SUPPORTING INFORMATION

Study and application of graphene oxide on the synthesis of 2,3-disubstituted quinolines via Povarov multicomponent reaction and subsequent oxidation

Table of contents

General methods

^1H and ^{13}C NMR spectra were recorded on a Varian Mercury 300 (at 300 MHz, and 75 MHz respectively) or on JEOL 400 (at 400 MHz and 101 MHz respectively).
Unless otherwise stated, NMR spectra were recorded using residual solvent as the internal standard ^1H NMR: $CDCl_3$ = 7.26, CD_3OD = 4.87; $(CD_3)_2SO$ = 2.50; and ^{13}C NMR: $CDCl_3$ = 77.0; CD_3OD =49.0;$(CD_3)_2SO$ = 39.52. Data for ^1H NMR spectra are reported as follows: chemical shift (δ ppm), integration, multiplicity and coupling constants (Hz). Data for ^{13}C NMR spectra are reported in terms of chemical shift (δ ppm). Interpretation of spectra has been made also with the aid of gCOSY and gHSQC experiments. The following abbreviations are used to indicate the multiplicity in NMR spectra: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet.
I.R. spectra were recorded as solid, oil, or foamy samples, with the ATR (attenuated total reflectance) method.
TLC analyses were carried out on pre-coated Merck silica gel 60 F254 plates and viewed at UV (254 nm) and developed with Hanessian stain (dipping into a solution of $(NH_4)_4MoO_4\cdot 4H_2O$ (21 g) and $Ce(SO_4)_2\cdot 4H_2O$ (1 g) in H_2SO_4 (31 mL) and H_2O (469 mL) and warming). R_f were measured after an elution of 7–9 cm.
Column chromatographies were done with the "flash" methodology using 220–400 mesh silica. Petroleum ether (40–60 °C) is abbreviated as PE. In extractive work-up, aqueous solutions were always re-extracted three time with the appropriate organic solvent. Organic extracts were always dried over Na_2SO_4 and filtered, before evaporation of the solvent under reduced pressure.
All reactions using dry solvents were carried out under a nitrogen (or argon if specified) atmosphere. Unless otherwise noted, analytical grade solvents and commercially available reactants were used without further purification. Common reagents were purchased from commercial sources and were used without further purification. Graphene oxide (GO) was purchased from Graphenea and Abalonyx companies.
All products were characterized by ^1H,^{13}C NMR, IR and elemental analysis. The spectroscopic data of products were identical with the data reported in the literature.

Control experiments

Determination of the amount of Mn on GO (Graphenea): Quantification of the trace of Mn impurities contained within GO has been determined by using two methods. With ICP-OES (Inductively coupled plasma - optical emission spectrometry), we detected low quantities of Mn (4740 ppm) in GO Graphenea. Sample preparation: acidic digestion of Graphene oxide (10.3 mg, Graphenea) was dissolved in a mixture of HCl/HNO_3 (1 mL, 3:1) and heated at 110 °C for 24 h, then at 150 °C for 6 h. The mixture was cooled and diluted to 10 mL with milliQ water, and subsequently analyzed by ICP-OES, founding 4740 ppm of Mn. Alternatively, the sample has been digested by MW heating, obtaining similar results. Similar results (4400 ppm) were obtained by performing UV-Vis analysis of $KMnO_4$ after treatment of the sample with sulphuric acid and potassium periodate.

Povarov reaction with $MnCl_2$•$4H_2O$: to a solution of 4-chlorobenzaldehyde (35 mg, 0.25 mmol), aniline (30 mg, 30 µL, 0.33 mmol) and 2,3-dihydrofuran (26 mg, 28 µL, 0.38 mmol) in CH_3CN (0.3 mL), 6 µL of aq. solution of $MnCl_2$•$4H_2O$ (5mg/ml) was added and the mixture was stirred at rt for 24h. Then, the solvent was removed under vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 90:10) to afford **1a** (14 mg, 20%) as a mixture of diastereoisomers (*endo*/*exo* 80:20)

Oxidation reaction with $MnCl_2$•$4H_2O$: to a solution of pure ***endo*** **1a** (30 mg, 0.10 mmol) in CH_3CN/H_2O (1.00 mL), 10 µL of aq. solution of $MnCl_2$•$4H_2O$ (5mg/ml) was added and the mixture was stirred at 120 °C for 48 h. Then, the solvent was removed under vacuo to afford only unreacted ***endo*** **1a**.

GO recyclability experiments

GO reusability in Povarov reaction: reusability of GO (Graphenea) was verified for the standard reaction of 4-chlorobenzaldehyde (351 mg, 2.5 mmol), aniline (296 µL, 3.25 mmol) with 2,3-dihydrofuran (473 µL, 6.25 mmol) at room temperature for 24 h. The catalyst was recovered by dissolving the mixture in DCM/EtOAc 1:1 (10 mL) followed by centrifugation (5 min at 7800 rpm) for 4 times. The collected solutions were evaporated and the residue purified by column chromatography, giving **1a** (492 mg, 66%) as a mixture of diastereoisomers (*endo*/*exo* 80:20). The catalyst was washed with H_2O (20 mL), MeOH (20 mL) and acetone (20 mL), dried under vacuum overnight, and reused. This procedure was repeated for five reactions and **1a** was obtained with the yield of 48, 48, 41, 29 and 22%, respectively. The selectivity *endo*/*exo* resulted 80:20 by NMR of the crude after every run. The reusability experiments have been repeated by using commercial Abalonyx (S-126/36, No product 18000) affording **1a** in 60%, 46% and 45% yield, respectively. After the recyclability experiments, the recovered catalyst after the first and the last run were analyzed by XPS analysis.

GO reusability in oxidation reaction: reusability of GO (Graphenea) was verified for the standard reaction of ***endo*** **1a** (143 mg, 0.5 mmol) in CH_3CN/H_2O (4:1, 5.00 mL) at 120 °C for 48 h. The catalyst was recovered by dissolving the mixture in DCM/EtOAc 1:1 (10 mL) followed by centrifugation (5 min at 7800 rpm) for 4 times. The collected solutions were evaporated and the residue purified by column chromatography, giving **2a** (105 mg, 74%). The catalyst was washed with H_2O (2x5 mL), MeOH (2x5 mL) and acetone (2x5 mL), dried under vacuum overnight, and reused. This procedure was repeated for two reactions and **2a** was obtained with the yield of 49 and 49 %, respectively. After the recyclability experiments, the recovered catalyst after the first and the last run were analyzed by XPS analysis.

Note that GO Abalonyx must be sonicated for 30 min before used, as suggested by the vendor.

XPS analysis of GO (Graphenea and Abalonyx)

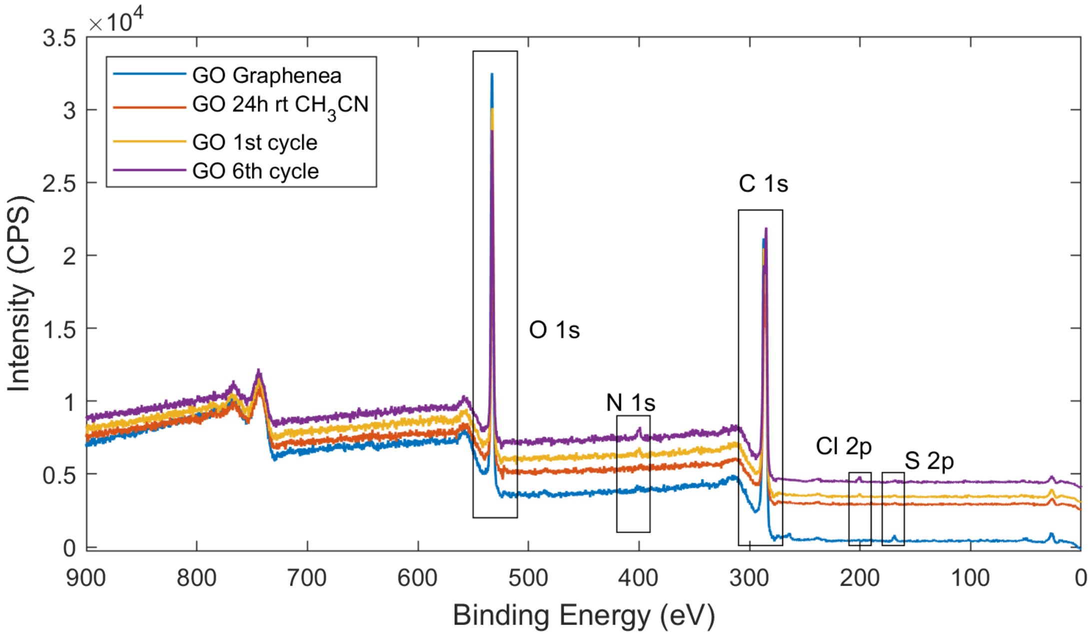


Figure S1. XPS Survey spectra of GO (Graphenea); GO after CH_3CN at room temperature for 24 h; GO after 1st cycle; GO after 6th cycle.

Elements Transition	Binding Energies eV	GO Graphenea	Control	1st cycle	6th cycle
C 1s	285	72.1 ± 0.9	71.8 ± 0.9	72.5 ± 0.9	73.4 ± 0.9
O 1s	532.7	26.1 ± 0.9	27.3 ± 0.9	26.2 ± 0.9	24.6 ± 0.9
N 1s	401-399	0.4±0.1	0.3±0.1	0.7±0.1	1.1±0.1
S 2p / S-O	168.5	0.40±0.05	0.4±0.1	0.4±0.0.1	0.20±0.05
Si 2p / Si-O	101.7	0.9±0.1	0.2±0.1	0.10±0.05	0.3±0.1
Mn $2p_{3/2}$ MnOx	641.8	0.15±0.03*	0.05±0.03	-	-
Cl 2p	199.8	-	-	0.20±0.05	0.4±0.1
O/C Area		0.36±0.01	0.38±0.01	0.36±0.01	0.34±0.01

Table S1. XPS Atomic composition of GO (Graphenea); GO after CH_3CN at room temperature for 24 h; GO after 1st cycle; GO after 6th cycle. *Mn sensitivity c.a. 0,03%.

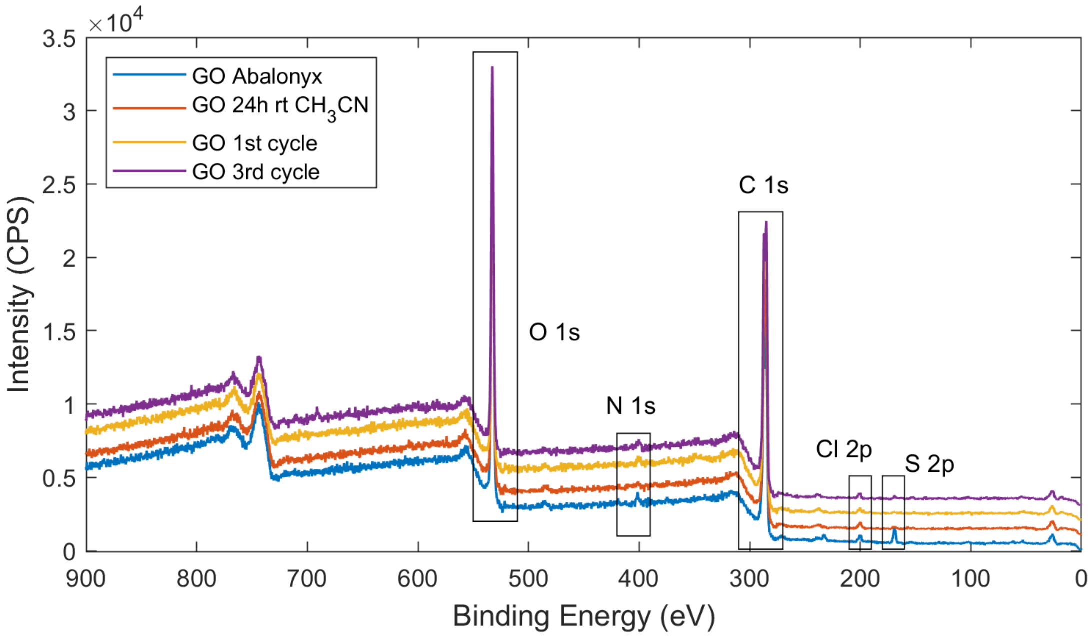


Figure S2. XPS Survey spectra of GO (Abalonyx GO); GO after CH_3CN at room temperature for 24 h; GO after 1st cycle; GO after 3rd cycle.

Elements	Binding Energies eV	GO Aba	Control	1st cycle	3rd cycle
C 1s	285	65.9 ± 0.9	70.3 ± 0.9	73.9 ± 0.9	73.5 ± 0.9
O 1s	532.7	30.3 ± 0.9	28.5 ± 0.9	24.5 ± 0.9	24.7 ± 0.9
N 1s	401-399	1.0±0.1	0.3±0.03	0.7±0.1	1.0±0.1
S 2p / S-O	168.5	1.8±0.2	0.20±0.05*	0.20±0.05	0.20±0.05
Si 2p / Si-O	101.7	0.4±0.1	0.3±0.1	0.2±0.1	0.3±0.1
Cl 2p	199.8	0.6±0.1	0.5±0.03	0.5±0.05	0.4±0.1
O/C Area		0.46±0.01	0.41±0.01*	0.33±0.01	0.34±0.01

Table S2. XPS Atomic composition of GO (Abalonyx GO); GO after CH_3CN at room temperature for 24 h; GO after 1st cycle; GO after 3rd cycle. O/C decrease mainly due to decrease of SO_4, not due reduction of C-O groups.

C groups In C1s XPS	GO Aba	Control	1st cycle	3rd Cycle
C=C sp^2 284.4 eV	32.9±0.9	30.0±0.9	29.6±0.9	31.5±0.9
C=C* -0.8 eV	4.4±0.4	5.4±0.9	4.8±0.9	4.3±0.5
C-C sp^3 +0.6	7.7±0.5	8.1±0.5	18.0±0.5	17.8±0.5
C-OH +1.8	18.0±0.4	19.8±0.4	11.8±0.4	11.0±0.4
C-O-C +2.4	28.3±0.9	28.3±0.9	28.7±0.9	29.0±0.9
C=O +3.8	6.6±0.5	7.2±0.5	5.1±0.5	4.6±0.5
O-C=O +4.7	2.2±0.2	1.1±0.2	2.0±0.2	1.9±0.2
O/C fit	0.43±0.02	0.43±0.02	0.35±0.02	0.34±0.02

Table S3. XPS C 1s fitting of GO (Abalonyx GO); GO after CH_3CN at room temperature for 24 h; GO after 1st cycle; GO after 3rd cycle.

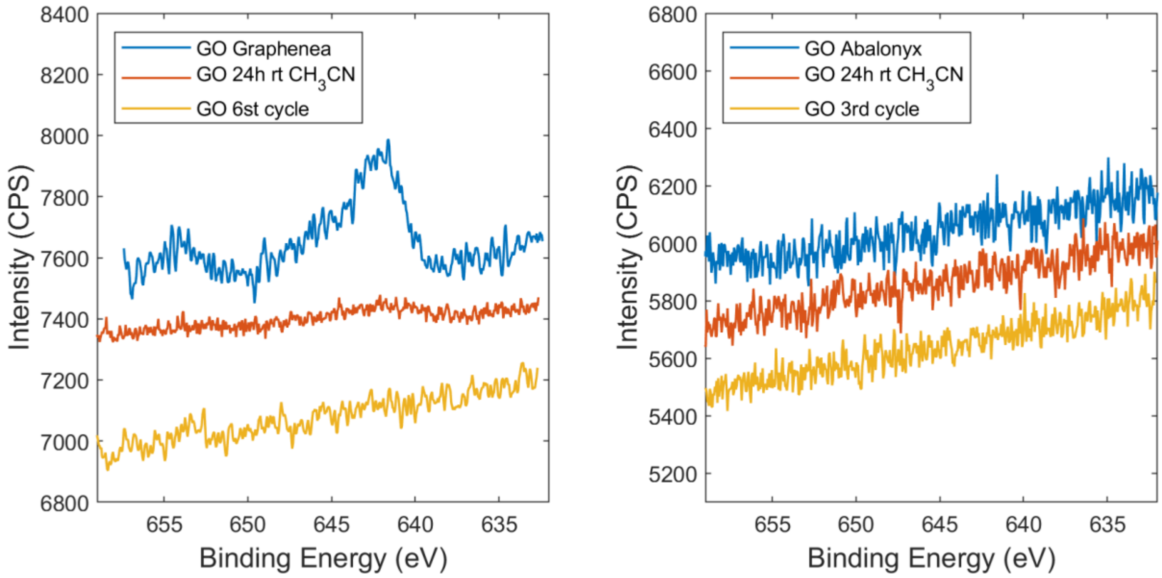


Figure S3. XPS Mn 2p spectra of GO (Graphenea); GO after CH_3CN at room temperature for 24 h; GO after 6th cycle (left). GO (Abalonyx); GO after CH_3CN at room temperature for 24 h; GO after 3rd cycle (right).

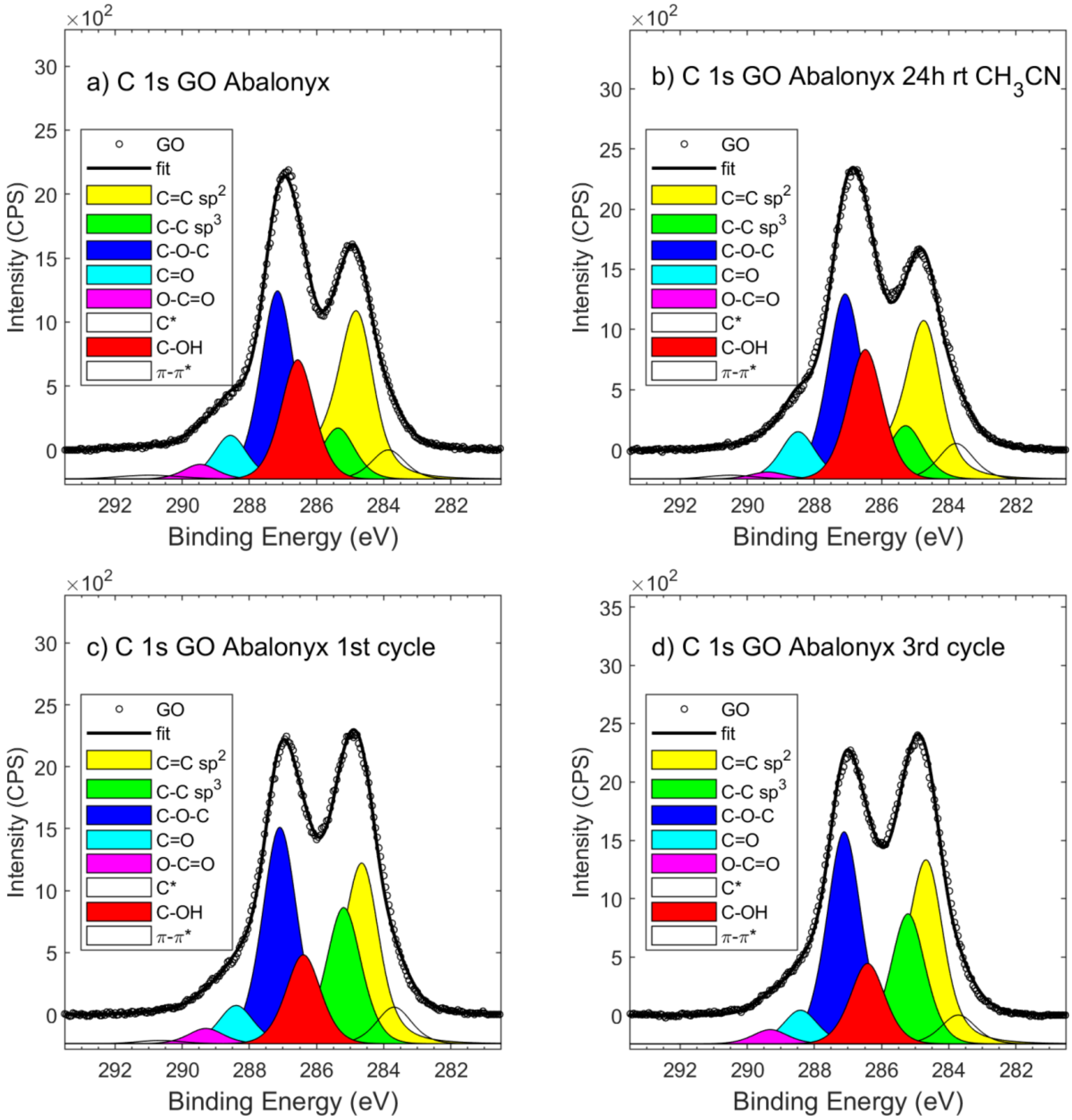


Figure S4. XPS C 1s signal of: a) commercial Abalonyx GO; b) GO after CH_3CN at room temperature for 24 h; c) GO after 1st cycle; d) GO after 3rd cycle.

C groups In C1s XPS	GO Graphenea	Control	1st cycle	6th cycle
C=C sp^2 284.4 eV	42.2±0.9	35.4±0.9	43.7±0.9	45.5±0.9
C=C* -0.8 eV	4.3±0.4	7.2±0.9	6.0±0.9	5.6±0.5
C-C sp^3 +0.6	3.9±0.5	6.4±0.5	3.4±0.5	7.0±0.5
C-OH +1.8	12.6±0.4	16.1±0.4	20.0±0.4	12.3±0.4
C-O-C +2.4	29.1±0.9	25.6±0.9	22.0±0.9	24.5±0.9
C=O +3.8	6.0±0.5	7.8±0.5	4.2±0.5	3.8±0.5
O-C=O +4.7	1.9±0.2	1.4±0.2	0.7±0.2	1.3±0.2
O/C fit	0.37±0.02	0.41±0.02	0.37±0.02	0.31±0.02

Table S4. XPS C 1s fitting of GO (Graphena GO); GO after CH_3CN at room temperature for 24 h; GO after 1st cycle; GO after 6th cycle.

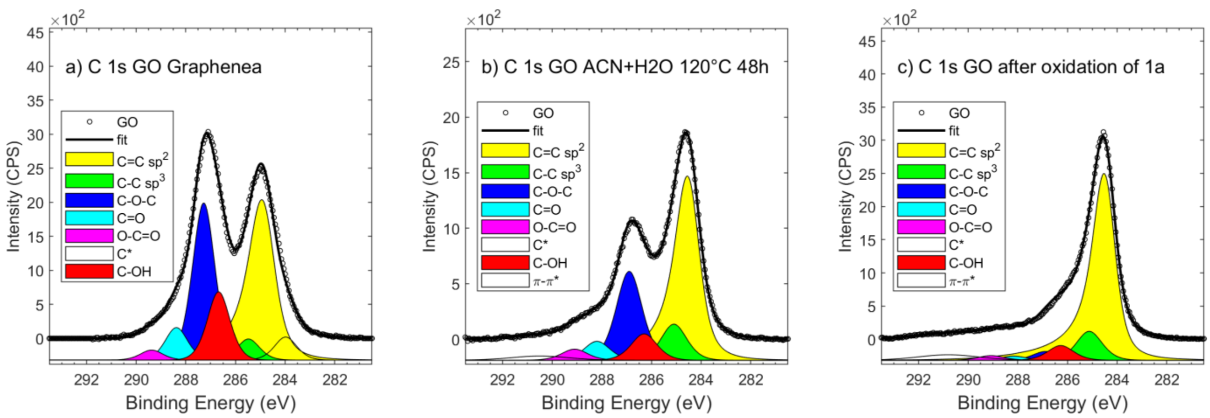


Figure S5. XPS C 1s signal of: a) commercial Graphenea GO; b) GO after CH_3CN/H_2O 4:1 at 120°C for 48 h; c) GO after oxidation. Sp^2 fraction was 42%, 54% and 78%, respectively.

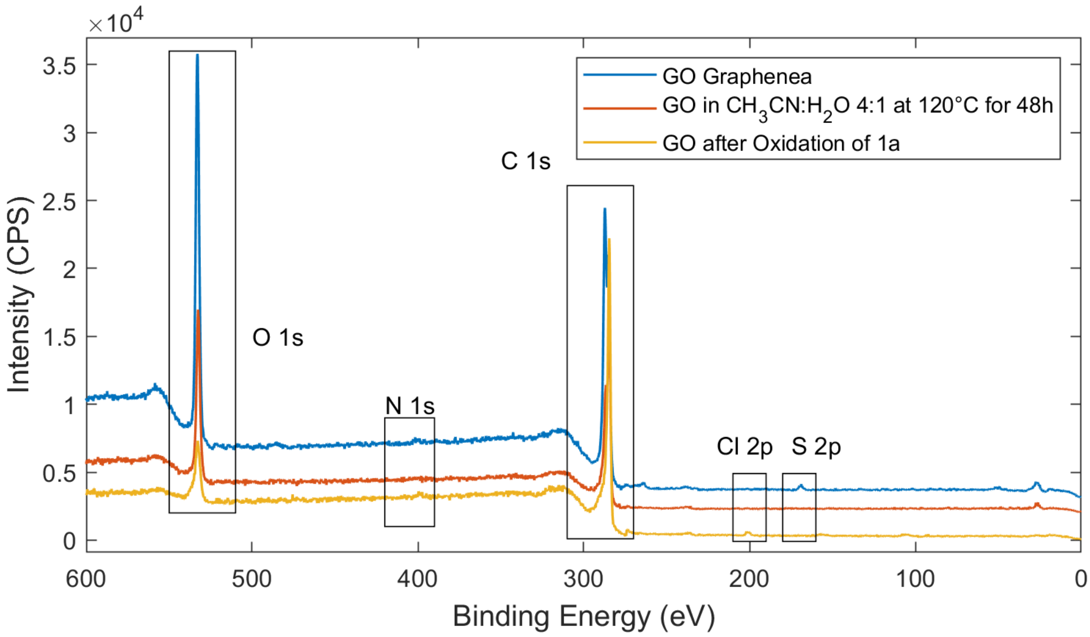


Figure S6. XPS survey spectra of commercial Abalonyx GO; GO after CH_3CN/H_2O 4:1 at 120°C for 48 h; GO after oxidation.

Elements	GO Graphenea	Control	GO after oxidation
C	72.1 ± 0.9	78.3 ± 0.9	88.2 ± 0.9
O	26.1 ± 0.9	21.4 ± 0.9	10.7 ± 0.9
N	0.4±0.1	0.3±0.1	0.4±0.1
S-O	0.40±0.05	-	-
Si-O	0.9±0.1	-	-
MnOx	0.15±0.03*	-	-
Cl	-	-	0.70±0.05
O/C Area	0.36±0.01	0.28±0.01	0.12±0.01

Table S5. XPS Atomic composition of GO (Graphenea); GO after CH_3CN/H_2O 4:1 at 120°C for 48 h; GO after oxidation. *Mn sensitivity c.a. 0,03%.

ssNMR analysis of GO (Graphenea and Abalonyx)

conditions	Csp2 130 ppm	C sp3 31 ppm	COH 70 ppm	C-O-C 60 ppm	O-C=O 167 ppm
GO Graphenea control in ACN, 24h, 20°C	30.0±0.9	-	25.9±0.9	43.3±0.9	0.8±0.3
GO Graphenea after 1 cycle	27.8±0.9	13.0±0.9	18.5±0.9	39.0±0.9	1.8±0.3
GO Graphenea after 6 cycles	30.1±0.9	14.4±0.9	20.7±0.9	34.6±0.9	0.3±0.2
GO Abalonyx control in ACN, 24h, 20°C	28.0±0.9	-	23.5±0.9	38.5±0.9	9.9±0.3
GO Abalonyx after 1 cycle	26.5±0.9	14.4±0.9	20.3±0.9	33.7±0.9	5.1±0.3
GO Abalonyx after 3 cycles	29.2±0.9	13.9±0.9	20.9±0.9	33.0±0.9	3.0±0.3

Table S6. Quantitative composition of GO in different conditions obtained by using ssNMR 13C direct excitation.

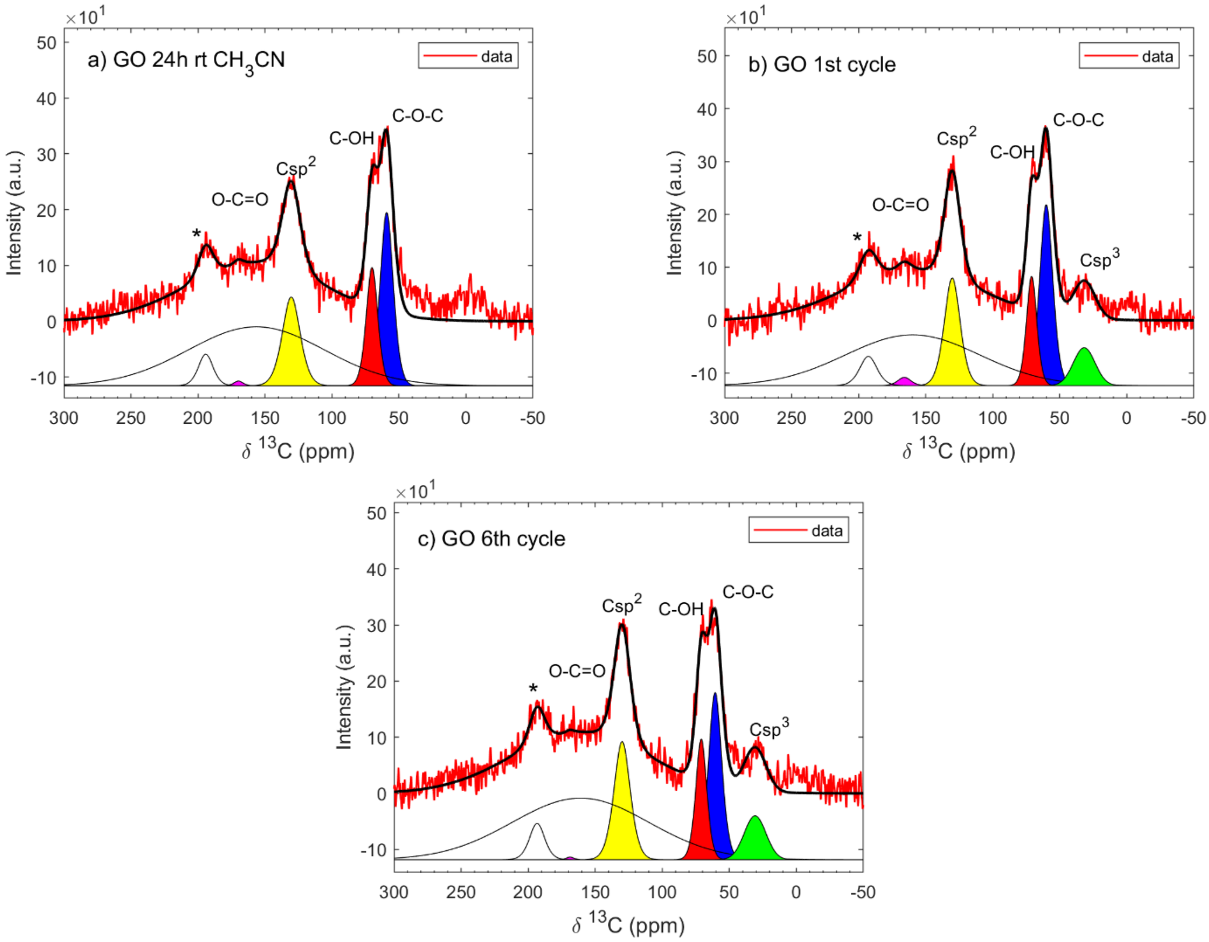


Figure S7. 13C direct excitation ssNMR spectra of GO (Graphenea) after CH_3CN at room temperature for 24 h; GO after 1st cycle; GO after 6th cycle. spinning side bands are marked with *.

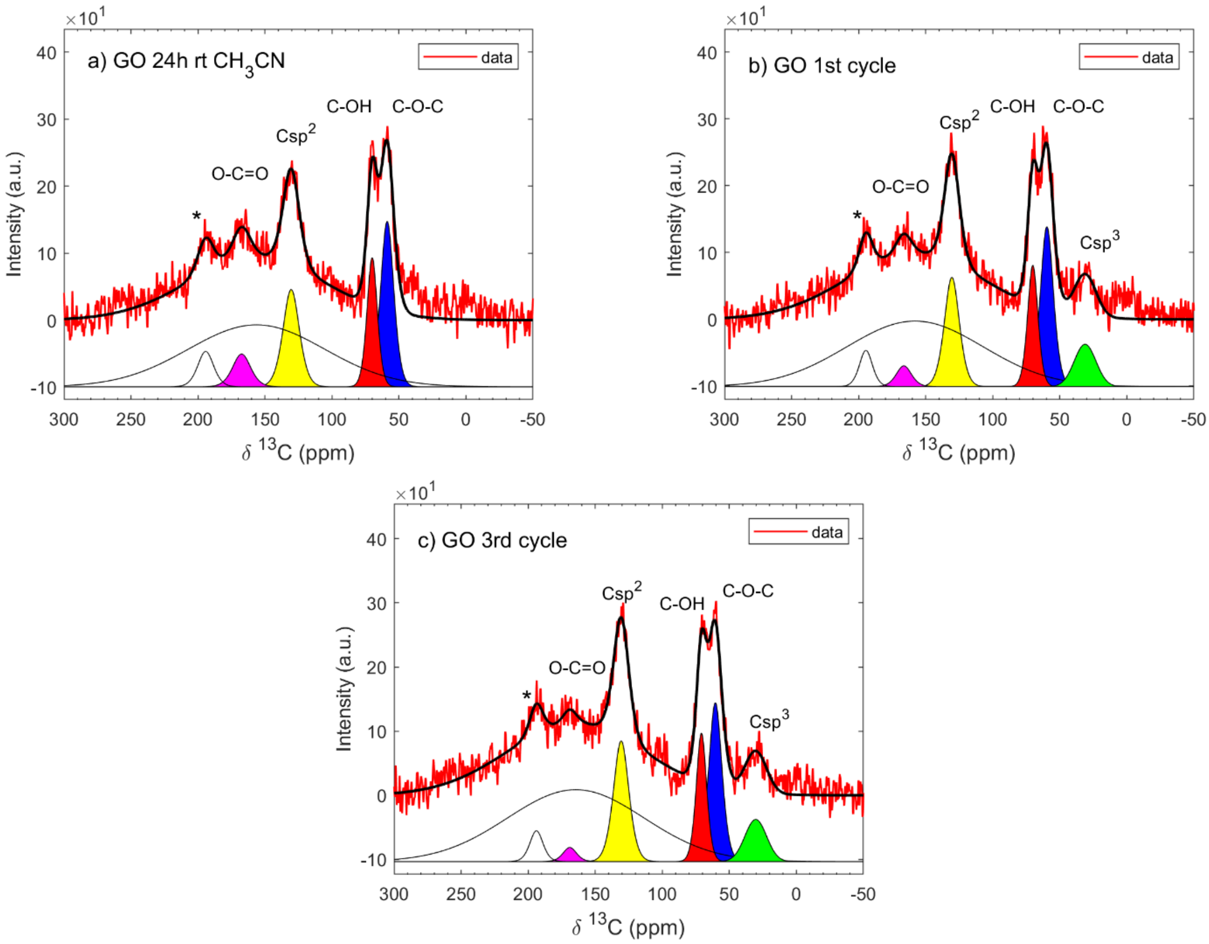
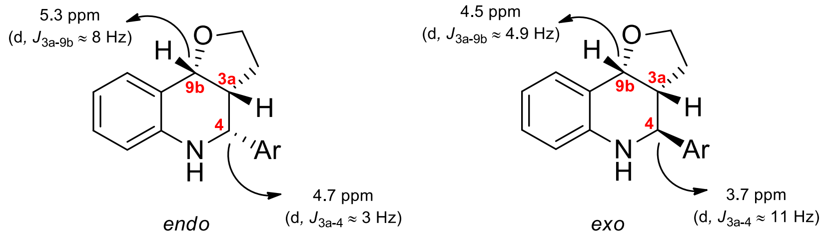
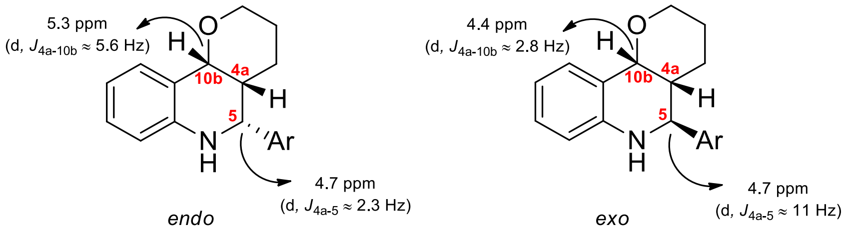


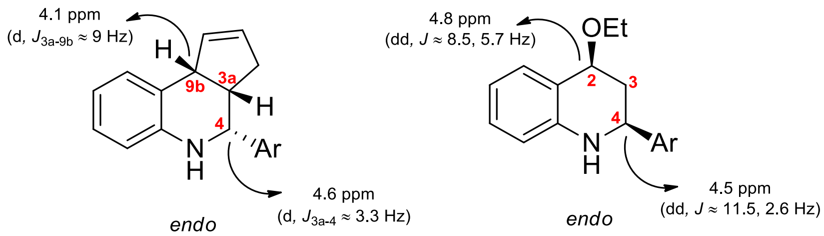
Figure S8. 13C direct excitation ssNMR spectra of GO (Abalonyx) after CH_3CN at room temperature for 24 h; GO after 1st cycle; GO after 3rd cycle.

Structural assignment of tetrahydroquinoline derivatives





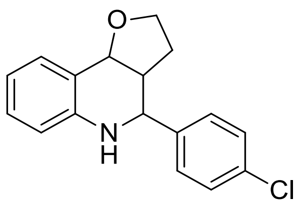
The stereochemistry of the furo- and pyrano- tetrahydroquinolines has been determined comparing coupling constants of protons 3*a*-9*b* and 3*a*-4, or 4*a*-10*b* and 4*a*-5 with the data reported on the litareture.[1]



The stereochemistry of cyclopentatetrahydroquinoline and of ethoxy-tetrahydroquinoline has been determined comparing coupling constants of protons 3a-9b and 3a-4, or 2-3 and 3-4 with the data reported on the litareture.[2]

Synthesis of 1 via Povarov reaction

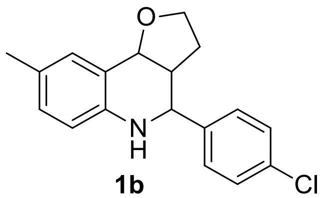
Synthesis of 4-(4-chlorophenyl)-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinoline 1a.



A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 4-chlorobenzaldehyde (35 mg, 0.25 mmol), aniline (30 mg, 30 µL, 0.325 mmol) and 2,3-dihydrofuran (26 mg, 28 µL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 4 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 85:15) to afford **1a** as a mixture of diastereoisomers (*endo*/*exo* 80:20 determined by ^{1}H NMR) as white solid (44 mg, 62%). Trituration from CH_3CN gave the pure ***endo*** **1a** as white powder. The physical and spectral data agreed with those reported.[3]

endo **1a:** R_f = 0.46 (PE/acetone 85:15); m.p. 204 - 206°C (CH_3CN) (Lit.[3] mp: 152–153 °C); I.R.: ῡ (cm^{-1}) = 3388, 3317, 3059, 2978, 2923, 2880, 2851, 1608, 1588, 1486, 1410, 1366, 1338, 1319, 1297, 1262, 1185, 1145, 1117, 1085, 1057, 1035, 1022, 1013, 996, 973, 942, 914, 884, 843, 824, 794, 751, 673; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.32 (m, 5H, 9-*H*, 4H-Ar), 7.10 (t, *J* = 7.5 Hz, 1H, 7-*H*), 6.83 (td, *J* = 7.4, 1.2 Hz, 1H, 8-*H*), 6.61 (dd, *J* = 8.0, 1.1 Hz, 1H, 6-*H*), 5.27 (d, *J* = 7.9 Hz, 1H, 9b-*H*), 4.68 (d, *J* = 3.1 Hz, 1H, 4-*H*), 3.88 – 3.77 (m, 2H, N-*H* and 2-*H*), 3.72 (td, *J* = 8.5, 6.9 Hz, 1H, 2-*H*), 2.81 – 2.70 (m, 1H, 3a-*H*), 2.23 – 2.10 (m, 1H, 3-*H*), 1.57 – 1.45 (m, 1H, 3-*H*); ^{13}C NMR (101 MHz, $CDCl_3$) δ 144.7, 140.8, 133.4, 130.2, 128.9, 128.6, 128.0, 122.7, 119.5, 115.2, 75.9, 66.9, 57.0, 45.7, 24.7; Anal. Calcd. for $C_{17}H_{16}ClNO$: % C 71.45; H 5.64; N 4.90; O 5.60: C 71.46; H 5.73; N 4.80; O 5.64.

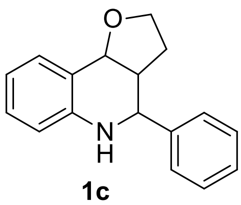
Synthesis of 4-(4-chlorophenyl)-8-methyl-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinoline 1b.



1b

A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 µL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 4-chlorobenzaldehyde (35 mg, 0.25 mmol), *p*-toluidine (35 mg, 36 µL, 0.33 mmol) and 2,3-dihydrofuran (26 mg, 28 µL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 24 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 85:15) to afford **1b** as a mixture of diastereoisomers (*endo*/*exo* 68:32 determined by ^{1}H NMR) as cream amorphous solid (30 mg, 40%). The physical and spectral data agreed with those reported.[4, 5] R_f = 0.30 (PE/acetone 90:10); I.R.: ῡ (cm^{-1}) = 3304, 2973, 2942, 2910, 2876, 1621, 1509, 1489, 1409, 1362, 1299, 1261, 1159, 1085, 1034, 819; ^{1}H NMR (300 MHz, $CDCl_3$) selected data for ***endo*** **1b**: δ 7.44 – 7.32 (m, 4H, 4*H*-Ar), 7.17 (d, *J* = 1.6 Hz, 1H, 9-*H*), 6.97 – 6.88 (m, 1H, 7-*H*), 6.55 (t, *J* = 7.8 Hz, 1H, 6-*H*), 5.24 (d, *J* = 8.0 Hz, 1H, 9b-*H*), 4.62 (d, *J* = 3.1 Hz, 1H, 4-*H*), 3.89 – 3.77 (m, 1H, 2-*H*), 3.77 – 3.66 (m, 2H, N-*H* and 2-*H*), 2.81 – 2.68 (m, 1H, 3a-*H*), 2.27 (s, 3H, CH_3), 2.24 – 2.09 (m, 1H, 3-*H*), 1.55 – 1.43 (m, 1H, 3-*H*); ^{13}C NMR (75 MHz, $CDCl_3$) selected data for ***endo*** **1b**: δ 142.5, 141.0, 133.3, 130.5, 129.7, 129.3, 128.9, 128.0, 122.7, 115.2, 76.0, 66.9, 57.3, 45.9, 24.7, 20.7.

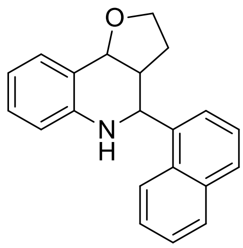
Synthesis of 4-phenyl-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinoline 1c.



