Supporting information

Silver-Catalyzed Regioselective Synthesis of Pyrano Heterocycles: A Versatile Route to Samoquasine A Derivatives

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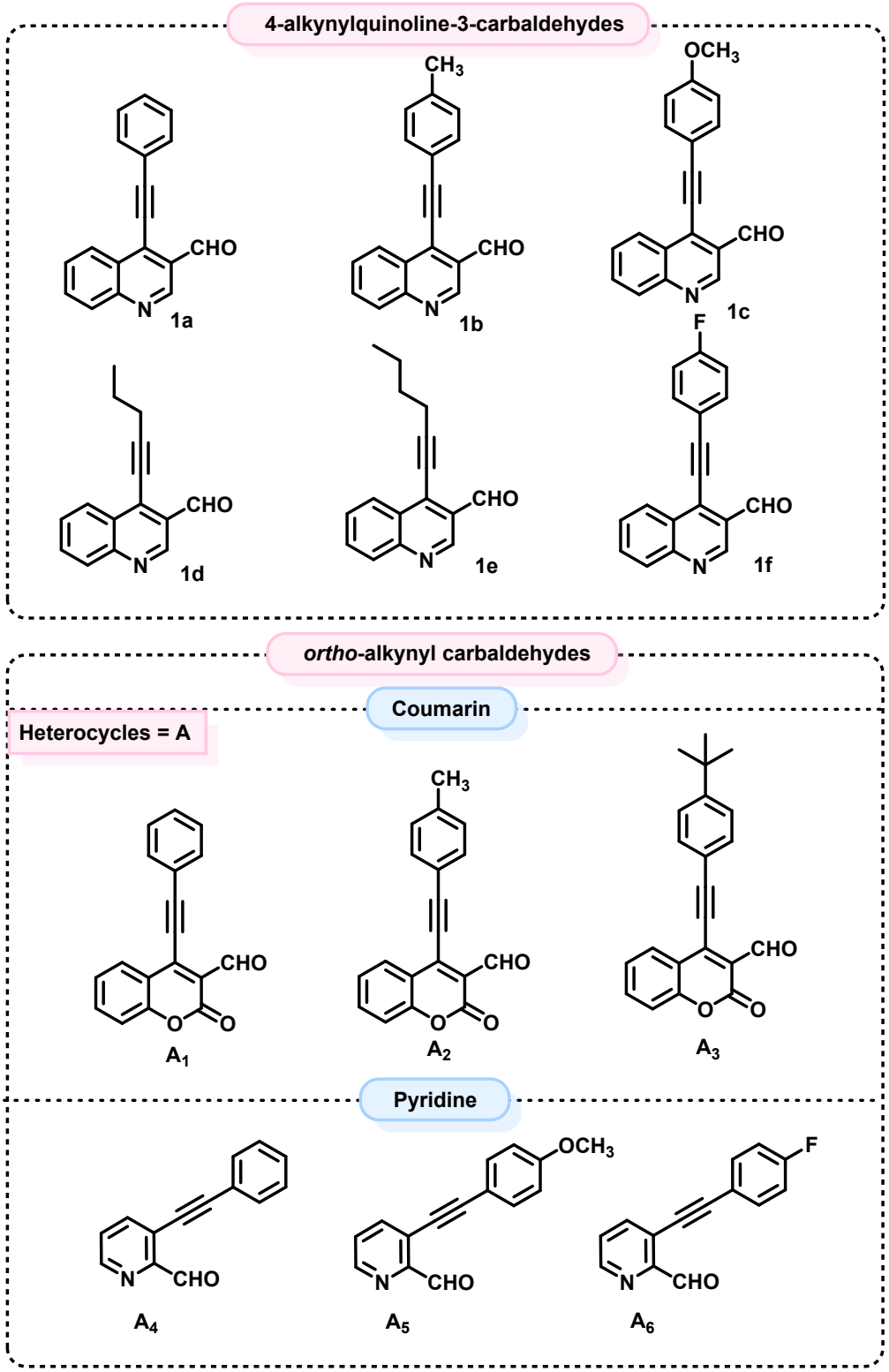
1. **General Information:** All chemicals were purchased from Sigma-Aldrich, Alfa Aesar and S. D. Fine Chemicals, Pvt. Ltd. India and used without further purification. ACME silica gel (230–400 mesh) was used for column chromatography and thin-layer chromatography was performed on Merck-pre-coated silica gel 60-F254 plates. TLC plates are visualized by UV-light and developed by Iodine. All the solvents were obtained from commercial sources and purified using standard methods. All ^{1}H, ^{13}C and ^{19}F NMR spectra were recorded on Avance-300, Avance-400 and Avance-500 MHz Spectrometer. Chemical shifts (δ) are reported in ppm, using TMS (δ = 0) as an internal standard in $CDCl_3$. The peak patterns are indicated as follows: s, singlet; d, doublet; t, triplet; q, quartet; dd, doublet of doublet; dt, doublet of triplet. The coupling constants (J) are reported in Hertz (Hz). Mass spectral data were compiled using MS (ESI), HRMS mass spectrometers.

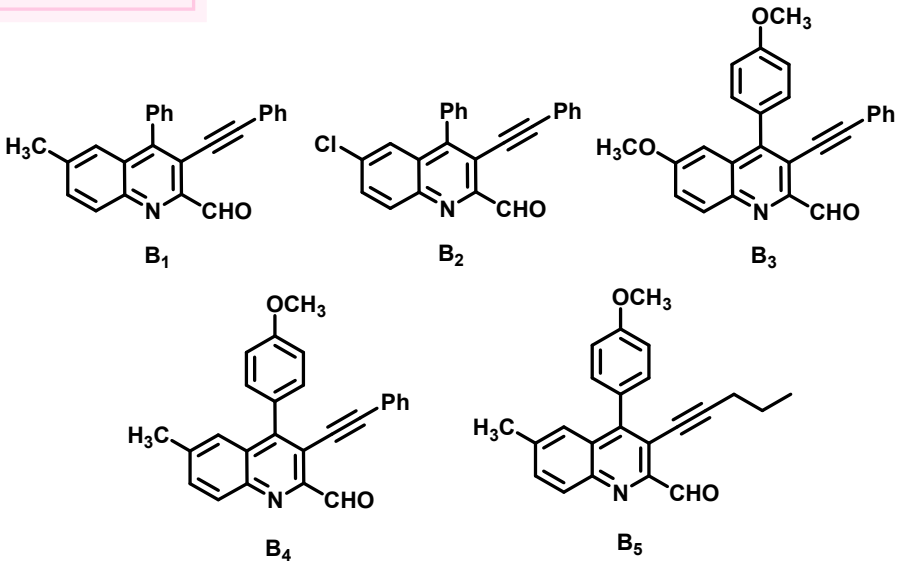
2. Starting material introduction:



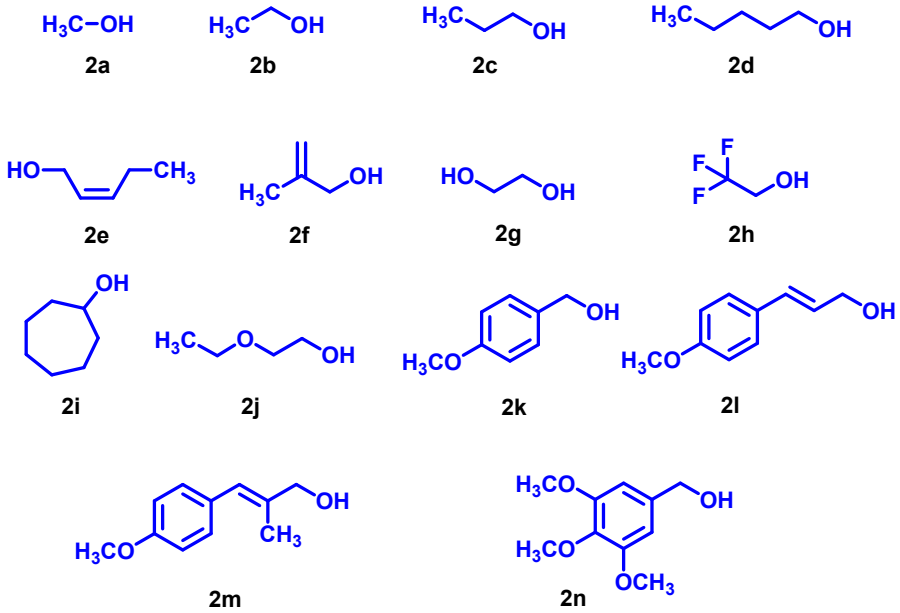
ortho-alkynyl carbaldehydes

Quinoline

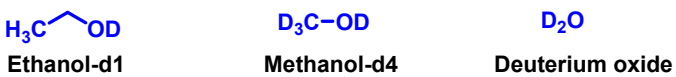
Heterocycles = B



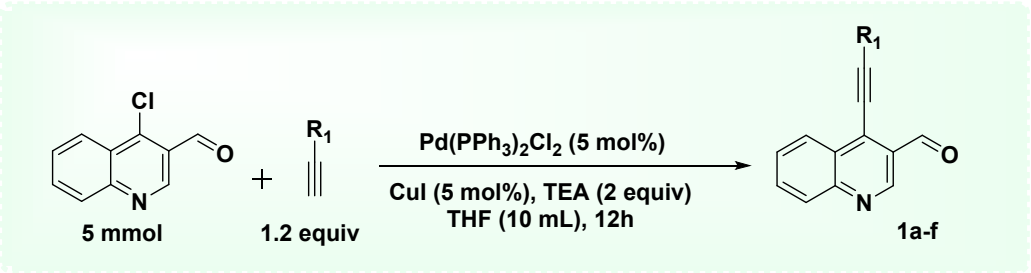
Alcohol



d- Solvent



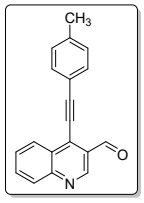
3. General procedure for sonogashira coupling for synthesis of compounds (1a-f):



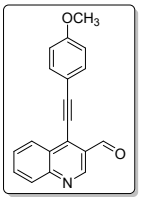
In a dried reaction vial, 4-Chloroquinoline-3-carbaldehyde (955mg, 5 mmol) was weighed along with $Pd(PPh_3)_2Cl_2$ (5 mol%) and CuI (5 mol%). The vial was subjected to an inert (N_2) atmosphere. Subsequently, 10 mL of THF (for aliphatic alkynes DMF) and Triethylamine (2 equiv) were added, and the mixture was stirred. After 15 minutes of stirring, alkynes (1.2 equiv) were slowly introduced into the reaction over a period of 15-20 minutes. The reaction was further stirred for 12 hours at room temperature and later the reaction mixture was passed through a celite bed and filtered (workup with ethyl acetate and ice in case of DMF). The filtrate was concentrated under reduced pressure, yielding a residue. This residue was then subjected to chromatography using silica mesh (100-200) as the stationary phase and an eluent mixture of ethyl acetate and hexane (1:10) to obtain purified products **1a-f**.

Compound **1a** spectral data is matches with the previous report.[1]

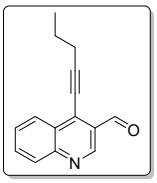
4-(*p*-tolylethynyl)quinoline-3-carbaldehyde (1b) – The compound chromatographed by using of 1:10 ethyl acetate/hexane, obtained **1b** yellow solid (M.pt. 138-140°C) (1.17 g, 86% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 10.82 (s, 1H), 9.35 (s, 1H), 8.50 (dd, *J* = 8.3, 0.8 Hz, 1H), 8.17 (d, *J* = 8.4 Hz, 1H), 7.89 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.72 (ddd, *J* = 8.1, 7.0, 1.1 Hz, 1H), 7.61 (d, *J* = 8.1 Hz, 2H), 7.27 (d, *J* = 8.0 Hz, 2H), 2.44 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 191.0, 149.9, 147.9, 141.0, 135.0, 132.6, 132.1 (two carbon overlap), 130.1, 129.6 (two carbon merged), 128.1, 127.0 (two carbon merged), 126.8, 118.2, 107.4, 80.6, 21.7. **HRMS** (ESI) calcd. for $C_{19}H_{14}ON$ $(M+H)^+$ 272.1070, found 272.1065.



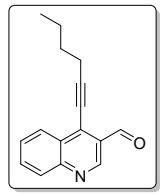
4-((4-methoxyphenyl)ethynyl)quinoline-3-carbaldehyde (1c) – The compound chromatographed by using of 1:10 ethyl acetate/hexane, obtained **1c** orangish solid (M.pt. 142-144°C) (1.28 g, 89% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 10.81 (s, 1H), 9.34 (s, 1H), 8.16 (d, J = 8.4 Hz, 1H), 7.88 (ddd, J = 8.3, 7.0, 1.3 Hz, 1H), 7.72 (dd, J = 8.2, 7.0 Hz, 1H), 7.66 (dd, J = 9.1, 2.3 Hz, 2H), 6.98 (dd, J = 9.2, 2.3 Hz, 2H), 3.88 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 191.01, 161.3, 149.8, 147.9, 135.2, 133.9 (two carbon merged), 132.6, 130.1, 128.0, 127.0 (two carbon merged), 126.8, 114.5 (two carbon merged), 113.2, 107.7, 80.4, 55.4. **HRMS** (ESI) calcd. for $C_{19}H_{14}O_2N$ $(M+H)^+$ 288.1019, found 288.1014.



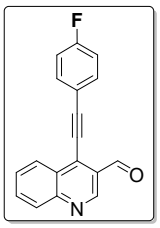
4-(pent-1-yn-1-yl)quinoline-3-carbaldehyde (1d) – The compound chromatographed by using of 1:10 ethyl acetate/hexane, obtained **1d** orangish semi-solid (0.87 g, 78% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 10.71 (s, 1H), 9.31 (s, 1H), 8.39 (dd, *J* = 8.3, 0.9 Hz, 1H), 8.14 (d, *J* = 8.4 Hz, 1H), 7.86 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.68 (ddd, *J* = 8.2, 7.0, 1.1 Hz, 1H), 2.69 (t, *J* = 7.0 Hz, 2H), 1.87 – 1.72 (m, 2H), 1.16 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 191.3, 149.8, 147.7, 135.9, 132.5, 130.0, 127.9, 127.5, 127.3, 127.0, 109.6, 72.9, 22.0, 21.8, 13.7. **HRMS** (ESI) calcd. for $C_{15}H_{14}ON$ $(M+H)^+$ 224.1070, found 224.1066.



4-(hex-1-yn-1-yl)quinoline-3-carbaldehyde (1e) – The compound chromatographed by using of 1:10 ethyl acetate/hexane, obtained **1e** orangish semisolid solid (0.89 g, 75% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 10.69 (s, 1H), 9.30 (s, 1H), 8.38 (dd, *J* = 8.3, 0.9 Hz, 1H), 8.13 (d, *J* = 8.3 Hz, 1H), 7.85 (ddd, *J* = 8.4, 6.9, 1.5 Hz, 1H), 7.67 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 2.70 (t, *J* = 7.1 Hz, 2H), 1.80 – 1.67 (m, 2H), 1.63 – 1.51 (m, 2H), 1.01 (t, *J* = 7.3 Hz, 3H). **^{13}C NMR** (75 MHz, $CDCl_3$) δ 191.3, 149.8, 147.7, 135.9, 132.5, 130.0, 127.9, 127.5, 127.3, 127.0, 109.8, 76.6, 72.6, 30.3, 22.2, 19.8, 13.5. **HRMS** (ESI) calcd. for $C_{16}H_{16}ON$ $(M+H)^+$ 238.1226, found 238.1222.

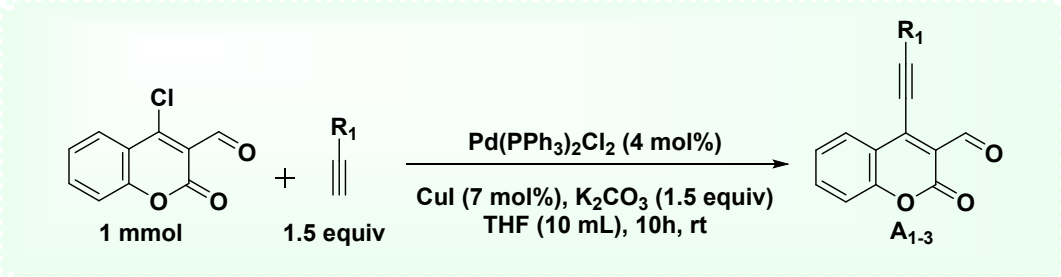


4-((4-fluorophenyl)ethynyl)quinoline-3-carbaldehyde (1f): – The compound chromatographed by using of 1:10 ethyl acetate/hexane, obtained **1f** orangish semisolid solid (1.21 g, 88% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 10.79 (s, 1H), 9.35 (s, 1H), 8.46 (dd, *J* = 8.3, 0.9 Hz, 1H), 8.17 (d, *J* = 8.3 Hz, 1H), 7.89 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.75 – 7.68 (m, 3H), 7.21 – 7.13 (m, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 190.7, 163.7 (d, *J* = 253.3 Hz), 149.9, 147.9, 134.4, 134.3 (d, *J* = 8.7 Hz) (two carbons merged), 132.7, 130.2, 128.2, 127.0, 126.8, 126.7, 117.4 (d, *J* = 3.2 Hz), 116.3 (d, *J* = 22.3 Hz) (two carbons merged), 105.6, 80.9. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -106.90. **HRMS** (ESI) calcd. for $C_{18}H_{11}ONF$ $(M+H)^+$ 276.0819, found 276.0825.

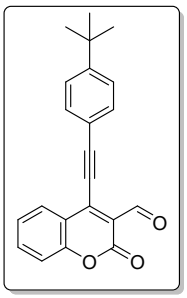


4-chloro-3-formylcoumarin was successfully synthesized using the Vilsmeier-Haack Formylation reaction. Characterization of the product with NMR confirmed its identity and matched the data in literature.[2]

4. General procedure for compound A_1, A_2, and A_3:



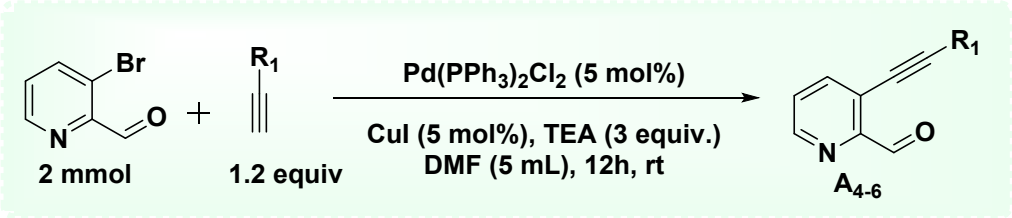
In a reaction flask under Nitrogen, 4-chloro-3-formylcoumarin (0.207 g, 1.0 mmol) was dissolved in THF (7-8 mL). K_2CO_3 (0.20 g, 1.5 equiv.) was added, followed by $PdCl_2(PPh_3)_2$ (4 mol %) and CuI (7 mol %). Acetylenes (1.5 equiv.) was then added dropwise over 10 minutes. The mixture was stirred at room temperature for 10 hours and later crude mixture was passed through celite bed and filtered was concentrated under reduced pressure to get residue which was subject to column chromatography with a particle size range of 230-400, and elution was carried out using a mixture of ethyl acetate and hexane in a ratio of 1:10. This process led to the isolation of purified products identified as **A_1**, **A_2.** The resulting products were characterized with NMR spectra and it was matched with previous report.[3] While compound **A_3** was used directly within the reaction mixture (in-*situ*), its isolated form was not analyzed. However, complete characterization was performed using ^{1}H, ^{13}C, and HRMS spectroscopy.[2]



4-((4-(*tert*-butyl)phenyl)ethynyl)-2-oxo-2*H*-chromene-3-carbaldehyde (A_3) : The compound chromatographed by using of 1:10 ethyl acetate/hexane, obtained **A_3** chrome yellow semi-solid (0.267 g, 81% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 10.49 (s, 1H), 8.20 (dd, *J* = 8.0, 1.4 Hz, 1H), 7.73

(d, *J* = 8.4 Hz, 2H), 7.71 – 7.66 (m, 1H), 7.50 (d, *J* = 8.4 Hz, 2H), 7.45 – 7.40 (m, 1H), 7.37 (d, *J* = 8.3 Hz, 1H), 1.36 (s, 9H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 187.6, 159.5, 155.3, 154.1, 140.2, 134.6, 133.0 (two carbons merged), 128.7, 125.9 (two carbons merged), 125.0, 120.6, 118.6, 117.8, 117.1, 113.4, 83.1, 35.2, 31.2, 31.0 (three carbons merged). **HRMS** (ESI) calcd. for $C_{22}H_{19}O_3$ $(M+H)^+$ 331.1329, found 331.1325.

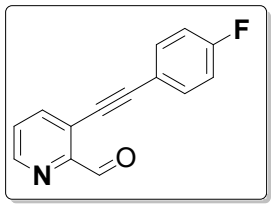
5. General procedure for the synthesis of compound A_{4-6}:



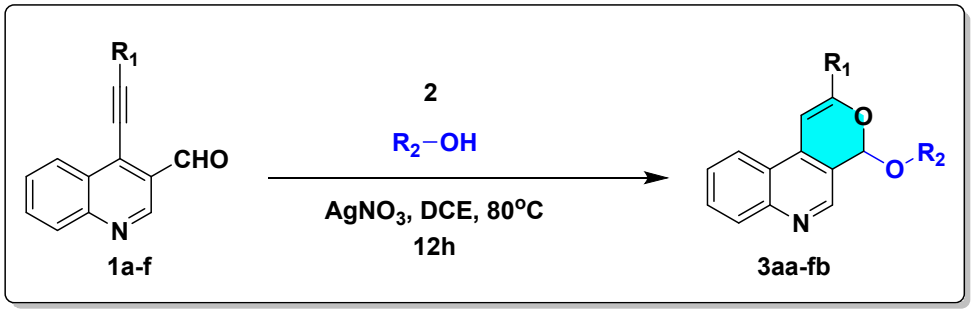
To a stirring solution of 3-bromopicolinaldehyde (2 mmol), $Pd(PPh_3)_2Cl_2$ (5 mol%), CuI (5 mol%), triethylamine (3 equiv.) and DMF 5 mL under inert condition, Alkynes (1.2 equiv) was added dropwise to the reaction after 15min. The reaction was allowed to stirrer at room temperature until complete conversion of starting material (checked with TLC). After completion of reaction (12h), the reaction mixture workup with water and ethyl acetate and extract was evaporated under reduce pressure to get a residue. The residue purified with silica mesh (230-400) using (ethyl acetate/ hexane 1:5) as an eluent to get corresponding products.

A_4, **A_5**, and **B_{1-5}** compounds data match with literature.[4,5] Whereas, Compound **A_6** was underwent full characterization using ^{1}H, ^{13}C, ^{19}F NMR, and HRMS.

3-((4-fluorophenyl)ethynyl)picolinaldehyde (A_6) - The compound chromatographed by using of 1:10 ethyl acetate/hexane, obtained **A_6** orange semi solid (0.267 g, 85% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 10.36 (s, 1H), 8.74 (dd, *J* = 4.6, 1.6 Hz, 1H), 7.96 (dd, *J* = 7.9, 1.5 Hz, 1H), 7.66 – 7.57 (m, 2H), 7.49 (dd, *J* = 7.9, 4.6 Hz, 1H), 7.12 – 7.05 (m, 2H). **^{13}C NMR** (75 MHz, $CDCl_3$) δ 191.1, 163.1 (d, *J* = 251.5 Hz), 151.7, 148.9, 141.2, 134.0 (d, *J* = 8.5 Hz) (two carbons merged), 126.4, 121.1, 118.3 (d, *J* = 3.1 Hz), 115.9 (d, *J* = 22.2 Hz) (two carbons merged), 97.3, 84.0. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -108.9 (s). **HRMS** (ESI) calcd. for $C_{14}H_9FNO$ $(M+H)^+$ 226.0663, found 226.0669.

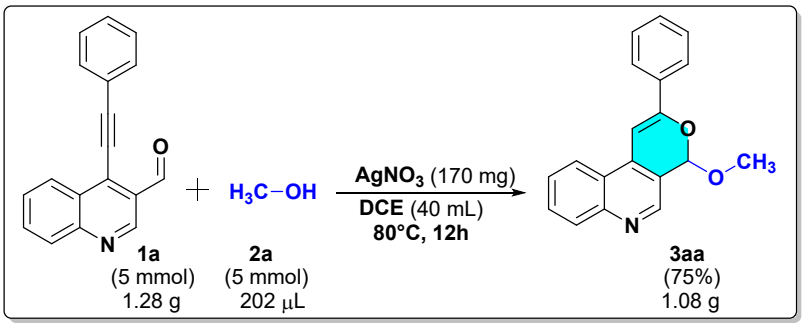


6. General procedure for the synthesis of compounds (3aa-fb):

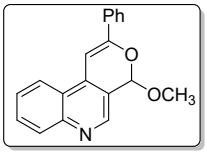


In a reaction vial, 0.2 mmol of compound **1** was weighed and combined with $AgNO_3$ (6.8 mg, 20 mol%) in 2 mL of dichloroethane (DCE). Subsequently, alcohol **2** (0.2 mmol) was introduced into the mixture. The reaction was then stirred for a duration of 12 hours at a temperature of 80°C. The reaction mixture was passed through a small celite bed and the filtrate was concentrated under reduced pressure, resulting in the formation of a residue. This residue was then subjected to column chromatography, utilizing silica mesh with a particle size range of 230-400, and elution was carried out using a mixture of ethyl acetate and hexane in a ratio of 3:10. This process led to the isolation of purified products identified as **3aa-fb**.

7. Gram scale synthesis procedure of compound 3aa:



In a reaction vial, compound **1a** (5 mmol, 1.28 g) was combined with $AgNO_3$ (170 mg, 20 mol%) in 40 mL of dichloroethane (DCE). Alcohol **2a** (202 µL, 5 mmol) was then added, and the reaction mixture was stirred at 80°C for 12 hours. After completion, the mixture was filtered through a small celite bed, and the filtrate was concentrated under reduced pressure to yield a residue. The residue was purified by column chromatography on silica gel (230-400 mesh) using a 3:10 mixture of ethyl acetate and hexane, affording the purified product **3aa** with a yield of 1.08 g (75%).



4-methoxy-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3aa) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3aa** brown semi-solid (49 mg, 85% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.77 (s, 1H), 8.21 (d, *J* = 8.1 Hz, 1H), 8.15 (d, *J* = 8.3 Hz, 1H), 7.94 (dd, *J* = 7.9, 1.7 Hz, 2H), 7.76 (ddd, *J* = 8.3, 6.9, 1.3 Hz, 1H), 7.65 – 7.60 (m, 1H), 7.53 – 7.42 (m, 3H), 7.25 (s, 1H), 6.42 (s, 1H), 3.68 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.3, 147.9, 147.4, 135.2, 133.6, 130.2,

130.0, 129.5, 128.7 (two carbons merged), 126.7, 125.7 (two carbons merged), 122.8, 122.2, 116.9, 98.5, 94.2, 55.4. **HRMS** (ESI) calcd. for $C_{19}H_{16}O_2N$ $(M+H)^+$ 290.1176, found 290.1185.

4-ethoxy-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3ab) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3ab** yellow semi-solid (53 mg, 88% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.77 (s, 1H), 8.22 (d, *J* = 8.4 Hz, 1H), 8.17 (d, *J* = 8.4 Hz, 1H), 7.93 (ddd, *J* = 6.1, 4.2, 2.5 Hz, 2H), 7.77 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.63 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.53 – 7.44 (m, 3H), 7.26 (s, 1H), 6.53 (s, 1H), 4.12 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.93 (dq, *J* = 9.5, 7.1 Hz, 1H), 1.26 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.5, 147.7, 147.3, 135.4, 133.8, 130.2, 130.0, 129.3, 128.7 (two carbons merged), 126.7, 125.7 (two carbons merged), 122.9, 122.3, 117.1, 97.3, 94.2, 64.0, 15.2. **HRMS** (ESI) calcd. for $C_{20}H_{18}O_2N$ $(M+H)^+$ 304.1332, found 304.1341

2-phenyl-4-propoxy-4*H*-pyrano[3,4-*c*]quinoline (3ac) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3ac** yellow semi-solid (52 mg, 82% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.77 (s, 1H), 8.22 (d, *J* = 7.8 Hz, 1H), 8.11 (d, *J* = 8.1 Hz, 1H), 7.93 (dt, *J* = 8.5, 2.2 Hz, 2H), 7.75 (ddd, *J* = 8.3, 6.9, 1.3 Hz, 1H), 7.61 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.53 – 7.42 (m, 3H), 7.25 (s, 1H), 6.52 (s, 1H), 4.02 (dt, *J* = 9.4, 6.6 Hz, 1H), 3.82 (dt, *J* = 9.4, 6.7 Hz, 1H), 1.69 – 1.59 (m, 2H), 0.91 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.0, 148.5, 147.9, 134.7, 134.0, 130.0, 129.9, 129.7, 128.7 (two carbons merged), 126.5, 125.7 (two carbons merged), 122.8, 122.4, 117.2, 97.6, 94.2, 70.1, 22.9, 10.5. **HRMS** (ESI) calcd. for $C_{21}H_{20}O_2N$ $(M+H)^+$ 318.1489, found 318.1505.

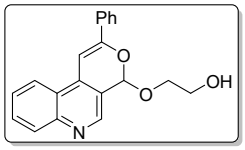
4-(pentyloxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3ad) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3ad** light red semi-solid (52 mg, 79% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.76 (s, 1H), 8.22 (dd, *J* = 8.5, 0.9 Hz, 1H), 8.12 (dd, *J* = 8.4, 0.6 Hz, 1H), 7.95 – 7.91 (m, 2H), 7.75 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.62 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.52 – 7.42 (m, 3H), 7.25 (s, 1H), 6.51 (s, 1H), 4.05 (dt, *J* = 9.5, 6.6 Hz, 1H), 3.85 (dt, *J* = 9.5, 6.7 Hz, 1H), 1.61 (dt, *J* = 10.1, 6.2 Hz, 2H), 1.32 – 1.25 (m, 4H), 0.83 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.1, 148.3, 147.8, 134.8, 133.9, 130.0, 129.7, 129.7, 128.6 (two carbons merged), 126.5, 125.6 (two carbons merged), 122.8, 122.3, 117.2, 97.6, 94.1, 68.5, 29.3, 28.1, 22.3, 13.9. **HRMS** (ESI) calcd. for $C_{23}H_{24}O_2N$ $(M+H)^+$ 346.1802, found 346.1815.

(*Z*)-4-(pent-2-en-1-yloxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3ae) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3ae** burgundy semi-solid (54 mg, 79% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.74 (s, 1H), 8.21 (dd, *J* = 8.6, 0.9 Hz, 1H), 8.12 (dd, *J* = 8.4, 0.6 Hz, 1H), 7.94 (ddd, *J* = 6.0, 3.3, 1.2 Hz, 2H), 7.75 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.62 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.53 – 7.43 (m, 3H), 7.27 (s, 1H), 6.56 (s, 1H), 5.74 – 5.63 (m, 1H), 5.56 (dddt, *J* = 10.7, 7.7, 6.3, 1.4 Hz, 1H), 4.58 – 4.51 (m, 1H), 4.50 – 4.44 (m, 1H), 2.20 – 2.10 (m, 2H), 0.99 (t, *J* = 7.5 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 154.9, 148.4, 147.8, 137.1, 134.8, 133.9, 130.0, 129.8, 129.7, 128.6 (two carbons merged), 126.5, 125.6 (two carbons merged), 123.9, 122.8, 122.3, 117.1, 96.2, 94.3, 63.0, 20.9, 14.1. **HRMS** (ESI) calcd. for $C_{23}H_{22}O_2N$ $(M+H)^+$ 344.1645, found 344.1658.

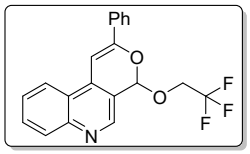
4-((2-methylallyl)oxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3af) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3af** yellow semi-solid (57 mg, 87% yield). **^{1}H NMR**

(500 MHz, $CDCl_3$) δ 8.76 (s, 1H), 8.23 (d, *J* = 8.2 Hz, 1H), 8.13 (d, *J* = 8.4 Hz, 1H), 7.95 – 7.90 (m, 2H), 7.78 – 7.71 (m, 1H), 7.65 – 7.60 (m, 1H), 7.52 – 7.44 (m, 3H), 7.27 (s, 1H), 6.54 (s, 1H), 5.08 (d, *J* = 0.7 Hz, 1H), 4.98 (s, 1H), 4.40 (d, *J* = 12.5 Hz, 1H), 4.32 (d, *J* = 12.4 Hz, 1H), 1.76 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.0, 148.4, 147.8, 141.0, 134.9, 133.9, 130.0, 129.9, 129.7, 128.7 (two carbons overlap), 126.6, 125.7 (two carbons overlap), 122.8, 122.3, 117.0, 113.7, 96.4, 94.3, 71.7, 19.5. **HRMS** (ESI) calcd. for $C_{22}H_{20}O_2N$ $(M+H)^+$ 330.1489, found 330.1492.

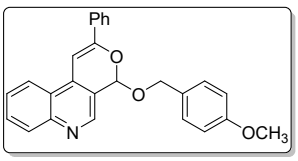
2-((2-phenyl-4*H*-pyrano[3,4-*c*]quinolin-4-yl)oxy)ethan-1-ol (3ag) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3ag** light red semi-solid (42 mg, 65% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.76 (s, 1H), 8.18 (d, *J* = 8.2 Hz, 1H), 8.10 (d, *J* = 8.4 Hz, 1H), 7.91 (dd, *J* = 7.7, 1.6 Hz, 2H), 7.74 (dd, *J* = 11.2, 4.0 Hz, 1H), 7.61 (dd, *J* = 11.2, 3.8 Hz, 1H), 7.54 – 7.42 (m, 3H), 7.21 (s, 1H), 6.55 (s, 1H), 4.17 – 4.11 (m, 1H), 3.99 (ddd, *J* = 10.2, 6.2, 3.8 Hz, 1H), 3.83 – 3.71 (m, 2H). **^{13}C NMR** (75 MHz, $CDCl_3$) δ 155.0, 148.1, 147.6, 134.9, 133.6, 130.2, 129.9, 129.6, 128.7 (two carbons merged), 126.7, 125.7 (two carbons merged), 122.8, 122.2, 116.8, 97.8, 94.2, 69.6, 61.6. **HRMS** (ESI) calcd. for $C_{20}H_{18}O_3N$ $(M+H)^+$ 320.1281, found 320.1296.



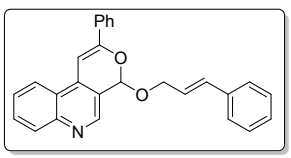
2-phenyl-4-(2,2,2-trifluoroethoxy)-4*H*-pyrano[3,4-*c*]quinoline (3ah) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3ah** yellow solid (M.pt. 120-122°C) (66 mg, 92% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.81 (s, 1H), 8.23 (d, *J* = 8.0 Hz, 1H), 7.94 – 7.87 (m, 2H), 7.79 (ddd, *J* = 8.3, 6.9, 1.3 Hz, 1H), 7.65 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.54 – 7.45 (m, 3H), 7.30 (s, 1H), 4.33 (dq, *J* = 12.4, 8.4 Hz, 1H), 4.16 (dq, *J* = 12.4, 8.7 Hz, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 154.3, 148.7, 147.7, 134.7, 133.2, 130.3, 130.1, 130.1, 128.8 (two carbons merged), 126.9, 125.5 (two carbons merged), 126.9 – 120.2 (m, J = splitting merged), 122.8, 122.1, 115.6, 97.7, 94.6, 64.33 (q, J = 35.0 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -73.97 (s). **HRMS** (ESI) calcd. for $C_{20}H_{15}O_2NF_3$ $(M+H)^+$ 358.1049, found 358.1065.



4-((4-methoxybenzyl)oxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3ak) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3ak** yellow solid (M.pt. 146-148°C) (55 mg, 69% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.67 (s, 1H), 8.21 (d, *J* = 8.3 Hz, 1H), 8.11 (d, *J* = 8.4 Hz, 1H), 7.91 (dt, *J* = 4.4, 2.4 Hz, 2H), 7.75 (ddd, *J* = 8.3, 6.9, 1.3 Hz, 1H), 7.62 (ddd, *J* = 8.2, 7.0, 1.1 Hz, 1H), 7.52 – 7.44 (m, 3H), 7.34 – 7.28 (m, 2H), 7.27 (s, 1H), 6.90 – 6.85 (m, 2H), 6.56 (s, 1H), 4.92 (s, 2H), 3.79 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 159.5, 155.0, 148.4, 147.8, 134.8, 133.9, 130.0, 129.9, 129.7 (three carbon merged), 129.0, 128.7 (two carbon merged), 126.6, 125.7 (two carbon merged), 122.8, 122.3, 117.1, 114.0 (two carbon merged), 96.1, 94.4, 69.4, 55.3. **HRMS** (ESI) calcd. for $C_{26}H_{22}O_3N$ $(M+H)^+$ 396.1597, found 396.1615.

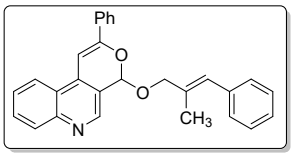


4-(cinnamyloxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3al) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3al** pale yellow solid (M.pt. 140-142°C) (56 mg, 72% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.76 (s, 1H), 8.20 (d, *J* = 8.0 Hz, 1H), 8.10 (d, *J* = 8.2 Hz, 1H), 7.95 – 7.89 (m, 2H), 7.73 (ddd, *J* = 8.3, 6.9, 1.3 Hz, 1H), 7.63 – 7.57 (m, 1H), 7.47 – 7.41 (m, 3H), 7.29 (ddd, *J* = 7.5, 5.8, 1.9 Hz, 3H), 7.25 – 7.18 (m, 2H), 6.65 (d, *J* = 15.9 Hz, 1H), 6.60 (s, 1H), 6.28 (dt, *J* = 15.9, 6.2 Hz, 1H), 4.65 – 4.54 (m, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 154.9, 148.5, 147.8, 136.3, 134.8, 133.8, 133.6, 130.0, 129.9, 129.7, 128.7 (two carbon merged), 128.5 (two carbon merged),



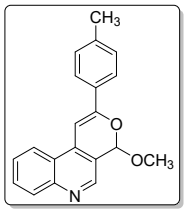
127.9, 126.6, 126.5 (two carbon merged), 125.7 (two carbon merged), 124.8, 122.8, 122.3, 117.0, 96.8, 94.4, 68.8. **HRMS** (ESI) calcd. for $C_{27}H_{22}O_2N$ $(M+H)^+$ 392.1648, found 392.1666.

(E)-4-((2-methyl-3-phenylallyl)oxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3am) - The compound



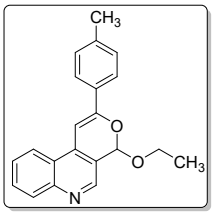
chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3am** pale yellow solid (M.pt. 132-134°C) (72 mg, 88% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.71 (s, 1H), 8.16 (d, *J* = 7.6 Hz, 1H), 8.04 (dd, *J* = 8.4, 0.7 Hz, 1H), 7.87 (ddd, *J* = 6.2, 4.2, 2.5 Hz, 2H), 7.68 (ddd, *J* = 8.3, 6.9, 1.4 Hz, 1H), 7.55 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.42 – 7.35 (m, 3H), 7.27 – 7.23 (m, 2H), 7.21 (s, 1H), 7.19 (s, 1H), 7.18 (d, *J* = 2.3 Hz, 1H), 7.17 – 7.13 (m, 1H), 6.54 (s, 1H), 6.54 (s, 2H), 4.46 (dd, *J* = 12.1, 1.0 Hz, 1H), 4.41 (d, *J* = 12.1 Hz, 1H), 1.83 (d, *J* = 1.3 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 154.9, 148.6, 147.8, 137.1, 134.8, 134.0, 133.8, 130.0 (two carbon merged), 129.7, 128.9 (two carbon merged), 128.7(two carbon merged), 128.3, 128.1 (two carbon merged), 126.7, 126.6, 125.7 (two carbon merged), 122.8, 122.3, 117.0, 96.6, 94.3, 74.3, 15.6. **HRMS** (ESI) calcd. for $C_{28}H_{24}O_2N$ $(M+H)^+$ 406.1806, found 406.1823.

4-methoxy-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3ba) - The compound chromatographed by using of 3:10



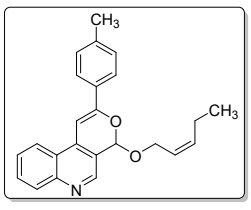
ethyl acetate/hexane, obtained **3ba** light red solid (M.pt. 142-144°C) (49 mg, 81% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.76 (s, 1H), 8.21 (dd, *J* = 8.5, 0.8 Hz, 1H), 8.11 (dd, *J* = 8.4, 0.6 Hz, 1H), 7.84 (d, *J* = 8.3 Hz, 2H), 7.74 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.61 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.29 (d, *J* = 8.0 Hz, 2H), 7.21 (s, 1H), 6.42 (s, 1H), 3.67 (s, 3H), 2.43 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.0, 148.6, 147.9, 140.4, 134.8, 131.0, 130.0, 129.6, 129.4 (two carbon merged), 126.5, 125.6 (two carbon merged), 122.8, 122.2, 116.8, 98.6, 93.5, 55.3, 21.4. **HRMS** (ESI) calcd. for $C_{20}H_{18}O_2N$ $(M+H)^+$ 304.1332, found 304.1338.

4-ethoxy-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3bb) - The compound chromatographed by using of 3:10 ethyl



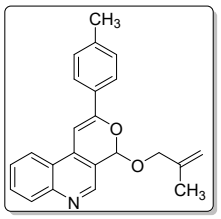
acetate/hexane, obtained **3bb** yellow semi-solid (55 mg, 86% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.75 (s, 1H), 8.21 (dd, *J* = 8.5, 0.9 Hz, 1H), 8.10 (dd, *J* = 8.4, 0.7 Hz, 1H), 7.84 – 7.80 (m, 2H), 7.82 (d, *J* = 8.3 Hz, 2H), 7.74 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.60 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.29 (d, *J* = 8.0 Hz, 2H), 7.21 (s, 1H), 6.51 (s, 1H), 4.11 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.92 (dq, *J* = 9.5, 7.1 Hz, 1H), 2.43 (s, 3H), 1.25 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.1, 148.5, 147.9, 140.3, 134.9, 131.2, 129.9, 129.6, 129.4 (two carbon merged), 126.4, 125.6 (two carbon merged), 122.9, 122.3, 117.0, 97.4, 93.5, 63.8, 21.4, 15.2. **HRMS** (ESI) calcd. for $C_{21}H_{20}O_2N$ $(M+H)^+$ 318.1488, found 318.1503.

(Z)-4-(pent-2-en-1-yloxy)-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3be) - The compound chromatographed by

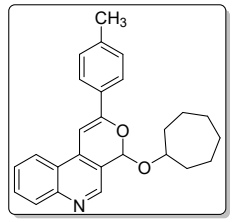


using of 3:10 ethyl acetate/hexane, obtained **3be** rust semi-solid (51 mg, 71% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.73 (s, 1H), 8.19 (dd, *J* = 8.6, 0.8 Hz, 1H), 8.10 (dd, *J* = 8.4, 0.7 Hz, 1H), 7.84 – 7.79 (m, 2H), 7.73 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.59 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.28 (d, *J* = 8.0 Hz, 2H), 7.21 (s, 1H), 6.53 (s, 1H), 5.73 – 5.62 (m, 1H), 5.56 (dddt, *J* = 10.7, 7.6, 6.3, 1.4 Hz, 1H), 4.56 – 4.50 (m, 1H), 4.49 – 4.42 (m, 1H), 2.42 (s, 3H), 2.20 – 2.09 (m, 2H), 1.00 (t, *J* = 7.5 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.0, 148.4, 147.8, 140.3, 137.0, 134.9, 131.1, 129.9, 129.6, 129.4 (two carbon merged), 126.4, 125.5 (two carbon merged), 124.0, 122.8, 122.3, 117.0, 96.2, 93.6, 62.9, 21.4, 20.9, 14.1. **HRMS** (ESI) calcd. for $C_{24}H_{24}O_2N$ $(M+H)^+$ 358.1803, found 358.1821.

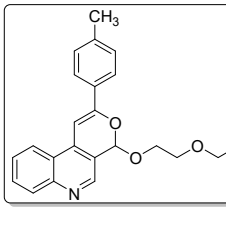
4-((2-methylallyl)oxy)-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3bf) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3bf** yellow solid (M.pt. 115-117°C) (57 mg, 83% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.74 (s, 1H), 8.21 (d, *J* = 8.1 Hz, 1H), 8.10 (d, *J* = 7.9 Hz, 1H), 7.82 (d, *J* = 8.2 Hz, 2H), 7.74 (ddd, *J* = 8.3, 6.9, 1.3 Hz, 1H), 7.61 (ddd, *J* = 8.1, 7.0, 1.1 Hz, 1H), 7.29 (d, *J* = 8.0 Hz, 2H), 7.22 (s, 1H), 6.52 (s, 1H), 5.07 (s, 1H), 4.97 (s, 1H), 4.39 (d, *J* = 12.4 Hz, 1H), 4.31 (d, *J* = 12.4 Hz, 1H), 2.43 (s, 3H), 1.76 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.1, 148.5, 147.8, 141.0, 140.3, 135.0, 131.1, 129.9, 129.6, 129.4 (two carbon merged), 126.4, 125.6 (two carbon merged), 122.8, 122.3, 116.9, 113.7, 96.4, 93.6, 71.6, 21.4, 19.52. **HRMS** (ESI) calcd. for $C_{23}H_{22}O_2N$ $(M+H)^+$ 344.1645, found 344.1656.



4-(cycloheptyloxy)-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3bi) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3bi** mustard solid (M.pt. 85-87°C) (52 mg, 68% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.62 (s, 1H), 8.11 (d, *J* = 8.2 Hz, 1H), 8.01 (d, *J* = 7.8 Hz, 1H), 7.72 (d, *J* = 8.2 Hz, 2H), 7.64 (ddd, *J* = 8.3, 6.9, 1.3 Hz, 1H), 7.54 – 7.47 (m, 1H), 7.20 (d, *J* = 8.0 Hz, 2H), 7.12 (s, 1H), 6.47 (s, 1H), 4.23 (tt, *J* = 8.4, 4.4 Hz, 1H), 2.34 (s, 3H), 2.05 – 1.98 (m, 1H), 1.83 – 1.76 (m, 1H), 1.76 – 1.67 (m, 1H), 1.67 – 1.60 (m, 1H), 1.54 – 1.42 (m, 7H), 1.30 (ddd, *J* = 11.2, 9.3, 3.3 Hz, 1H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.0, 148.3, 147.7, 140.2, 134.9, 131.3, 129.8, 129.5, 129.3 (two carbon merged), 126.3, 125.6 (two carbon merged), 122.9, 122.4, 117.4, 96.0, 93.5, 78.8, 35.5, 34.0, 28.2, 28.1, 22.8, 22.7, 21.4. **HRMS** (ESI) calcd. for $C_{26}H_{28}O_2N$ $(M+H)^+$ 386.2115, found 386.2130.

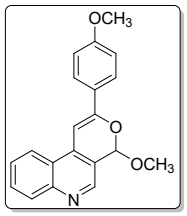


4-(2-ethoxyethoxy)-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3bj) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3bj** orange semi-solid (56 mg, 77% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.79 (s, 1H), 8.20 (d, *J* = 7.8 Hz, 1H), 8.11 (d, *J* = 8.0 Hz, 1H), 7.82 (d, *J* = 8.2 Hz, 2H), 7.74 (ddd, *J* = 8.3, 6.9, 1.3 Hz, 1H), 7.60 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.28 (d, *J* = 8.0 Hz, 2H), 7.20 (s, 1H), 6.62 (s, 1H), 4.14 – 4.01 (m, 2H), 3.63 – 3.59 (m, 2H), 3.50 (q, *J* = 7.0 Hz, 2H), 2.42 (s, 3H), 1.18 (t, *J* = 7.0 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.2, 148.3, 147.9, 140.4, 135.0, 131.0, 129.7, 129.4 (two carbon merged), 126.5, 125.6 (two carbon merged), 122.9, 122.3, 116.9, 97.8, 93.5, 69.7, 67.3, 66.7, 21.4, 15.1. **HRMS** (ESI) calcd. for $C_{23}H_{24}O_3N$ $(M+H)^+$ 362.1751, found 362.1768.

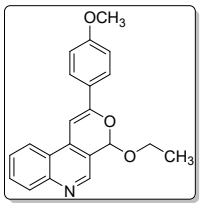


2-(*p*-tolyl)-4-((3,4,5-trimethoxybenzyl)oxy)-4*H*-pyrano[3,4-*c*]quinoline (3bn) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3bn** orange semi-solid (61 mg, 65% yield). **^{1}H NMR (**400 MHz, $CDCl_3$) δ 8.74 (s, 1H), 8.22 (dd, *J* = 8.5, 0.8 Hz, 1H), 8.11 (dd, *J* = 8.4, 0.7 Hz, 1H), 7.81 (d, *J* = 8.3 Hz, 2H), 7.75 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.62 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.28 (d, *J* = 8.0 Hz, 2H), 7.25 (s, 1H), 6.60 (s, 1H), 6.56 (s, 1H), 6.56 (s, 1H), 4.91 (q, *J* = 11.9 Hz, 2H), 3.80 (s, 3H), 3.77 (s, 6H), 2.43 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 155.1, 153.3 (two carbon merged), 148.3, 147.6, 140.5, 137.6, 135.1, 132.8, 130.9, 129.8, 129.7, 129.4 (two carbon merged), 126.6, 125.5 (two carbon merged), 122.8, 122.3, 116.8, 104.8 (two carbon merged), 96.5, 93.7, 69.7, 60.8, 56.0 (two carbon merged), 21.4. **HRMS** (ESI) calcd. for $C_{29}H_{28}O_5N$ $(M+H)^+$ 470.1962, found 470.1982.

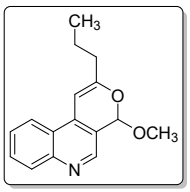
4-methoxy-2-(4-methoxyphenyl)-4*H*-pyrano[3,4-*c*]quinoline (3ca) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3ca** red solid (M.pt. 142-144°C) (48 mg, 76% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.75 (s, 1H), 8.20 (dd, *J* = 8.5, 0.9 Hz, 1H), 8.10 (dd, *J* = 8.4, 0.7 Hz, 1H), 7.92 – 7.87 (m, 2H), 7.74 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.61 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.15 (s, 1H), 7.04 – 6.93 (m, 2H), 6.41 (s, 1H), 3.89 (s, 3H), 3.67 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.2, 154.9, 148.5, 147.8, 135.0, 129.9, 129.6, 127.2 (two carbon merged), 126.4, 126.3, 122.8, 122.2, 116.6, 114.1 (two carbon merged), 98.6, 92.7, 55.4, 55.2. **HRMS** (ESI) calcd. for $C_{20}H_{18}O_3N$ $(M+H)^+$ 320.1281, found 320.1296.



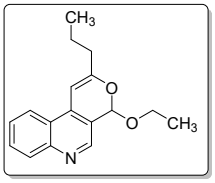
4-ethoxy-2-(4-methoxyphenyl)-4*H*-pyrano[3,4-*c*]quinoline (3cb) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3cb** light red semi-solid (53 mg, 79% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.74 (s, 1H), 8.20 (dd, *J* = 8.5, 0.8 Hz, 1H), 8.09 (d, *J* = 7.8 Hz, 1H), 7.89 – 7.85 (m, 2H), 7.73 (ddd, *J* = 8.3, 6.9, 1.4 Hz, 1H), 7.60 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.14 (s, 1H), 7.02 – 6.96 (m, 2H), 6.50 (s, 1H), 4.10 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.95 – 3.89 (m, 1H), 3.88 (s, 3H), 1.26 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 161.2, 155.1, 148.4, 147.8, 135.2, 129.8, 129.6, 127.3 (two carbon merged), 126.5, 126.4, 122.9, 122.3, 116.8, 114.1 (two carbon merged), 97.4, 92.7, 63.8, 55.4, 15.2. **HRMS** (ESI) calcd. for $C_{21}H_{20}O_3N$ $(M+H)^+$ 334.1437, found 334.1453.



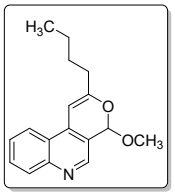
4-methoxy-2-propyl-4*H*-pyrano[3,4-*c*]quinoline (3da) – The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3da** red semi-solid (37 mg, 73% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.68 (s, 1H), 8.07 (d, *J* = 9.4 Hz, 2H), 7.71 (ddd, *J* = 8.3, 6.9, 1.4 Hz, 1H), 7.56 (ddd, *J* = 8.3, 6.9, 1.2 Hz, 1H), 6.48 (s, 1H), 6.23 (s, 1H), 3.59 (s, 3H), 2.53 – 2.31 (m, 2H), 1.81 – 1.67 (m, 2H), 1.03 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (75 MHz, $CDCl_3$) δ 160.5, 148.4, 147.9, 134.8, 129.7, 129.6, 126.3, 122.9, 121.9, 116.1, 98.4, 94.8, 55.2, 36.6, 20.4, 13.6. **HRMS** (ESI) calcd. for $C_{16}H_{18}O_2N$ $(M+H)^+$ 256.1332, found 256.1345.



4-ethoxy-2-propyl-4*H*-pyrano[3,4-*c*]quinoline (3db) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3da** maroon semi-solid (41 mg, 76% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.67 (s, 1H), 8.06 (dd, *J* = 8.5, 1.2 Hz, 2H), 7.75 – 7.65 (m, 1H), 7.57 – 7.48 (m, 1H), 6.47 (s, 1H), 6.32 (s, 1H), 4.01 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.82 (dq, *J* = 9.5, 7.1 Hz, 1H), 2.51 – 2.35 (m, 2H), 1.73 (h, *J* = 7.4 Hz, 2H), 1.25 (t, *J* = 7.1 Hz, 3H), 1.02 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (75 MHz, $CDCl_3$) δ 160.5, 148.4, 148.0, 134.8, 129.7, 129.5, 126.2, 122.9, 121.9, 116.4, 97.1, 94.7, 63.6, 36.7, 20.4, 15.2, 13.5. **HRMS** (ESI) calcd. for $C_{17}H_{20}O_2N$ $(M+H)^+$ 270.1489, found 270.1498.



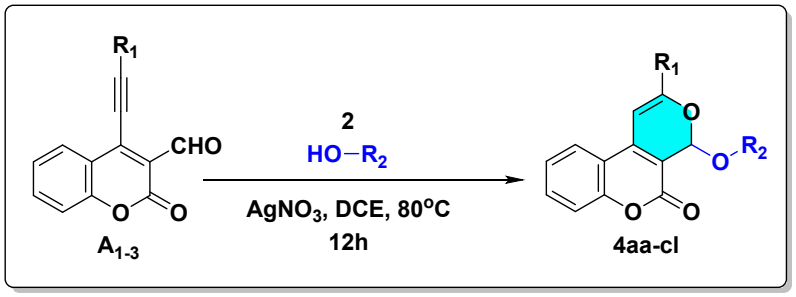
2-butyl-4-methoxy-4*H*-pyrano[3,4-c]quinoline (3ea) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3ea** light red semi-solid (32 mg, 65% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.68 (s, 1H), 8.07 (dd, *J* = 3.9, 0.9 Hz, 1H), 8.05 (dd, *J* = 3.7, 0.9 Hz, 1H), 7.70 (ddd, *J* = 8.3, 6.9, 1.3 Hz, 1H), 7.55 (ddd, *J* = 8.2, 6.9, 1.1 Hz, 1H), 6.47 (s, 1H), 6.22 (s, 1H), 3.59 (s, 3H), 2.54 – 2.34 (m, 2H), 1.77 – 1.61 (m, 2H), 1.50 – 1.36 (m, 2H), 0.97 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (75 MHz, $CDCl_3$) δ 160.8, 148.3, 147.8, 134.9, 129.6, 129.5, 126.2, 122.8, 121.8, 116.1, 98.3, 94.5, 55.1, 34.3, 29.1, 22.1, 13.8. **HRMS** (ESI) calcd. for $C_{17}H_{20}O_2N$ $(M+H)^+$ 270.1489, found 270.1483.



2-(4-fluorophenyl)-4-methoxy-4*H*-pyrano[3,4-*c*]quinoline (3fa) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3fa** maroon semi-solid (55 mg, 89% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.78 (s, 1H), 8.20 (d, *J* = 8.3 Hz, 1H), 8.13 (d, *J* = 8.4 Hz, 1H), 7.93 (ddd, *J* = 8.1, 5.0, 2.3 Hz, 2H), 7.76 (t, *J* = 7.6 Hz, 1H), 7.62 (t, *J* = 7.6 Hz, 1H), 7.18 (dd, *J* = 10.7, 6.5 Hz, 3H), 6.42 (s, 1H), 3.67 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.9 (d, *J* = 251.2 Hz), 154.4, 147.9, 147.4, 135.1, 130.0, 129.9 (d, *J* = 3.0 Hz), 129.5, 127.7 (d, *J* = 8.5 Hz), 126.8, 122.8, 122.2, 116.8, 116.0, 115.8 (d, *J* = 21.9 Hz), 98.7, 94.0, 55.5. **^{19}F NMR** (471 MHz, $CDCl_3$) δ -109.9 (s). **HRMS** (ESI) calcd. for $C_{19}H_{15}O_2NF$ $(M+H)^+$ 308.1081, found 308.1087.

4-ethoxy-2-(4-fluorophenyl)-4*H*-pyrano[3,4-*c*]quinoline (3fb) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **3fb** maroon semi-solid (56 mg, 87% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.70 (s, 1H), 8.12 (d, *J* = 7.9 Hz, 1H), 8.06 (d, *J* = 8.2 Hz, 1H), 7.87 – 7.80 (m, 2H), 7.68 (ddd, *J* = 8.3, 6.9, 1.3 Hz, 1H), 7.54 (ddd, *J* = 8.2, 6.9, 1.1 Hz, 1H), 7.13 – 7.06 (m, 3H), 6.44 (s, 1H), 4.03 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.85 (dq, *J* = 9.5, 7.1 Hz, 1H), 1.19 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 163.9 (d, *J* = 251.1 Hz), 154.4, 147.9, 147.4, 135.1, 130.1 (d, *J* = 2.9 Hz) (two carbon merged), 129.9, 129.4, 127.69 (d, *J* = 8.4 Hz), 126.7, 122.8, 122.3, 117.0, 115.8 (d, J = 21.9 Hz) (two carbon merged), 97.4, 93.9, 64.0, 15.2. **^{19}F NMR** (471 MHz, $CDCl_3$) δ -109.98 (s). **HRMS** (ESI) calcd. for $C_{20}H_{17}O_2NF$ $(M+H)^+$ 322.1238, found 322.1245.

8. General procedure for the synthesis of compounds (4aa-cl):

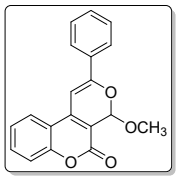


In a reaction vial, 0.2 mmol of **A** (Coumarin) was accurately weighed and combined with $AgNO_3$ (6.8 mg, 20 mol%) in 2 mL of dichloroethane (DCE). Subsequently, alcohol **2** was introduced into the mixture. The reaction was then stirred for a duration of 12 hours at a temperature of 80°C. Later, the reaction mixture was passed through a small celite bed and the filtrate was concentrated under reduced pressure, resulting in the formation of a residue. This residue was then subjected to column chromatography, utilizing silica mesh with a particle size range of 230-400, and elution was carried out using a mixture of ethyl acetate and hexane in a ratio of 3:10. This process led to the isolation of purified products identified as **4aa-cl**.

HRMS analysis revealed the lability of the alcohol group in coumarin moiety, evidenced by the presence of a single fragment peak in all the final products (**4aa-ch**).

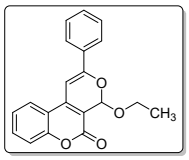
In the case of the **4cl** (M-1) peak, it's possible that the observation of this peak arises from the cleavage of the molecule on the opposite side, rather than the usual cleavage site.

4-methoxy-2-phenyl-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4aa) - The compound chromatographed by using of



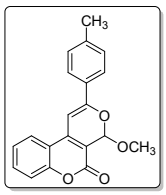
3:10 ethyl acetate/hexane, obtained **4aa** yellow solid (M.pt. 138-140°C) (48 mg, 79% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.93 – 7.89 (m, 2H), 7.85 (dd, *J* = 8.0, 1.4 Hz, 1H), 7.58 (ddd, *J* = 8.5, 7.3, 1.5 Hz, 1H), 7.51 – 7.48 (m, 3H), 7.39 – 7.33 (m, 2H), 6.87 (s, 1H), 6.41 (s, 1H), 3.70 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.6, 159.2, 153.8, 141.4, 133.1, 132.1, 131.0, 128.8 (two carbon merged), 126.1 (two carbon merged), 124.2, 123.7, 117.6, 116.2, 106.0, 96.6, 92.5, 56.1. **HRMS** (ESI) calcd. for $C_{18}H_{11}O_3$ (M+H-OR)$^+$ 275.0703, found 275.0700.

4-ethoxy-2-phenyl-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4ab) - The compound chromatographed by using of



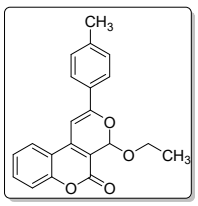
3:10 ethyl acetate/hexane, obtained **4ab** yellow solid (M.pt. 179-181°C) (53 mg, 82% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.91 – 7.88 (m, 2H), 7.85 (dd, *J* = 8.0, 1.4 Hz, 1H), 7.57 (ddd, *J* = 8.6, 7.3, 1.5 Hz, 1H), 7.50 (dd, *J* = 6.7, 3.8 Hz, 3H), 7.36 (td, *J* = 8.7, 1.0 Hz, 2H), 6.87 (s, 1H), 6.50 (s, 1H), 4.12 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.96 (dq, *J* = 9.6, 7.1 Hz, 1H), 1.27 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.6, 159.1, 153.8, 141.3, 133.3, 132.0, 130.9, 128.8 (two carbon merged), 126.2 (two carbon merged), 124.2, 123.7, 117.5, 116.3, 106.2, 95.4, 92.5, 64.7, 15.0. **HRMS** (ESI) calcd. for $C_{18}H_{11}O_3$ (M+H)$^+$ 275.0703, found 275.0700.

4-methoxy-2-(*p*-tolyl)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4ba) - The compound chromatographed by using



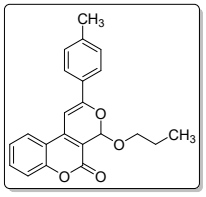
of 3:10 ethyl acetate/hexane, obtained **4ba** orange solid (M.pt. 210-212°C) (51 mg, 79% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.85 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.80 (d, *J* = 8.2 Hz, 2H), 7.60 – 7.53 (m, 1H), 7.39 – 7.36 (m, 1H), 7.36 – 7.32 (m, 1H), 7.29 (d, *J* = 8.0 Hz, 2H), 6.83 (s, 1H), 6.40 (s, 1H), 3.69 (s, 3H), 2.43 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 159.7, 159.4, 153.8, 141.6, 141.6, 132.1, 130.3, 129.5 (two carbon merged), 126.1 (two carbon merged), 124.2, 123.7, 117.6, 116.3, 105.7, 96.6, 91.8, 56.0, 21.5. **HRMS** (ESI) calcd. for $C_{19}H_{13}O_3$ (M+H-OR)$^+$ 289.0859, found 289.0856.

4-ethoxy-2-(*p*-tolyl)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4bb) - The compound chromatographed by using of



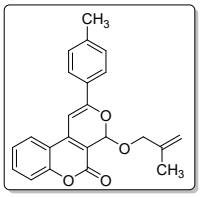
3:10 ethyl acetate/hexane, obtained **4bb** yellow solid (M.pt. 186-188°C) (50 mg, 75% yield).**^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.85 (dd, *J* = 8.0, 1.3 Hz, 1H), 7.79 (d, *J* = 8.3 Hz, 2H), 7.56 (ddd, *J* = 8.5, 7.3, 1.5 Hz, 1H), 7.39 – 7.32 (m, 2H), 7.29 (d, *J* = 8.0 Hz, 2H), 6.83 (s, 1H), 6.49 (s, 1H), 4.11 (dq, *J* = 9.6, 7.1 Hz, 1H), 3.95 (dq, *J* = 9.6, 7.1 Hz, 1H), 2.43 (s, 3H), 1.27 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.6, 159.3, 153.8, 141.5, 141.4, 131.9, 130.5, 129.5 (two carbon merged), 126.1 (two carbon merged), 124.1, 123.7, 117.5, 116.4, 105.8, 95.4, 91.6, 64.6, 21.5, 15.2. **HRMS** (ESI) calcd. for $C_{19}H_{13}O_3$ (M+H-OR)$^+$ 289.0859, found 289.0857.

4-propoxy-2-(*p*-tolyl)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4bc) - The compound chromatographed by using

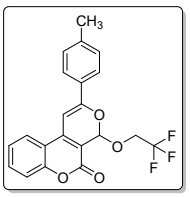


of 3:10 ethyl acetate/hexane, obtained **4bc** yellow solid (M.pt. 166-168°C) (48 mg, 69% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.78 (dd, *J* = 8.0, 1.3 Hz, 1H), 7.73 (dd, *J* = 8.2, 3.7 Hz, 2H), 7.49 (ddd, *J* = 8.6, 7.3, 1.5 Hz, 1H), 7.29 (tt, *J* = 8.3, 4.3 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 6.75 (s, 1H), 6.41 (s, 1H), 3.92 (dt, *J* = 9.5, 6.8 Hz, 1H), 3.78 (dt, *J* = 9.5, 6.7 Hz, 1H), 2.36 (s, 3H), 1.58 (dd, *J* = 14.2, 7.0 Hz, 2H), 0.84 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.6, 159.3, 153.8, 141.4, 131.9, 130.5, 129.5 (two carbon merged), 126.1 (two carbon merged), 124.1, 123.7, 117.5, 116.4, 105.8, 95.5, 91.7, 70.8, 22.9, 21.5, 10.4. **HRMS** (ESI) calcd. for $C_{19}H_{16}O_2N$ (M+H)$^+$ 289.0859, found 289.0856.

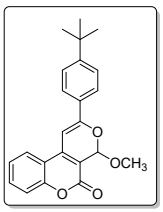
4-((2-methylallyl)oxy)-2-(*p*-tolyl)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4bf) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **4bf** yellow solid (M.pt. 208-210°C) (55 mg, 77% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.85 (d, *J* = 7.9 Hz, 1H), 7.79 (d, *J* = 8.1 Hz, 2H), 7.57 (t, *J* = 7.8 Hz, 1H), 7.39 – 7.31 (m, 2H), 7.29 (d, *J* = 8.1 Hz, 2H), 6.84 (s, 1H), 6.52 (s, 1H), 5.07 (s, 1H), 4.95 (s, 1H), 4.35 (q, *J* = 12.1 Hz, 2H), 2.43 (s, 3H), 1.77 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.5, 159.3, 153.8, 141.6, 141.5, 141.2, 132.0, 130.4, 129.5 (two carbon merged), 126.1 (two carbon merged), 124.1, 123.7, 117.5, 116.4, 113.9, 105.8, 94.6, 91.8, 72.5, 21.5, 19.5. **HRMS** (ESI) calcd. for $C_{19}H_{13}O_3$ (M+H-OR)$^+$ 289.0859, found 289.0856.



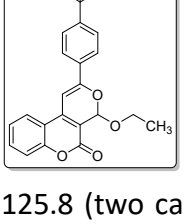
2-(*p*-tolyl)-4-(2,2,2-trifluoroethoxy)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4bh) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **4bh** light yellow solid (M.pt. 228-230°C) (67 mg, 86% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 7.8 Hz, 1H), 7.77 (d, *J* = 8.1 Hz, 2H), 7.60 (t, *J* = 7.7 Hz, 1H), 7.37 (dd, *J* = 13.9, 7.6 Hz, 2H), 7.30 (d, *J* = 8.0 Hz, 2H), 6.87 (s, 1H), 6.56 (s, 1H), 4.34 – 4.21 (m, 2H), 2.44 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 159.3, 159.0, 153.9, 141.8, 141.8, 132.4, 129.7, 129.6 (two carbon merged), 126.0 (two carbon merged), 124.3, 123.8, 123.3 (q, *J* = 278.2 Hz), 117.7, 116.0, 104.9, 96.0, 92.0, 65.78 (q, *J* = 35.3 Hz), 21.5. **^{19}F NMR** (377 MHz, $CDCl_3$) δ -77.39 (s). **HRMS** (ESI) calcd. for $C_{19}H_{13}O_3$ (M+H-OR)$^+$ 289.0859, found 289.0856.



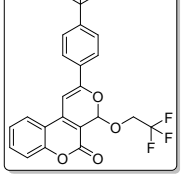
2-(4-(*tert*-butyl)phenyl)-4-methoxy-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4ca) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **4ca** light red semi-solid (59 mg, 82% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.87 – 7.83 (m, 3H), 7.57 (ddd, *J* = 8.5, 7.3, 1.5 Hz, 1H), 7.52 – 7.49 (m, 2H), 7.36 (ddd, *J* = 15.2, 8.3, 1.0 Hz, 2H), 6.84 (s, 1H), 6.40 (s, 1H), 3.69 (s, 3H), 1.37 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.6, 159.3, 154.7, 153.8, 141.6, 132.0, 130.3, 126.0 (two carbon merged), 125.8 (two carbon merged), 124.2, 123.7, 117.6, 116.3, 105.7, 96.6, 91.9, 56.0, 35.0, 31.1. **HRMS** (ESI) calcd. for $C_{22}H_{19}O_3$ (M+H-OR)$^+$ 331.1329, found 331.1326.



2-(4-(*tert*-butyl)phenyl)-4-ethoxy-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4cb) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **4cb** light red semi-solid (63 mg, 84% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.86 – 7.81 (m, 1H), 7.56 (ddd, *J* = 8.5, 7.3, 1.5 Hz, 1H), 7.53 – 7.49 (m, 1H), 7.35 (ddd, *J* = 15.2, 8.3, 1.0 Hz, 1H), 6.83 (s, 1H), 6.49 (s, 1H), 4.11 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.94 (dq, *J* = 9.5, 7.1 Hz, 1H), 1.37 (s, 3H), 1.27 (t, *J* = 7.1 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.6, 159.3, 154.6, 153.8, 141.5, 131.9, 130.4, 126.0 (two carbon merged), 125.8 (two carbon merged), 124.1, 123.7, 117.5, 116.4, 105.9, 95.4, 91.9, 64.6, 35.0, 31.1, 15.2. **HRMS** (ESI) calcd. for $C_{22}H_{19}O_3$ (M+H-OR)$^+$ 331.1329, found 331.1325.

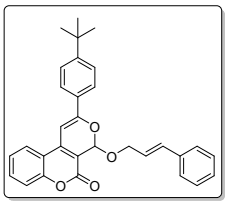


2-(4-(*tert*-butyl)phenyl)-4-(2,2,2-trifluoroethoxy)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4ch) - The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **4ch** yellow semi-solid (76 mg, 88% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.86 (d, *J* = 7.8 Hz, 1H), 7.83 – 7.79 (m, 2H), 7.62 – 7.56 (m, 1H), 7.54 – 7.49 (m, 2H), 7.37 (dd, *J* = 12.9, 7.8 Hz, 2H), 6.87 (s, 1H), 6.57 (s, 1H), 4.35 – 4.23 (m, 2H), 1.37 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.4, 159.0, 155.0, 153.9, 141.8, 132.4, 129.7, 125.9 (two carbon merged), 125.9 (two carbon merged), 124.3, 123.8, 123.3 (q, J = 278.3



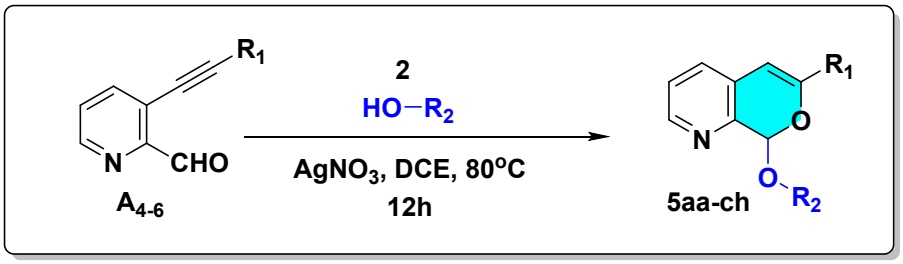
Hz), 117.7, 116.0, 104.9, 96.0, 92.1, 65.77 (q, *J* = 35.3 Hz), 35.0, 31.1. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -74.00 (s). **HRMS** (ESI) calcd. for $C_{22}H_{19}O_3$ $(M+H\text{-}OR)^+$ 331.1329, found 331.1326.

2-(4-(*tert*-butyl)phenyl)-4-(cinnamyloxy)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4cl) - The compound



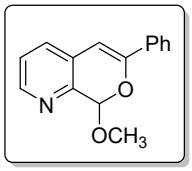
chromatographed by using of 3:10 ethyl acetate/hexane, obtained **4cl** pale yellow solid (M.pt. 140-142°C) (61 mg, 66% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.85 (t, *J* = 8.0 Hz, 3H), 7.59 – 7.54 (m, 1H), 7.46 (d, *J* = 8.5 Hz, 2H), 7.40 – 7.32 (m, 4H), 7.30 – 7.26 (m, 2H), 7.22 (t, *J* = 7.2 Hz, 1H), 6.86 (s, 1H), 6.68 (d, *J* = 15.9 Hz, 1H), 6.61 (s, 1H), 6.33 (dt, *J* = 15.9, 6.2 Hz, 1H), 4.68 – 4.59 (m, 2H), 1.36 (s, 9H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 159.6, 159.2, 154.6, 153.9, 141.6, 136.5, 133.3, 132.0, 130.2, 128.4 (two carbon merged), 127.7, 126.6 (two carbon merged), 126.0 (two carbon merged), 125.8 (two carbon merged), 125.2, 124.2, 123.7, 117.6, 116.4, 105.8, 95.2, 91.9, 69.8, 35.0, 31.1 (three carbon merged). **HRMS** (ESI) calcd. for $C_{22}H_{19}O_4$ $(M-H)^-$ 347.1278, found 347.1289.

9. General procedure for the synthesis of compounds (5aa-ch):



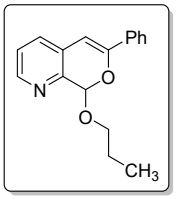
In a reaction vial, 0.2 mmol of **A** (Pyridine) was accurately weighed and combined with $AgNO_3$ (6.8 mg, 20 mol%) in 2 mL of dichloroethane (DCE). Subsequently, alcohol **2** was introduced into the mixture. The reaction was then stirred for a duration of 12 hours at a temperature of 80°C. Further, the reaction mixture was passed through a small celite bed and the filtrate was concentrated under reduced pressure, resulting in the formation of a residue. This residue was then subjected to column chromatography, utilizing silica mesh with a particle size range of 230-400, and elution was carried out using a mixture of ethyl acetate and hexane in a ratio of 1:5. This process led to the isolation of purified products identified as **5aa-ch**.

8-methoxy-6-phenyl-8*H*-pyrano[3,4-*b*]pyridine (5aa) - The compound chromatographed by using of 1:5 ethyl



acetate/hexane, obtained **5aa** red semi-solid (38 mg, 79% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.46 (dd, *J* = 4.7, 1.0 Hz, 1H), 7.85 – 7.80 (m, 2H), 7.55 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.47 – 7.36 (m, 3H), 7.31 (dd, *J* = 7.8, 4.9 Hz, 1H), 6.54 (s, 1H), 6.25 (s, 1H), 3.69 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 150.8, 146.9, 145.5, 133.8, 132.0, 129.3, 128.5 (two carbon merged), 126.2, 125.1 (two carbon merged), 124.7, 99.8, 97.7, 55.9. **HRMS** (ESI) calcd. for $C_{15}H_{14}O_2N$ $(M+H)^+$ 240.1019, found 240.1015.

6-phenyl-8-propoxy-8*H*-pyrano[3,4-*b*]pyridine (5ac) - The compound chromatographed by using of 1:5 ethyl



acetate/hexane, obtained **5ac** red semi-solid (38 mg, 71% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.46 (dd, *J* = 4.8, 1.3 Hz, 1H), 7.84 – 7.78 (m, 2H), 7.54 (dd, *J* = 7.8, 1.2 Hz, 1H), 7.46 – 7.35 (m, 3H), 7.29 (dd, *J* = 7.8, 4.8 Hz, 1H), 6.53 (s, 1H), 6.31 (s, 1H), 3.99 (dt, *J* = 9.4, 6.9 Hz, 1H), 3.84 (dt, *J* = 9.4, 6.7 Hz, 1H), 1.69 – 1.59 (m, 2H), 0.88 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ

150.8, 147.2, 146.0, 134.0, 131.7, 129.2, 128.5 (two carbon merged), 126.1, 125.1 (two carbon merged), 124.4, 98.9, 97.8, 70.4, 22.8, 10.4. **HRMS** (ESI) calcd. for $C_{17}H_{18}O_2N$ $(M+H)^+$ 268.1332, found 268.1328.

6-phenyl-8-(2,2,2-trifluoroethoxy)-8*H*-pyrano[3,4-*b*]pyridine (5ah) - The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **5ah** red semi-solid (55 mg, 89% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.50 (dd, *J* = 4.8, 1.4 Hz, 1H), 7.79 (dd, *J* = 8.1, 1.5 Hz, 2H), 7.61 (dd, *J* = 7.8, 1.2 Hz, 1H), 7.48 – 7.40 (m, 3H), 7.37 (dd, *J* = 7.8, 4.8 Hz, 1H), 6.59 (s, 1H), 6.46 (s, 1H), 4.35 – 4.18 (m, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 150.2, 147.7, 144.5, 133.3, 131.9, 129.5, 128.6 (two carbon merged), 126.0, 125.0 (two carbon merged), 123.48 (q, J = 278.3 Hz), 99.0, 98.3, 64.73 (q, *J* = 35.1 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -73.86 (s). **HRMS** (ESI) calcd. for $C_{16}H_{13}O_2NF_3$ $(M+H)^+$ 308.0893, found 308.0889.

8-methoxy-6-(4-methoxyphenyl)-8*H*-pyrano[3,4-*b*]pyridine (5ba) - The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **5ba** red semi-solid (41 mg, 76% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.44 (dd, *J* = 4.8, 1.5 Hz, 1H), 7.79 – 7.75 (m, 2H), 7.50 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.30 – 7.27 (m, 1H), 6.98 – 6.92 (m, 2H), 6.41 (s, 1H), 6.19 (s, 1H), 3.86 (s, 3H), 3.68 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.5, 150.6, 147.0, 145.7, 131.3, 126.7 (two carbon merged), 126.5, 126.3, 124.5, 113.9 (two carbon merged), 100.1, 96.2, 55.8, 55.3. **HRMS** (ESI) calcd. for $C_{16}H_{16}O_3N$ $(M+H)^+$ 270.1125, found 270.1120.

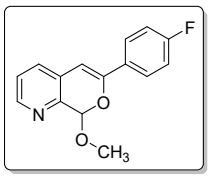
8-ethoxy-6-(4-methoxyphenyl)-8*H*-pyrano[3,4-*b*]pyridine (5bb) - The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **5bb** red semi-solid (45 mg, 79% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.43 (dd, *J* = 4.8, 1.5 Hz, 1H), 7.78 – 7.73 (m, 2H), 7.49 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.26 (dd, *J* = 7.8, 4.8 Hz, 1H), 6.97 – 6.92 (m, 2H), 6.41 (s, 1H), 6.28 (s, 1H), 4.10 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.92 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.85 (s, 3H), 1.25 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.5, 150.6, 147.0, 145.8, 131.3, 126.6 (three carbon merged), 126.3, 124.4, 113.9 (two carbon merged), 98.9, 96.3, 64.1, 55.3, 15.1. **HRMS** (ESI) calcd. for $C_{17}H_{18}O_3N$ $(M+H)^+$ 284.1281, found 284.1276.

6-(4-methoxyphenyl)-8-propoxy-8*H*-pyrano[3,4-*b*]pyridine (5bc) - The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **5bc** red semi-solid (42 mg, 70% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.42 (dd, *J* = 4.8, 1.3 Hz, 1H), 7.78 – 7.71 (m, 2H), 7.51 (d, *J* = 7.7 Hz, 1H), 7.28 (dd, *J* = 4.5, 3.2 Hz, 1H), 6.94 (d, *J* = 8.9 Hz, 2H), 6.41 (s, 1H), 6.31 (d, *J* = 1.4 Hz, 1H), 3.98 (dt, *J* = 9.4, 6.9 Hz, 1H), 3.85 (s, 3H), 3.84 – 3.80 (m, 1H), 1.70 – 1.59 (m, 2H), 0.88 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.6, 151.0, 146.1, 145.3, 131.8, 126.7 (three carbon merged), 126.5, 124.5, 113.9 (two carbon merged), 98.6, 96.0, 70.5, 55.3, 22.8, 10.4. **HRMS** (ESI) calcd. for $C_{19}H_{16}O_2N$ $(M+H)^+$ 238.0863, found 238.0860.

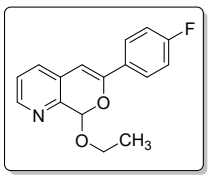
6-(4-methoxyphenyl)-8-(2,2,2-trifluoroethoxy)-8*H*-pyrano[3,4-*b*]pyridine (5bh) - The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **5bh** pale yellow semi-solid (62 mg, 92% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.49 (dd, *J* = 4.8, 1.4 Hz, 1H), 7.80 – 7.72 (m, 2H), 7.58 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.36 (dd, *J* = 7.8, 4.8 Hz, 1H), 7.03 – 6.93 (m, 2H), 6.48 (s, 1H), 6.43 (s, 1H), 4.36 – 4.19 (m, 2H), 3.89 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$)

δ 160.7, 150.3, 147.0, 144.0, 131.8, 127.35 – 119.60 (m), 126.6 (two carbon merged), 126.4, 125.8, 125.0, 114.0 (two carbon merged), 98.9, 96.5, 64.76 (q, *J* = 35.0 Hz), 55.4. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -71.43 (s). **HRMS** (ESI) calcd. for $C_{17}H_{15}O_3NF_3$ $(M+H)^+$ 338.0999, found 338.0993.

6-(4-fluorophenyl)-8-methoxy-8*H*-pyrano[3,4-*b*]pyridine (5ca) - The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **5ca** pale yellow semi-solid (42 mg, 82% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.46 (dd, *J* = 4.8, 1.5 Hz, 1H), 7.82 – 7.76 (m, 2H), 7.51 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.28 (dd, *J* = 7.8, 4.8 Hz, 1H), 7.14 – 7.07 (m, 2H), 6.45 (s, 1H), 6.19 (s, 1H), 3.67 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 163.3 (d, *J* = 249.7 Hz), 149.9, 147.2, 145.5, 131.8, 130.0 (d, *J* = 2.9 Hz), 127.0 (d, *J* = 8.3 Hz) (two carbon merged), 125.9, 124.6, 115.6 (d, *J* = 21.9 Hz) (two carbon merged), 99.9, 97.5, 55.9. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -111.46 (s). **HRMS** (ESI) calcd. for $C_{15}H_{13}O_2NF$ $(M+H)^+$ 258.0925, found 258.0930.

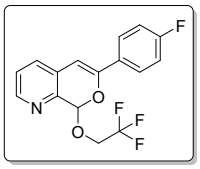


8-ethoxy-6-(4-fluorophenyl)-8*H*-pyrano[3,4-*b*]pyridine (5cb) - The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **5cb** pale yellow semi-solid (44 mg, 80% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.47 (dd, *J* = 4.8, 1.4 Hz, 1H), 7.84 – 7.69 (m, 2H), 7.51 (dd, *J* = 7.8, 1.3 Hz, 1H), 7.28 (dd, *J* = 7.8, 4.8 Hz, 1H), 7.14 – 7.06 (m, 2H), 6.46 (s, 1H), 6.28 (s, 1H), 4.09 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.92 (dq, *J* = 9.5, 7.1 Hz, 1H), 1.25 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 163.3 (d, *J* = 249.5 Hz), 149.8, 147.4, 145.9, 131.6, 130.2 (d, *J* = 2.8 Hz), 127.0 (d, *J* = 8.3 Hz) (two carbon merged), 125.9, 124.5, 115.5 (d, *J* = 21.8 Hz) (two carbon merged), 98.9, 97.6, 64.3, 15.1. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -111.66 (s). **HRMS** (ESI) calcd. for $C_{16}H_{15}O_2NF$ $(M+H)^+$ 272.1081, found 272.1086.

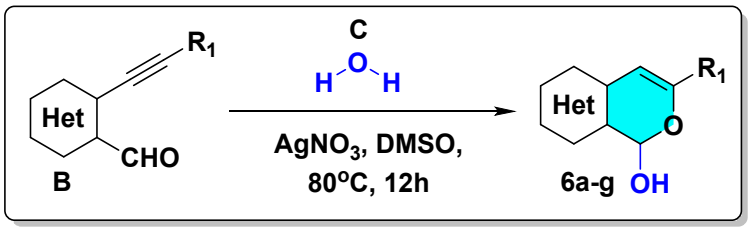


6-(4-fluorophenyl)-8-((2-methylallyl)oxy)-8*H*-pyrano[3,4-*b*]pyridine (5cf) - The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **5cf** pale yellow semi-solid (45 mg, 75% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.47 (dd, *J* = 4.8, 1.5 Hz, 1H), 7.81 – 7.76 (m, 2H), 7.51 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.28 (dd, *J* = 7.8, 4.8 Hz, 1H), 6.47 (s, 1H), 6.28 (s, 1H), 5.07 (d, *J* = 0.8 Hz, 1H), 4.94 (s, 1H), 4.37 (d, *J* = 12.4 Hz, 1H), 4.30 (d, *J* = 12.4 Hz, 1H), 1.74 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 163.3 (d, *J* = 249.5 Hz), 149.9, 147.3, 145.8, 141.1, 131.7, 130.2 (d, *J* = 2.9 Hz), 127.1 (d, *J* = 8.3 Hz) (two carbon merged), 126.1, 124.5, 115.5 (d, *J* = 21.8 Hz) (two carbon merged), 113.7, 98.0, 97.7, 72.2, 19.5. **^{19}F NMR** (471 MHz, $CDCl_3$) δ -111.6 (s). **HRMS** (ESI) calcd. for $C_{18}H_{17}O_2NF$ $(M+H)^+$ 298.1238, found 298.1244.

6-(4-fluorophenyl)-8-(2,2,2-trifluoroethoxy)-8*H*-pyrano[3,4-*b*]pyridine (5ch) - The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **5ch** pale yellow semi-solid (61 mg, 93% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.50 (dd, *J* = 4.8, 1.5 Hz, 1H), 7.80 – 7.71 (m, 2H), 7.55 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.33 (dd, *J* = 7.8, 4.8 Hz, 1H), 7.16 – 7.09 (m, 2H), 6.50 (s, 1H), 6.37 (s, 1H), 4.33 – 4.14 (m, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 163.5 (d, *J* = 250.2 Hz), 149.5, 147.5, 144.2, 132.0, 129.5 (d, *J* = 3.0 Hz), 127.0, 128.0 (d, *J* = 8.3 Hz), 125.1, 124.5, 122.3, 115.7 (d, *J* = 21.9 Hz), 99.0, 97.9, 65.0 (q, *J* = 35.2 Hz). **^{19}F NMR** (376 MHz, $CDCl_3$) δ -73.9 (s), -111.1 (s). **HRMS** (ESI) calcd. for $C_{15}H_{12}O_2NF_4$ $(M+H)^+$ 326.0799, found 326.0804.

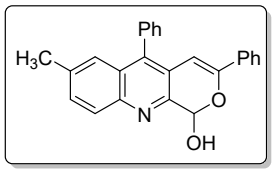


10. General procedure for the synthesis of compounds (6a-g):

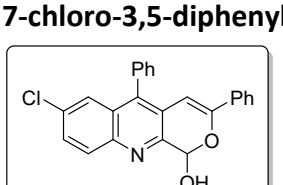


0.2 mmol of *ortho*-alkynyl carbaldehyde (**B**) was mixed with (6.8 mg, 20 mol%) $AgNO_3$ in 2 mL of DMSO in a reaction vial. Water (0.4 mmol, **C**) was then added to the mixture, and the reaction was stirred at 80°C for 12 hours. The reaction mixture was then worked up with ethyl acetate and water, and the organic layer was separated from the aqueous layer. The organic layer was concentrated to give a residue, which was purified by column chromatography using silica mesh (230-400 mesh) and eluted with ethyl acetate/hexane (2:5). The purified products were identified as **6a-g**.

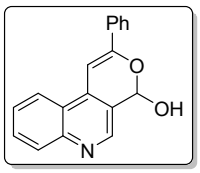
7-methyl-3,5-diphenyl-1*H*-pyrano[3,4-*b*]quinolin-1-ol (6a) : The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **6a** pale yellow solid (M.pt. 180-182°C) (54 mg, 80% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.08 (d, *J* = 8.5 Hz, 1H), 7.70 (d, *J* = 7.6 Hz, 2H), 7.66 – 7.57 (m, 3H), 7.47 (d, *J* = 8.4 Hz, 1H), 7.42 (d, *J* = 7.9 Hz, 1H), 7.35 (dd, *J* = 14.7, 8.6 Hz, 4H), 6.80 (s, 1H), 6.72 (s, 1H), 6.38 (s, 1H), 2.42 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 151.3, 149.5, 149.1, 144.5, 141.0, 137.3, 135.2, 134.2, 131.1, 130.2, 130.1, 129.2, 128.7 (two carbon merged), 128.4 (two carbon merged), 128.1, 125.4 (two carbon merged), 125.0, 121.4, 116.2, 96.7, 93.2, 21.9. **HRMS** (ESI) calcd. for $C_{25}H_{20}O_2N$ $(M+H)^+$ 366.1489, found 366.1480.



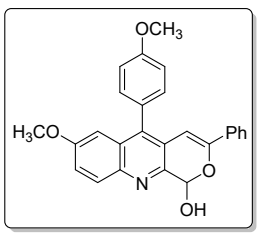
7-chloro-3,5-diphenyl-1*H*-pyrano[3,4-*b*]quinolin-1-ol (6b) : The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **6b** pale yellow solid (M.pt. 199-201°C) (66 mg, 85% yield). **^{1}H NMR** (400 MHz, $CDCl_3$+ DMSO) δ 8.00 (dd, *J* = 6.3, 2.1 Hz, 1H), 7.48 – 7.35 (m, 6H), 7.30 (d, *J* = 1.8 Hz, 1H), 7.23 – 7.17 (m, 1H), 7.12 (d, *J* = 1.7 Hz, 4H), 6.63 – 6.55 (m, 1H), 6.48 – 6.38 (m, 1H), 6.11 (d, *J* = 1.9 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.3, 154.5, 147.5, 146.1, 138.9, 138.8, 138.2, 134.7, 134.5, 134.3, 134.2, 133.8 (two carbon merged), 133.6, 133.2 (two carbon merged), 130.4 (two carbon merged), 129.7, 127.5, 120.7, 100.8, 97.4. **HRMS** (ESI) calcd. for $C_{24}H_{17}O_2NCl$ $(M+H)^+$ 386.0942, found 386.0933.



2-phenyl-4*H*-pyrano[3,4-*c*]quinolin-4-ol (6c) : The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **6c** light red semi-solid (48 mg, 88% yield). **^{1}H NMR** (400 MHz, DMSO) δ 8.78 (s, 1H), 8.62 (d, *J* = 8.2 Hz, 1H), 8.07 (d, *J* = 6.8 Hz, 2H), 8.02 (d, *J* = 8.3 Hz, 1H), 7.81 (dd, *J* = 11.1, 4.0 Hz, 1H), 7.72 – 7.66 (m, 2H), 7.64 (s, 1H), 7.57 – 7.46 (m, 3H), 6.79 (d, *J* = 6.6 Hz, 1H). **^{13}C NMR** (126 MHz, DMSO) δ 154.9, 148.5, 148.2, 134.5, 134.5, 130.5, 130.1, 129.7, 129.1 (two carbon merged), 127.0, 126.3 (two carbon merged), 124.5, 122.5, 119.5, 94.5, 91.8. **HRMS** (ESI) calcd. for $C_{18}H_{14}O_2N$ $(M+H)^+$ 276.1019, found 276.1015.

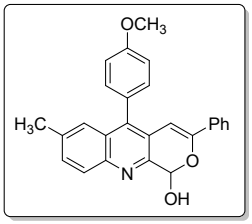


7-methoxy-5-(4-methoxyphenyl)-3-phenyl-1*H*-pyrano[3,4-*b*]quinolin-1-ol (6d) : The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **6d** light red semi-solid (65 mg, 79% yield). **^{1}H NMR** (400 MHz, $CDCl_3$ + DMSO) δ 8.07 (d, *J* = 9.1 Hz, 1H), 7.71 (dd, *J* = 7.8, 1.7 Hz, 2H), 7.39 – 7.34 (m, 4H), 7.33 – 7.28 (m, 2H), 7.16 – 7.09 (m, 2H), 6.89 (d,



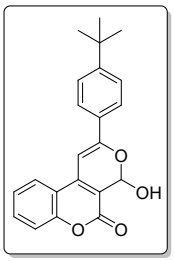
J = 2.7 Hz, 1H), 6.74 (s, 1H), 6.72 (s, 2H), 6.43 (s, 1H), 3.96 (s, 3H), 3.75 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.4, 158.0, 151.1, 149.9, 147.8, 142.2, 139.7, 134.6, 131.3, 131.14 130.4, 129.4, 129.0, 128.3 (two carbon merged), 127.4, 125.4 (two carbon merged), 121.7, 120.7, 116.0 (two carbon merged), 114.2, 114.1, 104.2, 96.9, 93.6, 55.3. **HRMS** (ESI) calcd. for $C_{26}H_{22}O_4N$ $(M+H)^+$ 412.1543, found 412.1535.

