Supporting Information for

Chiral Brønsted Acid-Catalyzed Dynamic Kinetic Resolution of Atropisomeric *ortho*-Formyl Naphthamides

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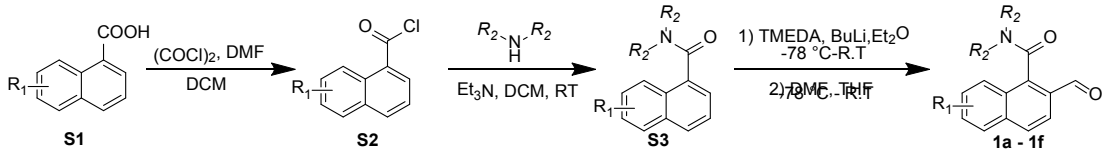
1. General information

Experimental: All reactions were set up under inert atmosphere utilizing glassware that was flame-dried and cooled under vacuum. All non-aqueous manipulations were using standard Schlenk techniques. Reactions were monitored using thin-layer chromatography (TLC) on silica gel plates. Visualization of the developed plates was performed under UV light (254 nm) or $KMnO_4$ stain. Silica gel flash column chromatography was performed on SYNTHWARE 40-63 μm silica gel.

Instrumentation: All NMR spectra were run at 400 MHz (^{1}H NMR) or 100 MHz (^{13}C NMR/^{31}P NMR) in $CDCl_3$, Methanol-$d_4$or d_6-DMSO solution.^{1}H NMR spectra were internally referenced to TMS. ^{13}C NMR spectra were internally referenced to the residual solvent signal. Data for ^{1}H NMR are reported as follows: chemical shift (δ ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m= multiplet, br = broad), coupling constants (J) were reported in Hz. High resolution mass spectra (HRMS) were recorded on Bruker MicrOTOF-QII mass instrument (ESI).

Materials: Unless otherwise indicated, starting catalysts and materials were obtained from Sigma Aldrich, TCI, Alfa Aesar, Adamas or Acros. Moreover, commercially available reagents were used without additional purification.

2. Synthesis and characterization data of amide naphthaldehyde

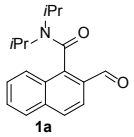


A 100 mL round-bottom flask was charged with 1-naphthoic acid **S1** (20 mmol), dry DCM (30 mL) and catalytic amount of DMF. The reaction mixture was cooled to 0 °C and stirred for 5 minutes. Then $(COCl)_2$ (1.3 equiv.) was added dropwise to the reaction mixture and stirred at room temperature for 12 h. The resulting mixture was concentrated under reduced pressure to afford acid chloride **S2** quantitatively which was used directly without further purification for the next step.

To a solution of amine (1.3 equiv.) and Et_3N (1.5 equiv.) in dry DCM (30 mL), acid chloride **S2** (1.0 equiv) was added dropwise at 0 °C and the reaction mixture was stirred at room temperature for 12 h. Then water (40 mL) was added and aqueous layer was extracted with DCM (3 x 30 mL). The combined organic layer was washed with saturated aqueous $NaHCO_3$ (30 mL) solution followed by water (30 mL). After that, the organic layer was dried over Na_2SO4 and concentrated under reduced pressure. The crude mass was purified by recrystal to give **S3**.

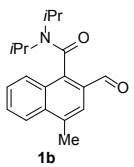
Under N_2, a solution of **S3** (10 mmol) and dry TMEDA (20 mmol, 2 equiv) in 20 mL of Et_2O was cooled to -78 °C, and *n*-BuLi (1.2 equiv) was slowly added. After complete addition, the resulting mixture was stirred for about 1 h at room temperature. Then dry THF (20 ml) and dry DMF (1.4 equiv) were slowly added at -78 °C under N_2 and the reaction mixture was stirred at room temperature for 1 h. Then water (40 mL) was added and aqueous layer was extracted with EA (3 x 30 mL). After that, the organic layer was dried over Na_2SO4 and concentrated under reduced pressure. The crude mass was purified by silica gel column chromatography to give **1a-1f**.

2-formyl-N,N-diisopropyl-1-naphthamide (1a) :



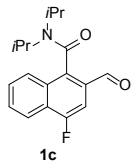
2.1 g (Flash column chromatography eluent, PE/EA = 4:1), 76% yield, white solid, **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 10.3 (s, 1H), 8.0 (dd, *J* = 11.4, 8.3 Hz, 2H), 7.9 (d, *J* = 8.3 Hz, 2H), 7.6 (p, *J* = 6.9 Hz, 2H), 3.7 (p, *J* = 6.9 Hz, 1H), 3.5 (p, *J* = 6.7 Hz, 1H), 1.8 (d, *J* = 6.8 Hz, 3H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.0 (t, *J* = 7.3 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 190.4, 166.9, 142.0, 136.2, 129.4, 129.1, 128.7, 128.6, 128.4, 127.6, 126.0, 122.5, 51.5, 46.6, 20.6, 20.5, 20.3, 20.3. **HRMS (ESI)** calcd. for $C_{18}H_{22}NO_2$ [M+H]: 284.1651, found: 284.1650.

2-formyl-N,N-diisopropyl-4-methyl-1-naphthamide (1b) :



2.4 g (Flash column chromatography eluent, PE/EA = 4:1), 80% yield, white solid, **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 10.3 (s, 1H), 8.0 (dd, *J* = 8.3, 1.2 Hz, 1H), 8.0 – 8.0 (m, 1H), 7.8 (s, 1H), 7.7 – 7.6 (m, 1H), 7.6 – 7.6 (m, 1H), 3.7 (p, *J* = 6.8 Hz, 1H), 3.5 (p, *J* = 6.6 Hz, 1H), 2.7 (t, *J* = 1.0 Hz, 3H), 1.8 (d, *J* = 6.8 Hz, 3H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.0 (t, *J* = 6.7 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 190.8, 179.6, 167.4, 140.9, 135.8, 135.6, 129.5, 128.4, 127.4, 126.8, 124.8, 122.7, 51.6, 46.8, 20.8, 20.7, 20.5, 19.6. **HRMS (ESI)** calcd. for $C_{19}H_{24}NO_2$ [M+H]: 298.1807, found: 298.1808.

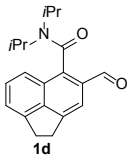
4-fluoro-2-formyl-N,N-diisopropyl-1-naphthamide (1c) :



1c

2.4 g (Flash column chromatography eluent, PE/EA = 3:1), 79% yield, white solid, **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 10.3 (d, *J* = 3.1 Hz, 1H), 8.2 (d, *J* = 8.3 Hz, 1H), 8.0 (d, *J* = 8.2 Hz, 1H), 7.8 – 7.7 (m, 2H), 7.6 (d, *J* = 10.5 Hz, 1H), 3.7 (q, *J* = 6.9 Hz, 1H), 3.5 (p, *J* = 6.7 Hz, 1H), 1.8 (d, *J* = 6.8 Hz, 3H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.1 (t, *J* = 6.3 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 189.3, 166.4, 158.7 (d, *J* = 255.5 Hz), 138.7, 131.0 (d, *J* = 4.8 Hz), 129.9, 129.4 (d, *J* = 7.3 Hz), 128.8, 126.9 (d, *J* = 17.6 Hz), 126.1 (d, *J* = 2.7 Hz), 121.4 (d, *J* = 5.2 Hz), 105.5 (d, *J* = 21.7 Hz), 51.7, 46.9, 20.8, 20.6, 20.5, 20.4. **HRMS (ESI)** calcd. for $C_{18}H_{21}FNO_2$ [M+H]: 302.1556, found: 302.1559.

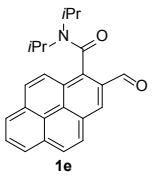
4-formyl-N,N-diisopropyl-1,2-dihydroacenaphthylene-5-carboxamide (1d) :



1d

The compound is prepared as reported in literature.[1] A solution of 5-bromo-1,2-dihydroacenaphthylene (20 mmol) in 200 mL of THF was cooled to –78 °C under N_2, and *n*-BuLi (1.2 equiv) was slowly added. After complete addition, the resulting yellow mixture was stirred for about 20 min at –78 °C. Excess dry ice pellets were dropped through the neck of the Schlenk flask against the N_2 flow, turning the mixture to milky white. It was stirred until it warmed up to room temperature, then acidified to pH = 6 with H_2SO_4, and extracted with Et_2O (2 x 50 mL). The combined organic layers were extracted with 1 M NaOH (2 x 50 mL). The combined aqueous extracts were acidified with conc HCl, yielding an off-white precipitate, which was filtered and recrystallized from EtOH to give 1,2-dihydroacenaphthylene-5-carboxylic acid as an off-white solid. The next step is the same as **1a.** 1.6 g (Flash column chromatography eluent, PE/EA = 4:1), 51% yield, white solid, **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 10.3 (s, 1H), 7.8 (s, 1H), 7.7 (d, *J* = 8.3 Hz, 1H), 7.5 (t, *J* = 7.6 Hz, 1H), 7.4 (d, *J* = 6.9 Hz, 1H), 3.6 (p, *J* = 6.8 Hz, 1H), 3.5 (p, *J* = 6.7 Hz, 1H), 3.4 – 3.3 (m, 4H), 1.8 (d, *J* = 6.8 Hz, 3H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.0 (dd, *J* = 6.7, 2.9 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 191.1, 167.3, 146.9, 146.4, 142.1, 138.9, 131.0, 129.5, 127.6, 123.3, 121.4, 115.9, 51.6, 46.7, 30.5, 30.1, 20.9, 20.8, 20.6, 20.5. **HRMS (ESI)** calcd. for $C_{20}H_{24}NO_2$ [M+H]: 310.1807, found: 310.1805.

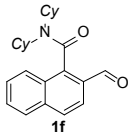
2-formyl-N,N-diisopropyl-4,8-dihydropyrene-1-carboxamide (1e) :



1e

2.4 g (Flash column chromatography eluent, PE/EA = 3:1), 69% yield, yellow solid, **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 10.5 (s, 1H), 8.6 (s, 1H), 8.1 – 8.1 (m, 4H), 8.0 (d, *J* = 8.5 Hz, 3H), 3.7 (p, *J* = 6.8 Hz, 1H), 3.4 (p, *J* = 6.7 Hz, 1H), 1.9 (d, *J* = 6.8 Hz, 3H), 1.8 (d, *J* = 6.8 Hz, 3H), 1.0 (dd, *J* = 12.9, 6.6 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 191.4, 167.9, 135.0, 131.9, 131.6, 130.6, 129.3, 128.8, 128.7, 127.6, 127.6, 127.5, 126.1, 125.9, 125.2, 124.1, 51.6, 46.7, 20.8, 20.4, 20.3. **HRMS (ESI)** calcd. for $C_{24}H_{24}NO_2$ [M+H]: 358.1807, found: 358.1807.

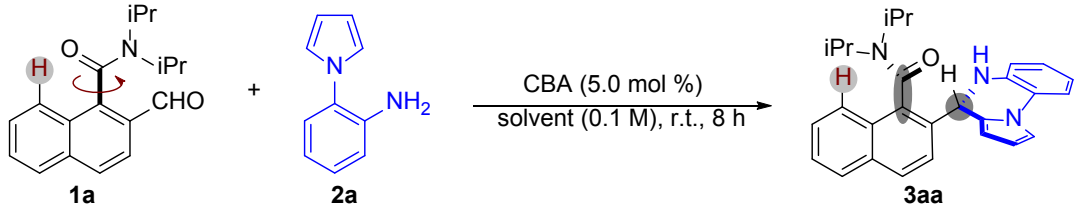
N,N-dicyclohexyl-2-formyl-1-naphthamide (1f) :

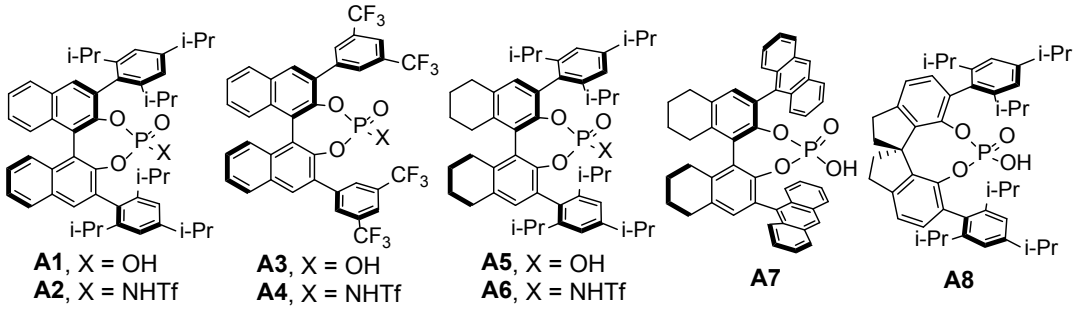


1f

2.6 g (Flash column chromatography eluent, PE/EA = 4:1), 72% yield, white solid, **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 10.3 (s, 1H), 8.0 (dd, *J* = 11.4, 8.4 Hz, 2H), 7.9 (d, *J* = 8.3 Hz, 2H), 7.6 – 7.5 (m, 2H), 3.2 (tt, *J* = 12.0, 3.8 Hz, 1H), 3.0 – 2.8 (m, 3H), 2.0 – 1.9 (m, 3H), 1.8 (d, *J* = 12.6 Hz, 1H), 1.7 (d, *J* = 5.6 Hz, 1H), 1.6 – 1.5 (m, 6H), 1.4 (dq, *J* = 15.6, 9.8, 6.6 Hz, 4H), 0.9 (qt, *J* = 13.2, 3.4 Hz, 1H), 0.7 (qt, *J* = 13.4, 3.8 Hz, 1H), 0.6 (dddd, *J* = 17.7, 13.7, 8.1, 3.9 Hz, 1H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 190.5, 167.1, 142.5, 136.2, 129.4, 129.1, 128.7, 128.5, 128.5, 127.6, 126.1, 122.3, 60.4, 56.8, 31.1, 30.8, 30.0, 29.7, 26.6, 26.6, 25.4, 25.3, 25.3, 24.8. **HRMS (ESI)** calcd. for $C_{24}H_{30}NO_2$ [M+H]: 364.2277, found: 364.2273.

3. Optimization of the Reaction Conditions.[a]

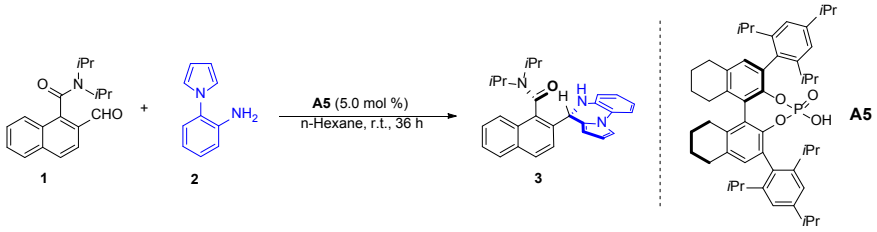




entry	CBA	solvent	yield (%)[b]	d.r.[c]	e.r.[d]
1	A1	CH_2Cl_2	91	>20:1	52:48
2	A2	CH_2Cl_2	56	>20:1	70:30
3	A3	CH_2Cl_2	95	>20:1	52:48
4	A4	CH_2Cl_2	96	>20:1	53:47
5	A5	CH_2Cl_2	92	>20:1	71:29
6	A6	CH_2Cl_2	95	>20:1	58:42
7	A7	CH_2Cl_2	95	>20:1	53:47
8	A8	CH_2Cl_2	91	>20:1	50:50
9	A5	THF	89	>20:1	72:28
10	A5	toluene	92	>20:1	70:30
11	A5	xylene	90	>20:1	70:30
12	A5	$CHCl_3$	93	>20:1	70:30
13	A5	CCl_4	93	>20:1	70:30
14	A5	Et_2O	72	>20:1	70:30
15	A5	MTBE	69	>20:1	69:31
16[e]	A5	n-hexane	98	>20:1	93:7
17[f]	A5	n-hexane	98	12:1	93:7
18[e,g]	A5	n-hexane	86	>20:1	76:23

[a] Reaction conditions: amide naphthaldehyde **1a** (0.1 mmol), 2-(1H-pyrrol-1-yl)aniline **2a** (0.15 mmol, 1.5 equiv.), catalysts **A1**-**8** (5.0 mol %) was stirred for 8 h in solvent (1.0 mL, 0.1 M) at room temperature under N_2. [b] Isolated yield. [c] The d.r. value was determined by ^{1}H NMR spectroscopy. [d] The e.r. value was determined by chiral HPLC analysis. [e] The reaction completed with 36 h. [f] 2.5 mol % of **A5** used and more than 72 h was needed for the reaction accomplishment. [g] 100 mg of 4 Å molecular sieves was added. Additionally, we didn't try other chiral phosphoric acids with smaller substituents.

4. Synthesis and characterization data of products

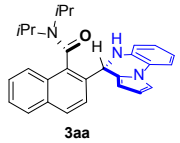


Amide naphthaldehyde **1** (0.1 mmol, 1.0 equiv), 2-(1H-pyrrol-1-yl) aniline **2** (0.15 mmol, 1.5 equiv.), chiral phosphoric acid **A5** (5.0 mol%) was stirred in *n*-hexane (1.0 mL, 0.1 M) at room temperature under N_2. Upon reaction completion, reaction solvent was removed and the crude reaction mixture was purified by flash column chromatography using petroleum ether / ethyl acetate as eluents to afford the desired products **3aa**-**an**, **3ba**-**fa, 3bh**-**3fh**.

Gram-scale reaction: 1

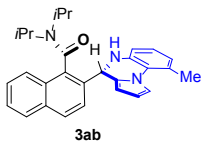
Under a nitrogen atmosphere, amide naphthaldehyde **1a** (3.75 mmol, 1.0 equiv), 2-(1H-pyrrol-1-yl) aniline **2a** (5.63 mmol, 1.5 equiv.), chiral phosphoric acid **A5** (5.0 mol%) was stirred in *n*-hexane (25 mL) at room temperature. Upon reaction completion, reaction solvent was removed and the crude reaction mixture was purified by flash column chromatography (silica gel, eluent: petroleum ether / ethyl acetate = 8:1) to give pure product **3aa** (1.5 g, 96% yield, >20:1 d.r., 90:10 e.r.).

(aS,S)-2-(4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1-naphthamide (3aa) :


3aa

40.6 mg (Flash column chromatography eluent, PE:EA = 8/1), 96% yield, white solid, >20:1 d.r.,93:7 e.r. (based on 0.1 mmol scale. Table 1, entry 16). When the reaction scaled up to gram-scale, 1.5 g of **3aa** was isolated in 96% yield with >20:1 d.r. and 90:10 e.r. (Scheme 2).**^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 – 7.8 (m, 3H), 7.6 (d, *J* = 8.6 Hz, 1H), 7.5 (dd, *J* = 6.7, 3.2 Hz, 2H), 7.3 (d, *J* = 7.9 Hz, 1H), 7.2 (dd, *J* = 3.0, 1.6 Hz, 1H), 7.0 – 6.9 (m, 1H), 6.9 (td, *J* = 7.7, 1.6 Hz, 1H), 6.7 (dd, *J* = 7.8, 1.6 Hz, 1H), 6.3 – 6.2 (m, 1H), 5.8 (s, 1H), 5.7 – 5.6 (m, 1H), 4.3 (s, 1H), 3.6 (p, *J* = 6.7 Hz, 1H), 3.5 (p, *J* = 6.8 Hz, 1H), 1.7 (d, *J* = 6.7 Hz, 3H), 1.5 (d, *J* = 6.7 Hz, 3H), 1.0 (d, *J* = 6.6 Hz, 3H), 0.9 (d, *J* = 6.4 Hz, 3H). **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.9, 135.8, 134.4, 133.3, 129.8, 128.9, 128.5, 128.2, 126.9, 126.7, 126.6, 126.4, 125.4, 125.2, 124.7, 119.3, 115.3, 114.7, 114.3, 110.6, 107.2, 54.4, 51.5, 46.4, 20.9, 20.6, 20.5, 20.4 **HRMS (ESI)** calcd. for $C_{28}H_{29}N_3O$ [M+H]: 423.2311, found: 423.2313. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 10.93 min, t_R (major) = 16.17 min.

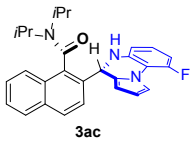
(aS,S)-N,N-diisopropyl-2-(9-methyl-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-1-naphthamide (3ab) :


3ab

42.8 mg (Flash column chromatography eluent, PE:EA = 8/1), 98% yield, white solid, >20:1 d.r., 92:8 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 – 7.8 (m, 3H), 7.6 (d, *J* = 8.6 Hz, 1H), 7.5 – 7.5 (m, 2H), 7.3 – 7.3 (m, 1H), 6.9 (t, *J* = 7.7 Hz, 1H), 6.7 (d, *J* = 7.6 Hz, 1H), 6.7 (d, *J* = 7.8 Hz, 1H), 6.2 (t, *J* = 3.3 Hz, 1H), 5.6 (s, 1H), 5.5 – 5.5 (m, 1H), 4.4 (s, 1H), 3.6 (p, *J* = 6.7 Hz, 1H), 3.5 (p, *J* = 6.8 Hz, 1H), 2.6 (s, 3H), 1.7 (d, *J* = 6.7 Hz, 3H), 1.5 (d, *J* = 6.7 Hz, 3H), 0.9 (d, *J* = 6.6 Hz, 3H), 0.7 (d, *J* = 6.6 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.1, 138.4, 134.7, 133.4, 132.2, 132.1, 130.0, 128.3, 128.2, 126.8, 126.7, 126.6, 126.5, 125.7, 125.4, 124.6, 123.8, 119.1, 114.1, 109.3, 105.6, 55.0, 51.6, 46.4, 21.5, 20.8, 20.5, 20.2. **HRMS (ESI)** calcd. for

$C_{29}H_{31}N_3O$ [M+H]: 437.2467, found: 437.2469. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 9.41 min, t_R (major) = 15.80 min.

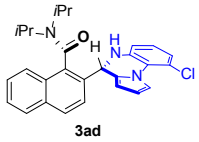
(aS,S)-2-(9-fluoro-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1-naphthamide (3ac) :



3ac

41.1 mg (Flash column chromatography eluent, PE:EA = 7/1), 93% yield, white solid, 18:1 d.r., 86:14 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 – 7.8 (m, 3H), 7.6 (d, *J* = 8.6 Hz, 1H), 7.5 – 7.5 (m, 3H), 6.9 (td, *J* = 8.1, 5.5 Hz, 1H), 6.6 (dd, *J* = 12.2, 8.4 Hz, 1H), 6.5 (d, *J* = 8.0 Hz, 1H), 6.2 (t, *J* = 3.2 Hz, 1H), 5.8 (d, *J* = 4.8 Hz, 1H), 5.6 (d, *J* = 3.4 Hz, 1H), 4.6 (s, 1H), 3.5 (dp, *J* = 36.0, 6.8 Hz, 2H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.5 (d, *J* = 6.8 Hz, 3H), 0.9 (d, *J* = 6.6 Hz, 3H), 0.8 (d, *J* = 6.6 Hz, 3H).**^{13}C NMR** (100 MHz, Chloroform-*d*) δ 168.9, 153.1 (d, *J* = 244.7 Hz), 138.5 (d, *J* = 5.1 Hz), 134.5, 133.4, 132.5, 130.0, 129.1, 128.5, 128.2, 126.9, 126.7, 126.4, 125.4, 124.5 (d, *J* = 9.7 Hz), 119.4 (d, *J* = 15.6 Hz), 114.4, 111.0, 110.5 (d, *J* = 3.0 Hz), 107.2 (d, *J* = 21.5 Hz), 106.6, 54.7, 51.6, 46.4, 20.9, 20.6, 20.5, 20.3. **HRMS (ESI)** calcd. for $C_{28}H_{28}FN_3O$ [M+H]: 441.2216, found: 441.2218. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 50/50, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 8.07 min, t_R (major) = 11.35 min.

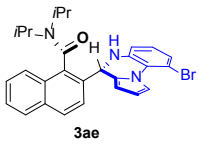
(aS,S)-2-(9-chloro-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1-naphthamide (3ad) :



3ad

44.8 mg (Flash column chromatography eluent, PE:EA = 7/1), 98% yield, white solid, >20:1 d.r., 87.5:12.5 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 8.0 (d, *J* = 3.2 Hz, 1H), 7.9 – 7.8 (m, 3H), 7.6 – 7.5 (m, 3H), 7.0 – 6.8 (m, 2H), 6.7 (d, *J* = 7.5 Hz, 1H), 6.2 (q, *J* = 3.0 Hz, 1H), 5.6 (d, *J* = 6.1 Hz, 1H), 5.5 (d, *J* = 3.5 Hz, 1H), 4.7 (s, 1H), 3.5 (dp, *J* = 33.2, 6.8 Hz, 2H), 1.7 (d, *J* = 6.7 Hz, 3H), 1.5 (d, *J* = 6.7 Hz, 3H), 0.9 (d, *J* = 6.5 Hz, 3H), 0.7 (d, *J* = 6.3 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.1, 139.7, 134.6, 133.6, 133.4, 131.5, 130.1, 128.3, 128.2, 126.9, 126.7, 126.6, 125.4, 125.1, 123.6, 122.6, 122.5, 119.8, 114.6, 109.6, 106.2, 55.0, 51.7, 46.4, 20.8, 20.5, 20.2. **HRMS (ESI)** calcd. for $C_{28}H_{28}ClN_3O$ [M+H]: 457.1921, found: 457.1923. **HPLC**: Chiralpak IA, hexane/*i*PrOH = 80/20, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (major) = 7.52 min, t_R (minor) = 8.49 min.

