

Supporting Information

A novel environmentally sustainable synthesis of Au-Ag@AgCl nanocomposites and their application as an efficient and recyclable catalyst for quinoline synthesis

Kanti Sapkota^{a,b}, Sung Soo Han^{a,b*}

^aSchool of Chemical Engineering, Yeungnam University, 280 Daehak-Ro, Gyeongsan, Gyeongbuk 38541, Republic of Korea

^bDepartment of Nano, Medical & Polymer Materials, College of Engineering, Yeungnam University, 280 Daehak-Ro, Gyeongsan, Gyeongbuk 38541, Republic of Korea

*Corresponding author

Prof. Sung Soo Han, Email: sshan@yu.ac.kr

Tel: +82-53-810-2773; Fax: +82-53-810-4686

Table of Contents

XPS spectrum of C 1s of Au-Ag@AgCl NCs	S2
DSC-TGA spectra of Au-Ag@AgCl NCs	S2
HAADF-STEM image of recycled Au-Ag@AgCl NCs	S3
XRD patterns of one-pot synthesized Au-Ag@AgCl NCs	S3
TEM images of one-pot synthesized Au-Ag@AgCl NCs	S4
¹H NMR and ¹³C NMR data and spectra of compounds 4a-4f	S5-S16
Reported chemical constituents of <i>Nephrolepis cordifolia</i>	S17
¹H NMR analysis of crude CHCl₃ extract of <i>Nephrolepis cordifolia</i>	S18

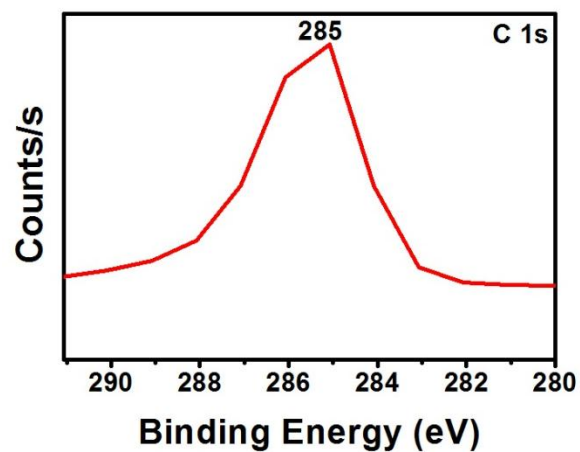


Figure S1. XPS spectrum of C 1s of Au-Ag@AgCl NCs.

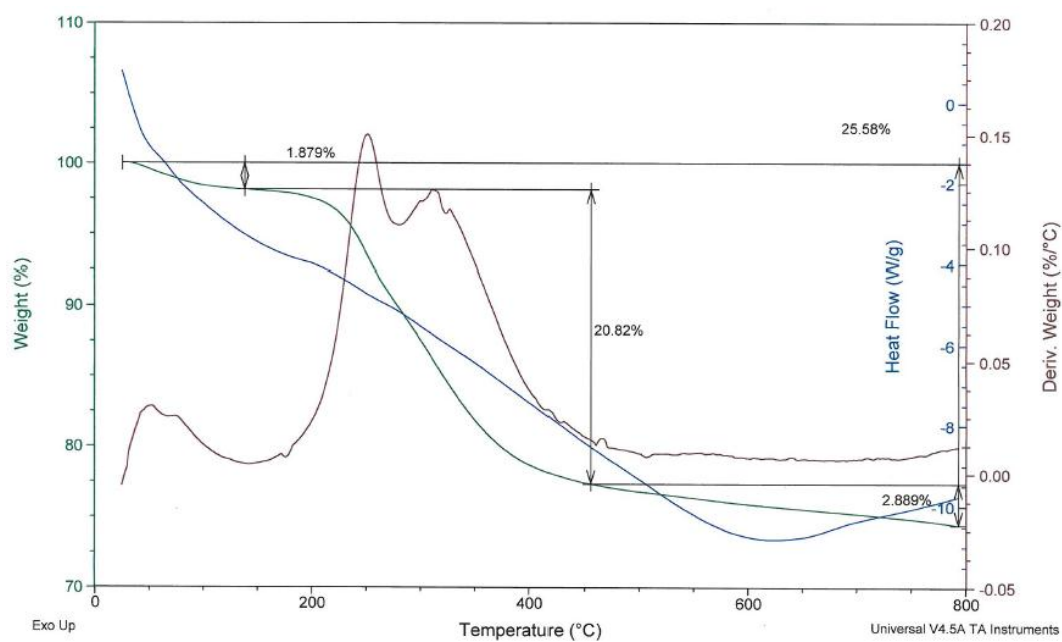


Figure S2. DSC-TGA spectra of Au-Ag@AgCl NCs.

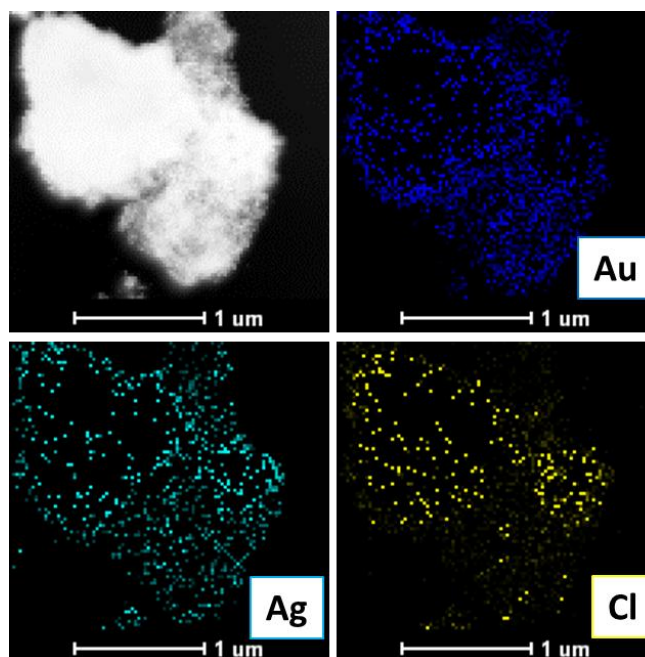


Figure S3. HAADF-STEM image of recycled recycled Au-Ag@AgCl NCs after after 5th catalytic cycle at 1 μm with the EDS elemental mapping of Au, Ag and Cl.

