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Pd–NHC Catalyzed Conjugate Addition versus the Mizoroki–Heck Reaction

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University of Groningen

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Supporting Information

Pd–NHC Catalyzed Conjugate Addition versus the Mizoroki–Heck Reaction

Aditya L. Gottumukkala,[a] Johannes G. de Vries,*[a, b] and Adriaan J. Minnaard*[a]

chem_201003643_sm_miscellaneous_information.pdf

General Information:

Glassware and Handling:

All experiments were carried out in flame dried or oven dried (150 °C) glassware, in an atmosphere of nitrogen, unless specified otherwise, by standard Schlenk techniques. Schlenk reaction tubes with screwcaps, and equipped with a Teflon-coated magnetic stirbar were flame dried under vacuum and allowed to return to room temperature prior to being charged with reactants. A manifold permitting switching between nitrogen atmosphere and vacuum was used to control the atmosphere in the reaction vessel. Once charged with all the reactants, the reaction vessel was cycled through at least 3 cycles of nitrogen-vacuum-nitrogen to ensure the atmosphere was inert.

Reaction temperature refers to the temperature of the oil bath.

Flash Chromatography was performed using Merck silica gel type 9385 (230-400 mesh), using the indicated solvents.

Microwave experiments were performed on a CEM Discover Microwave apparatus, in crimp-sealable reaction tubes. The tubes were prepared similar to reactions in oil bath. The reactions were performed under Constant-Temperature Mode (Temperature Max 80 °C), 110 W, with air-cooling, for 30 min. Work up and analysis was similar to reactions performed in oil bath.

Solvents and Reagents

All solvents used for extraction, filtration and chromatography were of commercial grade, and used without further purification, except for pentane, which was distilled prior to use. Peptide Synthesis grade DMF used for reaction was purchased from BIOSOLVE BV (The Netherlands) and degassed by a freeze-pump-thaw procedure (repeated cycles of freezing under vacuum with liquid nitrogen and thawing to room temperature) prior to use. The degassing was performed regularly in small batches, and once degassed, the DMF was used within a few days.

Reagents were purchased from Sigma-Aldrich, Strem or Acros and used without further purification. Analytical grade tri-*n*-butylamine was purchased from Sigma-Aldrich and stored in an atmosphere of nitrogen. Palladium complex **Pd^{II}-NHC** was synthesized as described in literature[1] and stored under ambient conditions. Palladium complex **Pd^{0}-NHC** was purchased from Sigma-Aldrich and stored in a nitrogen-filled glovebox, from which the requisite amounts were weighed out.

Analysis

TLC was performed on Merck silica gel 60, 0.25 mm plates and visualization was done by UV and staining with Seebach's reagent (a mixture of phosphomolybdic acid (25 g), cerium (IV) sulfate (7.5 g), H_2O (500 mL) and H_2SO_4 (25 mL)).

^{1}H- and ^{13}C-NMR were recorded on a Varian AMX400 (400, 100.59 MHz, respectively) using $CDCl_3$ as solvent, unless specified otherwise. Chemical shift values are reported in ppm with the solvent resonance as the internal standard ($CHCl_3$: δ7.26 for 1H, δ 77.0 for 13C). Data are reported as follows: chemical shifts (δ), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, br = broad, m = multiplet), coupling constants *J* (Hz), and integration.

GC-MS measurements were made using a HP 6890 Series Gas Chromatograph system equipped with a HP 5973 Mass Sensitive Detector. GC measurements were made using a Shimadzu GC 2014 gas chromatograph system bearing a AT5 column (Grace Alltech) and FID detection. Whenever GC yield is reported, the quantification was done using cyclo-octane as internal standard.

High Resolution Mass measurements were performed using a ThermoScientific LTQ Oribitrap XL spectrometer.

Experimental Procedure for Conjugate Addition:

A Schlenk tube equipped with screwcap and egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-Iodoanisole (2.72 mmol, 637 mg), and benzalacetone (1.14 mmol, 166.4 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with the DMF layer being colored and the tri-*n*-butylamine being nearly colorless or faint yellow. The Schlenk tube was then alternated through 3 cycles of vacuum and nitrogen, and placed into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column and eluted

Experimental Procedure for the Mizoroki-Heck Reaction:

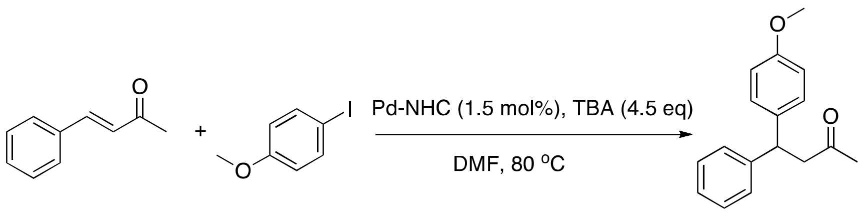
A Schlenk tube equipped with screwcap and egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-Iodoanisole (1 mmol, 234 mg), benzalacetone (1.5 mmol, 219 mg), and cesium pivalate (2 mmol, 652 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. The Schlenk tube was then alternated through 3 cycles of vacuum and nitrogen, and placed into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column and eluted.

CHARACTERIZATION DATA:

Preparation of 4-(4-methoxyphenyl)-4-phenylbutan-2-one (3a).

Equation:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg), benzalacetone (1.14 mmol, 166.4 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being nearly colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (237 mg, 82%) using pentane: ether (4:1) eluent system (R_f = 0.3), and obtained as a greenish yellow oil.

Appearance: greenish yellow oil

Yield: 82%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.38 – 7.07 (m, 7H), 6.82 (d, *J* = 8.7 Hz, 2H), 4.54 (t, *J* = 7.6 Hz, 1H), 3.76 (s, 3H), 3.15 (d, *J* = 7.6 Hz, 2H), 2.07 (s, 3H).

^{13}C NMR: 101 MHz, $CDCl_3$

δ 207.03, 158.04, 144.17, 135.91, 128.60, 127.56, 126.32, 113.91, 109.86, 55.21, 55.14, 49.85, 45.23, 30.64.

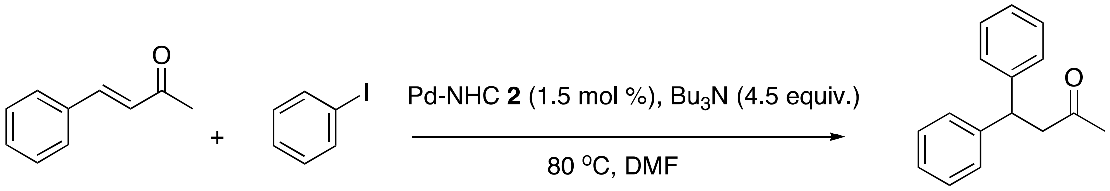
R_f: 0.3 (pentane: ether = 4:1)

APT spectrum and **EI-MS** Spectrogram are attached.

Characterization data matches with those reported in literature [2]

Preparation of 4,4-diphenylbutan-2-one (3f).

Equation:



A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. Iodobenzene (2.72 mmol, 555 mg), benzalacetone (1.14 mmol, 166 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being nearly colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (212 mg, 83%) using pentane:ether (4:1) eluent system (R_f = 0.3), and obtained as a yellow oil.

Appearance: yellow oil

Yield: 83%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.39 – 7.11 (m, 10H), 4.62 (t, J = 7.6 Hz, 1H), 3.20 (d, J = 7.6 Hz, 2H), 2.09 (s, 3H).

^{13}C NMR: 101 MHz, $CDCl_3$

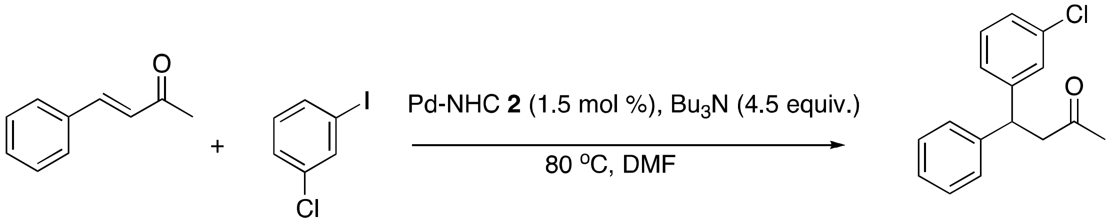
δ 30.6, 45.9, 49.6, 126.4, 127.6, 128.5, 143.8, 206.8

R$_f$: 0.3 (pentane: ether = 4:1)

Characterization data matches with that reported in literature [3]

Preparation of 4-(3-chlorophenyl)-4-phenylbutan-2-one (3g).

Equation:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 3-chloro-iodobenzene (2.72 mmol, 647 mg), benzalacetone (1.14 mmol, 166.4 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being nearly colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (153 mg, 52%) using toluene: EtOAc (98:2) eluent system (R_f = 0.5), and obtained as a yellow oil.

Appearance: yellow oil

Yield: 52%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.59 – 6.71 (m, 9H), 4.59 (t, J = 7.5 Hz, 1H), 3.18 (d, J = 7.5 Hz, 2H), 2.10 (s, 3H).

^{13}C NMR: 101 MHz, $CDCl_3$

δ 206.07, 145.93, 142.99, 134.23, 129.73, 128.62, 127.73, 127.55, 126.61, 126.54, 125.90, 49.19, 45.46, 30.50.

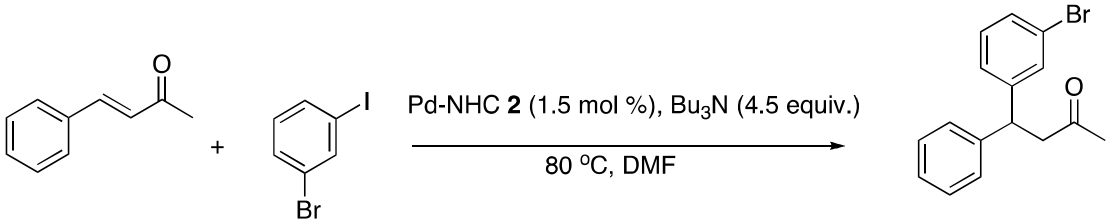
R_f: 0.5 (toluene: EtOAc = 98:2)

APT spectrum and **EI-MS** Spectrogram are attached.

Characterization data matches with that reported in literature [4]

Preparation of 4-(3-bromophenyl)-4-phenylbutan-2-one (3h).

Equation:



A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 3-bromo-iodobenzene (2.72 mmol, 767 mg), benzalacetone (1.14 mmol, 166.4 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being nearly colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (192 mg, 56%) using toluene:EtOAc (98:2) eluent system ($R_f = 0.5$), and obtained as a yellow oil.

Appearance: yellow oil

Yield: 56%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.60 – 6.90 (m, 9H), 4.58 (t, J = 7.5 Hz, 1H), 3.17 (d, J = 7.5 Hz, 2H), 2.09 (s, 3H).

^{13}C NMR: 101 MHz, $CDCl_3$

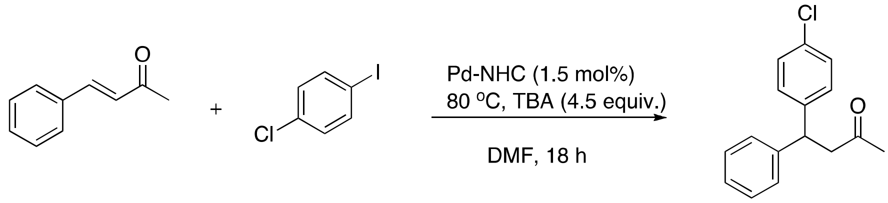
δ 205.97, 146.20, 142.92, 130.58, 130.00, 129.42, 128.58, 127.51, 126.58, 126.33, 122.51, 49.12, 45.39, 30.45.

R_f: 0.5 (toluene:EtOAc = 98:2)

APT spectrum and **EI-MS** Spectrogram are attached.

Preparation of 4-(4-chlorophenyl)-4-phenylbutan-2-one (3i).

Equation



Procedure

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodochlorobenzene (2.72 mmol, 647 mg), benzalacetone (1.14 mmol, 166.4 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being nearly colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (171 mg, 58%) using Toluene eluent system ($R_f = 0.2$), and obtained as a yellow oil.

Appearance: yellow oil

Yield: 58 %

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.42 – 7.07 (m, 3H), 4.59 (t, *J* = 7.5 Hz, 0H), 3.17 (d, *J* = 7.5 Hz, 1H), 2.09 (s, 1H).

^{13}C NMR: 101 MHz, $CDCl_3$,

δ 206.3, 143.3, 142.4, 132.0, 129.0, 128.6, 127.5, 126.6, 49.4, 45.2, 30.5.

R_f: 0.2 (toluene)

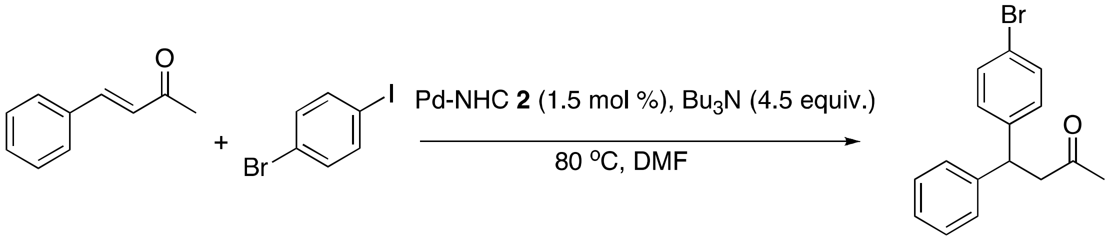
APT spectrum and **EI-MS** Spectrogram are attached.

Identification: Stains TLC spot blue upon dipping in Seebach Reagent and gentle warming

Characterization data matches with that reported in literature [5]

Preparation of 4-(4-bromophenyl)-4-phenylbutan-2-one (3j).

Equation



A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-bromo-chlorobenzene (2.72 mmol, 767 mg), benzalacetone (1.14 mmol, 166.4 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being nearly colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (217 mg, 63%) using Toluene:EtOAc eluent system (R_f = 0.5), and obtained as a yellow oil.

Appearance: yellow oil

Yield: 63 %

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.44 – 7.36 (m, 2H), 7.34 – 7.25 (m, 2H), 7.19 (dd, J = 7.2, 4.9 Hz, 3H), 7.10 (d, J = 8.5 Hz, 2H), 4.56 (t, J = 7.5 Hz, 1H), 3.16 (d, J = 7.5 Hz, 2H), 2.10 (s, 3H).

^{13}C NMR: 101 MHz, $CDCl_3$,

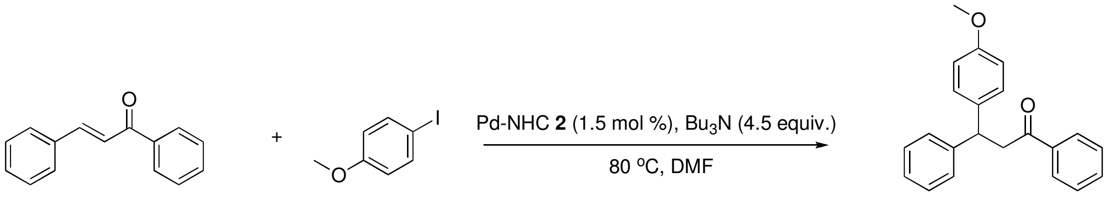
δ 206.30, 143.22, 142.90, 131.59, 129.43, 128.65, 127.56, 126.62, 120.23, 49.36, 45.29, 30.60.

R_f: 0.5 (Toluene:EtOAc = 98:2)

APT spectrum and **EI-MS** spectrogram are attached.

Preparation of 3-(4-methoxyphenyl)-1,3-diphenylpropan-1-one (4a).

Equation:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg), (*E*)-chalcone (1.14 mmol, 237 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 ^{o}C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (263 mg, 73%) using pentane:ether (4:1) eluent system, and obtained as a bright yellow oil.

Appearance: Bright Yellow oil

Yield: 73%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.99 – 7.92 (m, 2H), 7.98 – 7.89 (m, 2H), 7.59 – 7.52 (m, 1H), 7.62 – 7.50 (m, 1H), 7.48 – 7.40 (m, 2H), 7.31 – 7.25 (m, 4H), 7.50 – 7.01 (m, 11H), 7.22 – 7.17 (m, 3H), 6.87 – 6.76 (m, 2H), 6.89 – 6.79 (m, 2H), 4.80 (t, J = 7.3 Hz, 1H), 4.80 (t, J = 7.3 Hz, 1H), 3.76 (s, 3H), 3.79 – 3.69 (m, 6H), 3.73 (d, J = 7.4 Hz, 2H).

^{13}C NMR: 101 MHz, $CDCl_3$

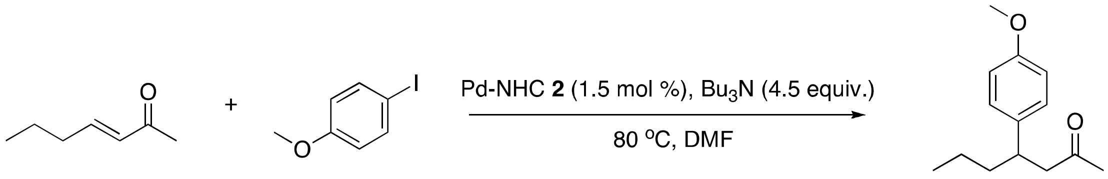
δ 198.1, 158.0, 144.5, 137.0, 136.2, 133.0, 128.7, 128.5, 128.5, 128.00, 127.7, 126.2, 113.87, 55.2, 45.1, 44.9.

R_f: 0.3 (pentane: ether = 5:1)

All other characterization matches completely with that reported earlier in literature[2]

Preparation of 4-(4-methoxyphenyl)heptan-2-one (5a).

Reaction:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg), (*E*)-hept-3-en-2-one (1.14 mmol,127.7 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (158 mg, 63%) using pentane:ether (4:1) eluent system, and obtained as a colorless oil.

Appearance: Colorless oil

Yield: 63%

^{1}H NMR: 400 MHz, $CDCl_3$

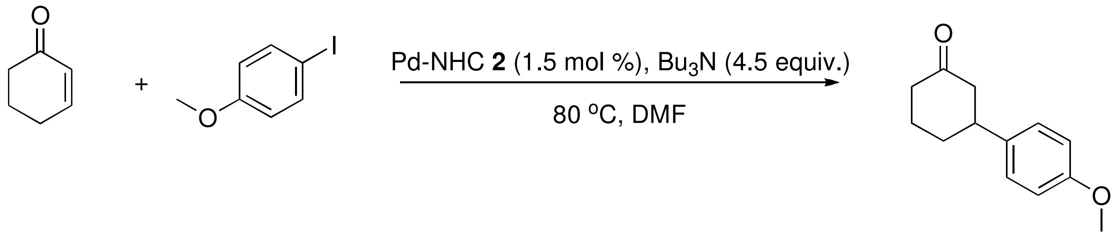
δ 7.08 (d, *J* = 8.7 Hz, 2H), 6.82 (d, *J* = 8.7 Hz, 2H), 3.76 (s, 3H), 3.07 (tt, *J* = 14.6, 7.2 Hz, 1H), 2.80 – 2.57 (m, 2H), 1.99 (s, 3H), 1.56 (s, 1H), 1.16 (d, *J* = 27.0 Hz, 1H), 1.00 – 0.88 (m, 2H), 0.83 (t, *J* = 7.3 Hz, 3H).

Rf : 0.3 (pentane: ether = 4:1)

All other characterization matches completely with that reported earlier in literature[7]

Preparation of 3-(4-methoxyphenyl)cyclohex-2-enone (6a).

Equation:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg) was charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. Cyclohexenone (1.14 mmol, 109.6 mg) was added via syringe. **Pd-NHC 2** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (130 mg, 56%) using pentane:ether (4:1) eluent system (R_f = 0.3), and obtained as a yellow oil.

Appearance: yellow oil

Yield: 56%

^{1}H NMR: 400 MHz, $CDCl_3$

1.73-1.83 (m, 2H), 2.05-2.14 (m, 2H), 2.3-2.6 (m, 4H), 2.93-3.00 (m, 1H), 6.87 (dd, *J*= 8.8 Hz, 2H), 7.14 (dd, *J*= 8.8 Hz, 2H).

^{13}C NMR: 101 MHz, $CDCl_3$

δ 199.8, 161.1, 159.0, 130.6, 127.5, 123.4, 123.40, 114.0, 55.2, 37.0, 27.7, 22.6.

R_f: 0.3 (pentane: ether = 4:1)

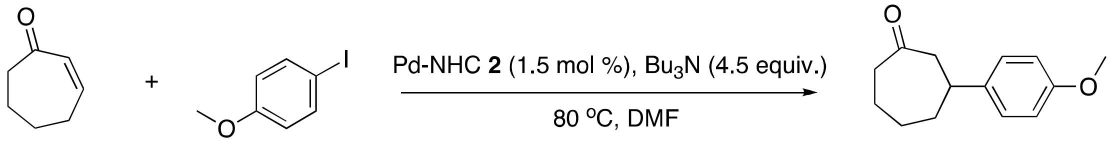
HRMS: Calculated for $[M+H]^+$ = 205.1223

Obtained $[M+H]^+ = 205.1228$

Characterization data matches with that reported in literature.[7]

Preparation of 4-(4-methoxyphenyl)heptan-2-one (7a).

Reaction:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg) was charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. Cycloheptenone (80% tech mix.) (1.42 mmol, 157 mg) was added via syringe. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (172 mg, 69%) using pentane:ether (4:1) eluent system, and obtained as a off white solid.

Appearance: Off-white micro-needles

Melting Point: 45.9 °C - 46.2 °C

Yield: 69%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.10 (d, J = 7.5 Hz, 2H), 6.84 (d, J = 7.5 Hz, 2H), 3.78 (s, 2H), 2.88 (p, J = 12.1 Hz, 1H), 2.69 – 2.45 (m, 1H), 2.02 (dd, J = 22.0, 15.3 Hz, 2H), 1.74 (dd, J = 24.7, 12.6 Hz, 1H), 1.48 (dd, J = 24.0, 11.7 Hz, 1H).

APT: 75 MHz, $CDCl_3$

δ 213.4, 158.0, 139.1, 127.2, 113.9, 55.2, 51.5, 43.9, 41.9, 39.3, 29.1, 24.1.

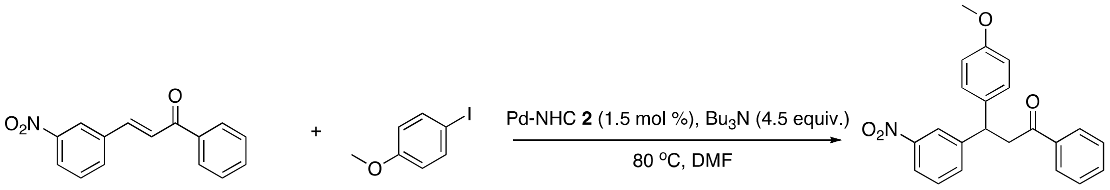
HRMS : Calculated Mass [M-OH] = 201.1274

Obtained Mass [M-OH] = 201.1273

R_f: 0.3 (pentane: ether = 4:1)

Preparation of 3-(4-methoxyphenyl)-3-(3-nitrophenyl)-1-phenylpropan-1-one (8a).

Reaction:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg), (*E*)-3-(3-nitrophenyl)-1-phenylprop-2-en-1-one (1.14 mmol, 288 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (379 mg, 92%) using pentane:ether (3:2) eluent system as a yellow oil.

Appearance: Yellow oil

Yield: 92%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 8.14 (s, 1H), 8.03 (m, 1H), 7.98 – 7.91 (m, 2H), 7.63 – 7.55 (m, 2H), 7.41-7.45 (m, 3H), 7.19 (d, J = 8.8 Hz, 2H), 6.84 (d, J = 8.7 Hz, 2H), 4.88 (t, J = 7.3 Hz, 1H), 3.78 (d, J = 1.3, 1H) 3.77 (br s, 3H).

^{13}C NMR: (101 MHz, CDCL3)

δ 197.2, 158.4,148.3, 146.7, 136.6, 134.8, 134.3, 133.4,133.3 129.40, 128.0, 122.4, 121.4, 114.2, 55.2, 55.2, 44.4.

R_f: 0.5 (Pentane:Ether = 3:2)

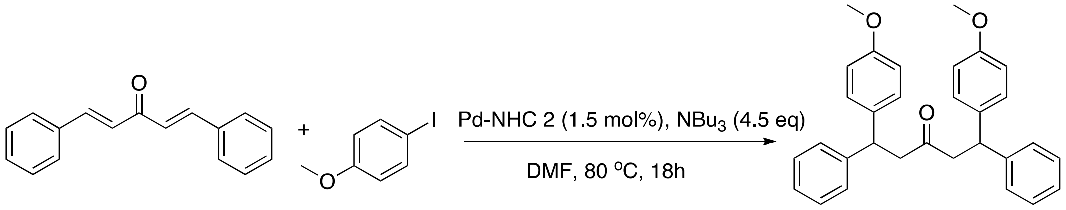
HRMS: Calculated mass $[M-H]^+$ = 360.1230
Obtained Mass $[M-H]^+$ = 360.1239

Identification: Invisible to naked eye on TLC. Stains yellow to Seebach Stain upon gentle heating, and turns blue-black on further heating.

Characterization data matches with that reported in literature [8]

Preparation of 1,5-bis(4-methoxyphenyl)-1,5-diphenylpentan-3-one (9a).

