A Supramolecular Strategy for Selective Catalytic Hydrogenation Independent of Remote Chain Length

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General Experimental Details

Unless otherwise noted, all reactions were carried out in oven-dried glassware sealed with rubber septa or in a Schlenk flask under nitrogen atmosphere with Teflon® coated magnetic stir bars. Hydrogenation experiments were performed in Teflon® lined septum cap 1-dram vials with Teflon® coated magnetic stir bars. Diethyl ether (Et_2O), benzene, and methylene chloride (DCM) were dried by passing the previously degassed solvents through activated alumina columns under argon. Di-deuterium (D_2) and Deuterated solvents were purchased from Cambridge Isotope Laboratories, the solvents were sparged with N_2 for 30 minutes prior to storing in the glovebox. $[Rh(COD)_2][BF_4]$, 1,2-bis(dimethylphosphino)ethane, and $Ga(acac)_3$ (99.99% trace metals analysis) were purchased from Sigma Aldrich and used as received. Hydrogen gas was purchased from Praxair and used as recieved. All other reagents were purchased from Sigma Aldrich or Fischer Scientific and used as received without further purification. Ga_4L_6 assemblies **1** and **16** were prepared following previously reported procedures.[1,2] [(DMPE)RhCOD][BF_4] and encapsulated (DMPE)RhCOD (**2**) were prepared following a previously published method.[3] Silver impregnated silica gel was prepared following previously reported method and was used for separation of alk-ene and/or -yne products from alkanes.[4]

Proton nuclear magnetic resonance (^{1}H NMR) and proton decoupled phosphorus nuclear magnetic resonance ($\{^1H\}^{31}P$ NMR) spectra were taken with AVB-400, AVQ-400, AV-500, DRX-500, AV-600, or AV-700 Bruker spectrometers operating at 400MHz, 500 MHz, 600 MHz, or 700 MHz. Chemical shifts are reported in parts per million (ppm) with reference to the appropriate residual solvent signal.[5] GC/MS analysis was performed on an Agilent Technologies 5973 Network Gas Chromatograph with Mass Selective Detector equipped with a HP 5ms with 5% phenyl-methyl silox column (30 m x 250 µm x 0.25 µm). The run method is as follows: injector temperature 250 °C with 12:1 split, 1 mL/min flow rate (He carrier gas), initial oven temperature 85 °C for 5 minutes followed by a 50 °C/min ramp to 300 °C, followed by a 6 minute hold at 300 °C.

General procedures:

Preparation of [(DMPE)Rh(COD)][BF_4]:

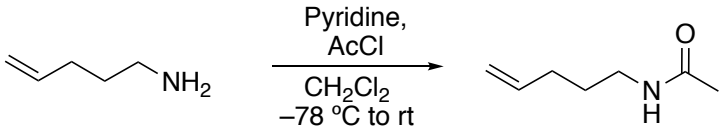
In an air-free glove box, a 20-mL scintillation vial was charged with a light orange solution of $[Rh(COD)_2][BF_4]$ (160 mg, 0.39 mmol) dissolved in CH_2Cl_2 (15 mL). DMPE (65 µL, 0.39 mmol) was added via syringe. The color turned deep orange and the solution was stirred for 30 min. The solvent was removed in vacuo to give an orange powder. The spectral data matched the previously published report: ^{1}H NMR (500 MHz, D_2O) δ: 5.24 (br, 4H, COD CH), 2.47 (m, 4H, COD

CH_2), 2.28 (br, 4H, COD CH_2), 1.85 (d, *J* = 18 Hz, 4H, dmpe CH_2), 1.50 (d, *J* = 8.8 Hz, 12H, dmpe CH_3). $^{13}C\{^1H\}$ NMR (D_2O) δ: 99.6 (s, COD CH), 30.2 (s, COD), 27.1 (m, dmpe), 12.7 (m, dmpe). $^{31}P\{^1H\}$ NMR (D_2O) δ: 35.9 (d, J_{Rh-P} = 144.7 Hz, dmpe).

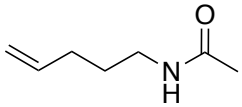
Encapsulation of [(DMPE)Rh(COD)][BF_4] (2) with Supramolecular host:

In an air-free glove box, an NMR tube was charged with rhodium species (4 mg, 0.009 mmol) dissolved in 0.5 mL D_2O. $Na_{12}[Ga_4L_6]$ (33 mg, 0.009 mmol) was added as a solid. The NMR tube was capped with a septum. The spectral data matched the previously published report: ^1H NMR (500 MHz, D_2O) δ: 8.13 (d, *J* = 5.65 Hz, 12H, aryl), 7.67 (d, *J* = 8.09 Hz, 12H, aryl), 7.38 (d, *J* = 8.09 Hz, 12H, aryl), 6.87 (t, *J* = 8.09 Hz, 12H, aryl), 6.76 (d, *J* = 6.71 Hz, 12H, aryl), 6.62 (d, *J* = 8.09 Hz, 12H, aryl), 1.74 (br, 4H, COD CH), 1.07 (m, 2H, COD CH_2), 0.91 (m, 2H, COD CH_2), 0.81 (m, 2H, COD CH_2), 0.81 (m, 2H, COD CH_2), 0.47 (m, 2H, COD CH_2), -0.63 (d, *J* = 8.09 Hz, 6H, dmpe CH_3), -0.86 (d, *J* = 8.09 Hz, 6H, dmpe CH_3), -1.20 (br, 4H, dmpe CH_2). $^{13}C\{^1H\}$ NMR (D_2O) δ: 126.6 (s), 119.8 (s), 118.6 (s), 116.0 (s), 115.7 (s), 115.4 (s), 96.1 (s), 95.4 (s), 31.1 (s), 27.7 (s), 24.7 (m), 11.4 (m), 10.8 (m). $^{31}P\{^1H\}$ NMR (D_2O) δ: 34.5 (d, J_{Rh-P} = 146.6 Hz, dmpe).

Preparation of hex-1-ene acetamide



1-Hexene amine (0.50 g, 5.0 mmol, 1.0 equiv.) was added to a flame dried round bottom equipped with a magnetic stir bar under positive nitrogen pressure. Dichloromethane (25 mL) was added via syringe and the reaction vessel was submerged into a –78 °C (acetone/dry ice) bath. Pyridine (0.71 mL, 8.8 mmol, 1.75 equiv.) was added by syringe followed by dropwise addition of acetyl chloride (0.45 mL, 6.3 equiv. 1.25 equiv.). The reaction flask was removed from the cold bath and allowed to come to room temperature and stirred for 3h until conversion was complete by TLC. The reaction was quenched with water (20 mL) and extracted with dichloromethane (3 x 20 mL). The combined organic layers were then washed with $CuSO_4$ (10% solution), brine, and then dried over Na_2SO_4. Solvent was removed under vacuum to yield a yellow oil. The crude material was purified by silica gel flash chromatography (100% hexanes to 95:5 to 90:10 to 85:15 to 80:20 hexanes/ethyl acetate) to yield the pure product.



N-(pent-4-en-1-yl)acetamide: ^{1}H NMR (499 MHz, $CDCl_3$) δ: 5.84–5.71 (m, 1H), 5.03–4.83 (m, 2H), 3.22 (q, *J* = 6.7 Hz, 2H), 2.05 (q, *J* = 7.3 Hz, 2H), 1.96 (s, 3H), 1.54–1.45 (m, 2H), 1.40 (p, *J* = 7.4 Hz, 2H).

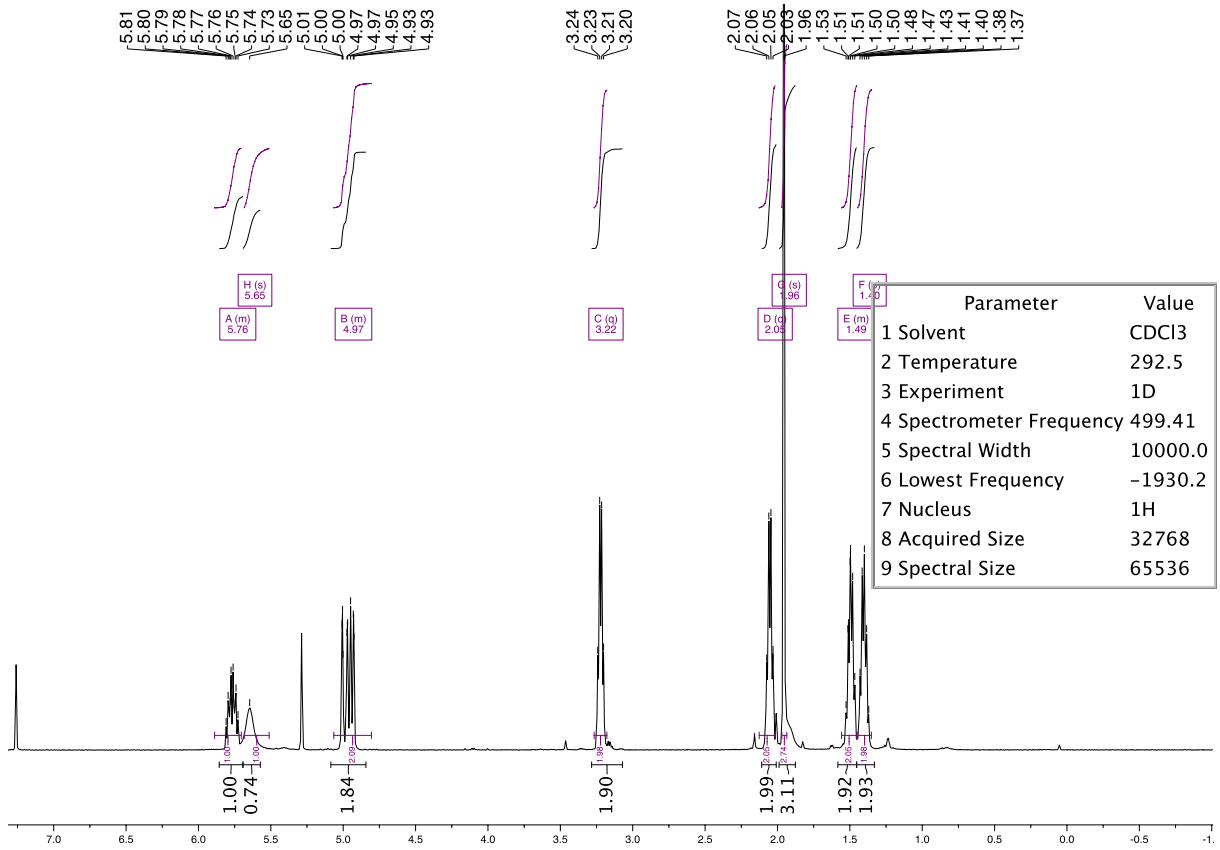
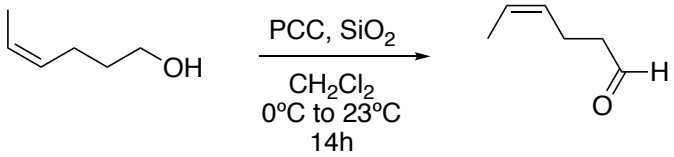


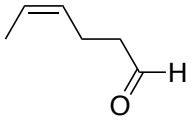
Figure S1. ^{1}H NMR of methyl-amide starting material.

Preparation of hex-2-ene-al



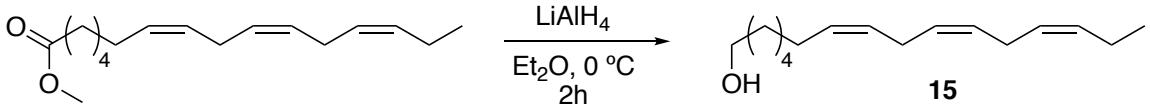
To a 250-mL round bottom flask equipped with a magnetic stir bar pyridinium dichromate (3.05 g, 8.0 mmol, 2 equiv.) and silica gel (1 g) were added. The flask was flushed with nitrogen and dichloromethane (20 mL) was added via syringe and the reaction was brought to 0 °C in an ice bath. To the dark stirring slurry, *cis*-4-hexen-1-ol (470 µL, 4.0 mmol, 1.0 equiv.) was added by syringe. The reaction was stirred for 14 h warming to room temperature. After 14 h full

conversion of the starting material was confirmed by TLC. The solids were removed by filtration over ceolite and the solvent was removed by rotatory evaporation to yield a yellow oil. The crude material was purified by silica gel flash chromatography (100% hexanes to 95:5 to 90:10 to 85:15 to 80:20 hexanes/diethyl ether) to yield the product in pure form.

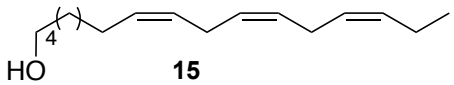


(*Z*)-hex-4-enal**:** ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.77 (t, *J* = 1.6 Hz, 1H), 5.58–5.42 (m, 2H), 5.41–5.29 (m, 2H), 2.49 (tt, *J* = 7.1, 1.4 Hz, 2H), 2.42–2.37 (m, 2H), 1.65–1.60 (m, 3H).

Preparation of linolenate alcohol (15)



To a 50-mL round bottom flask equipped with a magnetic stir bar methyl linolenate (1.0 g, 3.4 mmol, 1.0 equiv.) was added and the flask placed under positive N_2 pressure and placed into a 0 °C water bath. Diethyl ether was then added (20 mL) by syringe followed by portion-wise addition of $LiAlH_4$ (0.13 g, 3.4 mmol, 1.0 equiv.). The reaction was complete after 2h by TLC and quenched by the addition of water (1 mL) followed by 1.0 M NaOH solution and allowed to stir for 30 minutes. Solids were removed by filtration over ceolite and the organic layer was dried with $MgSO_4$. The solution was filtered and concentrated under rotatory evaporation to yield a yellow oil. The title compound was purified by silica gel column chromatography (4:1 hexanes/ethyl acetate) to yield **15** in pure form.



^{1}H NMR (500 MHz, $CDCl_3$) δ: 5.45–5.26 (m, 6H), 3.63 (t, *J* = 6.6 Hz, 2H), 2.80 (t, *J* = 6.2 Hz, 4H), 2.12–2.00 (m, 4H), 1.61–1.52 (m, 2H), 1.40–1.27 (m, 11H), 0.97 (t, *J* = 7.6 Hz, 3H).

