Supporting Information

Palladium-Catalyzed Carbonylative Heck-Type Reactions of Alkyl Iodides

Kayla S. Bloome and Erik J. Alexanian*

Department of Chemistry, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina 27599-3290

eja@email.unc.edu

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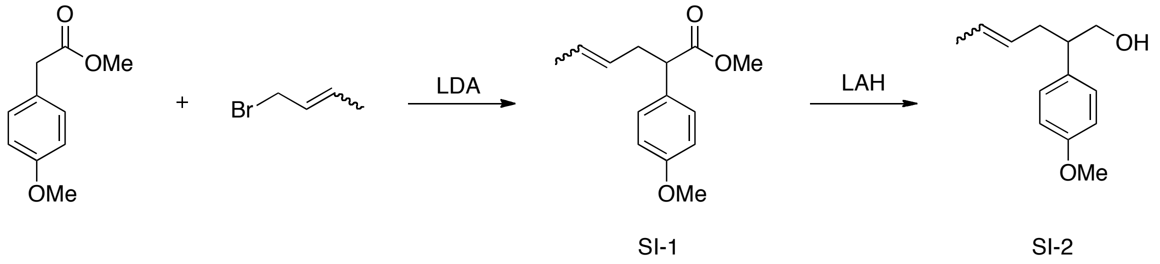
General Methods

Infrared (IR) spectra were obtained using a Jasco 260 Plus Fourier transform infrared spectrometer. Proton and carbon magnetic resonance spectra (^{1}H NMR and ^{13}C NMR) were recorded on a Bruker model DRX 400 or 500 or a Bruker AMX 300 (^{1}H NMR at 300 MHz, 400 MHz or 500 MHz and ^{13}C NMR at 100 or 126 MHz) spectrometer with solvent resonance as the internal standard (^{1}H NMR: $CDCl_3$ at 7.26 ppm, ^{13}C NMR: $CDCl_3$ at 77.0 ppm). ^{1}H NMR data are reported as follows: chemical shift, multiplicity (s = singlet, app s = apparent singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constants (Hz), and integration. Mass spectra were obtained either using a positive ion mode flow injection ESI (electrospray ionization) on a Bruker Daltonics, Inc., Billerica, MA, USA, BioToF Mass Spectrometer or electron impact ionization on an Agilent Technologies, Inc., Santa Clara, CA, USA, GCMS, 5973N Mass Selective Detector, using a HP-5MS (30m x 0.25mm) capillary column. Visualization was accomplished with short wave UV light (254 nm), aqueous basic potassium permanganate solution, or ethanolic acidic *p*-anisaldehyde solution followed by heating. Flash chromatography was performed using SiliaFlash P60 silica gel (40-63 μm) purchased from Silicycle. Tetrahydrofuran, diethyl ether, and toluene were dried by passage through a column of neutral alumina under nitrogen prior to use. Carbon

Monoxide, Research Purity 99.998% was purchased from Matheson Tri-Gas. All other reagents were obtained from commercial sources and used without further purification unless otherwise noted. The pressure reactors used were purchased from Parr Instrument Company and included a 4310 Gage Block Assembly and a GP VS 22 mL A SKT 316SS ST CLS.

Preparation of Alcohol Substrate Precursors

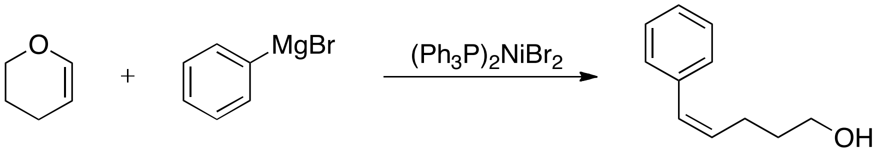
Synthesis of 2-(4-methoxyphenyl)hex-4-en-1-ol (SI-2)



2-(4-methoxyphenyl)hex-4-en-1-ol (SI-2) was synthesized by the following stepwise procedure: To a 0 °C solution of *i*Pr$_2$NH (2.9 mL, 21.0 mmol) in THF (90 mL) was added *n*BuLi (13.8 mL, 22.0 mmol, 1.6 M in hexanes) dropwise under Ar. The reaction mixture was stirred for 10 minutes and then cooled to –78 °C. Methyl 2-(4-methoxyphenyl)acetate (3.6 g, 20.0 mmol) was added dropwise in THF (10 mL). The reaction mixture was stirred for 30 minutes and then treated with crotyl bromide (3.24 g, 24.0 mmol, 85% (Acros)). The reaction was then warmed to room temperature and stirred overnight. The reaction mixture was then diluted with EtOAc, washed with sat. NH$_4$Cl, dried with MgSO$_4$, and concentrated *in vacuo* to give a crude oil that was purified by flash chromatography (20:1 Hexanes/EtOAc) to provide 3.33 g (71%) **SI-1** as a colorless oil (predominantly *trans*). Analytical data for **methyl 2-(4-methoxyphenyl)hex-4-enoate (SI-1)**: IR (thin film, cm^{-1}) 2999, 2951, 2915, 2855, 2836, 1737, 1612, 1512, 1436, 1302, 1250, 1179, 1160, 1035, 969, 833, 793; ^{1}H NMR (500 MHz, CDCl$_3$) δ 7.28 – 7.24 (d, J = 8.7 Hz, 2 H), 6.90 – 6.85 (d, J = 8.7 Hz, 2 H), 5.52 (m, 1 H), 5.39-5.28 (m, 1 H), 3.81 (s, 3 H), 3.68-3.66 (m, 3 H), 3.56 (m, 1 H), 2.85 – 2.79 (m, 0.17 H), 2.77 – 2.71 (m, 0.85 H), 2.55 - 2.48 (m, 0.17 H), 2.45 – 2.40 (m, 0.85 H), 1.65-1.59 (d, J = 6.25 Hz, 3 H); ^{13}C NMR (500 MHz, CDCl$_3$) δ 174.3, 174.3, 158.7, 158.7, 130.8, 130.8, 128.9, 127.7, 127.5, 126.8, 126.2, 113.9, 60.3, 51.8, 51.8, 51.0, 50.6, 36.6, 30.9, 17.9, 14.1, 12.8; LRMS (ESI) calculated for $[C_{14}H_{18}O_3+Na]^+$ 257.12, found 257.10.

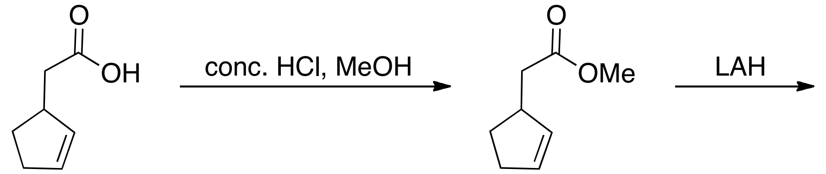
To a 0 °C solution of lithium aluminum hydride (810 mg, 21.34 mmol) in THF (80 mL) was added **SI-1** dropwise in THF (20 mL) under Ar. The reaction mixture was stirred for 1 hr at 0 °C. It was then quenched by the slow, dropwise addition of 810 μL H_2O, followed by 1.62 mL 10 wt % NaOH, and then 2.43 mL H_2O. The reaction mixture was stirred vigorously until a white solid appeared. The white precipitate was filtered, and the filtrate was concentrated *in vacuo*. The resulting oil was purified by flash chromatography (3:1 Hexanes/EtOAc) to provide 2.22 g (~ quant.) **SI-2** as a colorless oil (predominantly *trans*). Analytical data for **2-(4-methoxyphenyl)hex-4-en-1-ol (SI-2):** IR (thin film, cm^{-1}) 3376, 2998, 2915, 2835, 1513, 2058, 1301, 1242, 1178, 1036, 968, 912, 829; ^1H NMR (500 MHz, $CDCl_3$) δ 7.16 – 7.13 (d, *J* = 8.6 Hz, 2 H), 6.89 – 6.87 (d, *J* = 8.6 Hz, 2 H), 5.49 – 5.41 (m, 1 H), 5.37 – 5.30 (m, 1 H), 3.77 (s, 3 H), 3.75 – 3.61 (m, 2 H), 2.76 (m, 1 H), 2.51 – 2.48 (m, 0.18 H), 2.41 – 2.33 (m, 0.86 H), 2.32 – 2.23 (m, 1 H), 2.04 (s, 0.07 H), 1.97 (s, 0.95 H), 1.63 – 1.62 (d, *J* = 6.2 Hz, 2.55 H), 1.60 – 1.59 (d, *J* = 6.7 Hz, 0.45 H); ^{13}C NMR (500 MHz, $CDCl_3$) δ ppm 158.10, 158.05, 134.09, 134.03, 128.69, 127.9, 126.5, 125.0, 113.7, 66.8, 66.8, 55.0, 47.5, 47.5, 35.4. 29.6, 17.8, 12.7; LRMS (ESI) calculated for $[C_{13}H_{18}O_2+Na]^+$ 229.12, found 229.10.

Synthesis of (Z)-5-phenylpent-4-en-1-ol



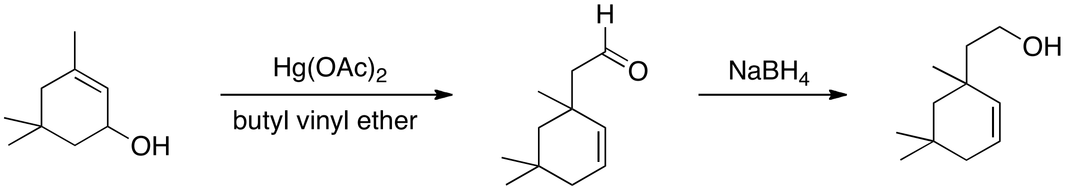
Prepared according to the literature procedure by Kulawiec *et. al.*[1] Physical and spectral data were in accordance with literature data.

Synthesis of 2-(cyclopent-2-en-1-yl)ethanol



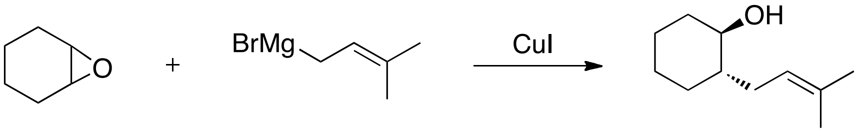
2-(cyclopent-2-en-1-yl)ethanol was prepared according to the literature procedure by Lopp *et. al.*[2] Physical and spectra data were in accordance with literature data.

Synthesis of 2-(1,5,5-trimethylcyclohex-2-enyl)ethanol



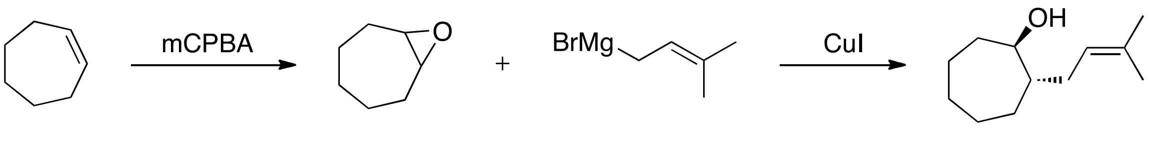
2-(1,5,5-trimethylcyclohex-2-enyl)ethanol was synthesized according to a literature Claisen rearrangement procedure[3] followed by standard sodium borohydride reduction. For 2-(1,5,5-trimethylcyclohex-2-enyl)acetaldehyde, physical and spectral data were in accordance with literature data.[4] For 2-(1,5,5-trimethylcyclohex-2-enyl)ethanol, physical and spectral data were in accordance with literature data.[5]

Synthesis of *trans*-2-(3-methylbut-2-en-1-yl)cyclohexanol



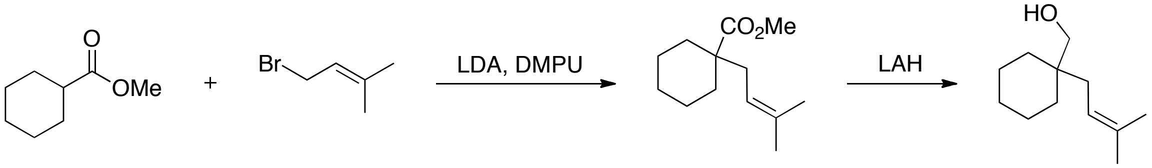
trans-2-(3-methylbut-2-en-1-yl)cyclohexanol was prepared according to the literature procedure by Linstrumelle *et. al.*[6] Physical and spectra data were in accordance with literature data.[7]

Synthesis of *trans*-2-(3-methylbut-2-en-1-yl)cycloheptanol



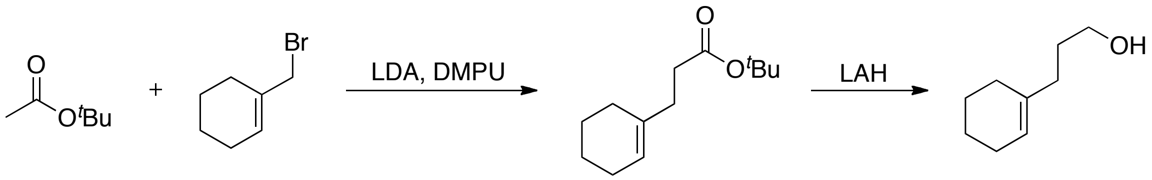
trans-2-(3-methylbut-2-en-1-yl)cycloheptanol was synthesized via epoxidation of cycloheptene oxide[8] and ring opening of the resulting epoxide.[6] The alcohol was taken directly to the iodination reaction.

Synthesis of (1-(3-methylbut-2-en-1-yl)cyclohexyl)methanol



(1-(3-methylbut-2-en-1-yl)cyclohexyl)methanol was synthesized by an alkylation reaction[9] followed by standard LAH reduction. For methyl 1-(3-methylbut-2-en-1-yl)cyclohexanecarboxylate, physical and spectral data were in accordance with literature data.[9] (1-(3-methylbut-2-en-1-yl)cyclohexyl)methanol was taken directly to an iodination reaction.

Synthesis of 3-(cyclohex-1-en-1-yl)propan-1-ol



SI-3

3-(cyclohex-1-en-1-yl)propan-1-ol (SI-3) was prepared according to literature procedures for an alkylation[10] followed by standard LAH reduction. Analytical data for ***tert*-butyl 3-(cyclohex-1-en-1-yl)propanoate (SI-3)**: IR (thin film, cm^{-1}) 3423, 2977, 2931, 2835, 1730, 1448, 1367, 1294, 1256, 1152, 827, 420; ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.38 (app s, 1H), 2.28 (t, J = 7.5 Hz, 2 H), 2.18, (t, J = 7.5 Hz, 2 H), 1.94 (m, 2H), 1.89 (m, 2 H), 1.58 (m, 2 H), 1.50 (m, 2 H), 1.41 (s, 9 H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 172.9, 136.1, 121.4, 79.9, 34.0, 33.2, 28.1, 25.1, 28.1, 22.8, 22.4; LRMS (ESI) calculated for $[C_{13}H_{22}O_2+H]^+$ 211.17, found 211.08. For 3-(cyclohex-1-en-1-yl)propan-1-ol, physical and spectral data in accordance with literature data.[11]

Preparation of Alkyl Iodide Substrates

Note: As a precaution alkyl iodides were stored in the dark, under inert atmosphere at -40 °C upon purification.

Method A

To a room temperature solution of an alcohol (1.0 equiv) in acetonitrile (0.8 M) and diethyl ether (0.2 M) under Ar, triphenylphosphine (2.0 equiv), imidazole (2.0 equiv), and iodine (2.0 equiv) were added successively. The reaction mixture was stirred approximately fifteen minutes. SiO_2 was then added, and the mixture was concentrated *in vacuo.* The SiO_2-loaded iodide was purified by flash chromatography with the specified solvent system.

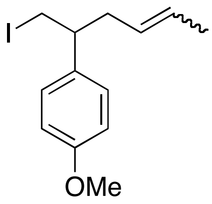
Method B

A 0 °C solution of triphenylphosphine (1.5 equiv), imidazole (1.5 equiv), and iodine (1.5 equiv) in CH_2Cl_2 (0.4 M) was stirred under Ar for 15 minutes. The alcohol (1.0 equiv) was added dropwise in CH_2Cl_2 (0.4 M). The reaction mixture was stirred for 30 minutes then warmed to room temperature, where it stirred for 30 minutes. The reaction was quenched with H_2O and extracted with CH_2Cl_2 (x 3). The combined organic layers were washed with $Na_2S_2O_3$, dried ($MgSO_4$), and concentrated *in vacuo*. The resulting oil was purified by flash chromatography with the specified solvent system.

