

Electronic Supplementary Information

New routes of azomethine ylide generation from prolines to synthesize diverse *n*-heterocycles: a DFT supported *endo*-selective mechanism

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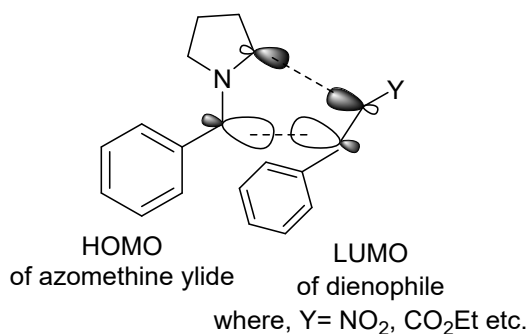
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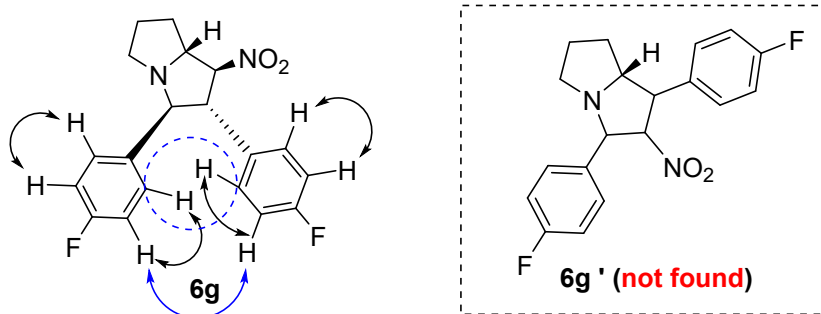
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1. Structure elucidation of **6g**: regio and stereo-selectivity

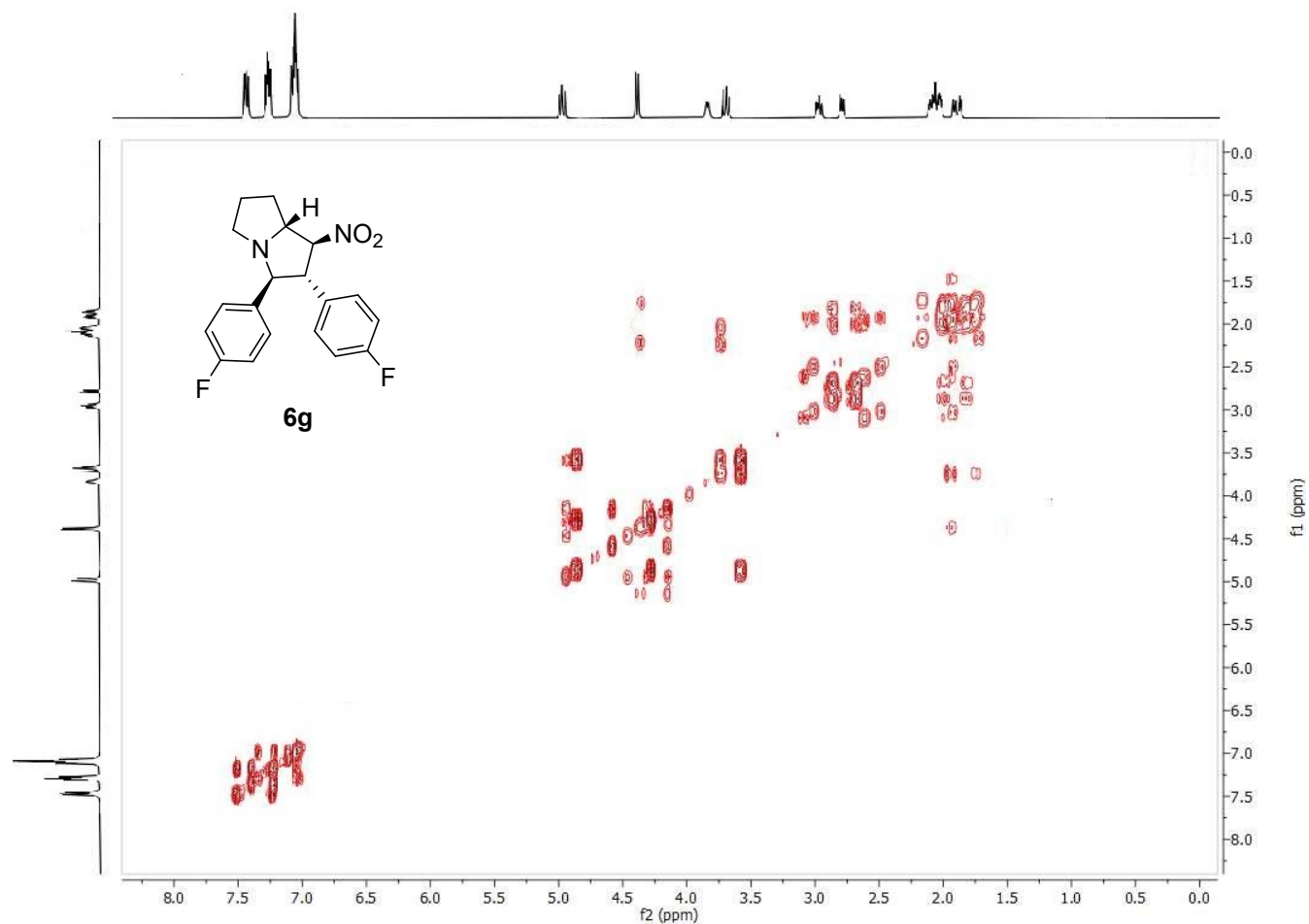


Azomethine ylide derived from L-proline undergoes a [3+2] cycloaddition reaction through the above-mentioned HOMO-LUMO interaction, which accounts for the regioselectivity. There is lots of theoretical and experimental evidence in the literature.¹ The reverse selectivity is observed with azomethine ylide derived from L-proline ester without decarboxylation.² The endo-selectivity is discussed in the manuscript with the help of literature.

From the NOESY spectra (SI figure 1) of compound **6g**, it is very clear that more contours are present in the aromatic region apart from the interaction of orthoprotons in aromatic rings. These excess interactions (blue clouded) among the aromatic protons are shown below.



SI Figure 1: NOESY spectra of compound **6g**

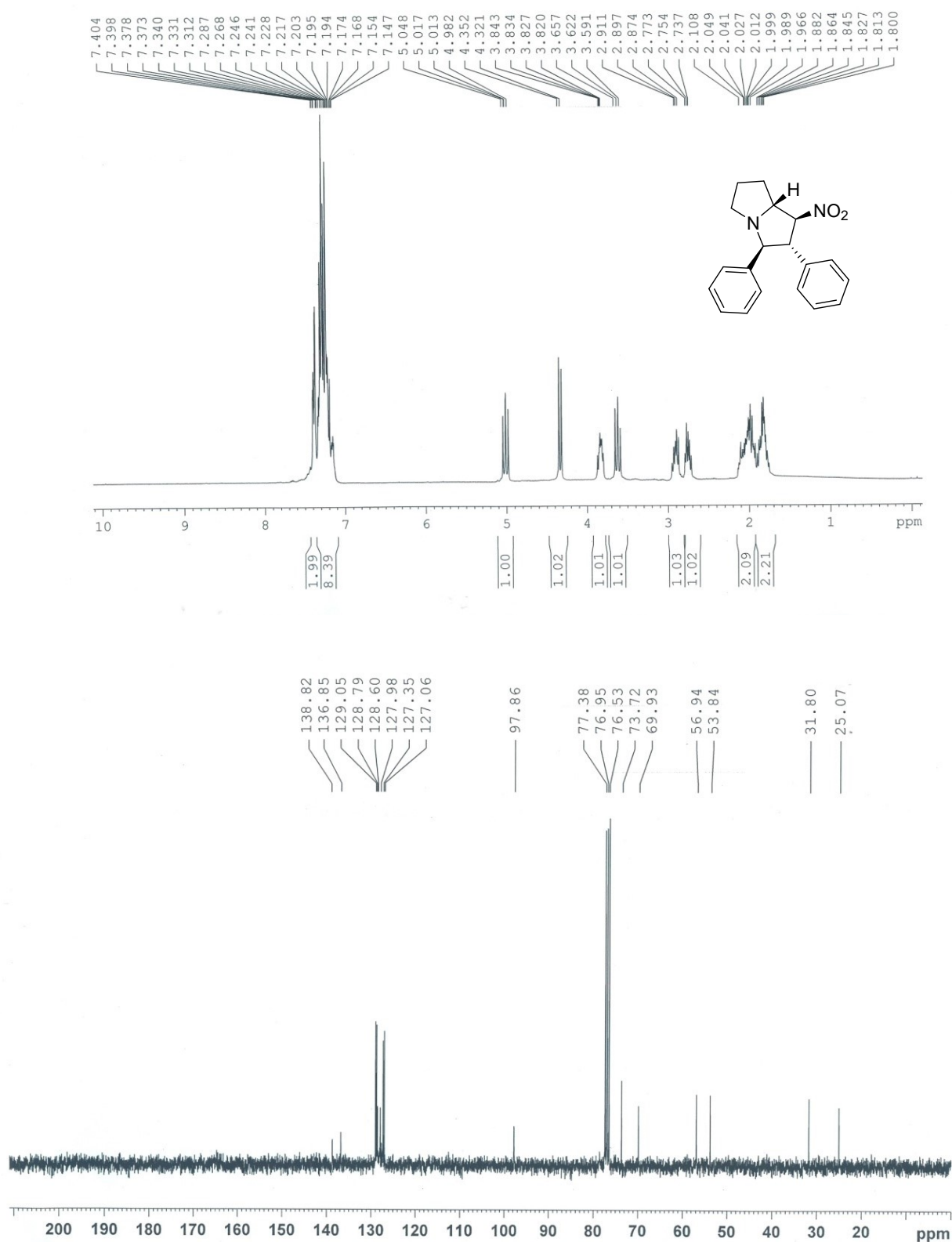


2. References

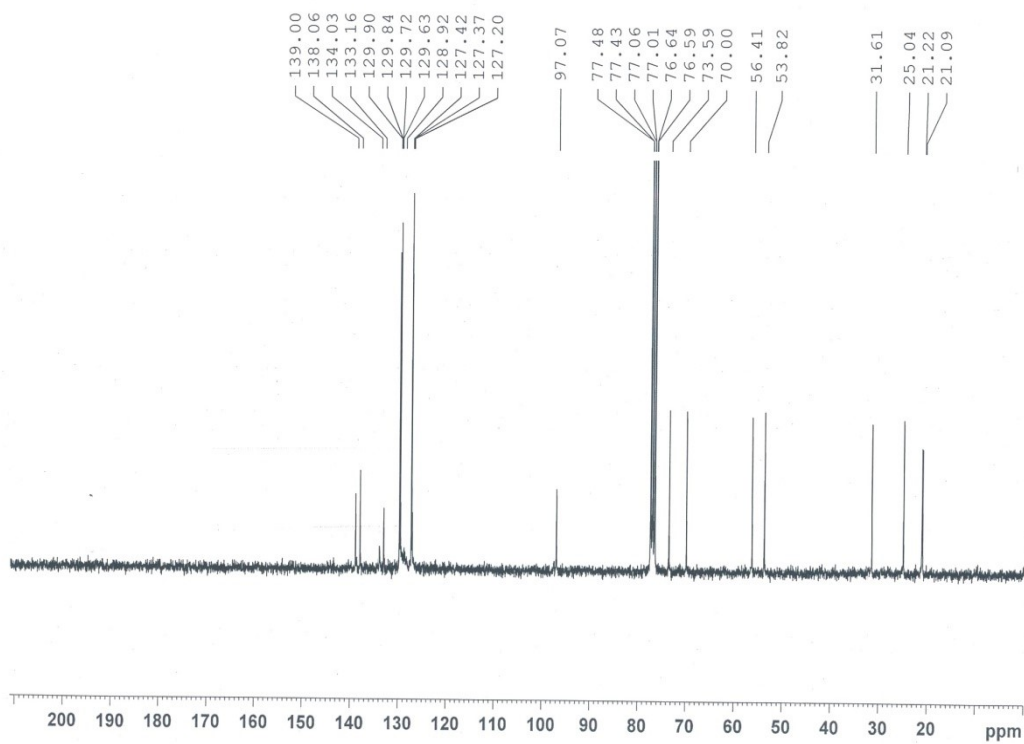
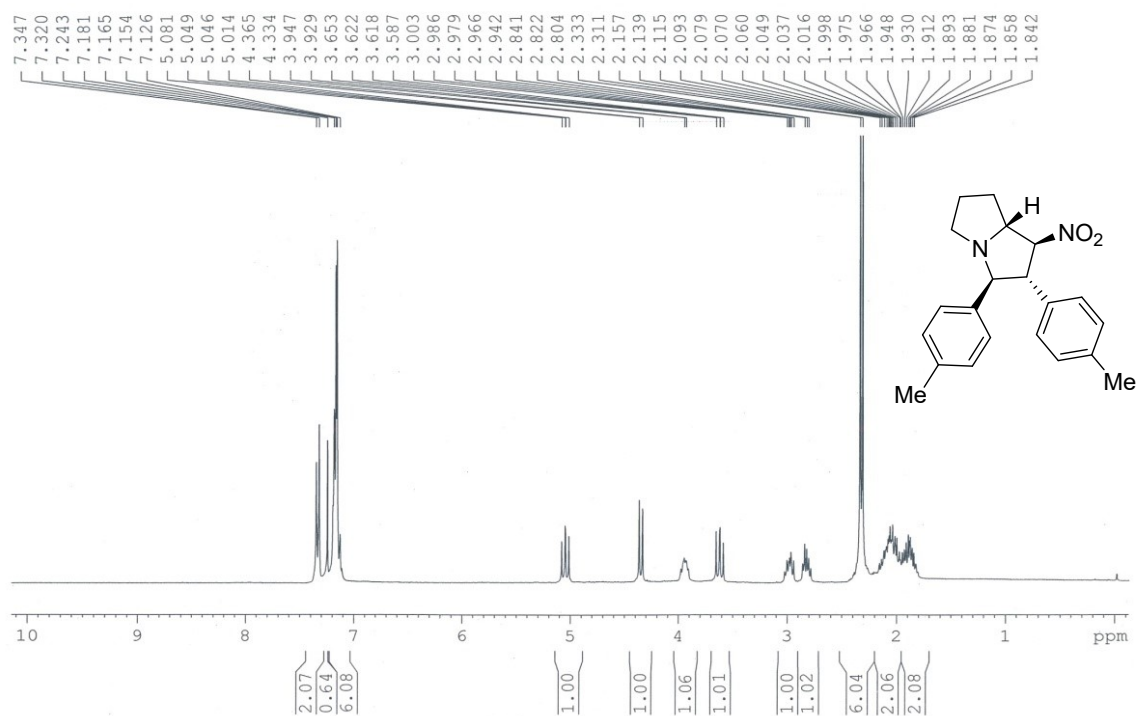
1. K. Alimohammadi, Y. Sarrafi, M. Tajbakhsh, S. Yeganegi, M. Hamzehloueian, *Tetrahedron*, 2011, **67** 1589; (a) Y. Toma, M. Kunigami, K. Watanabe, M. Higashi, S. Arimitsu, *J. Flu. Chem.*, 2016, **189**, 22; (c) K. Alimohammadi, Y. Sarrafi, B. Rajabpour, *C. R. Chimie*, 2014, **17**, 156; (d) T. L. Pavlovska, R. Gr. Redkin, V. V. Lipson, D. V. Atamanuk, *Mol Divers*, 2016, **20**, 299.
2. K. Yamazaki, P. Gabriel, G. D. Carmine, J. Pedroni, M. Farizyan, T. A. Hamlin, D. J. Dixon, *ACS Catal.*, 2021, **11**, 7489.

3. ^1H and ^{13}C -NMR spectra of all the compounds 6a-j, 7a-l, 8a-d, 9a-j, 10a-d and ^{19}F -NMR spectra of 6g, 7e, 9b

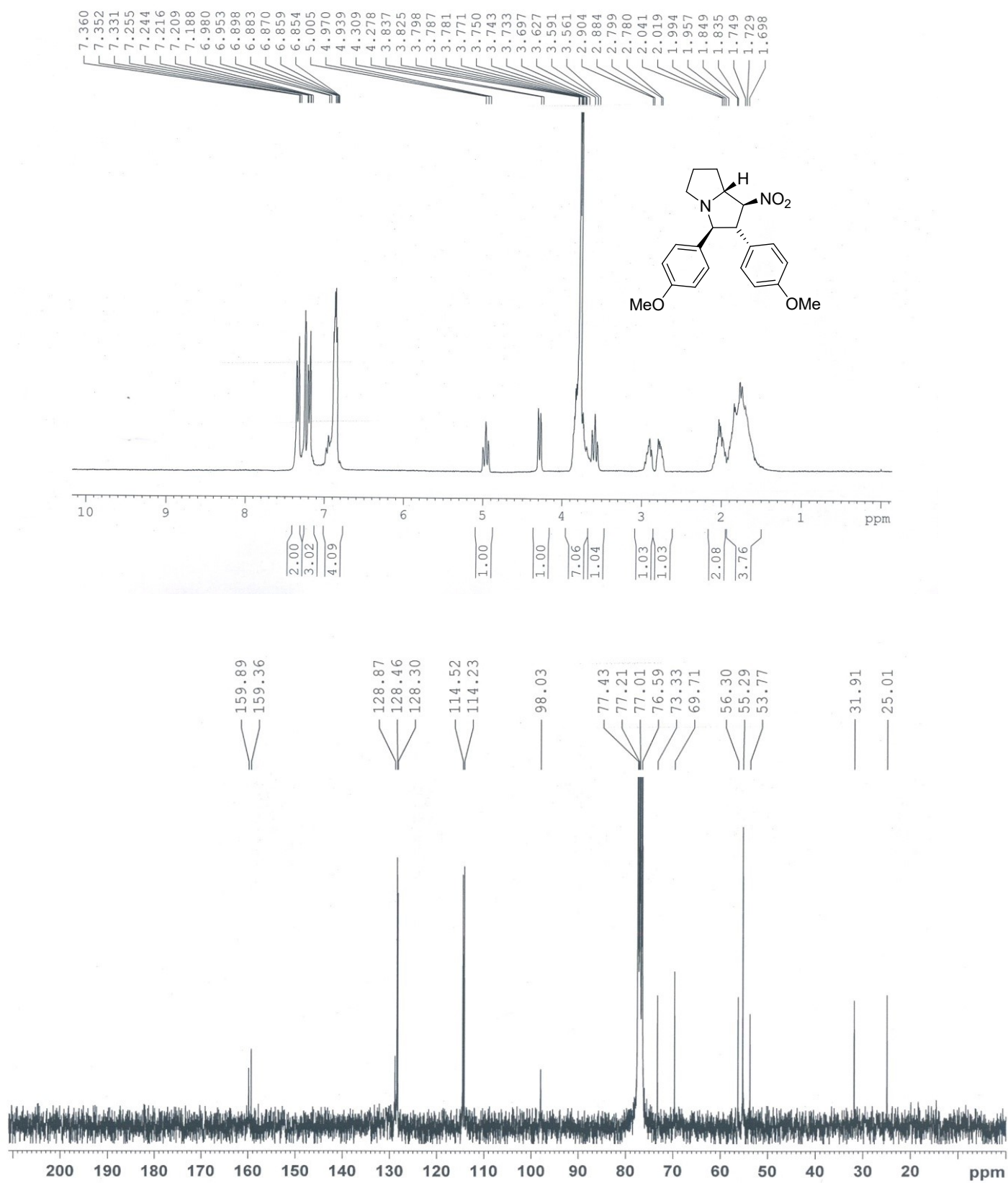
SI Figure 2: ^1H and ^{13}C -NMR spectra of compound 6a



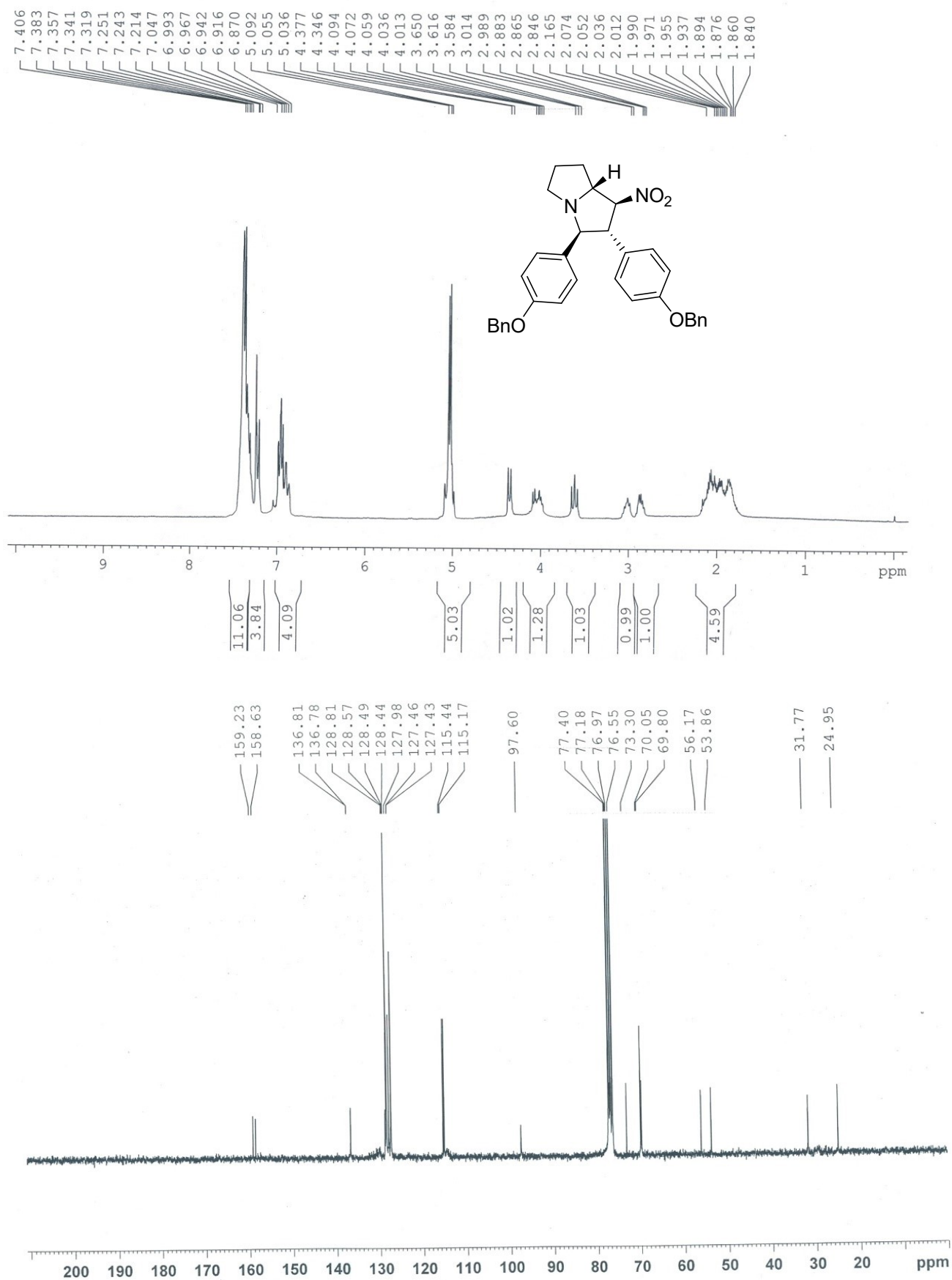
SI Figure 3: ^1H and ^{13}C -NMR spectra of compound **6b**



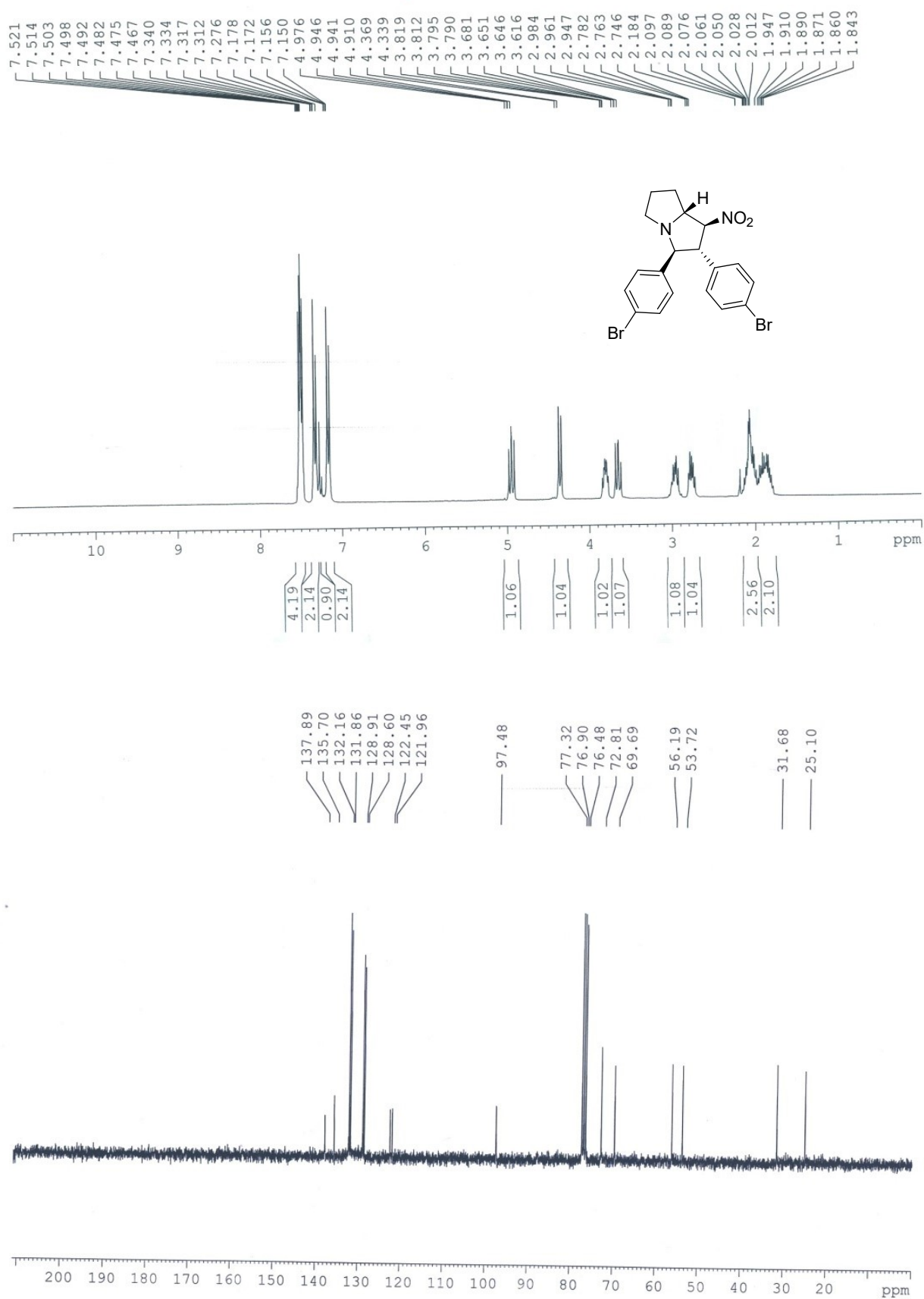
SI Figure 4: ^1H and ^{13}C -NMR spectra of compound **6c**



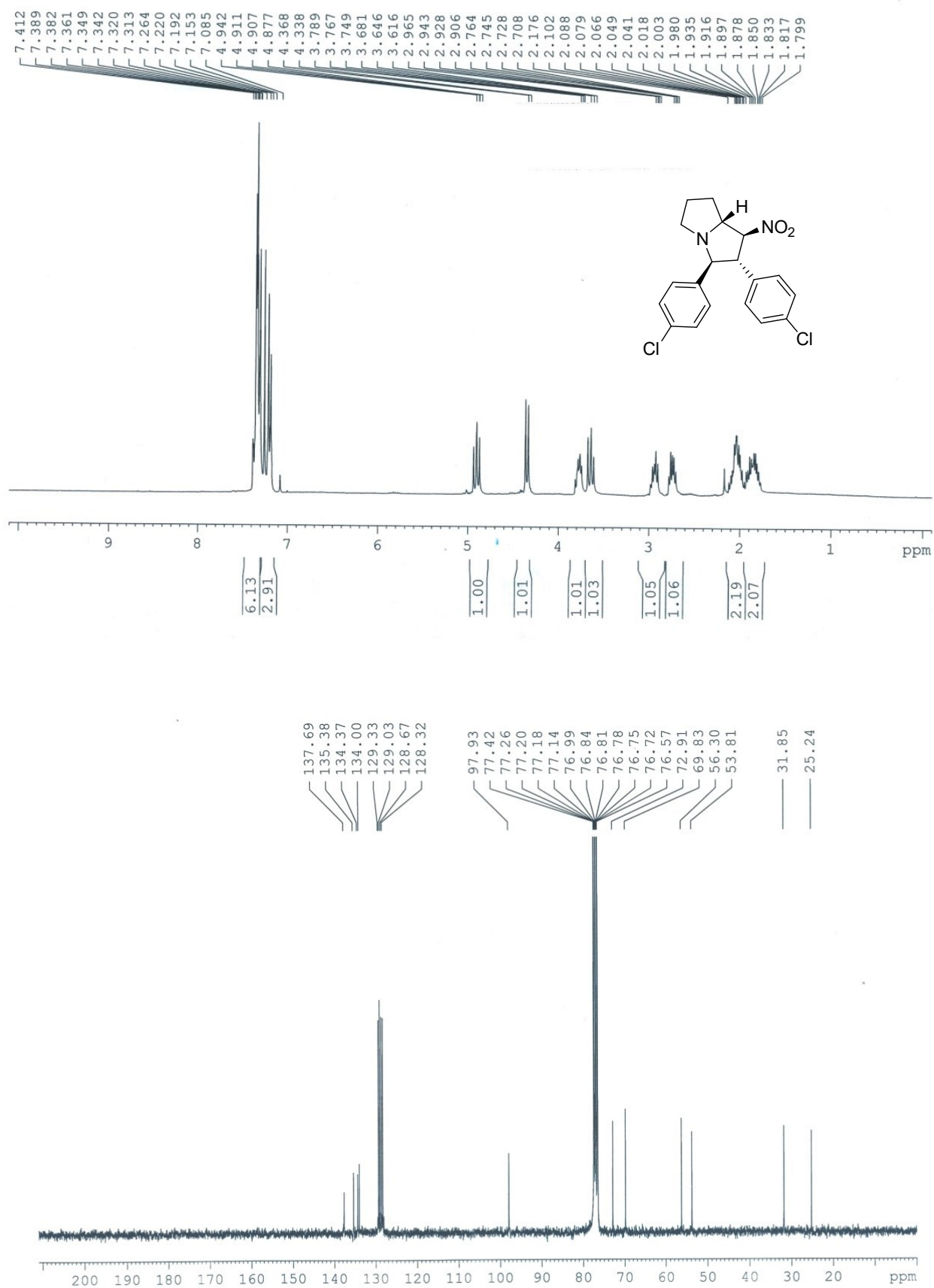
SI Figure 5: ^1H and ^{13}C -NMR spectra of compound **6d**



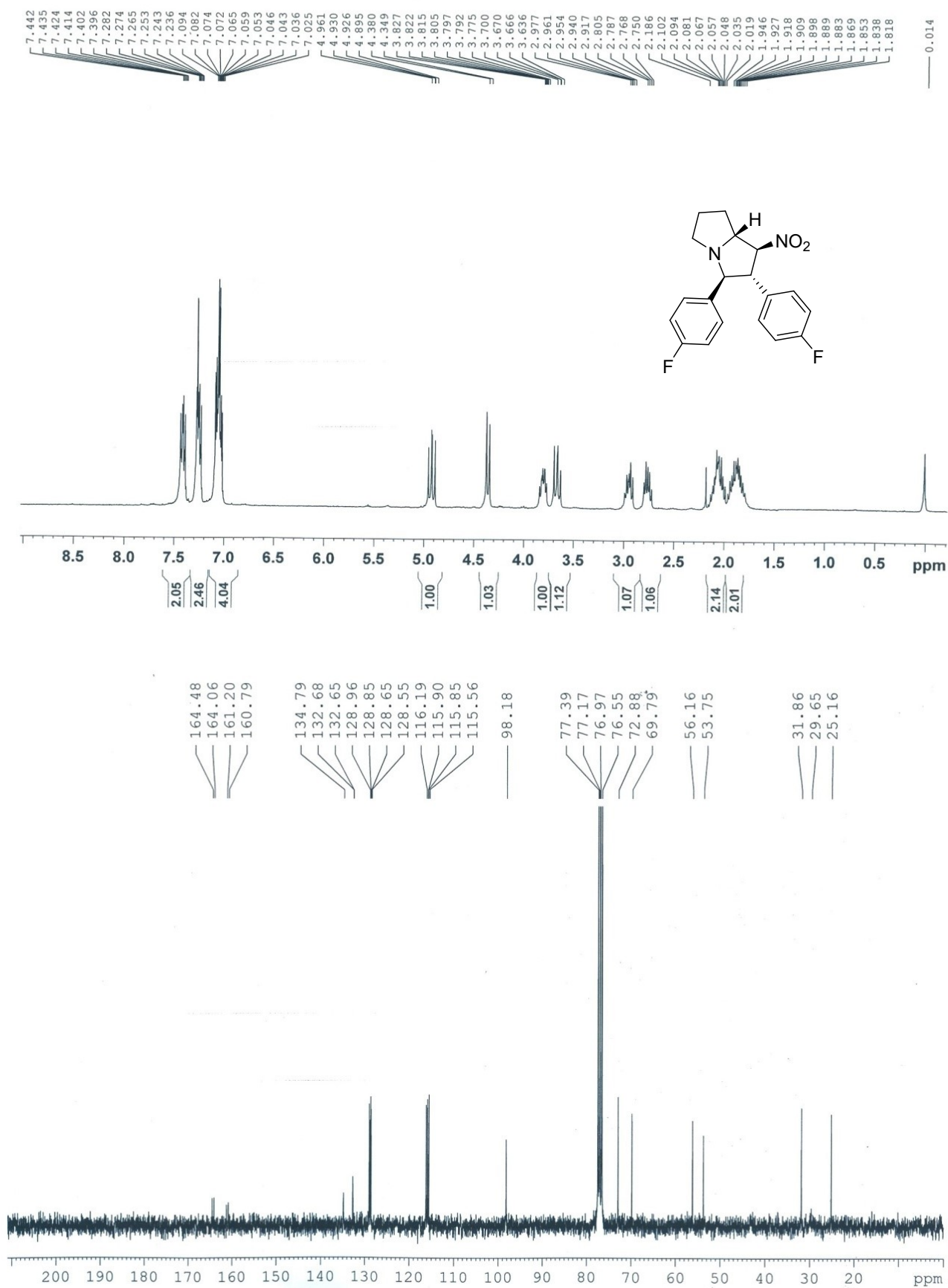
SI Figure 6: ^1H and ^{13}C -NMR spectra of compound 6e

