Electronic supplementary materials *Mendeleev Commun.*, 2024, **34**, 401–403

Copper(II)-catalyzed three-component coupling sequence for the efficient synthesis of 2-arylquinolines: 1,4-dioxane serving as the C_2 building block

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Contents

1 General experimental details

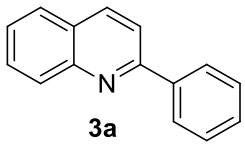
All chemicals were used as received without special purification. 1,4-Dioxane used in this reaction was purchased from Adamas (Grade: AR, > 99.5%). ^{1}H and ^{13}C NMR were recorded at ambient temperature on a 300 or 400 MHz NMR spectrometer (75 or 100 MHz for ^{13}C NMR). NMR experiments are reported in δ units, parts per million (ppm), and were referenced to $CDCl_3$ (δ 7.26 or 77.0 ppm) as the internal standard.

General procedure:

Aldehyde **1** (0.1 mmol), aniline **2 (**0.2 mmol), trifluoromethanesulfonic acid (4.9 μL, 0.05 mmol), $CuCl_2$ (0.02 mmol, 2.69 mg) and 1,4-dioxane (4 mL) was added into a 20 mL Schlenk tube equipped with a stir bar under air. The sealed Schlenk tube was stirred at 90 °C for about 12 h. After the reaction mixture was cooled to room temperature, the reaction mixture was diluted with EtOAc and washed with water. The organic layer was dried over anhydrous $MgSO_4$, filtered and the filtrate was concentrated in vacuum. The residue was purified by flash column chromatography on silica gel with petroleum ether (b.p 60-90°C) ethyl acetate as eluent to give the desired product. Chracteristics of known products are referenced in [S1]-[S4].

2 Characterization data for the products

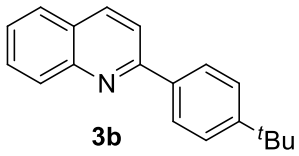
2-Phenylquinoline (3a)



3a

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3a** (12.7 mg, 62% yield) as a colorless solid.. The compound is known.[S1] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.16-8.24 (m, 4H), 7.82-7.89 (m, 2H), 7.72-7.76 (m, 1H), 7.52-7.55 (m, 3H), 7.46-7.49 (m, 1H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 157.4, 148.2, 139.6, 136.8, 129.7, 129.6, 129.3, 128.8, 127.6, 127.4, 127.1, 126.2, 119.0.

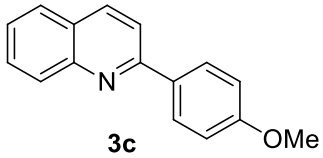
2-(4-*tert*-Butylphenyl)quinoline (3b)



3b

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3b** (13.3 mg, 51% yield) as a white solid. The compound is known.[S4] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.09-8.22 (m, 2H), 8.09-8.11 (d, J = 8.4 Hz, 2H), 7.81-7.88 (m, 2H), 7.70-7.74 (m, 1H), 7.50-7.57 (m, 3H), 1.39 (s, 9H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 157.4, 152.5, 148.3, 137.0, 136.6, 129.7, 129.6, 127.4, 127.3, 127.1, 126.1, 125.8, 119.0, 34.8, 31.3.

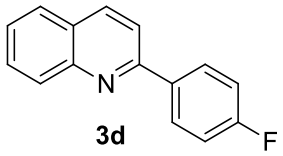
2-(4-Methoxyphenyl)quinoline (3c)



3c

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 20) gave **3c** (9.9 mg, 42% yield) as a white solid. The compound is known.[S1] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.13-8.19 (m, 4H), 7.79-7.85 (m, 2H), 7.69-7.73 (m, 1H), 7.48-7.52 (m, 1H), 7.04-7.06 (d, J = 8.3 Hz, 2H), 3.89 (s, 3H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 160.8, 156.9, 148.3, 136.6, 132.3, 129.6, 129.5, 128.9, 127.4, 126.9, 125.9, 118.6, 114.2, 100.0, 55.4.

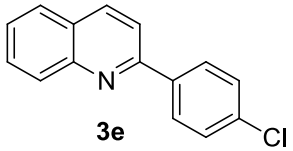
2-(4-Fluorophenyl)quinoline (3d)



3d

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 20) gave **3d** (12.9 mg, 58% yield) as a white solid. The compound is known.[S1] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.14-8.22 (m, 4H), 7.81-7.84 (d, J = 8.5 Hz, 2H), 7.72-7.76 (m, 1H), 7.51-7.55 (m, 1H), 7.19-7.23 (m, 2H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 163.8 (d, J = 247.5 Hz), 156.2, 148.2, 136.9, 135.8, 129.7 (d, J = 17.6 Hz), 129.4, 129.3, 127.4, 127.0, 126.3, 118.6, 115.7 (d, J = 21.5 Hz).

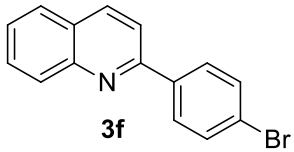
2-(4-Chlorophenyl)quinoline (3e)



3e

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3e** (15.5 mg, 65% yield) as a white solid. The compound is known.[S1] The compound is known.[1] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.21-8.23 (d, J = 8.6 Hz, 1H), 8.11-8.17 (m, 3H), 7.82-7.85 (m, 2H), 7.72-7.76 (m, 1H), 7.49-7.56 (m, 3H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 156.0, 148.2, 138.0, 136.9, 135.5, 129.8, 129.7, 129.0, 128.8, 127.5, 127.2, 126.5, 118.5.

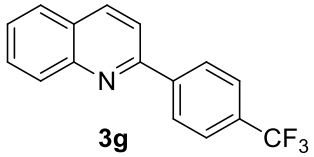
2-(4-Bromophenyl)quinoline (3f)



3f

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3f** (19.2 mg, 68% yield) as a white solid..The compound is known.[S1] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.15-8.22 (dd, J = 8.6 Hz, 2H), 8.04-8.06 (d, J = 8.3 Hz, 2H), 7.81-7.83 (d, J = 8.4 Hz, 2H), 7.72-7.75 (t, J = 7.1 Hz, 1H), 7.64-7.66 (d, J = 8.3 Hz, 2H), 7.52-7.56 (t, J = 7.4 Hz, 1H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 156.0, 148.2, 138.4, 136.9, 131.9, 129.8, 129.6, 129.0, 127.4, 127.2, 126.5, 123.9, 118.4.

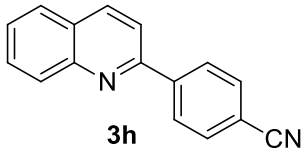
2-(4-Trifluoromethylphenyl)quinoline (3g)



3g

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3g** (17.1 mg, 63% yield) as a white solid. The compound is known.[S1] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.26-8.30 (m, 3H), 8.18-8.20 (d, J = 8.5 Hz, 1H), 7.85-7.90 (m, 2H), 7.75-7.79 (m, 3H), 7.55-7.59 (t, J = 7.7 Hz, 1H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 155.6, 148.2, 142.9, 137.1, 131.0 (d, J = 32.3Hz), 129.8 (d, J = 14.1Hz), 127.8 (2C), 127.5, 127.4, 126.8, 125.5 (q, J = 274.7 Hz), 125.7(q, J = 3.0 Hz), 118.8.

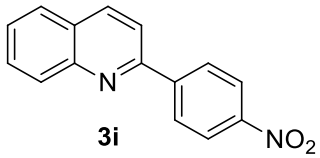
4-(Quinolin-2-yl)benzonitrile (3h)



3h

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 10) gave **3h** (13.1 mg, 57% yield) as a white solid. The compound is known.[S2] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.26-8.30 (m, 3H), 8.16-8.18 (d, J = 8.4 Hz, 1H), 7.84-7.89 (m, 2H), 7.75-7.77 (m, 3H), 7.56-7.60 (m, 1H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 154.9, 148.2, 143.6, 137.2, 132.5, 130.1, 129.8, 128.0, 127.5, 127.4, 127.1, 127.0, 118.6, 112.7.

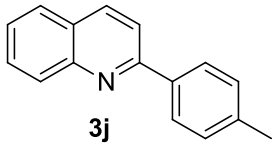
2-(4-Nitrophenyl)quinoline (3i)



3i

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **2i** (10.7 mg, 43% yield) as a white solid. The compound is known.[S4] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.33-8.38 (m, 4H), 8.29 (d, J = 8.6 Hz, 1H), 8.18 (d, J = 8.5 Hz, 1H), 7.91 (d, J = 8.6 Hz, 1H), 7.86 (d, J = 8.1 Hz, 1H), 7.76-7.80 (m, 1H), 7.59 (t, J = 7.3 Hz, 1H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 154.5, 148.3, 148.2, 145.5, 137.3, 130.2, 130.0, 128.3 (2C), 127.6, 127.3, 124.0, 118.8.

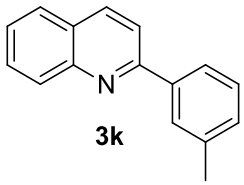
2-(*p*-Tolyl)quinoline (3j)



3j

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3b** (13.4 mg, 61% yield) as a white solid. The compound is known.[S1] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.15-8.21 (m, 2H), 8.05-8.06 (d, J = 8.08 *Hz*, 2H), 7.81-7.88 (m, 2H), 7.70-7.74 (m, 1H), 7.50-7.53 (m, 1H), 7.33-7.35 (d, J = 8.00 *Hz*, 2H), 2.44 (s, 3H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 157.3, 148.3, 139.4, 136.9, 136.6, 129.6, 129.5, 127.5, 127.4, 127.1, 126.1, 118.8, 21.3.

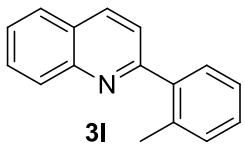
2-(*m*-Tolyl)quinoline (3k)



3k

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3k** (11.6 mg, 53% yield) as a white solid. The compound is known.[S2] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.19-8.21 (d, J = 8.5 Hz, 2H), 8.03 (s, 1H), 7.93-7.95 (d, J = 7.7 Hz, 1H), 7.81-7.88 (m, 2H), 7.72-7.76 (m, 1H), 7.51-7.56 (m, 1H), 7.41-7.45 (m, 1H), 7.26-7.30 (m, 1H), 2.50 (s, 3H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 157.5, 148.2, 139.6, 138.4, 136.6, 130.0, 129.6, 129.5, 128.7, 128.2, 127.4, 127.1, 126.2, 124.6, 119.1, 21.6.

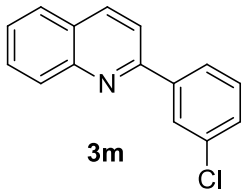
2-(*o*-Tolyl)quinoline (3l)



3l

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3l** (8.1 mg, 37% yield) as a white solid. The compound is known.[S4] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.21-8.23 (d, J = 8.4 Hz, 1H), 8.16-8.18 (d, J = 8.5 Hz, 1H), 7.86-7.88 (d, J = 8.1 Hz, 1H), 7.73-7.76 (t, J = 7.3 Hz, 1H), 7.49-7.59 (m, 3H), 7.34-7.35 (m, 3H), 2.42(s, 3H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 160.2, 147.8, 140.7, 136.0, 135.9, 130.8, 129.7, 129.6, 129.5, 128.5, 127.5, 126.7, 126.4, 126.0, 122.3, 20.3.

