

## Supporting Information

### **Nickel-Catalyzed Highly Selective Hydroalkenylation of Alkenyl Boronic Esters to Access Allyl Boron**

Penglin Zhang,<sup>a</sup> Min Zhang,<sup>a</sup> Yuqi Ji,<sup>a</sup> Mimi Xing,<sup>a</sup> Qian Zhao<sup>a</sup> and Chun Zhang\*,<sup>a</sup>

a. Institute of Molecular Plus, Tianjin Key Laboratory of Molecular Optoelectronic Science, Department of Chemistry, School of Science, Tianjin University, Weijin Rd. 92, Tianjin 300072, China.

E-mail: chunzhang@tju.edu.cn

## Supporting Information

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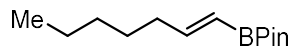
## 1. General information

All manipulations were conducted with Schlenk tube.  $^1\text{H}$  NMR spectra were recorded on a Bruker AVIII-400, JNM-ECZ400S/L1 and JNM-ECZ600R/S1 spectrometers. Chemical shifts (in ppm) were referenced to tetramethylsilane ( $\delta = 0$  ppm) in  $\text{CDCl}_3$  as an internal standard. Data were reported as follows: chemical shift (ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublets, m = multiplet), coupling constants (Hz), integration and assignment.  $^{13}\text{C}$  NMR spectra were obtained by using the same NMR spectrometers and were calibrated with  $\text{CDCl}_3$  ( $\delta = 77.00$  ppm).  $^{19}\text{F}$  NMR spectra were obtained by the same NMR and  $\text{CF}_3\text{COOH}$  was employed as external standard for the  $^{19}\text{F}$ -NMR measurement. HPLC data were collected on a Shimadzu LC-2030 spectrometer. GC analysis was completed on an Agilent Technologies GC-7890B gas chromatograph, using ethyl acetate for sample preparation and nitrogen as a carrier gas. GC-MS analysis was completed on a Shimadzu GCMS-QP2010SE gas chromatograph mass spectrometer, using ethyl acetate for sample preparation and helium as a carrier gas. High resolution mass spectrometry (HRMS) data were obtained on a QTOF mass analyzer with electrospray ionization (ESI) through a Waters Acquity UPLC Class I/Xevo G2 Q-ToF. Substrates were purchased from Aldrich, TCI, Acros, Energy, Aladdin, or synthesized according to the procedures outlined below. Unless otherwise noted, materials obtained from commercial suppliers were used without further purification.

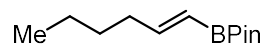
## 2. Synthesis of Substrates

### 2.1 Synthesis of alkenes

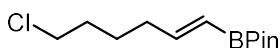
These substrates were prepared according to the corresponding literature reports. Analytical data ( $^1\text{H}$  NMR,  $^{13}\text{C}$  NMR) matches with the literature.



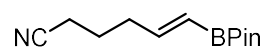
**1a:** (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane<sup>1</sup>



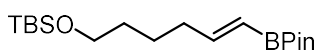
**1b:** (*E*)-2-(hex-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane<sup>1</sup>



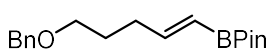
**1c:** (*E*)-2-(6-chlorohex-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane<sup>2</sup>



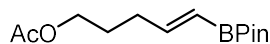
**1d:** (*E*)-6-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)hex-5-enitrile<sup>3</sup>



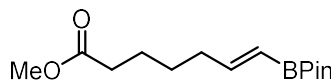
**1e:** (*E*)-*tert*-butyldimethyl((6-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)hex-5-en-1-yl)oxy)silane<sup>4</sup>



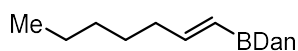
**1f:** (*E*)-2-(5-(benzyloxy)pent-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane<sup>5</sup>



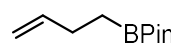
**1h:** (*E*)-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pent-4-en-1-yl acetate<sup>2</sup>



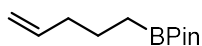
**1j:** methyl (*E*)-7-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)hept-6-enoate<sup>5</sup>



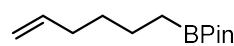
**1m:** (*E*)-2-(hept-1-en-1-yl)-2,3-dihydro-1*H*-naphtho[1,8-*de*][1,3,2]diazaborinine<sup>6</sup>



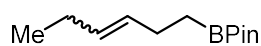
**1o:** 2-(but-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane<sup>7</sup>



**1p:** 4,4,5,5-tetramethyl-2-(pent-4-en-1-yl)-1,3,2-dioxaborolane<sup>7</sup>

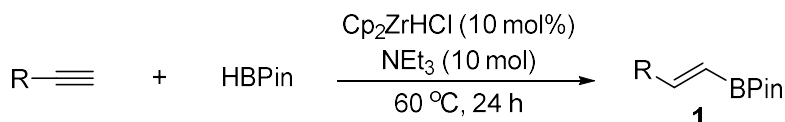


**1q:** 2-(hex-5-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane<sup>8</sup>



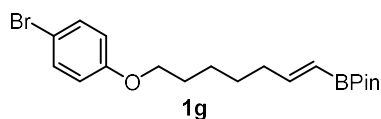
**1r:** 2-(hex-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane<sup>9</sup>

### Representative procedure for preparing alkenes<sup>2</sup>

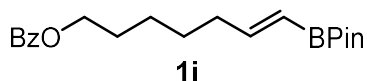


In an oven dried 50-ml Schlenk tube, which contained a stirring bar, was charged with Schwartz's reagent (258 mg, 1.0 mmol). The tube was then evacuated and back-filled under a  $\text{N}_2$  flow (this sequence was repeated three times), pinacolborane (1.34g, 10.5 mmol), alkyne (10.0 mmol) and  $\text{Et}_3\text{N}$  (101 mg, 1.0 mmol) was added subsequently under  $\text{N}_2$ , the tube was stirred at 60  $^\circ\text{C}$  (an oil bath) for 24 h. The reaction was allowed to cool to room temperature, diluted with EtOAc (10 ml),

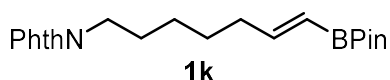
filtered through a pad of silica gel and concentrated by rotary evaporation. The residue was purified by silica gel column chromatography to afford the product **1**.



**(E)-2-(7-(4-Bromophenoxy)hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1g)**: The general procedure was followed using 1-bromo-4-(hept-6-yn-1-yloxy)benzene (2.66 g, 10.0 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 100) to afford product **1g** as a white solid (1.95 g, 49% yield): Rf = 0.8 (EtOAc : petroleum ether = 1 : 20);  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 600 MHz)  $\delta$ : 7.36-7.34 (m, 2H), 6.77-6.75 (m, 2H), 6.63 (dt,  $J_1$  = 18.0,  $J_2$  = 6.6 Hz, 1H), 5.44 (dt,  $J_1$  = 18.0,  $J_2$  = 1.8 Hz, 1H), 3.90 (t,  $J$  = 6.6 Hz, 2H); 2.20-2.17 (m, 2H), 1.79-1.74 (m, 2H), 1.50-1.43 (m, 4H), 1.26 (s, 12H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 150 MHz)  $\delta$ : 158.2, 154.2, 132.2, 116.3, 112.6, 83.0, 68.1, 35.6, 29.0, 27.9, 25.5, 24.8 ppm; **HRMS** (ESI)  $m/z$ :  $[\text{M}-\text{H}]^-$  calcd for  $\text{C}_{19}\text{H}_{27}\text{BrBO}_3$  392.1273; Found 392.1264.



**(E)-7-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)hept-6-en-1-yl benzoate (1i)**: The general procedure was followed using hept-6-yn-1-yl benzoate (2.16 g, 10.0 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 100) afforded product **1i** as a yellow oil (1.86 g, 54% yield): Rf = 0.9 (EtOAc : petroleum ether = 1 : 20);  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 600 MHz)  $\delta$ : 8.03 (dd,  $J_1$  = 8.4,  $J_2$  = 1.2 Hz, 2H), 7.54 (t,  $J$  = 7.2 Hz, 1H), 7.43 (t,  $J$  = 7.8 Hz, 2H), 6.63 (dt,  $J_1$  = 18.0,  $J_2$  = 6.6 Hz, 1H), 5.45 (dt,  $J_1$  = 18.0,  $J_2$  = 1.8 Hz, 1H), 4.31 (t,  $J$  = 5.4 Hz, 2H); 2.21-2.17 (m, 2H), 1.80-1.74 (m, 2H), 1.53-1.44 (m, 4H), 1.26 (s, 12H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 150 MHz)  $\delta$ : 166.6, 154.1, 132.7, 130.4, 129.5, 128.2, 82.9, 64.9, 35.5, 28.5, 27.8, 25.6, 24.7 ppm; **HRMS** (ESI)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{20}\text{H}_{30}\text{BO}_4$  344.2274; Found 344.2281.

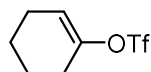


**(E)-2-(7-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)hept-6-en-1-yl)isoindoline-1,3-dione (1k)**: The general procedure was followed using 2-(hept-6-yn-1-yl)isoindoline-1,3-dione (2.41 g, 10.0 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **1k** as yellow oil (1.65 g, 45% yield): Rf = 0.7 (EtOAc : petroleum ether = 1 : 5);  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 600 MHz)  $\delta$ : 7.85-7.83 (m, 2H), 7.71-7.70 (m, 2H), 6.61 (dt,  $J_1$  = 18.0,  $J_2$  = 6.6 Hz, 1H), 5.42 (dt,  $J_1$  = 18.0,  $J_2$  = 1.8 Hz, 1H), 3.67 (t,  $J$  = 7.8 Hz, 2H); 2.17-2.13 (m, 2H), 1.70-1.65 (m, 2H), 1.49-1.44 (m, 2H), 1.39-1.34 (m, 2H), 1.26 (s, 12H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 150 MHz)  $\delta$ : 168.4, 154.1, 133.8, 132.1, 123.1, 83.0, 37.9, 35.5, 28.4, 27.7, 26.4, 24.7 ppm; **HRMS** (ESI)  $m/z$ :  $[\text{M} - \text{H}]^-$  calcd for  $\text{C}_{21}\text{H}_{27}\text{NBO}_4$  367.2069; Found 367.2067.

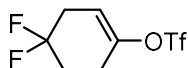


## 2.2 Synthesis of Alkenyl Triflates and Alkenyl Bromides

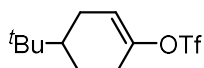
These substrates were prepared according to the corresponding literature reports. Analytical data ( $^1\text{H}$  NMR,  $^{13}\text{C}$  NMR) matches with the literature.



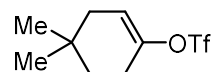
**2a:** cyclohex-1-en-1-yl trifluoromethanesulfonate<sup>12</sup>



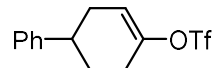
**2c:** 4,4-difluorocyclohex-1-en-1-yl trifluoromethanesulfonate<sup>14</sup>



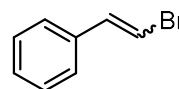
**2e:** 4-(*tert*-butyl)cyclohex-1-en-1-yl trifluoromethanesulfonate<sup>12</sup>



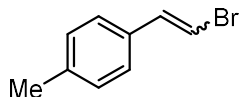
**2b:** 4,4-dimethylcyclohex-1-en-1-yl trifluoromethanesulfonate<sup>13</sup>



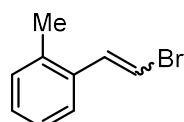
**2d:** 1,2,3,6-tetrahydro-[1,1'-biphenyl]-4-yl trifluoromethanesulfonate<sup>12</sup>



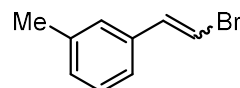
**2f:** (2-bromovinyl)benzene<sup>15</sup>



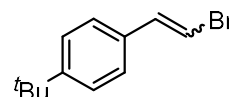
**2g:** 1-(2-bromovinyl)-4-methylbenzene<sup>15</sup>



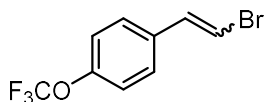
**5i:** 1-(2-bromovinyl)-2-methylbenzene<sup>15</sup>



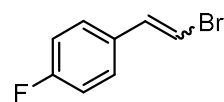
**5h:** 1-(2-bromovinyl)-3-methylbenzene<sup>15</sup>



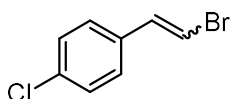
**5j:** 1-(2-bromovinyl)-4-(*tert*-butyl)benzene<sup>16</sup>



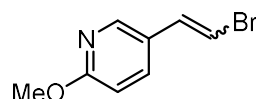
**5k:** 1-(2-bromovinyl)-4-(trifluoromethoxy)benzene<sup>17</sup>



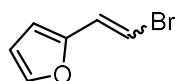
**5l:** 1-(2-bromovinyl)-4-fluorobenzene<sup>15</sup>



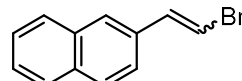
**5m:** 1-(2-bromovinyl)-4-chlorobenzene<sup>15</sup>



**5n:** 5-(2-bromovinyl)-2-methoxypyridine<sup>18</sup>



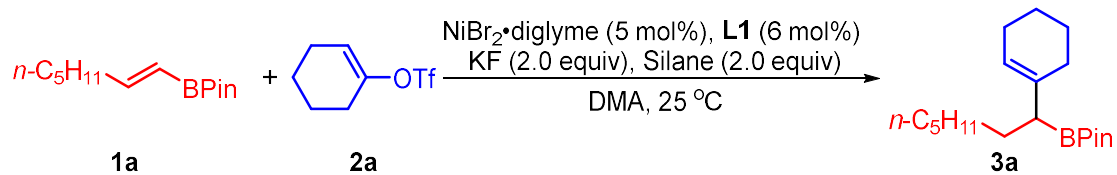
**5o:** 2-(2-bromovinyl)furan<sup>19</sup>



**5p:** 2-(2-bromovinyl)naphthalene<sup>19</sup>

### 3. The effect of different reaction conditions

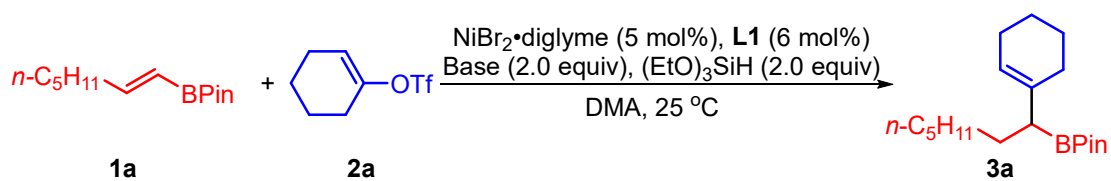
Table S1. The effect of different Silanes<sup>a,b</sup>



Entry	Silanes	Yield (%) <sup>b</sup>
1	(MeO) <sub>2</sub> MeSiH	24
2	(MeO) <sub>3</sub> SiH	42
3	(EtO) <sub>2</sub> MeSiH	29
4	(EtO) <sub>3</sub> SiH	63
5	Me(OTMS) <sub>2</sub> SiH	23
6	PMHS	33
7	PhSiH <sub>3</sub>	25
8	Et <sub>3</sub> SiH	0

<sup>a</sup> Reaction conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), NiBr<sub>2</sub>·diglyme (0.01 mmol), **L1** (0.012 mmol), KF (0.4 mmol), Silane (0.4 mmol), DMA (1.5 mL), at 25 °C for 24 h. <sup>b</sup> Yields determined by GC using *n*-dodecane as the internal standard.

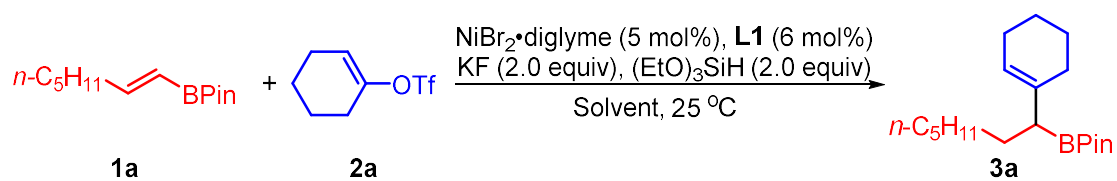
Table S2. The effect of different bases <sup>a,b</sup>



Entry	Bases	Yield (%) <sup>b</sup>
1	NaF	21
2	KF	63
3	CsF	0
4	NaHCO <sub>3</sub>	47
5	Na <sub>2</sub> CO <sub>3</sub>	51
6	K <sub>2</sub> CO <sub>3</sub>	1
7	KOMe	0
8	K <sub>3</sub> PO <sub>4</sub>	11
9	none	0

<sup>a</sup> Reaction conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), NiBr<sub>2</sub>·diglyme (0.01 mmol), **L1** (0.012 mmol), Base (0.4 mmol), (EtO)<sub>3</sub>SiH (0.4 mmol), DMA (1.5 mL), at 25 °C for 24 h. <sup>b</sup> Yields determined by GC using *n*-dodecane as the internal standard.

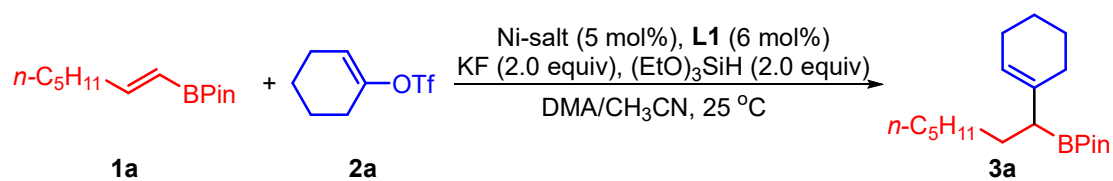
Table S3. The effect of different solvents<sup>a,b</sup>



Entry	Solvents	Yield (%) <sup>b</sup>
1	DMA	63
2	DMF	60
3	NMP	39
4	DME	17
5	Dioxane	1
6	THF	9
7	Toluene	0
8	CH <sub>3</sub> CN	16
9	DMA/CH <sub>3</sub> CN (30:1)	80

<sup>a</sup> Reaction conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), NiBr<sub>2</sub>·diglyme (0.01 mmol), **L1** (0.012 mmol), KF (0.4 mmol), (EtO)<sub>3</sub>SiH (0.4 mmol), Solvent (1.5 mL), at 25 °C for 24 h. <sup>b</sup> Yields determined by GC using *n*-dodecane as the internal standard.

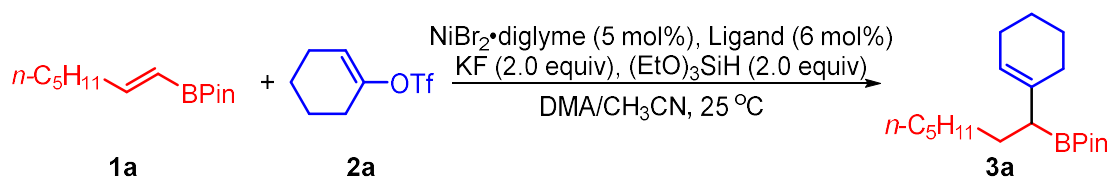
Table S4. The effect of different [Ni]-salts<sup>a,b</sup>



Entry	Ni-salts	Yield (%) <sup>b</sup>
1	NiBr <sub>2</sub> •diglyme	80
2	NiBr <sub>2</sub>	74
3	NiCl <sub>2</sub> •glyme	78
4	NiCl <sub>2</sub>	63
5	NiI <sub>2</sub>	13
6	Ni(acac) <sub>2</sub>	25
7	Ni(OTf) <sub>2</sub>	18
8	Ni(ClO <sub>4</sub> ) <sub>2</sub> •6H <sub>2</sub> O	74
9	none	0

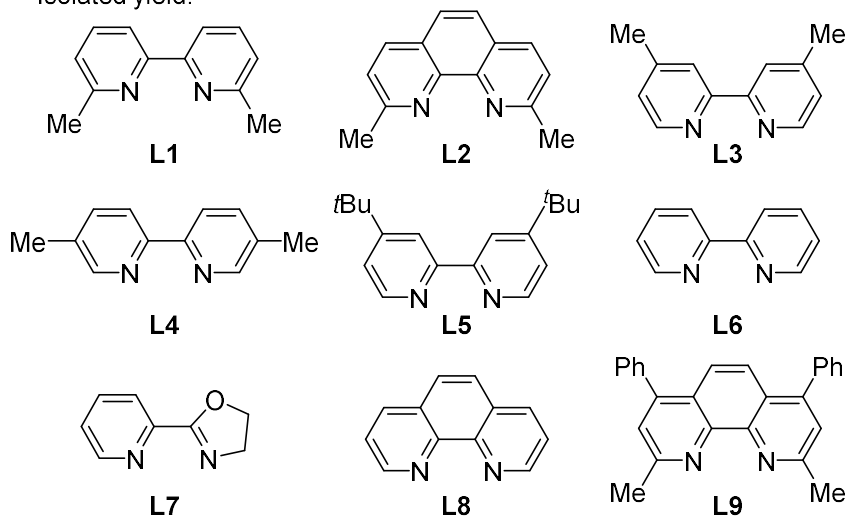
<sup>a</sup> Reaction conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), [Ni]-salt (0.01 mmol), **L1** (0.012 mmol), KF (0.4 mmol), (EtO)<sub>3</sub>SiH (0.4 mmol), DMA/CH<sub>3</sub>CN (30:1, 1.5 mL), at 25 °C for 24 h. <sup>b</sup> Yields determined by GC using *n*-dodecane as the internal standard.

Table S5. The effect of different ligands <sup>a,b</sup>



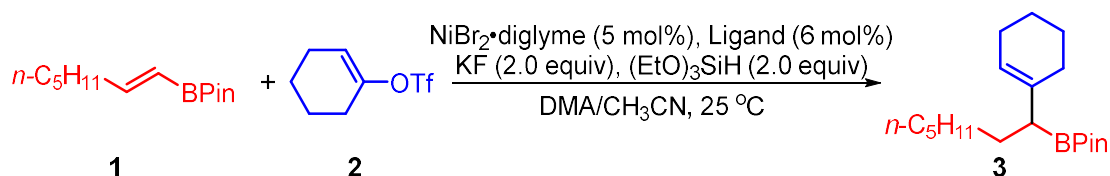
Entry	Ligand	Yield (%) <sup>b</sup>
1	<b>L1</b>	80 (68) <sup>c</sup>
2	<b>L2</b>	66
3	<b>L3</b>	0
4	<b>L4</b>	0
5	<b>L5</b>	0
6	<b>L6</b>	0
7	<b>L7</b>	0
8	<b>L8</b>	0
9	<b>L9</b>	71
10	none	0

<sup>a</sup> Reaction conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), NiBr<sub>2</sub>·diglyme (0.01 mmol), Ligand (0.012 mmol), KF (0.4 mmol), (EtO)<sub>3</sub>SiH (0.4 mmol), DMA/CH<sub>3</sub>CN (30:1, 1.5 mL), at 25 °C for 24 h. <sup>b</sup> Yields determined by GC using *n*-dodecane as the internal standard. <sup>c</sup> Isolated yield.



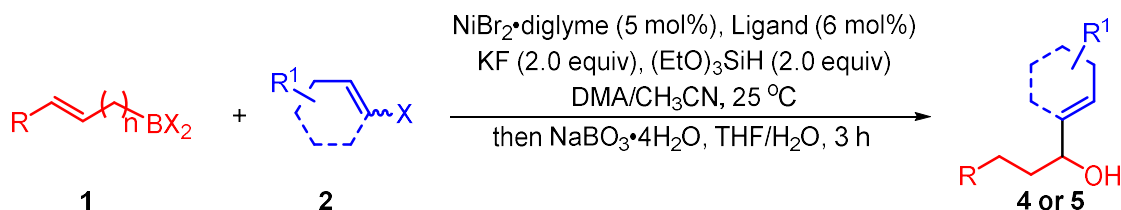
#### 4. General procedure for the reaction

General procedure A:



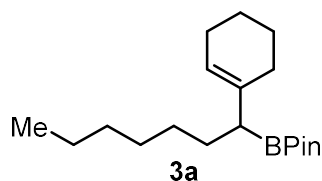
In an oven dried 25-ml Schlenk tube, which contained a stirring bar, was charged with  $\text{NiBr}_2\cdot\text{diglyme}$  (5 mol%), **L1** (6 mol%) and  $\text{KF}$  (0.4 mmol). The tube was then evacuated and back-filled under a  $\text{N}_2$  flow (this sequence was repeated three times), anhydrous  $\text{DMA/CH}_3\text{CN}$  (30:1, 1.5 ml) was added under  $\text{N}_2$ . The reaction mixture was stirred for another 10 min at  $25^\circ\text{C}$ , then  $(\text{EtO})_3\text{SiH}$  (0.4 mmol) was added. The reaction mixture was stirred for 10 min at  $25^\circ\text{C}$ , then **1** (0.2 mmol) and **2** (0.4 mmol) was added subsequently under  $\text{N}_2$ , the tube was stirred at  $25^\circ\text{C}$  for 24 h. *n*-Dodecane (23  $\mu\text{L}$ ) was added as an internal standard for GC analysis. The resulting mixture was diluted with  $\text{EtOAc}$  (2 mL) and quenched by  $\text{H}_2\text{O}$  (2 mL), then it was extracted with  $\text{EtOAc}$  (10 ml  $\times$  3), the organic layer was combined and dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated by rotary evaporation. The residue was purified by silica gel column chromatography to afford the product **3**.