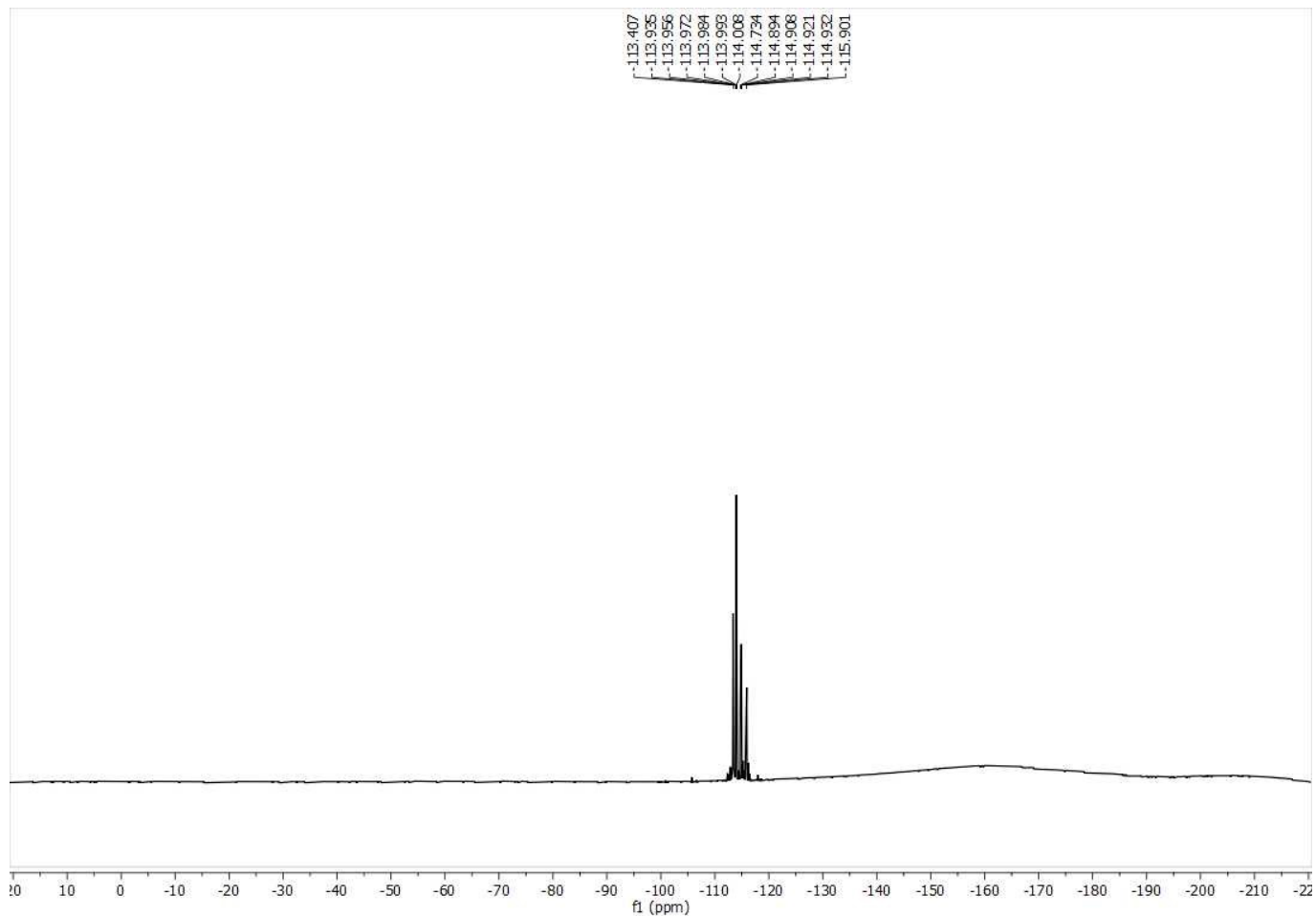


SI Figure 7: ^1H and ^{13}C -NMR spectra of compound 6f

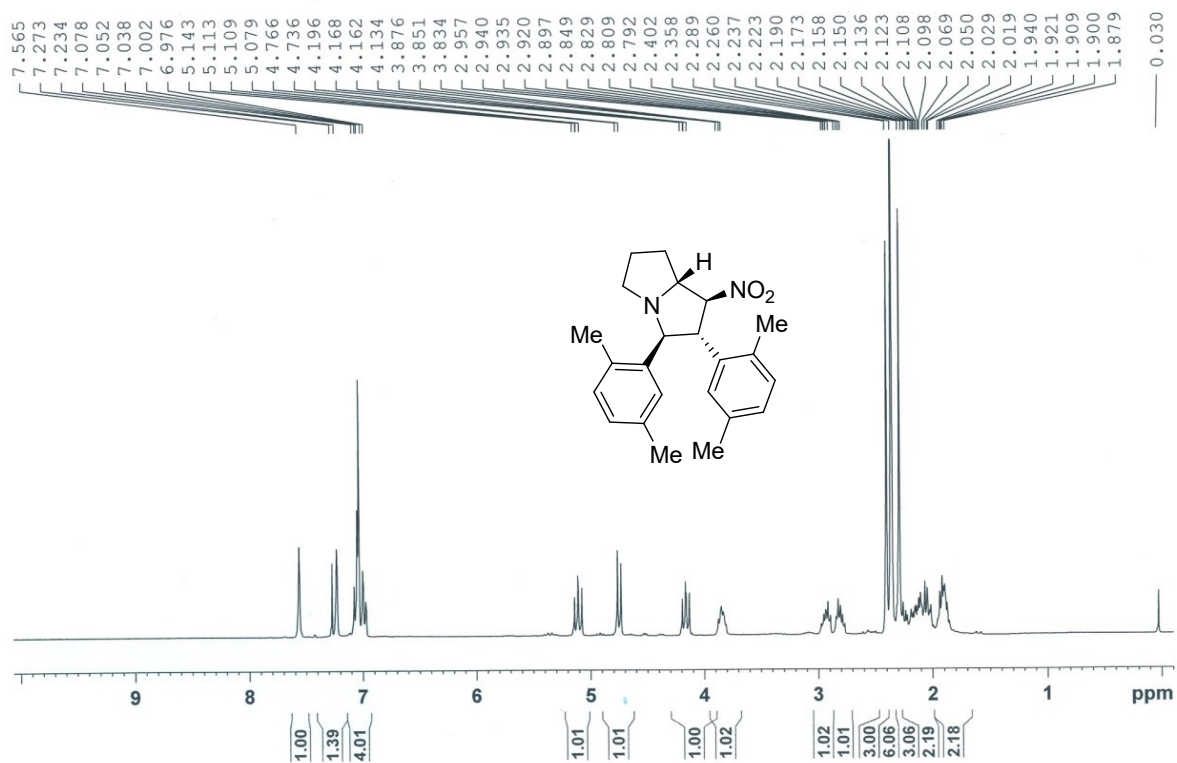


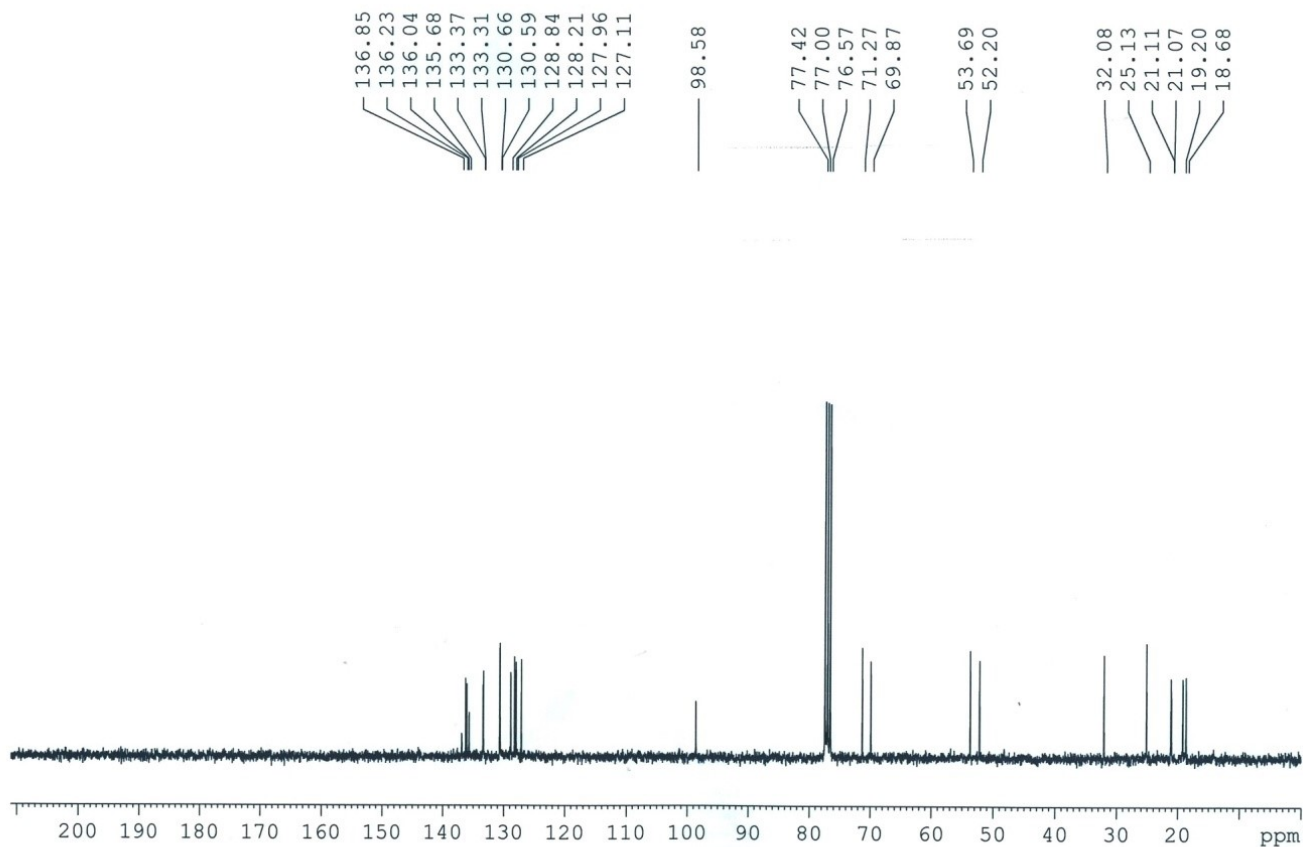
SI Figure 8: ^1H , ^{13}C and ^{19}F -NMR spectra of compound **6g**



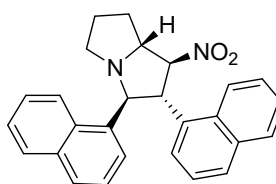
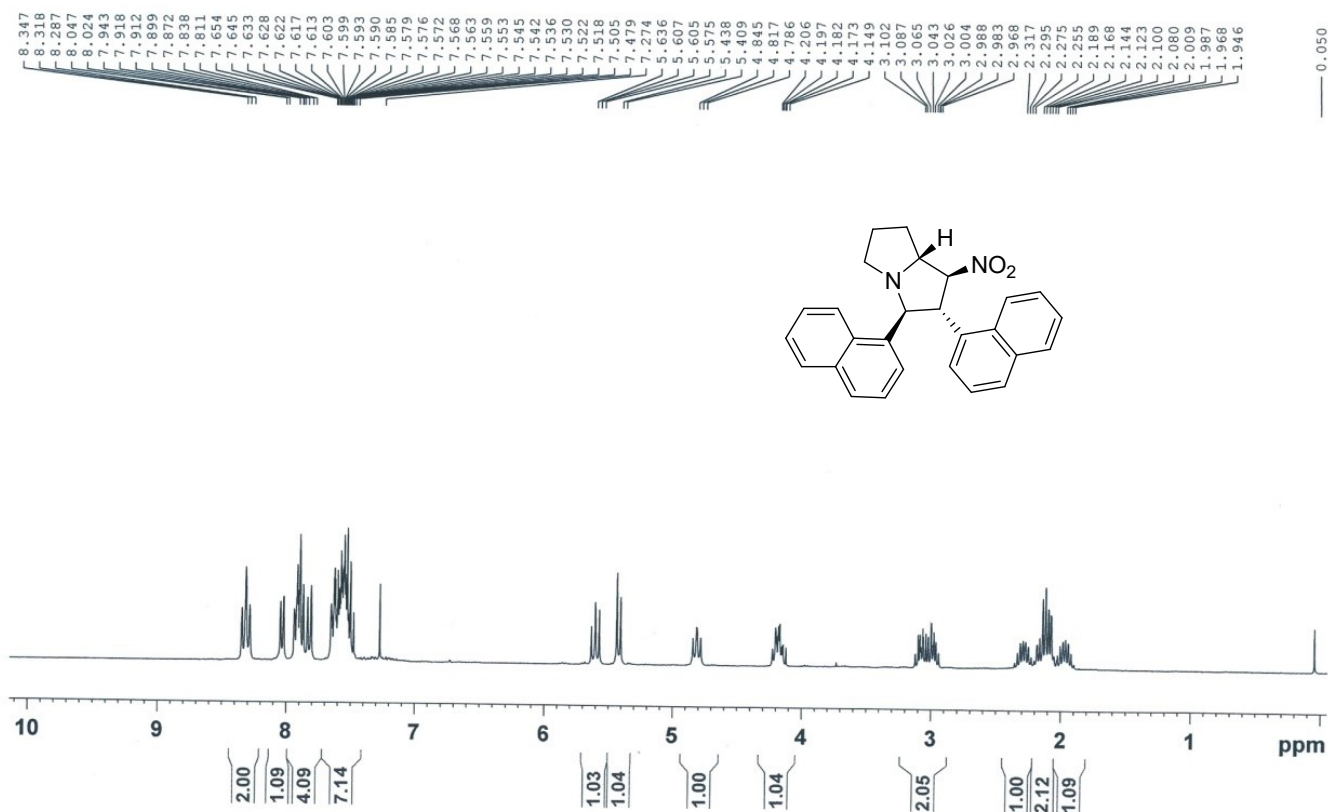


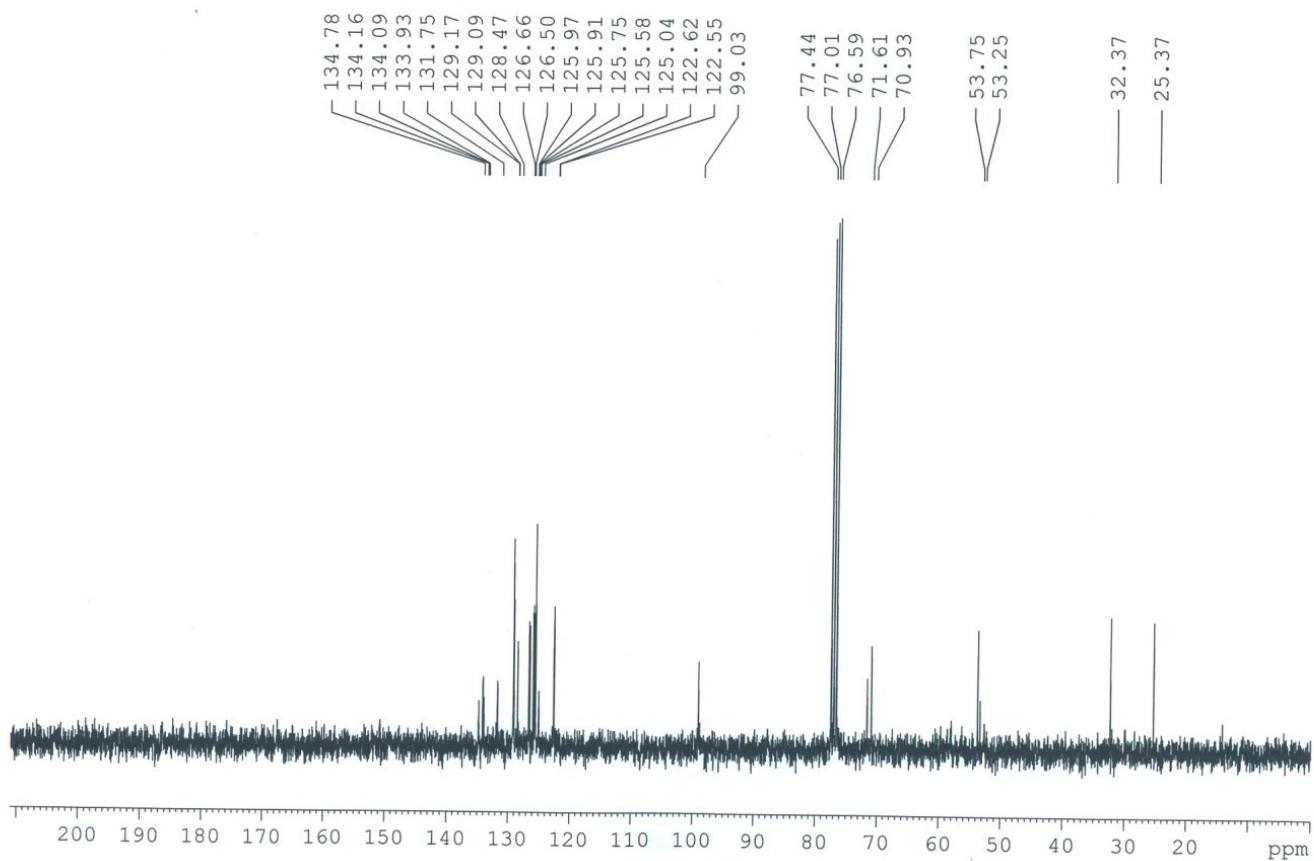
SI Figure 9: ^1H and ^{13}C -NMR spectra of compound **6h**



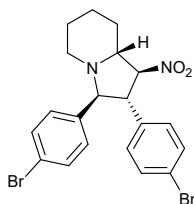
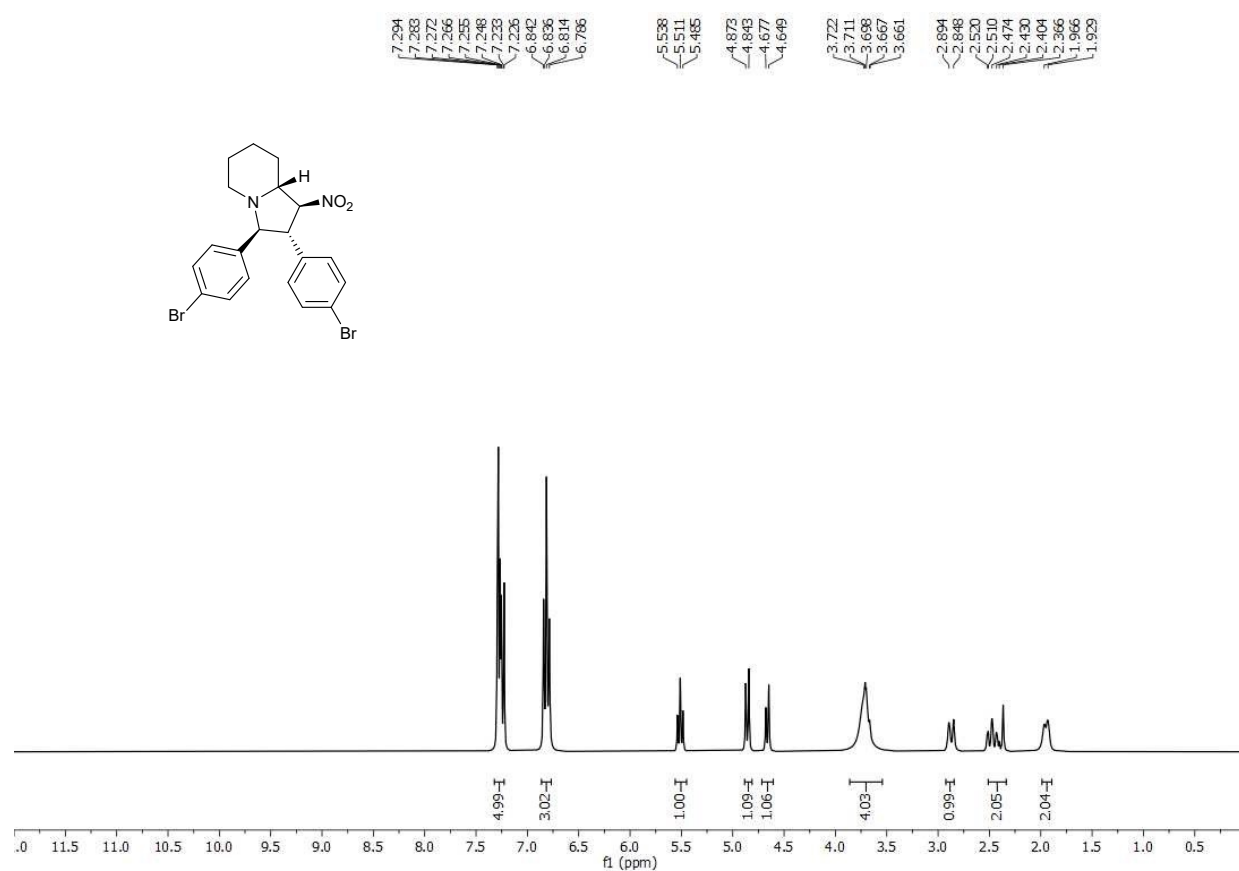


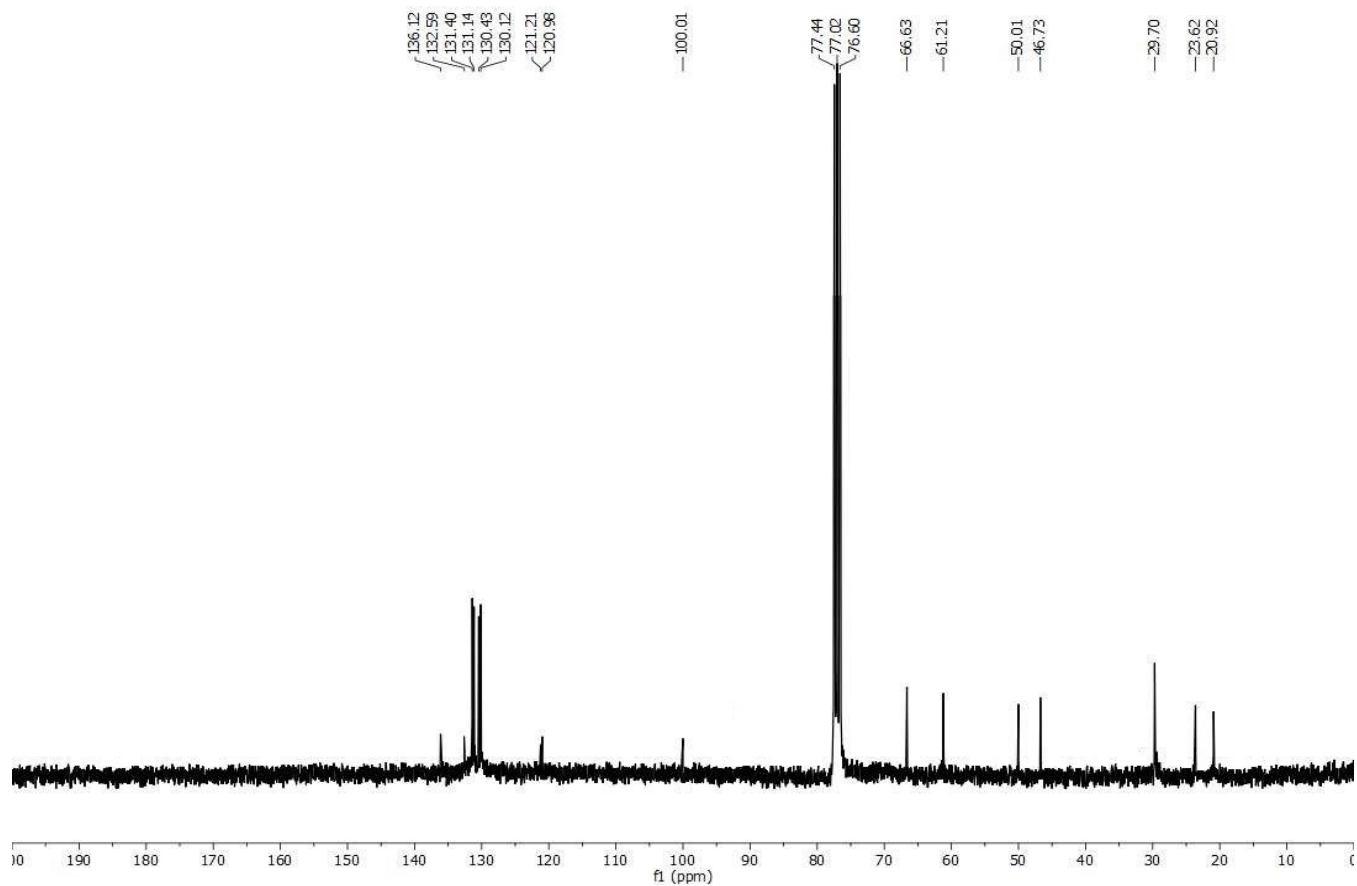
SI Figure 10: ^1H and ^{13}C -NMR spectra of compound 6i



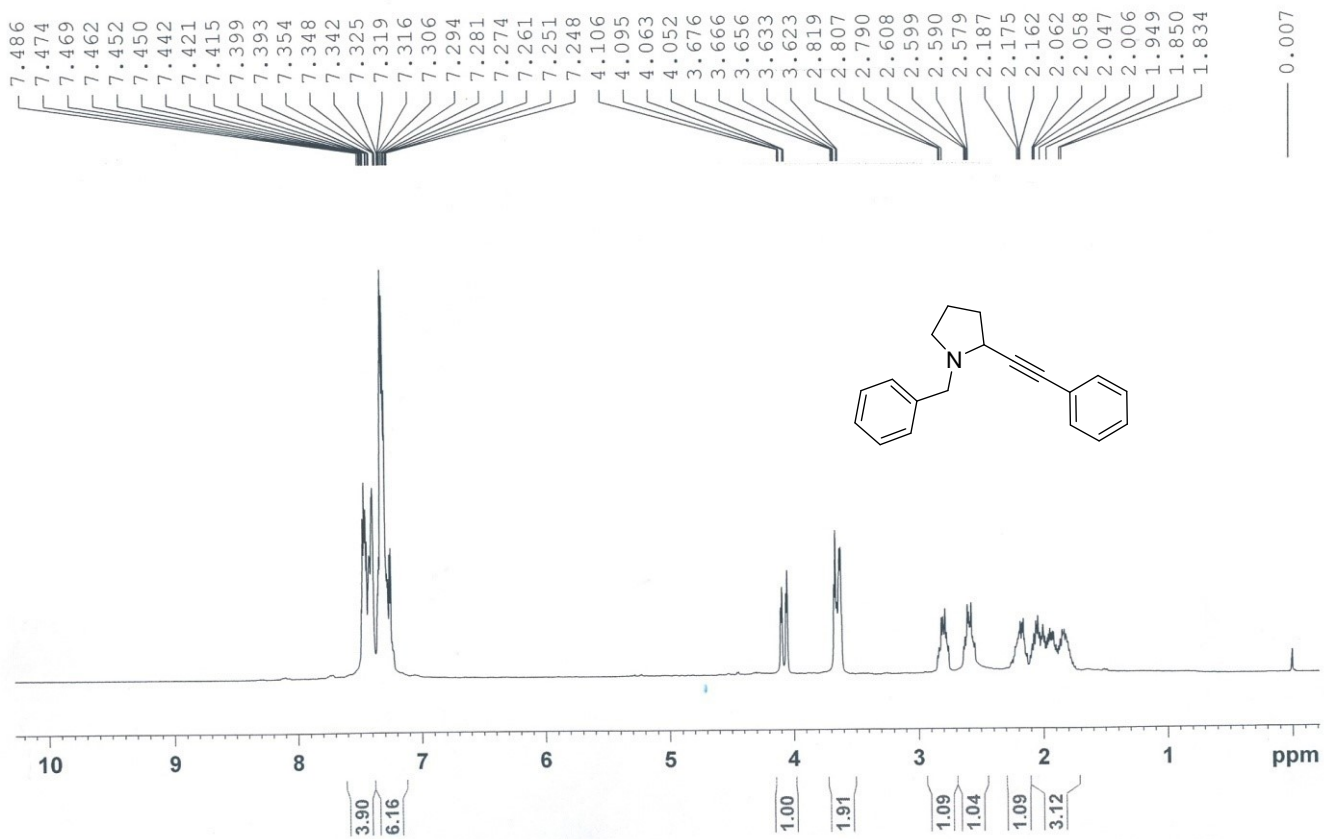


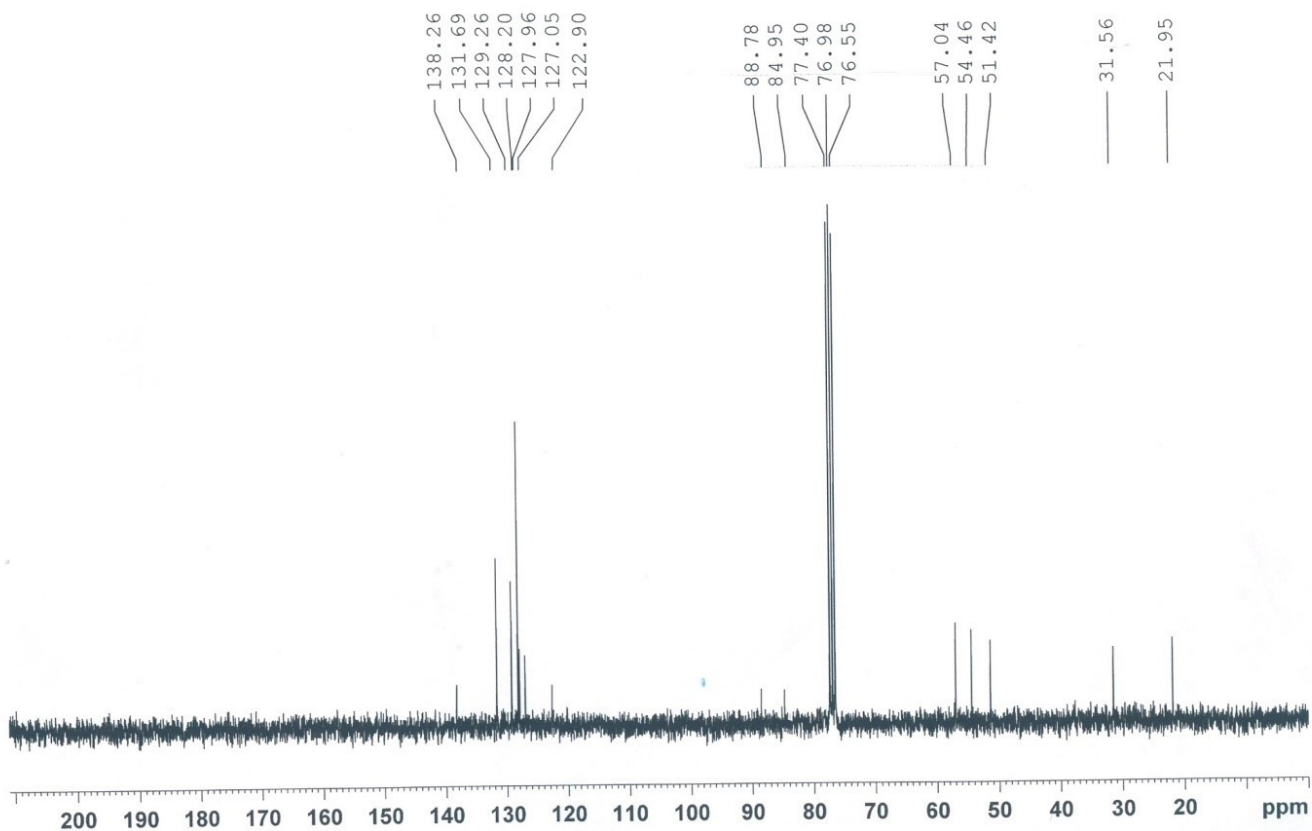
SI Figure 11: ^1H and ^{13}C -NMR spectra of compound 6j



