Supporting Information for:

Intramolecular [4+2] Cycloadditions of 1,3-Enynes or Arylalkynes with Alkenes with Highly Reactive Cationic Phosphine Au(I) Complexes

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Synthesis of [Au(L)Cl] complexes:

These complexes were prepared following a literature procedure:[1] Sodium tetrachloroaurate(III) dihydrate[2] (1 mmol) was dissolved in water, and the orange solution was cooled in ice. To this solution 2,2'-thiodiethanol (3 mmol) was slowly added (ca. 45 min) with stirring. A solution of the phosphine ligand (1 mmol) in EtOH was added dropwise to give a white solid. The solid was filtered off, washed with MeOH, and dried in vacuo.

[Au(PPh_3)Cl]

Yield 84%; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.03-1.93 (m, 9H), 1.89-1.85 (m, 6H), 1.75-1.72 (m, 3H), 1.52-1.41 (m, 6H), 1.35-1.21 (m, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 33.28 (d, $^1J(^{13}C\text{-}^{31}P)$ = 31 Hz), 30.75, 26.96 (d, $^2J(^{13}C\text{-}^{31}P)$ = 12.2Hz), 25.80 (d, $^3J(^{13}C\text{-}^{31}P)$ = 1.5 Hz); ^{31}P NMR (161.98 MHz, $CDCl_3$) δ 57.12. HRMS-ESI Cald. for $C_{20}H_{36}AuNP$ (M^++MeCN-Cl): 518.2251. Found: 518.2241.

[Au{$P(C_6F_5)_3$}Cl]

Yield 82 %; ^{31}P NMR (161.98 MHz, $CDCl_3$) δ 57.08.

[Au{P(*o*-Tol)$_3$}Cl]

Yield 49%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (tt, J = 7.5, 1.5 Hz, 3H), 7.35 (m, 3H), 7.19 (t, J = 7.7 Hz, 3H), 6.92 (ddd, J = 13.3, 7.8, 1.1 Hz, 3H), 2.67 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 143.0 (d, $^2J(^{13}C\text{-}^{31}P)$ = 12 Hz), 133.49 (d, $^3J(^{13}C\text{-}^{31}P)$ = 9.6 Hz), 132.42 (d, $^3J(^{13}C\text{-}^{31}P)$ = 9.1 Hz), 131.97 (d, $^4J(^{13}C\text{-}^{31}P)$ = 2.6 Hz), 126.69 (d, $^2J(^{13}C\text{-}^{31}P)$ = 10.5 Hz), 125.00 (d, $^1J(^{13}C\text{-}^{31}P)$ = 61.3 Hz), 23.31 (d, $^3J(^{13}C\text{-}^{31}P)$ = 11.3 Hz); ^{31}P NMR (161.98 MHz, $CDCl_3$) δ 11.50. HRMS-ESI Cald. for $C_{23}H_{24}AuNP$ (M^++MeCN-Cl): 542.1312. Found: 542.1318.

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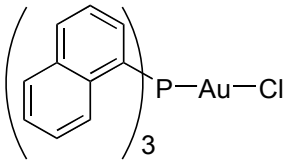
(1) Al-Sa'Ady, A. K.; McAuliffe, C. A.; Parish, R. V.; Sandeank, J. A. *Inorg. Synt.* **1985**, 191-194.
(2) Tetrachloroauric acid can also be used as the starting salt.

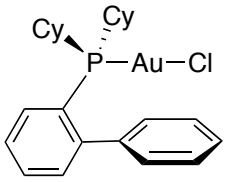
[Au(AsPh$_3$)Cl]

Yield 88%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55-7.50 (m, 15H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 133.23, 131.44, 131.05, 129.62. HRMS-ESI Cald. for $C_{20}H_{18}AuNAs$ (M^++MeCN-Cl): 544.0321. Found: 544.0306.



This compound was prepared according to the described procedure.[3] Yield 80%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.82 (d, J = 8.5 Hz, 3H), 8.09 (d, J = 8.0 Hz, 3H), 8.00 (d, J = 8.2 Hz, 3H), 7.61 (dd, J = 7.9, 7.1 Hz, 3H), 7.51 (dd, J = 8.1, 7.5 Hz, 3H) 7.33 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.04 (d, $^3J(^{13}C\text{-}^{31}P)$ = 8.1 H Hz), 134.14 (d, $^3J(^{13}C\text{-}^{31}P)$ = 8.1 Hz), 133.94 (d, $^2J(^{13}C\text{-}^{31}P)$ = 11.8 Hz), 133.51, 129.26 (d, $^4J(^{13}C\text{-}^{31}P)$ = 1.3 Hz), 127.79, 126.97, 126.50 (d, $^2J(^{13}C\text{-}^{31}P)$ = 14.4 Hz), 125.13 (d, $^2J(^{13}C\text{-}^{31}P)$ = 12.0 Hz), 122.53 (d, $^1J(^{13}C\text{-}^{31}P)$ = 62.7 Hz); ^{31}P NMR (161.98 MHz, $CDCl_3$) δ 9.59. HRMS-ESI Cald. for $C_{32}H_{24}AuNP$ (M^++MeCN-Cl): 650.1312. Found: 650.1335.

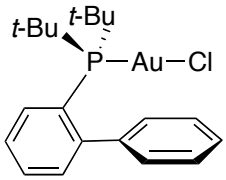
Complex 1a



Yield 69%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76-7.71 (m, 1H), 7.57-7.44 (m, 5H), 7.33-7.28 (m, 1H), 7.18 (d, J = Hz, 3H), 2.08-1.94 (m, 4H) 1.83-1.74 (m, 4H), 1.68-1.43 (m, 6H) 1.33-1.18 (m, 8H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.09, 134.29, 132.48 (d, $^3J(^{13}C\text{-}^{31}P)$ = 7.4 Hz), 130.71, 129.24, 128.64, 128.35, 127.43 (d, $^3J(^{13}C\text{-}^{31}P)$ = 8.4 Hz), 124.43, 36.58 (d, $^1J(^{13}C\text{-}^{31}P)$ = 33.3 Hz), 31.16 (d, $^3J(^{13}C\text{-}^{31}P)$ = 4.5 Hz), 29.42, 26.54 (d, $^2J(^{13}C\text{-}^{31}P)$ = 10 Hz), 24.43 (d, $^2J(^{13}C\text{-}^{31}P)$ = 14 Hz), 25.58; ^{31}P NMR (161.98 MHz, $CDCl_3$) δ 47.15. HRMS-ESI Cald. for $C_{26}H_{34}AuNP$ (M^++MeCN-Cl): 588.2094. Found: 588.2075.

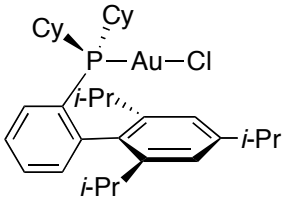
(3) Müller, T. E.; Green, J. C.; Mingos, D. M. P.; McPartlin, C. M.; Whittingham, C.; Williams, D. J.; Woodroffe, T. M. *J. Organomet. Chem.* **1998**, *551*, 313-330.

Complex 1b



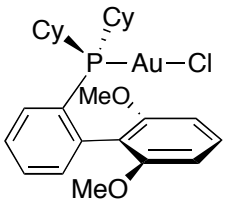
Yield 43%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (td, J = 7.7, 1.7 Hz, 1H), 7.51 (m, 5H), 7.31 (m, 1H), 7.13 (dd, J = 8.0. 1.0 Hz, 2H), 1.41 (d, J = 15.6, 18H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.16 (d, $^{2}J(^{13}C\text{-}^{31}P)$ = 13.5 Hz), 142.10 (d, $^{3}J(^{13}C\text{-}^{31}P)$ = 6.3 Hz), 133.46 (d, $^{4}J(^{13}C\text{-}^{31}P)$ = 3.0 Hz), 133.22 (d, $^{3}J(^{13}C\text{-}^{31}P)$ = 7.5 Hz), 129.19, 128.67, 128.22, 126.67 (d, $^{3}J(^{13}C\text{-}^{31}P)$ = 6.8), 126.06 (d, $^{1}J(^{13}C\text{-}^{31}P)$ = 45.3 Hz), 37.75 (d, $^{1}J(^{13}C\text{-}^{31}P)$ = 25.7 Hz), 30.84 (d, $^{2}J(^{13}C\text{-}^{31}P)$ = 6.7 Hz); ^{31}P NMR (161.98 MHz, $CDCl_3$) δ 63.11. HRMS-ESI Cald. for $C_{22}H_{30}AuNP$ (M^++MeCN-Cl): 536.1781. Found: 536.1779.

Complex 1c



Yield 61%.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57-7.55 (m, 1H), 7.47-7.45 (m, 2H), 7.23 (m, 1H), 7.05 (s, 2H), 2.95 (hept, J = 7.0 Hz, 1H), 2.21 (hept, J = 6.7 Hz, 2H) 2.05-2.01 (m, 4H), 1.83-1.71 (m, 6H), 1.67-1.61 (m, 2H), 1.53-1.42 (m, 3H), 1.35 (s, 3H), 1.34 (s, 3H), 1.28 (s, 3H), 1.26 (s, 3H), 1.23-1.13 (m, 7H), 0.92 (s, 3H), 0.91 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.06, 145.48, 133.82 (d, $^{3}J(^{13}C\text{-}^{31}P)$ = 8.1 Hz), 132.04 (d, $^{1}J(^{13}C\text{-}^{31}P)$ = 3.2 Hz), 130.35 (d, $^{1}J(^{13}C\text{-}^{31}P)$ = 1.8 Hz), 127.08 (d, $^{1}J(^{13}C\text{-}^{31}P)$ = 7.1 Hz), 121.70, 37.23 (d, $^{1}J(^{13}C\text{-}^{31}P)$ = 33.5 Hz), 34.30, 30.93, 30.81, 27.01 (d, $^{1}J(^{13}C\text{-}^{31}P)$ = 13.5 Hz), 26.69 (d, $^{1}J(^{13}C\text{-}^{31}P)$ = 12.9 Hz), 24.36, 23.12; ^{31}P NMR (161.98 MHz, $CDCl_3$) δ 38.48. HRMS-ESI Cald. for $C_{33}H_{49}AuPNa$ (M^++Na): 731.2823. Found: 731.2789.

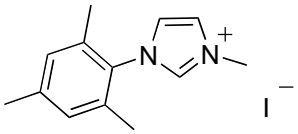
Complex 1d



Yield 51%.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66-7.42 (m, 4H), 7.23-7.20 (m, 1H), 6.66 (d, J = 8.4 Hz, 2H), 3.70 (s, 6H), 2.18-2.13 (m, 2H), 1.98-1.93 (m, 2H) 1.83-1.64 (m, 8H), 1.48-1.36 (m, 4H),

1.33-1.15 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.44, 152.44 (d, $^1J(^{13}C\text{-}^{31}P)$ = 7.9 Hz), 151.08 (d, $^1J(^{13}C\text{-}^{31}P)$ = 3.9 Hz), 150.19 (d, $^1J(^{13}C\text{-}^{31}P)$ = 2.4 Hz), 149.25, 146.27 (d, $^1J(^{13}C\text{-}^{31}P)$ = 3.3 Hz), 146.16 (d, $^1J(^{13}C\text{-}^{31}P)$ = 2.9 Hz), 123.60, 74.54, 55.58 (d, $^1J(^{13}C\text{-}^{31}P)$ = 34.20 Hz), 49.52 (d, $^1J(^{13}C\text{-}^{31}P)$ = 3.8 Hz), 48.45, 45.94 (d, $^1J(^{13}C\text{-}^{31}P)$ = 12.8 Hz), 45.80 (d, $^1J(^{13}C\text{-}^{31}P)$ = 14.3 Hz), 44.94 (d, $^1J(^{13}C\text{-}^{31}P)$ = 1.6 Hz); ^{31}P NMR (161.98 MHz, $CDCl_3$) δ 41.79. HRMS-ESI Cald. for $C_{28}H_{38}AuPNO_2$ (M^++MeCN-Cl): 648.2306. Found: 648.2286.

N-Methyl-N'-(2,4,6-trimethylphenyl)imidazolium Iodide[4]



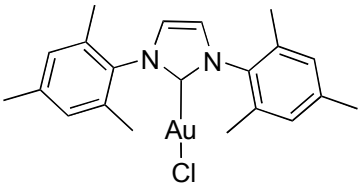
Over a solution of the 1-(2,4,6-trimethyl)imidazole[5] (500 mg, 2.7 mmol) in THF (2 ml), MeI (1916.2 mg, 13.5 mmol) was added dropwise. The mixture was refluxed while the white product precipitated. After 48 h, the reaction mixture was filtered to give a white solid (1.98 mmol, 73%). The solid was used without any further purification.^{1}H NMR (300 MHz, $CDCl_3$) δ 9.91 (s, 1H), 7.86 (t, J = 1.8 Hz, 1H), 7.18 (t, J = 1.8 Hz, 1H), 6.99 (s, 2H), 4.36 (s, 3H), 2.33 (s, 3H), 2.08 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 141.39, 137.66, 134.25, 130.46, 129.85, 124.69, 123.07, 37.96, 21.06, 17.91. HRMS-EI Cald. for $C_{13}H_{16}N_2I$ (M^+-H): 327.0358. Found: 327.0359.

General Procedure for NHC Au(I) complexes 2a-c[6]

Ag_2O (0.5 mmol) was added to a solution of the imidazolium ligand (1mmol)[7] in CH_2Cl_2. The suspension became clear after stirring 3 h at room temperature. Then a solution of Me_2SAuCl (1mmol) in CH_2Cl_2 was added drop wise. The reaction mixture was stirred for another 4 h. Then the solution was filtered through Celite and the solvent was partially evaporated. Addition of hexane led to the precipitation of the methiodides.

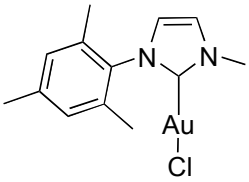
(4) Bohm, V. P. W.; Weskamp, T.; Gstottmayr, C. W. K.; Herrmann, W. A. *Angew. Chem. Int. Ed.* **2000**, *39*, 1602-1604.
(5) Gardiner, M. G.; Herrmann, W. A.; Reisinger, C.-P.; Schwarz, J.; Spiegler, M. *J. Organomet. Chem.* **1999**, *572*, 239-247.
(6) (a)Wang, H. M. J.; Lin, I. J. B. *Organomet.* **1998**, *17*, 972-975. (b) Wang, H. M. J.; Chen, C. Y. L.; Lin, I. J. B. *Organomet.* **1999**, *18*, 1216-1223.
(7) Synthesis of *N,N'*-dimethylimidazolium iodide: Overberger, C. G.; Salamone, J. C.; Yaroslavsky, S. *J. Org. Chem.* **1965**, *30*, 3580.

Complex 2a



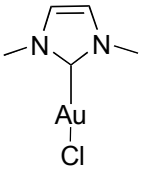
Yield 49%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.08 (s, 2H), 6.97 (bs, 4H), 2.33 (s, 6H), 2.09 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 139.79, 134.68, 129.49, 122.12, 21.13, 17.75 (one signal is missing). HRMS-FAB Cald. for $C_{21}H_{25}AuN_2Cl$ (M^++H): 537.1372. Found: 537.1361.

Complex 2b



Yield 60%. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.14 (d, J = 2.0 Hz, 1H), 6.95 (bs, 2H), 6.88 (d, J = 2.0 Hz, 1H), 3.95 (s, 3H), 2.32 (s, 3H), 2.00 (s 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.69, 139.71, 134.80, 134.69, 129.45, 122.18, 121.69, 38.37, 21.12, 17.85. HRMS-ESI Cald. for $C_{13}H_{17}AuN_2Cl$ (M^++H): 433.0746. Found: 433.0739.

Complex 2c



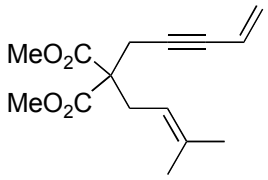
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.92 (bs, 2H), 3.82 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.32, 121.72, 38.19.

General procedure for the synthesis of substituted alkynes.[8]

CuI (0.1 mmol) and [$Pd(PPh_3)_2Cl_2$] (0.05 mmol) were suspended in i-Pr_2NH, and the resulting mixture was stirred for 5 min. The corresponding alkenyl- or arylbromide (1.3 mmol) and the alkyne 1,6-enyne (1 mmol) in i-Pr_2NH were added sequentially. The reaction was stirred at room temperature until TLC showed total conversion. The crude mixture was diluted with Et_2O, filtered through Celite, and purified by chromatography.

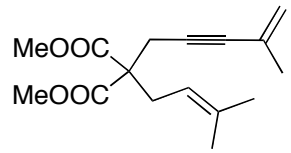
(8) Forsyth, C. J.; Clardy, J. *J. Am. Chem. Soc.* **1990**, *112*, 3497-3505.

Dienyne 5a



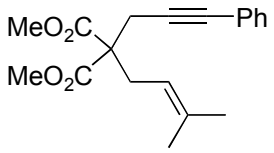
Yield 83%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.71 (ddt, J = 17.5, 11.0, 2.1 Hz, 1H), 5.53 (ddt, J = 17.5, 2.2, 0.6 Hz, 1H), 5.39 (dd, J = 11.0, 2.3 Hz, 1H), 4.91 (bt, J = 7.7 Hz, 1H), 3.73 (s, 6H), 2.88 (d, J, = 2.1 Hz, 2H), 2.76 (d, J = 7.7 Hz, 2H), 1.70 (d, J = 1.1 Hz, 3H), 1.65 (d, J = 1.0Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.58, 136.74, 126.49, 117.08, 117.06, 85.30, 81.99, 57.36, 52.62, 30.91, 26.03, 23.40, 17.87. HRMS-CI Cald. for $C_{15}H_{21}O_4$ (M^++H): 265.1440. Found: 265.1441.

Dienyne 5b



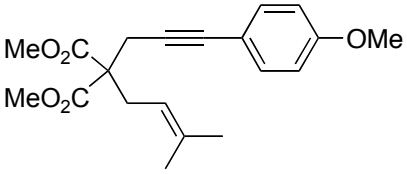
^{1}H RMN (500 MHz, $CDCl_3$) δ 5.21 (s, 1H), 5.17 (s, 1H), 4.93 (t, J = 7.7 Hz, 1H), 3.75 (s, 6H), 2.89 (s, 2H), 2.79 (d, J = 7.7 Hz, 2H), 1.85 (s, 3H), 1.72 (s, 3H), 1.68 (s, 3H); ^{13}C RMN (125 MHz, $CDCl_3$) δ 170.6, 136.7, 126.7, 121.2, 117.2, 84.6, 83.7, 57.5, 52.6, 30.9, 26.1, 23.5, 23.3, 17.9; HRMS-CI Cald. for $C_{16}H_{23}O_4$ (M^++H) 279.1596. Found: 279.1696.

