Electronic Supplementary Material (ESI) for Chemical Communications

Supporting Information for

The Pauson-Khand Reaction of Medium Sized *trans*-Cycloalkenes

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Summary

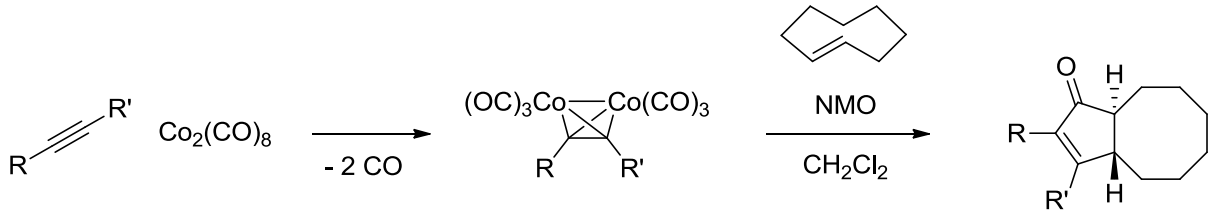
General Methods

All reactions were carried out under nitrogen atmosphere in solvents dried using a Solvent Purification System (SPS). All experiments were monitored by analytical thin layer chromatography (TLC) performed on silica gel TLC-aluminum sheets (Merck 60 F_{254}). Chromatographic purifications were carried out using a Combiflash® (Teledyne Isco) automated chromatography system. NMR spectra were recorded at room temperature on a Varian Mercury 400 apparatus. ^{1}H NMR and ^{13}C NMR spectra were referenced to tetramethylsilane and residual solvent peaks respectively. Signal multiplicities in the ^{13}C spectra have been assigned by HSQC experiments. Melting points were determined using a Büchi melting point apparatus and were not corrected. HRMS spectra were recorded using an LTQ-FT Ultra electrospray ionization spectrometer (Thermo Scientific). IR spectra were acquired on a Thermo Nicolet Nexus FT-IR apparatus. Acetone and dry ice were used to prepare low-temperature baths.

Preparation of *E*-cyclooctene and *E*-1-methylcyclooctene.

E-cyclooctene and *E*-1-methylcyclooctene were prepared from cyclooctene oxide and *Z*-1-methylcyclooctene respectively following the procedure previously described (K. J. Shea and J. S. Kim, *J. Am. Chem. Soc.*, 1992, **114**, 4846-4855) with slight modifications. After the extractive work-up of the β-hydroxyphoshpine oxide elimination reaction, the pentane layer was distilled under atmospheric pressure through a 20 cm Vigreux column to remove the solvent. The residue was then distilled under vacuum (b.p. 42-46 ^{o}C, 20 Torr) to yield the pure *trans*-alkene. Starting from 52.9 g of the pure β-hydroxyphoshpine oxide (161 mmol) 11.6 g of pure *E*-cyclooctene were obtained (65% yield). *E*-1-methylcyclooctene was obtained similarly in 56% yield from the corresponding β-hydroxyphoshpine oxide at 1 g scale (b.p. 47 ^{o}C, 17 Torr).

General procedure for the Pauson-Khand reactions.



1a-i **2a-i**

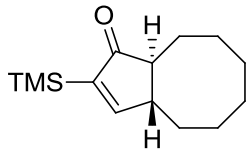
Preparation of the starting complex.

Dicobalt octacarbonyl (2.10 mmol) is weighed in a 100 mL round bottom flask and quickly dissolved in hexanes (30 mL) under a nitrogen atmosphere. An outlet for CO evolution is provided. The alkyne (2.0 mmol) or a solution of it in hexanes or ethyl acetate (ca 5 mL) is then added dropwise and the mixture is stirred for 1 – 2 h at room temperature, bubbling is observed throughout the reaction progress. The crude is filtered through a plug of neutral alumina eluting with hexanes or hexanes/ethyl acetate mixture. The solvent is removed under vacuum and the red complex obtained is used in the next step without further purification. Yields are in the 60 – 90 % range depending on the alkyne and the quality of the starting dicobalt octacarbonyl.

Pauson-Khand reaction.

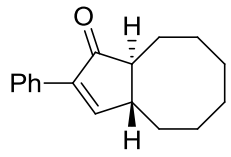
The starting dicobalt alkyne hexacarbonyl complex **1a-i** (0.7 mmol) is weighed in a 50 mL round bottom flask and dissolved in 3 mL of dry dichloromethane under nitrogen. The flask is cooled down to the required temperature and a solution of the alkene in dry dichloromethane (1 mL) is added. A solution of anhydrous *N*-methylmorpholine *N*-oxide (NMO) in 3 mL of dry dichloromethane is then added dropwise. The solution is stirred in the cooling bath for the indicated time and then the bath removed. When the flask has reached room temperature the flask is open to the air and the solution is rapidly stirred until the crude becomes purple (ca 30 min). The crude is then filtered through a short plug of silica gel (eluting with DCM or AcOEt) and the product purified by flash column chromatography using hexanes/ehtyl acetate mixtures.

(1*S,8*S**)-10-Trimethylsilyl-bicyclo[6.3.0]undec-10-en-9-one, 2a.**



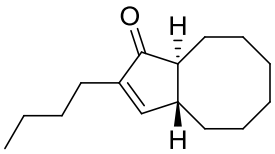
Prepared following the general procedure from 103 mg (0.268 mmol) of the dicobalt alkyne hexacarbonyl **1a** complex, 89 mg (0.808 mmol) of *trans*-cyclooctene and 188 mg (1.61 mmol) of NMO. The reaction was stirred at 0 °C for 30 min and 30 min at room temperature. The product was purified eluting with hexane/ethyl acetate (97:3), yielding 53 mg (84%) of a colourless oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.52 (d, *J* = 2.0 Hz, 1H, C*H*), 2.72 (ddd, *J* = 3.4, 5.5, 12.4 Hz, 1H, C*H*), 2.17 (m, 1H, CH_2), 2.10 (m, 1H, C*H*), 2.00 (m 1H, CH_2), 1.73-1.88 (m, 4H, CH_2), 1.37-1.60 (m, 4H, CH_2), 1.11-1.28 (m, 2H, CH_2), 1.63 (s, 9H, CH_3) ppm. ^{13}C-NMR (100 MHz, $CDCl_3$): δ 215.4 (Cq), 175.4 (CH), 144.3 (Cq), 53.0(CH), 49.0 (CH), 34.6(CH_2), 30.0 (CH_2), 27.7 (CH_2), 27.2 (CH_2), 25.8 (CH_2), 25.7 (CH_2), -1.7 (CH_3) ppm. IR (film, NaCl): ν 3372, 2917, 2847, 1700, 1572, 1444, 1246, 829 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{14}H_{25}OSi^+$ ([M+H]$^+$): 237.1669; found: 237.1673.

(1*S,8*S**)-10-Phenyl-bicyclo[6.3.0]undec-10-en-9-one, 2b.**



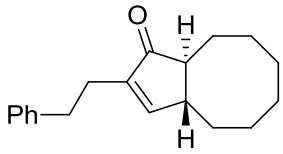
Prepared following the general procedure from 179 mg (0.461 mmol) of the dicobalt alkyne hexacarbonyl complex **1b**, 153 mg (1.38 mmol) of *trans*-cyclooctene and 324 mg (2.77 mmol) of NMO. The NMO was added at -20 °C and the bath was let to warm up to 0 °C over 1.5 h, upon which the bath was removed and the mixture further stirred for 30 min. The product was purified eluting with hexane/ethyl acetate (100:0 to 95:5), yielding 76 mg (69%) of a white solid. M.p.: 123-140 ºC. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.73 – 7.69 (m, 2H, C*H*), 7.65 (d, 1H, C*H*), 7.40 – 7.34 (m, 3H, C*H*), 2.97 (m, 1H, C*H*), 2.44 (m, 1H), 2.20 (m, 1H), 1.88 – 1.71 (m, 4H), 1.68 – 1.42 (m, 6H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ 209.6 (CO), 162.2 (CH), 141.0 (Cq), 131.8 (Cq), 128.5 (CH), 128.4 (CH), 127.2 (CH), 53.4 (CH), 45.0 (CH), 34.7 (CH_2), 30.2 (CH_2), 27.7 (CH_2), 27.1 (CH_2), 25.6 (CH_2), 25.4 (CH_2) ppm. IR (film, NaCl) ν 3033, 2917, 1688, 1590 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{17}H_{21}O^+$ ([M+H]$^+$): 241.1592; found: 241.1600.

(1*R,8*S**)-10-Butyl-bicyclo[6.3.0]undec-10-en-9-one, 2c.**



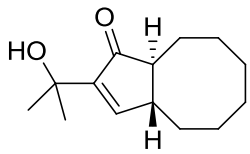
Prepared following the general procedure from 217 mg (0.590 mmol) of the dicobalt alkyne hexacarbonyl complex **1c**, 195 mg (1.77 mmol) of *trans*-cyclooctene and 414 mg (3.54 mmol) of NMO. The NMO was added at -20 °C and the bath was let to warm up to 0 °C over 1.5 h, upon which the bath was removed and the mixture further stirred for 30 min. The product was purified eluting with hexane/ethyl acetate (100:0 to 97:3), yielding 103 mg (79%) of a colourless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.05 (s, 1H, C*H*), 2.62 (d, *J* = 11.7 Hz, 1H, C*H*), 2.24 – 2.09 (m, 4H, C*H* + CH_2), 1.98 (m, 1H, C*H*), 1.81 (m, 4H, CH_2), 1.62 – 1.09 (m, 10H, CH_2), 0.9 (t, *J* = 7.3 Hz, 3H, CH_3) ppm.^{13}C NMR (100 MHz, $CDCl_3$): δ 212 (CO), 160.8 (CH), 144.1 (Cq), 52.4 (CH), 45.4 (CH), 34.98 (CH_2), 30.2 (CH_2), 30 (CH_2), 27.8 (CH_2), 27.2 (CH_2), 25.8 (CH_2), 25.5 (CH_2), 24.5 (CH_2), 22.6 (CH_2), 14.0 (CH_3) ppm. IR (film) ν 2924, 2853, 1700, 1630 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{15}H_{25}O^+$ ([M+H]$^+$): 221.18999; found: 221.18909.

(1*R,8*S**)-10-(2-hydroxypropan-2-yl)-bicyclo[6.3.0]undec-10-en-9-one, 2d.**



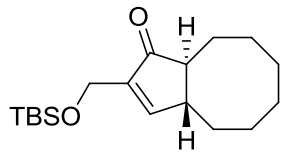
Prepared following the general procedure from 279 mg (0.670 mmol) of the dicobalt alkyne hexacarbonyl complex **1d**, 222 mg (2.01 mmol) of *trans*-cyclooctene and 471 mg (4.02 mmol) of NMO. The NMO was added at -25 °C and the bath was let to warm up to 0 °C over 1.5 h, upon which the bath was removed and the mixture further stirred for 30 min. The product was purified eluting with hexane/ethyl acetate (100:0 to 96:4), yielding 166 mg (92%) of a colourless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27 (m, 2H, CH), 7.17 (m, 3H, CH), 6.97 (s, 1H, CH), 2.79 (m, 2H, CH_2), 2.60 (d, *J* = 12.6 Hz, 1H, CH), 2.48 (m, 2H, CH_2), 2.24 – 2.09 (m, 3H, CH_2+CH), 1.92 (m, 1H, CH_2), 1.81 (m, 4H, 2 x CH_2), 1.62 – 1.37 (m, 4H, 2 x CH_2), 1.16 (m, 2H, 2 x CH_2) ppm. ^{13}C NMR (100 MHz, $CDCl_3$) δ 211.7 (CO), 161.7 (CH), 142.9 (Cq), 141.6 (Cq), 128.6 (CH), 128.4 (CH), 126.0 (CH), 52.4 (CH), 45.5 (CH), 34.8 (CH_2), 33.9 (CH_2), 30.1 (CH_2), 27.7 (CH_2), 27.1 (CH_2), 26.6 (CH_2), 25.7 (CH_2), 25.5 (CH_2) ppm. IR (film, NaCl) ν 3027, 2922, 2849, 1697, 1631, 1495, 1452, 698 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{19}H_{24}O^+$ ([M+H]$^+$): 269.1900; found: 269.1901.

(1*R,8*S**)-10-(2-hydroxypropan-2-yl)-bicyclo[6.3.0]undec-10-en-9-one, 2g.**



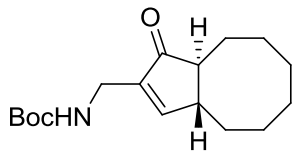
Prepared following the general procedure from 249 mg (0.673 mmol) of the dicobalt alkyne hexacarbonyl complex **1g**, 222 mg (2.01 mmol) of *trans*-cyclooctene and 473 mg (4.04 mmol) of NMO. The NMO was added at -50 °C and the bath was let to warm up to 0 °C over 2 h, upon which the bath was removed and the mixture further stirred for 30 min. The product was purified eluting with hexane/ethyl acetate (100:0 to 92:8), yielding 120 mg (80%) of a colourless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.15 (d, *J* = 2.3 Hz, 1H, CH), 3.80 (s, 1H, OH), 2.66 (dd, *J* = 12.5, 3.1 Hz, 1H, CH), 2.26 – 2.11 (m, 2H, CH+CH_2), 1.99 (m, 1H, CH_2), 1.82 (m, 4H, 2 x CH_2), 1.55 (m, 2H, CH_2), 1.42 (s, 6H, 2 x CH_3), 1.29 – 1.13 (m, 2H, 2 x CH_2) ppm. ^{13}C NMR (100 MHz, $CDCl_3$) δ 212.4 (CO), 159.3 (CH), 148.6 (Cq), 69.6 (Cq), 53.2 (CH), 44.9 (CH), 34.5 (CH_2), 29.8 (CH_2), 29.0 (CH_3), 28.9 (CH_3), 27.6 (CH_2), 27.0 (CH_2), 25.6 (CH_2), 25.2 (CH_2) ppm. IR (film, NaCl) ν 3456, 2971, 2923, 2851, 1693, 1628, 1460, 1312, 1171, 960 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{14}H_{23}O_2^+$ ($[M+H]^+$): 223.1693; found: 223.1691.

(1*S,8*R**)-10-(*tert*-Butyldimethylsiloxy)methyl-bicyclo[6.3.0]undec-10-en-9-one, 2h.**



Prepared following the general procedure from 200 mg (0.440 mmol) of the dicobalt alkyne hexacarbonyl **1h** complex, 145 mg (1.32 mmol) of *trans*-cyclooctene and 308 mg (2.63 mmol) of NMO. The reaction was stirred at 0 °C for 45 min and 2 h at room temperature. The product was purified eluting with hexane/ethyl acetate (90:10), yielding 51 mg (38%) of a pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.28 (d, *J* = 2.0 Hz, 1H, C*H*), 4.34 (m, 2H, CH_2), 2.68 (ddd, *J* = 12.1, 5.6, 2.8 Hz, 1H, C*H*), 2.20 – 1.20 (m, 13H, CH_2 + C*H*), 0.91 (s, 9H, CH_3), 0.1 (s, 6H, CH_3) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ 210.5 (Cq), 161.2 (CH), 144.0 (Cq), 58.4 (CH), 53.2 (CH), 45.7 (CH_2), 34.7 (CH_2), 30.0 (CH_2), 28.0 (CH_2), 27.1 (CH_2), 26.0 (CH_3), 25.8 (CH_2), 25.5 (CH_2), 18.5 (Cq), -5.3 (CH_3) ppm. IR (film, NaCl) ν 2924, 2853, 1701, 1256, 1108, 839 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{18}H_{33}O_2Si^+$ ($[M+H]^+$) 309.2244, found: 309.2236.

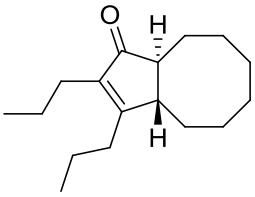
(1*R,8*S**)-10-(*N-tert*-Butoxycarbonyl)aminomethyl-bicyclo[6.3.0]undec-10-en-9-one, 2f.**



Prepared following the general procedure from 201 mg (0.456 mmol) of the dicobalt alkyne hexacarbonyl complex **1f**, 151 mg (1.37 mmol) of *trans*-cyclooctene and 320 mg (2.73 mmol) of NMO. The NMO was added at -45 °C and the bath was let to warm up to 0 °C over 2 h, upon which the bath was removed and the mixture further stirred for 30 min. The product was purified eluting with hexane/ethyl acetate (100:0 to 90:10), yielding 131 mg (98%) of a pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.25 (s, 1H, C*H*), 5.02 (s, 1H, N*H*), 3.90 (d, *J* = 4.8 Hz, 2H, CH_2), 2.70 (d, *J* = 12.4, 1.7 Hz, 1H, C*H*), 2.22 – 2.13 (m, 2H, *CH* + CH_2), 1.99 (m, 1H, CH_2), 1.81 (m, 4H, CH_2), 1.60-1.50 (m, 2H, CH_2), 1.45 (s, 11H, CH_2 + CH_3) ppm.^{13}C NMR (100 MHz, $CDCl_3$): δ 211.2 (CO), 162.6 (CO), 156.0 (C*H*), 140.5 (Cq), 79.6 (Cq), 52.7 (CH), 51.2***** (CH), 45.6 (CH), 44.8***** (CH), 36.3 (CH_2), 34.5 (CH_2), 31.2 (CH_2), 30.4***** (CH_2), 29.9 (CH_2), 28.5 (CH_3), 27.6 (CH_2), 27.0***** (CH_2), 26.0 (CH_2), 25.9***** (CH_2) 25.6 (CH_2), 25.3***** (CH_2) ppm. IR (film, NaCl) ν 3353, 2971, 2920, 2847, 1701, 1639 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{17}H_{28}NO_3^+$ ([M+H]$^+$): 294.2064; found: 294.2055.

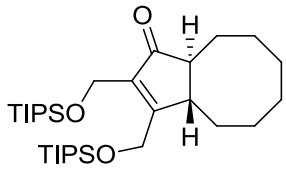
(*: Doubled resonances arising from amide rotamers).