Reaction:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (5.44 mmol, 1.28 g), *trans, trans*-dibenzylideneacetoen(2.28 mmol, 534 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.034 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (10.2 mmol, 2.4 mL) was added via syringe, and the septum was replaced by a screw cap. The reaction mixture is biphasic with DMF layer being colored and the tri-*n*-butylamine being colorless or faint yellow. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, (sampled from the DMF layer) the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (380 mg, 74%) using pentane:ether (4:1) eluent system as a yellow oil.

Appearance: yellow oil.

Yield: 74%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.32 – 7.24 (m, 4H), 7.21-7.14 (m, 6H), 7.07 (d, J = 6.3 Hz, 4H), 6.81 (d, J = 6.1 Hz, 4H), 4.54 (t, J = 7.4 Hz, 2H), 3.78 (s, 6H), 3.11 (d, J = 7.6 Hz, 4H).

^{13}C NMR: 101 MHz, $CDCl_3$

δ 206.8, 157.9, 144.1, 135.8, 128.6, 127.5, 126.2, 113.8, 55.1, 49.7, 44.8.

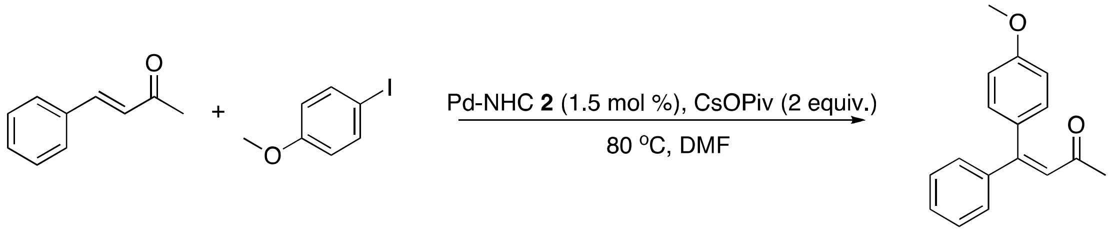
R_f: 0.2 (pentane:ether = 4:1)

HRMS: Calculated mass $[M+Na]^+$ = 473.2087
Obtained Mass $[M+Na]^+$ = 473.2054

Identification: Stains Red-brown to Seebach stain upon gentle heating.

Preparation of 4-(4-methoxyphenyl)-4-phenylbut-3-en-2-one (3b).

Reaction:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (1 mmol, 234 mg), benzalacetone (1.5 mmol, 219 mg), cesium pivalate (2 mmol, 652 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.015 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. The septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (209 mg, 83%) using pentane:ether (4:1) eluent system (R_f = 0.3), and obtained as a yellow oil.

Appearance: Yellow Oil.

Yield: 83%

^{1}H NMR: 400 MHz, $CDCl_3$. Obtained as an inseparable mixture of E & Z isomers. See NMR spectrum for details.

δ 7.14-7.42 (m, 7H), 6.89 (dd, J = 7.1, 33 Hz, 2H), 6.53 (d, J = 21.3 Hz, 1H), 3.84 (d, J = 16.6 Hz, 3H), 1.88 (d, J = 29.4 Hz, 3H).

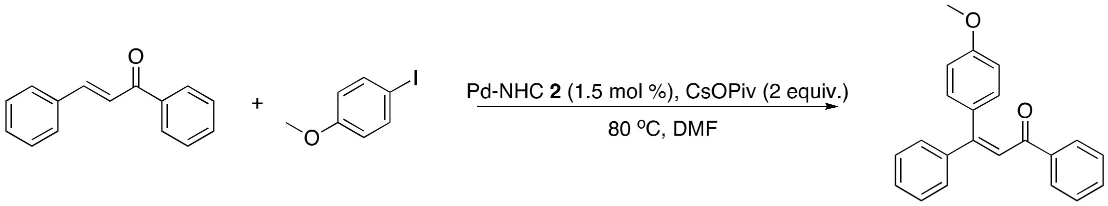
R_f: 0.3 (pentane:ether = 4:1)

Identification: Stains greenish yellow to Seebach stain upon gentle heating.

All other characterization matches completely with that reported earlier in literature[9]

Preparation of 3-(4-methoxyphenyl)-1,3-diphenylprop-2-en-1-one (4b).

Reaction:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (1 mmol, 234 mg), (*E*)-chalcone (1.5 mmol, 312 mg), cesium pivalate (2 mmol, 652 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.015 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. The septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 ^{o}C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (251 mg, 80%) using pentane:ether (9:1) eluent system (R_f = 0.2), and obtained as a fluorescent yellow oil.

Appearance: Fluorescent yellow oil.

Yield: 80%

^{1}H NMR: 400 MHz, $CDCl_3$. Obtained as an inseparable mixture of E & Z isomers. See NMR spectrum for details.

δ 7.92 (d, J = 7.1 Hz, 1H), 7.40-6.79 (m, 13H) 3.82 (d, J = 25.2 Hz, 3H).

APT spectrum attached.

HRMS: Calculated Mass $[M+H]^+$ = 315.1379

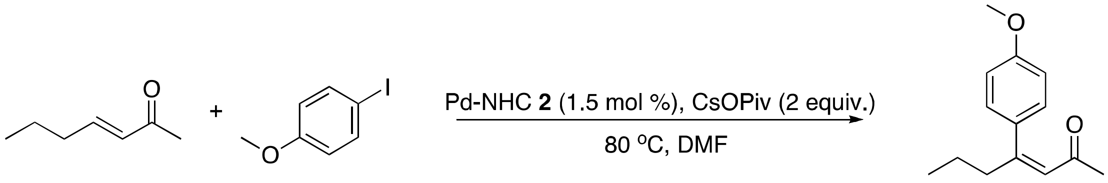
Obtained Mass $[M+H]^+$ = 315.1381

R_f: 0.2 (pentane:ether = 9:1)

Identification: Appears as bright yellow spot on TLC. Stains greenish yellow to Seebach stain upon gentle heating.

This compound has been previously described in literature[10]

Preparation of 4-(4-methoxyphenyl)hept-3-en-2-one (5b).



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (1 mmol, 234 mg), cesium pivalate (2 mmol, 652 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. (*E*)-heptenone (1.2 mmol, 134 mg) was added via syringe. **Pd^0-NHC** (1.5 mol%, 0.015 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. The septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (183 mg, 84%) using pentane: ether (4:1) eluent system (R_f = 0.4), and obtained as a pale brown oil.

Appearance: Pale brown oil.

Yield: 84%

^{1}H NMR: 200 MHz, $CDCl_3$ (Obtained as a mixture of *E,Z* isomers.)

δ 7.43 (d, J = 7.5 Hz, 2H), 6.90 (d, J = 7.5 Hz, 2H), 6.40 (s, 1H), 3.82 (s, 3H), 3.0 (t, J= 7.6,7.9 Hz, 2H), 2.26 (s, 3H), 1.50 -1.35 (m, 1H), 0.93 (t, J = 7.3 Hz, 3H).

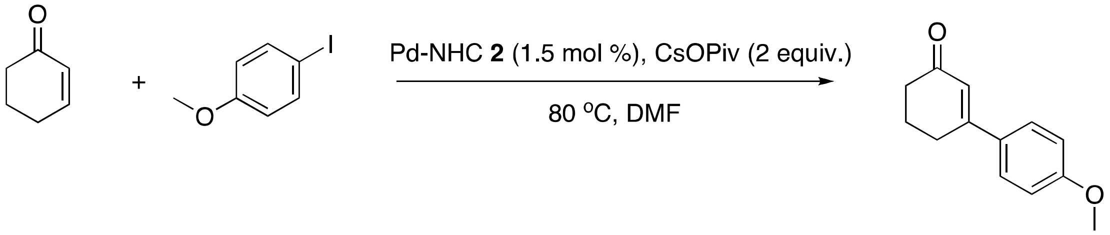
^{13}C NMR: 101 MHz, $CDCl_3$

δ 198.28, 160.38, 158.47, 133.54, 128.12, 123.1, 113.86, 55.3, 32.6, 32.3, 22.5, 14.1.

R_f: 0.4 (pentane: ether = 4:1)

Preparation of 3-(4-methoxyphenyl)cyclohex-2-enone (6b).

Reaction:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (1 mmol, 234 mg), cesium pivalate (2 mmol, 652 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. Cyclohexenone (1.5 mmol, 144.3 mg) was added via syringe. **Pd^0-NHC** (1.5 mol%, 0.015 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. The septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (130 mg, 64%) using pentane:ether (3:2) eluent system (R_f = 0.3), and obtained as a yellow oil.

Appearance: Yellow Oil.

Yield: 64%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.48 (d, J = 7.1 Hz, 2H), 6.89 (d, J = 7.1 Hz, 2H), 6.36 (s, 1H), 3.81 (s, 3H), 2.71 (t, J = 6.0 Hz, 2H), 2.43 (dd, J = 9.7, 3.5 Hz, 2H), 2.10 (dd, J = 12.0, 5.8 Hz, 2H).

^{13}C NMR: 101 MHz, $CDCl_3$

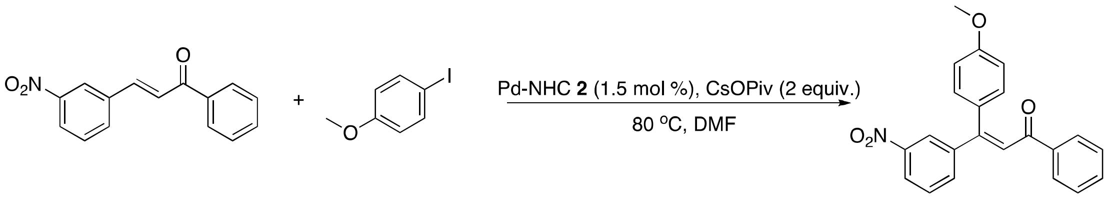
δ 199.8, 161.1, 159.0, 130.6, 127.5, 123.4, 114.0, 55.2, 55.2, 37.0, 27.7, 22.6

R_f: 0.3 (pentane:ether = 3:2)

All other characterization matches completely with that reported earlier in literature[11]

Preparation of 3-(4-methoxyphenyl)-3-(3-nitrophenyl)-1-phenylprop-2-en-1-one (8b).

Reaction:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (1 mmol, 234 mg), (*E*)-3-nitrochalcone (1.5 mmol, 379.5 mg), cesium pivalate (2 mmol, 652 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.015 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. The septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (256 mg, 71%) using pentane:ether (7:3) eluent system (R_f = 0.3), and obtained as a bright yellow oil.

Appearance: Bright Yellow Oil

Yield: 71%

^{1}H NMR: 400 MHz, $CDCl_3$. Obtained as an inseparable mixture of E & Z isomers. See NMR spectrum for details.

δ 8.28 – 8.22 (m, 0H), 8.22 – 8.17 (m, 0H), 8.07 (s), 7.95 – 7.87 (m), 7.72 (d, J = 8.7), 7.57 – 7.26 (m), 7.09 (d, J = 8.7 Hz), 7.03 (s), 6.92 (d, J = 8.9 Hz), 6.80 (d, J = 8.7 Hz), 3.85 (s), 3.77 (s)

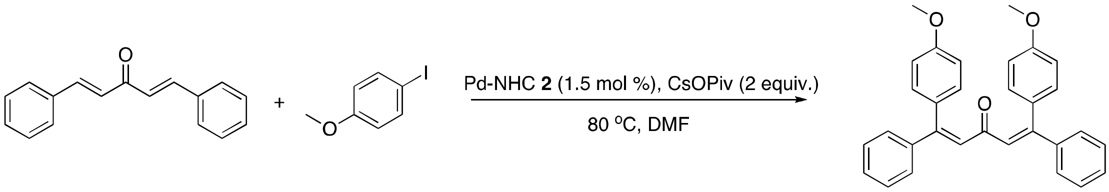
APT Spectrum attached

R_f: 0.3 (pentane:ether = 7:3)

Identification: Appears as a bright yellow spot on TLC.

Preparation of 1,5-bis(4-methoxyphenyl)-1,5-diphenylpenta-1,4-dien-3-one (9b).

Equation



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2 mmol, 468 mg), *E, E* –dibenzylideneacetone (1 mmol, 234 mg), cesium pivalate (2 mmol, 652 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.015 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. The septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (411 mg, 92%) using toluene:EtOAc (98:2) eluent system (R_f = 0.5), and obtained as a red-brown oil.

Appearance: Red-Brown oil

Yield: 92%

^{1}H NMR: 400 MHz, $CDCl_3$. Obtained as an inseparable mixture of isomers. See NMR spectrum for details.

δ 7.49 – 7.04 (m, 10H), 6.99 – 6.63 (m, 8H), 6.25 – 6.03 (m, 2H), 3.91 – 3.74 (m, 6H).

^{13}C NMR: (101 MHz, $CDCl_3$) (Mixture of isomers. See attached spectra for details)

δ 195.65, 160.28, 160.24, 160.13, 150.84, 150.74, 150.72, 141.44, 139.89, 133.60, 133.53, 131.86, 131.59, 129.99, 129.97, 129.72, 129.71, 128.70, 128.46, 128.44, 128.35, 128.21, 128.19, 127.82, 127.28, 127.01, 113.67, 113.64, 113.29, 55.32, 55.20, 55.18.

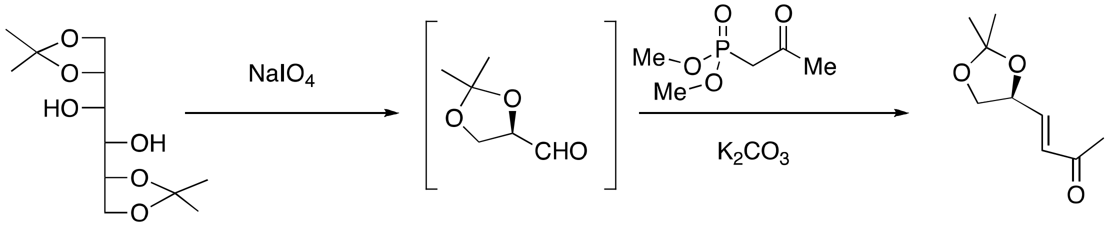
HRMS: Calculated mass $[M+H]^+$ = 447.1955

Obtained Mass $[M+H]^+$ = 447.1921

R_f: 0. 5 (toluene:EtOAc = 98:2)

Identification: stains red-purple when dipped into Seebach Solution.

Synthesis of 10

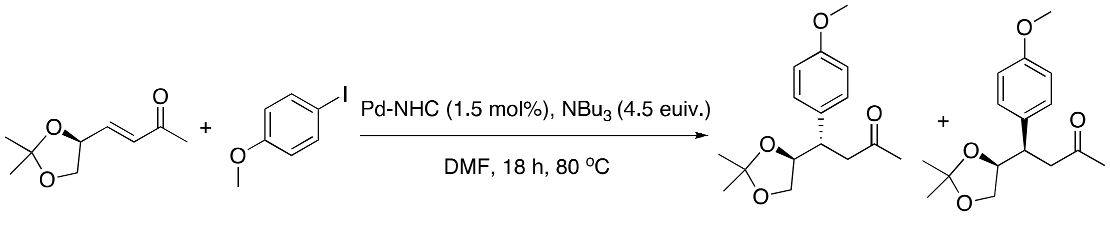


92%

10 was synthesized in a two step procedure, as described in literature[12], in 92% overall yield.

Preparation of 4-(2,2-dimethyl-1,3-dioxolan-4-yl)-4-(4-methoxyphenyl)butan-2-one, (10a, 10b).

Reaction:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg), (*S*,*E*)-4-(2,2-dimethyl-1,3-dioxolan-4-yl)but-3-en-2-one (1.14 mmol, 194 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated using pentane:ether:Et_3N (70:29:1) eluent system (R_f=0.5 for *anti* product, R_f=0.4 for *syn* product) in an overall yield of 85% (270 mg). The *Anti : Syn* ratio was determined by isolation of the *anti* and *syn* diastereomers.

Yield: 85%

Anti : Syn = 4.8:1

***ANTI* ^{1}H NMR:** 400 MHz, $CDCl_3$

δ 7.11 (d, J = 8.7 Hz, 2H), 6.81 (d, J = 8.7 Hz, 2H), 4.14 (dt, J = 9.3, 6.3 Hz, 1H), 3.75 (s, 3H), 3.70 (dd, J = 8.5, 6.1 Hz, 1H), 3.53 (dd, J = 8.5, 6.6 Hz, 1H), 3.19 (td, J = 9.4, 4.5 Hz, 1H), 3.05 (dd, J = 16.4, 4.5 Hz, 1H), 2.76 (dd, J = 16.4, 9.5 Hz, 1H), 2.02 (s, 3H), 1.41 (s, 3H), 1.33 (s, 3H).

^{13}C NMR: 101 MHz, $CDCl_3$

δ 207.32, 158.49, 132.59, 128.83, 114.02, 109.50, 79.30, 68.26, 55.09, 47.27, 44.81, 30.57, 26.72, 25.57.

HRMS: Calculated mass $[M+Na]^+$ = 301.1410
Obtained Mass $[M+Na]^+$ = 301.1403

***SYN* ^{1}H NMR:** 400 MHz, $CDCl_3$

δ 7.15 (d, J = 8.7 Hz, 2H), 6.82 (d, J = 8.8 Hz, 2H), 4.31-4.26 (m,1H), 3.89 (dd, J = 8.1, 6.3 Hz, 1H), 3.78 (s, 3H), 3.50 (t, J = 7.9 Hz, 1H), 3.43 – 3.34 (m, 1H), 2.88 (dd, J = 7.0, 3.7 Hz, 2H), 2.07 (s, 3H), 1.31 (s, 3H), 1.28 (s, 3H).

R_f: 0.5 (*anti*), 0.4 (*syn*) (pentane:ether:Et_3N =70:29:1)

APT, **NOESY** and **EI-MS** Spectra are attached.

Identfication: The product stains yellow-green upon dipping in Seebach reagent and gentle heating.

Preparation of 1-methoxy-4-(2-nitro-1-phenylethyl)benzene (11a).

Reaction:

Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg), β-nitrostyrene (1.14 mmol, 170.05 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (83 mg, 28%) using pentane:ether (4:1) eluent system (R_f = 0.5), and obtained as a pale brown oil.

Appearance: pale brown oil.

Yield: 28%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.39 – 7.20 (m, 5H), 7.17 (d, J = 8.4, 2H), 6.86 (dd, J = 8.1 Hz,2H), 4.99 – 4.93 (m, 2H), 4.9-4.85 (m, 1H), 3.78 (s, 3H).

^{13}C NMR: 101 MHz, $CDCl_3$

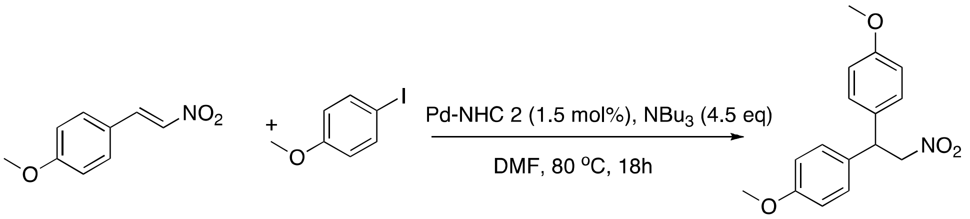
δ 158.9, 139.5, 131.1, 129.0, 128.7, 127.5, 114.3, 79.4, 55.3, 55.2, 48.2

R_f: 0.5 (pentane:ether = 4:1)

All other characterization matches completely with that reported earlier in literature[13]

Preparation of 4,4'-(2-nitroethane-1,1-diyl)bis(methoxybenzene) (12a)

Reaction:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg), 4-methoxy-β-nitrostyrene (1.14 mmol, 204.3 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (175 mg, 54%) using pentane: ether (4:1) eluent system (R_f=0.3).

Appearance: Brownish-purple oil.

Yield: 54%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.14 (d, J= 8.8 Hz, 4H), 6.86 (d, J = 8.7, 4H), 4.91 (d, J =8.4 Hz, 2H), 4.81 (t, J =7.8, 8.5 Hz, 1H), 3.78 (s, 6H).

^{13}C NMR: 101 MHz, $CDCl_3$

δ 158.8, 131.5, 128.6, 114.3, 79.6, 55.2, 47.5.

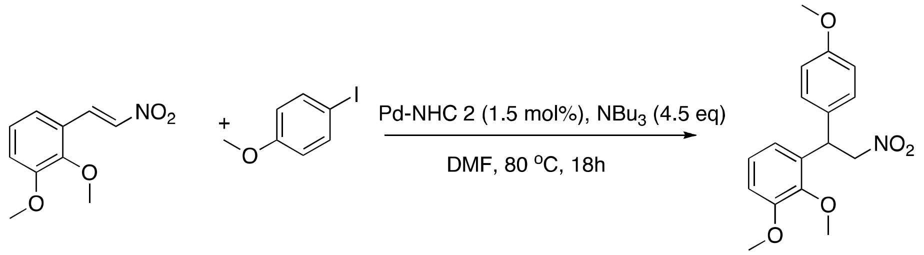
R_f: 0.3 (pentane: ether = 5:1)

The compound has been previously described in literature[14]

Identification: Stains TLC purple upon dipping in Seebach stain followed by gentle warming.

Preparation of 1,2-dimethoxy-3-(1-(4-methoxyphenyl)-2-nitroethyl) benzene (13a).

Reaction:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg), 2,3-dimethoxy-β-nitrostyrene (1.14 mmol, 239 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (232 mg, 64%) using pentane:ether (4:1) eluent.

Yield: 64%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.19 (d, J = 8.7 Hz, 2H), 7.02 (t, J = 8.0 Hz, 1H), 6.88 – 6.80 (m, 1H), 6.78 (d, J = 8.2 Hz, 1H), 5.23 (t, J = 8.2 Hz, 1H), 5.03 – 4.88 (m, 2H), 3.84 (s, 3H), 3.76 (s, 3H), 3.71 (s, 3H).

^{13}C NMR: 101 MHz, $CDCl_3$

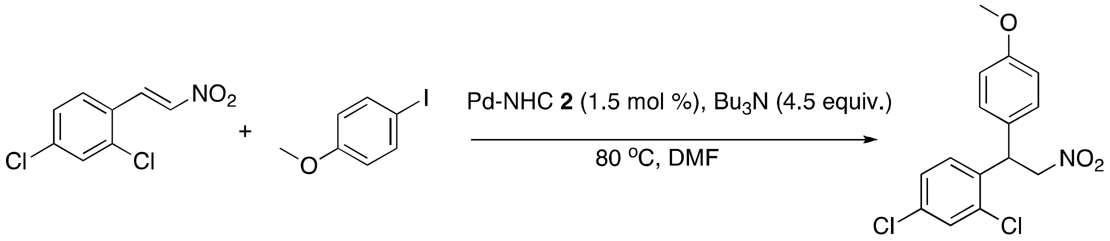
δ 158.7, 153.0, 146.7, 133.2, 131.2, 128.8, 124.1, 119.3, 114.1, 111.7, 78.6, 60.6, 55.7, 55.3, 42.4

HRMS: Calculated Mass [M+Na] = 340.1155

Obtained mass [M+Na] = 340.1162

Preparation of 2,4-dichloro-1-(1-(4-methoxyphenyl)-2-nitroethyl)benzene (14a)

Equation:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg), 2,4-dichloro-1-(2-nitrovinyl)benzene (1.14 mmol, 248.5 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (77 mg, 21%) using pentane: ether (5:1) eluent system (R_f=0.3)

Appearance: Yellow oil.

Yield: 21%

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.44-7.42 (m,1H), 7.26 – 7.23 (m, 2H), 7.20 – 7.10 (m, 3H), 6.88 (dd, J = 2.2, 7.4 Hz, 2H), 5.33 (t, J = 8.1 Hz,1H), 4.91 (m, 2H), 3.78 (s, 3H).

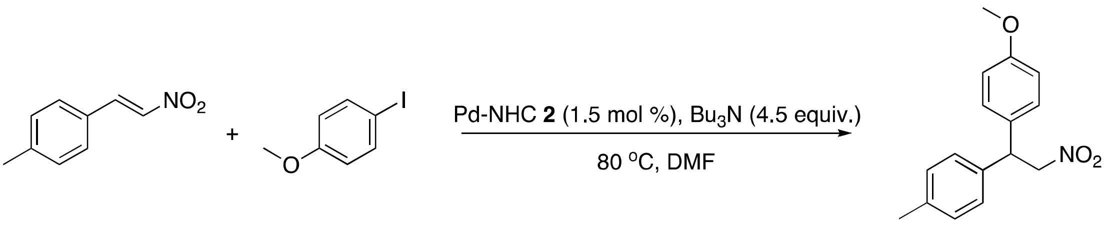
^{13}C NMR: 101 MHz, $CDCl_3$

δ 226.32, 159.13, 135.51, 134.78, 133.97, 130.20, 129.01, 128.94, 128.81, 127.52, 114.48, 77.70, 55.3, 44.1.

APT spectrum and **EI-MS** Spectrogram attached.

Preparation of 1-methoxy-4-(2-nitro-1-*p*-tolylethyl)benzene (15a)

Equation:



Procedure:

A Schlenk reaction tube capped with screwable cap and containing an egg-shaped Teflon coated stirbar was flame dried under vacuum and allowed to cool down to room temperature while still under vacuum. The tube was backfilled with nitrogen prior to opening the cap. 4-iodoanisole (2.72 mmol, 637 mg), 1-methyl-4-(2-nitrovinyl)benzene (1.14 mmol, 186 mg) were charged under a stream of nitrogen. The tube was capped with a rubber septum and subjected to 3 cycles of vacuum and nitrogen. **Pd^0-NHC** (1.5 mol%, 0.017 mmol) was weighed under nitrogen, dissolved in 1 mL of degassed DMF and injected into the reaction tube. Tri-*n*-butylamine (5.1 mmol, 1.2 mL) was added via syringe, and the septum was replaced by a screw cap. The Schlenk reaction tube was then alternated through 3 cycles of vacuum and nitrogen, and placed at into a pre-heated oil bath at 80 °C.