Method C

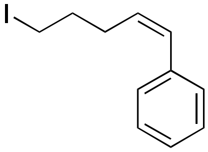
To a 0 °C solution of alcohol (1.0 equiv), triphenylphosphine (1.2 equiv), and pyridine (1.9 equiv) in CH_2Cl_2 (0.1 M) was added iodine (1.2 equiv) under Ar. The reaction mixture was stirred at 0 °C for 1 hr. The reaction as then washed with 1 N HCl, $Na_2S_2O_3$, sat. $NaHCO_3$, and brine. The organic layer was dried ($MgSO_4$) and concentrated *in vacuo*. The resulting oil was purified with flash chromatography with the specified solvent system.

4:



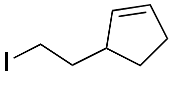
1-(1-iodohex-4-en-2-yl)-4-methoxybenzene (4) was synthesized via ***Method A*** in 79% yield. Flash chromatography (30:1 Hexanes/EtOAc) was used to purify to provide 2.25 g of a colorless oil an as inseparable mixture of stereoisomers (85:15) with *trans* as the major isomer. Analytical data for **4**: IR (thin film, cm^{-1}) 2998, 2954, 2933, 2912, 2833, 1611, 1583, 1512, 1461, 1439, 1302, 1249, 1178, 1036, 967, 828, 804, 556, 453; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.12-7.08 (d, *J* = 8.7 Hz, 2 H), 6.90-6.87 (d, *J* = 8.7 Hz, 2 H), 5.54-5.47 (m, 1 H), 5.32-5.25 (m, 1 H), 3.81 (s, 3 H), 3.47-3.40 (m, 1 H), 3.40-3.33 (m, 1 H), 2.91-2.81 (m, 1 H), 2.68-2.61 (m, 0.19 H), 2.52-2.46 (m, 0.9 H), 2.40-2.34 (m, 1 H), 1.64-1.59 (d, *J* = 6.4 Hz, 3 H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 158.3, 158.3, 134.8, 134.7, 128.3, 128.2, 127.9, 127.5, 127.2, 125.9, 113.7, 113.7, 55.1, 4 7.1, 47.0, 38.7, 33.0, 17.9, 14.1, 13.9, 13.0; LRMS (ESI) calculated for $[C_{13}H_{17}IO+H]^+$ 317.04, found 317.04.

6:



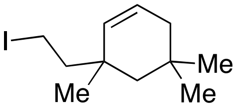
(*Z*)-(5-iodopent-1-en-1-yl)benzene (6) was synthesized via ***Method A*** in 64% yield. Purification was accomplished using flash chromatography (40:1 Hexanes/EtOAc) to provide 700 mg of **6** as a colorless oil. Physical and spectral data were in accordance with literature data.[12]

8:



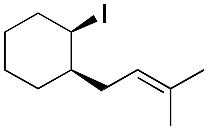
3-(2-iodoethyl)cyclopent-1-ene (8) was synthesized via ***Method B*** in 78% yield. Purification was accomplished using flash chromatography (100:1 Hexanes/EtOAc) to provide 2.04 g of **8** as a colorless oil. Physical and spectral data were in accordance with the literature data.[13]

1:



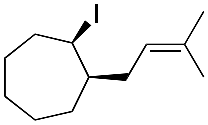
3-(2-iodoethyl)-3,5,5-trimethylcyclohex-1-ene (1) was synthesized via ***Method B*** in 70% yield. Purification was accomplished using flash chromatography (100:1 Hexanes/EtOAc) to provide 1.12 g of **1** as a colorless oil. Analytical data for **1**: IR (thin film, cm^{-1}) 3011, 2950, 2903, 2866, 1455, 1363, 1171, 413; ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.62 (m, 1 H), 5.34 (d, *J* = 10.0 Hz, 1 H), 3.11 (m, 2 H), 1.99-1.88 (m, 2 H), 1.72 (m, 2 H), 1.39 (d, *J* = 13.8 Hz, 1 H), 1.23 (d, *J* = 13.8 Hz, 1H), 1.02, (s, 3 H), 0.95 (s, 6 H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 133.4, 124.9, 49.4, 46.5, 38.5, 38.0, 31.7, 29.8, 28.6, 27.7, 1.1; GCMS calculated for [M] 278.05, found 278.

11:



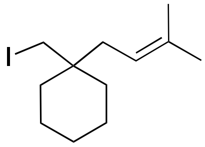
cis*-1-iodo-2-(3-methylbut-2-en-1-yl)cyclohexane (11)** was synthesized via ***Method C. Purification was accomplished using flash chromatography (50:1 Hexanes/EtOAc) to provide a colorless oil. Analytical data for **11**: IR (thin film, cm^{-1}) 2927, 2852, 1708, 1637, 1446; ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.06 (m, 1 H), 4.72 (m, 1 H), 2.19 (m, 1 H), 1.93 (m, 1 H), 1.86 (m, 1 H), 1.78-1.68 (m, 5 H) 1.65 (s, 3 H), 1.55 (m, 1 H), 1.47 (m, 1 H), 1.33-1.25 (m, 3 H), 0.43 (m, 1 H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 133.3, 121.5, 48.4, 43.5, 36.9, 36.7, 28.8, 25.9, 25.6, 22.8, 18.3; LRMS (ESI) calculated for [$C_{11}H_{19}I$] 278.05, found 278.

13:



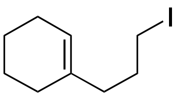
cis*-1-iodo-2-(3-methylbut-2-en-1-yl)cycloheptane (13)** was synthesized via ***Method C in 70% yield. Purification was accomplished using flash chromatography (50:1 Hexanes/EtOAc) to provide 541 mg of **13** as a colorless oil. Analytical data for **13**: IR (thin film, cm^{-1}) 2964, 2926, 2855, 1446, 1375, 485; ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.04 (t, *J* = 7.25 Hz, 1H), 4.70 (app t, *J* = 2.8 Hz, 1H), 2.26 (m, 1H), 2.02-1.82 (m, 3H), 1.76-1.68 (m, 7 H), 1.62-1.50 (m, 3 H), 1.43-1.35 (m, 1 H), 0.80-0.74 (m, 1H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 133.5, 122.4, 49.7, 46.2, 36.5, 32.9, 27.0, 26.4, 25.9, 25.6, 18.3; GCMS calculated for [$C_{12}H_{21}I$] 292.07, found 292.

15:



1-(iodomethyl)-1-(3-methylbut-2-en-1-yl)cyclohexane (15) was synthesized by addition of triphenylphosphine (908 mg, 3.46 mmol) to a 0 °C solution of (1-(3-methylbut-2-en-1-yl)cyclohexyl)methanol (234 mg, 1.28 mmol) and imidazole (332 mg, 4.88 mmol) in THF (15 mL) under Ar. The reaction mixture was stirred 10 minutes, followed by addition of iodine (845 mg, 3.33 mmol). The reaction mixture was then warmed to room temperature and stirred overnight. The solution was quenched with $Na_2S_2O_3$ and extracted with Et_2O (x 3). The combined organic layers were washed with brine, dried ($MgSO_4$), and concentrated *in vacuo*. The resulting oil was purified using flash chromatography (30:1 Hexanes/EtOAc) to provide 179 mg of **15** as a colorless oil. Analytical data for **15**: IR (thin film, cm^{-1}) 2926, 2855, 1453, 412; ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.06 (t, *J* = 7.6 Hz, 1 H), 3.24 (s, 2 H), 2.02 (d, *J* = 7.6 Hz, 2 H), 1.71 (s, 3 H), 1.66 (s, 3 H), 1.48-1.33 (m, 10 H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 134.3, 119.0, 36.3, 35.0, 26.2, 26.1, 22.6, 21.9, 18.4; LRMS (ESI) calculated for [$C_{12}H_{21}I$] 292.07, found 292.

17:

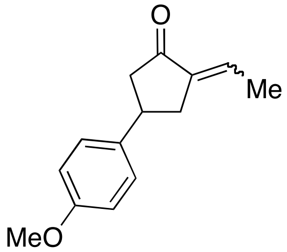


1-(3-iodopropyl)cyclohex-1-ene: Prepared by a procedure according to Crotti *et. al.*[14] Physical and spectral data were in accordance with the literature data.

General Procedure for the Carbonylative Heck-Type Reaction

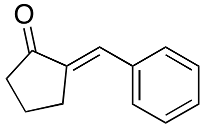
In a glovebox, the alkyl iodide (1.0 equiv), $Pd(PPh_3)_4$ (0.1 equiv), *i*Pr_2NEt (2.0 equiv), and toluene (0.5 M) were combined in a 20 mL Parr reactor. The reactor was sealed and then removed from the glovebox. The Parr reactor was purged with carbon monoxide (x 1) at 150 psi and then pressurized to 735 psi carbon monoxide. The reaction vessel was then placed in a 130 °C oil bath for 12 hr, after which it was allowed to cool to room temperature before depressurizing. The Parr reactor was then opened and the reaction mixture was transferred out of the vessel by multiple rinses with Et_2O. Brine was added, and the aqueous layer was then extracted with Et_2O (x 3). The combined organic layers were dried ($MgSO_4$) and concentrated *in vacuo*. The resulting enone was purified by flash chromatography with the specified solvent system.

5:



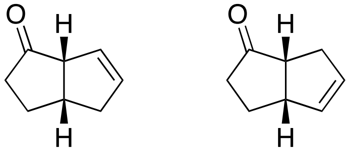
2-ethylidene-4-(4-methoxyphenyl)cyclopentanone (5) was synthesized according to the general procedure using **4** (150 mg, 0.474 mmol). The resulting enone was purified by flash chromatography (30:1 Hexanes/EtOAc) to afford **5** (79.0 mg, 0.365 mmol, 77% yield) as a partially separable mixture of stereoisomers (10:1 *trans:cis*) as a pale yellow oil. Analytical data for major **5-*trans* *isomer***: IR (thin film, cm^{-1}) 2925, 2854, 1721, 1652, 1513, 1248, 1203, 1180, 1035, 829; ^1H NMR (400 MHz, $CDCl_3$) δ 7.17 (d, J = 8.5 Hz, 2 H), 6.87 (d, J = 8.5 Hz, 2 H), 6.68 (m, 1 H), 3.79 (s, 3 H), 3.34 (m, 1 H), 3.07 (dd, J = 7.0 Hz, J = 1.1 Hz, 1 H), 2.74 (dd, J = 7.0 Hz, J = 1.1 Hz, 1 H), 2.63-2.40 (m, 2 H), 1.82 (d, J = 6.9 Hz, 3 H); ^{13}C NMR (400 MHz, $CDCl_3$) δ 205.3, 158.2, 138.3, 135.7, 131.4, 127.5, 113.9, 55.2, 46.3, 38.1, 35.1, 15.2; LRMS (ESI) calculated for $[C_{14}H_{16}O_2+Na]^+$ 239.10, found 239.10. Analytical data for minor **5-*cis* *isomer***: IR (thin film, cm^{-1}) 2925, 2855, 1720, 1652, 1612, 1513, 1249, 1035, 829; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16 (d, *J* = 8.6 Hz, 2 H), 6.87 (d, *J* = 8.6 Hz, 2 H), 6.09 (m, 1 H), 3.79 (s, 3 H), 3.33 (m, 1 H), 2.96 (dd, *J* = 15.2, *J* = 6.8 Hz, 1 H), 2.77-2.63 (m, 2 H), 2.47 (m, 1 H), 2.16 (d, *J* = 7.2 Hz, 3 H); ^{13}C NMR (400 MHz, $CDCl_3$) δ 206.9, 158.3, 136.2, 135.6, 135.4, 127.6, 114.1, 55.3, 48.2, 40.1, 38.7, 14.5; LRMS (ESI) calculated for $[C_{14}H_{16}O_2+Na]^+$ 239.10, found 239.10.

7:



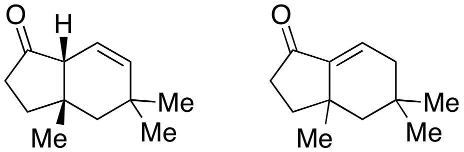
(*E*)-2-benzylidenecyclopentanone (7) was synthesized according to the general procedure using **6** (70 mg, 0.257 mmol). The resulting enone was purified by flash chromatography (20:1 hexanes/EtOAc) to afford **7** (24.3 mg, 0.141 mmol, 55% yield) as a pale yellow oil. Physical and spectral data were in accordance with the literature data.[15]

9 and 10:



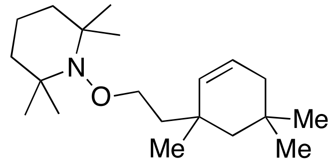
(*cis*)-2,3,3a,4-tetrahydropentalen-1(6aH)-one (9) and (*cis*)-3,3a,6,6a-tetrahydropentalen-1(2H)-one (10) were synthesized according to the general procedure using **8** (200 mg, 0.90 mmol). The resulting enones were purified by flash chromatography (15:1 Pentane/Et_2O) to afford a 1.3:1 inseparable mixture of **9** and **10** (67.7 mg, 0.554 mmol, 62% yield) as a yellow oil. *Warning: volatile compound.* Physical and spectral data were in accordance with the literature data.[16]

2 and 3:



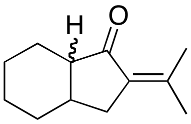
(*cis*)-3a,5,5-trimethyl-2,3,3a,4,5,7a-hexahydro-1H-inden-1-one (2) and 3a,5,5-trimethyl-2,3,3a,4,5,6-hexahydro-1H-inden-1-one (3) were synthesized according to the general procedure using **1** (70 mg, 0.25 mmol), but reaction time was 5 hr. The resulting enones were purified by flash chromatography (20:1 Hexanes:EtOAc) to afford **2** and **3** (33.0 mg, 0.185 mmol, 74% yield) as a yellow oil. The two regioisomers were partially separable. Analytical data for **2**: IR (thin film, cm^{-1}) 3011, 2918, 2848, 1443, 1226, 1176, 689; ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.58 (app s, 2 H), 2.35 (app s, 1 H), 2.29 (m, 2 H), 1.90 (m, 1 H), 1.65 (m, 1 H), 1.39 (s, 2 H), 1.21 (s, 3 H), 1.06 (s, 3 H), 0.97 (s, 3 H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 219.5, 138.6, 118.7, 56.3, 44.7, 38.26, 35.9, 35.2, 32.6, 32.0, 30.2, 28.42; GCMS calculated for [M] 178.14, found 178. Analytical data for minor isomer **3**: ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm 6.57 (t, J = 4.4 Hz, 1 H), 2.44-2.19 (m, 2 H), 2.03 (m, 2 H), 1.90-1.95 (m, 1 H), 1.69 (m, 1 H), 1.47-1.44 (m, 1 H), 1.23 (m, 1 H), 1.16 (s, 3 H), 1.06 (s, 3 H), 0.98 (s, 3 H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 207.0, 145.4, 130.5, 49.9, 39.4, 37.6, 35.6, 35.3, 31.3, 31.2, 30.1, 26.0.

19:



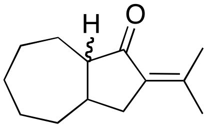
2,2,6,6-tetramethyl-1-(2-(1,5,5-trimethylcyclohex-2-en-1-yl)ethoxy)piperidine (TEMPO reaction byproduct) (19) was isolated from the reaction of **1** (111.3 mg, 0.41 mmol) according to the general procedure, but with the addition of TEMPO (64.1 mg, 0.41 mmol) and using a 5 hr reaction time. The resulting product was purified by flash chromatography (50:1 Hexanes/EtOAc) to afford **19**. The yield of **19** was obtained using 1,4-dinitrobenzene as internal NMR standard. Analytical data for **19**: IR (thin film, cm^{-1}) 2929, 2869, 2360, 2342, 1455, 1373, 1359; ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.56-5.52 (m, 1 H), 5.39 (d, J = 10.0 Hz, 1 H), 3.76 (m, 2 H), 1.79-1.68 (m, 2 H), 1.59-1.22 (m, 10 H), 1.15 (s, 6 H), 1.07 (s, 6 H), 1.02 (s, 3 H), 0.94 (s, 6 H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 135.2, 123.5, 73.9, 59.5, 47.6, 42.1, 39.5, 38.6, 34.3, 33.0, 31.4, 29.9, 29.2, 28.6, 20.2, 17.1; LRMS (ESI) calculated for $[C_{20}H_{37}NO+H]^+$ 308.30, found 308.29.

