

## **APPENDIX 1**

*Spectra Relevant to Chapter 1:*

*Enantioselective Construction of  $\alpha$ -Quaternary Cyclobutanones by*

*Catalytic Asymmetric Allylic Alkylation*

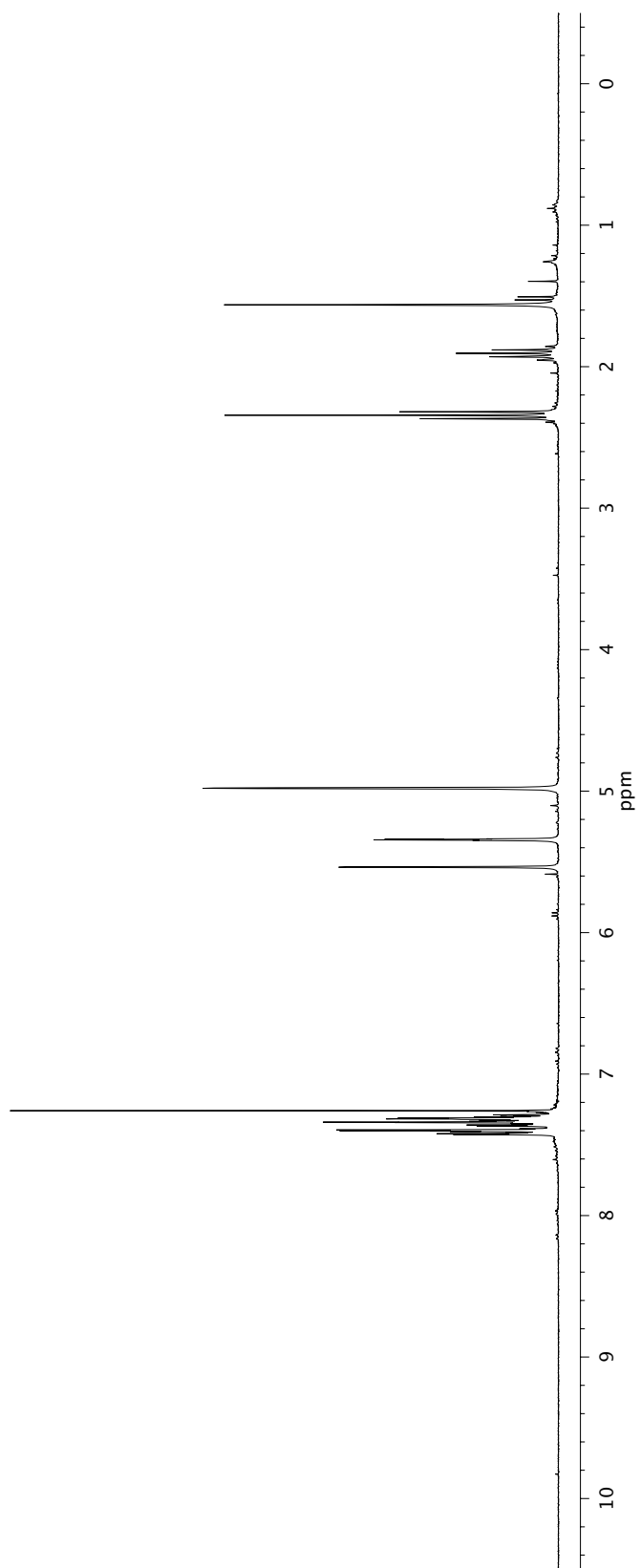
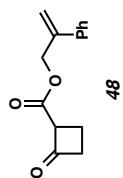


Figure A1.1  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) of compound 48.

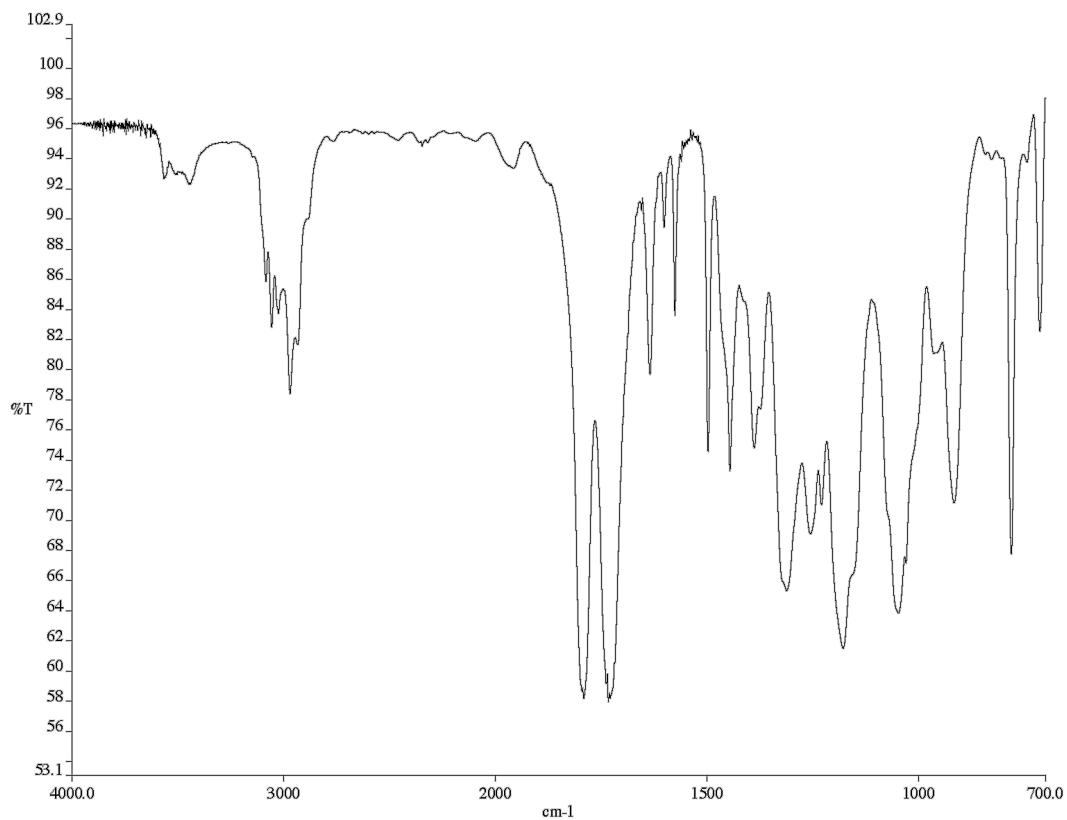


Figure A1.2 Infrared spectrum (thin film/NaCl) of compound **48**

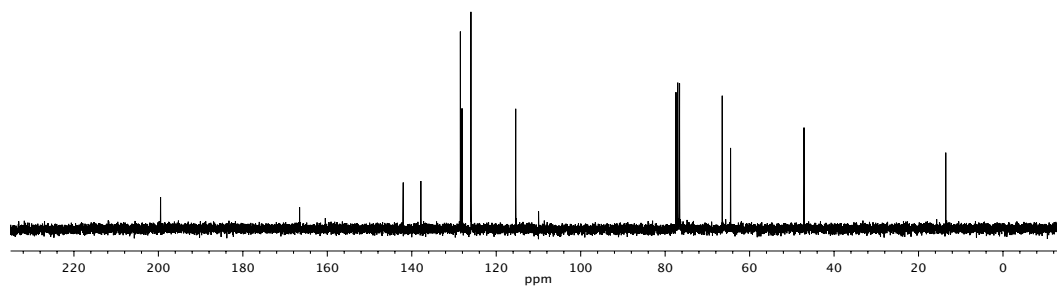


Figure A1.3 <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>) of compound **48**

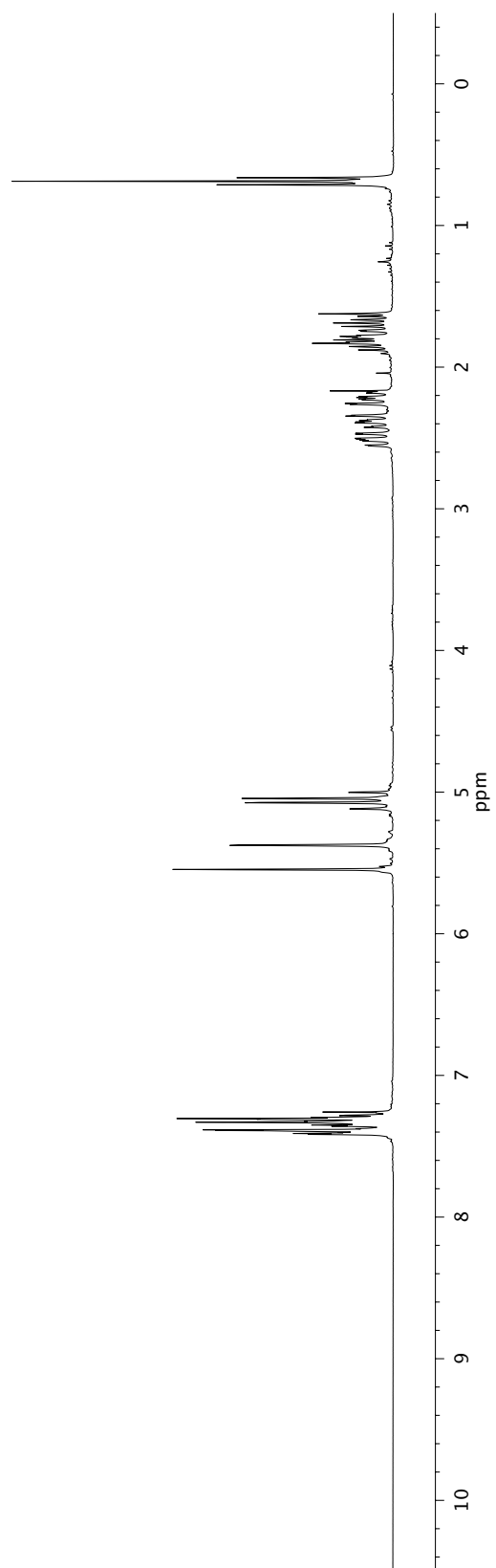
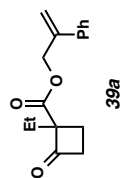


Figure A1.4 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **39a**.

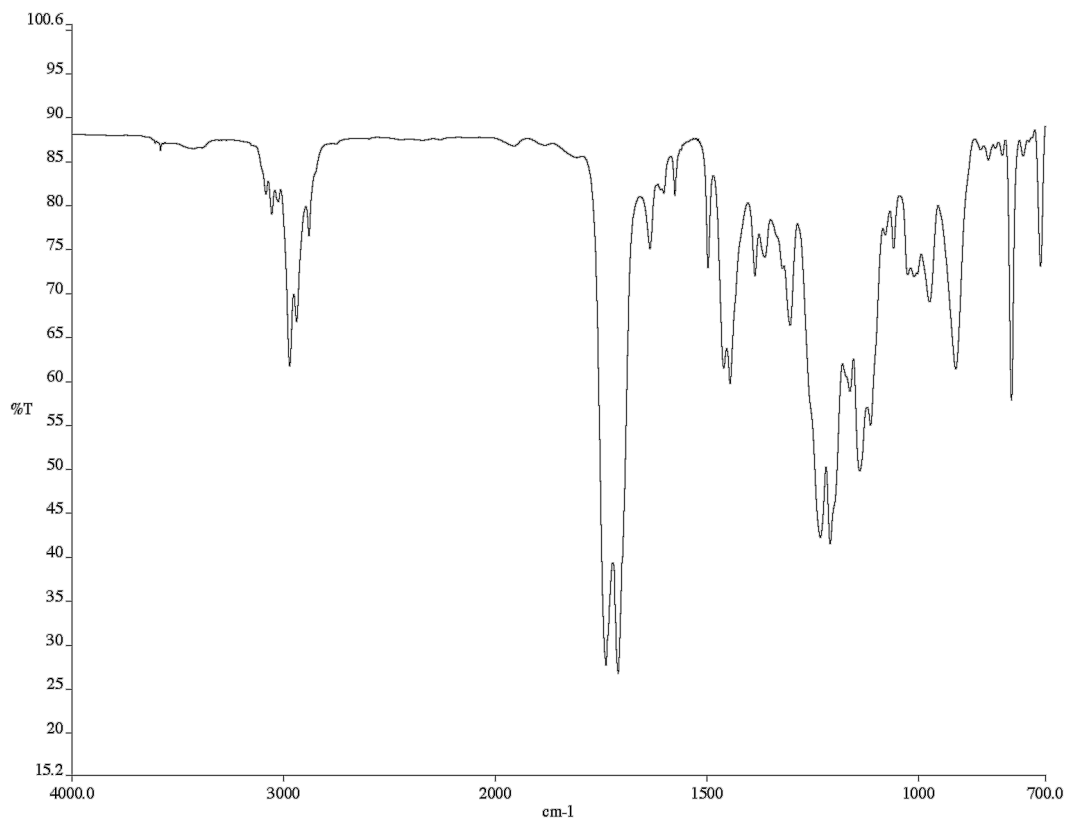


Figure A1.5 Infrared spectrum (thin film/NaCl) of compound **39a**

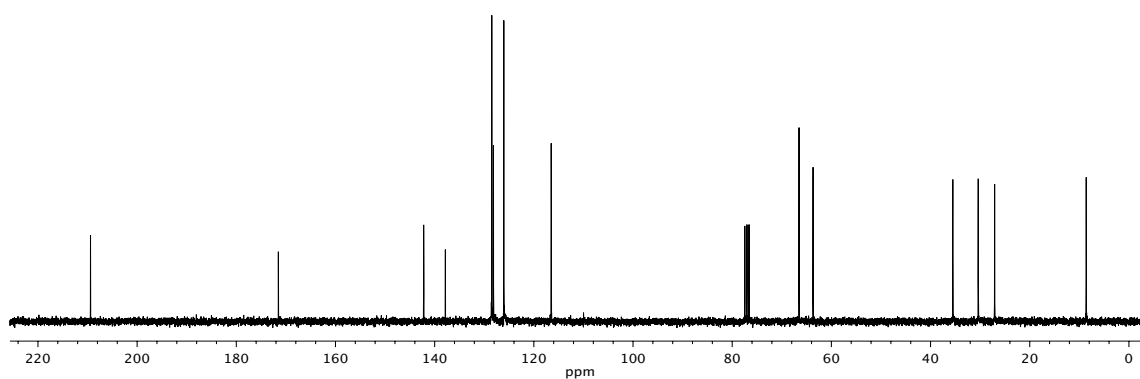


Figure A1.6 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **39a**

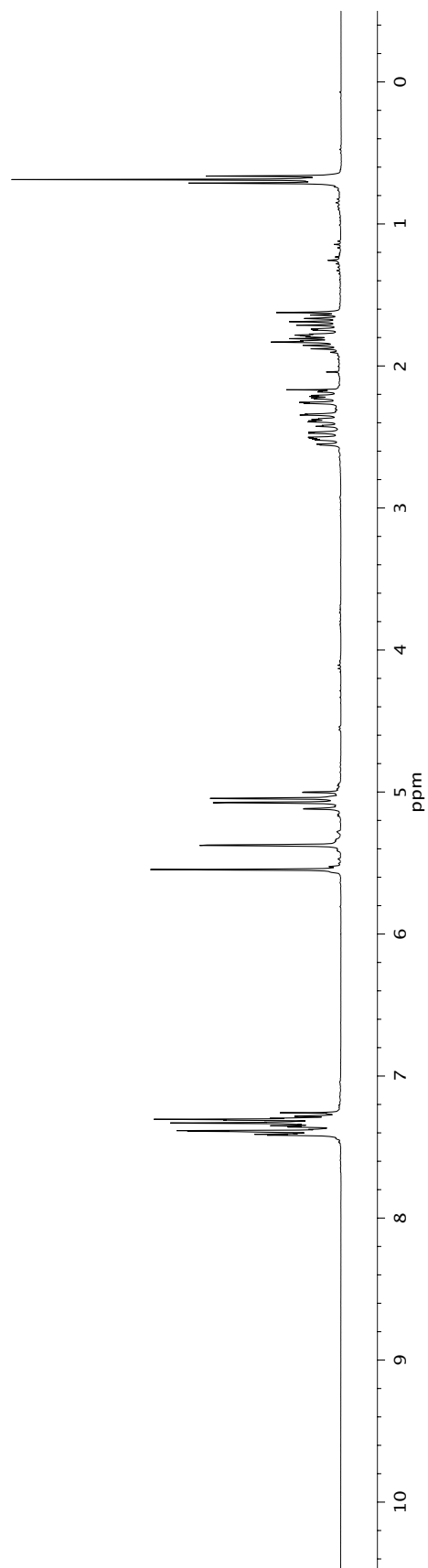
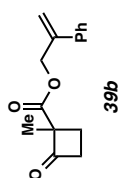


Figure A1.7 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **39b**.

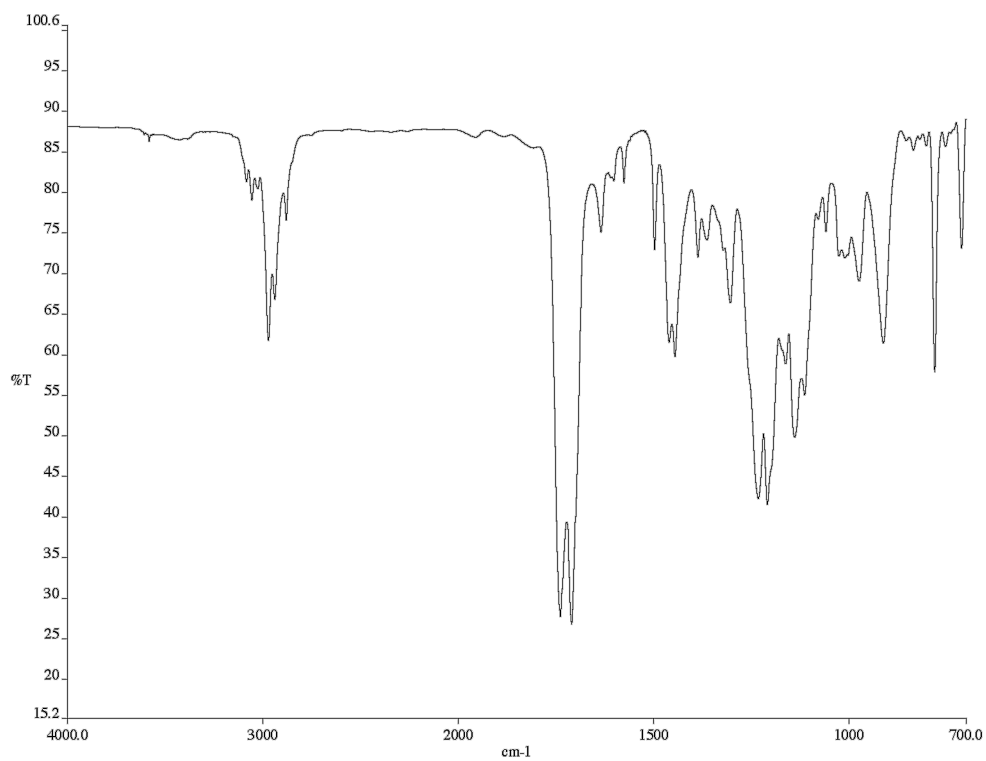


Figure A1.8 Infrared spectrum (thin film/NaCl) of compound **39b**.

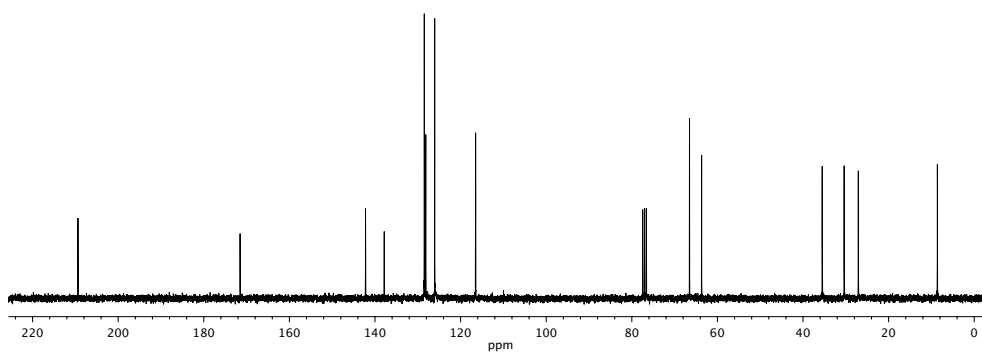


Figure A1.9 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **39b**.

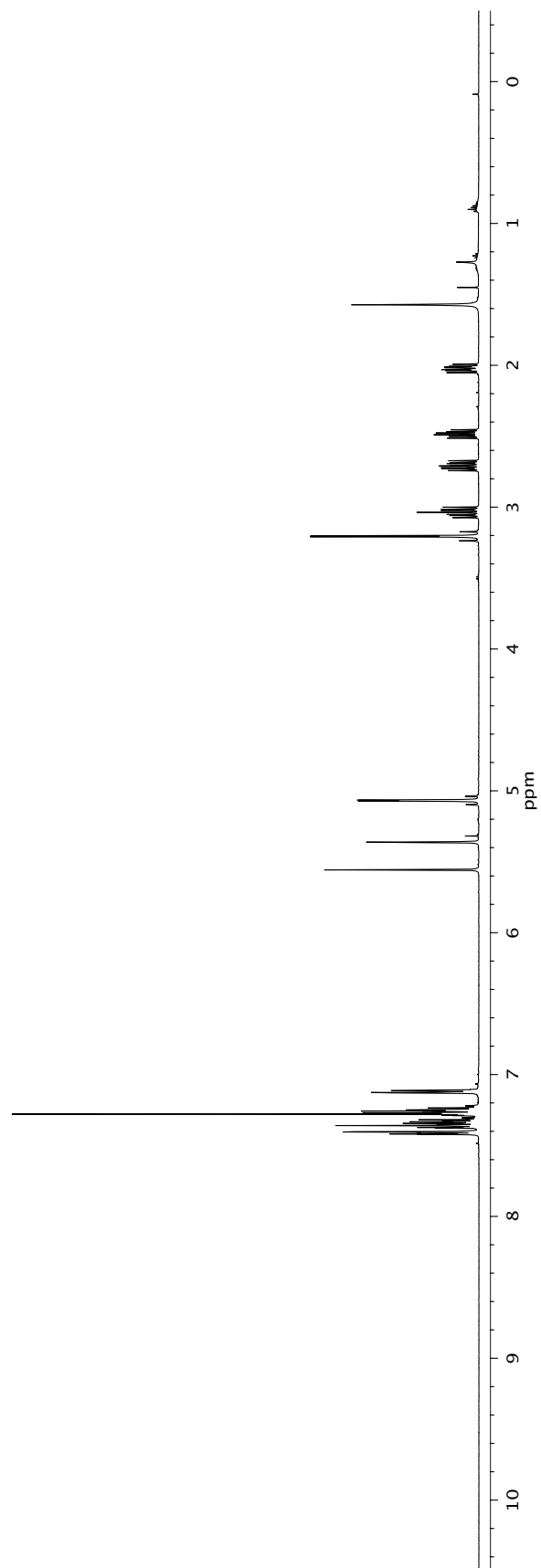
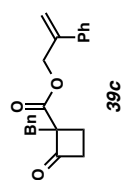


Figure A1.10 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **39c**.



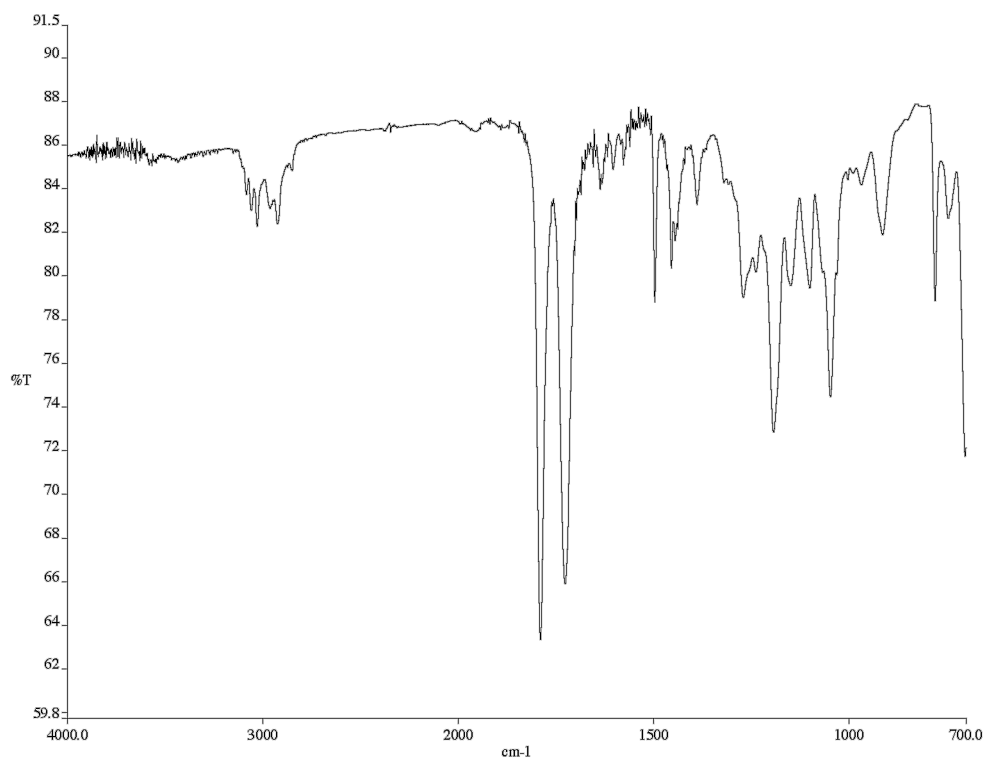


Figure A1.11 Infrared spectrum (thin film/NaCl) of compound **39c**.

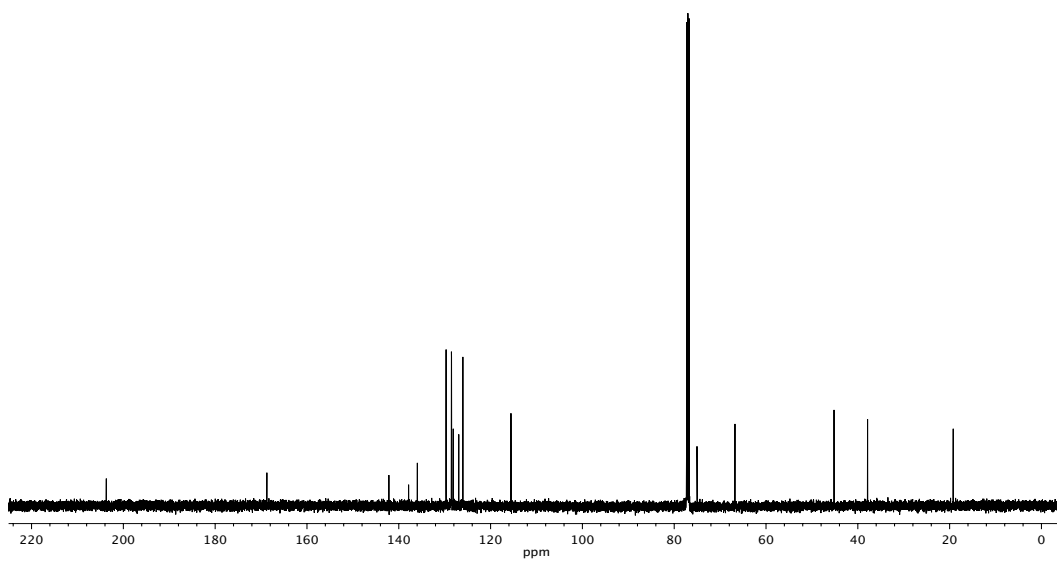


Figure A1.12 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **39c**.

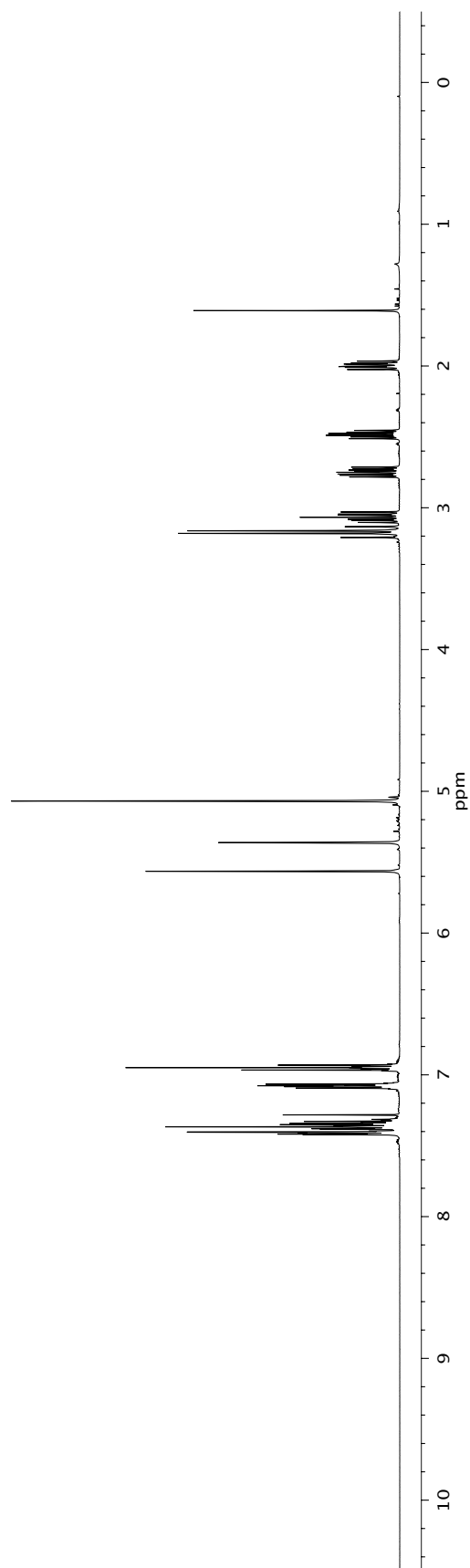
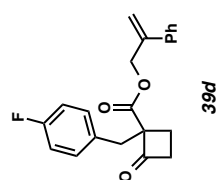


Figure A1.13 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **39d**.

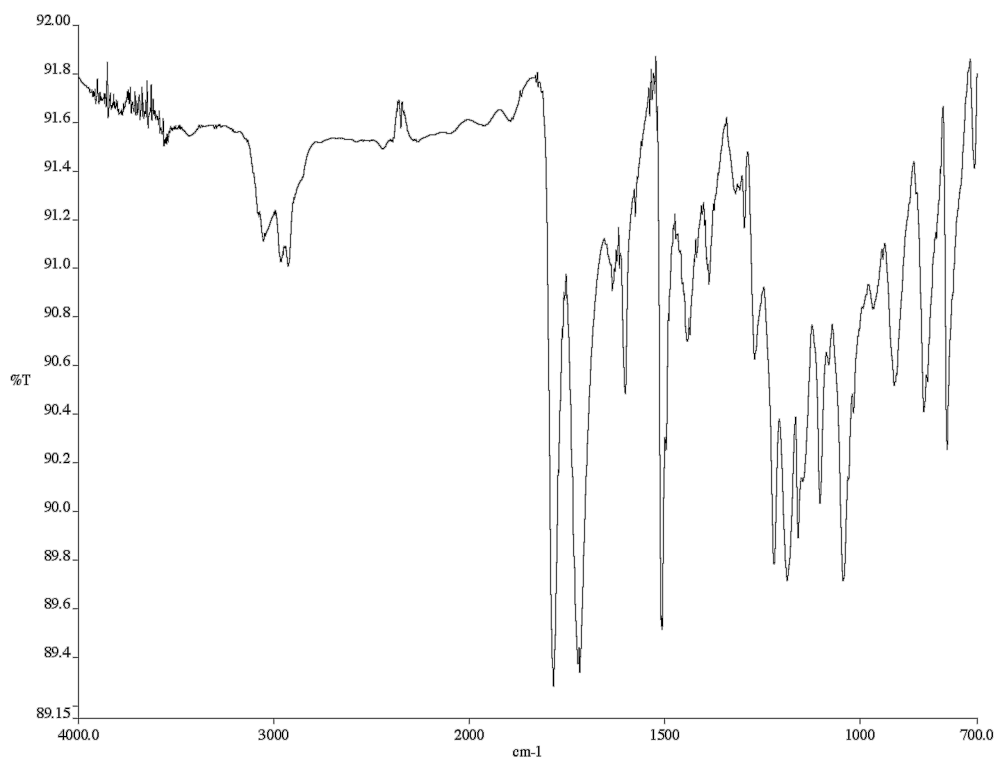


Figure A1.14 Infrared spectrum (thin film/NaCl) of compound **39d**.

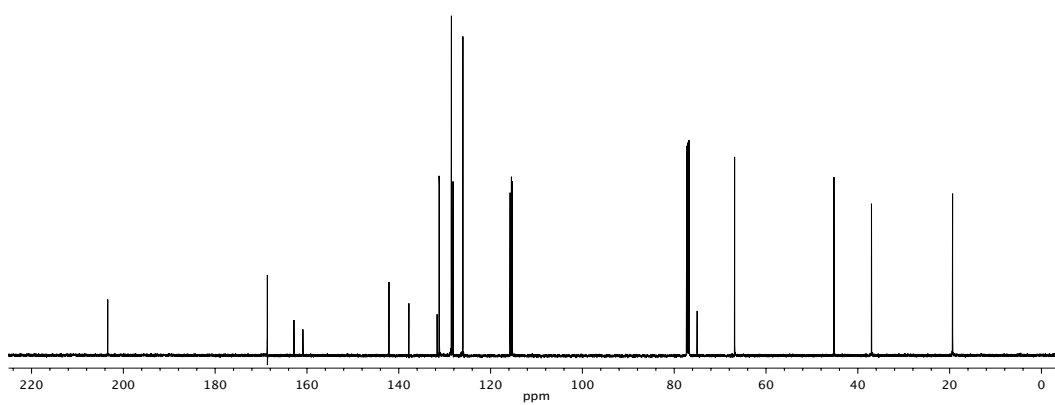


Figure A1.15 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **39d**.