1c

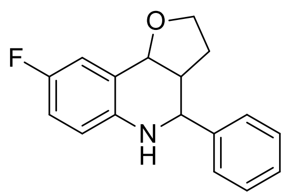
A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then benzaldehyde (26 mg, 25 μL, 0.25 mmol), aniline (30 mg, 30 μL, 0.33 mmol) and 2,3-dihydrofuran (26 mg, 28 μL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 4 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 85:15) to afford **1c** as a mixture of diastereoisomers (*endo*/*exo* 79:21) as amber foam (39 mg, 62%). The physical and spectral data agreed with those reported.[6, 7] R_f = 0.49 (PE/acetone 80:20); I.R.: ῡ (cm^{-1}) =3345, 3293, 3059, 3027, 2971, 2939, 2881, 1609, 1588, 1484, 1451, 1368, 1337, 1294, 1253, 1197, 1159, 1143, 1082, 1058, 1038, 1020, 994, 967, 941, 912, 855, 752, 708, 646; ^{1}H NMR (400 MHz, $CDCl_3$) selected data for ***endo*** **1c**: δ 7.50 – 7.30 (m, 6H, 9-*H* and 5*H*-Ph), 7.10 (t, *J* = 7.6 Hz, 1H, 7-*H*), 6.83 (td, *J* = 7.5, 1.2 Hz, 1H, 8-*H*), 6.61 (dd, *J* = 8.1, 1.2 Hz, 1H, 6-*H*), 5.29 (d, *J* = 8.0 Hz, 1H, 9b-*H*), 4.71 (d, *J* = 3.1 Hz, 1H, 4-*H*), 3.90 – 3.78 (m, 2H, N-*H* and 2-*H*), 3.73 (td, *J* = 8.5, 6.8 Hz, 1H, 2-*H*), 2.85 – 2.74 (m, 1H, 3a-*H*), 2.29 – 2.15 (m, 1H, 3-*H*), 1.53 (dddd, *J* = 11.8, 8.1, 6.9, 3.4 Hz, 1H, 3-*H*); ^{13}C NMR (101 MHz, $CDCl_3$) selected data for ***endo*** **1c**: δ 145.1, 142.2, 130.2, 128.8, 128.5, 127.8, 126.6, 122.8, 119.3, 115.1, 76.1, 66.9, 57.6, 45.9, 24.8.

Synthesis of 4-(naphthalen-1-yl)-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinoline 1d.



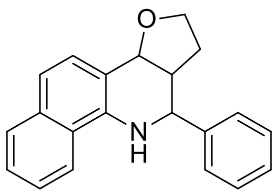
A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 µL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 1-naphthaldehyde (39 mg, 34 µL, 0.25 mmol), aniline (30 mg, 30 µL, 0.33 mmol) and 2,3-dihydrofuran (26 mg, 28 µL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 4 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 85:15) to afford **1d** as a mixture of diastereoisomers (*endo*/*exo* 81:19) as white foam (35 mg, 47%); R_f = 0.40 (PE/acetone 80:20); I.R.: ῡ (cm^{-1}) = 3354, 3312, 3049, 2972, 2931, 2872, 1609, 1589, 1478, 1382, 1339, 1322, 1295, 1257, 1191, 1169, 1156, 1138, 1061, 1026, 979, 908, 802, 782, 749, 641; ^{1}H NMR (300 MHz, $CDCl_3$) selected data for ***endo*** **1d**: δ 8.13 – 8.05 (m, 1H, 1*H*-Ar), 7.96 – 7.81 (m, 3H, 3*H*-Ar), 7.61 – 7.48 (m, 3H, 3*H*-Ar), 7.41 (dd, *J* = 7.7, 1.6 Hz, 1H, 9-*H*), 7.13 (t, *J* = 7.6 Hz, 1H, 7-*H*), 6.86 (td, *J* = 7.4, 1.2 Hz, 1H, 8-*H*), 6.68 (dd, *J* = 8.0, 1.2 Hz, 1H, 6-*H*), 5.53 (d, *J* = 2.7 Hz, 1H, 4-*H*), 5.40 (d, *J* = 8.1 Hz, 1H, 9b-*H*), 3.90 – 3.76 (m, 2H, N-*H* and 2-*H*), 3.67 (td, *J* = 8.6, 6.7 Hz, 1H, 2-*H*), 3.17 – 3.02 (m, 1H, 3a-*H*), 2.32 – 2.14 (m, 1H, 3-*H*), 1.35 (dddd, *J* = 12.0, 8.4, 6.8, 3.5 Hz, 1H, 3-*H*); ^{13}C NMR (75 MHz, $CDCl_3$) selected data for ***endo*** **1d**: δ 145.7, 137.7, 134.0, 130.4, 129.3, 128.6, 128.2, 126.5, 125.9, 125.7(x2), 123.2, 123.2, 122.3, 119.5, 115.39, 76.1, 67.0, 53.4, 43.9, 25.3.

Synthesis of 8-fluoro-4-phenyl-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinoline 1e.



A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 µL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then benzaldehyde (26 mg, 25 µL, 0.25 mmol), 4-fluoroaniline (36 mg, 31 µL, 0.33 mmol) and 2,3-dihydrofuran (26 mg, 28 µL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 4 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 85:15) to afford **1e** as a mixture of diastereoisomers (*endo*/*exo* 82:18) as yellow foam (35 mg, 52%); R_f = 0.27 (PE/acetone 90:10)**;** I.R.: ῡ (cm^{-1}) = 3371, 3291, 3032, 2974, 2921, 2888, 1601, 1496, 1479, 1451, 1368, 1356, 1333, 1315, 1298, 1248, 1213, 1150, 1136, 1092, 1058, 1028, 997, 979, 937, 923, 875, 808, 776, 734, 705; ^{1}H NMR (400 MHz, $CDCl_3$) selected data for ***endo*** **1e**: δ 7.48 – 7.30 (m, 5H, Ph), 7.07 (ddd, *J* = 9.2, 2.9, 0.7 Hz, 1H, 9-*H*), 6.81 (td, *J* = 8.5, 3.0 Hz, 1H, 7-*H*), 6.54 (dd, *J* = 8.8, 4.6 Hz, 1H, 6-*H*), 5.23 (d, *J* = 7.9 Hz, 1H, 9b-*H*), 4.66 (d, *J* = 3.0 Hz, 1H, 4-*H*), 3.88 – 3.69 (m, 3H, N-*H* and 2-C*H*$_2$), 2.84 – 2.71 (m, 1H, 3a-*H*), 2.26 – 2.12 (m, 1H, 3-*H*), 1.53 (dddd, *J* = 11.9, 8.2, 6.9, 3.4 Hz, 1H, 3-*H*); ^{13}C NMR (101 MHz, $CDCl_3$) selected data for ***endo*** **1e**: δ 156.7, 142.1, 141.2, 128.8, 128.4, 127.9, 126.6, 116.0, 115.9, 115.5, 75.9, 67.1, 57.8, 45.6, 24.5.

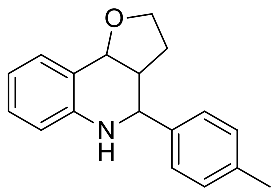
Synthesis of 1-phenyl-1,2,3a,10,11,11a-hexahydrobenzo[h]furo[3,2-c]quinoline 1f



A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then benzaldehyde (26 mg, 25 μL, 0.25 mmol), 1-naphthylamine (47 mg, 0.33 mmol) and 2,3-dihydrofuran (26 mg, 28 μL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 24 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 80:20) to afford **1f** as a mixture of diastereoisomers (*endo*/*exo* 46:54) as pink foam (22 mg, 29%);

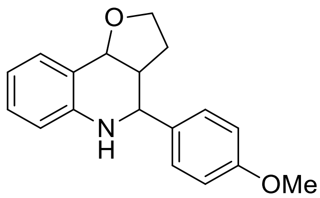
R_f = 0.54 (PE/acetone 80:20); I.R.: ῡ (cm^{-1}) = 3356, 3057, 2930, 2872, 1626, 1576, 1520, 1463, 1453, 1407, 1366, 1339, 1317, 1297, 1145, 1090, 1038, 952, 907, 857, 803, 764, 732, 700, 662; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.84 – 7.29 (m, 22H, aromatics, *endo* and *exo*), 5.49 (d, *J* = 7.8 Hz, 1H, 9b-*H* of *endo*), 4.90 (brs, 1H, N-*H*, *exo*), 4.83 (d, *J* = 3.0 Hz, 1H, 4-*H*, *endo*), 4.73 (d, *J* = 5.0 Hz, 1H, 9b-*H*, *exo*), 4.58 (brs, 1H, N-*H*, *endo*), 4.09 (td, *J* = 8.5, 5.9 Hz, 1H, 2-*H*, *exo*), 3.95 – 3.85 (m, 2H, 2-*H* and 4-*H*, *exo*), 3.81 – 3.74 (m, 2H, 2-C*H*$_2$, *endo*), 2.95 – 2.82 (m, 1H, 3a-*H*, *endo*), 2.56 (dddd, *J* = 11.1, 7.6, 5.1, 2.1 Hz, 1H, 3a-*H*, *exo*), 2.10 (dddd, *J* = 13.1, 9.2, 8.0, 5.9 Hz, 1H, 3-*H*, *exo*), 2.35 – 2.24 (m, 1H, 3-*H*, *endo*), 1.85 – 1.72 (m, 1H, 3-*H*, *exo*), 1.61 (dddd, *J* = 12.5, 8.3, 6.1, 4.5 Hz, 1H, 3-H, *endo*). ^{13}C NMR (75 MHz, $CDCl_3$) δ 142.5, 141.8, 140.8, 139.6, 134.2, 133.8, 128.95, 128.93, 128.9, 128.8, 128.7, 128.6, 128.4, 128.0, 127.6, 126.9, 126.1, 126.0, 125.3, 125.1, 122.9, 122.9, 120.2, 120.0, 119.0, 118.2, 116.8, 114.3, 76.8 (*endo*), 76.7 (*exo*), 66.8 (*endo*), 65.4 (*exo*), 58.2 (*exo*), 57.7 (*endo*), 45.5 (*endo*), 43.1 (*exo*), 29.0 (*exo*), 24.6 (*endo*).

Synthesis of 4-(p-tolyl)-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinoline 1g.



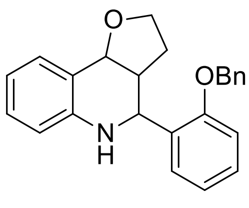
A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then *p*-tolualdehyde (30 mg, 29 μL, 0.25 mmol), aniline (30 mg, 30 μL, 0.33 mmol) and 2,3-dihydrofuran (26 mg, 28 μL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 4 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 85:15) to afford **1g** as a mixture of diastereoisomers (*endo*/*exo* 85:15) as white foam (44 mg, 66%). The physical and spectral data agreed with those reported;[8] R_f = 0.48 (PE/acetone 80:20); I.R.: ῡ (cm^{-1}) = 3367, 3327, 3052, 3027, 2978, 2936, 2883, 1905, 1796, 1609, 1587, 1515, 1488, 1469, 1420, 1364, 1336, 1318, 1296, 1253, 1186, 1147, 1129, 1112, 1087, 1049, 1038, 1020, 995, 971, 942, 911, 849, 820, 748, 685, 634; ^{1}H NMR (400 MHz, $CDCl_3$) selected data for ***endo*** **1g**: δ 7.38 – 7.32 (m, 3H, 9-*H* and 2*H*-Ar), 7.24 – 7.18 (m, 2H, 2*H*-Ar), 7.09 (t, *J* = 7.8 Hz, 1H, 7-*H*), 6.82 (td, *J* = 7.4, 1.1 Hz, 1H, 8-*H*), 6.60 (dd, *J* = 8.1, 1.2 Hz, 1H, 6-*H*), 5.28 (d, *J* = 8.0 Hz, 1H, 9b-*H*), 4.67 (d, *J* = 3.0 Hz, 1H,4-*H*), 3.88 – 3.78 (m, 2H, N-*H* and 2-*H*), 3.72 (td, td, *J* = 8.5, 6.8 Hz, 1H, 2-*H*), 2.82 – 2.73 (m, 1H, 3a-*H*), 2.38 (s, 3H, CH_3), 2.28 – 2.16 (m, 1H, 3-*H*), 1.55 (dddd, *J* = 11.8, 8.1, 6.8, 3.4 Hz, 1H, 3-*H*); ^{13}C NMR (101 MHz, $CDCl_3$) selected data for ***endo*** **1g**: δ 145.2, 139.3, 137.5, 130.2, 129.4, 128.4, 126.6, 122.8, 119.2, 115.0, 76.1, 57.4, 45.9, 24.8, 21.2.

Synthesis of 4-(4-methoxyphenyl)-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinoline 1h.



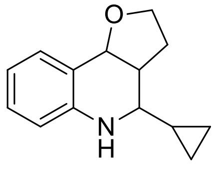
A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 4-methoxybenzaldehyde (34 mg, 30 μL, 0.25 mmol), aniline (30 mg, 30 μL, 0.33 mmol) and 2,3-dihydrofuran (26 mg, 28 μL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 4 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 85:15) to afford **1h** as a mixture of diastereoisomers (*endo*/*exo* 85:15) as white foam (50 mg, 71%). The physical and spectral data agreed with those reported;[8] R_f = 0.31 (PE/acetone 80:20); I.R.: ῡ (cm^{-1}) = 3349, 2968, 2925, 2877, 2835, 1606, 1587, 1512, 1479, 1452, 1436, 1366, 1331, 1290, 1240, 1175, 1156, 1111, 1065, 1027, 994, 967, 928, 828, 796, 775, 749, 696, 638; ^{1}H NMR (400 MHz, $CDCl_3$) selected data for ***endo*** **1h**: δ 7.44 – 7.33 (m, 3H, 9-*H*, 2*H*-Ar), 7.09 (t, 1H, 7-*H*), 6.96 – 6.88 (m, 2*H*, 2H-Ar), 6.81 (td, *J* = 7.4, 1.2 Hz, 1H, 8-*H*), 6.59 (dd, *J* = 8.1, 1.1 Hz, 1H, 6-*H*), 5.27 (d, *J* = 7.9 Hz, 1H, 9b-*H*), 4.65 (d, *J* = 3.0 Hz, 1H, 4-*H*), 3.88 – 3.79 (m, 5H, C*H*$_3$, N-*H* and 2-*H*), 3.72 (td, *J* = 8.6, 6.8 Hz, 1H, 2-*H*), 2.82 – 2.68 (m, 1H, 3a-*H*), 2.30 – 2.12 (m, 1H, 3-*H*), 1.62 – 1.49 (m, 1H, 3-*H*); ^{13}C NMR (101 MHz, $CDCl_3$) selected data for ***endo*** **1h**: δ 159.2, 145.2, 134.4, 130.3, 128.5, 127.8, 122.8, 119.2, 115.0, 114.1, 76.1, 67.0, 57.1, 55.5, 46.1, 24.8.

Synthesis of 4-(2-(benzyloxy)phenyl)-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinoline 1i



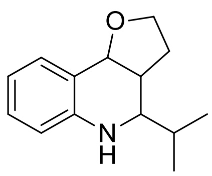
A 5 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (20 mg) and CH_3CN (1 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 2-benzyloxybenzaldehyde (212 mg, 158 μL, 1.00 mmol), aniline (121 mg, 118 μL, 1.30 mmol) and 2,3-dihydrofuran (105 mg, 113 μL, 1.50 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 24 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (30 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 80:20) to afford **1i** as a mixture of diastereoisomers (*endo*/*exo* 60:40) as white foam (64 mg, 60%). The diastereoisomers were separated by a second flash column chromatography, eluting with PE/EtOAc (95:5 to 90:10) to afford ***endo*** **1i** (128 mg, 36%) as white solid and then ***exo*** **1i** (86 mg, 24%) as white foam; ***endo*** **1i:** mp 119-121°C (DCM)**;** R_f = 0.35 (PE/EtOAc 90:10); I.R.: ῡ (cm^{-1}) =3335, 3045, 2960, 2922, 2896, 1629, 1599, 1551, 1492, 1452, 1400, 1375, 1336, 1283, 1240, 1164, 1114, 1079, 1025, 1001, 971, 927, 910, 864, 802, 753, 704, 670, 644, 620; ^1H NMR (300 MHz, $CDCl_3$) δ 7.68 (dd, *J* = 7.8, 1.8 Hz, 1H, 1*H*-Ar), 7.47 – 7.25 (m, 7H, 5*H*-benzyl, 1*H*-Ar, 9-*H*), 7.13 – 6.97 (m, 3H, 2*H*-Ar and 7-*H*), 6.82 (td, *J* = 7.4, 1.2 Hz, 1H, 8-*H*), 6.61 (dd, *J* = 8.0, 1.2 Hz, 1H, 6-*H*), 5.26 (d, *J* = 8.1 Hz, 1H, 9b-*H*), 5.21 – 5.06 (m, 3H, 4-*H* and CH_2 of benzyl), 3.83 (td, *J* = 8.5, 3.6 Hz, 1H, 2-*H*), 3.78 – 3.67 (m, 2H, N-*H* and 2-*H*), 3.12 – 2.97 (m, 1H, 3a-*H*), 2.27 – 2.10 (m, 1H, 3-*H*), 1.51 (dddd, *J* = 12.1, 8.3, 6.9, 3.6 Hz, 1H, 3-*H*); ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.5, 145.7, 137.0, 130.8, 130.3, 128.8, 128.4, 128.3, 128.1, 127.1, 126.7, 123.1, 121.1, 119.2, 115.2, 111.7, 76.0, 70.0, 66.9, 51.0, 42.5, 25.1; Anal. Calcd. for $C_{24}H_{23}NO_2$: % C 80.64; H 6.49; N 3.92; O 8.95, found: C 80.70; H 6.52; N 3.80; O 8.96; ***exo*** **1i:** R_f = 0.29 (PE/EtOAc 90:10); I.R.: ῡ (cm^{-1}) = 3372, 3326, 3032, 2926,2857, 1602, 1587, 1488, 1451, 1364, 1287, 1237, 1158, 1086, 1039, 909, 852, 796, 748, 696, 633; ^1H NMR (300 MHz, $CDCl_3$) δ 7.58 (dd, *J* = 7.6, 1.8 Hz, 1H, 1*H*-Ar), 7.46 – 7.26 (m, 7H, 5*H*-benzyl, 1*H*-Ar and 9-*H*), 7.16 – 7.00 (m, 3H, 2*H*-Ar and 7-*H*), 6.79 (td, *J* = 7.4, 1.2 Hz, 1H, 8-*H*), 6.60 (dd, *J* = 8.1, 1.1 Hz, 1H, 6-*H*), 5.11 (s, 2H, CH_2-benzyl), 4.64 (d, *J* = 5.0 Hz, 1H, 9b-*H*), 4.57 (d, *J* = 11.0 Hz, 1H, 4-*H*), 4.07 (brs, 1H, N-*H*), 3.98 – 3.87 (m, 1H, 2-*H*), 3.82 (ddd, *J* = 9.3, 8.3, 5.4 Hz, 1H, 2-*H*), 2.51 (dddd, *J* = 11.0, 7.5, 5.0, 2.1 Hz, 1H, 3a-*H*), 2.06 (dddd, *J* = 12.8, 9.2, 7.8, 6.9 Hz, 1H, 3-*H*), 1.85 (dddd, *J* = 13.0, 7.8, 5.4, 2.1 Hz, 1H, 3-*H*); ^{13}C NMR (75 MHz, $CDCl_3$) δ 156.8, 145.9, 136.8, 131.2, 130.8, 128.9, 128.79, 128.77, 128.6, 128.2, 127.5, 121.6, 120.3, 118.3, 114.9, 112.2, 76.3, 70.5, 65.6, 49.1, 43.4, 29.1; Anal. Calcd. for $C_{24}H_{23}NO_2$: % C 80.64; H 6.49; N 3.92; O 8.95, found: C 80.72; H 6.54; N 3.85; O 8.85.

Synthesis of 4-cyclopropyl-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinoline 1j



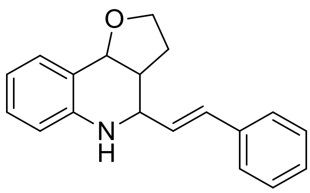
A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then cyclopropanecarboxaldehyde (18 mg, 19 μL, 0.25 mmol), aniline (30 mg, 30 μL, 0.33 mmol) and 2,3-dihydrofuran (26 mg, 28 µL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 24 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 85:15) to afford afford ***endo* 1j** (25 mg, 47%) as white solid and ***exo* 1j** (6 mg, 11%) as white foam. The ratio *endo*/*exo* was determined by ^{1}H NMR of the crude and resulted 80:20; ***endo* 1j:** mp 130-133°C (DCM); R_f = 0.40 (PE/EtOAc 90:10); I.R.: ῡ (cm^{-1}) = 3314, 3079, 3061, 3007, 2977, 2952, 2928, 1607, 1590, 1500, 1490, 1452, 1428, 1397, 1363, 1328, 1300, 1268, 1257, 1201, 1148, 1115, 1059, 1045, 1034, 1023, 1015, 1005, 973, 937, 926, 911, 876, 826, 784, 752, 704, 672; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.29 (dd, *J* = 7.7, 1.6 Hz, 1H, 9-*H*), 7.04 (td, *J* = 7.7, 1.6 Hz, 1H, 7-*H*), 6.74 (td, *J* = 7.4, 1.2 Hz, 1H, 8-*H*), 6.53 (dd, *J* = 8.1, 1.2 Hz, 1H, 6-*H*), 5.08 (d, *J* = 8.0 Hz, 1H, 9b-*H*), 3.87 – 3.79 (m, 2H, 2-CH_2), 3.77 (brs, 1H, N-*H*), 2.81 – 2.68 (m, 1H, 3a-*H*), 2.50 (dd, *J* = 9.6, 3.0 Hz, 1H, 4-*H*), 2.26 – 2.10 (m, 1H, 3-*H*), 2.10 – 1.94 (m, 1H, 3-*H*), 1.06 – 0.92 (m, 1H, C*H*-cyclopropyl), 0.67 – 0.51 (m, 2H, CH_2-cyclopropyl), 0.32 – 0.17 (m, 2H, CH_2-cyclopropyl); ^{13}C NMR (75 MHz, $CDCl_3$) δ 145.1, 130.2, 128.4, 122.8, 118.7, 114.5, 75.9, 66.8, 59.1, 43.0, 25.0, 15.1, 3.6, 2.1; Anal. Calcd. for $C_{14}H_{17}NO$: % C 78.10; H 7.96; N 6.51; O 7.43, found: C 78.16; H 8.05; N 6.53; O 7.43; ***exo* 1j:** R_f = 0.34 (PE/EtOAc 90:10); I.R.: ῡ (cm^{-1}) = 3327, 3075, 2996, 2928, 2861, 2810, 2762, 1610, 1587, 1492, 1453, 1365, 1301, 1265, 1199, 1138, 1104, 1028, 996, 979, 918, 881, 826, 748, 647; ^{1}H NMR (400 MHz, $CDCl_3$) 7.33 (dd, *J* = 7.6, 1.3 Hz, 1H, 9-*H*), 7.09 (t, *J* = 7.4 Hz, 1H, 7-*H*), 6.74 (td, *J* = 7.5, 1.2 Hz, 1H, 8-*H*), 6.63 (dd, *J* = 8.0, 0.8 Hz, 1H, 6-*H*), 4.57 (d, *J* = 5.2 Hz, 1H, 9b-*H*), 4.08 (brs, 1H, N-*H*), 3.95 – 3.78 (m, 2H, 2-CH_2), 2.35 – 2.28 (m, 1H, 3a-*H*), 2.26 – 2.18 (m, 2H, 3-CH_2), 2.02 (t, *J* = 9.7 Hz, 1H, 4-*H*), 0.93 (dtt, *J* = 9.1, 8.1, 5.1 Hz, 1H, C*H*-cyclopropyl), 0.72 (dddd, *J* = 8.9, 8.0, 5.8, 4.5 Hz, 1H, 1H of CH_2-cyclopropyl), 0.53 (dddd, *J* = 8.8, 7.9, 5.5, 4.2 Hz, 1H, 1H of CH_2-cyclopropyl), 0.48 – 0.39 (m, 1H, 1H of CH_2-cyclopropyl), 0.25 – 0.16 (m, 1H, 1H of CH_2-cyclopropyl); ^{13}C NMR (101 MHz, $CDCl_3$) δ 145.2, 131.1, 129.0, 120.5, 118.2, 114.7, 76.3, 65.4, 57.24, 43.3, 28.7, 16.1, 4.5, 1.1; , 2.1; Anal. Calcd. for $C_{14}H_{17}NO$: % C 78.10; H 7.96; N 6.51; O 7.43, found: C 78.12; H 8.01; N 6.52; O 7.43.

Synthesis of 4-isopropyl-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinoline 1k



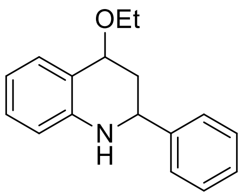
A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then isobutyraldehyde (18 mg, 23 μL, 0.25 mmol), aniline (30 mg, 30 μL, 0.33 mmol) and 2,3-dihydrofuran (26 mg, 28 μL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 24 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5) to afford ***endo*** **1k** (27mg, 50%) as amorphous solid and then **1k** as a mixture of diastereoisomers (*endo*/*exo* 50:50) as white foam (7 mg, 13%). The physical and spectral data agreed with those reported;[9] ***endo*** **1k**: R_f = 0.41 (PE/EtOAc 90:10); I.R.: ῡ (cm^{-1}) = 3348, 3059, 3021, 2957, 2885, 1609, 1591, 1489, 1469, 1387, 1365, 1333, 1304, 1288, 1256, 1245, 1198, 1156, 1142, 1095, 1061, 1035, 1020, 971, 936, 910, 849, 801, 750, 705, 639; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.29 (dd, *J* = 7.6, 1.6 Hz, 1H, 9-*H*), 7.04 (t, *J* = 7.6, 1H, 7-*H*), 6.74 (td, *J* = 7.4, 1.2 Hz, 1H, 8-*H*), 6.53 (dd, *J* = 8.1, 1.2 Hz, 1H, 6-*H*), 5.12 (d, *J* = 8.0 Hz, 1H, 9b-*H*), 3.85 – 3.73 (m, 2H, 2-C*H*$_2$), 3.69 (brs, 1H, N-*H*), 3.04 (dd, *J* = 9.1, 2.8 Hz, 1H, 4-*H*), 2.82 – 2.69 (m, 1H, 3a-*H*), 2.10 – 1.94 (m, 1H, 3-*H*), 1.91 – 1.79 (m, 1H, 3-*H*), 1.78 – 1.64 (m, 1H, C*H*-(CH_3)$_2$), 1.06 (d, J = 6.5 Hz, 3H, C*H*$_3$), 1.0.2 (d, J = 6.8 Hz, 3H, C*H*$_3$); ^{13}C NMR (75 MHz, $CDCl_3$): δ 145.2, 130.0, 128.3, 122.8, 118.8, 114.6, 76.1, 66.6, 59.0, 40.8, 31.3, 23.9, 20.0, 19.2; Anal. Calcd. for $C_{14}H_{19}NO$: % C 77.38; H 8.81; N 6.45; O 7.36, found: C 77.43; H 8.65; N 6.42; O 7.69.

Synthesis of (E)-4-styryl-2,3,3a,4,5,9b-hexahydrofuro[3,2-c]quinoline 1l.



A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (10 mg) and CH_3CN (600 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then *trans*-cinnamaldehyde (66 mg, 63 μL, 0.50 mmol), aniline (61 mg, 59 μL, 0.65 mmol) and 2,3-dihydrofuran (53 mg, 57 μL, 0.75 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 24 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 85:15) to afford **1l** as a mixture of diastereoisomers (*endo*/*exo* 83:17) as yellow foam (69 mg, 50%). The physical and spectral data agreed with those reported;[10] R_f = 0.42 (PE/acetone 80:20); I.R.: ῡ (cm^{-1}) =3373, 3326, 3024, 2970, 2925, 2873, 1674, 1609, 1589, 1479, 1449, 1364, 1293, 1259, 1190, 1155, 1127, 1062, 1038, 1026, 967, 908, 748, 728, 691, 646; ^{1}H NMR (400 MHz, $CDCl_3$) selected data for ***endo*** **1l**: δ 7.46 – 7.27 (m, 6H, 5*H*-Ar and 9-*H*), 7.09 (t, *J* = 7.6 Hz, 1H, 7-*H*), 6.80 (td, *J* = 7.5, 1.2 Hz, 1H, 8-*H*), 6.64 (d, *J* = 16.0 Hz, 1H, 1*H*-styryl), 6.58 (dd, *J* = 8.0, 1.1 Hz, 1H, 6-*H*), 6.30 (dd, *J* = 15.9, 7.9 Hz, 1H, 1*H*-styryl), 5.08 (d, *J* = 7.3 Hz, 1H, 9b-*H*), 4.16 (ddd, *J* = 7.9, 3.7, 1.0 Hz, 1H, 4-*H*), 3.86 – 3.77 (m, 3H, 2-CH_2 and N-*H*), 2.79 – 2.70 (m, 1H, 3a-*H*), 2.18 – 2.11 (m, 1H, 3-*H*), 2.06 – 1.98 (m, 1H, 3-*H*); ^{13}C NMR (101 MHz, $CDCl_3$) selected data for ***endo*** **1l**: δ 144.4, 136.7, 131.6, 130.5, 129.8, 128.8, 128.7, 127.9, 126.6, 122.1, 119.1, 115.0, 75.5, 66.6, 55.9, 42.8, 25.7.

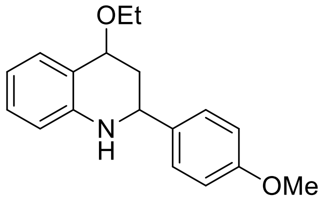
Synthesis of 4-ethoxy-2-phenyl-1,2,3,4-tetrahydroquinoline 1m



A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (10 mg) and CH_3CN (600 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then using benzaldehyde (26 mg, 25 μL, 0.25 mmol), aniline (30 mg, 30 μL, 0.33 mmol) and ethyl vinyl ether (27 mg, 36 μL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 24 h. After completion of the reaction, the mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/EtOAc (95:5 to 90:10) to afford **1m** as a mixture of diastereoisomers (*endo*/*exo* 95:5) as a white foam (32 mg, 51%). The physical and spectral data agreed with those reported; R_f = 0.31 (PE/EtOAc 95:5); I.R.: ῡ (cm^{-1}) =3340, 3061, 3030, 2973, 694, 642, 6152926, 2849, 1608, 1582, 1488, 1452, 1358, 1338, 1310, 1262, 1210, 1174, 1119, 1086, 1028, 947, 907, 863, 843, 775, 747, 722; ^{1}H NMR (400 MHz, $CDCl_3$) selected data for ***endo*** **1m**: δ 7.50 – 7.29 (m, 6H, 9-*H*, 5*H*-Ar), 7.06 (t, *J* = 7.6 Hz, 1H, 7-*H*), 6.76 (td, *J* = 7.5, 1.2 Hz, 1H, 8-*H*), 6.53 (dd, *J* = 8.0, 1.2 Hz, 1H, 6-*H*), 4.83 (dd, *J* = 10.6, 5.6 Hz, 1H, 2-*H*), 4.54 (dd, *J* = 11.6, 2.7 Hz, 1H, 4-*H*), 3.95 (brs, 1H, N-*H*), 3.71 (dq, *J* = 9.0, 6.9 Hz, 1H, CH_2 of ethyl), 3.58 (dq, *J* = 9.0, 7.0 Hz, 1H, CH_2 of ethyl), 2.43 (ddd, *J* = 12.3, 5.7, 2.7 Hz, 1H, 3-*H*), 2.09 (ddd, *J* = 12.4, 11.6, 10.6 Hz, 1H, 3-*H*), 1.27 (t, *J* = 7.0 Hz, 3H, CH_3 of ethyl); ^{13}C NMR (101 MHz,

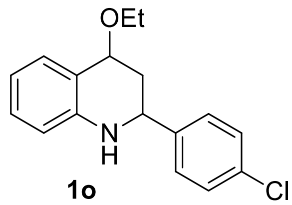
$CDCl_3$) selected data for ***endo* 1m**: δ 144.7, 143.8, 128.8, 128.4, 127.9, 127.4, 126.8, 122.7, 117.9, 114.2, 74.1, 63.6, 56.0, 37.2, 15.8.

Synthesis of 4-ethoxy-2-(4-methoxyphenyl)-1,2,3,4-tetrahydroquinoline 1n



A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 4-methoxybenzaldehyde (34 mg, 30 µL, 0.25 mmol), aniline (30 mg, 30 µL, 0.33 mmol) and ethyl vinyl ether (27 mg, 36 µL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 48 h. After this time, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 90:10) to afford **1n** as a mixture of diastereoisomers (*endo*/*exo* 75:25) as white foam (45 mg, 64%); ***endo* 1n** was separated by a second flash column chromatography, eluting with PE/EtOAc (95:5). The physical and spectral data agreed with those reported.[11] ***endo* 1n**: R_f = 0.40 (PE/EtOAc 80:20); I.R.: ῡ (cm^{-1}) = 3363, 3346, 3058, 3032, 2970, 2933, 2897, 2869, 2835, 1606, 1583, 1511, 1488, 1464, 1441, 1370, 1333, 1311, 1297, 1264, 1241, 1176, 1110, 1083, 1064, 1028, 945, 904, 864, 825, 780, 768, 746, 722, 672, 632, 607; ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.43 – 7.32 (m, 3H, 9-*H*, 2*H*-Ar), 7.05 (t, *J* = 7.6 Hz, 1H, 7-*H*), 6.93 – 6.88 (m, 2H, 2*H*-Ar), 6.74 (td, *J* = 7.4, 1.2 Hz, 1H, 8-*H*), 6.50 (dd, *J* = 7.9, 1.2 Hz, 1H, 6-*H*), 4.87 – 4.78 (m, 1H, 2-*H*), 4.48 (dd, *J* = 11.7, 2.6 Hz, 1H, 4-*H*), 3.88 (brs, 1H, N-*H*), 3.82 (s, 3H, O-CH_3), 3.71 (dq, *J* = 9.2, 7.0 Hz, 1H, CH_2 of ethyl), 3.58 (dq, *J* = 9.1, 7.0 Hz, 1H, CH_2 of ethyl), 2.38 (ddd, *J* = 12.3, 5.7, 2.7 Hz, 1H, 3-*H*), 2.12 – 1.98 (m, 1H, 3-*H*), 1.27 (t, *J* = 7.0 Hz, 3H, CH_3 of ethyl); ^{13}C NMR (75 MHz, $CDCl_3$): δ 159.3, 144.8, 135.9, 128.3, 127.9, 127.3, 122.7, 117.9, 114.2, 114.1, 74.2, 63.6, 55.5 (x2), 37.3, 15.8; Anal. Calcd. for $C_{18}H_{21}NO_2$: % C 76.29; H 7.47; N 4.94; O 11.29, found: C 76.33; H 7.52; N 4.94; O 11.42.

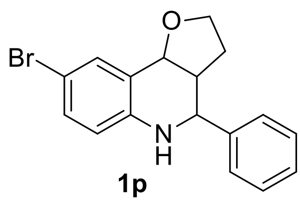
Synthesis of 2-(4-chlorophenyl)-4-ethoxy-1,2,3,4-tetrahydroquinoline 1o.



1o

A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 4-chlorobenzaldehyde (35 mg, 0.25 mmol), aniline (30 mg, 30 μL, 0.33 mmol) and ethyl vinyl ether (27 mg, 36 μL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 24 h. After this time, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/EtOAc (95:5) to afford **1o** as a mixture of diastereoisomers (*endo*/*exo* 91:9) as white foam (31 mg, 45%). The physical and spectral data agreed with those reported;[11] R_f = 0.33 (PE/EtOAc 95:5); I.R.: ῡ (cm^{-1}) = 3364, 3334, 3055, 3031, 2973, 2868, 2843, 1607, 1585, 1488, 1406, 1331, 1310, 1263, 1208, 1173, 1120, 1086, 1029, 1012, 865, 844, 813, 775, 748, 725, 696, 630, 615; ^{1}H NMR (300 MHz, $CDCl_3$) selected data for ***endo*** **1o**: δ 7.43 – 7.29 (m, 5H, 9-*H*, 4*H*-Ar), 7.06 (t, *J* = 7.5 Hz, 1H, 7-*H*), 6.75 (td, *J* = 7.5, 1.2 Hz, 1H, 8-*H*), 6.53 (dd, *J* = 8.0, 1.1 Hz, 1H, 6-*H*), 4.79 (dd, *J* = 10.2, 5.7 Hz, 1H, 2-*H*), 4.52 (dd, *J* = 11.3, 2.8 Hz, 1H, 4-*H*), 3.91 (brs, 1H, N-*H*), 3.74 – 3.49 (m, 2H, CH_2 of ethyl), 2.37 (ddd, *J* = 12.4, 5.7, 3.0 Hz, 1H, *H*-3), 2.04 (ddd, *J* = 12.4, 11.3, 10.3 Hz, 1H, *H*-3), 1.24 (t, *J* = 7.0 Hz, 3H, CH_3 of ethyl). ^{13}C NMR (75 MHz, $CDCl_3$) selected data for ***endo*** **1o**: δ 144.5, 142.4, 133.5, 128.9, 128.5, 128.1, 127.6, 122.7, 118.2, 114.3, 73.9, 63.7, 55.4, 37.2, 15.8.

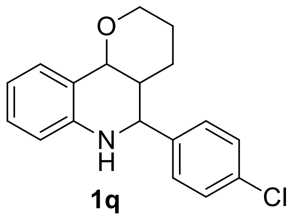
Synthesis of 8-bromo-4-phenyl-2,3,3a,4,5,9b-hexahydrofuro[3,2-*c*]quinoline 1p



1p

A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then benzaldehyde (26 mg, 25 μL, 0.25 mmol), 4-bromoaniline (56 mg, 0.33 mmol) and 2,3-dihydrofuran (26 mg, 28 μL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 4 h. After this time, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5 to 85:15) to afford **1p** as a mixture of diastereoisomers (*endo*/*exo* 74:26) as cream color foam (30 mg, 36%). The physical and spectral data agreed with those reported;[12] R_f = 0.47 (PE/acetone 80:20); I.R.: ῡ (cm^{-1}) = 3370, 3293, 3051, 3030, 2980, 2925, 2893, 2877, 1596, 1483, 1449, 1367, 1353, 1332, 1296, 1259, 1174, 1057, 1026, 994, 973, 915, 878, 806, 775, 759, 726, 700, 671; ^{1}H NMR (400 MHz, $CDCl_3$) selected data for ***endo*** **1p**: δ 7.47 – 7.29 (m, 6H, 5*H*-Ph and 9-*H*), 7.16 (dd, *J* = 8.5, 2.3 Hz, 1H, 7-*H*), 6.48 (d, *J* = 8.5 Hz, 1H, 6-*H*), 5.21 (d, *J* = 7.8 Hz, 1H, 9b-*H*), 4.68 (d, *J* = 3.0 Hz, 1H, 4-*H*), 3.91 – 3.79 (m, 2H, N-*H* and 2-*H*), 3.79 – 3.69 (m, 1H, 2-*H*), 2.81 – 2.72 (m, 1H, 3a-*H*), 2.23 – 2.10 (m, 1H, 3-*H*), 1.53 (dddd, *J* = 11.8, 8.1, 7.0, 3.4 Hz, 1H, 3-*H*). ^{13}C NMR (101 MHz, $CDCl_3$) selected data for ***endo*** **1p**: δ 144.2, 142.2, 133.1, 131.6, 129.2, 128.3, 126.9, 125.1, 117.0, 111.2, 75.9, 67.4, 57.6, 45.8, 24.9.

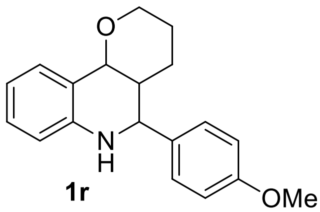
Synthesis of 5-(4-chlorophenyl)-3,4,4a,5,6,10b-hexahydro-2*H*-pyrano[3,2-*c*]quinoline 1q



1q

A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 4-chlorobenzaldehyde (25 mg, 0.25 mmol), aniline (30 mg, 30 μL, 0.33 mmol) and 3,4-dihydropyran (32 mg, 34 μL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 48 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting PE/Et_2O/DCM (90:5:5 to 80:10:10) to afford ***endo*** **1q** (14 mg, 19%) as cream color solid and ***exo*** **1q** (7 mg, 9%) as white solid. The ratio *endo*/*exo* was determined by ^{1}H NMR of the crude and resulted 65:35. The physical and spectral data agreed with those reported;[13] ***endo*** **1q:** mp 153- 155°C (DCM)*;* R_f = 0.35 (PE/Et_2O/DCM 80:10:10); I.R.: ῡ (cm^{-1}) = 3387, 3049, 3022, 2985, 2940, 2894, 2850, 1602, 1582, 1483, 1460, 1435, 1407, 1375, 1342, 1317, 1275, 1256, 1205, 1185, 1142, 1121, 1084, 1069, 1041, 1014, 969, 943, 926, 861, 843, 814, 747, 705, 664; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.40 (m, 1H, 10-*H*), 7.40 – 7.31 (m, 4H, Ar), 7.10 (t, *J* = 7.5 Hz, 1H, 8-*H*), 6.81 (td, *J* = 7.5, 1.2 Hz, 1H, 9-*H*), 6.61 (dd, *J* = 8.0, 1.2 Hz, 1H, 7-*H*), 5.32 (d, *J* = 5.7 Hz, 1H, 10b-*H*), 4.67 (d, *J* = 2.6 Hz, 1H, 5-*H*), 3.82 (brs, 1H, N-*H*), 3.65 – 3.54 (m, 1H, 2-*H*), 3.48 – 3.37 (m, 1H, 2-*H*), 2.21- 2.05 (m, 1H, 4a-*H*), 1.63 – 1.39 (m, 3H, 2*H*-3 and *H*-4, overlapped with H_2O signal), 1.37 – 1.22 (m, 1H, *H*-4); ^{13}C NMR (101 MHz, $CDCl_3$) δ 145.0, 139.8, 133.3, 128.7, 128.3 (x2), 127.8, 120.1, 118.7, 114.7, 72.8, 60.8, 58.9, 39.0, 25.5, 18.1; Anal. Calcd. for $C_{18}H_{18}ClNO$: % C 72.11; H 6.05; N 4.67; O 5.34, found: C 72.15; H 6.05; N 4.75; O 5.45; ***exo*** **1q**: mp 125-127 °C (DCM); R_f = 0.28 (PE/Et_2O/DCM 80:10:10); I.R.: ῡ (cm^{-1}) = 3365, 3020, 2954, 2937, 2916, 2855, 2827, 1609, 1591, 1484, 1447, 1441, 1410, 1364, 1341, 1321, 1299, 1263, 1255, 1212, 1204, 1185, 1157, 1121, 1107, 1078, 1050, 1031, 1014, 1003, 973, 962, 936, 914, 884, 839, 817, 791, 748, 727, 713, 662, 640, 625; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.31 (m, 4H, Ar), 7.23 (dd, *J* = 7.6, 1.6 Hz, 1H, 10-*H*), 7.10 (t, *J* = 8.0 Hz, 1H, 8-*H*), 6.72 (td, *J* = 7.4, 1.1 Hz, 1H, 9-*H*), 6.54 (dd, *J* = 8.0, 1.1 Hz, 1H, 7-*H*), 4.71 (d, *J* = 10.80 Hz, 1H, 5-*H*), 4.39 (d, *J* = 2.7 Hz, 1H, 10b-*H*), 4.15 – 4.06 (m, 1H, 2-*H*), 4.04 (brs, 1H, N-*H*), 3.73 (td, *J* = 11.5, 2.6 Hz, 1H, 2-*H*), 2.05 (ddt, *J* = 10.6, 5.2, 2.8 Hz, 1H, 4a-*H*), 1.91 – 1.74 (m, 1H, 3-*H*), 1.66 (tt, *J* = 13.4, 4.6 Hz, 1H, 4-*H*), 1.49 – 1.42 (m, 1H, 4-H), 1.40 – 1.31 (m, 1H, 3-*H*); ^{13}C NMR (101 MHz, $CDCl_3$) δ 144.7, 141.0, 133.7, 131.1, 129.6, 129.3, 129.0, 120.8, 117.9, 114.4, 74.5, 68.8, 54.4, 39.1, 24.2, 22.1; Anal. Calcd. for $C_{18}H_{18}ClNO$: % C 72.11; H 6.05; N 4.67; O 5.34, found: C 72.17; H 6.06; N 4.74; O 5.40.

