

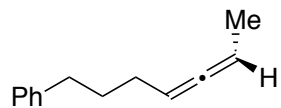
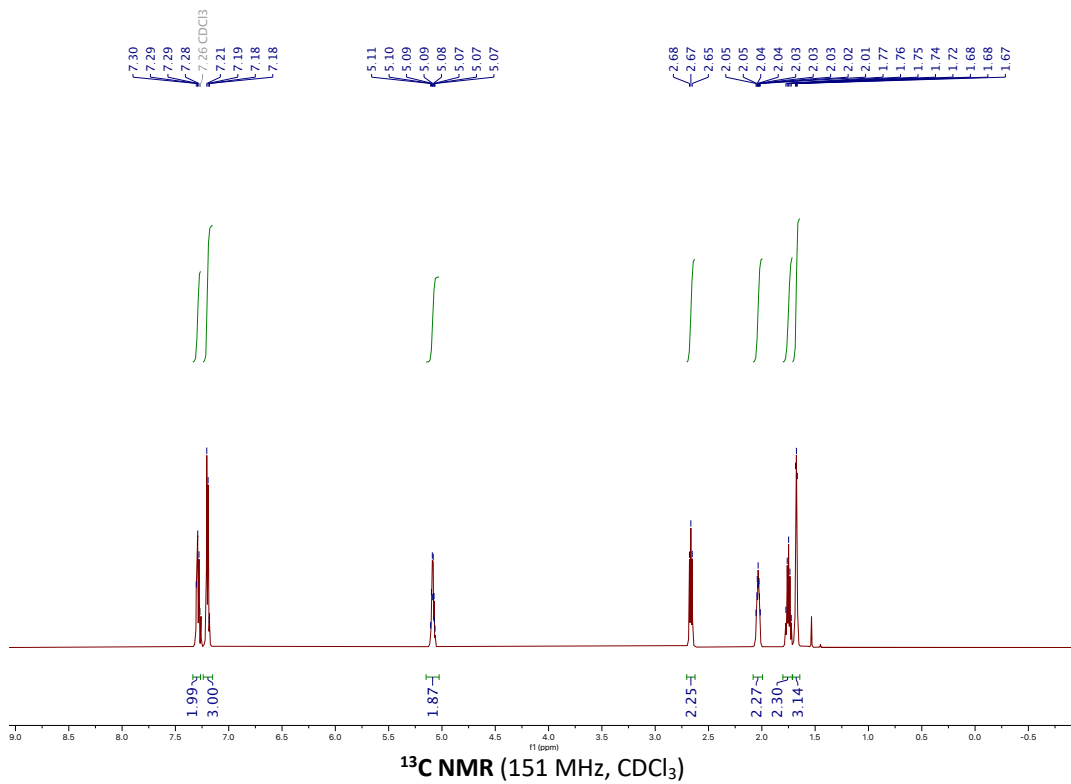
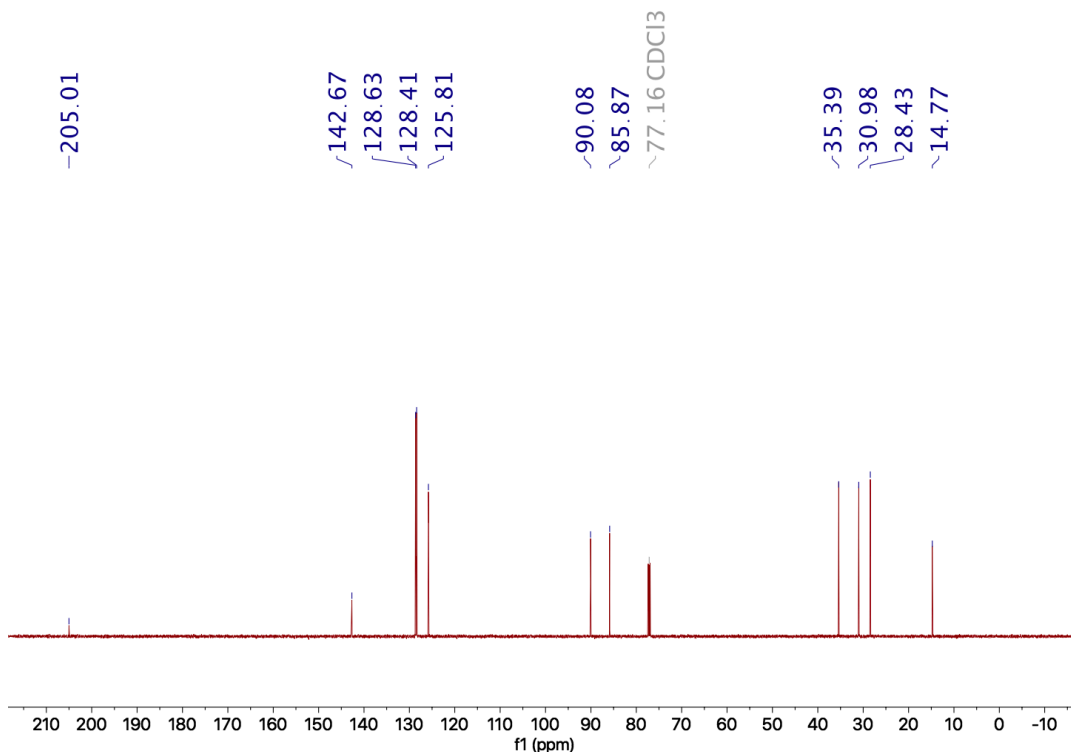
*Compiled NMR Spectra*

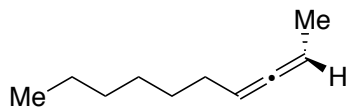
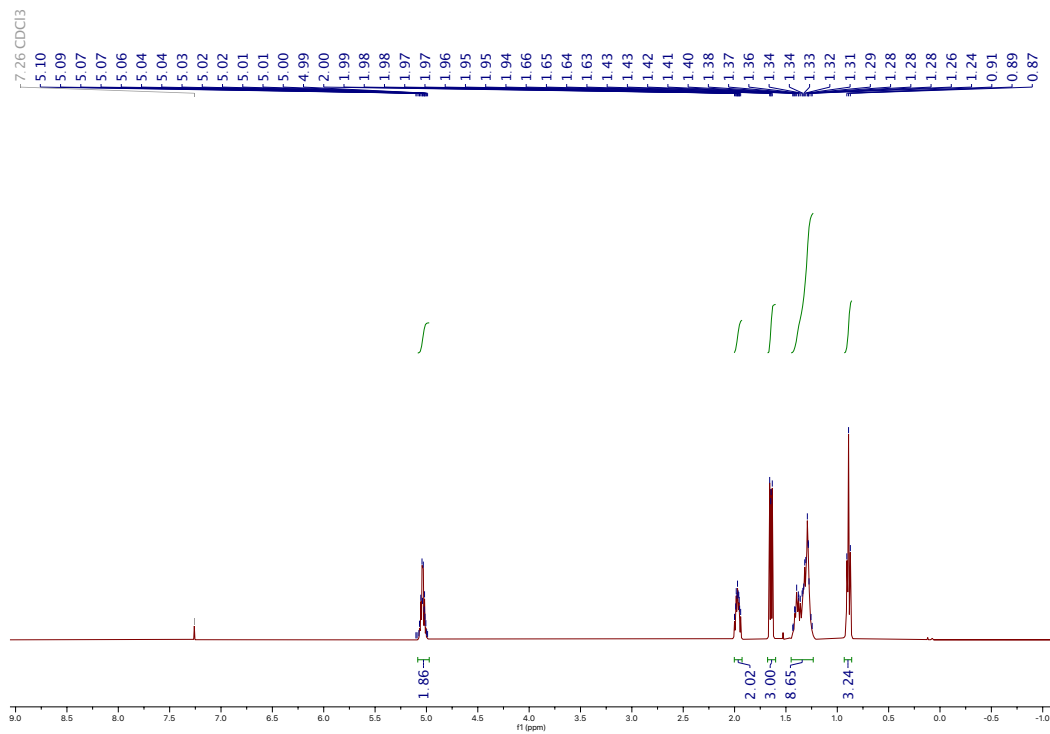
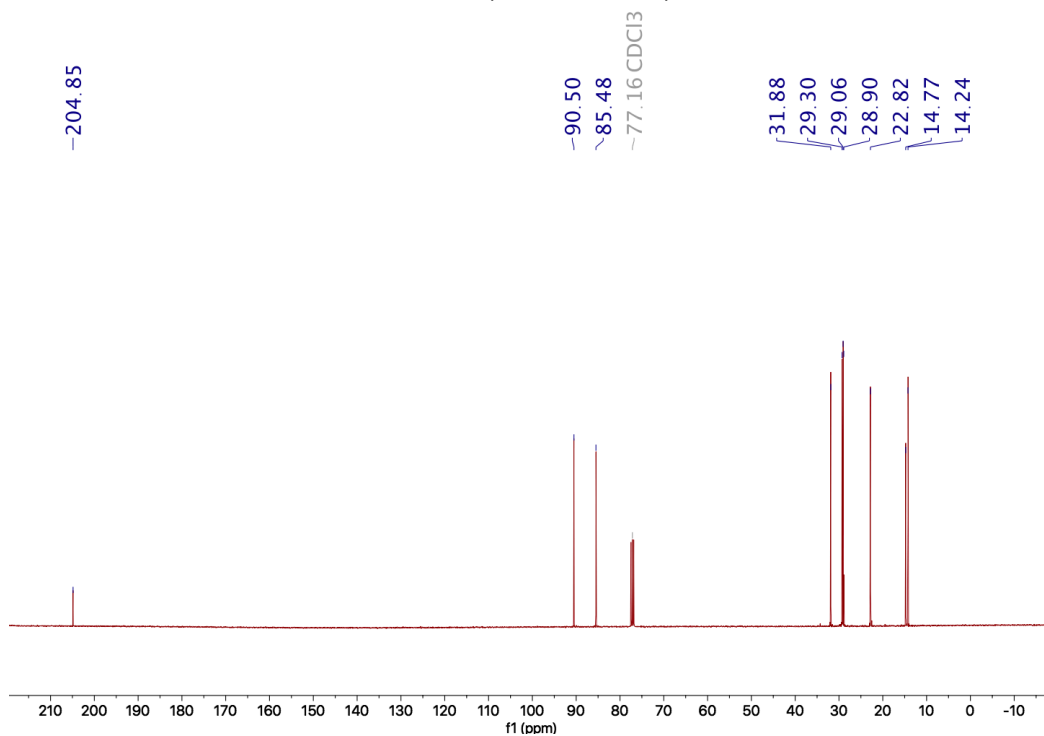
**Copper Hydride-Catalyzed Enantioselective Synthesis of Axially  
Chiral 1,3-Disubstituted Allenes**

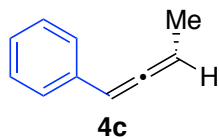
**Liela Bayeh-Romero and Stephen L. Buchwald\***

Department of Chemistry, Massachusetts Institute of Technology, Cambridge, Massachusetts  
02139, United States

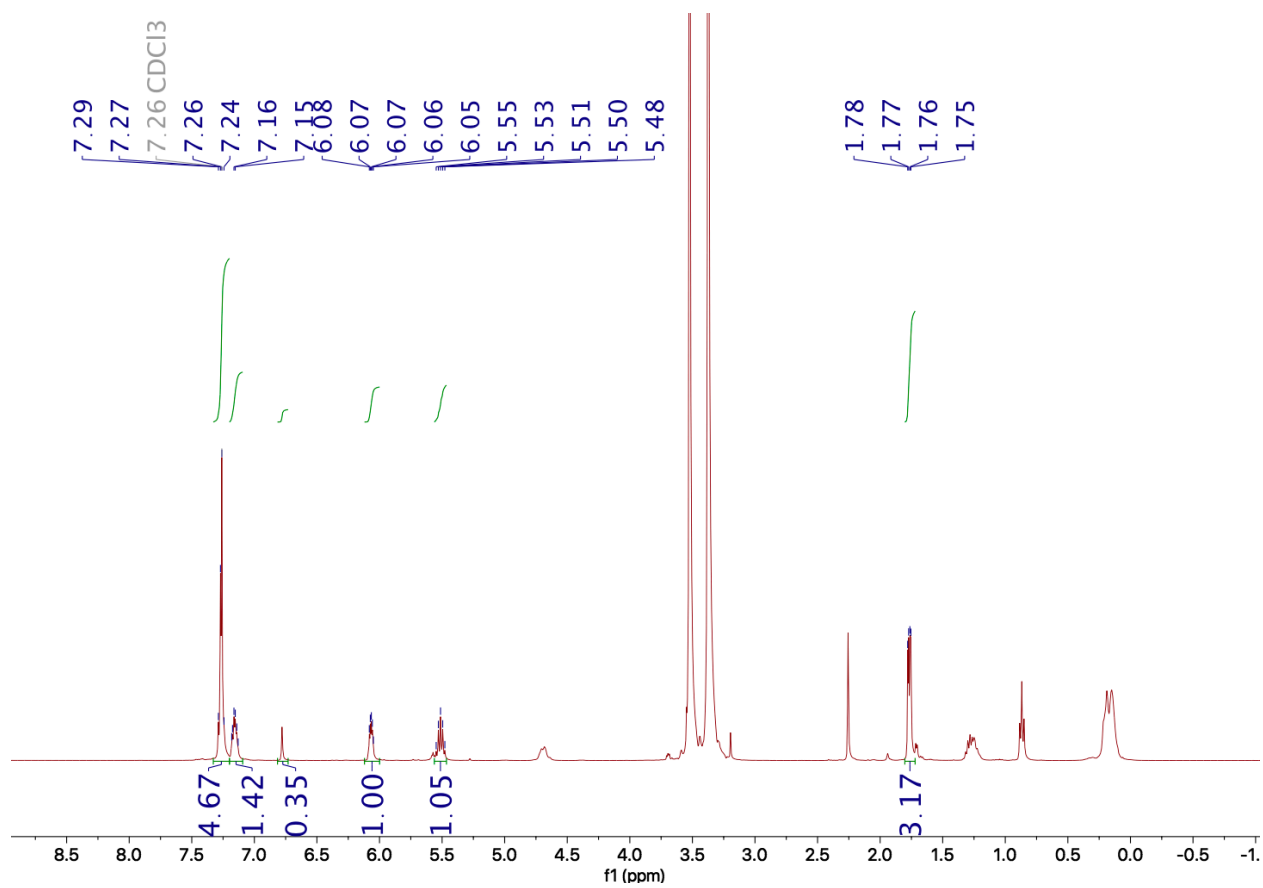
\*Correspondence to: [sbuchwal@mit.edu](mailto:sbuchwal@mit.edu)

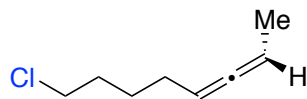
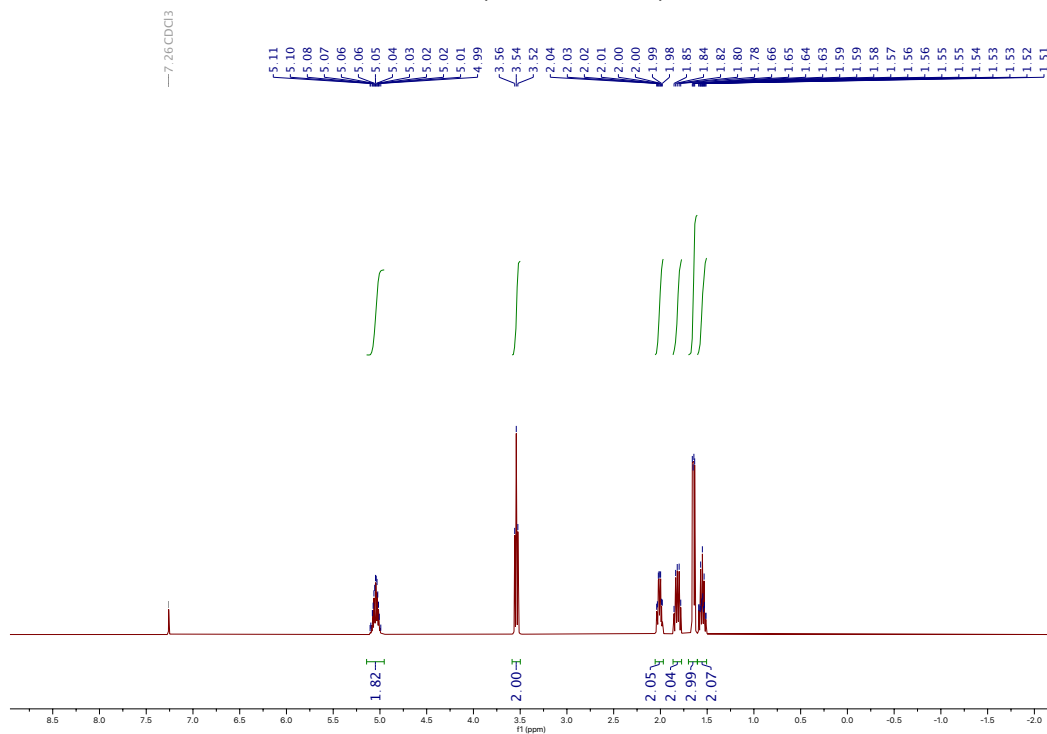
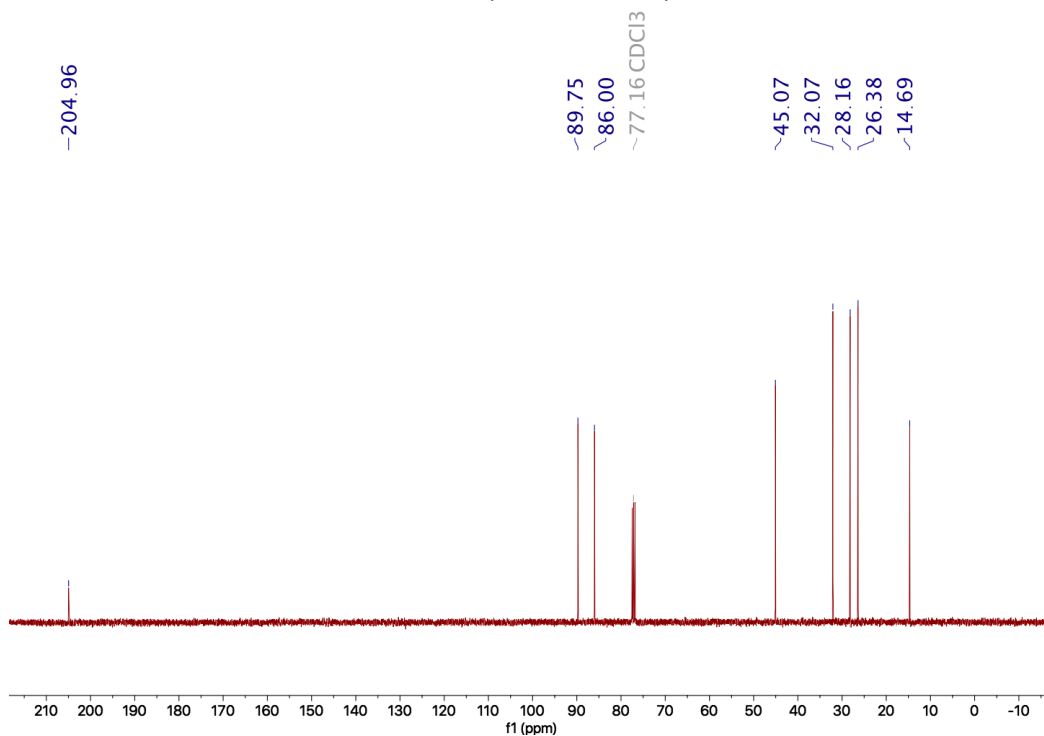
**4a** $^1\text{H NMR}$  (500 MHz,  $\text{CDCl}_3$ ) $^{13}\text{C NMR}$  (151 MHz,  $\text{CDCl}_3$ )

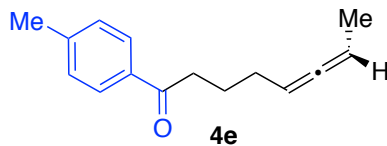
**4b**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>)