Upon completion as judged by GC-MS and/or TLC, the reaction was cooled to room temperature and poured into 10% HCl (v/v) solution (10 mL) and extracted with ether (3 X 25 mL). The organic extracts were combined, dried over anhydrous $MgSO_4$ and concentrated *in vacuo.* The concentrate was loaded directly or adsorbed onto silica prior to loading onto a silica gel column. The product was isolated (118 mg, 38%) using toluene:EtOAc eluent system (R_f=0.3)

^{1}H NMR: 400 MHz, $CDCl_3$

δ 7.16 – 7.12 (m, 6H), 6.85 (d, J = 8.8 Hz, 2H), 4.94 – 4.92 (m, 2H), 4.82 (t,J = 8.4 Hz,1H), 3.77 (s, 3H), 2.31 (s, 3H).

^{13}C NMR: 101 MHz, $CDCl_3$

δ 158.83, 137.15, 136.49, 131.42, 129.62, 128.63, 127.37, 114.32, 79.54, 55.22, 47.88, 20.97.

R_f: 0.3 (toluene:EtOAc = 98:2)

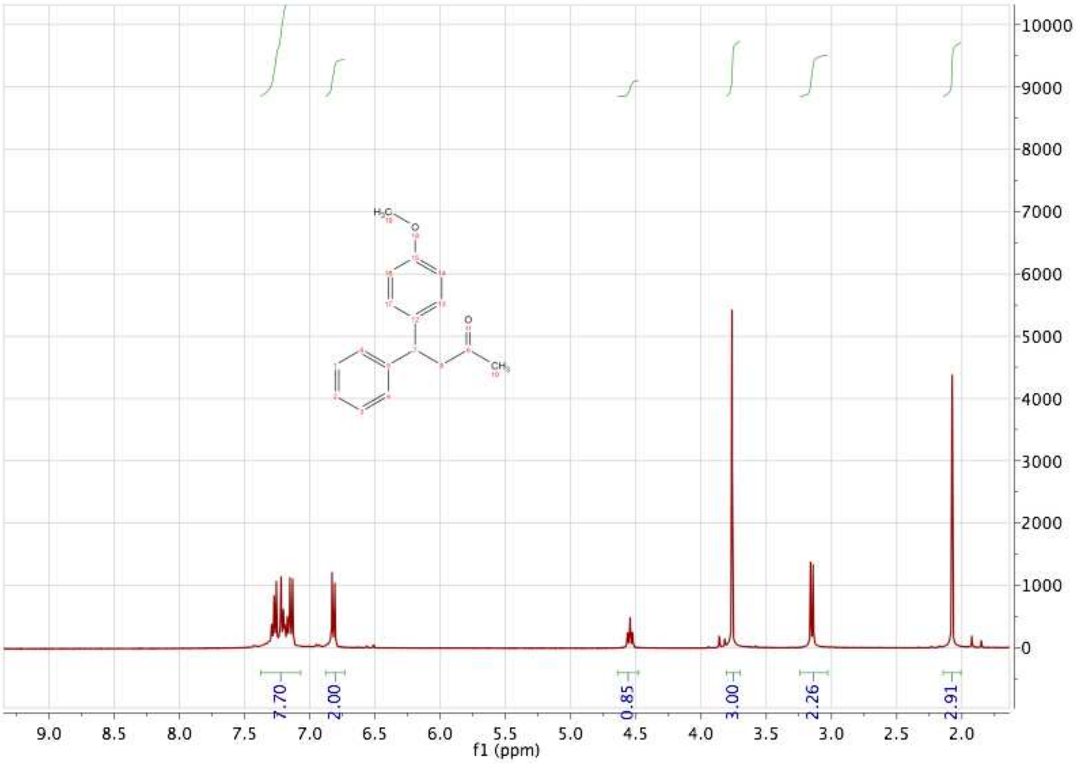
EI-MS Spectrogram of the compound is attached.

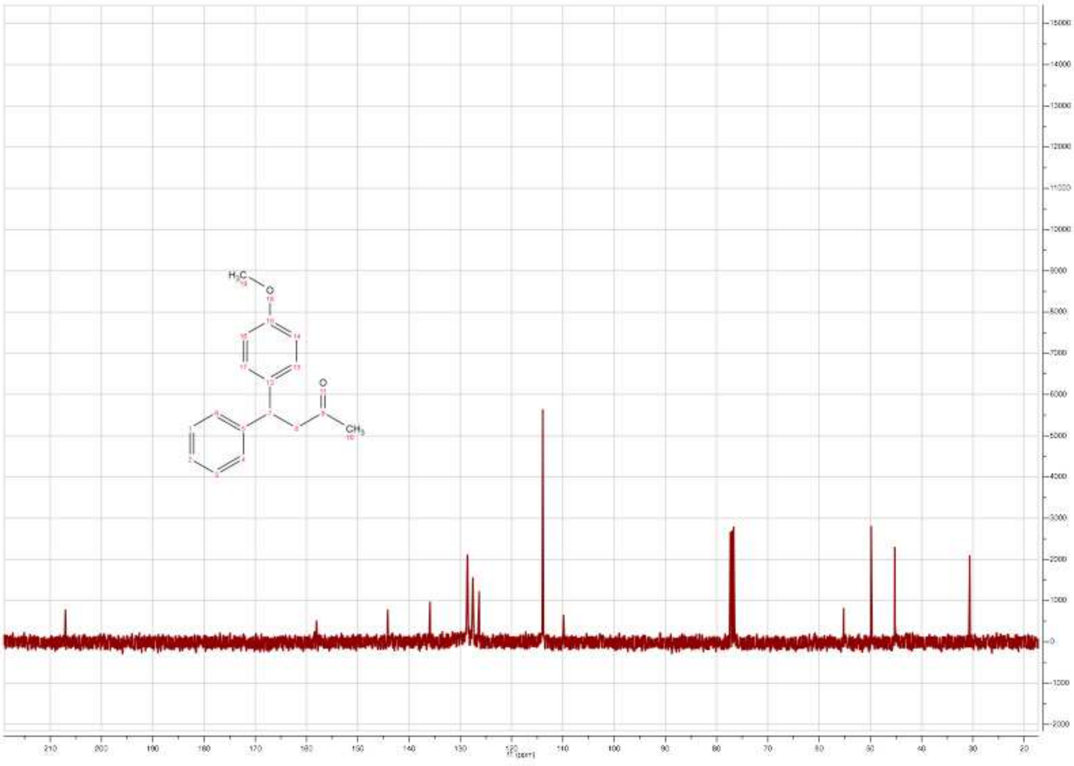
Identification: Stains brown-purple on TLC upon gentle warming after dipping in Seebach solution.

This compound has already been described in literature[15]

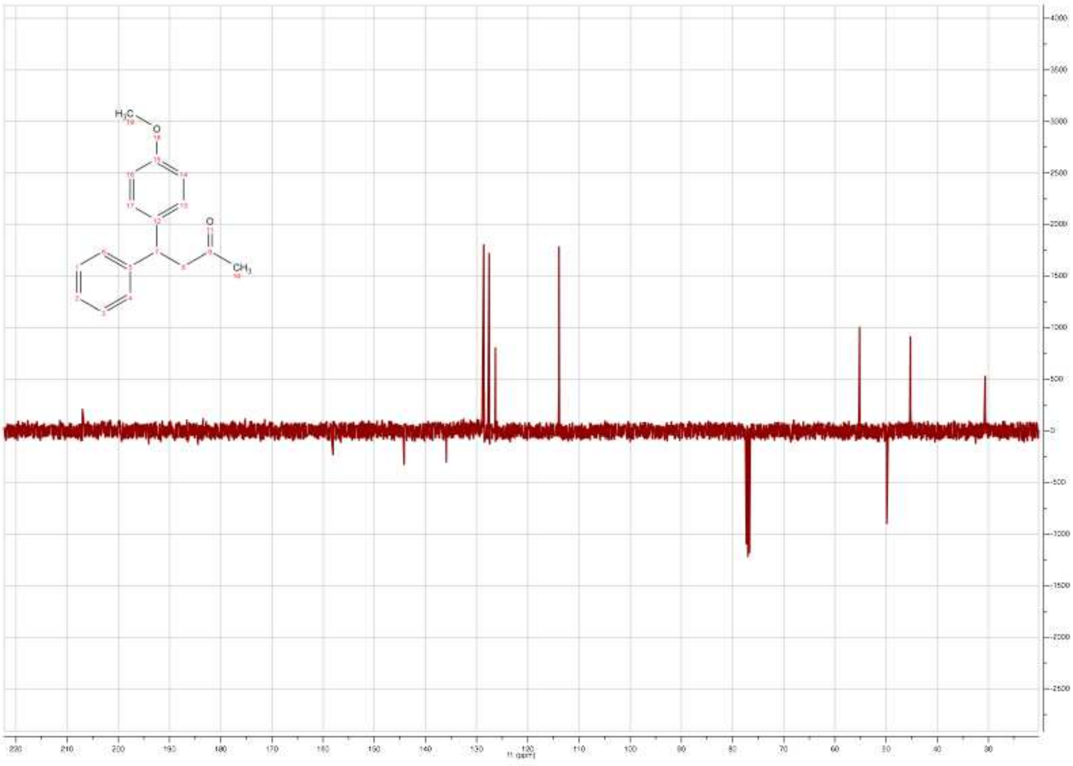
Spectra:

4-(4-methoxyphenyl)-4-phenylbutan-2-one (3a)

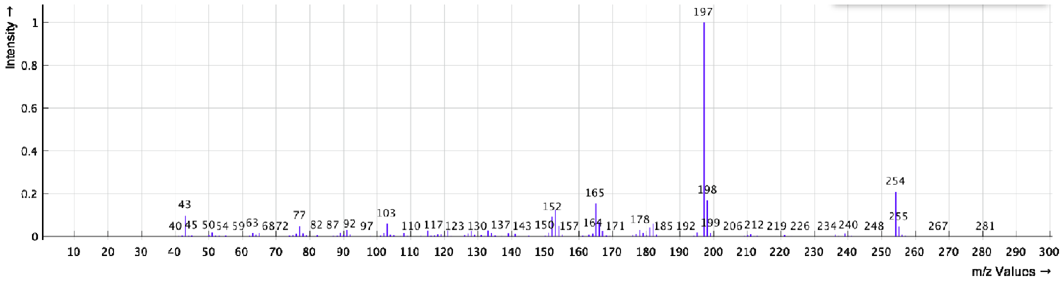




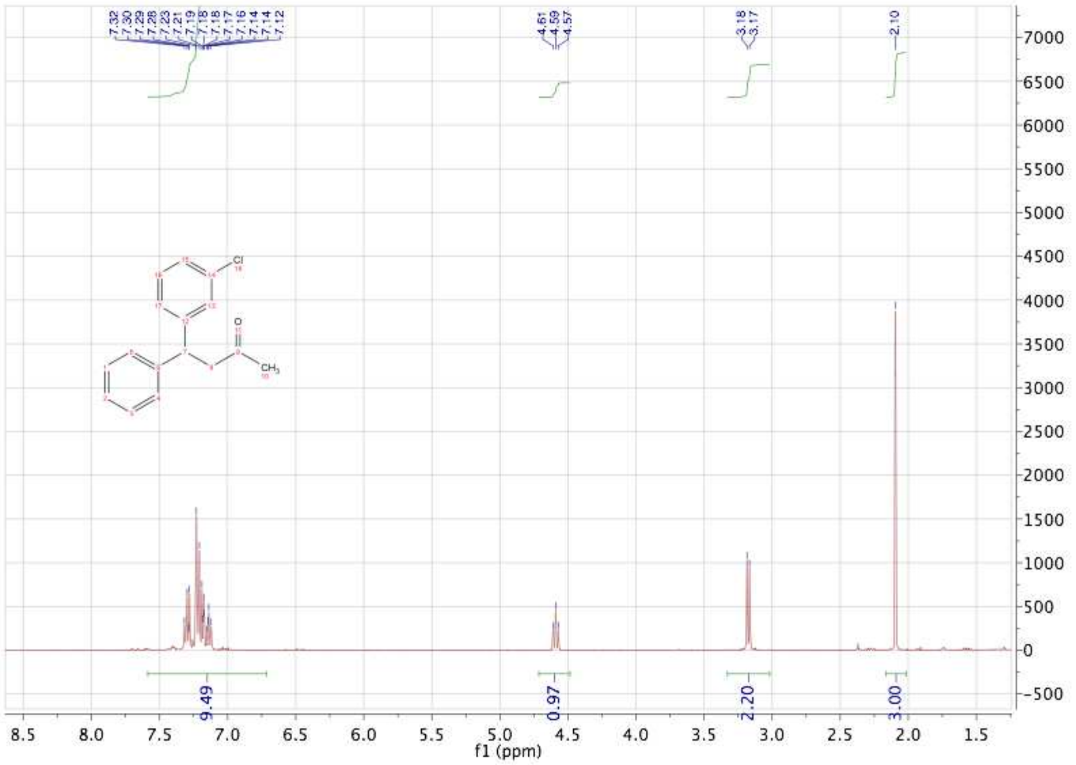
4-(4-methoxyphenyl)-4-phenylbutan-2-one (3a)

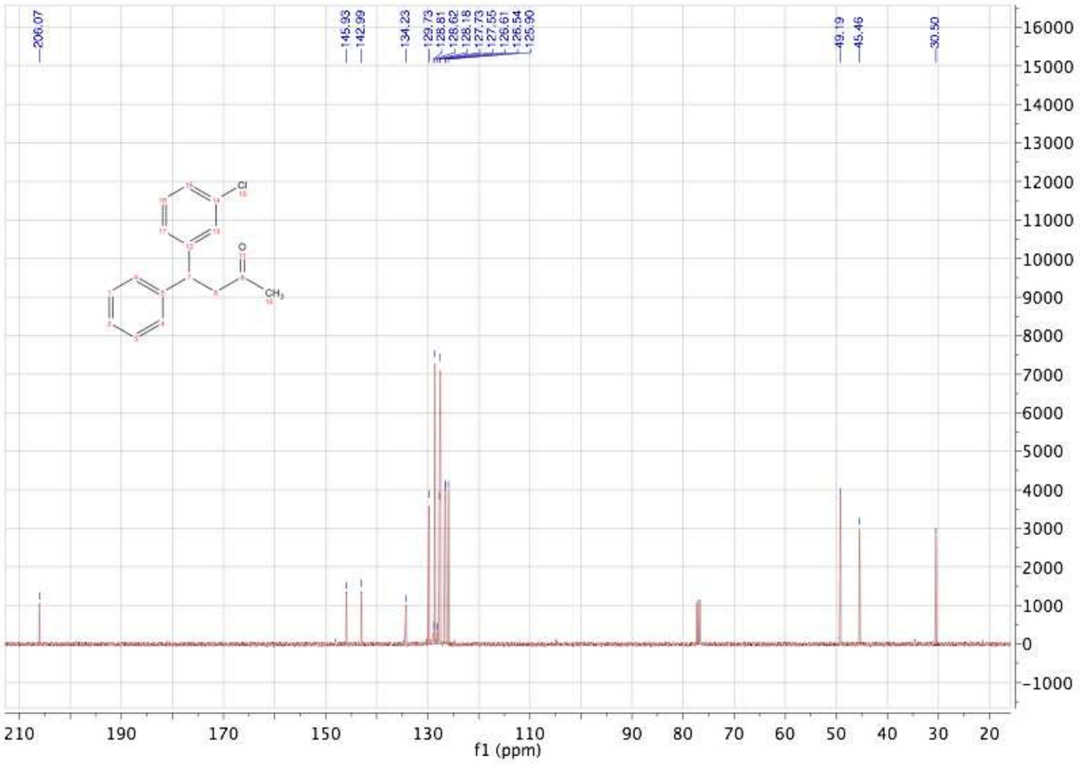


EI-MS Spectrogram for 3a

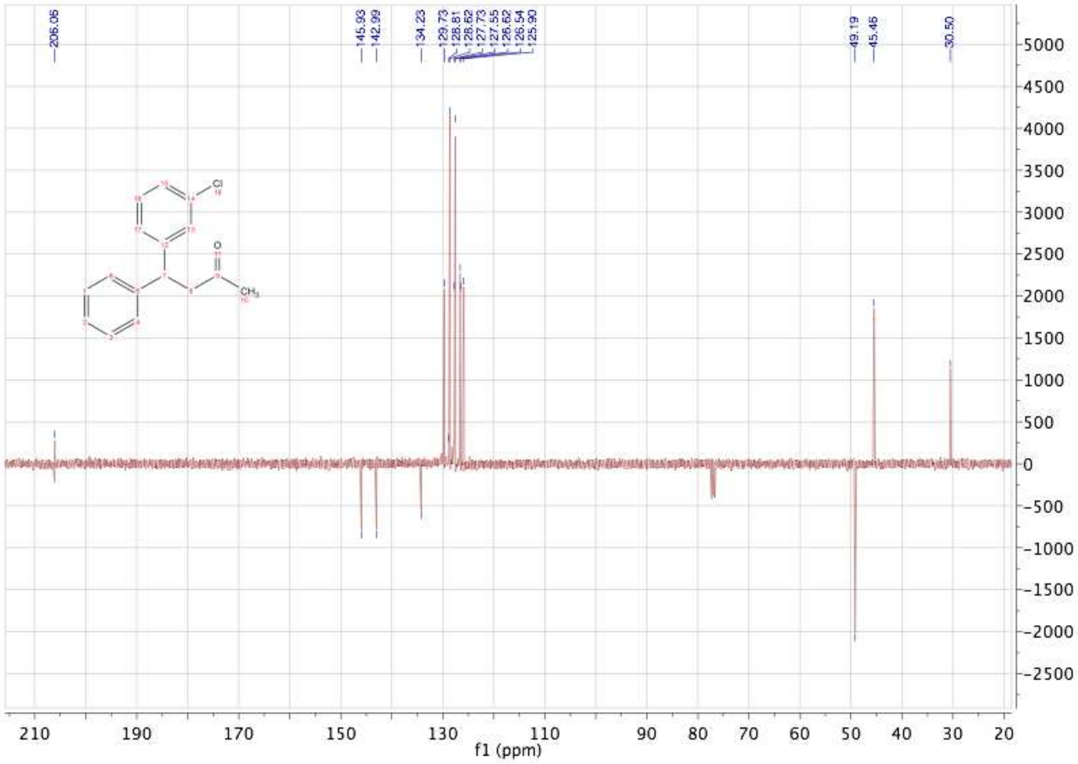


4-(3-chlorophenyl)-4-phenylbutan-2-one (3g)

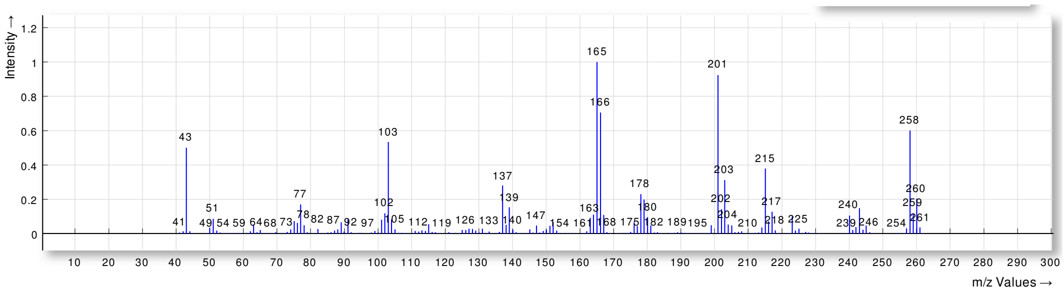




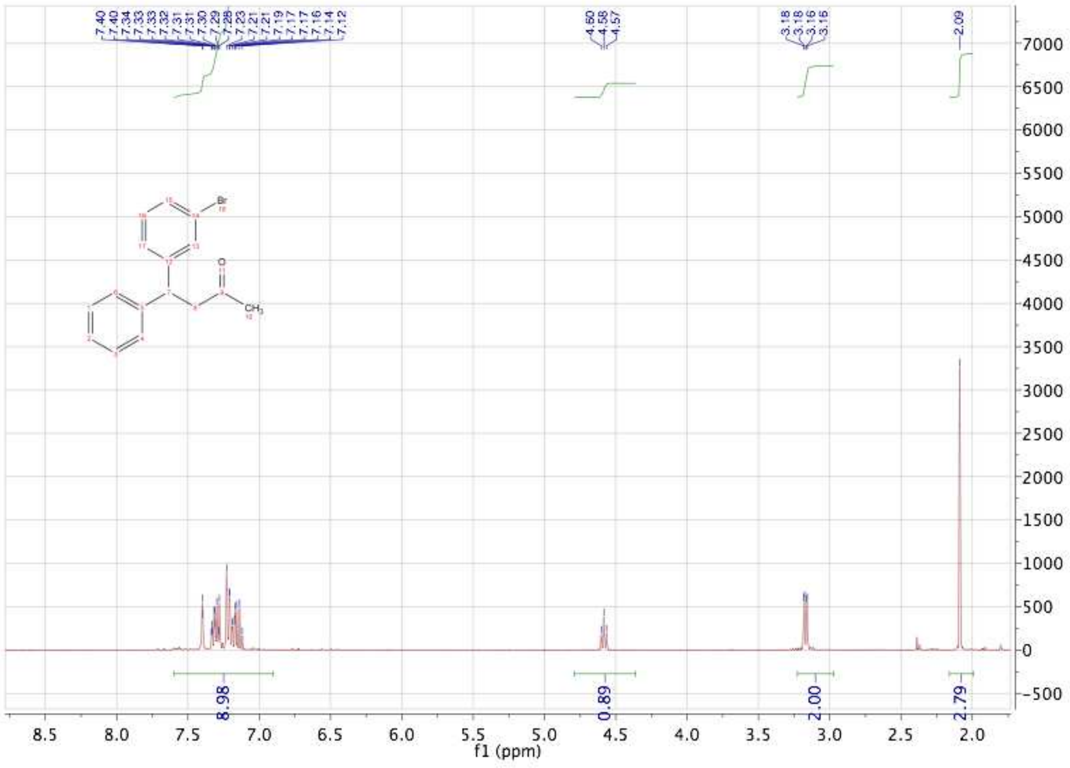
4-(3-chlorophenyl)-4-phenylbutan-2-one (3g)

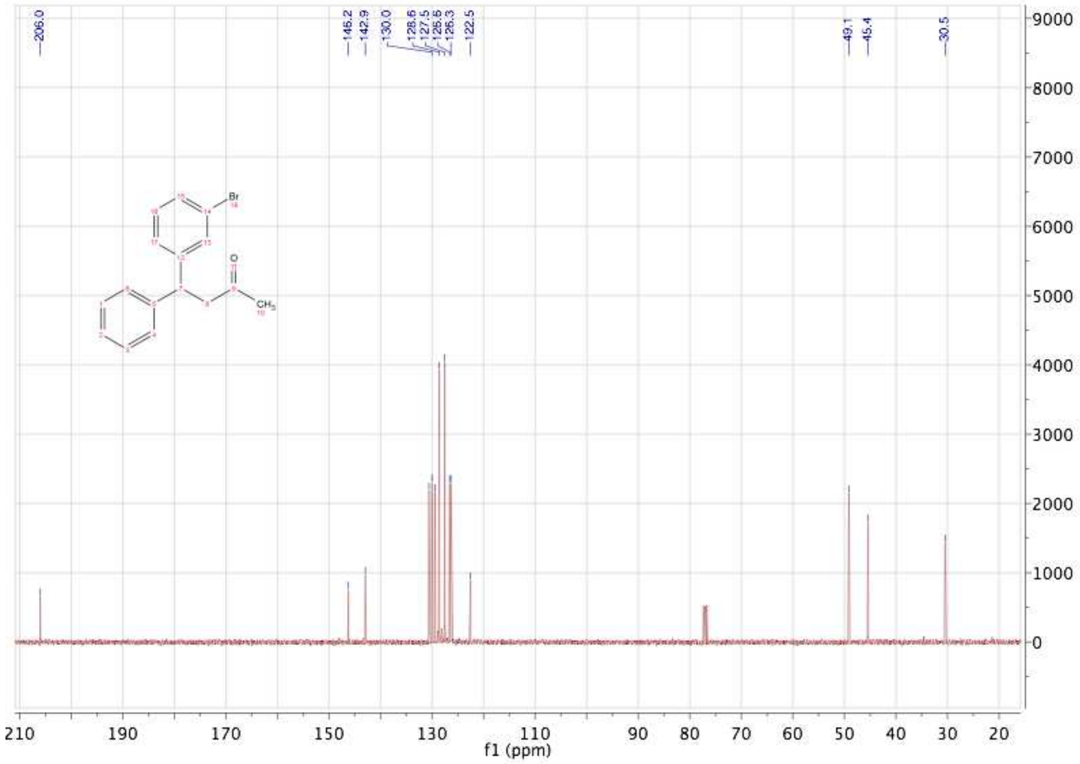


EI-MS Spectrogram for 3g

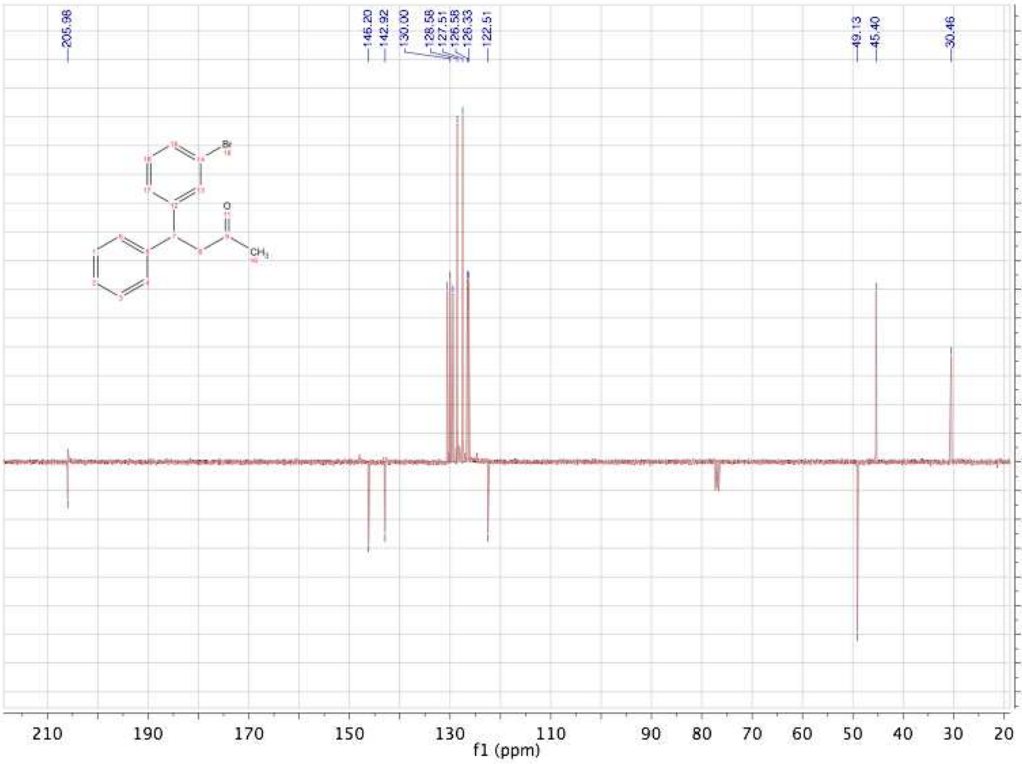


4-(3-bromophenyl)-4-phenylbutan-2-one (3h)

