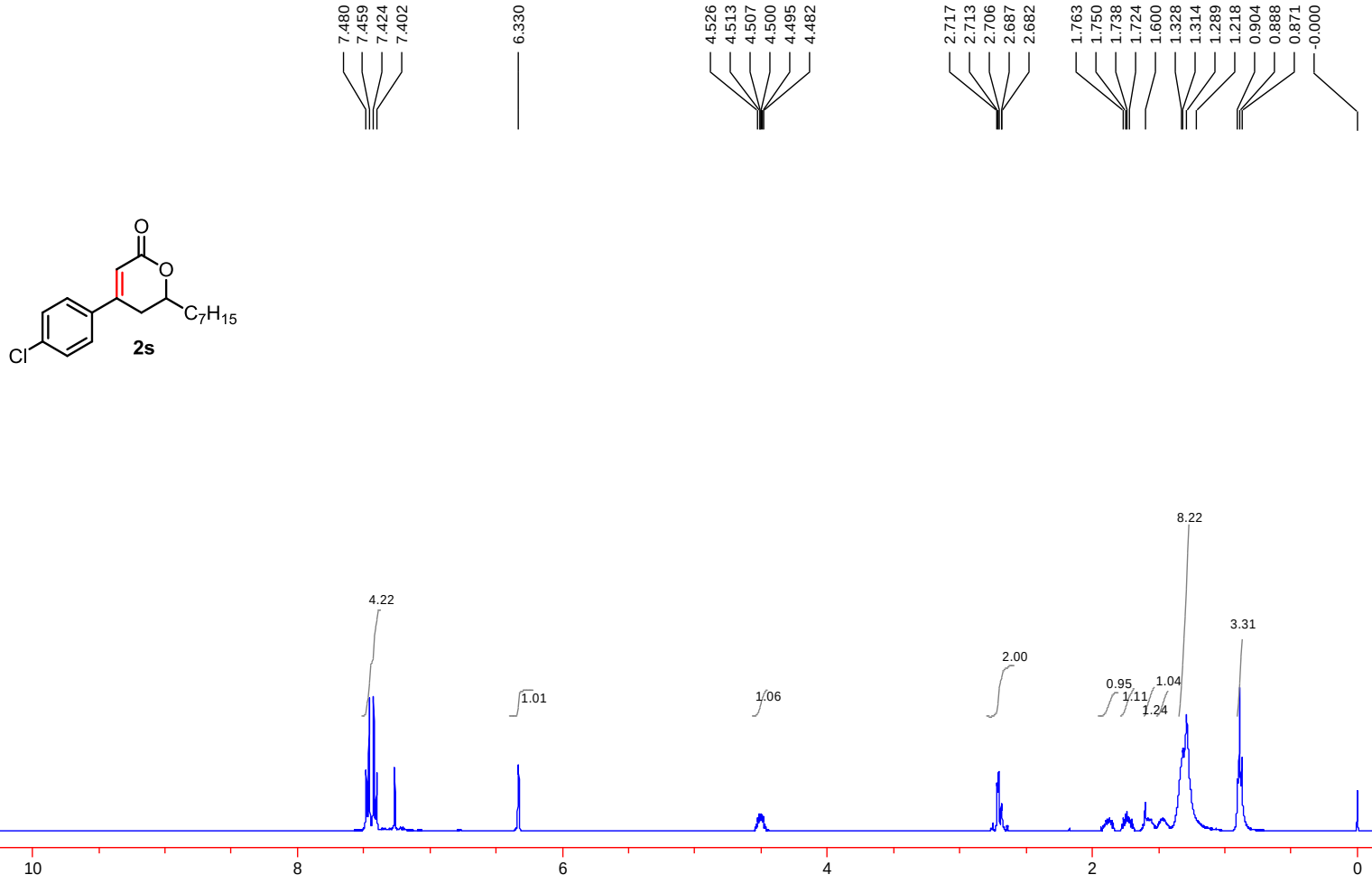
^{1}H NMR (400 MHz, $CDCl_3$)



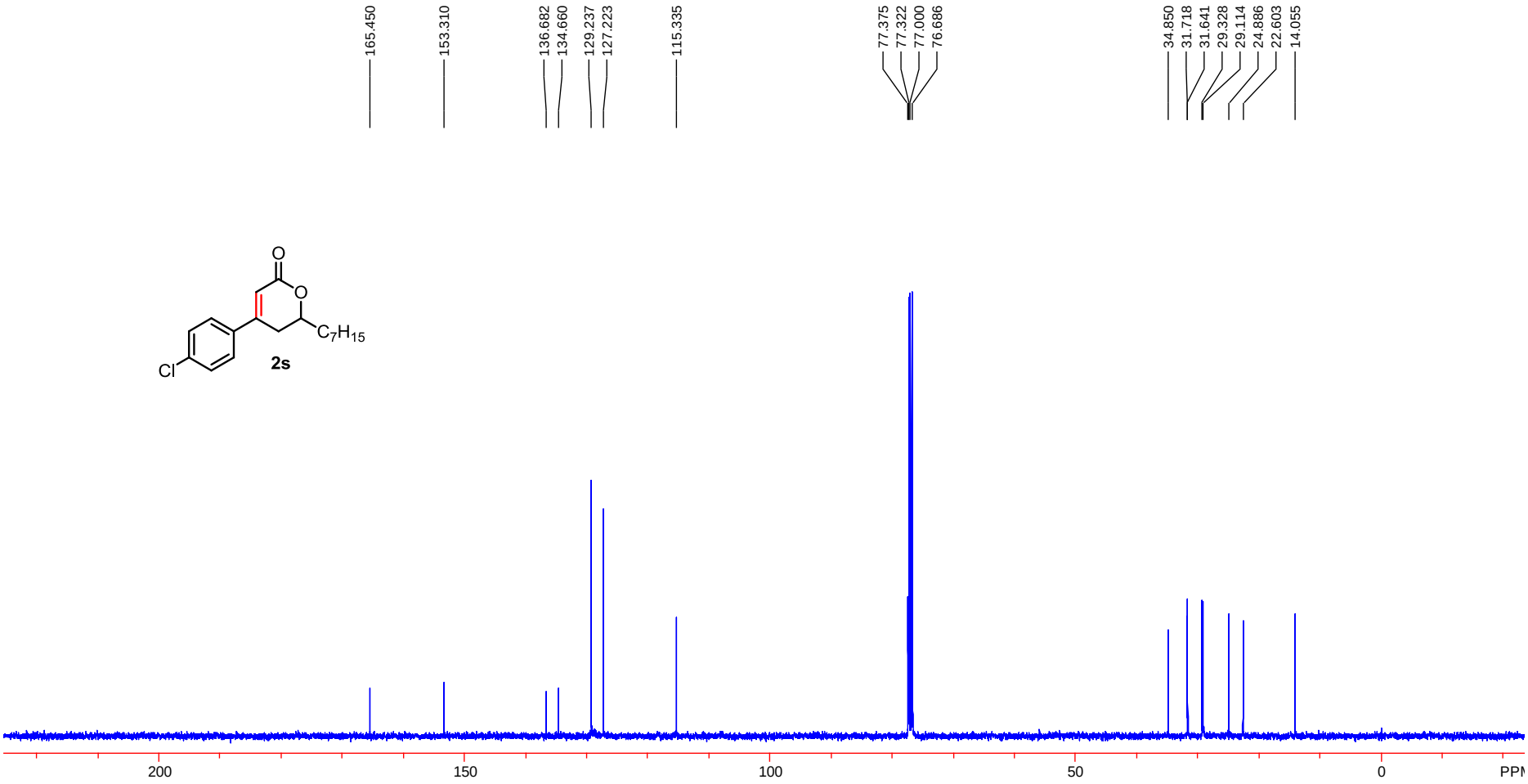
^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)



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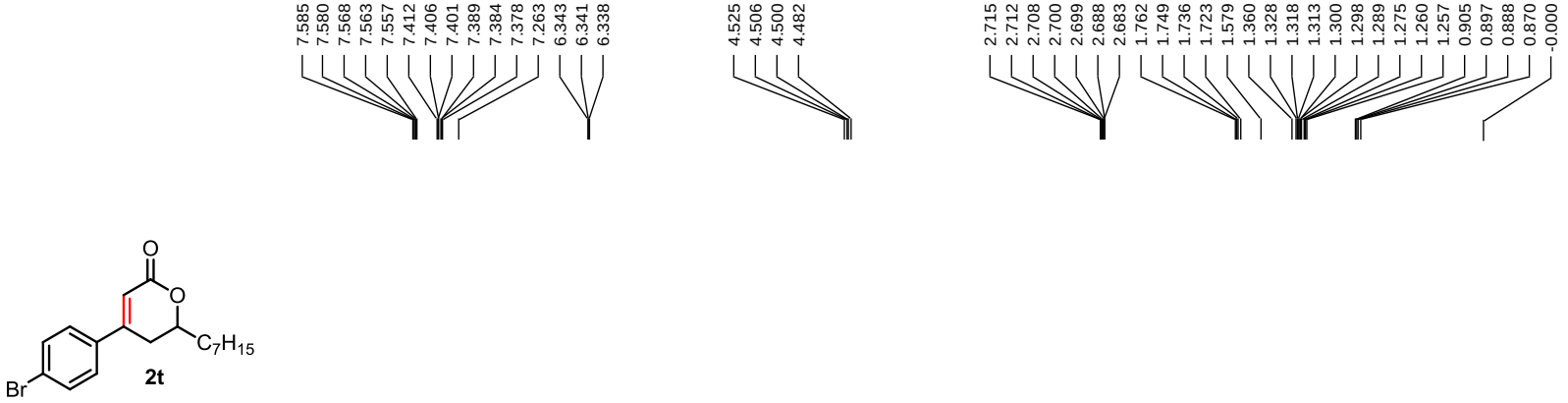

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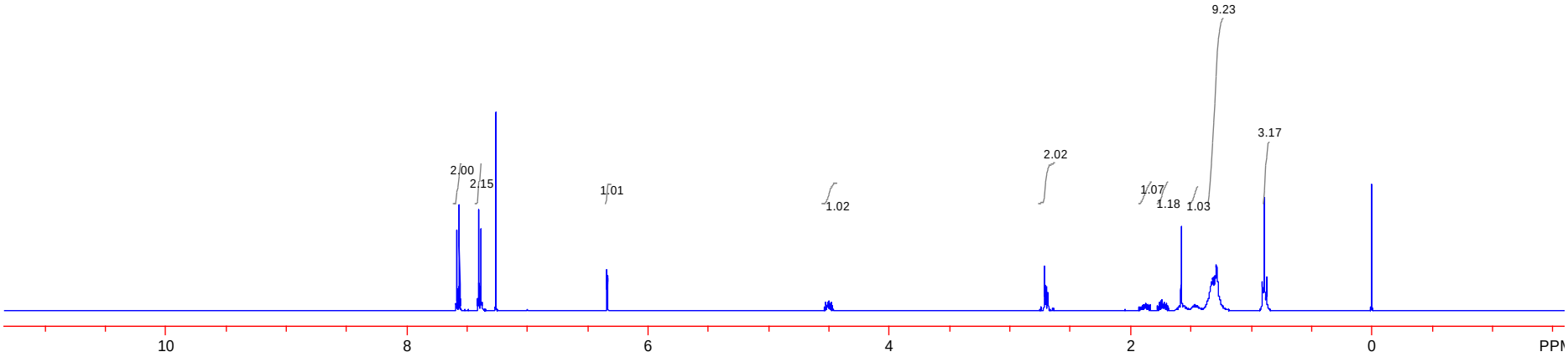
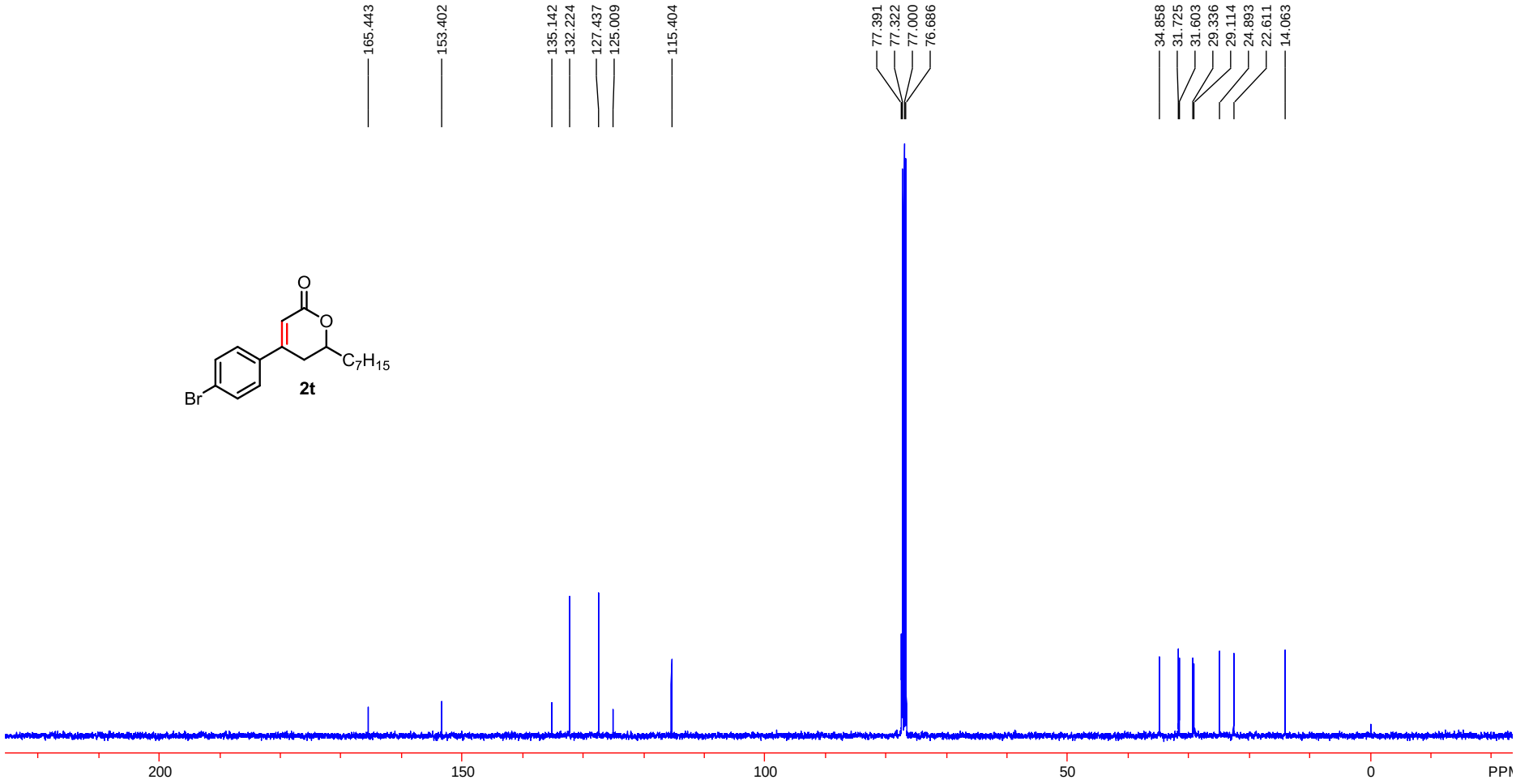
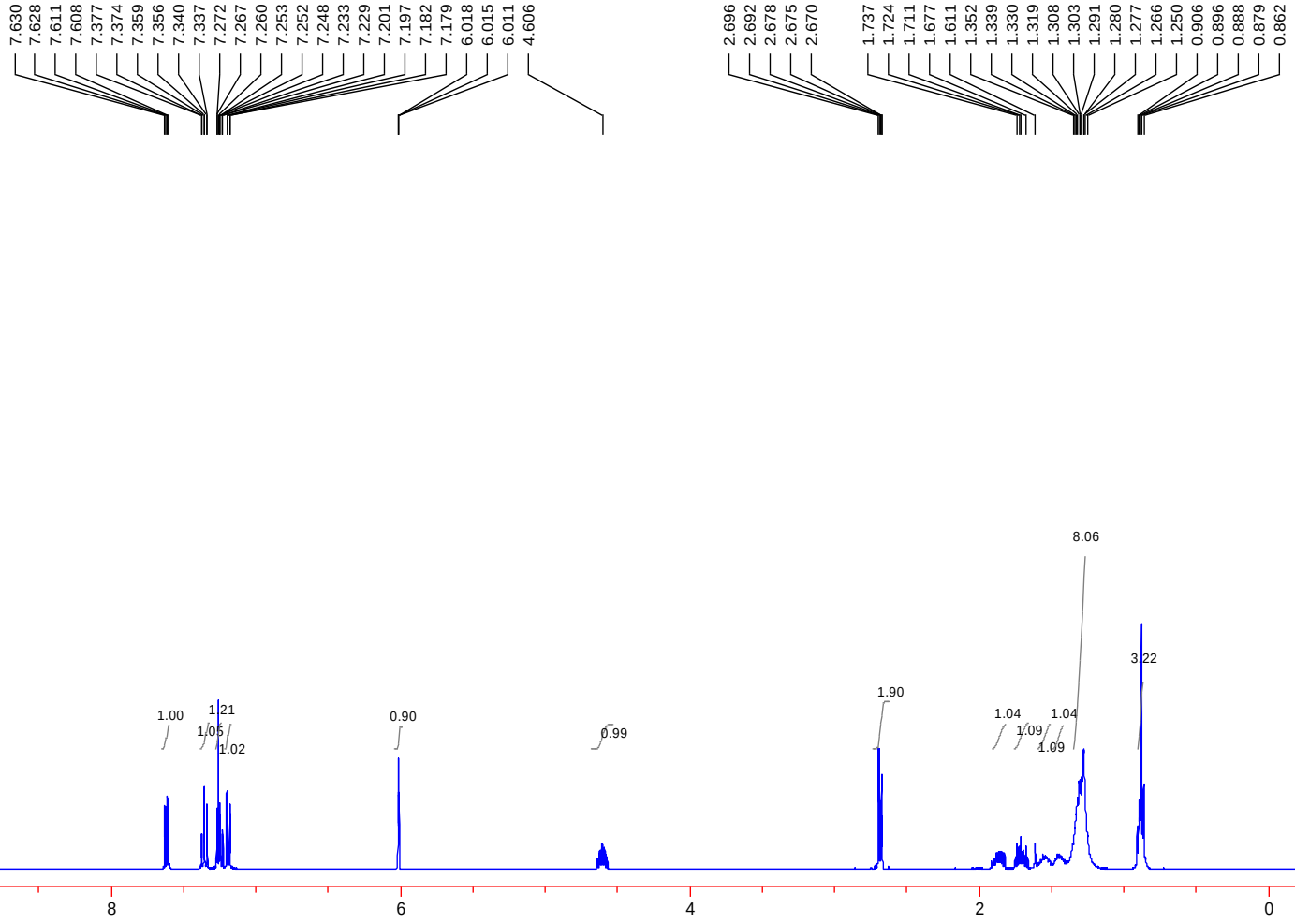


^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (400 MHz, $CDCl_3$)



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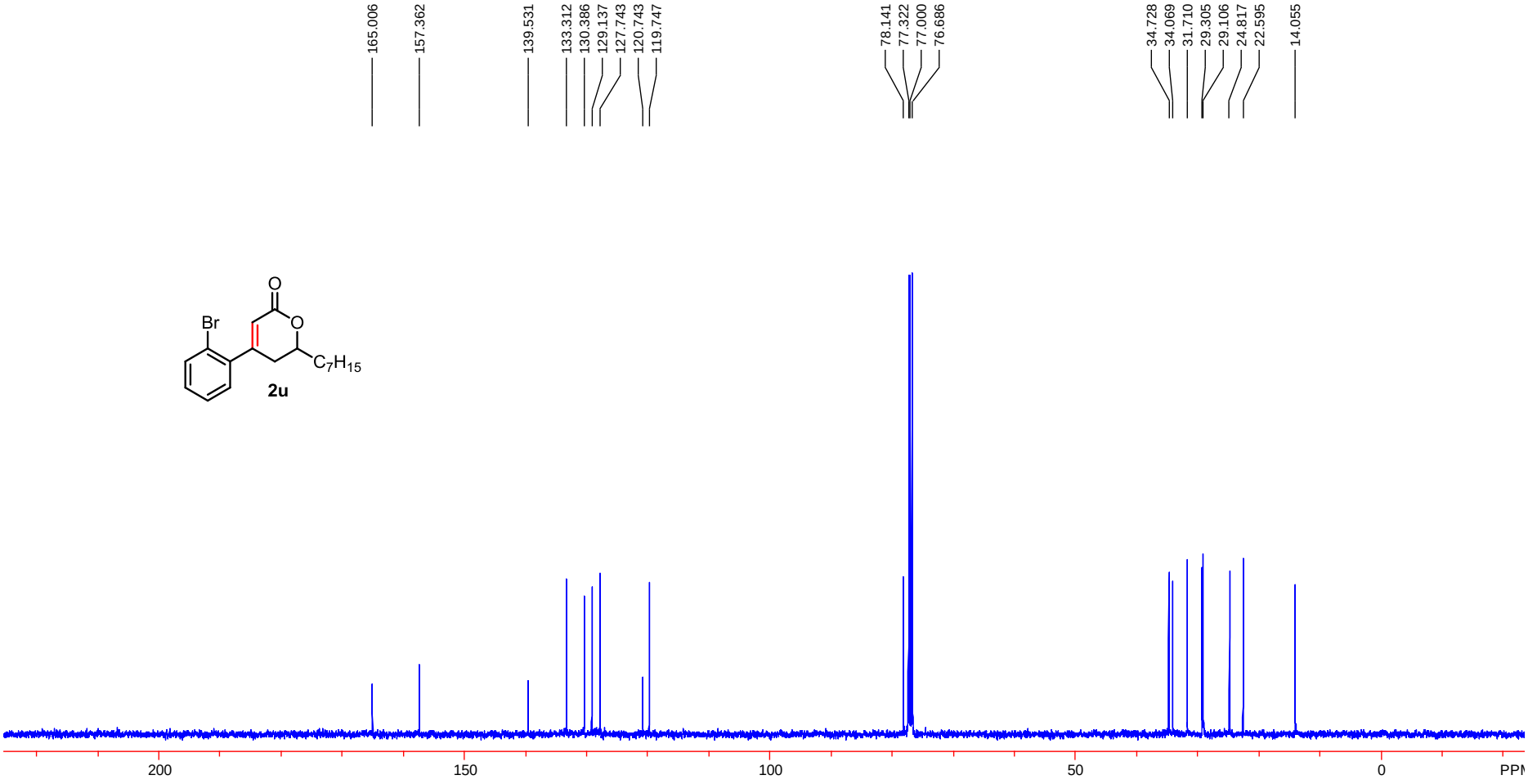

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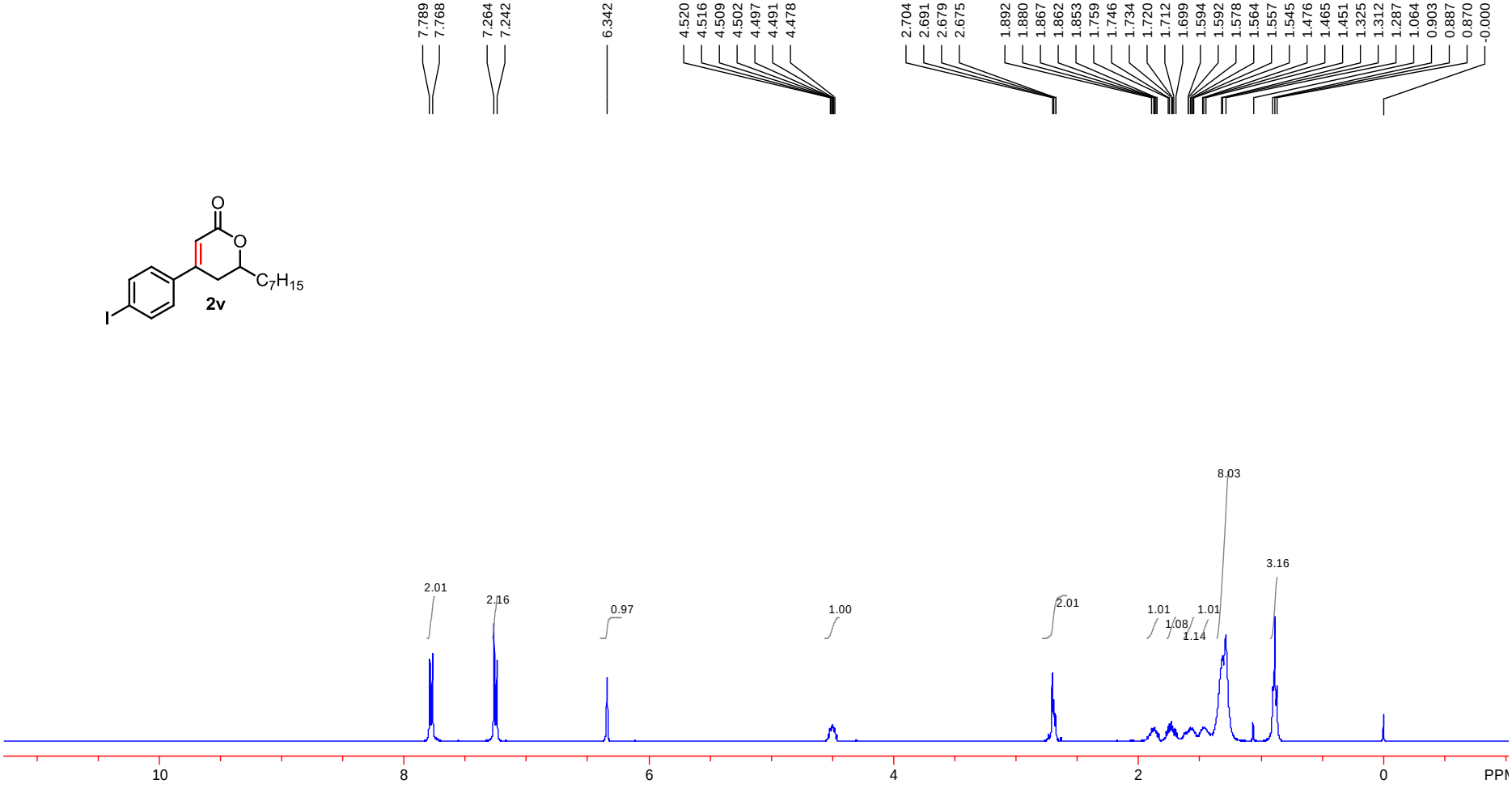

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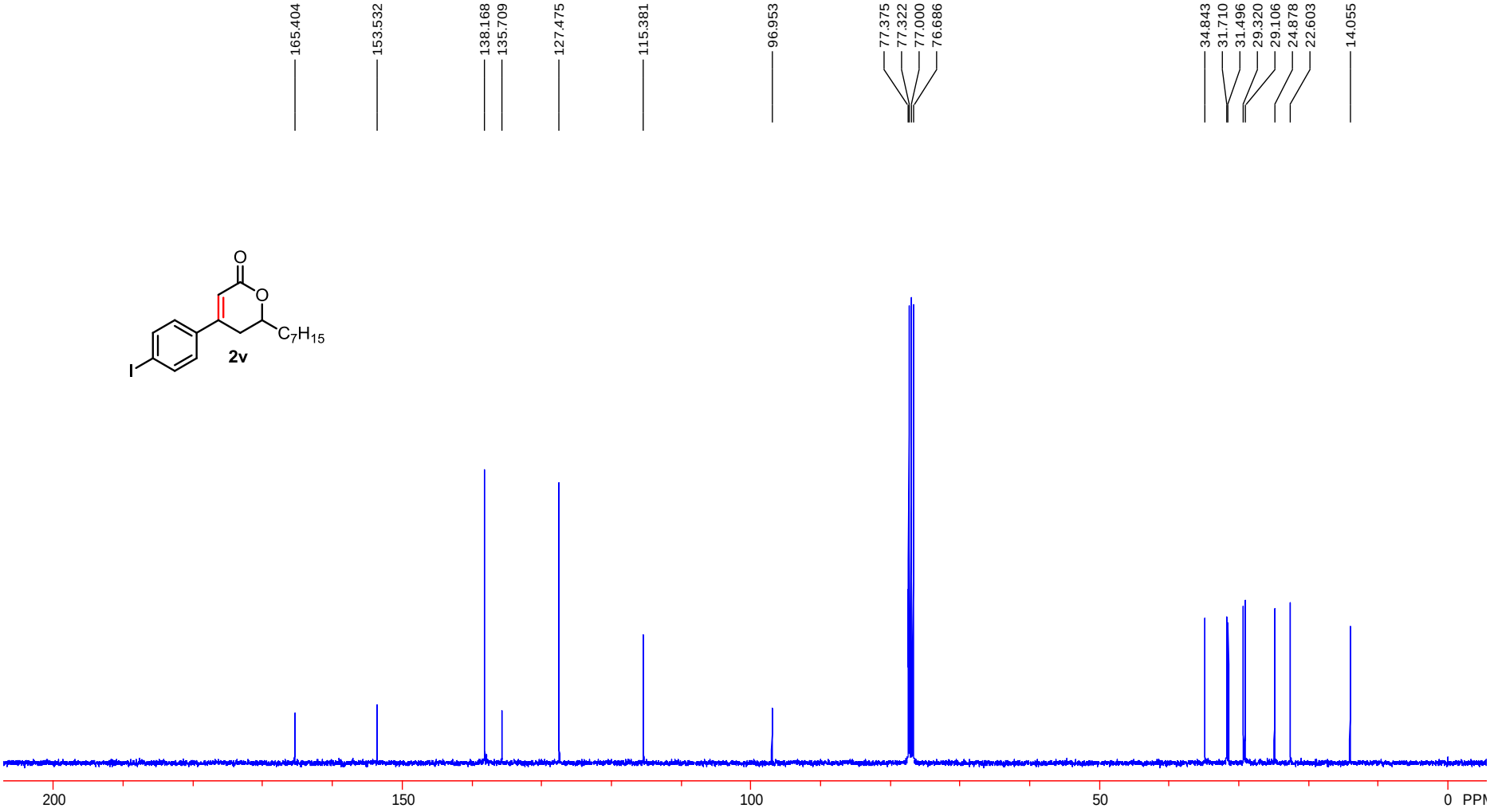
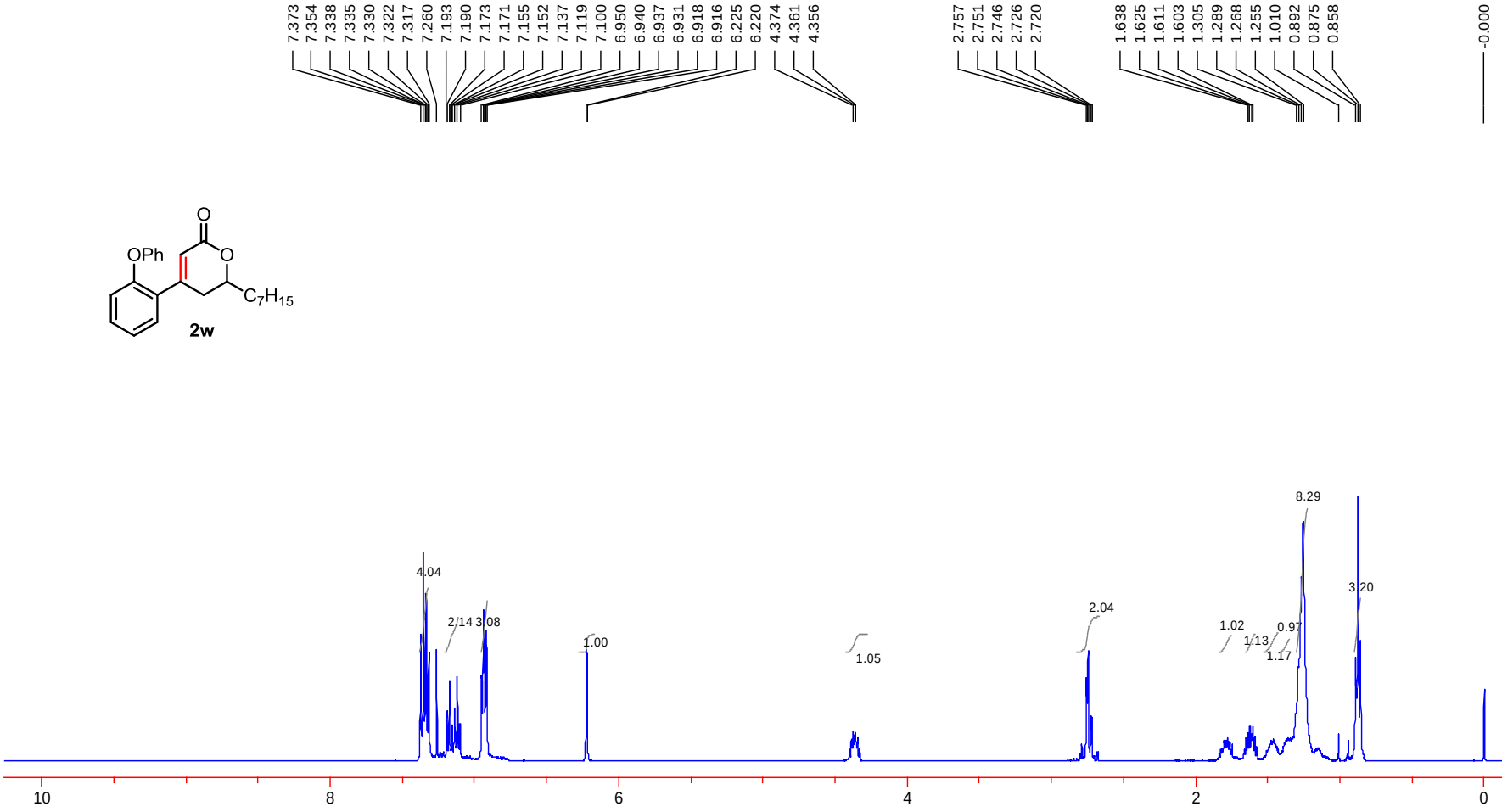


^{1}H NMR (400 MHz, $CDCl_3$)



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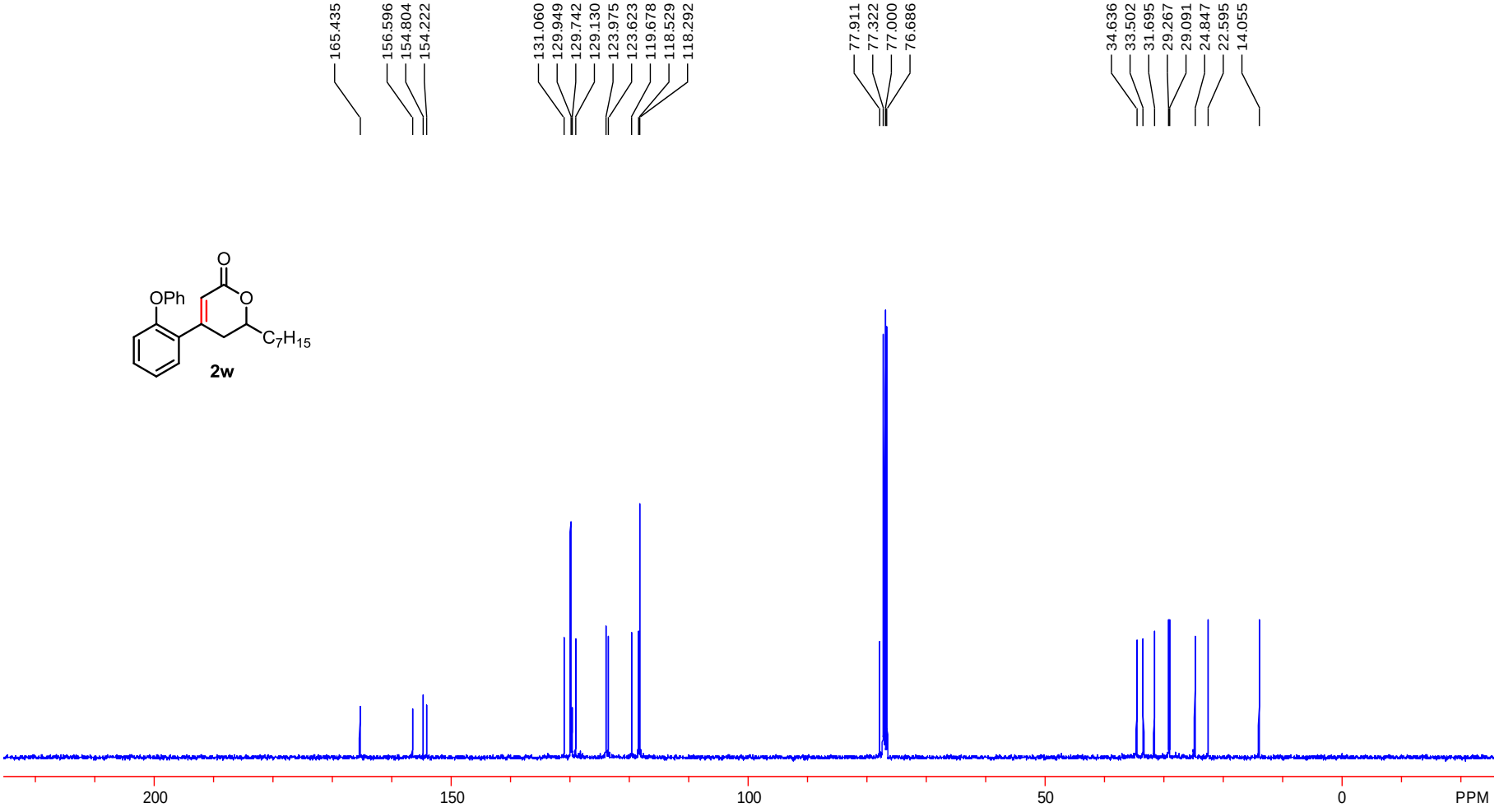