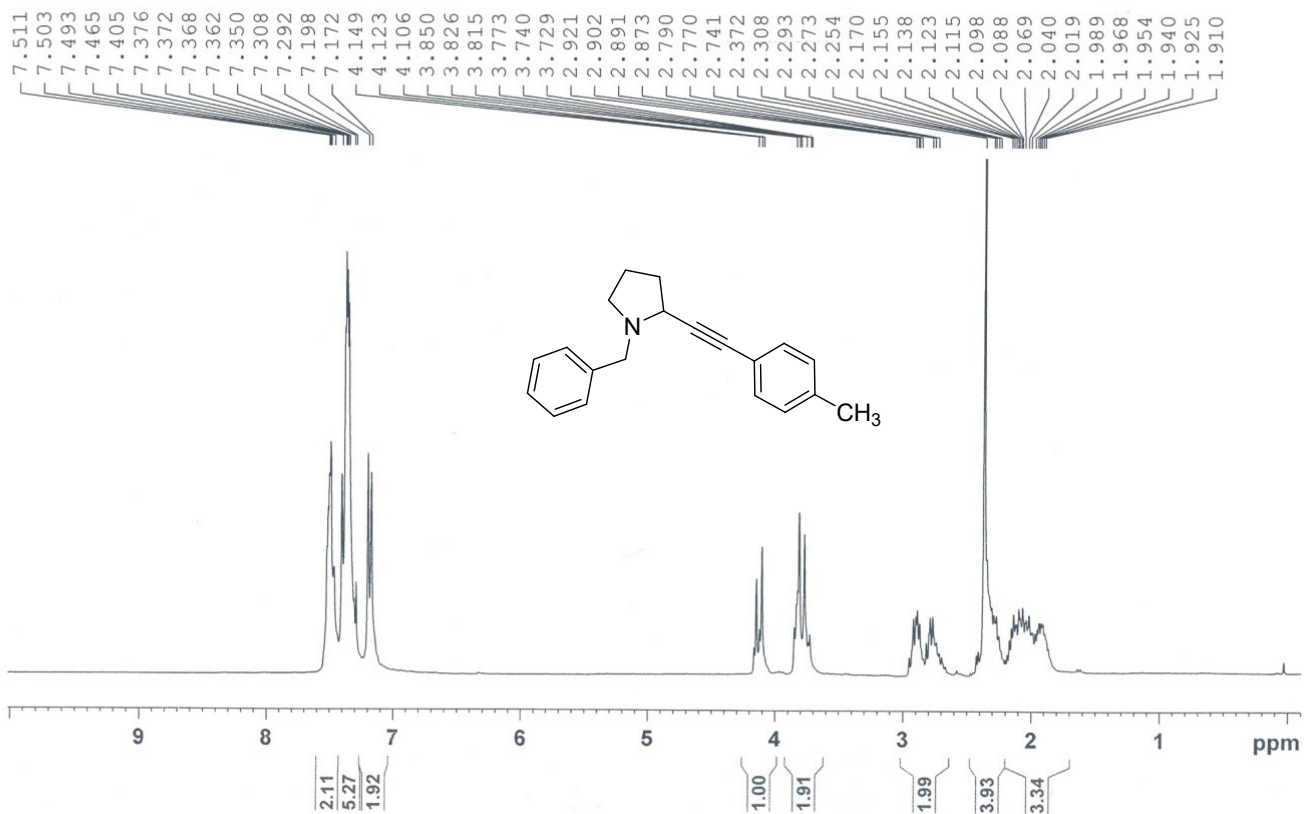


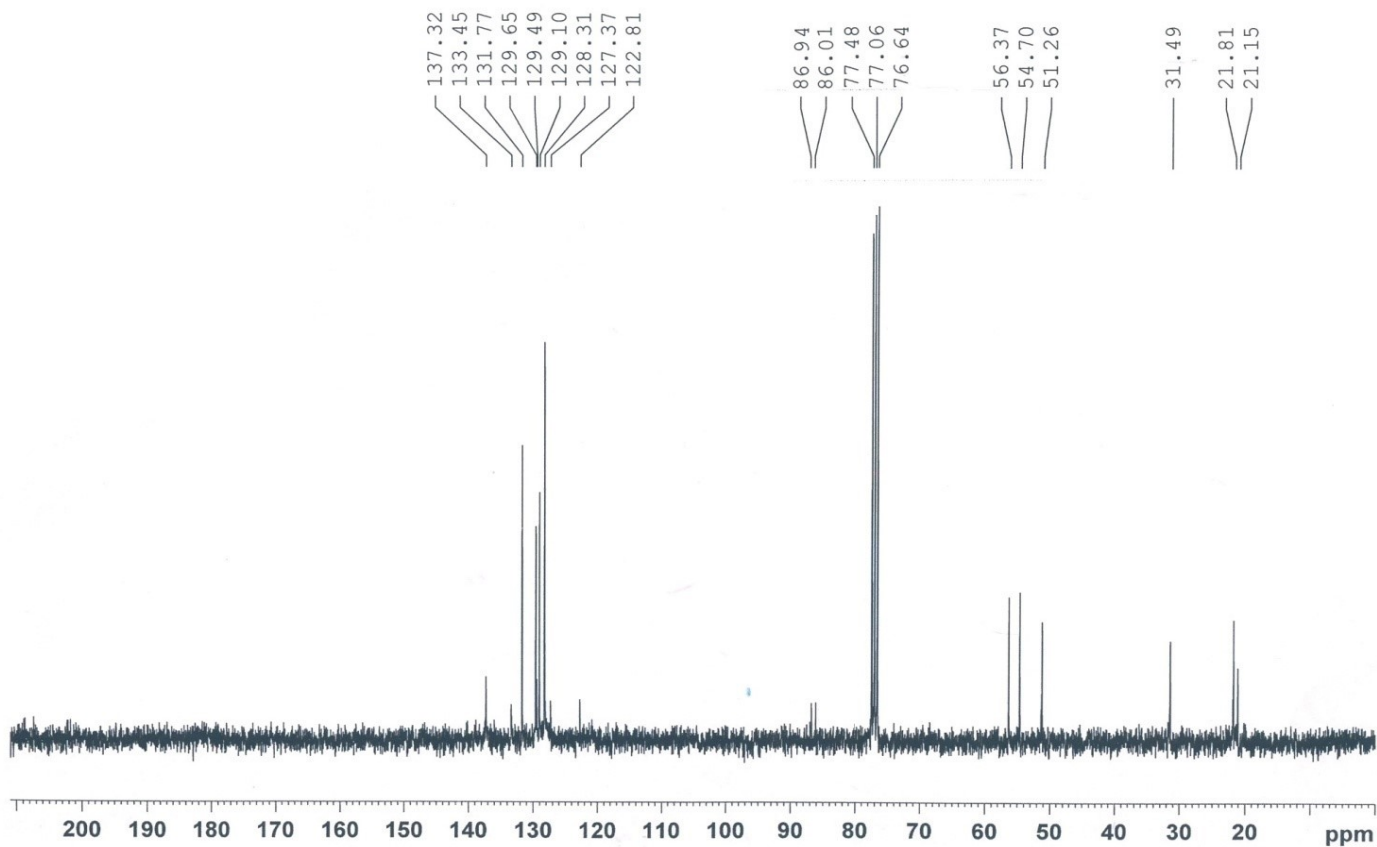
SI Figure 12: ^1H and ^{13}C -NMR spectra of compound 7a



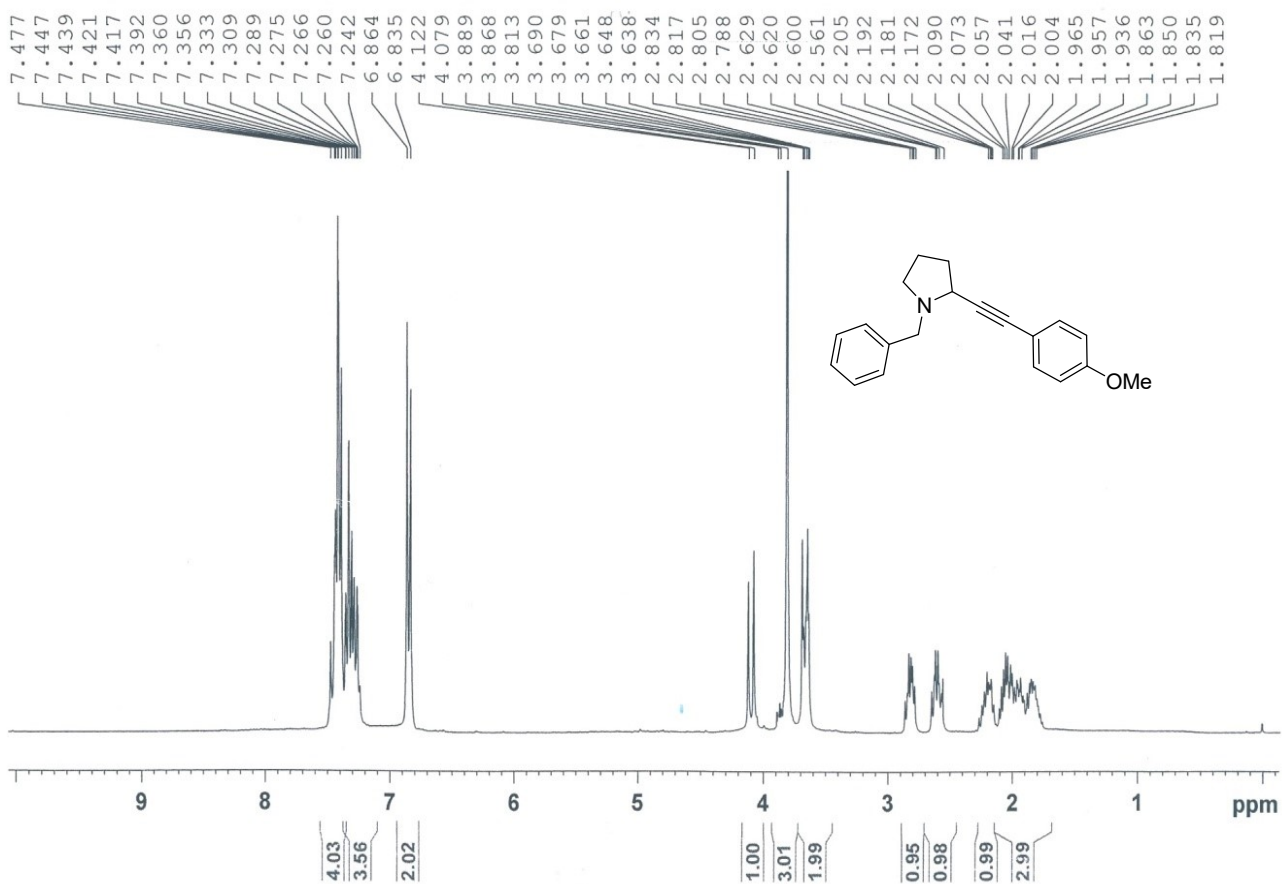


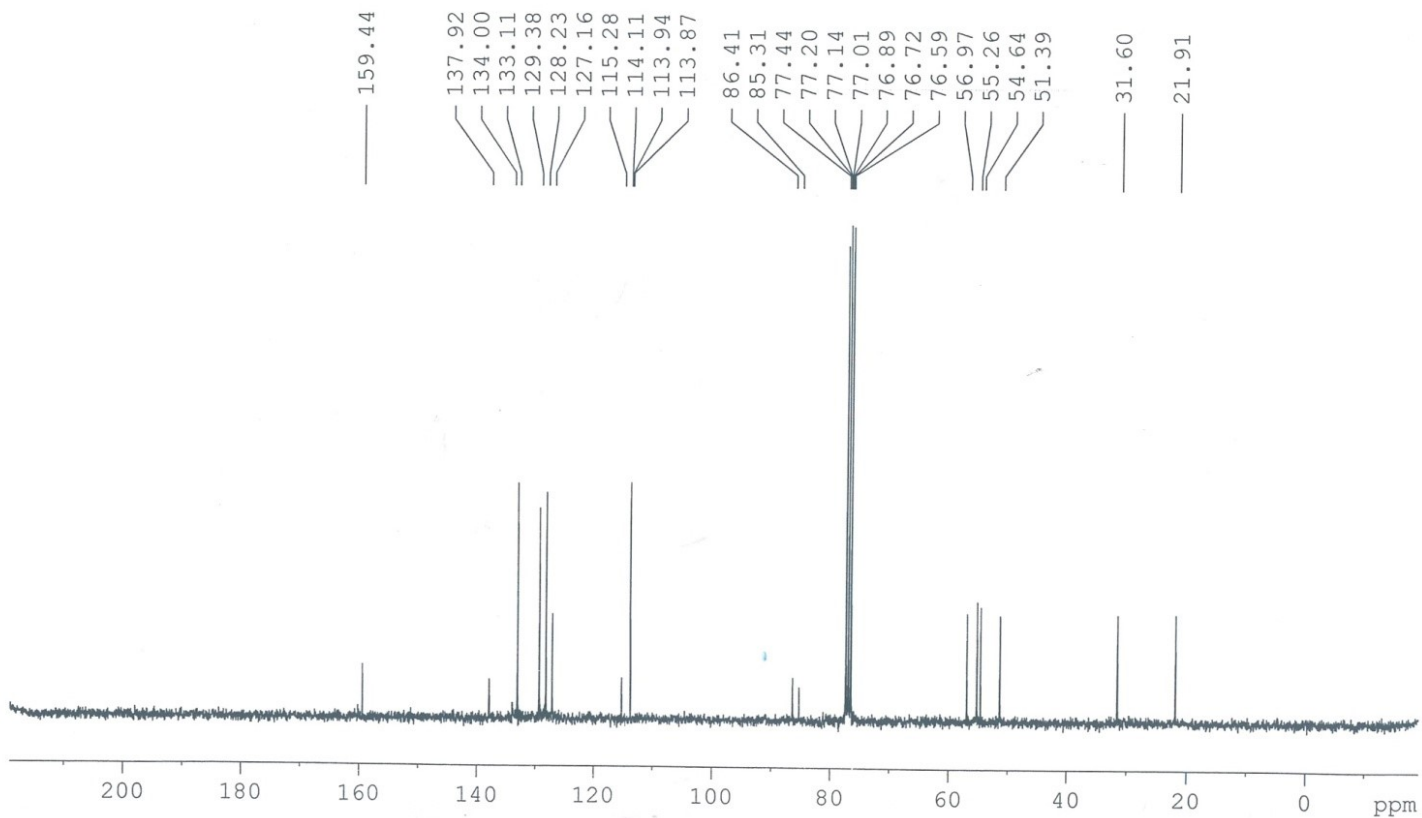
SI Figure 13: ¹H and ¹³C-NMR spectra of compound 7b



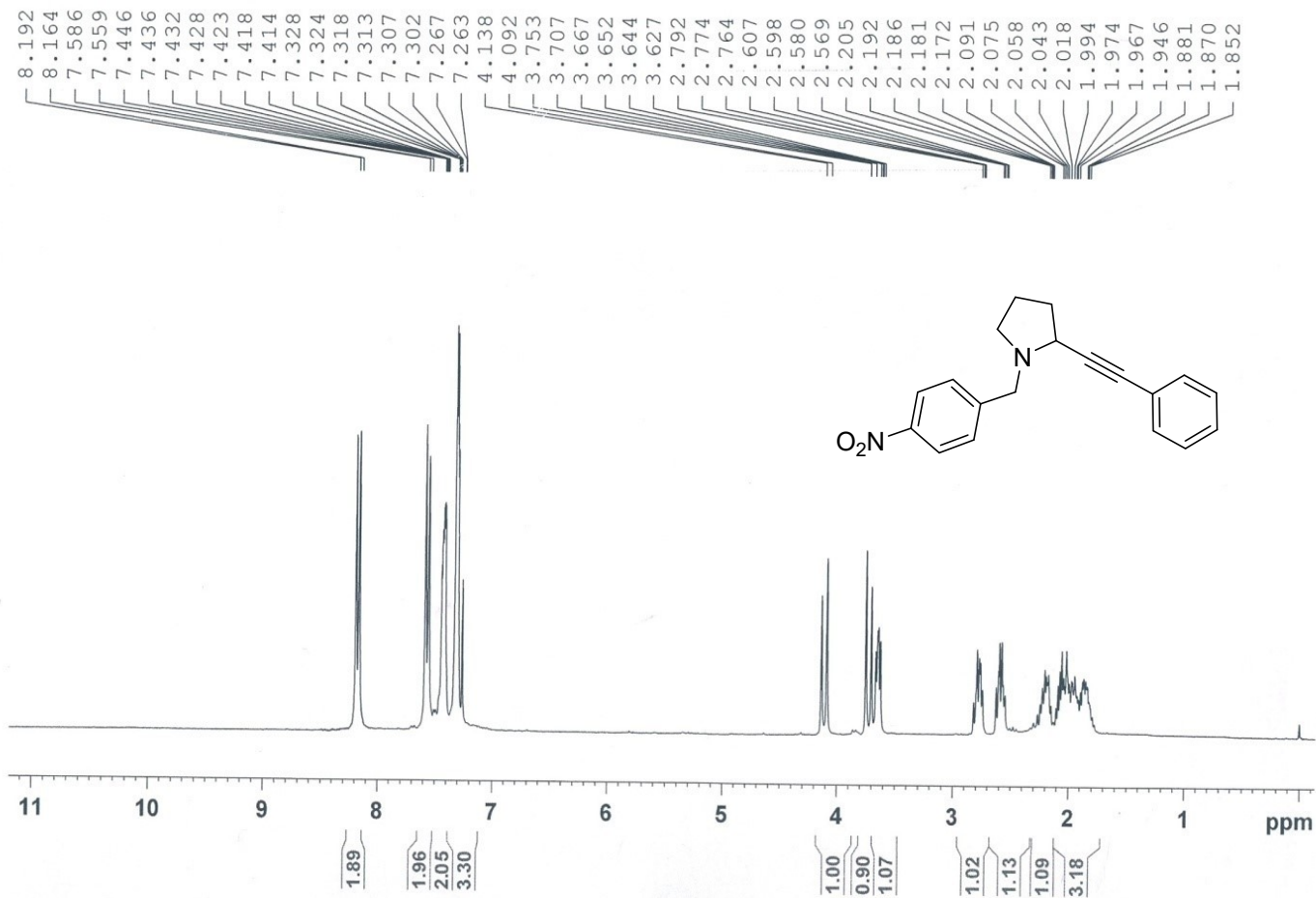


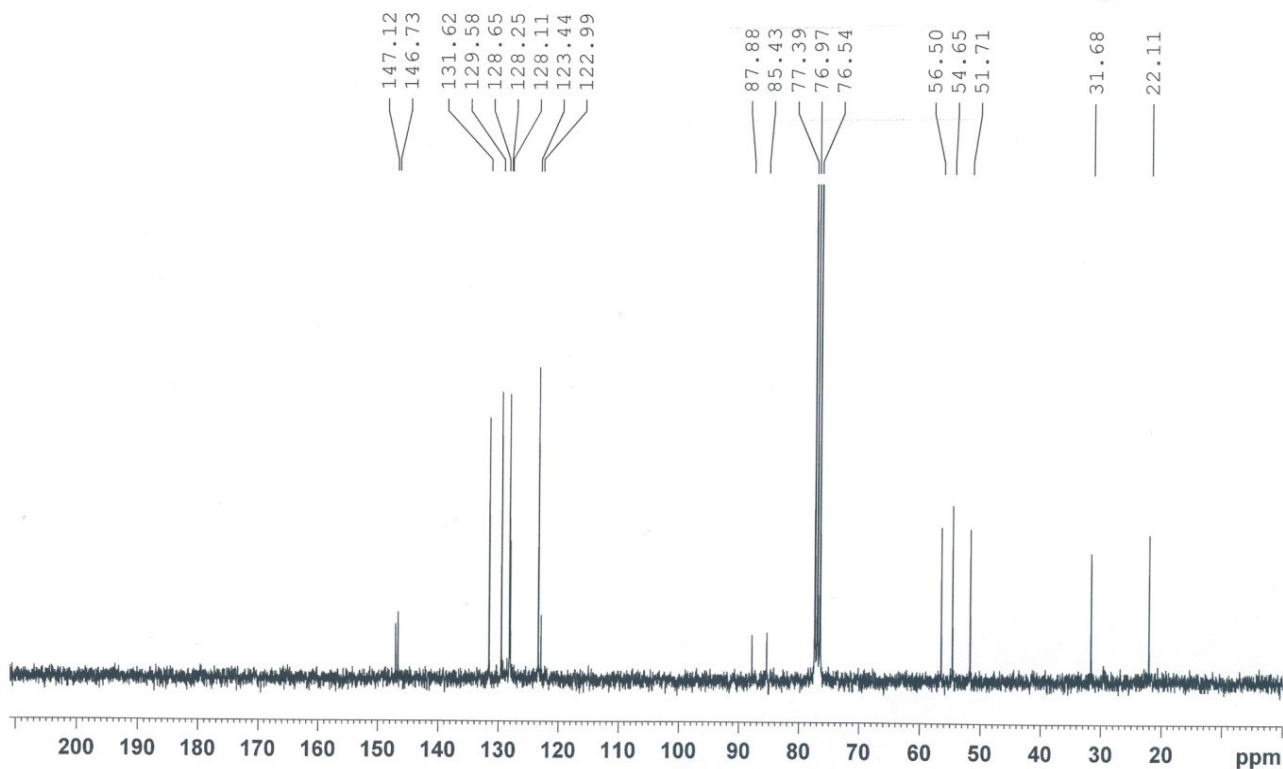
SI Figure 14: ^1H and ^{13}C -NMR spectra of compound 7c



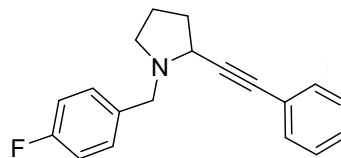
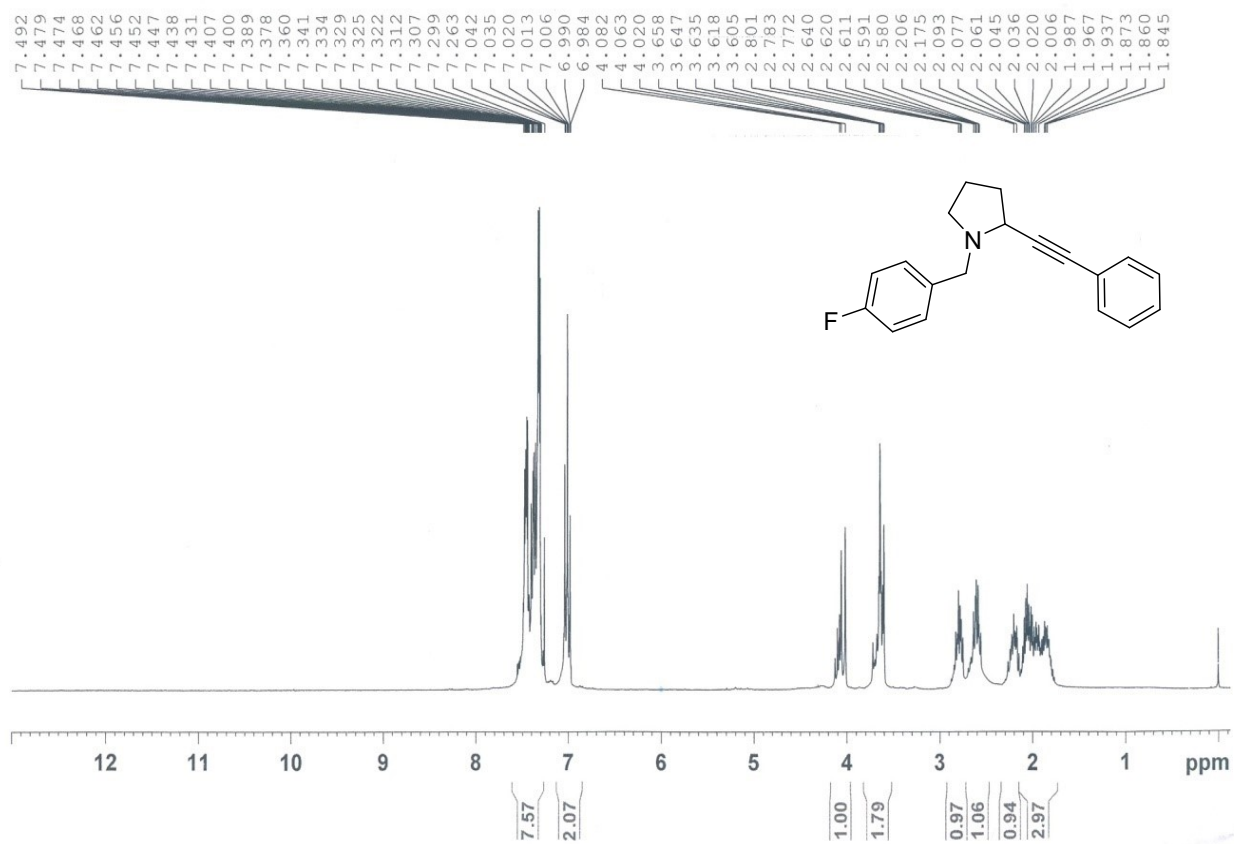


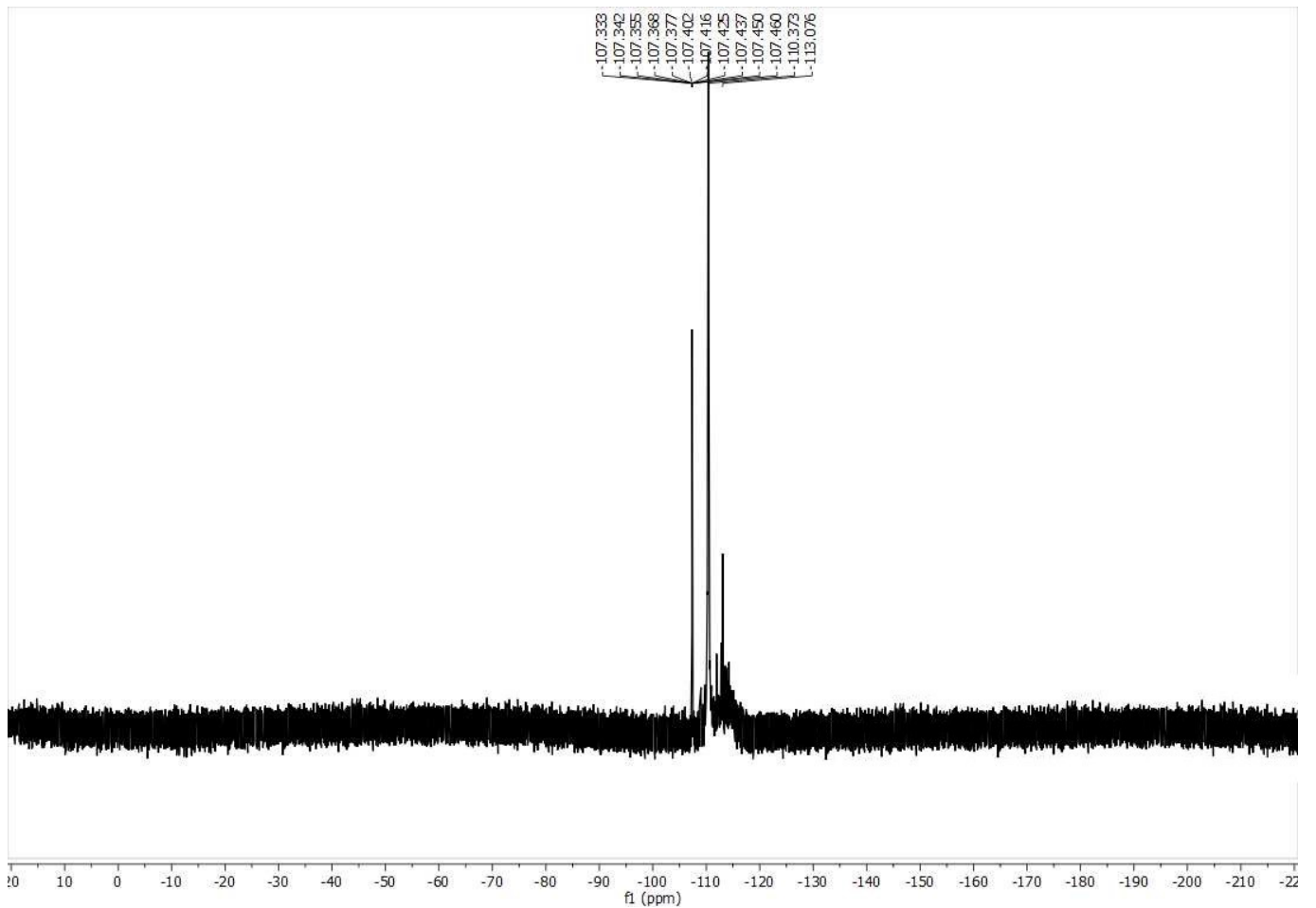
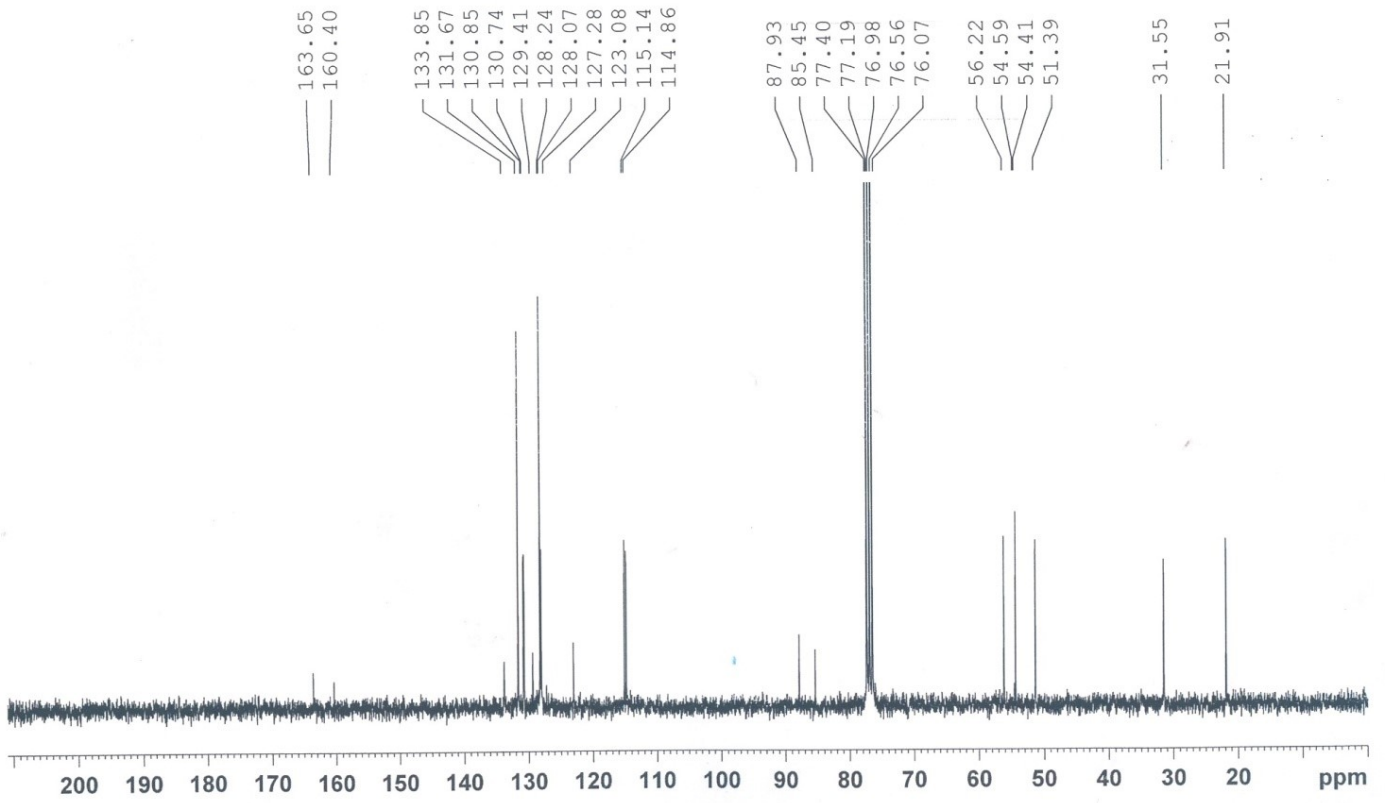
SI Figure 15: ^1H and ^{13}C -NMR spectra of compound **7d**