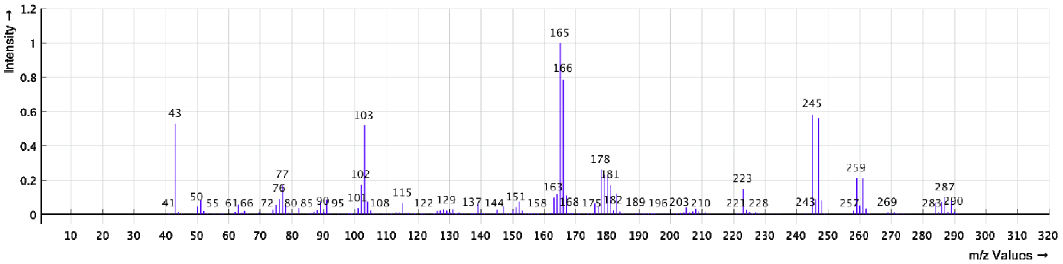




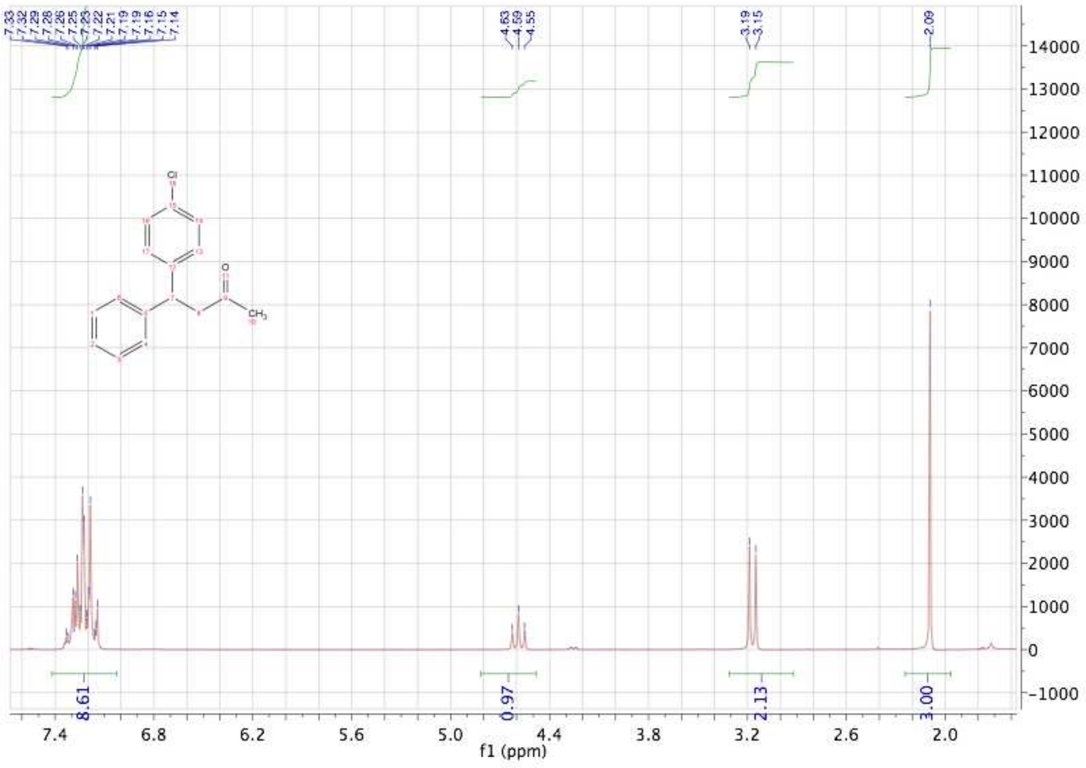
4-(3-bromophenyl)-4-phenylbutan-2-one (3h)

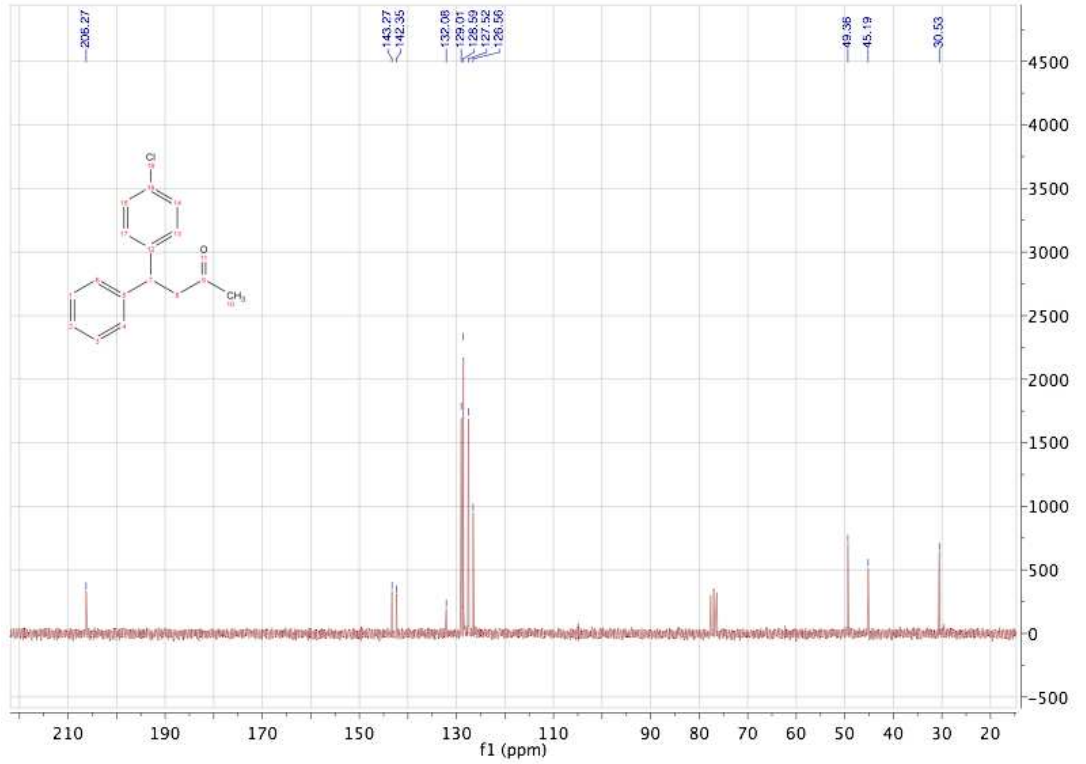


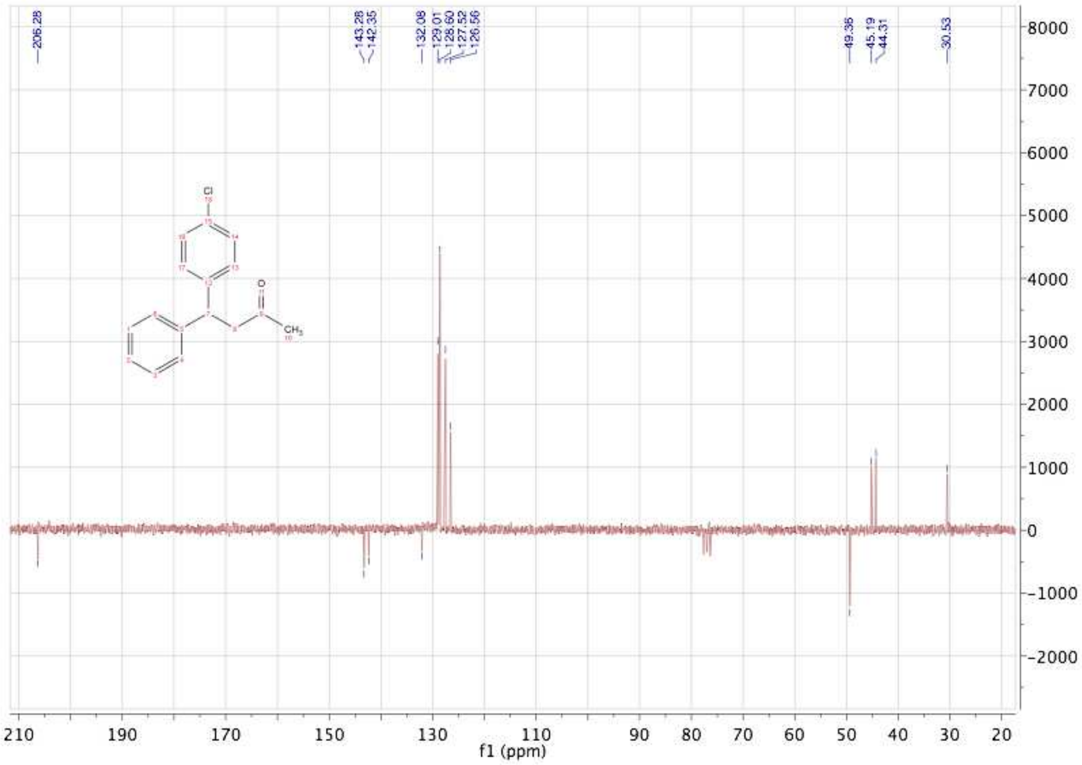
EI-MS Spectrogram 3h



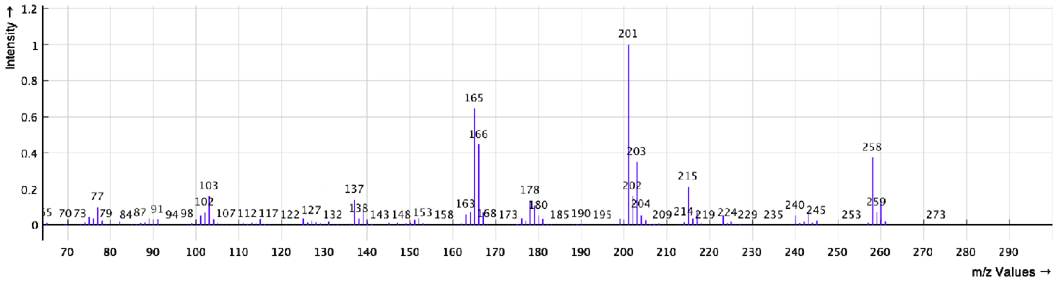
4-(4-chlorophenyl)-4-phenylbutan-2-one (3i)





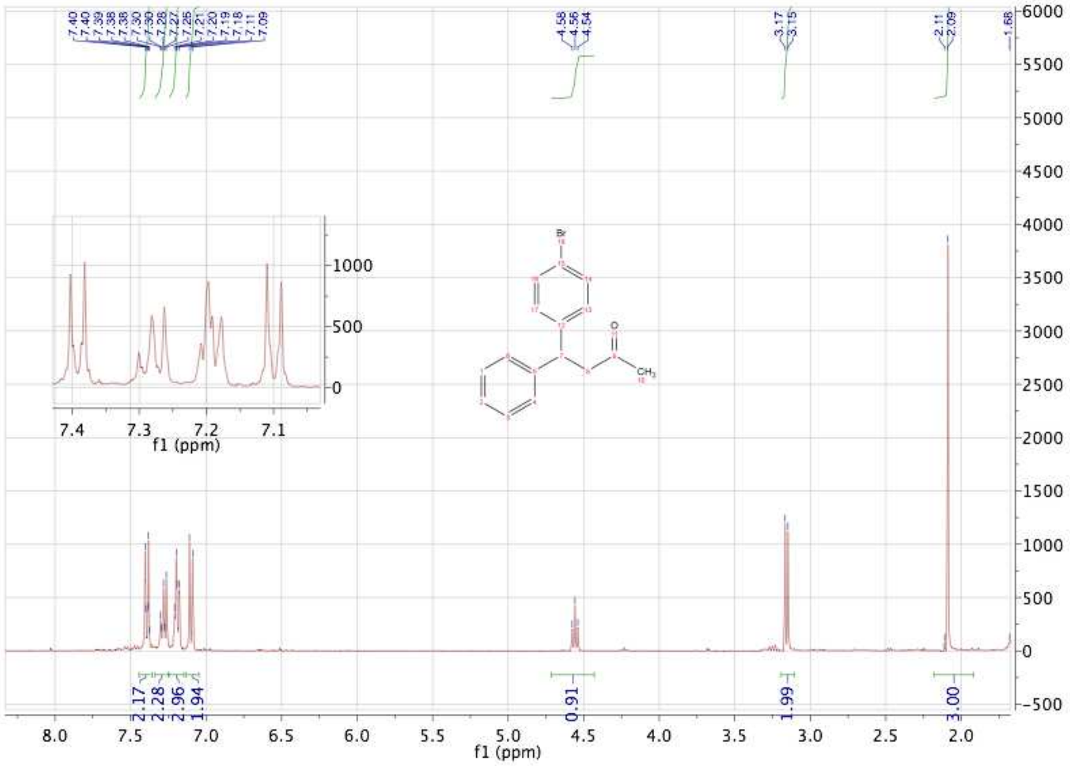


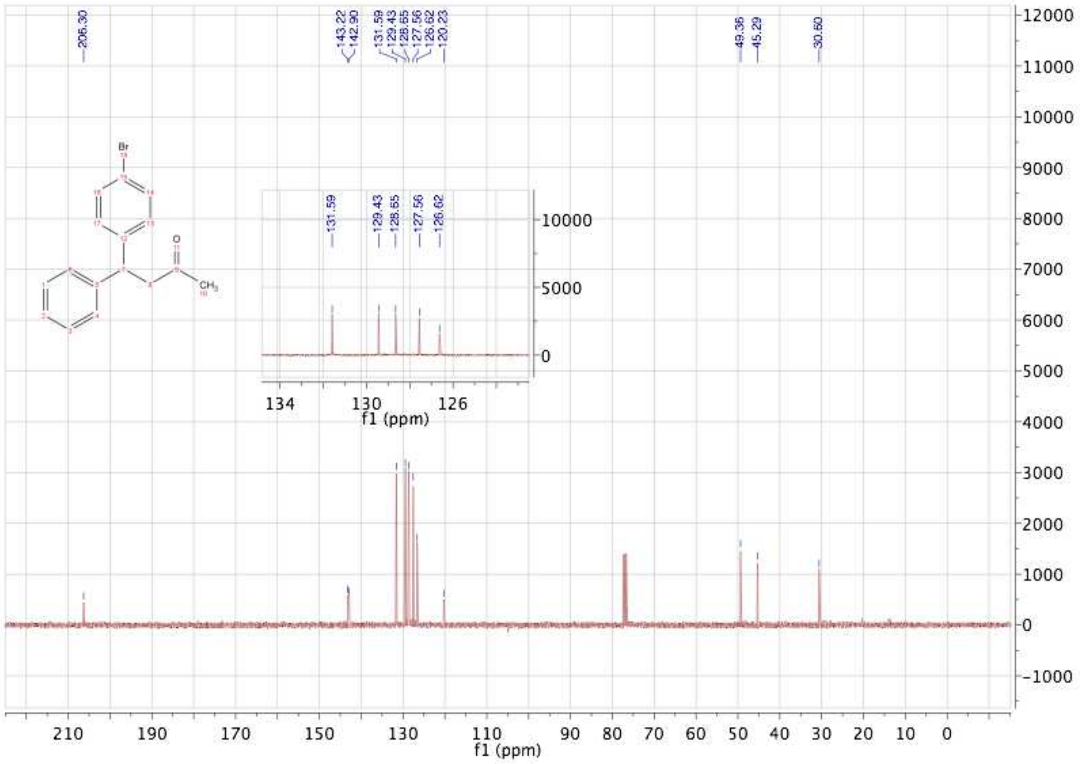
EI-MS Spectrogram for 3j

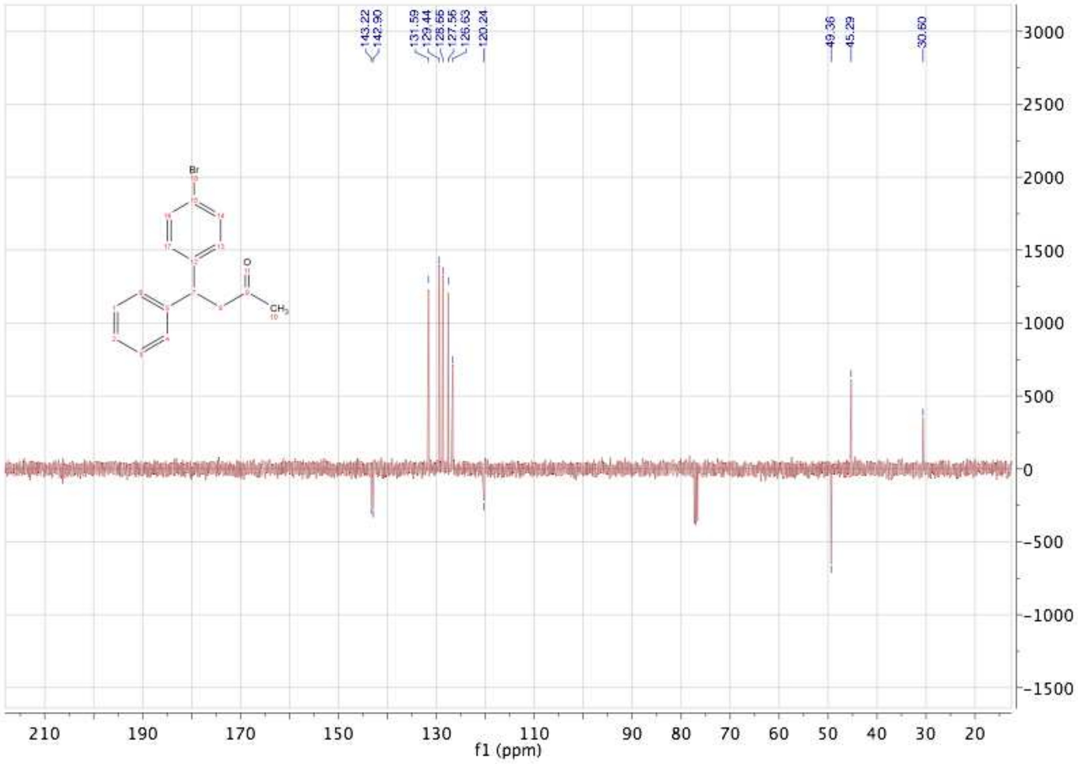


4-(4-chlorophenyl)-4-phenylbutan-2-one (3i)

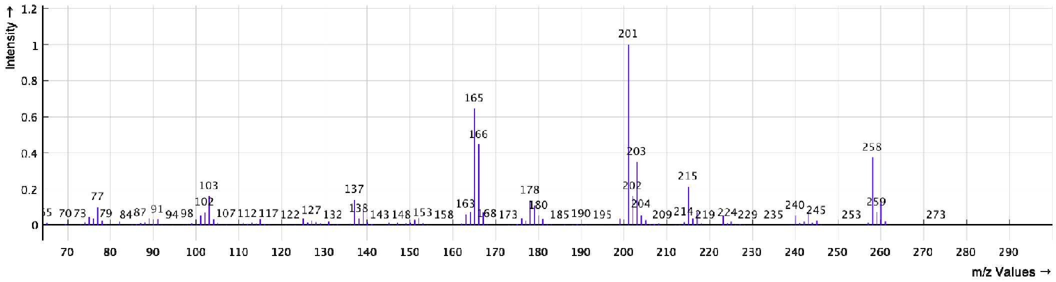
4-(4-bromophenyl)-4-phenylbutan-2-one (3i)





