

# **Cerium Oxide Nanoparticle-Catalyzed Three-Component Protocol for the Synthesis of Highly Substituted Novel Quinoxalin-2-amine Derivatives and 3,4-Dihydroquinoxalin-2-amines in Water**

Naushad Edayadulla, and Yong Rok Lee\*

*School of Chemical Engineering, Yeungnam University, Gyeongsan 712-749, Republic of Korea*

*E-mail: [yrlee@yu.ac.kr](mailto:yrlee@yu.ac.kr)*

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## **I. Catalyst details**

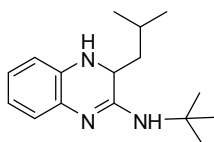
**CeO<sub>2</sub>-NPs purchased from Sigma –Aldrich, South Korea**

**Cerium(IV) oxide - Catlog No.544841.**

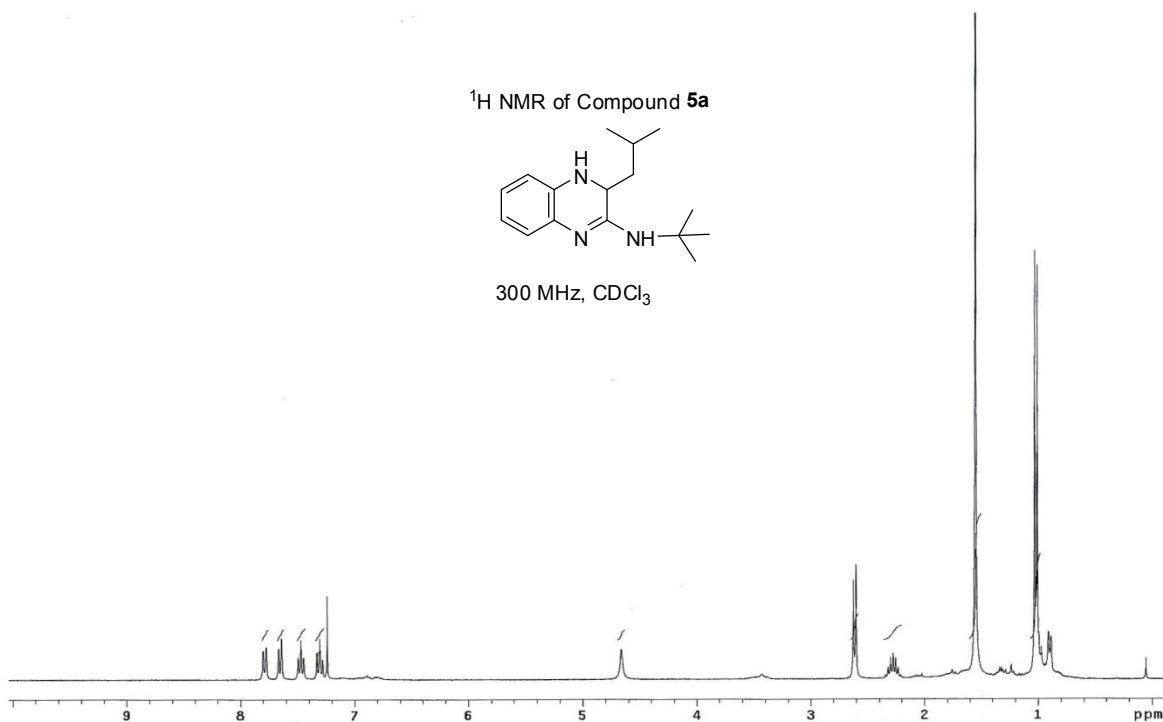
**Nanopowder, <25 nm particle size (BET).**

## II. $^1\text{H}$ NMR and $^{13}\text{C}$ NMR spectra of compounds (5a-5q)

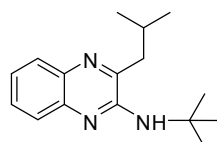
$^1\text{H}$  NMR of Compound **5a**



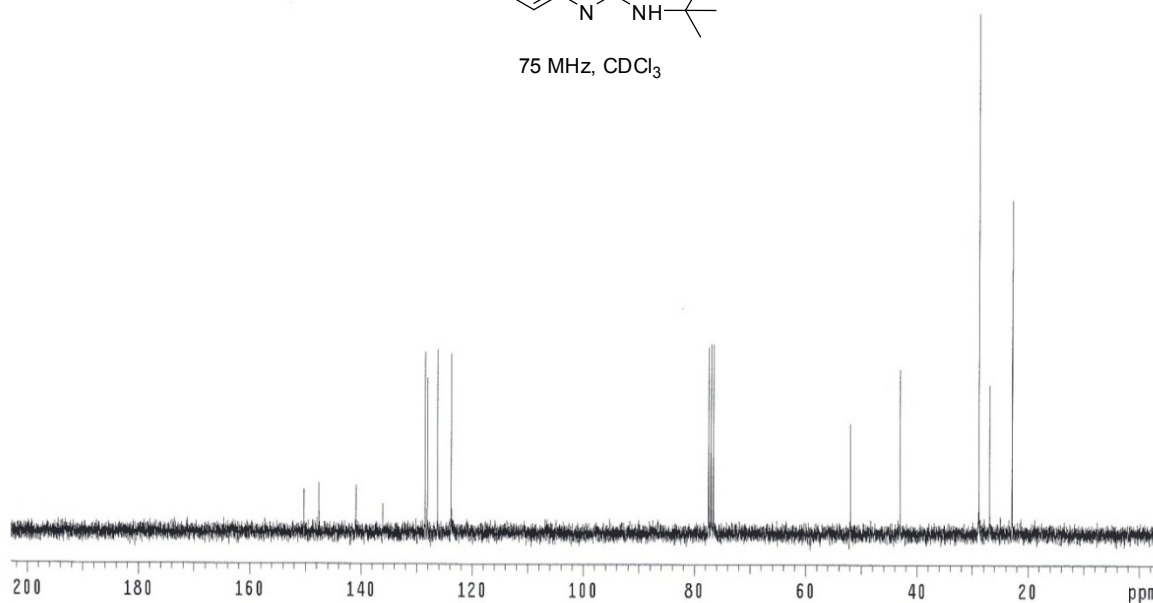
300 MHz,  $\text{CDCl}_3$



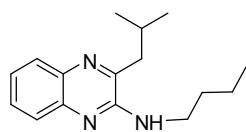
$^{13}\text{C}$  NMR of Compound **5a**



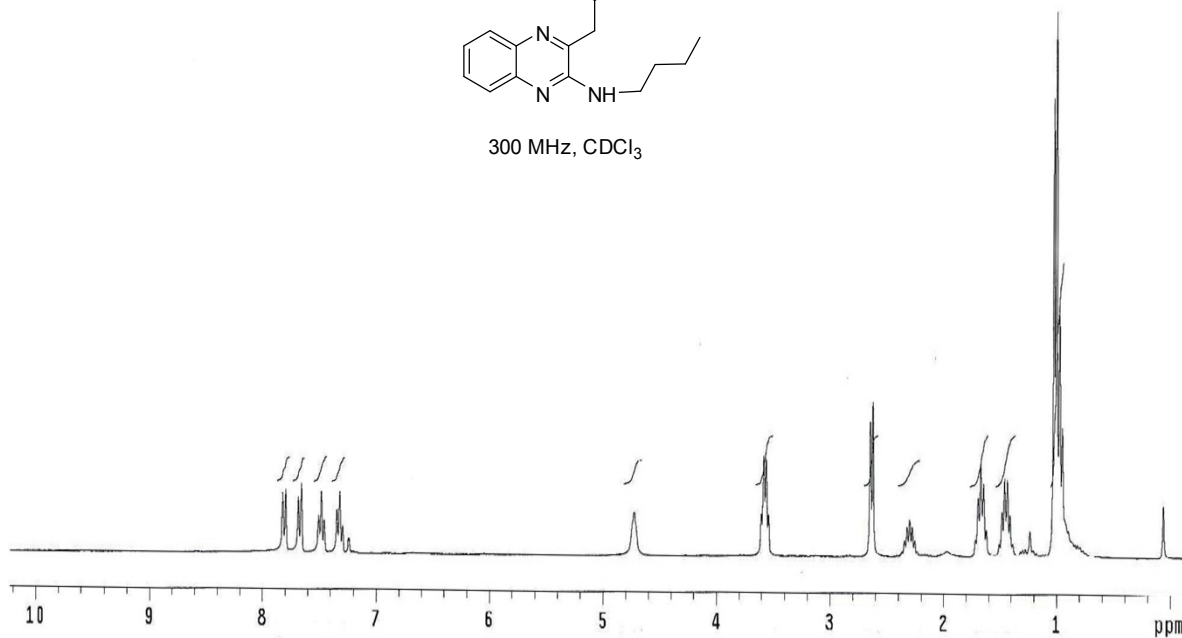
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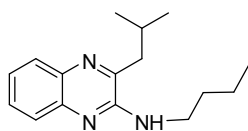
<sup>1</sup>H NMR of Compound **5b**



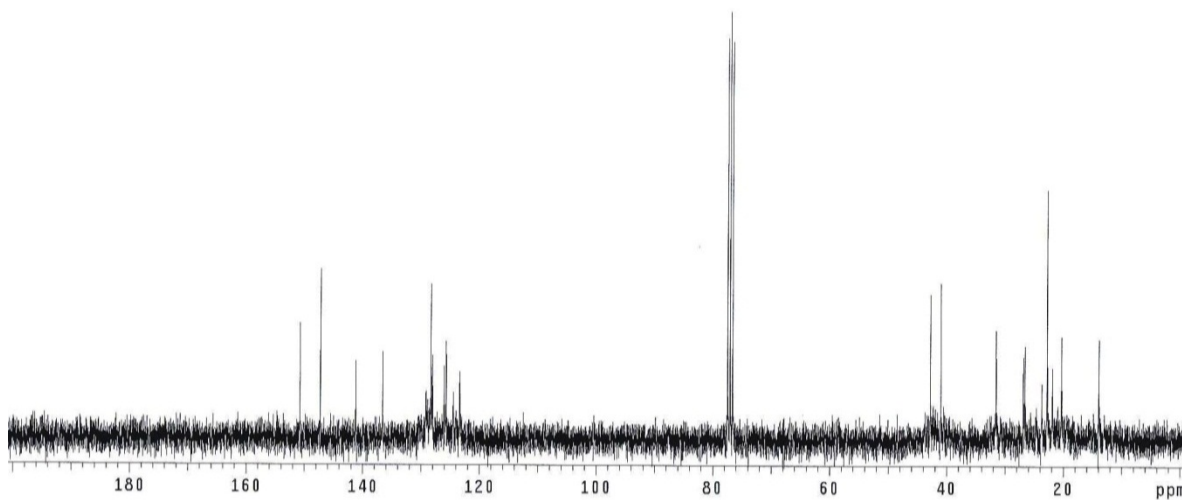
300 MHz, CDCl<sub>3</sub>



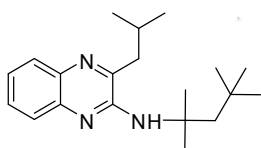
<sup>13</sup>C NMR of Compound **5b**



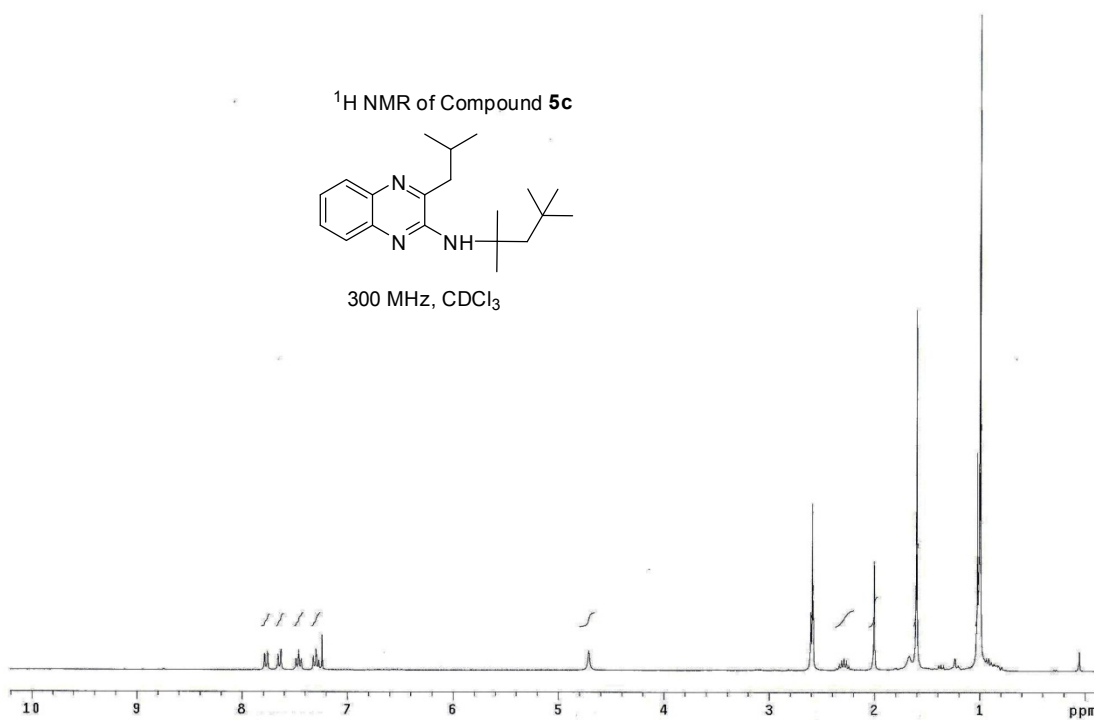
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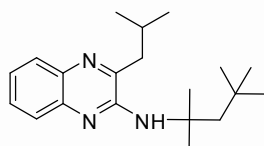
<sup>1</sup>H NMR of Compound **5c**



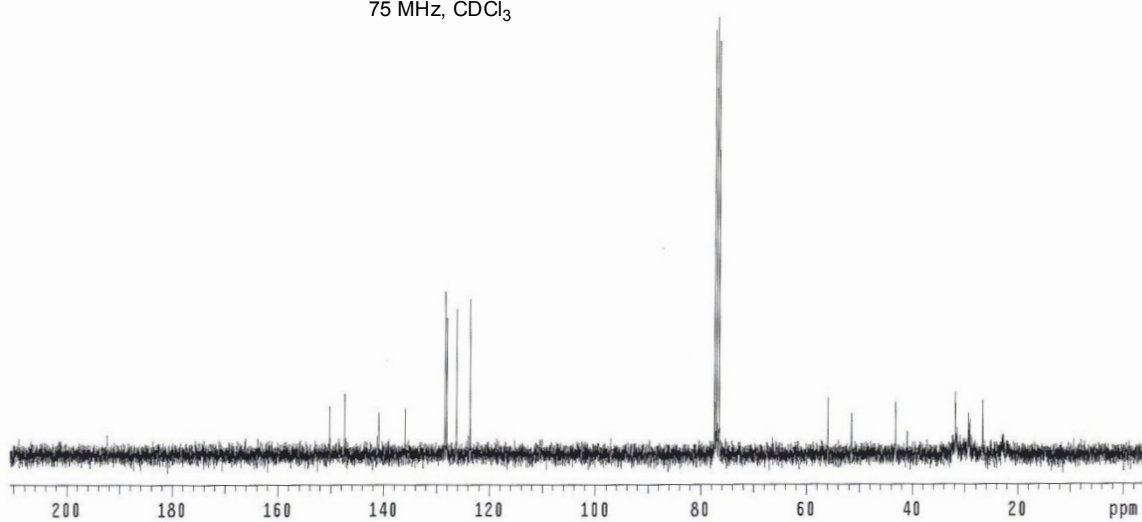
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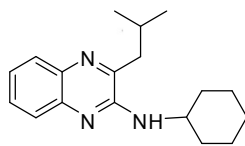
<sup>13</sup>C NMR of Compound **5c**