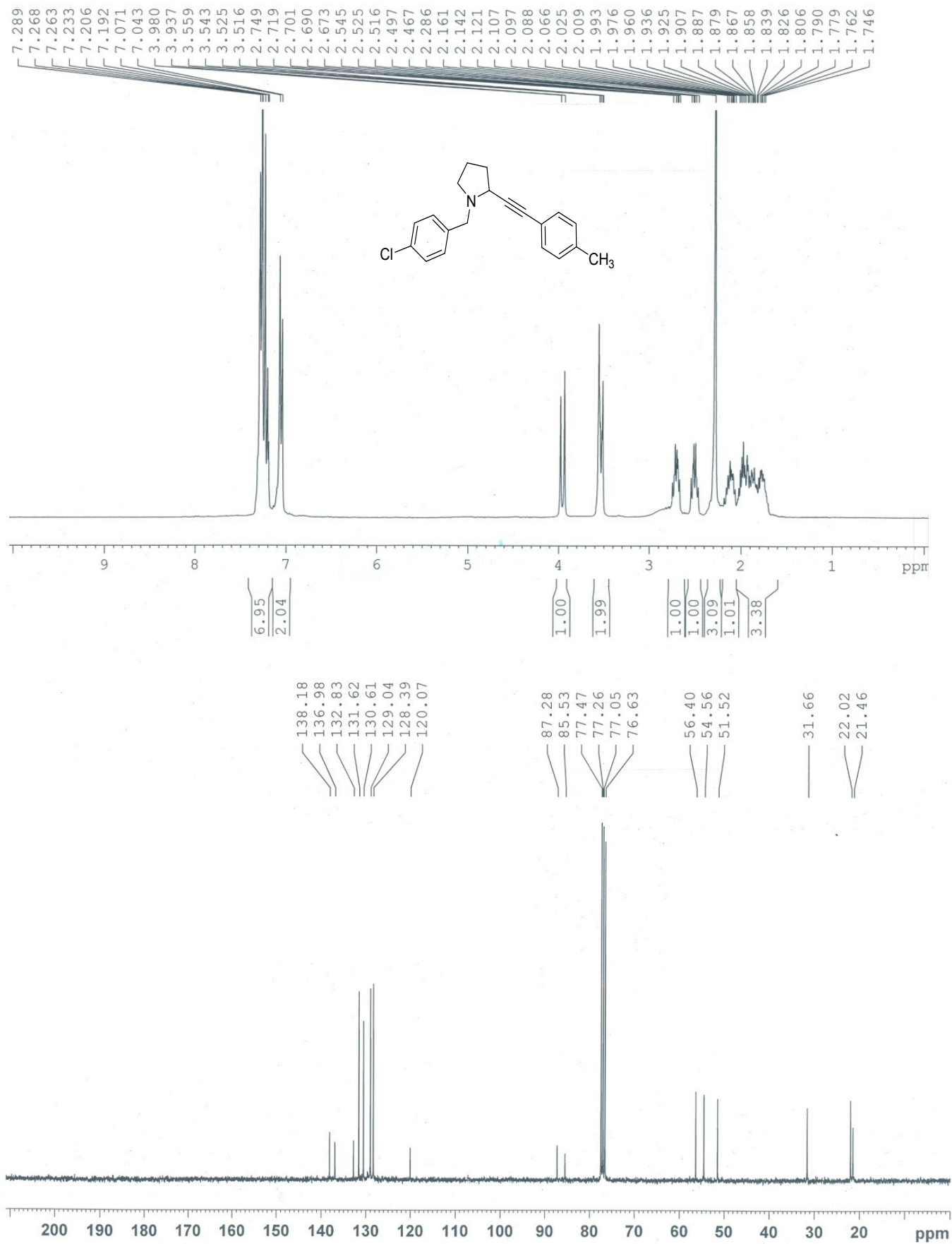


SI Figure 16: ^1H , ^{13}C and ^{19}F -NMR spectra of compound **7e**

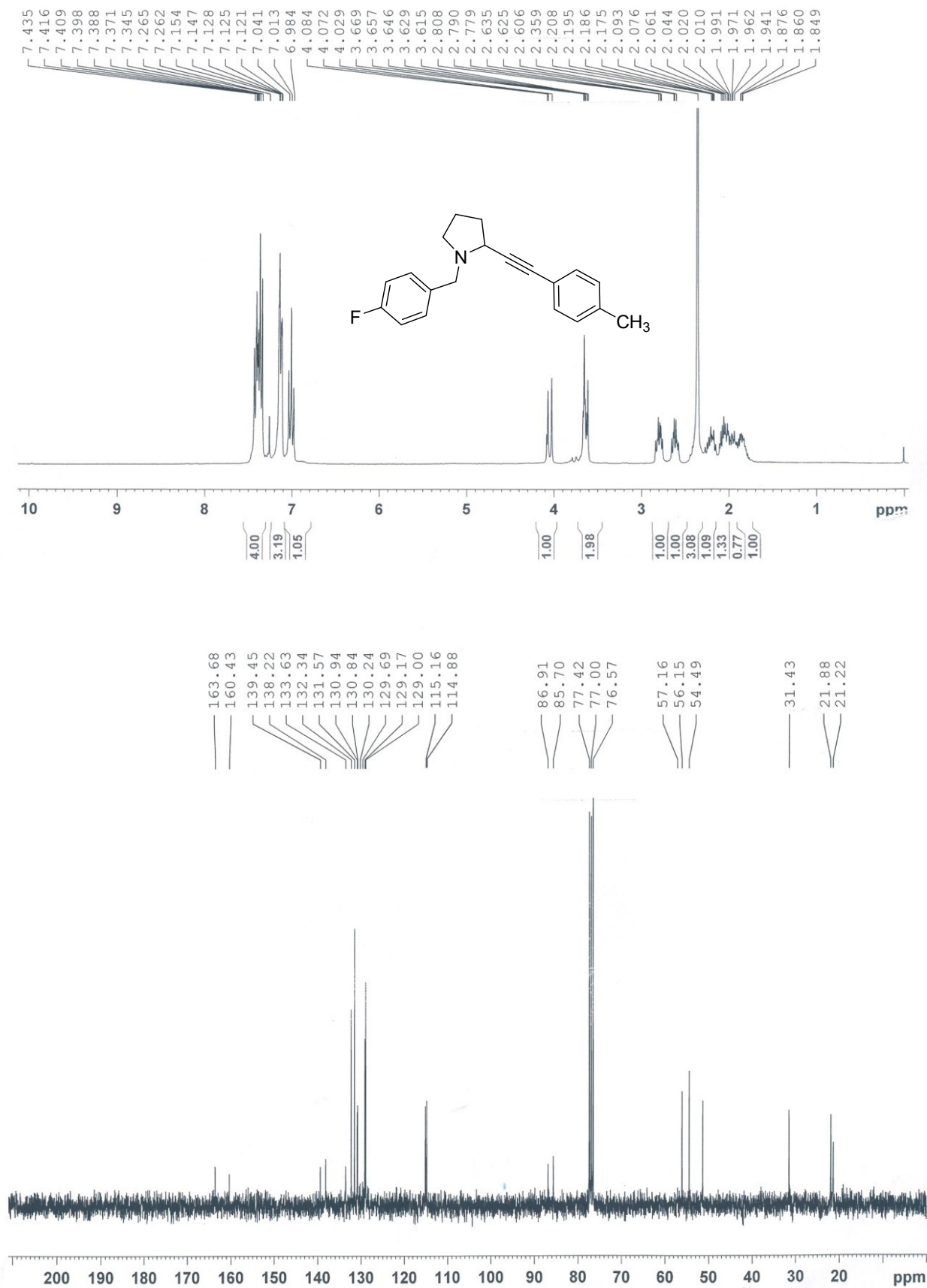




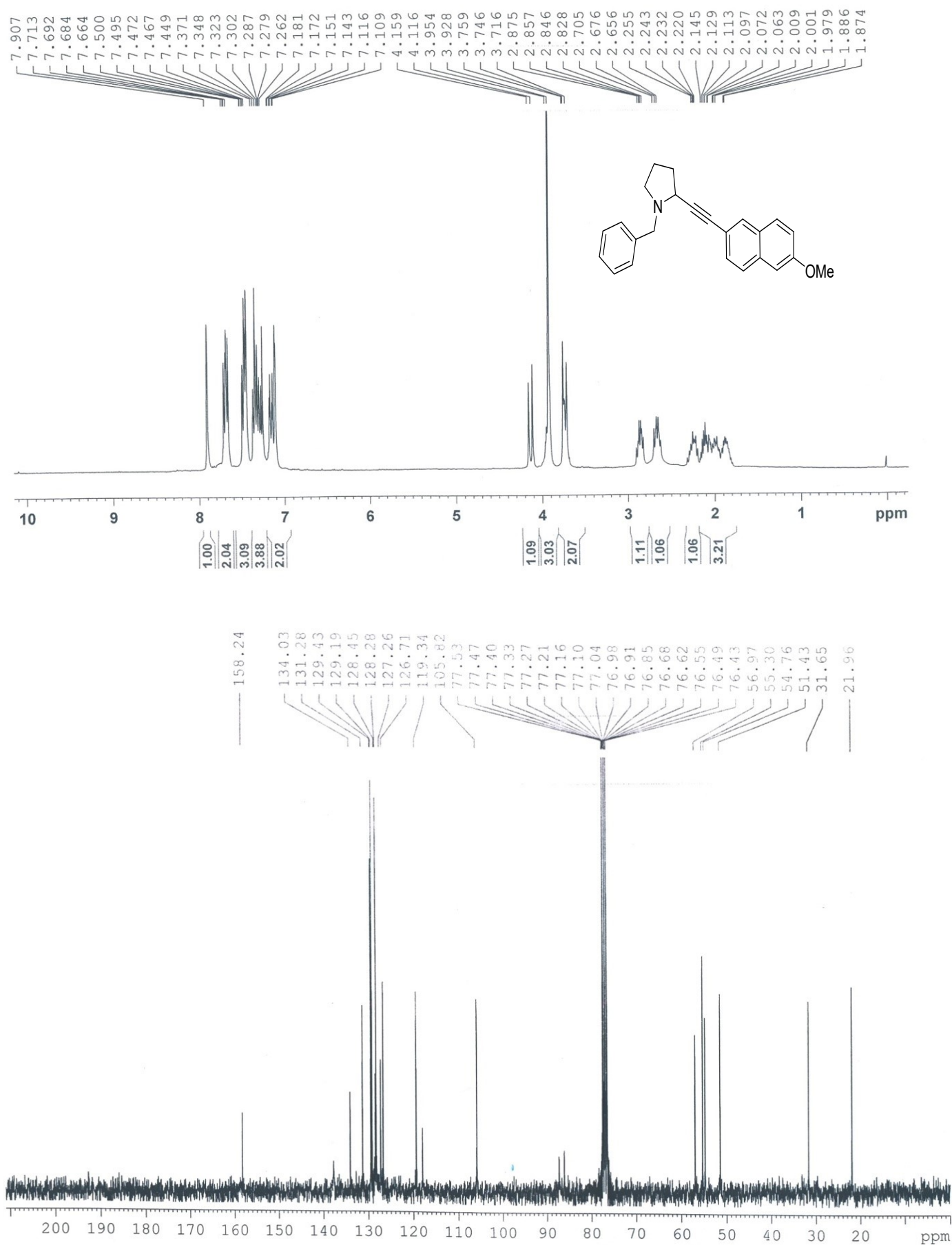
SI Figure 17: ^1H and ^{13}C -NMR spectra of compound 7f



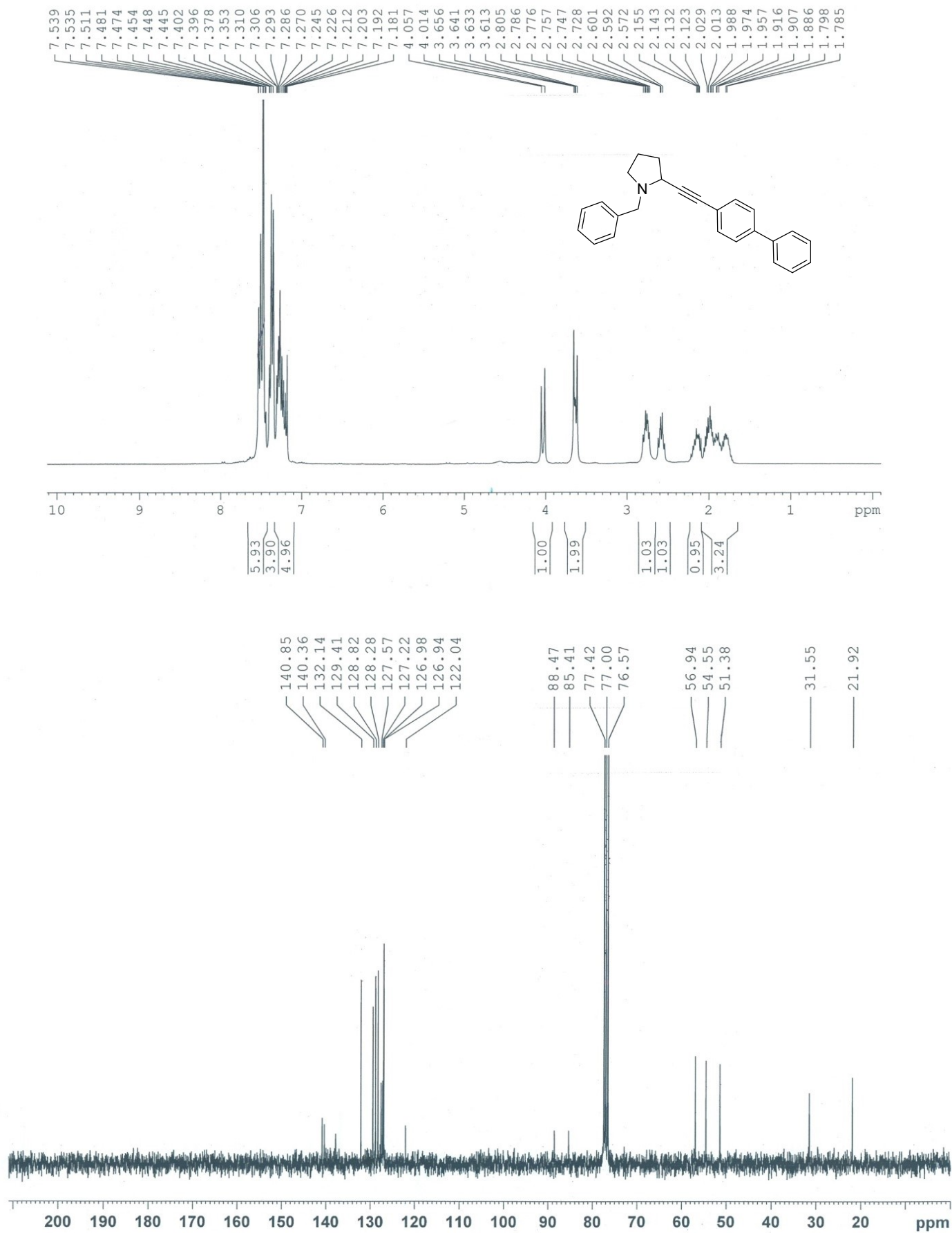
SI Figure 18: ^1H and ^{13}C -NMR spectra of compound 7g



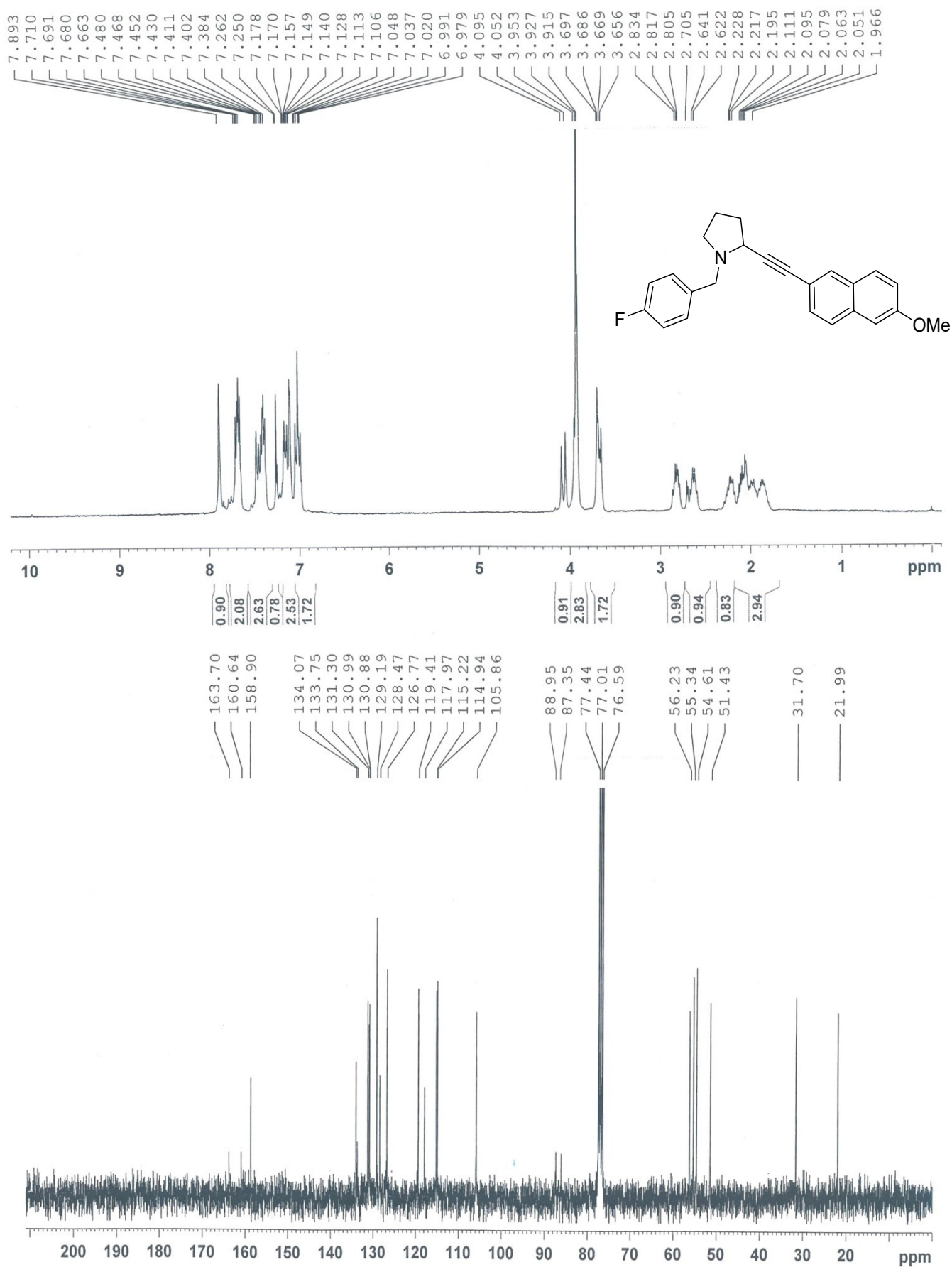
SI Figure 19: ^1H and ^{13}C -NMR spectra of compound **7h**



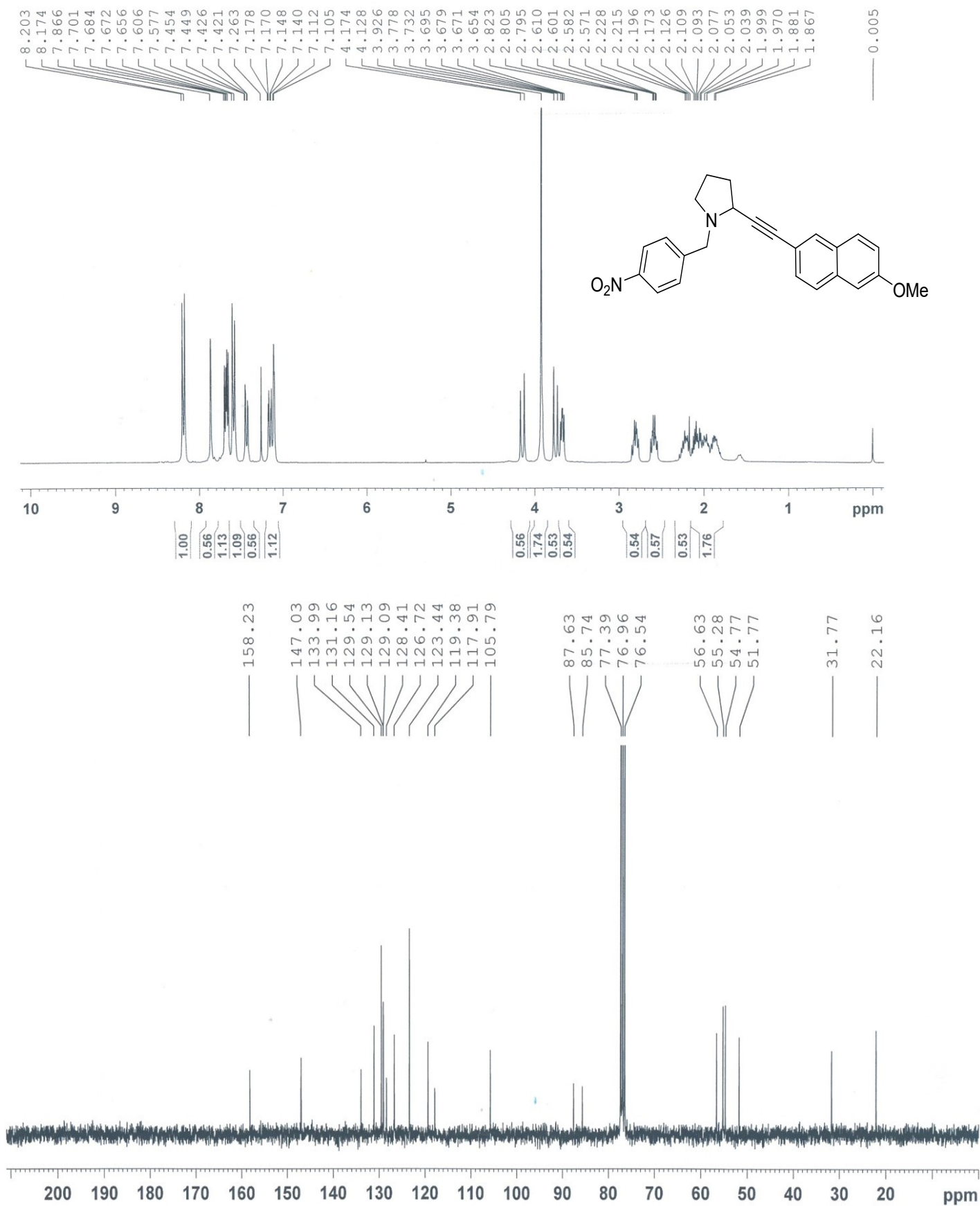
SI Figure 20: ^1H and ^{13}C -NMR spectra of compound 7i



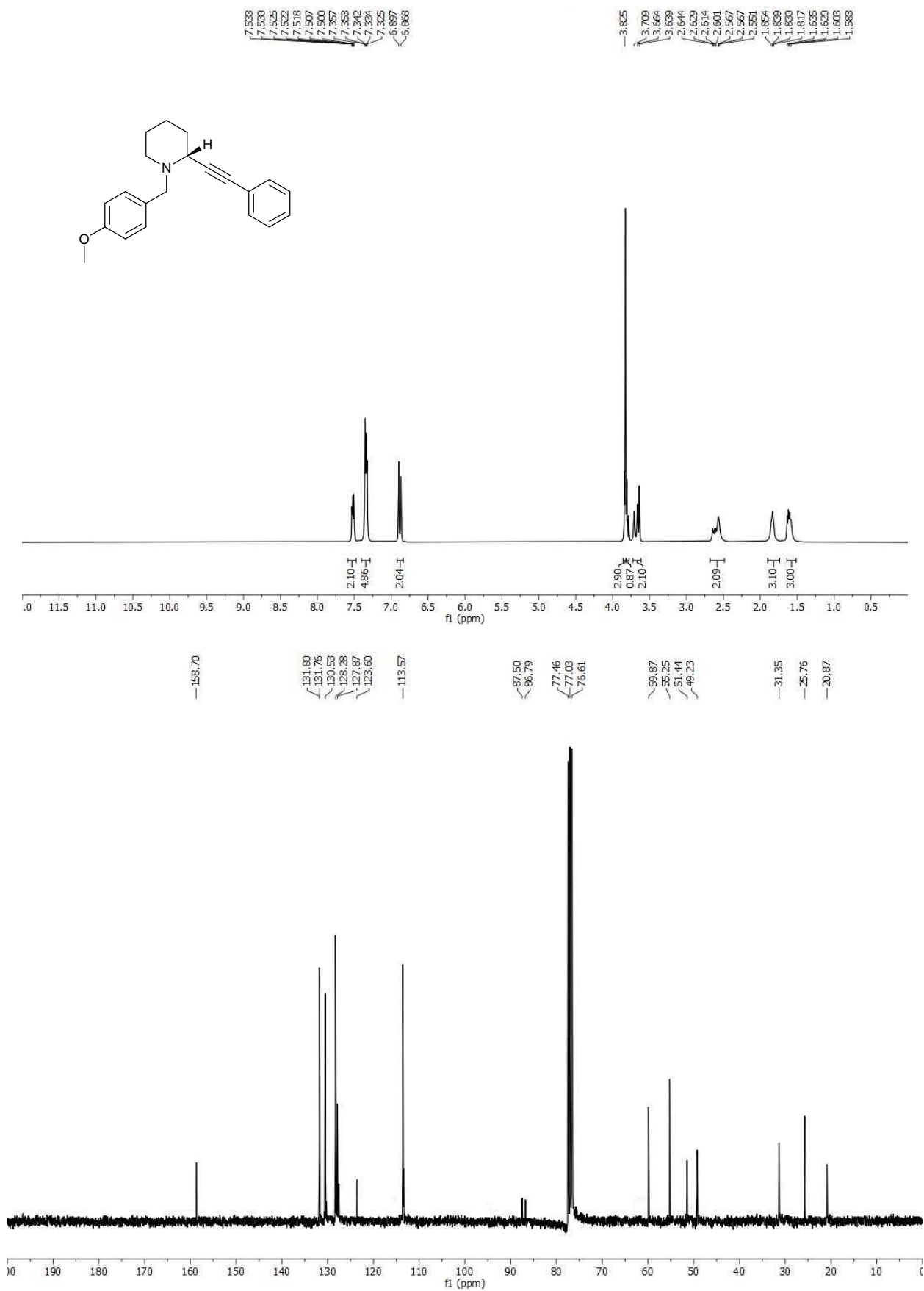
SI Figure 21: ^1H and ^{13}C -NMR spectra of compound 7j



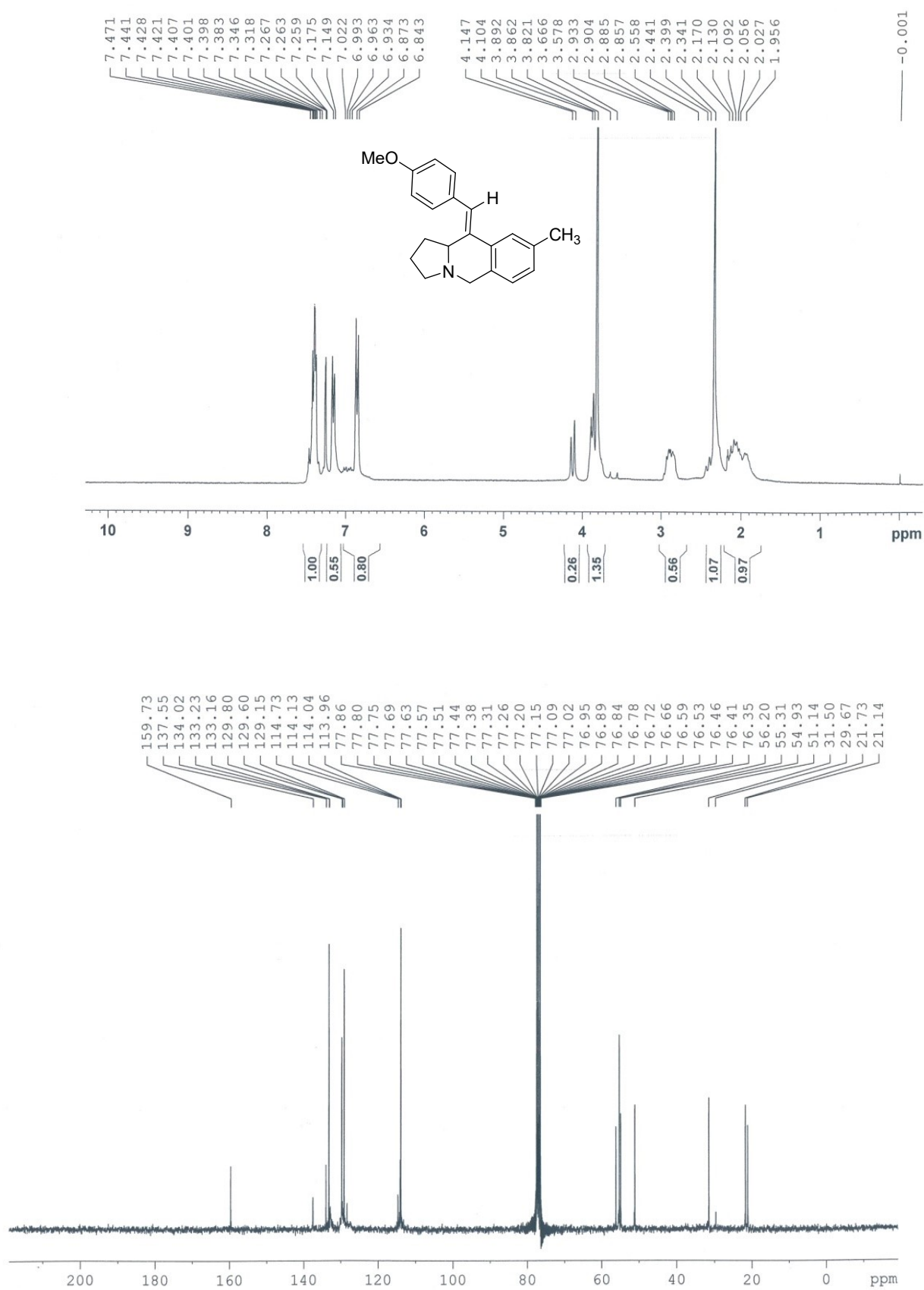
SI Figure 22: ^1H and ^{13}C -NMR spectra of compound 7k



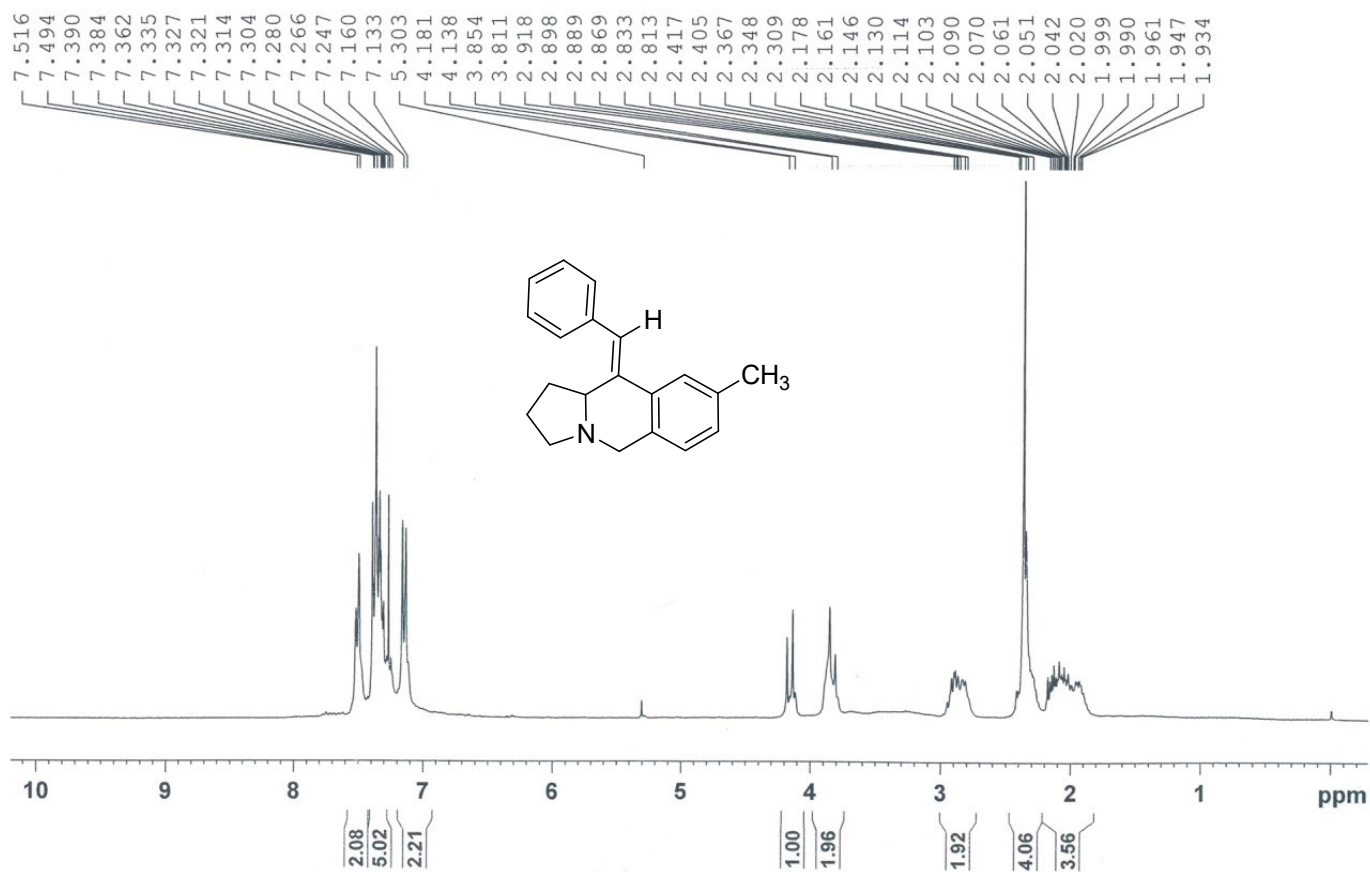
SI Figure 23: ^1H and ^{13}C -NMR spectra of compound 71