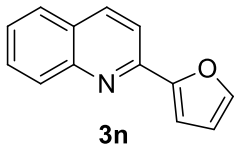
2-(3-Chlorophenyl)quinoline (3m)



3m

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3m** (15.0 mg, 63% yield) as a white solid. The compound is known.[S4] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.19-8.22 (m, 2H), 7.84-7.87 (m, 1H), 7.69-7.77 (m, 3H), 7.50-7.60 (m, 2H), 7.34-7.44 (m, 2H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 157.3, 148.0, 139.5, 135.6, 132.2, 131.6, 130.0, 129.8, 129.6, 129.5, 127.5, 127.1, 127.0, 126.7, 122.7.

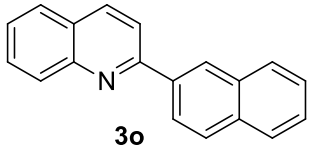
2-(Furan-2-yl)quinoline (3n)



3n

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 20) gave **3n** (12.6 mg, 65% yield) as a white solid. The compound is known.[S1] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.12-8.16 (t, J = 8.2 Hz, 2H), 7.76-7.82 (m, 2H), 7.68-7.72 (t, J = 8.0 Hz, 1H), 7.62 (s, 1H), 7.47-7.51 (t, J = 7.3 Hz, 1H), 7.21-7.22 (d, J = 3.3 Hz, 1H), 6.58-6.59 (d, J = 1.4 Hz, 1H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 153.6, 149.0, 148.0, 144.1, 136.6, 129.8, 129.3, 127.5, 127.1, 126.1, 117.4, 112.1, 110.1.

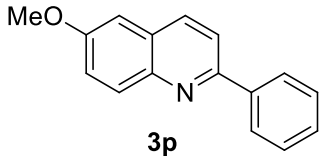
2-(Naphthalen-2-yl)quinoline (3o)



3o

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 20) gave **3o** (15.3 mg, 60% yield) as a white solid. The compound is known.[S4] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.63 (s, 1H), 8.37-8.40 (m, 1H), 8.25 (t, J = 9.0 Hz, 2H), 8.00-8.04 (m, 3H), 7.90-7.92 (m, 1H), 7.84-7.86 (m, 1H), 7.74-7.78 (m, 1H), 7.52-7.57 (m, 3H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 157.1, 148.4, 136.9, 136.8, 133.8, 133.5, 129.7, 129.6, 128.8, 128.5, 127.7, 127.5, 127.2, 127.1, 126.7, 126.4, 126.3, 125.0, 119.1.

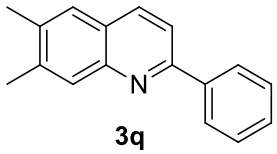
6-Methoxy-2-phenylquinoline (3p)



3p

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 10) gave **3p** (10.6 mg, 45% yield) as a white solid. The compound is known.[S3] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.06-8.14 (m, 4H), 7.82-7.84 (m, 1H), 7.50-7.54 (m, 2H), 7.37-7.46 (m, 2H), 7.09-7.10 (m, 1H), 3.95 (s, 3H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 157.6, 155.0, 144.3, 139.8, 135.5, 131.1, 128.9, 128.8, 128.1, 127.3, 122.3, 119.2, 105.0, 55.5.

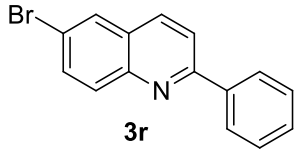
6,7-Dimethyl-2-phenylquinoline (3q)



3q

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3q** (12.8 mg, 55% yield) as a white solid. The compound is known.[S4] ^{1}H NMR ($CDCl_3$ 300 MHz): δ 8.05-8.16 (m, 3H), 7.94 (s, 1H), 7.77-7.80 (m, 1H), 7.44-7.56 (m, 4H), 2.49 (s, 3H), 2.45 (s, 3H). ^{13}C NMR ($CDCl_3$ 75 MHz): δ 156.4, 147.3, 139.9, 139.8, 136.1, 135.6, 129.0, 128.9, 128.7, 127.4, 126.6, 125.7, 118.2, 20.4, 20.0.

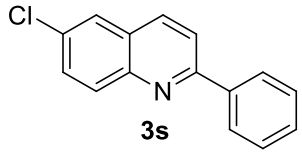
6-Bromo-2-phenylquinoline (3r)



3r

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3s** (17.5 mg, 62% yield) as a white solid. The compound is known.[S4] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.11-8.16 (m, 3H), 8.04 (d, J = 8.9 Hz, 1H), 7.98 (d, J = 1.9 Hz, 1H), 7.89 (d, J = 8.6 Hz, 1H), 7.77-7.80 (m, 1H), 7.46-7.55 (m, 3H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 157.6, 146.8, 139.2, 135.7, 133.1, 131.4, 129.6, 129.5, 128.9, 128.2, 127.5, 120.0, 119.7.

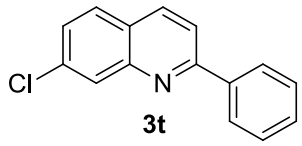
6-Chloro-2-phenylquinoline (3s)



3s

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3s** (13.8 mg, 58% yield) as a white solid. The compound is known.[S1] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.09-8.16 (m, 4H), 7.87-7.90 (m, 1H), 7.79-7.80 (m, 1H), 7.64-7.68 (m, 1H), 7.45-7.56 (m, 3H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 157.5, 146.6, 139.1, 135.8, 131.8, 131.2, 130.5, 129.5, 128.9, 127.7, 127.5, 126.0, 119.8.

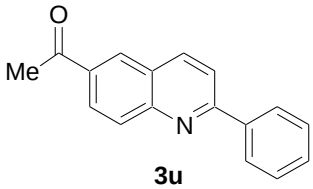
7-Chloro-2-phenylquinoline (3t)



3t

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 30) gave **3t** (13.3 mg, 56% yield) as a white solid. The compound is known.[S1] ^{1}H NMR ($CDCl_3$ 300 MHz): δ 8.14-8.19 (m, 4H), 7.85-7.88 (m, 1H), 7.73-7.76 (m, 1H), 7.45-7.57 (m, 4H). ^{13}C NMR ($CDCl_3$ 75 MHz): δ 158.2, 148.6, 139.1, 136.6, 135.4, 129.6, 128.9, 128.6, 127.5, 127.2, 125.5, 119.1.

1-(2-Phenylquinolin-6-yl)ethanone (3u)



3u

The product was purified by preparative TLC on GF254 (ethyl acetate: petroleum ether, 1: 5) gave **3u** (16.0 mg, 65% yield) as a white solid. The compound is known.[S4] ^{1}H NMR ($CDCl_3$ 400 MHz): δ 8.44 (d, J = 1.6 Hz, 1H), 8.31 (d, J = 8.6 Hz, 1H), 8.26-8.28 (m, 1H), 8.18-8.21 (m, 3H), 7.94 (d, J = 8.6 Hz, 1H), 7.48-7.57 (m, 3H), 2.74 (s, 3H). ^{13}C NMR ($CDCl_3$ 100 MHz): δ 197.1, 159.4, 150.2, 139.0, 138.1, 134.5, 130.2, 130.0, 128.5, 128.9, 127.9, 127.7, 126.3, 119.7, 26.7.

References

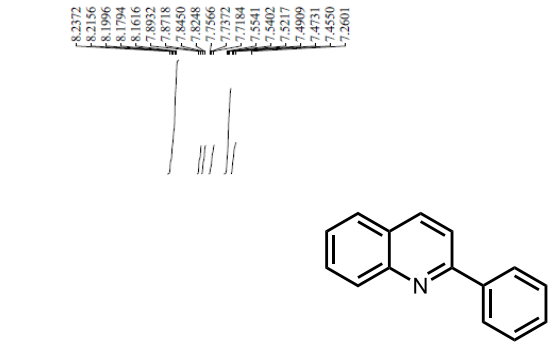
S1. K. Patra, A. Bhattacherya, C. Li, J. K. Bera and H. S. Soo, *ACS Catal.,* 2022, **12**, 15168.

S2. D. Pathak, B. K. Kalita, A. Sarmah, H. Sharma, B. Bora, T. K. Goswami and B. Sarma, *Green Chem*., 2023, **25**, 7642.

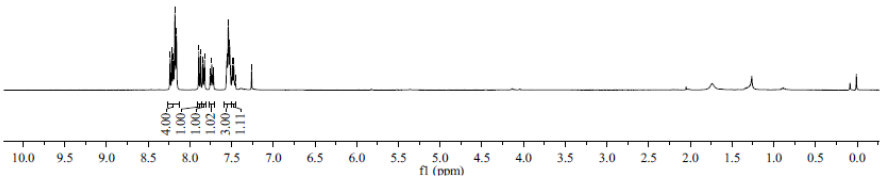
S3. Y. Ding, T. Guo, Z. Li, B. Zhang, F. E. Kühn, C. Liu, J. Zhang, D. Xu, M. Lei, T. Zhang and C. Li, *Angew. Chem., Int. Ed.,* 2022, **61**, e202206284.

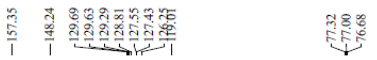
S4. X. Ji, H. Huang, Y. Li, H. Chen and H. Jiang, *Angew. Chem., Int. Ed*., 2012, **51**, 7292.

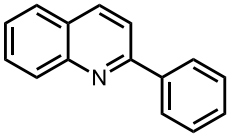
3 Copies of ^{1}H NMR and ^{13}C NMR spectra of 3a-3u



3a ^{1}H NMR







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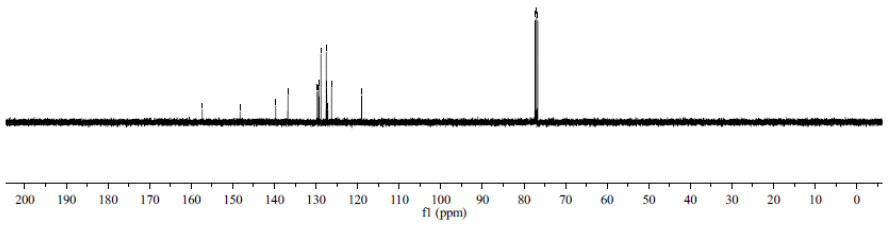