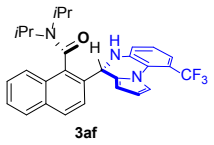
(aS,S)-2-(9-bromo-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1-naphthamide (3ae) :



3ae

49.1 mg (Flash column chromatography eluent, PE:EA = 7/1), 98% yield, white solid, >20:1 d.r., 92:8 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 8.1 (dd, *J* = 3.1, 1.5 Hz, 1H), 7.9 – 7.8 (m, 3H), 7.6 – 7.5 (m, 3H), 7.1 (dd, *J* = 7.9, 1.4 Hz, 1H), 6.8 (t, *J* = 7.9 Hz, 1H), 6.7 (dd, *J* = 8.0, 1.5 Hz, 1H), 6.2 (t, *J* = 3.3 Hz, 1H), 5.6 (s, 1H), 5.5 (q, *J* = 1.5 Hz, 1H), 4.7 (s, 1H), 3.5 (dp, *J* = 31.5, 6.7 Hz, 2H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.5 (d, *J* = 6.8 Hz, 3H), 0.9 (d, *J* = 6.6 Hz, 3H), 0.7 (d, *J* = 6.6 Hz, 3H).**^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.1, 140.0, 134.5, 133.3, 131.9, 131.3, 130.0, 128.2, 128.1, 126.9, 126.7, 126.6, 126.0, 125.5, 125.3, 125.0, 119.5, 115.3, 110.6, 109.2, 106.2, 55.0, 51.7, 46.4, 20.7, 20.5, 20.1. **HRMS (ESI)** calcd. for $C_{28}H_{28}BrN_3O$ [M+H]: 501.1416, found: 501.1415. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 7.71 min, t_R (major) = 15.30 min.

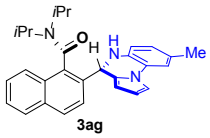
(aS,S)-N,N-diisopropyl-2-(9-(trifluoromethyl)-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-1-naphthamide (3af) :



3af

47.5 mg (Flash column chromatography eluent, PE:EA = 6/1), 97% yield, white solid, 6:1 d.r.,90.5:9.5 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 – 7.8 (m, 3H), 7.6 – 7.5 (m, 3H), 7.4 – 7.3 (m, 1H), 7.2 – 7.2 (m, 1H), 7.1 (t, *J* = 7.9 Hz, 1H), 7.0 (d, *J* = 7.7 Hz, 1H), 6.2 (t, *J* = 3.4 Hz, 1H), 5.6 (s, 1H), 5.5 (d, *J* = 3.5 Hz, 1H), 5.0 (s, 1H), 3.5 (dp, *J* = 30.8, 6.7 Hz, 2H), 1.7 (d, *J* = 6.9 Hz, 3H), 1.5 (d, *J* = 6.8 Hz, 3H), 0.9 (d, *J* = 6.7 Hz, 3H), 0.6 (d, *J* = 6.6 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.3, 139.7, 134.6, 133.4, 133.0, 132.4, 131.1, 130.2, 128.3, 128.2, 127.0, 126.8, 126.7, 125.0 (q, *J* = 256.5 Hz), 125.4, 124.4, 120.9, 119.7, 118.8, 118.8, 110.7, 106.4, 55.0, 51.8, 46.5, 20.8, 20.5, 20.4, 20.1. **HRMS (ESI)** calcd. for $C_{29}H_{28}F_3N_3O$ [M+H]: 491.2184, found: 491.2186. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 5.33 min, t_R (major) = 9.95 min.

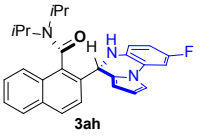
(aS,S)-N,N-diisopropyl-2-(8-methyl-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-1-naphthamide (3ag) :



3ag

42.4 mg (Flash column chromatography eluent, PE:EA = 8/1), 97% yield, white solid, >20:1 d.r.,94:6 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.8 (ddd, *J* = 16.0, 7.9, 1.6 Hz, 2H), 7.7 (d, *J* = 8.6 Hz, 1H), 7.5 (dqd, *J* = 8.2, 6.9, 1.5 Hz, 2H), 7.3 – 7.2 (m, 2H), 7.2 (d, *J* = 1.7 Hz, 1H), 6.7 (dd, *J* = 8.0, 1.8 Hz, 1H), 6.6 (d, *J* = 7.9 Hz, 1H), 6.3 (t, *J* = 3.2 Hz, 1H), 5.8 – 5.7 (m, 2H), 4.7 (s, 1H), 3.7 (p, *J* = 6.7 Hz, 1H), 3.6 (p, *J* = 6.8 Hz, 1H), 2.3 (s, 3H), 1.8 (d, *J* = 6.8 Hz, 3H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.1 (dd, *J* = 6.7, 1.7 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.6, 135.7, 134.6, 133.0, 132.9, 129.1, 128.5, 128.3, 128.3, 127.9, 126.8, 126.5, 125.9, 125.4, 124.9, 124.7, 115.8, 115.0, 114.2, 110.0, 106.0, 53.1, 51.5, 46.4, 21.2, 20.9, 20.7, 20.7, 20.6. **HRMS (ESI)** calcd. for $C_{29}H_{31}N_3O$ [M+H]: 437.2467, found: 437.2466. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 13.71 min, t_R (major) = 20.54 min.

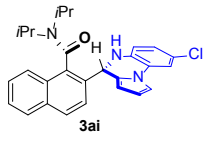
(aS,S)-2-(8-fluoro-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1-naphthamide (3ah) :



3ah

42.7 mg (Flash column chromatography eluent, PE:EA = 8/1), 97% yield, white solid, >20:1 d.r.,90:10 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 – 7.8 (m, 3H), 7.6 (d, *J* = 8.6 Hz, 1H), 7.5 (dd, *J* = 6.5, 2.9 Hz, 2H), 7.1 (dd, *J* = 9.2, 2.4 Hz, 2H), 6.7 – 6.6 (m, 2H), 6.2 (t, *J* = 3.2 Hz, 1H), 5.8 (s, 1H), 5.7 – 5.6 (m, 1H), 4.3 (s, 1H), 3.6 (p, *J* = 6.8 Hz, 1H), 3.5 (p, *J* = 6.8 Hz, 1H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.5 (d, *J* = 6.7 Hz, 3H), 0.9 (d, *J* = 6.6 Hz, 3H), 0.8 (d, *J* = 6.6 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 168.9, 156.7 (d, *J* = 236.7 Hz), 134.5, 133.4, 132.9, 132.0, 129.9, 129.3, 128.5, 128.2, 126.9, 126.7, 126.3, 125.7 (d, *J* = 10.4 Hz), 125.4, 115.7 (d, *J* = 8.7 Hz), 114.5, 111.2, 110.8 (d, *J* = 22.5 Hz), 107.5, 102.6 (d, *J* = 27.3 Hz), 54.6, 51.5, 46.4, 20.9, 20.6, 20.5, 20.4. **HRMS (ESI)** calcd. for $C_{28}H_{28}FN_3O$ [M+H]: 441.2216, found: 441.2217. **HPLC**: Chiralpak IA, hexane/*i*PrOH = 95/5, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 28.07min, t_R (major) = 31.93 min.

(aS,S)-2-(8-chloro-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1-naphthamide (3ai) :

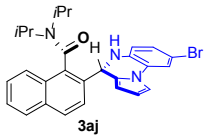


3ai

44.7 mg (Flash column chromatography eluent, PE:EA = 7/1), 98% yield, white solid, >20:1 d.r., 97:3 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 – 7.8 (m, 3H), 7.6 – 7.5 (m, 3H), 7.3 (d, *J* = 2.3 Hz, 1H), 7.1 (d, *J* = 2.2 Hz, 1H), 6.9 (dd, *J* = 8.4, 2.3 Hz, 1H), 6.7 (dd, *J* = 8.3, 2.3 Hz, 1H), 6.2 (q, *J* = 3.0 Hz, 1H), 5.8 (s, 1H), 5.7 (d, *J* = 3.6 Hz, 1H), 4.5 (s, 1H), 3.5 (dp, *J* = 29.9, 7.0 Hz, 2H), 1.7 (d, *J* = 6.6 Hz, 3H), 1.5 (d, *J* = 6.6 Hz, 3H), 0.9 (d, *J* = 6.3 Hz, 3H), 0.7 (d, *J* = 6.3 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 168.9, 134.4, 134.3, 133.3, 132.8, 129.9, 128.8, 128.6, 128.2, 127.0, 126.7, 126.2, 125.8, 125.4, 124.4, 123.8, 116.1, 115.0, 114.5, 111.3, 107.6, 54.6, 51.6,

46.4, 20.9, 20.6, 20.5, 20.3. **HRMS (ESI)** calcd. for $C_{28}H_{28}ClN_3O$ [M+H]: 457.1921, found: 457.1924. **HPLC**: Chiralpak IA, hexane/*i*PrOH = 80/20, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 8.77 min, t_R (major) = 9.79 min.

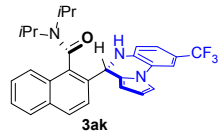
(aS,S)-2-(8-bromo-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1-naphthamide (3aj) :



3aj

46.6 mg (Flash column chromatography eluent, PE:EA = 7/1), 93% yield, white solid, 16:1 d.r.,96.5:3.5 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 – 7.8 (m, 3H), 7.6 – 7.5 (m, 3H), 7.4 (d, *J* = 2.1 Hz, 1H), 7.1 (dd, *J* = 3.0, 1.5 Hz, 1H), 7.0 (dd, *J* = 8.4, 2.1 Hz, 1H), 6.6 (d, *J* = 8.4 Hz, 1H), 6.2 (t, *J* = 3.3 Hz, 1H), 5.8 (s, 1H), 5.7 (q, *J* = 1.5 Hz, 1H), 4.5 (s, 1H), 3.5 (dp, *J* = 29.8, 6.7 Hz, 2H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.5 (d, *J* = 6.8 Hz, 3H), 0.9 (d, *J* = 6.6 Hz, 3H), 0.8 (d, *J* = 6.6 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 168.9, 134.8, 134.2, 133.3, 129.9, 128.7, 128.5, 128.2, 127.3, 126.9, 126.7, 126.2, 126.1, 125.4, 117.7, 116.5, 114.5, 111.3, 110.6, 107.6, 54.5, 51.5, 46.4, 20.9, 20.6, 20.5, 20.3. **HRMS (ESI)** calcd. for $C_{28}H_{28}BrN_3O$ [M+H]: 501.1416, found: 501.1415. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 10.85 min, t_R (major) = 17.56 min.

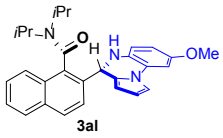
(aS,S)-N,N-diisopropyl-2-(8-(trifluoromethyl)-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-1-naphthamide (3ak) :



3ak

44.7 mg (Flash column chromatography eluent, PE:EA = 7/1), 91% yield, white solid, 10:1 d.r., 85:15 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 – 7.8 (m, 3H), 7.5 – 7.5 (m, 4H), 7.2 – 7.1 (m, 2H), 6.8 (d, *J* = 8.3 Hz, 1H), 6.2 (t, *J* = 3.3 Hz, 1H), 5.8 (s, 1H), 5.7 (d, *J* = 3.6 Hz, 1H), 4.9 (s, 1H), 3.5 (dp, *J* = 26.1, 6.7 Hz, 2H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.5 (d, *J* = 6.8 Hz, 3H), 0.9 (d, *J* = 6.6 Hz, 3H), 0.7 (d, *J* = 6.8 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 168.9, 138.4, 134.1, 133.4, 132.6, 130.0, 128.7, 128.3, 128.2, 127.0, 126.8, 126.2, 125.4, 124.4, 122.1 (q, *J* = 230.3 Hz), 121.9, 120.7, 114.8, 114.5, 111.8, 111.6, 107.9, 54.5, 51.6, 46.5, 20.9, 20.7, 20.5, 20.4. **HRMS (ESI)** calcd. for $C_{29}H_{28}F_3N_3O$ [M+H]: 491.2184, found: 491.2185. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 7.27 min, t_R (major) = 11.03 min.

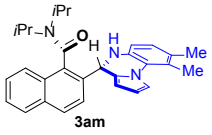
(aS,S)-N,N-diisopropyl-2-(8-methoxy-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-1-naphthamide (3al) :



3al

43.9 mg (Flash column chromatography eluent, PE:EA = 10/1), 97% yield, white solid, >20:1 d.r., 81:19 e.r. (>99.5:0.5 e.r. recrstl.). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 – 7.8 (m, 3H), 7.6 (d, *J* = 8.6 Hz, 1H), 7.5 – 7.5 (m, 2H), 7.1 (dd, *J* = 3.0, 1.5 Hz, 1H), 6.9 (d, *J* = 2.6 Hz, 1H), 6.7 (d, *J* = 8.5 Hz, 1H), 6.6 – 6.6 (m, 1H), 6.2 (t, *J* = 3.2 Hz, 1H), 5.7 (s, 1H), 5.6 – 5.6 (m, 1H), 4.1 (s, 1H), 3.8 (s, 3H), 3.7 – 3.6 (m, 1H), 3.5 (p, *J* = 6.8 Hz, 1H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.5 – 1.5 (m, 3H), 1.0 (d, *J* = 6.5 Hz, 3H), 0.7 (d, *J* = 6.3 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.0, 153.6, 134.6, 133.4, 133.3, 129.9, 129.9, 129.7, 128.5, 128.2, 126.9, 126.7, 126.5, 126.3, 125.5, 116.0, 114.4, 110.8, 109.7, 107.2, 102.0, 56.0, 54.8, 51.5, 46.4, 21.0, 20.7, 20.6, 20.4. **HRMS (ESI)** calcd. for $C_{29}H_{31}N_3O_2$ [M+H]: 453.2416, found: 453.2416. **HPLC**: Chiralpak IA, hexane/*i*PrOH = 80/20, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 12.63 min, t_R (major) = 14.45 min.

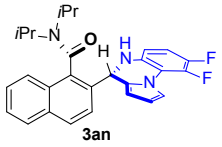
(aS,S)-2-(8,9-dimethyl-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1-naphthamide (3am) :



3am

42.7 mg (Flash column chromatography eluent, PE:EA = 8/1), 95% yield, white solid, 13:1 d.r., 91.5:8.5 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 – 7.8 (m, 3H), 7.6 (d, *J* = 8.6 Hz, 1H), 7.5 – 7.5 (m, 2H), 7.2 – 7.2 (m, 1H), 6.8 (d, *J* = 7.9 Hz, 1H), 6.6 (d, *J* = 7.8 Hz, 1H), 6.2 (t, *J* = 3.3 Hz, 1H), 5.5 (s, 1H), 5.4 (dt, *J* = 2.5, 1.2 Hz, 1H), 4.4 (s, 1H), 3.6 (q, *J* = 6.6 Hz, 1H), 3.5 (p, *J* = 6.8 Hz, 1H), 2.5 (s, 3H), 2.3 (s, 3H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.5 (d, *J* = 6.8 Hz, 3H), 0.9 (d, *J* = 6.6 Hz, 3H), 0.7 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.2, 136.9, 134.7, 133.4, 132.7, 132.1, 130.0, 129.5, 128.2, 126.8, 126.8, 126.6, 126.4, 126.2, 125.5, 125.4, 119.7, 113.2, 109.0, 105.3, 55.2, 51.7, 46.4, 20.8, 20.5, 20.4, 20.1, 17.2. **HRMS (ESI)** calcd. for $C_{30}H_{33}N_3O$ [M+H]: 451.2624, found: 451.2627. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 9.28 min, t_R (major) = 16.71 min.

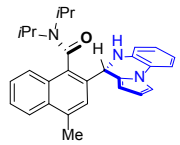
(aS,S)-2-(8,9-difluoro-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1-naphthamide (3an) :



3an

44.1 mg (Flash column chromatography eluent, PE:EA = 7/1), 96% yield, white solid, >20:1 d.r., 89.5:10.5 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 – 7.8 (m, 3H), 7.6 – 7.5 (m, 3H), 7.4 (q, *J* = 2.7 Hz, 1H), 6.8 – 6.7 (m, 1H), 6.4 (ddd, *J* = 9.0, 4.4, 2.0 Hz, 1H), 6.2 (t, *J* = 3.3 Hz, 1H), 5.7 (s, 1H), 5.6 (d, *J* = 3.5 Hz, 1H), 4.5 (s, 1H), 3.5 (dp, *J* = 27.8, 6.8 Hz, 2H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.5 (d, *J* = 6.8 Hz, 3H), 0.9 (d, *J* = 6.6 Hz, 3H), 0.8 (d, *J* = 6.8 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 168.9, 145.2 (d, $J = 225.0$ Hz), 134.6, 133.8, 133.4, 132.1, 130.0, 129.4, 128.5, 128.2, 127.0, 126.8, 126.4, 125.4, 119.2 (d, *J* = 15.1 Hz), 111.5 (d, *J* = 18.6 Hz), 111.1 (d, *J* = 2.8 Hz), 109.4 (d, *J* = 4.0 Hz), 109.3, 109.2(d, *J* = 4.0 Hz), 106.9, 77.5, 77.2, 76.8, 54.8, 51.6, 46.4, 20.9, 20.6, 20.6, 20.3. **HRMS (ESI)** calcd. for $C_{28}H_{27}F_2N_3O$ [M+H]: 459.2122, found: 459.2124. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 9.31 min, t_R (major) = 13.17 min.

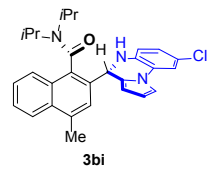
(aS,S)-2-(4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-4-methyl-1-naphthamide (3ba) :



3ba

42.8 mg (Flash column chromatography eluent, PE:EA = 8/1), 98% yield, white solid, 13:1 d.r., 82:18 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.99 (dd, *J* = 7.1, 2.2 Hz, 1H), 7.92 – 7.86 (m, 1H), 7.53 (ddd, *J* = 11.4, 6.5, 4.2 Hz, 3H), 7.33 (d, *J* = 7.6 Hz, 1H), 7.16 (d, *J* = 0.9 Hz, 1H), 6.99 – 6.92 (m, 1H), 6.84 (td, *J* = 7.8, 1.0 Hz, 1H), 6.77 – 6.69 (m, 1H), 6.20 (t, *J* = 3.2 Hz, 1H), 5.79 (s, 1H), 5.67 (d, *J* = 3.3 Hz, 1H), 4.28 (s, 1H), 3.64 (dt, *J* = 13.1, 6.6 Hz, 1H), 3.50 (dt, *J* = 13.6, 6.8 Hz, 1H), 2.65 (s, 3H), 1.72 (d, *J* = 6.8 Hz, 3H), 1.48 (d, *J* = 6.8 Hz, 3H), 0.94 (d, *J* = 6.6 Hz, 3H), 0.85 (d, *J* = 6.4 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.1, 135.8, 135.0, 133.1, 132.8, 132.7, 130.0, 129.1, 126.8, 126.5, 126.0, 125.2, 124.7, 124.4, 119.3, 115.3, 114.8, 114.3, 110.6, 107.2, 54.4, 51.4, 46.3, 20.9, 20.7, 20.5, 20.5, 19.6. **HRMS (ESI)** calcd. for $C_{29}H_{31}N_3O$ [M+H]: 437.2467, found: 437.2465. **HPLC**: Chiralpak IA, hexane/*i*PrOH = 80/20, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 5.77 min, t_R (major) = 7.73 min.

(aS,S)-2-(8-chloro-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-4-methyl-1-naphthamide (3bi) :

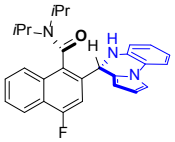


3bi

46.5 mg (Flash column chromatography eluent, PE:EA = 7/1), 99% yield, white solid, 10:1 d.r., 88:12 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 8.0 – 8.0 (m, 1H), 7.9 – 7.8 (m, 1H), 7.5 (dtd, *J* = 8.2, 6.8, 5.2 Hz, 2H), 7.4 (s, 1H), 7.3 (d, *J* = 2.2 Hz, 1H), 7.1 (dd, *J* = 3.0, 1.6 Hz, 1H), 6.9 (dt, *J* = 8.4, 2.0 Hz, 1H), 6.6 (dd, *J* = 8.4, 3.1 Hz, 1H), 6.2 (t, *J* = 3.2 Hz, 1H), 5.8 (d, *J* = 3.6 Hz, 1H), 5.7 (dt, *J* = 2.9, 1.3 Hz, 1H), 4.4 (s, 1H), 3.6 (p, *J* =

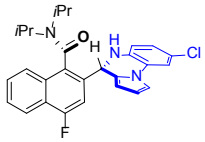
6.6 Hz, 1H), 3.5 (p, *J* = 6.8 Hz, 1H), 2.7 (s, 3H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.5 (d, *J* = 6.8 Hz, 3H), 0.9 (d, *J* = 6.6 Hz, 3H), 0.8 (d, *J* = 6.7 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.1, 135.0, 134.5, 133.0, 132.7, 132.2, 130.0, 128.9, 126.6, 126.0, 125.9, 124.7, 124.6, 124.4, 124.3, 123.8, 116.0, 114.9, 114.4, 111.2, 107.6, 54.5, 51.5, 46.3, 20.8, 20.6, 20.5, 20.4, 19.6. **HRMS (ESI)** calcd. for $C_{29}H_{30}ClN_3O$ [M+H]: 471.2077, found: 471.2077. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 50/50, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (major) = 9.05 min, t_R (minor) = 14.71 min.

(aS,S)-2-(4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-4-fluoro-N,N-diisopropyl-1-naphthamide (3ca) :


3ca

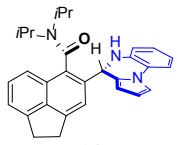
43.2 mg (Flash column chromatography eluent, PE:EA = 7/1), 98% yield, white solid, 5:1 d.r., 82:18 e.r. (94:6 e.r.). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 8.1 – 8.0 (m, 1H), 7.9 – 7.8 (m, 1H), 7.6 (pd, *J* = 6.9, 1.5 Hz, 2H), 7.4 (dd, *J* = 8.0, 1.3 Hz, 1H), 7.3 (dd, *J* = 3.0, 1.5 Hz, 1H), 7.0 – 6.9 (m, 2H), 6.8 (td, *J* = 7.6, 1.4 Hz, 1H), 6.7 (dd, *J* = 7.9, 1.4 Hz, 1H), 6.3 (t, *J* = 3.2 Hz, 1H), 5.8 (dt, *J* = 4.9, 1.5 Hz, 2H), 5.0 – 4.8 (m, 1H), 3.7 (dp, *J* = 33.0, 6.7 Hz, 2H), 1.8 (d, *J* = 6.8 Hz, 3H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.1 (dd, *J* = 6.7, 3.9 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.0, 158.5 (d, *J* = 253.5 Hz), 136.7 (d, *J* = 6.8 Hz), 134.9, 130.7, 130.7, 130.6, 127.9, 126.9 (d, *J* = 4.9 Hz), 125.0, 124.8 (d, *J* = 2.9 Hz), 124.6, 123.5 (d, *J* = 17.2 Hz), 121.0 (d, *J* = 5.1 Hz), 119.0, 115.8, 114.5, 114.5, 110.3, 109.4 (d, *J* = 21.4 Hz), 106.2, 77.3, 52.8, 51.6, 46.5, 21.2, 20.7, 20.6, 20.5. **HRMS (ESI)** calcd. for $C_{28}H_{28}FN_3O$ [M+H]: 441.2216, found: 441.2217. **HPLC**: Chiralpak IA, hexane/*i*PrOH = 90/10, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 9.02 min, t_R (major) = 10.17 min (enantiomer t_R (minor) = 6.02 min, t_R (major) = 11.59 min).

(aS,S)-2-(8-chloro-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-4-fluoro-N,N-diisopropyl-1-naphthamide (3ci) :


3ci

43.7 mg (Flash column chromatography eluent, PE:EA = 6/1), 92% yield, white solid, 3:1 d.r. 95:5 e.r. (99.5:0.5 e.r.). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 8.1 – 8.1 (m, 1H), 7.9 – 7.8 (m, 1H), 7.6 (q, *J* = 3.3 Hz, 2H), 7.3 (d, *J* = 2.2 Hz, 1H), 7.3 (d, *J* = 2.6 Hz, 1H), 7.1 – 7.1 (m, 1H), 6.9 (dd, *J* = 8.4, 2.2 Hz, 1H), 6.7 (d, *J* = 8.4 Hz, 1H), 6.2 (t, *J* = 3.3 Hz, 1H), 5.8 (s, 1H), 5.8 – 5.7 (m, 1H), 4.4 (s, 1H), 3.5 (dq, *J* = 27.6, 6.7 Hz, 2H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.5 (d, *J* = 6.8 Hz, 3H), 1.0 (d, *J* = 6.6 Hz, 3H), 0.8 (d, *J* = 6.6 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 168.2, 158.4 (d, *J* = 253.2 Hz), 134.1, 133.6, 131.4, (d, *J* = 4.4 Hz), 128.1, 127.9, 127.1, 125.7, 125.3, 124.8, 124.5, 124.0, 123.8, 120.9 (d, *J* = 5.4 Hz), 116.2, 115.0, 114.6, 111.4, 109.4, 107.7, 54.4, 51.6, 46.5, 20.9, 20.6, 20.5, 20.4. **HRMS (ESI)** calcd. for $C_{28}H_{27}ClFN_3O$ [M+H]: 475.1827, found: 475.1829. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 70/30, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 8.04 min, t_R (major) = 8.91 min (enantiomer t_R (major) = 4.46 min).