5-(4-methoxyphenyl)-7-methyl-3-phenyl-1*H*-pyrano[3,4-*b*]quinolin-1-ol (6e) : The compound



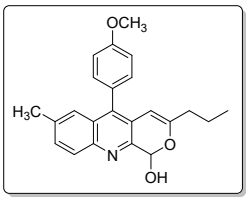
chromatographed by using of 3:10 ethyl acetate/hexane, obtained **6e** yellow semi-solid (51 mg, 65% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.07 (d, *J* = 8.5 Hz, 1H), 7.74 – 7.71 (m, 2H), 7.47 (dd, *J* = 8.6, 1.8 Hz, 1H), 7.40 – 7.32 (m, 5H), 7.30 (dd, *J* = 8.3, 2.1 Hz, 1H), 7.14 (dt, *J* = 8.4, 2.8 Hz, 2H), 6.78 (s, 1H), 6.56 (s, 1H), 6.44 (s, 1H), 3.97 (s, 3H), 2.43 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.6, 151.2, 149.4, 144.8, 140.8, 137.1, 134.4, 131.5, 131.4, 131.0, 129.2, 128.6, 128.5, 128.4 (two carbon merged), 127.4, 125.5 (two carbon merged), 125.1, 121.6, 114.2, 114.1, 97.0, 93.3, 55.4, 21.9. **HRMS** (ESI) calcd. for $C_{26}H_{22}O_3N$ $(M+H)^+$ 396.1594, found 396.1587.

2-(4-(*tert*-butyl)phenyl)-4-hydroxy-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (6f) : The compound



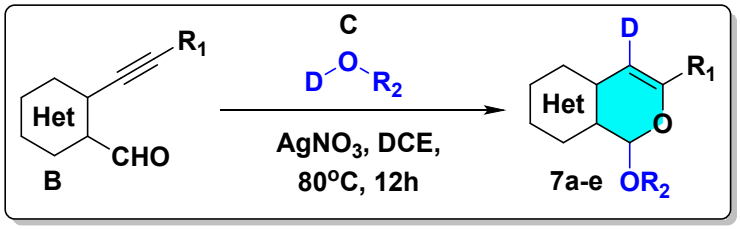
chromatographed by using of 3:10 ethyl acetate/hexane, obtained **6f** yellow semi-solid (50 mg, 72% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.89 – 7.82 (m, 1H), 7.58 (t, *J* = 7.8 Hz, 1H), 7.49 (d, *J* = 8.4 Hz, 1H), 7.37 (dd, *J* = 13.2, 7.8 Hz, 1H), 6.83 (d, *J* = 3.5 Hz, 1H), 4.30 (s, 1H), 1.36 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 160.0, 159.6, 154.8, 153.8, 141.5, 132.1, 130.3, 126.2 (two carbon merged), 125.7 (two carbon merged), 124.3, 123.8, 117.7, 116.3, 106.5, 91.3, 89.6, 35.0, 31.2. **HRMS** (ESI) calcd. for $C_{22}H_{19}O_3$ $(M+H)^+$ 331.1329, found 331.1323.

5-(4-methoxyphenyl)-7-methyl-3-propyl-1*H*-pyrano[3,4-*b*]quinolin-1-ol (6g) : The compound



chromatographed by using of 3:10 ethyl acetate/hexane, obtained **6g** light orange solid (M.pt. 139-141°C) (51 mg, 70% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.03 (d, *J* = 8.5 Hz, 1H), 7.43 (dd, *J* = 8.6, 1.8 Hz, 1H), 7.30 (s, 1H), 7.29 – 7.25 (m, 1H), 7.21 (dd, *J* = 8.6, 2.0 Hz, 1H), 7.09 (ddd, *J* = 8.5, 4.8, 2.3 Hz, 2H), 5.63 (s, 1H), 3.93 (s, 3H), 2.40 (s, 3H), 2.33 – 2.19 (m, 2H), 1.73 – 1.58 (m, 2H), 0.97 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.3, 156.3, 149.5, 144.4, 139.2, 136.7, 131.3, 131.2, 130.4, 128.4, 128.3, 127.6, 124.8, 121.7, 114.0, 113.9, 96.6, 92.5, 55.3, 36.3, 21.8, 20.1, 13.6. **HRMS** (ESI) calcd. for $C_{23}H_{24}O_3N$ $(M+H)^+$ 362.1751, found 362.1744.

11. General procedure for the synthesis of compounds (7a-e):



0.2 mmol of *ortho*-alkynyl carbaldehyde (**B**) was mixed with (6.8 mg) 20 mol% $AgNO_3$ in 2 mL of DCE (DMSO for D_2O) in a reaction vial. deuterated solvent (0.2 mmol, **C**) was then added to the mixture, and the reaction was stirred at 80°C for 12 hours. The reaction mixture was then worked up with ethyl acetate and water, and the organic layer was separated from the aqueous layer. The organic layer was concentrated to give a residue, which

was purified by column chromatography using silica mesh (230-400 mesh) and eluted with ethyl acetate/hexane (4:10). The purified products were identified as **7a-e**.

4-ethoxy-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline-1-d (7a) : The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **7a** light red semi-solid (49 mg, 80% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.77 (s, 1H), 8.20 (dd, *J* = 8.4, 0.9 Hz, 1H), 8.11 (d, *J* = 8.4 Hz, 1H), 7.93 (dd, *J* = 8.1, 1.5 Hz, 2H), 7.74 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.61 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.53 – 7.44 (m, 3H), 7.25 (s, 1H(**d-70%**)), 6.52 (s, 1H), 4.12 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.93 (dq, *J* = 9.5, 7.1 Hz, 1H), 1.26 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (75 MHz, $CDCl_3$) δ 155.1, 148.1, 147.6, 134.9, 133.8, 130.0, 129.8, 129.6, 128.7 (two carbon merged), 126.6, 125.7 (two carbon merged), 122.8, 122.3, 117.1, 97.4, 94.2, 63.9, 15.2. **HRMS** (ESI) calcd. for $C_{20}H_{17}DO_2N$ $(M+H)^+$ 305.1395, found 305.1387.

4-ethoxy-2-(4-methoxyphenyl)-4*H*-pyrano[3,4-*c*]quinoline-1-d (7b) : The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **7b** dark brown semi-solid (57 mg, 85% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.73 (s, 1H), 8.19 (dd, *J* = 8.4, 1.3 Hz, 1H), 8.09 (d, *J* = 8.4 Hz, 1H), 7.89 – 7.85 (m, 2H), 7.73 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.59 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H), 7.13 (s, 1H **d-70%**), 7.04 – 6.94 (m, 2H), 6.50 (s, 1H), 4.10 (dq, *J* = 9.5, 7.1 Hz, 1H), 3.95 – 3.88 (m, 1H), 3.88 (s, 3H), 1.25 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.2, 155.0, 155.0, 148.4, 147.8, 135.2, 135.1, 129.8, 129.6, 127.3 (two carbon merged), 126.5, 126.4, 126.4, 122.9, 122.3, 116.8, 114.1 (two carbon merged), 97.4, 92.6, 63.7, 55.4, 15.2. **HRMS** (ESI) calcd. for $C_{21}H_{19}DO_3N$ $(M+H)^+$ 335.1500, found 335.1492.

2-(4-(*tert*-butyl)phenyl)-4-(methoxy-d3)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one-1-d (7c) : The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **7c** light yellow solid (M.pt. 132-134°C) (64 mg, 88% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.84 (d, *J* = 8.3 Hz, 3H), 7.59 – 7.54 (m, 1H), 7.51 (d, *J* = 8.5 Hz, 2H), 7.35 (dd, *J* = 15.5, 7.8 Hz, 2H), 6.84 (s, 1H **d-80%**), 6.40 (s, 1H), 1.37 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.7, 159.3, 154.7, 153.8, 141.5, 132.0, 130.2, 126.0 (two carbon merged), 125.8 (two carbon merged), 124.2, 123.7, 117.6, 116.3, 105.7, 96.5, 91.9, 35.0, 31.1. **HRMS** (ESI) calcd. for $C_{22}H_{18}DO_3$ $(M+H)^+$ 332.1391, found 332.1384.

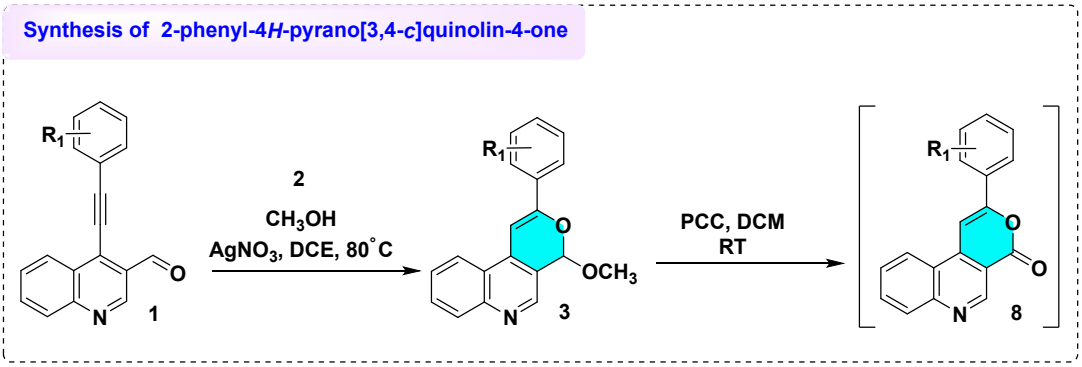
2-(4-(*tert*-butyl)phenyl)-4-hydroxy-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one-1-d (7d) : The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **7d** yellow solid (M.pt. 162-164°C) (55 mg, 79% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.86 (dd, *J* = 12.7, 4.9 Hz, 3H), 7.60 – 7.55 (m, 1H), 7.49 (d, *J* = 8.5 Hz, 2H), 7.41 – 7.33 (m, 2H), 6.83 (s, 1H), 6.82 (s, 1H **d-50%**), 4.26 (s, 1H), 1.36 (s, 9H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.1, 159.6, 154.7, 153.8, 141.5, 132.1, 130.3, 126.2 (two carbon merged), 125.7 (two carbon merged), 124.3, 123.8, 117.6, 116.3, 106.4, 91.3, 89.6, 35.0, 31.1 (three carbon merged). **HRMS** (ESI) calcd. for $C_{22}H_{19}O_3$ $(M+H)^+$ 331.1329, found 331.1326.

2-(4-(*tert*-butyl)phenyl)-4-ethoxy-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one-1-d (7e) : The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **7e** light yellow solid (M.pt. 142-144°C) (64 mg, 84% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.88 – 7.79 (m, 3H), 7.58

– 7.54 (m, 1H), 7.50 (d, *J* = 8.5 Hz, 2H), 7.35 (dd, *J* = 16.2, 8.0 Hz, 2H), 6.83 (s, 1H **d-70%**), 6.49 (s, 1H), 4.11 (dq, *J* = 9.4, 7.1 Hz, 1H), 3.94 (dq, *J* = 9.5, 7.1 Hz, 1H), 1.37 (s, 9H), 1.27 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 159.6, 159.3, 154.5, 153.8, 141.4, 131.9, 130.4, 126.0 (two carbon merged), 125.8 (two carbon merged), 124.1, 123.7, 117.5, 116.4, 105.8, 95.4, 91.9, 64.6, 34.9, 31.1, 15.2. **HRMS** (ESI) calcd. for $C_{22}H_{18}DO_3$ $(M+H)^+$ 332.1391, found 332.1386.

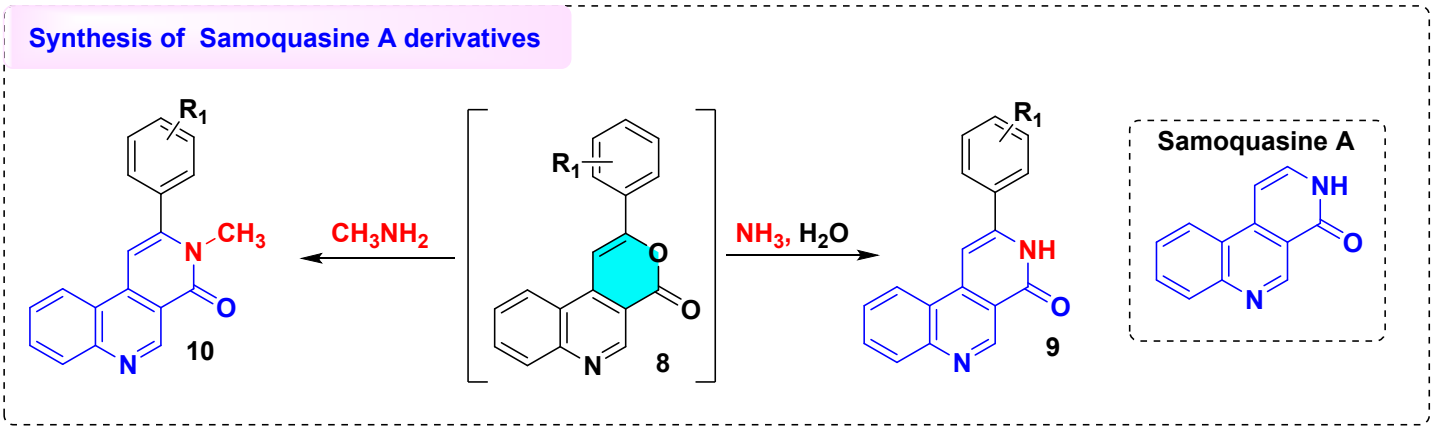
12. Stepwise synthesis of Samoquasine A derivatives:

1. Synthesis of 2-phenyl-4*H*-prano[3,4-*c*]quinoline-4-one (8) from 4-alkynylquinoline-3-carbaldehyde:



In an oven dried reaction vial, compound **3** (0.5 mmol) was weighed which were subjected to oxidation in dichloromethane (DCM) (5 mL) at room temperature using (2 equiv) PCC (Pyridinium chlorochromate) as the oxidant. Upon completion of the reaction, a standard workup procedure was performed, employing ethyl acetate and water to separate the organic and aqueous layers. The acquired organic layer was then concentrated under reduced pressure, yielding a crude residue **8**. Notably, this residue was directly employed in the subsequent step without undergoing further purification.

2. Synthesis of Samoquasine A derivatives from 2-phenyl-4*H*-prano[3,4-*c*]quinoline-4-one:

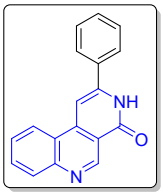


13. General procedure for compound 9a-d:

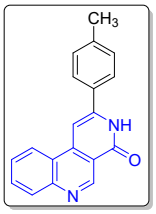
In crude mixture of **8** (0.5 mmol), 4 mL of ammonia solution was added, and the reaction mixture was stirred at 80°C for 6 hours. Upon completion of the reaction, the formed precipitate was filtered and thoroughly dried.

Finally, the dried precipitate was subjected to column chromatography, which yielded the desired compound **9a-d**.

2-phenylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (9a) : The compound chromatographed by using of 7:10 ethyl acetate/hexane, obtained **9a** yellow solid (M.pt. 266-268°C) (112 mg, 82% yield). **^{1}H NMR** (400 MHz, $CDCl_3$ + DMSO) δ 12.27 (s, 1H), 9.51 (s, 1H), 8.72 (d, *J* = 7.9 Hz, 1H), 8.10 (d, *J* = 8.1 Hz, 1H), 7.93 (d, *J* = 3.2 Hz, 2H), 7.90 – 7.84 (m, 1H), 7.77 – 7.69 (m, 1H), 7.64 (s, 1H), 7.59 – 7.45 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.7, 146.7, 146.5, 141.3, 131.5, 129.9, 128.7, 127.0 (two carbon merged), 126.4, 126.3, 125.8 (two carbon merged), 125.7, 123.1, 120.8, 114.0, 96.3. **HRMS** (ESI) calcd. for $C_{18}H_{13}ON_2$ $(M+H)^+$ 273.1022, found 273.1019.

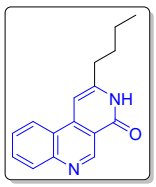


2-(*p*-tolyl)benzo[*c*][2,7]naphthyridin-4(3*H*)-one (9b) : The compound chromatographed by using of 7:10 ethyl acetate/hexane, obtained **9b** yellow solid (M.pt. 260-262°C) (113 mg, 79% yield). **^{1}H NMR** (400 MHz, $CDCl_3$ + DMSO) δ 12.25 (s, 1H), 9.52 (s, 1H), 8.88 (d, *J* = 8.1 Hz, 1H), 8.15 (d, *J* = 8.2 Hz, 1H), 7.96 (dd, *J* = 11.8, 7.7 Hz, 3H), 7.81 (d, *J* = 7.4 Hz, 1H), 7.78 (s, 1H), 7.42 (d, *J* = 8.0 Hz, 2H), 2.45 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 167.7, 154.1, 152.6, 152.4, 147.5, 145.6, 136.7, 135.5 (two carbon merged), 134.7, 134.4, 132.6 (two carbon merged), 132.5, 130.1, 127.5, 120.7, 102.7, 26.1. **HRMS** (ESI) calcd. for $C_{19}H_{15}ON_2$ $(M+H)^+$ 287.1179, found 287.1175.



2-propylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (9c) : The compound chromatographed by using of 7:10 ethyl acetate/hexane, obtained **9b** light red solid (M.pt. 244-246°C) (82 mg, 69% yield). **^{1}H NMR** (400 MHz, $CDCl_3$ + DMSO) δ 12.00 (s, 1H), 9.65 (s, 1H), 8.32 (d, *J* = 7.7 Hz, 1H), 8.19 (d, *J* = 8.3 Hz, 1H), 7.83 (ddd, *J* = 8.3, 7.0, 1.3 Hz, 1H), 7.66 (ddd, *J* = 8.2, 7.1, 1.2 Hz, 1H), 2.84 – 2.79 (m, 2H), 1.92 (dq, *J* = 14.8, 7.4 Hz, 2H), 1.10 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (75 MHz, $CDCl_3$) δ 163.7, 149.9, 149.3, 147.3, 143.1, 131.4, 129.2, 127.1, 123.6, 122.1, 115.3, 98.6, 35.8, 21.8, 13.4. **HRMS** (ESI) calcd. for $C_{15}H_{15}ON_2$ $(M+H)^+$ 239.1179, found 239.1175.

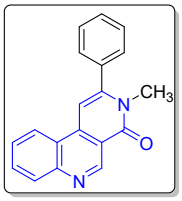
2-butylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (9d) : The compound chromatographed by using of 7:10 ethyl acetate/hexane, obtained **9b** light red solid (M.pt. 220-222°C) (90 mg, 71% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 11.99 (s, 1H), 9.58 (s, 1H), 8.27 (d, *J* = 8.3 Hz, 1H), 8.16 (d, *J* = 8.2 Hz, 1H), 7.78 (t, *J* = 7.6 Hz, 1H), 7.61 (t, *J* = 7.5 Hz, 1H), 7.00 (s, 1H), 2.77 (t, *J* = 7.7 Hz, 2H), 1.79 (dt, *J* = 15.2, 7.6 Hz, 2H), 1.45 (dq, *J* = 14.6, 7.3 Hz, 2H), 0.96 (t, *J* = 7.3 Hz, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 164.3, 150.8, 149.3 (two carbon merged), 143.3, 131.5, 129.6, 127.3, 123.7, 122.3, 115.3, 98.8, 34.1, 30.7, 22.3, 13.8. **HRMS** (ESI) calcd. for $C_{16}H_{17}ON_2$ $(M+H)^+$ 253.1335, found 253.1333.



14. General procedure for compound 10a-d:

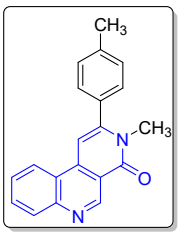
In 0.5 mmol of crude mixture of **8**, 4mL of a 40% aqueous methylamine solution was introduced. The reaction mixture was then stirred for 6 hours under controlled conditions of 80°C. Upon completion of the reaction, the resulting precipitate was filtered and dried. Finally, the dried precipitate was subjected to column chromatography, yielding the targeted compound **10a-d.**

3-methyl-2-phenylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (10a) : The compound chromatographed by using of 3:10 ethyl acetate/hexane, obtained **10a** yellow solid (M.pt. 138-140°C) (121 mg, 85% yield). **^{1}H**



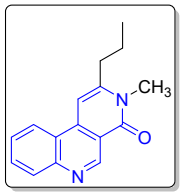
NMR (400 MHz, $CDCl_3$) δ 9.75 (s, 1H), 8.26 (d, *J* = 7.8 Hz, 1H), 8.20 (d, *J* = 8.2 Hz, 1H), 7.81 (ddd, *J* = 8.3, 7.0, 1.3 Hz, 1H), 7.65 – 7.59 (m, 1H), 7.58 – 7.53 (m, 3H), 7.51 – 7.46 (m, 2H), 7.11 (s, 1H), 3.50 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.6, 150.6, 150.2, 147.6, 140.3, 135.5, 131.1, 129.9, 129.7, 128.9 (two carbon merged), 128.4 (two carbon merged), 127.1, 123.3, 122.0, 115.7, 101.7, 34.3. **HRMS** (ESI) calcd. for $C_{19}H_{15}ON_2$ $(M+H)^+$ 287.1179, found 287.1176.

3-methyl-2-(*p*-tolyl)benzo[*c*][2,7]naphthyridin-4(3*H*)-one (10b) : The compound chromatographed by using of



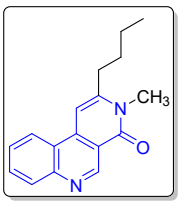
3:10 ethyl acetate/hexane, obtained **10b** yellow solid (M.pt. 228-230°C) (114 mg, 76% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.75 (s, 1H), 8.26 (d, *J* = 7.9 Hz, 1H), 8.20 (d, *J* = 8.3 Hz, 1H), 7.81 (ddd, *J* = 8.3, 7.0, 1.3 Hz, 1H), 7.62 (ddd, *J* = 8.2, 7.1, 1.1 Hz, 1H), 7.40 – 7.32 (m, 4H), 7.10 (s, 1H), 3.51 (s, 3H), 2.47 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.7, 150.9, 150.2, 147.5, 140.4, 140.0, 132.7, 131.1, 129.8, 129.6 (two carbon merged), 128.3 (two carbon merged), 127.1, 123.4, 122.1, 115.7, 101.6, 34.3, 21.4. **HRMS** (ESI) calcd. for $C_{20}H_{17}ON_2$ $(M+H)^+$ 301.1335, found 301.1334.

3-methyl-2-propylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (10c) : The compound chromatographed by using of



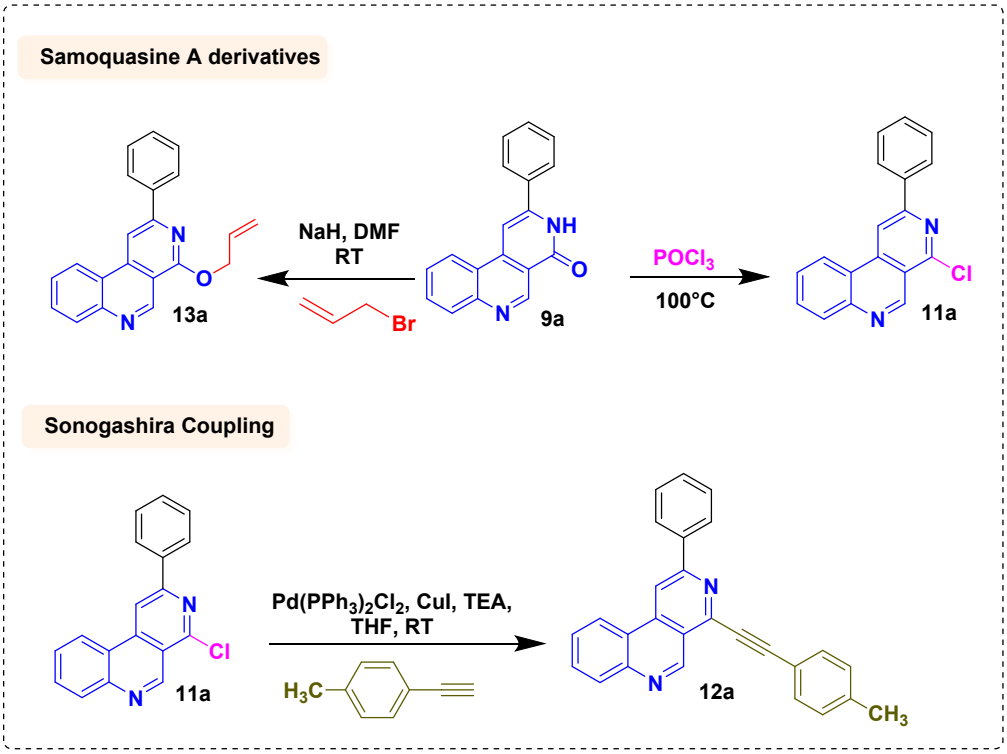
3:10 ethyl acetate/hexane, obtained **10c** light red solid (M.pt. 170-172°C) (96 mg, 76% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.69 (s, 1H), 8.30 (dd, *J* = 8.3, 1.1 Hz, 1H), 8.16 (dd, *J* = 8.3, 0.8 Hz, 1H), 7.81 (ddd, *J* = 8.3, 7.0, 1.4 Hz, 1H), 7.64 (ddd, *J* = 8.2, 7.0, 1.2 Hz, 1H), 7.02 (s, 1H), 3.67 (s, 3H), 2.80 – 2.76 (m, 2H), 1.81 (dq, *J* = 14.9, 7.4 Hz, 2H), 1.12 (t, *J* = 7.3 Hz, 3H). **^{13}C NMR** (75 MHz, $CDCl_3$) δ 162.8, 150.5 (two carbon merged), 147.8, 140.1, 130.8, 130.1, 126.8, 123.2, 121.8, 115.1, 99.0, 36.4, 30.7, 21.4, 13.8. **HRMS** (ESI) calcd. for $C_{16}H_{17}ON_2$ $(M+H)^+$ 253.1335, found 253.1332.

2-butyl-3-methylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (10d) : The compound chromatographed by using of



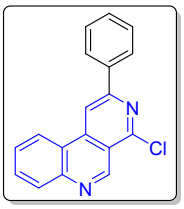
3:10 ethyl acetate/hexane, obtained **10c** light red semi-solid (101 mg, 76% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.66 (s, 1H), 8.31 (d, *J* = 8.2 Hz, 1H), 8.16 (d, *J* = 8.2 Hz, 1H), 7.85 – 7.78 (m, 1H), 7.68 – 7.61 (m, 1H), 7.02 (s, 1H), 3.67 (s, 3H), 2.85 – 2.75 (m, 2H), 1.76 (dt, *J* = 15.4, 7.6 Hz, 2H), 1.54 (dq, *J* = 14.5, 7.4 Hz, 3H), 1.04 (t, *J* = 7.3 Hz, 3H). **^{13}C NMR** (75 MHz, $CDCl_3$) δ 162.9, 151.0, 150.5, 147.7, 140.4, 131.0, 130.0, 126.9, 123.3, 121.8, 115.1, 99.1, 34.3, 30.8, 30.3, 22.5, 13.8. **HRMS** (ESI) calcd. for $C_{17}H_{19}ON_2$ $(M+H)^+$ 267.1492, found 267.1489.

15. Further synthetic transformation of Samoquasine A derivatives:



16. Synthetic procedure for compound 11a:

In a nitrogen-purged reaction vial, 0.5 mmol of compound **9a** was carefully weighed. Subsequently, 3 mL of $POCl_3$ was added to the reaction vial, and the mixture was heated to 100°C for 12 hours. After completion of the reaction, the reaction mixture was quenched with crushed ice. The aqueous layer was neutralized with a saturated solution of sodium acetate (NaOAc), and the organic layer was extracted with ethyl acetate. The combined organic layers were then washed with brine and dried over anhydrous sodium sulfate (Na_2SO_4). Finally, the solvent was removed under reduced pressure to afford a crude residue. The residue was purified via column chromatography using silica gel (230-400 mesh) and a 1:10 mixture of ethyl acetate and hexane as the eluent, providing the pure desired product **11a**.



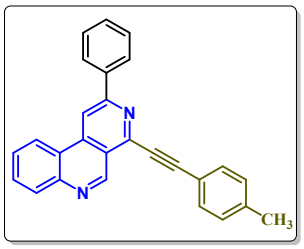
4-chloro-2-phenylbenzo[*c*][2,7]naphthyridine (11a) : The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **11a** white solid (M.pt. 189-191°C) (116 mg, 80% yield). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.72 (s, 1H), 8.68 (s, 1H), 8.61 (d, *J* = 8.0 Hz, 1H), 8.25 (d, *J* = 8.0 Hz, 1H), 8.22 – 8.18 (m, 2H), 7.93 – 7.86 (m, 1H), 7.81 – 7.75 (m, 1H), 7.55 (t, *J* = 7.3 Hz, 2H), 7.51 (dd, *J* = 8.3, 6.1 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 156.1, 152.2, 150.2, 146.0, 140.8, 137.4, 131.4, 130.6, 130.2, 129.0 (two carbon merged), 128.1, 127.5 (two carbon merged), 122.9, 121.7, 117.9, 110.7. **HRMS** (ESI) calcd. for $C_{18}H_{12}N_2Cl$ $(M+H)^+$ 291.0684, found 291.0679.

17. Synthetic procedure for compound 12a (Sonogashira coupling reaction of compound 11a):

Within a dried reaction vial, precise amounts of $Pd(PPh_3)_2Cl_2$ (5 mol%) and CuI (5 mol%) were carefully weighed, followed by the addition of compound **11a** (0.3 mmol). Subsequently, the vial was purged with nitrogen to create an inert atmosphere. Next, 3 mL of THF and 2 equivalents of triethylamine (TEA) were introduced to the

vial, and the resulting solution was stirred for 15 minutes. After this initial stirring, the *p*-Tolylacetylene (2 equivalents) was meticulously added dropwise to the stirring solution, and the reaction was allowed to proceed for 12 hours. Upon completion of the reaction, a celite pad was employed to remove any metal contaminants. The organic filtrate was then concentrated under reduced pressure using a rotary evaporator to yield a crude mixture. Finally, the crude mixture was purified via column chromatography, utilizing silica gel (230-400 mesh) and a 1:10 mixture of ethyl acetate and hexane as the eluent, affording the pure desired product **12a**.

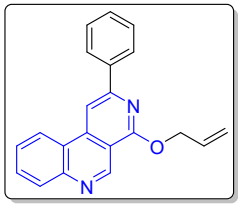
2-phenyl-4-(*p*-tolylethynyl)benzo[*c*][2,7]naphthyridine (12a) : The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **12a** light red solid (M.pt. 158-161°C) (102 mg, 92% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.94 (s, 1H), 8.69 (s, 1H), 8.65 (d, *J* = 8.1 Hz, 1H), 8.25 (t, *J* = 6.8 Hz, 3H), 7.89 (t, *J* = 7.5 Hz, 1H), 7.77 (t, *J* = 7.5 Hz, 1H), 7.68 (d, *J* = 7.9 Hz, 2H), 7.57 (t, *J* = 7.3 Hz, 2H), 7.54 – 7.49 (m, 1H), 7.28 (d, *J* = 1.9 Hz, 2H), 2.44 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 156.9, 151.6, 145.8, 145.0, 140.1, 138.7, 138.3, 132.3 (two carbon merged), 130.9, 130.5, 129.7, 129.4 (two carbon merged), 128.9 (two carbon merged), 127.7 (three carbon merged), 122.7, 122.1, 120.5, 118.6, 110.9, 95.9, 85.6, 21.7. **HRMS** (ESI) calcd. for $C_{27}H_{19}N_2$ $(M+H)^+$ 371.1543, found 371.1538.



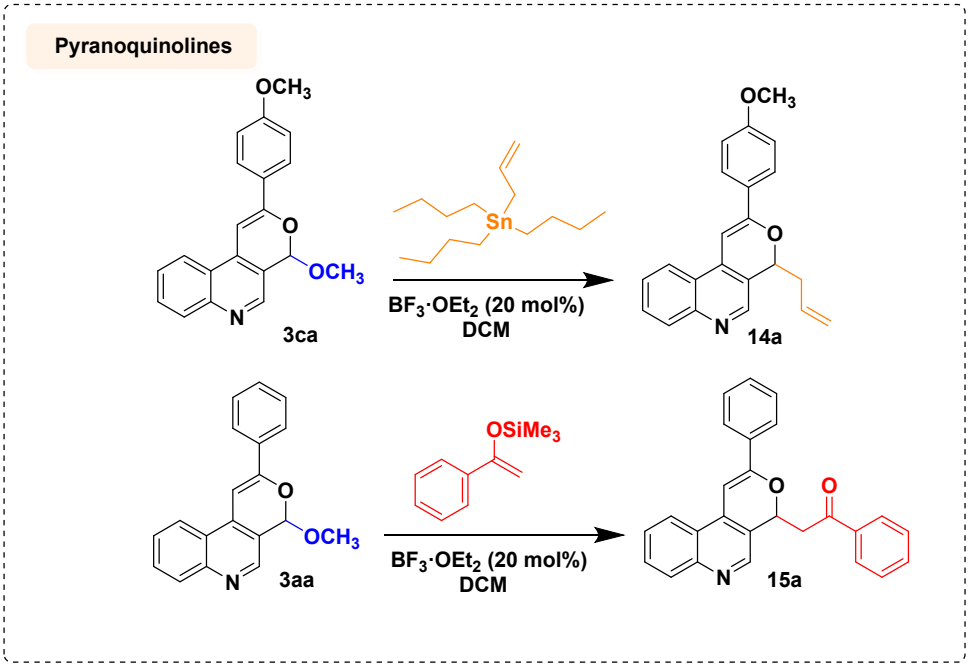
18. Synthetic procedure for compound 13a:

In a nitrogen-purged reaction vial, a precise amount (2 equiv) of NaH was carefully weighed. DMF (5 mL) was then added to the vial and stirred for 5 minutes to ensure complete dissolution. Subsequently, compound **9a** (0.5 mmol), dissolved in DMF, was slowly added dropwise until the evolution of hydrogen gas ceased. The resulting mixture was stirred for an additional 15 minutes at room temperature. Following this, allyl bromide was cautiously added dropwise to the stirring solution, and the reaction was allowed to proceed for 4 hours. Upon completion, the reaction mixture was quenched with saturated ammonium chloride (NH_4Cl) solution. A standard workup procedure was then performed using ethyl acetate to obtain the organic layer. This organic layer was dried (with Na_2SO_4) and concentrated under reduced pressure to yield a crude residue. Finally, the residue was purified via column chromatography using silica gel (230-400 mesh) and a mixture of ethyl acetate and hexane (1:5) as the eluent, affording the pure desired product **13a**.

4-(allyloxy)-2-phenylbenzo[*c*][2,7]naphthyridine (13a) : The compound chromatographed by using of 1:10 ethyl acetate/hexane, obtained **13a** light yellow solid (M.pt. 118-120°C) (117 mg, 75% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.66 (s, 1H), 8.55 (dd, *J* = 8.2, 0.9 Hz, 1H), 8.33 (s, 1H), 8.27 – 8.19 (m, 3H), 7.84 (ddd, *J* = 8.3, 7.1, 1.3 Hz, 1H), 7.71 (ddd, *J* = 8.2, 7.2, 1.2 Hz, 1H), 7.57 – 7.51 (m, 2H), 7.48 (ddd, *J* = 7.3, 3.6, 1.3 Hz, 1H), 6.28 (ddt, *J* = 17.1, 10.6, 5.6 Hz, 1H), 5.56 (ddd, *J* = 17.2, 3.1, 1.5 Hz, 1H), 5.37 (ddd, *J* = 10.5, 2.6, 1.2 Hz, 1H), 5.23 (dt, *J* = 5.6, 1.4 Hz, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.1, 154.8, 148.3, 145.4, 141.2, 138.6, 133.0, 130.8, 129.7 (two carbon merged), 128.8 (two carbon merged), 127.5, 127.3 (two carbon merged), 123.0, 122.6, 118.1, 110.03, 104.87, 67.40. **HRMS** (ESI) calcd. for $C_{21}H_{17}ON_2$ $(M+H)^+$ 313.1335, found 313.1330.

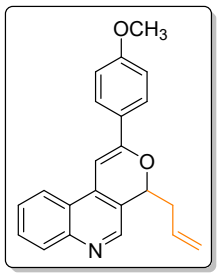


19. Further synthetic transformation of Pyranoquinolines products:



20. Synthetic procedure for compound 14a:

In a nitrogen atmosphere, 0.2 mmol of compound **3ca** was precisely measured and placed in a reaction vial. Dichloromethane (2 mL) was added, followed by the dropwise addition of 2 equivalents of allyl tributyltin to the stirred solution. After dissolving the starting materials, $BF_3.OEt_2$ (0.2 equiv) was added to the reaction mixture, which was then stirred for 6 hours until complete conversion of the starting material was observed. Following the reaction, a standard workup using a saturated solution of $NaHCO_3$ and DCM was performed. The organic layer containing the product was collected and evaporated using a rotary evaporator to yield a residue. This residue was subsequently subjected to column chromatography using 230-400 mesh silica gel and a 1:5 ratio of ethyl acetate and hexane as the eluent, successfully isolating the pure product.



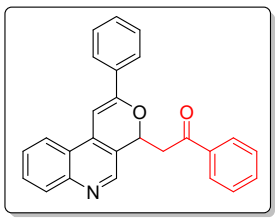
4-allyl-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (14a) : The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **14a** light yellow solid (M.pt. 115-117°C) (63 mg, 95% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.56 (s, 1H), 8.13 (d, *J* = 8.0 Hz, 1H), 8.06 (d, *J* = 8.2 Hz, 1H), 7.85 – 7.78 (m, 2H), 7.70 (td, *J* = 7.0, 3.5 Hz, 1H), 7.61 – 7.54 (m, 1H), 7.00 – 6.95 (m, 2H), 6.95 (s, 1H), 5.97 (ddt, *J* = 17.1, 10.2, 7.0 Hz, 1H), 5.61 (dd, *J* = 8.2, 5.3 Hz, 1H), 5.18 (d, *J* = 10.2 Hz, 1H), 5.13 (dd, *J* = 17.1, 1.5 Hz, 1H), 3.87 (s, 3H), 2.92 (dt, *J* = 15.4, 7.8 Hz, 1H), 2.63 (ddd, *J* = 13.3, 6.6, 5.4 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.3, 156.8, 148.0, 146.3, 135.6, 132.8, 129.7, 129.2, 127.7 (two carbon merged), 126.3, 126.2, 122.6, 122.2, 120.0, 118.8, 113.9 (two carbon merged), 92.6, 76.4, 55.4, 38.5. **HRMS** (ESI) calcd. for $C_{22}H_{20}O_2N$ $(M+H)^+$ 330.1489, found 330.1485.

21. Synthetic procedure for compound 15a:

In a nitrogen atmosphere, 0.2 mmol of compound **3aa** was precisely measured and placed in a reaction vial. Dichloromethane (2 mL) was added, followed by the dropwise addition of 1.2 equivalents of 1-styrenyloxytrimethylsilane to the stirred solution. After dissolving the starting materials, $BF_3.OEt_2$ was added to

the reaction mixture, which was then stirred for 6 hours until complete conversion of the starting material was observed. Following the reaction, a standard workup using a saturated solution of $NaHCO_3$ and DCM was performed. The organic layer containing the product was collected and evaporated using a rotary evaporator to yield a residue. This residue was subsequently subjected to column chromatography using 230-400 mesh silica gel and a 1:5 ratio of ethyl acetate and hexane as the eluent, successfully isolating the pure product.

1-phenyl-2-(2-phenyl-4*H*-pyrano[3,4-*c*]quinolin-4-yl)ethan-1-one 15a : The compound chromatographed by using of 1:5 ethyl acetate/hexane, obtained **15a** light red semi-solid (55 mg, 73% yield). **^{1}H NMR** (400 MHz, CDCl3) δ 8.73 (s, 1H), 8.16 (d, *J* = 8.4 Hz, 1H), 8.09 (d, *J* = 8.3 Hz, 1H), 7.94 (d, *J* = 7.5 Hz, 2H), 7.73 (dd, *J* = 14.5, 7.5 Hz, 3H), 7.63 – 7.57 (m, 1H), 7.56 – 7.50 (m, 1H), 7.44 – 7.36 (m, 4H), 7.13 (s, 1H), 6.39 (dd, *J* = 7.8, 5.0 Hz, 1H), 3.99 (dd, *J* = 16.6, 8.1 Hz, 1H), 3.40 (dd, *J* = 16.6, 4.9 Hz, 1H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 196.4, 156.8, 148.1, 146.2, 136.7, 135.2, 133.5, 133.4, 130.2, 129.8, 129.4, 128.6 (two carbon merged), 128.5 (two carbon merged), 128.2 (two carbon merged), 126.6, 126.0 (two carbon merged), 122.5, 122.2, 120.0, 94.4, 73.2, 42.3. **HRMS** (ESI) calcd. for $C_{26}H_{20}O_2N$ $(M+H)^+$ 378.1489, found 378.1482.



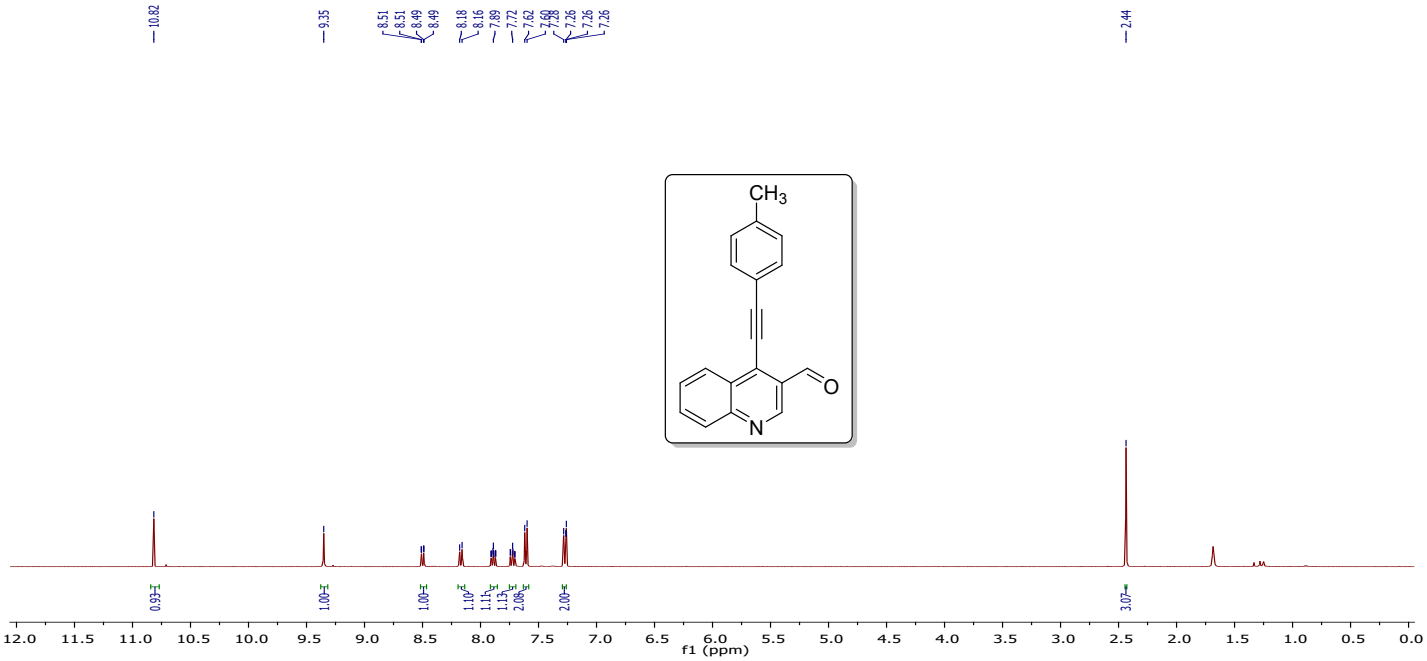
22. Reference:

1. Prakash, K. S.; Nagarajan, R. An Efficient Synthesis of Indol-3-Yl Benzonaphthyridines via Copper(II) Triflate-Catalyzed Heteroannulation. *Tetrahedron Lett.* 2013, **54**, 3635–3638.
2. Li, K.-T.; Lin, Y.-B.; Yang, D.-Y. One-Pot Synthesis of Pyranocoumarins via Microwave-Assisted Pseudo Multicomponent Reactions and Their Molecular Switching Properties. *Org. Lett.* 2012, **14**, 1190–1193.
3. Xiao, J.; Chen, Y.; Zhu, S.; Wang, L.; Xu, L.; Wei, H. Diversified Construction of Chromeno[3,4-*c*]Pyridin-5-one and Benzo[*c*]Chromen-6-one Derivatives by Domino Reaction of 4-Alkynyl-2-oxo-2*H* -chromene-3-carbaldehydes. *Adv. Synth. Catal.* 2014, **356**, 1835–1845.
4. Vani, D.; Chahal, K.; Preethi, P.; Balasubramanian, S.; Rajender Reddy, K. Synthesis of Substituted Pyrano[3,4-*b*]Quinolines by Silver-Catalyzed Regioselective Intramolecular Cyclization of 3-Alkynylquinoline Aldehydes. *Asian J. Org. Chem.* 2022, **11**, e202100740.
5. Chahal, K.; Vani, D.; Pranay, K.; Madhu, I.; Sridhar, B.; Reddy, K. R. Silver Catalyzed Cascade Strategy for the Synthesis of Diversely Substituted Polycyclic Fused 1,7-Naphthyridine Scaffolds. *ChemistrySelect* 2023, **8**, e202304260.

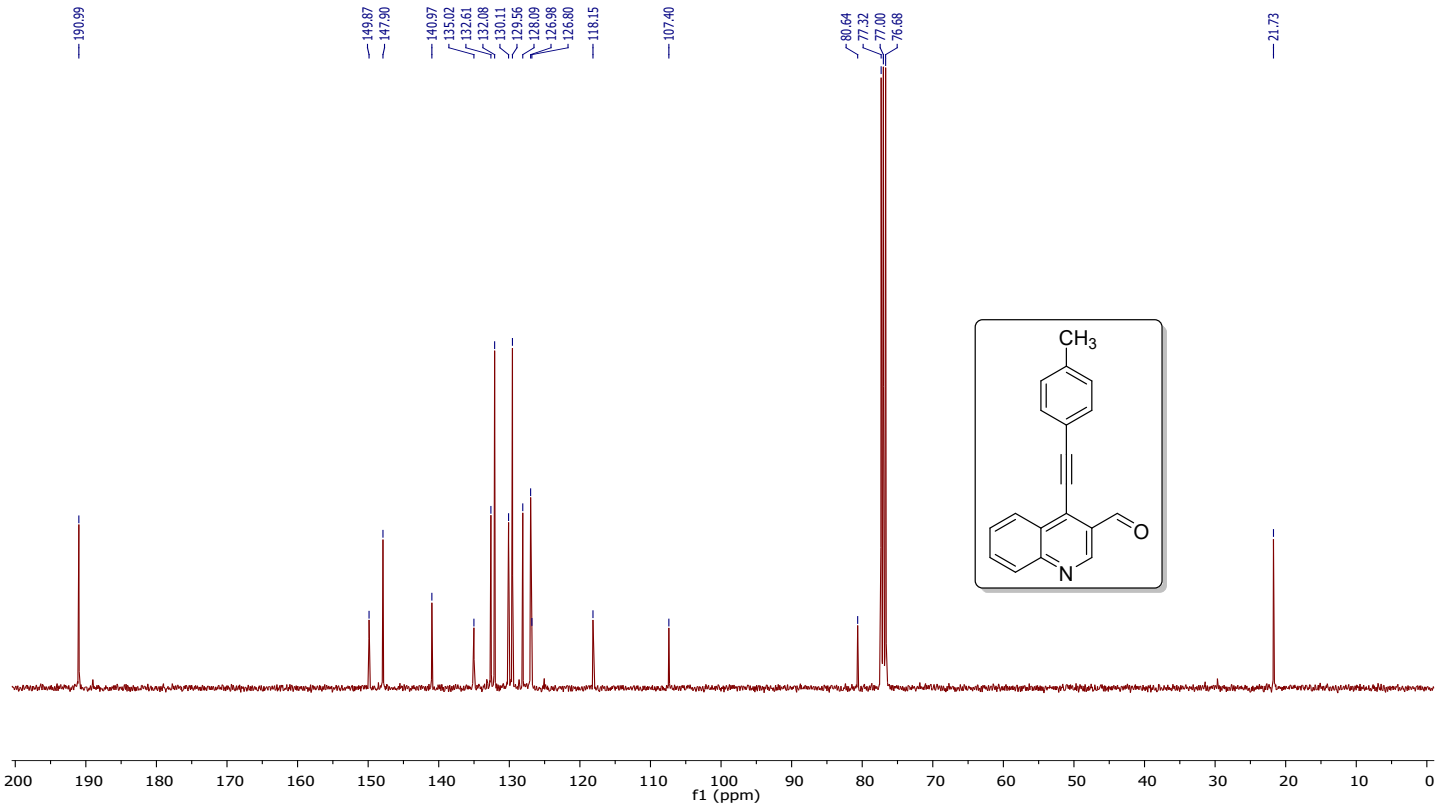
23. ^{1}H, ^{13}C & ^{19}F of compounds:

4-(*p*-tolylethynyl)quinoline-3-carbaldehyde (1b)

^{1}H NMR (400 MHz, $CDCl_3$)

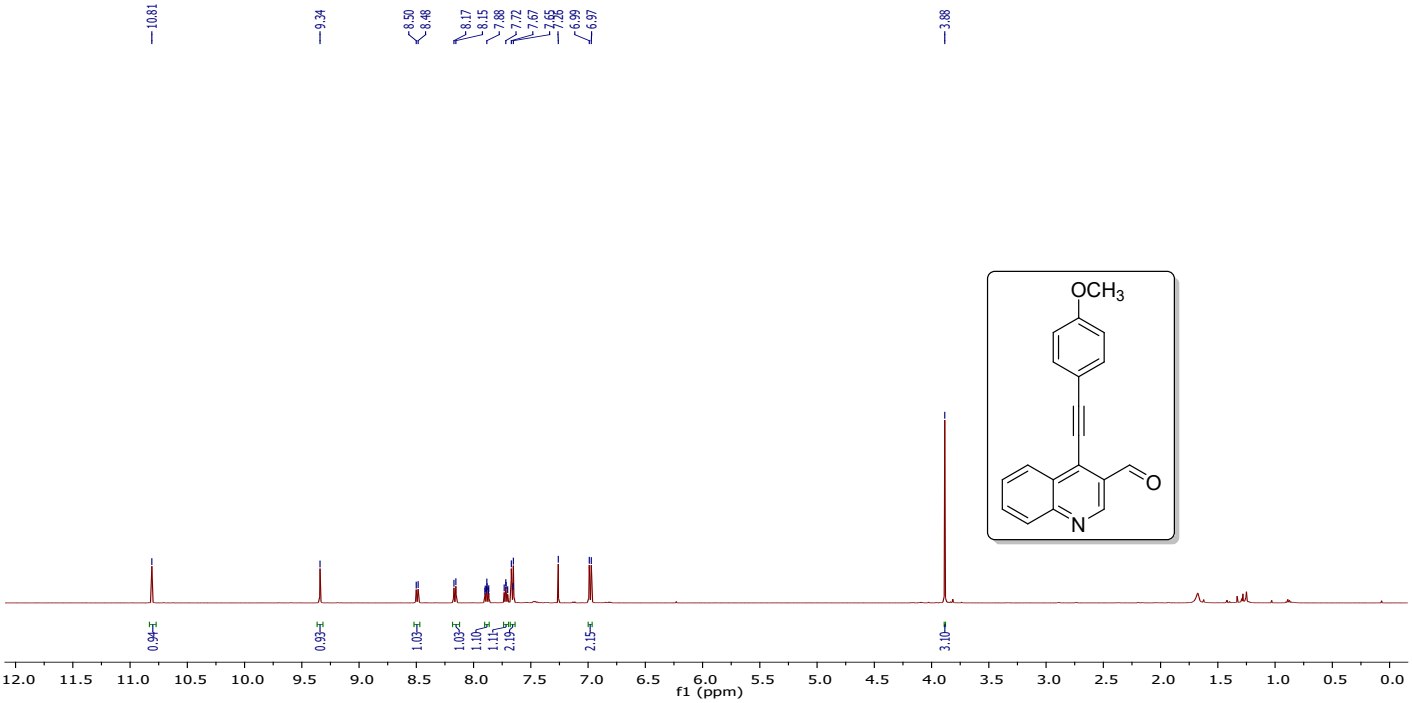


^{13}C NMR (101 MHz, $CDCl_3$)

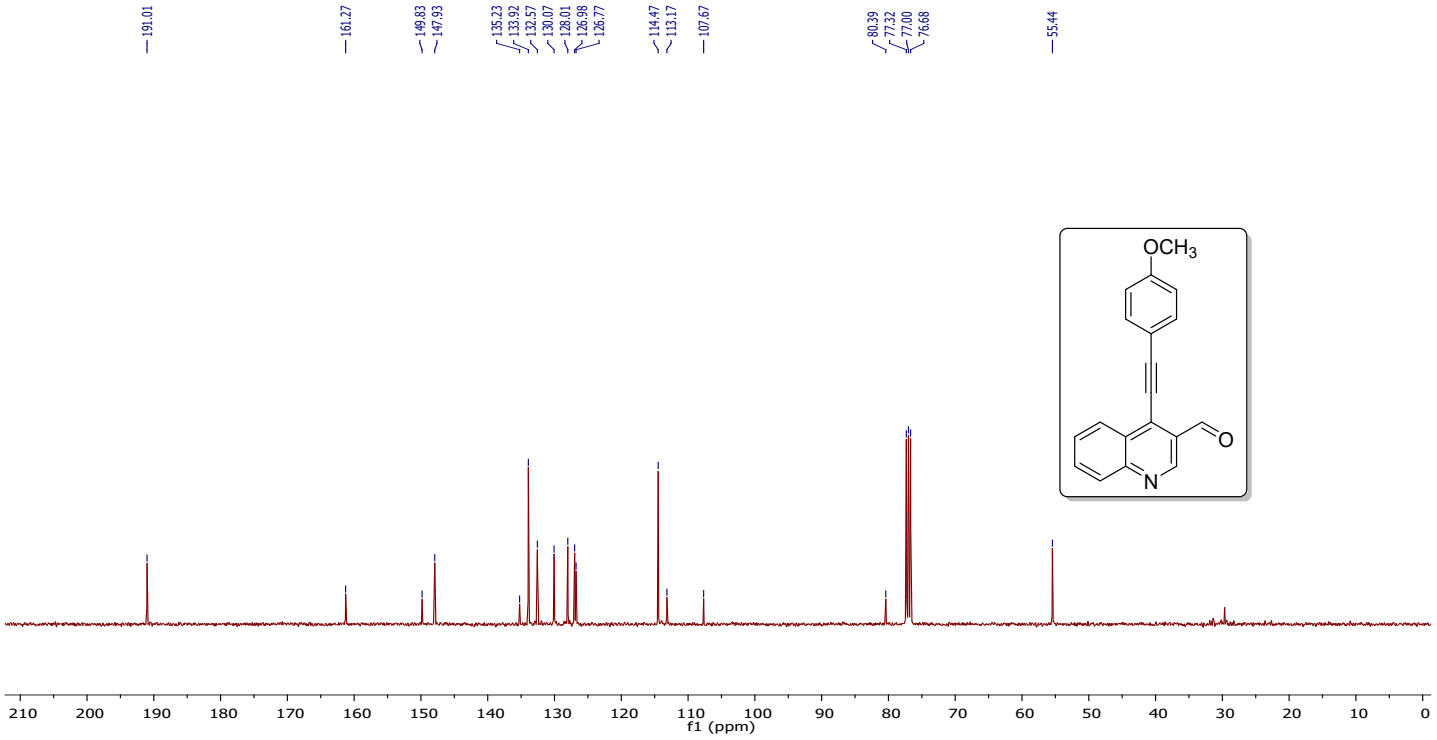

190.99
149.87
147.90
140.97
135.02
132.61
132.08
130.11
129.56
128.09
126.98
126.80
118.15
107.40
80.64
77.32
77.00
76.68
21.73
CH3
O
N
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4-((4-methoxyphenyl)ethynyl)quinoline-3-carbaldehyde (1c)

^{1}H NMR (500 MHz, $CDCl_3$)

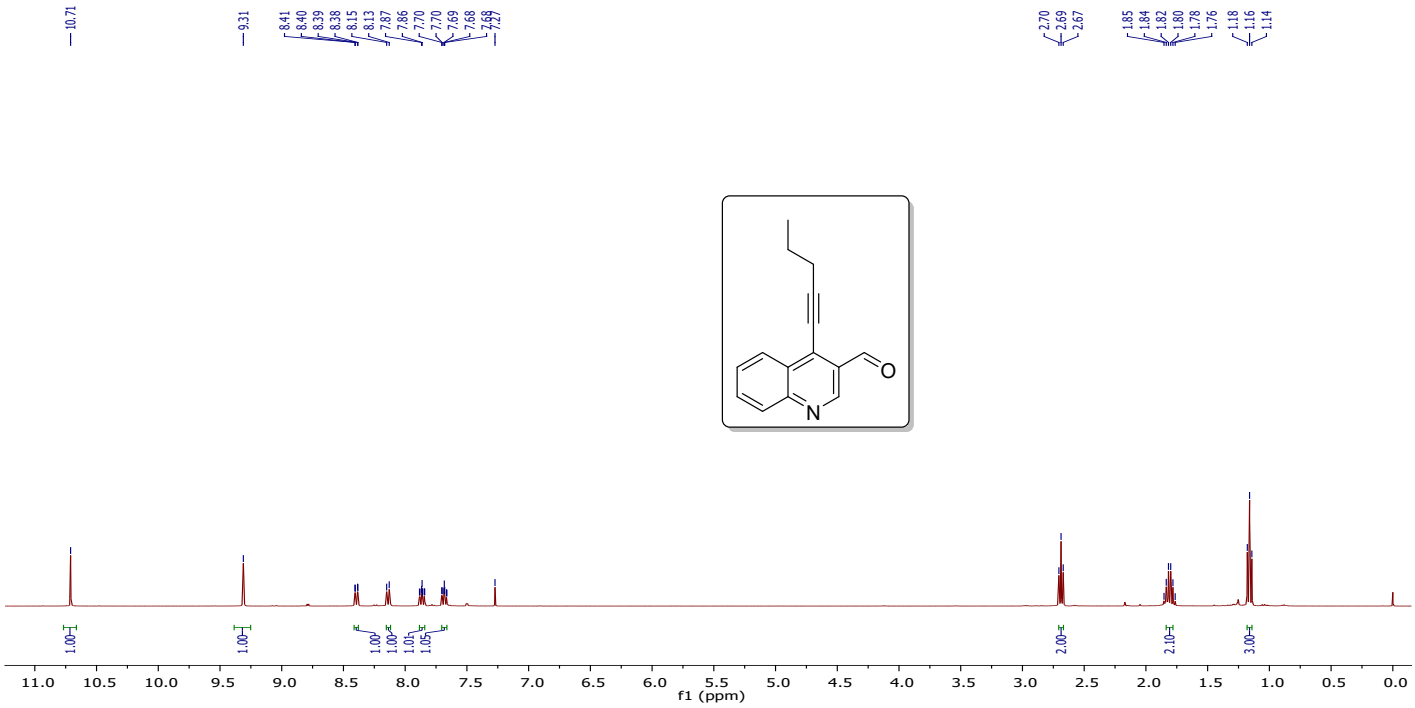


^{13}C NMR (101 MHz, $CDCl_3$)

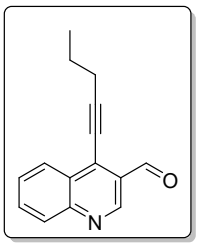


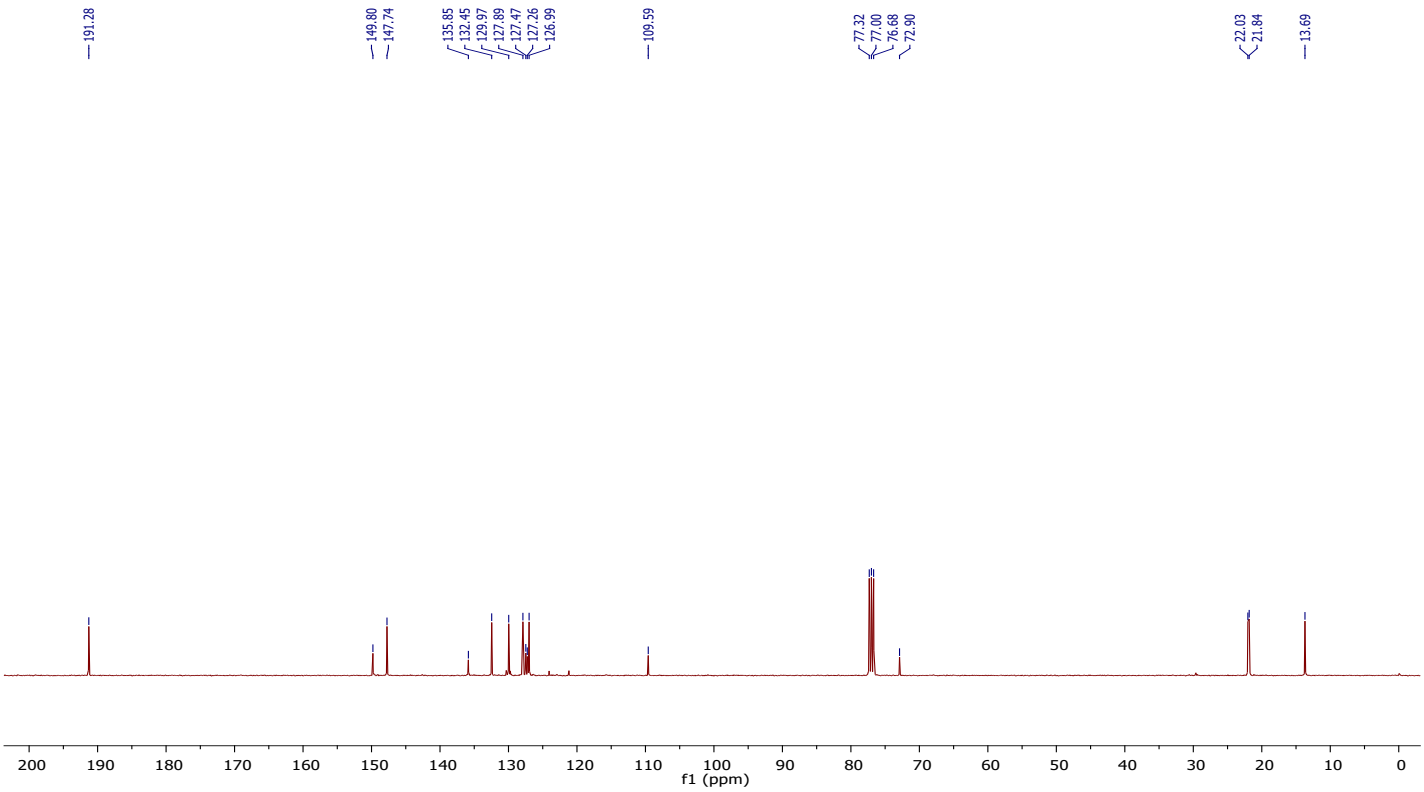
4-(pent-1-yn-1-yl)quinoline-3-carbaldehyde (1d)

^{1}H NMR (400 MHz, $CDCl_3$)



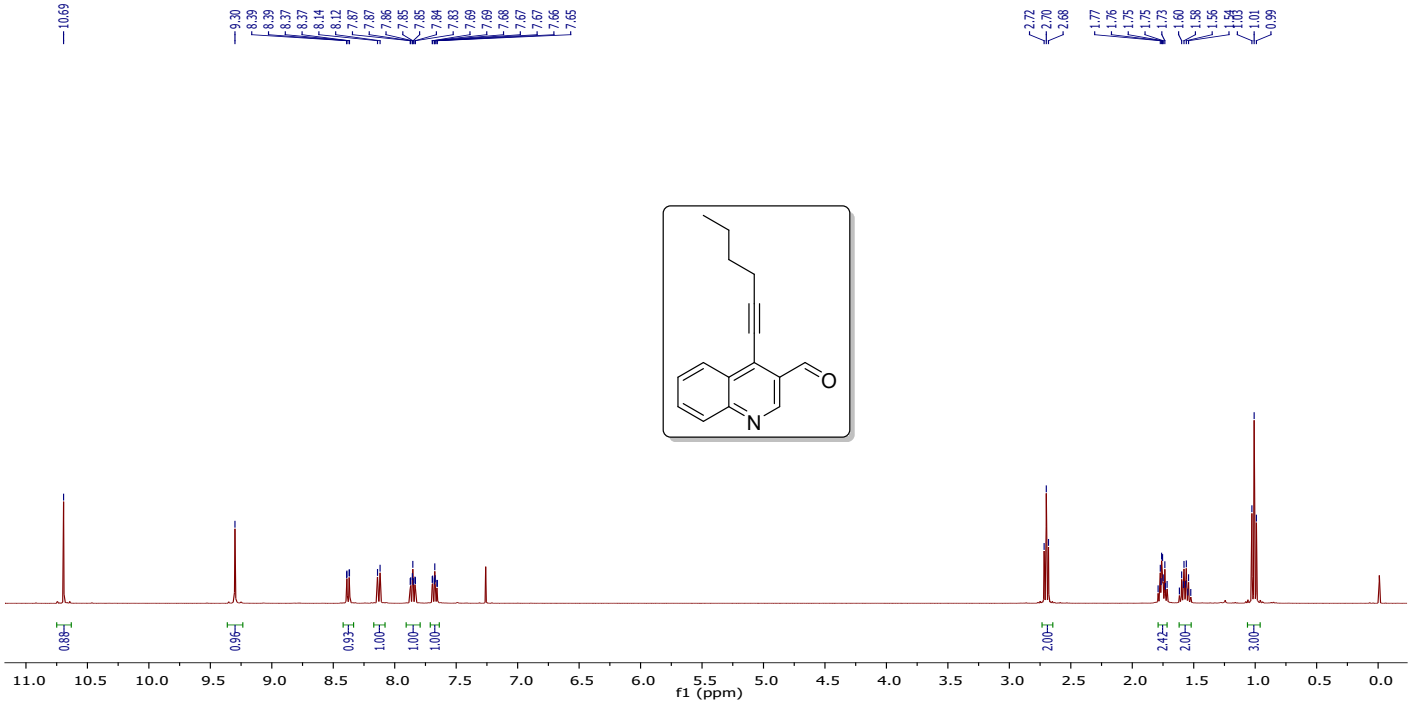
^{13}C NMR (101 MHz, $CDCl_3$)



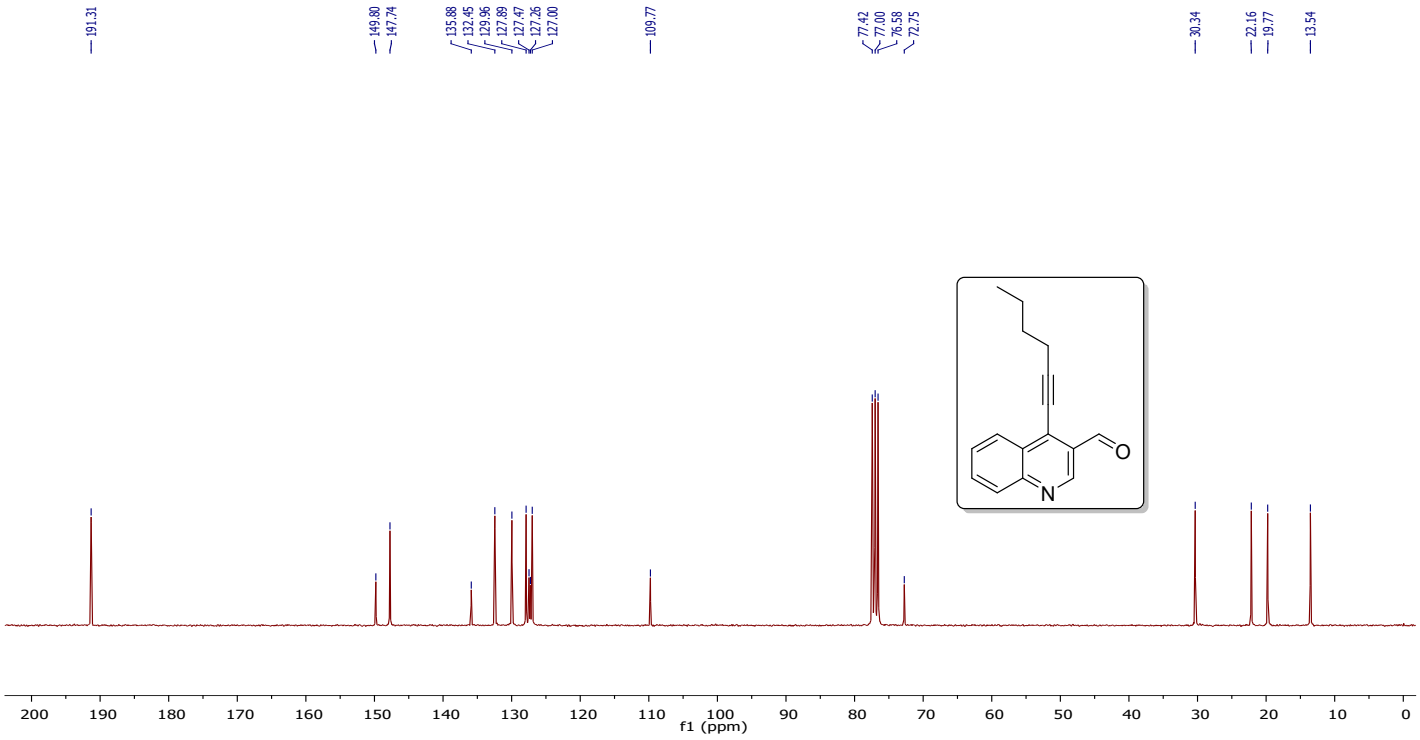

191.28
149.80
147.74
135.85
132.45
129.97
127.89
127.47
127.26
126.99
109.59
77.32
77.00
76.68
72.90
22.03
21.84
13.69
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4-(hex-1-yn-1-yl)quinoline-3-carbaldehyde (1e)

^{1}H NMR (400 MHz, $CDCl_3$)

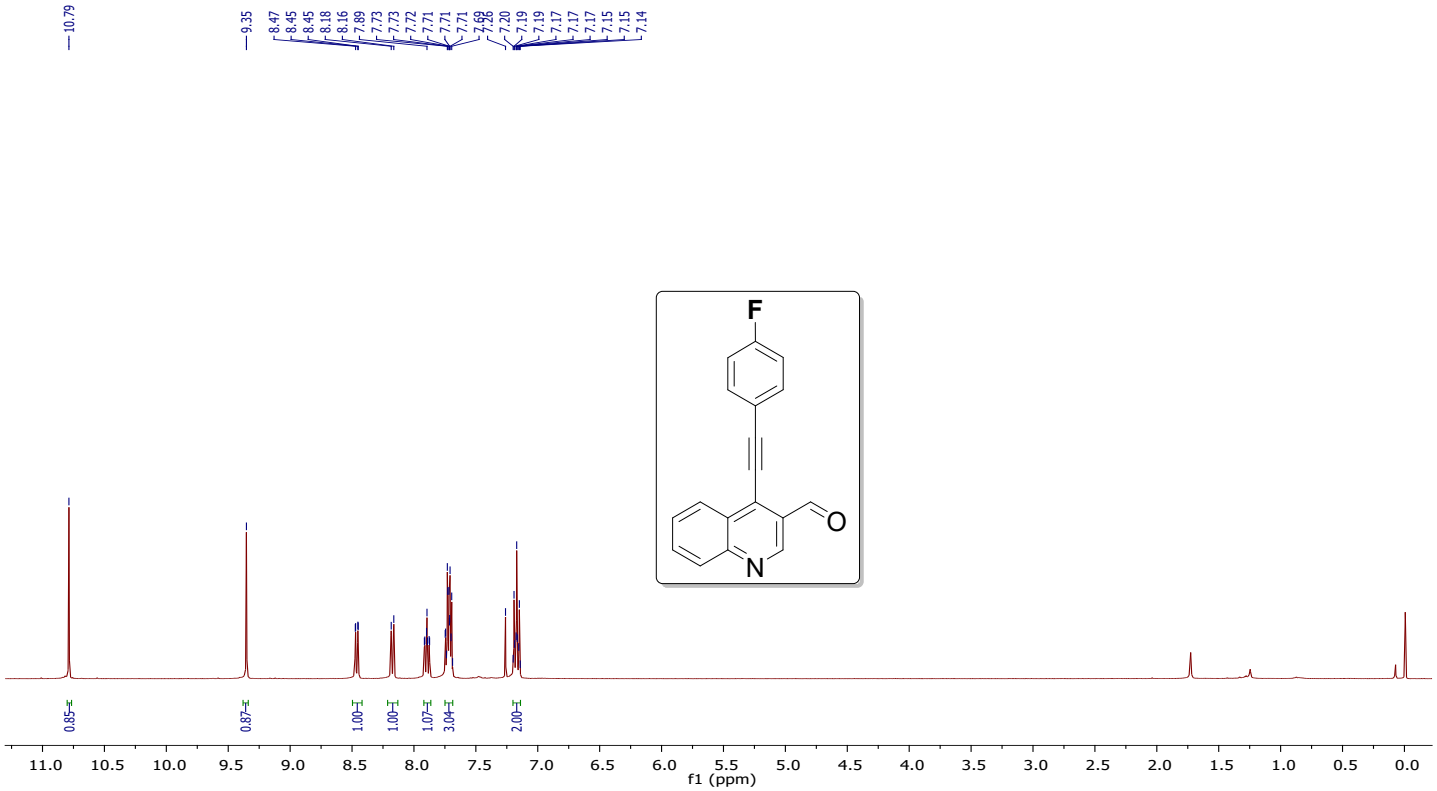


^{13}C NMR (75 MHz, $CDCl_3$)

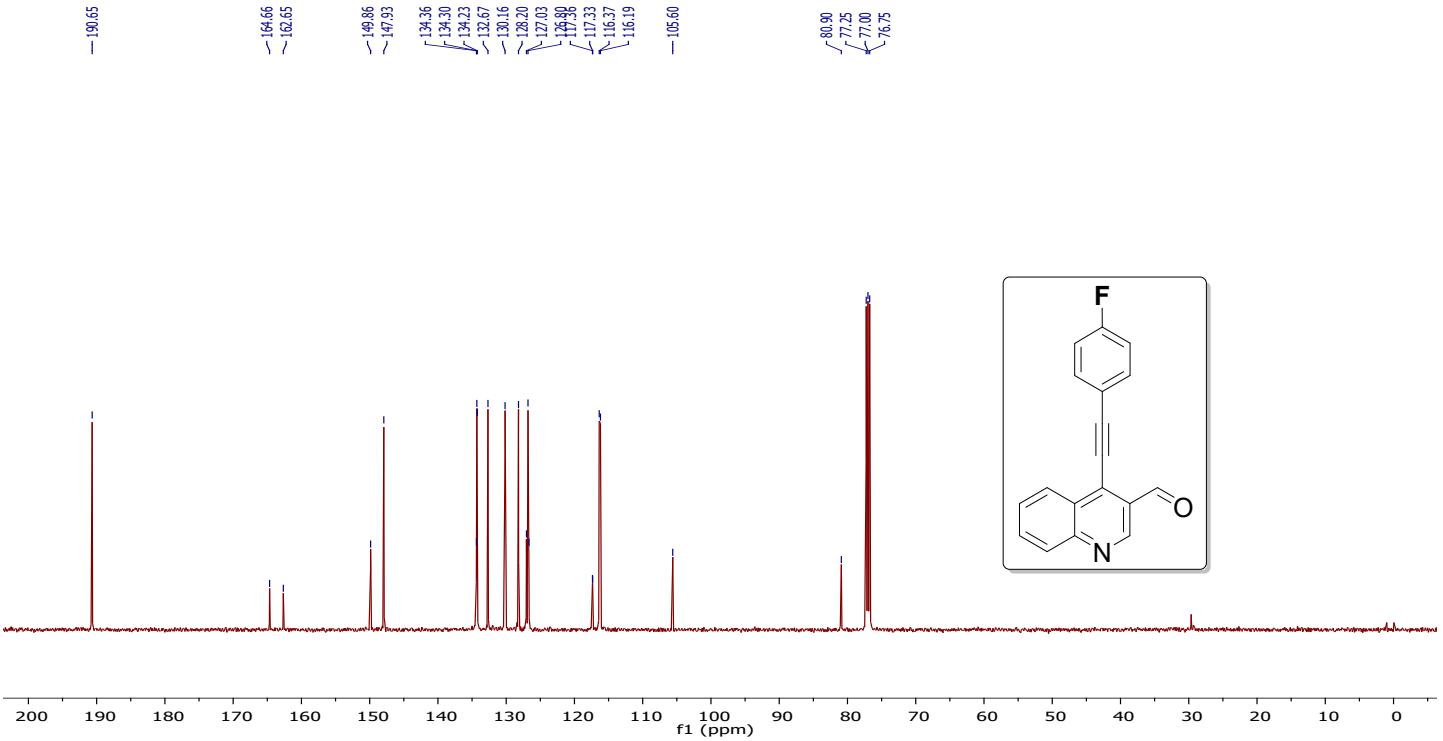


4-((4-fluorophenyl)ethynyl)quinoline-3-carbaldehyde (1f)

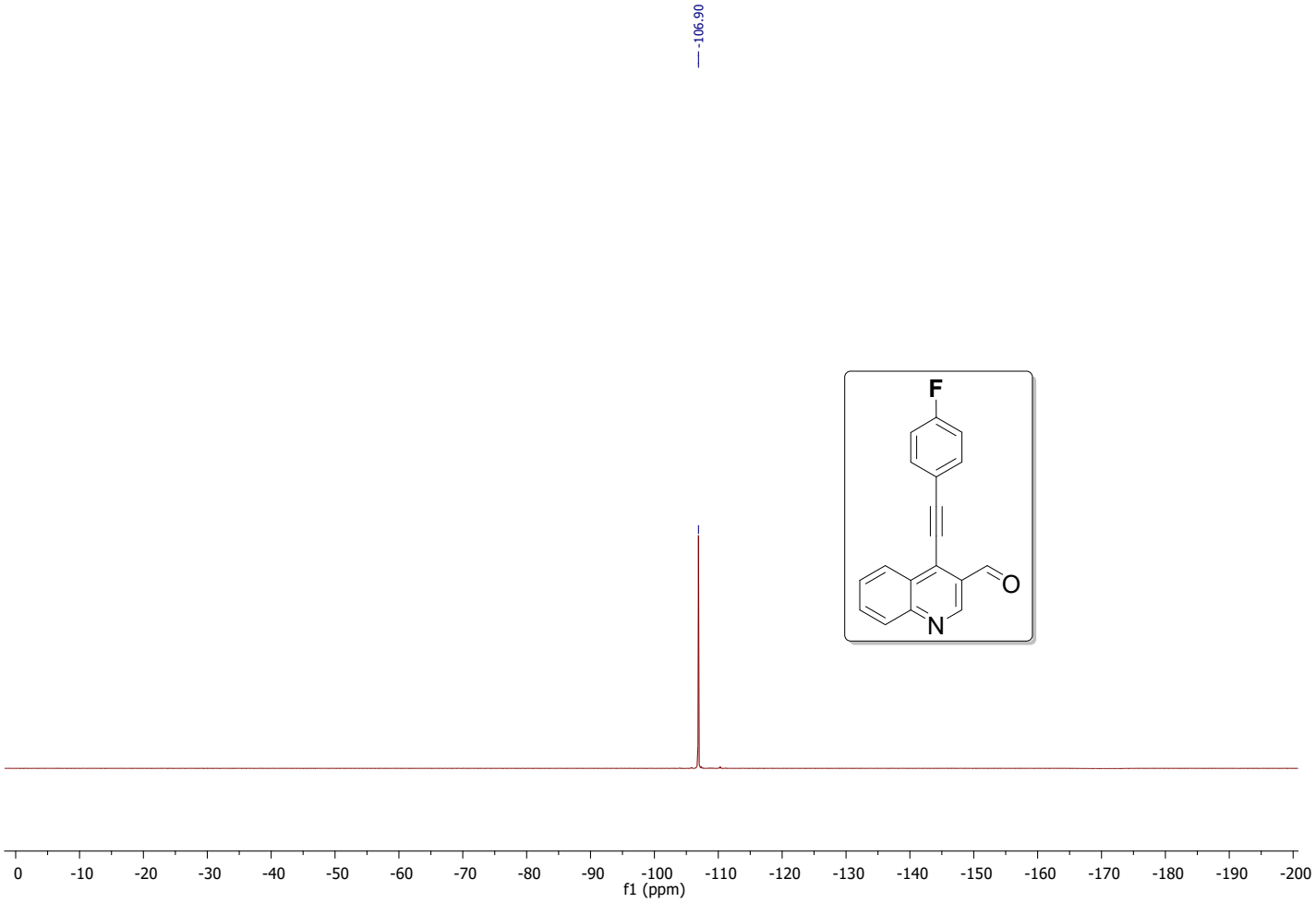
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (126 MHz, $CDCl_3$)

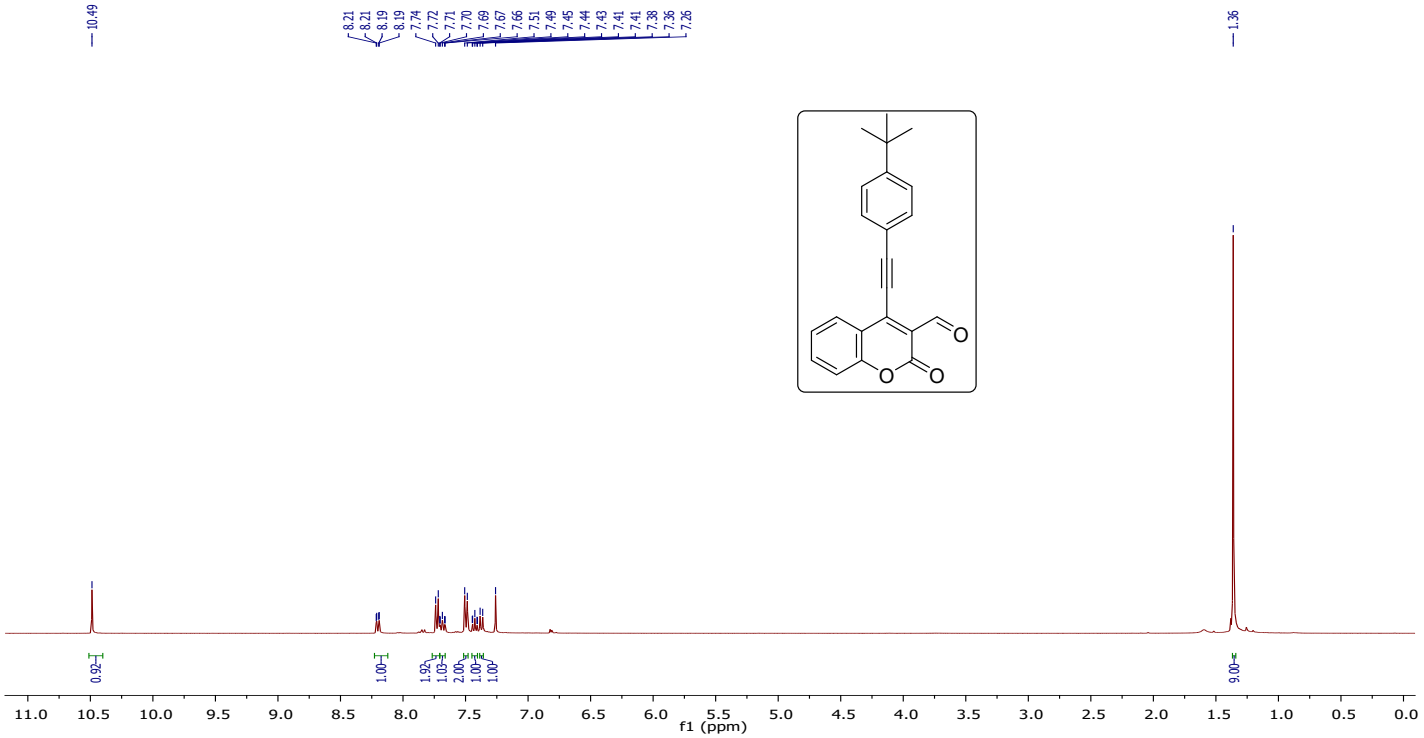


^{19}F NMR (377 MHz, $CDCl_3$)

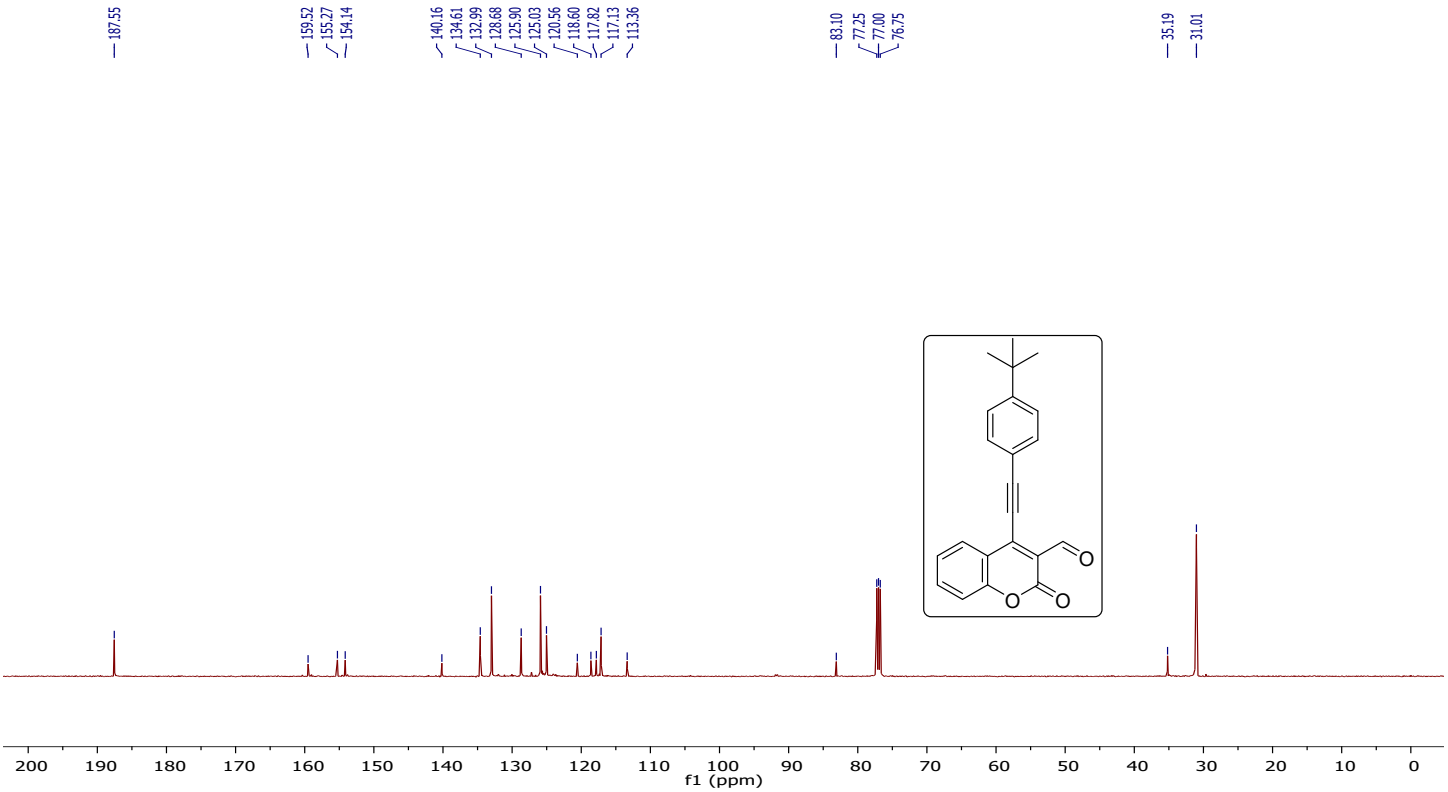


4-((4-(*tert*-butyl)phenyl)ethynyl)-2-oxo-2*H*-chromene-3-carbaldehyde (A_3)

^{1}H NMR (400 MHz, $CDCl_3$)

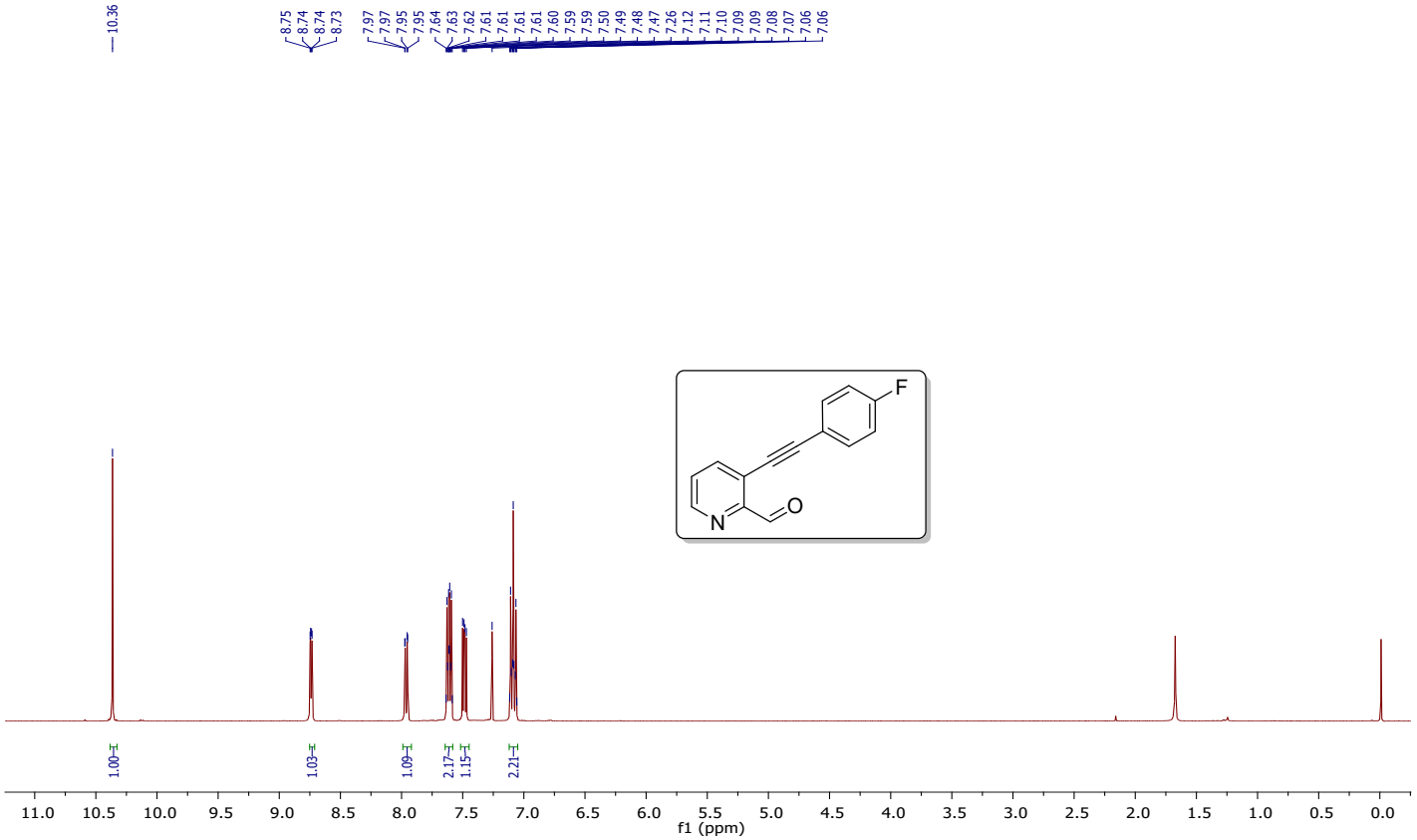


^{13}C NMR (126 MHz, $CDCl_3$)

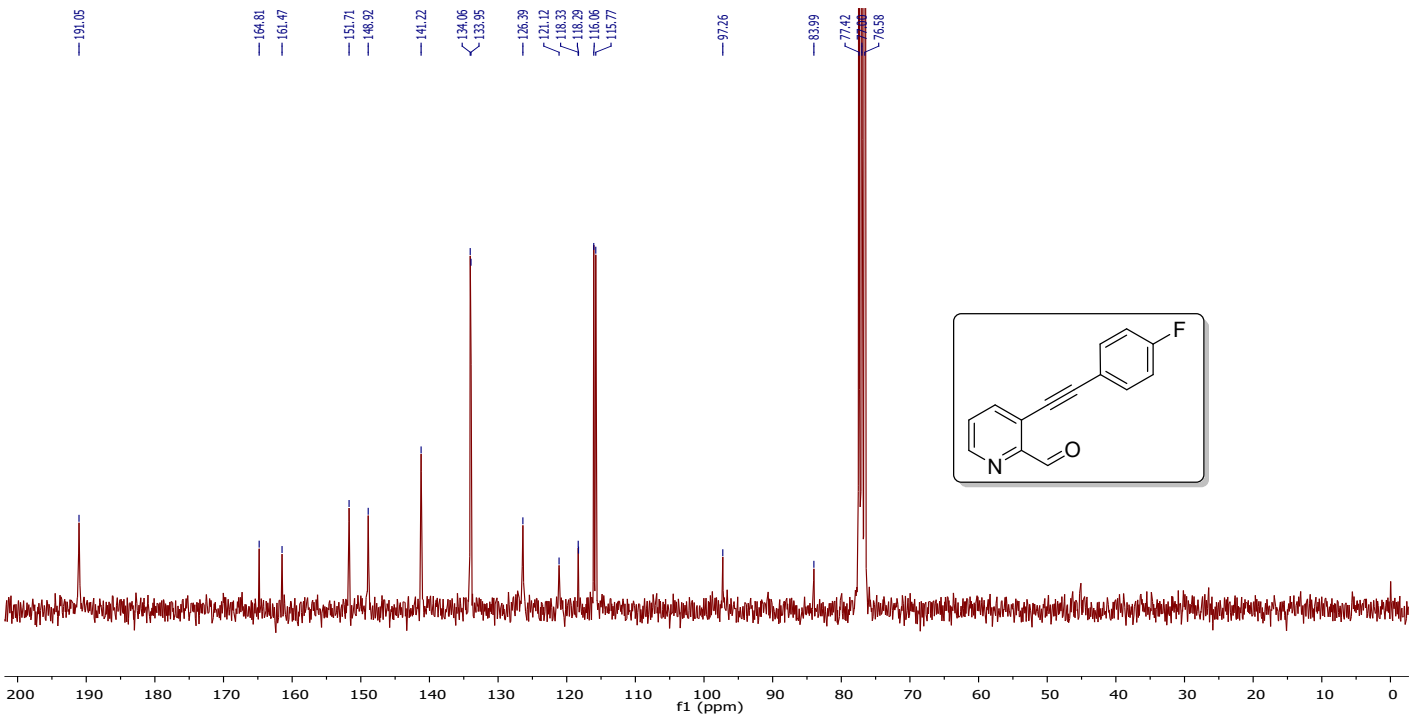


3-((4-fluorophenyl)ethynyl)picolinaldehyde (A_6)