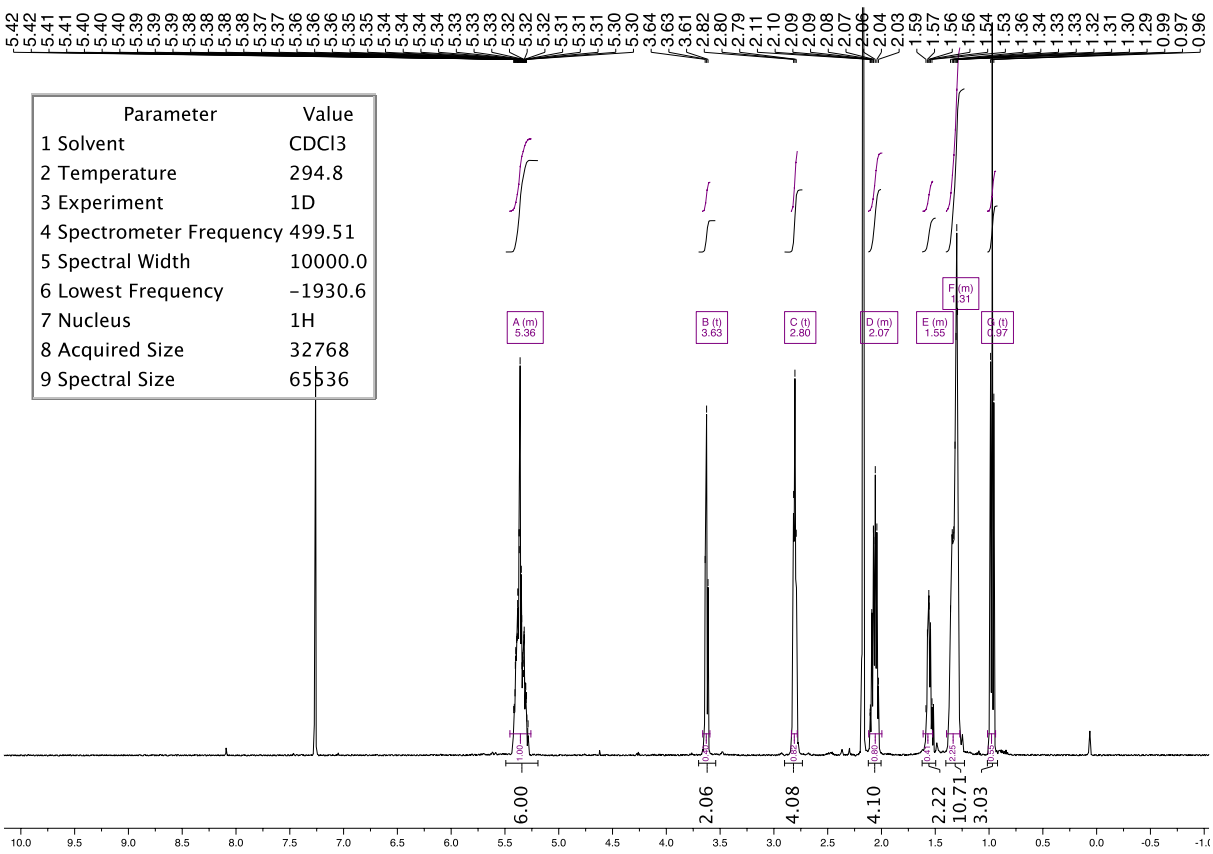


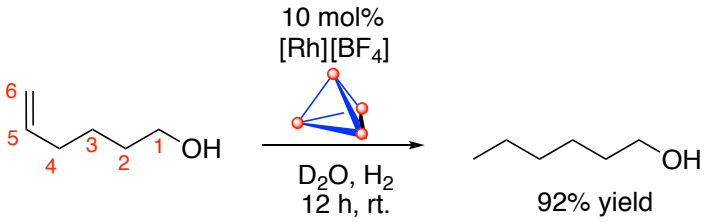
Figure S2. ^{1}H NMR of linolenic alcohol starting material **15**.

General Procedure for Hydrogenation Reactions:

In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol), and degassed H_2O (1.0 mL). To this substrate was added (0.05 mmol) by microliter syringe and then sealed with a Teflon® lined septum cap. The reaction vial was removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred at room temperature for the given reaction time under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layer was collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath for volatile compounds. The product and/or starting material was then isolated via gravity silica gel column chromatography.

<u>Hydrogenation of Substrates from Table 1</u>

Hydrogenation of 5-hexen-1-ol



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed D_2O (1.0 mL). To this substrate was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 12 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the organic layers were collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compound was then passed over a plug of silica gel eluting with dichloromethane to yield the product in pure form (5 mg, 0.046 mmol, 92 % yield).

In-situ NMR pre-hydrogenation:

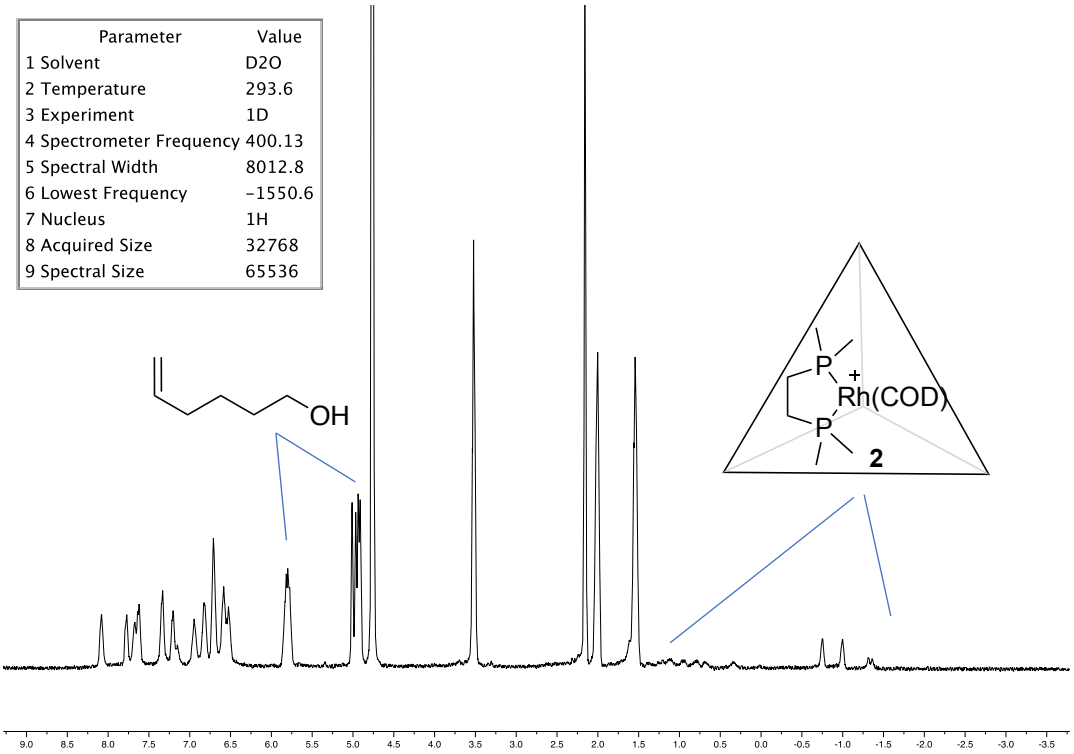


Figure S3. In-situ ^{1}H NMR of substrate and encapsulated (DMPE)RhCOD$^+$ (**1**).

Post-hydrogenation [Et_4N][Cl] addition:

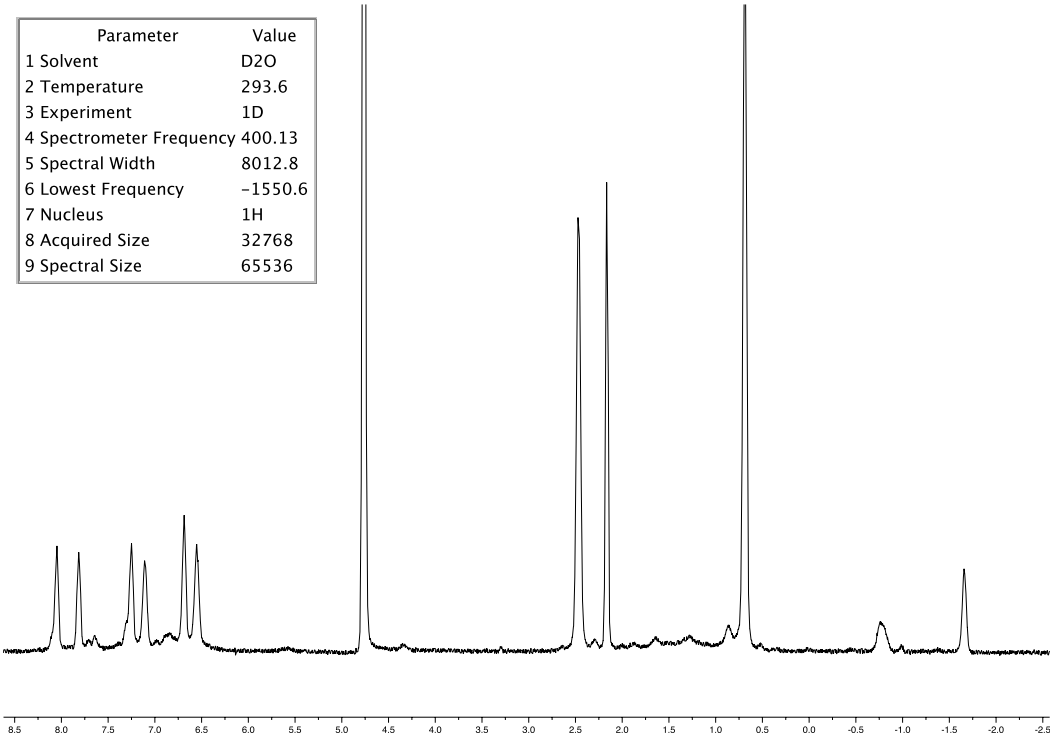
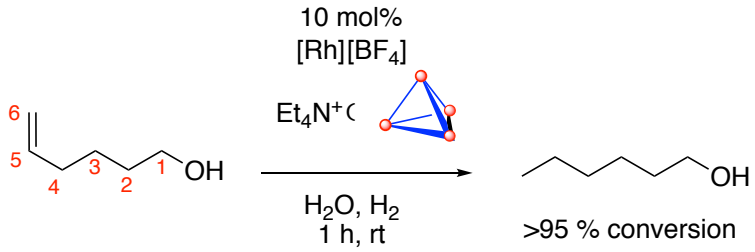


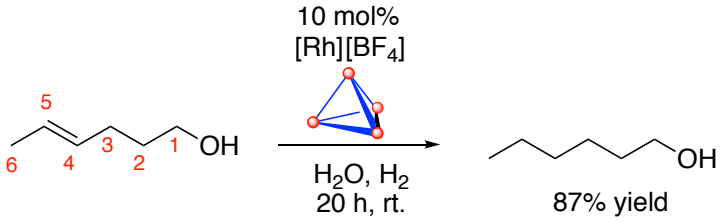
Figure S4. Addition of 1.0 equivalent of [Et_4N][Cl] after hydrogenation reaction, demonstrating that the supramolecular host remained stable over the reaction time.

Et_4N^+-blocked control for Hydrogenation of 5-hexen-1-ol



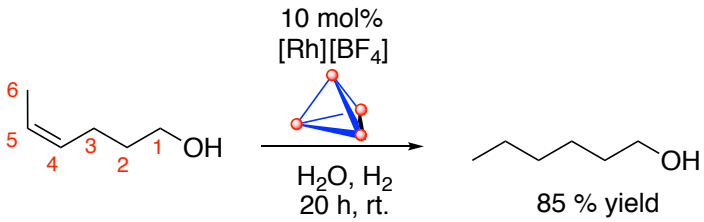
In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), [Et_4N][Cl] (1.0 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this substrate was added (6 µL, 0.050 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 1 hour. The reaction was then extracted into $CDCl_3$ (0.60 µL) showing full conversion of starting material to 1-hexanol.

Hydrogenation of *trans*-4-hexen-1-ol



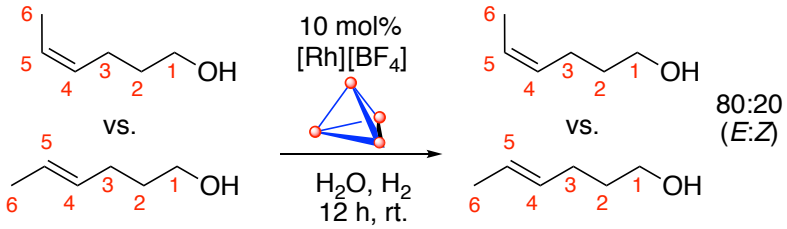
In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this, substrate was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 20 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the organic layers were collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compound was then passed over a plug of silica gel eluting with dichloromethane to yield the product in pure form (4.4 mg, 0.043 mmol, 87 % yield).

Hydrogenation of *cis*-4-hexen-1-ol



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this substrate was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 20 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the organic layers were collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compound was then passed over a plug of silica gel eluting with dichloromethane to yield the product in pure form (4.3 mg, 0.042 mmol, 85 % yield).

Competition reaction *cis*- vs *trans*-4-hexen-1-ol



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this equimolar amounts of substrates were added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 12 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the organic layers were collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The reaction mixture was then dissolved into $CDCl_3$ to determine conversion ratio by ^{1}H NMR.

Parameter	Value
1 Solvent	CDCl3
2 Temperature	292.5
3 Experiment	1D
4 Spectrometer Frequency	499.51
5 Spectral Width	10000.0
6 Lowest Frequency	-661.8
7 Nucleus	1H
8 Acquired Size	32768
9 Spectral Size	65536

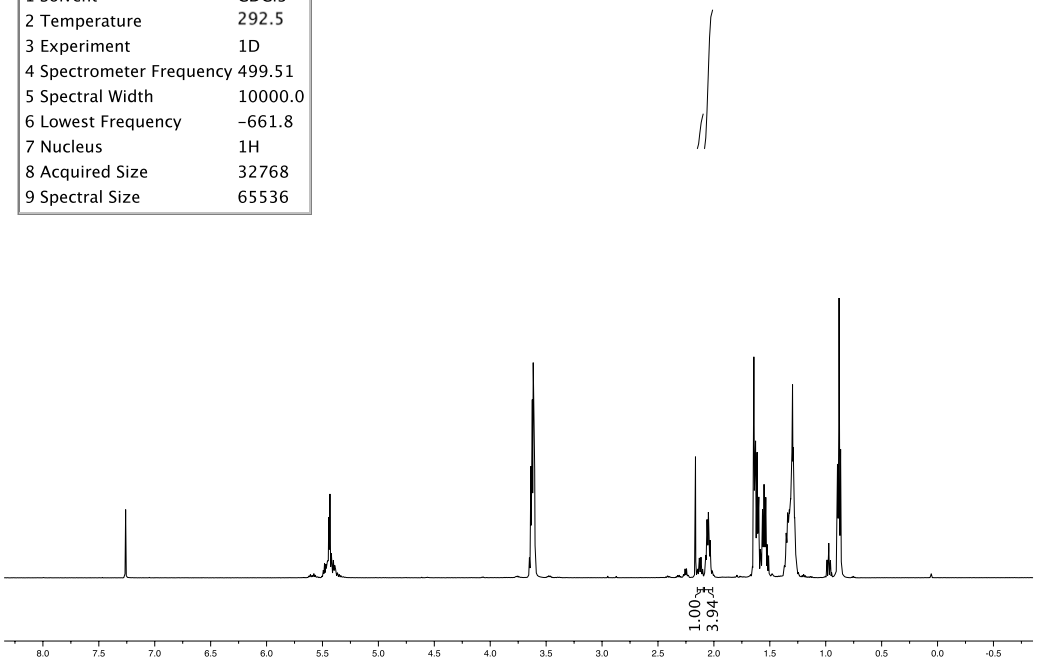
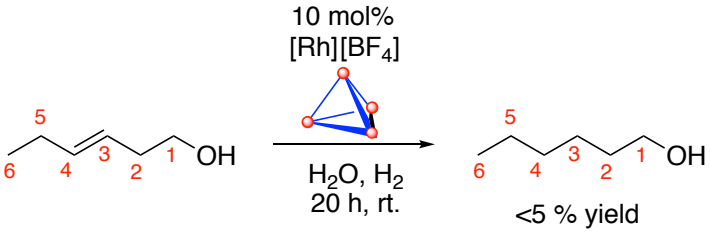


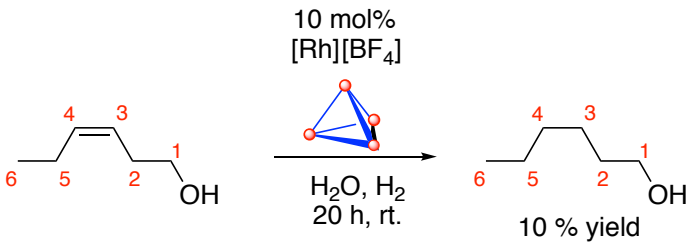
Figure S5. ^{1}H NMR of crude reaction demonstrating *cis*- olefin is consumed at a greater rate than *trans*-olefin.