Enyne 9a



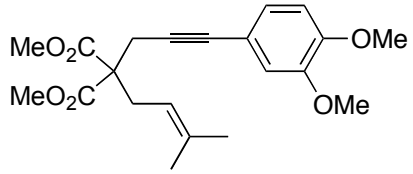
Yield 81%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37-7.33 (m, 2H), 7.29-7.23 (m, 3H), 4.96 (t, J = 7.7 Hz, 1H), 3.75 (s, 6H), 2.99 (s, 2H), 2.84 (d, J = 7.7 Hz, 2H), 1.71 (s, 3H), 1.67 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.11, 170.65, 136.82, 131.62, 128.18, 127.91, 123.31, 117.17, 84.76, 83.34, 57.53, 52.67, 30.80, 26.07, 23.48, 17.97. HRMS-CI Cald. for $C_{19}H_{22}O_4$ (M^++H): 315.1596. Found: 315.1596.

Enyne 9b



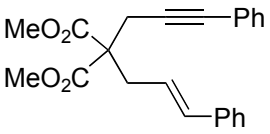
Yield 20%. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.31 (d, J = 8.8 Hz, 2H), 6.81 (d, J = 8.8Hz, 3H), 4.97 (t, J = 7.7 Hz, 1H), 3.80 (s, 3H), 3.76 (s, 6H), 2.98 (s, 2H), 2.85 (d, J = 7.7 Hz, 2H), 1.73 (s, 3H), 1.69 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.71, 159.34, 136.74, 132.98, 117.23, 115, 47, 113.82, 83.12, 60.37, 57.56, 55.25, 52.64, 30.96, 26.07, 23.48, 17.96. HRMS-CI Cald. for $C_{20}H_{25}O_5$ (M^++H): 345.1702. Found: 345.1697.

Enyne 9c



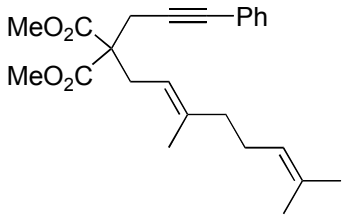
Yield 35%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.95 (dt, J = 8.1, 1.6 Hz, 1H), 6.85 (t, J = 1.5 Hz, 1H), 6.75 (dd, J = 8.1, 1.4 Hz, 1H), 4.94 (m, 1H), 3.85 (s, 3H), 3.84 (s, 3H), 3.74 (s, 6H), 2.94 (s, 2H), 2.83 (d, J = 8.1 Hz, 2H), 1.71 (s, 3H), 1.67 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.22, 149.25, 136.62, 127.21, 117.11, 115.50, 114.35, 110.91, 107.92, 83.35, 83.07, 57.53, 55.91, 52.67, 31.03, 26.10, 23.52, 18.00. HRMS-CI Cald. for $C_{21}H_{27}O_6$ (M^++H): 375.1808. Found: 375.1794.

Enyne 9d



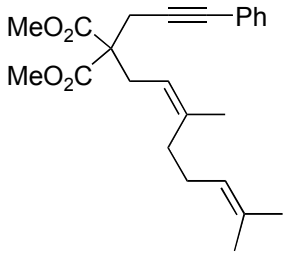
Yield 80%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39-7.18 (m, 10H), 6.51 (d, J = 15.7Hz, 1H), 6.02 (dt, J = 15.5, 7.6 Hz, 1H), 3.78 (s, 6H), 3.07 (s, 2H), 3.02 (dd, J = 7.6, 1.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.33, 137.03, 134.61, 131.66, 128.48, 128.21, 128.01, 127.48, 126.30, 123.34, 84.27, 83.77, 57.66, 52.82, 36.21, 23.96 (one signal is missing due to overlapping). HRMS-CI Cald. for $C_{23}H_{23}O_4$ (M^++H): 363.1596. Found: 363.1597.

Enyne 9e



Yield 79%. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37-7.33 (m, 2H), 7.28-7.24 (m, 3H), 5.05 (m, 1H), 4.95 (m, 1H), 3.75 (s, 6H), 2.99 (s, 2H), 2.85 (d, J = 7.7 Hz, 2H), 2.11-1.98 (m, 4H), 1.68 (s, 3H), 1.66 (s, 3H), 1.59 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.64, 140.36, 131.61, 131.58, 128.17, 127.89, 124.01, 123.39, 117.24, 84.85, 83.29, 57.55, 52.66, 39.99, 30.86, 26.50, 25.66, 23.40, 17.69, 16.20. HRMS-CI Cald. for $C_{24}H_{31}O_4$ (M^++H): 383.2222. Found: 383.2223.

Enyne 9f

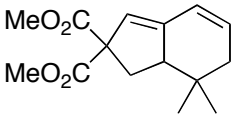


Yield 74%. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.38-7.34 (m, 2H), 7.29-7.26 (m, 3H), 5.09 (m, 1H), 4.95 (t, J = 7.8 Hz, 1H), 3.77 (s, 6H), 3.01 (s, 2H), 2.87 (d, J = 7.3 Hz, 2H), 2.37-1.88 (m, 4H), 1.73 (s, 3H), 1.65 (s, 3H), 1.59 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.63, 140.63, 131.67, 128.51, 127.91, 124.122, 117.63, 117.26, 109.83, 84.73, 83.44, 57.48, 52.69, 39.99, 32.02, 30.60, 25.63, 23.47, 17.62, 16.20. HRMS-CI Cald. for $C_{24}H_{31}O_4$ (M^++H): 383.2222. Found: 383.2226.

General Procedure for the Cyclization of Scheme 3 and Table 1

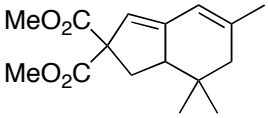
To a solution of Au(I) complex (0.002 mmol) and $AgSbF_6$ (0.002 mmol) in dry CH_2Cl_2 (0.5 mL), the enyne was added dissolved in dry CH_2Cl_2 (0.5 mL). The reaction was stirred at the stated conditions for 1-48 h. The resulting mixture was filtered through Celite and purified by chromatography.

Dimethyl 4,4-Dimethyl-3a,4-dihydro-1*H*-indene-2,2(6*H*)dicarboxylate (6a)



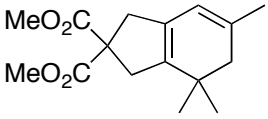
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.24 (dd, J = 9.7, 2.9 Hz, 1H), 5.84 (ddd, J = 9.6, 5.9, 2.1 Hz, 1H), 5.56 (d, J = 2.4 Hz, 1H), 3.74 (s, 3H), 3.70 (s, 3H), 2.76 (td, J = 9.5, 2.2 Hz, 1H), 2.62 (dd, J = 13.2, 7.6 Hz, 1H), 2.07 (t, J = 18.2 Hz, 1H), 1.99 (dd, J = 13.2, 9.3 Hz, 1H), 1.94 (td, J = 18.1, 5.9 Hz, 1H), 0.97 (s, 3H), 0.70 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.24, 171.51, 145.79, 132.55, 122.70, 120.91, 65.38, 52.65, 52.63, 52.12, 42.03, 33.16, 32.50, 28.72, 19.42. HRMS-CI Cald. for $C_{18}H_{21}O_4$ (M^++H): 265.1440. Found: 265.1441. The structure was confirmed by COSY, HMQC and HMBC experiments.

Dimethyl 4,4,6-Trimethyl-3a,4-dihydro-1*H*-indene-2,2(6*H*)dicarboxylate (6b)



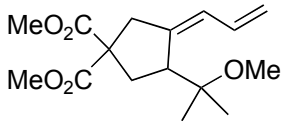
^{1}H-RMN (500 MHz, $CDCl_3$) δ 6.01 (s, 1H), 5.43 (s, 1H), 3.74 (s, 3H), 3.69 (s, 3H), 2.69 (td, J = 9.4, 2.9 Hz, 1H), 2.59 (dd, J = 13.1, 7.6 Hz, 1H), 2.11 (d, J = 17.4 Hz, 1H), 1.95 (dd, J = 13.1, 9.3 Hz, 1H), 1.75 (s, 3H) overlap 1.77 (t, J = 8.7 Hz, 1H), 0.96 (s, 3H), 0.68 (s, 3H); ^{13}C-RMN (125 MHz, $CDCl_3$) δ 172.4, 171.7, 146.7, 141.9, 118.4, 118.1, 65.5, 52.5, 51.7, 47.3, 32.9, 32.4, 28.6, 23.8, 19.3; HRMS-CI Cald. for $C_{16}H_{23}O_4$ (M^++H) 279.1596. Found: 279.1606. The structure was confirmed by COSY, HMQC and HMBC experiments.

Dimethyl 4,4,6-Trimethyl-4,5-dihydro-1*H*-indene-2,2(3*H*)dicarboxylate (7)



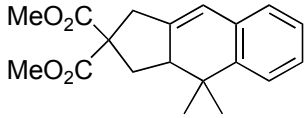
^{1}H-RMN (500 MHz, $CDCl_3$) δ 5.58 (s, 1H), 3.73 (s, 6H), 3.02 (s, 4H), 1.97 (s, 2H), 1.77 (s, 3H), 0.95 (s, 6H); ^{13}C-RMN (125 MHz, $CDCl_3$) δ 172.7, 137.3, 135.5, 129.2, 116.8, 58.5, 52.7, 45.3, 41.6, 39.2, 32.5, 25.9, 23.3. HRMS-CI Cald. for $C_{16}H_{23}O_4$ (M^++H) 279.1596. Found: 279.1600. The structure was confirmed by COSY, HMQC and HMBC experiments.

(*Z*)-Dimethyl 3-Allylidene-4-(2-methoxypropan-2-yl)cyclopentane-1,1-dicarboxylate (8)



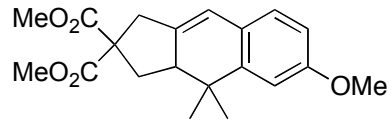
^{1}H NMR (400MHz, $CDCl_3$) δ 6.47 (dt, J = 16.9, 10.6 Hz, 1H), 6.06 (d, J = 11.0 Hz, 1H), 5.11 (d, J = 16.8 Hz, 1H), 5.03 (d, J = 10.2 Hz, 1H), 3.75 (s, 3H), 3.70 (s, 3H), 3.19 (d, J = 15.0Hz, 1H), 3.15 (s, 3H), 3.01 (m, 1H), 2.71 (d, J = 14.9 Hz, 1H), 2.61 (dd, J = 13.9, 9.1 Hz, 1H), 2.35 (dd, J = 14.1, 5.2 Hz, 1H), 1.19 (s, 3H), 1.11 (s, 3H); ^{13}C NMR (100MHz, $CDCl_3$) δ 172.49, 172.10, 143.20, 134.41, 126.27, 115.99, 77.71, 58.41, 52.72, 52.62, 49.01, 48.41, 44.15, 34.99, 23.04. HRMS-CI Cald. for $C_{15}H_{21}O_4$ (M^+-OMe): 265.1434. Found: 265.1431. The structure was confirmed by COSY, HMQC and HMBC experiments.

Dimethyl 4,4-Dimethyl-3a,4-dihydro-1*H*-cyclopenta[*b*]naphthalene-2,2(3*H*)dicarboxylate (10a)



^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29-7.27 (m, 1H), 7.13 (m, 2H), 7.01 (m, 1H), 6.34 (bs, 1H), 3.77 (s, 3H), 3.71 (s, 3H), 3.27 (dd, J = 18.0, 1.3 Hz, 1H), 2.97 (dt, J = 18.0, 3.0 Hz, 1H), 2.69-2.63 (m, 1H), 2.57 (ddd, J = 12.3, 7.6, 1.1 Hz, 1H), 2.13 (t, J = 12.3 Hz, 1H), 1.42 (s, 3H), 0.92 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.09, 171.19, 143.99, 142.85, 133.87, 126.87, 123.23, 126.20, 123.42, 119.32, 58.86, 52.83, 52.81, 48.40, 39.15, 36.58, 34.76, 25.59, 21.98. HRMS-CI Cald. for $C_{19}H_{22}O_4$ (M^+): 314.1518. Found: 314.1511. The structure was confirmed by COSY, HMQC and HMBC experiments.

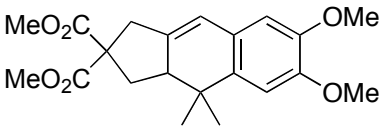
Dimethyl 6-Methoxy-4,4-dimethyl-3a,4-dihydro-1*H*-cyclopenta[*b*]naphthalene-2,2(3*H*)dicarboxylate (10b)



^{1}H NMR (500 MHz, $CDCl_3$) δ 6.96 (d, J = 8.3 Hz, 1H), 6.88 (d, J = 2.5 Hz, 1H), 6.67 (dd, J = 8.2, 2.6 Hz, 1H), 6.31 (bs, 1H), 3.82 (s, 3H), 3.78 (s, 3H), 3.73 (s, ·H), 3.28 (dd, J = 17.9, 1.5 Hz, 1H), 2.98 (dt, J = 17.8, 3.0 Hz, 1H), 2.69-2.63 (m, 1H), 2.59 (ddd, J = 13.6, 7.5, 1.3 Hz, 1H), 2.14 (t, J = 12.3 Hz, 1H), 1.41 (s, 3H), 0.90 (s, 3H); 13C NMR (125 MHz, $CDCl_3$) δ 172.19, 172.02, 158.74, 146.00, 140.16, 127.13, 118.71, 110.81, 110.02, 100.03, 59.00, 55.30, 52.87, 52.84, 48.22, 39.08,

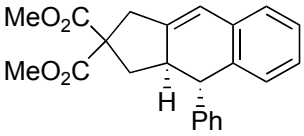
36.96, 34.85, 25.59, 21.94. HMRS-CI Cald. for C20H25O5 (M^++H): 345.1702. Found: 345.1692. The structure was confirmed by COSY, HMQC and HMBC experiments.

Dimethyl 6,7-Dimetoxy-4,4-dimethyl-3a,4-dihydro-1*H*-cyclopenta[*b*]naphthalene-2,2(3*H*)dicarboxylate (10c)

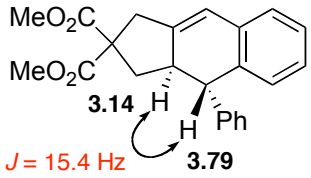


^{1}H NMR (400 MHz, $CDCl_3$) δ 6.77 (s, 1H), 6.51 (s, 1H), 6.19 (bs, 1H), 3.82 (s, 3H), 3.78 (s, 3H), 3.70 (s, 3H), 3.65 (s, 3H), 3.21 (d, J = 17.8 Hz, 1H), 2.90 (dt, J = 17.8, 2.8 Hz, 1H), 2.63-2.46 (m, 2H), 2.05 (t, J = 12.0 Hz, 1H), 1.34 (s, 3H), 0.83 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.14, 171.96, 147.65, 147.14, 141.03, 136.72, 127.17, 118.75, 109.95, 107.97, 58.97, 56.20, 55.92, 52.82, 48.57, 39.12, 36.44, 38.84, 25.88, 21.90. HMRS-CI Cald. for C21H27O6 (M^++H): 375.1808. Found: 375.1796. The structure was confirmed by COSY, HMQC and HMBC experiments.

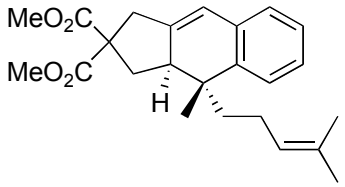
(3a*R,4*S**)-Dimethyl 4-Phenyl-3a,4-dihydro-1*H*-cyclopenta[*b*]naphthalene-2,2(3*H*)-dicarboxylate (10d)**



^{1}H NMR (400MHz, $CDCl_3$) δ 7.38 (t, J = 6.9 Hz, 2H), 7.31 (t, J = 7.8 Hz, 3H), 7.12 (td, J = 7.3, 1.1 Hz, 1H), 7.06 (dd, J = 7.5, 1.3 Hz, 1H), 6.97 (td, J = 7.5, 1.4 Hz, 1H), 6.55 (d, J = 7.7 Hz, 1H), 6.41 (bs, 1H), 3.79 (d, J = 15.4 Hz, 1H), 3.72 (s, 3H), 3.69 (s, 3H), 3.33 (d, J = 18.5 Hz, 1H), 3.16 (dt, J = 17.7, 2.4 Hz, 1H), 3.14 (m, 1H), 2.34 (dd, J = 13.0, 7.4 Hz, 1H), 1.95 (dd, J = 13.1, 11.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.07, 144.40, 141.78, 137.99, 135.21, 128.74, 128.26, 126.92, 126.91, 126.62, 126.47, 125.58, 119.42, 59.08, 52.82, 52.22, 45.07, 39.75, 38.81. HRMS-CI Cald. for $C_{23}H_{23}O_4$ (M^++H): 363.1596. Found: 363.1598. The structure was confirmed by COSY, HMQC and HMBC experiments. The configuration was assigned on the basis of the observed ^3J:

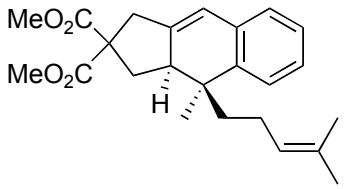


(3a*R,4*S**)-Dimethyl 4-Methyl-4-(4-methylpent-3-enyl)-3a,4-dihydro-1*H*-cyclopenta[*b*]naphthalene-2,2(3*H*)-dicarboxylate (10e)**



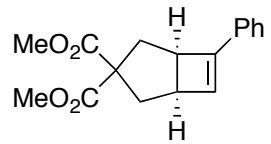
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22-7.10 (m, 3H), 7.04-7.01 (m, 1H), 6.31 (bs, 1H), 5.19 (m, 1H), 3.77 (s, 3H), 3.72 (s, 3H), 3.30 (dd, *J* = 17.8, 1.0 Hz, 1H), 3.02 (dt, *J* = 21.1, 2.9 Hz, 1H) 2.94 (m, 1H) 2.56 (dd, *J* = 11.4, 7.4 Hz, 1H), 2.11-1.98 (m, 5H), 1.71 (s, 3H), 1.60 (s, 3H), 0.99 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.09, 171.89, 142.78, 141.47, 134.84, 131.50, 126.82, 126.80, 126.10, 124.56, 123.97, 118.23, 58.92, 52.84, 43.78, 40.29, 39.27, 36.88, 34.31, 25.72, 23.28, 23.05, 17.63. HRMS-CI Cald. for $C_{24}H_{31}O_4$ (M^++H): 383.2222. Found: 383.2220. The structure was confirmed by COSY, NOESY, HMQC and HMBC experiments.

(3a*R,4*R**)-Dimethyl 4-Methyl-4-(4-methylpent-3-enyl)-3a,4-dihydro-1*H*-cyclopenta[*b*]naphthalene-2,2(3*H*)-dicarboxylate (10f)**



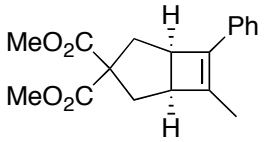
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.24-7.18 (m, 1H), 7.15-7.11 (m, 2H), 6.98-6.95 (m, 1H), 6.33 (bs, 1H), 4.92 (dd, *J* = 7.2, 6.9 Hz, 1H), 3.78 (s, 3H), 3.75 (s, 3H), 3.30 (d, *J* = 18.0 Hz, 1H), 2.96 (dt, *J* = 18.0, 2.9 Hz, 1H) 2.79-2.72 (m, 1H), 2.60-2.56 (m, 1H), 2.24 (t, *J* = 12.6 Hz, 1H), 1.88-1.68 (m, 4H), 1.60 (s, 3H), 1.40 (s, 3H), 1.30 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.15, 142.77, 140.82, 134.52, 131.23, 126.31, 126.21, 126.04, 125.58, 124.72, 119.53, 58.82, 52.86, 52.78, 49.58, 39.18, 34.37, 32.60, 25.59, 23.41, 23.21, 17.35 (one signal is missing due to overlapping). HRMS-CI Cald. for $C_{24}H_{31}O_4$ (M^++H): 383.2222. Found: 383.2206. The structure was confirmed by COSY, NOESY, HMQC and HMBC experiments.