(1*S,8*S**)-10,11-Dipropyl-bicyclo[6.3.0]undec-10.-en-9-one, 2e.**



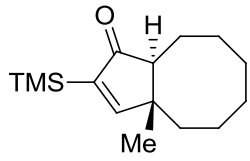
Prepared following the general procedure from 247 mg (0.624 mmol) of the dicobalt alkyne hexacarbonyl complex **1e**, 206 mg (1.87 mmol) of *trans*-cyclooctene and 438 mg (3.74 mmol) of NMO. The NMO was added at -20 °C and the bath was let to warm up to 0 °C over 1.5 h, upon which the bath was removed and the mixture further stirred for 30 min. The product was purified eluting with hexane/ethyl acetate (100:0 to 98:2), yielding 121 mg (78%) of a colourless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.58 (d, *J* = 12.3 Hz, 1H, C*H*), 2.41 (ddd, *J* = 13.6, 9.4, 7.1 Hz, 1H, C*H*), 2.28 (m, 1H, C*H*), 2.19 – 1.95 (m, 5H, C*H* + CH_2), 1.84 – 1.66 (m, 4H, CH_2), 1.63 – 1.29 (m, 8H, CH_2), 1.06 (m, 2H, CH_2), 0.93 (t, *J* = 7.4 Hz, 3H, CH_3), 0.84 (t, *J* = 7.4 Hz, 3H, CH_3) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ 211.1 (CO), 175.6 (Cq), 138.8 (Cq), 50.8 (CH), 46.2 (CH), 32.8 CH_2), 30.8 (CH_2), 30.3 (CH_2), 27.5 (CH_2), 27.2 (CH_2), 25.2 (CH_2), 25.1 (CH_2), 25.1 (CH_2), 22.0 (CH_2), 21.0 (CH_2), 14.4 (CH_3), 14.12 (CH_3) ppm. IR (film, NaCl) ν 2956, 2924, 2867, 1694, 1636, 1451, 1361 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{17}H_{29}O^+$ ([M+H]$^+$): 241.2213; found: 241.2211.

(1*S,8*S**)-10,11-Bis(triisopropylsiloxymethyl)-bicyclo[6.3.0]undec-10-en-9-one, 2i.**



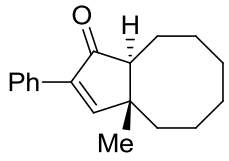
Prepared following the general procedure from 249 mg (0.364 mmol) of the dicobalt alkyne hexacarbonyl complex **1i**, 120 mg (1.09 mmol) of *trans*-cyclooctene and 256 mg (2.18 mmol) of NMO. The NMO was added at -30 ^{o}C and the bath was let to warm up to 0 ^{o}C over 2 h, upon which the bath was removed and the mixture further stirred for 30 min. The product was purified eluting with hexane/ethyl acetate (100:0 to 98:2), yielding 168 mg (86%) of a colourless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.16 (d, *J* = 15.6 Hz, 1H, CH_2), 4.66 (d, *J* = 15.6 Hz, 1H, CH_2), 4.48 (d, *J* = 13.2 Hz, 1H, CH_2), 4.31 (dt, *J* = 13.2, 1.6 Hz, 2H, CH_2), 3.02 (d, *J* = 12.1 Hz, 1H, C*H*), 2.40 (m, 1H, CH_2), 2.22 – 2.12 (m, 2H, C*H* + CH_2), 1.89 – 1.69 (m, 4H, CH_2), 1.65 – 1.43 (m, 4H, CH_2), 1.35 – 0.95 (m, 44H, CH_3 + CH_2 + C*H*) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ ^{13}C NMR (101 MHz, cdcl$_3$) δ 209.7 (CO), 178.2 (Cq), 135.8 (Cq), 60.3 (CH_2), 56.2 (CH_2), 51.2 (CH), 45.6 (CH), 32.8 (CH_2), 30.7 (CH_2), 27.6 (CH_2), 27.4 (CH_2), 25.6 (CH_2), 25.5 (CH_2), 18.1 (CH_3), 12.1 (CH), 12.0 (CH) ppm. IR (film, NaCl) ν 2933, 2865, 1700, 1651, 1463, 1095, 883, 685 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{31}H_{61}O_3Si_2^+$ ([M+H]$^+$): 537.4154; found: 537.4153.

(1*S,8*S**)-1-Methyl-10-trimethylsilyl-bicyclo[6.3.0]undec-10-en-9-one, 5a.**



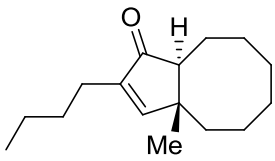
Prepared following the general procedure from 116 mg (0.302 mmol) of the dicobalt alkyne hexacarbonyl complex **1a**, 41 mg (0.330 mmol) of *trans*-1-methylcyclooctene and 212 mg (1.81 mmol) of NMO. The reaction was stirred at 0 ^{o}C for 30 min and 1 h at room temperature. The product was purified eluting with hexane/ethyl acetate (100:0 to 95:5), yielding 47 mg (62%) of a white solid. M.p.: 69-74 ºC. ^{1}H NMR (400 MHz, $CDCl_3$): δ7.39 (s, 1H, C*H*), 2.1 (m, 1H, C*H*), 1.75 (m, 6H, CH_2), 1.25 (m, 6H, CH_2), 1.00 (s, 3H, CH_3), 0.16 (s, 9H, CH_3) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ 215 (CO), 180 (CH), 140 (Cq), 58 (CH), 48 (Cq), 42 (CH_2), 29.5 (CH_2), 29 (CH_2), 28.5 (CH_2), 25 (CH_2), 24 (CH_2), 22.5 (CH_3), -1.5 (CH_3) ppm. IR (film, NaCl): ν 2955, 2923, 2846, 1687, 1578, 1444, 1232, 835 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{15}H_{26}NaOSi^+$ ([M+Na]$^+$): 273.1645; found: 273.1647.

(1*R,8*S**)-10-Phenyl-1-methyl-bicyclo[6.3.0]undec-10-en-9-one, 5b.**



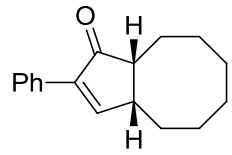
Prepared following the general procedure from 100 mg (0.27 mmol) of the dicobalt alkyne hexacarbonyl complex **1b**, 49 mg (0.40 mmol) of *trans*-1-methylcyclooctene and 186 mg (1.59 mmol) of NMO. The reaction was stirred at 0 °C for 30 min and 3 h at room temperature. The product was purified eluting with hexane/ethyl acetate (100:0 to 95:5), yielding 17 mg (27%) of a pale yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.72 (d, *J* = 7.4 Hz, 2H, C*H*), 7.49 (s, 1H, C*H*), 7.41 – 7.30 (m, 3H, C*H*), 2.40 (d, *J* = 9.6 Hz, 1H, C*H*), 2.30 (m, 1H, C*H*), 2.06 – 1.78 (m, 5H, CH_2), 1.67 – 1.32 (m, 4H, CH_2), 1.24 (m, 2H, CH_2), 1.13 (s, 3H, CH_3) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ 208.7 (CO), 167.5 (CH), 162.5 (Cq), 138.3 (CH), 131.8 (Cq), 128.5 (CH), 128.4 (CH), 127.2 (CH), 59.3 (CH), 58.0 (CH), 44.5, 42.5 (CH_2), 29.0 (CH_2), 28.8 (CH_2), 28.5 (CH_2), 24.9 (CH_2), 24.4 (CH_2), 22.7 (CH_3) ppm. IR (film, NaCl) ν 3020, 2917, 2853, 1707, 1598 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{18}H_{23}O^+$ ([M+H]+): 255.1743; found: 255.1736.

(1*R,8*S**)-10-Butyl-1-methyl-bicyclo[6.3.0]undec-10-en-9-one, 5c.**



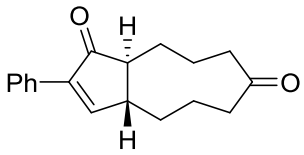
Prepared following the general procedure from 125 mg (0.34 mmol) of the dicobalt alkyne hexacarbonyl complex **1c**, 60 mg (0.51 mmol) of *trans*-1-methylcyclooctene and 240 mg (2.04 mmol) of NMO. The reaction was stirred at 0 °C for 30 min and 3 h at room temperature. The product was purified eluting with hexane/ethyl acetate (100:0 to 95:5), yielding 30 mg (43%) of a pale yellow oil mixture of the 2 regioisomers (3.3:1 ratio by ^{1}H NMR). From this mixture a pure fraction of the major isomer (**5c**) can be isolated by careful chromatography. ^{1}H NMR (400 MHz, $CDCl_3$): δ 6.92 (s, 1H, C*H*), 2.24 – 2.08 (m, 5H, 2 x CH_2 + C*H*), 2.14 (m, 2H, CH_2), 1.87 - 1.39 (m, 8H, 4 x CH_2), 1.01 (s, 3H, CH_3), 0.90 (t, *J* = 7.3 Hz, 3H, CH_3) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): 211.0 (Cq), 166.5 (CH), 141.0 (Cq), 56.9 (CH), 44.6 (Cq), 42.5 (CH_2), 29.8 (CH_2), 28.6 (CH_2), 29.1 (CH_2) 28.4 (CH_2), 24.9 (CH_2), 24.3 (CH_2), 24.1 (CH_2), 22.7 (CH_2), 22.4 (CH_3), 13.9 (CH_3). IR (film, NaCl) ν 2949, 2917, 2853, 1693, 1457 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{16}H_{26}ONa^+$ ([M+Na]$^+$): 257.1876; found: 257.1879.

(1*R,8*R**)-10-Phenyl-bicyclo[6.3.0]undec-10-en-9-one, 4b.**



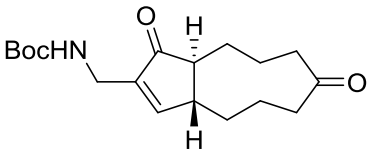
Prepared following the general procedure from 100 mg (0.26 mmol) of the dicobalt alkyne hexacarbonyl complex **1b**, 187 mg (1.70 mmol) of *cis*-cyclooctene and 180 mg (1.55 mmol) of NMO. The reaction was stirred at 0 ^{o}C for 1 h and 2 days at room temperature. The product was purified eluting with hexane/ethyl acetate (100:0 to 95:5), yielding 11 mg (18%) of a pale brown solid. M.p: 93-100 ºC. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.71 (d, *J* = 6.9 Hz, 2H), 7.61 (d, *J* = 2.6 Hz, 1H), 7.40 – 7.29 (m, 3H), 2.79 (dt, *J* = 12.3, 1H), 2.35 (m, 1H), 2.28 (m,1H), 2.08 (m, 1H), 1.85 – 1.84 (m, 4H), 1.60 (m, 2H),1.48 (m, 2H), 1.30 (m, 2H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ 209.6 (CO), 162.2 (CH), 140.9 (Cq), 131.8 (Cq), 128.5 (CH), 127.3 (CH), 124.6 (CH), 124.1(CH), 119.2 (CH), 53.5 (CH), 45.06 (CH), 34.8 (CH_2), 31.6 (CH), 30.3 (CH), 30.3 (CH_2), 29.9 (CH_2), 27.7 (CH_2), 27.1 (CH_2), 25.7 (CH_2), 25.4 (CH_2) ppm. IR (film, NaCl) ν 3039, 2917, 1688, 1600 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{17}H_{21}O^{+}$ ([M+H]$^{+}$): 241.1587; found: 241.1580.

(1*R,9*S**)-11-Phenyl-bicyclo[7.3.0]dodec-11-en-5,10-dione, 7b.**



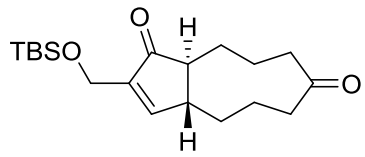
Prepared following the general procedure from 183 mg (0.472 mmol) of the dicobalt alkyne hexacarbonyl complex **1b**, 195 mg (1.41 mmol) of (*E*)-cyclonon-5-en-1-one and 331 mg (2.83 mmol) of NMO. The NMO was added at -20 ^{o}C and the bath was let to warm up to 0 ^{o}C over 2 h, upon which the bath was removed and the mixture further stirred for 30 min. The product was purified eluting with hexane/ethyl acetate (95:5 to 85:15), yielding 55 mg (18%) of an off-white solid. M.p.: 66-69 ºC. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.70 – 7.62 (m, 2H, CH), 7.56 (d, *J* = 2.9 Hz, 1H, CH), 7.41 – 7.27 (m, 3H, CH), 2.65 (m, 2H, CH_2), 2.60 – 2.46 (m, 3H, CH_2+CH), 2.30 (m, 1H, CH_2), 2.24 – 2.01 (m, 5H, CH_2), 1.46 – 1.29 (m, 2H, CH_2) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ 215.5 (CO), 208.9 (CO), 162.2 (CH), 140.4 (Cq), 131.4 (Cq), 128.6 (CH), 128.5 (CH), 127.3 (CH), 53.7 (CH), 45.1 (CH), 43.1 (CH_2), 43.0 (CH_2), 33.9 (CH_2), 30.5 (CH_2), 24.9 (CH_2), 24.2 (CH_2) ppm. IR (film, NaCl) ν 3054, 2930, 2856, 1699, 1447, 1306, 1130, 763, 696 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{18}H_{21}O_2$ ([M+H]$^{+}$): 269.15361; found: 269.15370.

(1*R,9*S**)-11-(*N-tert*-Butoxycarbonyl)aminomethyl-bicyclo[7.3.0]dodec-11-en-5,10-dione, 7f.**



Prepared following the general procedure from 134 mg (0.304 mmol) of the dicobalt alkyne hexacarbonyl complex **1f**, 126 mg (0.911 mmol) of (*E*)-cyclonon-5-en-1-one and 214 mg (1.82 mmol) of NMO. The NMO was added over the DCM solution containing the complex and the alkene at -20 ^{o}C, at a rate of 3 mL/h. The temperature was kept constant throughout the addition. The mixture was further stirred at -20 ^{o}C for 30 min and then let to reach room temperature. After the regular work-up the product was purified eluting with hexane/ethyl acetate (90:10 to 80:20), yielding 65 mg (67%) of a pale brown oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.21 (s, 1H, CH), 5.00 (s, 1H, NH), 3.86 (d, J = 5.2 Hz, 2H, CH_2), 2.68 – 2.47 (m, 4H, CH_2), 2.46 (m, 1H, CH), 2.25 – 1.95 (m, 5H, CH_2), 1.94 (dt, J = 10.4, 2.5 Hz, 1H, CH_2), 1.43 (s, 9H, CH_3), 1.34 – 1.20 (m, 2H, CH_2) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ215.3 (CO), 210.5 (CO), 162.8 (CH), 155.9 (CO), 140.1 (Cq), 79.7 (Cq), 53.0 (CH), 45.9 (CH), 43.1 (CH_2), 42.9 (CH_2), 36.1 (CH_2), 33.6 (CH_2), 30.2 (CH_2), 28.5 (CH_3), 24.9 (CH_2), 24.2 (CH_2) ppm. IR (film, NaCl) ν 3356, 2973, 2930, 2864, 1698, 1644, 1519, 1365, 1249, 1171 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{18}H_{28}NO_4$ ([M+H]$^{+}$): 322.20129; found: 322.20142.

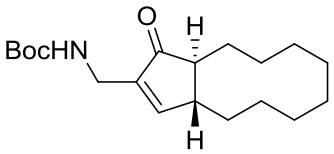
(1*R,9*S**)-11-(*tert*-Butyldimethylsiloxy)methyl-bicyclo[7.3.0]dodec-11-en-5,10-dione, 7h.**



Prepared following the general procedure from 293 mg (0.642 mmol) of the dicobalt alkyne hexacarbonyl complex **1h**, 266 mg (1.92 mmol) of (*E*)-cyclonon-5-en-1-one and 451 mg (3.85 mmol) of NMO. The NMO was added over the DCM solution containing the complex and the alkene at -20 ^{o}C, at a rate of 3 mL/h. The temperature was kept constant throughout the addition. The mixture was further stirred at -20 ^{o}C for 30 min and then let to reach room temperature. After the regular work-up the product was purified eluting with hexane/ethyl acetate (90:10 to 80:20), yielding 132 mg (61%) of a pale brown oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.24 (dd, J = 2.1, 2.1 Hz, 1H, CH), 4.31 (m, 2H, CH_2), 2.61 – 2.41 (m, 5H, CH+CH_2), 2.23 – 1.98 (m, 6H, CH_2), 1.95 (ddd, J = 10.3, 3.1, 1.9 Hz, 1H, CH), 1.35 – 1.21 (m, 2H, CH_2), 0.90 (s, 9H, CH_3), 0.06 (s, 6H, CH_3) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ215.3 (CO), 209.8 (CO), 161.4 (CH), 143.5 (Cq), 58.3 (CH_2), 53.5 (CH), 45.9 (CH), 43.0 (CH_2), 42.9 (CH_2), 33.8 (CH_2), 30.2 (CH_2), 26.0 (CH_3), 24.9 (CH_2), 24.2 (CH_2), 18.4 (Cq), -5.3 (CH_3) ppm. IR (film,

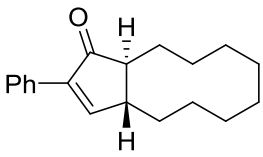
NaCl) ν 2956, 2929, 2856, 1700, 1646, 1473, 1254, 1116, 837, 776 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{19}H_{33}O_3Si$ ($[M+H]^+$): 337.21935; found: 337.21945.

(1*R,10*S**)-12-(*N-tert*-Butoxycarbonyl)aminomethyl-bicyclo[8.3.0]tridec-12-en-11-one, 8f.**



Prepared following the general procedure from 204 mg (0.462 mmol) of the dicobalt alkyne hexacarbonyl complex **1f**, 192 mg (1.39 mmol) of (*E*)-cyclodecene and 330 mg (2.82 mmol) of NMO. The NMO was added over the DCM solution containing the complex and the alkene at -20 °C, at a rate of 3 mL/h. The temperature was kept constant throughout the addition. The mixture was further stirred at -20 °C for 30 min and then let to reach room temperature. After the regular work-up the product was purified eluting with hexane/ethyl acetate (90:10 to 80:20), yielding 96 mg (65%) of a pale brown oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.29 (s, 1H, CH), 5.03 (bs, 1H, NH), 3.88 (d, *J* = 5.2 Hz, 2H, CH_2), 2.77 (d, *J* = 10.4 Hz, 1H, CH), 2.33 (dd, *J* = 10.4, 5.7 Hz, 1H, CH), 1.91 (m, 1H, CH_2), 1.82 (m, 1H, CH_2), 1.71 – 1.48 (m, 10H, CH_2), 1.44 (s, 9H, CH_3), 1.44 – 1.18 (m, 4H, CH_2) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ 212.5 (CO), 163.2 (CH), 156.0 (CO), 139.6 (Cq), 79.6 (Cq), 50.6 (CH), 44.6 (CH), 36.3 (CH_2), 33.6 (CH_2), 30.7 (CH_2), 28.5 (CH_3), 26.2 (CH_2), 26.0 (CH_2), 25.8 (CH_2), 24.4 (CH_2), 24.0 (CH_2) ppm. IR (film, NaCl) ν 3355, 2926, 2867, 1699, 1640, 1514, 1152, 1052 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{19}H_{32}NO_3$ ($[M+H]^+$): 322.23767; found: 322.23785.