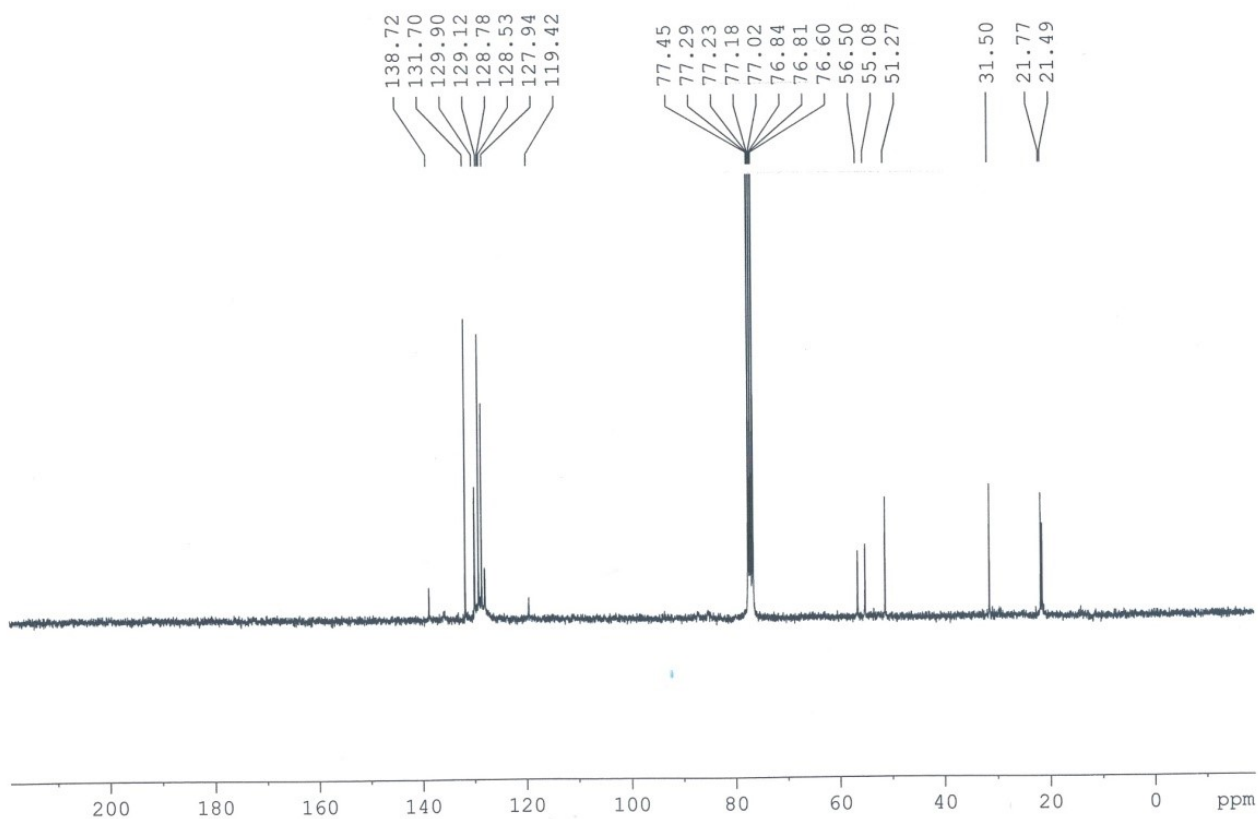


SI Figure 24: ^1H and ^{13}C -NMR spectra of compound **8a**

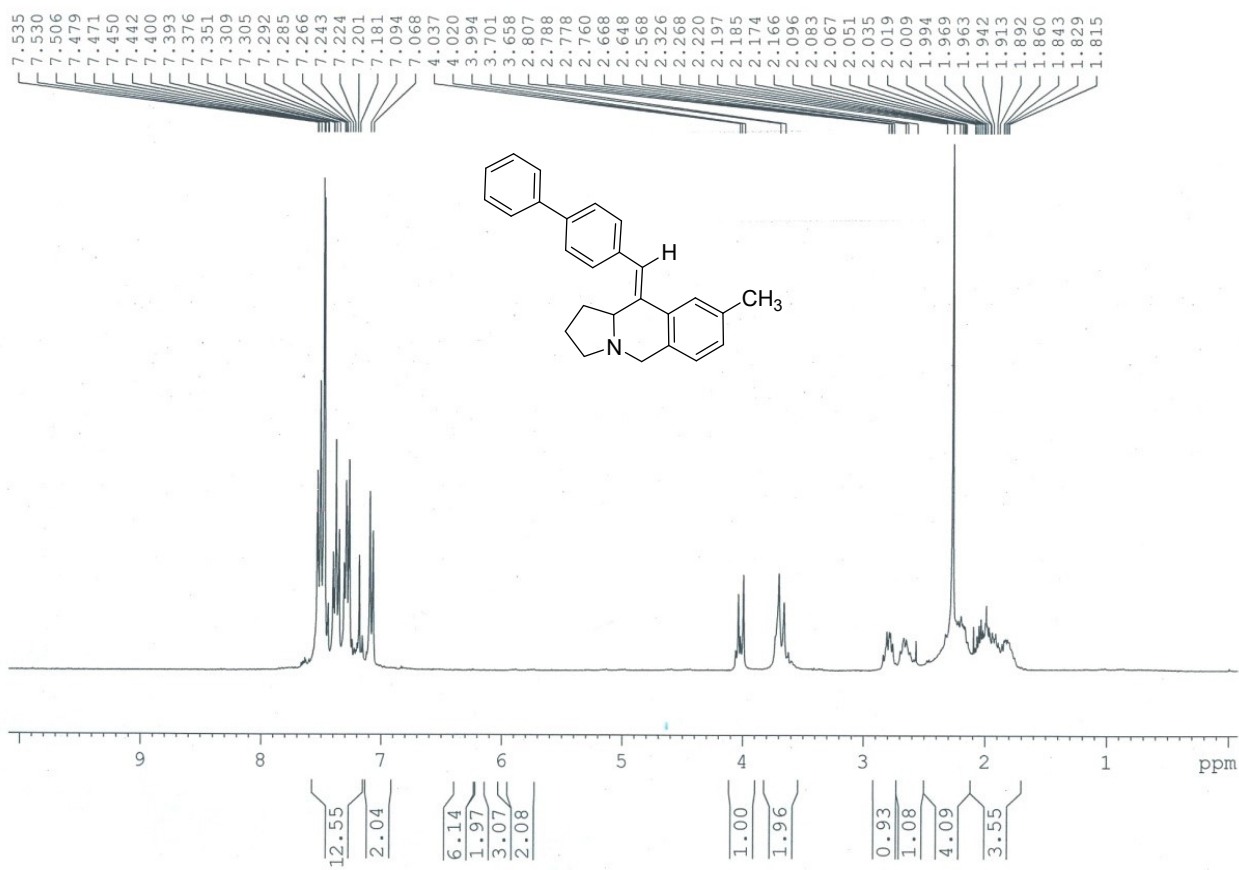


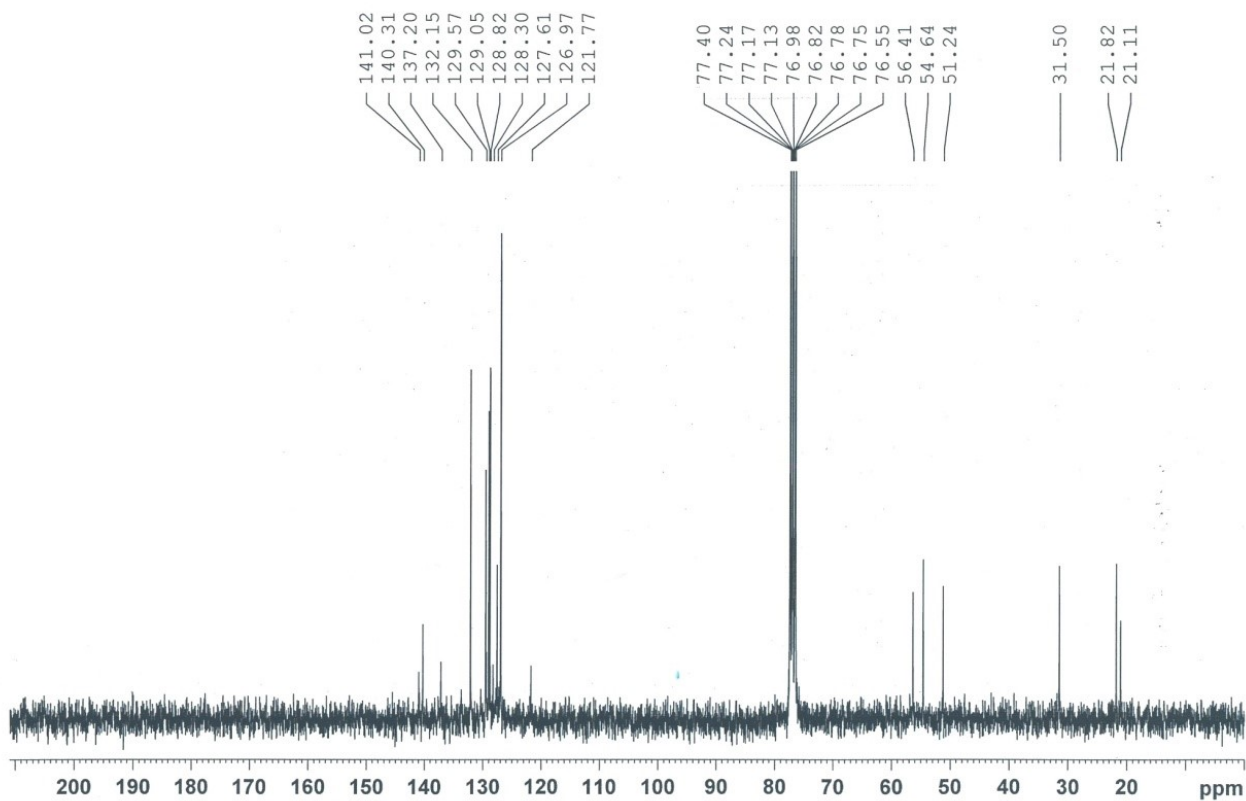
SI Figure 25: ^1H and ^{13}C -NMR spectra of compound **8b**



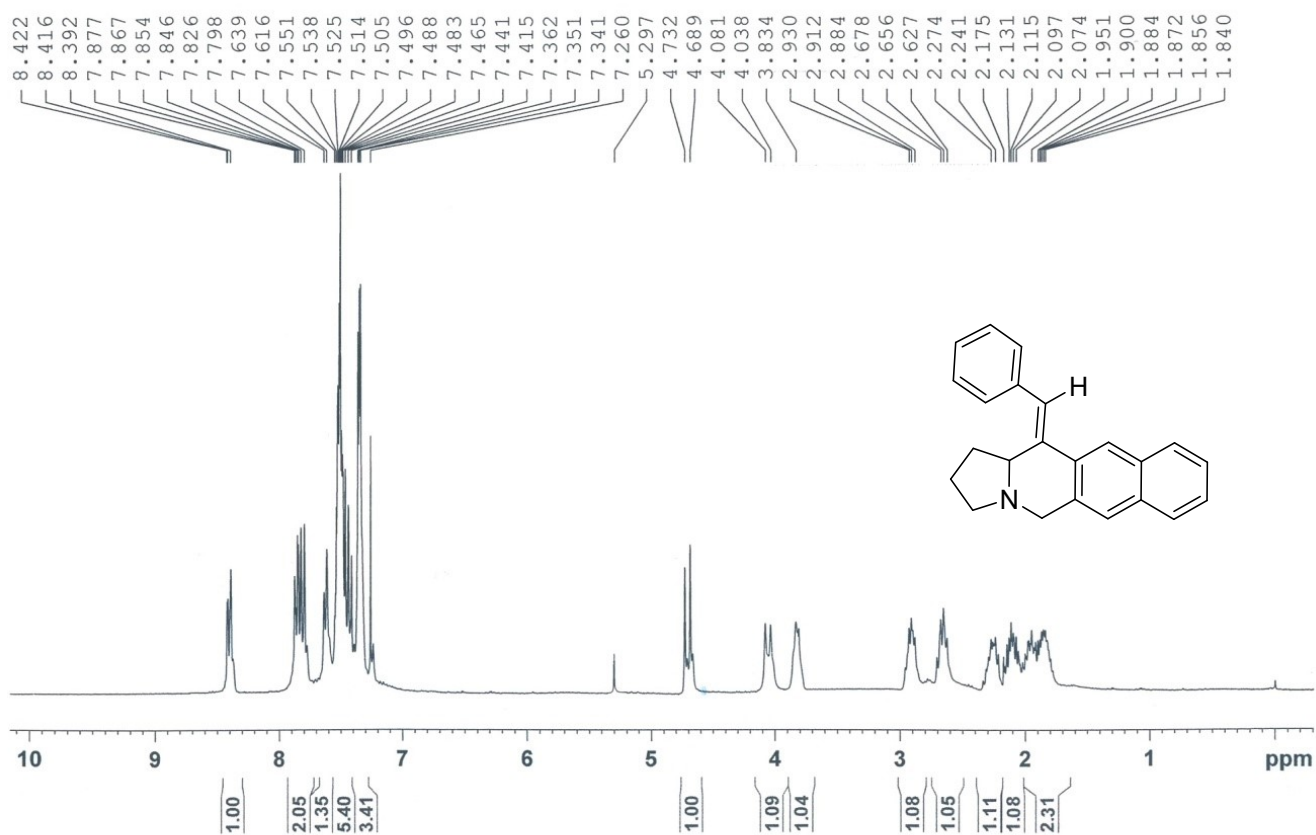


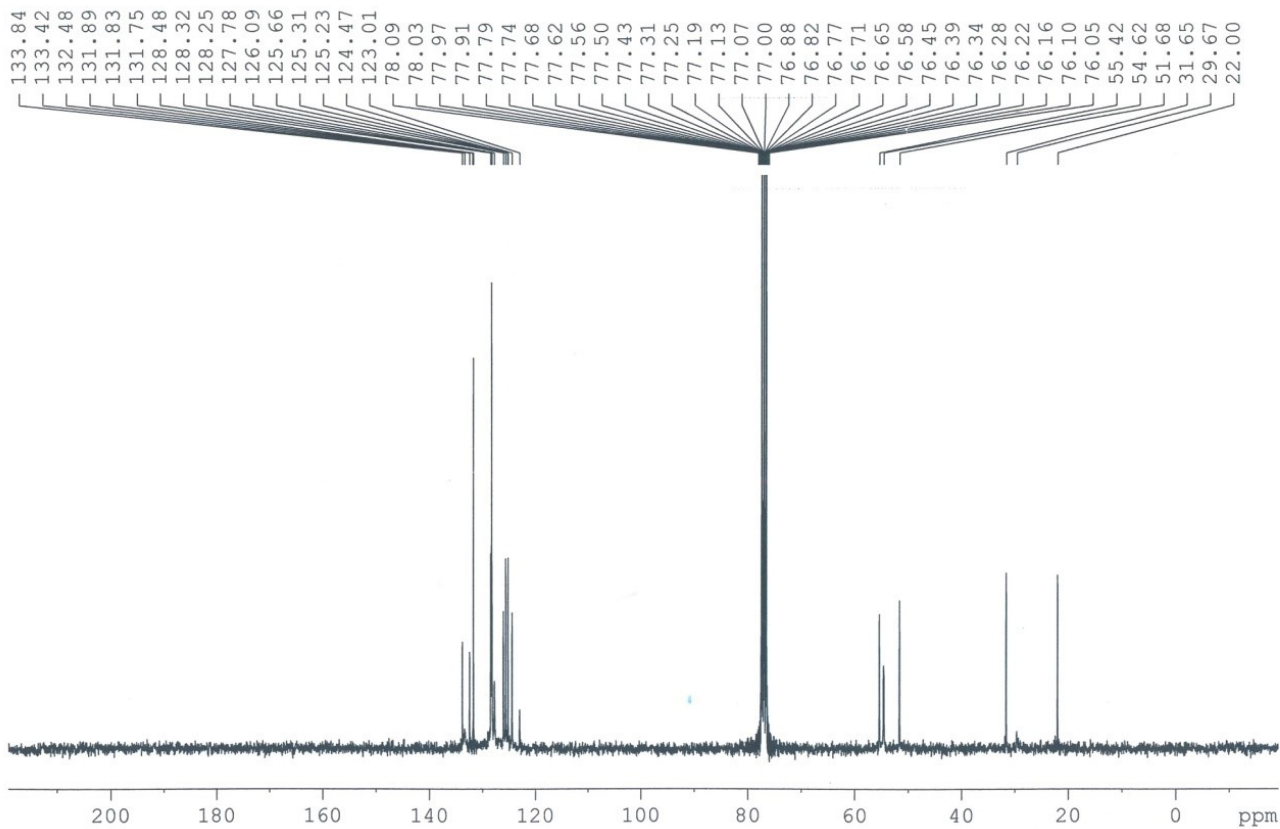
SI Figure 26: ^1H and ^{13}C -NMR spectra of compound **8c**



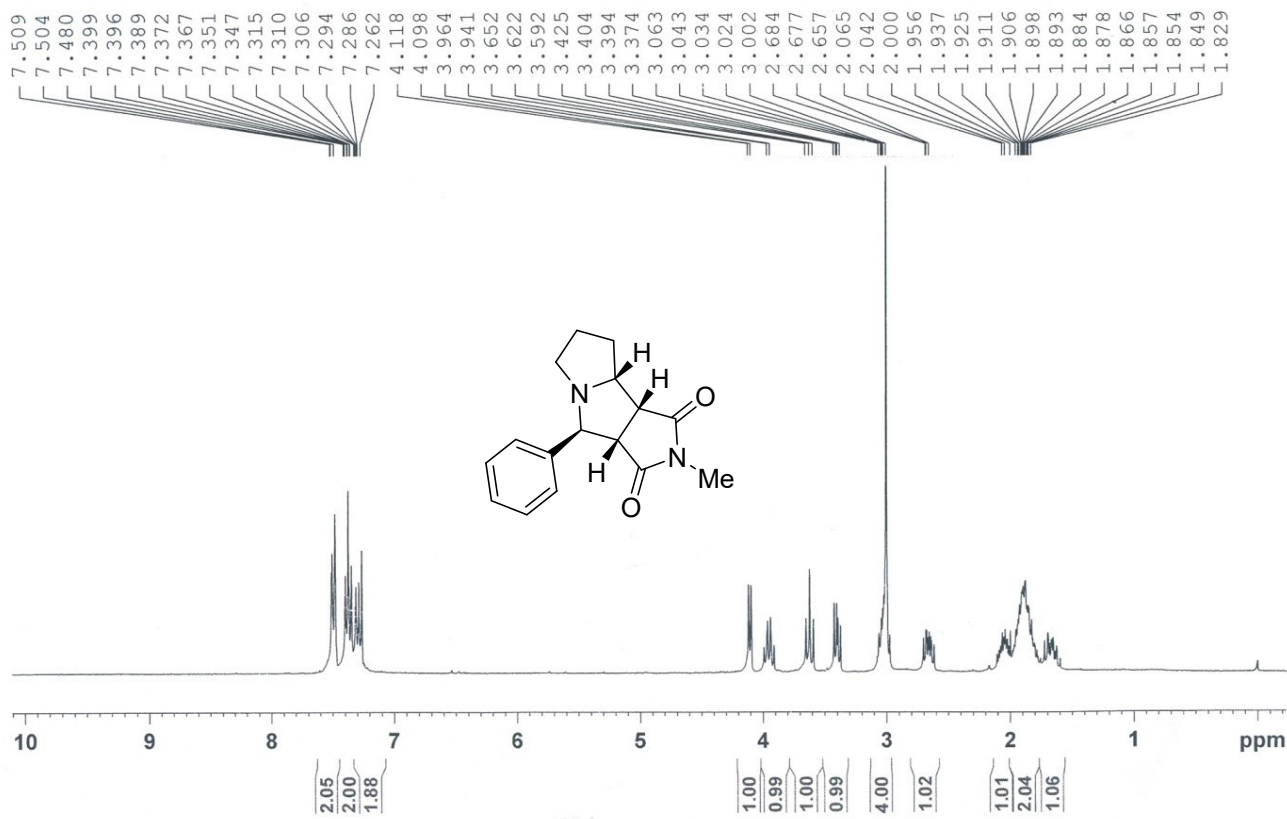


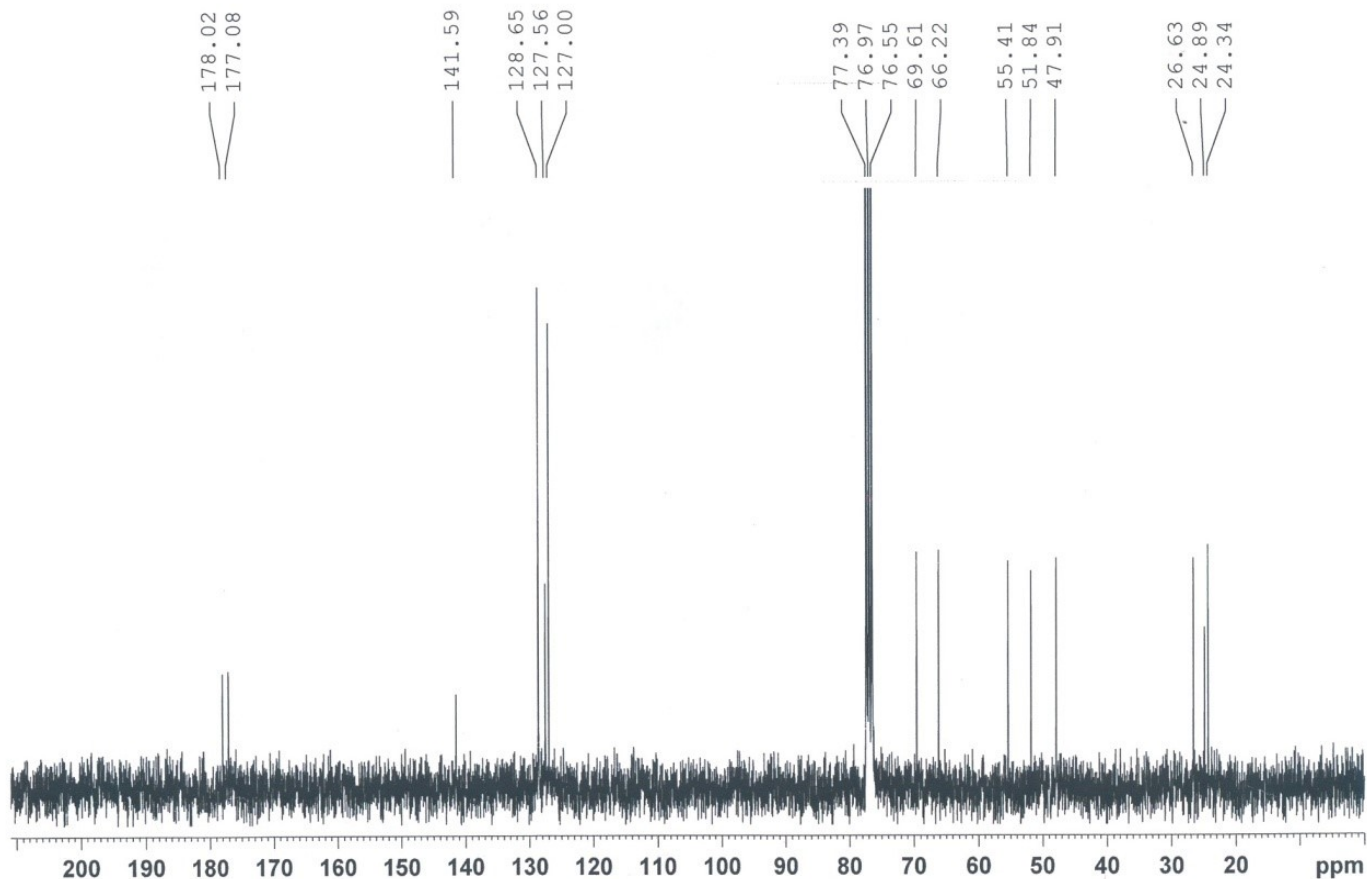
SI Figure 27: ^1H and ^{13}C -NMR spectra of compound **8d**



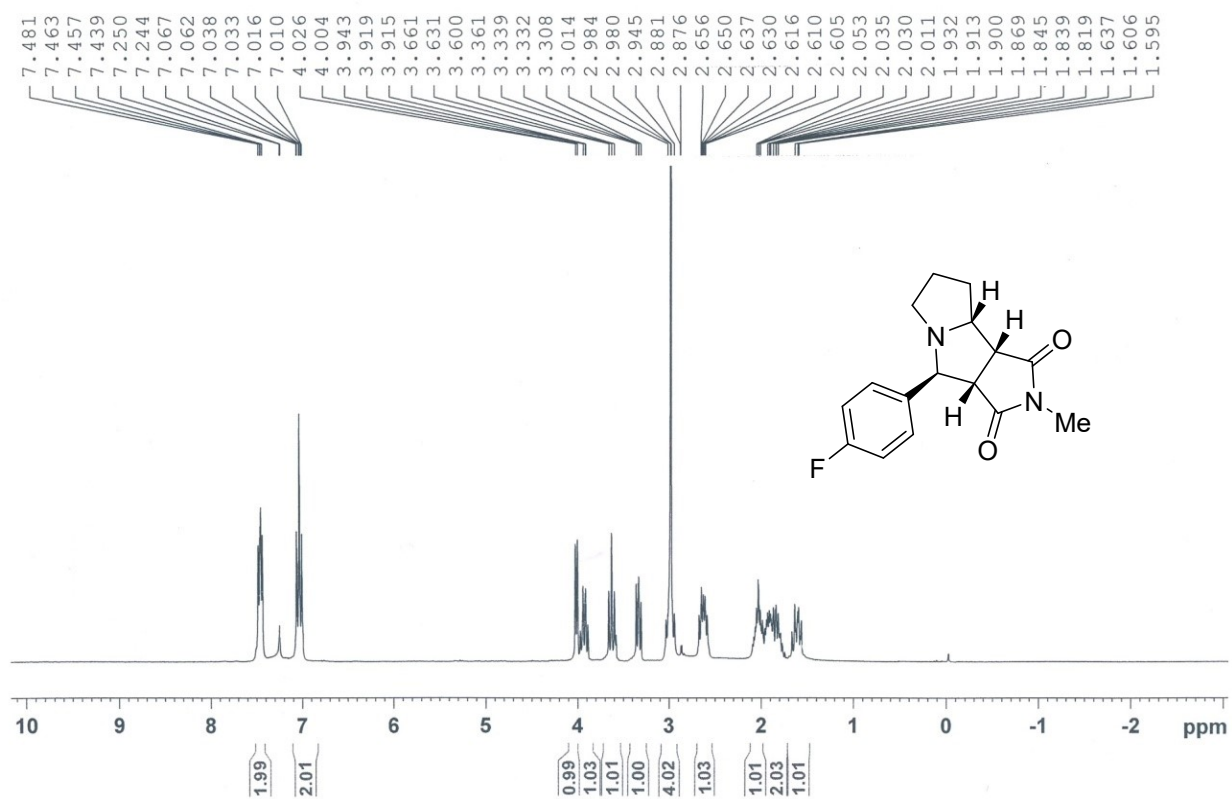


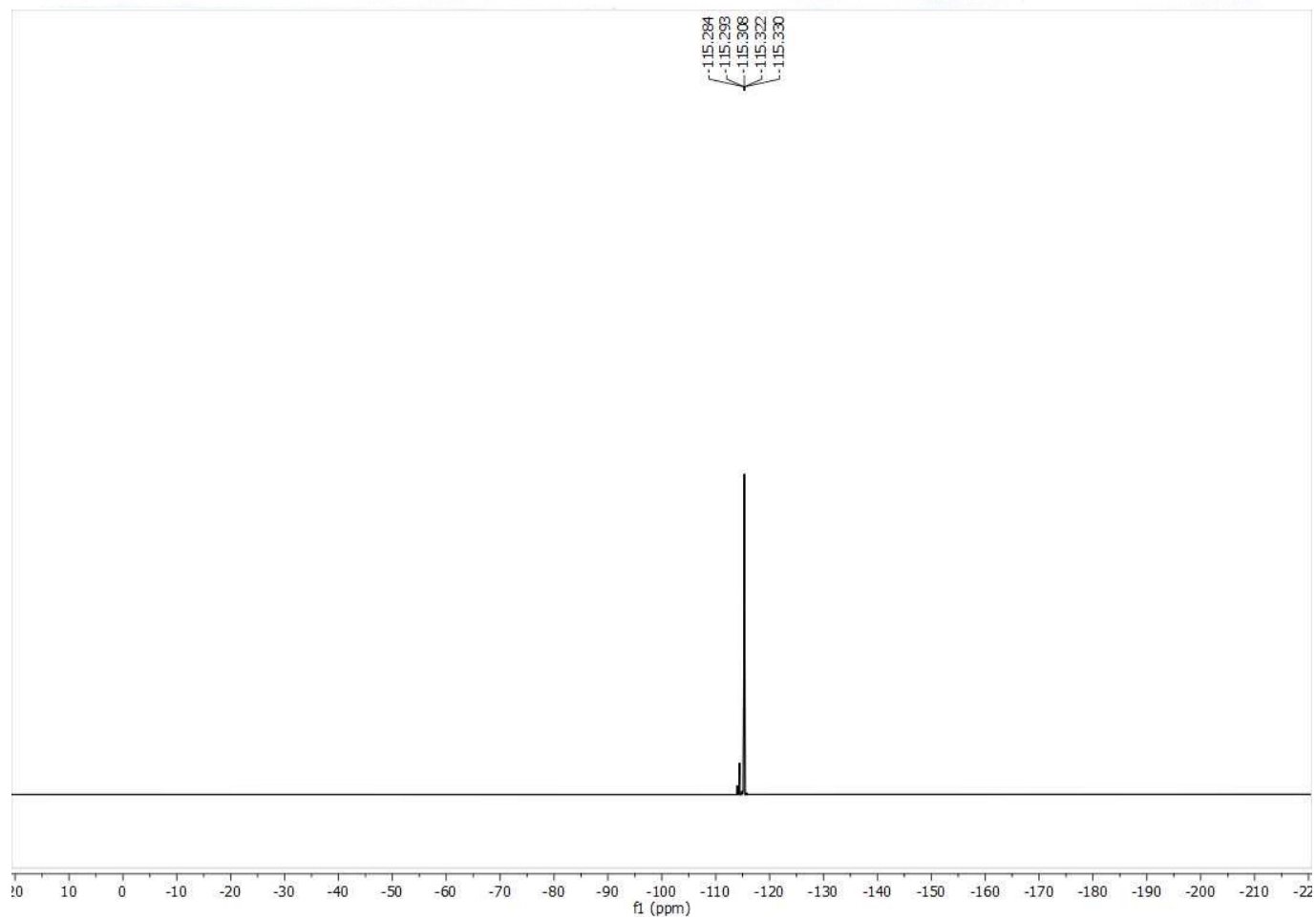
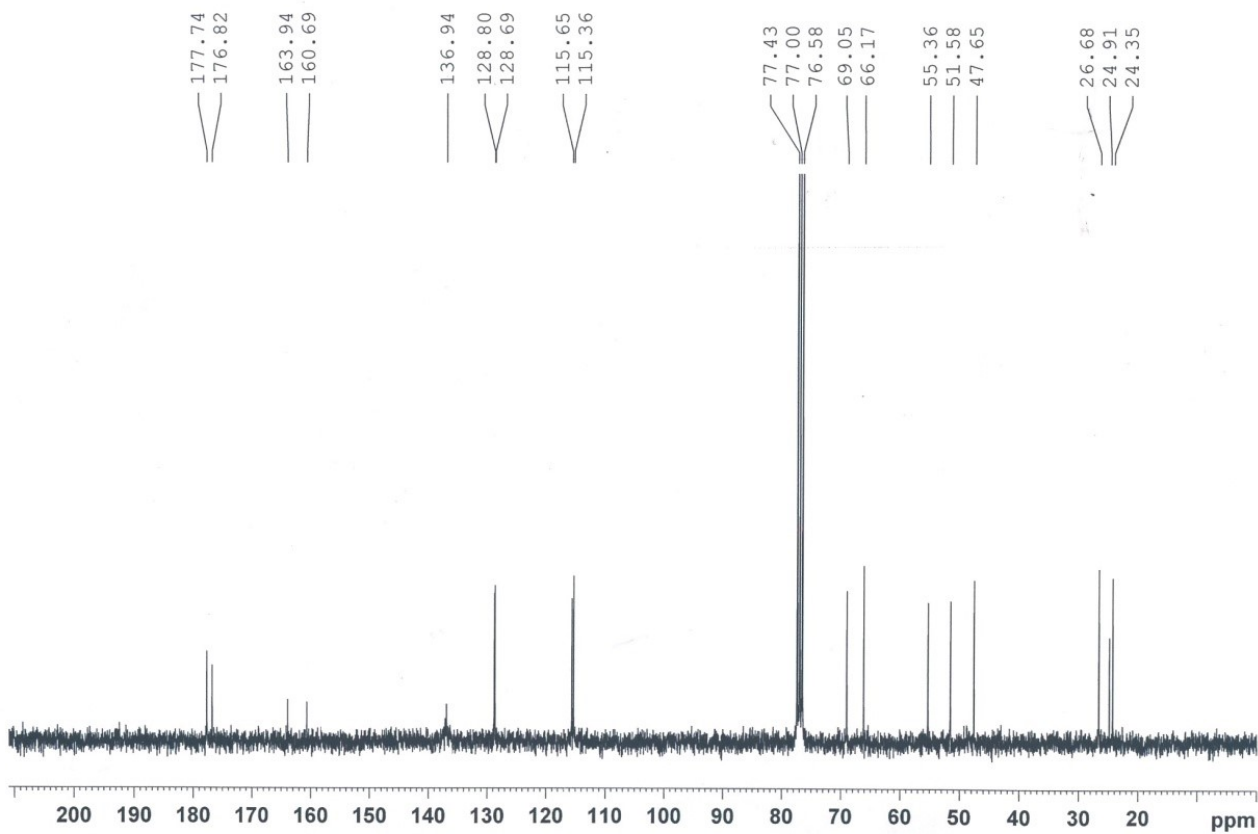
SI Figure 28: ^1H and ^{13}C -NMR spectra of compound **9a**