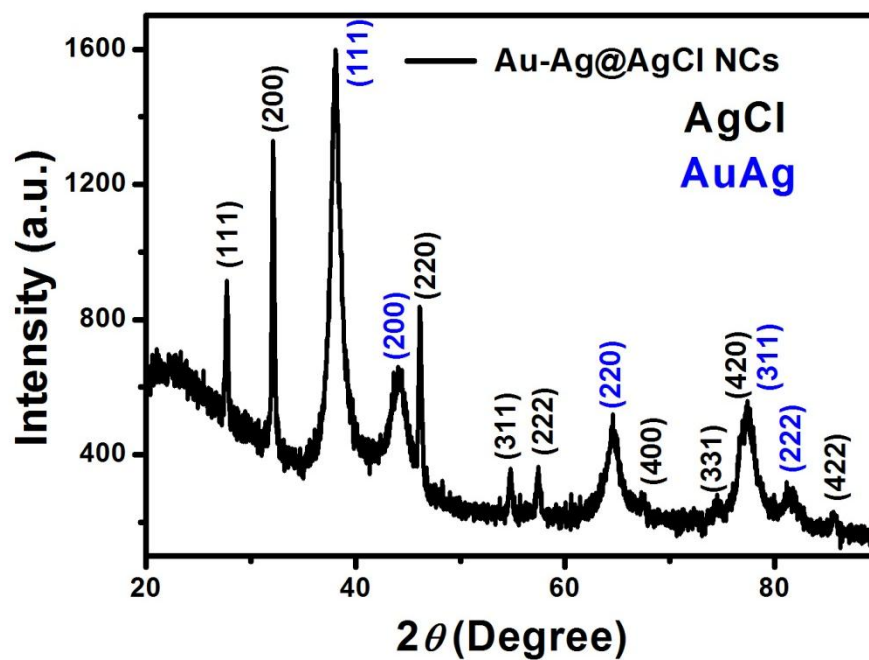


Figure S4. XRD patterns of one-pot synthesized Au-Ag@AgCl NCs

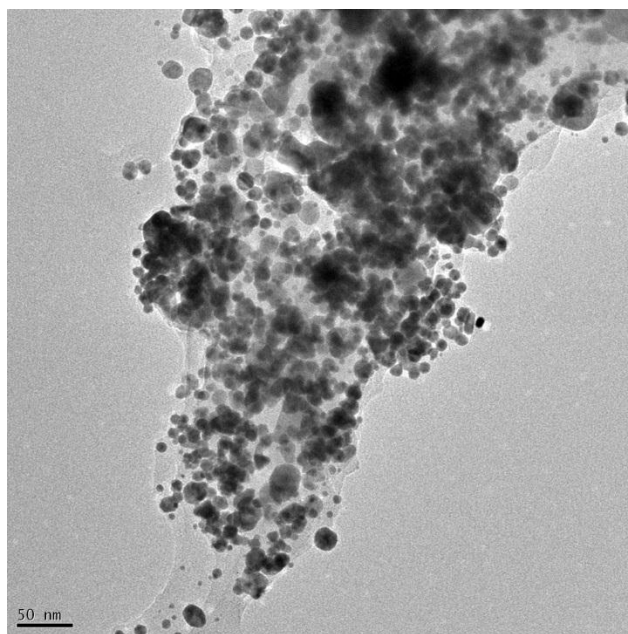
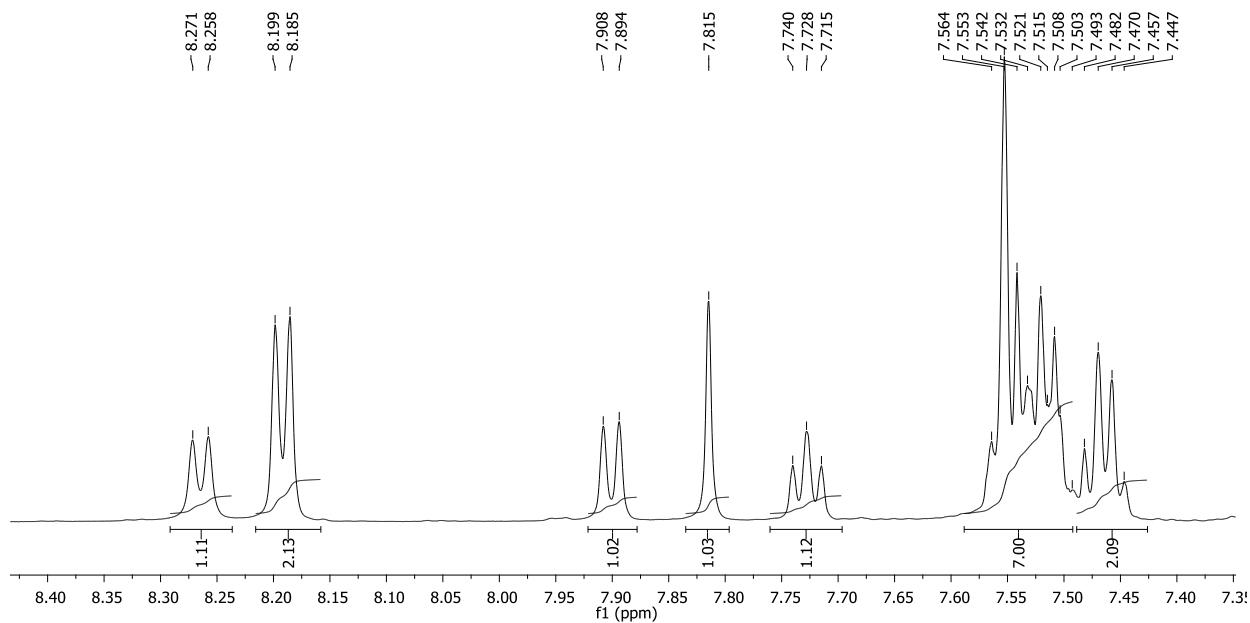
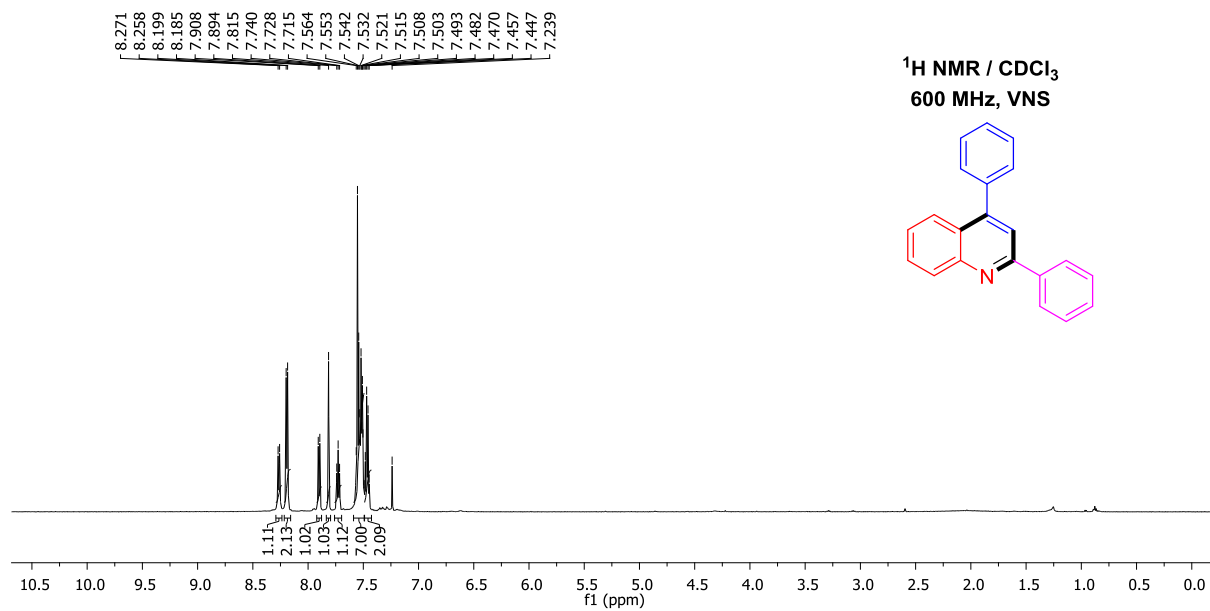


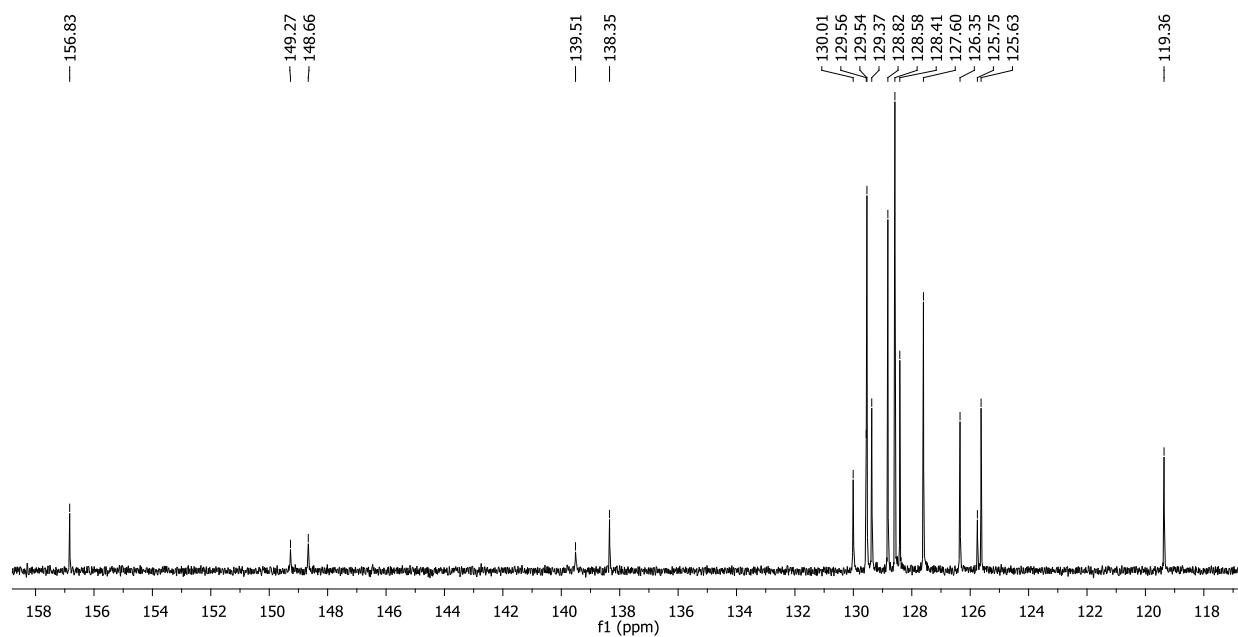
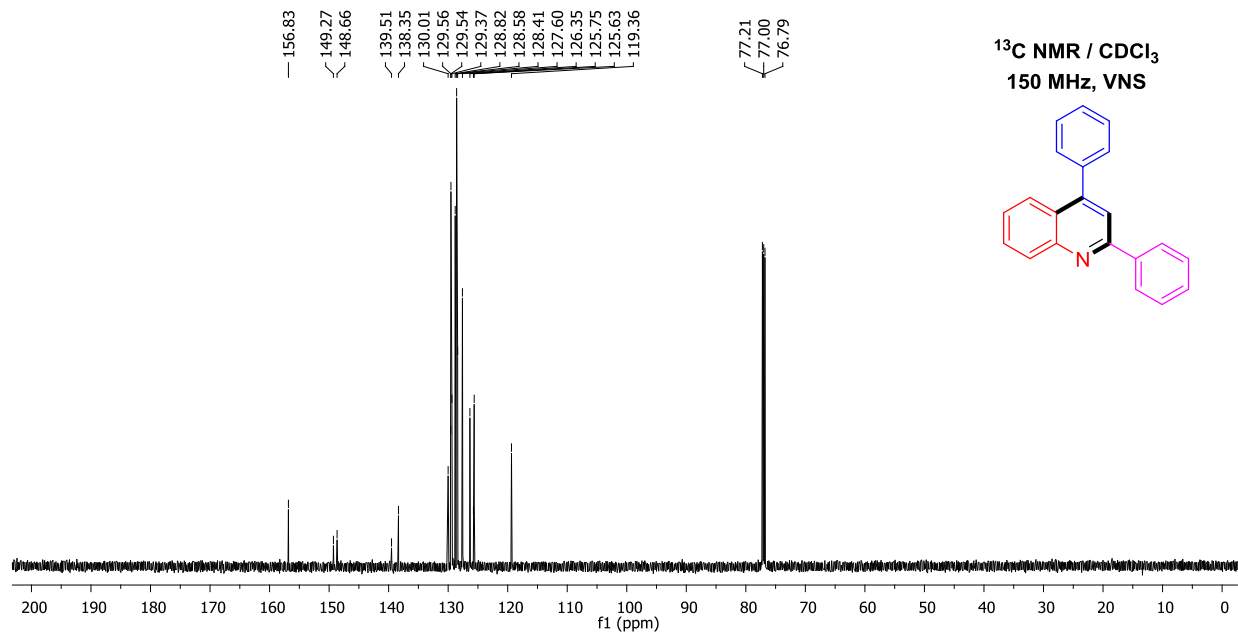
Figure S5. TEM images of one-pot synthesized Au-Ag@AgCl NCs at scale bar 50 nm.