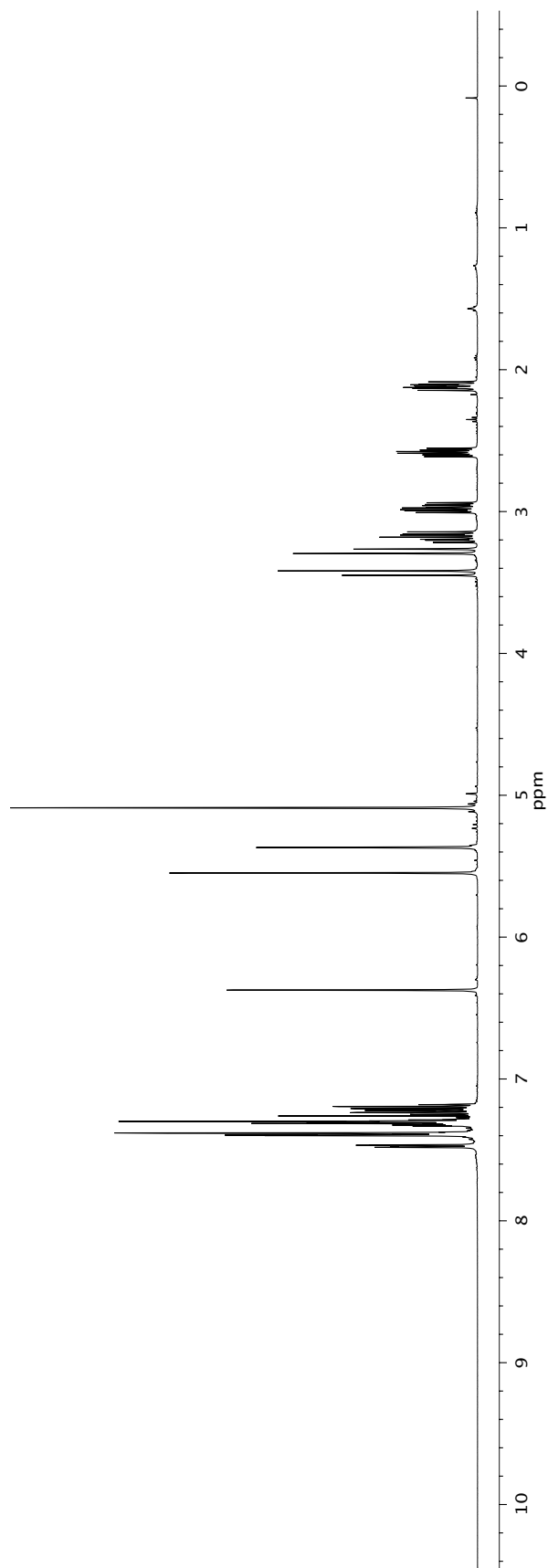
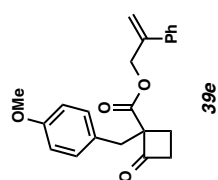


Figure A1.16 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **39e**.

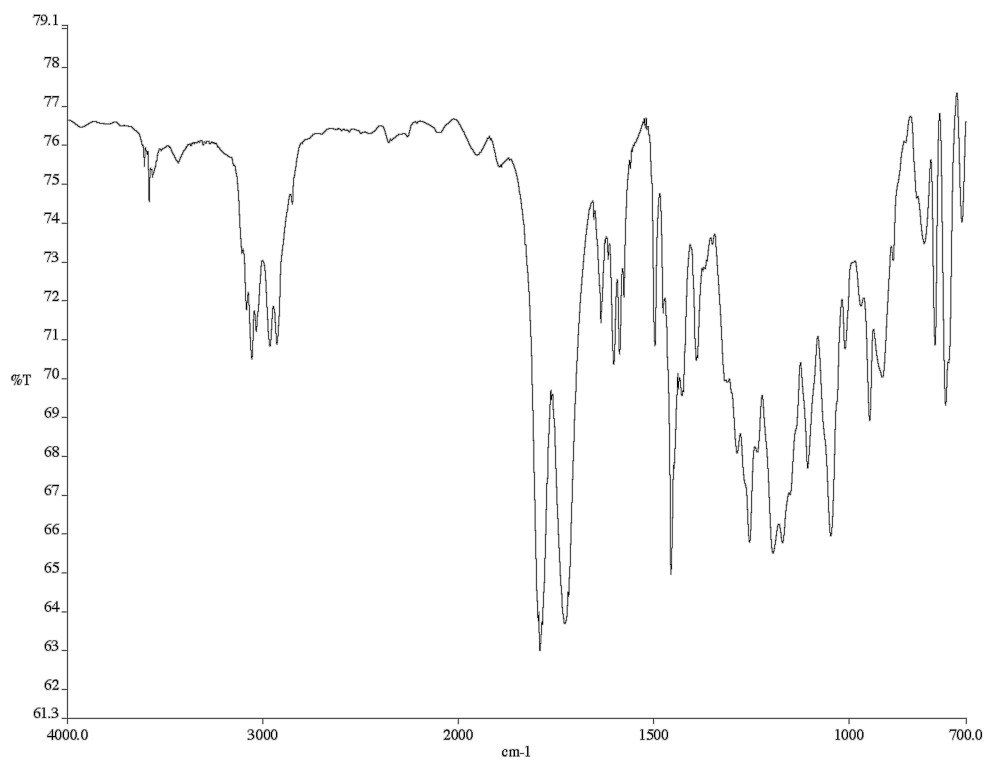


Figure A1.17 Infrared spectrum (thin film/NaCl) of compound **39e**.

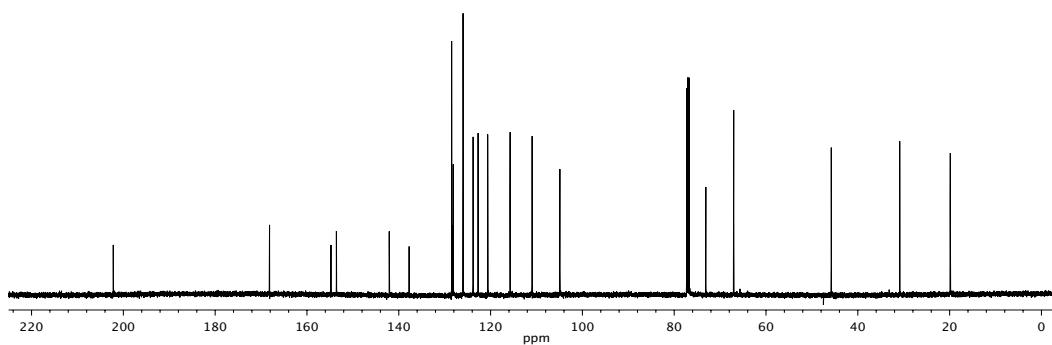


Figure A1.18 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **39e**.

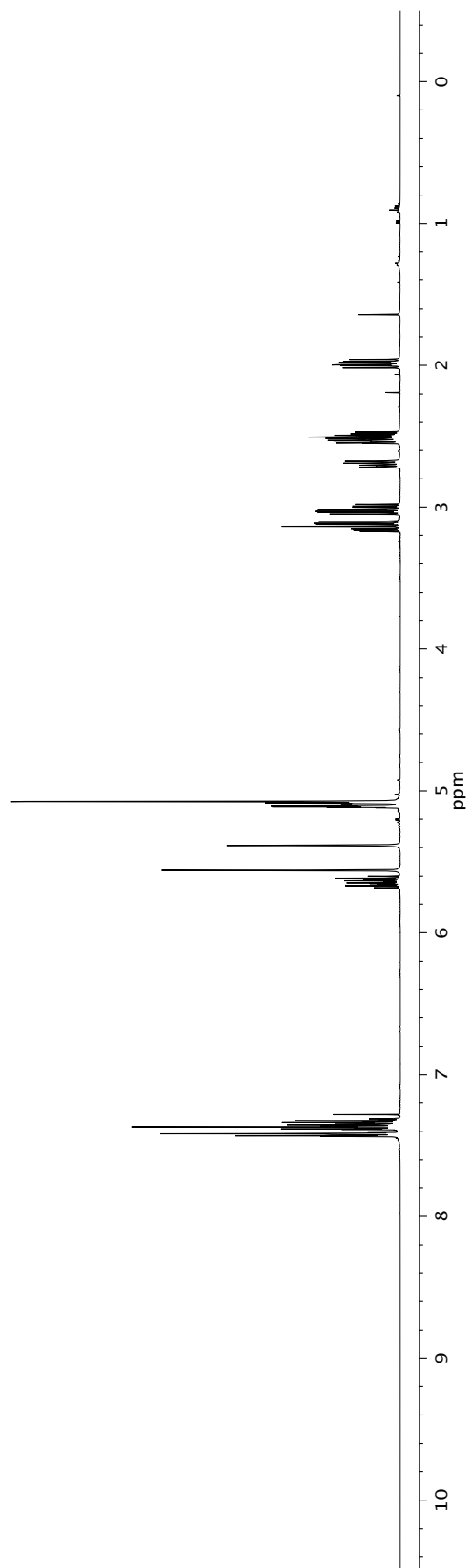
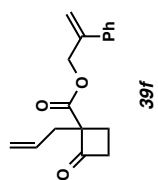


Figure A1.19 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **39f**.

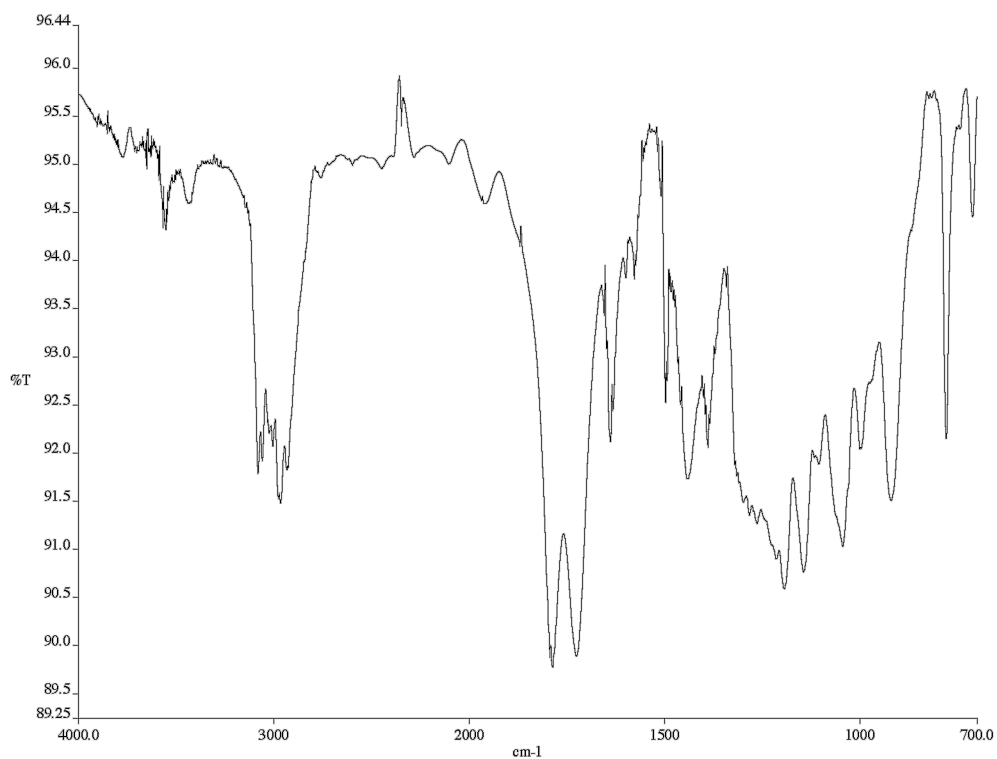


Figure A1.20 Infrared spectrum (thin film/NaCl) of compound **39f**.

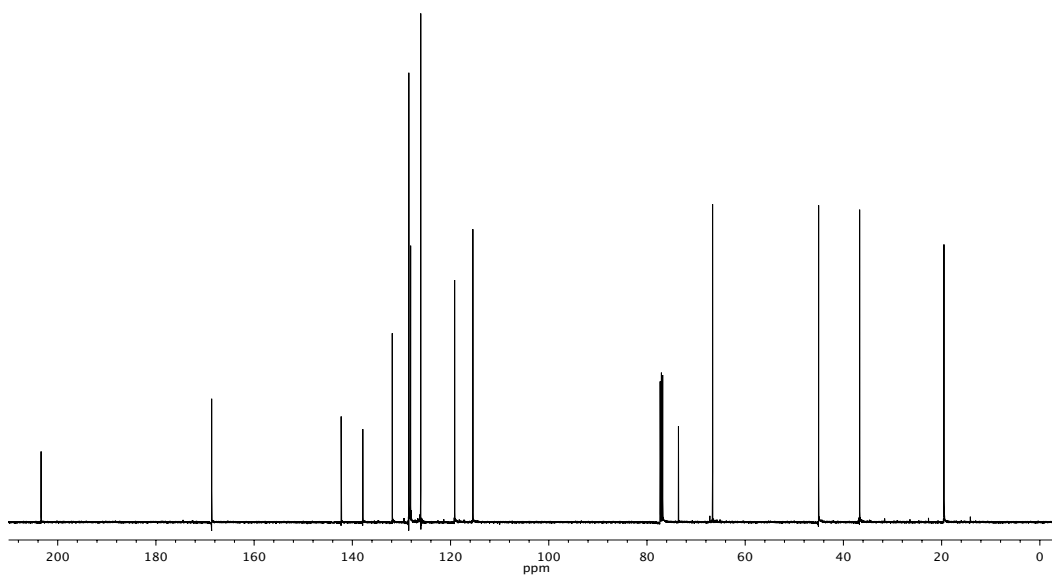


Figure A1.21 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **39f**.

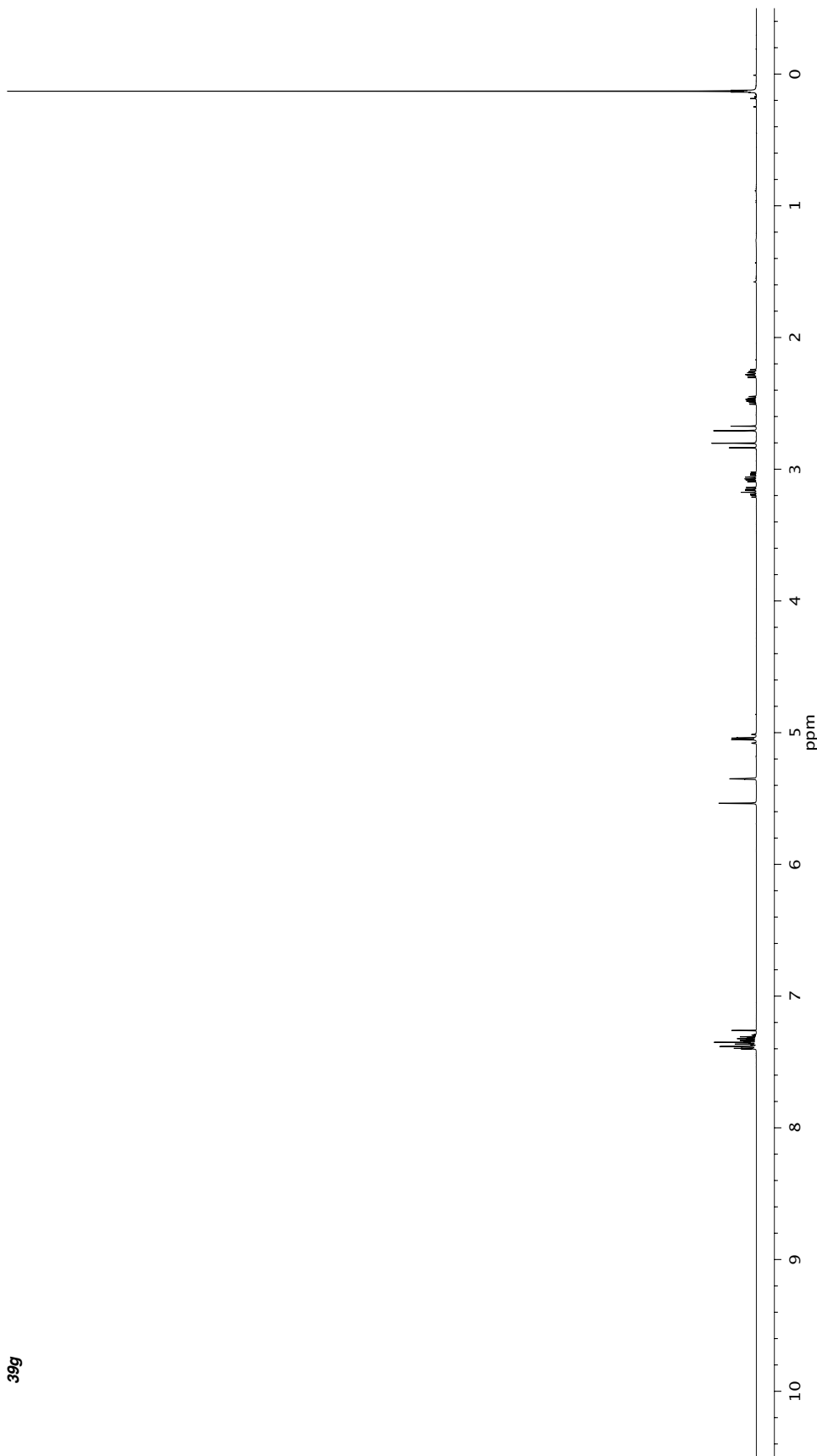
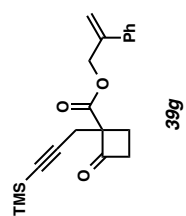


Figure A1.22 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **39g**.



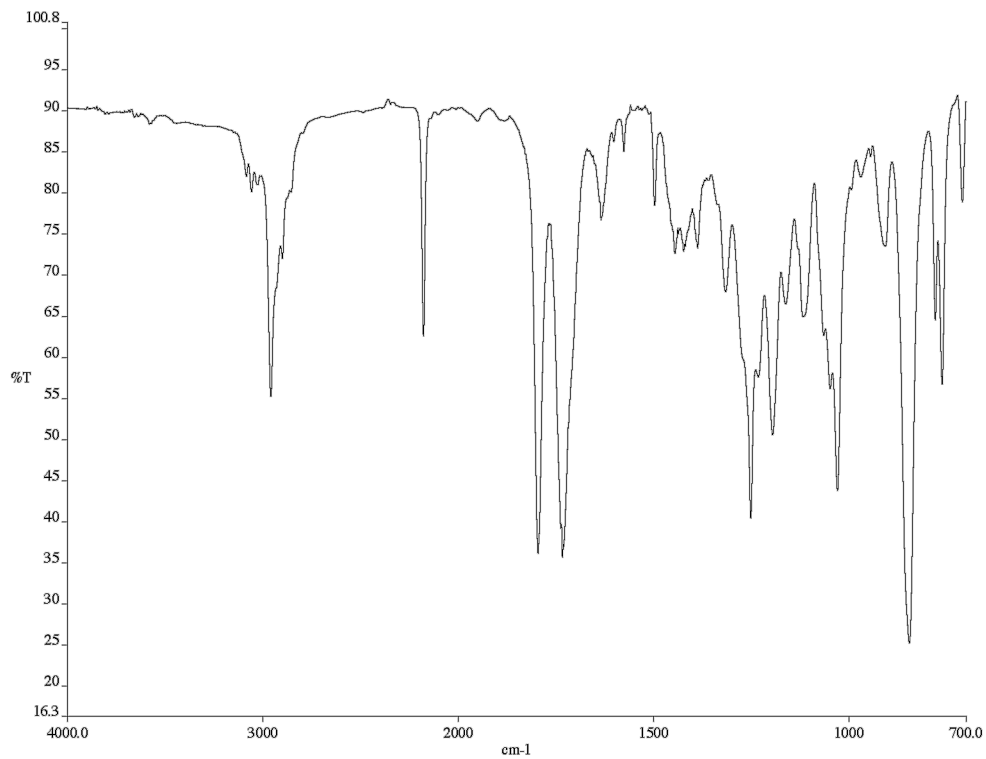


Figure A1.23 Infrared spectrum (thin film/NaCl) of compound **39g**.

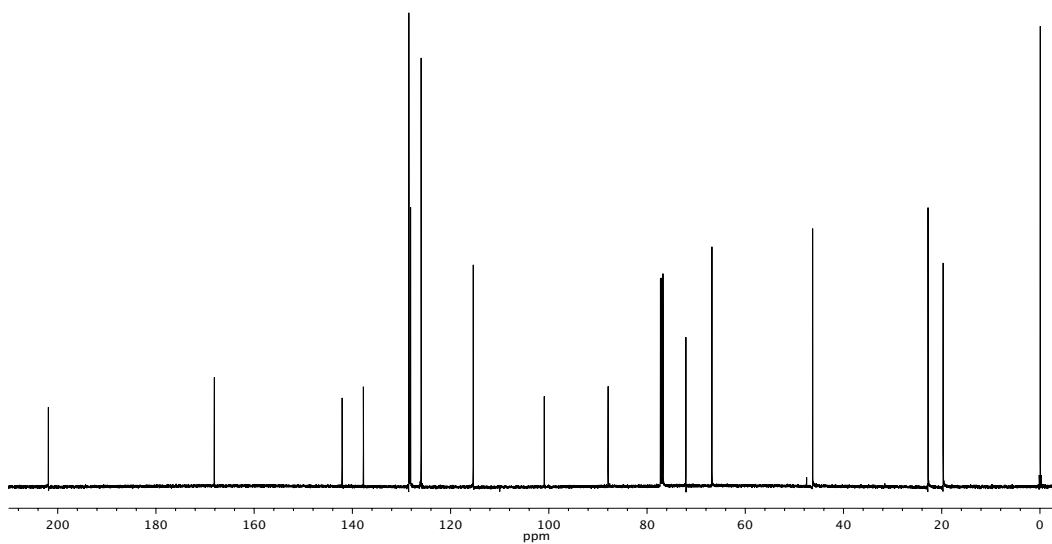


Figure A1.24  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ ) of compound **39g**.

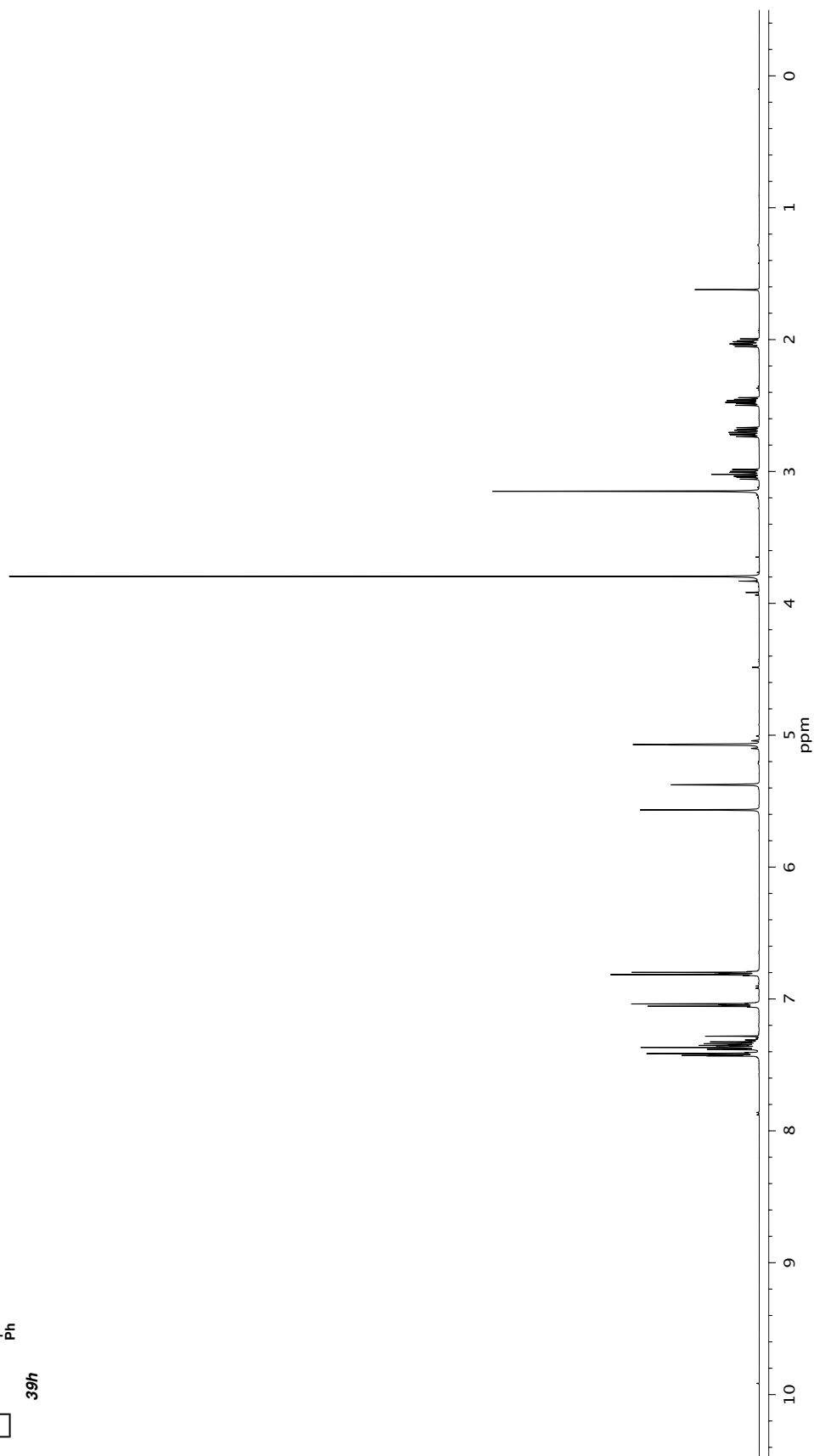
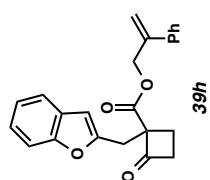


Figure A1.25  $^1\text{H NMR}$  (500 MHz,  $\text{CDCl}_3$ ) of compound **39h**.

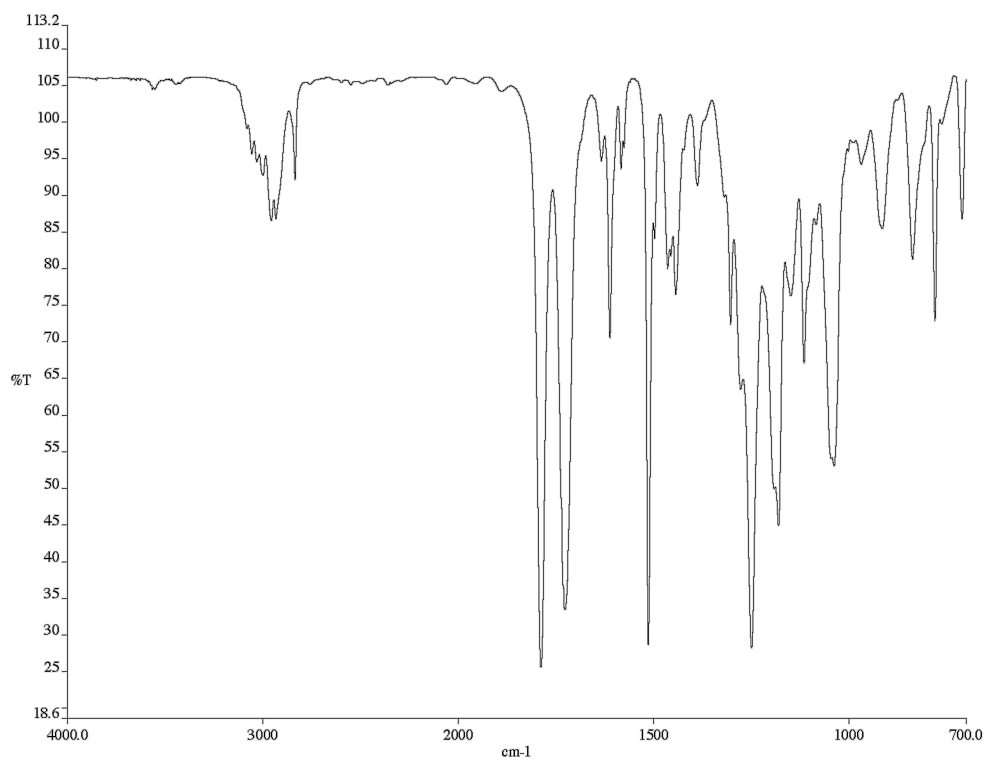


Figure A1.26 Infrared spectrum (thin film/NaCl) of compound **39h**.

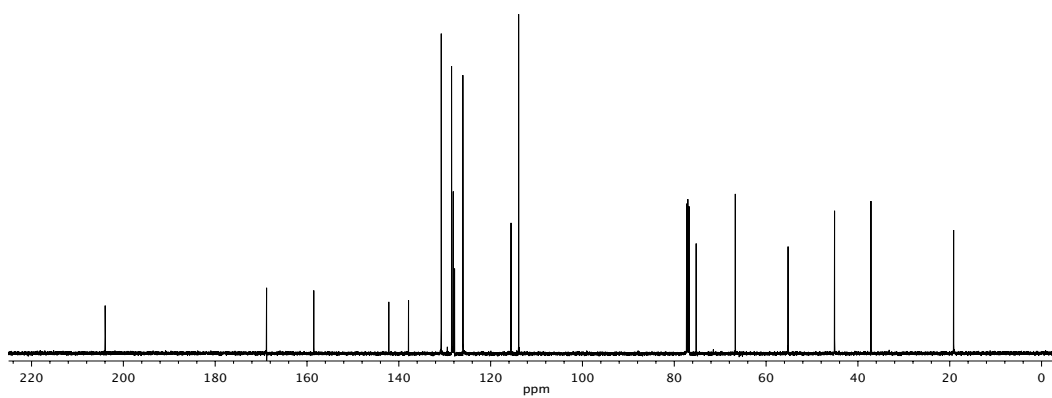
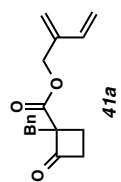
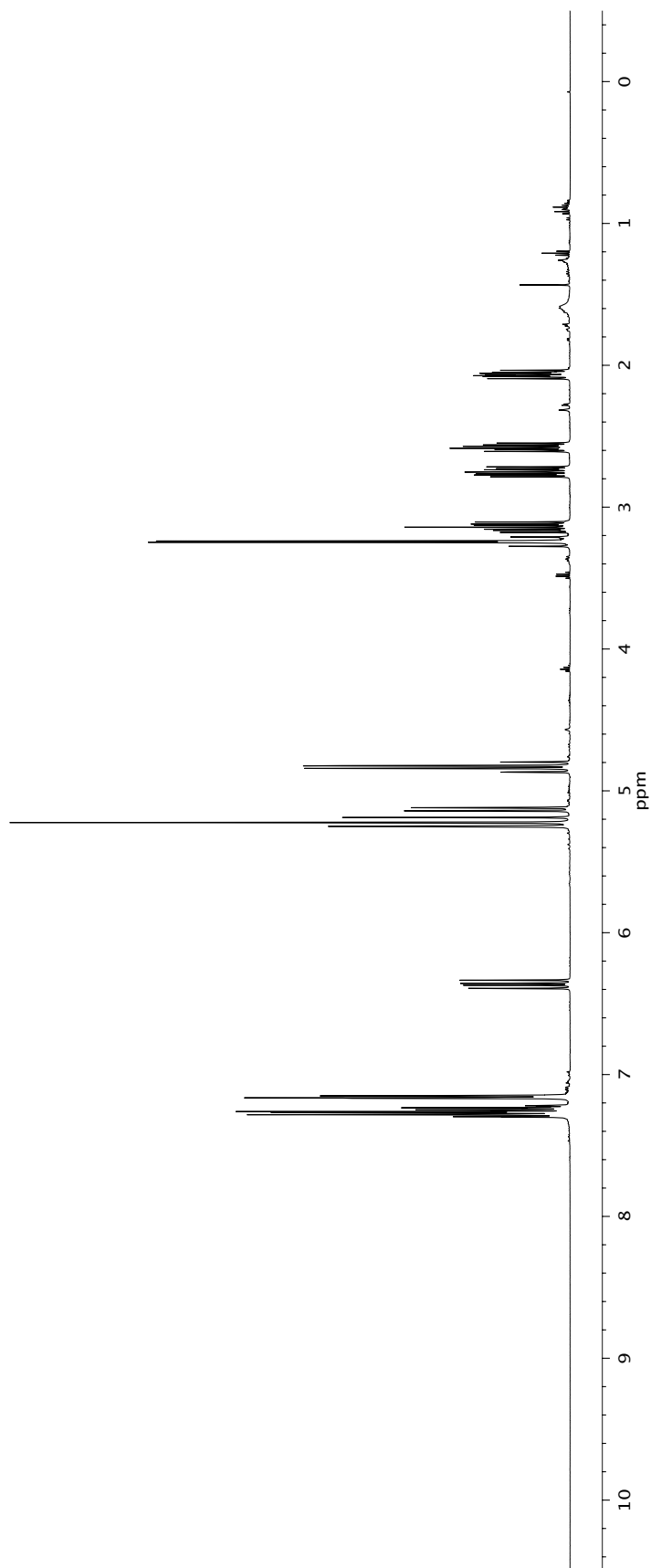


Figure A1.27 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **39h**.



41a

Figure A1.28 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 41a.

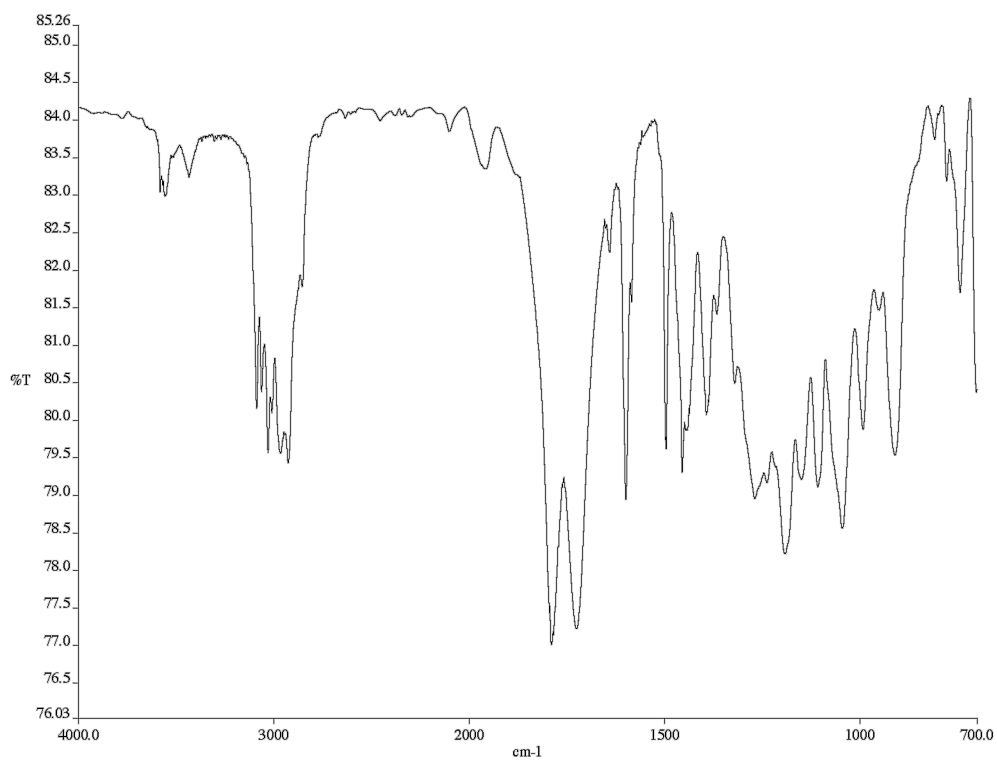


Figure A1.29 Infrared spectrum (thin film/NaCl) of compound **41a**.