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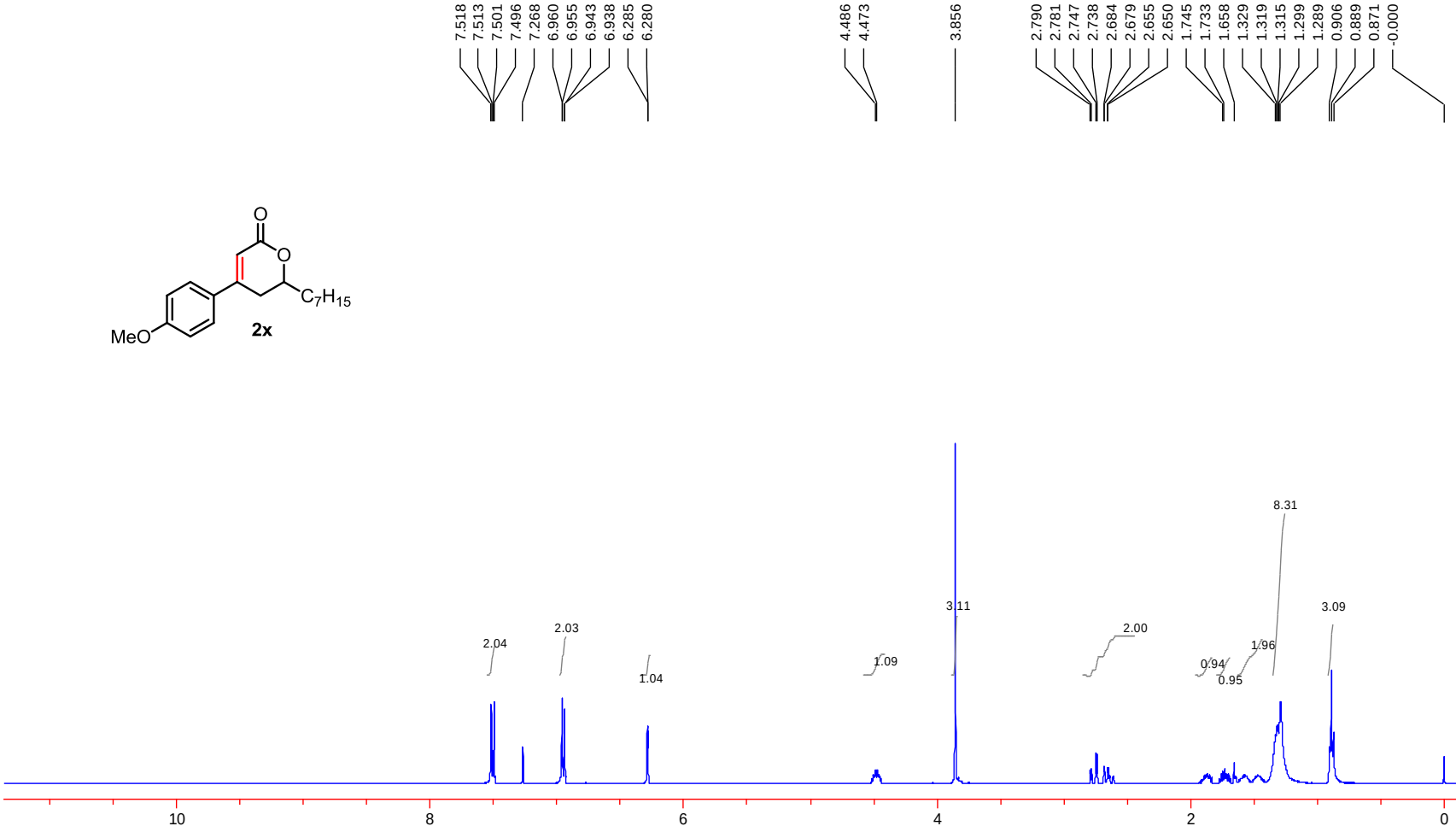

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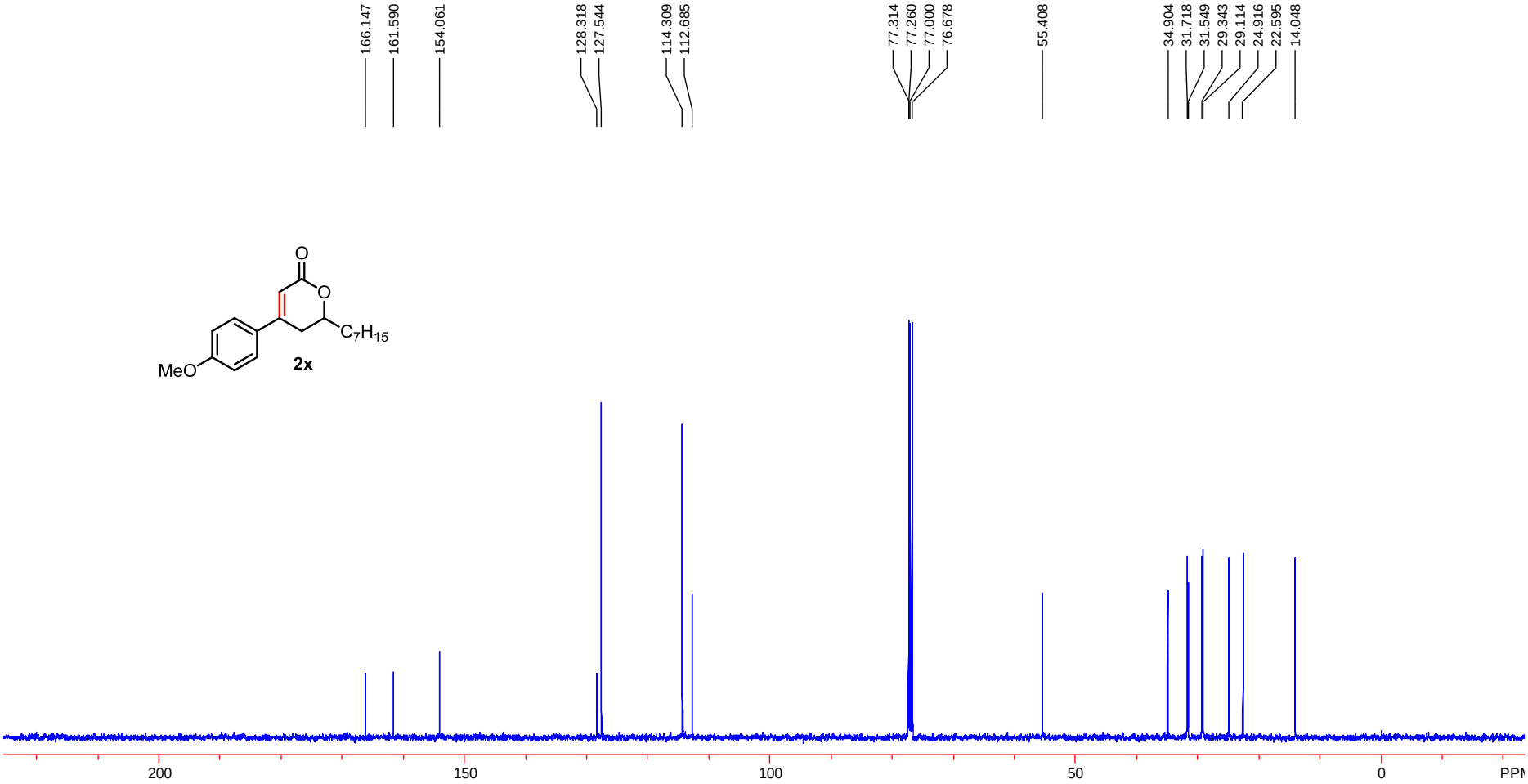

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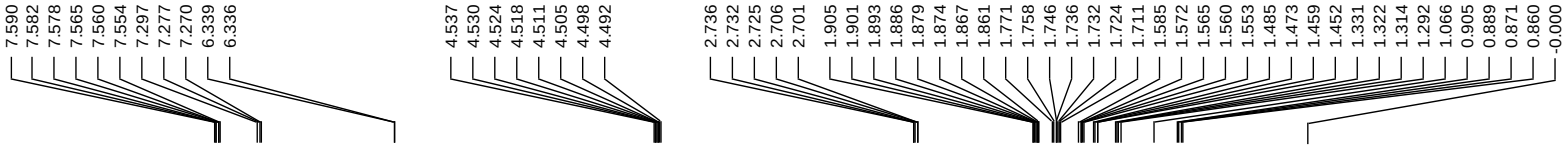

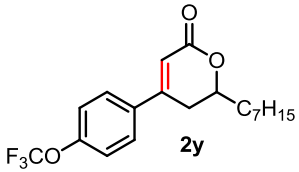

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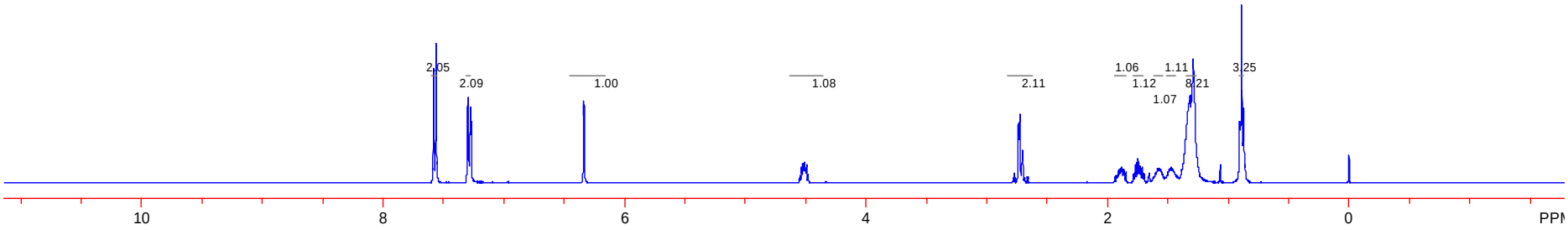
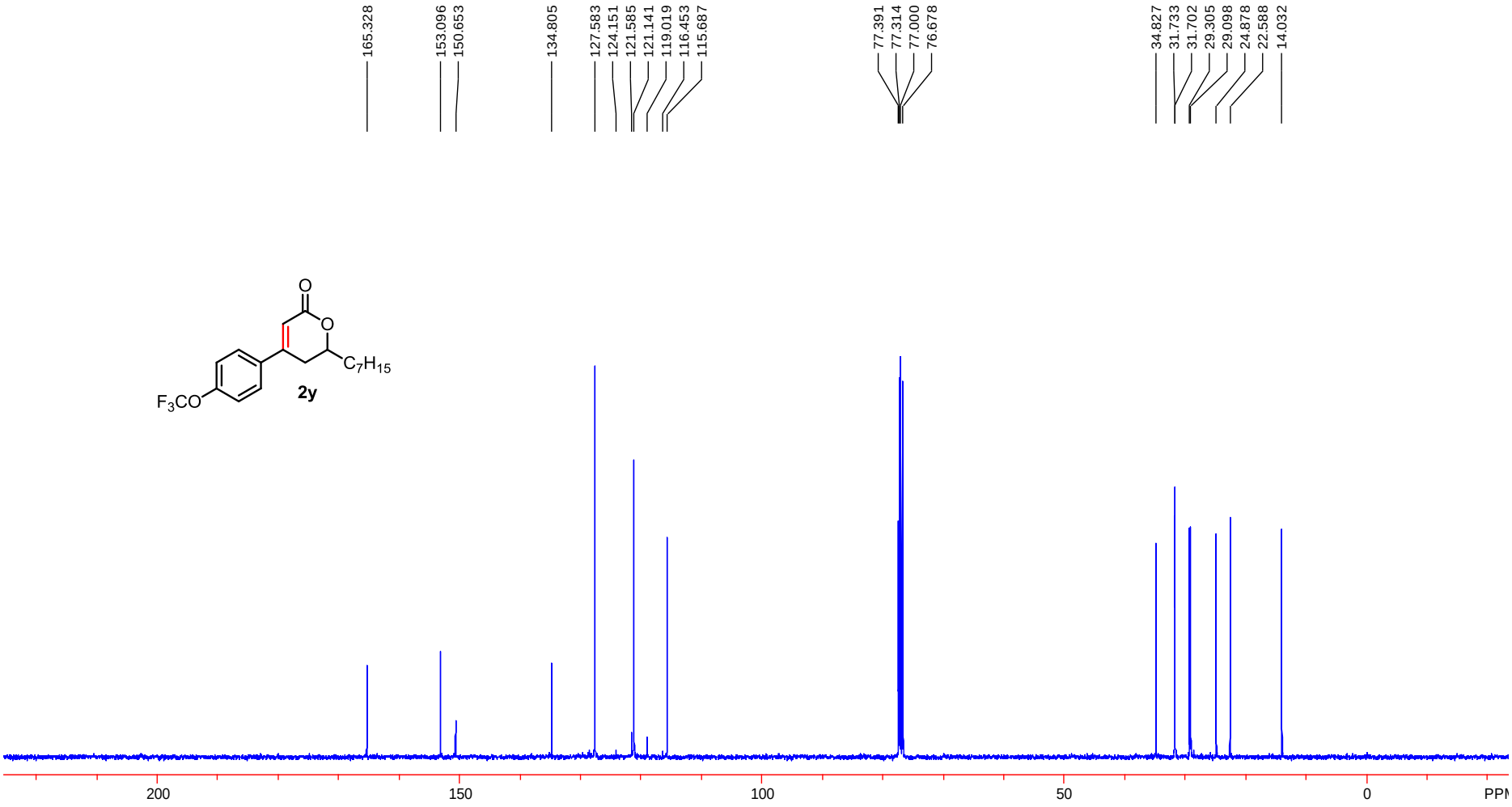
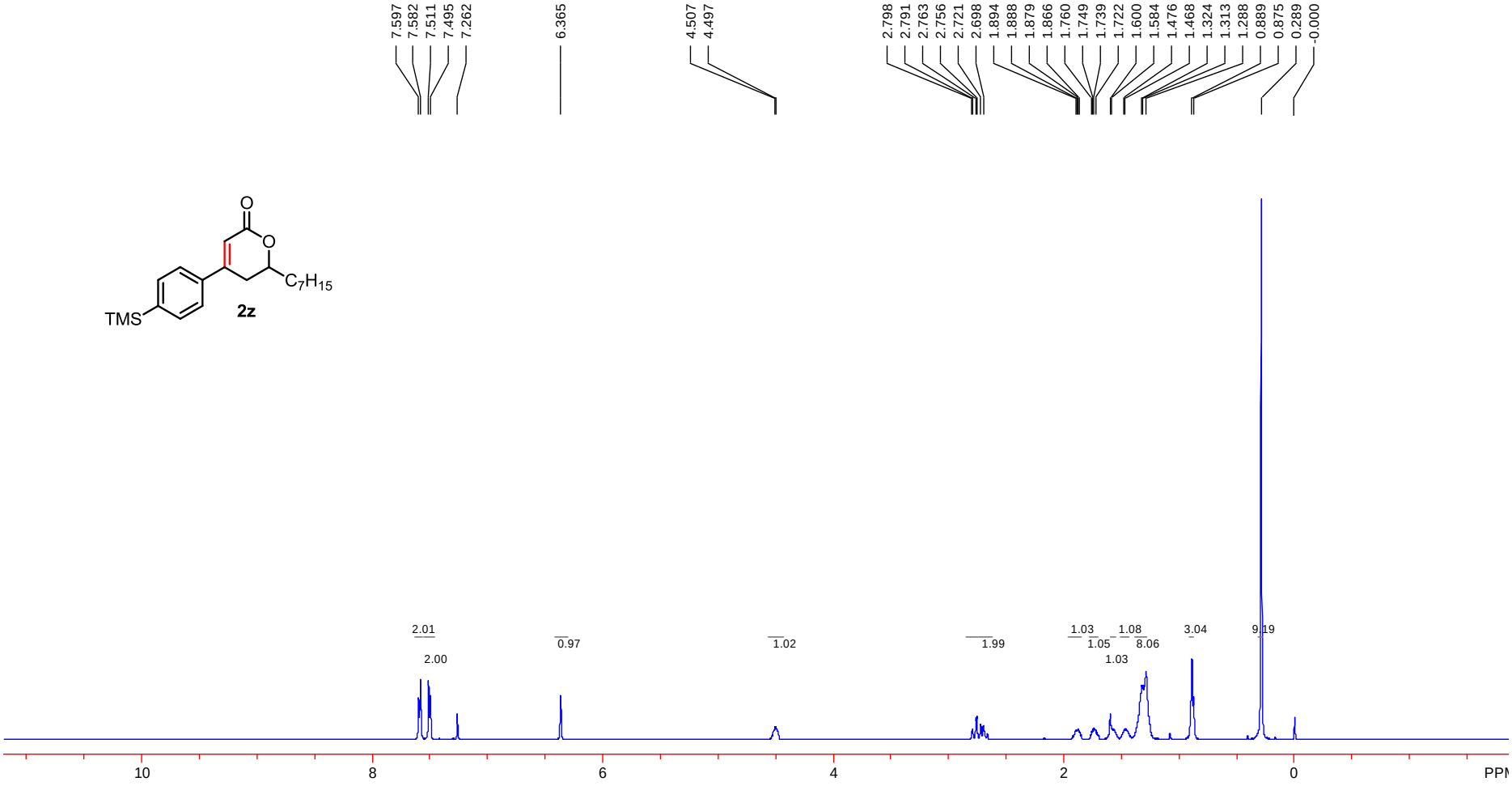


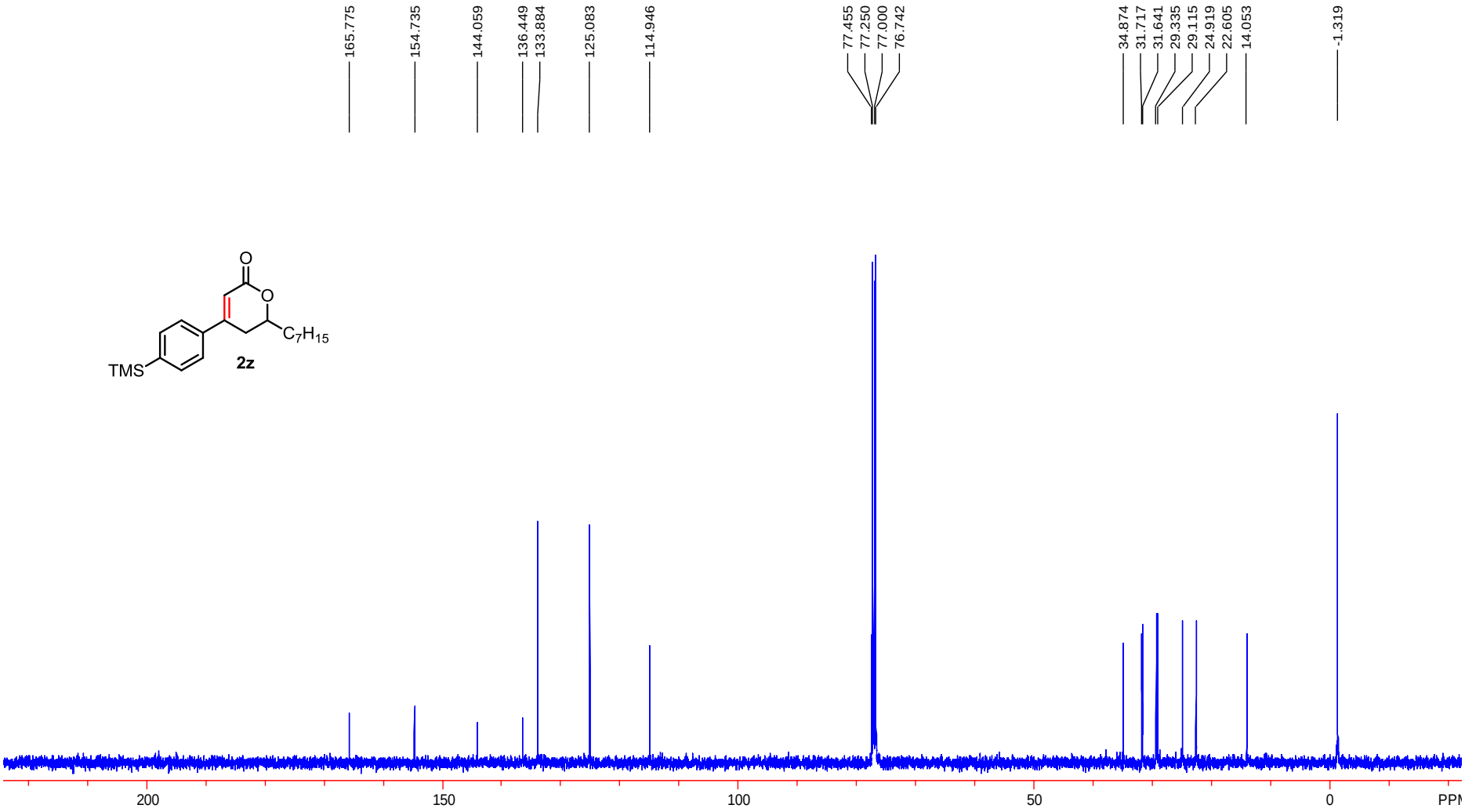
^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$)



^{13}C NMR (125 MHz, $CDCl_3$)



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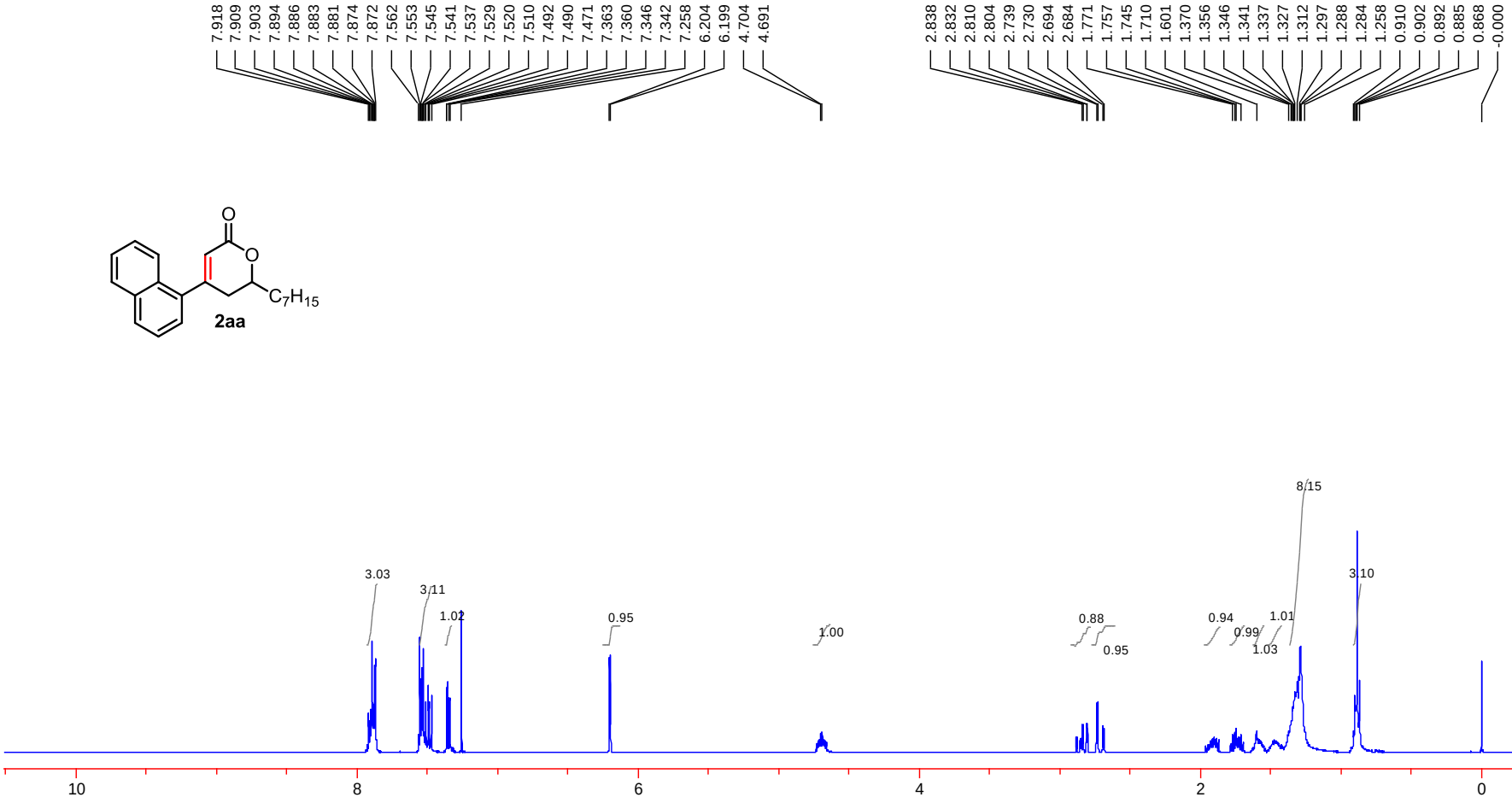

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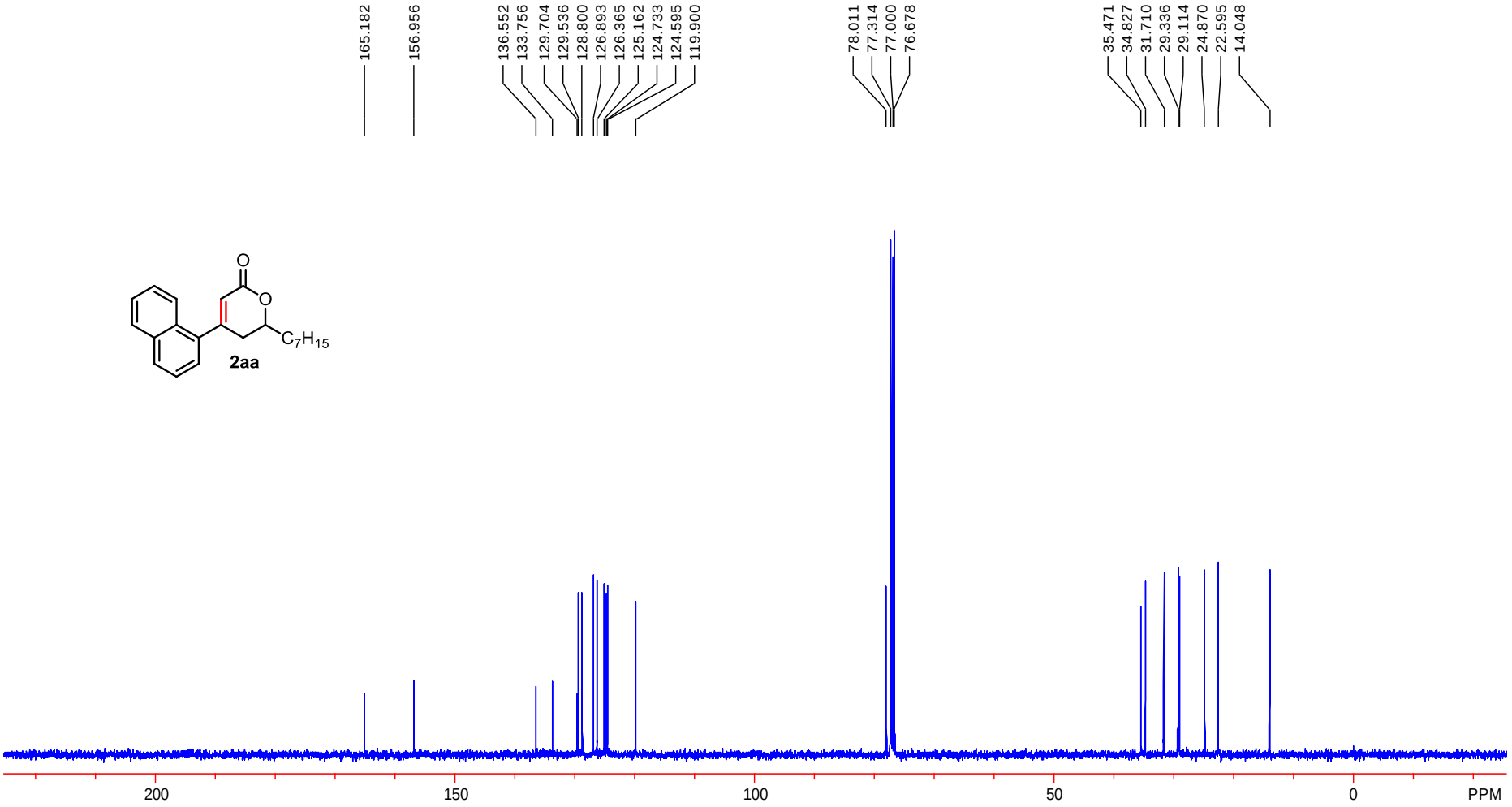

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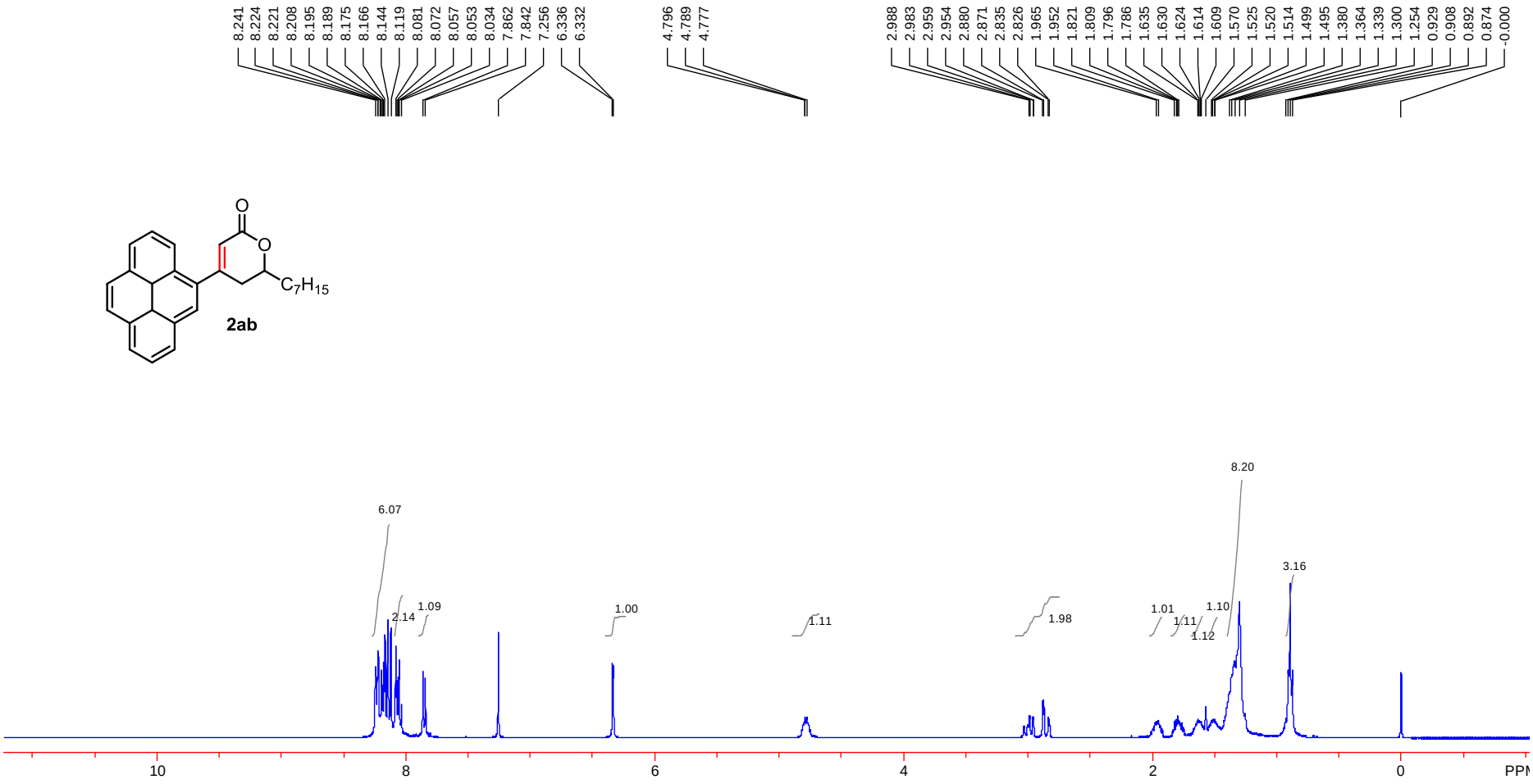

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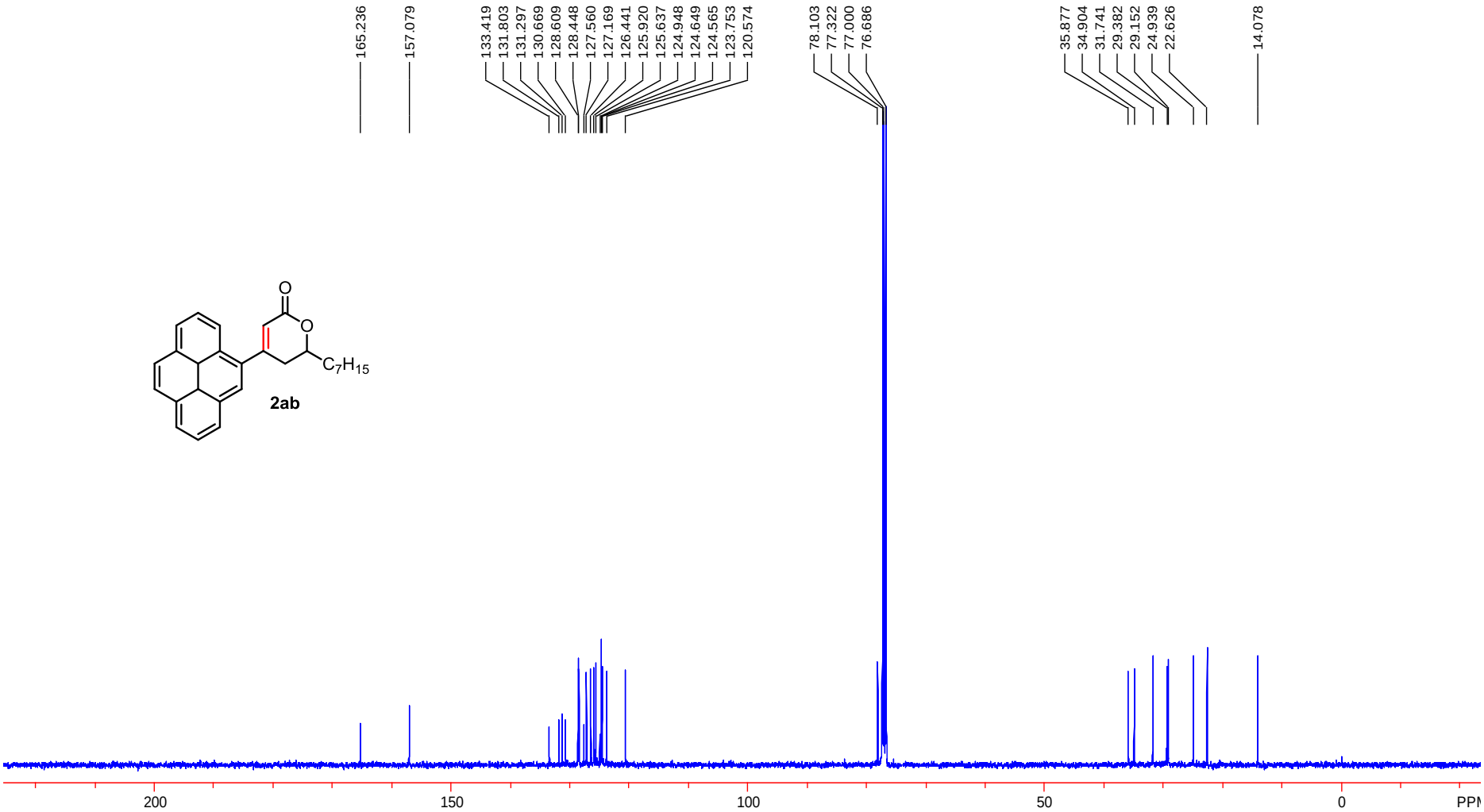