General procedure B:

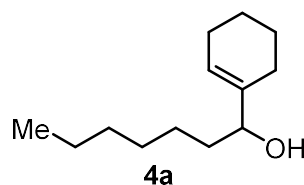


In an oven dried 25-ml Schlenk tube, which contained a stirring bar, was charged with  $\text{NiBr}_2\cdot\text{diglyme}$  (5 mol%), **L1** (6 mol%) and  $\text{KF}$  (0.4 mmol). The tube was then evacuated and back-filled under a  $\text{N}_2$  flow (this sequence was repeated three times). Anhydrous  $\text{DMA/CH}_3\text{CN}$  (30:1, 1.5 ml) was added under  $\text{N}_2$ . The reaction mixture was stirred for 10 min at  $25^\circ\text{C}$ , then  $(\text{EtO})_3\text{SiH}$  (0.4 mmol) was added, the reaction mixture was stirred for another 10 min at  $25^\circ\text{C}$ , then **1** (0.2 mmol) and **2** (0.4 mmol) was added subsequently under  $\text{N}_2$ . The tube was stirred at  $25^\circ\text{C}$  for 24 h. The resulting mixture was diluted with  $\text{EtOAc}$  (2 mL) and quenched by  $\text{H}_2\text{O}$  (2 mL). Then it was extracted with  $\text{EtOAc}$  (10 ml  $\times$  3). The organic layer was combined and dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated by rotary evaporation. The residue was dissolved in tetrahydrofuran (THF, 2.0 mL),  $\text{NaBO}_3\cdot 4\text{H}_2\text{O}$  (154 mg, 1.0 mmol) and  $\text{H}_2\text{O}$  (2.0 mL) were added, the resulting mixture was allowed to stir at  $25^\circ\text{C}$  for three hours. The reaction mixture diluted with  $\text{EtOAc}$  (5.0 ml) and  $\text{H}_2\text{O}$  (5.0 ml), then it was extracted with  $\text{EtOAc}$  (5.0 ml  $\times$  3), the organic layer was combined and dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated by rotary evaporation. The residue was purified by silica gel chromatography ( $\text{EtOAc}$ /petroleum ether) to afford the product **4** or **5**.

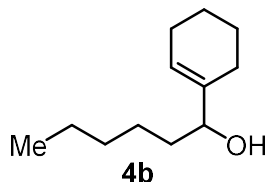
## 5. Analytical data for compounds



**2-(1-(Cyclohex-1-en-1-yl)heptyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3a):** The general procedure A was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 200) afforded product **3a** as a colorless oil (41 mg, 68% yield):  $R_f = 0.8$  (EtOAc : petroleum ether = 1 : 20);  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 600 MHz)  $\delta$ : 5.39 (s, 1H), 2.01-1.89 (m, 4H), 1.64-1.51 (m, 6H), 1.46-1.40 (m, 1H), 1.30-1.24 (m, 8H), 1.23 (s, 6H), 1.22 (s, 6H), 0.87 (t,  $J = 7.2$  Hz, 3H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 150 MHz)  $\delta$ : 138.2, 120.4, 82.9, 31.8, 29.4, 29.3, 29.2, 28.4, 25.5, 24.7, 24.5, 23.3, 22.7, 22.6, 14.1 ppm; **HRMS** (ESI)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $\text{C}_{19}\text{H}_{36}\text{BO}_2$  306.2845; Found 306.2850.

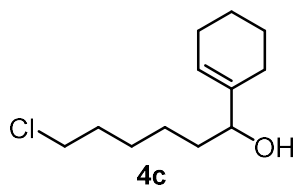


**1-(Cyclohex-1-en-1-yl)heptan-1-ol (4a):** The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4a** as a colorless oil (25 mg, 64% yield):  $R_f = 0.6$  (EtOAc : petroleum ether = 1 : 4);  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 5.65-5.63 (m, 1H), 3.95 (t,  $J = 6.8$  Hz, 1H), 2.09-2.00 (m, 3H), 1.94-1.87 (m, 1H), 1.68-1.50 (m, 6H), 1.38 (s, 1H), 1.36-1.20 (m, 8H), 0.88 (t,  $J = 6.8$  Hz, 3H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 140.0, 123.1, 76.8, 34.8, 31.8, 29.3, 25.8, 25.0, 23.3, 22.64, 22.60, 14.1 ppm; **HRMS** (ESI)  $m/z$ :  $[\text{M}-\text{H}]^-$  calcd for  $\text{C}_{13}\text{H}_{23}\text{O}$  195.1749; Found 195.1740.

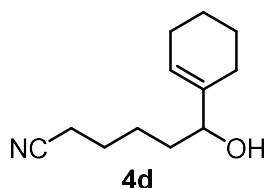


**1-(Cyclohex-1-en-1-yl)hexan-1-ol (4b):** The general procedure B was followed using (*E*)-2-(hex-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1b**, 42 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4b** as a colorless oil (24 mg, 67% yield):  $R_f = 0.6$  (EtOAc : petroleum ether = 1 : 4);  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 5.65-5.63 (m, 1H), 3.95 (t,  $J = 6.8$  Hz, 1H), 2.09-2.00 (m, 3H), 1.94-1.86 (m, 1H), 1.68-1.50 (m, 6H), 1.40 (s, 1H), 1.38-1.21 (m, 6H), 0.89 (t,  $J = 6.8$  Hz, 3H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ ,

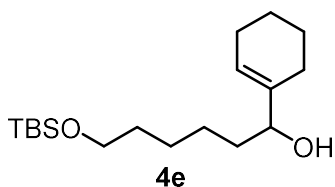
100 MHz)  $\delta$ : 140.0, 123.1, 76.8, 34.8, 31.8, 25.5, 25.0, 23.3, 22.66, 22.60, 14.0 ppm; **HRMS** (ESI)  $m/z$ :  $[M + H]^+$  calcd for  $C_{12}H_{23}O$  183.1749; Found 183.1740.



**6-Chloro-1-(cyclohex-1-en-1-yl)hexan-1-ol (4c)**: The general procedure B was followed using (*E*)-2-(6-chlorohex-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1c**, 49 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4c** as a colorless oil (27 mg, 63% yield):  $R_f$  = 0.5 (EtOAc : petroleum ether = 1 : 4);  **$^1H$  NMR** ( $CDCl_3$ , 400 MHz)  $\delta$ : 5.66-5.64 (m, 1H), 3.96 (t,  $J$  = 6.8 Hz, 1H), 3.54 (t,  $J$  = 6.8 Hz, 2H), 2.09-2.00 (m, 3H), 1.93-1.86 (m, 1H), 1.82-1.75 (m, 2H), 1.69-1.51 (m, 6H), 1.50-1.33 (m, 4H), 1.32-1.24 (m, 1H);  **$^{13}C$  NMR** ( $CDCl_3$ , 100 MHz)  $\delta$ : 139.9, 123.2, 76.7, 45.1, 34.6, 32.5, 26.8, 25.1, 24.9, 23.3, 22.60 ppm; **HRMS** (ESI)  $m/z$ :  $[M-H]^-$  calcd for  $C_{12}H_{20}ClO$  215.1203; Found 215.1196.

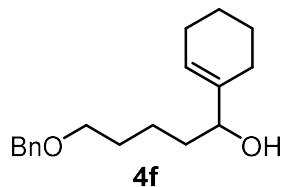


**6-(Cyclohex-1-en-1-yl)-6-hydroxyhexanenitrile (4d)**: The general procedure B was followed using (*E*)-6-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)hex-5-enenitrile (**1d**, 44 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 5) afforded product **4d** as a colorless oil (27 mg, 70% yield):  $R_f$  = 0.2 (EtOAc : petroleum ether = 1 : 4);  **$^1H$  NMR** ( $CDCl_3$ , 400 MHz)  $\delta$ : 5.67-5.65 (m, 1H), 3.97 (t,  $J$  = 6.8 Hz, 1H), 2.35 (t,  $J$  = 7.2 Hz, 2H), 2.08-2.00 (m, 3H), 1.92-1.87 (m, 1H), 1.73-1.50 (m, 9H), 1.49-1.40 (m, 2H);  **$^{13}C$  NMR** ( $CDCl_3$ , 100 MHz)  $\delta$ : 139.6, 123.5, 119.7, 76.3, 33.7, 25.3, 25.0, 24.9, 23.3, 22.6, 17.1 ppm; **HRMS** (ESI)  $m/z$ :  $[M + H]^+$  calcd for  $C_{12}H_{20}ON$  194.1545; Found 194.1548.

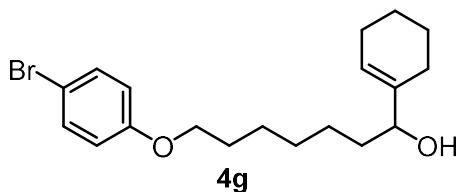


**6-((Tert-butyldimethylsilyloxy)-1-(cyclohex-1-en-1-yl)hexan-1-ol (4e)**: The general procedure B was followed using (*E*)-tert-butyldimethyl((6-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)hex-5-en-1-yl)oxy)silane (**1e**, 68 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4e** as a colorless oil (38 mg, 60% yield):  $R_f$  = 0.7 (EtOAc : petroleum ether = 1 : 4);  **$^1H$  NMR** ( $CDCl_3$ , 400 MHz)  $\delta$ : 5.65-5.63 (m, 1H), 3.95 (t,  $J$  =

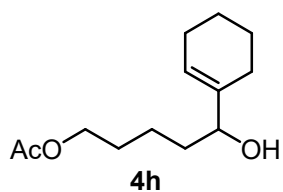
6.8 Hz, 1H), 3.60 (t,  $J = 6.8$  Hz, 2H), 2.09-2.00 (m, 3H), 1.94-1.87 (m, 1H), 1.70-1.49 (m, 8H), 1.44 (s, 1H), 1.38-1.22 (m, 4H), 0.89 (s, 9H), 0.05 (s, 6H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 140.0, 123.1, 76.7, 63.2, 34.8, 32.8, 26.0, 25.8, 25.6, 25.0, 23.3, 22.6, 18.4, -5.3 ppm; HRMS (ESI)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{18}\text{H}_{37}\text{O}_2\text{Si}$  313.2563; Found 313.2576.



**5-(Benzyloxy)-1-(cyclohex-1-en-1-yl)pentan-1-ol (4f)**: The general procedure B was followed using (*E*)-2-(5-(benzyloxy)pent-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1f**, 60 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4f** as a colorless oil (30 mg, 55% yield):  $R_f = 0.4$  (EtOAc : petroleum ether = 1 : 4);  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 7.37-7.27 (m, 5H), 5.64-5.63 (m, 1H), 4.50 (s, 2H), 3.95 (t,  $J = 6.8$  Hz, 1H), 3.47 (t,  $J = 6.8$  Hz, 2H), 2.08-2.00 (m, 3H), 1.93-1.85 (m, 1H), 1.68-1.52 (m, 8H), 1.47-1.30 (m, 3H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 139.9, 138.6, 128.3, 127.6, 127.5, 123.3, 76.6, 72.9, 70.3, 34.6, 29.6, 25.0, 23.3, 22.6, 22.5 ppm; HRMS (ESI)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{18}\text{H}_{27}\text{O}_2$  275.2011; Found 275.2023.

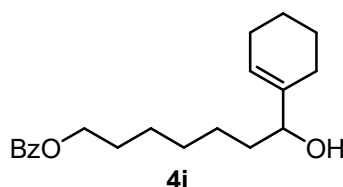


**7-(4-Bromophenoxy)-1-(cyclohex-1-en-1-yl)heptan-1-ol (4g)**: The general procedure B was followed using (*E*)-2-(7-(4-bromophenoxy)hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1g**, 79 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4g** as a colorless oil (44 mg, 60% yield):  $R_f = 0.5$  (EtOAc : petroleum ether = 1 : 4);  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 7.37-7.34 (m, 2H), 6.78-6.76 (m, 2H), 5.65-5.63 (m, 1H), 3.97-3.89 (m, 3H), 2.08-1.99 (m, 3H), 1.94-1.86 (m, 1H), 1.80-1.73 (m, 2H), 1.67-1.33 (m, 13H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 158.2, 140.0, 132.2, 123.2, 116.3, 112.5, 76.8, 68.2, 34.7, 29.3, 29.1, 25.9, 25.7, 25.0, 23.3, 22.6 ppm; HRMS (ESI)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{19}\text{H}_{28}\text{BrO}_2$  367.1273; Found 367.1266.

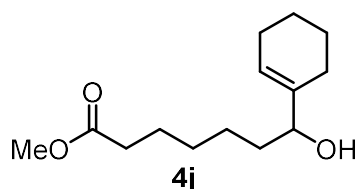


**5-(Cyclohex-1-en-1-yl)-5-hydroxypentyl acetate (4h)**: The general procedure B was followed using (*E*)-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pent-4-en-1-yl acetate (**1h**, 51 mg, 0.2

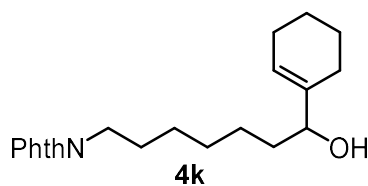
mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4h** as a colorless oil (27 mg, 60% yield): Rf = 0.4 (EtOAc : petroleum ether = 1 : 4); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 5.67-5.64 (m, 1H), 4.06 (t, *J* = 6.8 Hz, 2H), 3.96 (t, *J* = 6.8 Hz, 1H), 2.09-2.00 (m, 6H), 1.93-1.87 (m, 1H), 1.69-1.53 (m, 8H), 1.48-1.39 (m, 2H), 1.37-1.30 (m, 1H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 171.2, 139.8, 123.3, 76.5, 64.4, 34.3, 28.5, 24.9, 23.3, 22.6, 22.2, 21.0 ppm; HRMS (ESI) *m/z*: [M-H]<sup>-</sup> calcd for C<sub>13</sub>H<sub>21</sub>O<sub>3</sub> 225.1491; Found 225.1491.



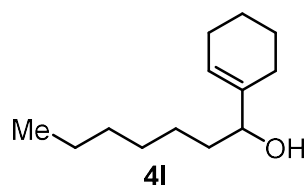
**7-(Cyclohex-1-en-1-yl)-7-hydroxyheptyl benzoate (4i)**: The general procedure B was followed using (*E*)-7-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)hept-6-en-1-yl benzoate (**1i**, 69 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4i** as a colorless oil (37 mg, 59% yield): Rf = 0.4 (EtOAc : petroleum ether = 1 : 4); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 8.06-8.03 (m, 2H), 7.57-7.53 (m, 1H), 7.46-7.42 (m, 2H), 5.64-5.63 (m, 1H), 4.31 (t, *J* = 6.8 Hz, 2H), 3.95 (t, *J* = 6.8 Hz, 1H), 2.09-1.99 (m, 3H), 1.93-1.86 (m, 1H), 1.80-1.73 (m, 2H), 1.66-1.51 (m, 6H), 1.48-1.35 (m, 6H), 1.31-1.26 (m, 1H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 166.7, 140.0, 132.8, 130.5, 129.5, 128.3, 123.1, 76.7, 65.0, 34.7, 29.2, 28.7, 26.0, 25.7, 24.9, 23.3, 22.6 ppm; HRMS (ESI) *m/z*: [M+H]<sup>+</sup> calcd for C<sub>20</sub>H<sub>29</sub>O<sub>3</sub> 317.2117; Found 317.2112.



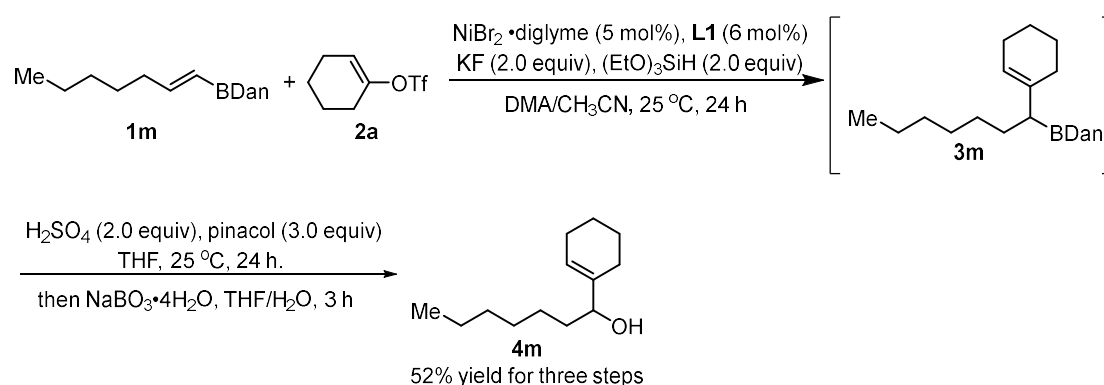
**Methyl 7-(cyclohex-1-en-1-yl)-7-hydroxyheptanoate (4j)**: The general procedure B was followed using methyl (*E*)-7-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl) hept-6-enoate (**1j**, 54 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4j** as a colorless oil (31 mg, 65% yield): Rf = 0.3 (EtOAc : petroleum ether = 1 : 4); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 5.65-5.63 (m, 1H), 3.94 (t, *J* = 6.8 Hz, 1H), 3.67 (s, 3H), 2.31 (t, *J* = 7.6 Hz, 2H), 2.08-2.00 (m, 3H), 1.93-1.85 (m, 1H), 1.67-1.50 (m, 8H), 1.42 (s, 1H), 1.39-1.26 (m, 4H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 174.2, 139.9, 123.1, 76.7, 51.5, 34.6, 34.0, 29.1, 25.5, 24.94, 24.86, 23.3, 22.6 ppm; HRMS (ESI) *m/z*: [M+H]<sup>+</sup> calcd for C<sub>14</sub>H<sub>25</sub>O<sub>3</sub> 241.1804; Found 241.1817.



**2-(7-(Cyclohex-1-en-1-yl)-7-hydroxyheptyl)isoindoline-1,3-dione (4k):** The general procedure B was followed using (*E*)-2-(7-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)hept-6-en-1-yl)isoindoline-1,3-dione (**1k**, 74 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 5) afforded product **4k** as a colorless oil (45 mg, 66% yield): *R*<sub>f</sub> = 0.3 (EtOAc : petroleum ether = 1 : 4); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 7.85-7.83 (m, 2H), 7.72-7.70 (m, 2H), 5.64-5.62 (m, 1H), 3.93 (t, *J* = 6.8 Hz, 1H), 3.67 (t, *J* = 7.2 Hz, 2H), 2.08-1.99 (m, 3H), 1.92-1.85 (m, 1H), 1.73-1.49 (m, 8H), 1.46 (s, 1H), 1.37-1.25 (m, 6H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 168.4, 139.9, 133.8, 132.1, 123.1, 76.7, 38.0, 34.6, 29.1, 28.5, 26.8, 25.6, 24.9, 23.2, 22.6 ppm; HRMS (ESI) *m/z*: [M+H]<sup>+</sup> calcd for C<sub>21</sub>H<sub>28</sub>O<sub>3</sub>N 342.2069; Found 342.2057.

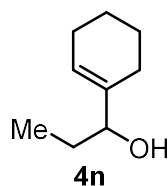


**1-(Cyclohex-1-en-1-yl)heptan-1-ol (4l):** The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,6,6-tetramethyl-1,3,2-dioxaborinane (**1l**, 48 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4l** as a colorless oil (18 mg, 45% yield): *R*<sub>f</sub> = 0.6 (EtOAc : petroleum ether = 1 : 4). The analytical data matches with **4a**.

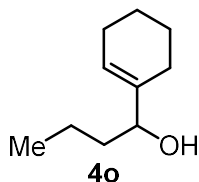


**1-(Cyclohex-1-en-1-yl)heptan-1-ol (4m):** In an oven dried 25-ml Schlenk tube, which contained a stirring bar, was charged with NiBr<sub>2</sub>·diglyme (5 mol%, 3.5 mg), **L1** (6 mol% 2.2 mg), KF (0.4 mmol, 23 mg), the tube was then evacuated and back-filled under a N<sub>2</sub> flow (this sequence was repeated three times). Anhydrous DMA/CH<sub>3</sub>CN (30:1, 1.5 ml) was added under N<sub>2</sub>, the reaction mixture was stirred for 10 min at 25 °C, then (EtO)<sub>3</sub>SiH (0.4 mmol, 66 mg) was added. The reaction mixture was stirred for 10 min at 25 °C, then (*E*)-2-(hept-1-en-1-yl)-2,3-dihydro-1H-naphtho [1,8-de][1,3,2]diazaborinine (**1m**, 53 mg, 0.2 mmol), cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol) were added, subsequently under N<sub>2</sub>, the tube was stirred at 25 °C for 24 h. the resulting mixture was diluted with EtOAc (2 mL) and quenched by H<sub>2</sub>O (2 mL), then it was extracted with EtOAc (10 ml × 3). The organic layer was combined and dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated by rotary evaporation. The residue was dissolved in tetrahydrofuran (THF, 2.0 mL), H<sub>2</sub>SO<sub>4</sub> (0.2 mL, 2 mol/L, 0.4 mmol) and pinacol (70.9 mg, 0.6 mmol), the resulting mixture was allowed to stir at 25 °C for 24 hours. The reaction mixture

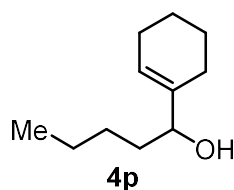
quenched by H<sub>2</sub>O (5.0 ml), then it was extracted with EtOAc (5.0 ml × 3). The organic layer was combined and dried over Na<sub>2</sub>SO<sub>4</sub>, then filtered and concentrated by rotary evaporation. The residue was dissolved in tetrahydrofuran (THF, 2.0 mL). NaBO<sub>3</sub>·4H<sub>2</sub>O (153.8 mg, 1.0 mmol) and H<sub>2</sub>O (2.0 mL) were added. The resulting mixture was allowed to stir at 25 °C for three hours. The reaction mixture diluted with EtOAc (5.0 ml) and H<sub>2</sub>O (5.0 ml). Then it was extracted with EtOAc (5.0 ml × 3). The organic layer was combined and dried over Na<sub>2</sub>SO<sub>4</sub>. Then filtered and concentrated by rotary evaporation. The residue was purified by silica gel chromatography (EtOAc : petroleum ether = 1 : 10) afforded product **4m** as a colorless oil (20 mg, 52% yield). The analytical data matches with **4a**.



**1-(Cyclohex-1-en-1-yl)propan-1-ol (4n)**: The general procedure B was followed using 2-allyl-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1n**, 34 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4n** as a colorless oil (19 mg, 69% yield): R<sub>f</sub> = 0.6 (EtOAc : petroleum ether = 1 : 4); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 5.66-5.64 (m, 1H), 3.88 (t, *J* = 6.8 Hz, 1H), 2.09-2.00 (m, 3H), 1.93-1.86 (m, 1H), 1.69-1.51 (m, 6H), 1.41 (s, 1H), 0.87 (t, *J* = 7.2 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 139.6, 123.3, 78.2, 27.6, 25.0, 23.3, 22.65, 22.64, 10.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>9</sub>H<sub>17</sub>O 141.1279; Found 141.1272.

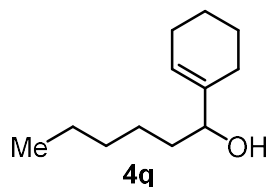


**1-(Cyclohex-1-en-1-yl)butan-1-ol (4o)**: The general procedure B was followed using 2-(but-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1o**, 36 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4o** as a colorless oil (20 mg, 66% yield): R<sub>f</sub> = 0.6 (EtOAc : petroleum ether = 1 : 4); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 5.66-5.63 (m, 1H), 3.97 (t, *J* = 6.8 Hz, 1H), 2.10-2.00 (m, 3H), 1.95-1.87 (m, 1H), 1.67-1.49 (m, 6H), 1.40-1.26 (m, 3H), 0.93 (t, *J* = 7.2 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 140.0, 123.1, 76.6, 37.0, 25.0, 23.3, 22.7, 19.0, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>10</sub>H<sub>19</sub>O 155.1436; Found 155.1434.

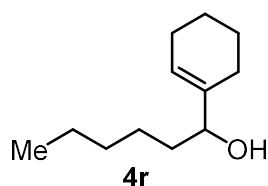


**1-(Cyclohex-1-en-1-yl)pentan-1-ol (4p)**: The general procedure B was followed using 4,4,5,5-tetramethyl-2-(pent-4-en-1-yl)-1,3,2-dioxaborolane (**1p**, 39 mg, 0.2 mmol) and

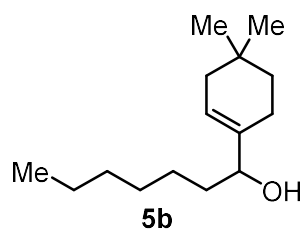
cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4b** as a colorless oil (15 mg, 44% yield): Rf = 0.6 (EtOAc : petroleum ether = 1 : 4); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 5.66-5.63 (m, 1H), 3.95 (t, *J* = 6.8 Hz, 1H), 2.09-2.00 (m, 3H), 1.94-1.88 (m, 1H), 1.67-1.51 (m, 6H), 1.38 (s, 1H), 1.37-1.20 (m, 4H), 0.90 (t, *J* = 6.8 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 140.0, 123.1, 76.8, 34.5, 28.0, 25.0, 23.3, 22.7, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>11</sub>H<sub>21</sub>O 169.1592; Found 169.1584.



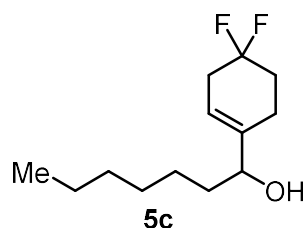
**1-(Cyclohex-1-en-1-yl)hexan-1-ol (4q)**: The general procedure B was followed using 2-(hex-5-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1q**, 42 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4q** as a colorless oil (16 mg, 45% yield): Rf = 0.6 (EtOAc : petroleum ether = 1 : 4). The analytical data matches with **4b**.



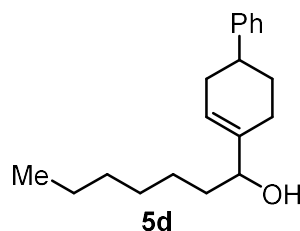
**1-(Cyclohex-1-en-1-yl)heptan-1-ol (4r)**: The general procedure B was followed using 2-(hex-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1r**, 42 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **4r** as a colorless oil (19 mg, 52% yield): Rf = 0.6 (EtOAc : petroleum ether = 1 : 4). The analytical data matches with **4b**.



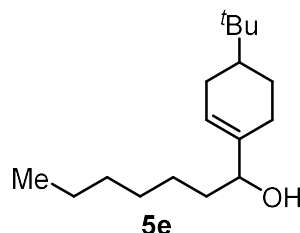
**1-(4,4-Dimethylcyclohex-1-en-1-yl)heptan-1-ol (5b)**: The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 4,4-dimethylcyclohex-1-en-1-yl trifluoromethanesulfonate (**2b**, 103 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **5b** as a colorless oil (25 mg, 55% yield): Rf = 0.7 (EtOAc : petroleum ether = 1 : 4); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 5.58-5.56 (m, 1H), 3.99 (t, *J* = 6.8 Hz, 1H), 2.13-2.05 (m, 1H), 1.97-1.75 (m, 3H), 1.57-1.51 (m, 2H), 1.41-1.19 (m, 11H), 0.91 (s, 3H), 0.90-0.86 (m, 6H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 138.5, 122.3, 76.6, 39.0, 35.4, 34.9, 31.8, 29.3, 28.9, 28.8, 27.5, 25.7, 22.6, 20.9, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>15</sub>H<sub>29</sub>O 225.2218; Found 225.2231.