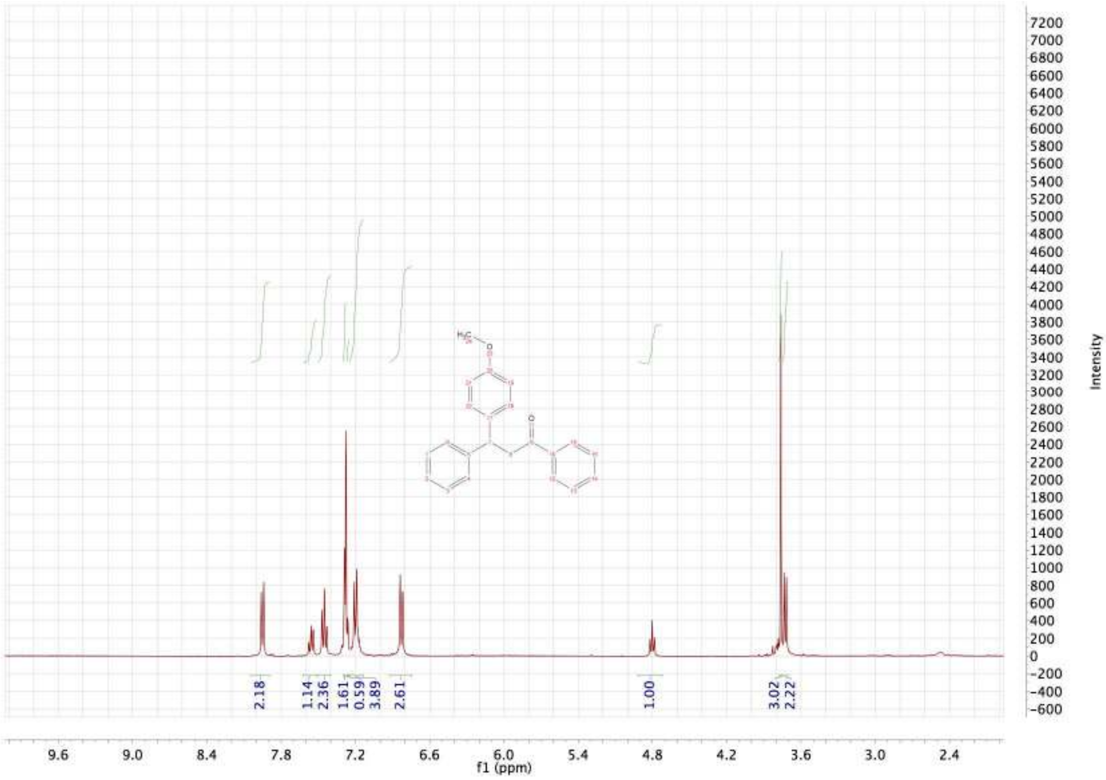


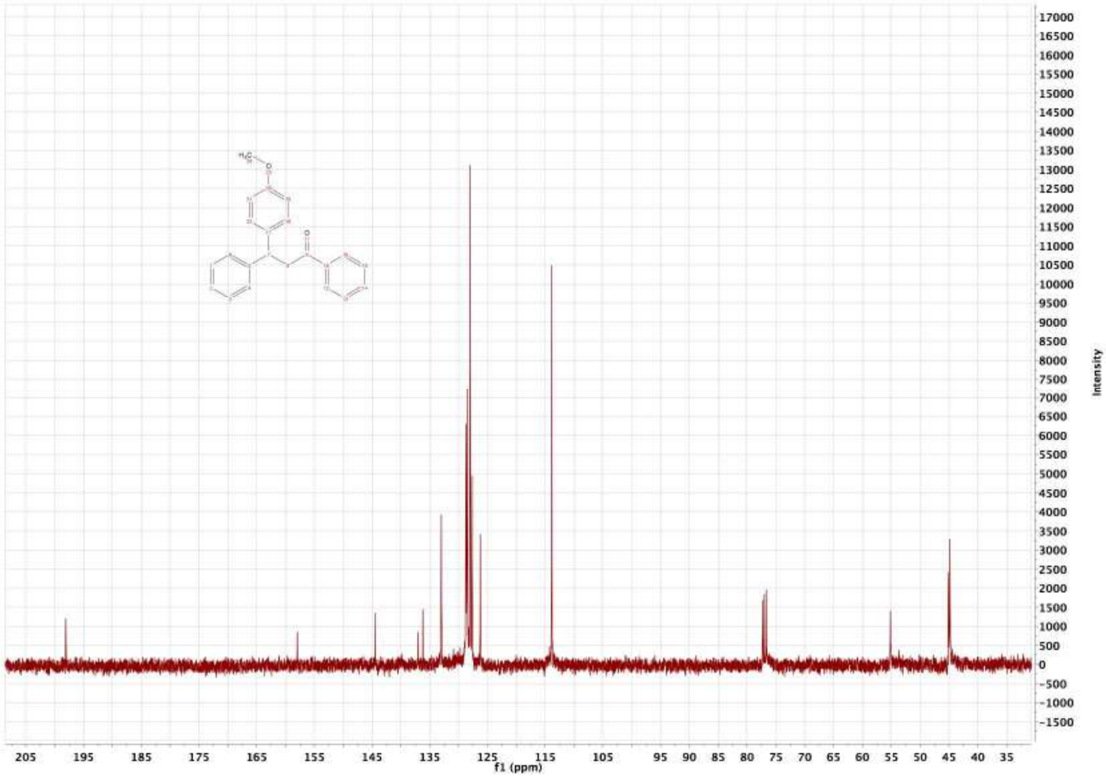
EI-MS Spectrogram for 3j



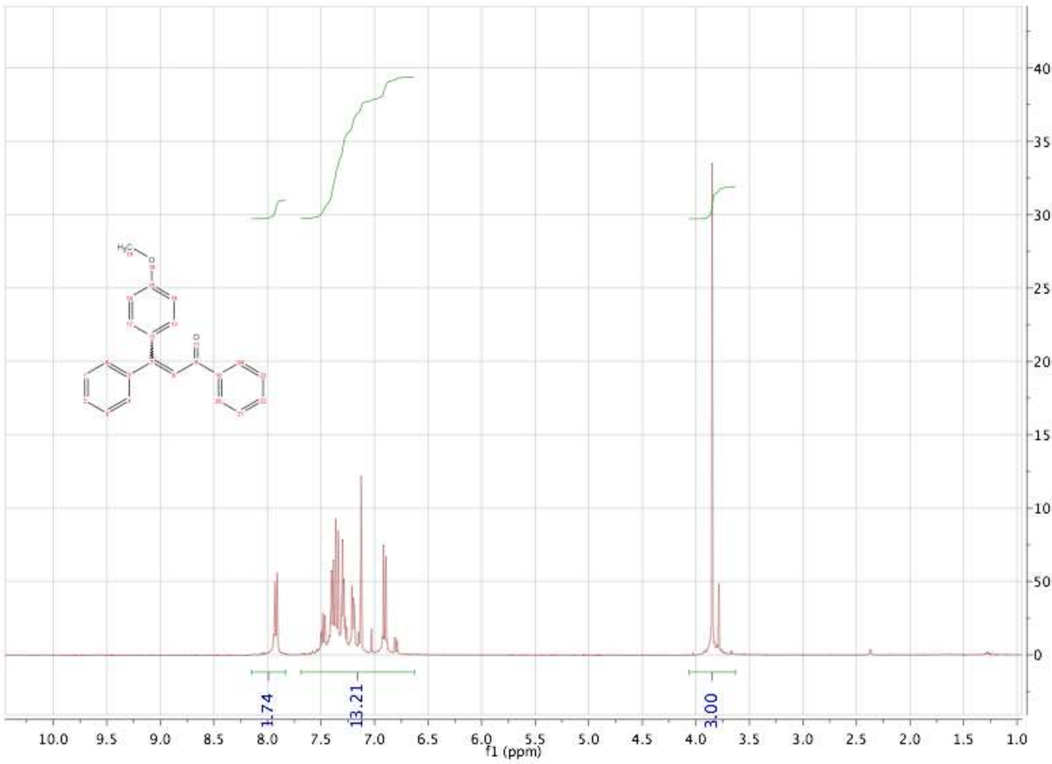
4-(4-bromophenyl)-4-phenylbutan-2-one (3j)

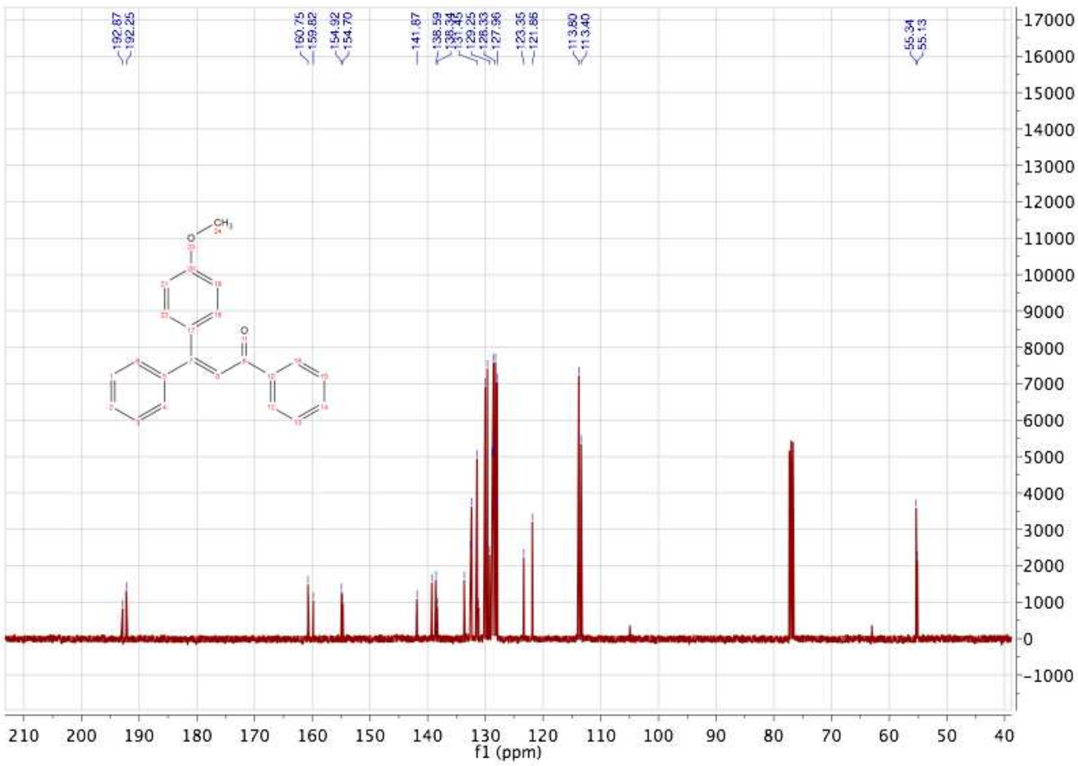
3-(4-methoxyphenyl)-1,3-diphenylpropan-1-one (4a)



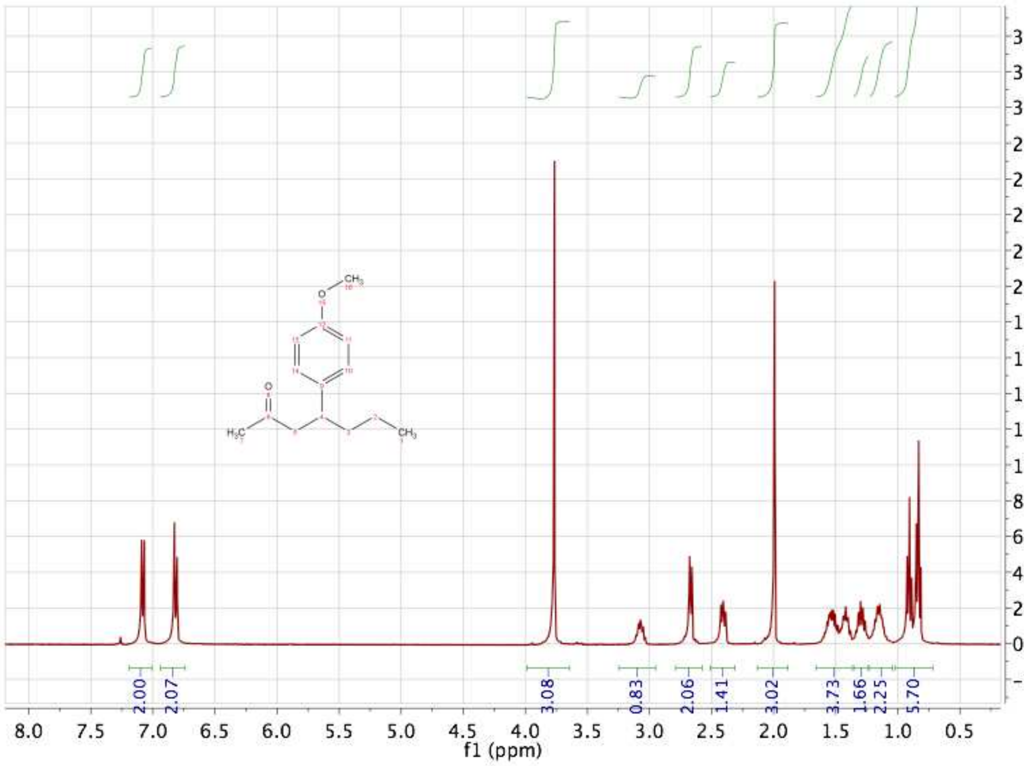


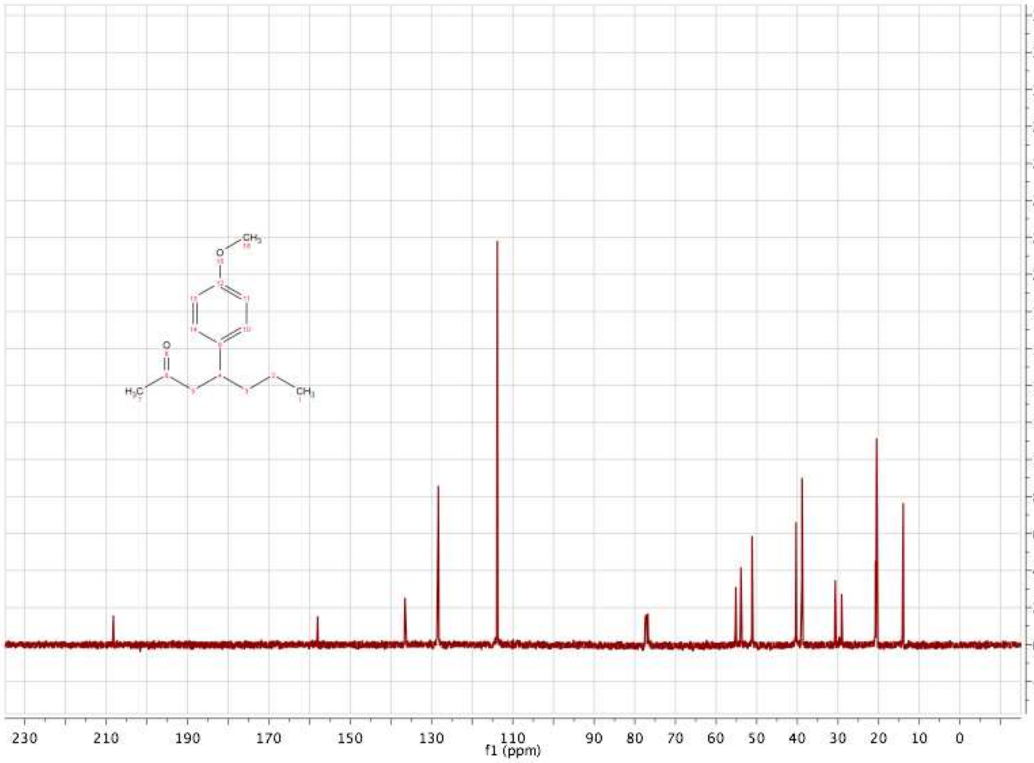
3-(4-methoxyphenyl)-1,3-diphenylprop-2-en-1-one (4b)



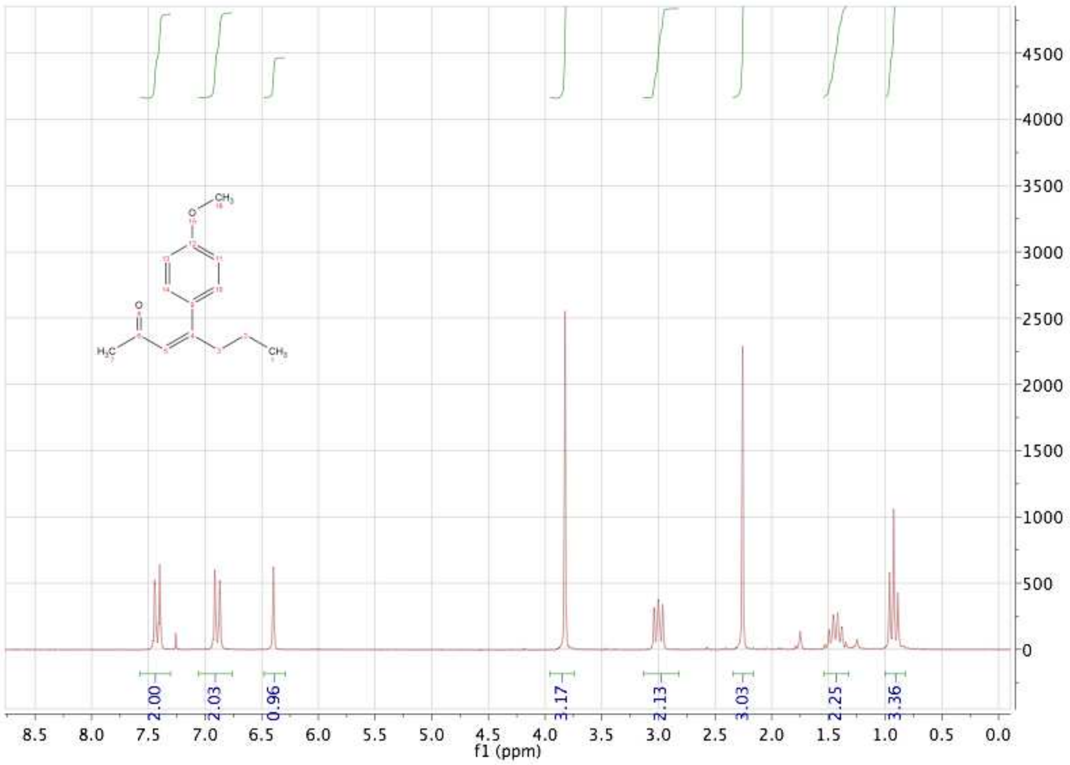


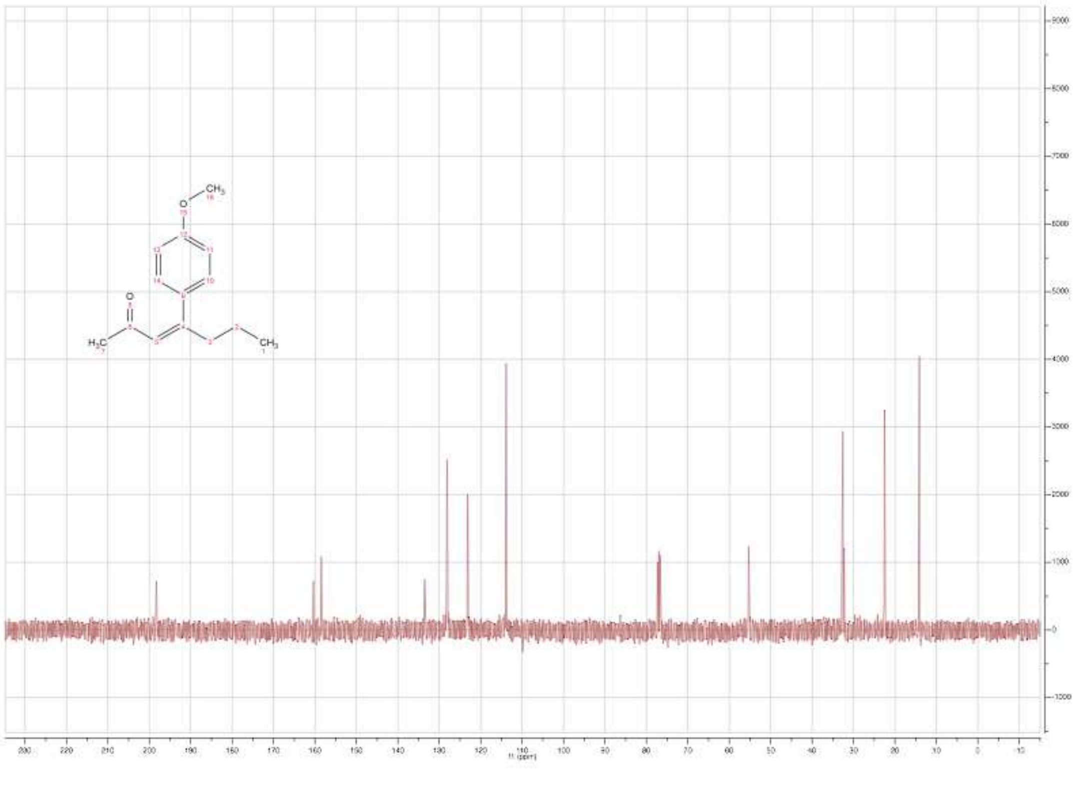
4-(4-methoxyphenyl)heptan-2-one (5a)



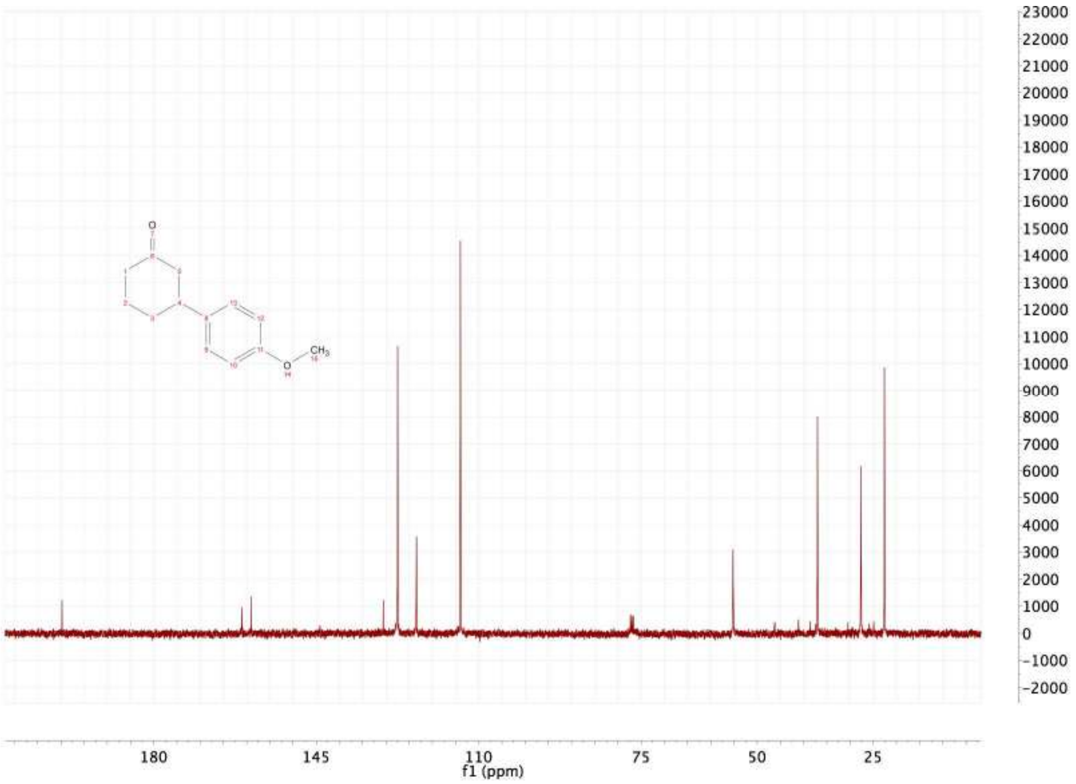


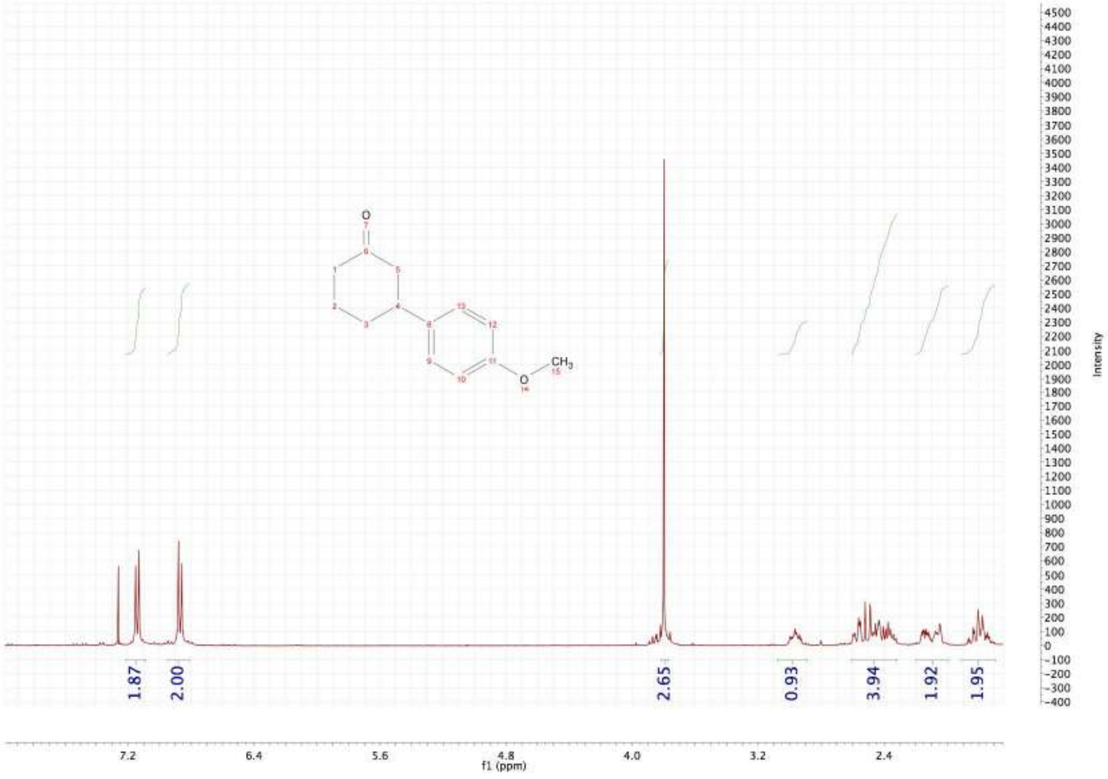
4-(4-methoxyphenyl)hept-3-en-2-one (5b)