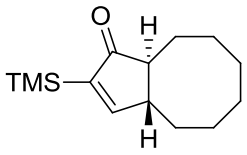
(1*R,10*S**)-12-Phenyl-bicyclo[8.3.0]tridec-12-en-11-one, 8b.**



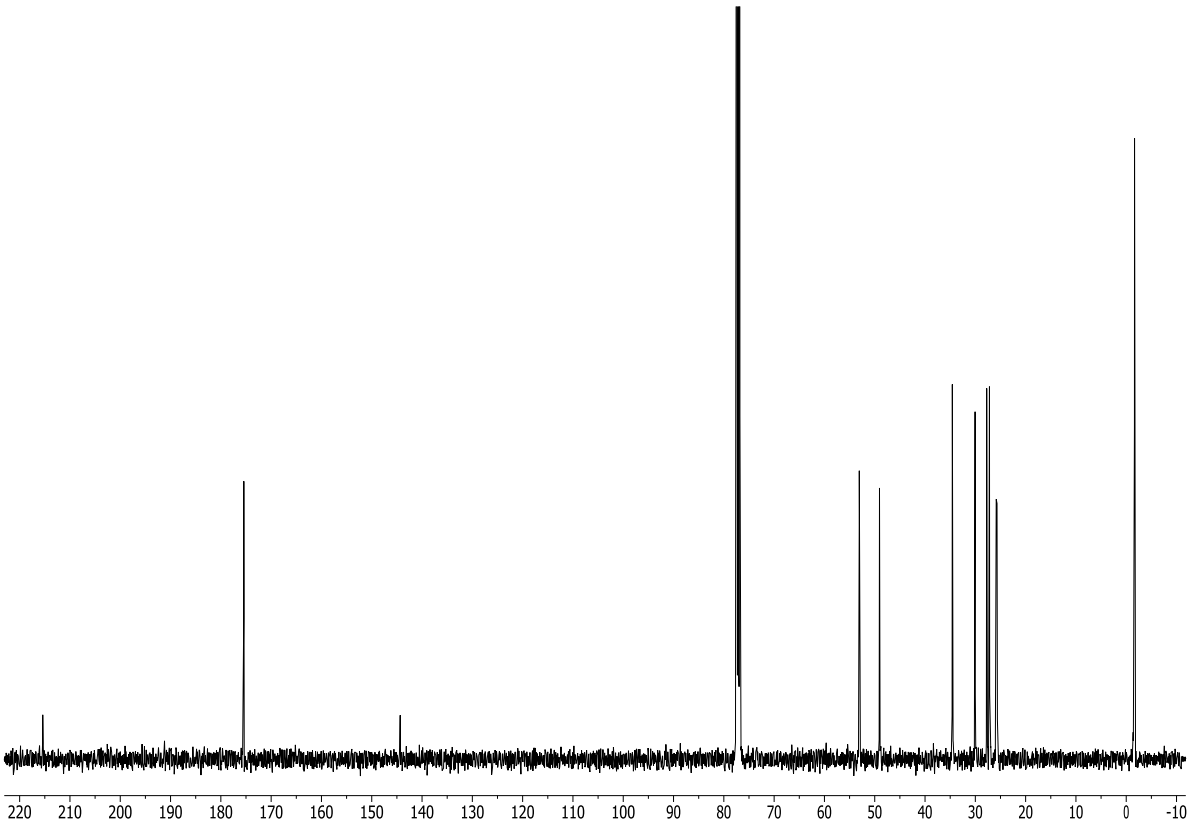
Prepared following the general procedure from 239 mg (0.616 mmol) of the dicobalt alkyne hexacarbonyl complex **1b**, 255 mg (1.85 mmol) of (*E*)-cyclodecene and 433 mg (3.70 mmol) of NMO. The NMO was added over the DCM solution containing the complex and the alkene at -20 °C, at a rate of 3 mL/h. The temperature was kept constant throughout the addition. The mixture was further stirred at -20 °C for 30 min and then let to reach room temperature. After the regular work-up the product was purified eluting with hexane/ethyl acetate (90:10 to 80:20), yielding 31 mg (19%) of an off-white solid. M.p.: 44-47 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.74 – 7.67 (m, 2H, CH), 7.66 (d, *J* = 2.9 Hz, 1H, CH), 7.42 – 7.28 (m, 3H, CH), 2.86 (m, 1H, CH), 2.50 (ddd, *J* = 10.1, 5.2, 1.7 Hz, 1H, CH), 2.03 (m, 1H, CH_2), 1.91 (m, 1H, CH_2), 1.81 – 1.51 (m, 10H, CH_2), 1.51 – 1.39 (m, 3H, CH_2), 1.33 (m, 1H, CH_2) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ 210.7 (CO), 162.7 (CH), 140.1 (Cq), 131.9 (Cq), 128.5 (CH), 128.4 (CH), 127.2 (CH), 51.4 (CH), 43.8 (CH),

33.8 (CH_2), 31.1 (CH_2), 26.3 (CH_2), 26.2 (CH_2), 26.0 (CH_2), 25.8 (CH_2), 24.5 (CH_2), 24.1 (CH_2) ppm. IR (film, NaCl) ν 2926, 2864, 2847, 1700, 1492, 1470, 1444, 1302, 1130, 694 cm^{-1}. HRMS (ESI) *m/z* calcd. for $C_{19}H_{25}O$ ($[M+H]^+$): 269.18999; found: 269.19006.

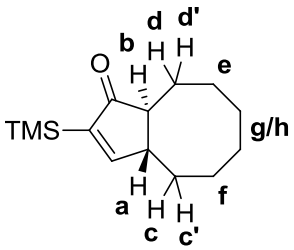
^{1}H and ^{13}C spectra of new compounds