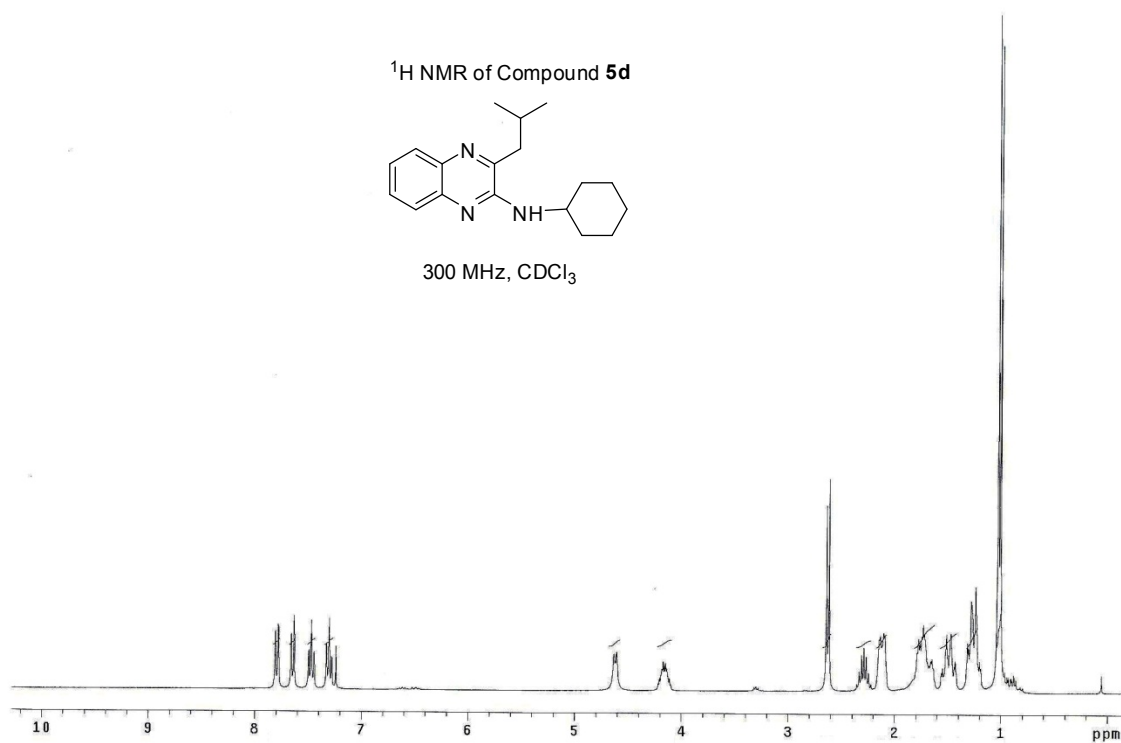
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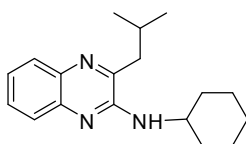
<sup>1</sup>H NMR of Compound **5d**



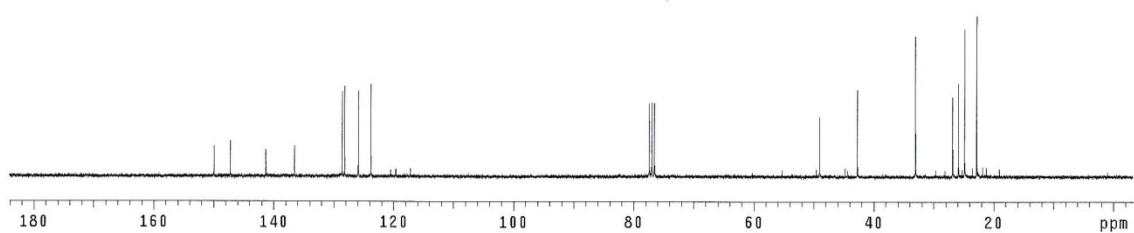
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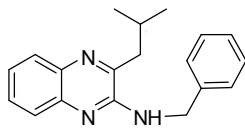
<sup>13</sup>C NMR of Compound **5d**



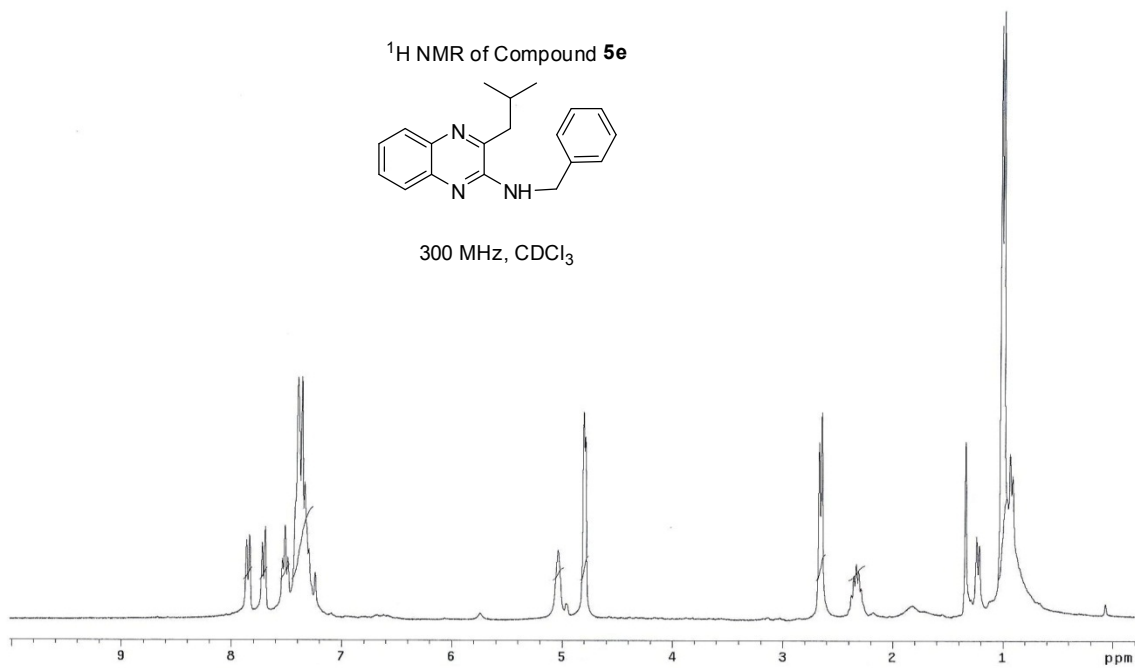
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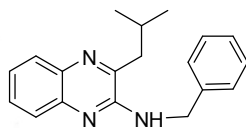
<sup>1</sup>H NMR of Compound **5e**



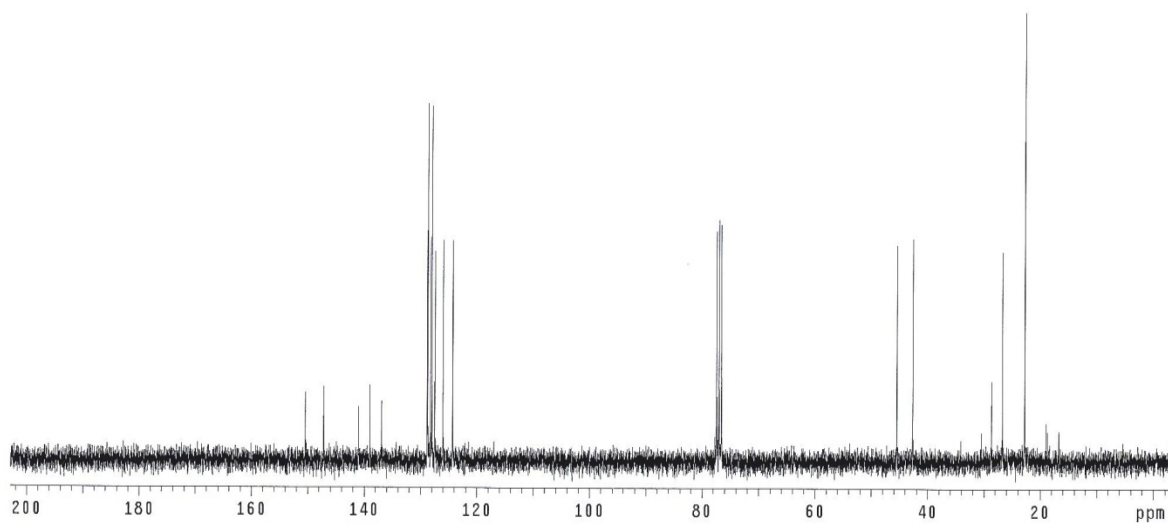
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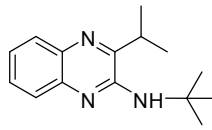
<sup>13</sup>C NMR of Compound **5e**



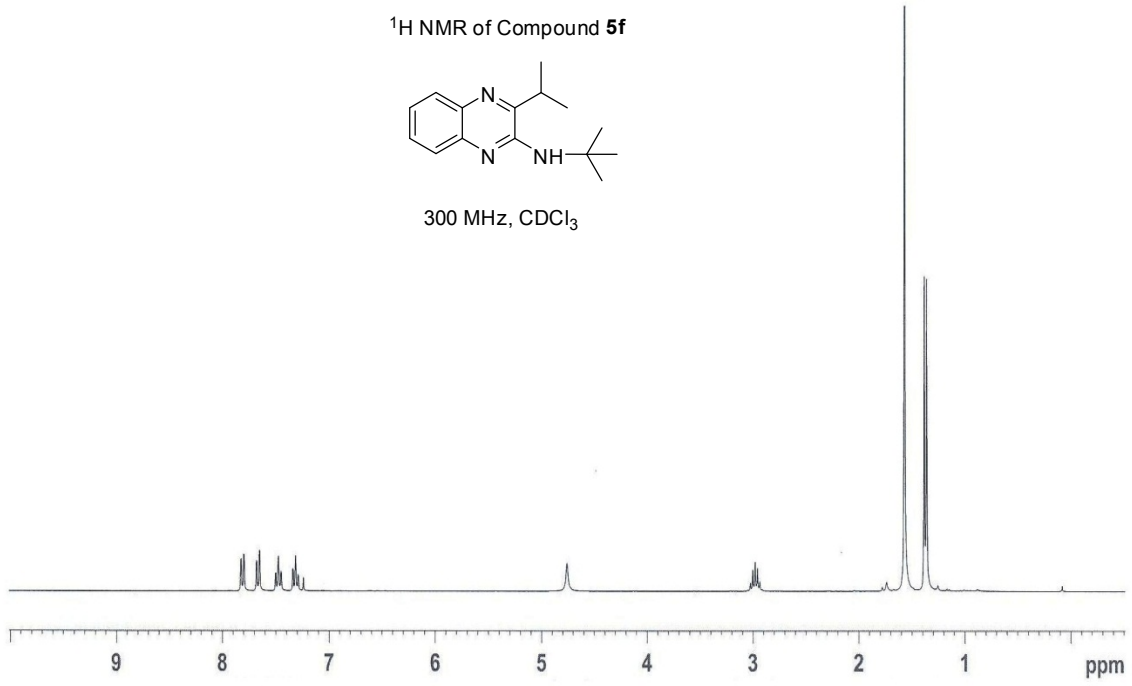
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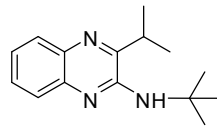
<sup>1</sup>H NMR of Compound **5f**



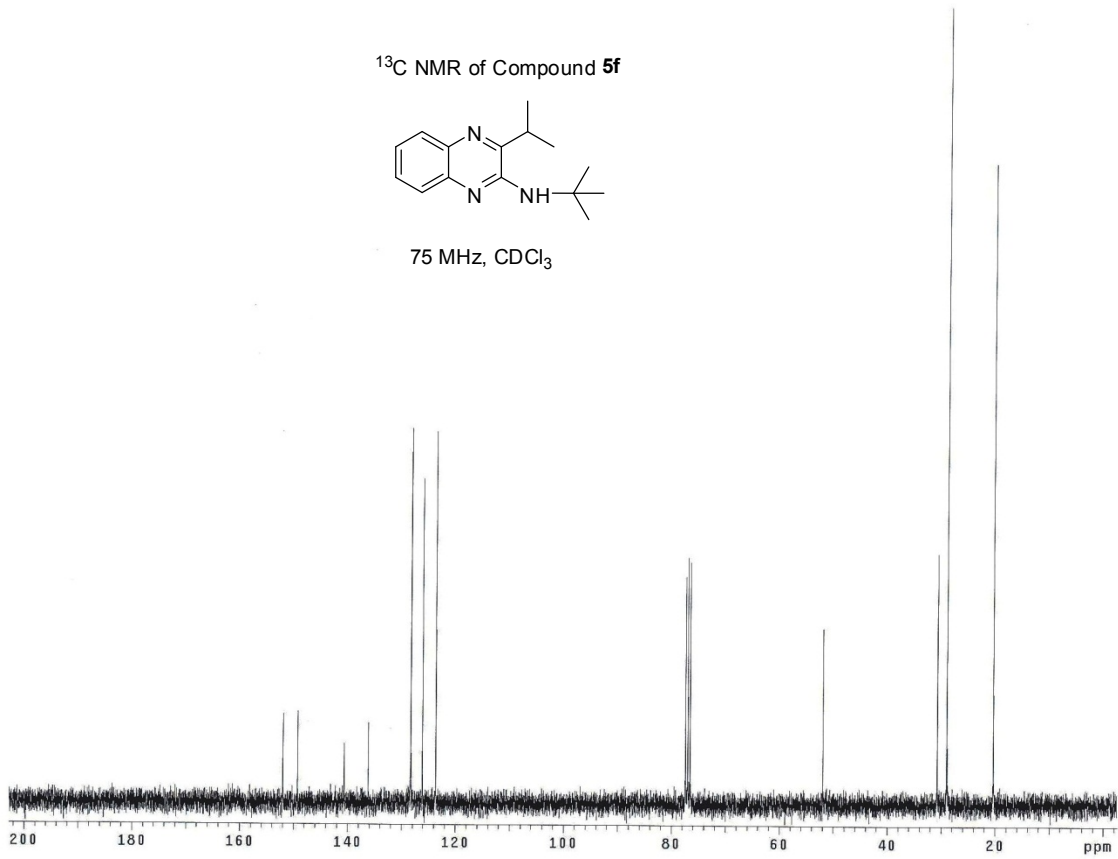
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<sup>13</sup>C NMR of Compound **5f**

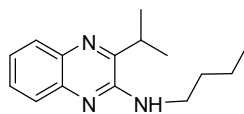


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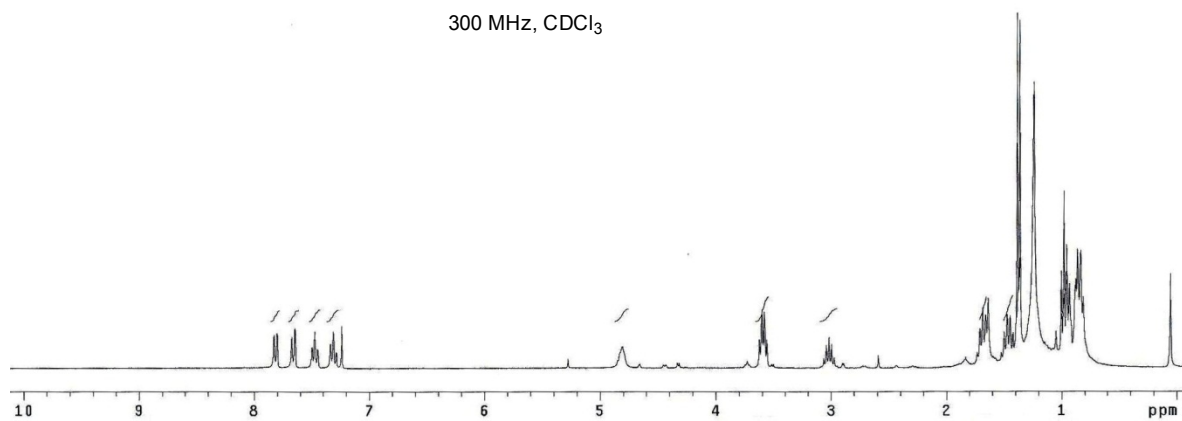




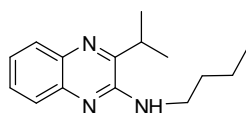
<sup>1</sup>H NMR of Compound **5g**



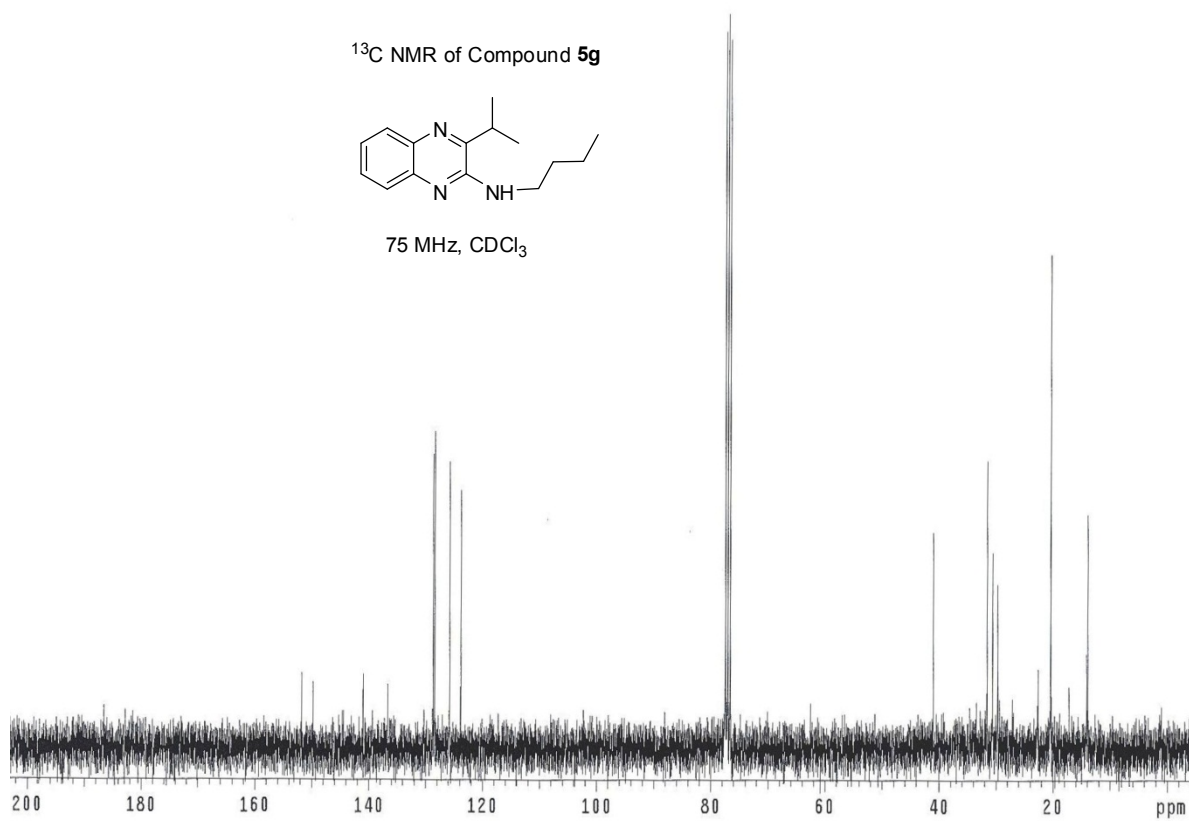
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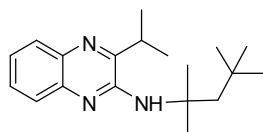
<sup>13</sup>C NMR of Compound **5g**