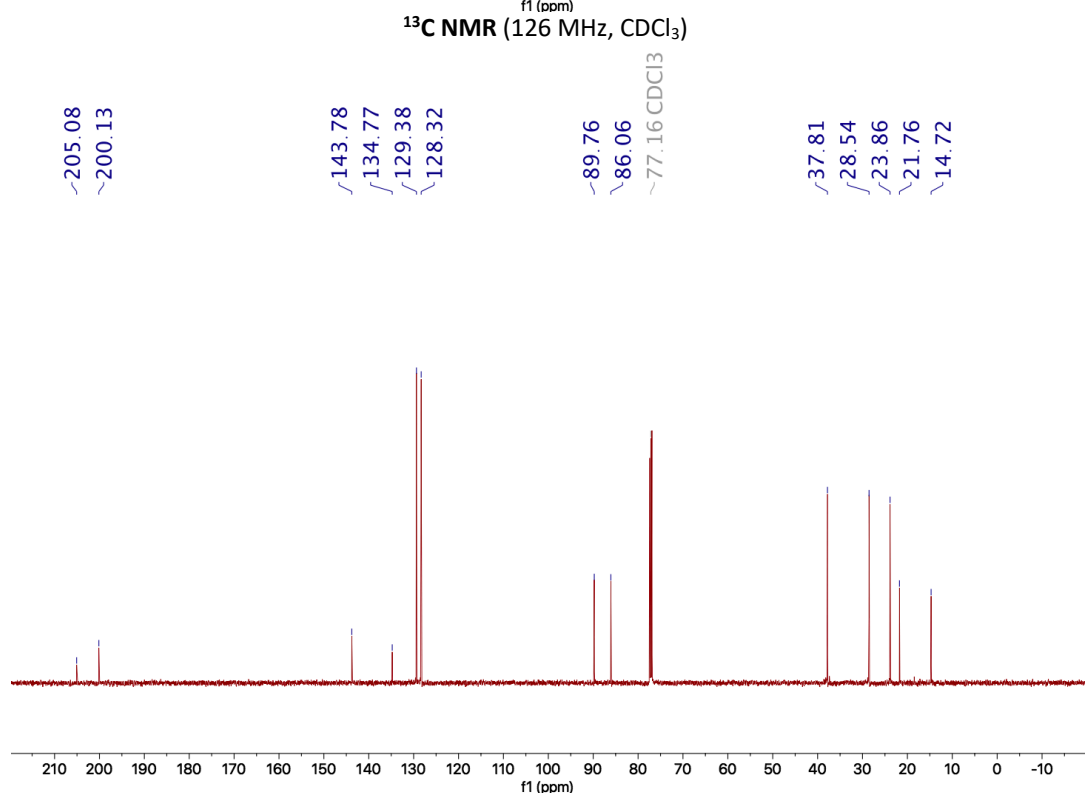
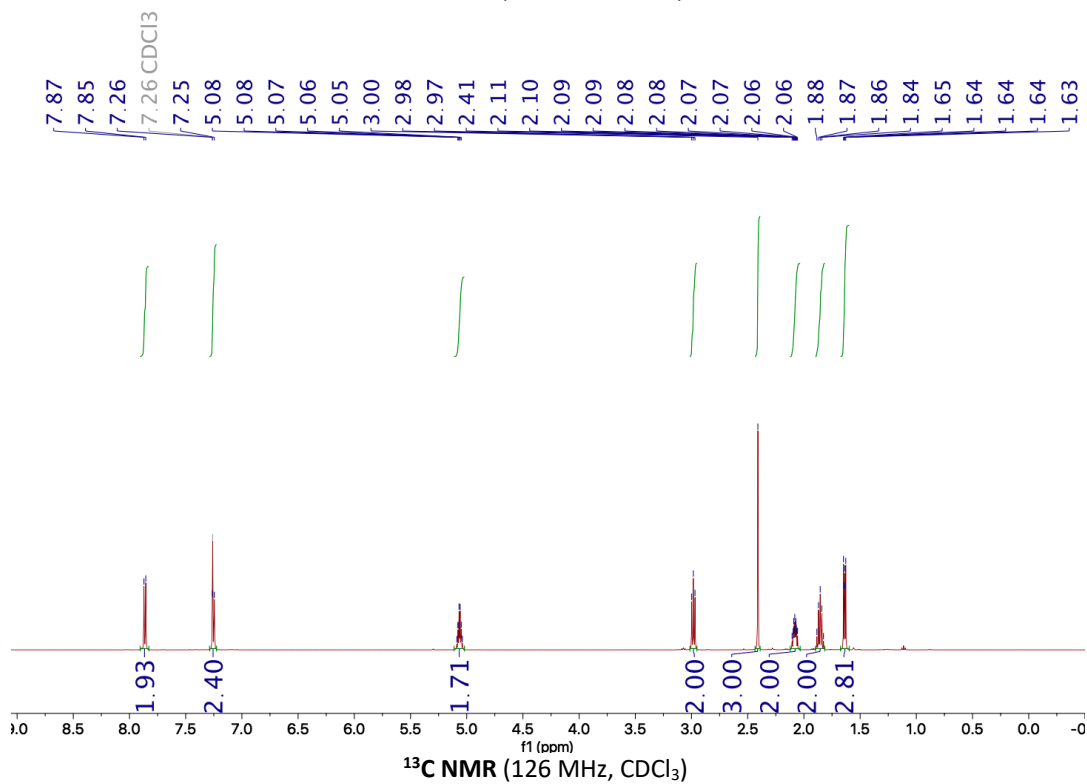
**<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) of crude reaction mixture containing 0.10 mmol mesitylene internal standard

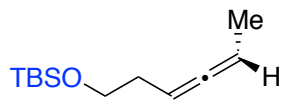
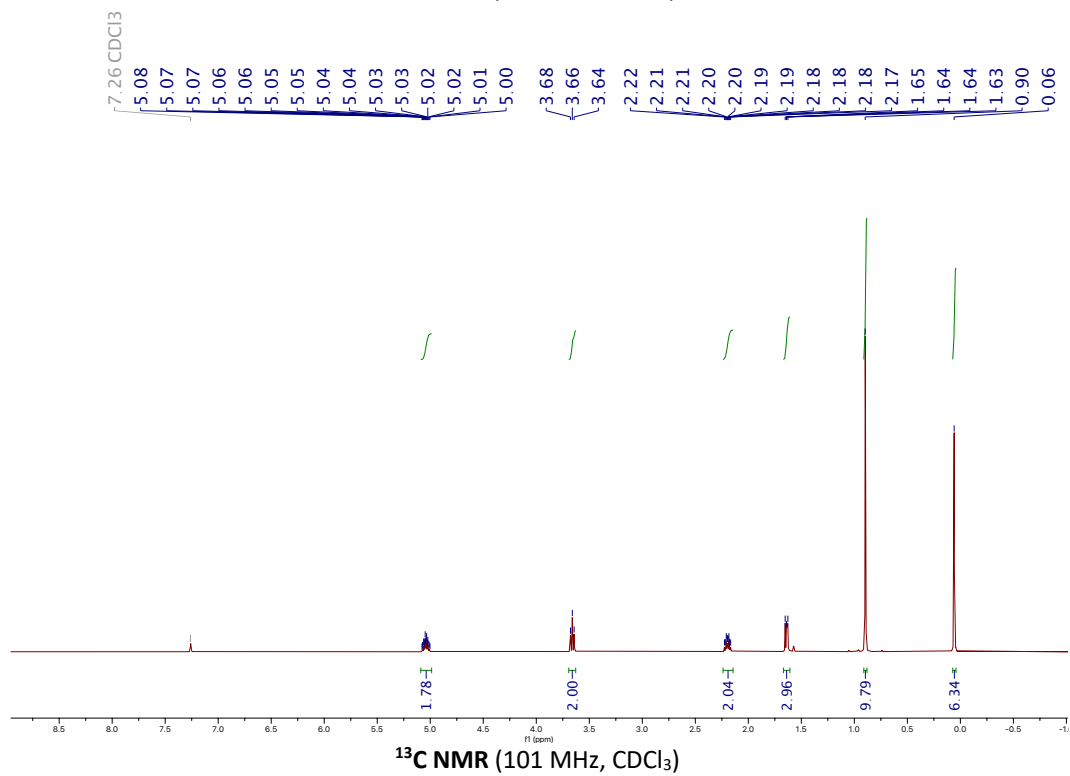
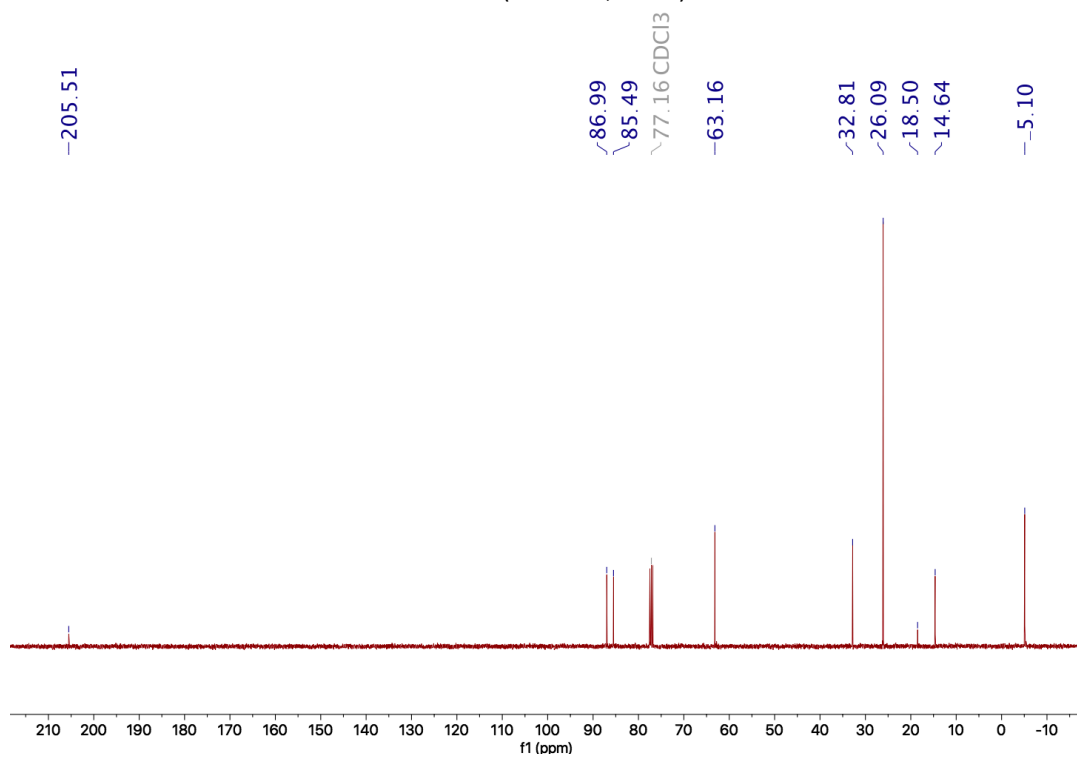


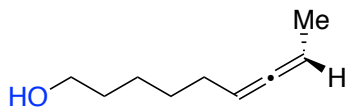
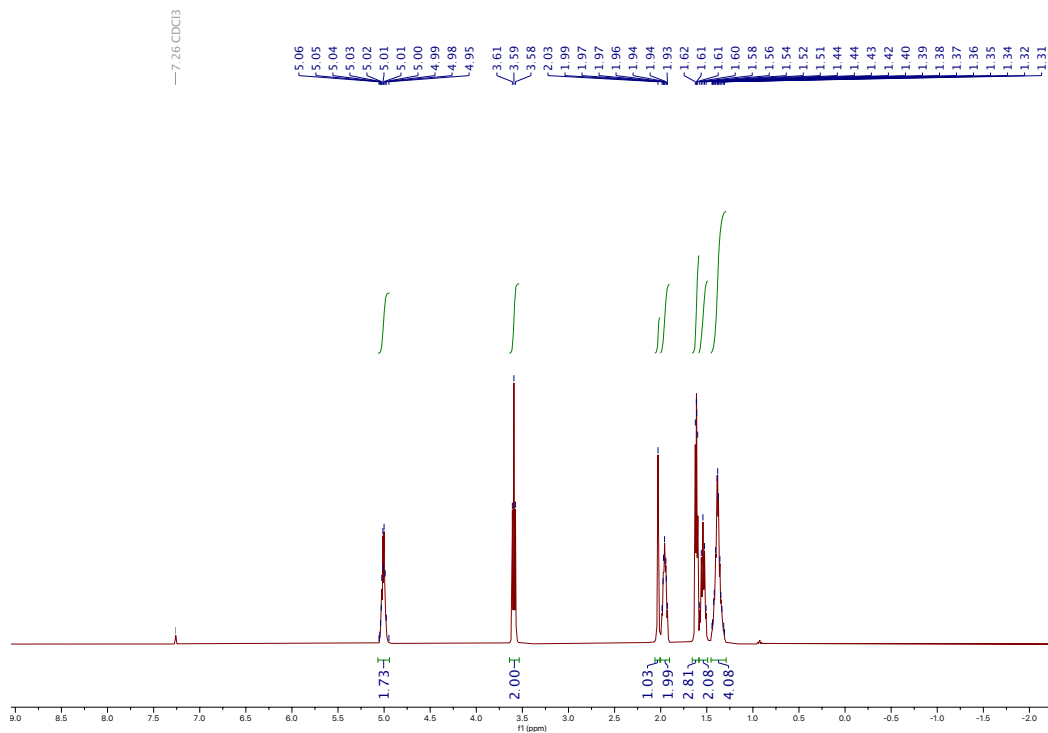
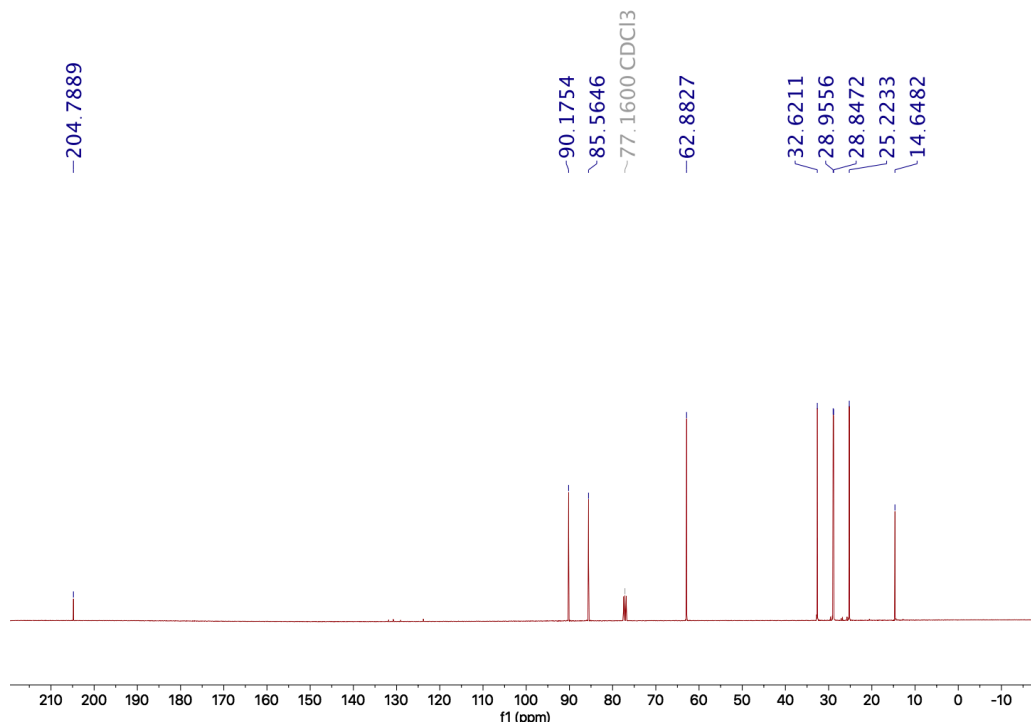
**4d**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>)



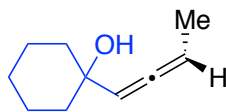
$^1\text{H NMR}$  (500 MHz,  $\text{CDCl}_3$ )



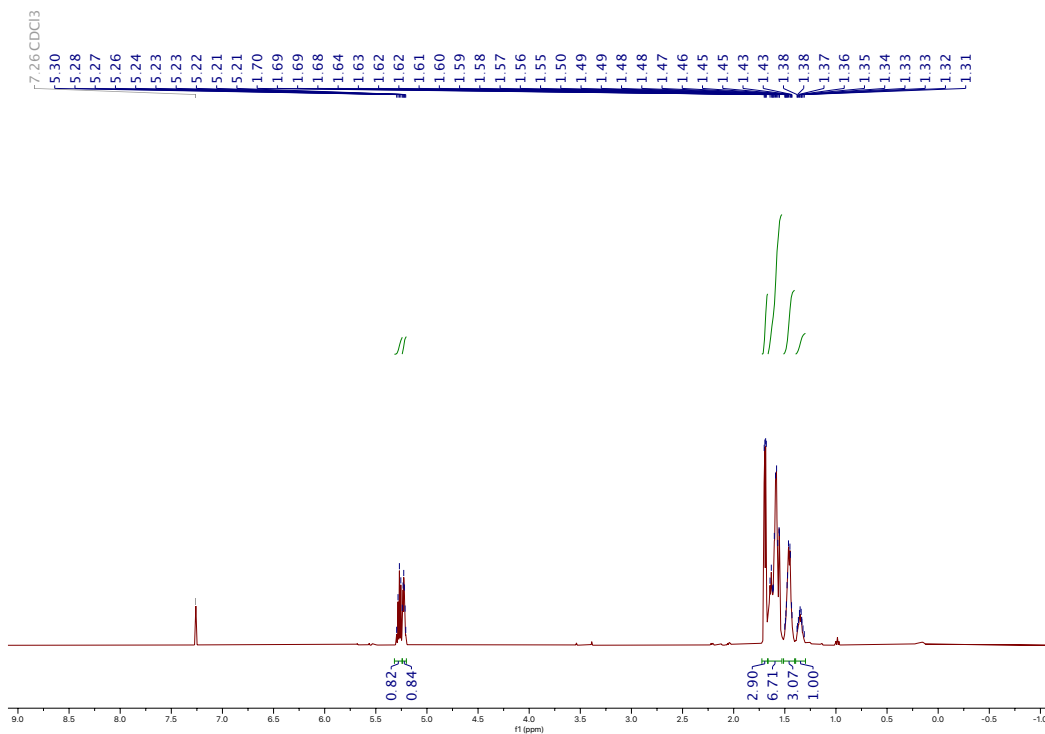
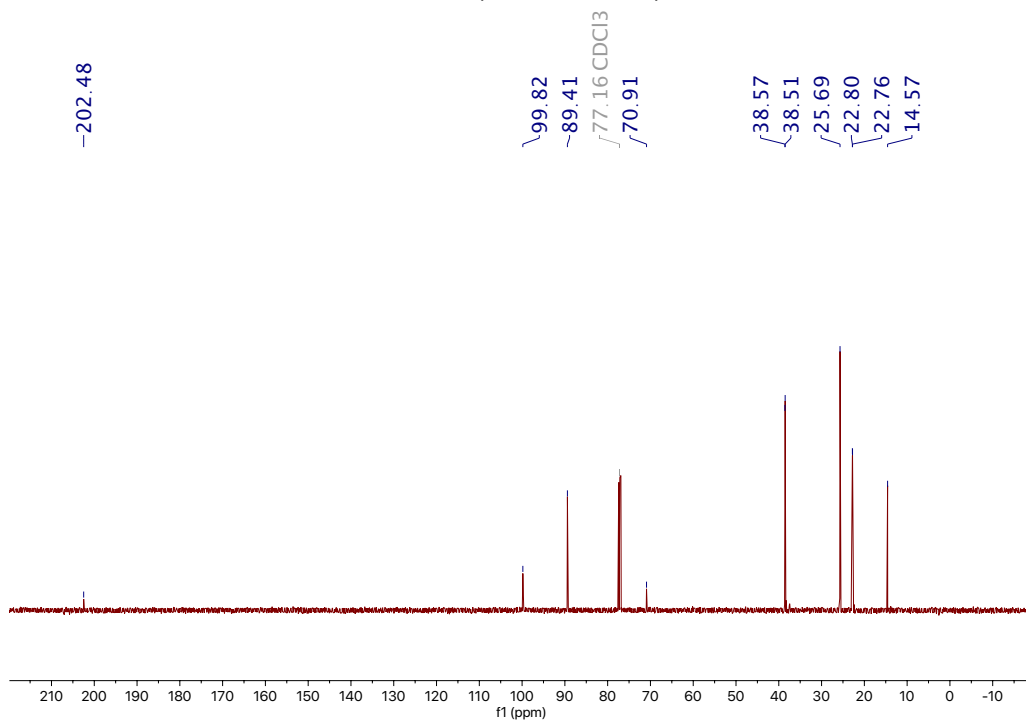
**4f**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>)