^1H NMR and ^{13}C NMR data and spectra of compounds 4a-4f

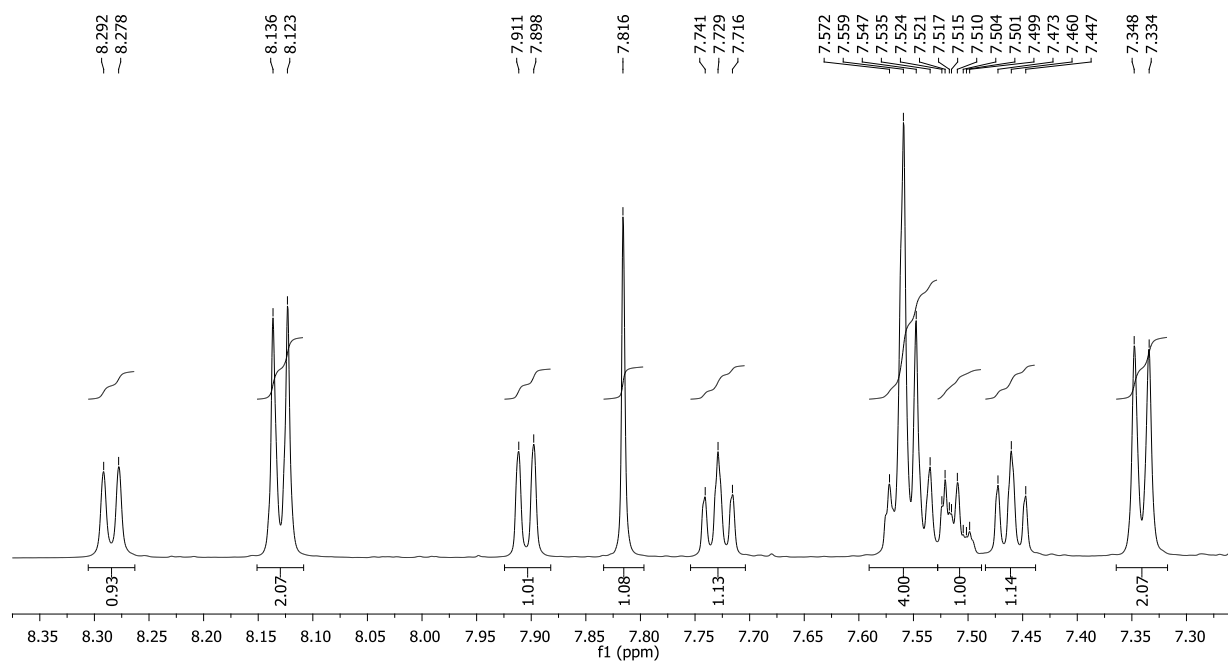
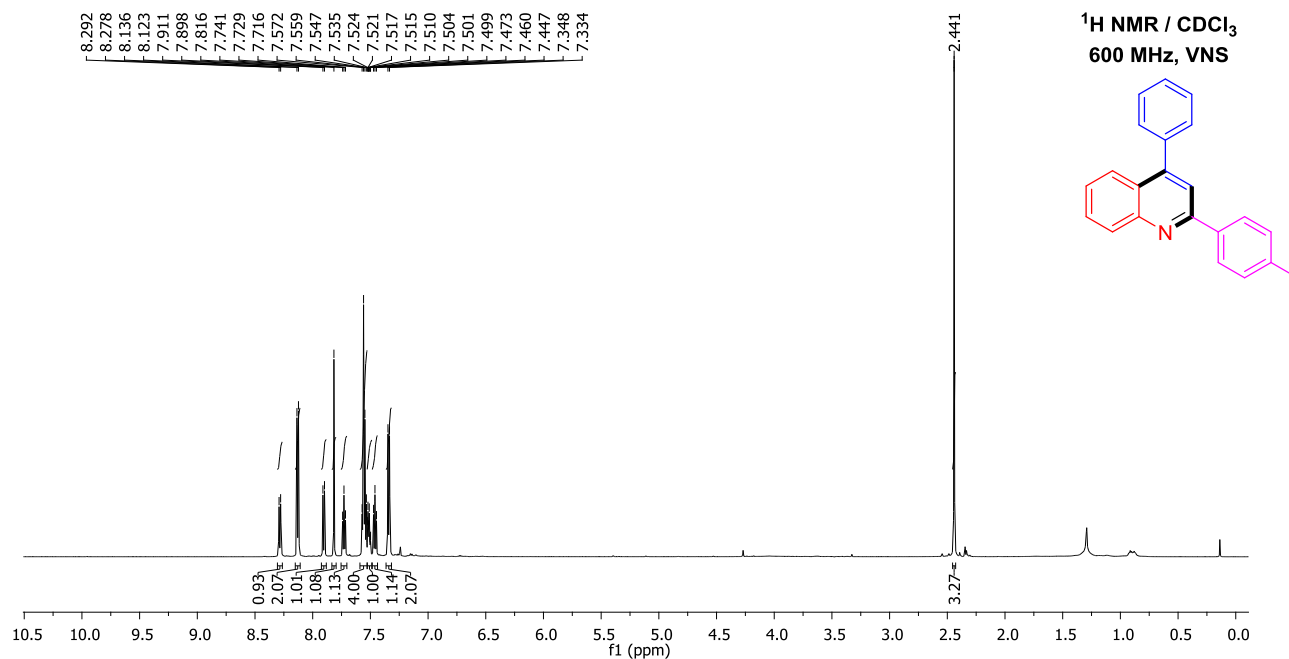
2,4-Diphenylquinoline (4a): ^1H NMR (600 MHz, CDCl_3) δ 8.26 (d, J = 8.2 Hz, 1H), 8.19 (d, J = 7.9 Hz, 2H), 7.90 (d, J = 8.5 Hz, 1H), 7.81 (s, 1H), 7.73 (t, J = 7.6 Hz, 1H), 7.56 – 7.49 (m, 7H), 7.49 – 7.44 (m, 2H).



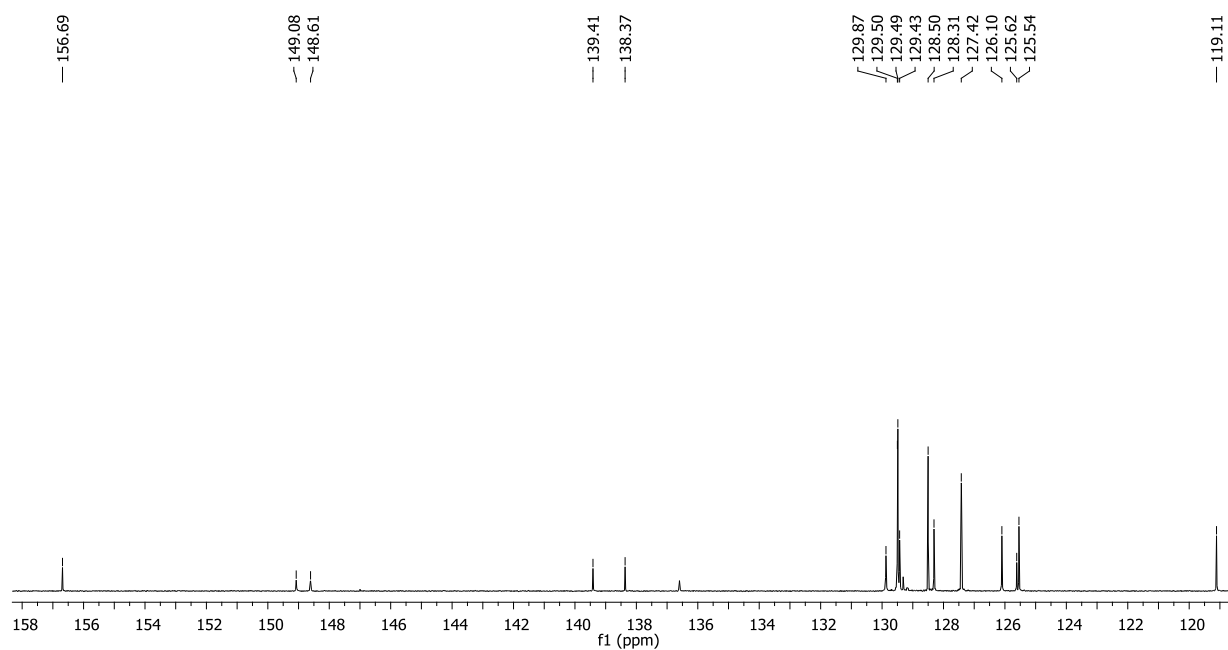
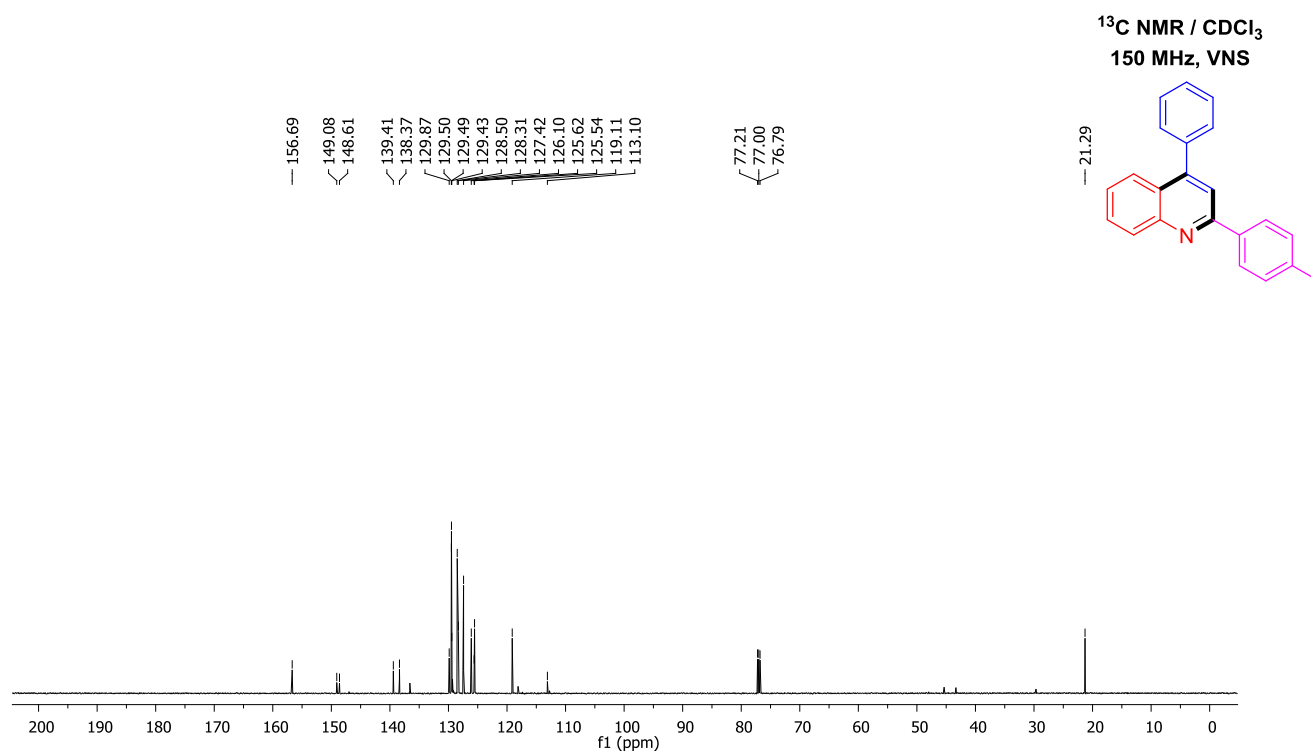
2,4-Diphenylquinoline (4a): ^{13}C NMR (150 MHz, CDCl_3) δ 156.83, 149.27, 148.66, 139.51, 138.35, 130.01, 129.56, 129.54, 129.37, 128.82, 128.58, 128.41, 127.60, 126.35, 125.75, 125.63, 119.36.