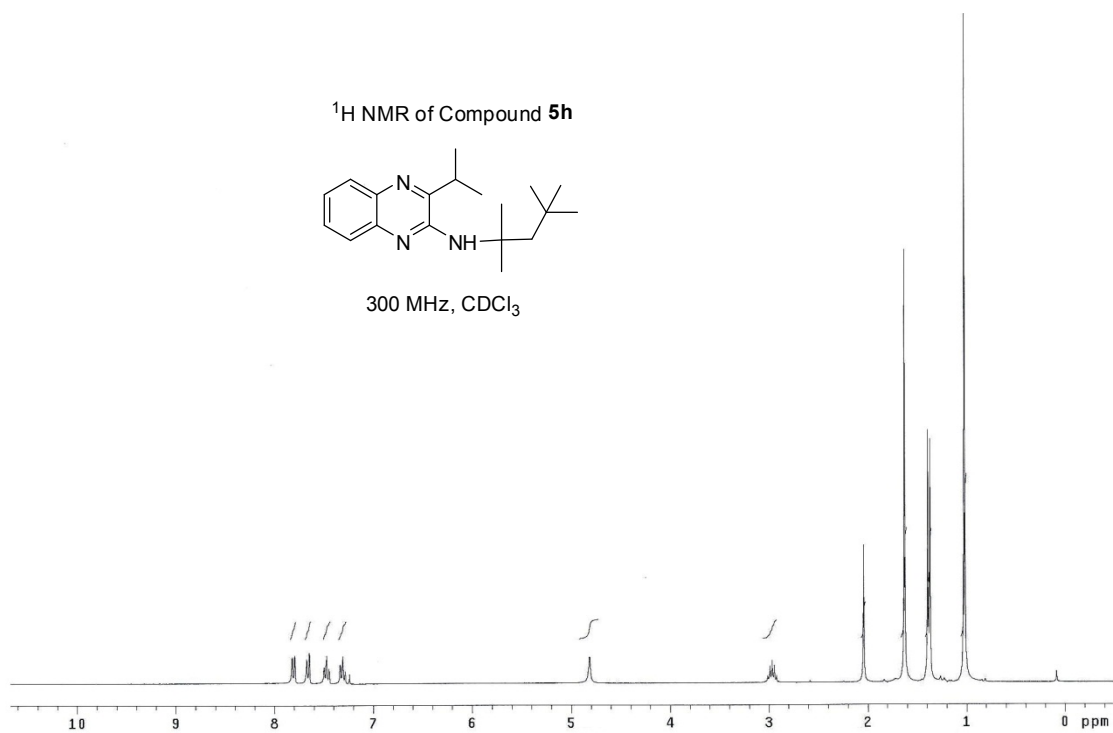
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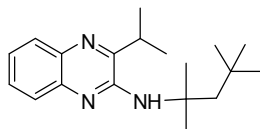
<sup>1</sup>H NMR of Compound **5h**



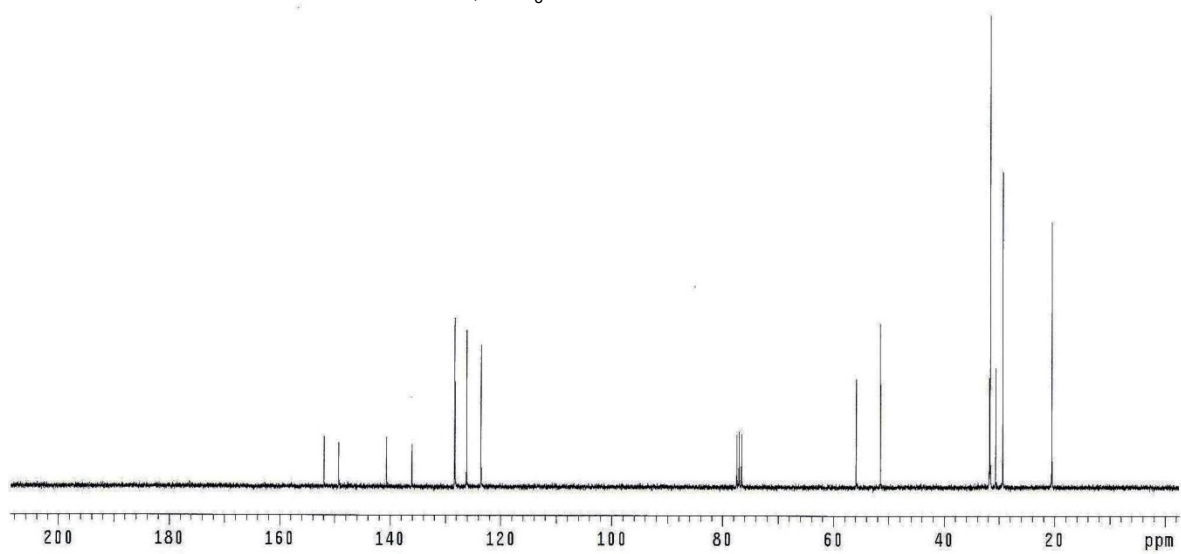
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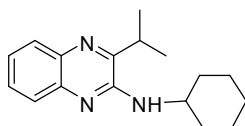
<sup>13</sup>C NMR of Compound **5h**



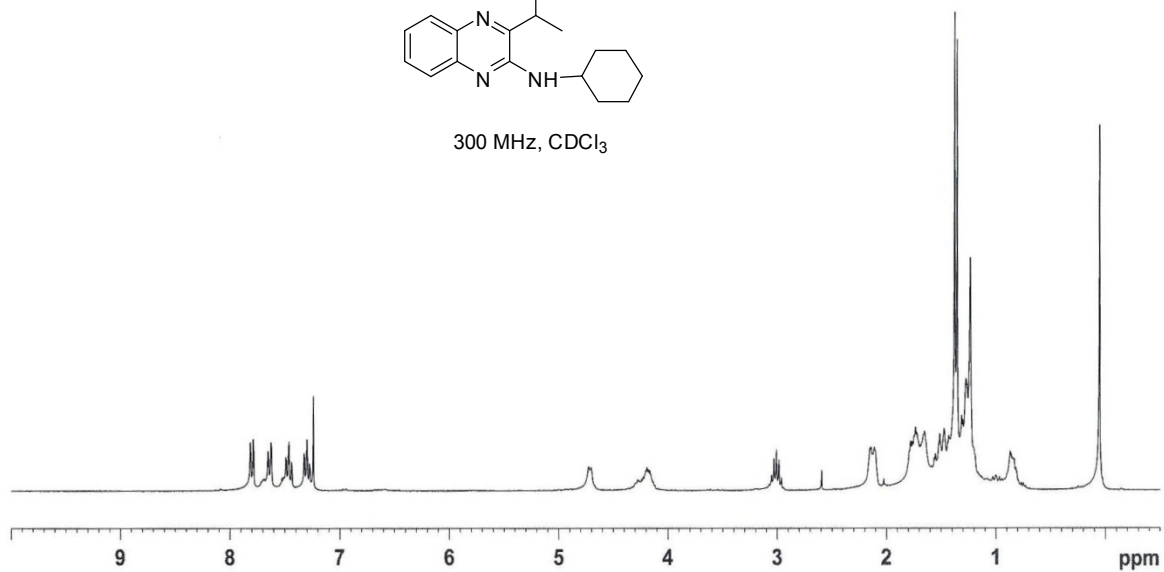
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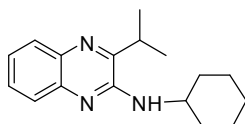
<sup>1</sup>H NMR of Compound **5i**



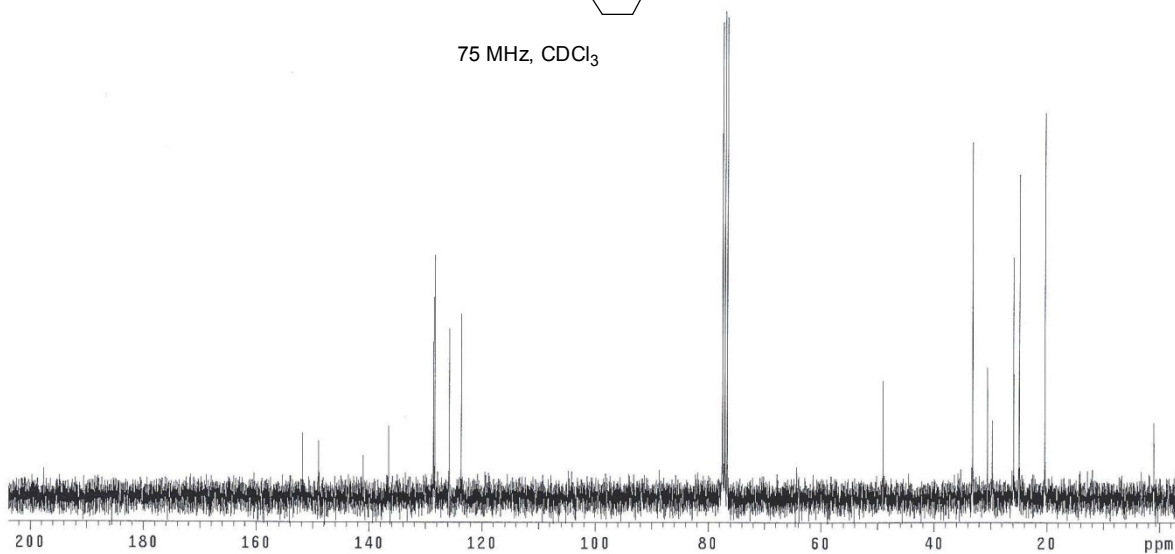
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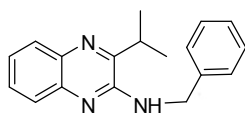
<sup>13</sup>C NMR of Compound **5i**



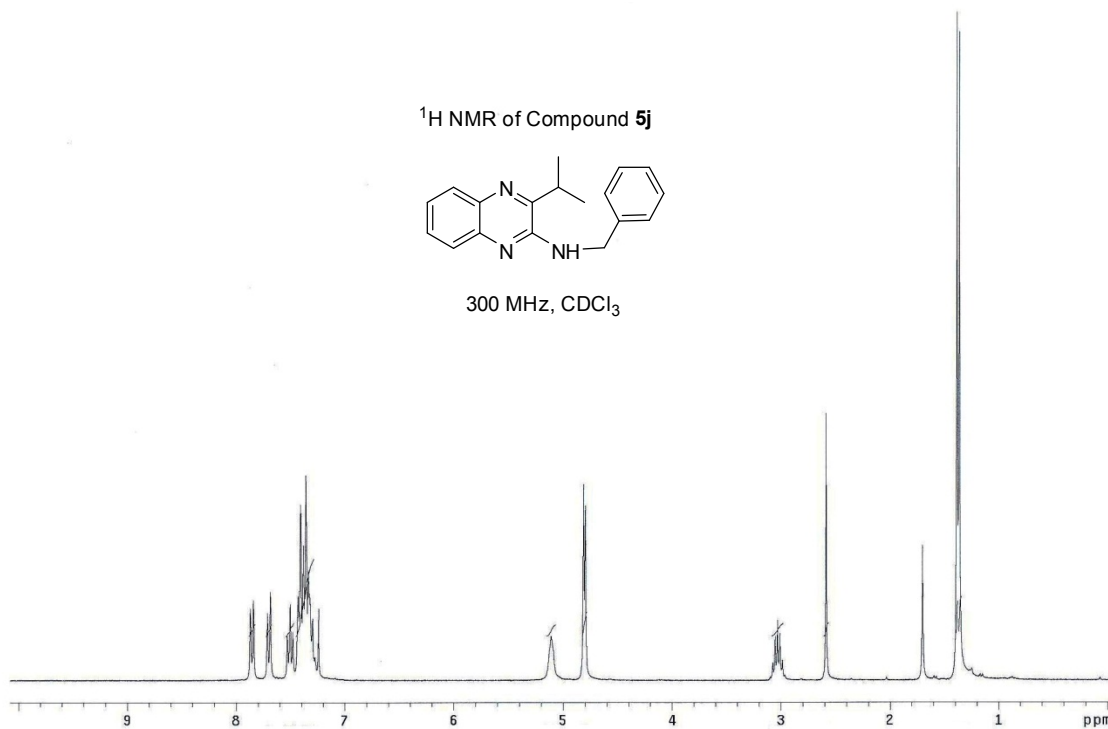
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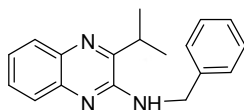
<sup>1</sup>H NMR of Compound **5j**



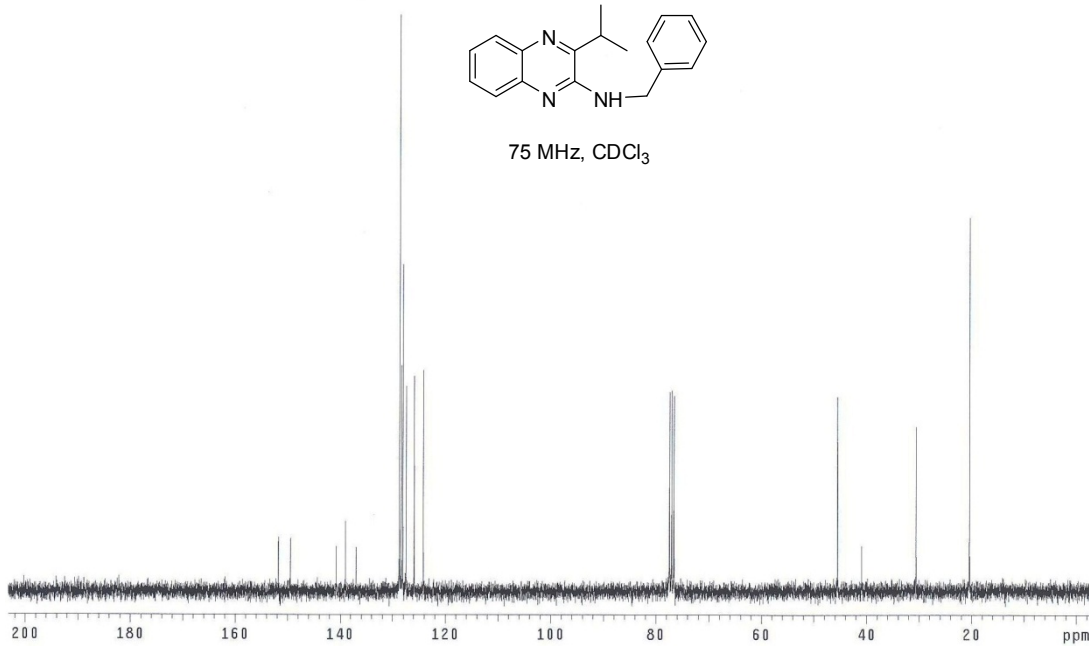
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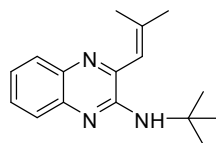
<sup>13</sup>C NMR of Compound **5j**