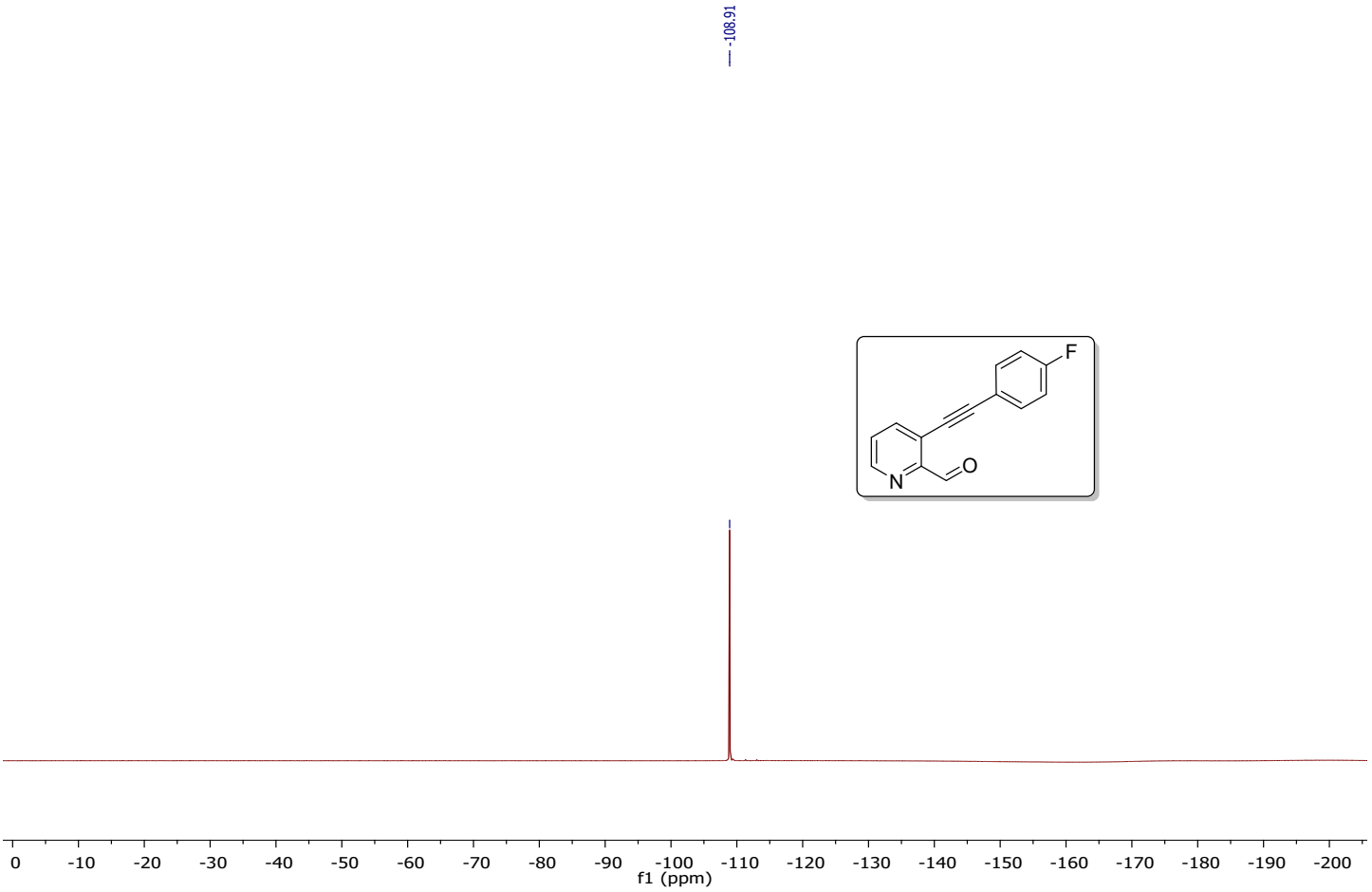
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (75 MHz, $CDCl_3$)

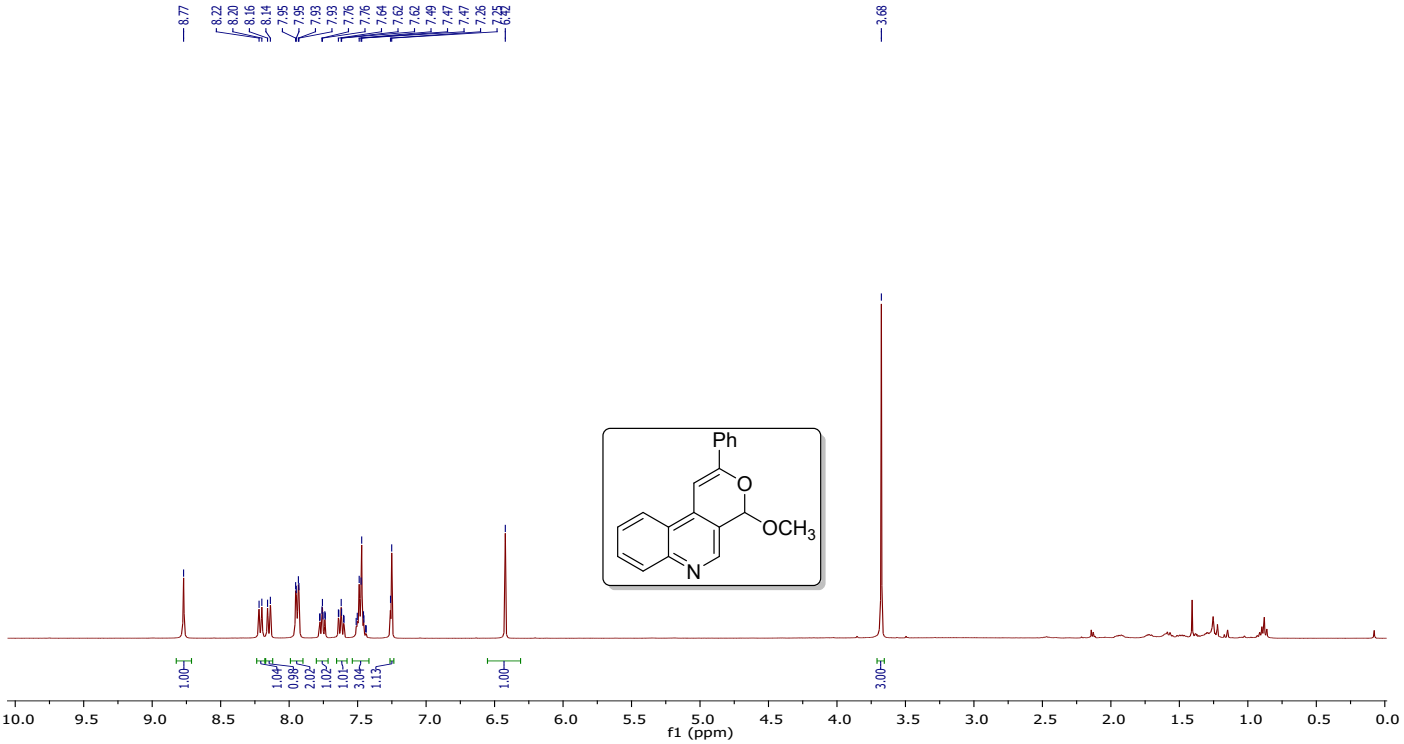


^{19}F NMR (376 MHz, $CDCl_3$)

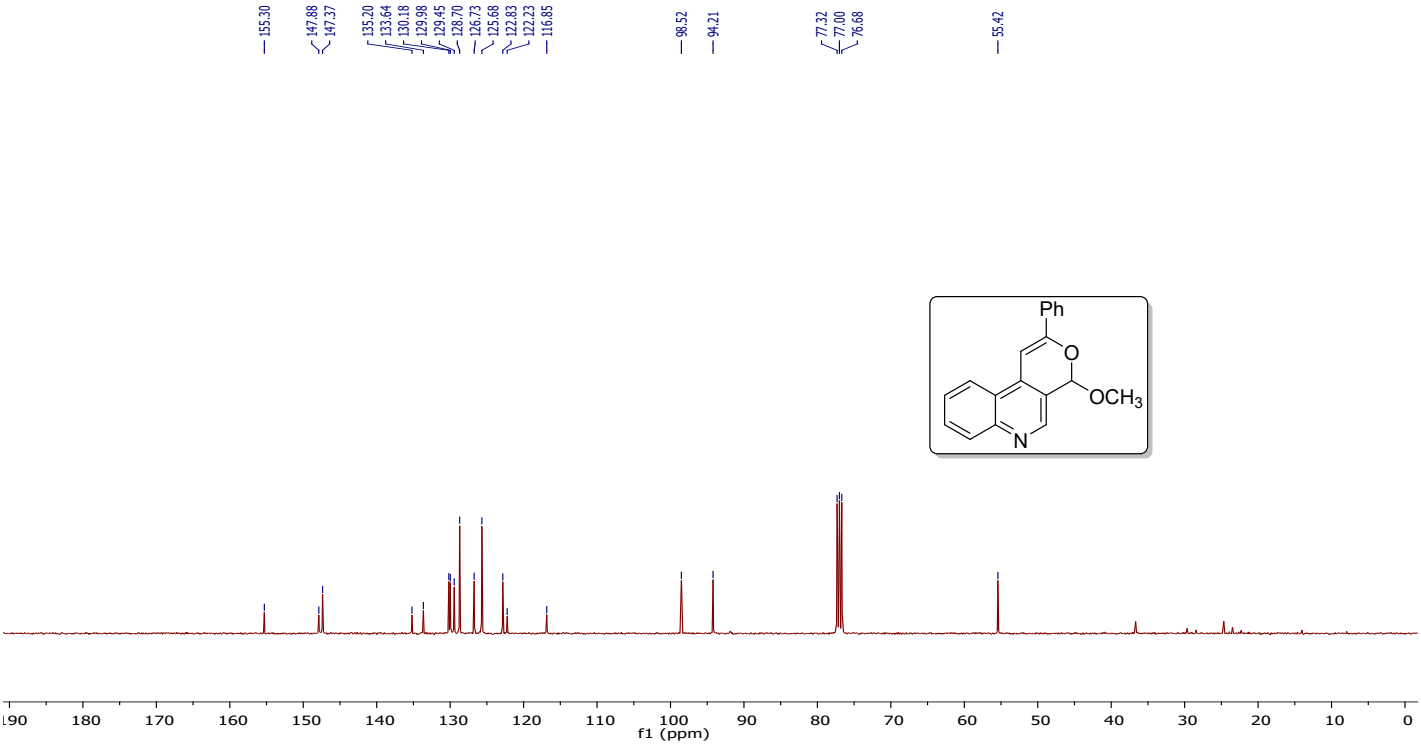


4-methoxy-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3aa)

^{1}H NMR (400 MHz, $CDCl_3$)

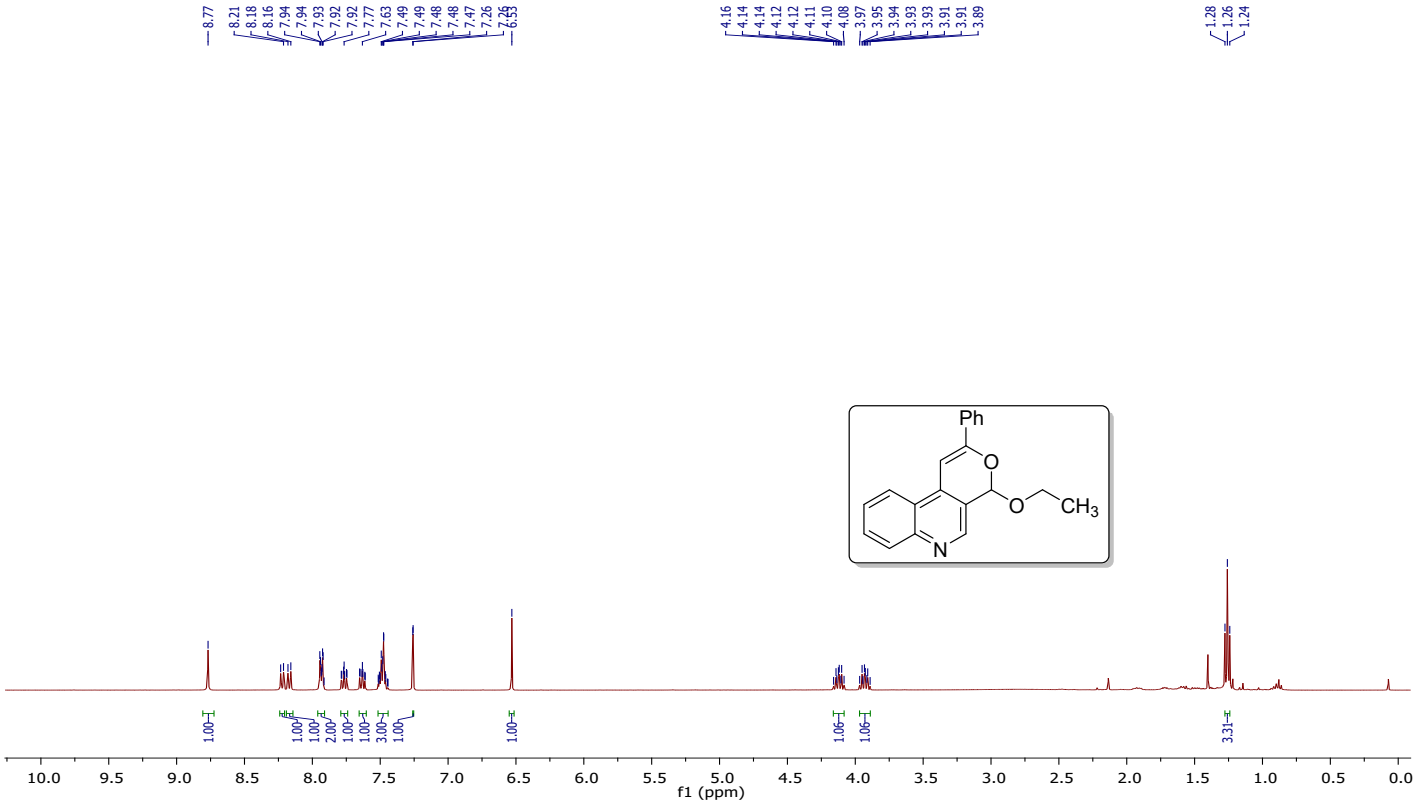


^{13}C NMR (101 MHz, $CDCl_3$)

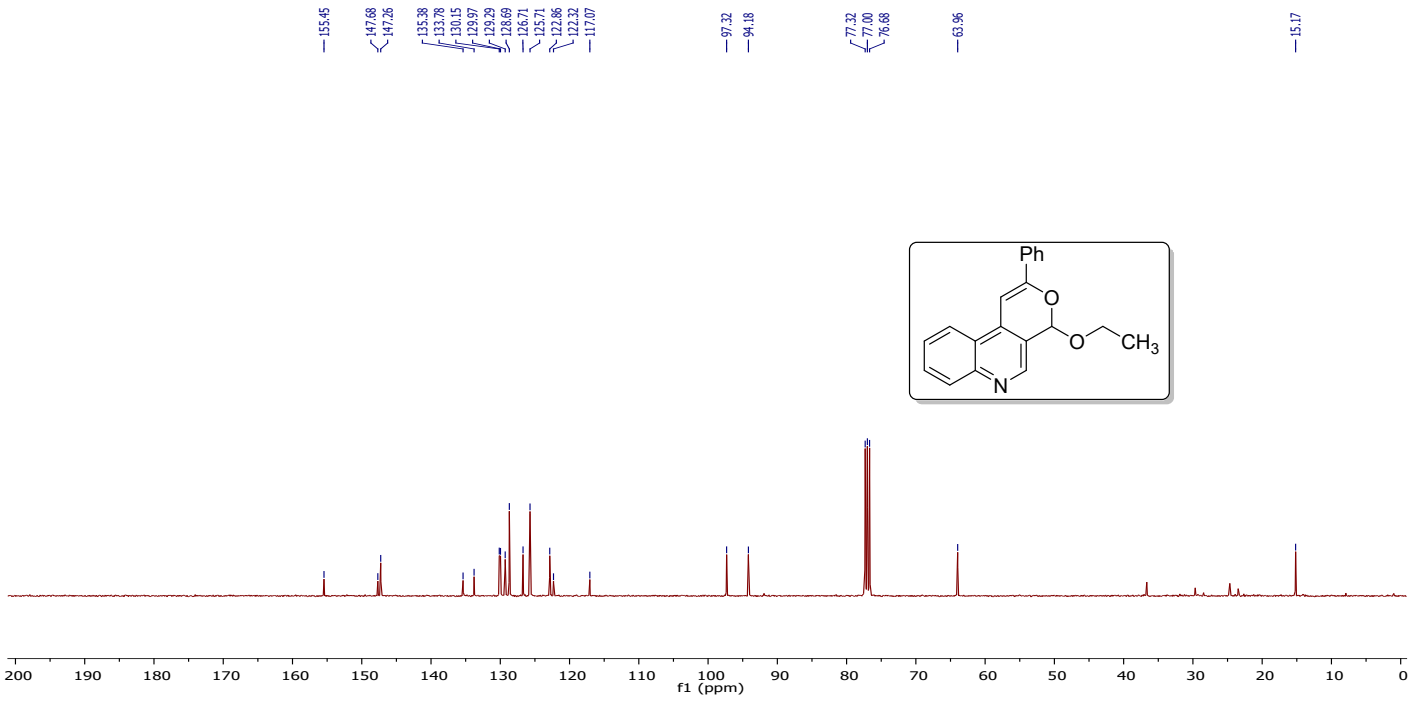


4-ethoxy-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3ab)

^{1}H NMR (400 MHz, $CDCl_3$)

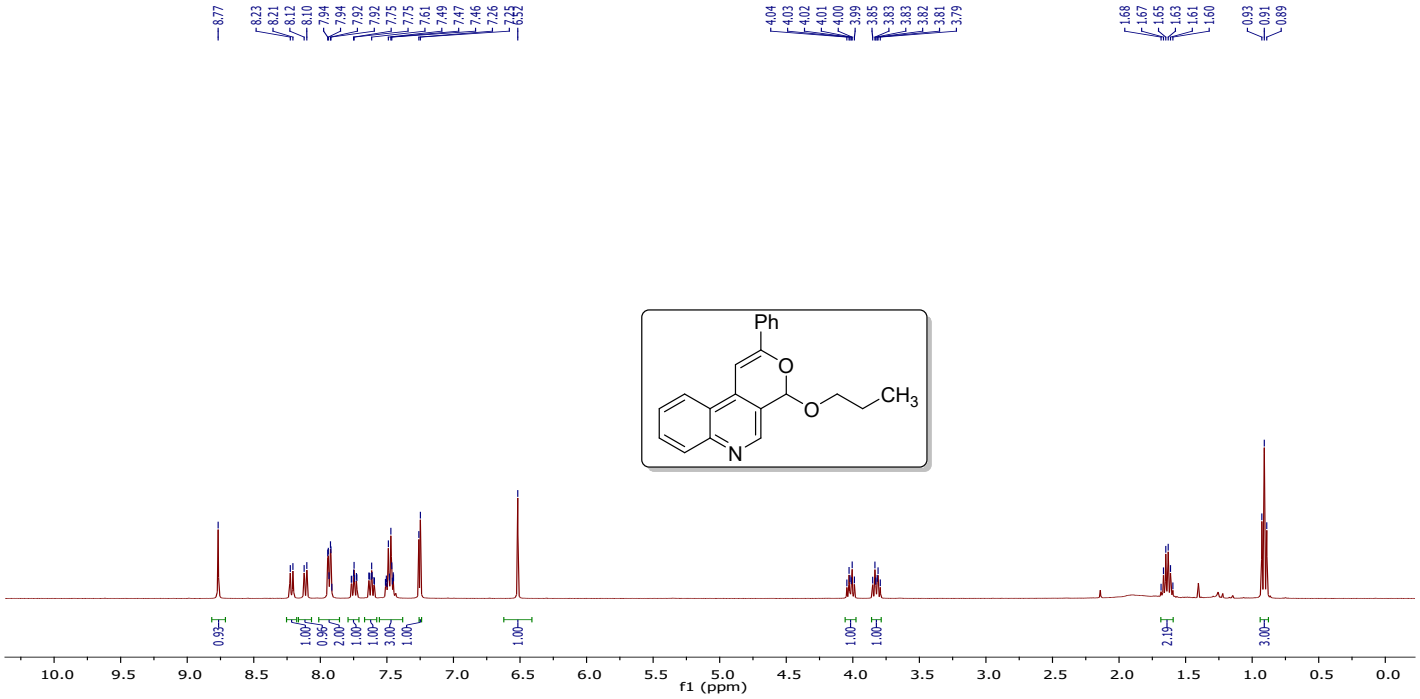


^{13}C NMR (101 MHz, $CDCl_3$)

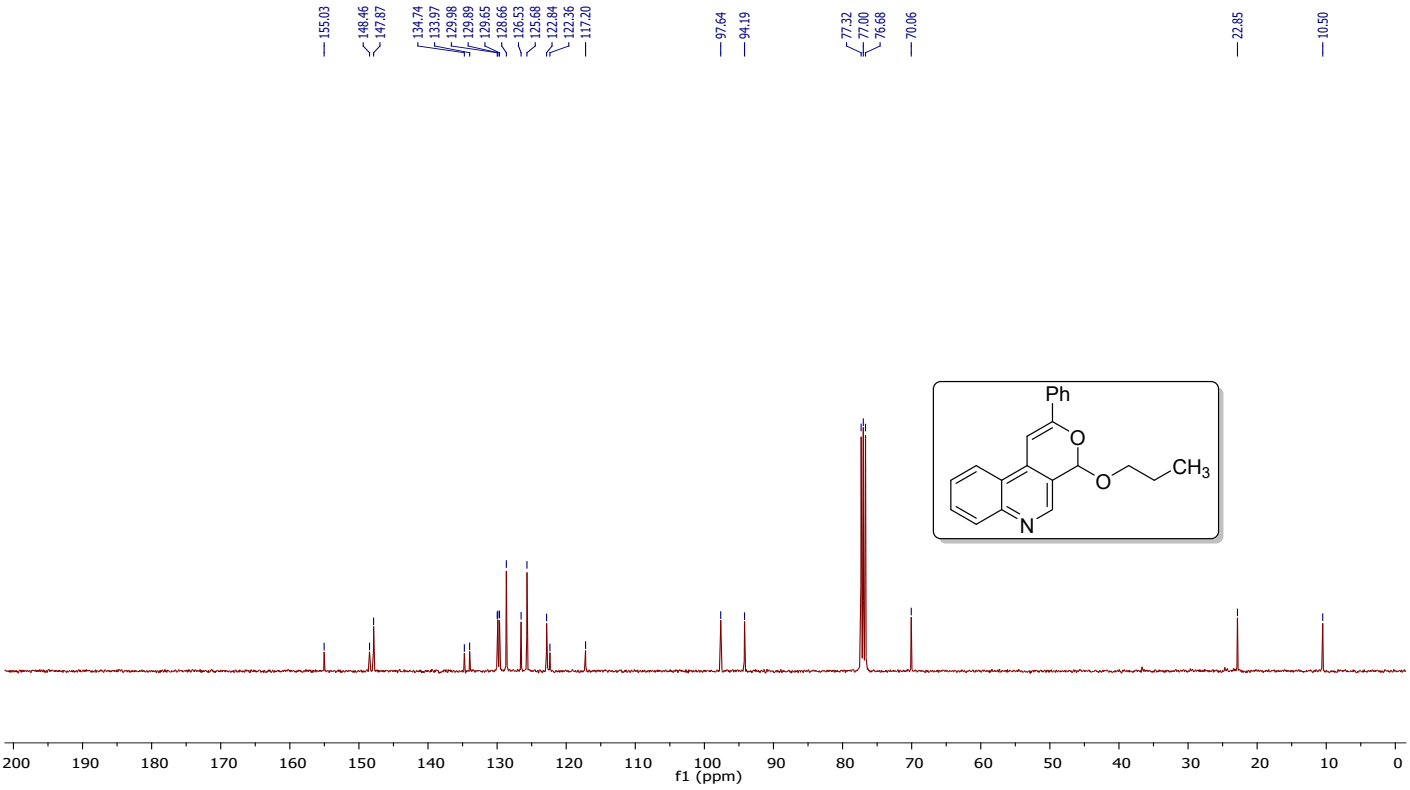


2-phenyl-4-propoxy-4*H*-pyrano[3,4-*c*]quinoline (3ac)

^{1}H NMR (400 MHz, $CDCl_3$)

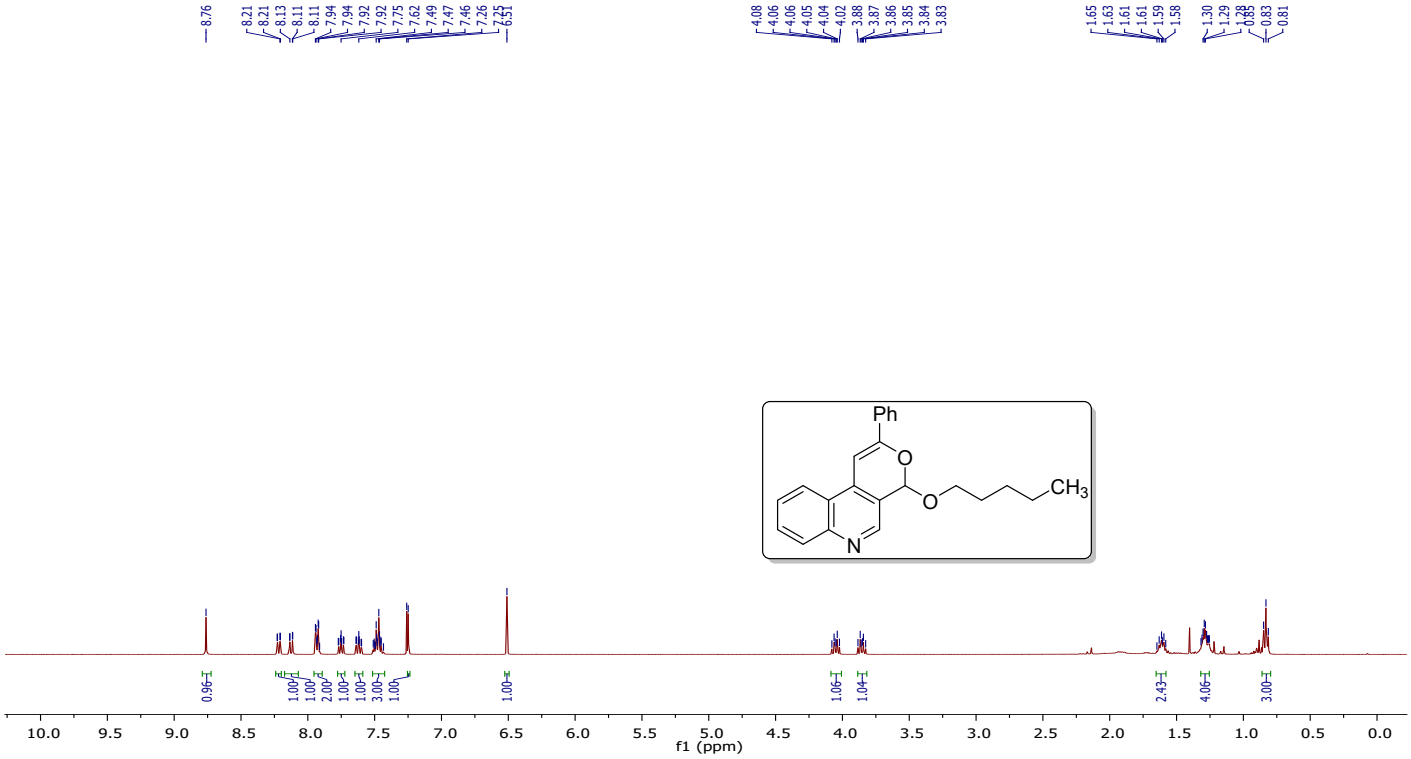


^{13}C NMR (101 MHz, $CDCl_3$)

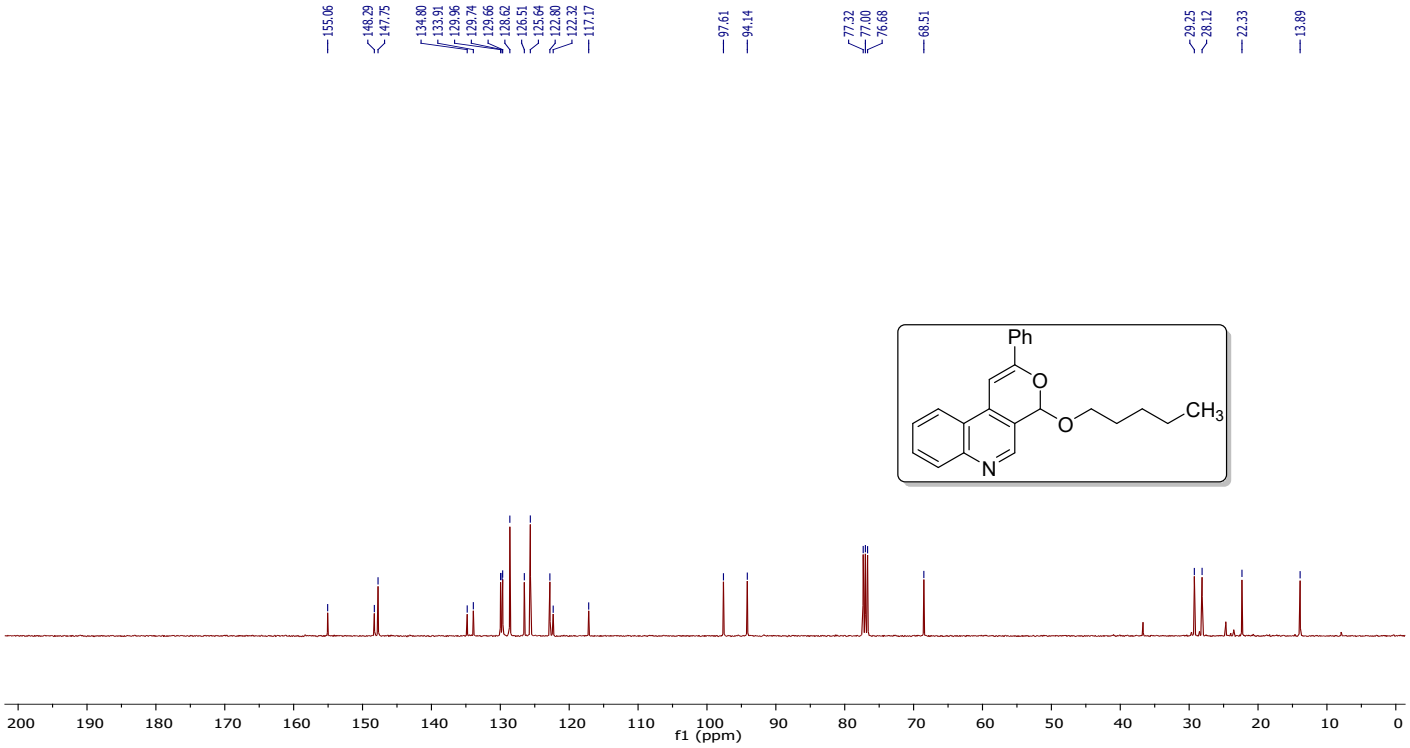


4-(pentyloxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3ad)

^{1}H NMR (400 MHz, $CDCl_3$)

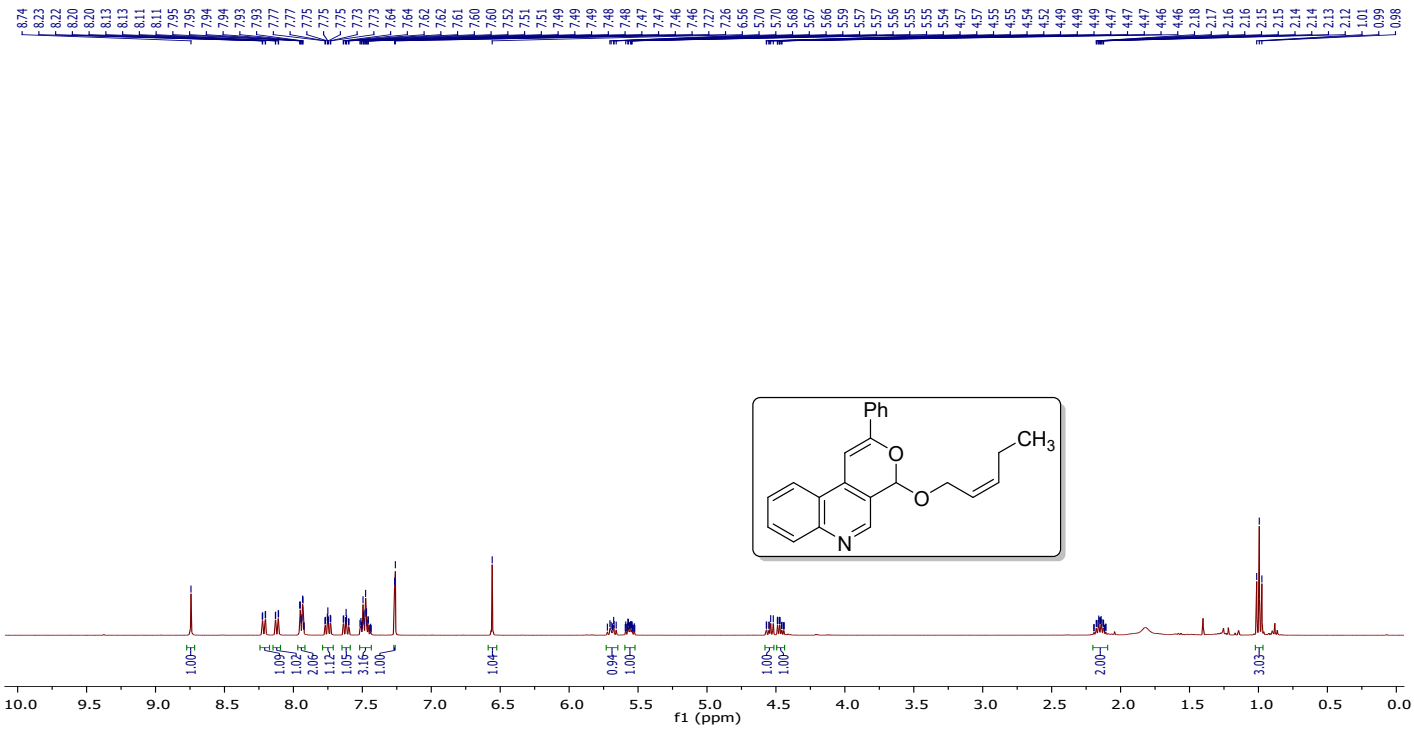


^{13}C NMR (101 MHz, $CDCl_3$)

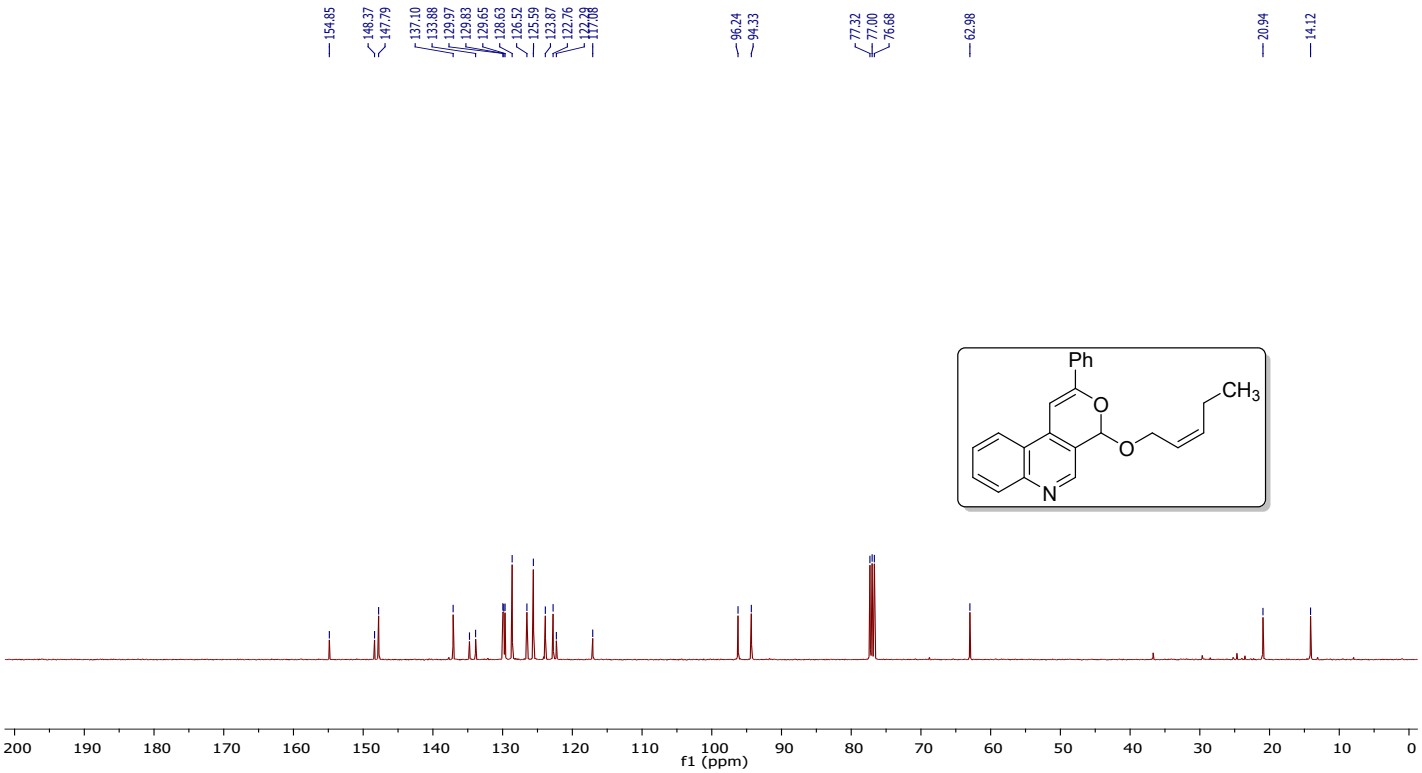


(Z)-4-(pent-2-en-1-yloxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3ae)

^{1}H NMR (400 MHz, $CDCl_3$)

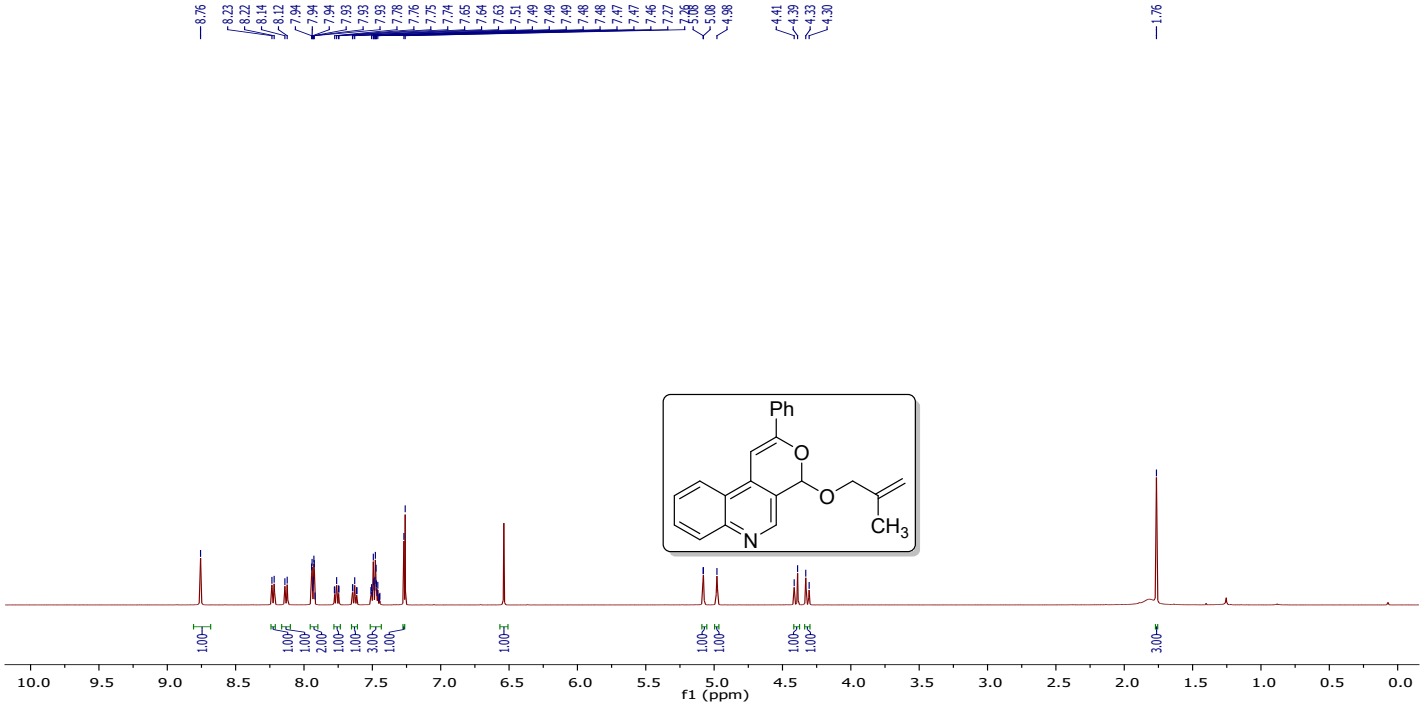


^{13}C NMR (101 MHz, $CDCl_3$)

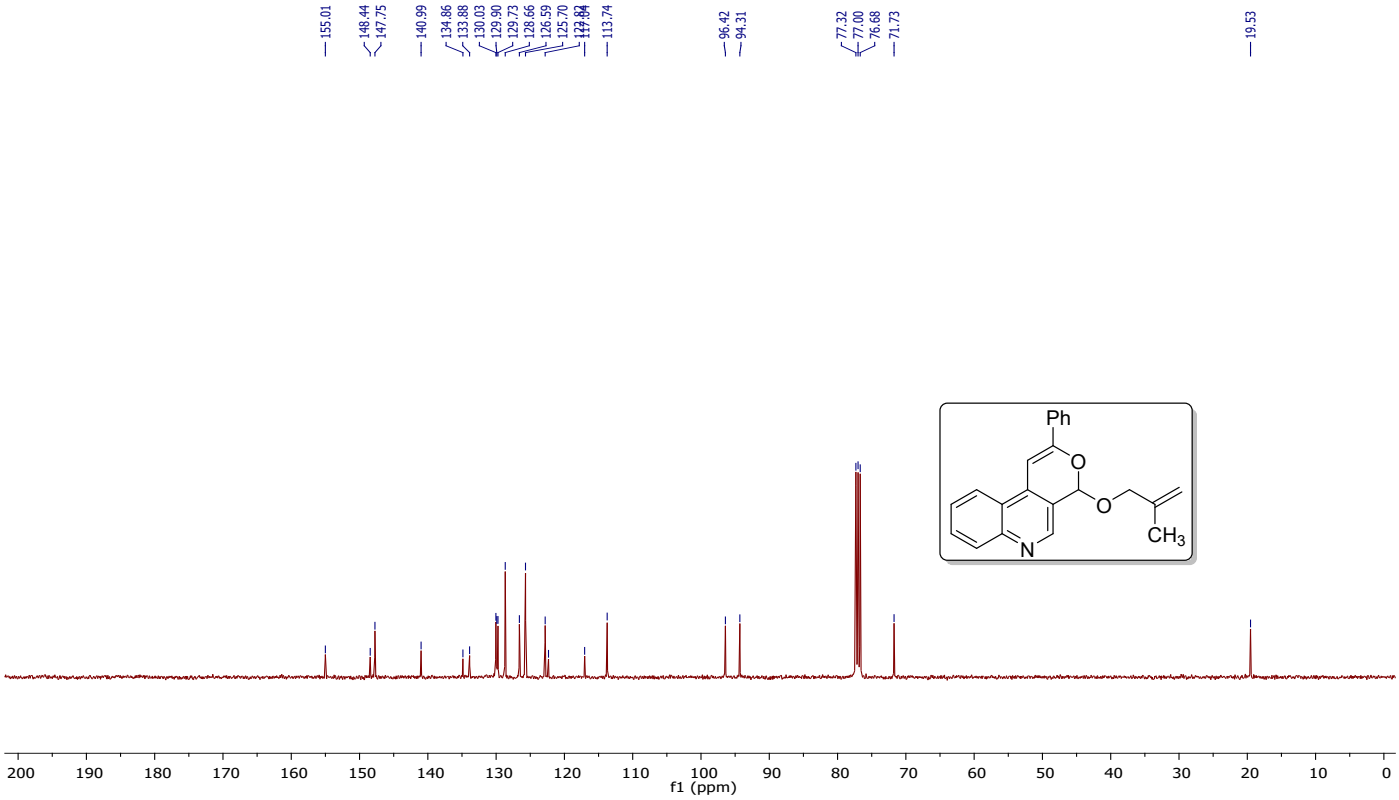


4-((2-methylallyl)oxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3af)

^{1}H NMR (500 MHz, $CDCl_3$)

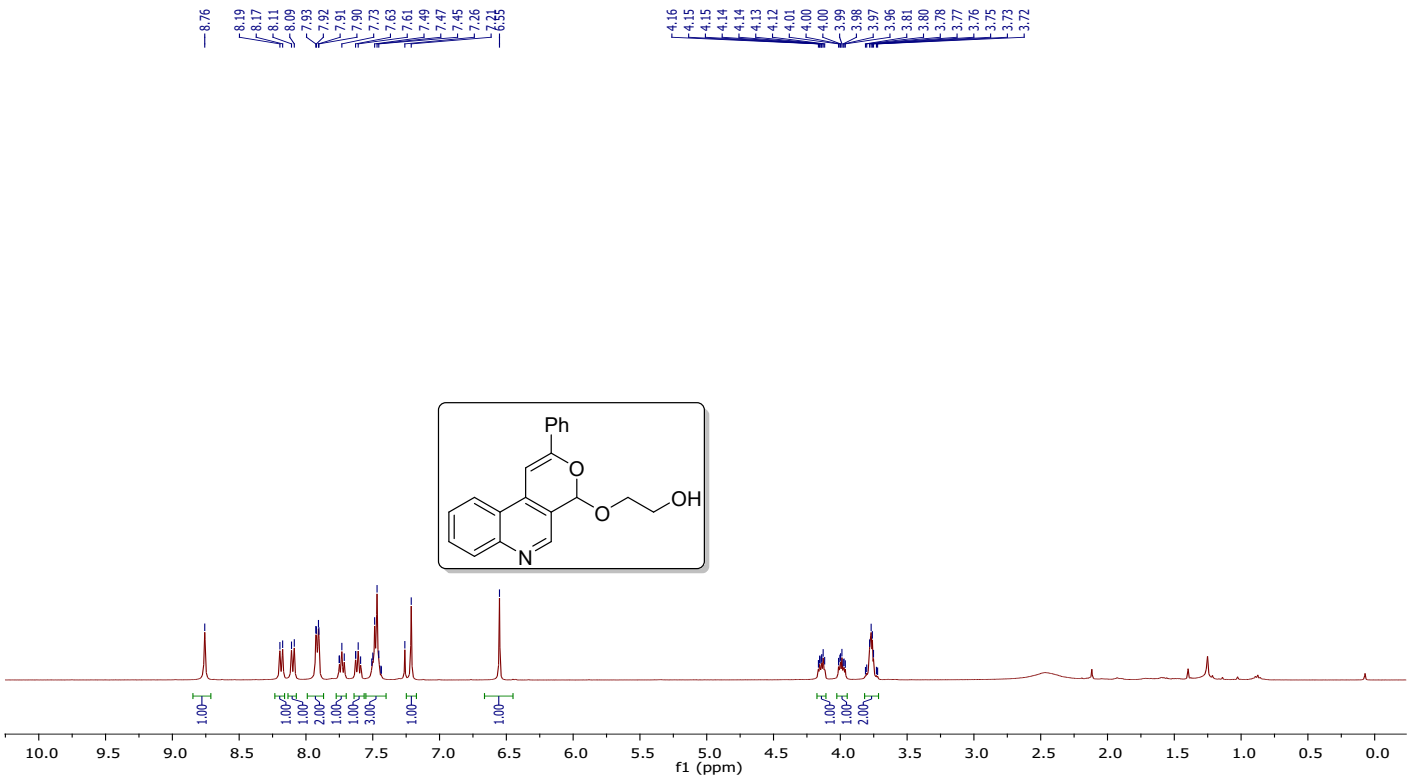


^{13}C NMR (101 MHz, $CDCl_3$)

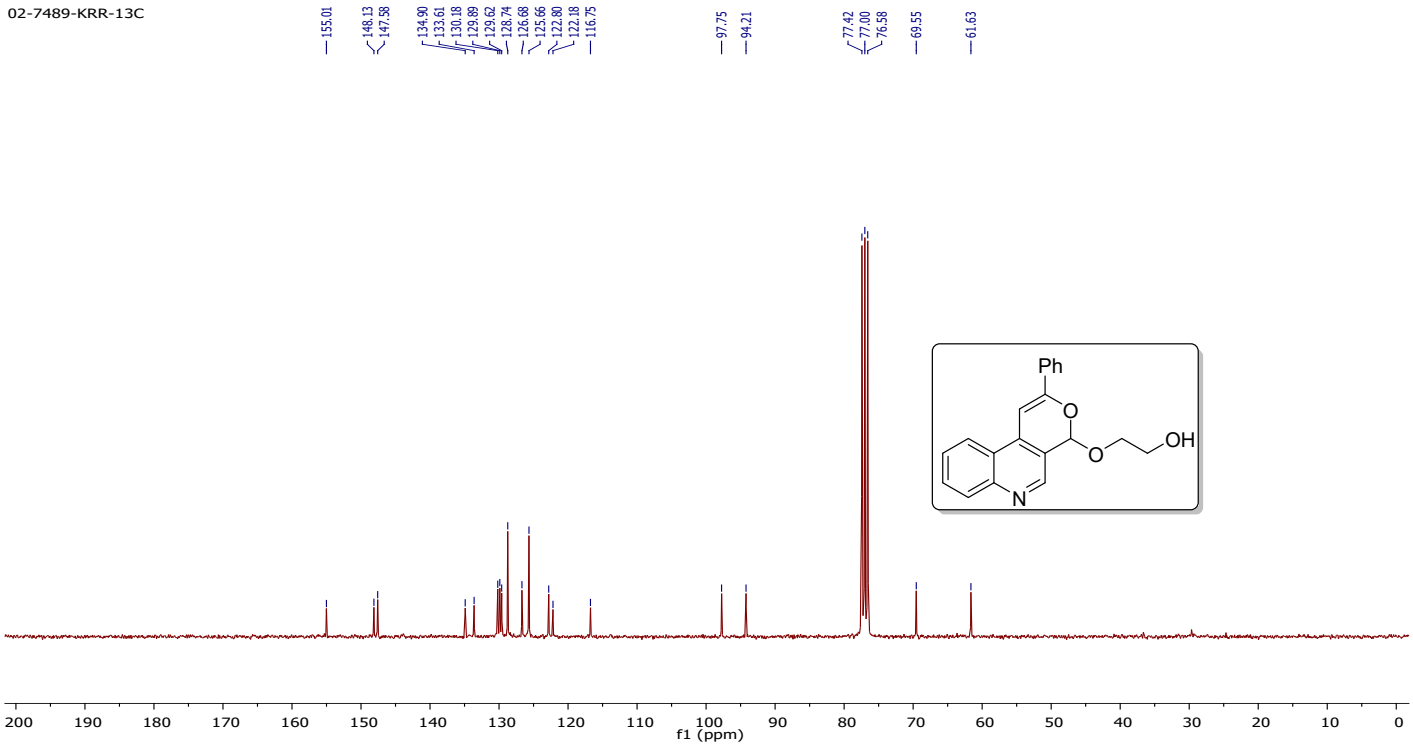


2-((2-phenyl-4*H*-pyrano[3,4-*c*]quinolin-4-yl)oxy)ethan-1-ol (3ag)

^{1}H NMR (400 MHz, $CDCl_3$)

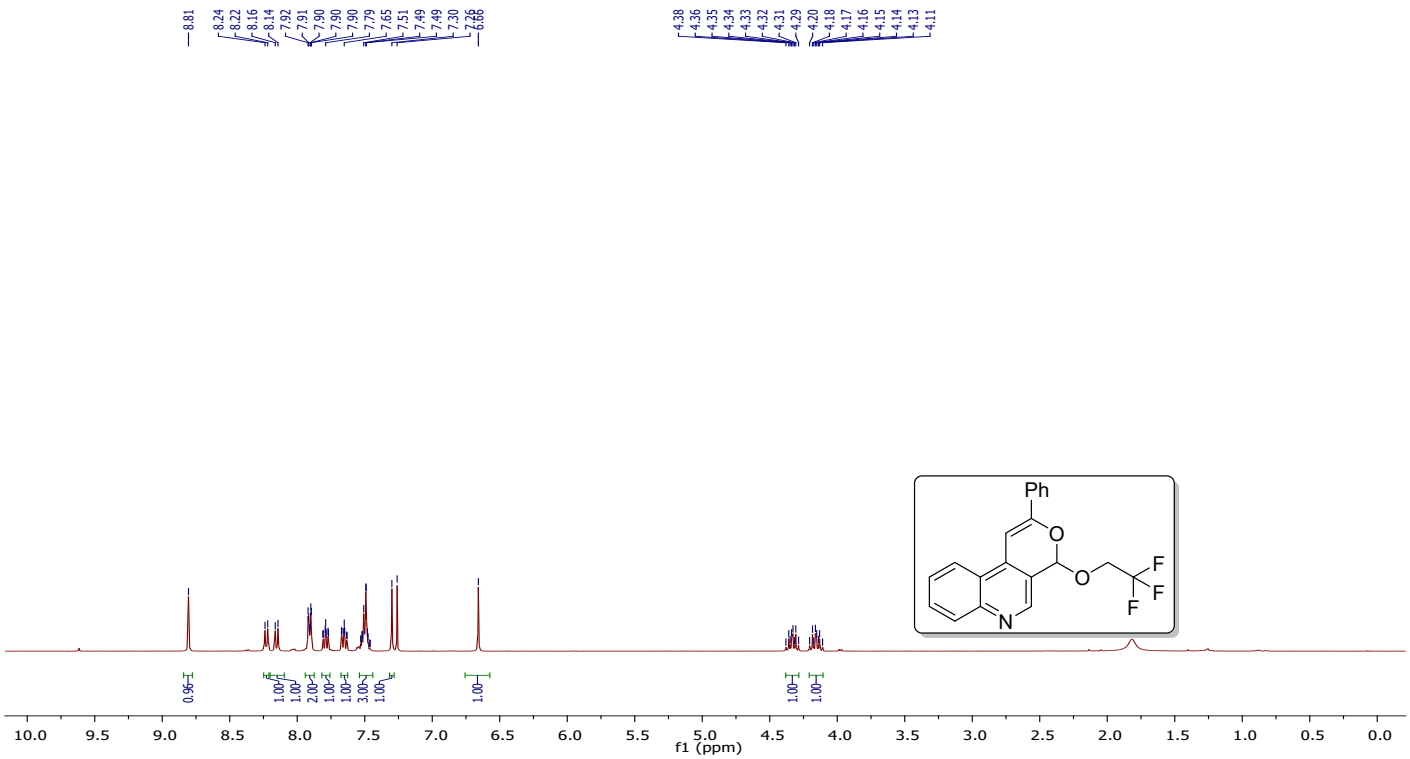


^{13}C NMR (101 MHz, $CDCl_3$)

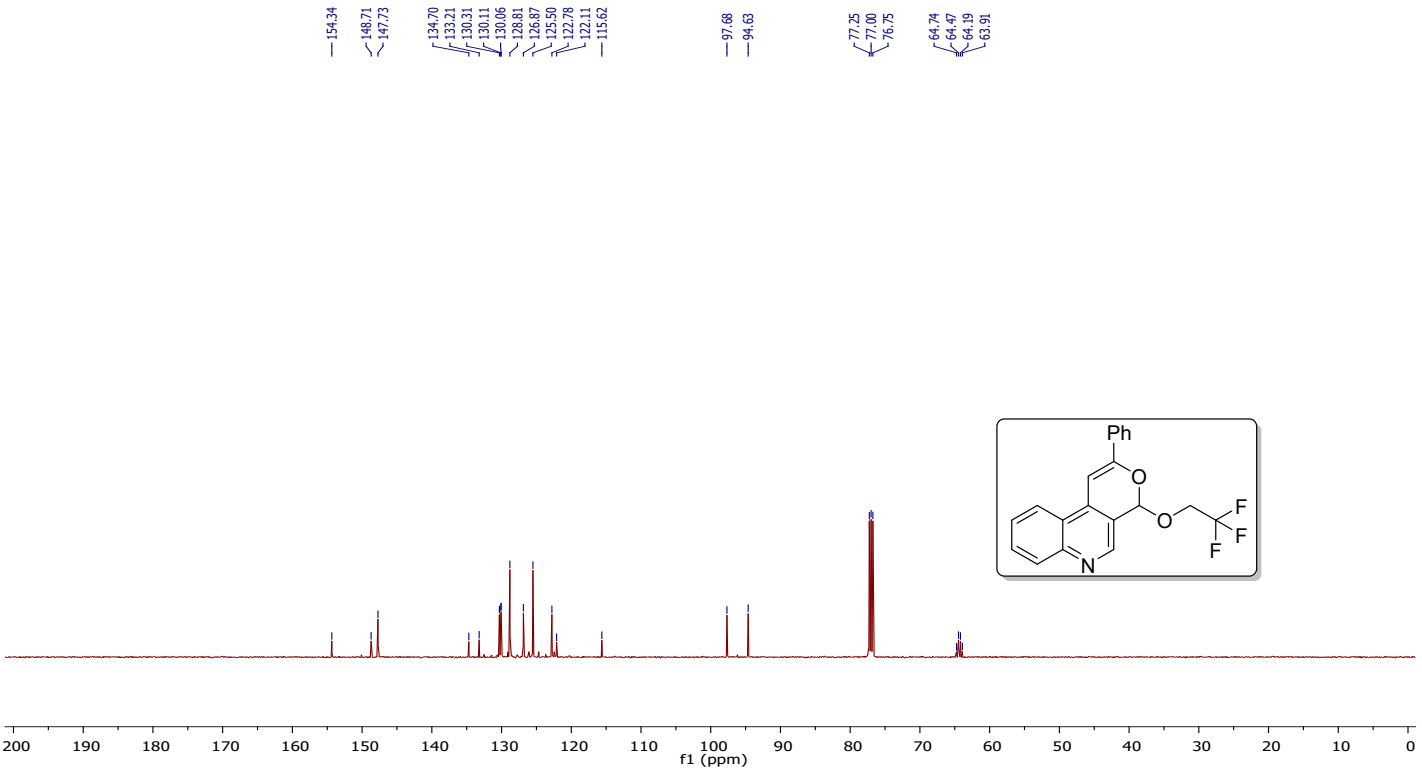


2-phenyl-4-(2,2,2-trifluoroethoxy)-4*H*-pyrano[3,4-*c*]quinoline (3ah)

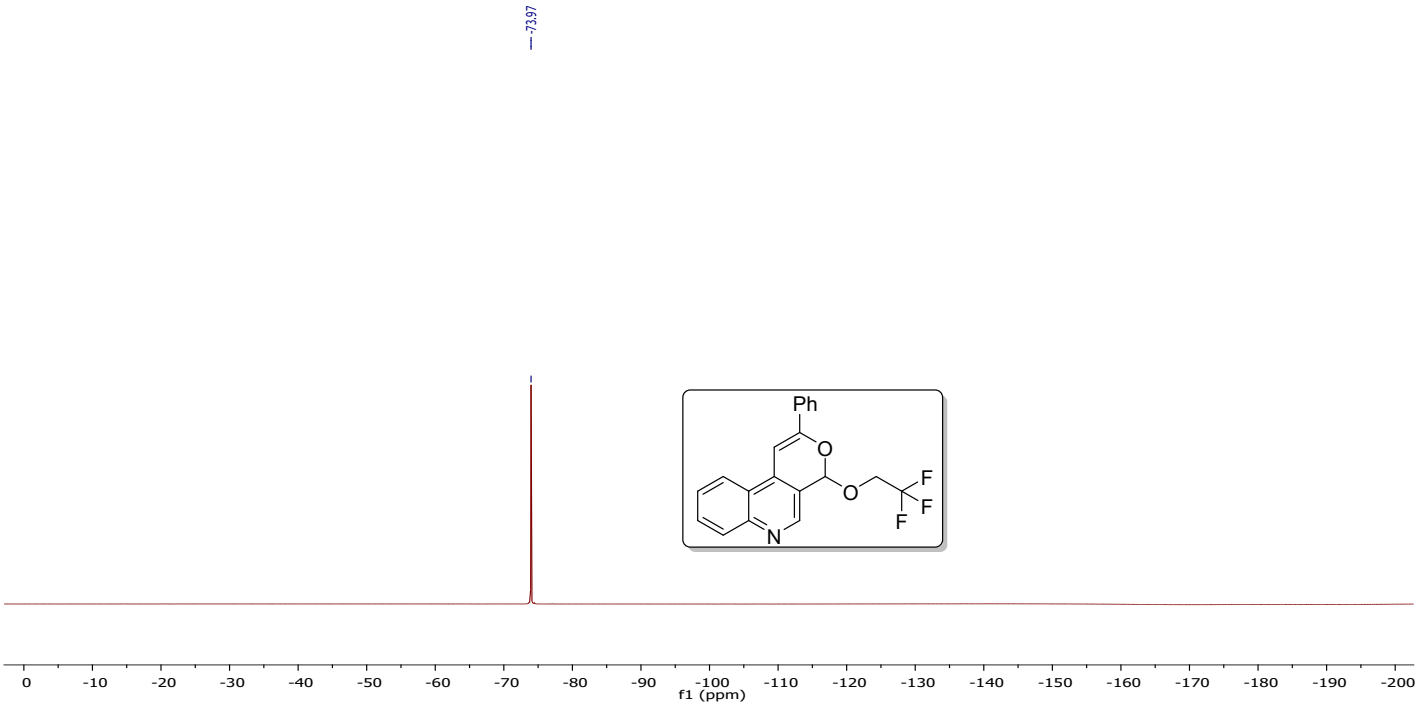
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (126 MHz, $CDCl_3$)

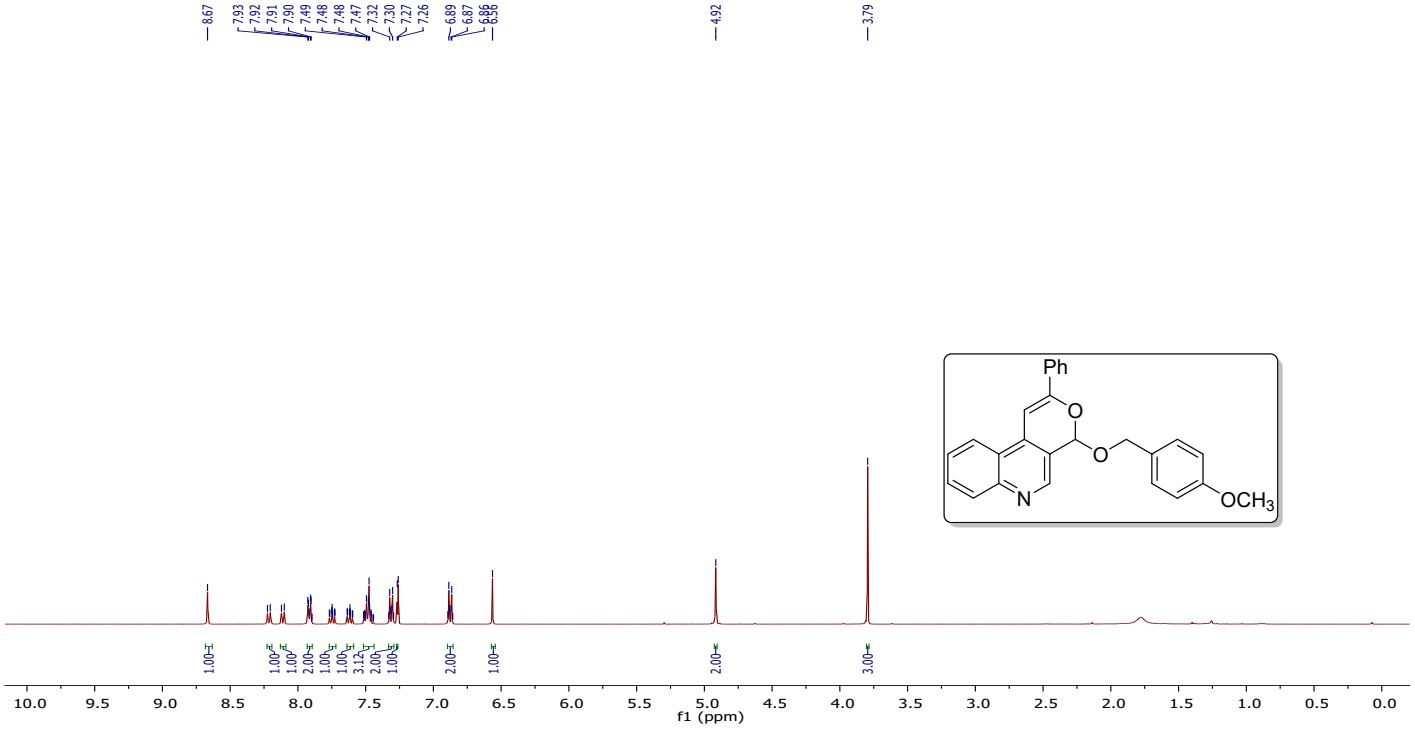


^{19}F NMR (376 MHz, $CDCl_3$)

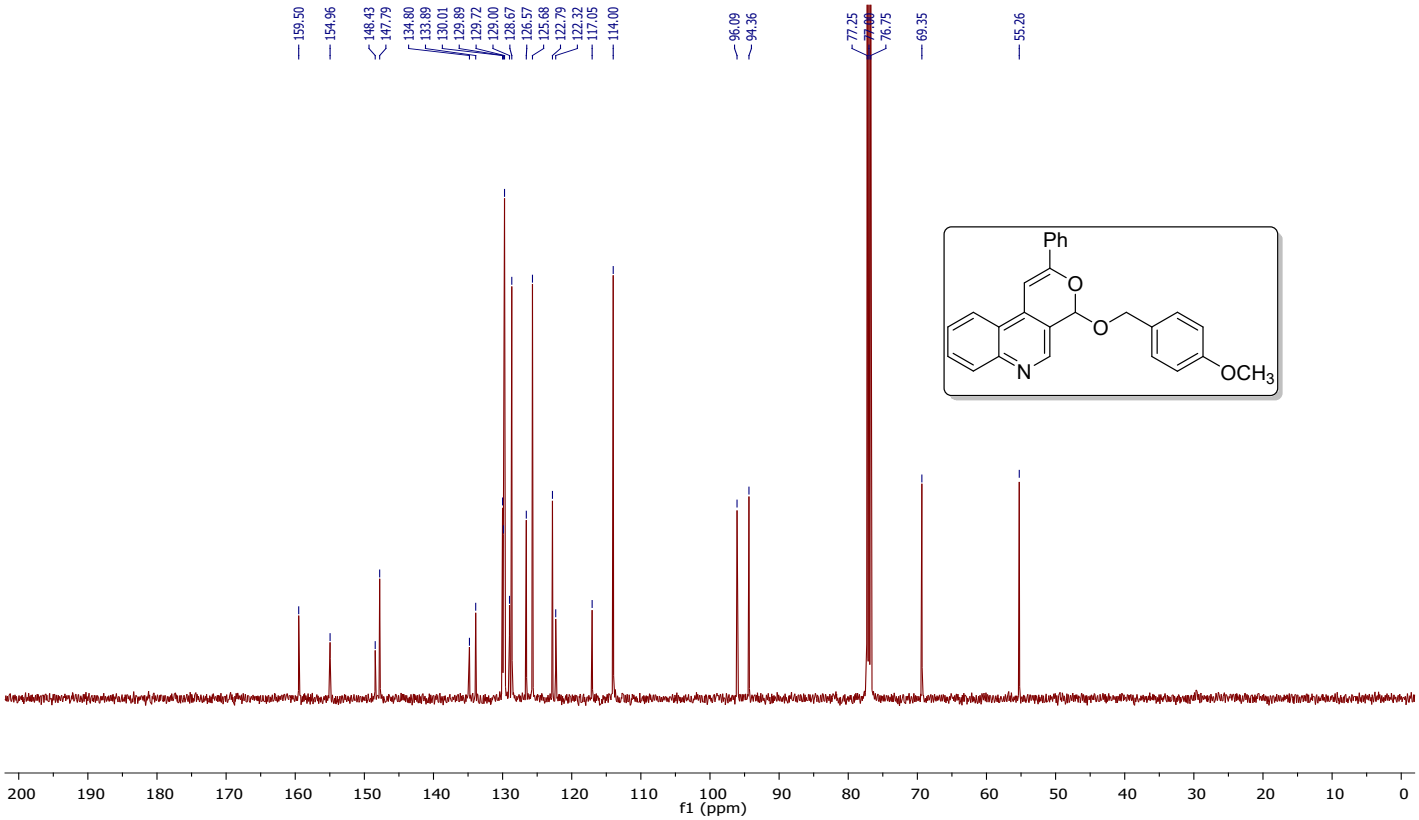


4-((4-methoxybenzyl)oxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3ak)

^{1}H NMR (400 MHz, $CDCl_3$)

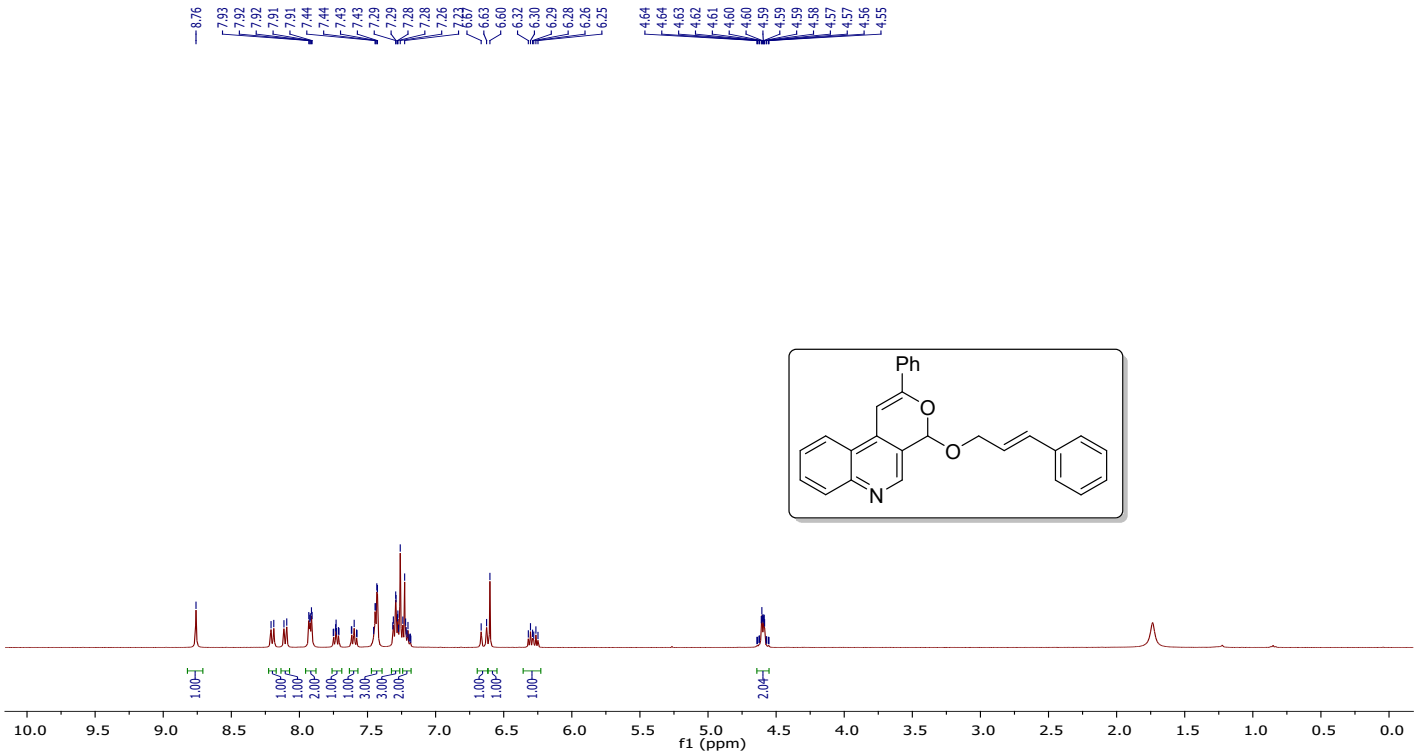


^{13}C NMR (126 MHz, $CDCl_3$)

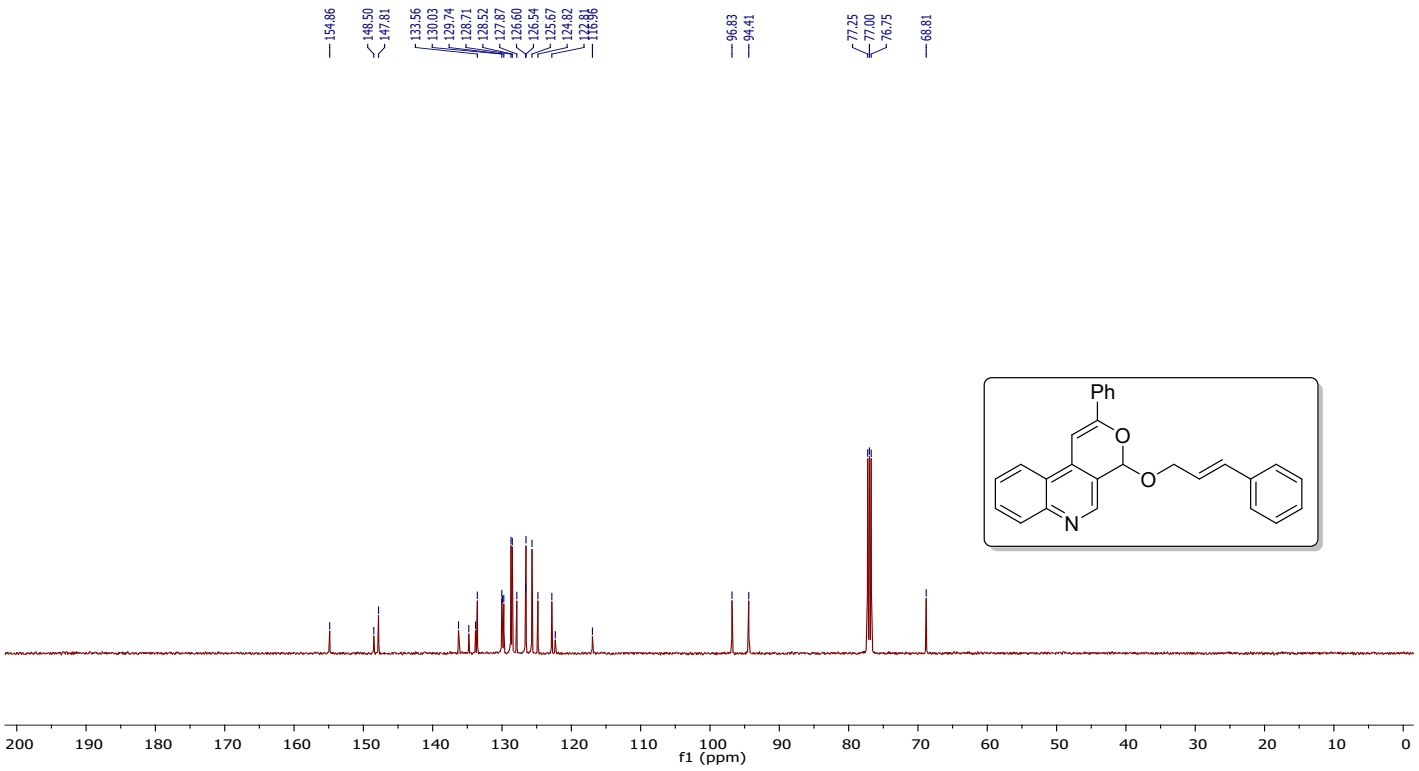


4-(cinnamyloxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3al)

^{1}H NMR (400 MHz, $CDCl_3$)

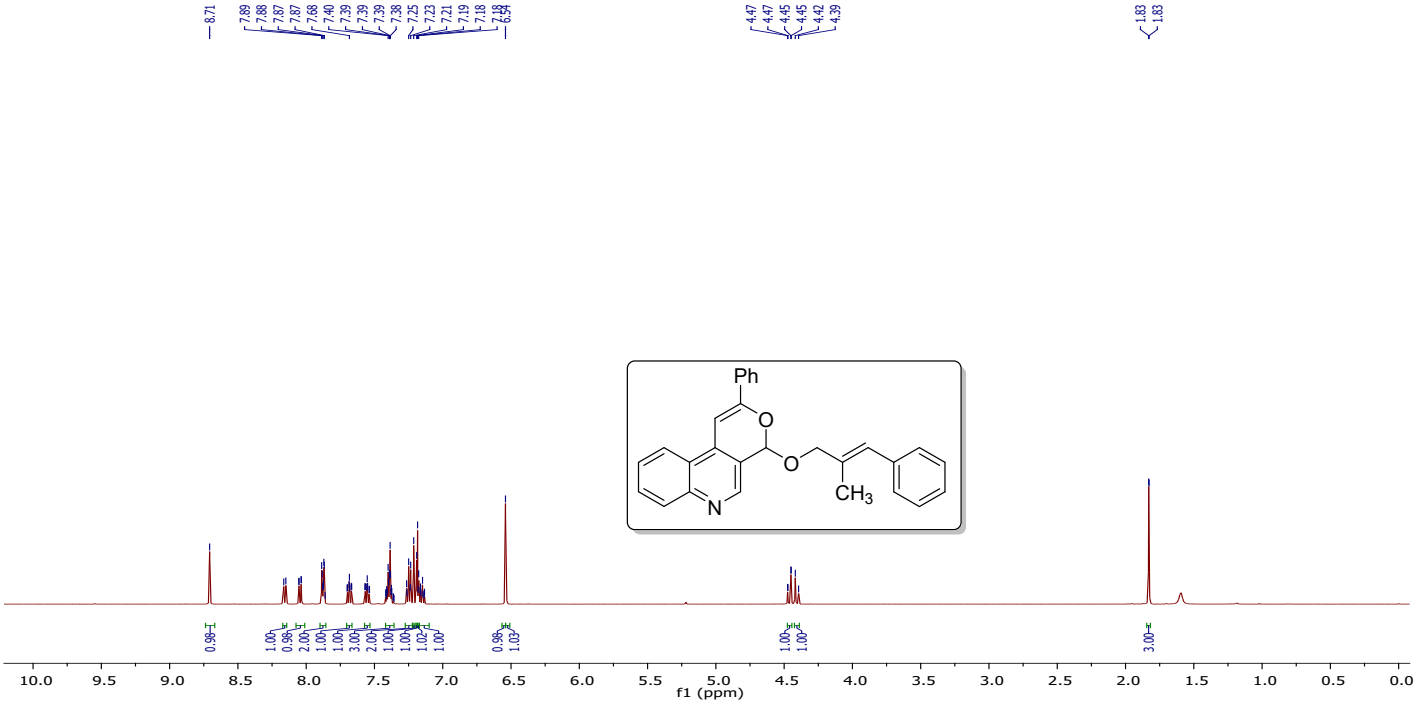


^{13}C NMR (126 MHz, $CDCl_3$)

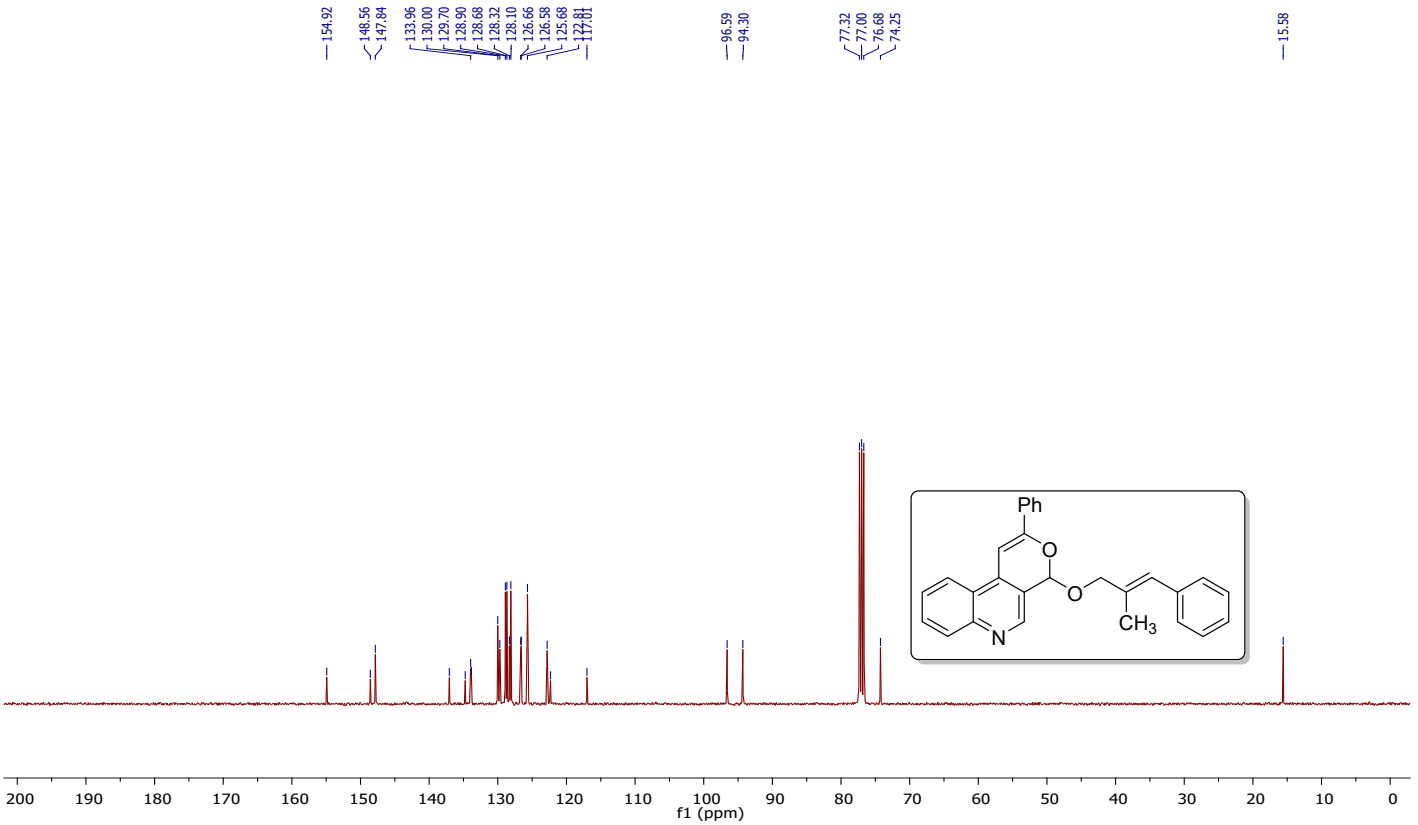


(*E*)-4-((2-methyl-3-phenylallyl)oxy)-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (3am)

^{1}H NMR (500 MHz, $CDCl_3$)

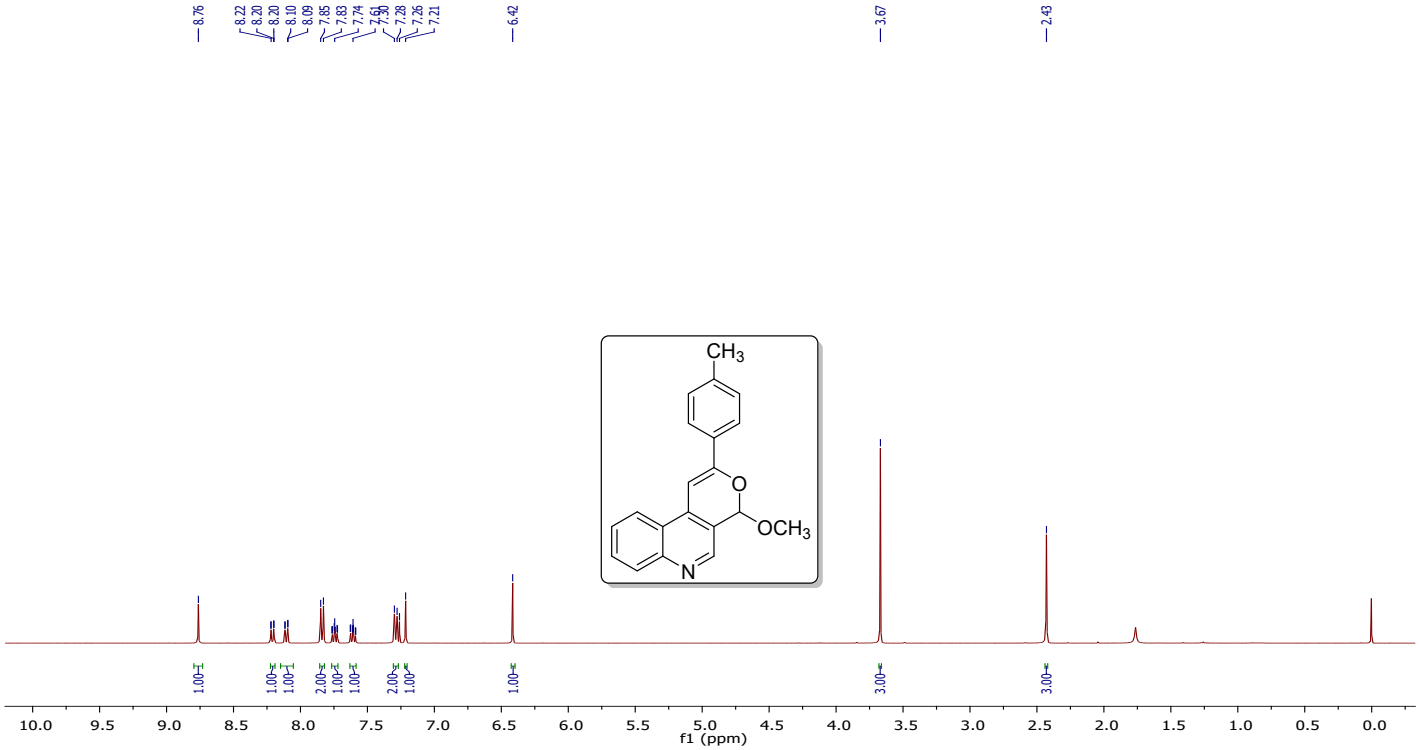


^{13}C NMR (101 MHz, $CDCl_3$)

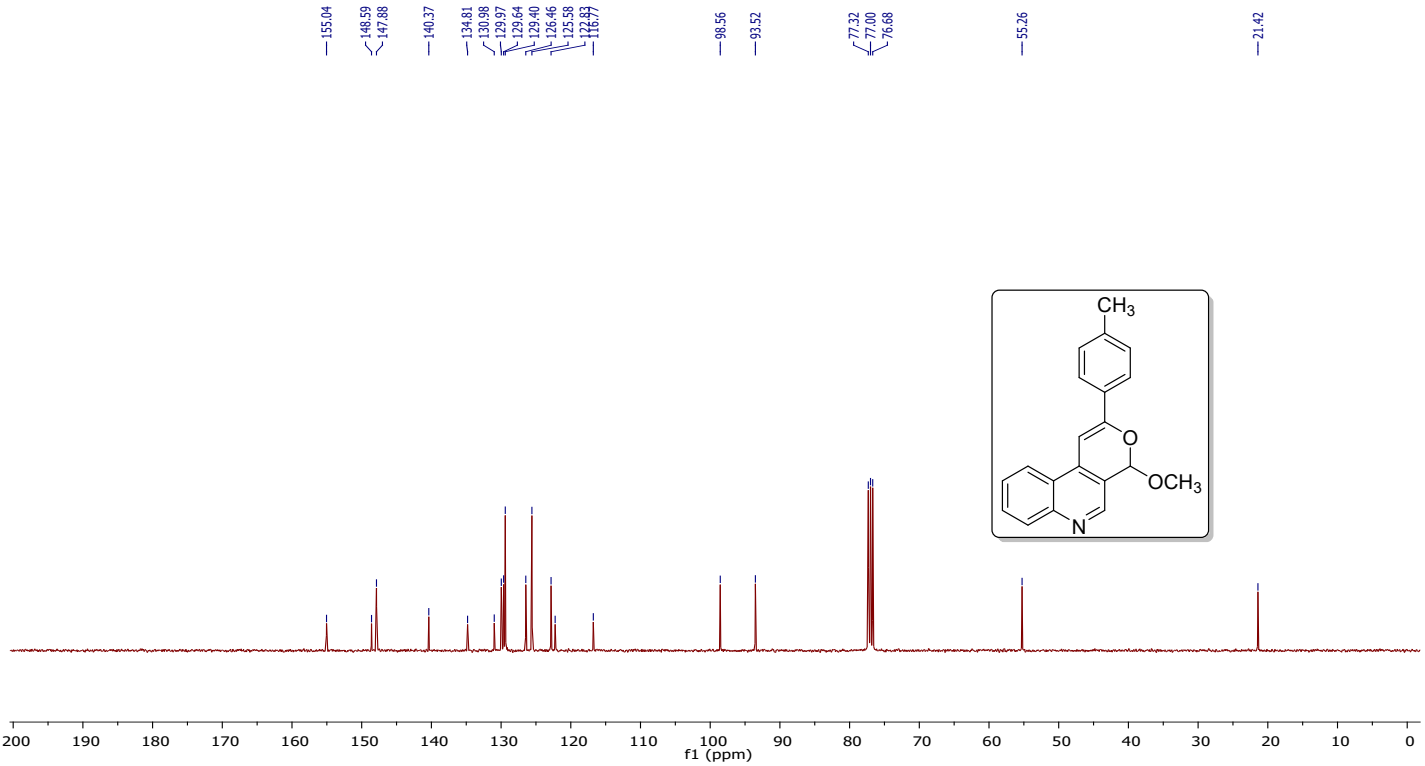


4-methoxy-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3ba)

^{1}H NMR (400 MHz, $CDCl_3$)

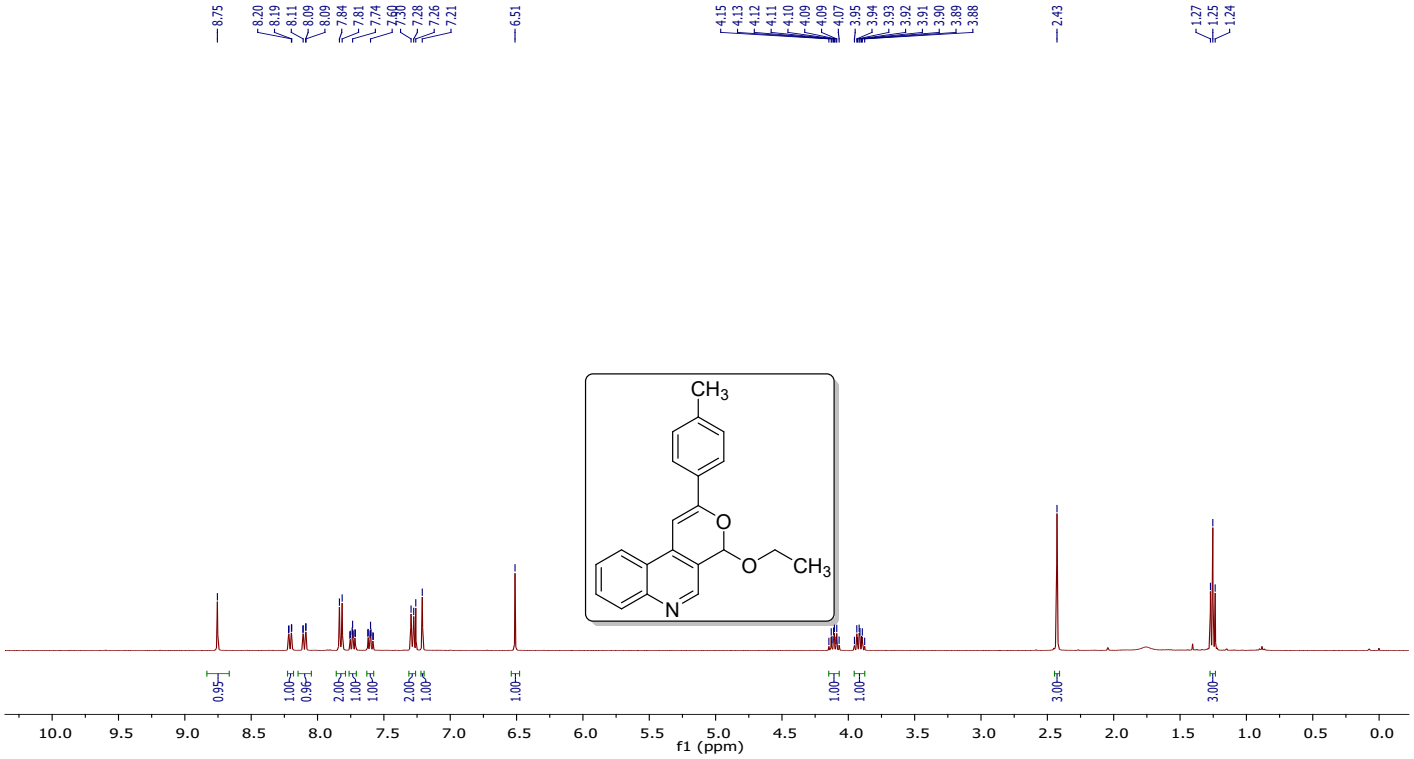


^{13}C NMR (101 MHz, $CDCl_3$)