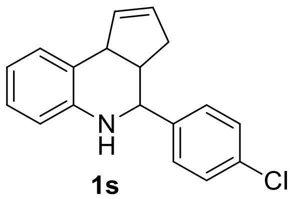
Synthesis of 5-(4-methoxyphenyl)-3,4,4a,5,6,10b-hexahydro-2H-pyrano[3,2-c]quinoline 1r



1r

A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN/H_2O (4:1, 300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 4-methoxybenzaldehyde (34 mg, 0.25 mmol), aniline (30 mg, 30 µL, 0.33 mmol) and 3,4-dihydropyran (32 mg, 34 µL, 0.38 mmol) were added to the mixture. The sealed reaction vial was stirred at 60 °C for 48 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/DCM/Et_2O (80:10:10) to afford a mixture of aldehyde/imine/***endo*** **1r** (65:10:25, 13 mg, 5%) and then ***exo*** **1r** (26 mg, 35%) as pale yellow solid (26 mg, 35%). The ratio *endo*/*exo* was determined by ^{1}H NMR of the crude and resulted 25:75. The physical and spectral data agreed with those reported;[14] ***exo*** **1r:** m.p. = 121 - 123°C (DCM); R_f = 0.18 (PE/DCM/Et_2O 80:10:10); I.R.: ῡ (cm^{-1}) = 3385, 2931, 2838, 1607, 1588, 1510, 1487, 1463, 1441, 1366, 1351, 1303, 1287, 1257, 1239, 1222, 1182, 1111, 1081, 1057, 1025, 1004, 915, 888, 852, 838, 814, 797, 765, 748, 733, 693, 651; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.38 – 7.30 (m, 2H, 2*H*-Ar), 7.22 (dd, *J* = 7.6, 1.6 Hz, 1H, 10-*H*), 7.09 (t, *J* = 7.5 Hz, 1H, 8-*H*), 6.95 – 6.88 (m, 2H, 2*H*-Ar), 6.70 (td, *J* = 7.4, 1.1 Hz, 1H, 9-*H*), 6.52 (dd, *J* = 8.1, 1.1 Hz, 1H, 7-*H*), 4.68 (d, *J* = 10.9 Hz, 1H, 5-*H*), 4.39 (d, *J* = 2.8 Hz, 1H, 10b-*H*), 4.15 – 4.06 (m, 1H, 2-*H*), 4.03 (brs, 1H, N-*H*), 3.83 (s, 3H, C*H*$_3$), 3.73 (td, *J* = 11.5, 2.5 Hz, 1H, 2-*H*), 2.06 (ddt, *J* = 10.8, 5.2, 2.8 Hz, 1H, 4a-*H*), 1.93 – 1.75 (m, 1H, 3-*H*), 1.65 (tt, *J* = 13.2, 4.6 Hz, 1H, 4-*H*), 1.59 – 1.44 (m, 1H, 4-*H*), 1.38 – 1.28 (m, 1H, 3-*H*); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.4, 145.0, 134.4, 131.1, 129.5, 129.0, 120.8, 117.5, 114.2, 114.1, 74.8, 68.9, 55.5, 54.2, 39.1, 24.3, 22.1; Anal. Calcd. for $C_{19}H_{21}NO_2$: % C 77.26; H 7.17; N 4.74; O 10.83, found: C 77.32; H 7.18; N 4.75; O 10.87.

Synthesis of 4-(4-chlorophenyl)-3a,4,5,9b-tetrahydro-3H-cyclopenta[c]quinoline 1s.

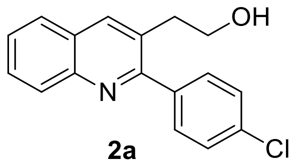


1s

A 2 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (300 μL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 4-chlorobenzaldehyde (34 mg, 0.25 mmol), aniline (30 mg, 30 μL, 0.33 mmol) and freshly distilled cyclopentadiene (66 mg, 84 μL, 1.00 mmol) were added to the mixture. The sealed reaction vial was stirred at 60 °C for 24 h. After completion of the reaction, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness in vacuo and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (95:5) to afford **1s** as a mixture of diastereoisomers (*endo*/*exo* 90:10) as white foam (49 mg, 70%). Crystallization from Et_2O/pentane gave the pure ***endo*** **1s** as white crystals. The physical and spectral data agreed with those reported;[2] ***endo*** **1s**: m.p. = 137-139°C (Et_2O/pentano); R_f = 0.63 (PE/acetone 90:10); I.R.: ῡ (cm^{-1}) = 3360, 3046, 2961, 2929, 2871, 2849, 1604, 1591, 1489, 1469, 1435, 1419, 1408, 1354, 1318, 1289, 1264, 1226, 1203, 1177, 1160, 1129, 1113, 1086, 1033, 1014, 1001, 968, 956, 939, 890, 866, 843, 810, 794, 752, 725, 697, 680, 632, 621; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 – 7.31 (m, 4H, 4*H*-Ar), 7.07 (d, *J* = 7.6 Hz, 1H, 9-*H*), 7.00 (t, *J* = 7.6 Hz, 1H, 7-*H*), 6.77 (td, *J* = 7.4, 1.3 Hz, 1H, 8-*H*), 6.64 (dd, *J* = 8.0, 1.3 Hz, 1H, 6-*H*), 5.89 – 5.82 (m, 1H, 1-*H*), 5.71 – 5.60 (m, 1H, 2-*H*), 4.62 (d, *J* = 3.3 Hz, 1H, 4-*H*), 4.12 (d, *J* = 9.2 Hz, 1H, 9b-*H*), 3.70 (brs, 1H, N-*H*), 2.97 (dddd, *J* = 8.9, 3.3 Hz, 1H, 3a-*H*), 2.60 (dddd, *J* = 16.5, 9.4, 2.4 Hz, 1H, 3-*H*), 1.80 (dddd, *J* = 16.3, 8.7, 2.7, 1.5 Hz, 1H, 3-*H*); ^{13}C NMR (101 MHz, $CDCl_3$) δ 145.4, 141.5, 134.1, 133.0, 130.4, 129.2, 128.8, 128.0, 126.5, 126.1, 119.5, 116.1, 57.6, 46.4, 46.0, 31.5; Anal. Calcd. for $C_{18}H_{16}ClN$: % C 76.72; H 5.72; N 4.97, found: C 76.62; H 5.63; N 5.03.

Synthesis of quinolines 2 via oxidation of Povarov products

Synthesis of 2-(2-(4-chlorophenyl)quinolin-3-yl)ethan-1-ol 2a.



2a

A 10 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (16 mg) and CH_3CN/H_2O (4:1, 1.6 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath. **1a** (45 mg, 0.16 mmol, *endo*/*exo* = 80:20) was added and the mixture was stirred at 120 °C for 24 h. After completion of the reaction, as indicated by thin-layer chromatography (TLC), the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL) and MeOH (5 mL). The filtrate was evaporated to dryness and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (90:10 to 60:40) to afford unreacted ***exo*** **1a** (6 mg, 13%) and then **2a** (33 mg, 73%). as white solid.

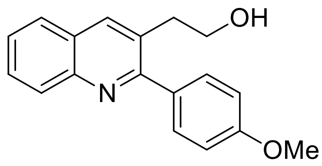
Quinoline **2a** has been obtained in 92 % isolated yield, following the same procedure starting from pure ***endo*** **1a**.

Quinoline **2a** has been obtained in 88 % isolated yield, starting from pure ***endo*** **1a** and using microwaves irradiation as described below: a suspension of GO (10 mg) and ***endo*** **1a** (30 mg, 0.10 mmol) in CH_3CN/H_2O (2:1, 1.0 mL) was sonicated for 2 min using an ultrasonic bath and then heated at 120 °C under MW irradiation for 3 h. The reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (90:10 to 60:40) to afford unreacted ***endo*** **1a** (2 mg, 8%) and then **2a** (25 mg, 88%) as white solid.

2a: mp 116-119°C (PE/acetone); R_f = 0.37 (PE/acetone 75:25); I.R.: ῡ (cm^{-1}) = 3351, 3176, 3055, 2934, 1622, 1598, 1559, 1485, 1423, 1395, 1338, 1264, 1161, 1121, 1089, 1042, 1005, 958, 907, 841, 793, 751, 618; ^1H NMR (300 MHz, $CDCl_3$) δ 8.10 (s, 1H, 4-*H*), 8.07 (d, *J* = 7.9 Hz, 1H, 8-*H*), 7.78 (d, *J* = 8.2, 1H, 5-*H*), 7.71 – 7.62 (m, 1H, 7-*H*), 7.53 (tt, *J* = 8.3, 1.5 Hz, 1H, 6-*H*), 7.48 – 7.37 (m, 4H, Ar), 3.69 (td, *J* = 6.6, 1.9 Hz, 2H, CH_2-O), 2.97 (td, *J* = 6.7, 2.0 Hz, 2H, CH_2-C), 2.19 (brs, 1H, OH); ^{13}C

NMR (75 MHz, $CDCl_3$) δ 159.4, 146.6, 139.0, 137.3, 134.5, 130.4, 129.9, 129.5, 129.1, 128.7, 127.6, 127.2, 126.9, 62.4, 35.8; Anal. Calcd. for $C_{17}H_{14}ClNO$: % C 71.96; H 4.97; N 4.94; O 5.64, found: C 72.03; H 5.05; N 5.03; O 5.74.

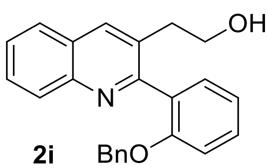
2-(2-(4-methoxyphenyl)quinolin-3-yl)ethan-1-ol 2h



2h

A 10 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (10 mg) and CH_3CN/H_2O (4:1, 1.0 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath. **1h** (28 mg, 0.10 mmol, *endo*/*exo* = 80:20) was added and the mixture was stirred at 120 °C for 24 h. After completion of the reaction, as indicated by thin-layer chromatography (TLC), the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (90:10 to 60:40) to afford unreacted ***exo*** **1h** (4 mg, 14%) and then **2h** (21 mg, 75%) as cream color solid: mp 127 -130 °C (PE/acetone); R_f = 0.21 (PE/acetone 80:20); I.R.: ῡ (cm^{-1}) = 3278, 3014, 2962, 2929, 2864, 2836, 1610, 1516, 1488, 1456, 1441, 1421, 1374, 1340, 1291, 1246, 1176, 1136, 1107, 1041, 1021, 970, 917, 869, 840, 815, 800, 763, 734, 636, 619; ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.13 – 8.07 (m, 2H, 4-*H* and 8-*H*), 7.79 (dd, *J* = 8.0, 1.4 Hz, 1H, 5-*H*), 7.67 (ddd, *J* = 8.6, 6.9, 1.5 Hz, 1H, 7-*H*), 7.55 – 7.46 (m, 3H, 6-*H* and 2*H*-Ar), 7.04 – 6.96 (m, 2H, 2*H*-Ar), 3.86 (s, 3H, C*H*$_3$), 3.78 – 3.70 (m, 2H C*H*$_2$-O), 3.07 (t, *J* = 6.7 Hz, 2H, C*H*$_2$-C), 1.67 (brs, 1H, O-*H*, overlapped with H_2O signal); ^{13}C NMR (75 MHz, $CDCl_3$) δ 160.5, 159.8, 146.8, 137.0, 133.2, 130.3, 130.1, 129.3 (x2), 127.4, 127.1, 126.6, 114.0, 62.7, 55.5, 36.2; Anal. Calcd. for $C_{18}H_{17}NO_2$: % C 77.40; H 6.13; N 5.01; O 11.46, found: C 77.38; H 6.12; N 5.03; O 11.54.

2-(2-(2-(benzyloxy)phenyl)quinolin-3-yl)ethan-1-ol 2i

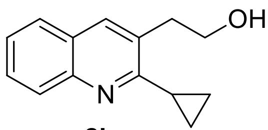


2i

A 10 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (10 mg) and CH_3CN/H_2O (4:1, 1.0 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath. **1i** (36 mg, 0.10 mmol, *endo*/*exo* = 60:40) was added and the mixture was stirred at

120 °C for 24 h. After completion of the reaction, as indicated by thin-layer chromatography (TLC), the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL) and MeOH (10 mL). The filtrate was evaporated to dryness and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (90:10 to 60:40) to afford unreacted ***exo*** **1i** (4 mg, 6%) and then **2i** (28 mg, 79%) as colorless oil: R_f = 0.21 (PE/acetone 80:20); I.R.: ῡ (cm^{-1}) = 3274, 3061, 3033, 2929, 2868, 1700, 1602, 1583, 1489, 1447, 1418, 1378, 1341, 1312, 1291, 1262, 1222, 1161, 1129, 1111, 1048, 1019, 908, 854, 793, 749, 727, 695, 644, 618; ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.14 (d, *J* = 8.4 Hz, 1H, 8-*H*), 8.08 (s, 1H, 4-*H*), 7.83 (dd, *J* = 8.0, 1.5 Hz, 1H, 5-*H*), 7.68 (ddd, *J* = 8.4, 6.8, 1.5 Hz, 1H, 7-*H*), 7.54 (ddd, *J* = 8.2, 6.9, 1.2 Hz, 1H, 6-*H*), 7.44 – 7.34 (m, 2H, Ar), 7.24 – 7.12 (m, 5H, Ph), 7.12 – 7.03 (m, 2H, Ar), 5.04 (d, *J* = 3.4 Hz, 2H, CH_2-benzyl), 3.71 (t, *J* = 6.1 Hz, 2H, CH_2-O), 2.94 (t, *J* = 6.6 Hz, 2H, CH_2-C), 1.44 (t, *J* = 6.0 Hz, 1H, O-*H*); ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.1, 155.9, 146.9, 137.0, 135.9, 131.5, 130.8, 130.7, 130.0, 129.4, 129.1, 128.5, 127.8, 127.7, 127.2, 126.9, 126.6, 121.8, 113.3, 70.6, 62.6, 36.0; Anal. Calcd. for $C_{24}H_{21}NO_2$: % C 81.10; H 5.96; N 3.94; O 9.00, found: C 81.23; H 6.03; N 3.96; O 9.12.

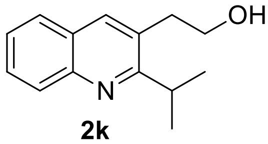
2-(2-cyclopropylquinolin-3-yl)ethan-1-ol 2j



2j

A 10 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (10 mg) and CH_3CN/H_2O (4:1, 1.0 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath. **1j** (22 mg, 0.10 mmol, *endo*/*exo* = 85:15) was added and the mixture was stirred at 120 °C for 24 h. After completion of the reaction, as indicated by thin-layer chromatography (TLC), the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (90:10 to 60:40) to afford unreacted **1j** (*endo*/*exo* 1:1, 3 mg, 14%) and then **2j** (13 mg, 61%) as colorless oil: R_f = 0.24 (PE/acetone 75:25); I.R.: ῡ (cm^{-1}) = 3426, 3057, 3007, 2937, 2873, 1619, 1601, 1562, 1492, 1425, 1345, 1224, 1143, 1063, 1047, 1022, 911, 852, 788, 753, 618; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.91 (d, *J* = 8.4 Hz, 1H, 8-*H*), 7.87 (s, 1H, 4-*H*), 7.70 (dd, *J* = 8.0, 1.5 Hz, 1H, 5-*H*), 7.59 (ddd, *J* = 8.5, 7.0, 1.5 Hz, 1H, 7-*H*), 7.41 (ddd, *J* = 8.1, 6.9, 1.3 Hz, 1H, 6-*H*), 4.03 (t, *J* = 6.7 Hz, 2H, CH_2-O), 3.23 (t, *J* = 6.7 Hz, 2H, CH_2-C), 2.30 (tt, *J* = 8.0, 4.8 Hz, 1H, C*H*-cyclopropyl), 1.64- 1.48 (m, 1H, O-*H*, overlapped with H_2O signal), 1.32 – 1.25 (m, 2H, CH_2-cyclopropyl), 1.09 – 0.99 (m, 2H, CH_2-cyclopropyl); ^{13}C NMR (75 MHz, $CDCl_3$) δ 161.8, 147.0, 135.7, 130.3, 128.8, 128.7, 127.0, 126.8, 125.5, 62.6, 36.1, 14.5, 9.8; Anal. Calcd. for $C_{14}H_{15}NO$: % C 78.84; H 7.09; N 6.57; O 7.50, found: C 78.96; H 7.12; N 6.54; O 7.56.

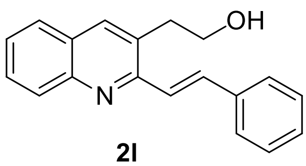
2-(2-isopropylquinolin-3-yl)ethan-1-ol 2k



2k

A 10 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (14 mg) and CH_3CN/H_2O (4:1, 1.4 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath. **1k** (30 mg, 0.14 mmol, *endo*/*exo* = 90:10) was added and the mixture was stirred at 120 °C for 24 h. After completion of the reaction, as indicated by thin-layer chromatography (TLC), the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL) and MeOH. The filtrate was evaporated to dryness and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (90:10 to 70:30) to afford unreacted **1k** (*endo*/*exo* 1:1, 6 mg, 20%) and then **2k** (21 mg, 70%) as colorless oil: R_f = 0.33 (PE/acetone 75:25); I.R.: ῡ (cm^{-1}) = 3322, 3061, 2961, 2930, 2871, 1621, 1600, 1563, 1491, 1455, 1422, 1378, 1359, 1219, 1137, 1043, 955, 908, 854, 796, 753, 729, 646, 618; ^1H NMR (300 MHz, $CDCl_3$) δ 8.03 (d, 1H, 8-*H*), 7.90 (s, 1H, 4-*H*), 7.72 (dd, *J* = 8.1, 1.2 Hz, 1H, 5-*H*), 7.62 (ddd, *J* = 8.4, 6.9, 1.5 Hz, 1H, 7-*H*), 7.44 (ddd, *J* = 8.1, 6.9, 1.2 Hz, 1H, 6-*H*), 3.99 – 3.88 (m, 2H, CH_2-O), 3.45 (hept, *J* = 6.7 Hz, 1H, C*H*-isopropyl), 3.11 (td, *J* = 6.8, 0.7 Hz, 2H, CH_2-C), 1.68 – 1.56 (m, 1H, O-*H*, overlapped with H_2O signal), 1.39 (d, *J* = 6.7 Hz, 6H, 2CH_3); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.4, 147.2, 136.3, 129.2, 129.0, 128.7, 127.0, 127.0, 125.8, 63.1, 35.6, 31.7, 22.5; Anal. Calcd. for $C_{14}H_{17}NO$: % C 78.10; H 7.96; N 6.51; O 7.43, found: C 78.14; H 7.98; N 6.54; O 7.56.

(*E*)-2-(2-styrylquinolin-3-yl)ethan-1-ol 2l

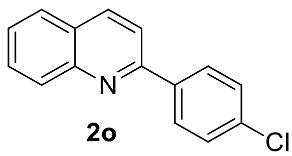


2l

A 10 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (10 mg) and CH_3CN/H_2O (4:1, 1.0 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath. **1l** (28 mg, 0.14 mmol, *endo*/*exo* = 80:20) was added and the mixture was stirred at 120 °C for 24 h. After completion of the reaction, as indicated by thin-layer chromatography (TLC), the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL). The filtrate was evaporated to dryness and the residue was purified by flash column chromatography

(SiO_2), eluting with PE/acetone (90:10 to 60:40) to afford unreacted ***exo* 1l** (2 mg, 9%) and then **2l** (16 mg, 58%) as cream solid: mp 113-114 °C (PE/acetone); R_f = 0.26 (PE/acetone 75:25); I.R.: ʊ̄ (cm^{-1}) = 3152, 3042, 2953, 2924, 2873, 1643, 1616, 1601, 1576, 1559, 1494, 1451, 1418, 1376, 1340, 1313, 1243, 1222, 1174, 1144, 1100, 1068, 1029, 988, 912, 875, 847, 820, 786, 751, 716, 689, 676, 626, 603; ^1H NMR (300 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.8 Hz, 1H, 8-*H*), 7.98 (d, *J* = 15.6 Hz, 1H, C*H*-styryl), 7.90 (s, 1H, 4-*H*), 7.70 – 7.60 (m, 4H, 5-*H*, 7-*H* and 2*H*-Ph), 7.51 (d, *J* = 15.5 Hz, 1H, C*H*-styryl), 7.46 – 7.31 (m, 4H, 6-*H* and 3*H*-Ph), 4.01 (t, *J* = 6.5 Hz, 2H, CH_2-O), 3.18 (t, *J* = 6.5 Hz, 2H, CH_2-C), 2.21 – 2.09 (m, 1H, O-*H*); ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.7, 147.1, 137.2, 137.0, 136.2, 130.0, 129.3, 129.0, 128.9, 128.7, 127.6, 127.6, 127.1, 126.3, 124.1, 62.7, 36.1; Anal. Calcd. for $C_{19}H_{17}NO$: % C 82.88; H 6.22; N 5.09; O 5.81, found: C 83.01; H 6.28; N 5.02; O 5.89.

2-(4-chlorophenyl)quinoline 2o

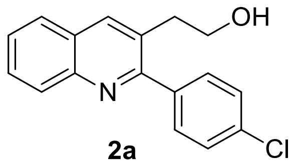


2o

A 10 mL screw-capped vial was equipped with a magnetic stirring bar and charged with GO (9 mg) and CH_3CN/H_2O (4:1, 0.9 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath. **1o** (25 mg, 0.09 mmol, *endo*/*exo* = 90:10) was added and the mixture was stirred at 120 °C for 24 h. After completion of the reaction, as indicated by thin-layer chromatography (TLC), the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL) and MeOH. The filtrate was evaporated to dryness and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (90:10 to 70:30) to afford unreacted **2o** (4 mg, 19%) as white solid. The physical and spectral data agreed with those reported;[15] mp 112-114 °C (PE/acetone); R_f = 0.52 (PE/EtOAc 90:10); I.R.: ʊ̄ (cm^{-1}) = 3057, 2919, 2850, 1617, 1588, 1578, 1553, 1509, 1486, 1431, 1399, 1378, 1318, 1286, 1263, 1244, 1211, 1158, 1128, 1106, 1089, 1050, 1007, 940, 815, 787, 771, 751, 733, 715, 672, 635, 621; ^1H NMR (300 MHz, $CDCl_3$) δ 8.23 (d, *J* = 8.6 Hz, 1H, 4-*H*), 8.18 – 8.09 (m, 3H, 2*H*-Ar and 8-*H*), 7.87 – 7.81 (m, 2H, 5-*H* and 3-*H*), 7.74 (ddd, *J* = 8.5, 6.9, 1.5 Hz, 1H, 7-*H*), 7.58 – 7.45 (m, 3H, 2H-Ar and 6-*H*); ^{13}C NMR (75 MHz, $CDCl_3$) δ 156.2, 148.4, 138.2, 137.1, 135.7, 130.0, 129.9, 129.2, 129.0, 127.6, 127.4, 126.7, 118.7; Anal. Calcd. for $C_{15}H_{10}ClN$: % C 75.16; H 4.21; N 5.84, found: C 75.19; H 4.28; N 5.80.

One-pot synthesis of 2,3-disubstituted quinolines 2

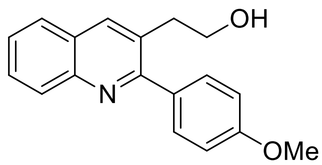
Synthesis of 2-(2-(4-chlorophenyl)quinolin-3-yl)ethan-1-ol 2a.



2a

A screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (1.3 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 4-chlorobenzaldehyde (35 mg, 0.25 mmol), aniline (30 mg, 30 µL, 0.323 mmol) and 2,3-dihydrofuran (44 mg, 47 µL, 0.62 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 6 h. After completion of the reaction, GO (20 mg), CH_3CN (0.7 mL) and H_2O (0.5 mL) were added and the resulting suspension was stirred at 120 °C for 48 h. Then, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL) and MeOH (5 mL). The filtrate was evaporated to dryness and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (90:10 to 60:40) to afford unreacted **1a** (17 mg, 24%, *endo*/*exo* 25:75) and then **2a** (30 mg, 42%) as white solid.

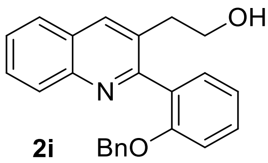
2-(2-(4-methoxyphenyl)quinolin-3-yl)ethan-1-ol 2h



2h

A screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (1.3 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 4-methoxybenzaldehyde (34 mg, 0.25 mmol), aniline (30 mg, 30 µL, 0.32 mmol) and 2,3-dihydrofuran (44 mg, 47 µL, 0.62 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 24 h. After completion of the reaction, GO (20 mg), CH_3CN (0.7 mL) and H_2O (0.5 mL) were added and the resulting suspension was stirred at 120 °C for 48 h. Then, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL) and MeOH (5 mL). The filtrate was evaporated to dryness and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (90:10 to 60:40) to afford unreacted **1h** (11 mg, 16%, *endo*/*exo* 10:90) and then **2h** (28 mg, 40%) as cream color solid.

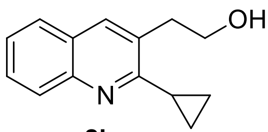
2-(2-(2-(benzyloxy)phenyl)quinolin-3-yl)ethan-1-ol 2i



2i

A screw-capped vial was equipped with a magnetic stirring bar and charged with GO (6 mg) and CH_3CN (1.5 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, then 2-benzyloxybenzaldehyde (64 mg, 0.30 mmol), aniline (36 mg, 36 µL, 0.39 mmol) and 2,3-dihydrofuran (53 mg, 57 µL, 0.75 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 24 h. After completion of the reaction, GO (24 mg), CH_3CN (0.9 mL) and H_2O (0.6 mL) were added and the resulting suspension was stirred at 120 °C for 48 h. Then, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL) and MeOH (5 mL). The filtrate was evaporated to dryness and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (90:10 to 60:40) to afford unreacted **1i** (26 mg, 29%, *endo*/*exo* 20:80) and then **2i** (37 mg, 42%)as colorless oil.

2-(2-cyclopropylquinolin-3-yl)ethan-1-ol 2j

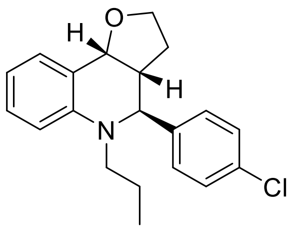


2j

A screw-capped vial was equipped with a magnetic stirring bar and charged with GO (5 mg) and CH_3CN (1.3 mL). The resulting suspension was sonicated for 2 min, using an ultrasonic bath, cyclopropanecarboxaldehyde (18 mg, 19 µL, 0.25 mmol), aniline (30 mg, 30 µL, 0.33 mmol) and 2,3-dihydrofuran (44 mg, 47 µL, 0.62 mmol) were added to the mixture. The sealed reaction vial was stirred at rt for 24 h. After completion of the reaction, GO (20 mg), CH_3CN (0.7 mL) and H_2O (0.5 mL) were added and the resulting suspension was stirred at 120 °C for 48 h. Then, the reaction mixture was filtered through a celite cake, washing with DCM/EtOAc 1:1 (15 mL) and MeOH (5 mL). The filtrate was evaporated to dryness and the residue was purified by flash column chromatography (SiO_2), eluting with PE/acetone (90:10 to 60:40) to afford unreacted **1j** (18 mg, 33%, *endo*/*exo* 80:20) and then **2j** (9 mg, 17%) as colorless oil.

Synthesis of *endo* 3 and 4

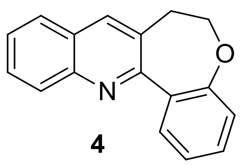
Synthesis of 4-(4-chlorophenyl)-5-propyl-2,3,3a,4,5,9b-hexahydrofuro[3,2-*c*]quinoline *endo* 3



***endo* 3a (rac)**

A solution of ***endo* 1a** (50 mg, 0.17 mmol) in dry DCM (2 mL) was treated with propionaldehyde (51 mg, 63 µL, 0.87 mmol) and AcOH (42 mg, 40 µL, 0.70 mmol) at rt under N_2. After stirring 15 min, $NaBH(OAc)_3$ (111 mg, 0.53 mmol) was added portion wise and the suspension was stirred for 2 h at rt. Then, the reaction mixture was diluted with saturated $NaHCO_3$ solution (5 mL) and extracted with DCM (10-15 mL). The combined organic phases were washed with brine, dried with anhydrous Na_2SO_4, filtrated and the solvent was removed. The desired product was isolated by flash chromatography over silica gel (PE/acetone 95:5 to 90:10) to afford ***endo* 3** as colorless oil (25 mg, Y = 45%); R_f = 0.59 (PE/acetone 85:15); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.37 (dd, *J* = 7.5, 1.2 Hz, 1H, 7-*H*), 7.26 – 7.16 (m, 5H, 4*H*-Ar and 9-*H*), 6.81 – 6.70 (m, 2H, 6-*H* and 8-*H*), 4.91 (d, *J* = 6.0 Hz, 1H, 9b-*H*), 4.45 (d, *J* = 5.5 Hz, 1H, 4-*H*), 3.66 (td, *J* = 8.4, 6.5 Hz, 1H, *H*-2) 3.31 (ddd, *J* = 14.8, 8.8, 6.1 Hz, 1H, 1H of CH_2-N), 3.19 (td, *J* = 8.5, 5.5 Hz, 1H, 1H of *H*-2), 2.84 (ddd, *J* = 14.8, 9.1, 6.9 Hz, 1H, 1H of CH_2-N), 2.78 – 2.67 (m, 1H, 3a-*H*), 2.05 – 1.81 (m, 2H, CH_2-3), 1.56 – 1.43 (m, 2H, CH_2-CH_3), 0.81 (t, *J* = 7.4 Hz, 3H, CH_3); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.7, 140.0, 133.0, 130.5, 129.8, 129.2, 128.4, 121.9, 117.2, 112.3, 75.4, 65.6, 62.2, 51.5, 42.5, 27.4, 19.4, 11.6; Anal. Calcd. for $C_{20}H_{22}ClNO$: % C 73.27; H 6.76; N 4.27; O 4.88, found: C 73.35; H 6.58; N 4.80; O 4.95.

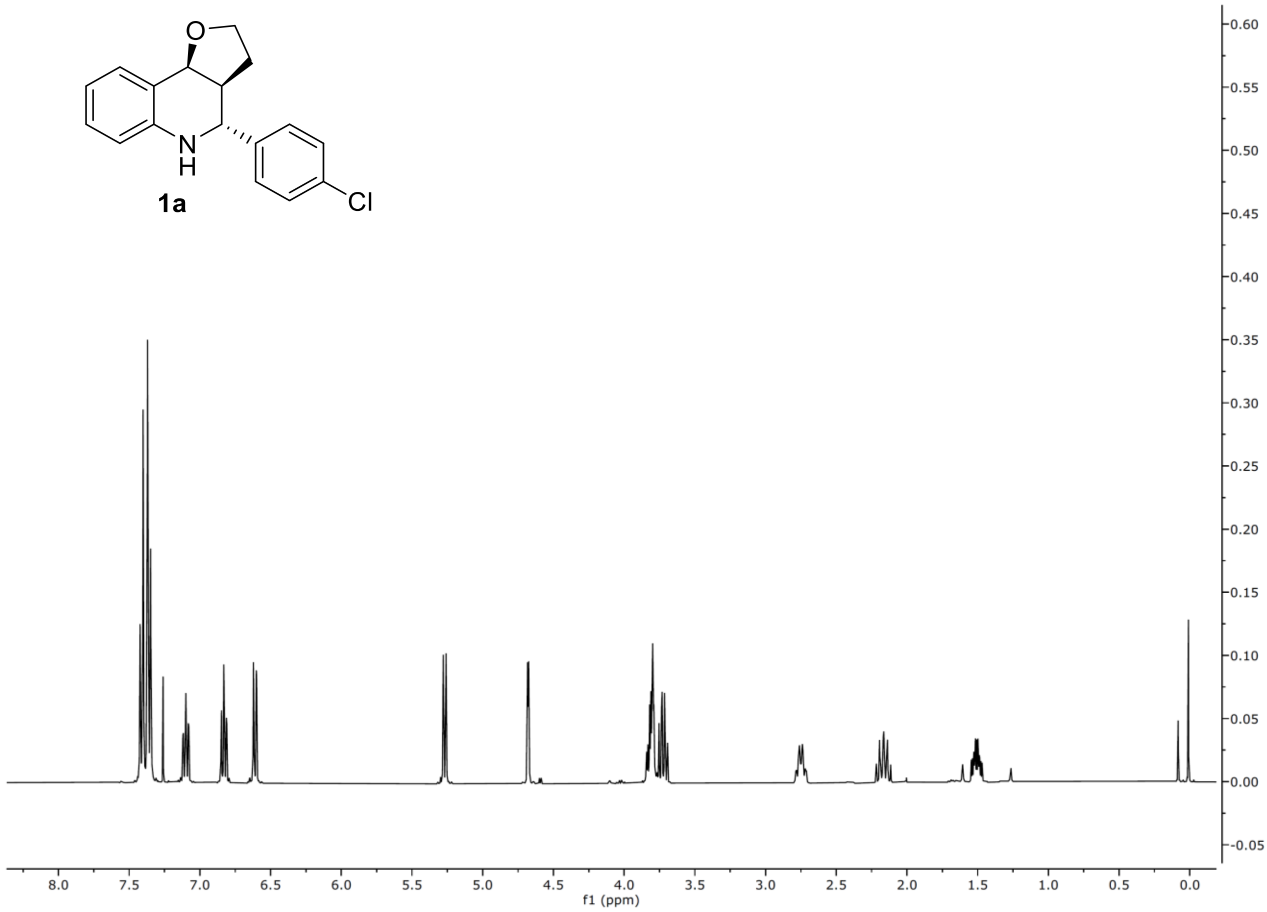
Synthesis of 6,7-dihydrobenzo[2,3]oxepino[4,5-b]quinolone 4

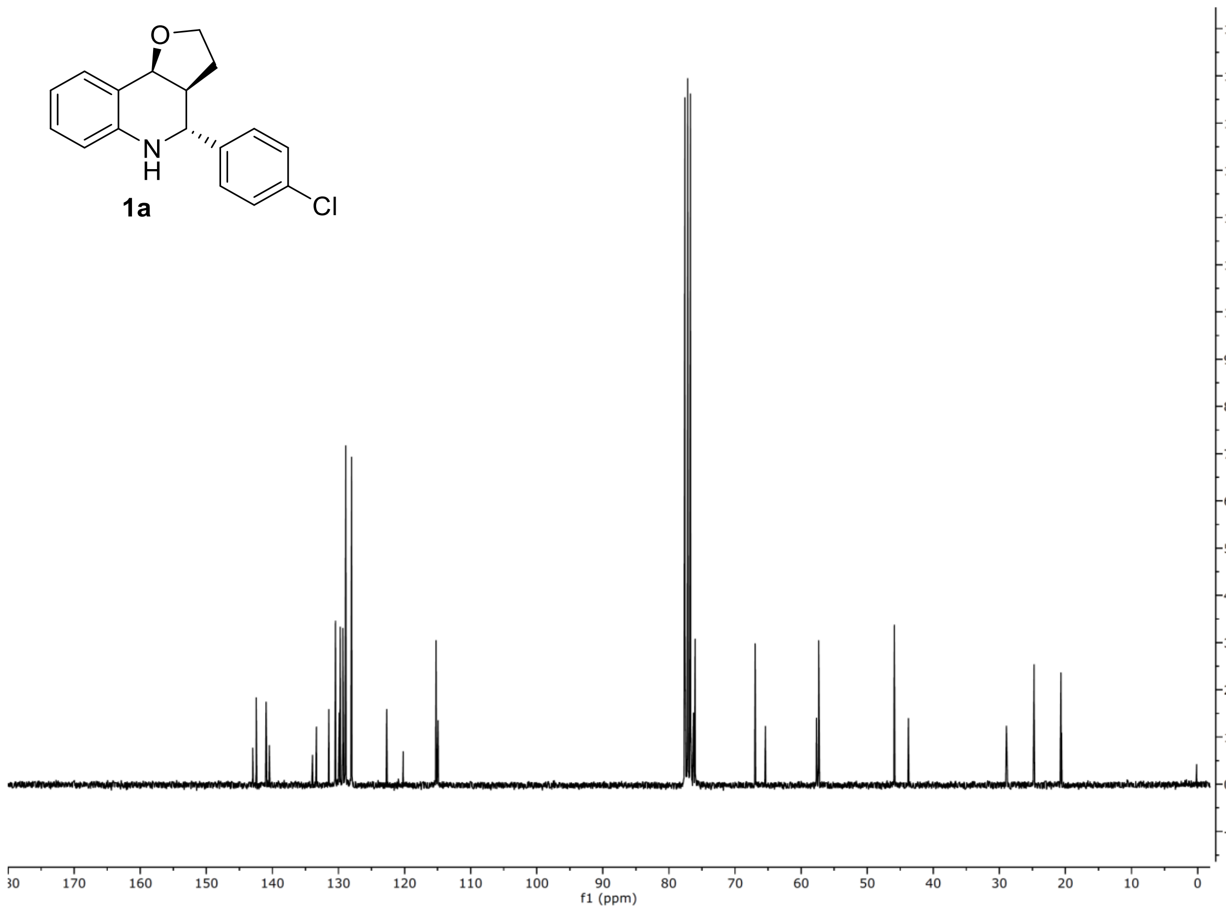


4

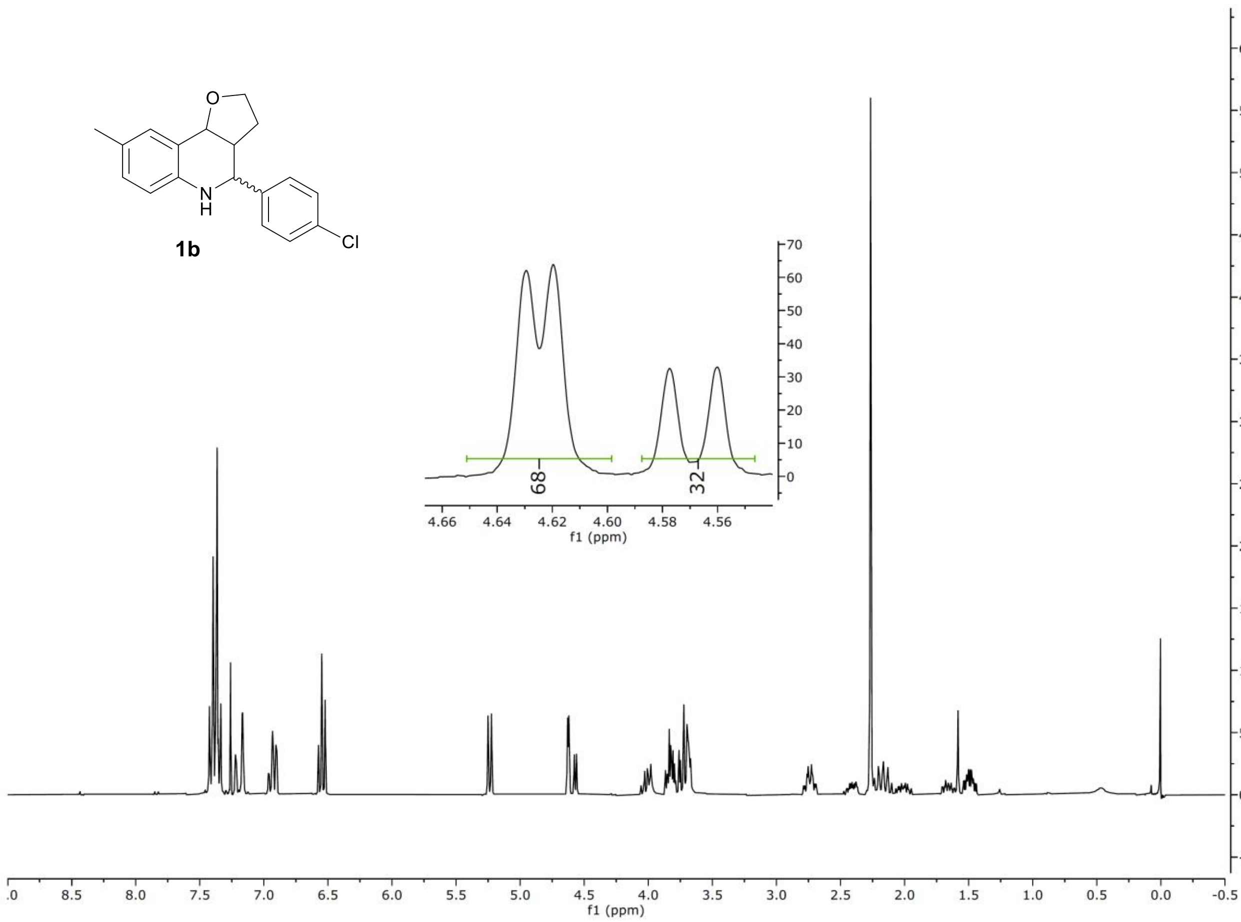
A solution of **2i** (50 mg, 0.14 mmol) in EtOH (96%, 2.5 mL) was treated with 10% Pd/C (15 mg, 30 wt. %) and hydrogenated at rt under the slight overpressure of an inflated balloon. After stirring overnight, the suspension was filtered through a celite cake, washing with a mixture of EtOH/DCM 1:1 and evaporated under reduced pressure. The crude filtrated on SiO_2 washing with EtOAc + 10%MeOH to afford debenzylated derivative (30 mg, 81%), which was taken up in dry THF (3 mL), cooled to 0 °C, and treated with triphenylphosphine (39 mg, 0.15 mmol) and *t*-butyl azodicarboxylate (35 mg, 0.15 mmol). The mixture was stirred for 30 min at rt. Then, the solvent was removed under reduced pressure and the resulting crude was purified by silica gel column chromatography, eluting with PE/EtOAc (95:5 to 85:15) to afford **4** as white solid (22 mg, 89%); mp 138-139 °C (PE/EtOAc); R_f = 0.53 (PE/EtOAc 80:20); I.R.: ῡ (cm^{-1}) = 3049, 2967, 2938, 2876, 1620, 1603, 1577, 1558, 1488, 1451, 1428, 1417, 1348, 1314, 1296, 1233, 1207, 1196, 1141, 1130, 1104, 1066, 1049, 1030, 1011, 949, 937, 921, 866, 852, 818, 796, 784, 766, 752, 725, 707, 660, 634, 615; ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.19 (ddt, *J* = 8.4, 1.3, 0.7 Hz, 1H, 16-*H*), 8.01 (s, 1H, 8-*H*), 7.97 (dd, *J* = 7.6, 1.9 Hz, 1H, 12-*H*), 7.82 (dd, *J* = 8.0, 1.5 Hz, 1H, 19-*H*), 7.71 (dddd, *J* = 8.4, 6.9, 1.5, 0.5 Hz, 1H, 17-H), 7.54 (dddd, *J* = 8.1, 6.9, 1.3, 0.5 Hz, 1H, 18-H), 7.45 (dddd, *J* = 7.9, 7.3, 1.9, 0.5 Hz, 1H,14-H), 7.34 (tdd, *J* = 7.5, 1.3, 0.5 Hz, 1H,13-H), 7.17 (dd, *J* = 7.9, 1.3 Hz, 1H, 15-H), 4.59 (t, *J* = 6.3 Hz, 2H, CH_2-O), 3.01 (t, *J* = 6.3, 2H, CH_2-C); ^{13}C NMR (75 MHz, $CDCl_3$) δ 158.1, 155.0, 147.8, 134.7, 134.4, 131.3, 131.1, 130.4, 129.7, 129.2, 127.6, 127.2, 126.6, 125.0, 122.3, 76.3, 32.7; Anal. Calcd. for $C_{17}H_{13}NO$: % C 82.57; H 5.30; N 5.66; O 6.47, found: C 82.63; H 5.29; N 5.64; O 6.49.