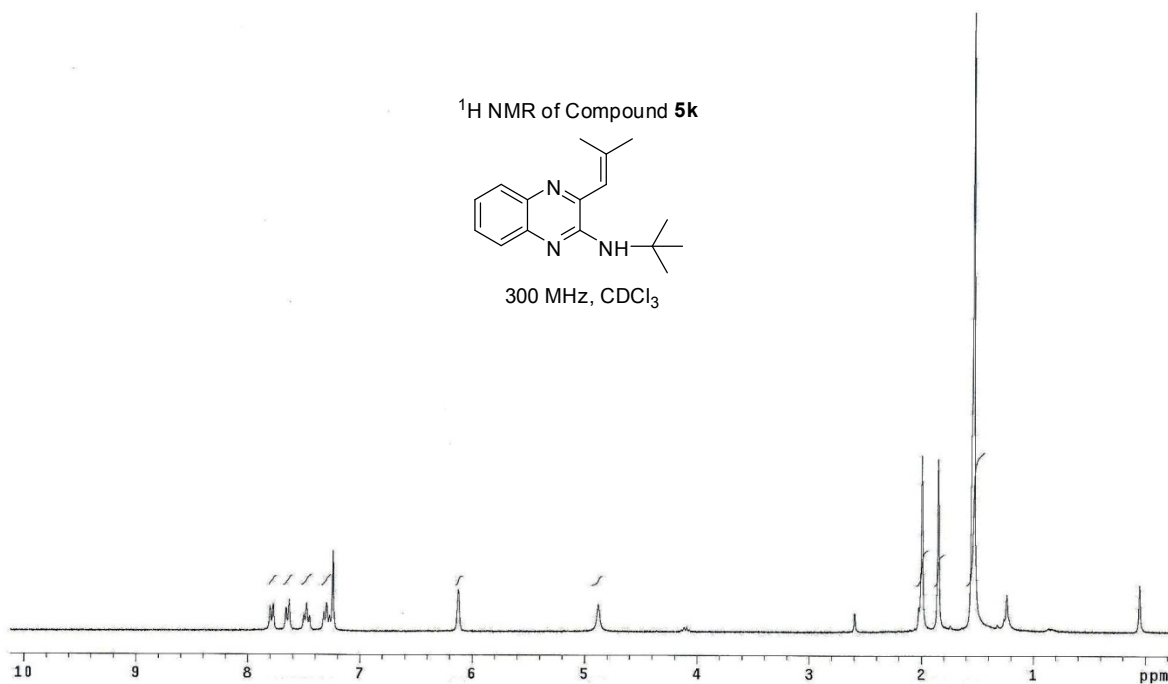
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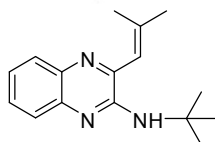
<sup>1</sup>H NMR of Compound **5k**



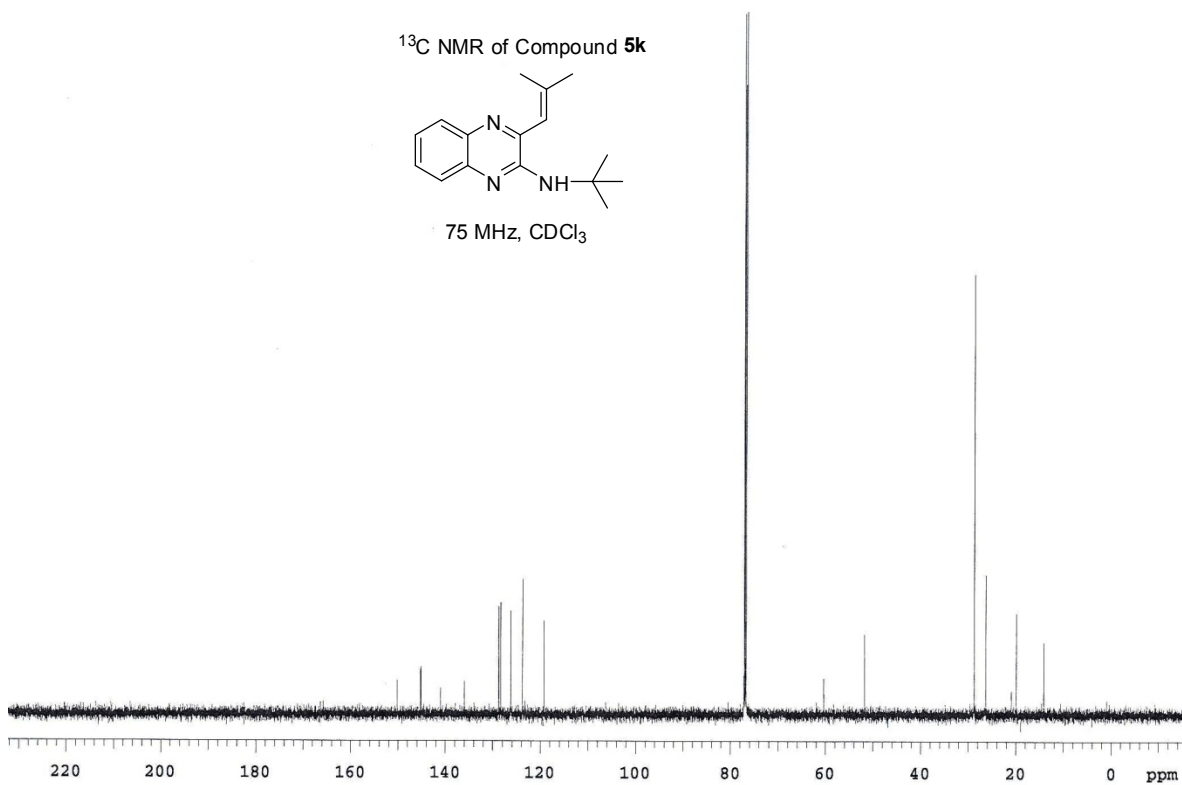
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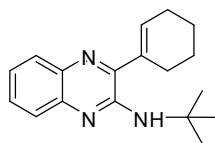
<sup>13</sup>C NMR of Compound **5k**



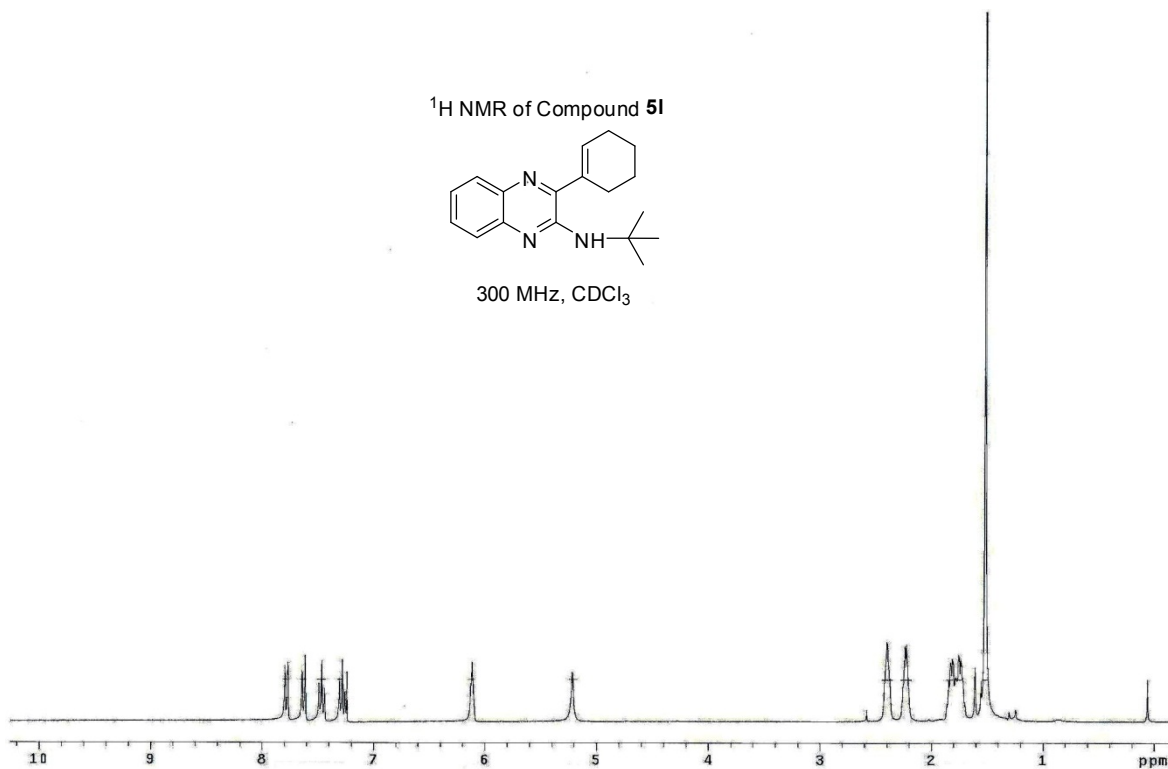
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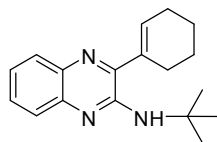
<sup>1</sup>H NMR of Compound **5I**



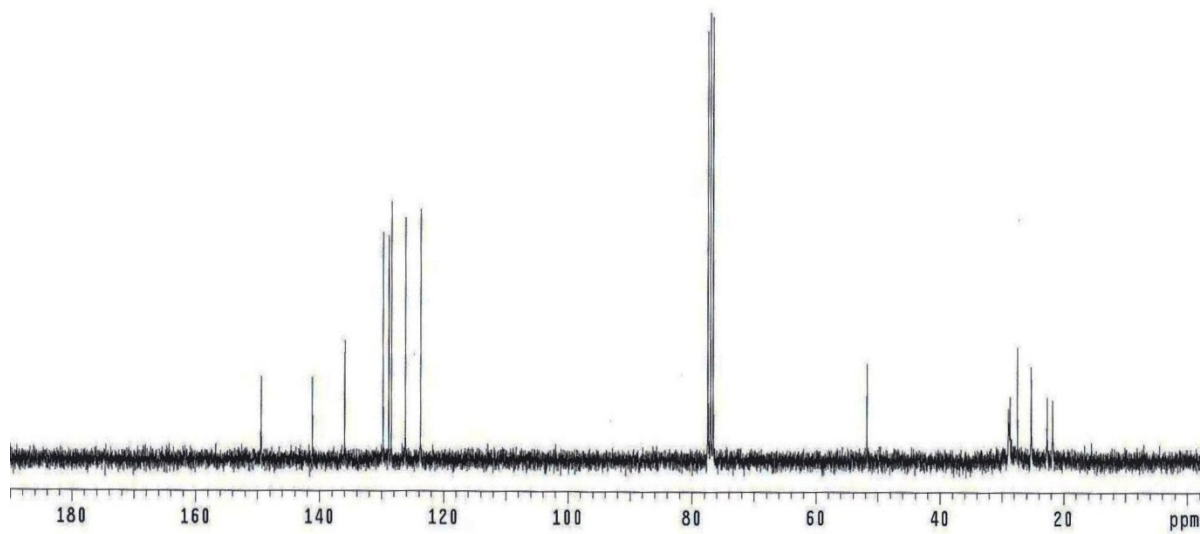
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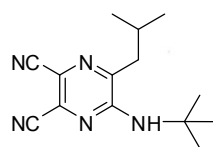
<sup>13</sup>C NMR of Compound **5I**



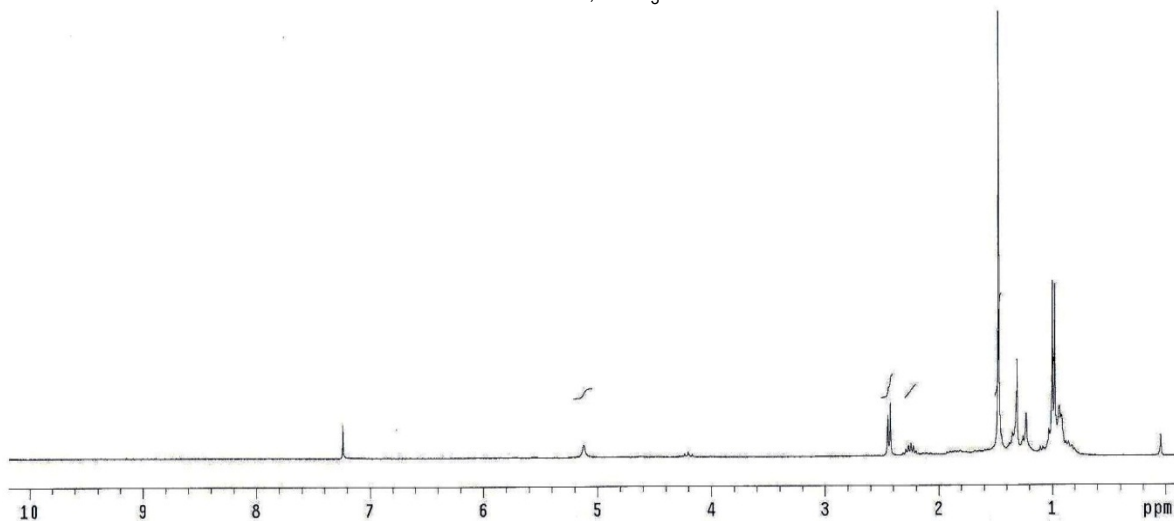
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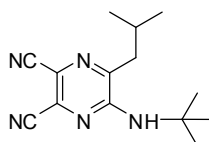
<sup>1</sup>H NMR of Compound **5n**



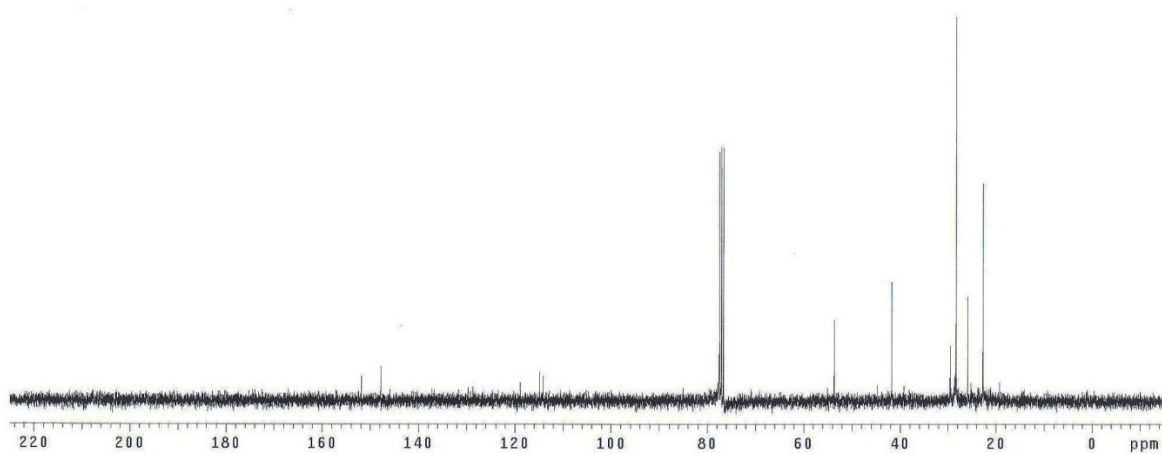
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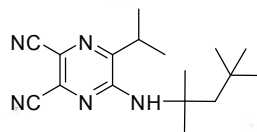
<sup>13</sup>C NMR of Compound **5n**



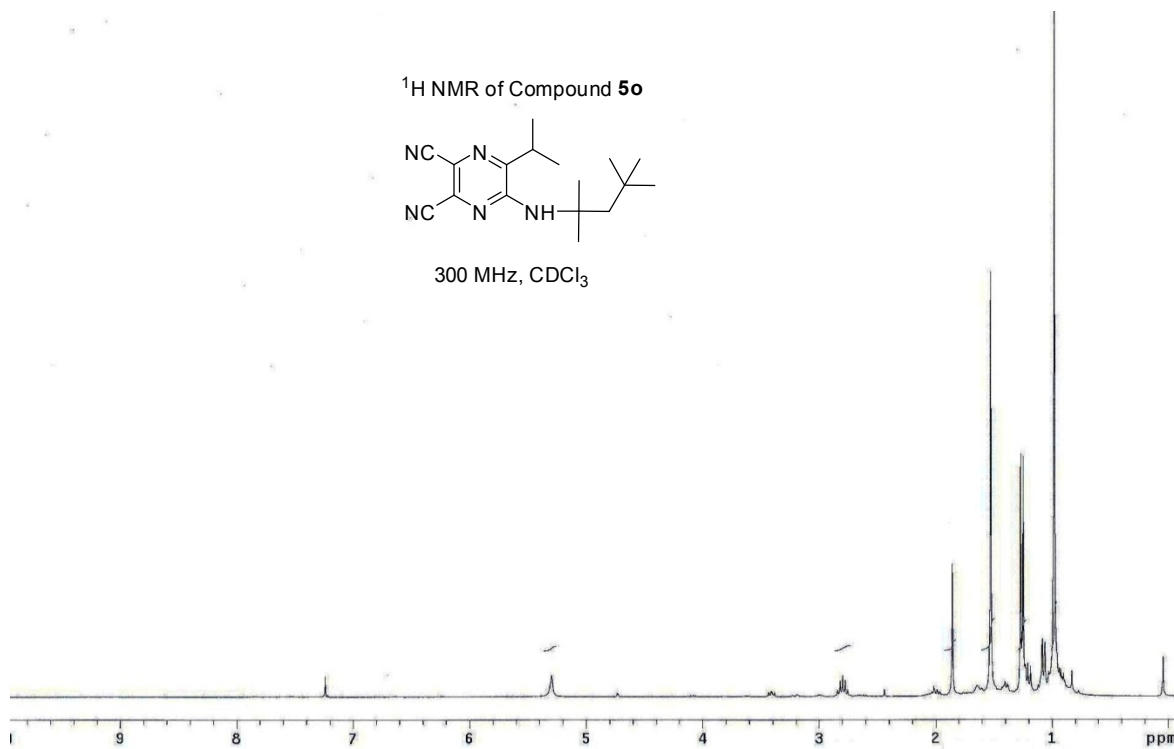
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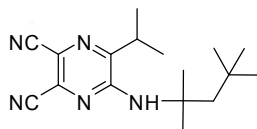
<sup>1</sup>H NMR of Compound **5o**