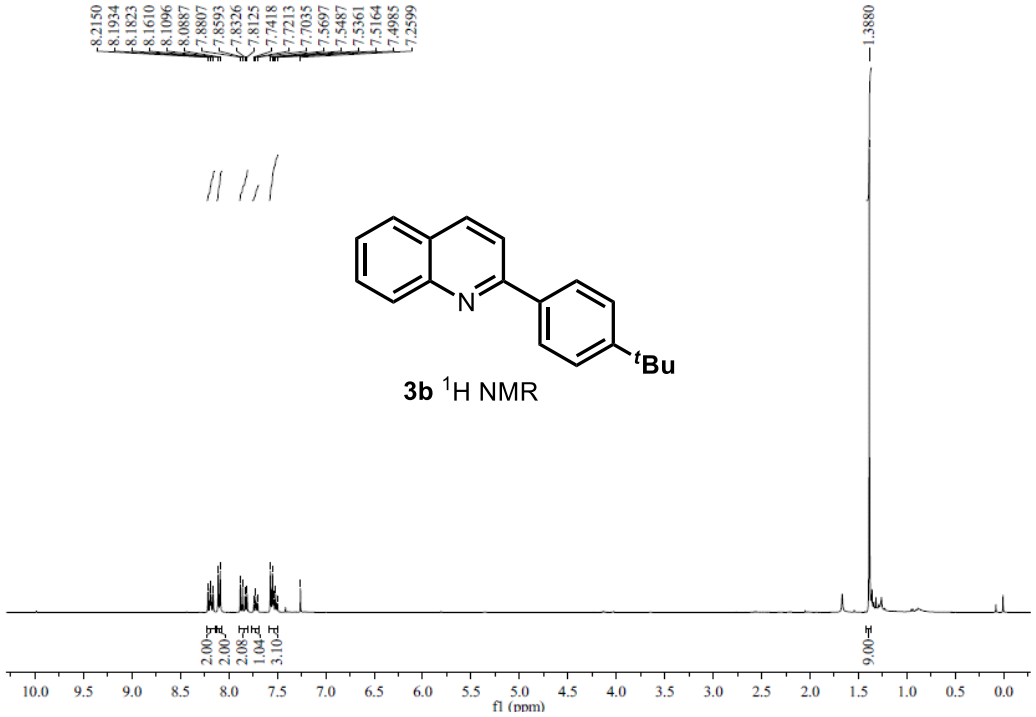

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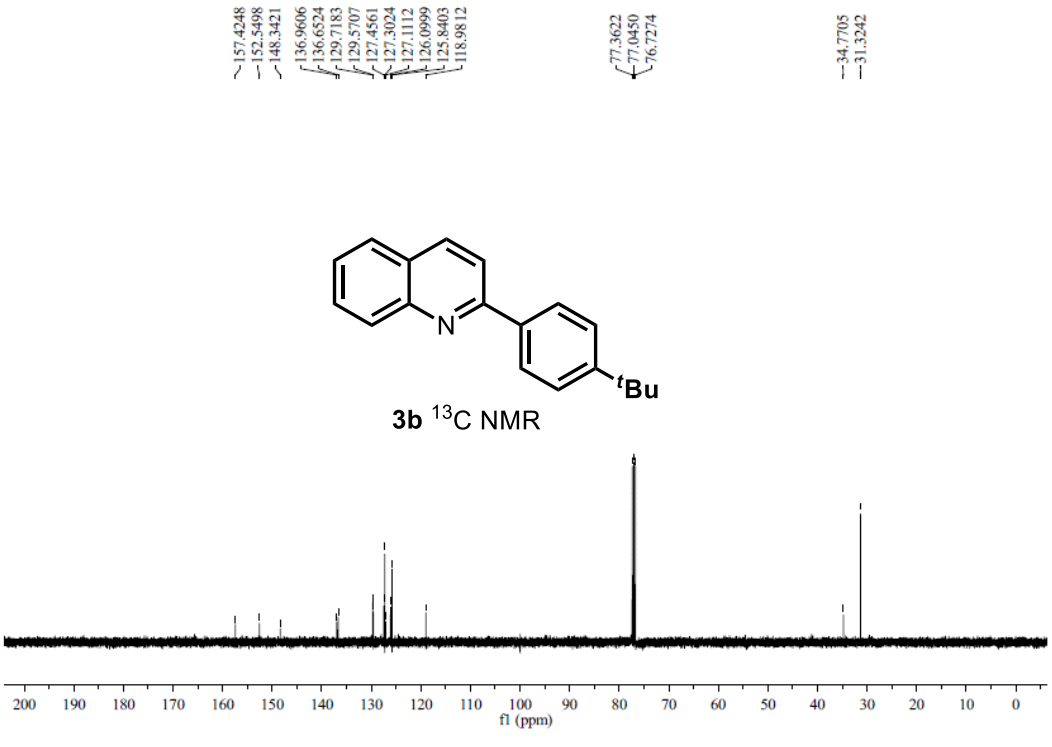

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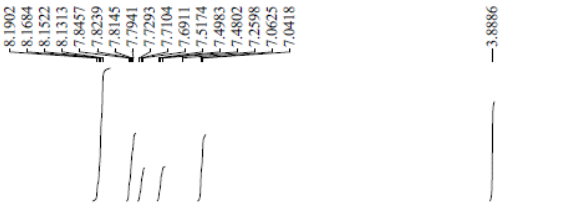

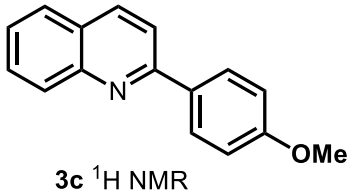

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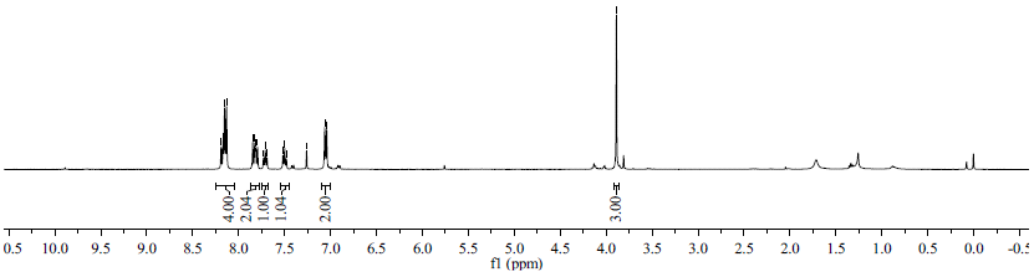
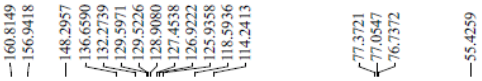
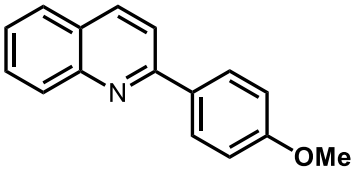
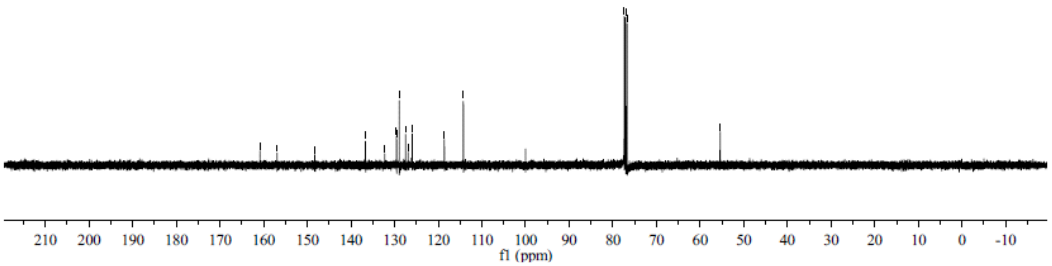
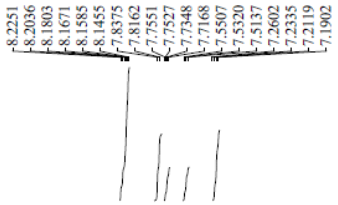


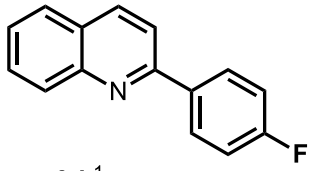




3c ^{13}C NMR







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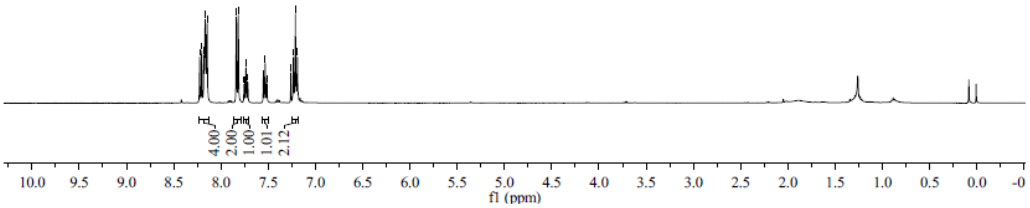
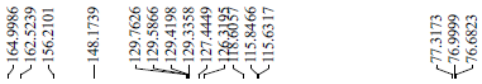
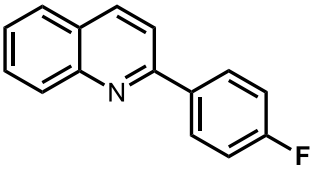
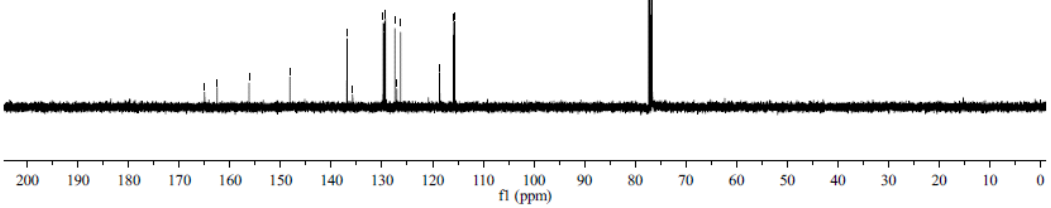
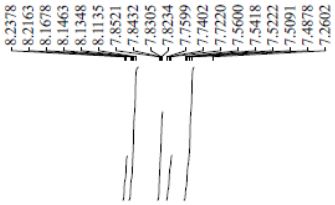


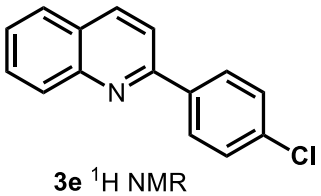




3d ^{13}C NMR







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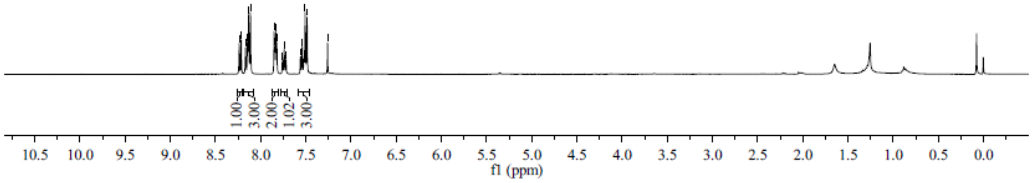

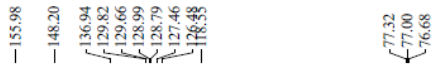

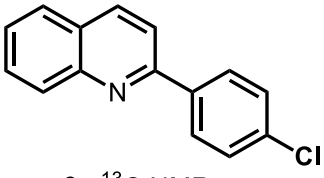

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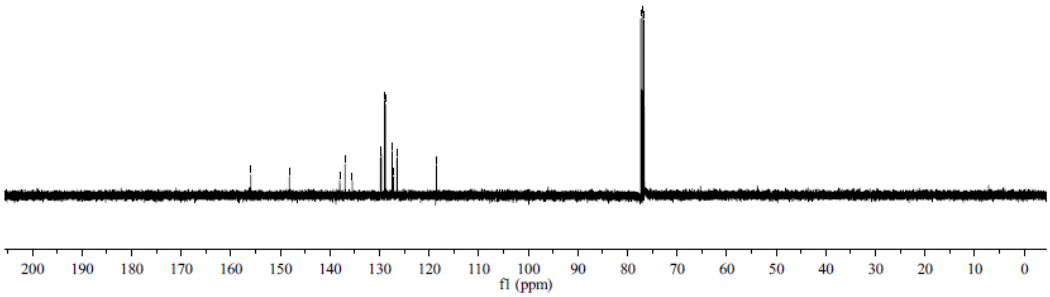