12:



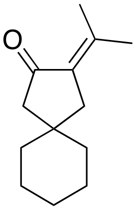
2-(propan-2-ylidene)octahydro-1H-inden-1-one (12) was synthesized according to the general procedure using **11** (70 mg, 0.25 mmol). The resulting enone was purified by flash chromatography (25:1 hexanes/EtOAc) to afford **12** (41.0 mg, 0.230 mmol, 92% yield) as an inseparable mixture of *cis* and *trans* stereoisomers as a colorless oil. Analytical data for **12**: IR (thin film, cm^{-1}) 2927, 2852, 1708, 1637, 1446; ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.63, (dd, *J* = 14.8 Hz, *J* = 6.2 Hz, 0.87 H), 2.52 (m, 1 H), 2.31-0.77 (m, 31.8 H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 207.6, 206.8, 147.7, 146.1, 131.1, 130.1, 56.7, 50.9, 40.6, 34.3, 33.9, 33.0, 32.3, 29.6, 26.1, 25.7, 25.5, 24.2, 24.2, 24.0, 23.0, 22.7, 20.4, 20.3; LRMS (ESI) calculated for $[C_{12}H_{18}O+Na]^+$ 201.13, found 201.12.

14:



2-(propan-2-ylidene)octahydroazulen-1(2H)-one (14) was synthesized according to the general procedure using **13** (100 mg, 0.34 mmol). The resulting enone was purified by flash chromatography (30:1 hexanes/EtOAc) to afford **14** (53.4 mg, 0.277 mmol, 82% yield) as an inseparable mixture of *cis* and *trans* stereoisomers as a colorless oil. Analytical data for **14**: IR (thin film, cm^{-1}) 2924, 2851, 1704, 1636; ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.78-2.66 (m, 1 H), 2.48 – 2.32 (m, 0.63 H), 2.19 – 2.14 (m, 4 H), 2.02 – 1.93 (m, 2.3 H), 1.85 – 1.69 (m, 5.8 H), 1.63 – 1.56 (m, 2.4 H), 1.48 – 1.42 (m, 2 H), 1.32 – 1.22 (m, 3 H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 209.8, 208.5, 146.5, 145.9, 131.5, 131.1, 56.5, 55.3, 40.4, 37.5, 36.5, 35.7, 35.7, 34.0, 31.4, 28.4, 28.3. 28.2, 28.0, 27.6, 27.2, 26.9, 24.3, 24.2, 20.4, 20.4; LRMS (ESI) calculated for $[C_{13}H_{20}O+H]^+$ 193.16, found 193.15.

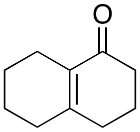
16:



3-(propan-2-ylidene)spiro[4.5]decan-2-one (16) was synthesized according to the general procedure using **15** (64.0 mg, 0.22 mmol). The resulting enone was purified by flash chromatography (20:1 hexanes/EtOAc) to afford **16** (38.1 mg, 0.198 mmol, 90%

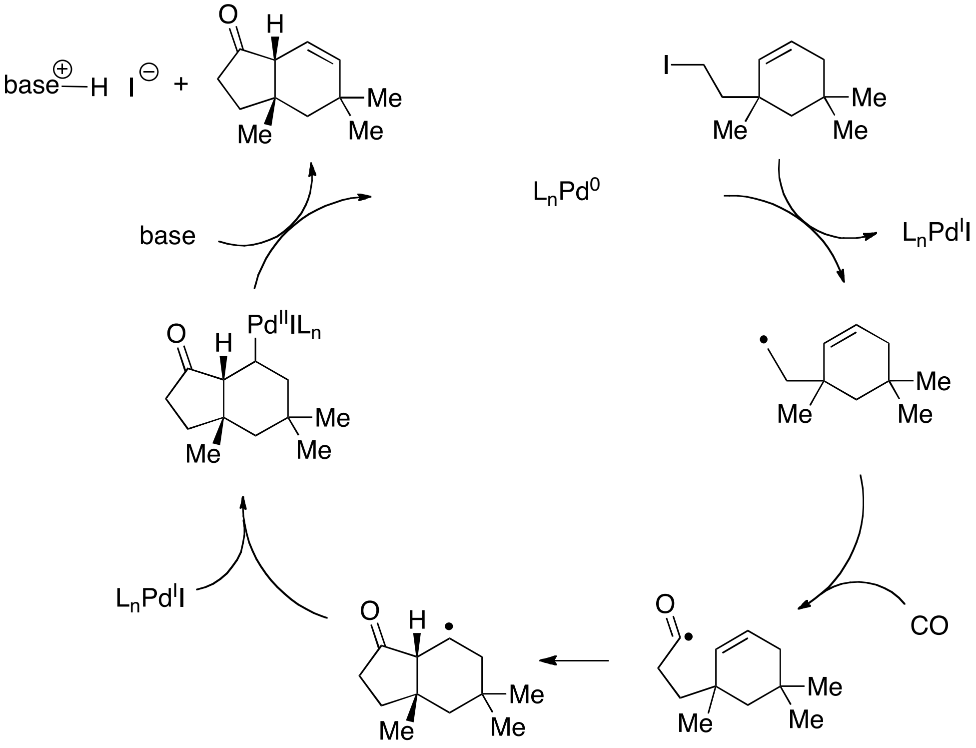
yield) as a colorless oil. Analytical data for **16**: IR (thin film, cm^{-1}) 2925, 2853, 1708, 1633; ^{1}H NMR (500 MHz, CDCl$_3$) δ 2.40 (t, *J* = 1.5 Hz, 2 H), 2.20 (s, 2 H), 2.19 (t, *J* = 1.9 Hz, 3 H), 1.80 (s, 3 H), 1.49-1.35 (m, 10 H); ^{13}C NMR (500 MHz, CDCl$_3$) δ 207.1, 147.4, 130.9, 37.6, 36.2, 25.9, 24.3, 22.8, 20.5; LRMS (ESI) calculated for $[C_{13}H_{20}O+Na]^+$ 215.14, found 215.11.

18:



3,4,5,6,7,8-hexahydronaphthalen-1(2H)-one (18) was synthesized according to the general procedure using **17** (150 mg, 0.60 mmol). The resulting enone was purified by flash chromatography (20:1 Hexanes/EtOAc) to afford **18** (63.6 mg, 0.423 mmol, 69% yield) as a yellow oil. Physical and spectral data for **18** were in accordance with the literature data.[17]

Possible catalytic cycle involving radical intermediates:



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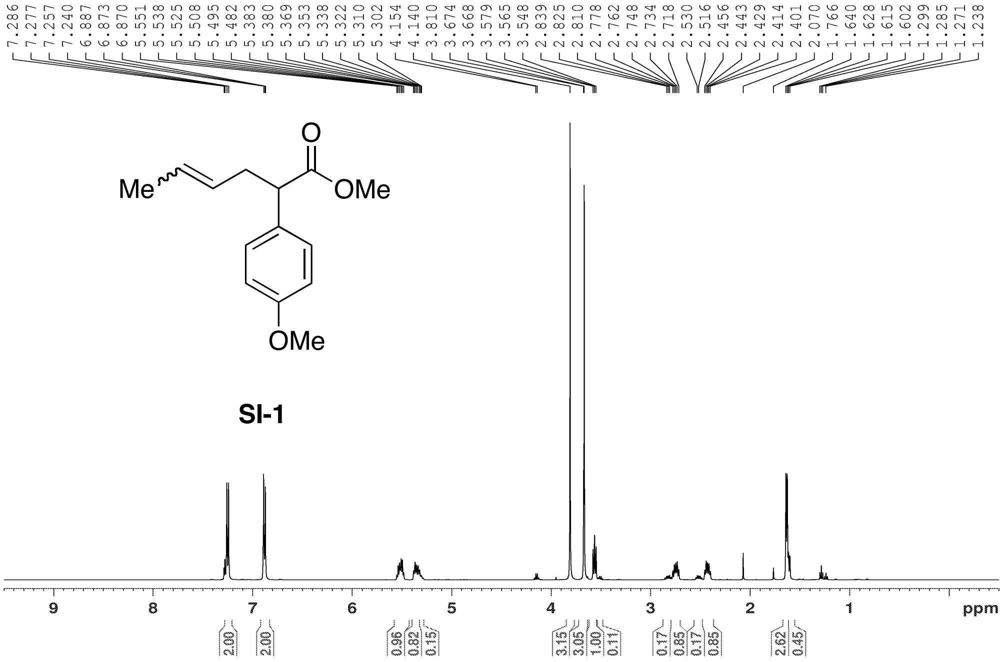
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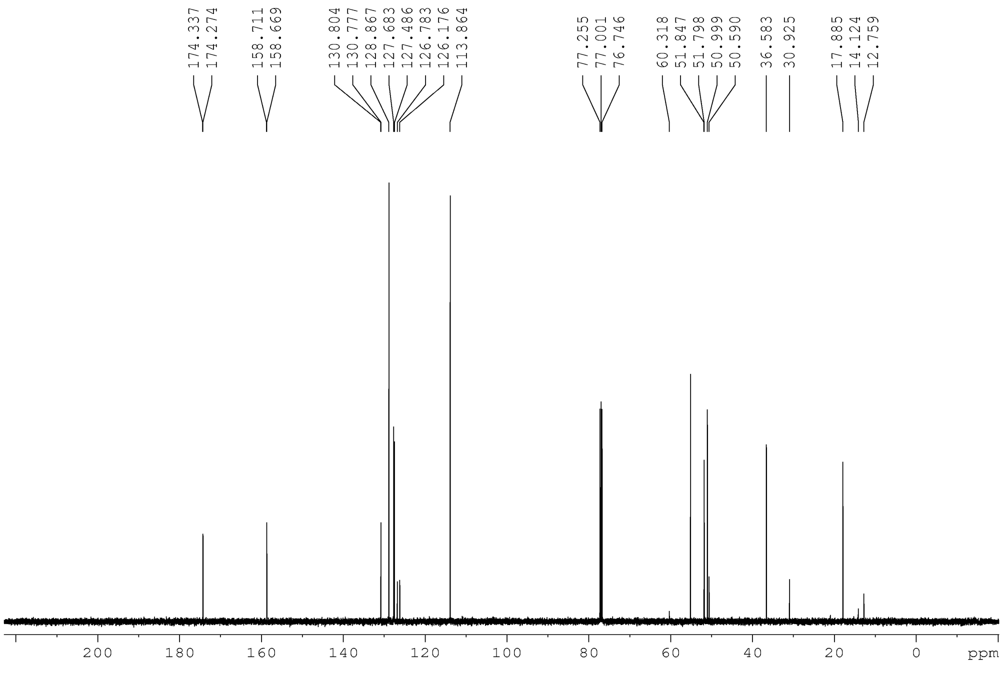
SI-1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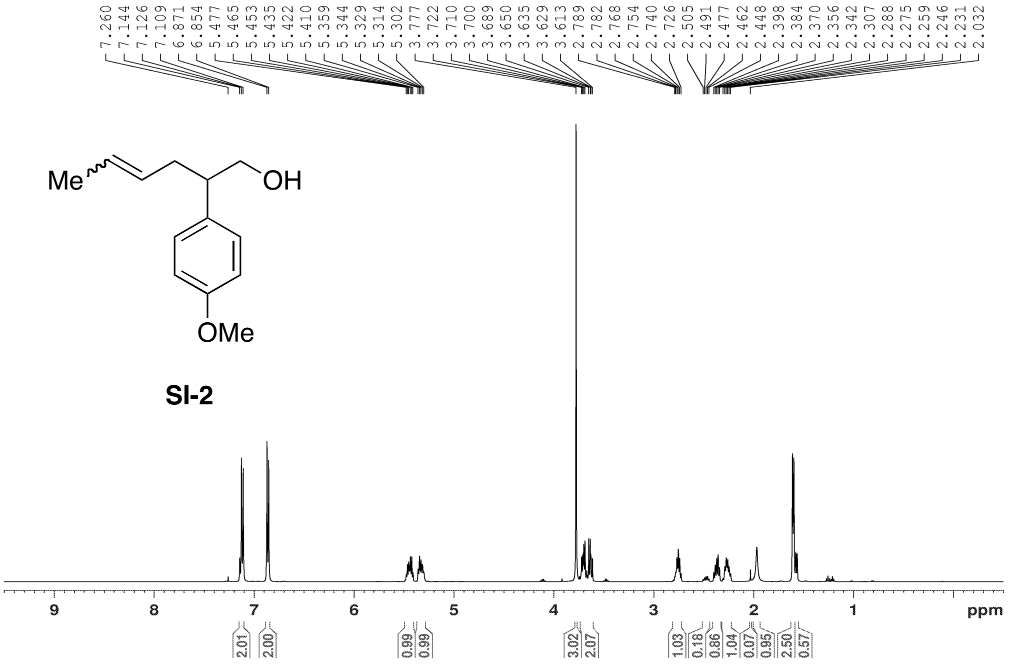
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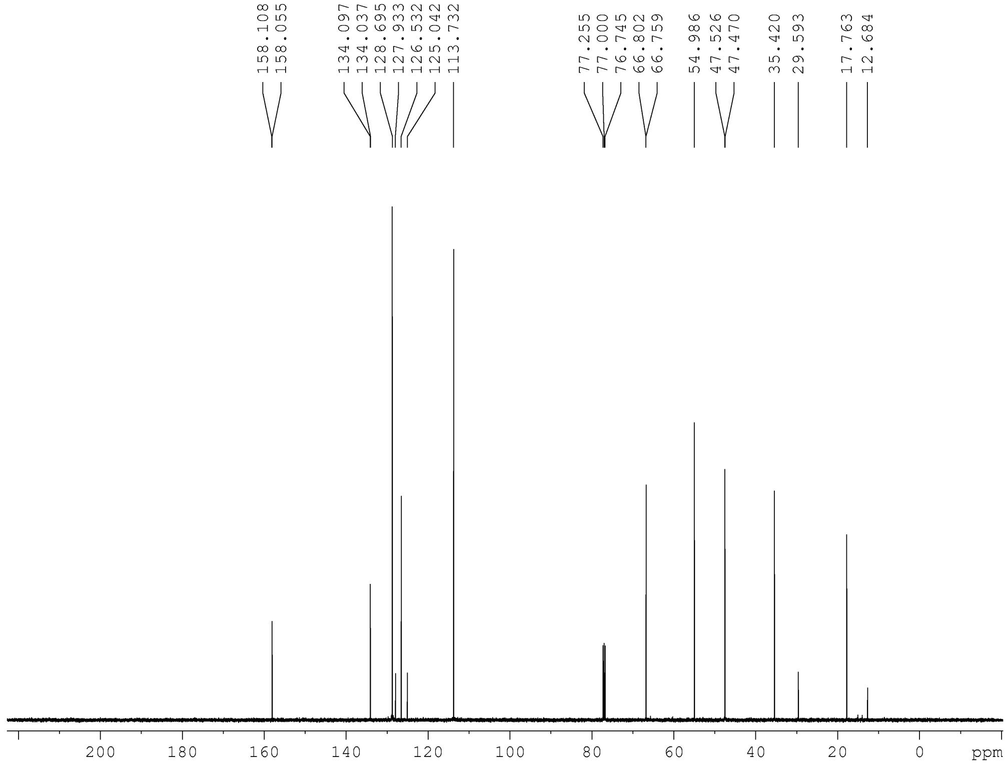
SI-2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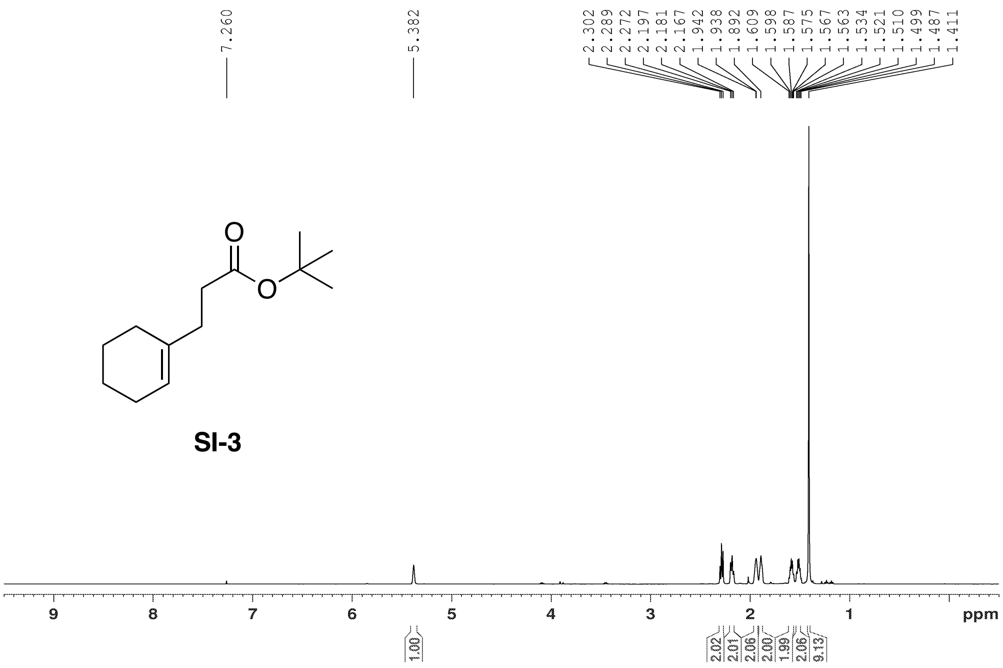