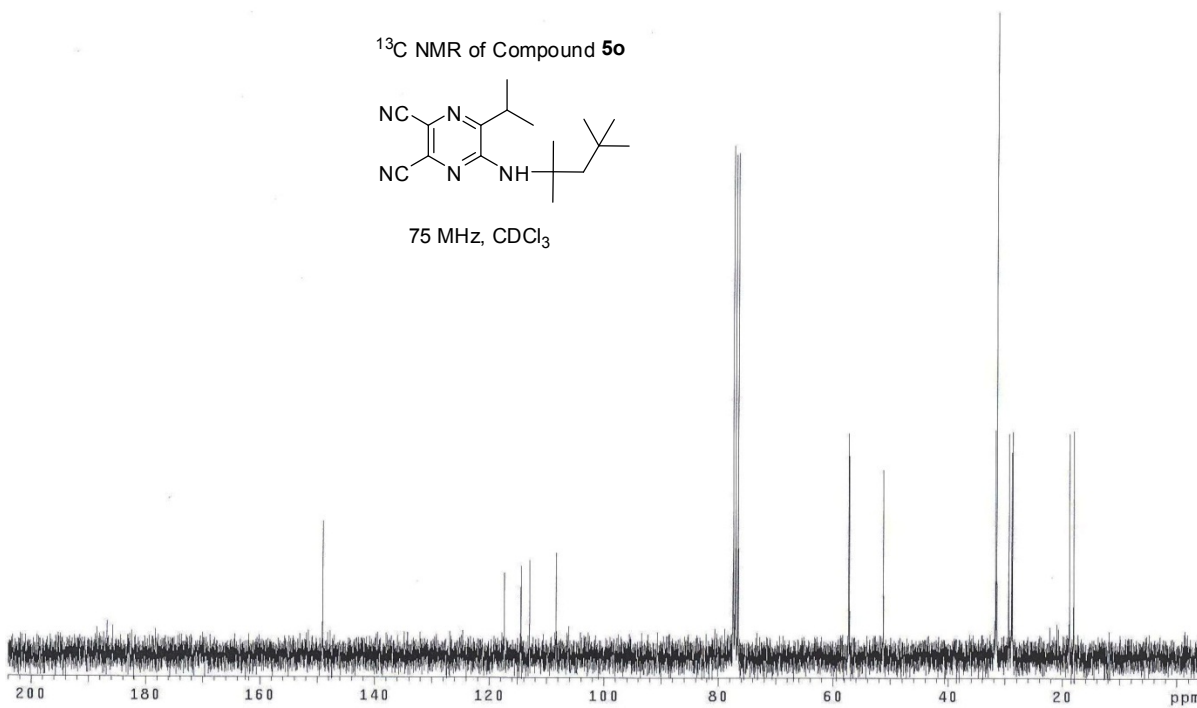
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<sup>13</sup>C NMR of Compound **5o**

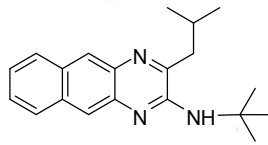


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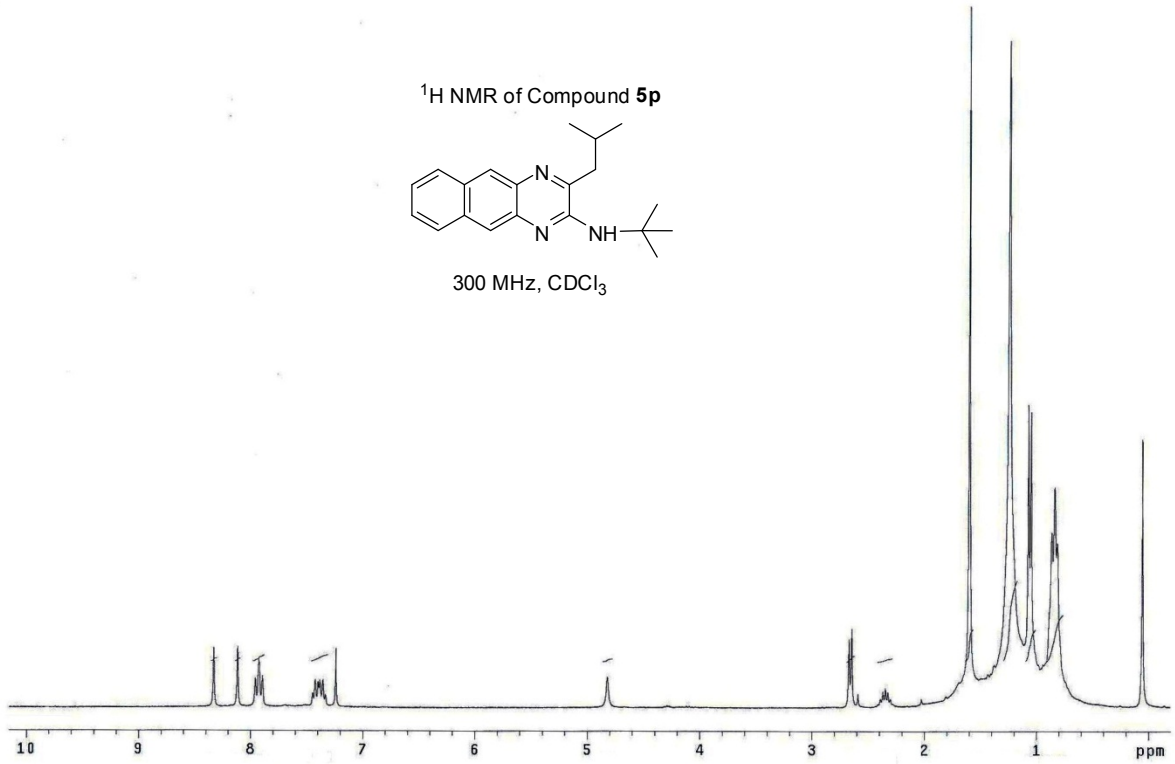




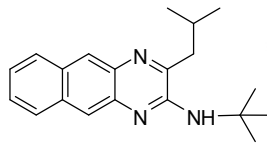
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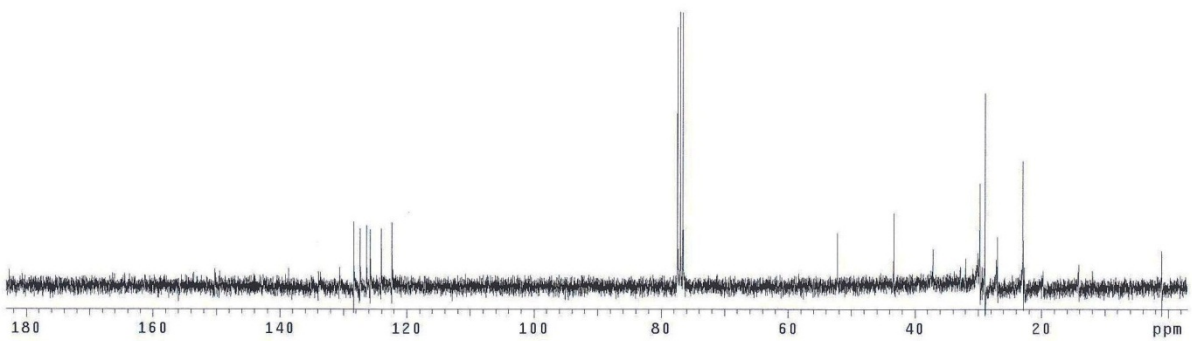
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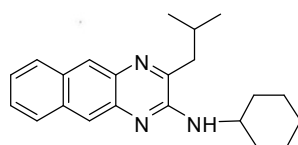
<sup>13</sup>C NMR of Compound **5p**



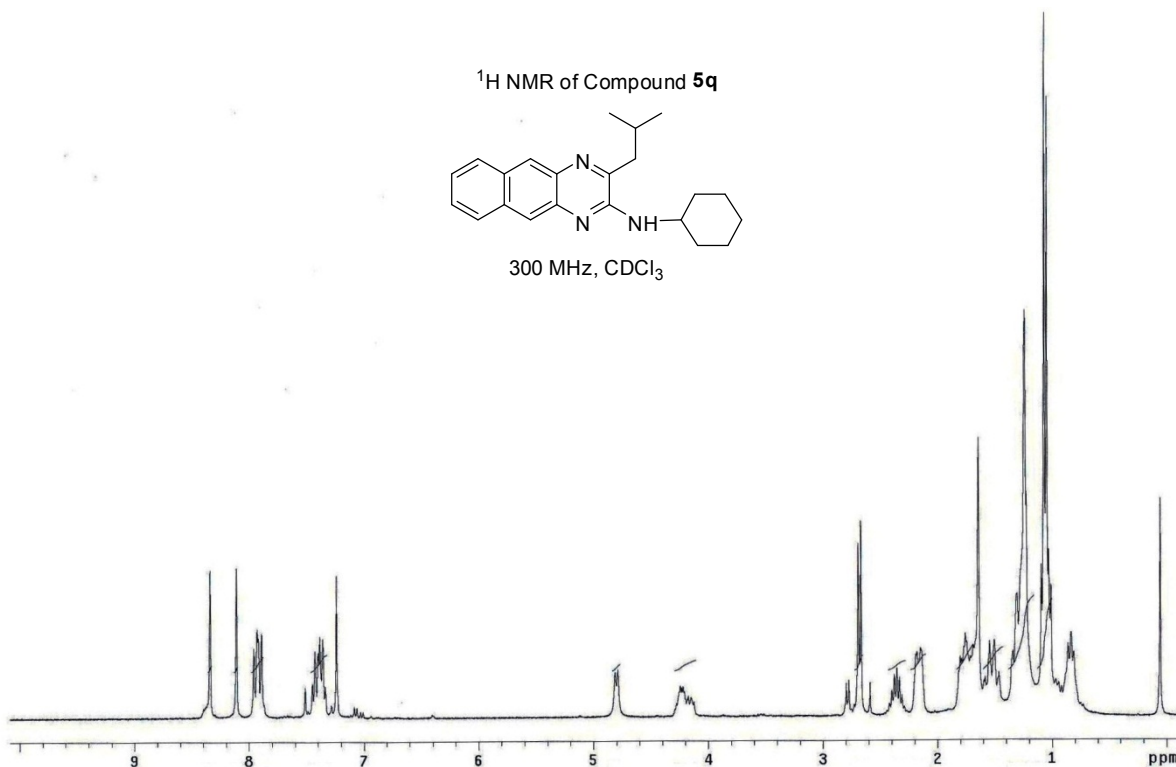
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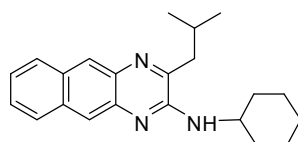
<sup>1</sup>H NMR of Compound **5q**



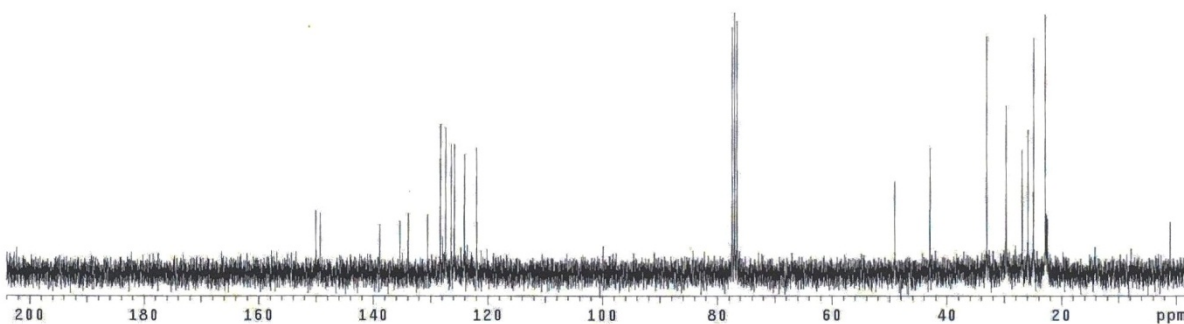
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<sup>13</sup>C NMR of Compound **5q**