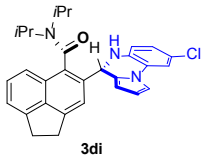
(aS,S)-4-(4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1,2-dihydroacenaphthylene-5-carboxamide (3da) :


3da

43.9 mg (Flash column chromatography eluent, PE:EA = 8/1), 98% yield, white solid, 3:1 d.r., 82:18 e.r. (96:4 e.r.). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.4 (d, *J* = 8.2 Hz, 1H), 7.4 – 7.4 (m, 1H), 7.3 (dd, *J* = 7.9, 1.4 Hz, 1H), 7.2 – 7.2 (m, 2H), 7.0 (s, 1H), 6.8 (td, *J* = 7.6, 1.4 Hz, 1H), 6.7 (td, *J* = 7.7, 1.4 Hz, 1H), 6.6 (dd, *J* = 7.8, 1.4 Hz, 1H), 6.3 (t, *J* = 3.2 Hz, 1H), 5.8 (s, 1H), 5.7 – 5.7 (m, 1H), 4.9 (s, 1H), 3.7 (p, *J* = 6.7 Hz, 1H), 3.5 (p, *J* = 6.8 Hz, 1H), 3.3 – 3.2 (m, 2H), 3.2 – 3.1 (m, 2H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.6 (d, *J* = 6.8 Hz, 3H), 1.0 (dd, *J* = 12.8, 6.7 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.9, 146.7, 146.3, 138.8, 138.1, 135.5, 130.6, 128.8, 128.1,

127.4, 124.9, 124.7, 120.2, 120.1, 119.3, 118.7, 115.8, 114.4, 114.2, 110.2, 106.1, 53.4, 51.6, 46.4, 30.5, 30.4, 30.3, 21.4, 20.9, 20.8, 20.8. **HRMS (ESI)** calcd. for $C_{30}H_{31}N_3O$ [M+H]: 449.2467, found: 449.2469. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 4.72 min, t_R (major) = 9.66 min (enantiomer t_R (major) = 15.37 min, t_R (minor) = 22.94 min).

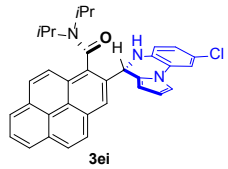
(aS,S)-4-(8-chloro-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1,2-dihydroacenaphthylene-5-carboxamide (3di) :



3di

47.3 mg (Flash column chromatography eluent, PE:EA = 7/1), 98% yield, white solid, 10:1 d.r., 98:2 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.52 – 7.43 (m, 2H), 7.30 (dd, *J* = 14.3, 4.5 Hz, 2H), 7.22 (dd, *J* = 2.9, 1.3 Hz, 1H), 6.98 (s, 1H), 6.82 (dd, *J* = 8.5, 2.2 Hz, 1H), 6.55 (d, *J* = 8.5 Hz, 1H), 6.35 (t, *J* = 3.3 Hz, 1H), 5.81 (s, 2H), 5.06 (s, 1H), 3.81 (dt, *J* = 13.3, 6.6 Hz, 1H), 3.63 (dt, *J* = 13.6, 6.8 Hz, 1H), 3.35 – 3.21 (m, 4H), 1.74 (d, *J* = 6.8 Hz, 3H), 1.64 (d, *J* = 6.8 Hz, 3H), 1.10 (dd, *J* = 13.6, 6.7 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.9, 146.8, 146.4, 138.8, 137.8, 134.0, 130.5, 129.0, 127.9, 127.4, 125.3, 124.6, 123.1, 120.3, 120.0, 119.0, 116.6, 114.7, 114.3, 110.9, 106.5, 53.3, 51.7, 46.4, 30.5, 30.4, 21.4, 20.9, 20.8, 20.8. **HRMS (ESI)** calcd. for $C_{30}H_{30}ClN_3O$ [M+H]: 483.2077, found: 483.2078. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 4.65 min, t_R (major) = 9.67 min.

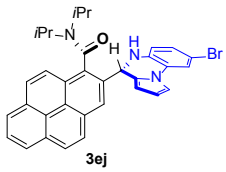
(aS,S)-2-(8-chloro-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropylpyrene-1-carboxamide (3ei) :



3ei

51.2 mg (Flash column chromatography eluent, PE:EA = 7/1), 96% yield, yellow solid, >20:1 d.r., 90:10 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 8.2 – 8.1 (m, 3H), 8.0 (d, *J* = 9.1 Hz, 1H), 8.0 – 7.9 (m, 2H), 7.8 (d, *J* = 9.0 Hz, 1H), 7.8 (s, 1H), 7.4 (d, *J* = 2.2 Hz, 1H), 7.3 (dd, *J* = 3.0, 1.5 Hz, 1H), 6.8 (dd, *J* = 8.4, 2.2 Hz, 1H), 6.6 (d, *J* = 8.5 Hz, 1H), 6.4 (t, *J* = 3.2 Hz, 1H), 6.1 (d, *J* = 1.6 Hz, 1H), 5.9 (dd, *J* = 3.5, 1.4 Hz, 1H), 5.3 (d, *J* = 1.8 Hz, 1H), 3.7 (pd, *J* = 6.6, 1.7 Hz, 2H), 1.9 (d, *J* = 6.8 Hz, 3H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.1 (t, *J* = 6.3 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 170.2, 136.1, 133.7, 131.9, 131.2, 131.1, 130.9, 128.8, 127.9, 127.6, 127.6, 126.8, 126.4, 125.8, 125.6, 125.5, 124.7, 124.4, 124.4, 124.1, 123.8, 123.4, 116.9, 114.7, 114.5, 111.0, 106.5, 77.3, 53.2, 51.8, 46.6, 21.1, 20.7, 20.7, 20.7. **HRMS (ESI)** calcd. for $C_{34}H_{30}ClN_3O$ [M+H]: 531.2077, found: 531.2076. **HPLC**: Chiralpak IA, hexane/*i*PrOH = 80/20, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (major) = 9.71 min, t_R (minor) = 12.61 min.

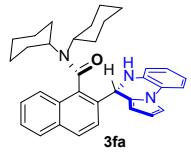
(aS,S)-2-(8-bromo-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropylpyrene-1-carboxamide (3ej) :



3ej

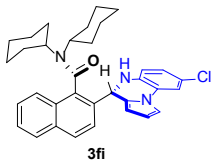
54.3 mg (Flash column chromatography eluent, PE:EA = 7/1), 94% yield, yellow solid, >20:1 d.r., 83:17 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 8.1 – 8.1 (m, 3H), 8.0 (d, *J* = 9.1 Hz, 1H), 8.0 – 7.9 (m, 2H), 7.8 (d, *J* = 9.0 Hz, 1H), 7.8 (s, 1H), 7.5 (d, *J* = 2.1 Hz, 1H), 7.3 (dd, *J* = 3.0, 1.5 Hz, 1H), 6.9 (dd, *J* = 8.5, 2.1 Hz, 1H), 6.5 (d, *J* = 8.4 Hz, 1H), 6.4 (t, *J* = 3.2 Hz, 1H), 6.1 (d, *J* = 1.6 Hz, 1H), 5.9 (dd, *J* = 3.5, 1.3 Hz, 1H), 5.3 (d, *J* = 1.8 Hz, 1H), 3.7 (h, *J* = 6.7 Hz, 2H), 1.9 (d, *J* = 6.8 Hz, 3H), 1.7 (d, *J* = 6.8 Hz, 3H), 1.1 (t, *J* = 6.2 Hz, 6H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 170.3, 136.1, 134.1, 131.8, 131.2, 131.1, 130.9, 128.8, 128.0, 127.6, 127.6, 127.5, 126.8, 126.4, 125.9, 125.8, 125.5, 124.4, 124.4, 124.1, 123.8, 117.4, 117.3, 114.5, 111.0, 110.2, 106.6, 77.3, 53.2, 51.8, 46.6, 21.1, 20.8, 20.7, 20.7. **HRMS (ESI)** calcd. for $C_{34}H_{30}BrN_3O$ [M+H]: 575.1572, found: 575.1573. **HPLC**: Chiralpak IA, hexane/*i*PrOH = 70/30, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (major) = 7.77 min, t_R (minor) = 9.74 min.

(aS,S)-N,N-dicyclohexyl-2-(4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-1-naphthamide (3fa) :


3fa

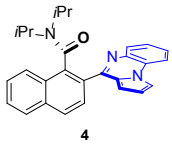
48.3 mg (Flash column chromatography eluent, PE:EA = 7/1), 96% yield, white solid, >20:1 d.r., 88.5:11.5 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 (dt, *J* = 29.5, 7.0 Hz, 3H), 7.6 (d, *J* = 8.6 Hz, 1H), 7.5 – 7.5 (m, 2H), 7.3 (d, *J* = 8.0 Hz, 1H), 7.2 (s, 1H), 7.0 (t, *J* = 7.6 Hz, 1H), 6.8 (t, *J* = 7.7 Hz, 1H), 6.7 (d, *J* = 7.8 Hz, 1H), 6.2 (t, *J* = 3.2 Hz, 1H), 5.8 (s, 1H), 5.7 (d, *J* = 3.4 Hz, 1H), 4.2 (s, 1H), 3.2 (t, *J* = 11.2 Hz, 1H), 3.1 (t, *J* = 10.9 Hz, 1H), 3.0 – 2.9 (m, 1H), 2.7 (q, *J* = 13.0, 12.3 Hz, 1H), 2.0 – 1.7 (m, 4H), 1.7 – 1.1 (m, 10H), 1.0 – 0.7 (m, 3H), 0.6 (q, *J* = 12.8 Hz, 1H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.1, 135.8, 134.7, 133.4, 132.9, 129.8, 129.1, 128.5, 128.1, 126.8, 126.6, 126.4, 125.5, 125.3, 124.7, 119.4, 115.2, 114.8, 114.3, 110.8, 107.0, 60.4, 56.6, 54.6, 31.3, 31.3, 30.0, 29.9, 26.8, 26.7, 25.8, 25.5, 25.4, 25.1. **HRMS (ESI)** calcd. for $C_{34}H_{37}N_3O$ [M+H]: 503.2937, found: 503.2935. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (major) = 10.98 min, t_R (minor) = 13.56 min.

(aS,S)-2-(8-chloro-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-dicyclohexyl-1-naphthamide (3fi) :


3fi

53.2 mg (Flash column chromatography eluent, PE:EA = 7/1), 99% yield, white solid, 10:1 d.r., 83:17 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 (dd, *J* = 6.7, 2.8 Hz, 1H), 7.8 (t, *J* = 9.0 Hz, 2H), 7.6 – 7.5 (m, 3H), 7.3 (d, *J* = 2.3 Hz, 1H), 7.1 – 7.1 (m, 1H), 6.9 (dd, *J* = 8.4, 2.3 Hz, 1H), 6.6 (d, *J* = 8.5 Hz, 1H), 6.2 (t, *J* = 3.2 Hz, 1H), 5.8 (s, 1H), 5.7 (d, *J* = 3.5 Hz, 1H), 4.4 (s, 1H), 3.1 (dddd, *J* = 26.5, 11.9, 7.8, 3.5 Hz, 2H), 2.9 (td, *J* = 12.0, 4.1 Hz, 1H), 2.7 (td, *J* = 12.4, 3.8 Hz, 1H), 1.9 – 1.7 (m, 3H), 1.5 – 1.3 (m, 12H), 0.9 – 0.7 (m, 2H), 0.6 – 0.5 (m, 1H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 169.1, 134.6, 134.4, 133.3, 132.3, 129.9, 128.9, 128.5, 128.1, 126.9, 126.7, 126.3, 125.9, 125.5, 124.3, 123.9, 116.1, 115.0, 114.5, 111.4, 107.4, 60.4, 56.6, 54.7, 31.3, 31.1, 30.0, 29.9, 26.8, 26.6, 25.8, 25.5, 25.4, 25.1. **HRMS (ESI)** calcd. for $C_{34}H_{36}ClN_3O$ [M+H]: 537.2547, found: 537.2545. **HPLC**: Chiralpak IC, hexane/*i*PrOH = 60/40, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (major) = 11.50 min, t_R (minor) = 14.12 min.

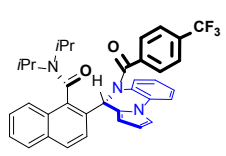
(aS)-N,N-diisopropyl-2-(pyrrolo[1,2-a]quinoxalin-4-yl)-1-naphthamide (4) :


4

The compound is prepared as reported in literature.[2] The reaction mixture of **3aa** (0.1 mmol) and $KMnO_4$ (2.0 equiv.) in acetone (1.0 mL) solvent was stirred at 0 °C until the completely substrates consumption. The reaction mixture was suspended in water and then extracted with ethyl acetate. The collected organic phases were dried and concentrated under vacuum to obtain a solid residue that was purified by silica gel column chromatography (PE/EA = 5:1) to provide the corresponding products **4** as white solid. 38.8 mg, yield 92%, 91.5:8.5 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 8.0 – 8.0 (m, 2H), 8.0 – 7.9 (m, 4H), 7.8 (d, *J* = 8.4 Hz, 1H), 7.5 (ddd, *J* = 22.2, 7.3, 2.4 Hz, 3H), 7.5 – 7.4 (m, 1H), 6.8 – 6.8 (m, 2H), 3.8 (p, *J* = 6.6 Hz, 1H), 3.3 (p, *J* = 6.8 Hz, 1H), 1.6 (d, *J* = 6.8 Hz, 3H), 1.0 (d, *J* = 6.8 Hz, 3H), 0.9 (d, *J* = 6.6 Hz, 3H), 0.8 (d, *J* = 6.6 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 168.0, 154.1, 136.0, 135.7, 133.8, 131.8, 130.4, 130.1, 128.1, 128.0, 127.6, 127.3, 126.9, 126.4, 126.2, 125.9, 125.1, 114.4, 114.0, 113.7, 109.8, 51.2, 45.9, 21.4, 20.7, 20.2, 20.0. **HRMS (ESI)** calcd. for $C_{28}H_{28}N_3O$ [M+H]: 422.2232,

found: 422.2235. **HPLC**: Chiralpak IA, hexane/*i*PrOH = 80/20, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (minor) = 11.88 min, t_R (major) = 26.37 min.

(aS,S)-N,N-diisopropyl-2-(5-(4-(trifluoromethyl)benzoyl)-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-1-naphthamide (5) :



5

The compound is prepared as reported in literature.[3] To a solution of **3aa** (0.1 mmol) in dry DCM (1 mL), in the presence of DIPEA (0.5 mmol), was added dropwise at 0 °C benzoylchloride (0.2 mmol), and the resulting mixture was stirred at room temperature for 3h. At the end of the reaction, the solvent was removed under vacuum and the residue was suspended in water and then extracted with ethyl acetate. The collected organic concentrated under reduced pressure to provide a crude residue that was purified by a silica gel flash chromatography (PE/EA = 10:1) to afford the pure compound **5** as a white solid**.** 56.6 mg, yield 95%, >20:1 d.r., >99.5:0.5 e.r. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ 7.9 (d, *J* = 8.5 Hz, 1H), 7.6 (d, *J* = 8.1 Hz, 1H), 7.5 – 7.4 (m, 9H), 7.2 – 7.2 (m, 2H), 6.9 (d, *J* = 8.8 Hz, 1H), 6.8 – 6.8 (m, 1H), 6.7 (d, *J* = 3.5 Hz, 1H), 6.6 (d, *J* = 8.0 Hz, 1H), 6.3 (t, *J* = 3.3 Hz, 1H), 3.8 (dq, *J* = 12.4, 6.5 Hz, 2H), 1.9 – 1.8 (m, 6H), 1.4 (d, *J* = 6.5 Hz, 3H), 1.0 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (100 MHz, Chloroform-*d*) δ 168.4, 168.1, 138.9, 134.3, 133.4, 132.5, 132.2, 131.9, 130.5, 129.9, 129.5, 129.2, 129.1, 128.8, 127.8, 127.3, 126.9, 126.5, 126.4, 126.2, 125.2 (dd, *J* = 3.8 Hz), 123.6 (q, *J* = 273.7 Hz), 123.7, 116.0, 114.1, 111.8, 109.3, 52.6, 51.6, 46.7, 21.2, 21.1, 21.0, 20.5. **HRMS (ESI)** calcd. for $C_{36}H_{33}F_3N_3O_2$ [M+H]: 596.2524, found: 596.2527. **HPLC**: Chiralpak IA, hexane/*i*PrOH = 80/20, Flow rate = 1.0 mL/min, UV = 254 nm, t_R (major) = 5.47 min.

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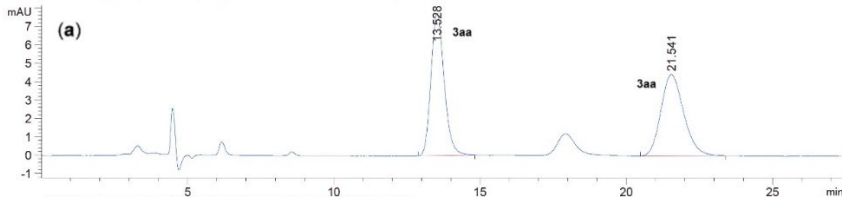
[1] G. Wang, M. A. Guino-o, D. S. Glueck, J. A. Golen, C. J. A. Daley, A. L. Rheingold. *Dalton Trans.*, **2015**, *44*, 9943.

[2] L. Tradtrantip, N. D. Sonawane, W. Namkung, A. S. Verkman. *J. Med. Chem.* **2009**, *52*, 6447.

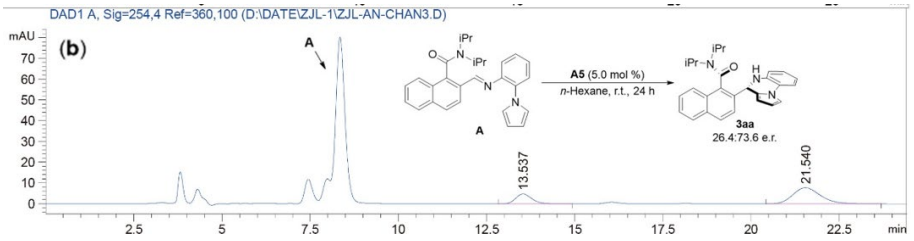
[3] W. You, D. Rotili, T. Li, C. Kambach, M. Meleshin, M. Schutkowski, K. F. Chua, A. Mai, C. Steegborn. *Angew. Chem. Int. Ed.* **2017**, *56*, 1007.

5. Mechanistic study



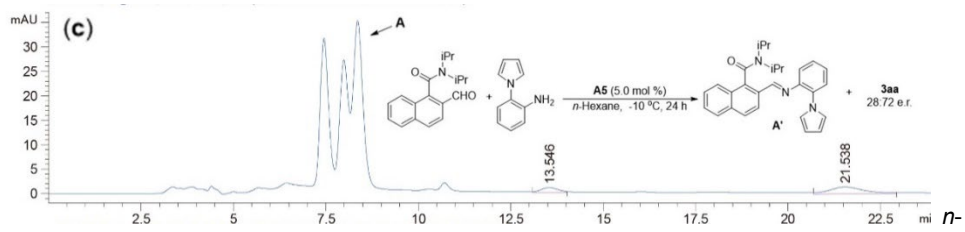
n-hexane/isopropanol 70:30, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.528	0.4870	244.1	7.7	50.368
2	21.541	0.7867	240.5	4.4	49.632



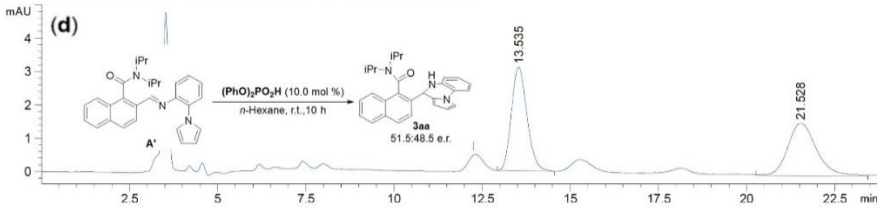
n-hexane/isopropanol 70:30, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.537	0.4801	151.1	4.7	26.384
2	21.540	0.8202	421.6	7.7	73.616



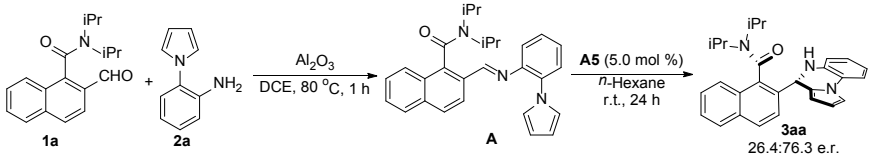
n-hexane/isopropanol 70:30, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.546	0.5554	34.9	1.1	27.959
2	21.538	1.0727	89.9	1.4	72.041



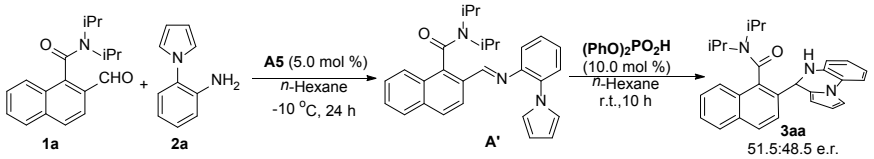
n-hexane/isopropanol 70:30, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.535	0.4675	95.9	3.1	51.504
2	21.528	0.9500	90.4	1.6	48.496



The solution of 1a (0.5 mmol) and 2a (0.5 mmol) in DCE (1 mL) was added Al_2O_3 (1.0 g) and then stirred at 80 °C for 1 h. After filtrating off Al_2O_3 the organic solvent was evaporated and the crude mixture purified by flash chromatography by flash chromatography (silica gel, eluent: petroleum ether / ethyl acetate= 7:1) to afford the reaction intermediate **A** (40% yield).

(b) Intermediate **A** was subjected into the standard reaction conditions and the reaction proceeded successfully to deliver the desired ring-closing axially chiral product **3aa** with 76.3:26.4 e.r. and >25:1 d.r. value, although a mixture of **1a**, **2a, A**, and **3aa** was finally detected.



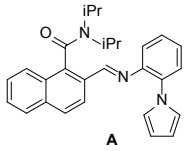
(c) The reaction of **1a** (0.2 mmol), **2a** (0.3 mmol, 1.5 equiv.) and chiral acid catalyst **A5** (5.0 mol %) were stirred in *n*-hexane (2.0 mL, 0.1 M) at -10 °C under N_2 for 24 h. The start materials of 1a and 2a of less than 50% was reacted to synthesize the intermediate A' and trace amount of **3aa** with 72:28 e.r. value.

(d) Then the intermediate **A'** (0.025 mmol) was catalyzed by racemic phosphoric acid (10.0 mol%) in *n*-hexane at r.t. under N_2 for 10 h. The desired product **3aa** was finally separated as a racemic mixture with only 51.5:48.5 e.r. value.

Racemic mixture of **3aa** was obtained from intermediate A', which generated from substrates **1a** and **2a** by chiral phosphoric acid (PA) **A5** under the optimized reaction conditions. This phenomenon indicated that the intermediate **A'**, similar as substrate **1a**, might undergo fast racemization due to lower rotational barrier or only a racemic intermediate obtained. So, the second reaction step was of importance to the chirality control of this transformation. Undoubtedly, optically active compound **3aa** with 26.4:73.6 e.r. was obtained from racemic intermediate **A** implied again that the imine could be chirally recognized by chiral catalyst and the second step was very indispensable for the chiral recognition. However, the e.r. value from **A** by chiral **A5** was lower than that from start material **1a** and **2a** directly under the standard reaction conditions (26.4:73.6 vs 90:10), probably resulted from the fact that the compound **1a** could be recognized by chiral catalyst to generate axially chiral intermediate **A'** followed immediately by ring-closing reaction to deliver the final product **3aa**. This possible of the interaction between aldehyde **1a** and phosphoric acid **A5** was partly demonstrated by similar recognition of imine **A'** by chiral catalyst, which was benefit for total chiral control by two steps to compose the chiral product **3aa** with high enantioselectivity. In conclusion, the mixed structure of imine and chiral PA via H-bond formed from aldehyde **1a** by asymmetric catalysis using chiral PA might be more efficient than racemic imine for the chiral control of the final product **3aa**, probably due to the chiral imine was initially formed from the first step. But the chiral imine was not stable enough to synthesize the final chiral product **3aa** in absence of chiral catalyst. The preliminary results imply that CPA catalyst might have chiral recognition for each step in the cascade reaction and the synergistic effect would benefit the final enantioselectivity. **Further investigation failed by**

virtue of the challenging: (1) the imine and final product could not be separated by silica gel; (2) the imine was not stable enough to be separated cleanly; (3) the intermediate imine could not be separated by HPLC, same as the start aldehyde **1a**.

2-(((2-(1H-pyrrol-1-yl)phenyl)imino)methyl)-N,N-diisopropyl-1-naphthamide (**A**):



A

^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.78 (s, 1H), 8.28 – 8.17 (m, 1H), 7.90 – 7.81 (m, 3H), 7.55 (d, *J* = 3.7 Hz, 2H), 7.41 (d, *J* = 4.5 Hz, 1H), 7.31 (s, 2H), 7.13 (s, 1H), 7.03 (d, *J* = 1.8 Hz, 2H), 6.30 (d, *J* = 1.8 Hz, 2H), 3.58 (ddd, *J* = 15.1, 10.4, 4.3 Hz, 2H), 1.75 (dd, *J* = 31.1, 2.4 Hz, 6H), 1.06 – 0.98 (m, 6H). **^{13}C NMR** (101 MHz, Chloroform-*d*) δ 168.2, 157.9, 145.0, 139.5, 135.3, 135.0, 129.4, 129.2, 128.7, 128.5, 128.2, 127.3, 127.3, 127.0, 125.6, 125.2, 123.5, 122.8, 119.1, 109.1, 51.5, 46.7, 20.9, 20.8, 20.7. **HRMS (ESI)** calcd. for $C_{28}H_{30}N_3O$ [M+H]: 424.2389, found: 424.2388.

6. Stability examination[1]

Approximately 1 mg of an enantioenriched sample was dissolved in the toluene solvent and heated at the specified temperature. The change in enantiomeric excess over time was monitored via chiral HPLC.