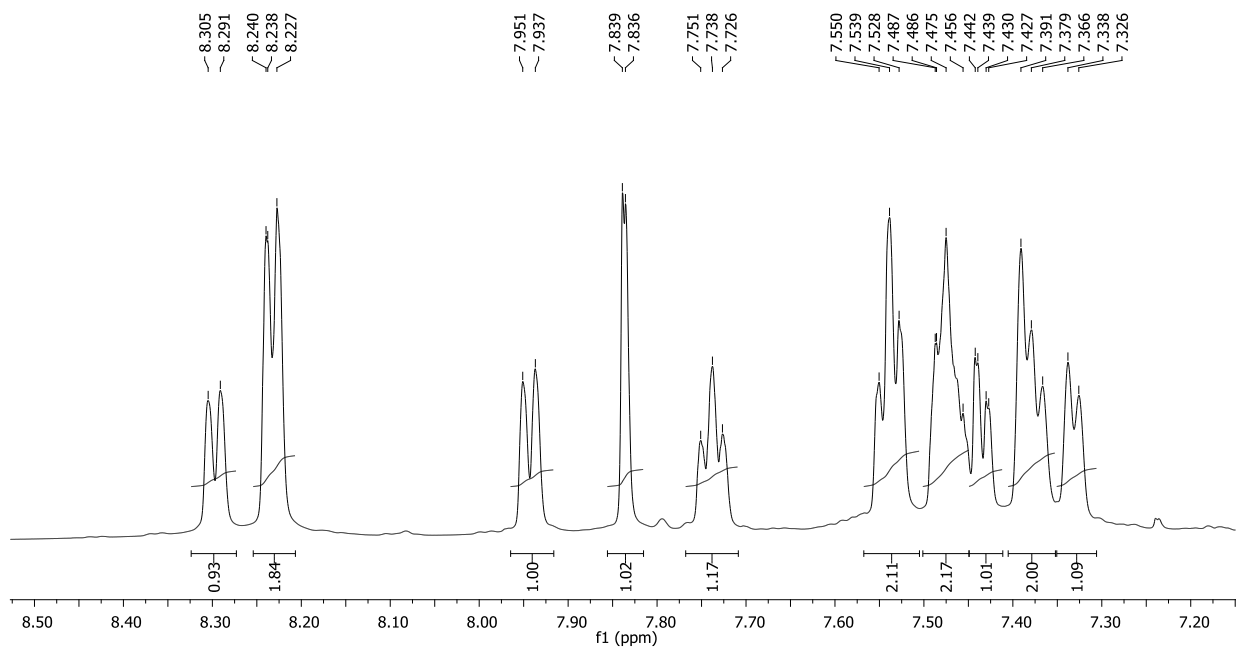
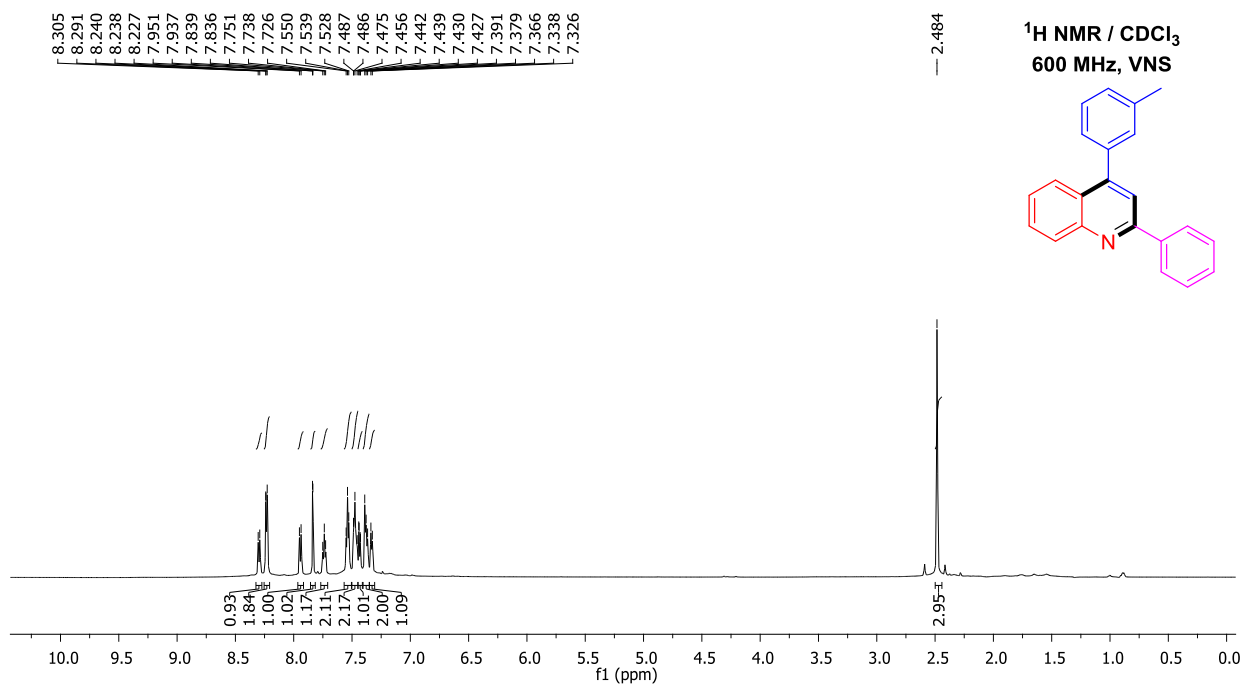
4-Phenyl-2-(*p*-tolyl)quinolone (4b): ^1H NMR (600 MHz, CDCl_3) δ 8.28 (d, $J = 8.2$ Hz, 1H), 8.13 (d, $J = 7.9$ Hz, 2H), 7.90 (d, $J = 8.2$ Hz, 1H), 7.82 (s, 1H), 7.73 (t, $J = 7.5$ Hz, 1H), 7.57–7.53 (m, 4H), 7.52 – 7.49 (m, 1H), 7.46 (t, $J = 7.6$ Hz, 1H), 7.34 (d, $J = 8.2$ Hz, 2H), 2.44 (s, 3H).



4-Phenyl-2-(*p*-tolyl)quinolone (4b): ^{13}C NMR (150 MHz, CDCl_3) δ 156.69, 149.08, 148.61, 139.41, 138.37, 129.87, 129.50, 129.49, 129.43, 128.50, 128.31, 127.42, 126.10, 125.62, 125.54, 119.11, 113.10, 21.29.

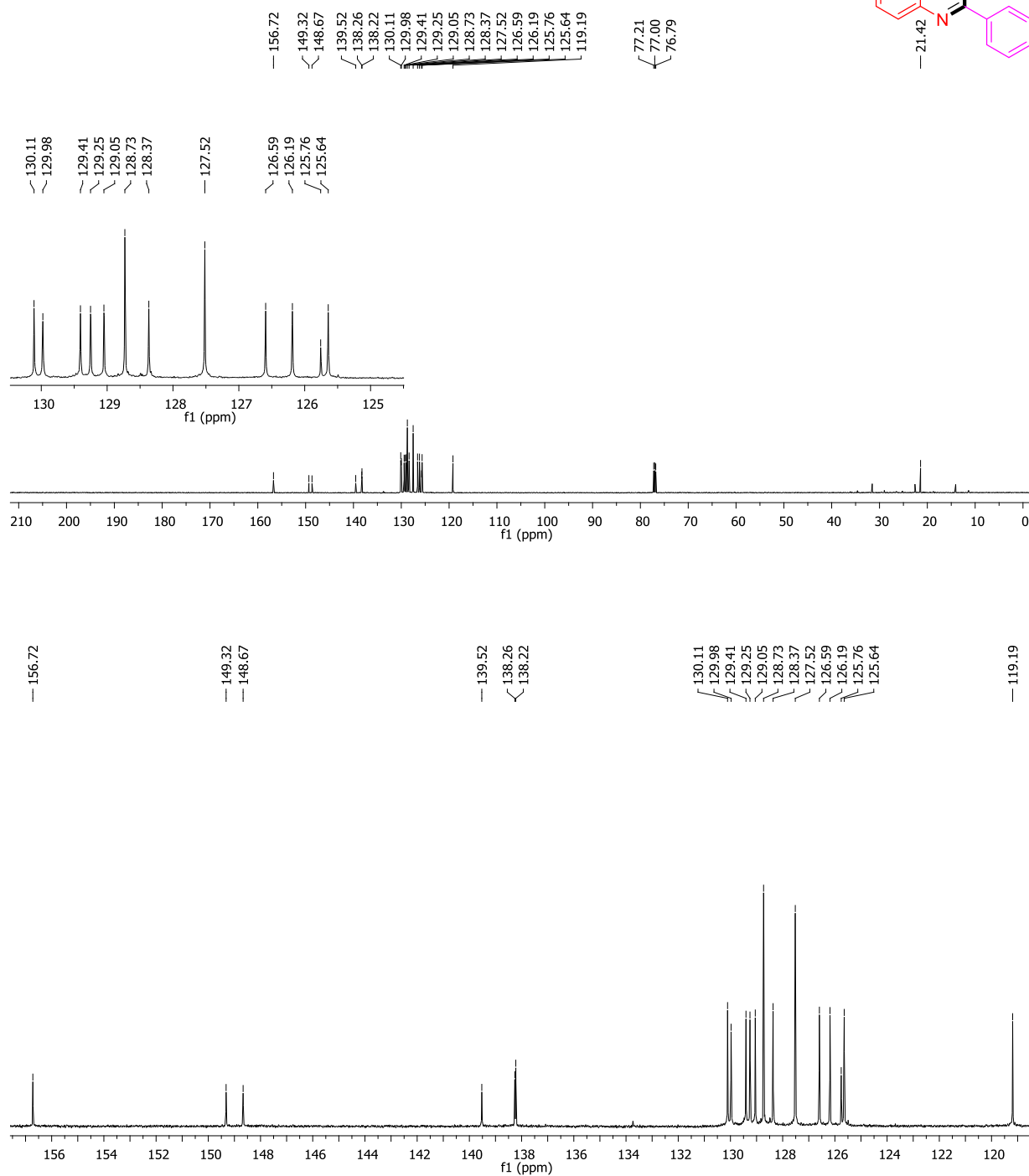
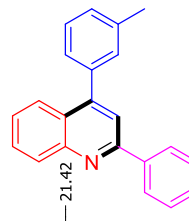