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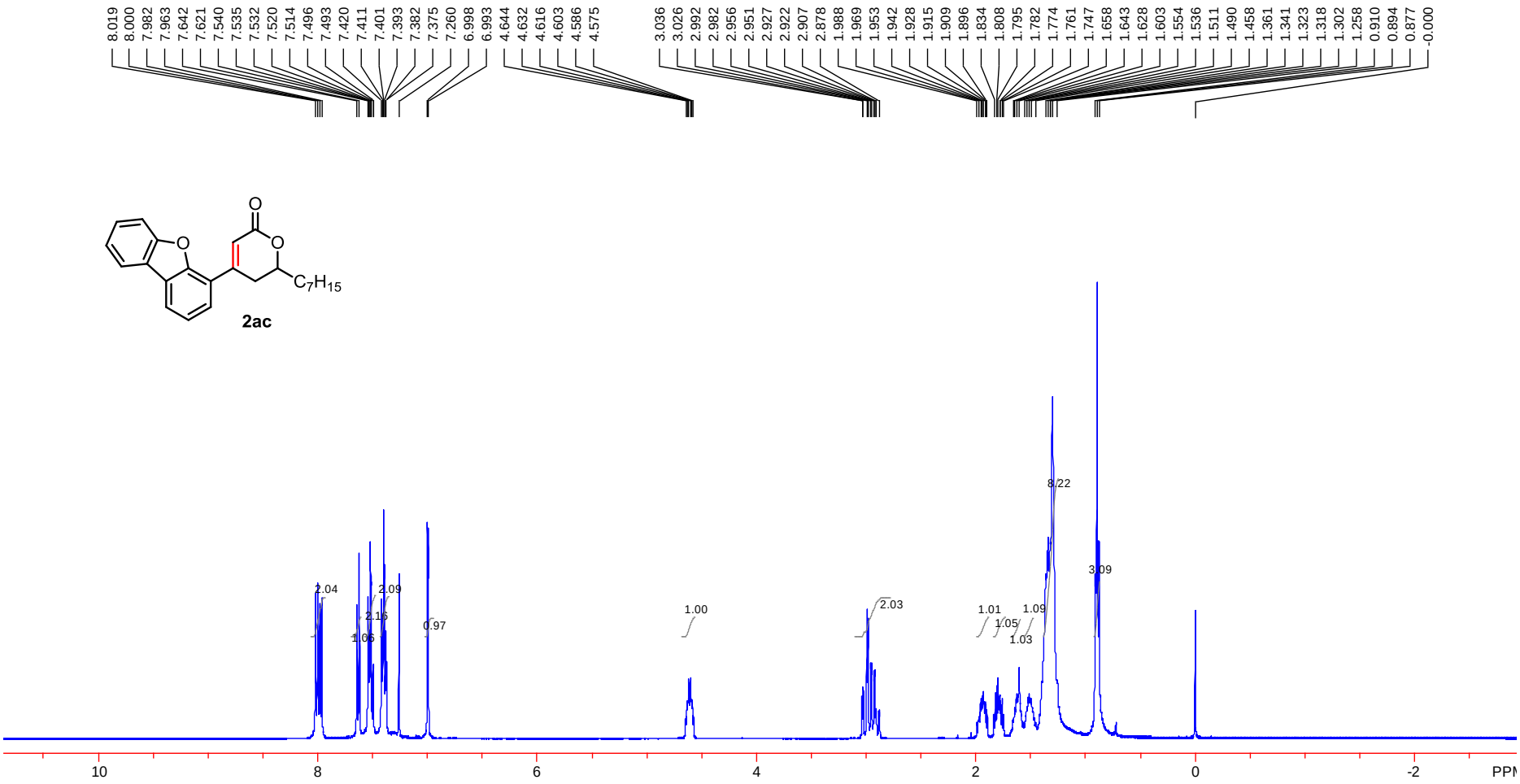
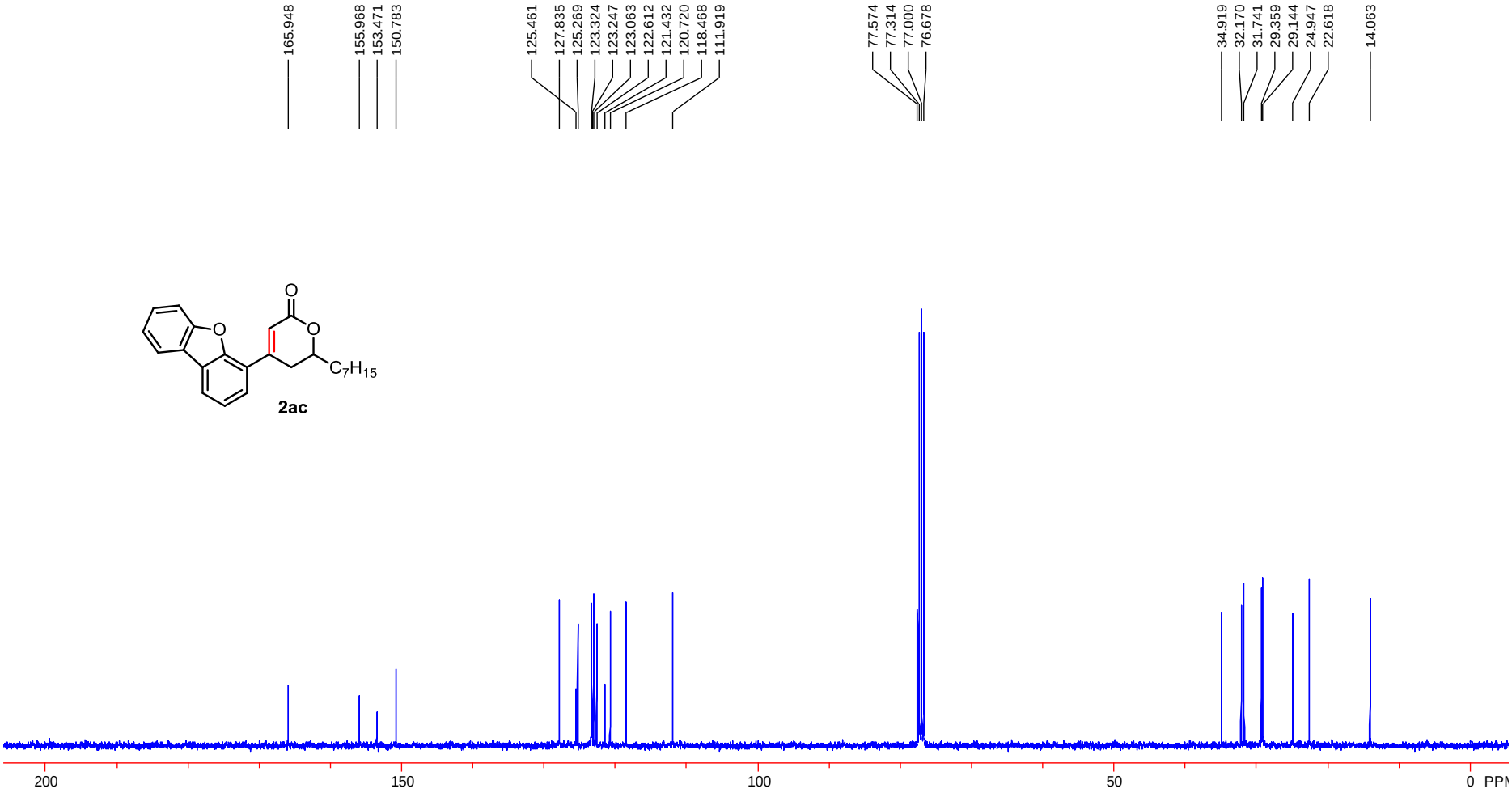


^{13}C NMR (101 MHz, $CDCl_3$)



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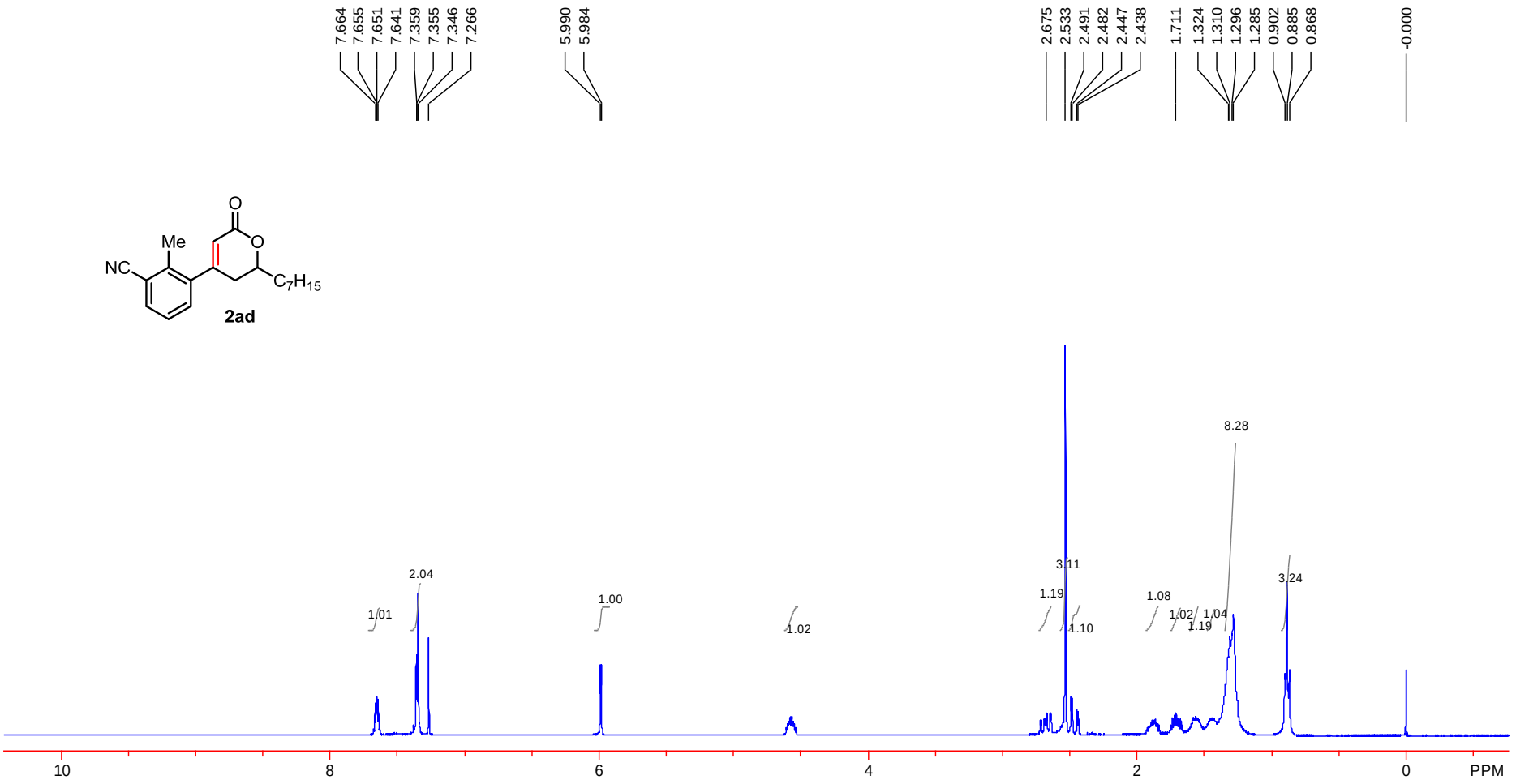

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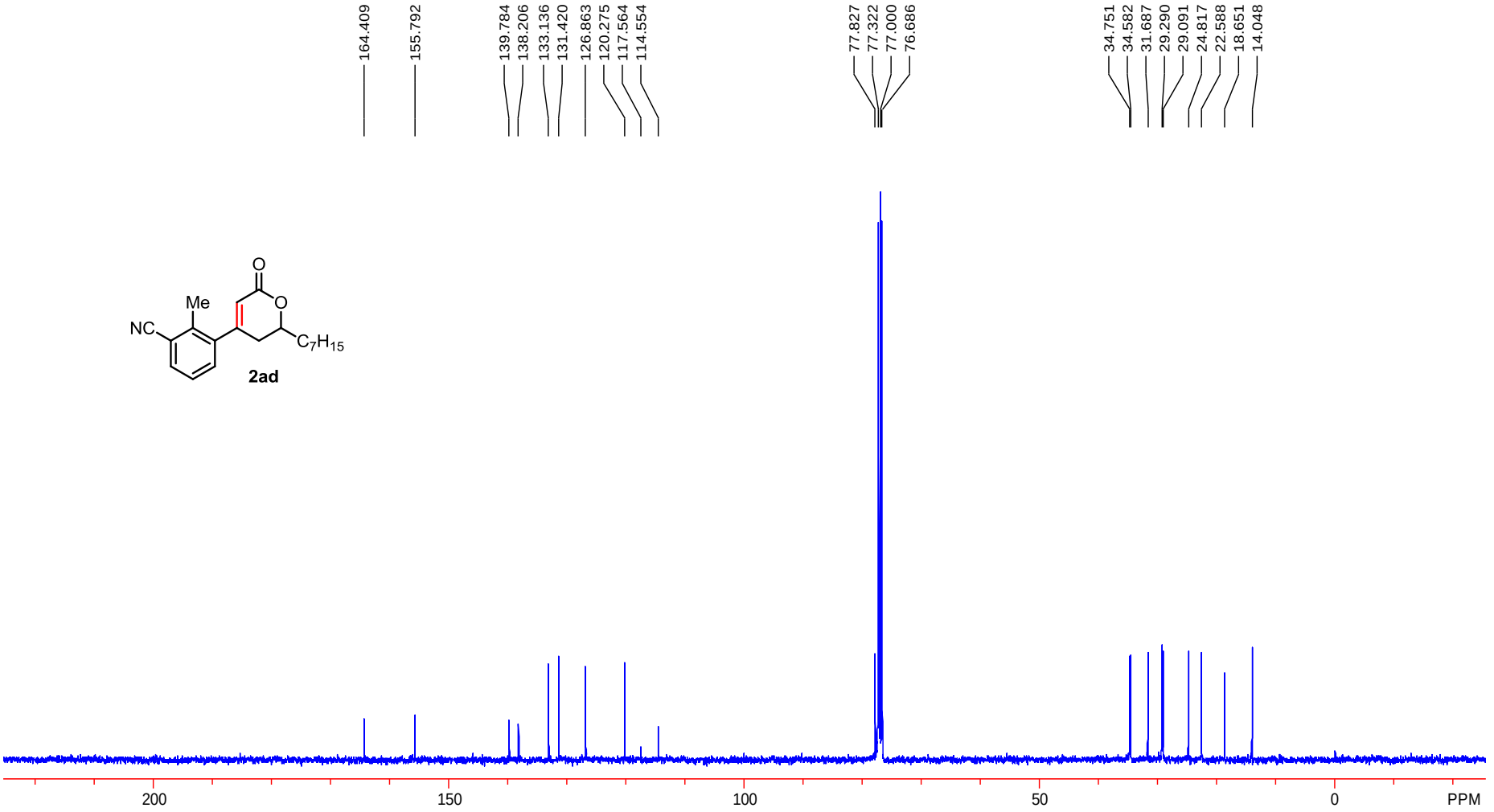

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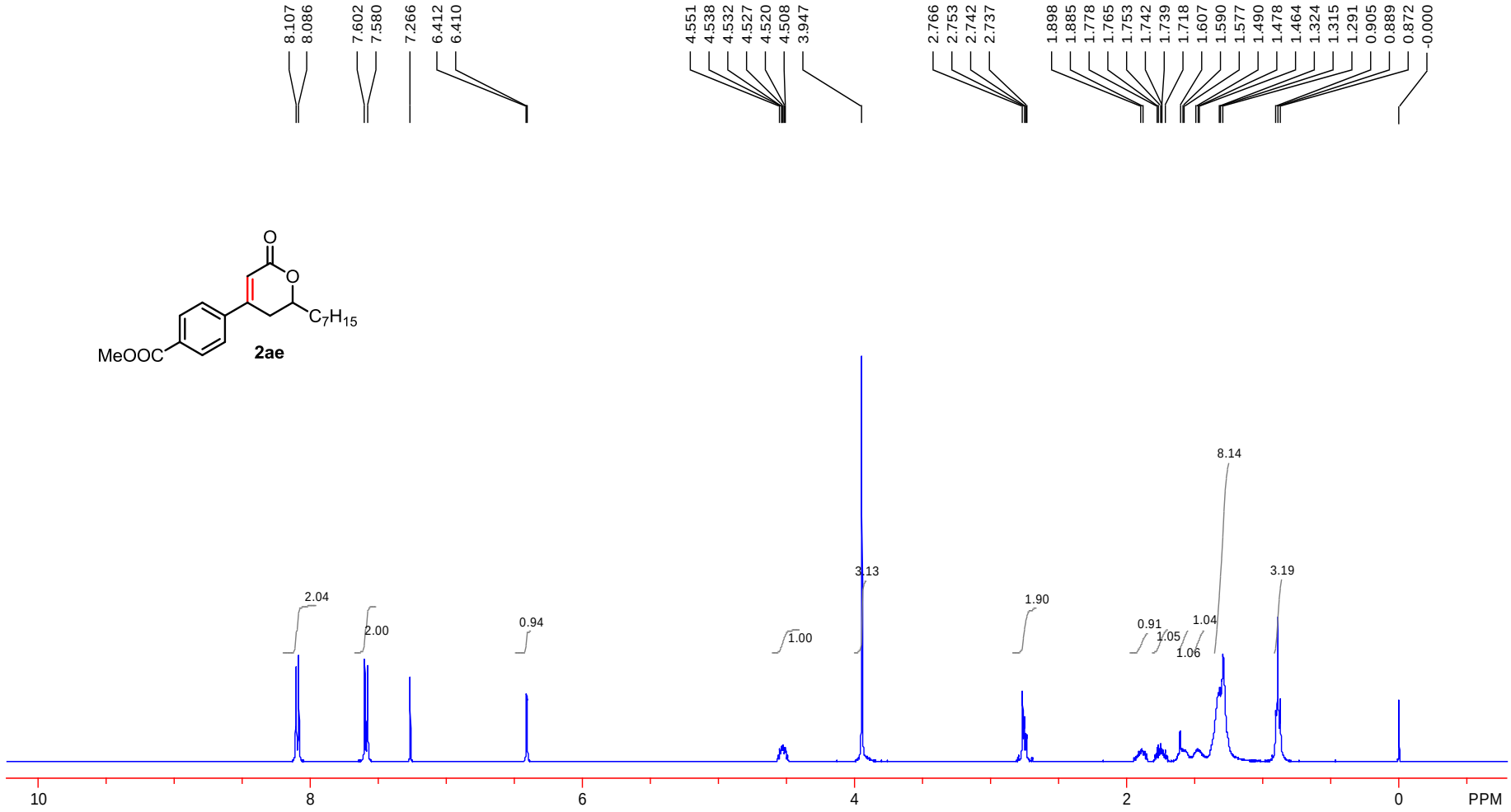

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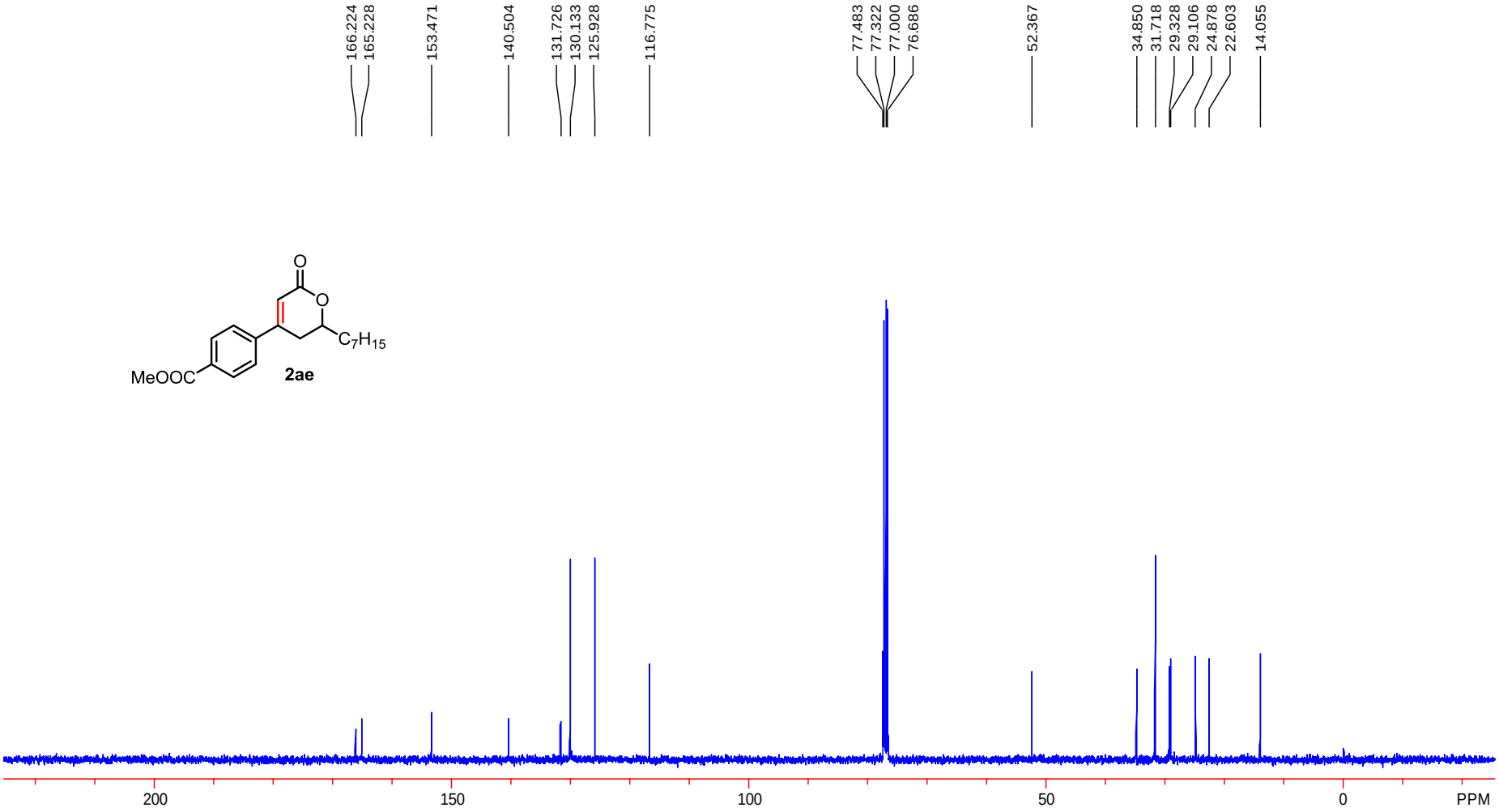

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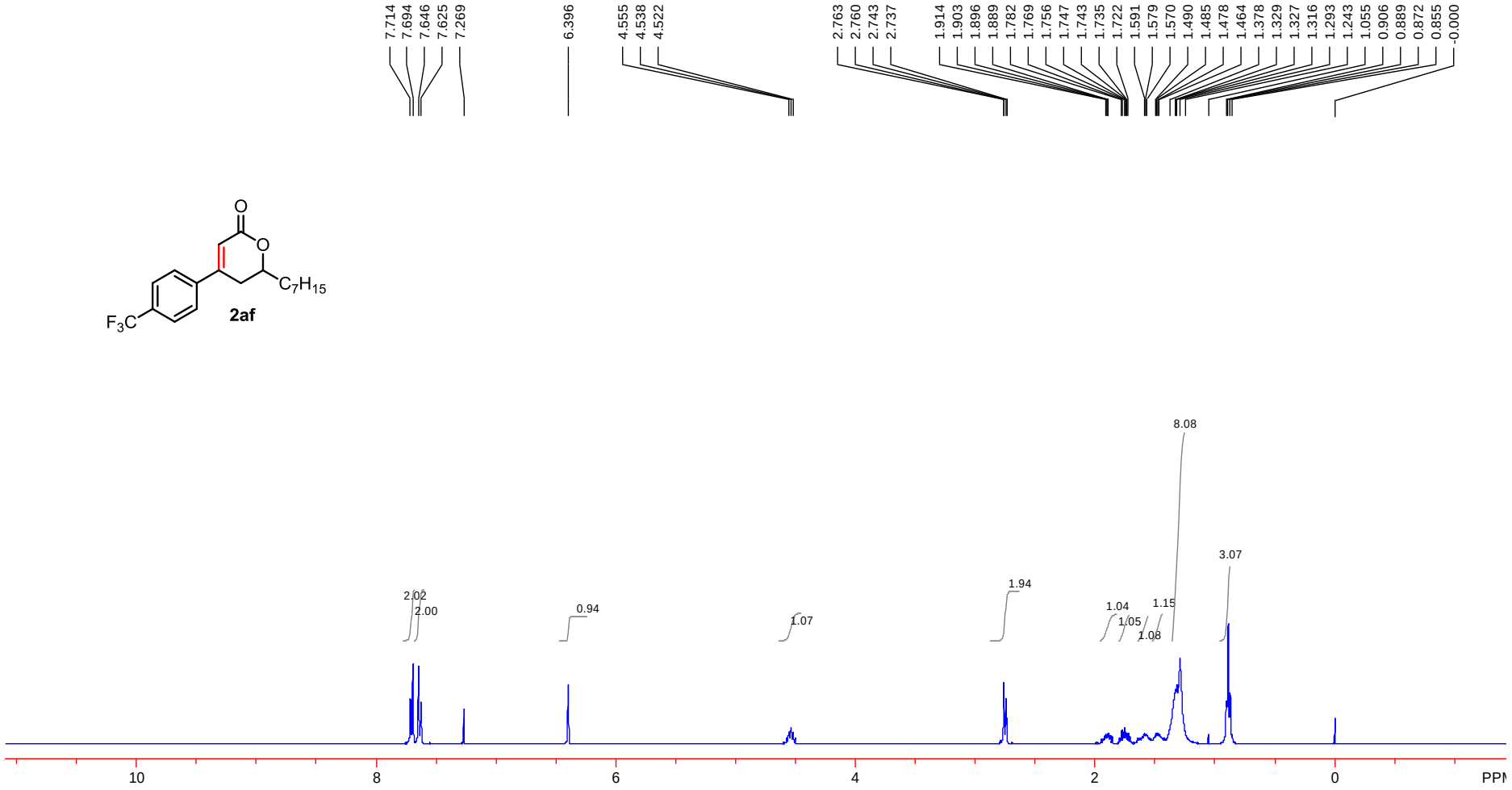

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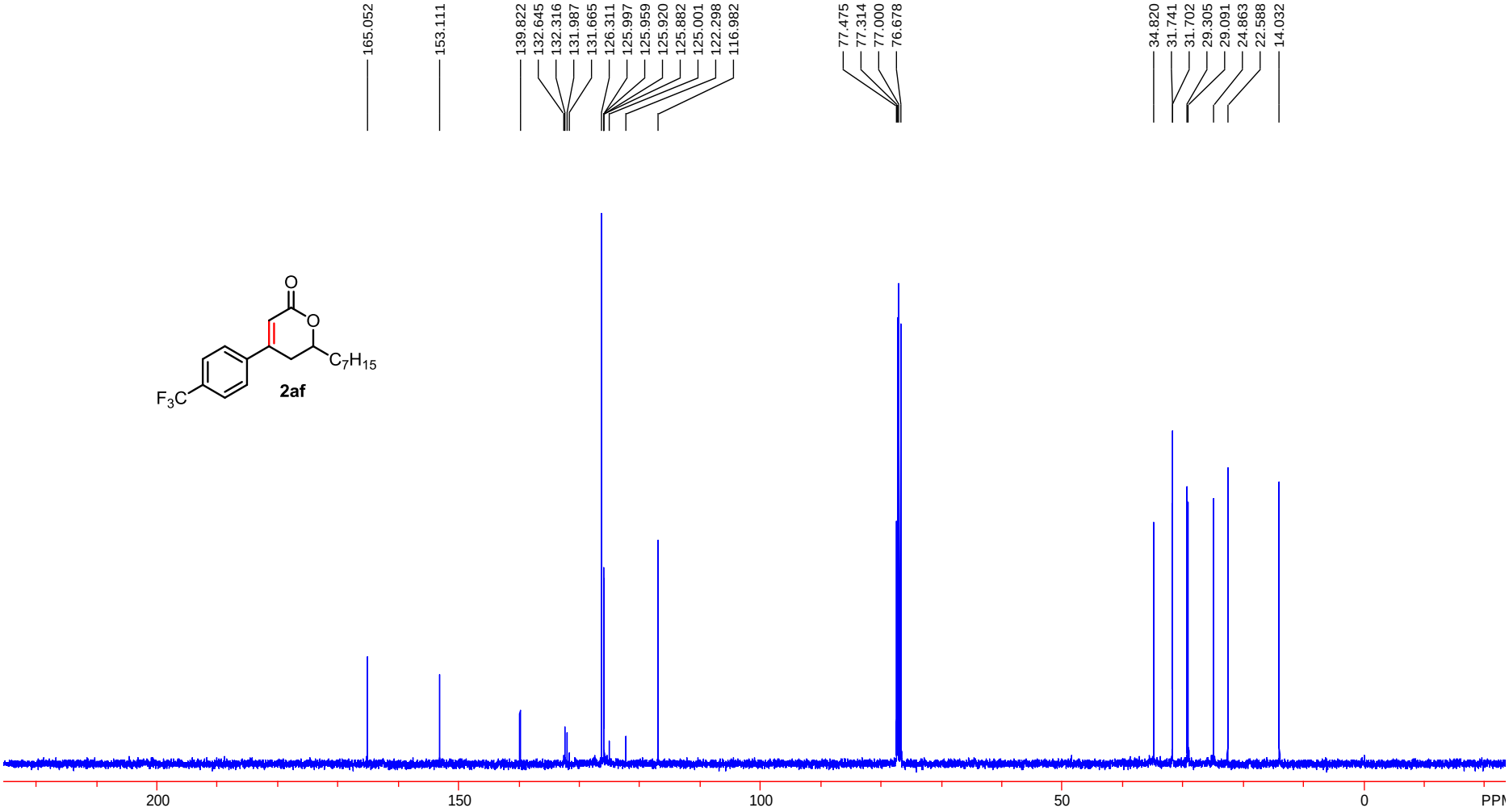

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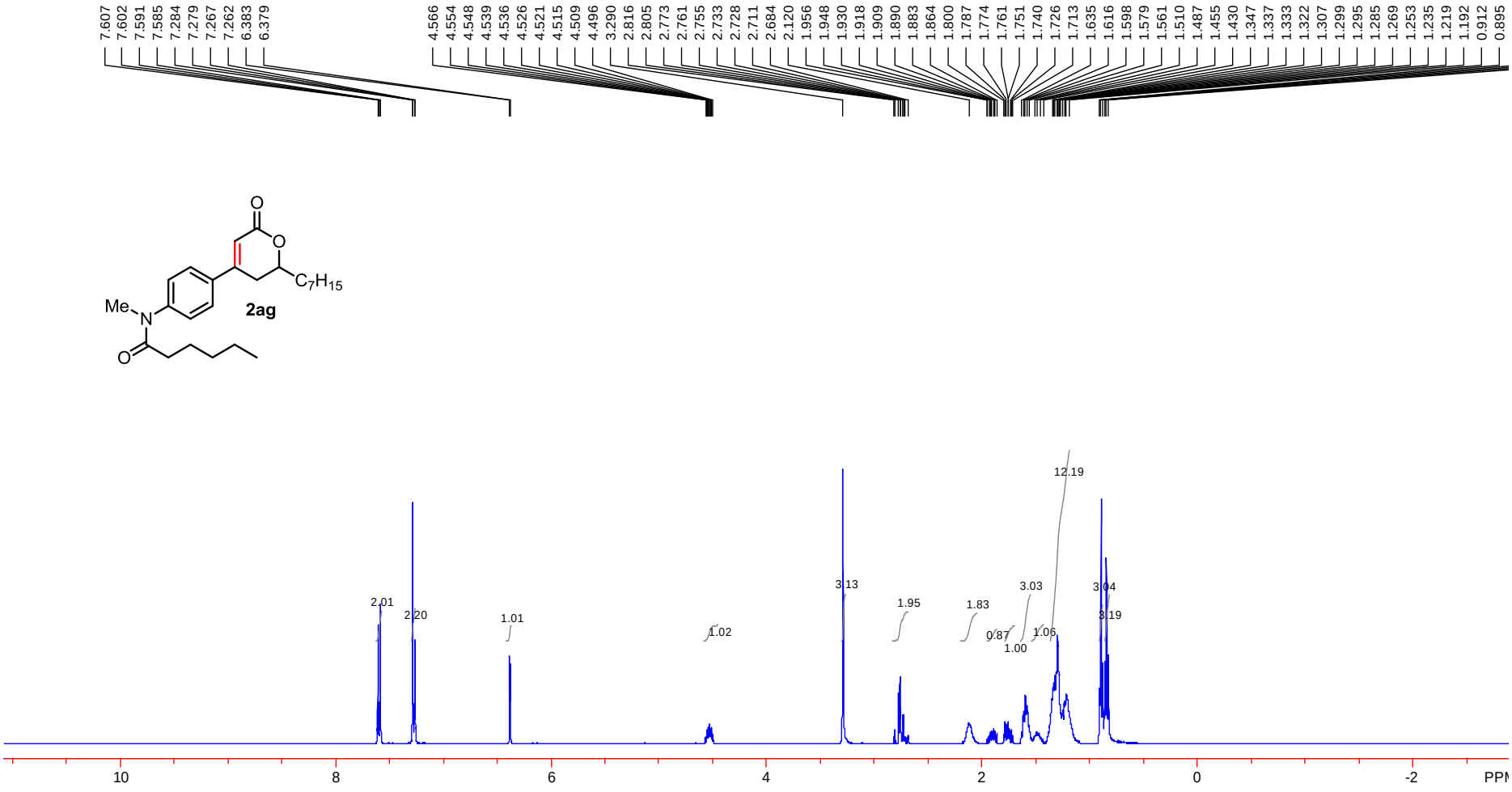