Copies of ^{1}H- and ^{13}C-NMR Spectra of Compounds

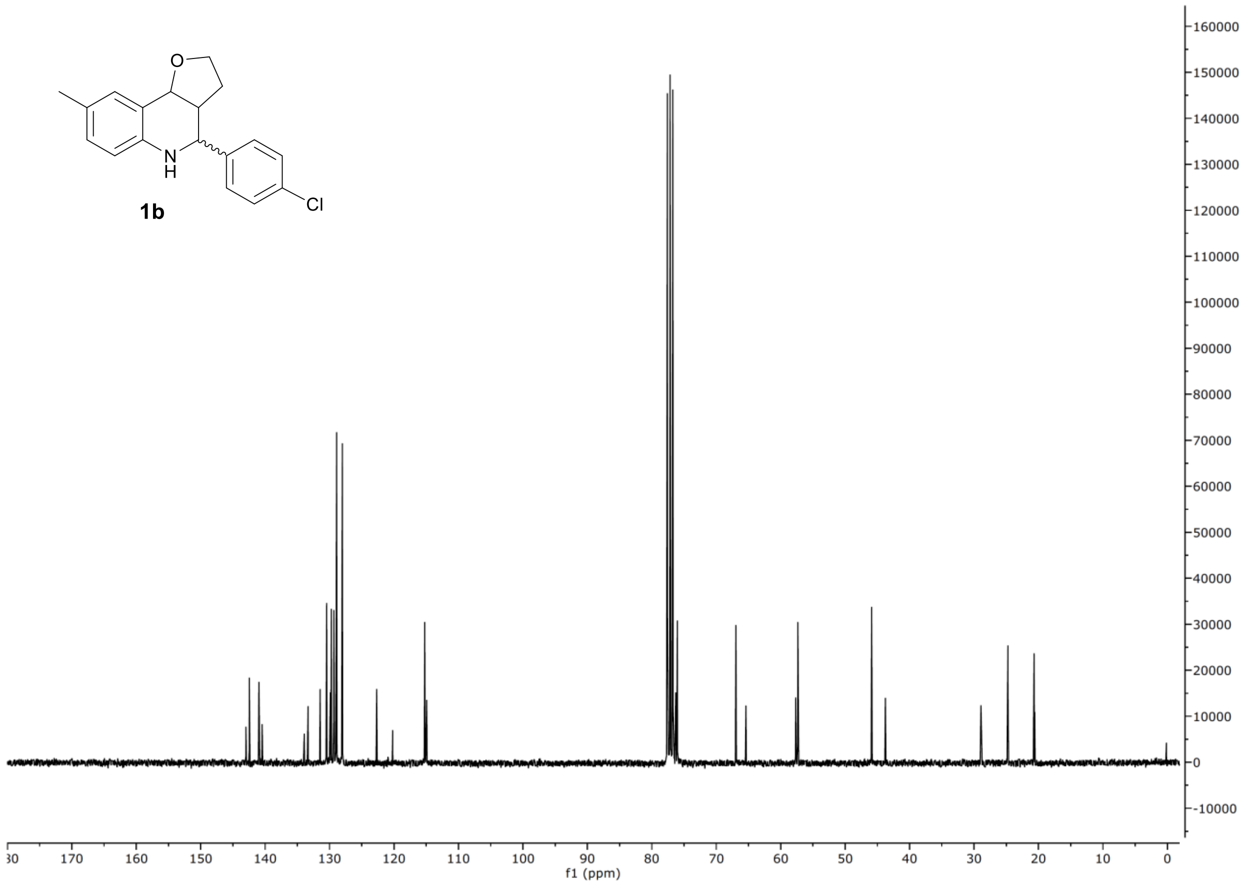


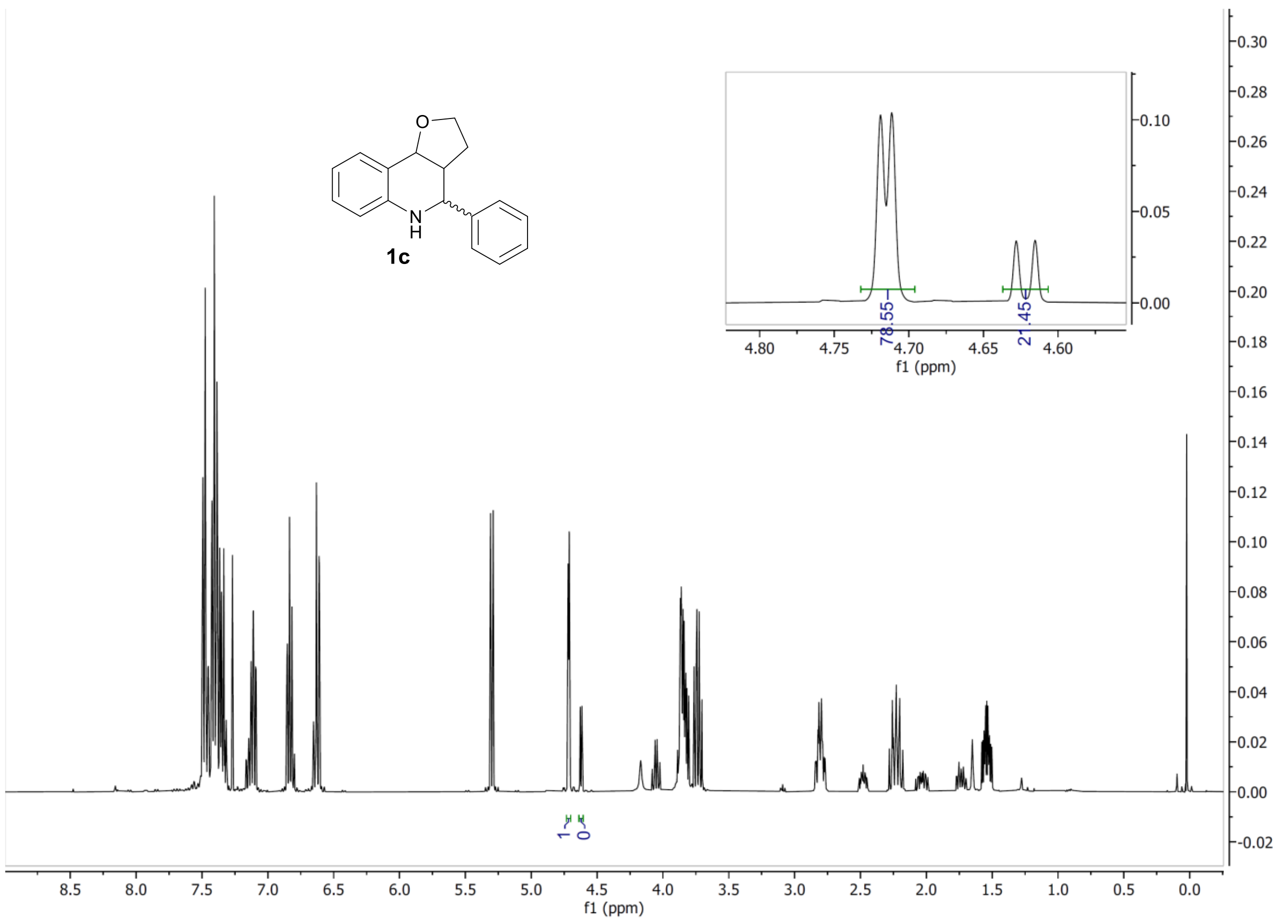


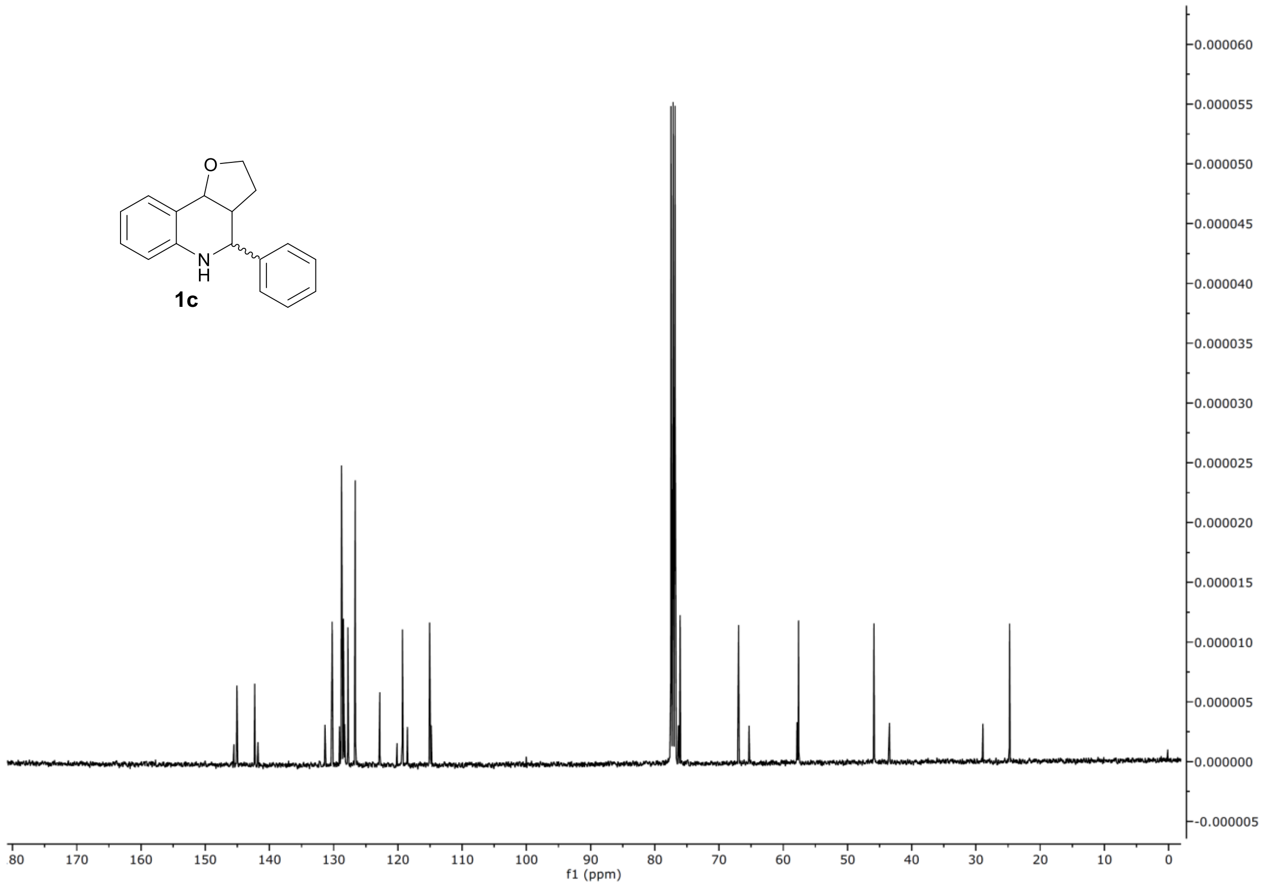
1a
Cl
O
N
H
f1 (ppm)

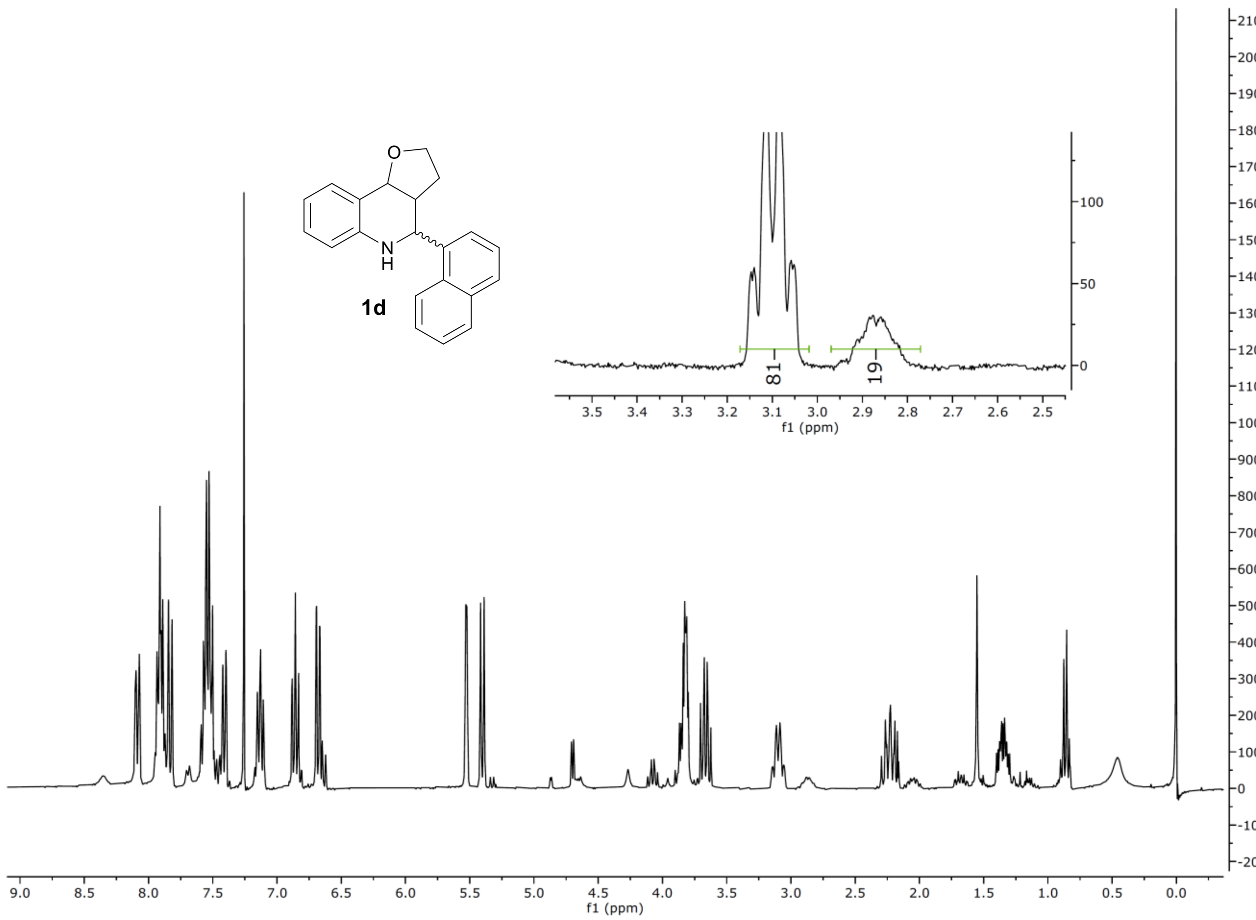


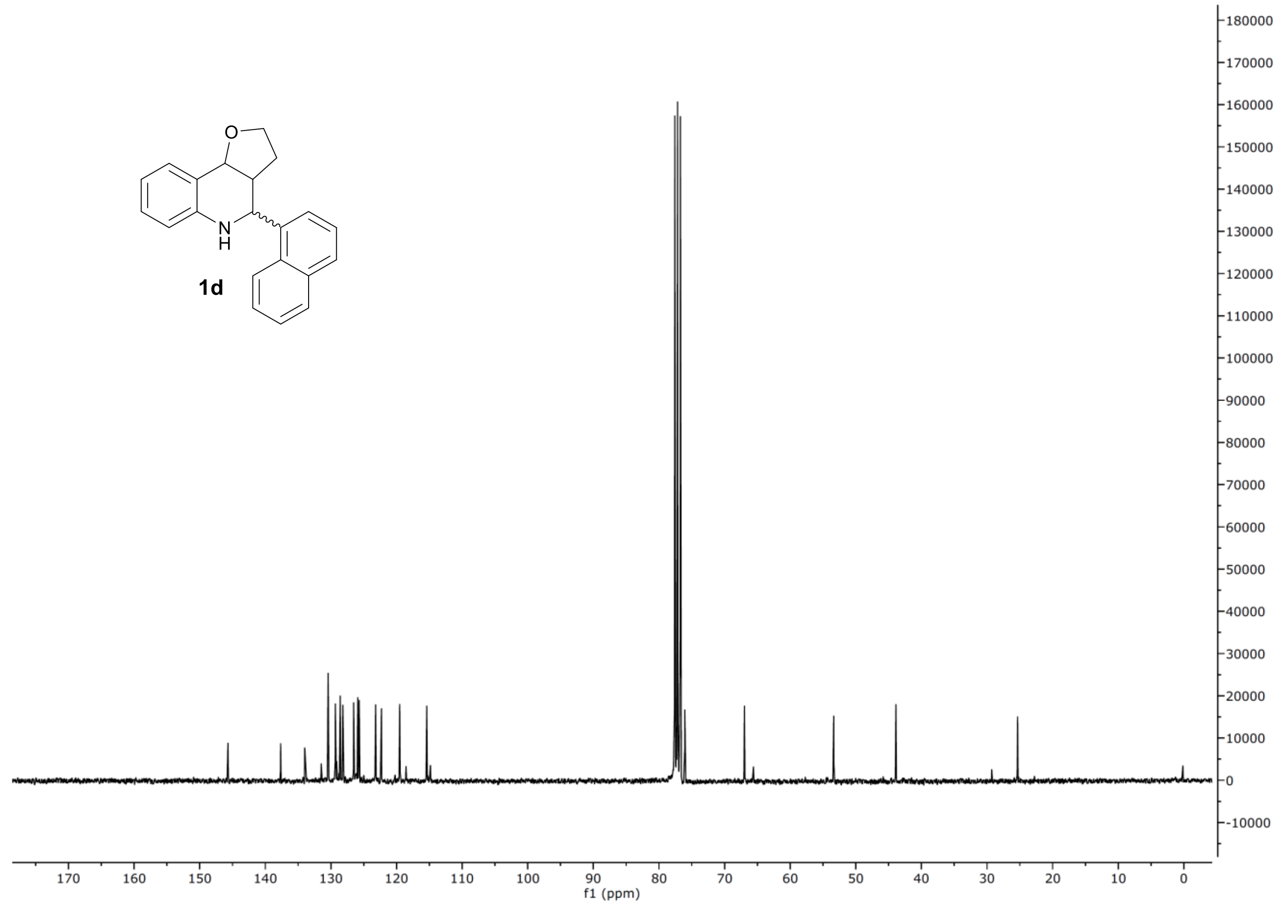
1b
Cl
O
N
H
68
32
f1 (ppm)

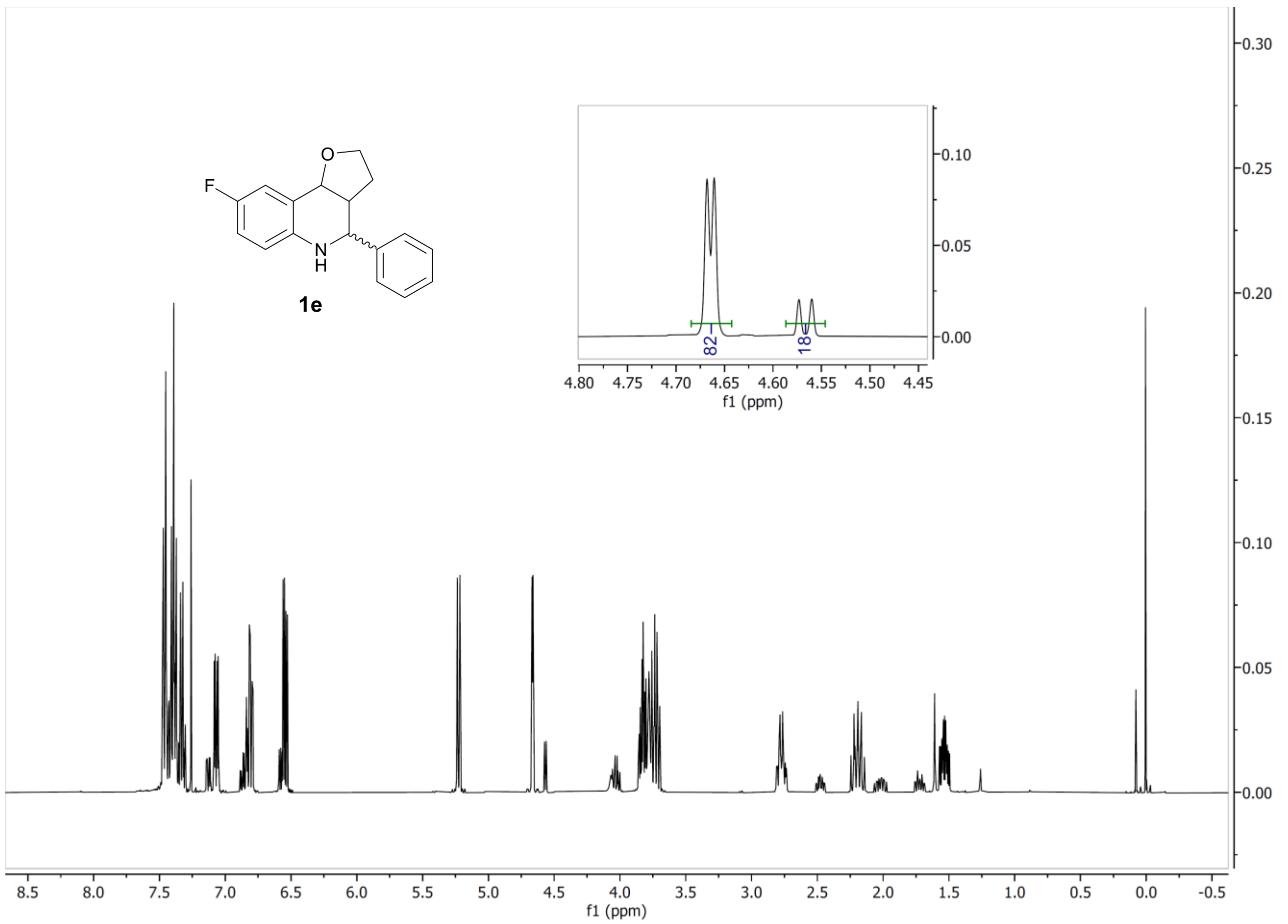

1b
Cl
f1 (ppm)

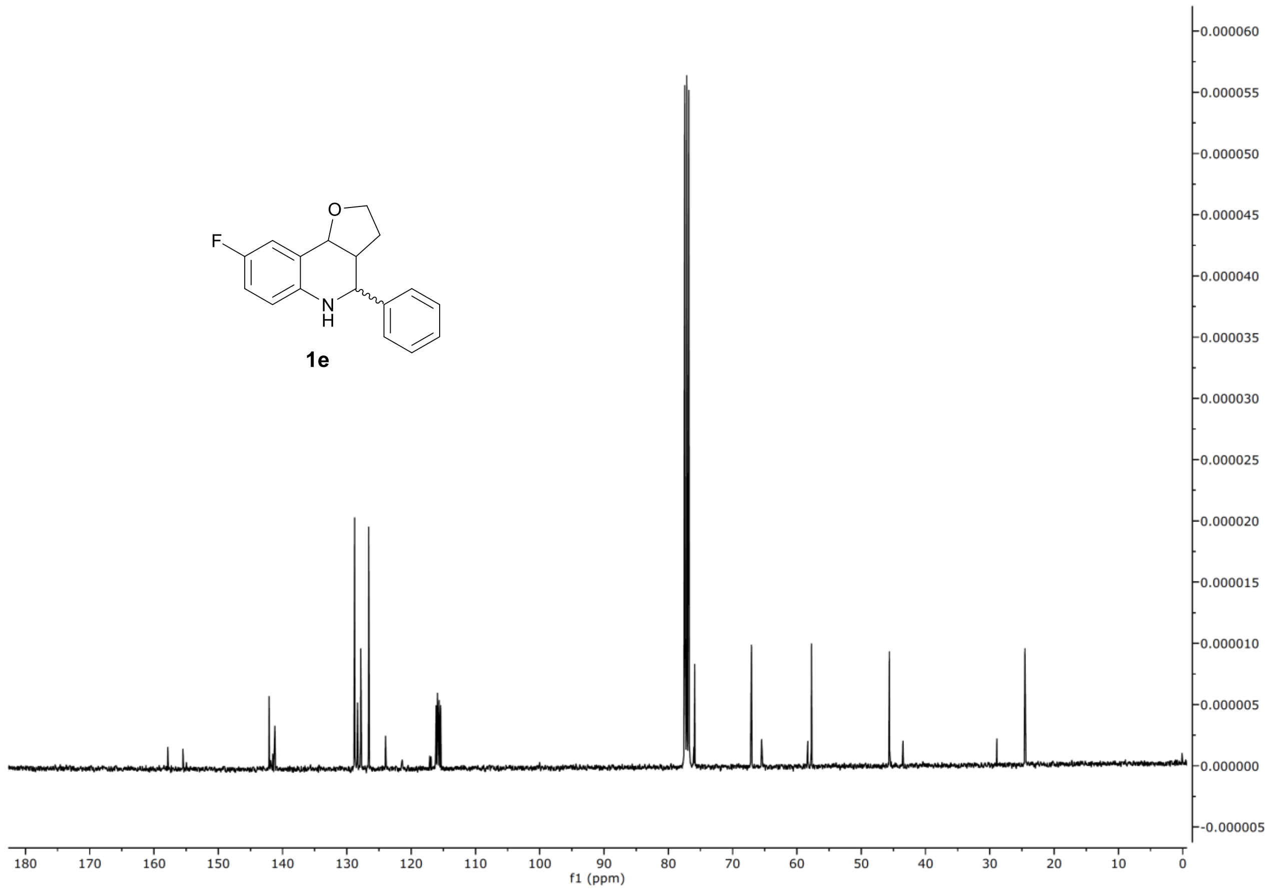

1c
78.55
21.45
f1 (ppm)

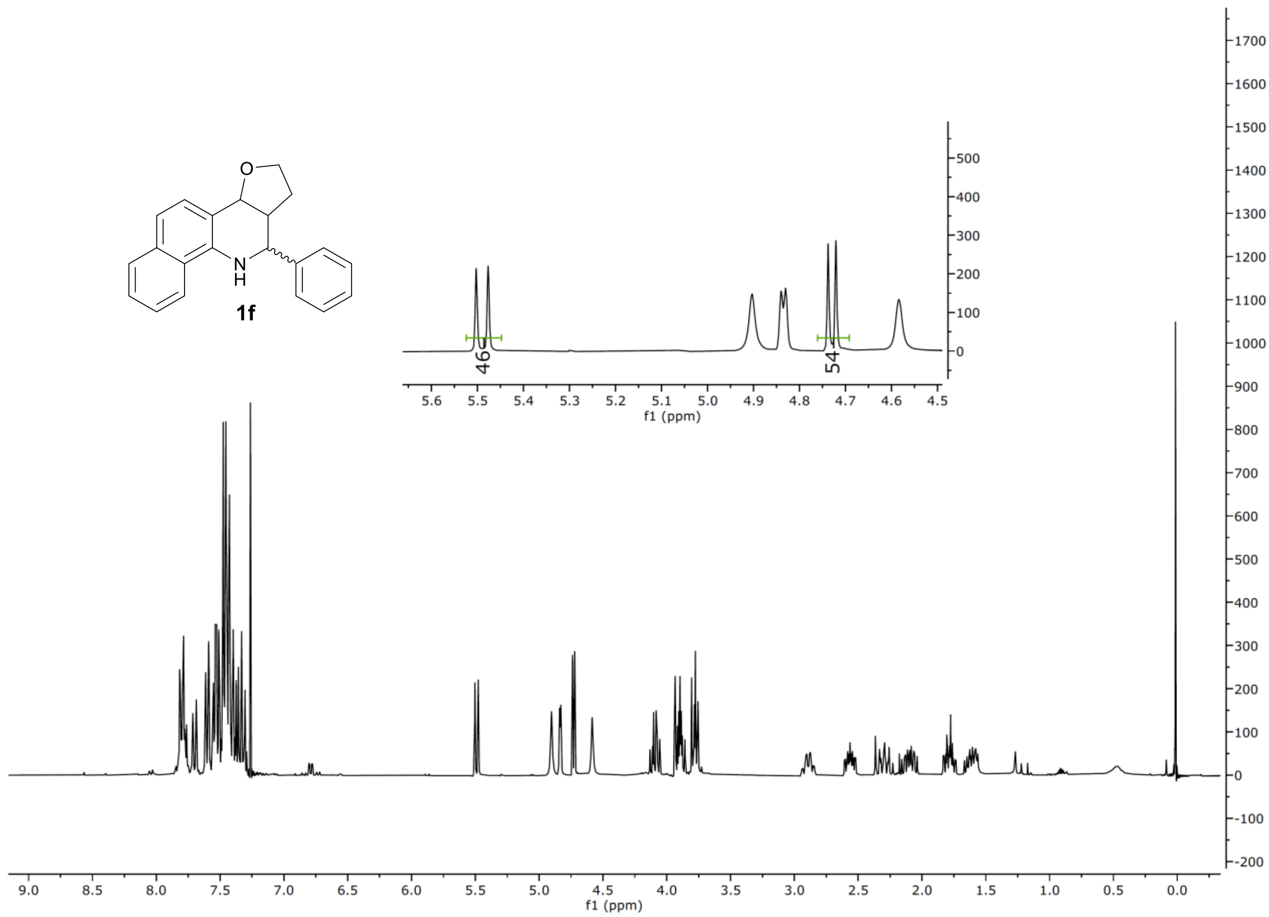

1c
f1 (ppm)

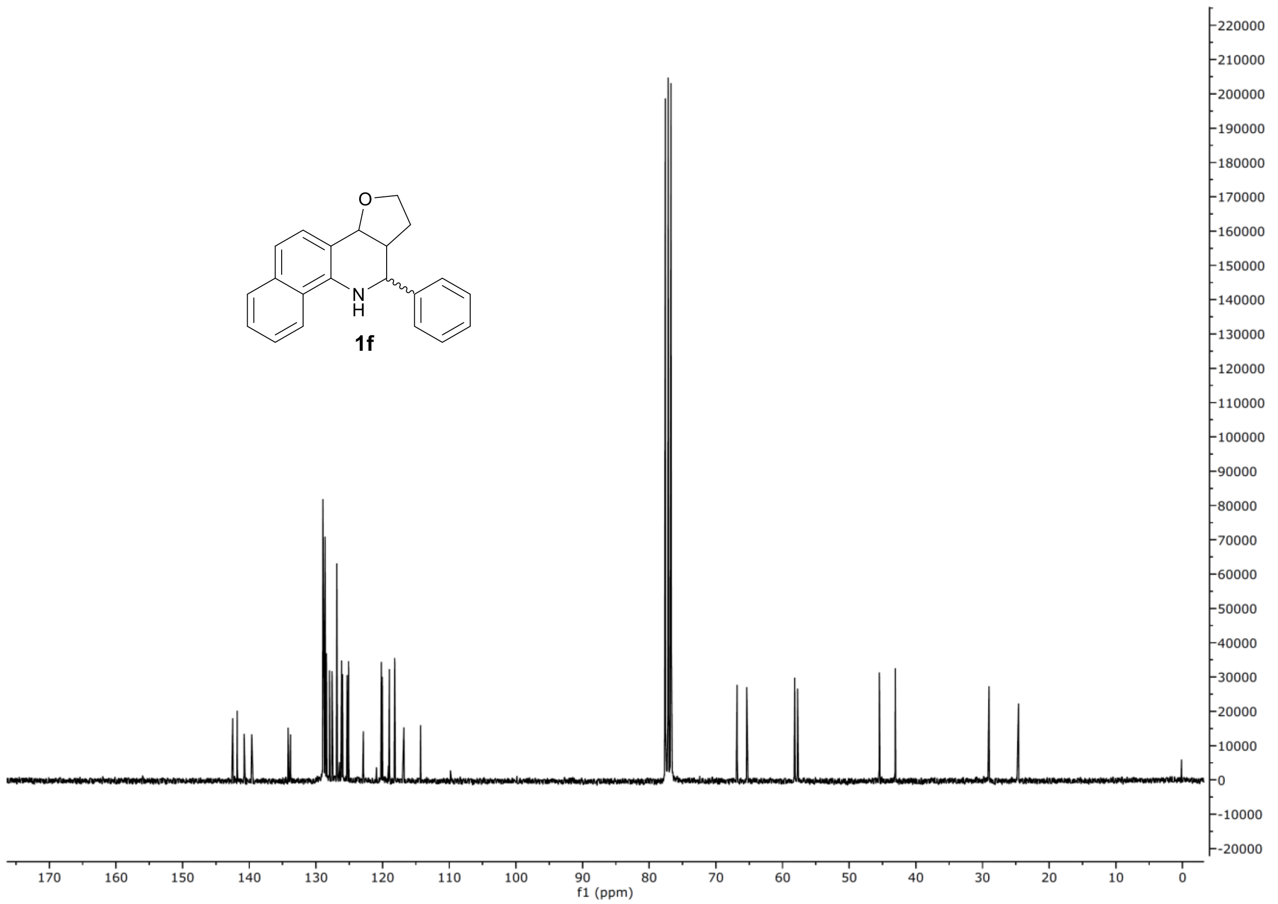

1d
81
19
f1 (ppm)
f1 (ppm)

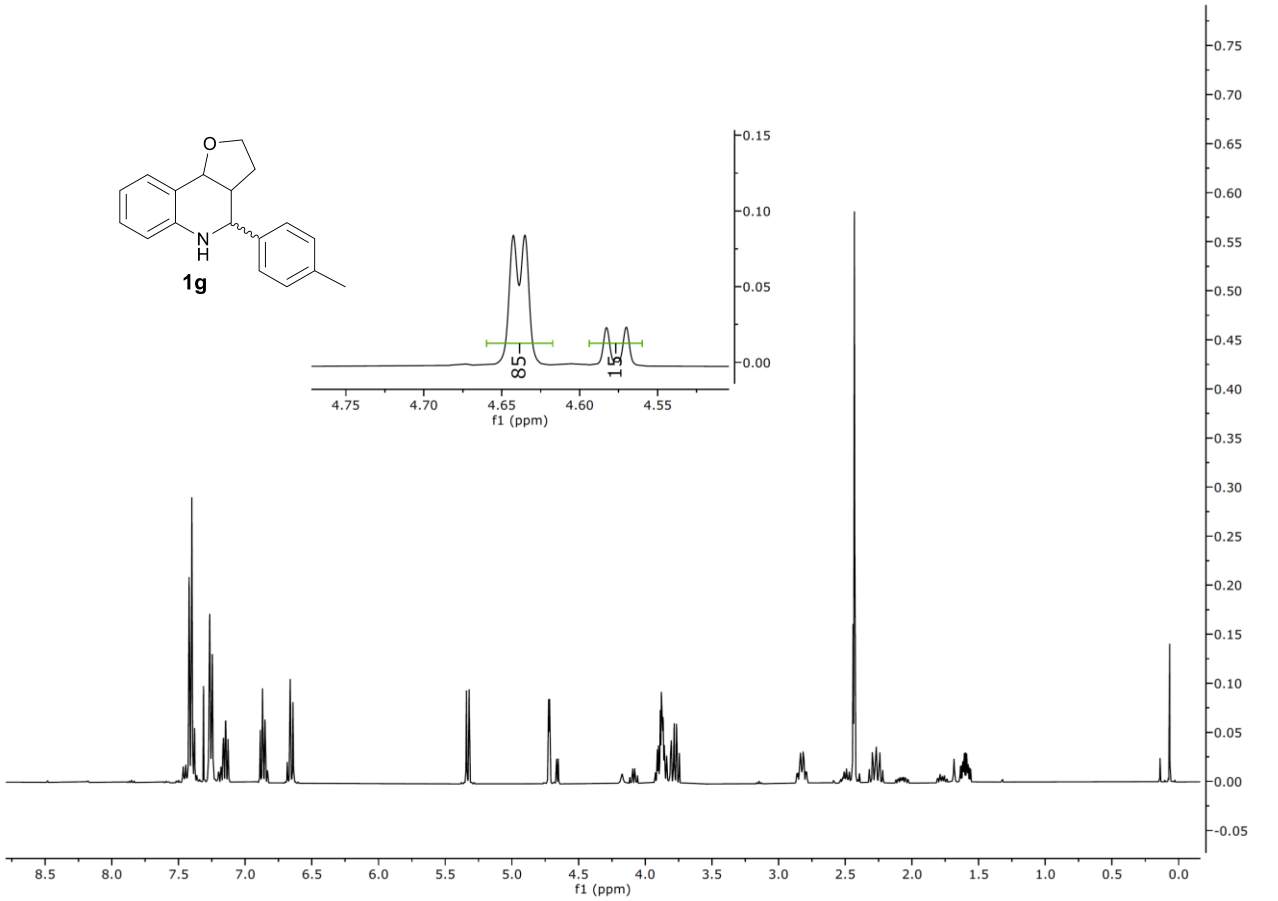

1d
f1 (ppm)

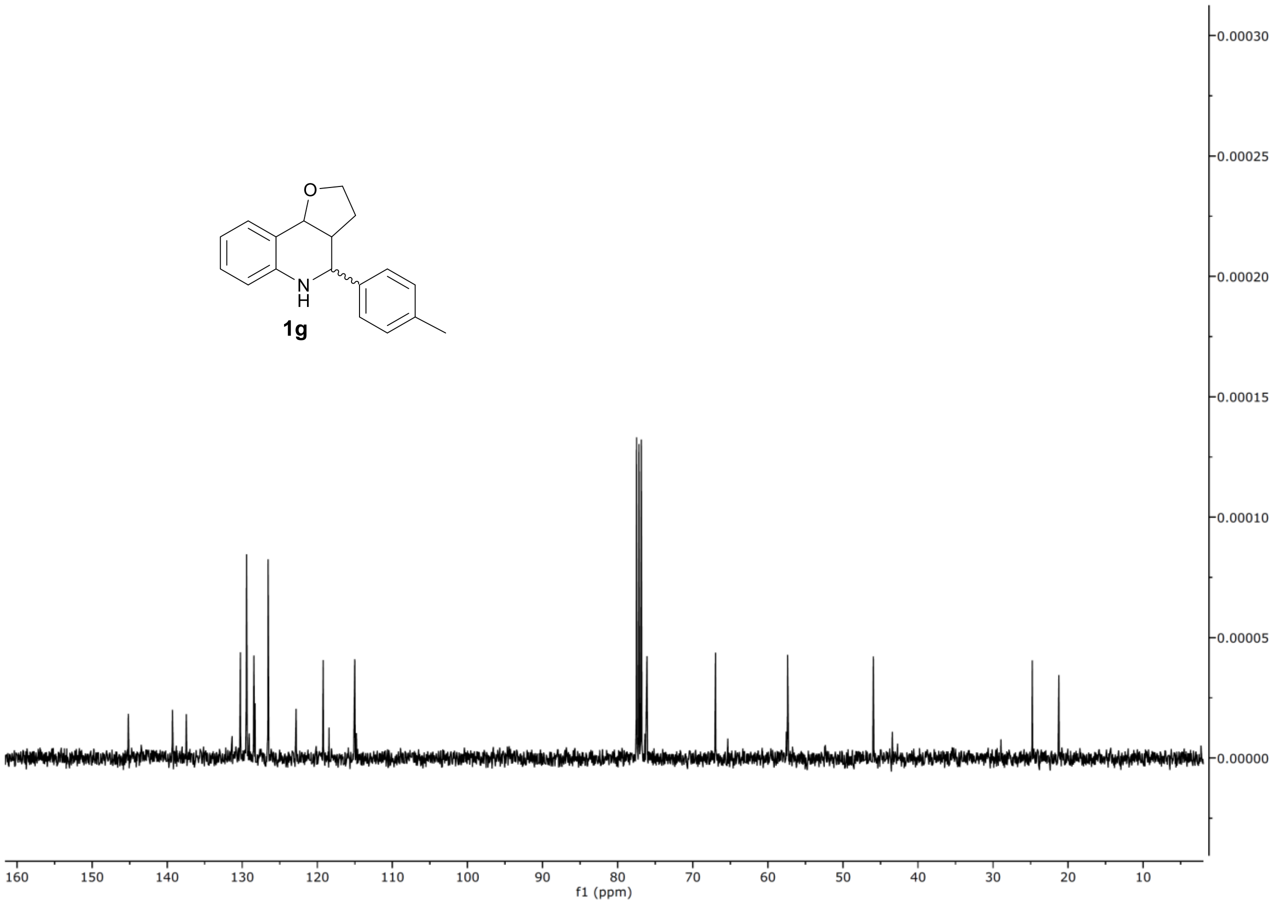

F
1e
82
18
f1 (ppm)
f1 (ppm)


F
O
N
H
1e
f1 (ppm)

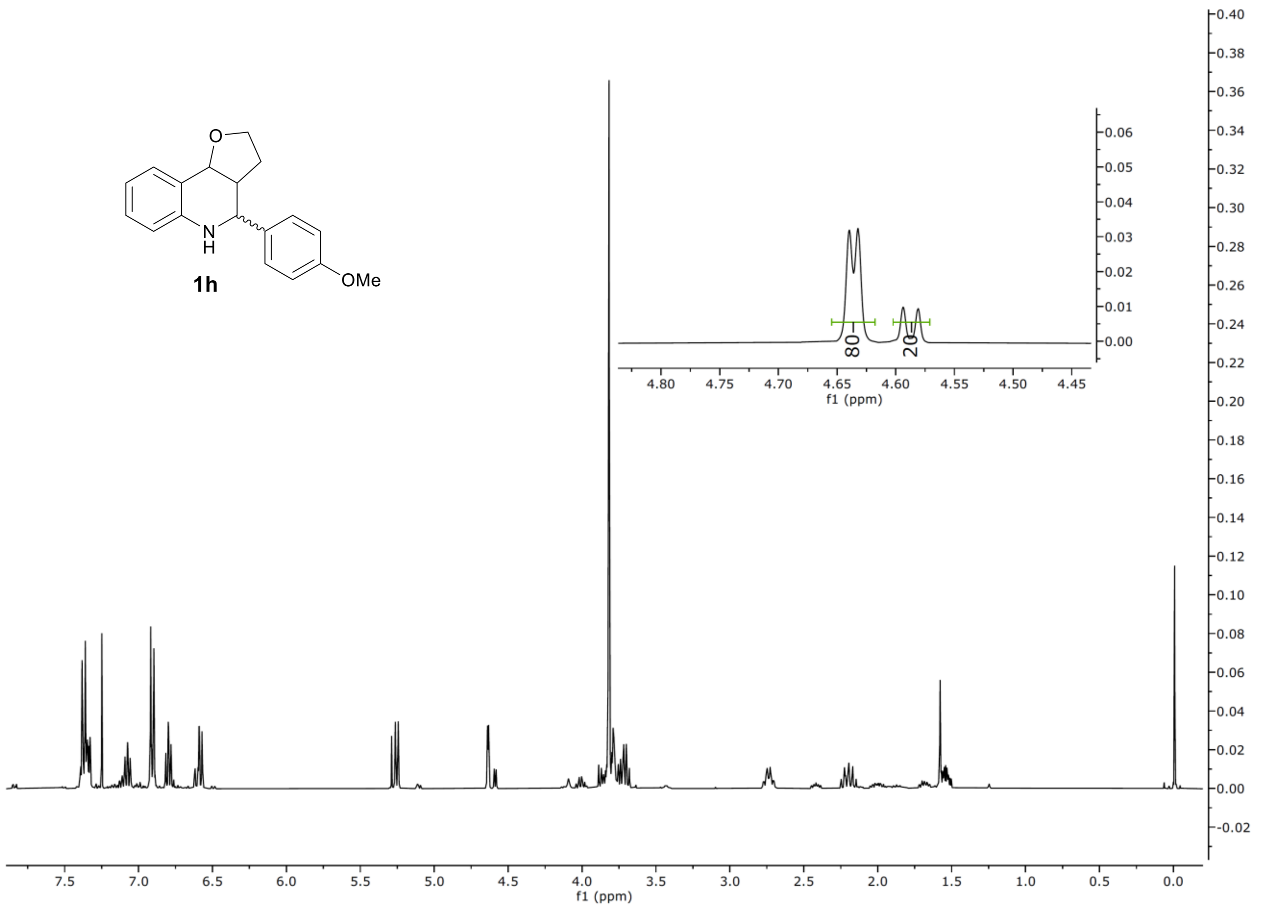

O
N
H
1f
46
54
f1 (ppm)
f1 (ppm)