Hydrogenation of *trans*-3-hexen-1-ol



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this substrate was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 20 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the organic layers were collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compound was then passed over a plug of silica gel eluting with dichloromethane. By ^{1}H NMR trace conversion of starting material was observed.

Hydrogenation of *cis*-3-hexen-1-ol



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this substrate was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 20 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the organic layers were collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compound was then passed over a plug of silica gel eluting with dichloromethane. By ^{1}H NMR ~10% conversion of starting material was observed.

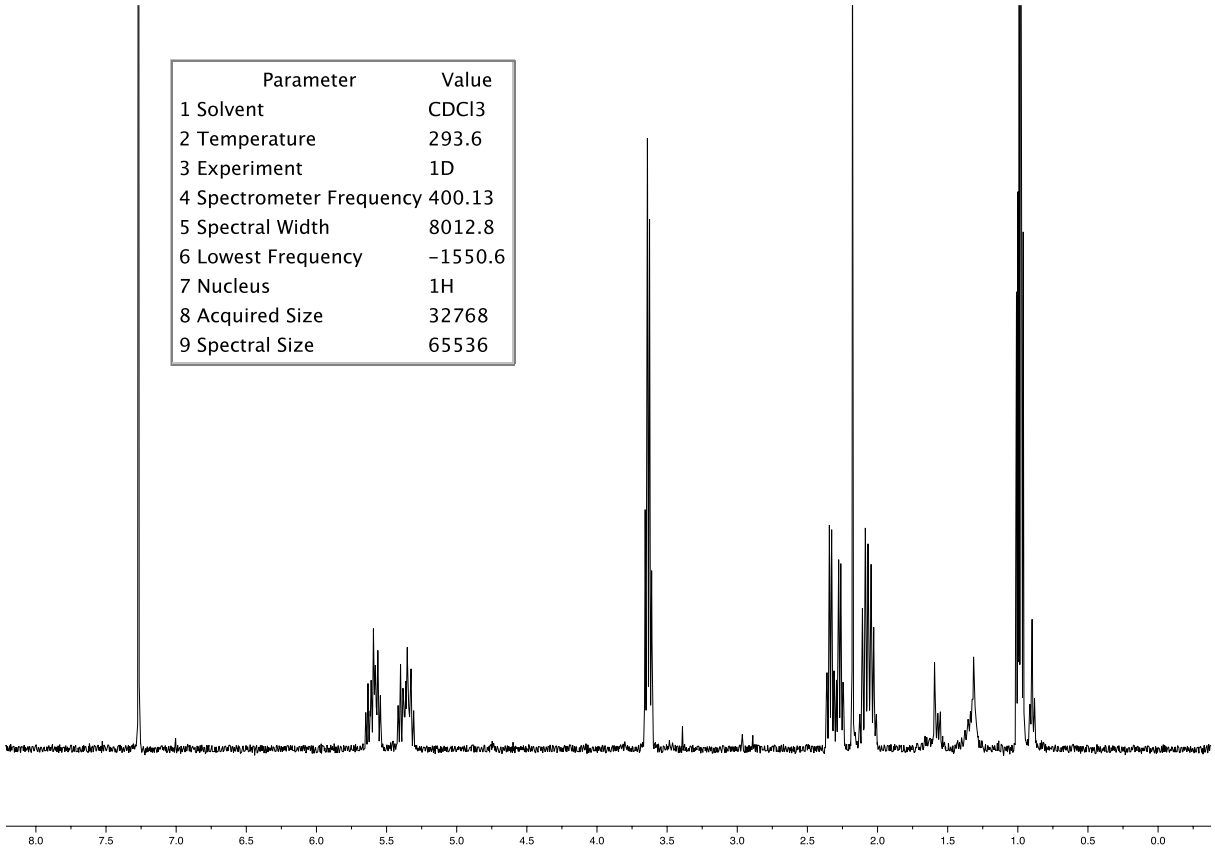
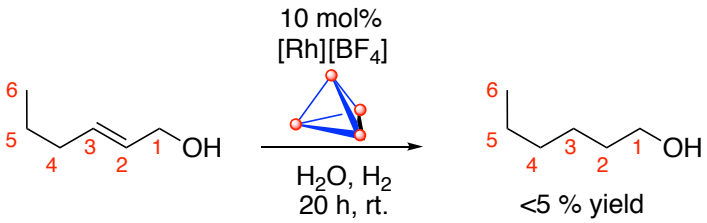


Figure S6. ^{1}H NMR showing minor conversion of the starting material under supramolecular catalysis conditions.

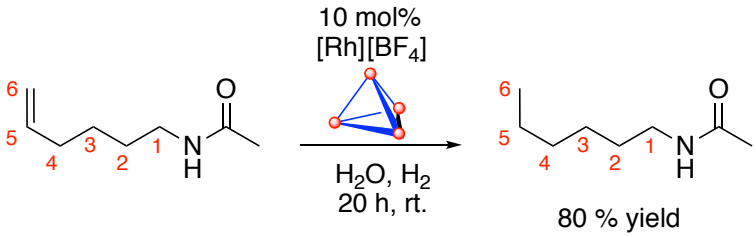
Hydrogenation of *cis*-4-hexen-1-ol



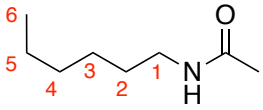
In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this substrate was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 20 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2

mL), the organic layers were collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compound was then passed over a plug of silica gel eluting with dichloromethane. By ^{1}H NMR trace conversion of starting material was observed.

Hydrogenation of *N*-Ac-hexen-1-en



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this substrate was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 20 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the organic layers were collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compound was then passed over a plug of silica gel eluting with dichloromethane to yield the product in pure form.



^{1}H NMR (300 MHz, $CDCl_3$) δ: 3.23 (q, *J* = 7.0, 2H), 2.18–2.22 (m, 2H), 1.98 (s, 3H), 1.47-1.52 (m, 2H), 1.11–1.29 (m, 9H), 0.89 (t, J=7.0 Hz, 3H).

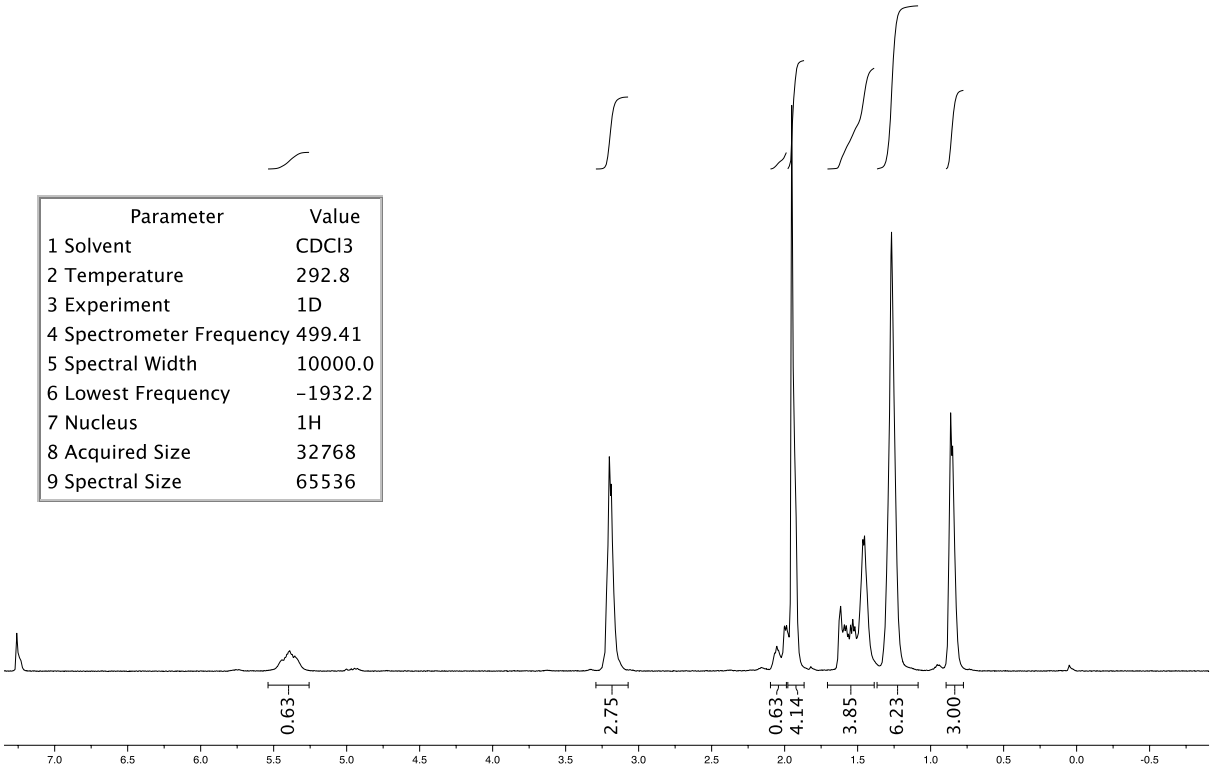
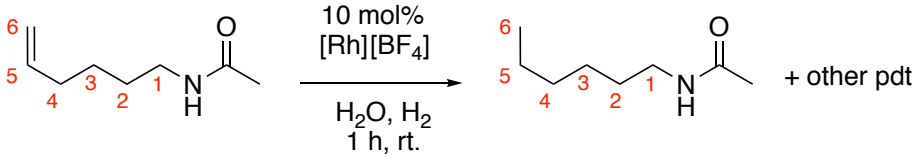


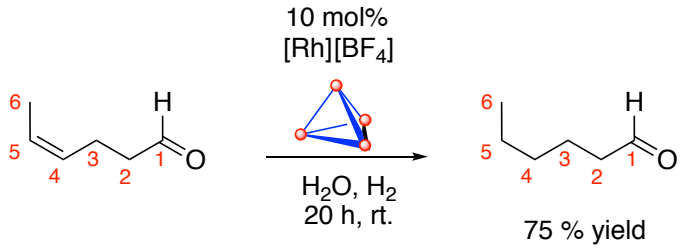
Figure S7. ^{1}H NMR of hydrogenated amide product from supramolecular hydrogenation.

Hydrogenation of *N*-Ac-hexen-1-en with free catalyst 2



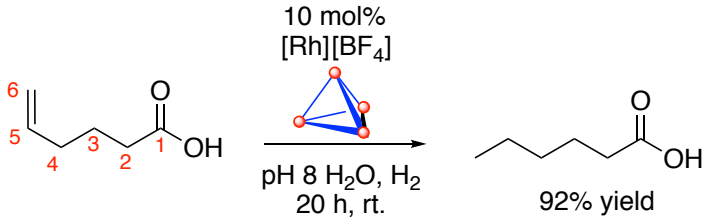
In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol, 0.1 equiv.) and degassed H_2O (1.0 mL). To this substrate was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 1 h. After this time, the red solution had become colorless and rhodium black was visible in the reaction vial. The sample was extracted into $CDCl_3$ (0.60 mL) and by ^{1}HNMR hydrogenated product was observed along with another product that was not identified. This other species was not observed in the supramolecular catalysis reaction.

Hydrogenation of hexen-2-enal



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this substrate was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction mixture was allowed to stir for 20 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layer was collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compound was then passed over a plug of silica gel eluting with dichloromethane to yield the product in pure form.

Hydrogenation of 5-hexenoic acid



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL, pH 8, 100 mM phosphate buffer). To this substrate was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction mixture was allowed to stir for 20 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layer was collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compound was then passed over a plug of silica gel eluting with dichloromethane to yield the product in pure form (5.3 mg, 0.046 mmol, 92 % yield).

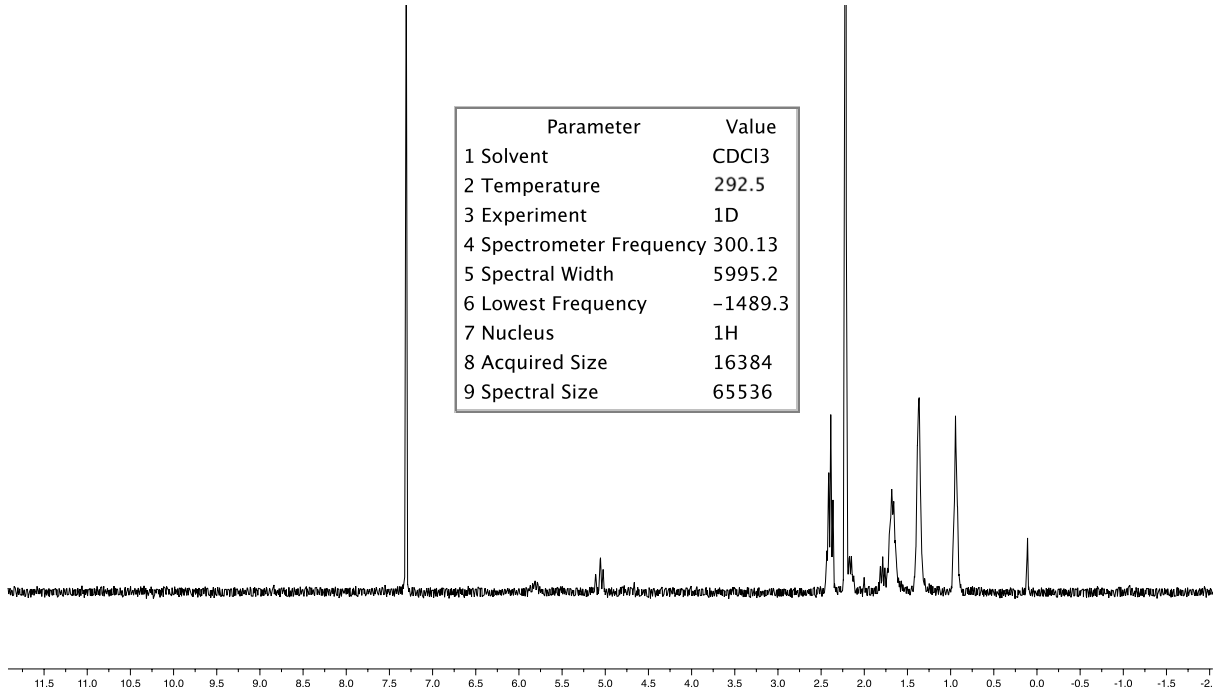
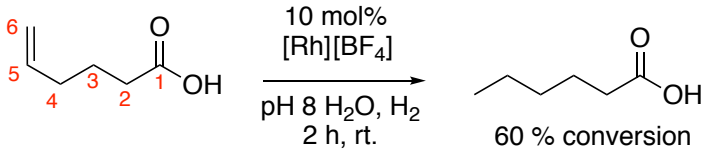


Figure S8. ^{1}H NMR of hydrogenated hexenoic acid under buffered conditions in the presence of the supramolecular catalyst.