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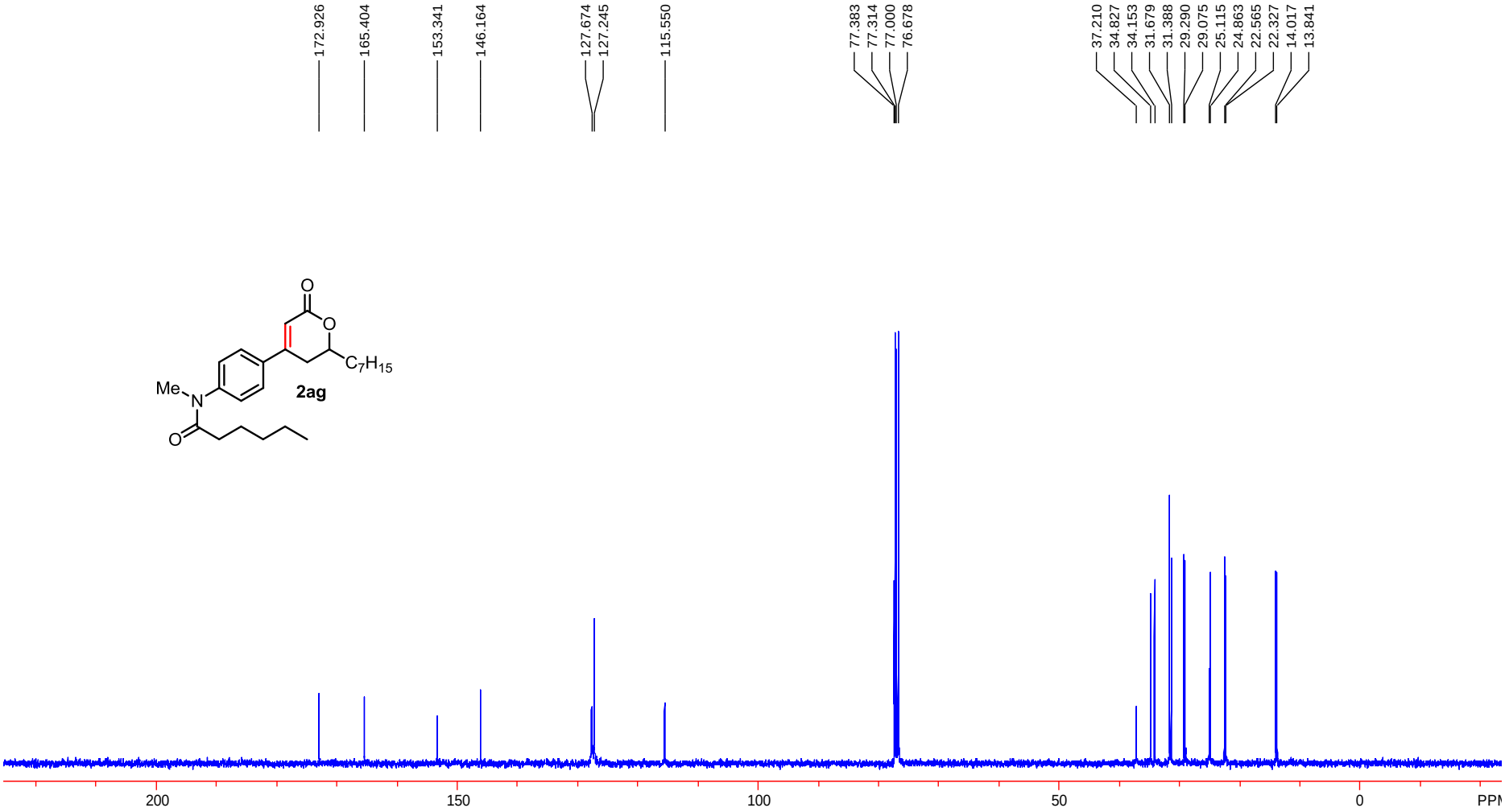

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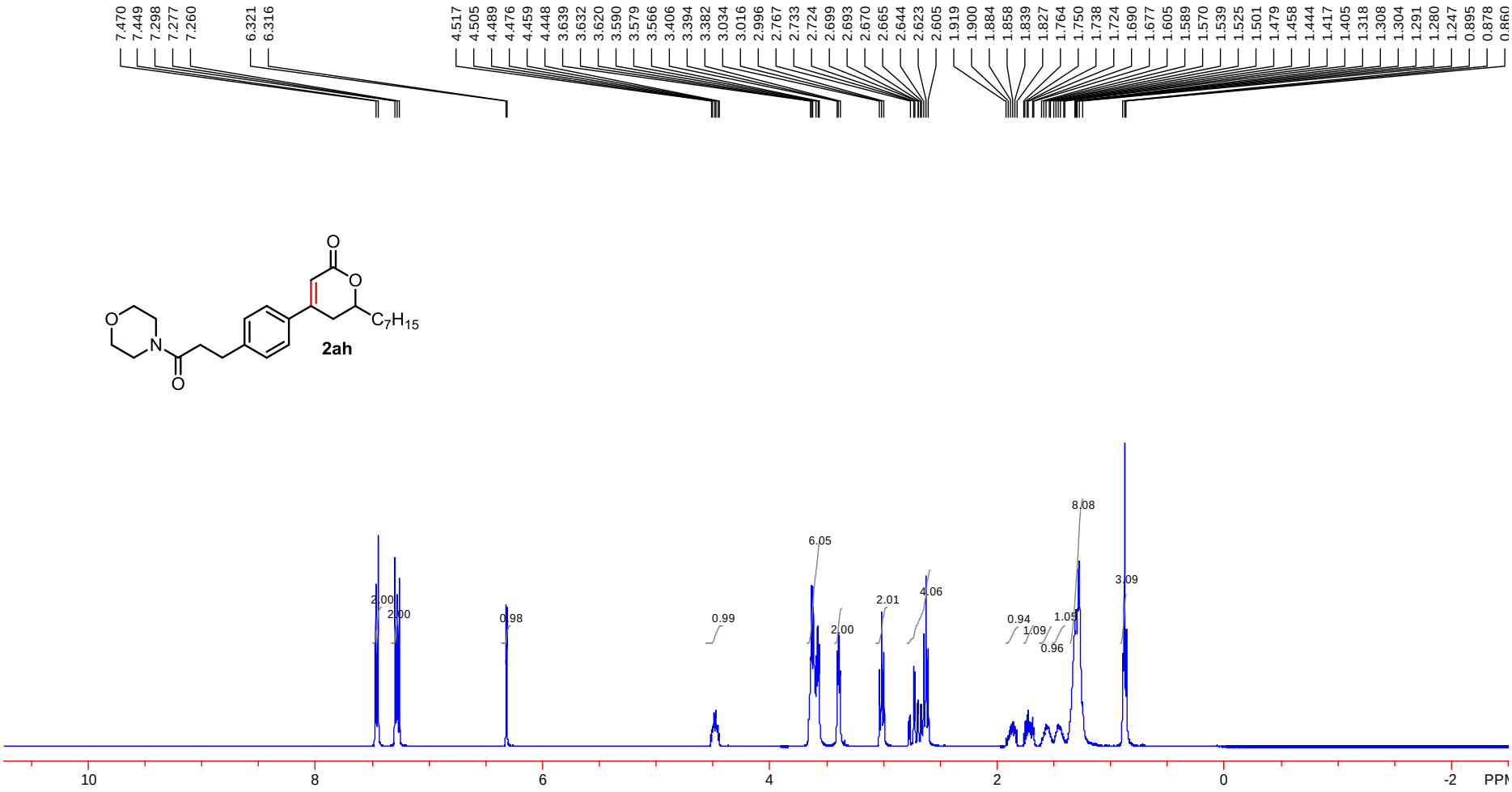

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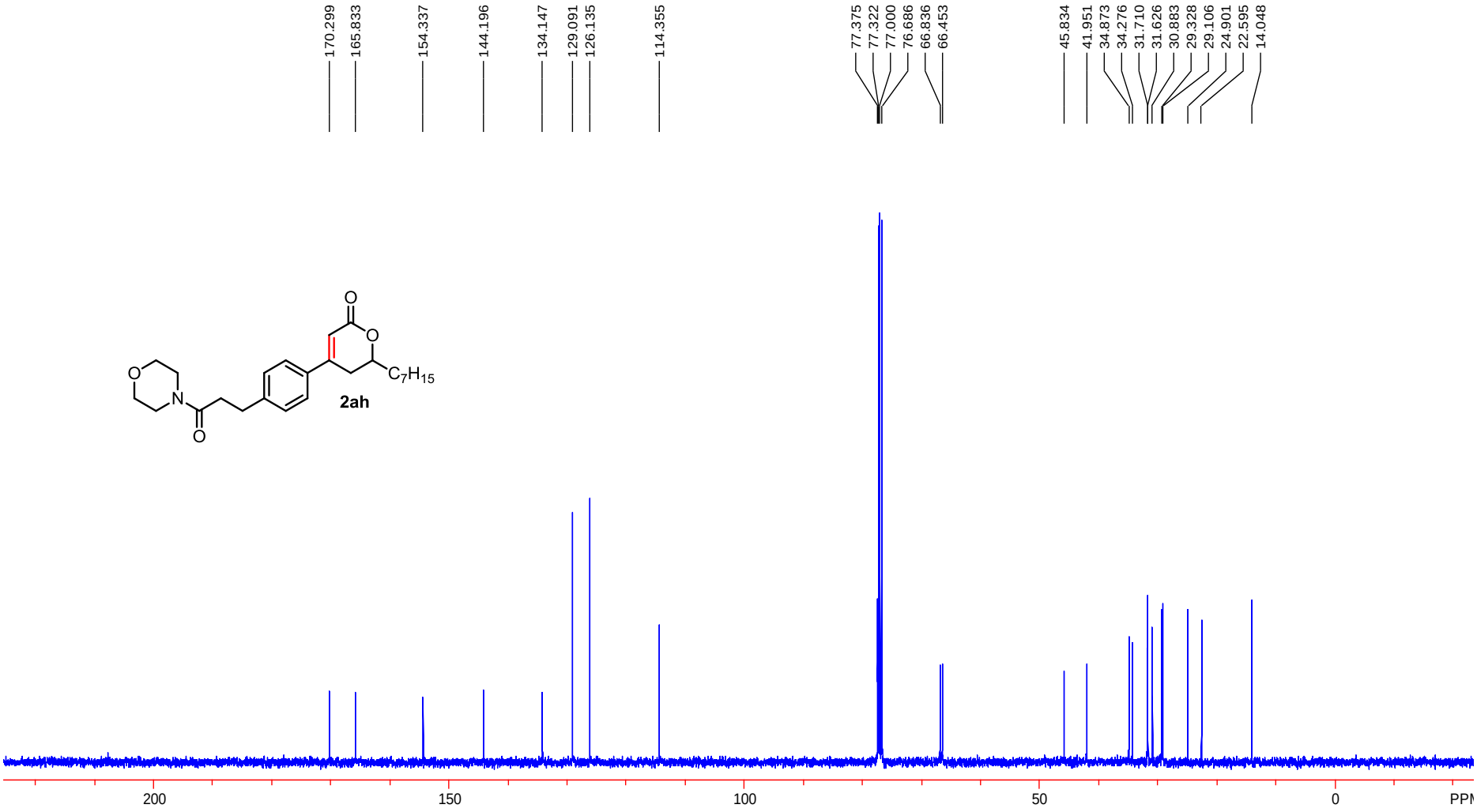
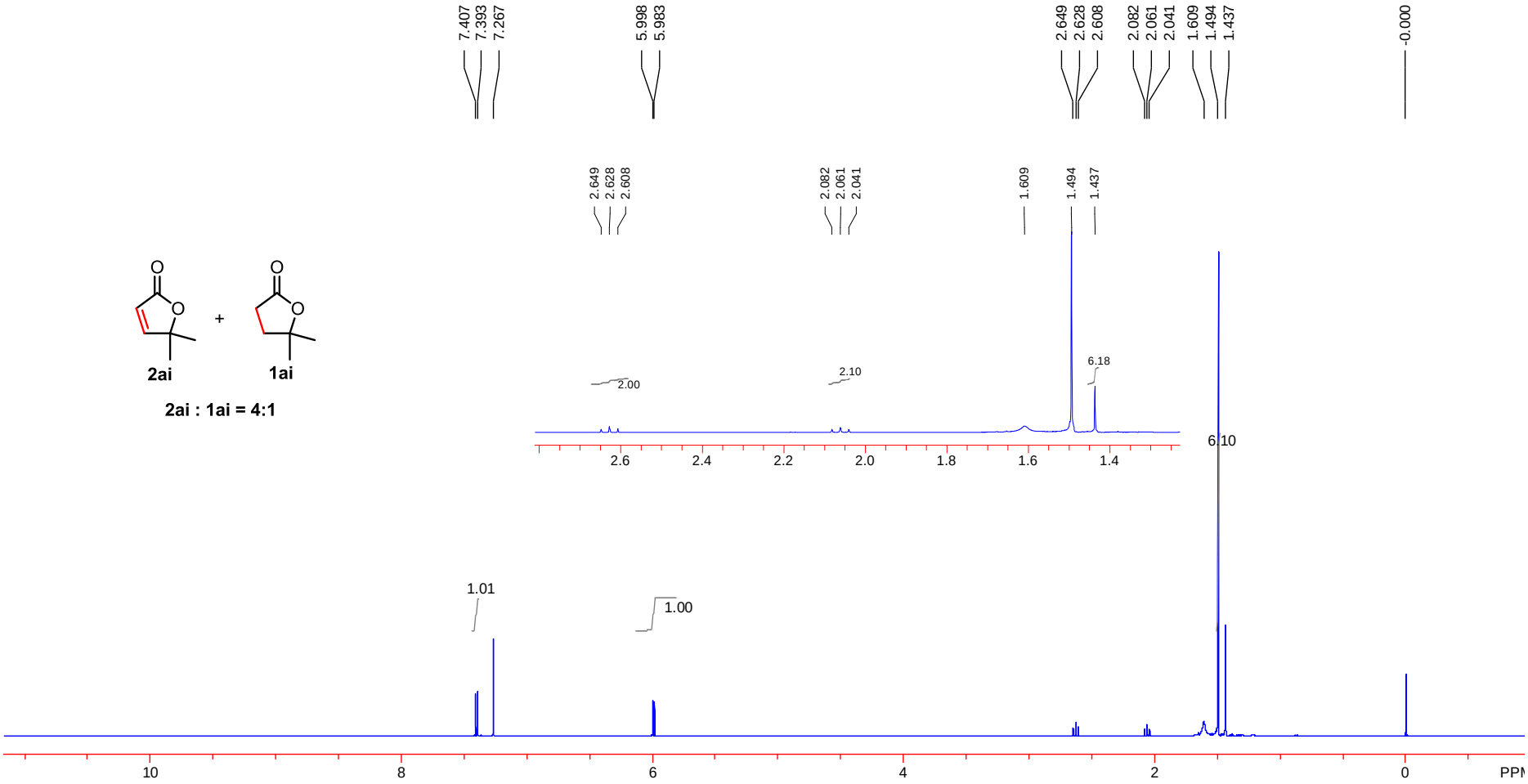


^{1}H NMR (400 MHz, $CDCl_3$)



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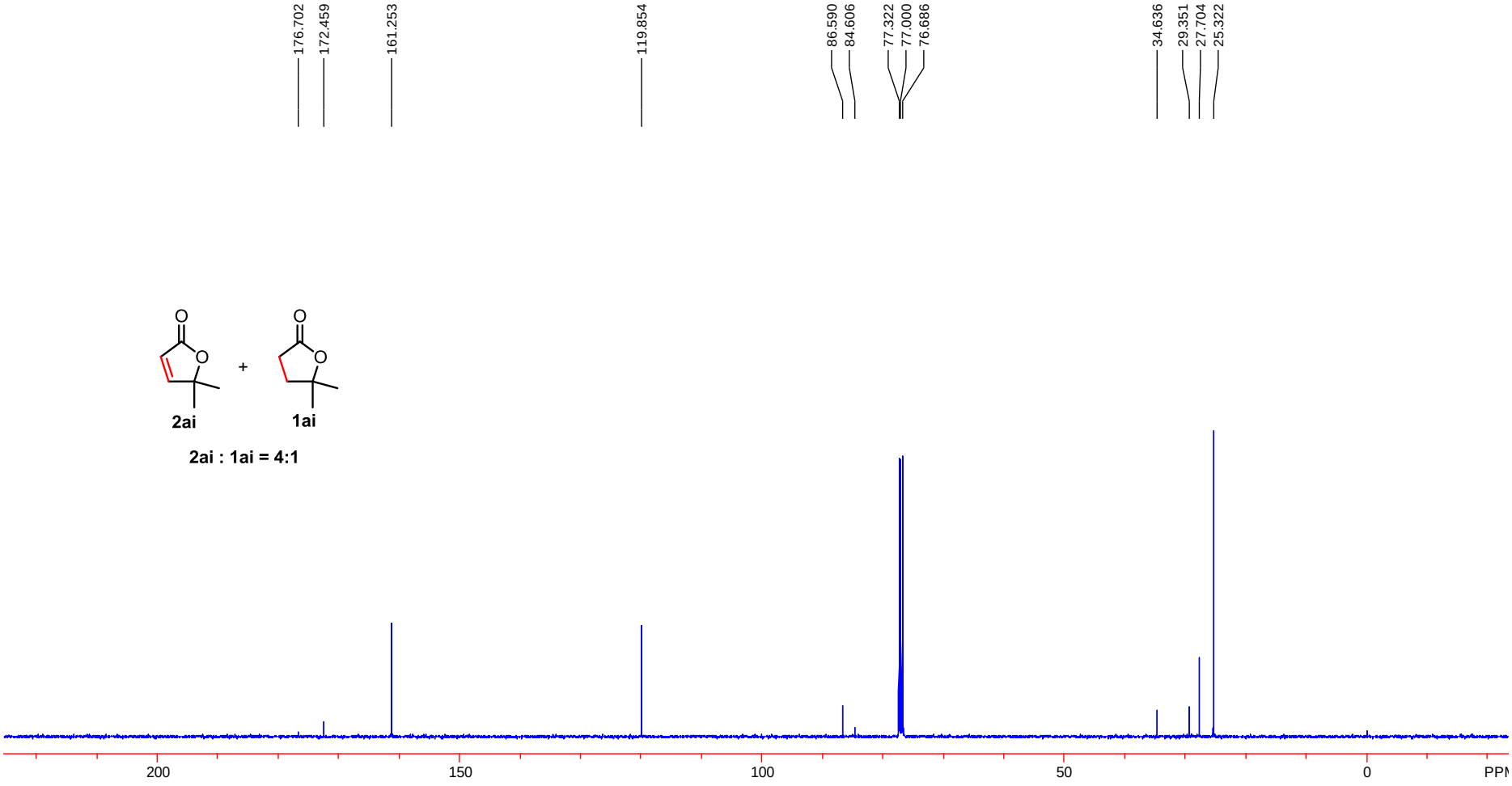

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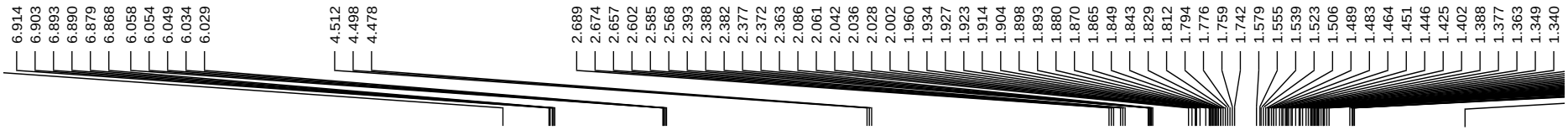

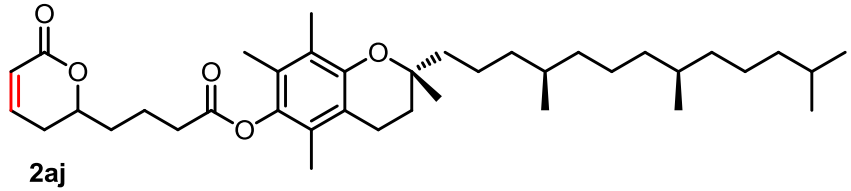

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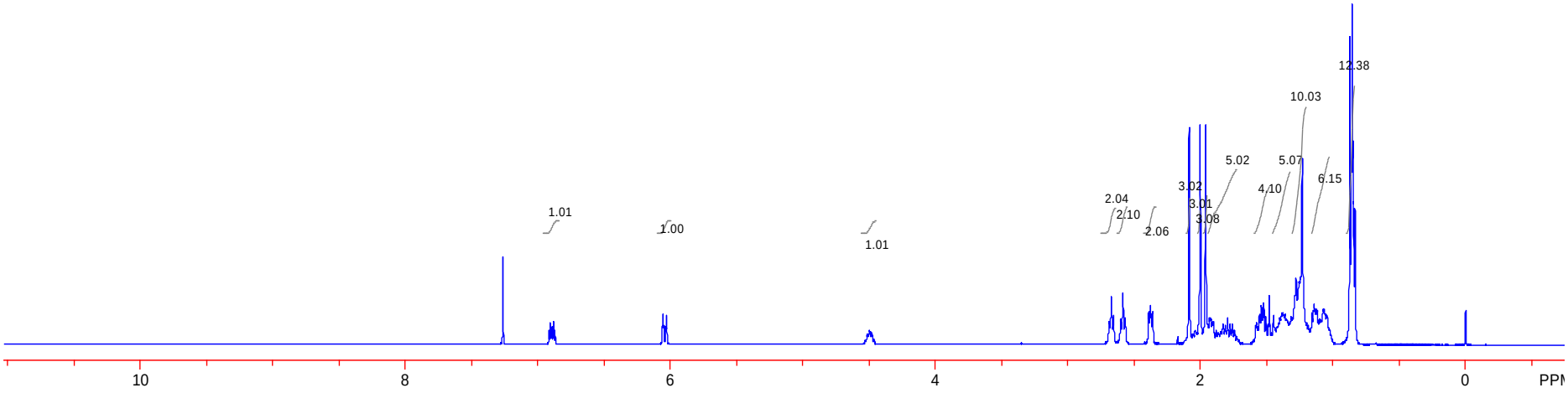
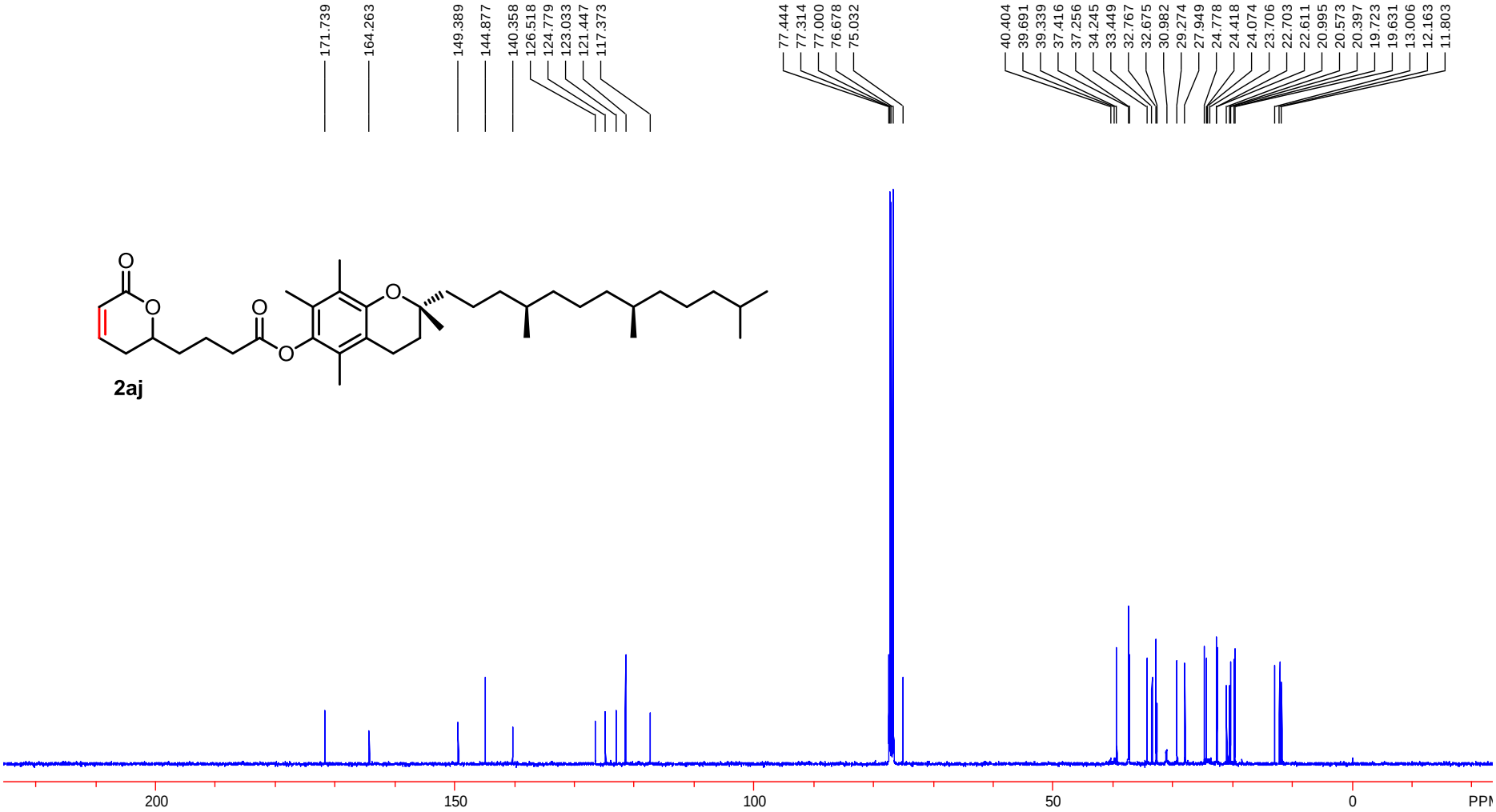


^{13}C NMR (101 MHz, $CDCl_3$)



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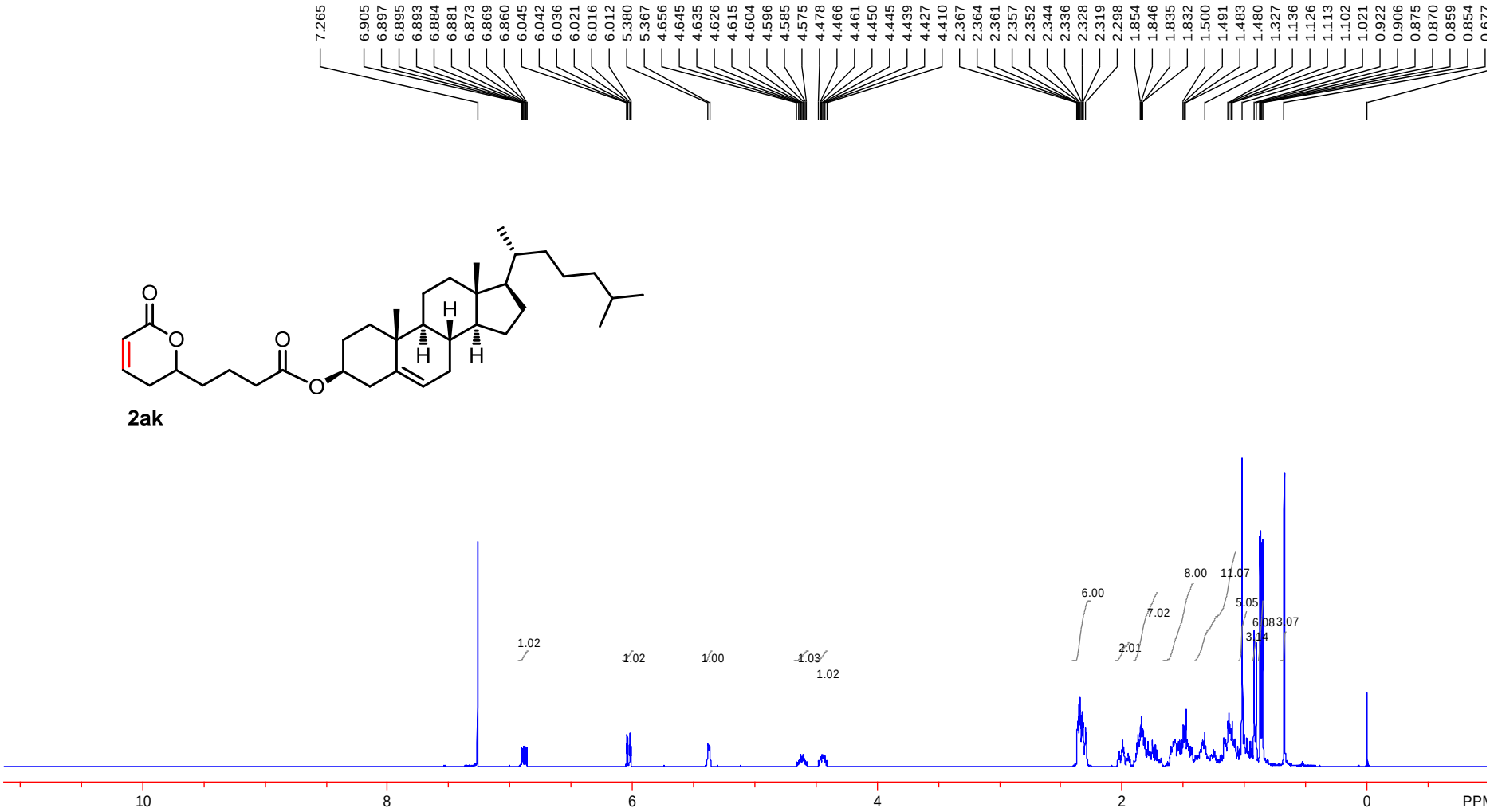

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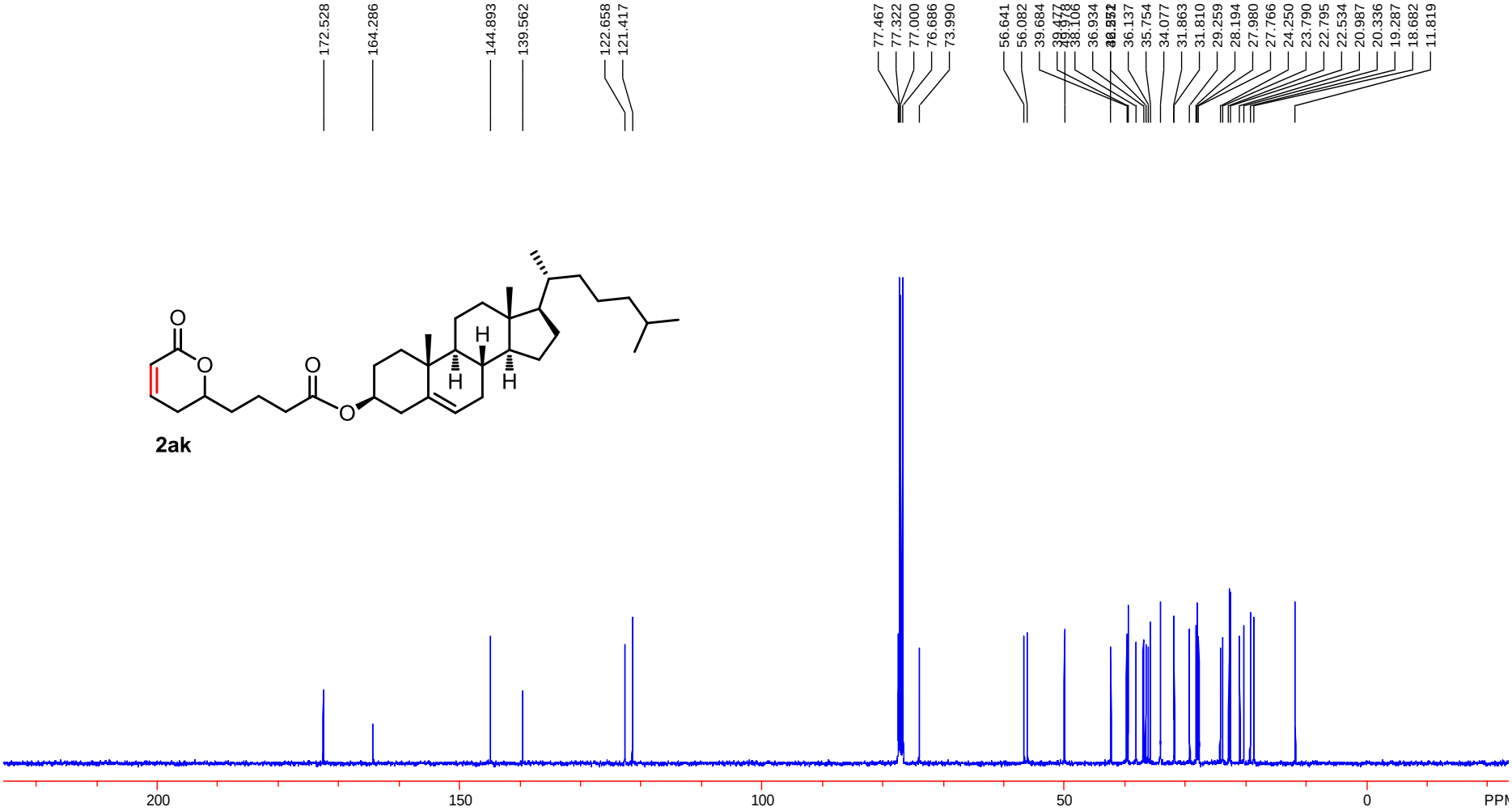

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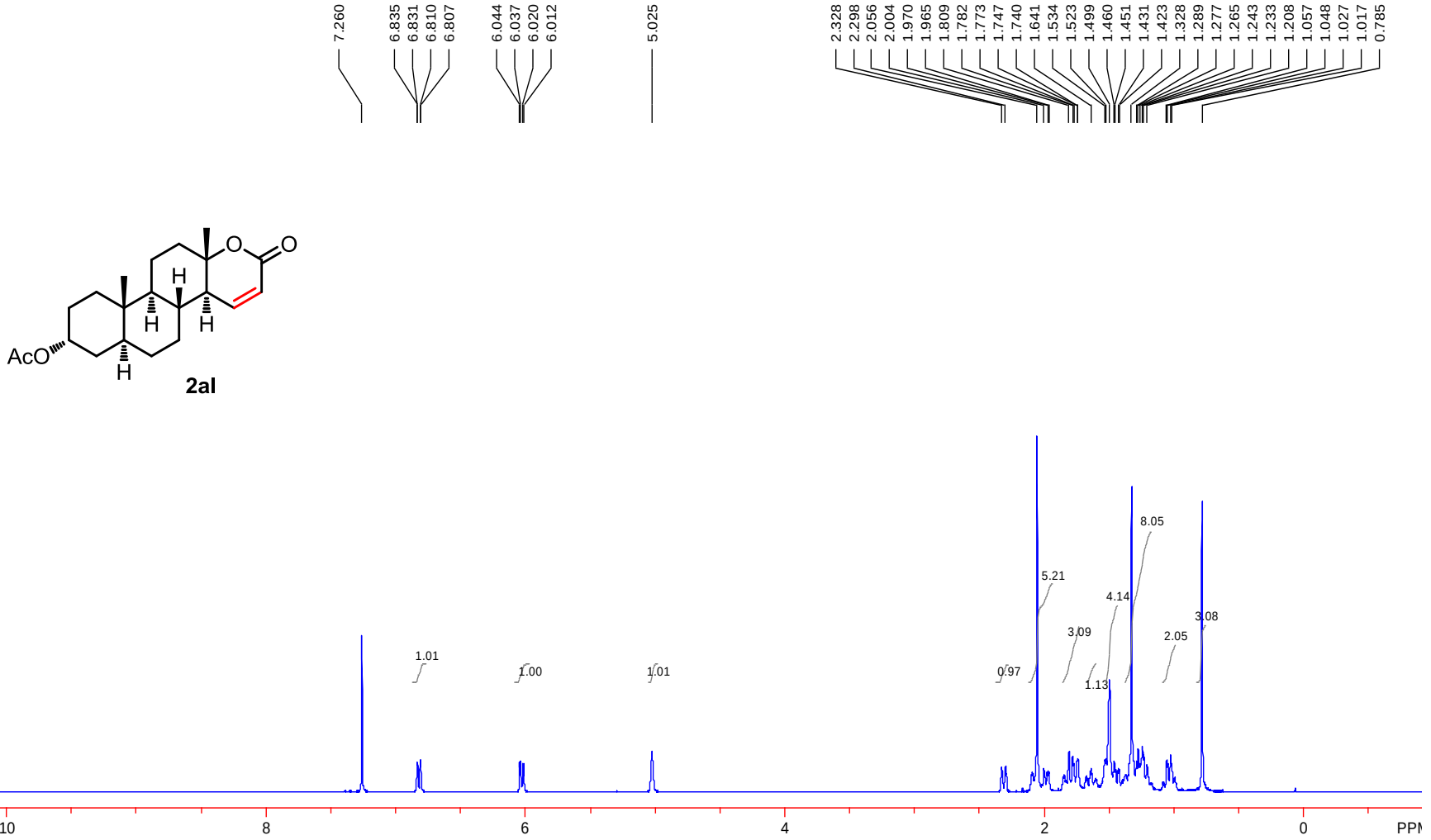