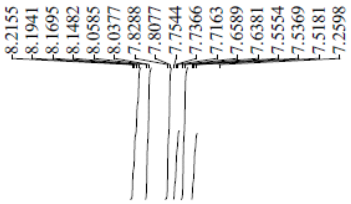

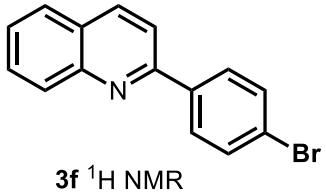

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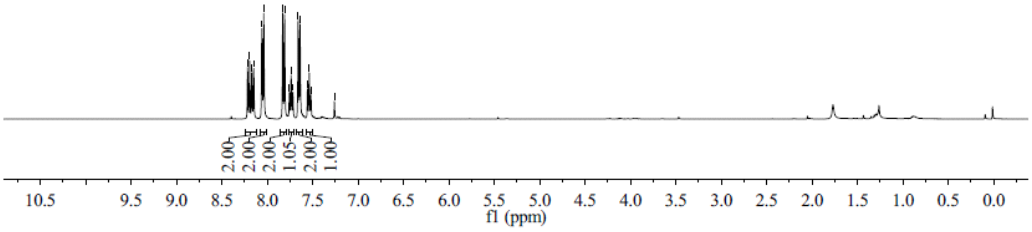

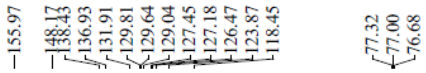

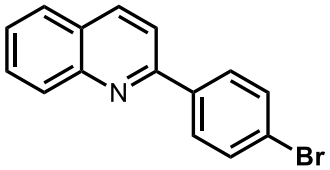

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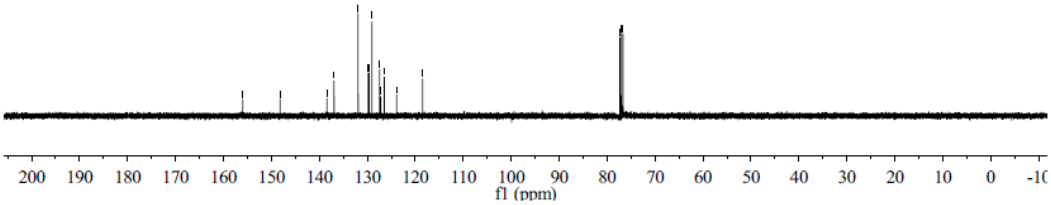

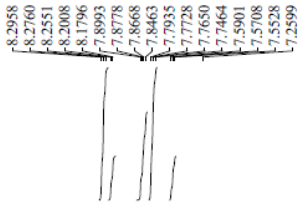
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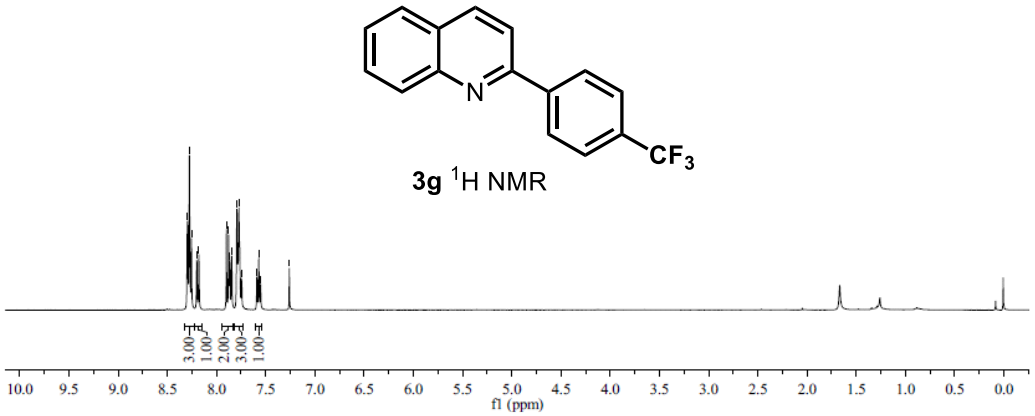
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1.00
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3.00
1.00
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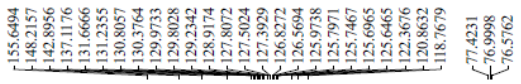
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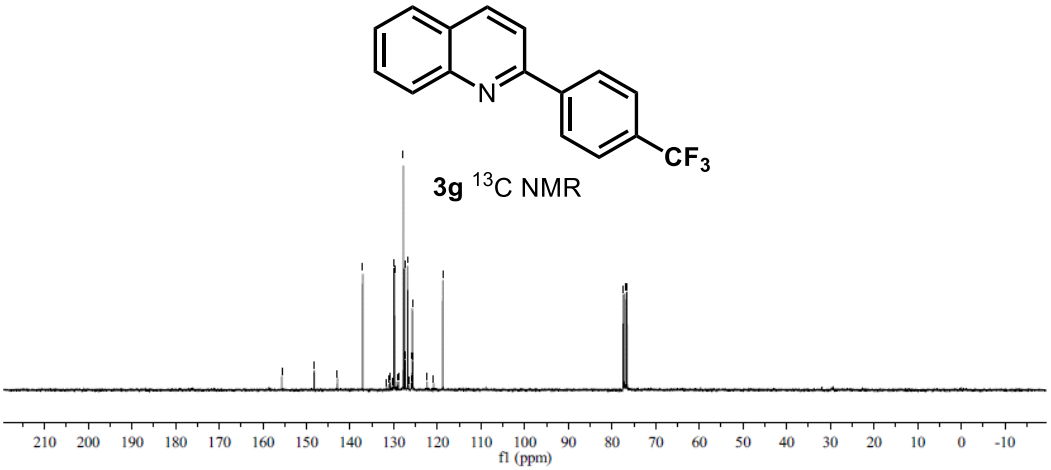
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CF3
3g 13C NMR
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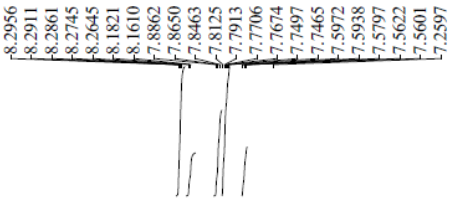
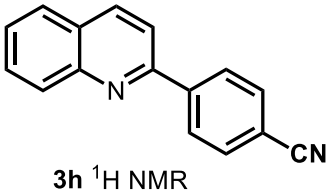
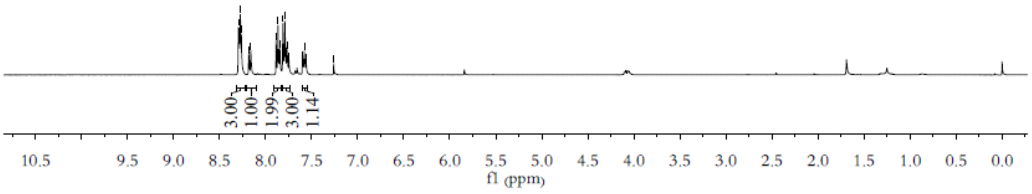
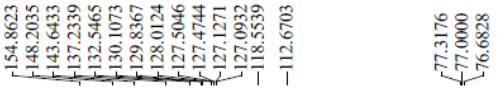
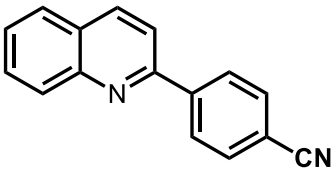