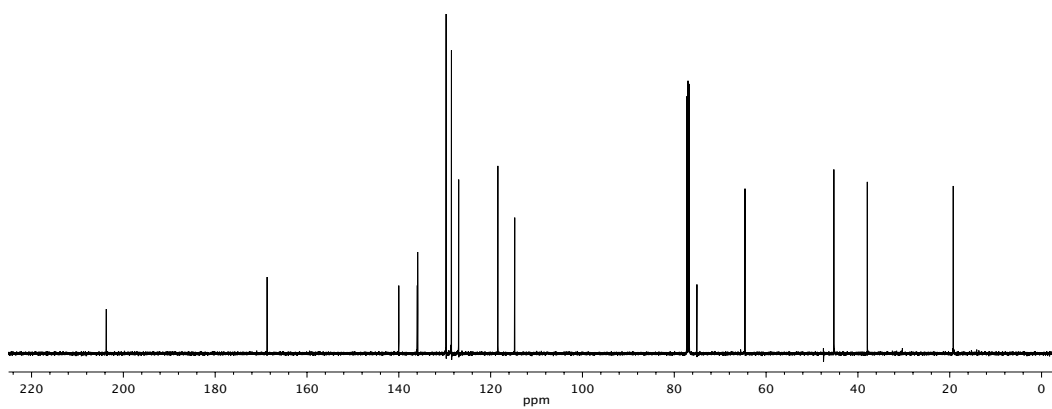


Figure A1.30  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ ) of compound **41a**.

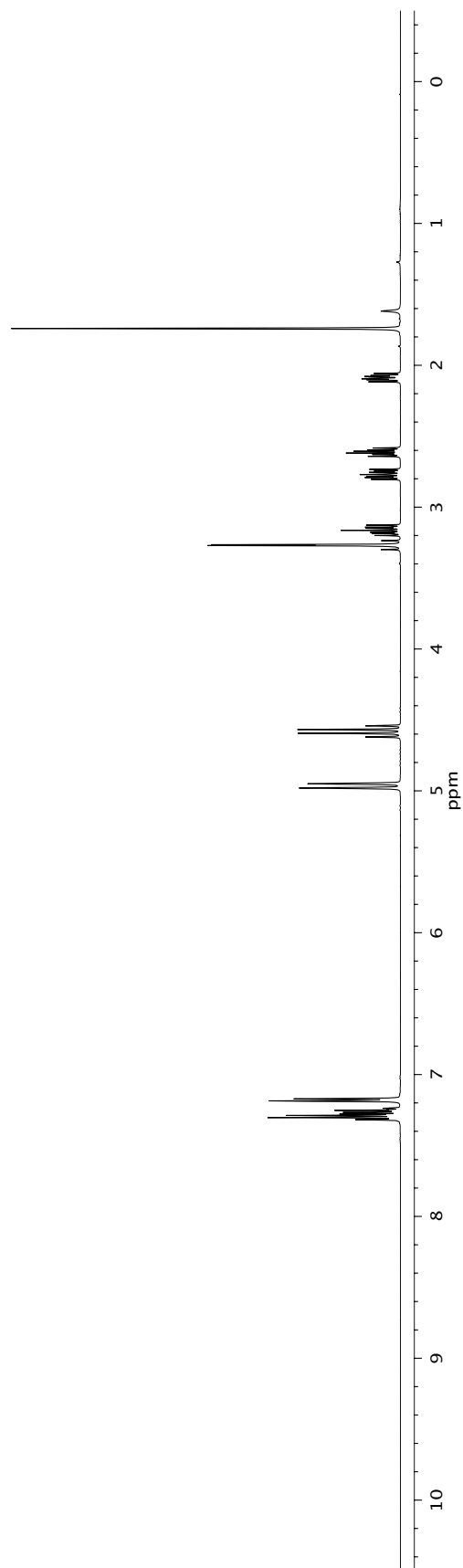
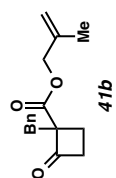


Figure A1.31 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **41b**.

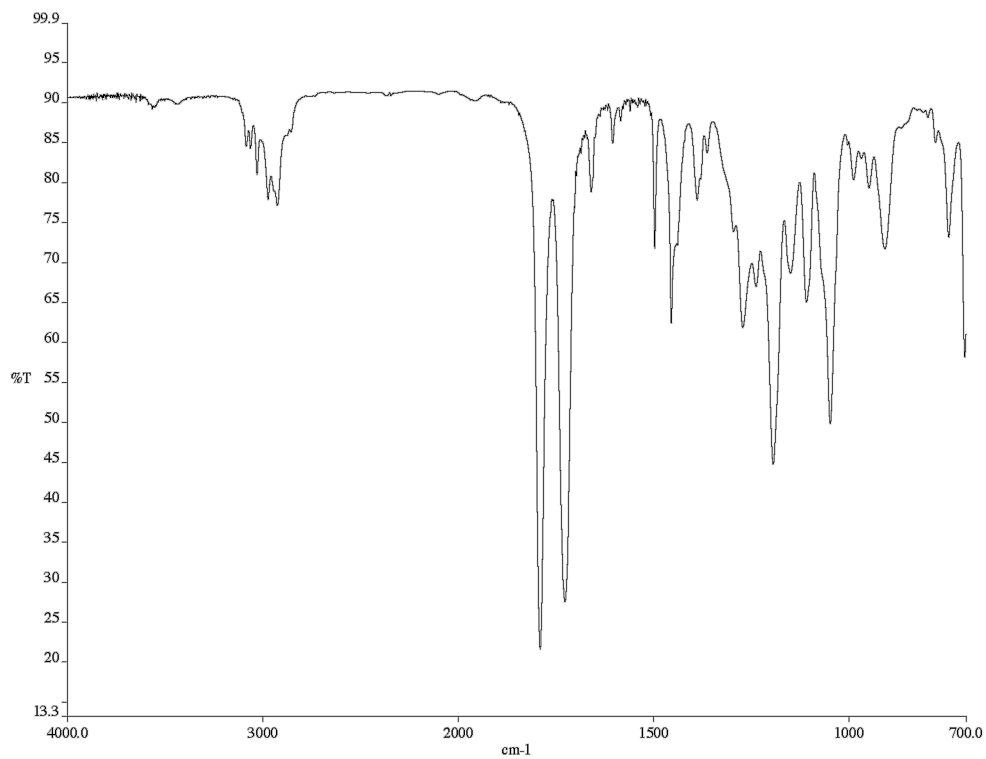


Figure A1.32 Infrared spectrum (thin film/NaCl) of compound **41b**.

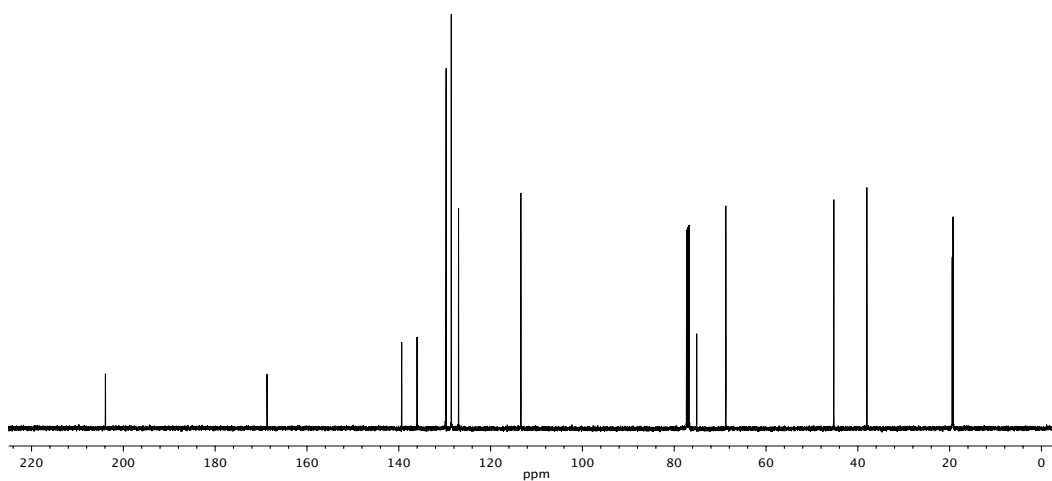


Figure A1.33 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **41b**.

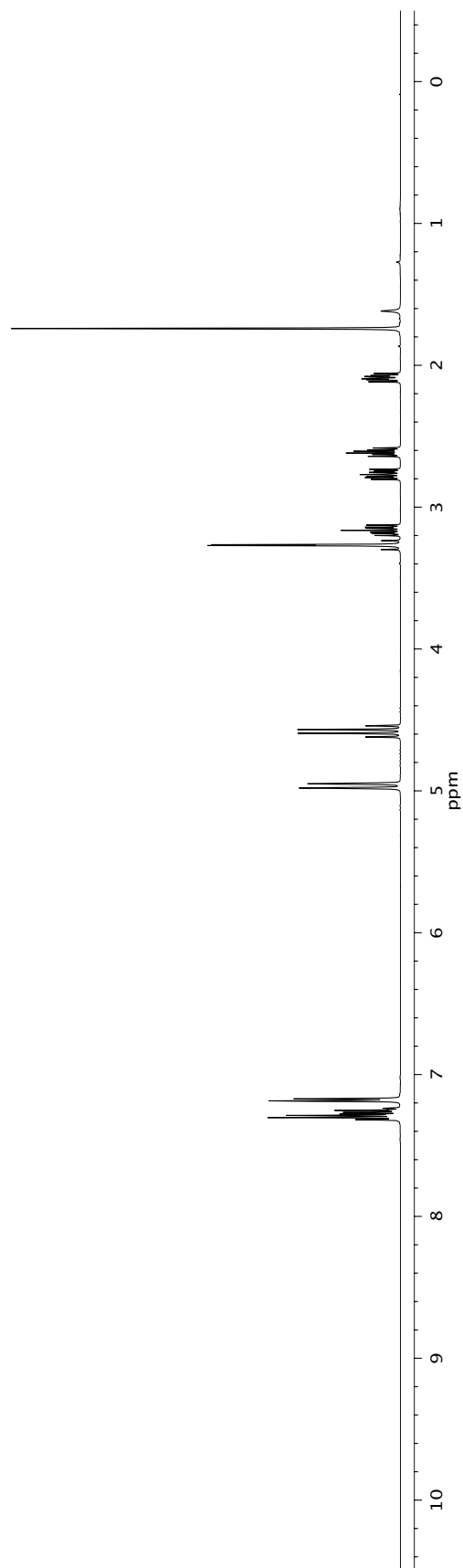
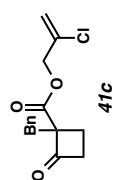


Figure A1.34  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) of compound 41c.



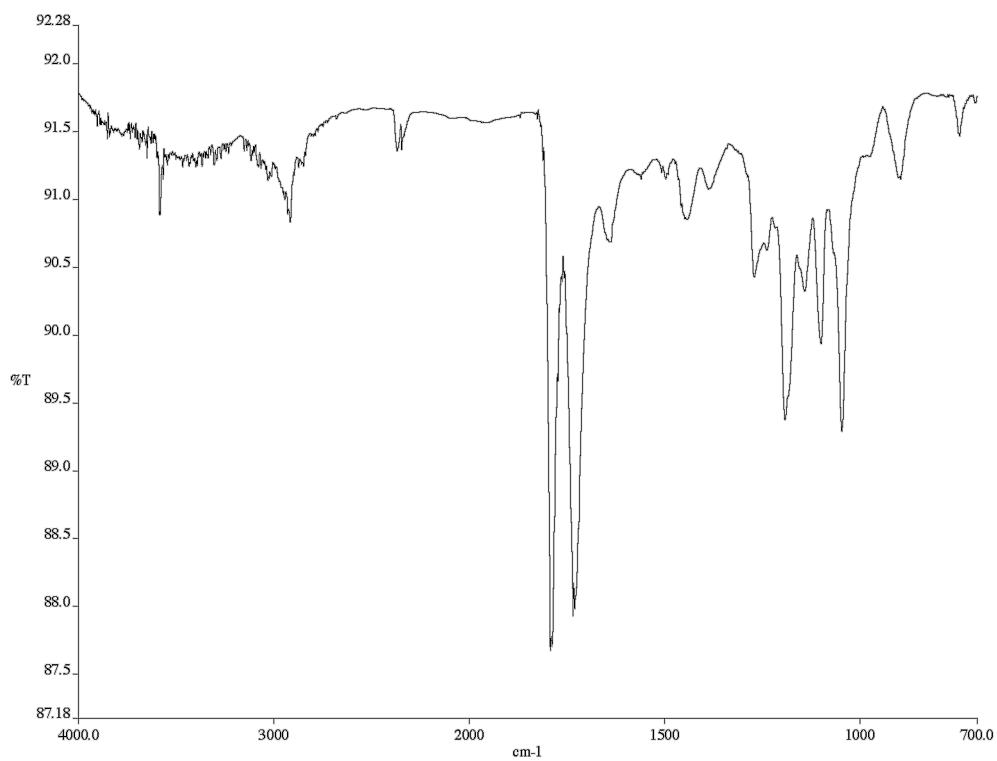


Figure A1.35 Infrared spectrum (thin film/NaCl) of compound **41c**.

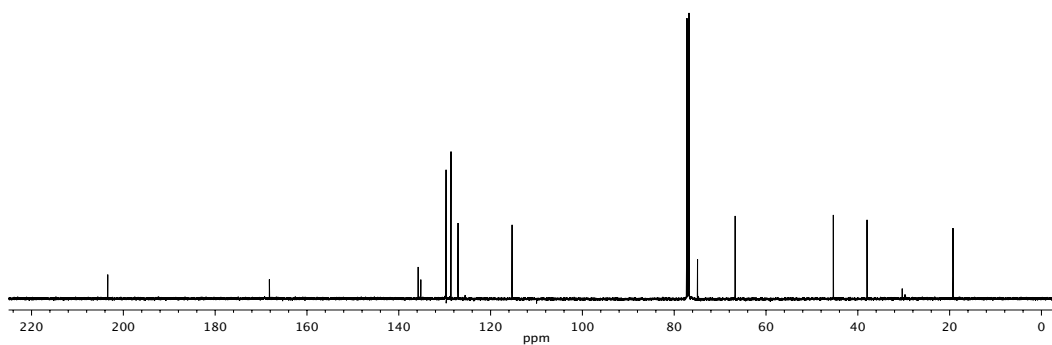


Figure A1.36 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **41c**.

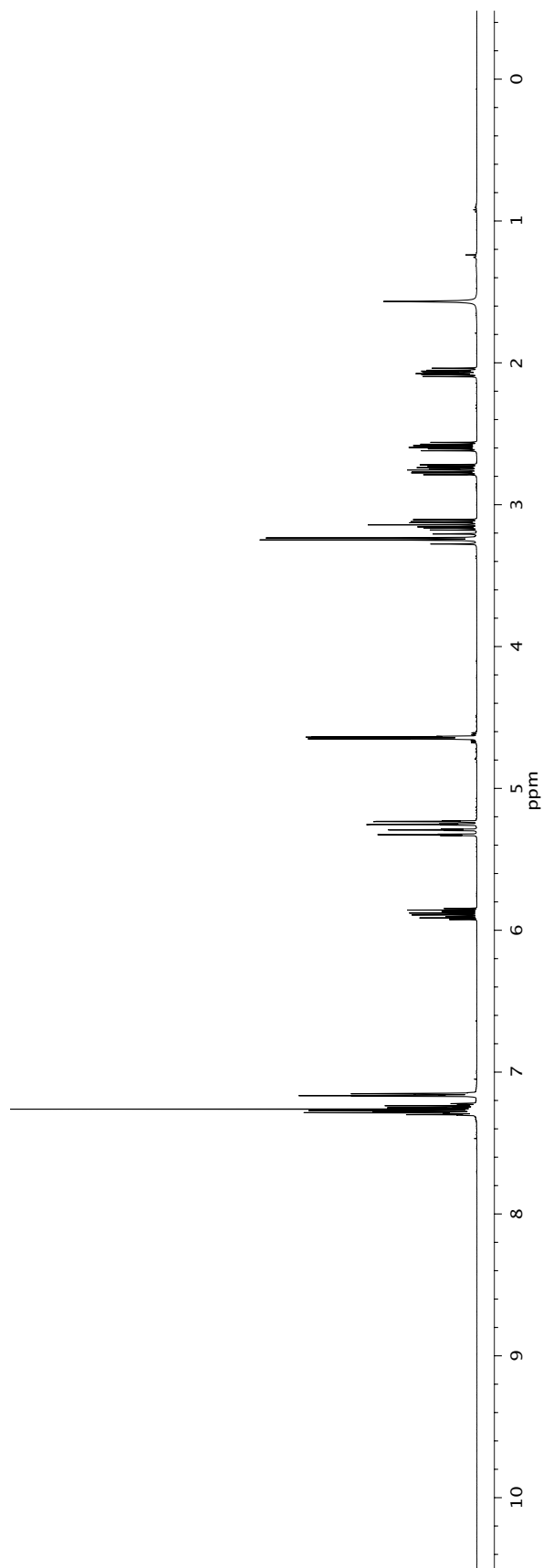
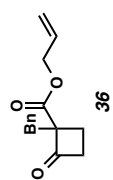


Figure A1.37  $^1\text{H NMR}$  (500 MHz,  $\text{CDCl}_3$ ) of compound **36**.

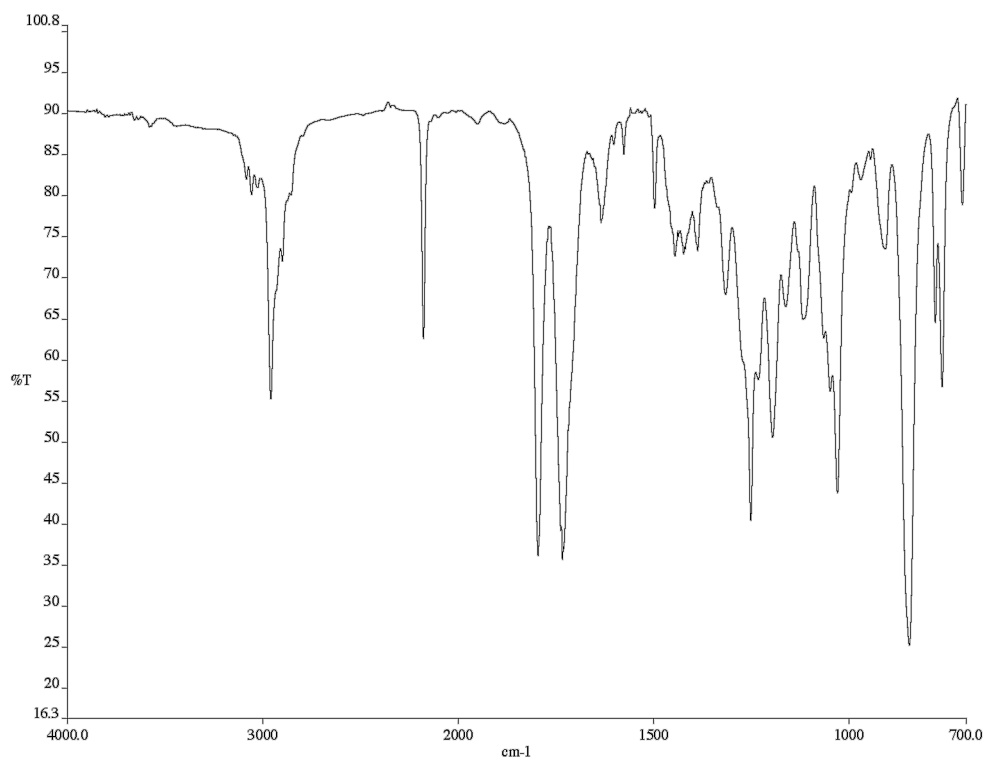


Figure A1.38 Infrared spectrum (thin film/NaCl) of compound 36.

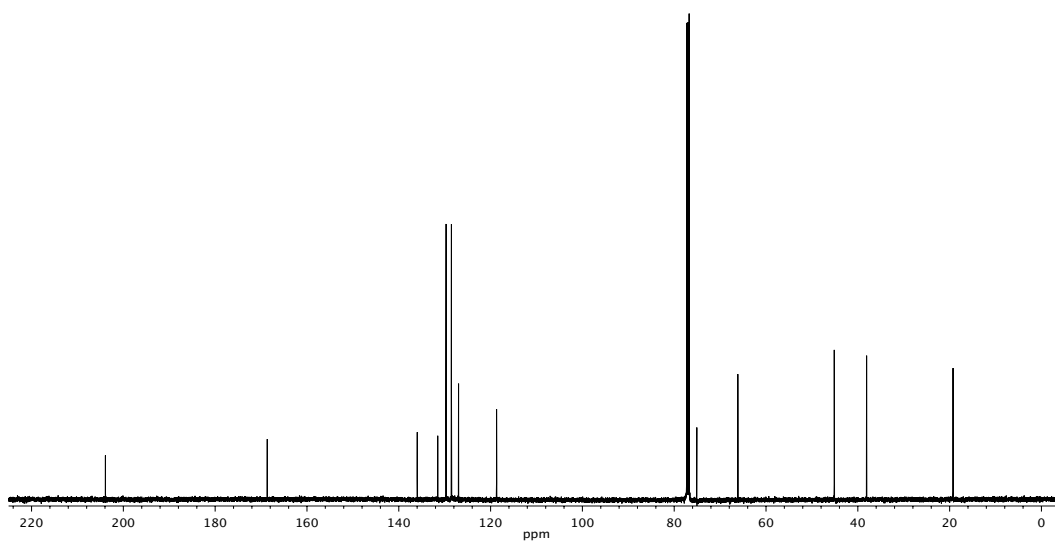


Figure A1.39 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound 36.

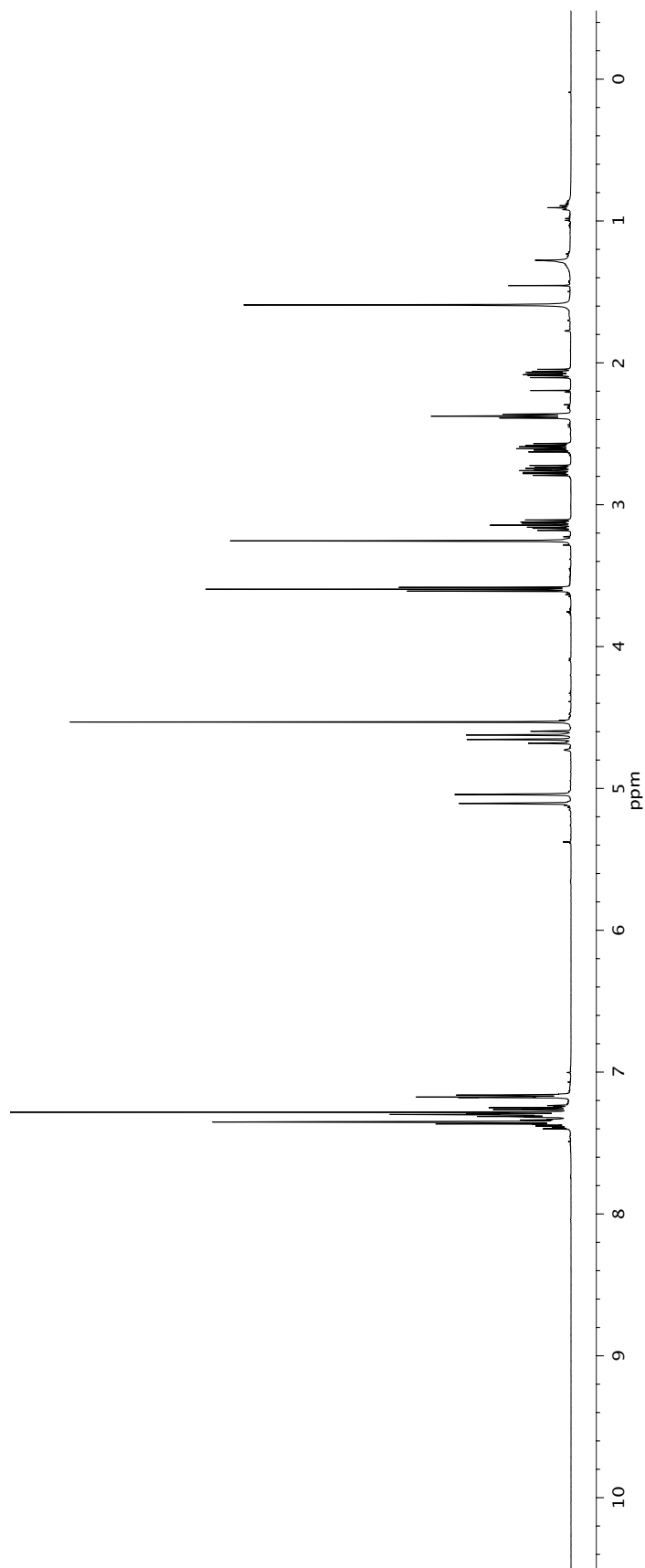
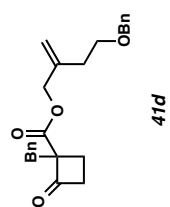


Figure A1.40 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **41d**.

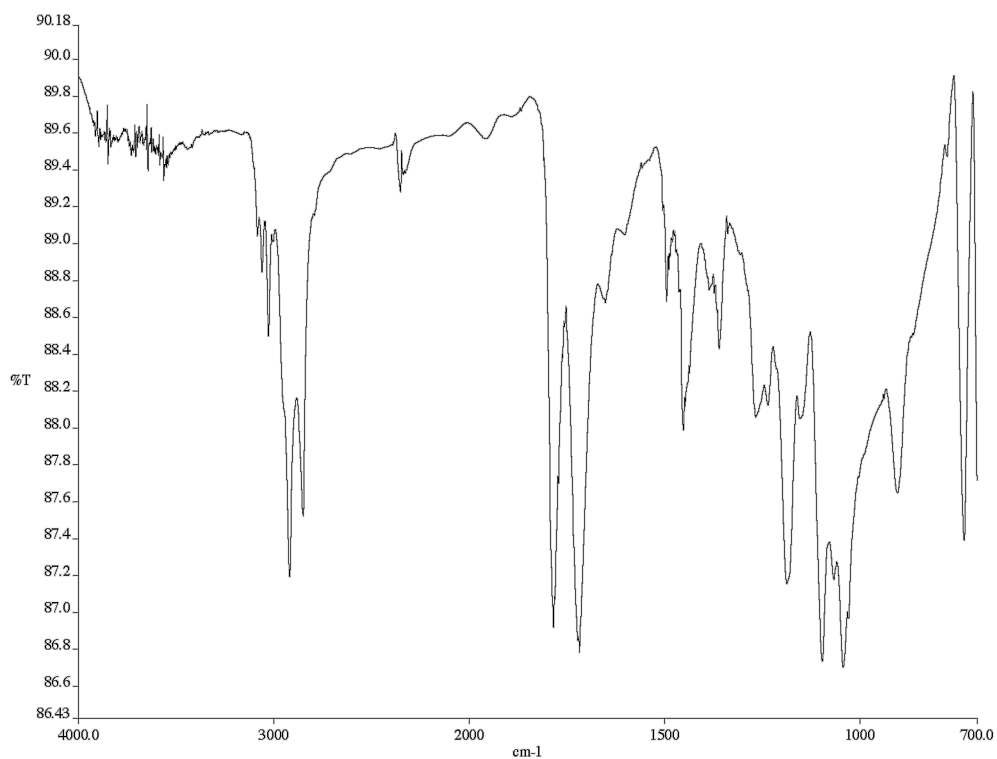


Figure A1.41 Infrared spectrum (thin film/NaCl) of compound **41d**.

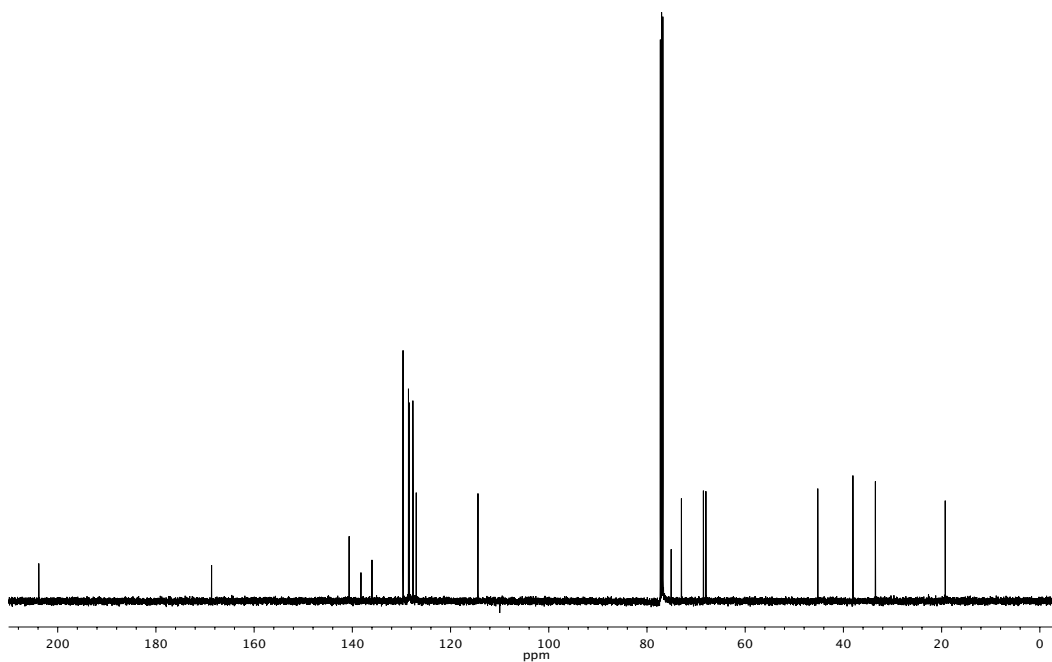


Figure A1.42 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **41d**.

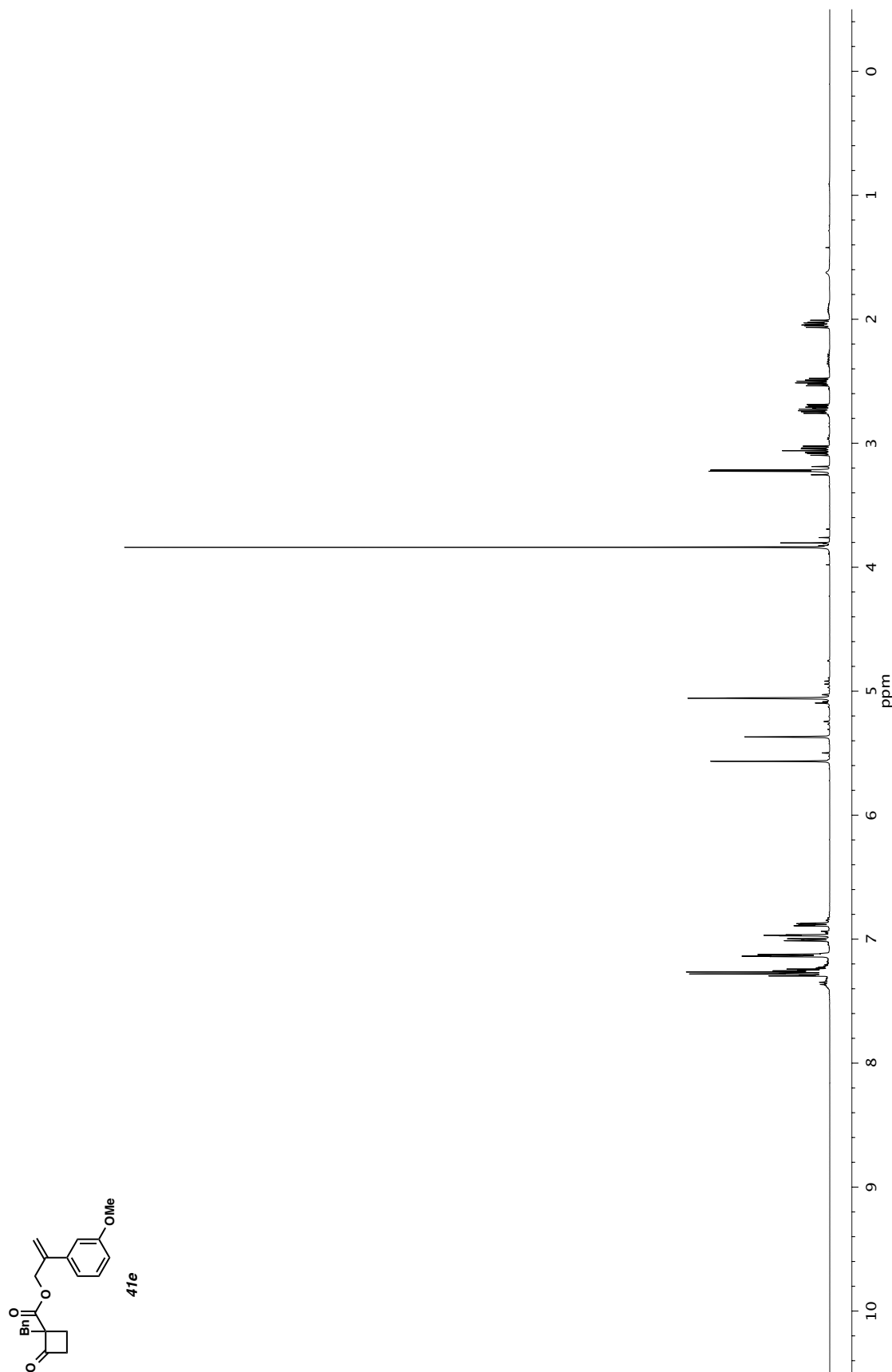


Figure A1.43  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) of compound **41e**.