(1*R,5*S**)-Dimethyl 7-Phenylbicyclo[3.2.0]hept-6-ene-3,3-dicarboxylate (11a)**



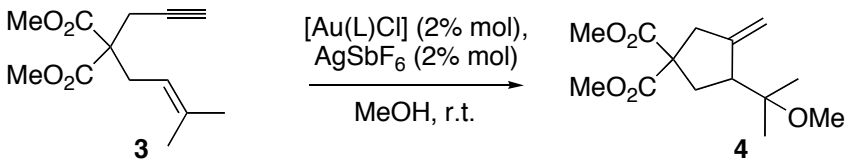
White solid: mp = 68-70ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25-7.15 (m, 5H), 6.01 (s, 1H); 3.63 (s, 3H), 3.56 (dd, *J* = 7.4, 3.5 Hz, 1H), 3.25 (dd, *J* = 7.5, 3.5 Hz, 1H), 3.15 (s, 3H), 2.76 (d, *J* = 13.5 Hz, 1H), 2.61 (d, *J* = 13.3 Hz, 1H) 1.95 (dd, *J* = 13.5, 7.5 Hz, 1H); 1.90 (dd, *J* = 13.3, 1.5 Hz, 1H); ^{13}C NMR (100MHz, $CDCl_3$) δ 172.57, 171.93, 146.69, 133.32, 129.80, 128.26, 127.77, 124.61, 60.89, 52.93, 51.76, 45.75, 43.48, 35.36, 34.05. HRMS-CI Cald. for $C_{17}H_{19}O_4$ (M^++H): 287.1283. Found: 287.1274. The structure was confirmed by COSY, NOESY, HMQC and HMBC experiments.

(1*R*,5*S*)-Dimethyl 6-Methyl-7-phenylbicyclo[3.2.0]hept-6-ene-3,3-dicarboxylate (11b)



^{1}H NMR (400MHz, $CDCl_3$) δ 7.33-7.25 (m, 4H), 7.21-7.15 (m, 1H), 3.68 (s, 3H), 3.50-3.45 (m, 1H), 3.22 (s, 3H), 3.15-3.11 (m, 1H), 2.72 (dd, *J* = 28.8, 13.3 Hz, 1H), 2.02 (dd, *J* = 13.4, 7.2 Hz, 1H), 1.86 (dd, *J* = 13.2, 7.6 Hz, 1H), 1.85 (dd, *J* = 2.8, 1.4 Hz, 3H); ^{13}C NMR (100MHz, $CDCl_3$) δ 172.65, 172.41, 140.89, 138.50, 134.61, 128.25, 126.73, 125.65, 60.58, 52.78, 51.83, 46.35, 43.57, 34.65, 33.56, 13.92. HRMS-CI Cald. for $C_{28}H_{20}O_4$ (M^++H): 301.1440. Found: 301.1437. The structure was confirmed by COSY, NOESY, HMQC and HMBC experiments.

Table 3. Au(I)-catalyzed methoxycyclization of enyne 3.[9]

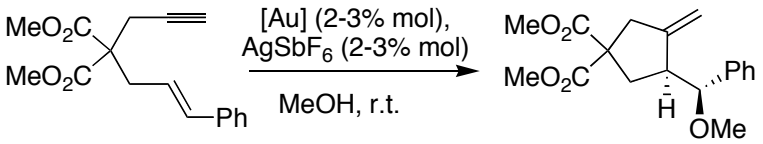


Entry	Complex	Time (h)	Conversion (%)[a]	Yield of **4** (%)
1	AuCl	24	32	10
2	[Au(Me_2S)Cl]	24	<2	<2
3	[Au(Ph_3P)Cl]	3	>98	84
4	[Au(Cy_3P)Cl]	3.5	>98	77
5	[Au{$(C_6F_5)_3P$}Cl]	5	>98	77
6	[Au{$(o\text{-Tol})_3P$}Cl]	24	>98	90
7	[Au(Ph_3As)Cl]	4	>98	78
8	[Au{$P(1\text{-Naph})_3$}Cl]	12	>98	76
9	**1b**	0.25	>98	90
10	**1a**	0.5	>98	97
11	**1c**	0.25	>98	92
12	**1d**	0.25	>98	89
13	**2a**	1.5	>98	71
14	**2b**	5	>98	87
15	**2c**	24	>98	34

[a] Conversions were determined by GC.

(9) Méndez, M.; Muñoz, M. P.; Nevado, C.; Cárdenas, D. J.; Echavarren, A. M. *J. Am. Chem. Soc.* **2001**, *123*, 10511-10520.

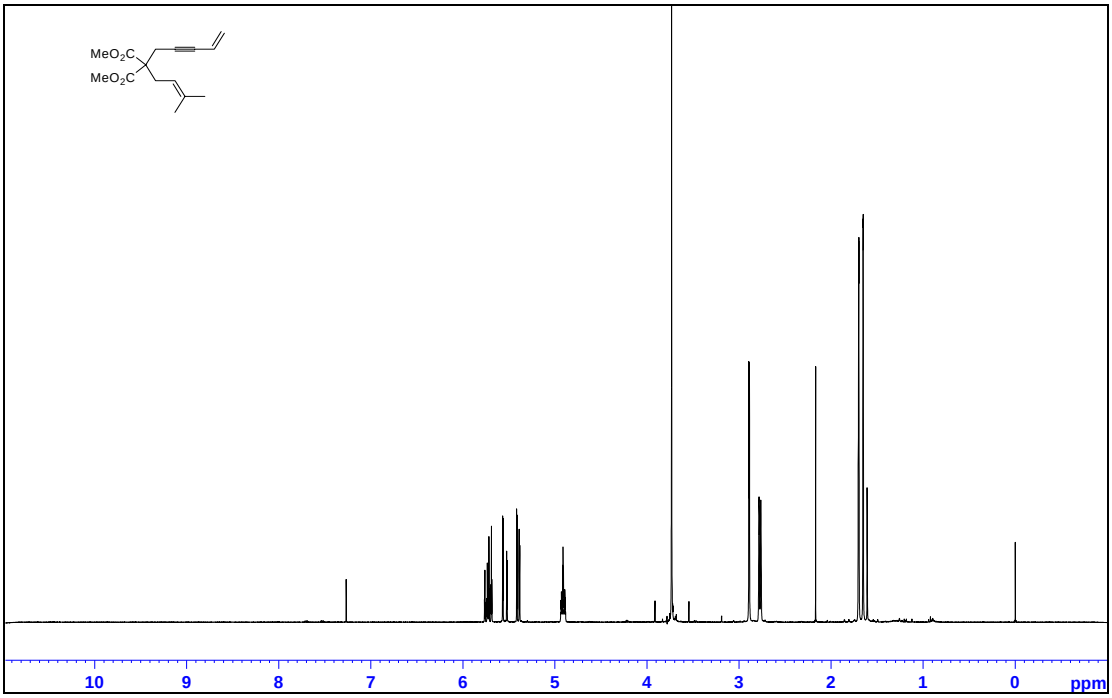
Table 4. Au(I)-catalyzed methoxycyclization of enyne 12.[9]

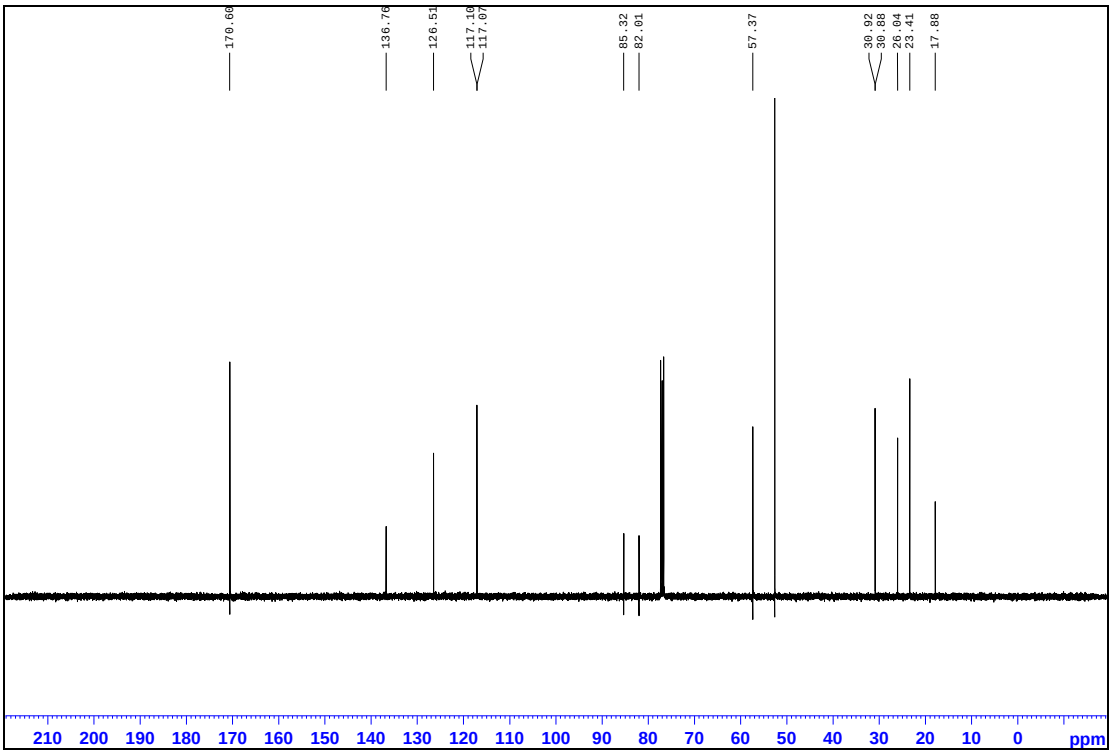


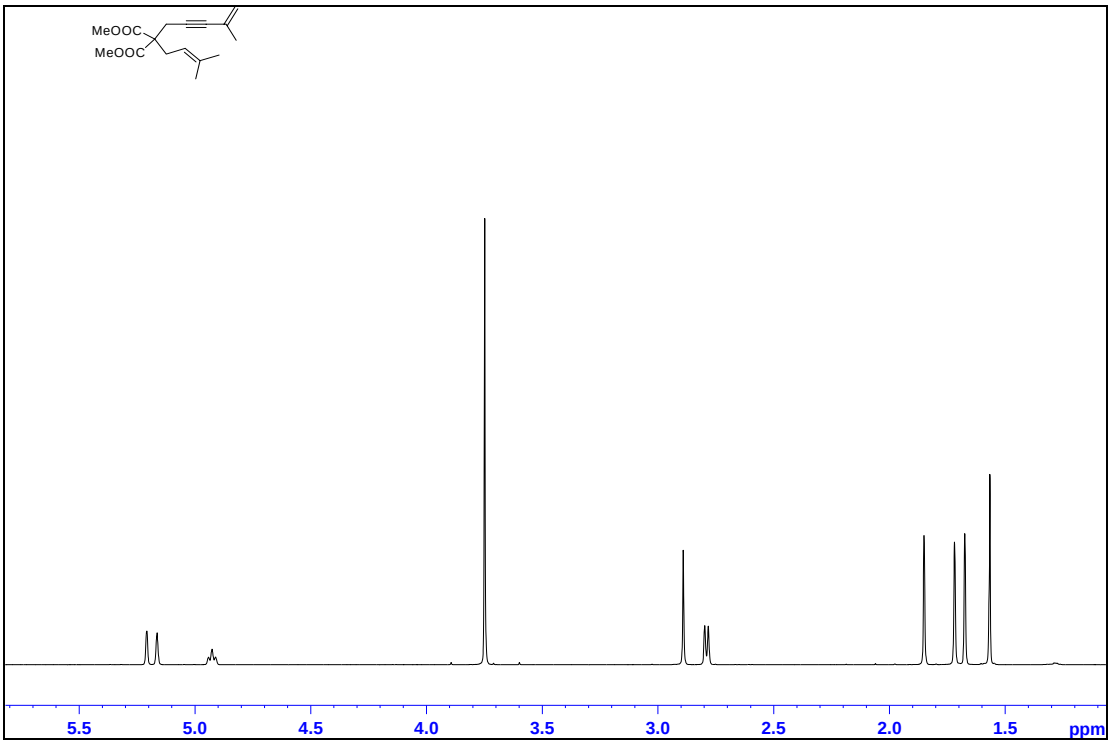
12 **13**

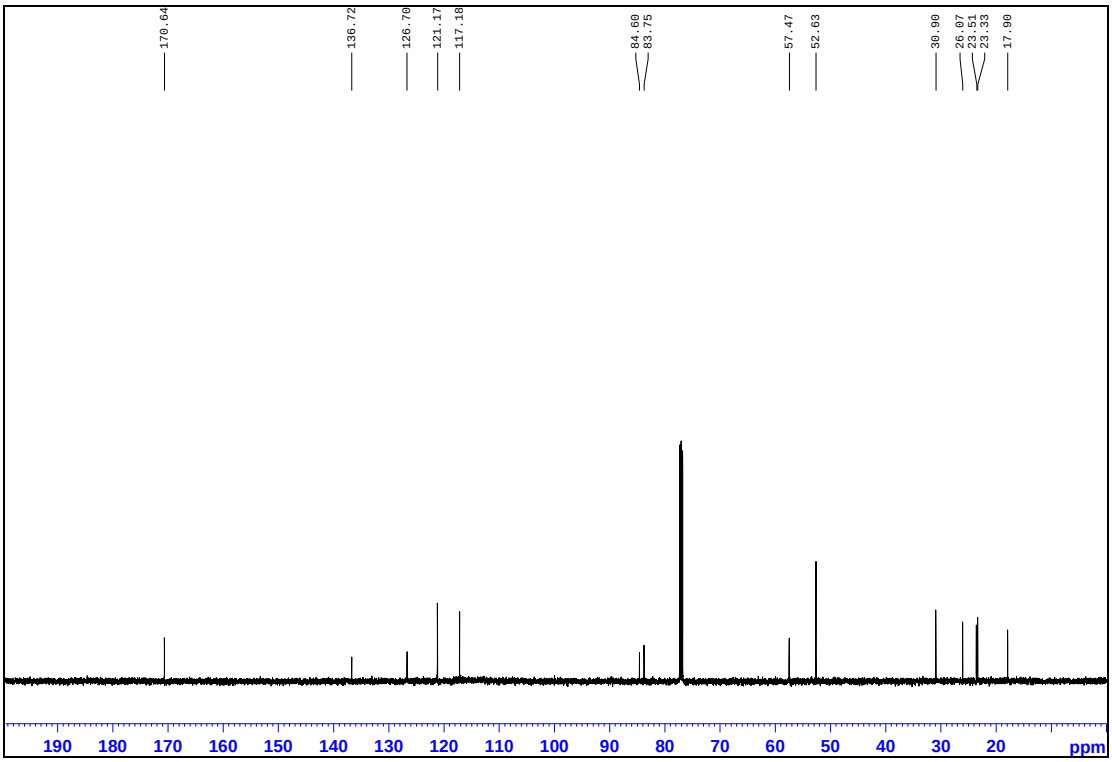
Entry	Complex	Time (h)	Conversion (%)[a]	Yield of **13** (%)
1	AuCl	48	50	35
2	[Au(Me_2S)Cl]	48	21	5
3	[Au(Ph_3P)Cl]	18	93	70
4	[Au(Cy_3P)Cl]	18	>98	83
5	[Au{(C_6F_5)$_3$P}Cl]	48	66	44
6	[Au{(*o*-Tol)$_3$P}Cl]	30	>98	79
7	[Au(Ph_3As)Cl]	48	68	48
8	**1a**	18	>98	68
9	**1c**	18	>98	94
10	**2a**	20	>98	76
11	**2b**	24	73	51
12	**2c**	48	84	48

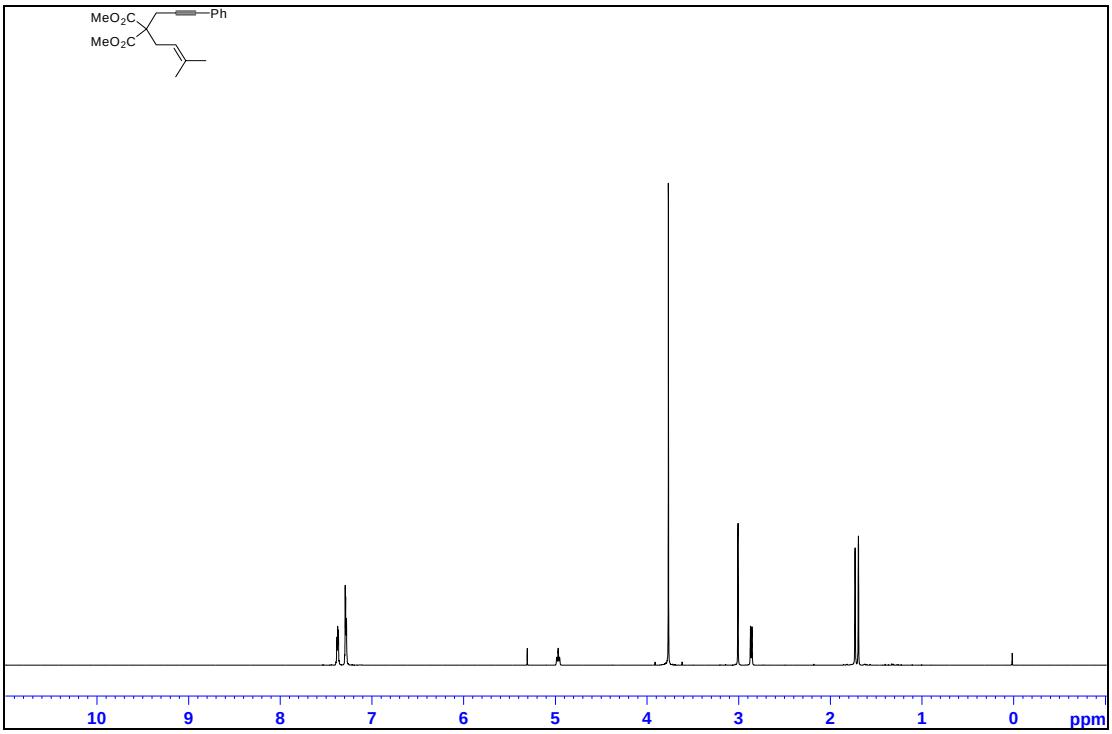
[a] Conversions were determined by GC.