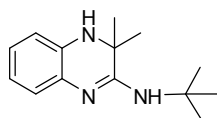


75 MHz, CDCl<sub>3</sub>

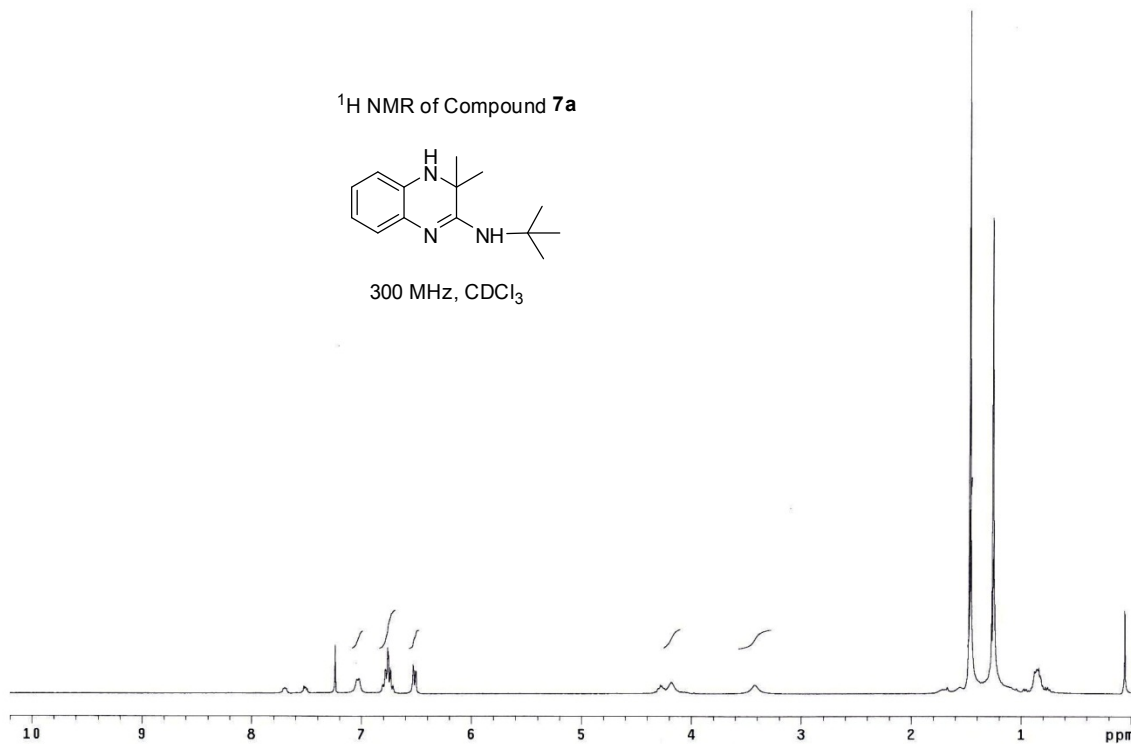


### III. $^1\text{H}$ NMR and $^{13}\text{C}$ NMR spectra of compounds (7a-7i)

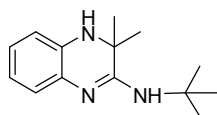
$^1\text{H}$  NMR of Compound 7a



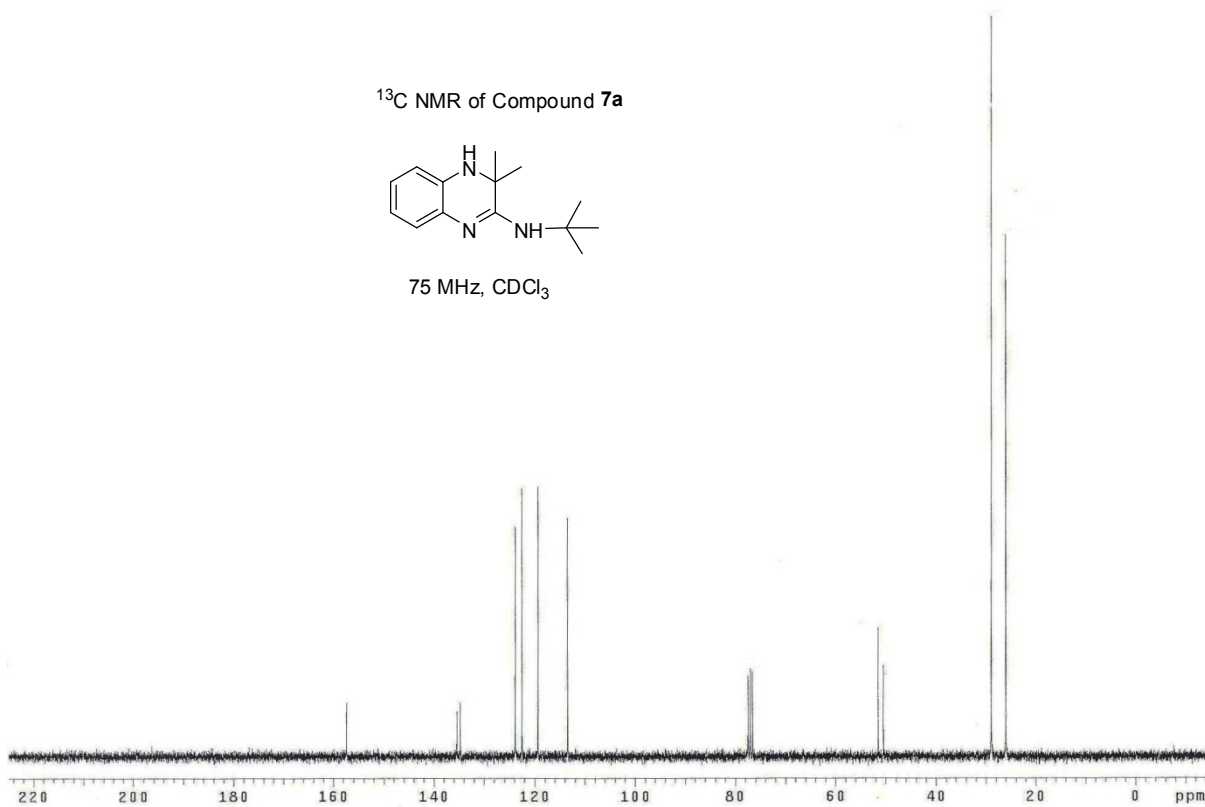
300 MHz,  $\text{CDCl}_3$



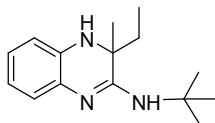
$^{13}\text{C}$  NMR of Compound 7a



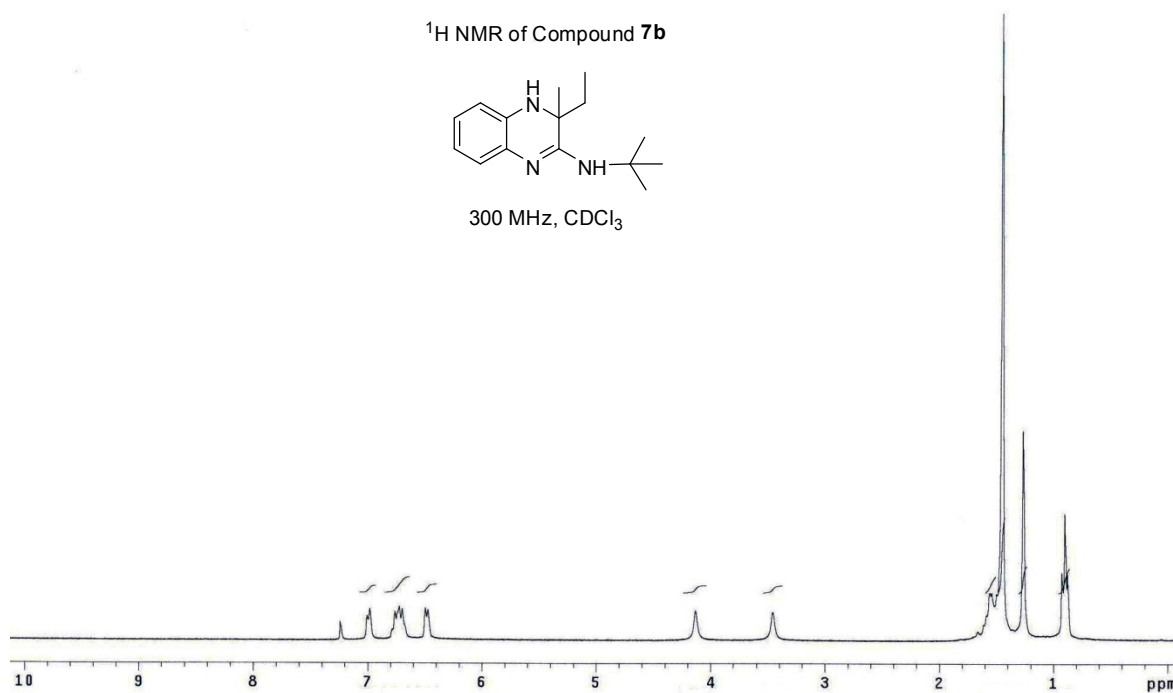
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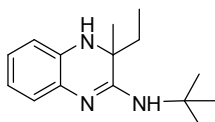
<sup>1</sup>H NMR of Compound **7b**



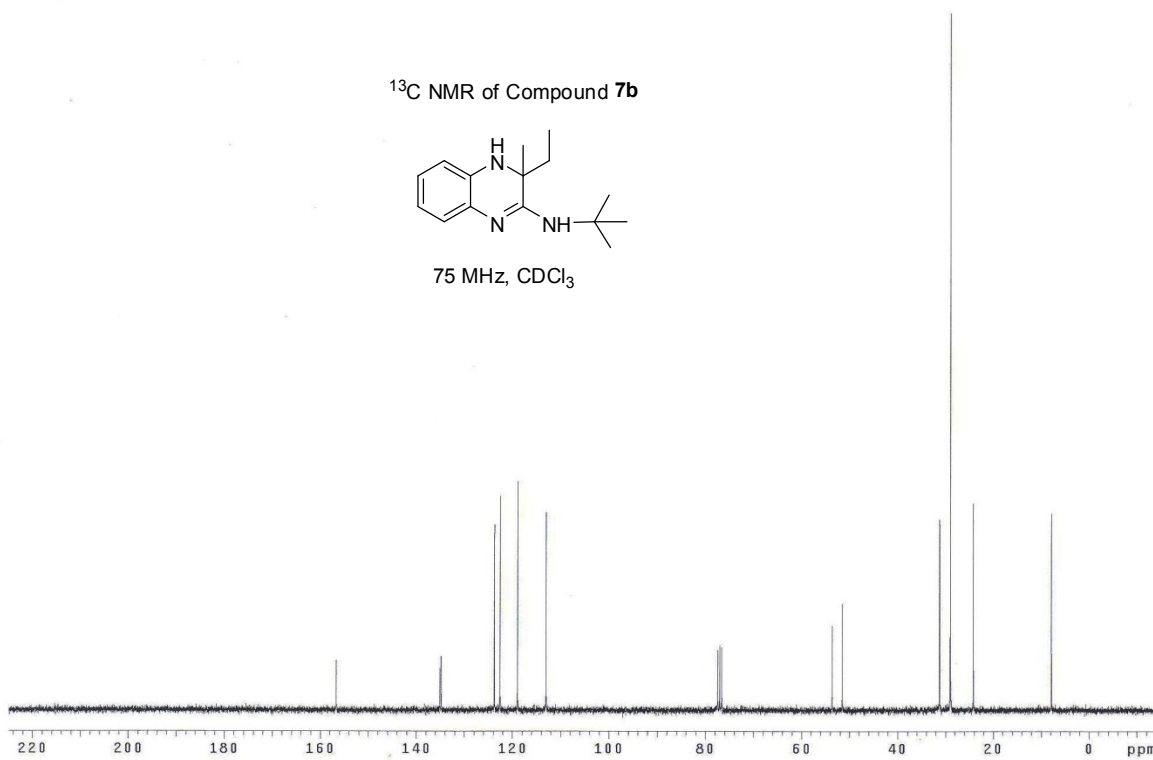
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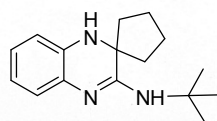
<sup>13</sup>C NMR of Compound **7b**



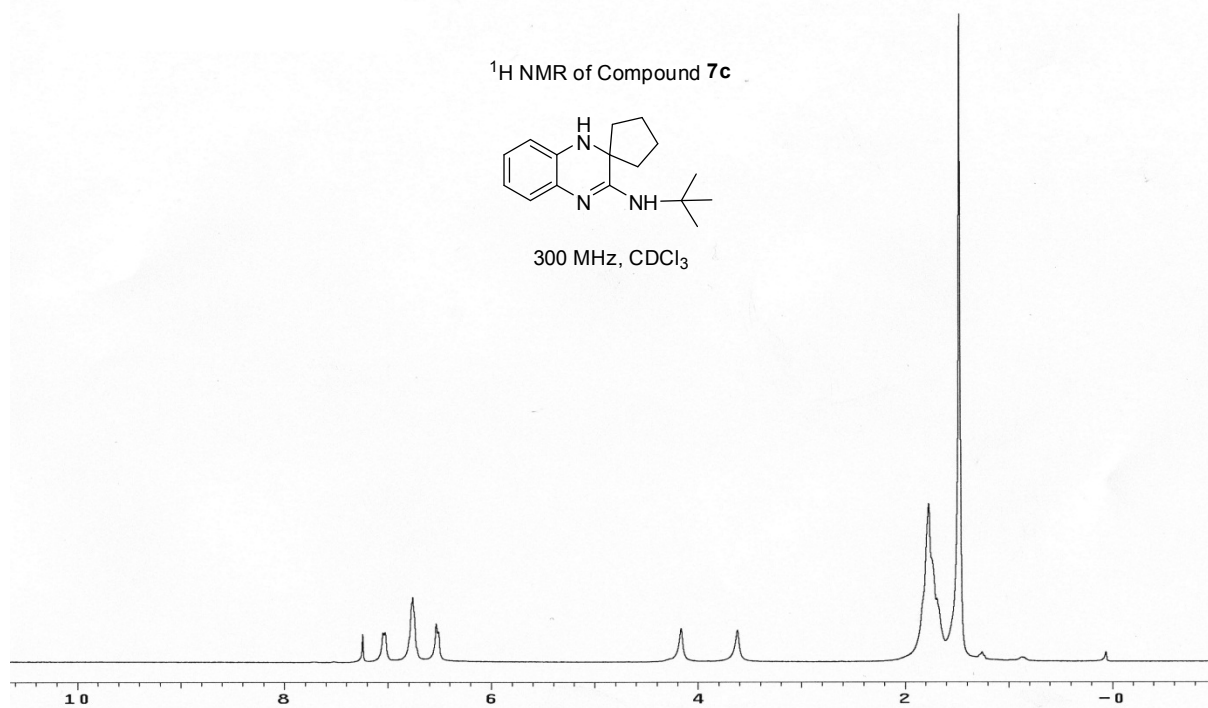
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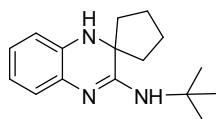
<sup>1</sup>H NMR of Compound 7c