**1-(4,4-Difluorocyclohex-1-en-1-yl)heptan-1-ol (5c):** The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 4,4-difluorocyclohex-1-en-1-yl trifluoromethanesulfonate (**2c**, 106 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **5c** as a colorless oil (24 mg, 53% yield): *R*<sub>f</sub> = 0.8 (EtOAc : petroleum ether = 1 : 4); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 600 MHz) δ: 5.54-5.52 (m, 1H), 4.05 (t, *J* = 6.6 Hz, 1H), 2.57-2.51 (m, 2H), 2.39-2.33 (m, 1H), 2.24-2.18 (m, 1H), 2.10-1.96 (m, 2H), 1.56-1.52 (m, 3H), 1.36-1.25 (m, 8H), 0.88 (t, *J* = 6.6 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 150 MHz) δ: 139.6, 129.6, 127.4, 124.6, 123.6, 123.0, 121.4, 117.68, 117.65, 117.61, 75.5, 35.0, 34.6, 34.4, 34.2, 31.8, 30.4, 30.2, 30.1, 29.1, 25.6, 22.6, 21.80, 21.76, 21.7, 14.0 ppm; <sup>19</sup>F NMR (CDCl<sub>3</sub>, 565 MHz) δ: -75.32, -95.48, -95.89, -95.94, -96.66, -96.70, -96.74, -97.11; HRMS (ESI) *m/z*: [M - H]<sup>-</sup> calcd for C<sub>13</sub>H<sub>21</sub>F<sub>2</sub>O 231.1561; Found 231.1565.

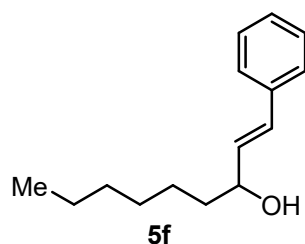


**1-(1,2,3,6-Tetrahydro-[1,1'-biphenyl]-4-yl)heptan-1-ol (5d):** The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 1,2,3,6-tetrahydro-[1,1'-biphenyl]-4-yl trifluoromethanesulfonate (**2d**, 122 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **5c** as a colorless oil (33 mg, 60% yield, 43:57 dr): *R*<sub>f</sub> = 0.6 (EtOAc : petroleum ether = 1 : 4); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 7.33-7.29 (m, 2H), 7.24-7.18 (m, 3H), 5.76-5.73 (m, 1H), 4.04 (t, *J* = 6.8 Hz, 1H), 2.86-2.71 (m, 1H), 2.39-1.97 (m, 5H), 1.80-1.70 (m, 1H), 1.60-1.54 (m, 2H), 1.44-1.42 (m, 1H), 1.37-1.26 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 147.0, 146.9, 140.0, 139.9, 128.4, 128.3, 126.9, 126.8, 126.03, 126.00, 123.1, 122.2, 76.5, 76.4, 40.4, 40.1, 35.1, 34.8, 33.4, 32.9, 31.8, 29.8, 29.7, 29.3, 25.9, 25.7, 24.0, 23.8, 22.6, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>19</sub>H<sub>29</sub>O 273.2218; Found 273.2213.

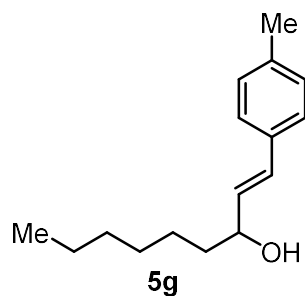


**1-(4-(Tert-butyl)cyclohex-1-en-1-yl)heptan-1-ol (5e):** The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and

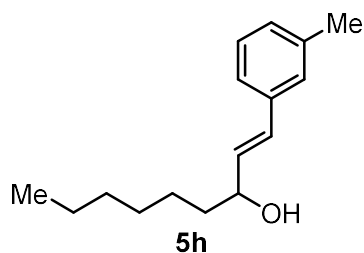
4-(tert-butyl)cyclohex-1-en-1-yl trifluoromethanesulfonate (**2e**, 114 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **5e** as a colorless oil (32 mg, 63% yield, 55:45 dr): Rf = 0.7 (EtOAc : petroleum ether = 1 : 4); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 5.65-5.63 (m, 1H), 3.97 (t, *J* = 6.8 Hz, 1H), 2.24-1.75 (m, 5H), 1.58-1.47 (m, 2H), 1.43 (s, 1H), 1.35-1.08 (m, 10H), 0.90-0.87 (m, 12H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 139.9, 139.8, 124.0, 122.5, 76.5, 76.3, 44.4, 35.2, 34.7, 32.2, 31.8, 29.3, 27.2, 26.6, 26.5, 25.9, 25.6, 25.3, 24.2, 24.00, 23.97, 22.6, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>17</sub>H<sub>33</sub>O 253.2531; Found 253.2534.



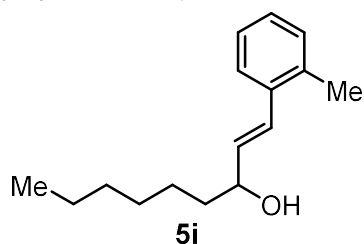
**(E)-1-Phenylnon-1-en-3-ol (5f)**: The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and (2-bromovinyl)benzene (**2f**, 73 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **5f** as a colorless oil (28 mg, 65% yield): Rf = 0.4 (EtOAc : petroleum ether = 1 : 10); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 600 MHz) δ: 7.39-7.37 (m, 2H), 7.33-7.30 (m, 2H), 7.25-7.22 (m, 1H), 6.55 (d, *J* = 16.2, 1H), 6.22 (dd, *J*<sub>1</sub> = 15.6, *J*<sub>2</sub> = 6.6 Hz, 1H), 4.28 (q, *J* = 6.6 Hz, 1H), 1.67-1.56 (m, 3H), 1.45-1.39 (m, 1H), 1.38-1.28 (m, 7H), 0.88 (t, *J* = 6.6 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 150 MHz) δ: 136.7, 132.6, 130.2, 128.6, 127.6, 126.4, 73.1, 37.4, 31.8, 29.2, 25.4, 22.6, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>15</sub>H<sub>23</sub>O 219.1749; Found 219.1761.



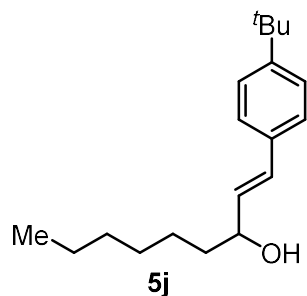
**(E)-1-(*p*-Tolyl)non-1-en-3-ol (5g)**: The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 1-(2-bromovinyl)-4-methylbenzene (**2g**, 79 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **5g** as a colorless oil (32 mg, 68% yield): Rf = 0.4 (EtOAc : petroleum ether = 1 : 10); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 7.29-7.27 (m, 2H), 7.13-7.11 (m, 2H), 6.53 (dd, *J*<sub>1</sub> = 16.0, *J*<sub>2</sub> = 1.2 Hz, 1H), 6.16 (dd, *J*<sub>1</sub> = 16.0, *J*<sub>2</sub> = 6.8 Hz, 1H), 4.25 (q, *J* = 6.8 Hz, 1H), 2.33 (s, 3H), 1.66-1.54 (m, 3H), 1.45-1.27 (m, 8H), 0.88 (t, *J* = 6.8 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 137.5, 134.0, 131.6, 130.2, 129.3, 126.4, 73.2, 37.4, 31.8, 29.2, 25.4, 22.6, 21.2, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>16</sub>H<sub>25</sub>O 233.1905; Found 233.1916.



**(E)-1-(*m*-Tolyl)non-1-en-3-ol (5h):** The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 1-(2-bromovinyl)-3-methylbenzene (**2h**, 79 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **5h** as a colorless oil (31 mg, 67% yield): *R*<sub>f</sub> = 0.4 (EtOAc : petroleum ether = 1 : 10); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 600 MHz) δ: 7.22-7.17 (m, 3H), 7.06-7.05 (m, 1H), 6.53 (dd, *J*<sub>1</sub> = 15.6, *J*<sub>2</sub> = 1.2 Hz, 1H), 6.20 (dd, *J*<sub>1</sub> = 15.6, *J*<sub>2</sub> = 6.6 Hz, 1H), 4.26 (q, *J* = 6.6 Hz, 1H), 2.34 (s, 3H), 1.67-1.57 (m, 3H), 1.46-1.39 (m, 1H), 1.37-1.28 (m, 7H), 0.88 (t, *J* = 6.6 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 150 MHz) δ: 138.1, 136.6, 132.4, 130.3, 128.5, 128.4, 127.1, 123.6, 73.2, 37.3, 31.8, 29.2, 25.4, 22.6, 21.4, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>16</sub>H<sub>25</sub>O 233.1905; Found 233.1897.

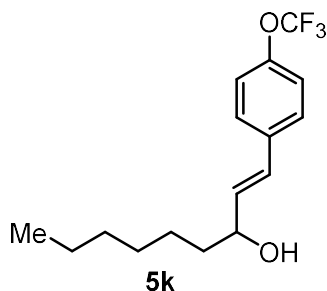


**(E)-1-(*o*-Tolyl)non-1-en-3-ol (5i):** The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 1-(2-bromovinyl)-2-methylbenzene (**2i**, 79 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **5i** as a colorless oil (29 mg, 63% yield): *R*<sub>f</sub> = 0.4 (EtOAc : petroleum ether = 1 : 10); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 600 MHz) δ: 7.44-7.43 (m, 1H), 7.18-7.14 (m, 3H), 6.77 (dd, *J*<sub>1</sub> = 15.6, *J*<sub>2</sub> = 1.2 Hz, 1H), 6.10 (dd, *J*<sub>1</sub> = 15.6, *J*<sub>2</sub> = 7.2 Hz, 1H), 4.29 (q, *J* = 7.2 Hz, 1H), 2.35 (s, 3H), 1.70-1.58 (m, 3H), 1.46-1.29 (m, 8H), 0.89 (t, *J* = 7.2 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 135.9, 135.5, 134.0, 130.3, 128.1, 127.5, 126.1, 125.7, 73.3, 37.4, 31.8, 29.2, 25.4, 22.6, 19.8, 14.1 ppm; HRMS (ESI) *m/z*: [M - H]<sup>-</sup> calcd for C<sub>16</sub>H<sub>23</sub>O 231.1749; Found 231.1743.

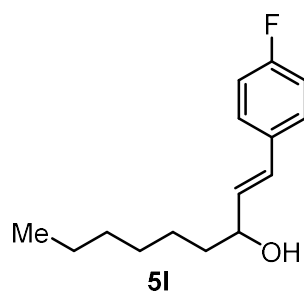


**(E)-1-(4-(Tert-butyl)phenyl)non-1-en-3-ol (5j):** The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 1-(2-bromovinyl)-4-(tert-butyl)benzene (**2j**, 96 mg, 0.4 mmol). Purification of this material by

chromatography on silica gel (EtOAc : petroleum ether = 1 : 20) afforded product **5j** as a colorless oil (31 mg, 56% yield): Rf = 0.4 (EtOAc : petroleum ether = 1 : 10); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 7.36-7.31 (m, 4H), 6.54 (dd, *J*<sub>1</sub> = 16.0, *J*<sub>2</sub> = 1.2 Hz, 1H), 6.18 (dd, *J*<sub>1</sub> = 16.0, *J*<sub>2</sub> = 6.8 Hz, 1H), 4.26 (q, *J* = 6.8 Hz, 1H), 1.68-1.57 (m, 3H), 1.42-1.28 (m, 17H), 0.88 (t, *J* = 6.8 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 150.8, 134.0, 131.9, 130.0, 126.2, 125.5, 73.3, 37.4, 34.6, 31.8, 31.3, 29.2, 25.4, 22.6, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>19</sub>H<sub>31</sub>O 275.2375; Found 275.2368.

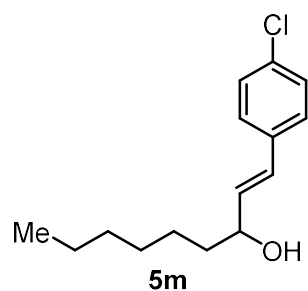


**(E)-1-(4-(Trifluoromethoxy)phenyl)non-1-en-3-ol (5k)**: The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 1-(2-bromovinyl)-4-(trifluoromethoxy)benzene (**2k**, 107 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **5k** as a colorless oil (40 mg, 67% yield): Rf = 0.4 (EtOAc : petroleum ether = 1 : 10); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 600 MHz) δ: 7.39 (d, *J* = 9.0 Hz, 2H), 7.16 (d, *J* = 8.4, 2H), 6.56 (dd, *J*<sub>1</sub> = 16.2, *J*<sub>2</sub> = 1.2 Hz, 1H), 6.20 (dd, *J*<sub>1</sub> = 15.6, *J*<sub>2</sub> = 6.6 Hz, 1H), 4.28 (q, *J* = 3.6 Hz, 1H), 1.68-1.59 (m, 3H), 1.46-1.41 (m, 1H), 1.38-1.28 (m, 7H), 0.88 (t, *J* = 6.6 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 150 MHz) δ: 148.5, 135.6, 133.7, 128.6, 127.6, 121.1, 72.9, 37.4, 31.8, 29.2, 25.4, 22.6, 14.1 ppm; <sup>19</sup>F NMR (CDCl<sub>3</sub>, 565 MHz) δ: -57.76; HRMS (ESI) *m/z*: [M - H]<sup>-</sup> calcd for C<sub>16</sub>H<sub>20</sub>O<sub>2</sub>F<sub>3</sub> 301.1415; Found 301.1414.

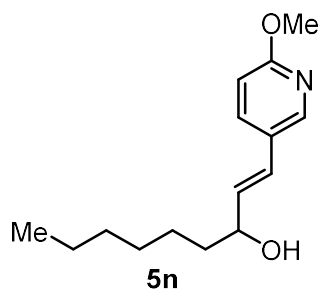


**(E)-1-(4-Fluorophenyl)non-1-en-3-ol (5l)**: The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 1-(2-bromovinyl)-4-fluorobenzene (**2l**, 80 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **5l** as a colorless oil (34 mg, 71% yield): Rf = 0.4 (EtOAc : petroleum ether = 1 : 10); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 7.36-7.33 (m, 2H), 7.02-6.98 (m, 2H), 6.53 (dd, *J*<sub>1</sub> = 16.0, *J*<sub>2</sub> = 1.2 Hz, 1H), 6.13 (dd, *J*<sub>1</sub> = 16.0, *J*<sub>2</sub> = 6.8 Hz, 1H), 4.26 (q, *J* = 6.8 Hz, 1H), 1.67-1.58 (m, 3H), 1.47-1.28 (m, 8H), 0.88 (t, *J* = 6.8 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 162.4 (d, *J* = 245.5 Hz), 132.9, 132.4, 129.0, 128.0, 127.9, 115.6, 115.4, 73.0, 37.4, 31.8, 29.2, 25.4, 22.6, 14.1 ppm; <sup>19</sup>F NMR (CDCl<sub>3</sub>, 376 MHz) δ: -114.35, -114.37, -114.39, -114.41, -114.43; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>15</sub>H<sub>22</sub>FO

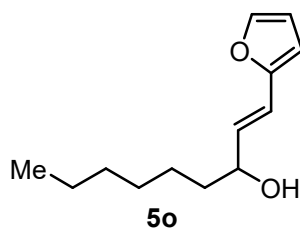
237.1655; Found 237.1653.



**(E)-1-(4-Chlorophenyl)non-1-en-3-ol (5m):** The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 1-(2-bromovinyl)-4-chlorobenzene (**2m**, 87 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **5m** as a colorless oil (31 mg, 62% yield):  $R_f = 0.4$  (EtOAc : petroleum ether = 1 : 10);  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 600 MHz)  $\delta$ : 7.31-7.27 (m, 4H), 6.52 (dd,  $J_1 = 15.6$ ,  $J_2 = 1.2$  Hz, 1H), 6.20 (dd,  $J_1 = 15.6$ ,  $J_2 = 7.2$  Hz, 1H), 4.27 (q,  $J = 6.6$  Hz, 1H), 1.67-1.56 (m, 3H), 1.45-1.40 (m, 1H), 1.39-1.28 (m, 7H), 0.88 (t,  $J = 6.6$  Hz, 3H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 150 MHz)  $\delta$ : 135.3, 133.3, 133.2, 128.9, 128.7, 127.6, 72.9, 37.4, 31.8, 29.2, 25.4, 22.6, 14.1 ppm; **HRMS** (ESI)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{15}\text{H}_{22}\text{OCl}$  253.1359; Found 253.1349.

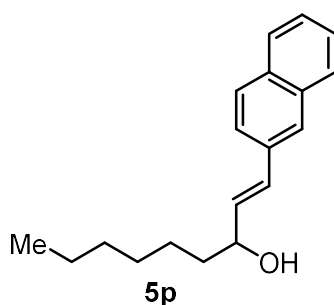


**(E)-1-(6-Methoxypyridin-3-yl)non-1-en-3-ol (5n):** The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 5-(2-bromovinyl)-2-methoxypyridine (**2n**, 86 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 5) afforded product **5n** as a colorless oil (29 mg, 57% yield):  $R_f = 0.2$  (EtOAc : petroleum ether = 1 : 10);  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 8.10 (d,  $J = 2.4$  Hz, 1H), 7.66 (dd,  $J = 8.8$ , 2.4 Hz, 1H), 6.72-6.70 (m, 1H), 6.50 (dd,  $J_1 = 16.0$ ,  $J_2 = 1.2$  Hz, 1H), 6.11 (dd,  $J_1 = 16.0$ ,  $J_2 = 6.8$  Hz, 1H), 4.27 (q,  $J = 6.8$  Hz, 1H), 3.93 (s, 3H), 1.73 (s, 1H), 1.67-1.55 (m, 2H), 1.47-1.27 (m, 8H), 0.88 (t,  $J = 6.8$  Hz, 3H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 163.6, 145.6, 135.6, 132.0, 126.3, 125.9, 110.9, 73.0, 53.5, 37.4, 31.8, 29.2, 25.4, 22.6, 14.0 ppm; **HRMS** (ESI)  $m/z$ :  $[\text{M} - \text{H}]^-$  calcd for  $\text{C}_{15}\text{H}_{22}\text{O}_2\text{N}$  248.1651; Found 248.1642.



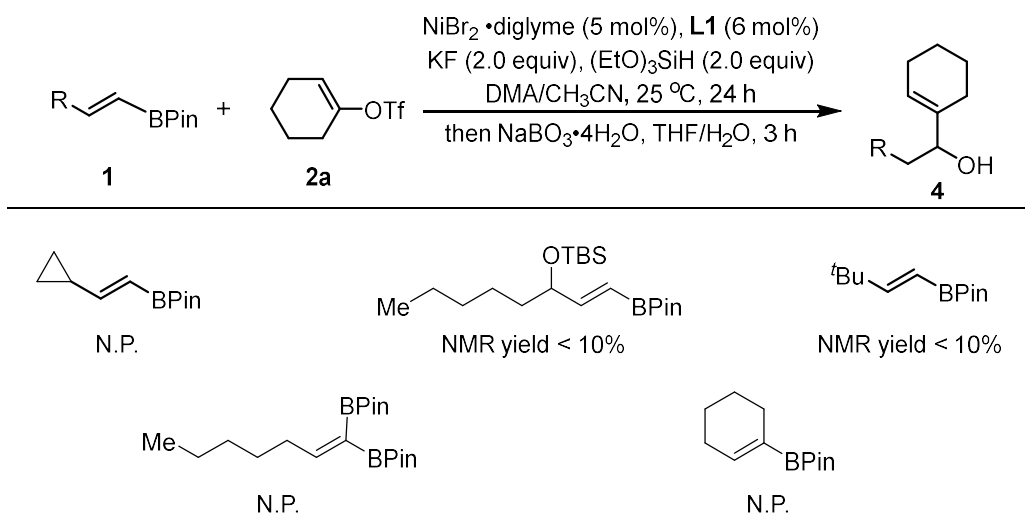
**(E)-1-(Furan-2-yl)non-1-en-3-ol (5o):** The general procedure B was followed using

(*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 2-(2-bromovinyl)furan (**2o**, 69 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **5o** as a colorless oil (25 mg, 61% yield): R<sub>f</sub> = 0.4 (EtOAc : petroleum ether = 1 : 10); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 7.34 (d, *J* = 2.0 Hz, 1H), 6.40 (d, *J* = 15.6 Hz, 1H), 6.37-6.36 (m, 1H), 6.23 (d, *J* = 3.2 Hz, 1H), 6.17 (dd, *J*<sub>1</sub> = 15.6, *J*<sub>2</sub> = 6.8 Hz, 1H), 4.24 (q, *J* = 6.8 Hz, 1H), 1.64-1.57 (m, 3H), 1.46-1.29 (m, 8H), 0.88 (t, *J* = 6.8 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 152.4, 141.9, 131.3, 118.4, 111.3, 107.9, 72.6, 37.4, 31.8, 29.2, 25.4, 22.6, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>13</sub>H<sub>21</sub>O<sub>2</sub> 209.1542; Found 209.1544.

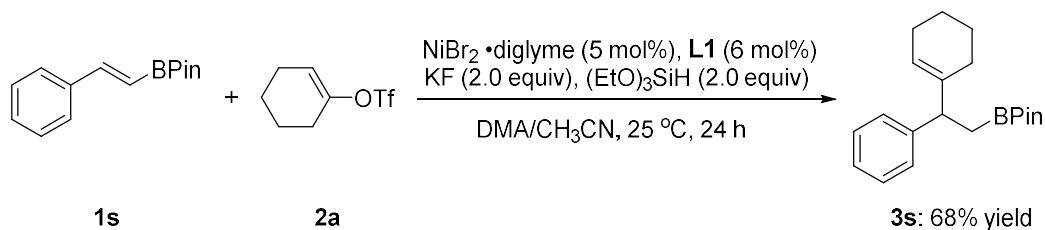


(*E*)-1-(Naphthalen-2-yl)non-1-en-3-ol (**5p**): The general procedure B was followed using (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol) and 2-(2-bromovinyl)naphthalene (**2p**, 93 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 10) afforded product **5p** as a colorless oil (40 mg, 75% yield): R<sub>f</sub> = 0.4 (EtOAc : petroleum ether = 1 : 10); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 7.81-7.77 (m, 3H), 7.73 (m, 1H), 7.60 (dd, *J*<sub>1</sub> = 8.8, *J*<sub>2</sub> = 2.0 Hz, 1H), 7.48-7.41 (m, 2H), 6.73 (dd, *J*<sub>1</sub> = 16.0, *J*<sub>2</sub> = 0.4 Hz, 1H), 6.35 (dd, *J*<sub>1</sub> = 16.0, *J*<sub>2</sub> = 6.8 Hz, 1H), 4.36-4.31 (m, 1H), 1.73-1.63 (m, 2H), 1.59 (s, 1H), 1.49-1.29 (m, 8H), 0.89 (t, *J* = 6.8 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 134.2, 133.6, 133.0, 130.3, 128.2, 127.9, 127.7, 126.4, 126.3, 125.9, 123.6, 73.2, 37.4, 31.8, 29.3, 25.4, 22.6, 14.1 ppm; HRMS (ESI) *m/z*: [M - H]<sup>-</sup> calcd for C<sub>19</sub>H<sub>23</sub>O 267.1749; Found 267.1736.

## 6. The data for some failed examples



<sup>a</sup> Reaction conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), [Ni]-salt (0.01 mmol), **L1** (0.012 mmol),  $\text{KF}$  (0.4 mmol),  $(\text{EtO})_3\text{SiH}$  (0.4 mmol), DMA: $\text{CH}_3\text{CN}$  (30:1, 1.5 mL), at 25 °C for 24 h.

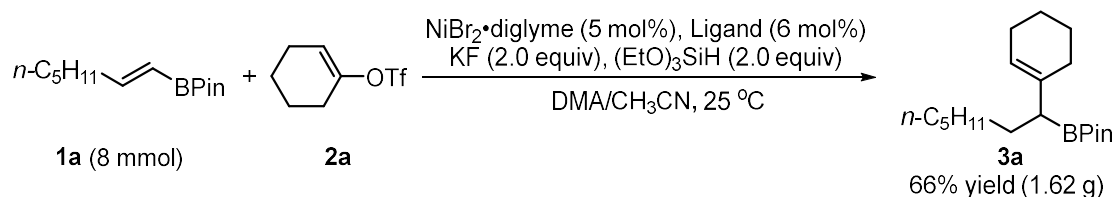


**2-(2-(cyclohex-1-en-1-yl)-2-phenylethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (3s)**: The general procedure A was followed using (*E*)-4,4,5,5-tetramethyl-2-styryl-1,3,2-dioxaborolane (**1s**, 46 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol). Purification of this material by chromatography on silica gel (EtOAc : petroleum ether = 1 : 50) afforded product **5p** as a colorless oil (43 mg, 68% yield):  $R_f$  = 0.8 (EtOAc : petroleum ether = 1 : 10); <sup>1</sup>H NMR ( $\text{CDCl}_3$ , 600 MHz)  $\delta$ : 7.25-7.20 (m, 4H), 7.15-7.12 (m, 1H), 5.65-5.53 (m, 1H), 3.44 (t,  $J$  = 8.4, 1H), 2.04-2.03 (m, 2H), 1.83-1.73 (m, 2H), 1.51-1.50 (m, 4H), 1.35-1.31 (m, 1H), 1.23-1.19 (m, 1H), 1.15 (s, 12H); <sup>13</sup>C NMR ( $\text{CDCl}_3$ , 150 MHz)  $\delta$ : 146.1, 141.6, 127.9, 127.6, 125.7, 120.5, 82.9, 48.2, 27.0, 25.3, 24.8, 24.6, 23.0, 22.6 ppm; HRMS (ESI)  $m/z$ : [M - H]<sup>-</sup> calcd for  $\text{C}_{20}\text{H}_{28}\text{BO}_2$  310.2219; Found 310.2231.