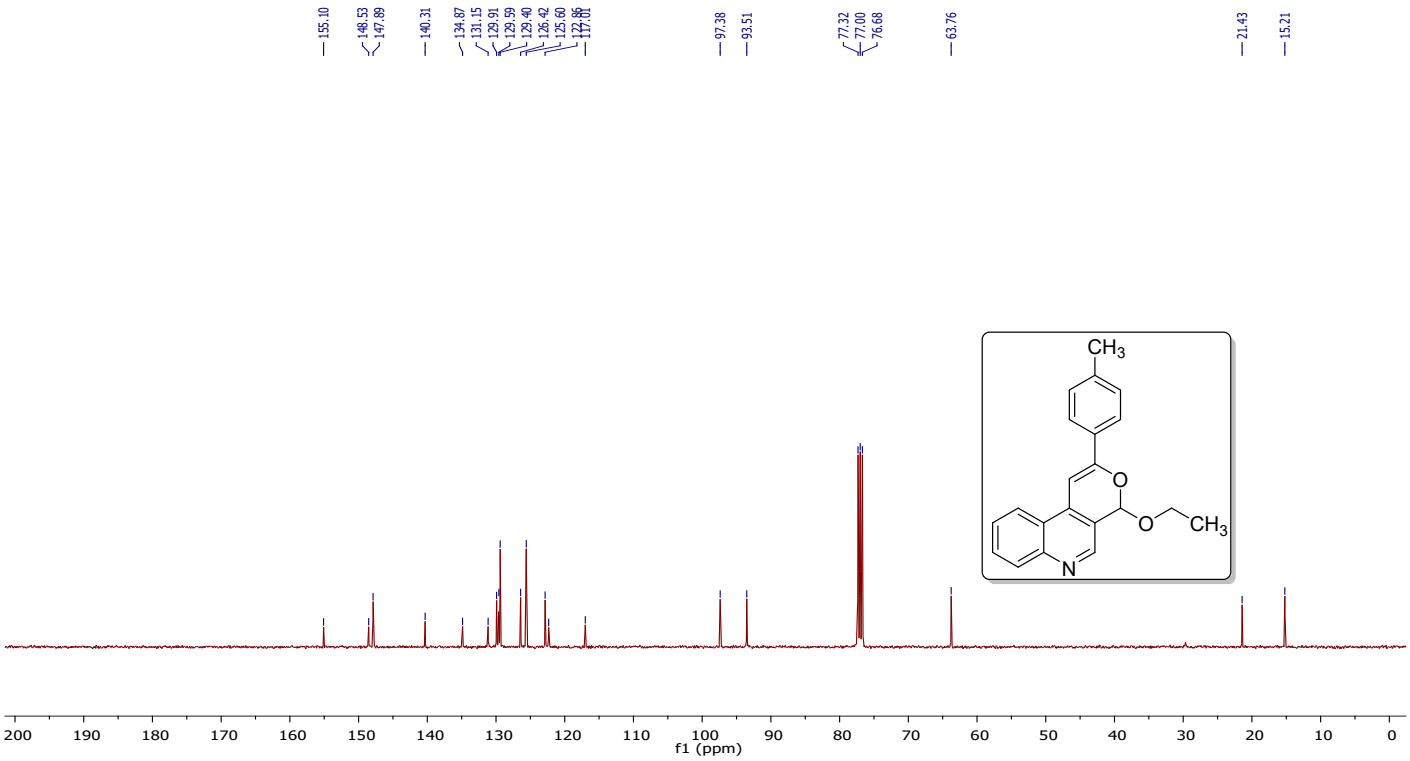


4-ethoxy-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3bb)

^{1}H NMR (400 MHz, $CDCl_3$)

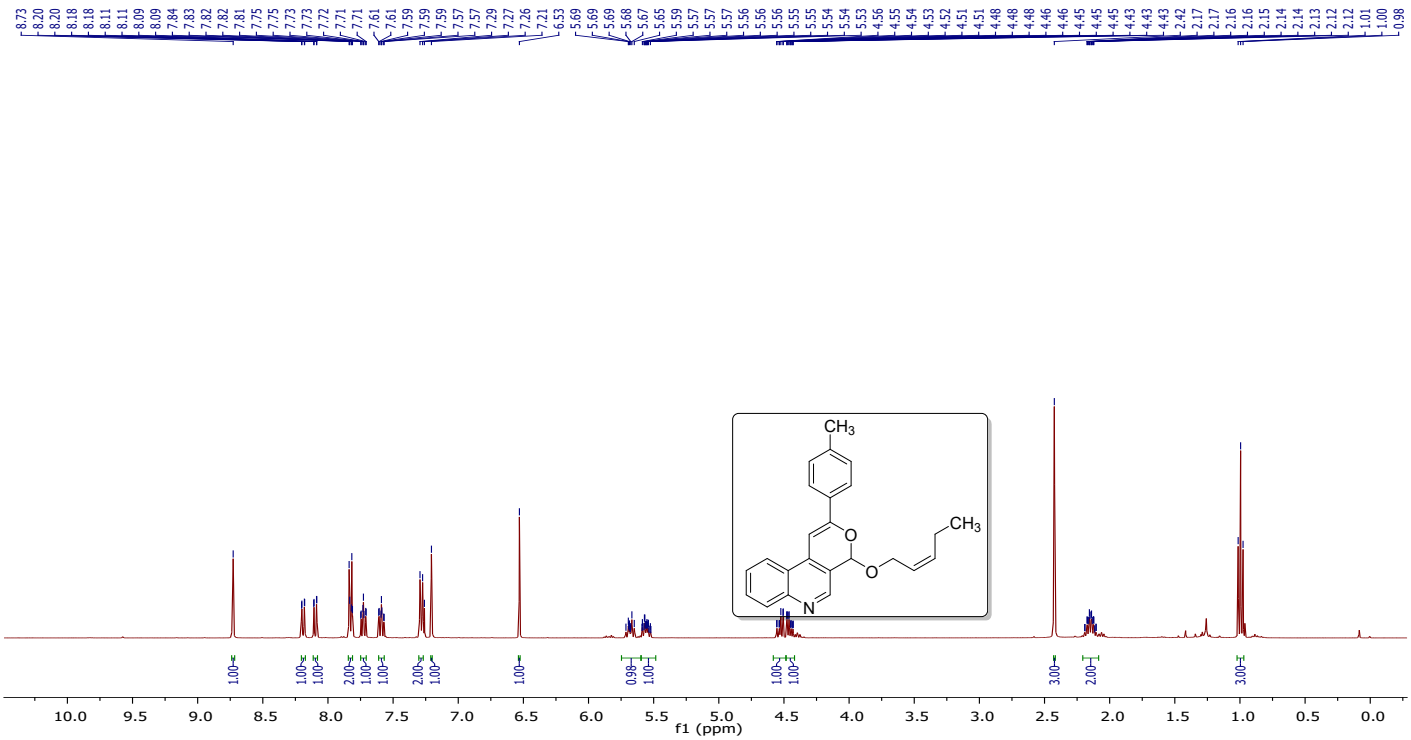


^{13}C NMR (101 MHz, $CDCl_3$)

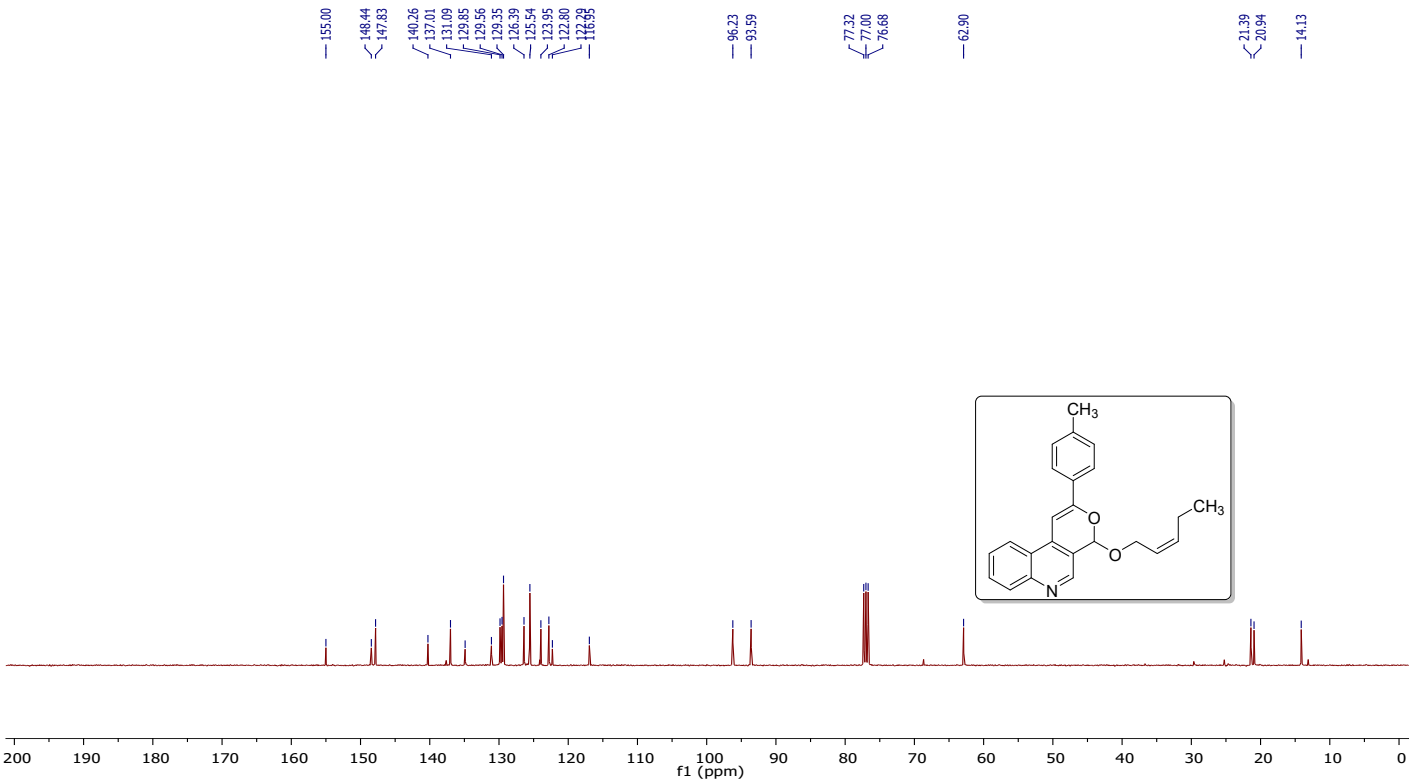


(Z)-4-(pent-2-en-1-yloxy)-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3be)

^{1}H NMR (400 MHz, $CDCl_3$)

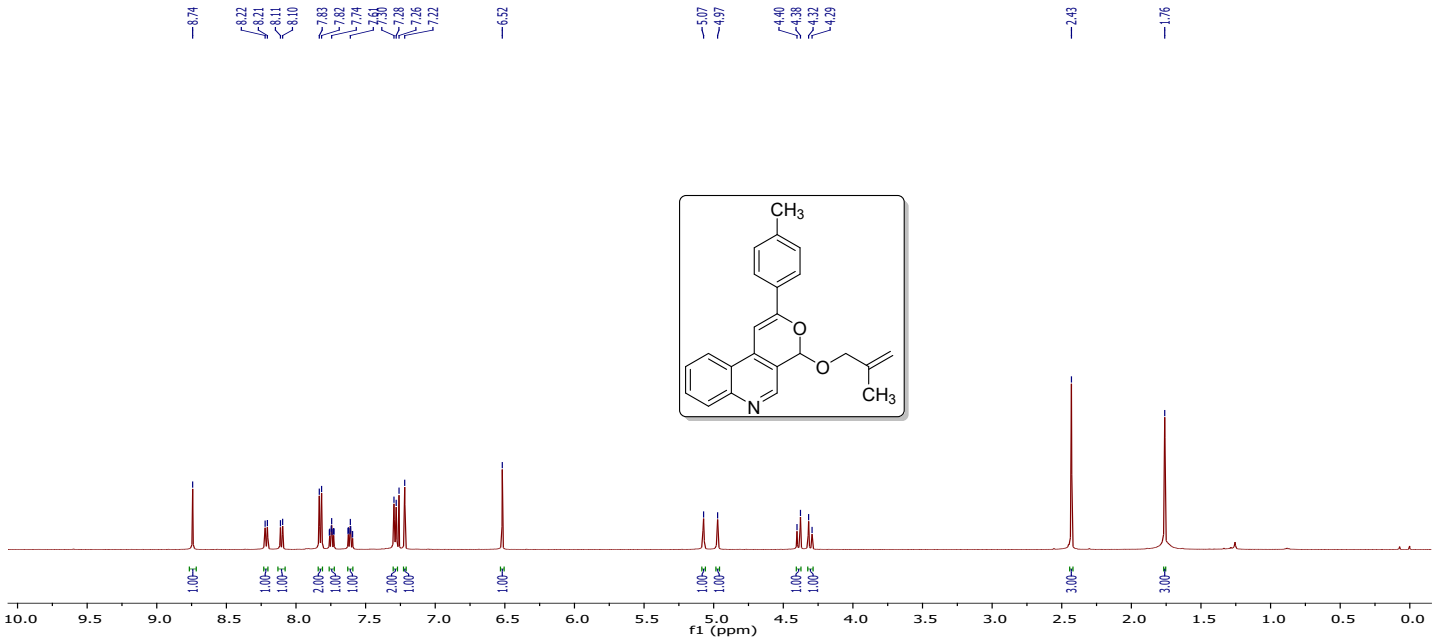


^{13}C NMR (101 MHz, $CDCl_3$)

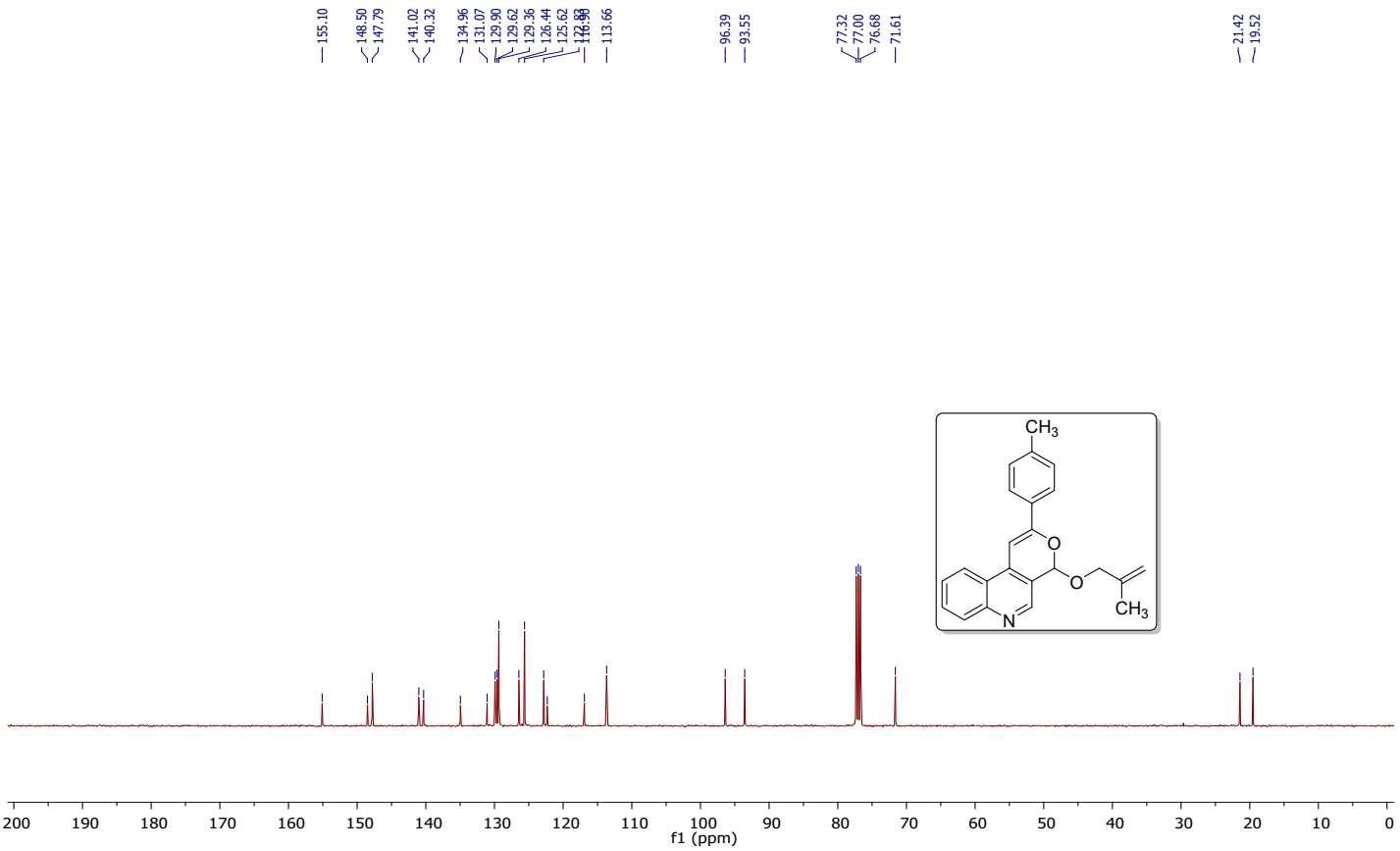


4-((2-methylallyl)oxy)-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3bf)

^{1}H NMR (500 MHz, $CDCl_3$)

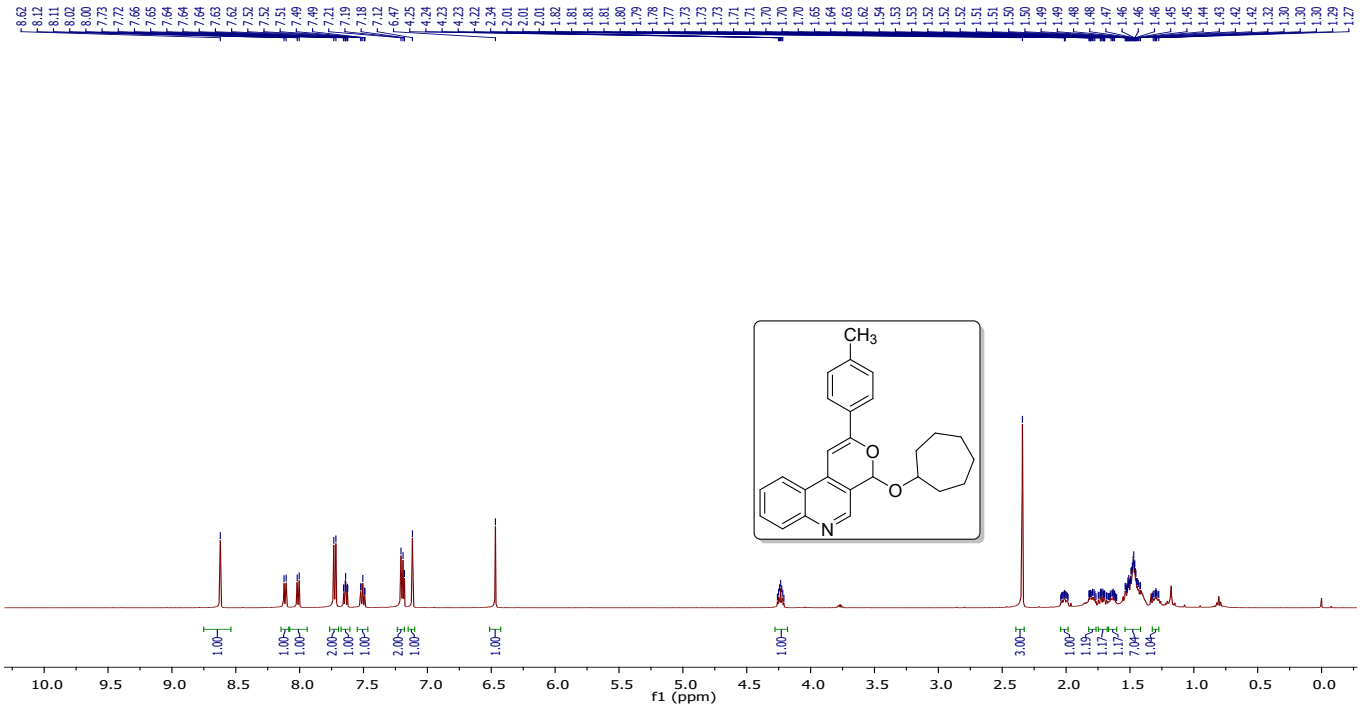


^{13}C NMR (101 MHz, $CDCl_3$)

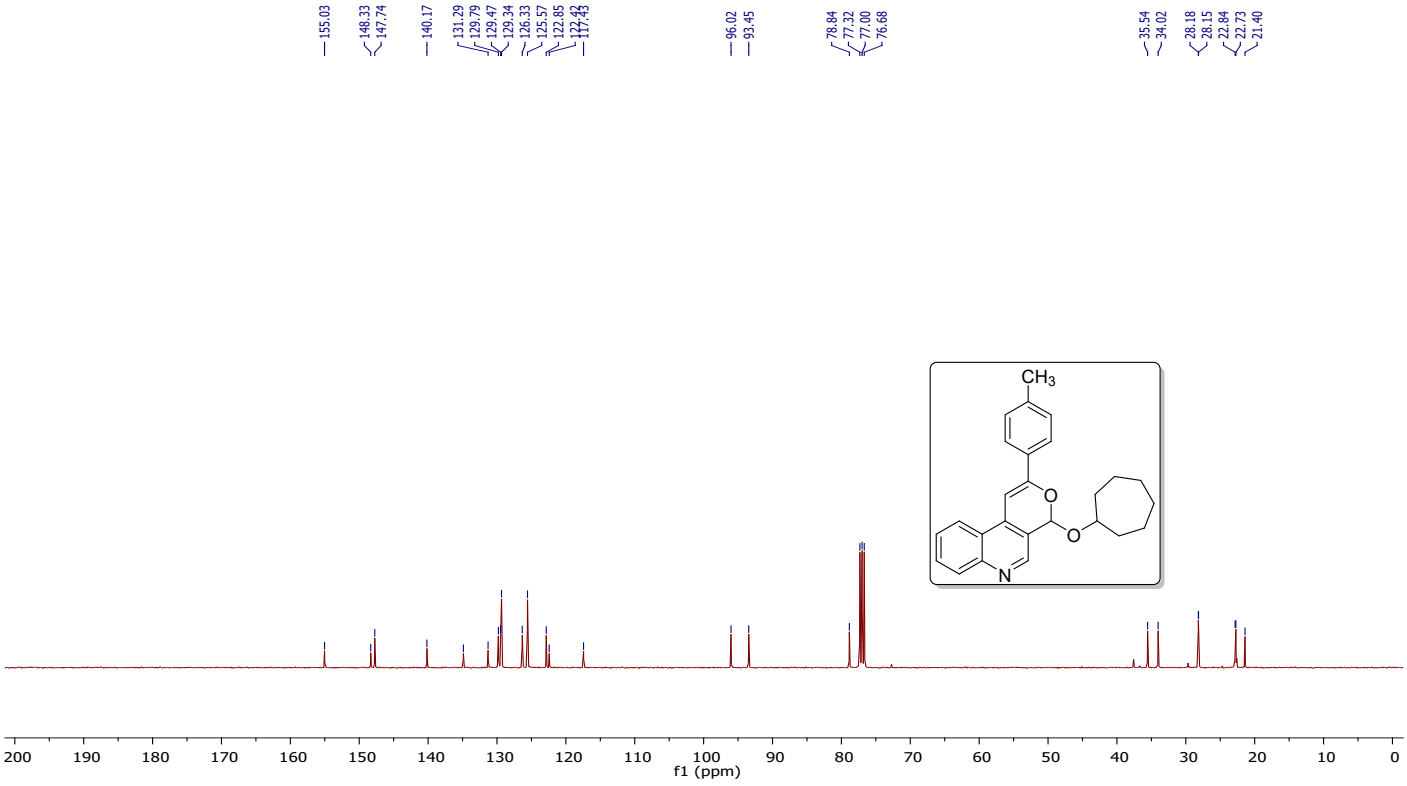


4-(cycloheptyloxy)-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3bi)

^{1}H NMR (500 MHz, $CDCl_3$)

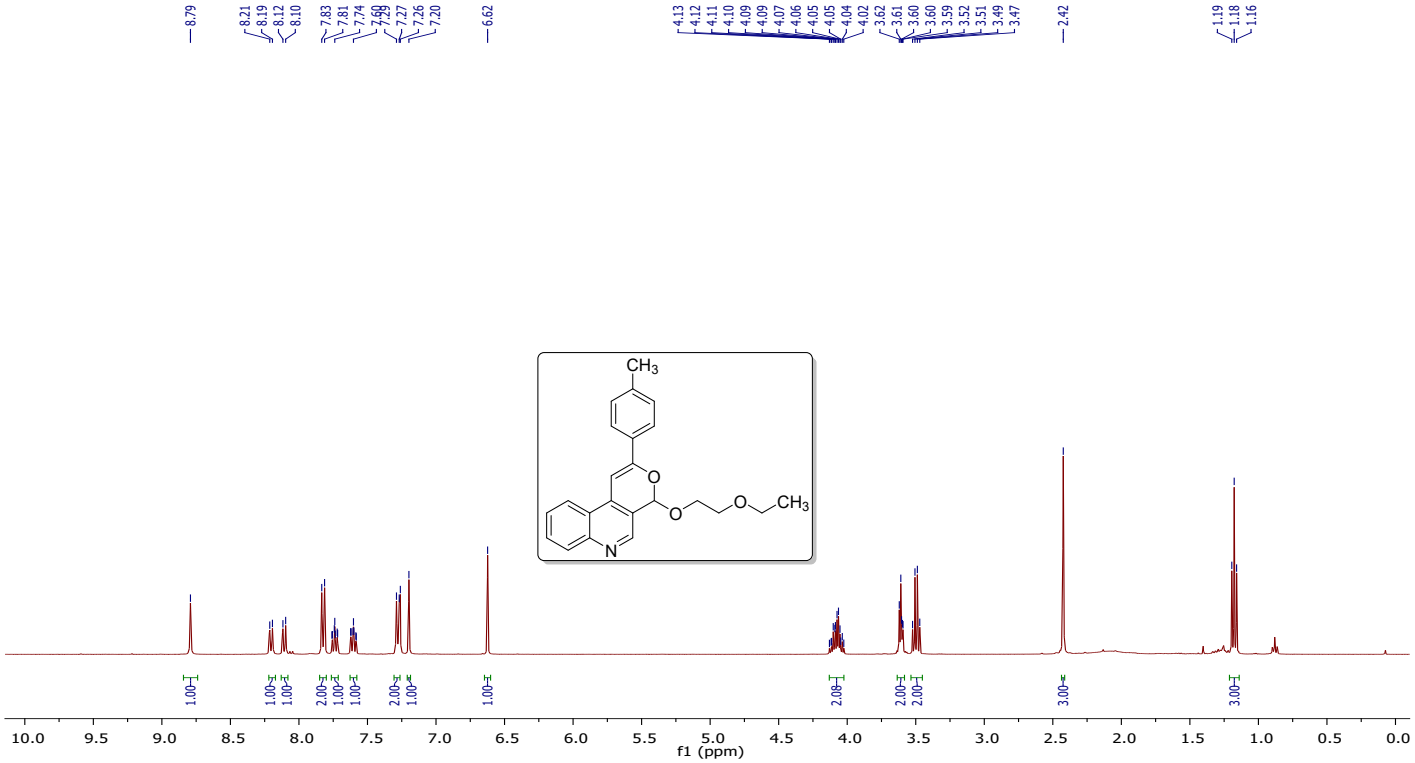


^{13}C NMR (101 MHz, $CDCl_3$)

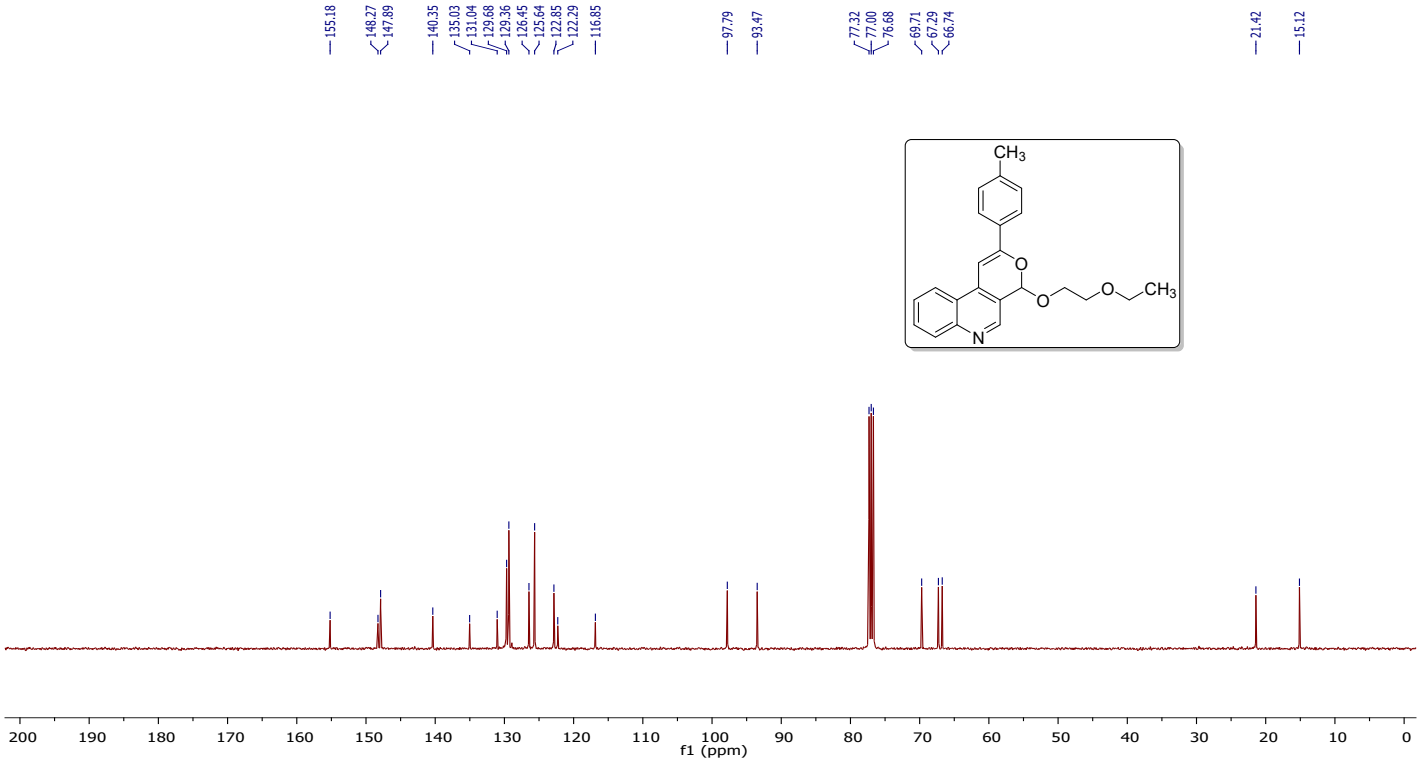


4-(2-ethoxyethoxy)-2-(*p*-tolyl)-4*H*-pyrano[3,4-*c*]quinoline (3bj)

^{1}H NMR (400 MHz, $CDCl_3$)

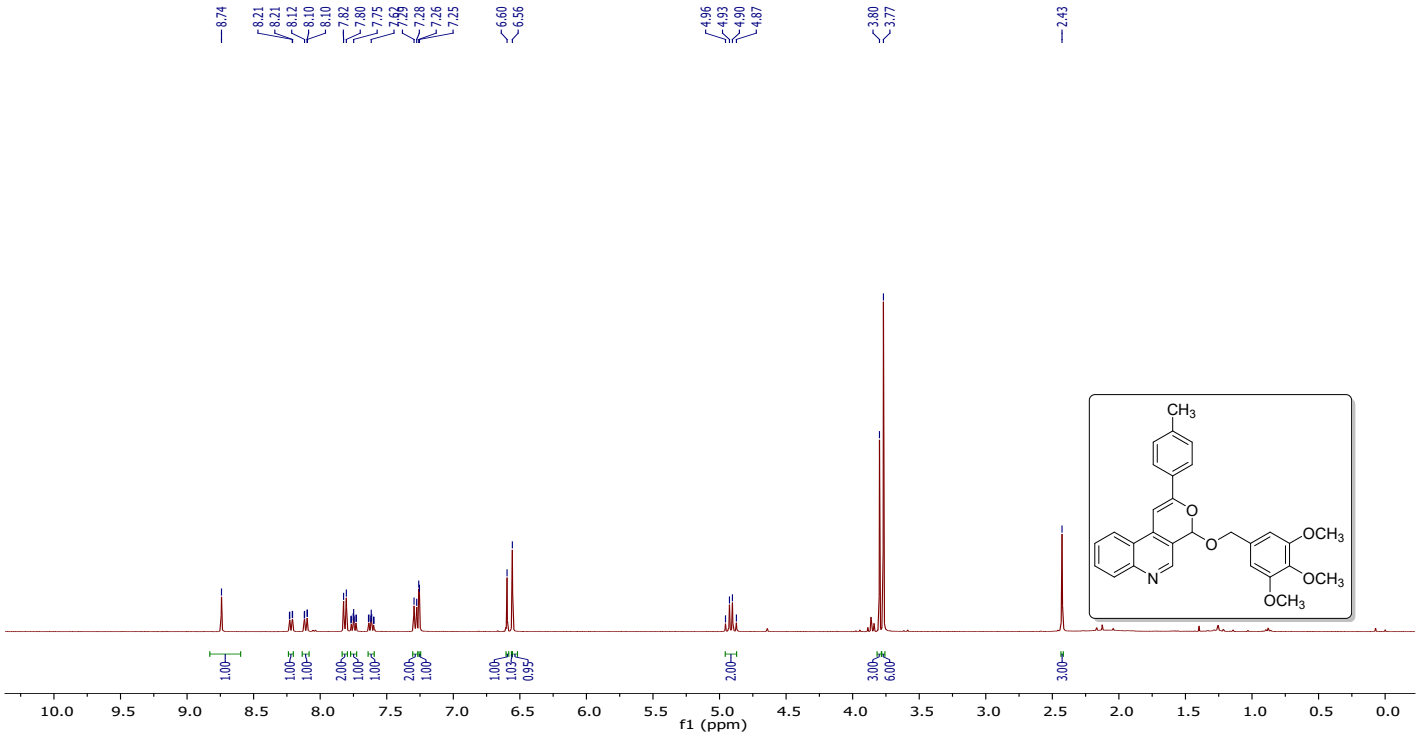


^{13}C NMR (101 MHz, $CDCl_3$)

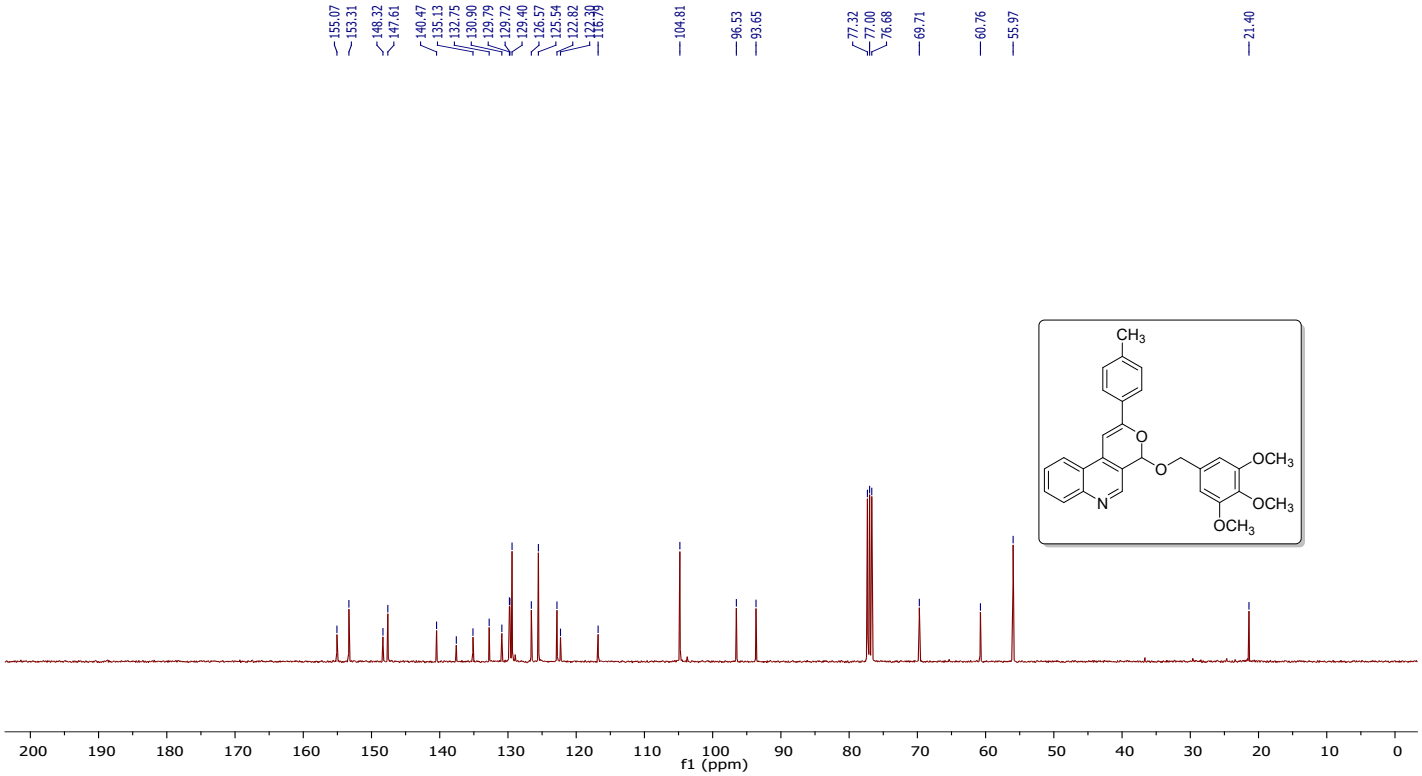


2-(*p*-tolyl)-4-((3,4,5-trimethoxybenzyl)oxy)-4*H*-pyrano[3,4-*c*]quinoline (3bn)

^{1}H NMR (400 MHz, $CDCl_3$)

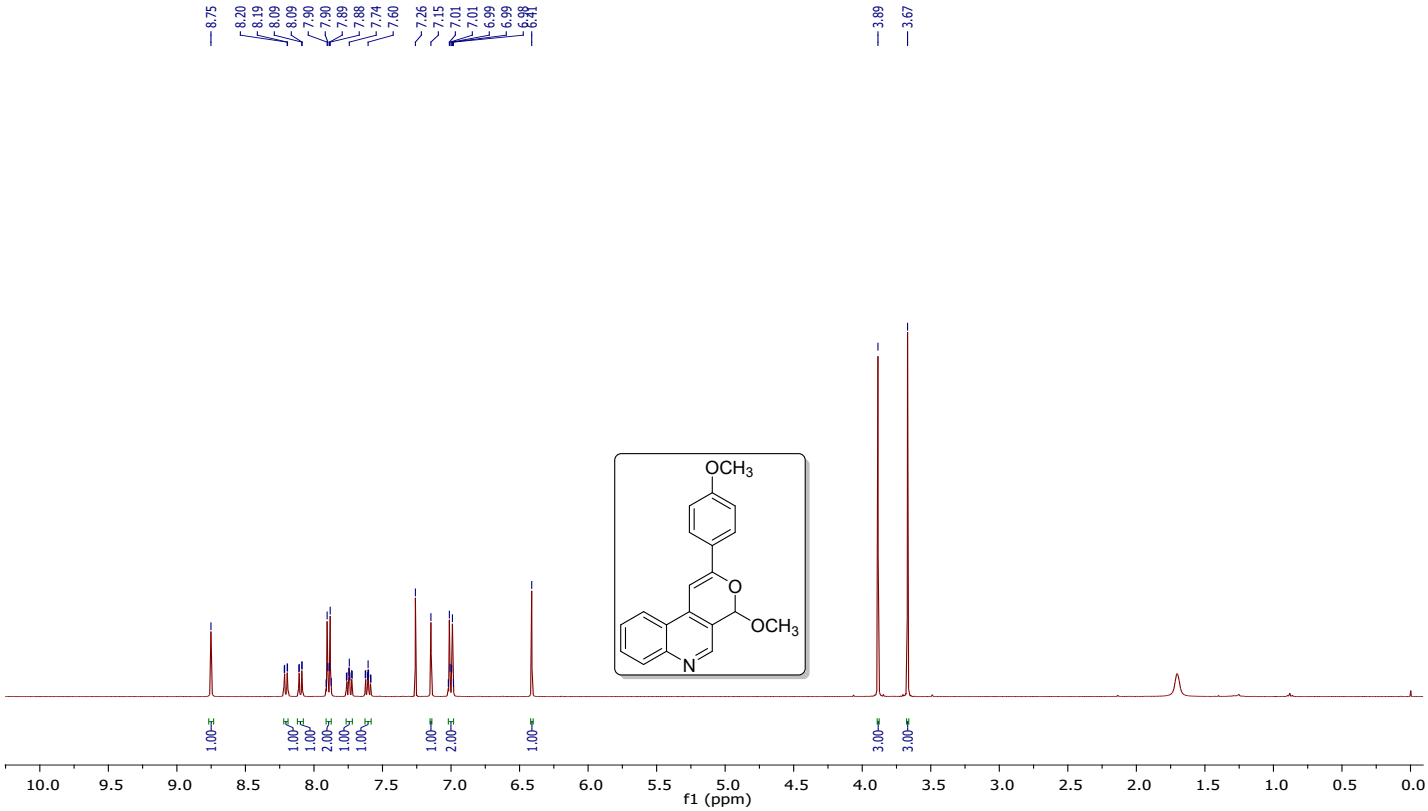


^{13}C NMR (101 MHz, $CDCl_3$)

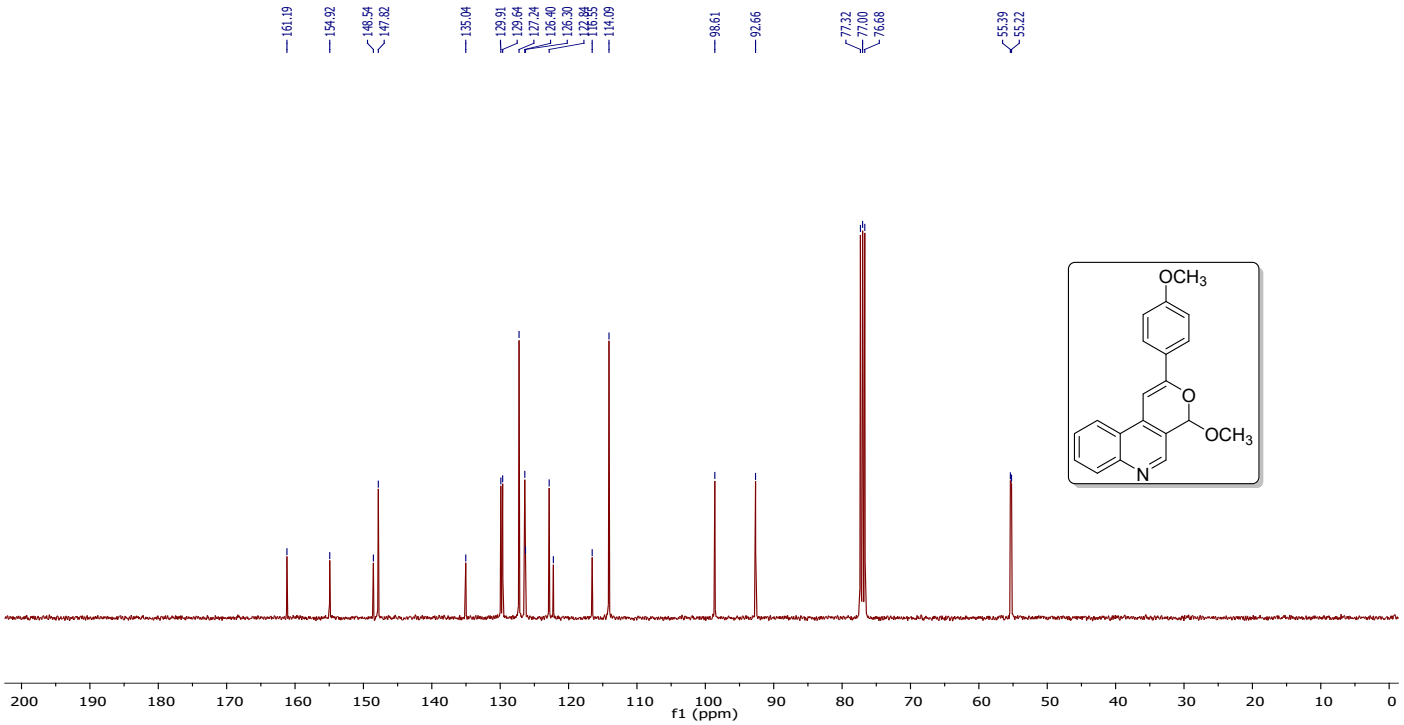


4-methoxy-2-(4-methoxyphenyl)-4*H*-pyrano[3,4-*c*]quinoline (3ca)

^{1}H NMR (400 MHz, $CDCl_3$)

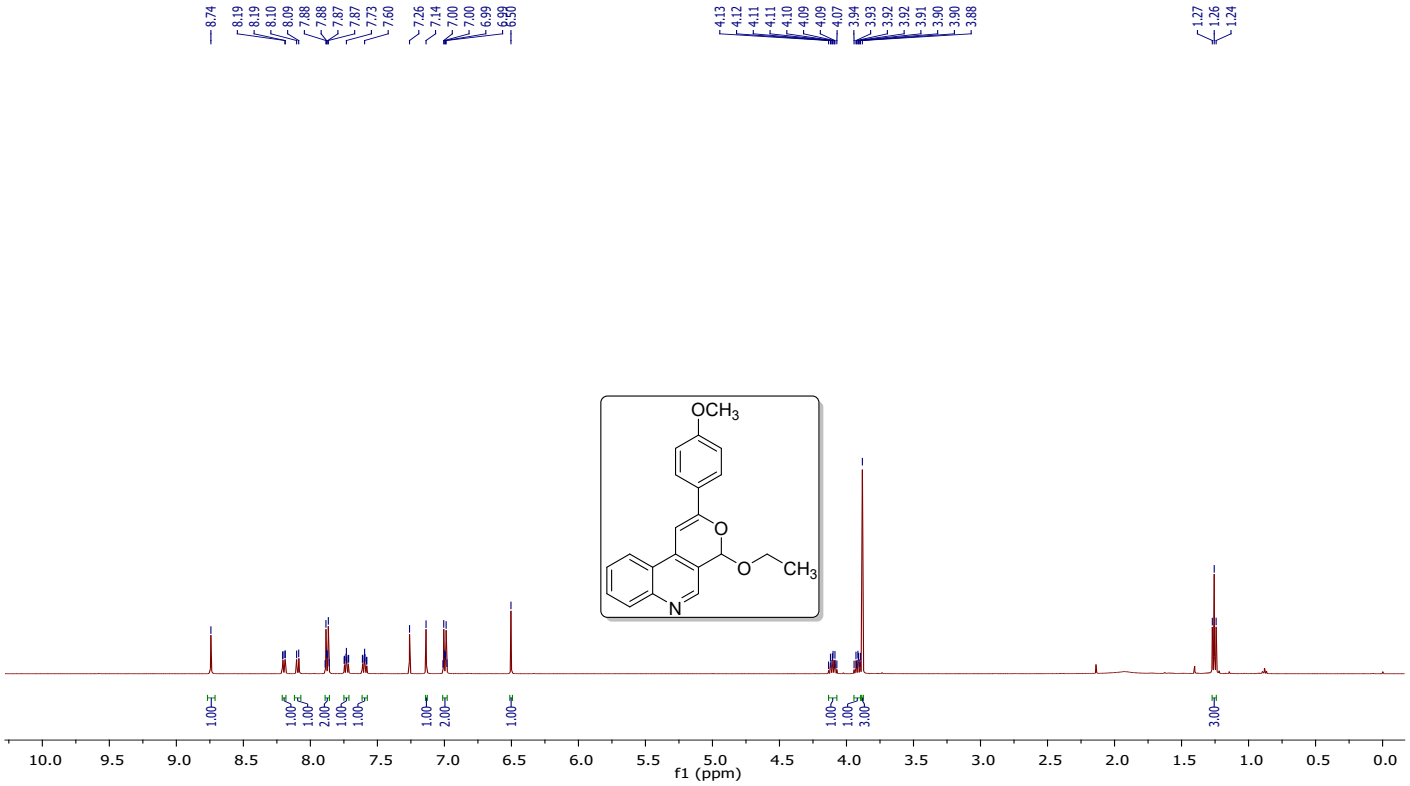


^{13}C NMR (101 MHz, $CDCl_3$)

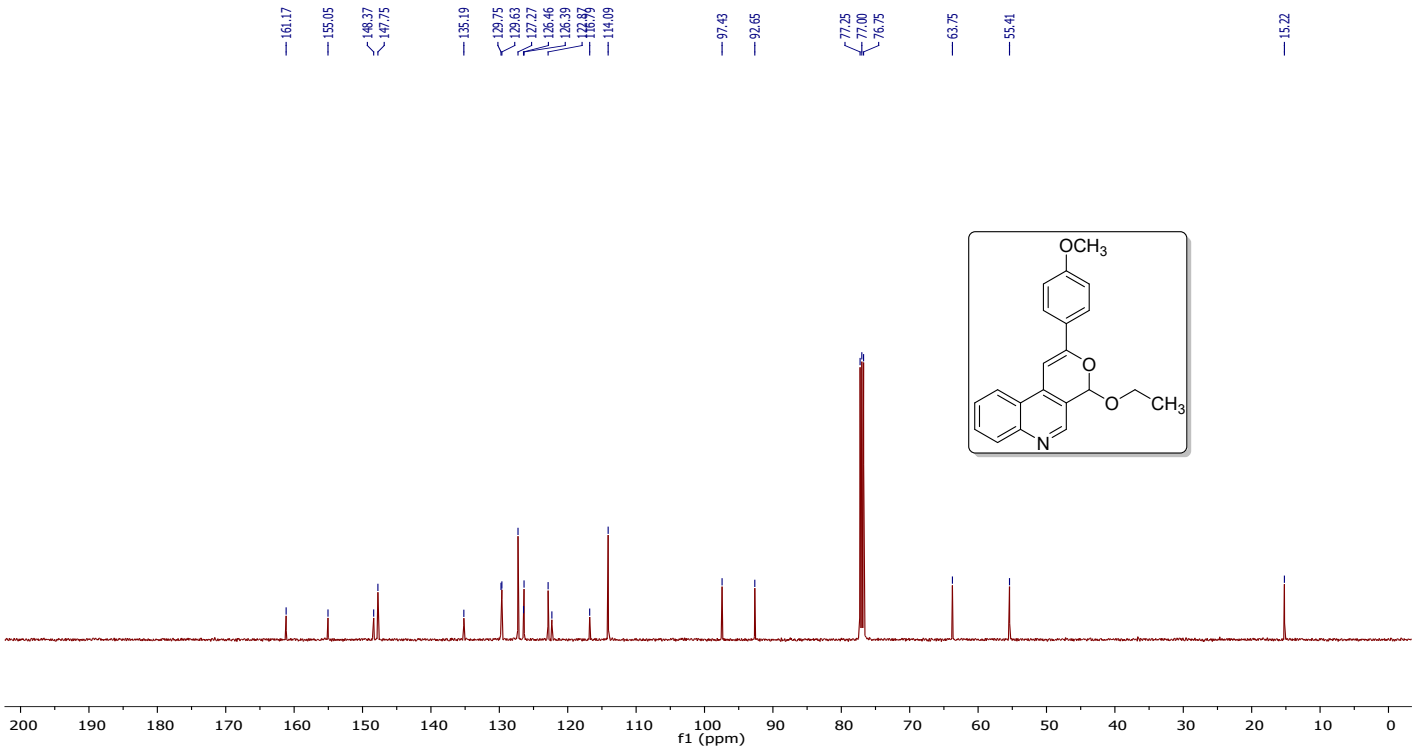


4-ethoxy-2-(4-methoxyphenyl)-4*H*-pyrano[3,4-*c*]quinoline (3cb)

^{1}H NMR (500 MHz, $CDCl_3$)

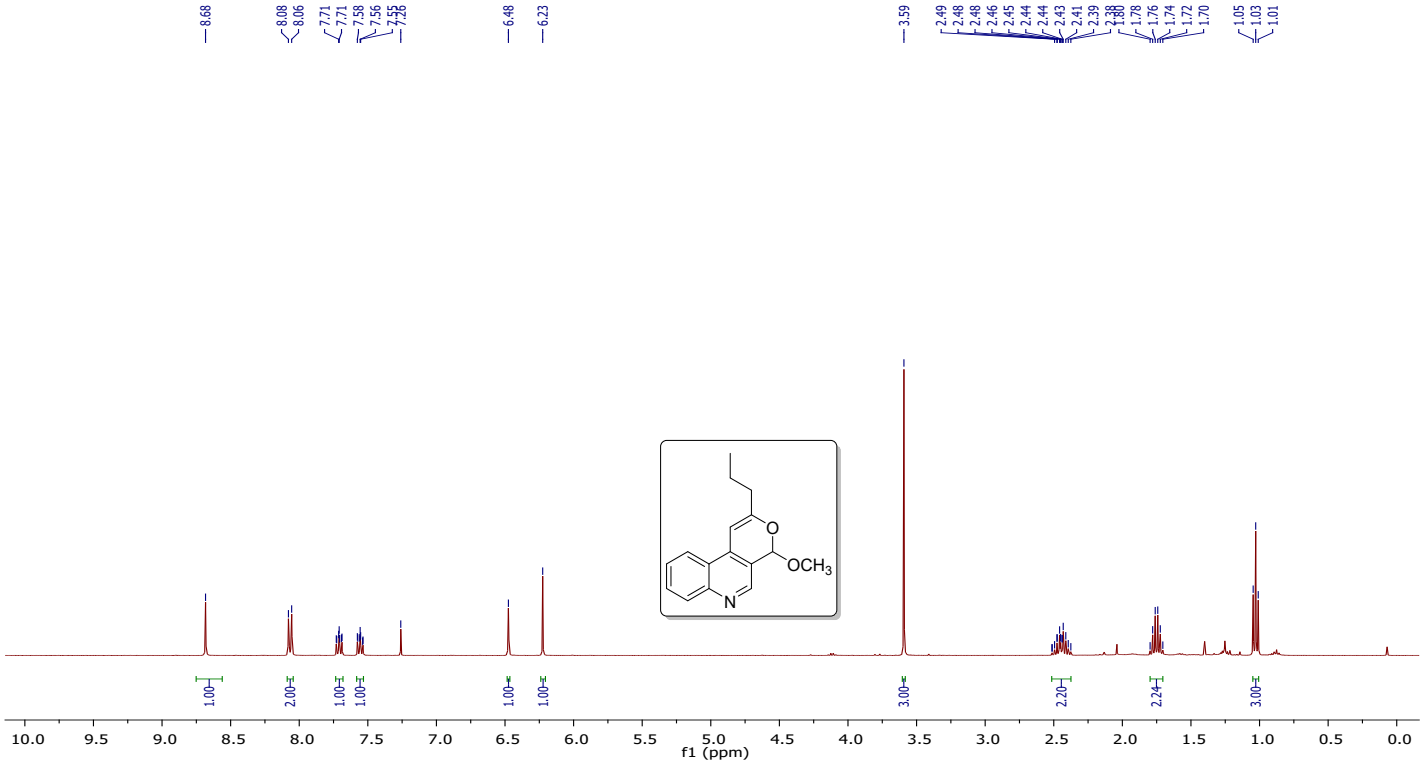


^{13}C NMR (126 MHz, $CDCl_3$)

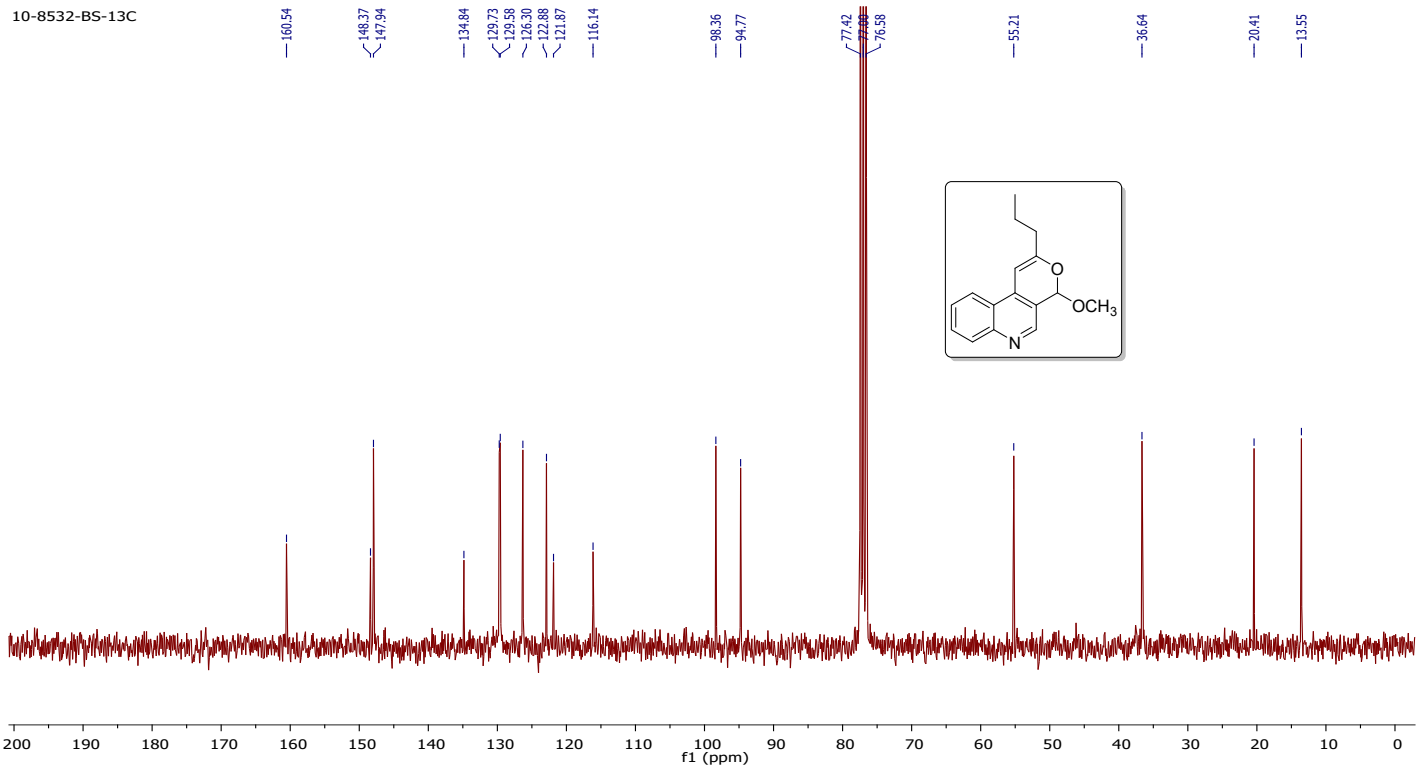


4-methoxy-2-propyl-4*H*-pyrano[3,4-*c*]quinoline (3da)

^{1}H NMR (400 MHz, $CDCl_3$)

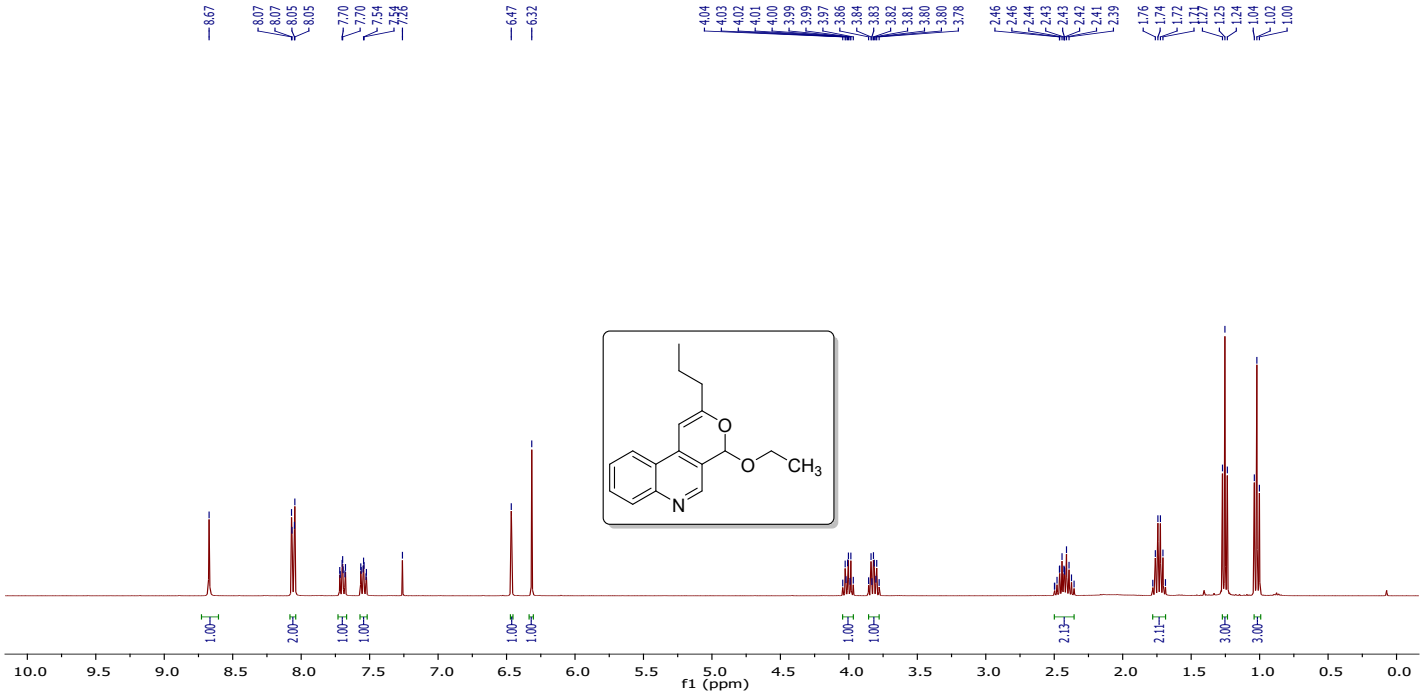


^{13}C NMR (75 MHz, $CDCl_3$)

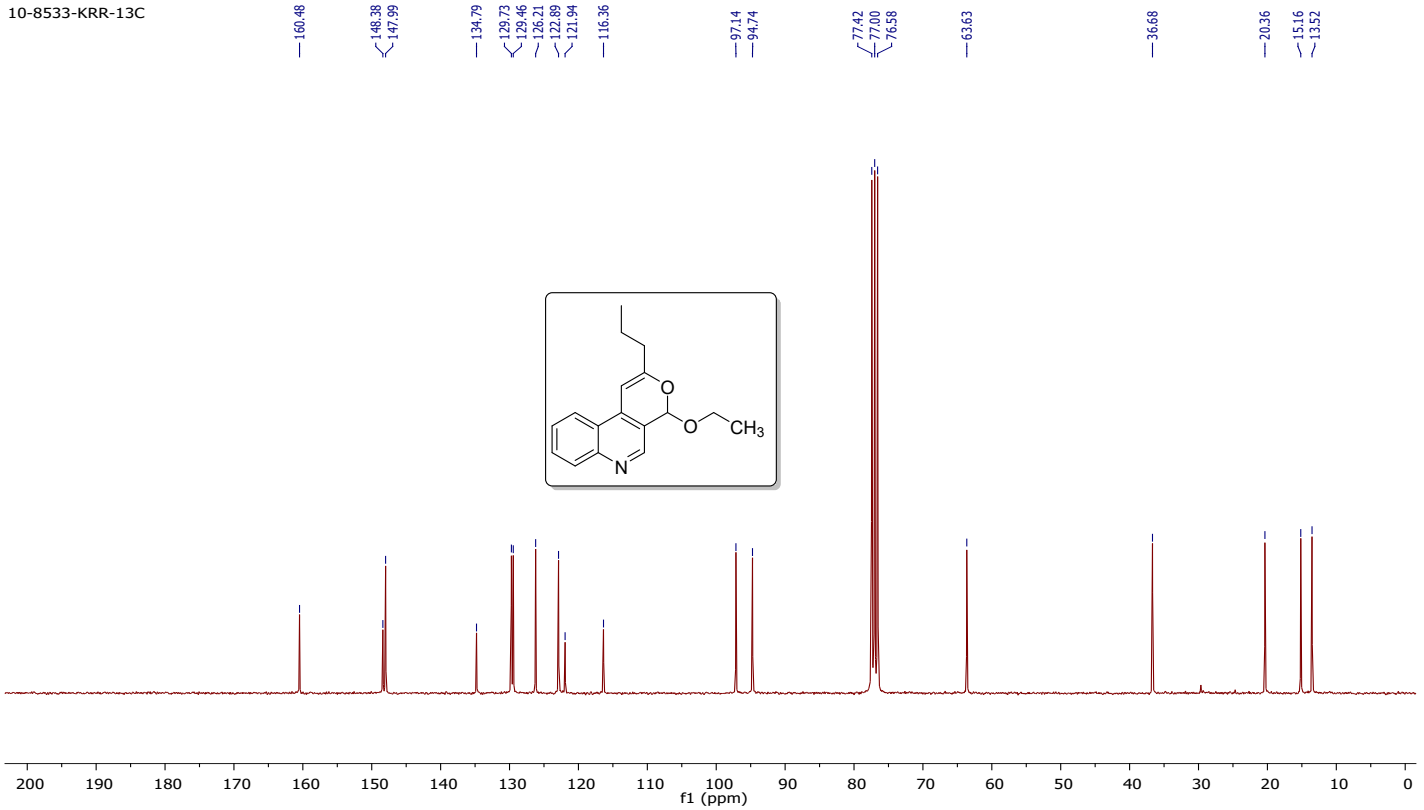


4-ethoxy-2-propyl-4*H*-pyrano[3,4-*c*]quinoline (3db)

^{1}H NMR (400 MHz, $CDCl_3$)

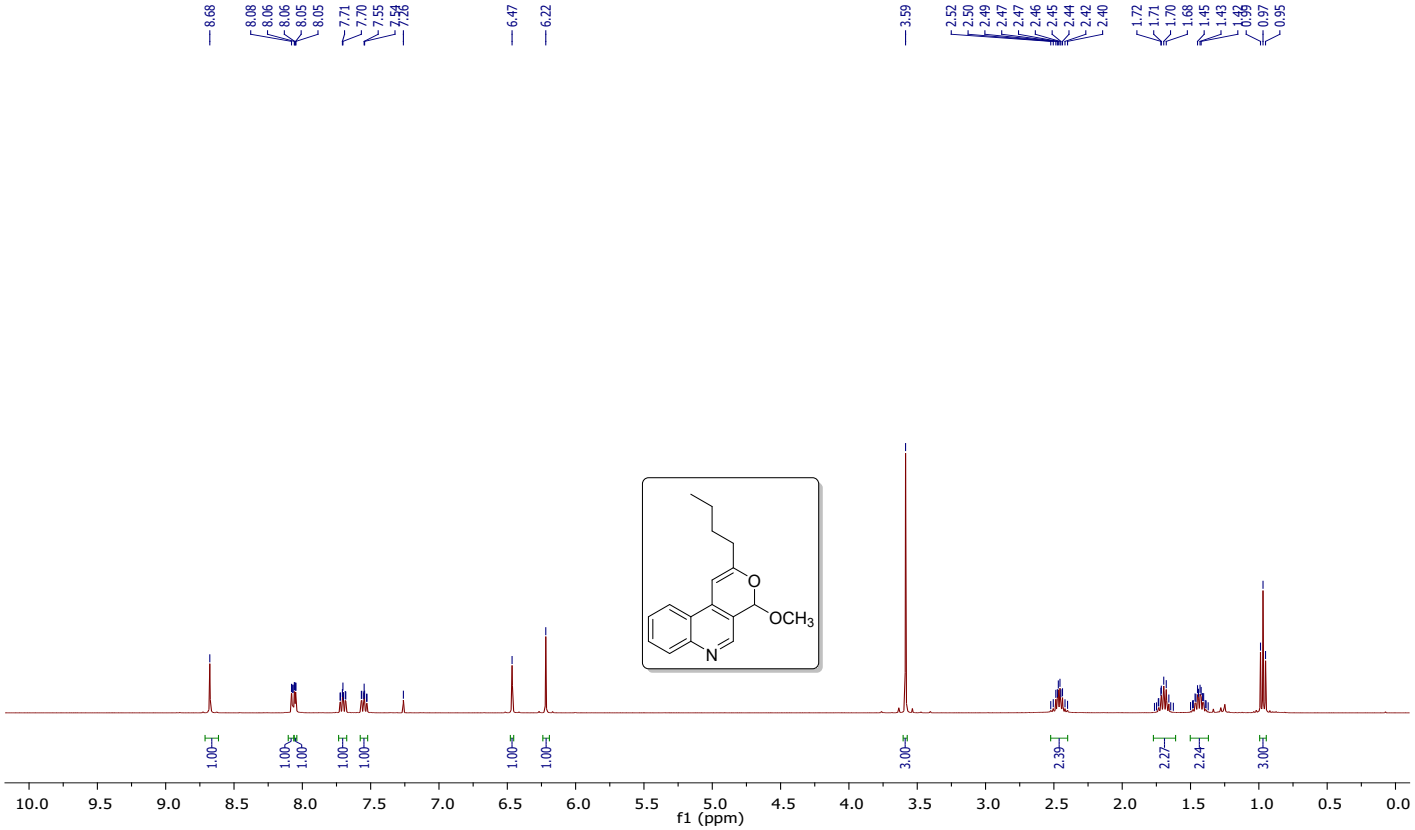


^{13}C NMR (75 MHz, $CDCl_3$)

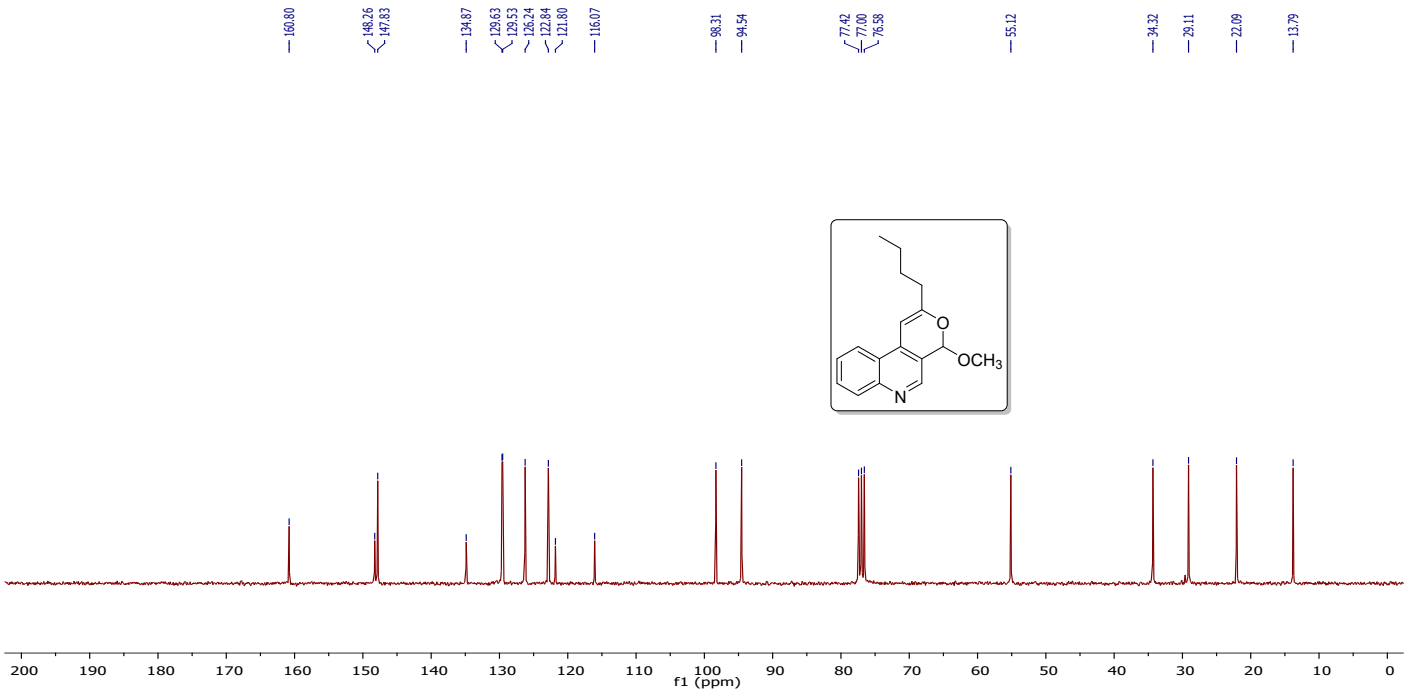


2-butyl-4-methoxy-4*H*-pyrano[3,4-*c*]quinoline (3ea)

^{1}H NMR (400 MHz, $CDCl_3$)

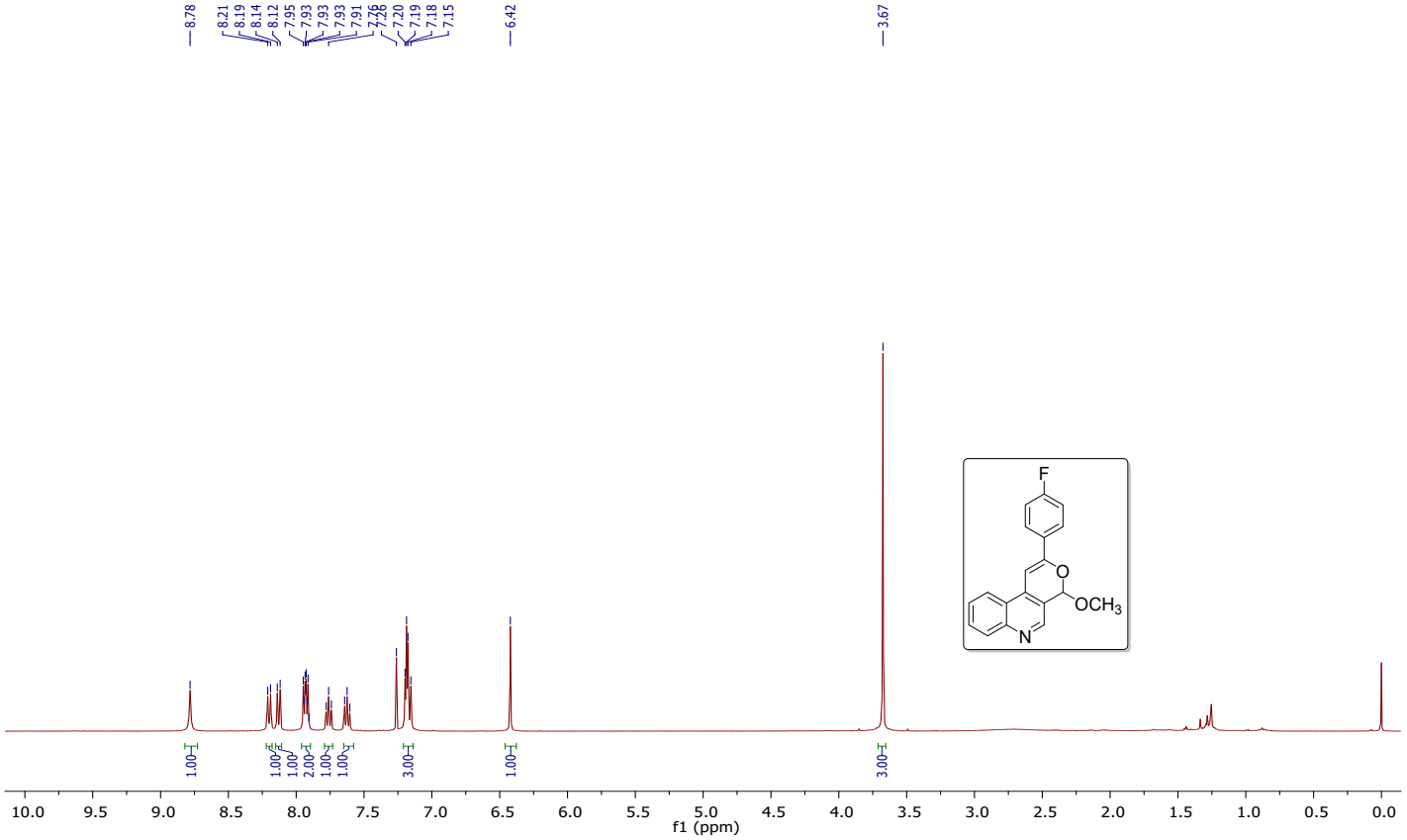


^{13}C NMR (75 MHz, $CDCl_3$)

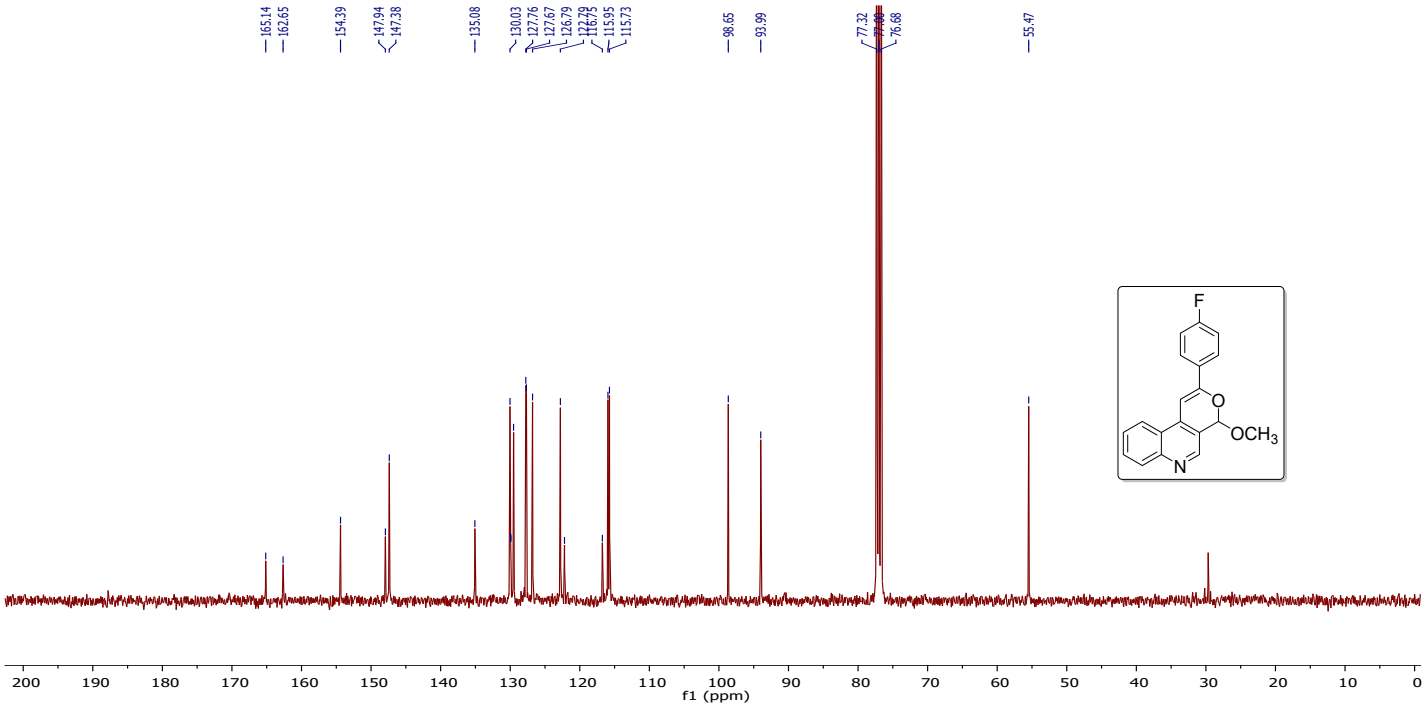


2-(4-fluorophenyl)-4-methoxy-4*H*-pyrano[3,4-*c*]quinoline (3fa)

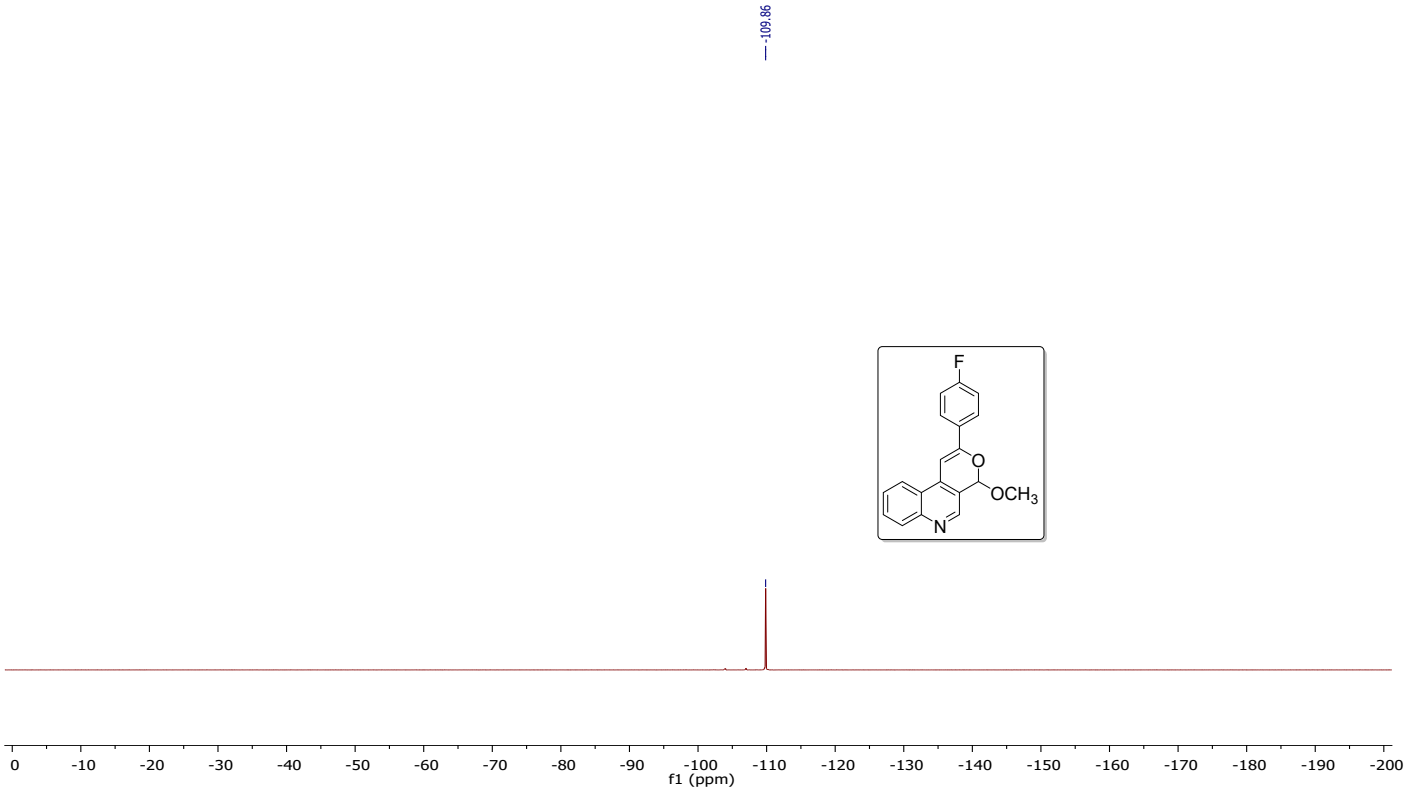
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)

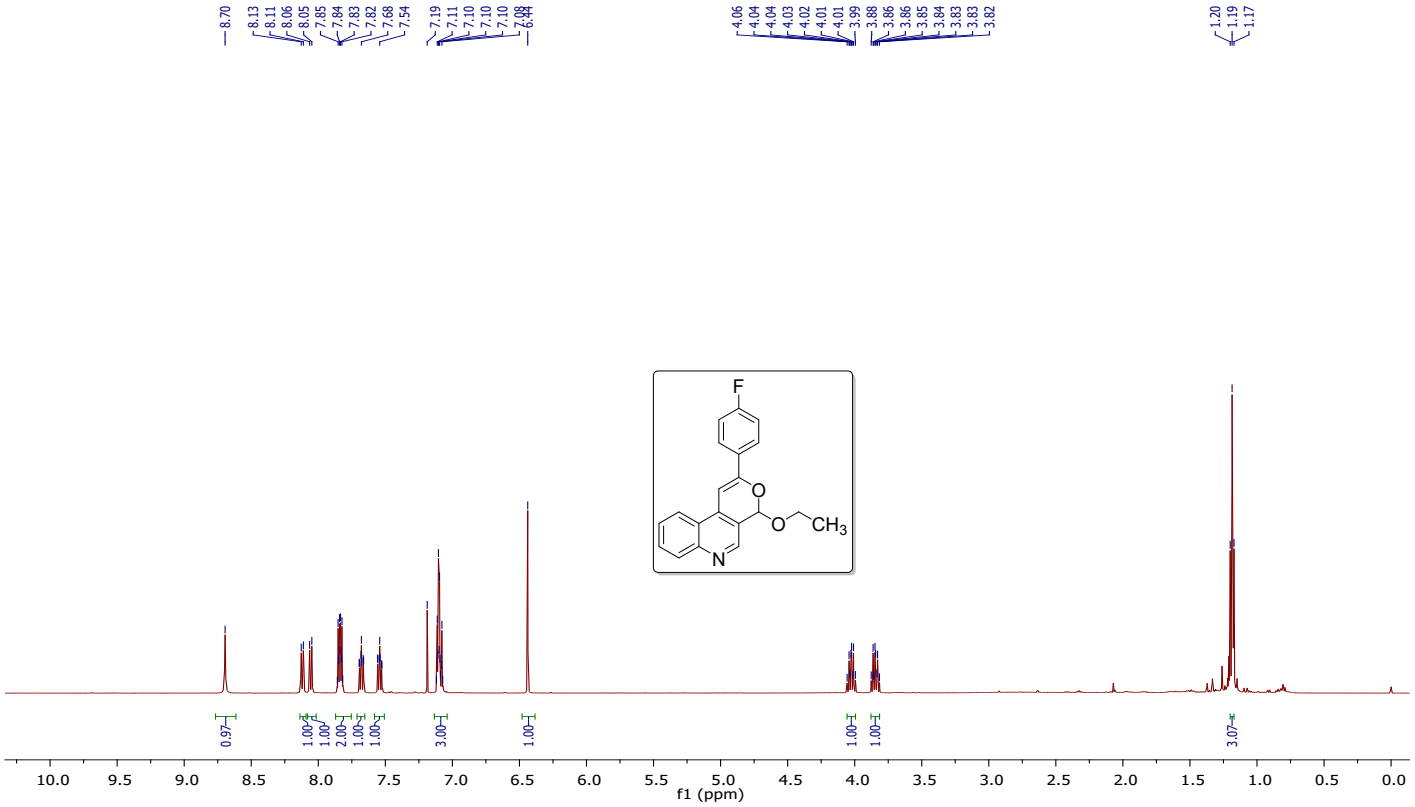


^{19}F NMR (471 MHz, $CDCl_3$)

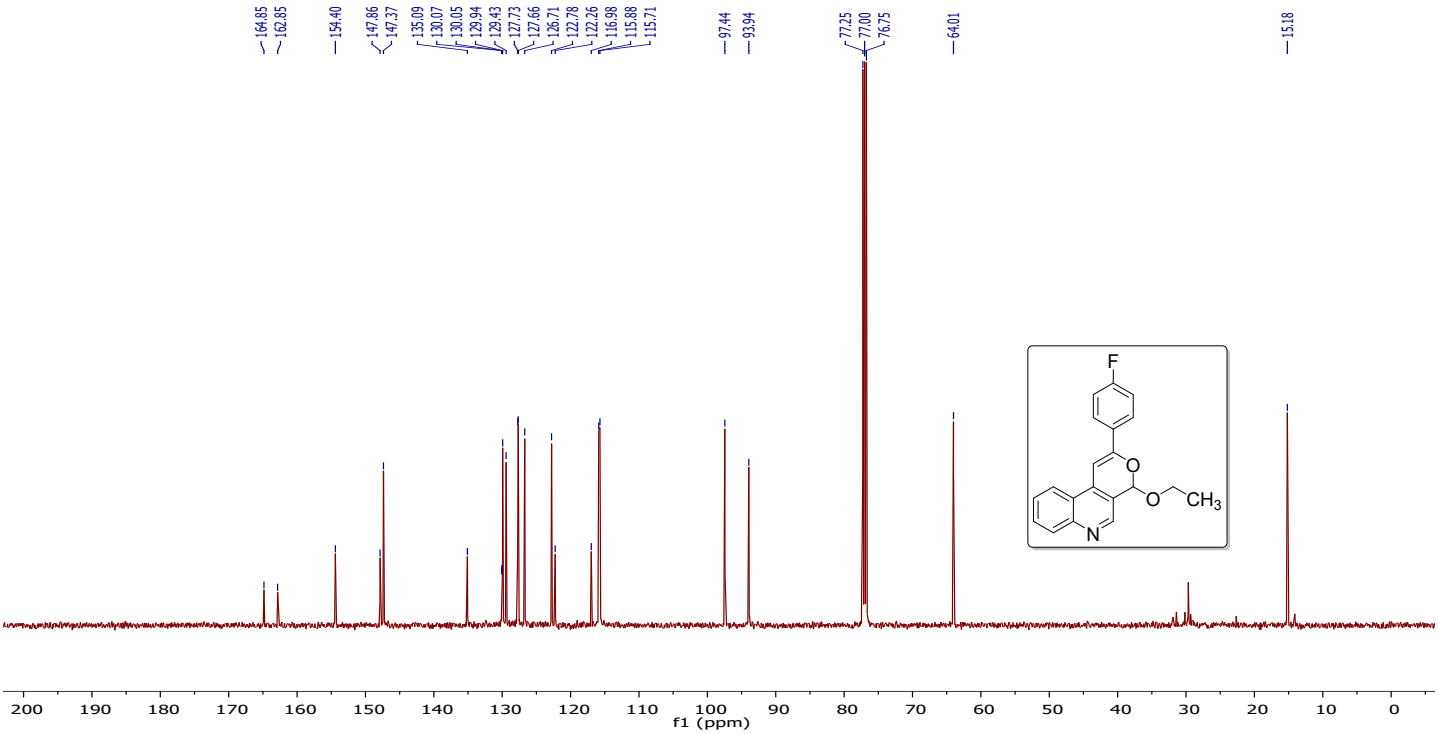


4-ethoxy-2-(4-fluorophenyl)-4*H*-pyrano[3,4-*c*]quinoline (3fb)