2-Phenyl-4-(m-tolyl)quinolone (4c): ^1H NMR (600 MHz, CDCl_3) δ 8.30 (d, $J = 8.2$ Hz, 1H), 8.25 – 8.21 (m, 2H), 7.94 (d, $J = 8.5$ Hz, 1H), 7.84 (d, $J = 2.1$ Hz, 1H), 7.74 (t, $J = 7.3$ Hz, 1H), 7.54 (t, $J = 6.7$ Hz, 2H), 7.48 (dd, $J = 12.6, 6.2$ Hz, 2H), 7.43 (dd, $J = 7.3, 1.8$ Hz, 1H), 7.41 – 7.35 (m, 2H), 7.33 (d, $J = 7.3$ Hz, 1H), 2.48 (s, 3H).

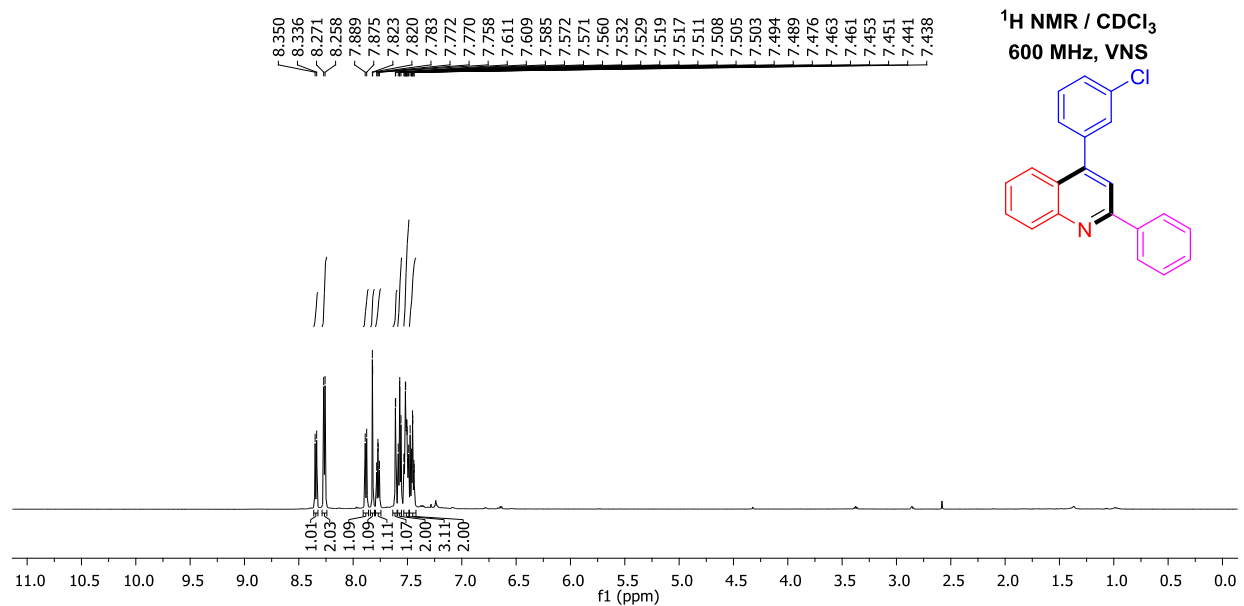


2-Phenyl-4-(m-tolyl)quinolone (4c): ^{13}C NMR (150 MHz, CDCl_3) δ 156.72, 149.32, 148.67, 139.52, 138.26, 138.22, 130.11, 129.98, 129.41, 129.25, 129.05, 128.73, 128.37, 127.52, 126.59, 126.19, 125.76, 125.64, 119.19, 21.42.

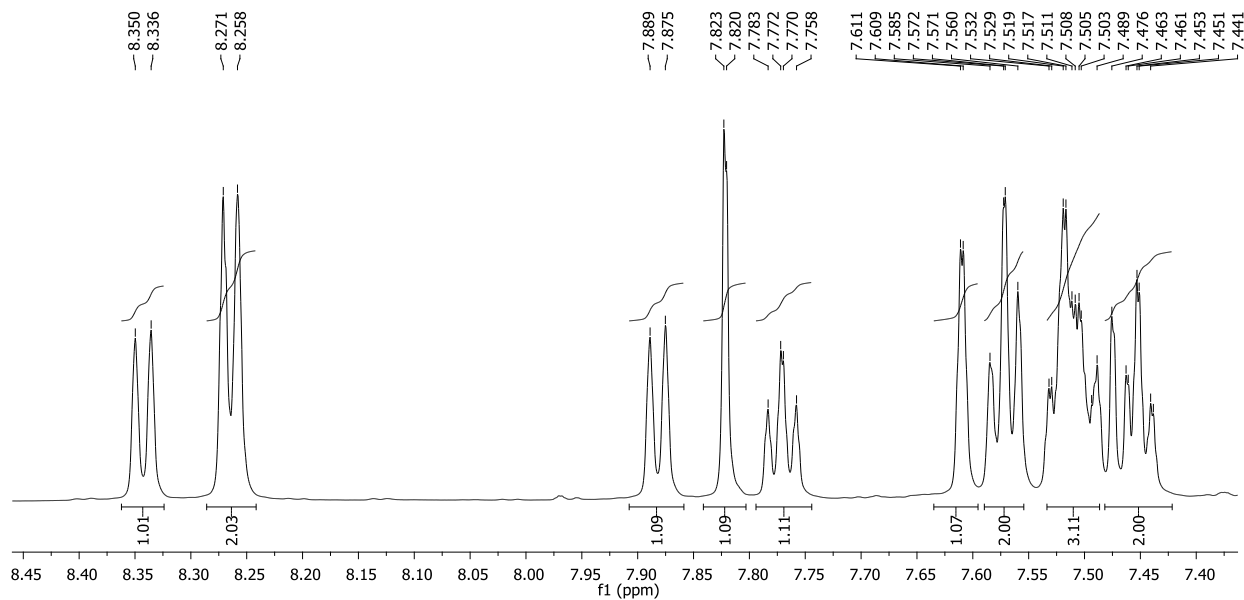
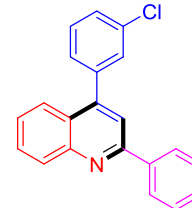
^{13}C NMR / CDCl_3
150 MHz, VNS