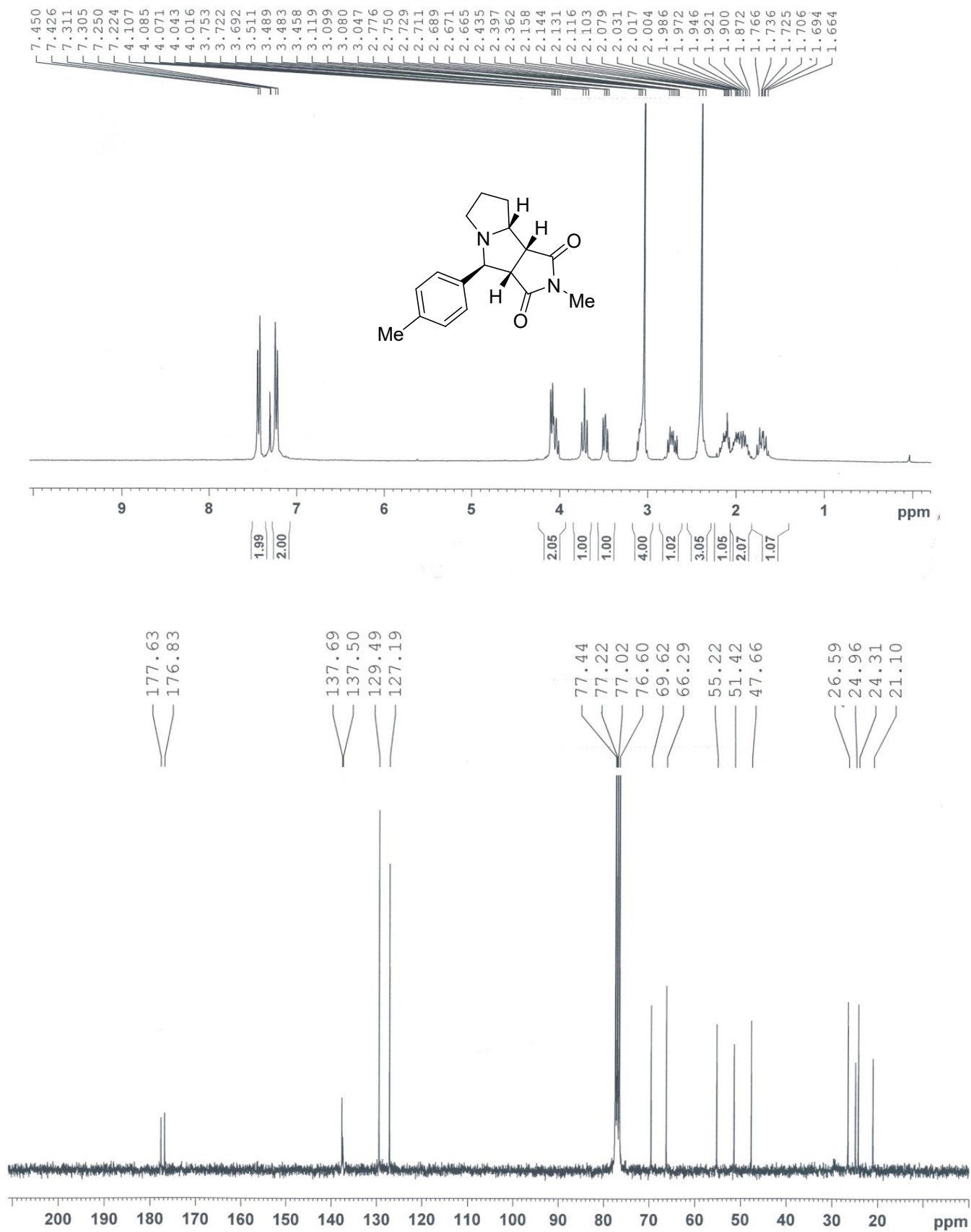


SI Figure 29: ^1H , ^{13}C and ^{19}F -NMR spectra of compound **9b**

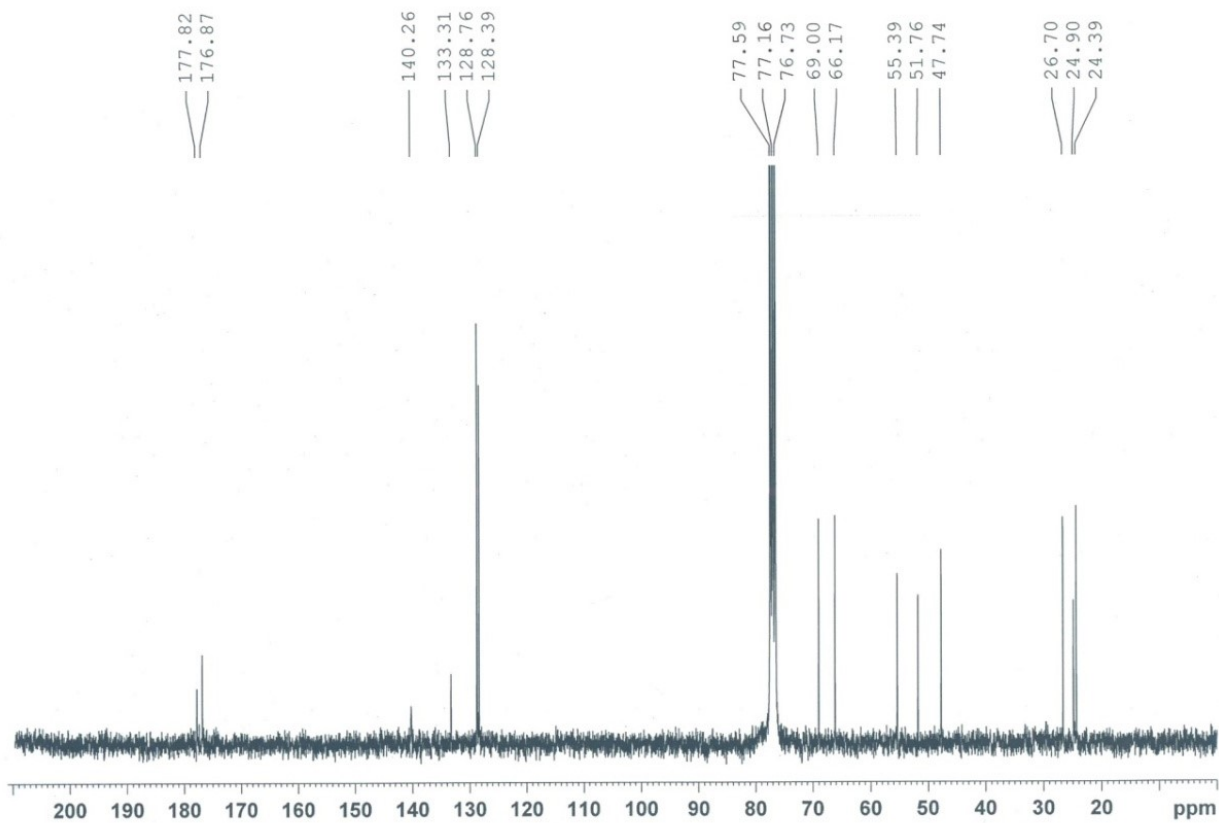
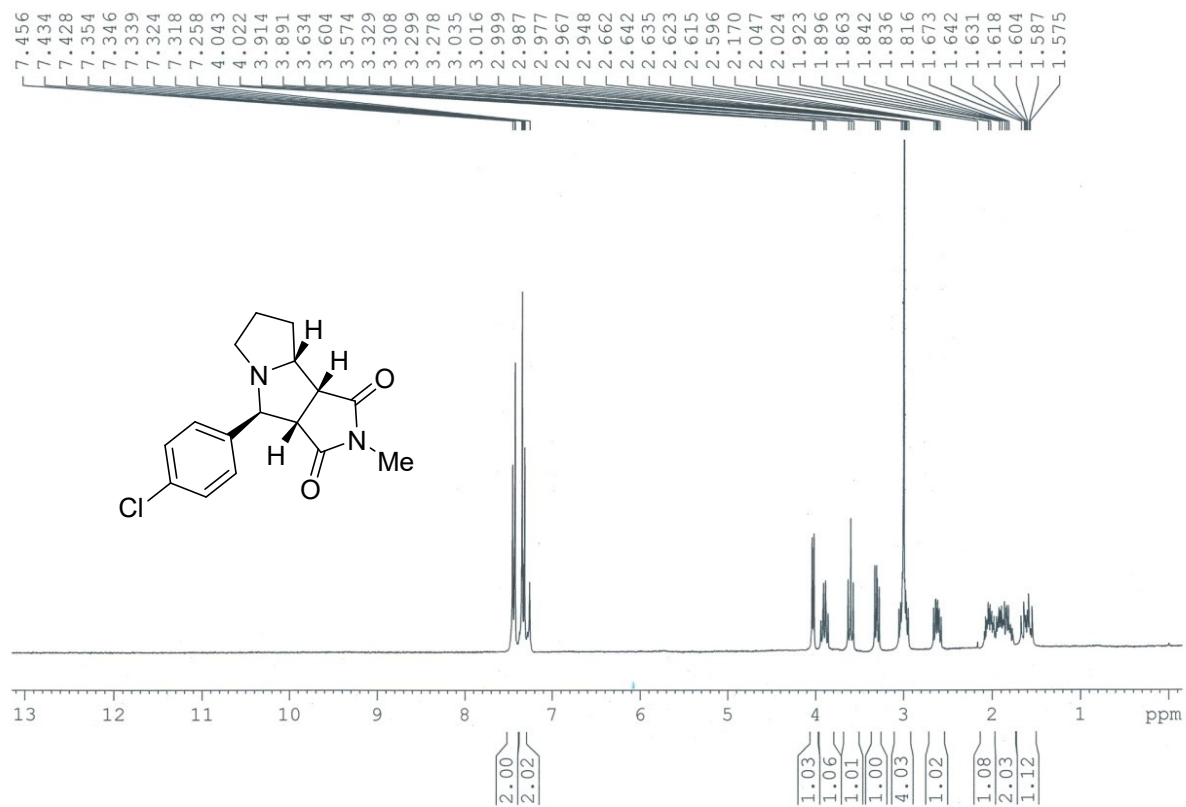




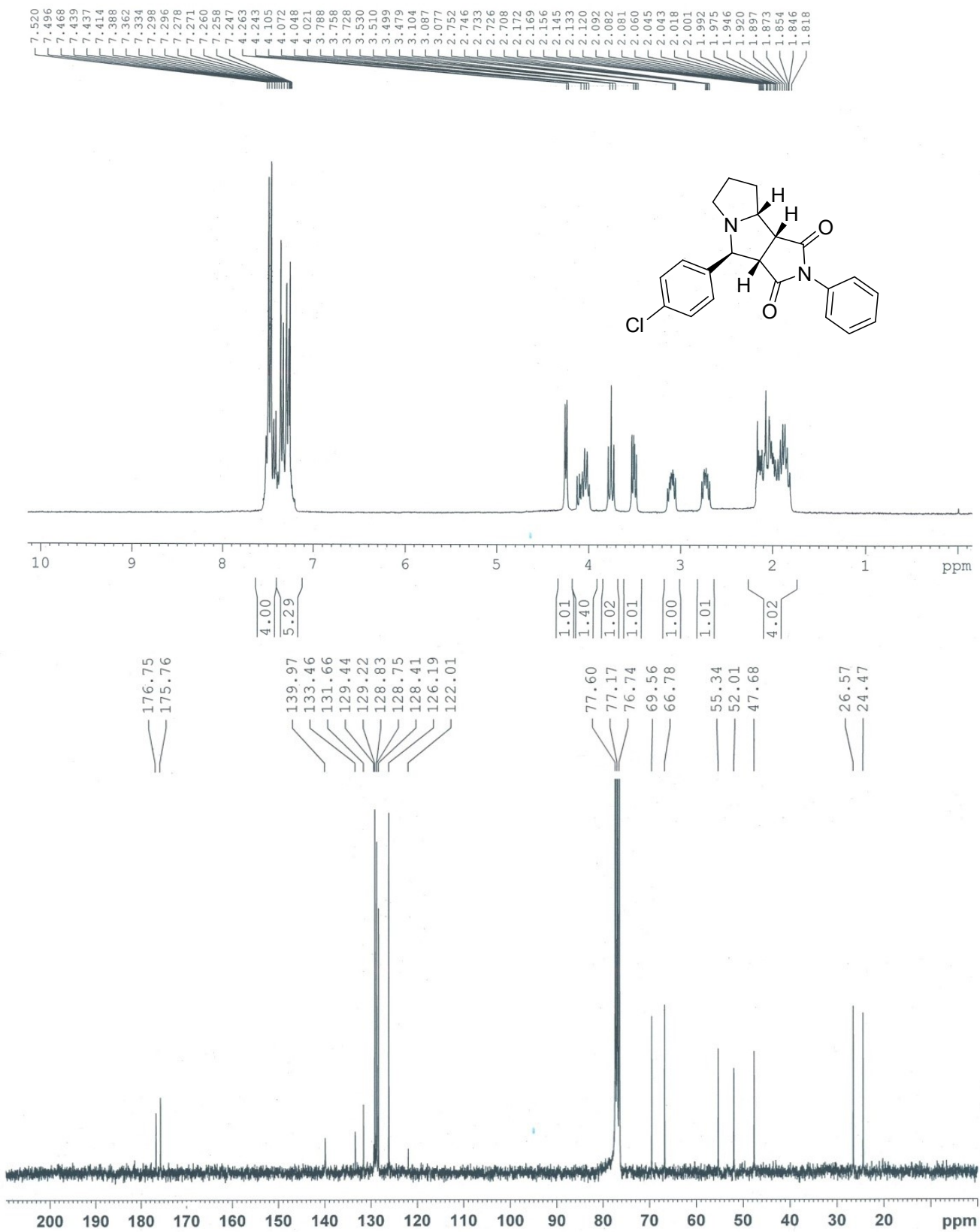
SI Figure 30: ^1H and ^{13}C -NMR spectra of compound **9c**



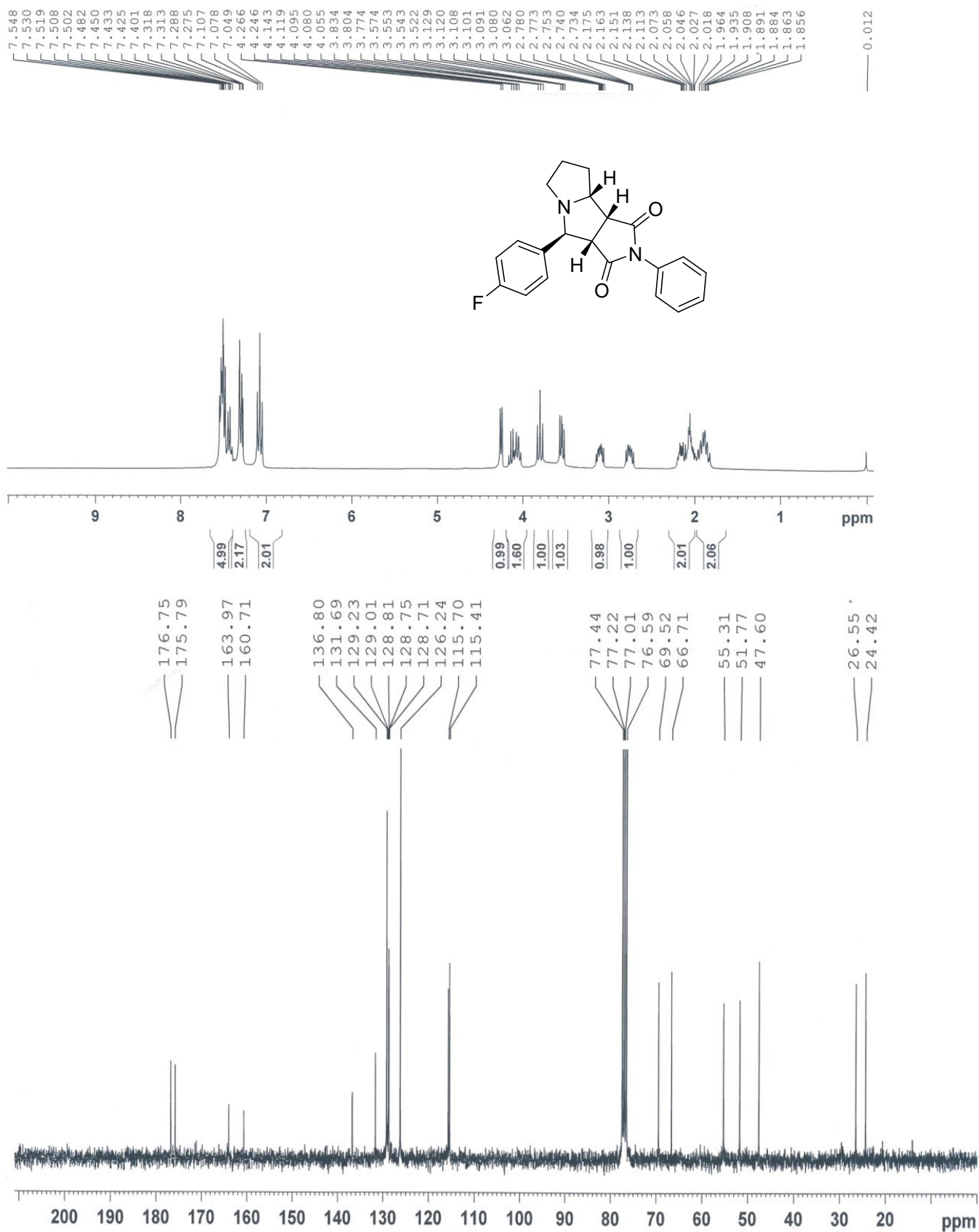
SI Figure 31: ^1H and ^{13}C -NMR spectra of compound **9d**



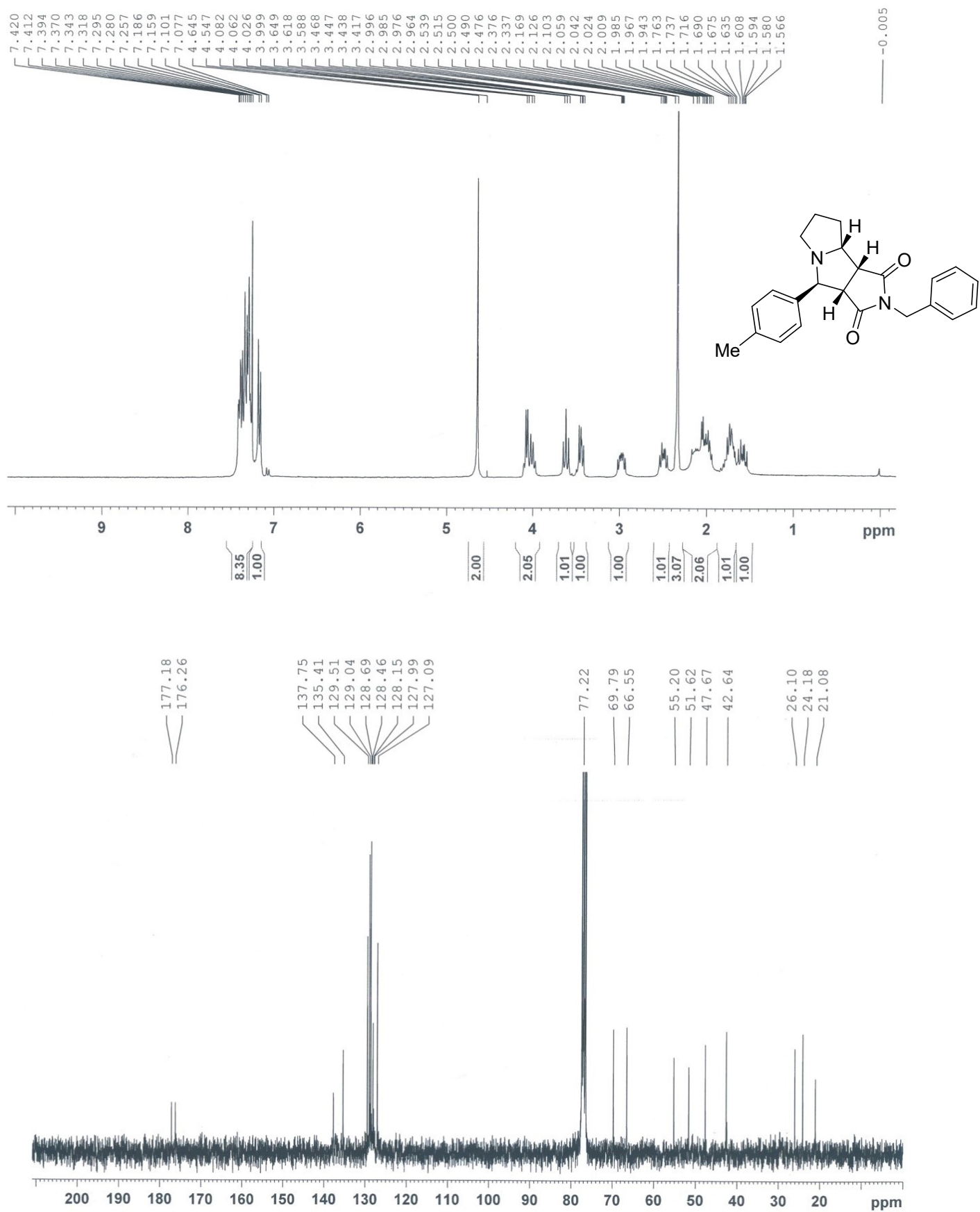
SI Figure 32: ¹H and ¹³C-NMR spectra of compound 9e



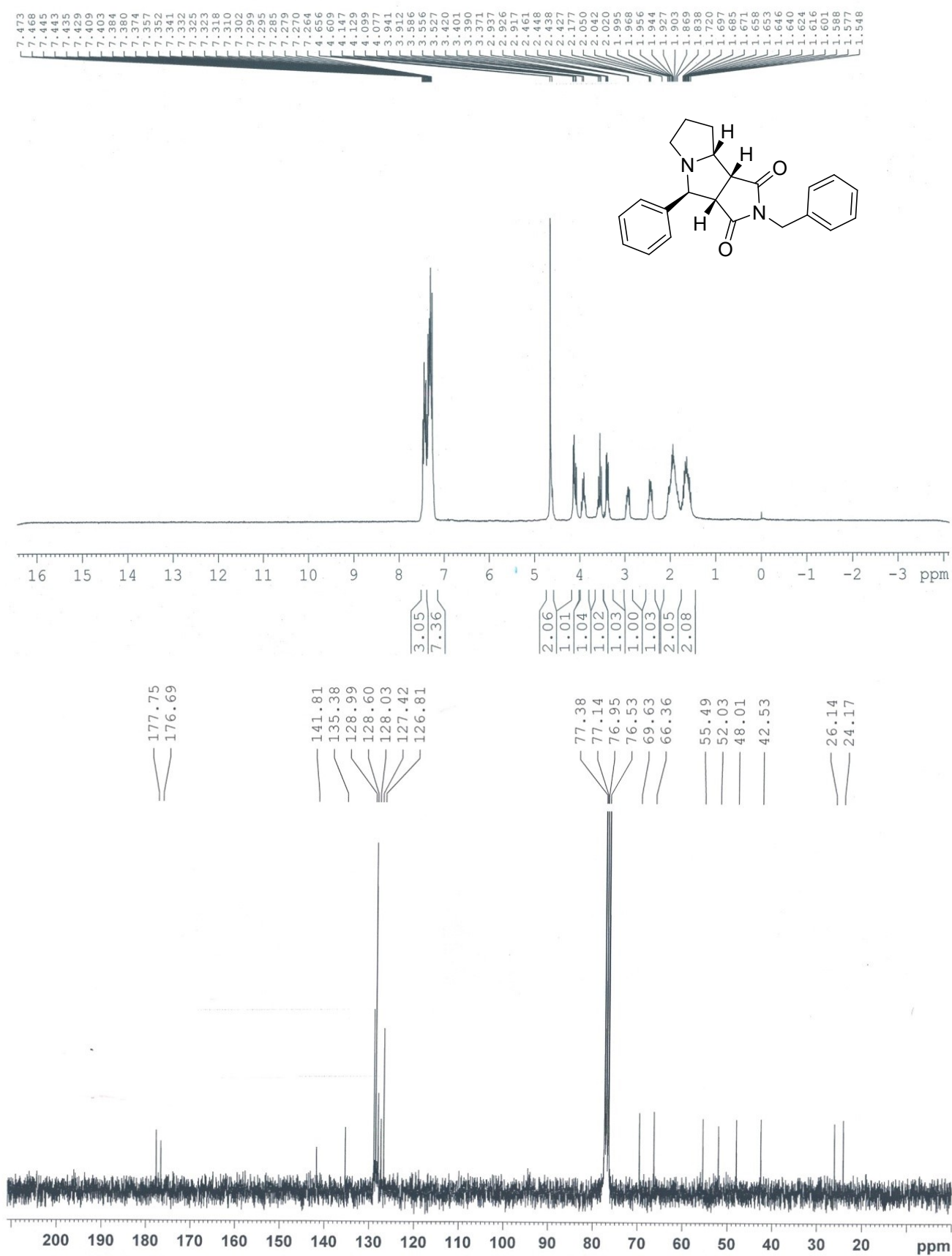
SI Figure 33: ^1H and ^{13}C -NMR spectra of compound **9f**



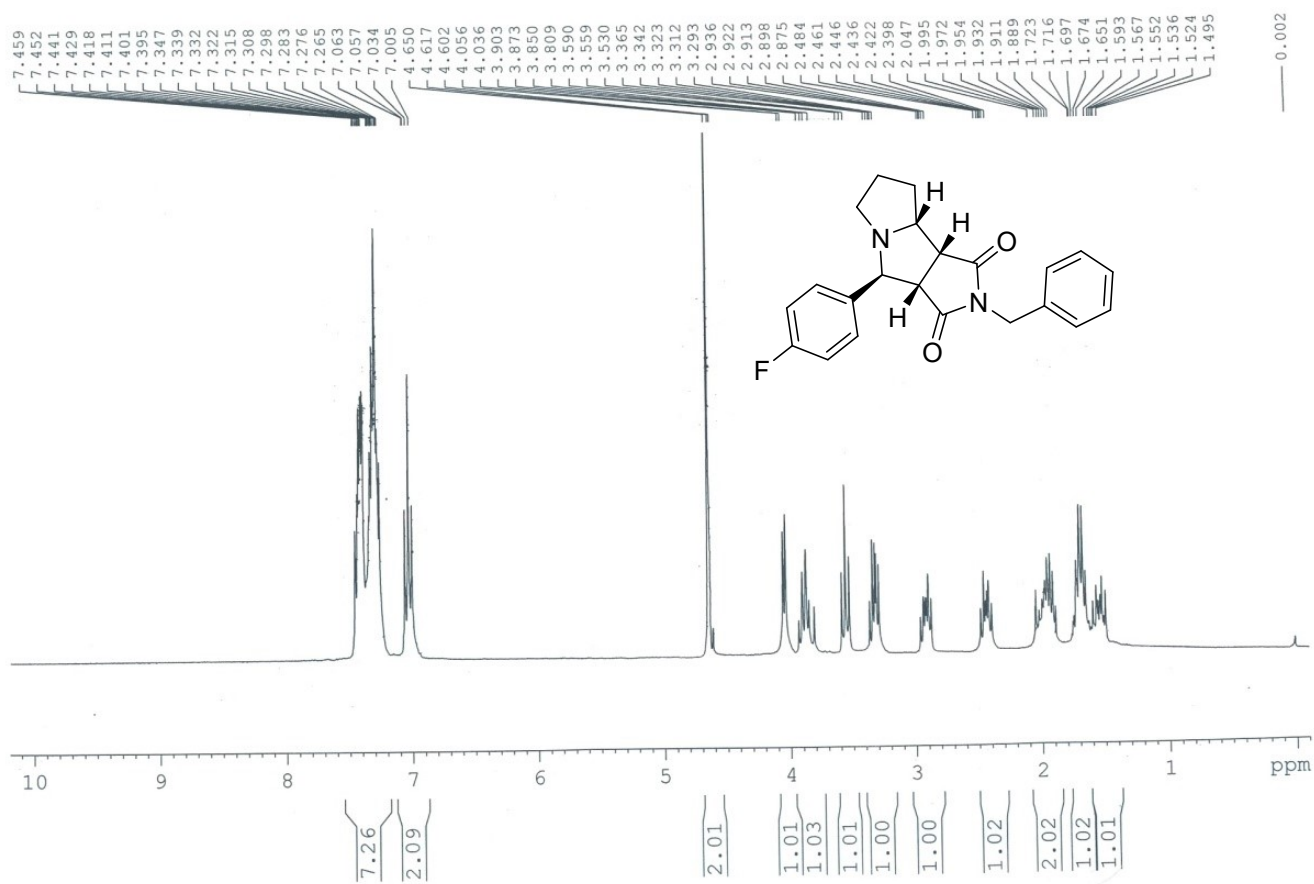
SI Figure 34: ^1H and ^{13}C -NMR spectra of compound **9g**

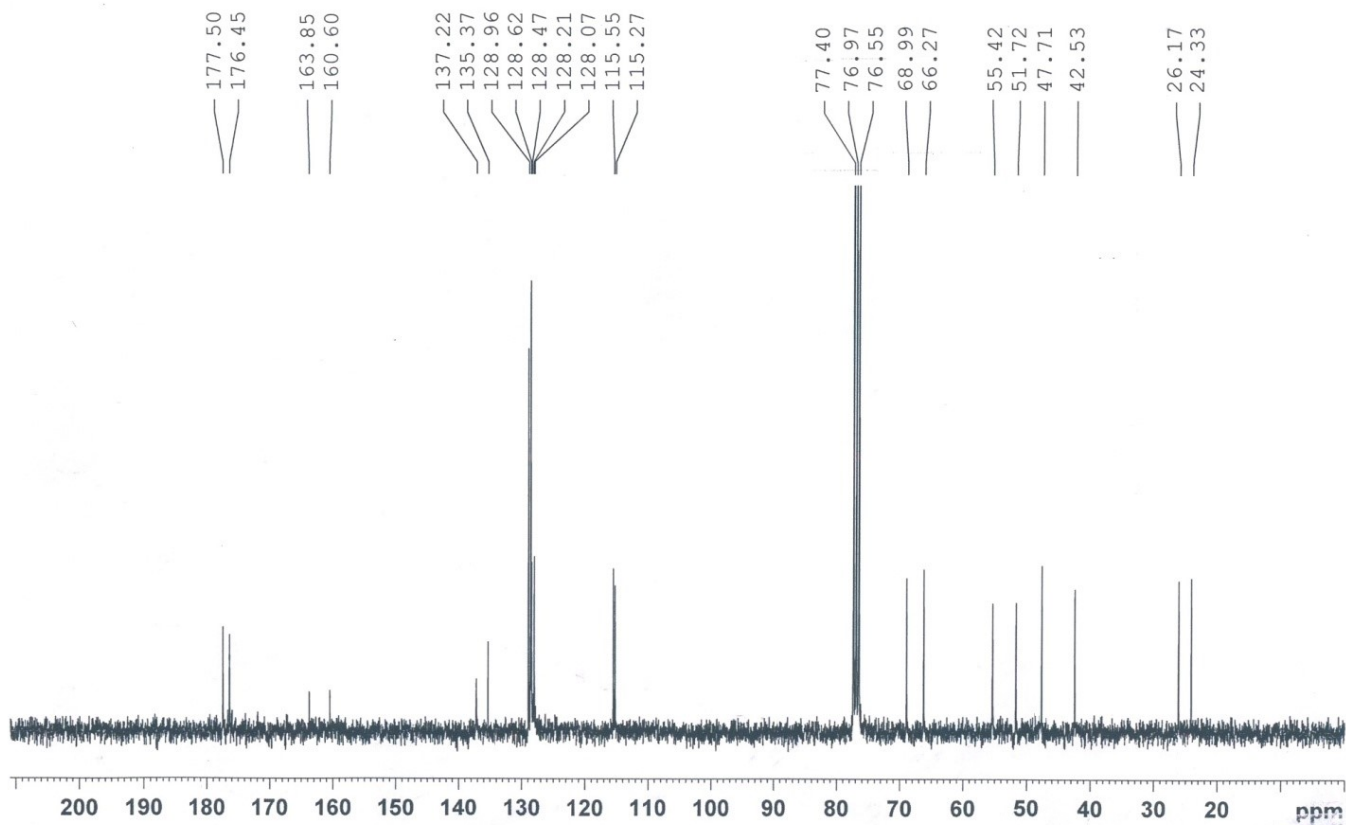


SI Figure 35: ^1H and ^{13}C -NMR spectra of compound **9h**

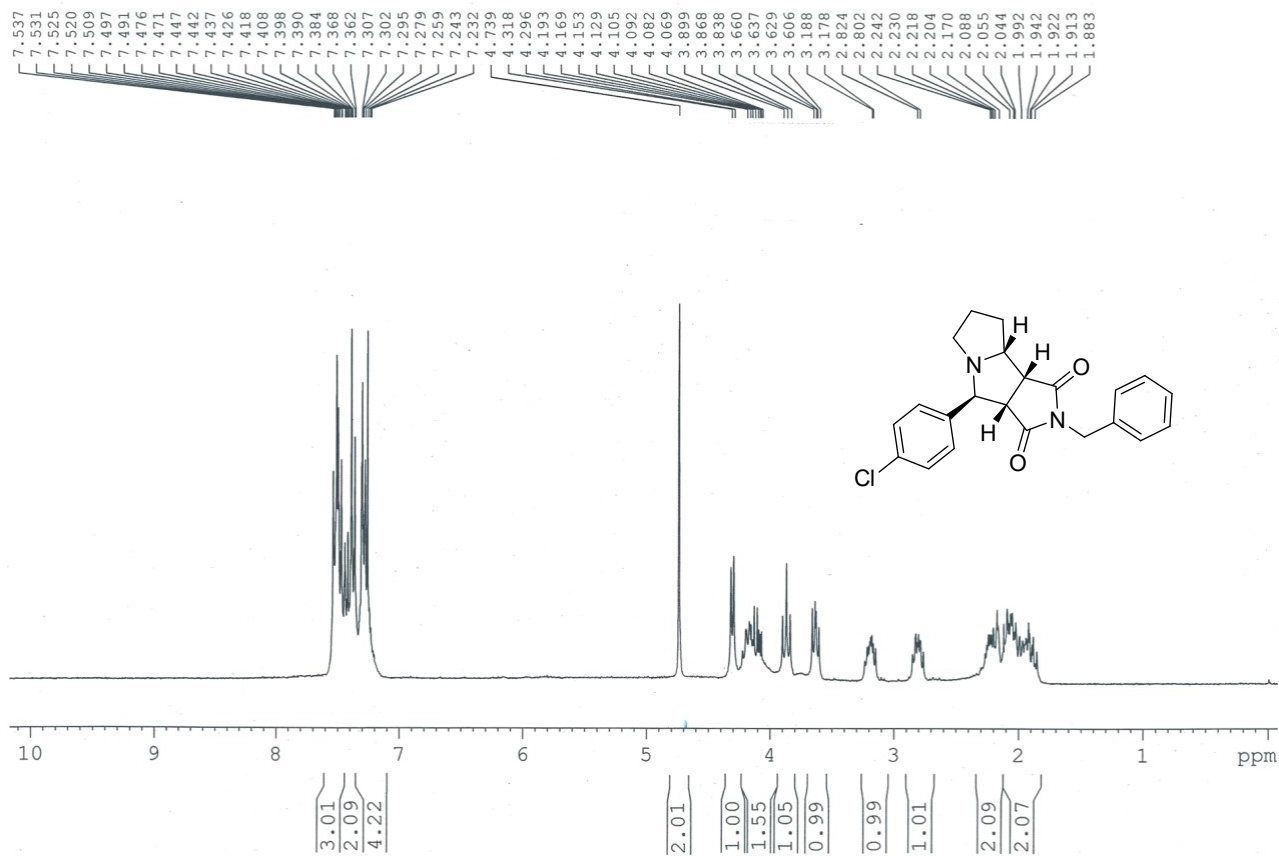


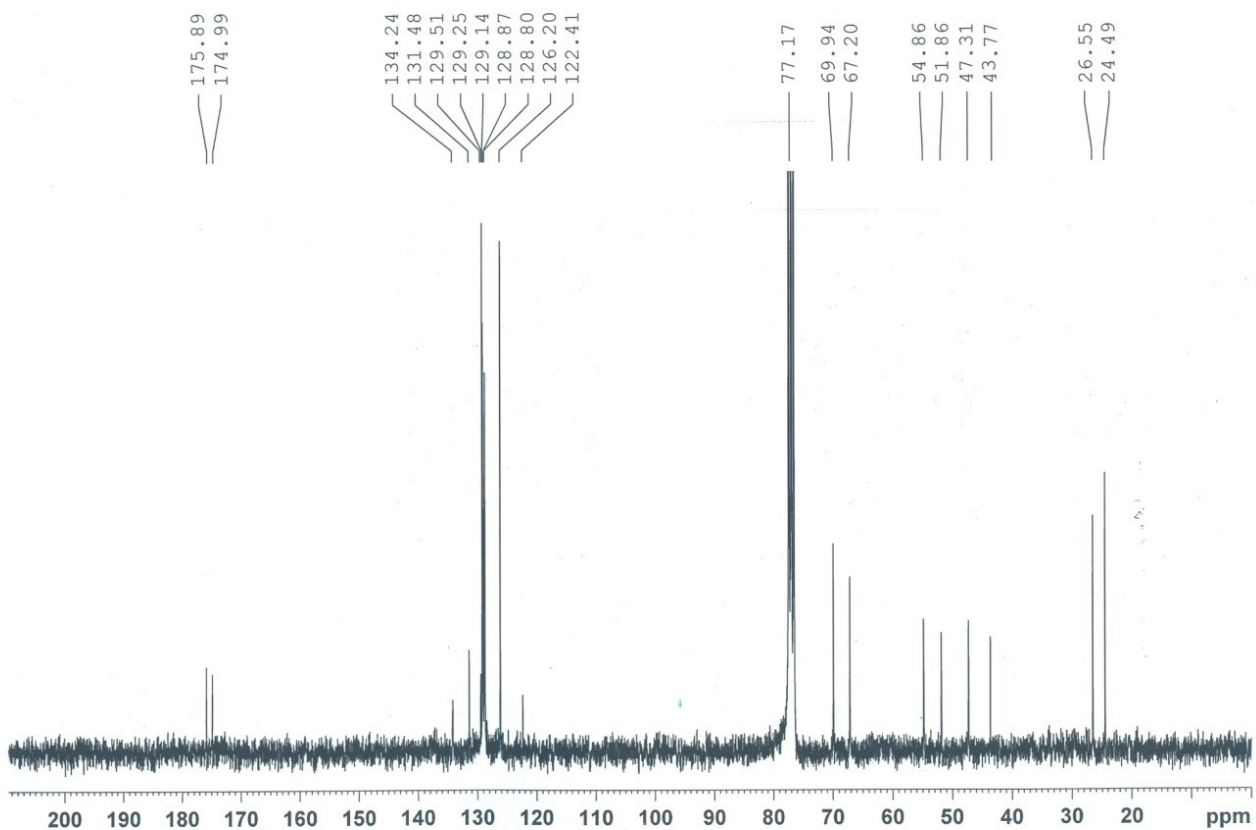
SI Figure 36: ^1H and ^{13}C -NMR spectra of compound **9i**