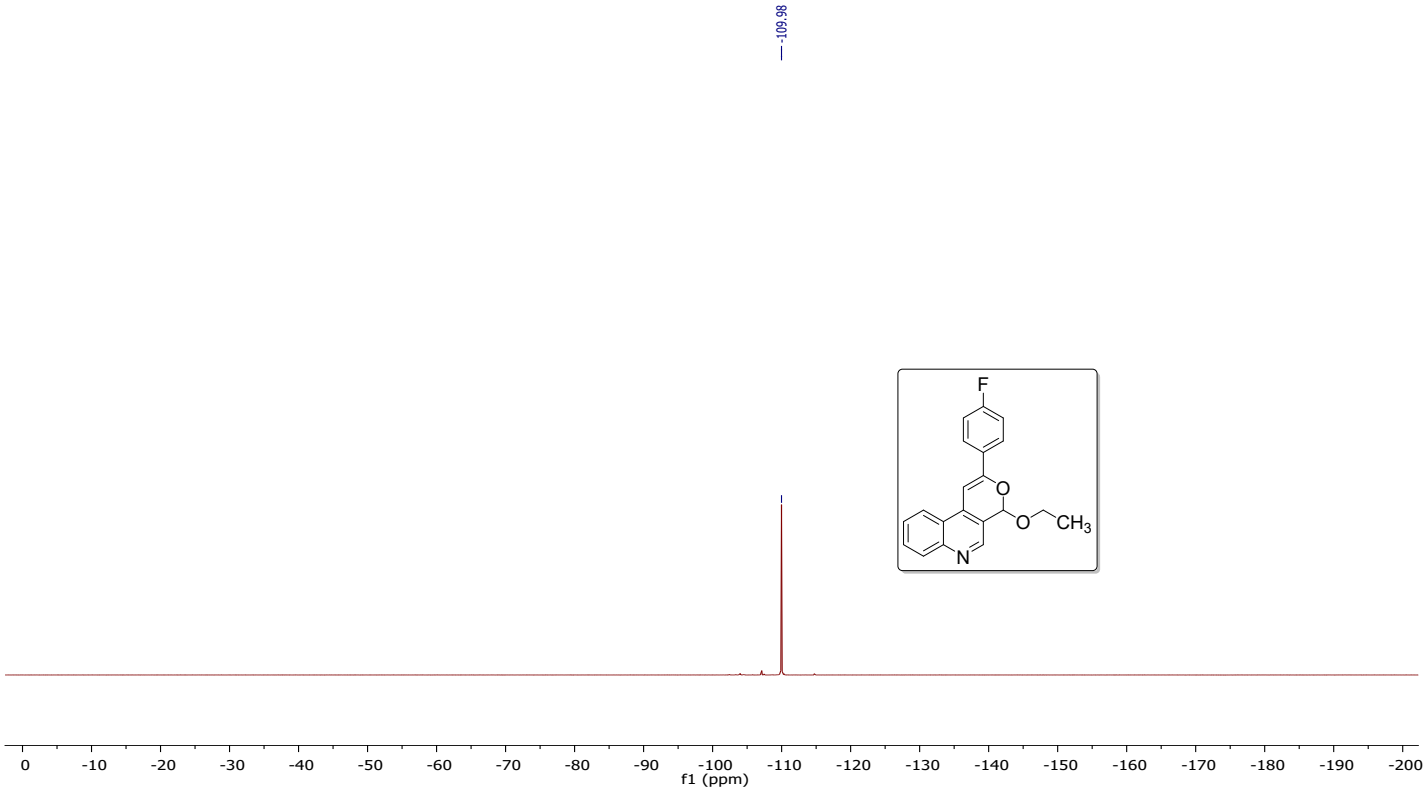
^{1}H NMR (500 MHz, $CDCl_3$)



^{13}C NMR (126 MHz, $CDCl_3$)

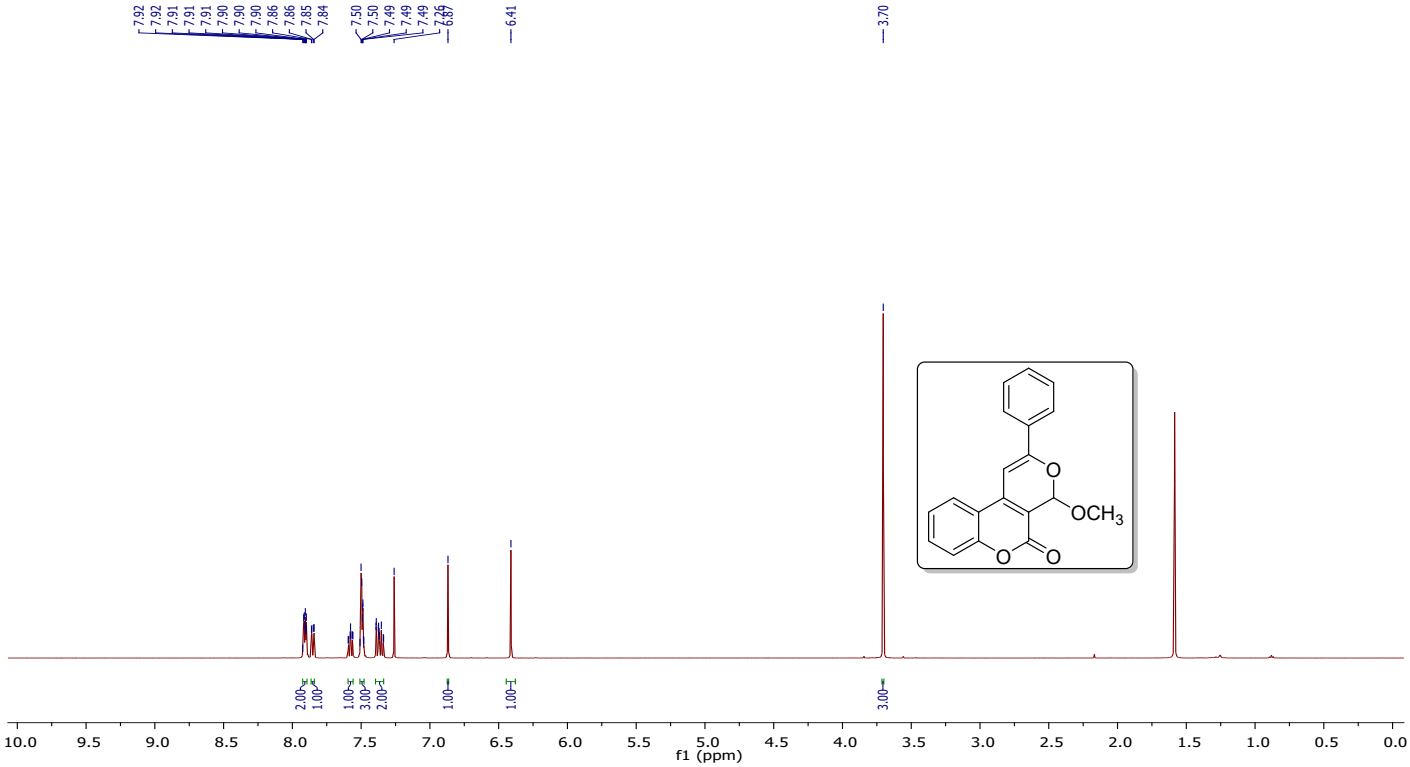


^{19}F NMR (471 MHz, $CDCl_3$)

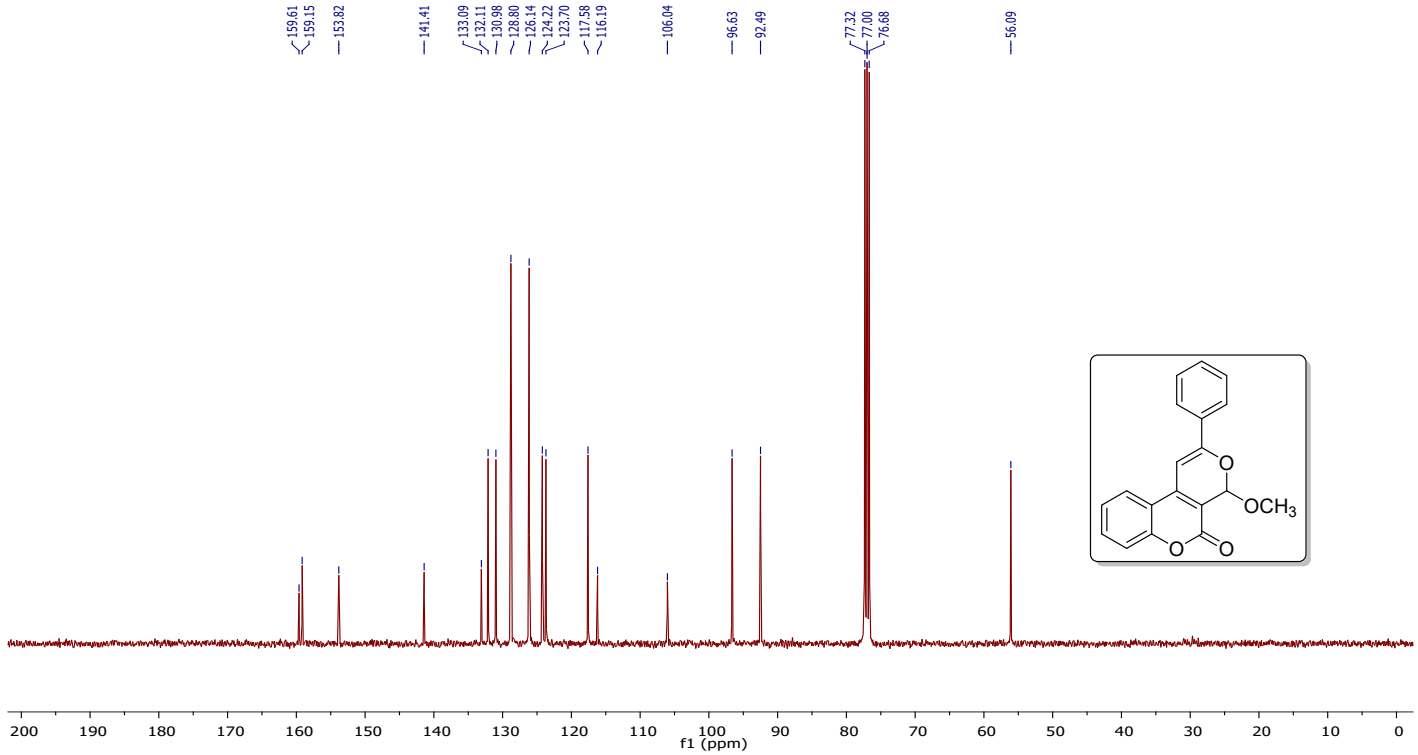


4-methoxy-2-phenyl-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4aa)

^{1}H NMR (500 MHz, $CDCl_3$)

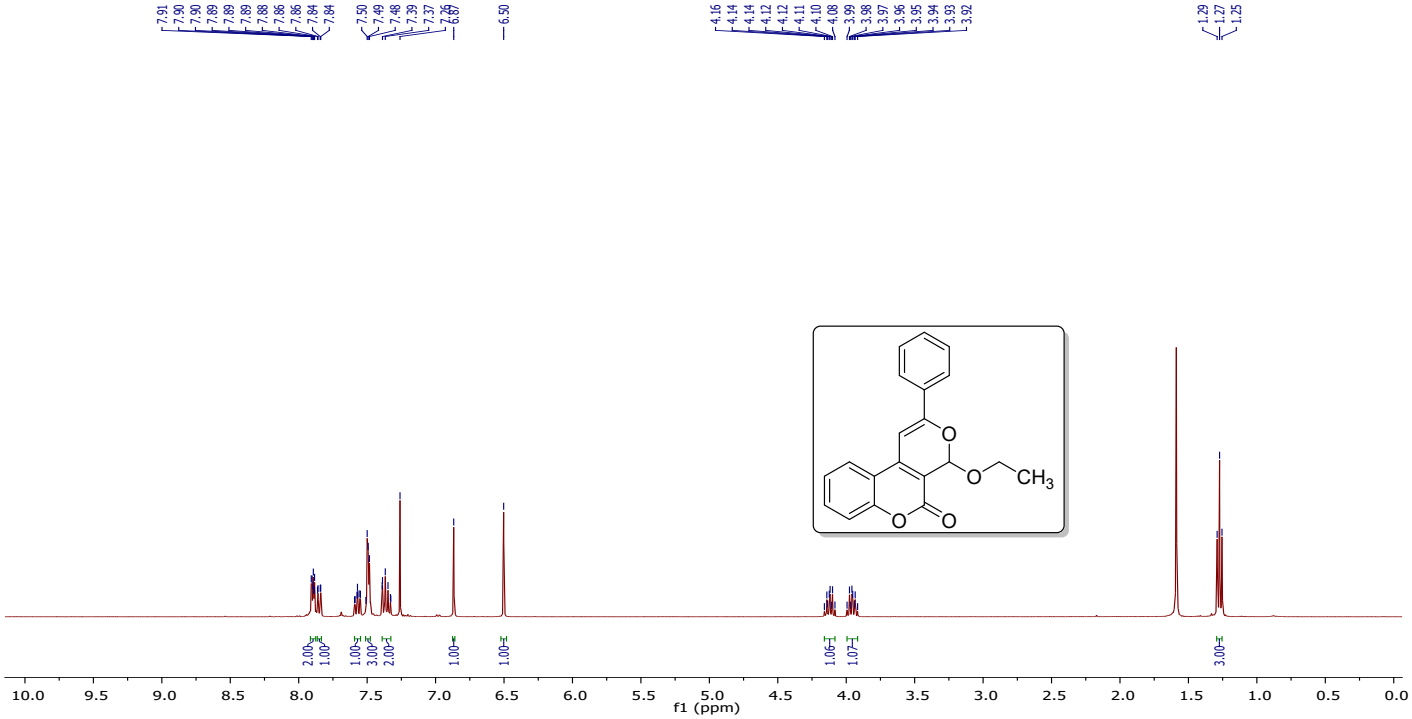


^{13}C NMR (101 MHz, $CDCl_3$)

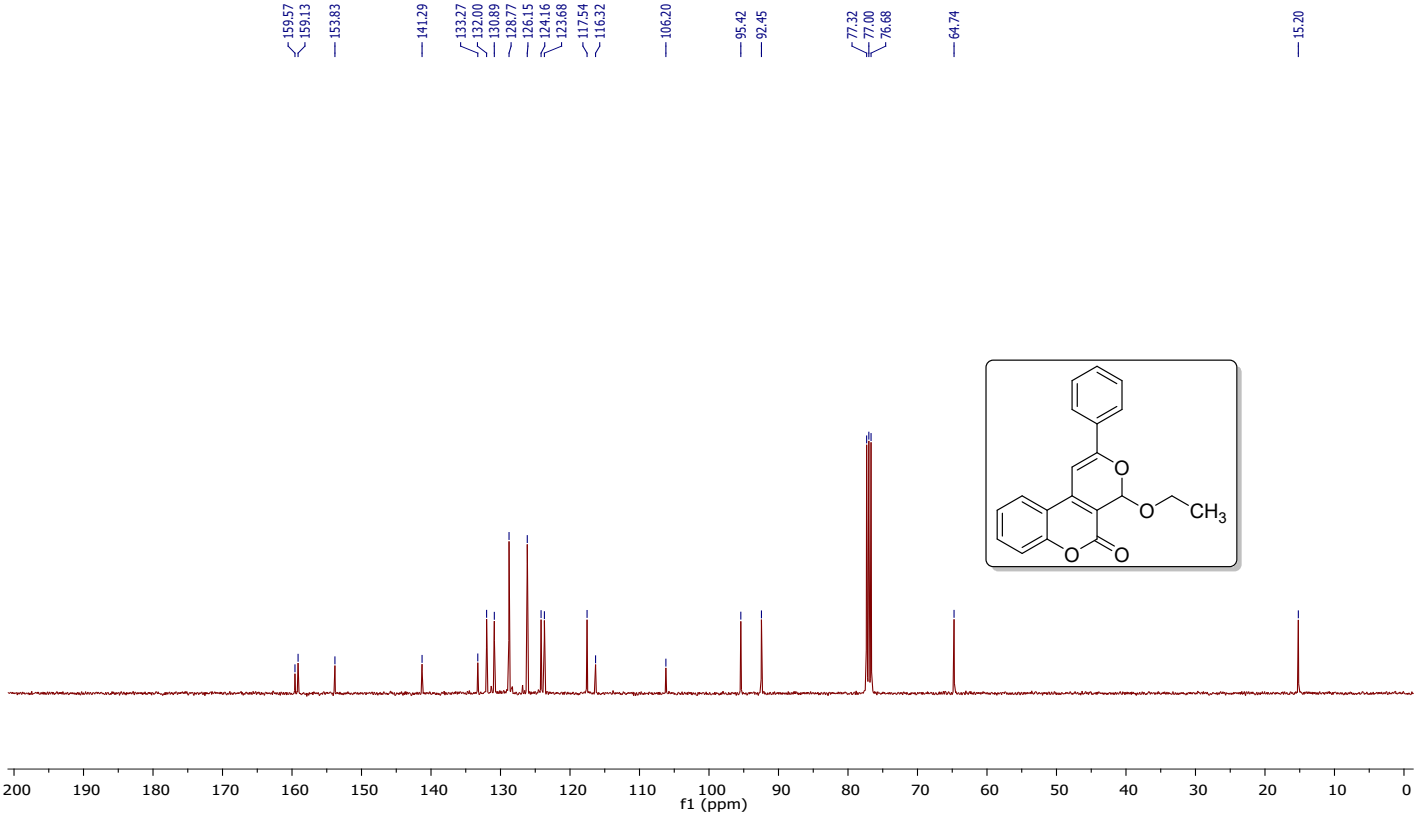


4-ethoxy-2-phenyl-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4ab)

^{1}H NMR (400 MHz, $CDCl_3$)

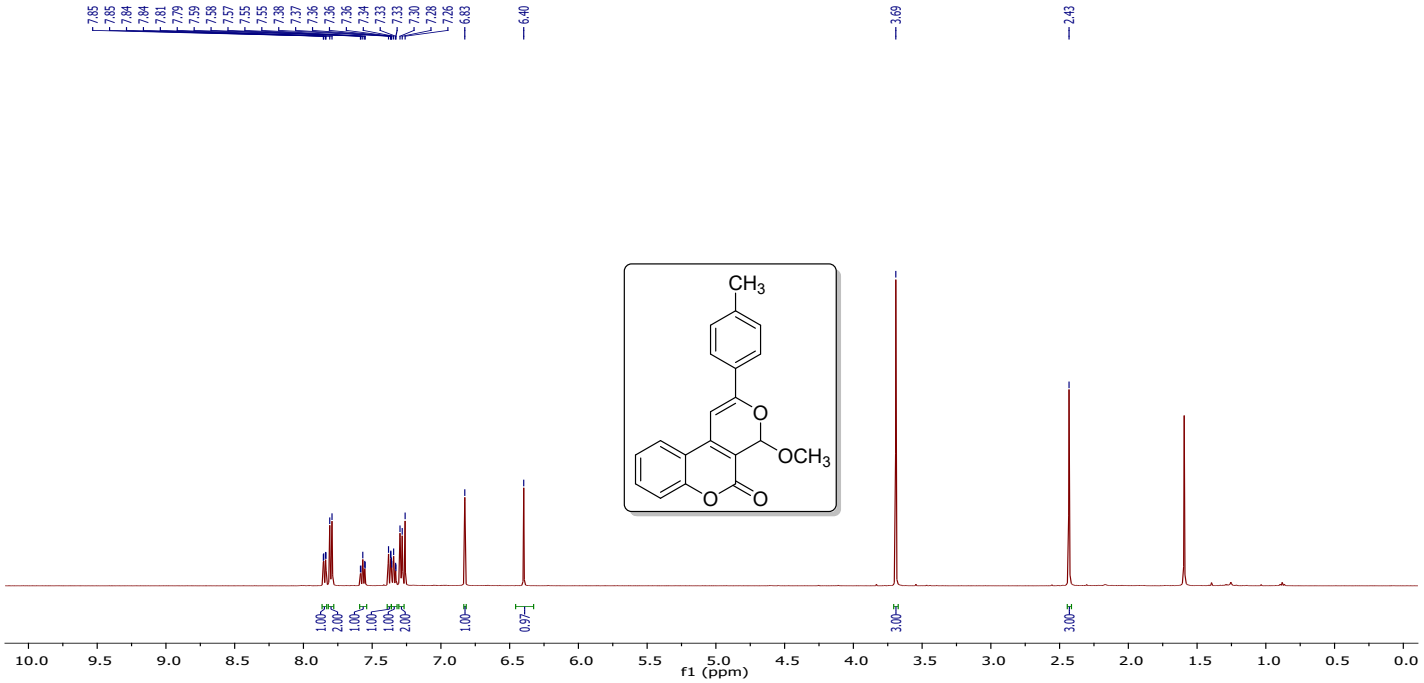


^{13}C NMR (101 MHz, $CDCl_3$)

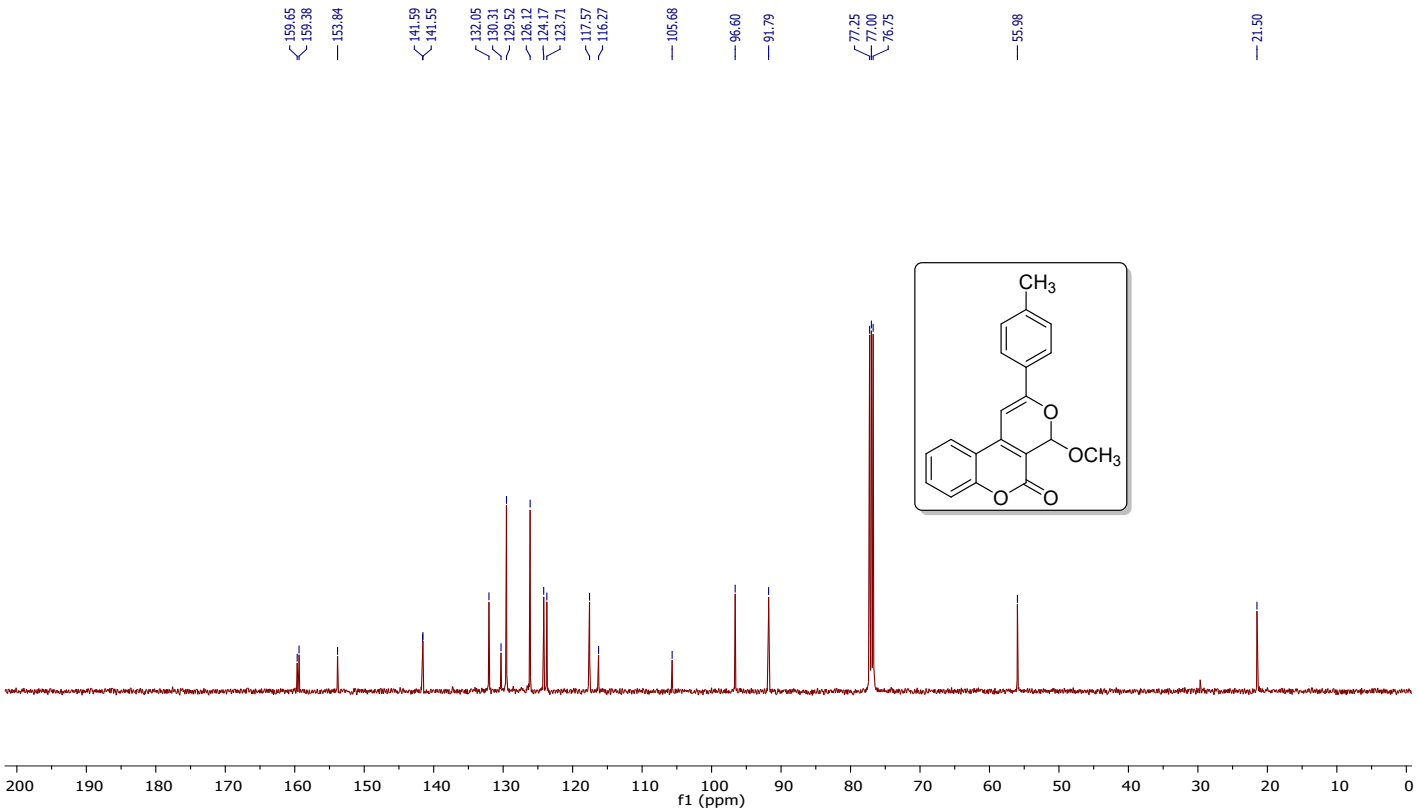


4-methoxy-2-(*p*-tolyl)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4ba)

^{1}H NMR (500 MHz, $CDCl_3$)

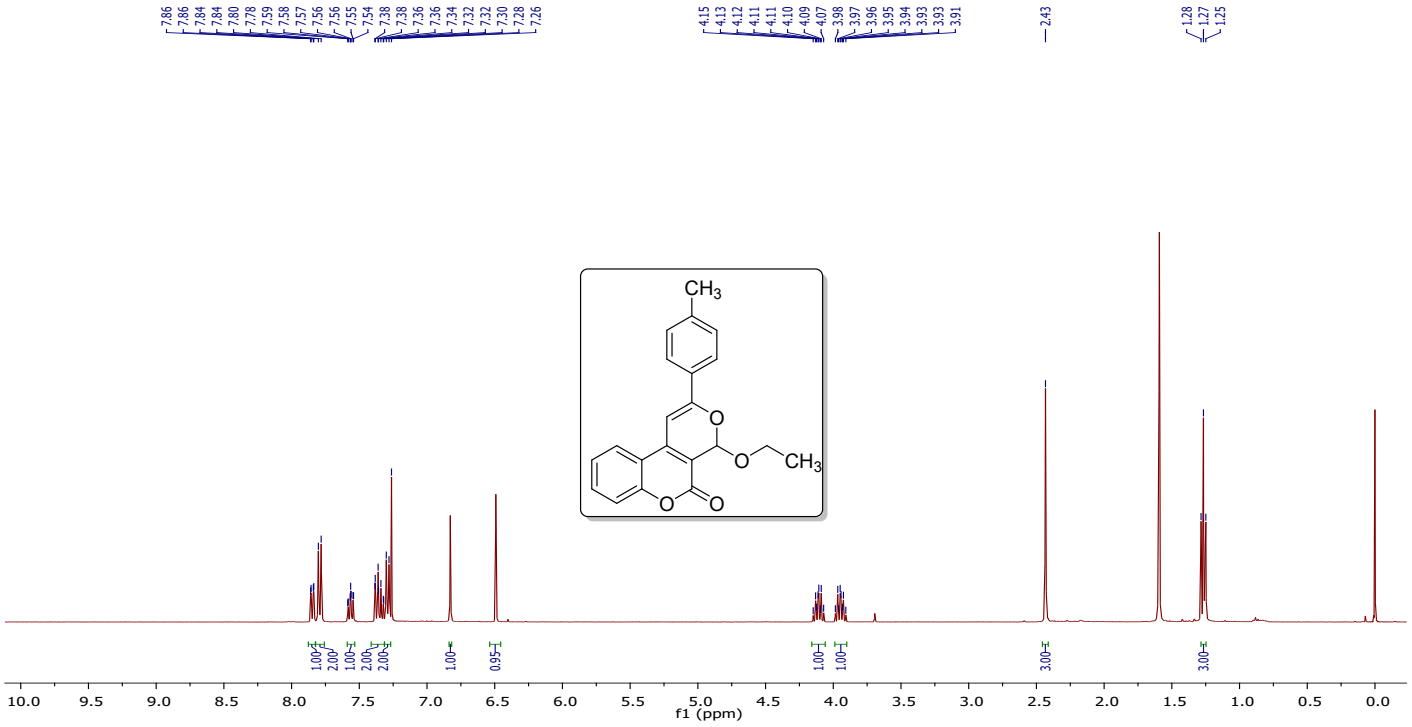


^{13}C NMR (126 MHz, $CDCl_3$)

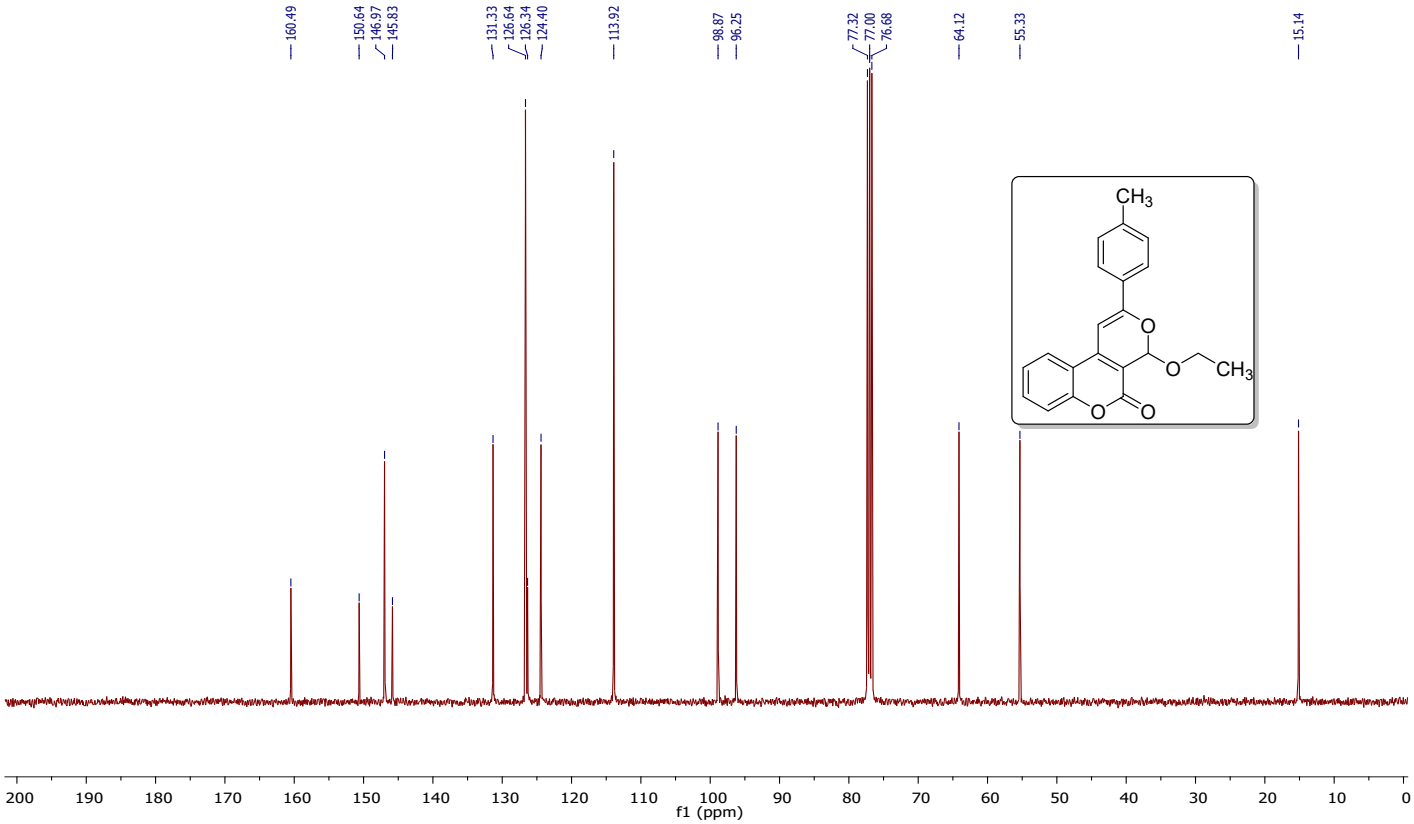


4-ethoxy-2-(*p*-tolyl)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4bb)

^{1}H NMR (400 MHz, $CDCl_3$)

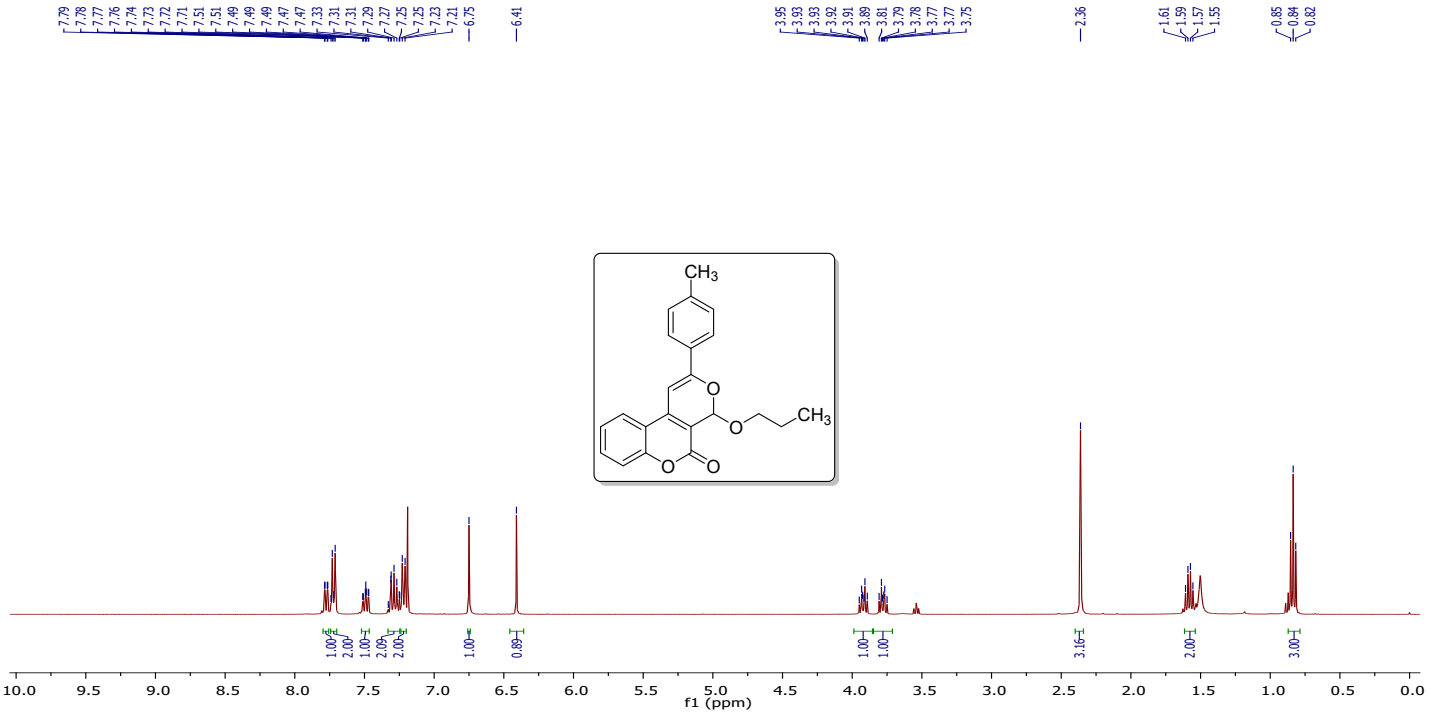


^{13}C NMR (101 MHz, $CDCl_3$)

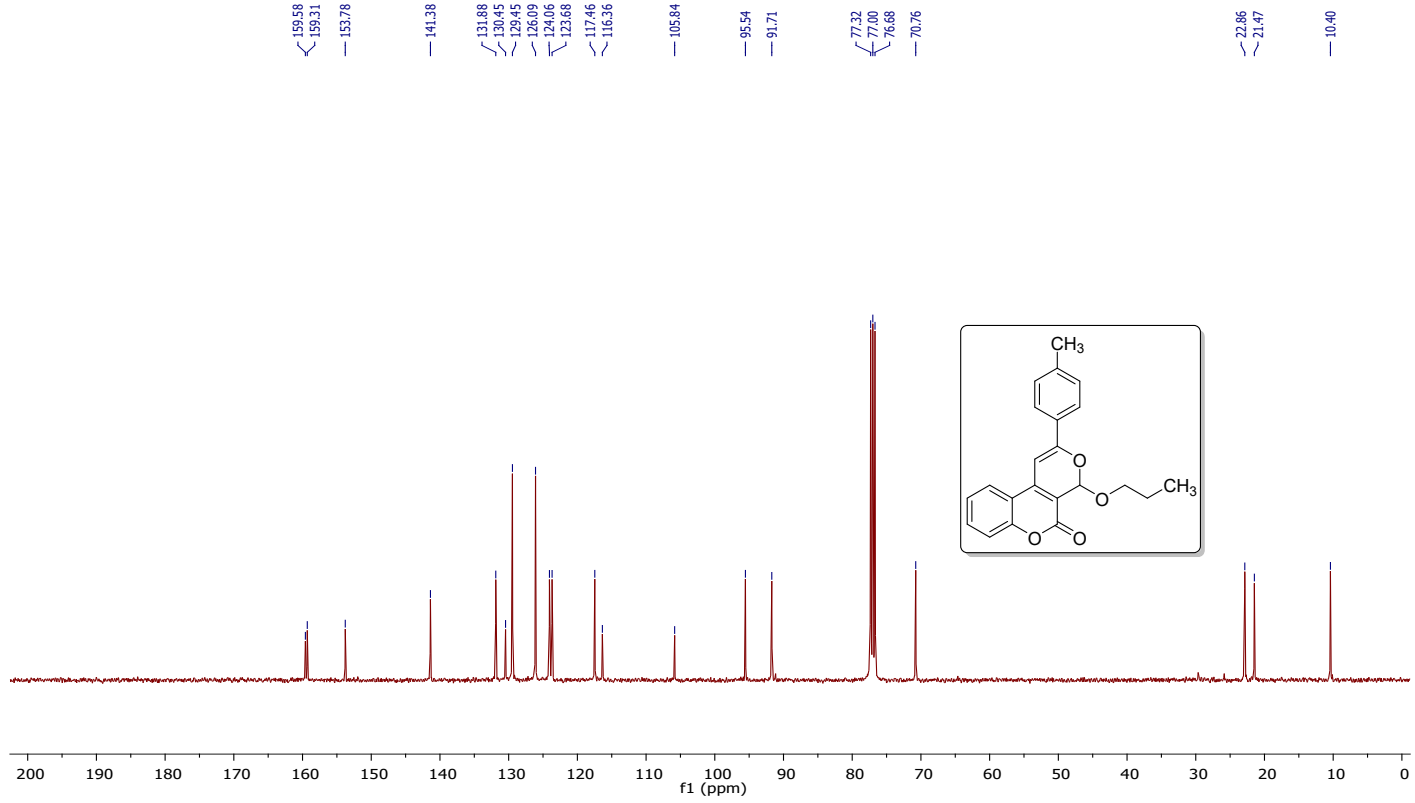


4-propoxy-2-(*p*-tolyl)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4bc)

^{1}H NMR (400 MHz, $CDCl_3$)

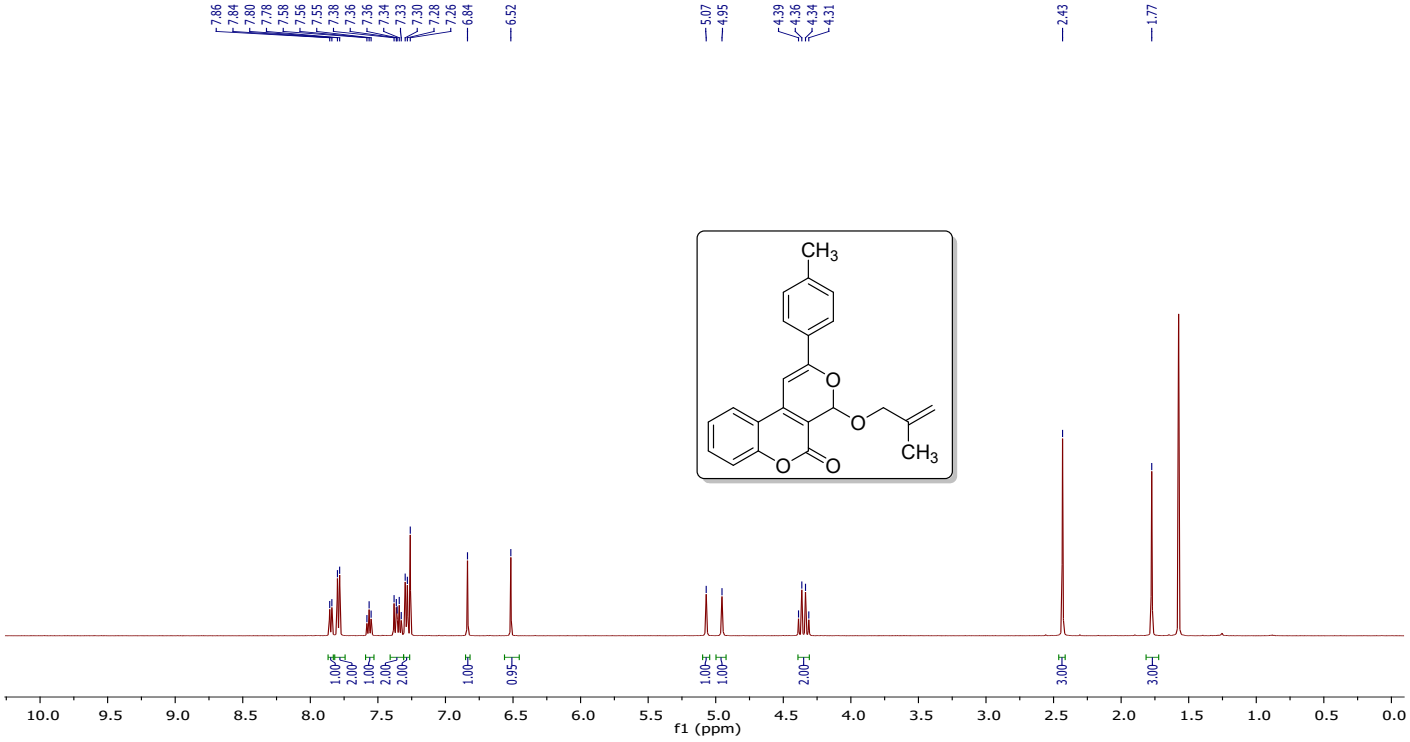


^{13}C NMR (101 MHz, $CDCl_3$)

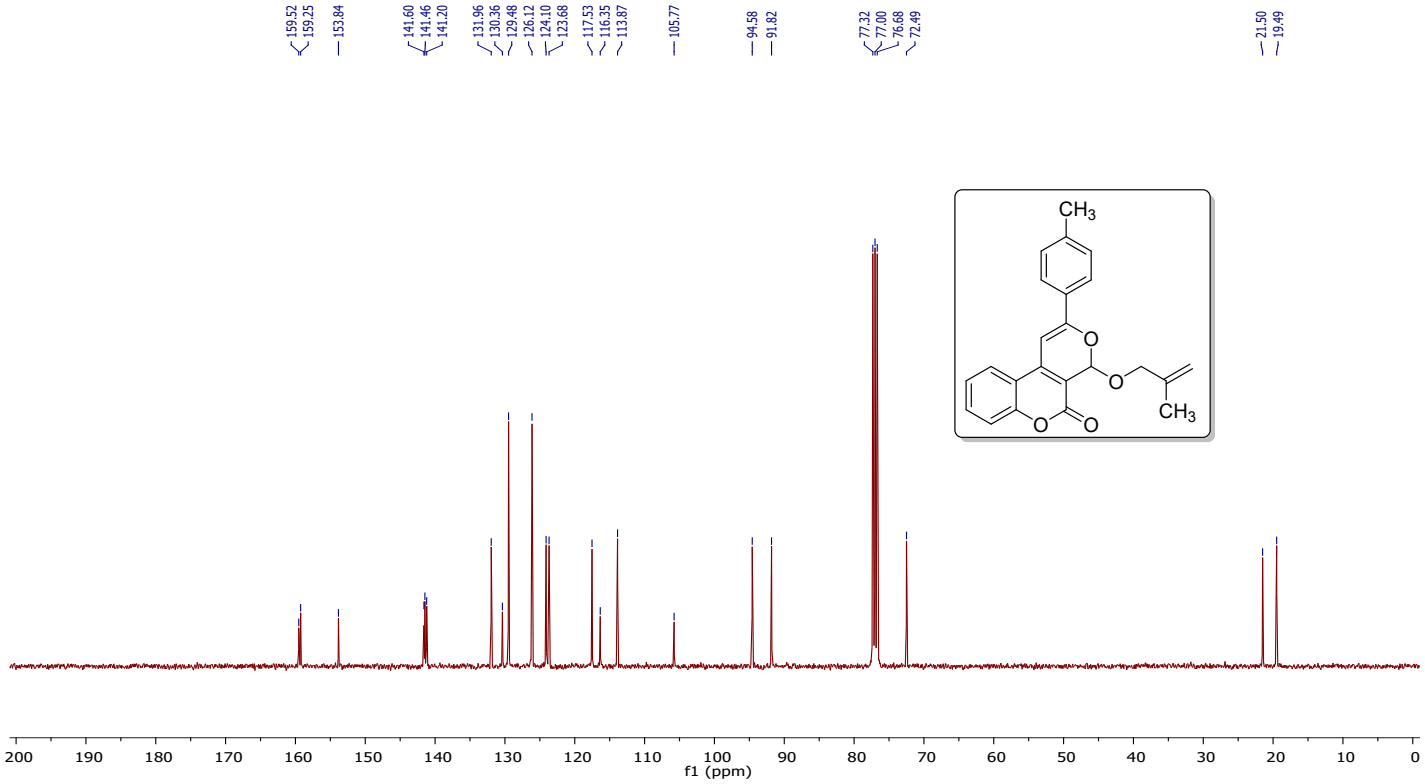


4-((2-methylallyl)oxy)-2-(*p*-tolyl)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4bf)

^{1}H NMR (500 MHz, $CDCl_3$)

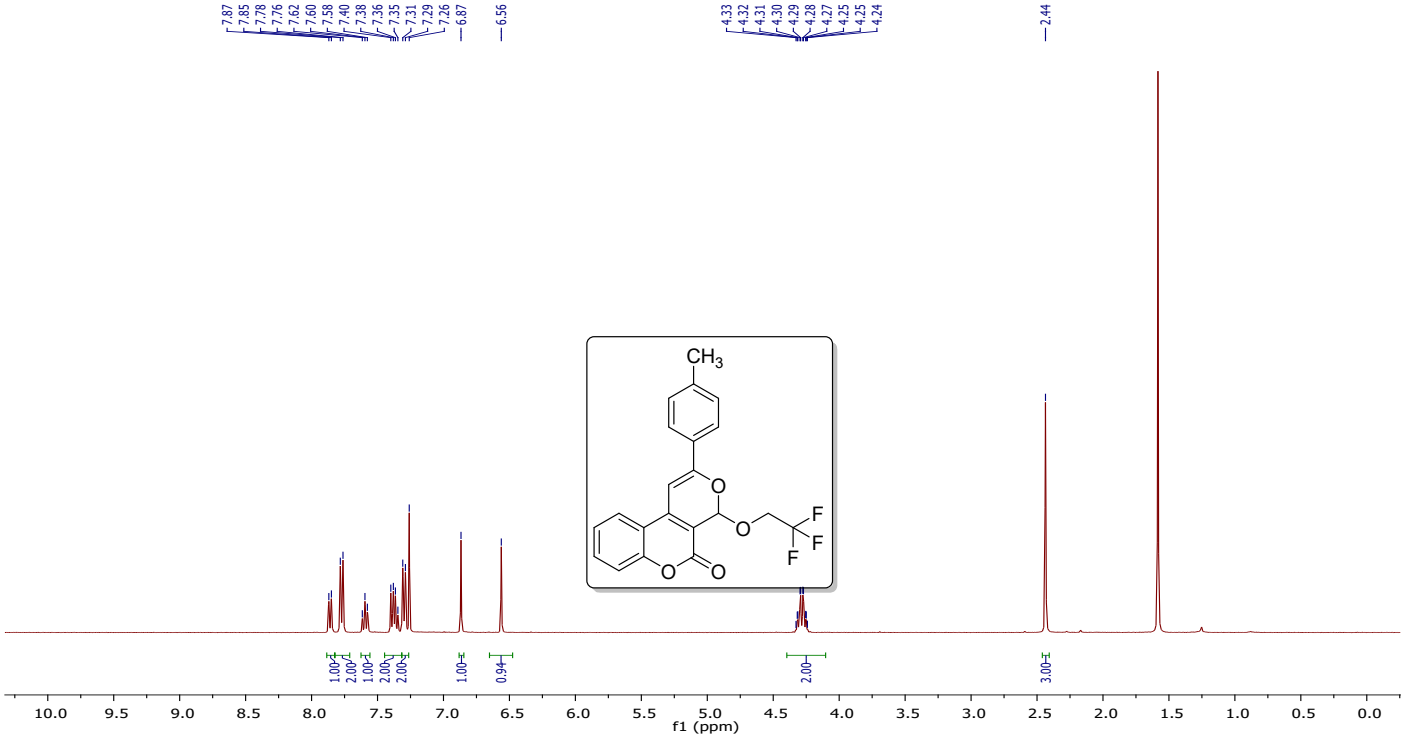


^{13}C NMR (101 MHz, $CDCl_3$)

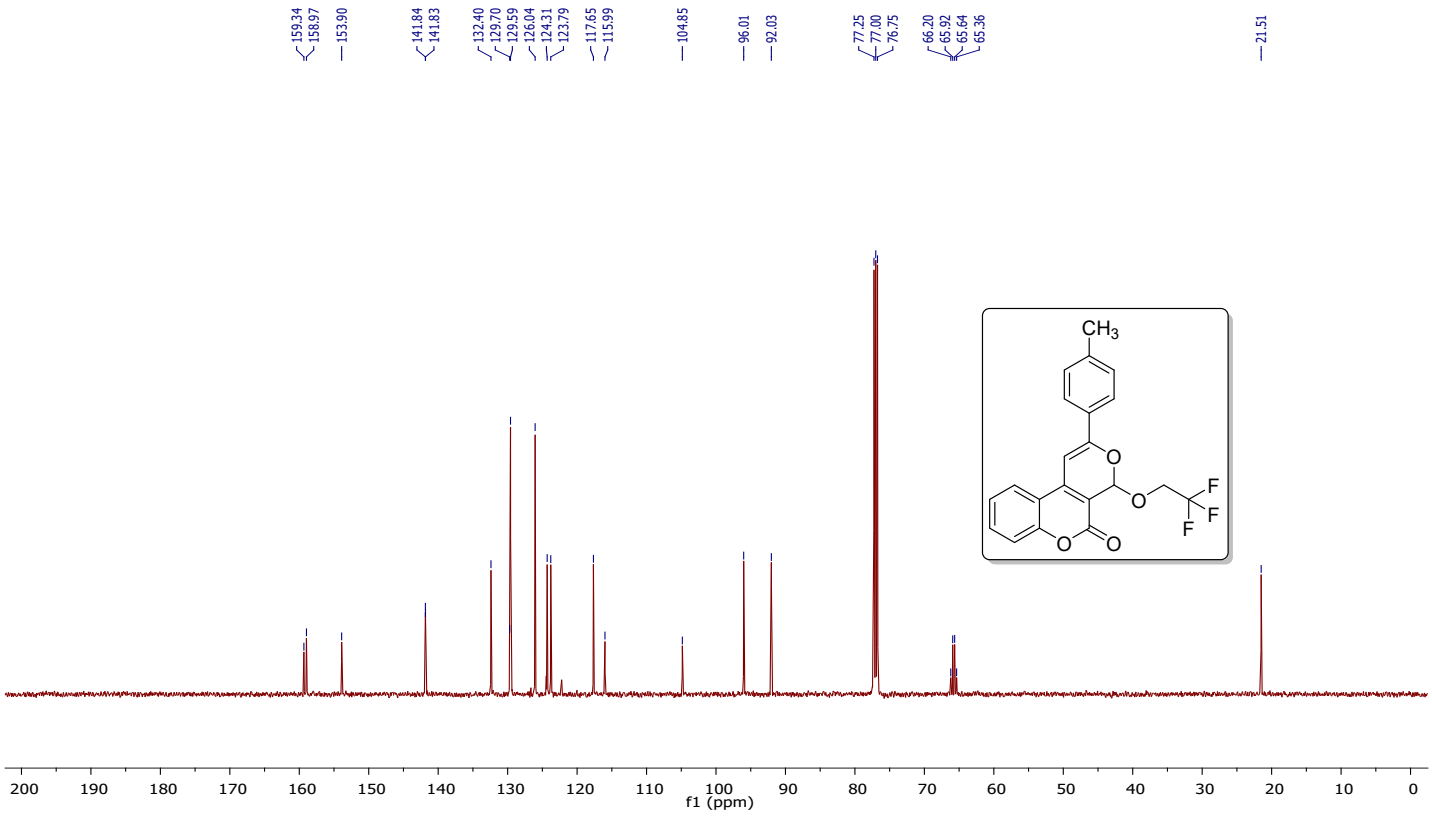


2-(*p*-tolyl)-4-(2,2,2-trifluoroethoxy)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4bh)

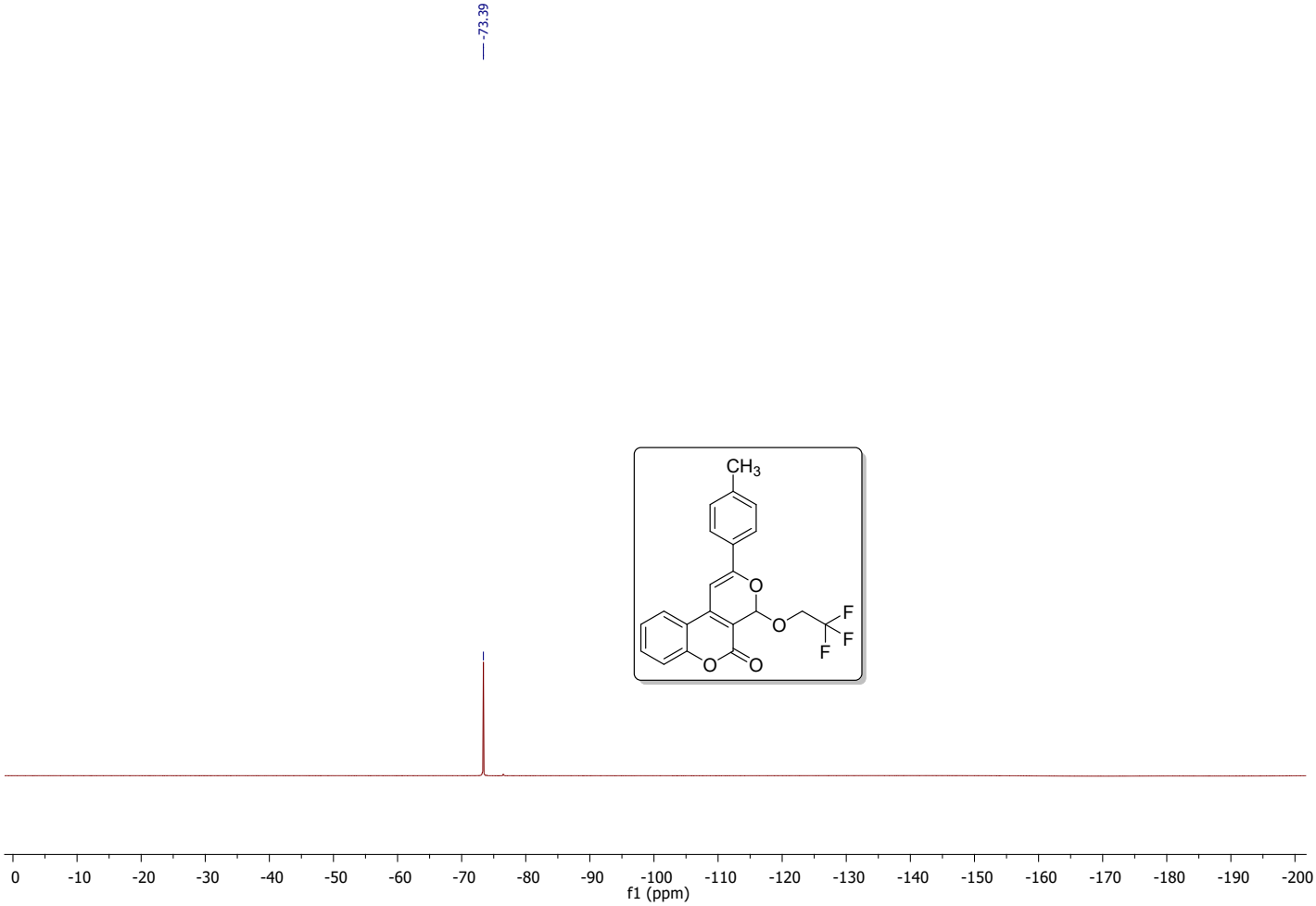
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (126 MHz, $CDCl_3$)

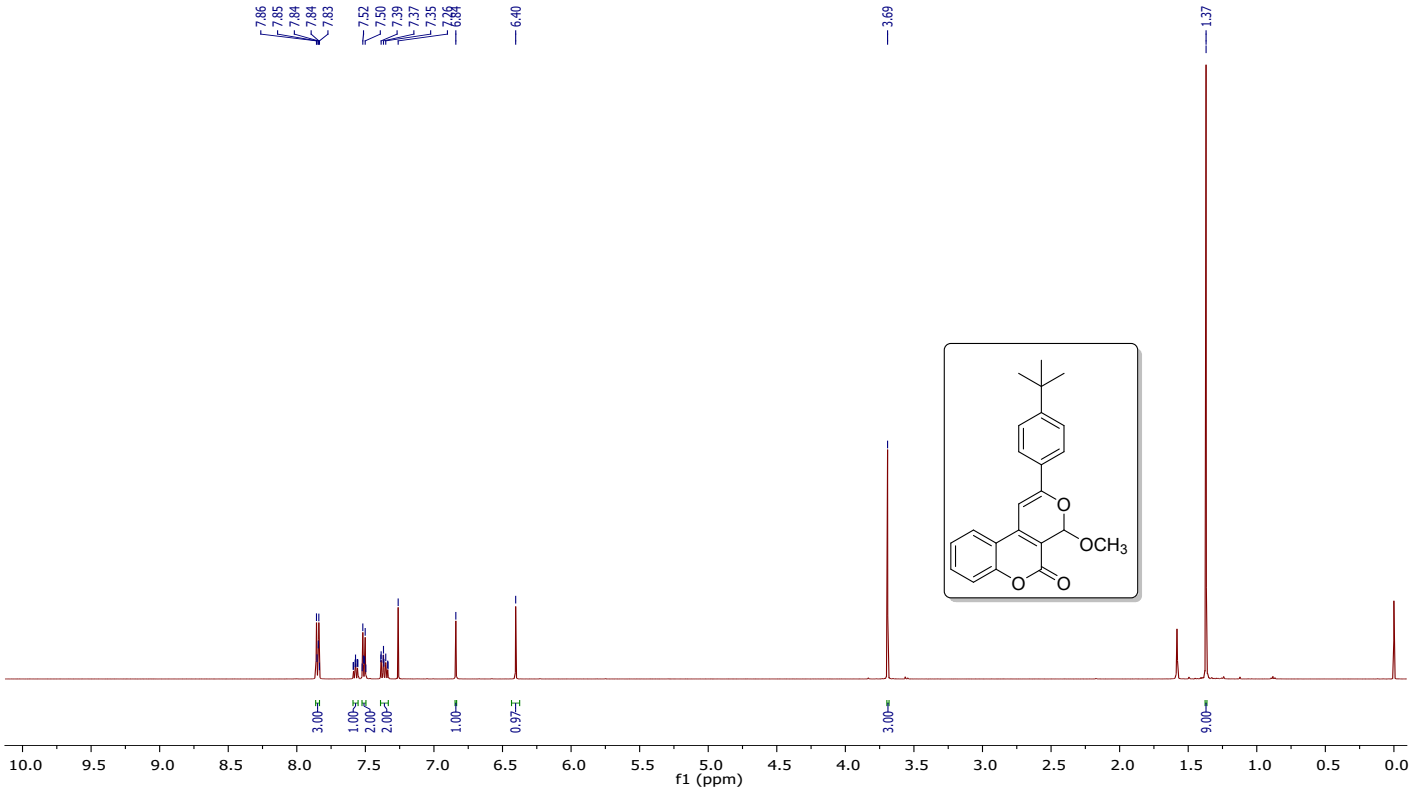


^{19}F NMR (377 MHz, $CDCl_3$)

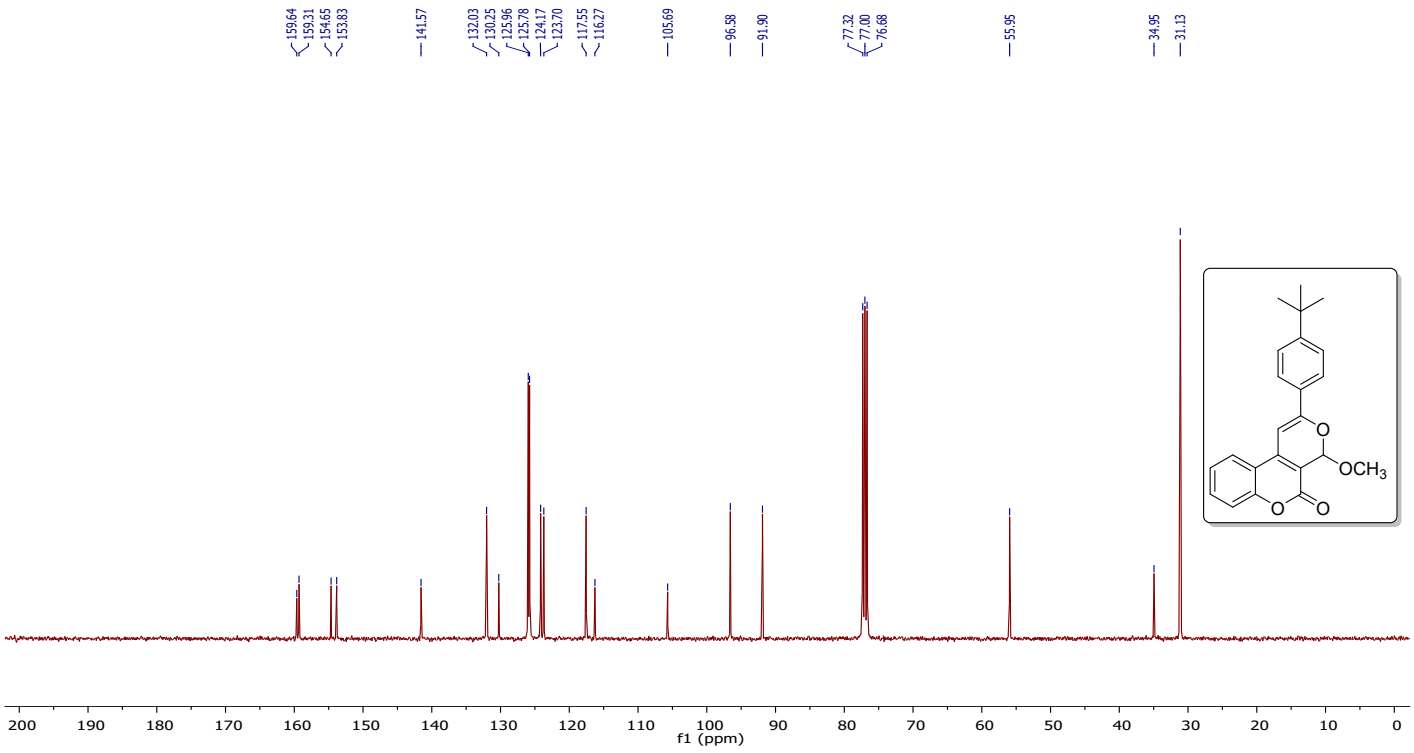


2-(4-(*tert*-butyl)phenyl)-4-methoxy-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4ca)

^{1}H NMR (500 MHz, $CDCl_3$)

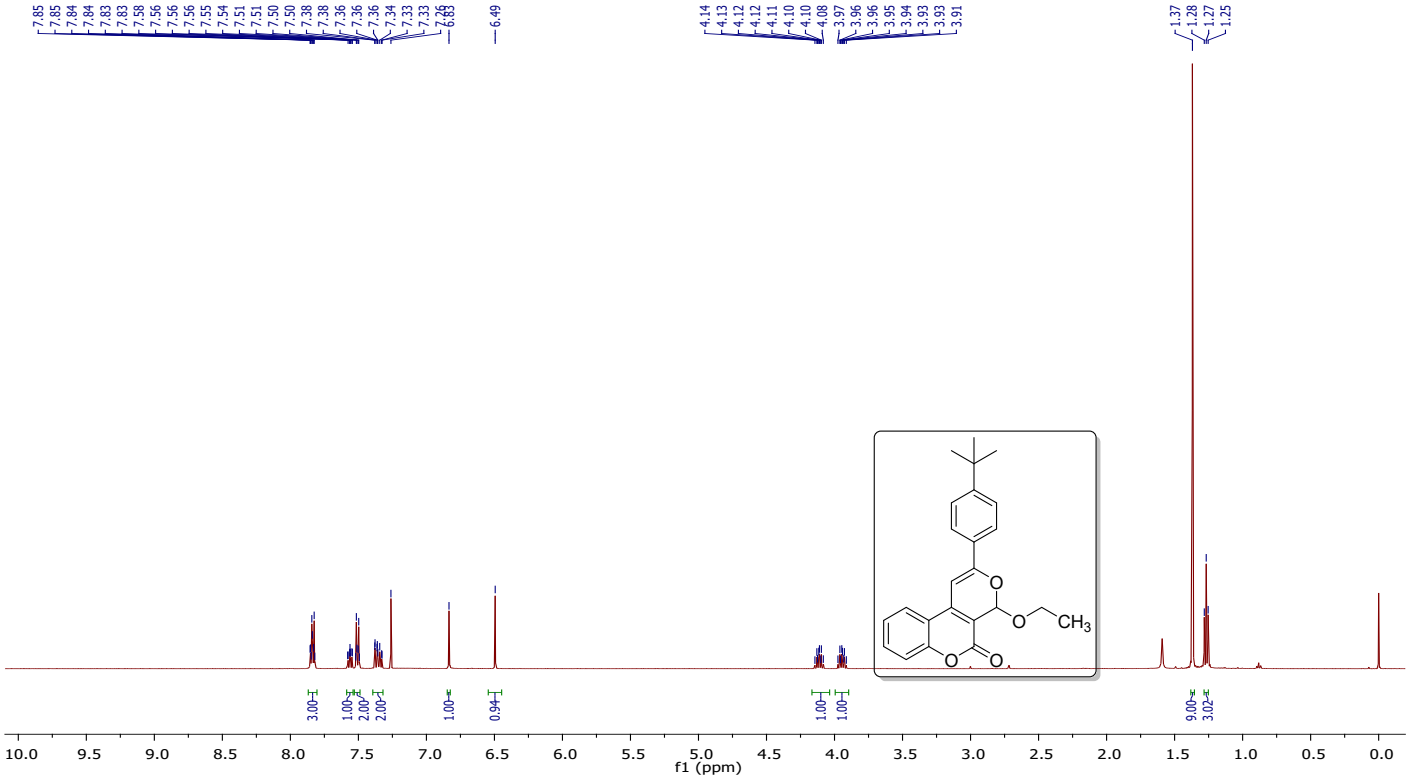


^{13}C NMR (101 MHz, $CDCl_3$)

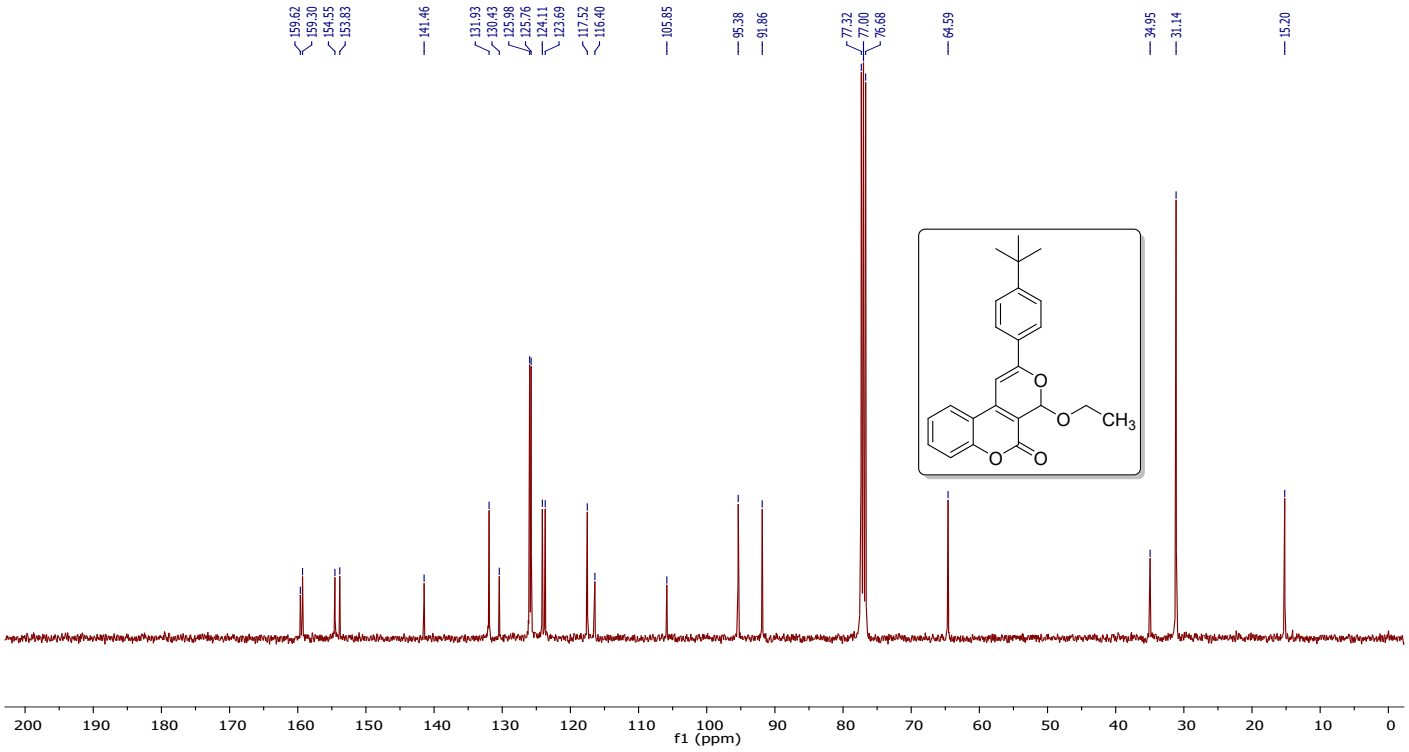


2-(4-(*tert*-butyl)phenyl)-4-ethoxy-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4cb)

^{1}H NMR (500 MHz, $CDCl_3$)

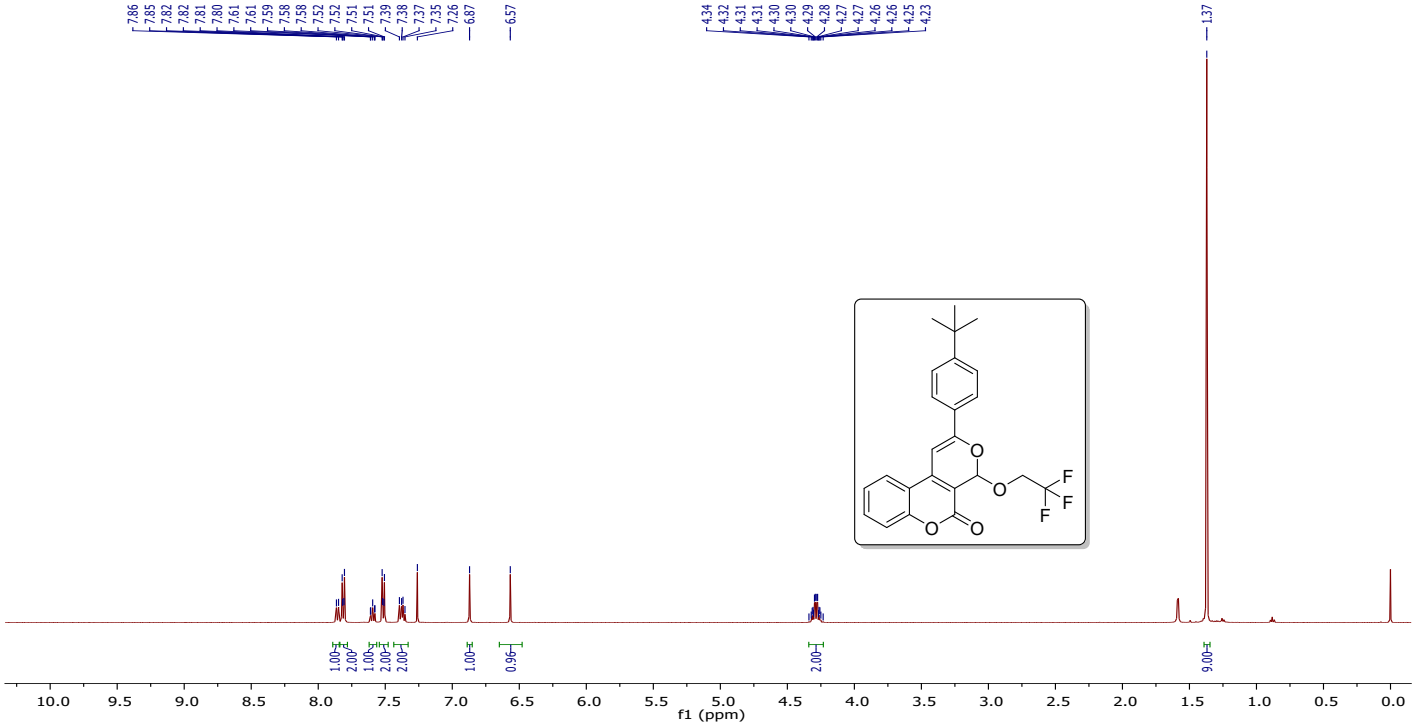


^{13}C NMR (101 MHz, $CDCl_3$)

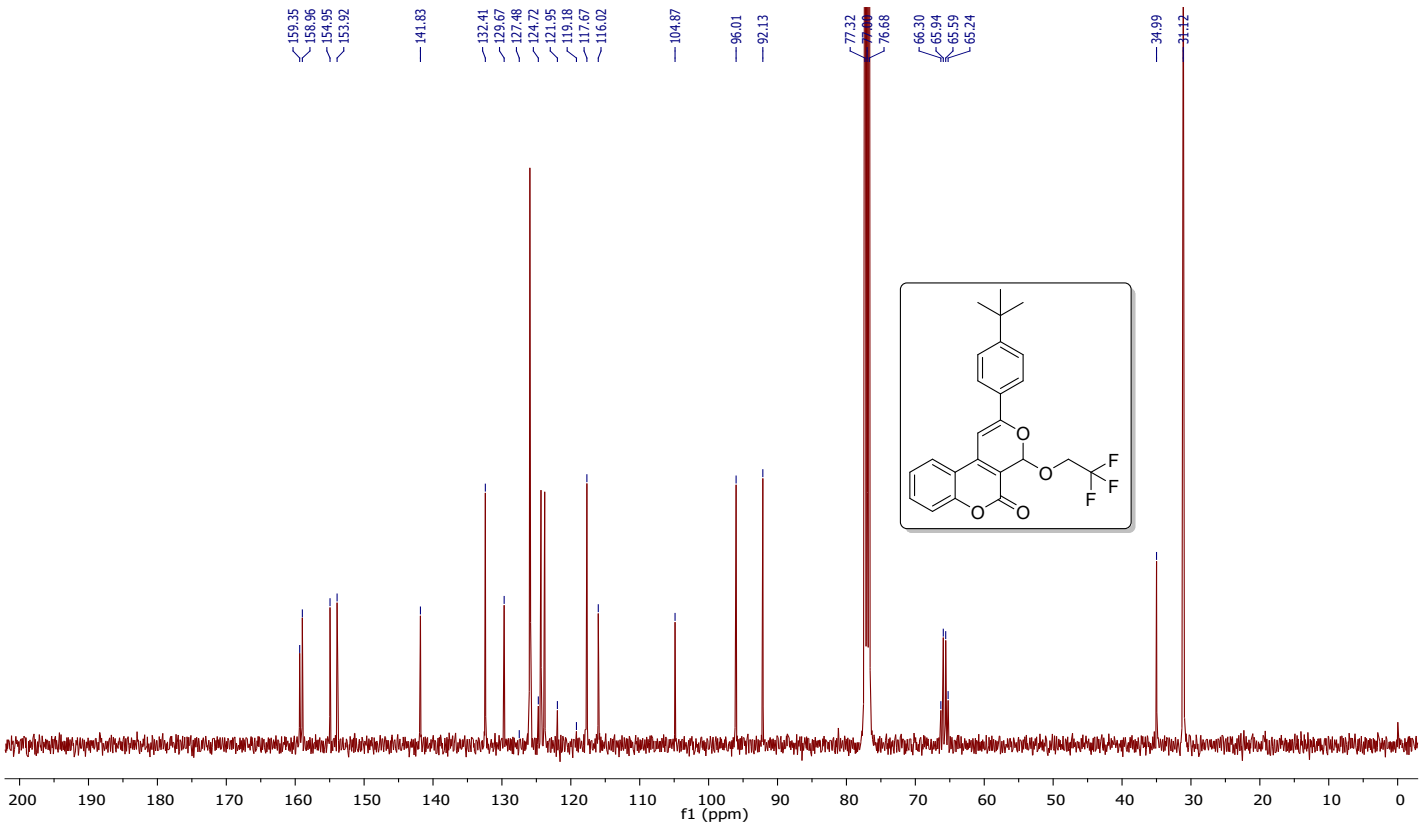


2-(4-(*tert*-butyl)phenyl)-4-(2,2,2-trifluoroethoxy)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4ch)

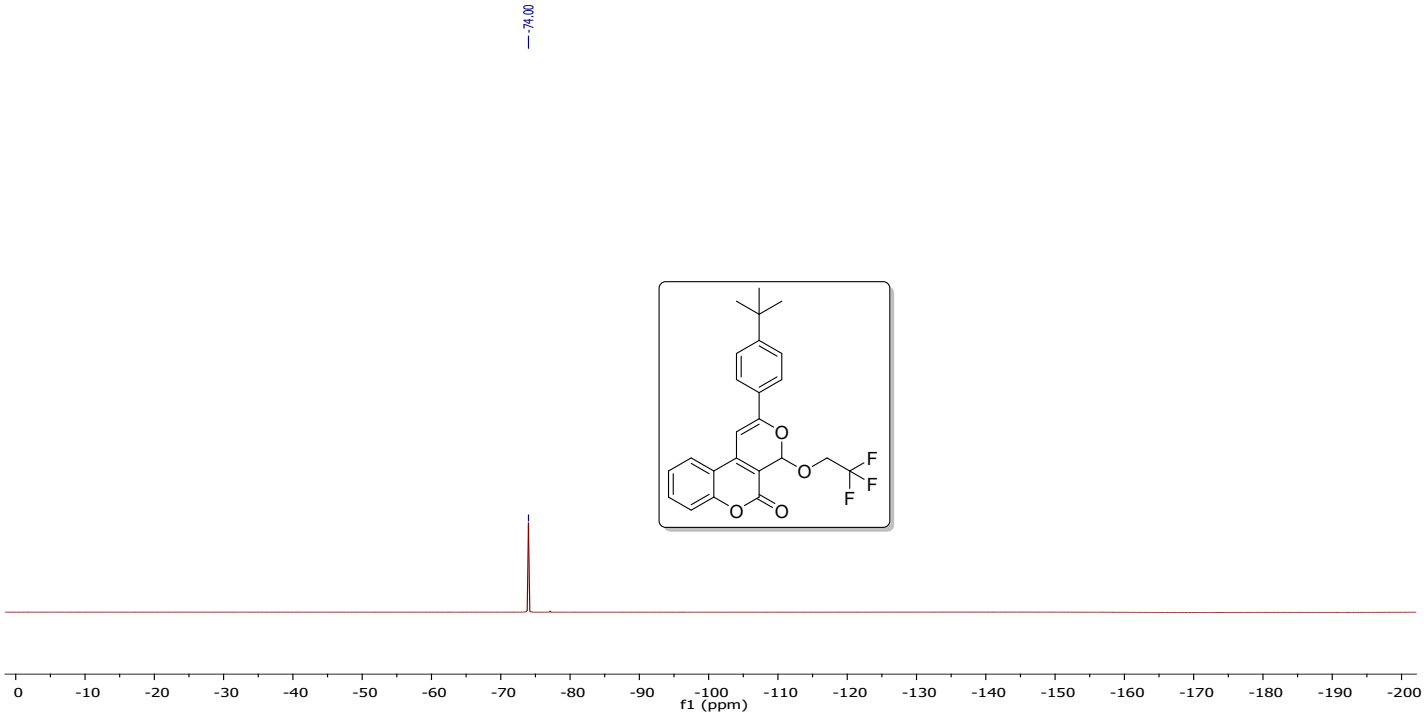
^{1}H NMR (500 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)

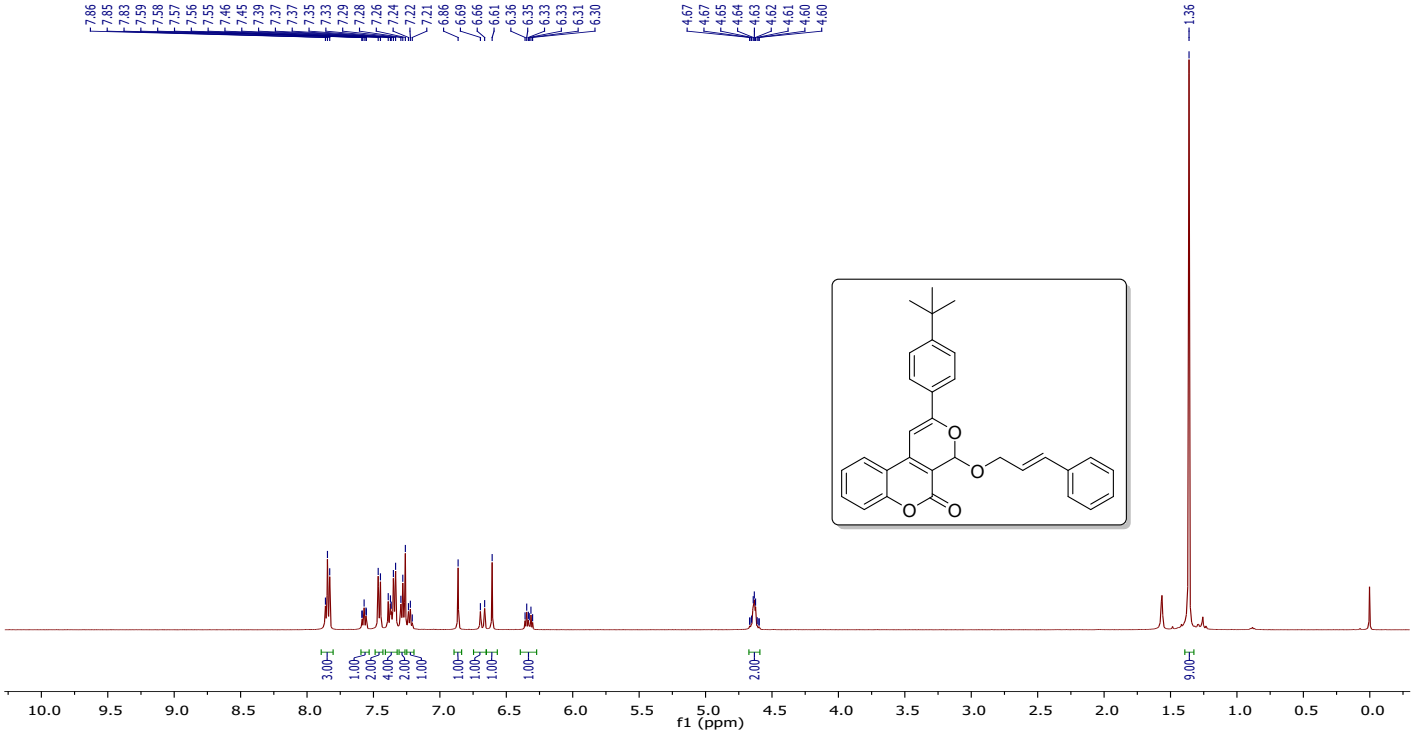


^{19}F NMR (376 MHz, $CDCl_3$)

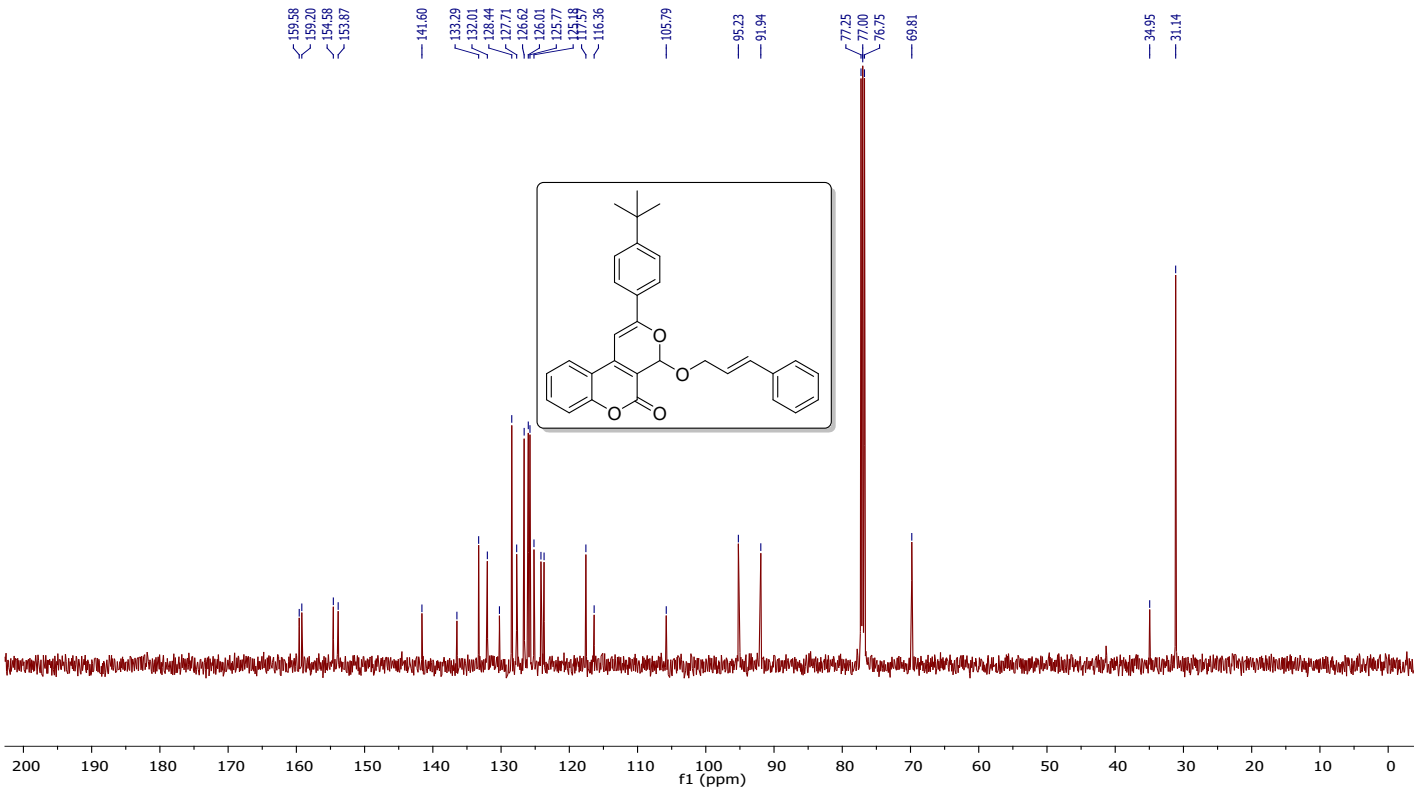


2-(4-(*tert*-butyl)phenyl)-4-(cinnamyloxy)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (4cl)

^{1}H NMR (500 MHz, $CDCl_3$)

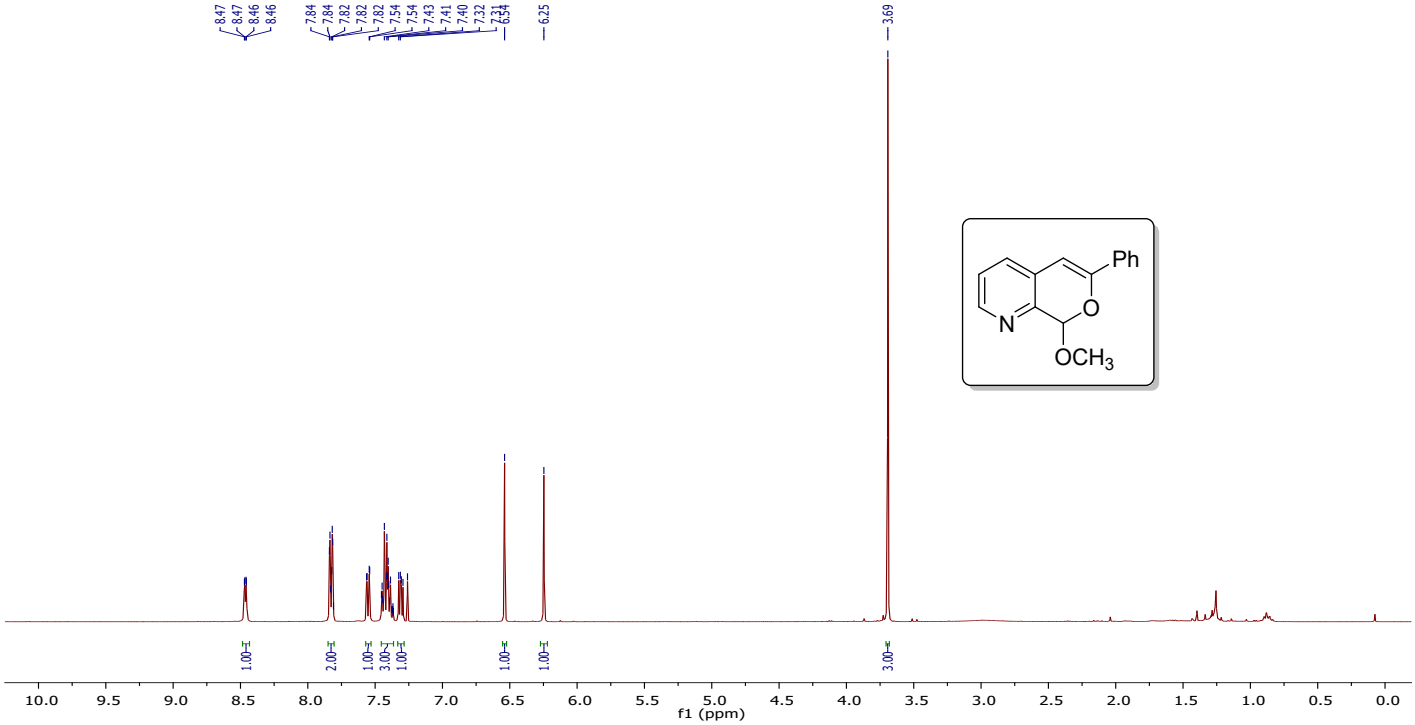


^{13}C NMR (126 MHz, $CDCl_3$)

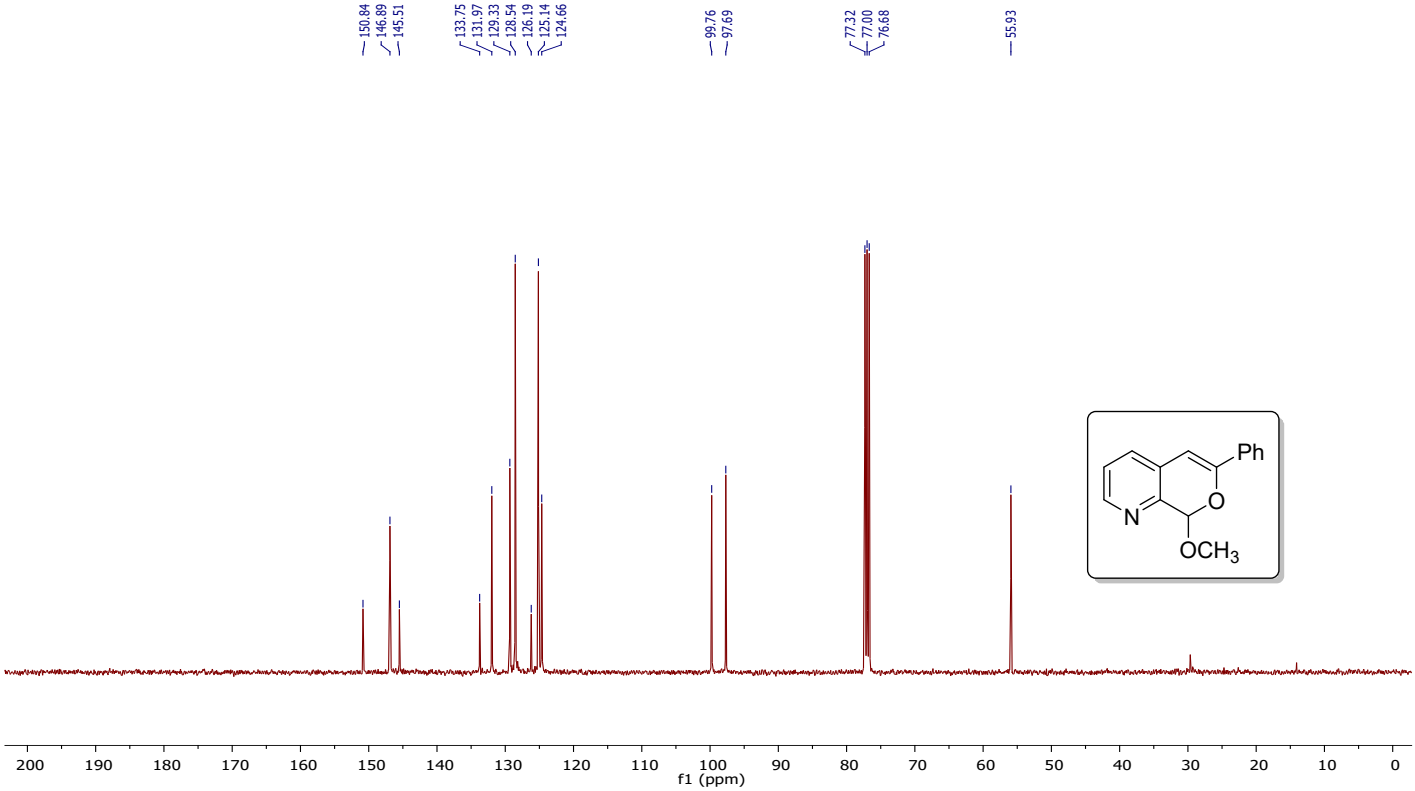


8-methoxy-6-phenyl-8*H*-pyrano[3,4-*b*]pyridine (5aa)

^{1}H NMR (400 MHz, $CDCl_3$)