Hydrogenation of 5-hexenoic acid with free catalyst 2



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol, 0.1 equiv.) and degassed H_2O (1.0 mL, pH 8, 100 mM phosphate buffer). To this substrate was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred. After 1 h of stirring the red solution had become colorless and rhodium black was visible in the reaction vial. After an addition 1 h, the sample was extracted into $CDCl_3$ (0.60 mL) and by ^{1}HNMR starting material remained along with 60% of the hydrogenated product.

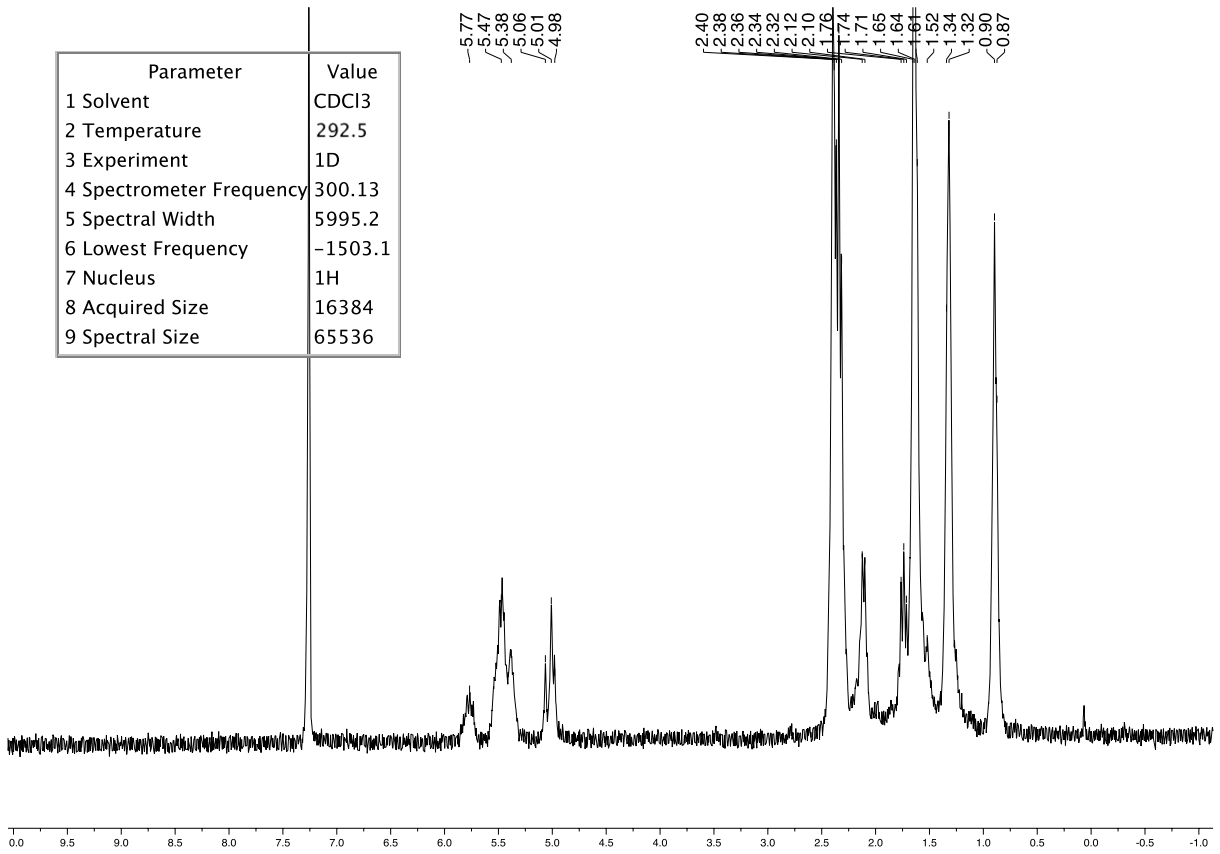
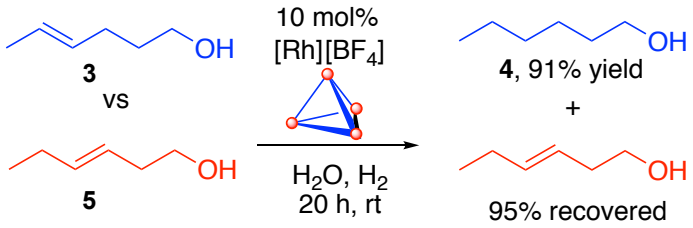


Figure S9. ^{1}H NMR showing incomplete conversion of hexenoic acid under non-supramolecular catalysis conditions. Rapid catalyst decomposition occurs resulting in incomplete conversion.

Supramolecular supported competition reaction between methyl- and ethyl-olefin



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this 1:1 amounts of both substrates were added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 20 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layer was collected and dried over sodium

sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compounds were then isolated via gravity silica gel (Ag impregnated) column (100% hexanes to 90:10 to 85:15 to 80:20 hexanes:ethyl acetate) to yield the product and recovered starting material in pure form.

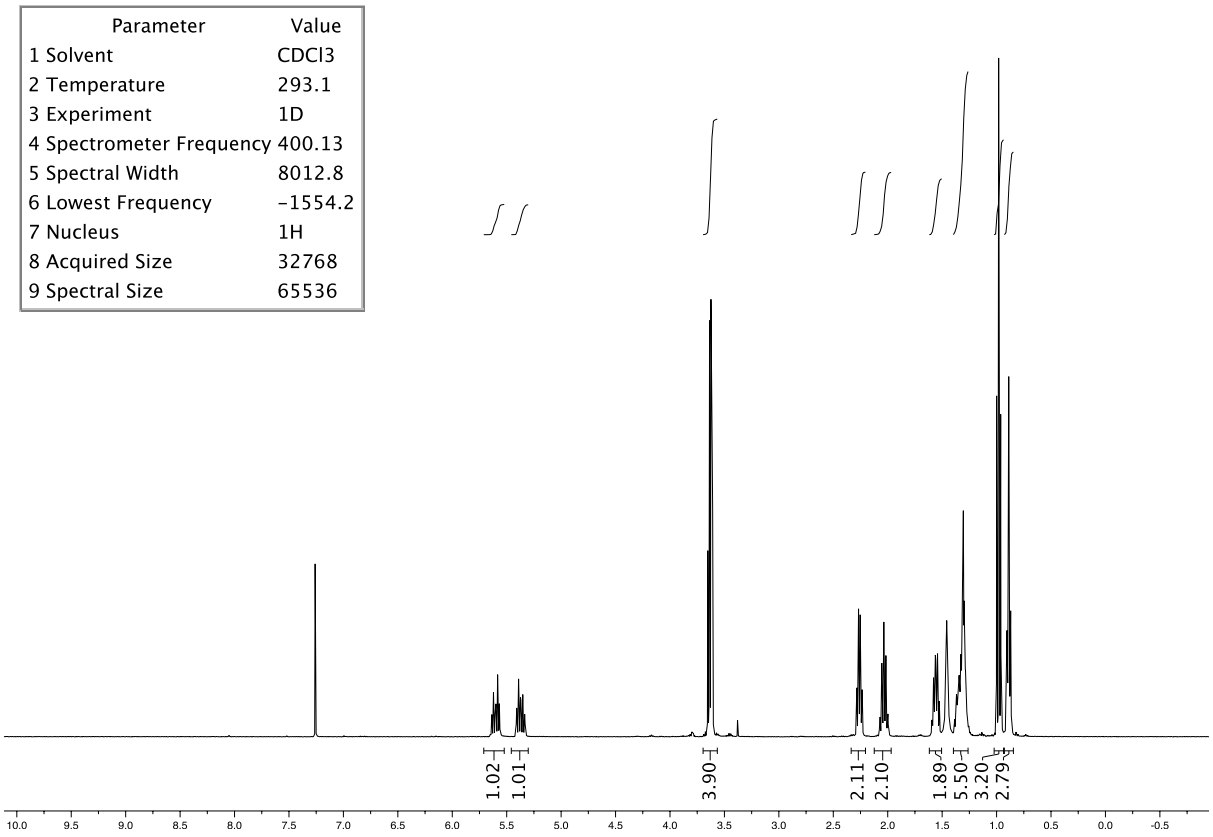
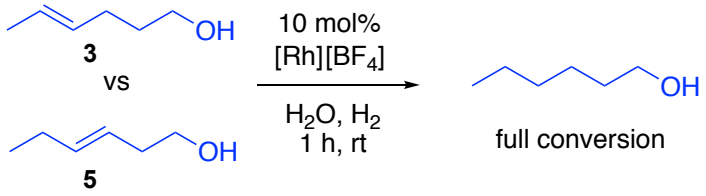


Figure S10. ^{1}H NMR showing complete conversion methyl-olefin substrate and remaining 3-*trans*-hexen-1ol.

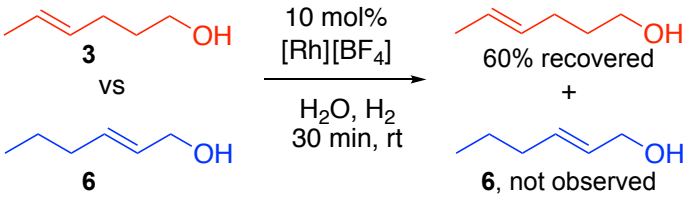
Free rhodium catalyzed competition reaction between methyl- and ethyl-olefin



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol) and degassed H_2O (1.0 mL). To this 1:1 amounts of both substrates were added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes.

After sparging, the vent needle was removed and the reaction was stirred for 1 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layers were collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. By ^{1}H NMR full conversion of starting material was observed.

Free rhodium catalyzed competition reaction between allylic and non-allylic substrates



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol) and degassed H_2O (1.0 mL). To this 1:1 amounts of both substrates were added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 30 minutes under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layers were collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. By ^{1}H NMR full conversion of **6** was observed and ~60% of **3** remained unreacted.

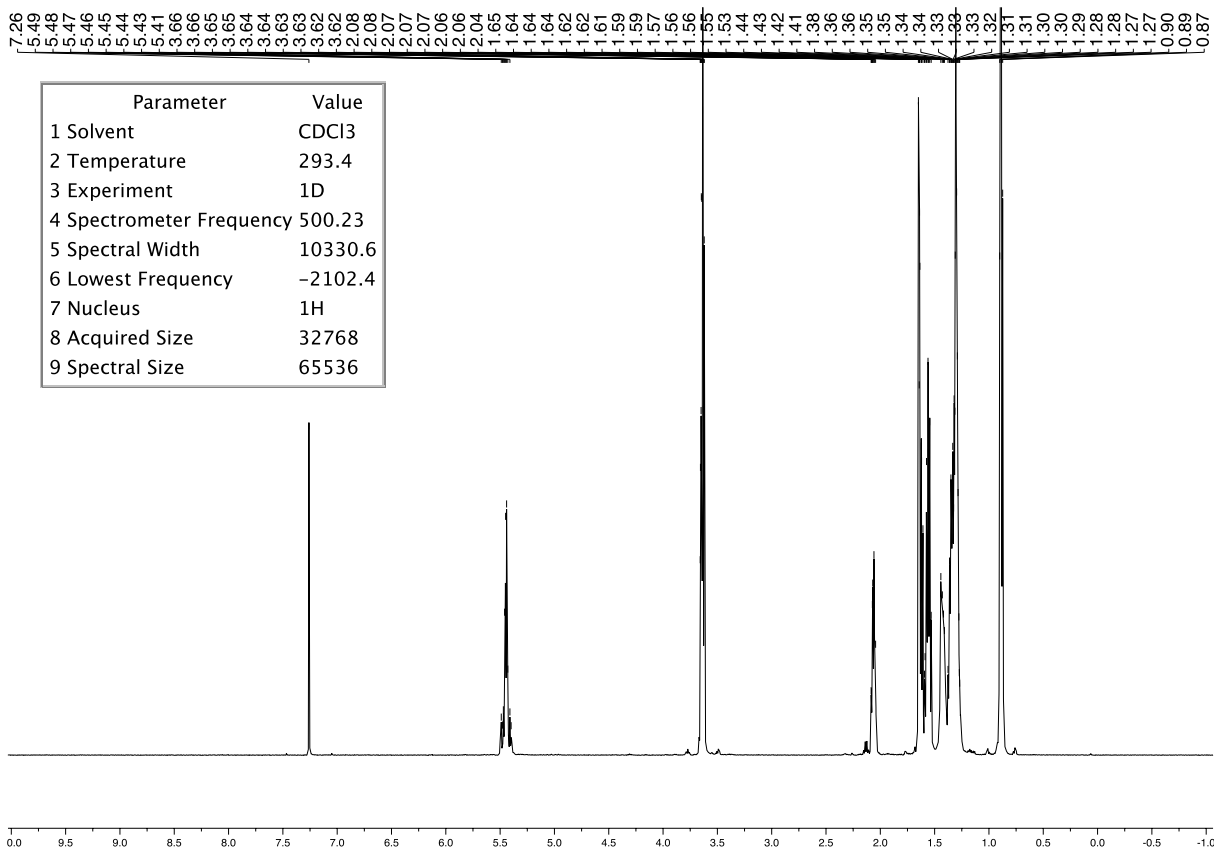
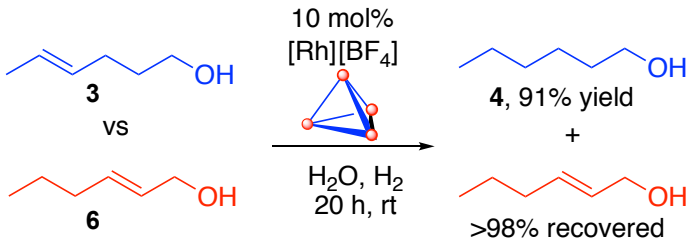


Figure S11. ^{1}H NMR showing full conversion of allylic-alcohol substrate and unreacted (~60% in-situ) methyl-olefin substrate after 30 minutes.

Supramolecular supported competition reaction between allylic and non-allylic substrates



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this 1:1 amounts of both substrates were added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The reaction vial was sealed with a Teflon® septum cap and removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 20 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layer was collected and dried over sodium

sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compounds were then isolated via gravity silica gel (Ag impregnated) column (100% hexanes to 95:5 to 90:10 to 85:15 to 80:20 hexanes:ethyl acetate) to yield the product and recovered starting material in pure form.