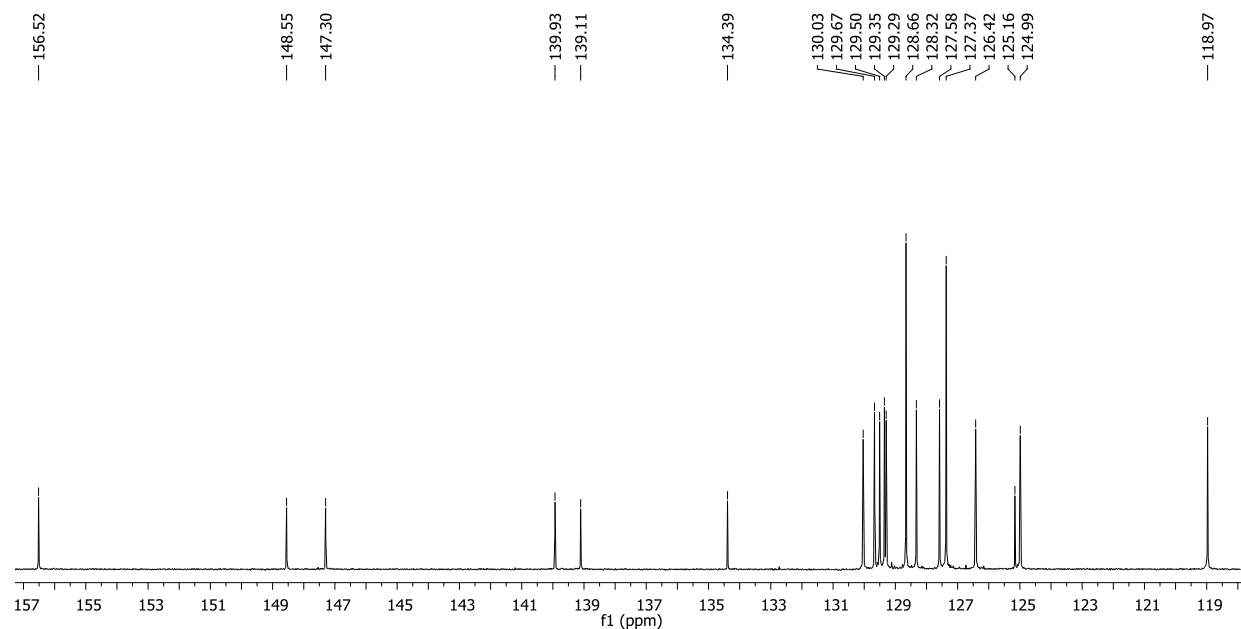
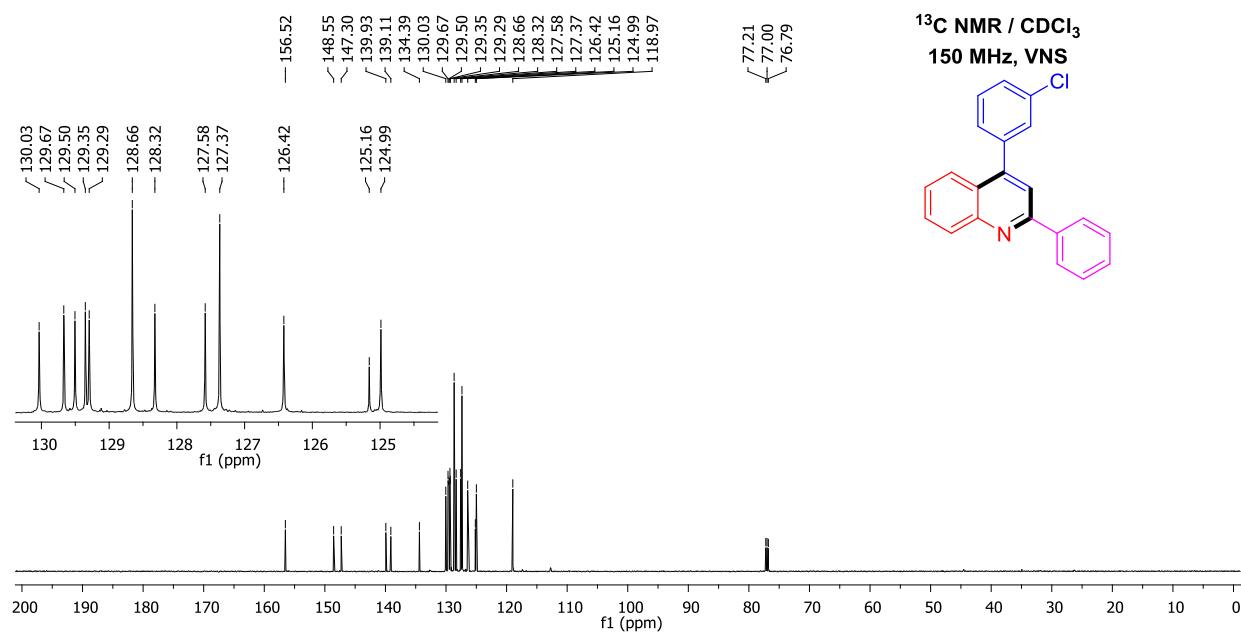
4-(3-Chlorophenyl)-2-phenylquinoline (4d): ^1H NMR (600 MHz, CDCl_3) δ 8.34 (d, $J = 8.5$ Hz, 1H), 8.26 (d, $J = 7.6$ Hz, 2H), 7.88 (d, $J = 8.2$ Hz, 1H), 7.82 (d, $J = 1.5$ Hz, 1H), 7.77 (t, $J = 8.4$ Hz, 1H), 7.61 (d, $J = 1.5$ Hz, 1H), 7.57 (t, $J = 7.9$ Hz, 2H), 7.53 – 7.49 (m, 3H), 7.48 – 7.42 (m, 2H).



^1H NMR / CDCl_3
600 MHz, VNS



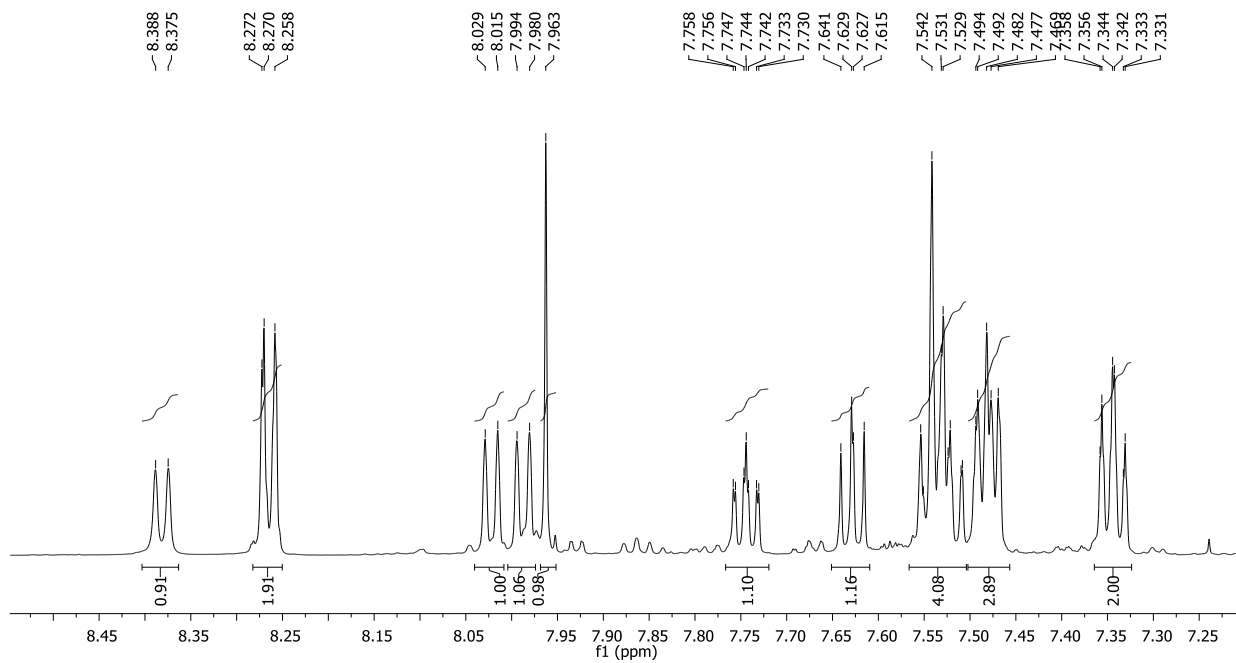
4-(3-Chlorophenyl)-2-phenylquinoline (4d): ^{13}C NMR (150 MHz, CDCl_3) δ 156.52, 148.55, 147.30, 139.93, 139.11, 134.39, 130.03, 129.67, 129.50, 129.35, 129.29, 128.66, 128.32, 127.58, 127.37, 126.42, 125.16, 124.99, 118.97.



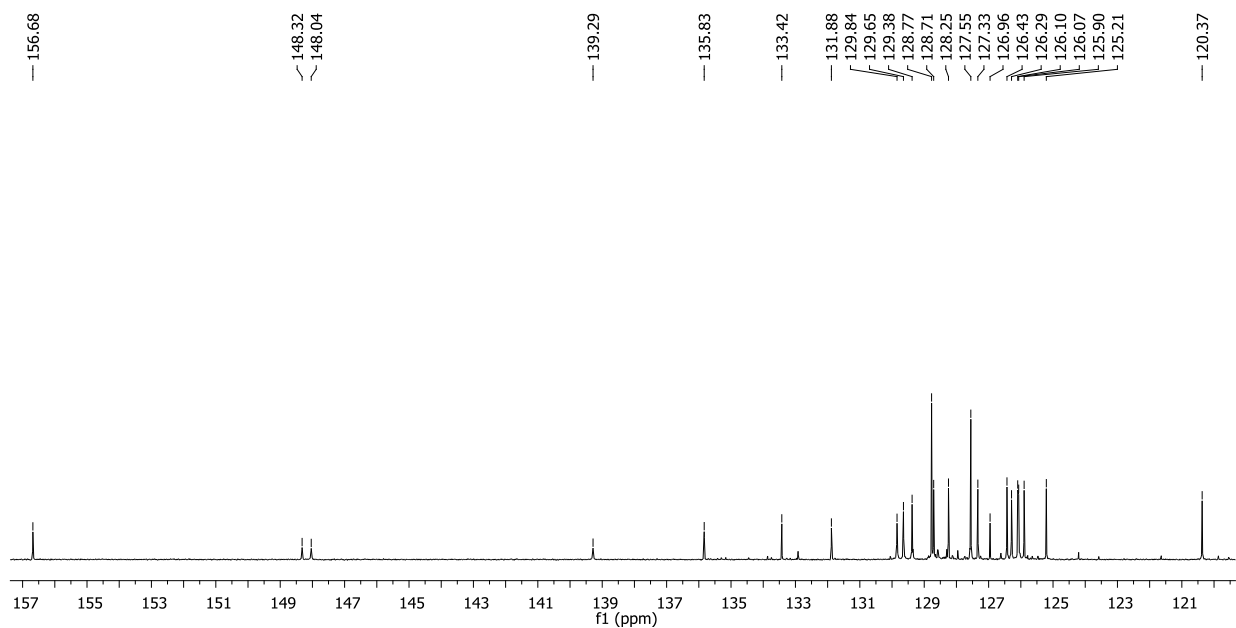
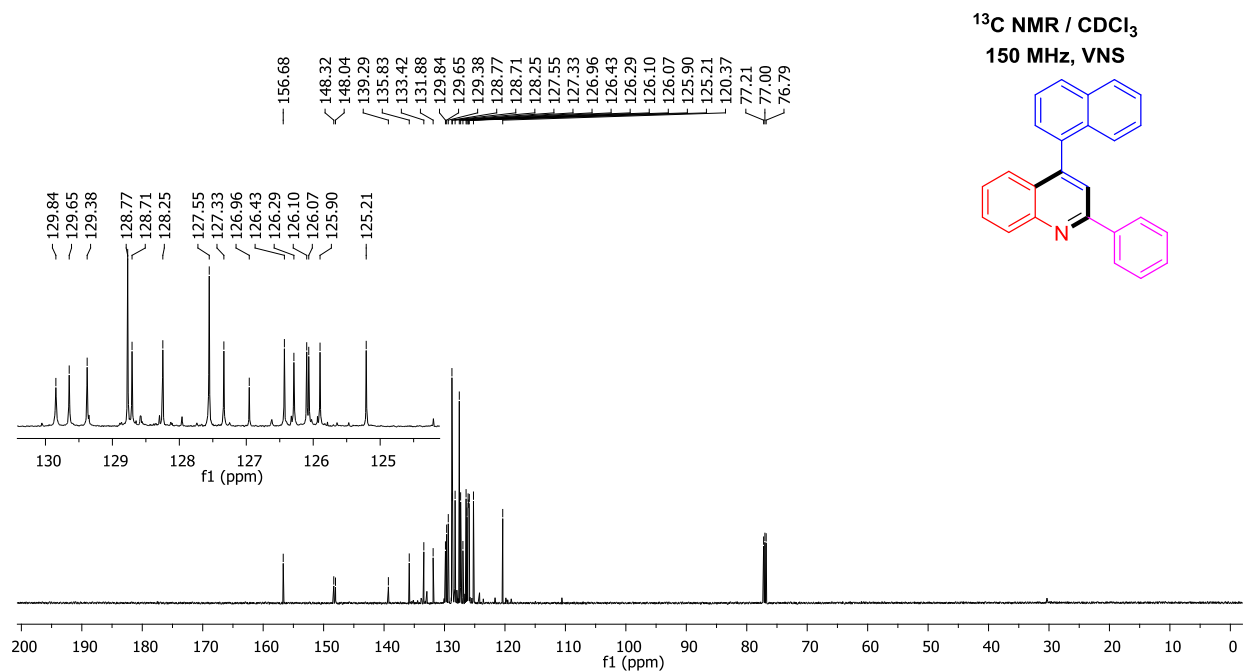
¹H NMR / CDCl₃
600 MHz, VNS