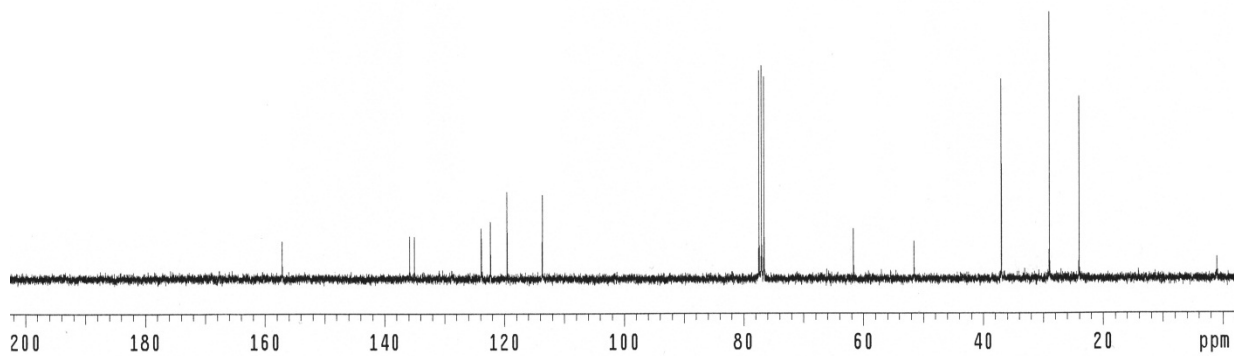
300 MHz, CDCl<sub>3</sub>



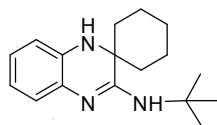
<sup>13</sup>C NMR of Compound 7c



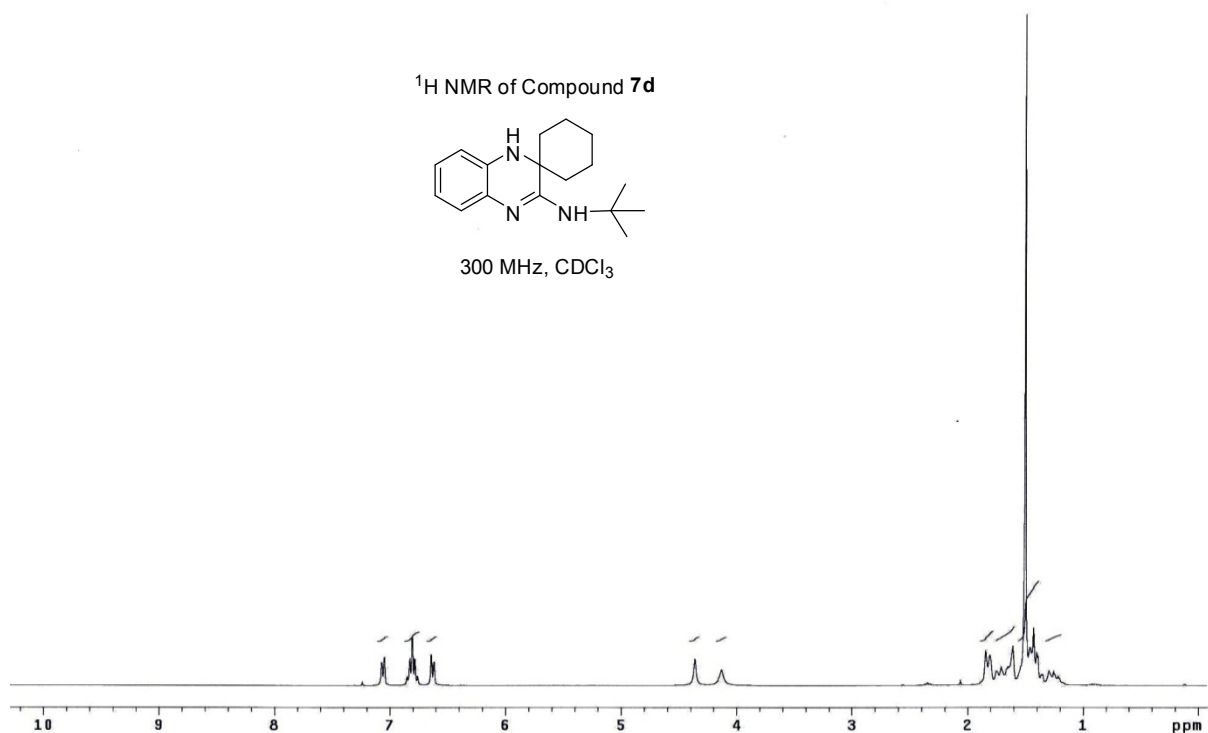
75 MHz, CDCl<sub>3</sub>



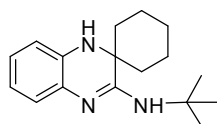
<sup>1</sup>H NMR of Compound 7d



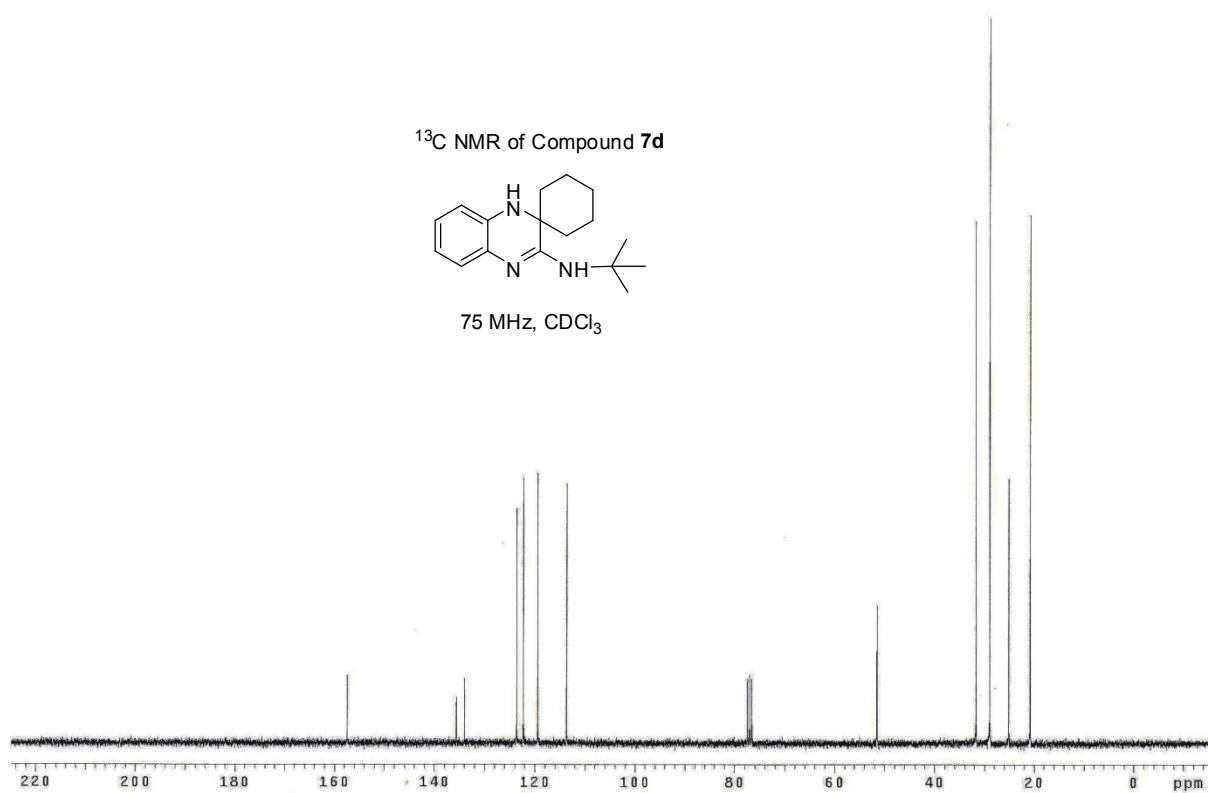
300 MHz, CDCl<sub>3</sub>



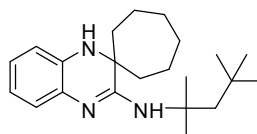
<sup>13</sup>C NMR of Compound 7d



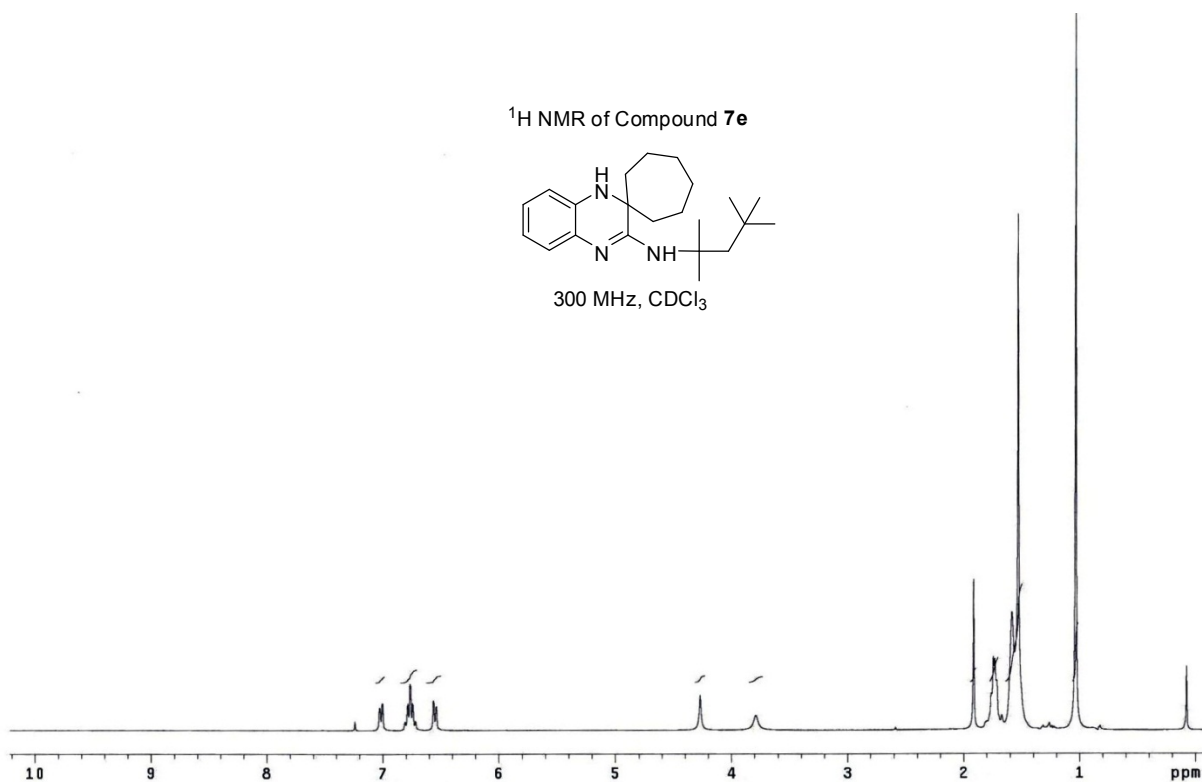
75 MHz, CDCl<sub>3</sub>



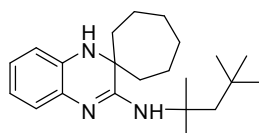
<sup>1</sup>H NMR of Compound 7e



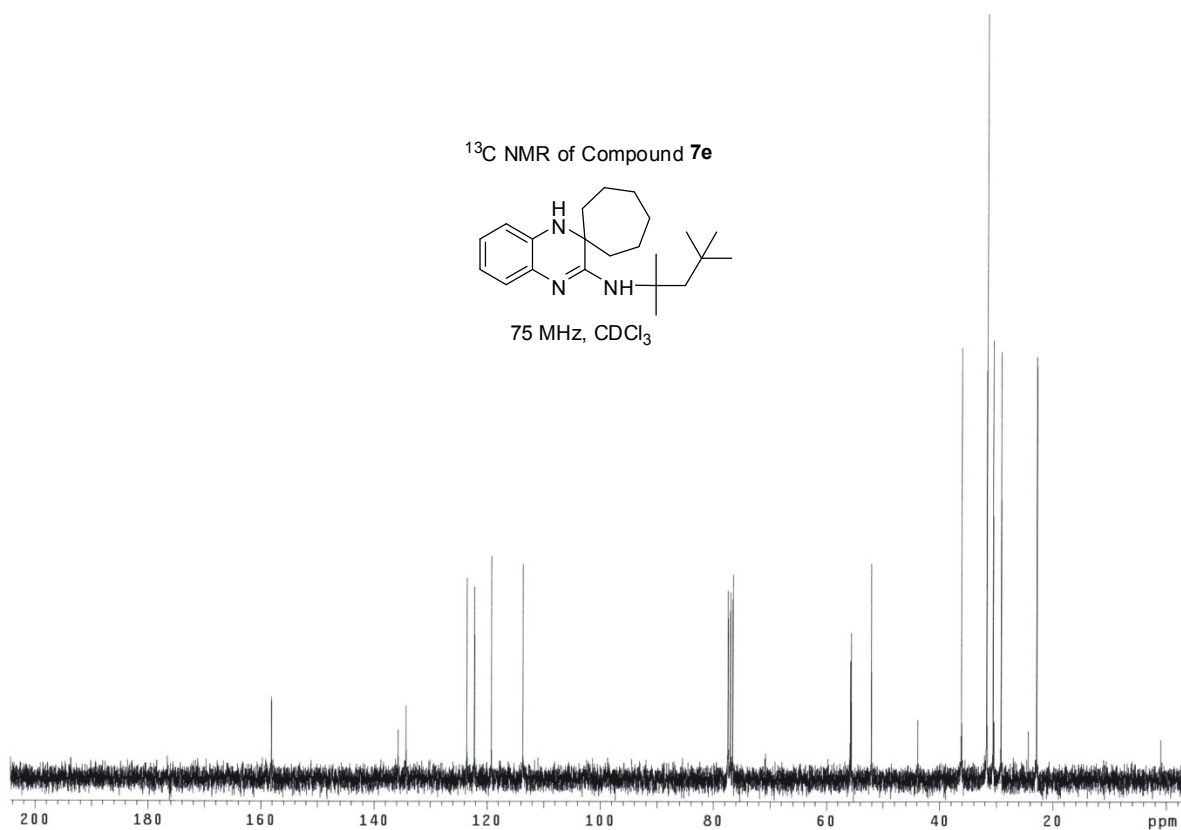
300 MHz, CDCl<sub>3</sub>



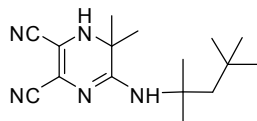
<sup>13</sup>C NMR of Compound 7e



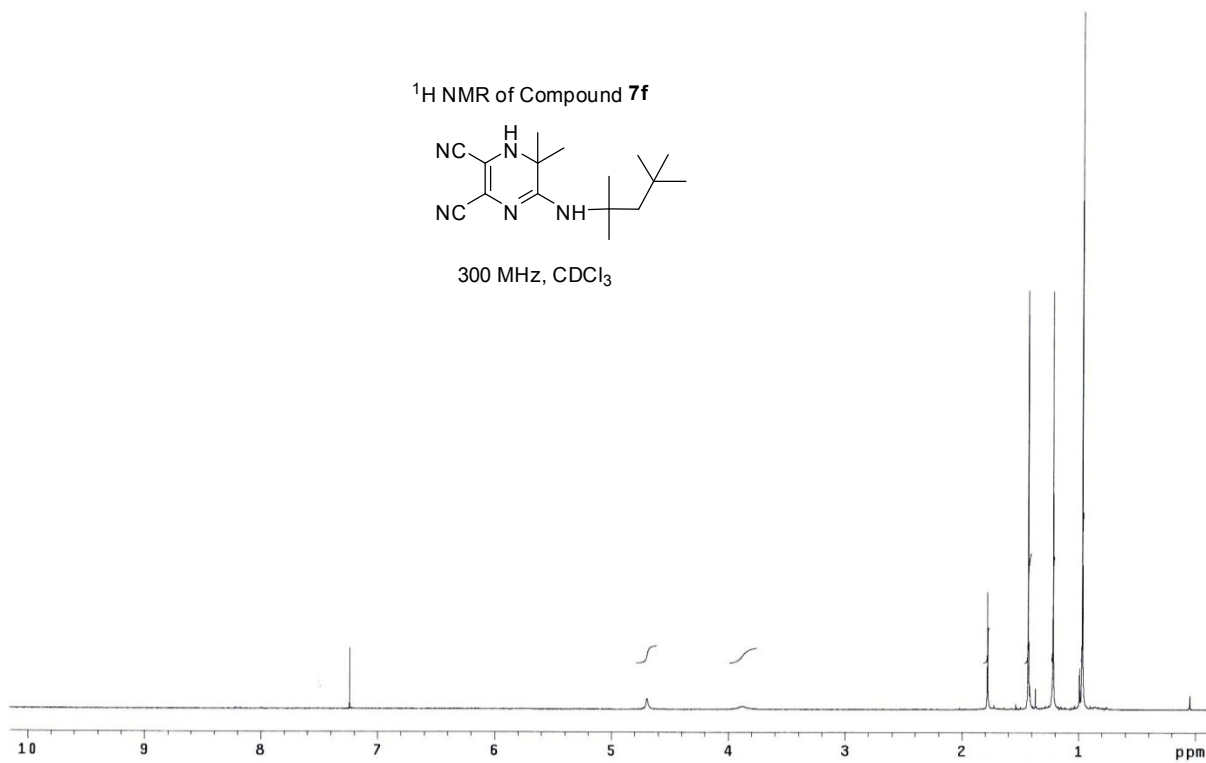
75 MHz, CDCl<sub>3</sub>



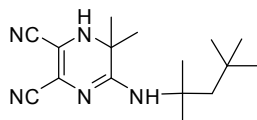
<sup>1</sup>H NMR of Compound **7f**



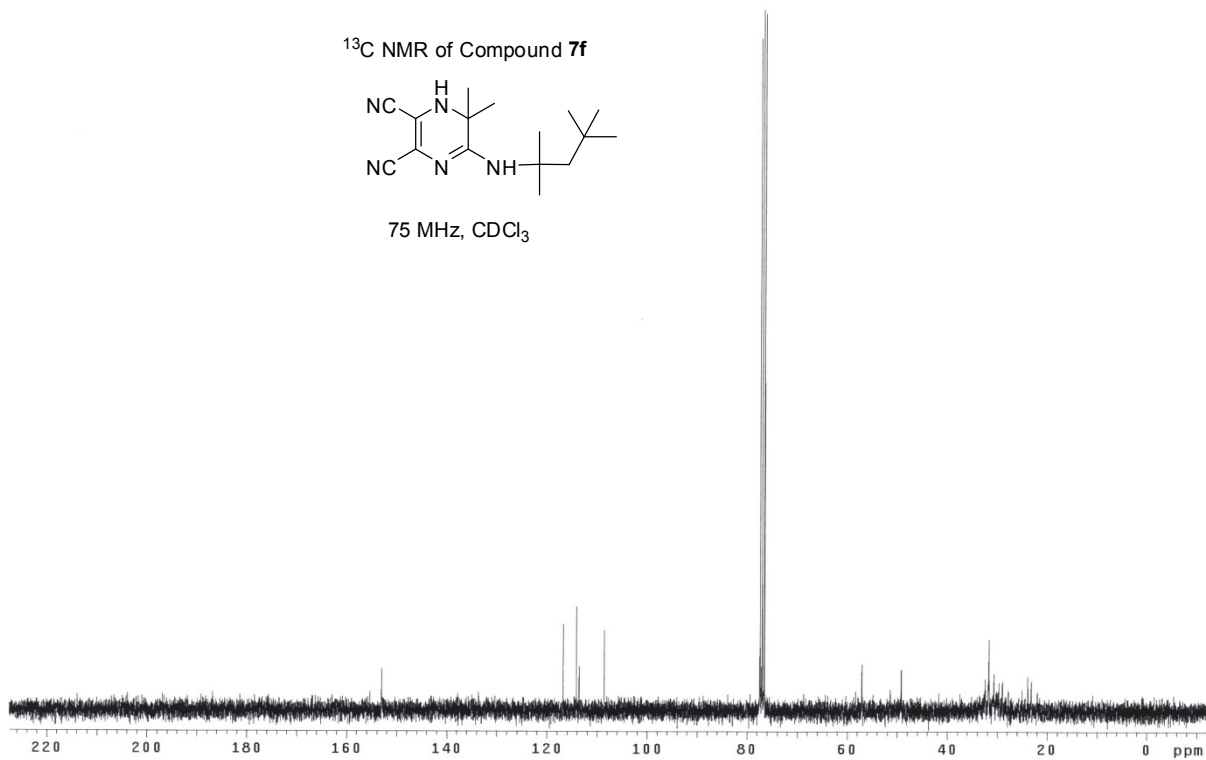
300 MHz, CDCl<sub>3</sub>



<sup>13</sup>C NMR of Compound **7f**

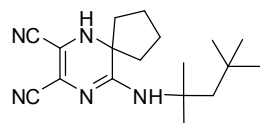


75 MHz, CDCl<sub>3</sub>

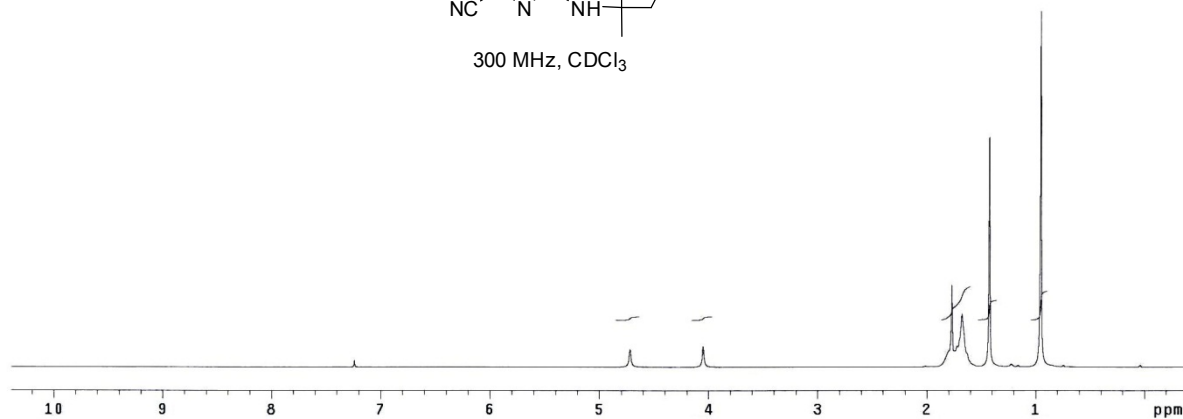




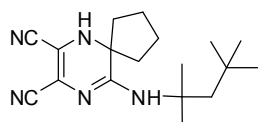
<sup>1</sup>H NMR of Compound 7g



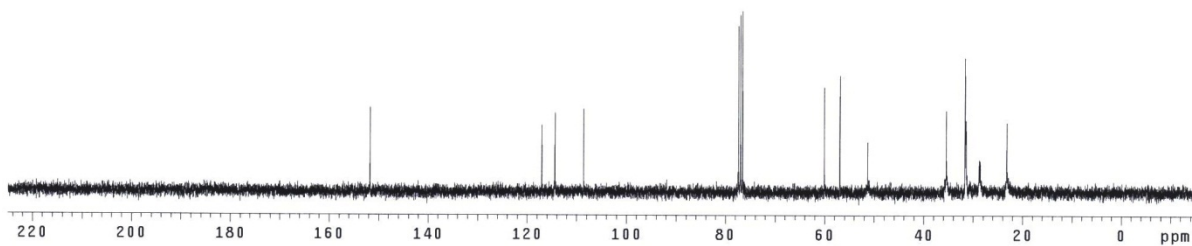
300 MHz, CDCl<sub>3</sub>



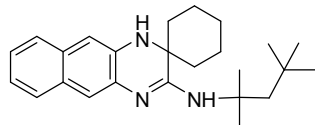