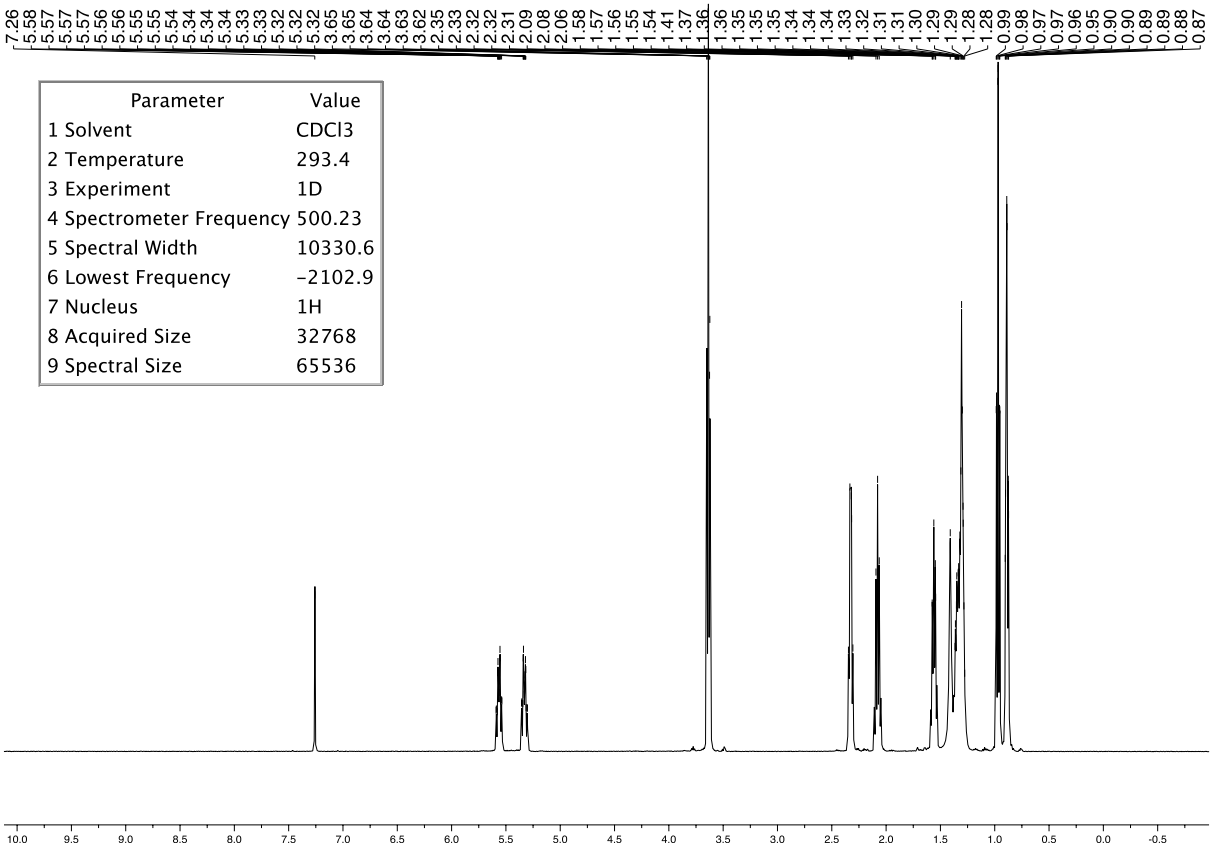
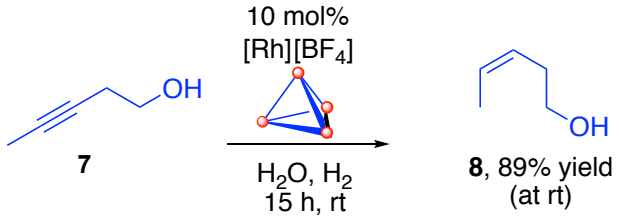


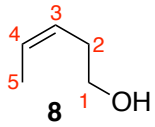
Figure S12. ^{1}H NMR showing full consumption of methyl-olefin substrate and remaining allylic alcohol substrate under supramolecular catalysis conditions.

Supramolecular supported hydrogenation of alkyne to *cis*-alkene



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this

substrate was added (5 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 15 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layer was collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with the sample in an ice bath. The compound was then passed over a plug of silica gel eluting with dichloromethane to yield the product in pure form (4 mg, 0.045 mmol, 89 % yield).



8

Matched previously reported NMR. *Cis*-pent-3-en-1-ol (**8**): ^{1}H NMR (400 MHz, $CDCl_3$) δ: 5.71 – 5.60 (m, 1H, H_3 or H_4), 5.40 (ddd, J = 12.7, 8.2, 6.3 Hz, 1H, H_3 or H_4), 3.63 (t, 3 $J_{H1,H2}$ = 6.6 Hz, 2H, H_1), 2.35 (pseudo q, J = 7.0 Hz, 2H), 1.66 (d, J = 6.8 Hz, 3H, H_5).

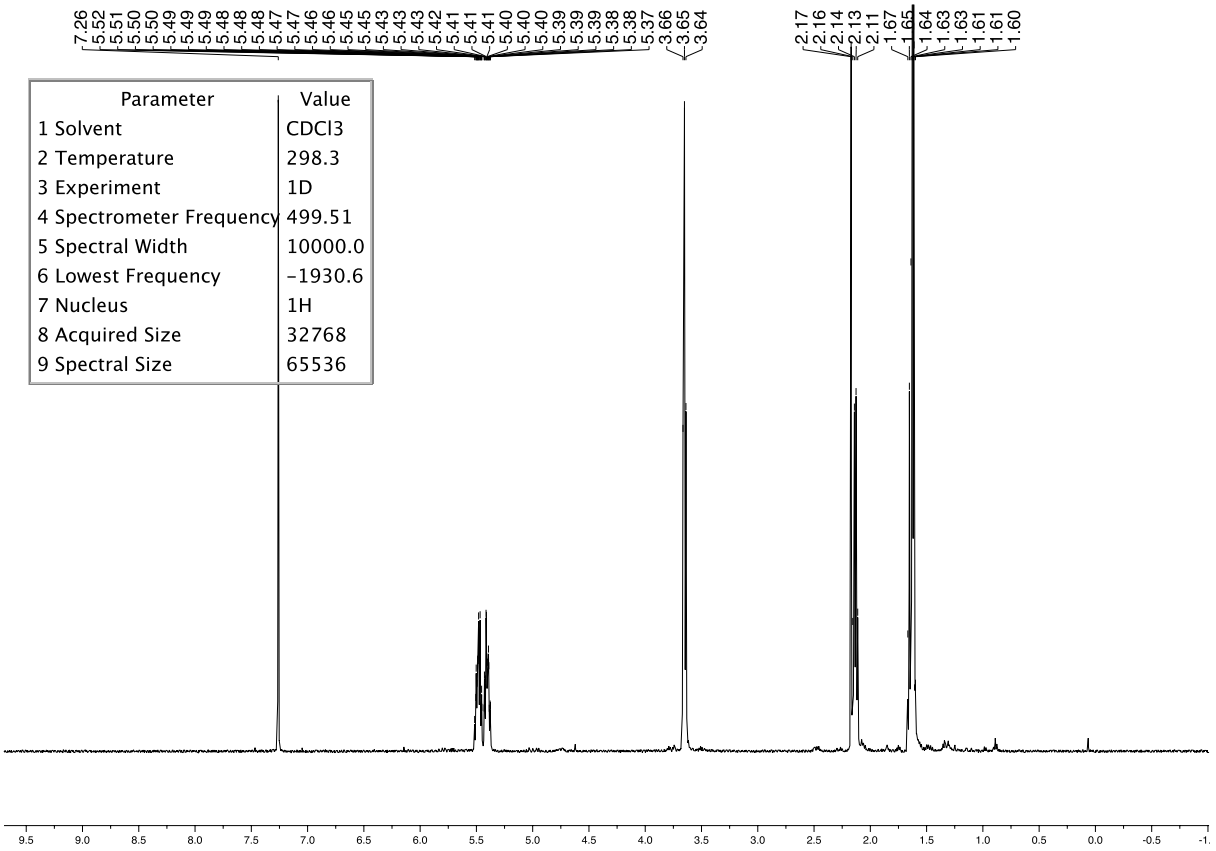
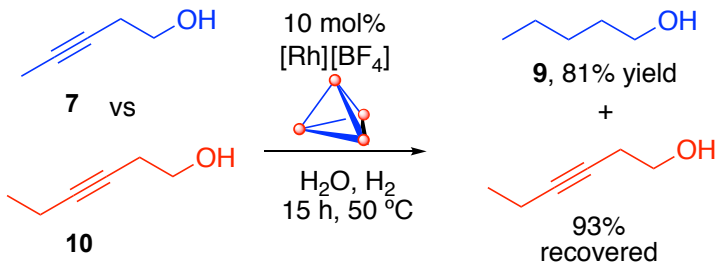


Figure S13. ^{1}H NMR showing *cis*-penten-3-ol product from selective alkyne to alkene hydrogenation under supramolecular catalysis conditions.

Supramolecular supported hydrogenation competition of methyl- vs ethyl-alkyne



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this 1:1 amounts of both substrates were added (5 and 6 µL (**7** and **10** respectively), 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 15 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layer was collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with an ice bath used to for volatile substrates. The compounds were then isolated via gravity silica gel (Ag impregnated) column (100% hexanes to 95:5 to 90:10 to 85:15 to 80:20 hexanes:ethyl acetate) to yield the product and recovered starting material in pure form.

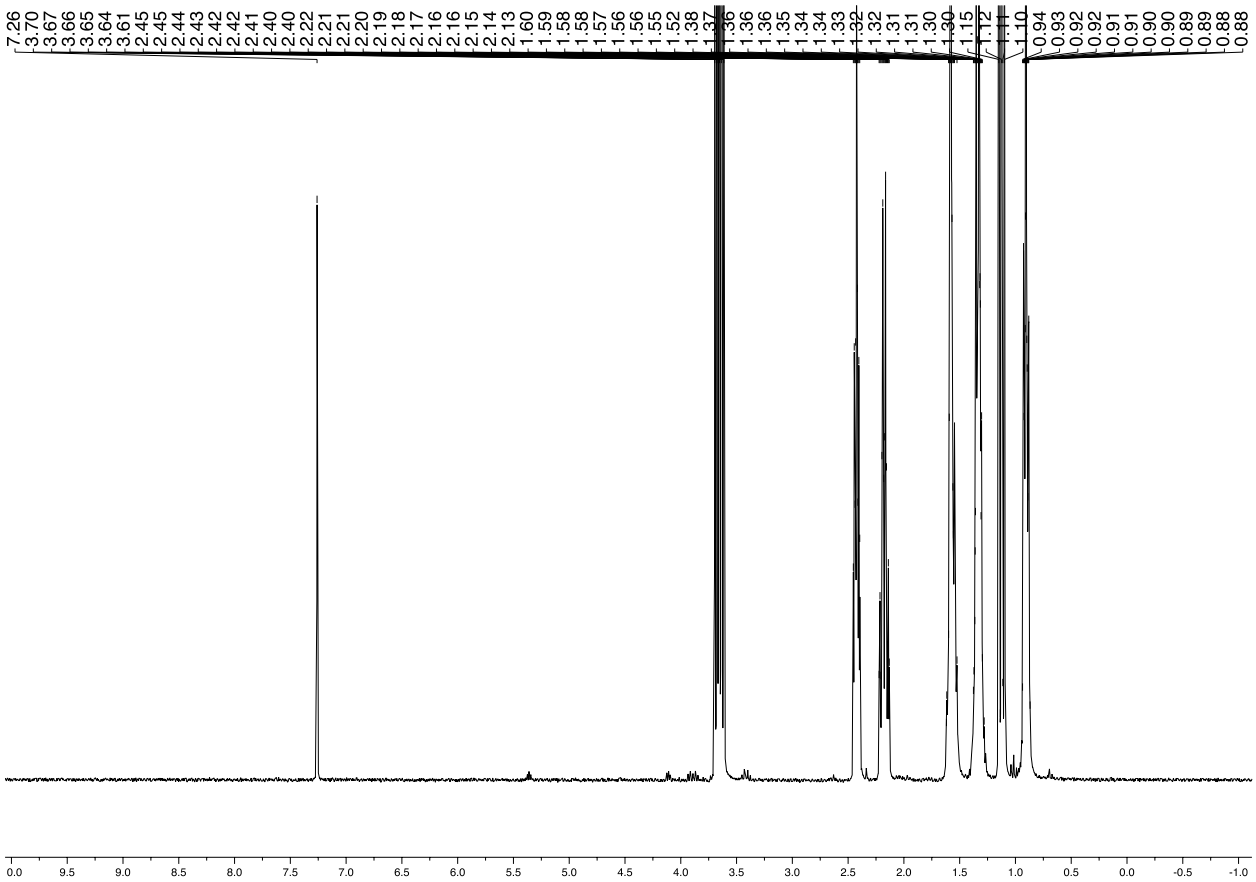
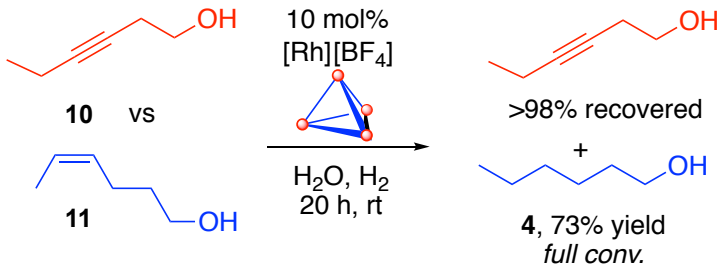


Figure S14. ^{1}H NMR showing full conversion of methyl-alkyne and unreacted ethyl-alkyne prior to isolation.

Supramolecular supported hydrogenation competition of alkene and alkyne



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this 1:1 amounts of both substrates were added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 20 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layer was collected and dried over sodium

sulfate. Under rotary evaporation the solvent was removed with an ice bath used to for volatile substrates. The compounds were then isolated via gravity silica gel (Ag impregnated) column (100% hexanes to 95:5 to 90:10 to 85:15 to 80:20 hexanes:ethyl acetate) to yield the product and recovered starting material in pure form.