This data was plotted as (ln[ee_0/ee]) versus time (seconds), where: ee_0= enantiomeric excess at time = 0. The gradient of this graph corresponds to the racemization constant, $K_{racemization}$, at the specified temperature. The rate constant for enantiomerization, $K_{enantiomerization}$, is related to the racemization rate constant according to the following equation:

$$k_{enantiomerization} = \frac{k_{racemization}}{2}$$

The barrier to rotation, $\Delta G^{\ddagger}_{enantiomerization}$, was subsequently calculated using the following form of the Eyring equation:

$$\Delta G^{\ddagger}_{enantiomerization} = RT_1 \ln \frac{K_B T_1}{h k_{enantiomerization}}$$

Where: R = Gas constant = 8.31454 $J{\cdot}K^{-1}{\cdot}mol^{-1}$, h = Planck constant = 6.62608×10^{-34} J·s, k_B = Boltzmann constant = 1.38066×10^{-23} $J{\cdot}K^{-1}$, and T_1 = temperature racemization studies were conducted at, in Kelvin.

Employing the hypothesis that $\Delta G^{\ddagger}_{enantiomerization}$ is independent of temperature, it is possible to extrapolate the racemization constant to other temperatures, in this case 25 °C, according to the following relationship:

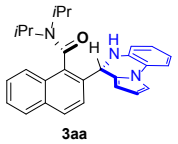
$$k_{racemization\ at\ 25℃} = 2 \cdot k_{enantiomerization\ at\ 25℃} = 2 \cdot \frac{k_B T_2}{h} \cdot e\left(\frac{-\Delta G^{\ddagger}_{enantiomerization}}{RT_2}\right)$$

Where T_2 = 298.15 K (25 °C)

The half-life at 25 °C is calculated as follows:

$$t_{1/2\ at\ 25\,℃} = \frac{\ln 2}{k_{racemization}}$$

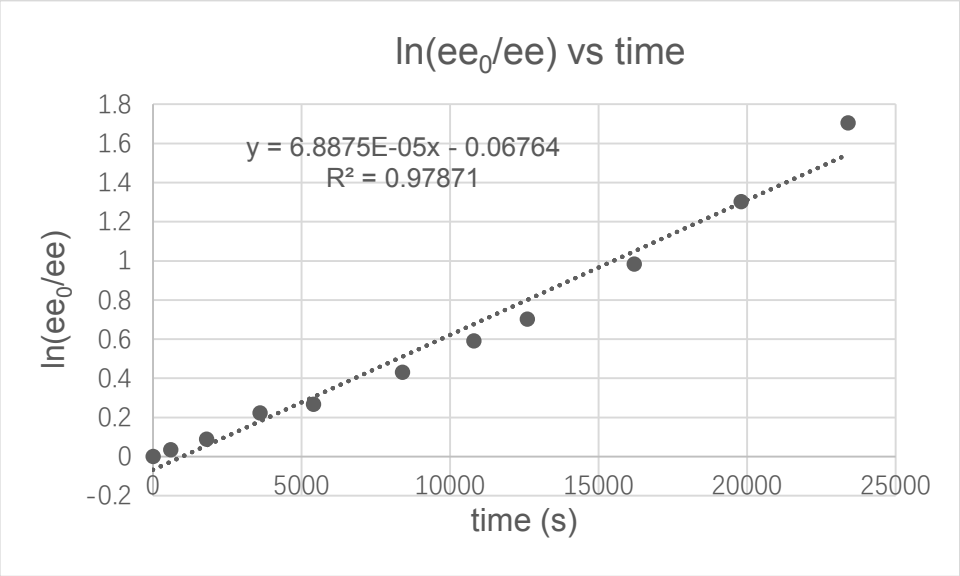
(aS,S)-2-(4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-N,N-diisopropyl-1-naphthamide (**3aa**) :



3aa

Solvent: toluene, Temperature: 50 °C

Time (seconds)	Enantiomeric Excess (ee)	First Order Racemization ($ln[ee_0/ee]$)
0	100	0
600	96.6	0.03459
1800	91.6	0.08774
3600	80.1	0.22189
5400	76.6	0.26657
8400	65	0.43078
10800	55.4	0.59059
12600	49.6	0.70118
16200	37.4	0.98349
19800	27.2	1.30195
23400	18.2	1.70375



$K_{racemization}$ (50 °C) = 6.8875×10^{-5} s^{-1}

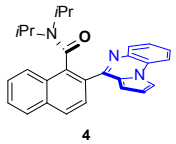
$K_{enantiomerization}$ (50 °C) = 3.4438×10^{-5} s^{-1}

$\Delta G_{enaniomerization}$ = 106.98 KJ•mol^{-1}

Kracemization (25 °C) =2.2556×10^{-6} s^{-1}

$t_{1/2}$ (25 °C) =3.57 days

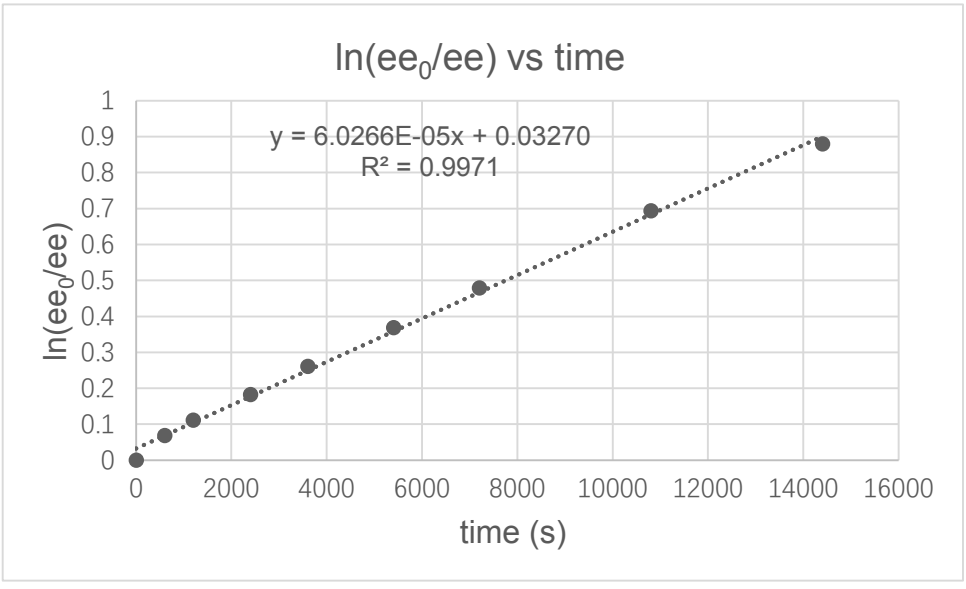
(aS)-N,N-diisopropyl-2-(pyrrolo[1,2-a]quinoxalin-4-yl)-1-naphthamide (**4**) :



4

Solvent: toluene, Temperature: 30 °C

Time (seconds)	Enantiomeric Excess (ee)	First Order Racemization ($\ln[ee_0/ee]$)
0	63.6	0
600	59.4	0.06832
1200	56.9	0.11132
2400	53	0.18232
3600	49	0.26079
5400	44	0.36842
7200	39.4	0.47885
10800	31.8	0.69315
14400	26.4	0.87925



$K_{racemization}$ (30 °C) = 6.0266×10^{-5} s^{-1}

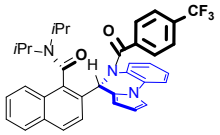
$K_{enantiomerization}$ (30 °C) = 3.0133×10^{-5} s^{-1}

$\Delta G_{enaniomerization}$ = 100.53 KJ•mol^{-1}

Kracemization (25 °C) = 3.0364×10^{-5} s^{-1}

$t_{1/2}$ (25 °C) = 6.34 h

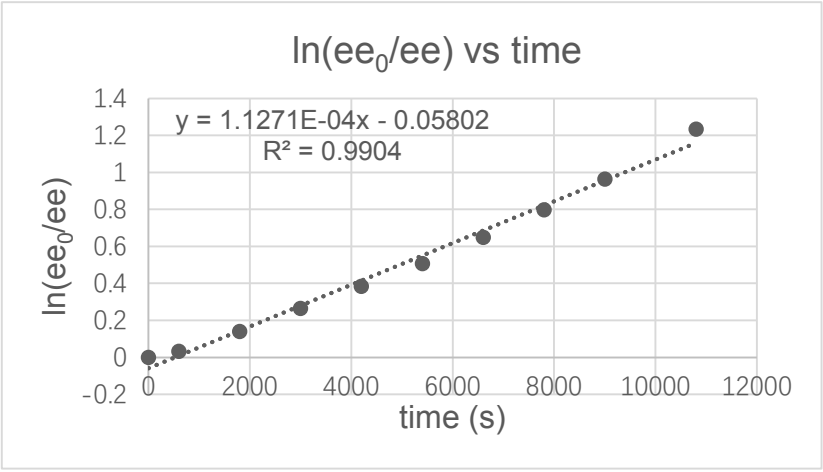
(aS,S)-N,N-diisopropyl-2-(5-(4-(trifluoromethyl)benzoyl)-4,5-dihydropyrrolo[1,2-a]quinoxalin-4-yl)-1-naphthamide (**5**) :



5

Solvent: toluene, Temperature: 60 °C

Time (seconds)	Enantiomeric Excess (ee)	First Order Racemization ($\ln[ee_0/ee]$)
0	90.6	0
600	87.8	0.03139
1800	78.8	0.13954
3000	69.6	0.26369
4200	61.8	0.38255
5400	54.6	0.50642
6600	47.4	0.64783
7800	40.8	0.79777
9000	34.6	0.9626
10800	26.4	1.23309



$K_{racemization}$ (60 °C) = 1.1271×10^{-4} s^{-1}

$K_{enantiomerization}$ (60 °C) = 5.6355×10^{-5} s^{-1}

$\Delta G_{enaniomerization}$ = 109.01 KJ•mol^{-1}

Kracemization (25 °C) = 9.9423×10^{-7} s^{-1}

$t_{1/2}$ (25 °C) = 8.07 days

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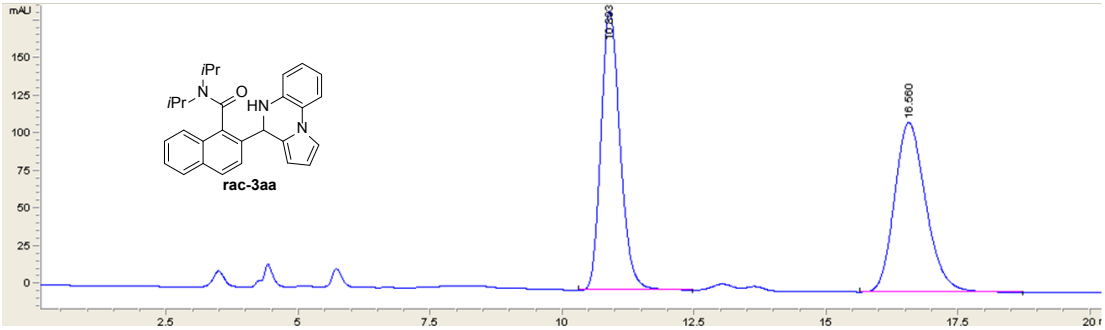
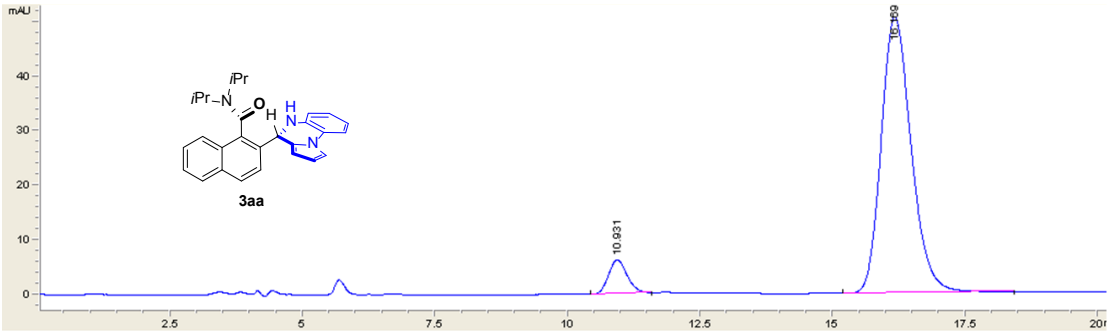
[1] J. McCormick, S. Mamone, Y. N. Ertas, Z. Liu, L. Verlinsky, S. Korchak, L.-S. Bouchard. *Angew. Chem. Int. Ed*. **2018**, 57, 10692–10696.

7. HPLC



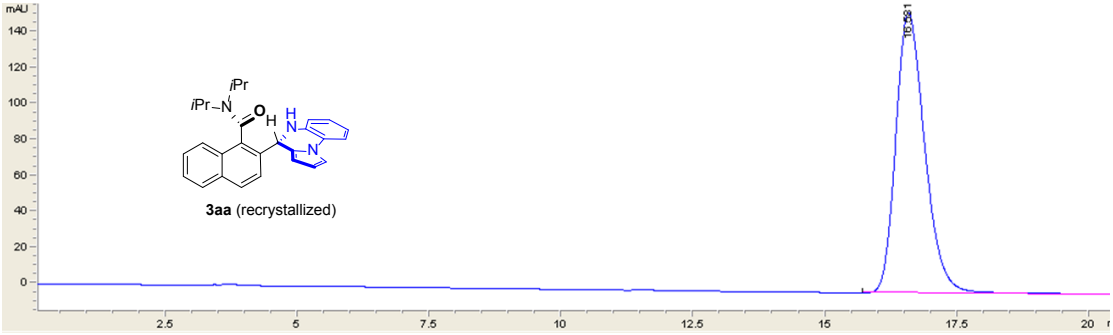
n-hexane/isopropanol 64:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.893	0.3915	4695.2	185.4	50.138
2	16.560	0.6419	4669.3	112.6	49.862



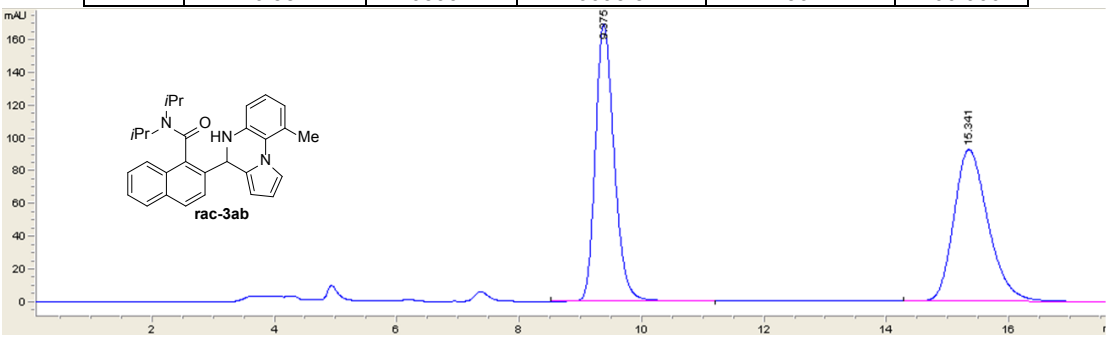
n-hexane/isopropanol 64:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.931	0.3757	150.7	150.7	7.040
2	16.169	0.6064	1989.4	1989.4	92.960



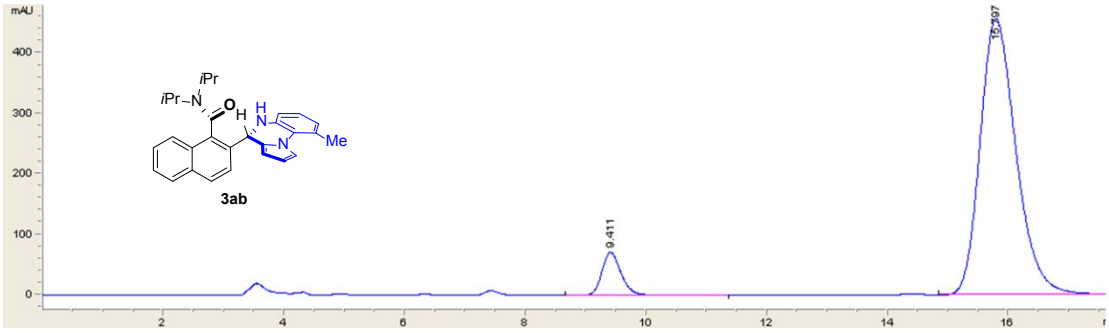
n-hexane/isopropanol 64:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.581	05994	6093.8	156.1	100.000



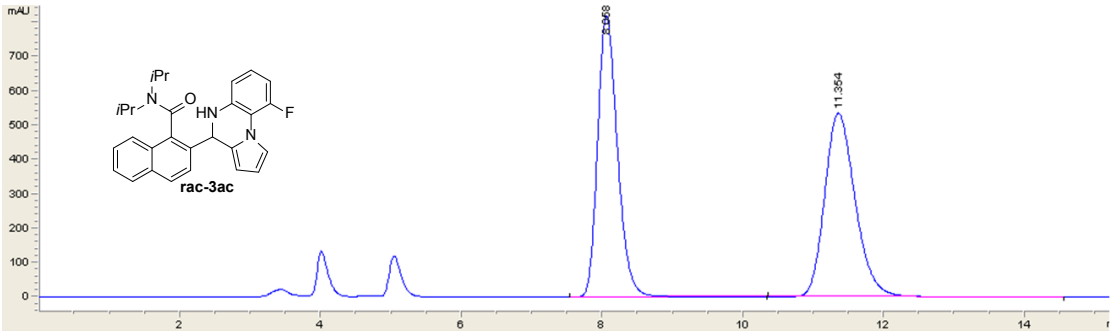
n-hexane/isopropanol 64:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.375	0.3289	3617.3	169.6	50.037
2	15.341	0.6010	3612.0	92.6	49.963



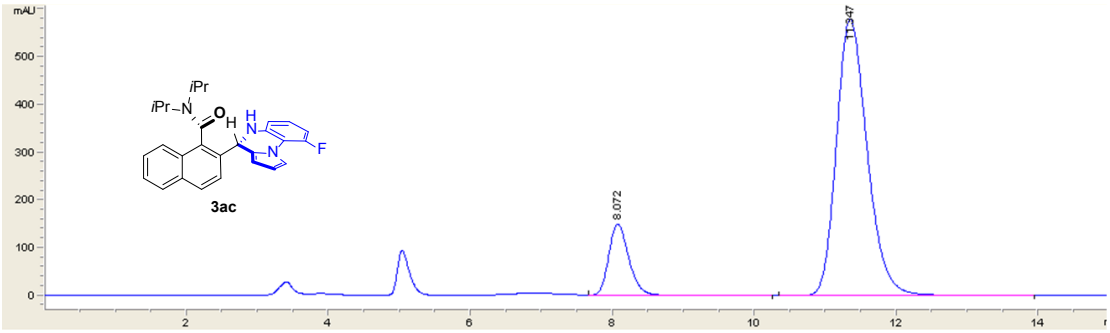
n-hexane/isopropanol 64:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.411	0.3412	1582.7	71.2	7.755
2	15.797	0.6325	18825.5	457.1	92.245



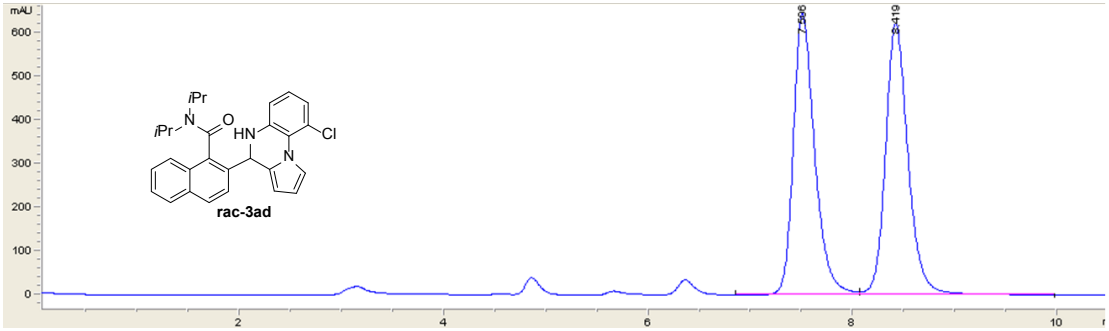
n-hexane/isopropanol 50:50, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.058	0.3023	16008.0	818.0	49.764
2	11.354	0.4646	16160.0	534.8	50.236



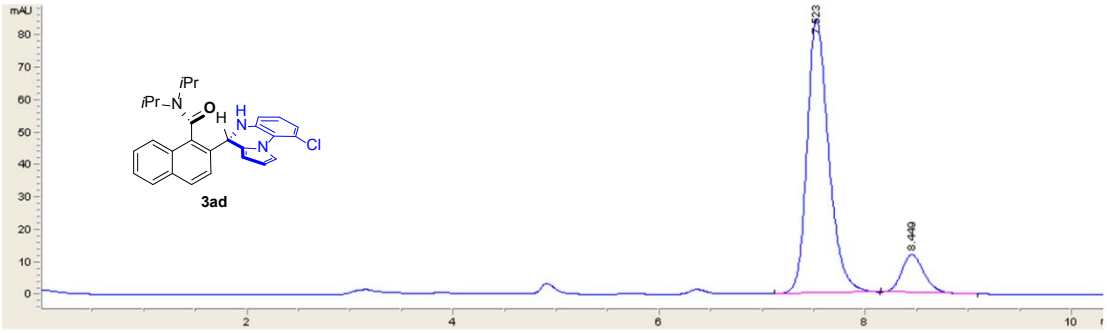
n-hexane/isopropanol 50:50, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.072	0.3038	2953.1	149.9	14.484
2	11.347	0.4627	17436.2	580.1	85.516



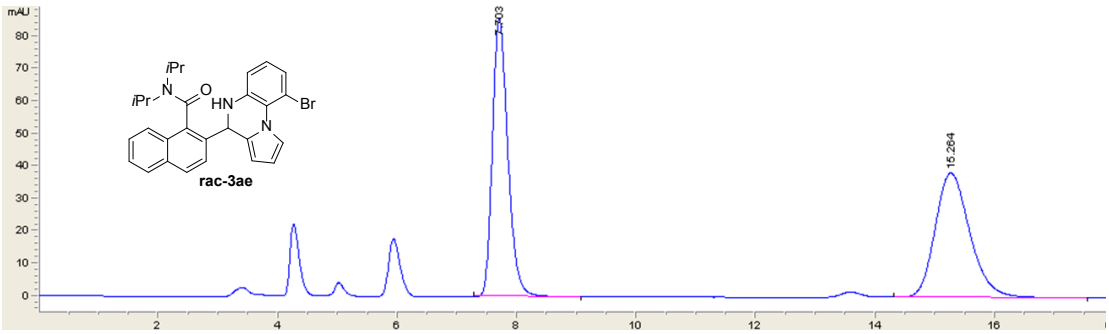
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.506	0.2197	9375.4	644.6	49.579
2	8.419	0.2330	9534.7	621.4	50.421



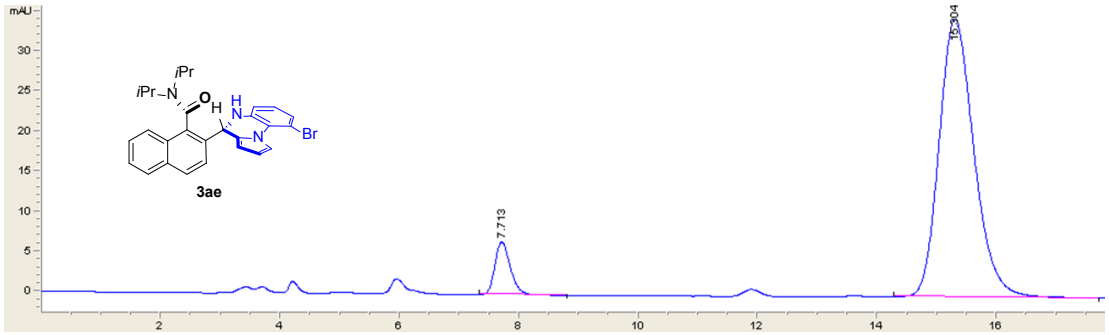
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.523	0.2200	1232.9	84.6	87.502
2	8.449	0.2314	176.1	11.7	12.498



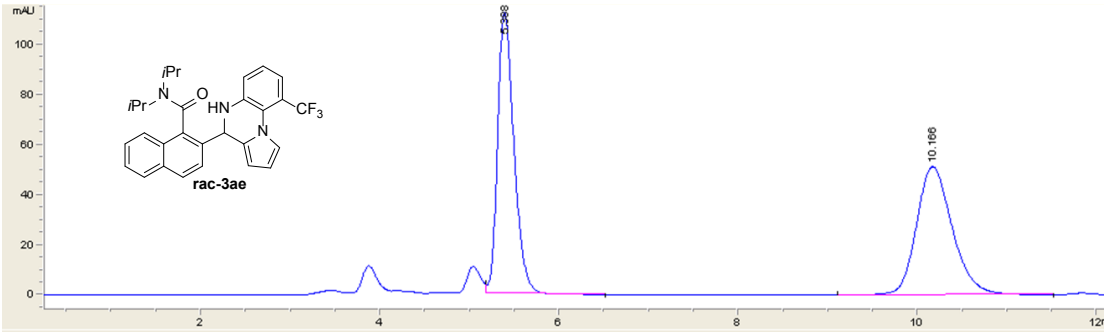
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.703	0.2780	1540.8	85.6	50.041
2	15.264	0.6204	1538.3	38.3	49.959