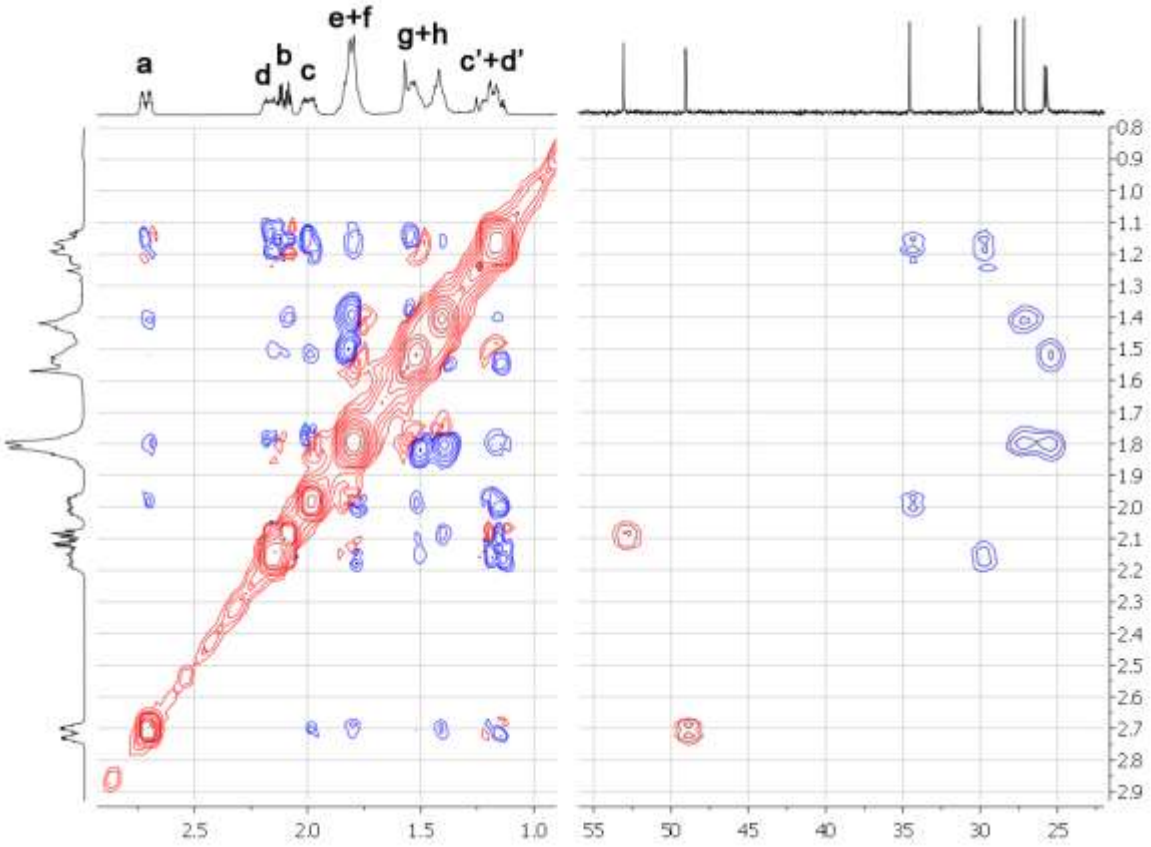


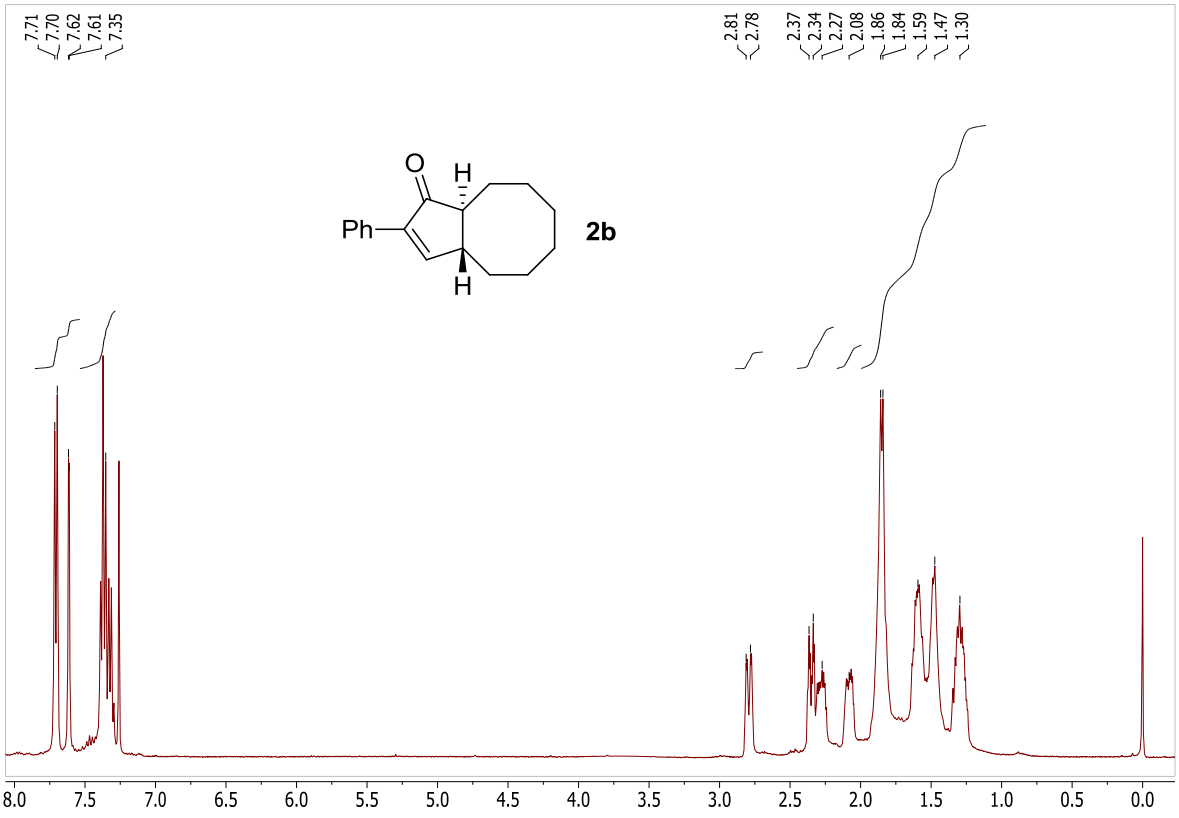
2a

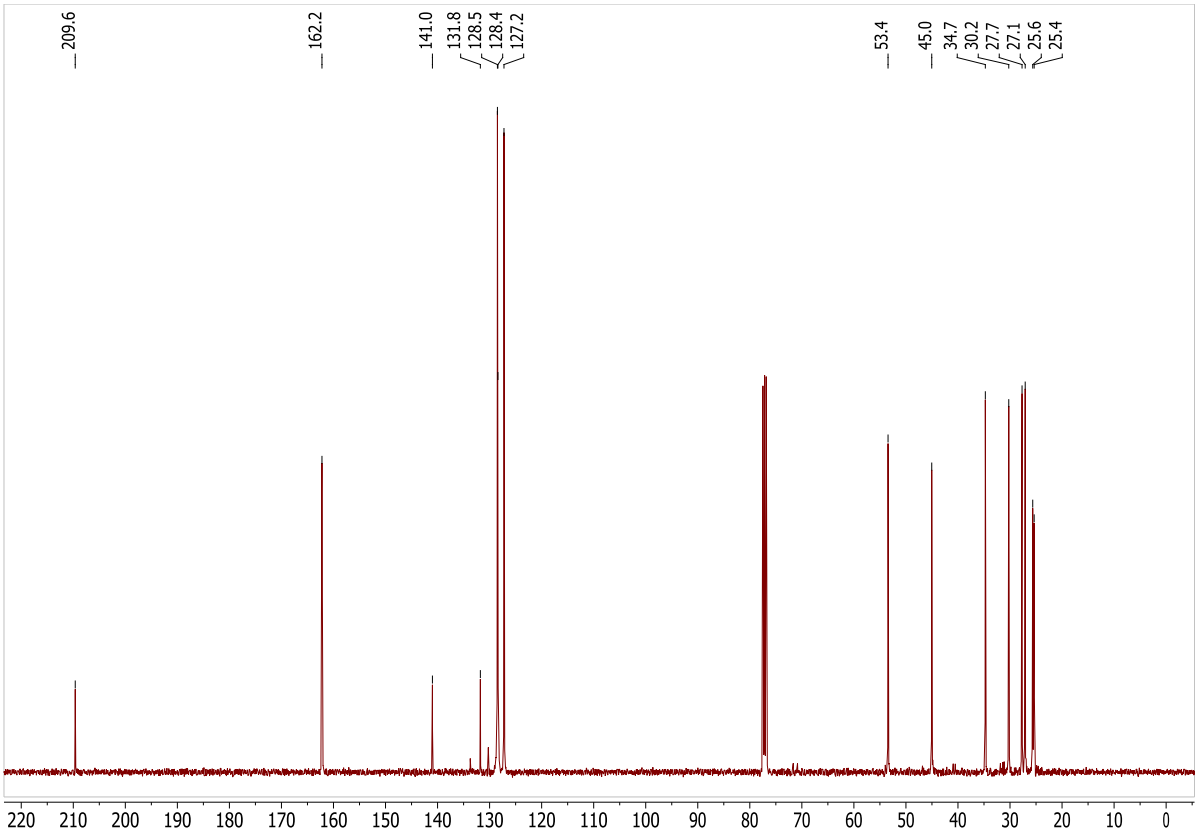


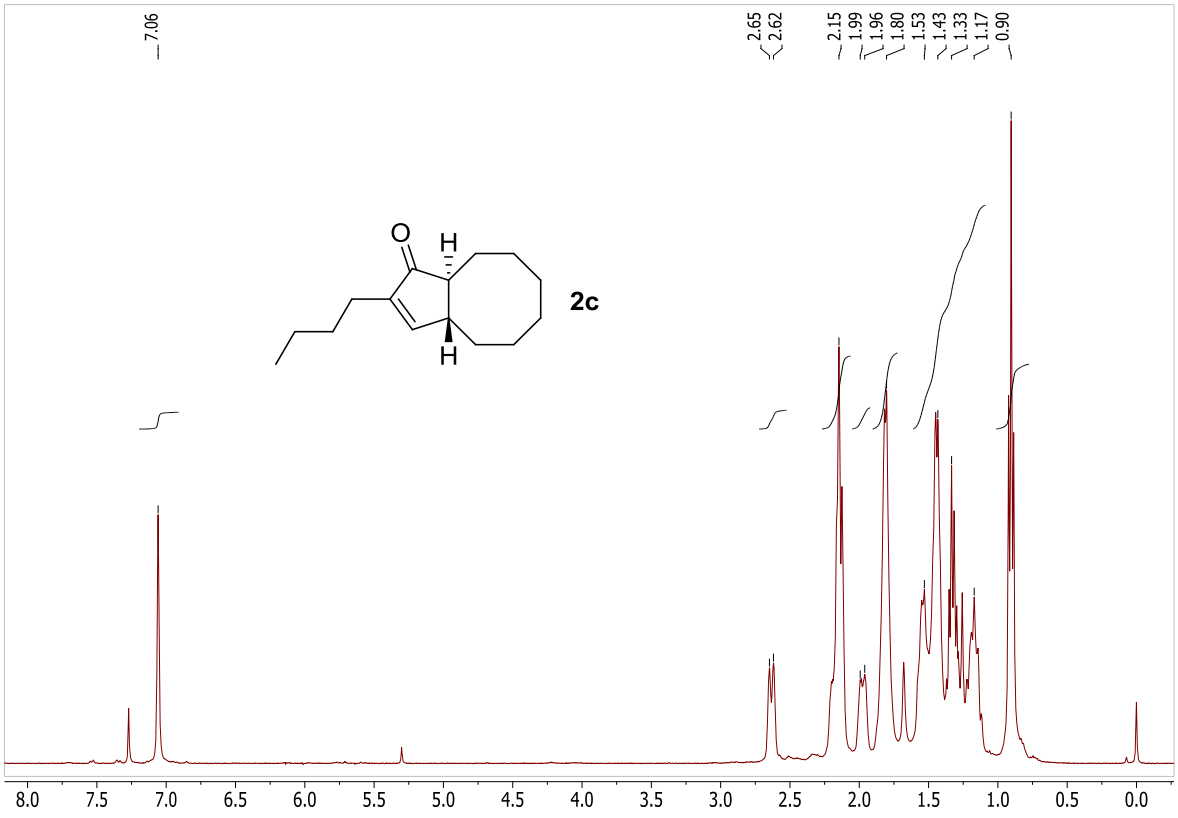
2D-NOESY / HSQC







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H
H
2c
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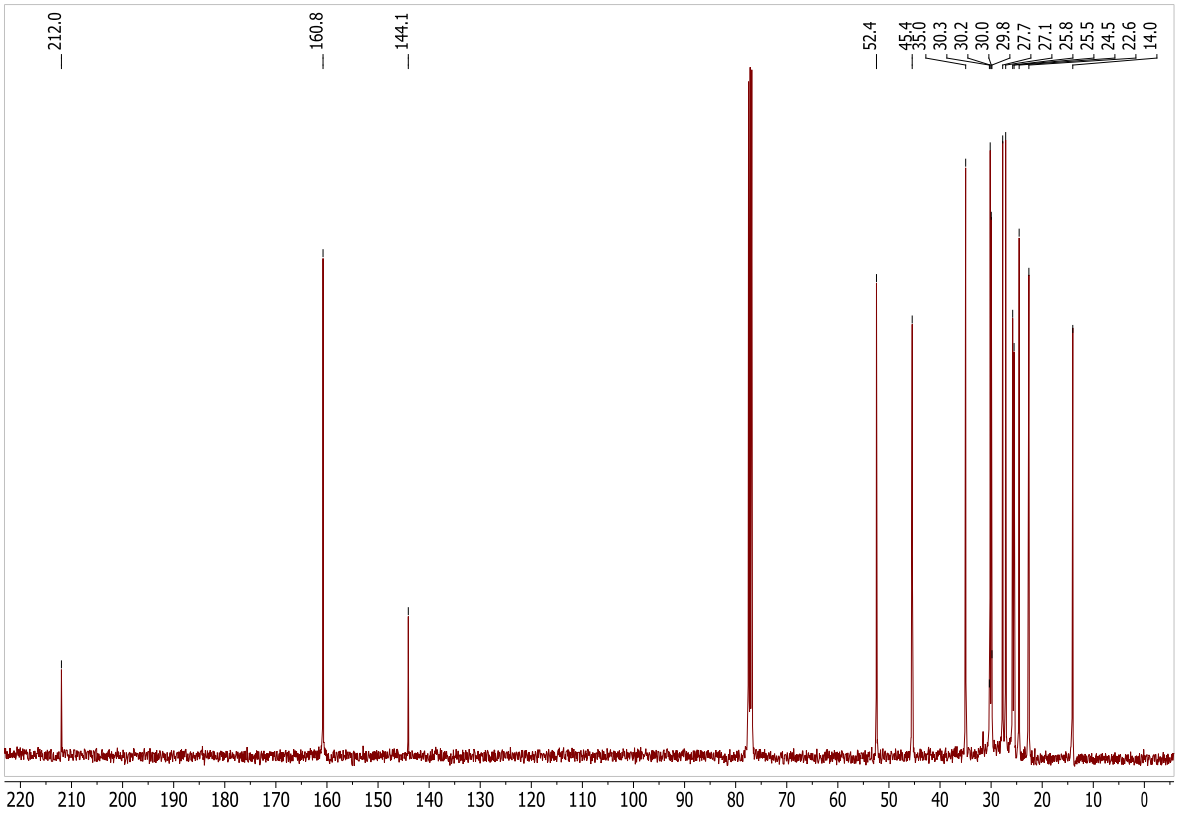