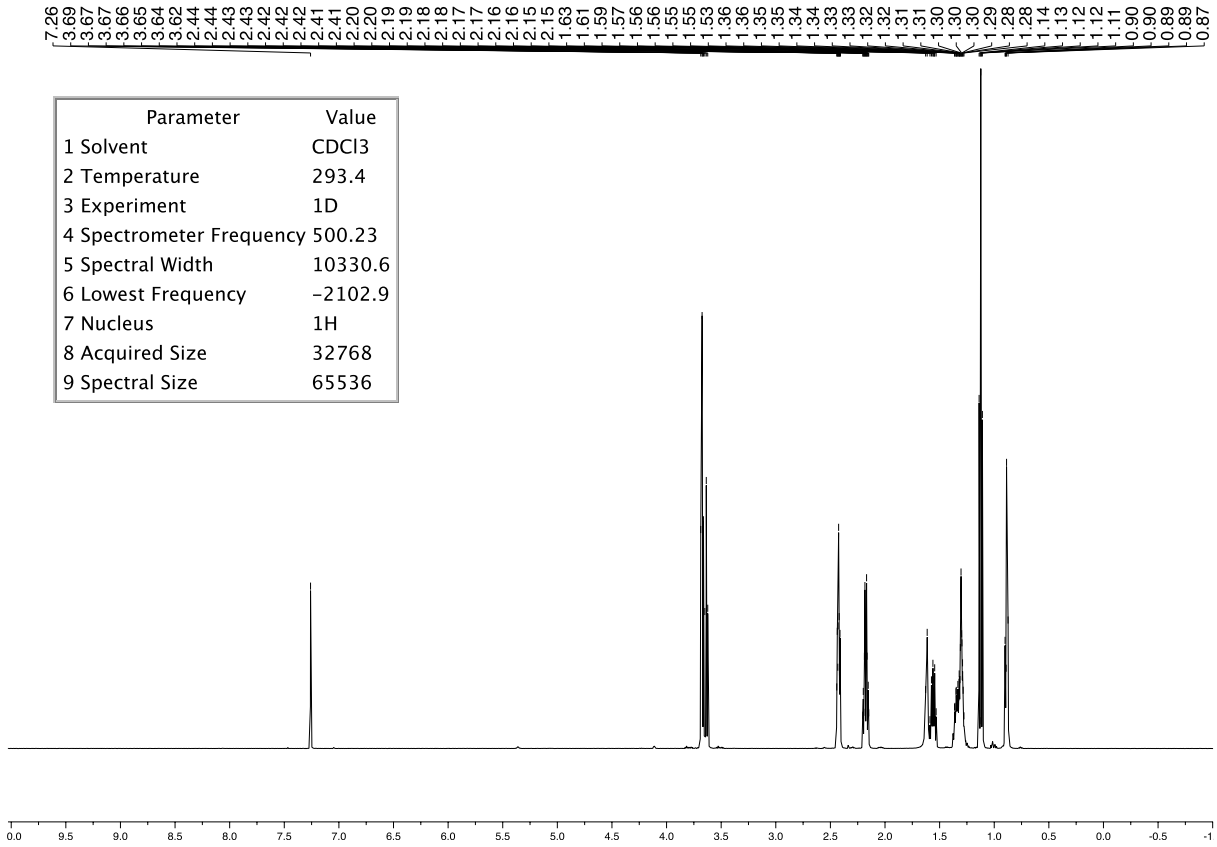
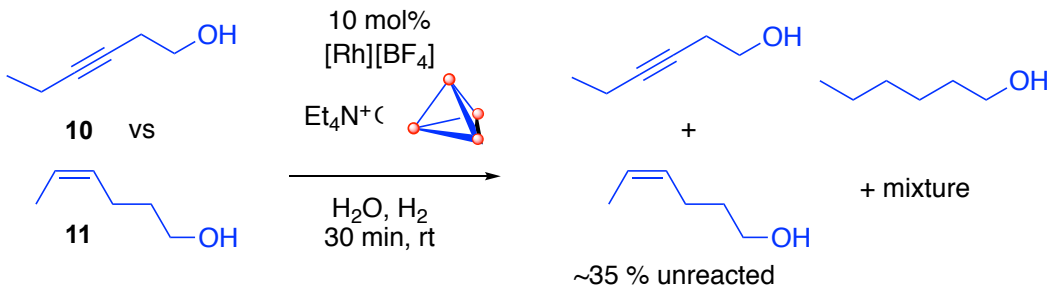


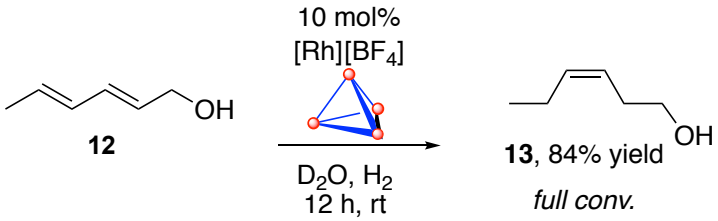
Figure S15. ^{1}H NMR showing full conversion of alkene substrate over the more reactive ethyl-alkyne substrate under supramolecular catalysis conditions.

Et_4N^+-blocked supramolecular host hydrogenation competition of alkene and alkyne



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), $[Et_4N][Cl]$ (1.0 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this substrates were added (6 µL each, 0.050 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 30 minutes. The reaction was then extracted into $CDCl_3$ (0.60 µL) and showed a mixture of products along with unreacted starting materials.

Supramolecular supported hydrogenation of diene-ol to *cis*-alkene



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (4.4 mg, 0.01 mmol), host (35 mg, 0.01 mmol, 0.10 equiv.), and degassed D_2O (1.0 mL). To this substrates was added (12 µL, 0.1 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 12 h under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layer was collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed with an ice bath used to for volatile substrates. The compound was then passed over a plug of silica gel eluting with dichloromethane to yield the product in pure form (8.4 mg, 0.084 mmol, 84 % yield).

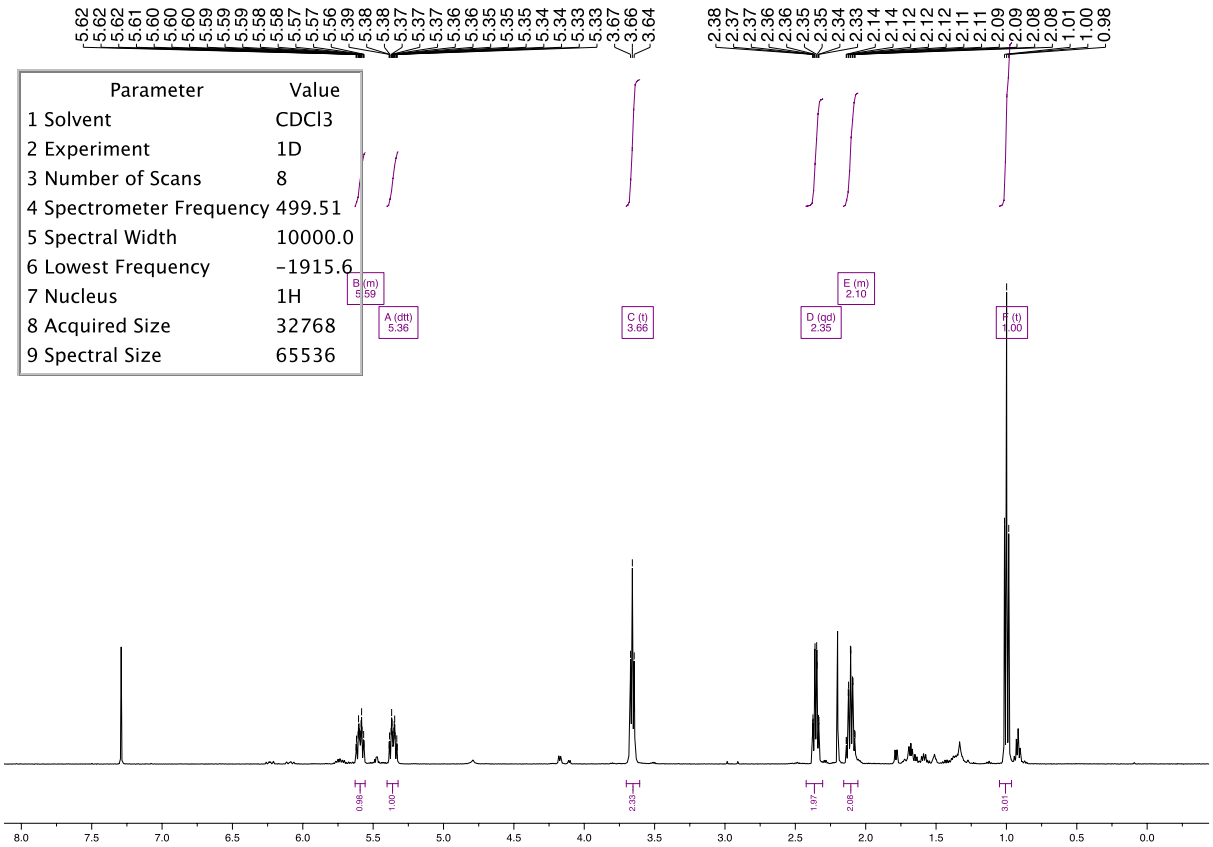
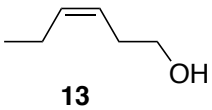


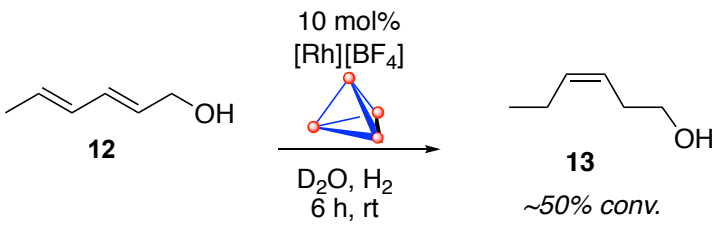
Figure S16. ^{1}H NMR showing reaction product **13** prior to flash chromatography.



13

Matched previously reported NMR. cis-hex-3-en-1-ol: ^{1}H NMR (500 MHz, $CDCl_3$) δ: 5.63 – 5.56 (m, 1H), 5.36 (dtt, *J* = 10.8, 7.4, 1.6 Hz, 1H), 3.66 (t, *J* = 6.5 Hz, 2H), 2.35 (qd, *J* = 6.6, 1.2 Hz, 2H), 2.16 – 2.06 (m, 2H), 1.00 (t, *J* = 7.5 Hz, 3H).

<u>In-situ reaction monitoring:</u>



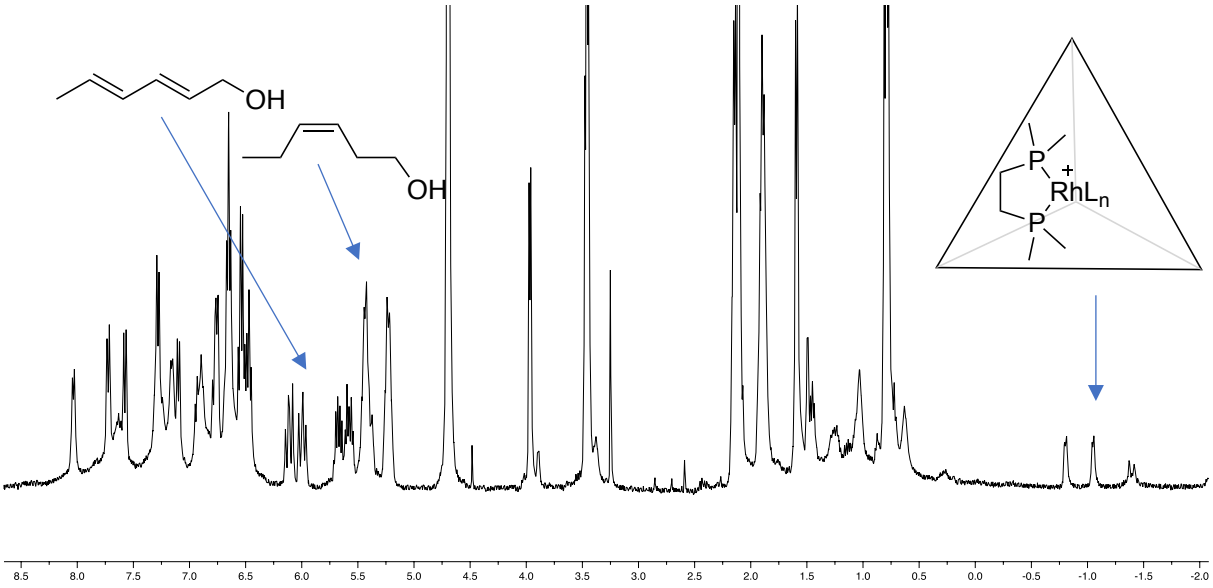
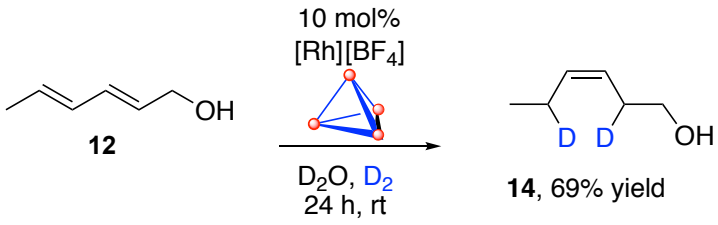
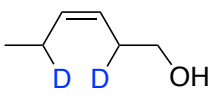


Figure S17. In-situ ^{1}H NMR (499.51 MHz, 292.5 K) at ~50% conversion. After 6h *cis*-product is visible and the (DMPE)Rh^{+} catalyst remains encapsulated.

Supramolecular supported deuteration of diene-ol to *cis*-alkene



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol), host (17.5 mg, 0.005 mmol, 0.10 equiv.), and degassed D_2O (1.0 mL). To this substrates was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of D_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 24 h under a balloon of D_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layer was collected and dried over sodium sulfate. Under rotary evaporation the solvent was removed the sample in an ice bath. The compound was then passed over a plug of silica gel eluting with dichloromethane to yield the product in pure form.



14

Cis-d_2-hex-3-en-1-ol (**14**): ^{1}H NMR (400 MHz, $CDCl_3$) δ: 5.62 – 5.52 (m, 1H), 5.33 (ddd, *J* = 11.8, 7.7, 1.6 Hz, 1H), 3.63 (d, *J* = 6.4 Hz, 2H), 2.05 (tdd, *J* = 9.6, 4.8, 2.0 Hz, 1H), 0.97 (dt, *J* = 7.5, 1.1 Hz, 3H).

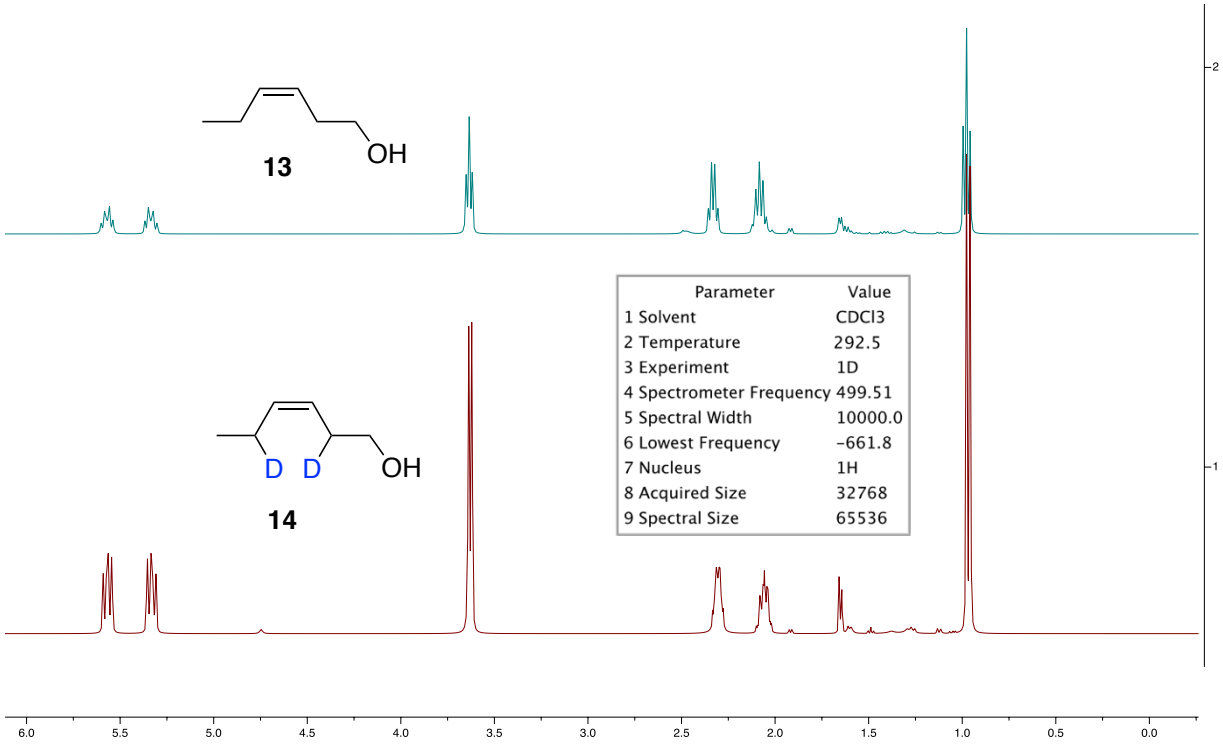
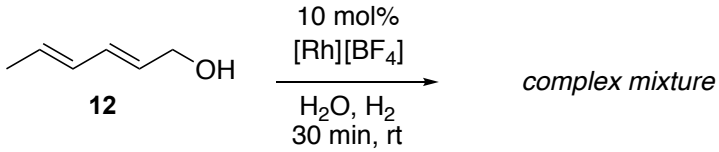


Figure S18. Stacked ^{1}H NMR showing the different splitting patterns for positions coupled to either H or D in the *cis*-alcohol product. H-coupling results in triplets for the methyl and alcohol resonances (top, green spectrum) and apparent doublets for D-coupled resonances of the same positions (bottom, red spectrum).