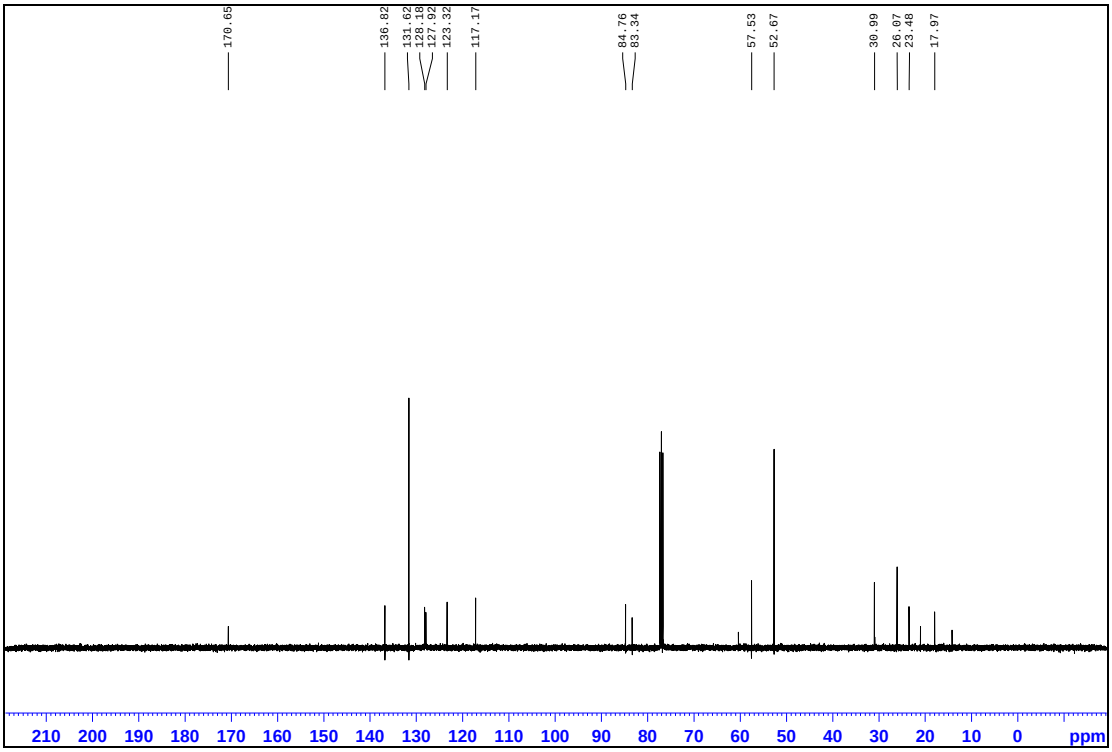

MeO2C
MeO2C
10
9
8
7
6
5
4
3
2
1
0
ppm

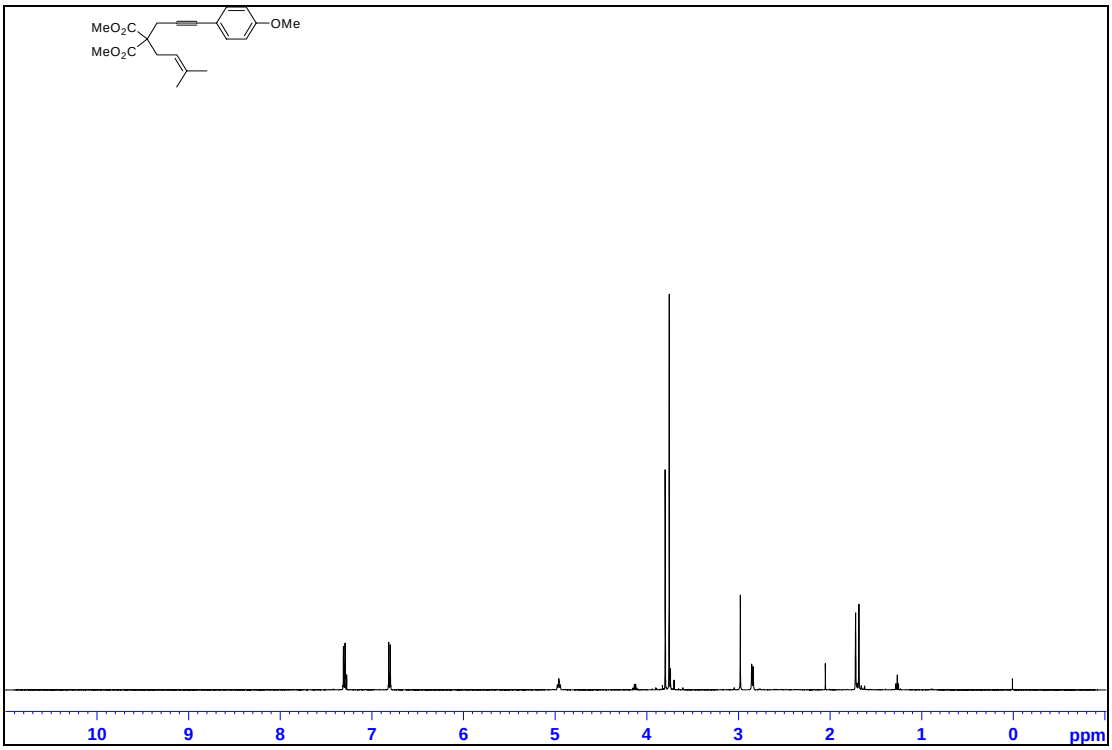

170.60
136.76
126.51
117.10
117.07
85.32
82.01
57.37
30.92
30.88
26.04
23.41
17.88
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

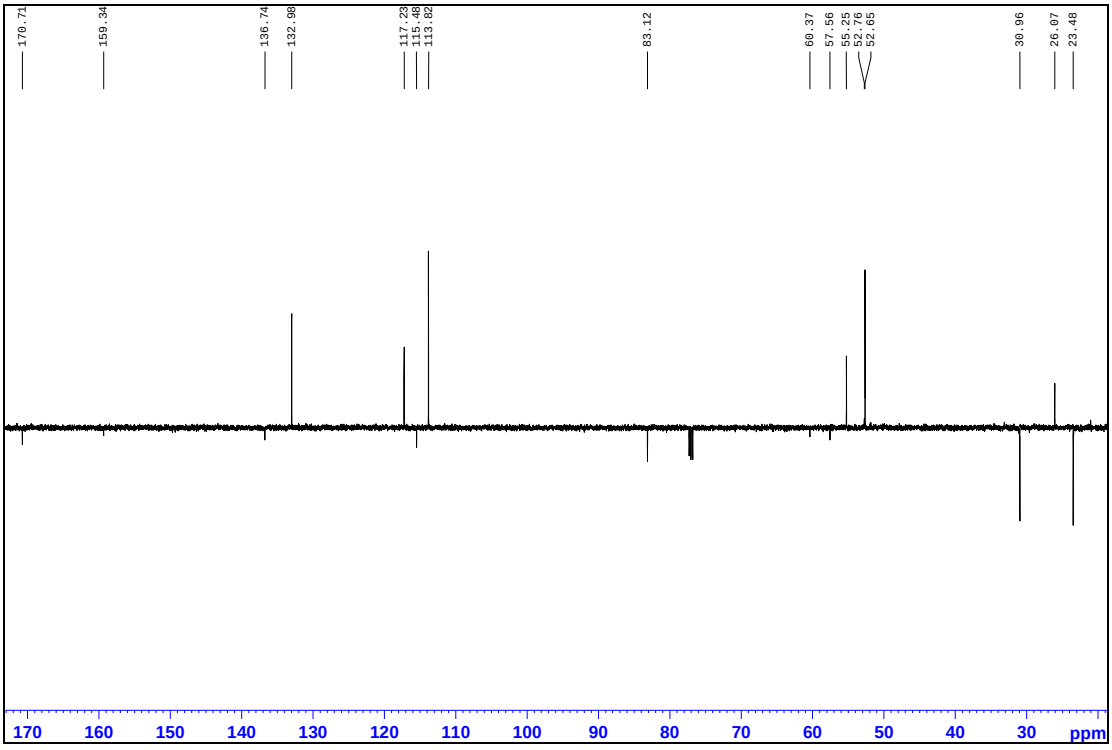

MeOOC
MeOOC
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm

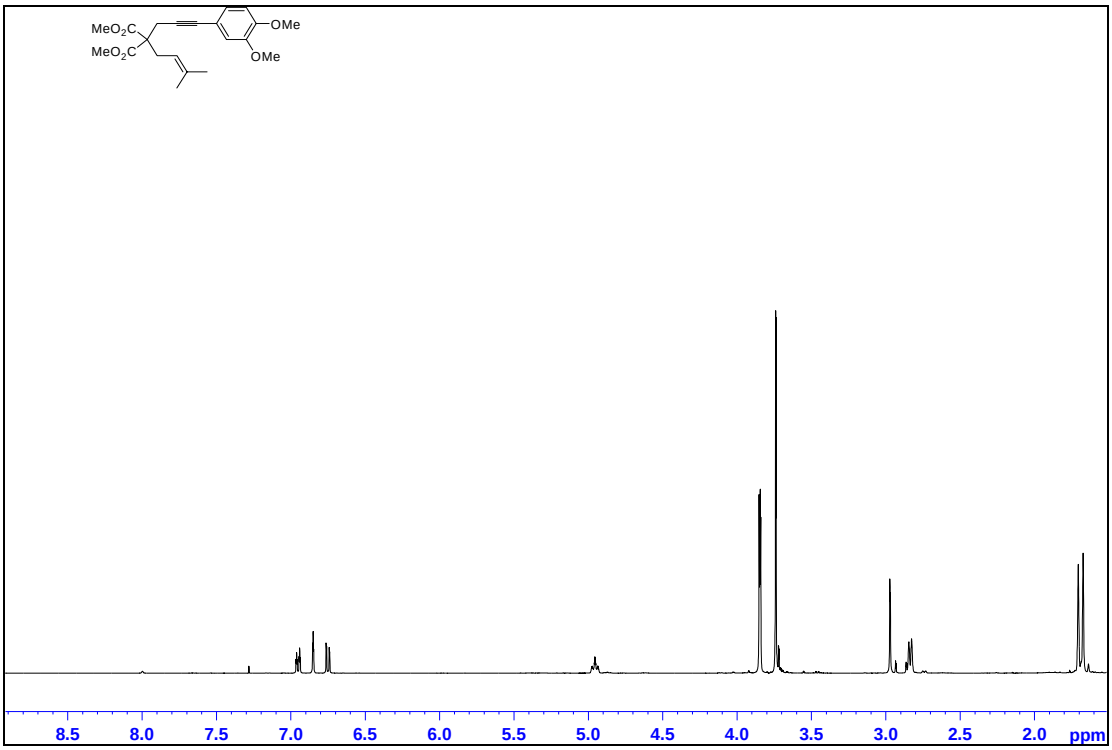

170.64
136.72
126.70
121.17
117.18
84.60
83.75
57.47
52.63
30.90
26.07
25.51
23.33
17.90
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

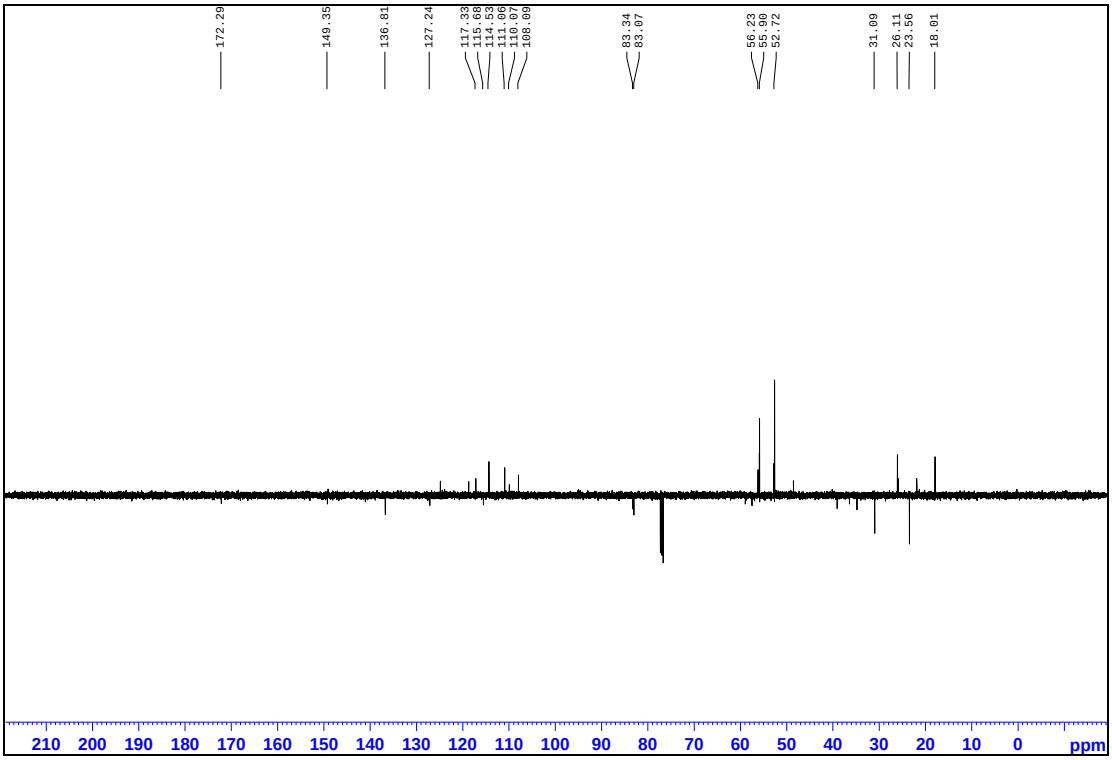

MeO2C
MeO2C
Ph
10
9
8
7
6
5
4
3
2
1
0
ppm

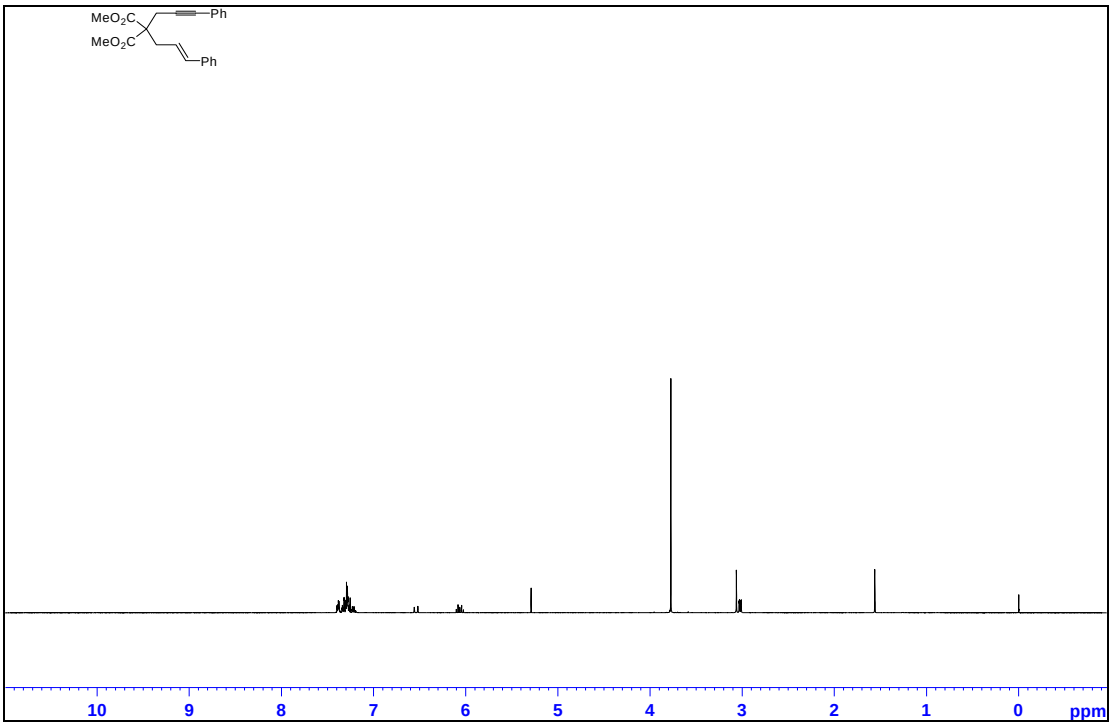

170.65
136.82
131.62
128.18
127.92
123.32
117.17
84.76
83.34
57.53
52.67
30.99
26.07
23.48
17.97
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

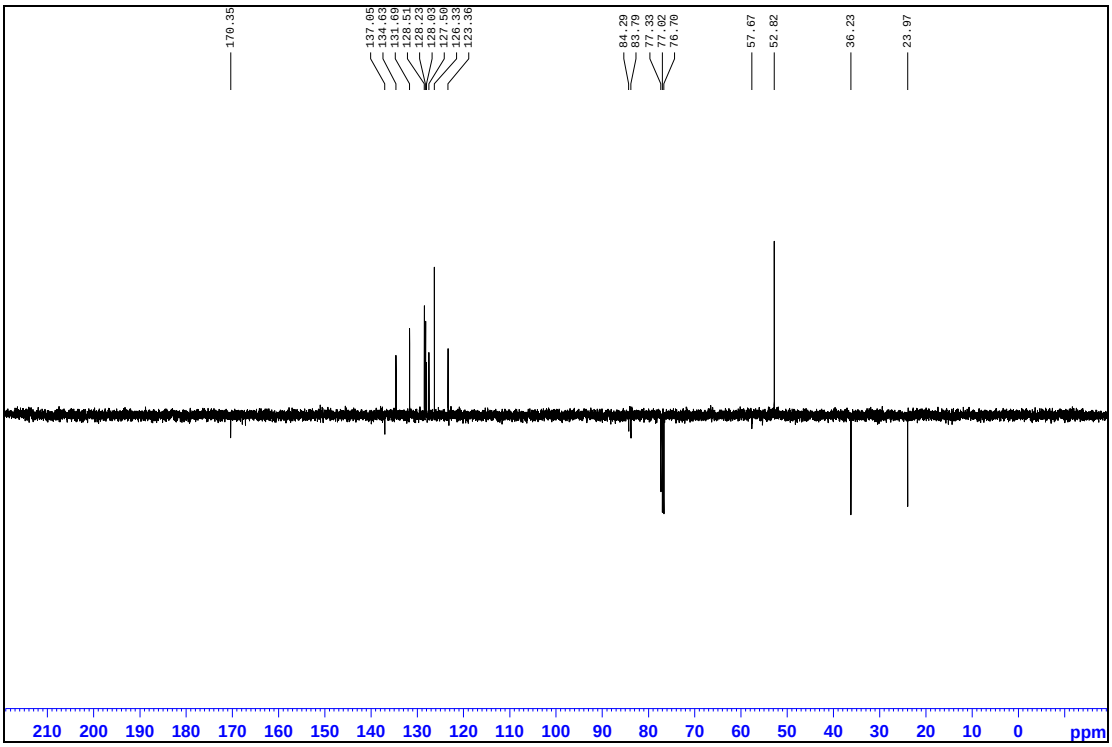

MeO2C
MeO2C
OMe
10
9
8
7
6
5
4
3
2
1
0
ppm

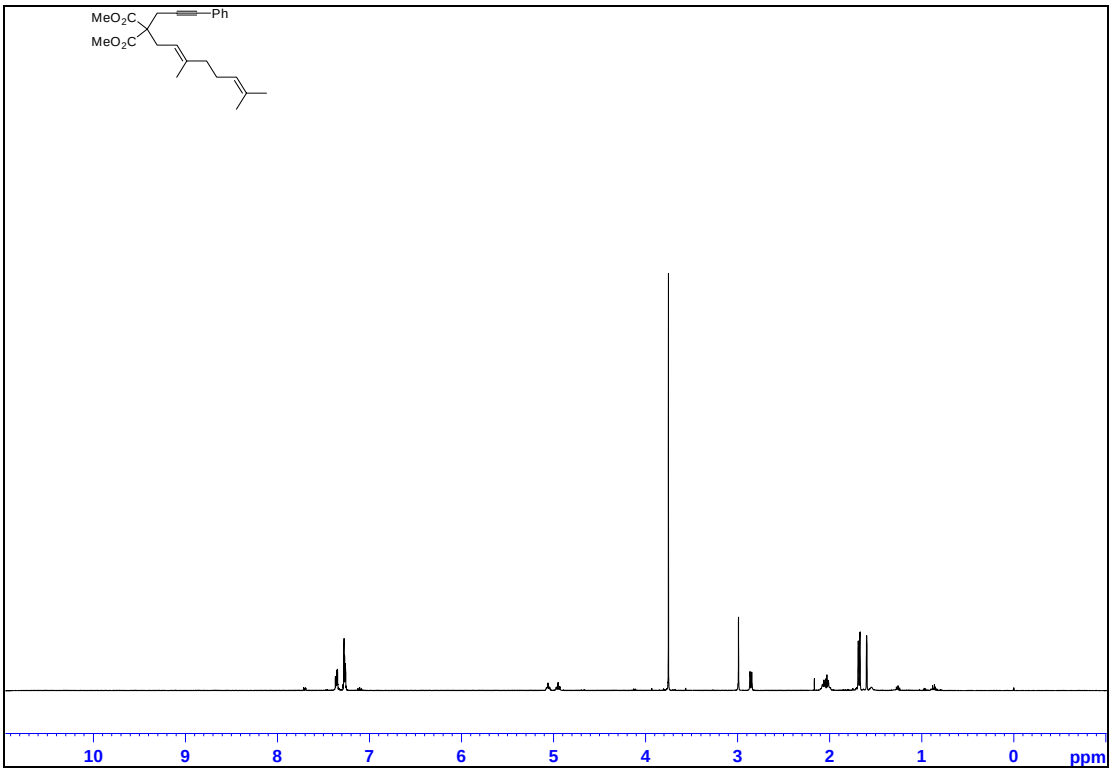

170.71
159.34
136.74
132.98
117.23
115.48
113.82
83.12
60.37
57.56
55.25
52.76
52.65
30.96
26.07
23.48
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm