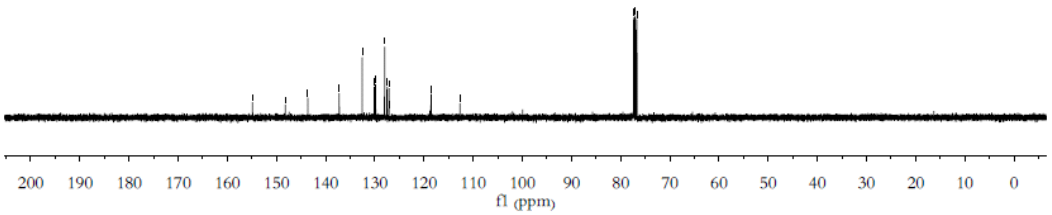
3h ^{1}H NMR

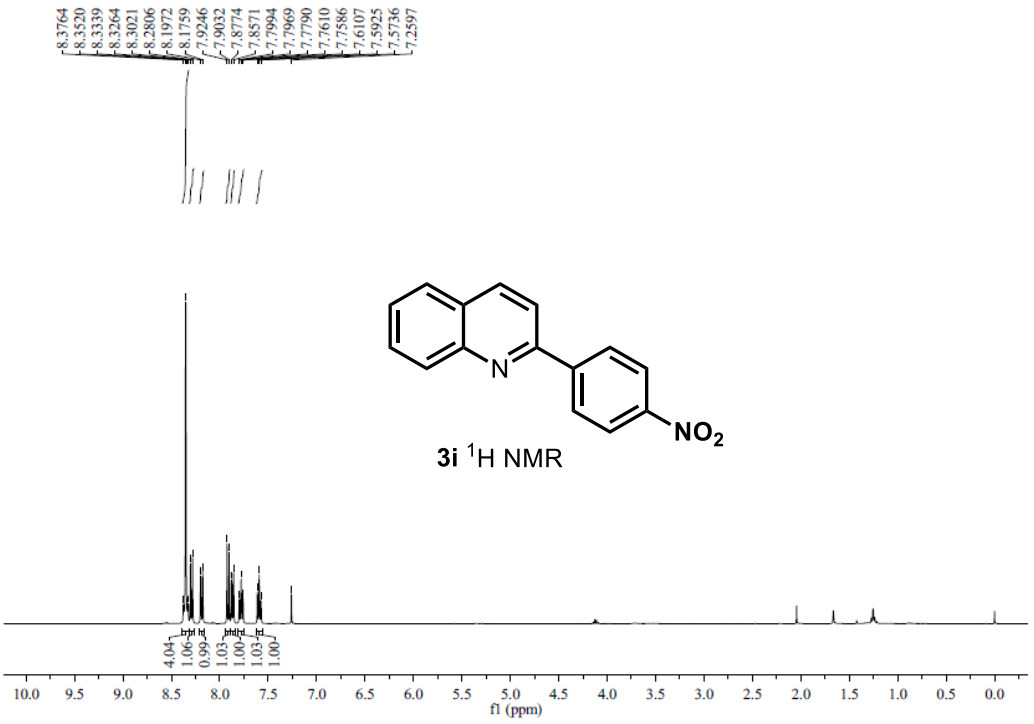




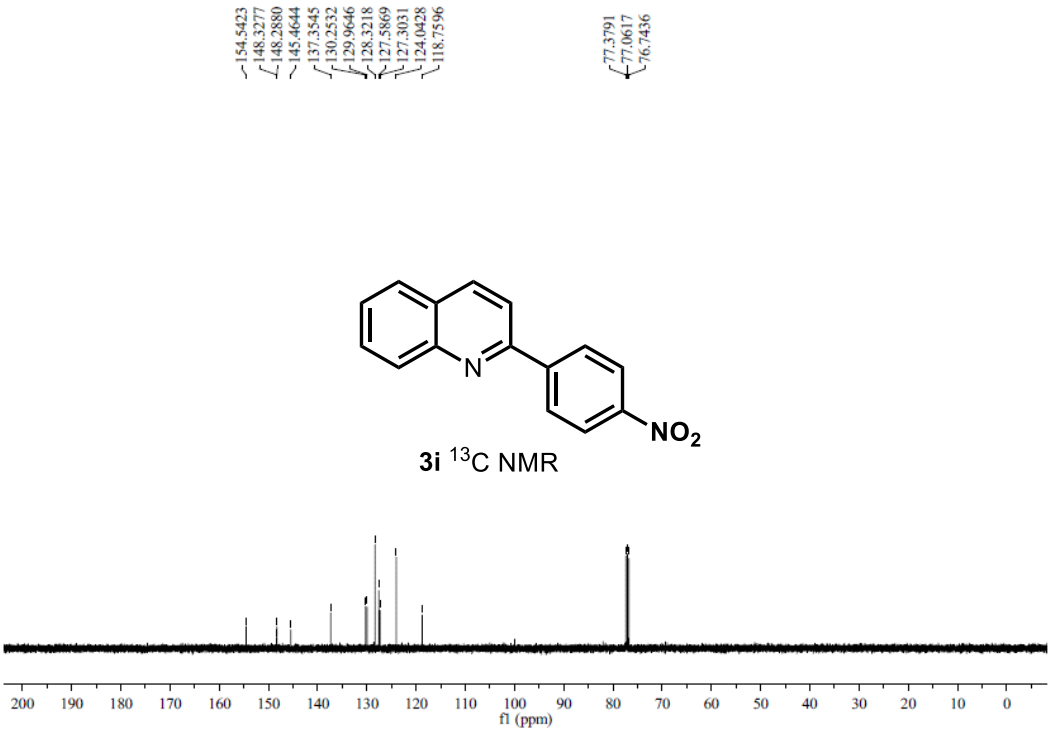


3h ^{13}C NMR





3i ^{1}H NMR



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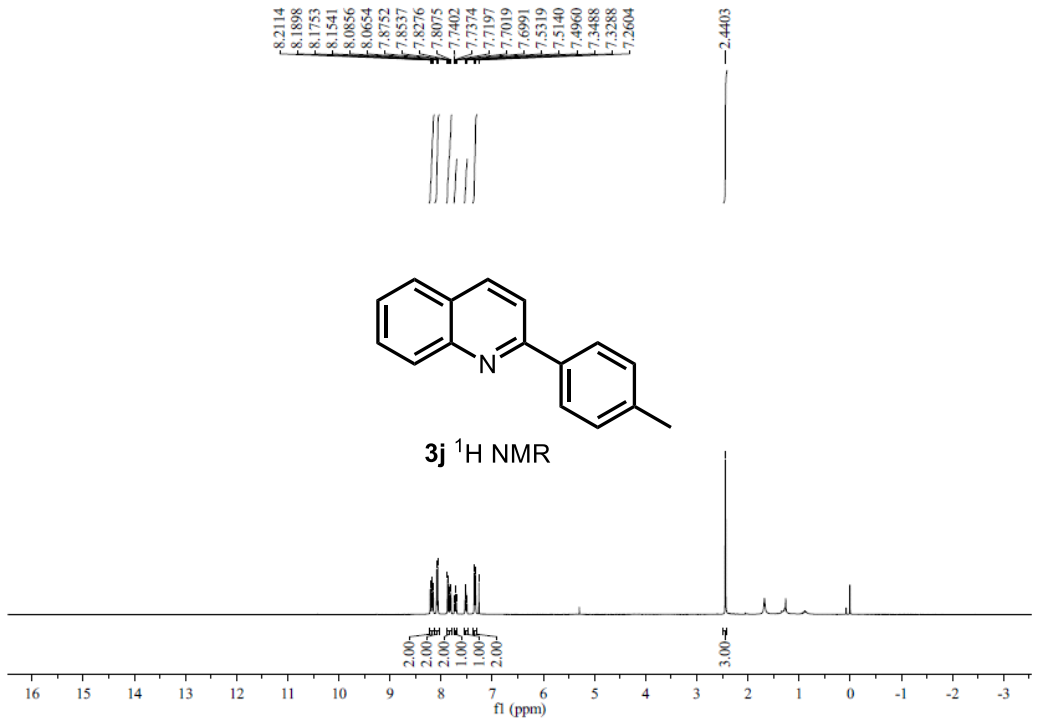

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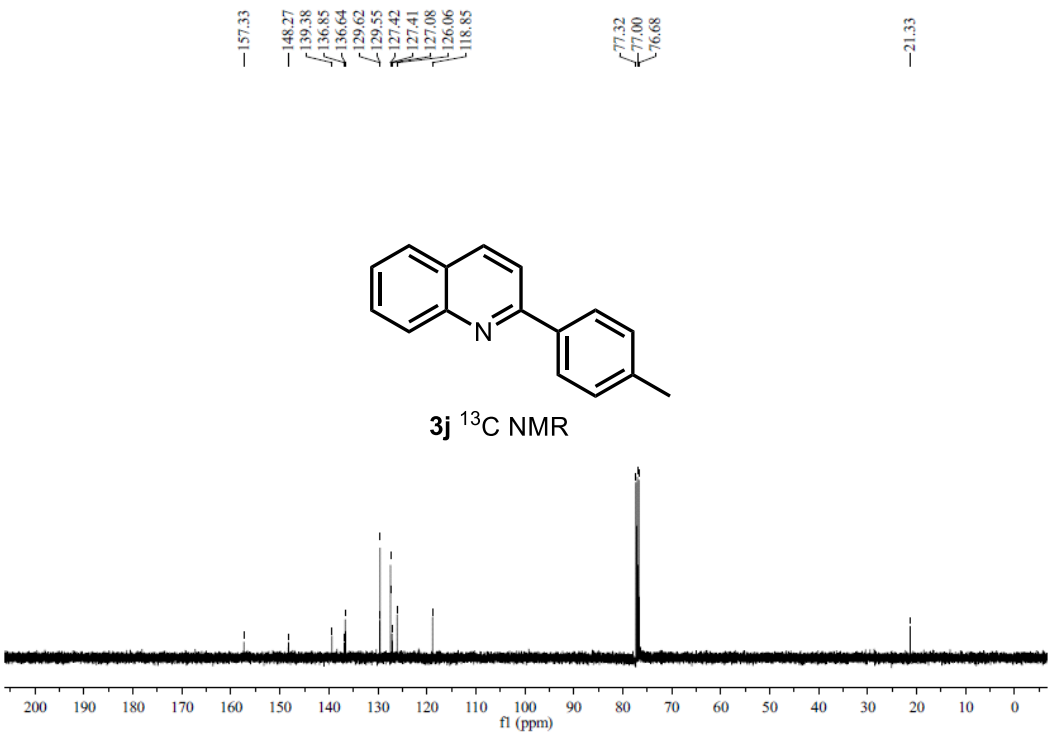

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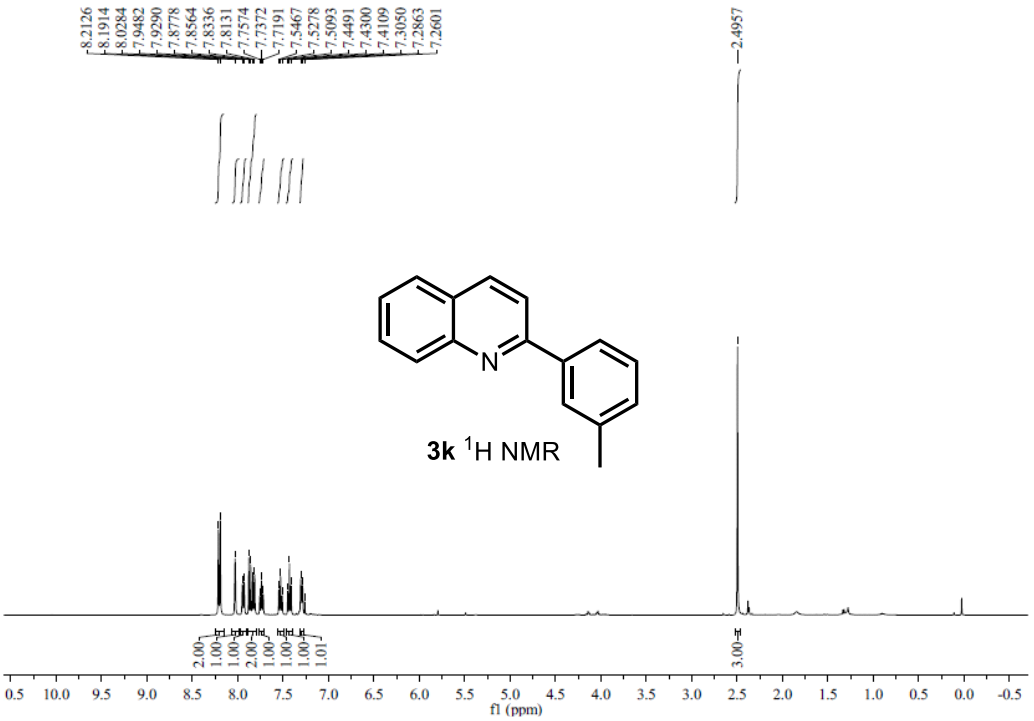
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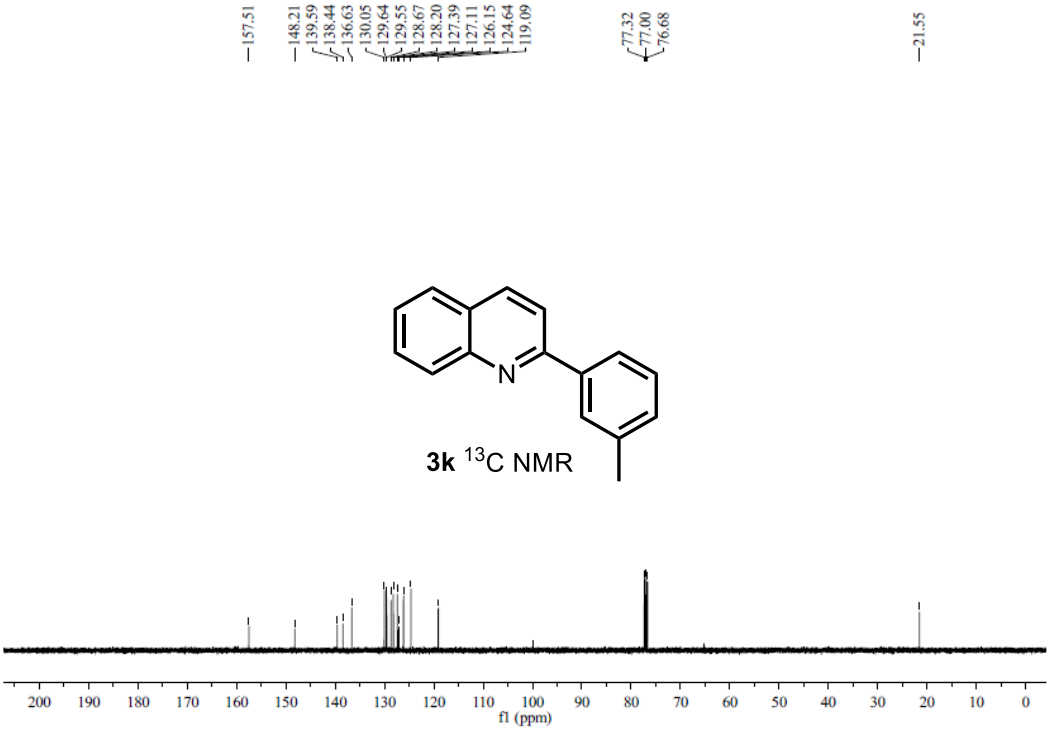
2.4957
N
3k 1H NMR
2.00
1.00
1.00
2.00
1.00
1.00
1.00
1.01
3.00
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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N
3k 13C NMR
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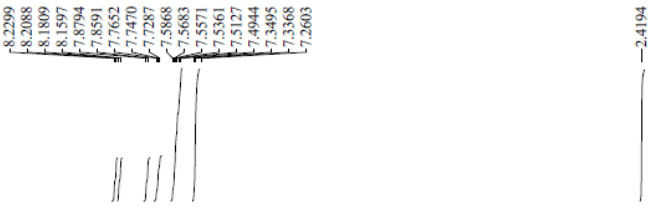
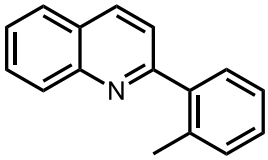
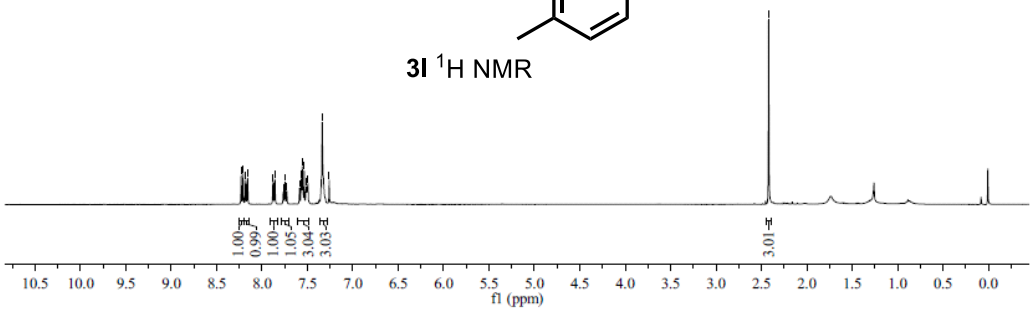
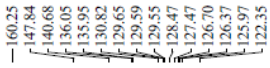
f1 (ppm)