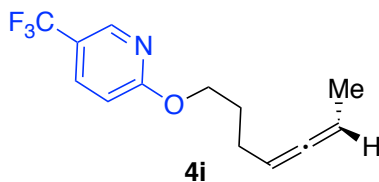
**4g****<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)****<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>)**



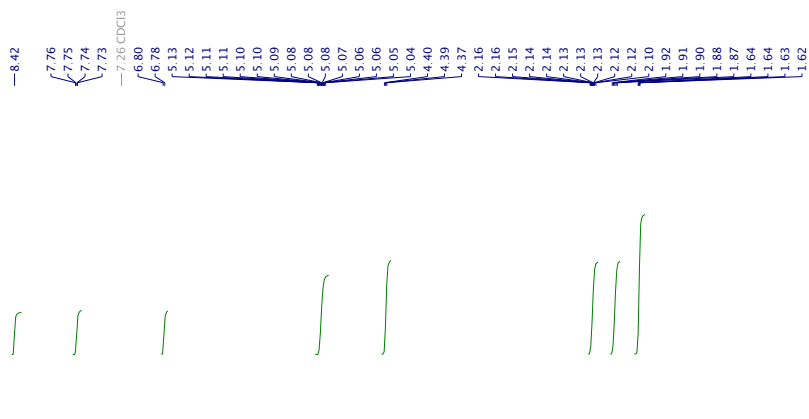


4h

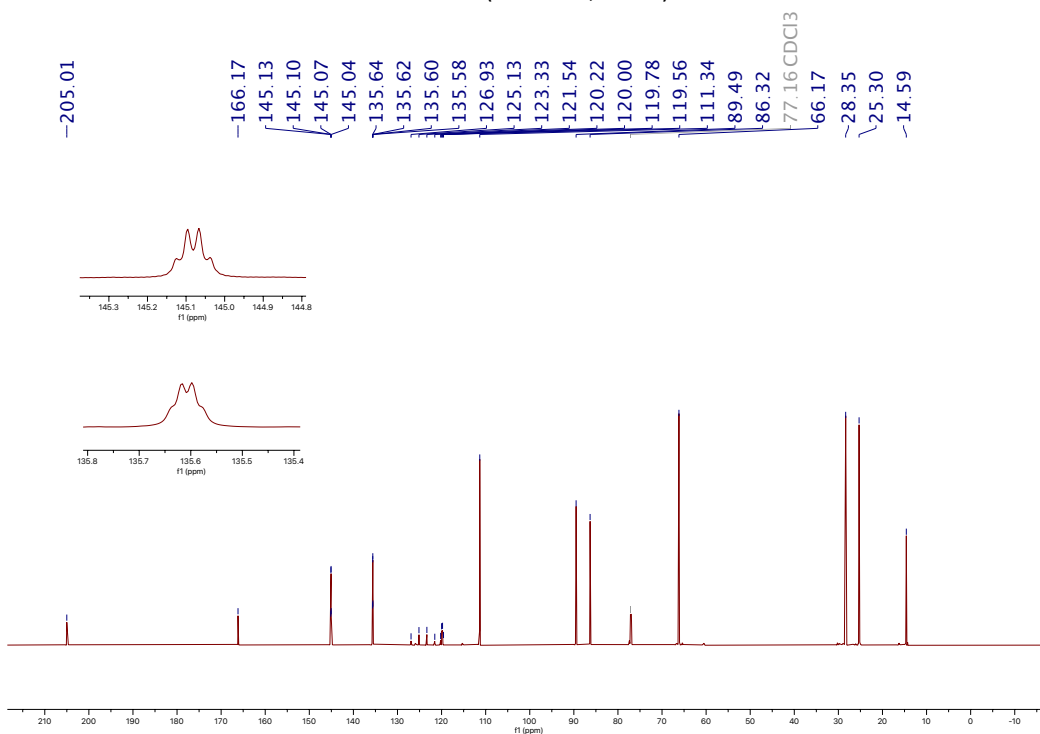
 $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )



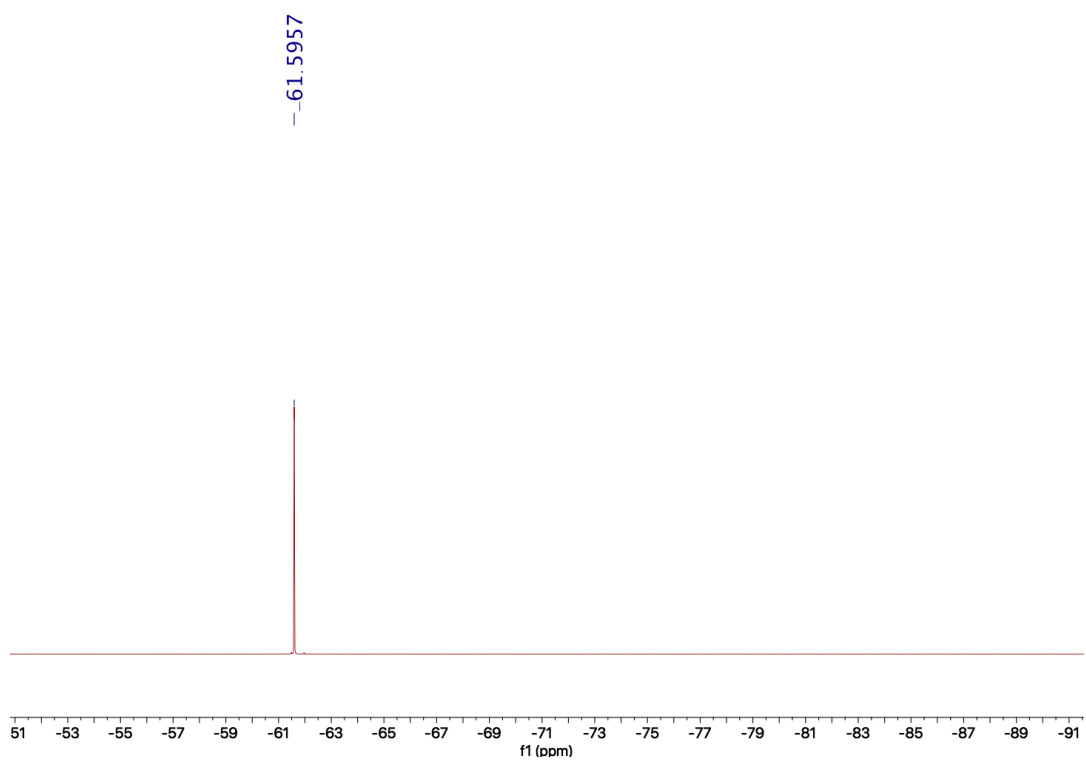
**<sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>)**

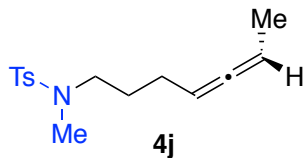


**<sup>13</sup>C NMR (151 MHz, CDCl<sub>3</sub>)**

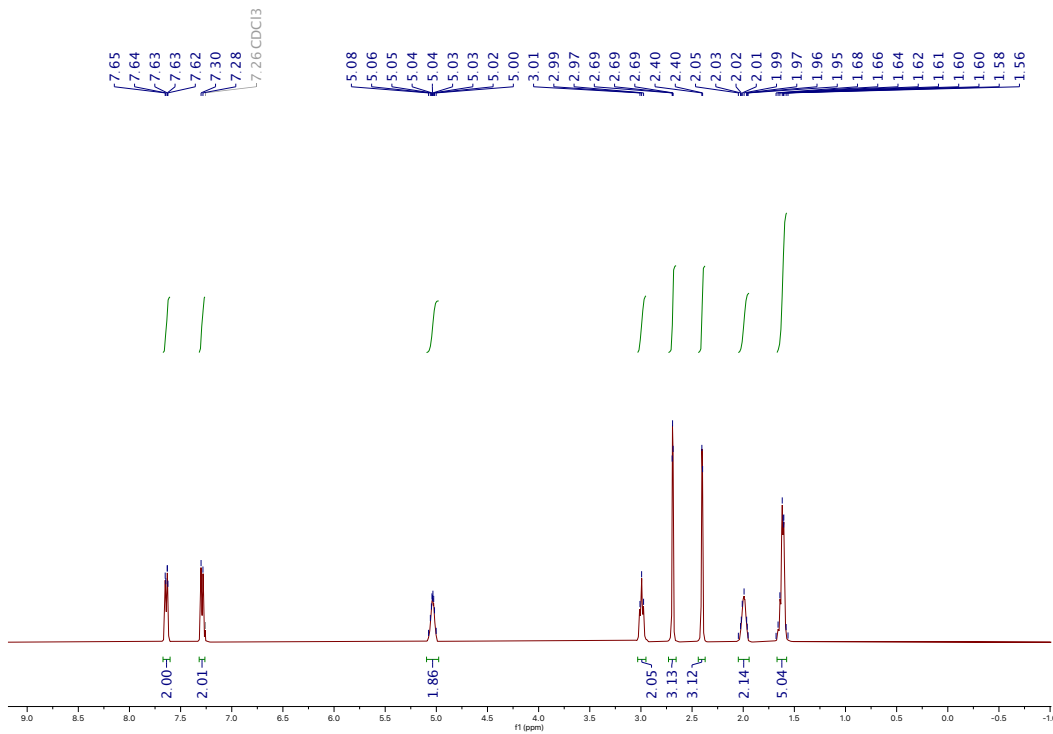


$^{19}\text{F}$  NMR (565 MHz,  $\text{CDCl}_3$ )

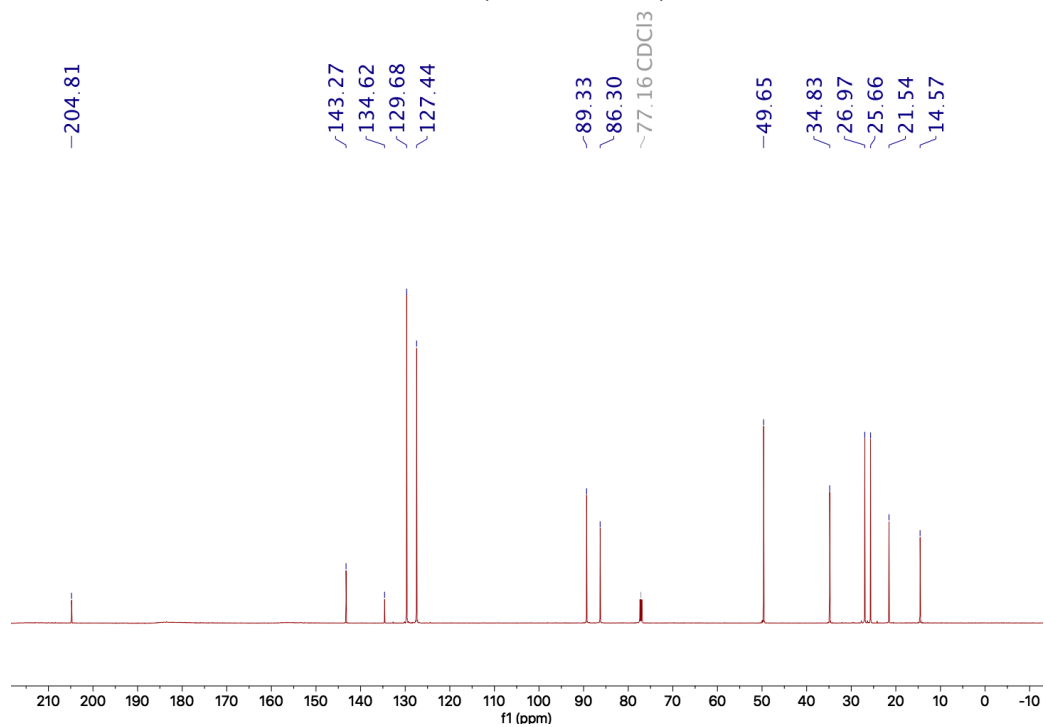


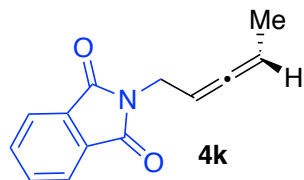


$^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )

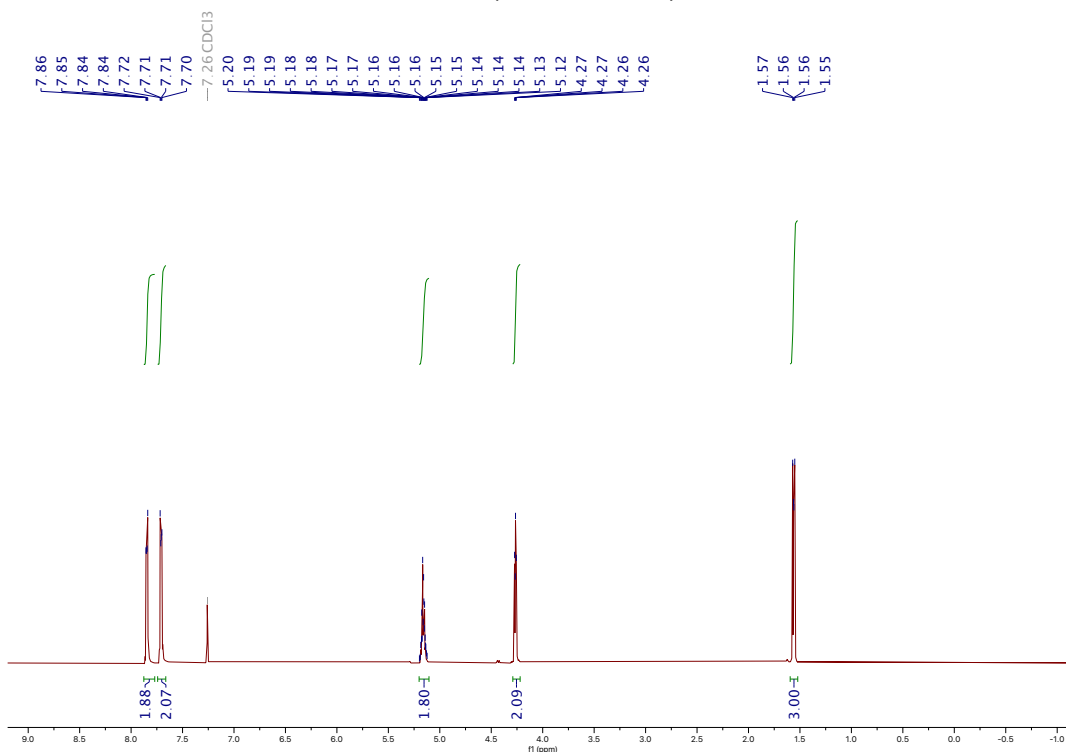


$^{13}\text{C NMR}$  (151 MHz,  $\text{CDCl}_3$ )

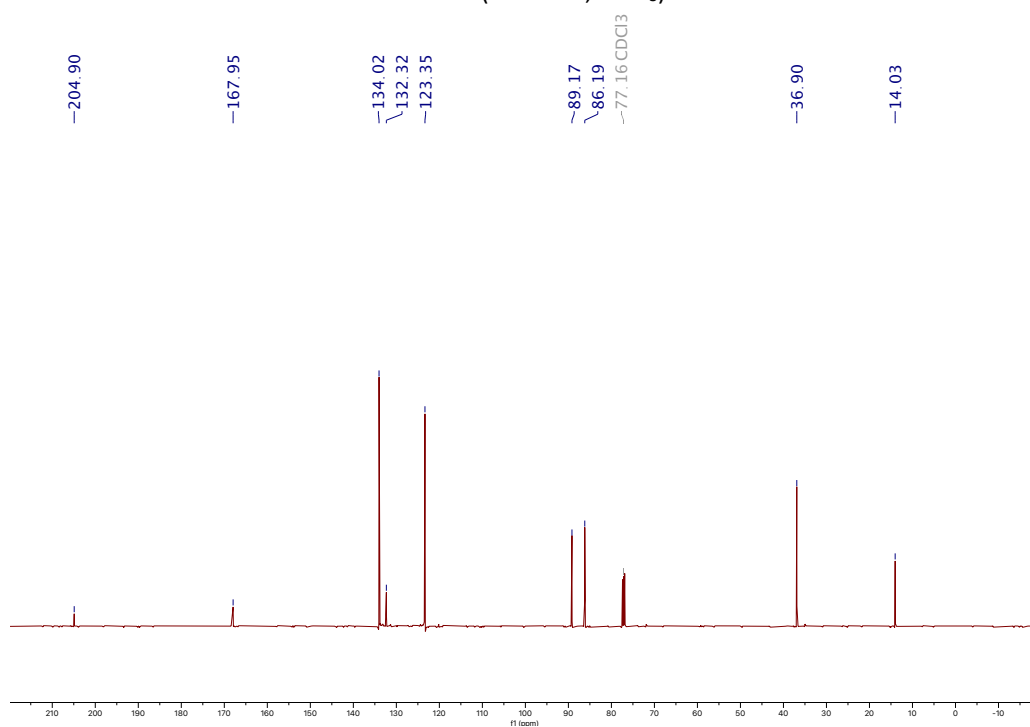


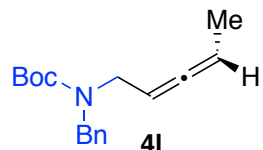


$^1\text{H NMR}$  (500 MHz,  $\text{CDCl}_3$ )

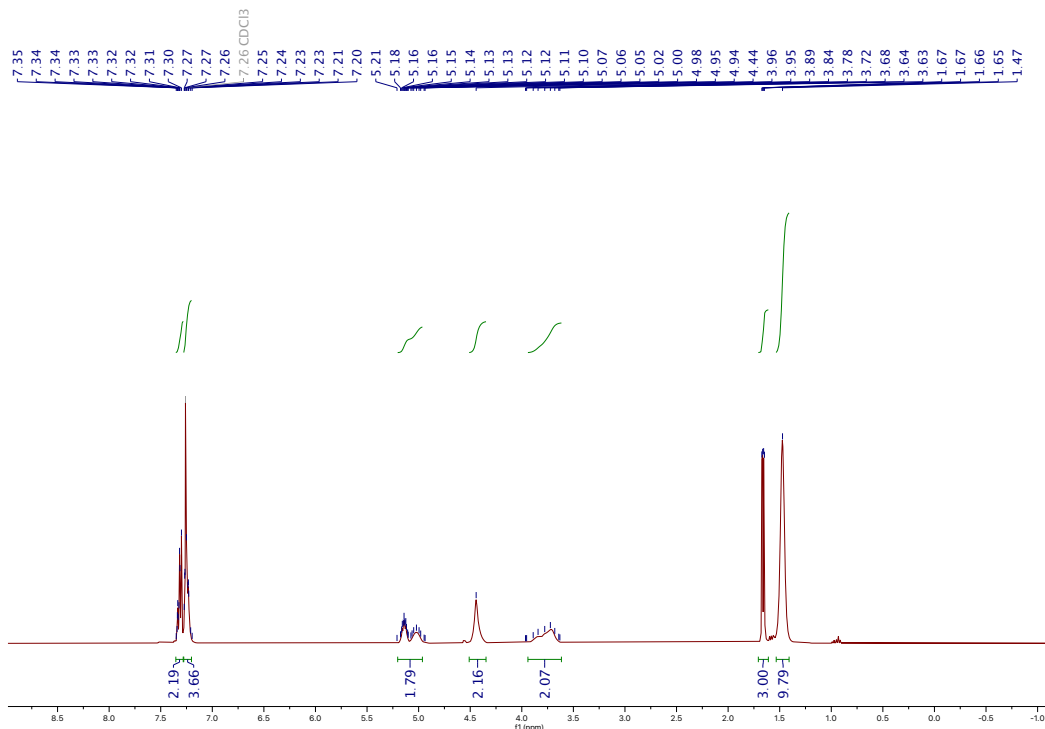


$^{13}\text{C NMR}$  (126 MHz,  $\text{CDCl}_3$ )