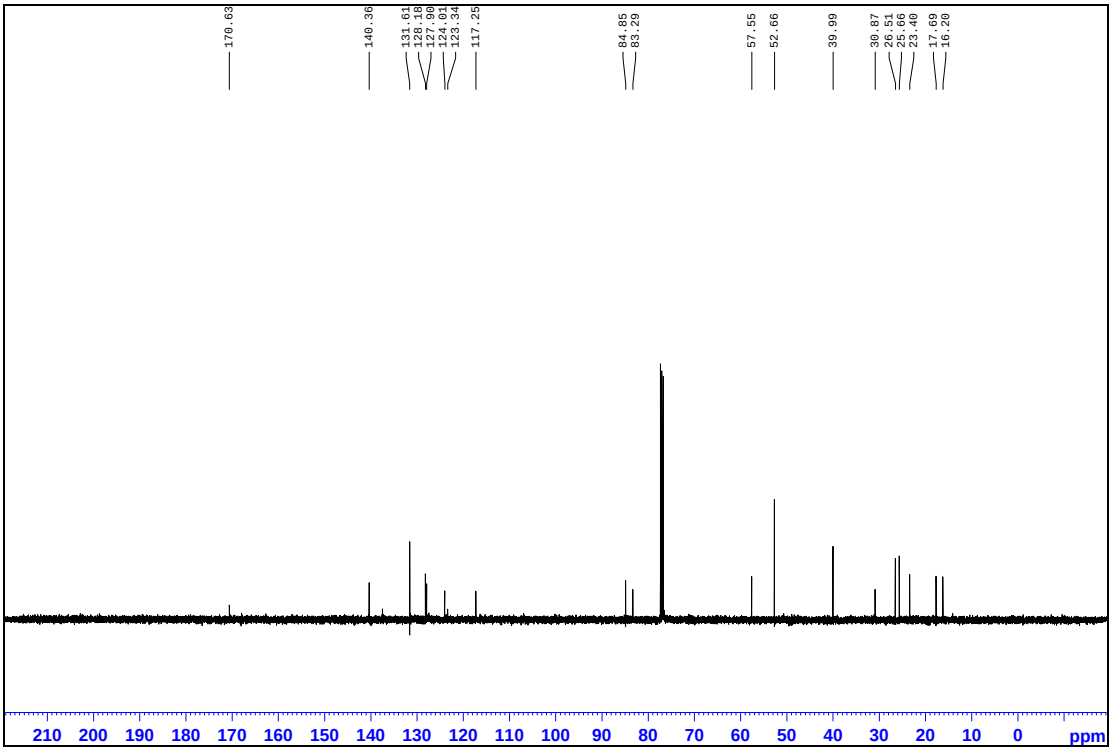

MeO2C
MeO2C
OMe
OMe
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
ppm

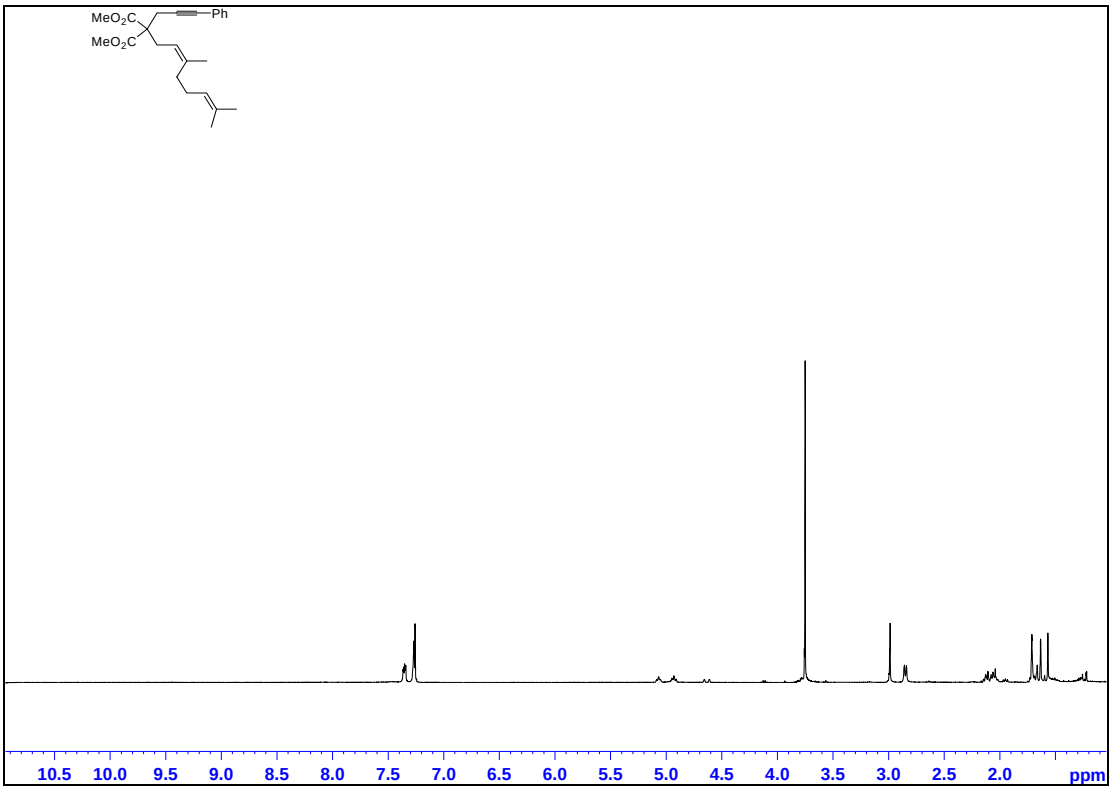

172.29
149.35
136.81
127.24
117.33
115.68
114.53
111.06
110.07
108.09
83.34
83.07
56.23
55.90
52.72
31.09
26.11
23.56
18.01
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

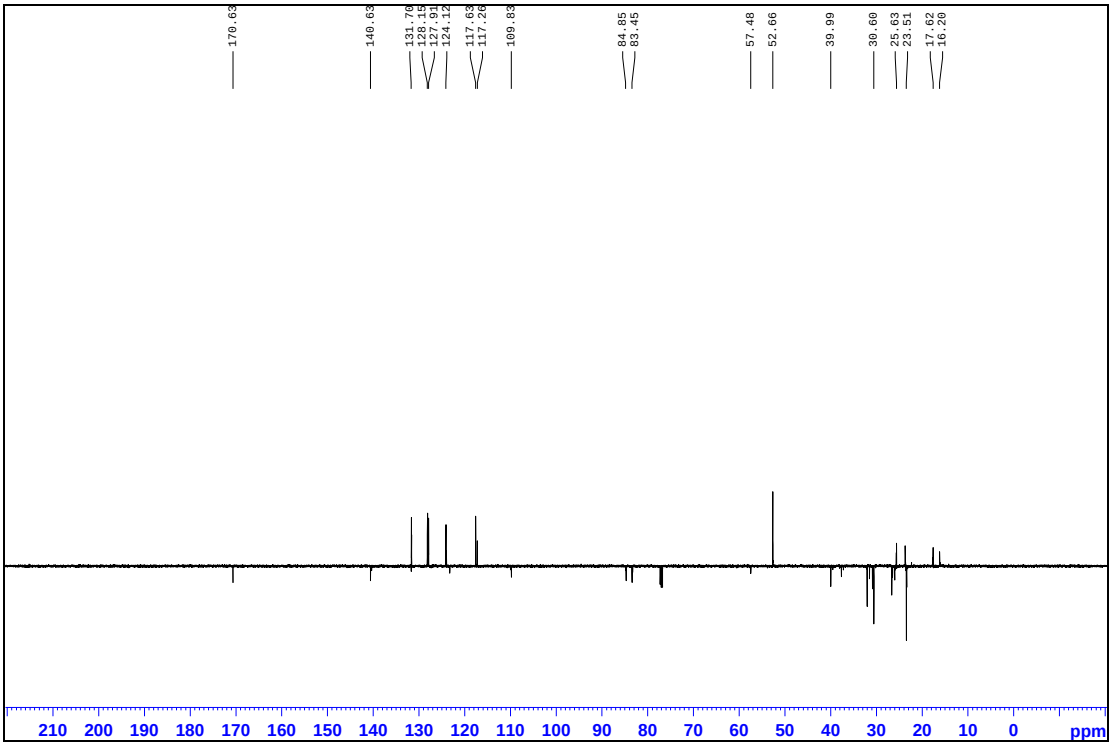

MeO2C
MeO2C
Ph
Ph
10
9
8
7
6
5
4
3
2
1
0
ppm

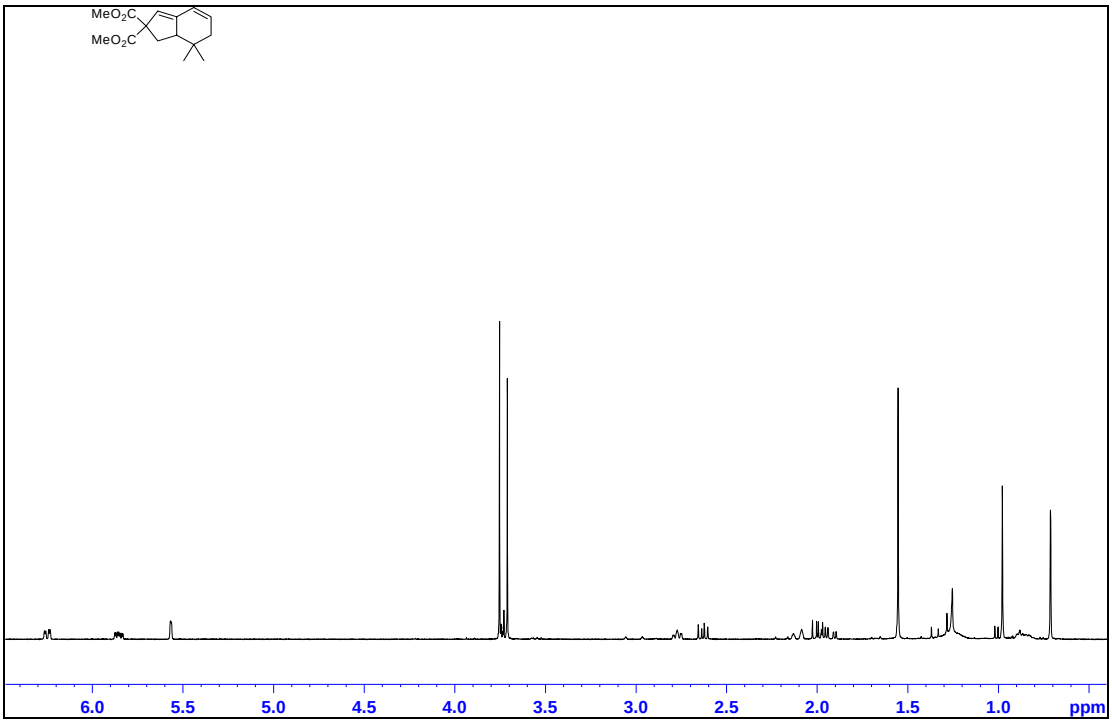

170.35
137.05
134.63
131.69
128.51
128.23
128.03
127.50
126.33
123.36
84.29
83.79
77.33
77.02
76.70
57.67
52.82
36.23
23.97
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

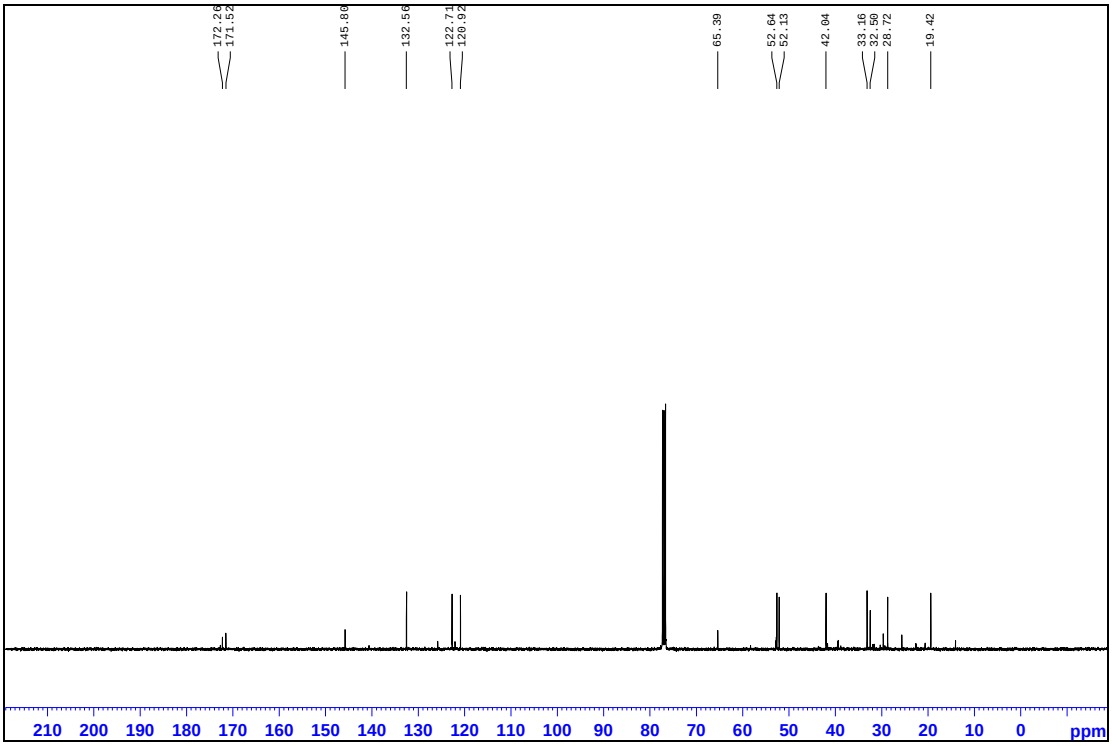

MeO2C
MeO2C
Ph
10
9
8
7
6
5
4
3
2
1
0
ppm

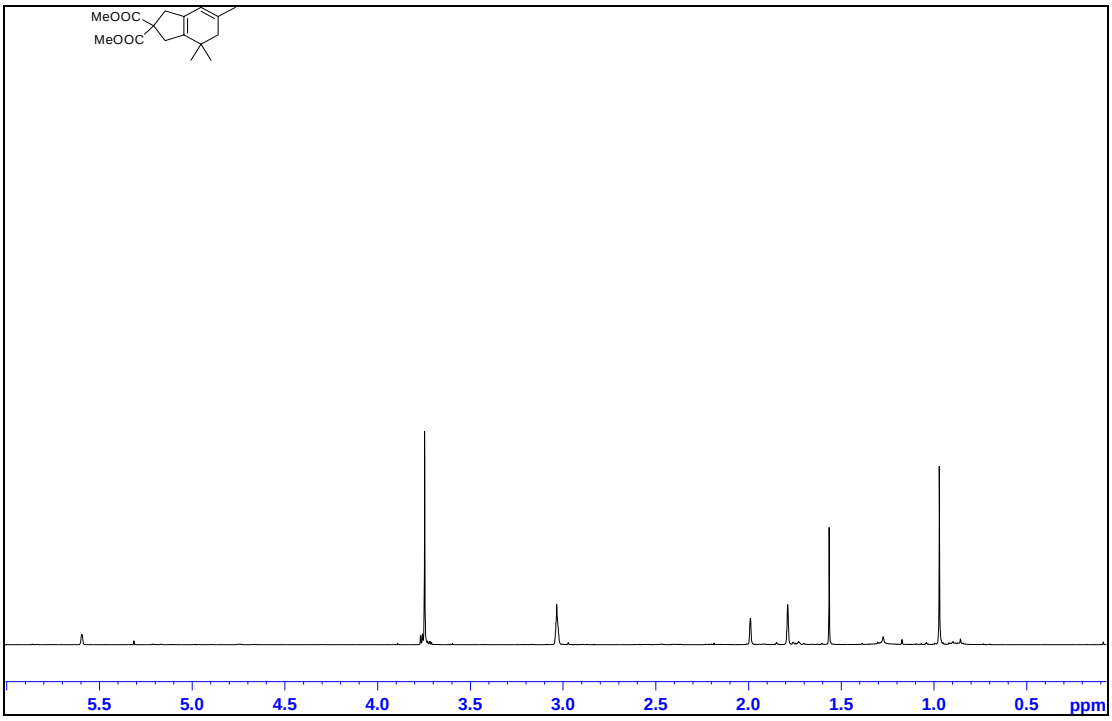

170.63
140.36
131.61
128.18
127.90
124.01
123.34
117.25
84.85
83.29
57.55
52.66
39.99
30.87
26.51
25.66
23.40
17.69
16.20
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