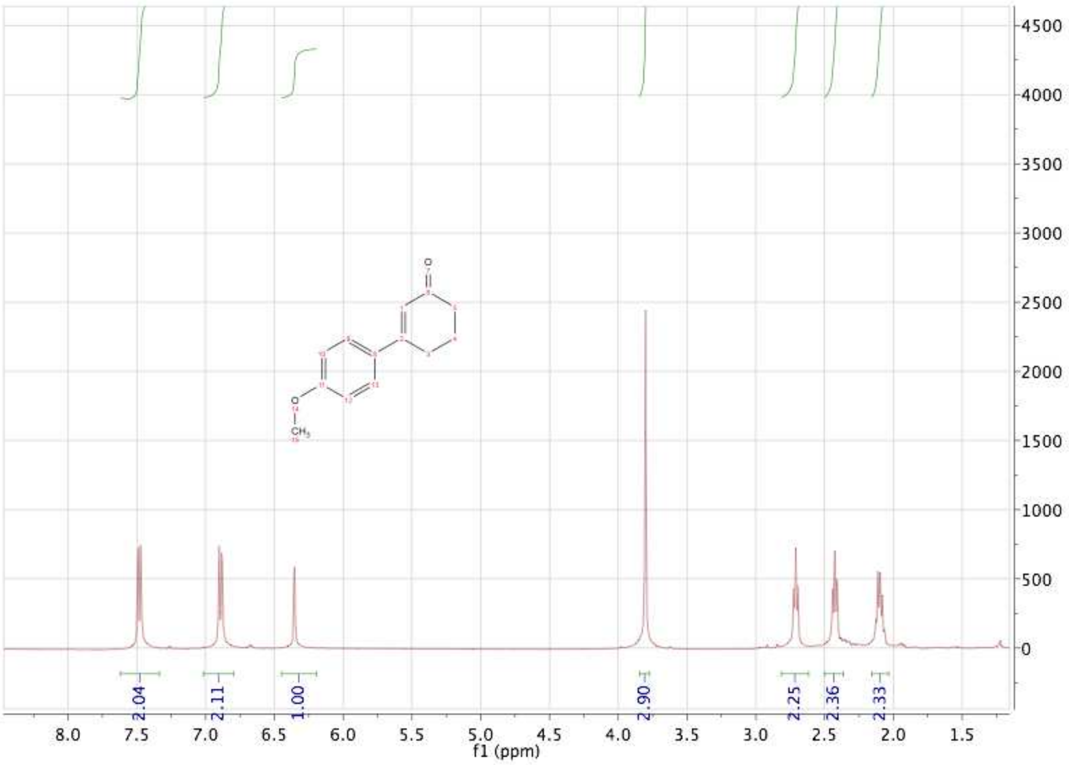


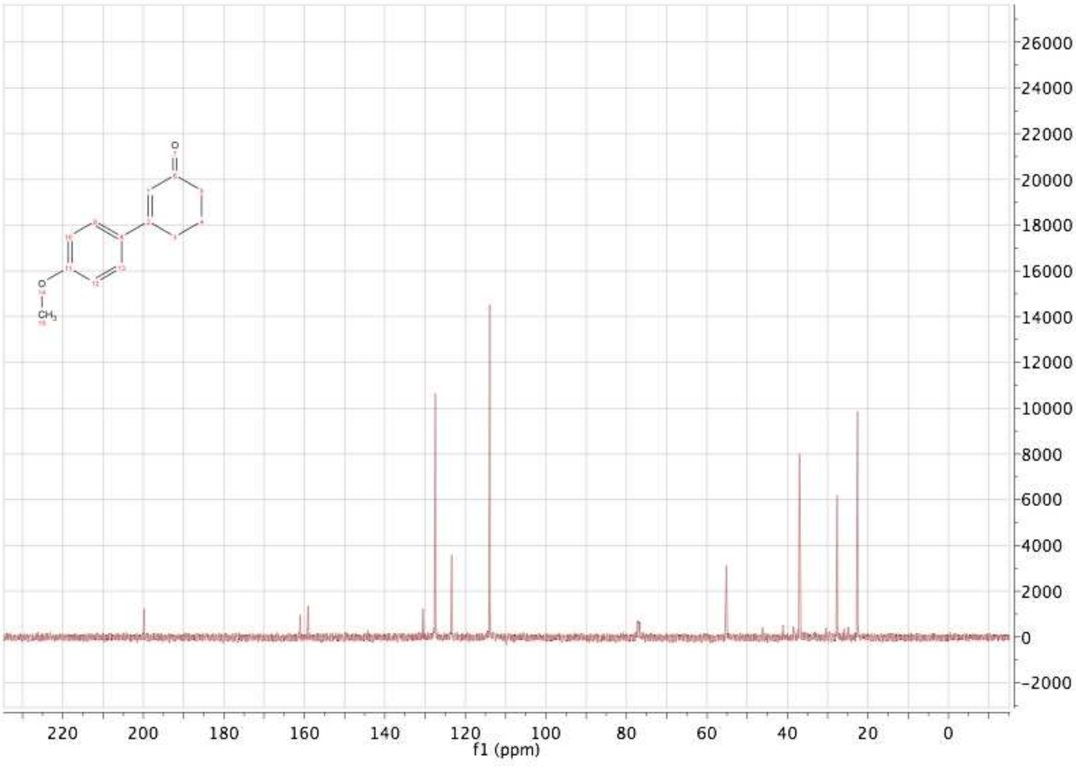
3-(4-methoxyphenyl)cyclohex-2-enone (6a)



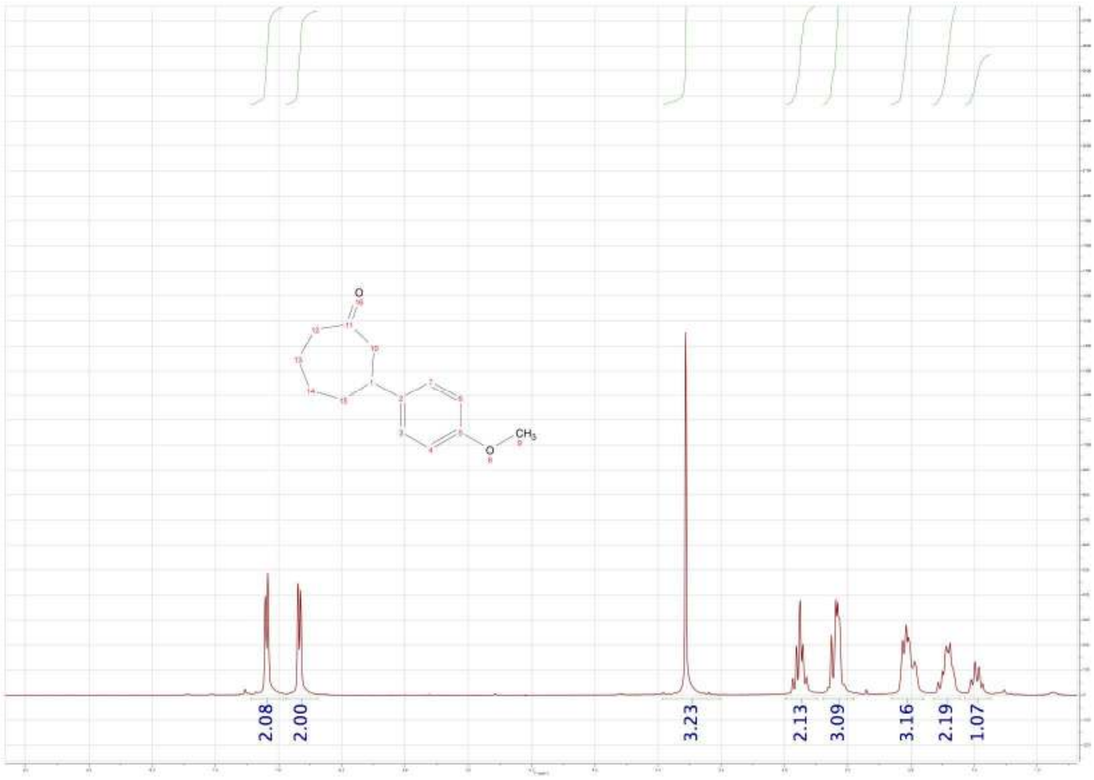


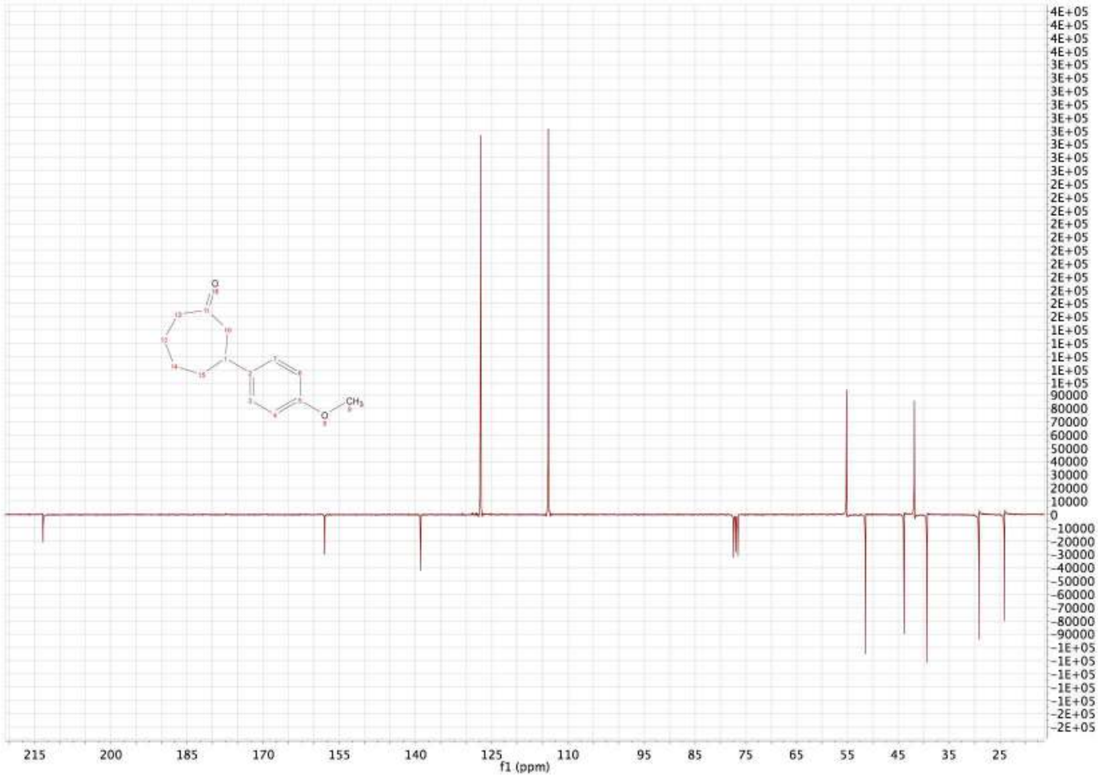
3-(4-methoxyphenyl)cyclohex-2-enone (6b)



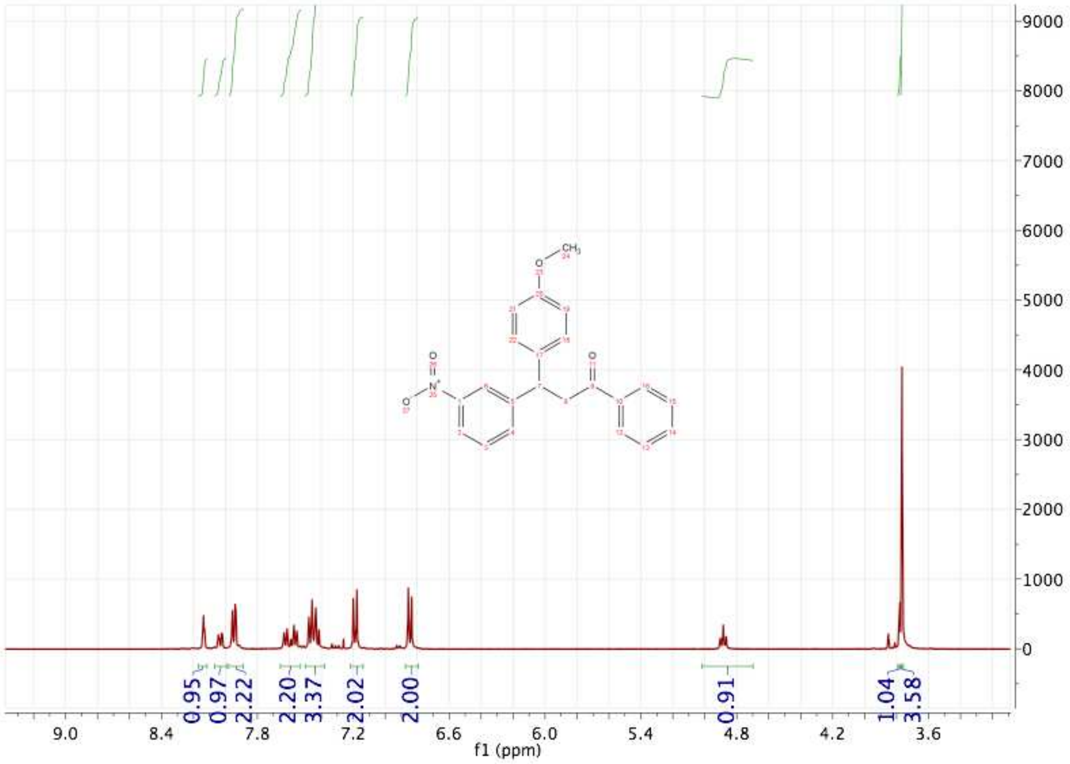


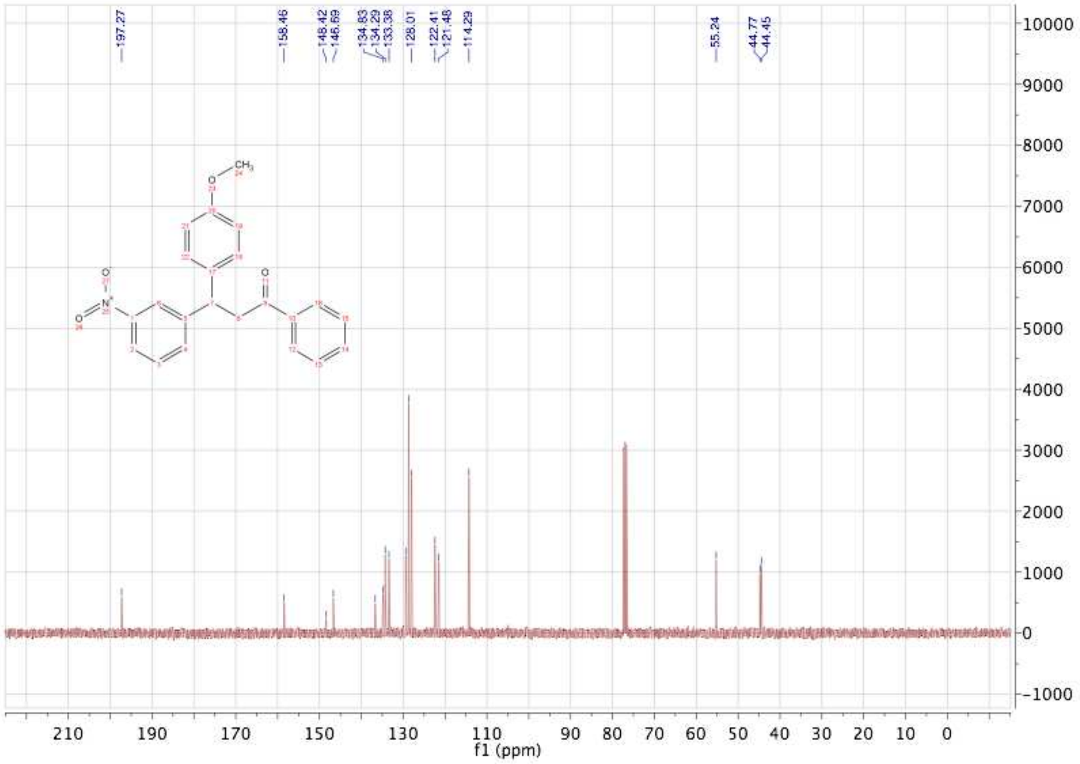
4-(4-methoxyphenyl)heptan-2-one (7a)



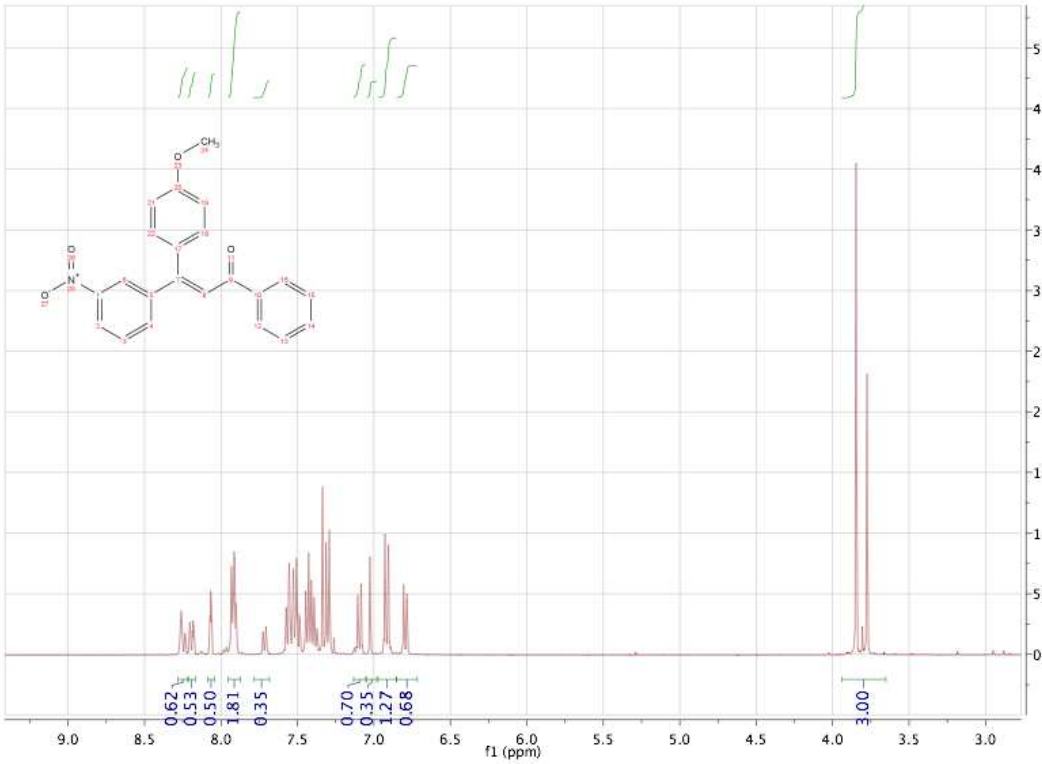


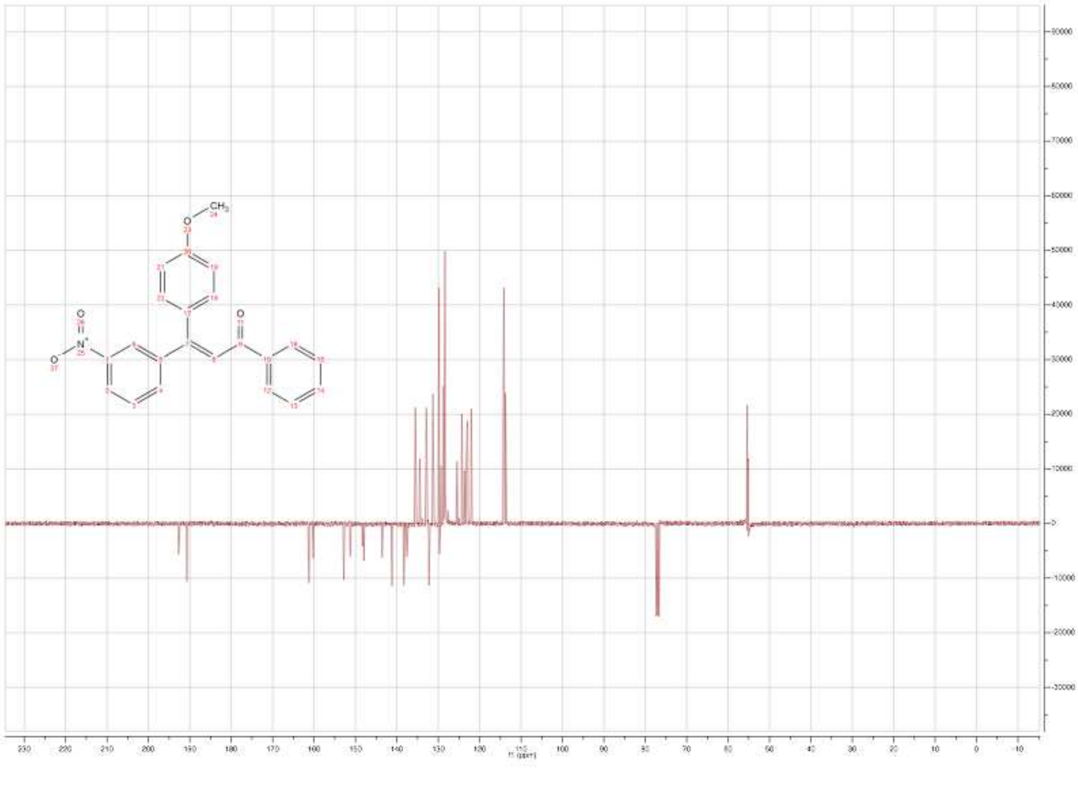
3-(4-methoxyphenyl)-3-(3-nitrophenyl)-1-phenylpropan-1-one (8a)



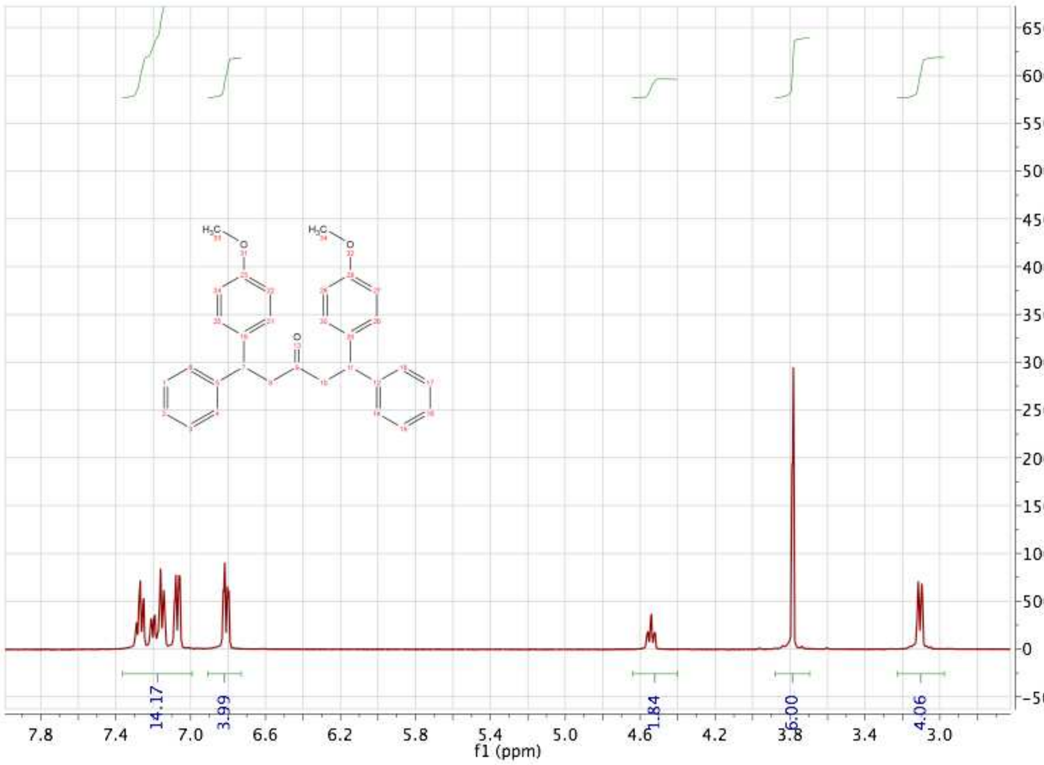


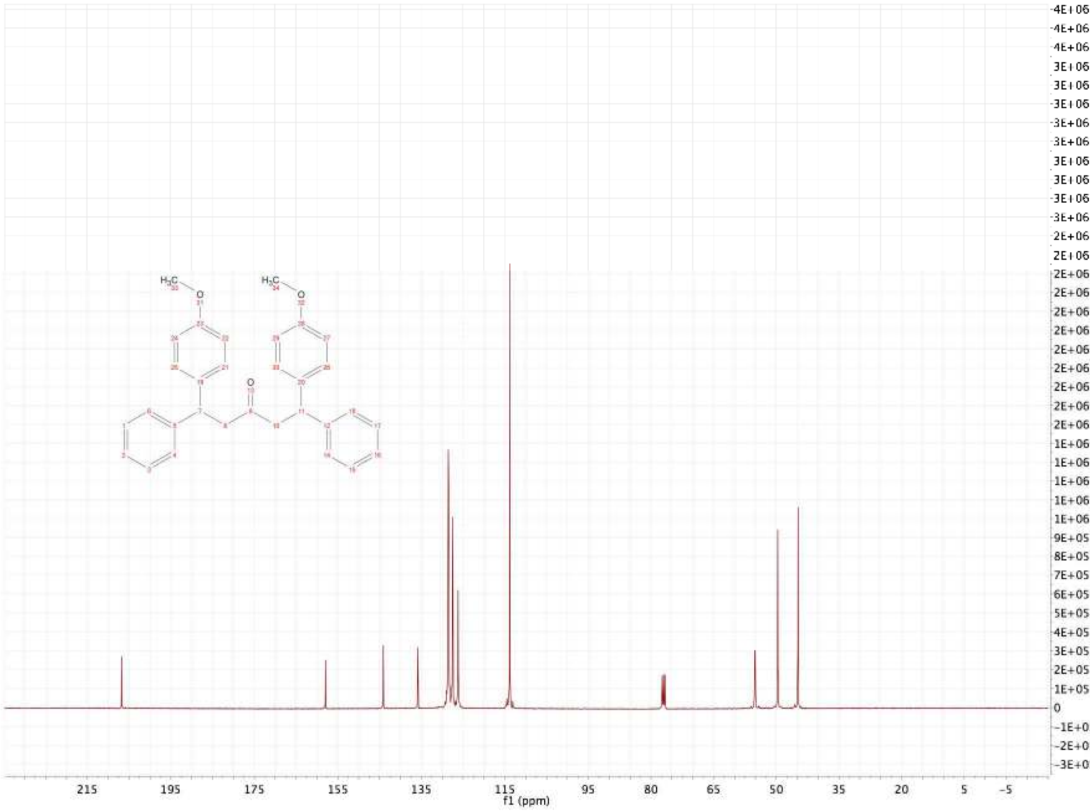
3-(4-methoxyphenyl)-3-(3-nitrophenyl)-1-phenylprop-2-en-1-one (8b)