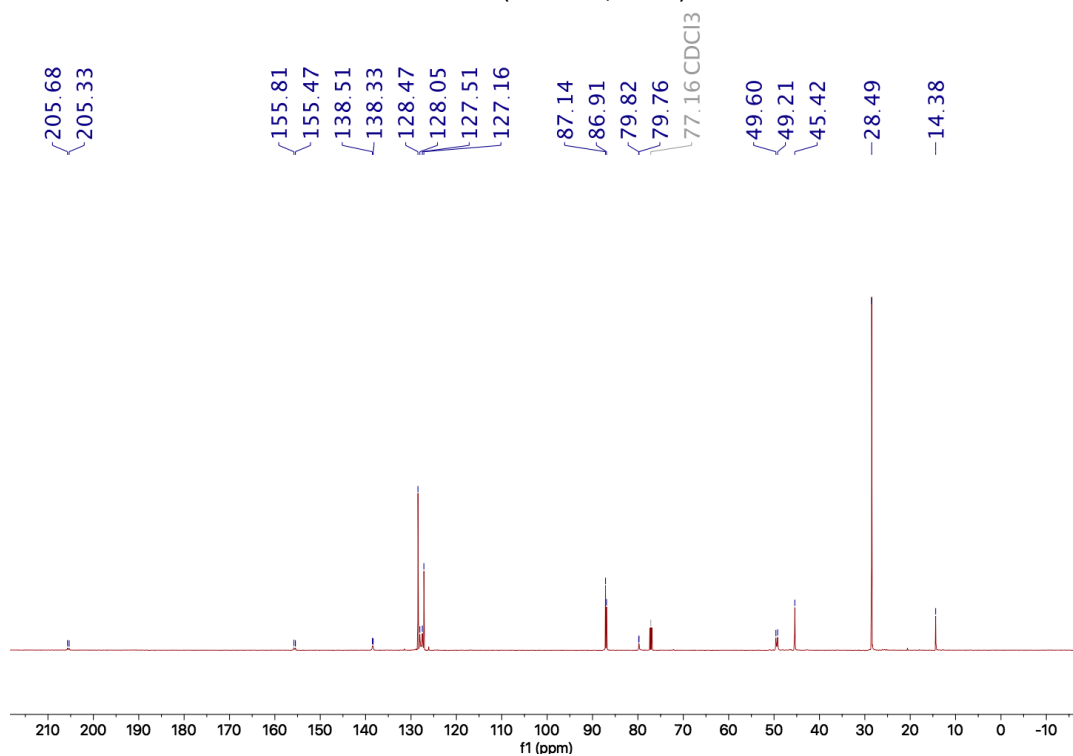


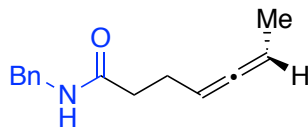


<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)

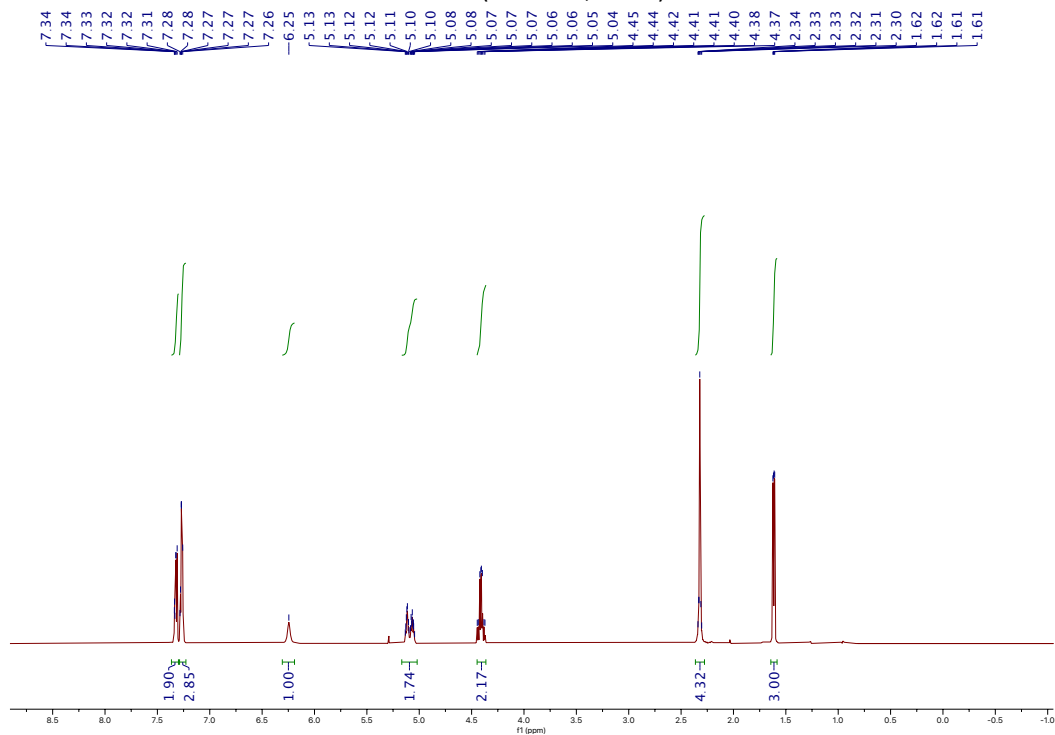


<sup>13</sup>C NMR (151 MHz, CDCl<sub>3</sub>)

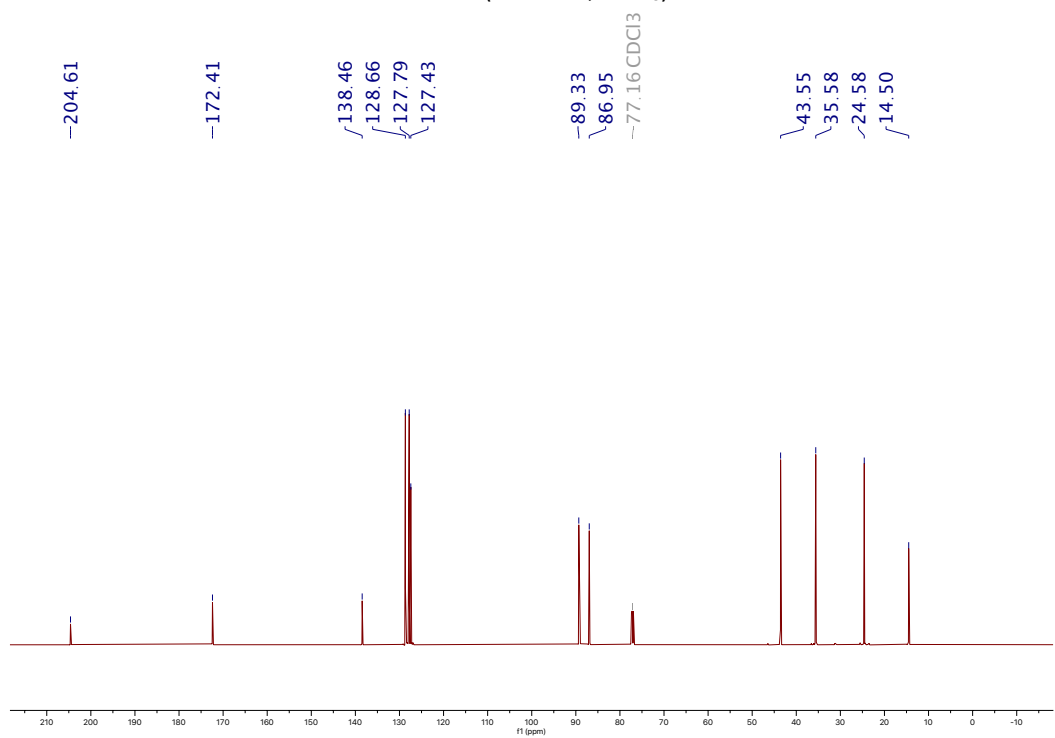


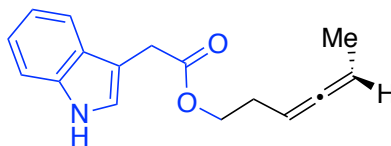
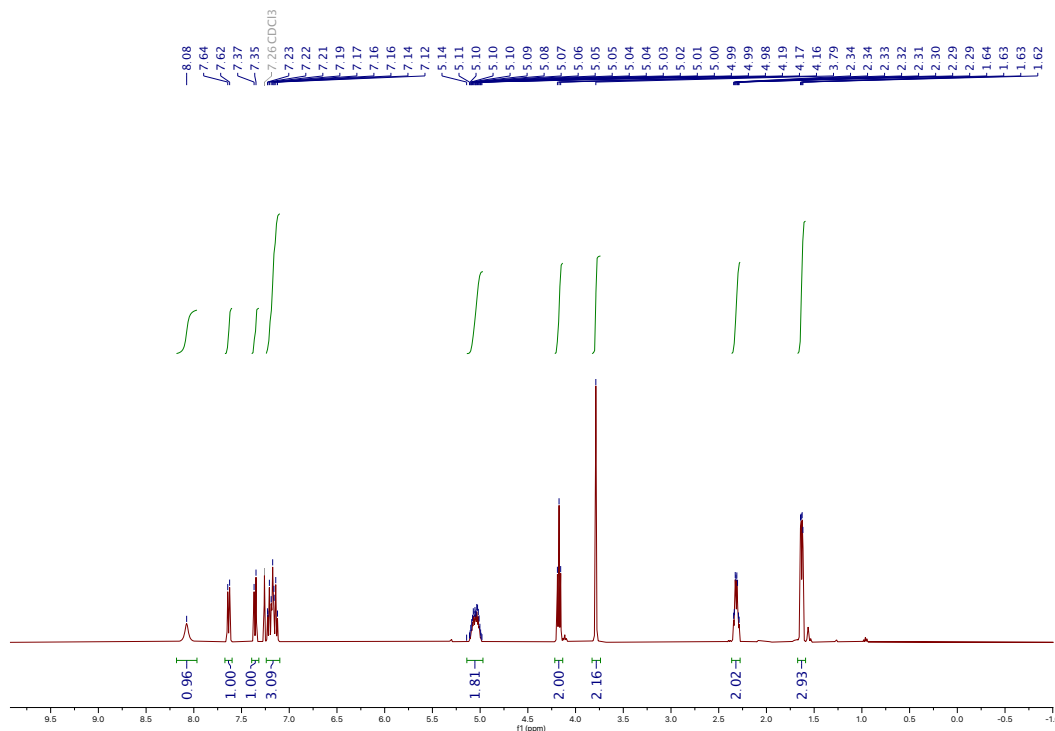
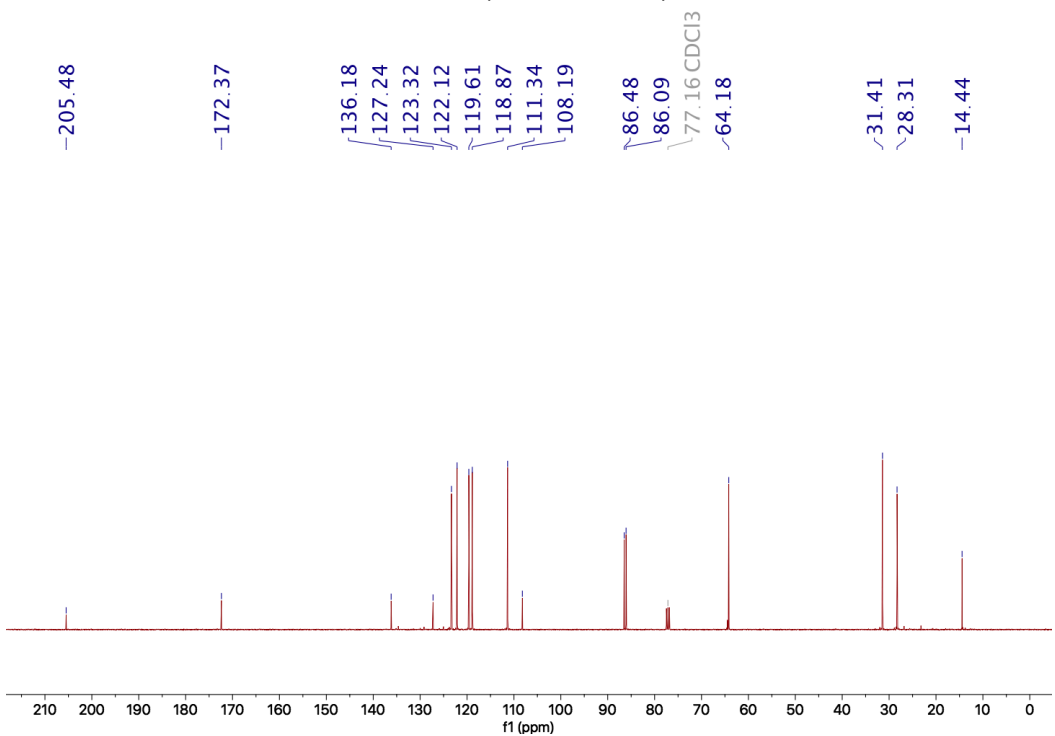


**<sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>)**

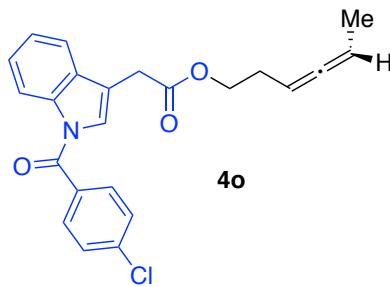


**<sup>13</sup>C NMR (151 MHz, CDCl<sub>3</sub>)**

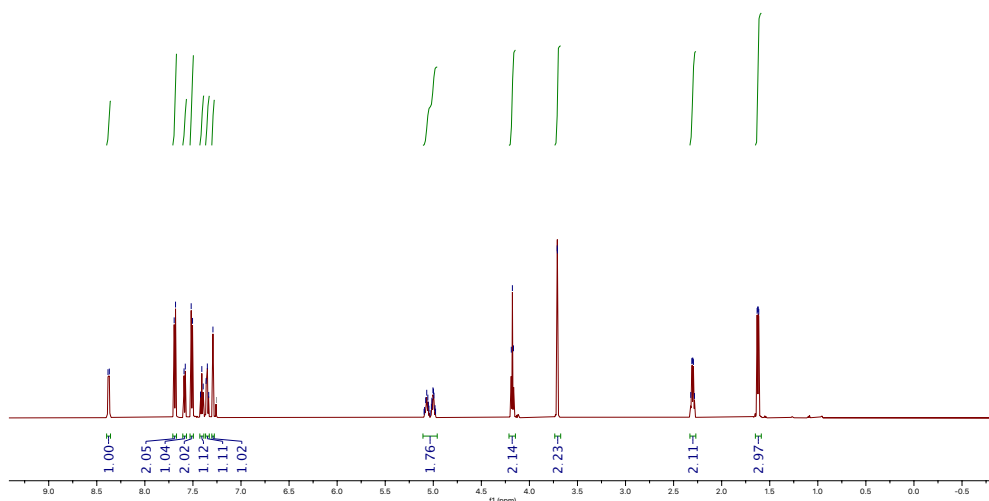


**4n****<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)****<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>)**

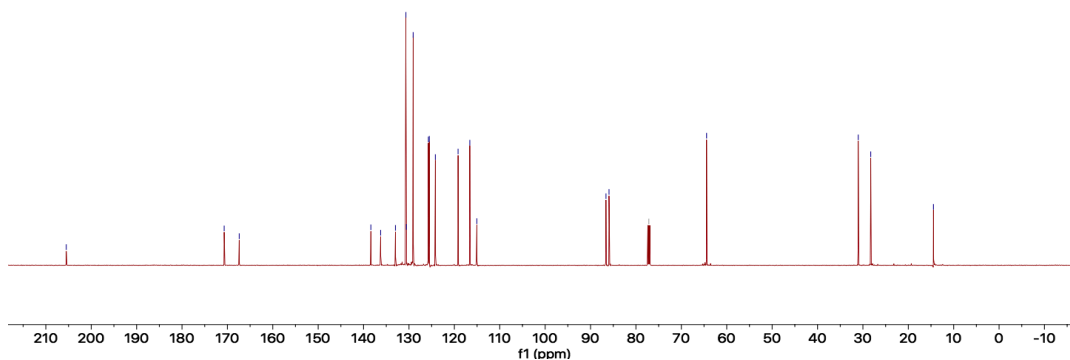
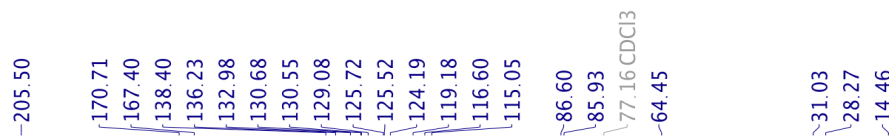


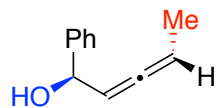
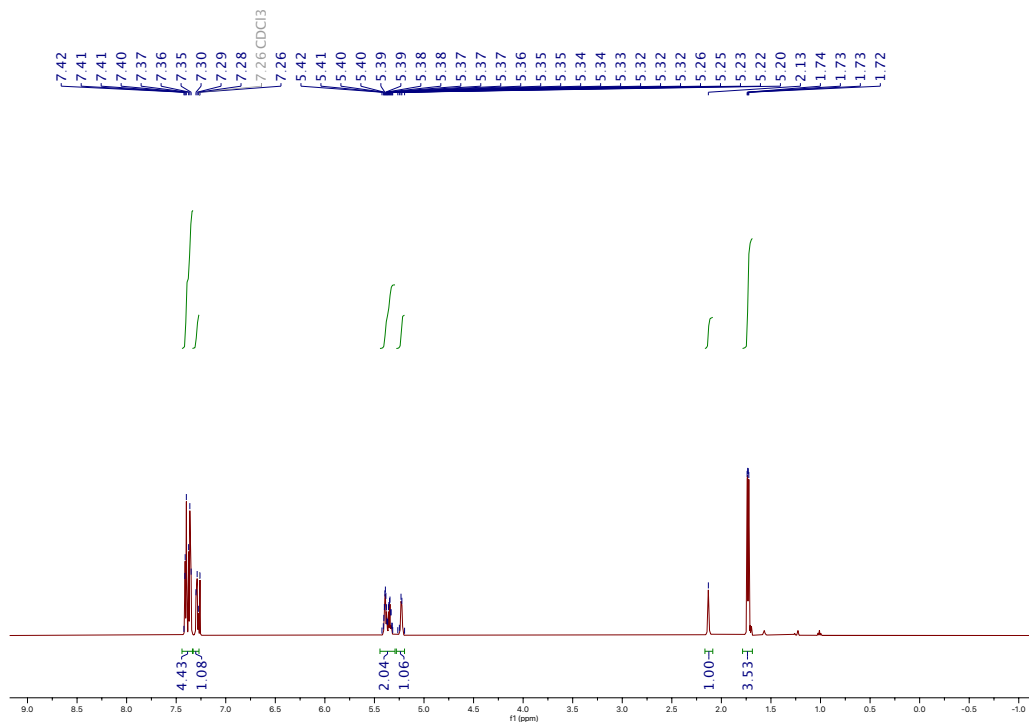
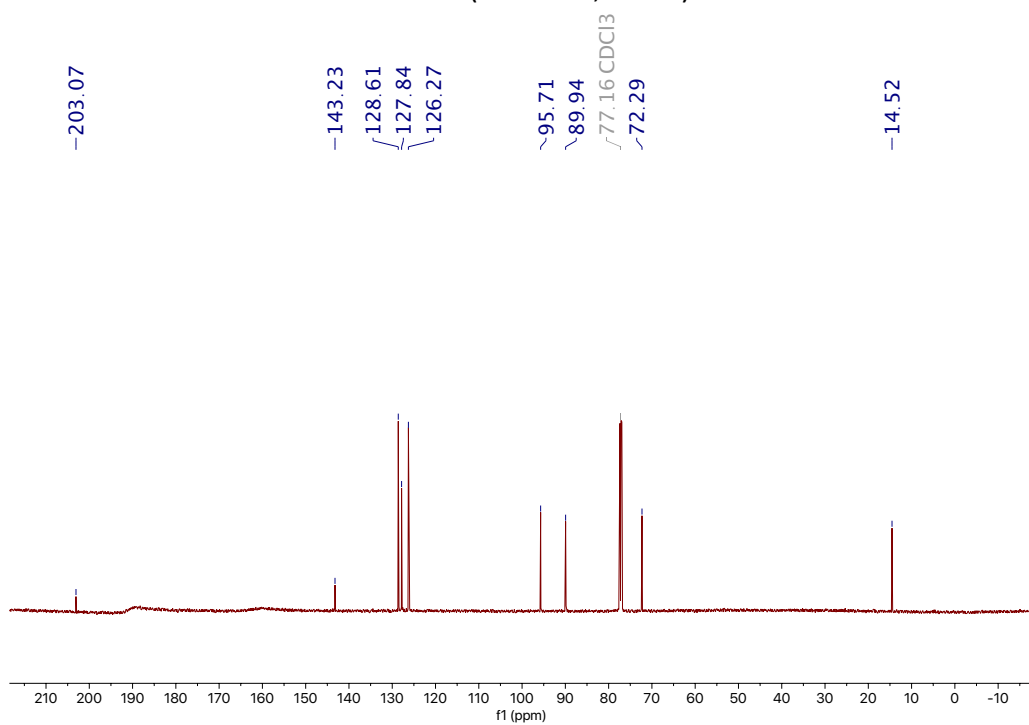