1f
f1 (ppm)

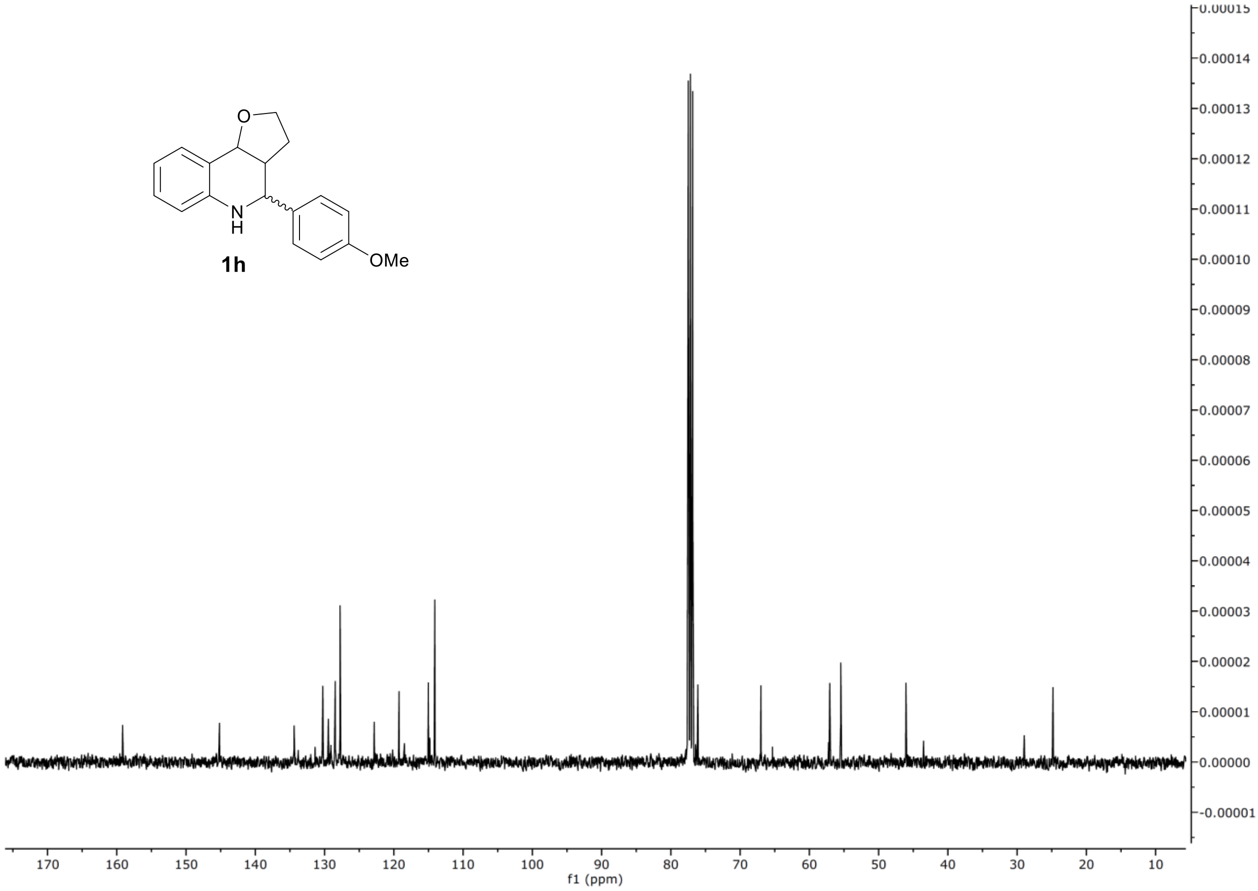

1g
85
15
f1 (ppm)
f1 (ppm)



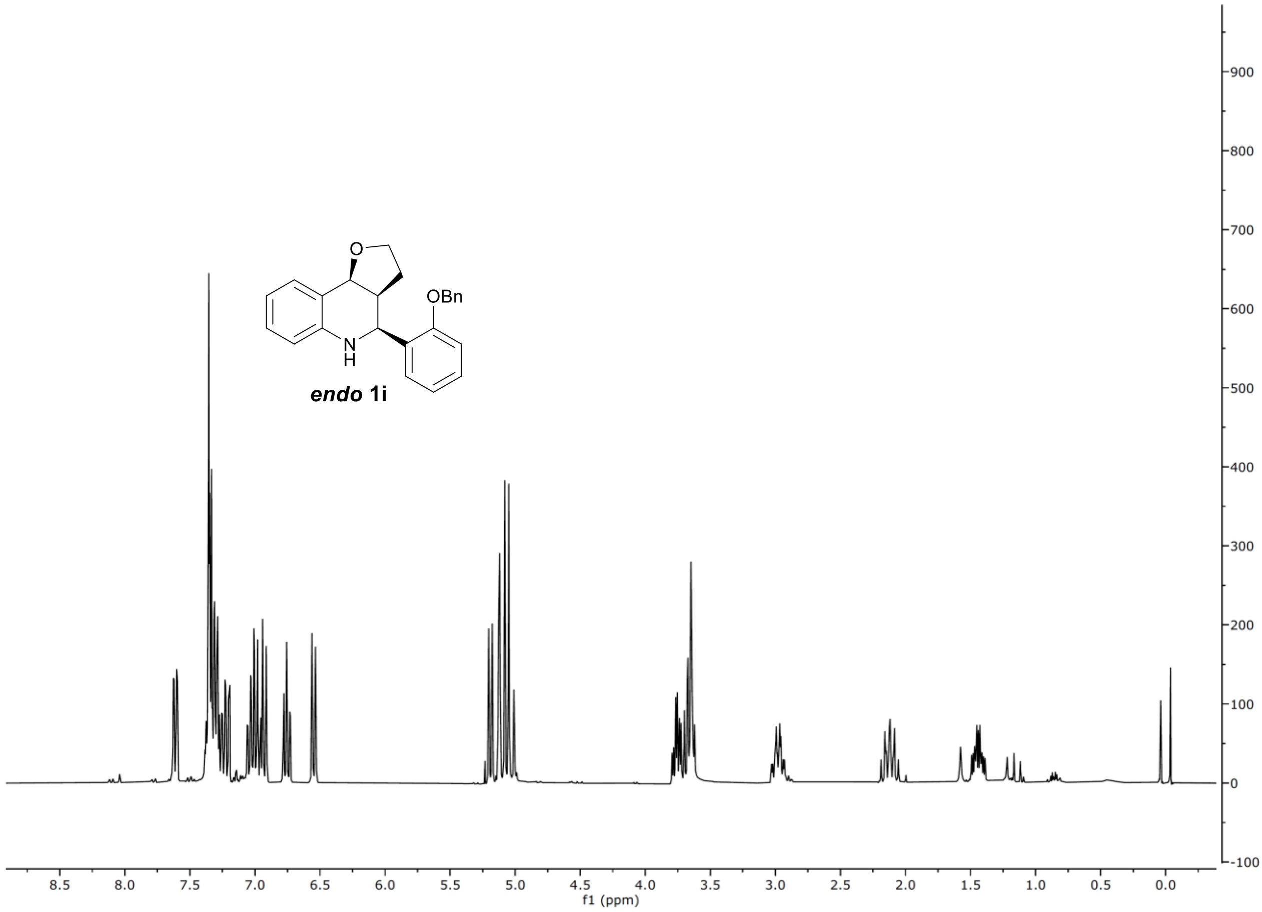
1g
O
N
H
f1 (ppm)

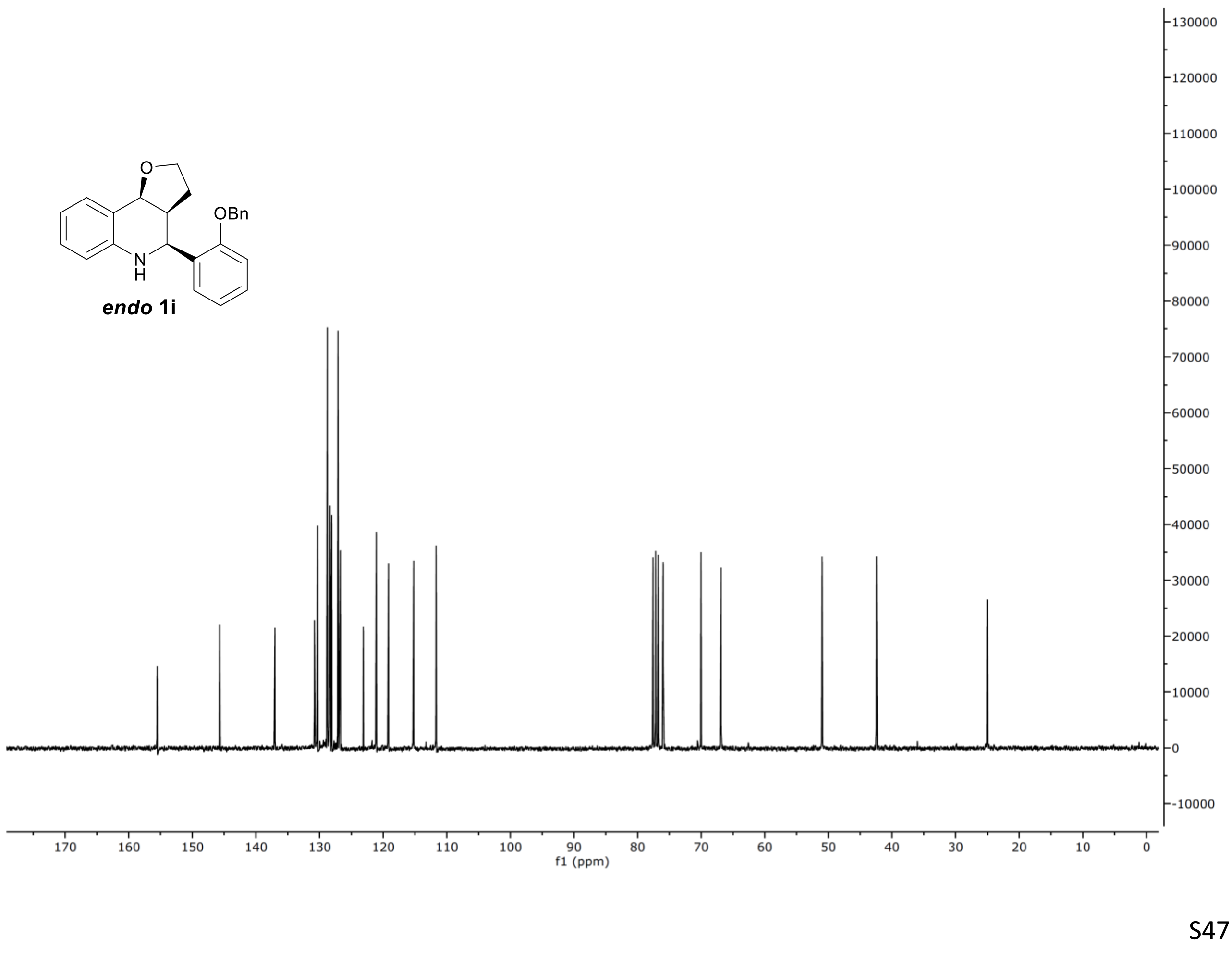


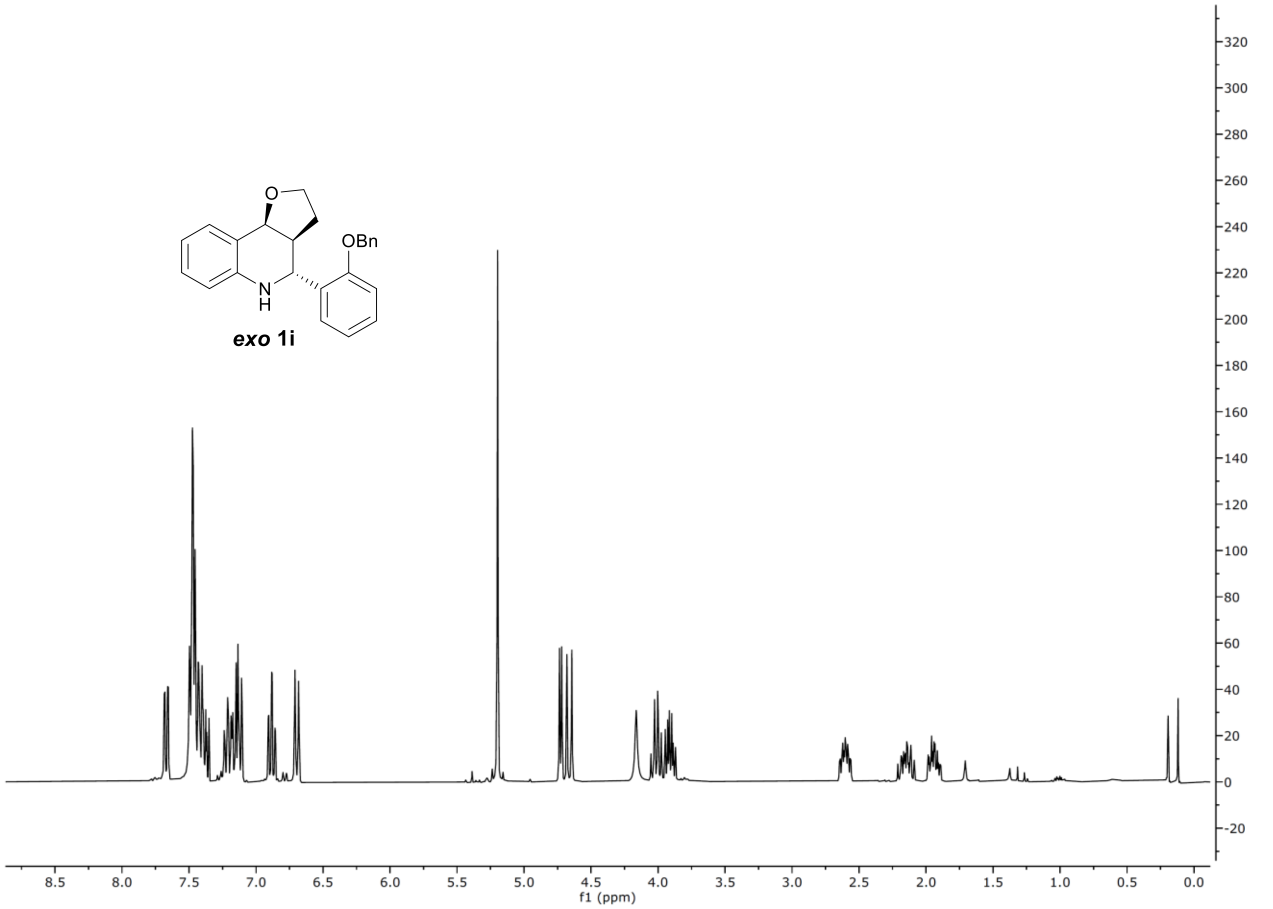
1h
O
N
H
OMe
80
20
f1 (ppm)

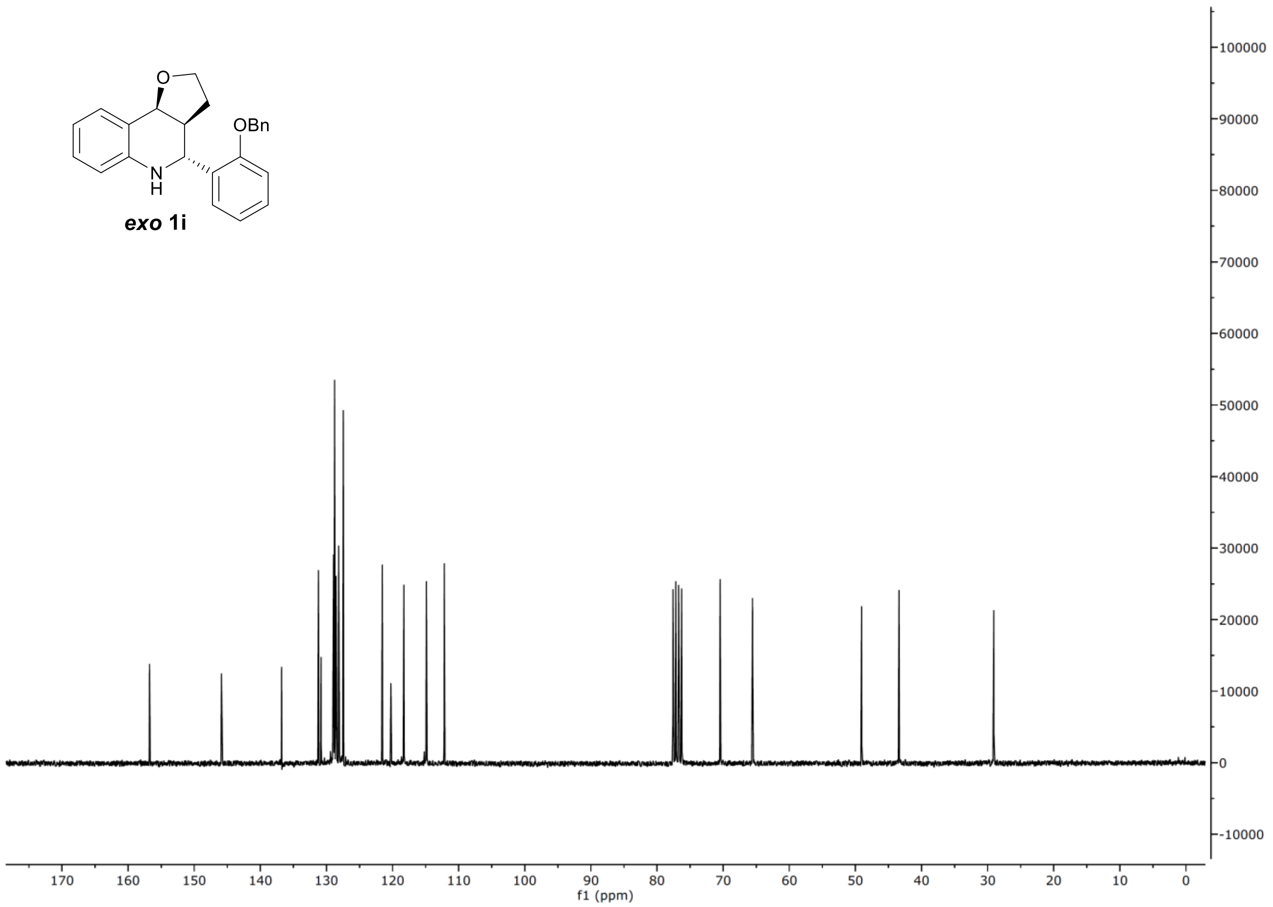


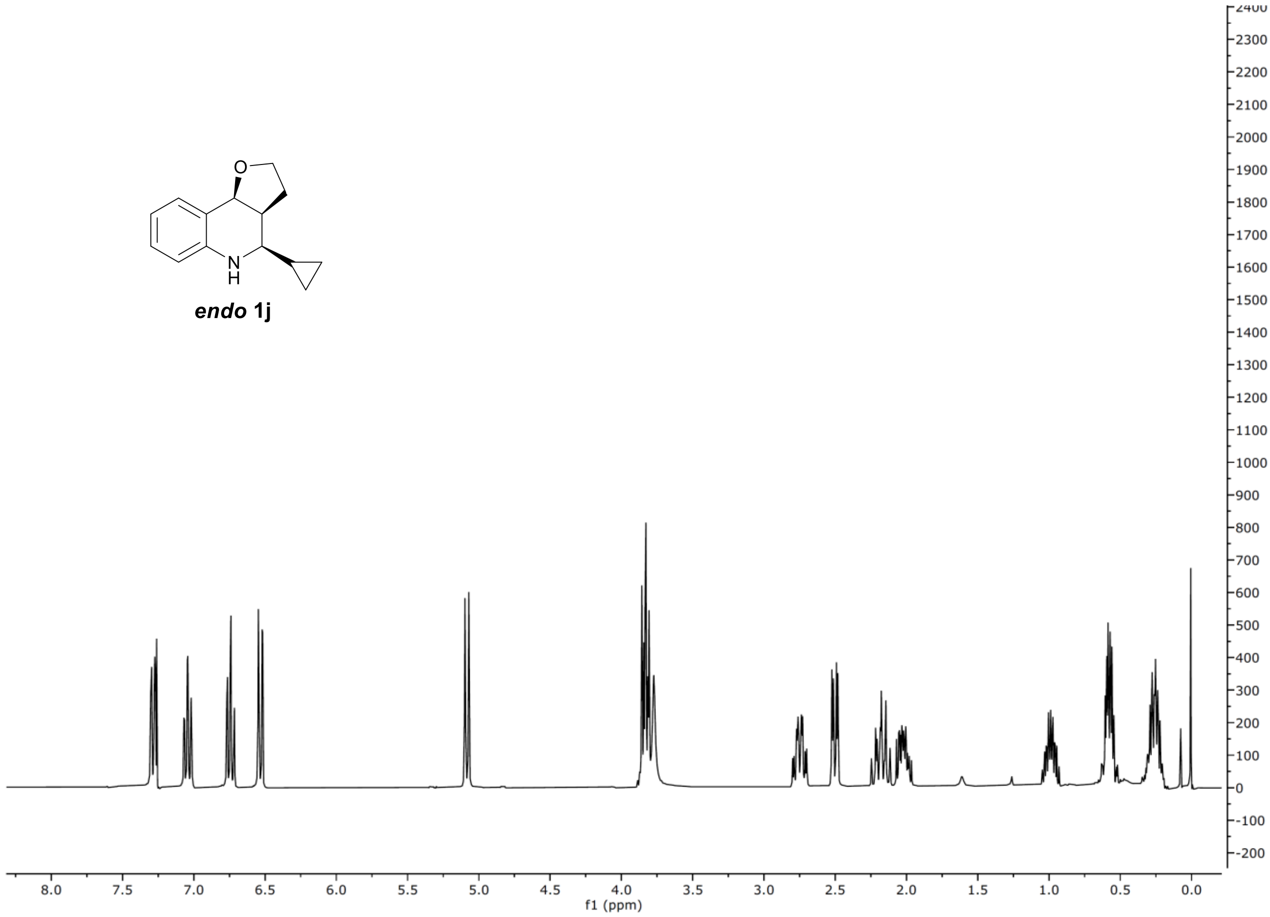
O
N
H
OMe
1h
f1 (ppm)

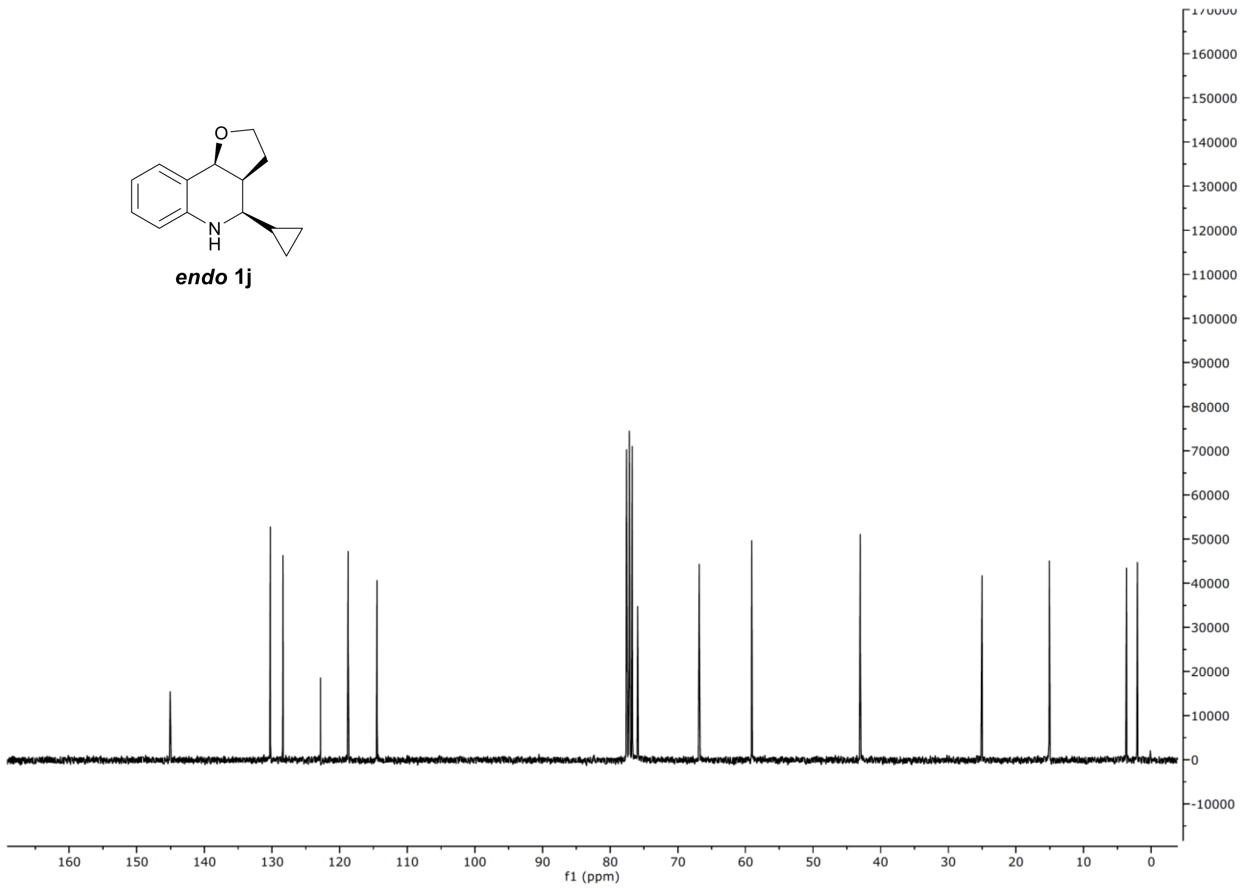

OBn
O
N
H
endo 1i
f1 (ppm)

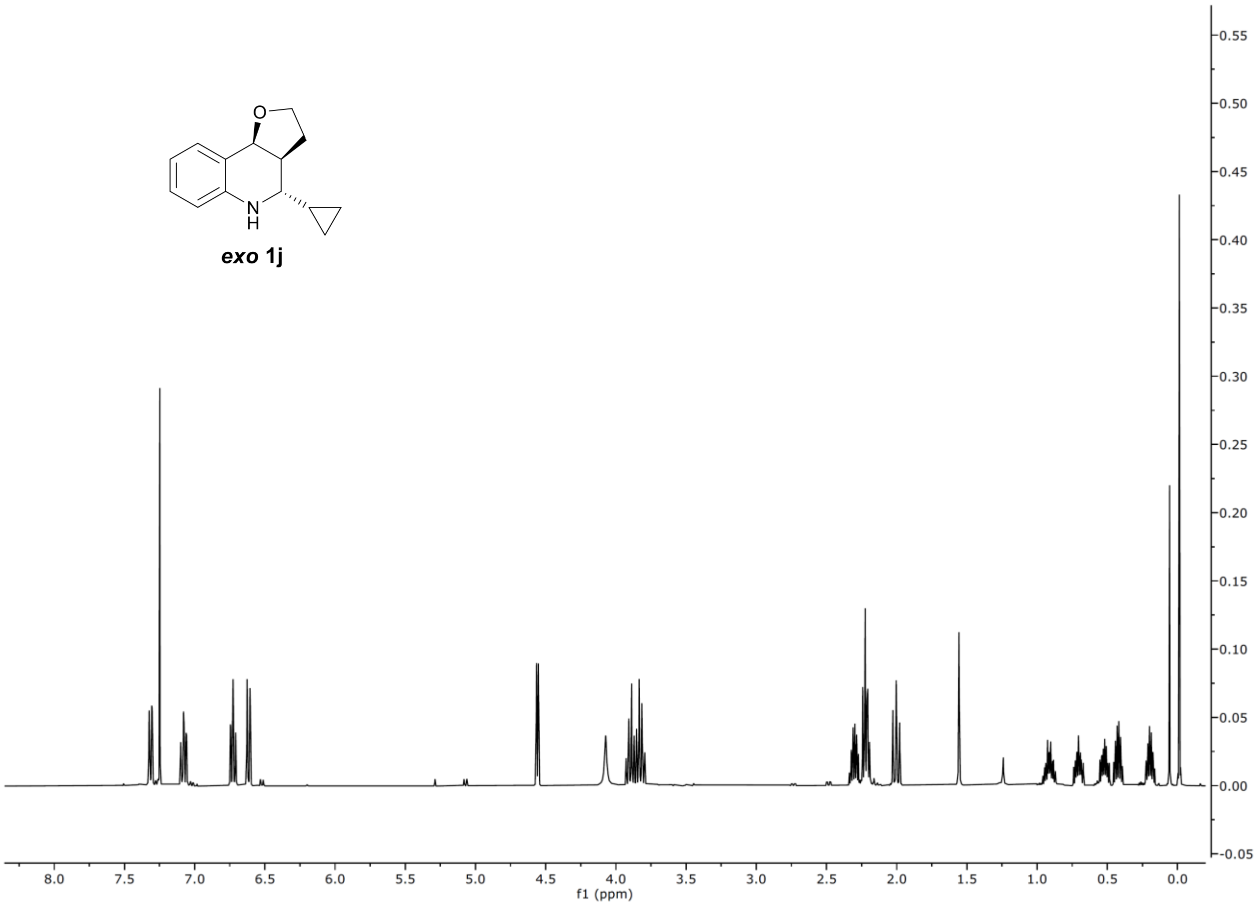

OBn
O
N
H
endo 1i
f1 (ppm)

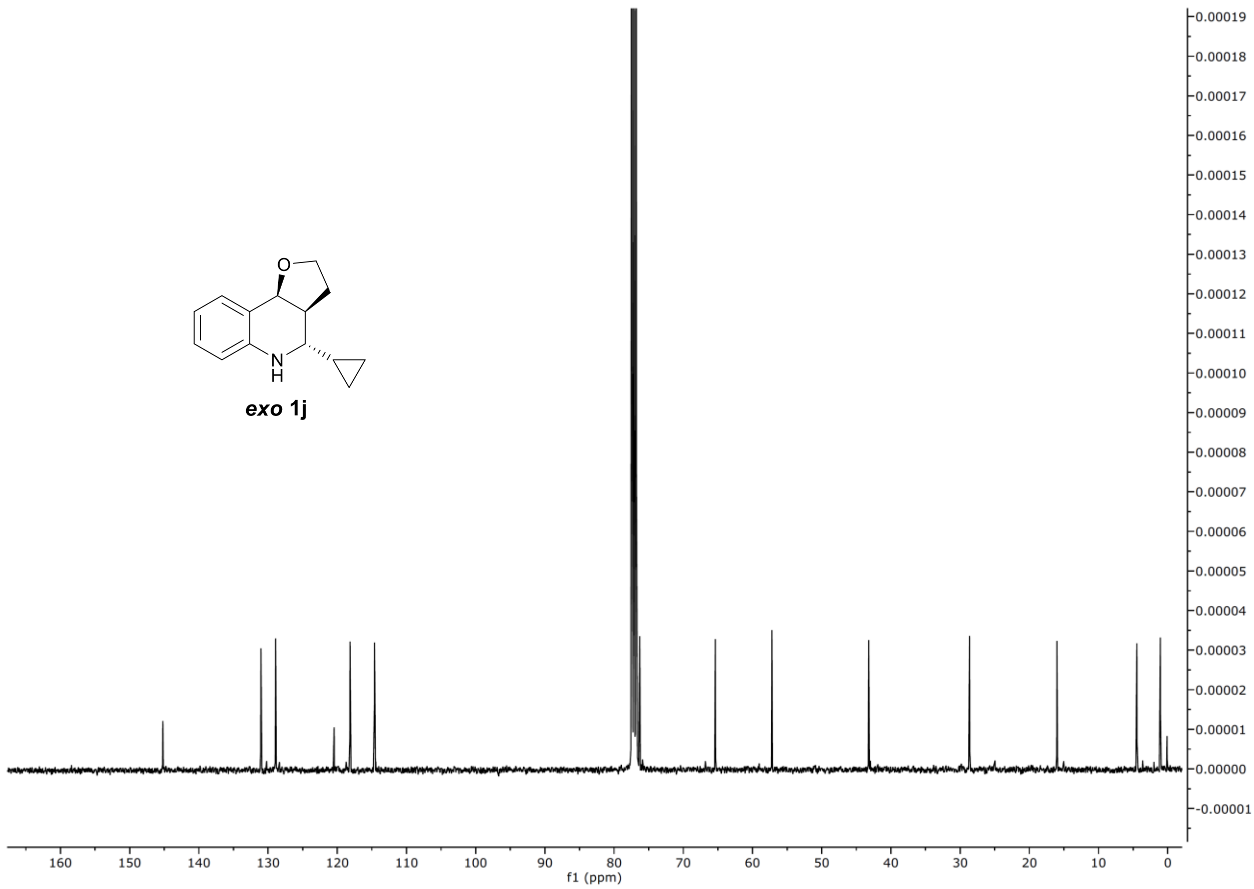

O
OBn
N
H
exo 1i
f1 (ppm)

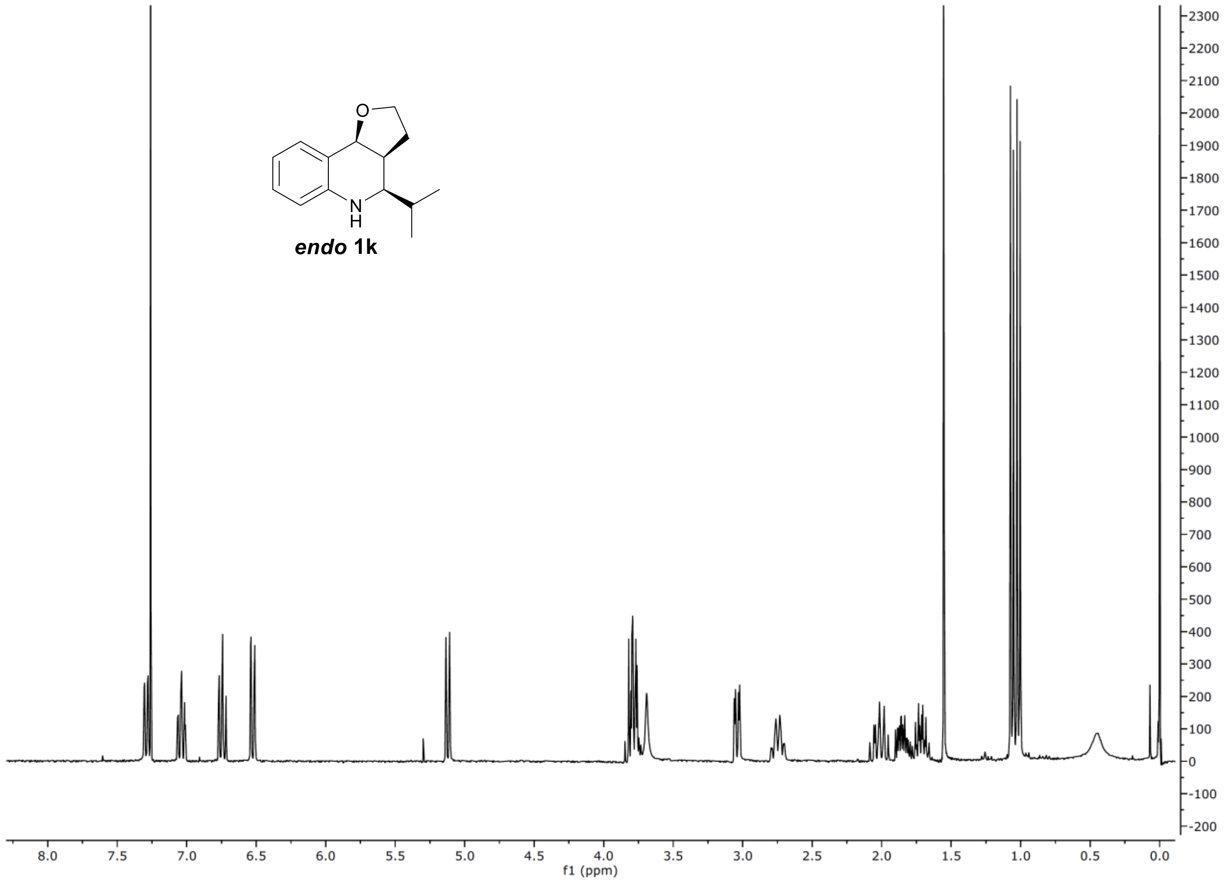

O
OBn
N
H
exo 1i
f1 (ppm)

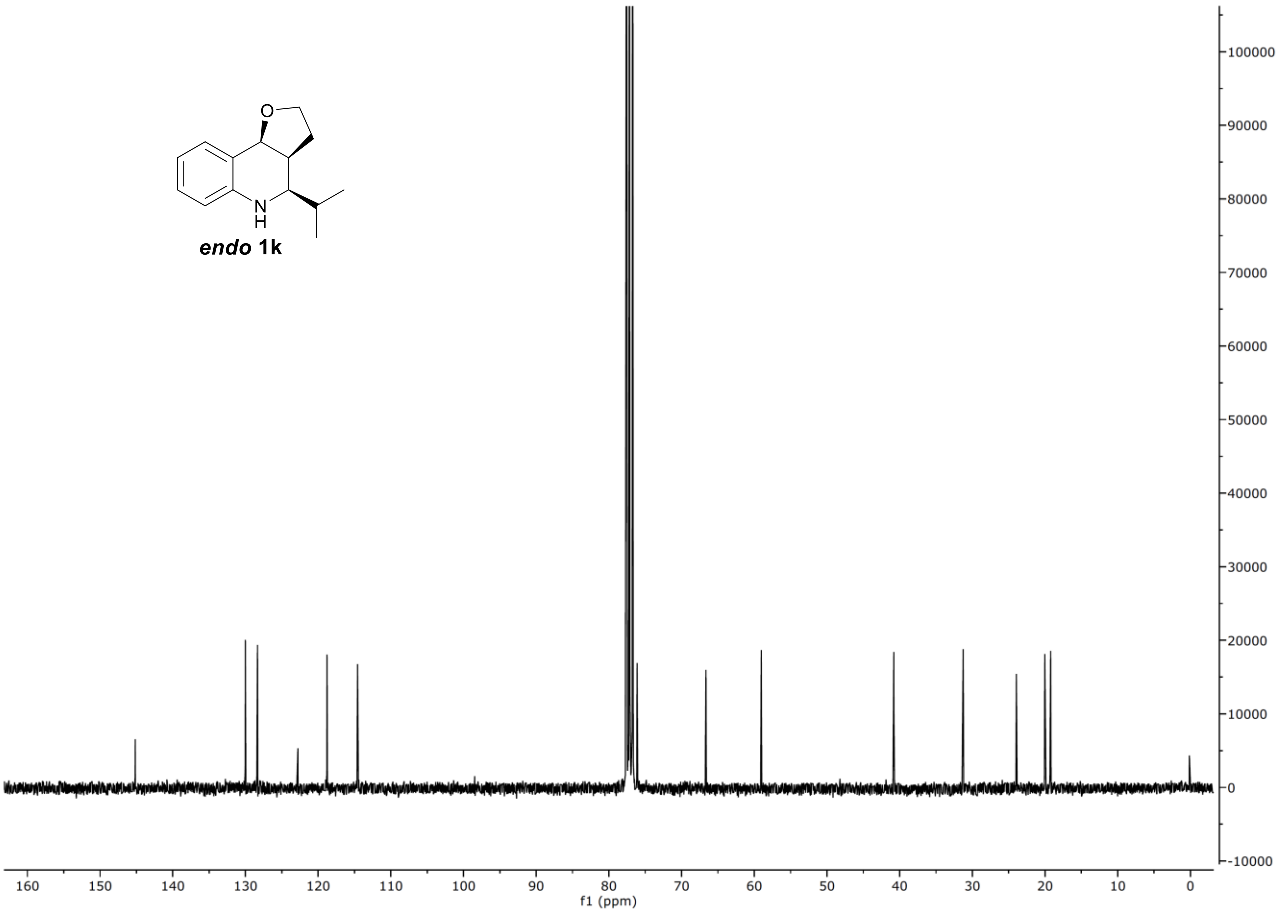

endo 1j
f1 (ppm)
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
2400 2300 2200 2100 2000 1900 1800 1700 1600 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200 100 0 -100 -200

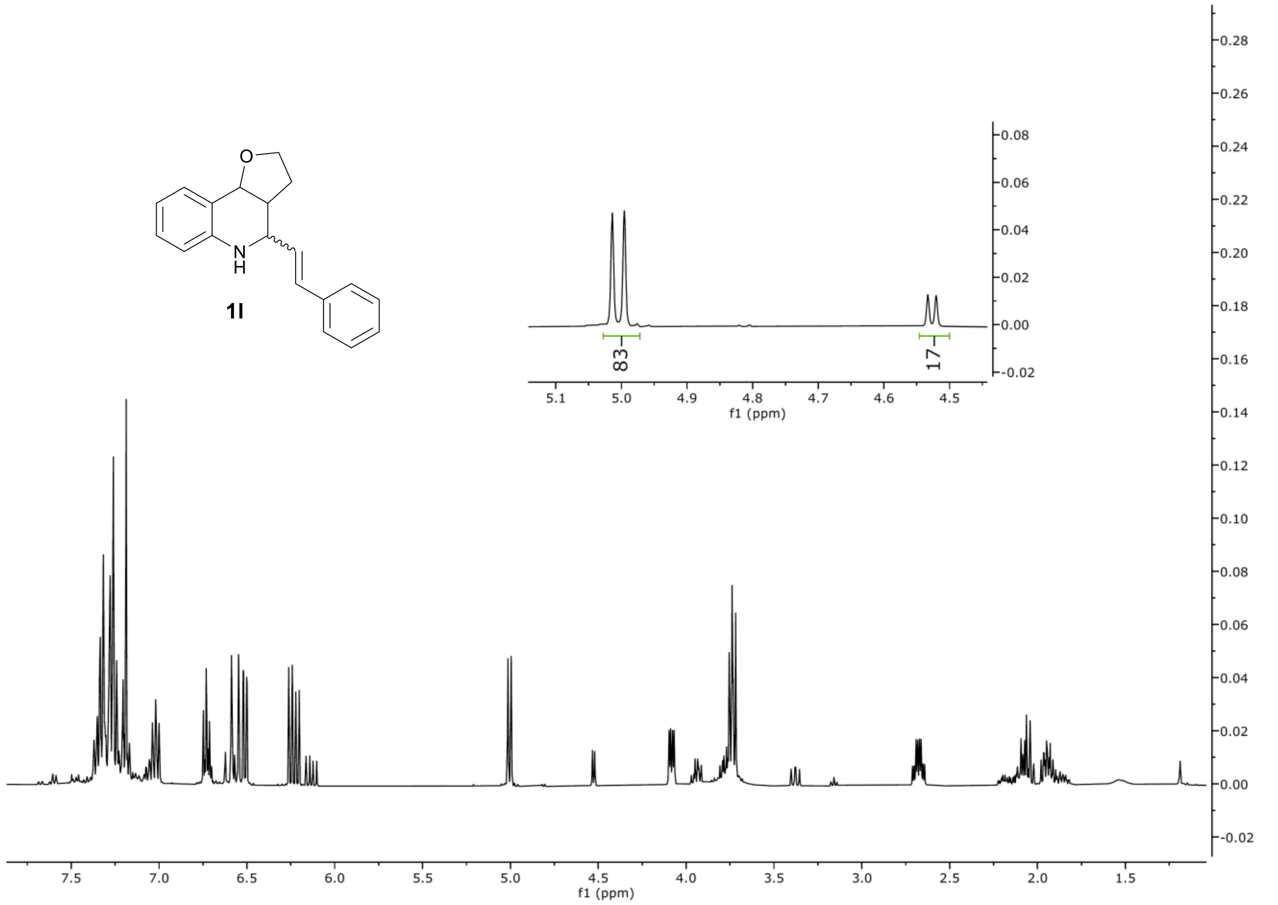

endo 1j
f1 (ppm)
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
170000 160000 150000 140000 130000 120000 110000 100000 90000 80000 70000 60000 50000 40000 30000 20000 10000 0 -10000