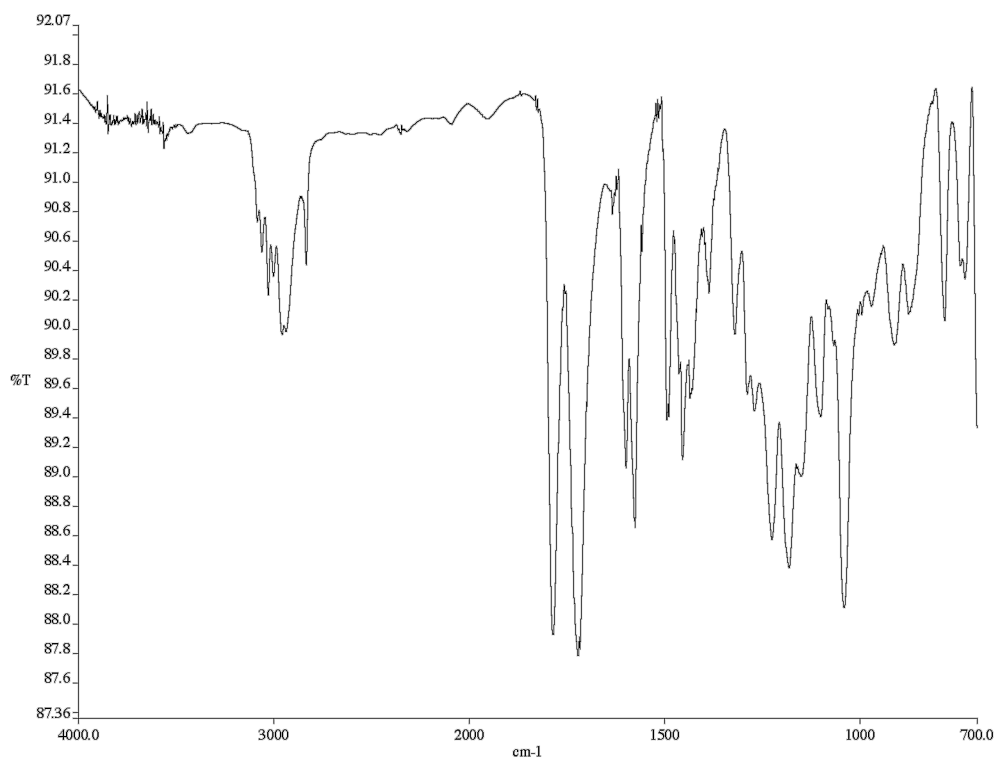


Figure A1.44 Infrared spectrum (thin film/NaCl) of compound **41e**.

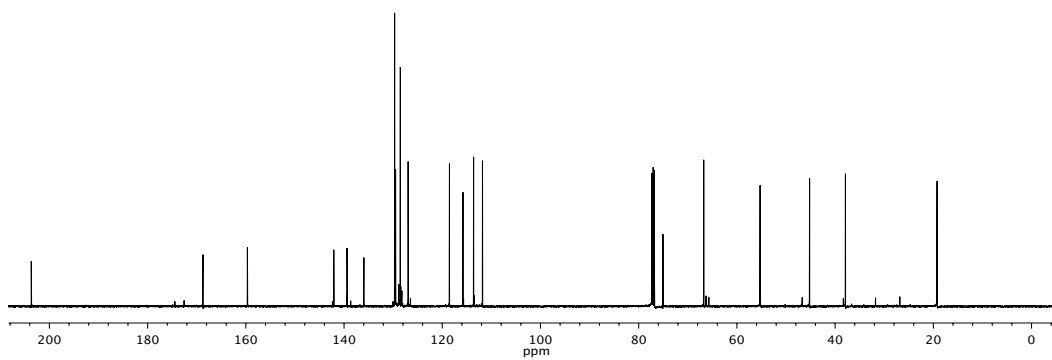


Figure A1.45 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **41e**.

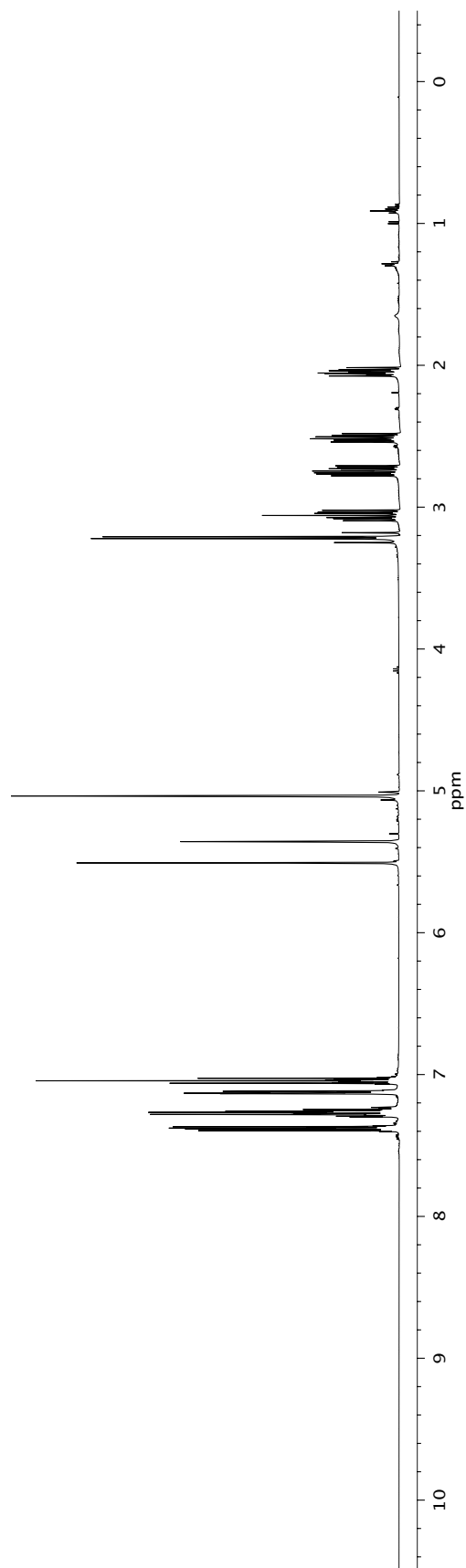
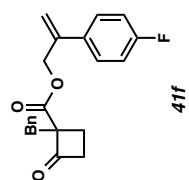


Figure A1.46  $^1\text{H NMR}$  (500 MHz,  $\text{CDCl}_3$ ) of compound **41f**.



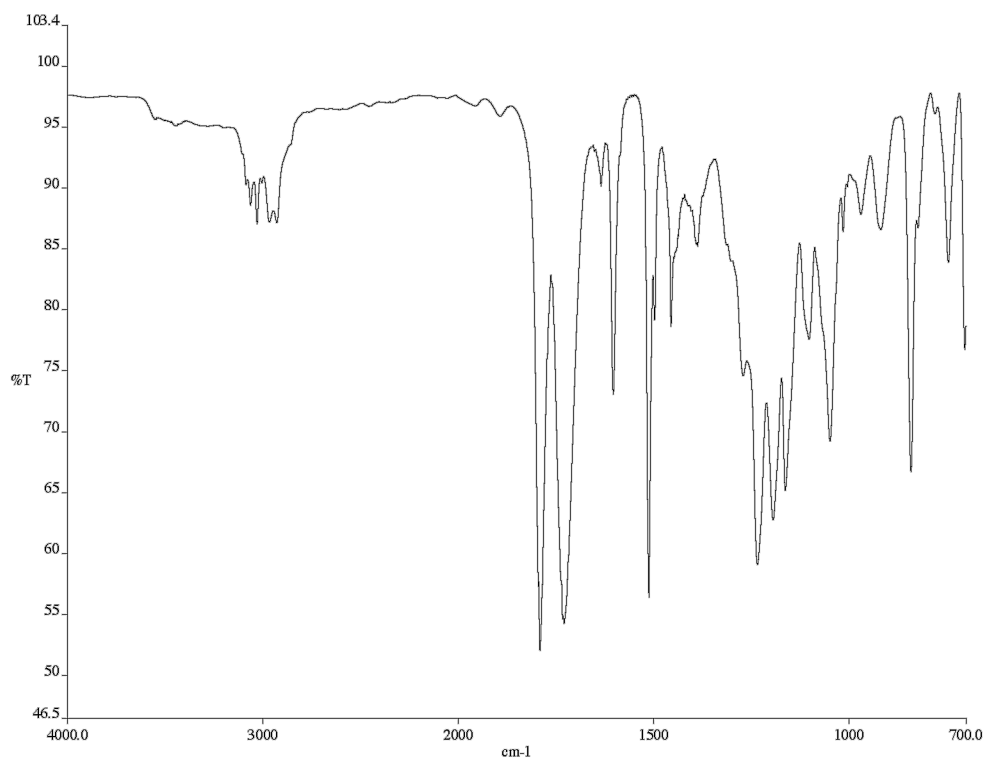


Figure A1.47 Infrared spectrum (thin film/NaCl) of compound **41f**.

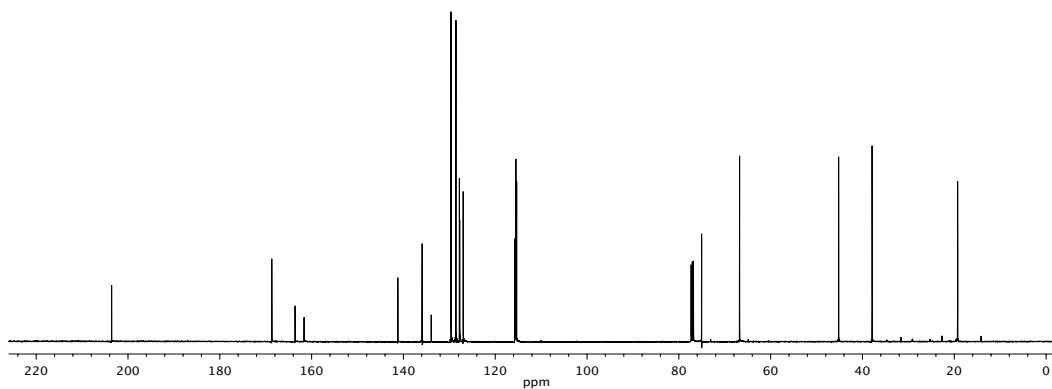


Figure A1.48 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **41f**.

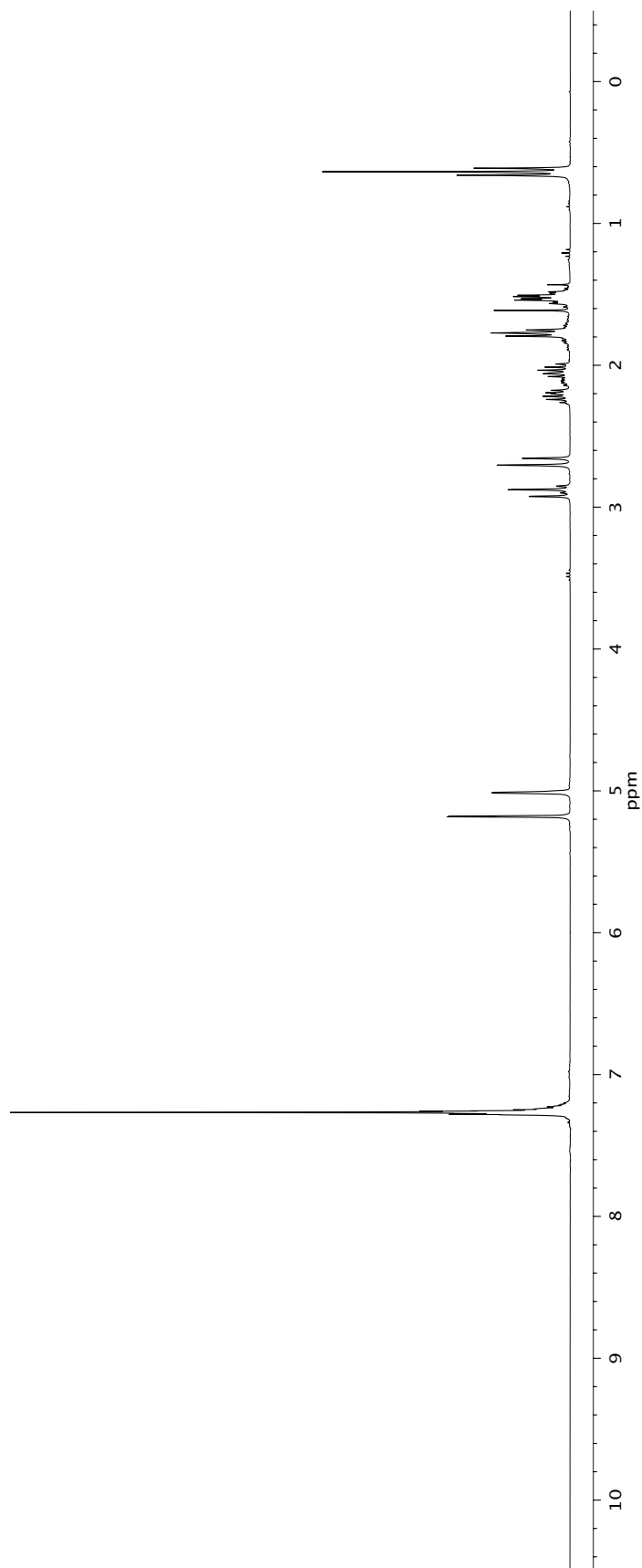
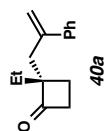


Figure A1.49 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 40a.

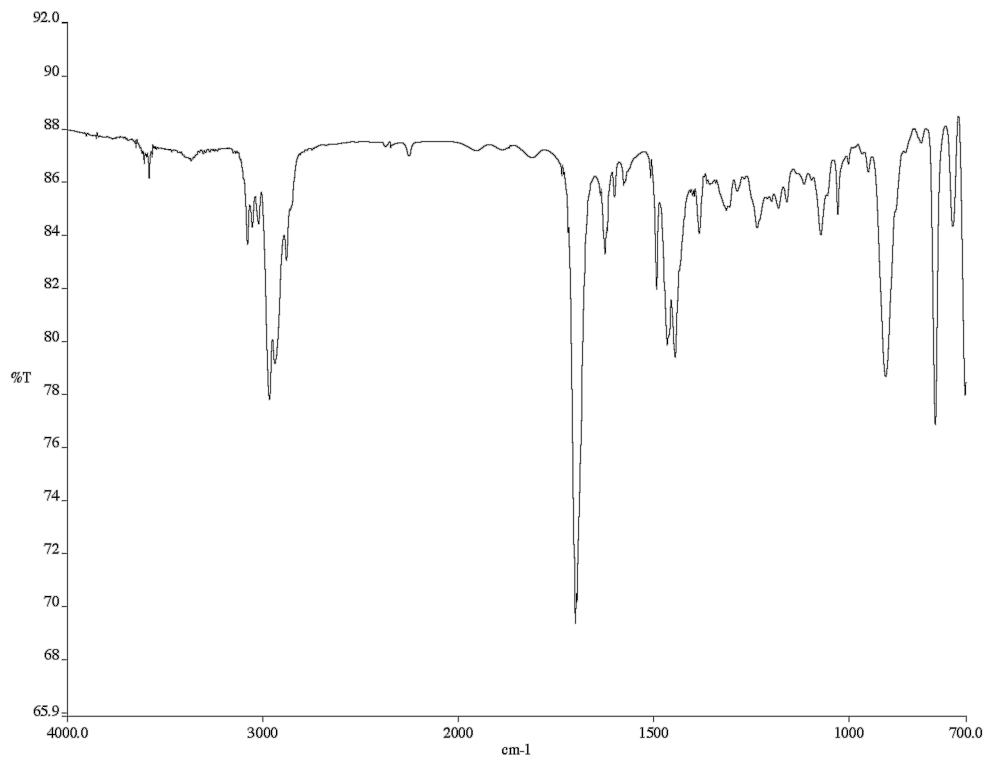


Figure A1.50 Infrared spectrum (thin film/NaCl) of compound **40a**.

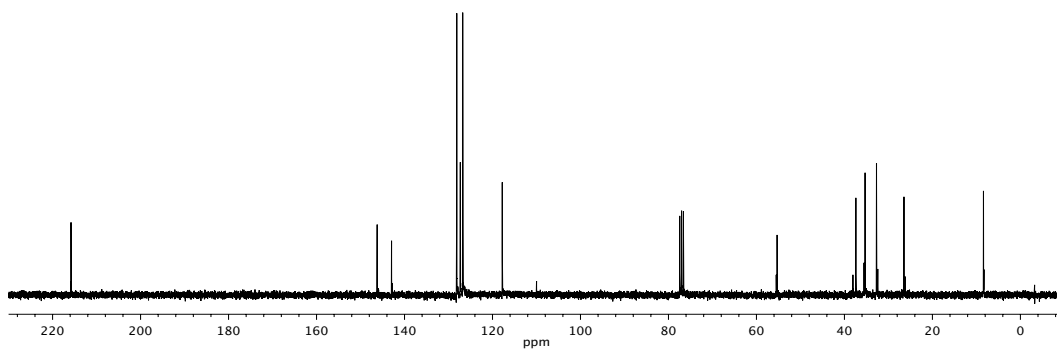


Figure A1.51 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **40a**.

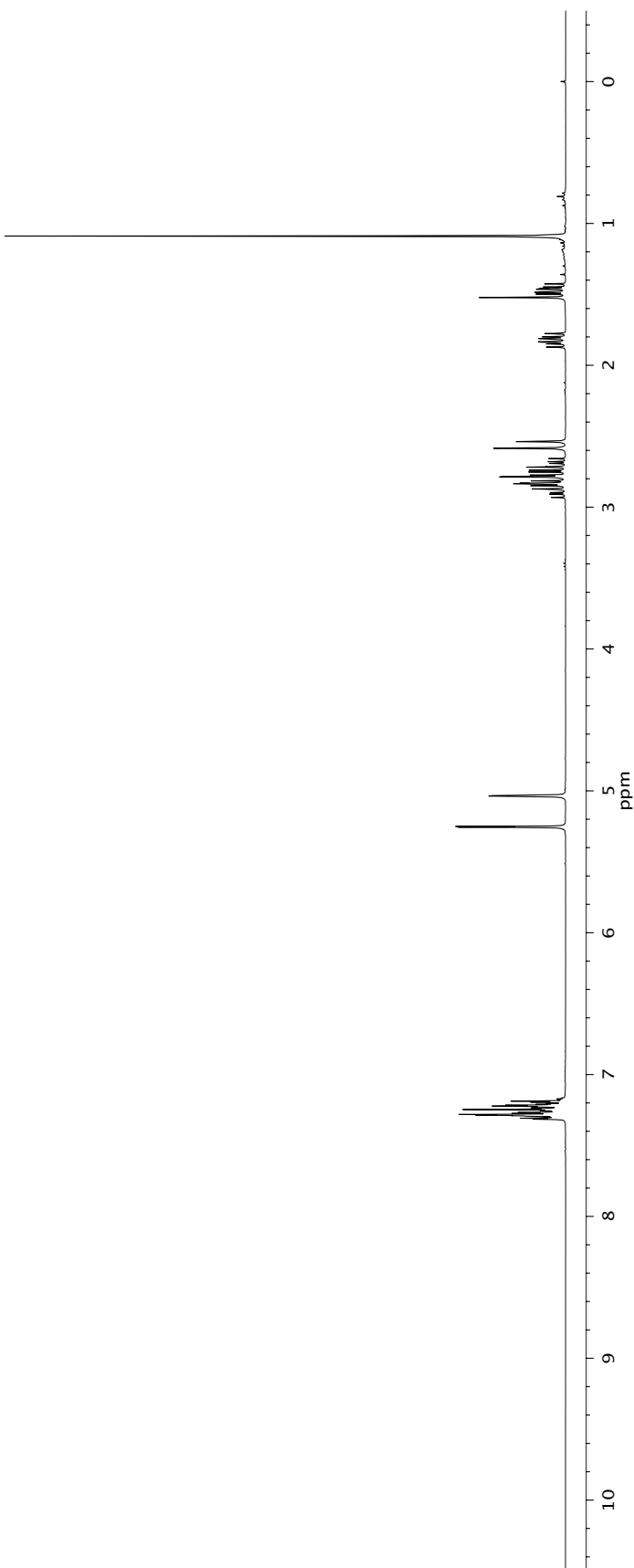
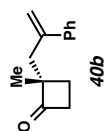


Figure A1.52 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 40b.

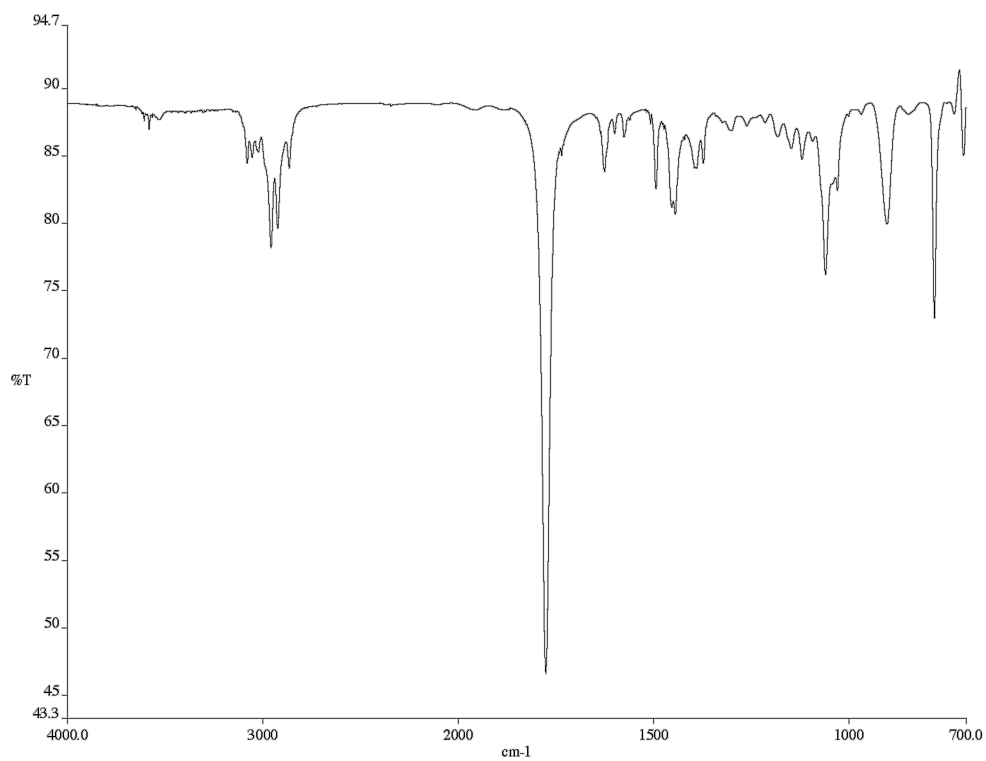


Figure A1.53 Infrared spectrum (thin film/NaCl) of compound **40b**.

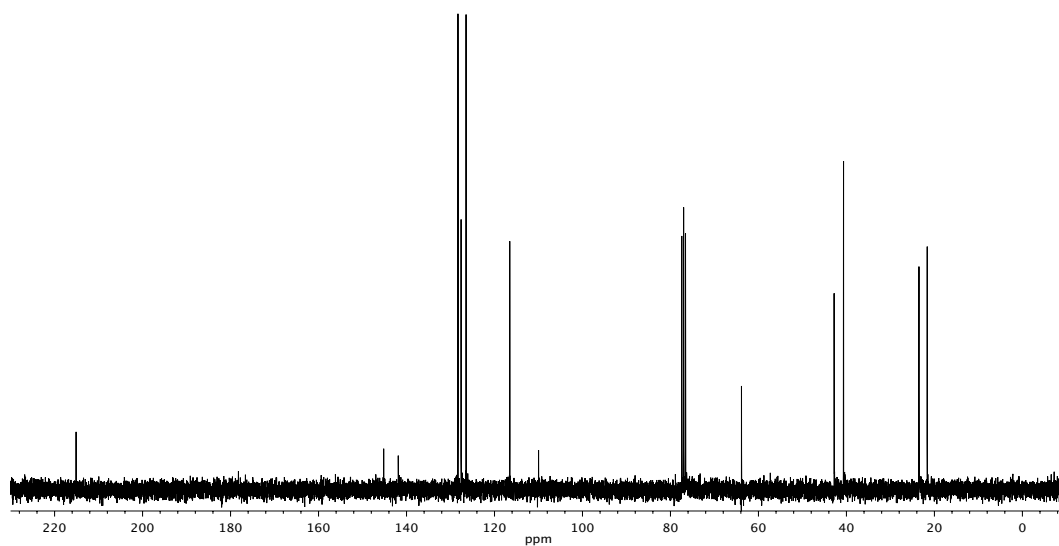


Figure A1.54 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **40b**.

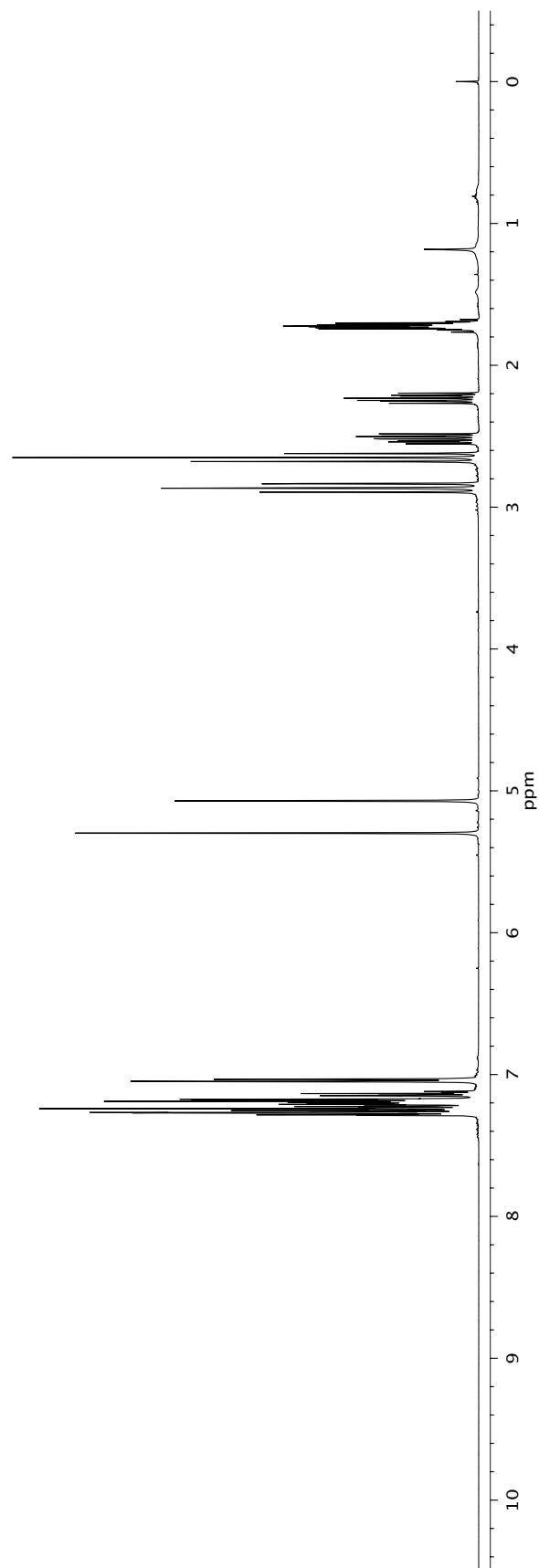
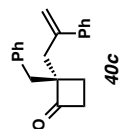


Figure A1.55 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 40c.

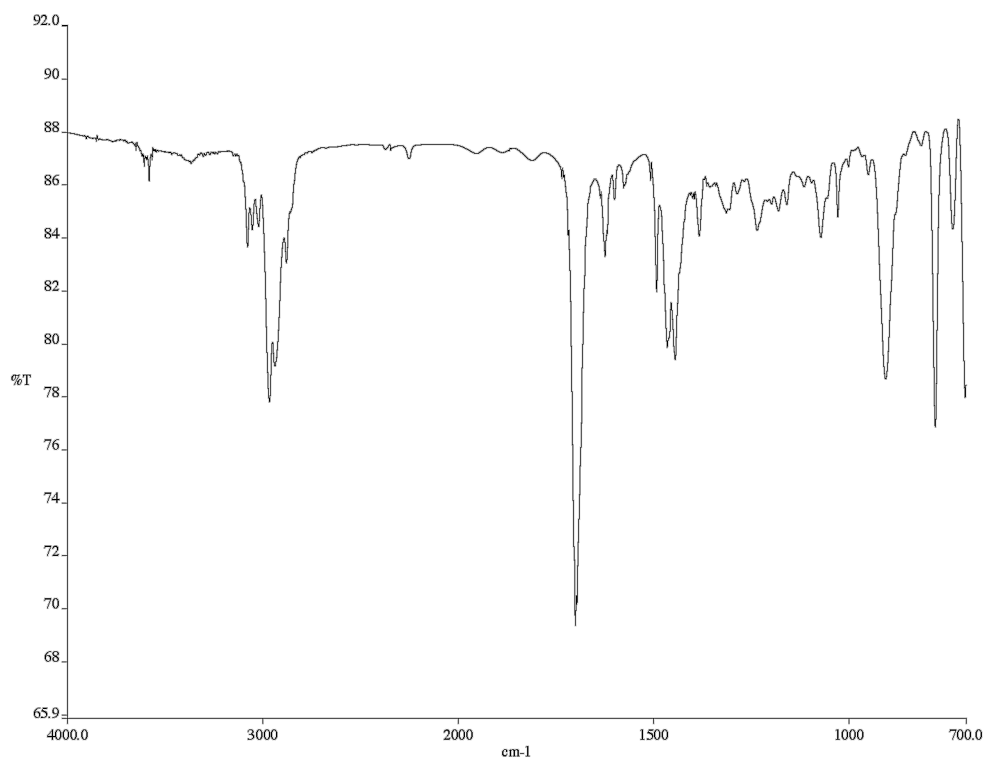


Figure A1.56 Infrared spectrum (thin film/NaCl) of compound **40c**.

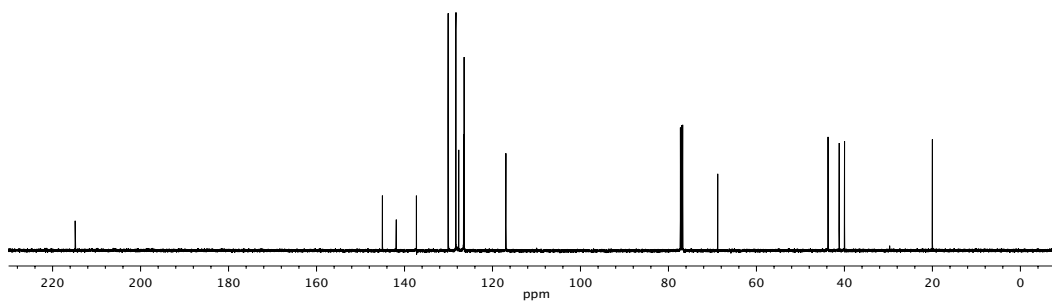


Figure A1.57 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **40c**.

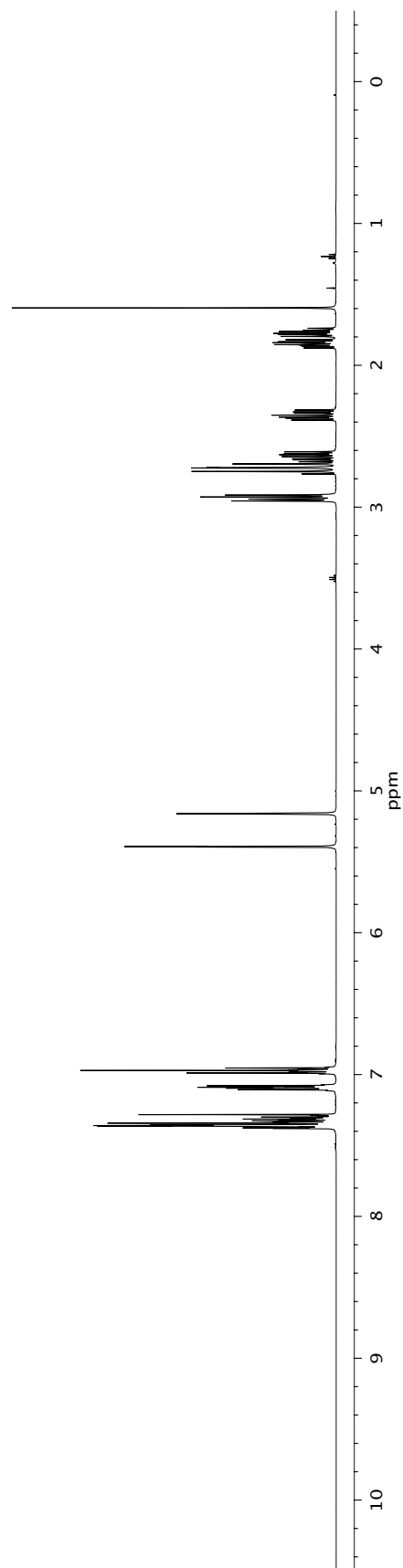
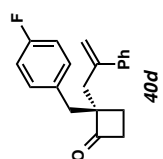


Figure A1.58 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **40d**.