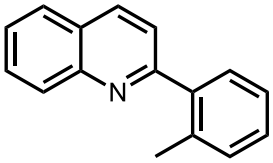




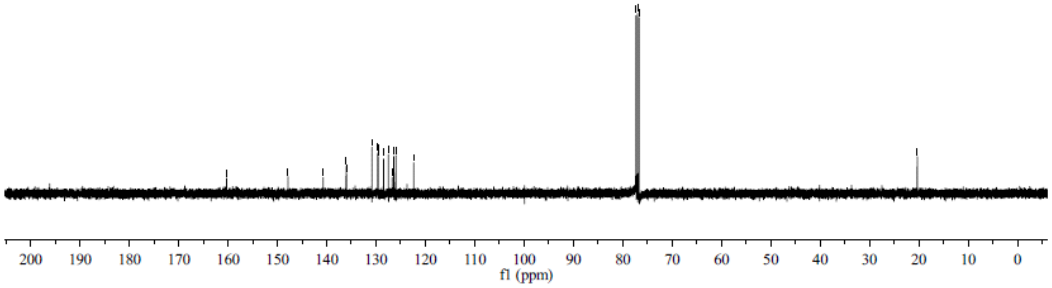
3l ^{1}H NMR

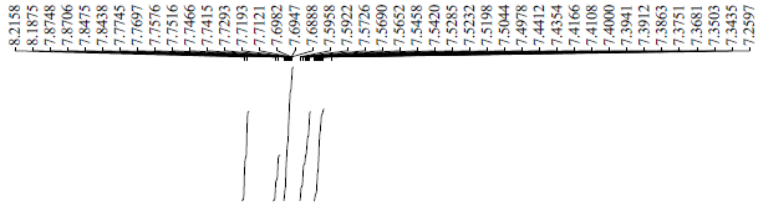


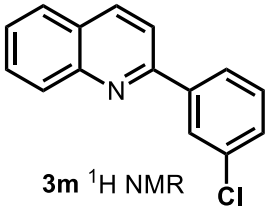




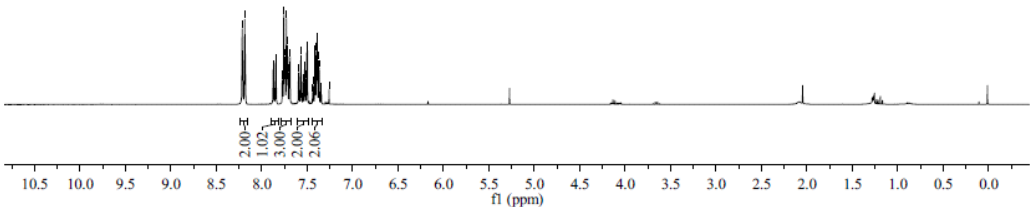
3l ^{13}C NMR

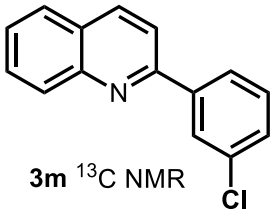




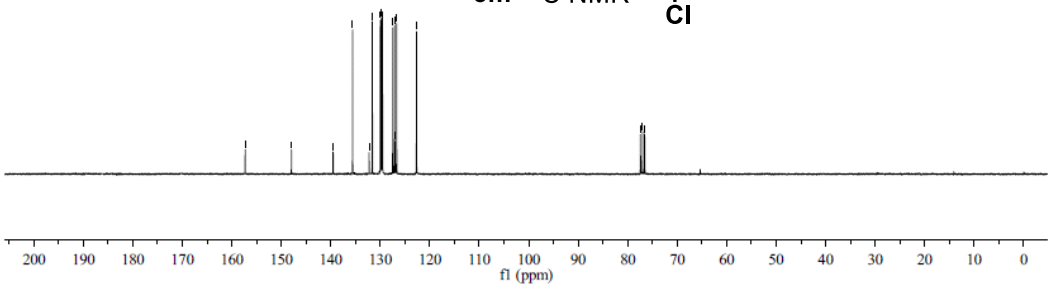


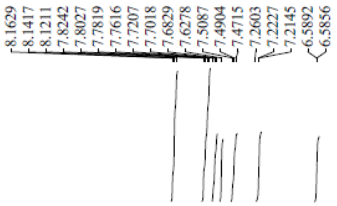
3m ^{1}H NMR

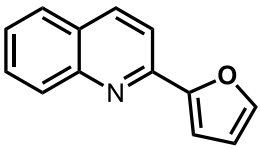




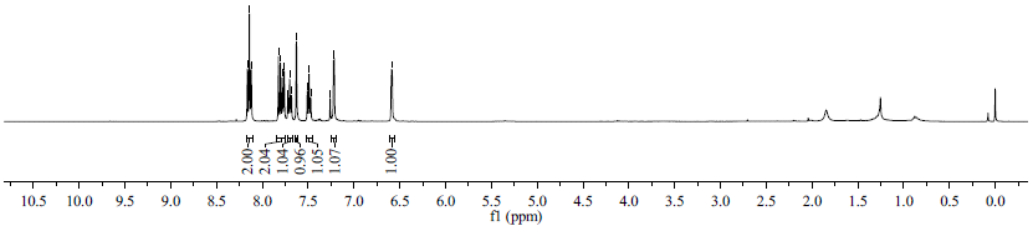
3m ^{13}C NMR

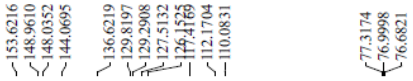


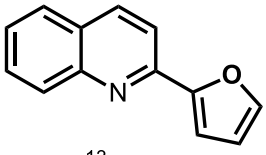




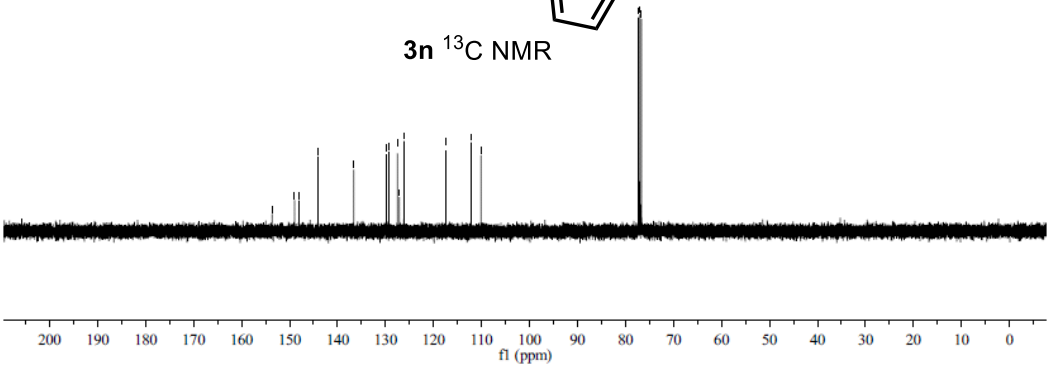
3n ^{1}H NMR

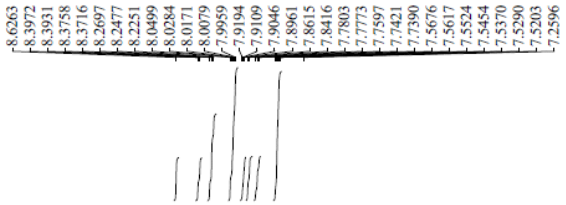


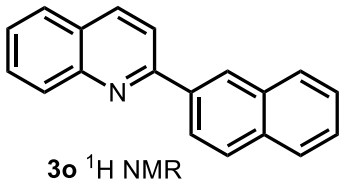




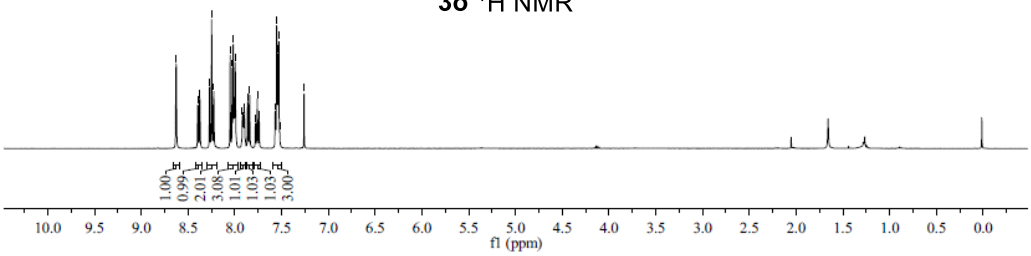
3n ^{13}C NMR

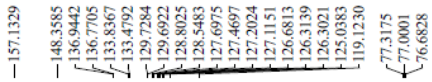


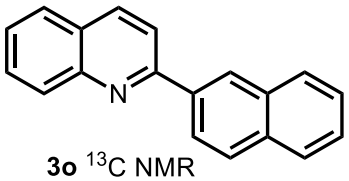




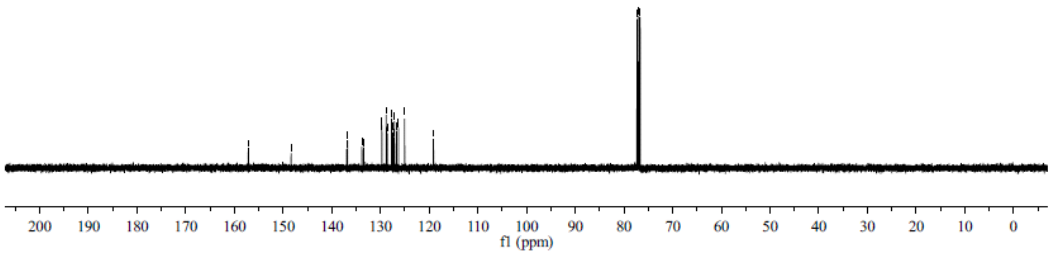
3o ^{1}H NMR