Chemical structure: c1ccc(cc1)-c2cc3ccccc3nc2-c4cccc5ccccc45

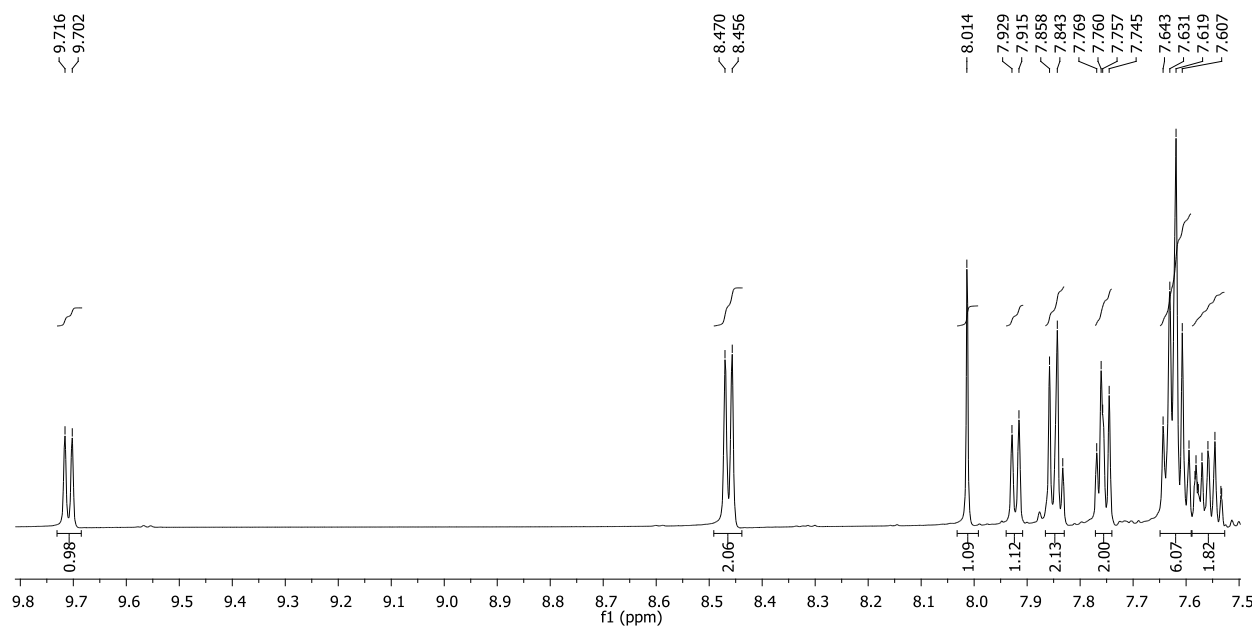
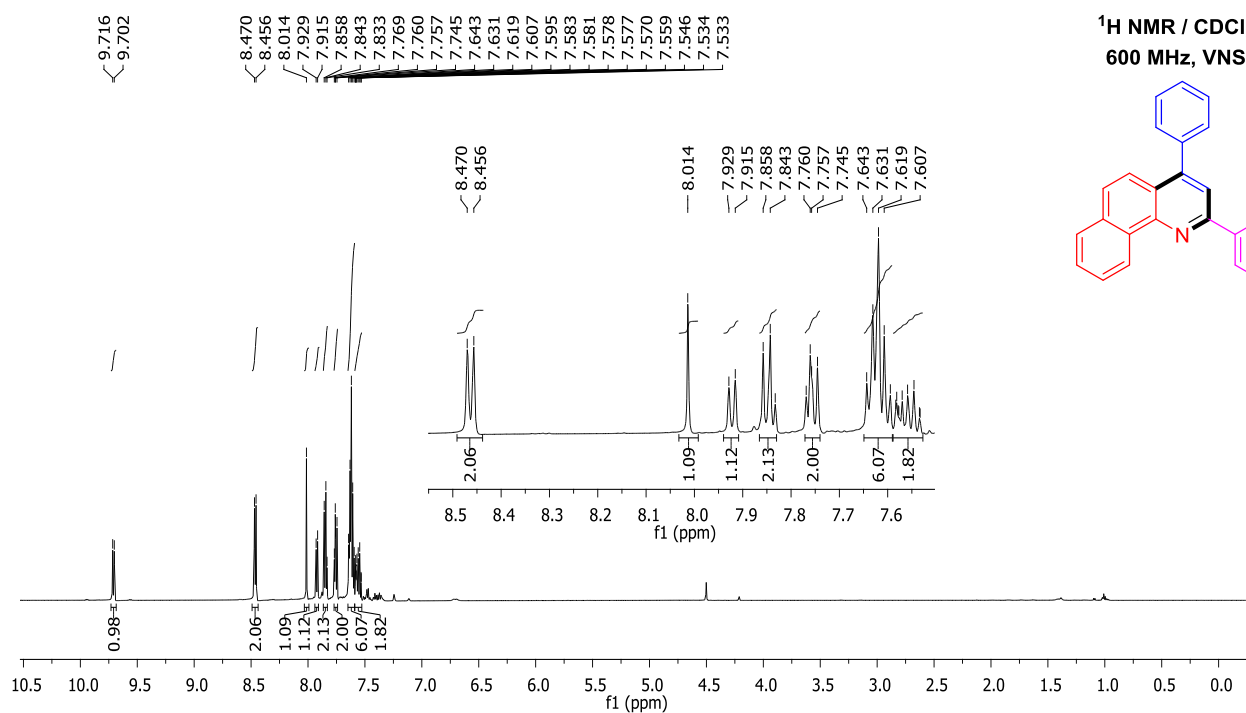
¹H NMR spectrum (600 MHz, VNS) showing peaks from 11.0 to 7.331 ppm. The spectrum is divided into two regions: 11.0 to 7.5 ppm (top) and 7.5 to 7.331 ppm (bottom). The top region shows peaks at 8.272, 8.270, 8.258, 8.256, 8.270, 8.015, 8.029, 8.015, 8.015, 7.994, 7.980, 7.963, 7.758, 7.756, 7.747, 7.744, 7.742, 7.733, 7.730, 7.641, 7.629, 7.615, 7.554, 7.551, 7.542, 7.531, 7.529, 7.524, 7.522, 7.510, 7.508, 7.494, 7.492, 7.482, 7.477, 7.469, 7.358, 7.356, 7.344, 7.342, 7.333, and 7.331 ppm. The bottom region shows peaks at 8.3, 8.1, 7.9, 7.7, 7.5, 7.3, 7.1, 6.9, 6.7, 6.5, 6.3, 6.1, 5.9, 5.7, 5.5, 5.3, 5.1, 4.9, 4.7, 4.5, 4.3, 4.1, 3.9, 3.7, 3.5, 3.3, 3.1, 2.9, 2.7, 2.5, 2.3, 2.1, 1.9, 1.7, 1.5, 1.3, 1.1, 0.9, 0.7, 0.5, 0.3, 0.1, and 0.0 ppm. Integration values are provided for each peak: 0.91, 1.91, 1.91, 1.91, 1.00, 1.06, 0.98, 1.10, 1.16, 4.08, 2.89, 2.00, 0.91, 1.00, 1.06, 0.98, 1.10, 1.16, 4.08, 2.89, 2.00.



4-(Naphthalen-1-yl)-2-phenylquinoline (4e): ^{13}C NMR (150 MHz, CDCl_3) δ 156.68, 148.32, 148.04, 139.29, 135.83, 133.42, 131.88, 129.84, 129.65, 129.38, 128.77, 128.71, 128.25, 127.55, 127.33, 126.96, 126.43, 126.29, 126.10, 126.07, 125.90, 125.21, 120.37.



2,4-Diphenylbenzo[*h*]quinolone (4f): ^1H NMR (600 MHz, CDCl_3) δ 9.71 (d, $J = 8.2$ Hz, 1H), 8.46 (d, $J = 8.2$ Hz, 2H), 8.01 (s, 1H), 7.92 (d, $J = 7.9$ Hz, 1H), 7.84 (t, $J = 7.5$ Hz, 2H), 7.76 – 7.74 (m, 2H), 7.65 – 7.59 (m, 6H), 7.59 – 7.53 (m, 2H).



2,4-Diphenylbenzo[*h*]quinolone (4f): ^{13}C NMR (150 MHz, CDCl_3) δ 154.70, 148.89, 146.65, 139.60, 138.71, 133.50, 131.94, 129.59, 129.14, 128.71, 128.48, 128.17, 128.12, 127.51, 127.39, 127.19, 126.78, 125.15, 123.21, 122.76, 119.34.