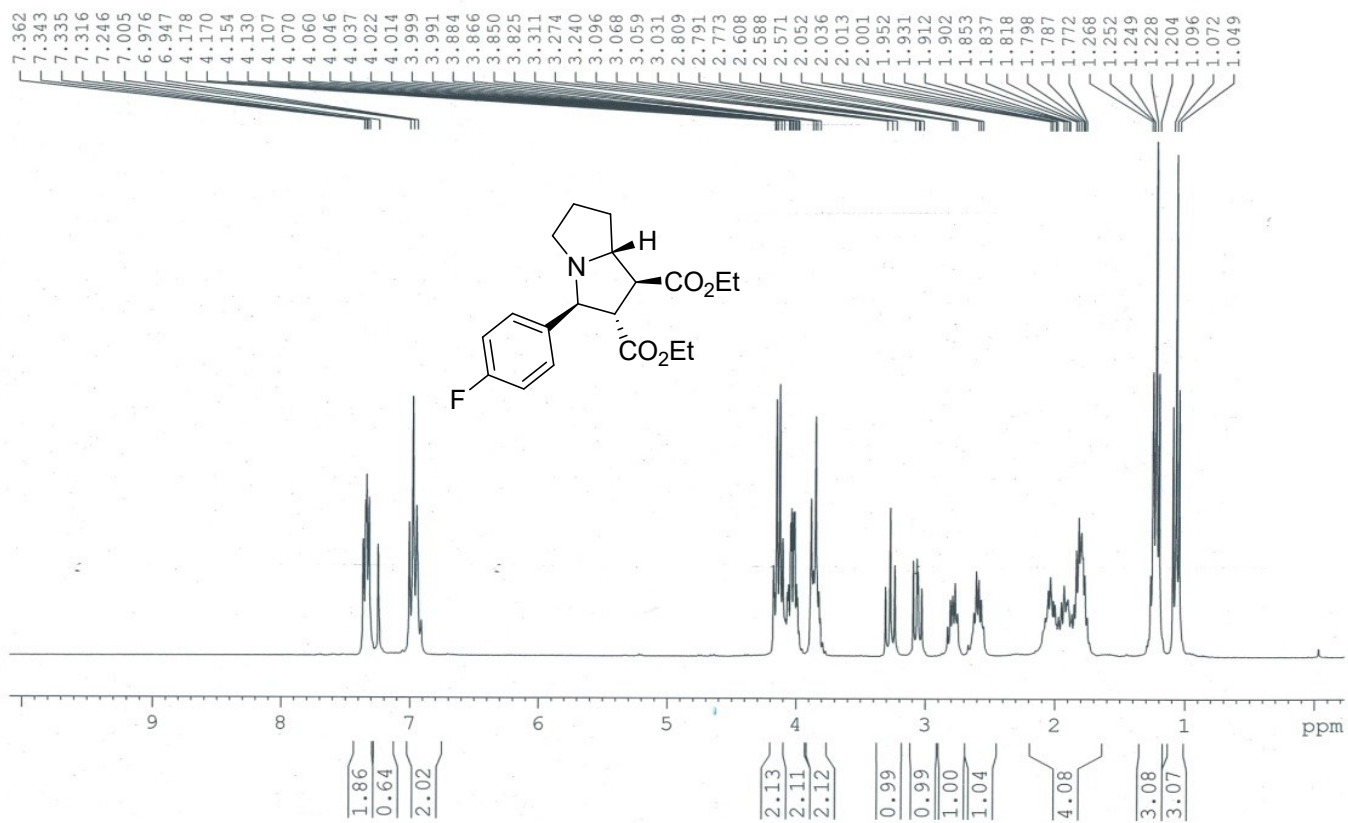


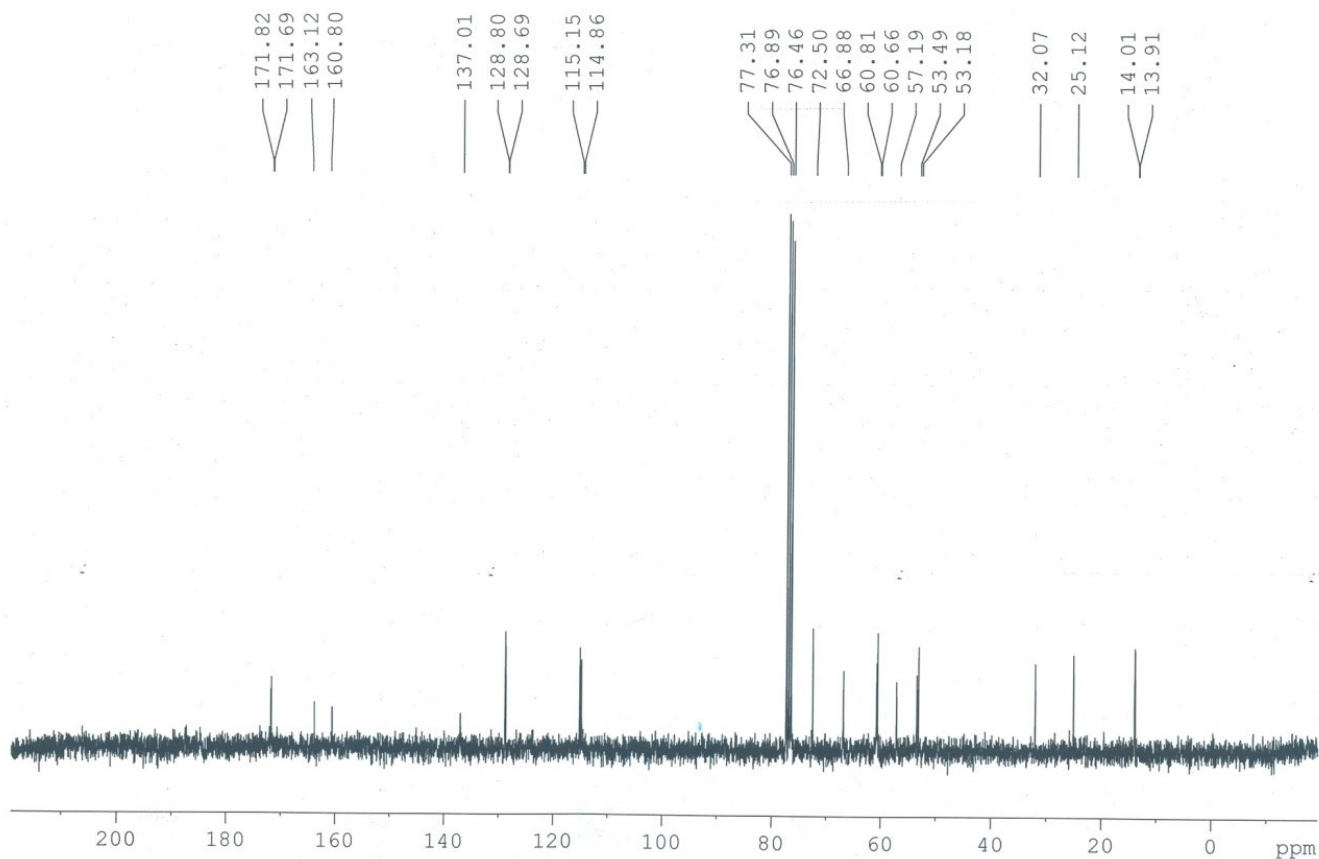
SI Figure 37: ^1H and ^{13}C -NMR spectra of compound **9j**



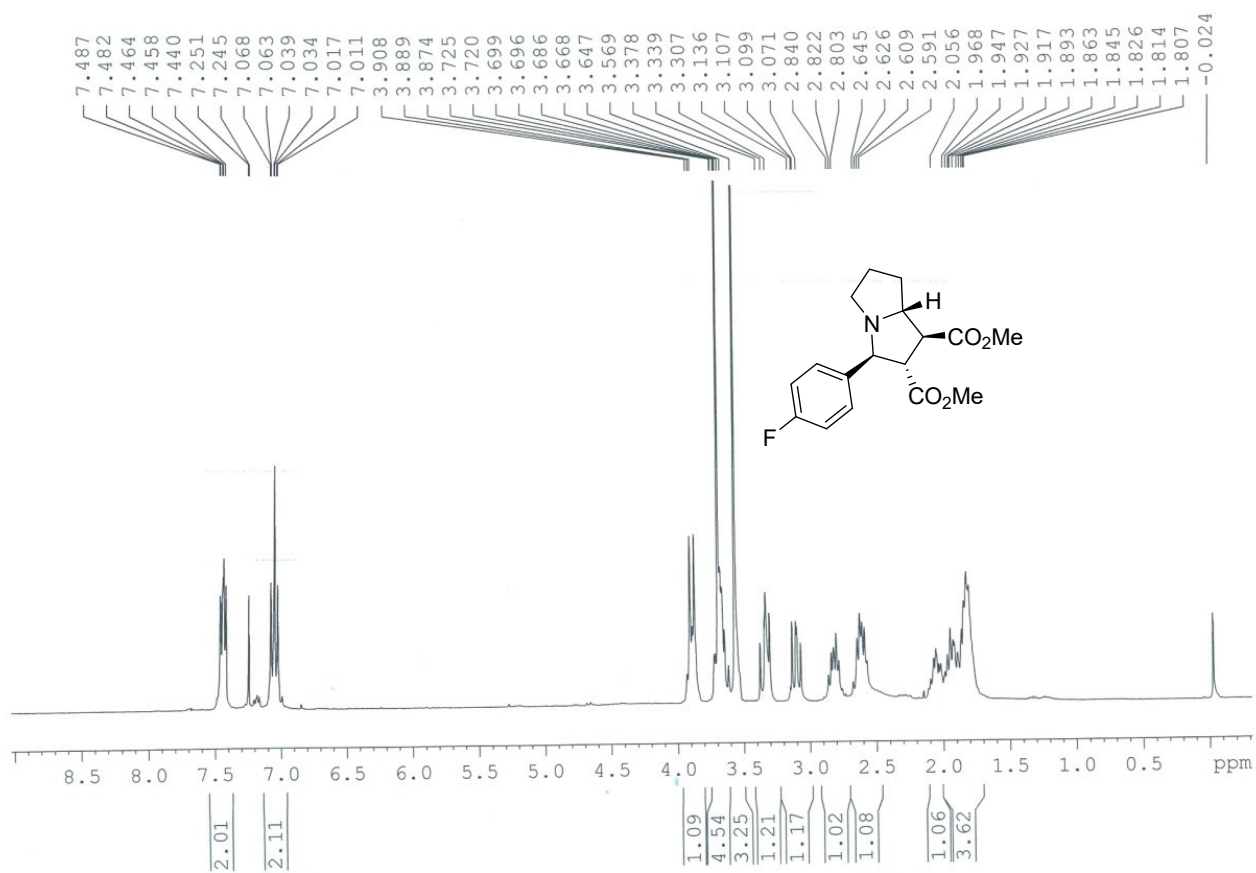


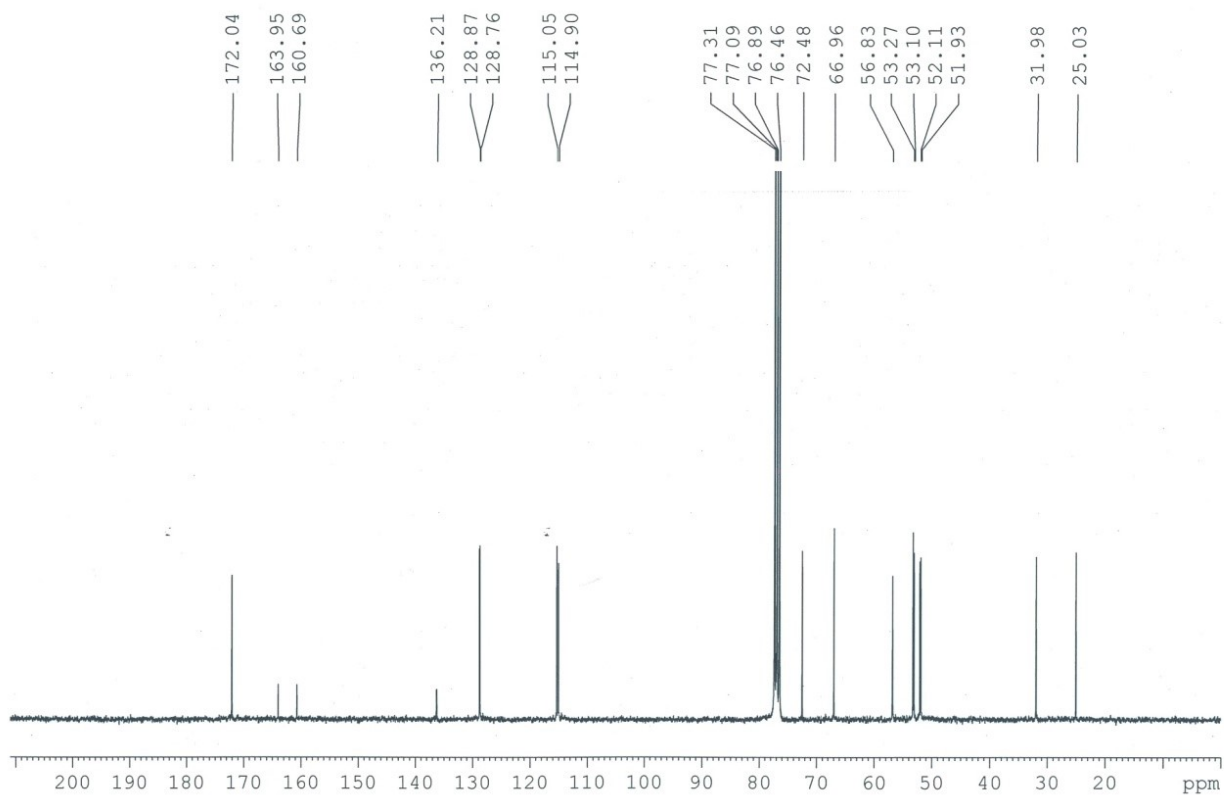
SI Figure 38: ^1H and ^{13}C -NMR spectra of compound 10a



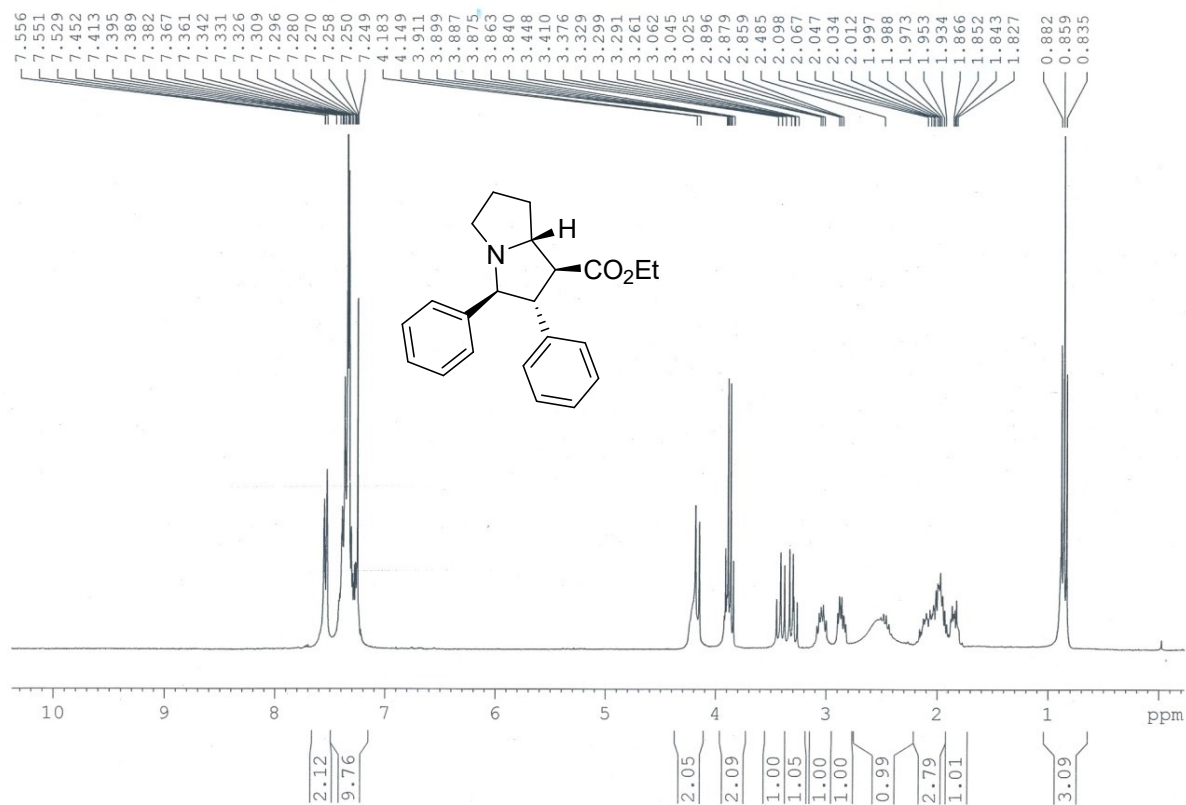


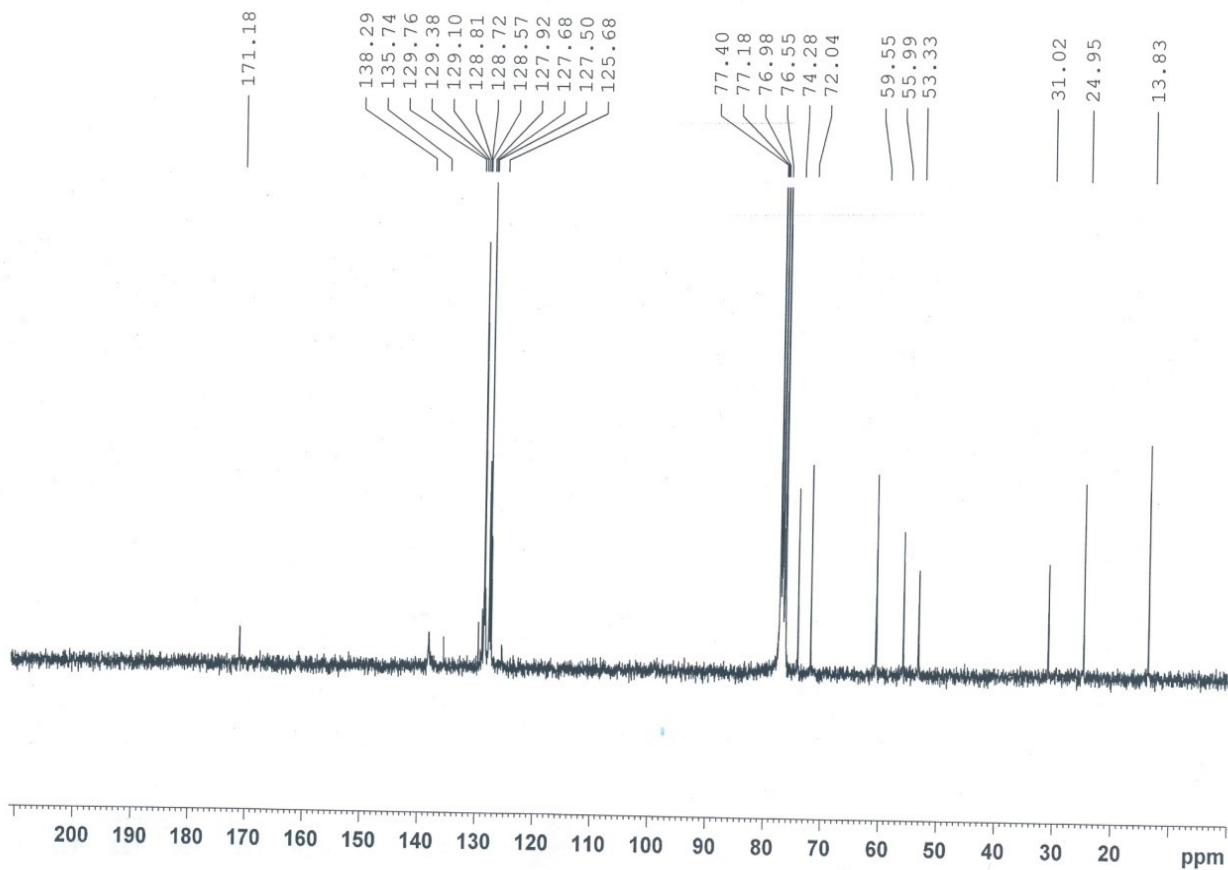
SI Figure 39: ^1H and ^{13}C -NMR spectra of compound **10b**



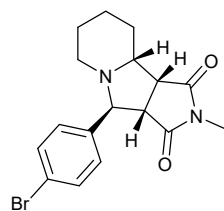
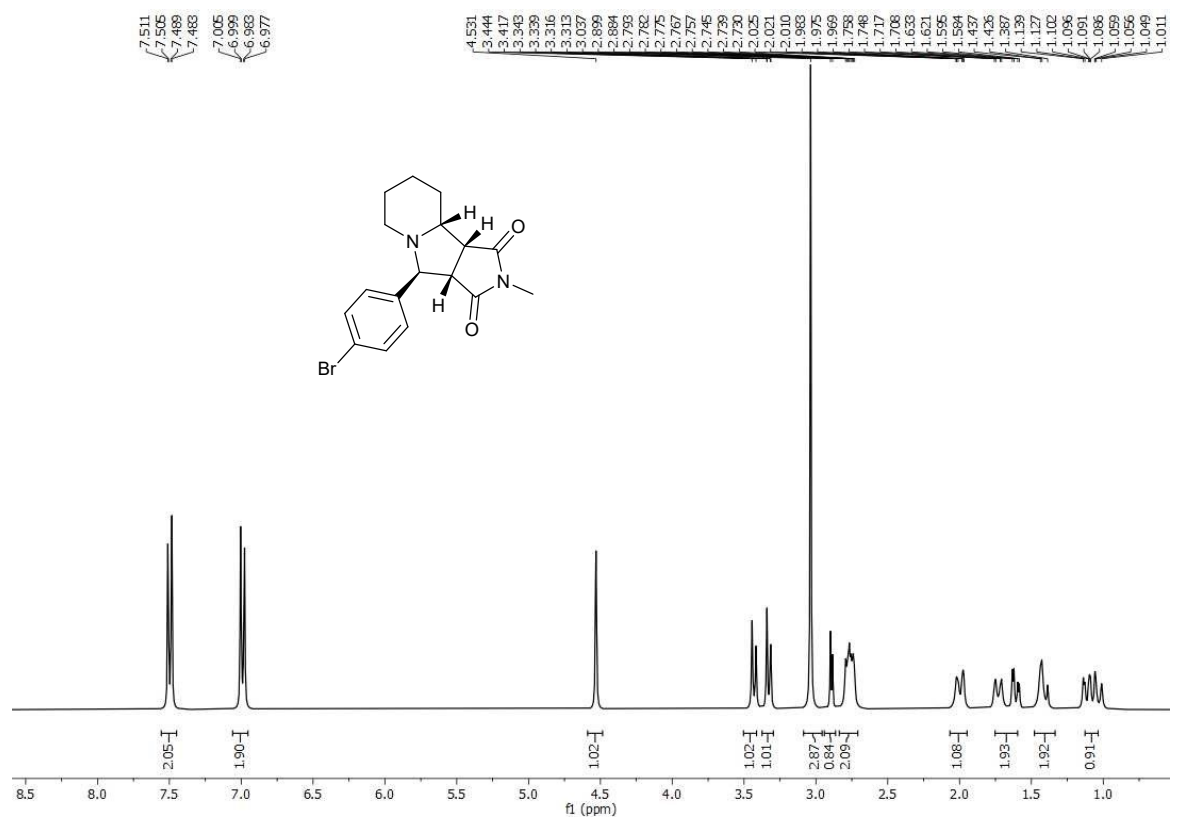


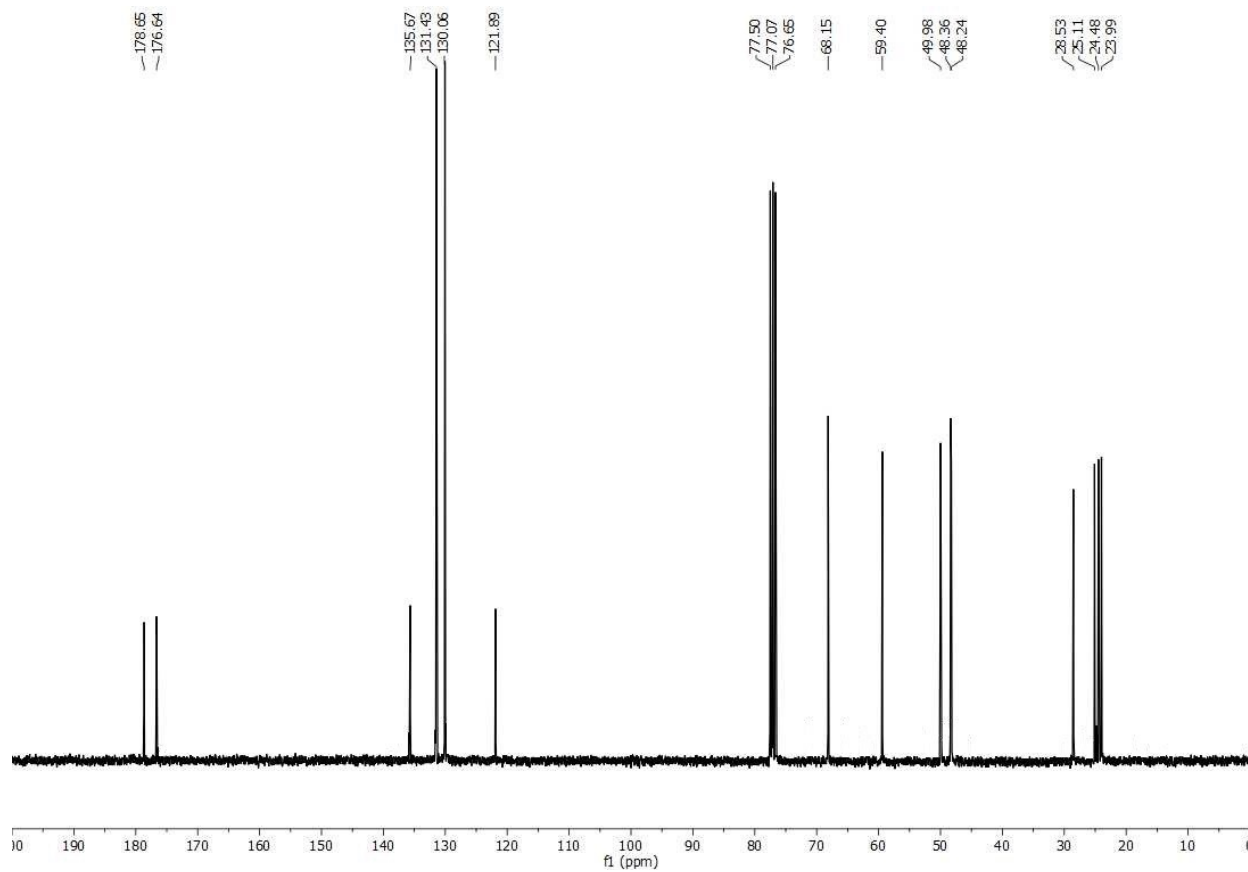
SI Figure 40: ^1H and ^{13}C -NMR spectra of compound 10c



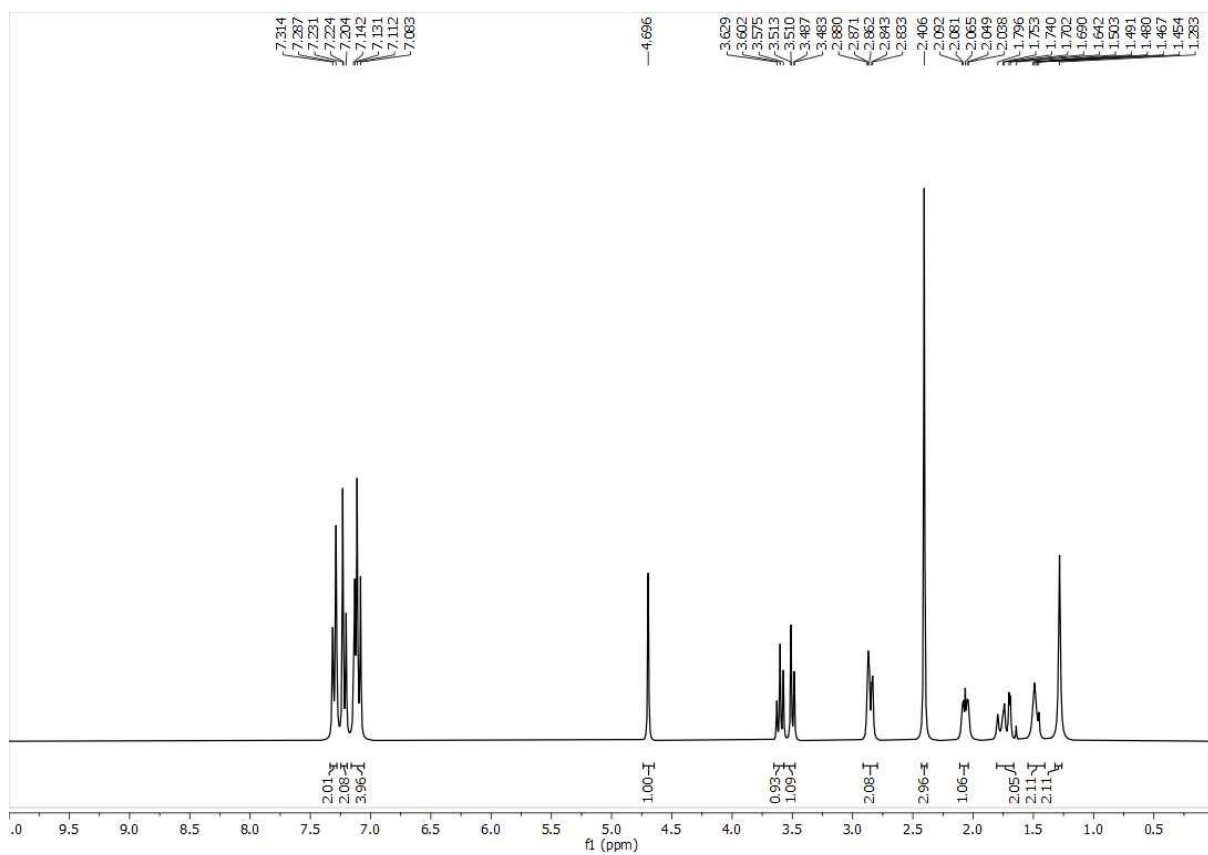


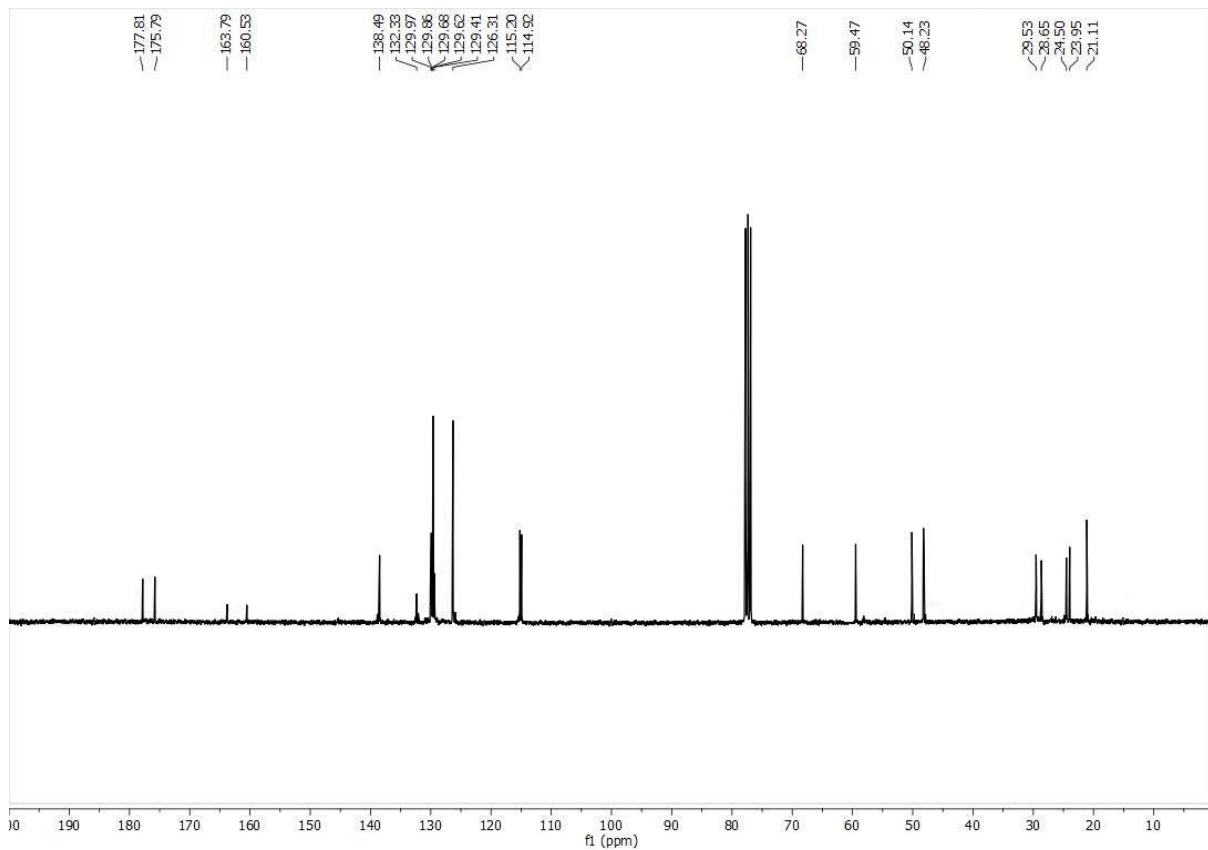
SI Figure 41: ^1H and ^{13}C -NMR spectra of compound 10d