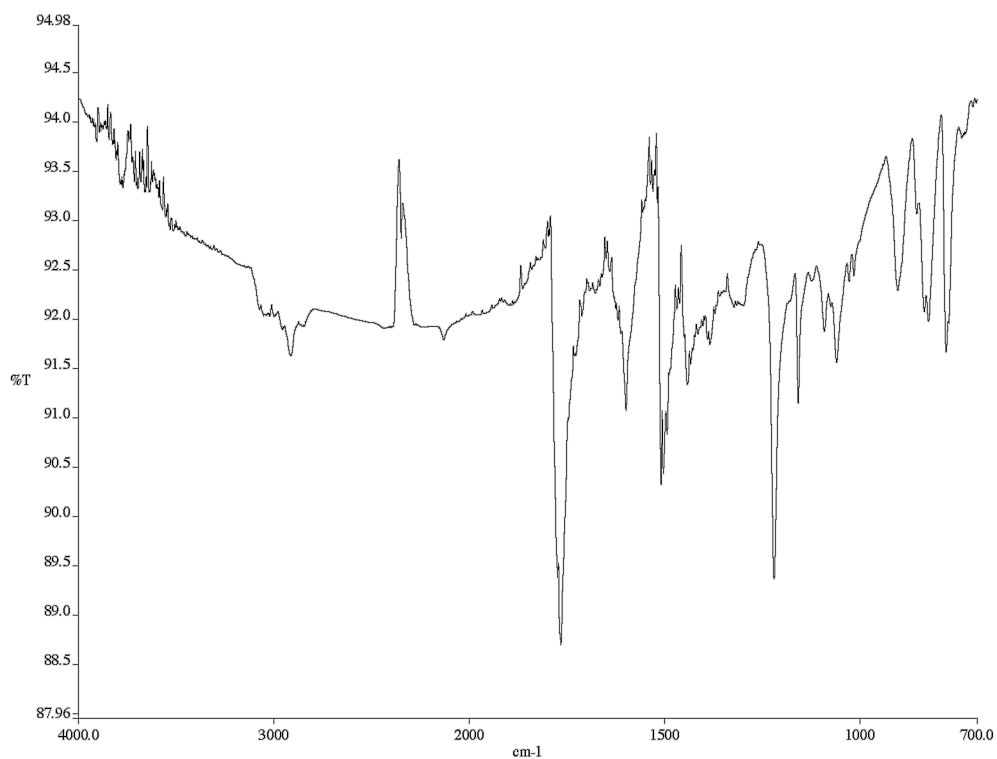


Figure A1.59 Infrared spectrum (thin film/NaCl) of compound **40d**.

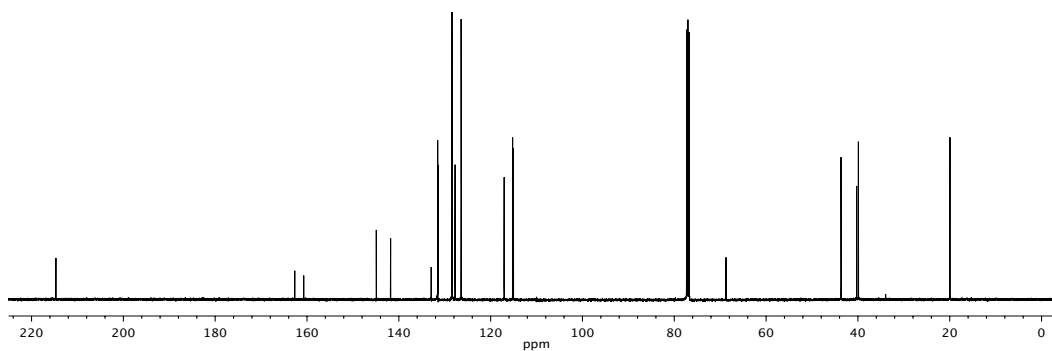


Figure A1.60 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **40d**.

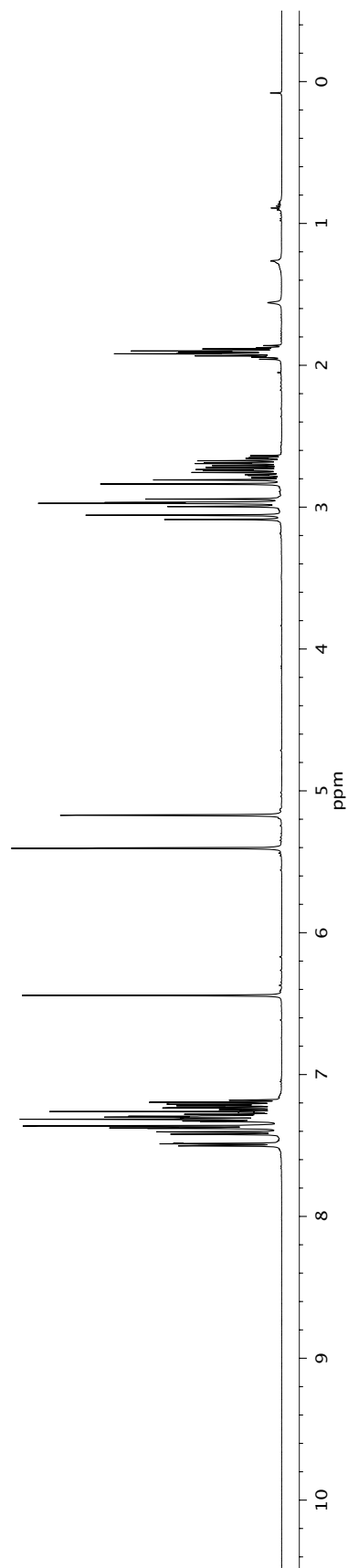
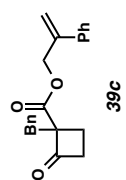


Figure A1.61 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **40e**.

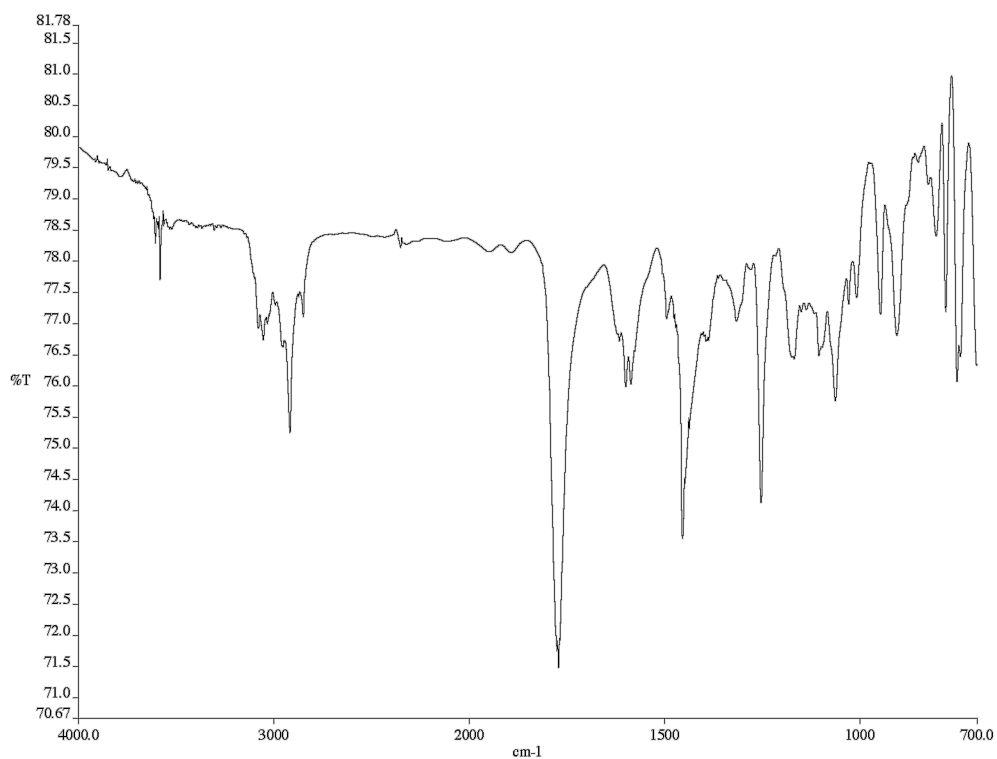


Figure A1.62 Infrared spectrum (thin film/NaCl) of compound **40e**.

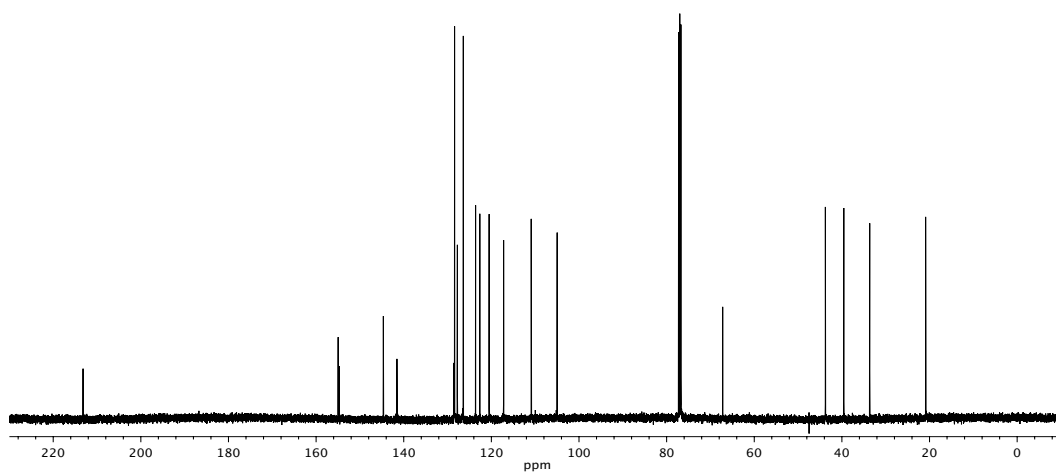


Figure A1.63 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **40e**.

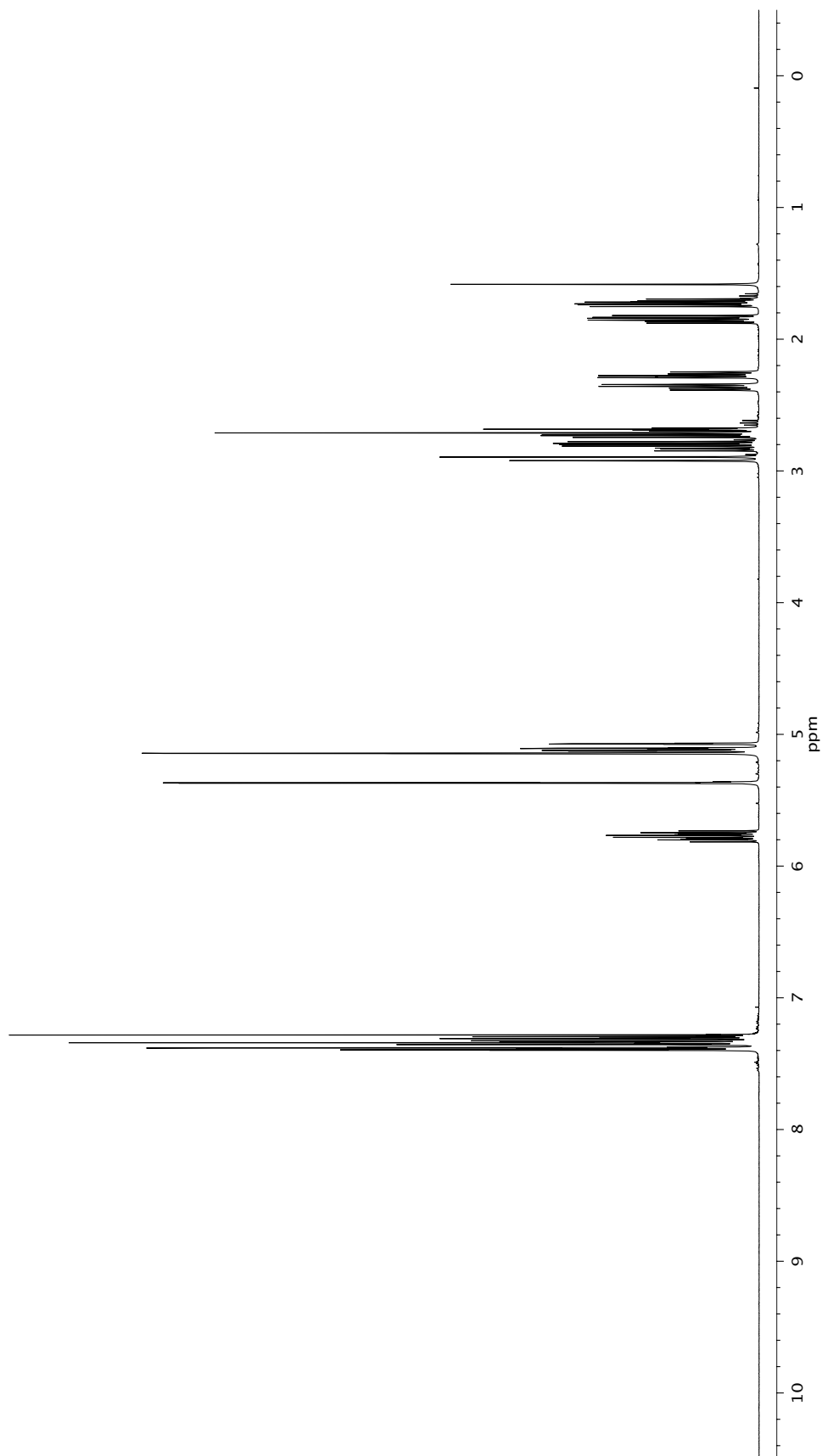
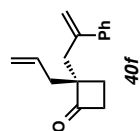


Figure A1.64  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) of compound 40f.

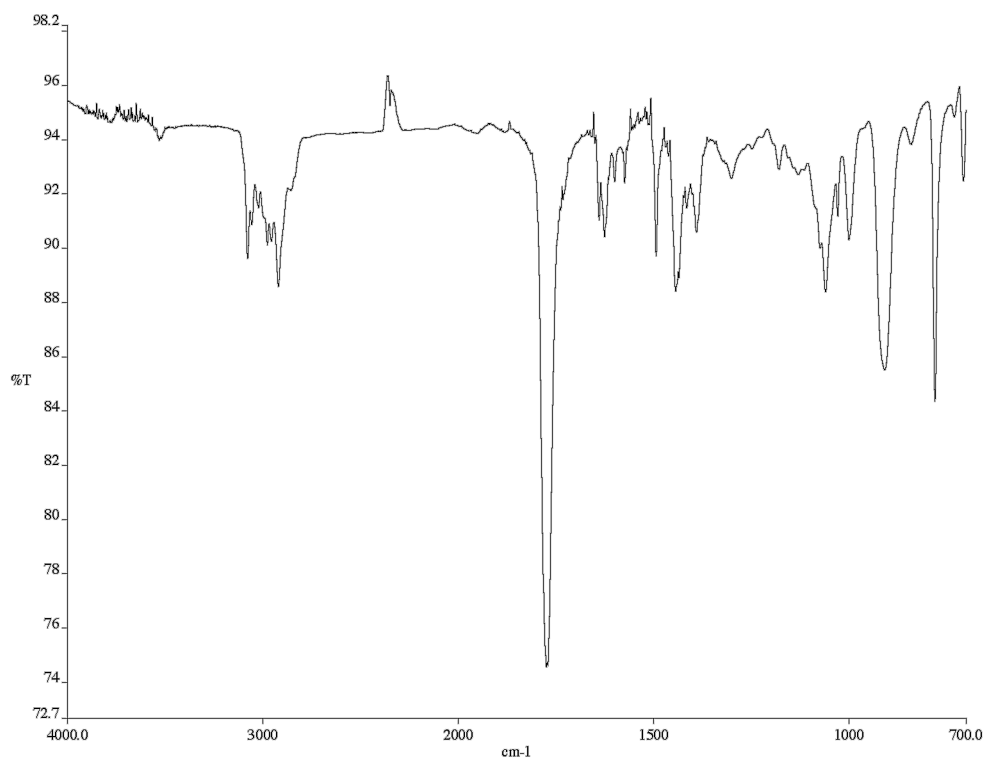


Figure A1.65 Infrared spectrum (thin film/NaCl) of compound **40f**.

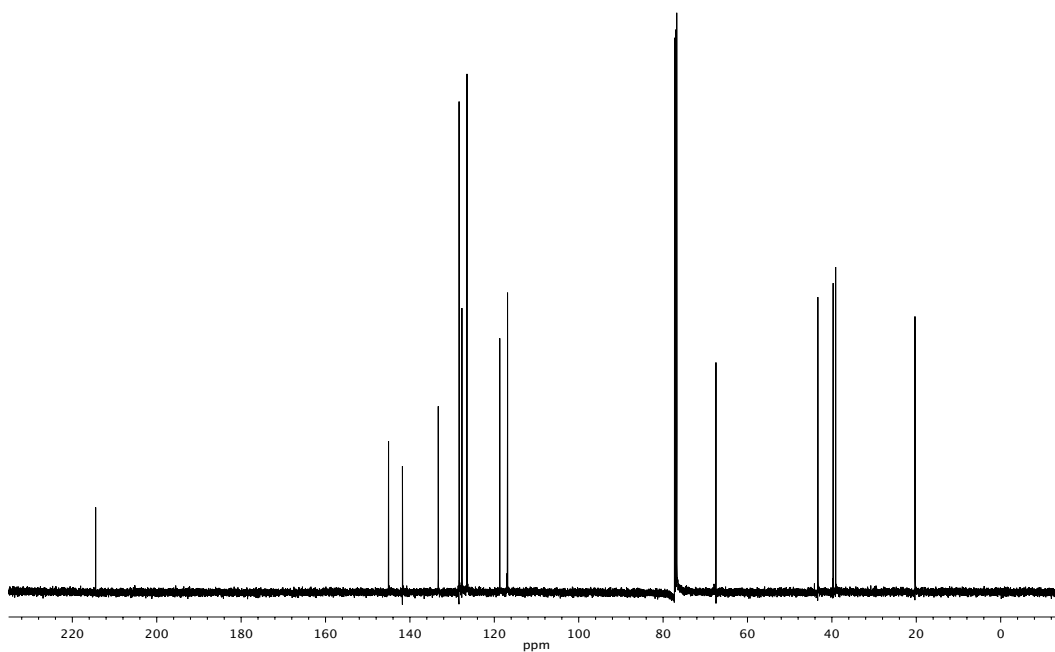


Figure A1.66 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **40f**.

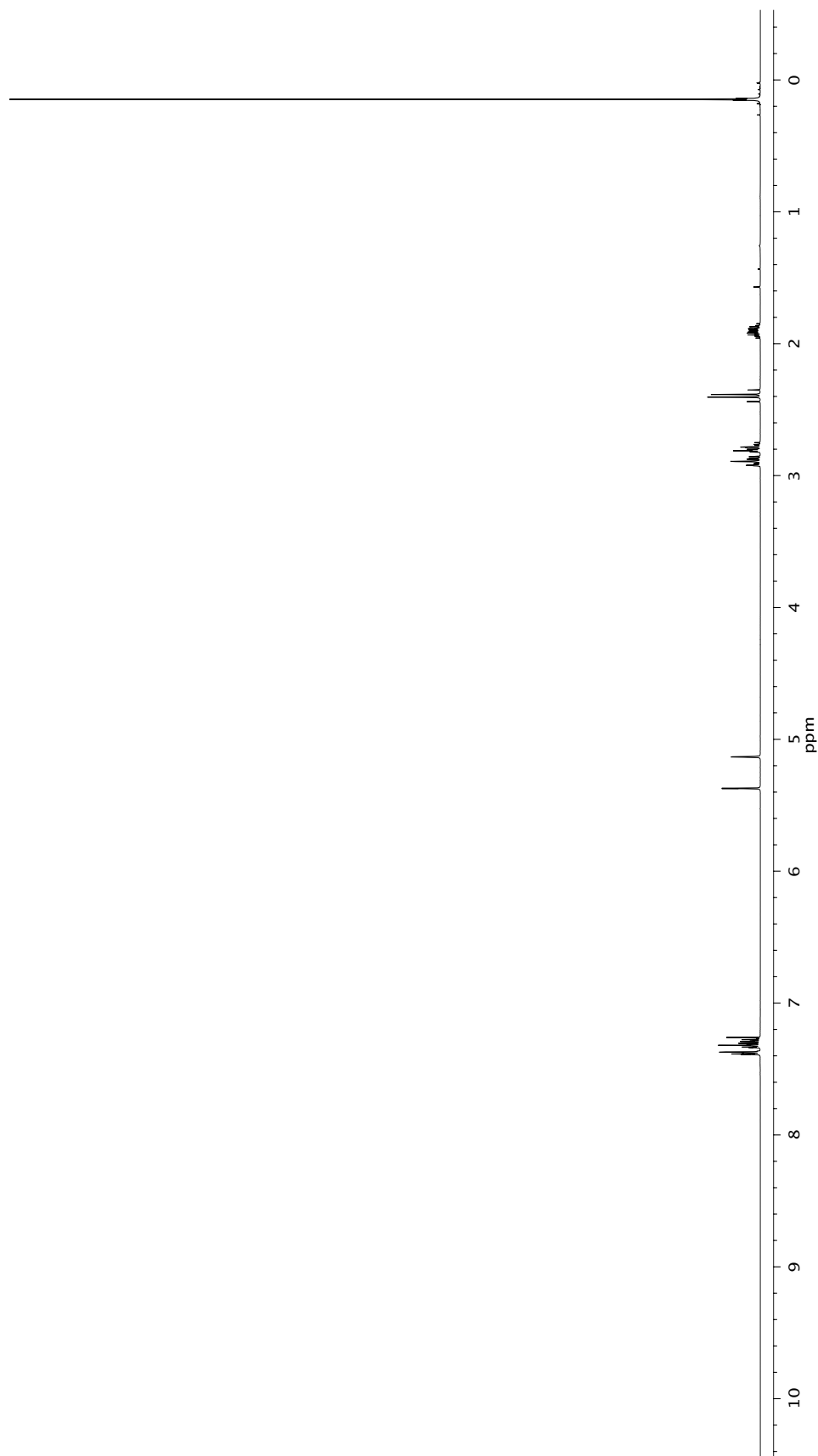
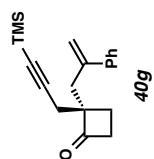


Figure A1.67  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) of compound 40g.

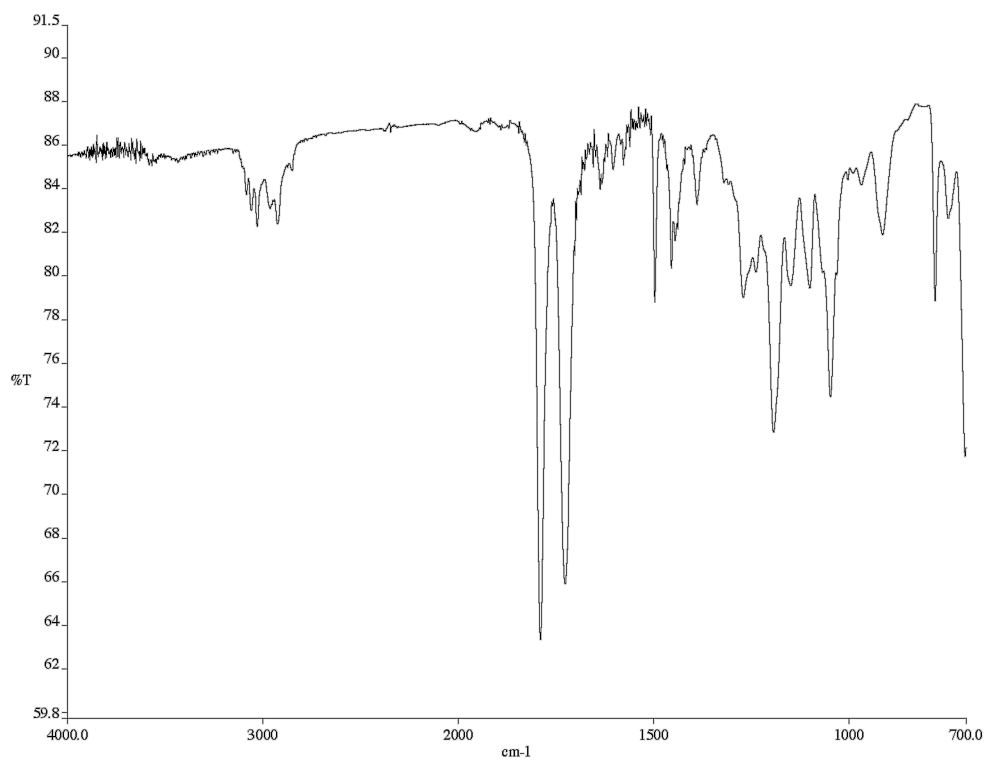


Figure A1.68 Infrared spectrum (thin film/NaCl) of compound **40g**.

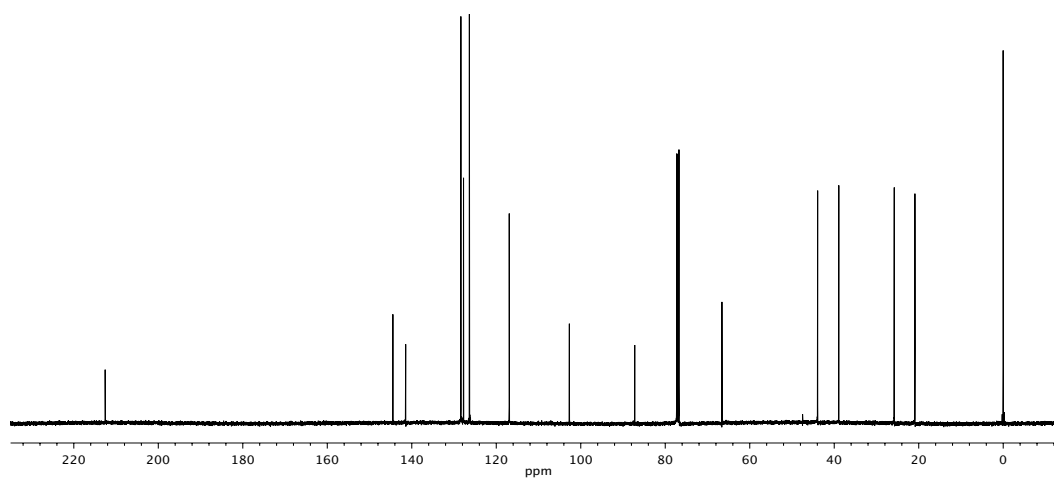


Figure A1.69 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **40g**.

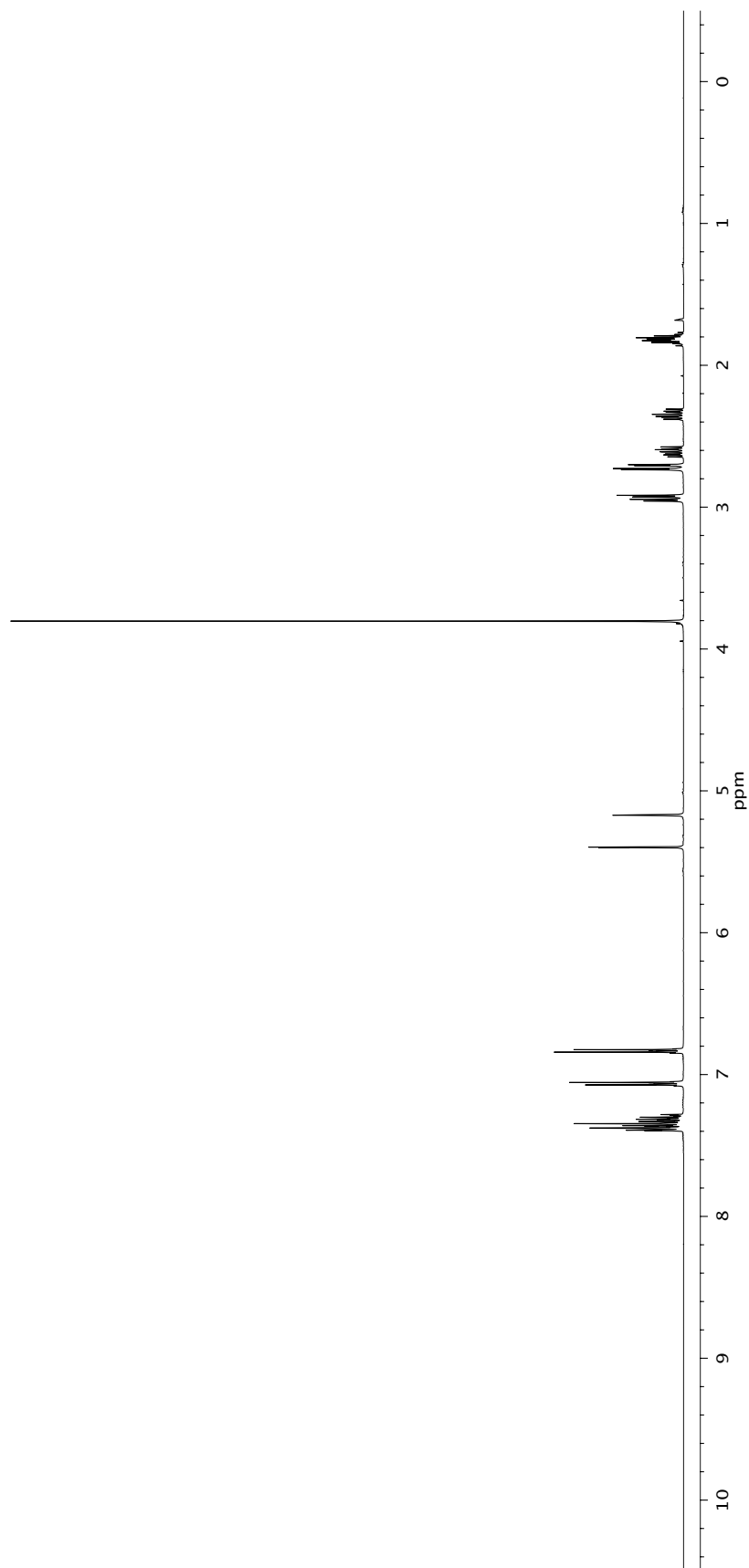
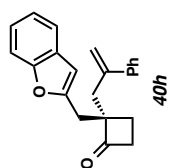


Figure A1.70  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) of compound 40h.



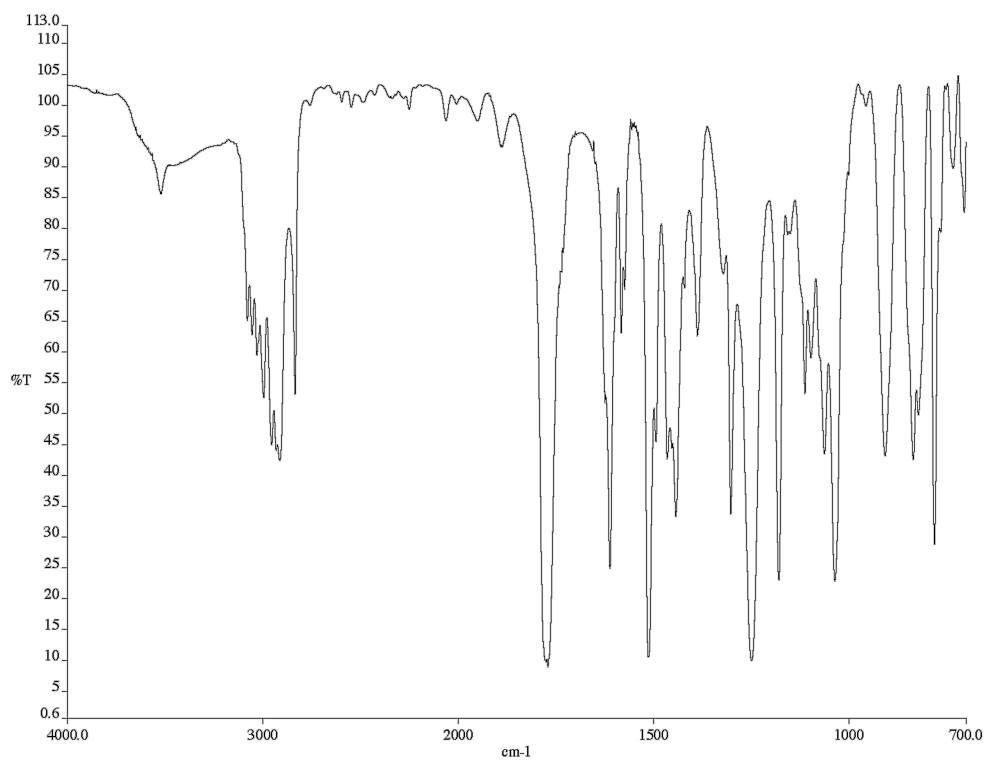


Figure A1.71 Infrared spectrum (thin film/NaCl) of compound **40h**.

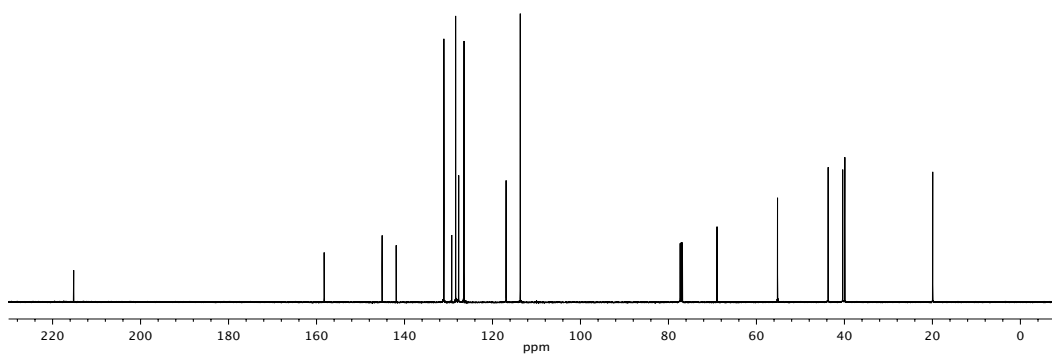


Figure A1.72 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **40h**.

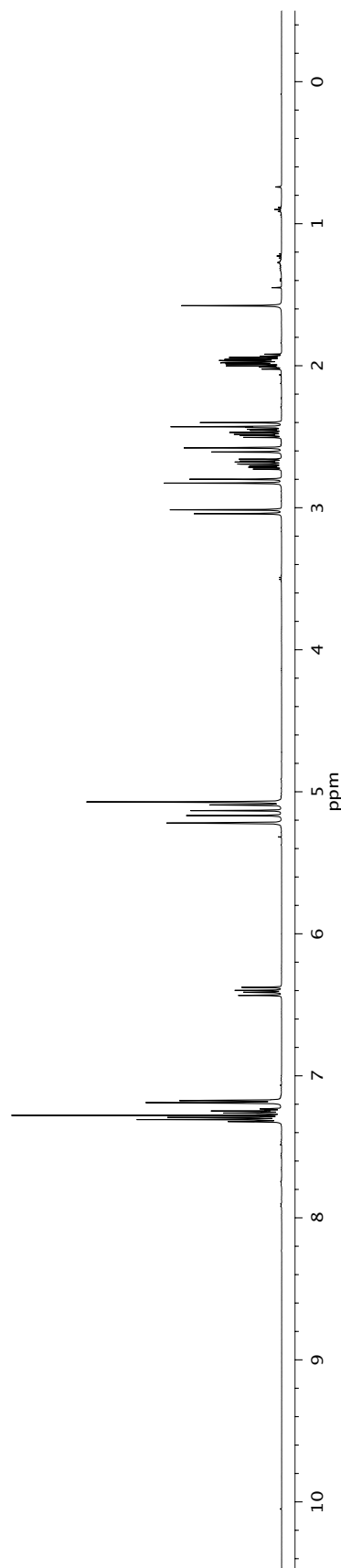
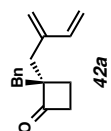


Figure A1.73 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 42a.