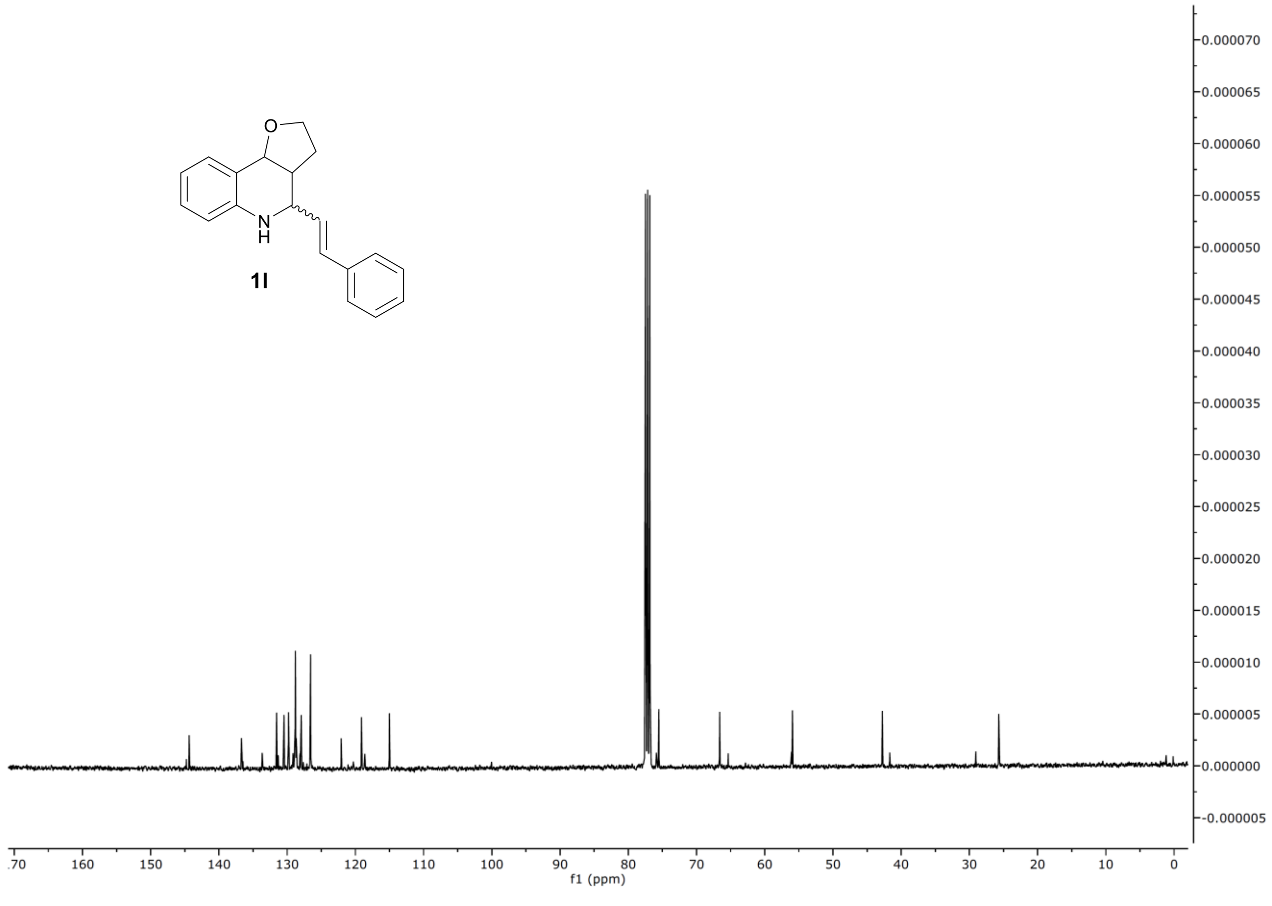

exo 1j
f1 (ppm)

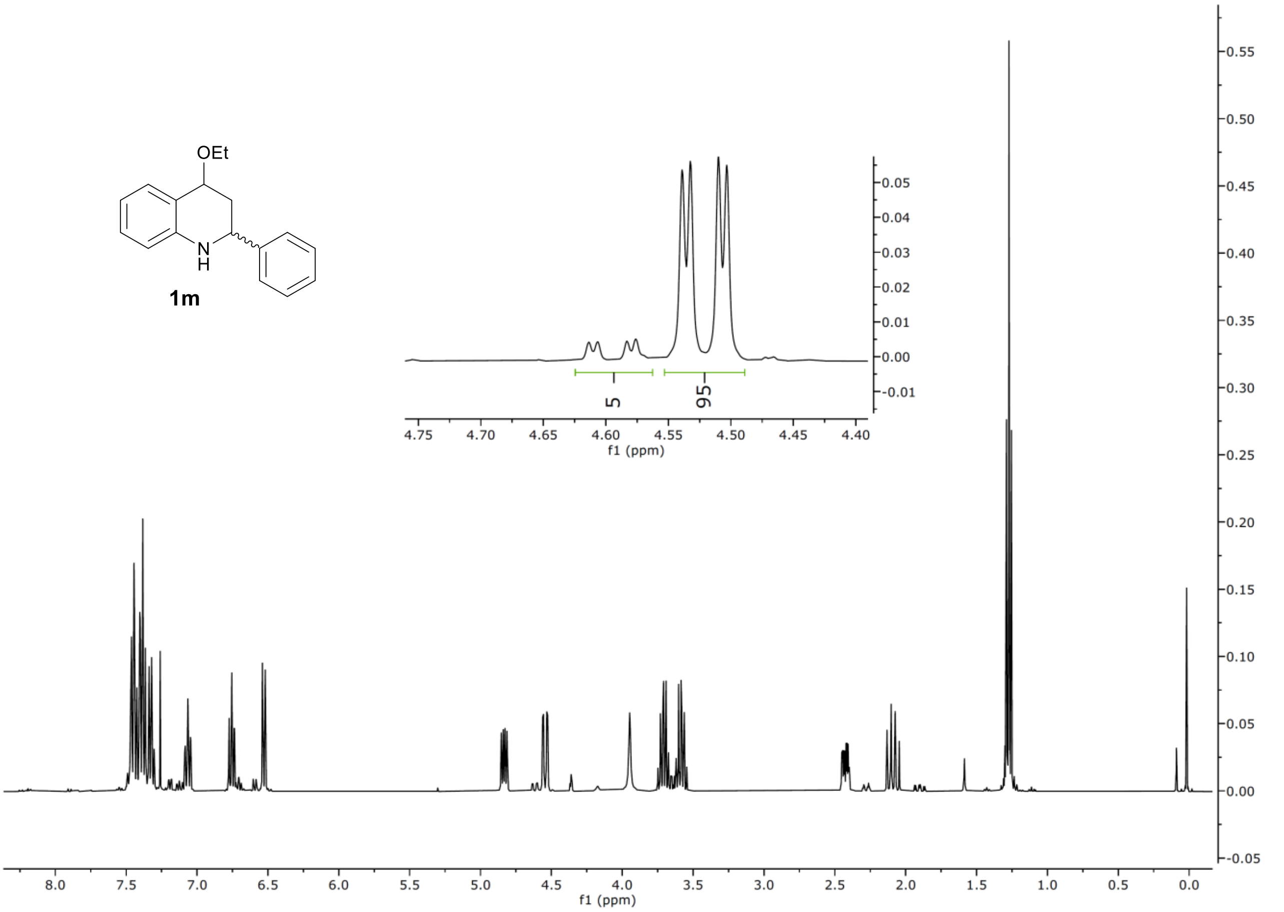

exo 1j
f1 (ppm)

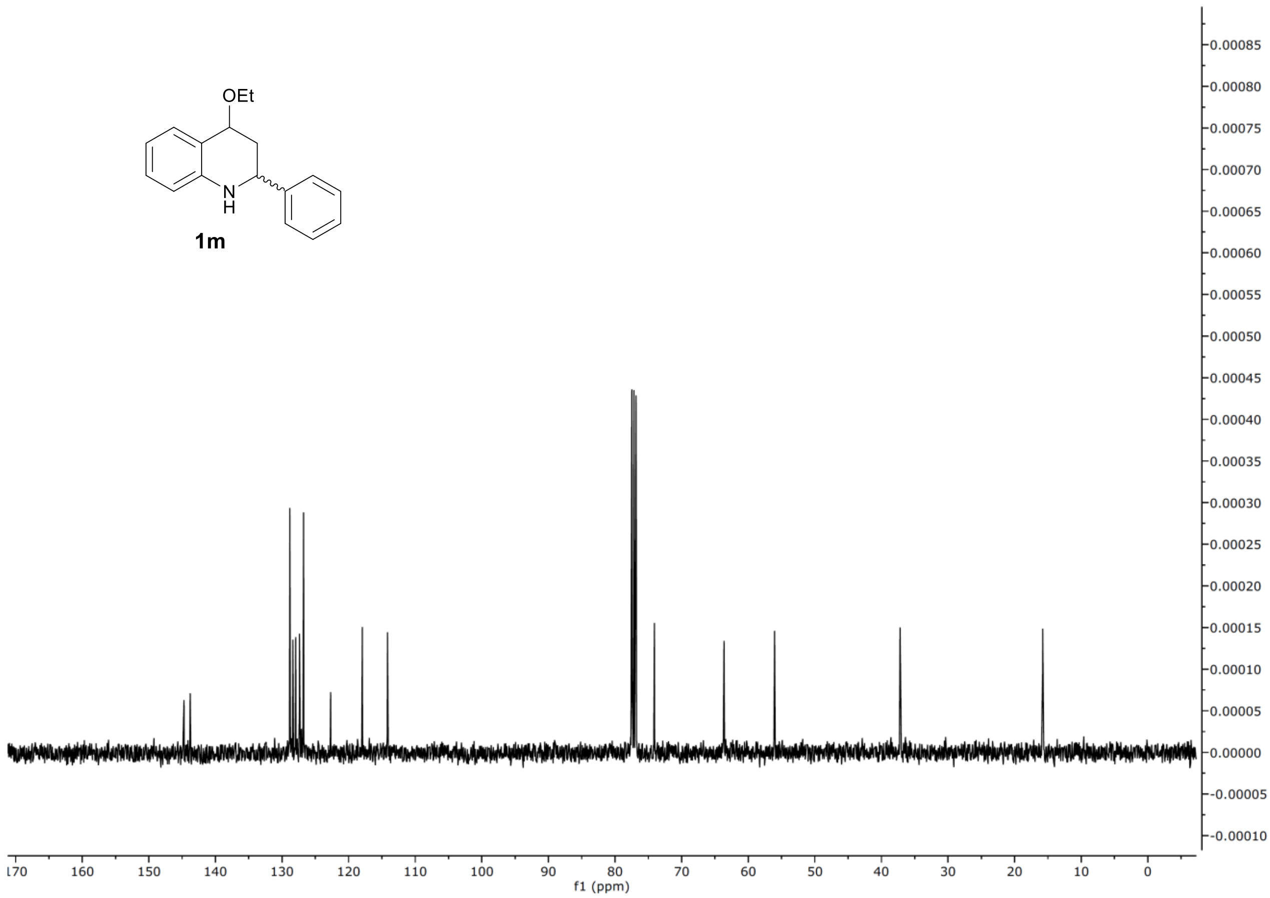

endo 1k
f1 (ppm)

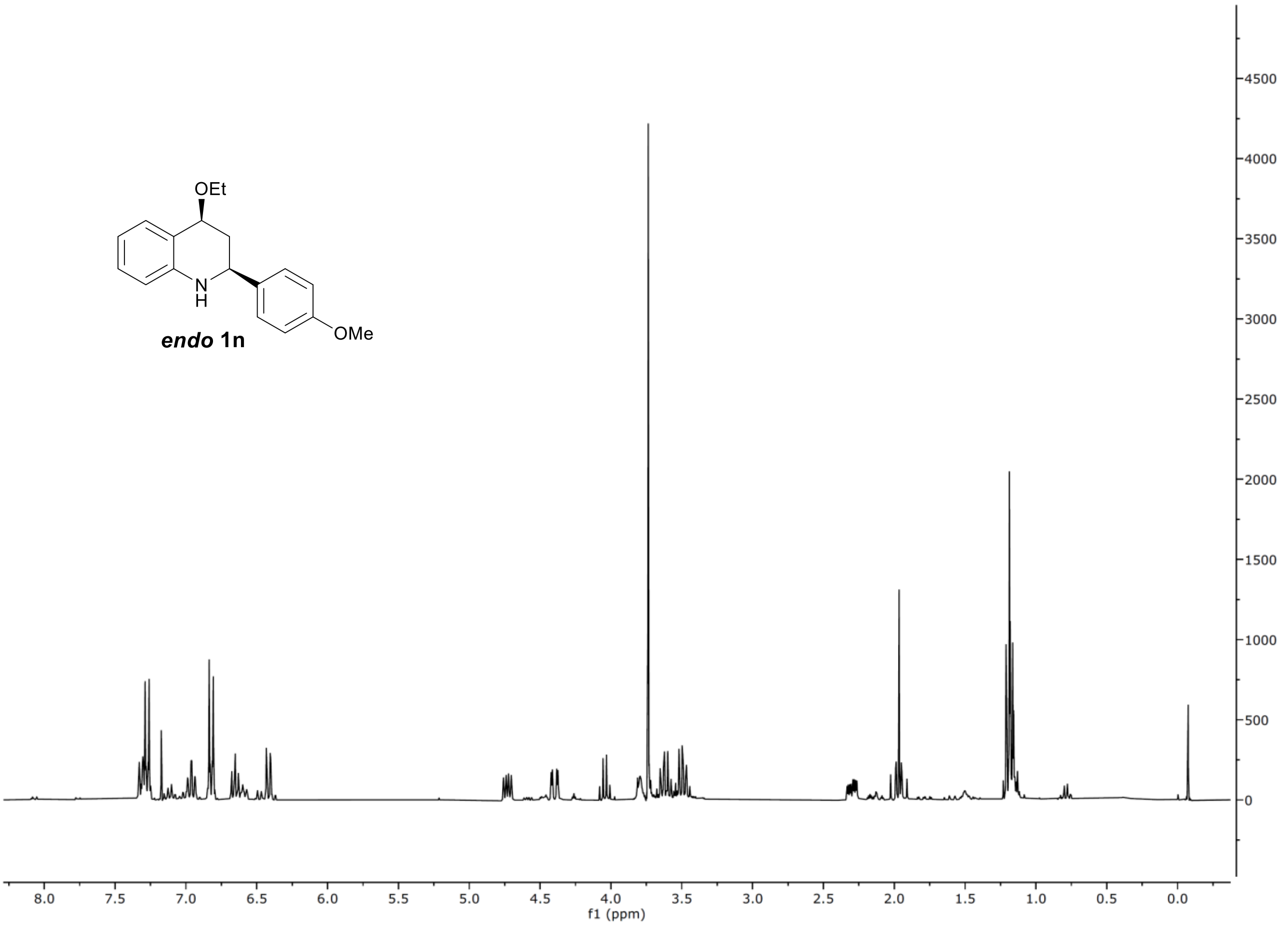

endo 1k
f1 (ppm)


1l
83
17
f1 (ppm)
f1 (ppm)

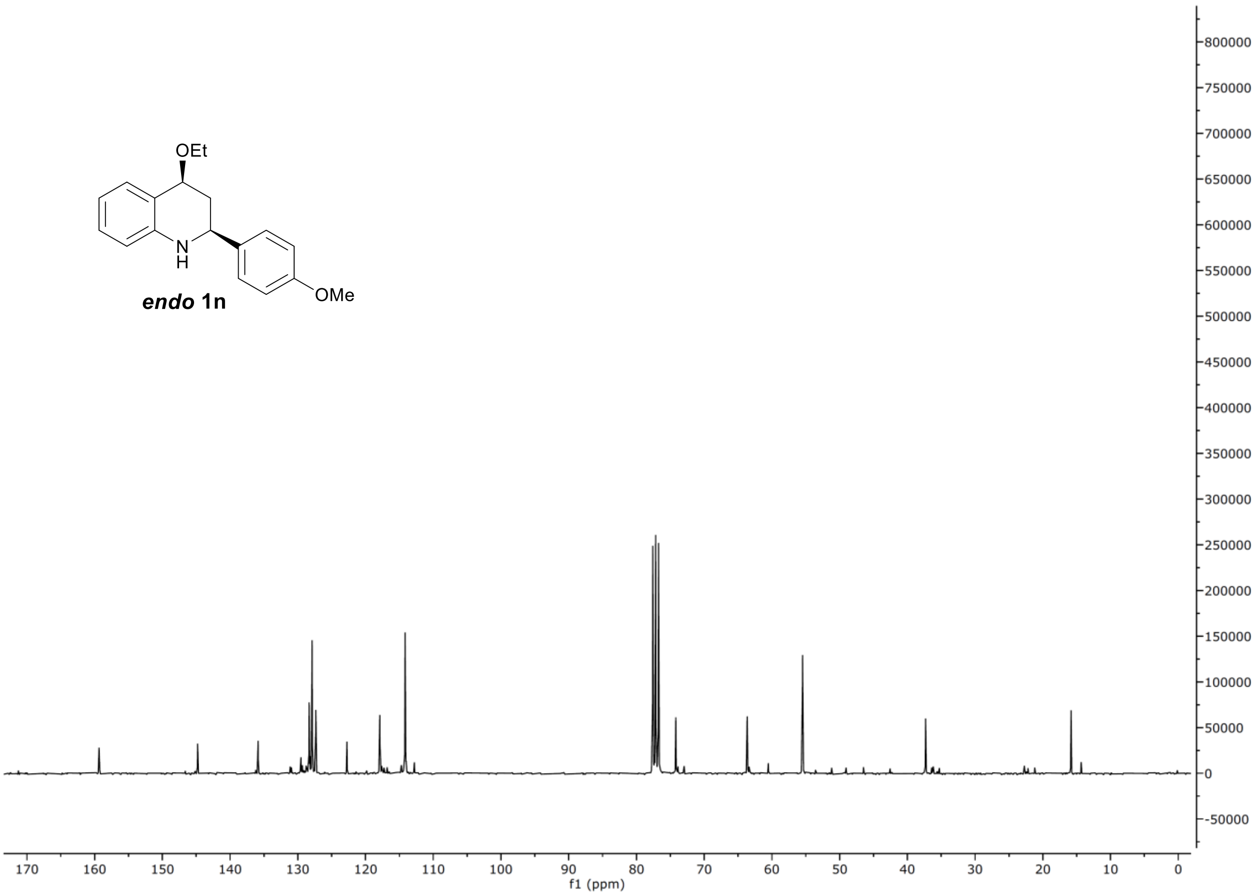

1l
f1 (ppm)


OEt
N
H
1m
5
95
f1 (ppm)
f1 (ppm)

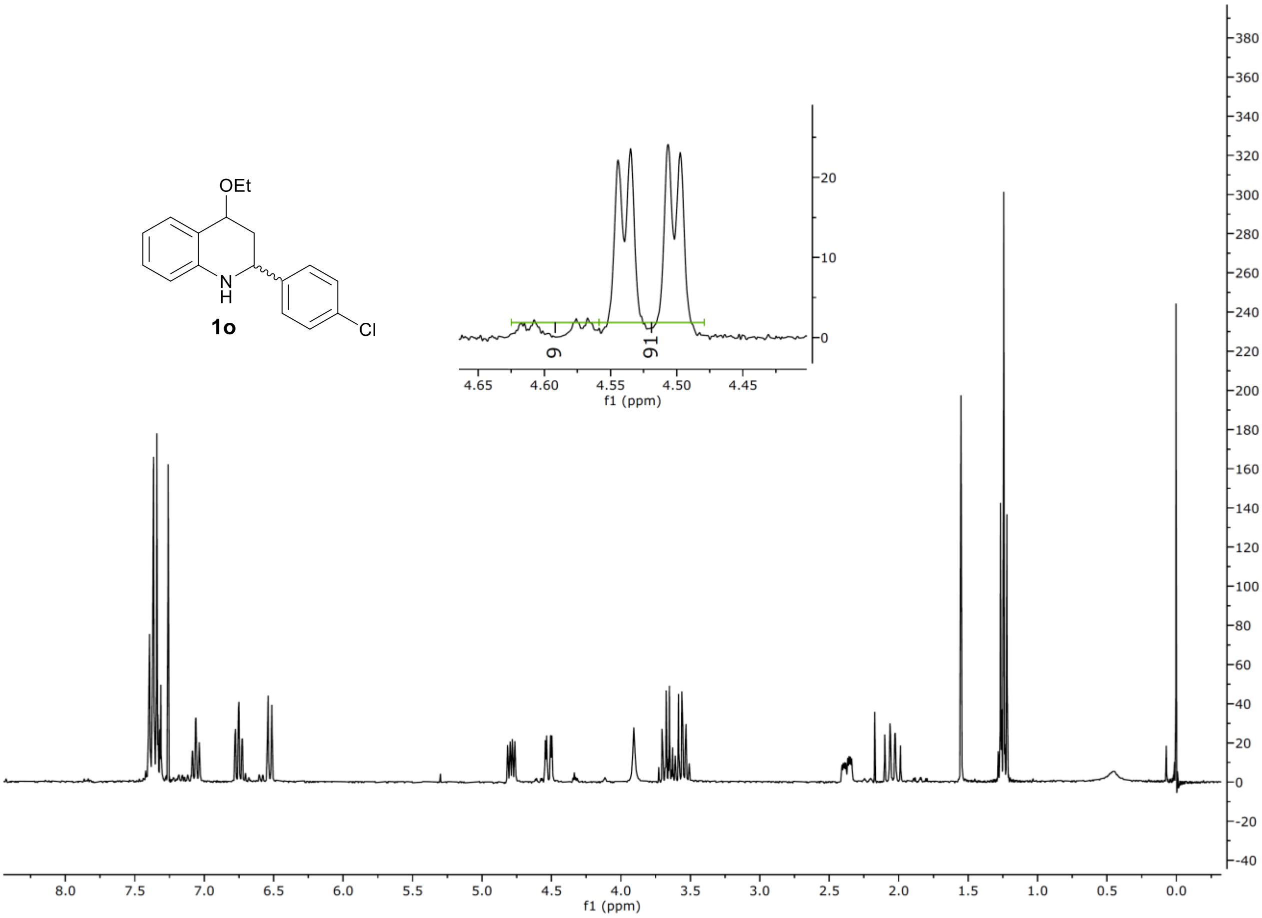

OEt
N
H
1m
f1 (ppm)

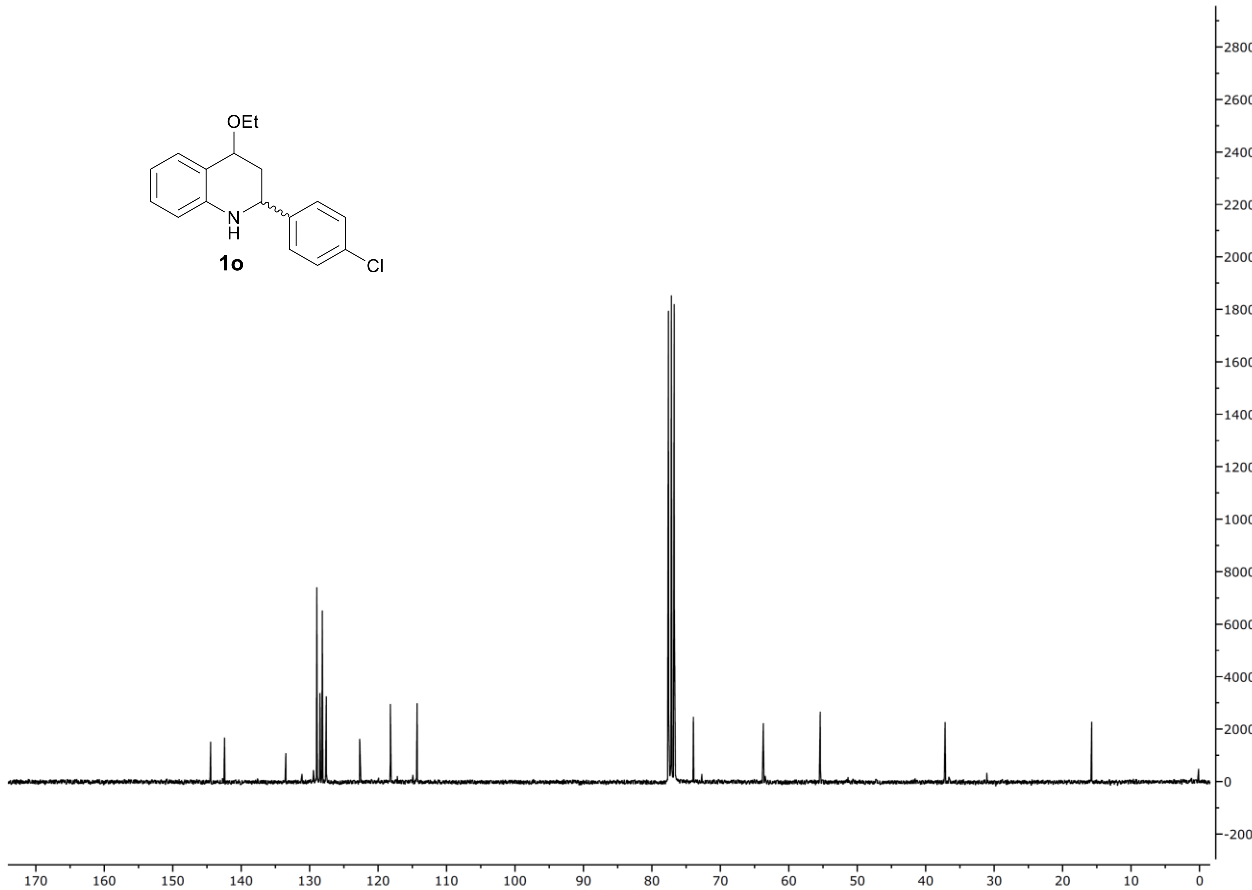


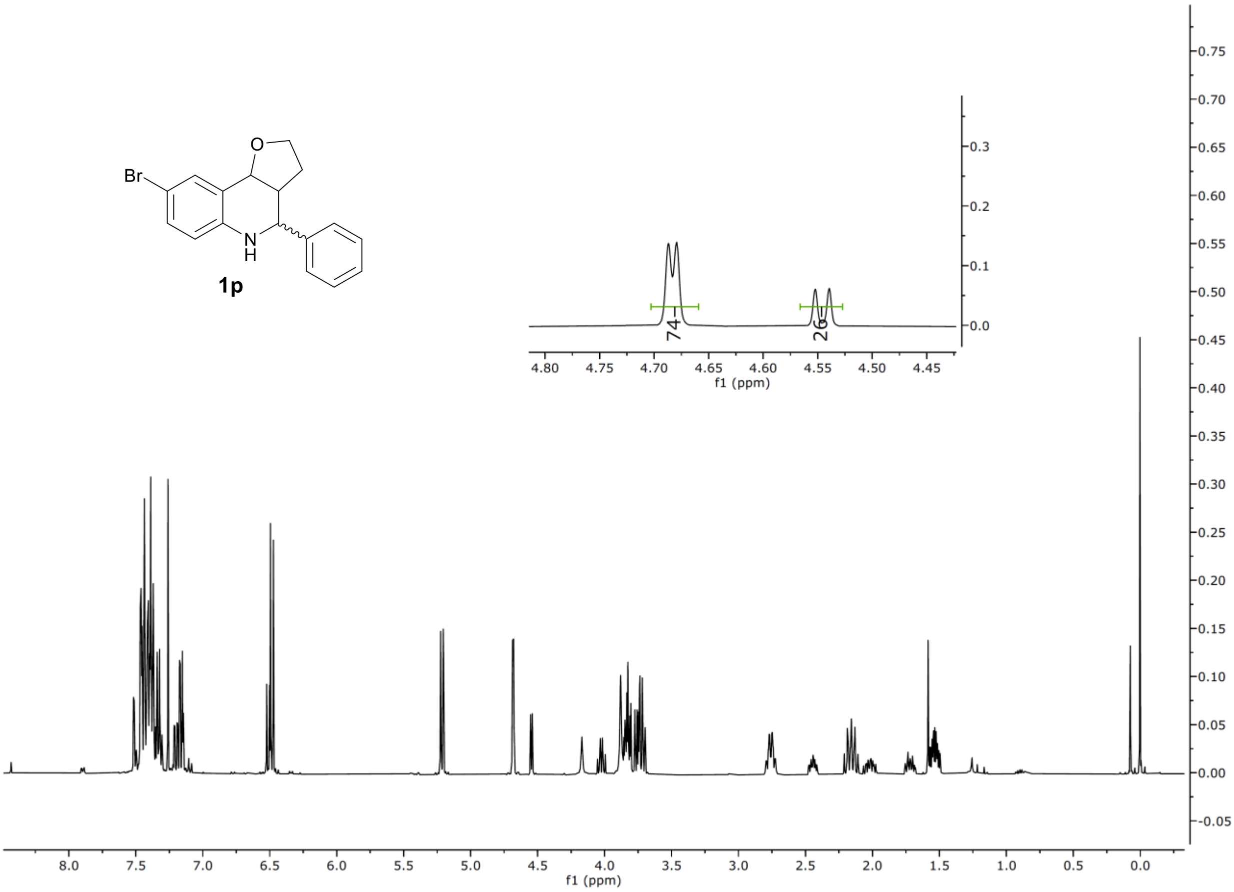
OEt
N
H
OMe
endo **1n**
f1 (ppm)

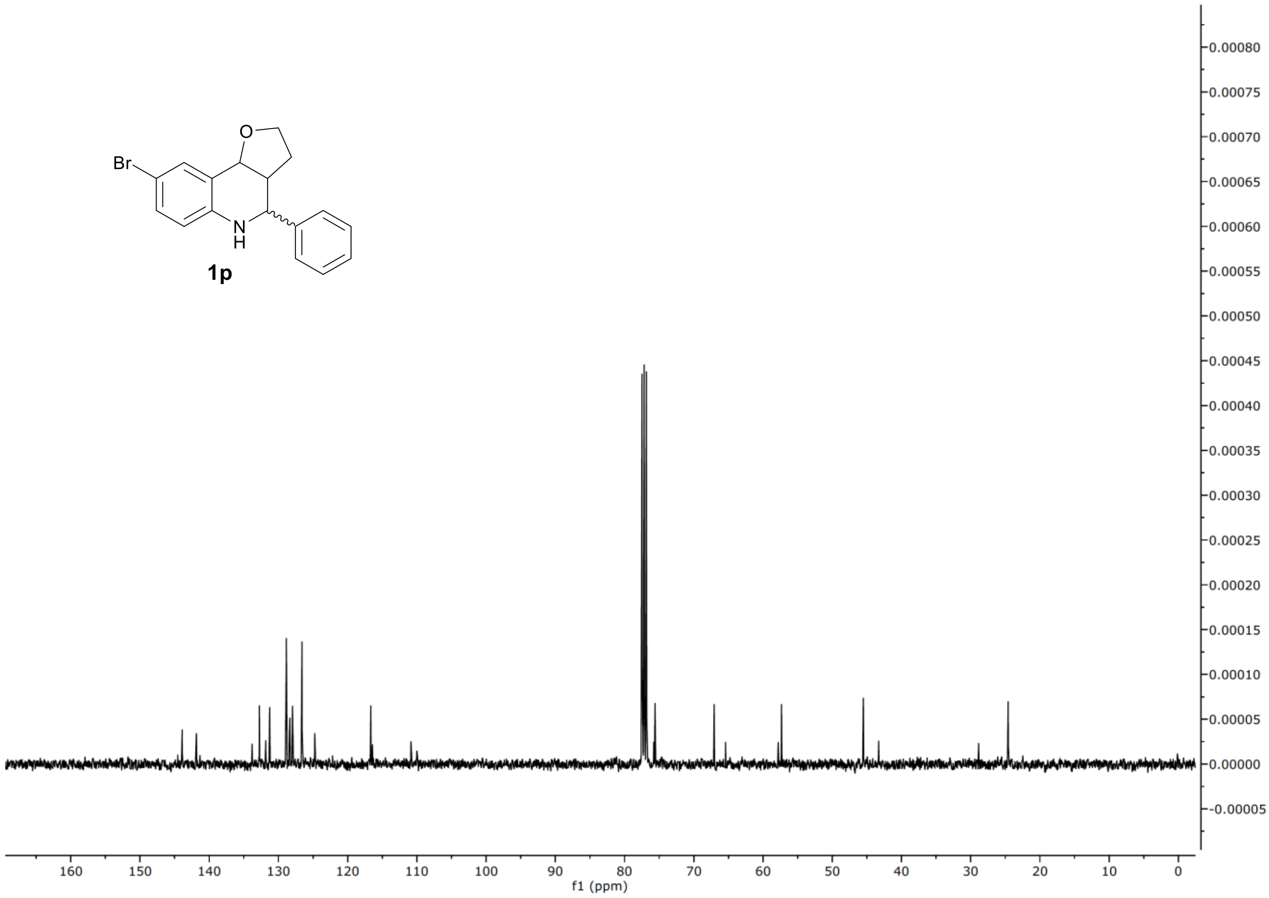


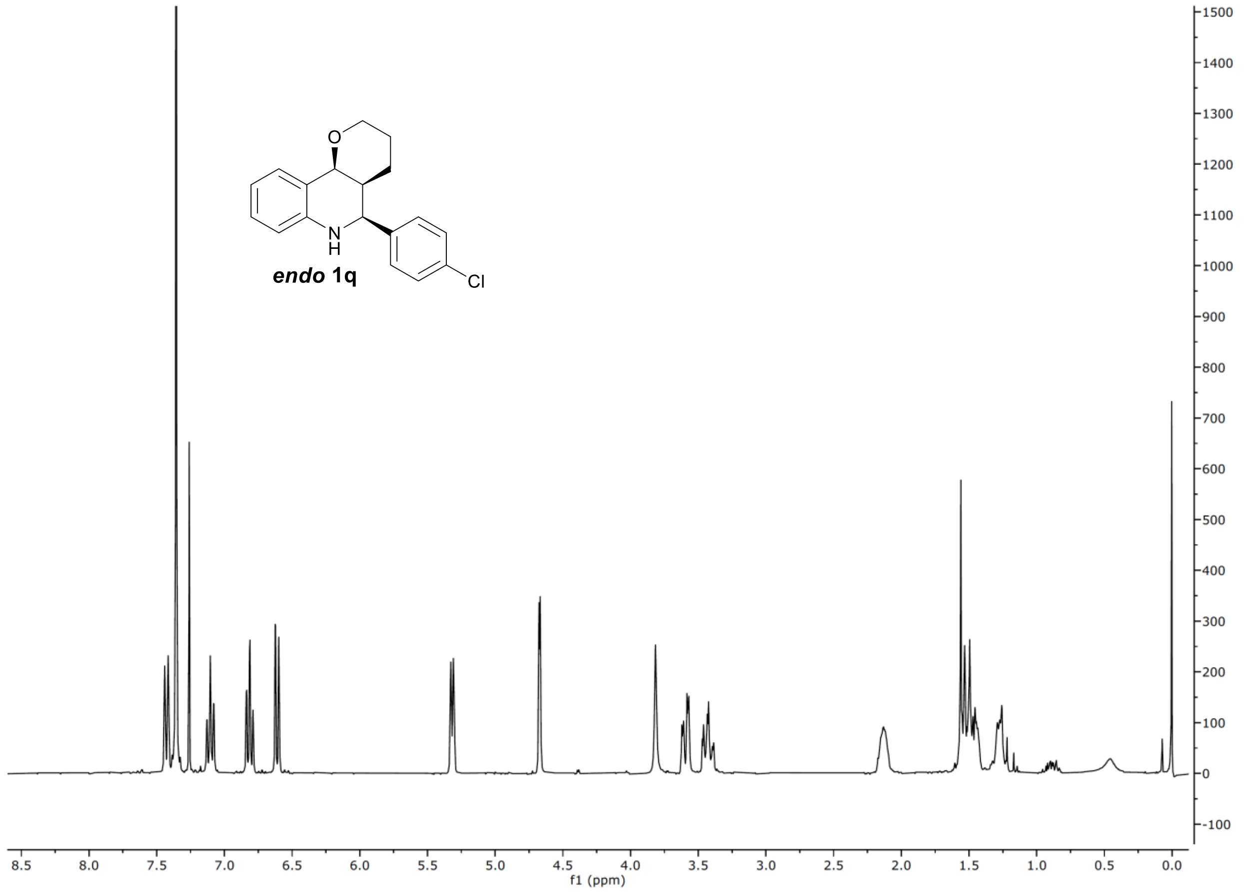
OEt
N
H
OMe
endo **1n**
f1 (ppm)

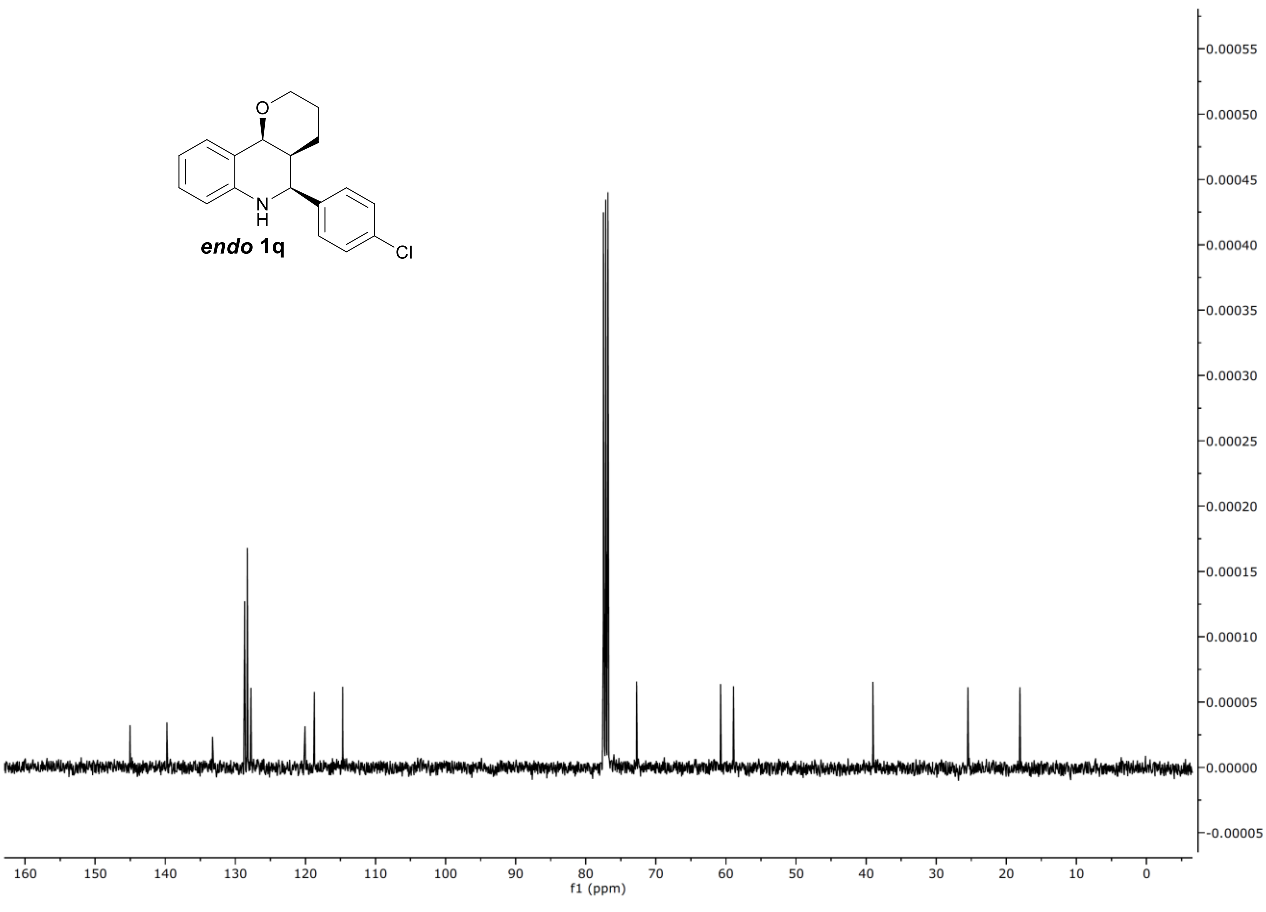

OEt
N
H
Cl
1o
f1 (ppm)