SI-3

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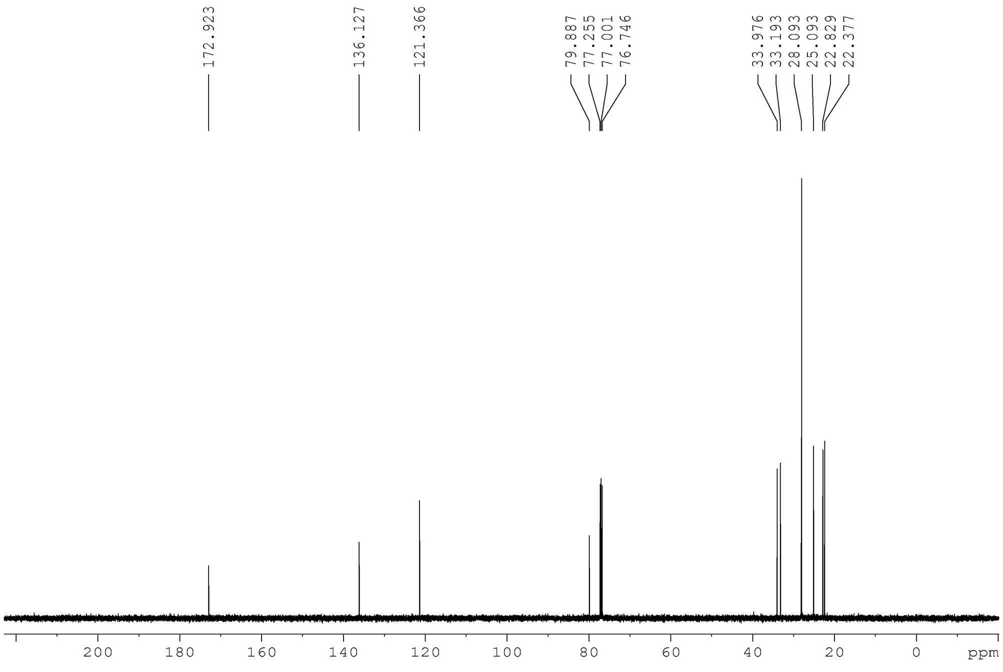

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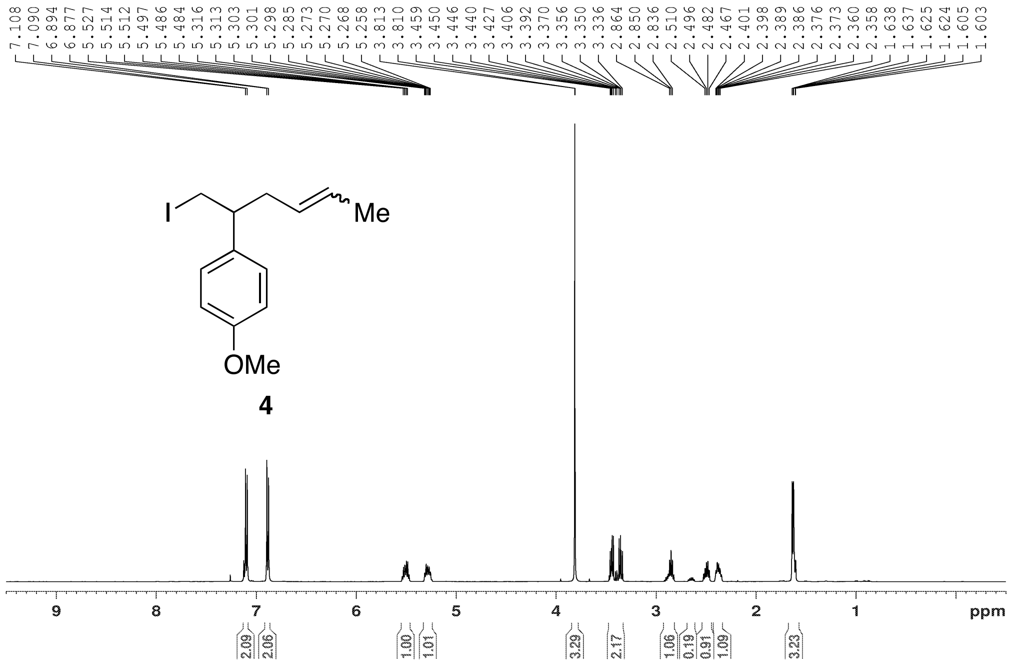
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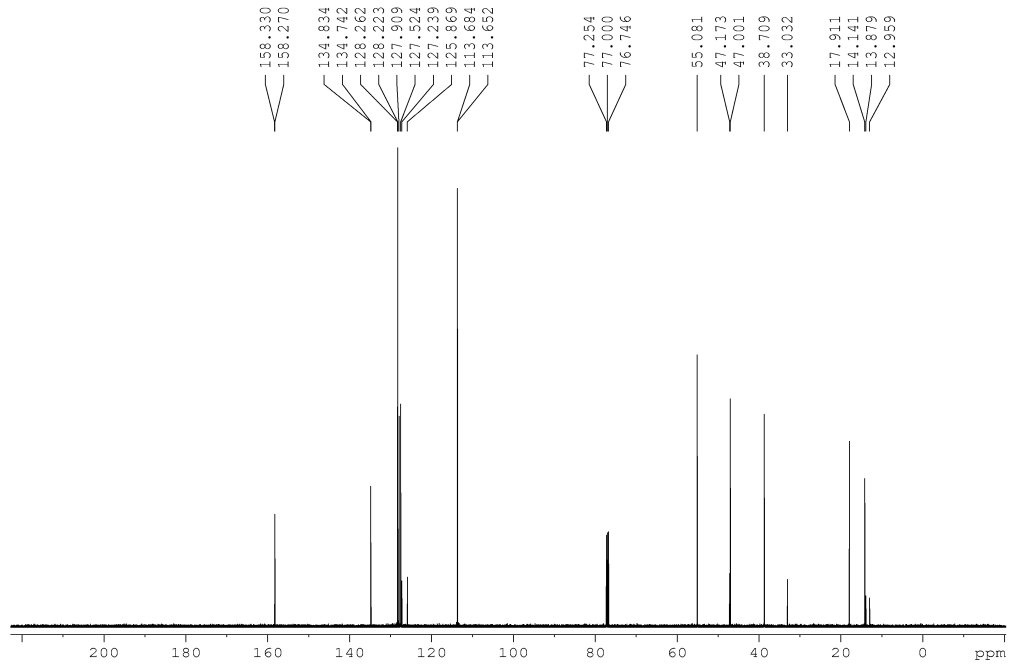
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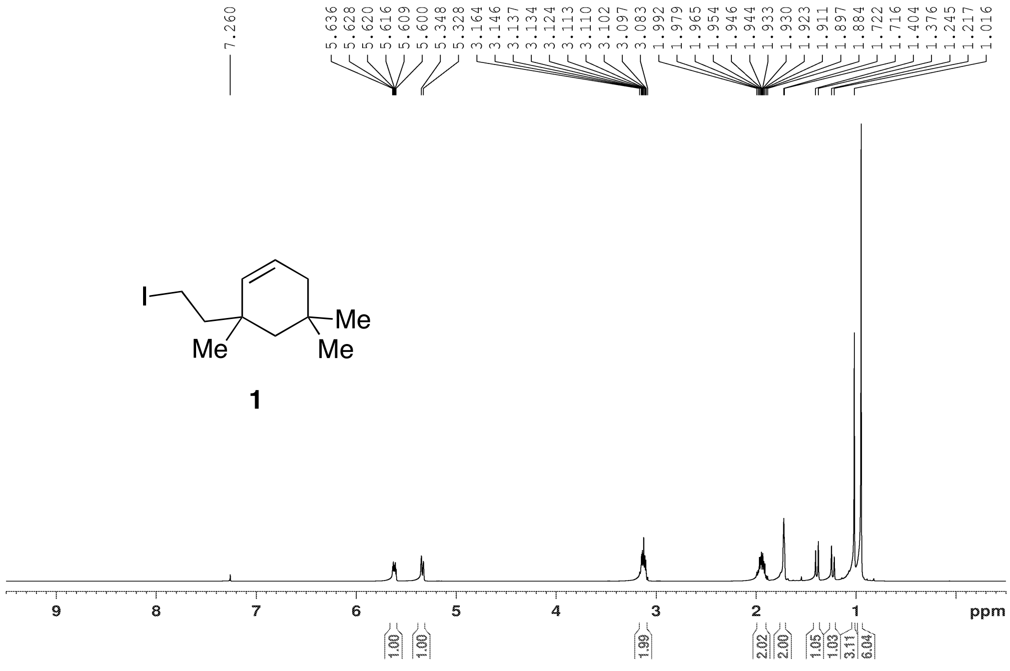
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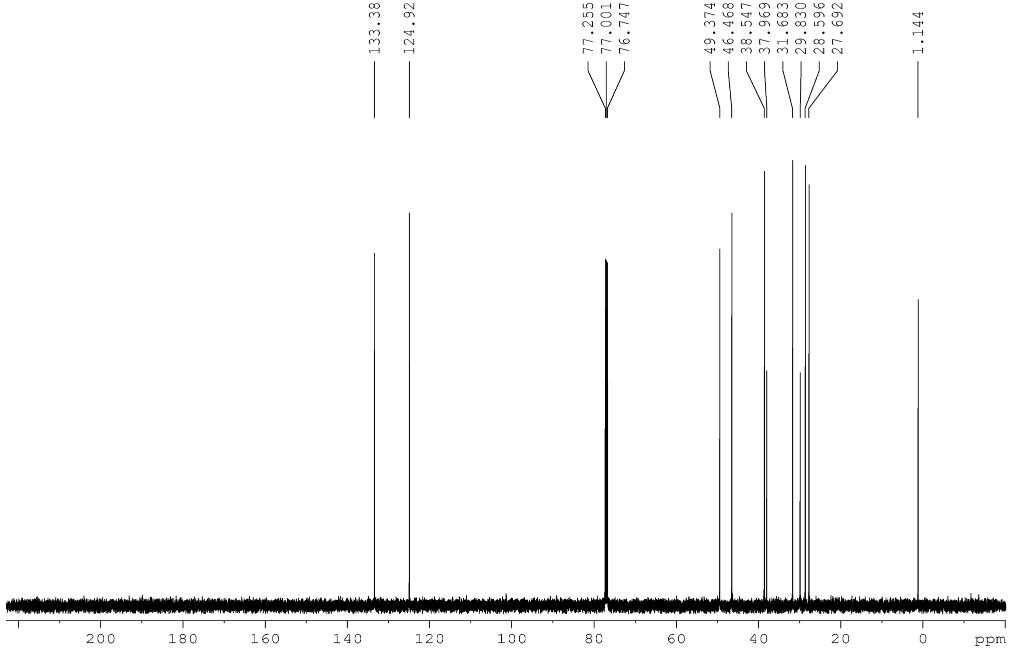
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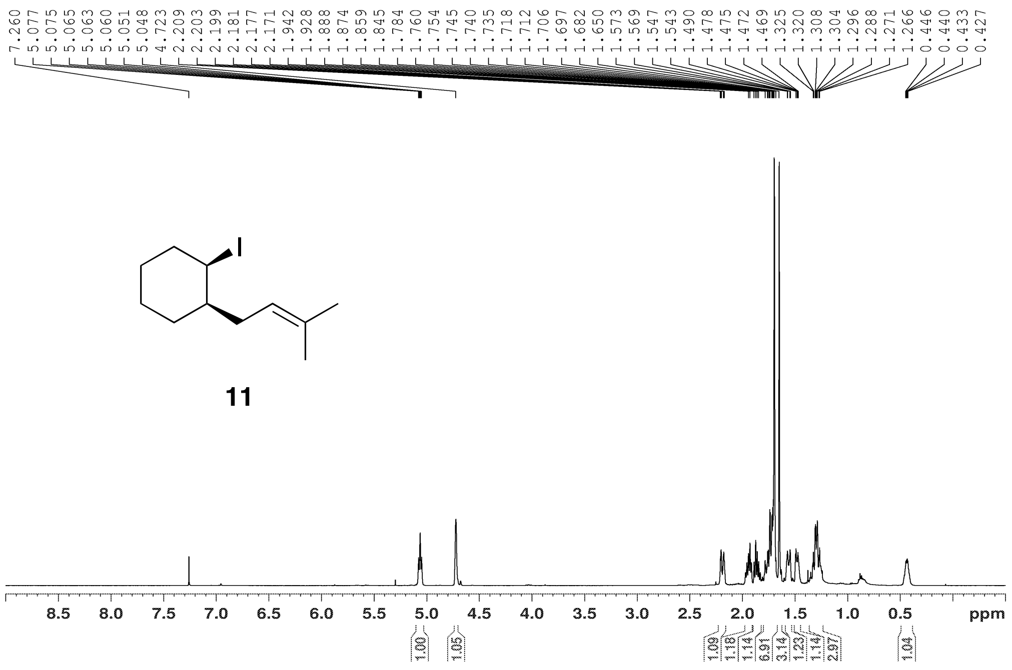
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2.177
2.171
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1.928
1.888
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1.754
1.745
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1.735
1.718
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1.697
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1.573
1.569
1.547
1.543
1.490
1.478
1.475
1.472
1.469
1.325
1.320
1.308
1.304
1.296
1.288
1.271
1.266
0.446
0.440
0.433
0.427
I
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6.0
5.5
5.0
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4.0
3.5
3.0
2.5
2.0
1.5
1.0
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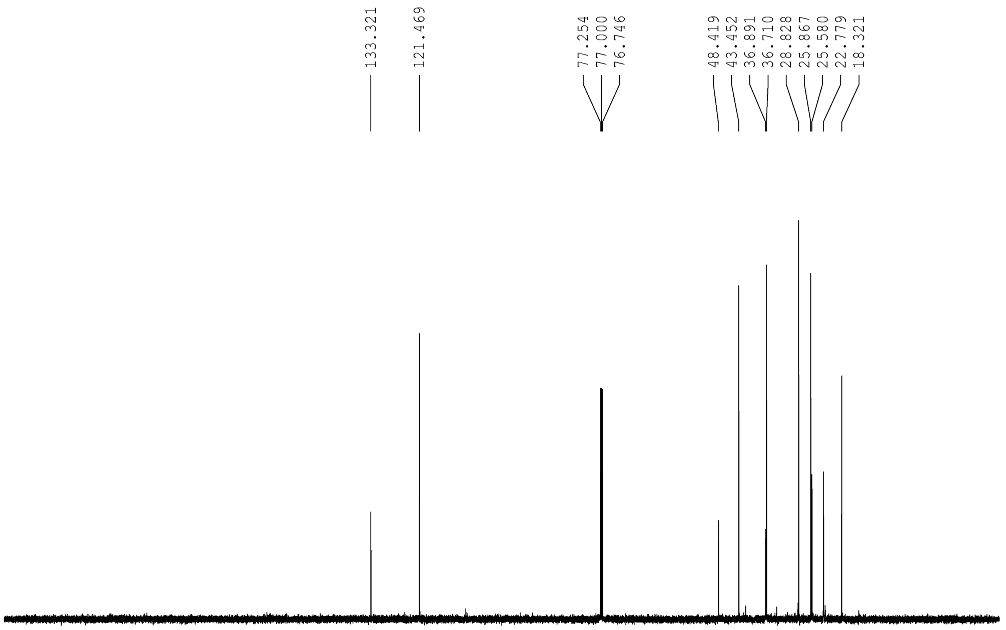
1.04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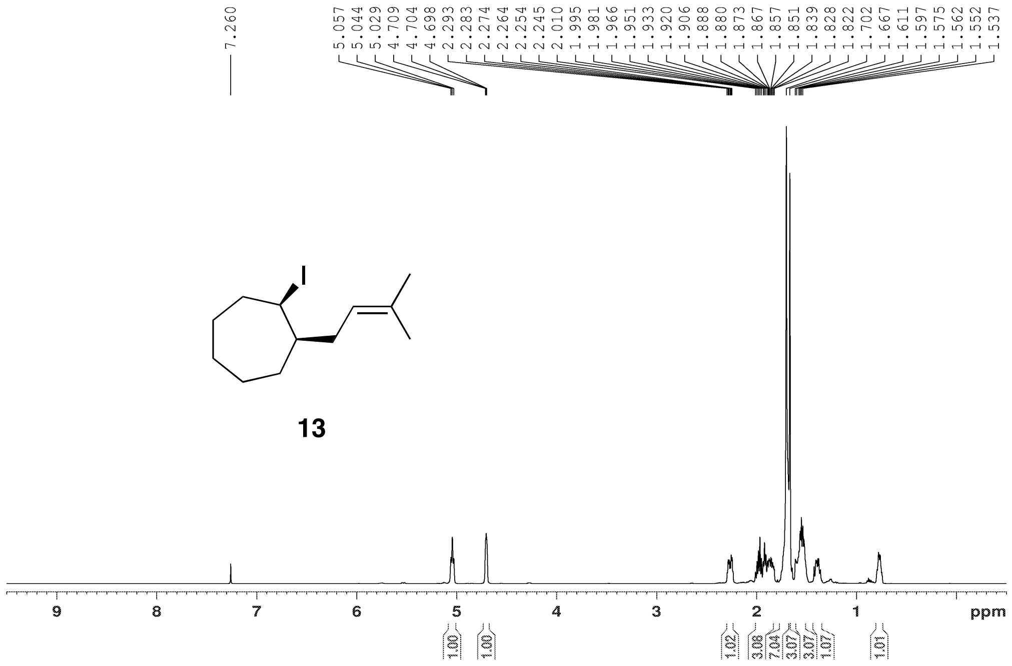
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2.010
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1.906
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1.880
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1.822
1.702
1.667
1.611
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1.562
1.552
1.537
I
9
8
7
6
5
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1.00
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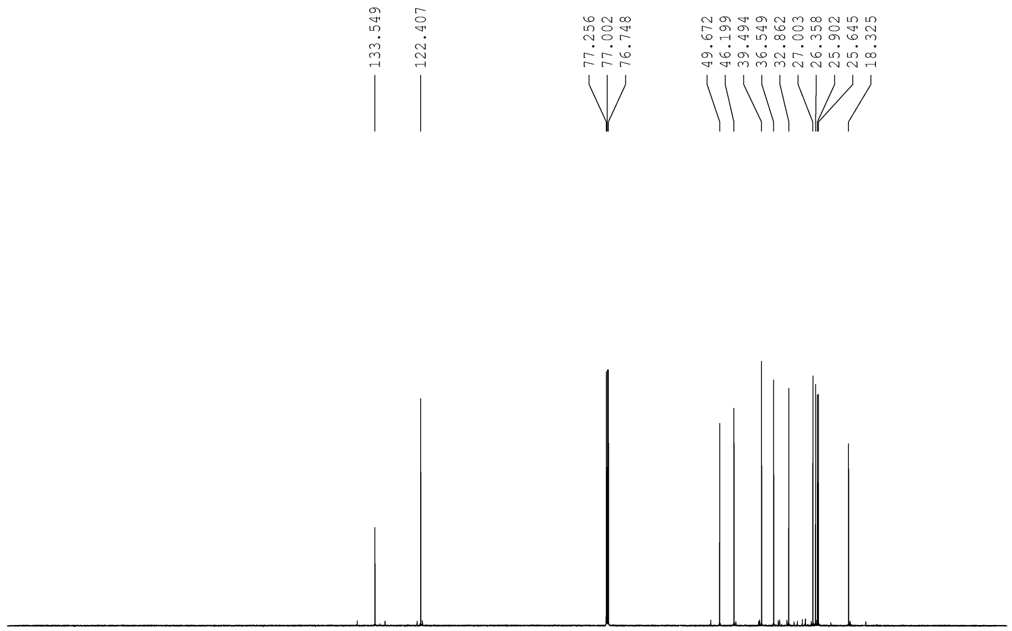
1.01