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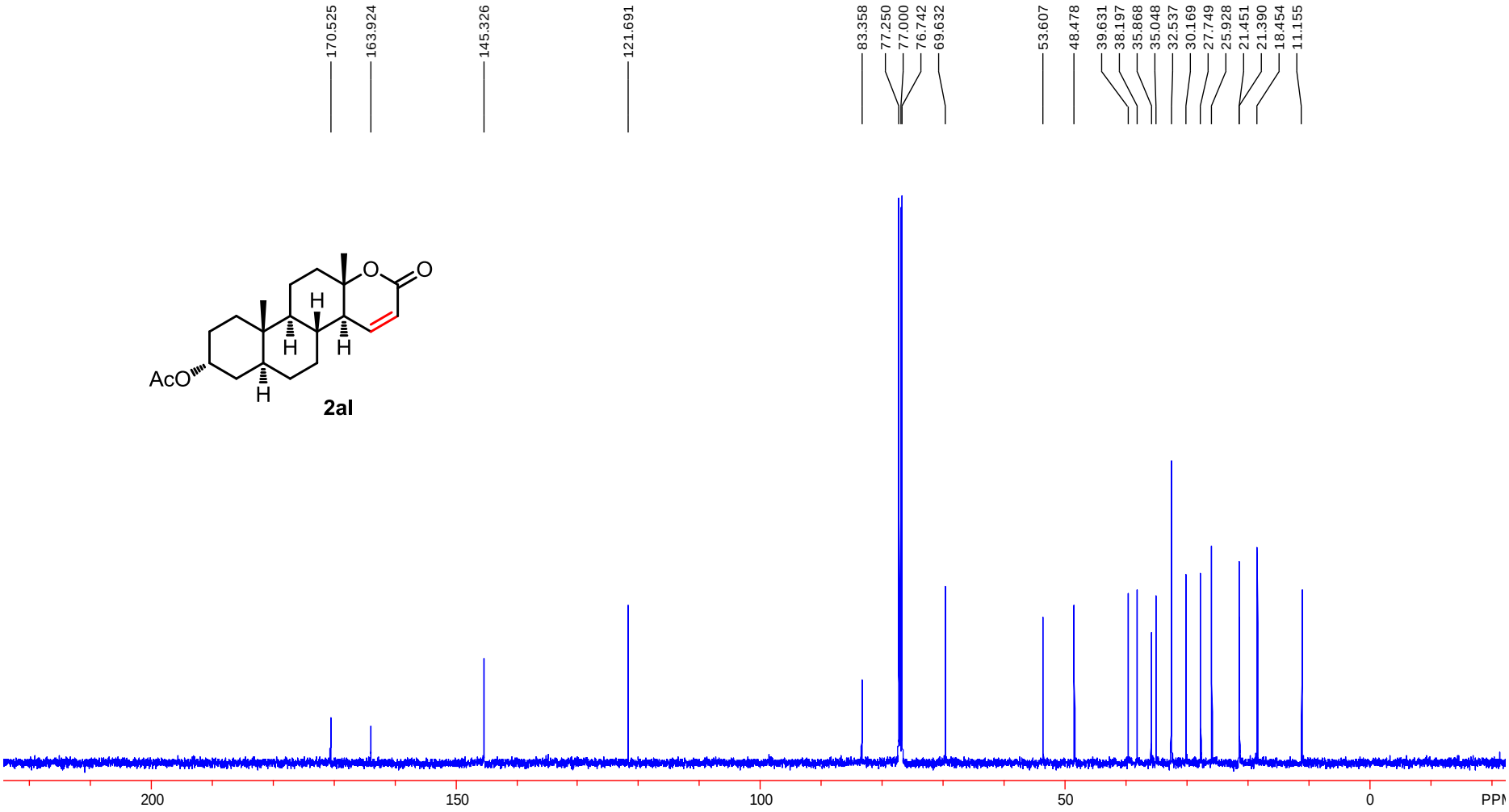
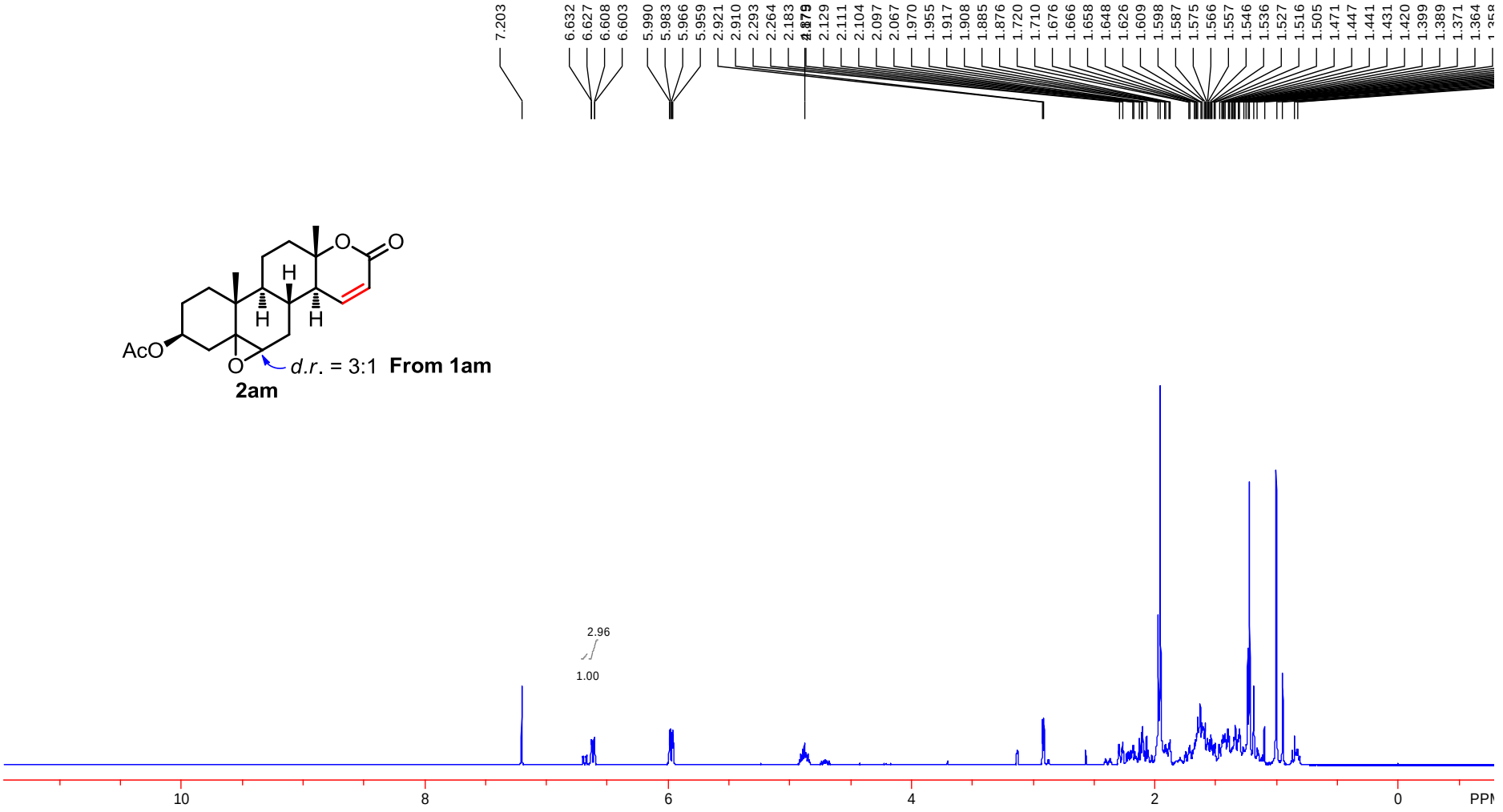
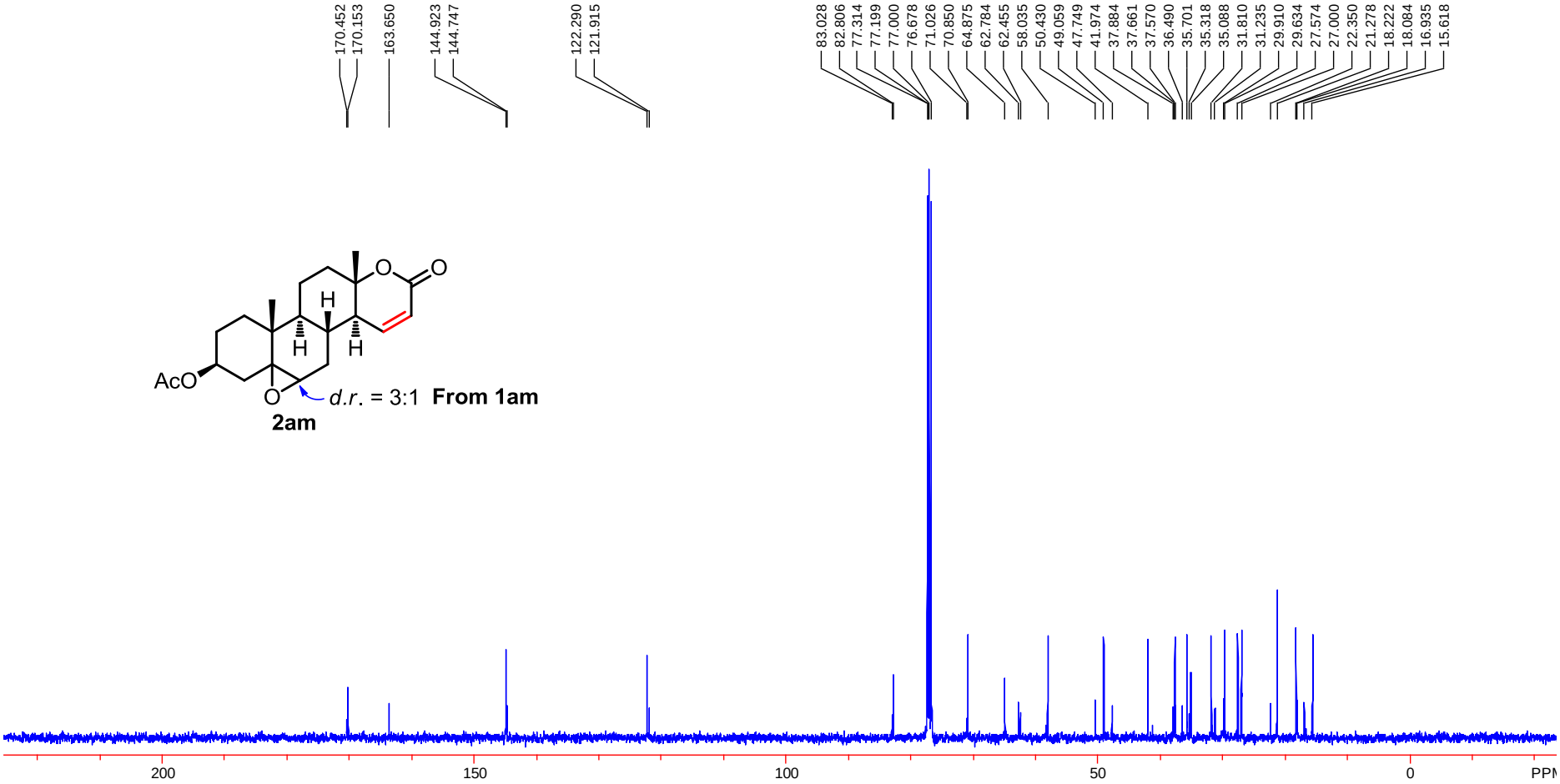


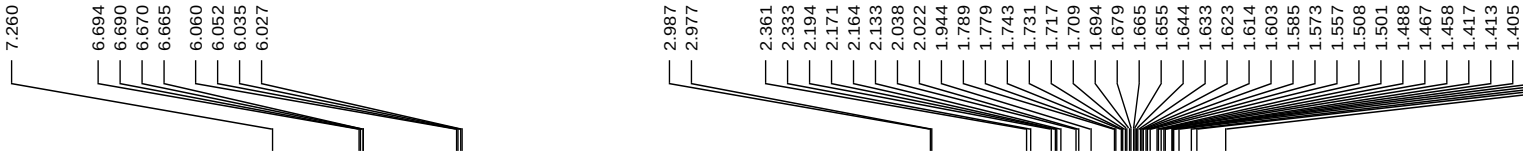
^{1}H NMR (400 MHz, $CDCl_3$)

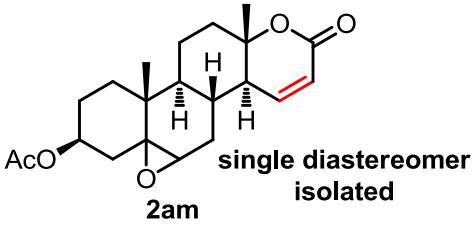


^{13}C NMR (101 MHz, $CDCl_3$)



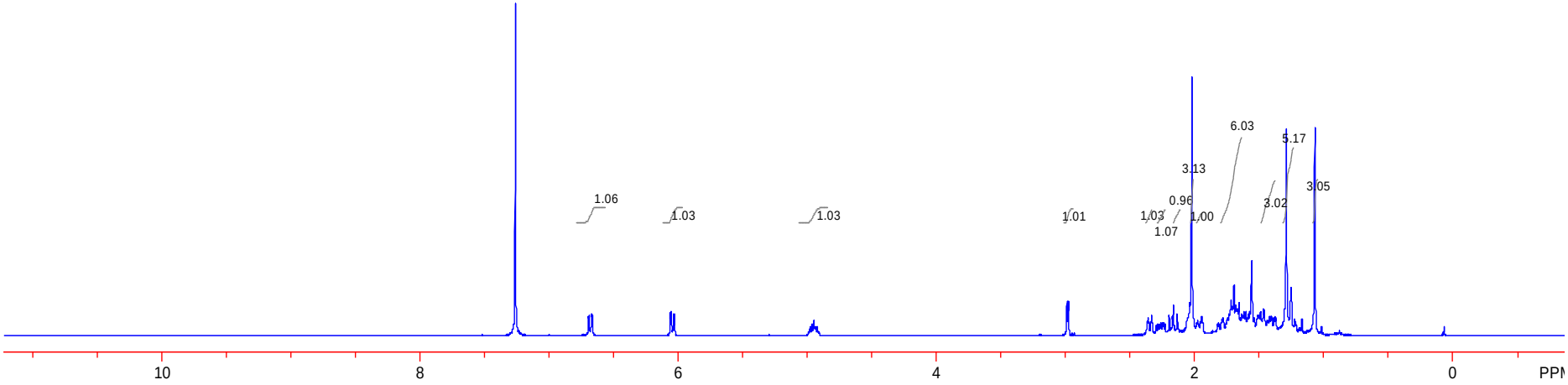
^{1}H NMR (400 MHz, $CDCl_3$)



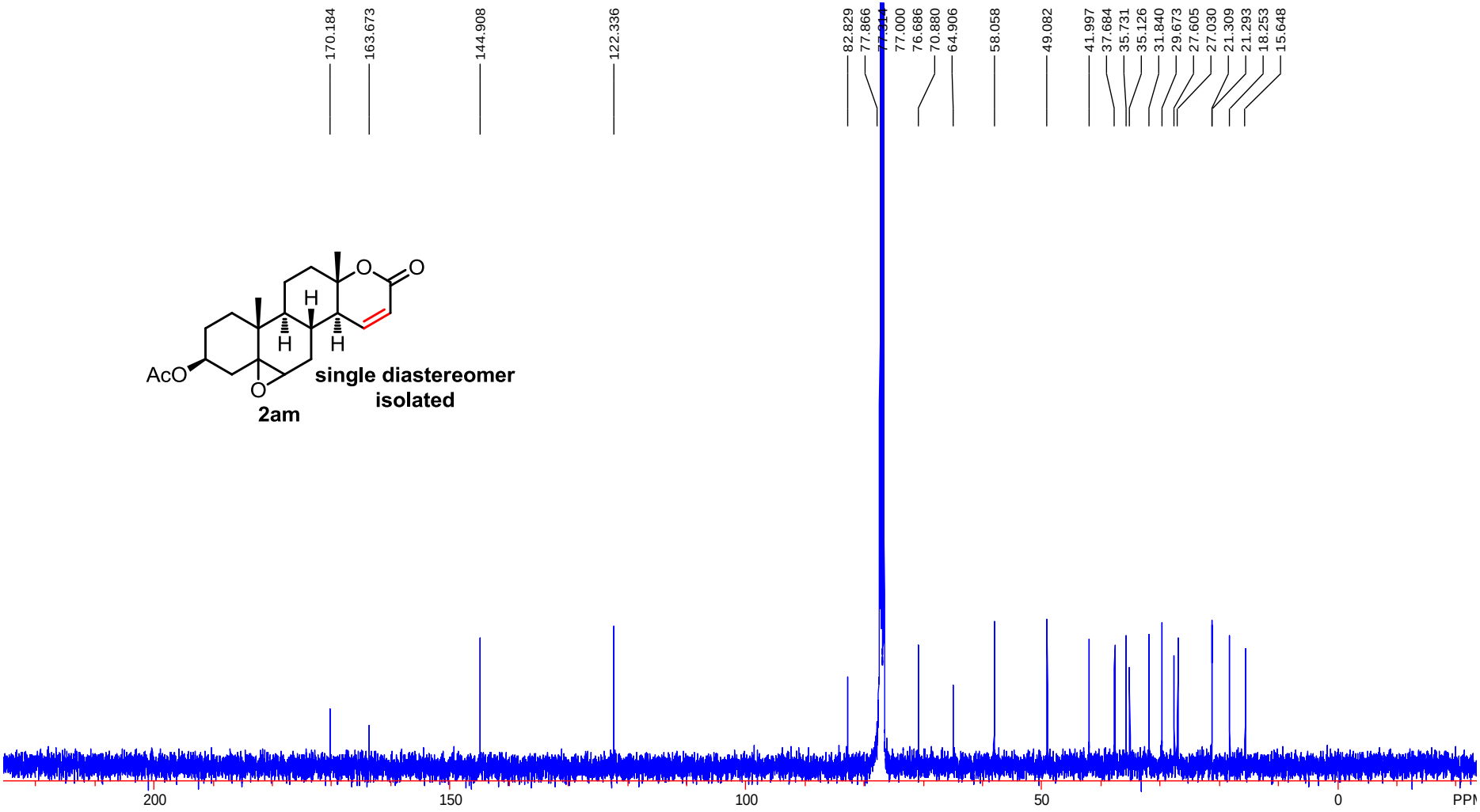


2am

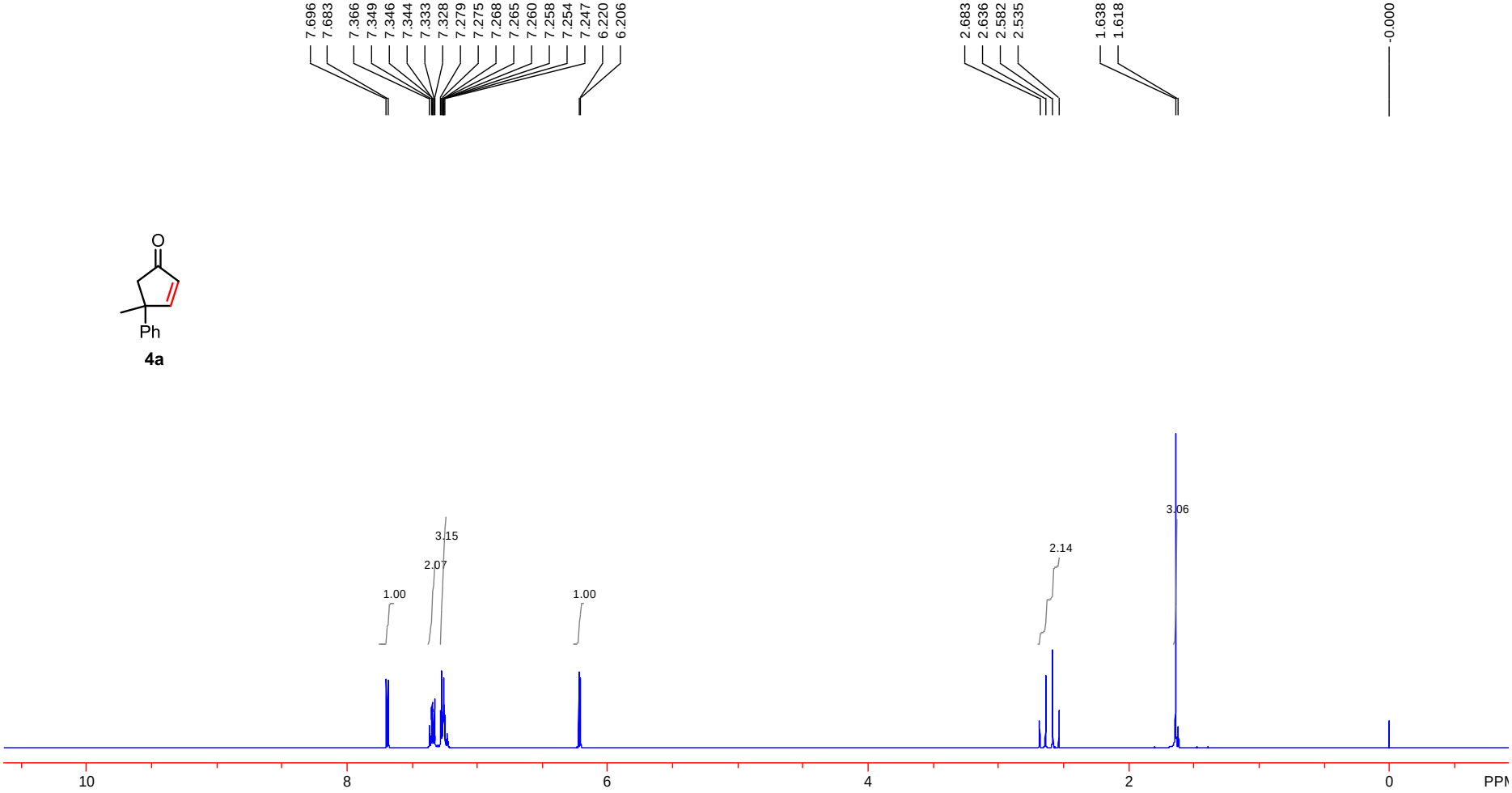
single diastereomer isolated



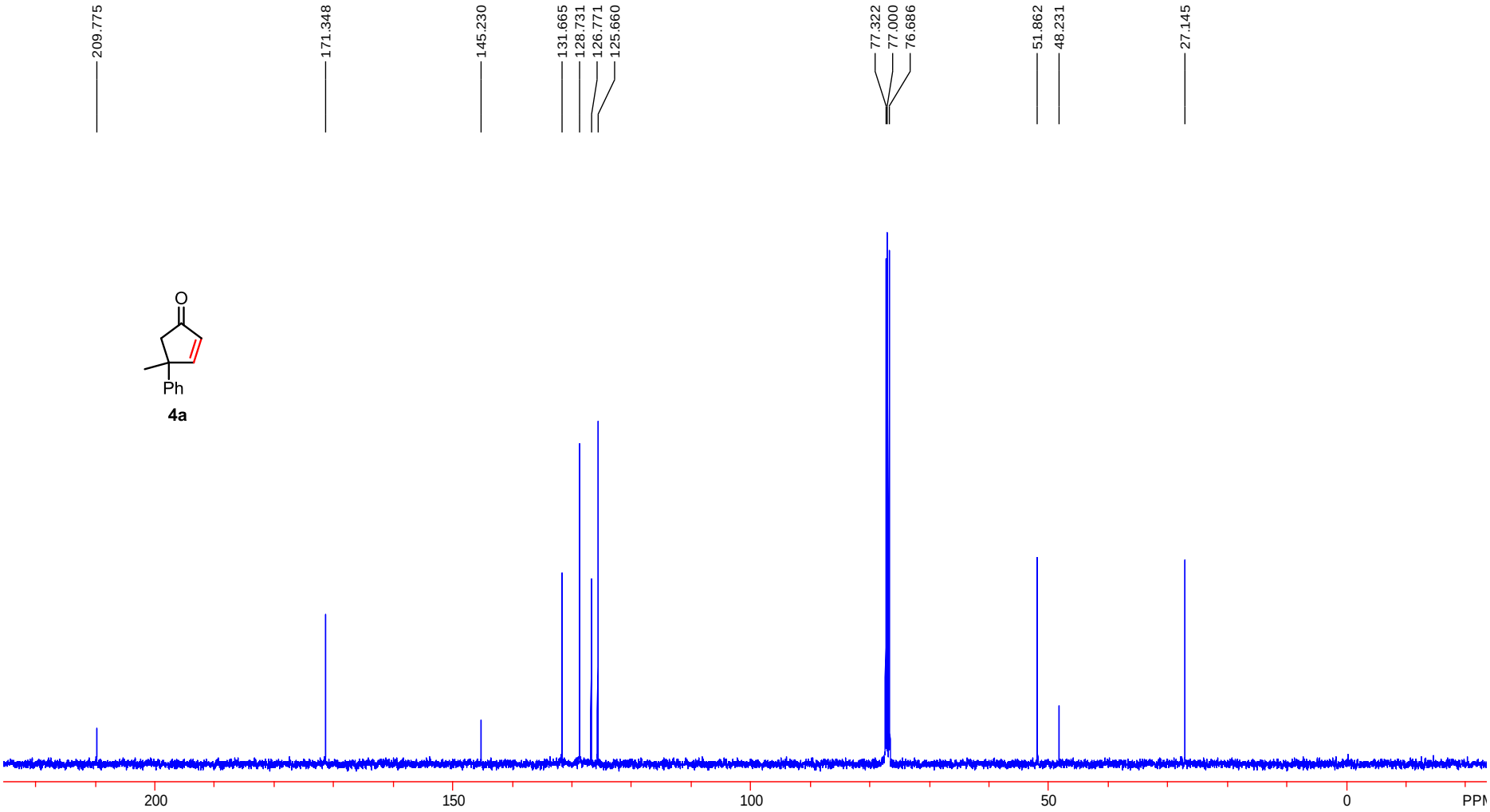
^{13}C NMR (101 MHz, $CDCl_3$)



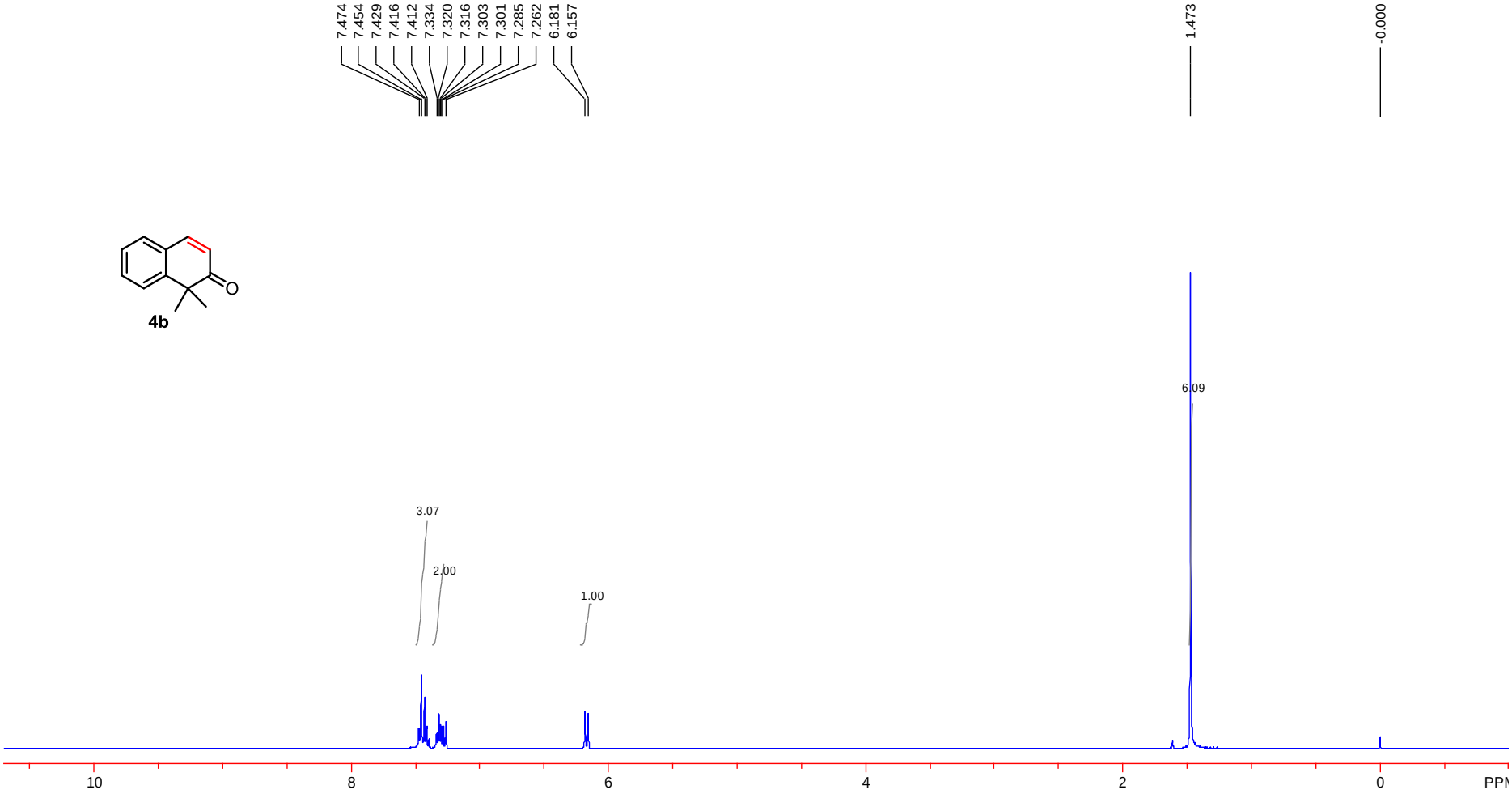
^{1}H NMR (400 MHz, $CDCl_3$)



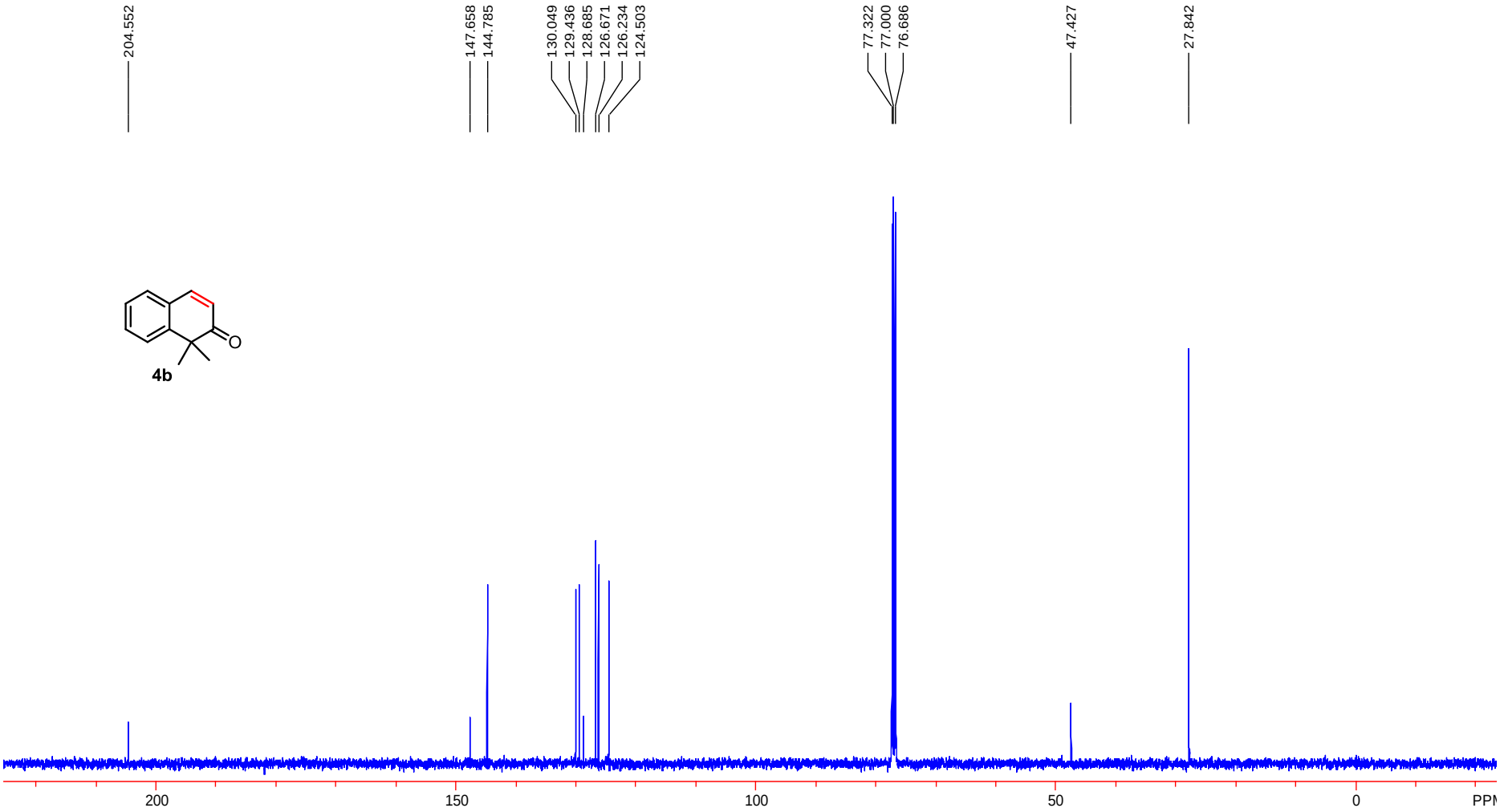
^{13}C NMR (101 MHz, $CDCl_3$)



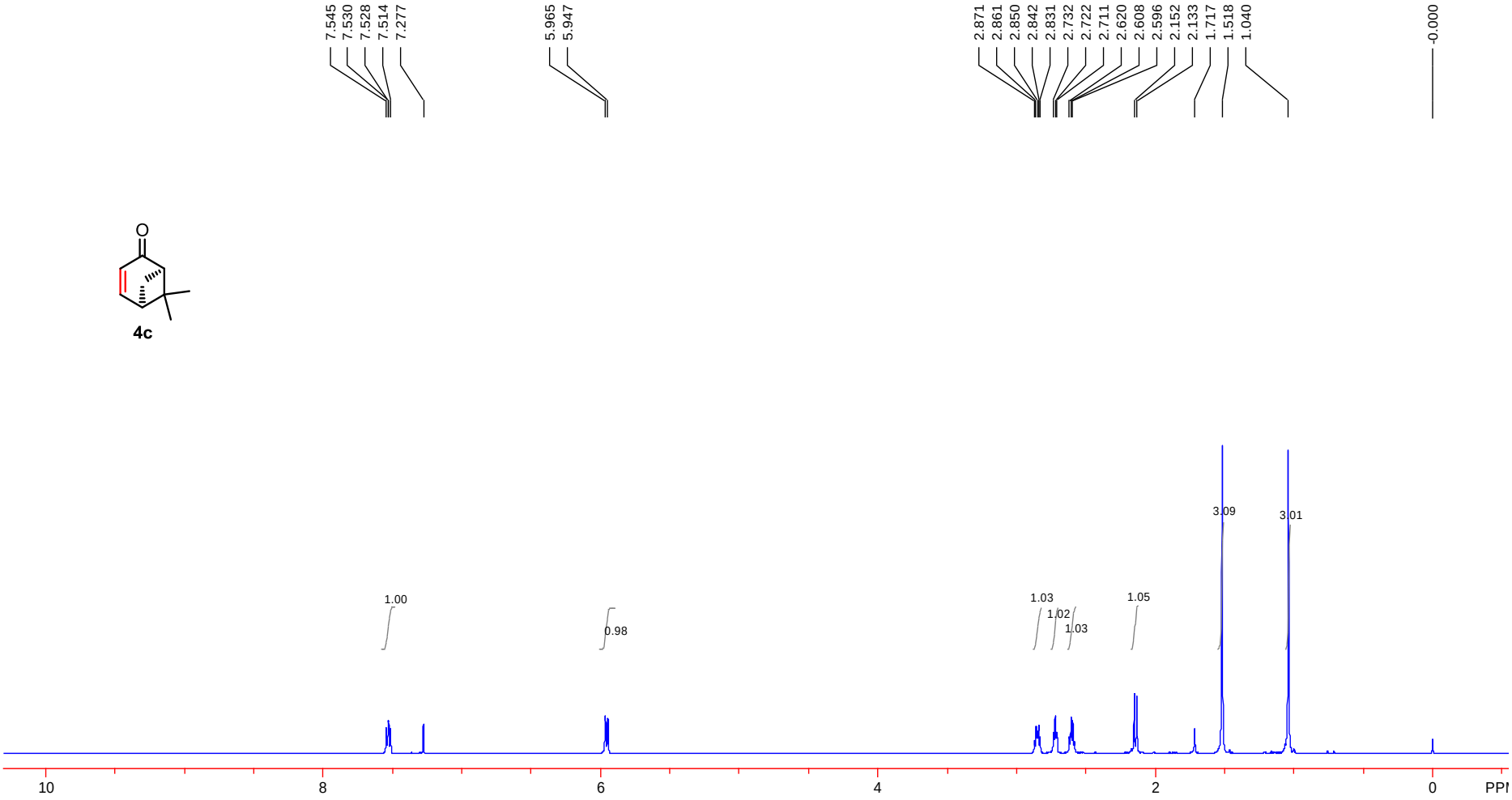
^{1}H NMR (400 MHz, $CDCl_3$)