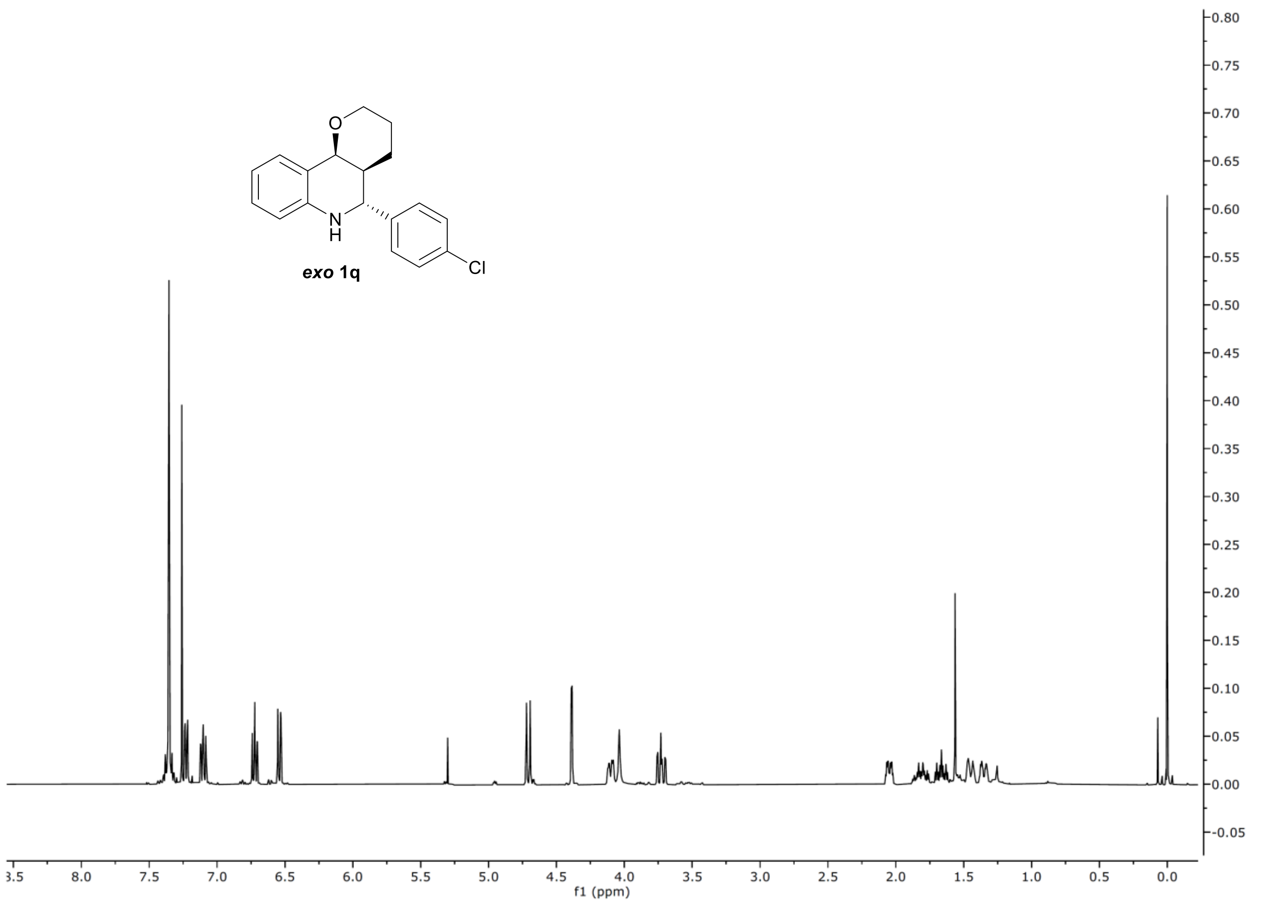

OEt
N
H
Cl
1o
f1 (ppm)

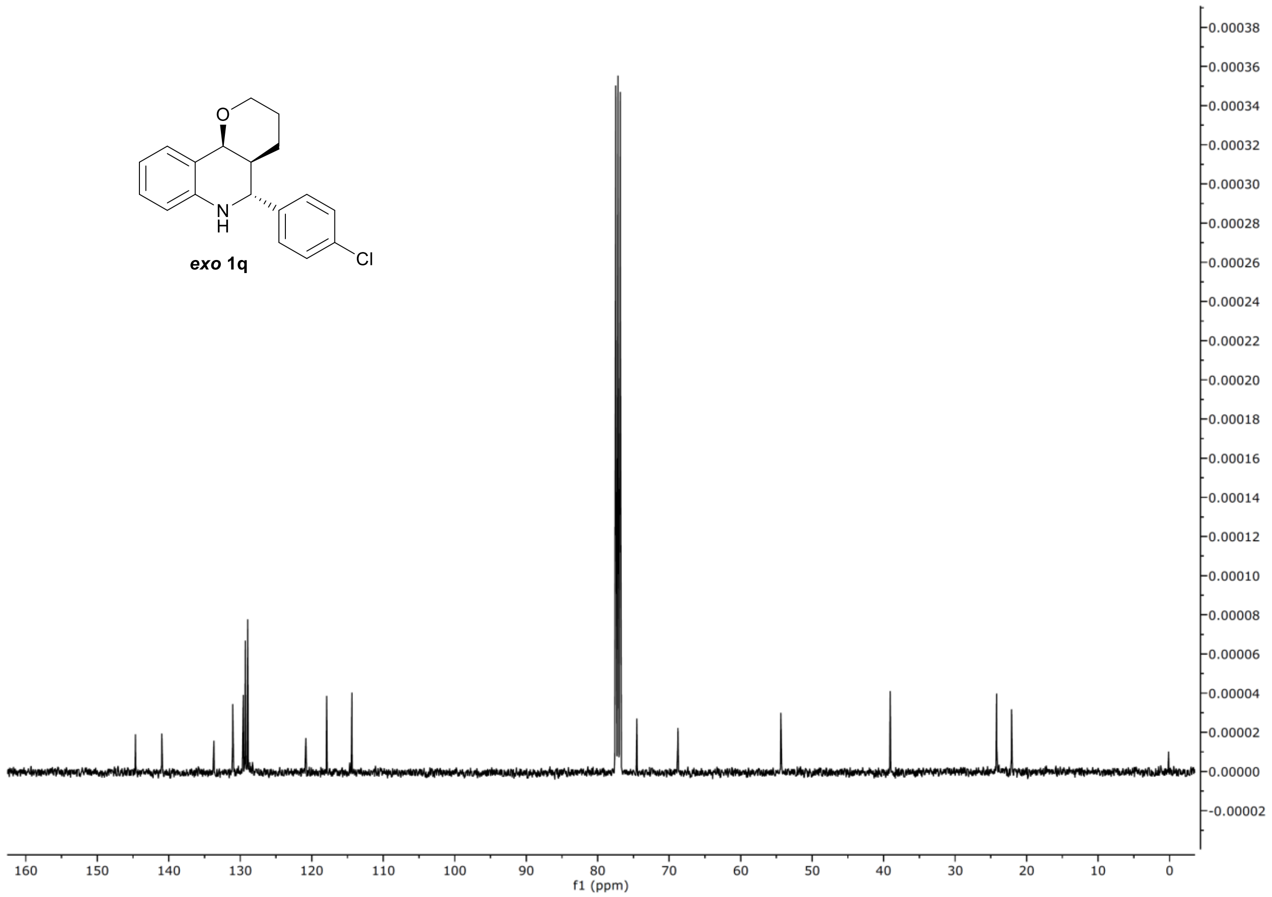

Br
O
N
H
1p
74
26
f1 (ppm)
f1 (ppm)

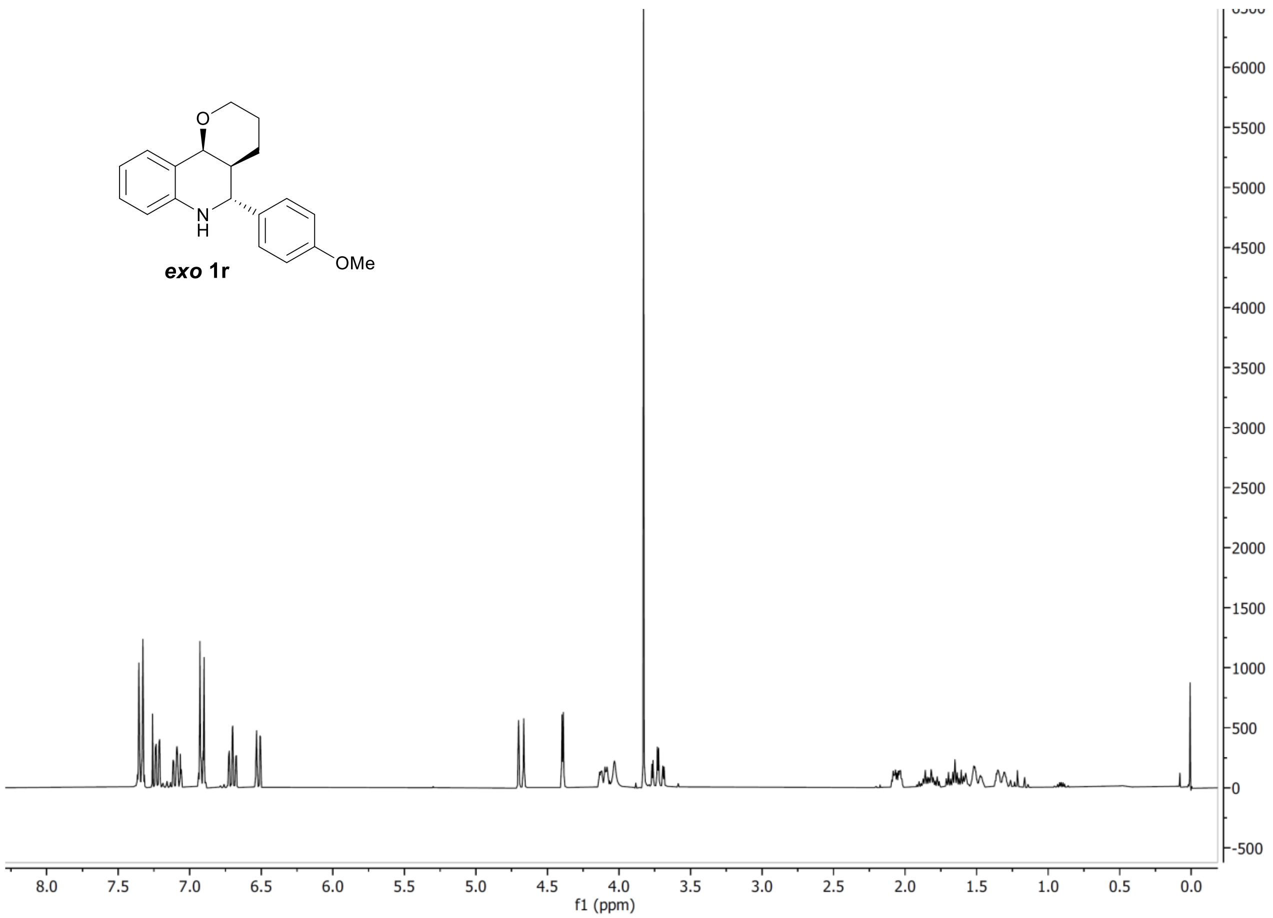

Br
O
N
H
1p
f1 (ppm)

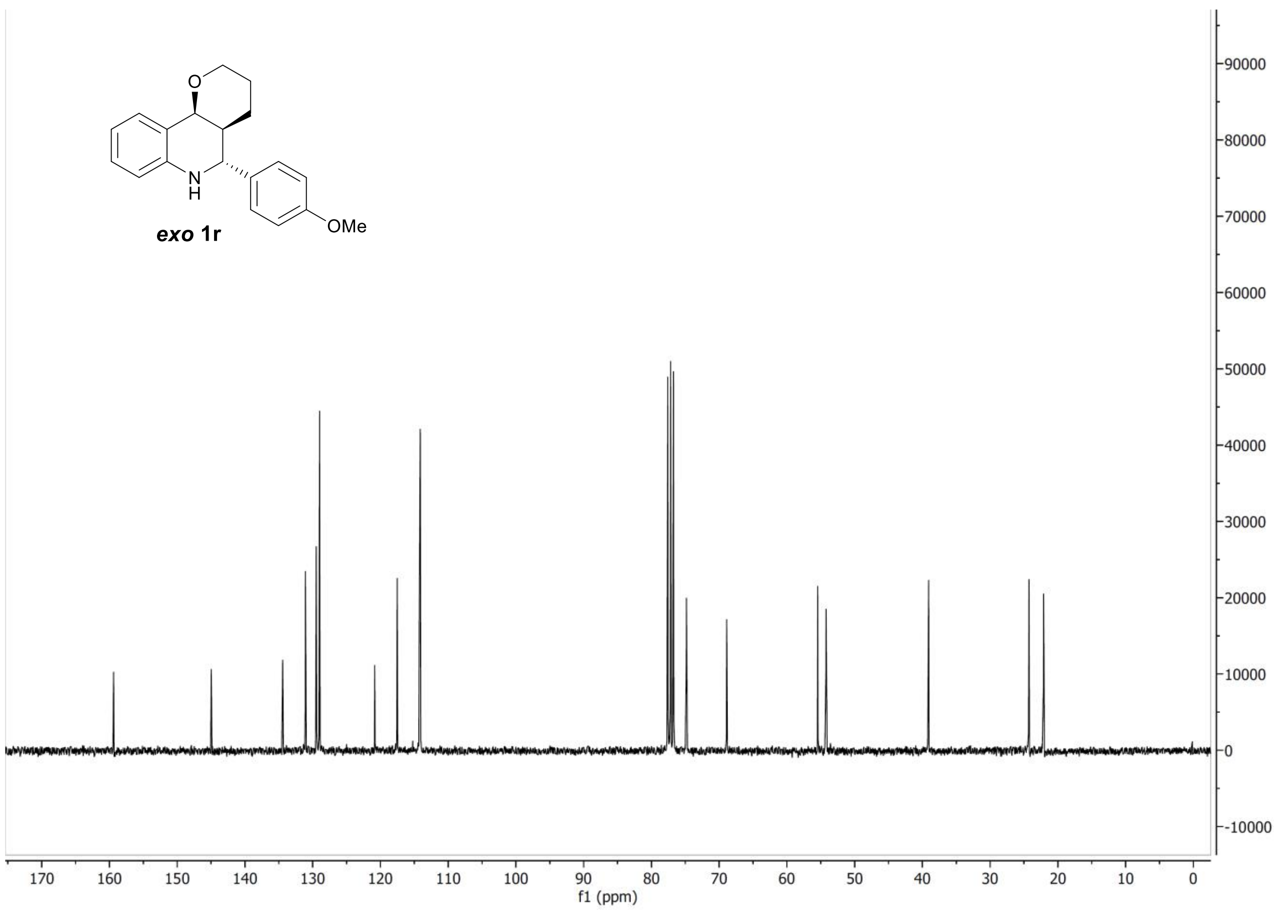

O
N
H
Cl
endo 1q
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


O
N
H
Cl
endo 1q
0.00055
0.00050
0.00045
0.00040
0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
-0.00005
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

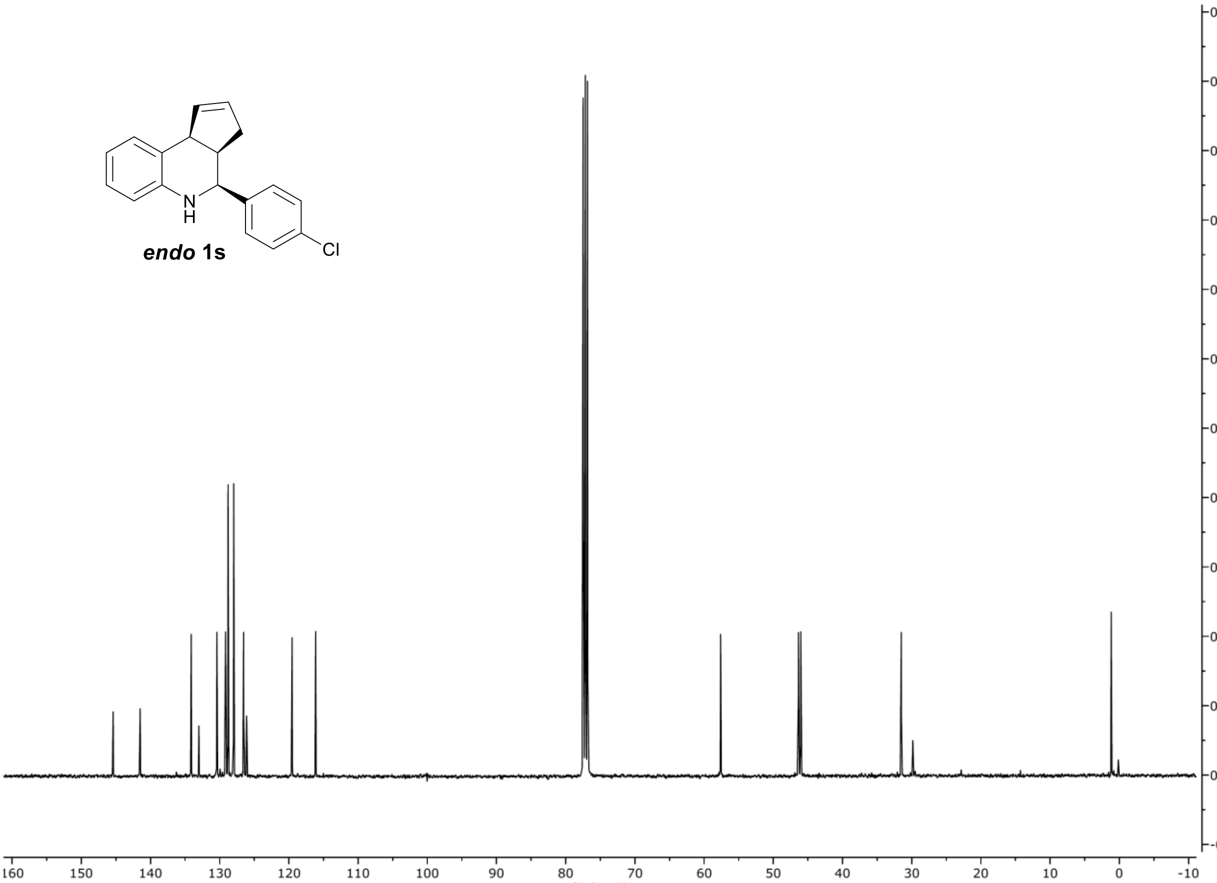

O
N
H
Cl
exo 1q
f1 (ppm)

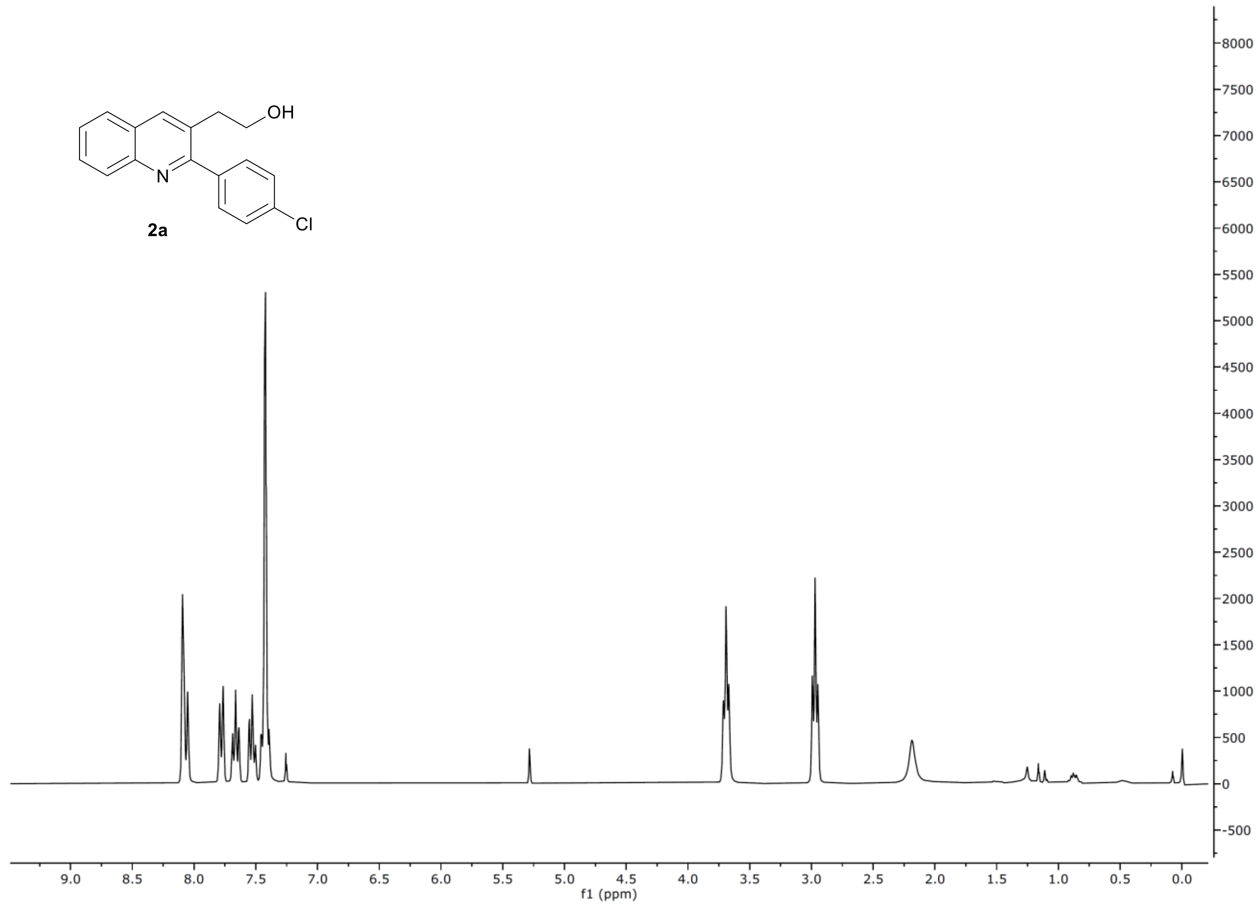

O
N
H
Cl
exo 1q
f1 (ppm)

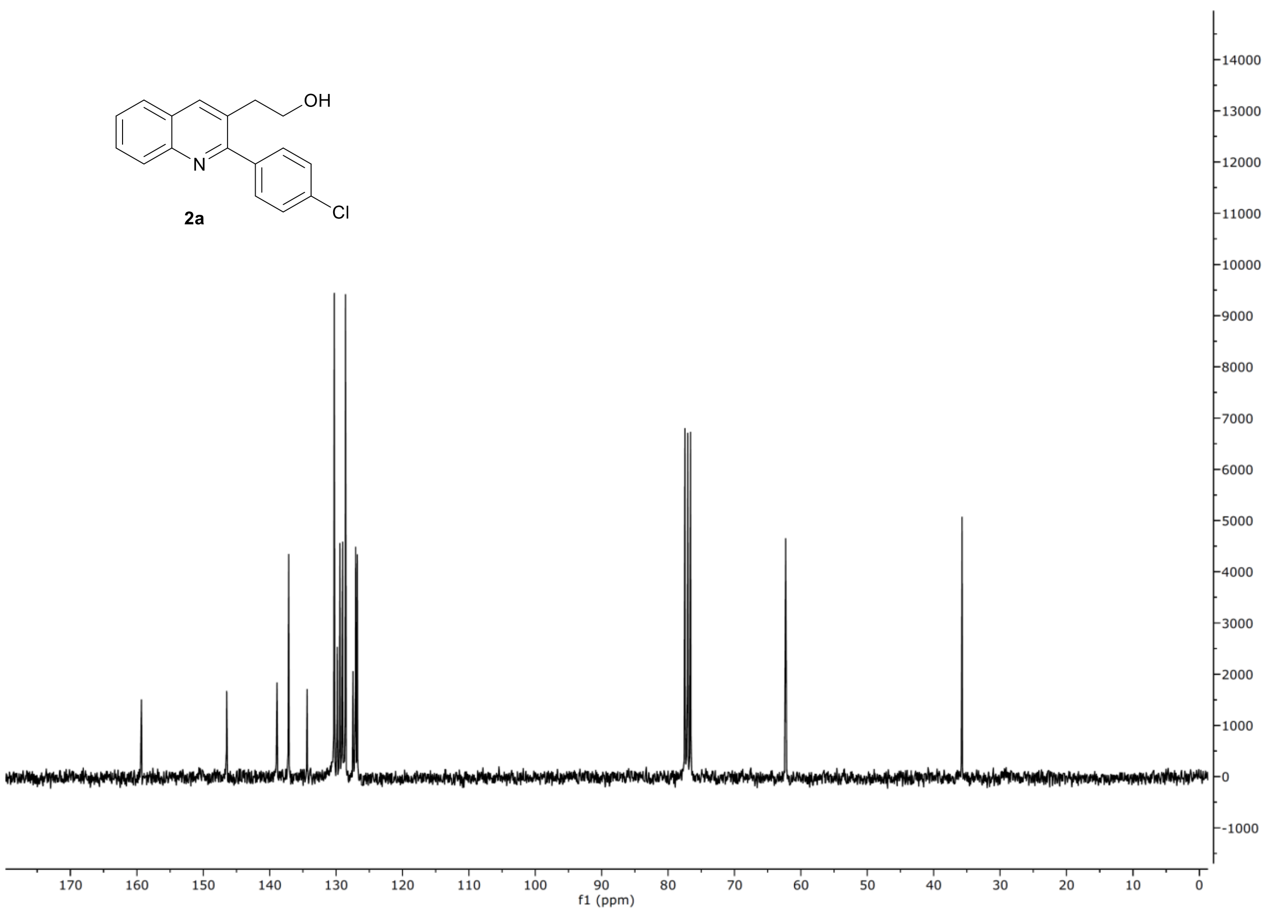

O
N
H
OMe
exo 1r
f1 (ppm)

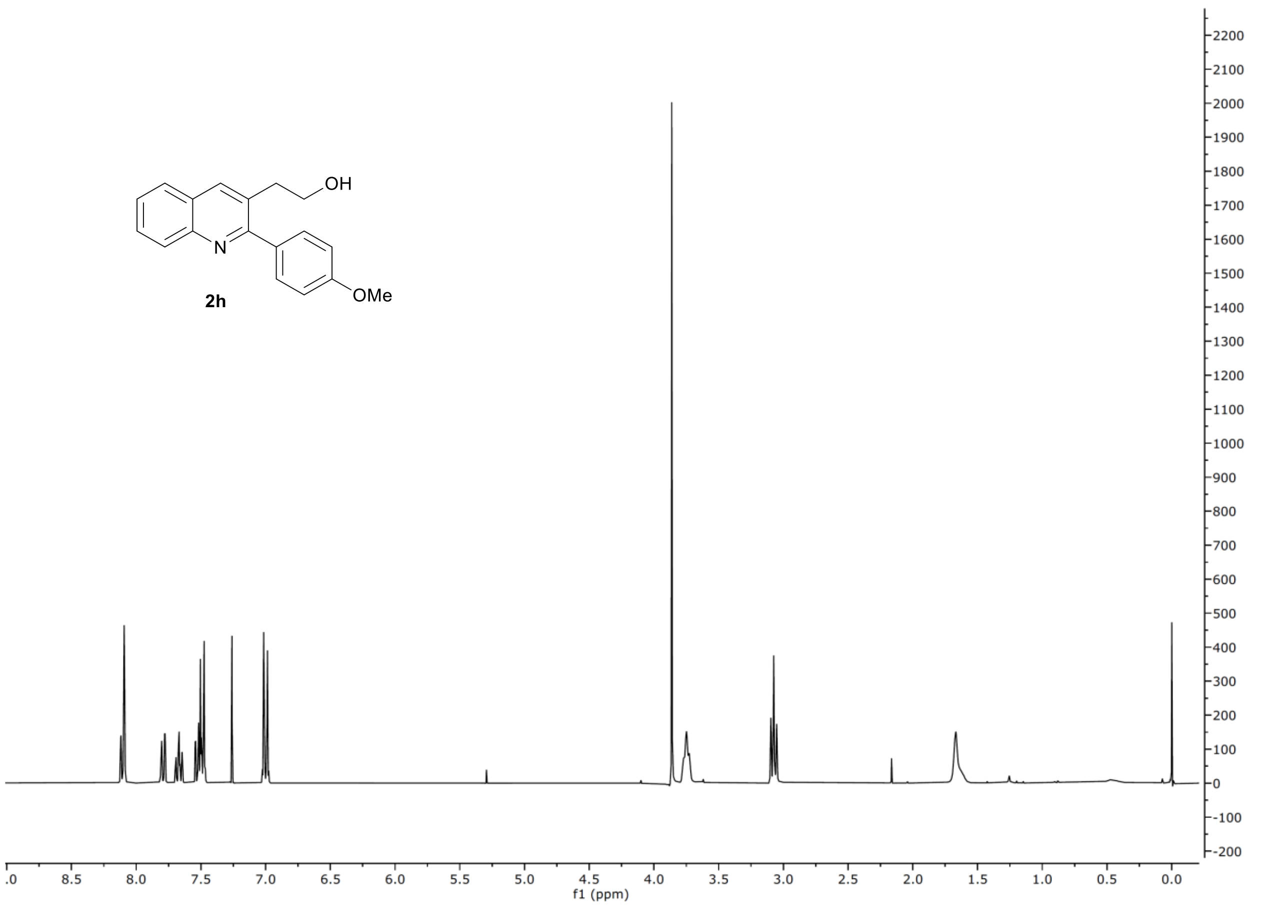

O
N
H
OMe
exo 1r
f1 (ppm)


endo 1s
Cl
N
H
f1 (ppm)

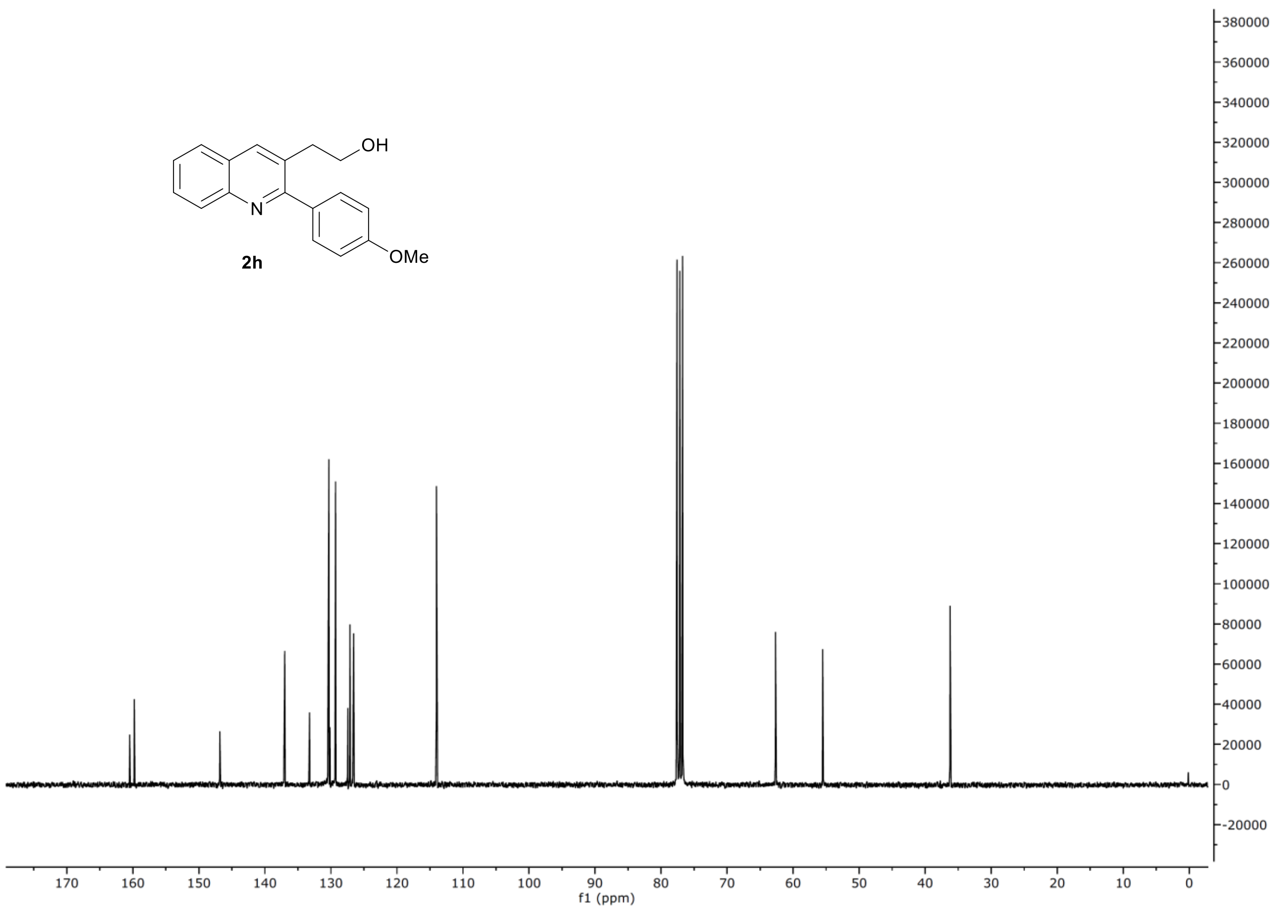

endo 1s
Cl
N
H
f1 (ppm)


OH
N
Cl
2a
f1 (ppm)

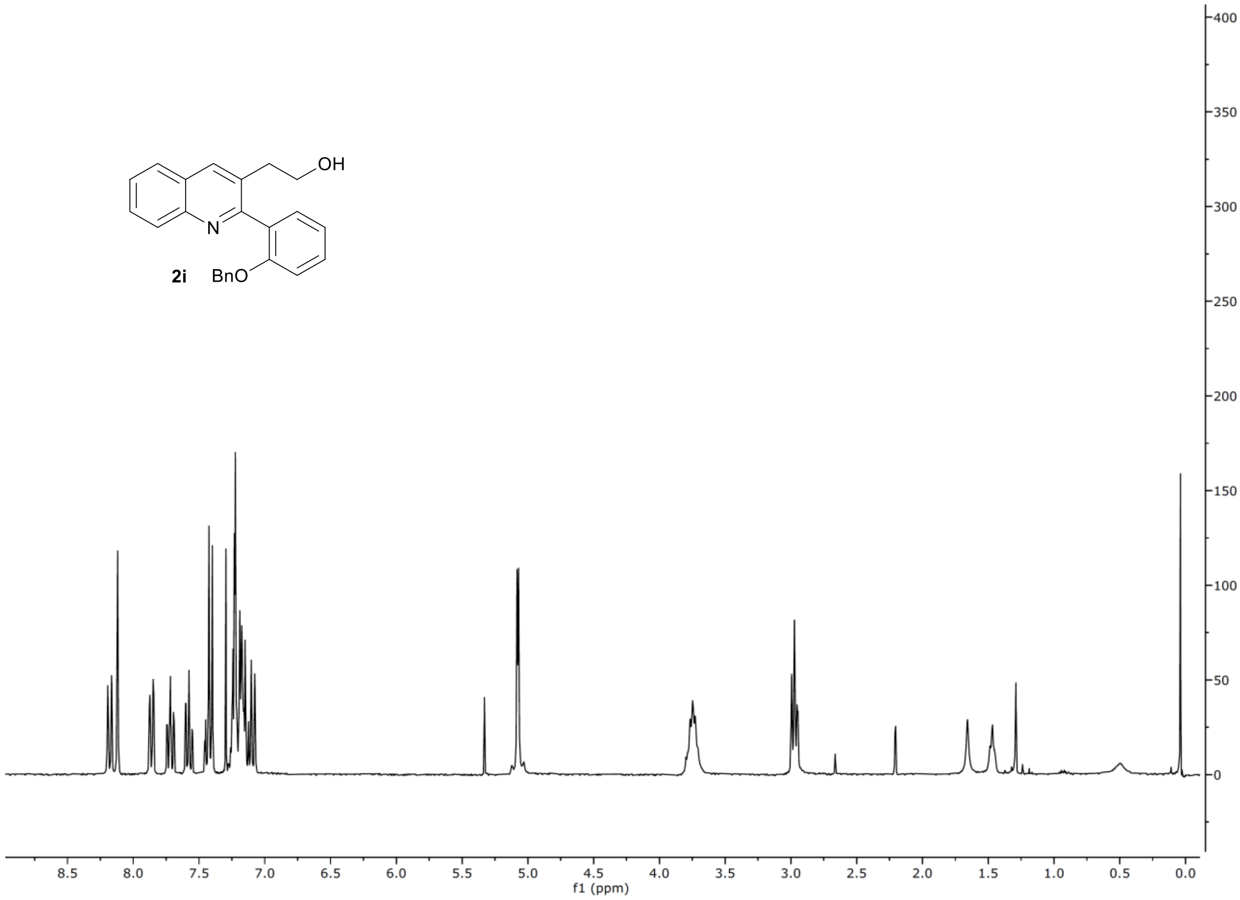

OH
N
Cl
2a
f1 (ppm)

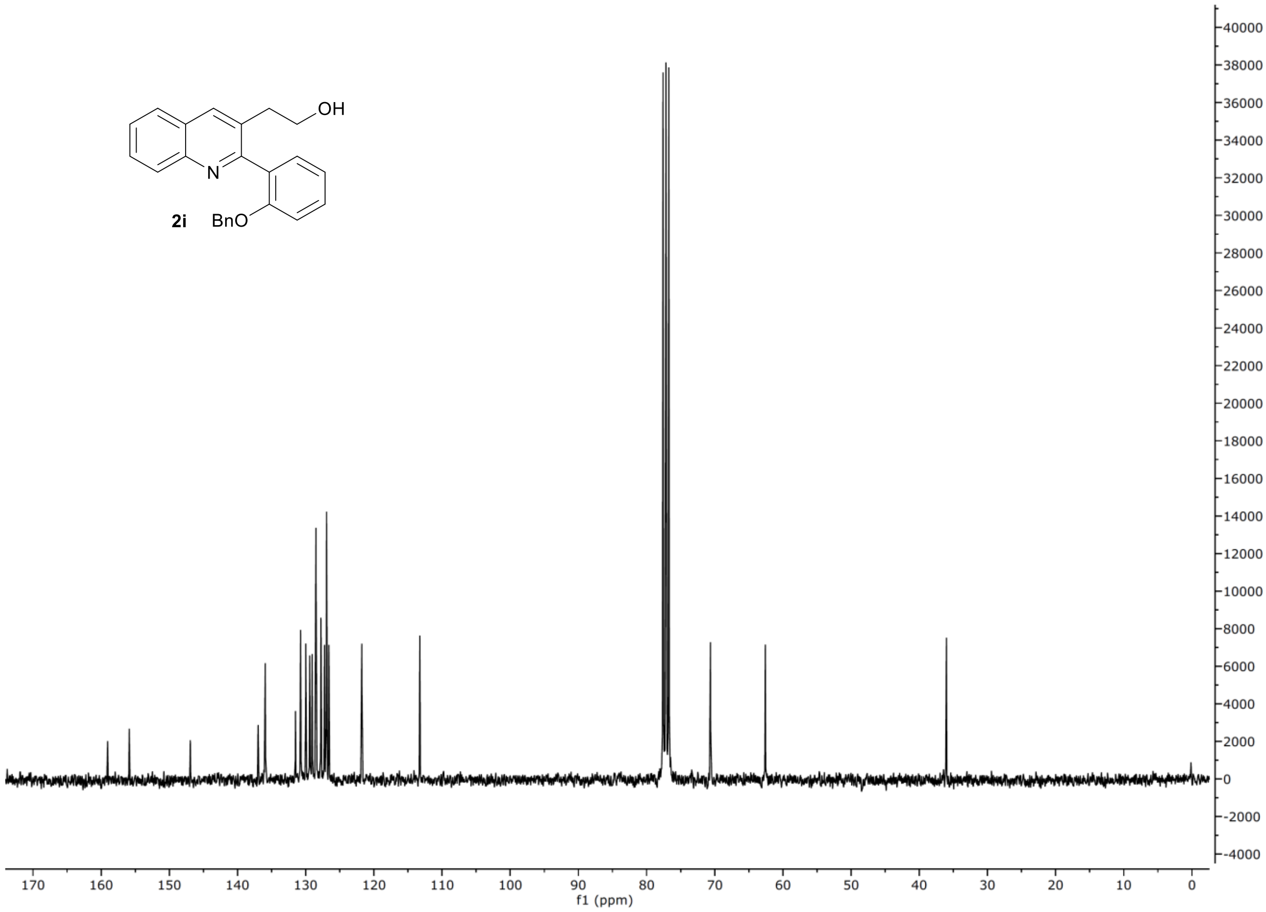


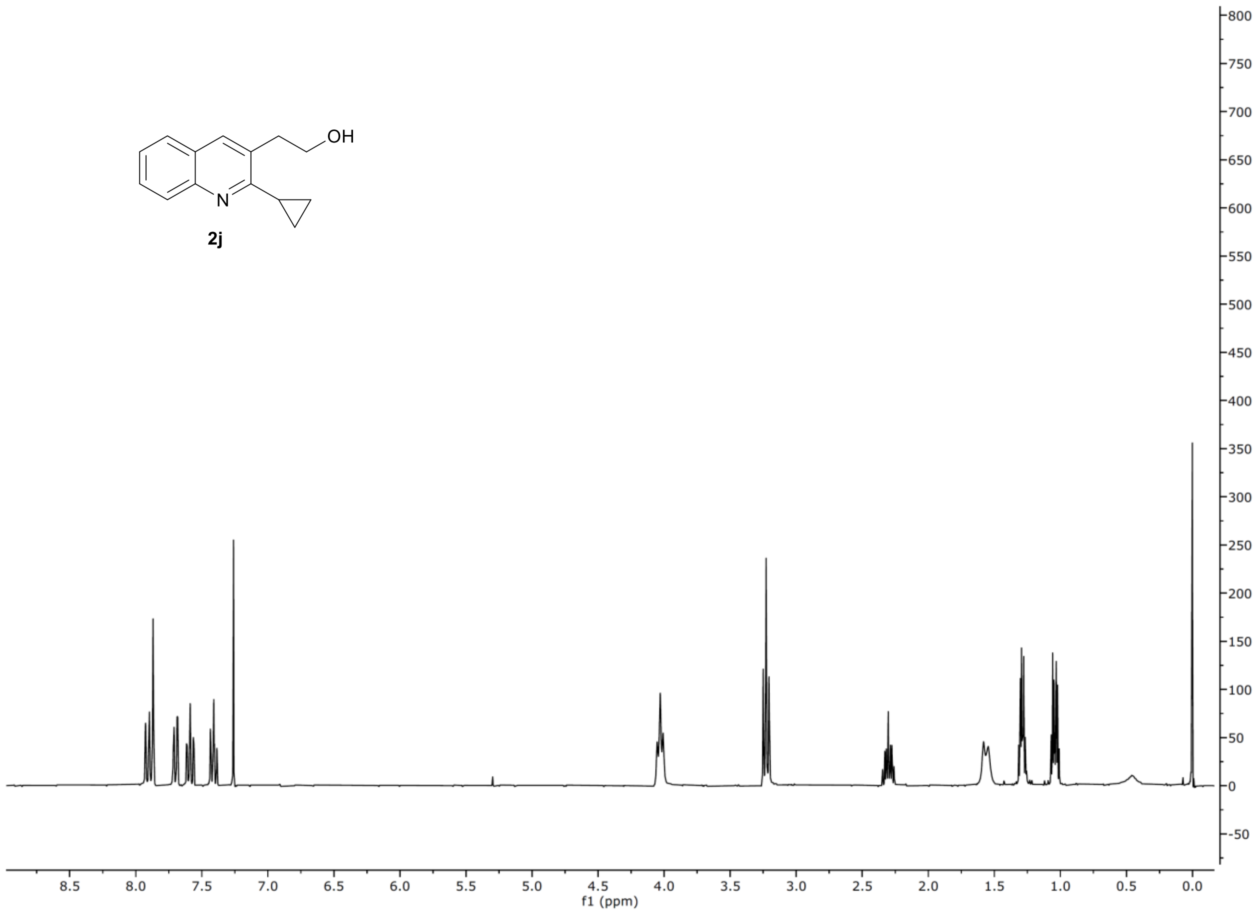
OH
N
OMe
2h
f1 (ppm)