13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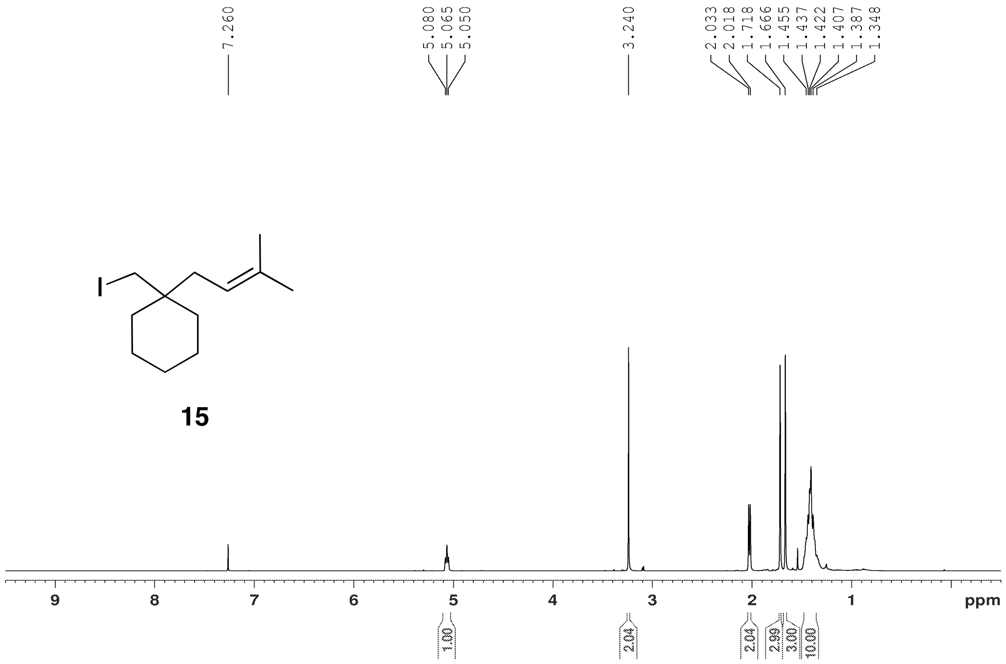
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1.387
1.348
I
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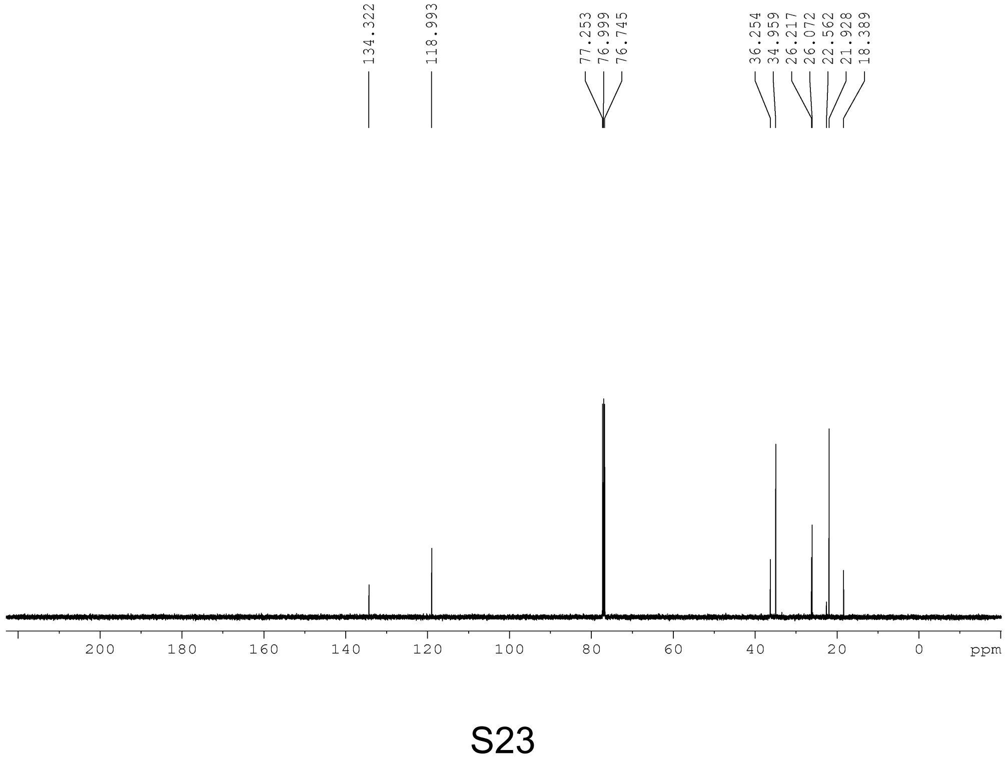
10.00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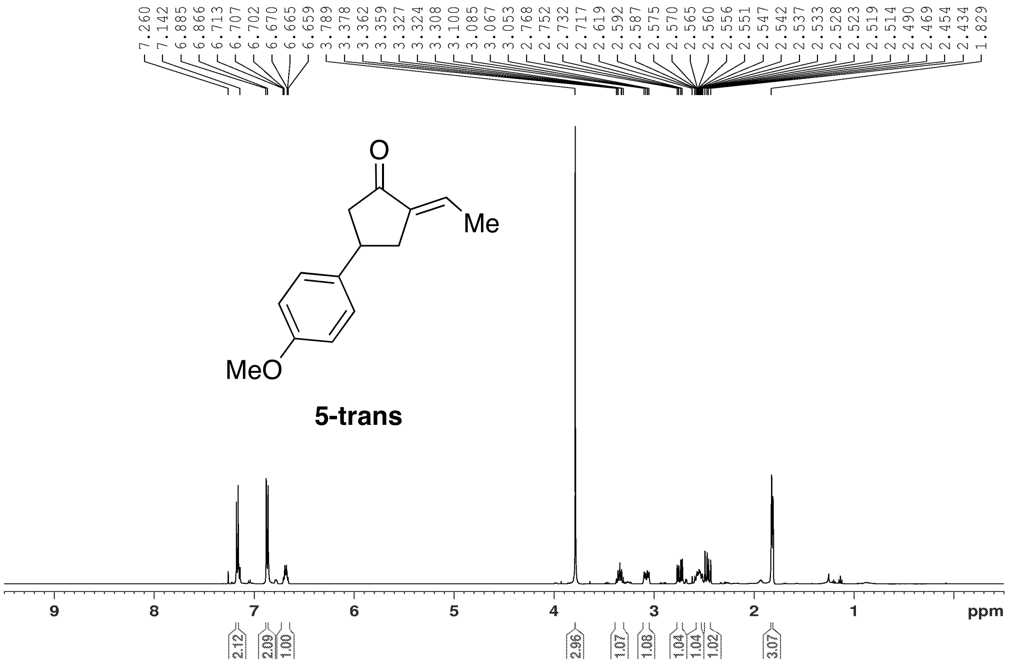
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3.359
3.327
3.324
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3.100
3.085
3.067
3.053
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2.752
2.732
2.717
2.619
2.592
2.587
2.575
2.570
2.565
2.560
2.556
2.551
2.547
2.542
2.537
2.533
2.528
2.523
2.519
2.514
2.490
2.469
2.454
2.434
1.829
O
Me
MeO
5-trans
9
8
7
6
5
4
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2.96
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1.08
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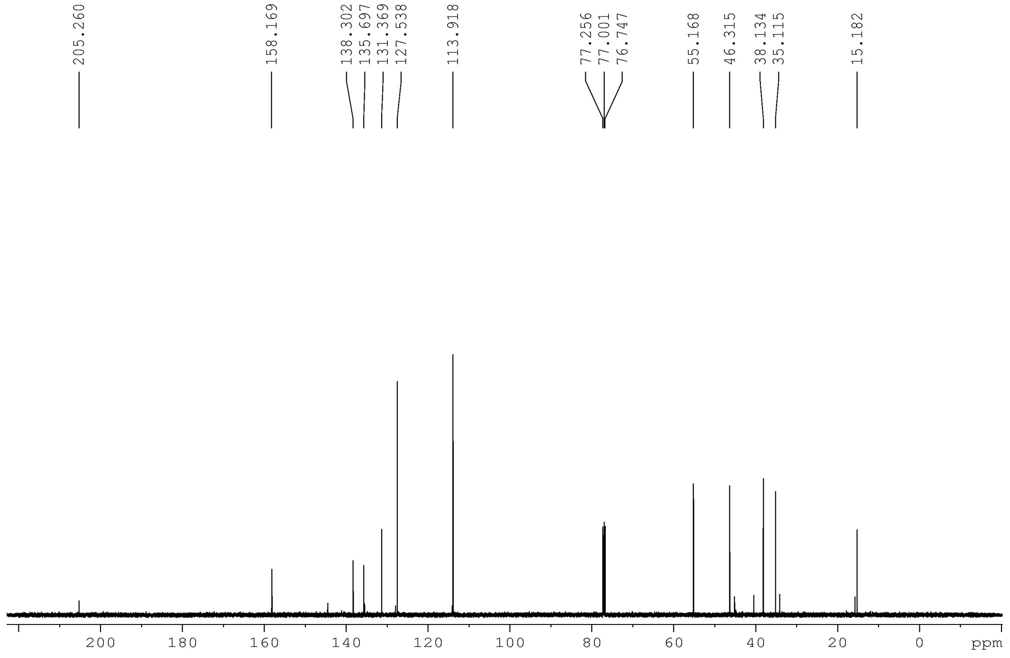
1.04
1.02
3.07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135.697
131.369
127.538
113.918
77.256
77.001
76.747
55.168
46.315
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15.182
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140
120
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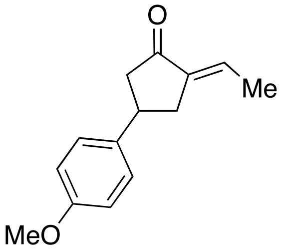
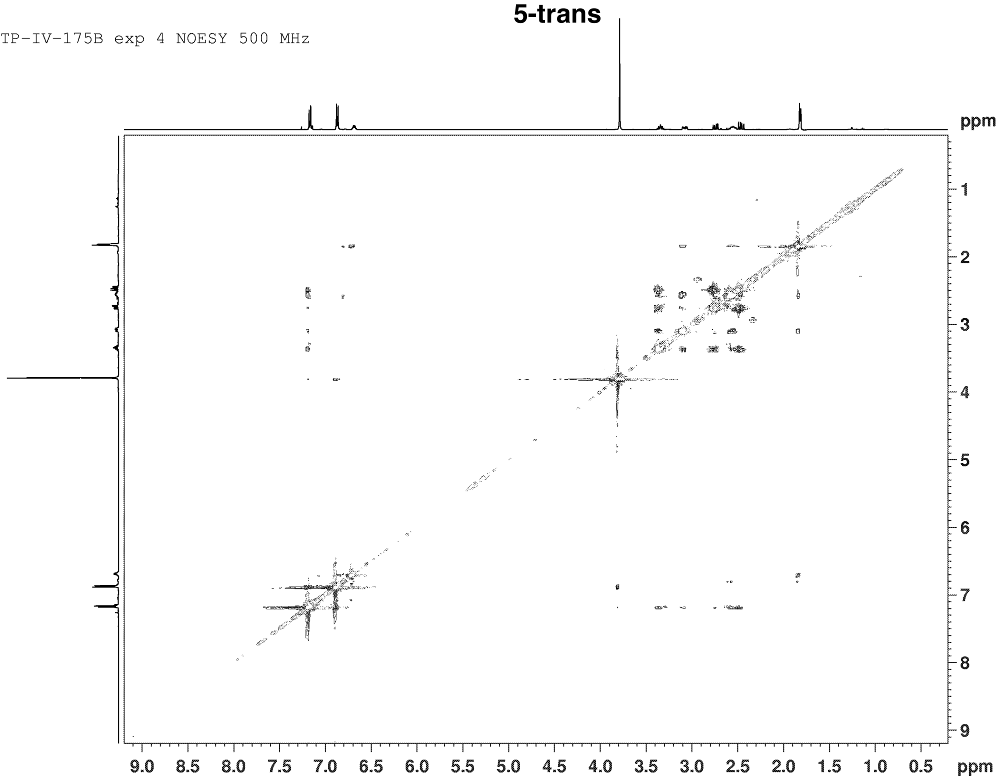
60
40
20
0
ppm