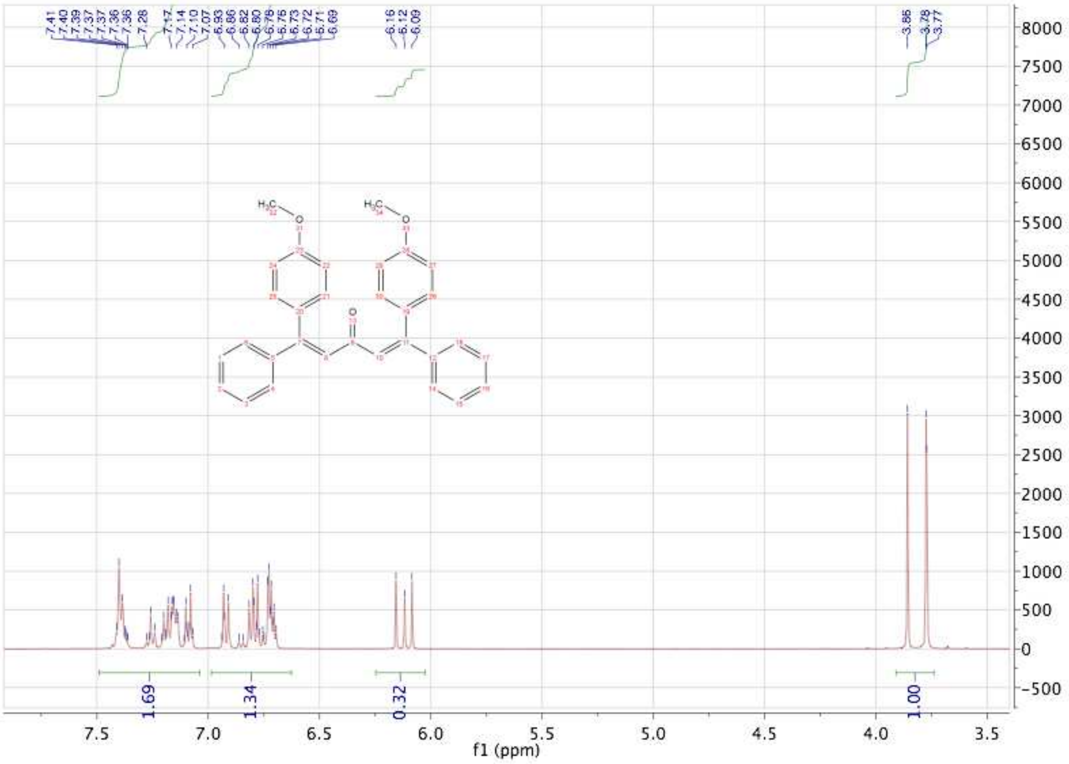


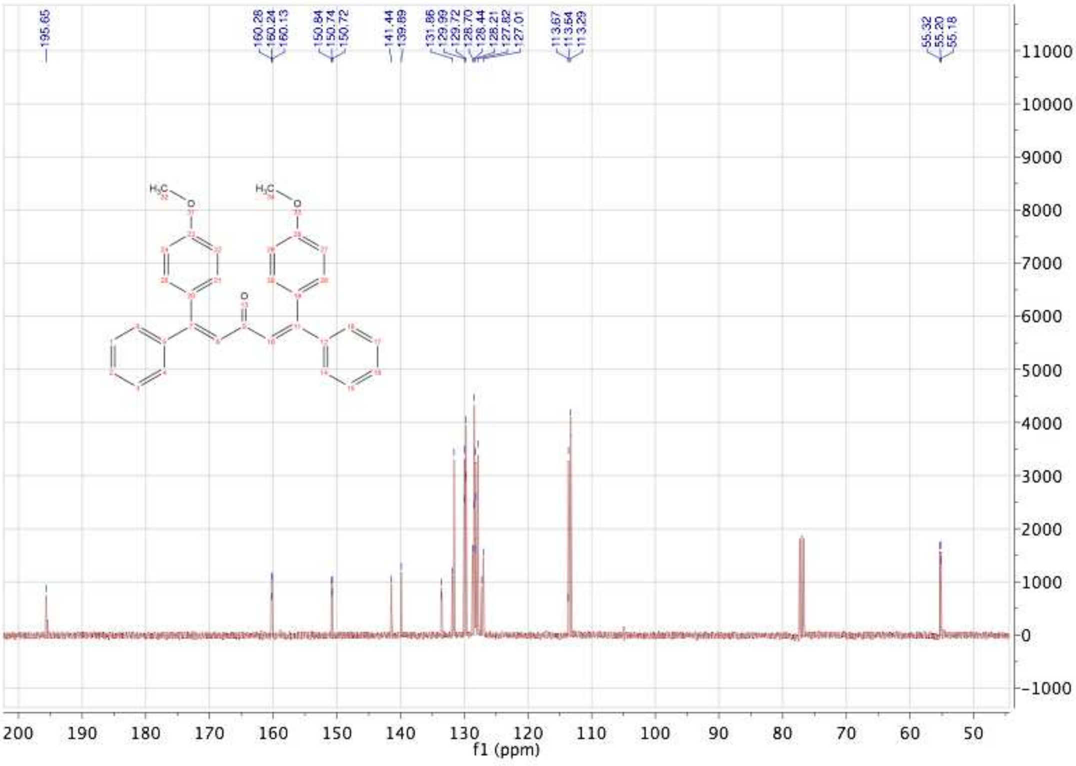
1,5-bis(4-methoxyphenyl)-1,5-diphenylpentan-3-one (9a)



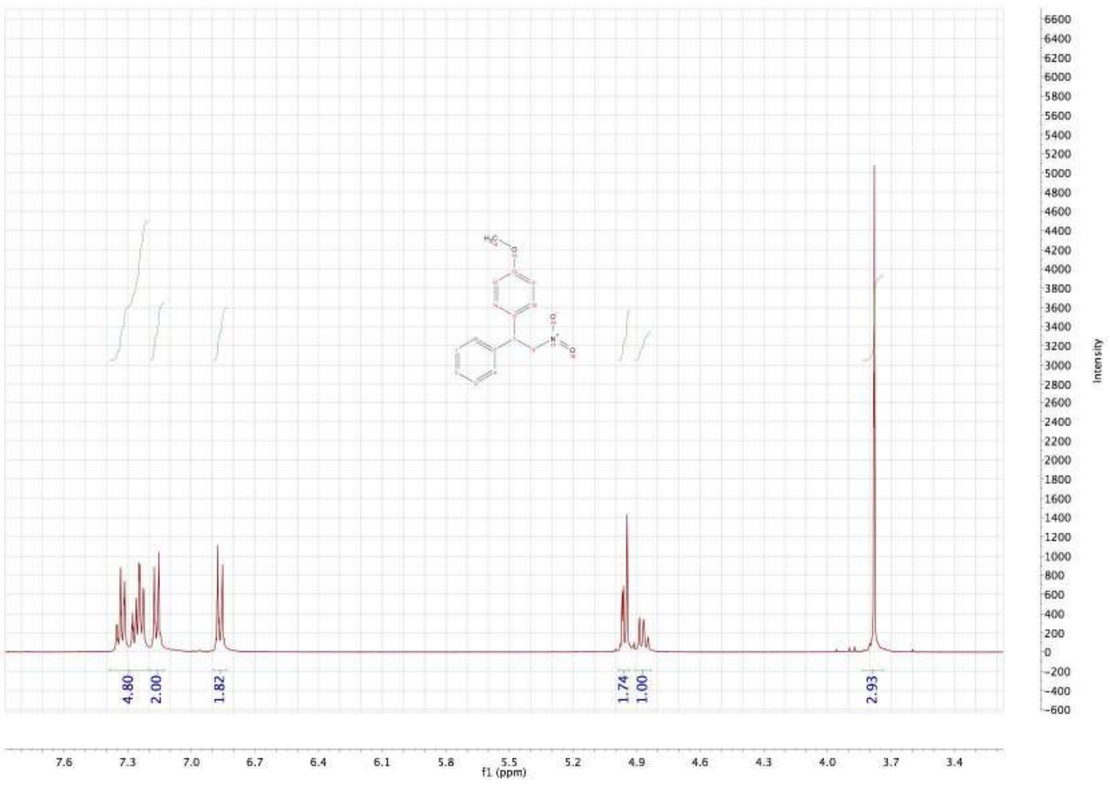


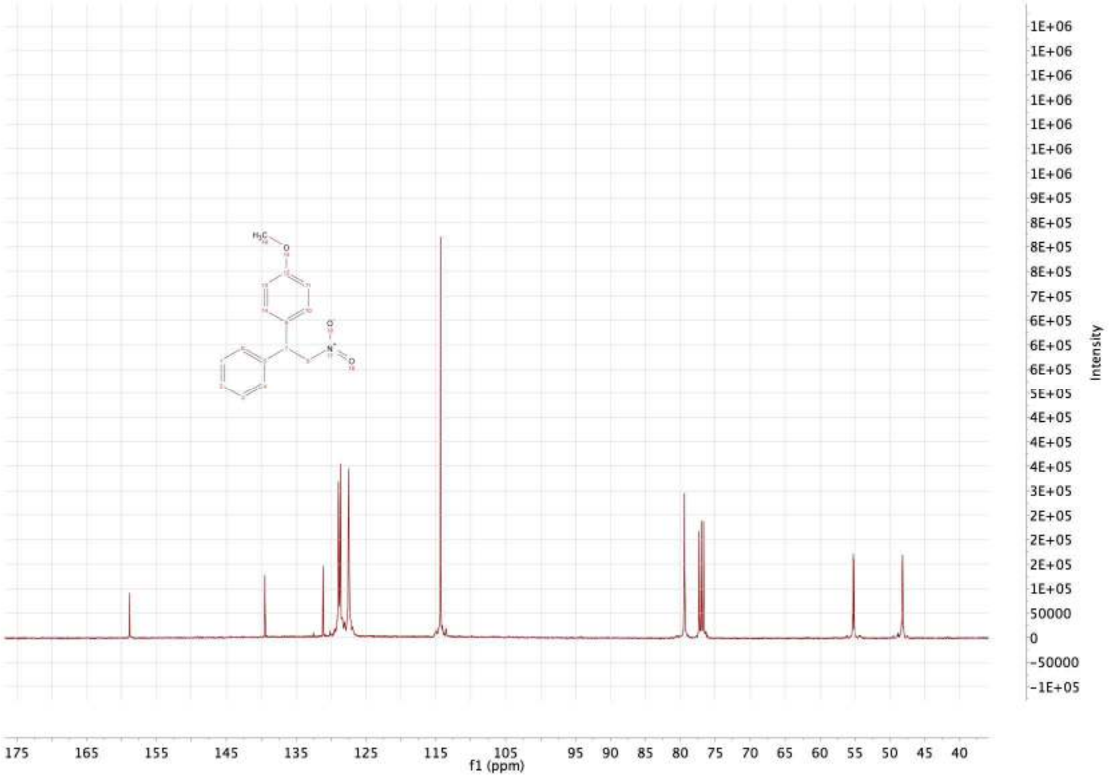
1,5-bis(4-methoxyphenyl)-1,5-diphenylpenta-1,4-dien-3-one (9b)



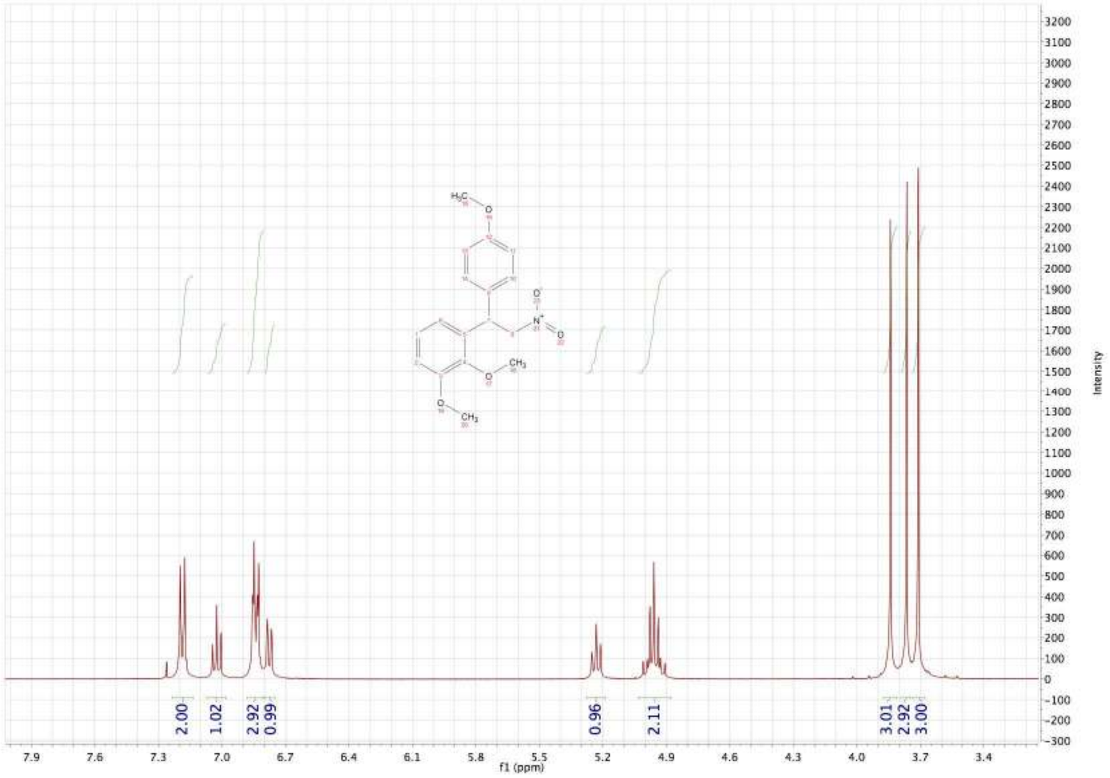


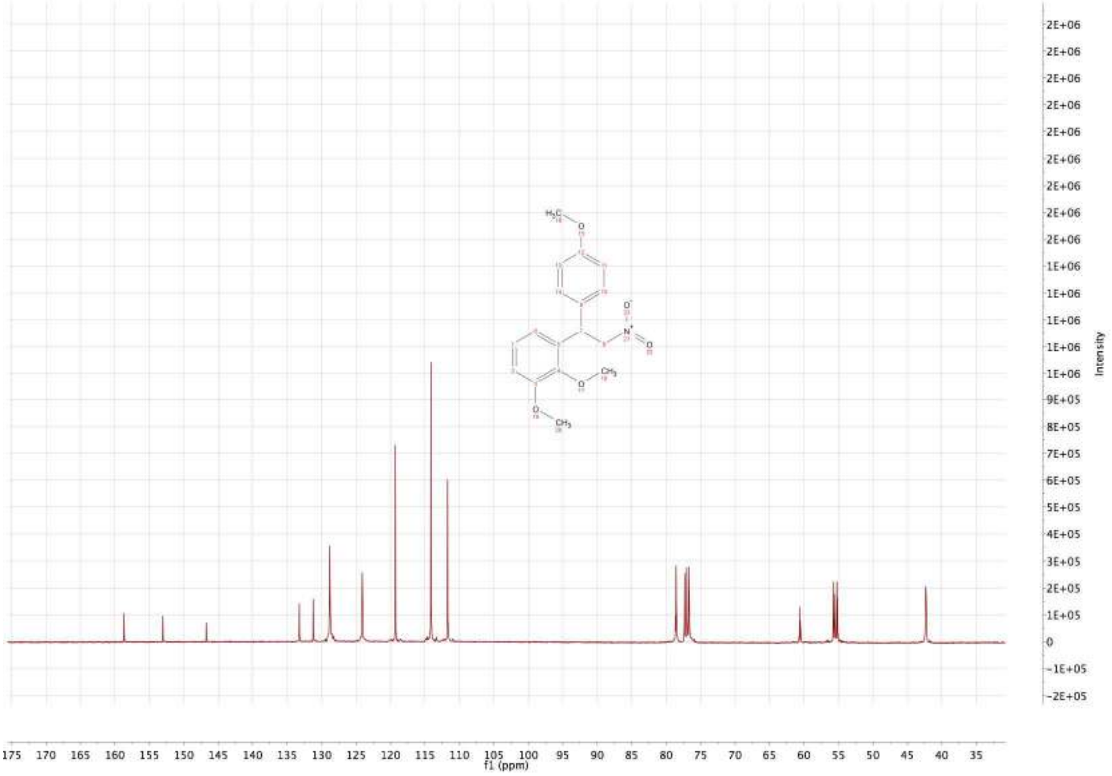
1-methoxy-4-(2-nitro-1-phenylethyl)benzene (11a)



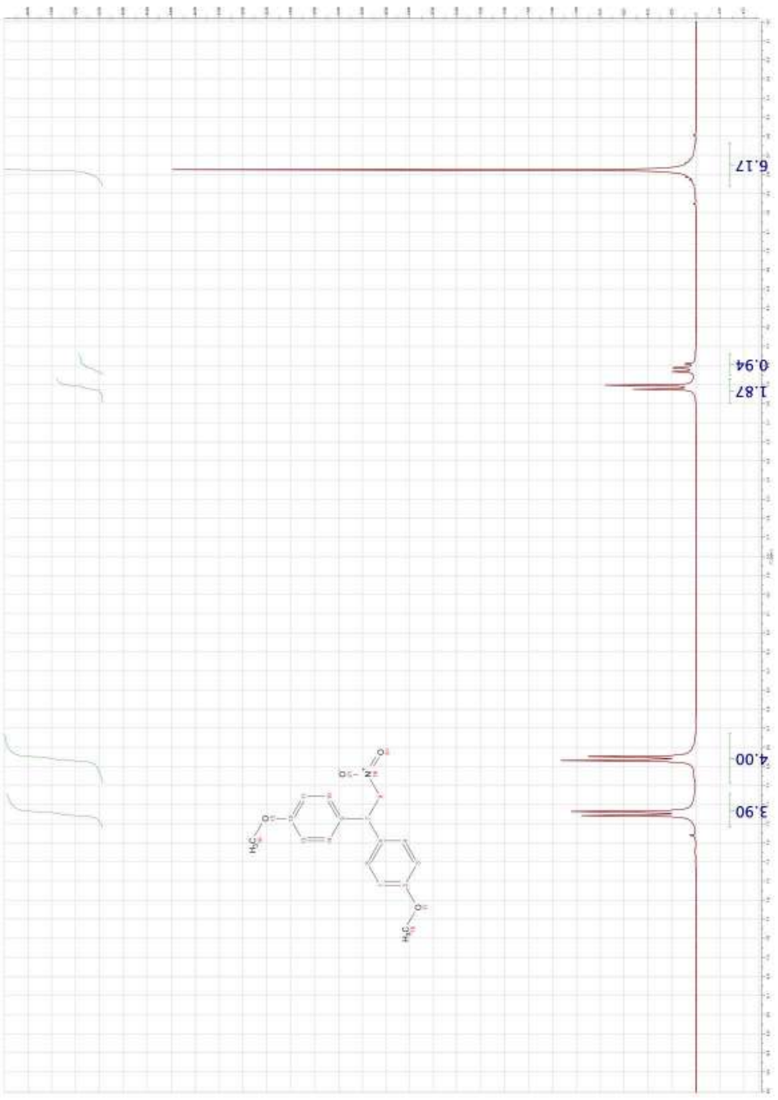


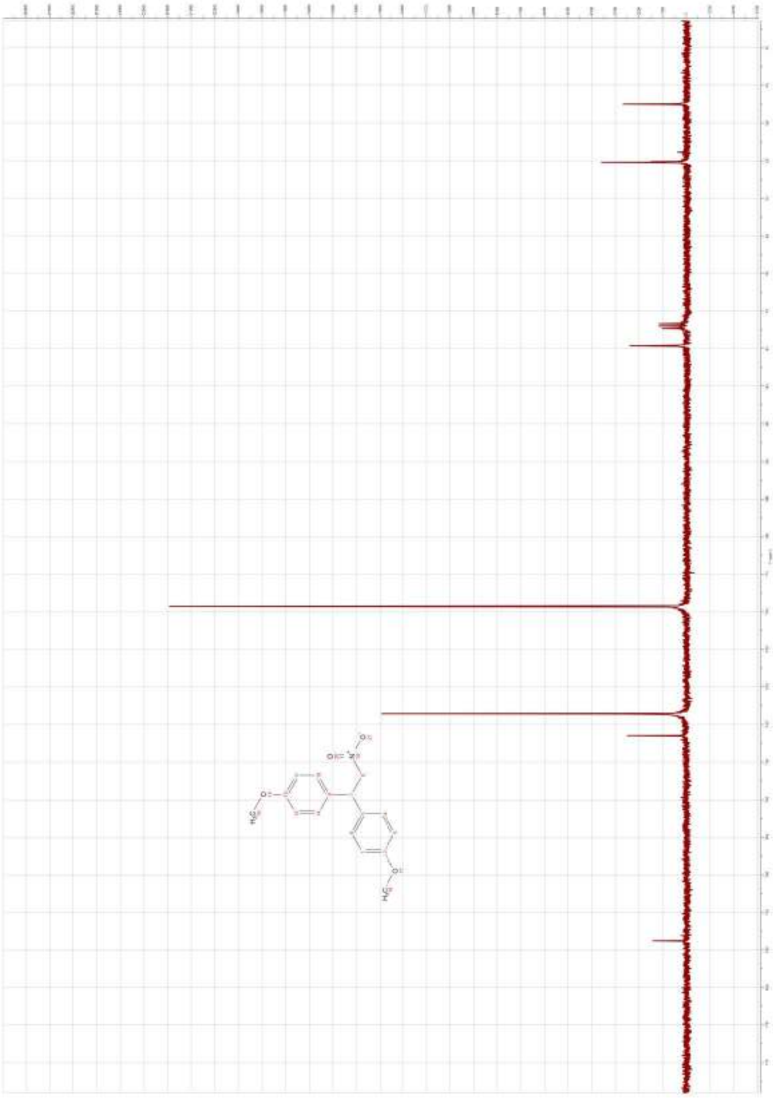
1,2-dimethoxy-3-(1-(4-methoxyphenyl)-2-nitroethyl) benzene (13a)



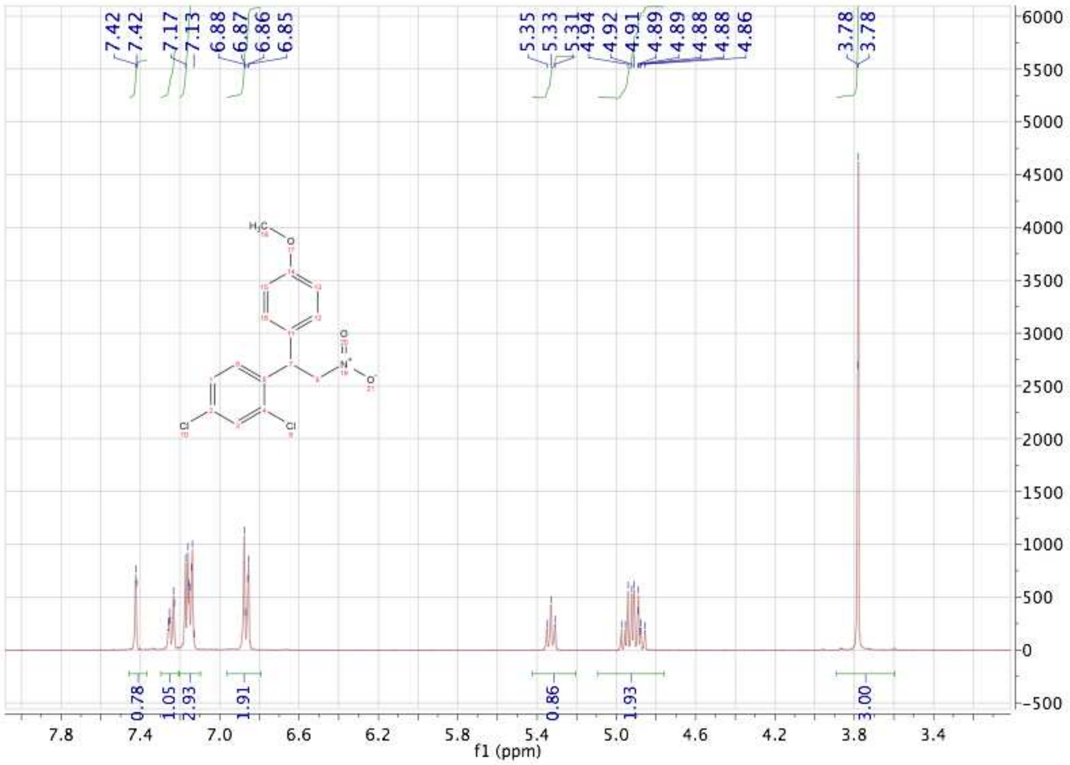


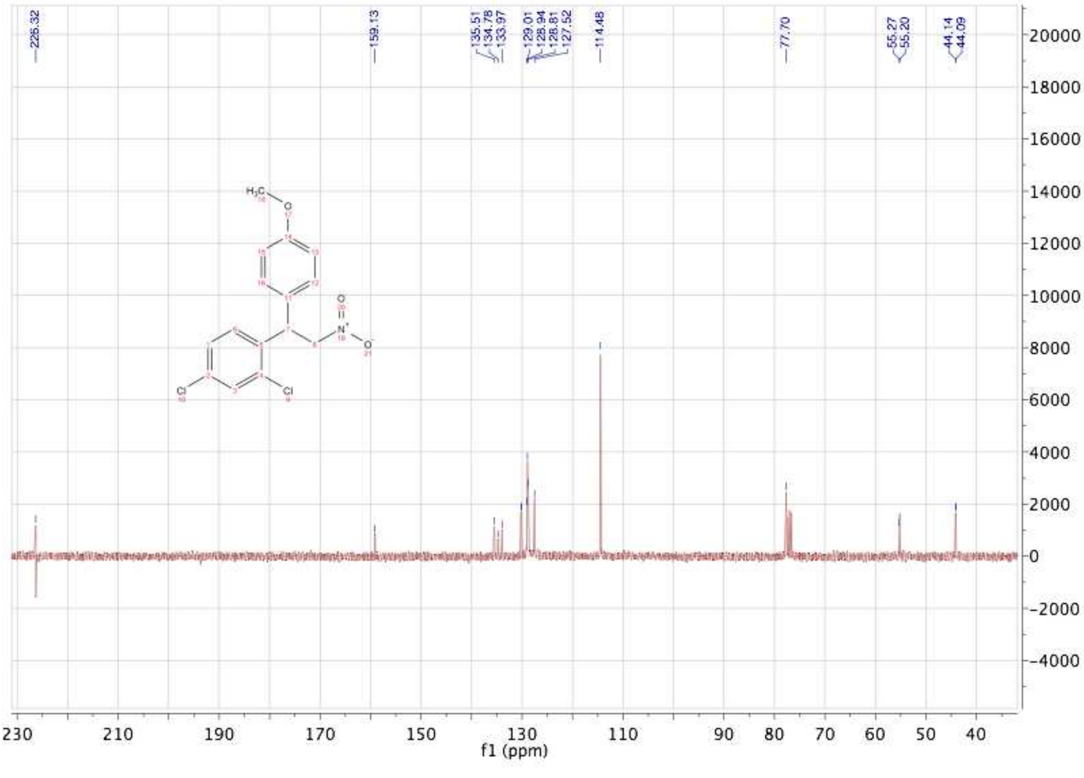
4,4'-(2-nitroethane-1,1-diyl)bis(methoxybenzene) (12a)