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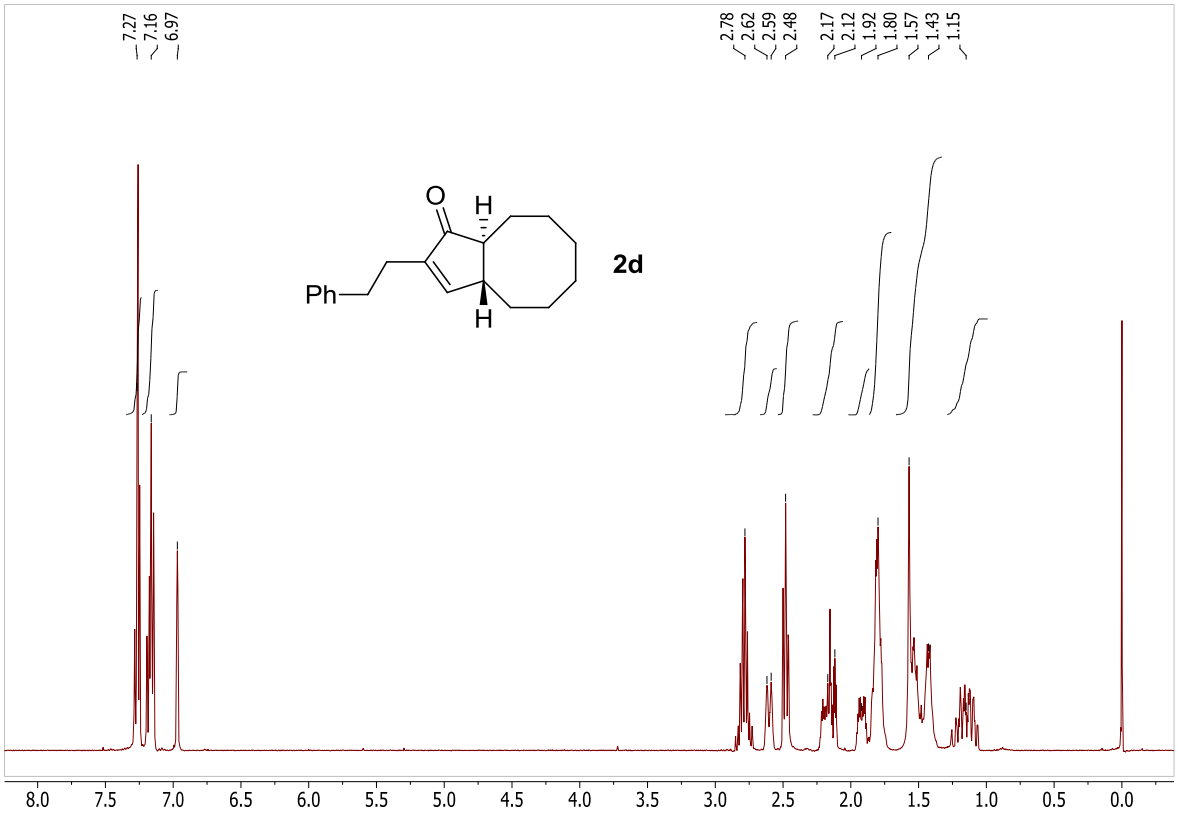

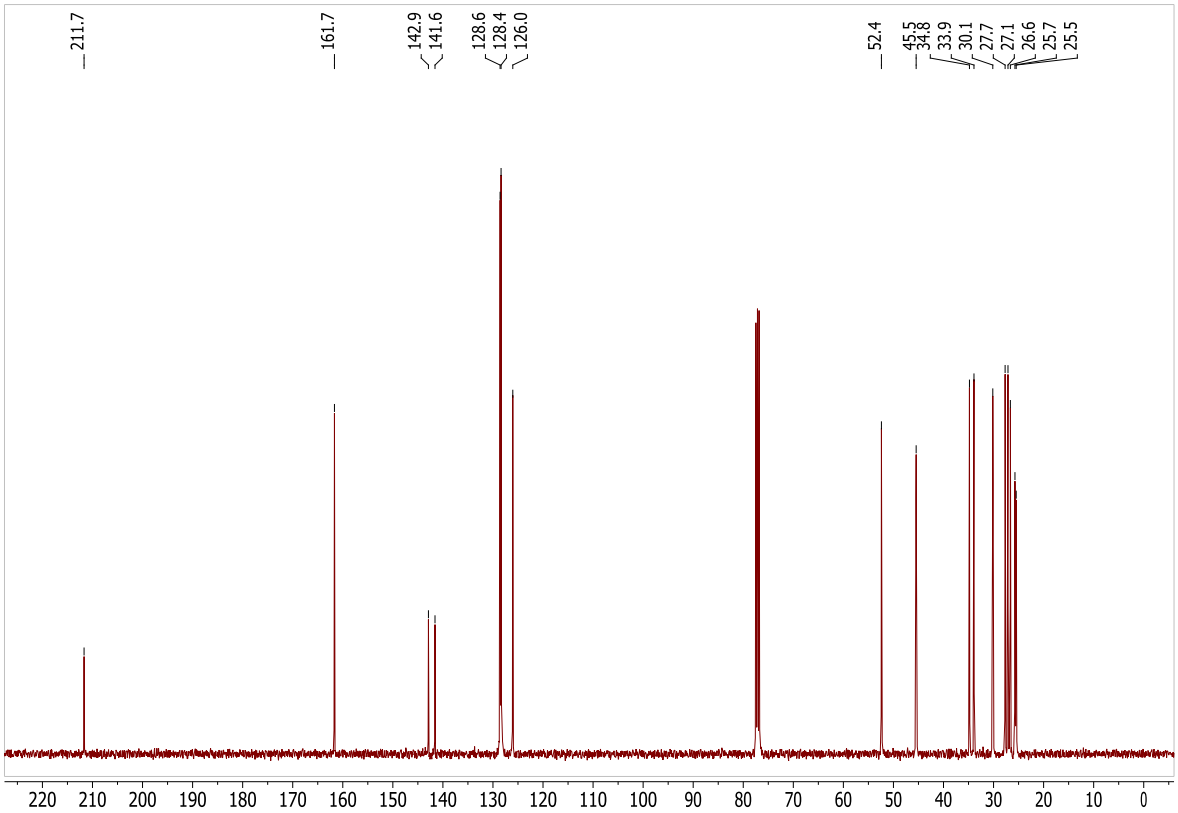

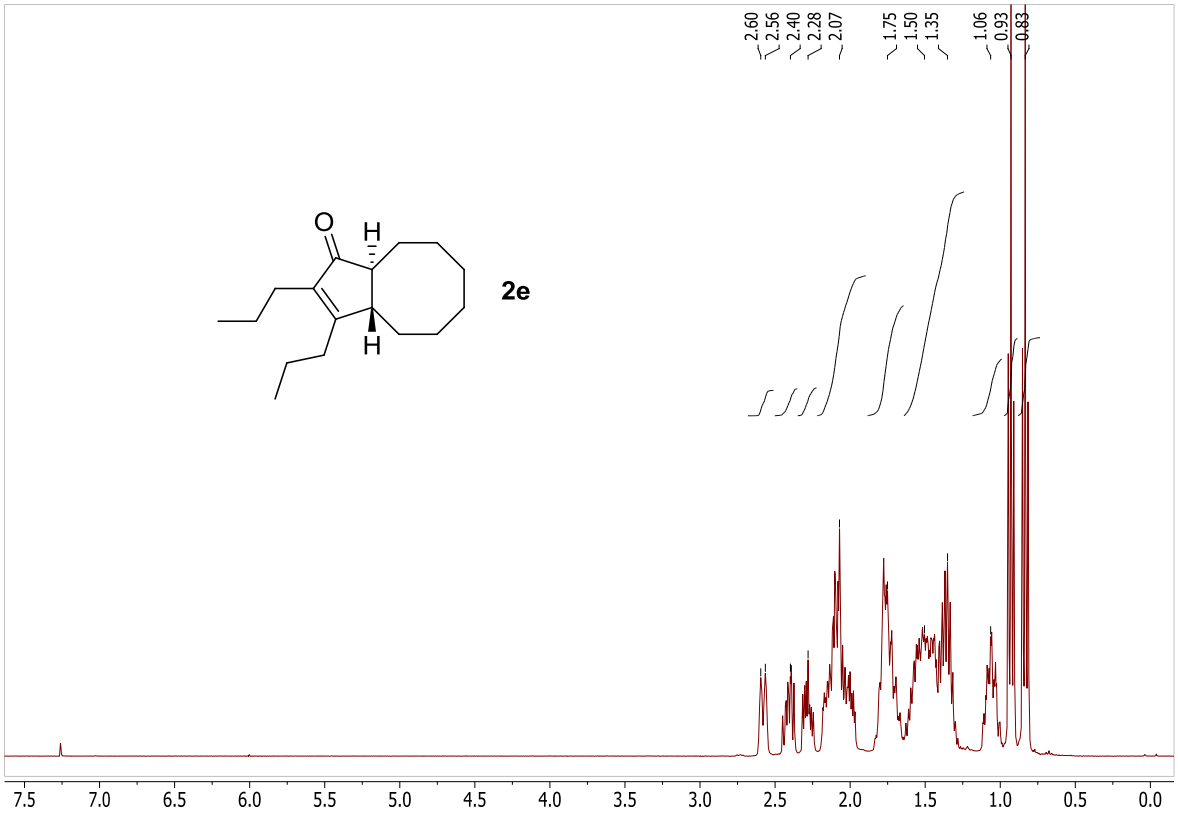
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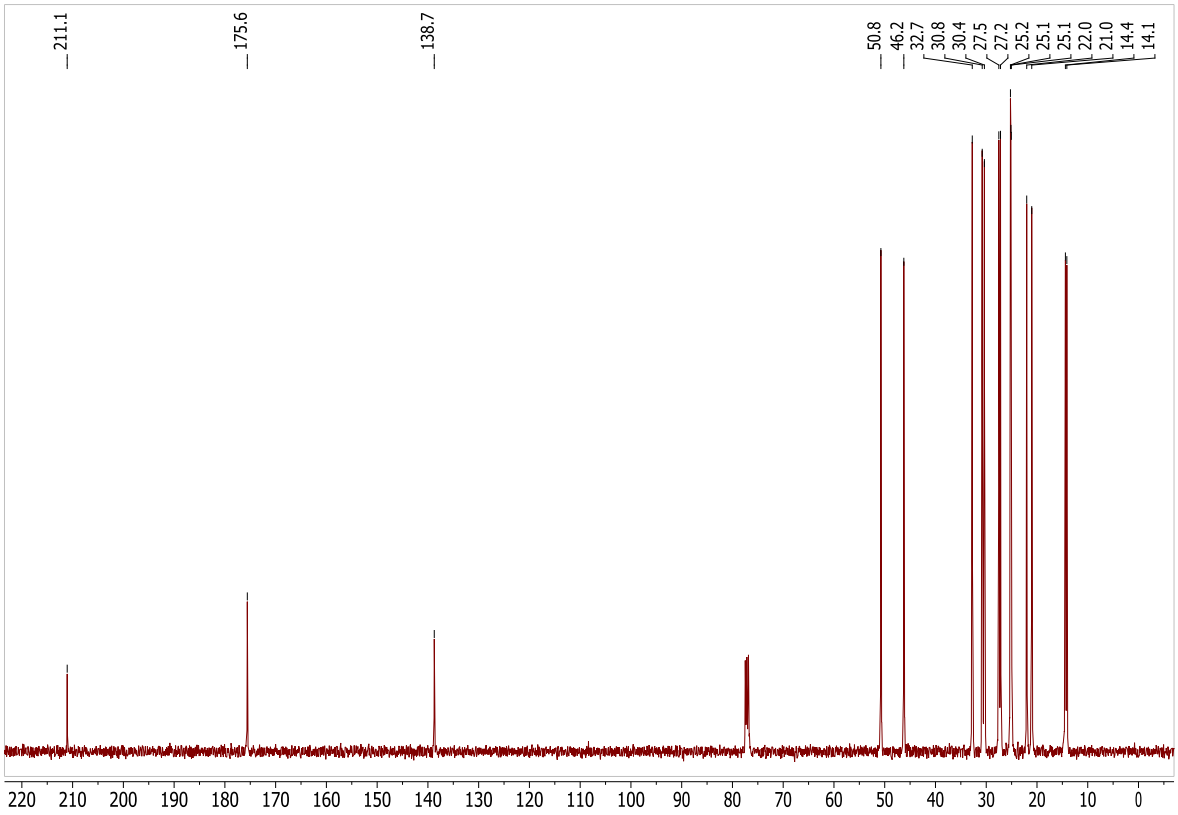
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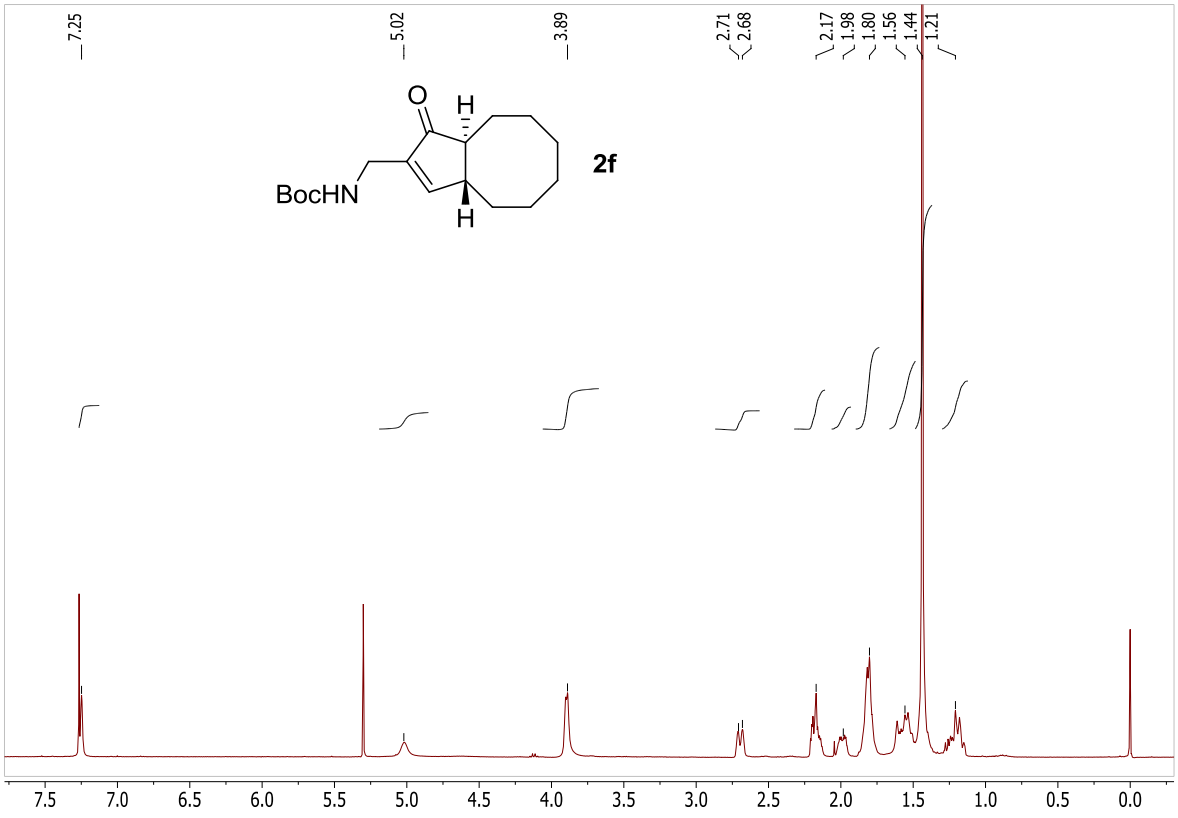