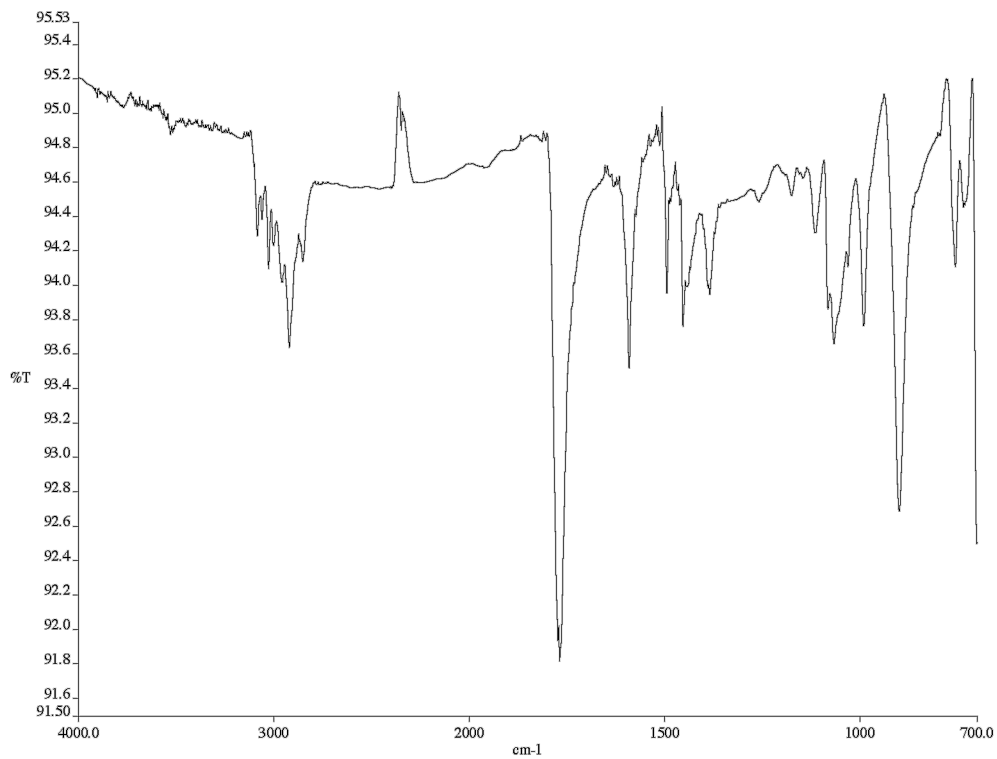


Figure A1.74 Infrared spectrum (thin film/NaCl) of compound **42a**.

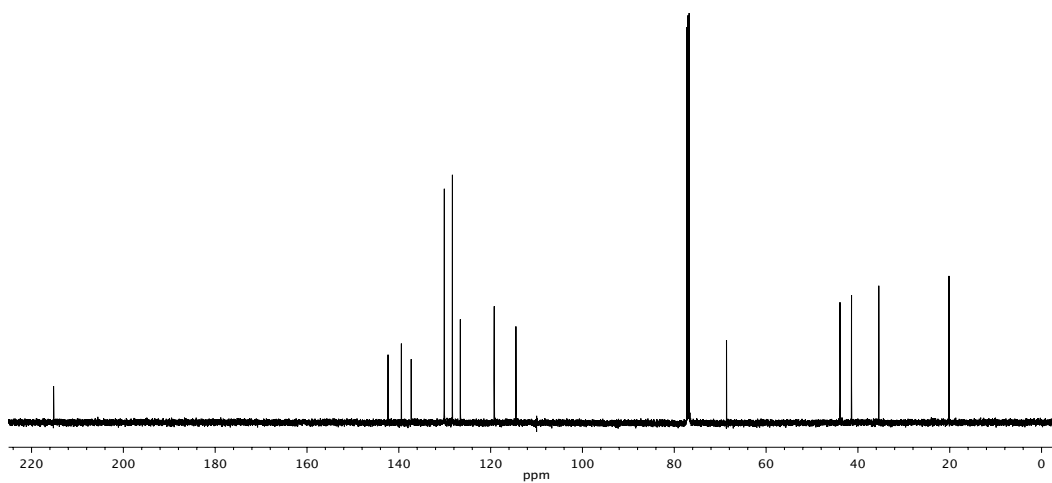


Figure A1.75 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **42a**.

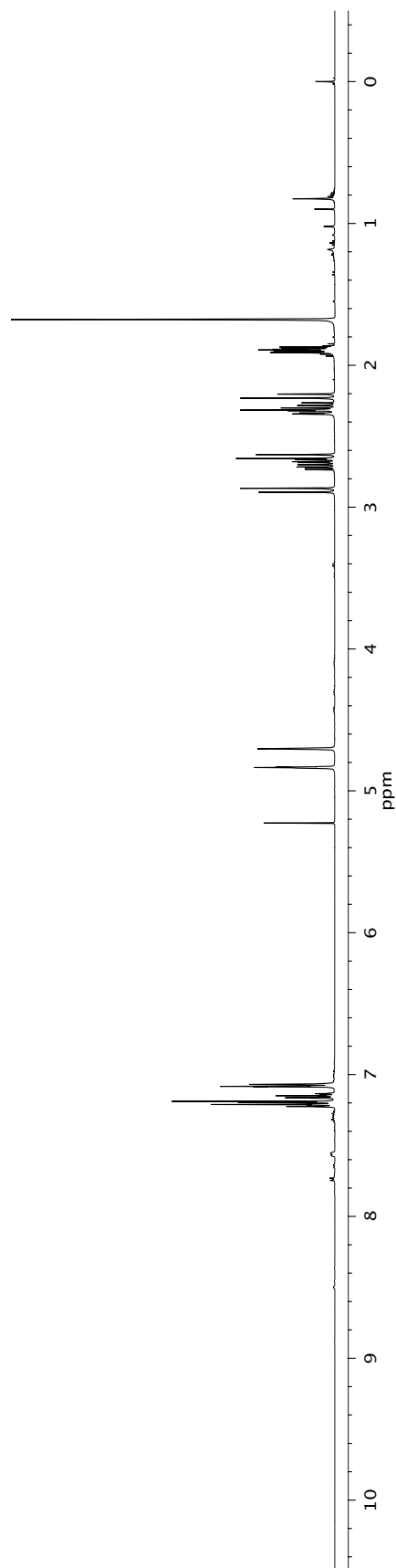
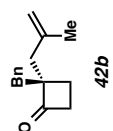


Figure A1.76 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 42b.

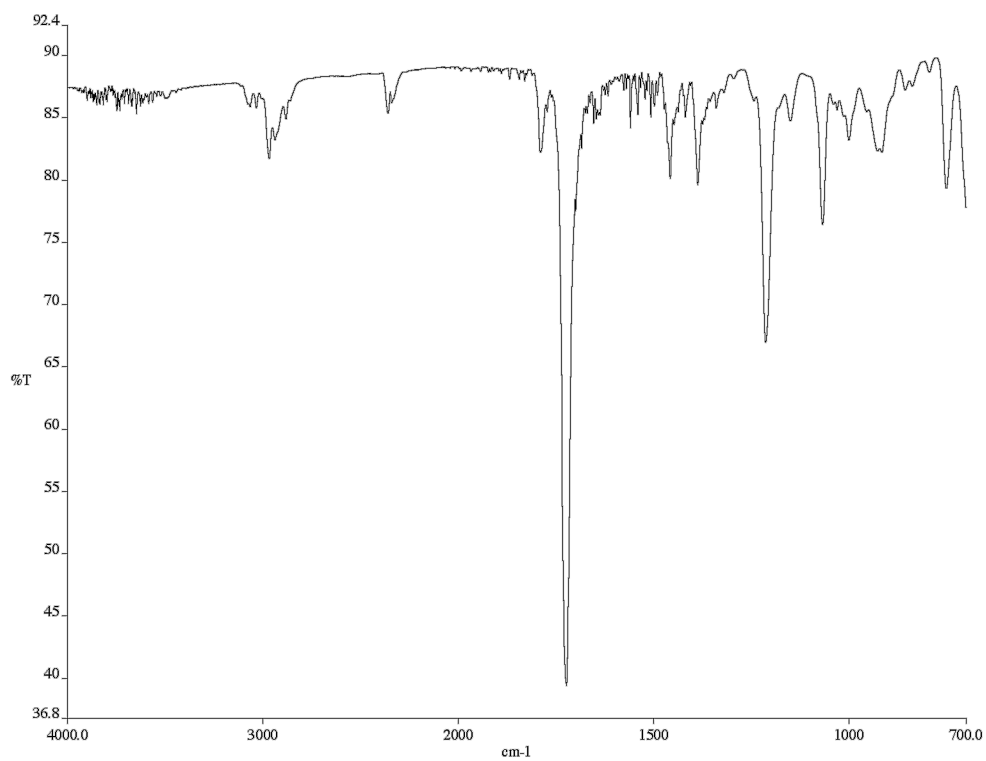


Figure A1.77 Infrared spectrum (thin film/NaCl) of compound **42b**.

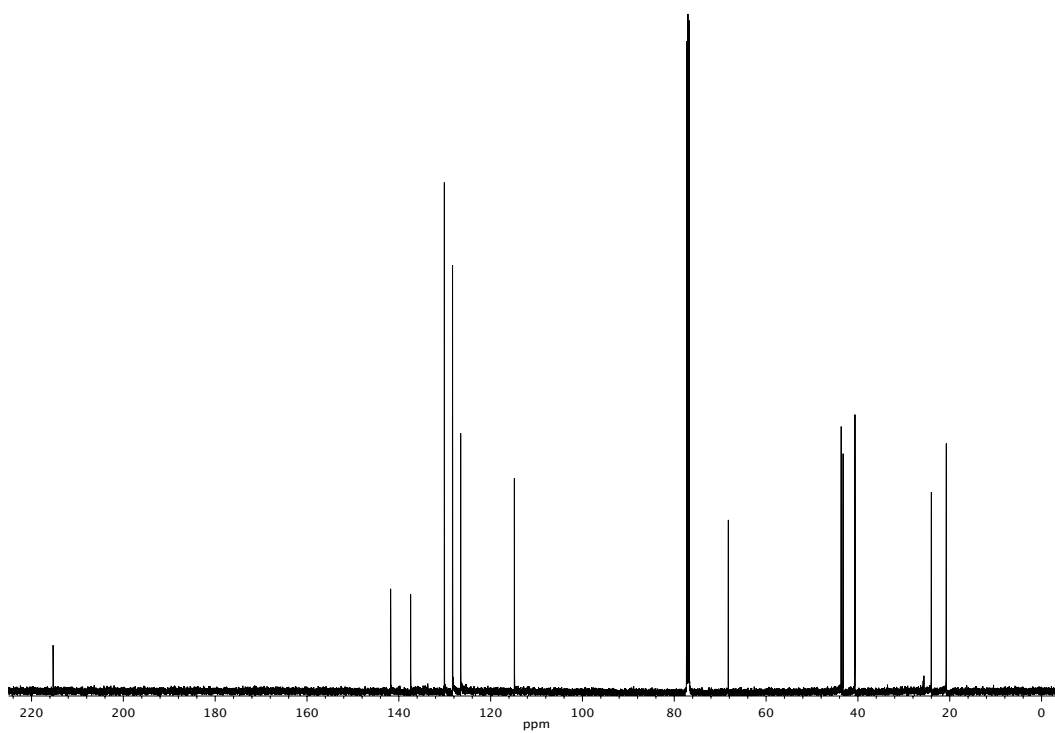


Figure A1.78 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **42b**.

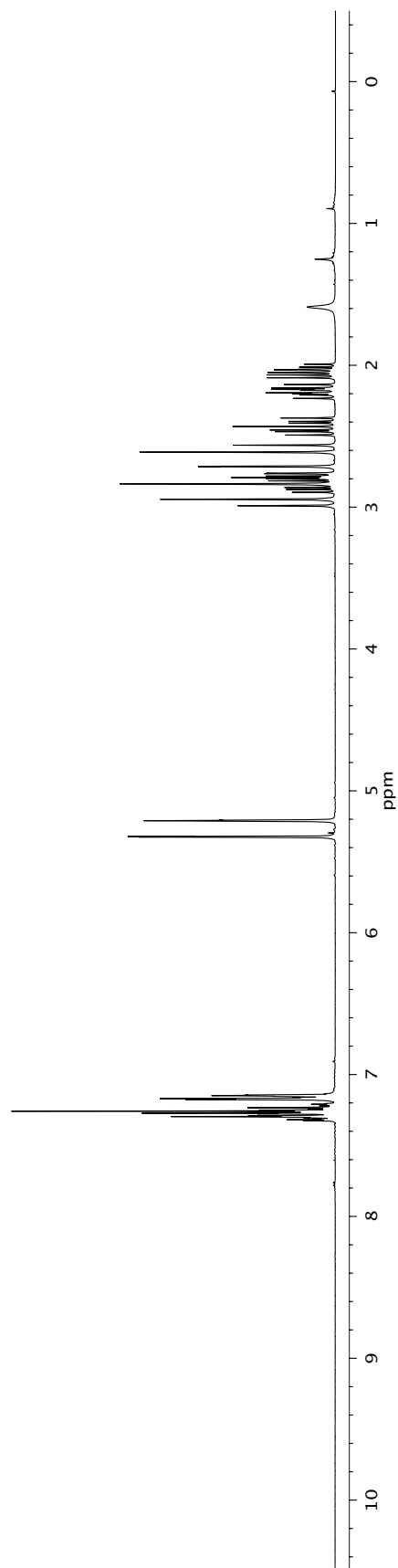
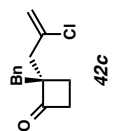


Figure A1.79 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **42c**.

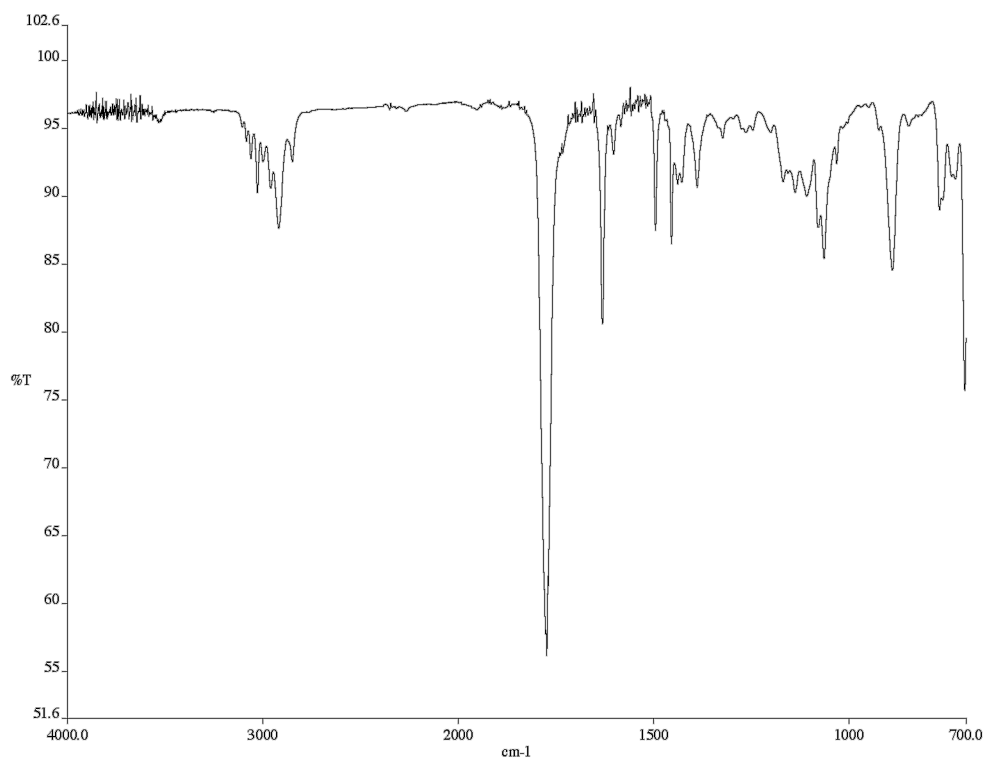


Figure A1.80 Infrared spectrum (thin film/NaCl) of compound **42c**.

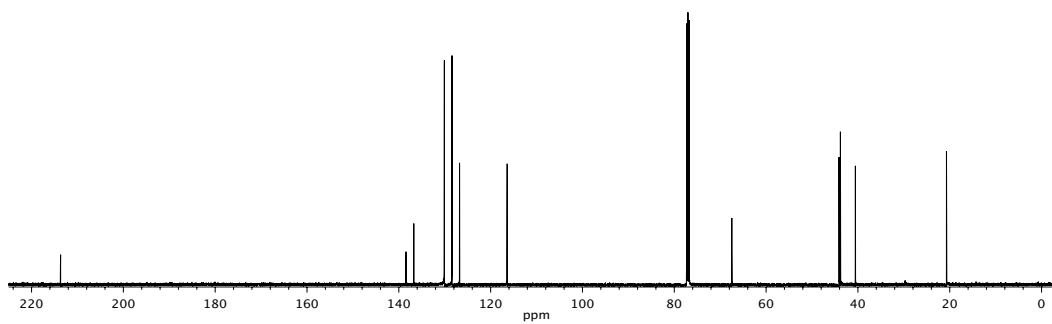


Figure A1.81 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **42c**.

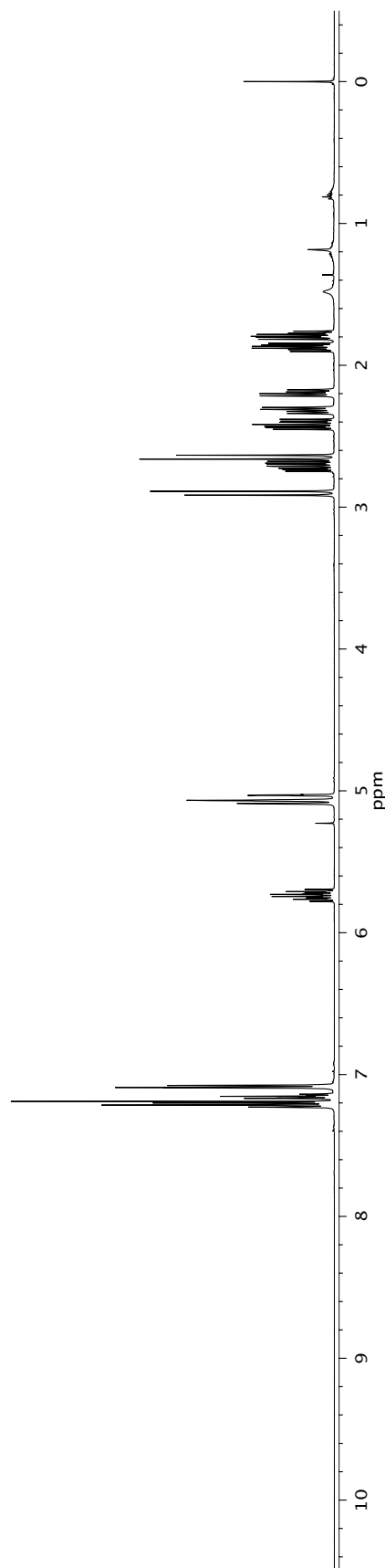
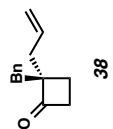


Figure A1.82 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound **38**.



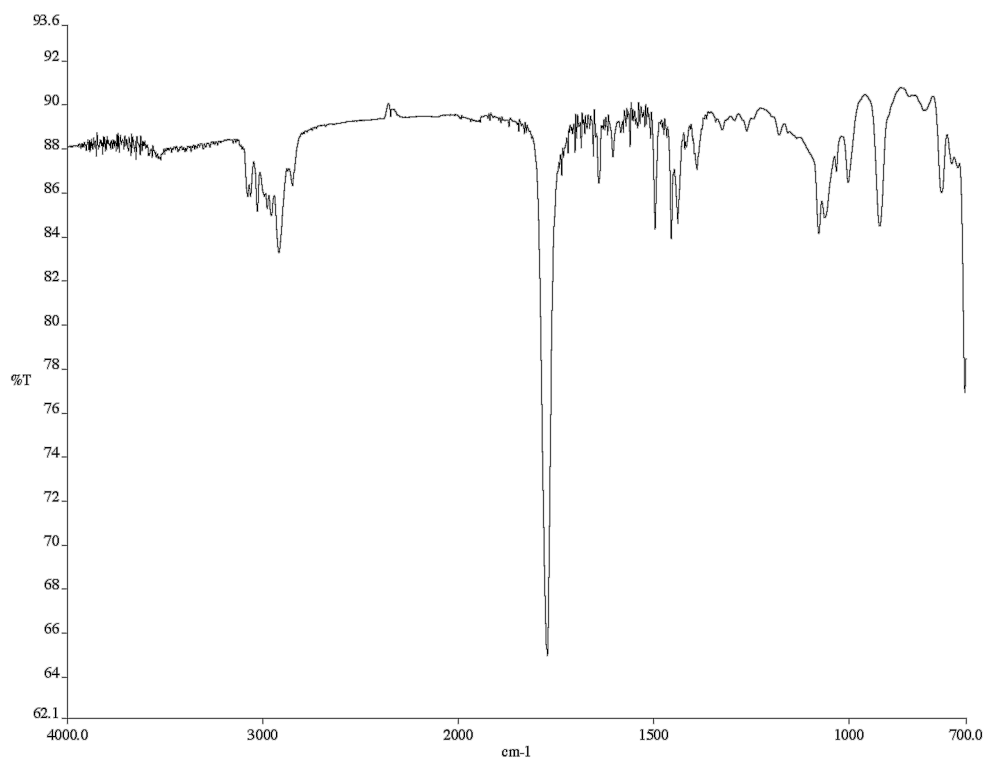


Figure A1.83 Infrared spectrum (thin film/NaCl) of compound **38**.

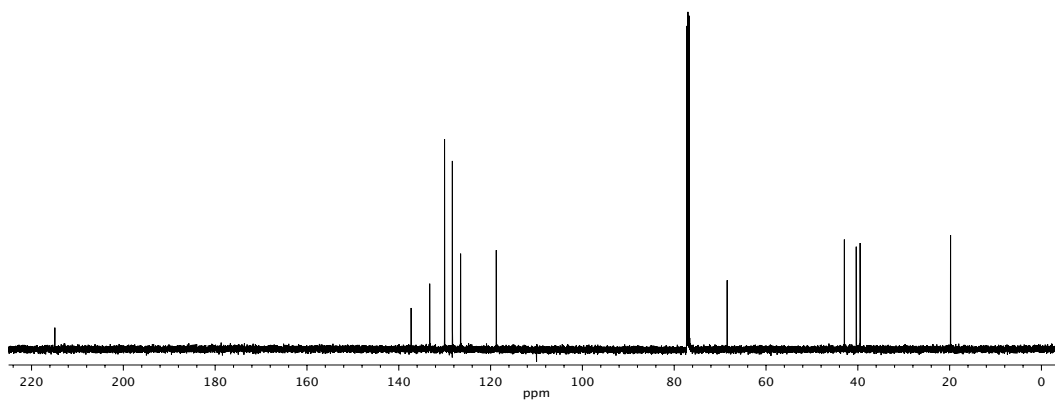


Figure A1.84 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **38**.

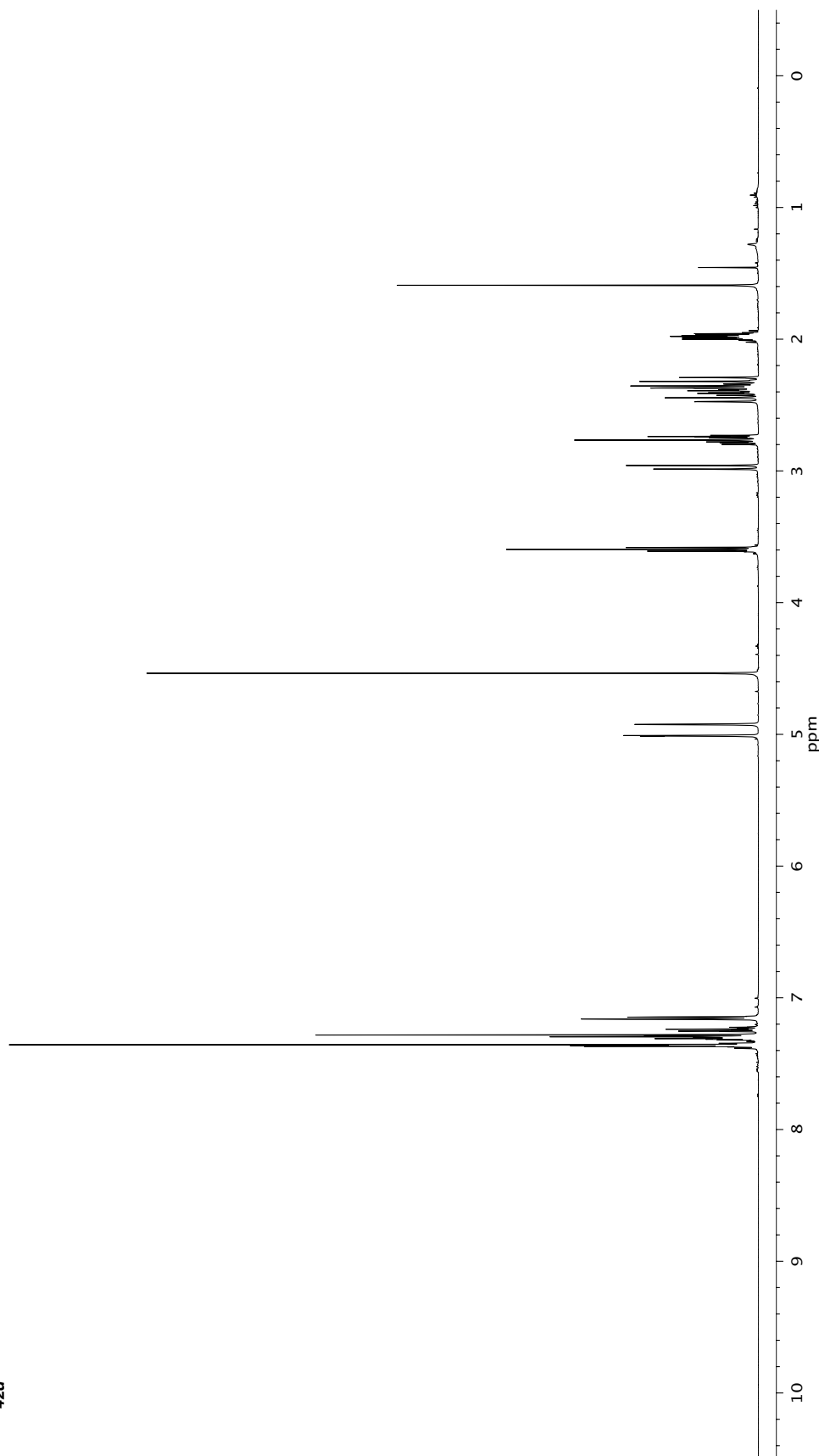
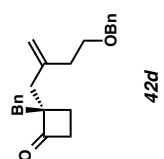


Figure A1.85 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 42d.

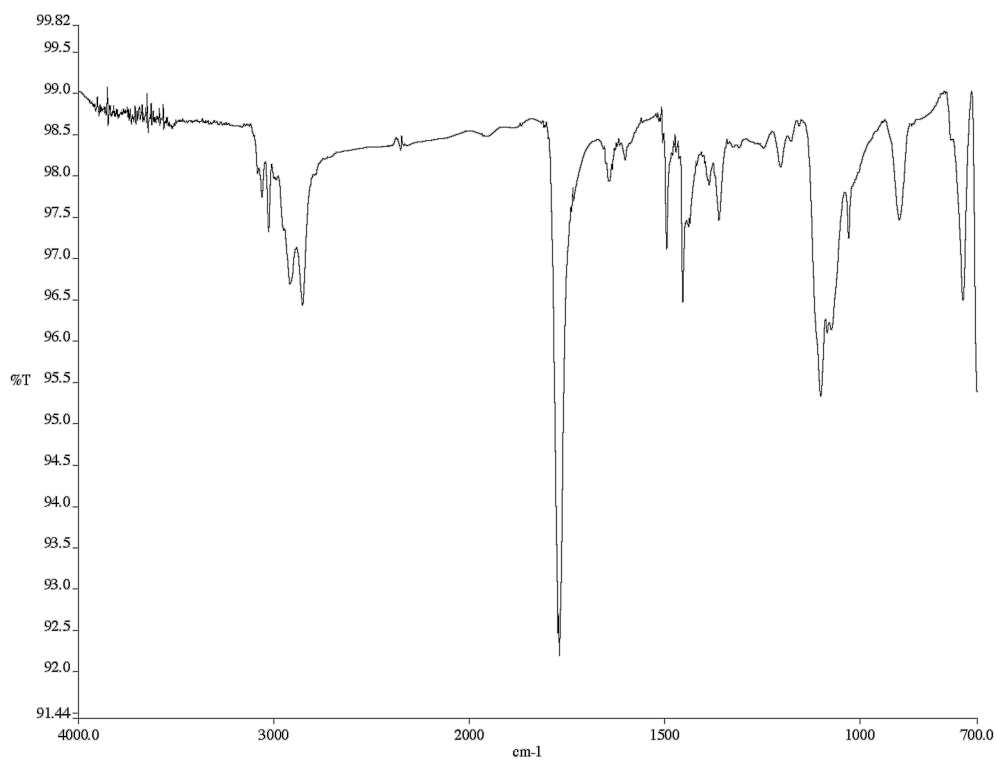


Figure A1.86 Infrared spectrum (thin film/NaCl) of compound **42d**.

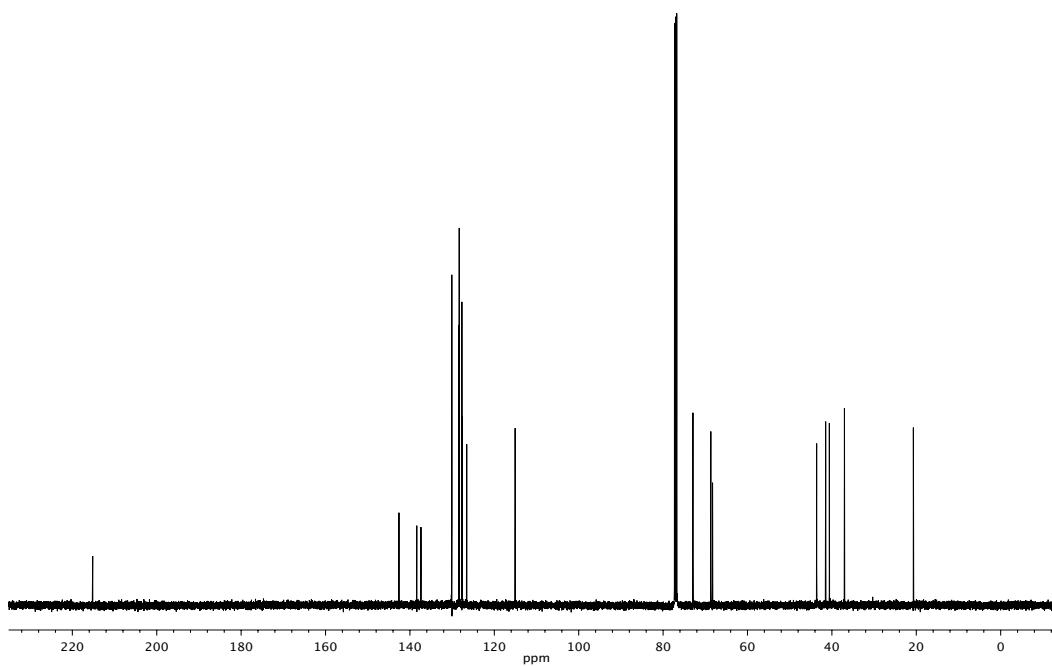
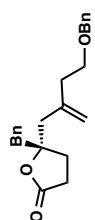
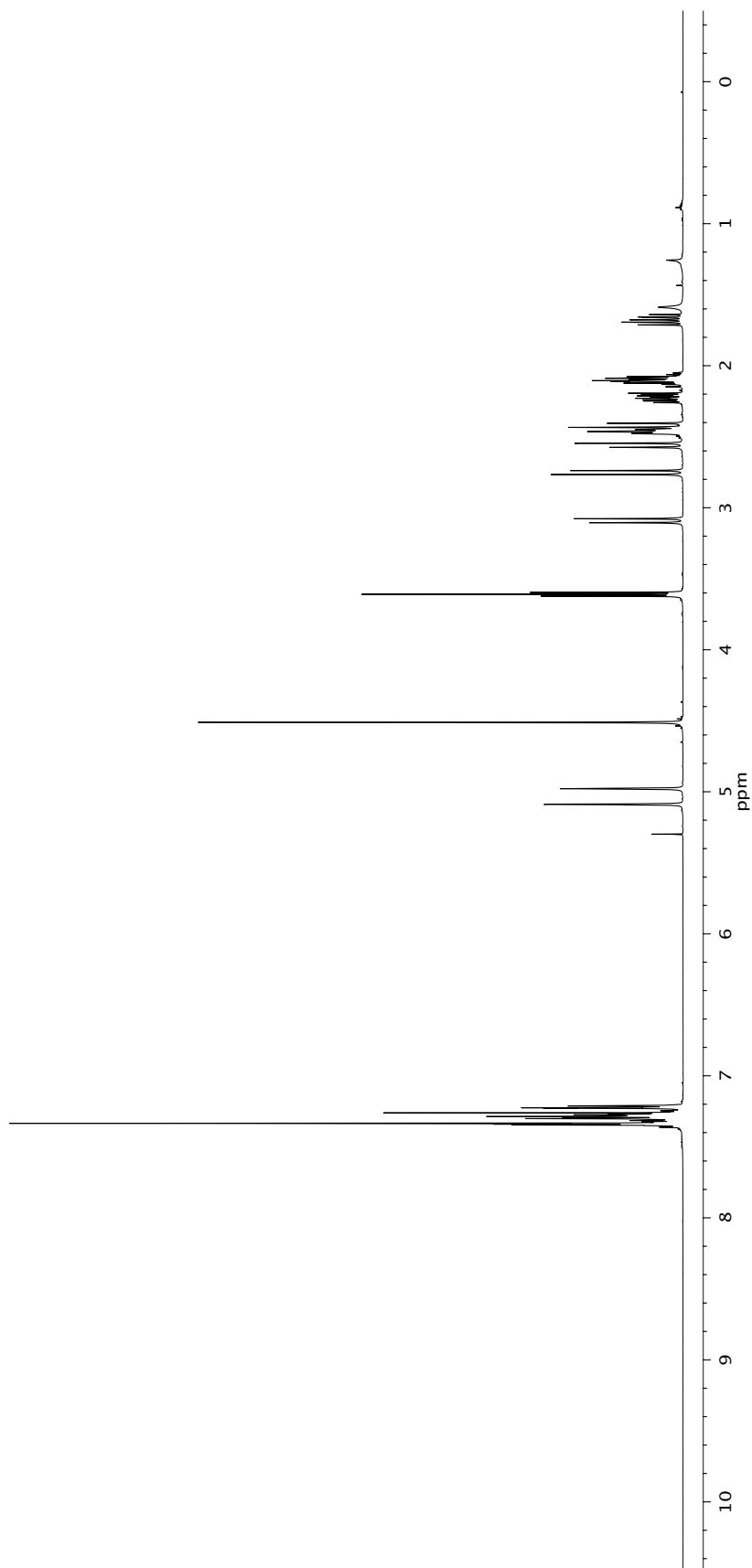


Figure A1.87 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **42d**.