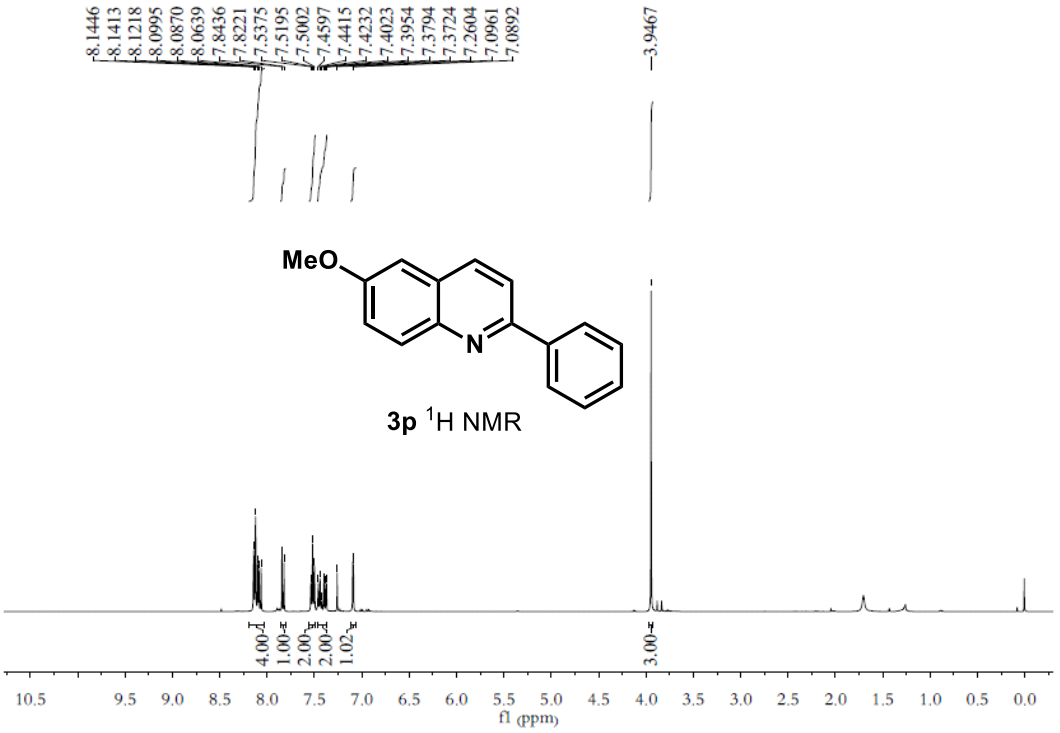




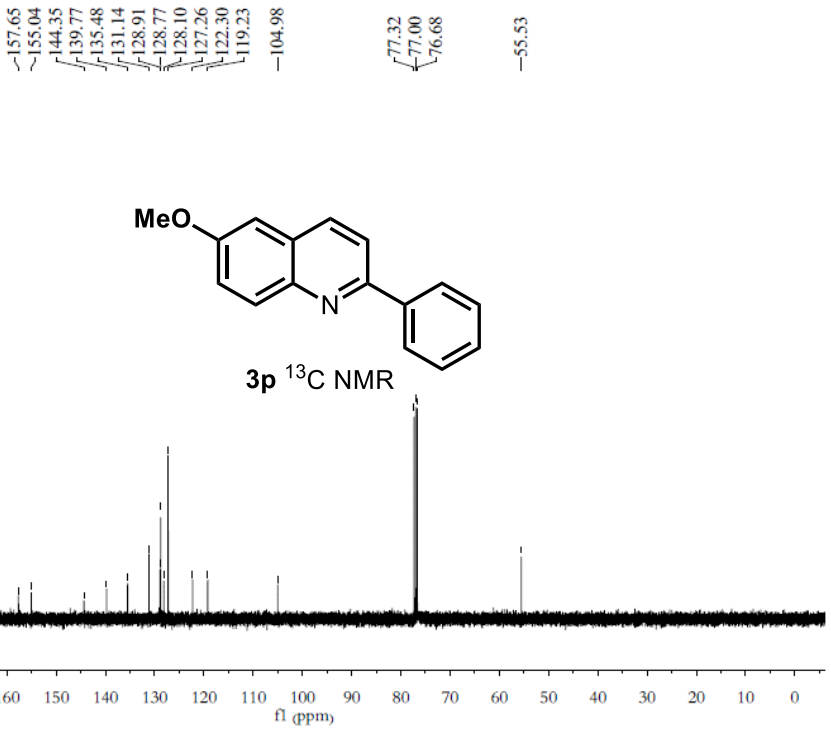


3o ^{13}C NMR

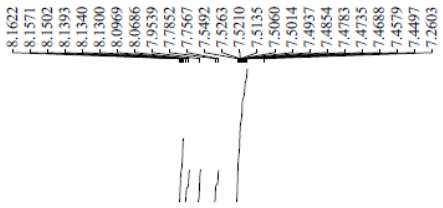


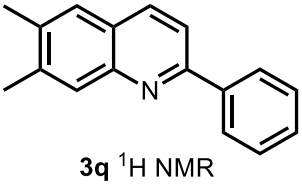


3p ^{1}H NMR

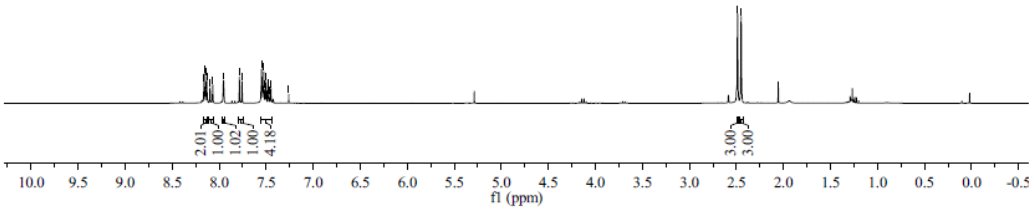


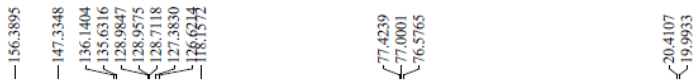
3p ^{13}C NMR

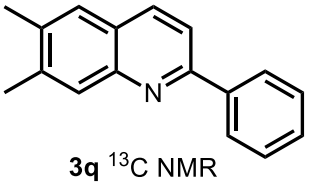




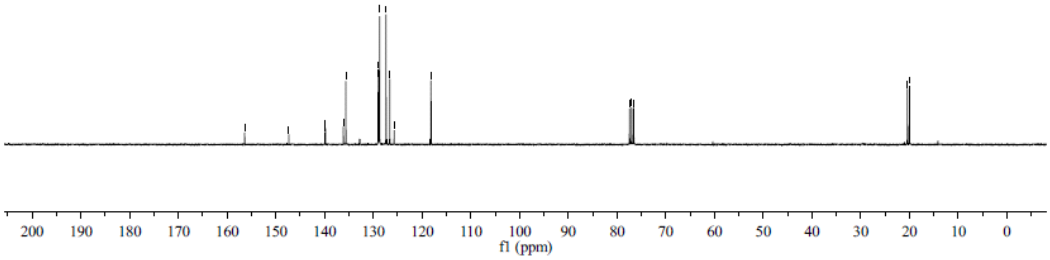
3q ^{1}H NMR

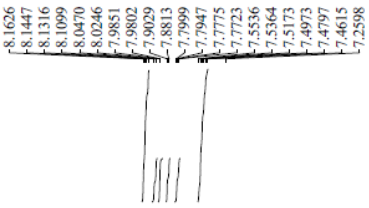


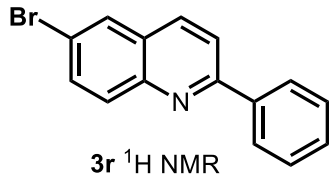




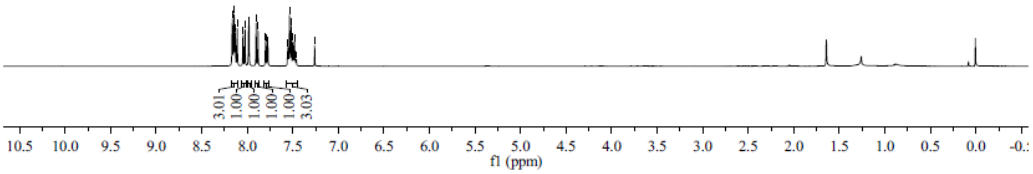
3q ^{13}C NMR

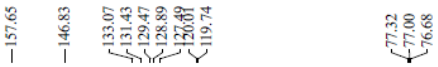


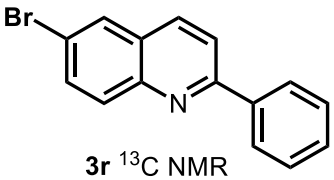




3r ^{1}H NMR







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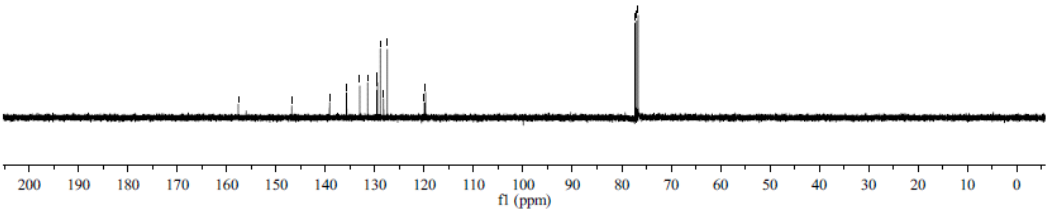
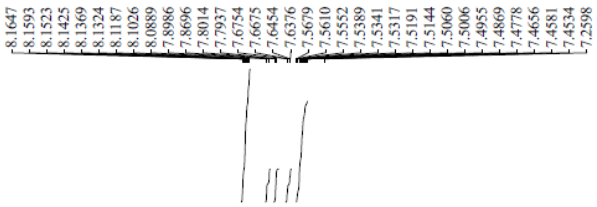
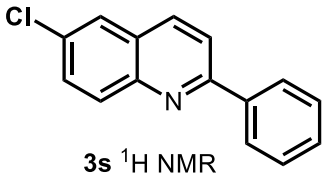
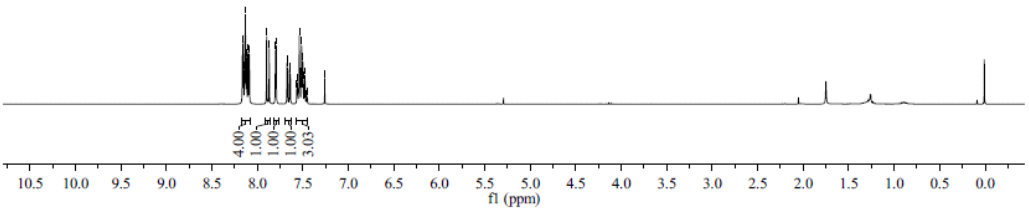
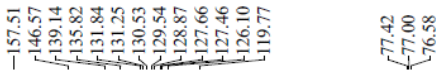