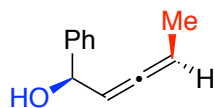
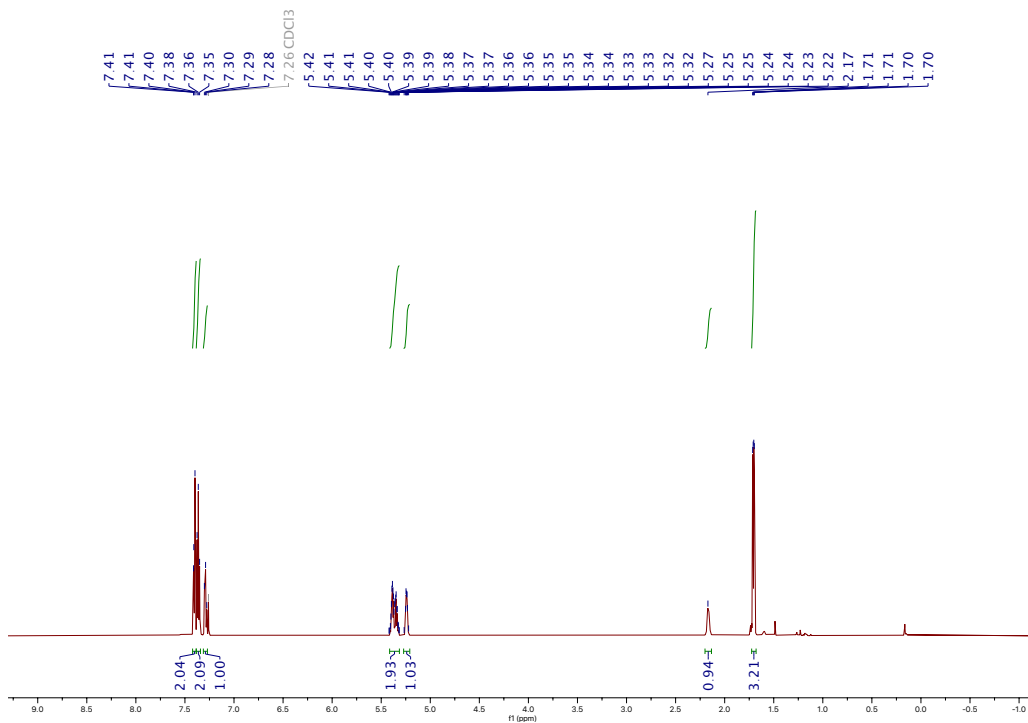
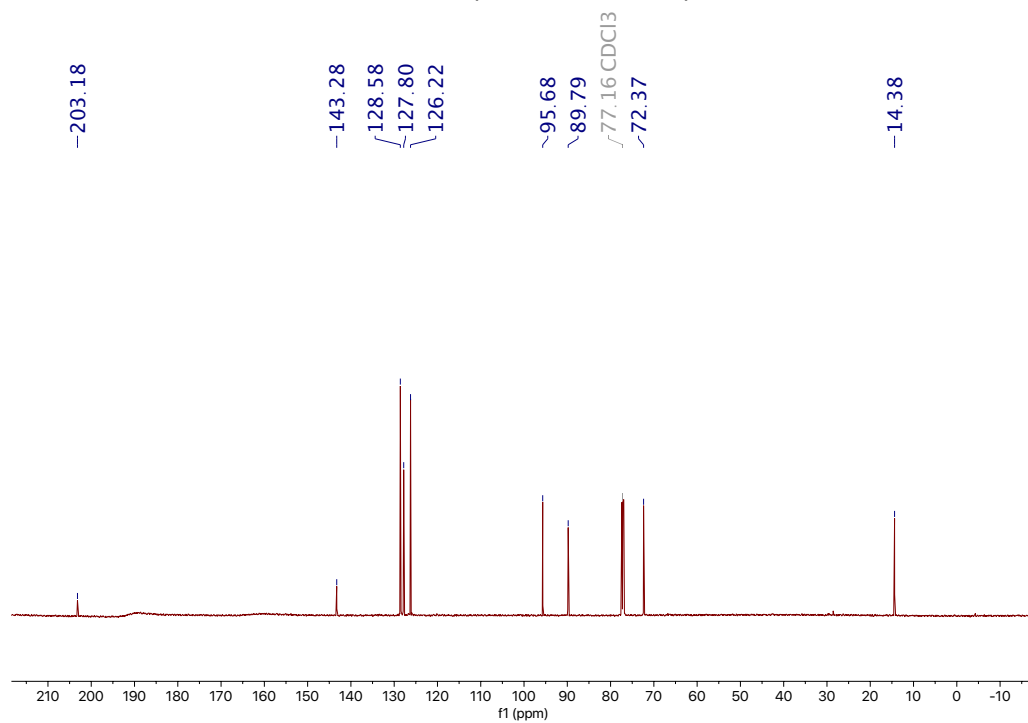
**<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>)

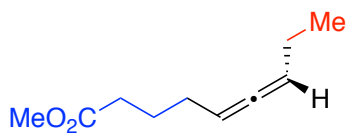


**<sup>13</sup>C NMR** (151 MHz, CDCl<sub>3</sub>)

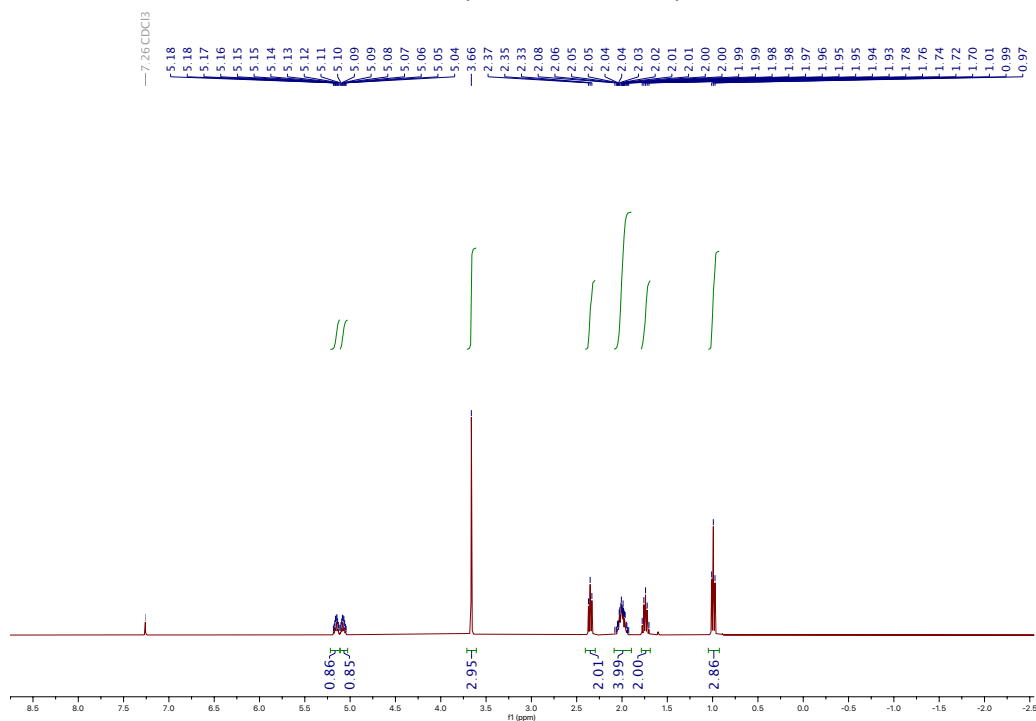
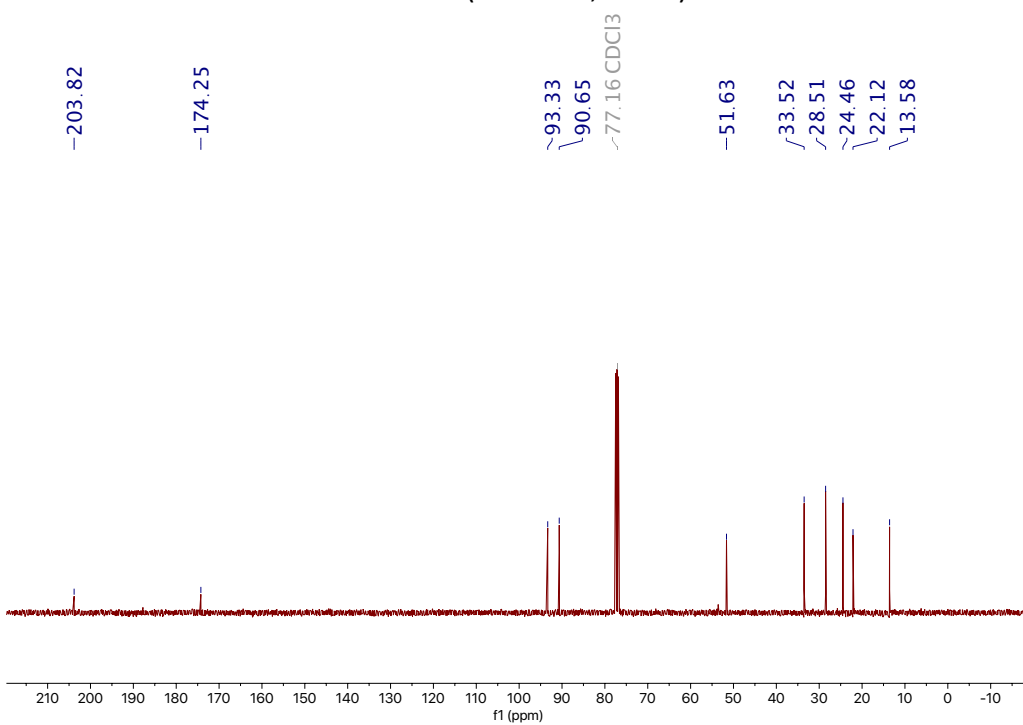


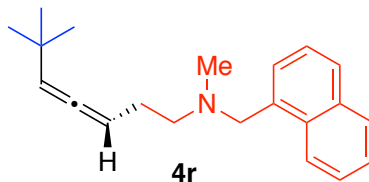
**(R,R)-4p****<sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>)****<sup>13</sup>C NMR (151 MHz, CDCl<sub>3</sub>)**

**(R,S)-4p****<sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>)****<sup>13</sup>C NMR (151 MHz, CDCl<sub>3</sub>)**

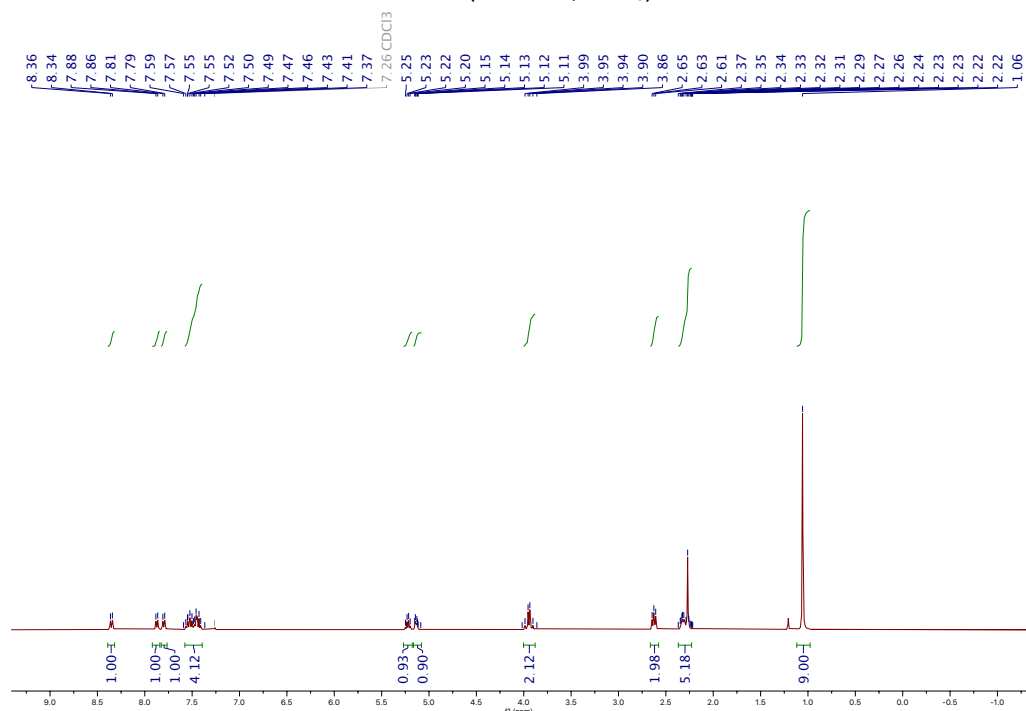


4q

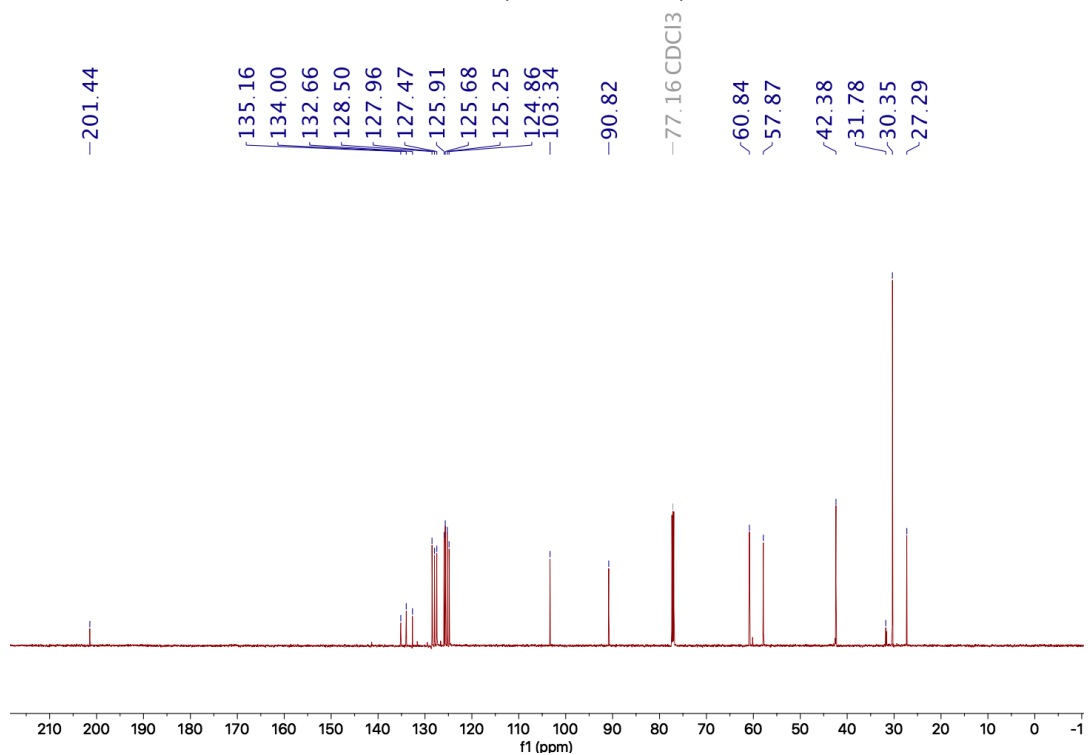
 $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ ) $^{13}\text{C NMR}$  (101 MHz,  $\text{CDCl}_3$ )

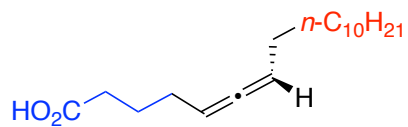


$^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )

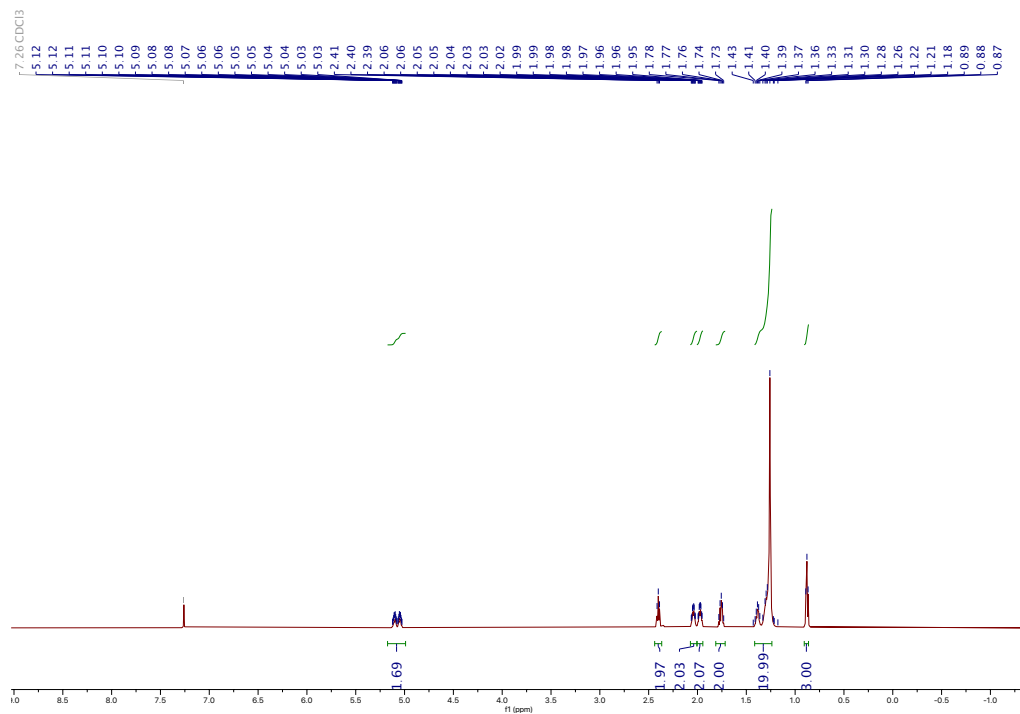


$^{13}\text{C NMR}$  (151 MHz,  $\text{CDCl}_3$ )