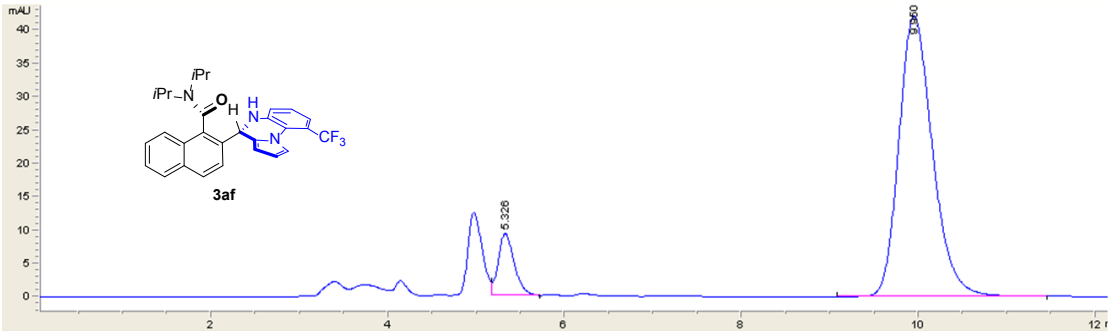
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.713	0.2792	118.7	6.6	7.772
2	15.304	0.6239	1409.2	34.7	92.228



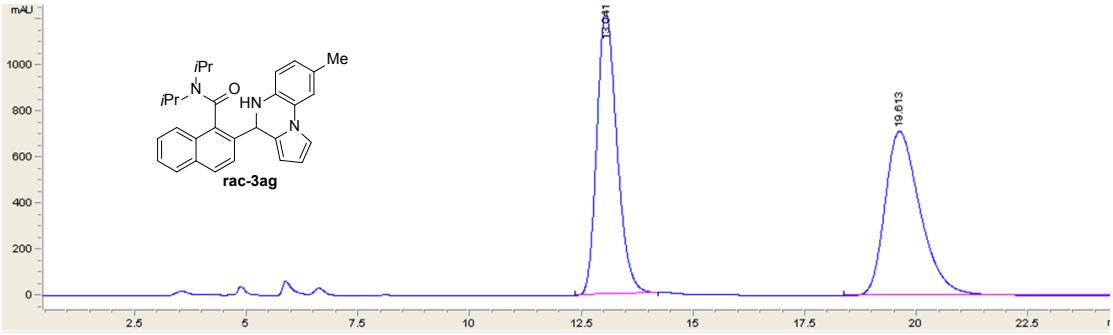
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.388	0.1938	1422.1	112.2	49.904
2	10.166	0.4296	1427.6	51.2	50.096



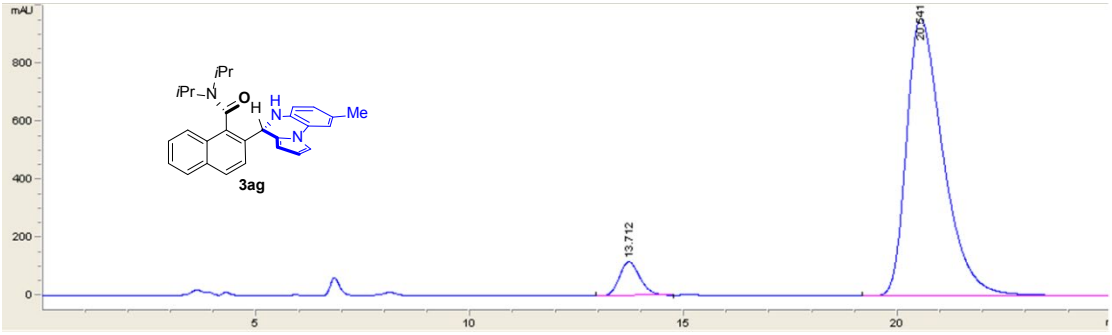
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.326	0.1924	116.6	9.3	9.473
2	9.950	0.4068	1114.4	42.1	90.527



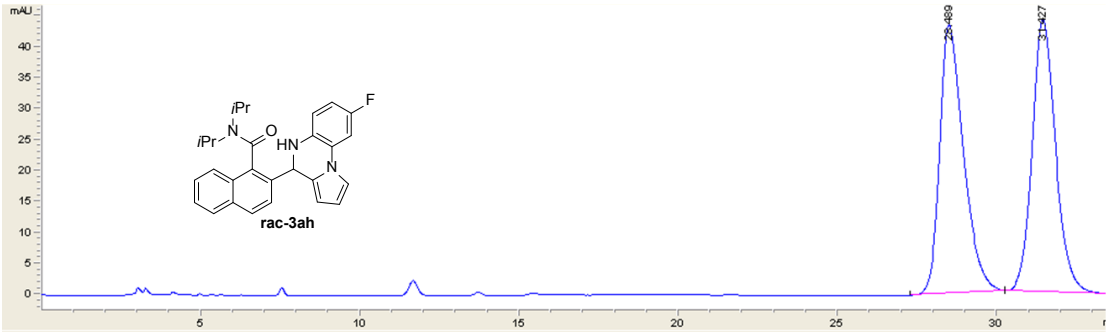
n-hexane/isopropanol 64:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.041	0.4824	38397.8	1229.5	49.441
2	19.613	0.8416	39265.4	714.0	50.559



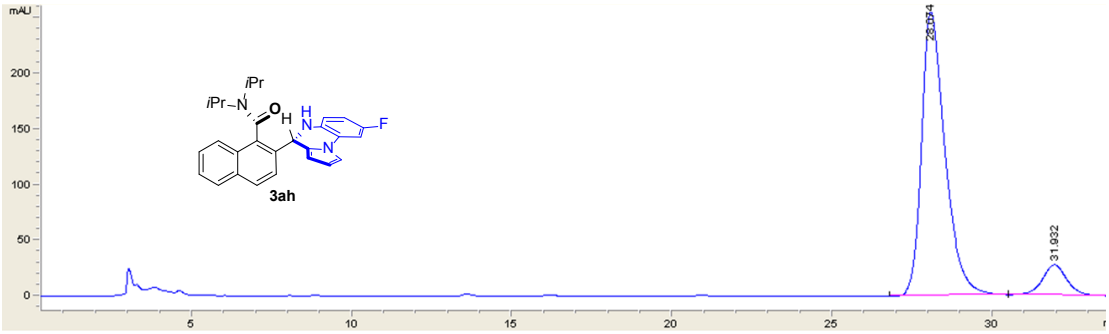
n-hexane/isopropanol 64:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.712	0.5193	3900.7	116.3	6.387
2	20.541	0.9067	57170.1	957.4	93.613



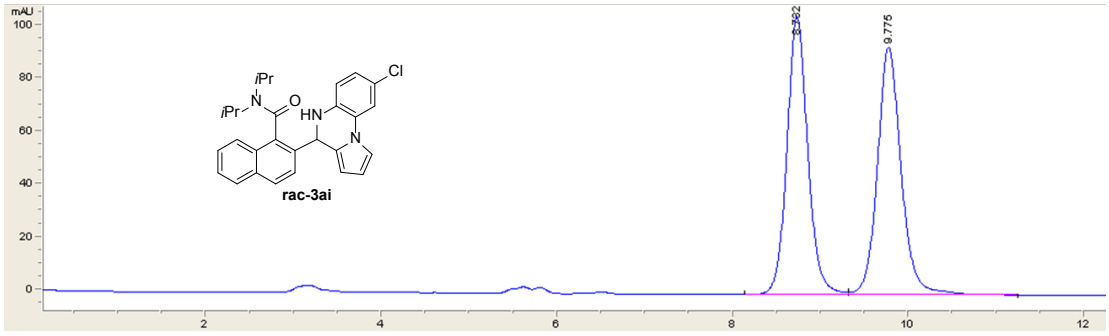
n-hexane/isopropanol 95:5, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	28.489	0.7705	2224.1	43.4	49.880
2	31.427	0.7672	2234.8	44.1	50.120



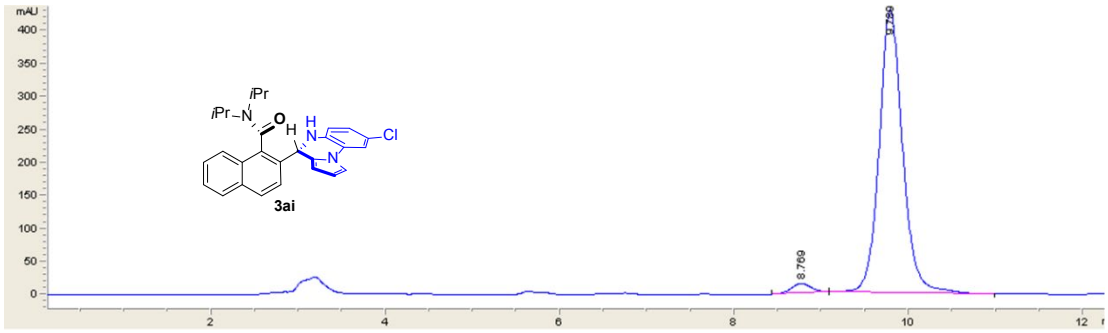
n-hexane/isopropanol 95:5, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	28.074	0.7551	12814.1	254.6	89.672
2	31.932	0.8110	1475.9	27.5	10.328



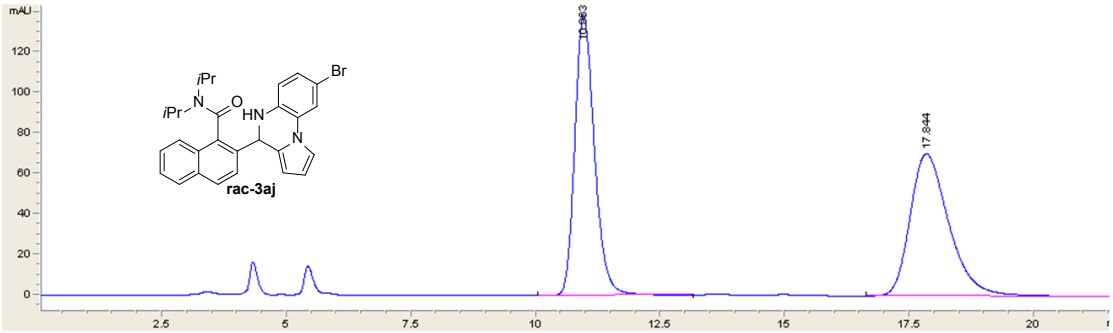
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.732	0.2501	1729.2	105.0	49.646
2	9.775	0.2832	1752.8	93.3	50.354



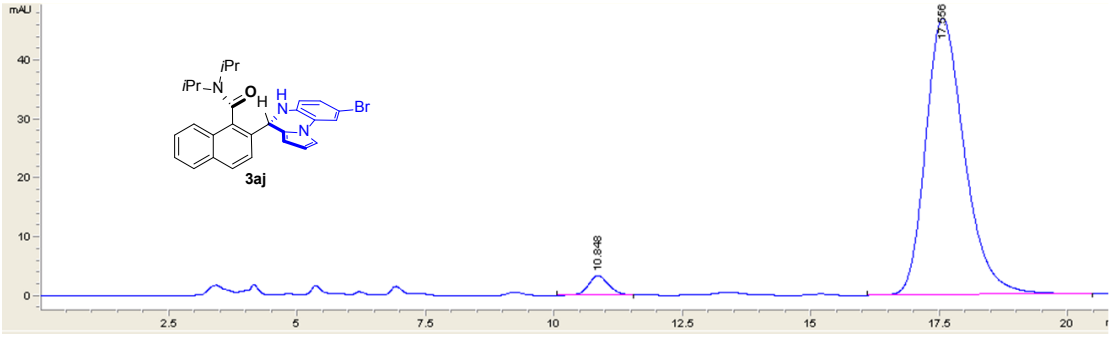
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.769	0.2370	216.0	14.1	2.629
2	9.789	0.2840	7999.6	428.2	97.371



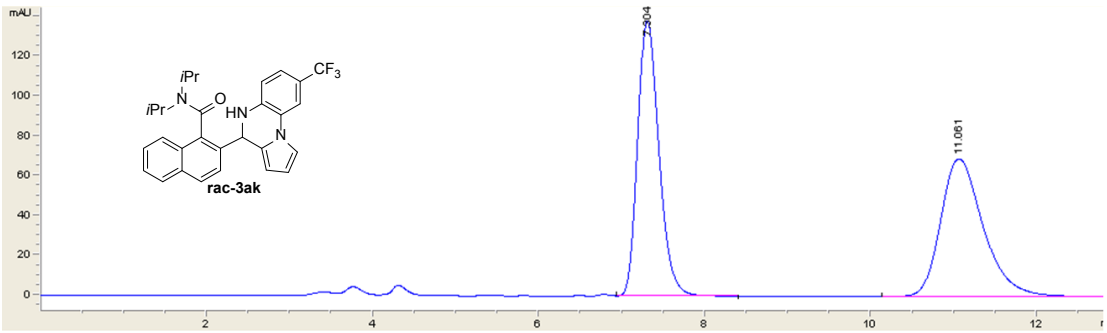
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.963	0.4213	3802.2	138.9	49.967
2	17.844	0.8281	3807.2	70.3	50.033



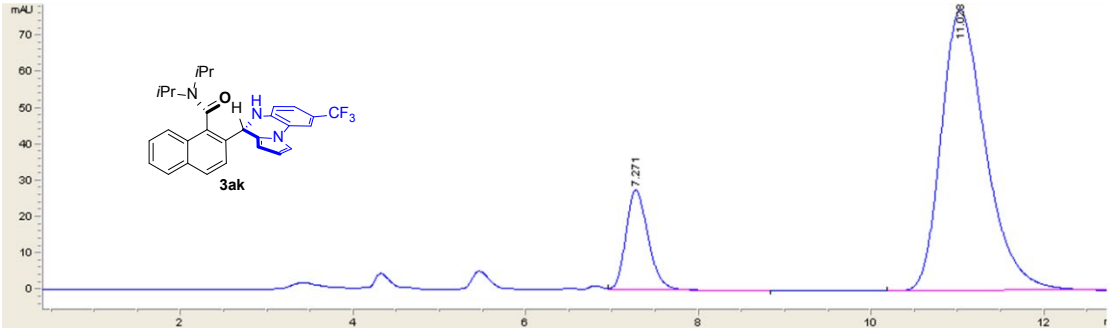
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.848	0.4180	88.8	3.3	3.471
2	17.556	0.8023	2467.9	47.0	96.529



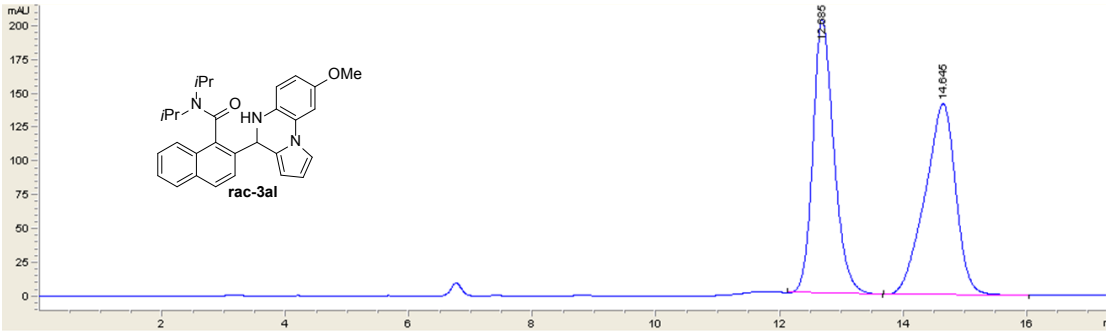
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.304	0.2761	159.4	13.5	2.033
2	11.061	0.5473	7681.3	307.9	97.967



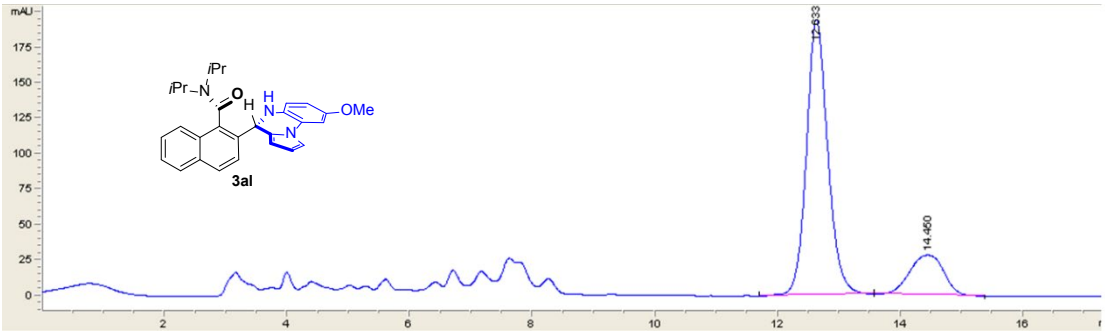
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.271	0.2774	493.0	27.5	15.093
2	11.028	0.5506	2773.3	77.3	84.907



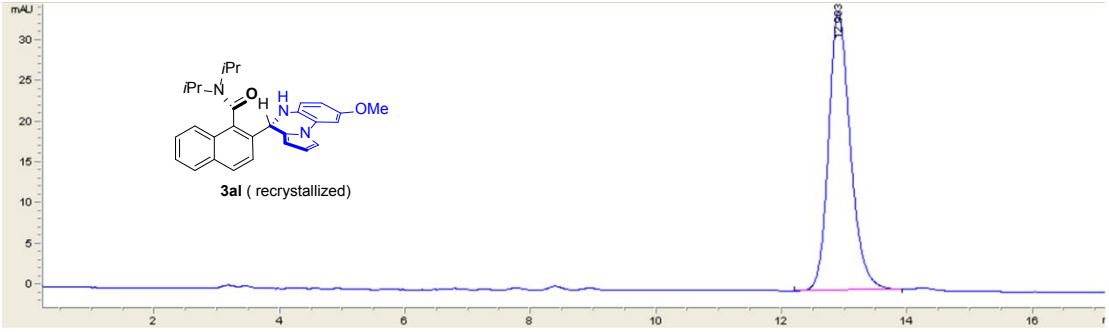
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.685	0.3574	4795.1	203.1	49.484
2	14.645	0.5077	4895.1	141.5	50.516



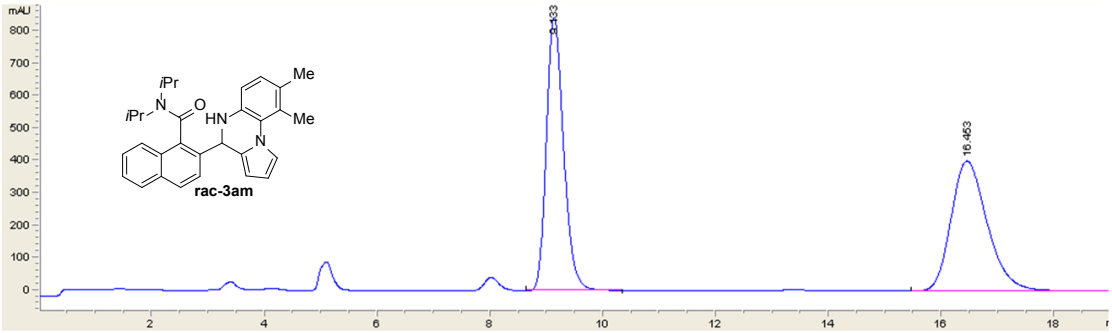
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.633	0.3686	4705.4	194.3	81.190
2	14.450	0.6213	1090.2	28.1	18.810



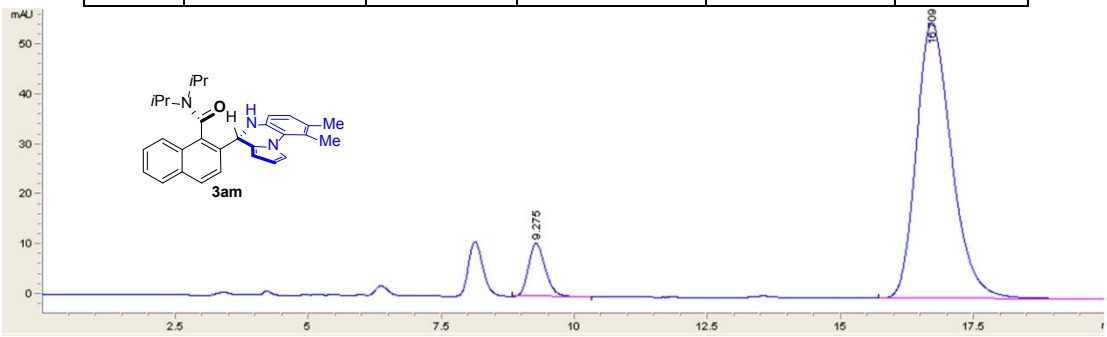
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.903	0.3677	827.1	34.3	100.000



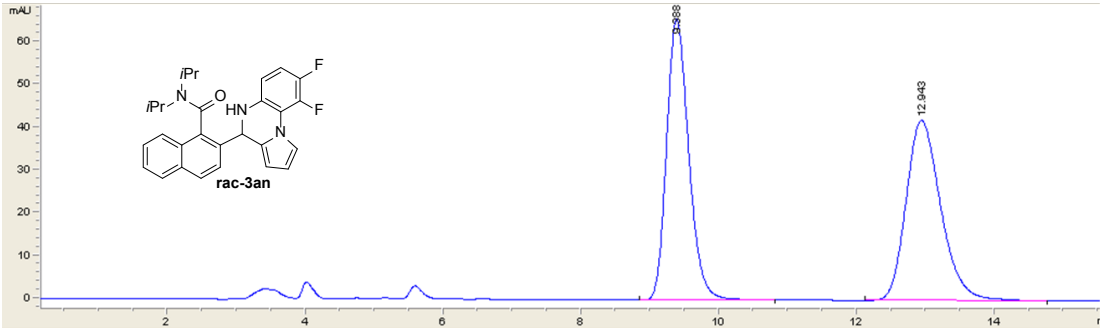
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.133	0.3277	17908.2	843.3	49.832
2	16.453	0.6887	18028.6	402.4	50.168



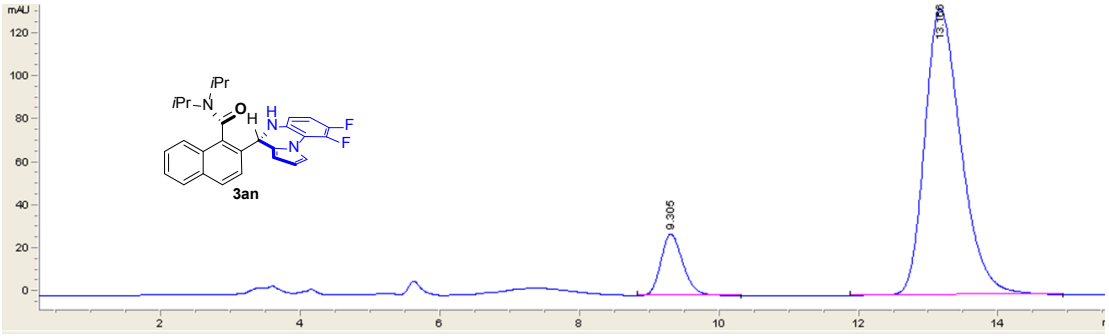
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.275	0.3376	233.5	10.7	8.413
2	16.709	0.7081	2541.8	55.3	91.587



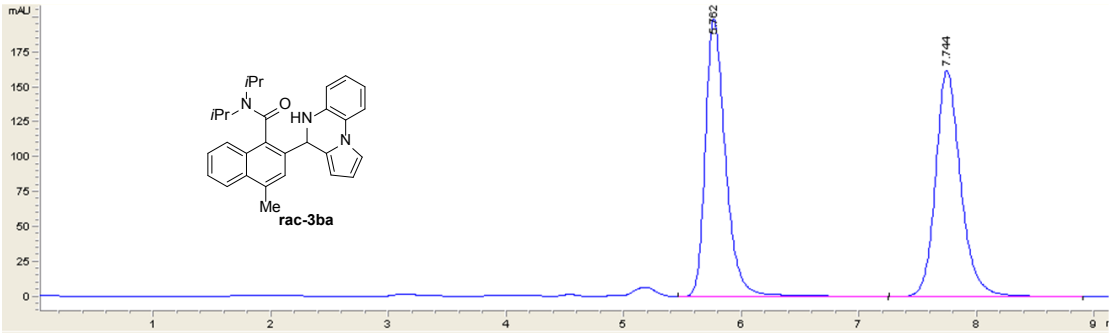
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.388	0.3418	1464.2	65.7	49.784
2	12.943	0.5409	1476.9	42.1	50.216



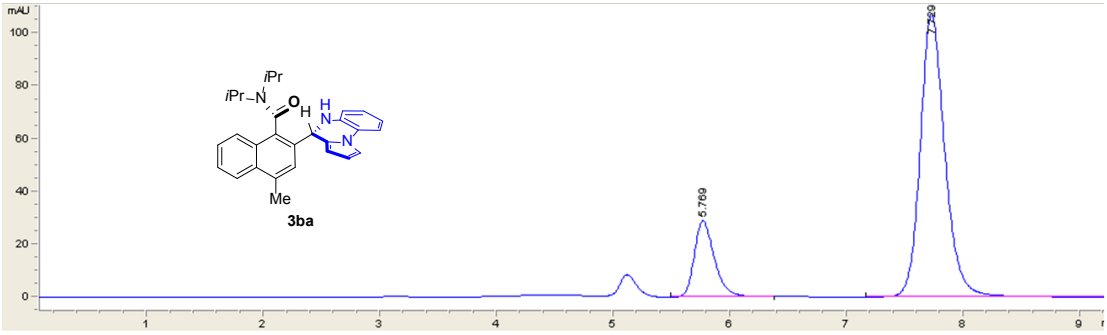
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.305	0.3376	624.7	28.5	11.499
2	13.166	0.5527	4808.0	133.3	88.501