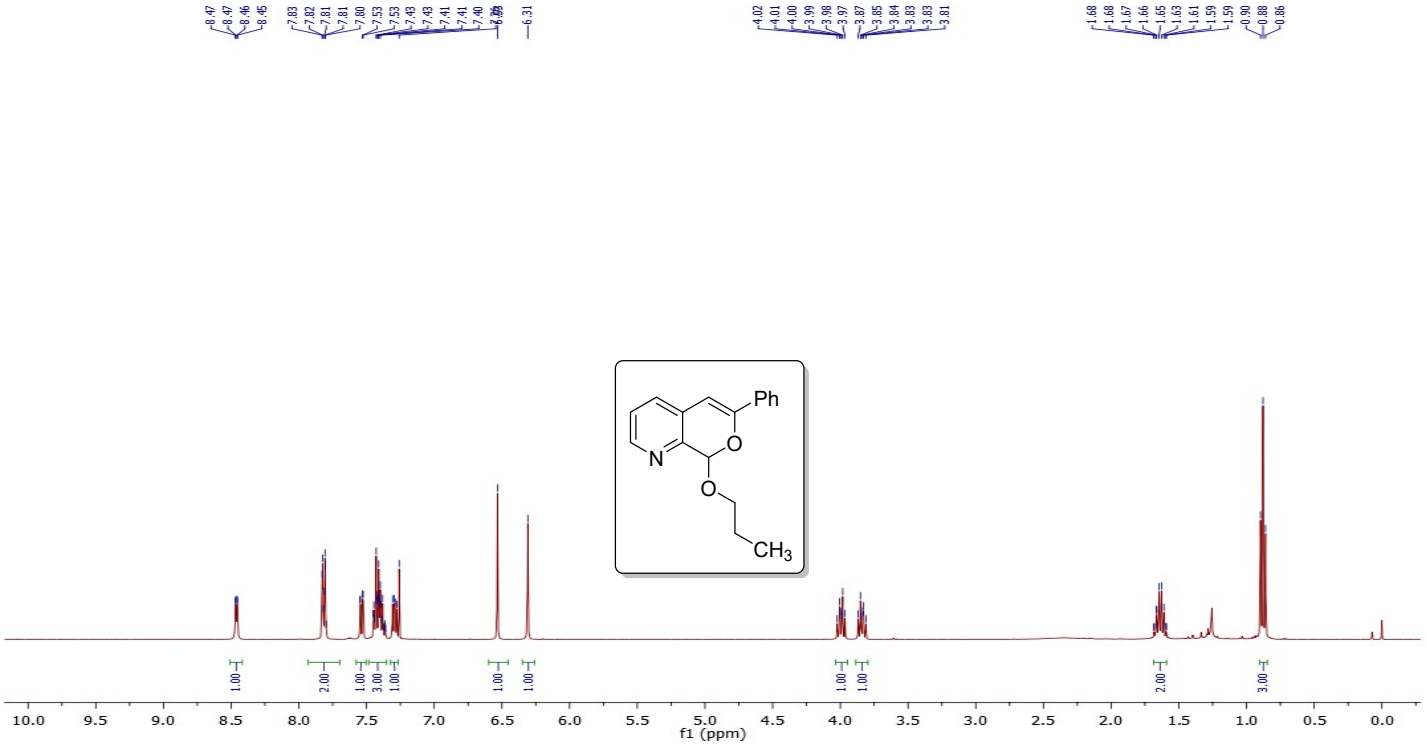


^{13}C NMR (101 MHz, $CDCl_3$)

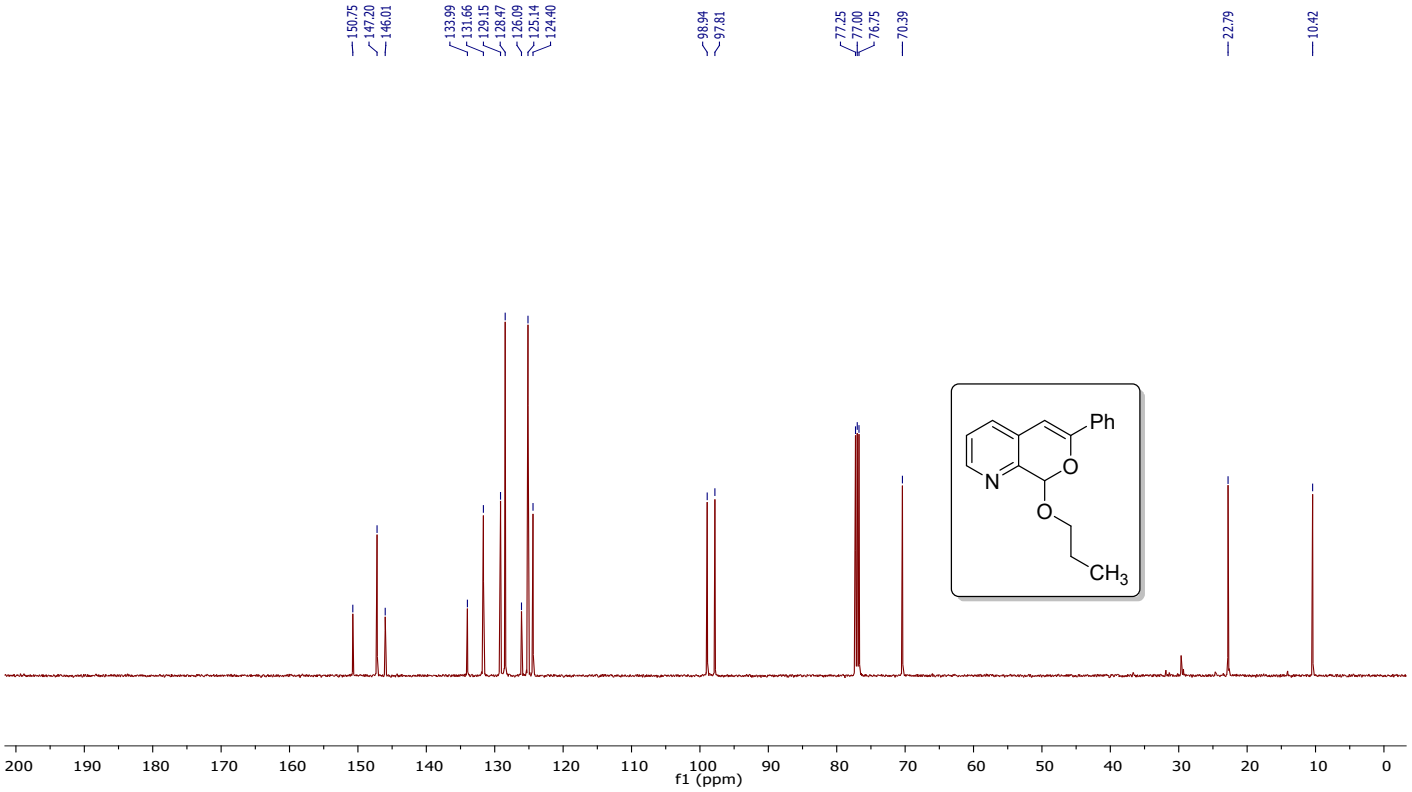


6-phenyl-8-propoxy-8*H*-pyrano[3,4-*b*]pyridine (5ac)

^{1}H NMR (400 MHz, $CDCl_3$)

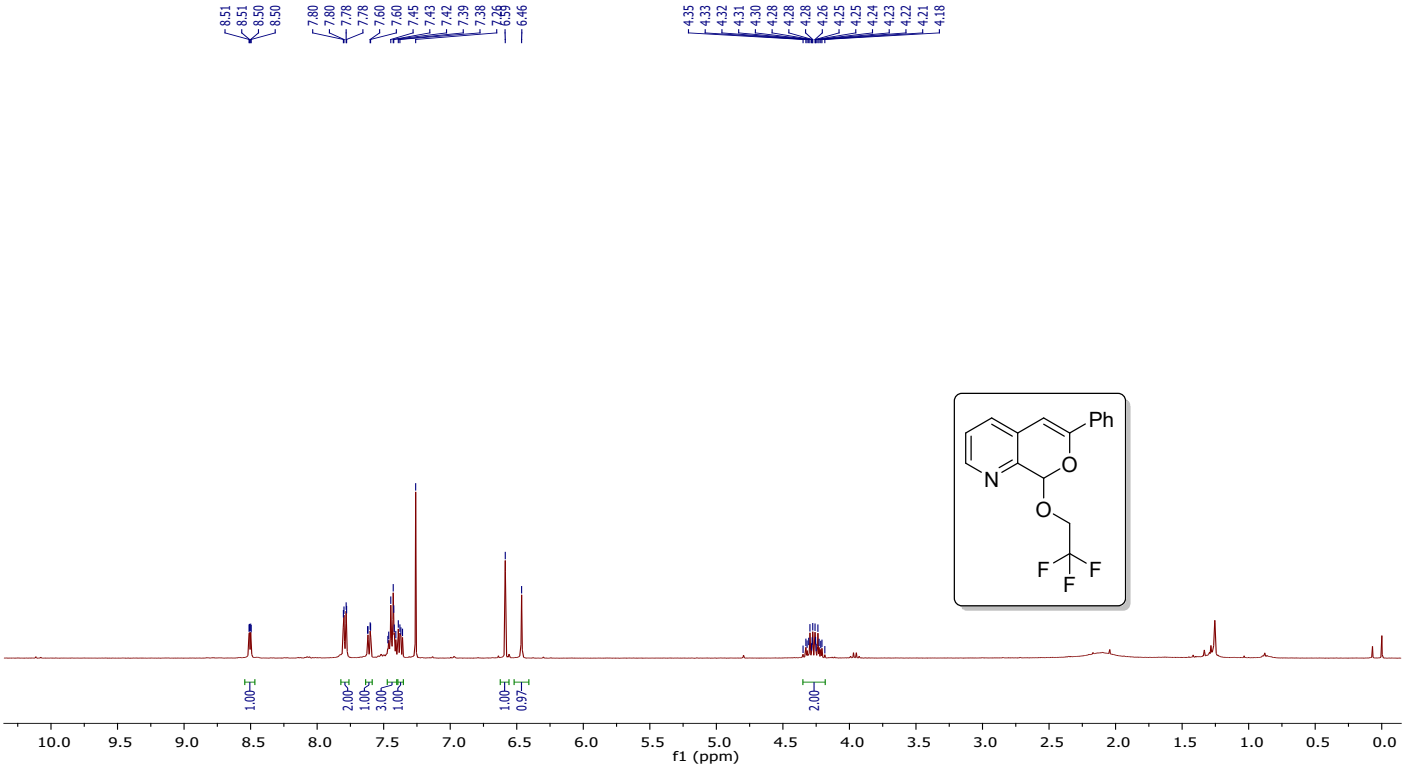


^{13}C NMR (126 MHz, $CDCl_3$)

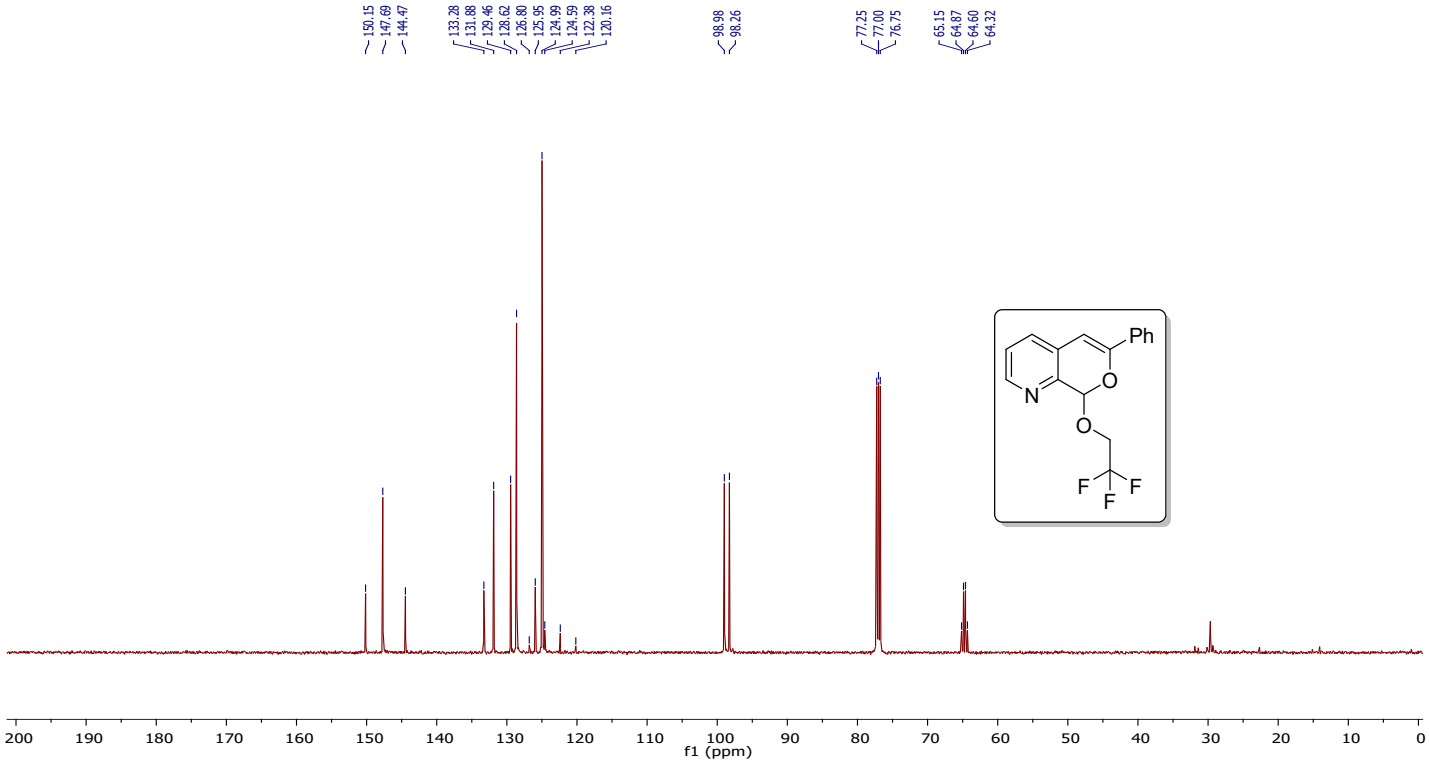


6-phenyl-8-(2,2,2-trifluoroethoxy)-8*H*-pyrano[3,4-*b*]pyridine (5ah)

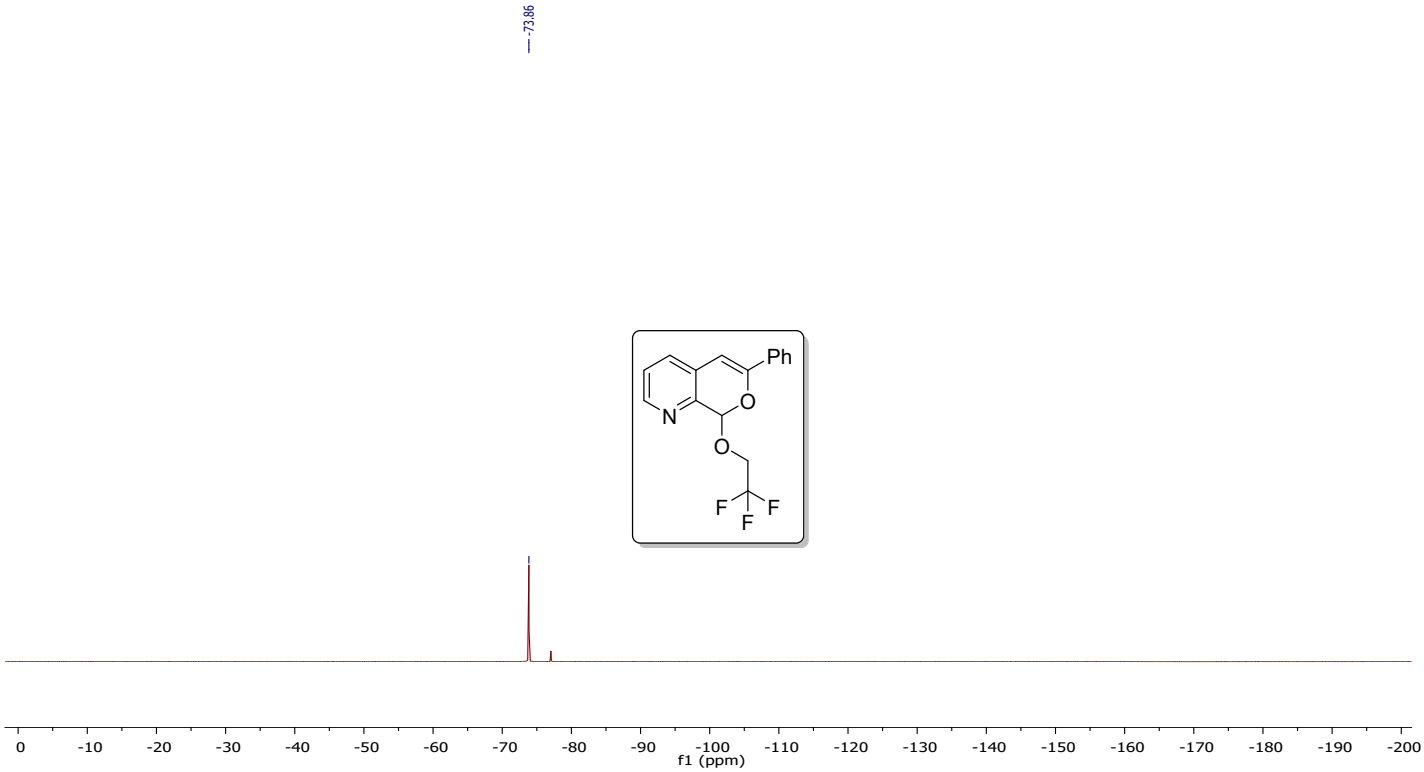
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (126 MHz, $CDCl_3$)

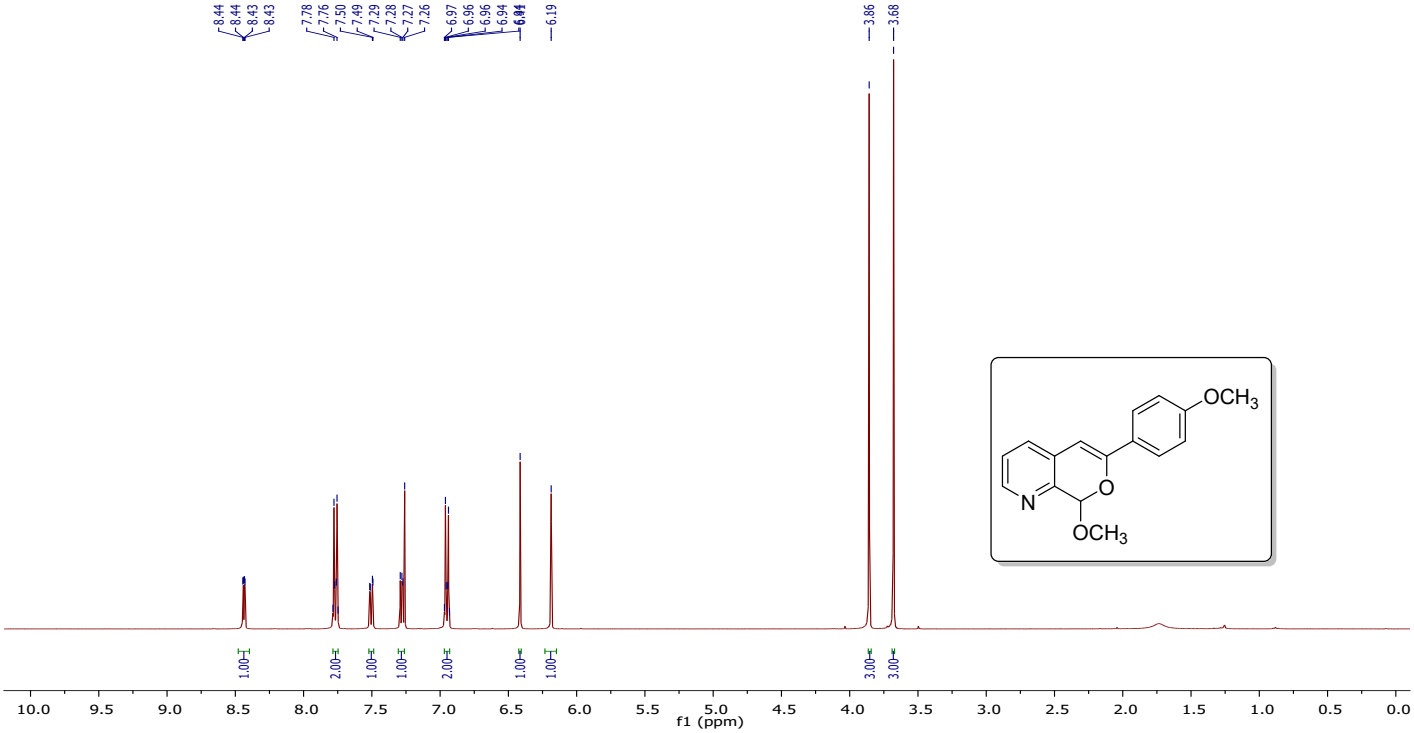


^{19}F NMR (376 MHz, $CDCl_3$)

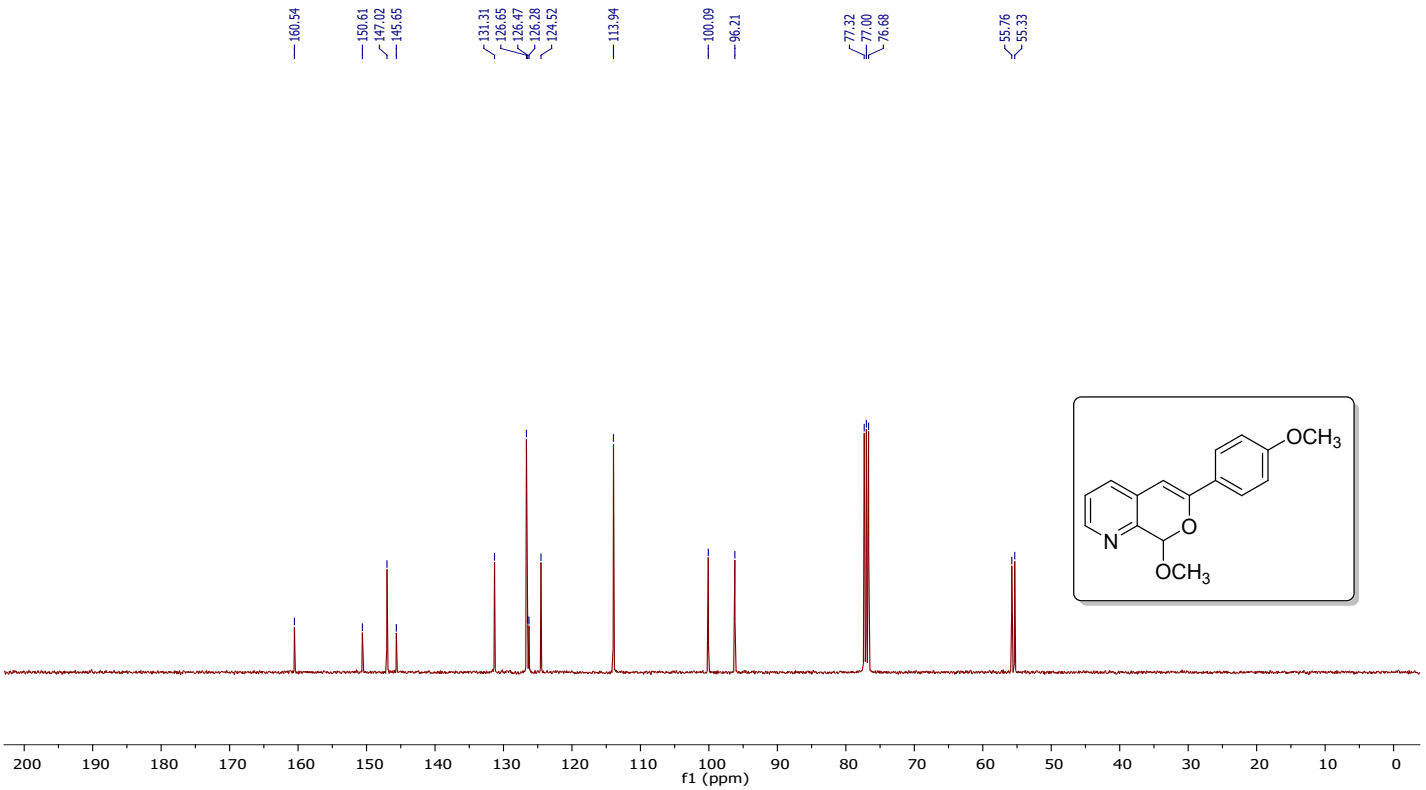


8-methoxy-6-(4-methoxyphenyl)-8*H*-pyrano[3,4-*b*]pyridine (5ba)

^{1}H NMR (400 MHz, $CDCl_3$)

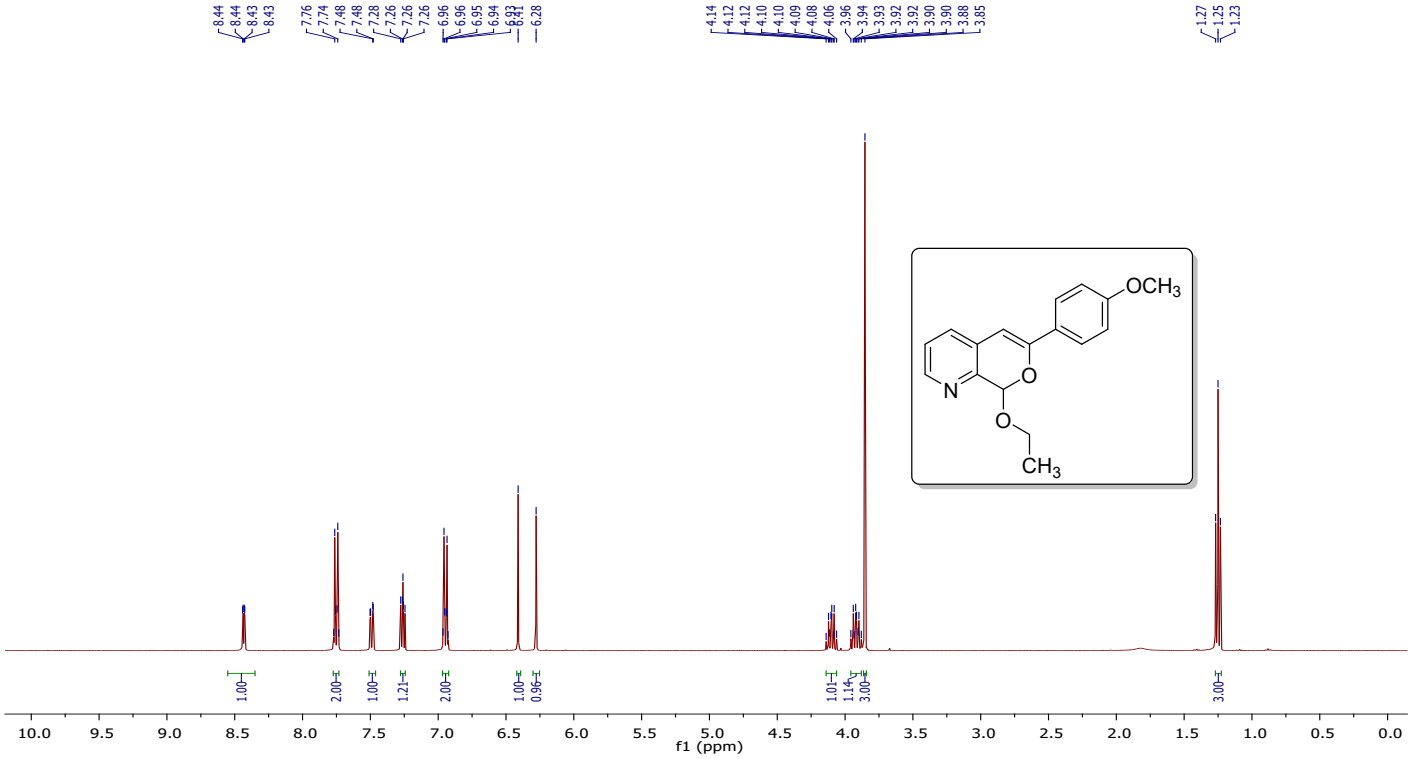


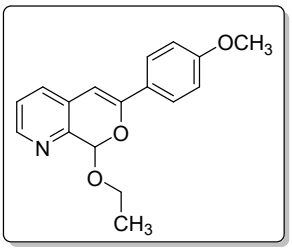
^{13}C NMR (101 MHz, $CDCl_3$)



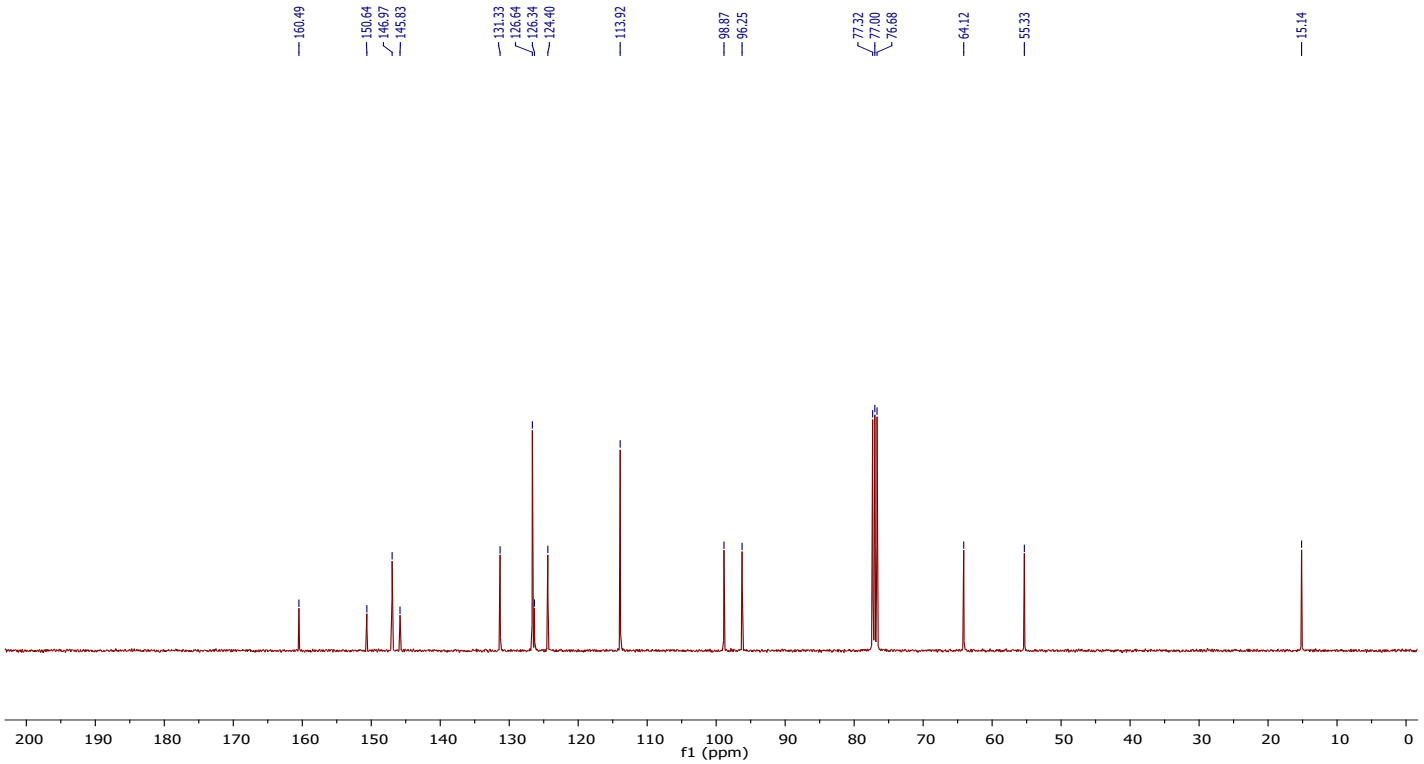
8-ethoxy-6-(4-methoxyphenyl)-8*H*-pyrano[3,4-*b*]pyridine (5bb)

^{1}H NMR (400 MHz, $CDCl_3$)



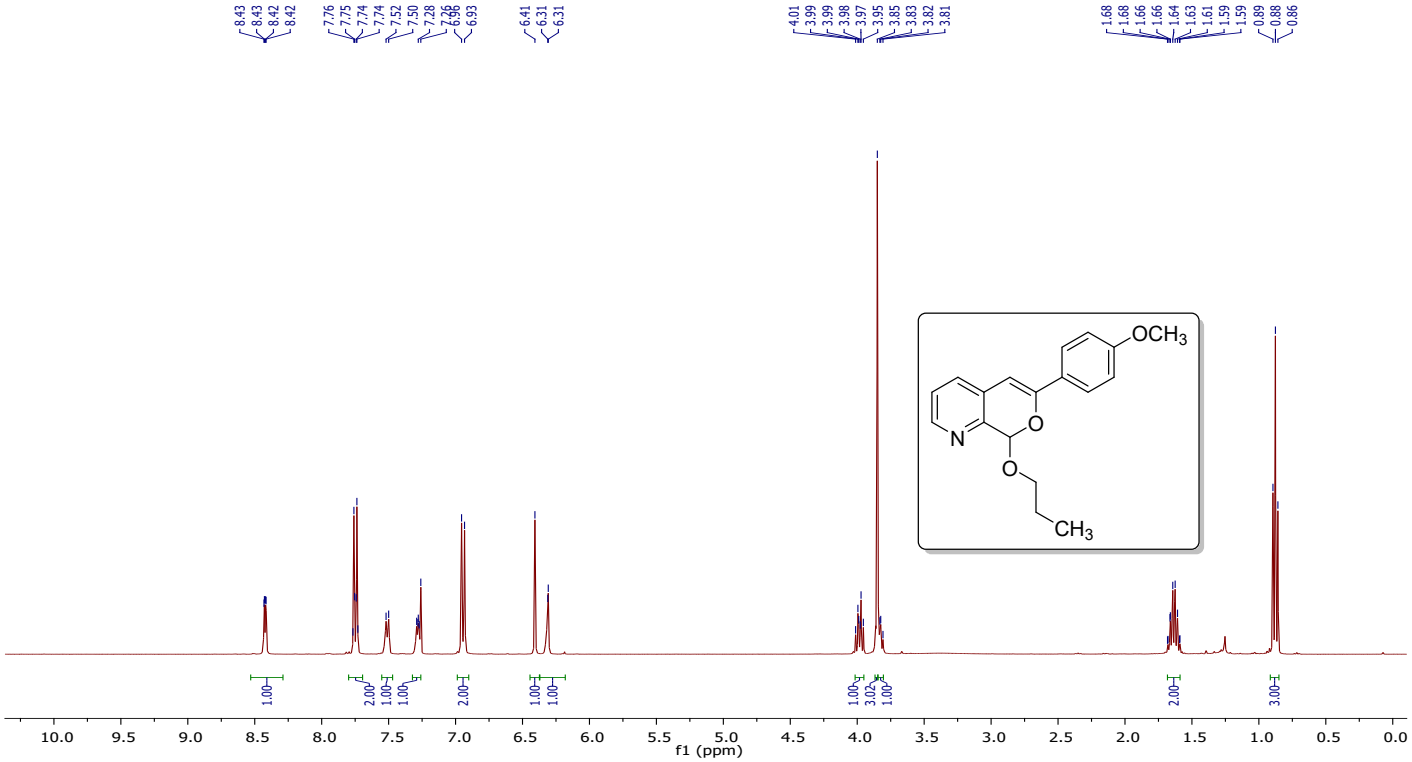


^{13}C NMR (101 MHz, $CDCl_3$)

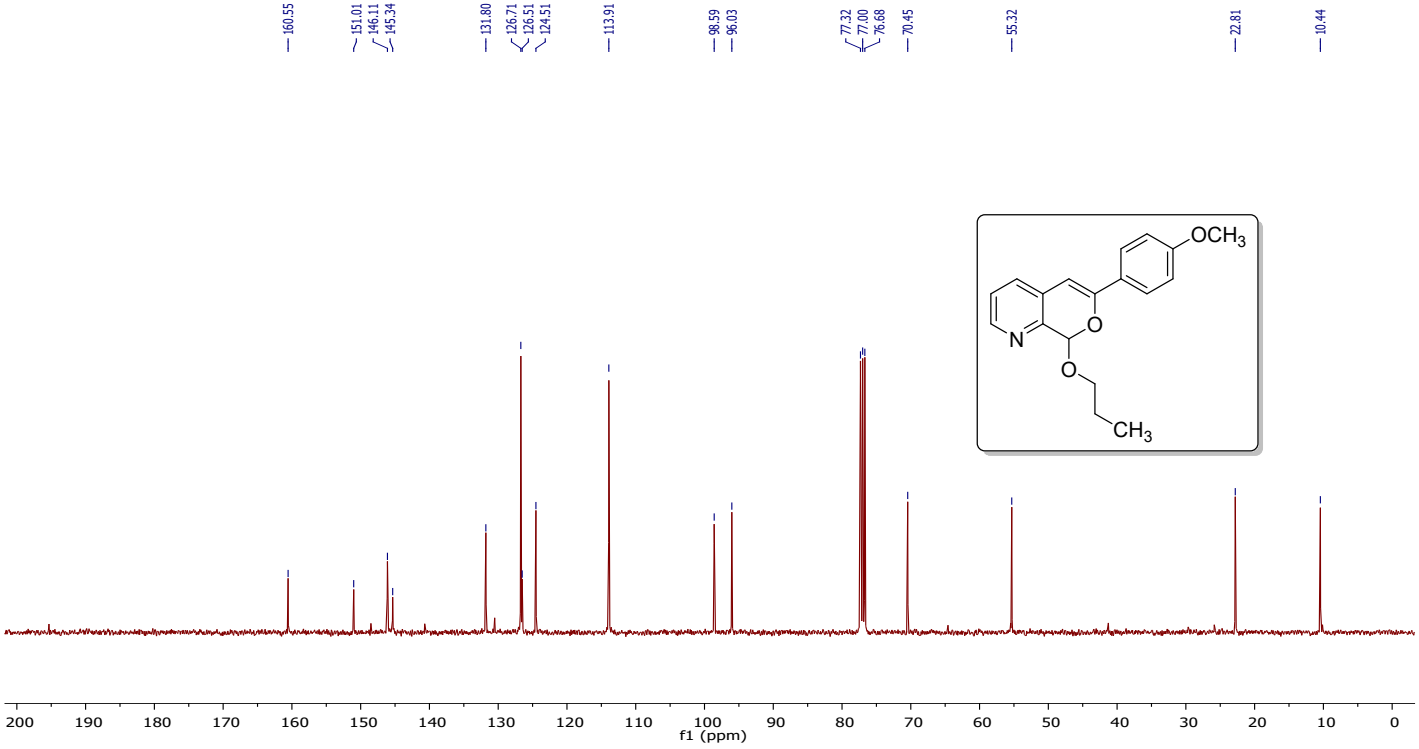


6-(4-methoxyphenyl)-8-propoxy-8*H*-pyrano[3,4-*b*]pyridine (5bc)

^{1}H NMR (400 MHz, $CDCl_3$)

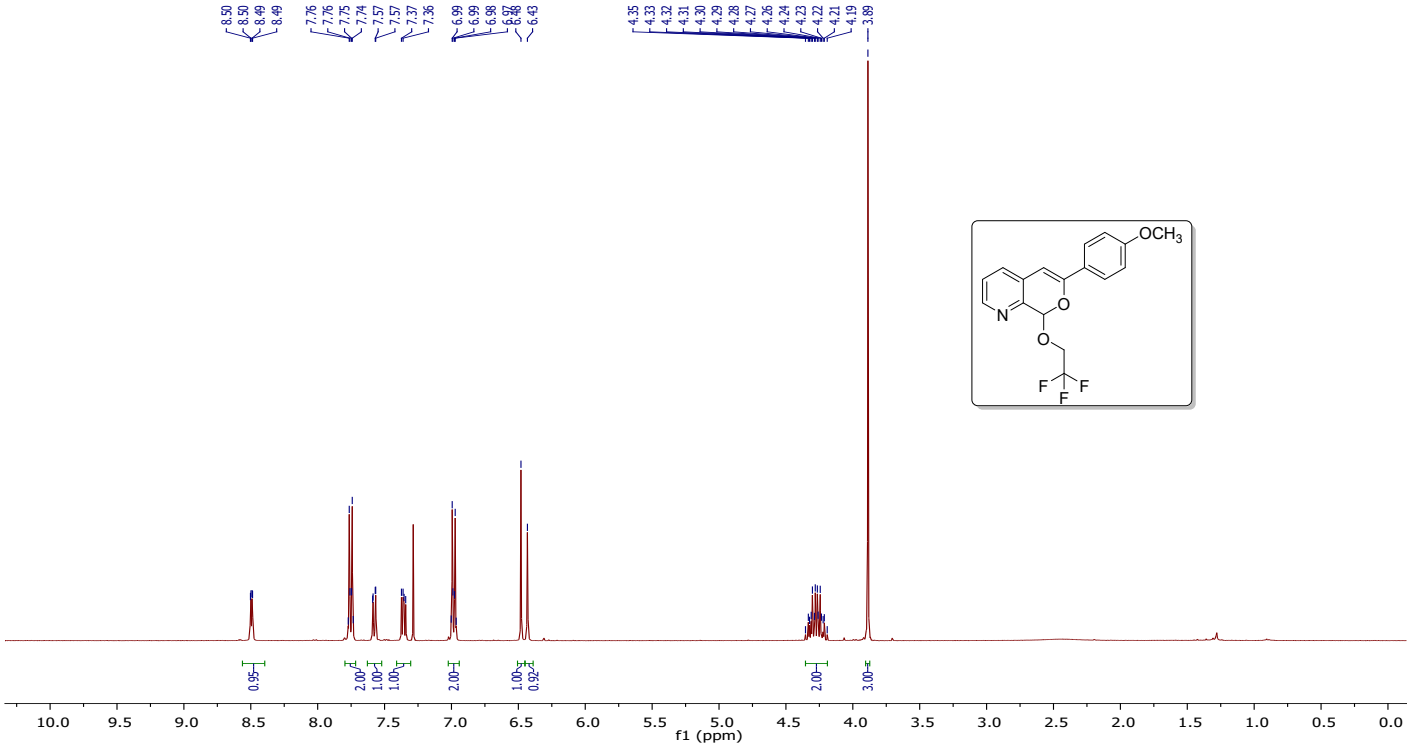


^{13}C NMR (101 MHz, $CDCl_3$)

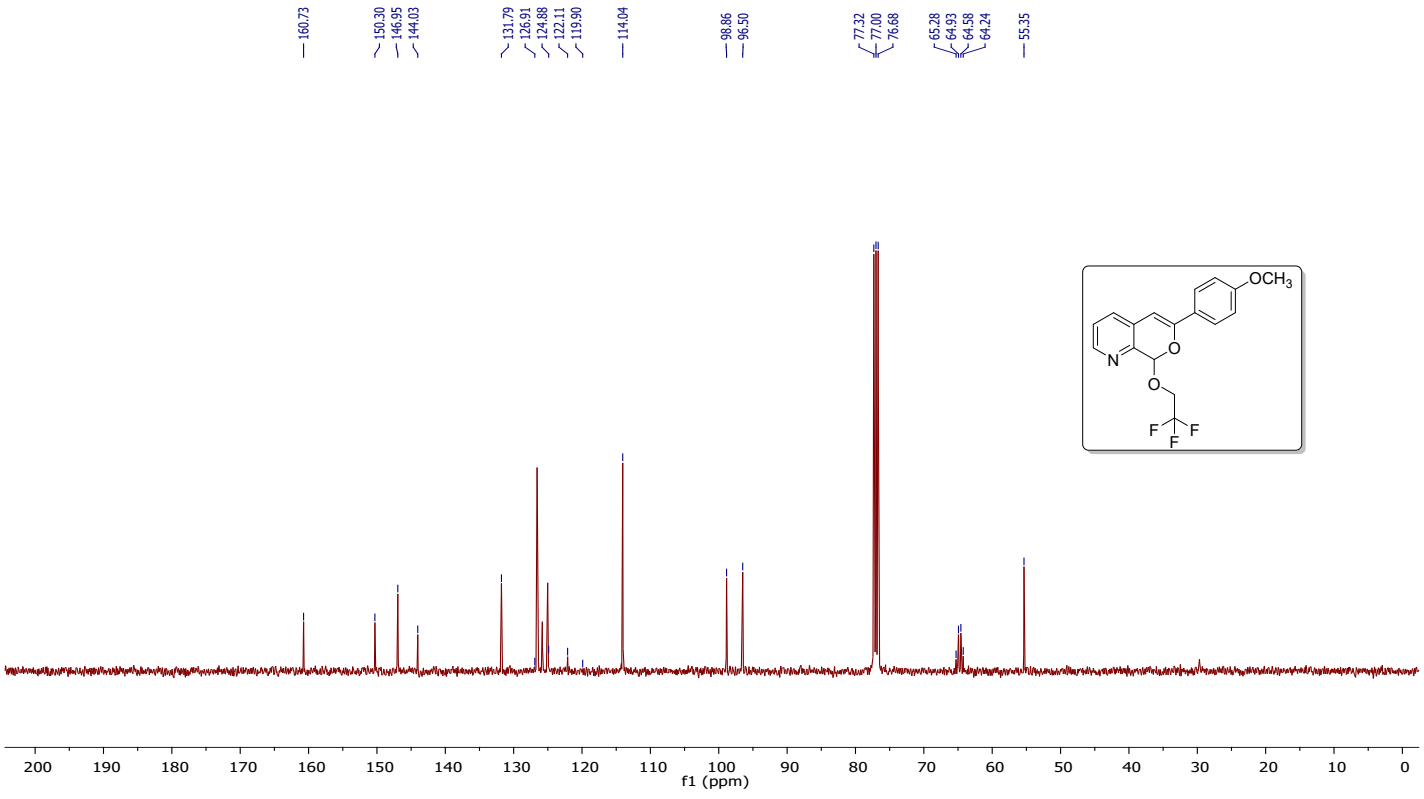


6-(4-methoxyphenyl)-8-(2,2,2-trifluoroethoxy)-8*H*-pyrano[3,4-*b*]pyridine (5bh)

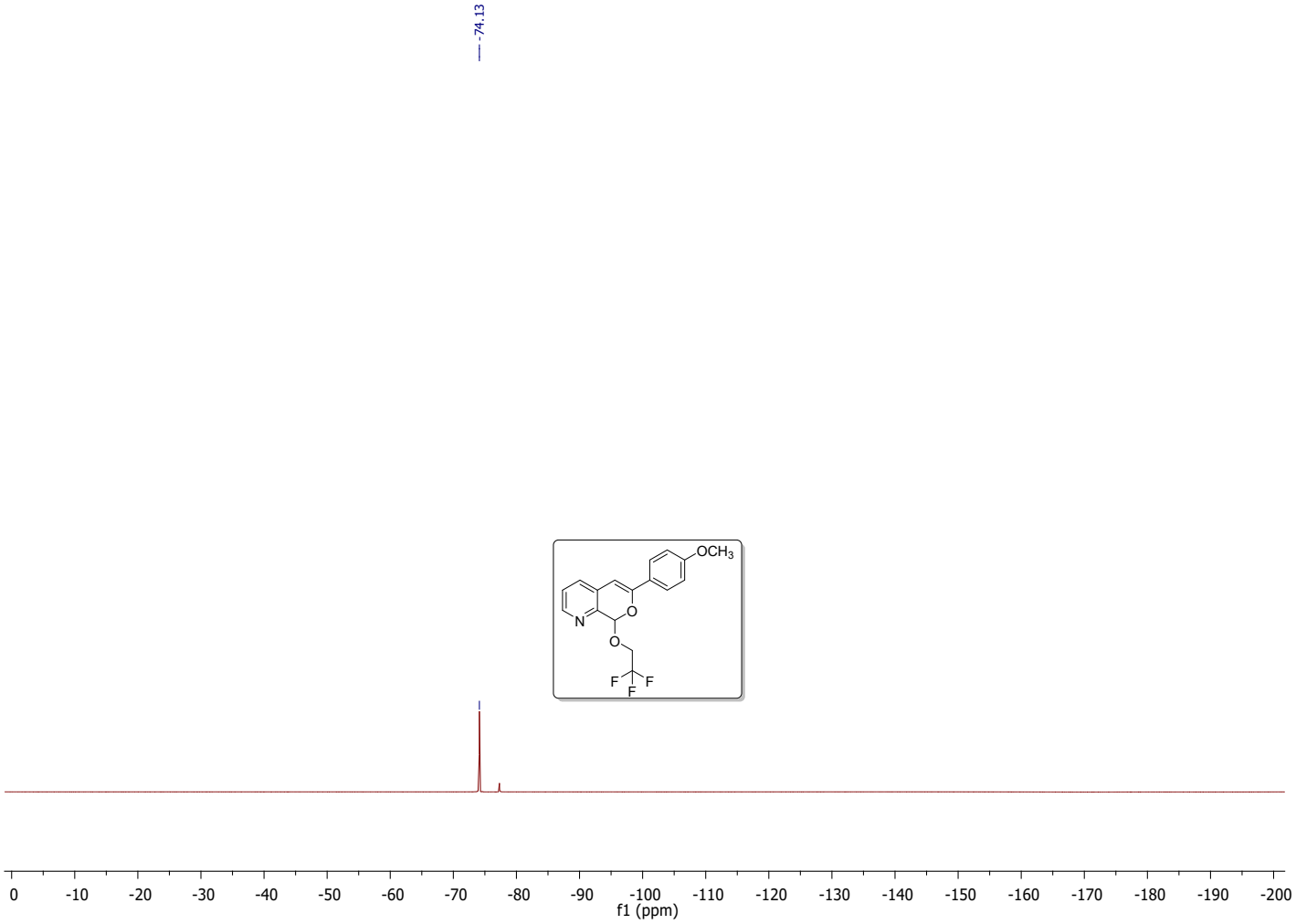
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)

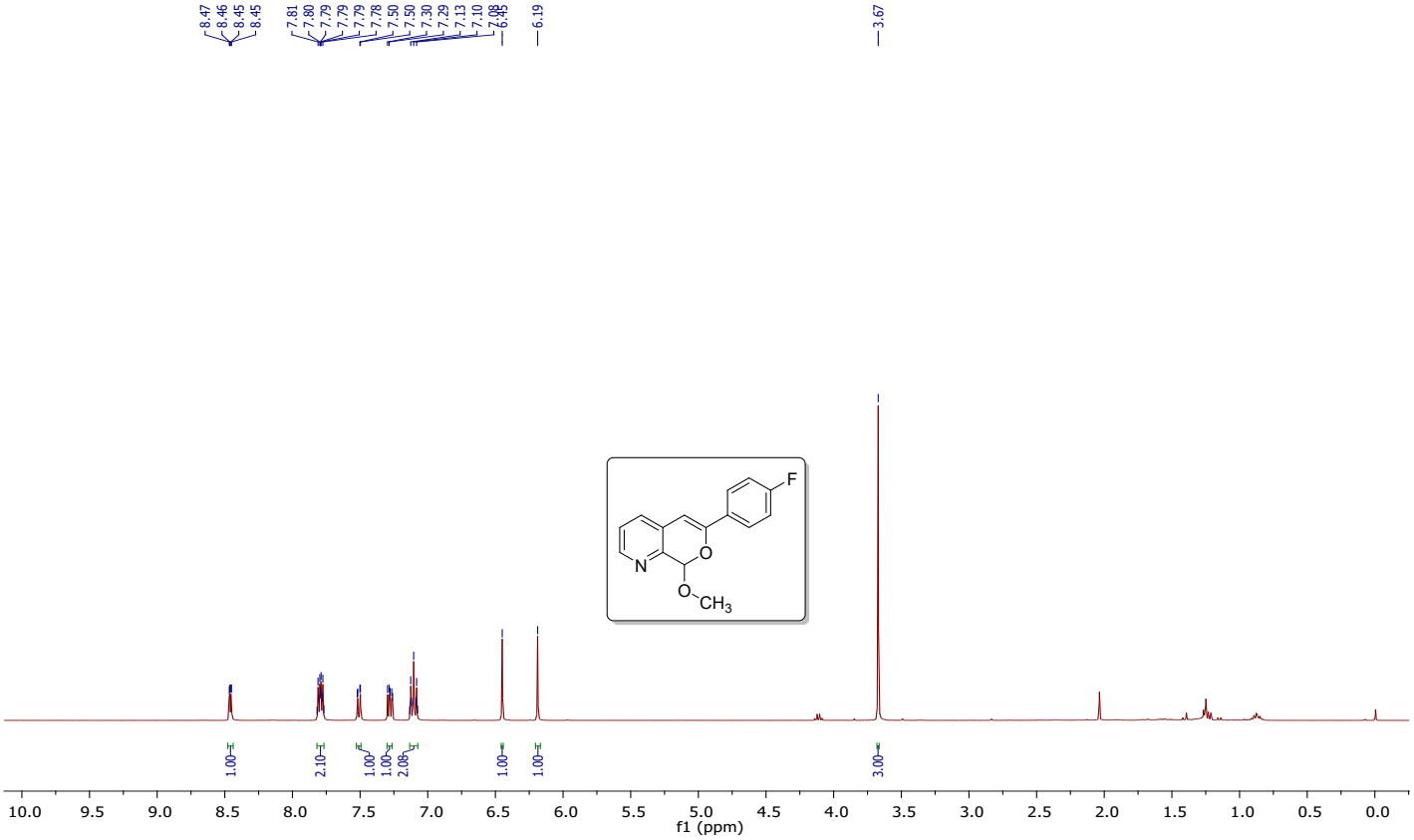


^{19}F NMR (376 MHz, $CDCl_3$)

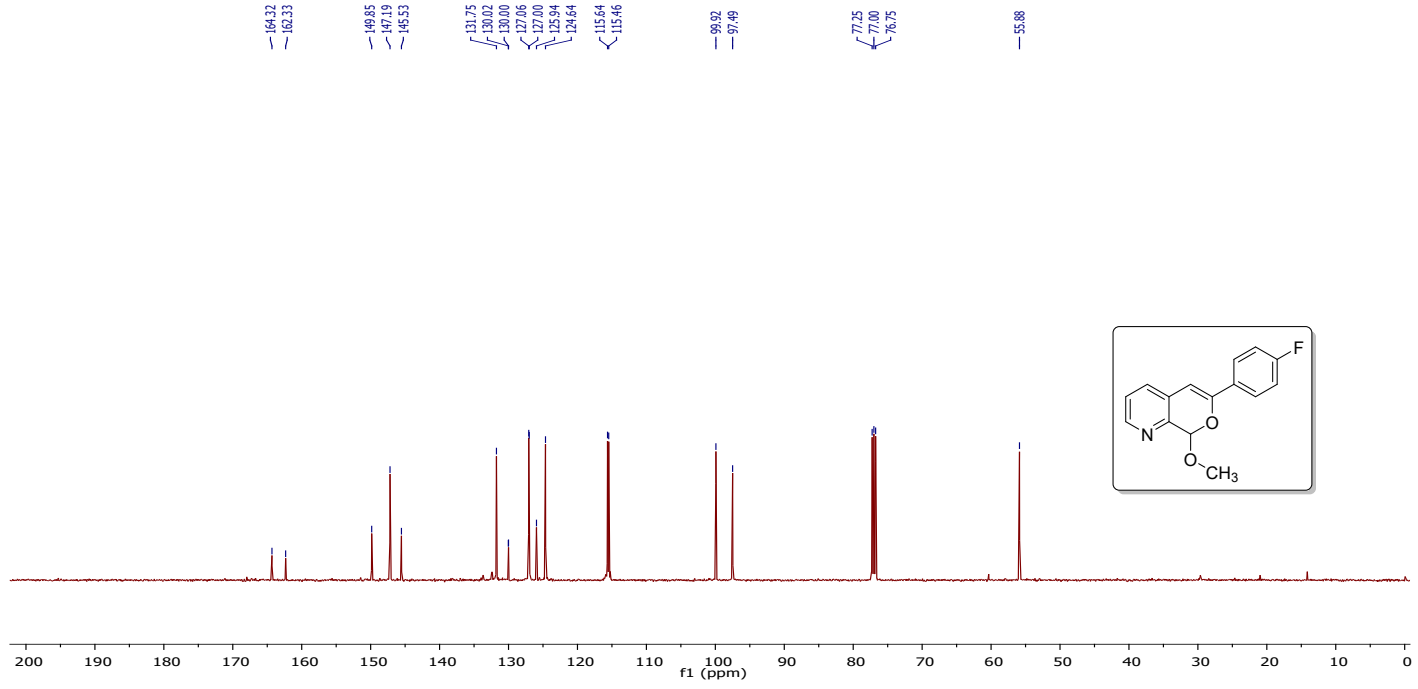


6-(4-fluorophenyl)-8-methoxy-8*H*-pyrano[3,4-*b*]pyridine (5ca)

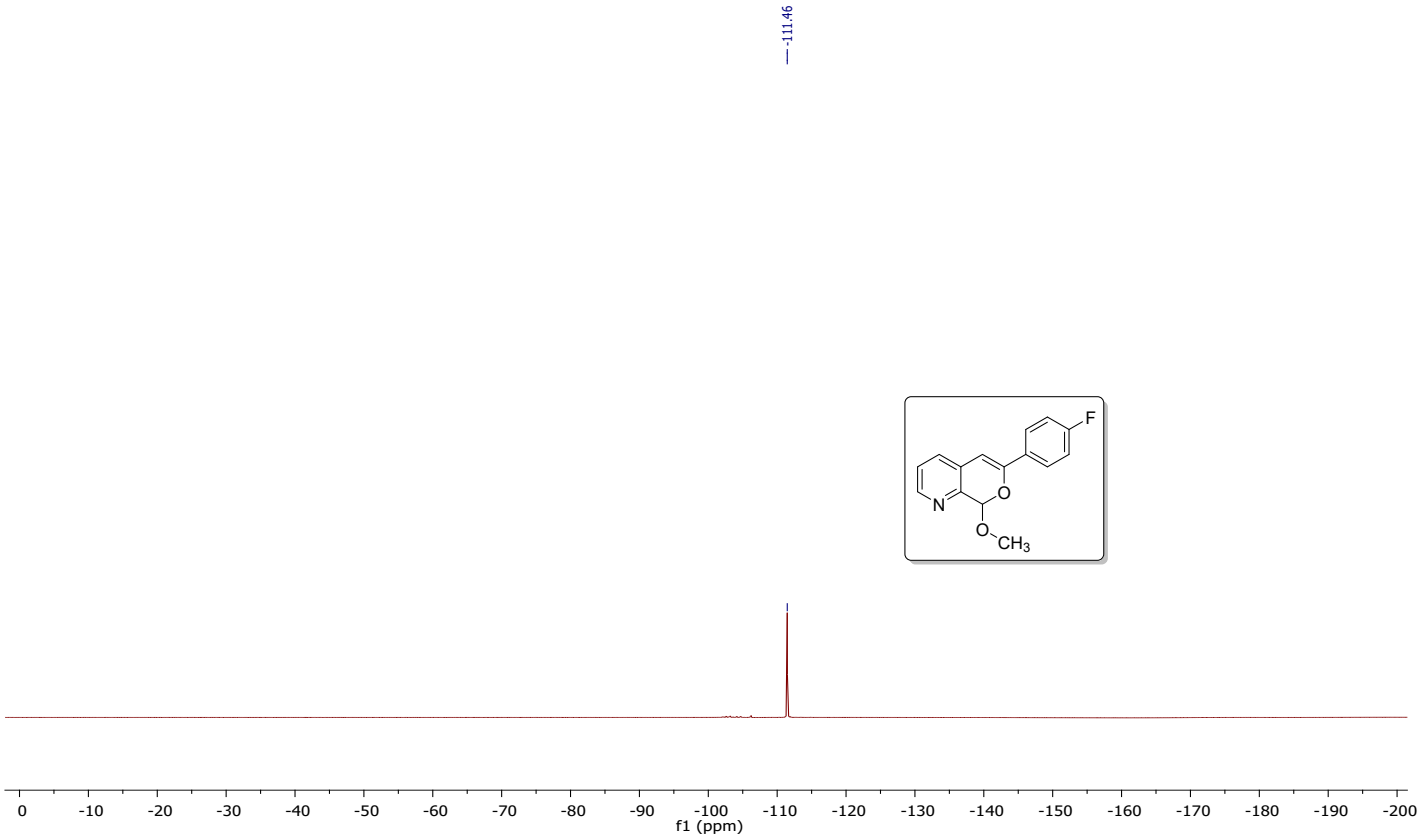
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (126 MHz, $CDCl_3$)

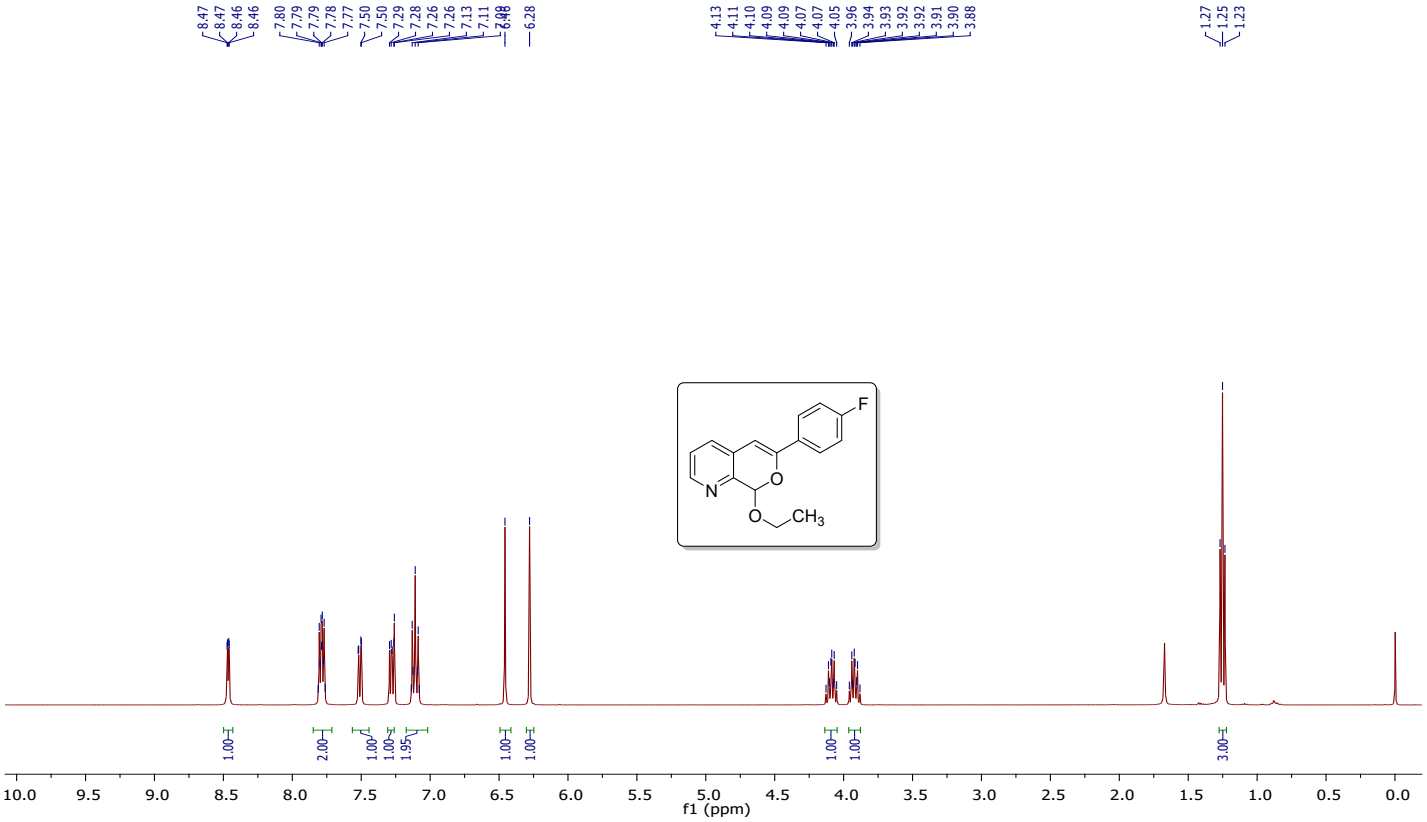


^{19}F NMR (376 MHz, $CDCl_3$)

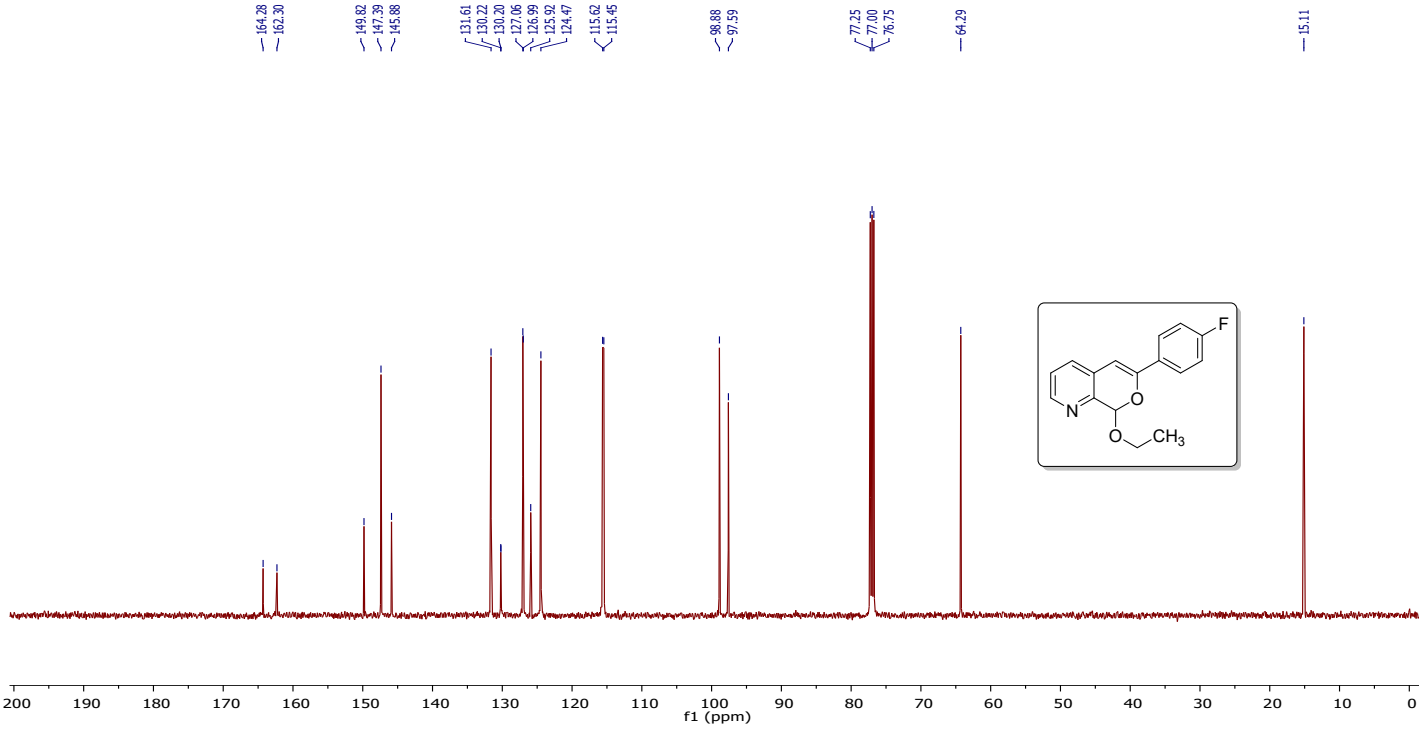


8-ethoxy-6-(4-fluorophenyl)-8*H*-pyrano[3,4-*b*]pyridine (5cb)

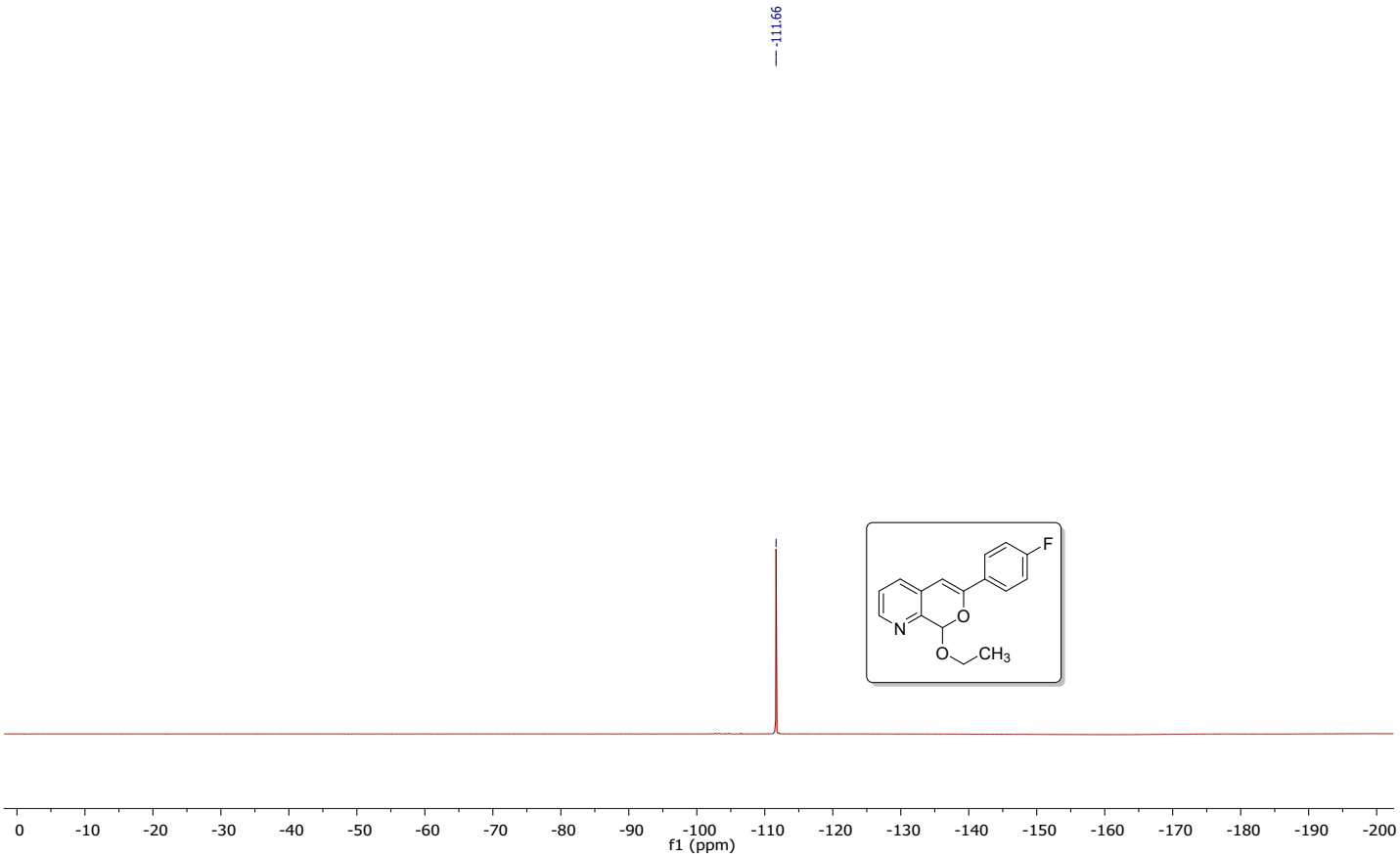
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (126 MHz, $CDCl_3$)

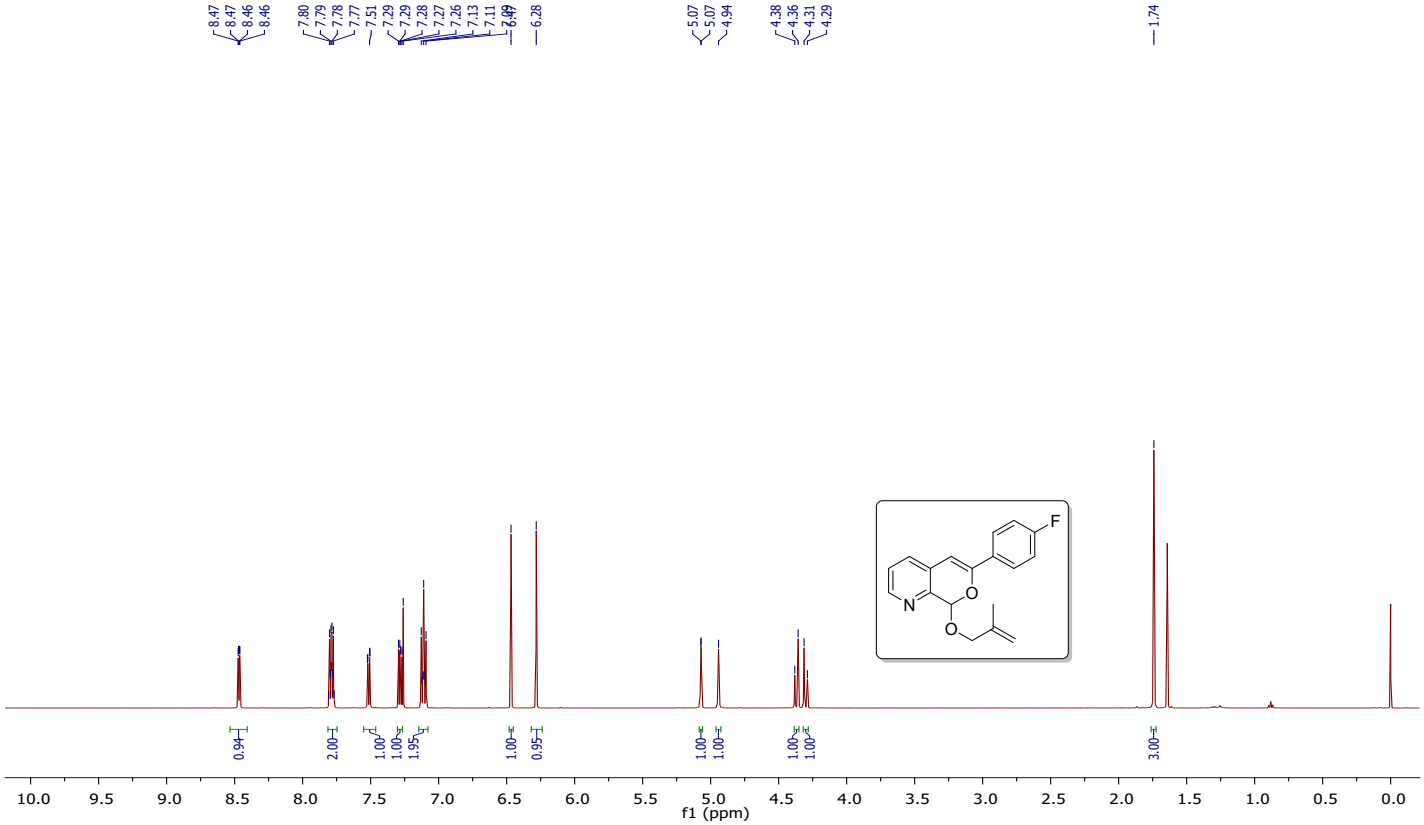


^{19}F NMR (376 MHz, $CDCl_3$)

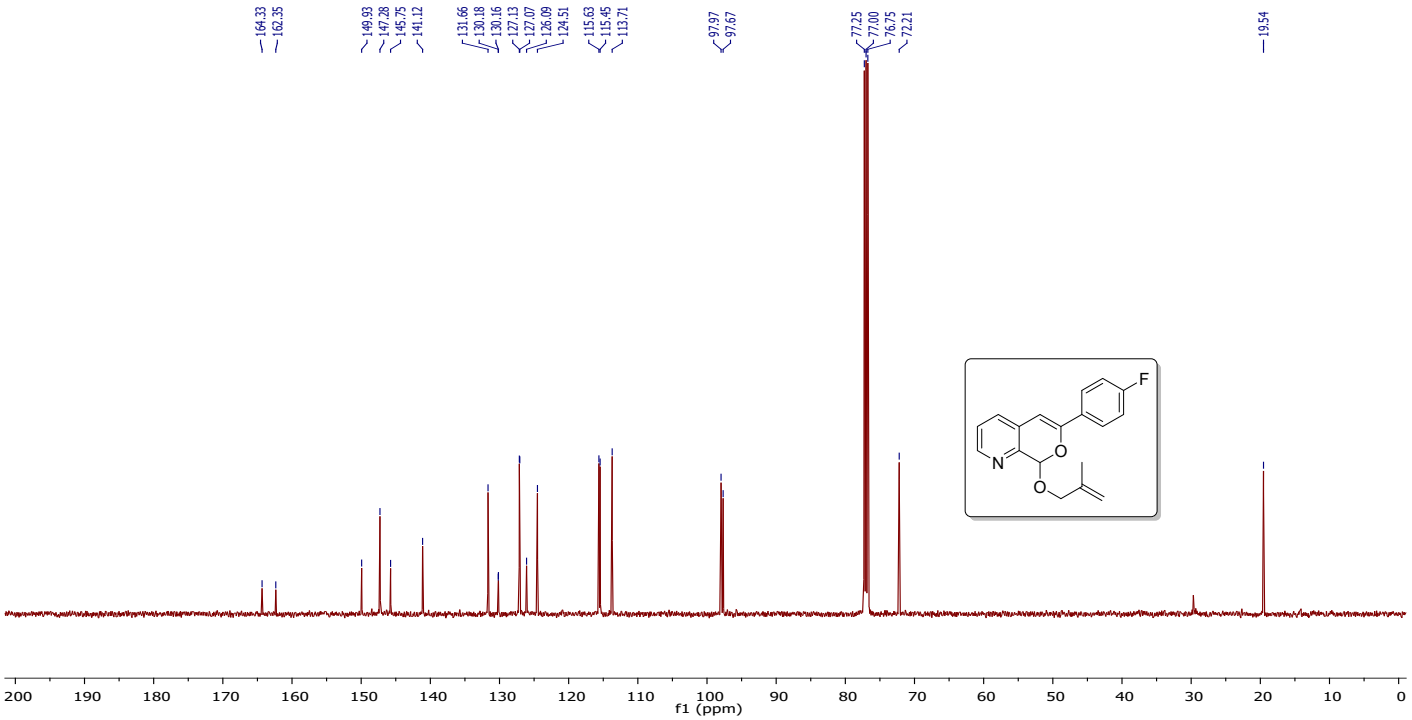


6-(4-fluorophenyl)-8-((2-methylallyl)oxy)-8*H*-pyrano[3,4-*b*]pyridine (5cf)

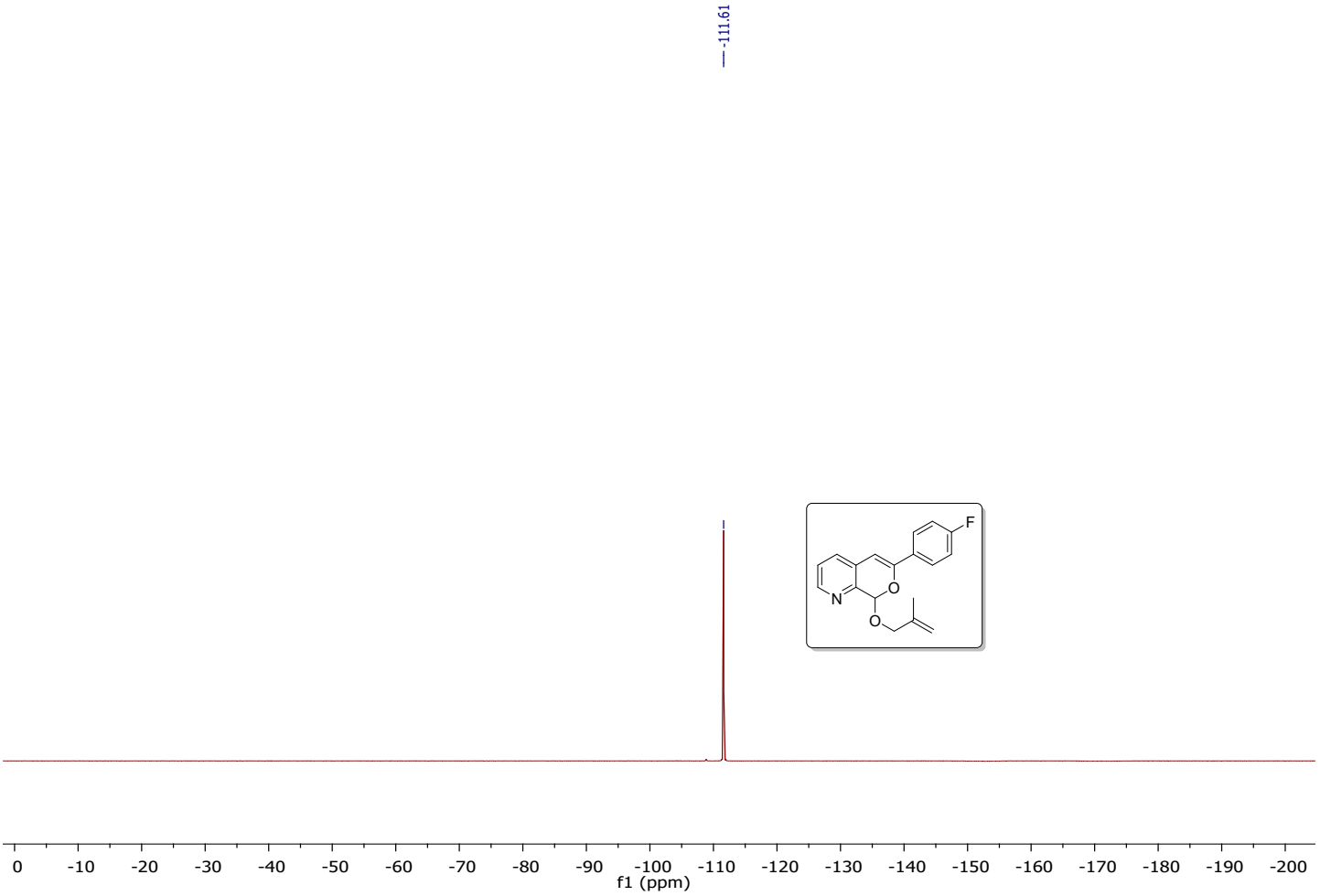
^{1}H NMR (500 MHz, $CDCl_3$)



^{13}C NMR (126 MHz, $CDCl_3$)

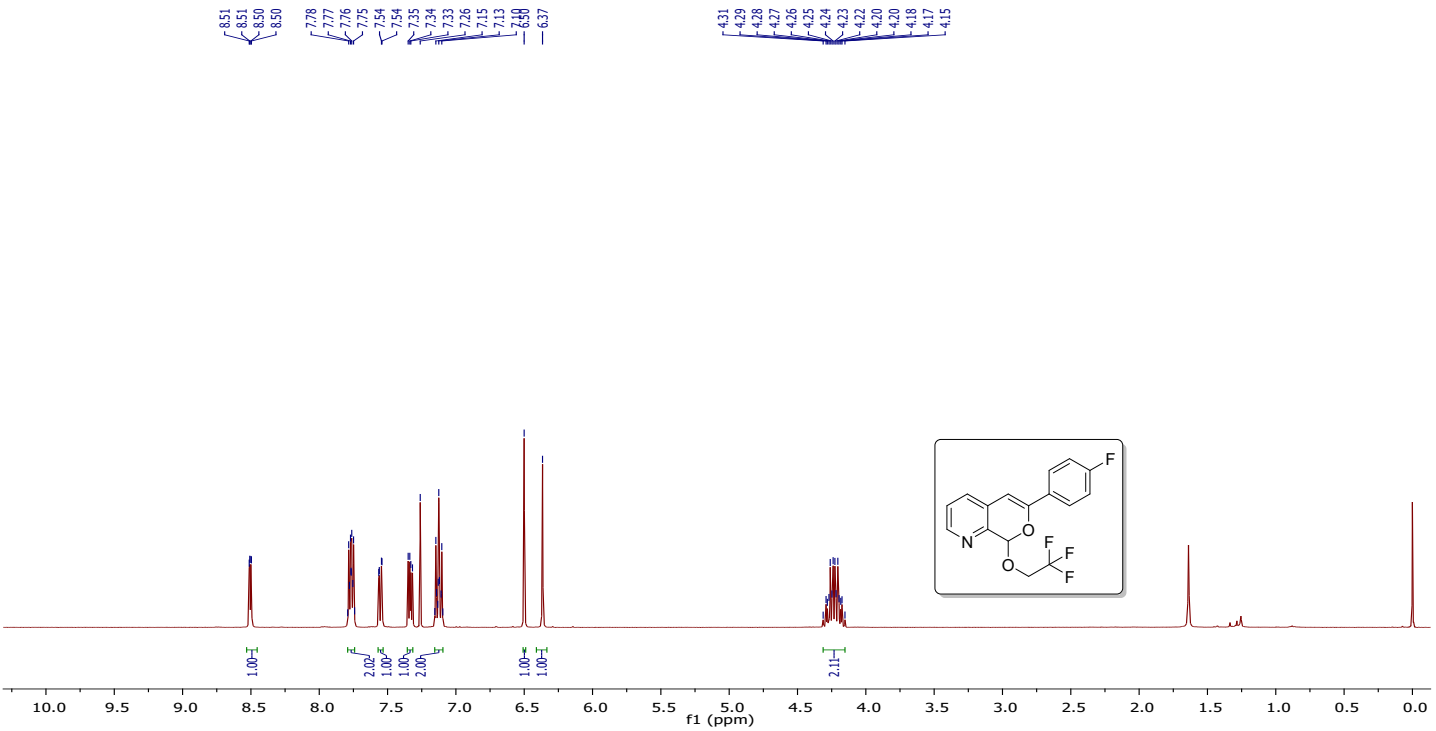


^{19}F NMR (471 MHz, $CDCl_3$)

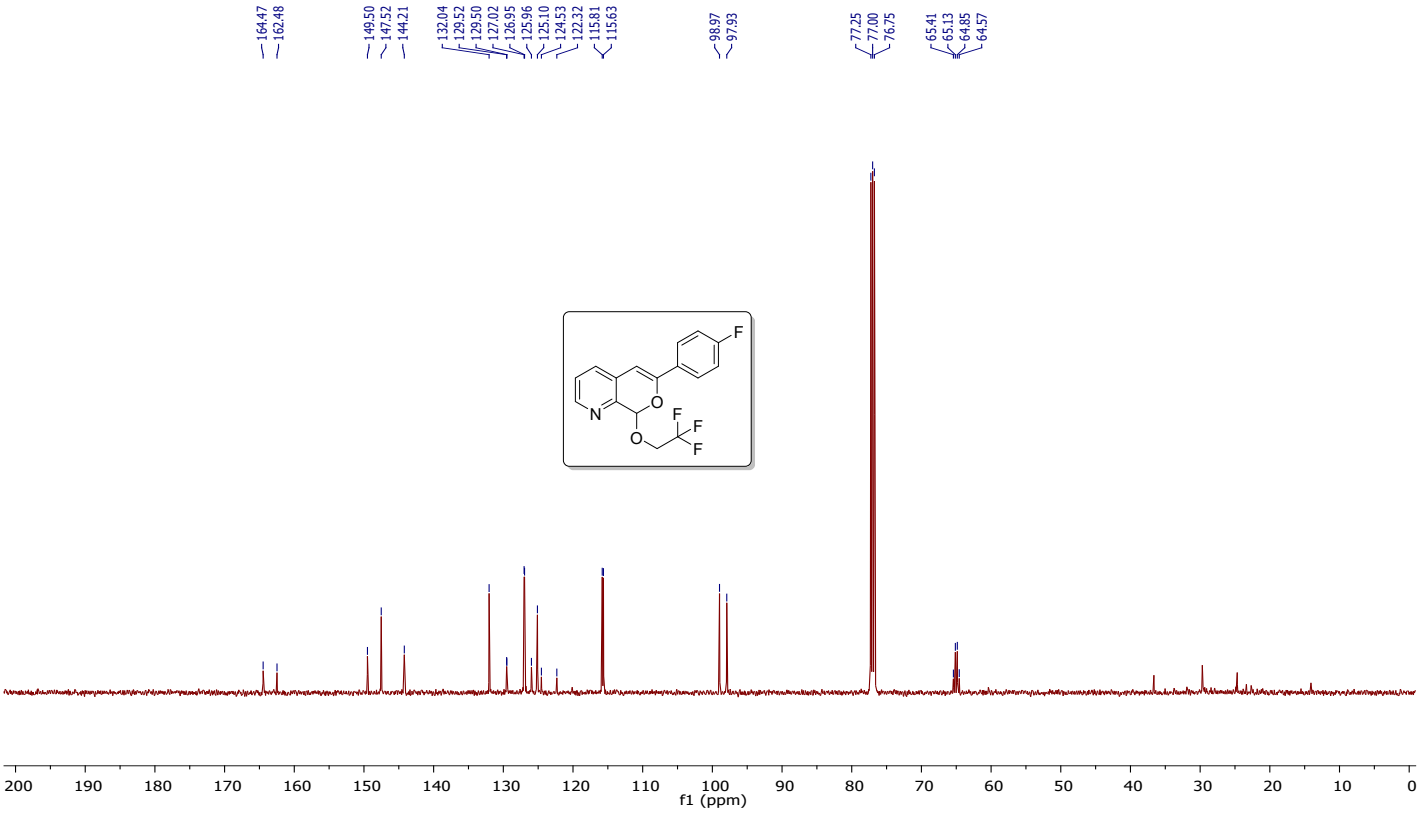


6-(4-fluorophenyl)-8-(2,2,2-trifluoroethoxy)-8*H*-pyrano[3,4-*b*]pyridine (5ch)

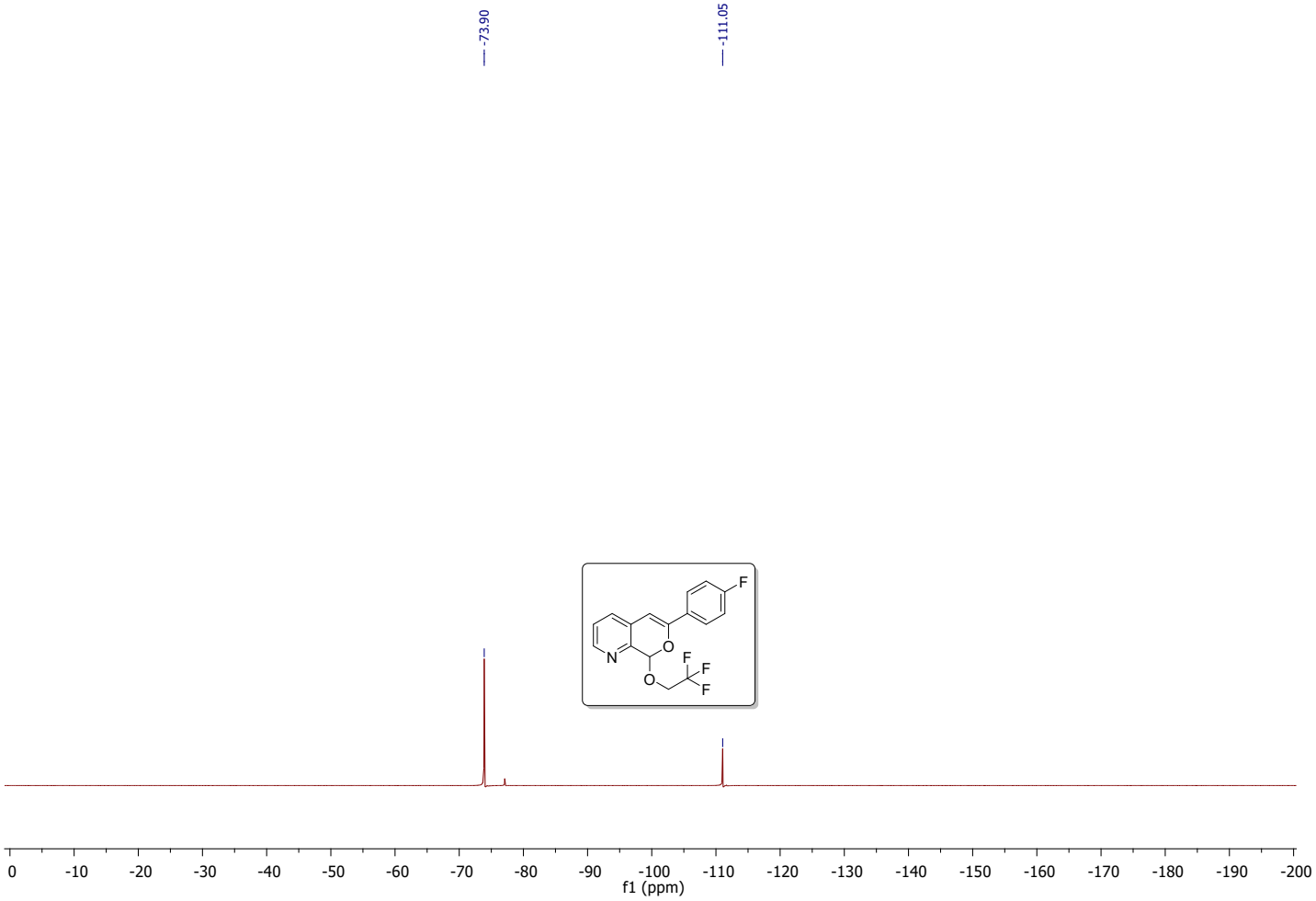
^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (126 MHz, $CDCl_3$)