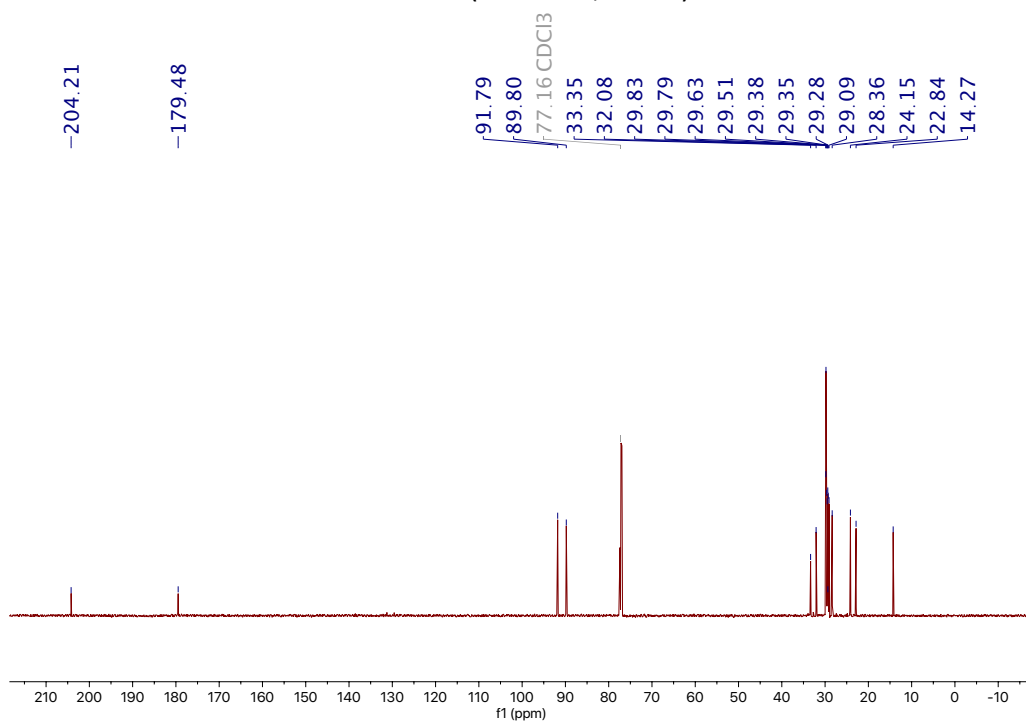


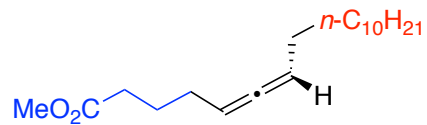


Laballenic acid (4s)  
<sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>)

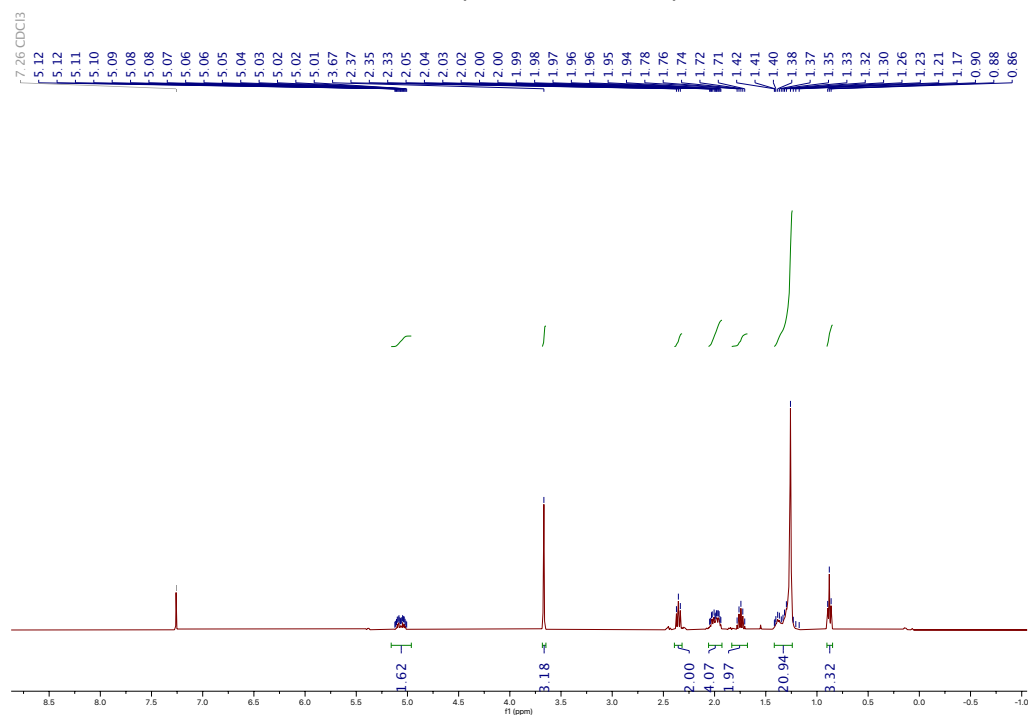


<sup>13</sup>C NMR (151 MHz, CDCl<sub>3</sub>)

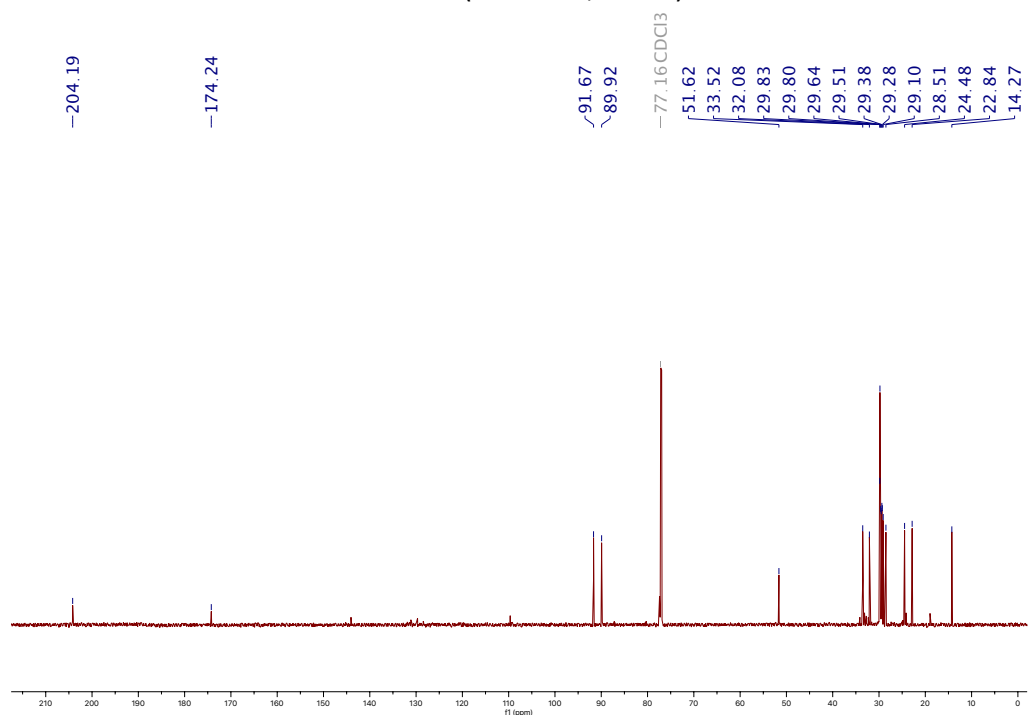


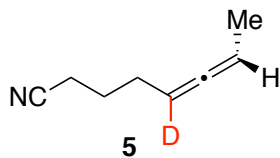


**$^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )**



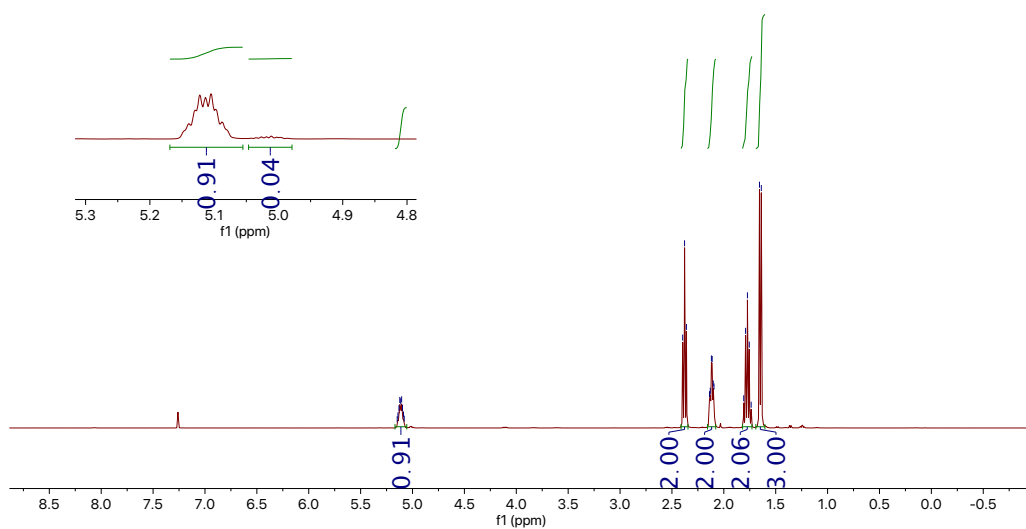
**$^{13}\text{C}$  NMR (151 MHz,  $\text{CDCl}_3$ )**





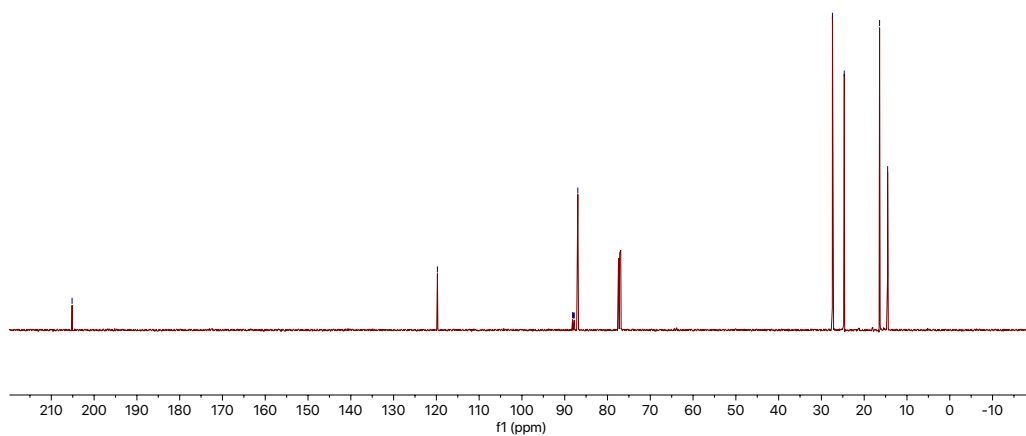
**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**

5.15  
5.14  
5.13  
5.12  
5.11  
5.10  
5.10  
5.09  
5.08  
2.40  
2.38  
2.36  
2.14  
2.13  
2.12  
2.11  
2.10  
2.09  
1.81  
1.79  
1.77  
1.75  
1.74  
1.66  
1.64



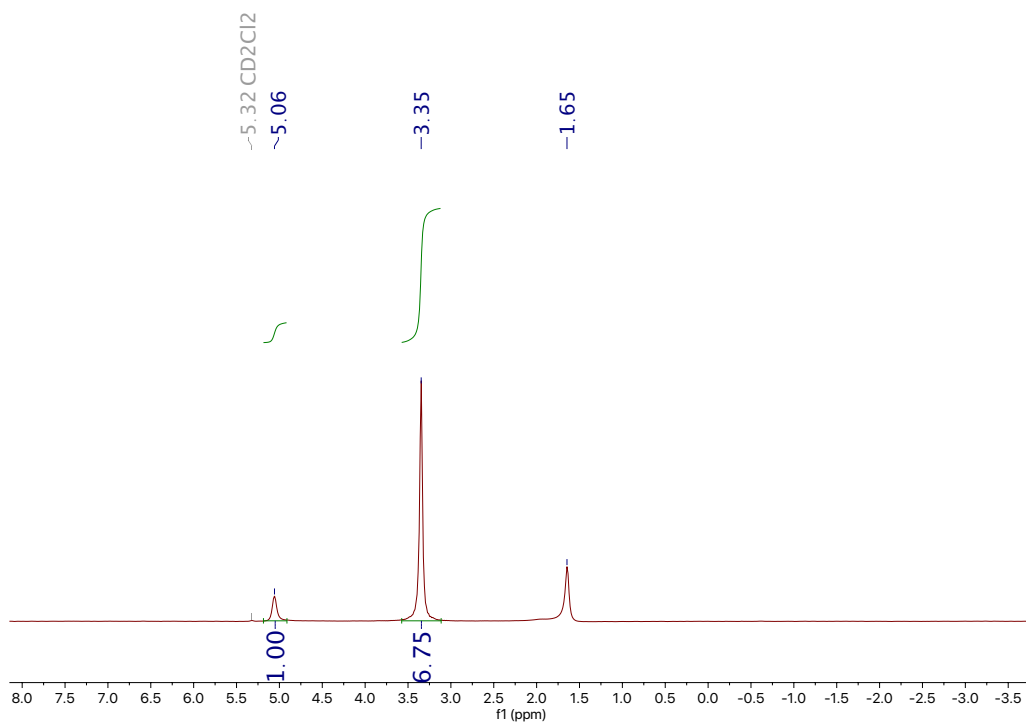
**<sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>)**

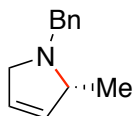
-205.1507  
-119.7539  
88.1641  
87.9658  
87.7684  
86.9317  
27.4214  
24.6613  
16.4041  
14.5158



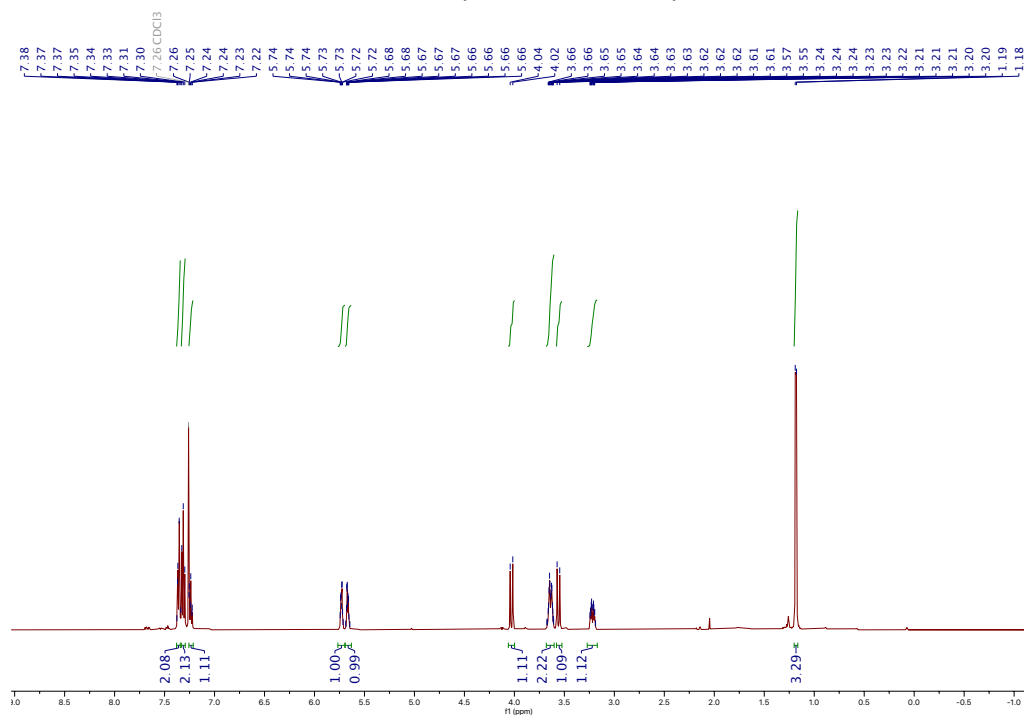
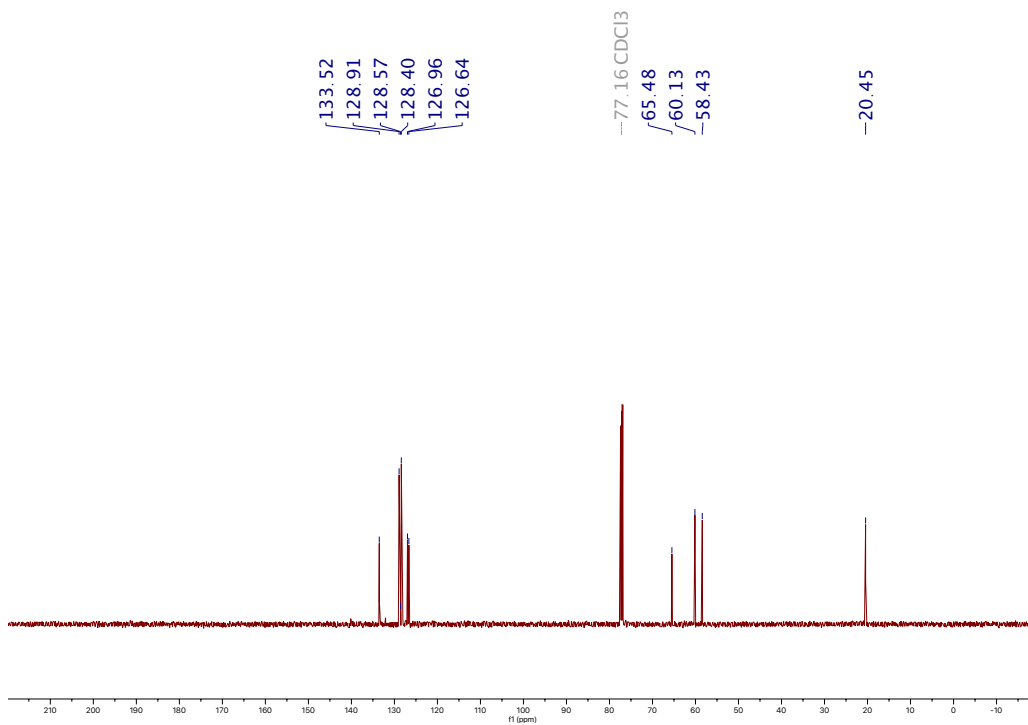


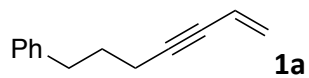
$^2\text{H}$  NMR (77 MHz,  $\text{CH}_2\text{Cl}_2$ ): 0.18 mmol **5** with 0.4 mmol methanol- $d_4$



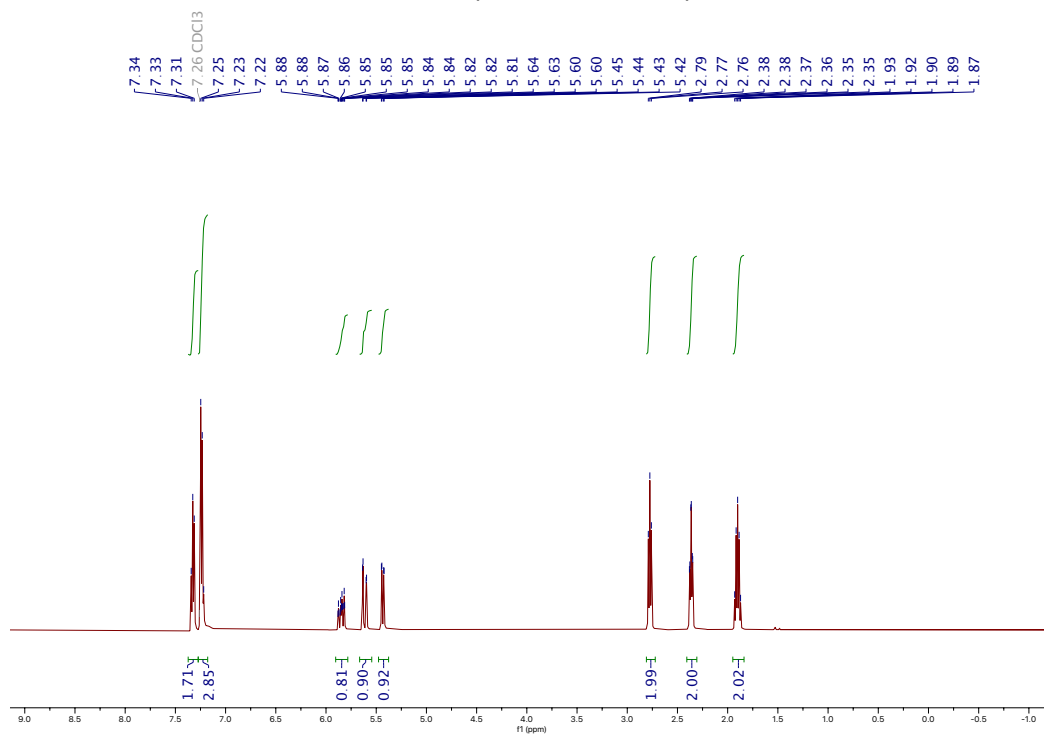


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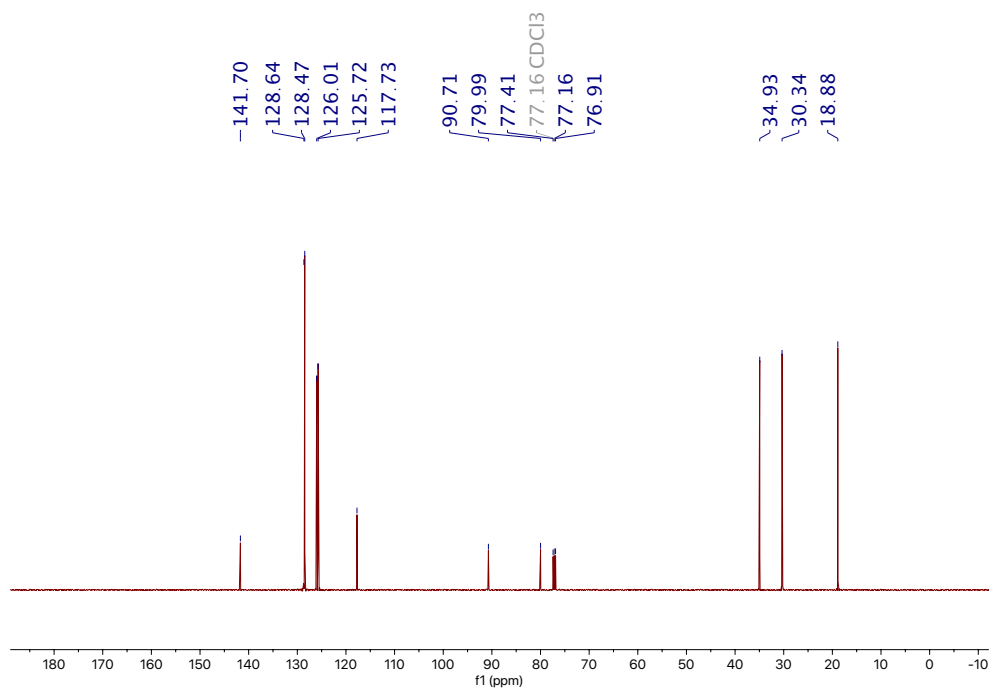
 $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )

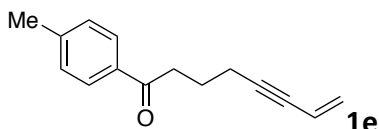


**$^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )**

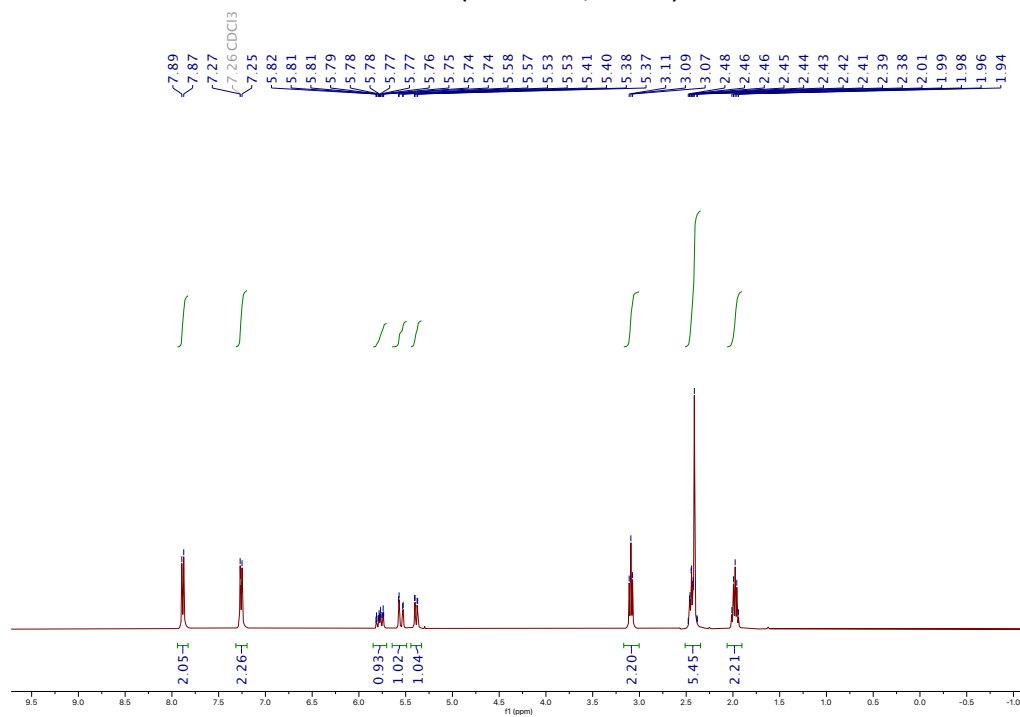


**$^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )**

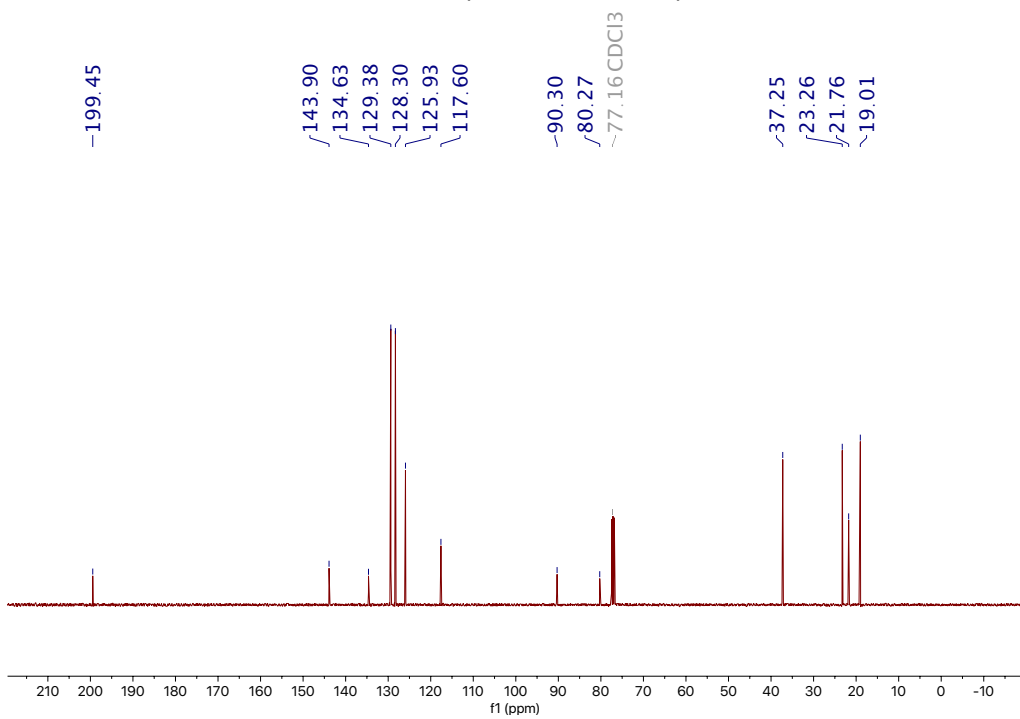


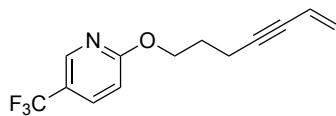


**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**

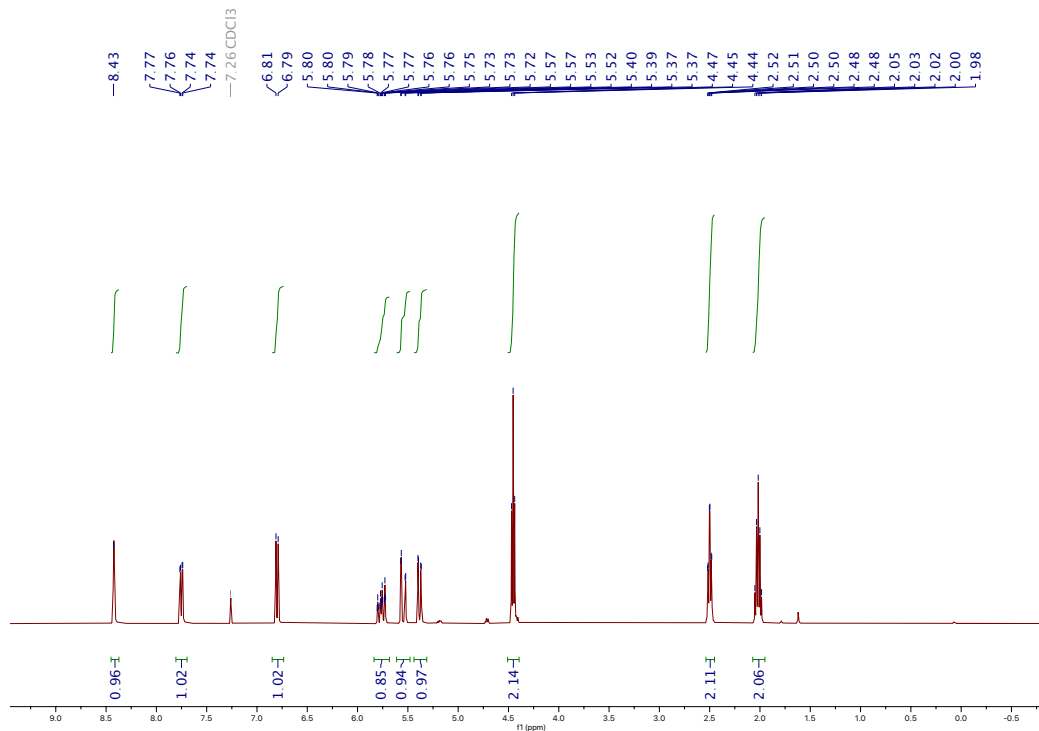


**<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>)**

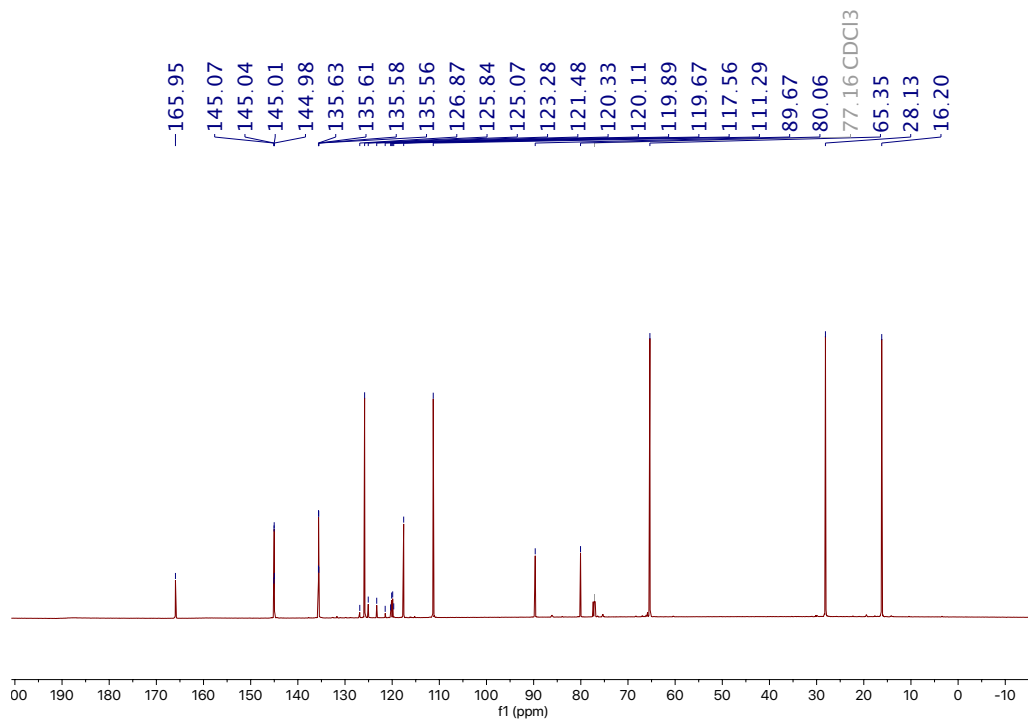


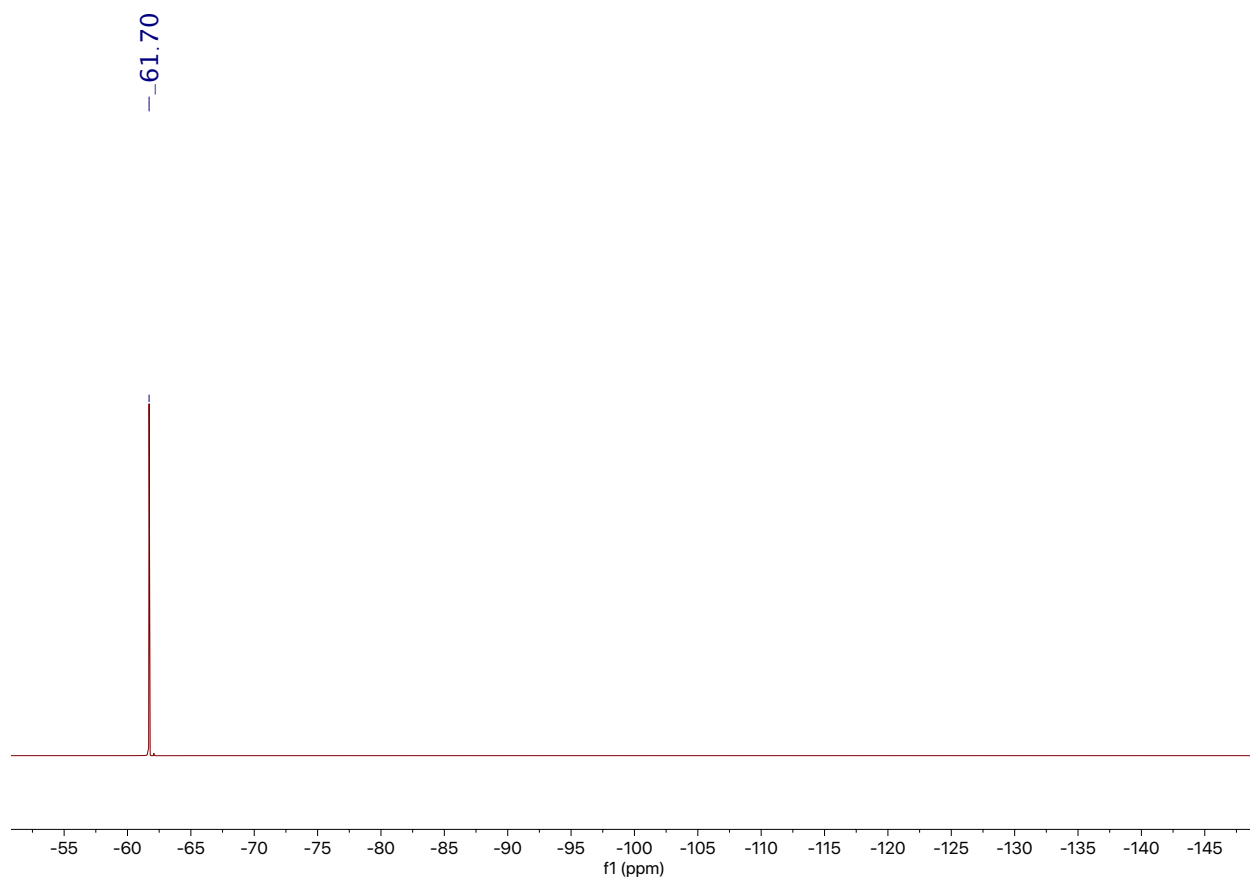


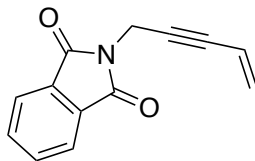
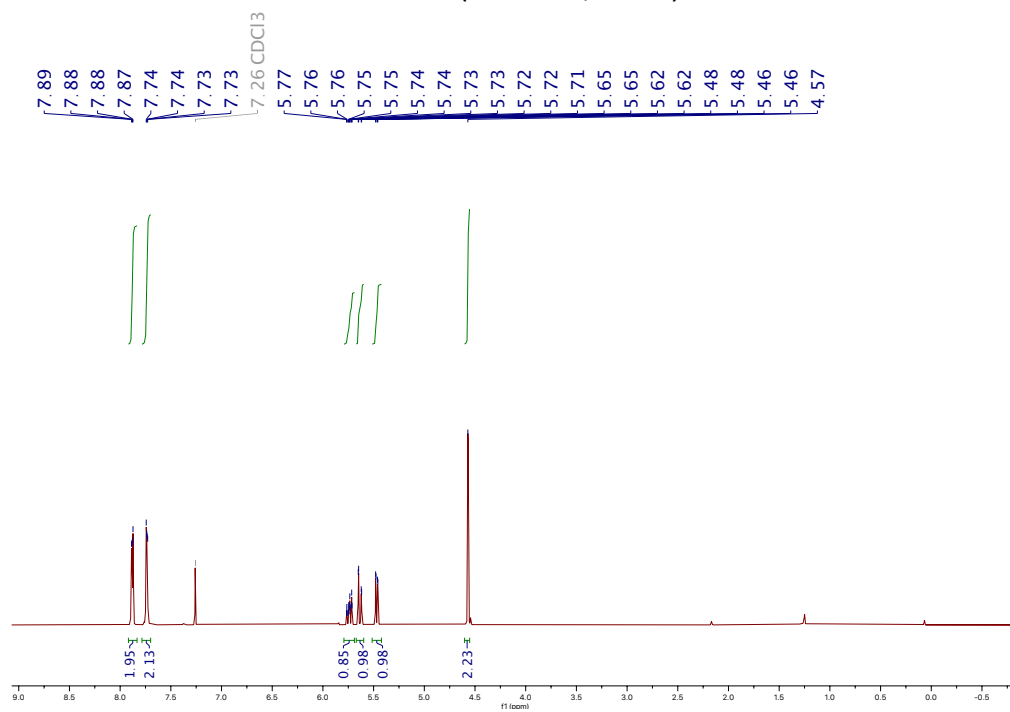
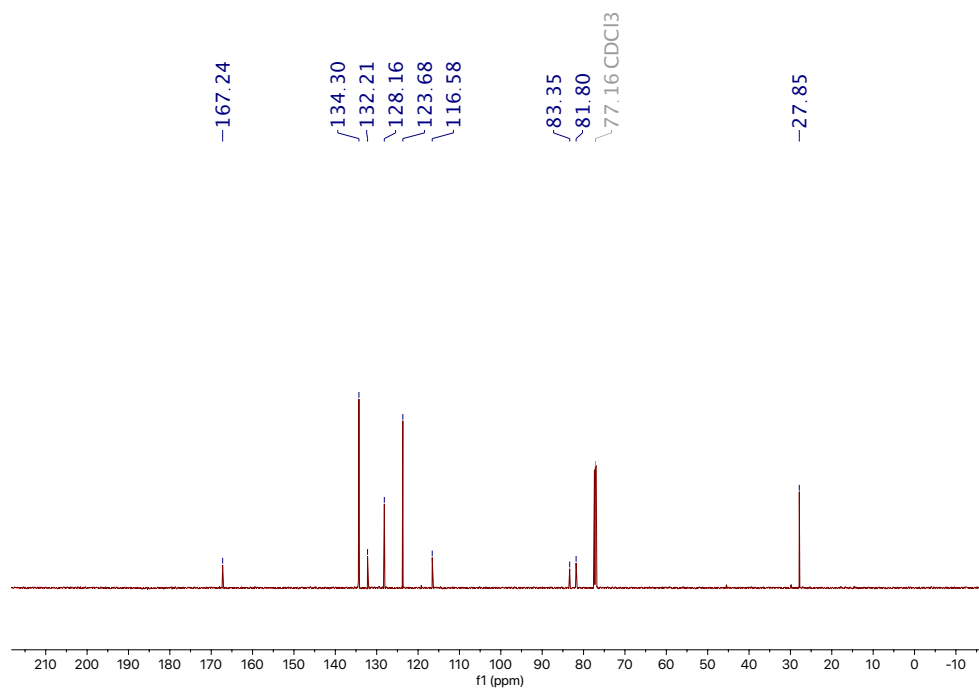
**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**