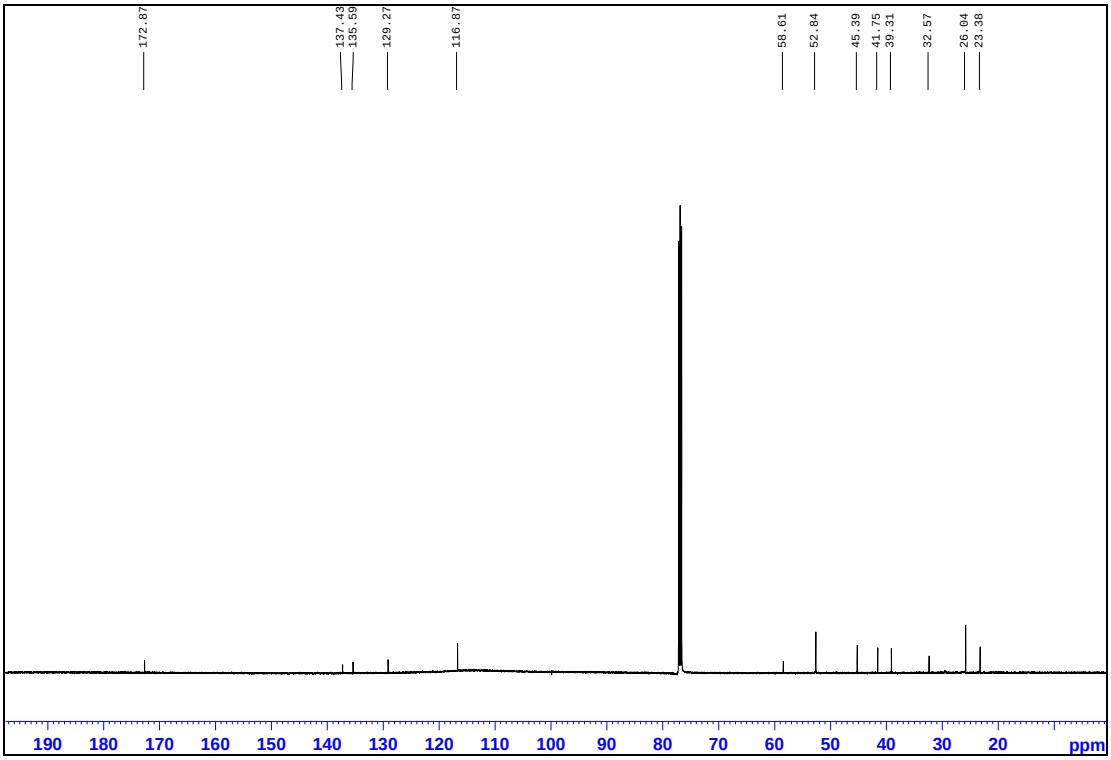

MeO2C
MeO2C
Ph
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0
ppm

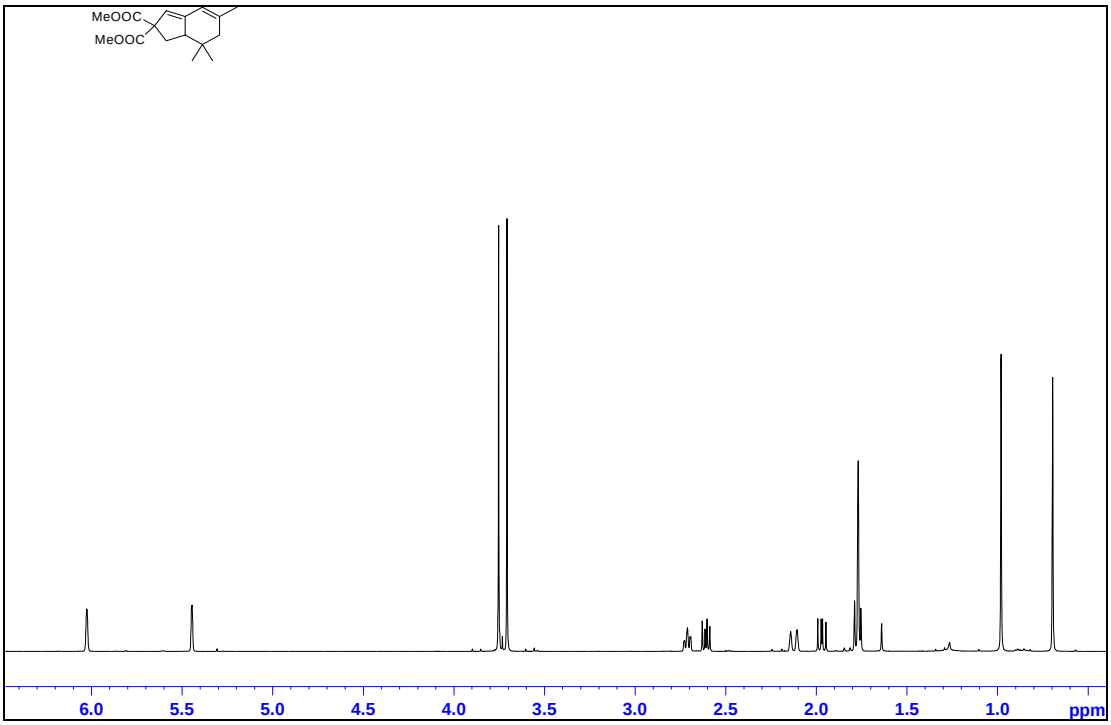

170.63
140.63
131.70
128.15
127.91
124.12
117.63
117.26
109.83
84.85
83.45
57.48
52.66
39.99
30.60
25.63
23.51
17.62
16.20
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
ppm

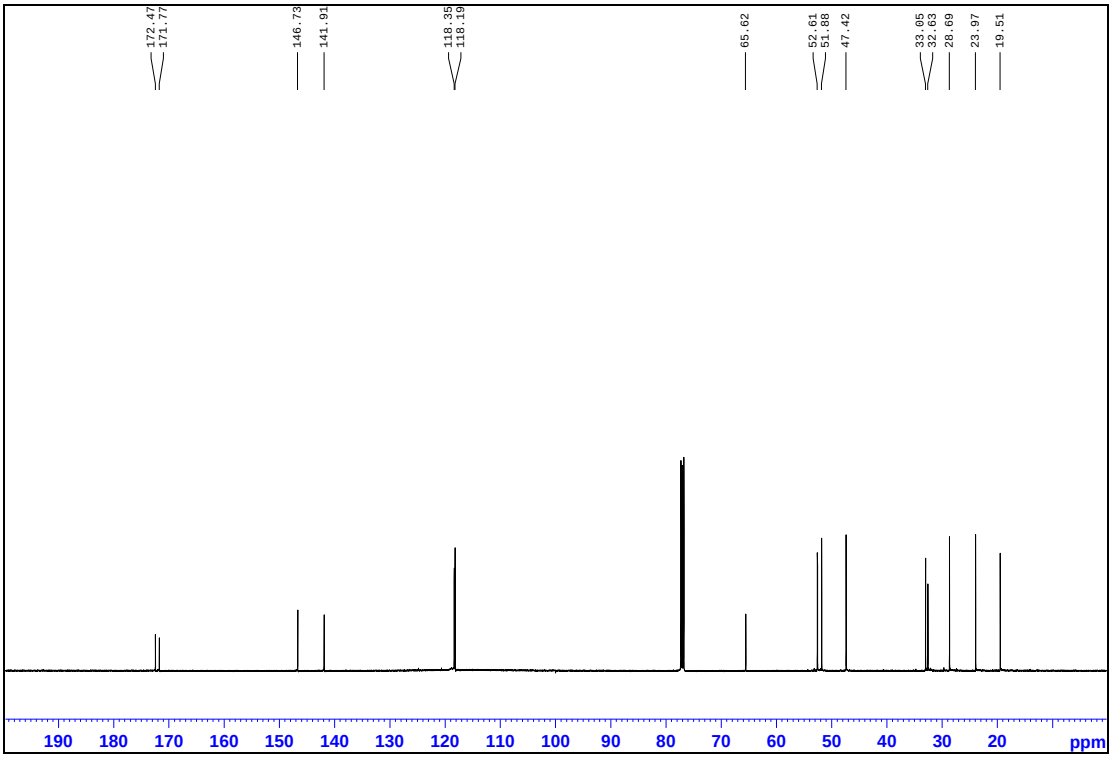

MeO2C
MeO2C
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm

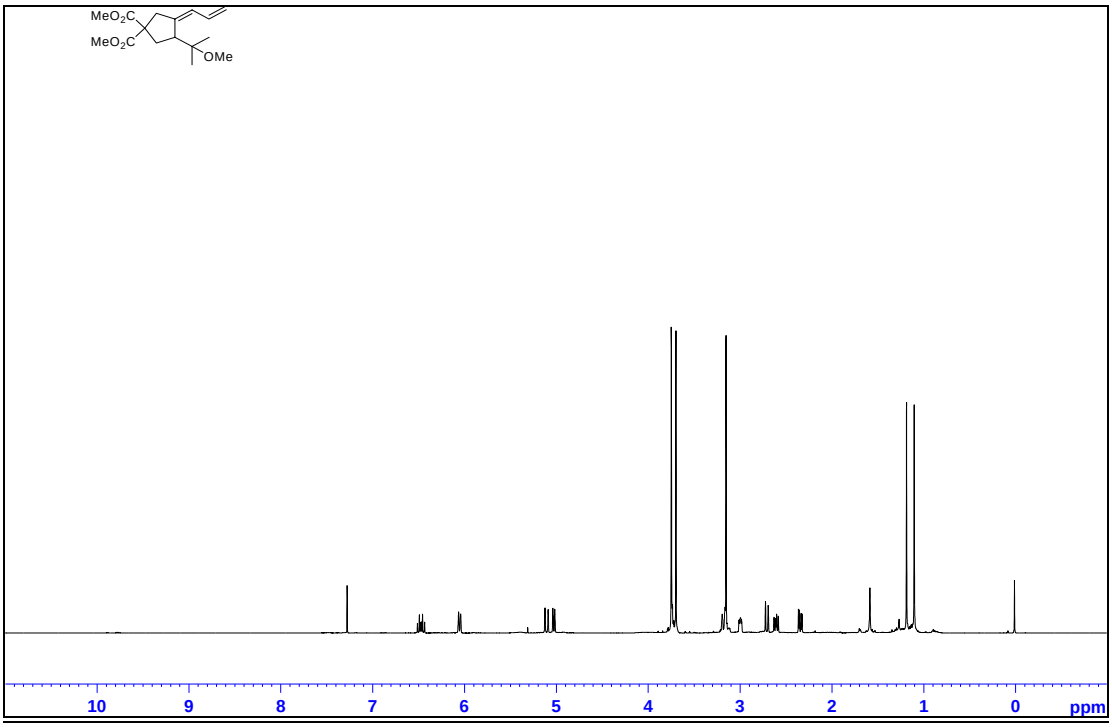

172.26
171.52
145.80
132.56
122.71
120.92
65.39
52.64
52.13
42.04
33.16
32.66
28.72
19.42
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

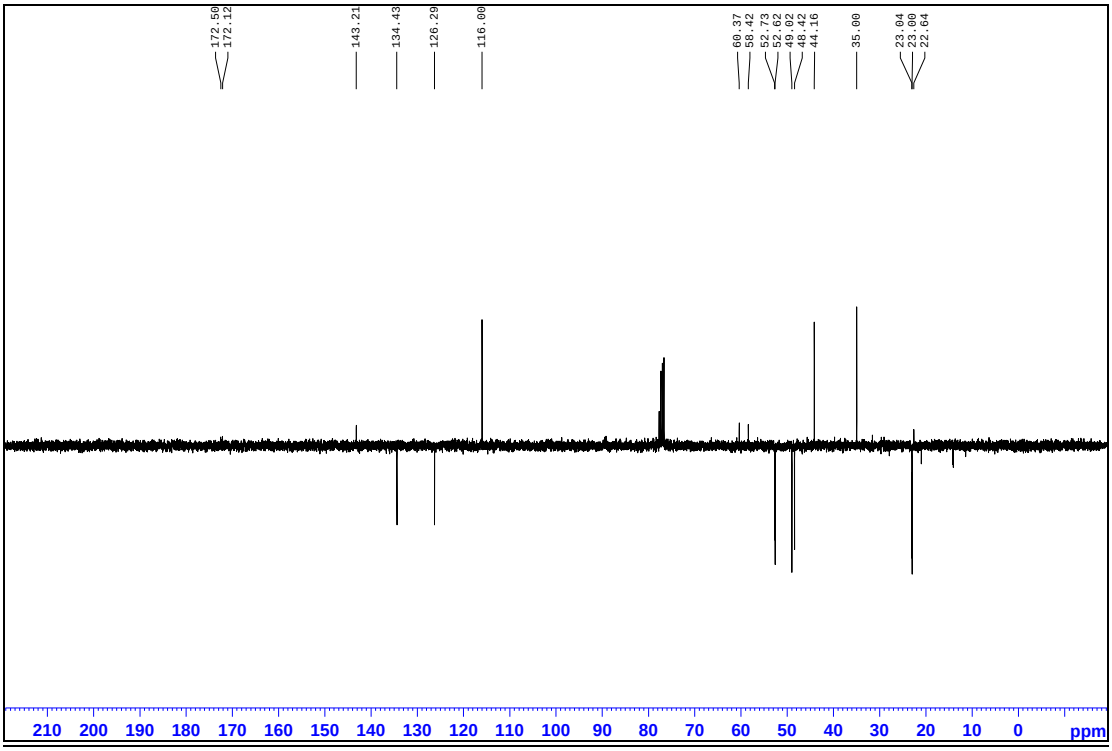

MeOOC
MeOOC
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm

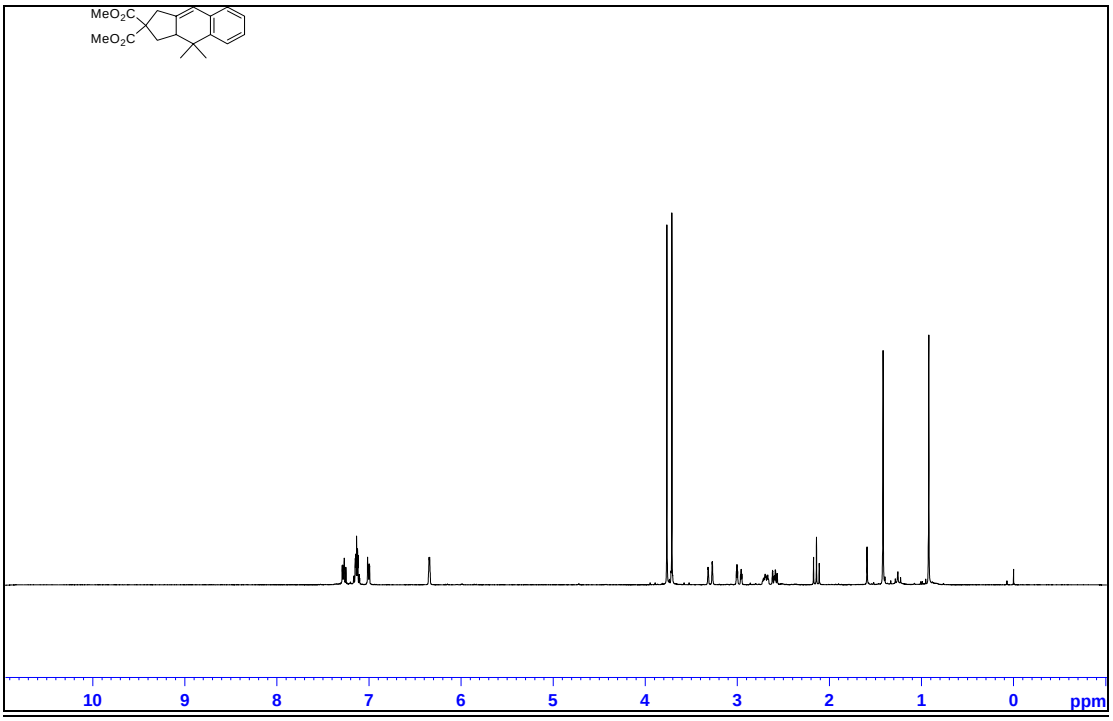

172.87
137.43
135.59
129.27
116.87
58.61
52.84
45.39
41.75
39.31
32.57
26.04
23.38
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