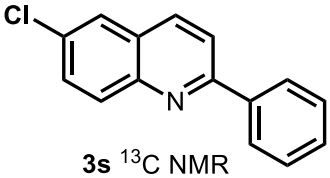




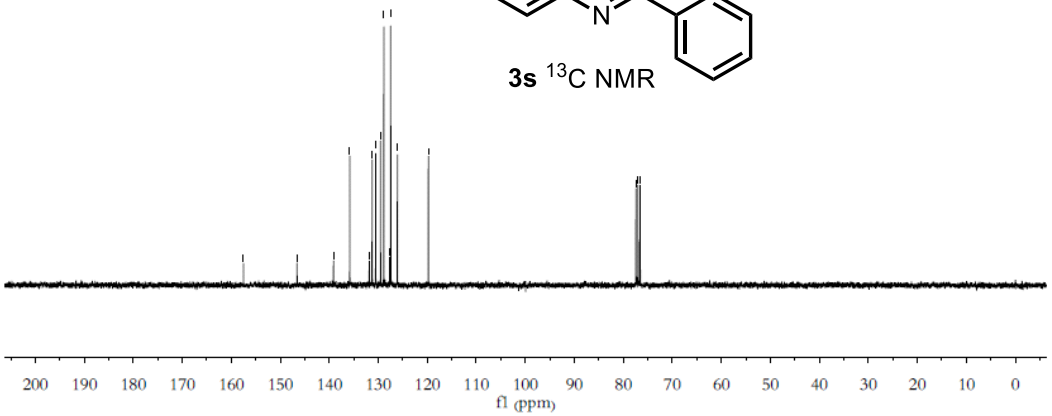
3s ^{1}H NMR

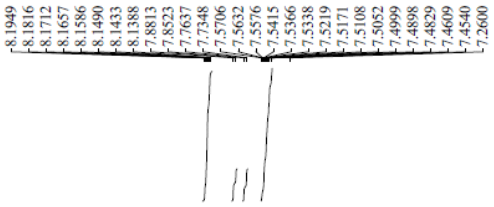


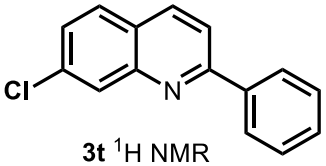




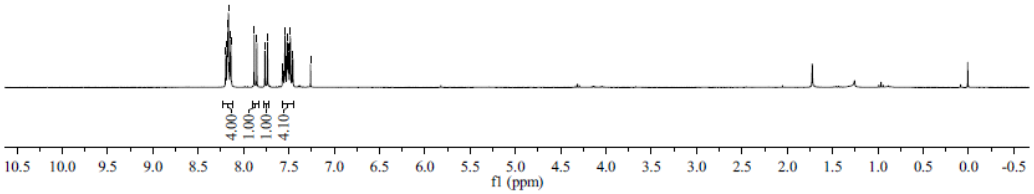
3s ^{13}C NMR

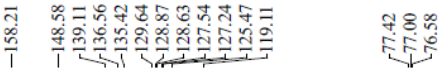


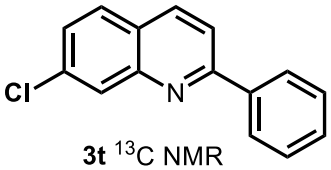




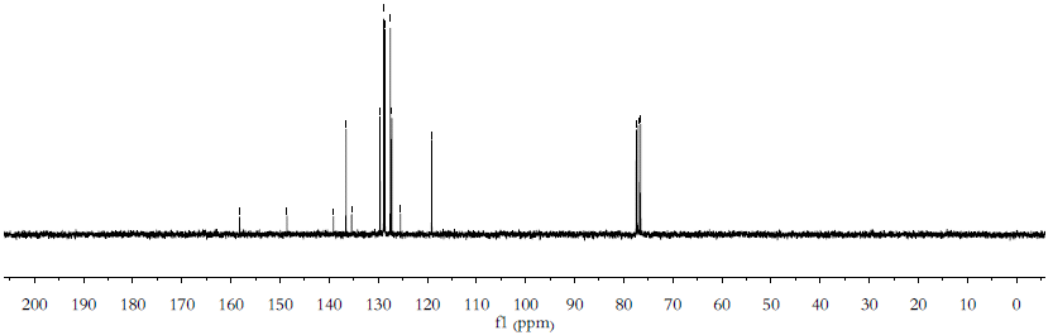
3t ^{1}H NMR

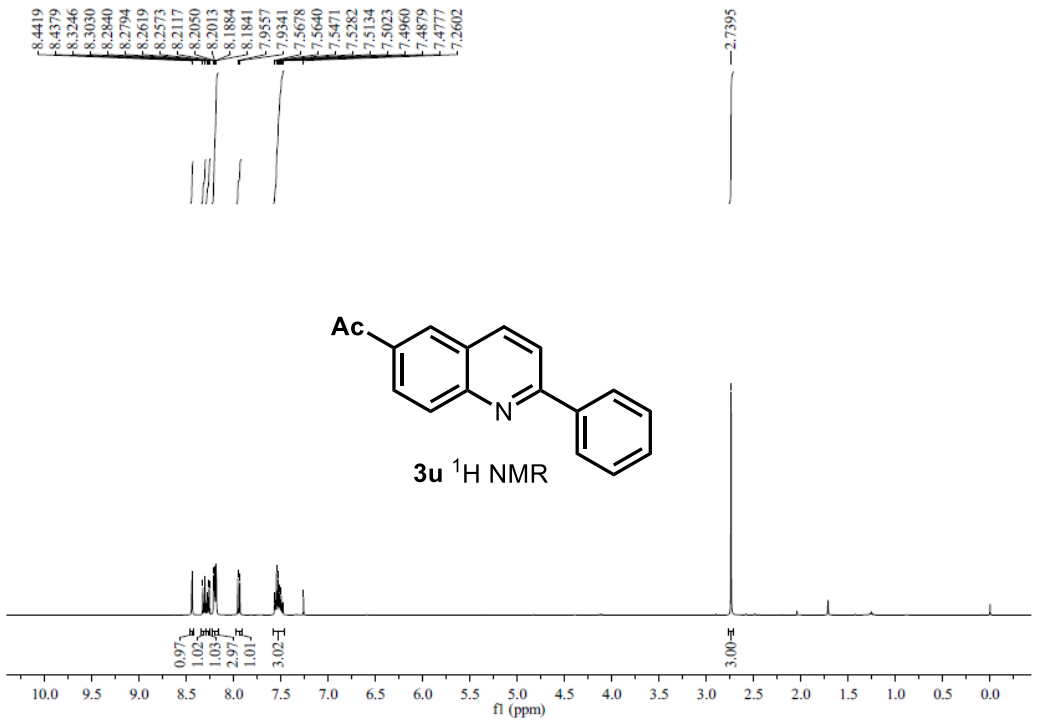






3t ^{13}C NMR

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8.1841
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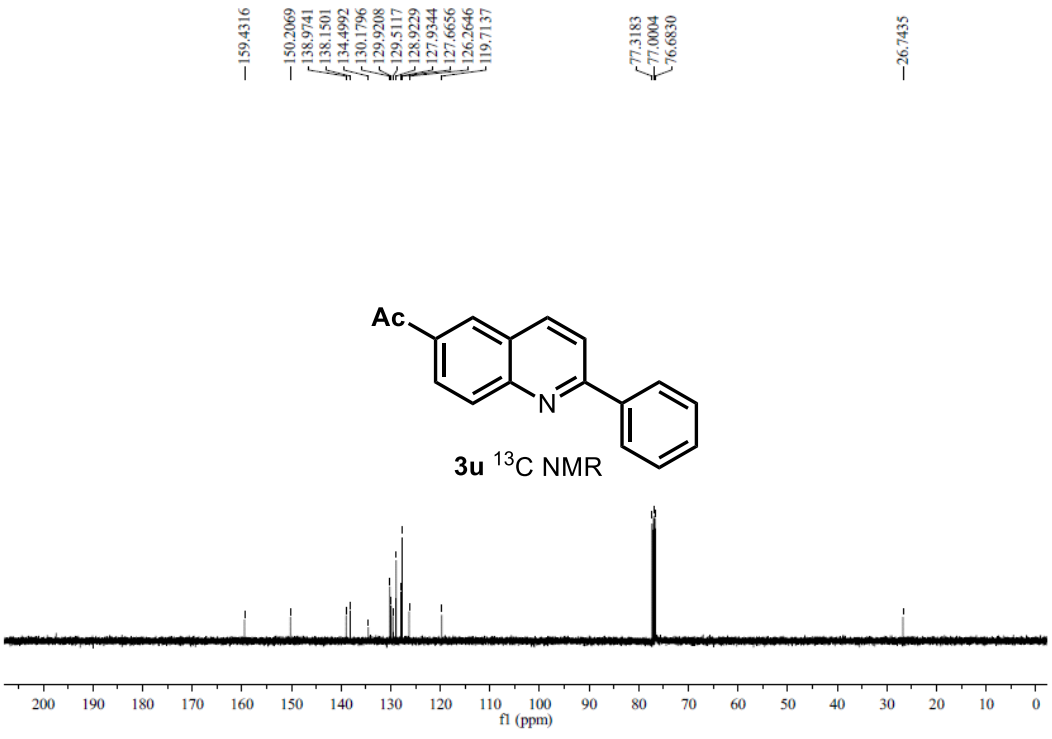
7.2602
2.7395
Ac
N
3u 1H NMR
0.97
1.02
1.03
2.97
1.01
3.02
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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26.7435
Ac
N
3u 13C NMR
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)