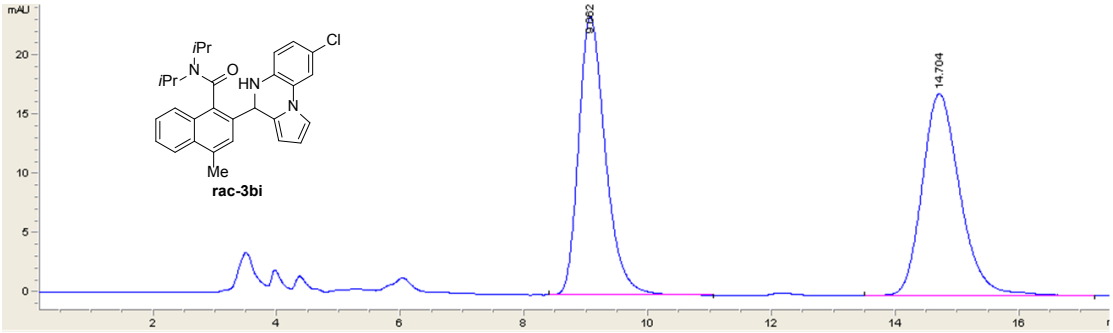
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.762	0.1821	2390.7	199.1	49.903
2	7.744	0.2248	2399.9	162.1	50.097



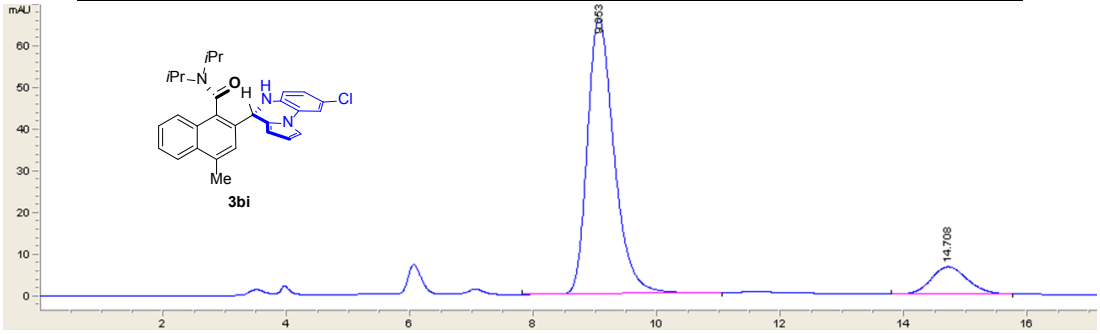
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.769	0.1819	345.7	28.8	18.020
2	7.729	0.2229	1572.6	107.3	81.980



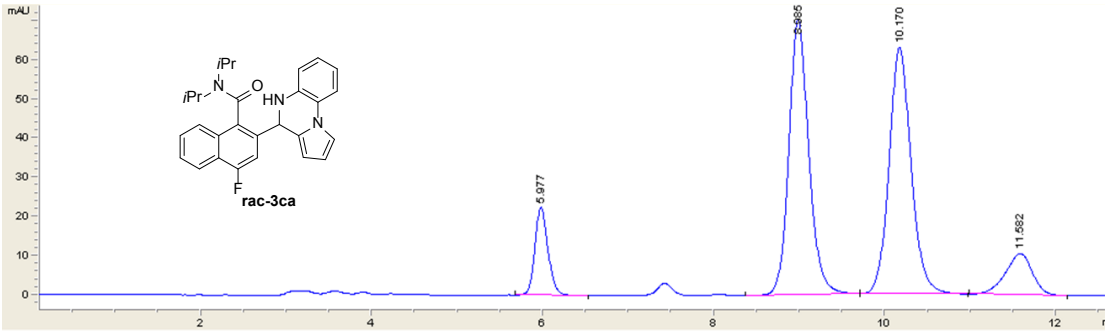
n-hexane/isopropanol 50:50, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.062	0.4637	707.6	23.5	49.396
2	14.704	0.6517	724.9	17.1	50.604



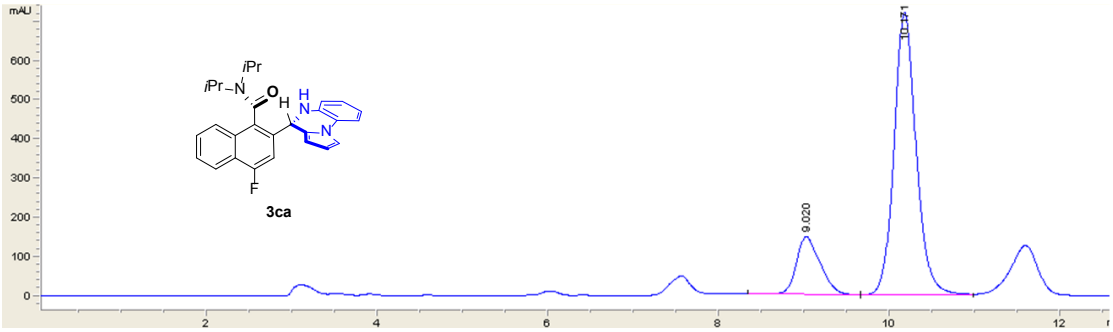
n-hexane/isopropanol 50:50, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.053	0.4587	1988.3	66.1	88.291
2	14.708	0.6133	263.7	6.5	11.709



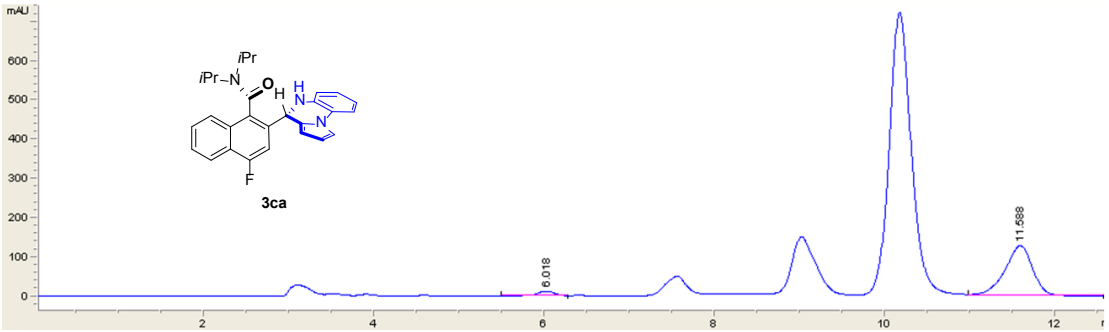
n-hexane/isopropanol 90:10, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.977	0.1608	236.6	22.5	8.641
2	8.985	0.2444	1137.7	70.4	41.547
3	10.170	0.2735	1131.2	63.0	41.312
4	11.582	0.3340	232.7	10.5	8.500



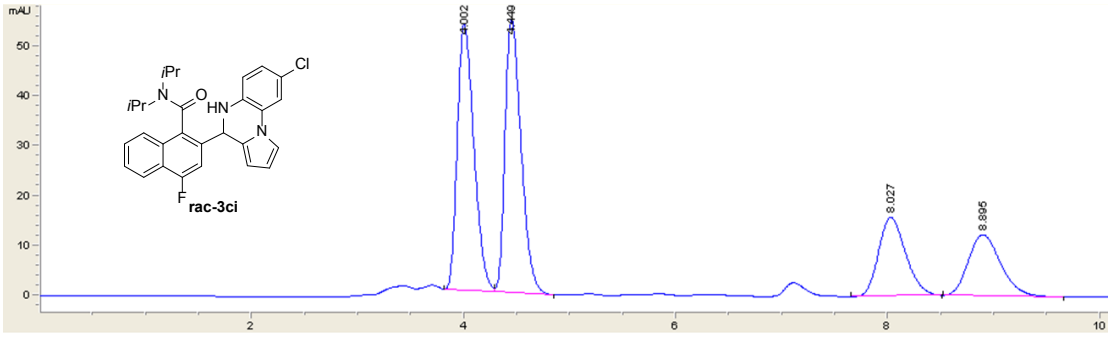
n-hexane/isopropanol 90:10, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.020	0.2824	2868.2	147.8	18.061
2	10.171	0.2724	13012.1	721.4	81.939



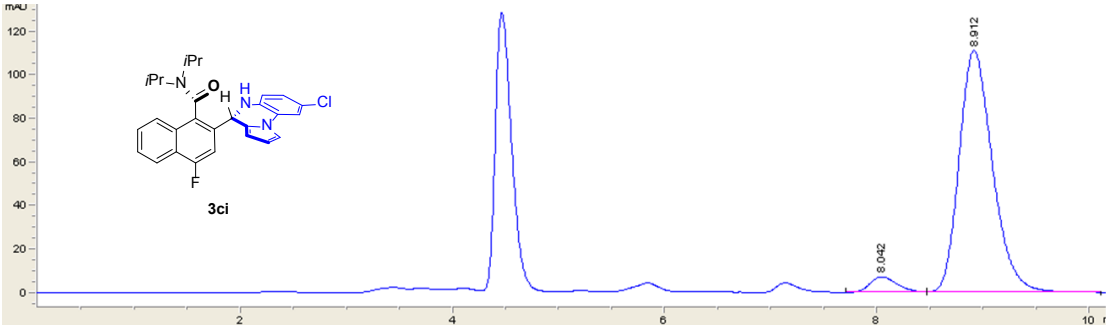
n-hexane/isopropanol 90:10, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.018	0.2294	171.9	11.6	5.622
2	11.588	0.3433	2885.6	126.9	94.378



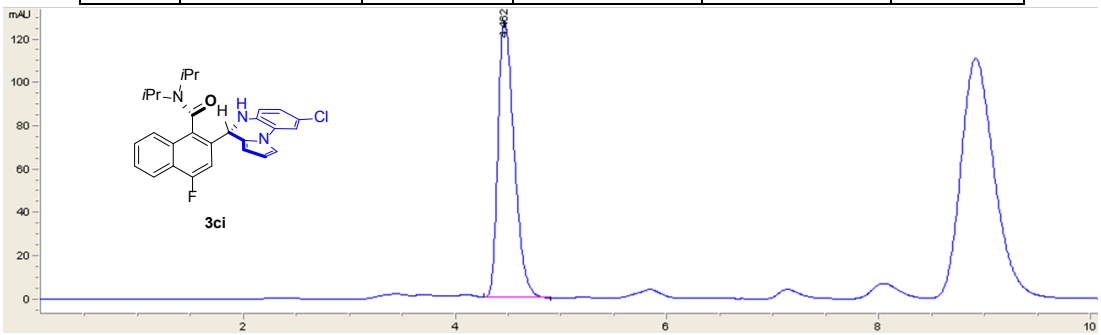
n-hexane/isopropanol 70:30, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.002	0.1715	585.4	53.6	34.296
2	4.449	0.1647	579.2	55.1	33.937
3	8.027	0.2782	281.6	15.8	16.497
4	8.895	0.3294	260.6	12.3	15.269



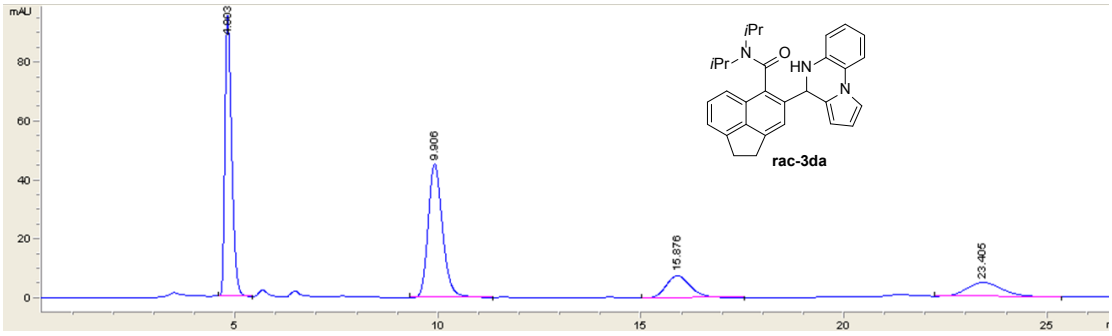
n-hexane/isopropanol 70:30, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.042	0.2756	126.0	7.1	4.932
2	8.912	0.3373	2428.0	111.0	95.068



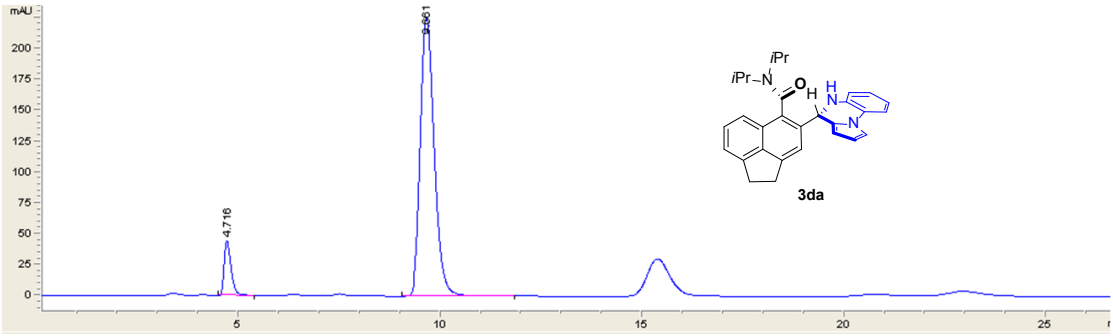
n-hexane/isopropanol 70:30, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.462	0.1637	1355.8	127.9	100.000



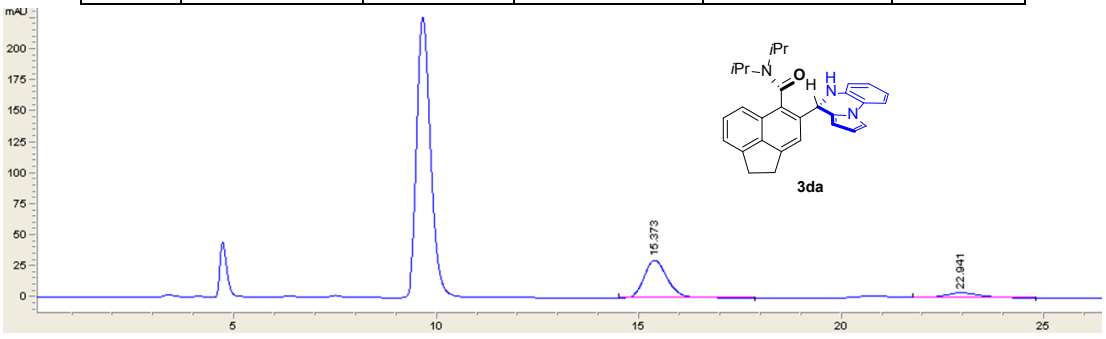
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.803	0.1761	1096.5	95.4	39.274
2	9.906	0.3766	1104.4	45.3	39.558
3	15.876	0.6306	307.2	7.5	11.002
4	23.405	0.8705	283.8	4.8	10.167



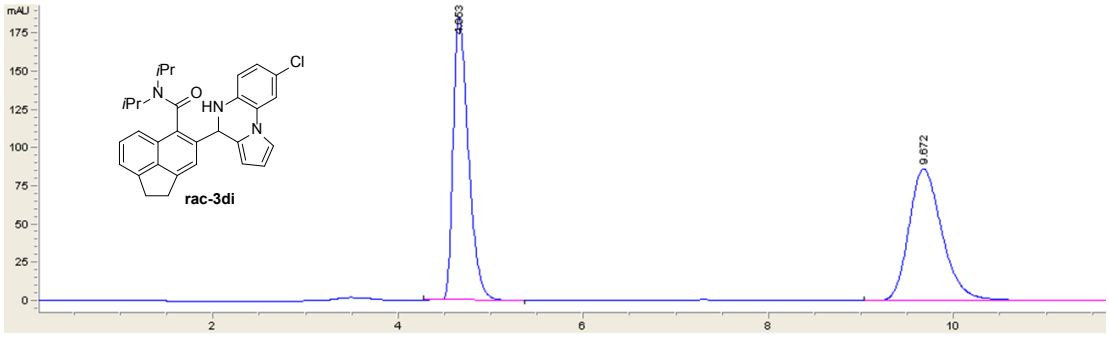
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.716	0.1818	520.1	44.1	8.819
2	9.661	0.3675	5377.8	226.1	91.181



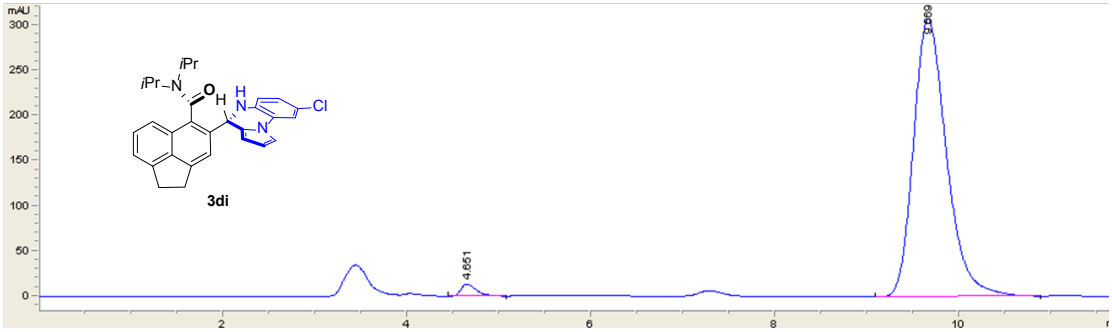
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.373	0.6039	1187.8	30.3	84.095
2	22.941	0.8112	224.7	3.8	15.905



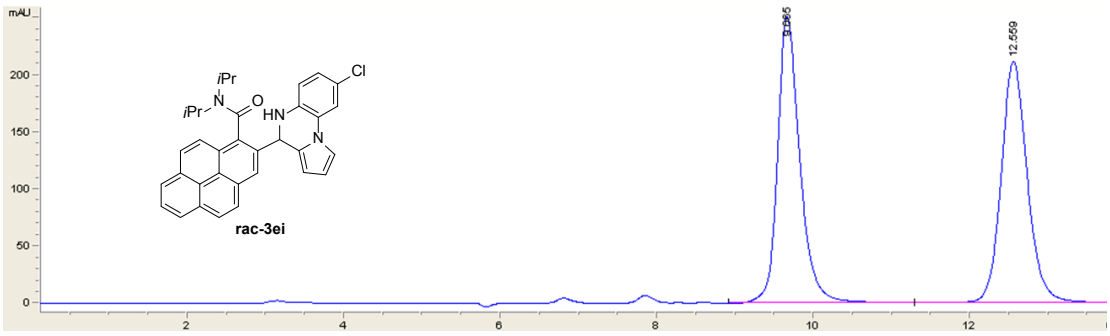
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.653	0.1760	2133.7	185.8	49.781
2	9.672	0.3826	2152.4	86.4	50.219



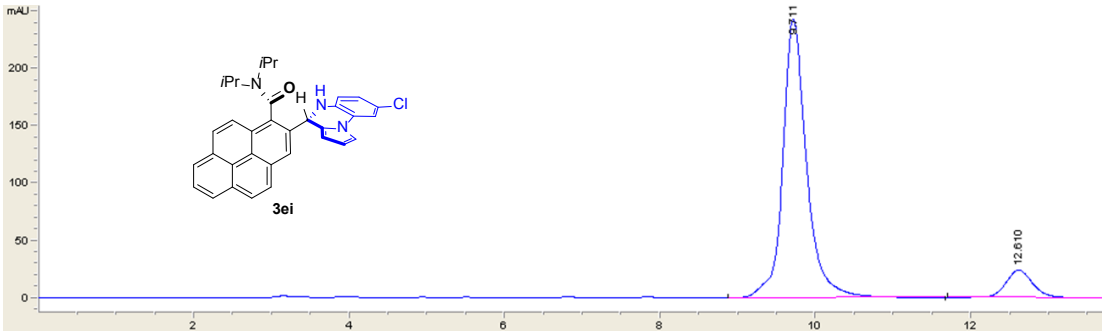
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.651	0.1794	159.4	13.5	2.033
2	9.669	0.3831	7681.3	307.9	97.967



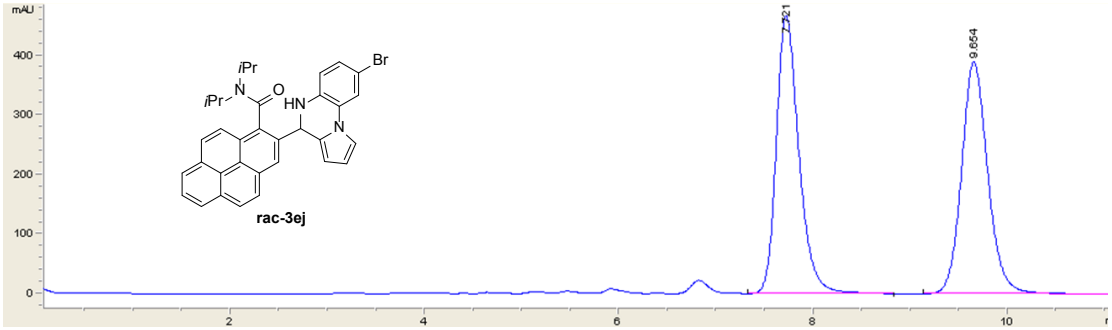
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.665	0.3018	4977.7	250.5	50.196
2	12.559	0.3549	4938.8	211.1	49.804



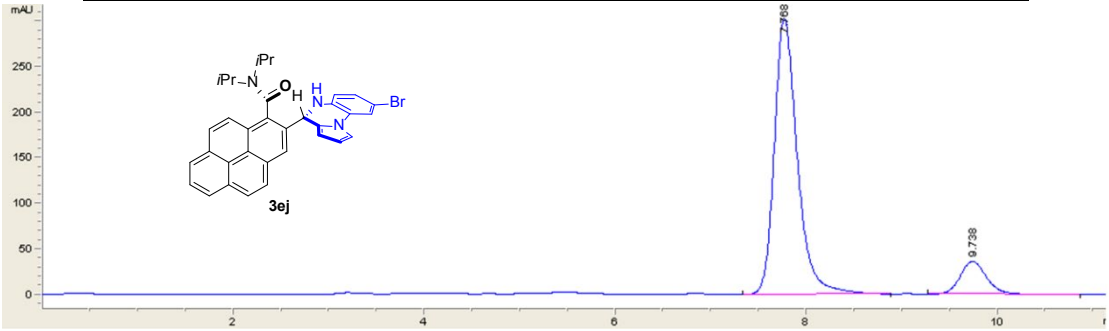
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.711	0.3175	5204.3	243.3	89.714
2	12.610	0.3713	596.7	24.2	10.286



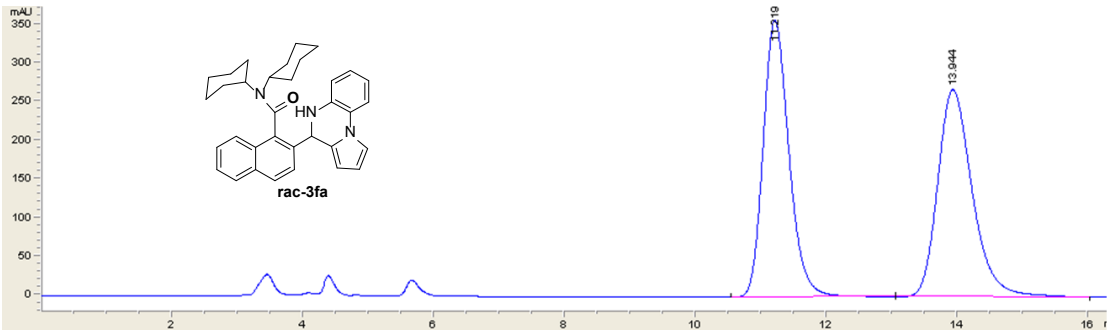
n-hexane/isopropanol 70:30, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.721	0.2463	7529.0	466.5	50.681
2	9.654	0.2876	7326.6	389.3	49.319



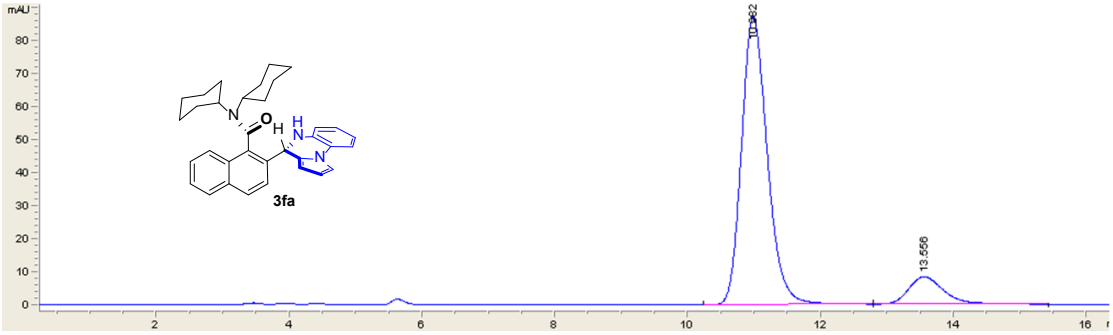
n-hexane/isopropanol 70:30, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.768	0.2528	5061.9	303.2	87.859
2	9.738	0.2927	699.5	36.3	12.141



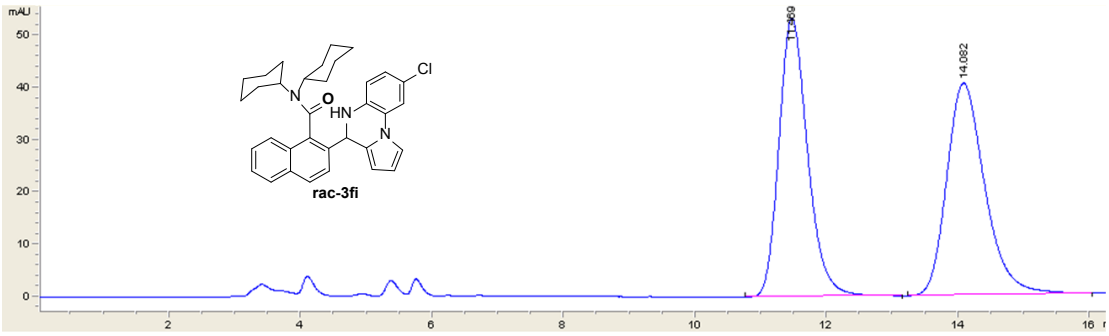
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.219	0.4206	9766.8	357.6	49.682
2	13.944	0.5672	9891.9	267.6	50.318