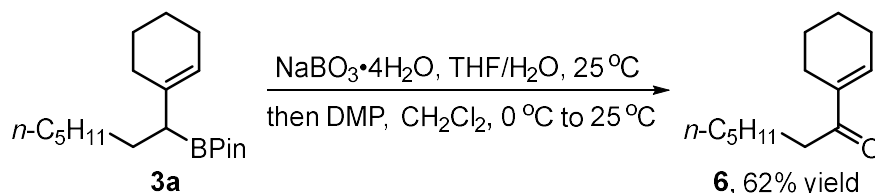
## 8. Further transformations for the product

### 8-1. Gram scale reaction



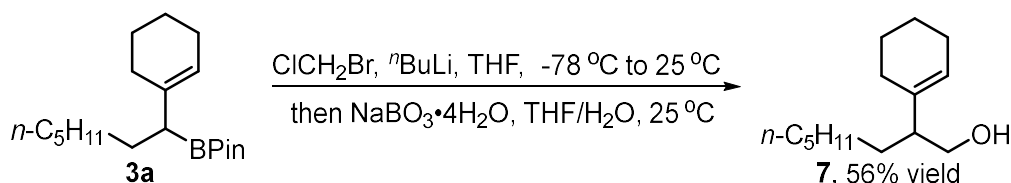
In an oven dried 250-ml Schlenk tube, which contained a stirring bar, was charged with  $\text{NiBr}_2\cdot\text{diglyme}$  (140 mg, 0.8 mmol), **L1** (88 mg, 0.48 mmol),  $\text{KF}$  (928 mg, 16.0 mmol). The tube was then evacuated and back-filled under a  $\text{N}_2$  flow (this sequence was repeated three times). Anhydrous  $\text{DMA/CH}_3\text{CN}$  (30:1, 62 ml) was added under  $\text{N}_2$ , the reaction mixture was stirred for another 20 min at  $25^\circ\text{C}$ , then  $(\text{EtO})_3\text{SiH}$  (2.63 g, 16.0 mmol) was added, the reaction mixture was stirred for 10 min at  $25^\circ\text{C}$ , then (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 1.79 g, 8.0 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 3.68 g, 16.0 mmol) was added subsequently under  $\text{N}_2$ , the tube was stirred at  $25^\circ\text{C}$  for 24 h. The resulting mixture was diluted with  $\text{EtOAc}$  (80 mL) and quenched by  $\text{H}_2\text{O}$  (80 mL). Then it was extracted with  $\text{EtOAc}$  (100 ml  $\times$  3). The organic layer was combined and dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated by rotary evaporation. The residue was purified by chromatography on silica gel ( $\text{EtOAc} : \text{petroleum ether} = 1 : 200$ ) afforded product **3a** as a colorless oil (1.62 g, 66% yield).

### 8-2. Procedure for synthesis of **6**<sup>[20]</sup>



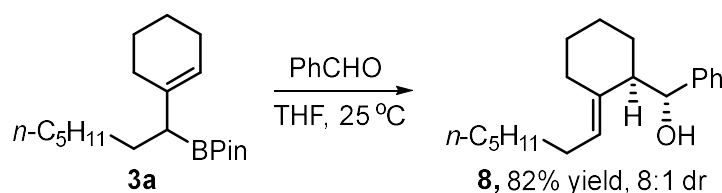
In an oven dried 10-ml Schlenk tube, which contained a stirring bar, was charged with the solution of **3a** (61 mg, 0.2 mmol, THF 2 ml),  $\text{NaBO}_3\cdot 4\text{H}_2\text{O}$  (154 mg, 1.0 mmol,) and  $\text{H}_2\text{O}$  (2.0 mL) were added. The resulting mixture was allowed to stir at  $25^\circ\text{C}$  for three hours. The reaction mixture diluted with  $\text{EtOAc}$  (5.0 ml) and  $\text{H}_2\text{O}$  (5.0 ml). Then it was extracted with  $\text{EtOAc}$  (5.0 ml  $\times$  3). The organic layer was combined and dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated by rotary evaporation. Then the residue was dissolved in  $\text{DCM}$  (4 mL), cooled at  $0^\circ\text{C}$  with an ice bath,  $\text{DMP}$  (170 mg, 0.4 mmol,) was added, the resulting mixture was allowed to stir at  $25^\circ\text{C}$  for three hours, diluted with  $\text{EtOAc}$  (10 mL), filtered and concentrated by rotary evaporation. The residue was purified by silica gel chromatography (1:100 =  $\text{EtOAc} : \text{petroleum ether}$ ) to afford the product **6** as a colorless oil (19 mg, 62% yield):  $R_f = 0.6$  (1:20 =  $\text{EtOAc} : \text{petroleum ether}$ );  $^1\text{H NMR}$  ( $\text{CDCl}_3$ , 400 MHz)  $\delta$ : 6.90-6.88 (m, 1H), 2.61 (t,  $J = 7.6$  Hz, 2H), 2.25-2.21 (m, 4H), 1.66-1.55 (m, 6H), 1.34-1.23 (m, 6H), 0.88 (t,  $J = 6.8$  Hz, 3H);  $^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 100 MHz)  $\delta$ : 210.8, 139.4, 139.2, 37.0, 31.6, 29.1, 26.0, 24.9, 23.1, 22.5, 22.0, 21.6, 14.0 ppm; **HRMS** (ESI)  $m/z$ :  $[\text{M} - \text{H}]^-$  calcd for  $\text{C}_{13}\text{H}_{21}\text{O}$  193.1592; Found 193.1586.

### 8-3. Procedure for synthesis of **7**<sup>[21]</sup>



In an oven dried 10-ml Schlenk tube, which contained a stirring bar, was charged with **3a** (61 mg, 0.2 mmol), the tube was then evacuated and back-filled under a N<sub>2</sub> flow (this sequence was repeated three times). Then THF (2.0 mL) and bromochloromethane (78 mg, 0.6 mmol) was added and the reaction was cooled to -78 °C, followed by the dropwise addition of *n*-BuLi (0.24 mL, 2.5 M in hexanes, 0.6 mmol) at -78 °C. The reaction stirred at -78 °C for 10 minutes, then warmed to 25 °C and stirred for 12 h. The reaction mixture was quenched by H<sub>2</sub>O (10 mL), then it was extracted with EtOAc (10 ml × 3). The organic layer was combined and dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated by rotary evaporation. The residue was dissolved in tetrahydrofuran (THF, 2.0 mL). NaBO<sub>3</sub>·4H<sub>2</sub>O (154 mg, 1.0 mmol) and H<sub>2</sub>O (2.0 mL) were added, the resulting mixture was allowed to stir at 25 °C for three hours. The reaction mixture diluted with EtOAc (5.0 ml) and H<sub>2</sub>O (5.0 ml), then it was extracted with EtOAc (5.0 ml × 3). The organic layer was combined and dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated by rotary evaporation. The residue was purified by silica gel chromatography (1:5 = EtOAc: petroleum ether) to afford the product **7** as a colorless oil (23 mg, 56% yield): *R<sub>f</sub>* = 0.3 (1:4 = EtOAc: petroleum ether); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 5.56-5.54 (m, 1H), 3.46-3.40 (m, 2H), 2.17-2.10 (m, 1H), 2.06-2.01 (m, 2H), 1.89-1.85 (m, 2H), 1.67-1.56 (m, 5H), 1.31-1.23 (m, 10H), 0.88 (t, *J* = 6.8 Hz, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 137.0, 125.4, 64.0, 50.3, 31.8, 29.4, 29.0, 27.3, 25.3, 24.4, 22.9, 22.7, 22.6, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>14</sub>H<sub>27</sub>O 211.2062; Found 211.2068;

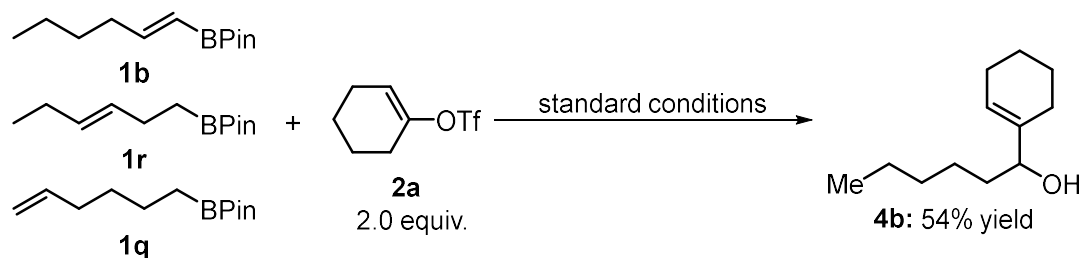
### 8-4. Procedure for synthesis of **8**<sup>[22]</sup>



In an oven dried 10 ml Schlenk tube benzaldehyde (42 mg, 0.4 mmol) was added into a solution of **3a** (61 mg, 0.2 mmol, in 2.0 ml THF), the reaction mixture was stirred at 25 °C under N<sub>2</sub> for 12 h. The reaction mixture diluted with EtOAc (5.0 ml) and H<sub>2</sub>O (5.0 ml), then it was extracted with EtOAc (5.0 ml × 3). The organic layer was combined and dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated by rotary evaporation. The residue was purified by silica gel chromatography (1:20 = EtOAc: petroleum ether) to afford the product **8** as a colorless oil (47 mg, 82% yield, 8:1 dr): *R<sub>f</sub>* = 0.3 (1:20 = EtOAc: petroleum ether); <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz) δ: 7.41-7.34 (m, 4H), 7.31-7.26 (m, 1H), 5.56-5.43 (m, 1H), 4.79-4.71 (m, 1H), 2.88-2.49 (m, 1H), 2.37-1.97 (m, 5H), 1.89-1.84 (m, 1H), 1.65-1.27 (m, 13H), 0.91-0.88 (m, 3H); <sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz) δ: 142.9, 137.9, 128.9, 128.3, 127.7, 127.1, 72.8, 45.1, 33.2, 31.8, 30.1, 29.0, 28.3, 27.8, 27.3, 22.6, 21.8, 14.1 ppm; HRMS (ESI) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>20</sub>H<sub>31</sub>O 287.2375; Found 285.2362;

## 9. Control Experiments

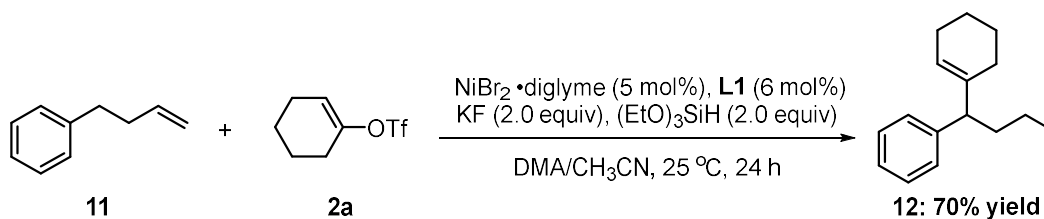
### 9-1. Regioconvergent experiments



(**1b**:**1r**:**1q** = 1:1:1; 1.0 equiv.)

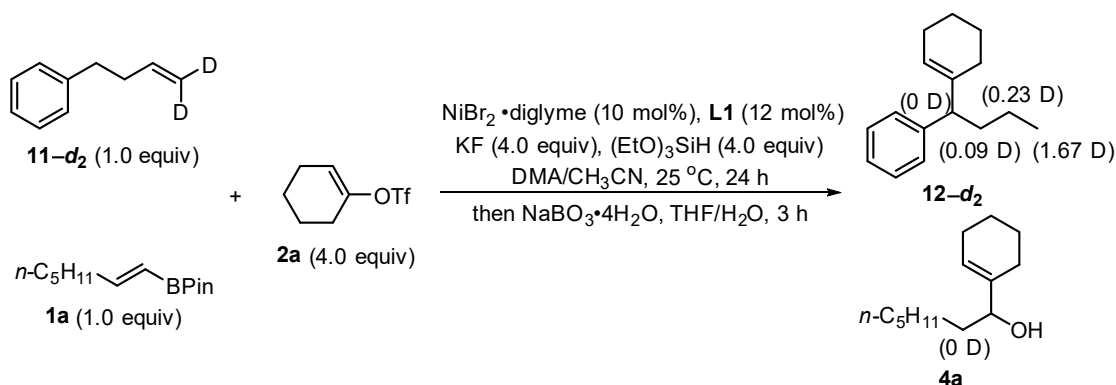
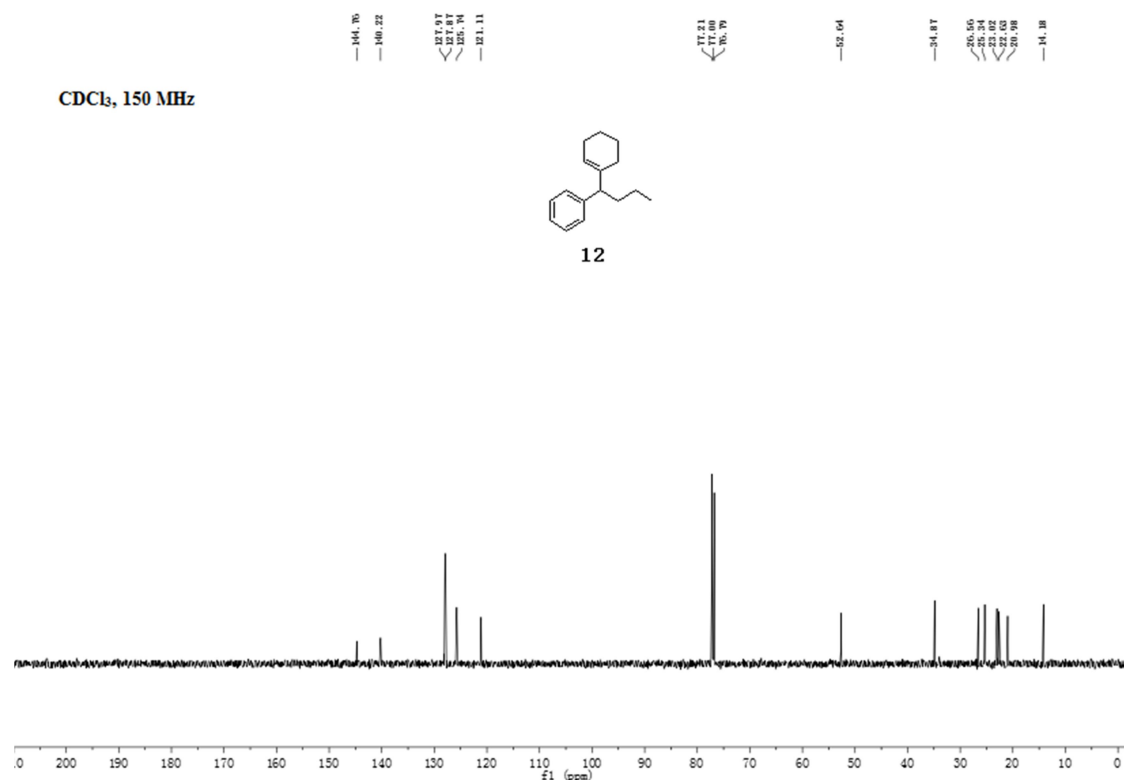
In an oven dried 25-ml Schlenk tube, which contained a stirring bar, was charged with NiBr<sub>2</sub>·diglyme (3.5 mg, 0.01 mol), **L1** (2.2 mg, 0.012 mmol), KF (23 mg, 0.4 mmol). The tube was then evacuated and back-filled under a N<sub>2</sub> flow (this sequence was repeated three times). Anhydrous DMA/CH<sub>3</sub>CN (30:1, 1.5 ml) was added under N<sub>2</sub>, the reaction mixture was stirred for another 10 min at 25 °C, then (EtO)<sub>3</sub>SiH (66 mg, 0.4 mmol) was added. The reaction mixture was stirred for 10 min at 25 °C, then (*E*)-2-(hex-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1b**, 14 mg, 0.07 mmol), 2-(hex-3-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1r**, 14 mg, 0.07 mmol), 2-(hex-5-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1q**, 14 mg, 0.07 mmol), cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol) were added subsequently under N<sub>2</sub>, the tube was stirred at 25 °C for 24 h. The resulting mixture was diluted with EtOAc (2 mL) and quenched by H<sub>2</sub>O (2 mL), then it was extracted with EtOAc (10 ml × 3). The organic layer was combined and dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated by rotary evaporation. The residue was dissolved in tetrahydrofuran (THF, 2.0 mL), NaBO<sub>3</sub>·4H<sub>2</sub>O (154 mg, 1.0 mmol) and H<sub>2</sub>O (2.0 mL) were added, the resulting mixture was allowed to stir at 25 °C for three hours. The reaction mixture diluted with EtOAc (5.0 ml) and H<sub>2</sub>O (5.0 ml). Then it was extracted with EtOAc (5.0 ml × 3), the organic layer was combined and dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated by rotary evaporation. The residue was purified by silica gel chromatography (EtOAc : petroleum ether = 1 : 10) afforded product **4b** as a colorless oil (20 mg, 54% yield).

### 9-2. Crossover experiments



In an oven dried 25-ml Schlenk tube, which contained a stirring bar, was charged with NiBr<sub>2</sub>·diglyme (3.5 mg, 0.01 mol), **L1** (2.2 mg, 0.012 mmol), KF (23 mg, 0.4 mmol). The tube was then evacuated and back-filled under a N<sub>2</sub> flow (this sequence was repeated three times). Anhydrous DMA/CH<sub>3</sub>CN (30:1, 1.5 ml) was added under N<sub>2</sub>, the reaction mixture was stirred for another 10 min at 25 °C, then (EtO)<sub>3</sub>SiH (66 mg, 0.4 mmol) was added. The reaction mixture was stirred for 10 min at 25 °C, then but-3-en-1-ylbenzene (**11**, 26 mg, 0.2 mmol) and cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 92 mg, 0.4 mmol) were added subsequently under N<sub>2</sub>, the tube was stirred at 25 °C for 24 h. The resulting mixture was diluted with EtOAc (2 mL) and quenched by H<sub>2</sub>O (2 mL), then it was extracted with EtOAc (10 ml × 3). The organic



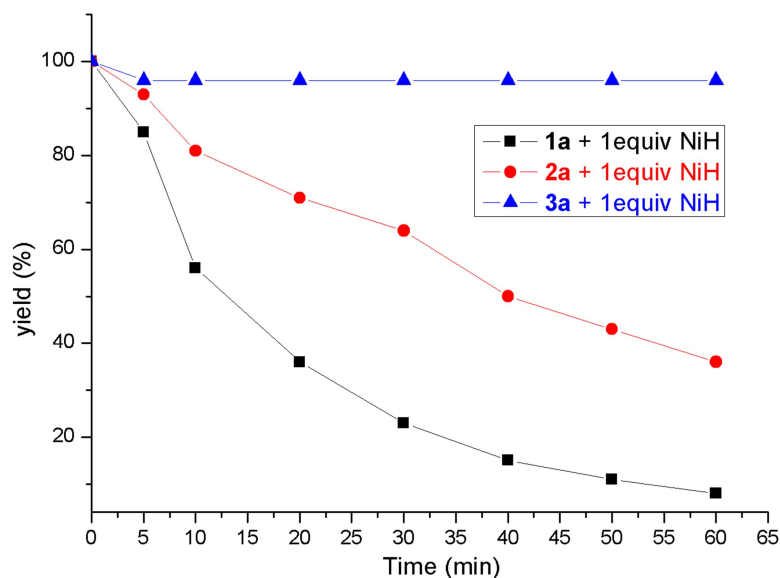


In an oven dried 25-ml Schlenk tube, which contained a stirring bar, was charged with NiBr<sub>2</sub>·diglyme (7.0 mg, 0.02 mol), **L1** (4.4 mg, 0.012 mmol), KF (46 mg, 0.4 mmol). The tube was then evacuated and back-filled under a N<sub>2</sub> flow (this sequence was repeated three times). Anhydrous DMA/CH<sub>3</sub>CN (30:1, 3.0 ml) was added under N<sub>2</sub>, the reaction mixture was stirred for another 10 min at 25 °C, then (EtO)<sub>3</sub>SiH (132 mg, 0.8 mmol) was added. The reaction mixture was stirred for 10 min at 25 °C, then but-3-en-1-ylbenzene (**11-d<sub>2</sub>**, 26 mg, 0.2 mmol), (*E*)-2-(hept-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**1a**, 45 mg, 0.2 mmol), cyclohex-1-en-1-yl trifluoromethanesulfonate (**2a**, 184 mg, 0.8 mmol) were added subsequently under N<sub>2</sub>, the tube was stirred at 25 °C for 24 h. The resulting mixture was diluted with EtOAc (2 mL) and quenched by H<sub>2</sub>O (2 mL), then it was extracted with EtOAc (10 ml × 3). The organic layer was combined and dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and concentrated by rotary evaporation. The residue was dissolved in tetrahydrofuran (THF, 2.0 mL), NaBO<sub>3</sub>·4H<sub>2</sub>O (154 mg, 1.0 mmol) and





## 10. Kinetic studies



Time/yield	0 min	5 min	10 min	20 min	30 min	40 min	50 min	60 min
<b>1a</b>	100%	85%	56%	36%	23%	15%	11%	8%
<b>2a</b>	100%	93%	81%	71%	64%	50%	43%	36%
<b>3a</b>	100%	96%	96%	96%	96%	96%	96%	96%

In an oven dried 25-ml Schlenk tube, which contained a stirring bar, was charged with charged with  $\text{NiBr}_2 \cdot \text{diglyme}$  (71 mg, 0.2 mmol), **L1** (44 mg, 0.24 mmol),  $\text{KF}$  (23 mg, 0.4 mmol). The tube was then evacuated and back-filled under a  $\text{N}_2$  flow (this sequence was repeated three times), Anhydrous  $\text{DMA}/\text{CH}_3\text{CN}$  (30:1, 1.5 ml) was added under  $\text{N}_2$ , the reaction mixture was stirred for another 20 min at 25 °C, then  $(\text{EtO})_3\text{SiH}$  (66 mg, 0.4 mmol) was added. The reaction mixture was stirred for 10 min at 25 °C, then the corresponding alkene (0.2 mmol) was added into each reaction system respectively under  $\text{N}_2$ . The alkene concentration was monitored at the indicated time. The monitoring of kinetic experiments was operated on GC-7890B. We chose the different time to the monitoring of kinetic experiments clearly illustrated the relative reaction rates of three kinds of alkenes with NiH species.