Supramolecular free supported hydrogenation of diene-ol control



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (2.2 mg, 0.005 mmol) and degassed H_2O (1.0 mL). To this substrates was added (6 µL, 0.05 mmol, 1.0 equiv.) by microliter syringe and. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 30 minutes under a balloon of H_2.

The reaction was then extracted into $CDCl_3$ (0.60 µL). By ^1H NMR and GC/MS analysis, the reaction mixture showed up to 4 randomly hydrogenated intermediates.

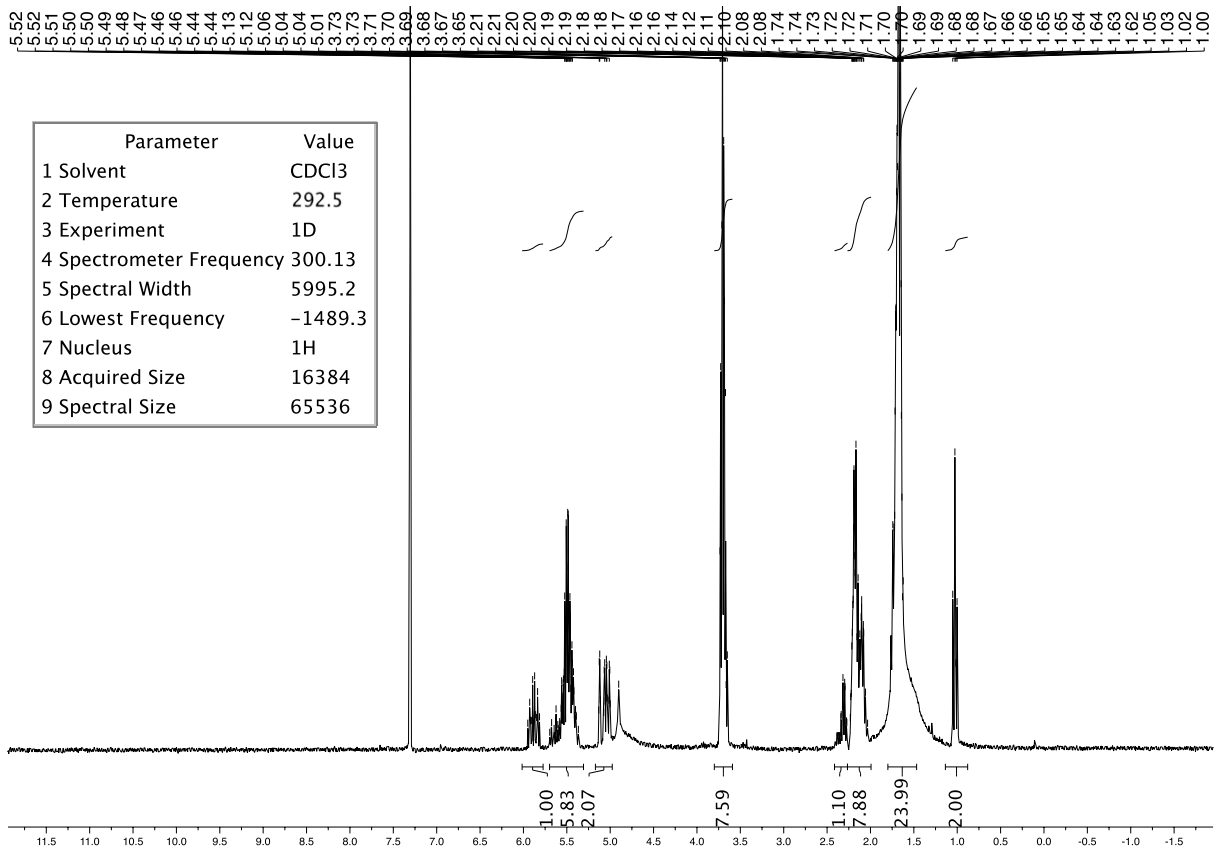


Figure S19. ^1H NMR showing mixture of species at an intermediate (30 min) reaction time. After 1 h full conversion to 1-hexanol is observed.

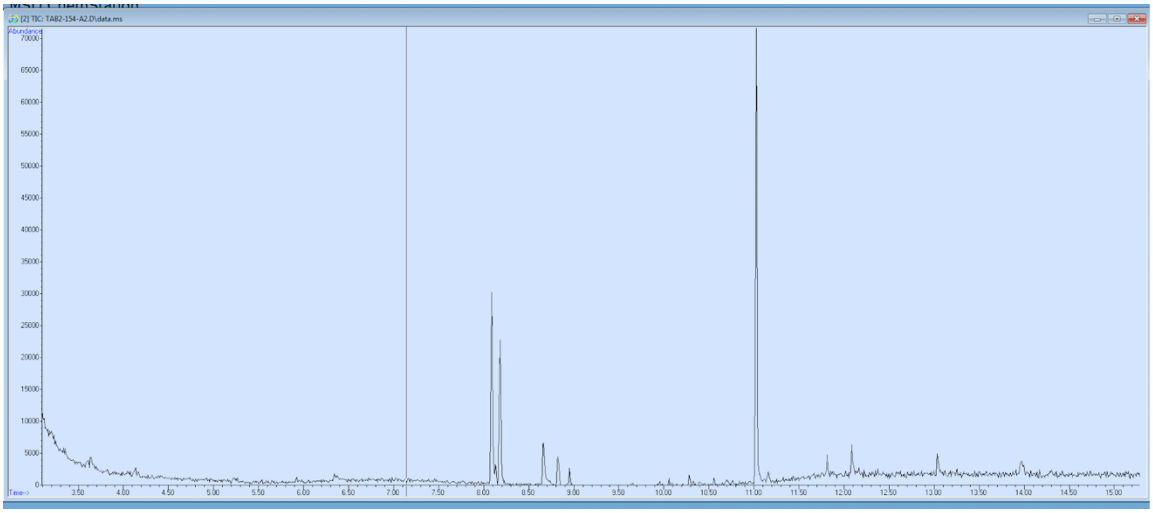
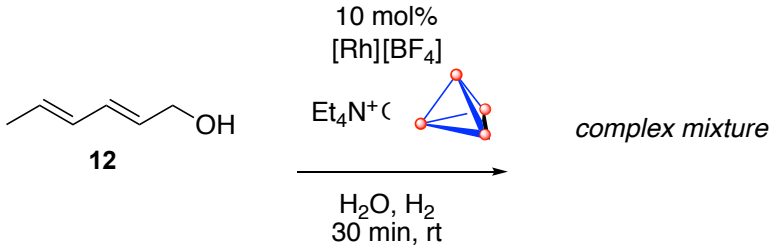


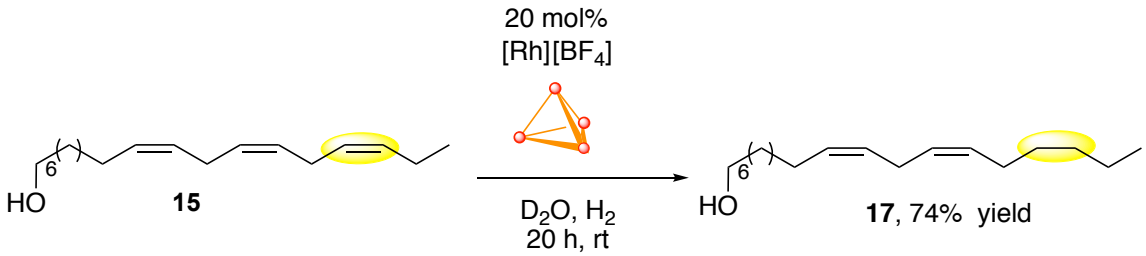
Figure S20. GC/MS trace showing a mixture of species at an intermediate (30 min) reaction time.

Et_4N^+-blocked supramolecular host hydrogenation of diene-ol control

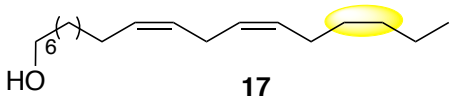


In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (4.4 mg, 0.005 mmol), host (35 mg, 0.005 mmol, 0.10 equiv.), [Et_4N][Cl] (1.0 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this substrates was added (12 µL, 0.1 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred at r.t. for the given reaction time under a balloon of H_2. After sparging, the vent needle was removed and the reaction was stirred for 30 minutes under a balloon of H_2. The reaction was then extracted into $CDCl_3$ (0.60 µL). As observed above (Figure 19 and 20) a mixture of products resulted.

Supramolecular supported mono-hydrogenation of tri-ene 15



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (4.4 mg, 0.01 mmol), host **16** (37 mg, 0.01 mmol, 0.10 equiv.), and degassed D_2O (1.0 mL). To this **15** was added (12 mg, 0.05 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 20 hours under a balloon of H_2. The reaction mixture was then extracted into dichloromethane (3 x 2 mL), the combined organic layer was collected, dried over sodium sulfate and the solvent removed under rotary evaporation. The compound was then passed over a plug of silica gel eluting with dichloromethane to yield the product in pure form.



17

^{1}H NMR (400 MHz, $CDCl_3$) δ: 5.43 – 5.27 (m, 4H), 3.63 (t, *J* = 6.8 Hz, 2H), 2.77 (t, *J* = 6.5 Hz, 2H), 2.04 (q, *J* = 6.8 Hz, 4H), 1.62 – 1.51 (m, 2H), 1.41 – 1.16 (m, 16H), 0.97 – 0.80 (m, 3H).

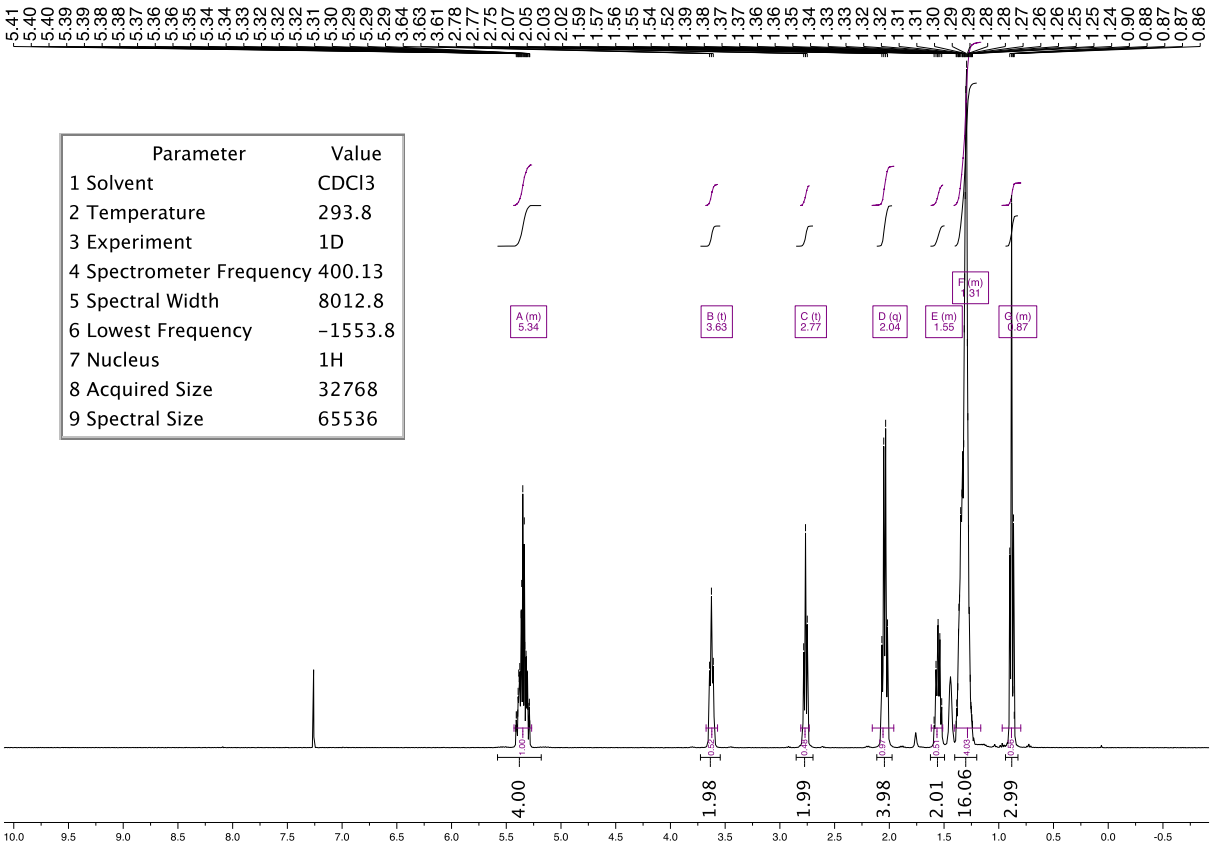


Figure S21. ^{1}H NMR of purified product **17** demonstrating four-alkene protons reduced by two from the original substrate. This ^{1}H NMR matches that of the authentic material as verified by a spiking experiment.