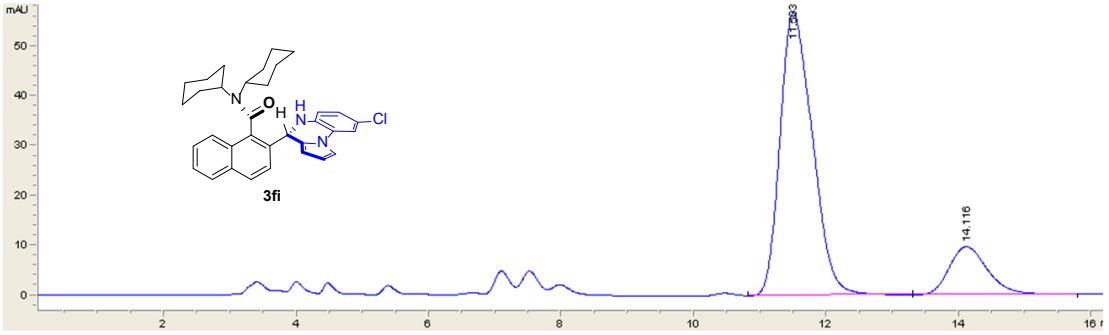
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.982	0.4134	2345.8	87.3	88.439
2	13.556	0.5689	306.6	8.3	11.561



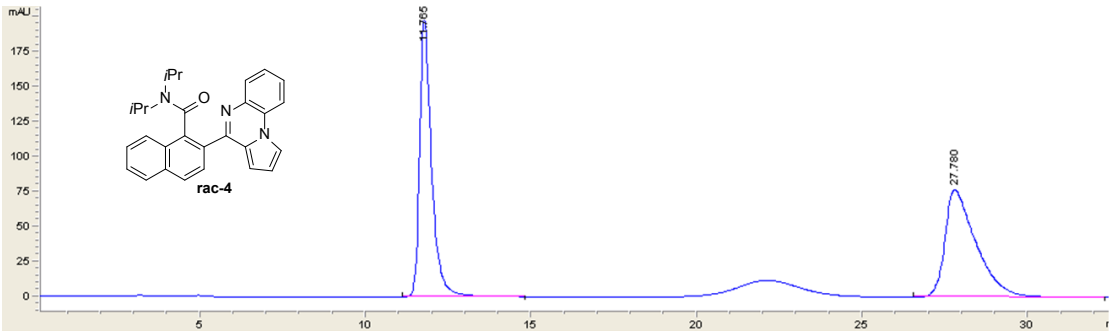
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.469	0.4655	1617.7	53.4	49.762
2	14.082	0.6178	1633.2	40.6	50.238



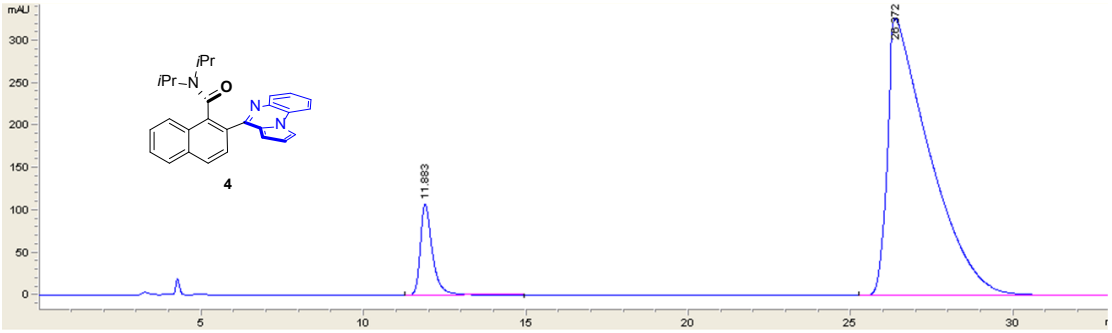
n-hexane/isopropanol 60:40, IC, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.503	0.5564	1930.9	56.8	83.178
2	14.116	0.6215	390.5	9.7	16.822



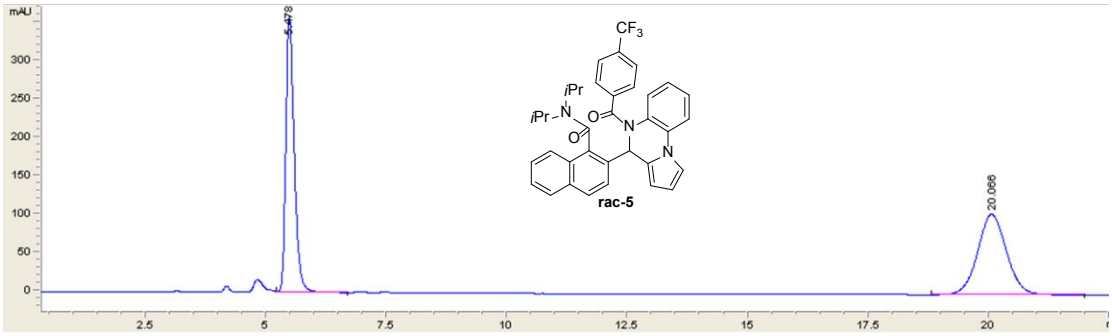
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.765	0.3763	4990.2	197.8	49.965
2	27.780	0.9278	4997.2	76.9	50.035



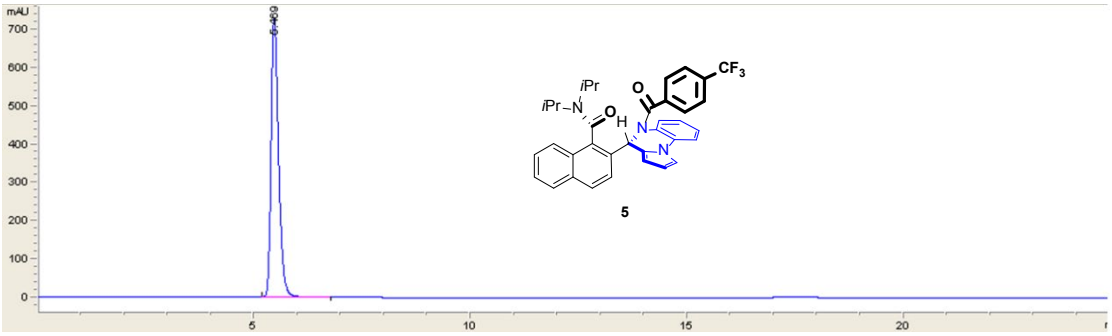
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.883	0.3830	2756.0	107.5	8.468
2	26.372	1.2517	29789.1	327.3	91.532



n-hexane/isopropanol 80:20, IA, 1.0 mL/min

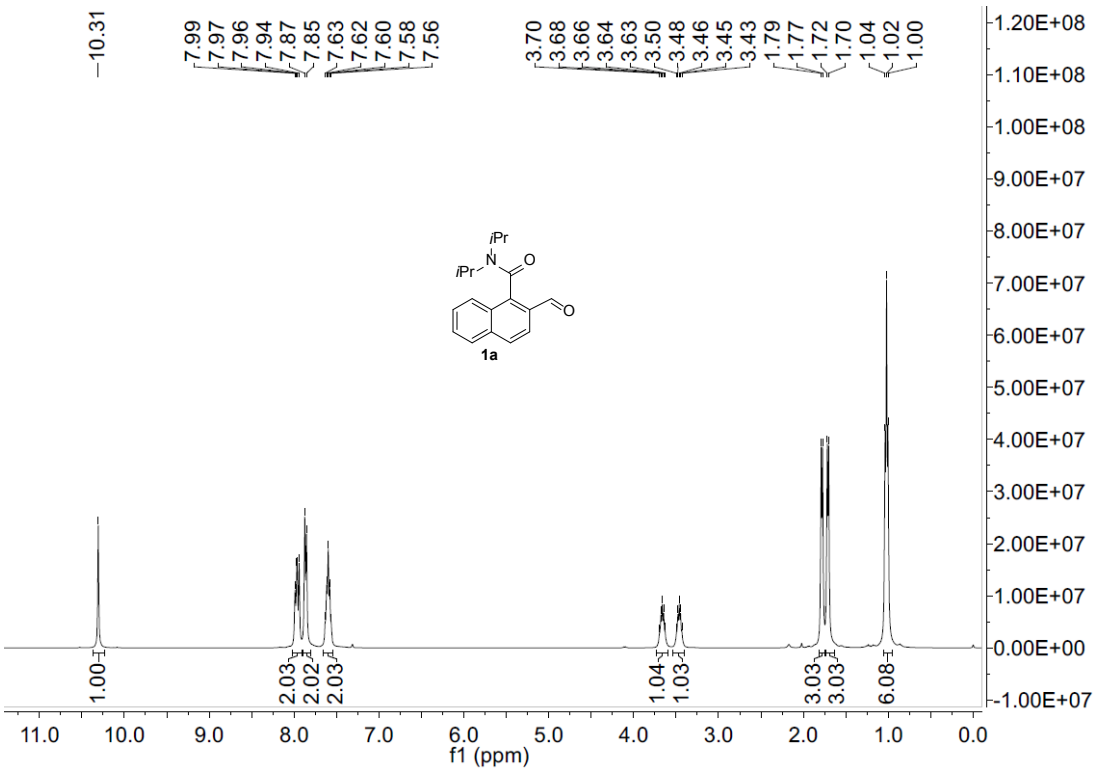
Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.478	0.1857	4392.5	361.6	50.120
2	20.066	0.6382	4371.6	104.9	49.880

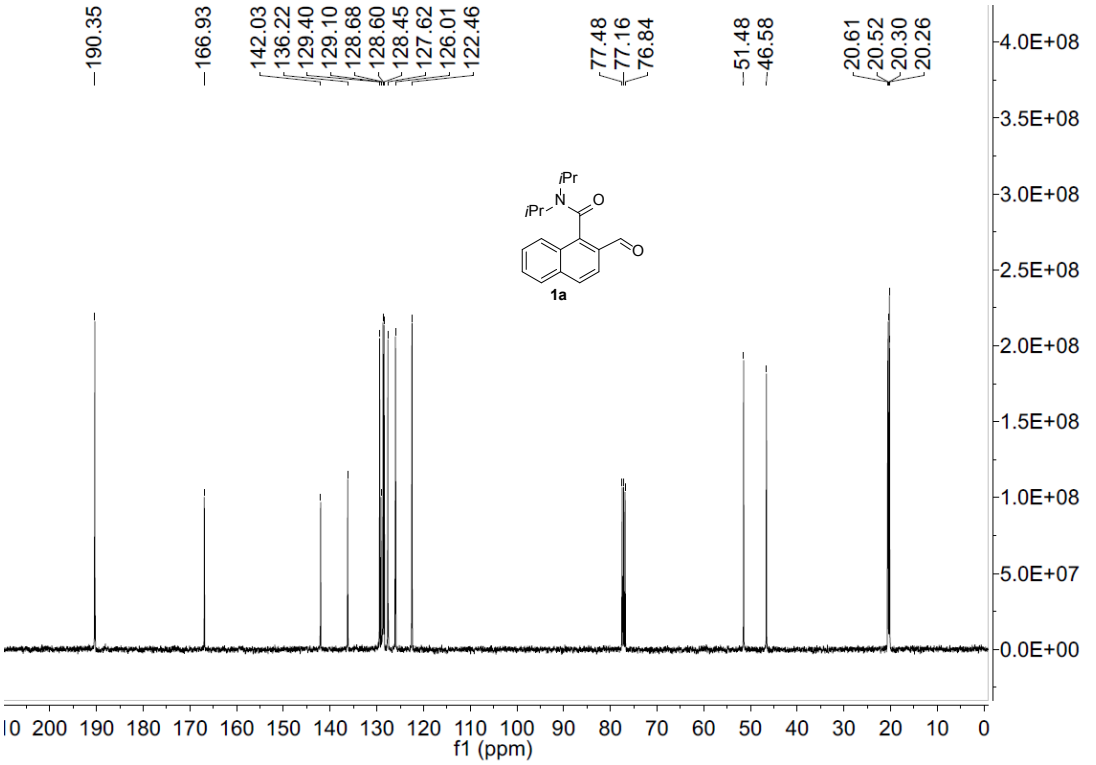


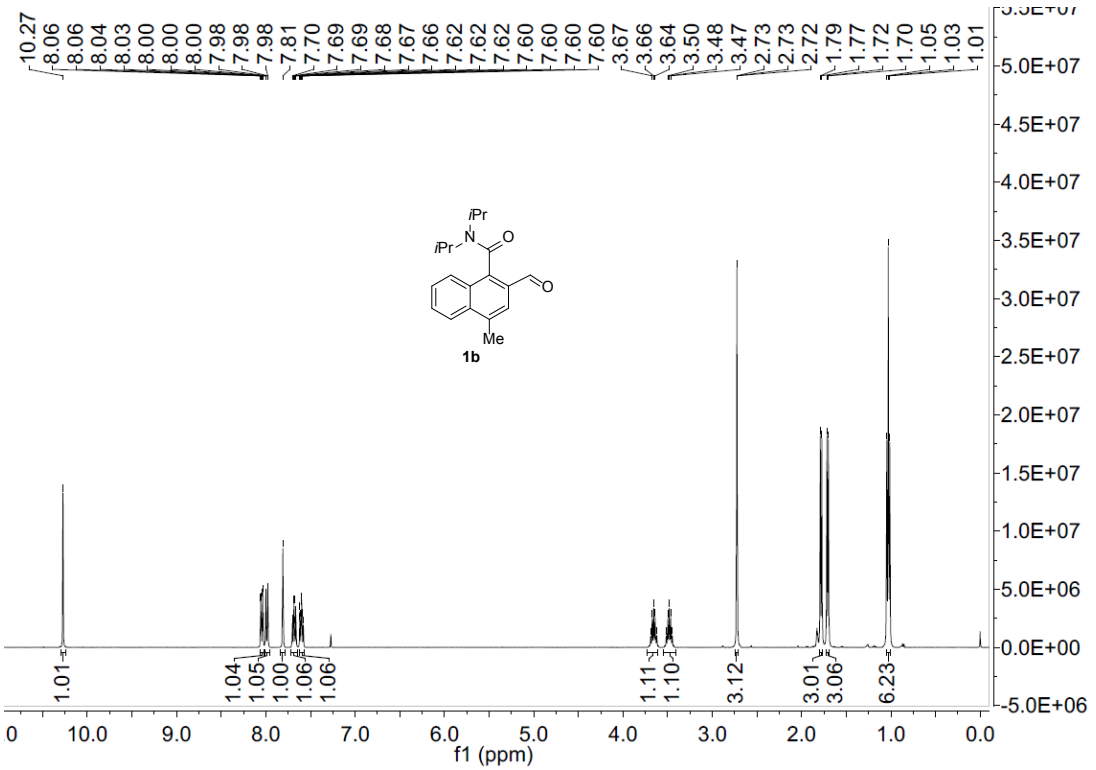
n-hexane/isopropanol 80:20, IA, 1.0 mL/min

Peak #	RetTime [min]	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.469	0.1845	8817.1	732.3	100.000

8.^{1}H and ^{13}C NMR spectra



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2.73
2.72
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1.77
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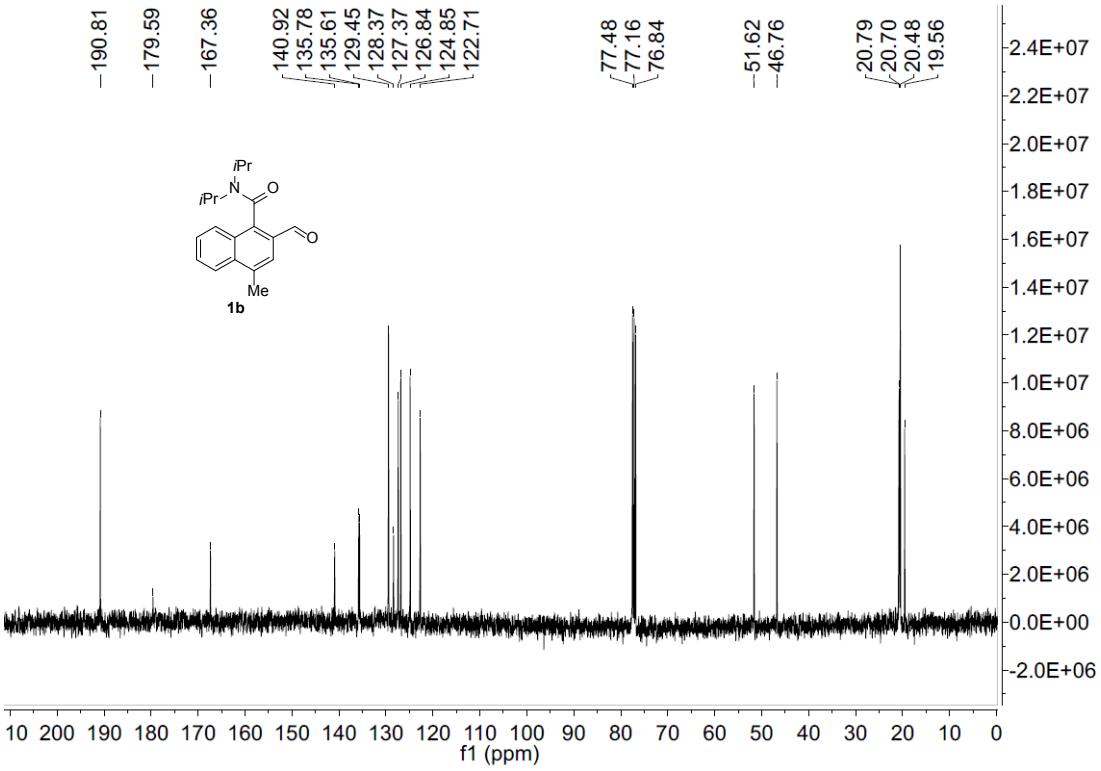
1.70
1.05
1.03
1.01
iPr
iPr
N
O
O
Me
1b
1.01
1.04
1.05
1.00
1.06
1.06
1.11
1.10
3.12
3.01
3.06
6.23
f1 (ppm)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135.78
135.61
129.45
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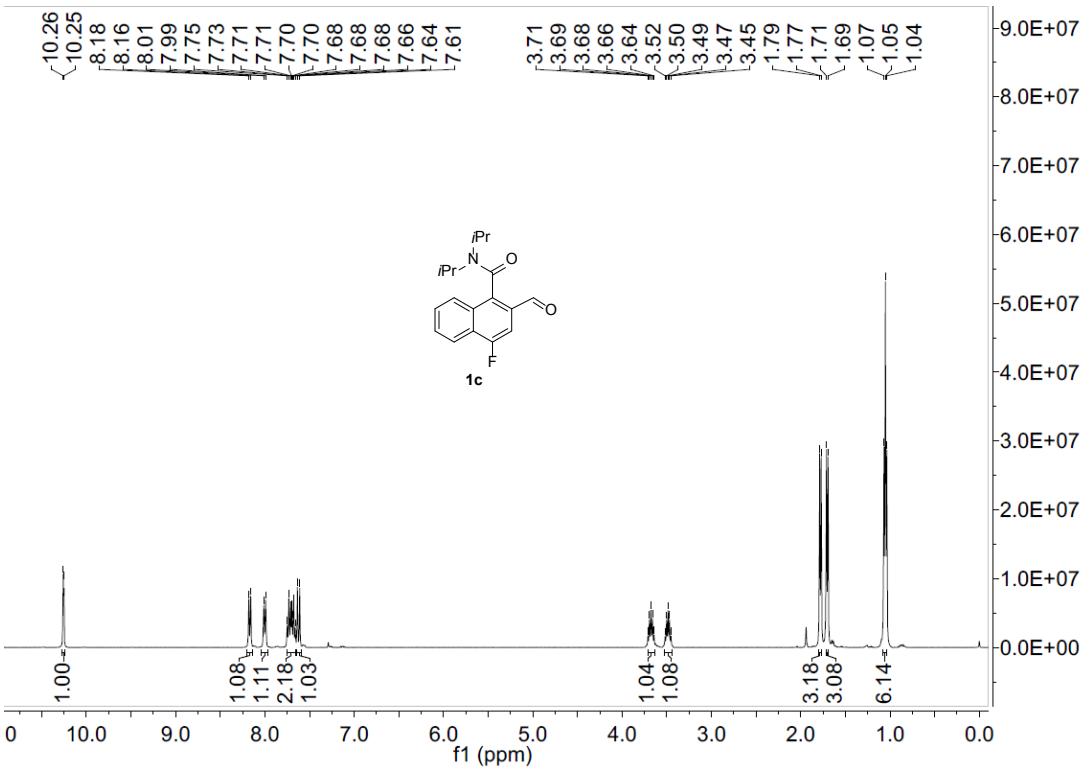
127.37
126.84
124.85
122.71
77.48
77.16
76.84
51.62
46.76
20.79
20.70
20.48
19.56
iPr
iPr
N
O
O
Me
1b
f1 (ppm)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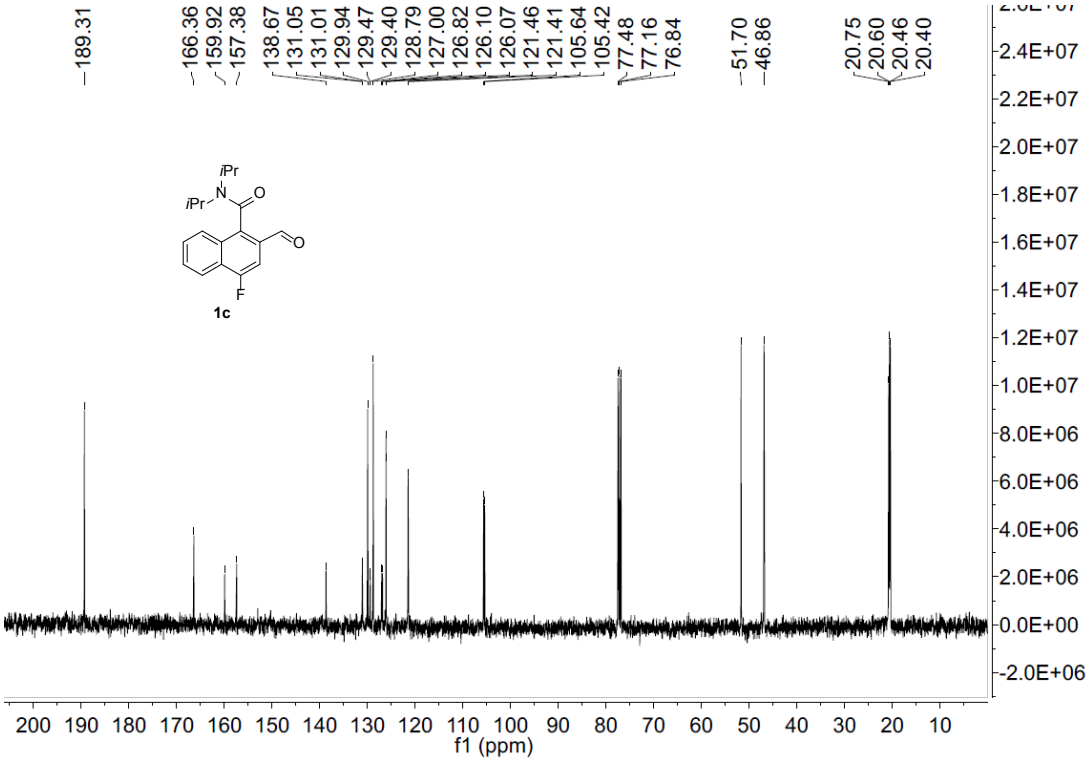
7.0E+07
6.0E+07
5.0E+07
4.0E+07
3.0E+07
2.0E+07
1.0E+07
0.0E+00
0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)