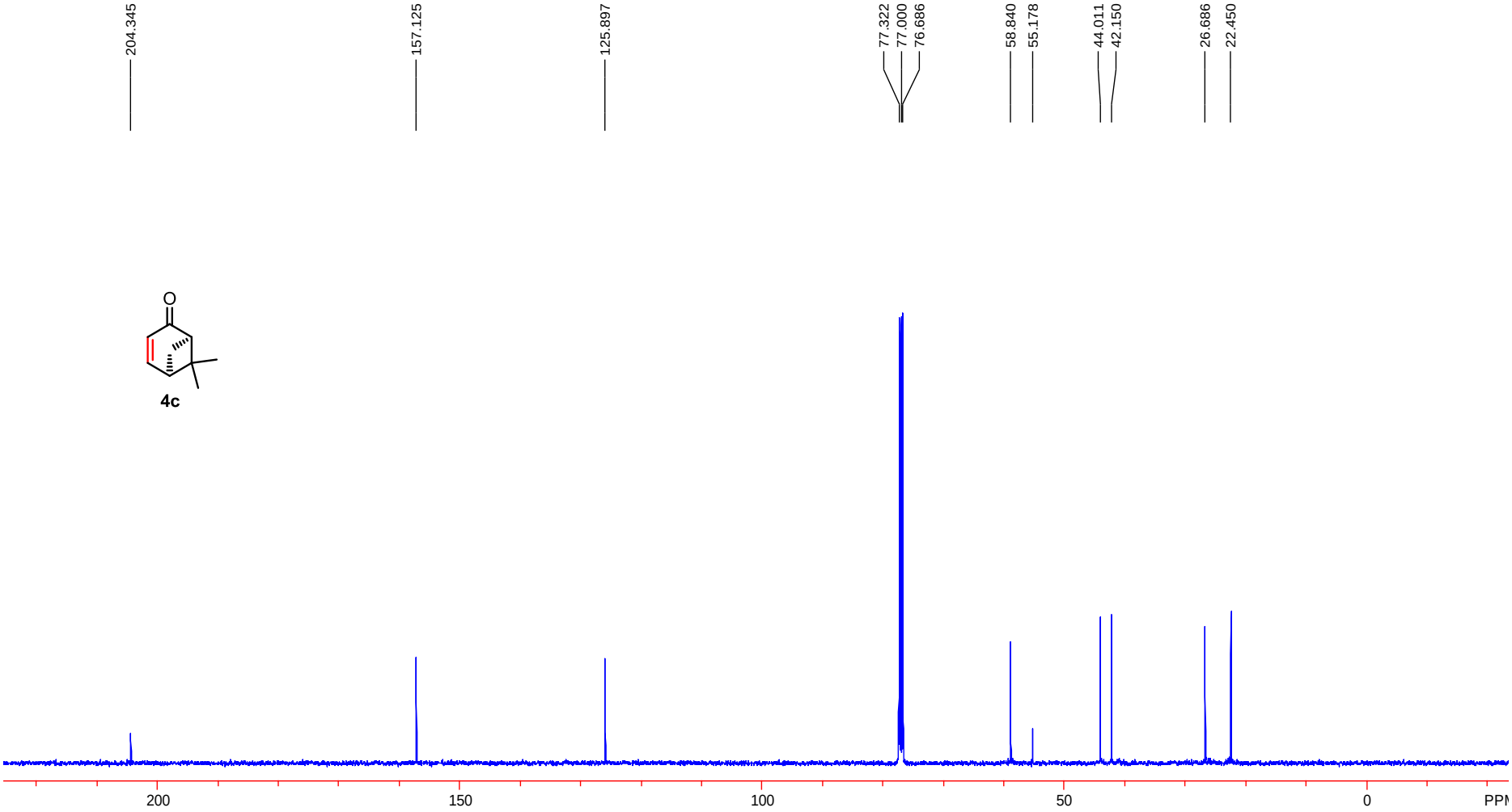
^{13}C NMR (101 MHz, $CDCl_3$)



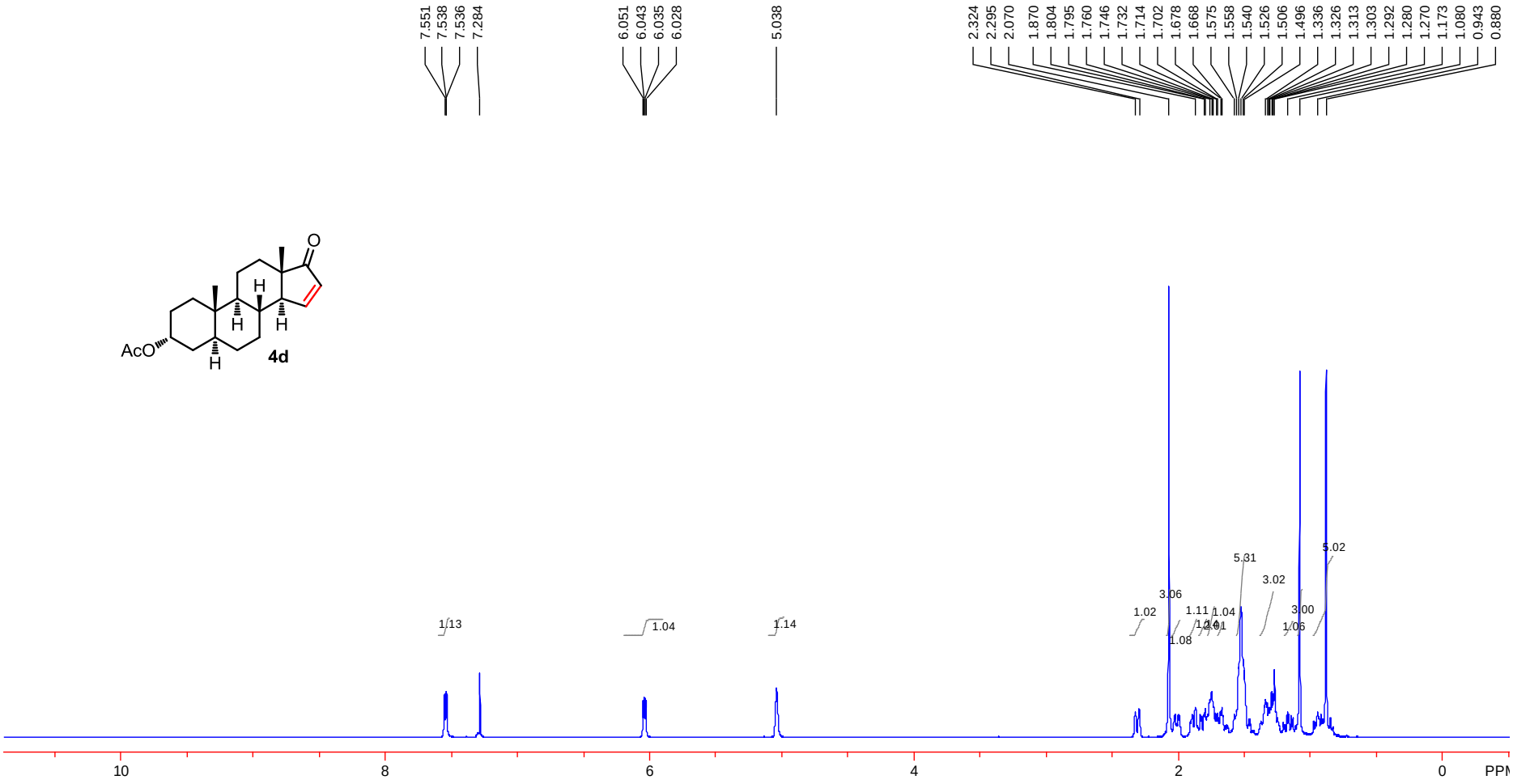
^{1}H NMR (400 MHz, $CDCl_3$)



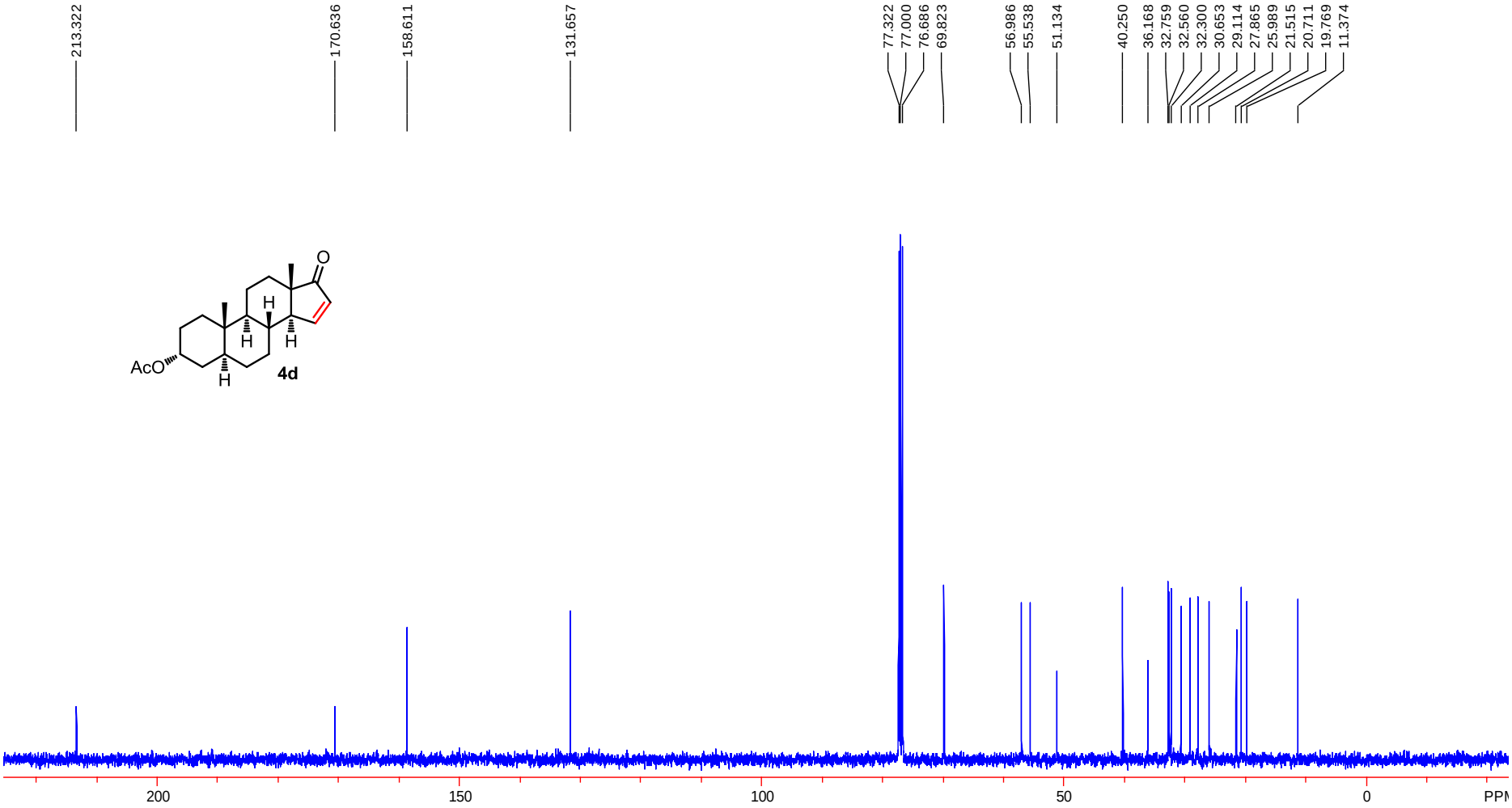
^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)



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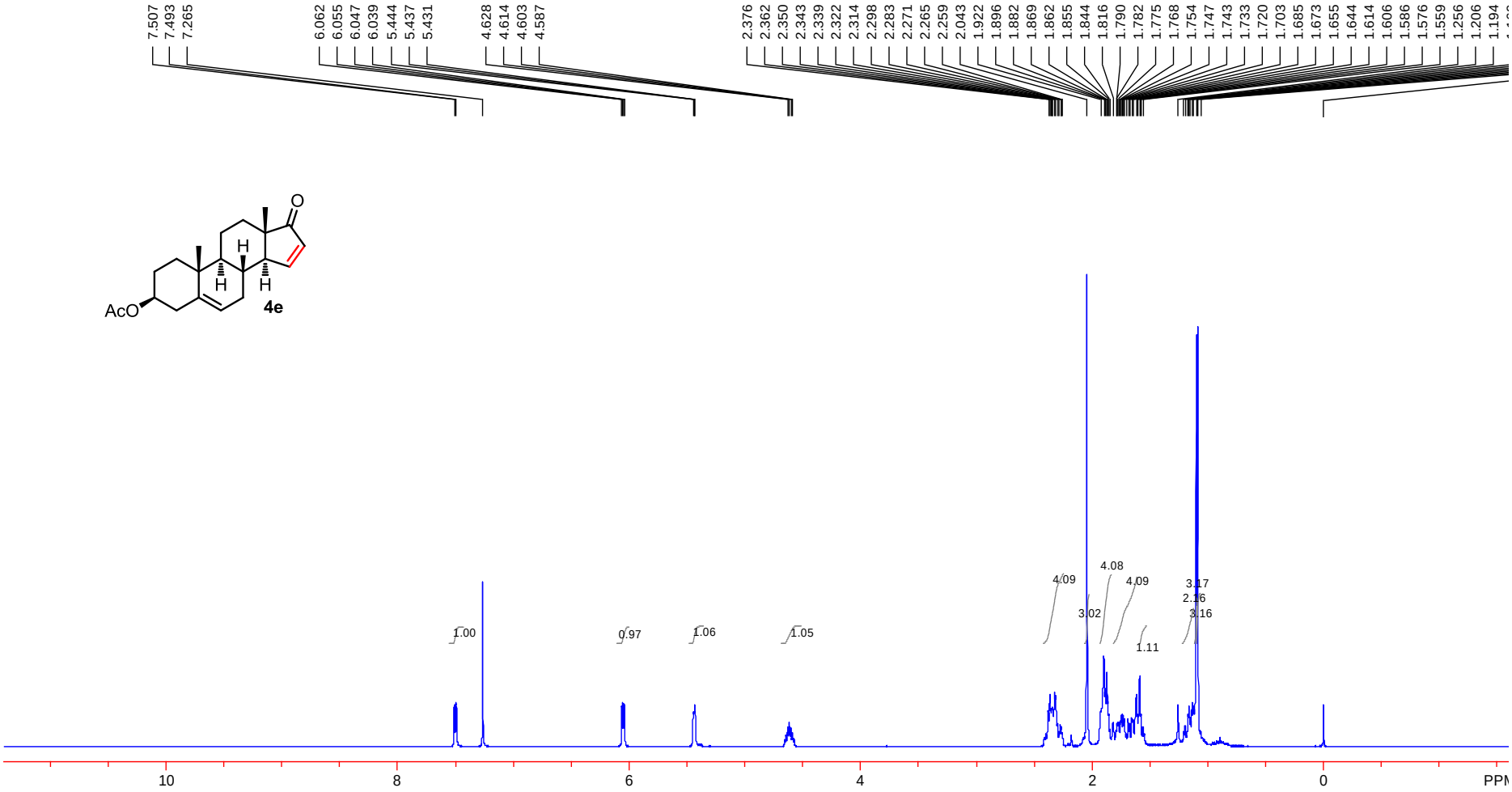
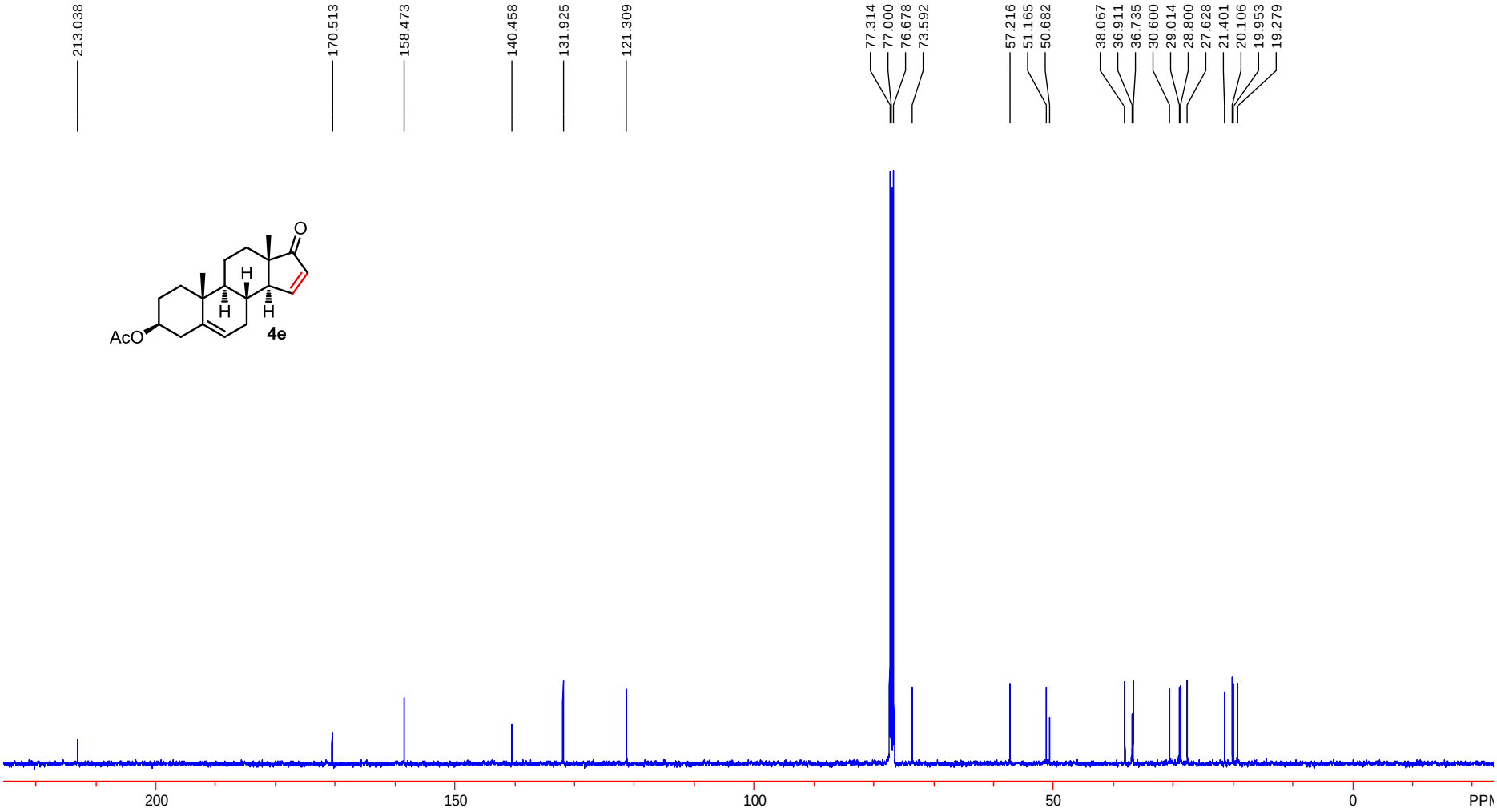
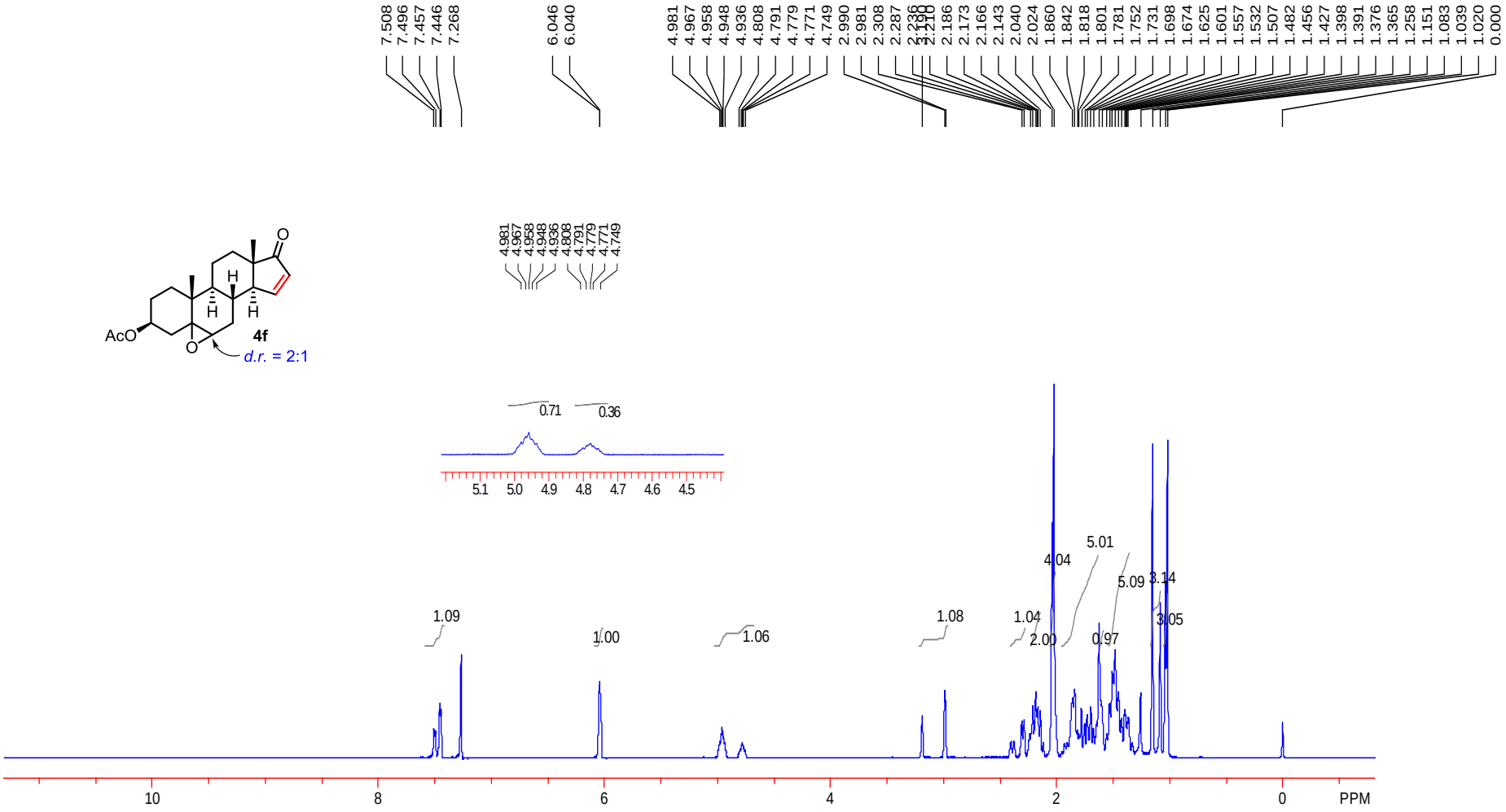


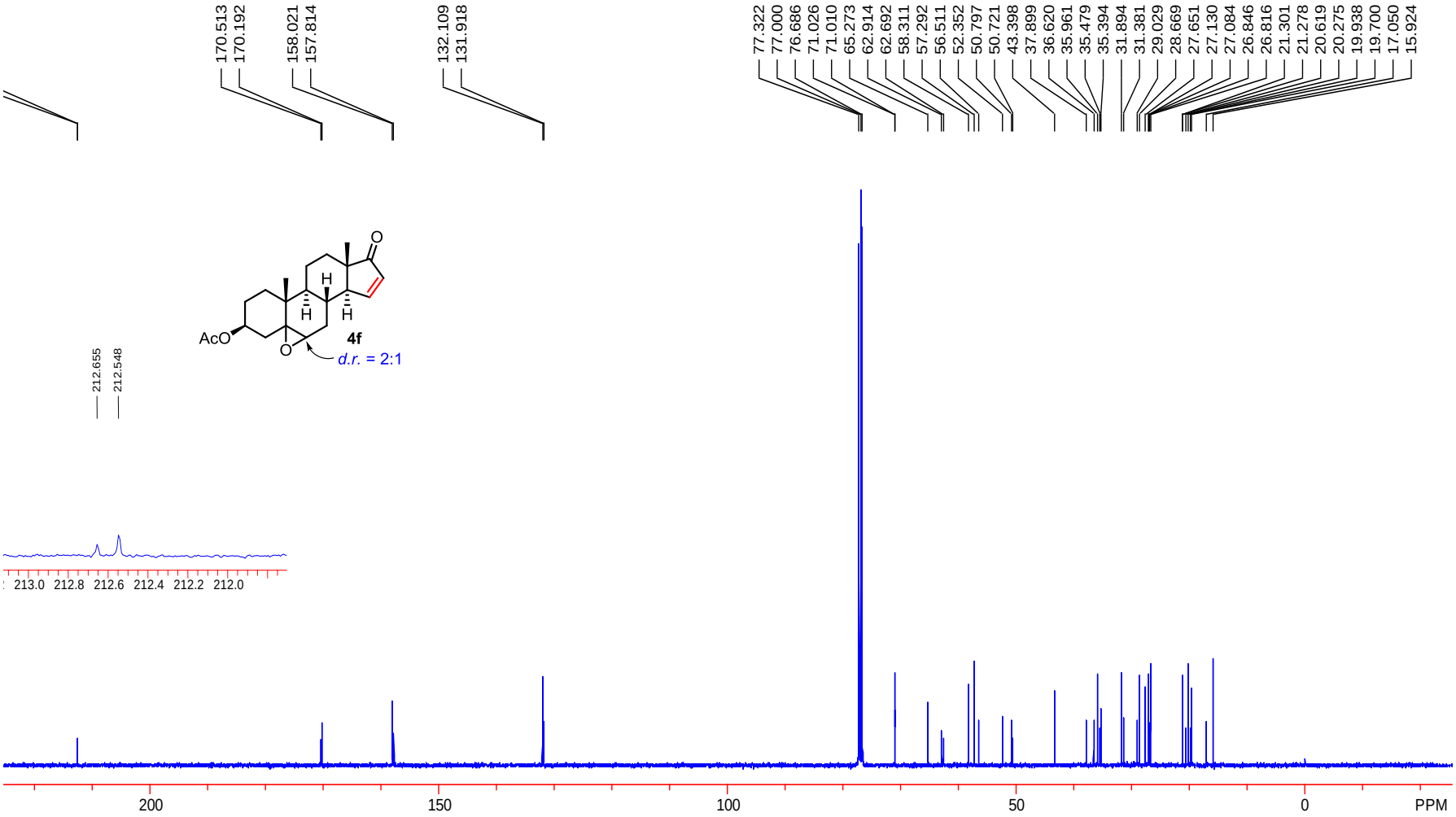
^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)



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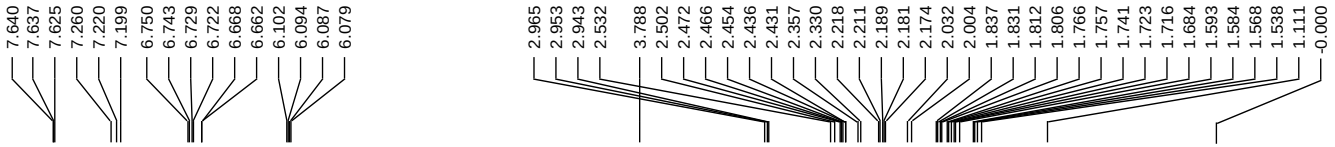
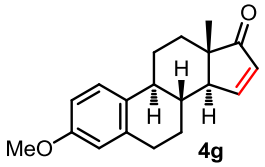
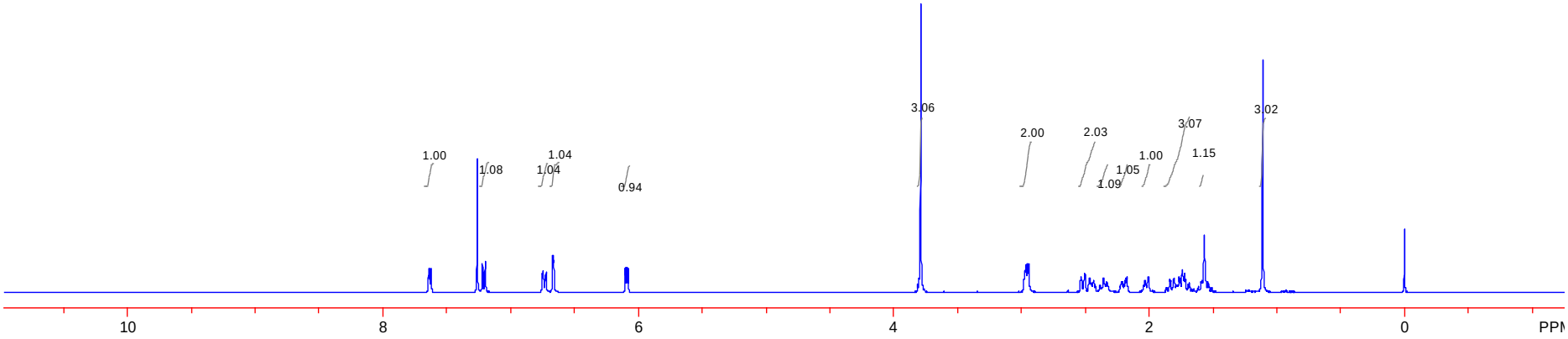
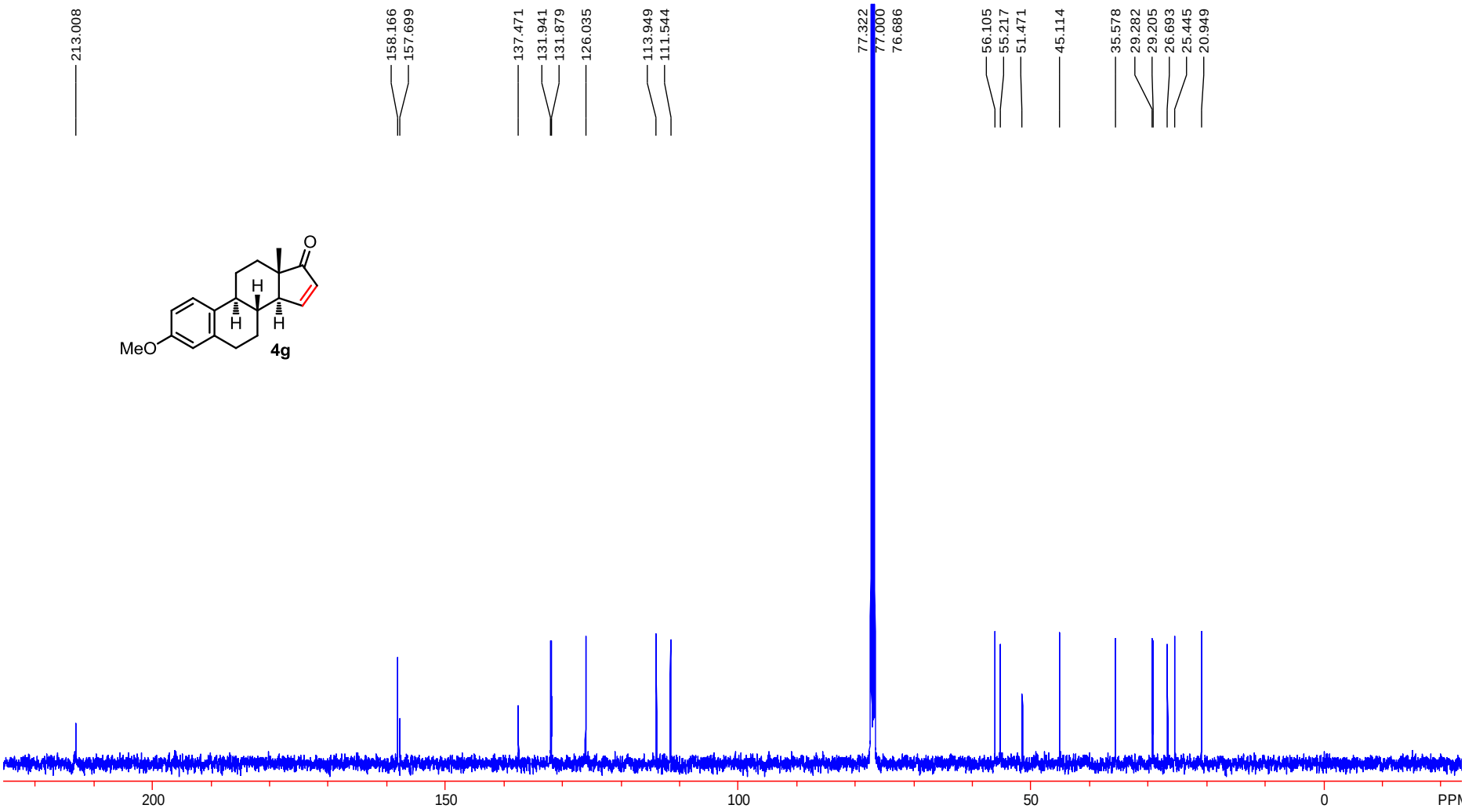