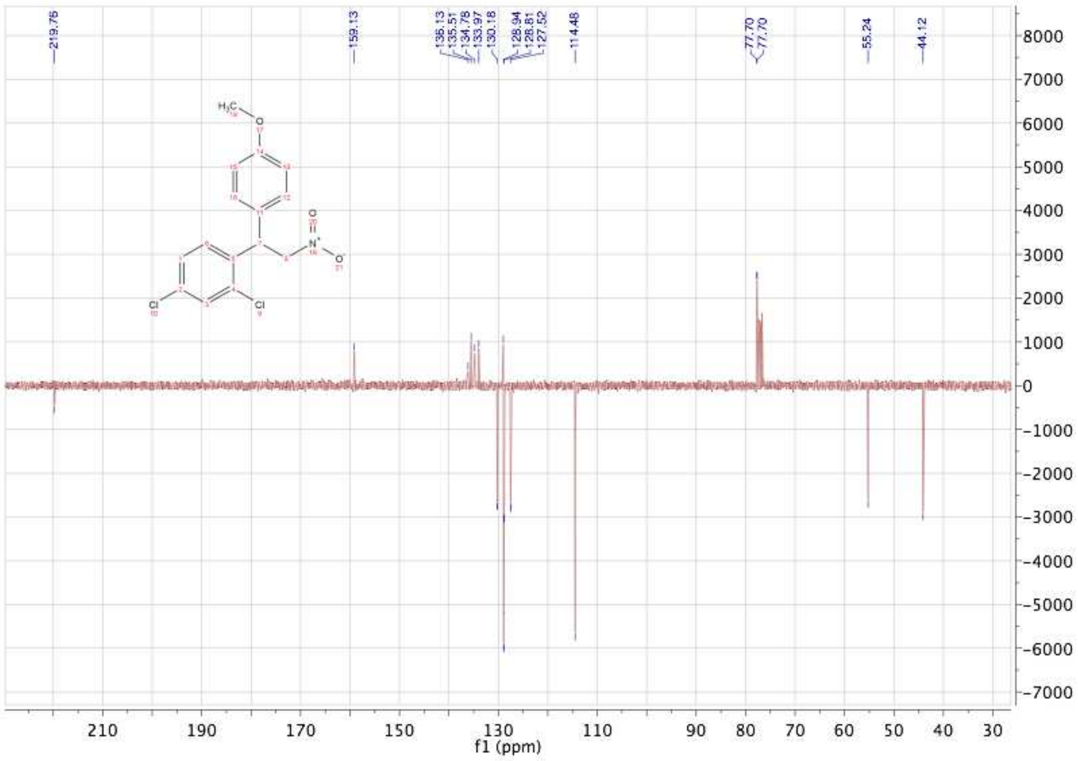


2,4-dichloro-1-(1-(4-methoxyphenyl)-2-nitroethyl)benzene (14a)

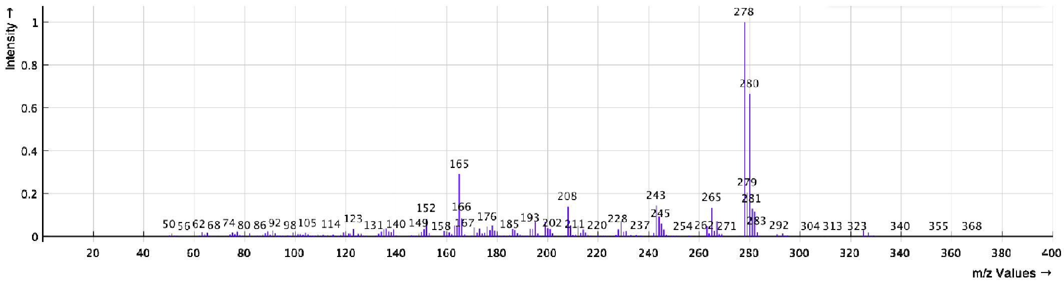




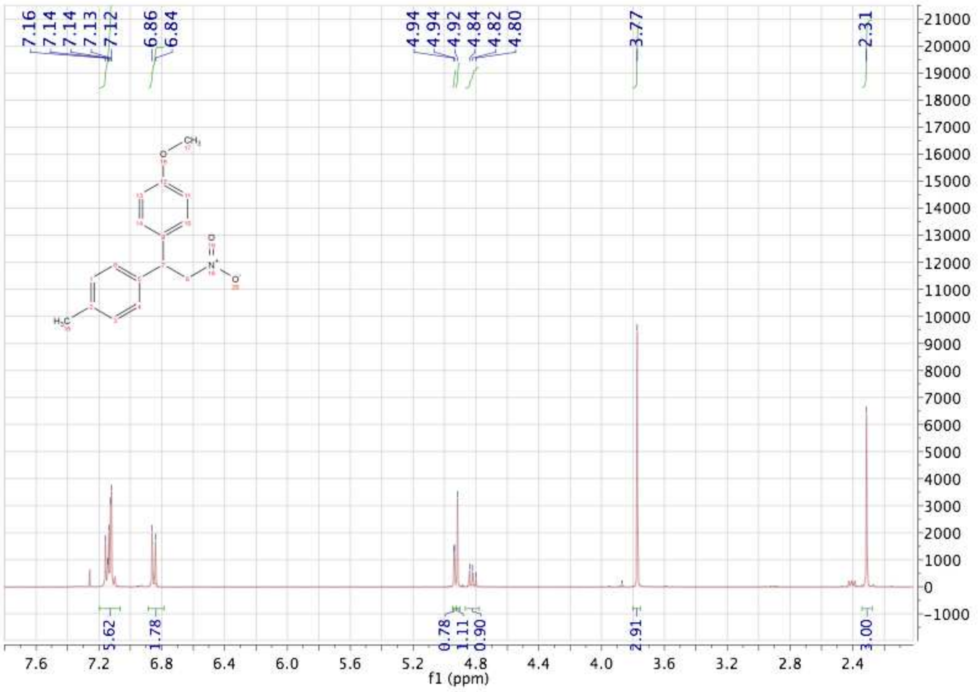
2,4-dichloro-1-(1-(4-methoxyphenyl)-2-nitroethyl)benzene (14a)

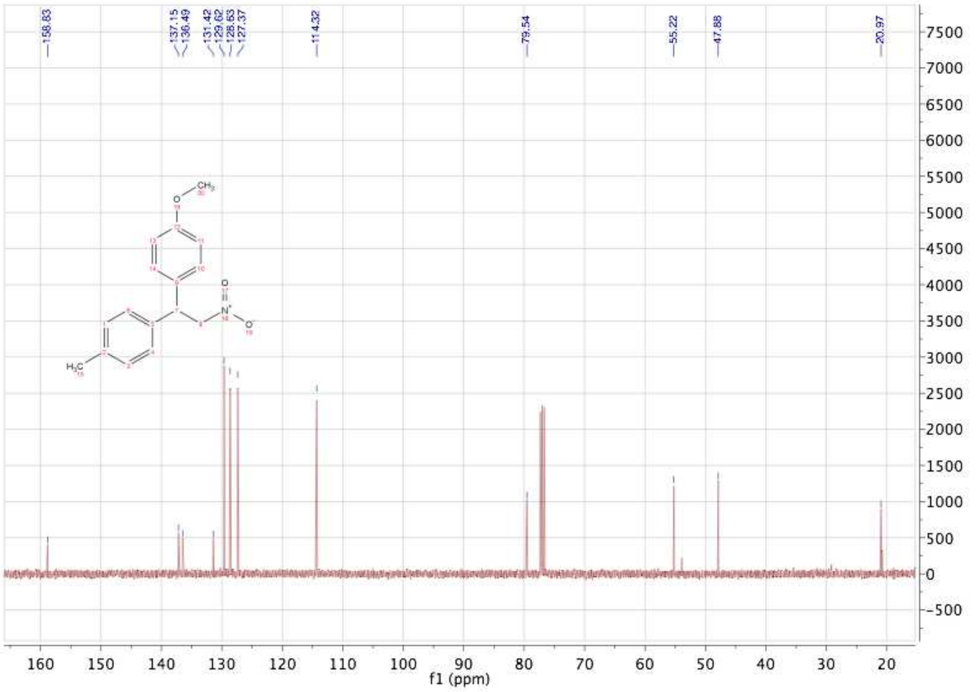


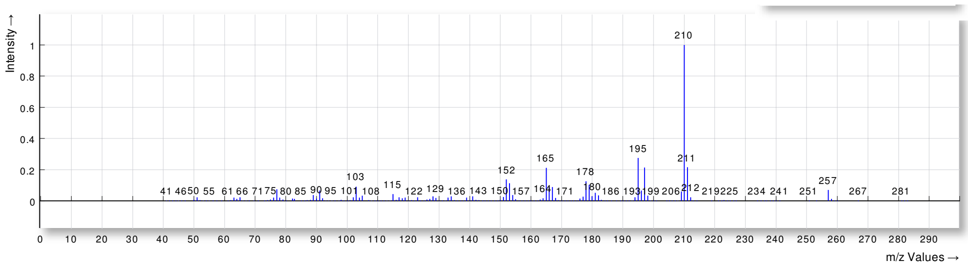
EI-MS Spectrogram for 14a



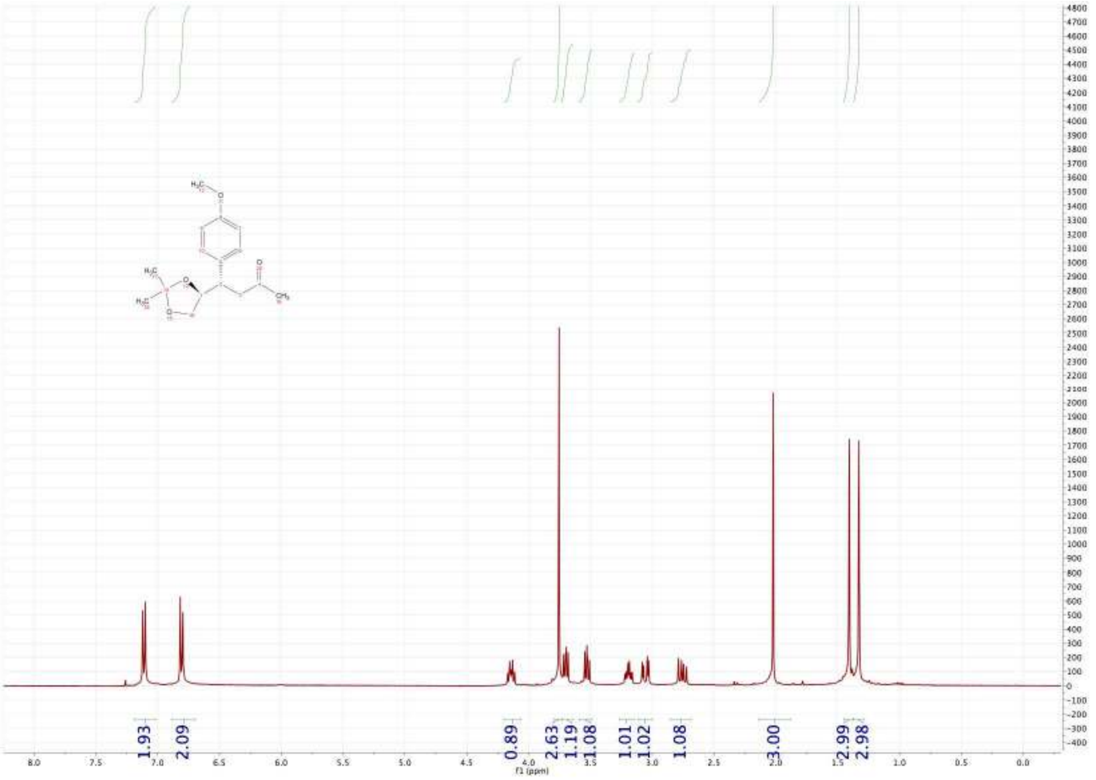
1-methoxy-4-(2-nitro-1-*p*-tolylethyl)benzene (15a)

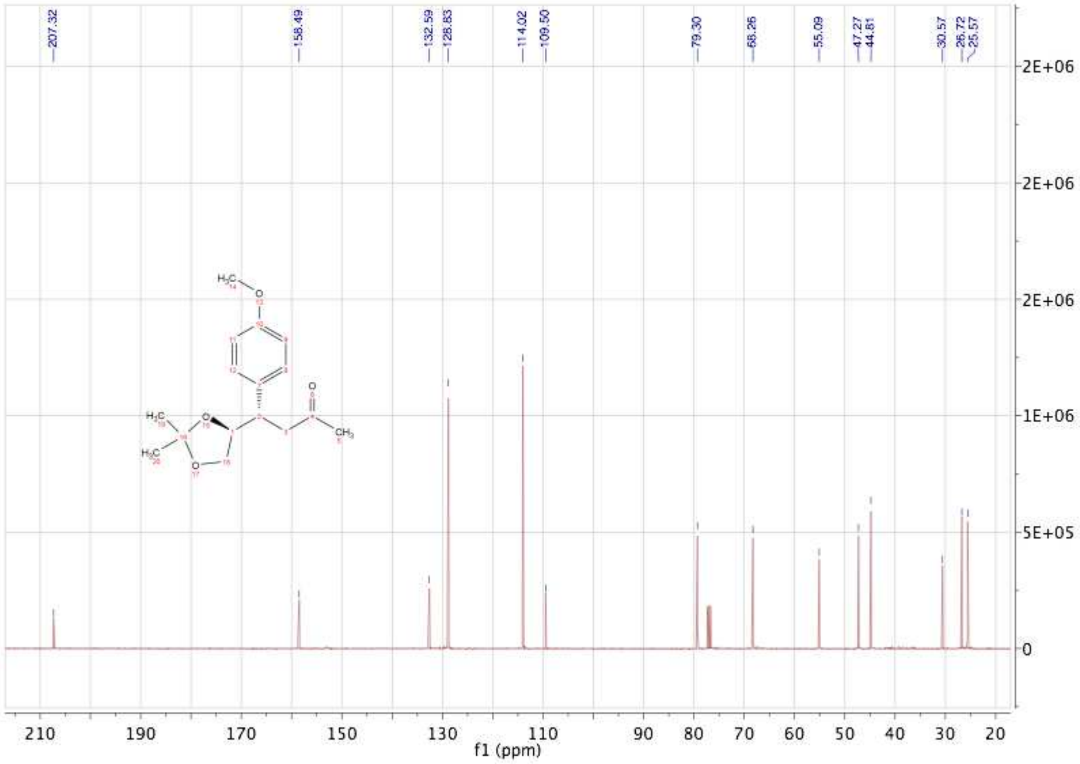




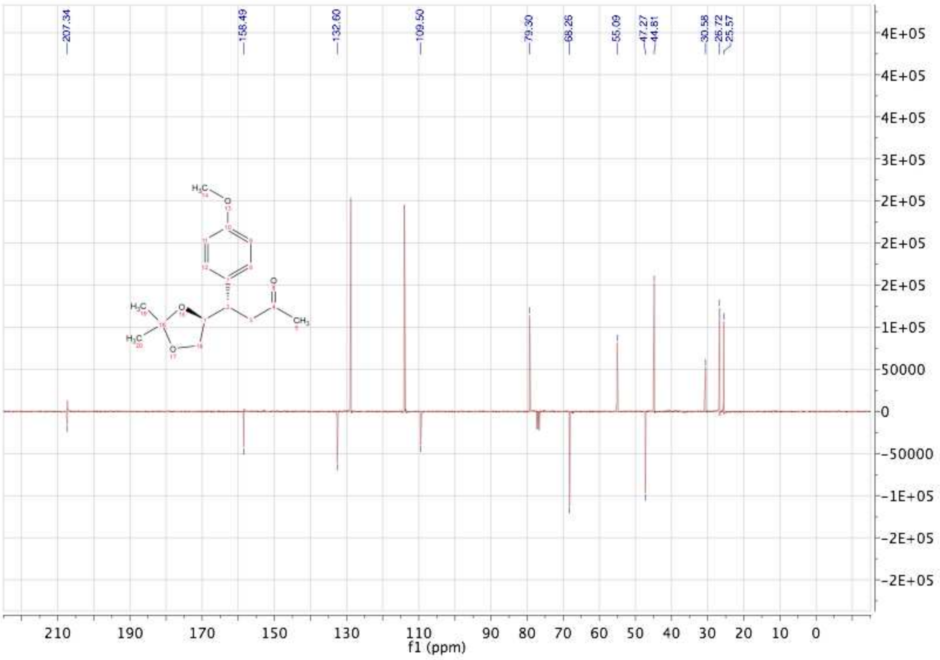


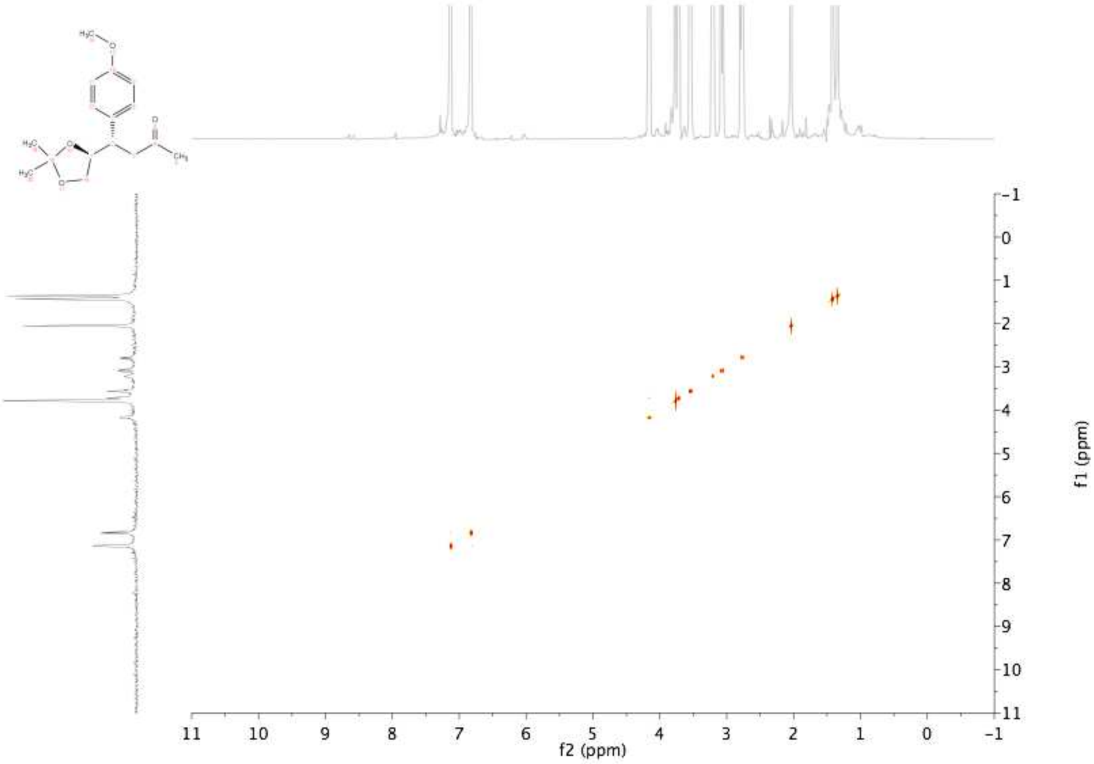
***ANTI*-4-(2,2-dimethyl-1,3-dioxolan-4-yl)-4-(4-methoxyphenyl)butan-2-one, 10a**

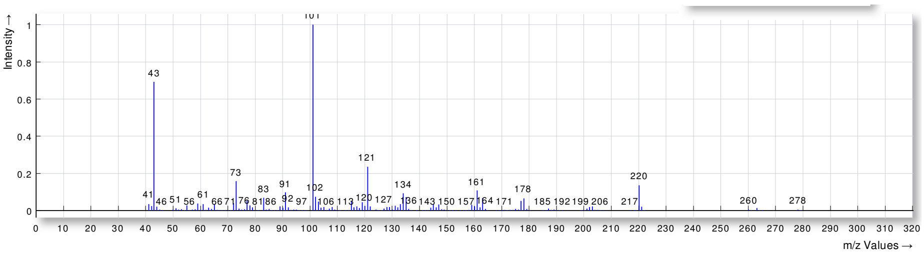




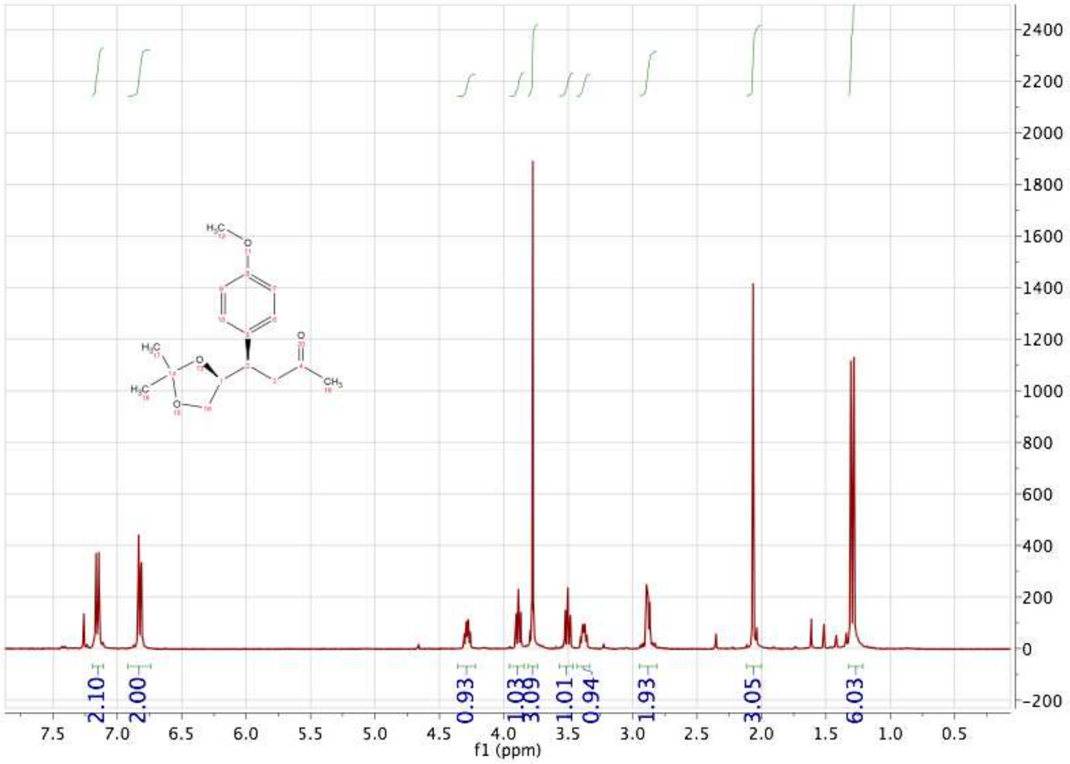
ANTI-4-(2,2-dimethyl-1,3-dioxolan-4-yl)-4-(4-methoxyphenyl)butan-2-one, 10a

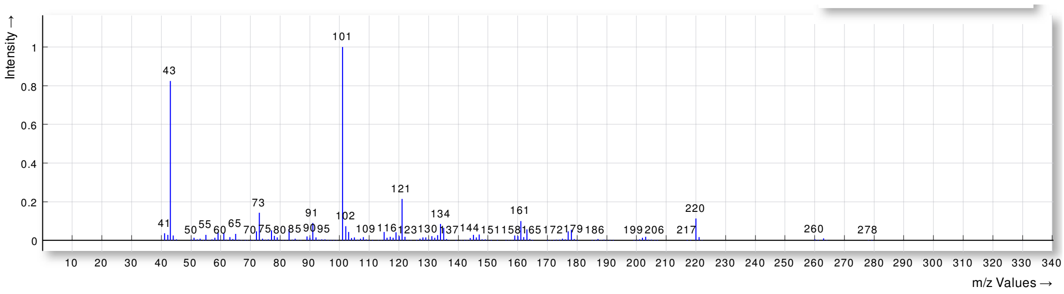






SYN–(2,2-dimethyl-1,3-dioxolan-4-yl)-4-(4-methoxyphenyl)butan-2-one, 10b





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