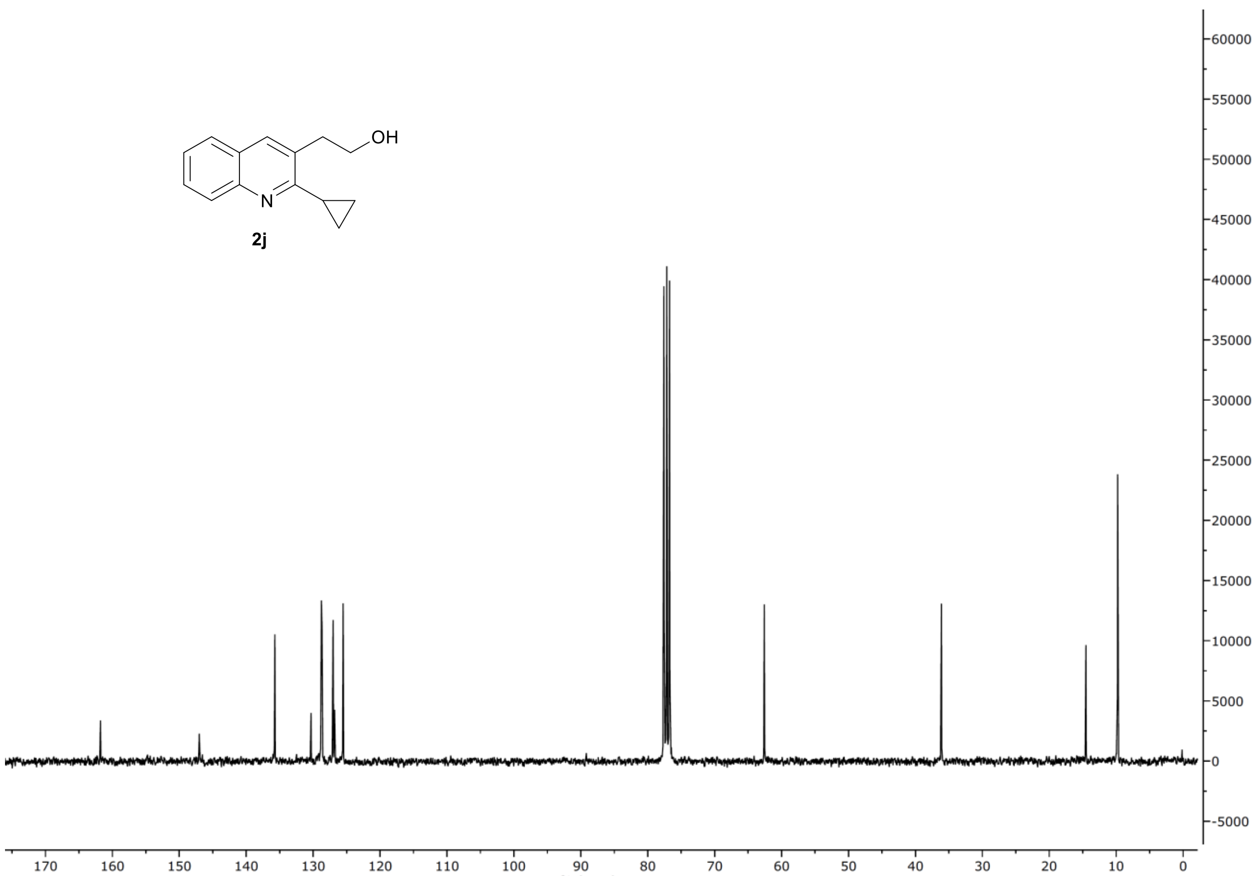


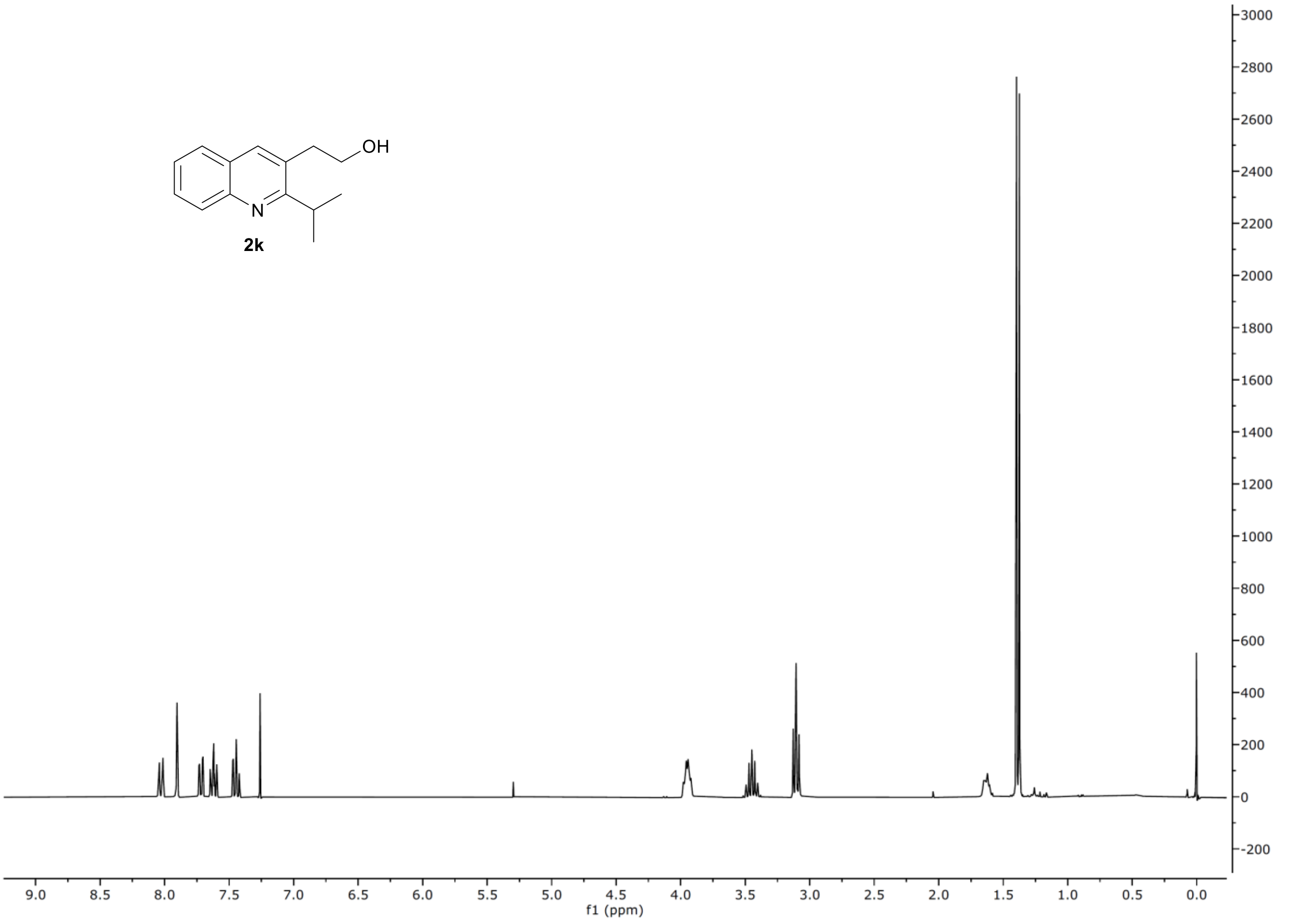
OH
N
OMe
2h
f1 (ppm)

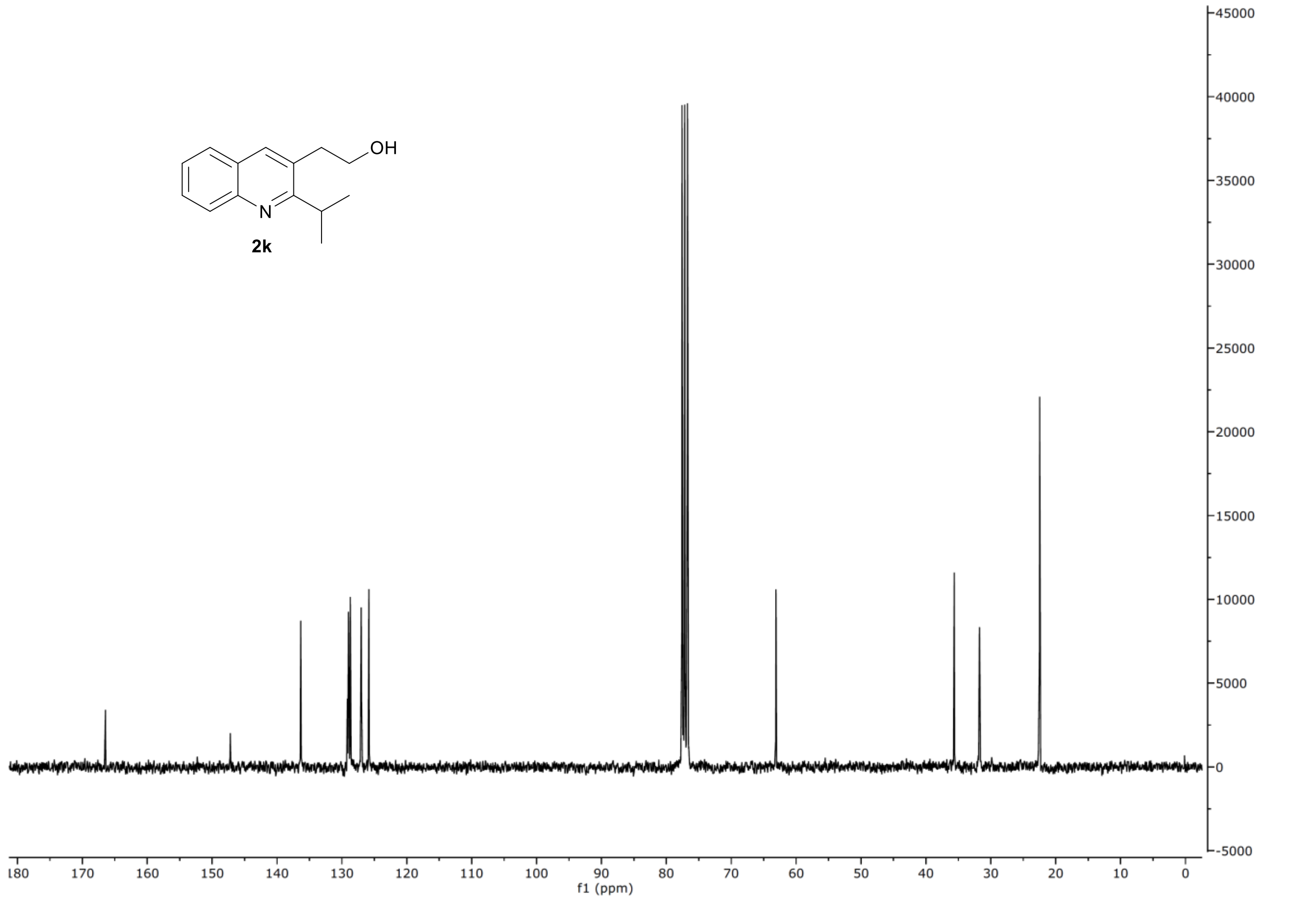

OH
N
2i
BnO
f1 (ppm)

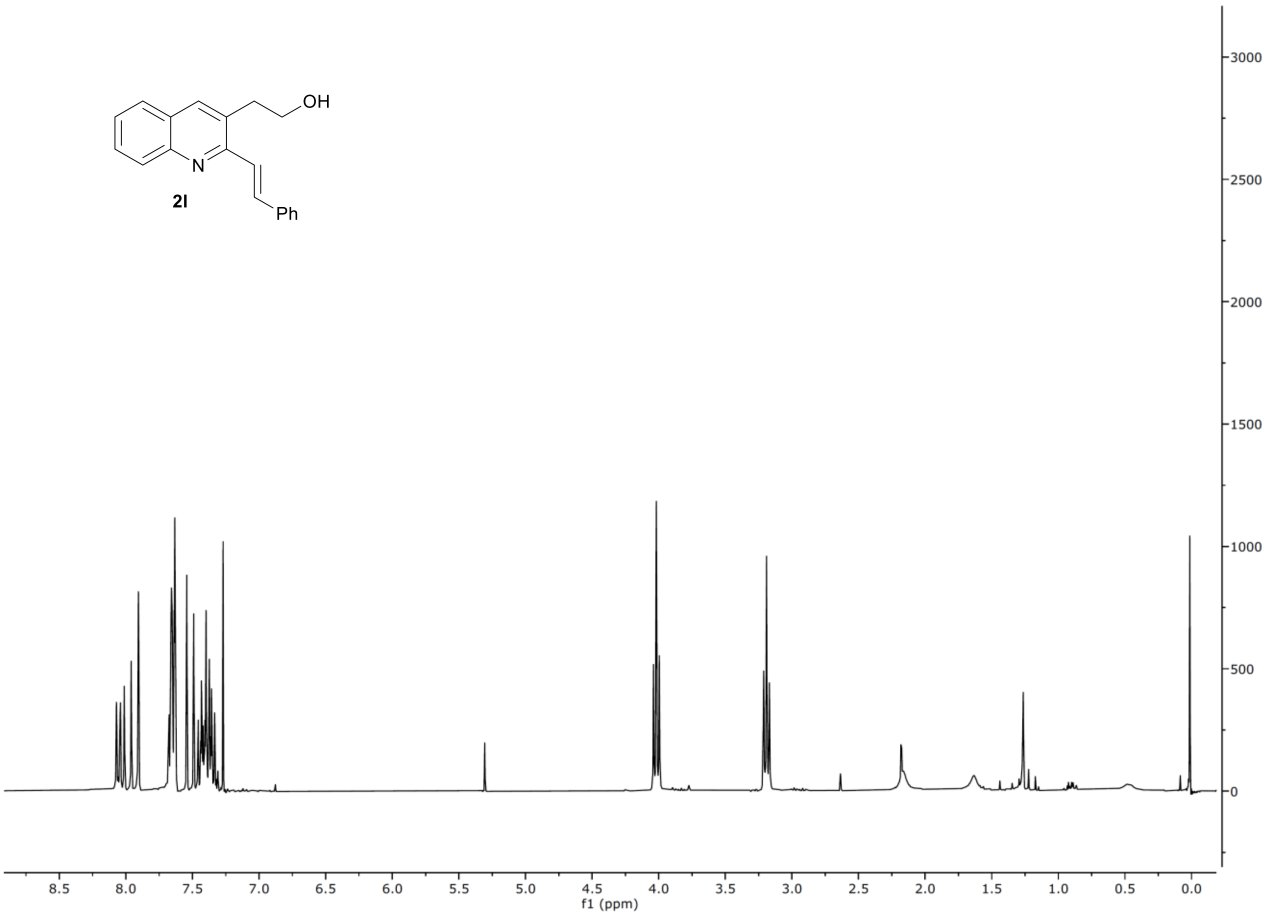

OH
N
2i
BnO
f1 (ppm)

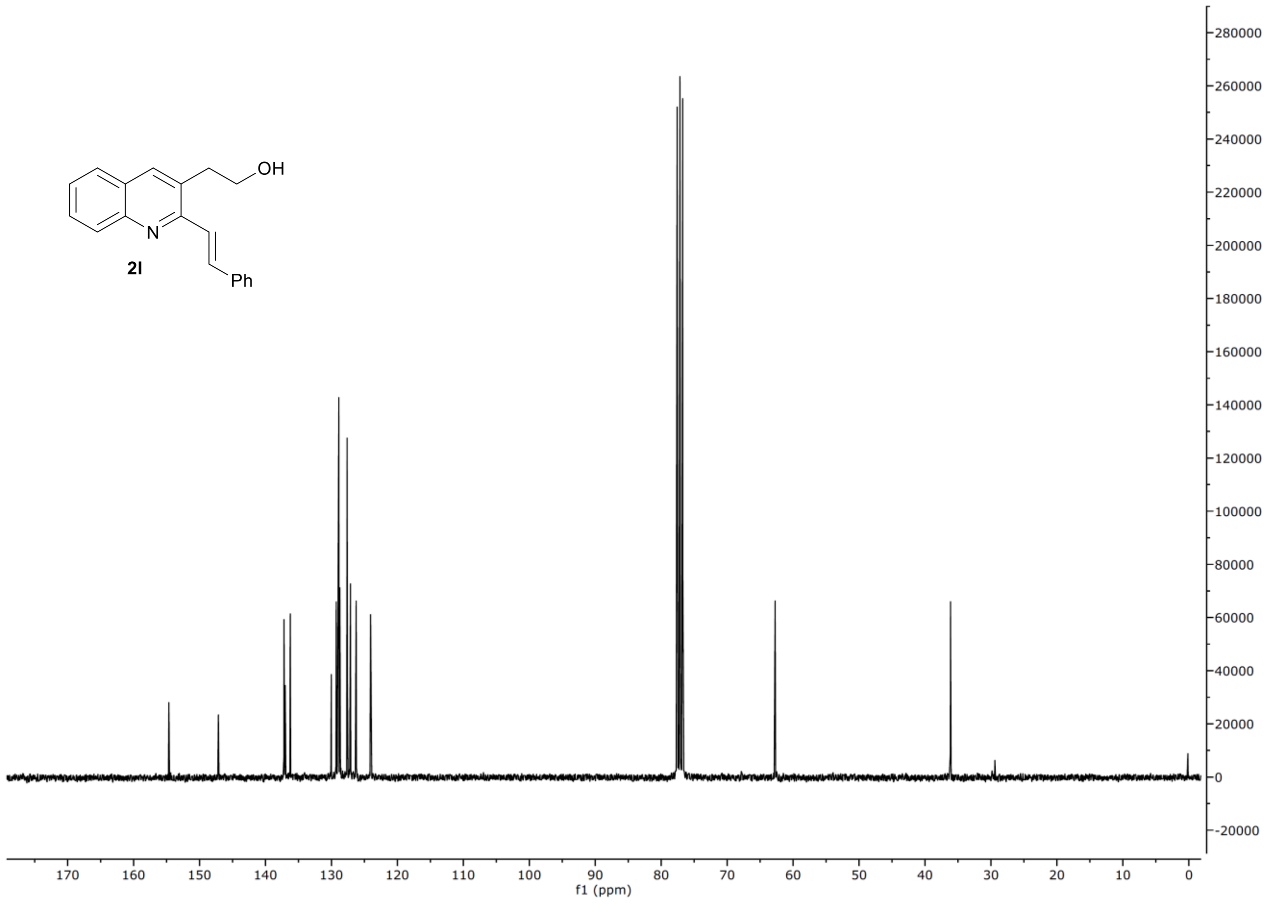

OH
N
2j
f1 (ppm)

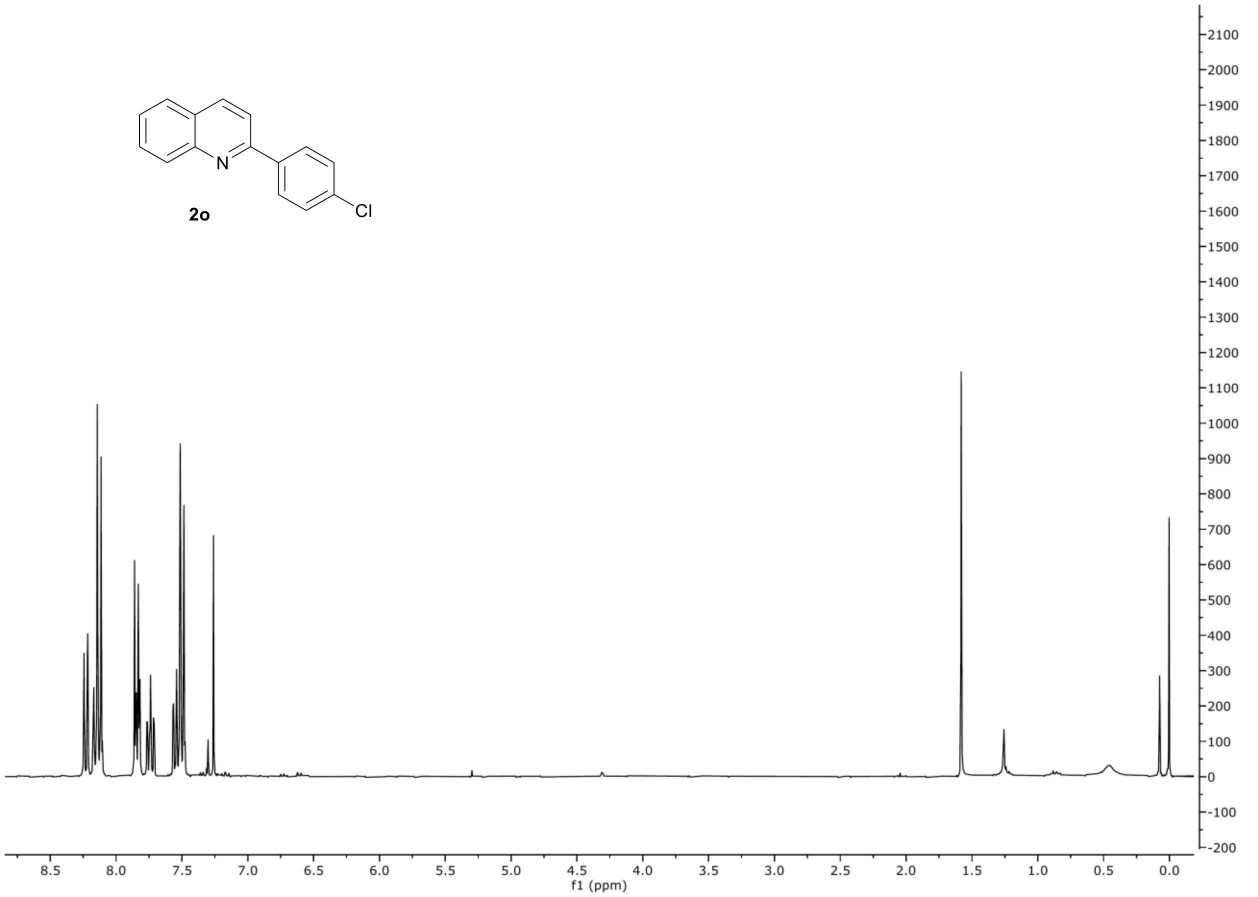

OH
N
2j
f1 (ppm)

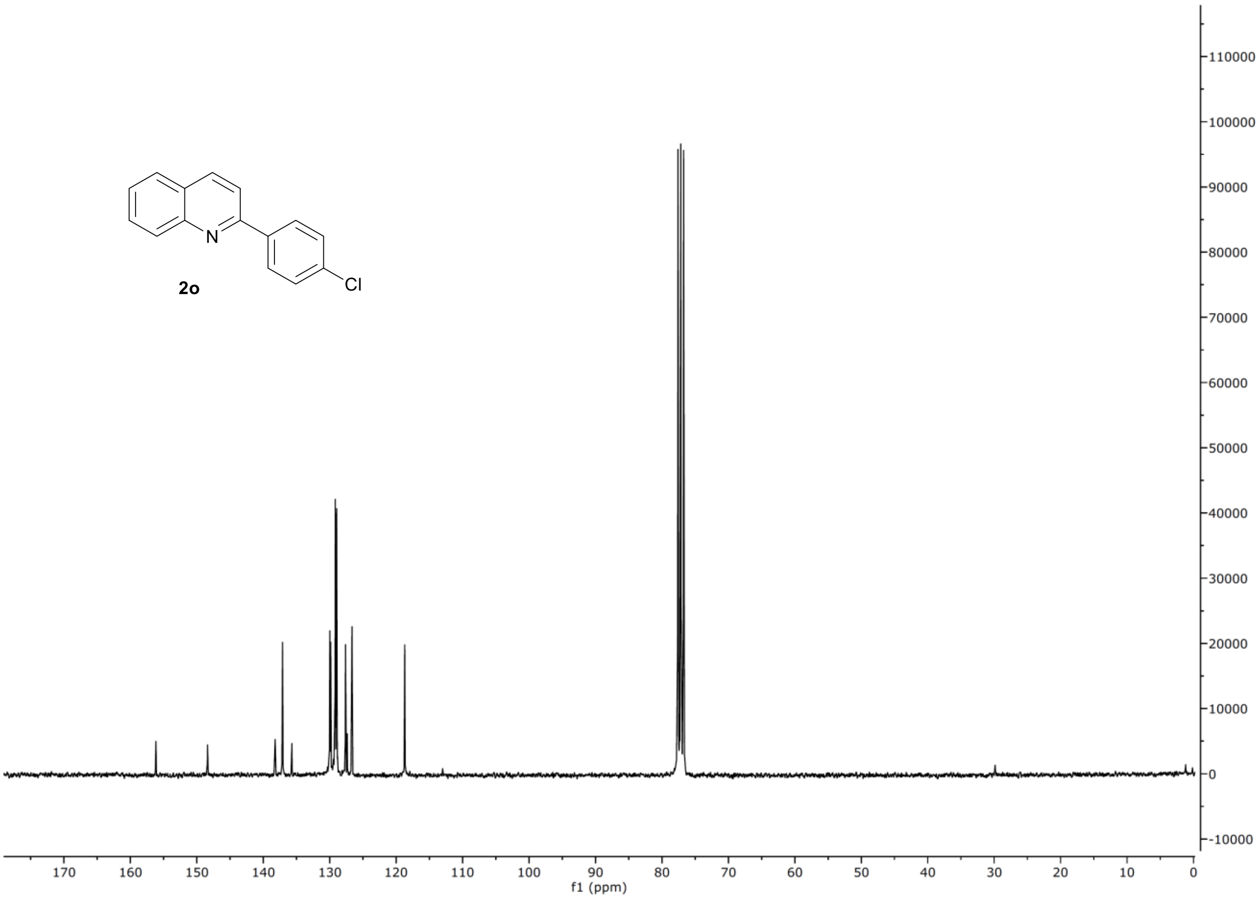

OH
N
2k
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200

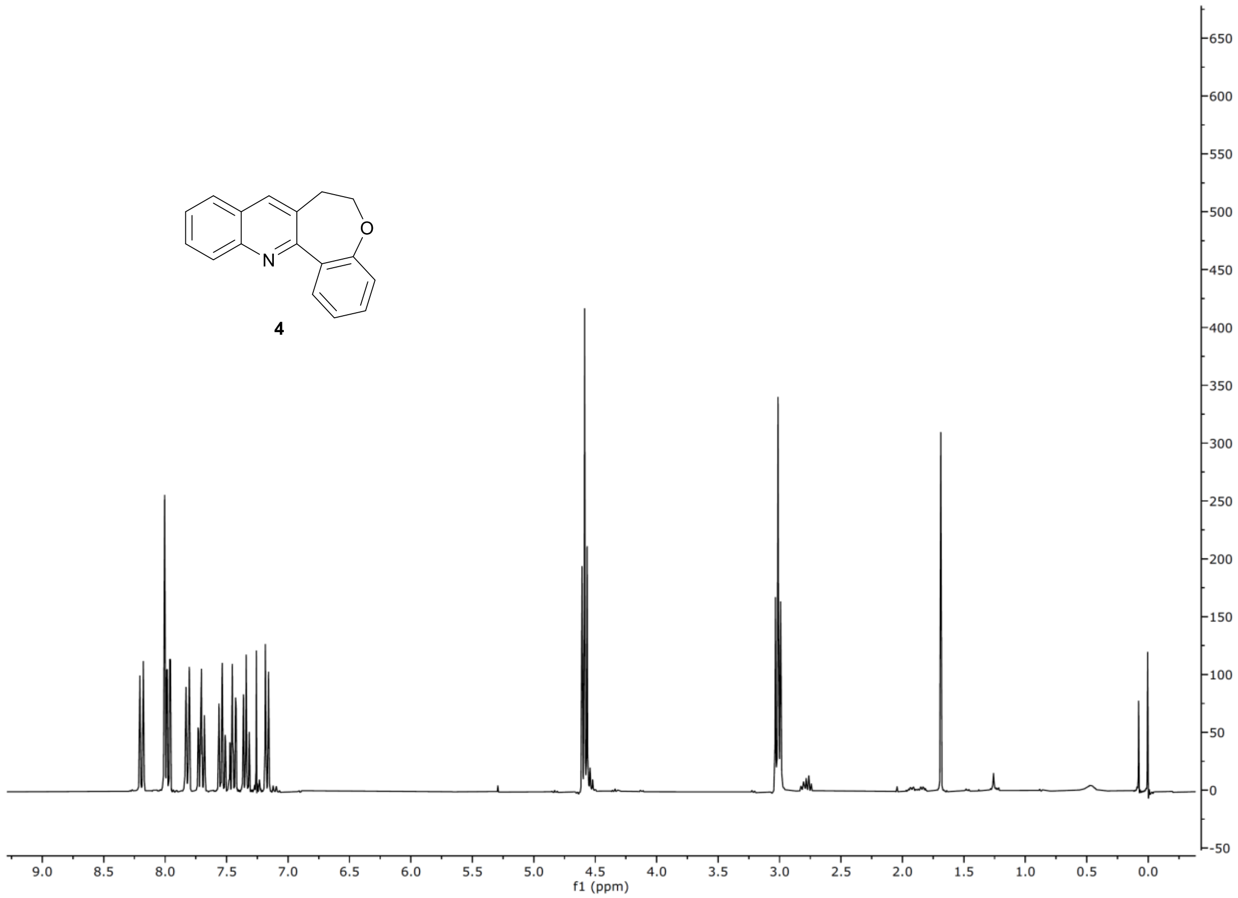

OH
N
2k
f1 (ppm)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000


OH
N
2l
Ph
f1 (ppm)

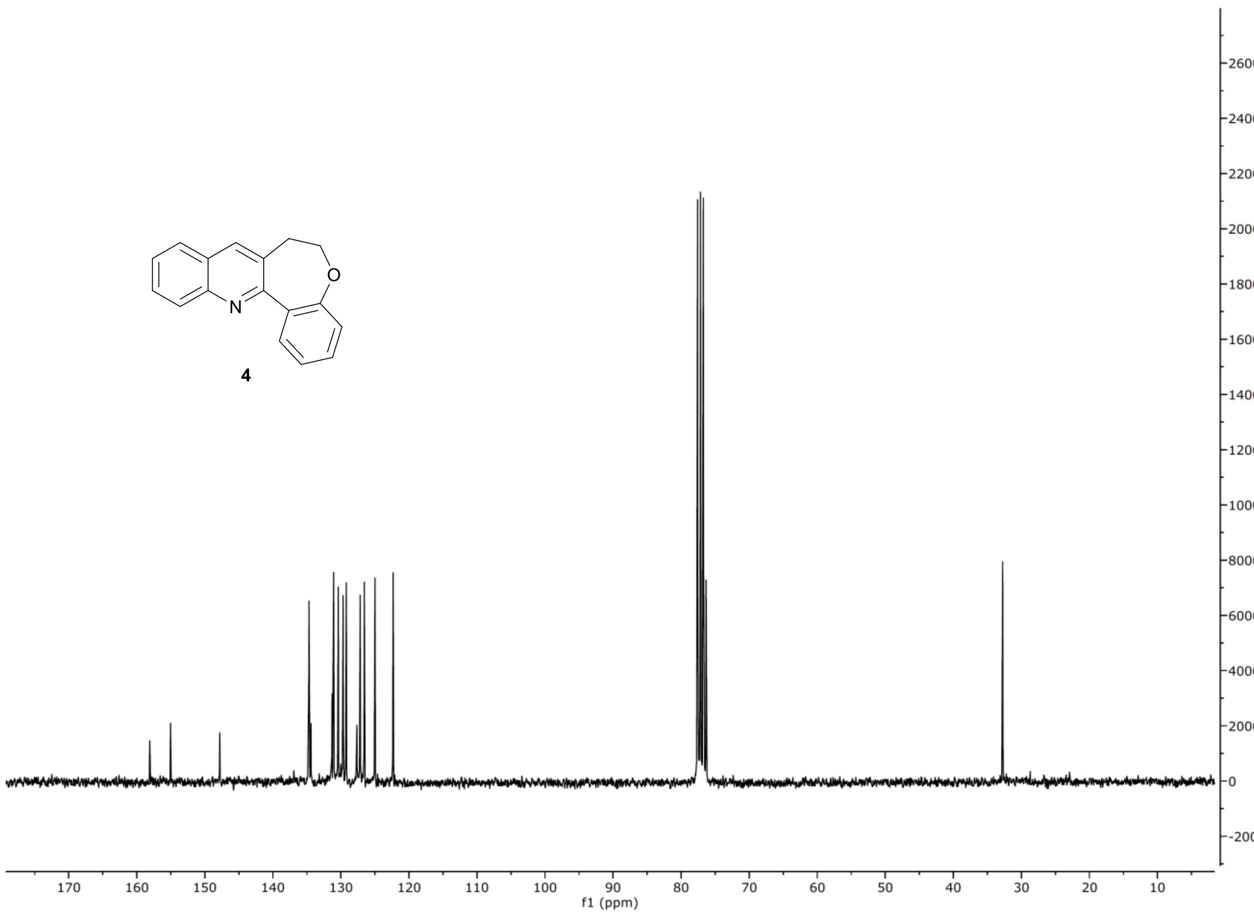

OH
N
2l
Ph
f1 (ppm)


N
Cl
2o
f1 (ppm)

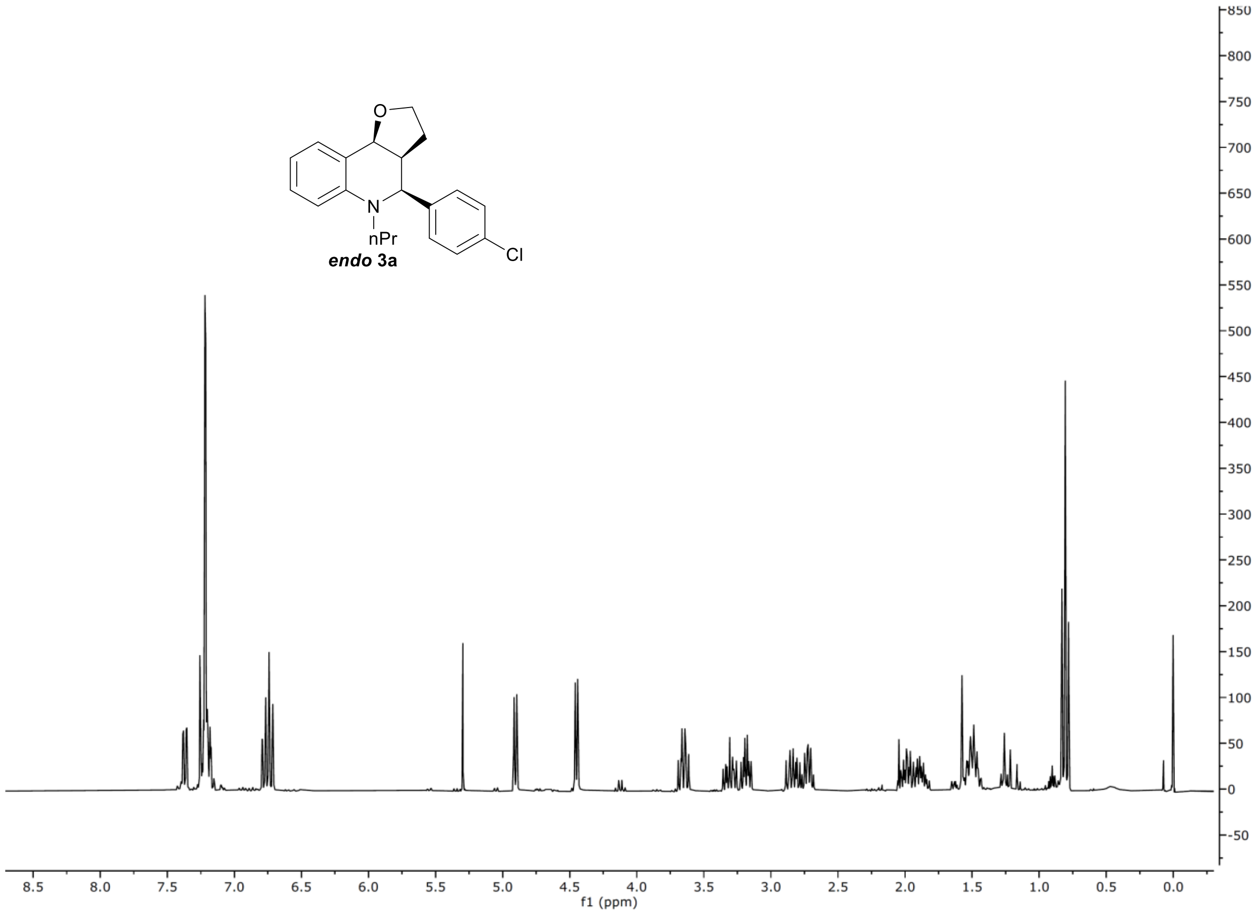

N
Cl
2o
f1 (ppm)

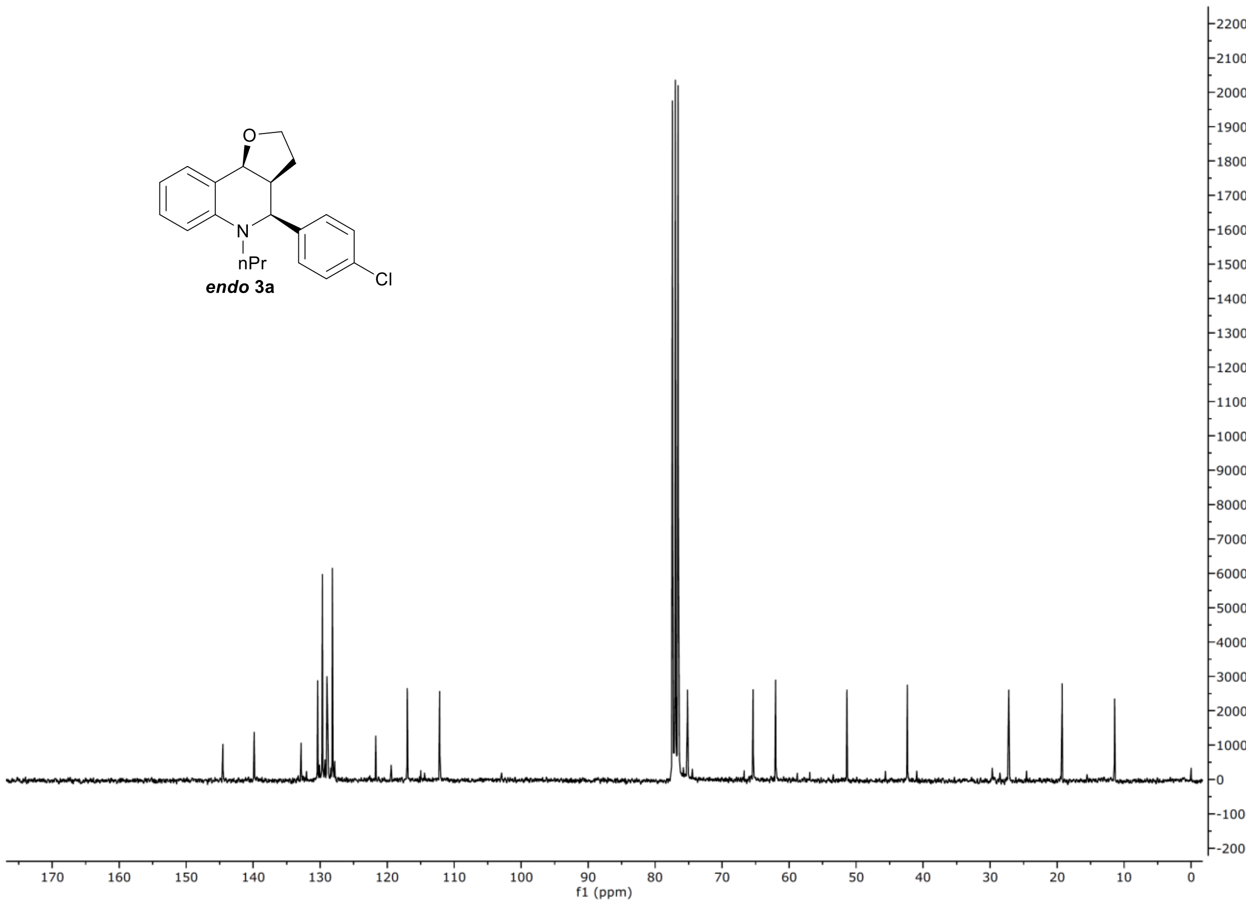


N
O
4
f1 (ppm)



N
O
4
f1 (ppm)


O
N
nPr
Cl
endo 3a
f1 (ppm)


O
N
nPr
Cl
endo 3a
f1 (ppm)

References

1. B. H. S. T. da Silva, N. L. Marana, A. C. Mafud and L. C. da Silva-Filho, A theoretical and experimental study to unequivocal structural assignment of tetrahydroquinoline derivatives, *Structural Chemistry*, 2013, **25**, 327-337.
2. H. G. Imrich, J. Conrad, D. Bubrin and U. Beifuss, From nitrobenzenes to substituted tetrahydroquinolines in a single step by a domino reduction/imine formation/aza-diels-alder reaction, *J Org Chem*, 2015, **80**, 2319-2332.
3. J. Salehi, H. Veisi, M. M. Khodaei and A. R. Khosropour, One-pot synthesis of pyrano- and furanoquinolines catalyzed by molten tetra-n-butylphosphonium bromide under solvent-free conditions, *Journal of Heterocyclic Chemistry*, 2011, **48**, 484-488.
4. J. S. Yadav, B. V. S. Reddy, V. Sunitha and K. S. Reddy, Novel Use of SelectfluorTM for the Synthesis of cis-Fused Pyrano- and Furanotetrahydroquinolines, *Advanced Synthesis & Catalysis*, 2003, **345**, 1203-1206.
5. B. Das, H. Holla, R. Ramu and K. Venkateswarlu, Synthesis of pyrano and furanoquinolines using silica chloride or amberlyst-15 as a heterogeneous catalyst, *Journal of Chemical Research*, 2005, **2005**, 793-795.
6. L.-P. Li, X. Cai, Y. Xiang, Y. Zhang, J. Song, D.-C. Yang, Z. Guan and Y.-H. He, The α-chymotrypsin-catalyzed Povarov reaction: one-pot synthesis of tetrahydroquinoline derivatives, *Green Chemistry*, 2015, **17**, 3148-3156.
7. C. Cimarelli, S. Bordi, P. Piermattei, M. Pellei, F. Del Bello and E. Marcantoni, An Efficient Lewis Acid Catalyzed Povarov Reaction for the One-Pot Stereocontrolled Synthesis of Polyfunctionalized Tetrahydroquinolines, *Synthesis*, 2017, **49**, 5387-5395.
8. X. Liu and P. H. Toy, Halogen Bond-Catalyzed Povarov Reactions, *Advanced Synthesis & Catalysis*, 2020, **362**, 3437-3441.
9. A. Olmos, J. Sommer and P. Pale, Scandium(III) Zeolites as New Heterogeneous Catalysts: [4+2]Cyclocondensation of in situ Generated Aryl Imines with Alkenes, *Chemistry – A European Journal*, 2011, **17**, 1907-1914.
10. V. Sridharan, C. Avendaño and J. C. Menéndez, CAN-Catalyzed Vinylogous Povarov Reactions: The First Three-Component Synthesis of 2-Functionalized Tetrahydroquinolines from Anilines, -Cinnamaldehyde and Vinyl Ethers, *Synlett*, 2007, **2007**, 1079-1082.
11. X. Feng, Y. Song and W. Lin, Dimensional Reduction of Lewis Acidic Metal–Organic Frameworks for Multicomponent Reactions, *Journal of the American Chemical Society*, 2021, **143**, 8184-8192.
12. G. Maiti and P. Kundu, Imino Diels–Alder reactions: an efficient one-pot synthesis of pyrano and furanoquinoline derivatives catalyzed by SbCl3, *Tetrahedron Letters*, 2006, **47**, 5733-5736.
13. M. Mahesh, C. V. Reddy, K. S. Reddy, P. V. K. Raju and V. V. N. Reddy, Imino Diels–Alder Reactions: Efficient Synthesis of Pyrano and Furoquinolines Catalyzed by ZrCl4, *Synthetic Communications*, 2004, **34**, 4089-4104.
14. A. Kumar, S. Srivastava, G. Gupta, V. Chaturvedi, S. Sinha and R. Srivastava, Natural Product Inspired Diversity Oriented Synthesis of Tetrahydroquinoline Scaffolds as Antitubercular Agent, *ACS Combinatorial Science*, 2011, **13**, 65-71.
15. O. M. Kuzmina, A. K. Steib, D. Flubacher and P. Knochel, Iron-Catalyzed Cross-Coupling of N-Heterocyclic Chlorides and Bromides with Arylmagnesium Reagents, *Organic Letters*, 2012, **14**, 4818-4821.