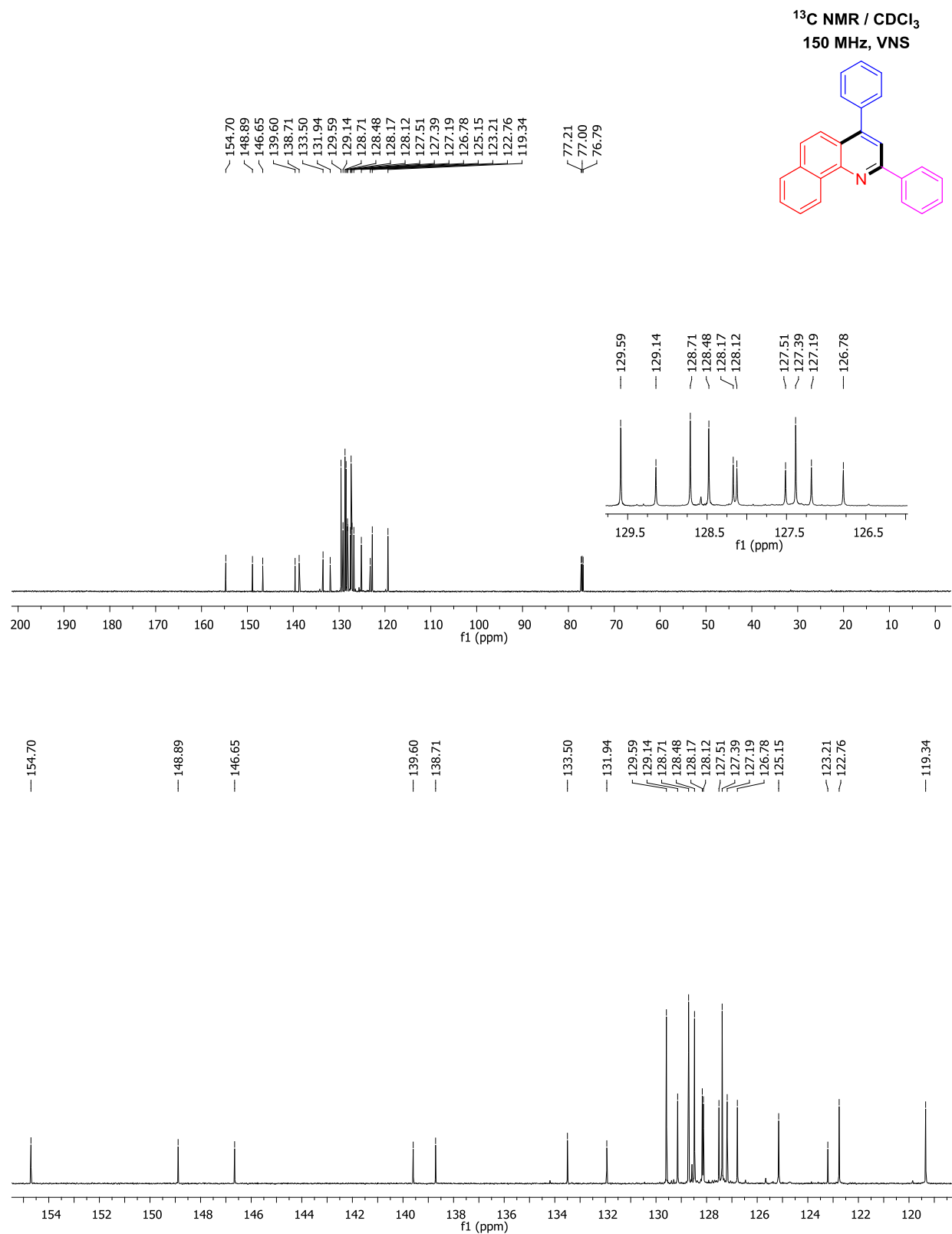
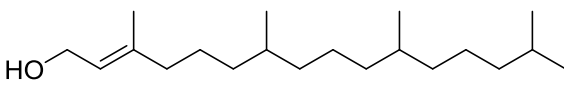
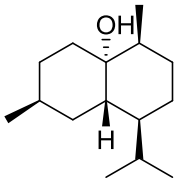
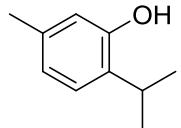
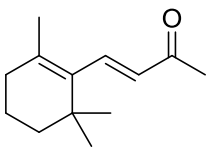
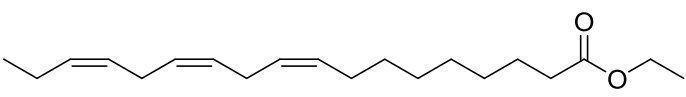
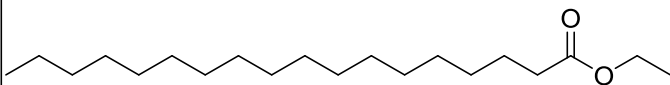
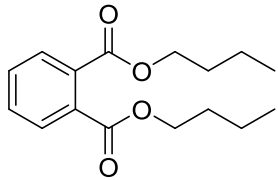
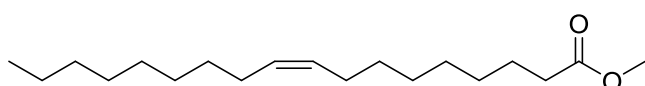
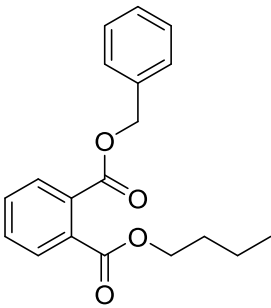
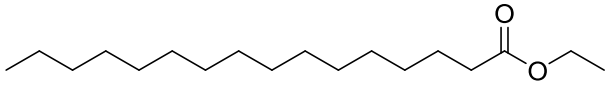
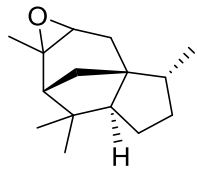
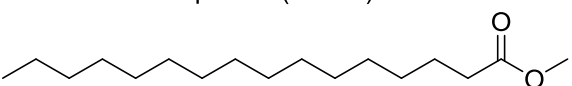
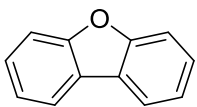


Table S1: Reported GC/MS analysis of volatile chemical constituents of *Nephrolepis cordifolia*

		
Phytol (3.93%)	α- Cadinol (3.30%)	Thymol (0.42%)
		
β-Ionone (5.59%)	Ethyl linolenate (6.33%)	
		
Ethyl stearate (3.19%)	Dibutyl phthalate (1.85%)	
		
Methyl oleate (0.54%)	Benzyl butyl phthalate (1.34%)	
		
Ethyl palmitate (8.0%)	α-cadrene epoxide (1.48%)	
		
Methyl palmitate (1.54%)	Dibenzofuran (0.77%)	

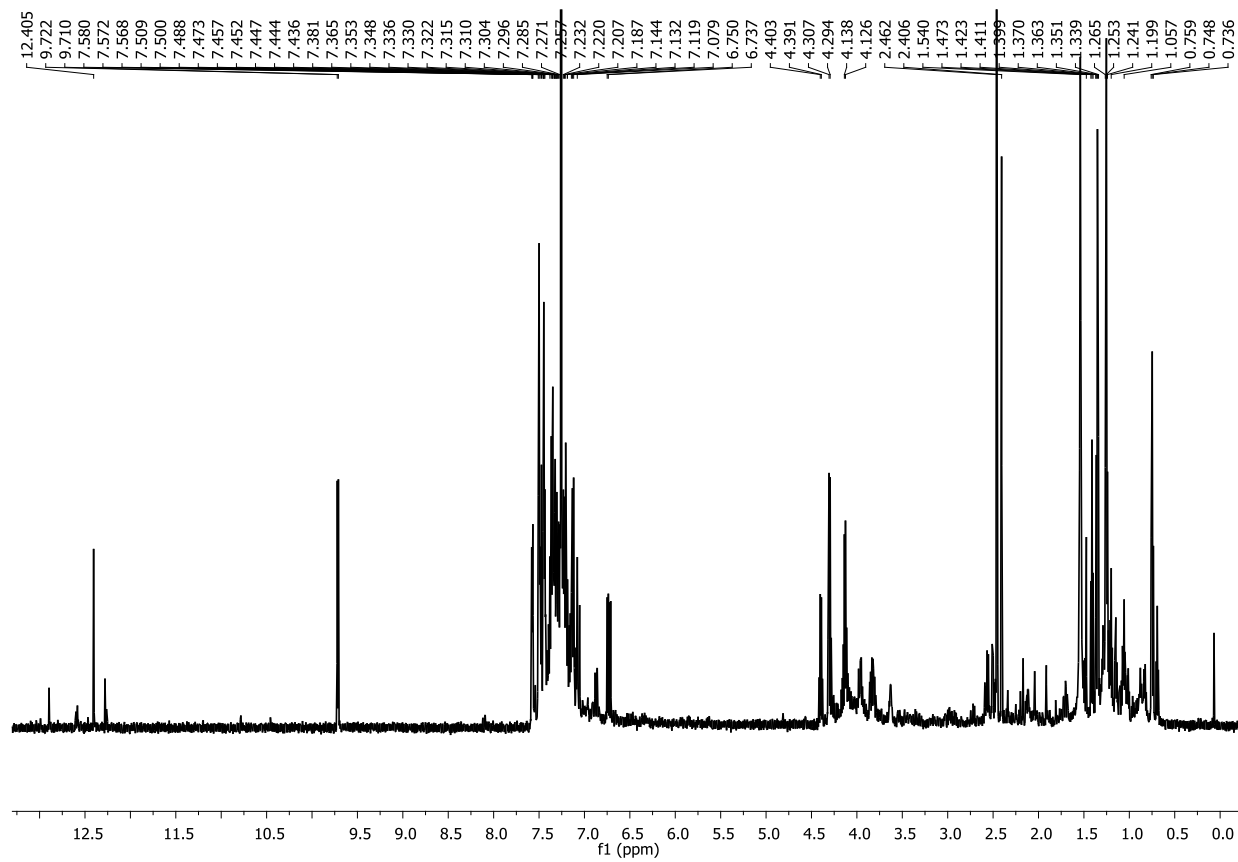


Figure S6: ^1H NMR analysis of crude CHCl_3 extract of *Nephrolepis cordifolia* tuber using VNS 600 MHz spectrometer using CDCl_3 as NMR solvent.