## 11. References

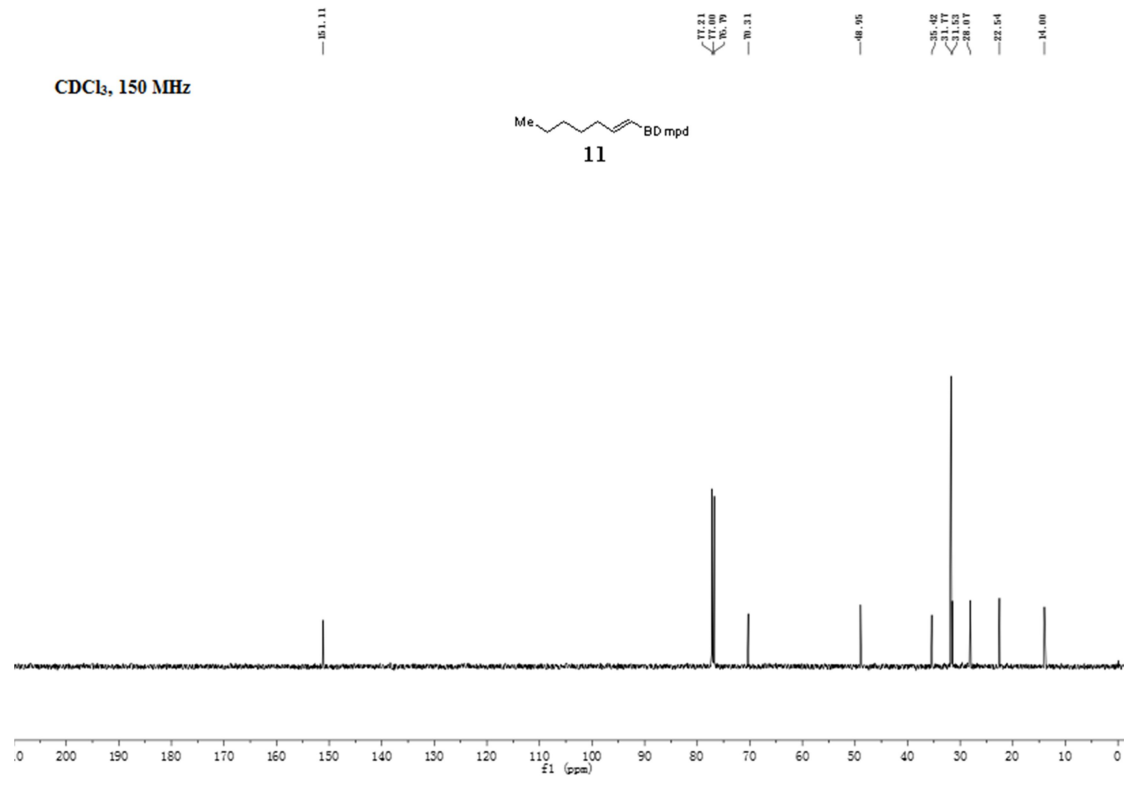
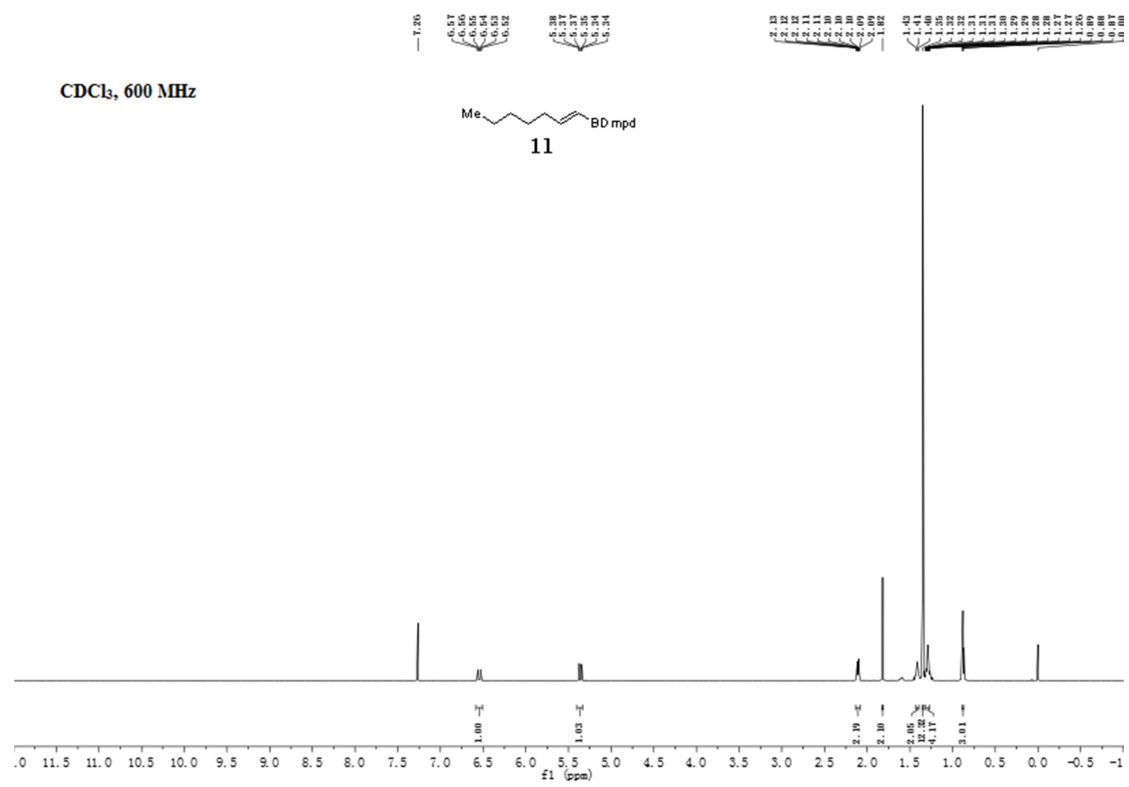
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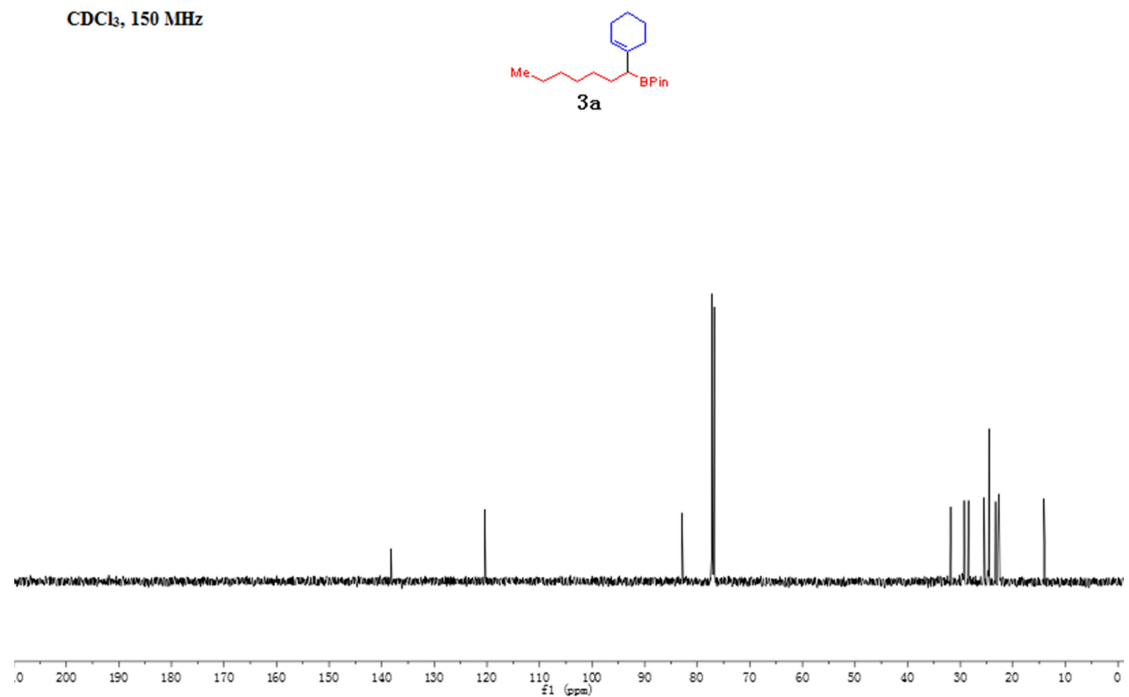
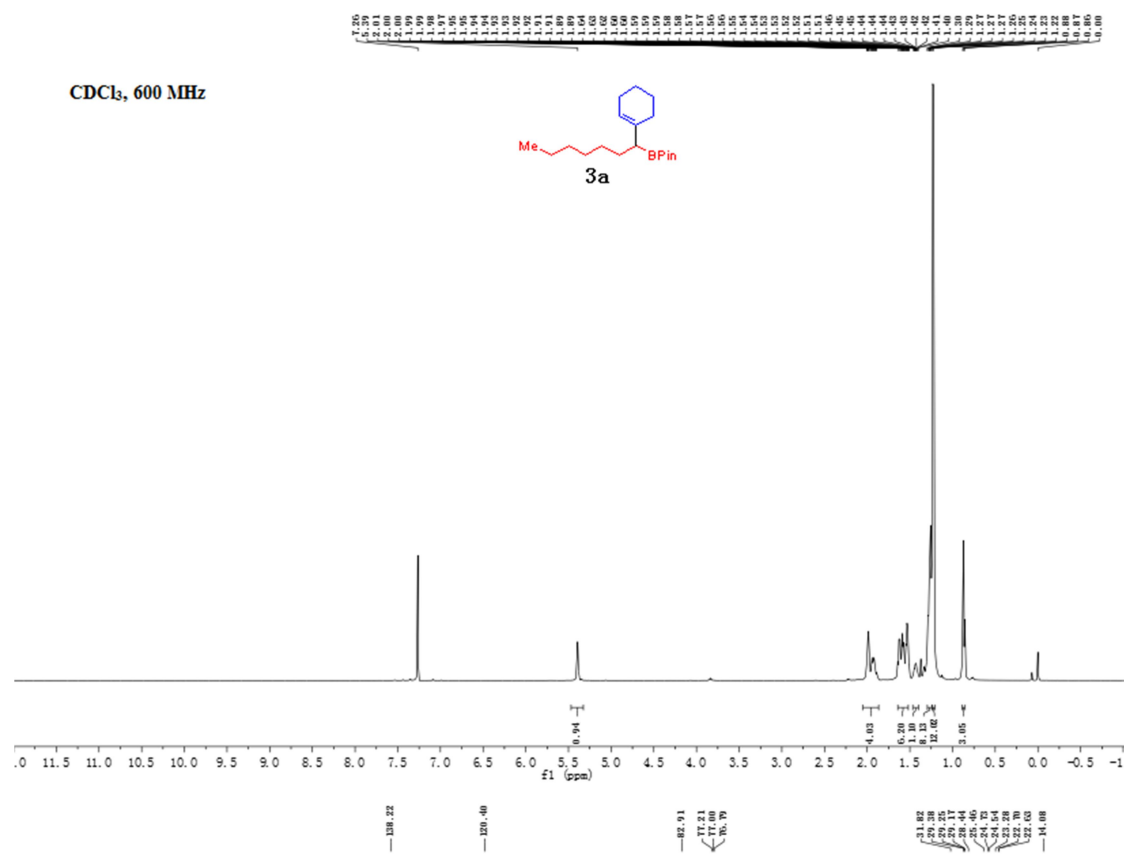
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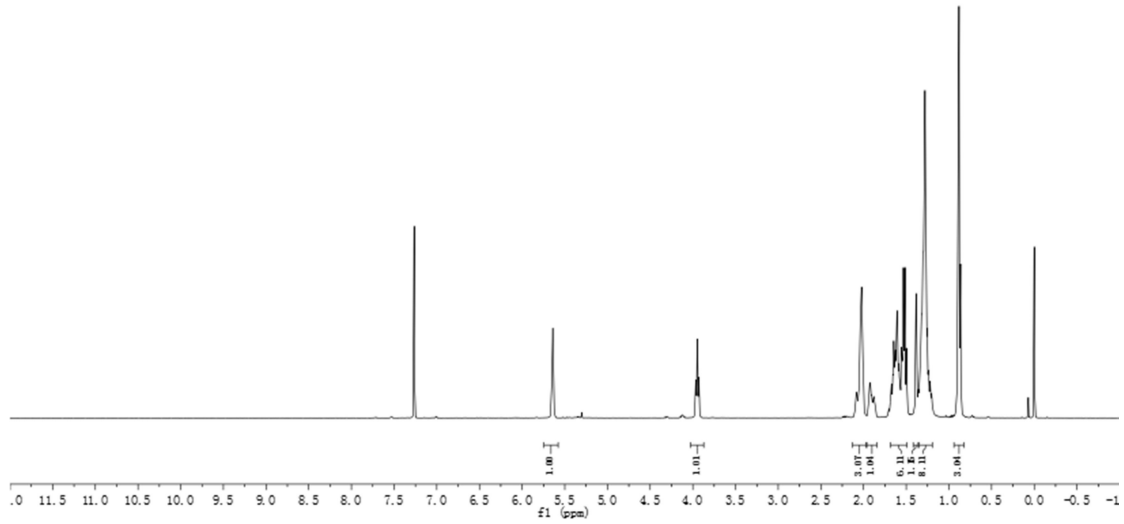
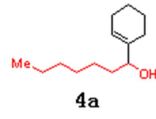




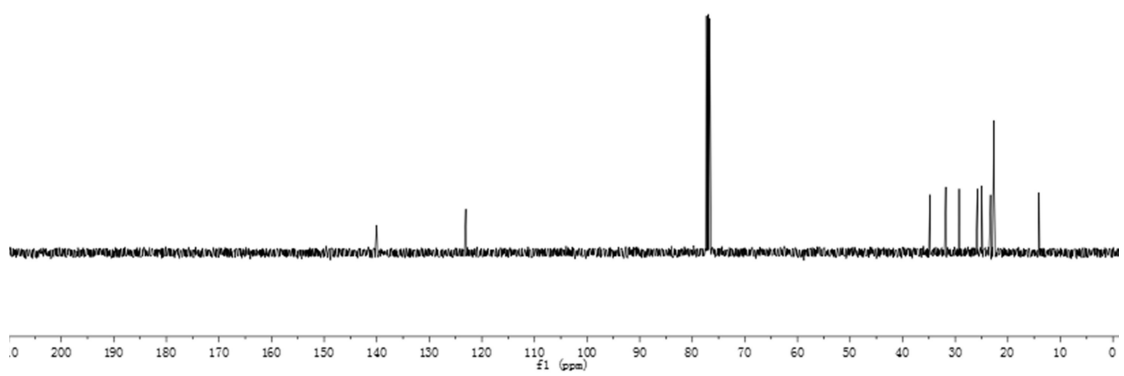
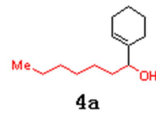


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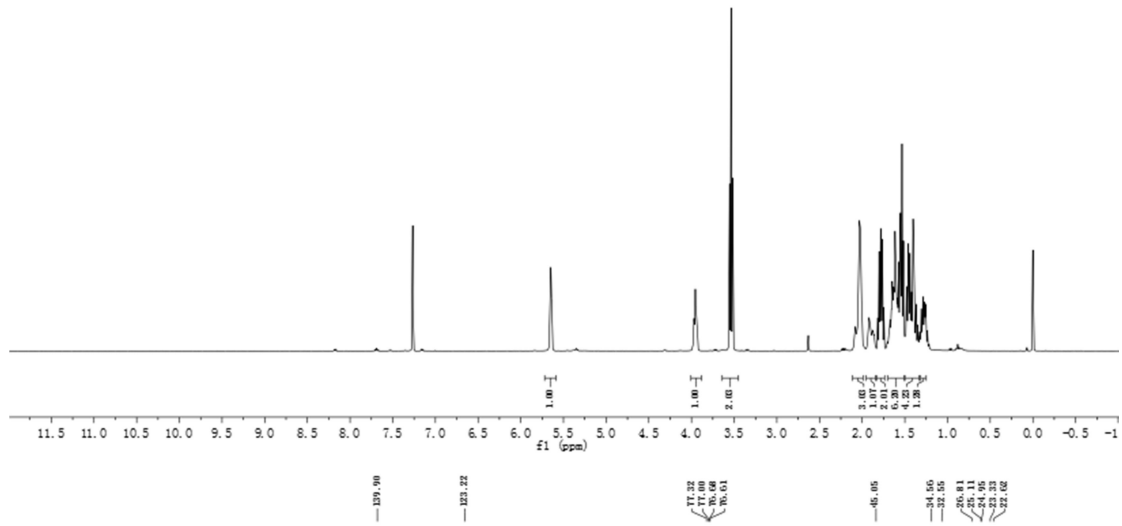
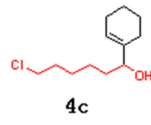
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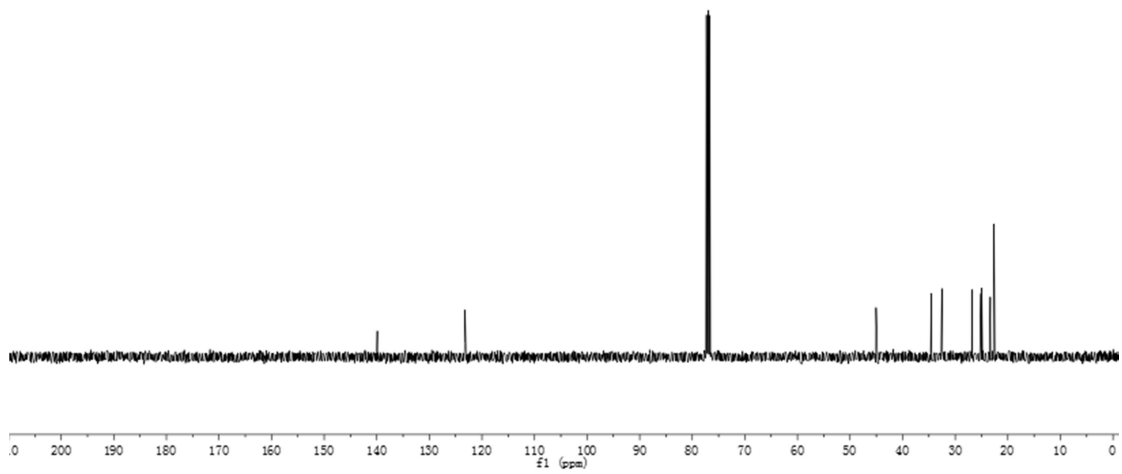
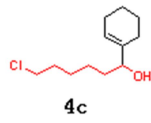


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CDCl<sub>3</sub>, 400 MHz

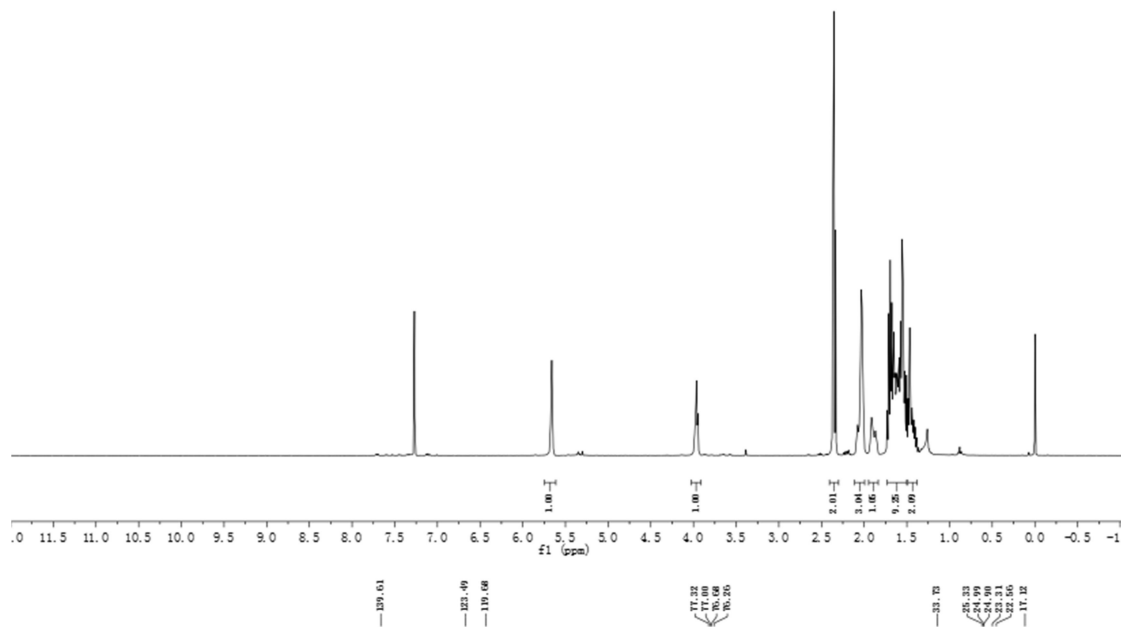
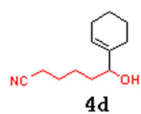


CDCl<sub>3</sub>, 100 MHz

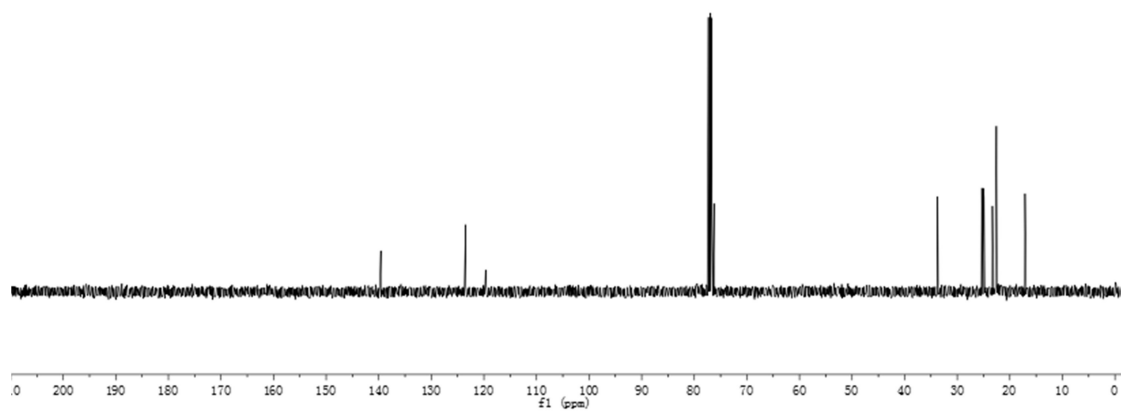
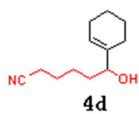


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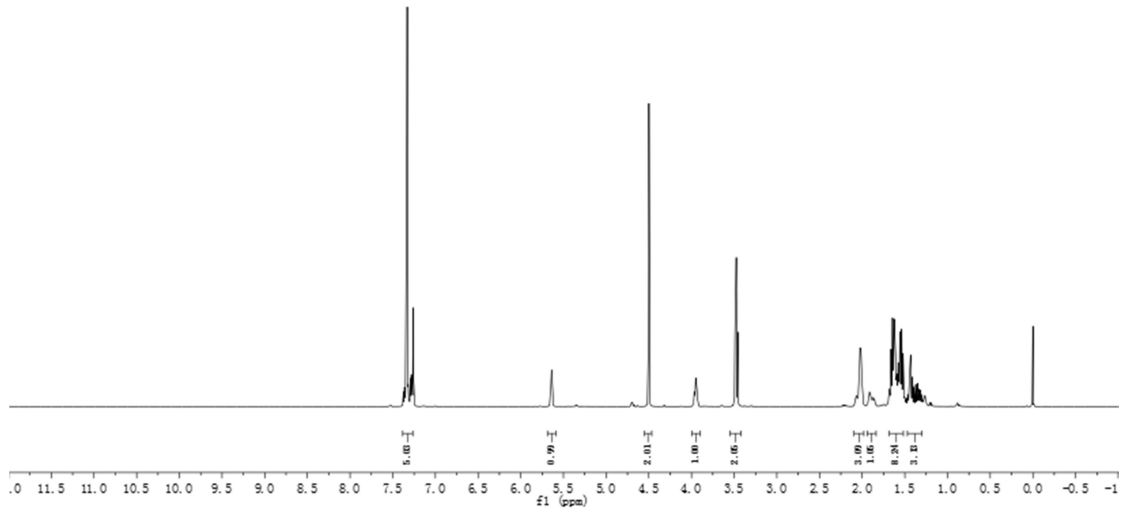
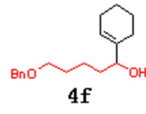
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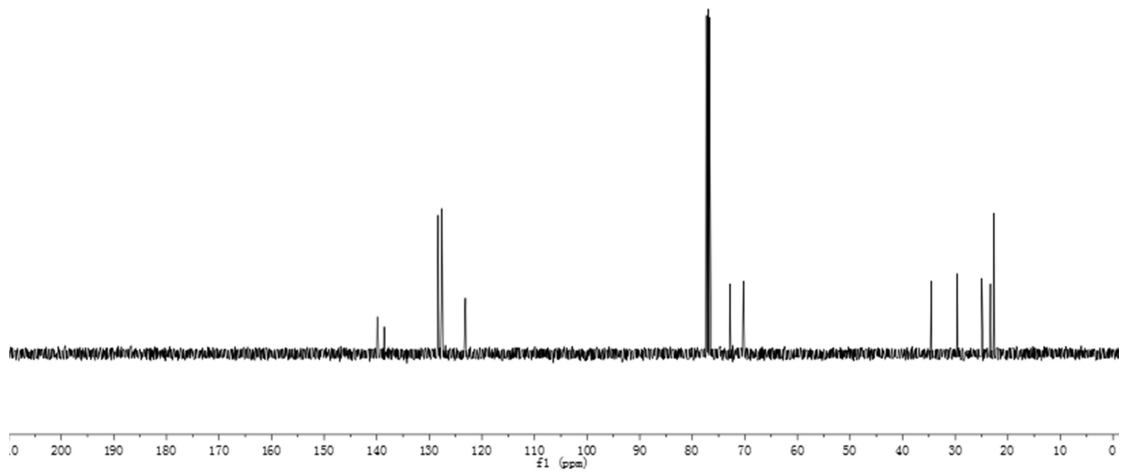
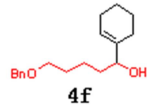
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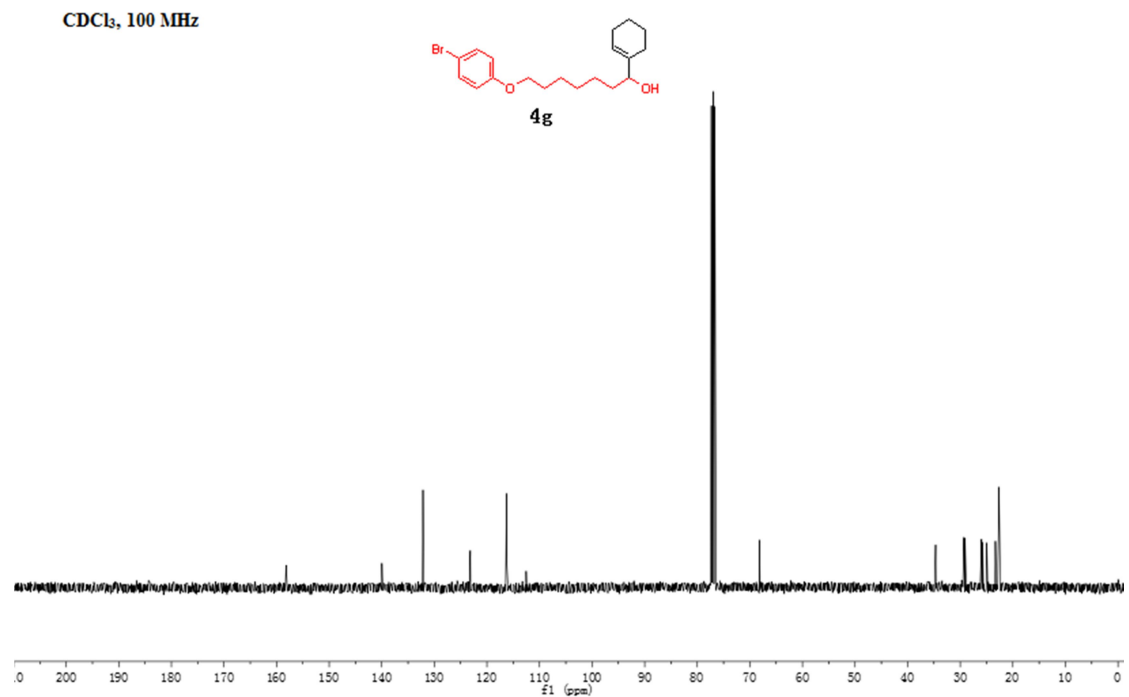
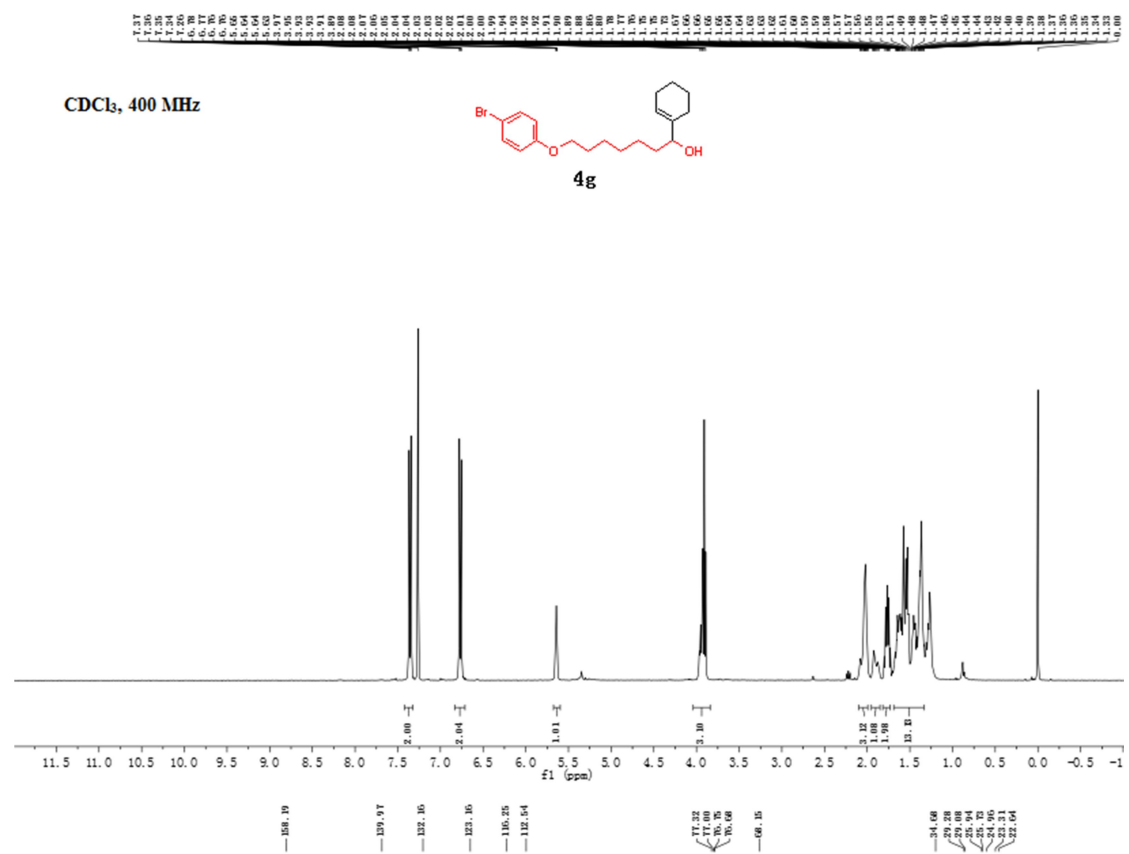
CDCl<sub>3</sub>, 400 MHz