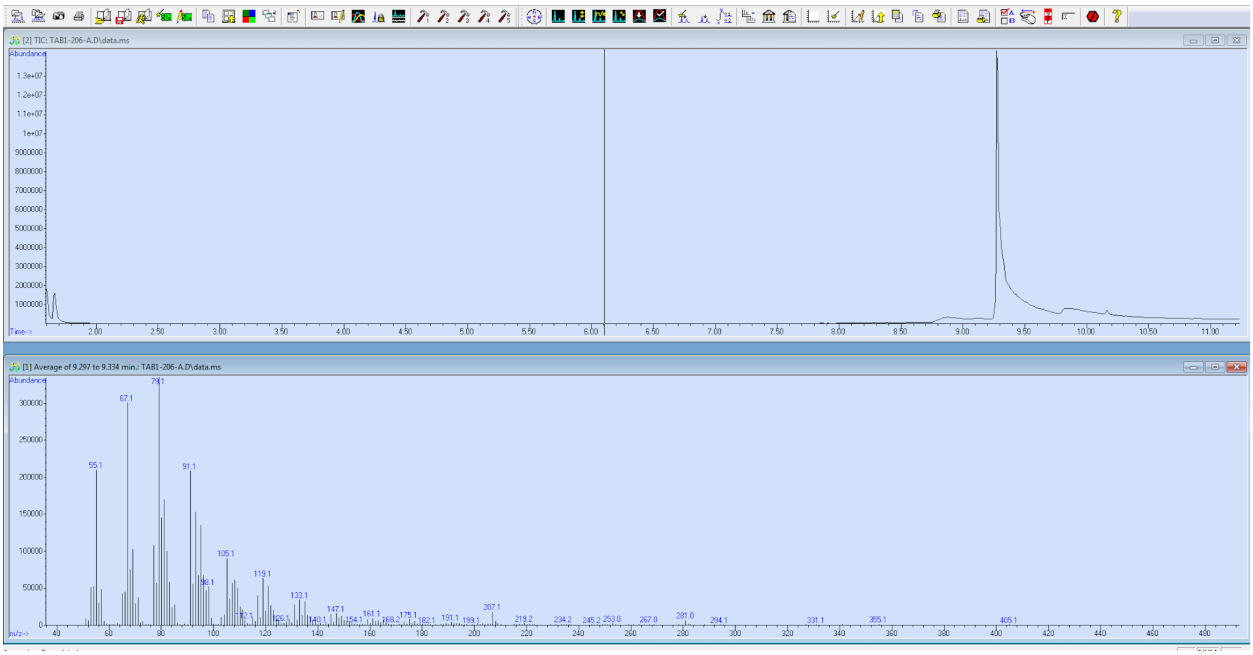
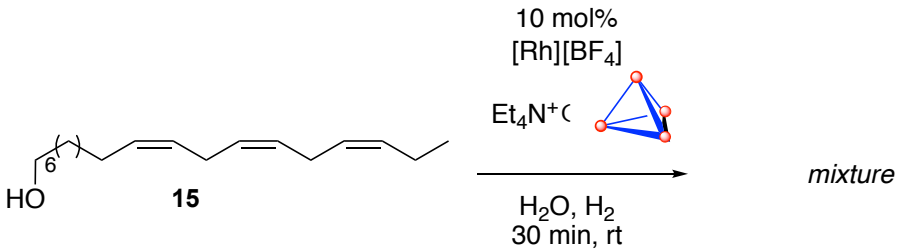


Figure S22. GC/MS trace single major species formed under supramolecular supported hydrogenation of **15**.

Et_4N^+-Blocked supramolecular host hydrogenation of tri-ene 15 control



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (4.4 mg, 0.01 mmol), host (37 mg, 0.01 mmol, 0.10 equiv.), $[Et_4N][Cl]$ (1.0 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (1.0 mL). To this **15** was added (12 mg, 0.05 mmol, 1.0 equiv.) by microliter syringe and then sealed with a Teflon® lined septum cap. The reaction vial was removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction was stirred for 30 minutes under a balloon of H_2. The reaction was then extracted into $CDCl_3$ (0.60 µL) providing a mixture of products.

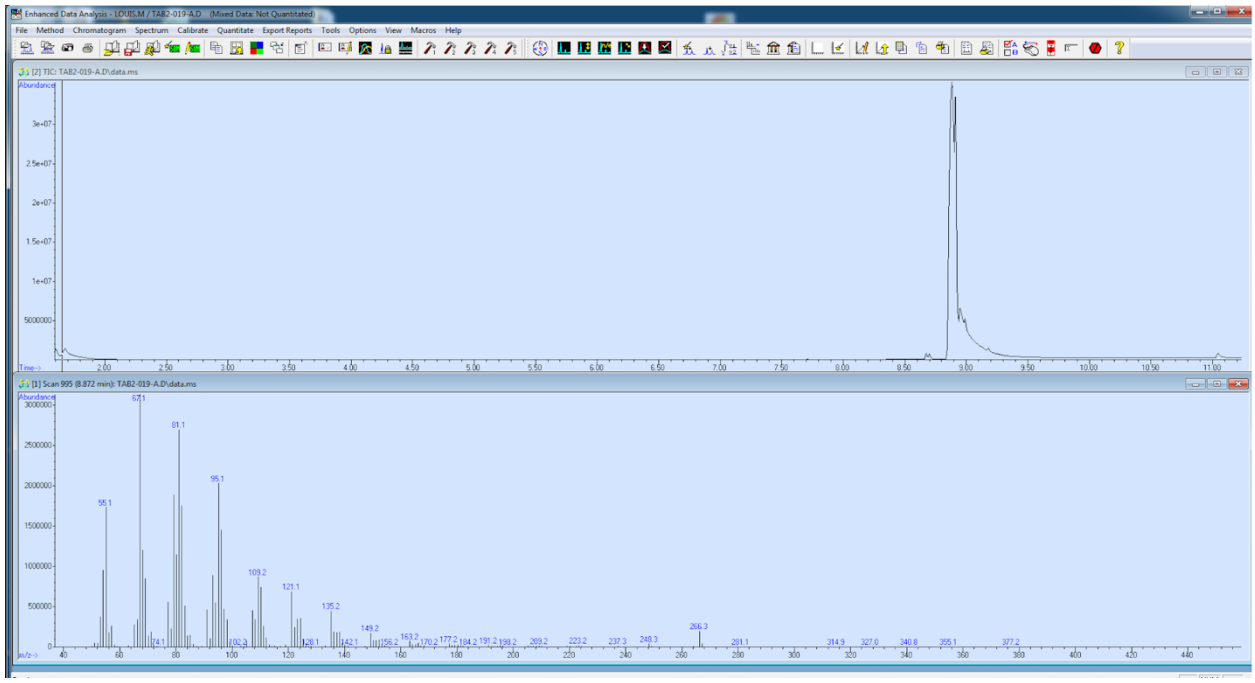
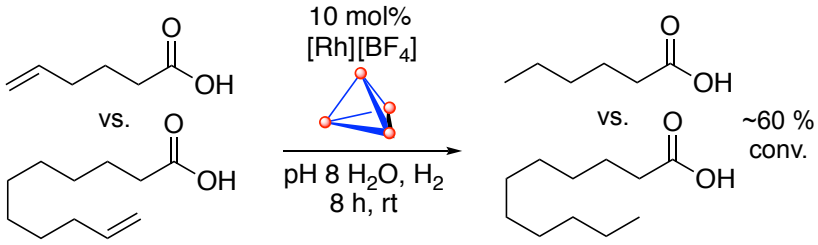


Figure S23. GC/MS trace showing closely spaced mixture of hydrogenated polyene compounds at an intermediate (30 min) reaction time. After 1 h full conversion is observed.

Supramolecular supported hydrogenation of short- and long-chain carboxylic acid



Due to decreased solubility of 11-undecenoic acid, the reaction was performed under more dilute conditions then those reported for the previous experiments. In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (1.1 mg, 0.0025 mmol), host (8.8 mg, 0.0025 mmol, 0.10 equiv.), and degassed H_2O (2.0 mL, pH 8, 100 mM phosphate buffer). To this the substrates were added in a 1:1 ratio (3 µL (hex-) and 5 µL (undec-), 0.025 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and the reaction mixture was stirred for 8 h under a balloon of H_2. The reaction was then extracted into $CDCl_3$ (0.60 µL) providing a ~1:1 mixture of partially converted starting materials.

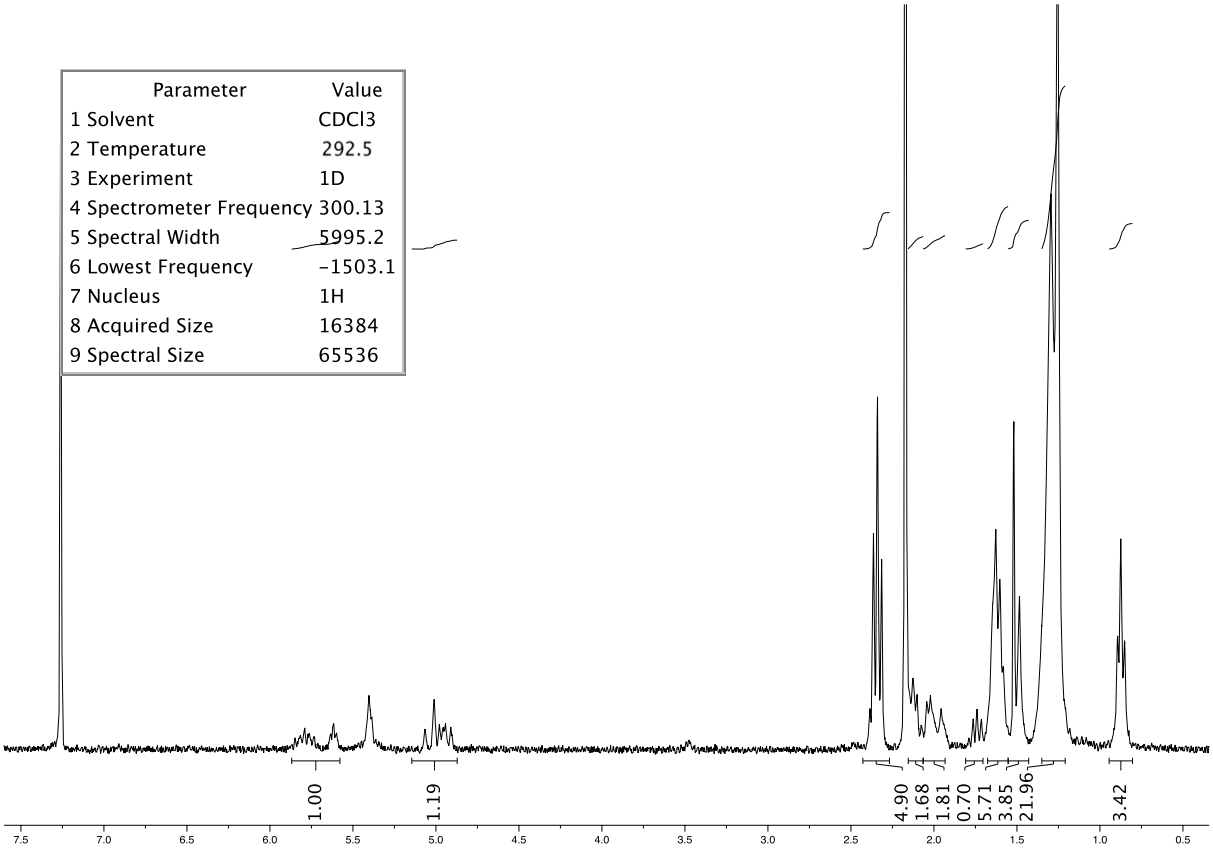
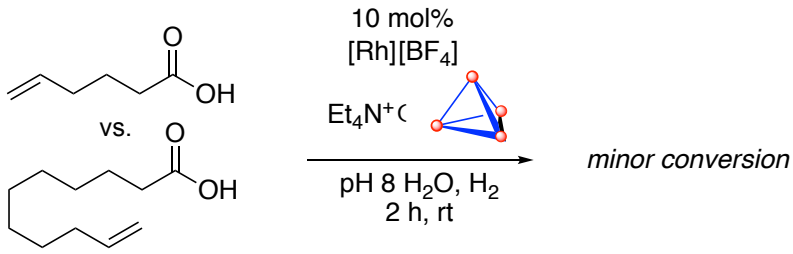


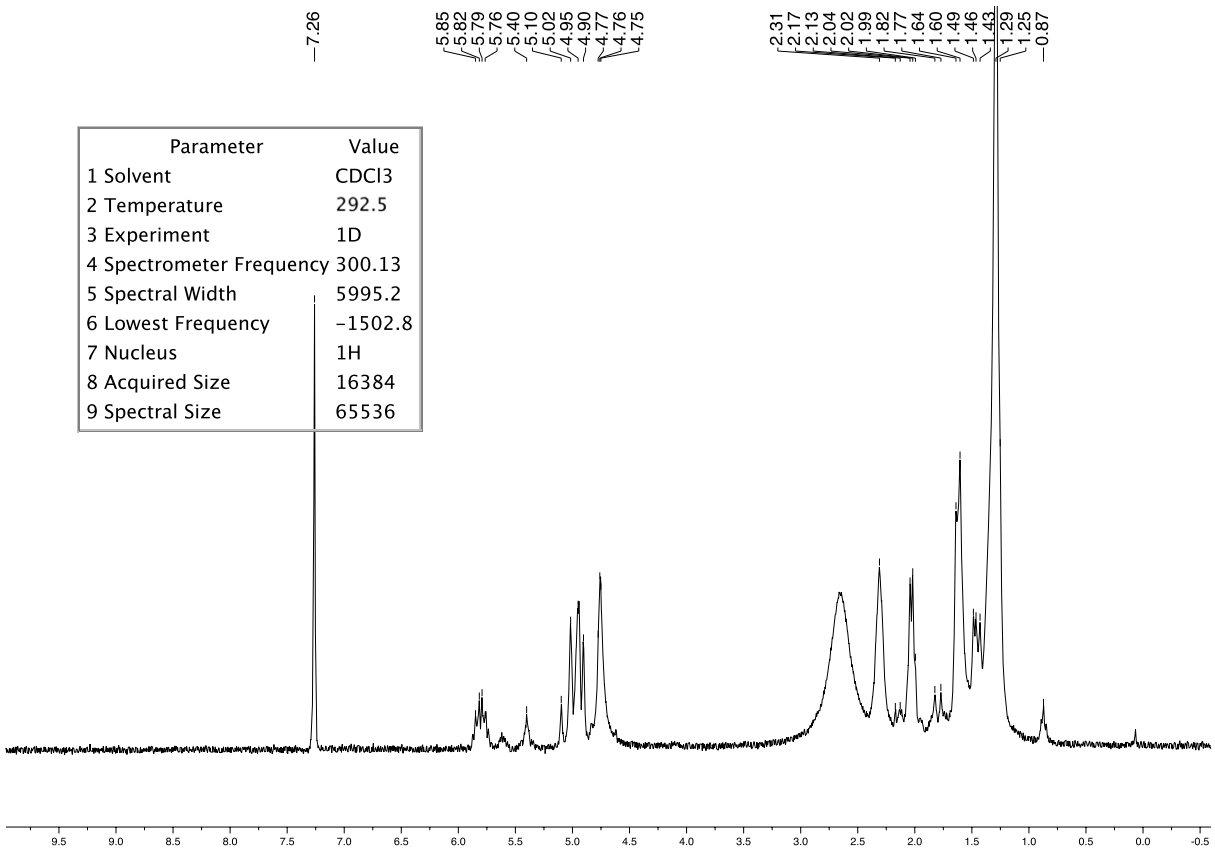
Figure S24. ^{1}H NMR showing ~1:1 hydrogenation of hexenoic and undecanoic acids after ~60% conversion.

Et_4N^+-blocked supramolecular host hydrogenation of short- and long-chain carboxylic acid



In an air-free glove box, a 1-dram vial equipped with a magnetic stir bar was charged with **2** (1.1 mg, 0.0025 mmol), host (8.8 mg, 0.0025 mmol, 0.10 equiv.), [Et_4N][Cl] (1.0 mg, 0.005 mmol, 0.10 equiv.), and degassed H_2O (2.0 mL, pH 8, 100 mM phosphate buffer). To this the substrates were added in a 1:1 ratio (3 µL (hex-) and 5 µL (undec-), 0.025 mmol, 1.0 equiv.) by microliter syringe. The vial was then sealed with a Teflon® lined septum cap, removed from the glove box and sparged with a balloon of H_2 gas for 2 minutes. After sparging, the vent needle was removed and

the reaction was stirred for 2 hours at which point rhodium black had formed. The reaction was then extracted into $CDCl_3$ (0.60 µL) providing minor conversion of both carboxylic acids.



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