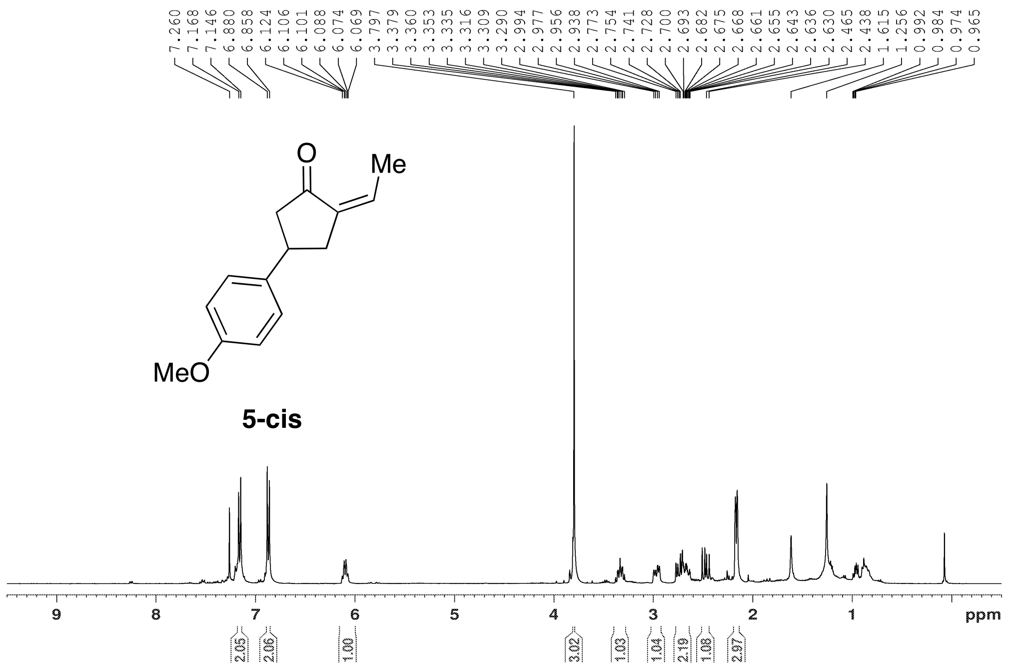
2-D NOESY



5-trans

ATP-IV-175B exp 4 NOESY 500 MHz




5-cis

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6.088
6.074
6.069
3.797
3.379
3.360
3.353
3.335
3.316
3.309
3.290
2.994
2.977
2.956
2.938
2.773
2.754
2.741
2.728
2.700
2.693
2.682
2.675
2.668
2.661
2.655
2.643
2.636
2.630
2.465
2.438
1.615
1.256
0.992
0.984
0.974
0.965
O
Me
MeO
9
8
7
6
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4
3
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ppm
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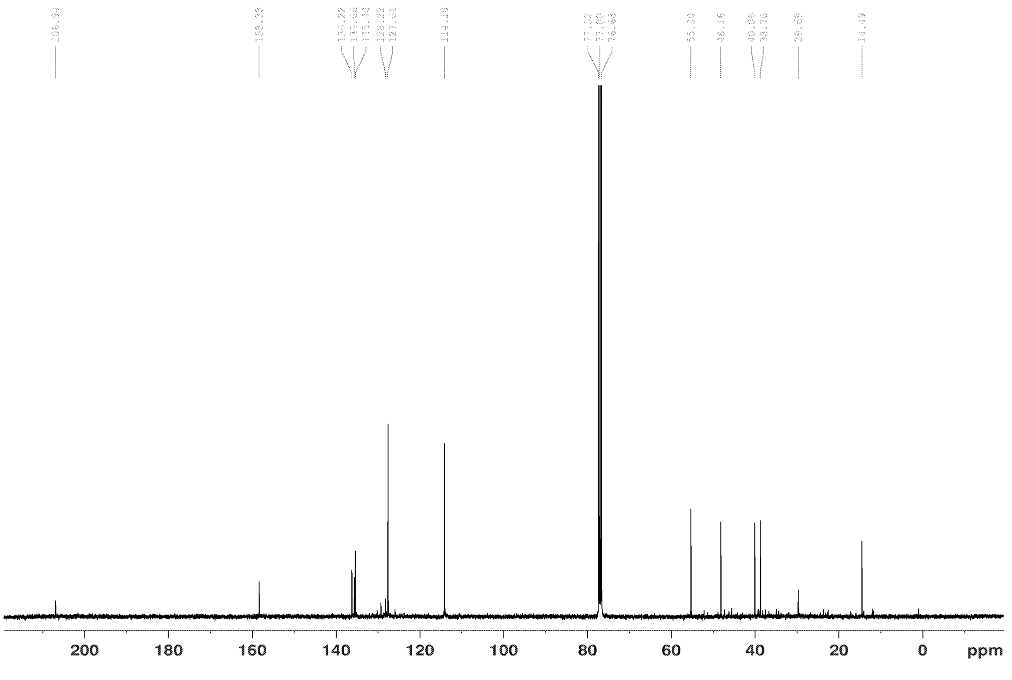
2.06
1.00
3.02
1.03
1.04
2.19
1.08
2.97



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128.22
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114.10
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77.00
76.68
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48.16
40.06
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14.49
200
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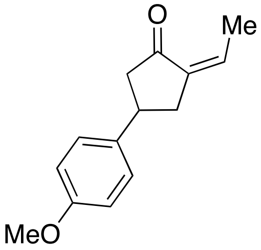
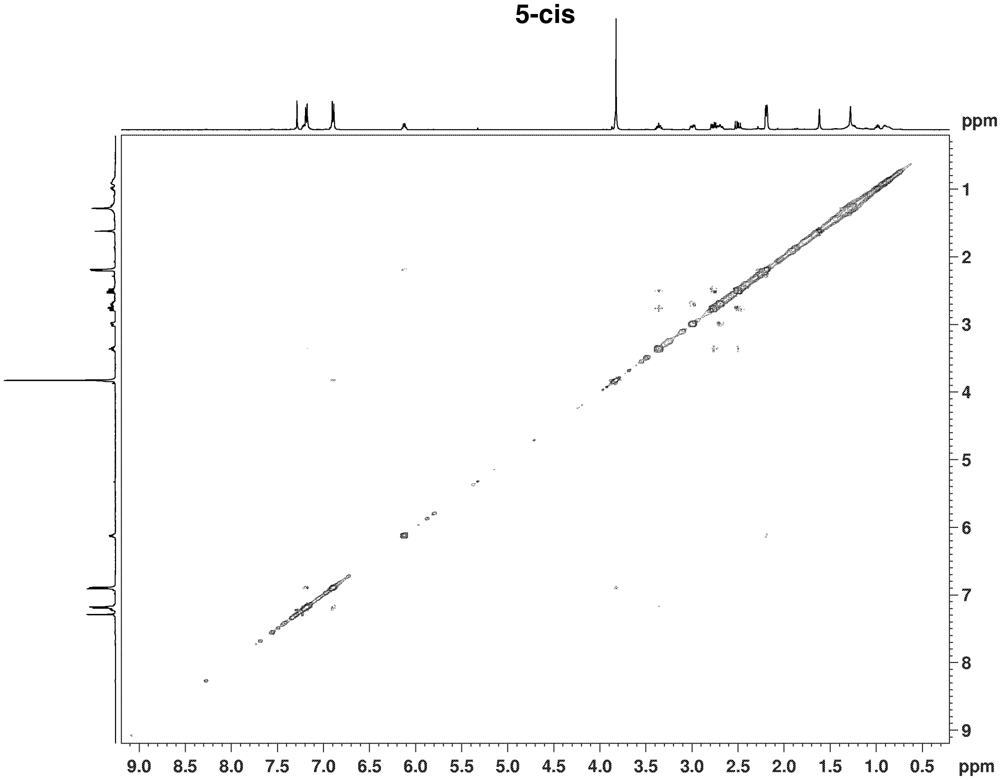
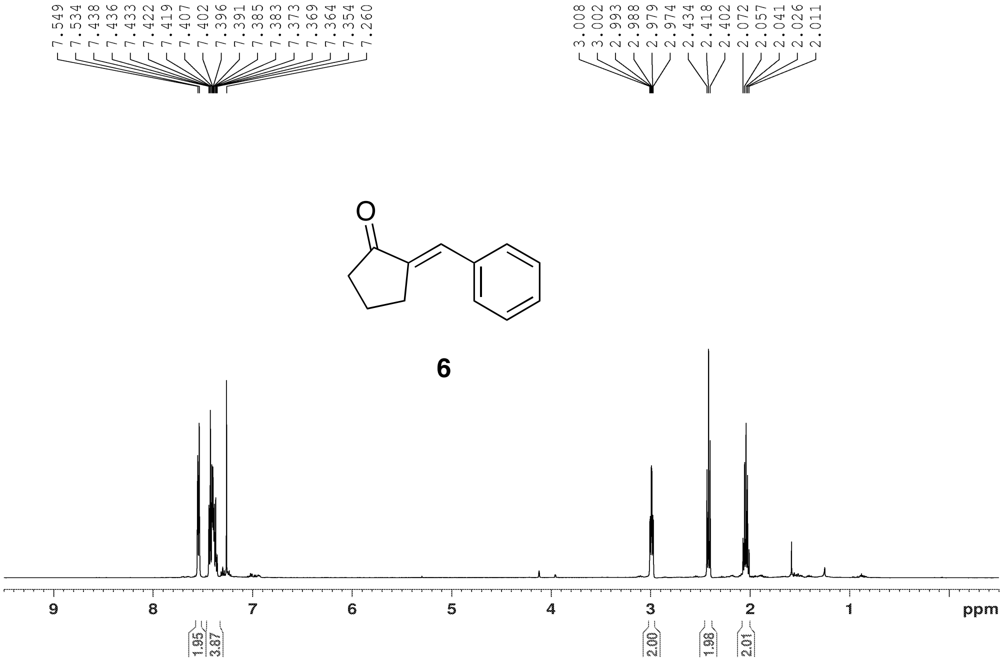
60
40
20
0
ppm

2-D NOESY



5-cis

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7.383
7.373
7.369
7.364
7.354
7.260
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3.002
2.993
2.988
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2.974
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2.402
2.072
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2.011
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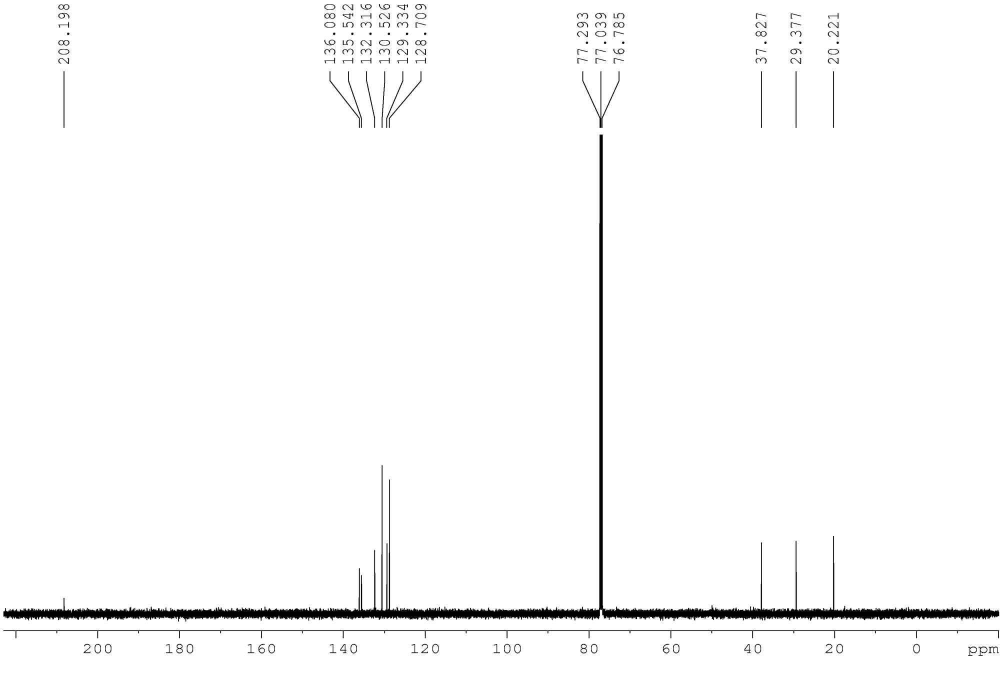
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77.293
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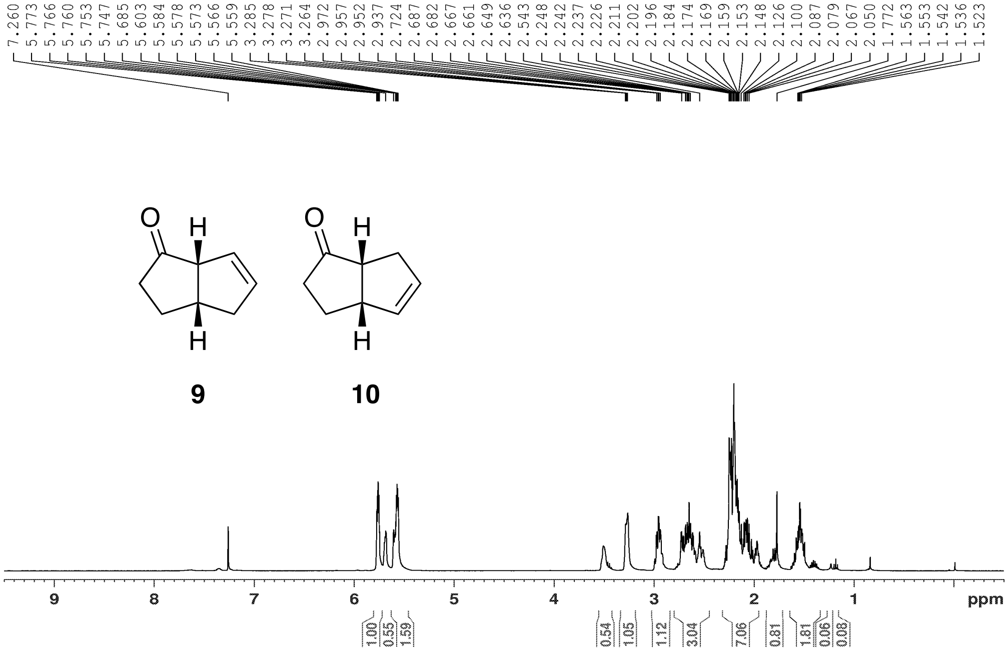
0
ppm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5.559
3.285
3.278
3.271
3.264
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2.957
2.952
2.937
2.724
2.687
2.682
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2.661
2.649
2.636
2.543
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2.242
2.237
2.226
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2.202
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2.148
2.126
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2.067
2.050
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1.563
1.553
1.542
1.536
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O
H
H
O
H
H
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10
9
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6
5
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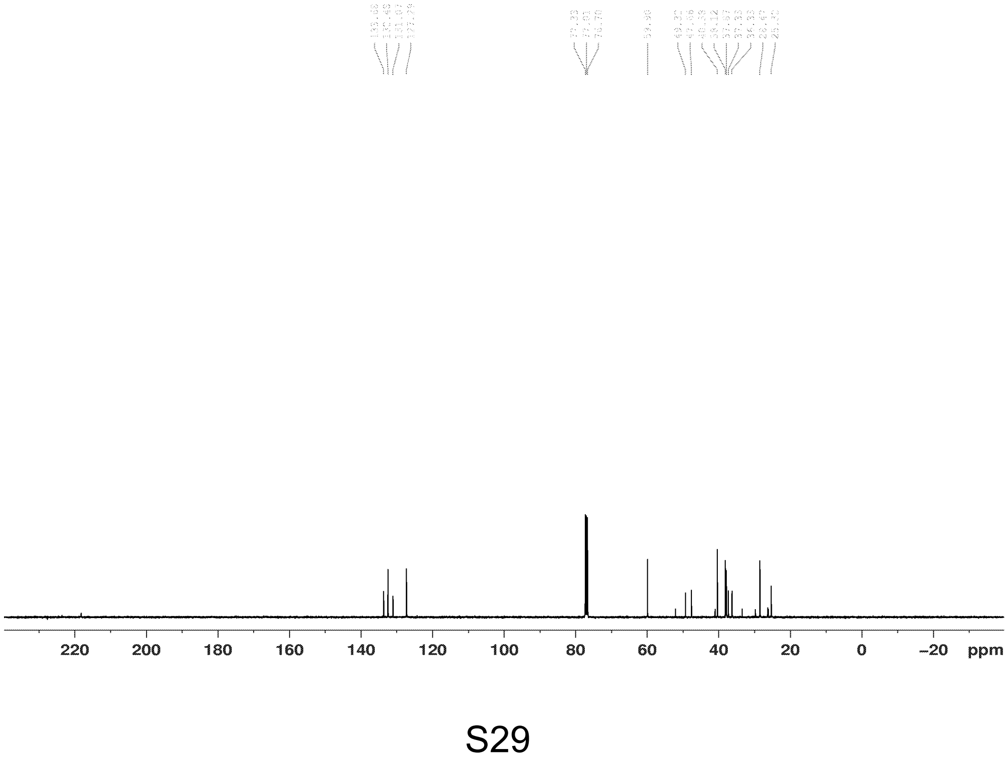
0.08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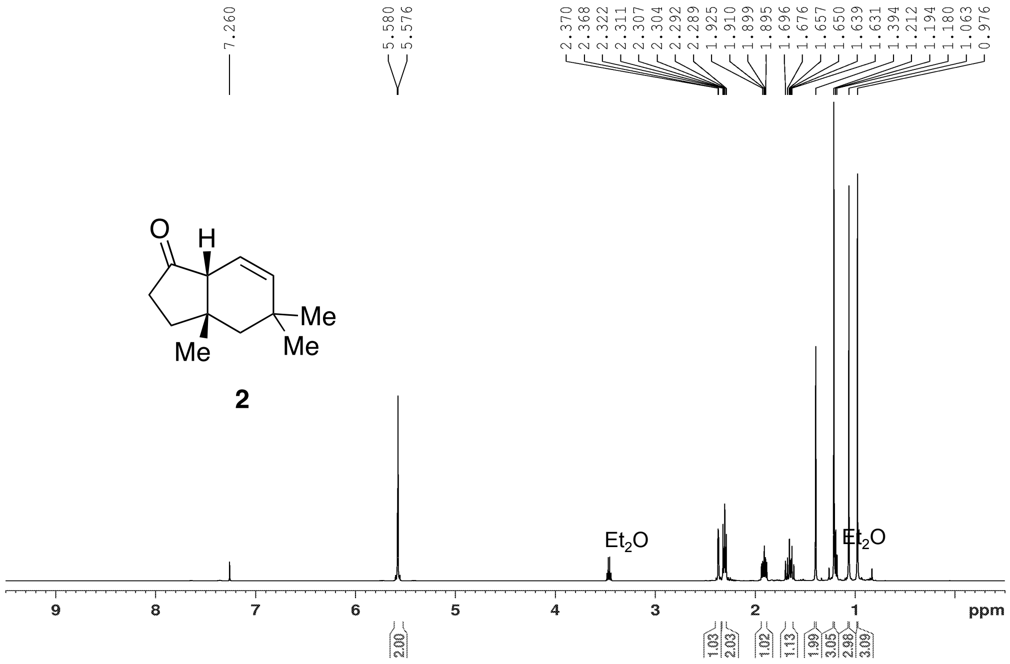
–20
ppm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1.910
1.899
1.895
1.696
1.676
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1.639
1.631
1.394
1.212
1.194
1.180
1.063
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H
Me
Me
Me
2
Et2O
Et2O
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8
7
6
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ppm
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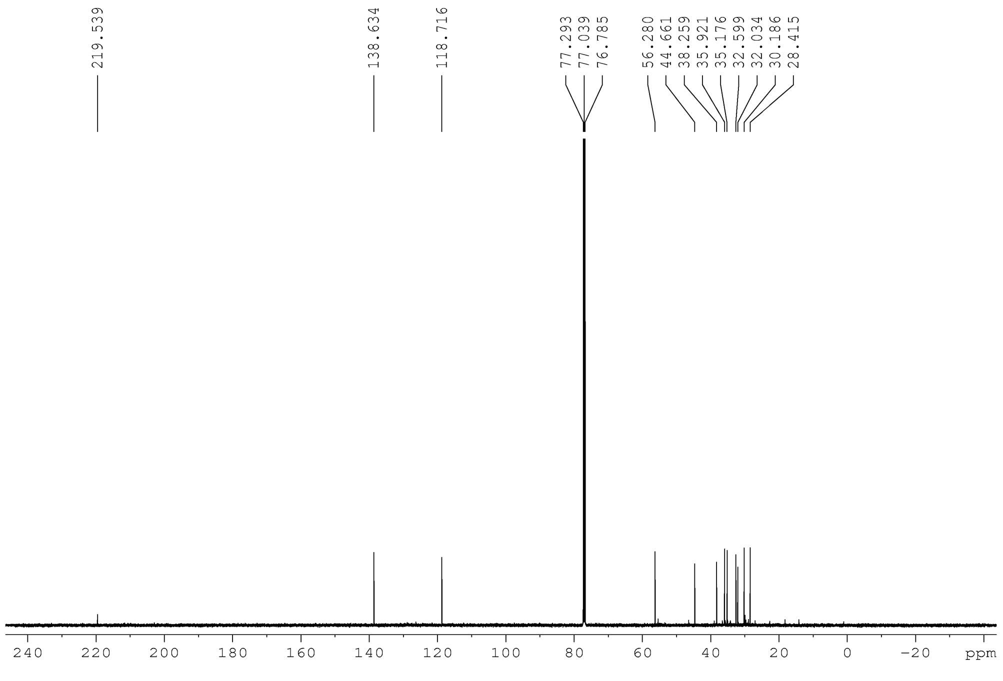
3.09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32.034
30.186
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200
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120
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40
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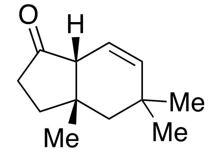
-20
ppm