139.88  
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127.41  
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72.85  
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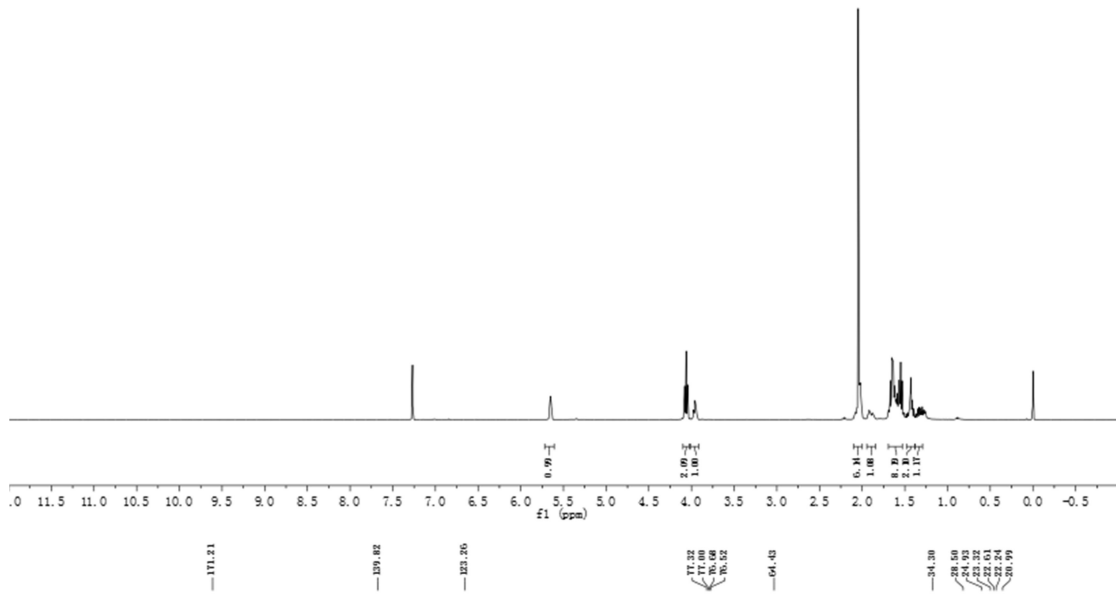
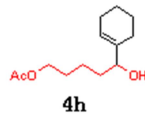
CDCl<sub>3</sub>, 100 MHz



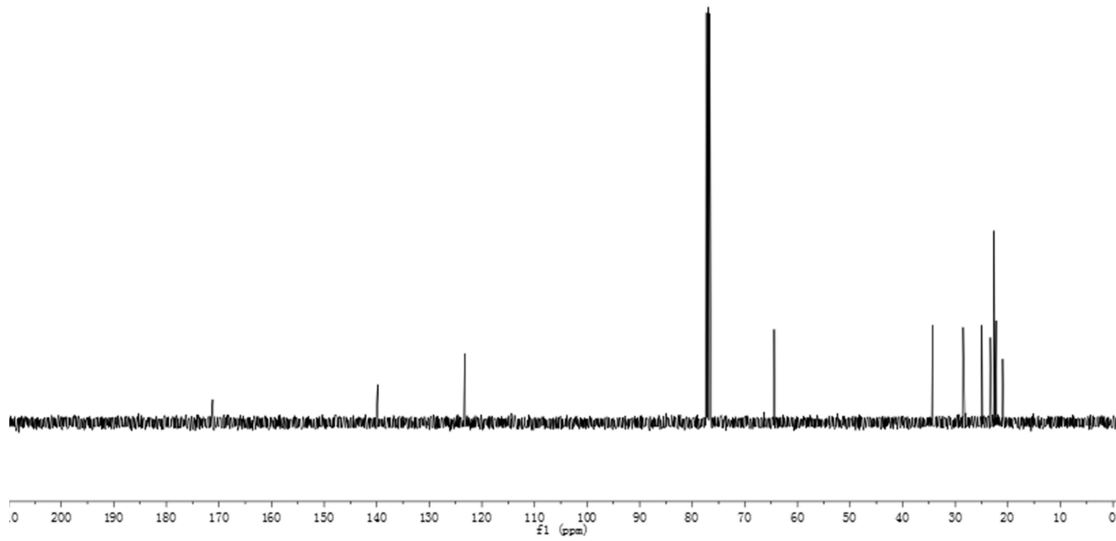
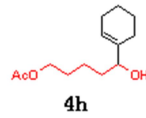


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CDCl<sub>3</sub>, 400 MHz



CDCl<sub>3</sub>, 100 MHz

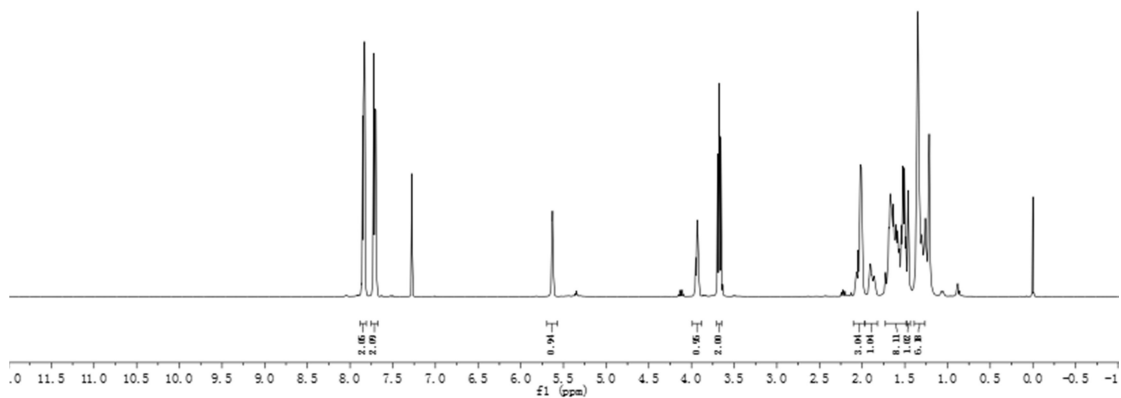
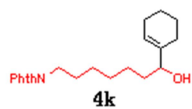






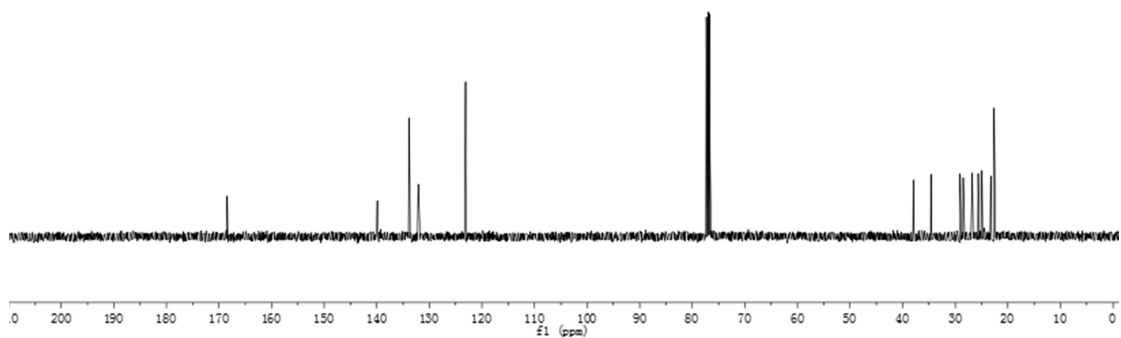
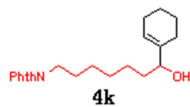
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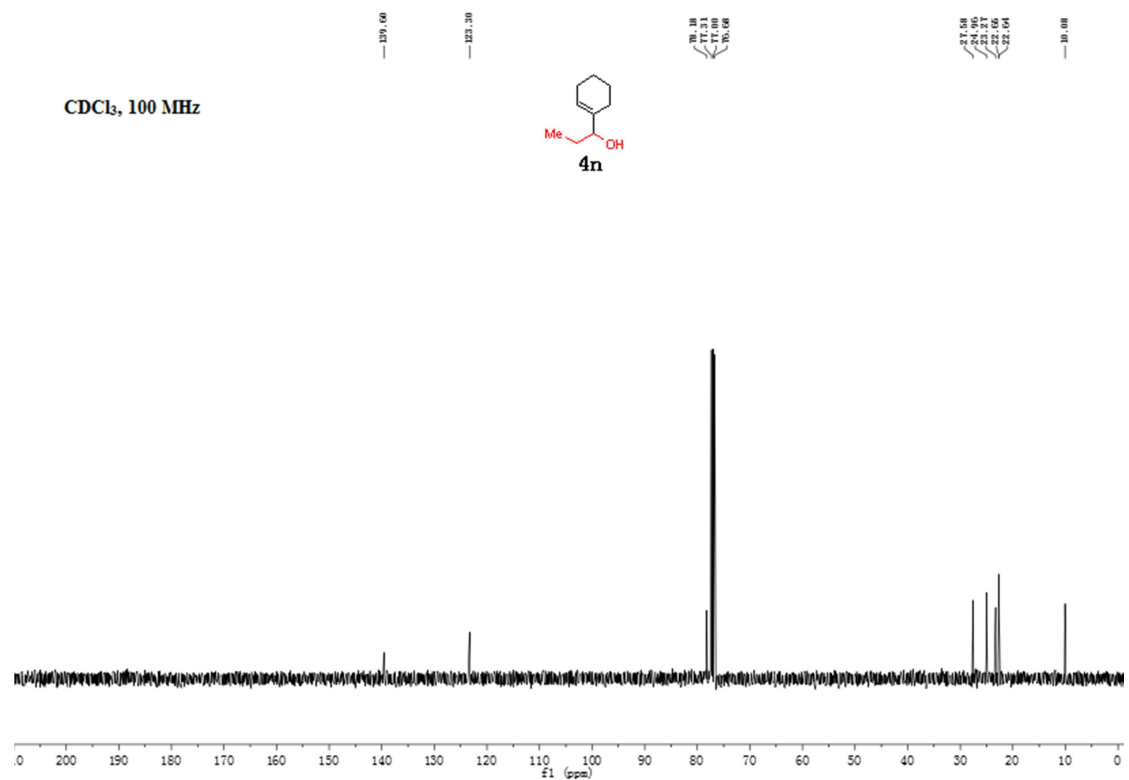
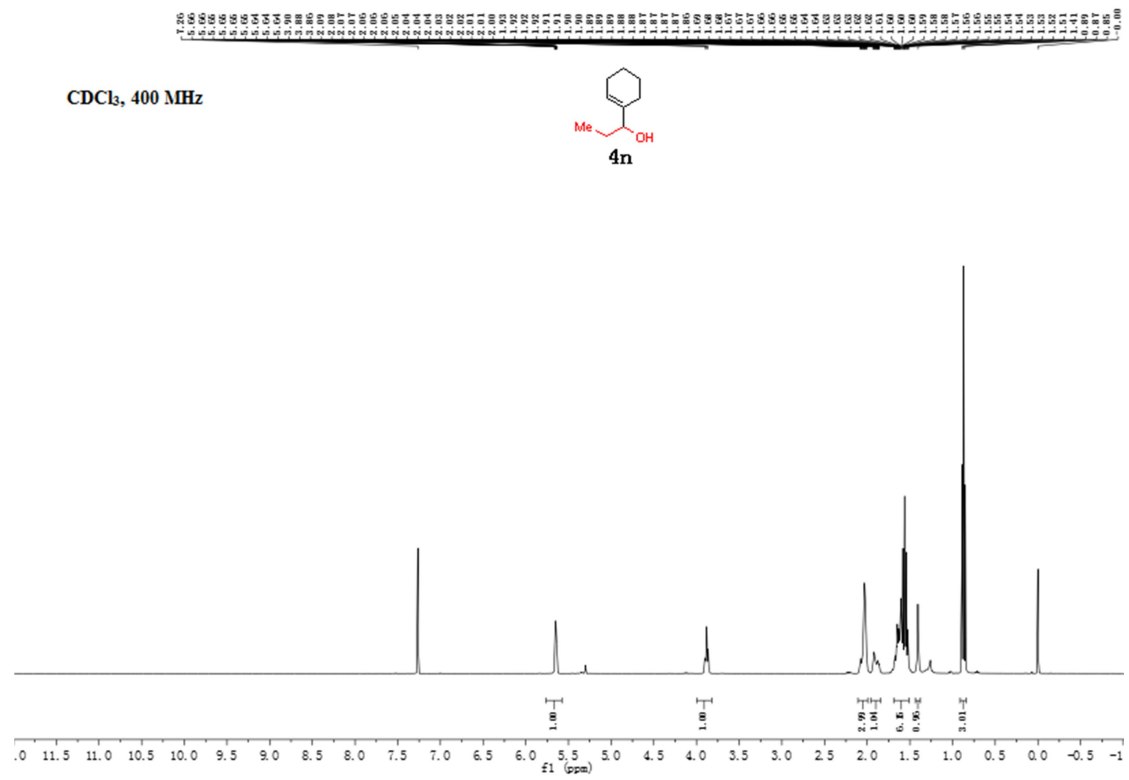
CDCl<sub>3</sub>, 400 MHz



166.43  
139.89  
133.81  
123.11  
123.11  
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37.95  
34.03  
29.77  
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26.70  
24.02  
23.24  
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CDCl<sub>3</sub>, 100 MHz

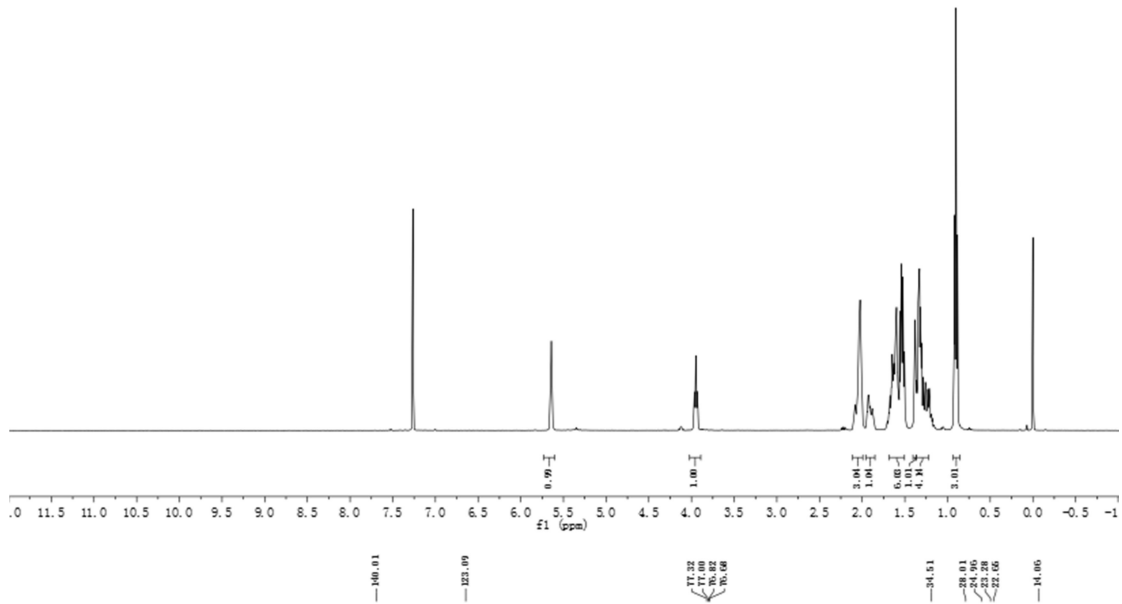
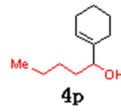




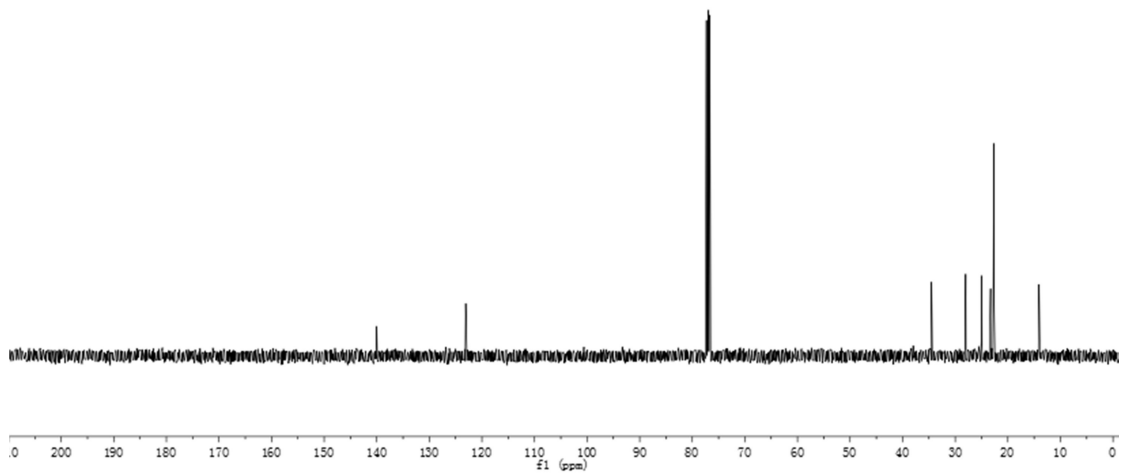
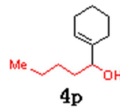


7.26  
6.06  
5.06  
4.04  
3.04  
2.97  
2.95  
2.09  
2.08  
2.05  
2.05  
2.05  
2.04  
2.02  
2.01  
2.00  
1.99  
1.97  
1.92  
1.91  
1.91  
1.89  
1.88  
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1.18  
1.18  
1.18

CDCl<sub>3</sub>, 400 MHz

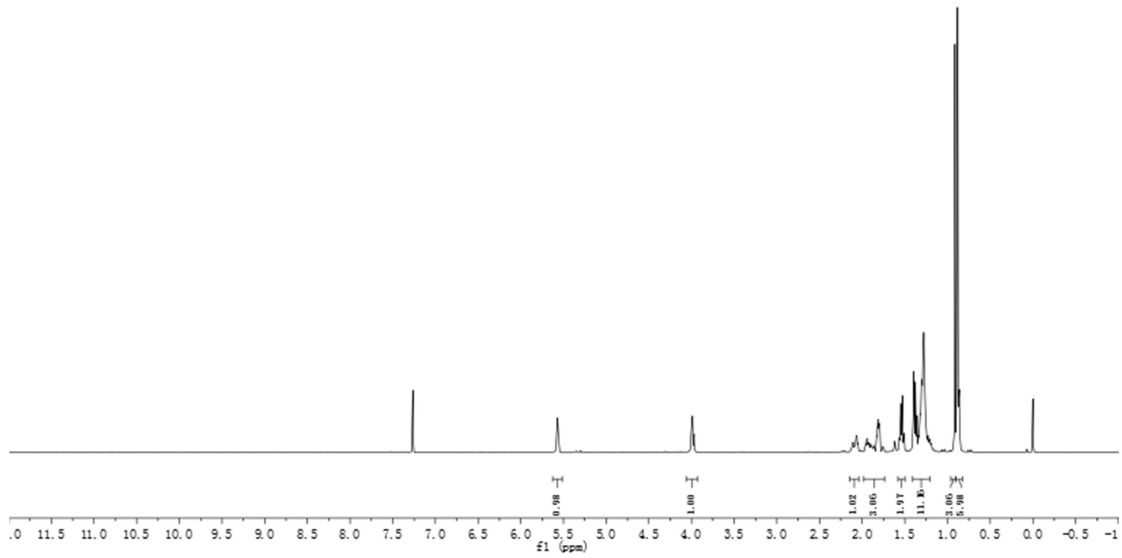
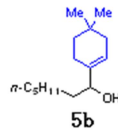


CDCl<sub>3</sub>, 100 MHz



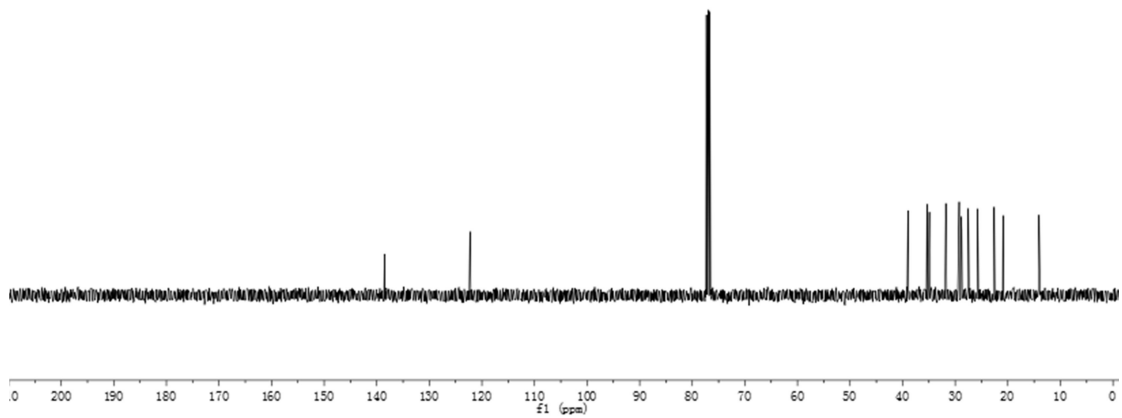
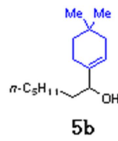
7.26  
6.98  
6.57  
6.55  
4.01  
3.99  
2.32  
2.11  
2.10  
2.10  
2.09  
2.08  
2.07  
2.07  
2.05  
2.05  
1.96  
1.95  
1.95  
1.95  
1.94  
1.94  
1.92  
1.92  
1.90  
1.90  
1.89  
1.89  
1.87  
1.87  
1.85  
1.82  
1.82  
1.80  
1.80  
1.79  
1.79  
1.76  
1.57  
1.55  
1.55  
1.53  
1.41  
1.41  
1.40  
1.38  
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1.23  
1.22  
1.22  
1.21  
1.21  
1.19  
1.19  
1.08  
1.08