<sup>13</sup>C NMR of Compound 7g



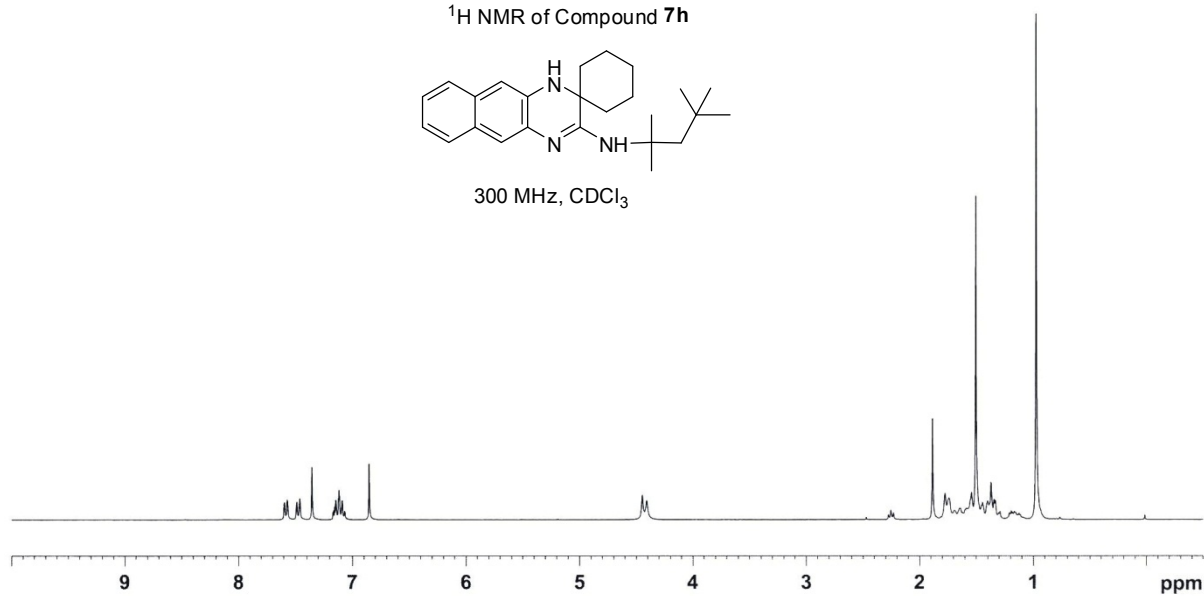
75 MHz, CDCl<sub>3</sub>



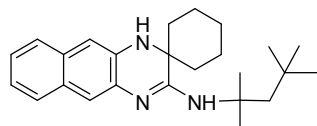
<sup>1</sup>H NMR of Compound 7h



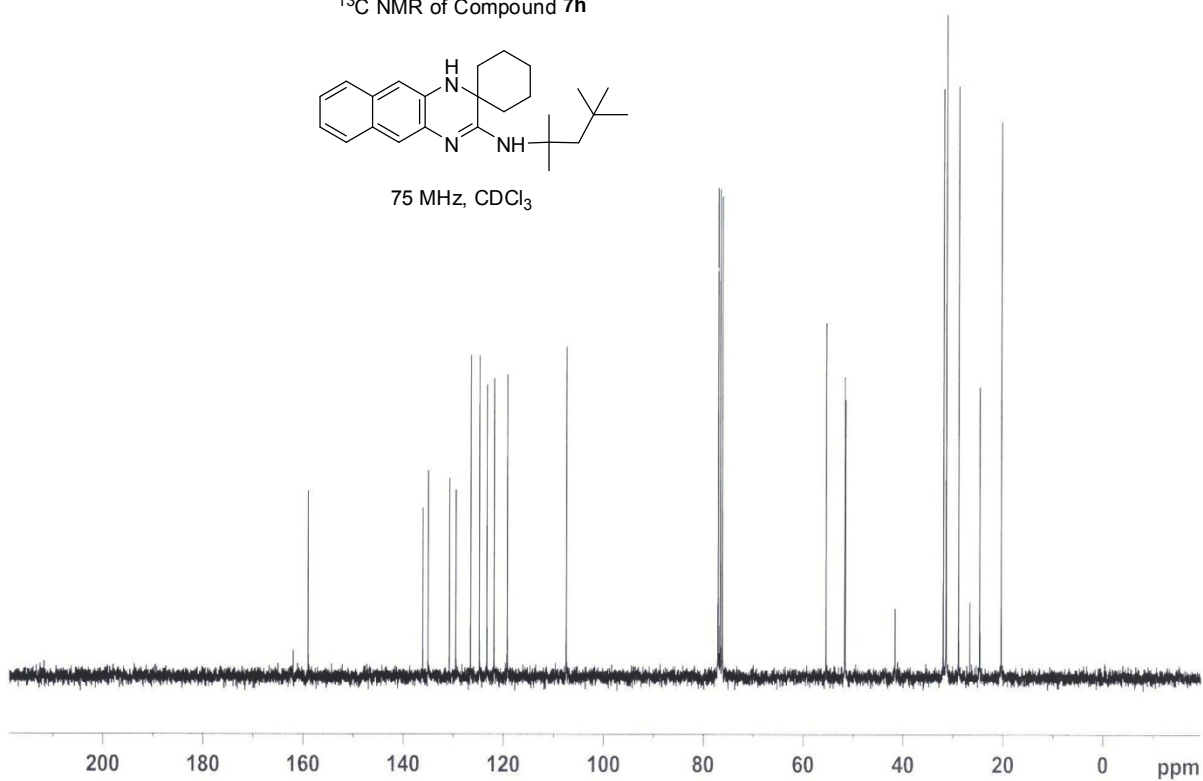
300 MHz, CDCl<sub>3</sub>



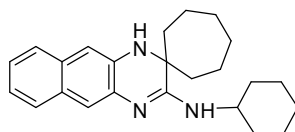
<sup>13</sup>C NMR of Compound 7h



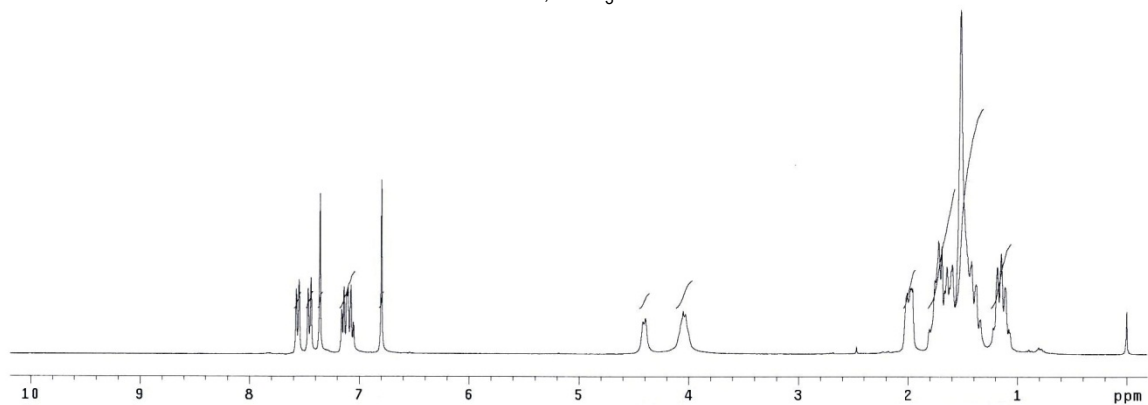
75 MHz, CDCl<sub>3</sub>



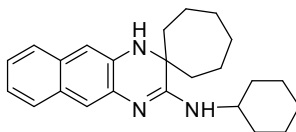
<sup>1</sup>H NMR of Compound 7i



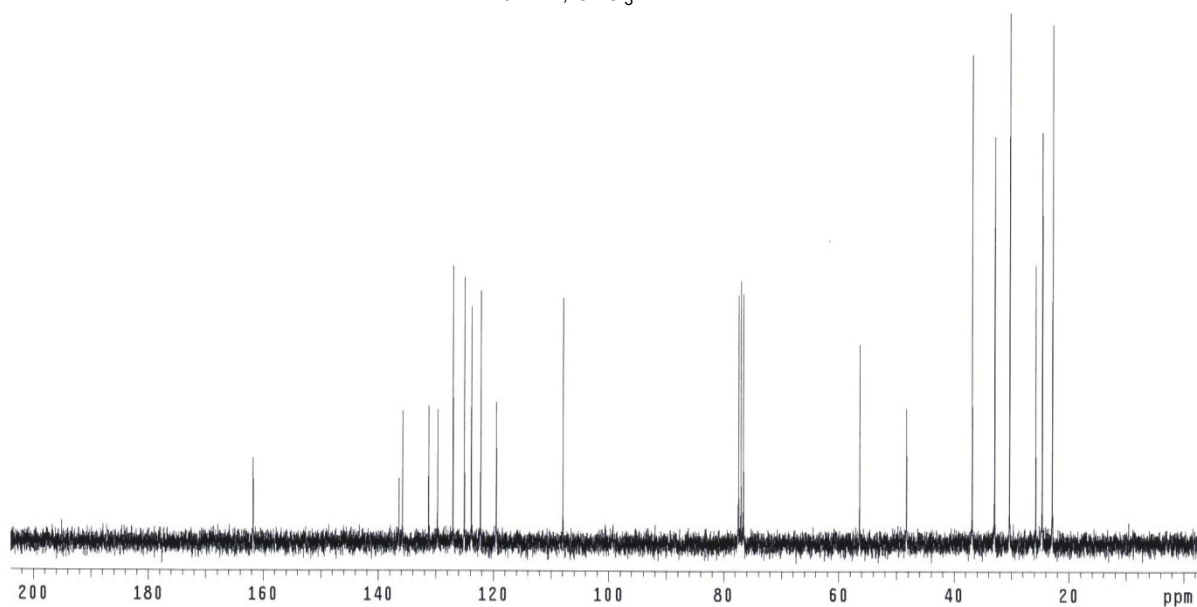
300 MHz, CDCl<sub>3</sub>



<sup>13</sup>C NMR of Compound 7i

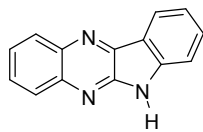


75 MHz, CDCl<sub>3</sub>

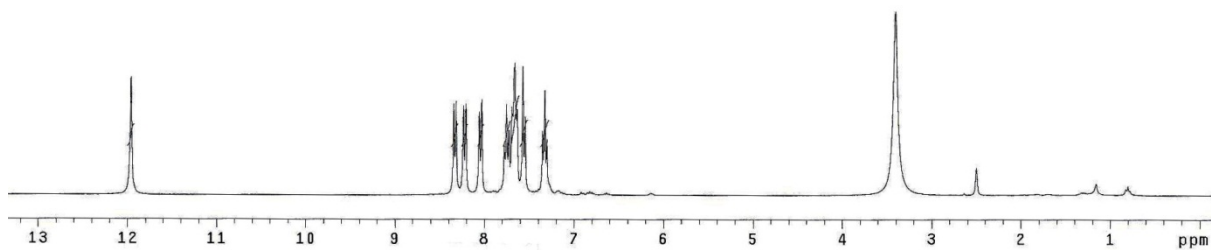


#### IV. $^1\text{H}$ NMR and $^{13}\text{C}$ NMR spectra of compounds (14a & 14b)

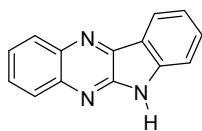
$^1\text{H}$  NMR of Compound 14a



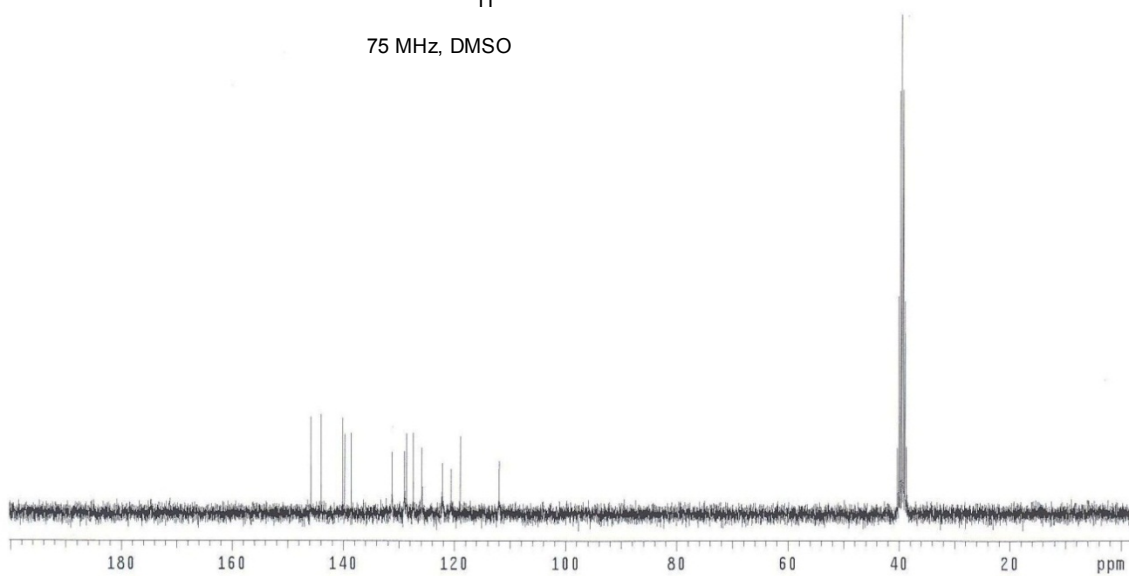
300 MHz, DMSO



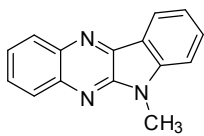
$^{13}\text{C}$  NMR of Compound 14a



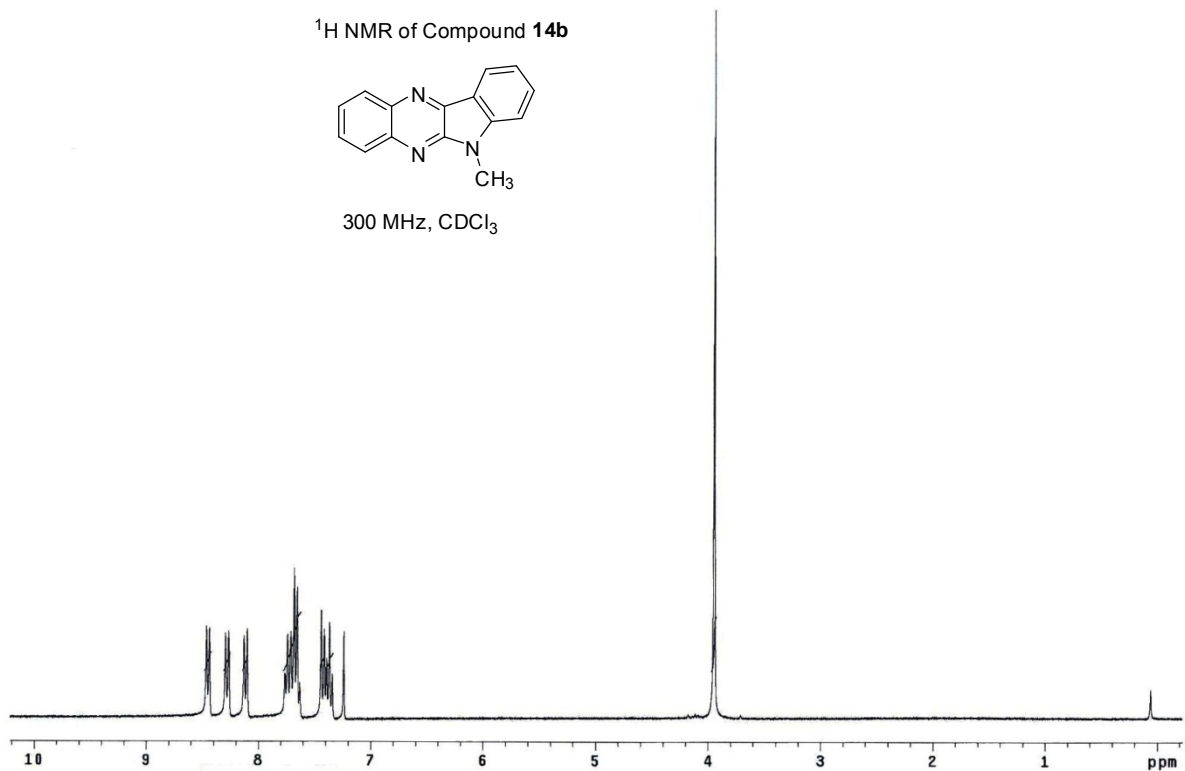
75 MHz, DMSO



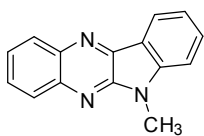
<sup>1</sup>H NMR of Compound **14b**



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



<sup>13</sup>C NMR of Compound **14b**



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