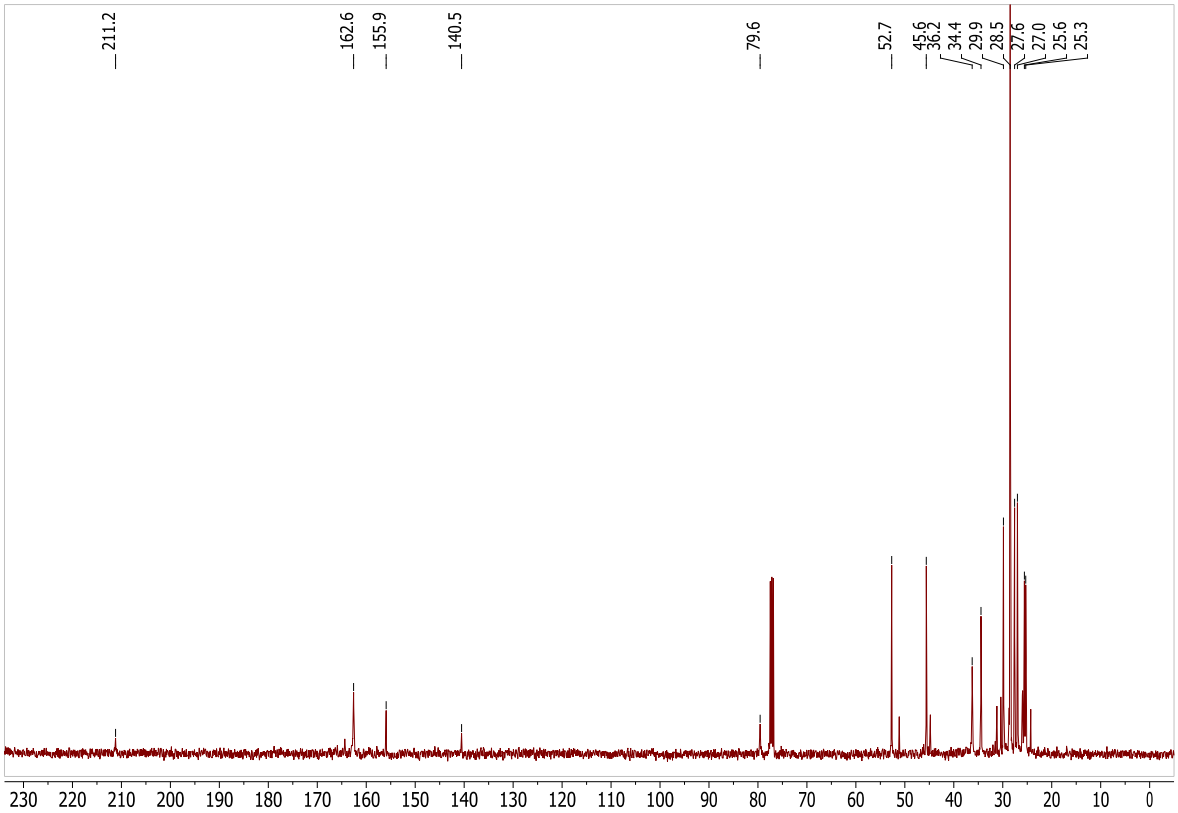

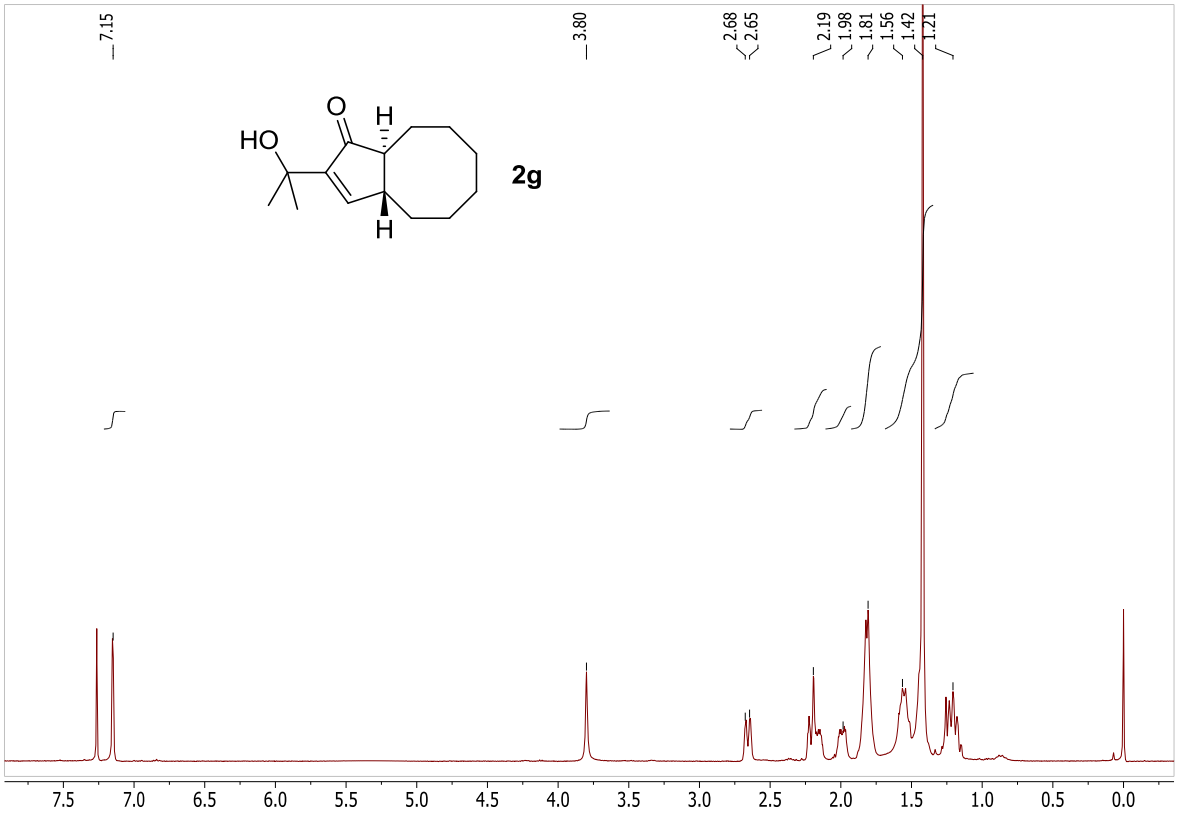
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H
2g
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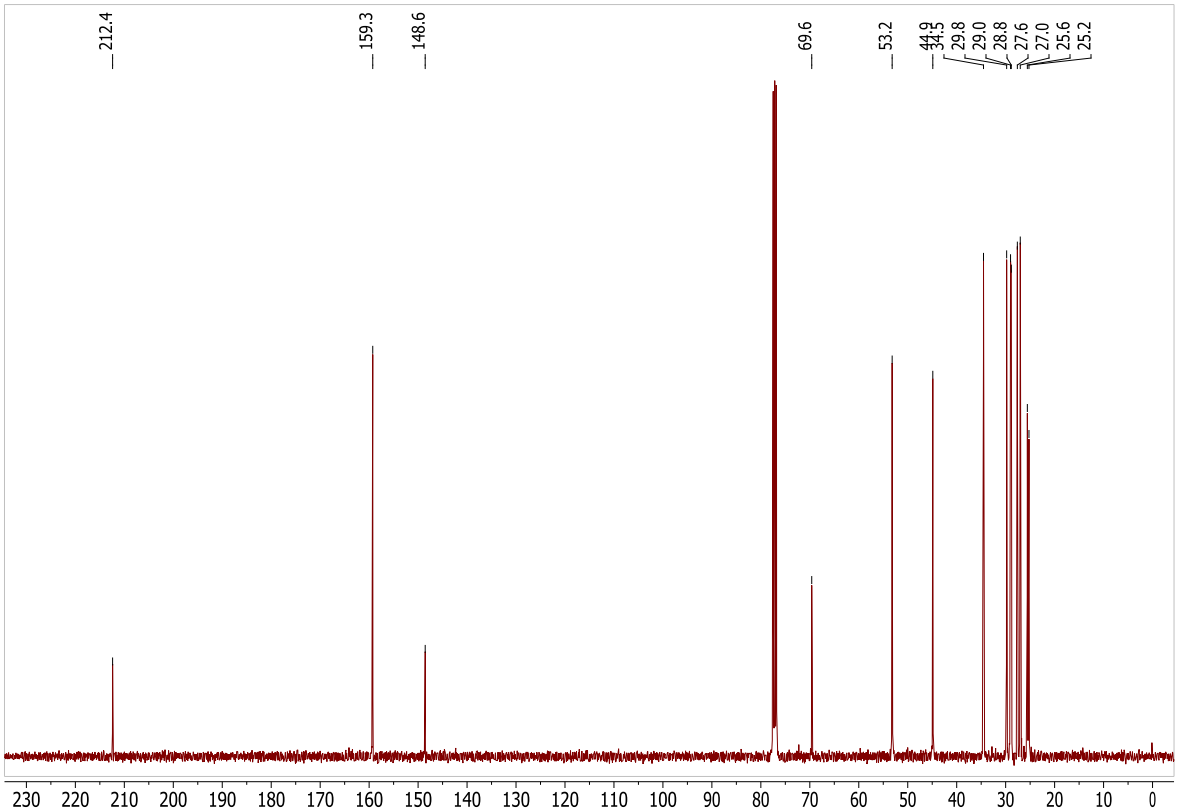
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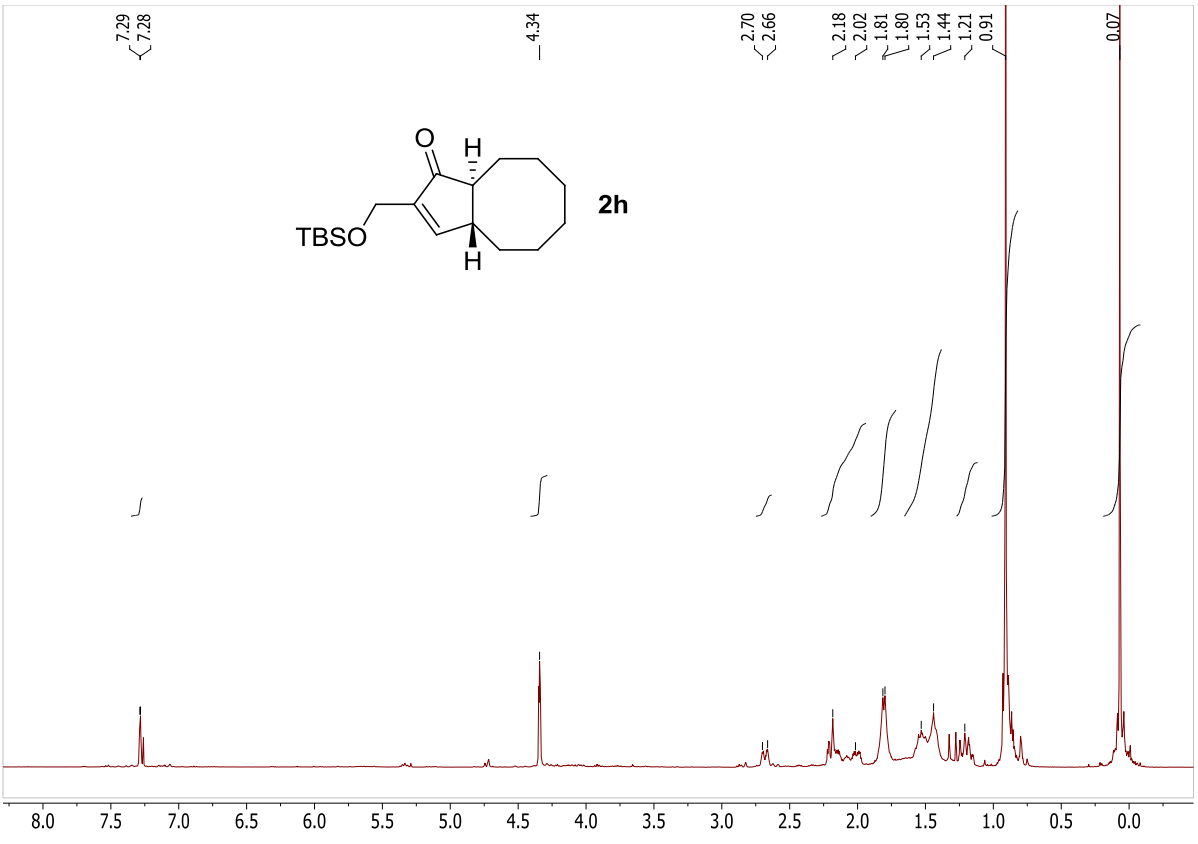
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H
TBSO
H
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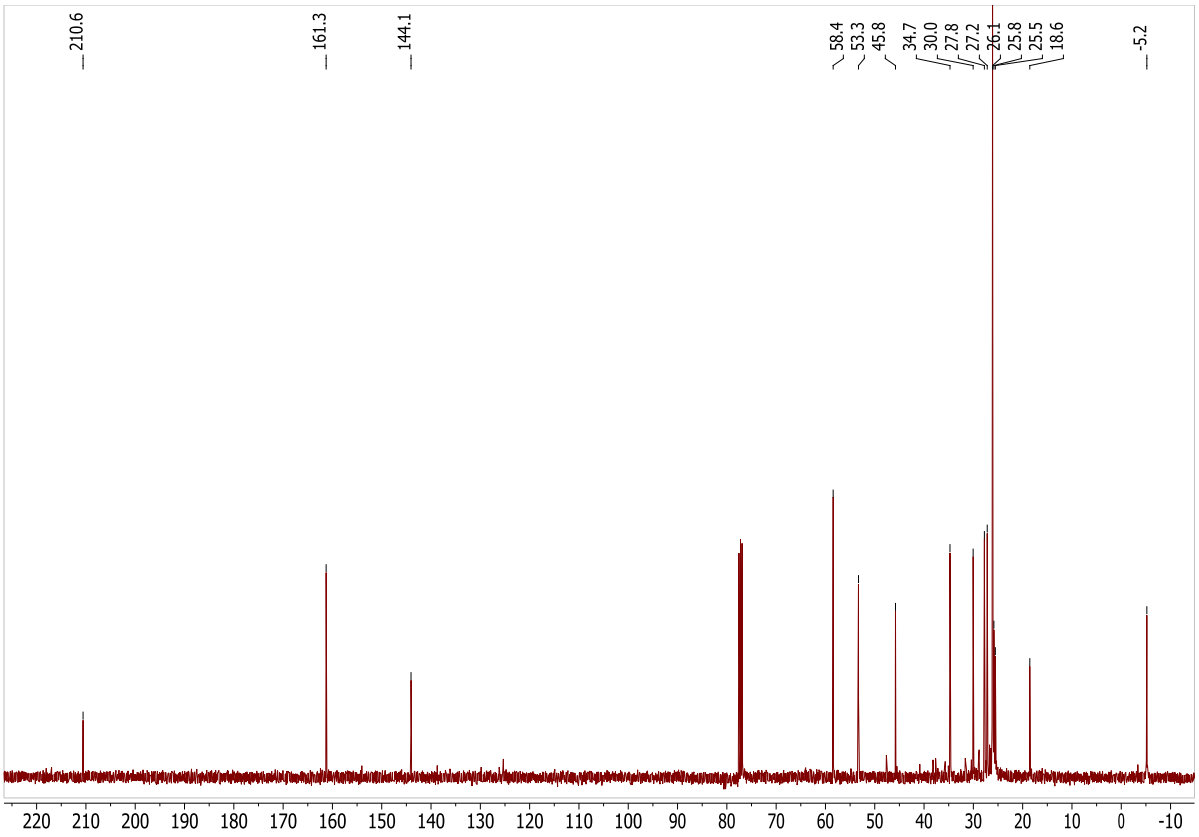
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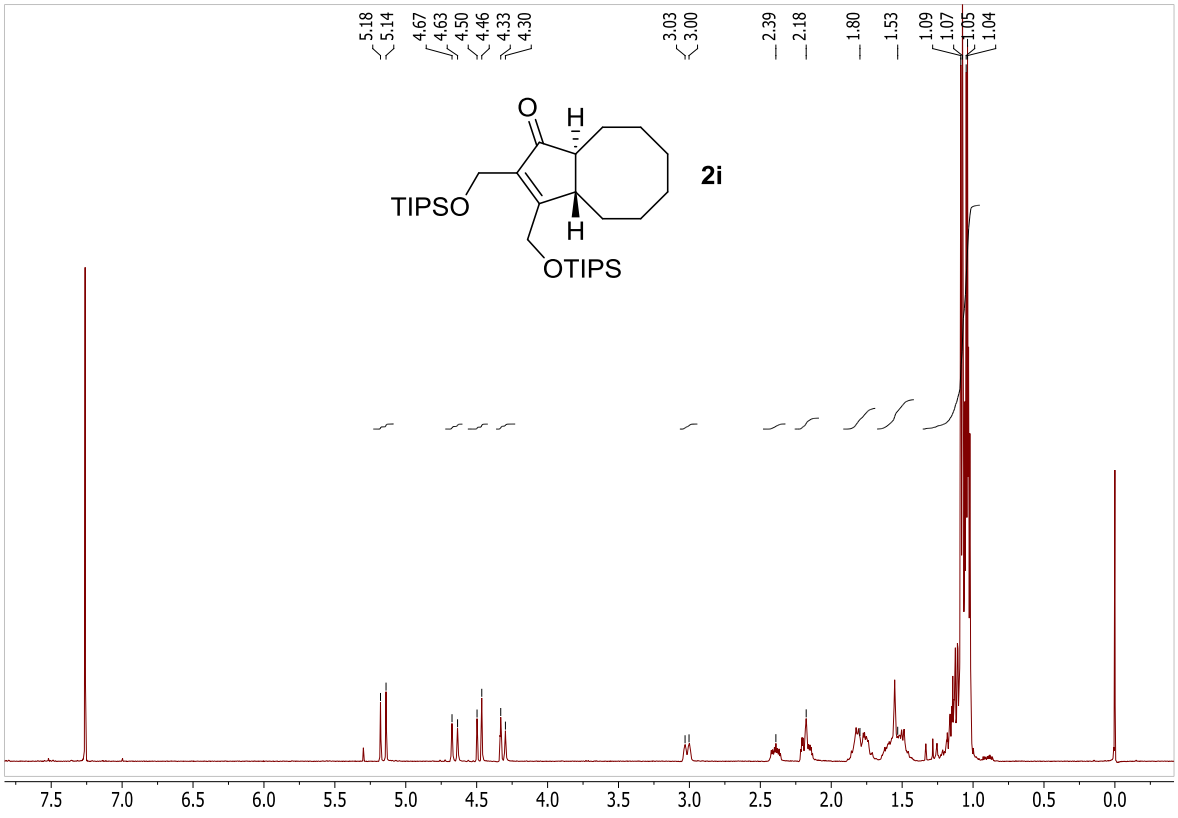
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1.53
1.09
1.07
1.05
1.04
O
H
TIPSO
H
OTIPS
2i
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6.0
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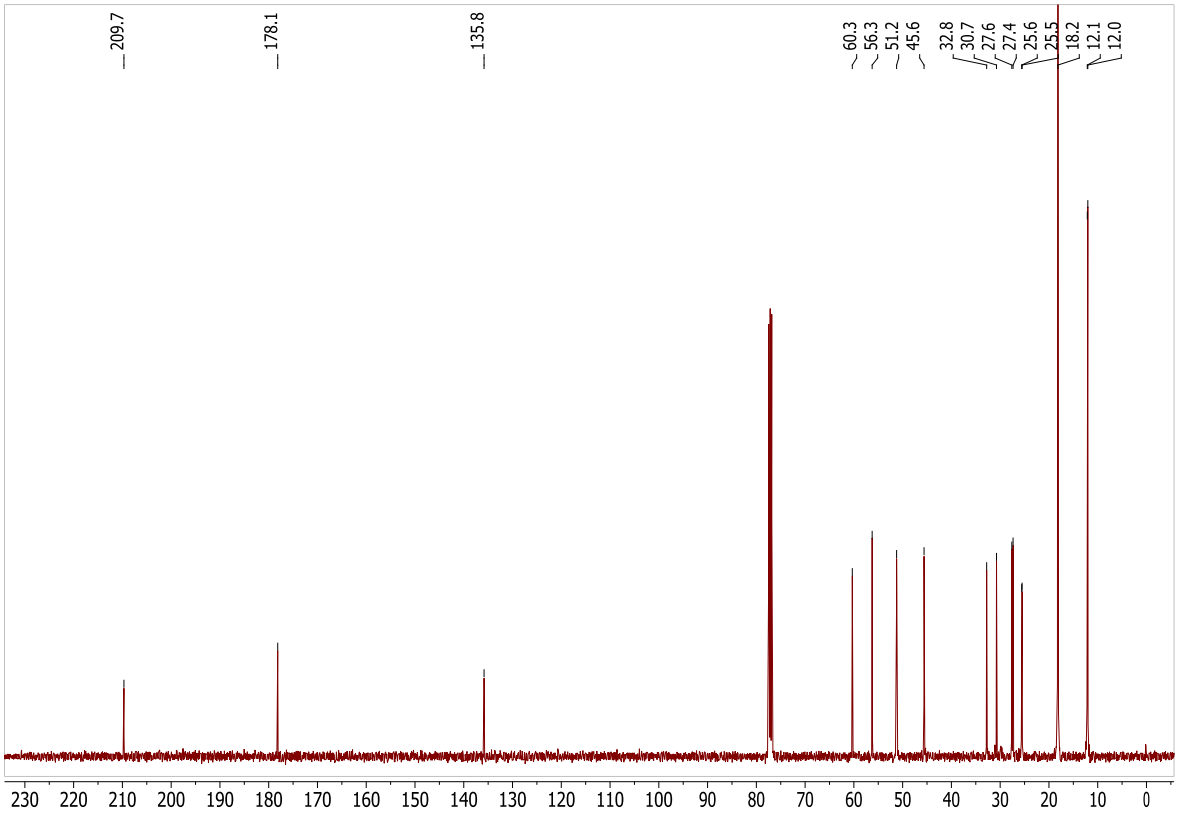
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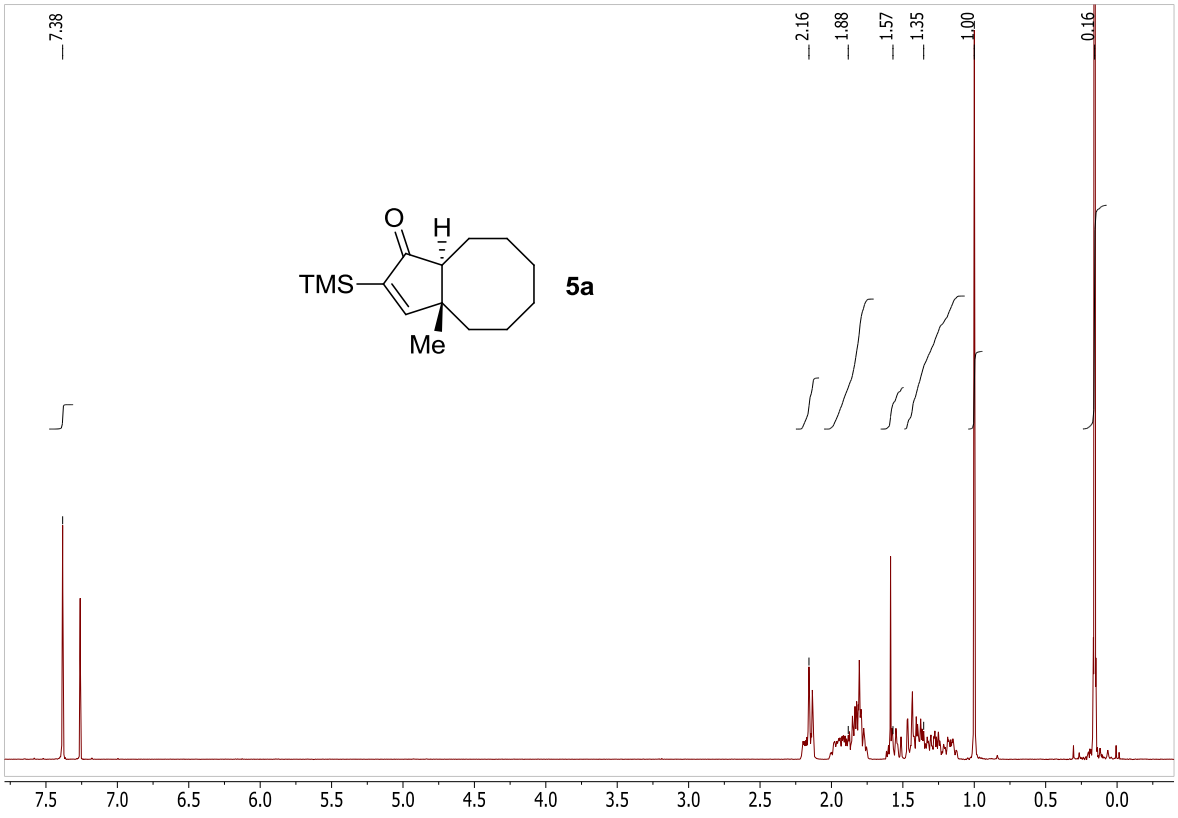