CDCl<sub>3</sub>, 400 MHz



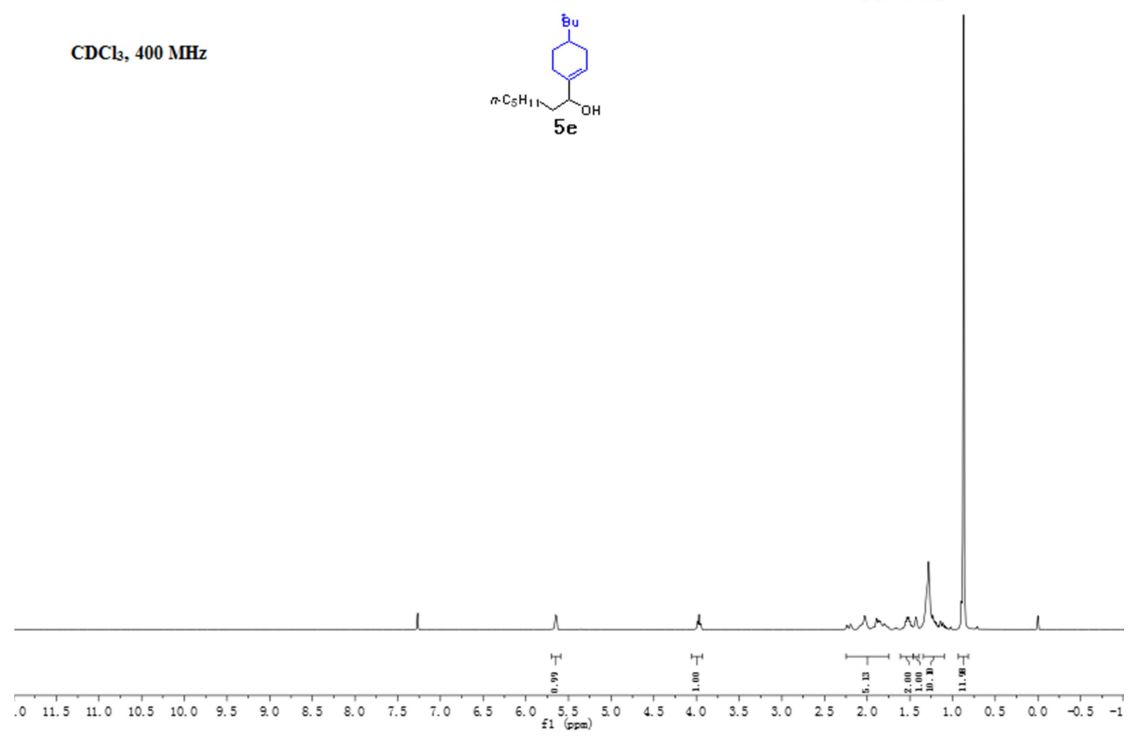
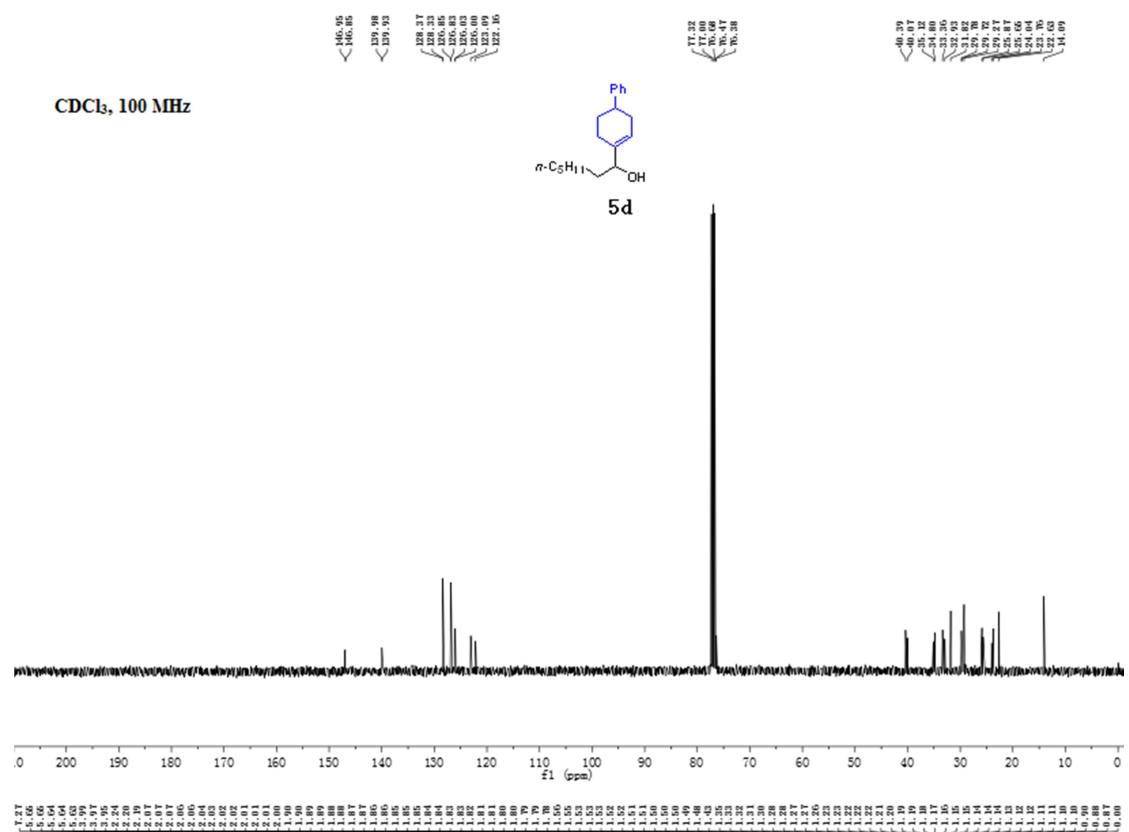
138.52  
122.27  
77.32  
76.68  
76.57  
38.99  
34.92  
31.60  
29.87  
29.78  
27.52  
22.59  
20.91  
-1.06

CDCl<sub>3</sub>, 100 MHz

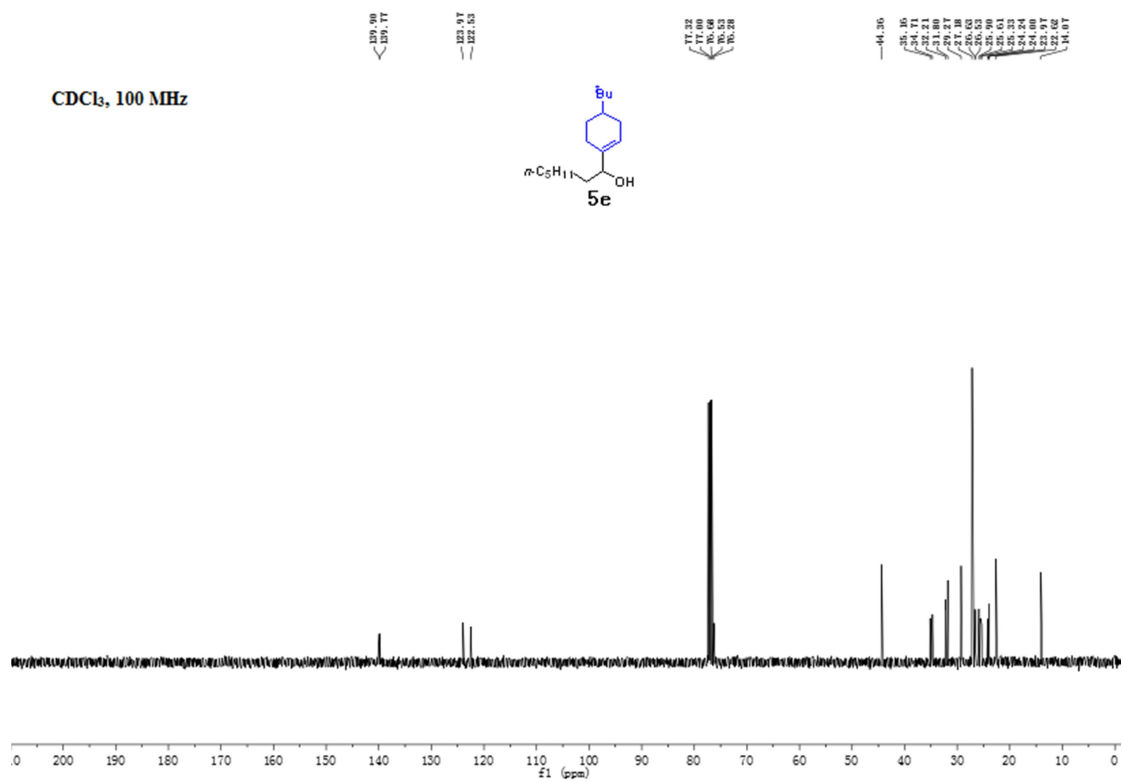
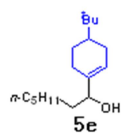




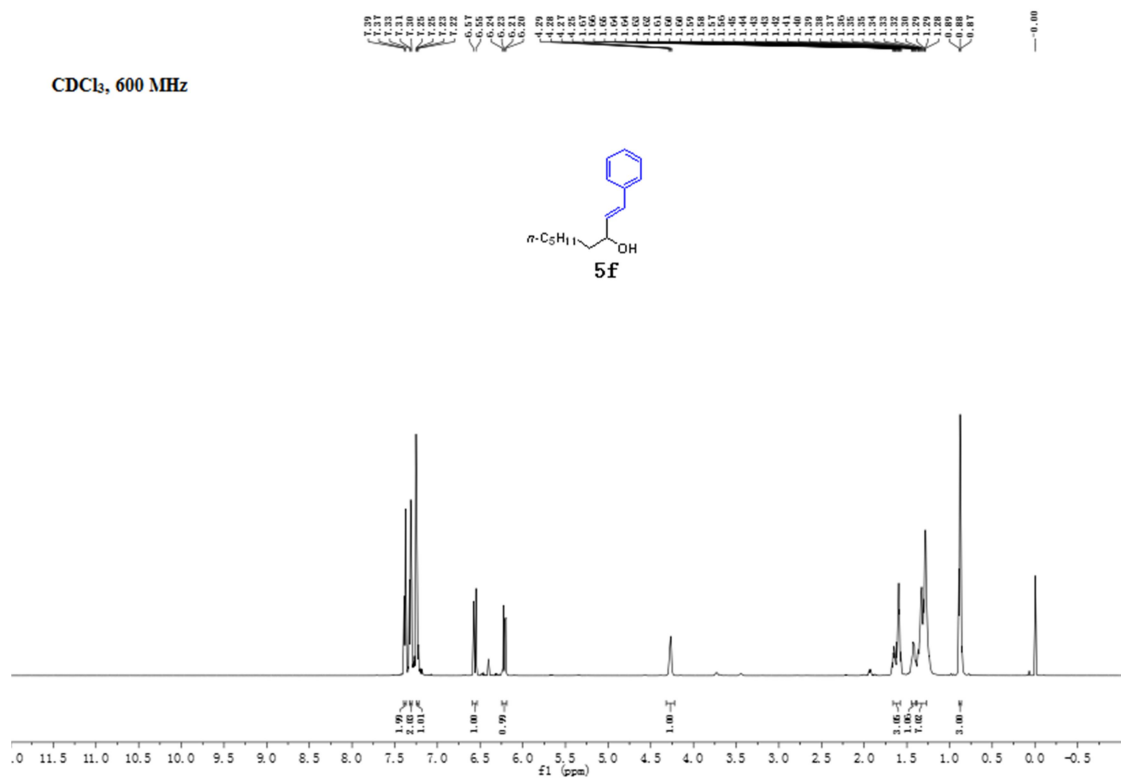
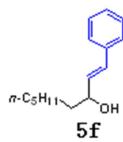




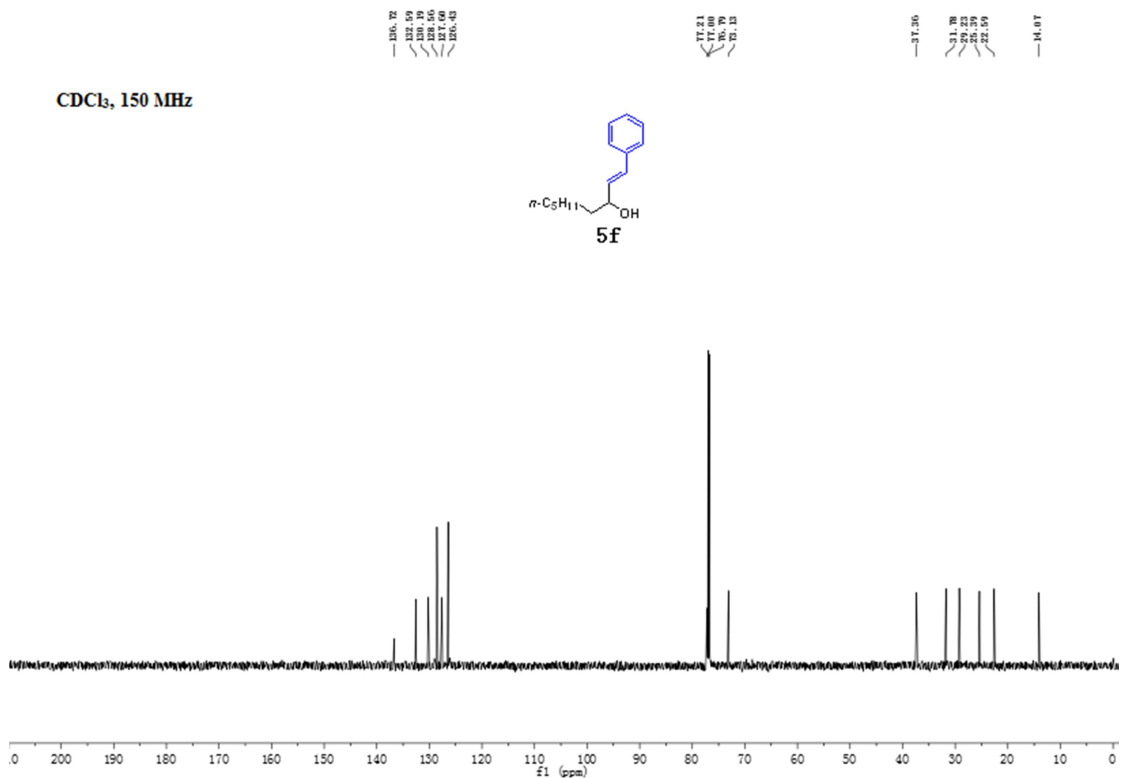
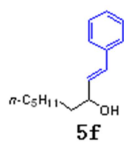
CDCl<sub>3</sub>, 100 MHz



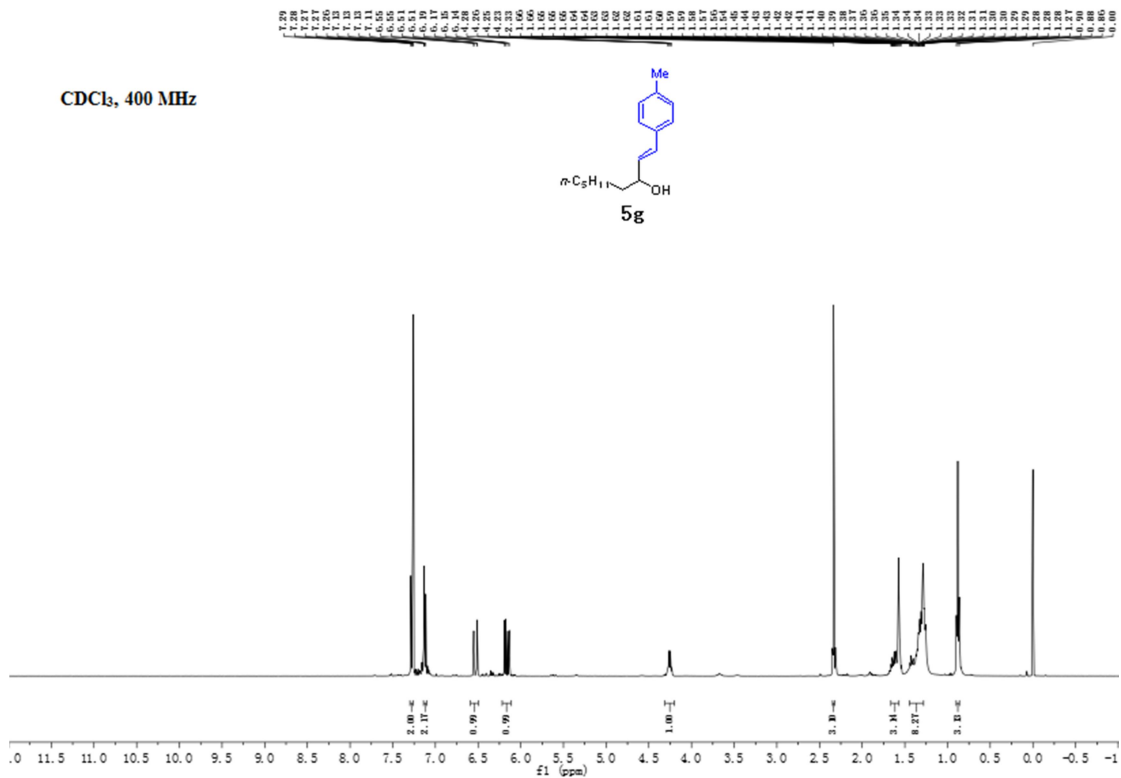
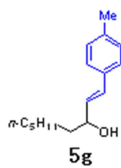
CDCl<sub>3</sub>, 600 MHz



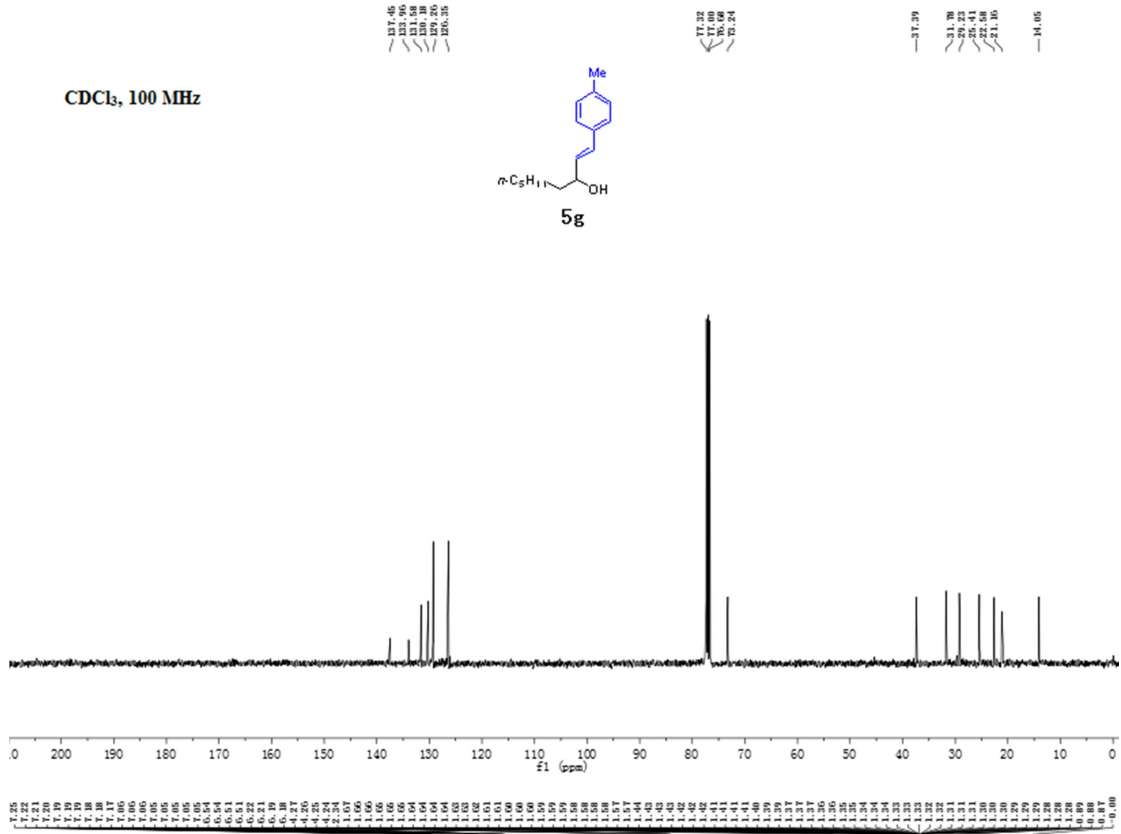
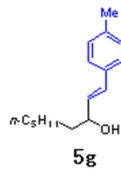
CDCl<sub>3</sub>, 150 MHz



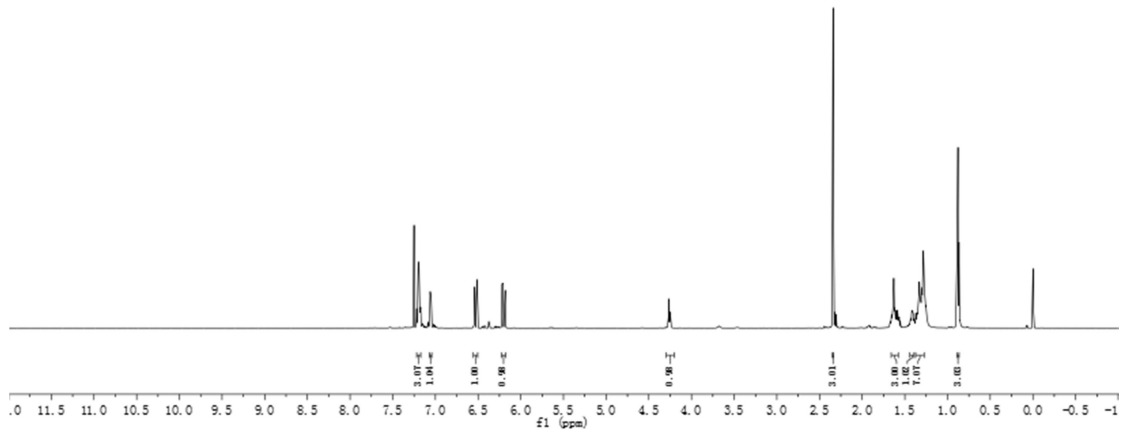
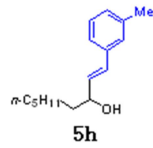
CDCl<sub>3</sub>, 400 MHz



CDCl<sub>3</sub>, 100 MHz



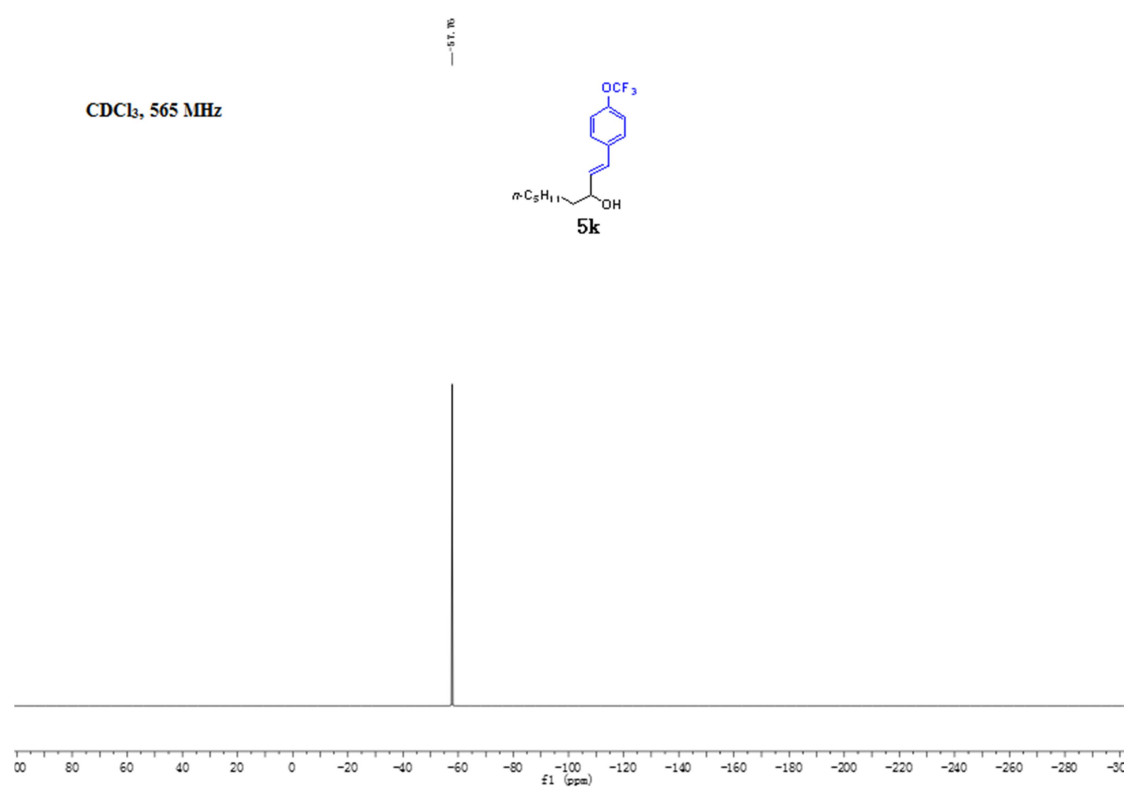
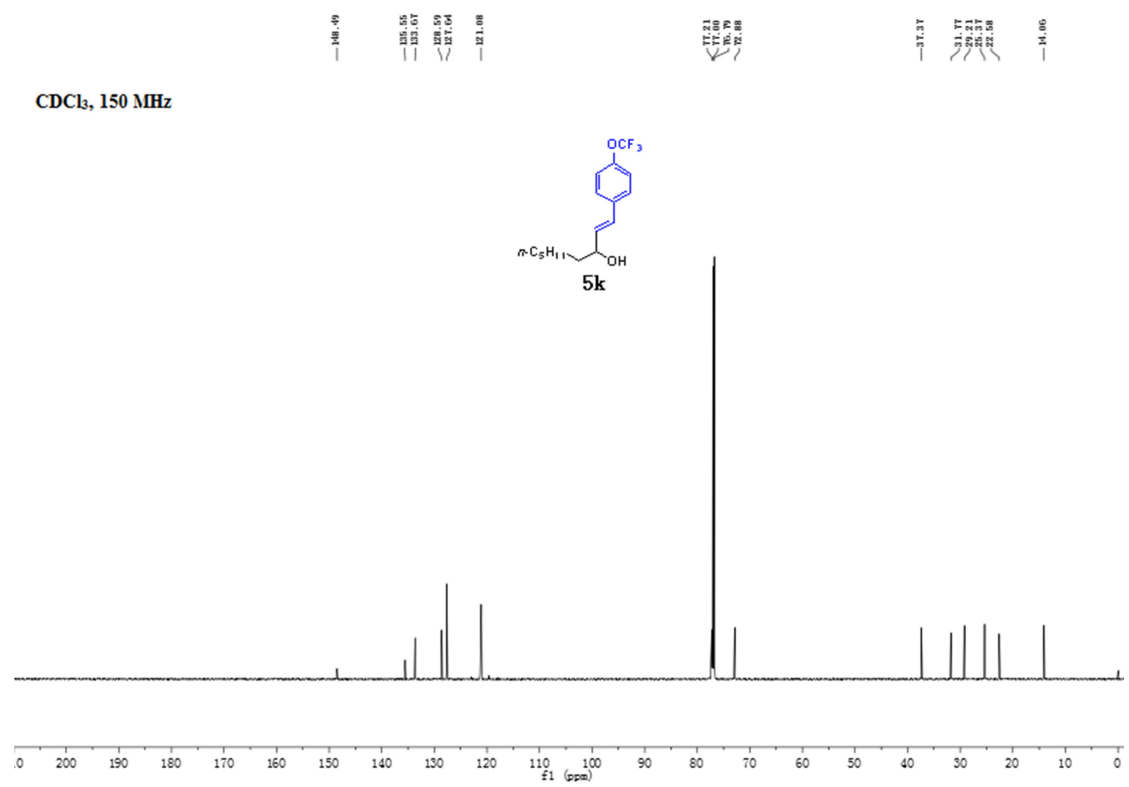
CDCl<sub>3</sub>, 600 MHz