2-D NOESY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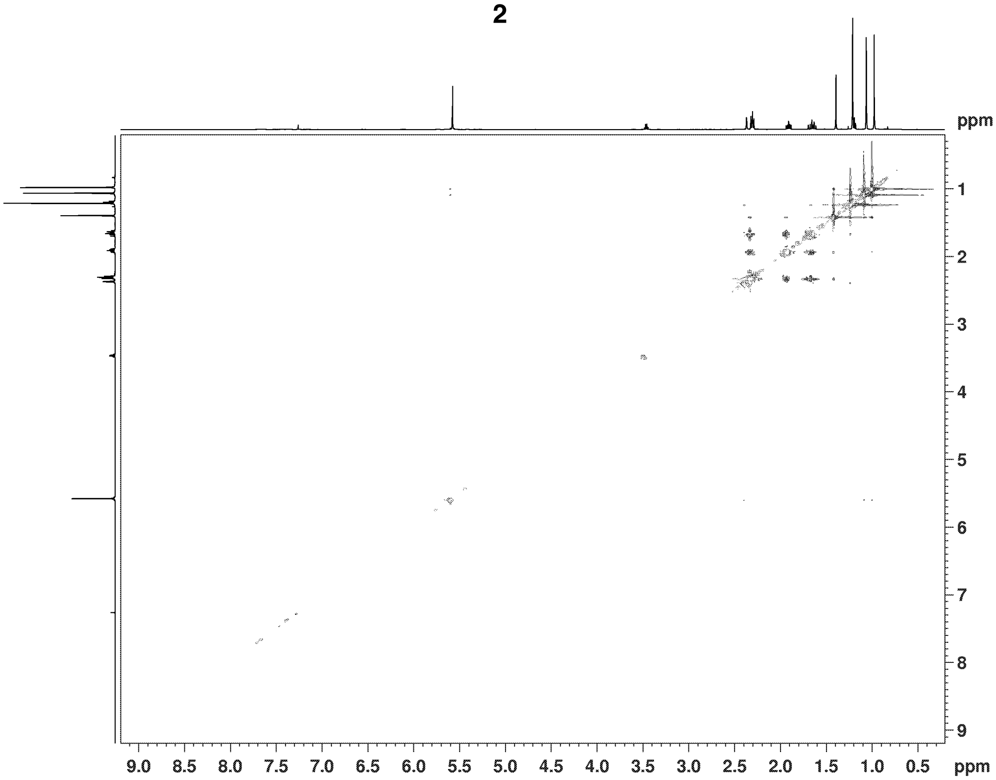
H
Me
Me
Me

2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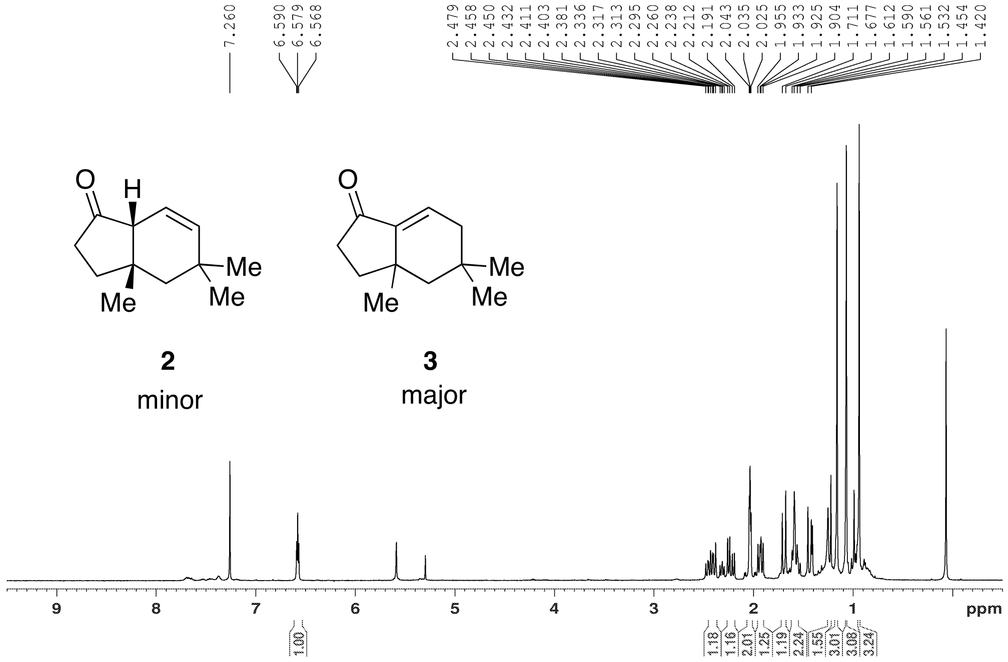
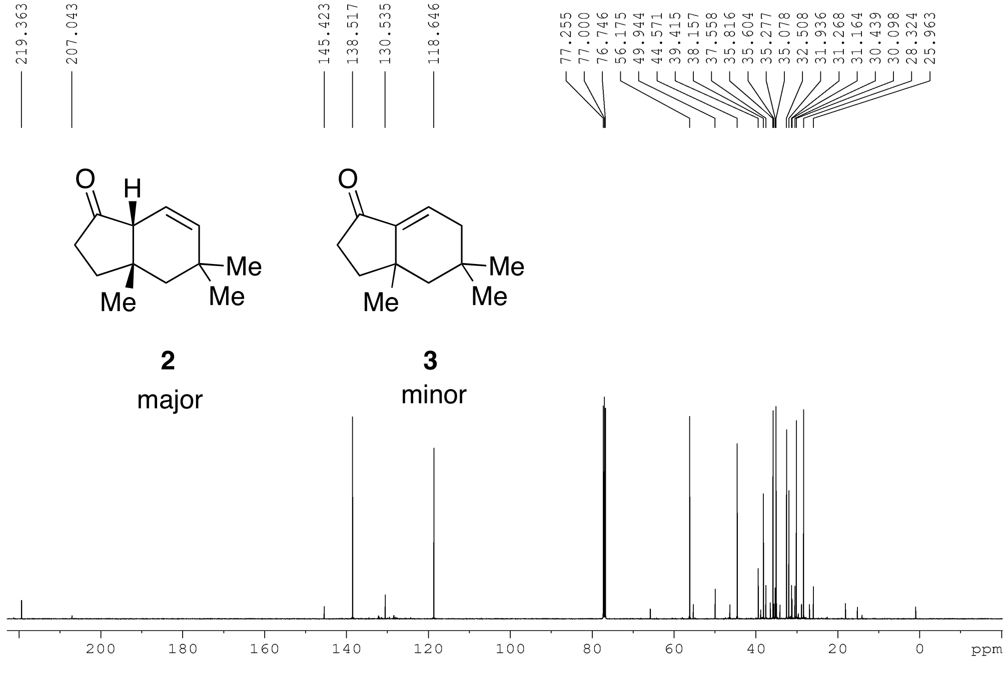
ppm



2
minor

3
major



2
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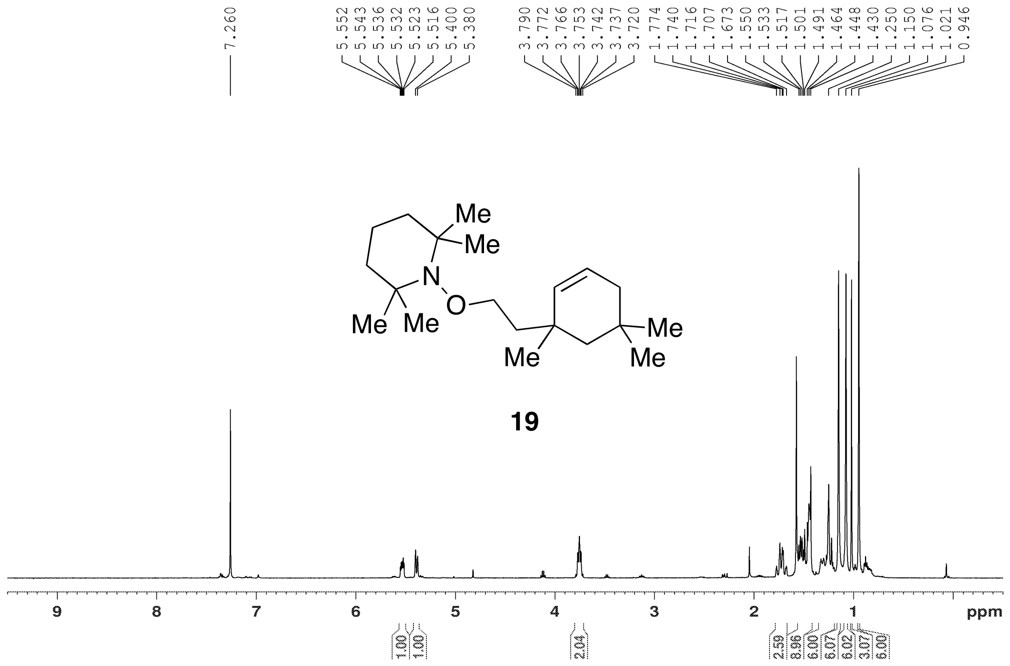
3
minor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1.533
1.517
1.501
1.491
1.464
1.448
1.430
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1.150
1.076
1.021
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N
O
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Me
Me
Me
Me
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5
4
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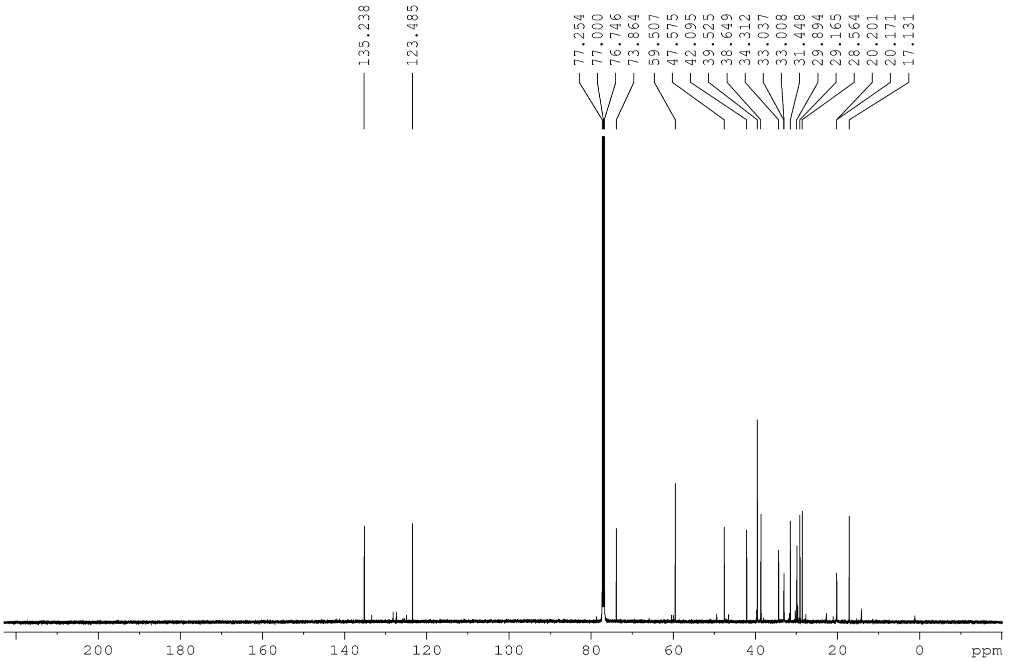
3.07
6.00