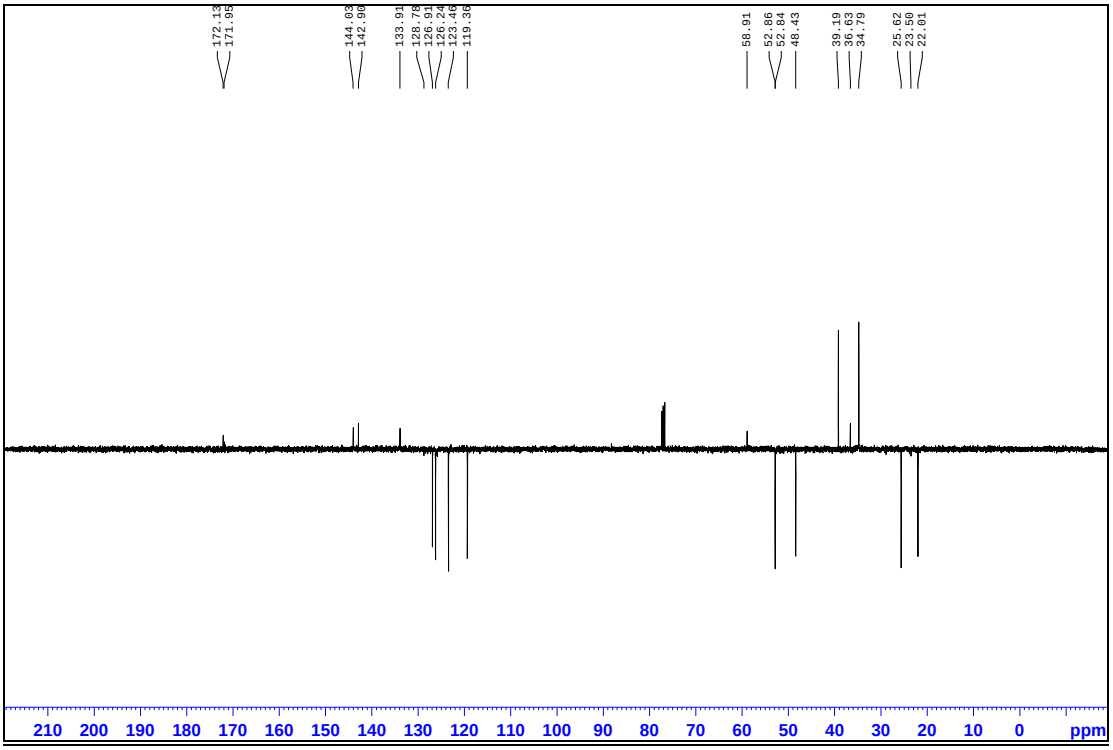

MeOOC
MeOOC
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm

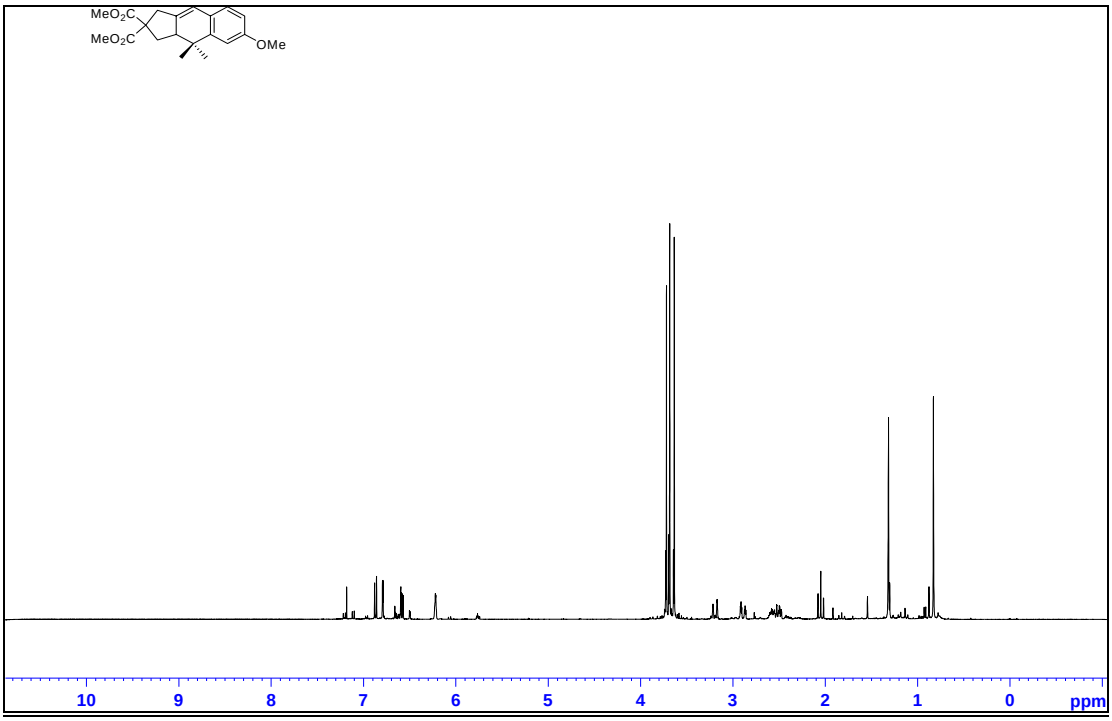

172.47
171.77
146.73
141.91
118.35
118.19
65.62
52.61
51.88
47.42
33.05
32.63
28.69
23.97
19.51
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

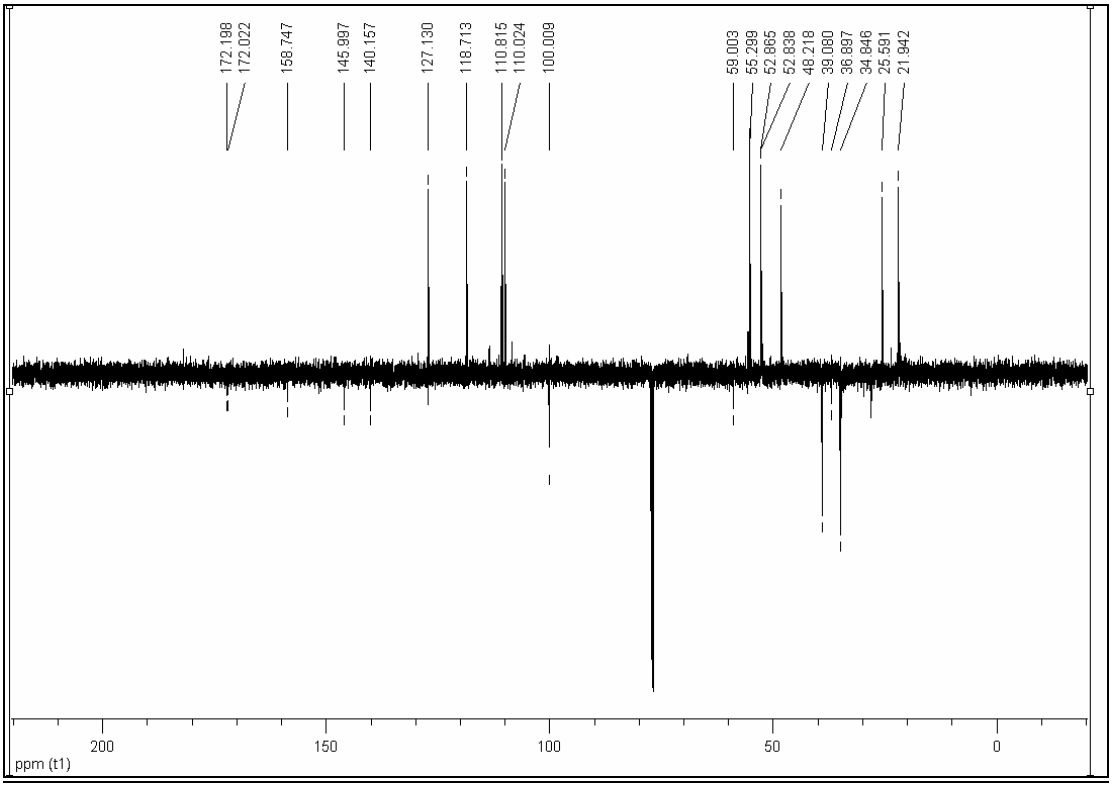

MeO2C
MeO2C
OMe
10
9
8
7
6
5
4
3
2
1
0
ppm

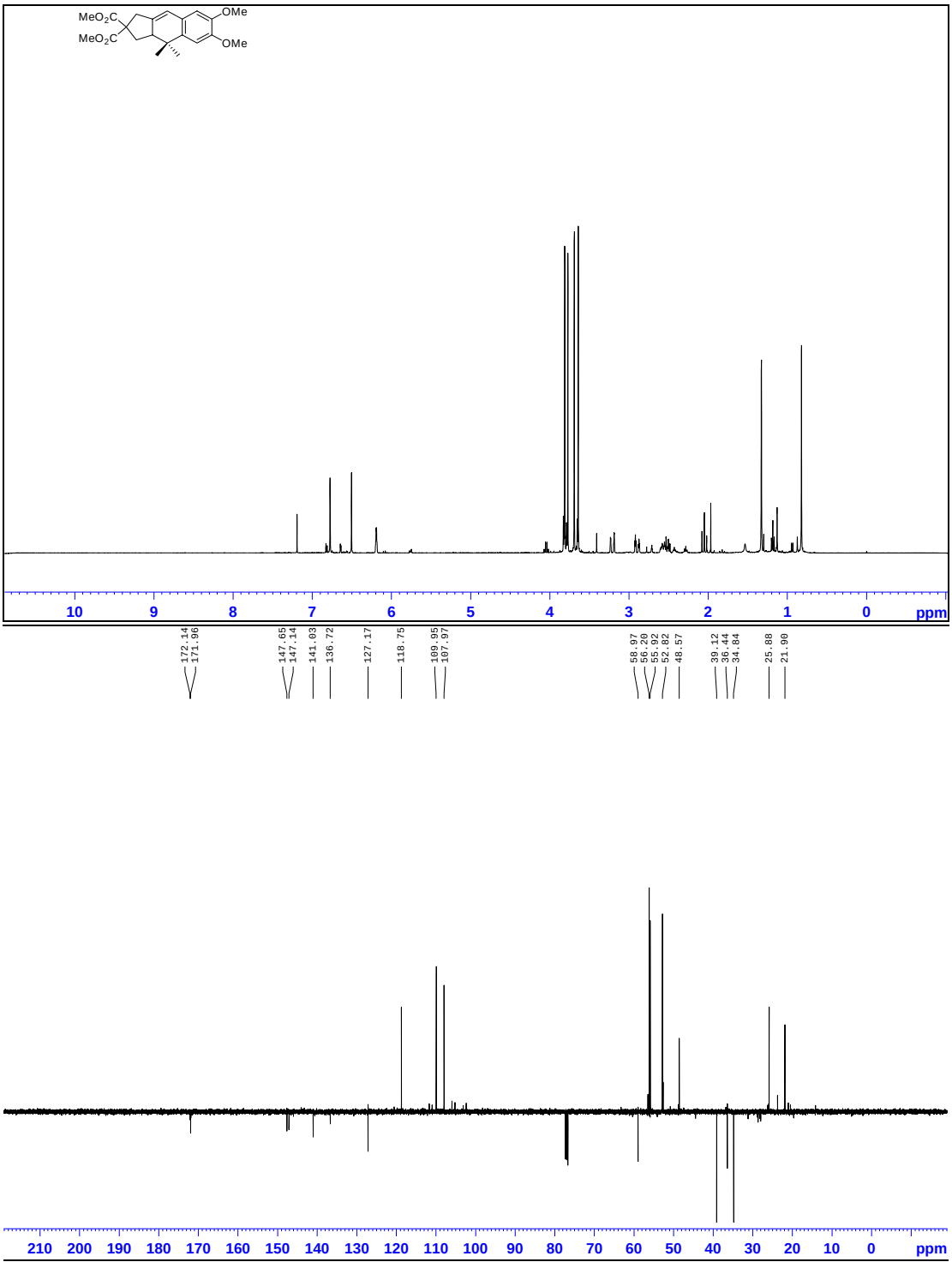

172.50
172.12
143.21
134.43
126.29
116.00
60.37
58.42
52.73
52.62
49.02
48.42
44.16
35.00
23.04
23.00
22.64
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

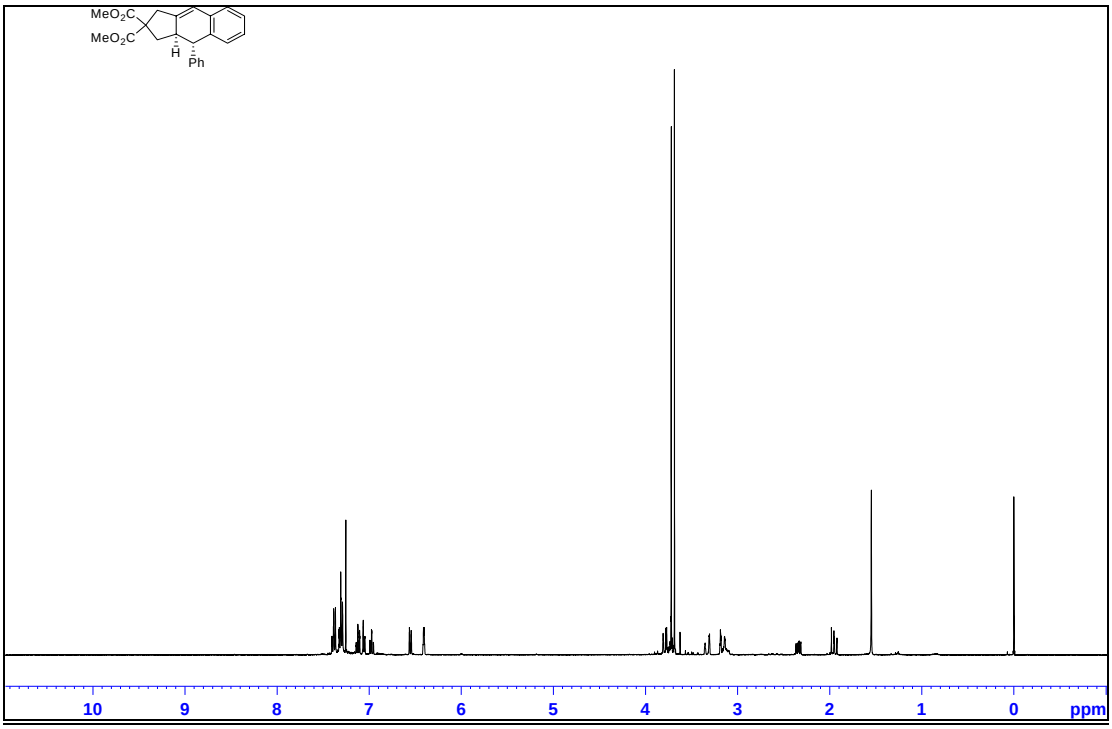

MeO2C
MeO2C
10 9 8 7 6 5 4 3 2 1 0 ppm

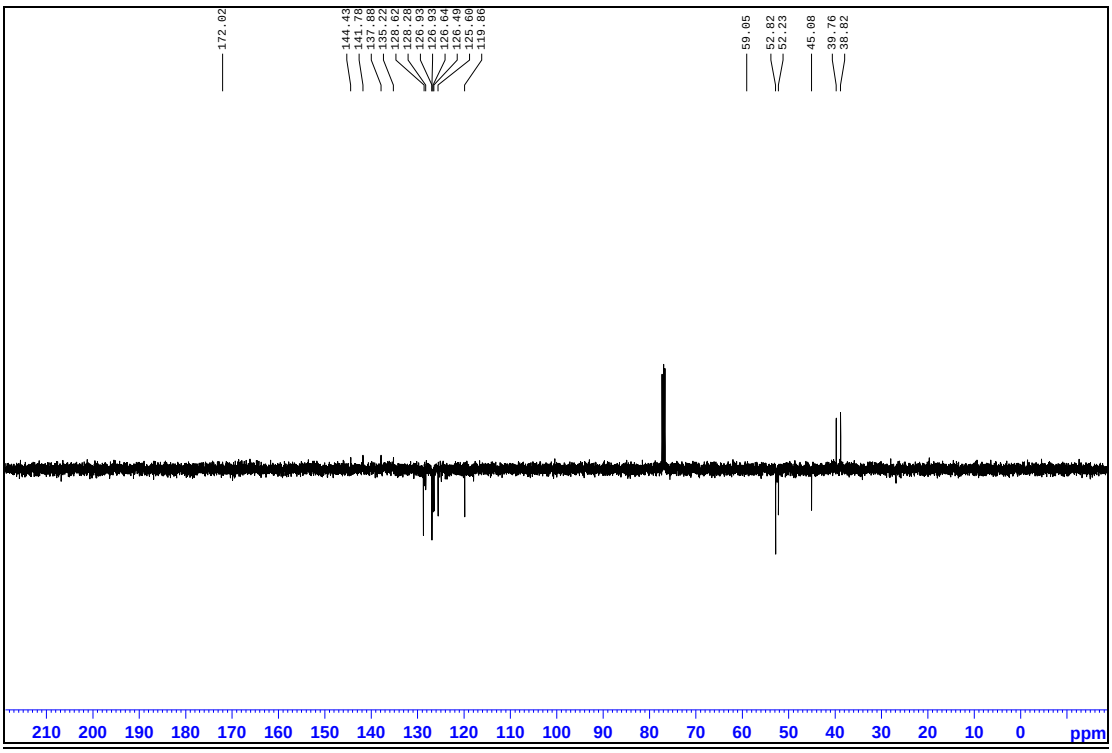

172.13
171.95
144.03
142.96
133.91
128.78
126.91
125.24
123.46
119.36
58.91
52.86
52.84
48.43
39.19
36.63
34.79
25.62
23.50
22.01
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

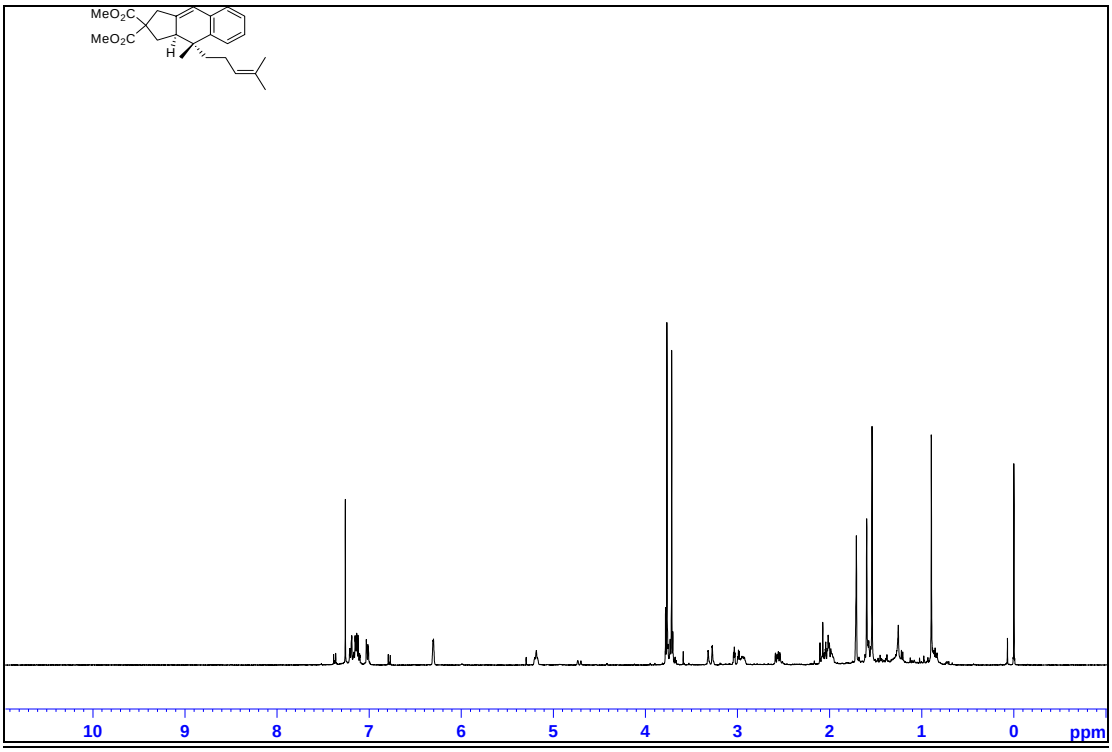

MeO2C
MeO2C
OMe
10
9
8
7
6
5
4
3
2
1
0
ppm

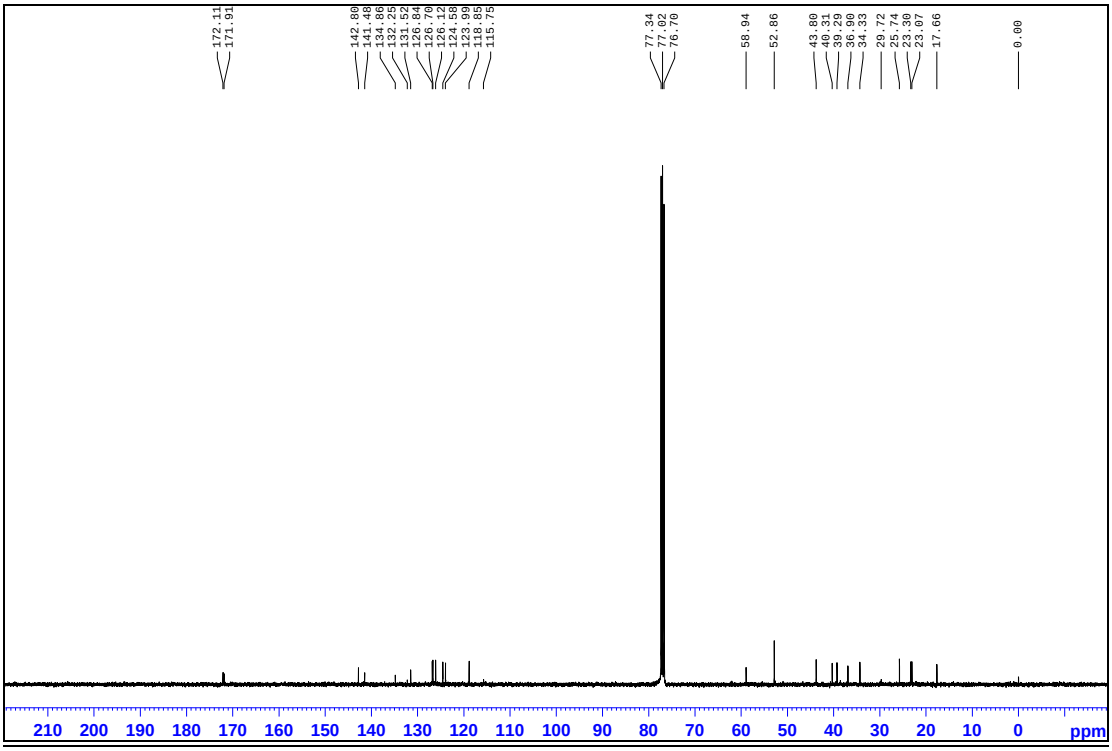

172.198
172.022
158.747
145.997
140.157
127.130
118.713
110.815
110.024
100.009
59.003
55.299
52.865
52.838
48.218
39.080
36.887
34.846
25.591
21.942
200
150
100
50
0
ppm (t1)