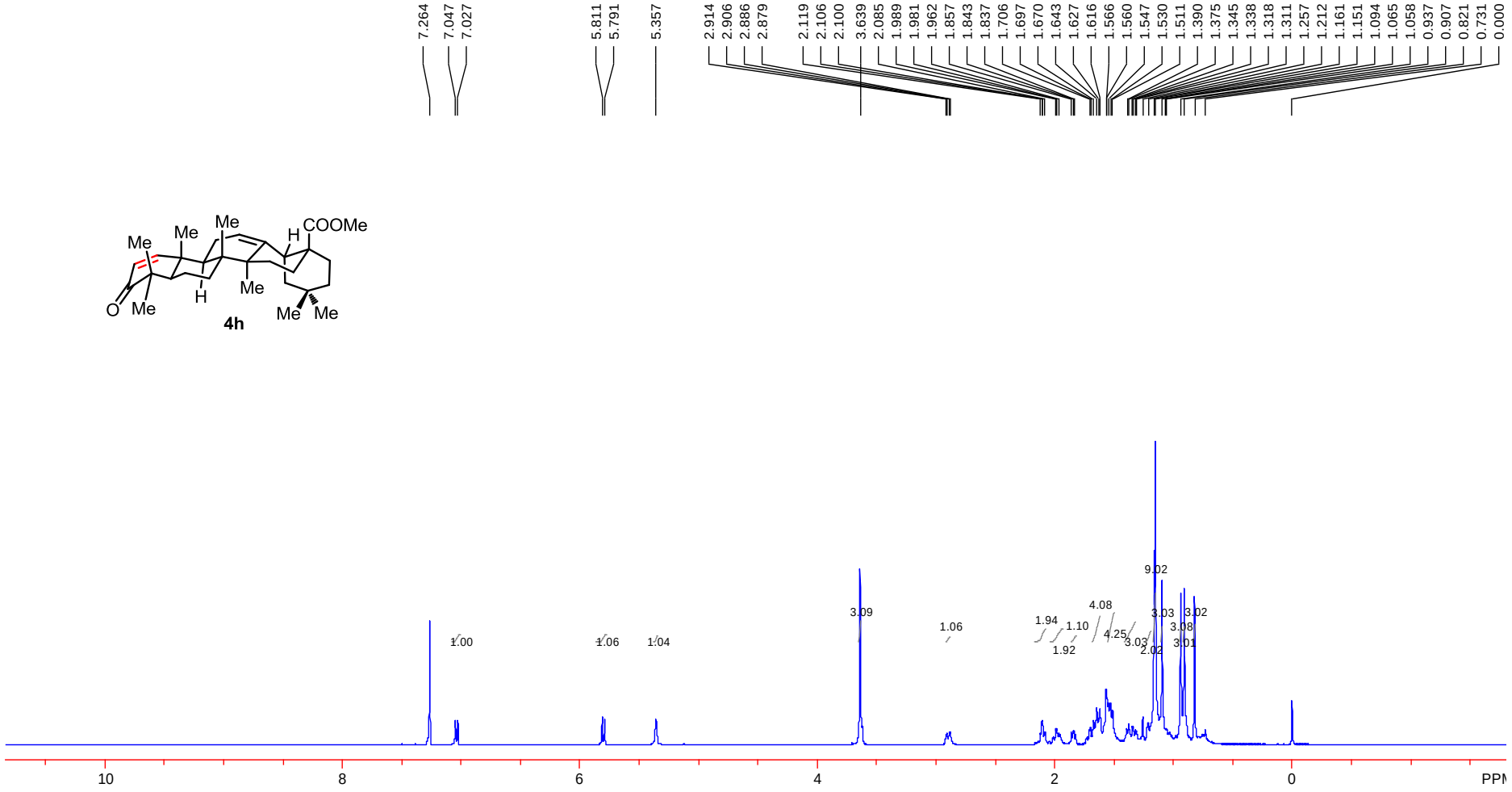
4g



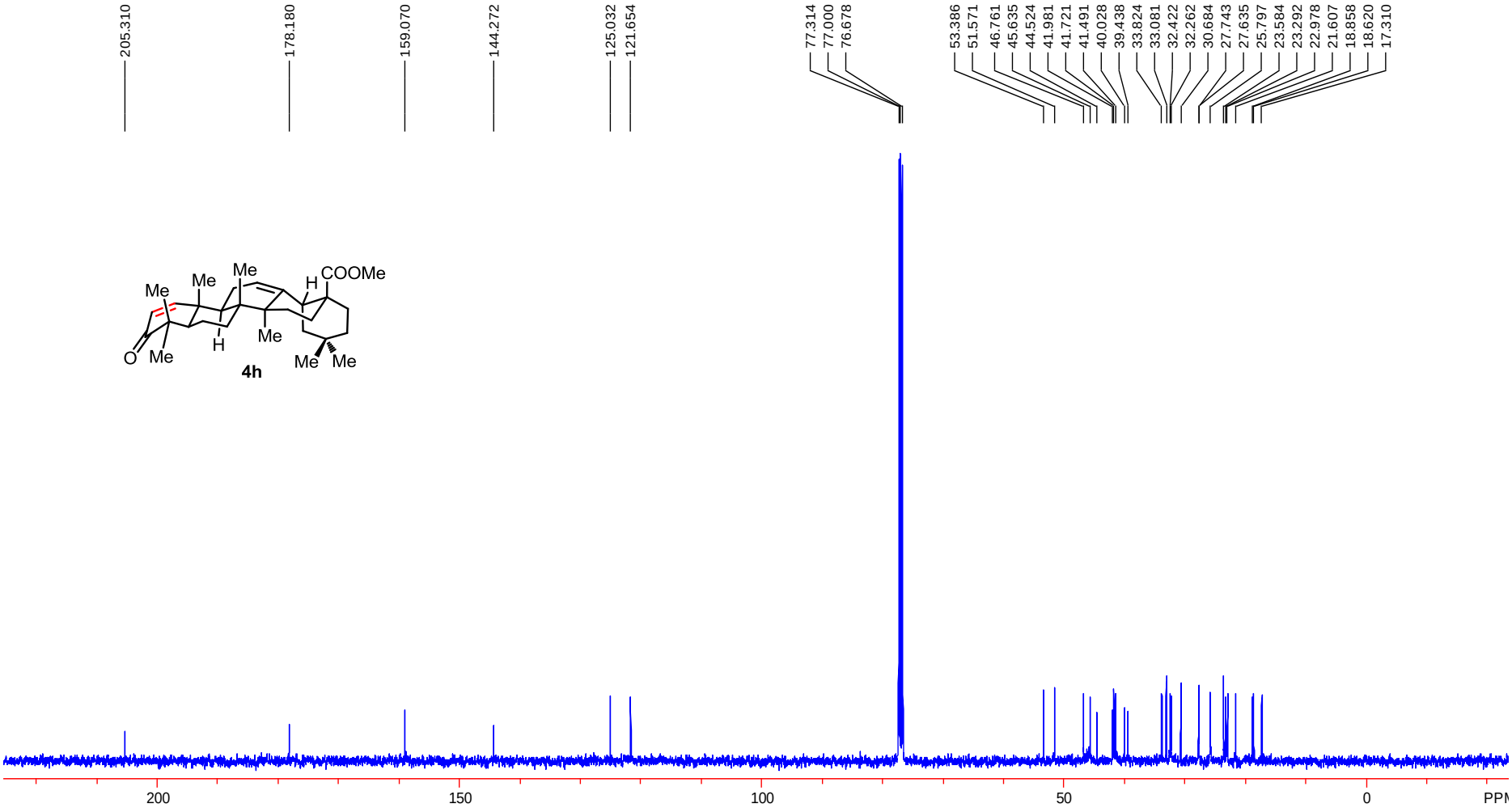
^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$)

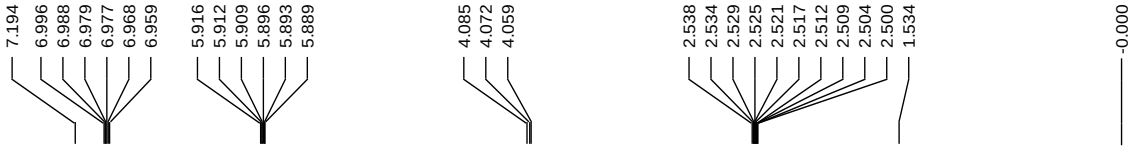


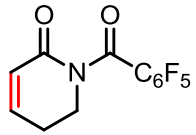
^{13}C NMR (101 MHz, $CDCl_3$)



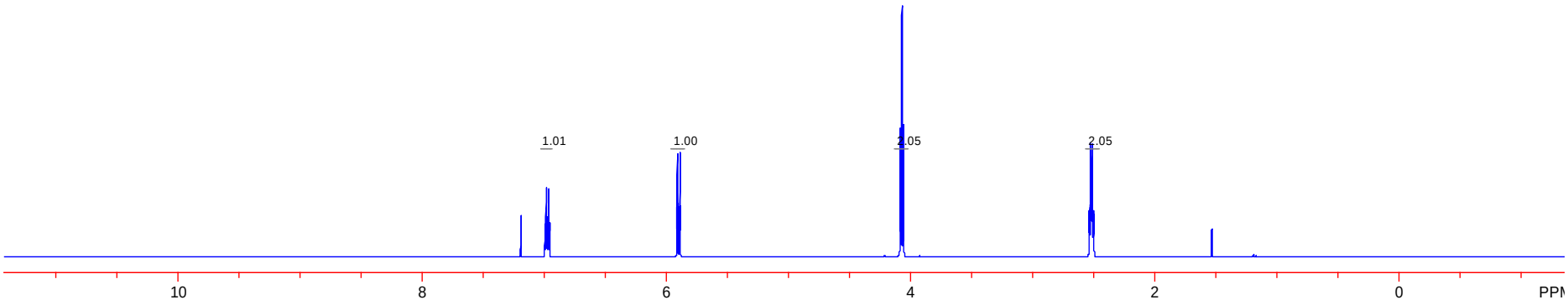
4h

^{1}H NMR (500 MHz, $CDCl_3$)

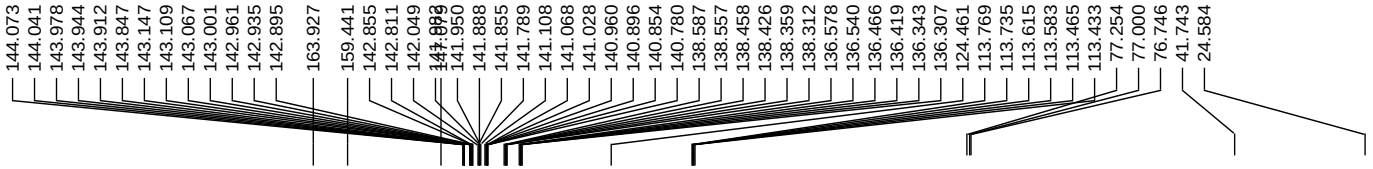


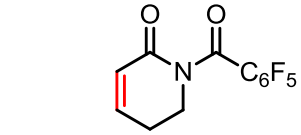


6a

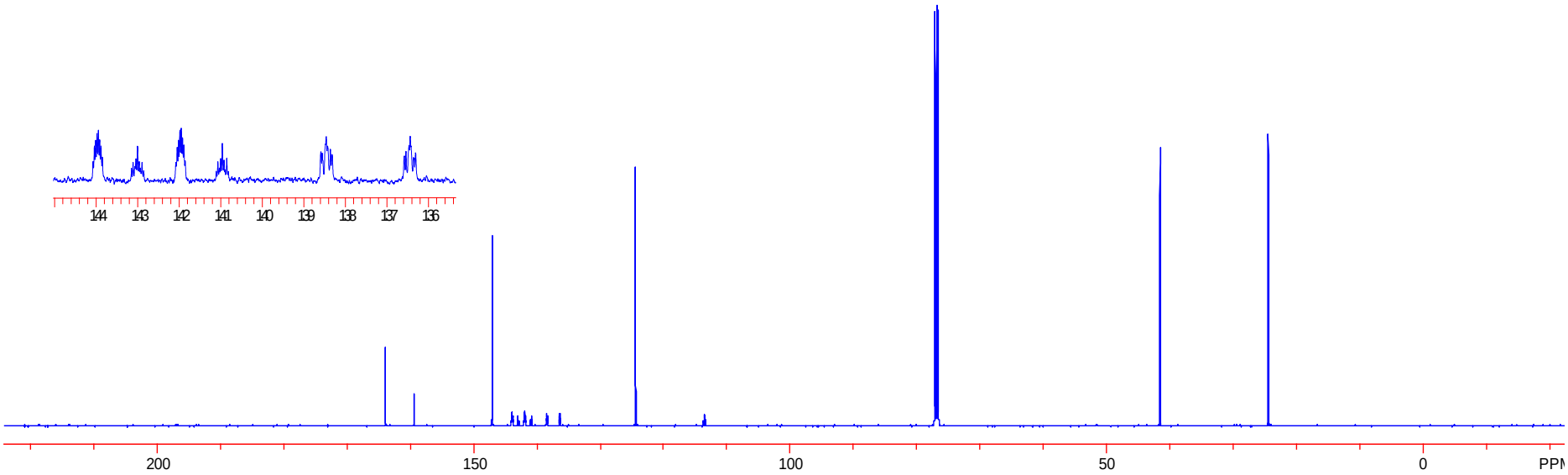


^{13}C NMR (125 MHz, $CDCl_3$)

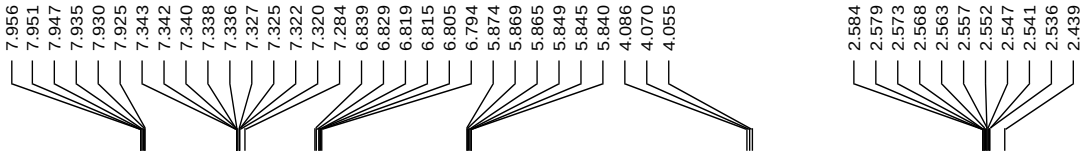


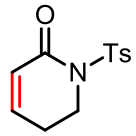


6a

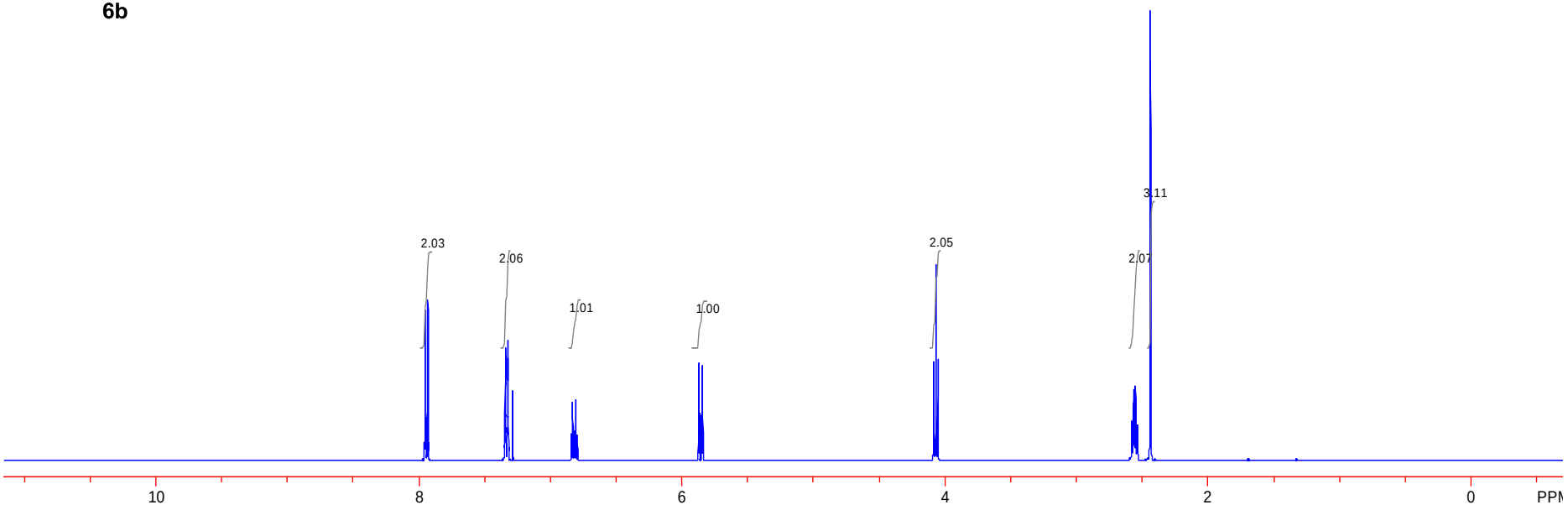


^{1}H NMR (400 MHz, $CDCl_3$)

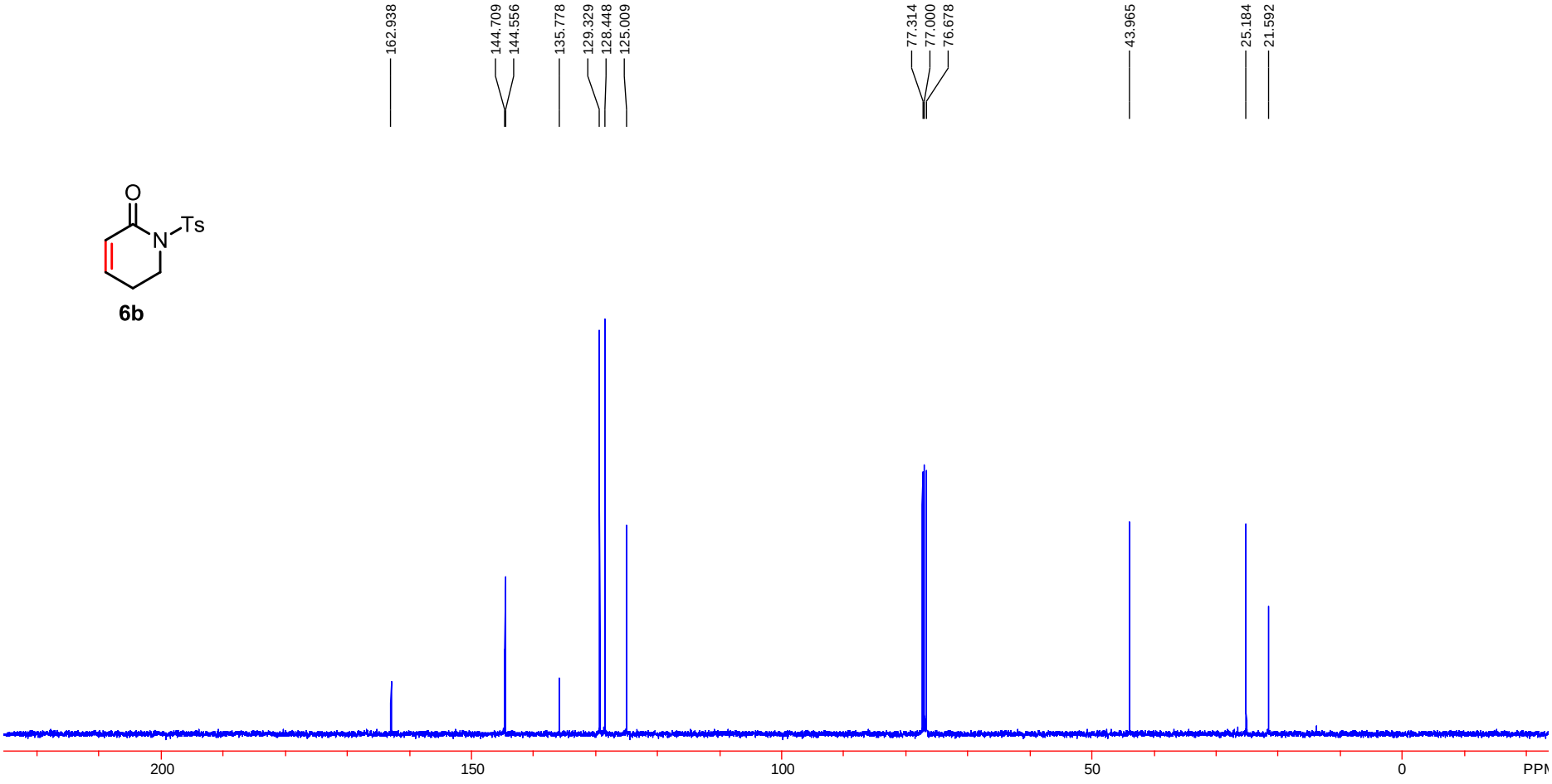




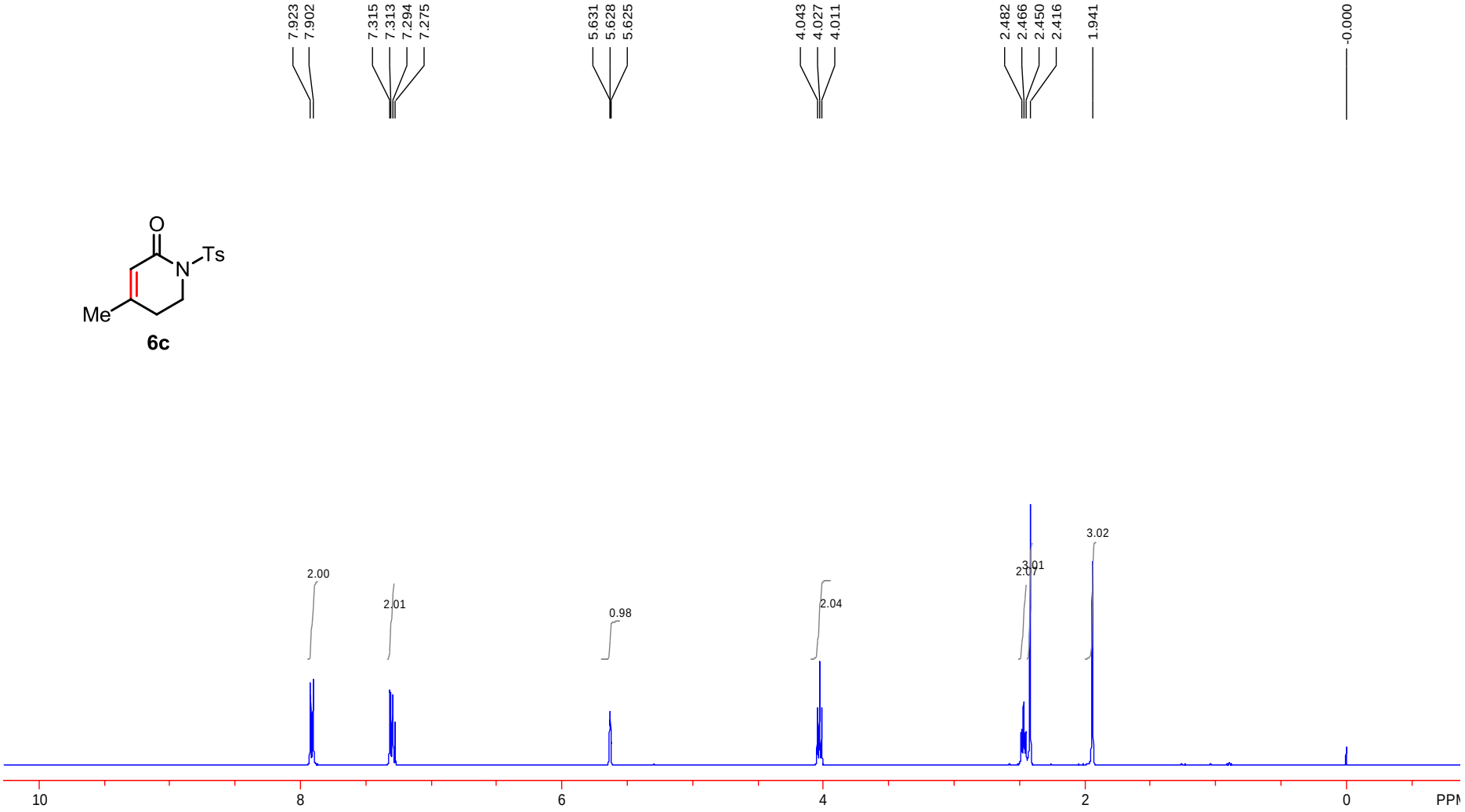
6b



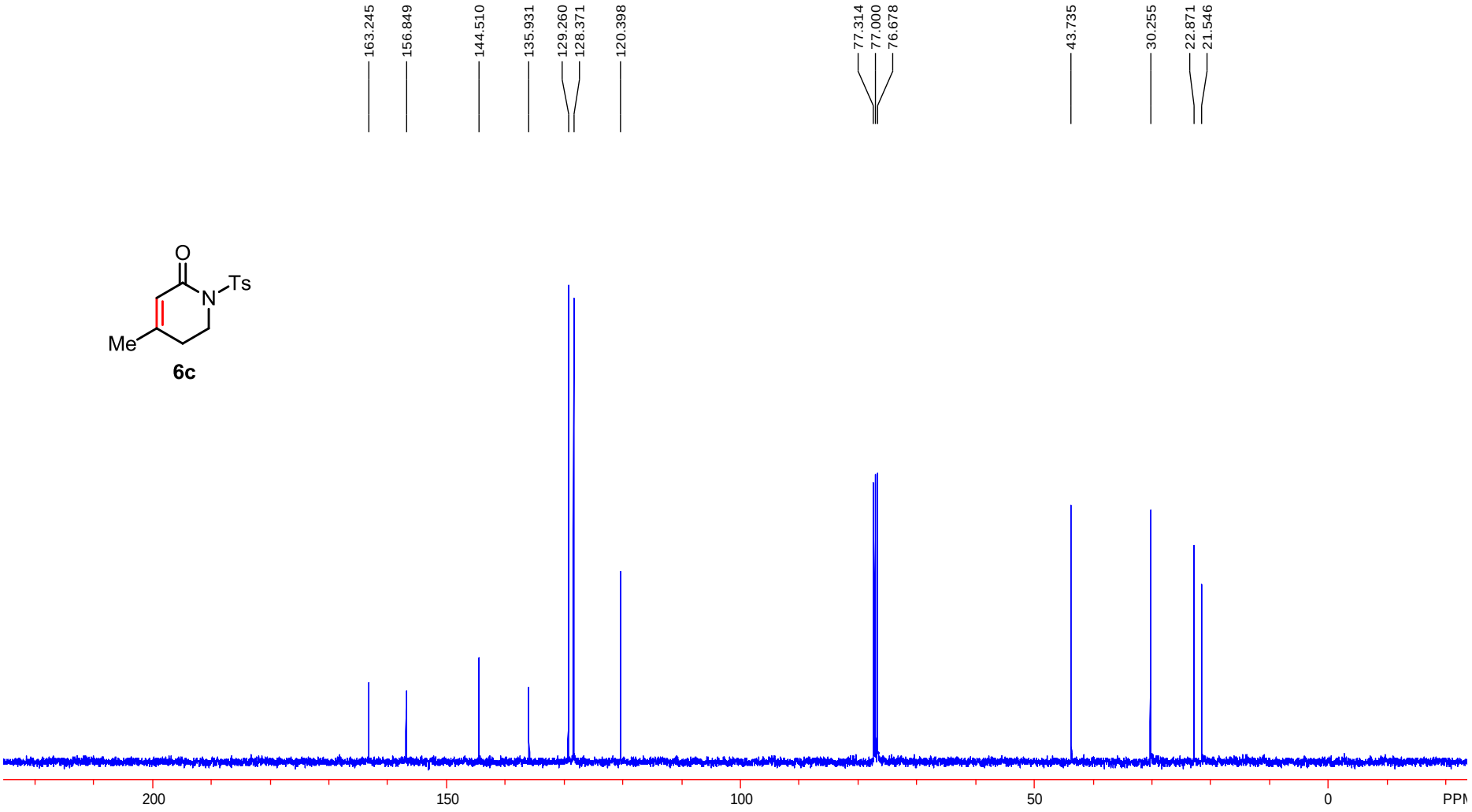
^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (400 MHz, $CDCl_3$)

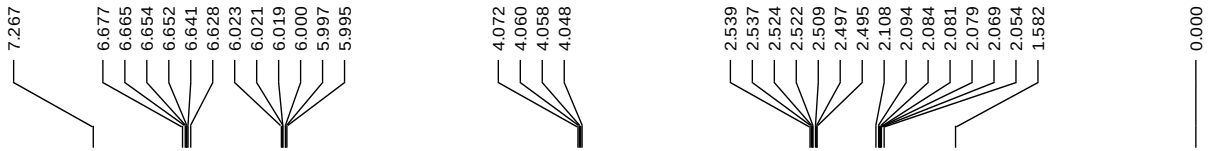


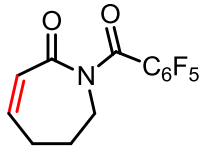
^{13}C NMR (101 MHz, $CDCl_3$)



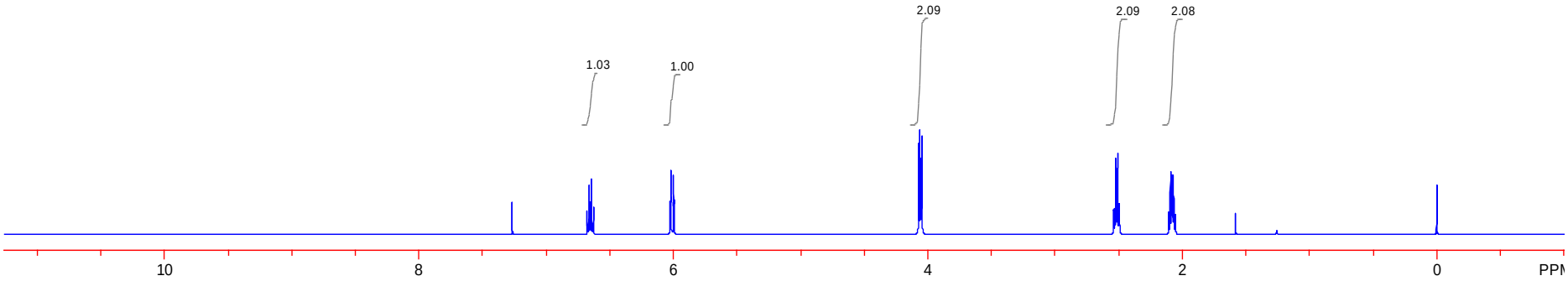
6c

^{1}H NMR (500 MHz, $CDCl_3$)

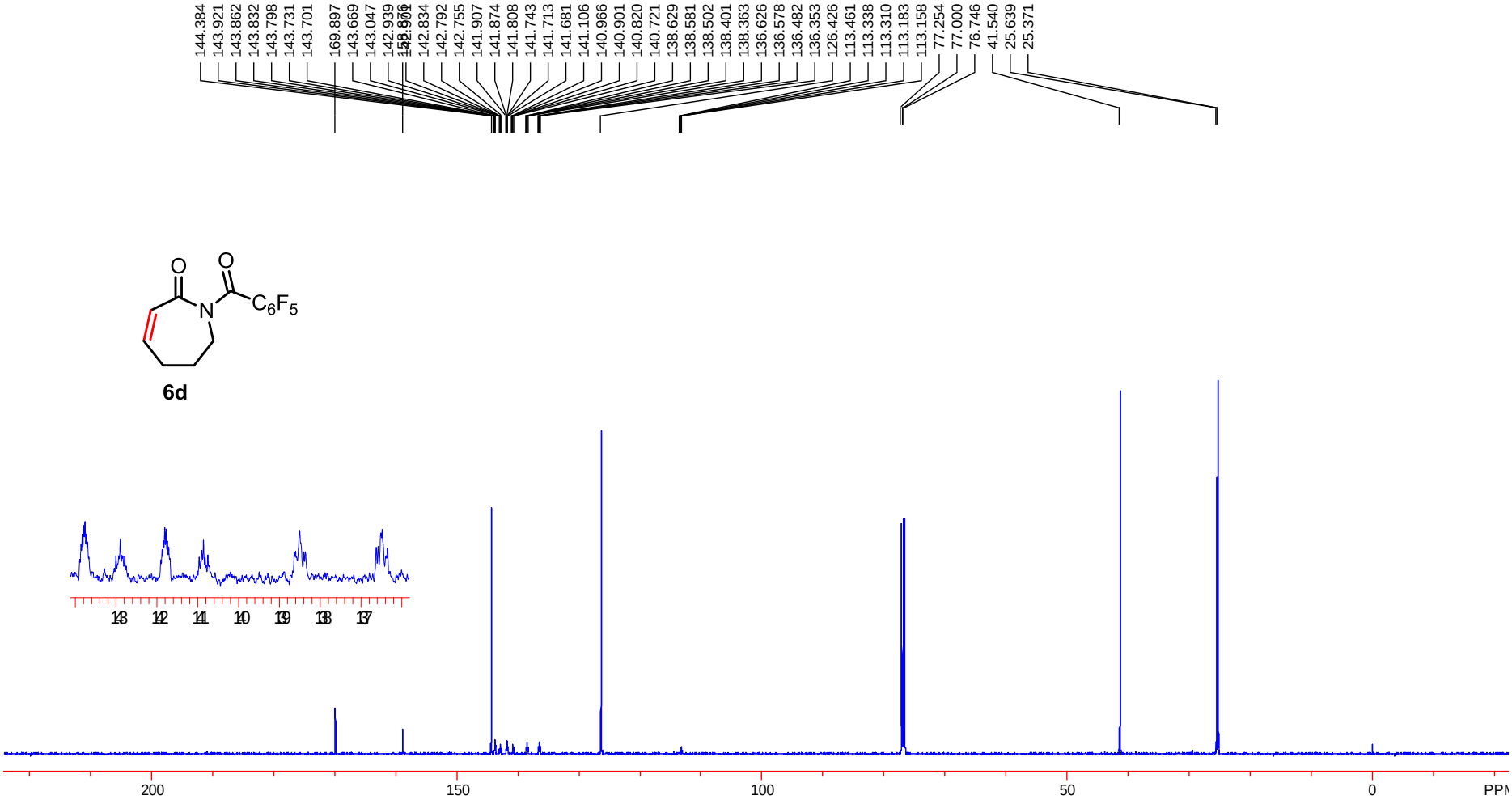




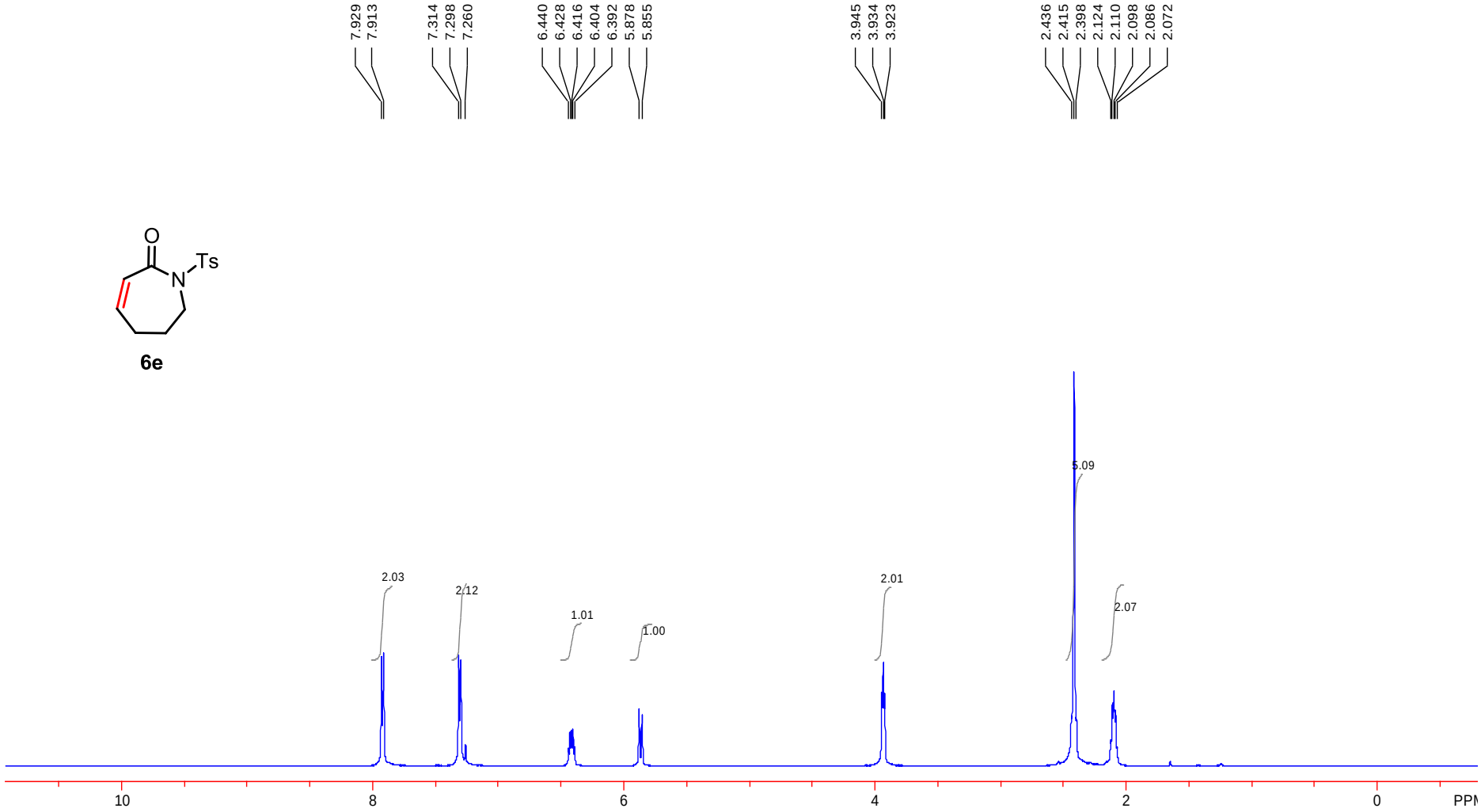
6d



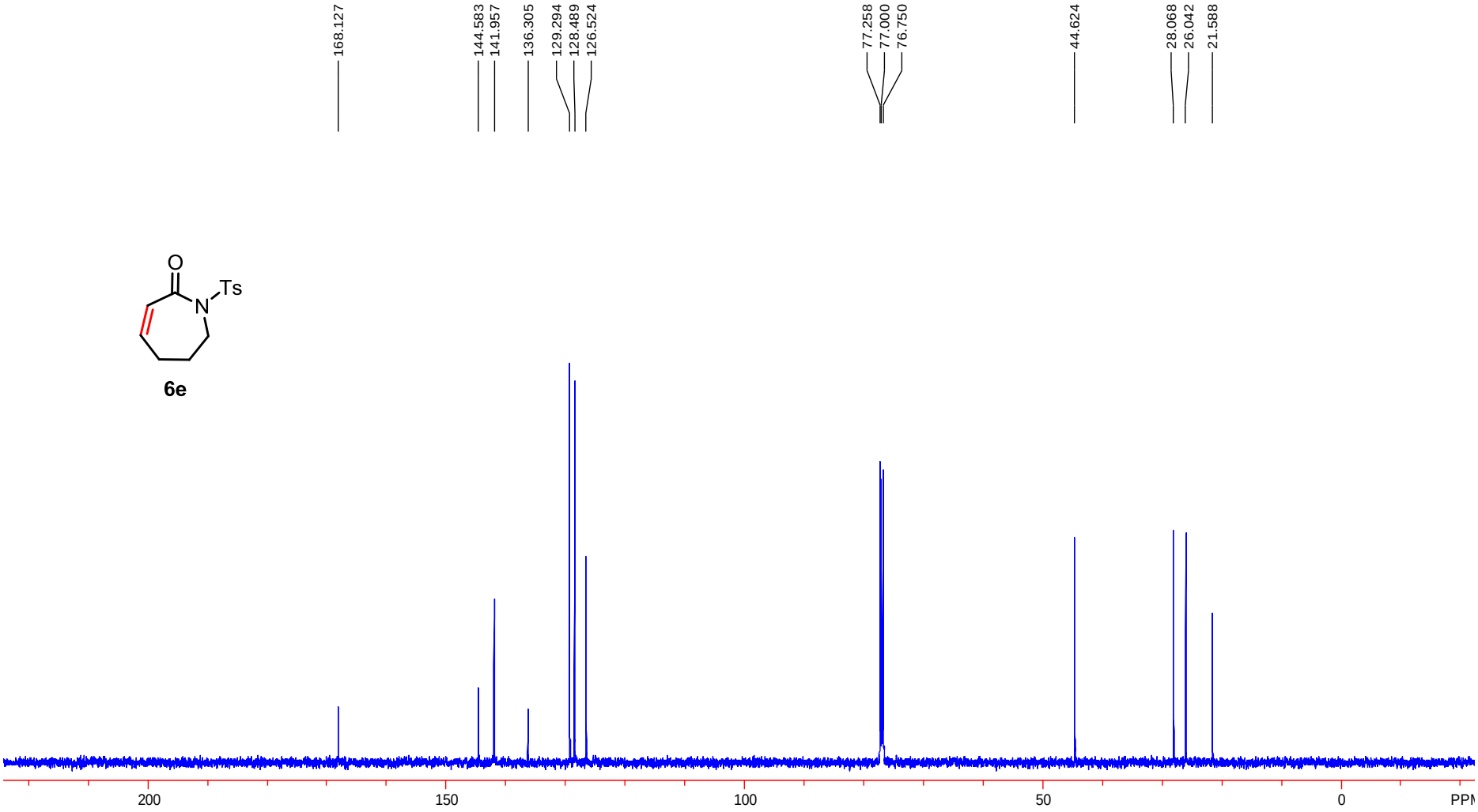
^{13}C NMR (125 MHz, $CDCl_3$)