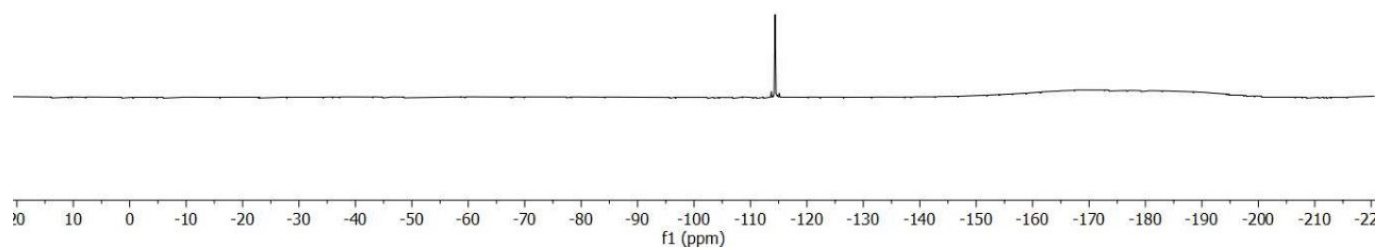


SI Figure 42: ^1H , ^{13}C and ^{19}F -NMR spectra of compound 10e

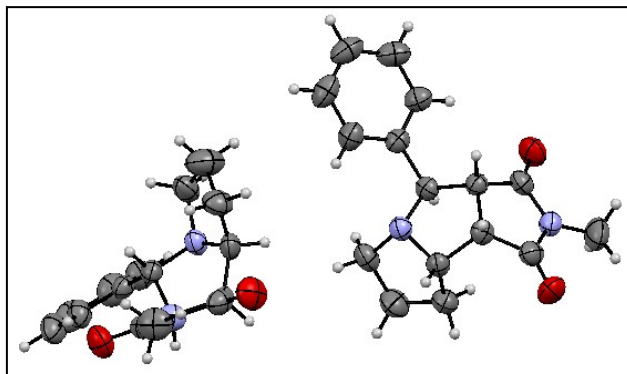




114.36

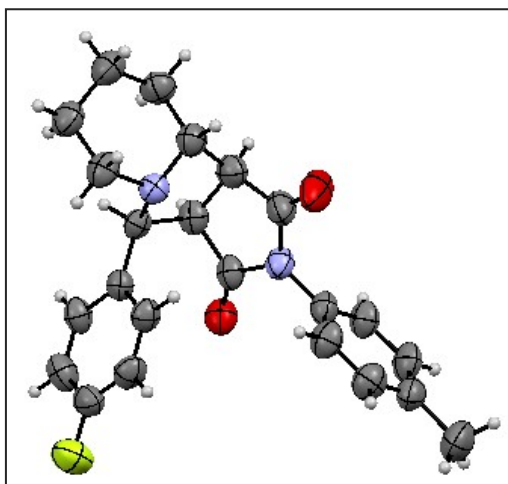


4. (a) Crystal Summary Data of Compound 9a (CCDC 1832647)



- ❖ Chemical formula and formula weight (M): C₁₆ H₁₈ N₂ O₂ and 270.14
- ❖ Crystal system: Triclinic
- ❖ Unit-cell dimensions (angstrom or pm, degrees) and volume, with edges: a=7.827(4) b=10.029(4) c=17.446(8) α=89.147(6) β=87.469(6) γ=82.695(6)
- ❖ Temperature: 296(2)
- ❖ Space group symbol: P -1
- ❖ No. of formula units in unit cell (Z): 4
- ❖ Number of reflections measured and/or number of independent reflections, Rint: 2746
- ❖ Final R values (and whether quoted for all or observed data): 0.0484

(b) Crystal Summary Data of Compound 10e (CCDC 2312186)



- ❖ Chemical formula and formula weight (M): C₂₃ H₂₃ F N₂ O₂ and 378.43
- ❖ Crystal system: Monoclinic
- ❖ Unit-cell dimensions (angstrom or pm, degrees) and volume, with edges: a=19.48(2) b=5.587(5) c=18.462(17) α=90 β=101.83(3) γ=90
- ❖ Temperature: 297(2)
- ❖ Space group symbol: P2(1)/c
- ❖ No. of formula units in unit cell (Z): 4
- ❖ Number of reflections measured and/or number of independent reflections, Rint: 2521
- ❖ Final R values (and whether quoted for all or observed data): 0.1224

5. Mass spectra data of intermediates

Mass spectra were taken in infusion method.

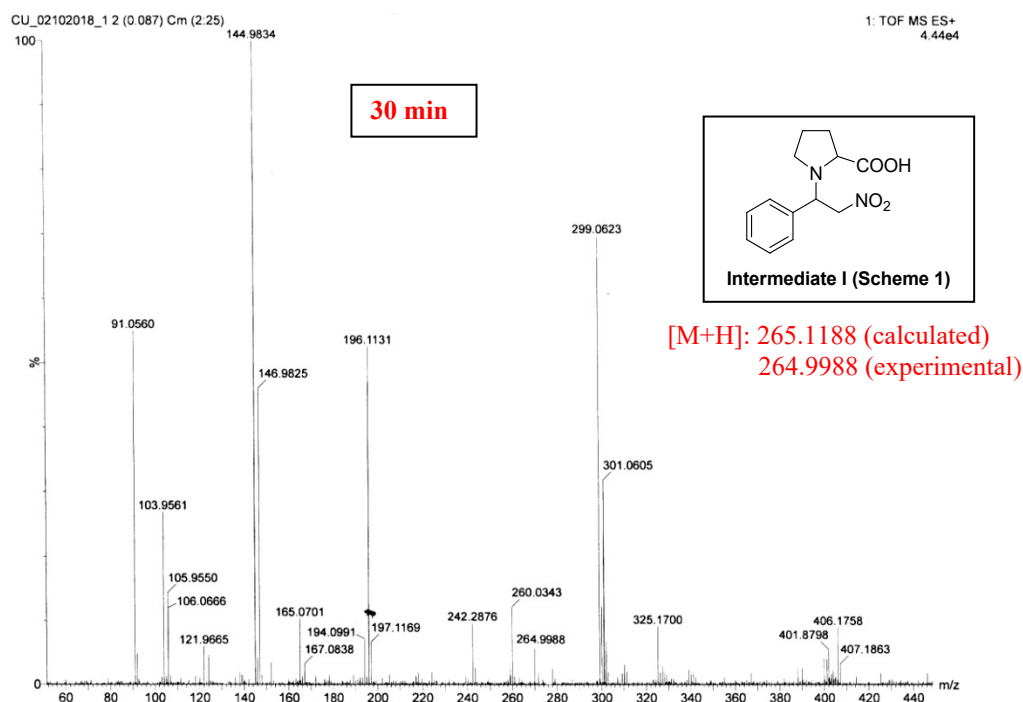
Parameters :

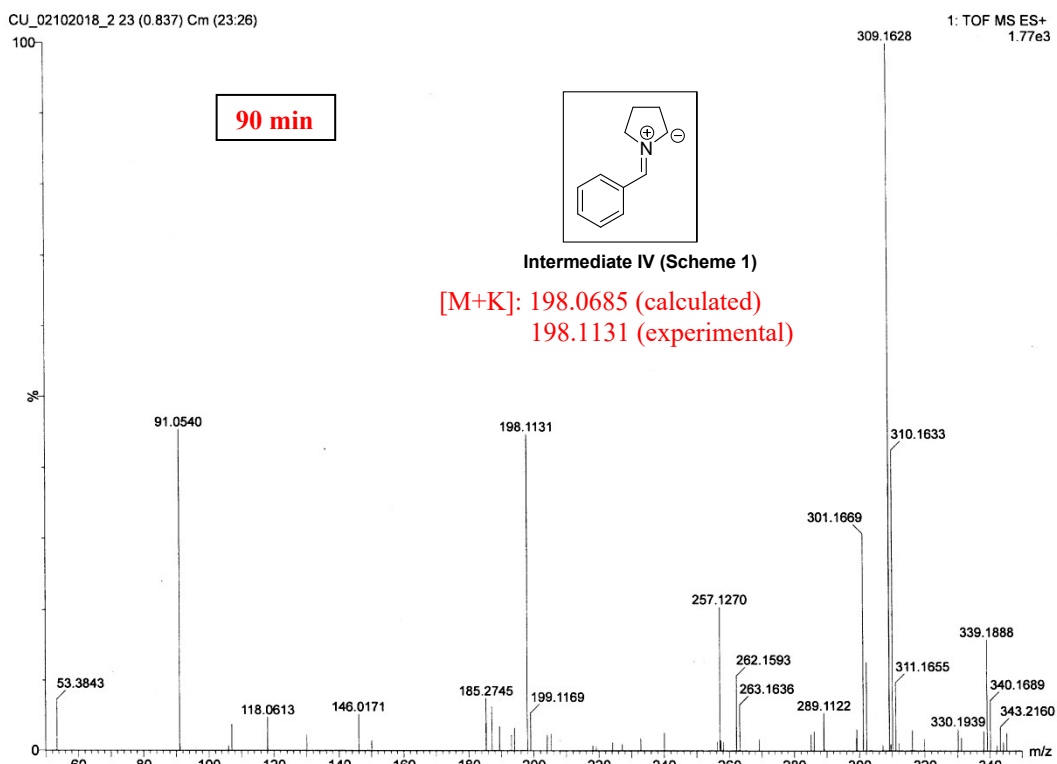
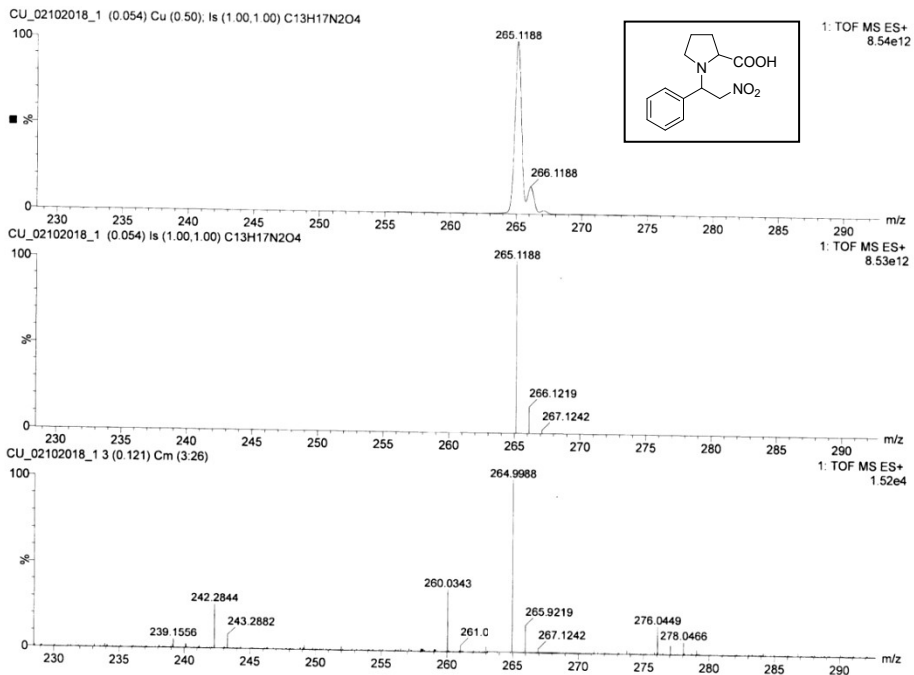
Source - capillary (kv): 3.06, Sampling cone: 85, source offset: 80

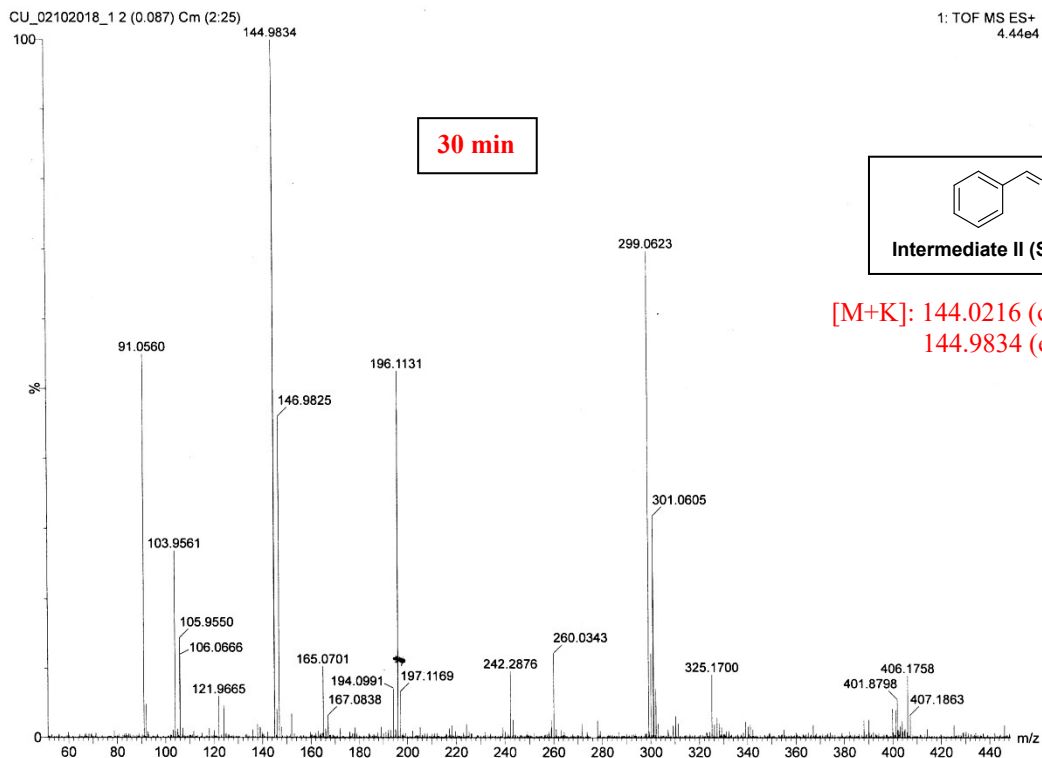
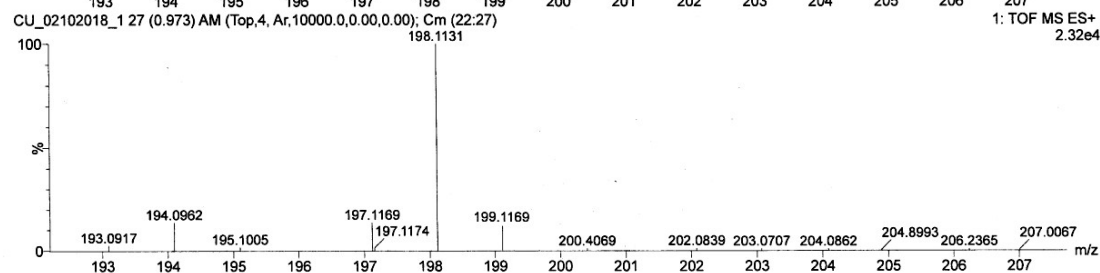
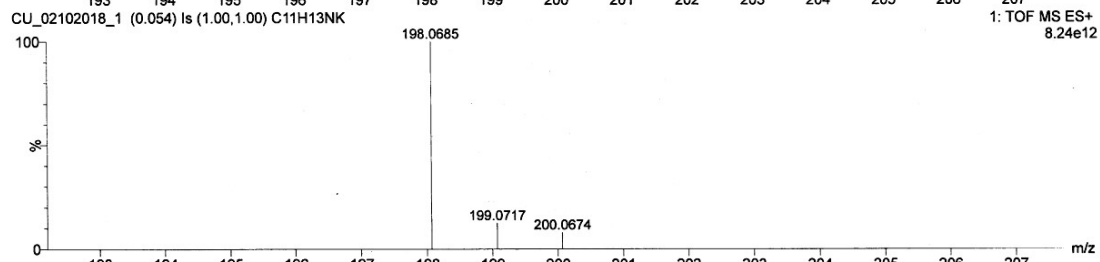
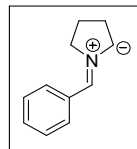
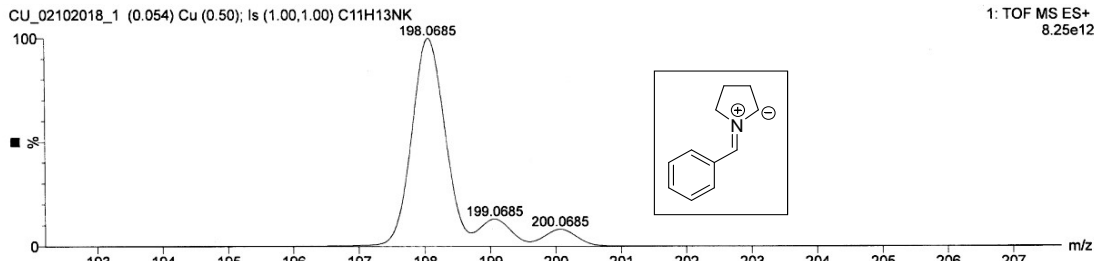
Temp (°C) - Source: 120, Desolvation: 300

Gas flows – Cone gas (L/h) 50, Desolvation gas (L/h) 600, Lock spray capillary (kv) 2.50

In order to ascertain the reaction pathway we carried out mass kinetics, for that we withdraw a little aliquot from the reaction mixture and performed mass analysis to find out any probable intermediate(s). To our delight for both of the reactions we got peaks corresponding to the probable intermediates which are shown below and the corresponding time is also shown.

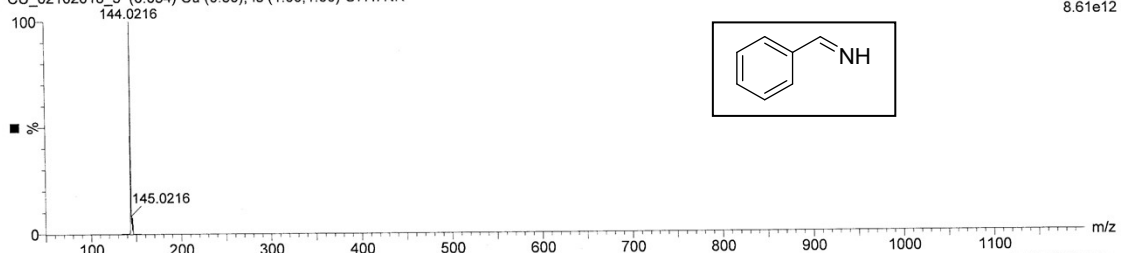






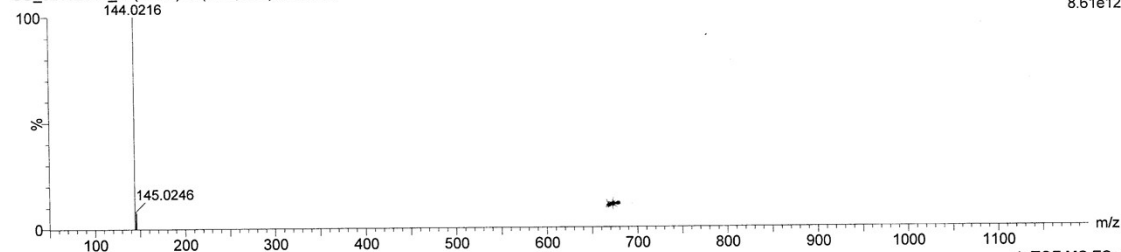
CU_02102018_3 (0.054) Cu (0.50); Is (1.00,1.00) C7H7NK

1: TOF MS ES+
8.61e12



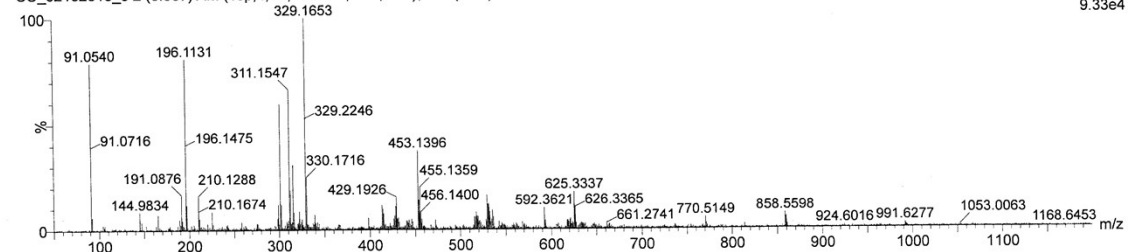
CU_02102018_3 (0.054) Is (1.00,1.00) C7H7NK

1: TOF MS ES+
8.61e12



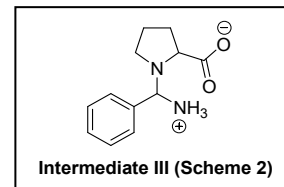
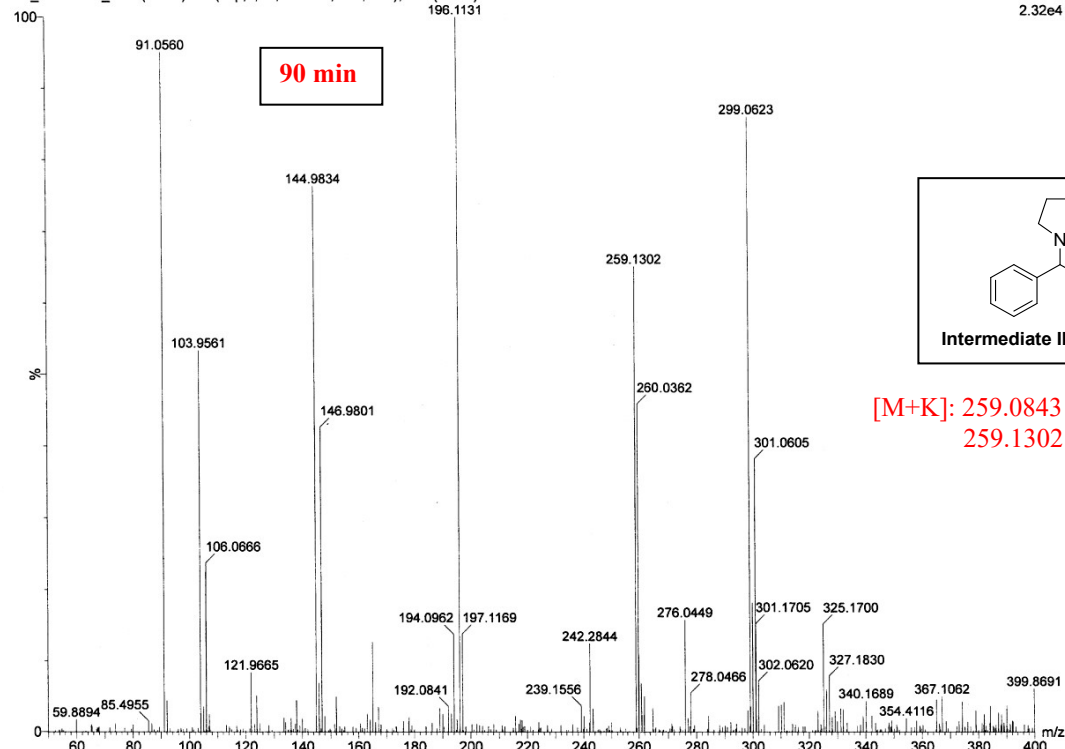
CU_02102018_3 2 (0.087) AM (Top,4, Ar,10000.0,0.00,0.00); Cm (2:27)

1: TOF MS ES+
9.33e4

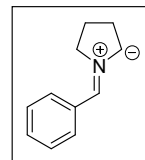
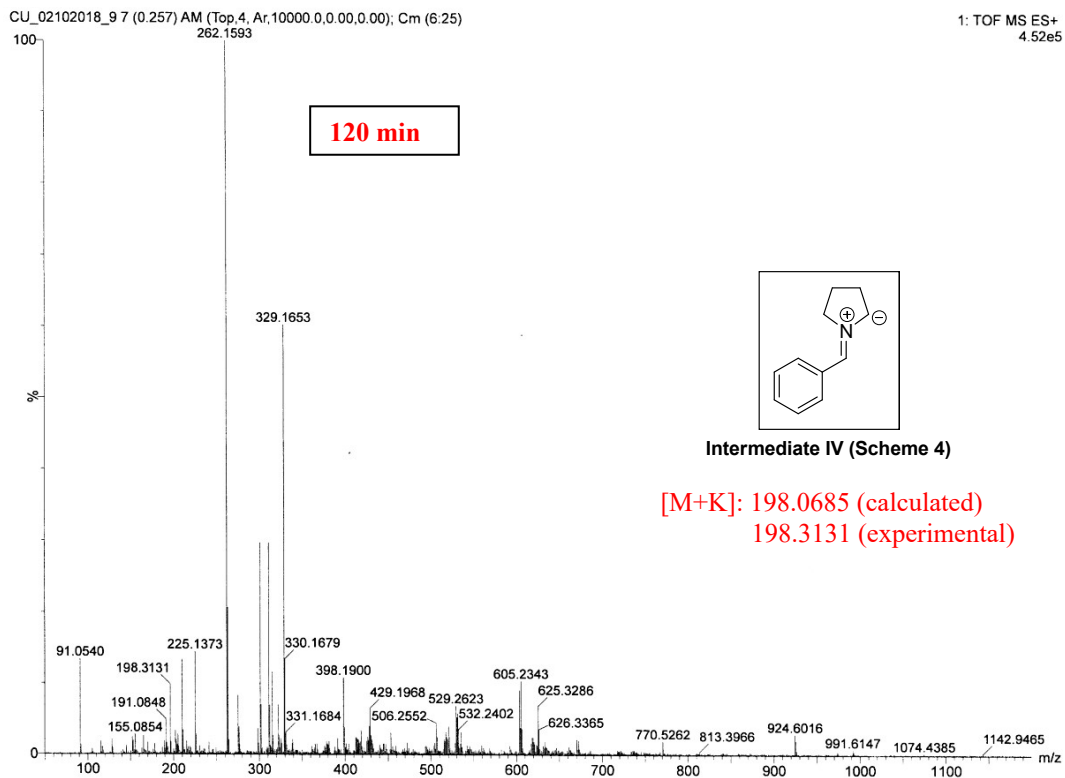
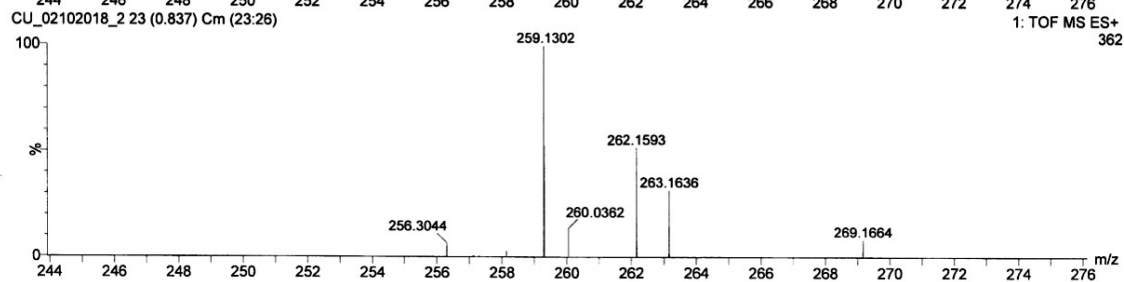
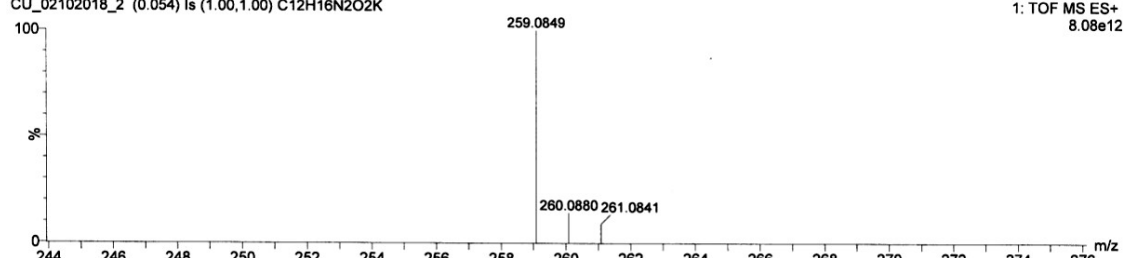
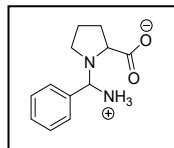
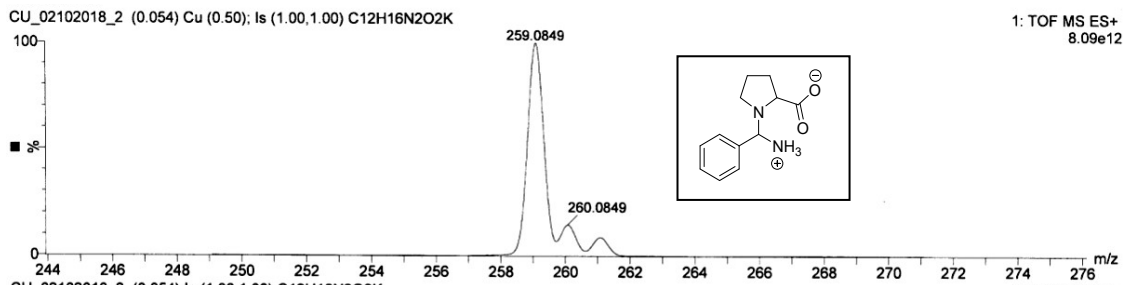


CU_02102018_1 27 (0.973) AM (Top,4, Ar,10000.0,0.00,0.00); Cm (22:27)

1: TOF MS ES+
2.32e4

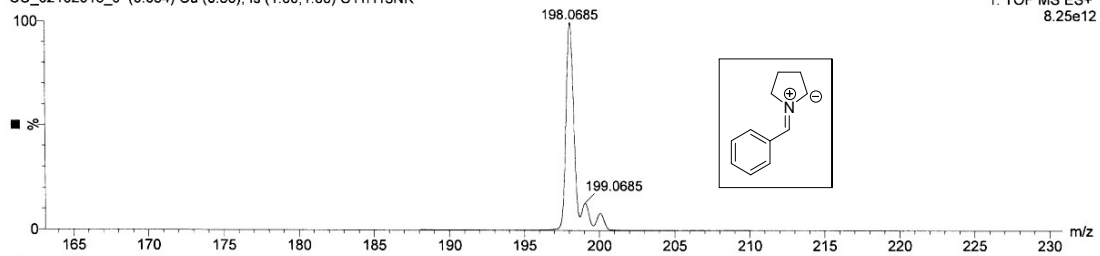


[M+K]: 259.0843 (calculated)
259.1302 (experimental)



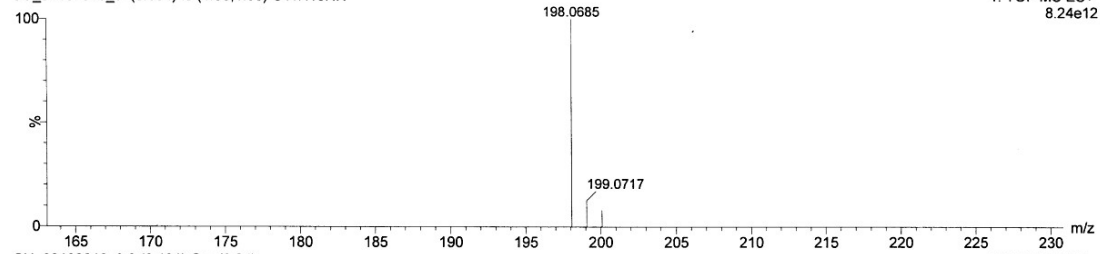
CU_02102018_9 (0.054) Cu (0.50); Is (1.00,1.00) C11H13NK

1: TOF MS ES+
8.25e12



CU_02102018_9 (0.054) Is (1.00,1.00) C11H13NK

1: TOF MS ES+
8.24e12



CU_02102018_9 3 (0.121) Cm (3:24)

1: TOF MS ES+
1.85e4