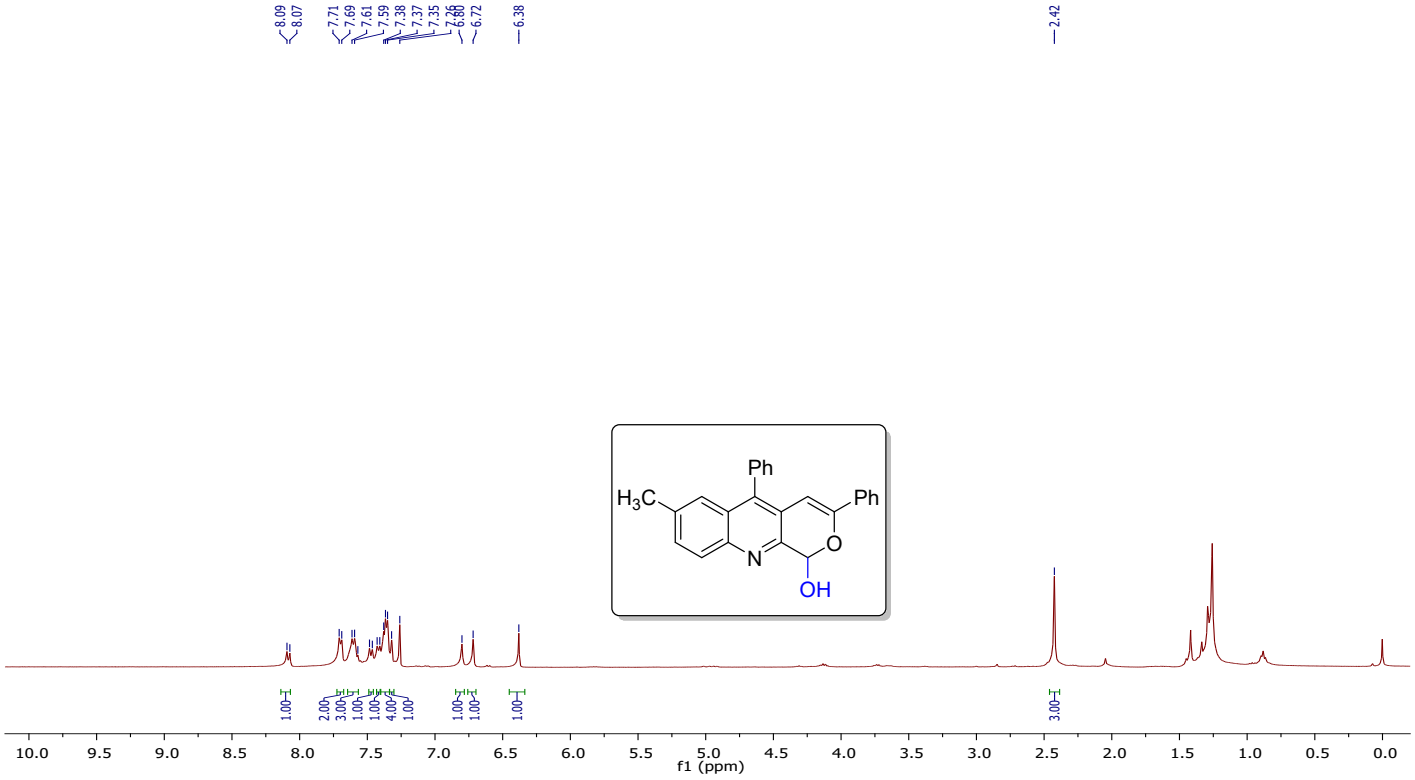


^{19}F NMR (376 MHz, $CDCl_3$)

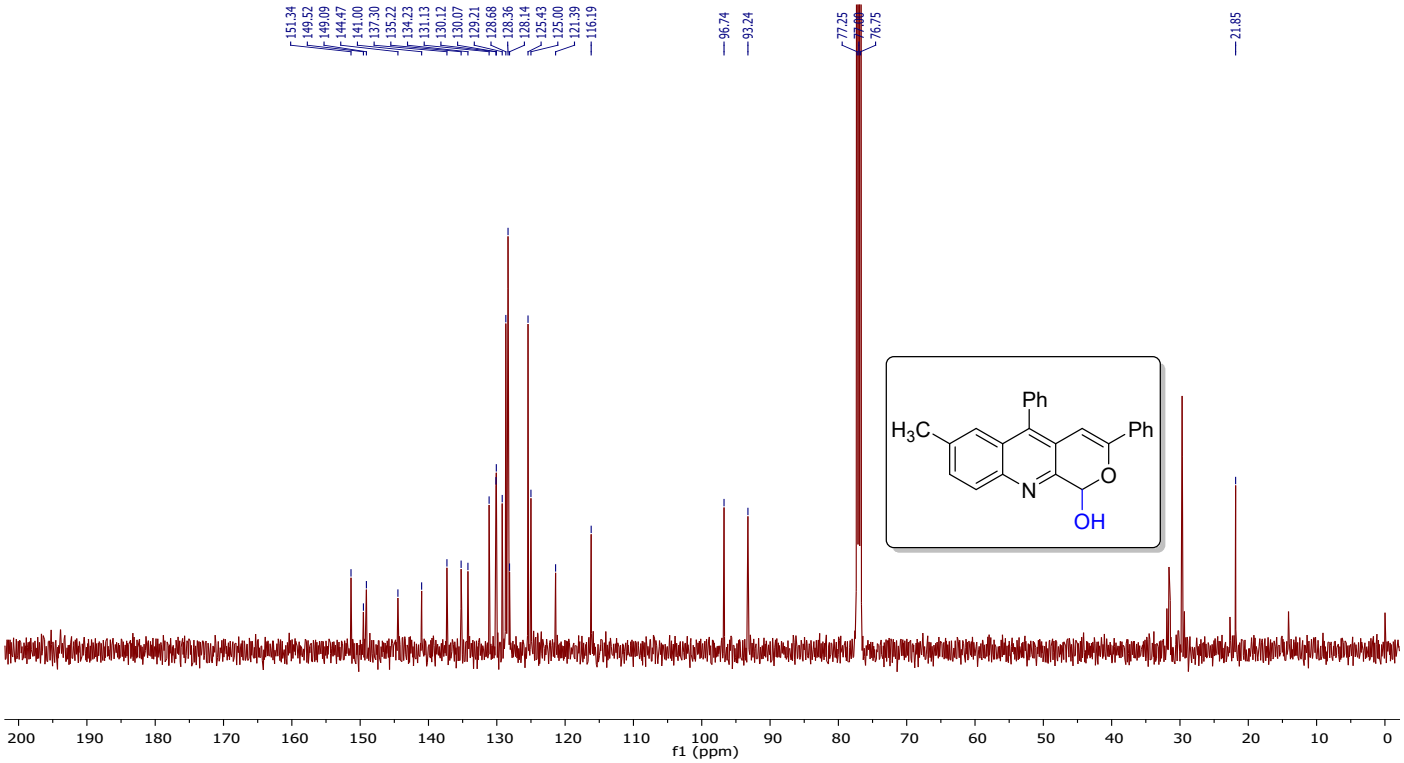


7-methyl-3,5-diphenyl-1*H*-pyrano[3,4-*b*]quinolin-1-ol (6a)

^{1}H NMR (400 MHz, $CDCl_3$) (poor solubility)

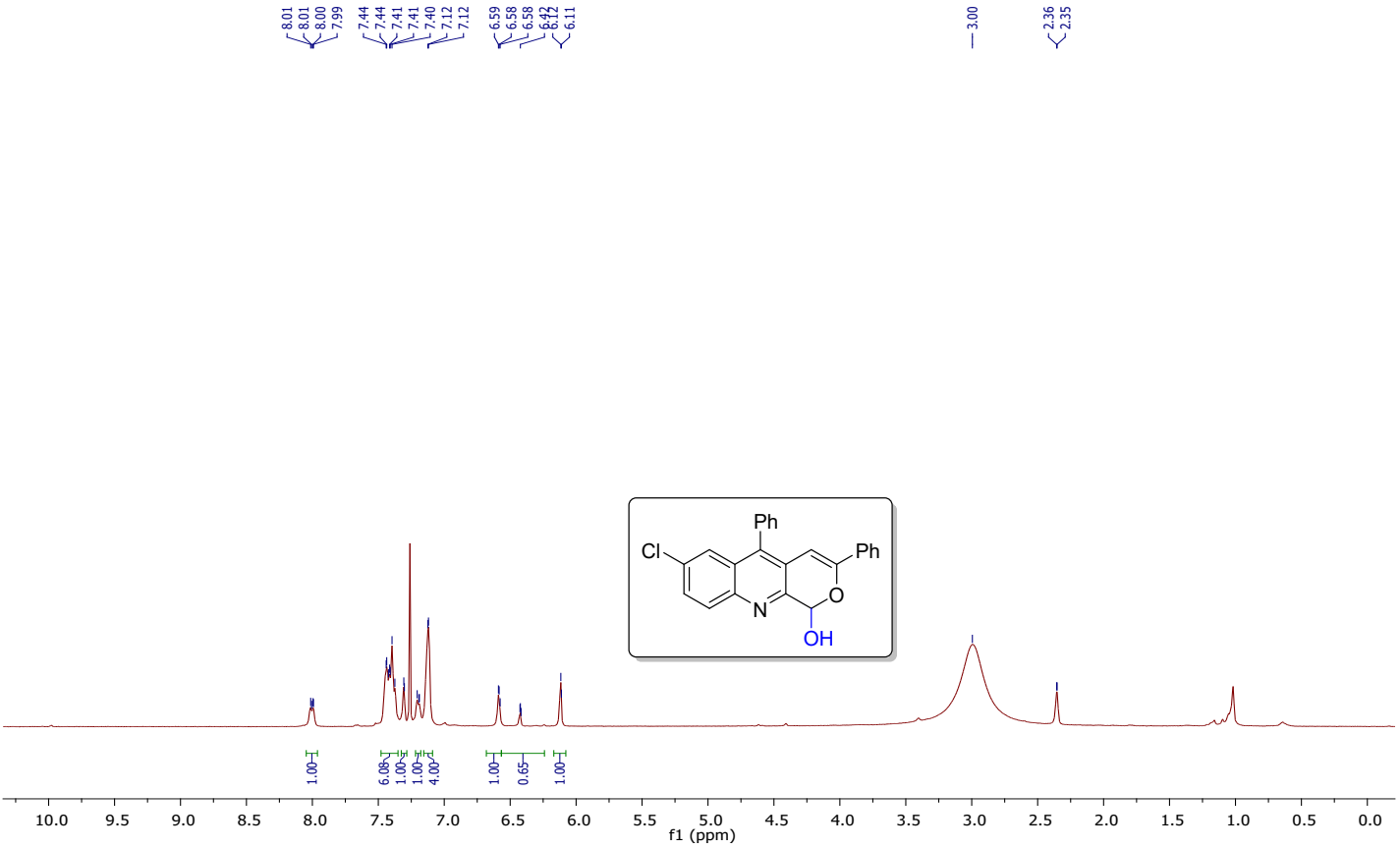


^{13}C NMR (126 MHz, $CDCl_3$)

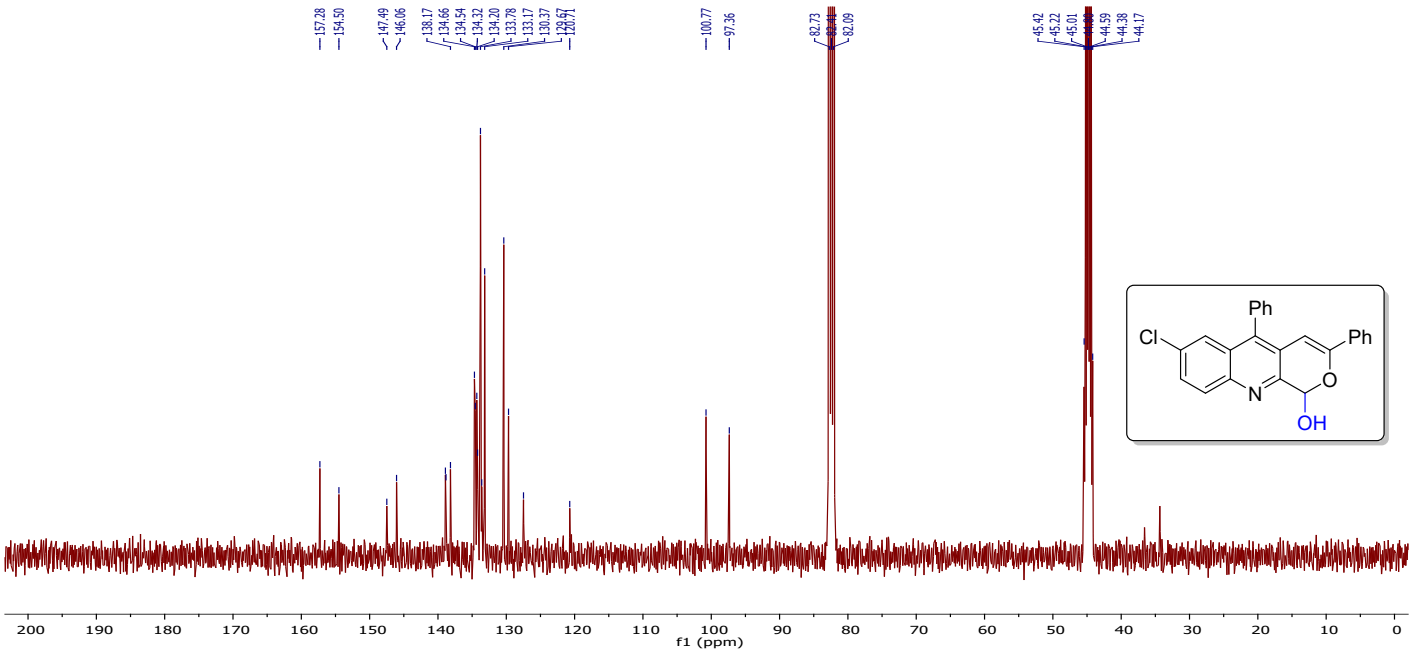


7-chloro-3,5-diphenyl-1*H*-pyrano[3,4-*b*]quinolin-1-ol (6b)

^{1}H NMR (400 MHz, $CDCl_3$+DMSO)



^{13}C NMR (101 MHz, $CDCl_3$+DMSO)


157.28
154.50
147.49
146.06
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134.54
134.32
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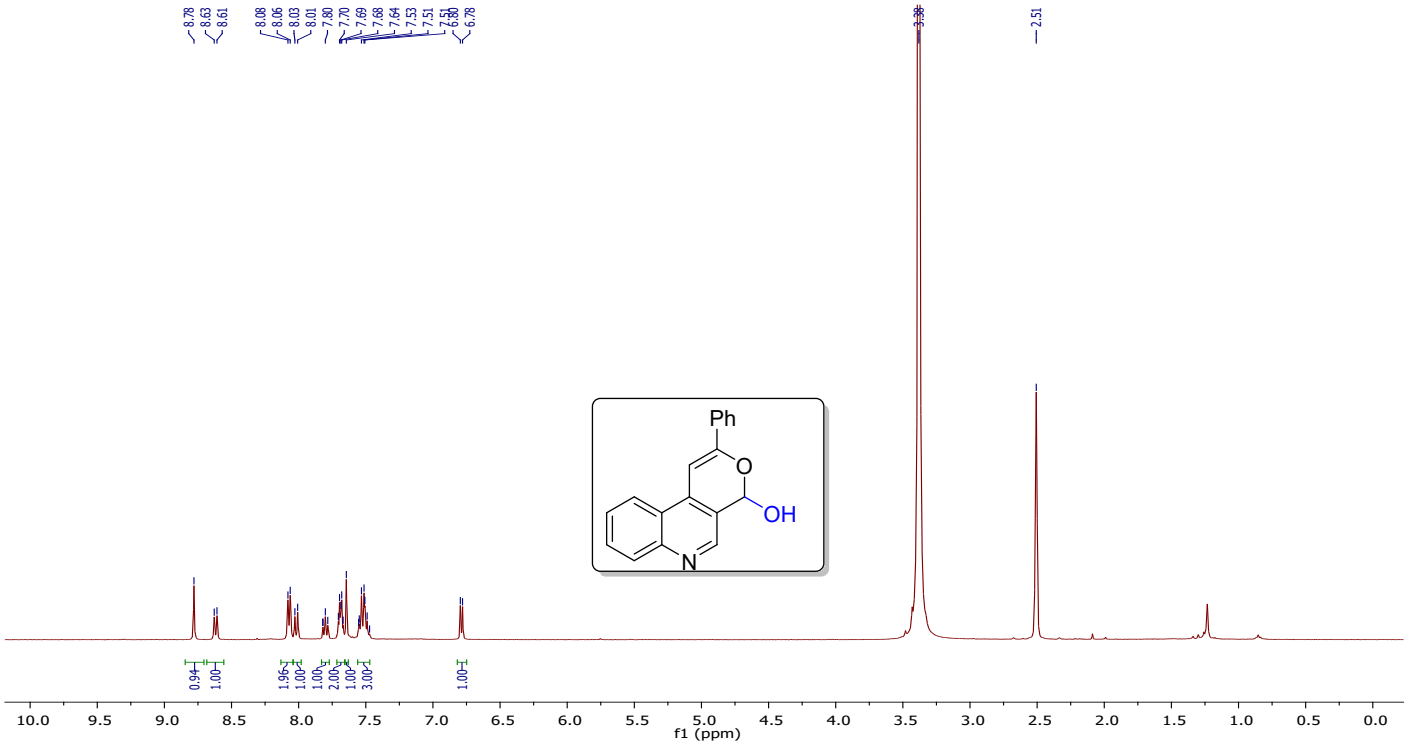
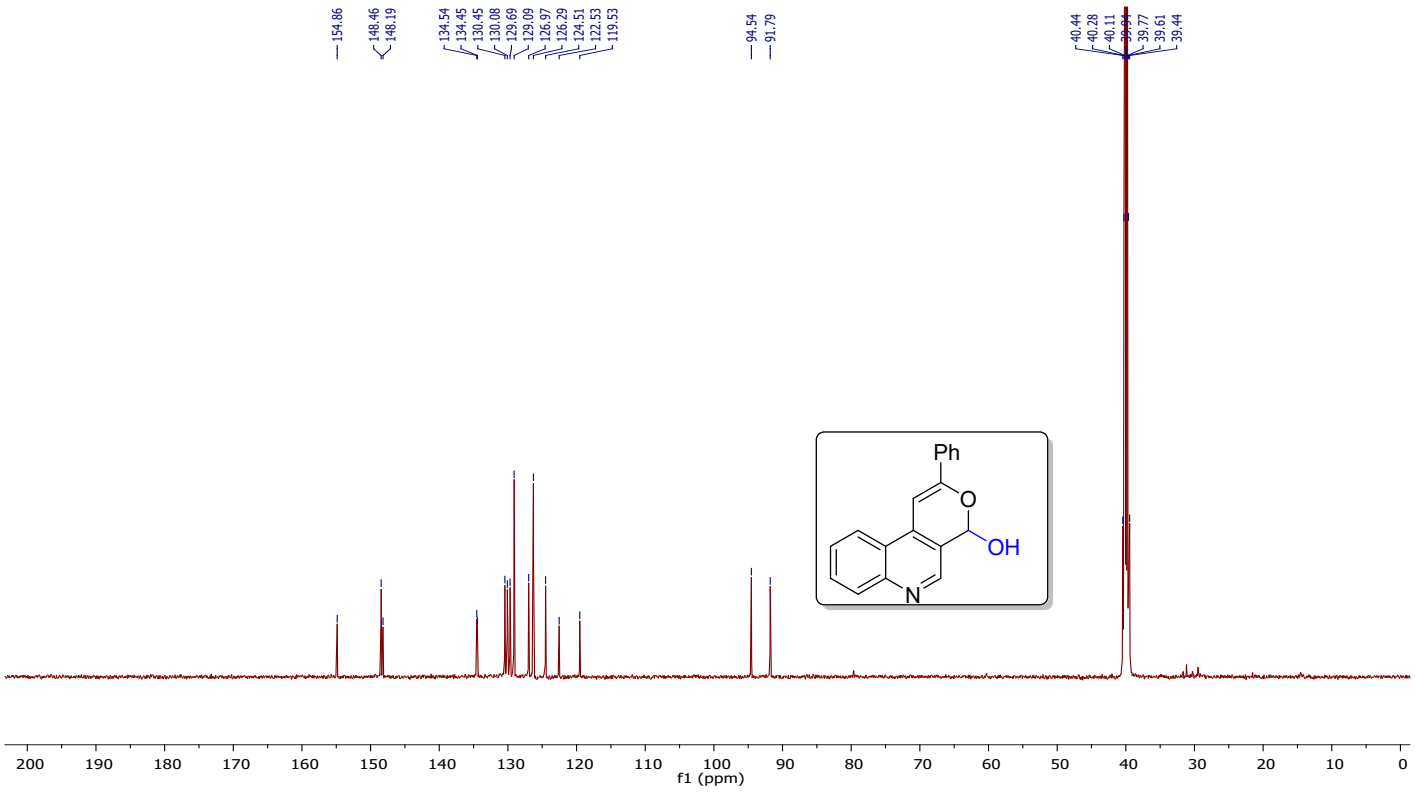
133.78
133.17
130.37
128.67
120.71
100.77
97.36
82.73
82.41
82.09
45.42
45.22
45.01
44.80
44.59
44.38
44.17
Ph
Cl
Ph
O
N
OH
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

2-phenyl-4*H*-pyrano[3,4-*c*]quinolin-4-ol (6c)

^{1}H NMR (400 MHz, DMSO)

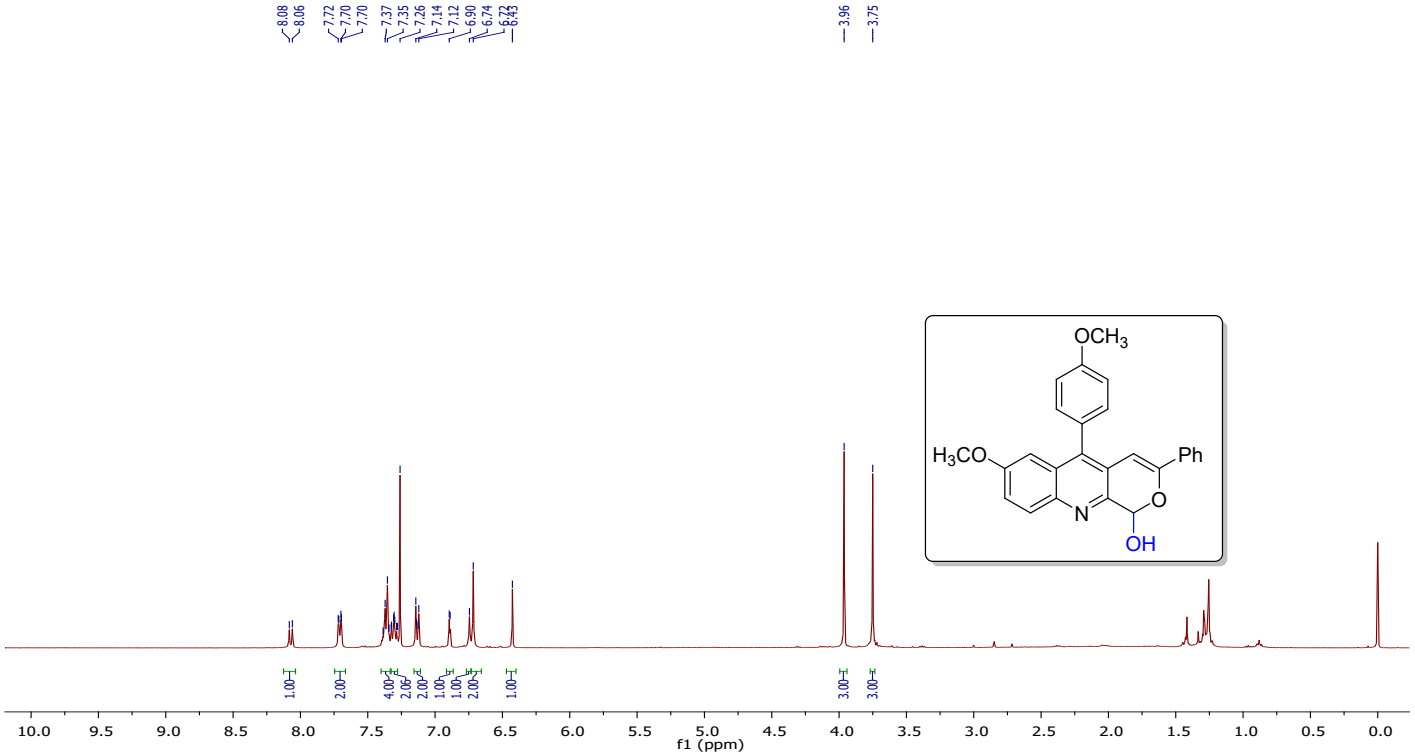


^{13}C NMR (126 MHz, DMSO)

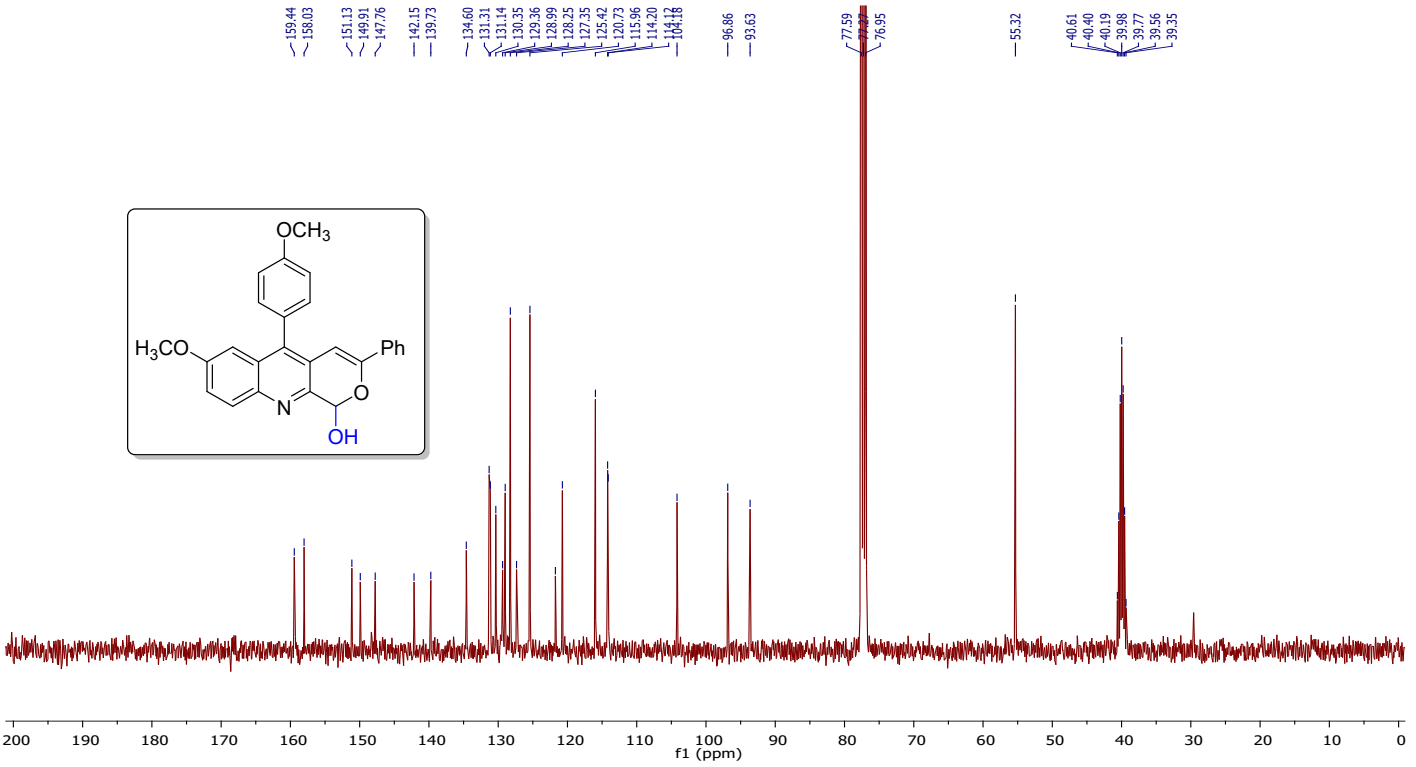


7-methoxy-5-(4-methoxyphenyl)-3-phenyl-1*H*-pyrano[3,4-*b*]quinolin-1-ol (6d)

^{1}H NMR (400 MHz, $CDCl_3$+DMSO) (poor solublity)

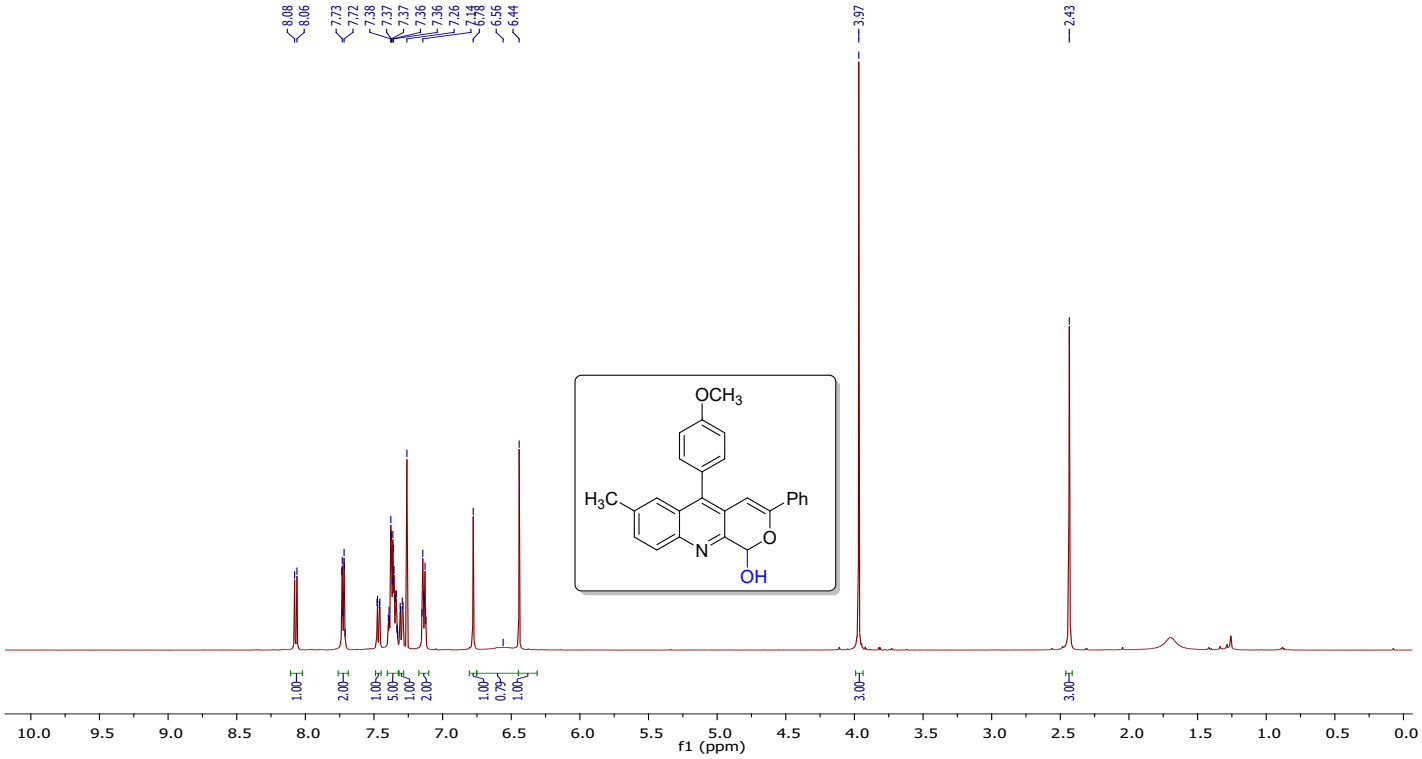


^{13}C NMR (101 MHz, $CDCl_3$+DMSO)

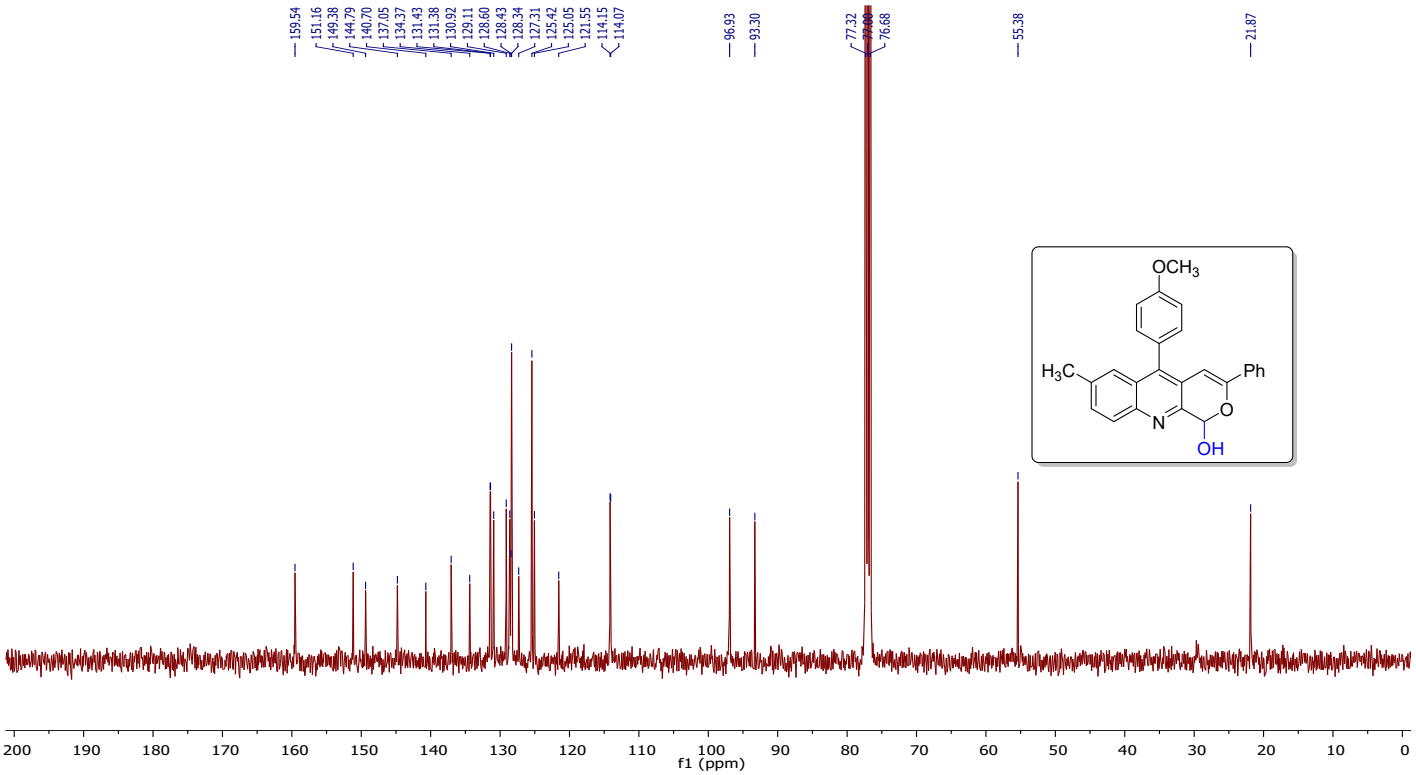


5-(4-methoxyphenyl)-7-methyl-3-phenyl-1*H*-pyrano[3,4-*b*]quinolin-1-ol (6e)

^{1}H NMR (500 MHz, $CDCl_3$)

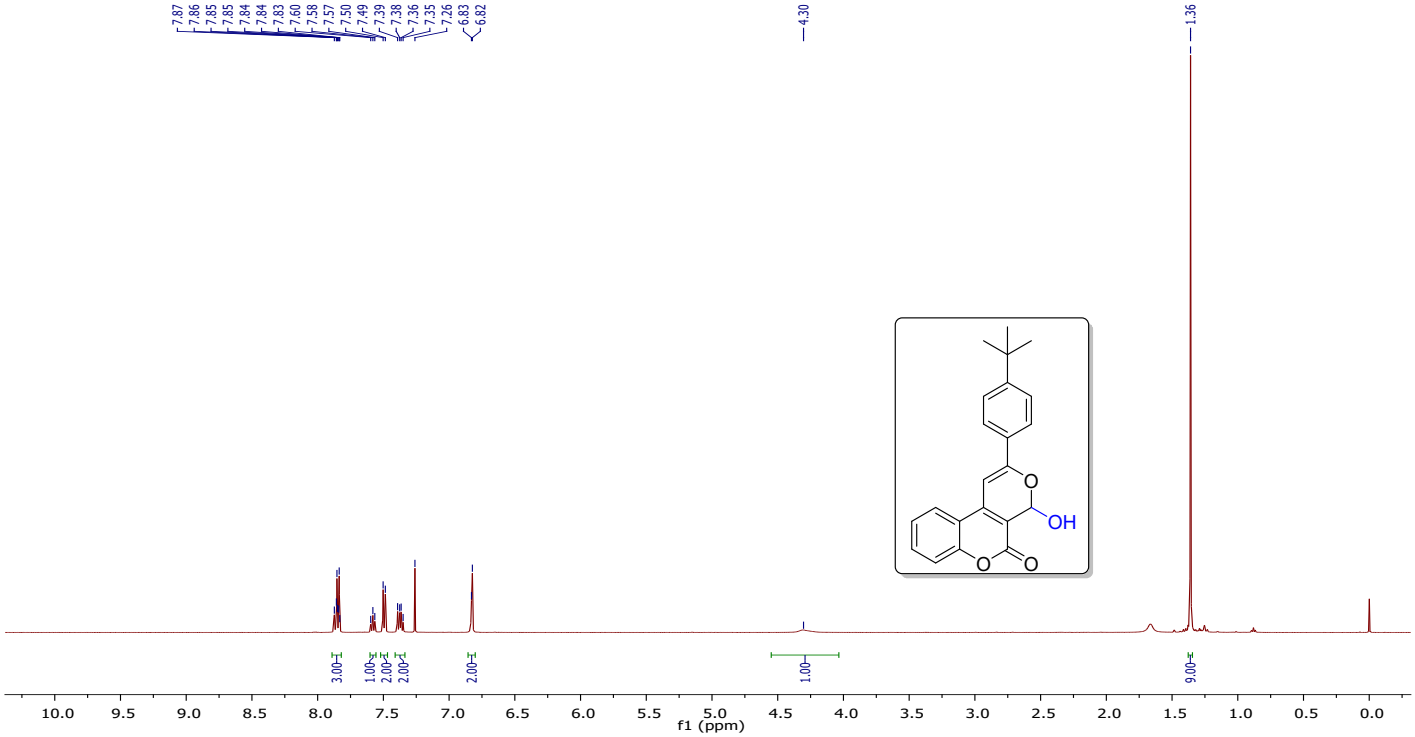


^{13}C NMR (101 MHz, $CDCl_3$)

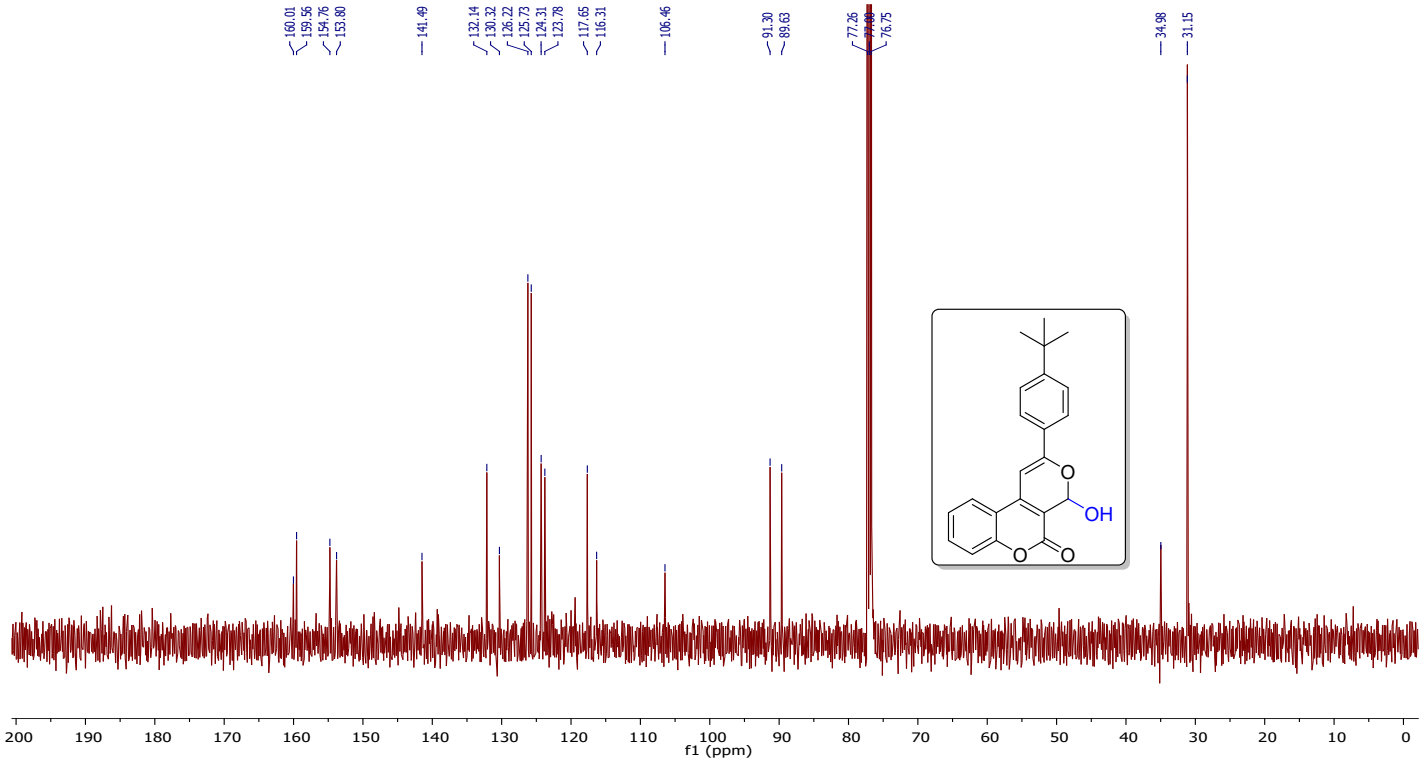


2-(4-(*tert*-butyl)phenyl)-4-hydroxy-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one (6f)

^{1}H NMR (500 MHz, $CDCl_3$)

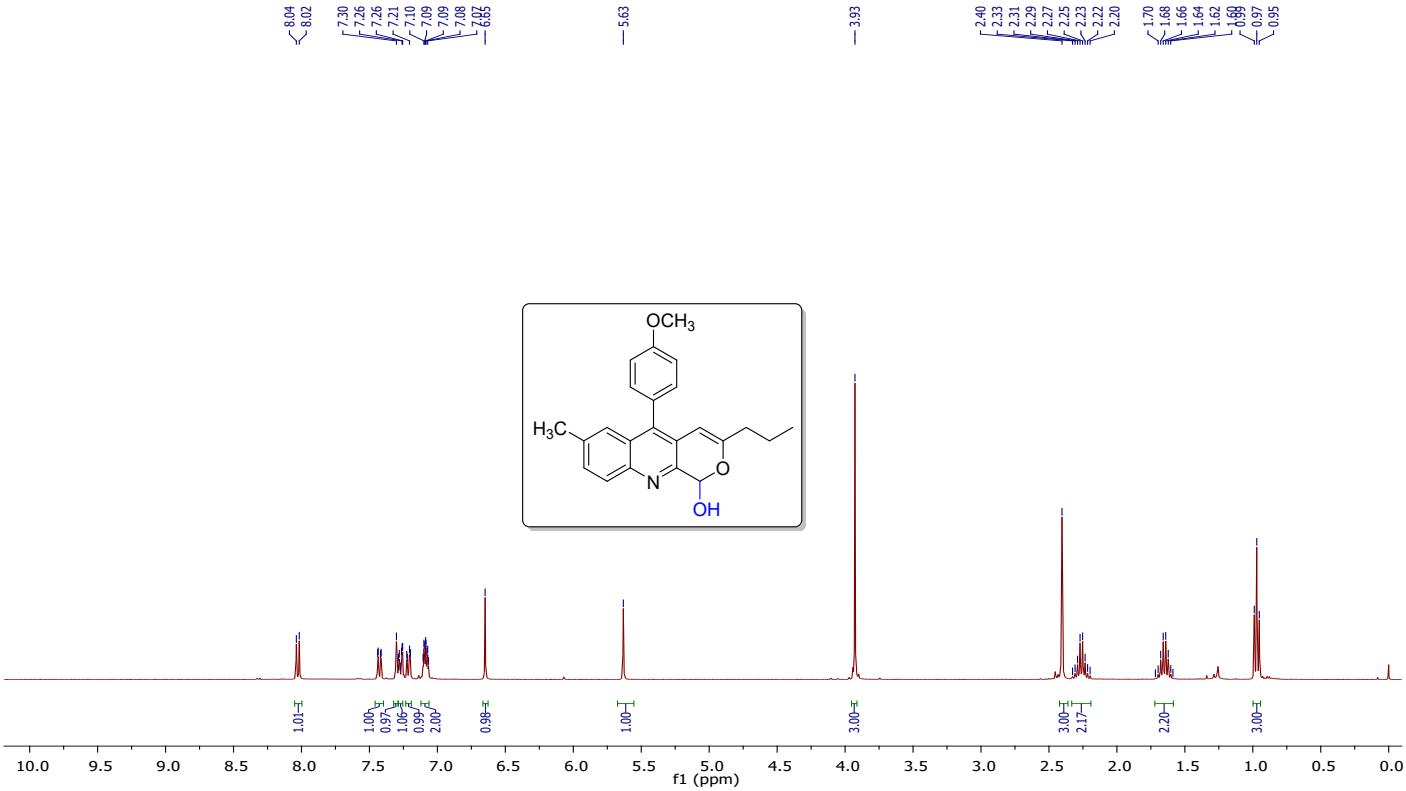


^{13}C NMR (126 MHz, $CDCl_3$)

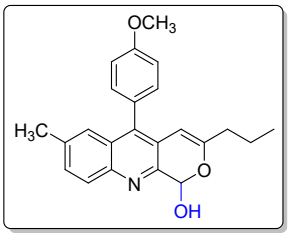


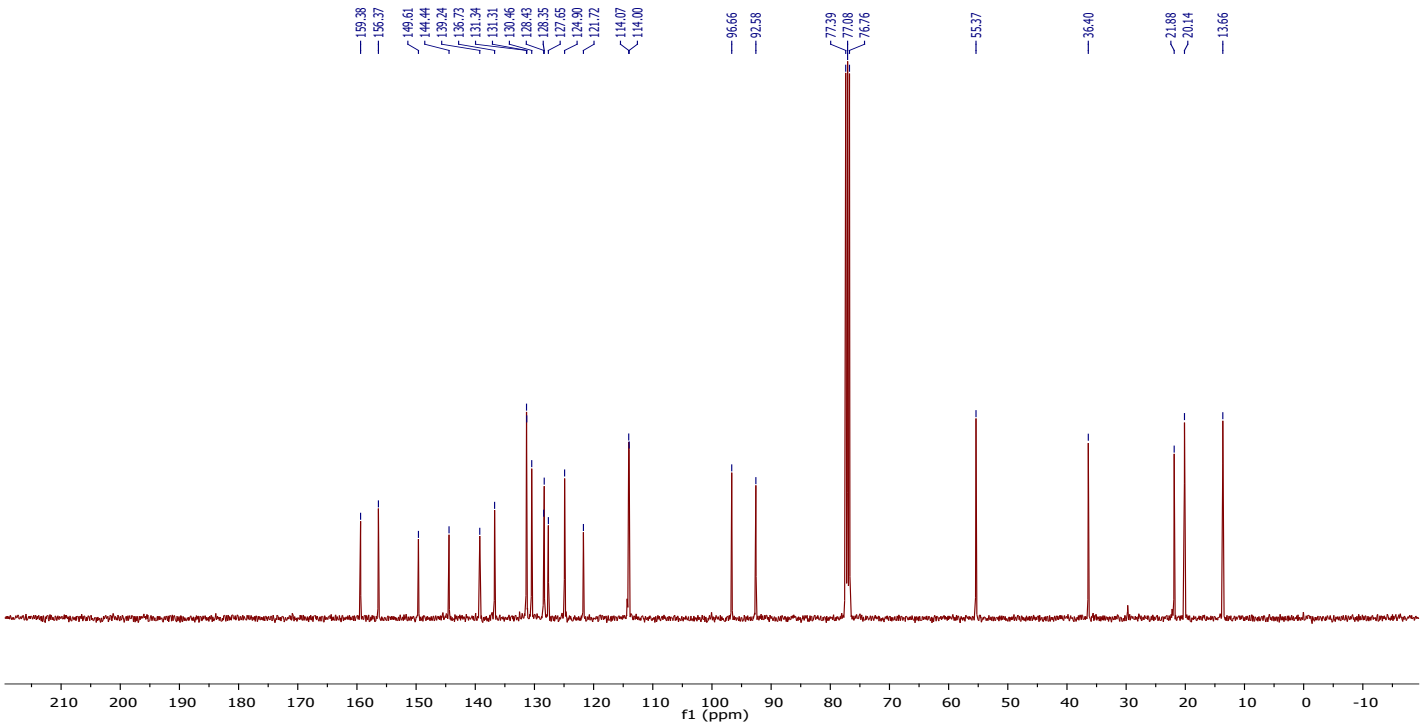
5-(4-methoxyphenyl)-7-methyl-3-propyl-1*H*-pyrano[3,4-*b*]quinolin-1-ol (6g)

^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)




159.38
156.37
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144.44
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136.73
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131.31
130.46
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127.65
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114.00
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92.58
77.39
77.08
76.76
55.37
36.40
21.88
20.14
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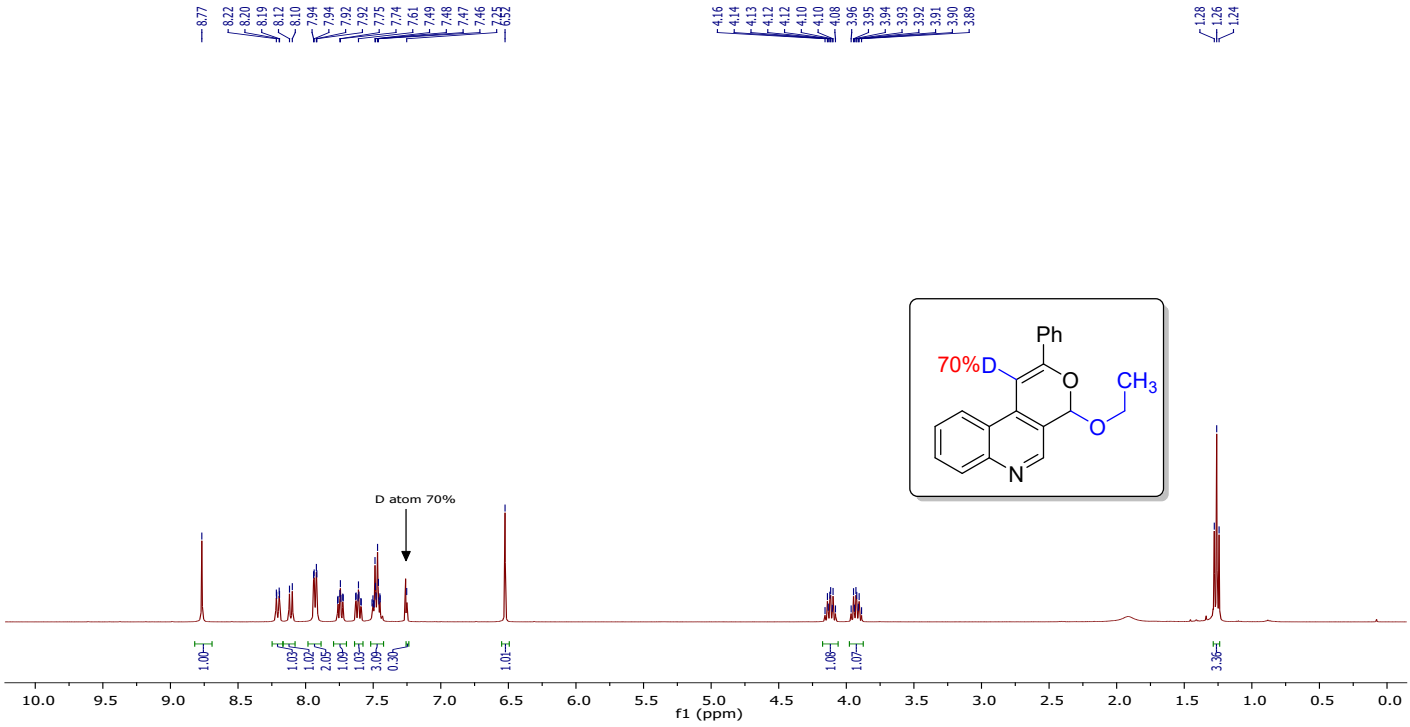
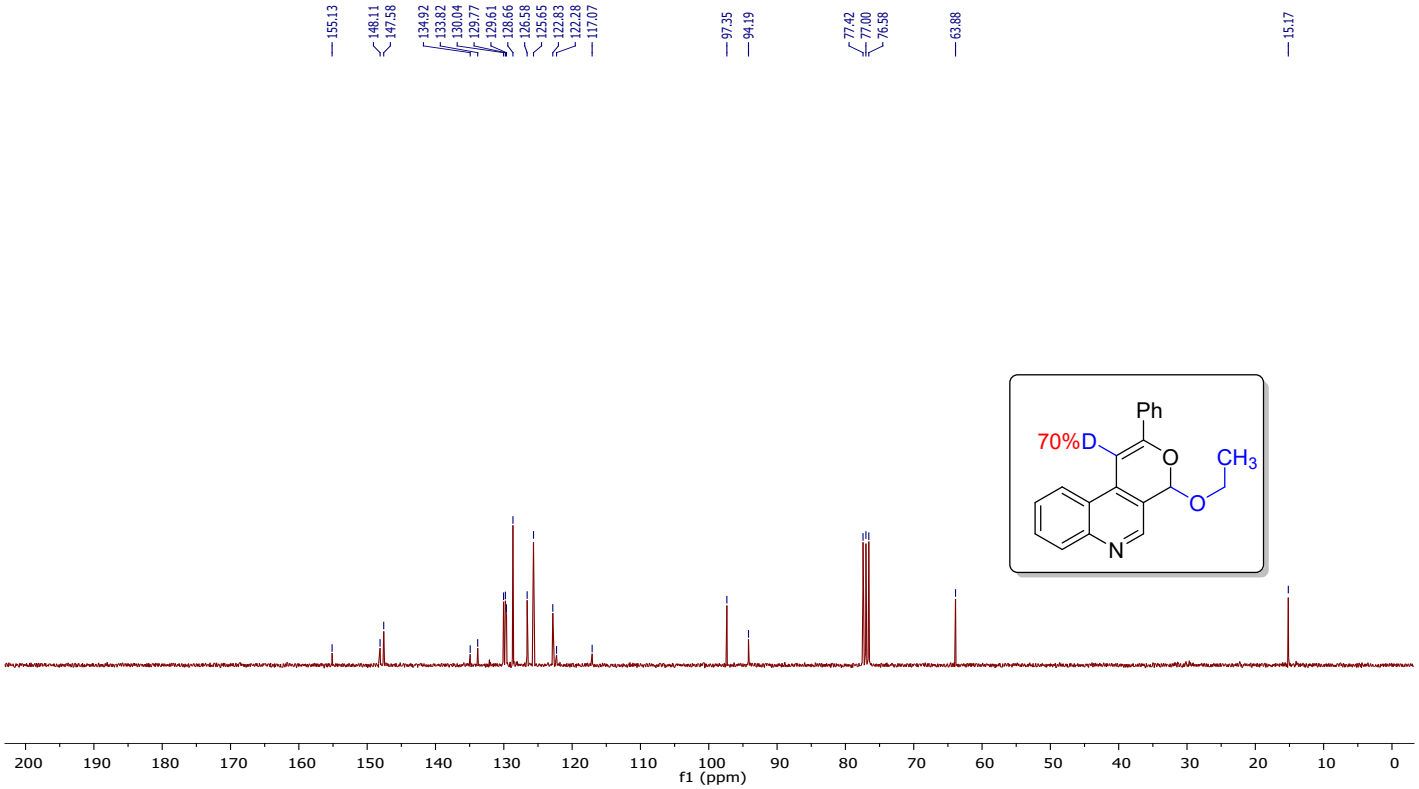
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

4-ethoxy-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline-1-d (7a)

^{1}H NMR (400 MHz, $CDCl_3$)

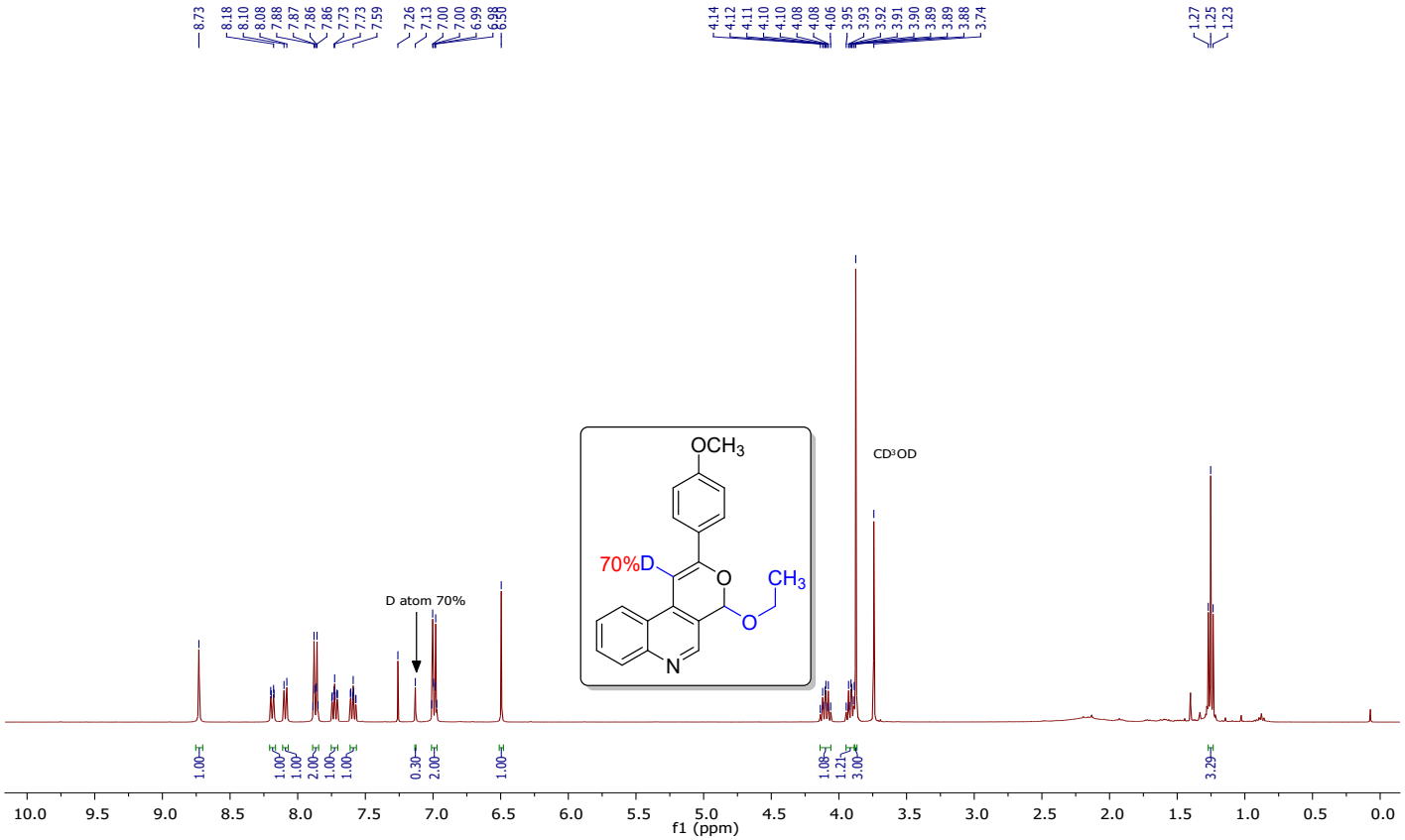


^{13}C NMR (75 MHz, $CDCl_3$)

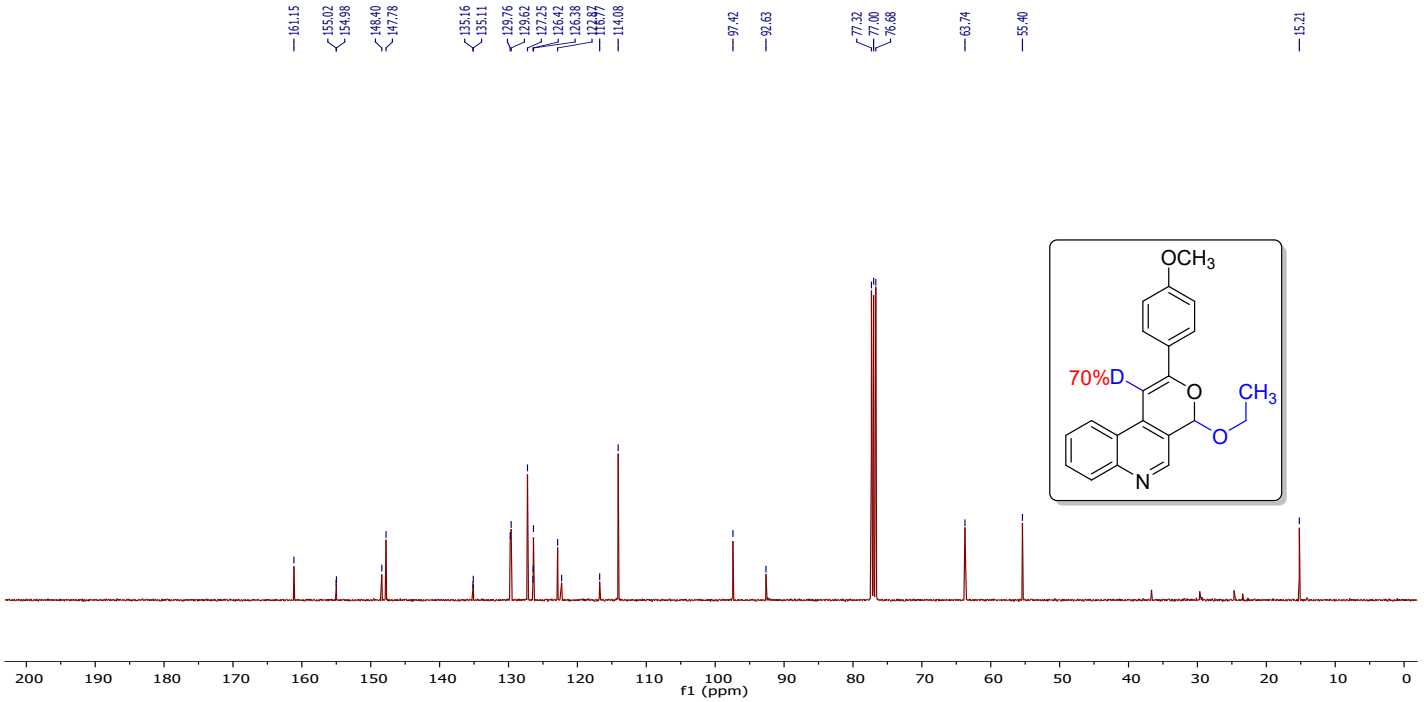


4-ethoxy-2-(4-methoxyphenyl)-4*H*-pyrano[3,4-*c*]quinoline-1-*d* (7b)

^{1}H NMR (400 MHz, $CDCl_3$)

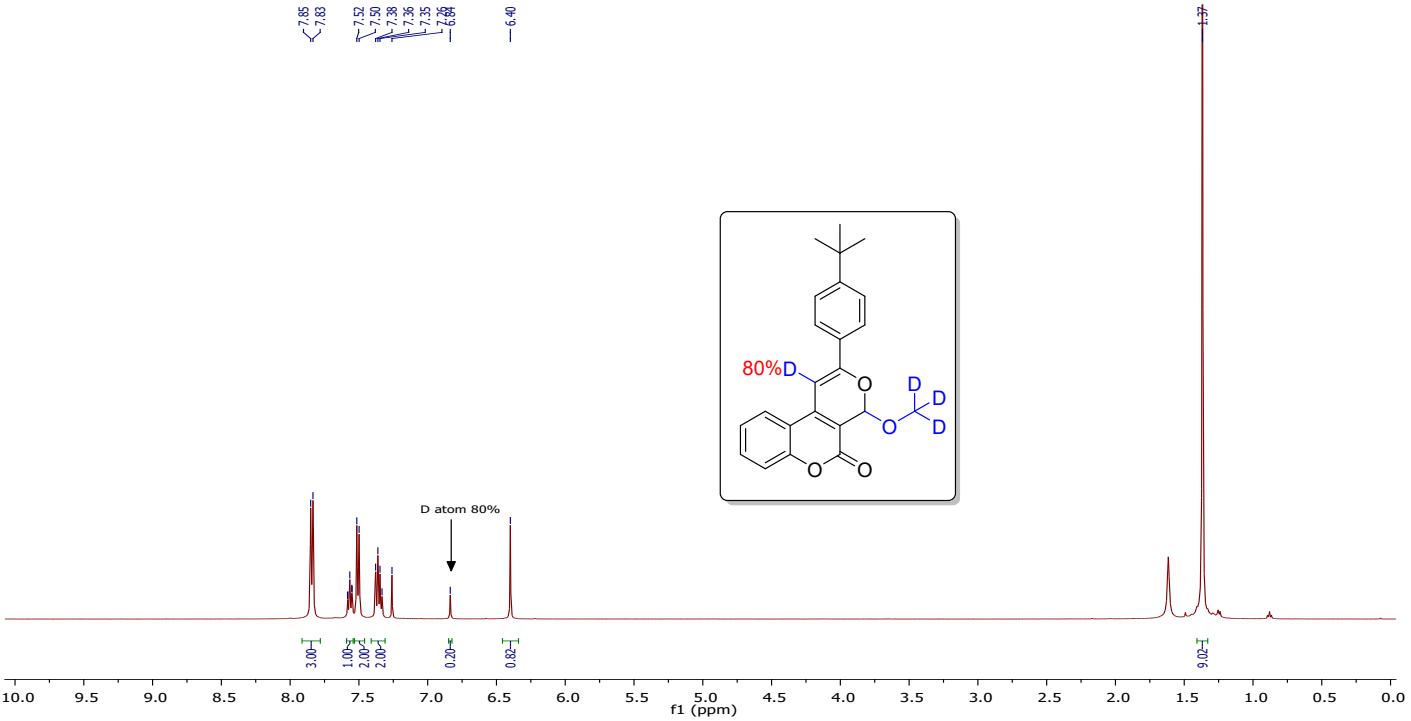


^{13}C NMR (101 MHz, $CDCl_3$)

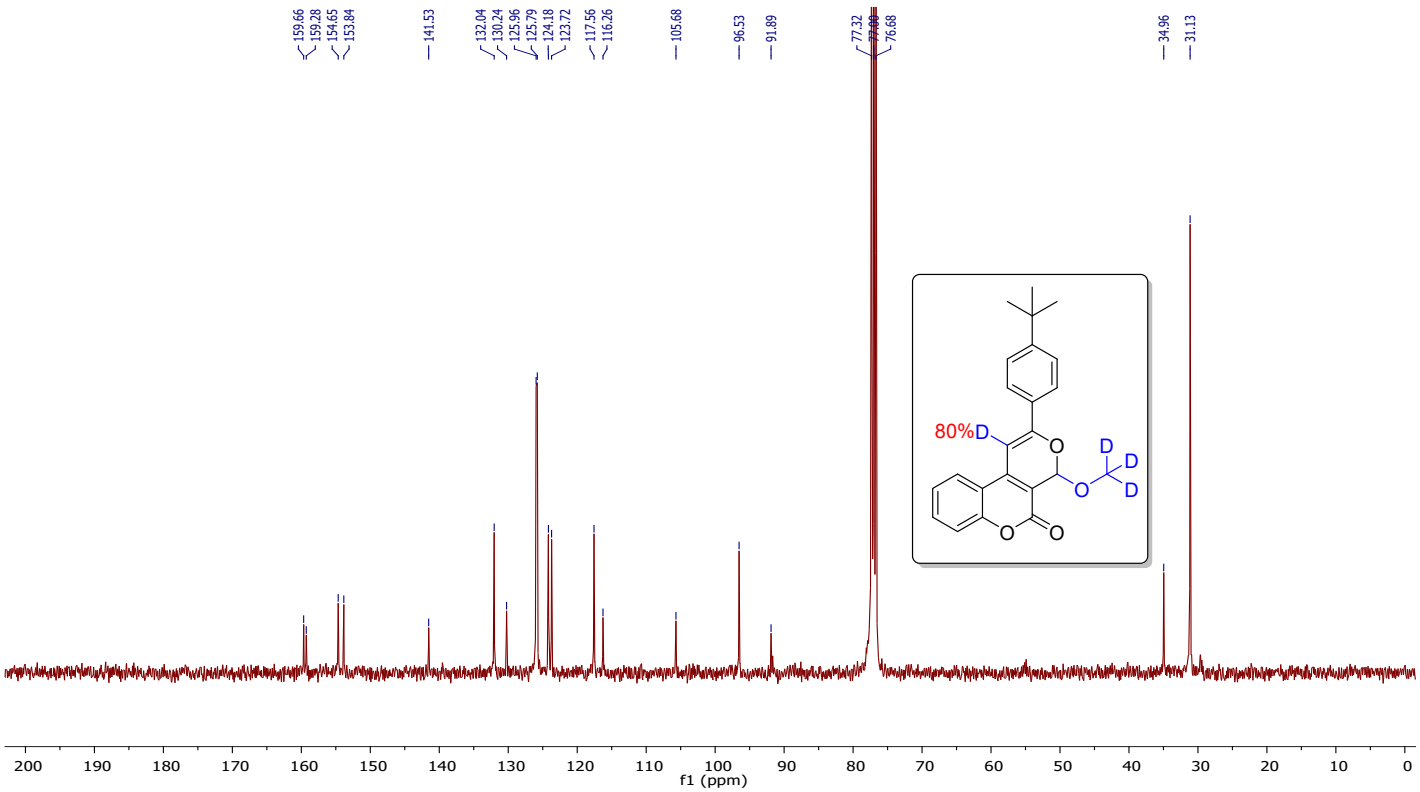


2-(4-(*tert*-butyl)phenyl)-4-(methoxy-d_3)-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one-1-*d* (7c)

^{1}H NMR (500 MHz, $CDCl_3$)

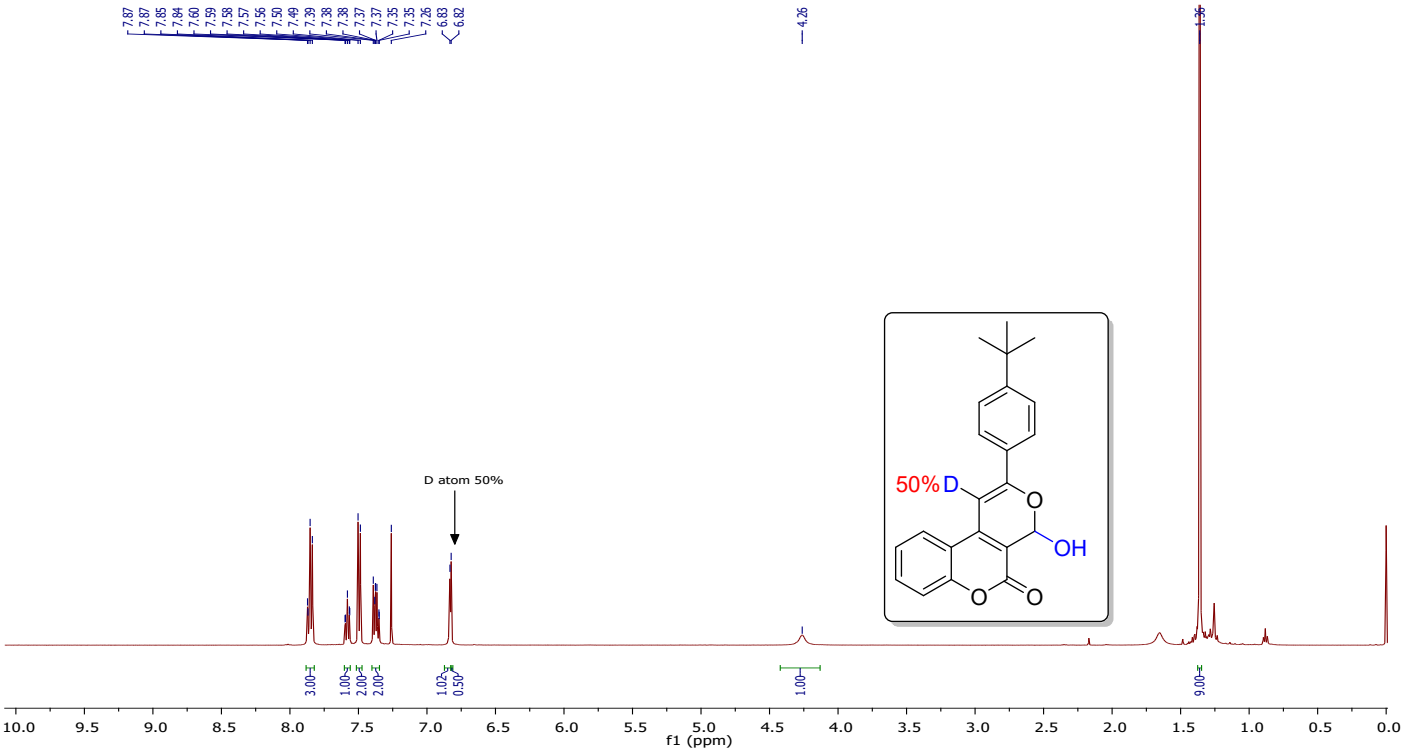


^{13}C NMR (101 MHz, $CDCl_3$)

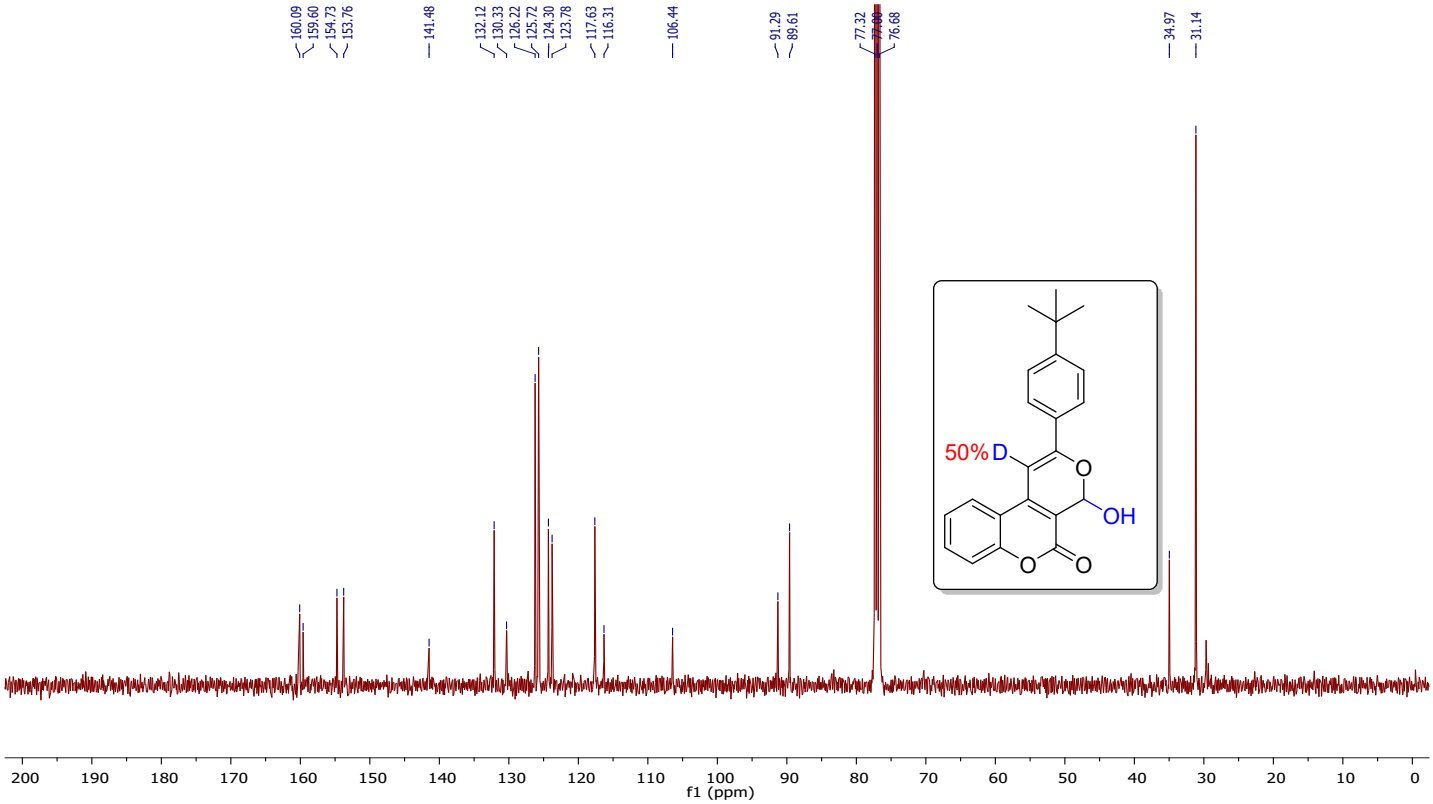


2-(4-(*tert*-butyl)phenyl)-4-hydroxy-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one-1-*d* (7d)

^{1}H NMR (500 MHz, $CDCl_3$)

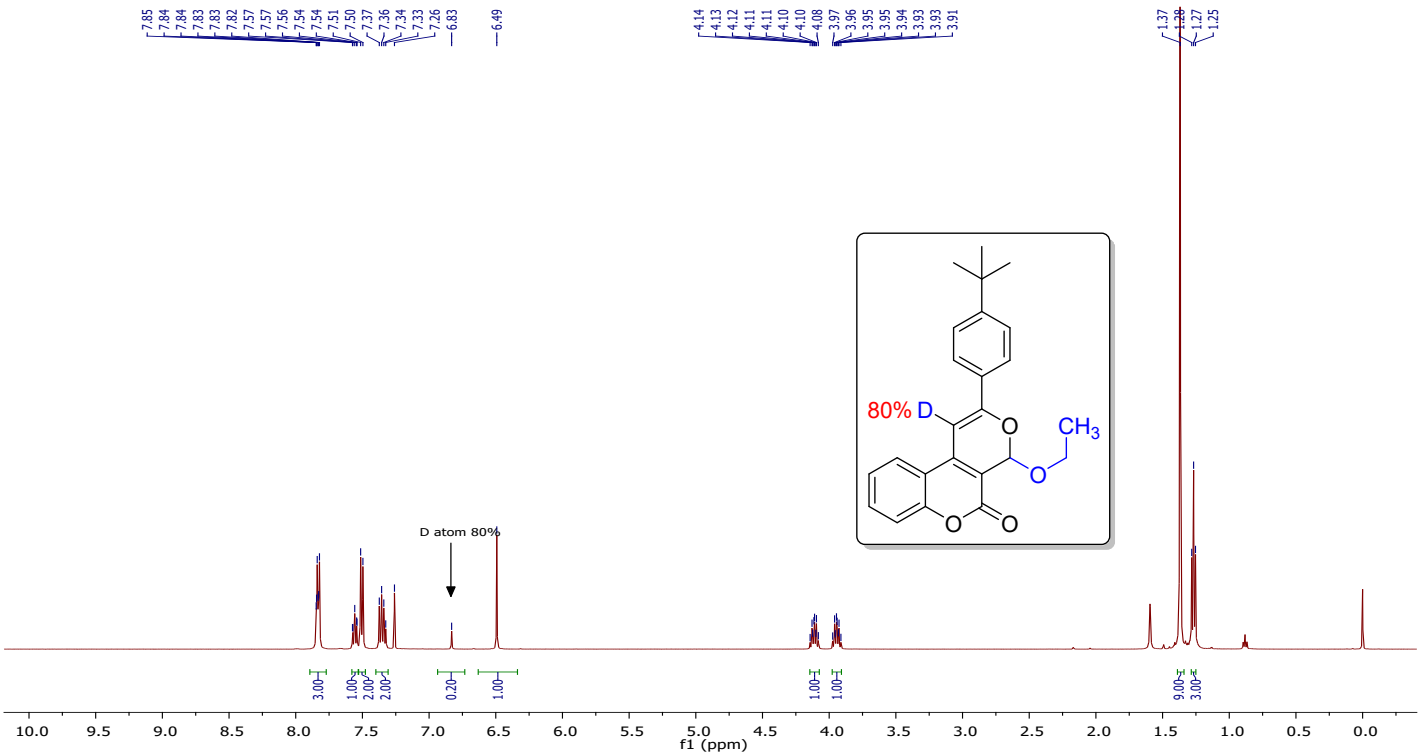


^{13}C NMR (101 MHz, $CDCl_3$)

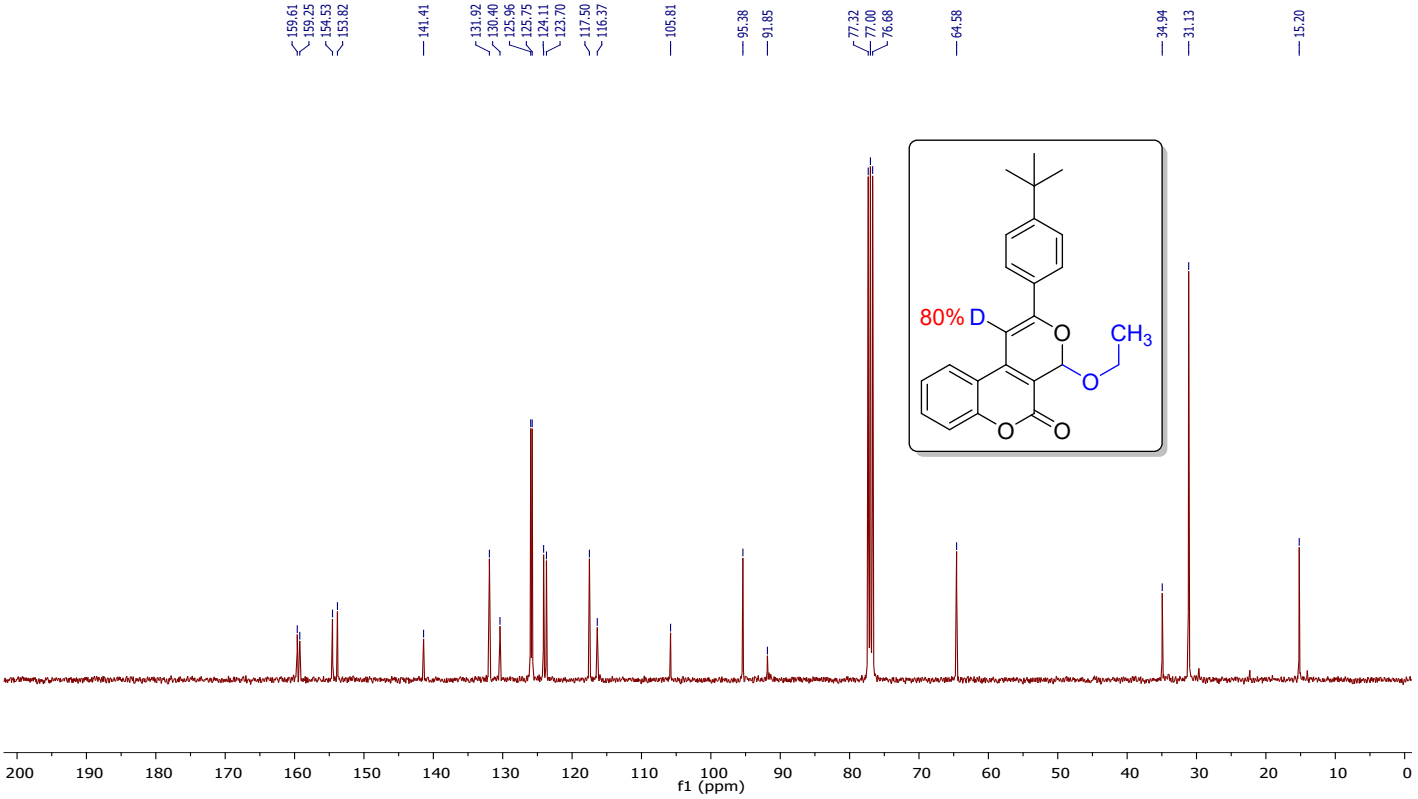


2-(4-(*tert*-butyl)phenyl)-4-ethoxy-4*H*,5*H*-pyrano[3,4-*c*]chromen-5-one-1-*d* (7e)

^{1}H NMR (500 MHz, $CDCl_3$)

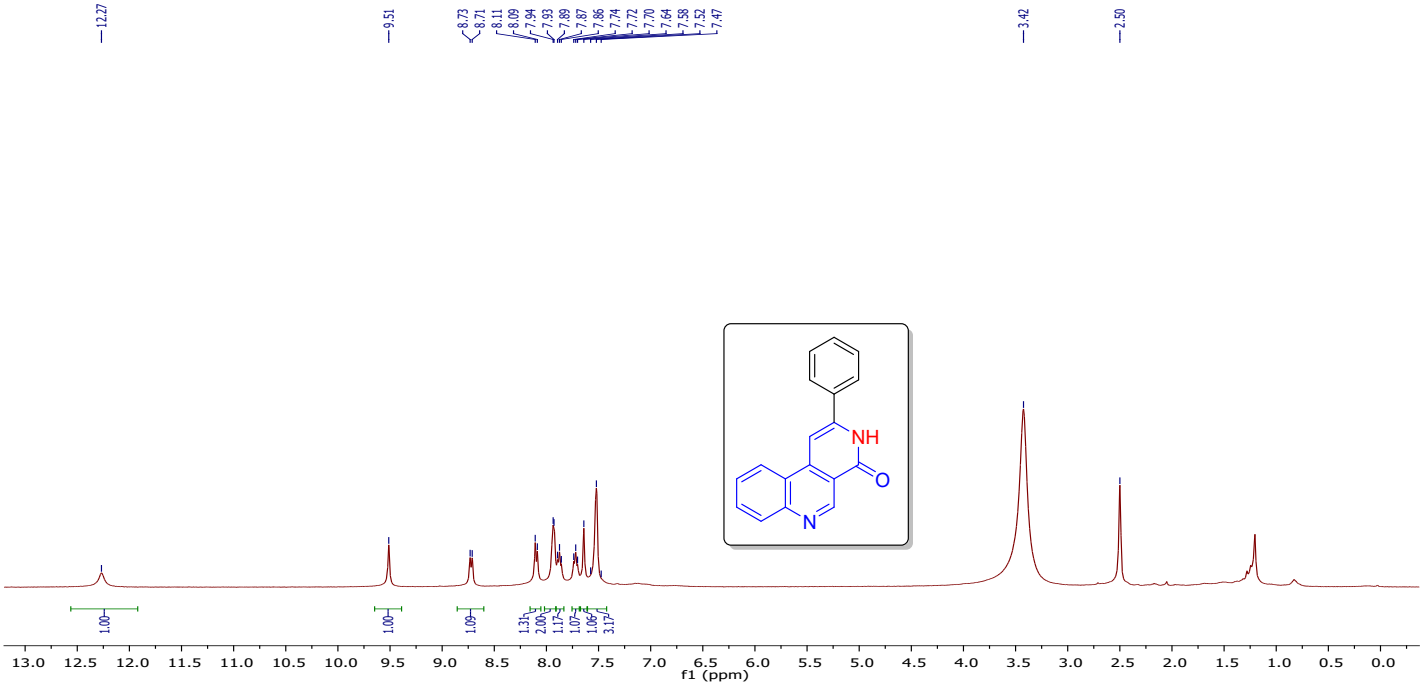


^{13}C NMR (101 MHz, $CDCl_3$)

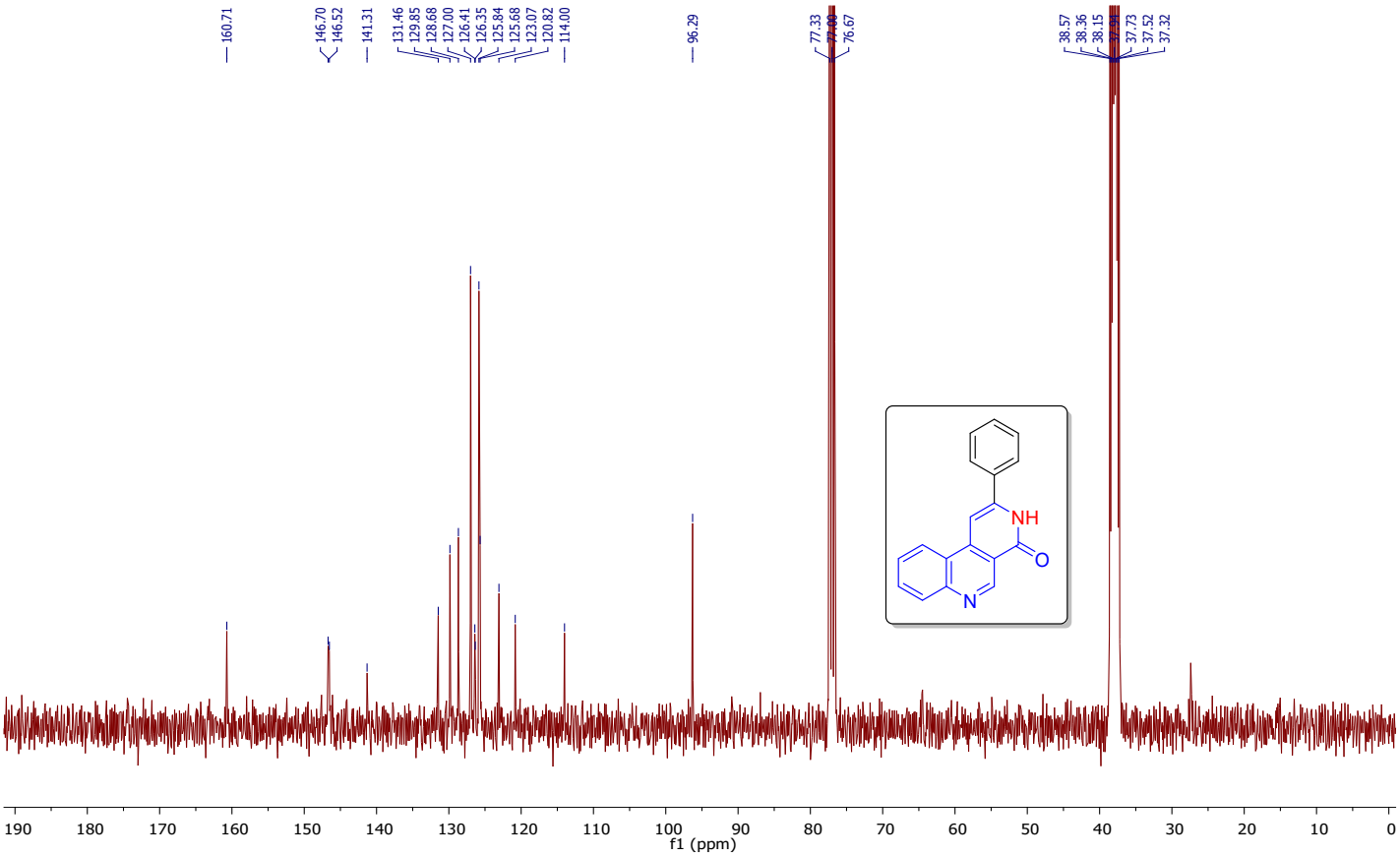


2-phenylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (9a)

^{1}H NMR (400 MHz, $CDCl_3$+DMSO) (poor solubility)

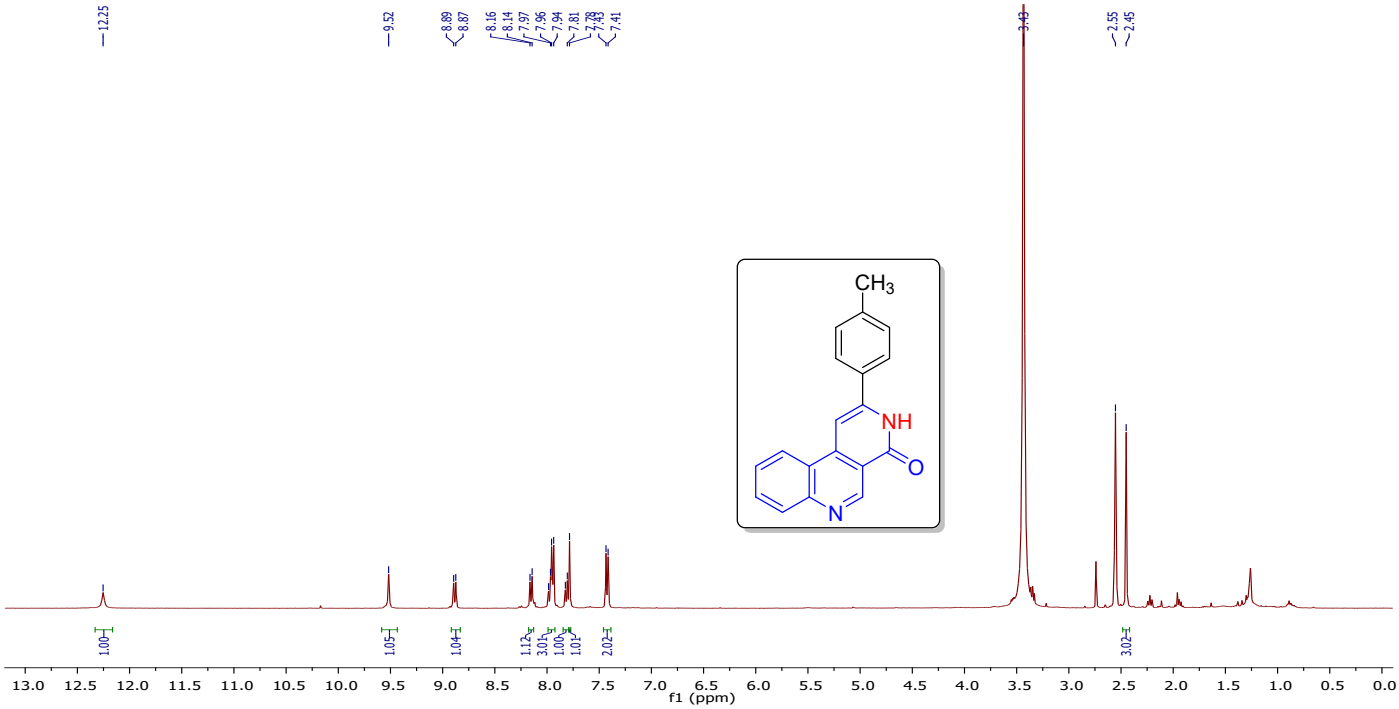


^{13}C NMR (101 MHz, $CDCl_3$+DMSO) (poor solubility)