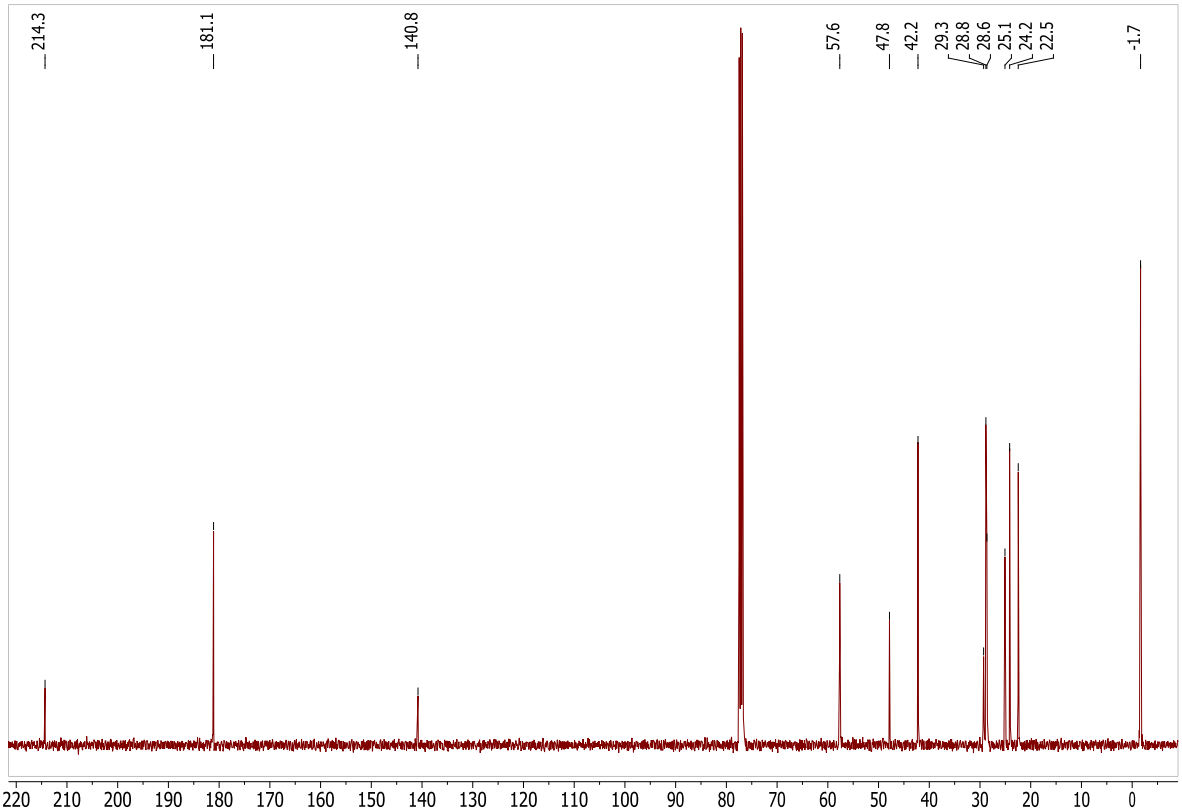

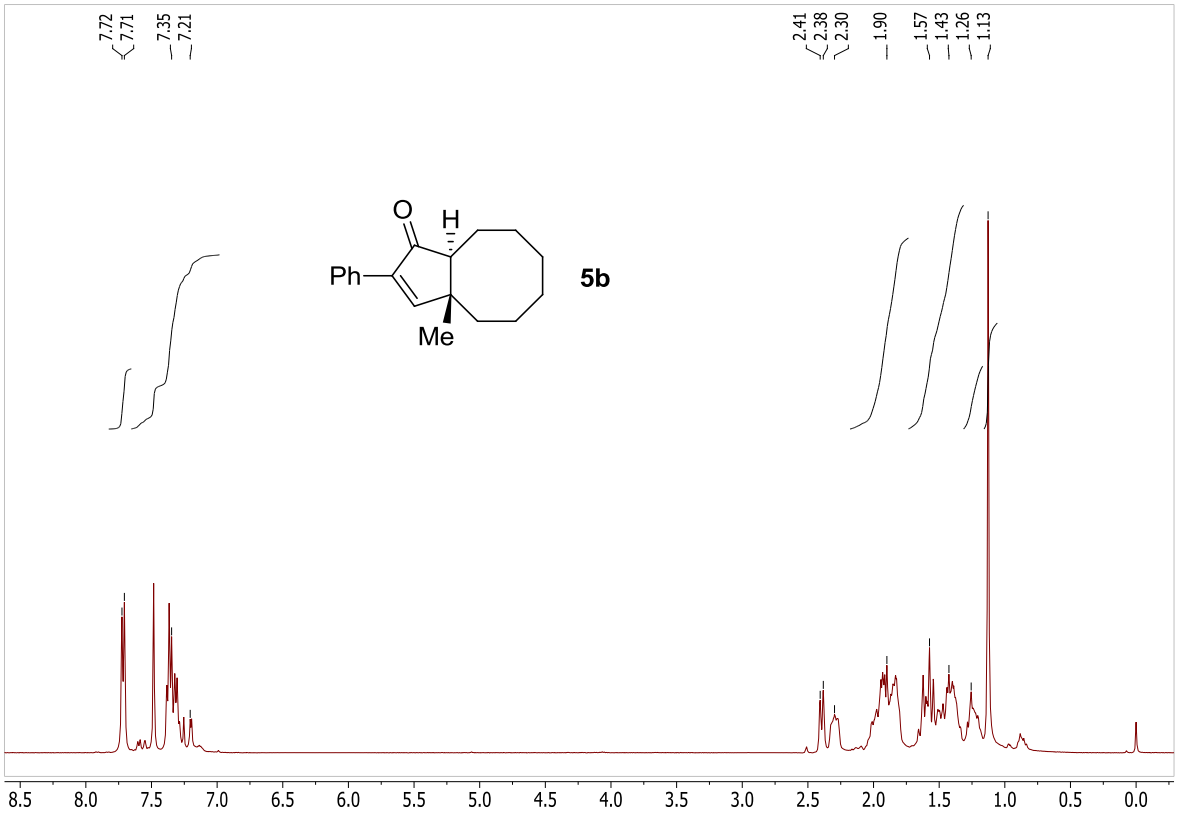
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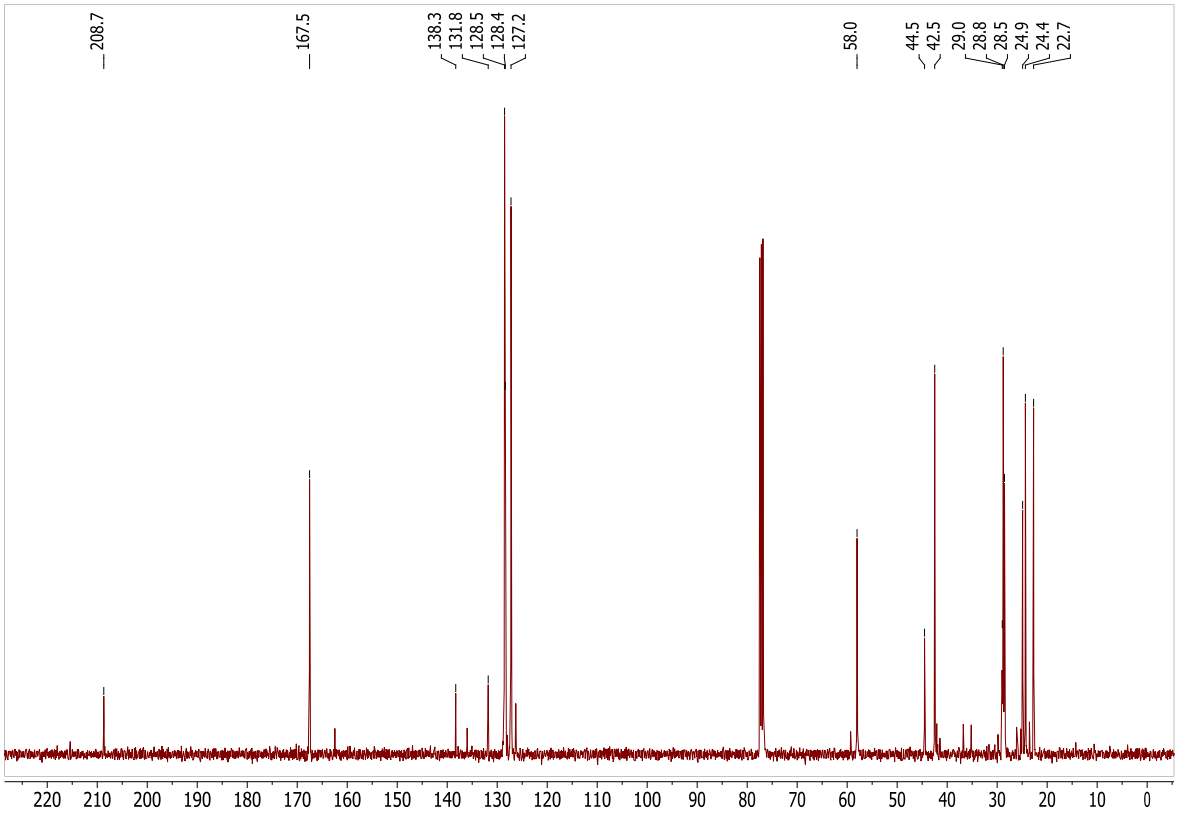
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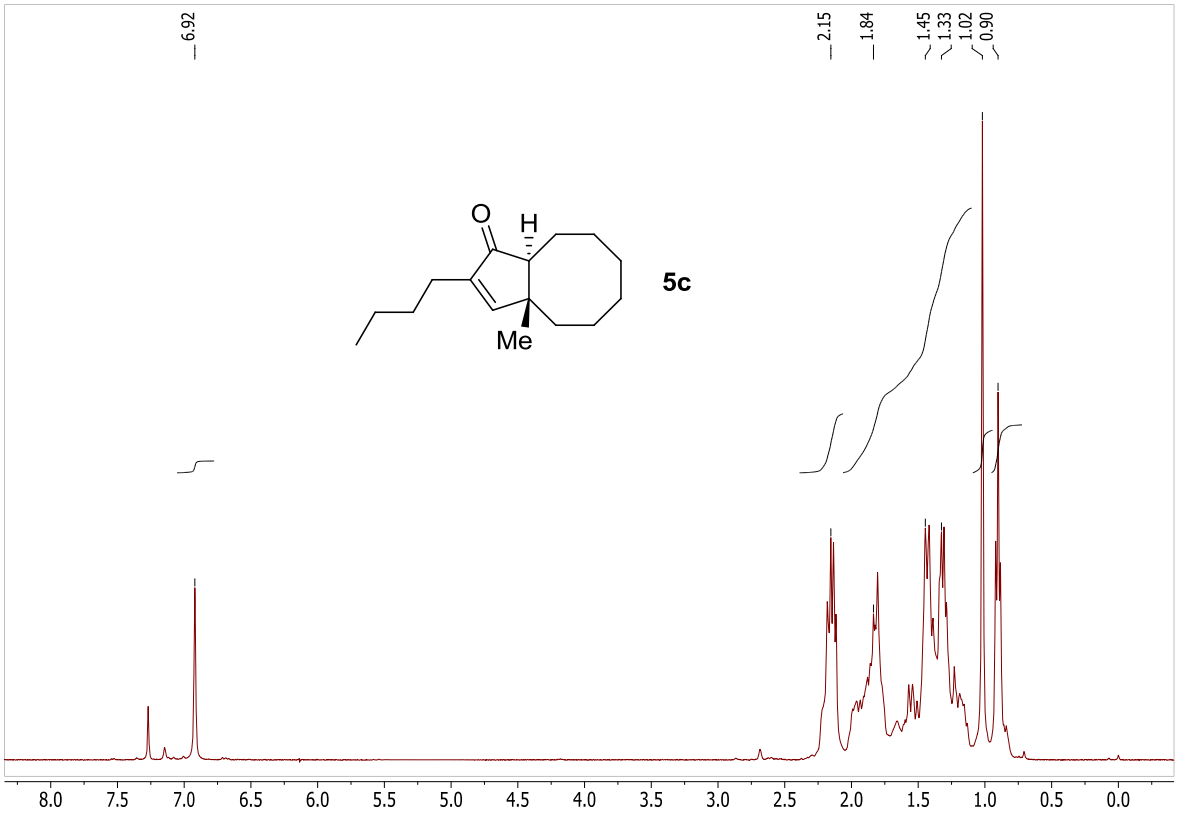
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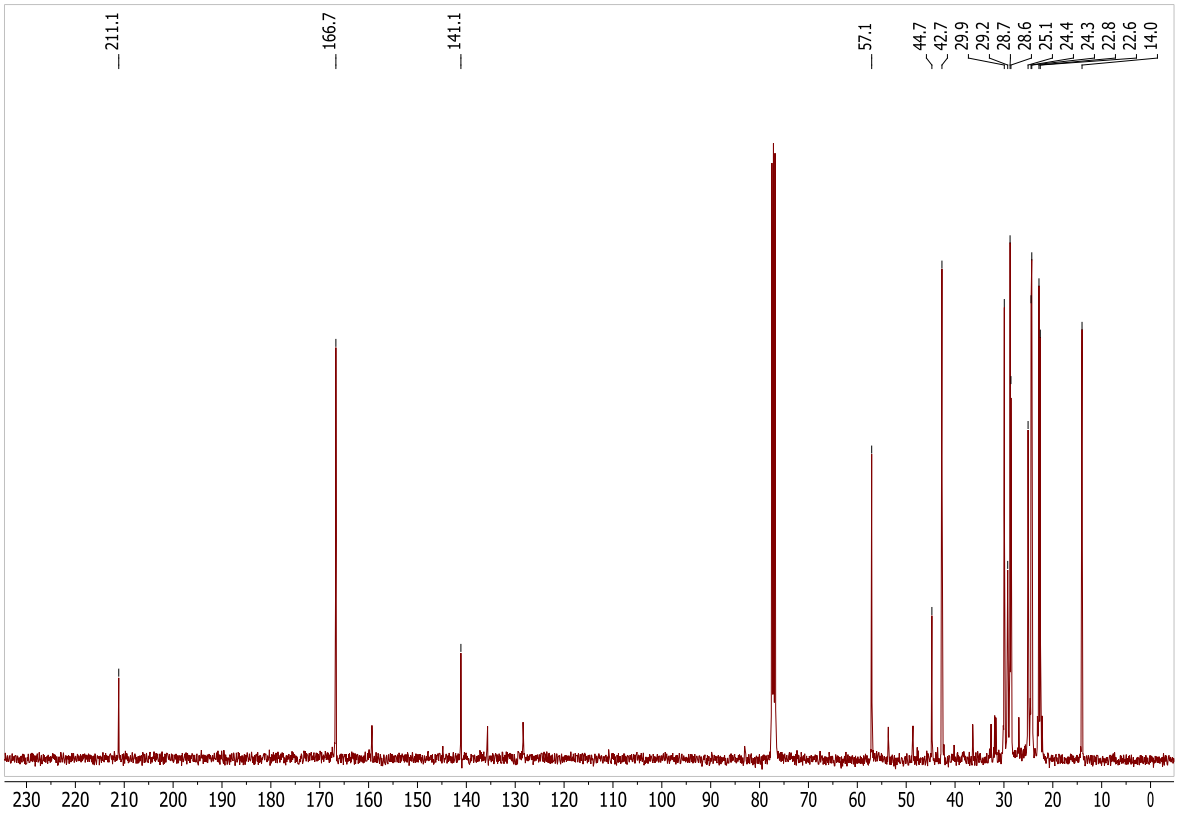
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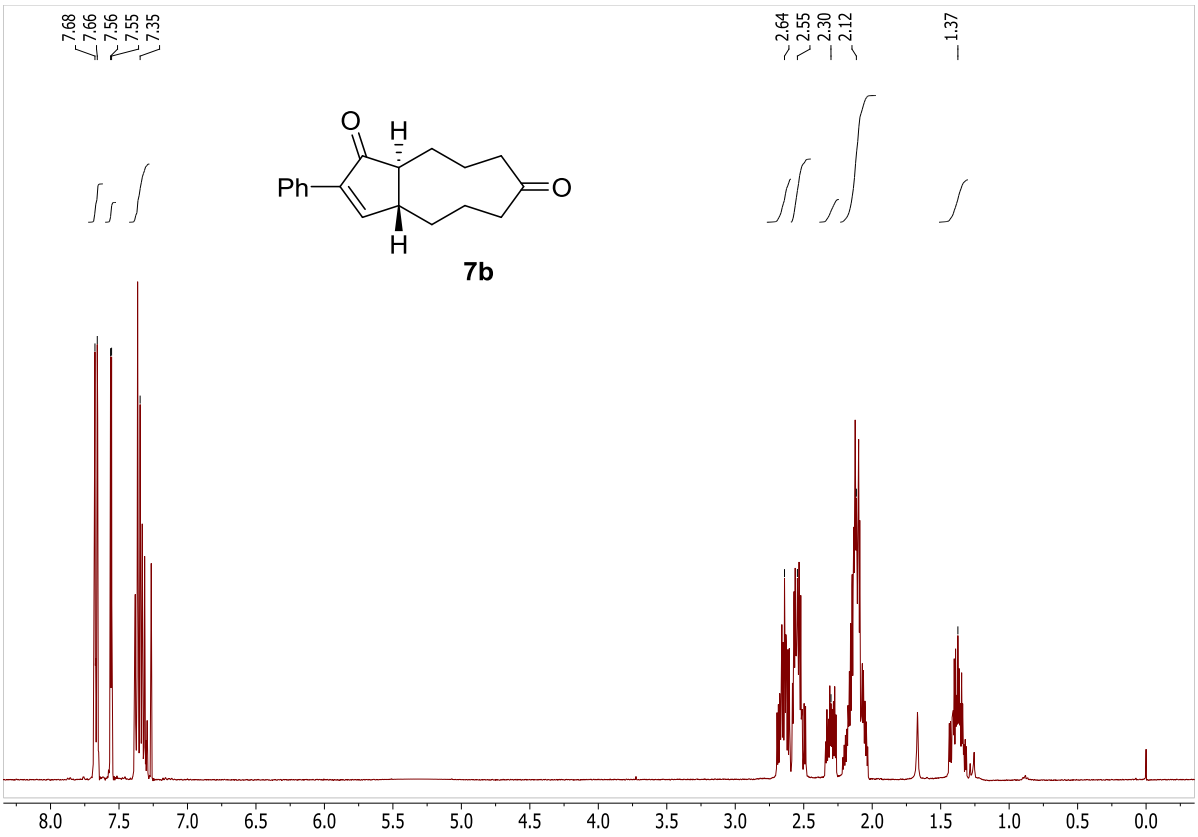