19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33.008
31.448
29.894
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20.171
17.131
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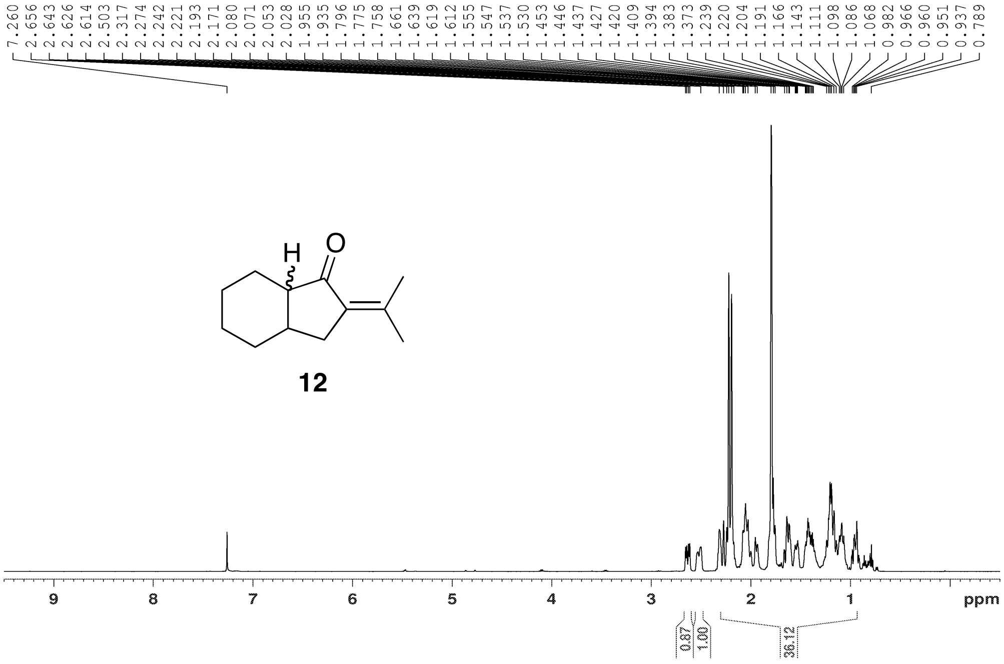
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2.071
2.053
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1.619
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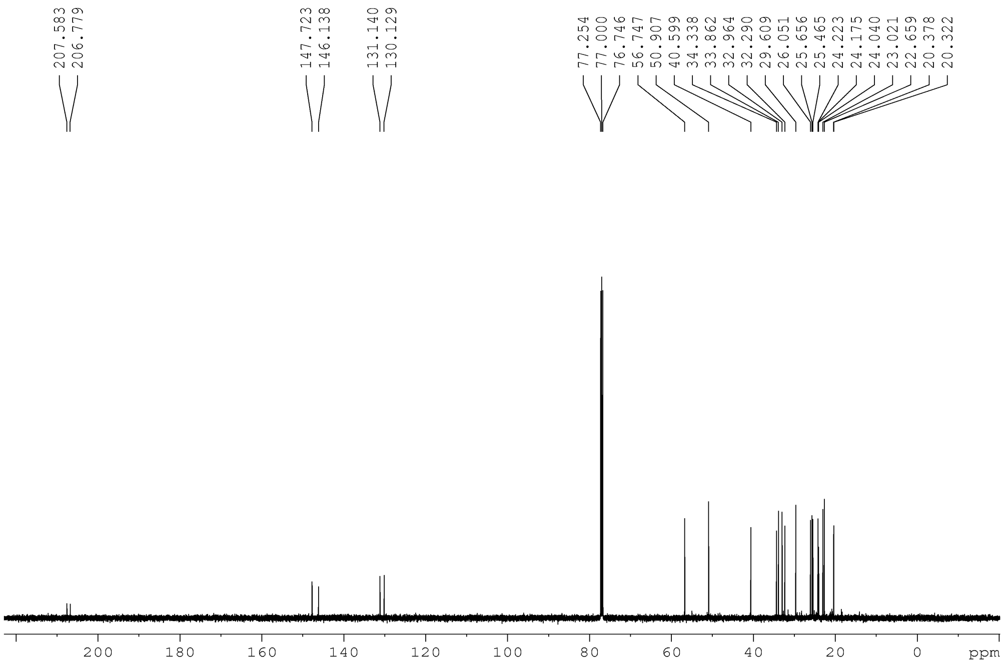
12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40.599
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33.862
32.964
32.290
29.609
26.051
25.656
25.465
24.223
24.175
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120
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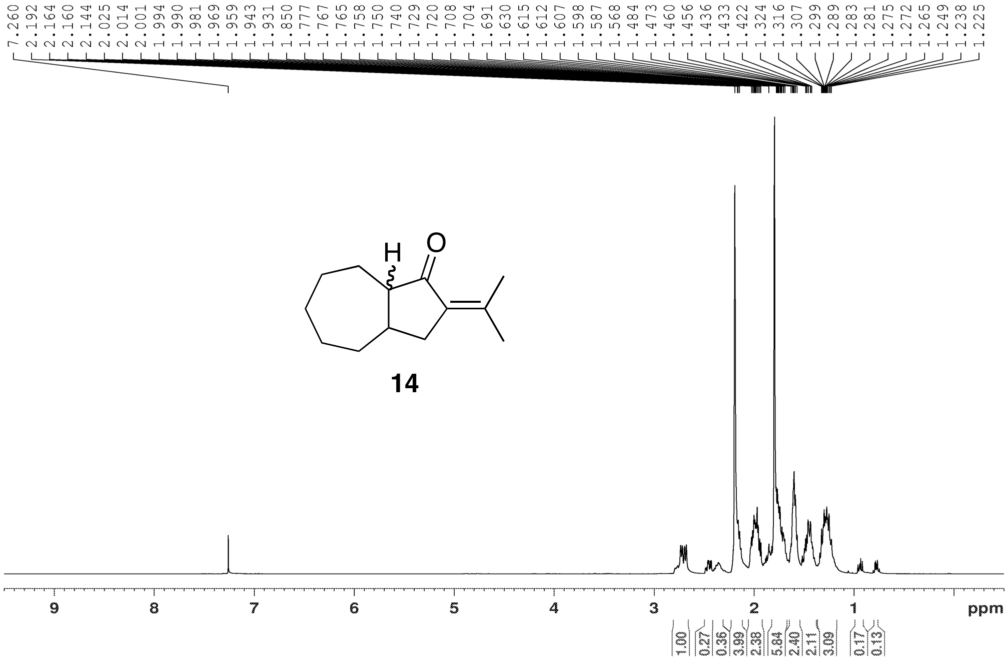
ppm



14

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1.750
1.740
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1.720
1.708
1.704
1.691
1.630
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1.612
1.607
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1.484
1.473
1.460
1.456
1.436
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H
O
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5
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3
2
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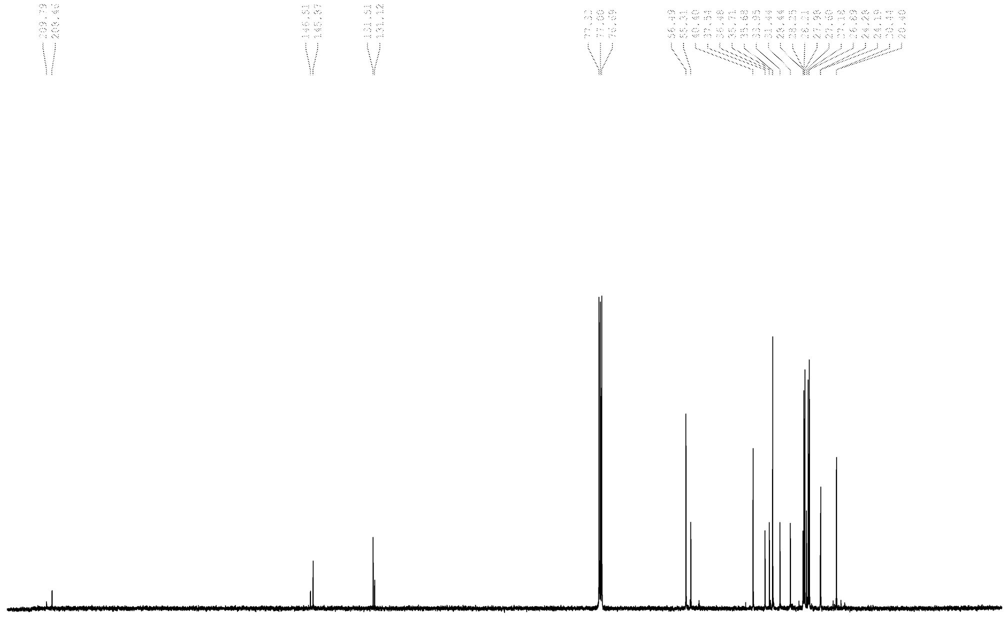

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24.28
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20.44
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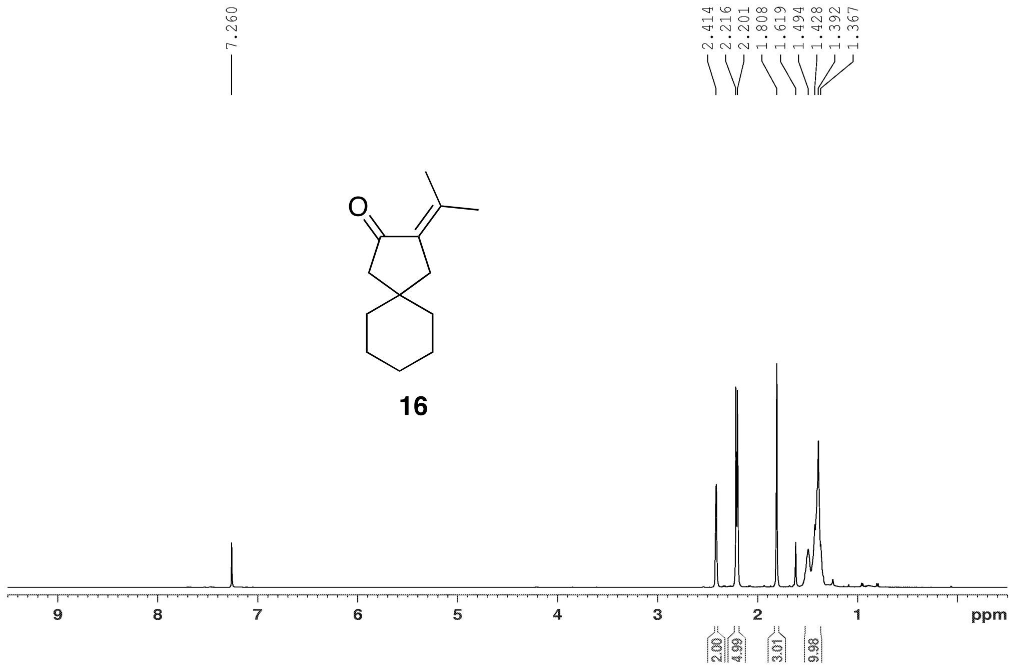
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5
4
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1
ppm
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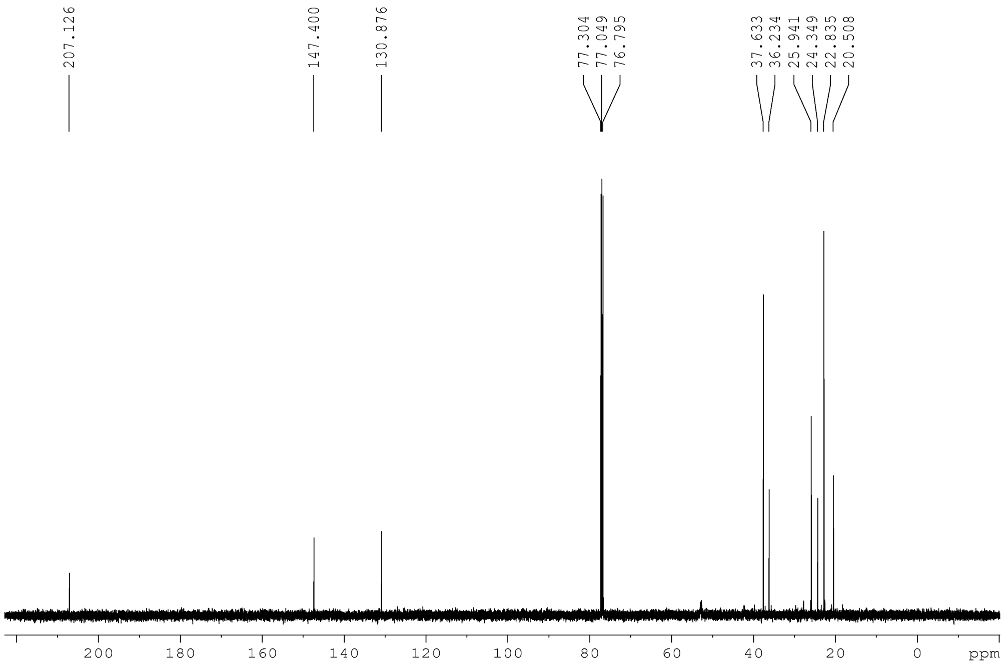
3.01
9.98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76.795
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200
180
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120
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60
40
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0
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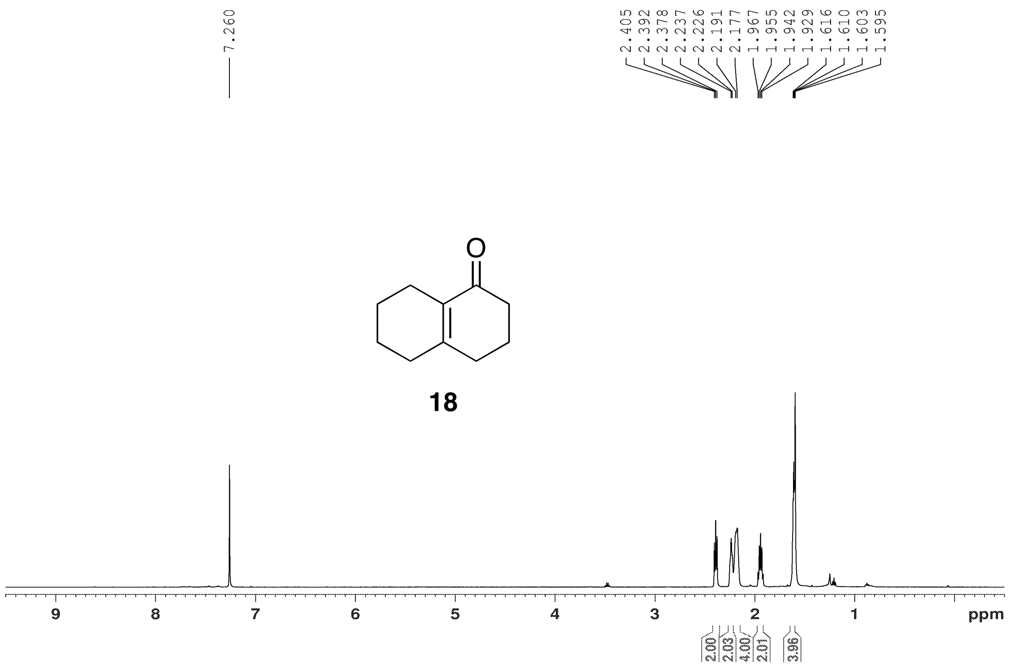
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1.610
1.603
1.595
O
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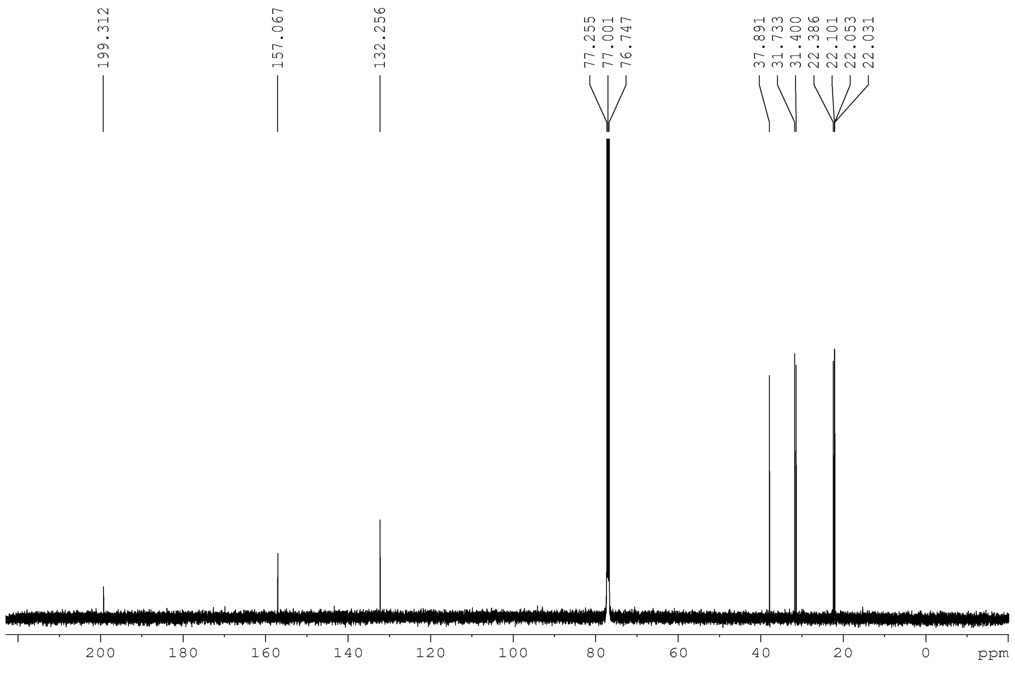
2.03
4.00
2.01
3.96

18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22.031
200
180
160
140
120
100
80
60
40
20
0
ppm