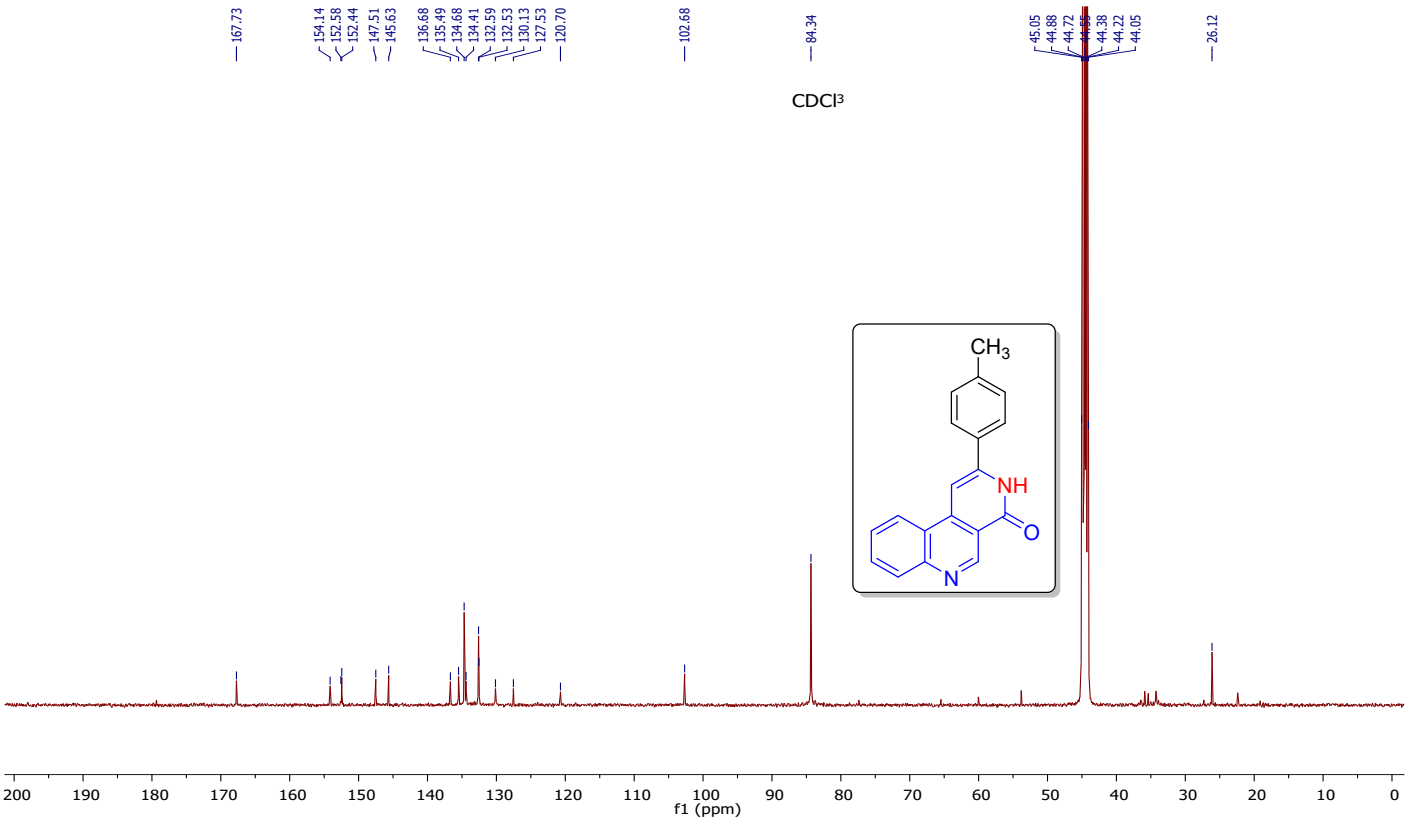


2-(*p*-tolyl)benzo[*c*][2,7]naphthyridin-4(3*H*)-one (9b)

^{1}H NMR (400 MHz, $CDCl_3$+DMSO) (poor solubility)

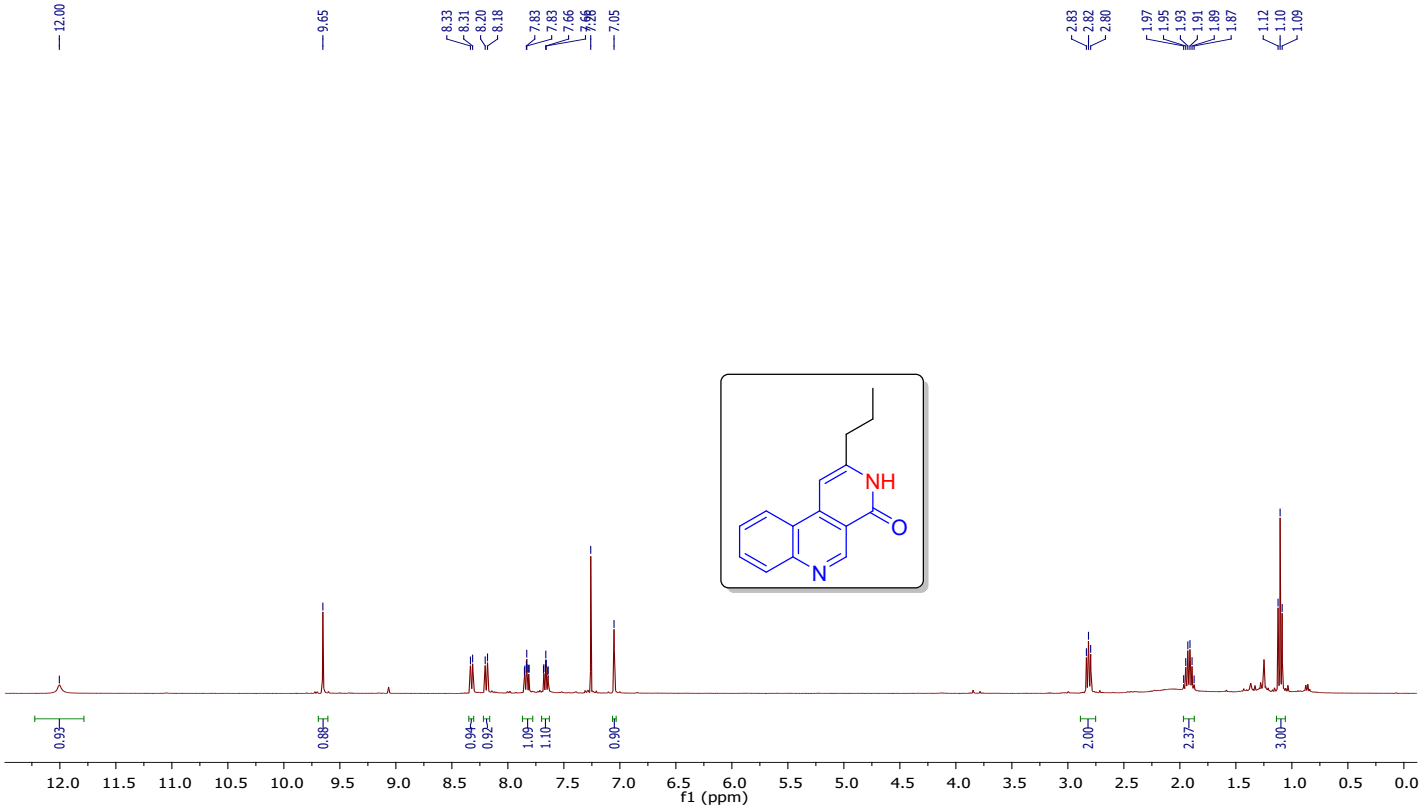


^{13}C NMR (126 MHz, DMSO) (poor solubility)

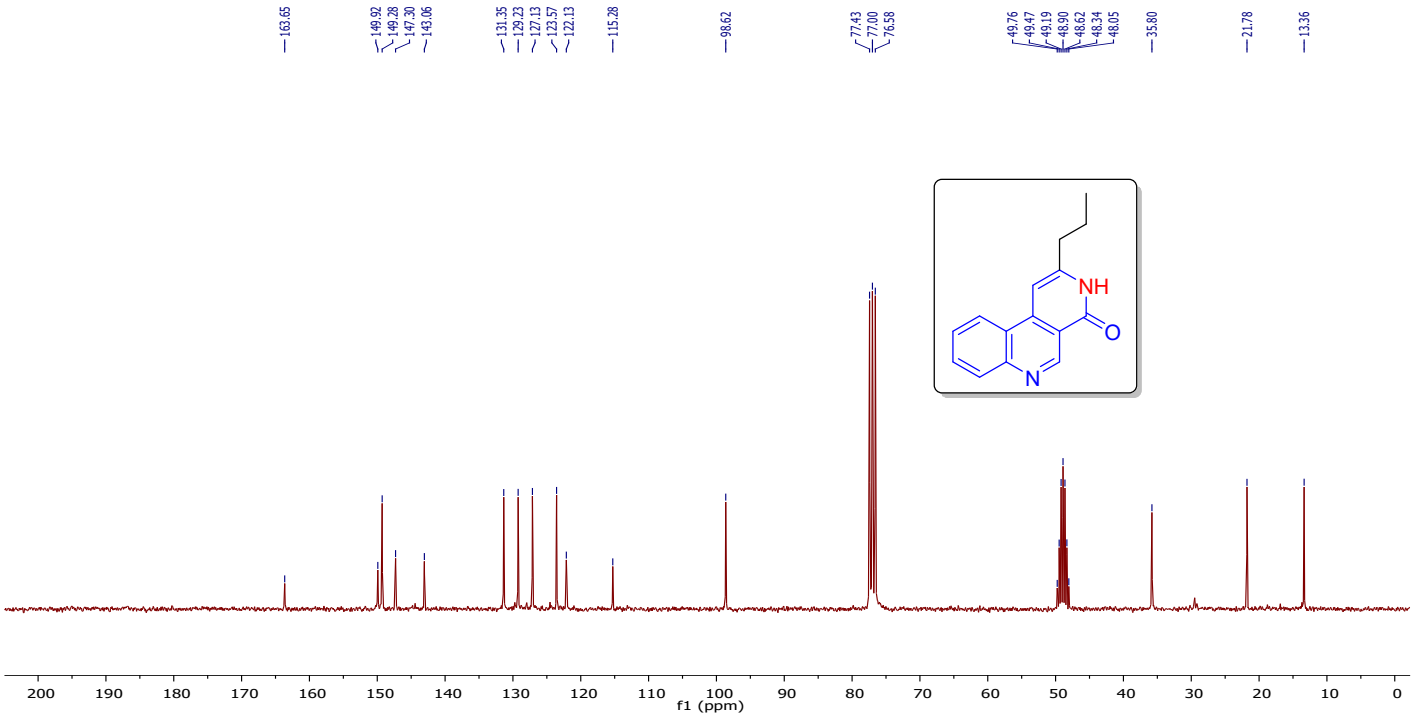


2-propylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (9c)

^{1}H NMR (400 MHz, $CDCl_3$+DMSO)

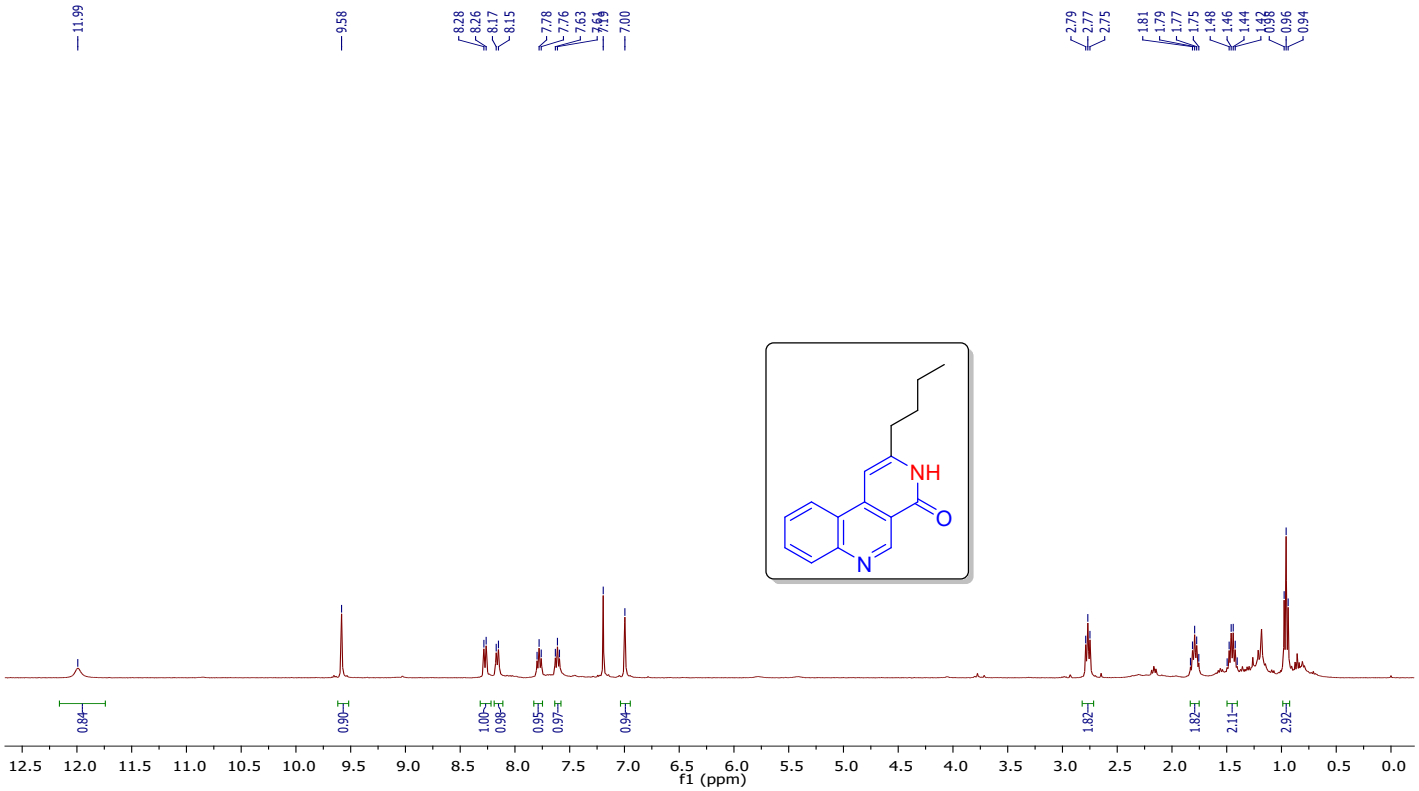


^{13}C NMR (75 MHz, $CDCl_3$+DMSO)

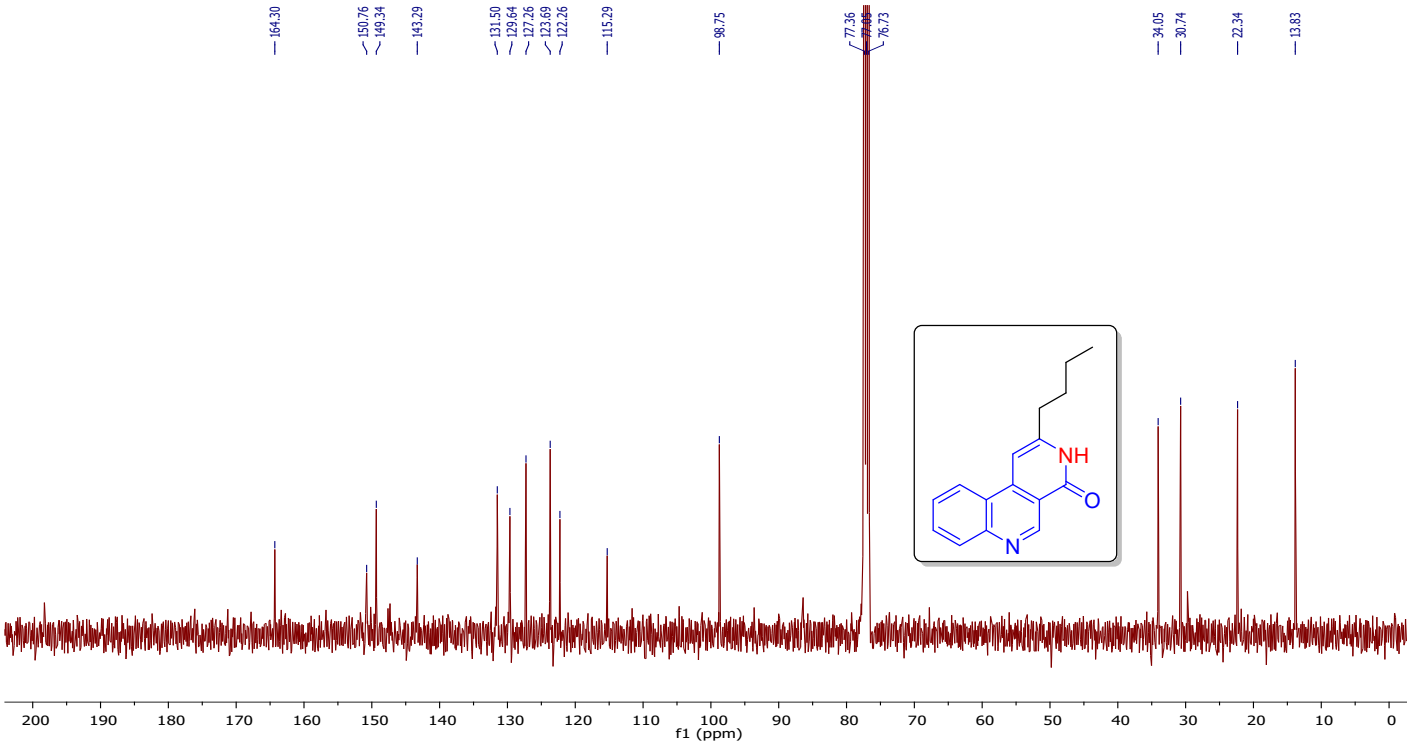


2-butylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (9d)

^{1}H NMR (400 MHz, $CDCl_3$)

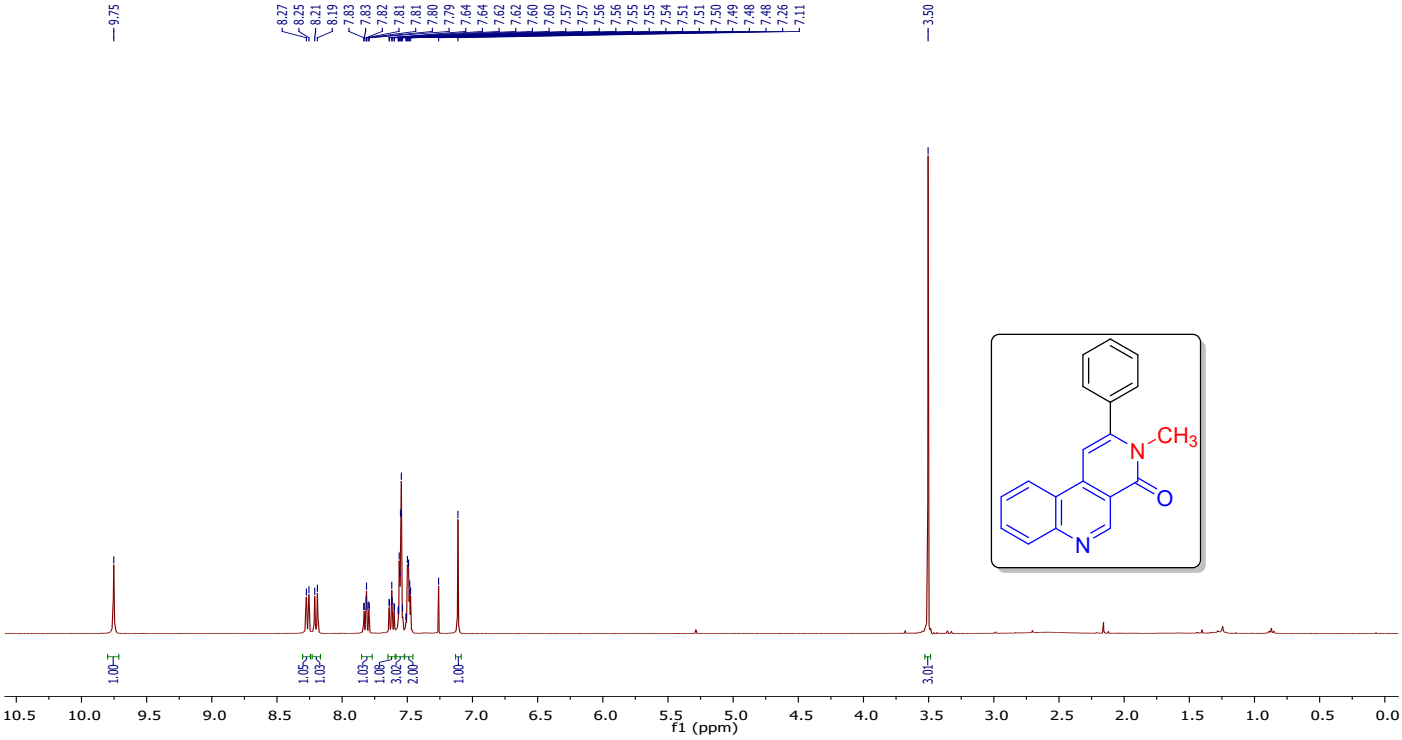


^{13}C NMR (101 MHz, $CDCl_3$)

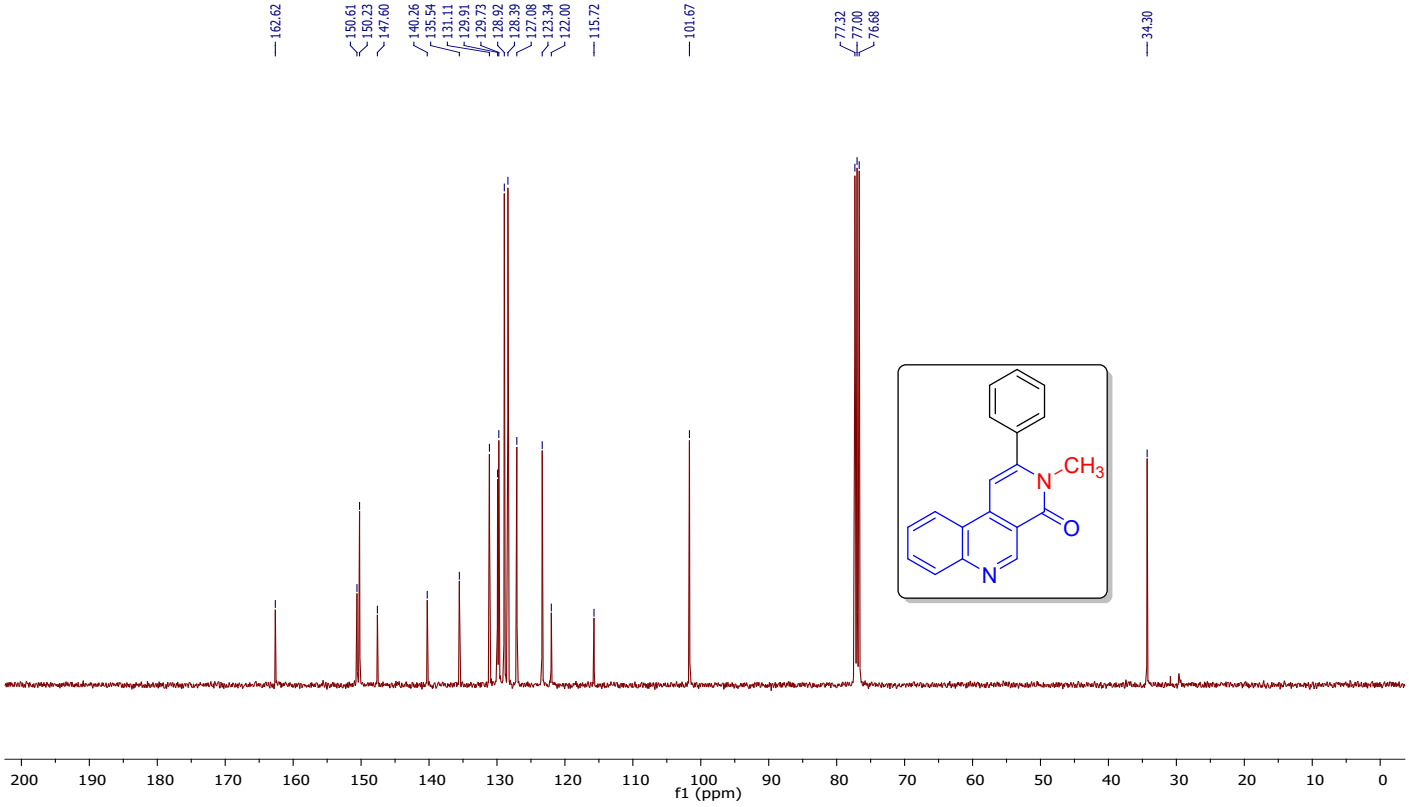


3-methyl-2-phenylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (10a)

^{1}H NMR (400 MHz, $CDCl_3$)

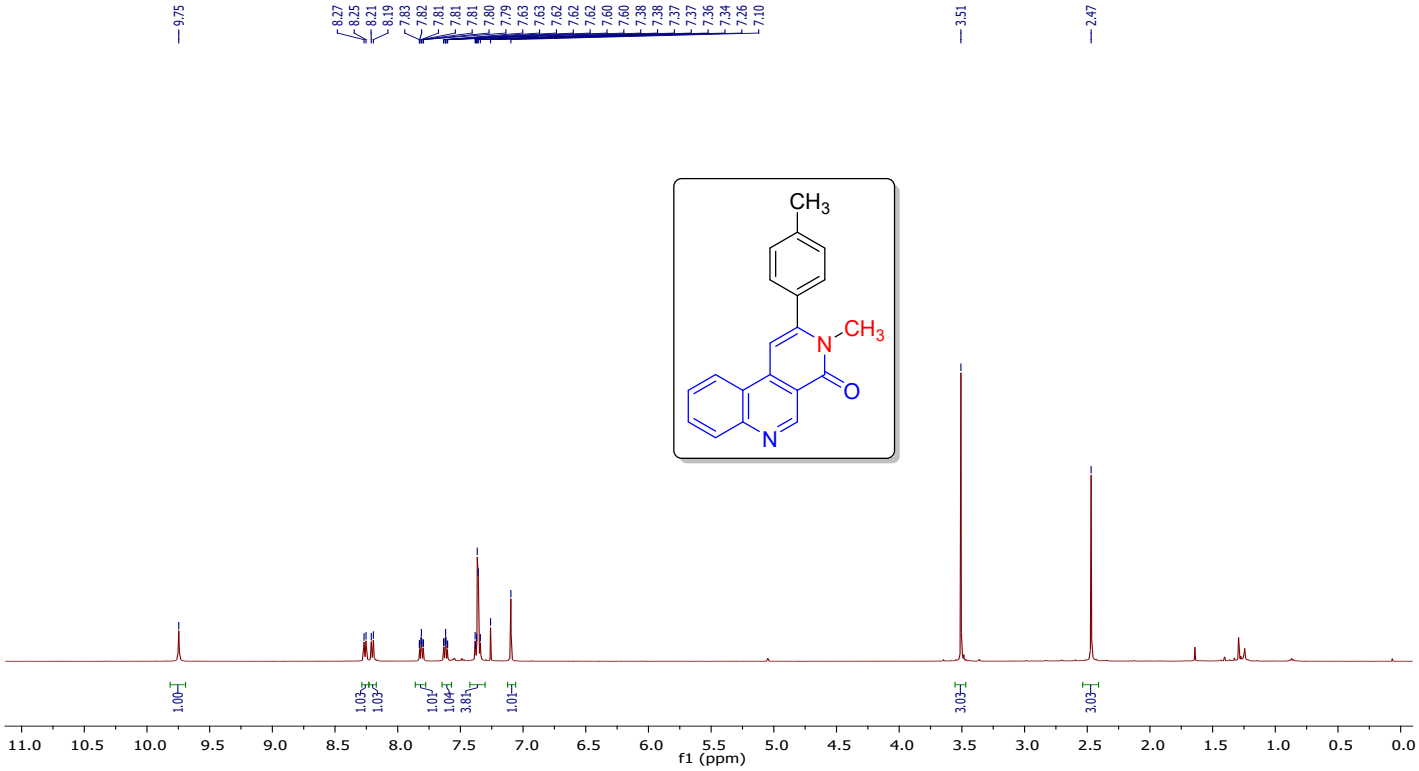


^{13}C NMR (101 MHz, $CDCl_3$)

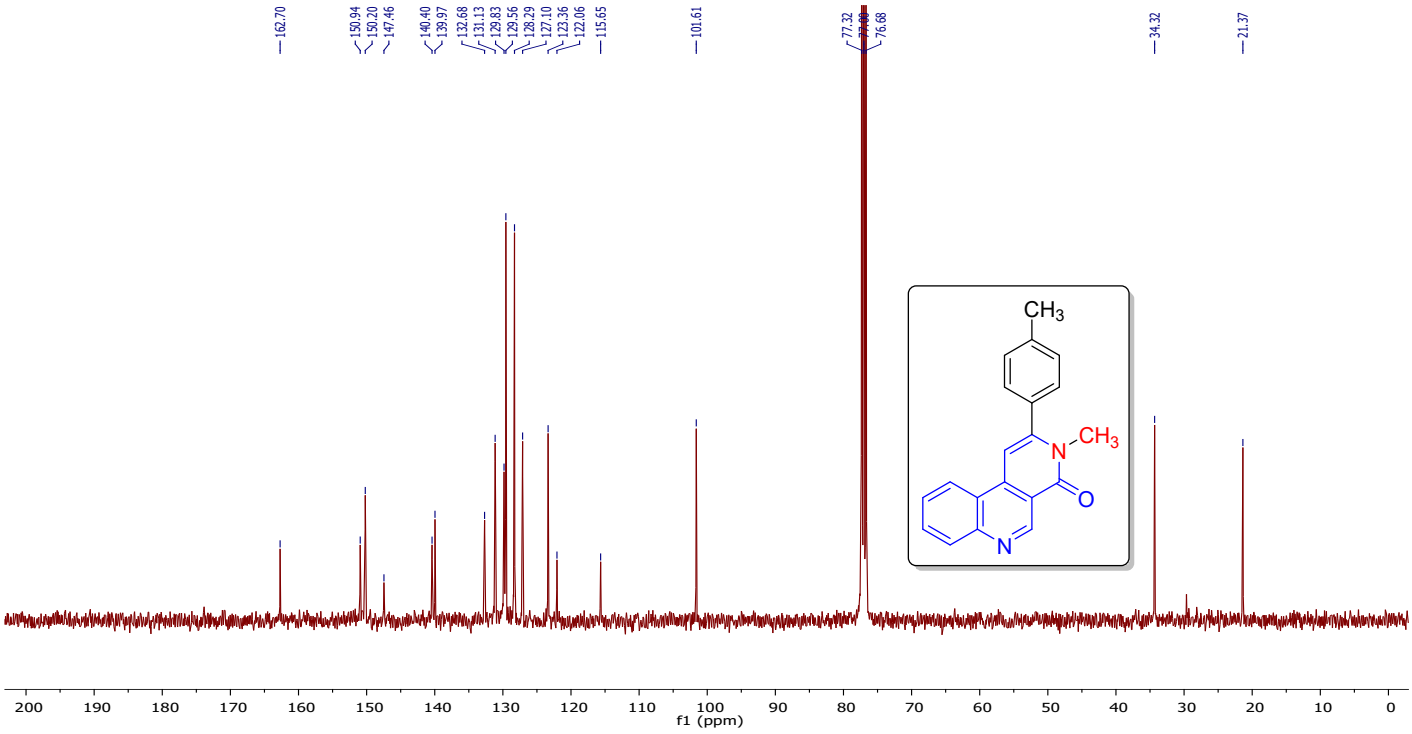


3-methyl-2-(*p*-tolyl)benzo[*c*][2,7]naphthyridin-4(3*H*)-one (10b)

^{1}H NMR (500 MHz, $CDCl_3$)

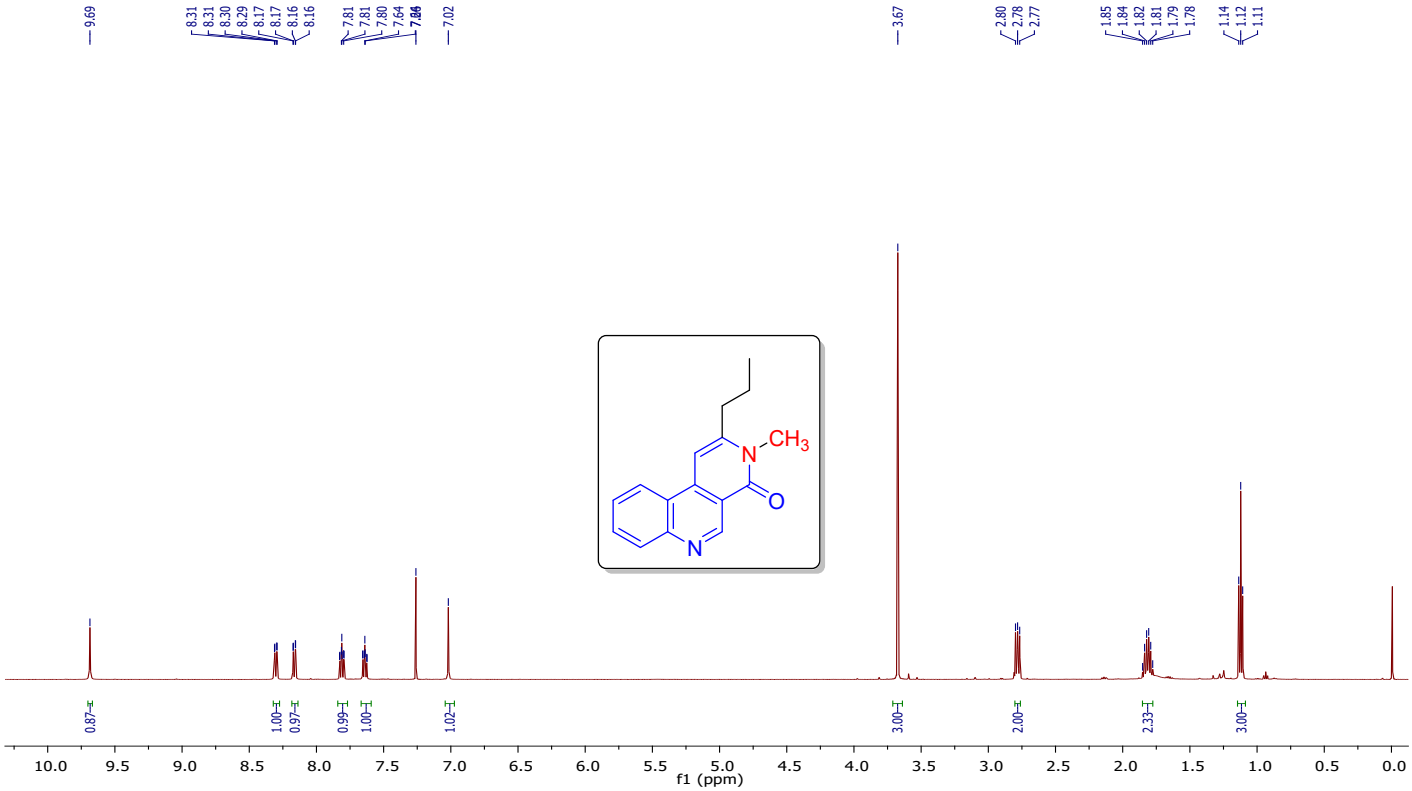


^{13}C NMR (101 MHz, $CDCl_3$)

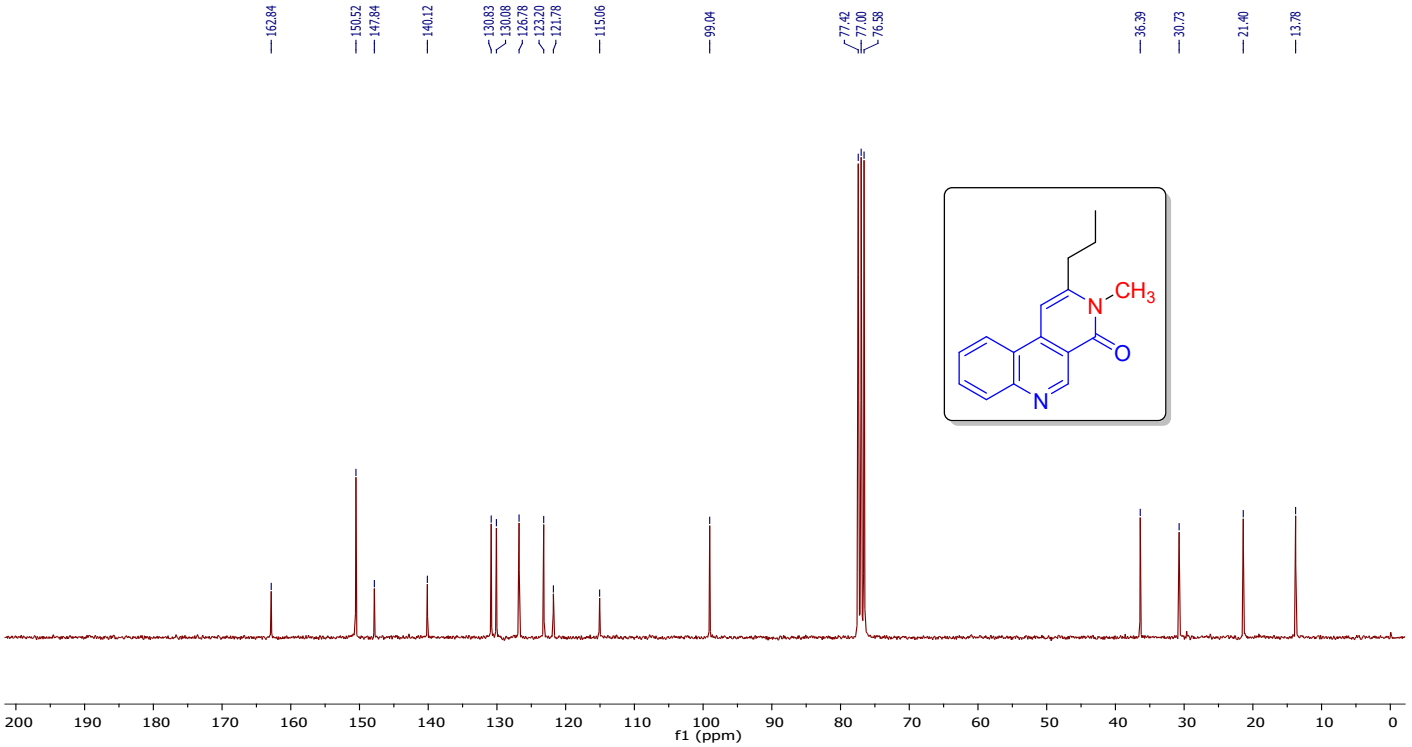


3-methyl-2-propylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (10c)

^{1}H NMR (500 MHz, $CDCl_3$)

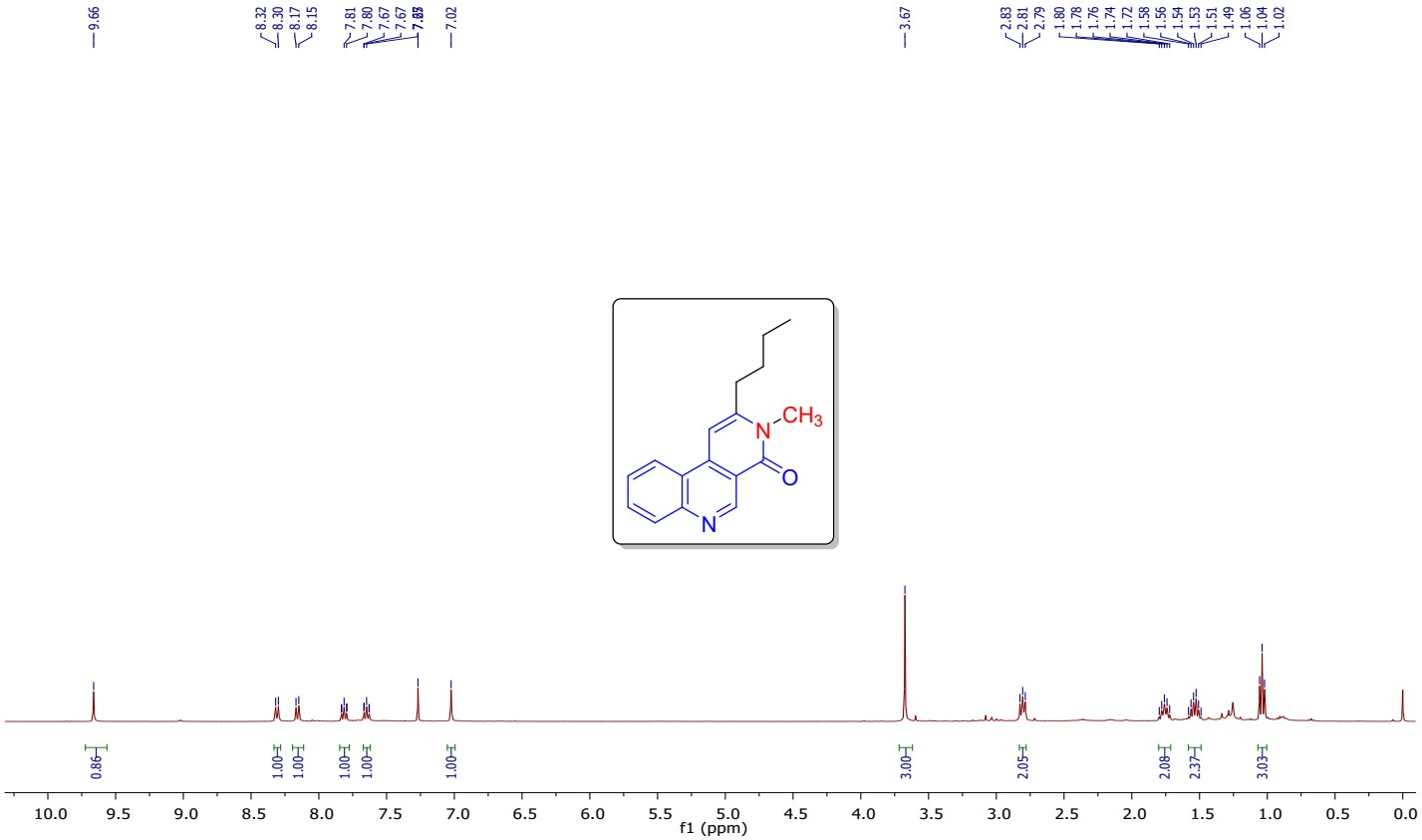


^{13}C NMR (75 MHz, $CDCl_3$)

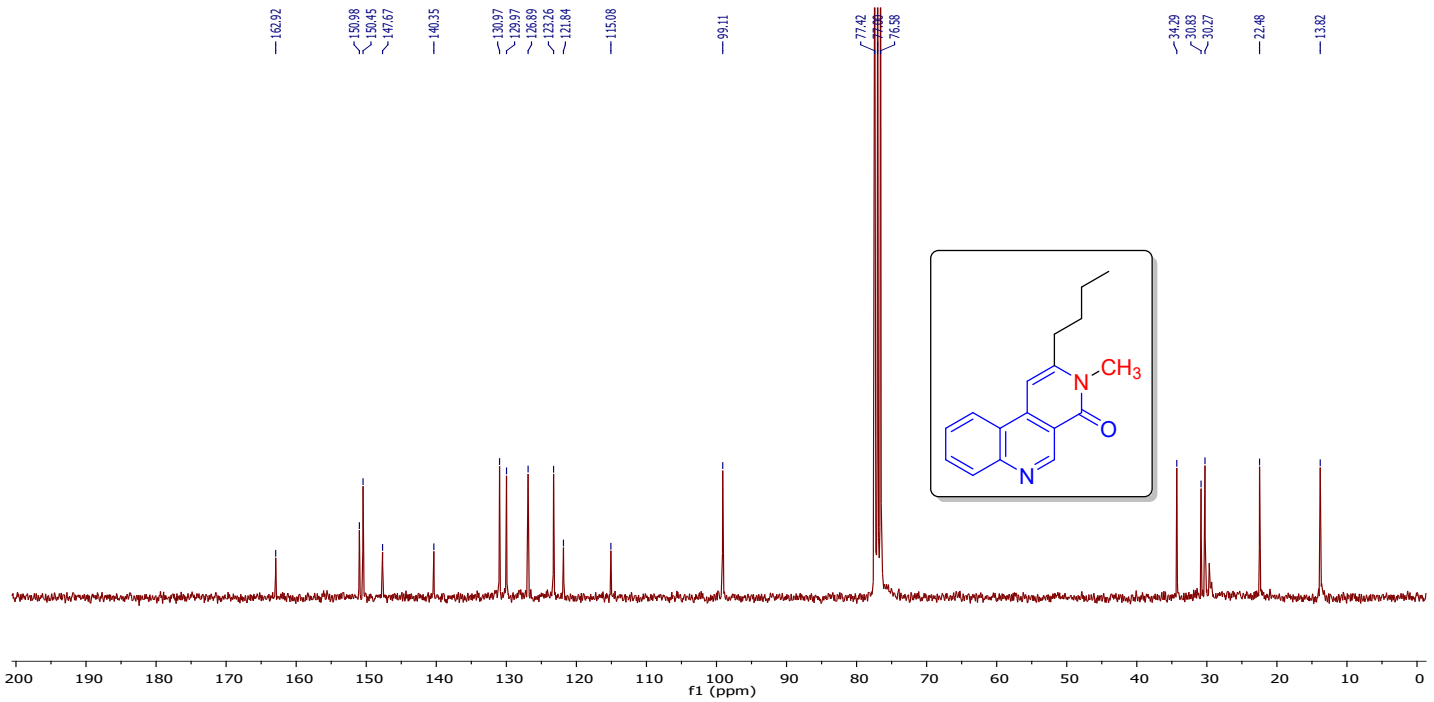


2-butyl-3-methylbenzo[*c*][2,7]naphthyridin-4(3*H*)-one (10d)

^{1}H NMR (400 MHz, $CDCl_3$)

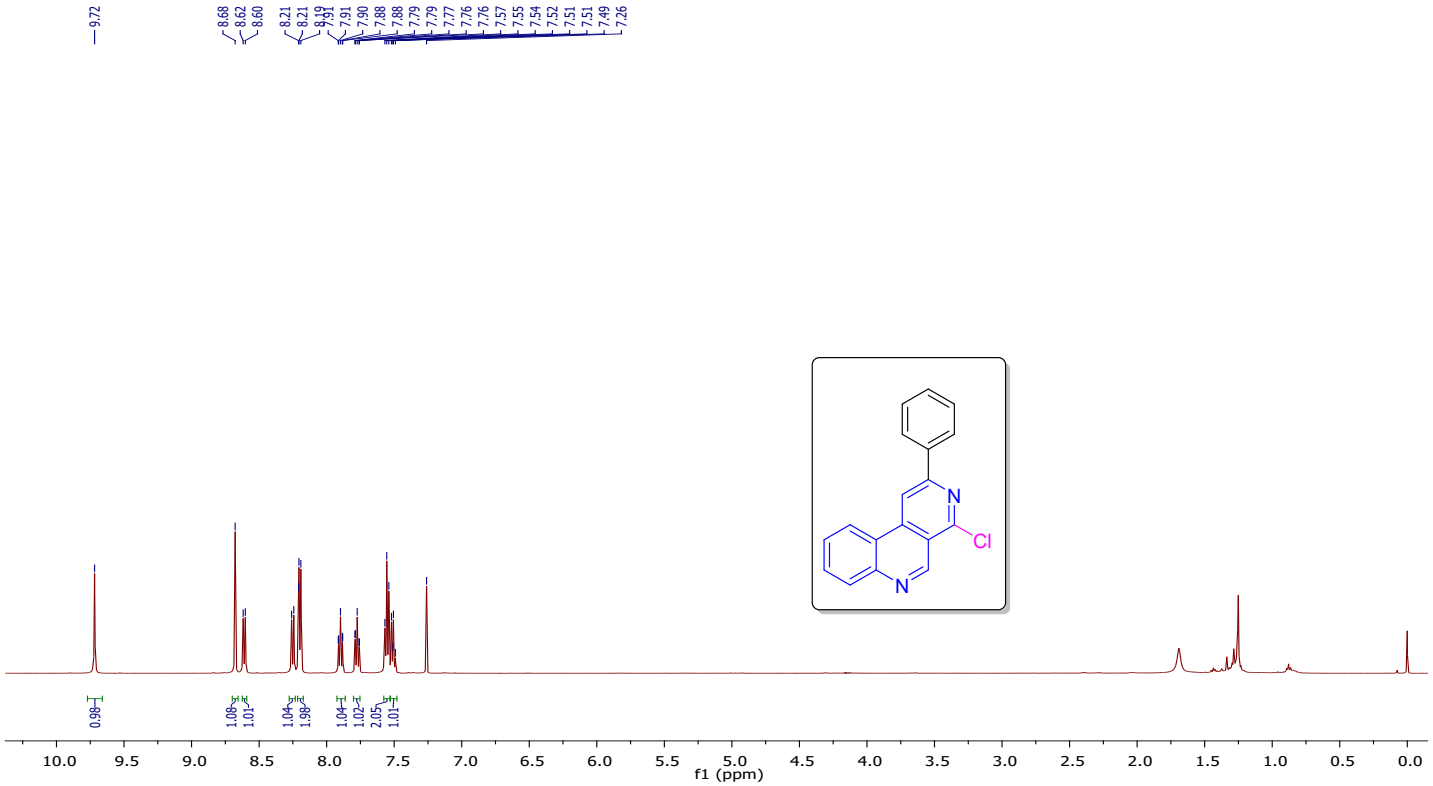


^{13}C NMR (75 MHz, $CDCl_3$)

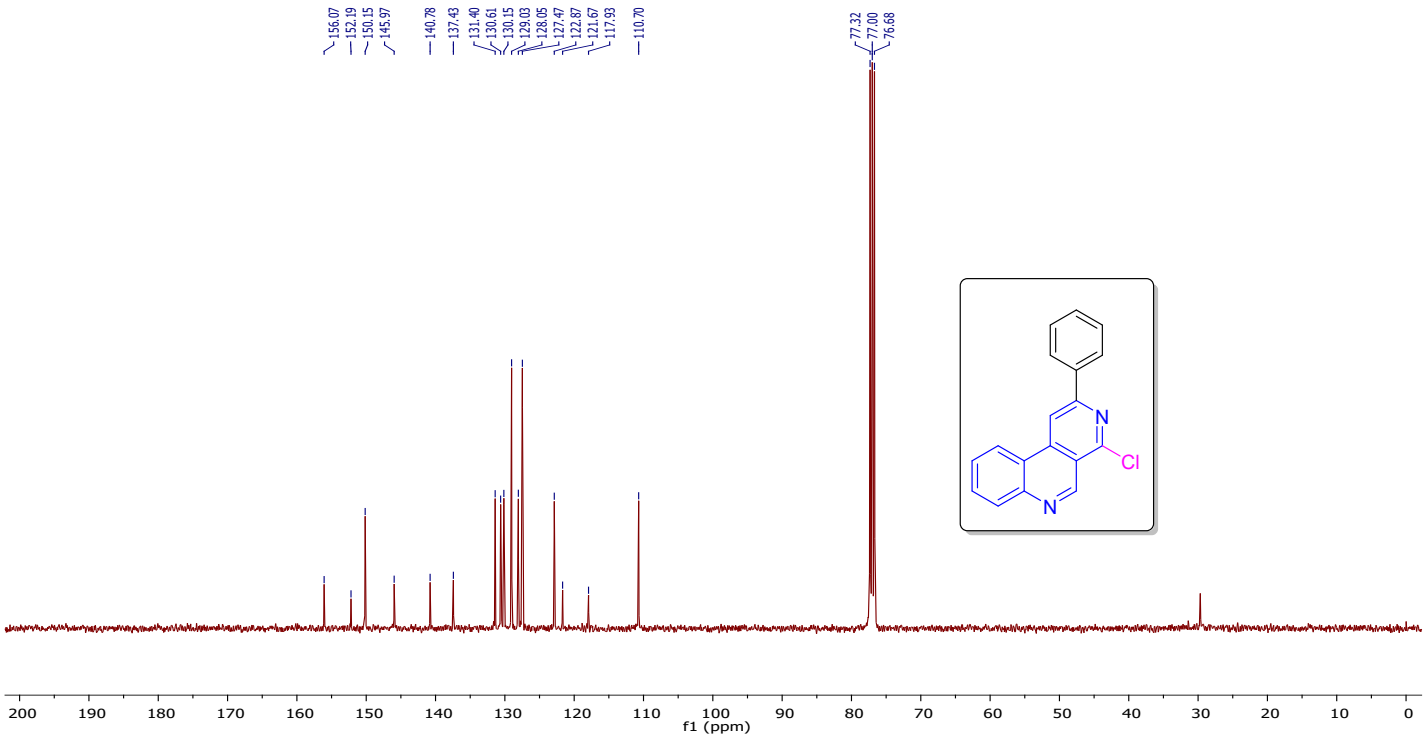


4-chloro-2-phenylbenzo[*c*][2,7]naphthyridine (11a)

^{1}H NMR (500 MHz, $CDCl_3$)

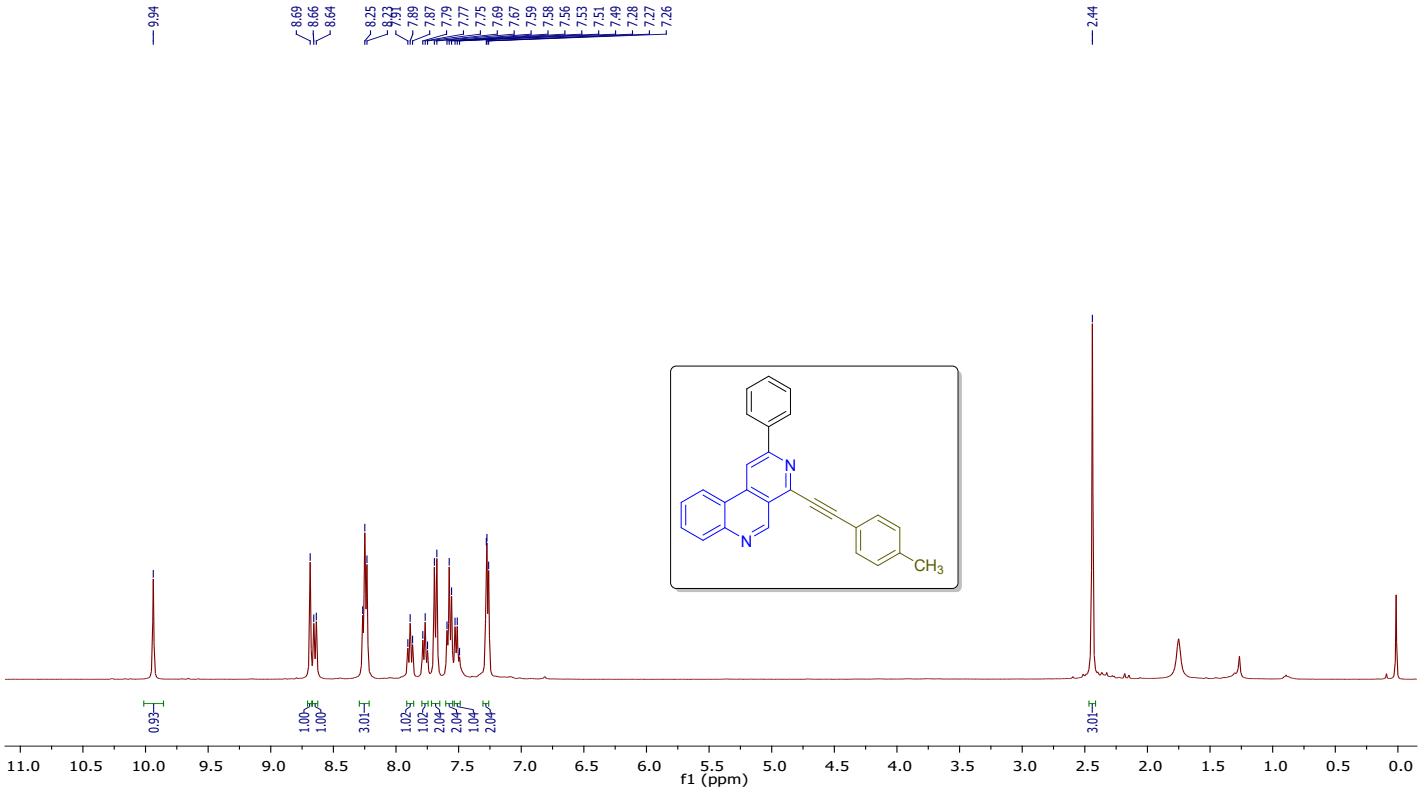


^{13}C NMR (101 MHz, $CDCl_3$)

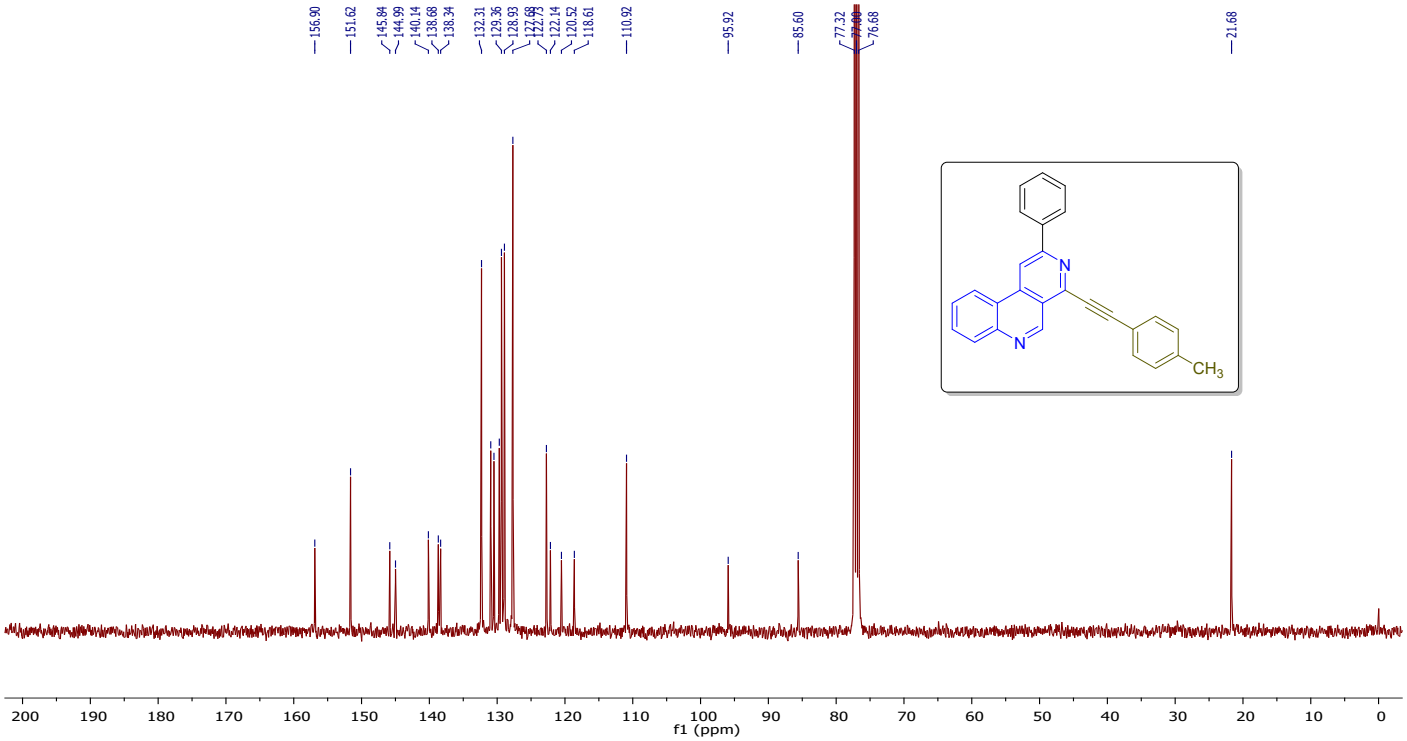


2-phenyl-4-(*p*-tolylethynyl)benzo[*c*][2,7]naphthyridine (12a)

^{1}H NMR (400 MHz, $CDCl_3$)

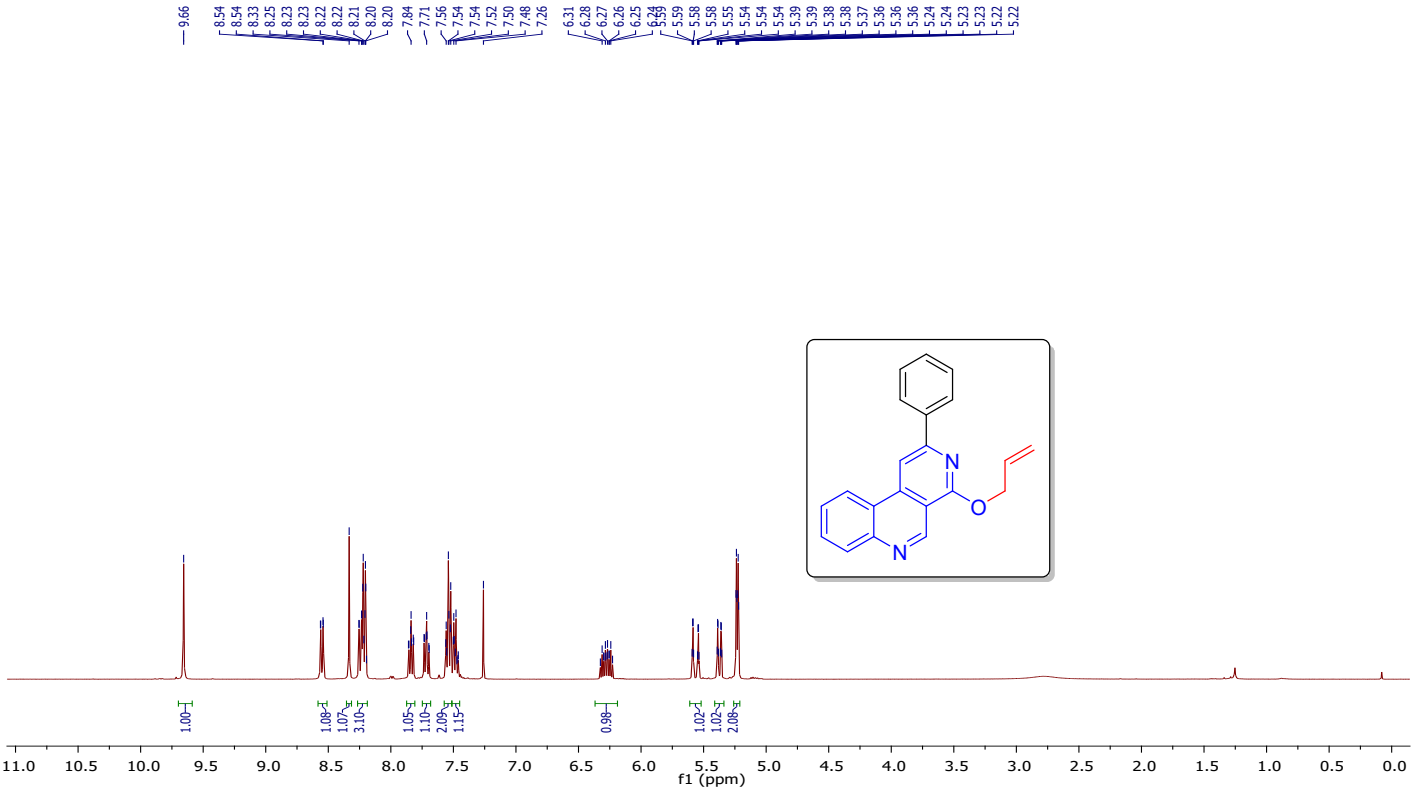


^{13}C NMR (101 MHz, $CDCl_3$)

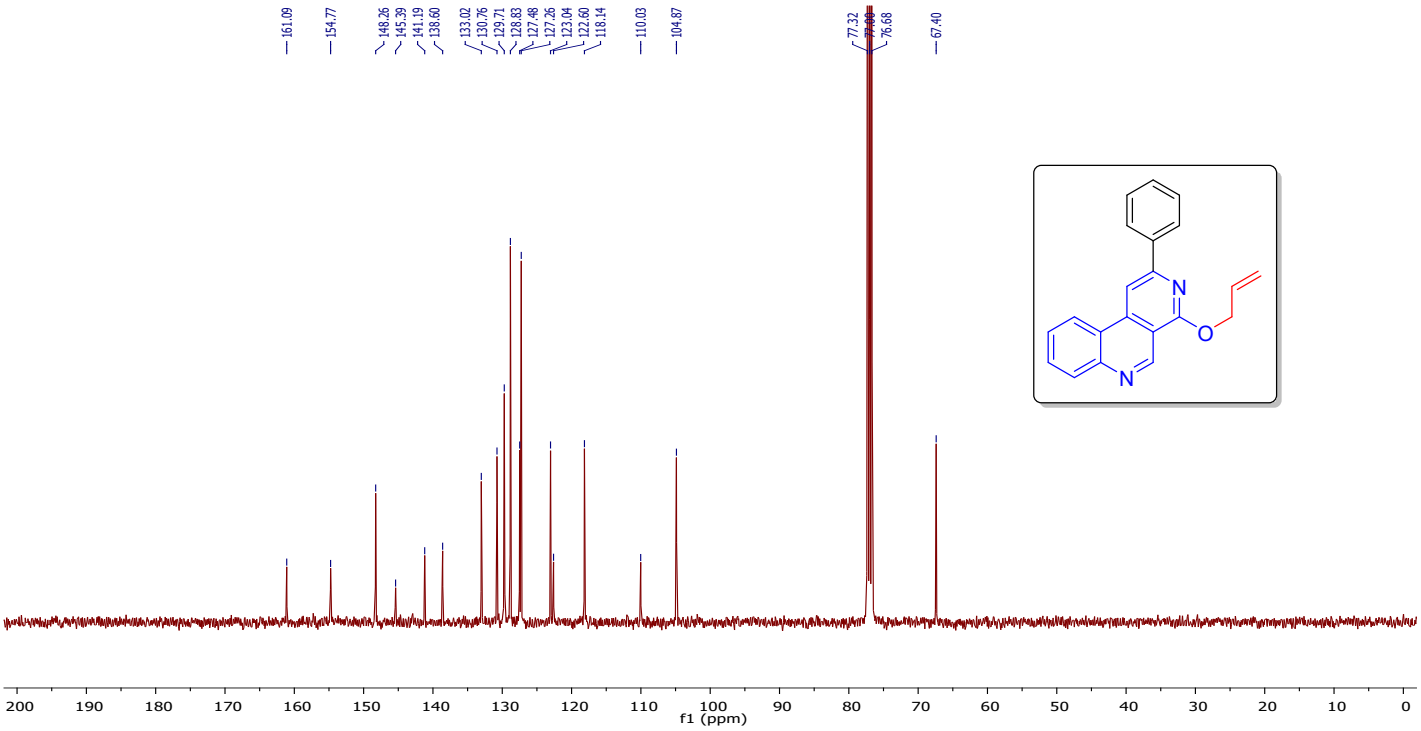


4-(allyloxy)-2-phenylbenzo[*c*][2,7]naphthyridine (13a)

^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (101 MHz, $CDCl_3$)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122.60
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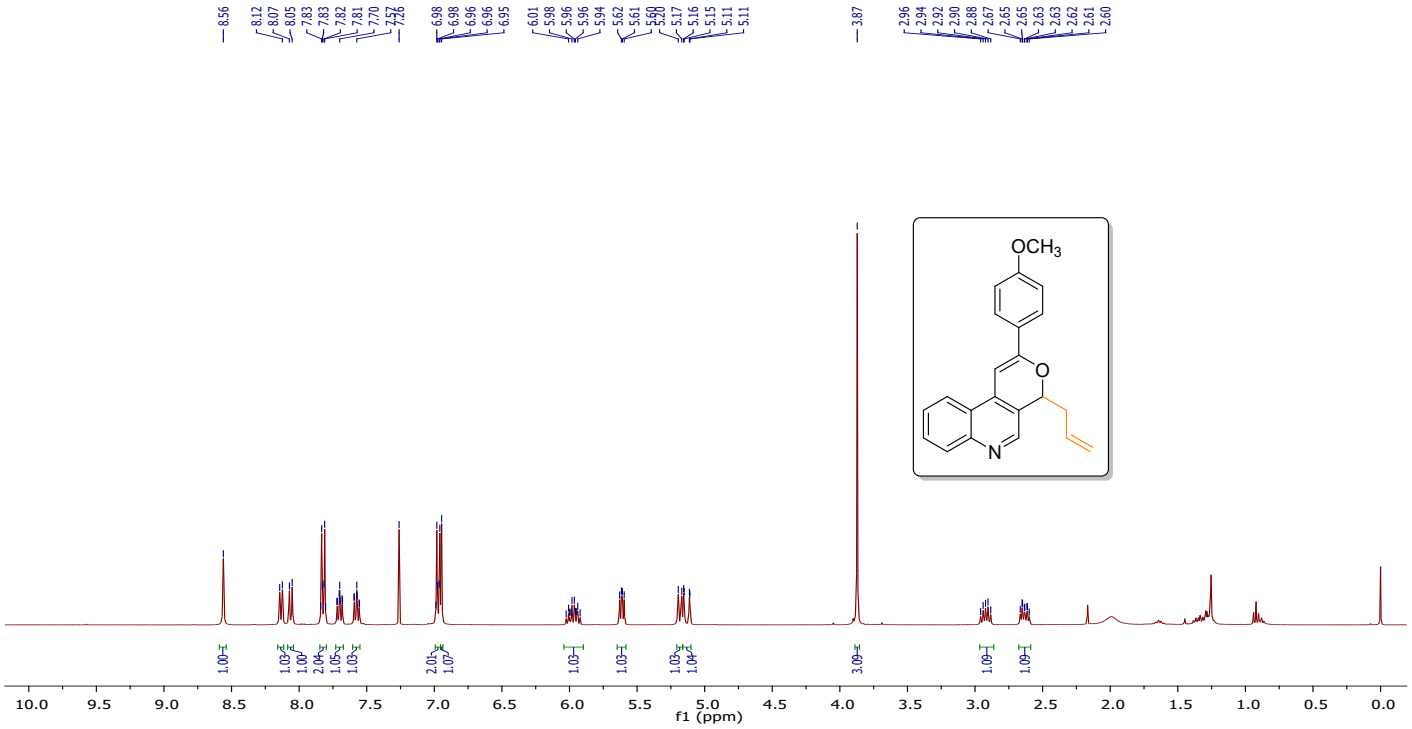
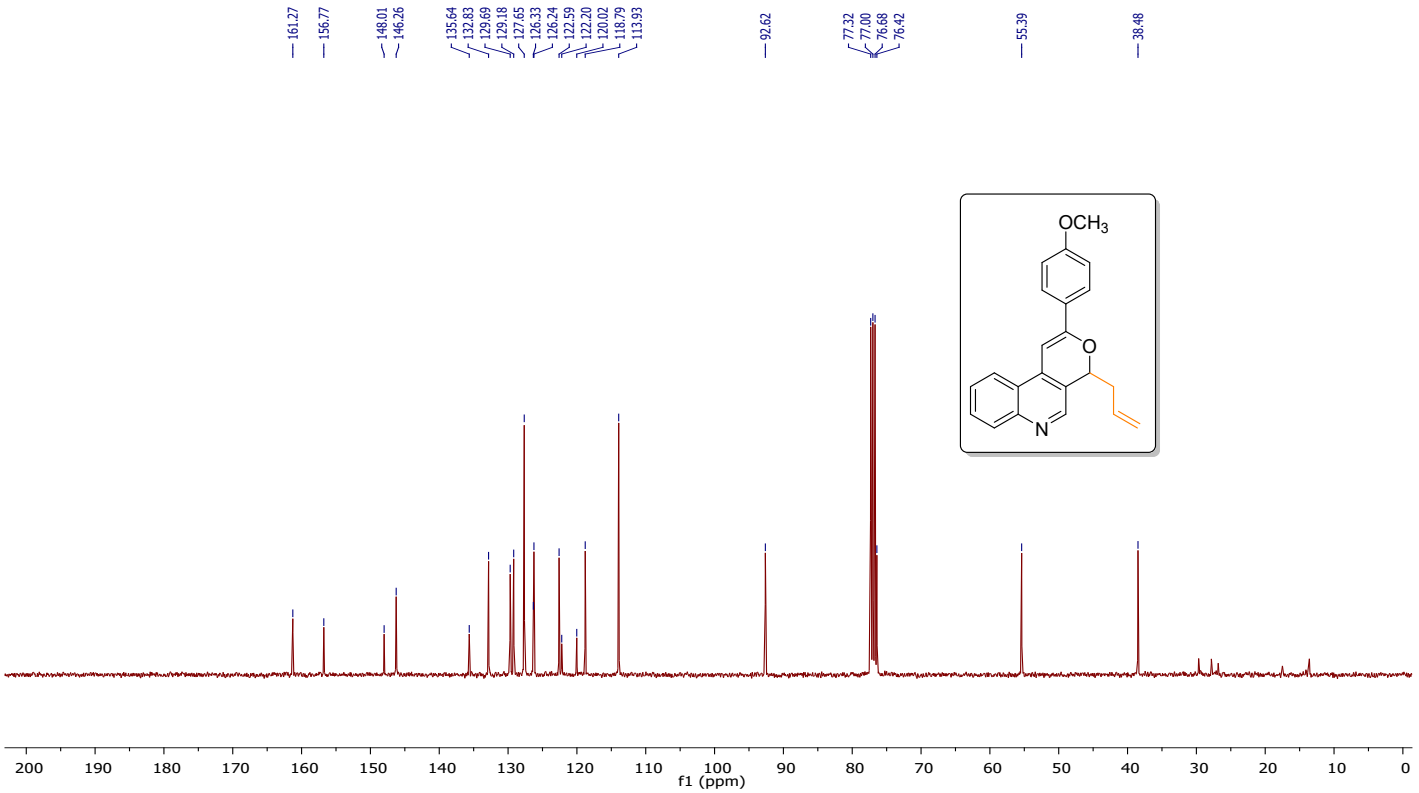
10
0
f1 (ppm)

4-allyl-2-phenyl-4*H*-pyrano[3,4-*c*]quinoline (14a)

^{1}H NMR (400 MHz, $CDCl_3$)

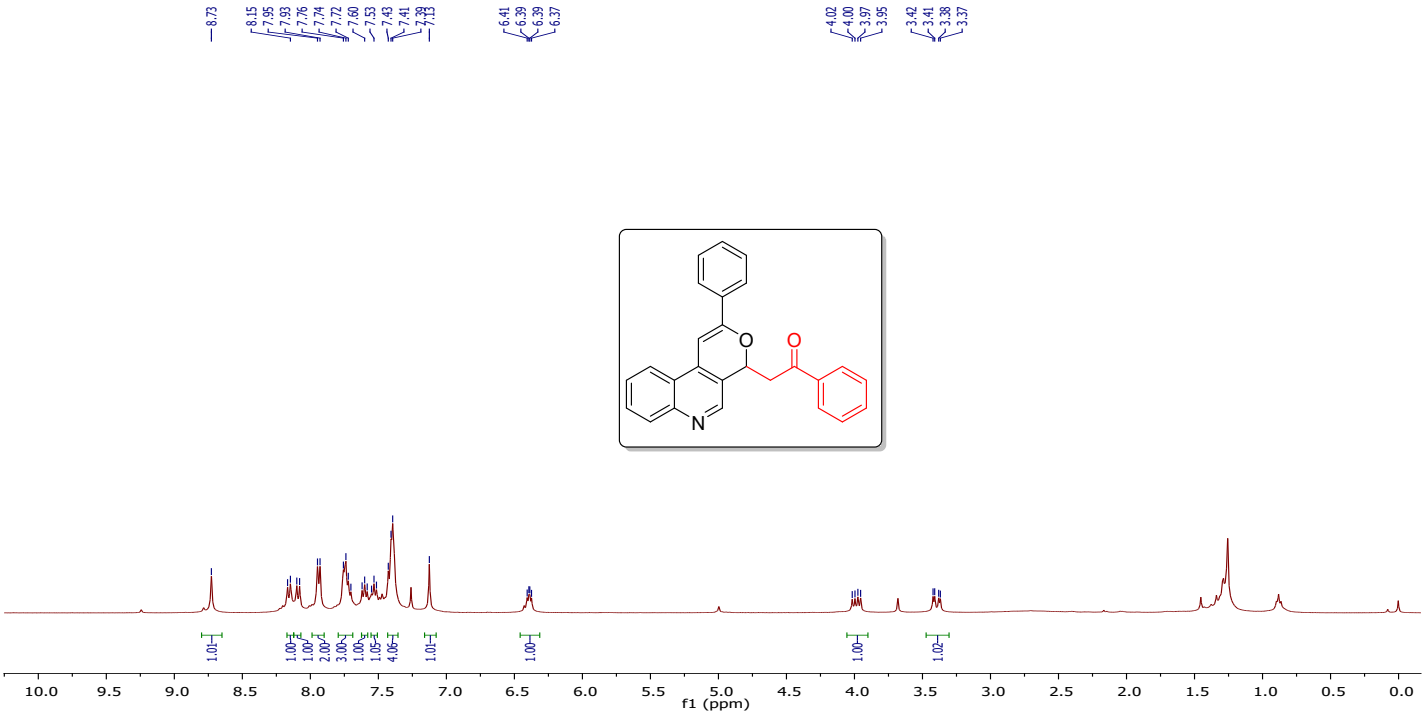


^{13}C NMR (101 MHz, $CDCl_3$)

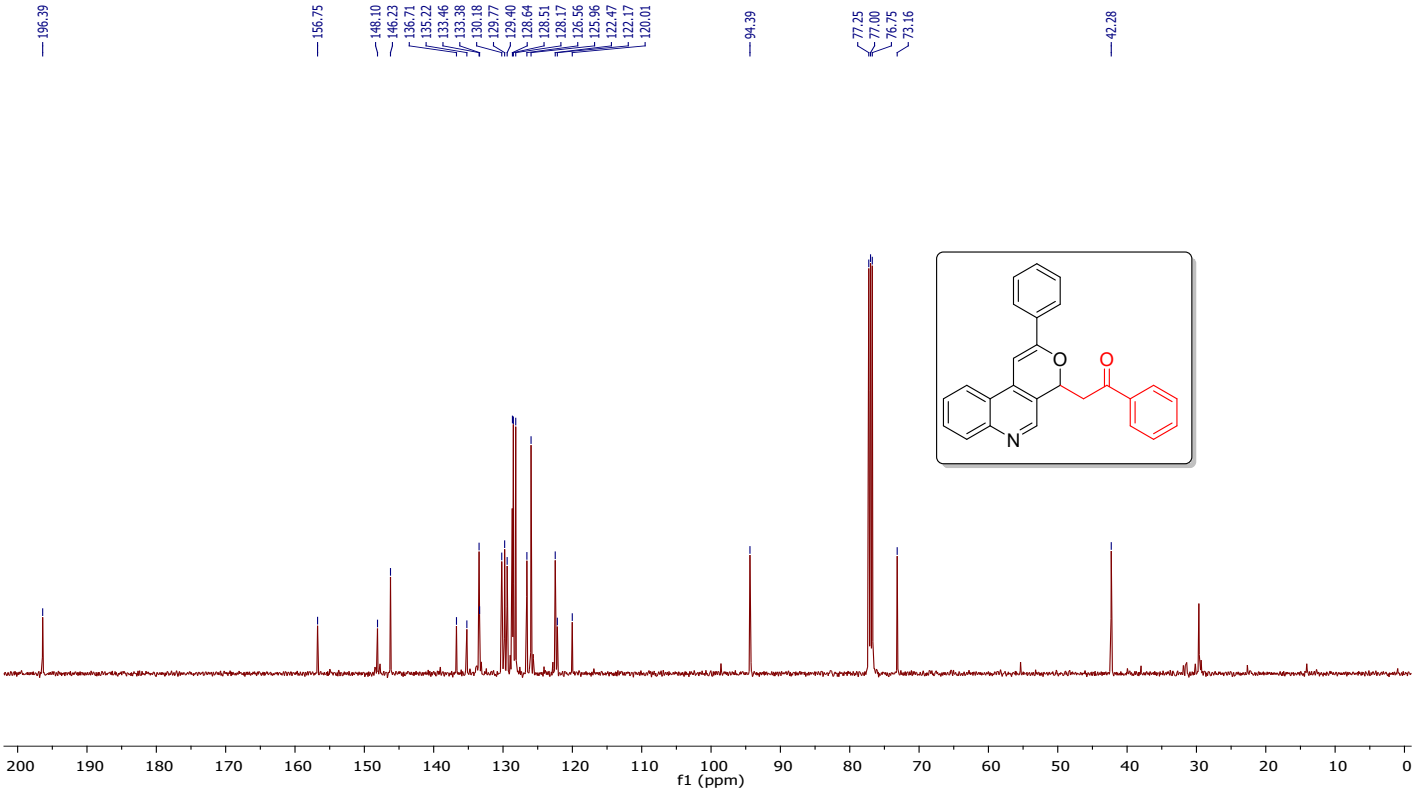


1-phenyl-2-(2-phenyl-4*H*-pyrano[3,4-*c*]quinolin-4-yl)ethan-1-one (15a)

^{1}H NMR (400 MHz, $CDCl_3$)



^{13}C NMR (126 MHz, $CDCl_3$)



24. X-ray Crystallography:

X-ray data for the compound was collected at room temperature on a Bruker D8 QUEST instrument with an IμS Mo microsource (λ = 0.7107 A) and a PHOTON-III detector. The raw data frames were reduced and corrected for absorption effects using the Bruker Apex 3 software suite programs[1]. The structure was solved using intrinsic phasing method[2] and further refined with the SHELXL[2] program and expanded using Fourier techniques. Anisotropic displacement parameters were included for all non-hydrogen atoms. All C bound H atoms were positioned geometrically and treated as riding on their parent C atoms [C-H = 0.93-0.97 Å, and Uiso(H) = 1.5Ueq(C) for methyl H or 1.2Ueq(C) for other H atoms].

Crystal structure determination of 10a

Crystal Data for $C_{19}H_{14}N_2O$ (*M* =286.32 g/mol): monoclinic, space group $P2_1/c$ (no. 14), *a* = 7.9636(5) Å, *b* = 17.0485(10) Å, *c* = 10.3861(7) Å, *β* = 92.710(3)°, *V* = 1408.52(15) Å^3, *Z* = 4, *T* = 294.15 K, μ(MoKα) = 0.085 mm^{-1}, *Dcalc* = 1.350 g/cm^3, 22983 reflections measured (5.12° ≤ 2Θ ≤ 61.022°), 4119 unique (R_{int} = 0.0541, R_{sigma} = 0.0484) which were used in all calculations. The final R_1 was 0.0548 (I > 2σ(I)) and wR_2 was 0.1544 (all data). **CCDC 2329603** deposition numbers contains the supplementary crystallographic data for this paper which can be obtained free of charge at https://www.ccdc.cam.ac.uk/structures/

1. Bruker (2016). APEX3, SAINT and SADABS. Bruker AXS, Inc., Madison, Wisconsin, USA.
2. Sheldrick G. M. (2015). ActaCrystallogr C71: 3-8.

25. ORTEP diagram of KB1225 (10a)

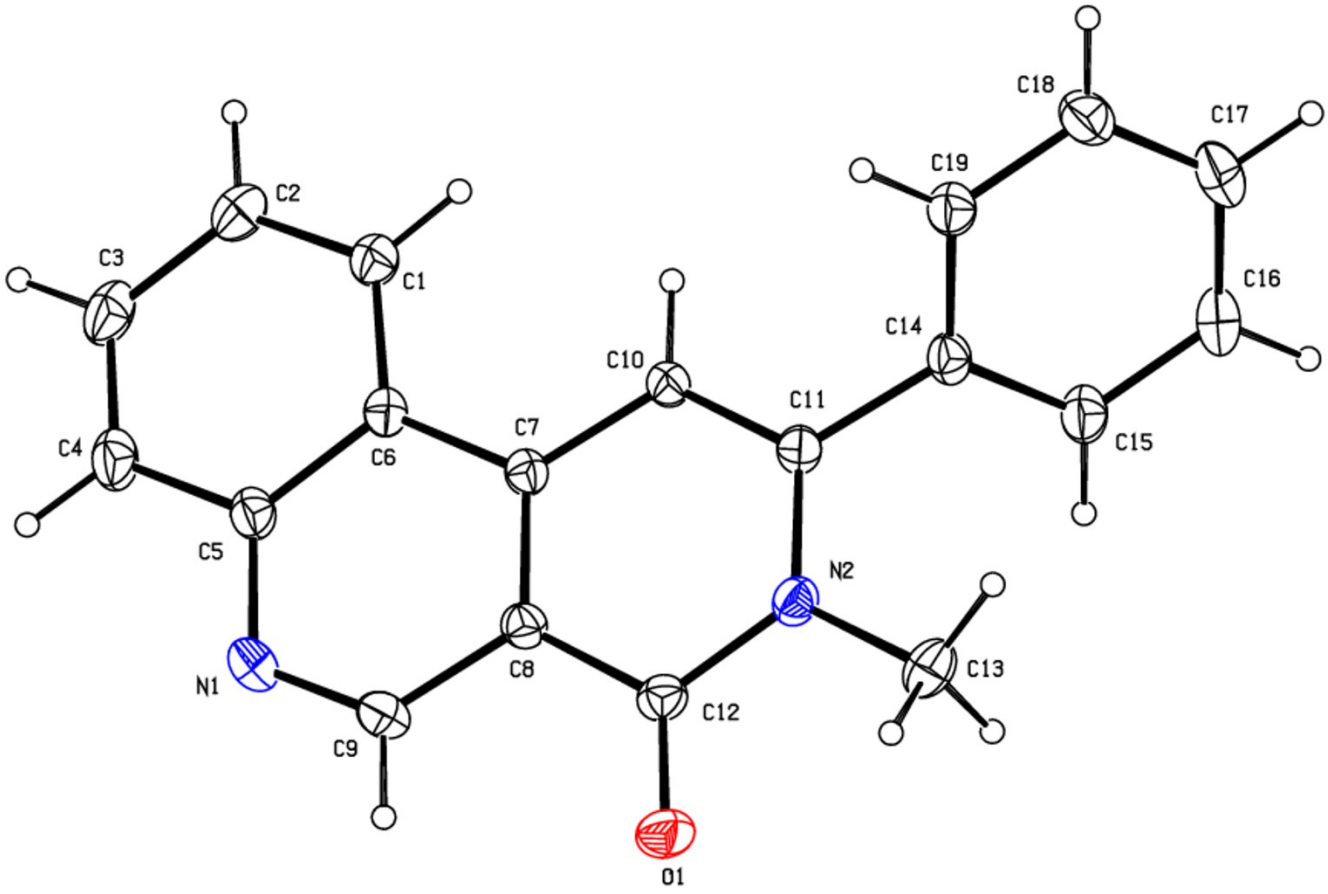
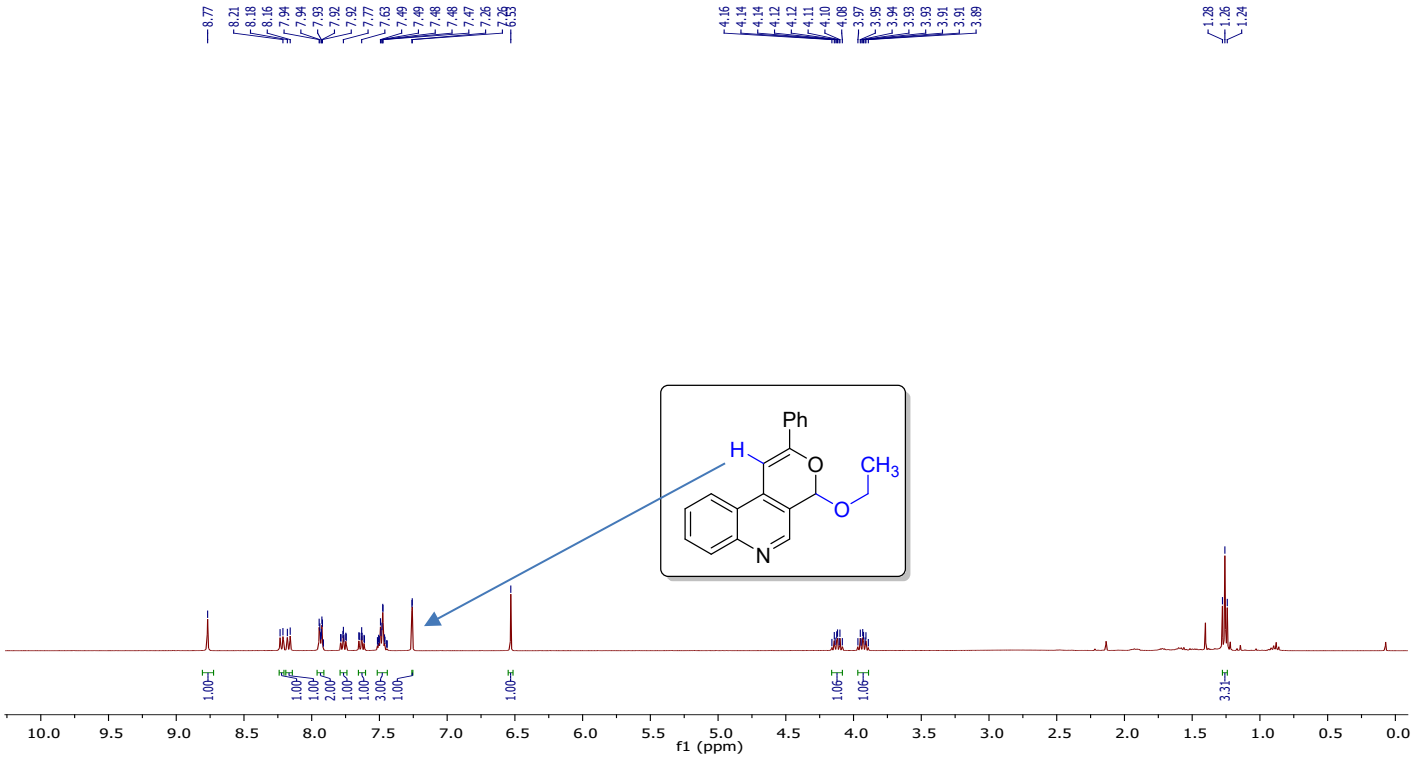
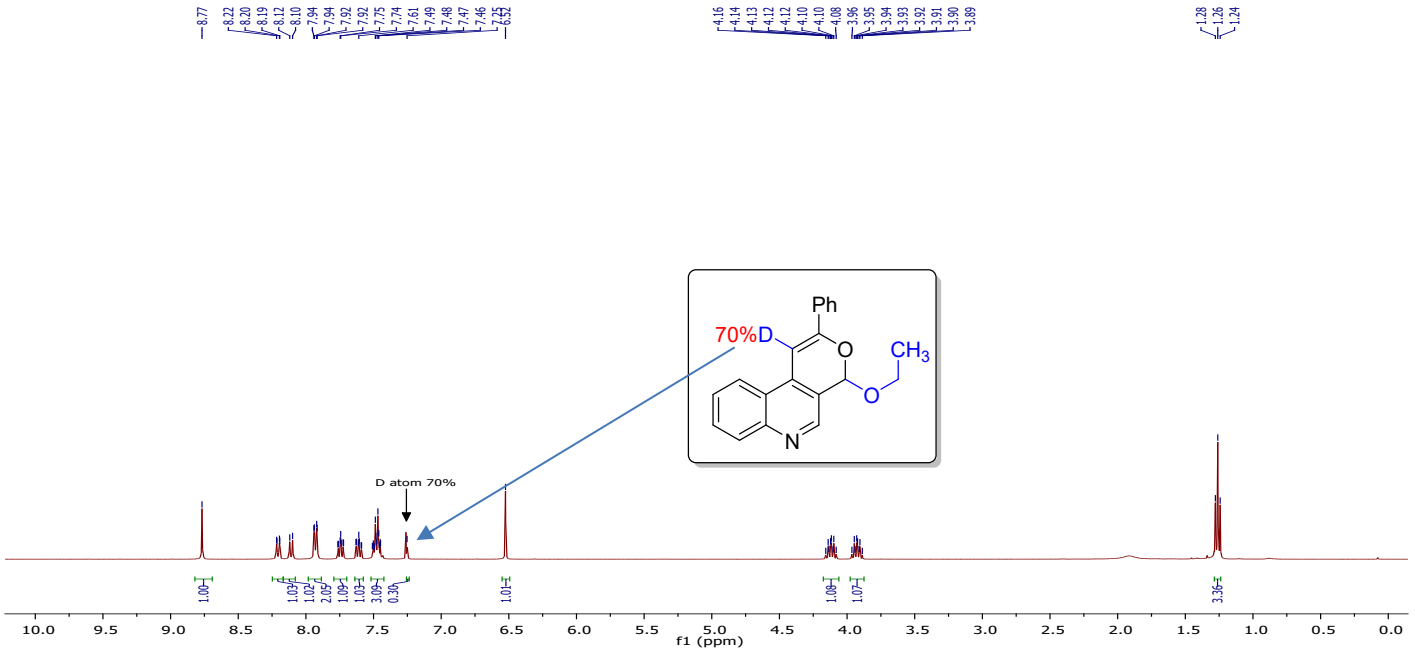


Figure 1: ORTEP diagram of **10a** compound with the atom-numbering. Displacement ellipsoids are drawn at the 30% probability level and H atoms are shown as small spheres of arbitrary radius.

26. Comparison between NMR spectra of 3ab and 7a





Deturated NMR shows that even proton is coming from alcohols which shows atom economy approach of this method.