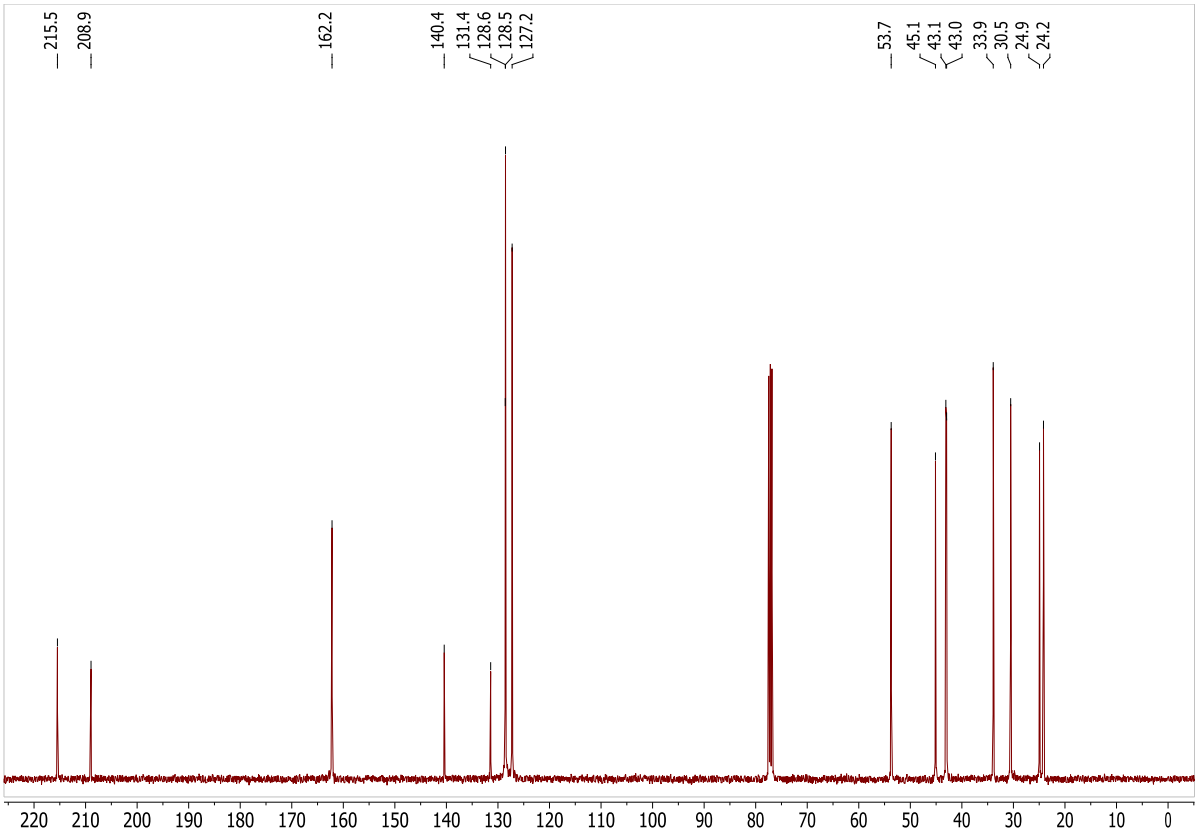

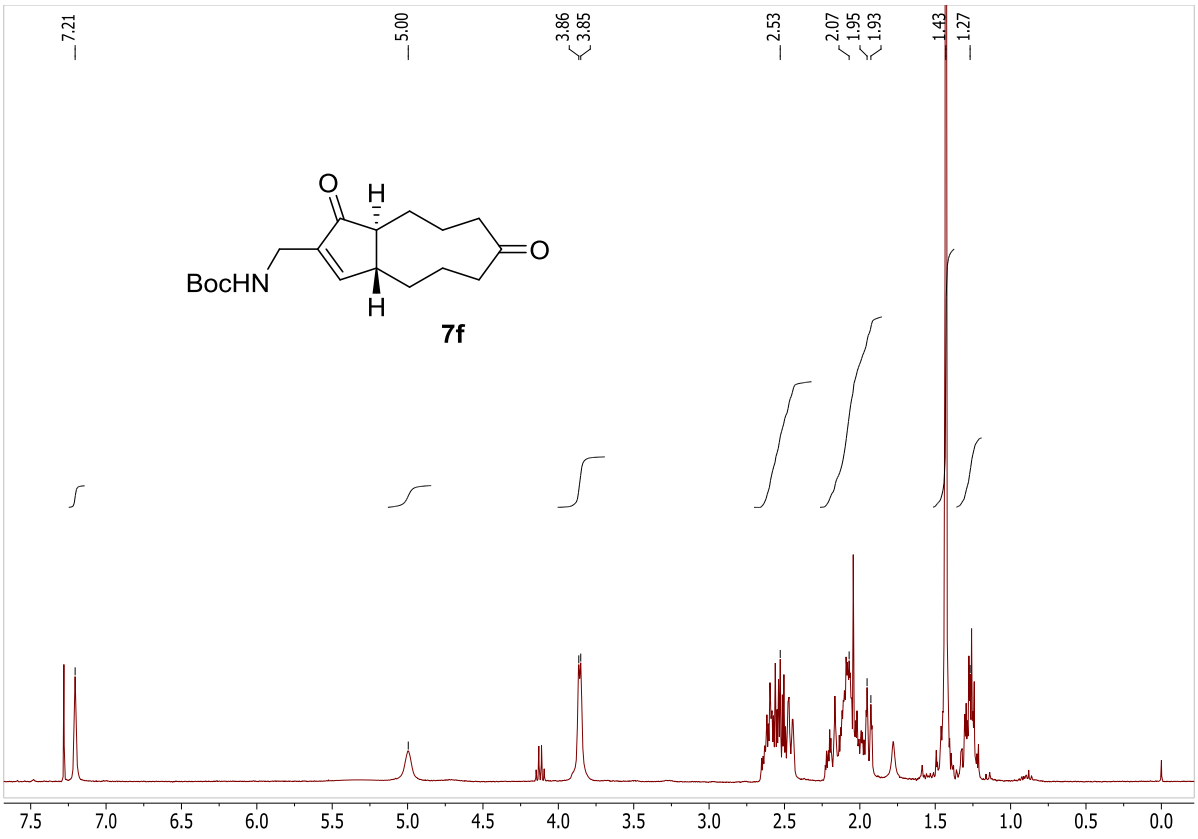

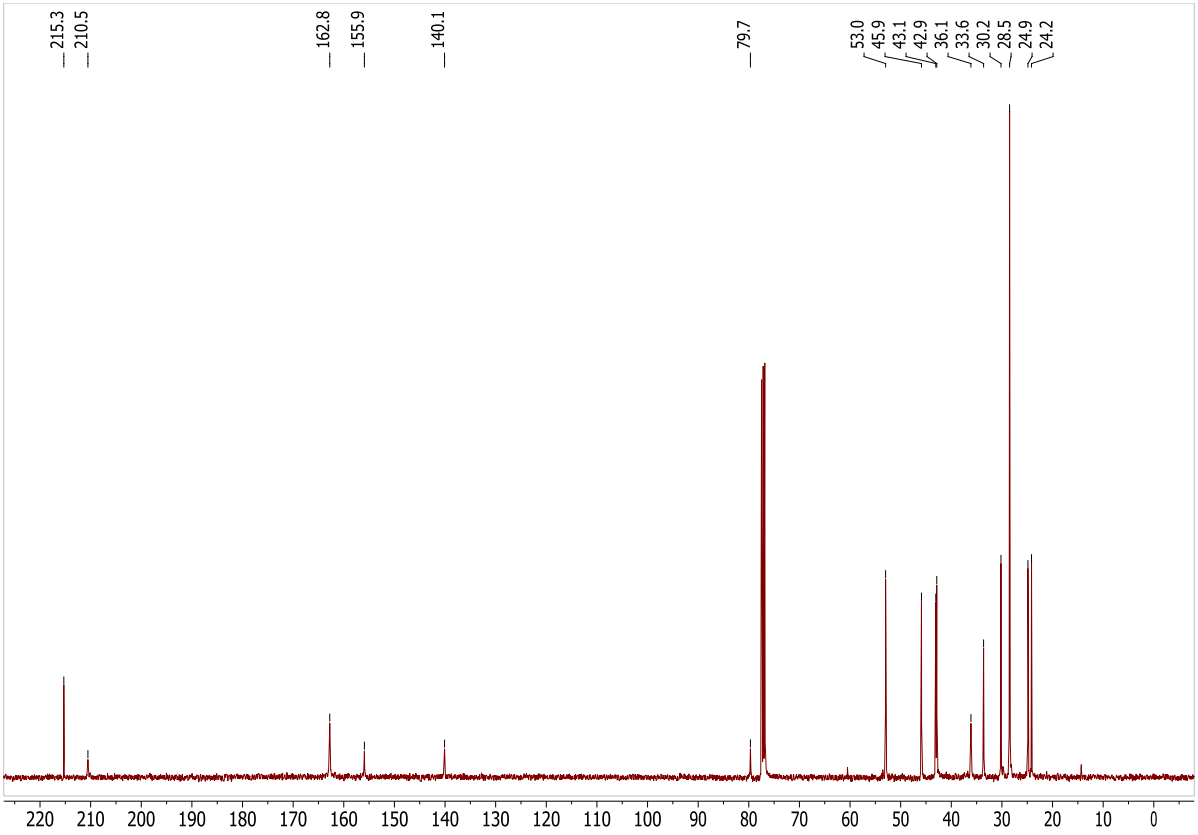

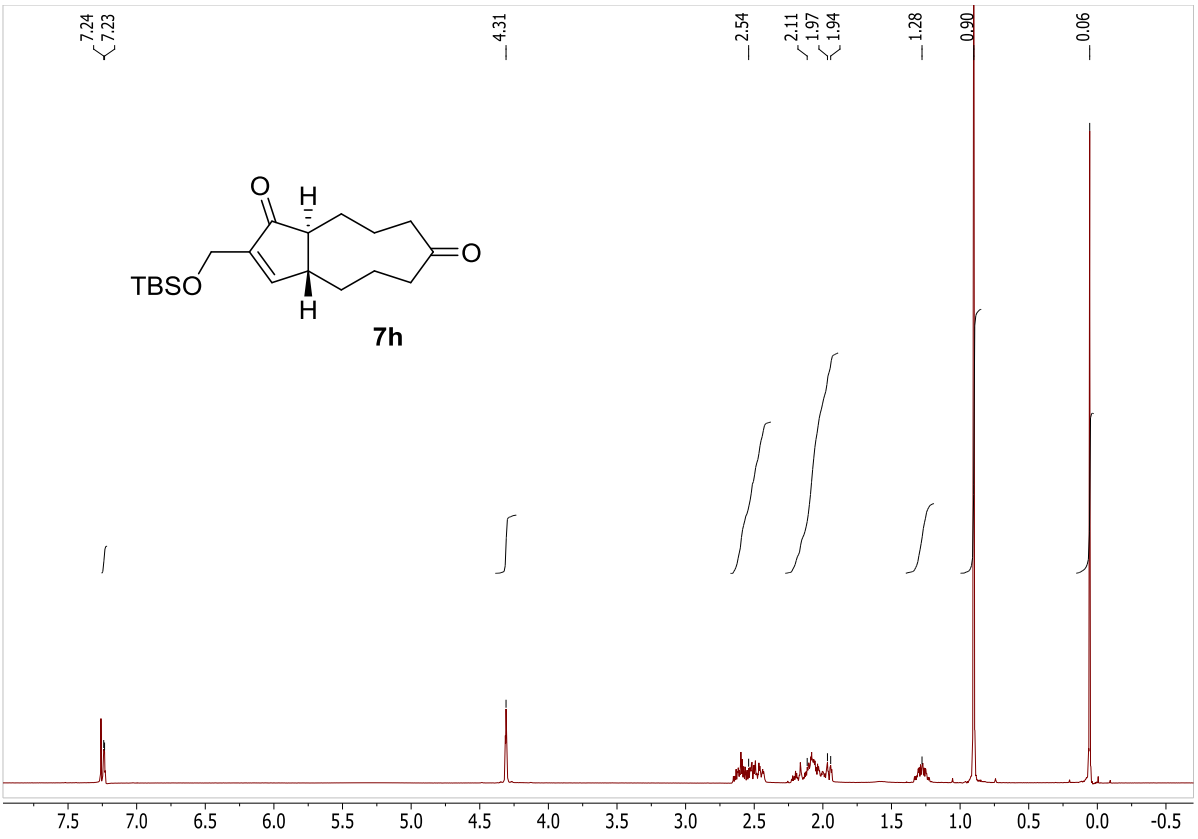
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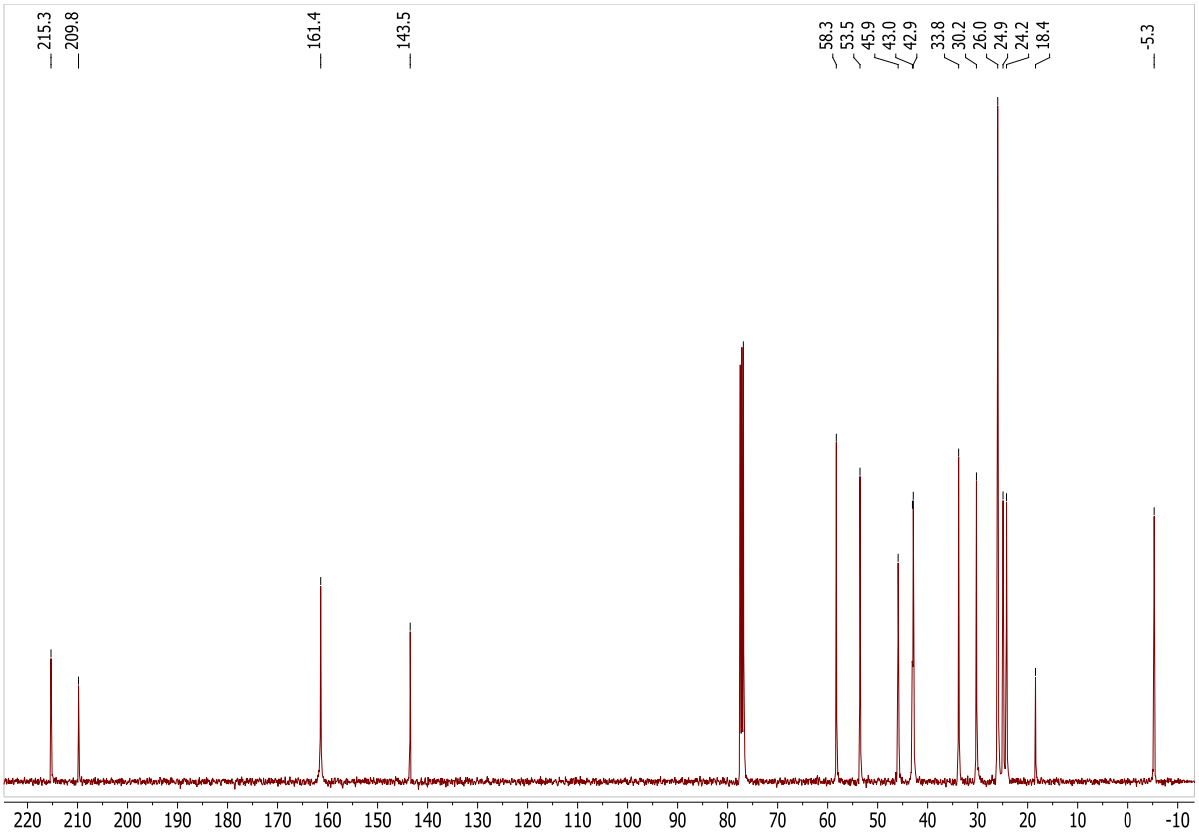
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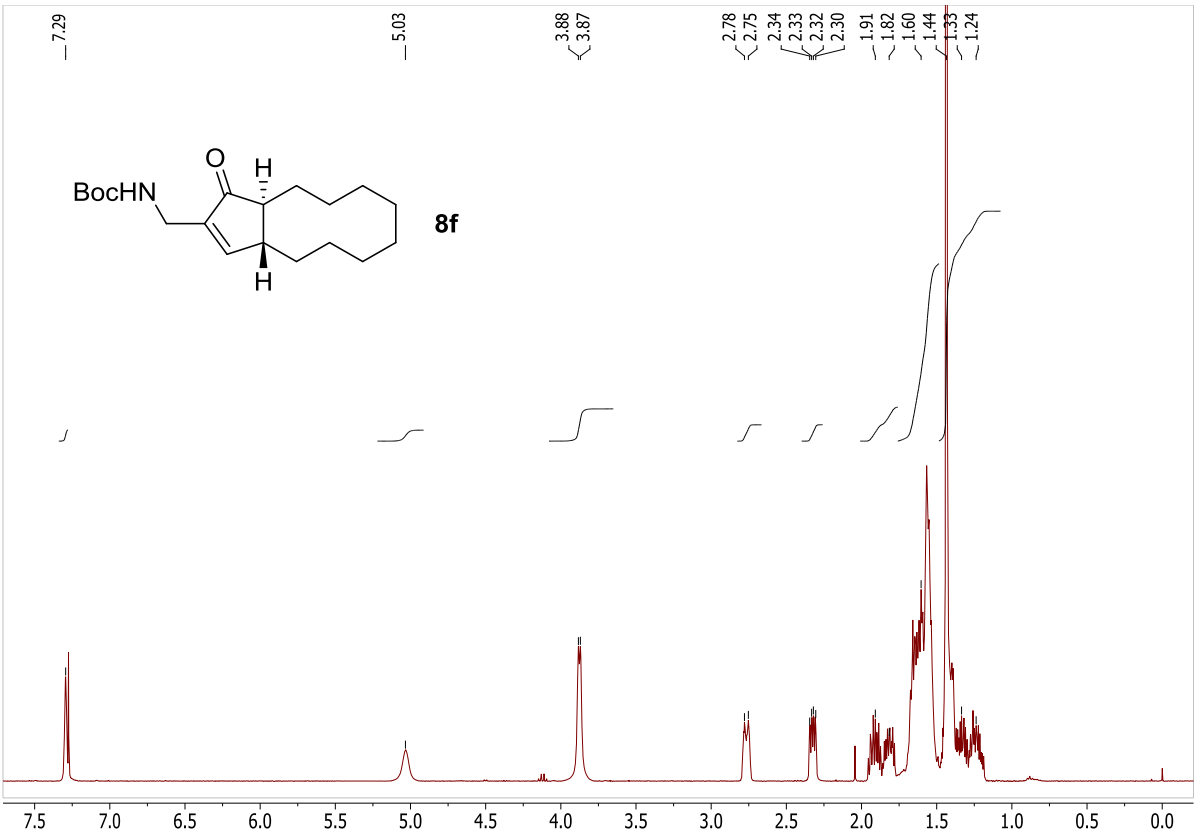
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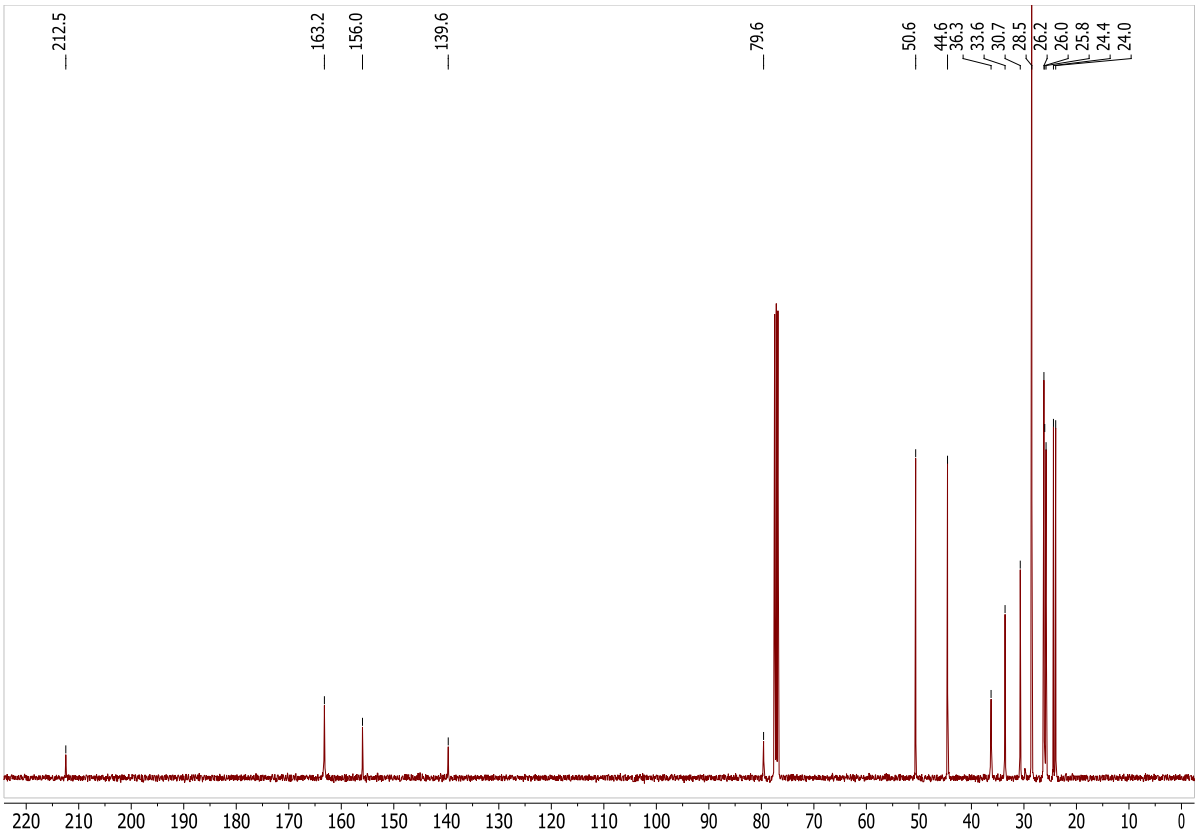
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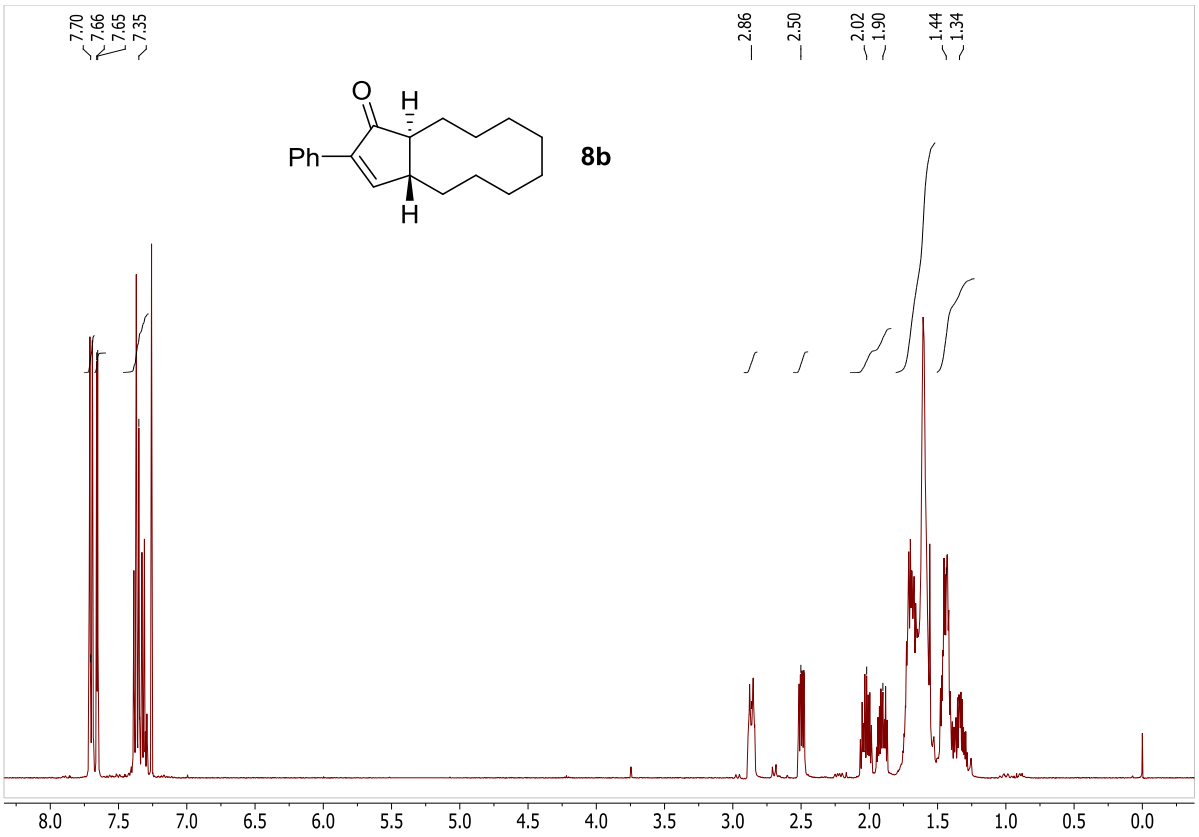
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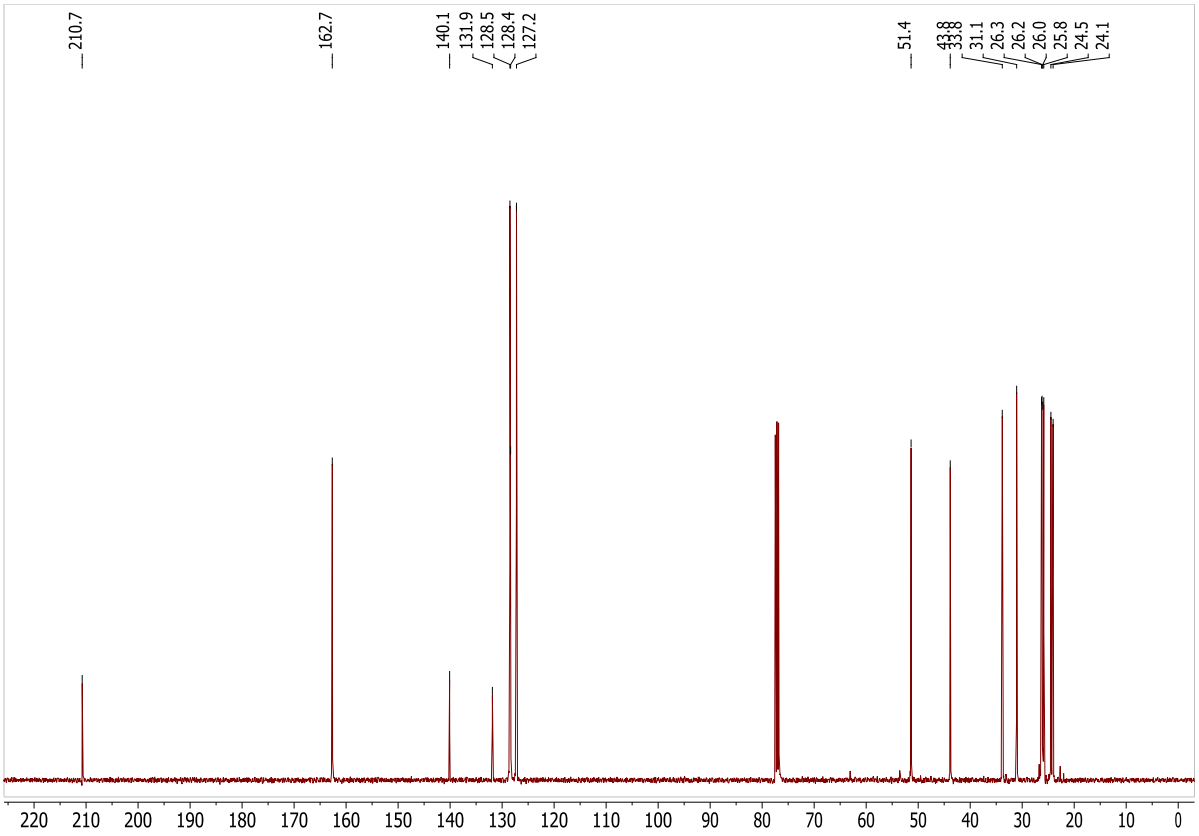
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