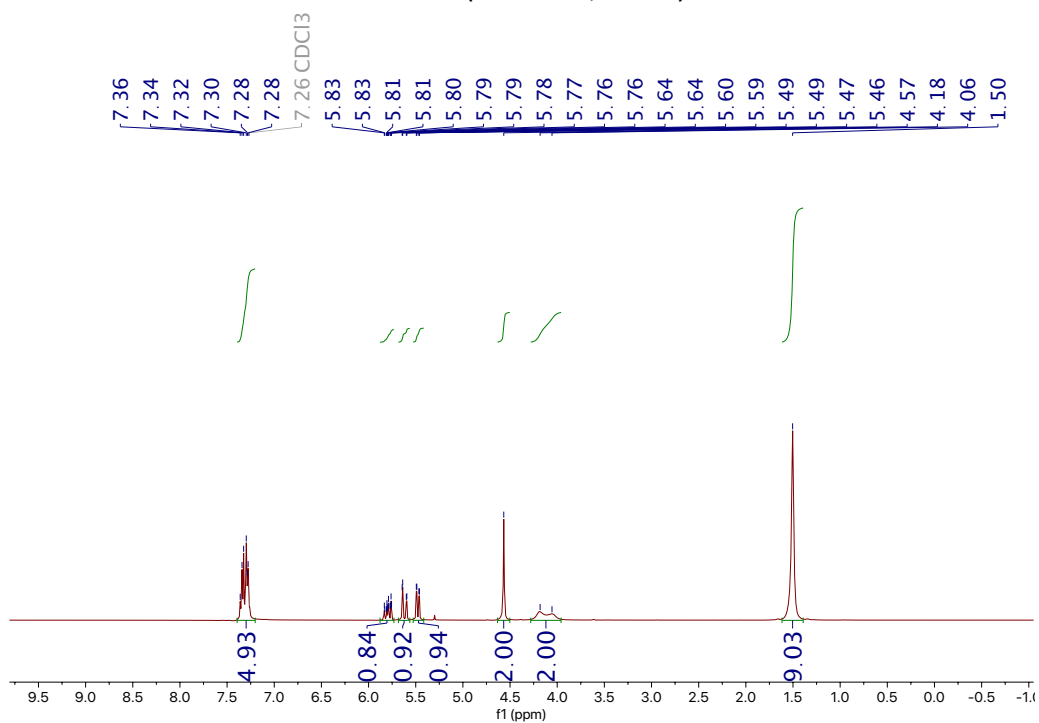
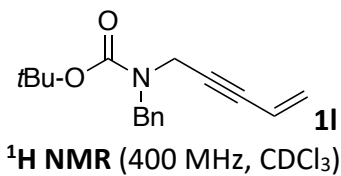


**<sup>13</sup>C NMR (151 MHz, CDCl<sub>3</sub>)**

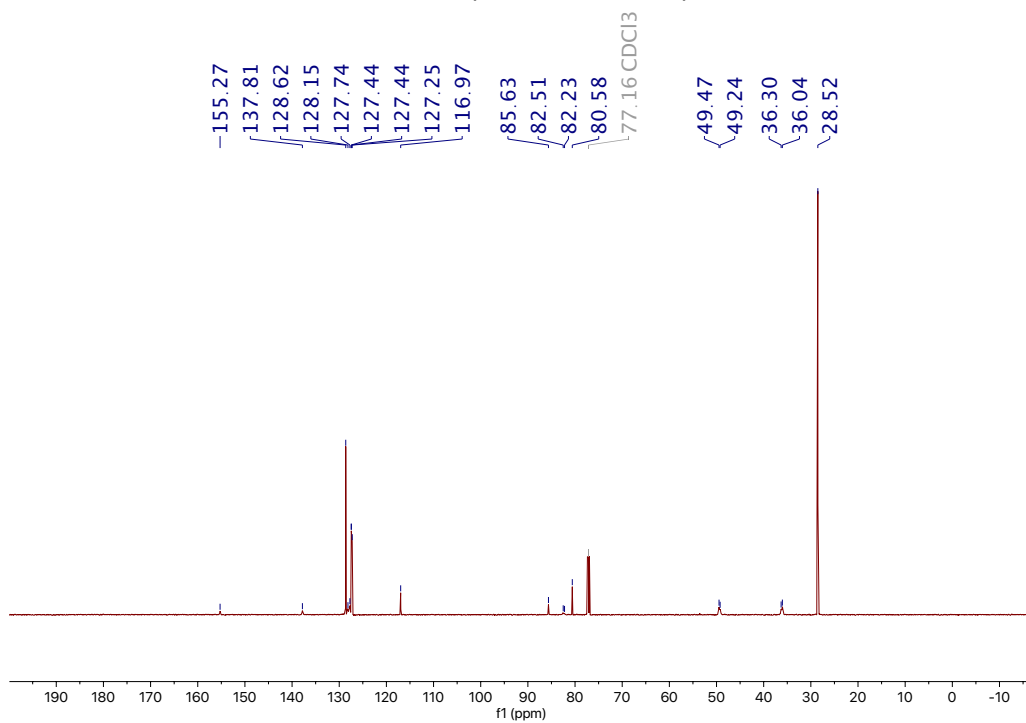


**$^{19}\text{F}$  NMR (565 MHz,  $\text{CDCl}_3$ )**

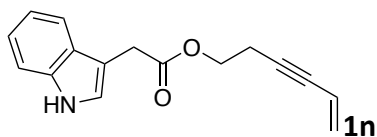
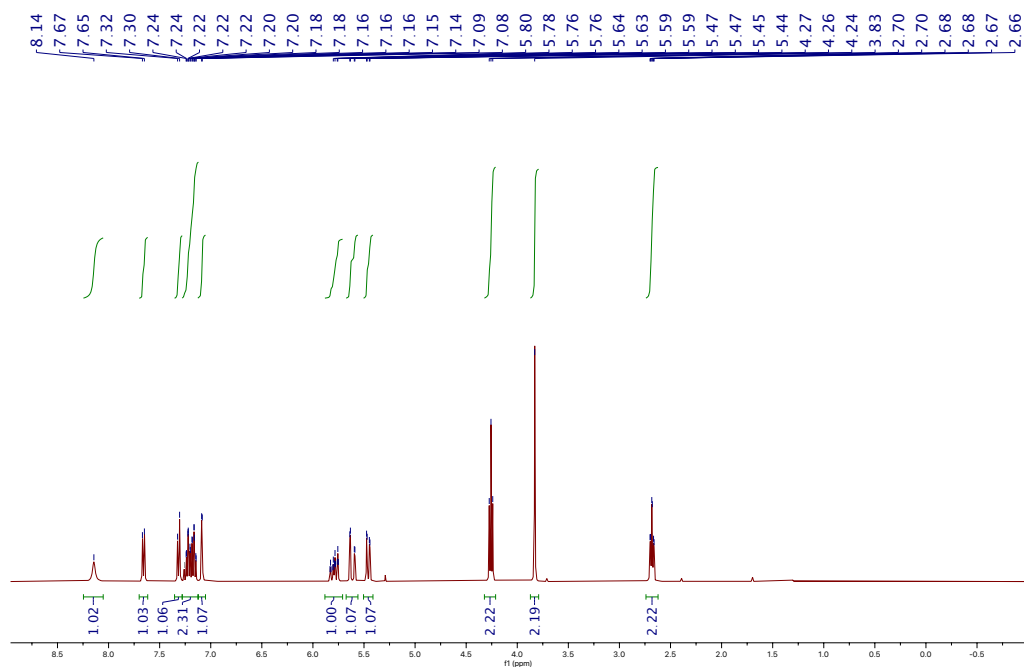
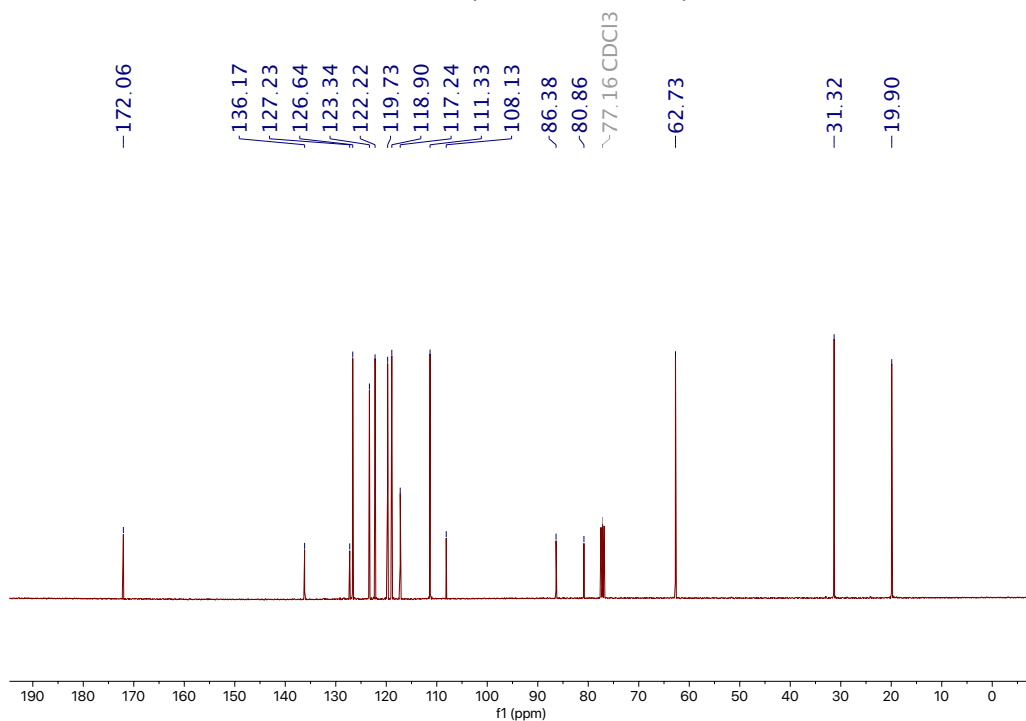
**1k****<sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>)****<sup>13</sup>C NMR (151 MHz, CDCl<sub>3</sub>)**

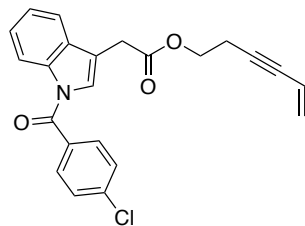


**<sup>13</sup>C NMR (151 MHz, CDCl<sub>3</sub>)**

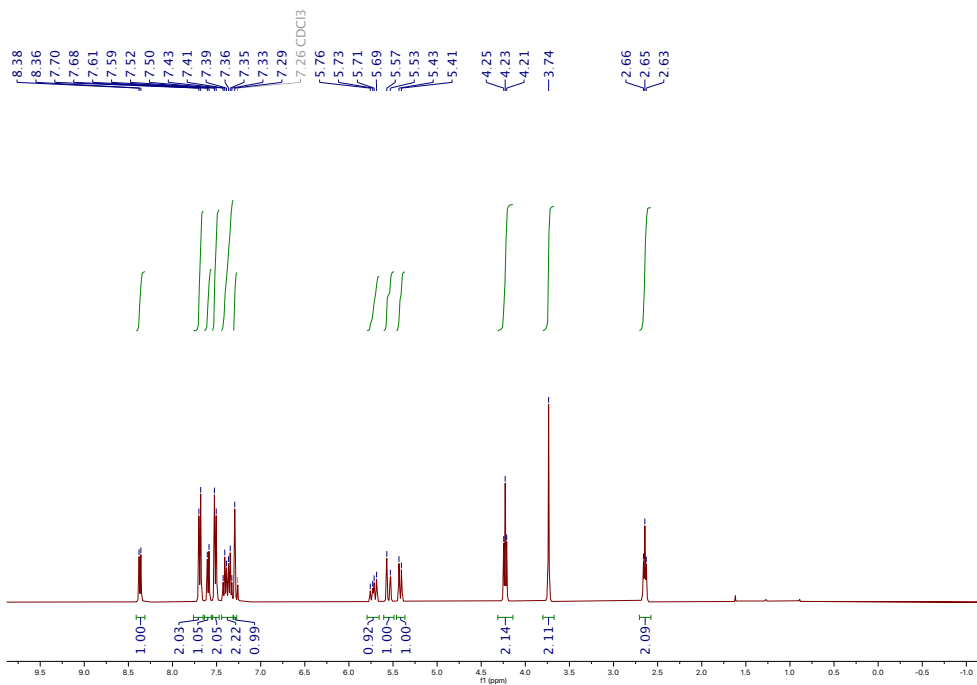




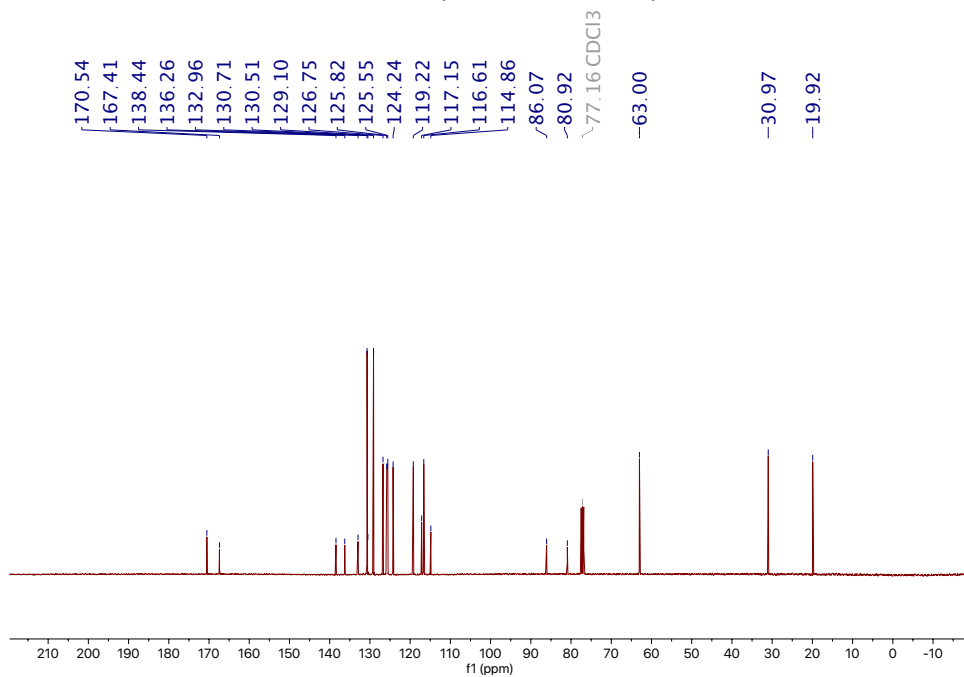
**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)****<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>)**

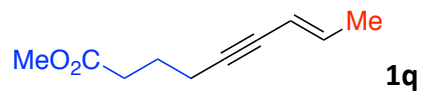


**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)**

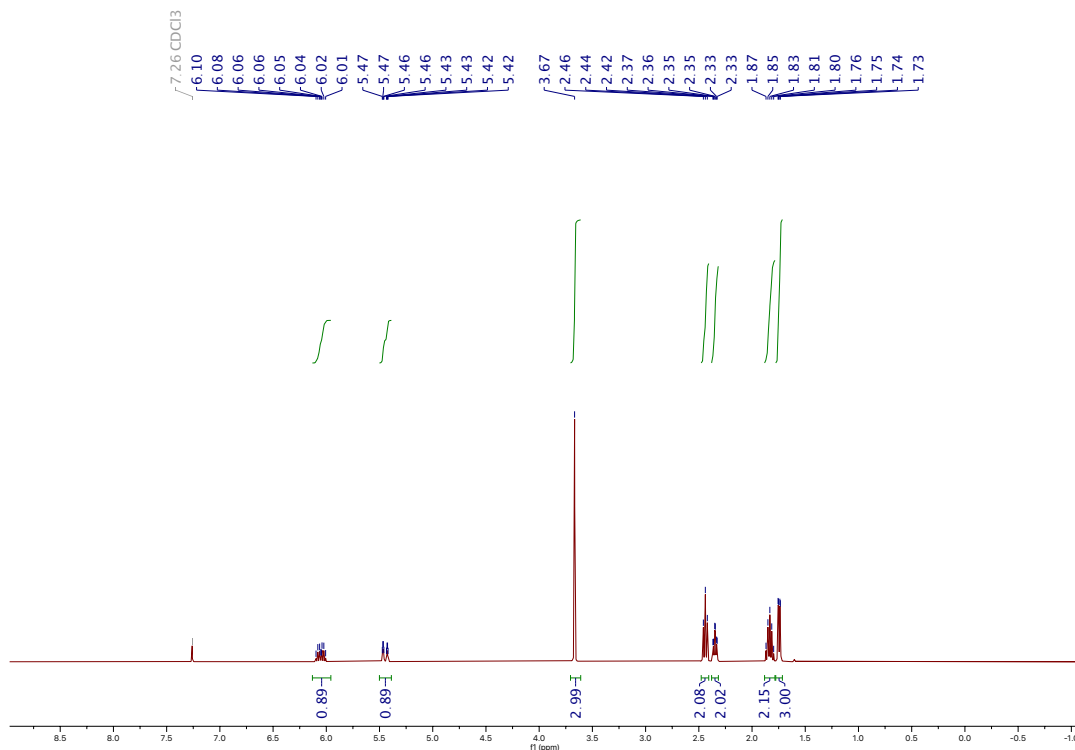


**<sup>13</sup>C NMR (101 MHz, CDCl<sub>3</sub>)**

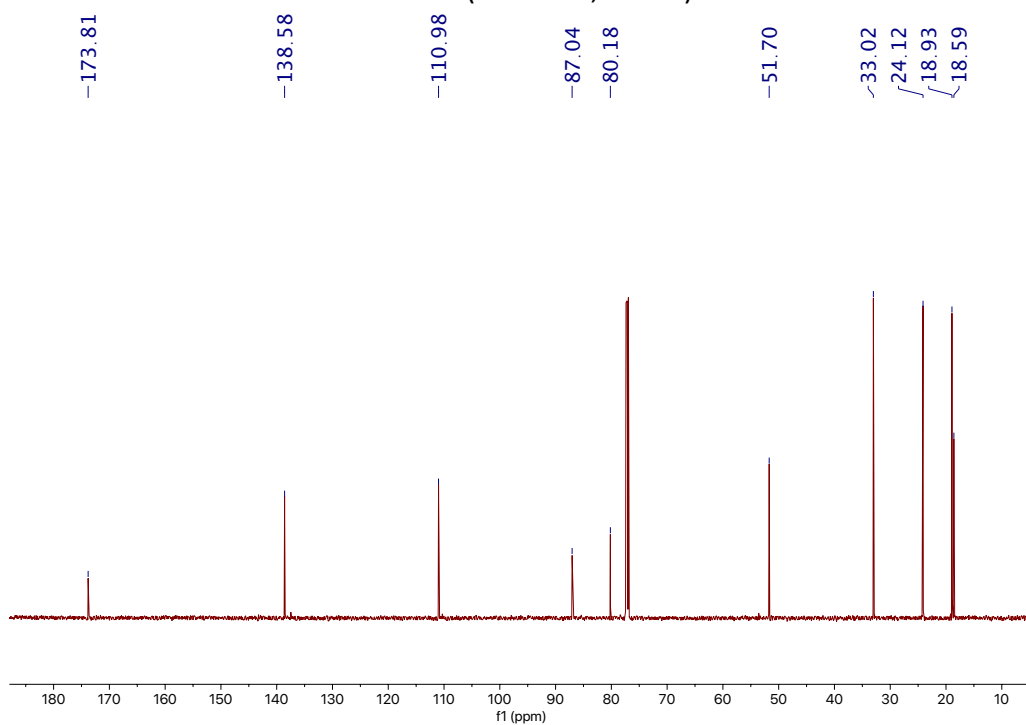


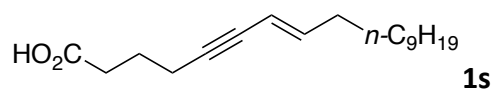


<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)



<sup>13</sup>C NMR (151 MHz, CDCl<sub>3</sub>)





<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)