MeO2C
MeO2C
OMe
OMe
10 9 8 7 6 5 4 3 2 1 0 ppm
172.14
171.96
147.65
147.14
141.03
136.72
127.17
118.75
109.95
107.97
58.97
56.20
55.92
52.82
48.57
39.12
35.44
34.84
25.88
21.90
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


MeO2C
MeO2C
H
Ph
10
9
8
7
6
5
4
3
2
1
0
ppm


172.02
144.43
141.78
137.88
135.22
128.62
128.28
126.93
126.64
126.49
125.60
119.86
59.05
52.82
52.23
45.08
39.76
38.82
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


MeO2C
MeO2C
H
10
9
8
7
6
5
4
3
2
1
0
ppm


172.11
171.91
142.80
141.48
134.86
132.25
131.52
126.84
126.79
126.72
124.58
123.99
118.85
115.75
77.34
77.02
76.70
58.94
52.86
43.80
40.31
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36.90
34.33
29.72
25.74
23.30
23.07
17.66
0.00
210
200
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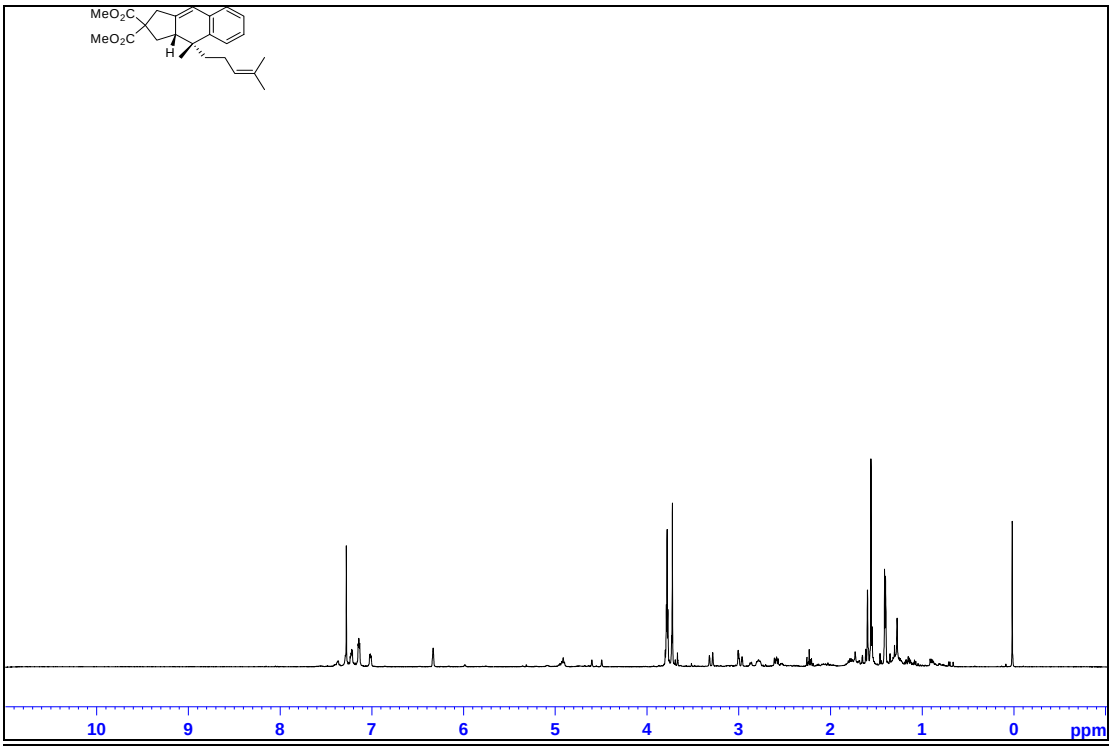
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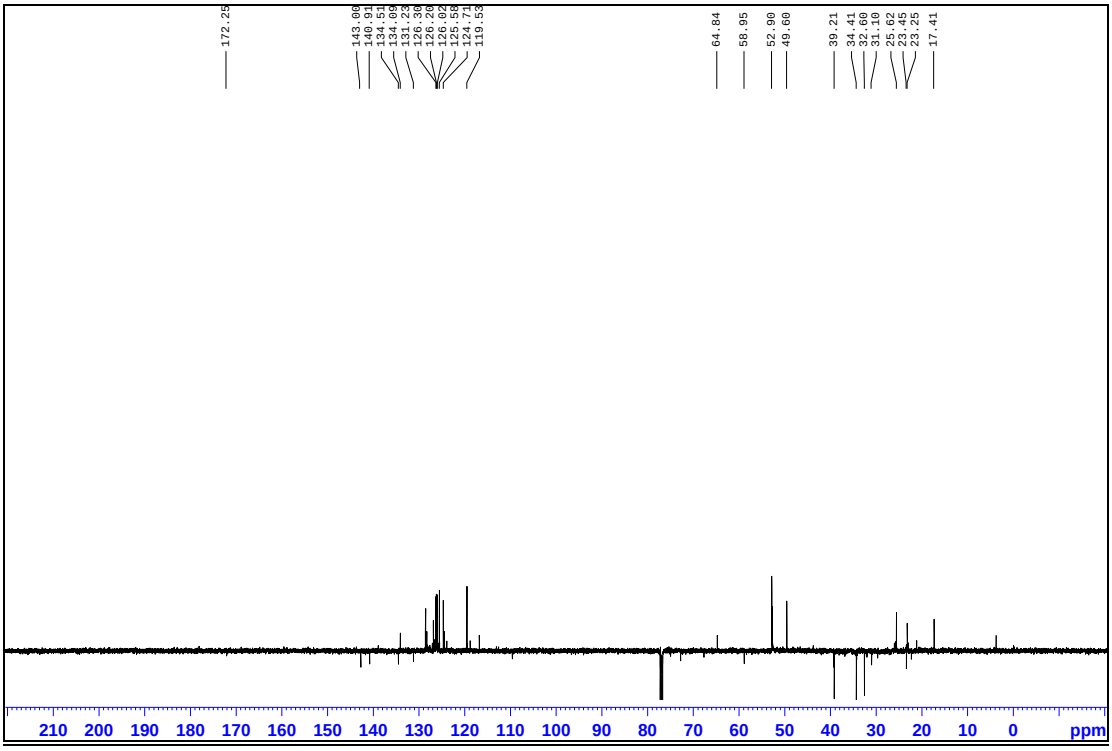
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134.09
131.23
126.30
126.20
126.02
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124.71
119.53
64.84
58.95
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49.60
39.21
34.41
32.60
31.10
25.02
23.45
23.25
17.41
210
200
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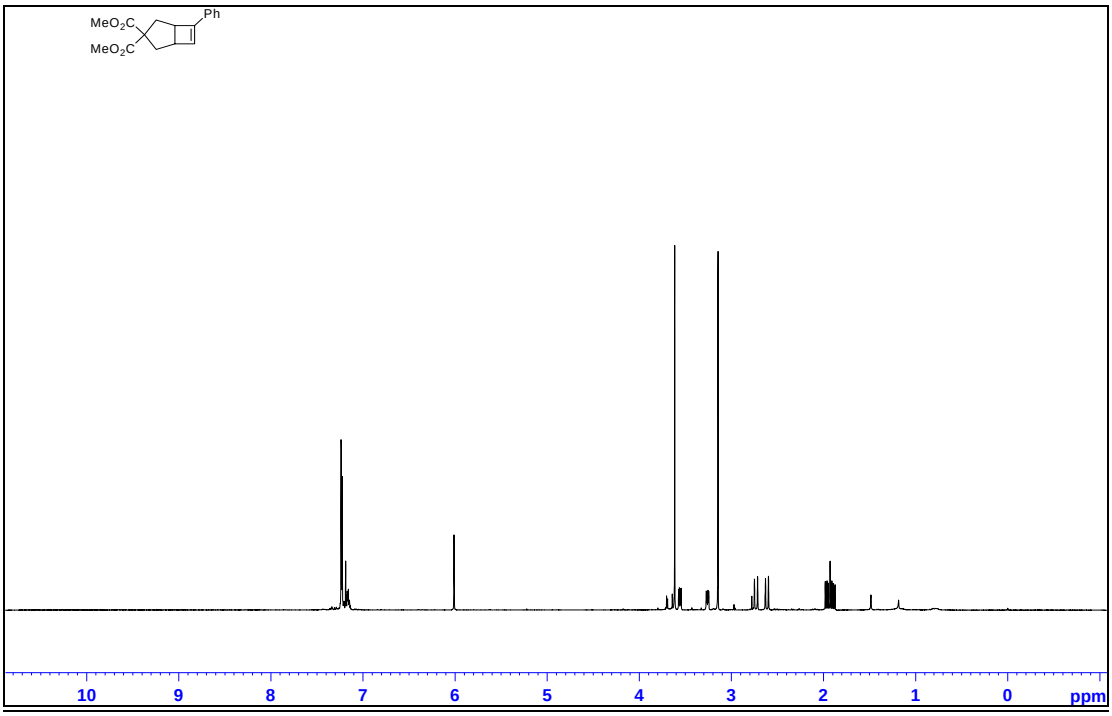
MeO2C
MeO2C
Ph
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8
7
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4
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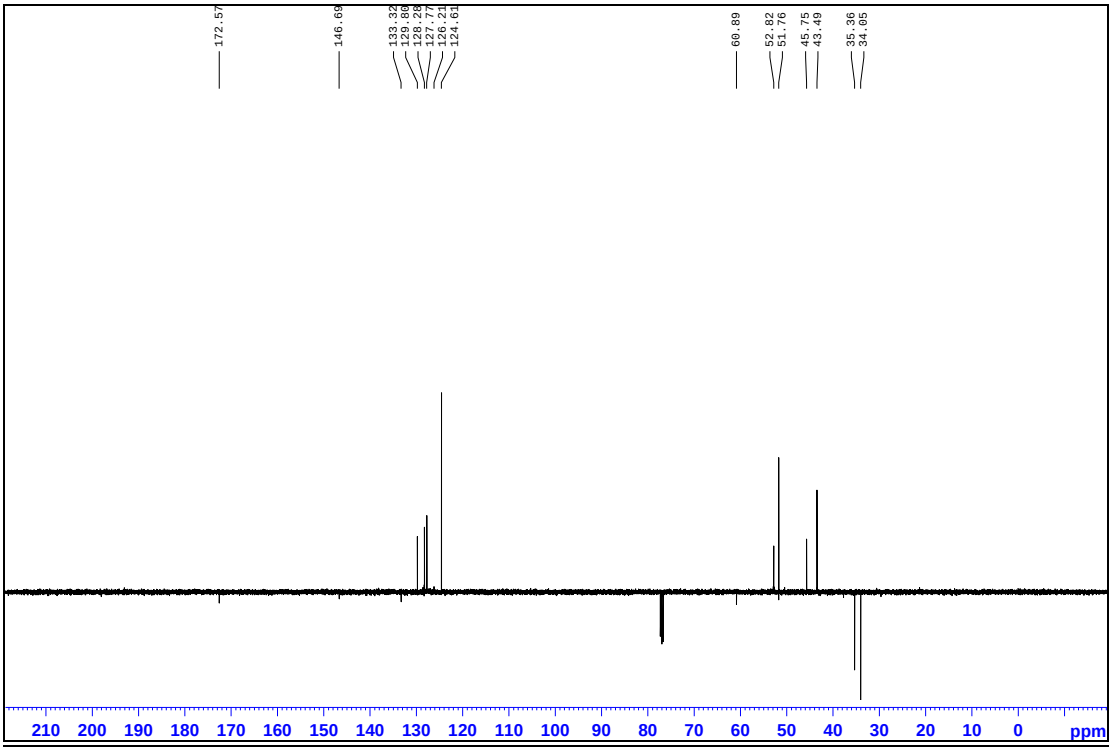
0
ppm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128.28
127.77
126.21
124.61
60.89
52.82
51.76
45.75
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35.36
34.05
210
200
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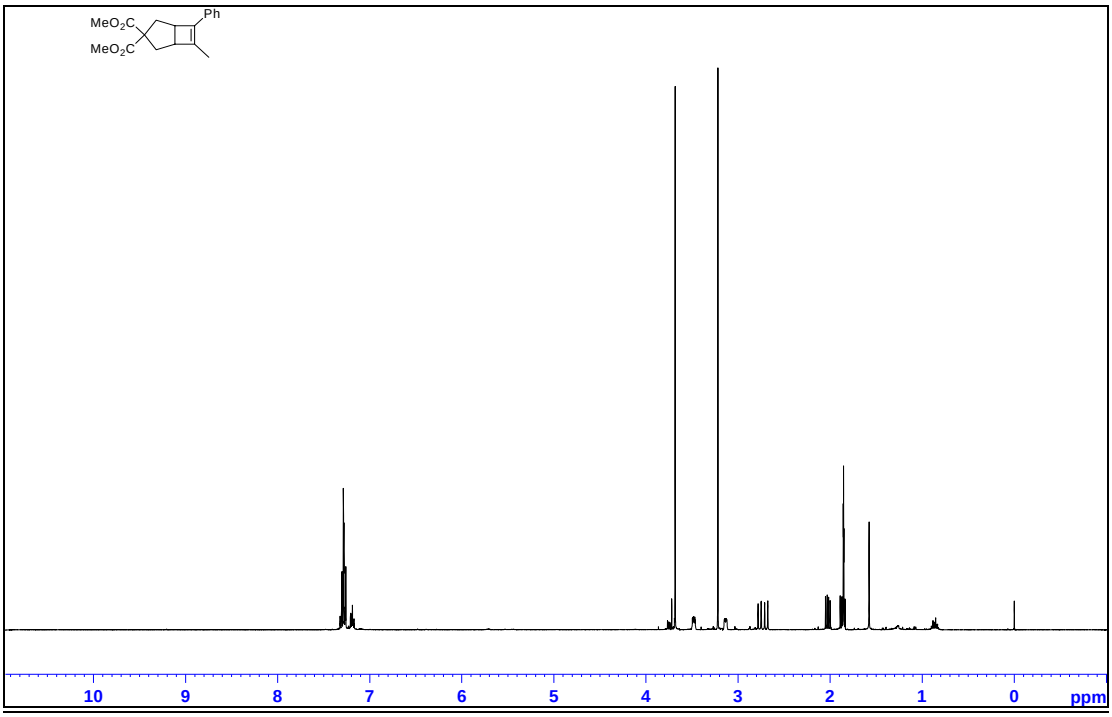
MeO2C
MeO2C
Ph
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9
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7
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4
3
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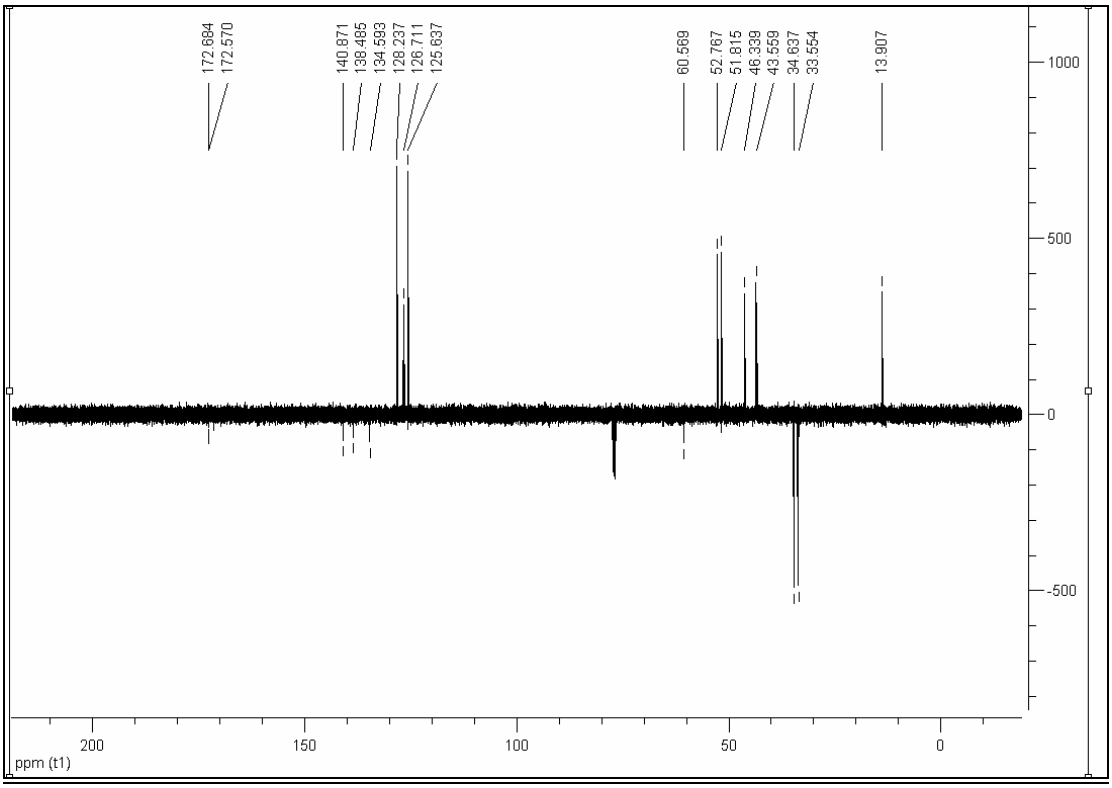
ppm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138.485
134.593
128.237
126.711
125.637
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52.767
51.815
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43.559
34.637
33.554
13.907
1000
500
0
-500
200
150
100
50
0
ppm (t1)