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Figure A1.88  $^1\text{H NMR}$  (500 MHz,  $\text{CDCl}_3$ ) of compound 49.

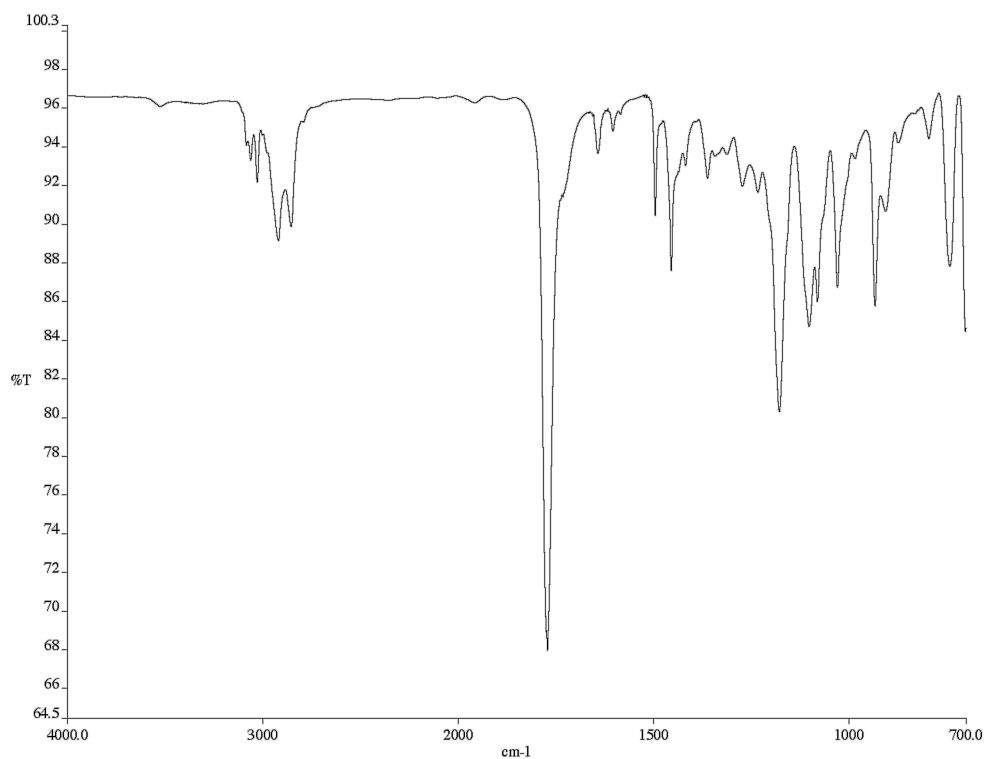


Figure A1.89 Infrared spectrum (thin film/NaCl) of compound 49.

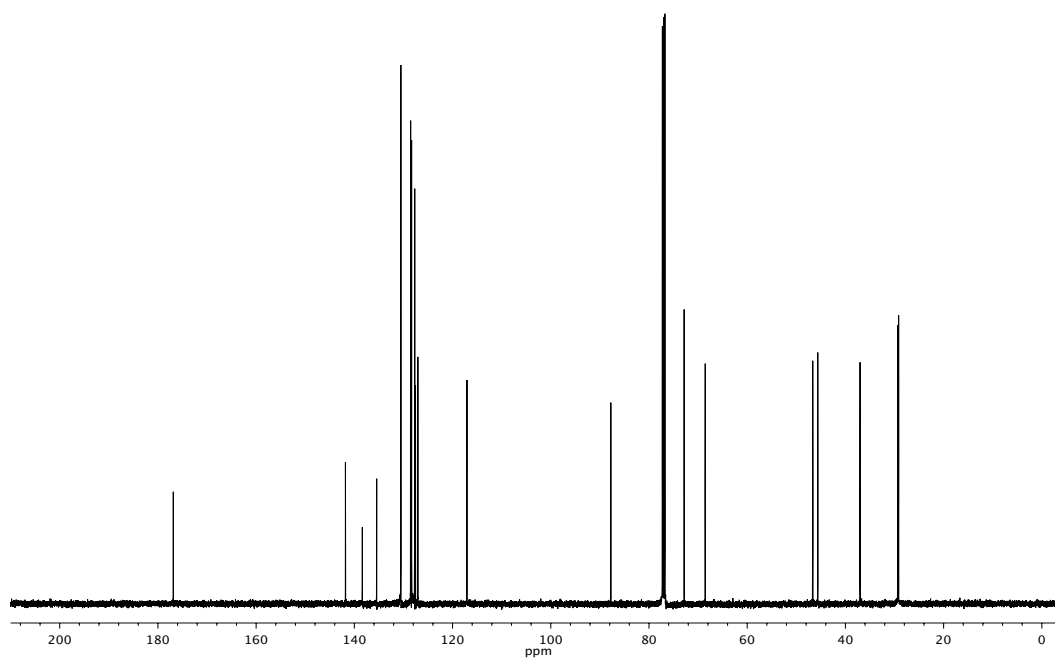


Figure A1.90 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound 49.

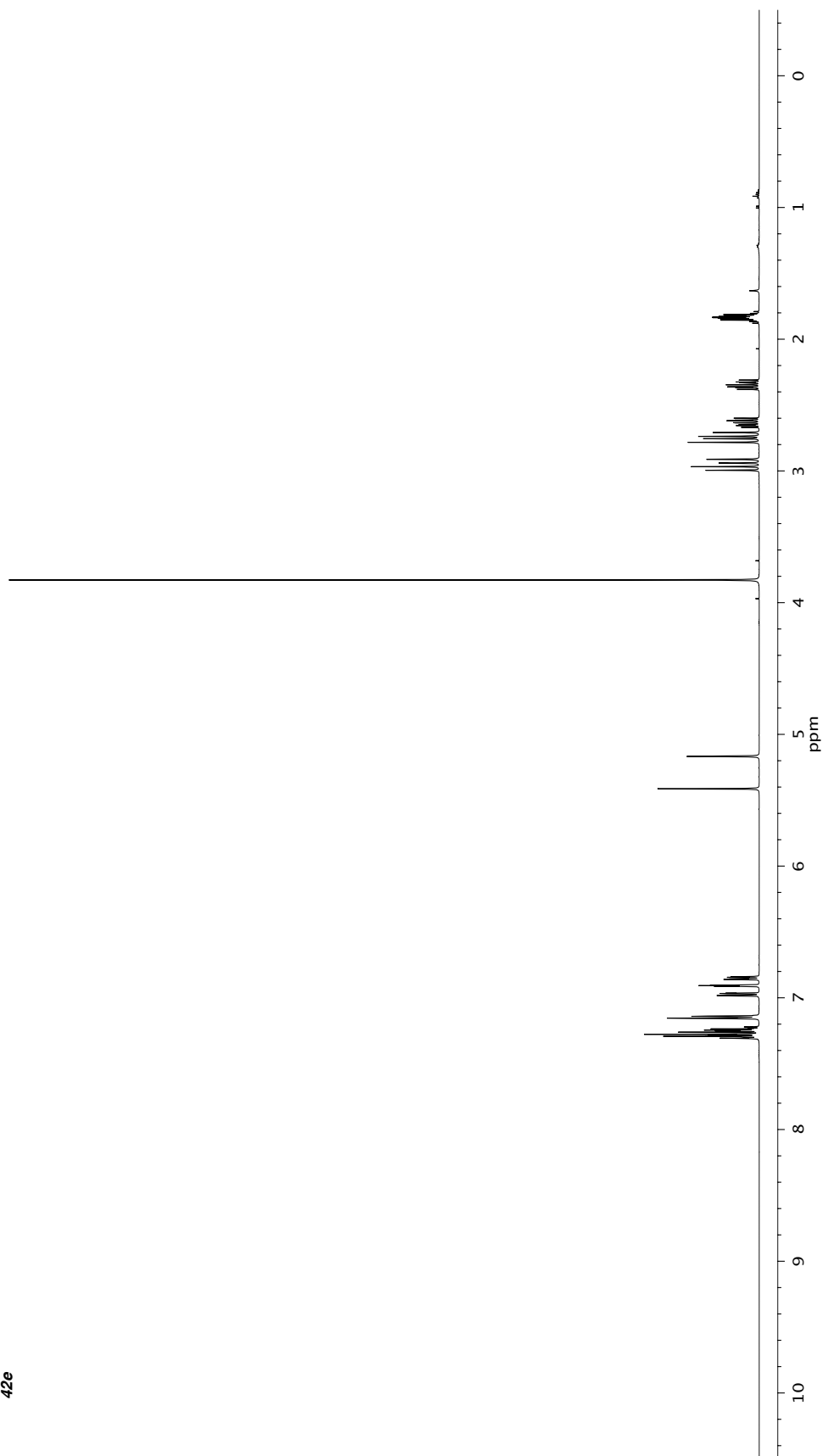
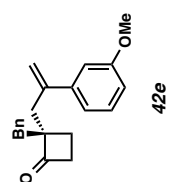


Figure A1.91 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 42e.

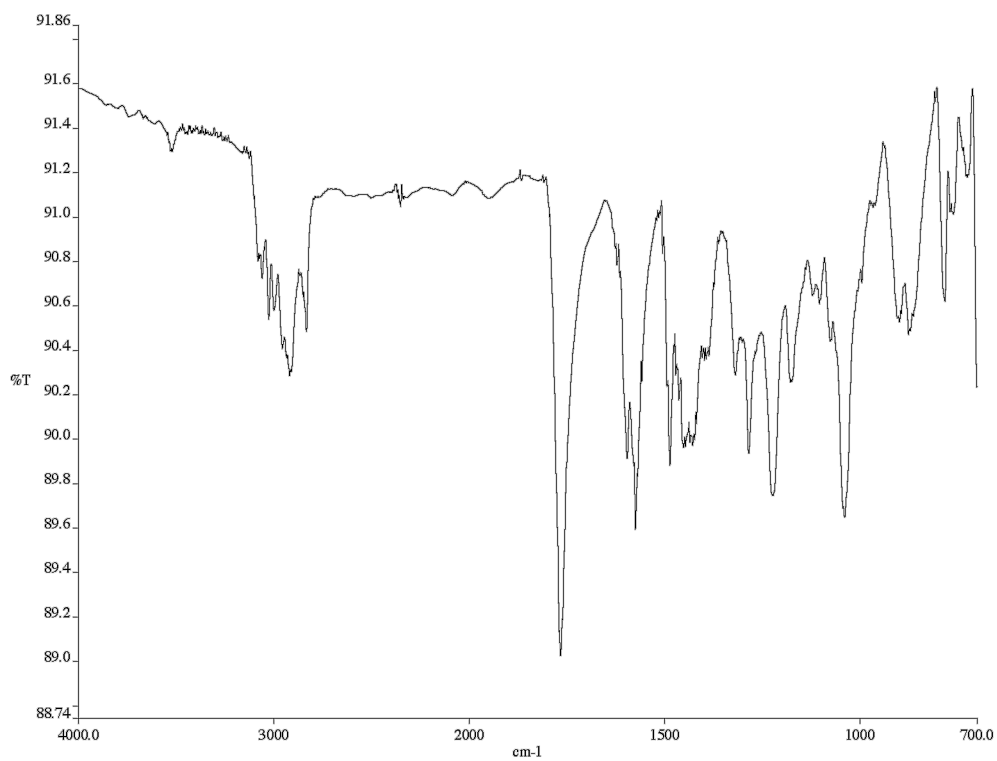


Figure A1.92 Infrared spectrum (thin film/NaCl) of compound **42e**.

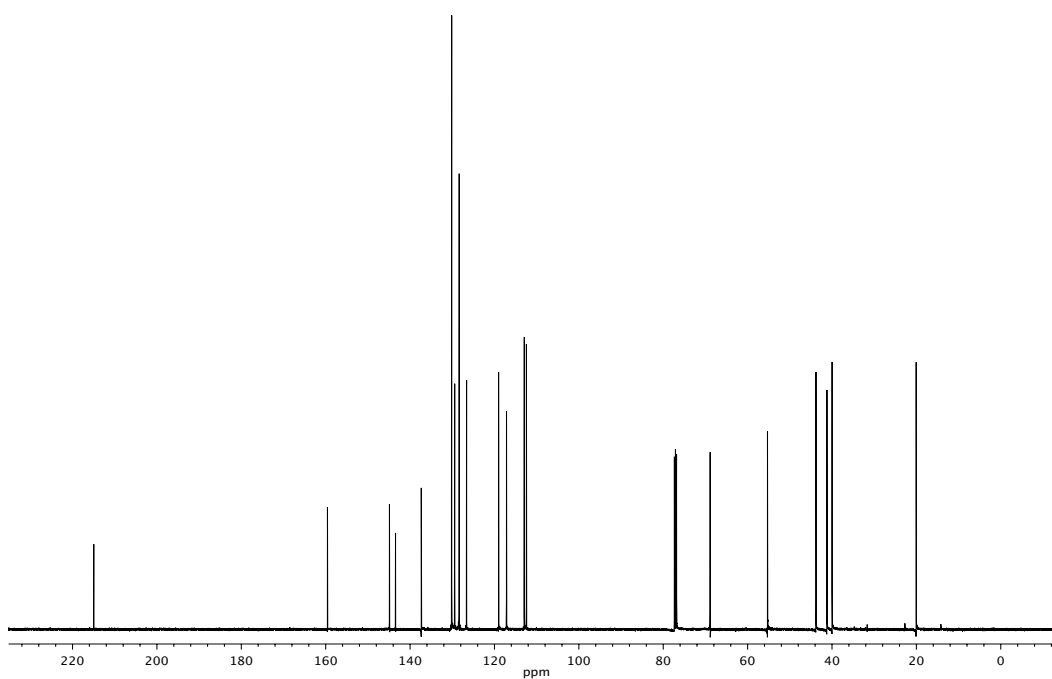


Figure A1.93 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **42e**.

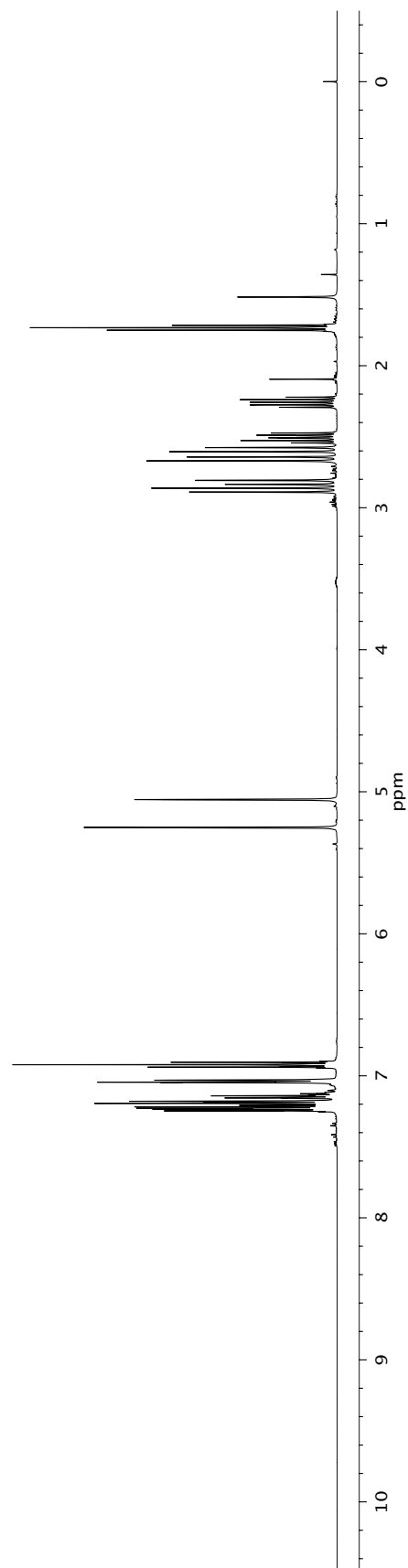
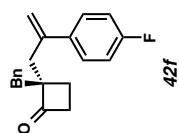


Figure A1.94 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 42f.



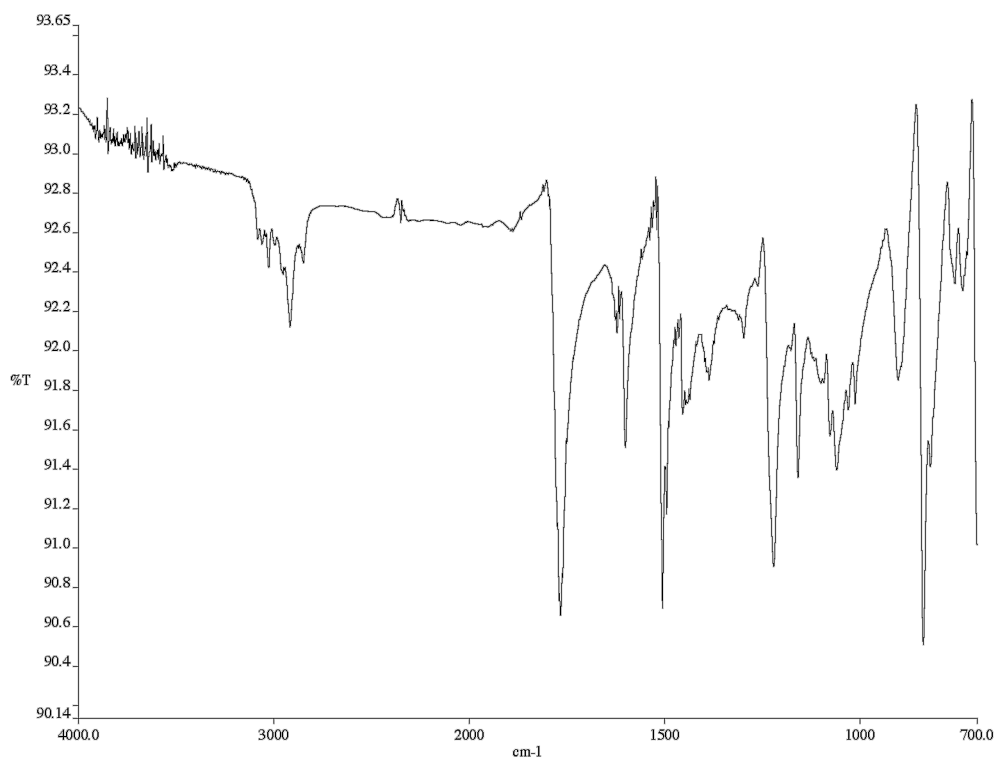


Figure A1.95 Infrared spectrum (thin film/NaCl) of compound **42f**.

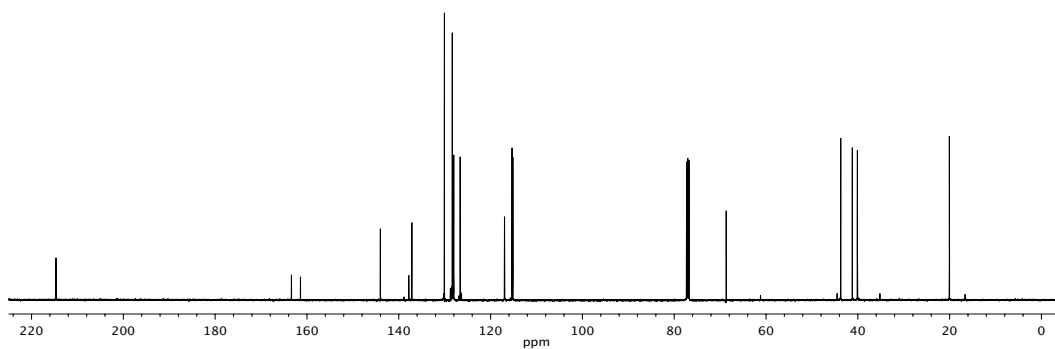


Figure A1.96 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **42f**.

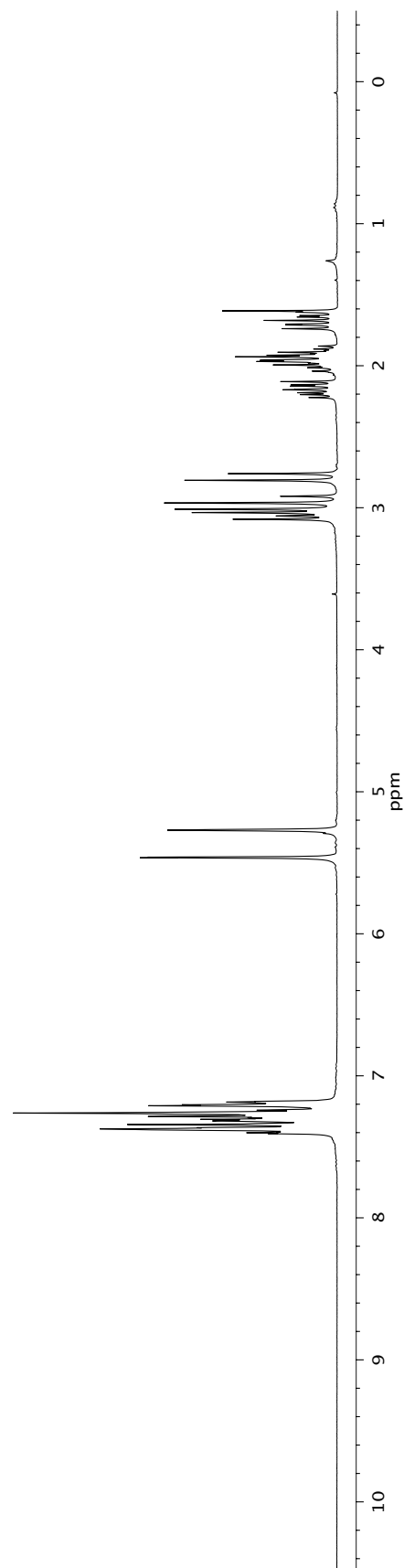
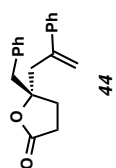


Figure A1.97 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 44.

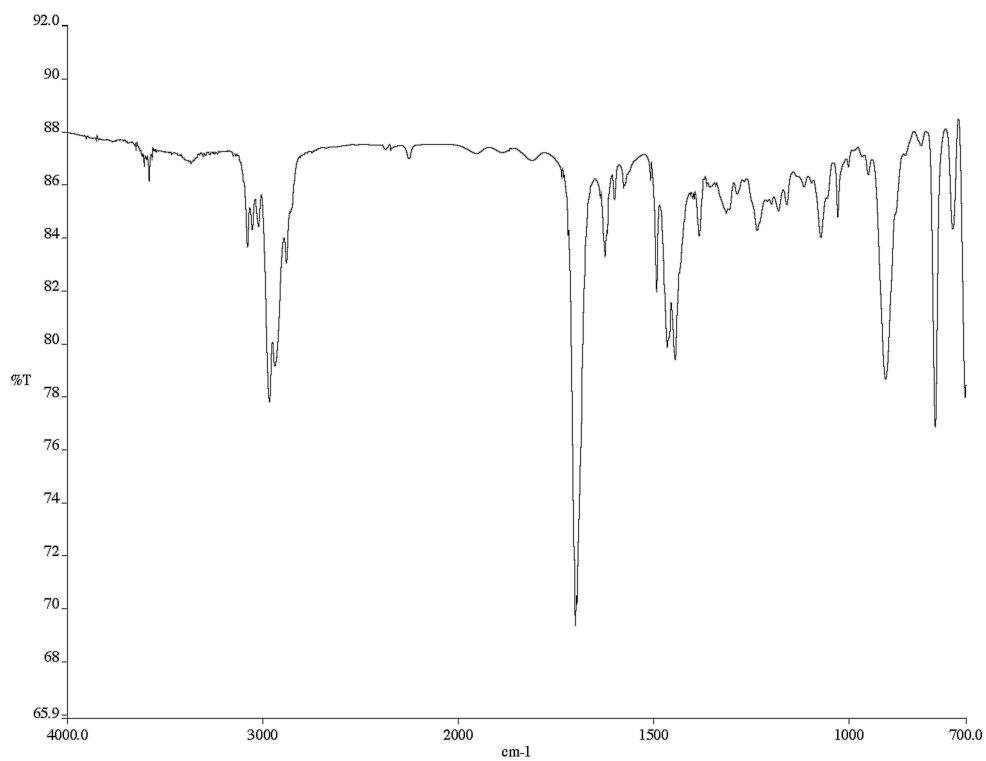


Figure A1.98 Infrared spectrum (thin film/NaCl) of compound 44.

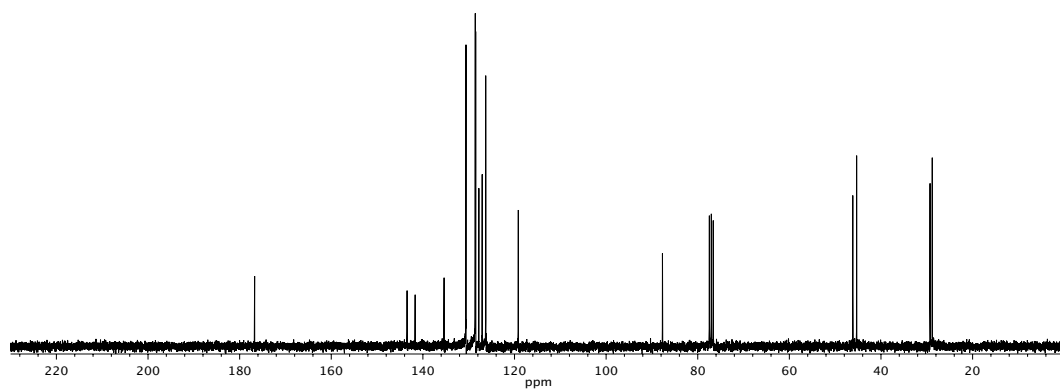
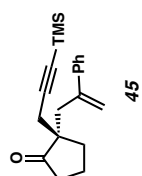


Figure A1.99 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound 44.



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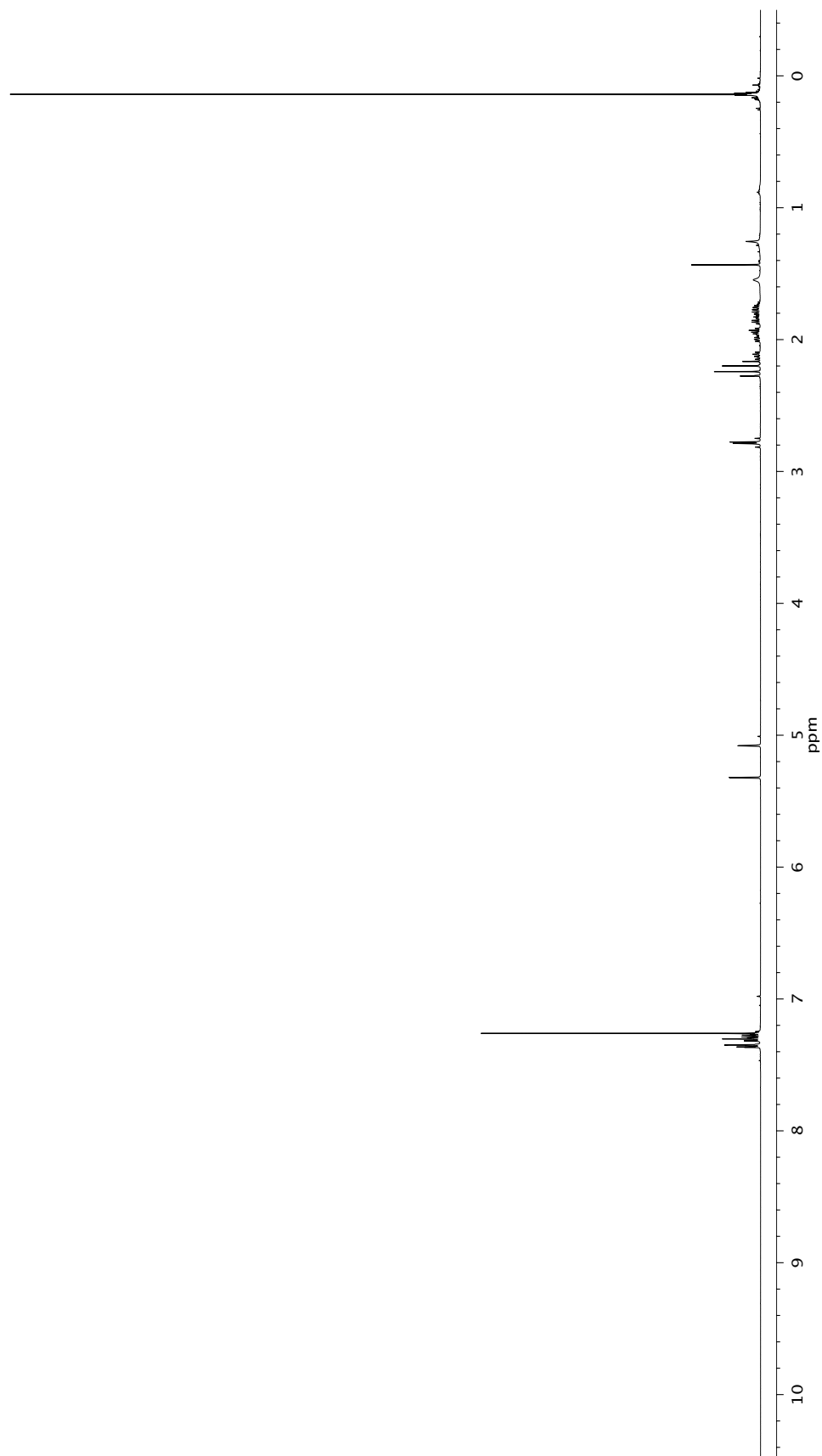


Figure A1.100 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 45.

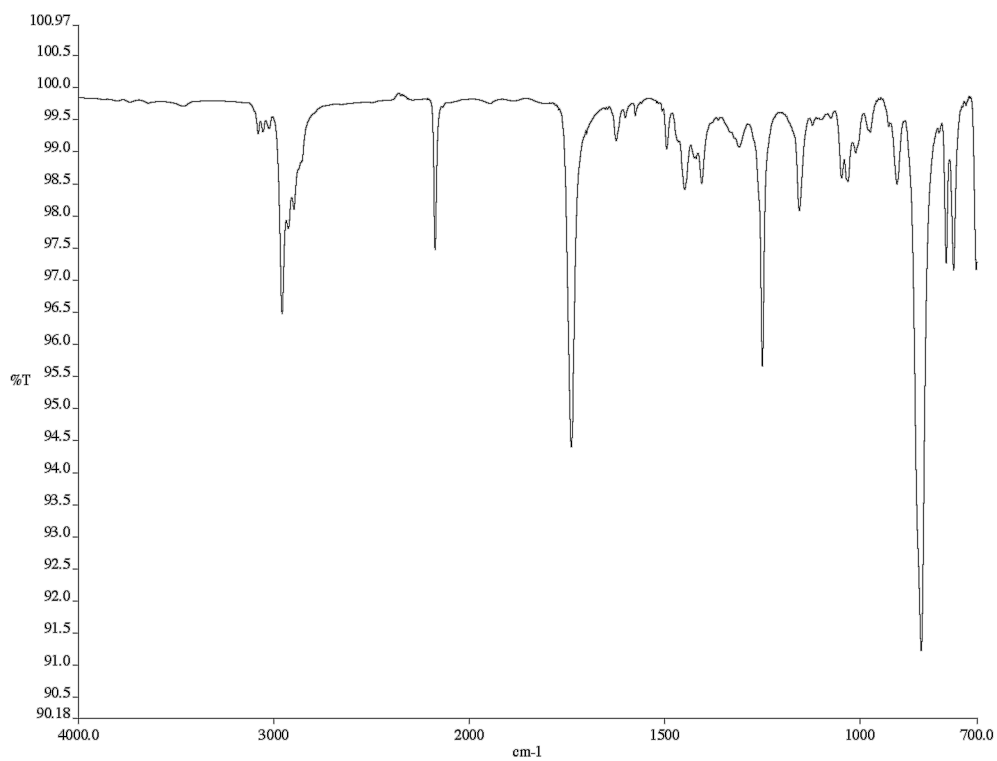


Figure A1.101 Infrared spectrum (thin film/NaCl) of compound **45**.