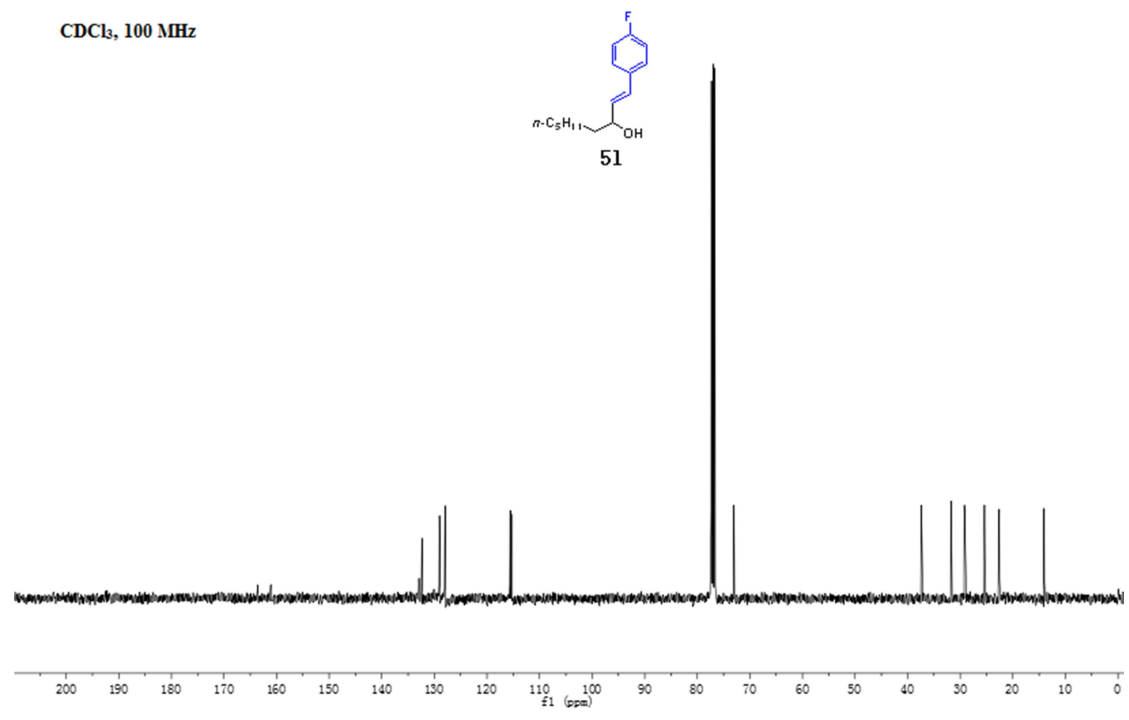
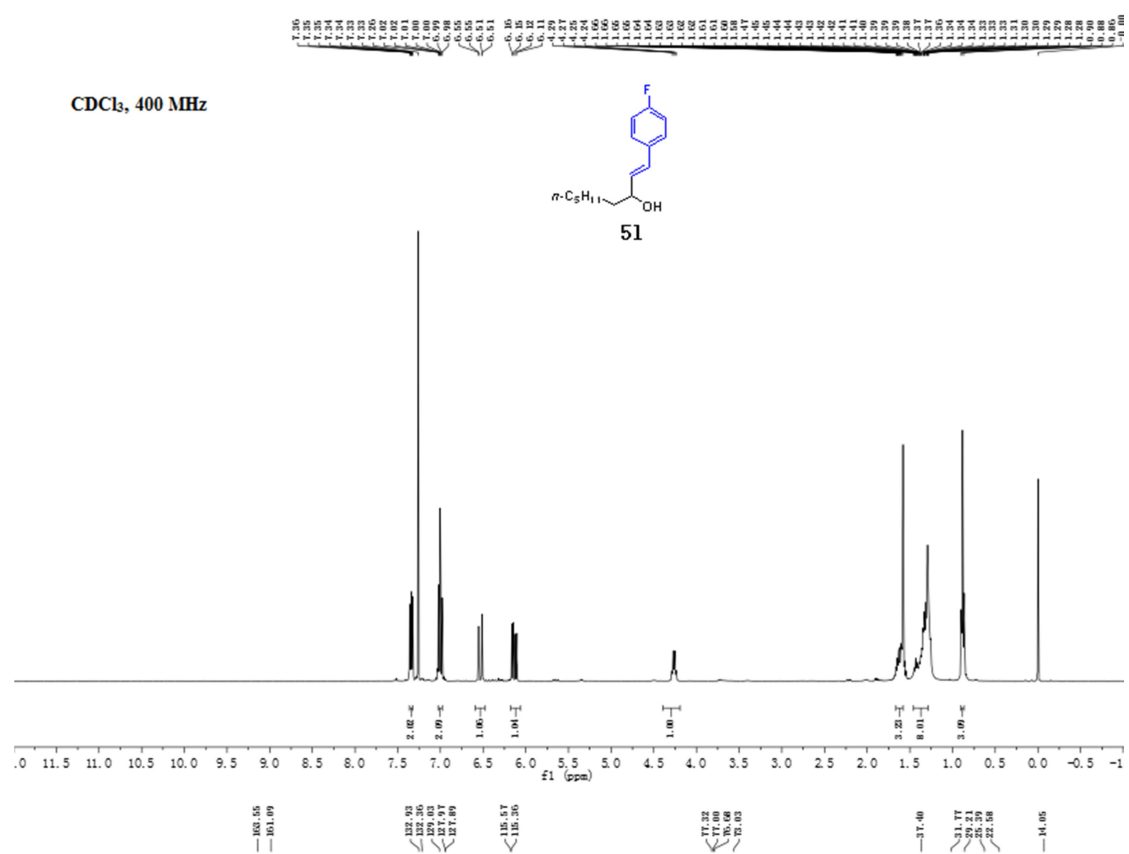




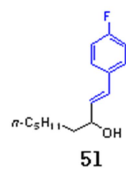




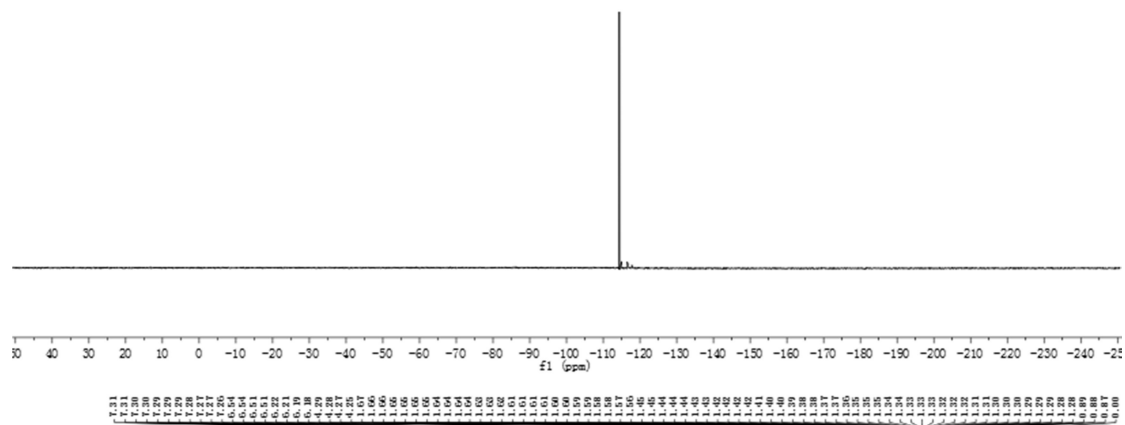




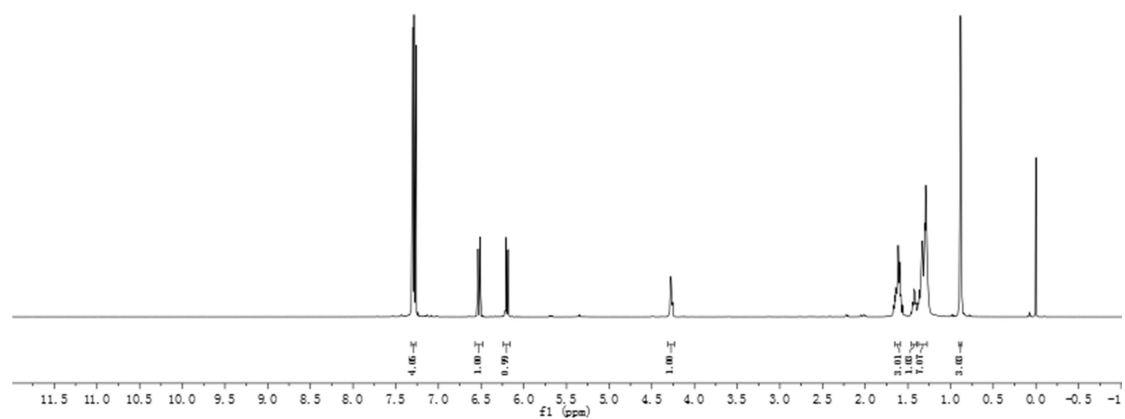
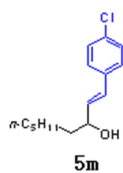
CDCl<sub>3</sub>, 376 MHz



114.37  
114.35  
114.33  
114.31



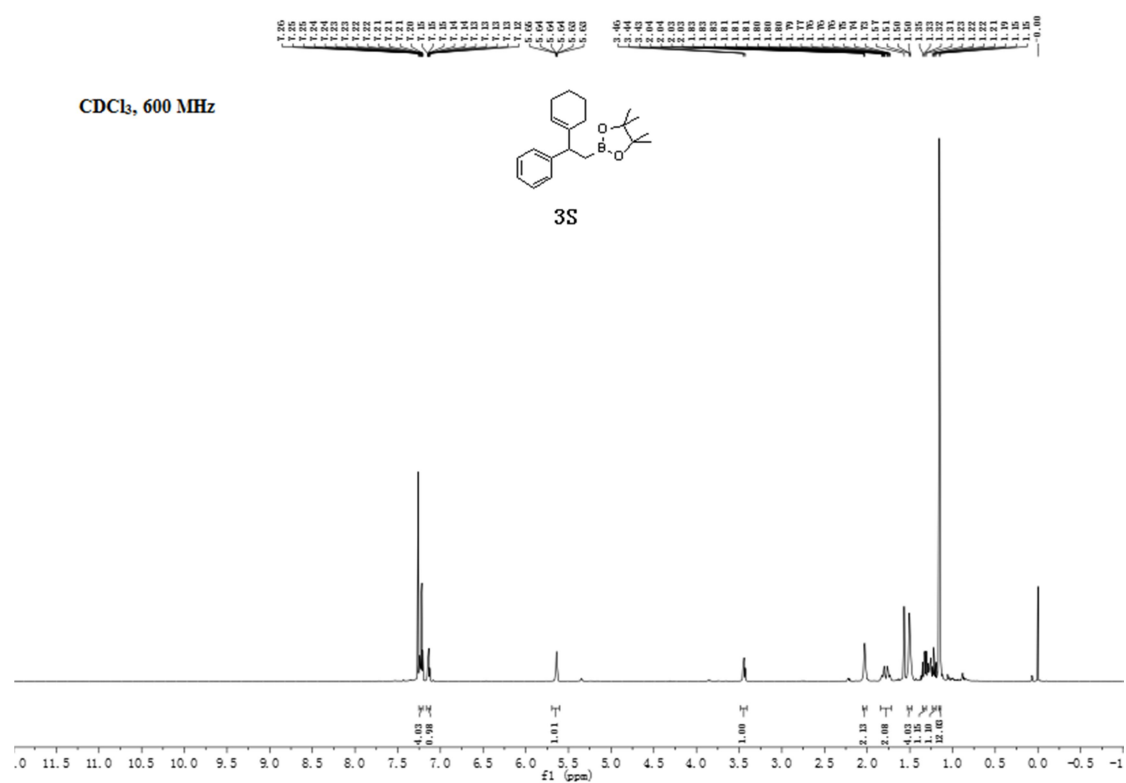
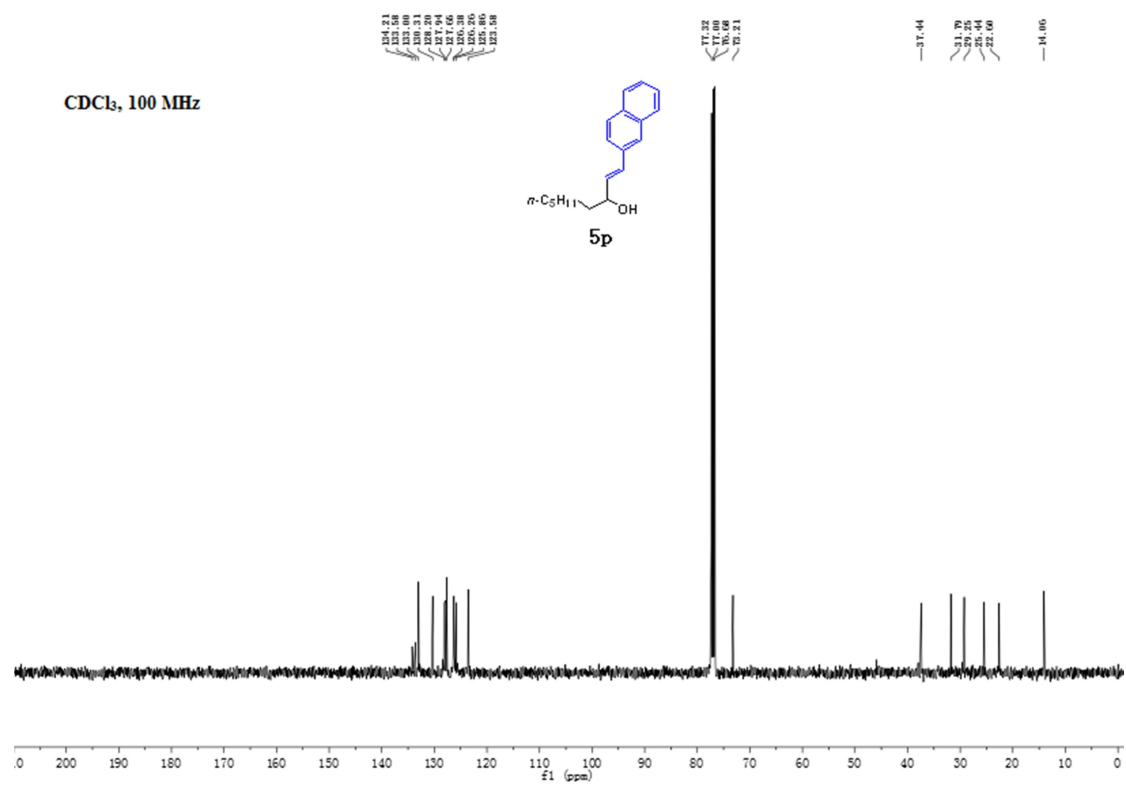
CDCl<sub>3</sub>, 600 MHz

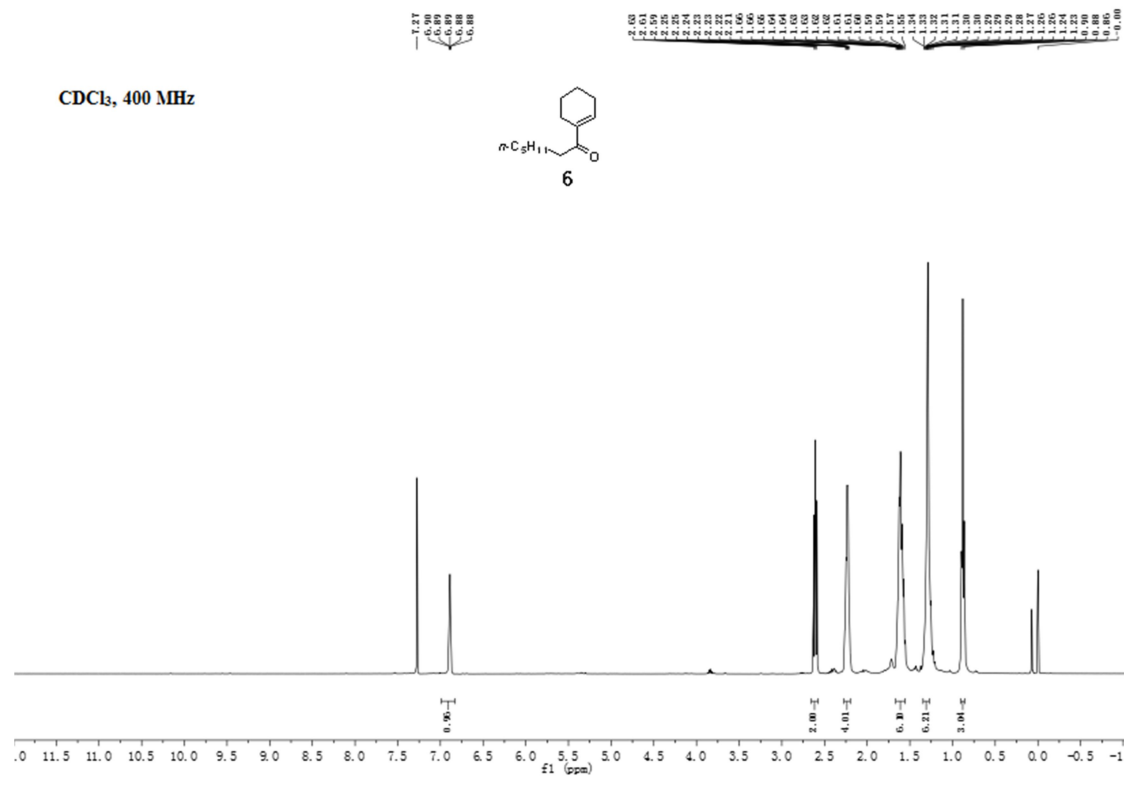
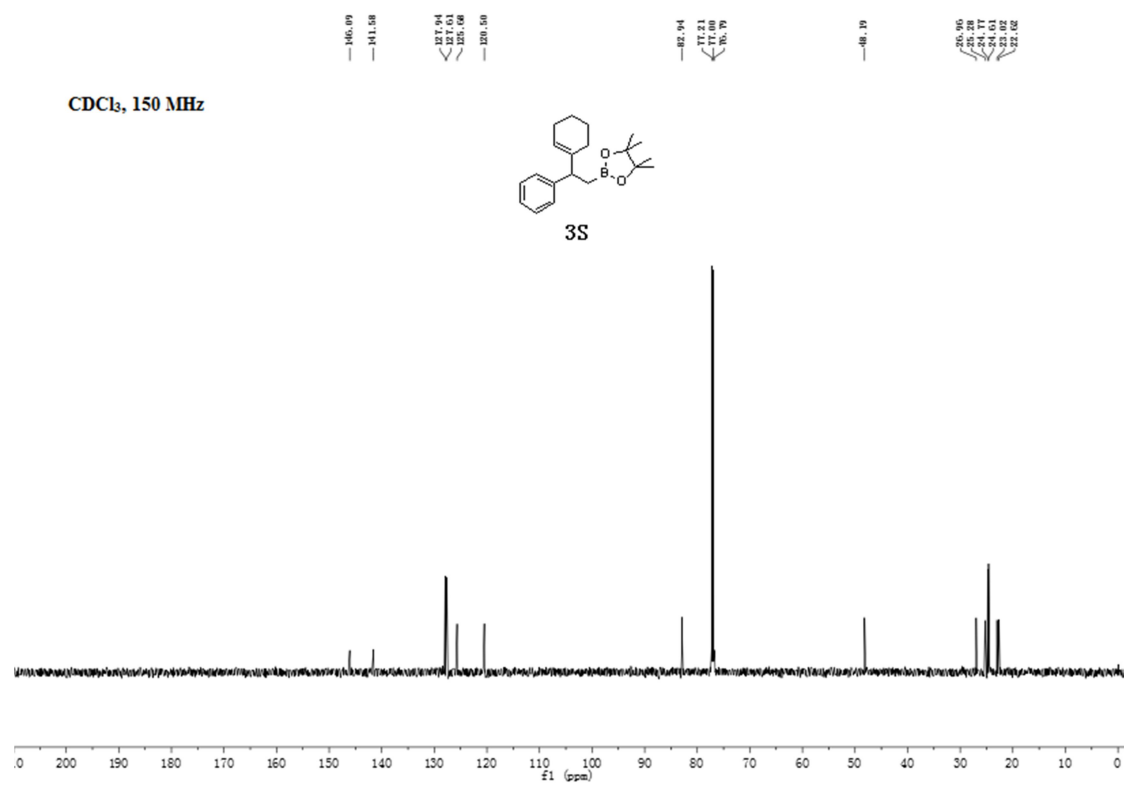






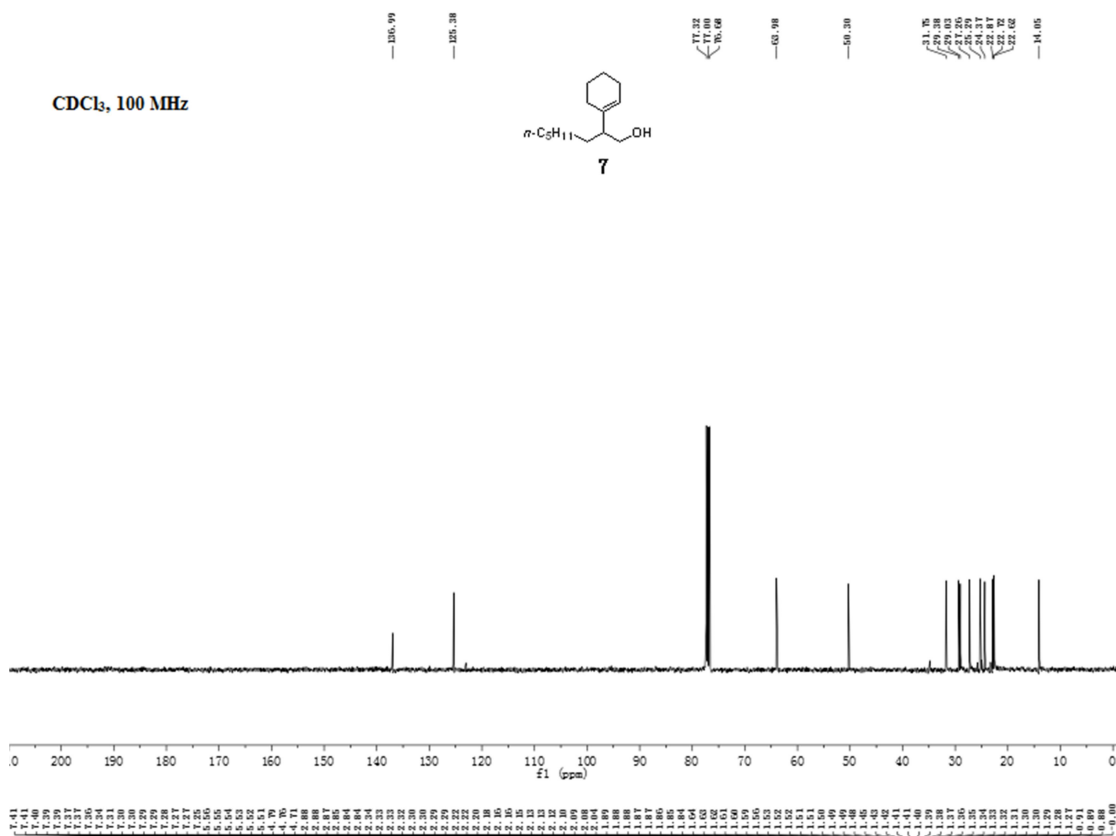
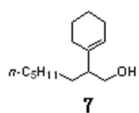




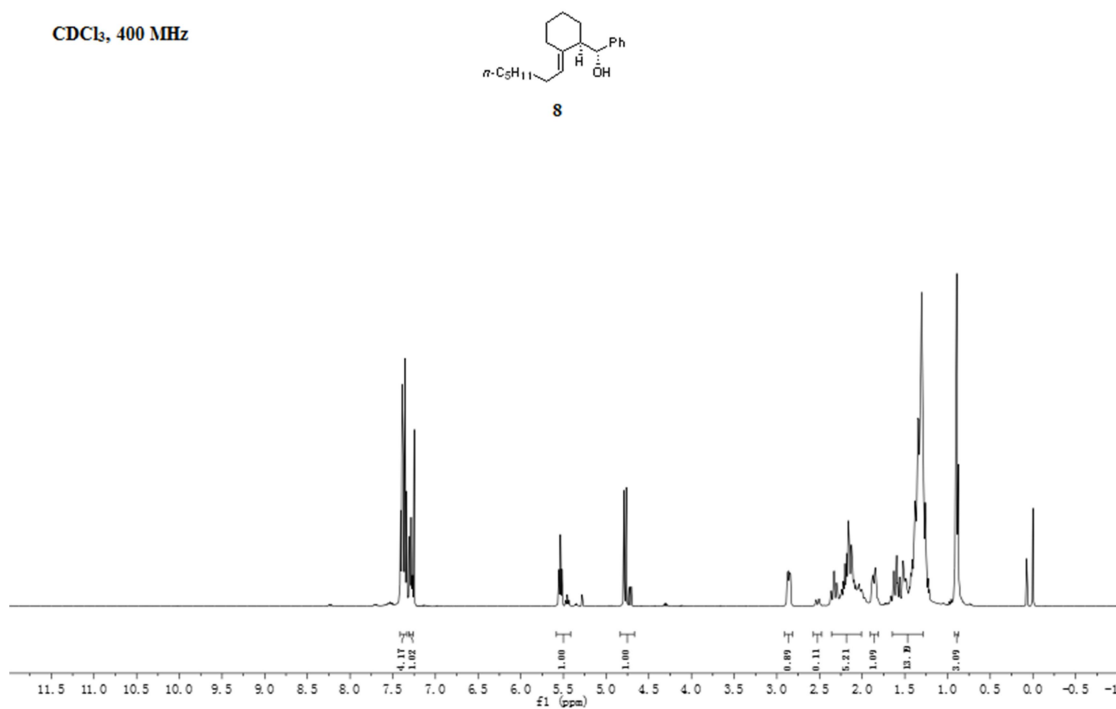
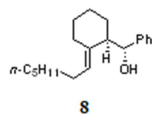




CDCl<sub>3</sub>, 100 MHz



CDCl<sub>3</sub>, 400 MHz



CDCl<sub>3</sub>, 100 MHz

142.87  
137.94

128.85  
127.60  
127.09

77.32  
77.00  
76.74  
76.47

46.07

33.16  
30.07  
28.99  
27.84  
27.25  
23.88

14.08