^{1}H NMR (500 MHz, $CDCl_3$)

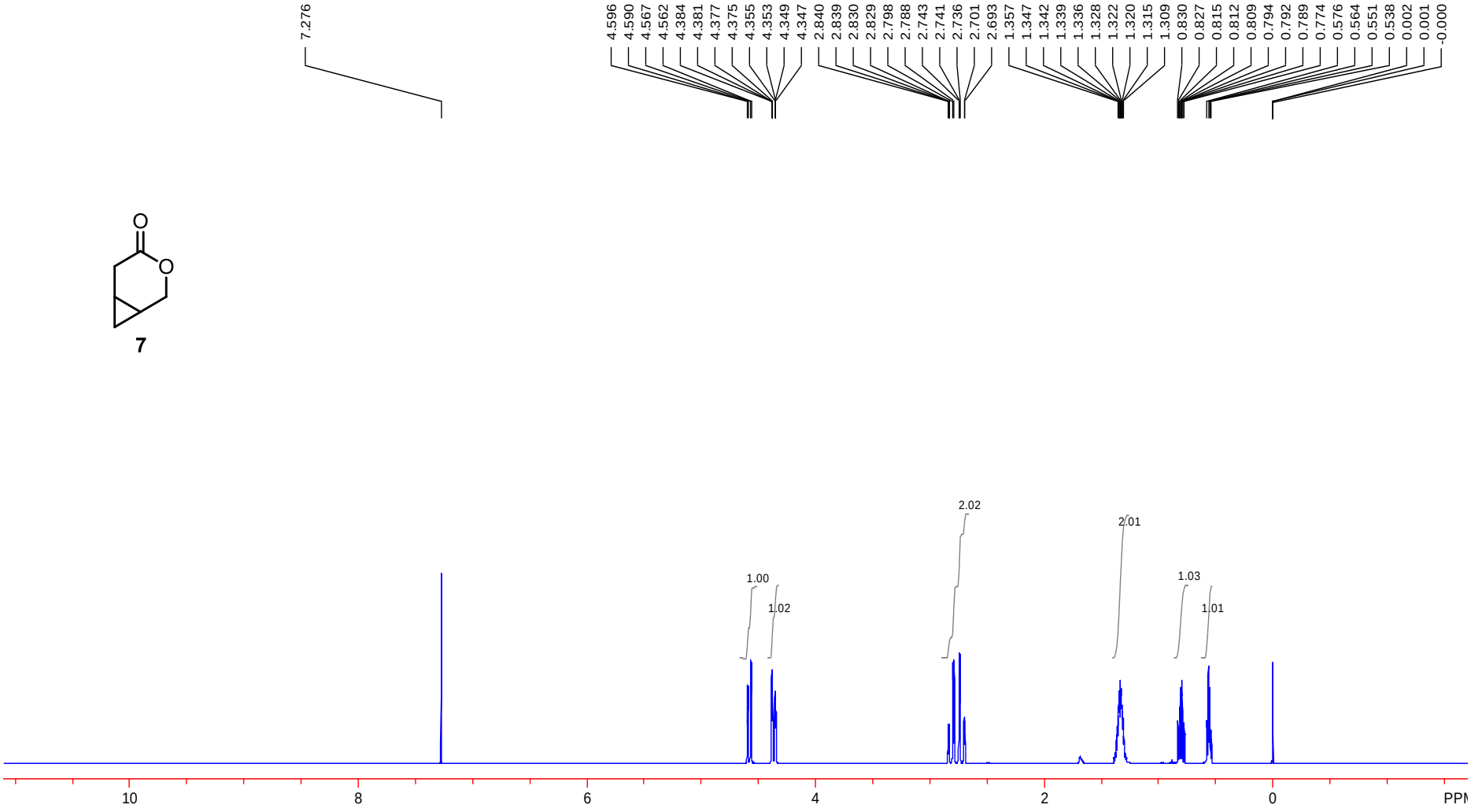


^{13}C NMR (125 MHz, $CDCl_3$)

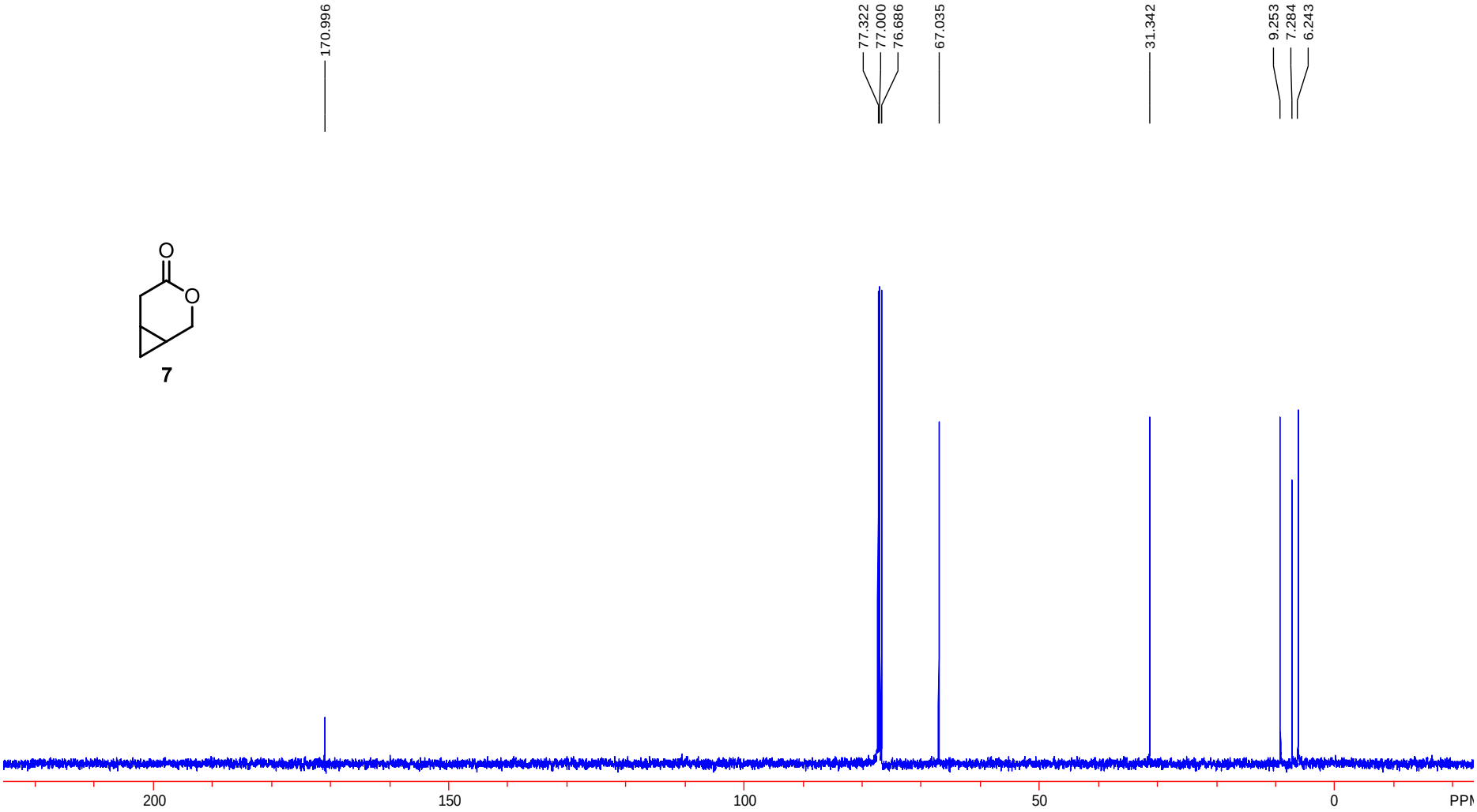


6e

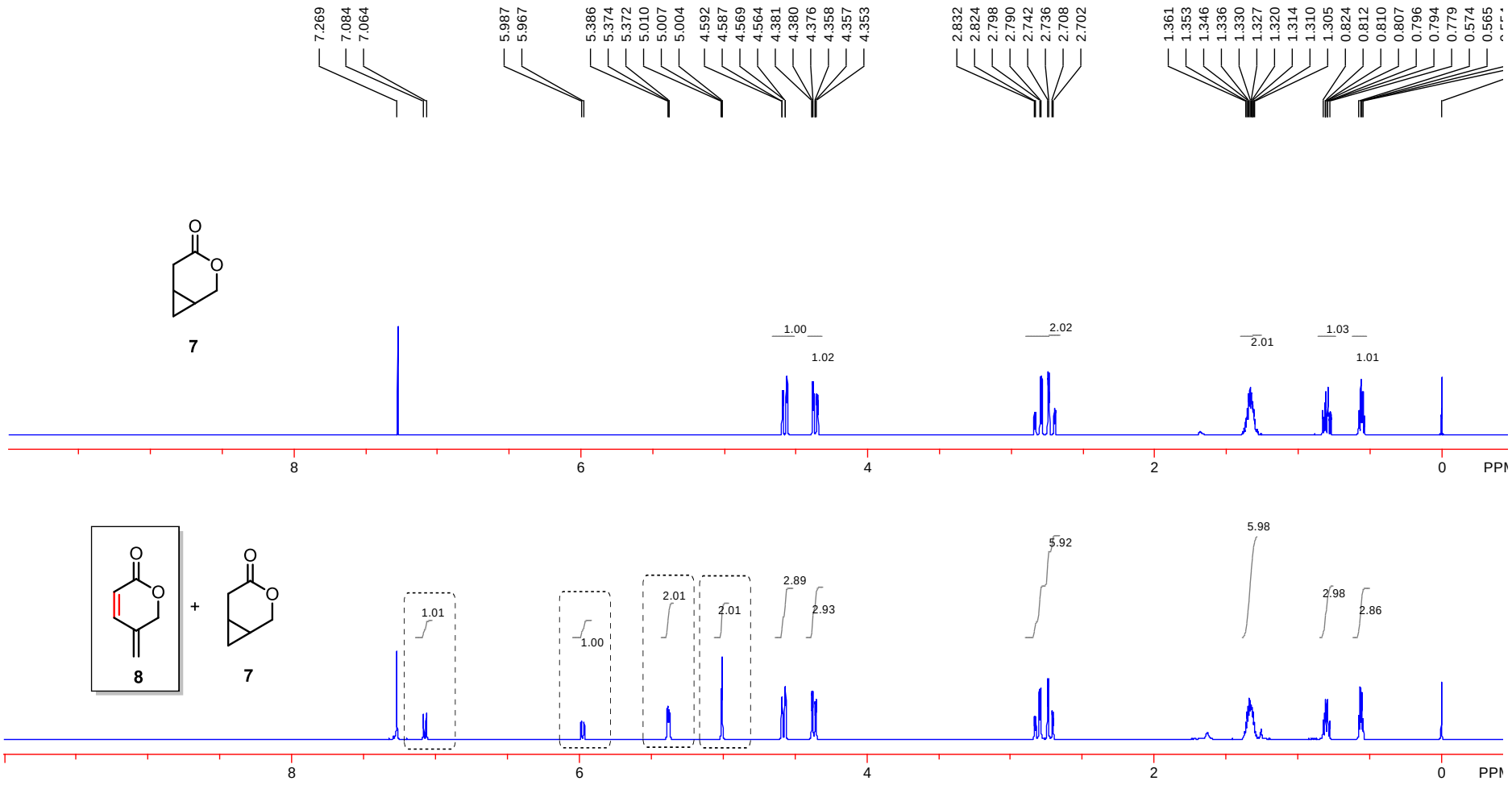
^{1}H NMR (400 MHz, $CDCl_3$)



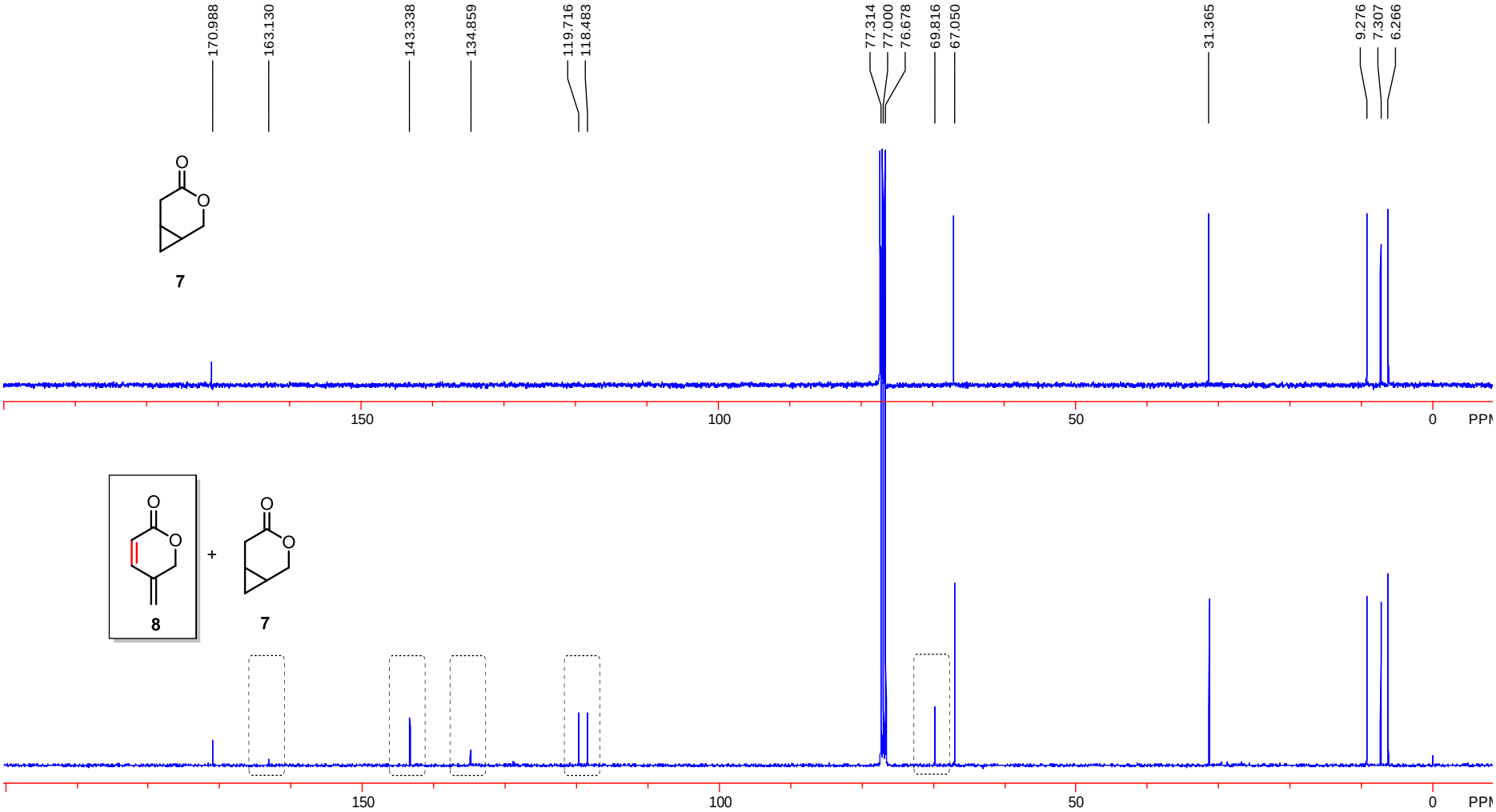
^{13}C NMR (101 MHz, $CDCl_3$)



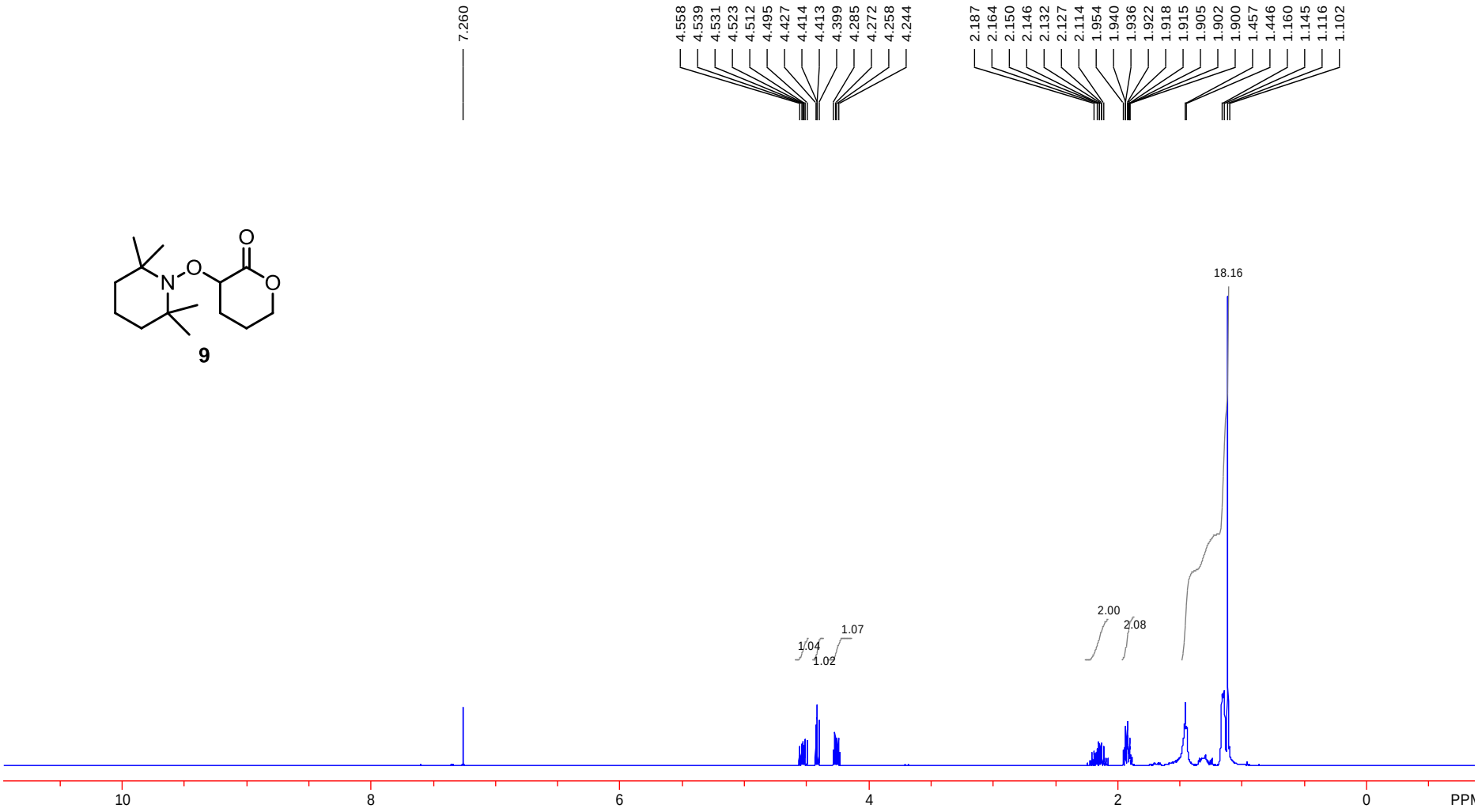
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)

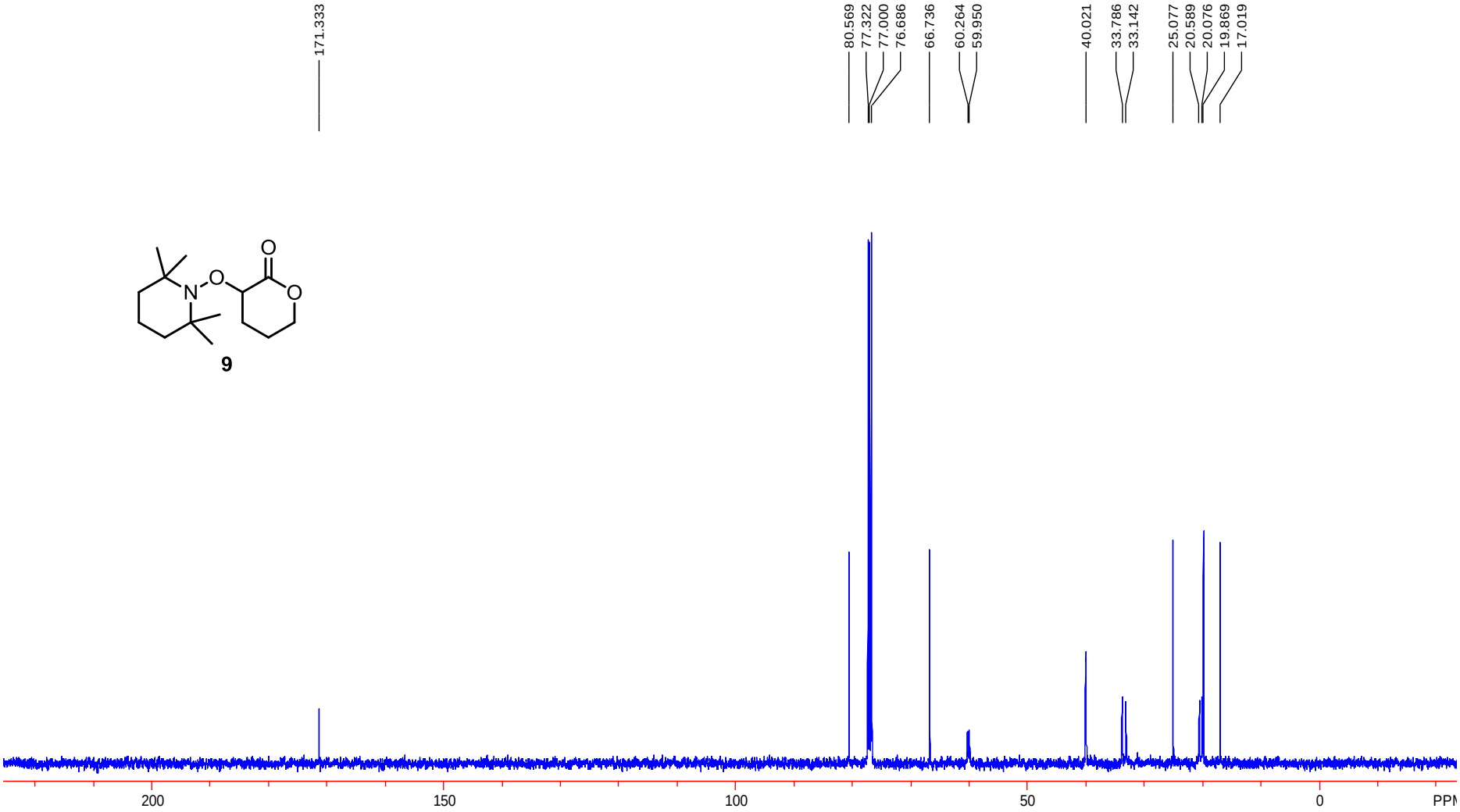


^{1}H NMR (400 MHz, $CDCl_3$)



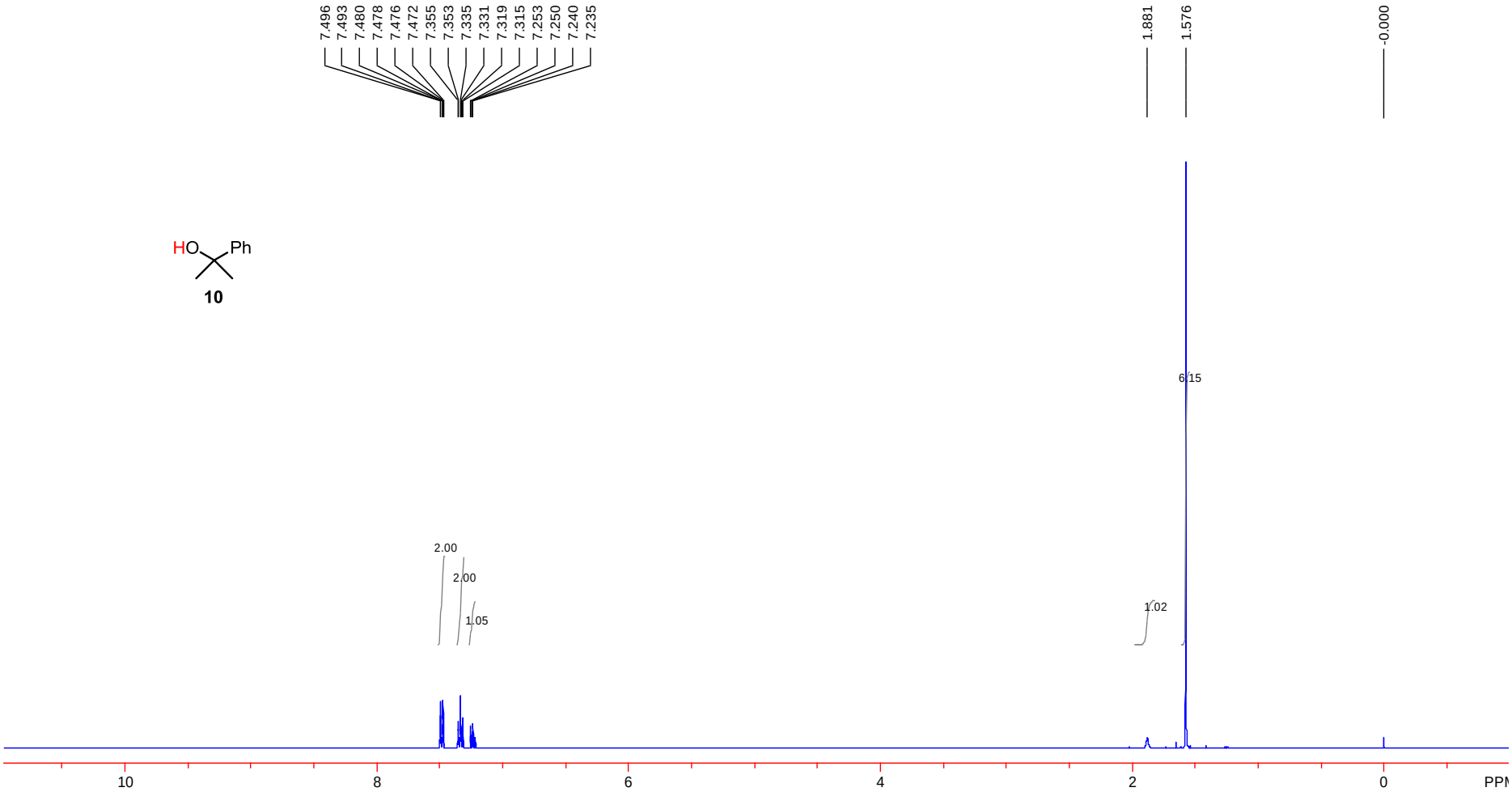
9

^{13}C NMR (101 MHz, $CDCl_3$)

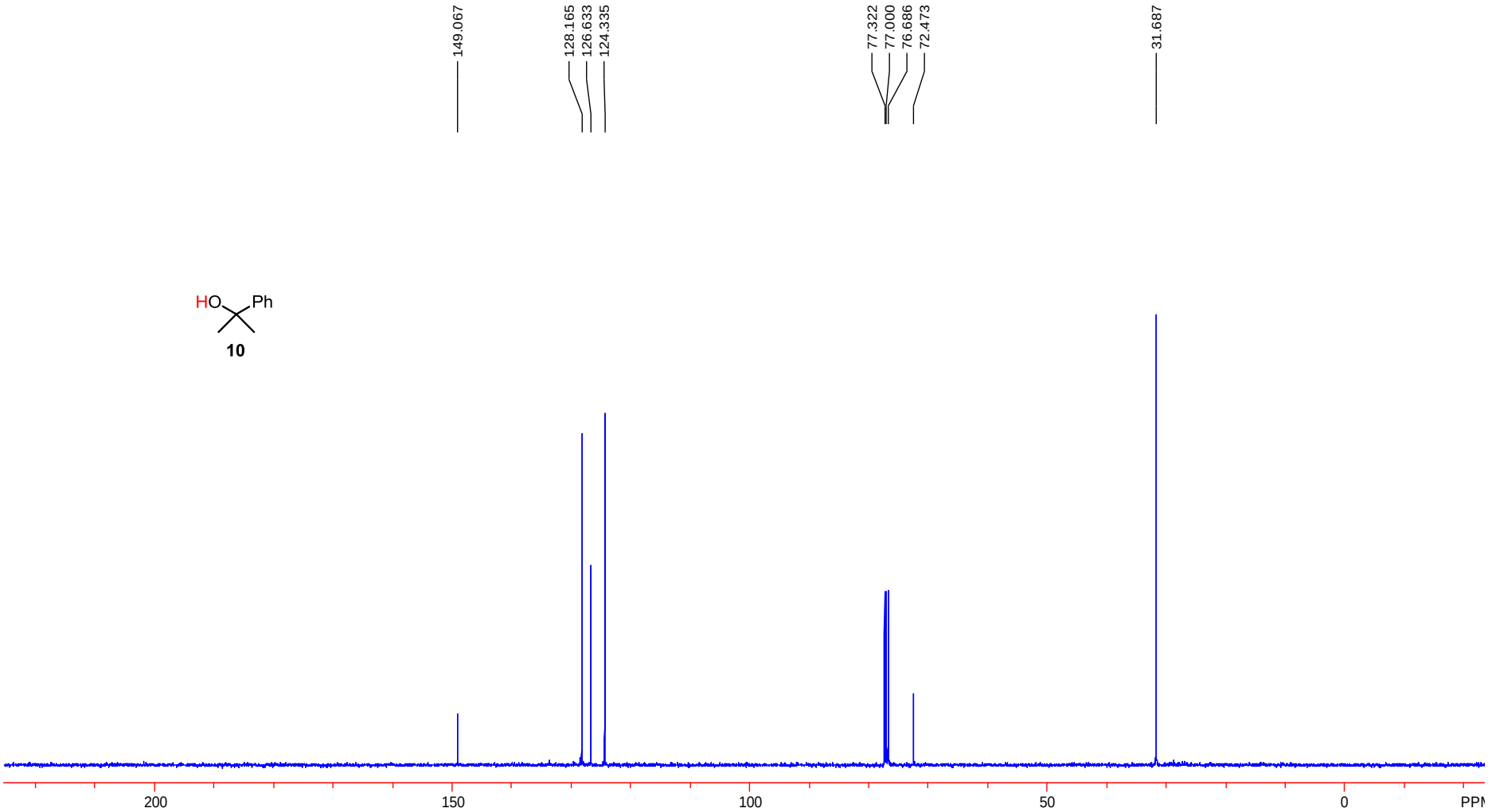


9

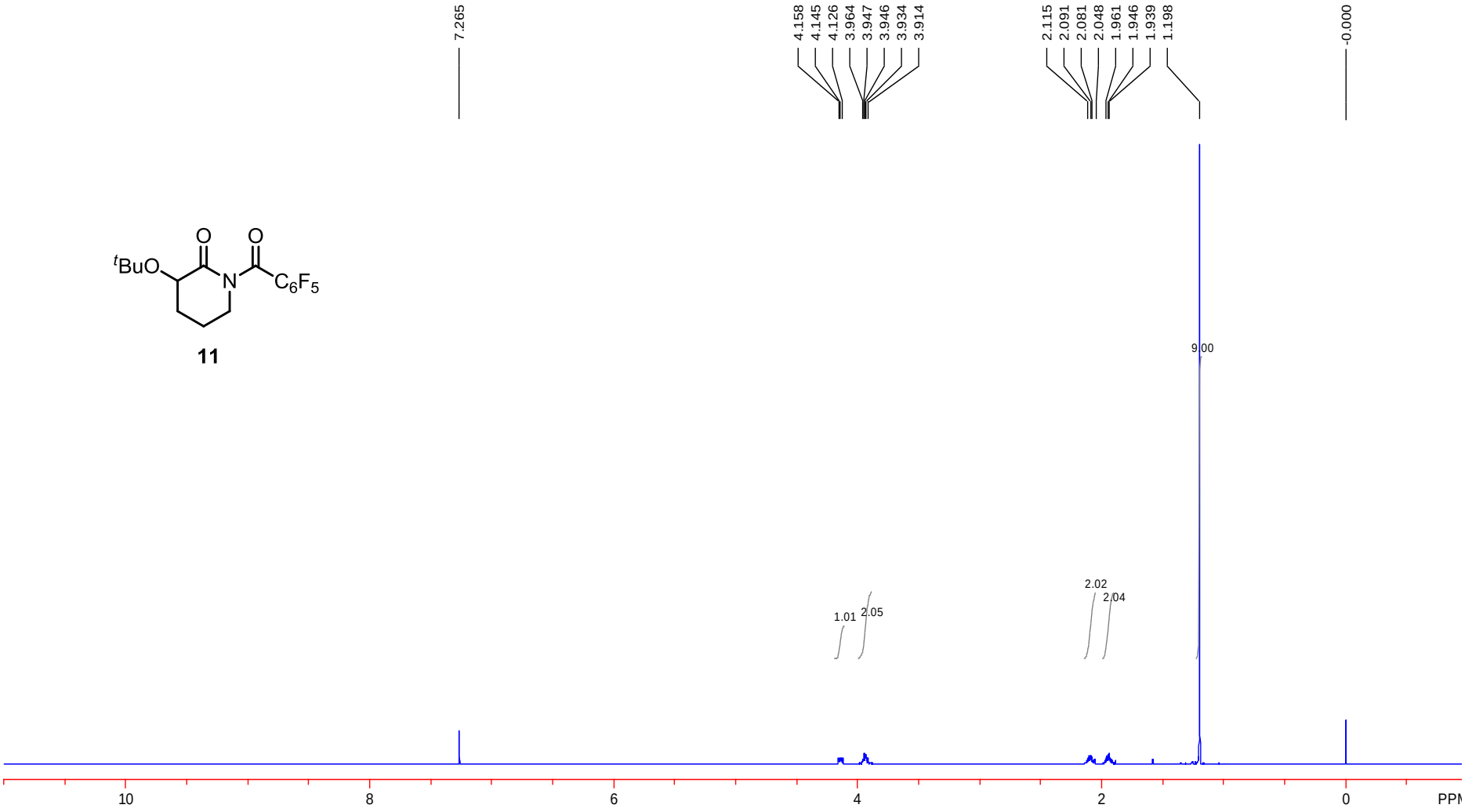
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)



^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)