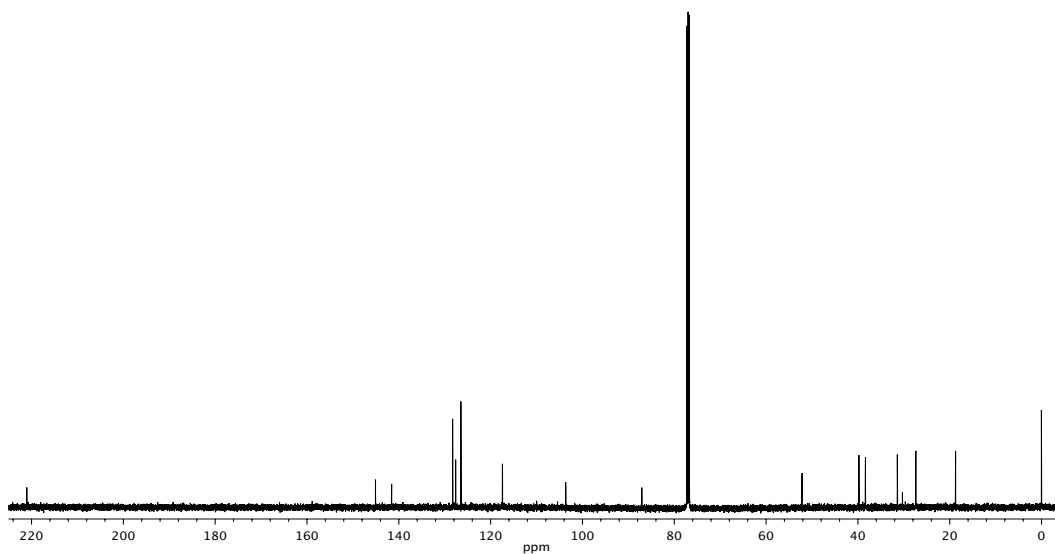
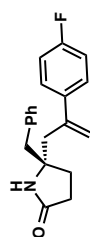


Figure A1.102 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **45**.



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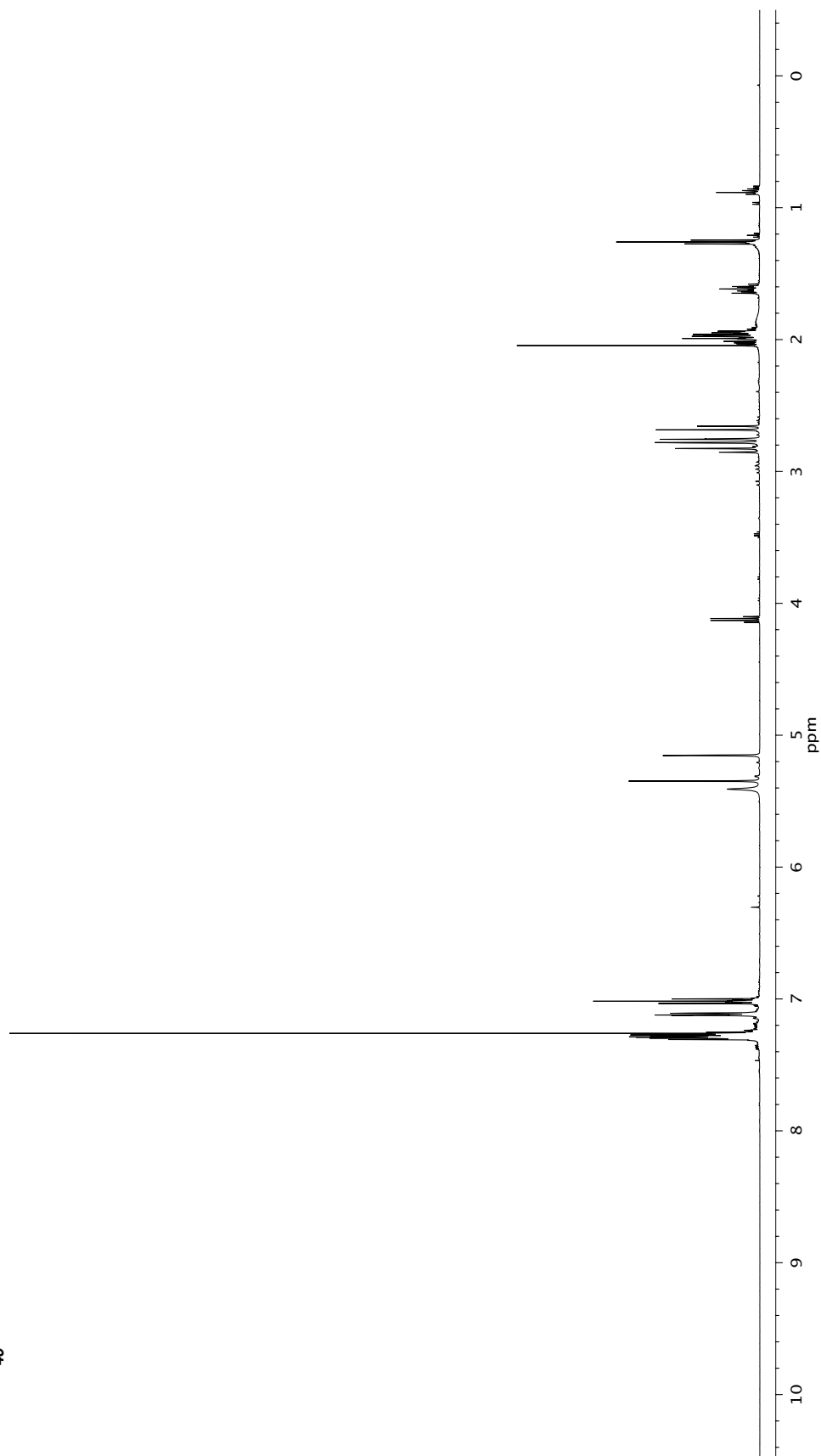


Figure A1.103  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) of compound **46**.

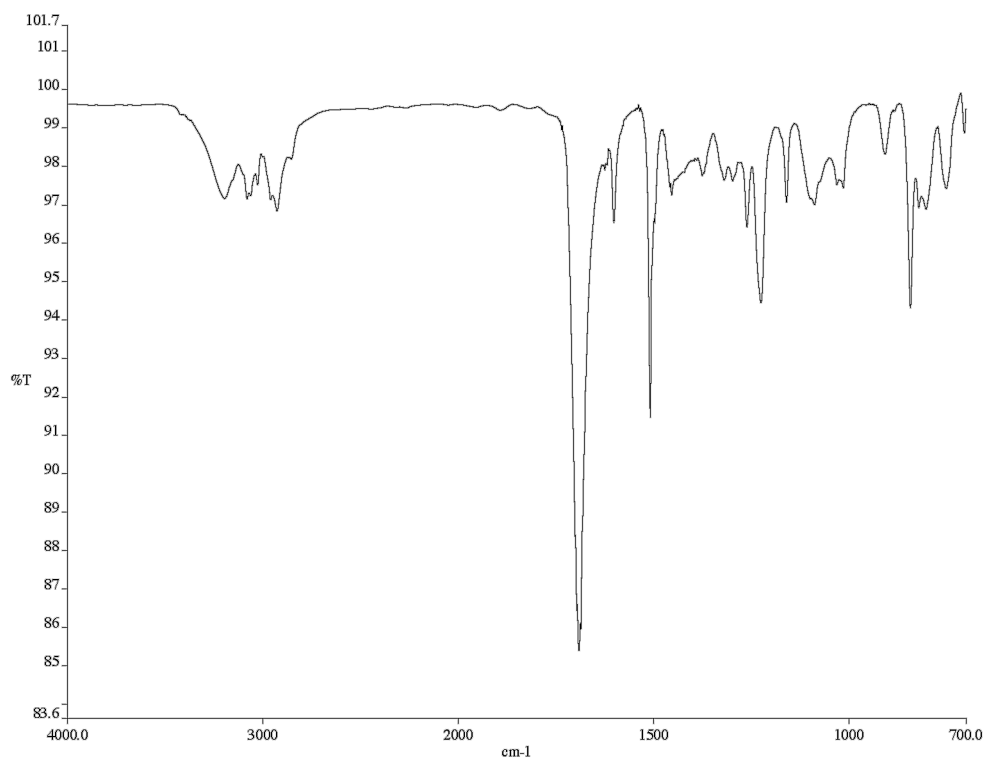


Figure A1.104 Infrared spectrum (thin film/NaCl) of compound **46**.

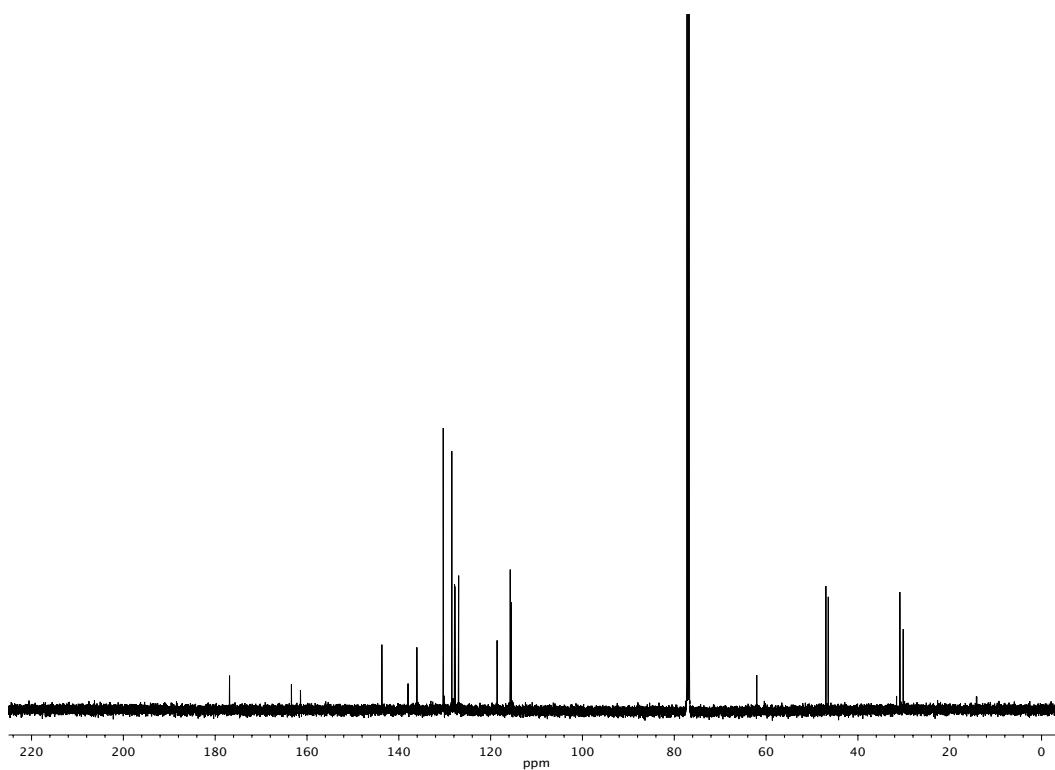


Figure A1.105 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **46**.

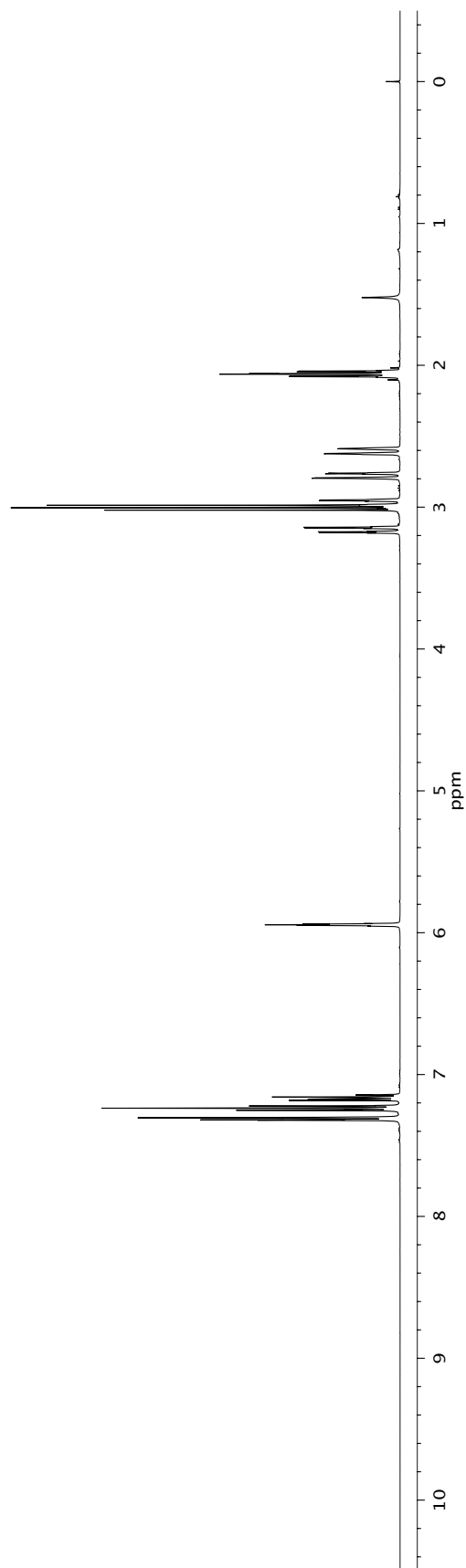
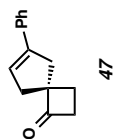


Figure A1.106 <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) of compound 47.



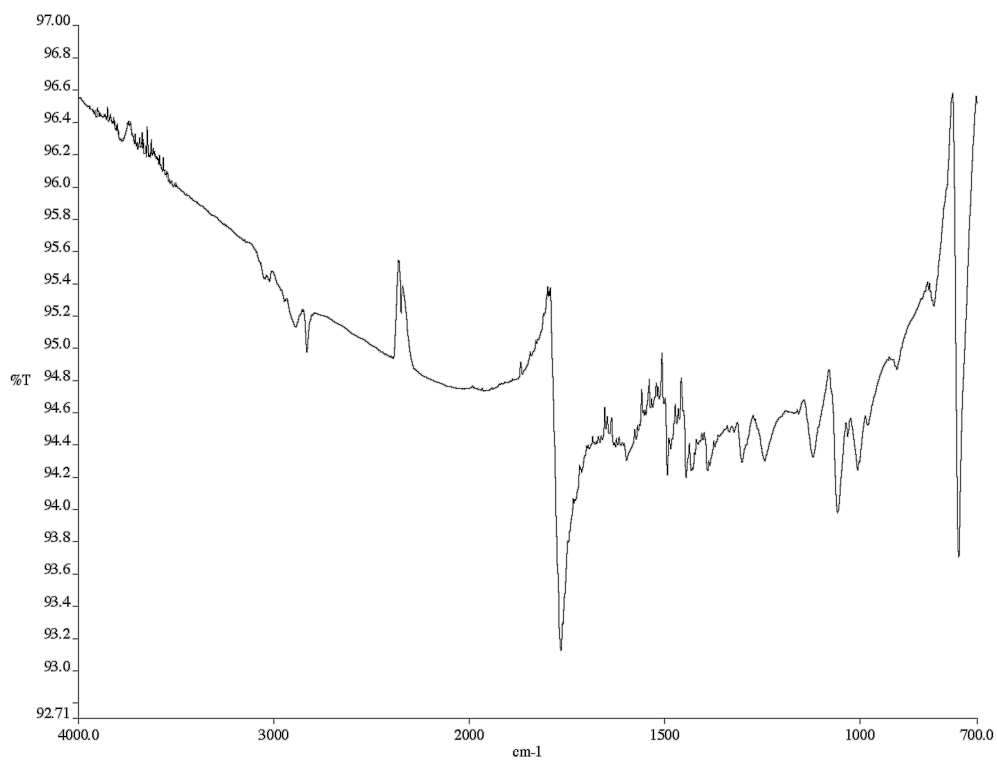


Figure A1.107 Infrared spectrum (thin film/NaCl) of compound **47**.

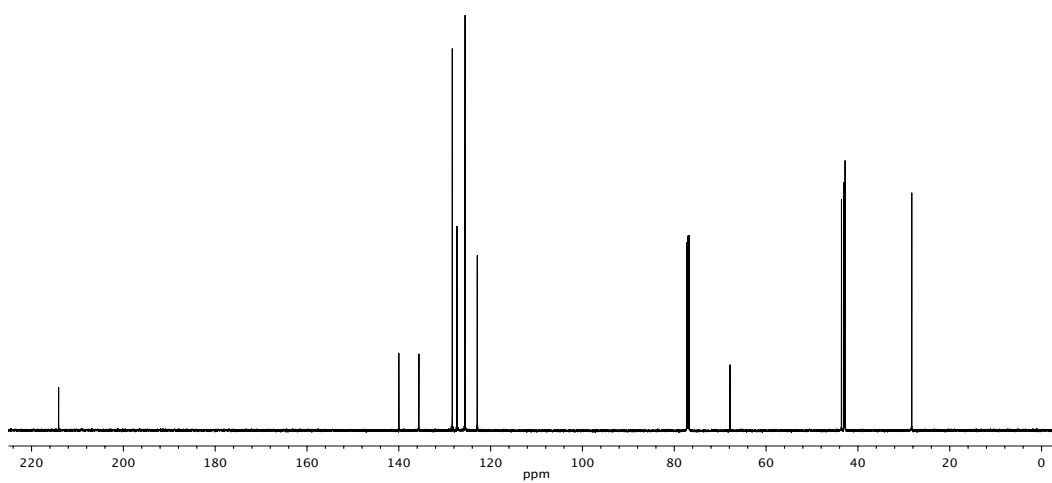


Figure A1.108 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **47**.

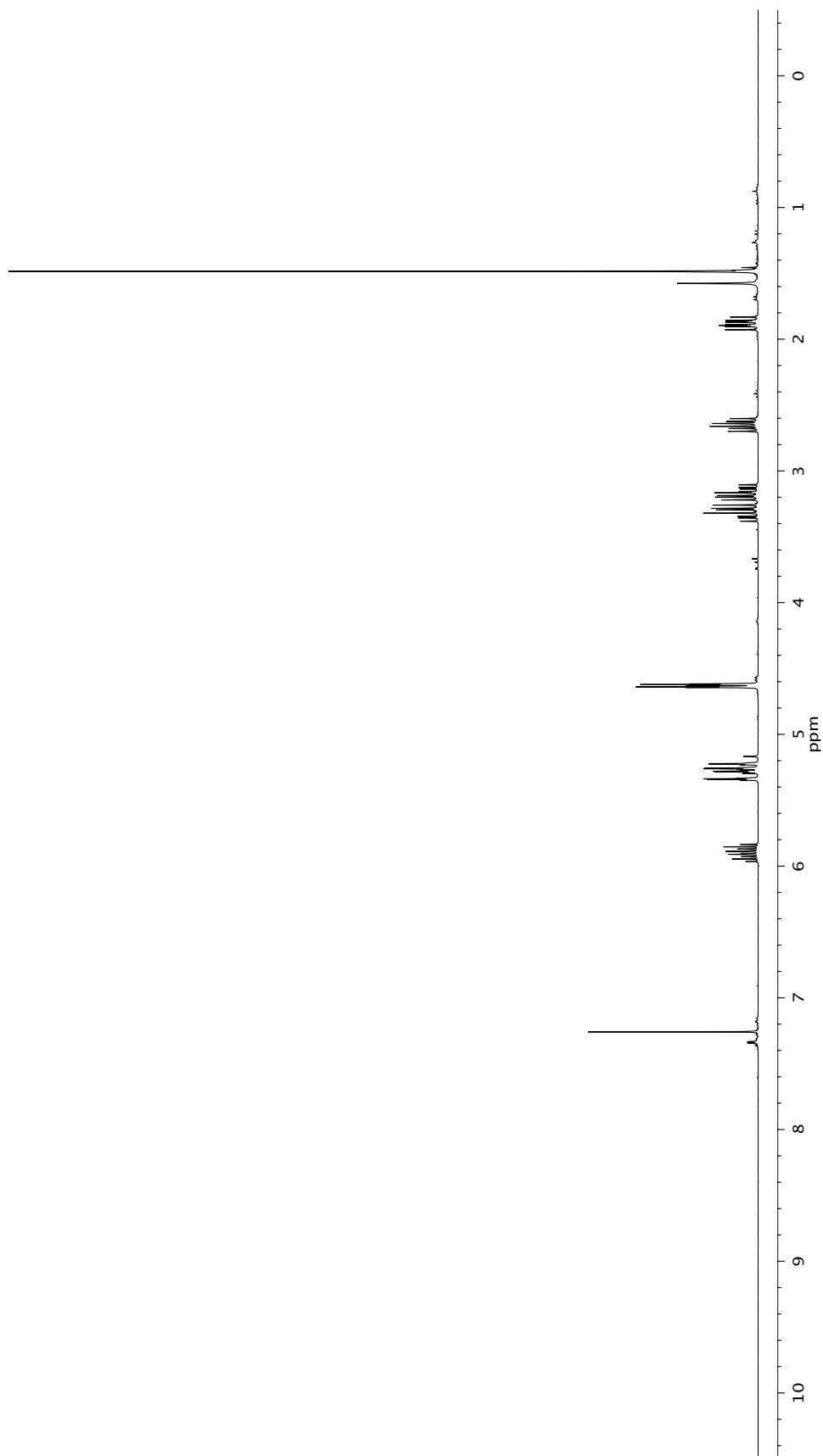
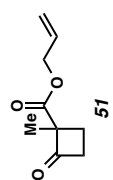


Figure A1.109  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) of compound **51**.

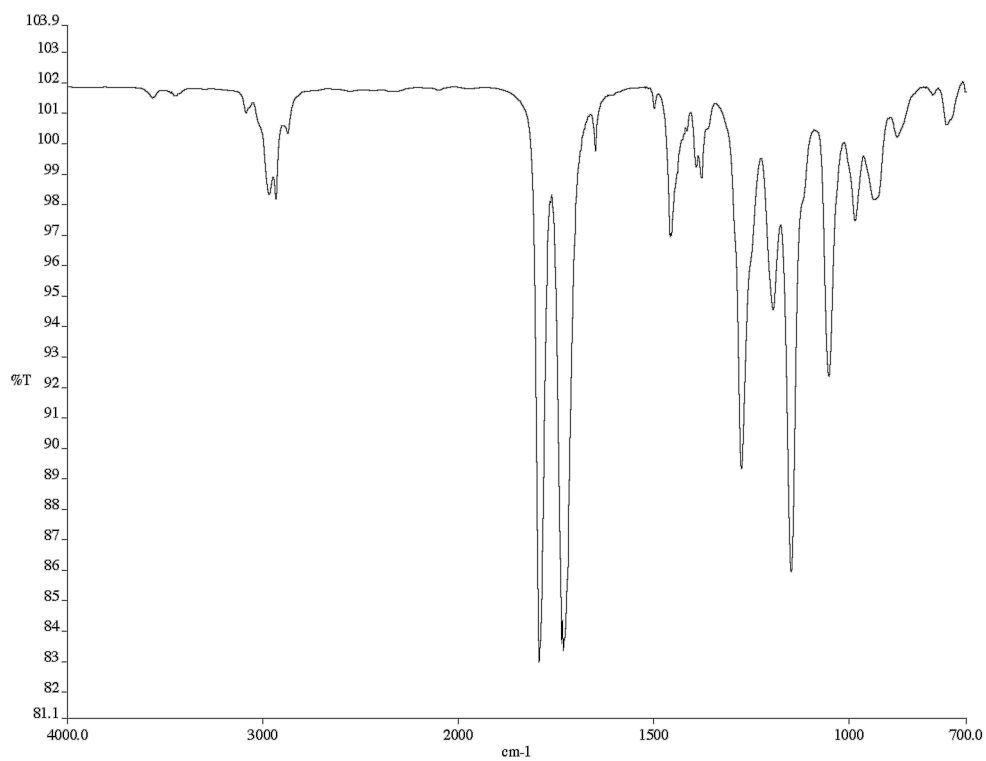


Figure A1.110 Infrared spectrum (thin film/NaCl) of compound 51.

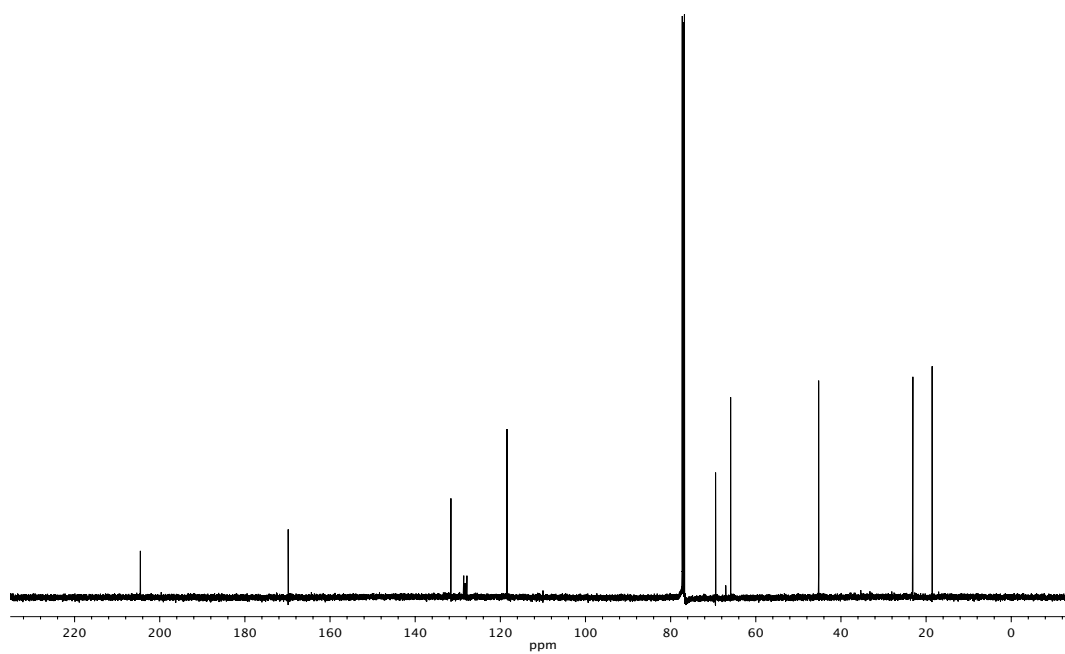


Figure A1.111 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound 51.

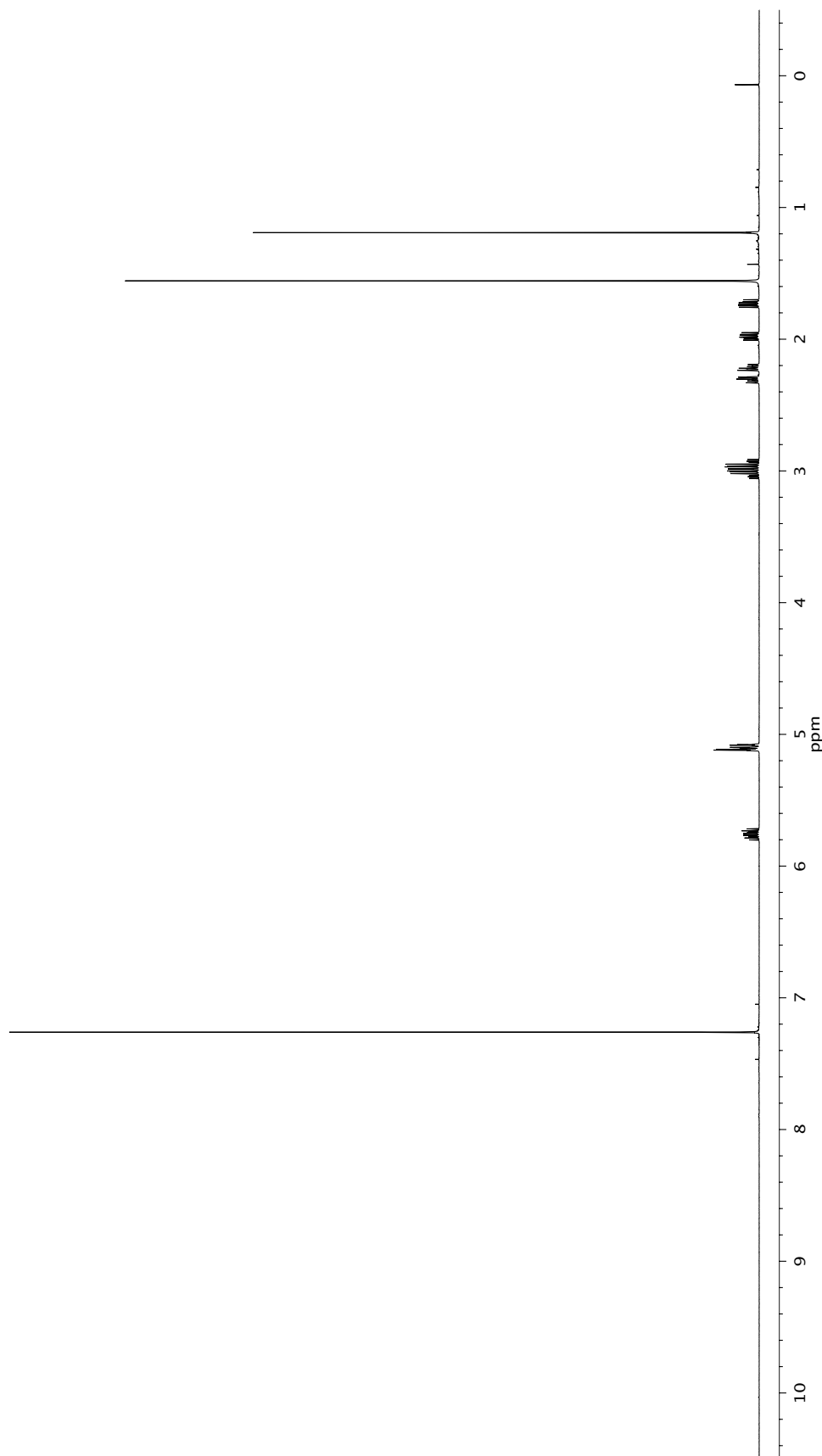
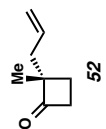


Figure A1.112  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) of compound 52.

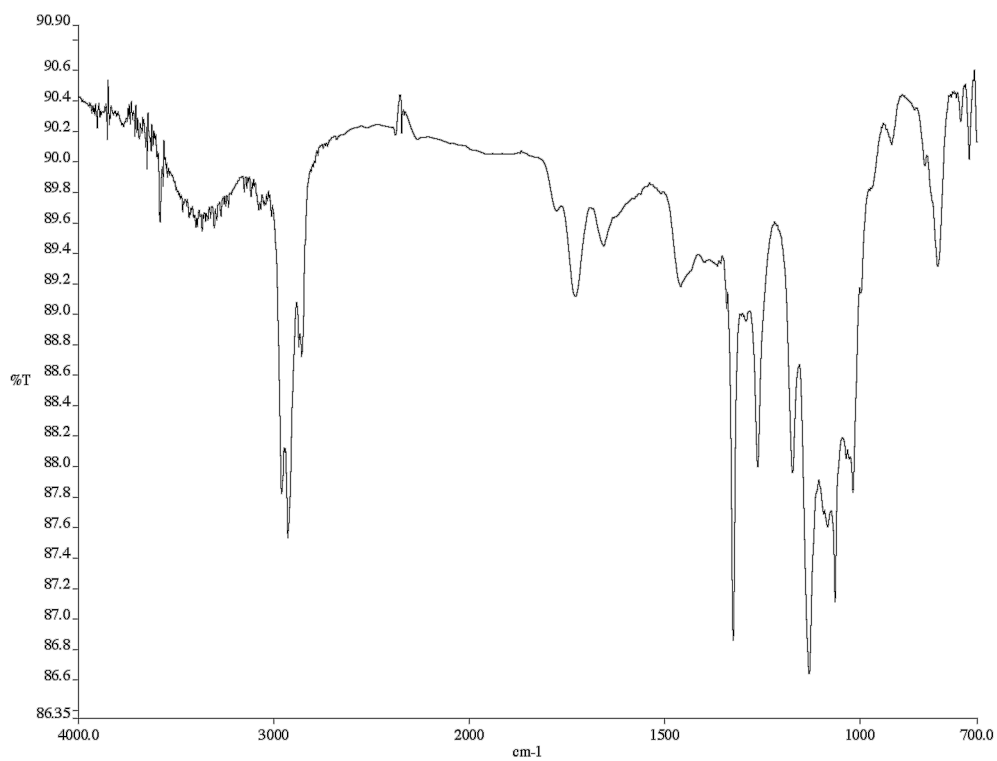


Figure A1.113 Infrared spectrum (thin film/NaCl) of compound **52**.

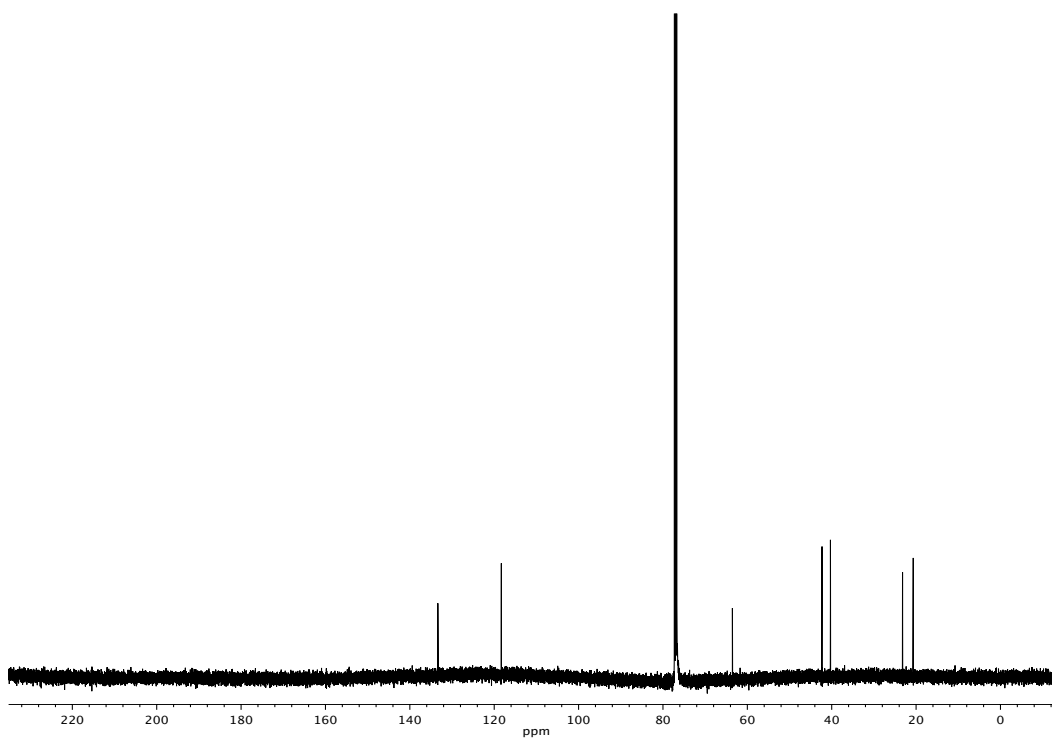


Figure A1.114 <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>) of compound **52**.