189.31
166.36
159.92
157.38
138.67
131.05
131.01
129.94
129.47
129.40
128.79
127.00
126.82
126.10
126.07
121.46
121.41
105.64
105.42
77.48
77.16
76.84
51.70
46.86
20.75
20.60
20.46
20.40
iPr
iPr
N
O
O
F
1c
2.4E+07
2.2E+07
2.0E+07
1.8E+07
1.6E+07
1.4E+07
1.2E+07
1.0E+07
8.0E+06
6.0E+06
4.0E+06
2.0E+06
0.0E+00
-2.0E+06
200
190
180
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120
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100
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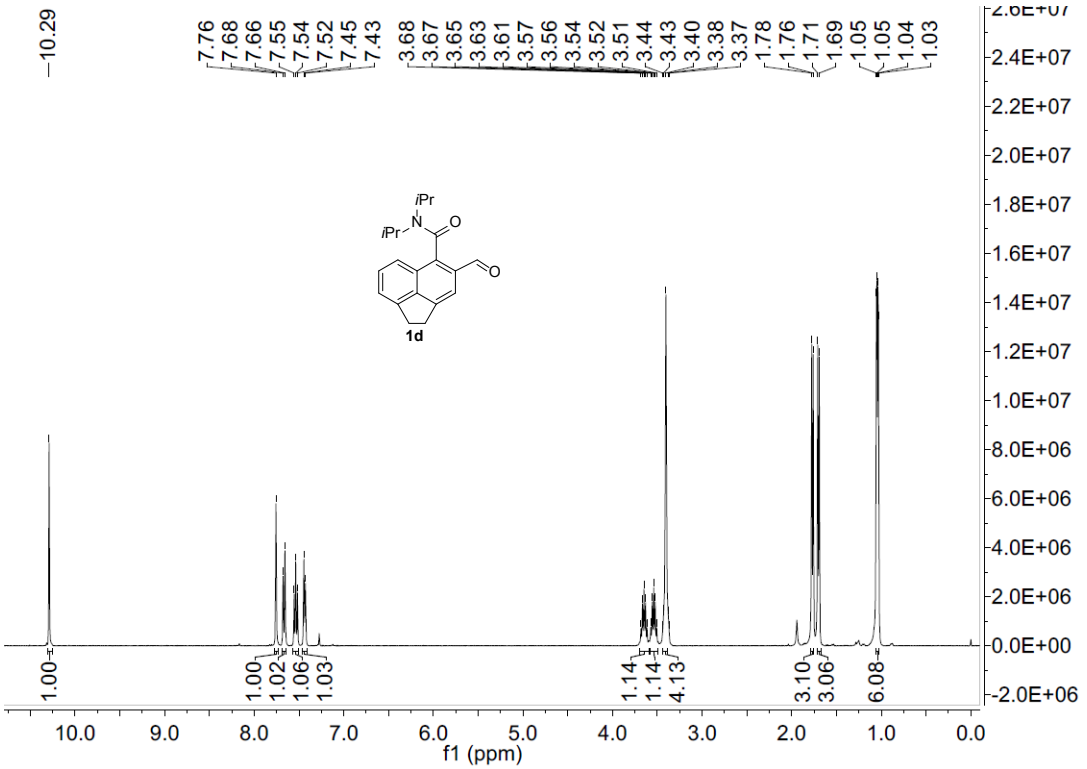
f1 (ppm)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3.57
3.56
3.54
3.52
3.51
3.44
3.43
3.40
3.38
3.37
1.78
1.76
1.71
1.69
1.05
1.04
1.03
iPr
iPr
N
O
O
1d
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1.03
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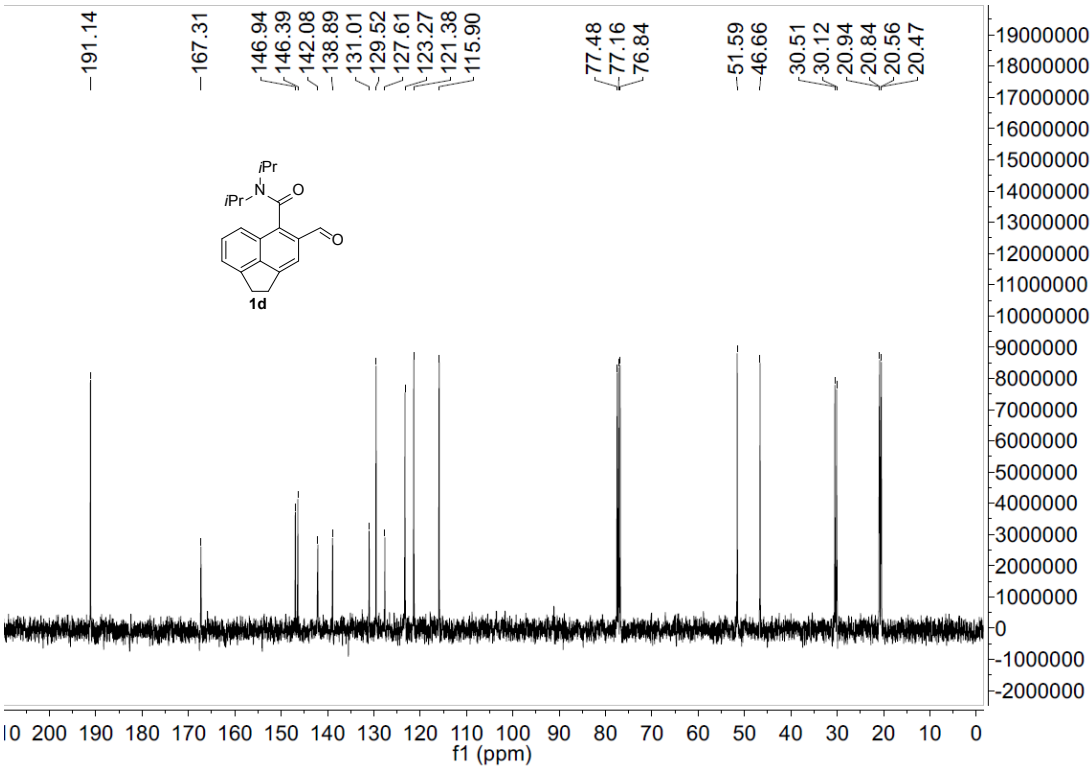
3.10
3.06
6.08
f1 (ppm)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123.27
121.38
115.90
77.48
77.16
76.84
51.59
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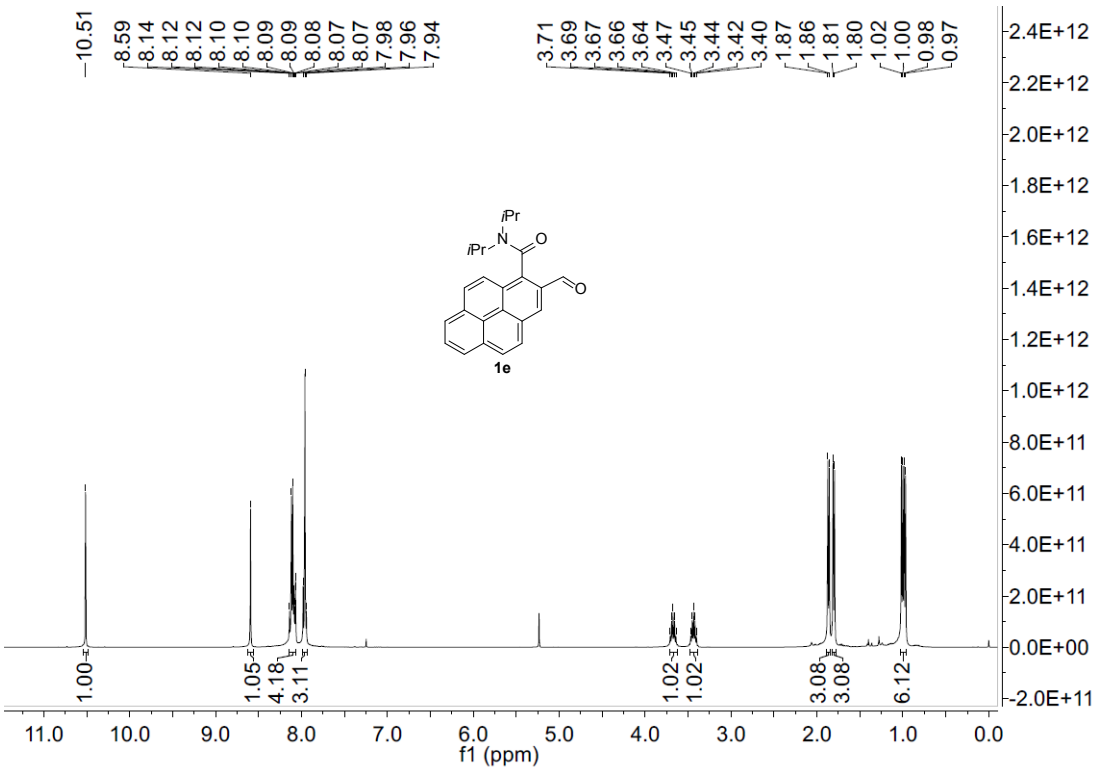
20.84
20.56
20.47
iPr
iPr
N
O
O
1d
f1 (ppm)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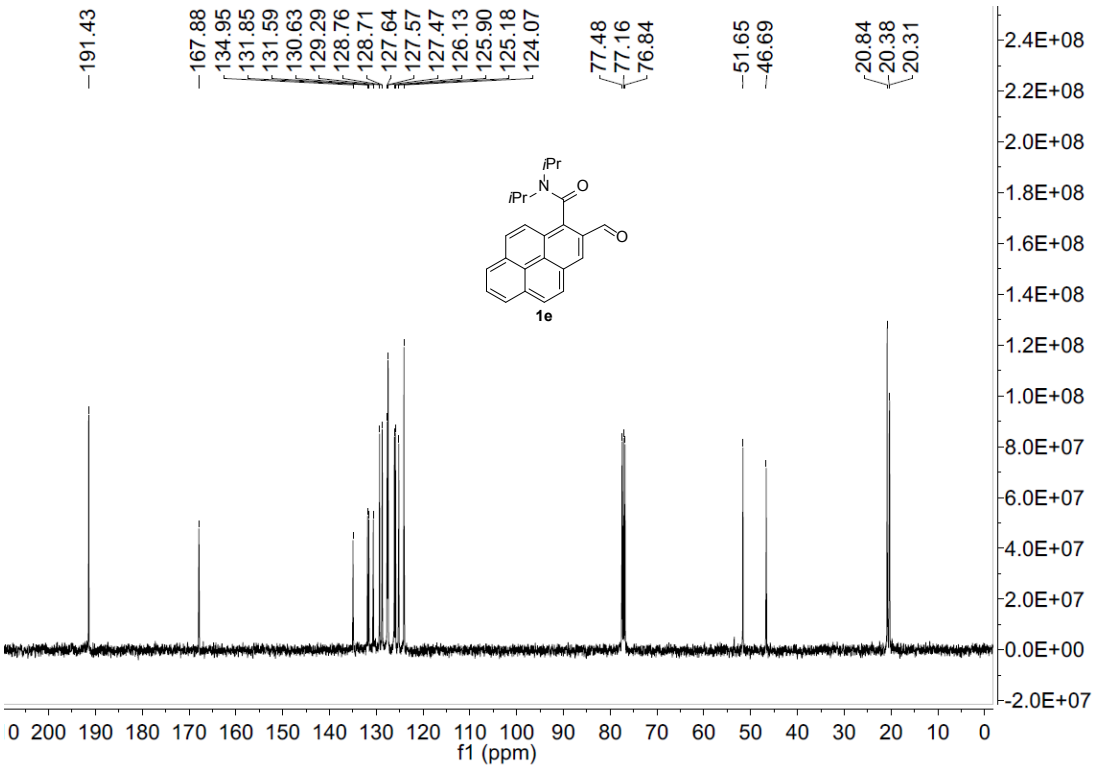
8.09
8.08
8.07
8.07
7.98
7.96
7.94
3.71
3.69
3.67
3.66
3.64
3.47
3.45
3.44
3.42
3.40
1.87
1.86
1.81
1.80
1.02
1.00
0.98
0.97
iPr
iPr
N
O
O
1e
1.00
1.05
4.18
3.11
1.02
1.02
3.08
3.08
6.12
f1 (ppm)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126.13
125.90
125.18
124.07
77.48
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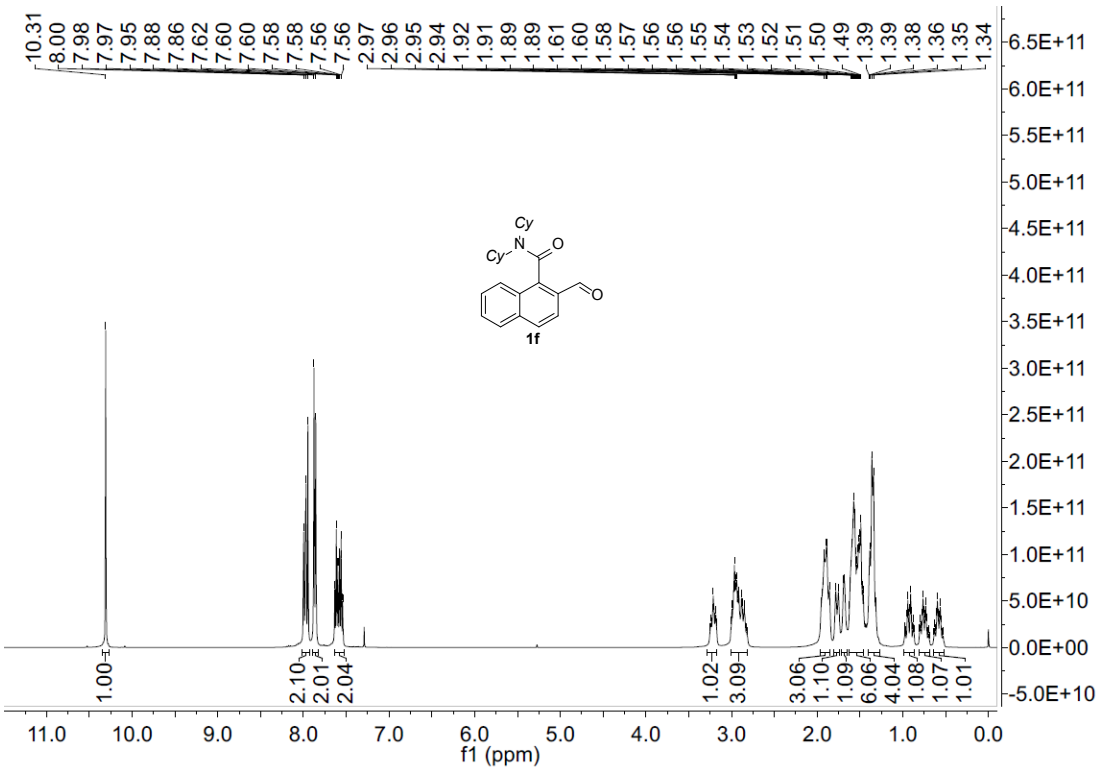
46.69
20.84
20.38
20.31
iPr
iPr
N
O
O
1e
f1 (ppm)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7.56
7.56
2.97
2.96
2.95
2.94
1.92
1.91
1.89
1.89
1.61
1.60
1.58
1.57
1.56
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1.50
1.49
1.39
1.39
1.38
1.36
1.35
1.34
Cy
N
Cy
O
O
1f
1.00
2.10
2.01
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3.06
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1.09
6.06
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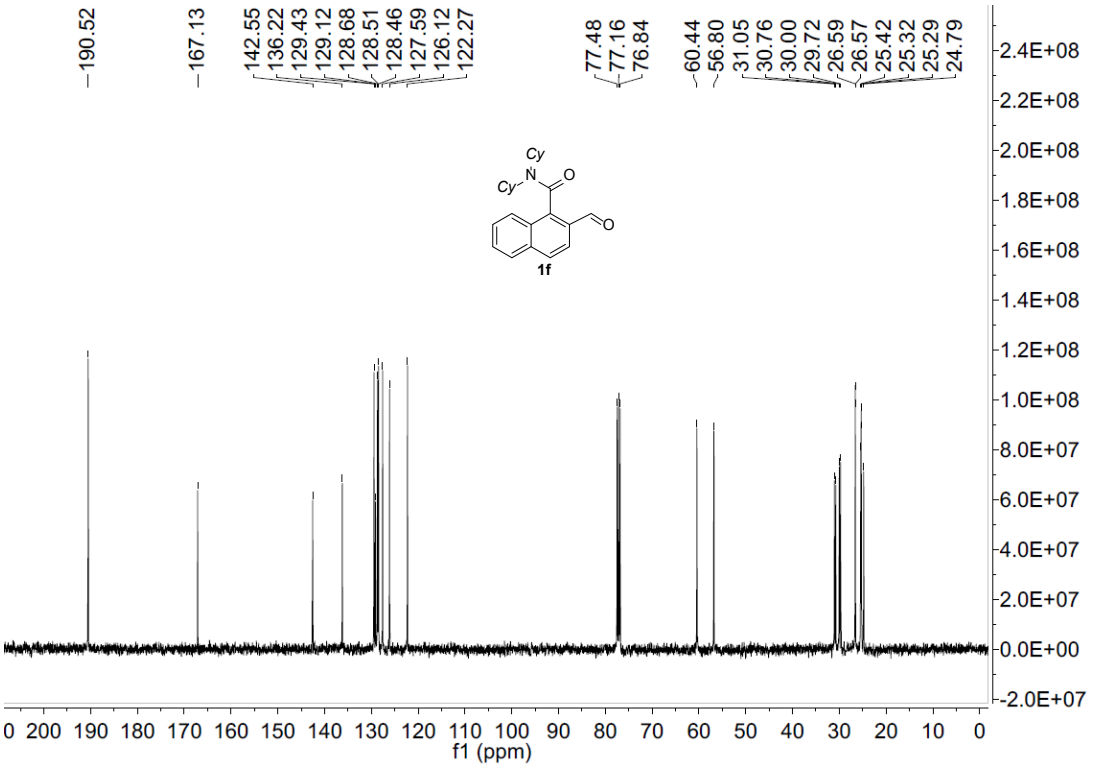
1.08
1.07
1.01
f1 (ppm)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126.12
122.27
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77.16
76.84
60.44
56.80
31.05
30.76
30.00
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26.59
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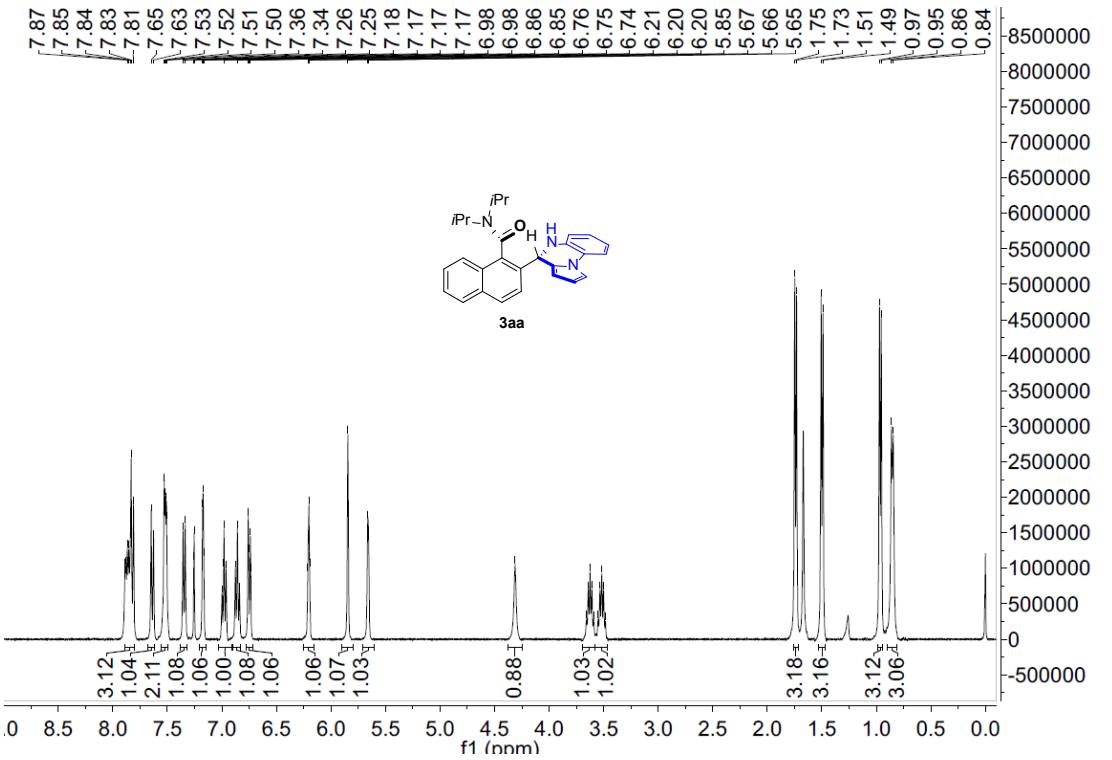
25.42
25.32
25.29
24.79
Cy
N
Cy
O
O
1f
f1 (ppm)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7.50
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7.34
7.26
7.25
7.18
7.17
7.17
7.17
6.98
6.98
6.86
6.85
6.76
6.75
6.74
6.21
6.20
6.20
5.85
5.67
5.66
5.65
1.75
1.73
1.51
1.49
0.97
0.95
0.86
0.84
iPr
iPr–N
O
H
H
N
N
3aa
3.12
1.04
2.11
1.08
1.06
1.00
1.08
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1.06
1.07
1.03
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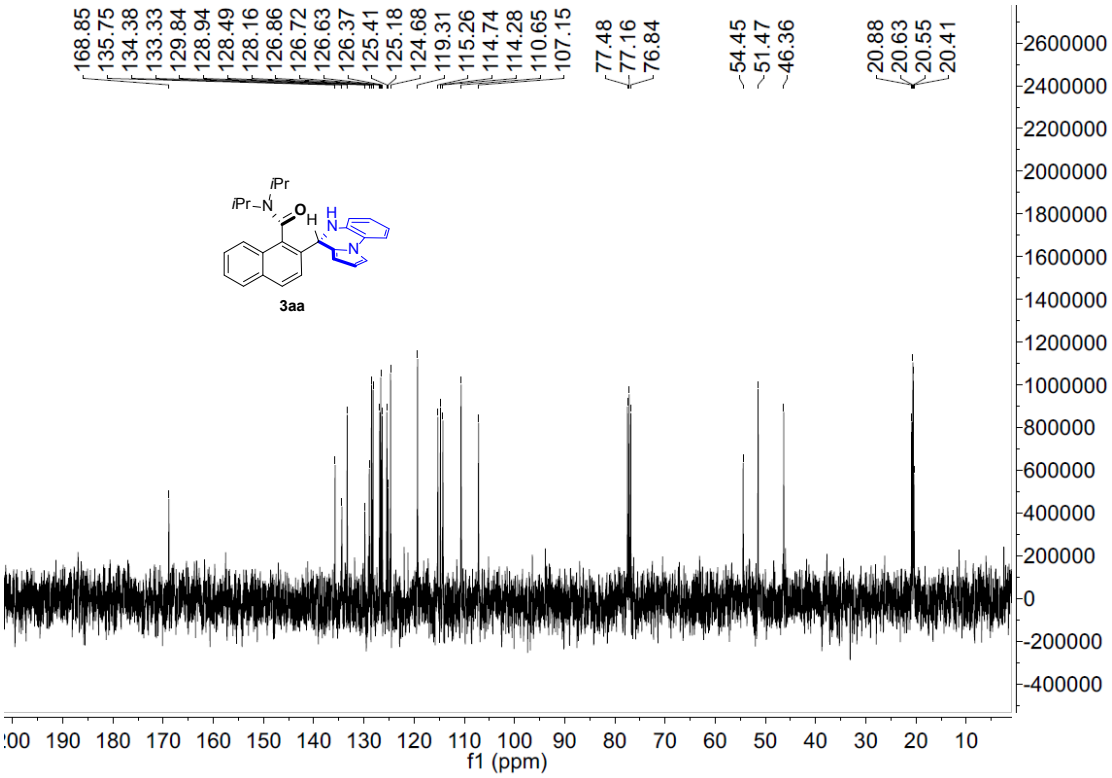
1.03
1.02
3.18
3.16
3.12
3.06
f1 (ppm)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126.37
125.41
125.18
124.68
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115.26
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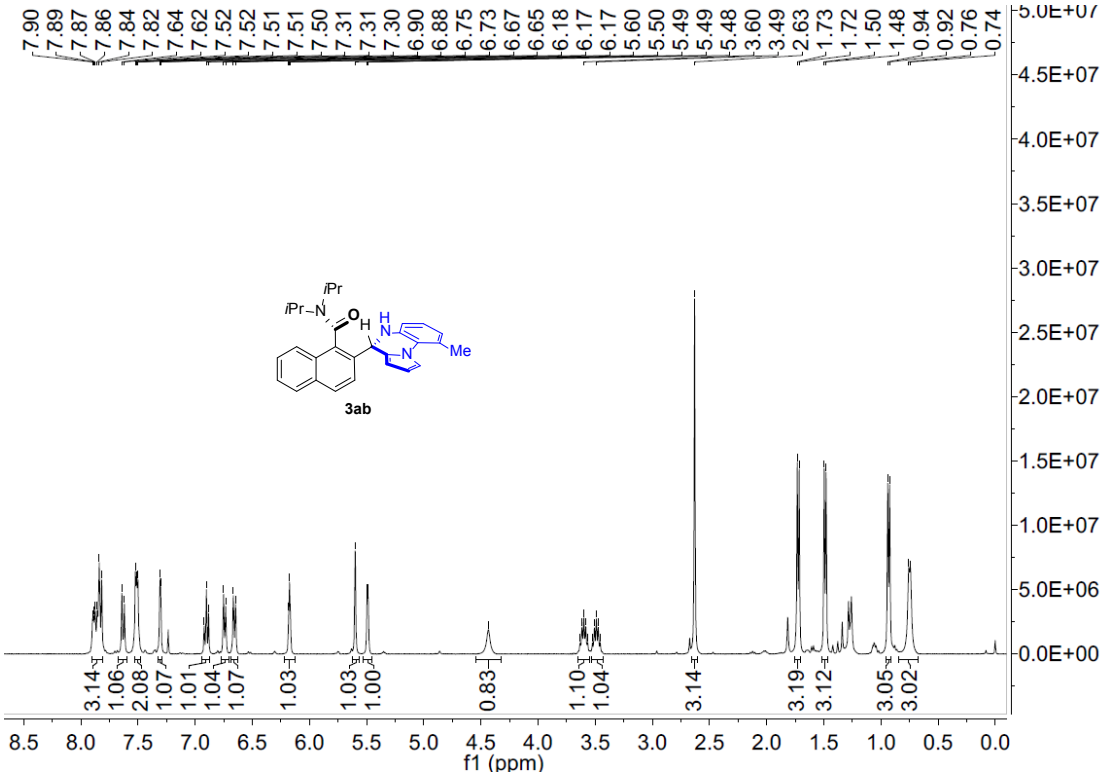
114.28
110.65
107.15
77.48
77.16
76.84
54.45
51.47
46.36
20.88
20.63
20.55
20.41
iPr
iPr–N
O
H
H
N
N
3aa
f1 (ppm)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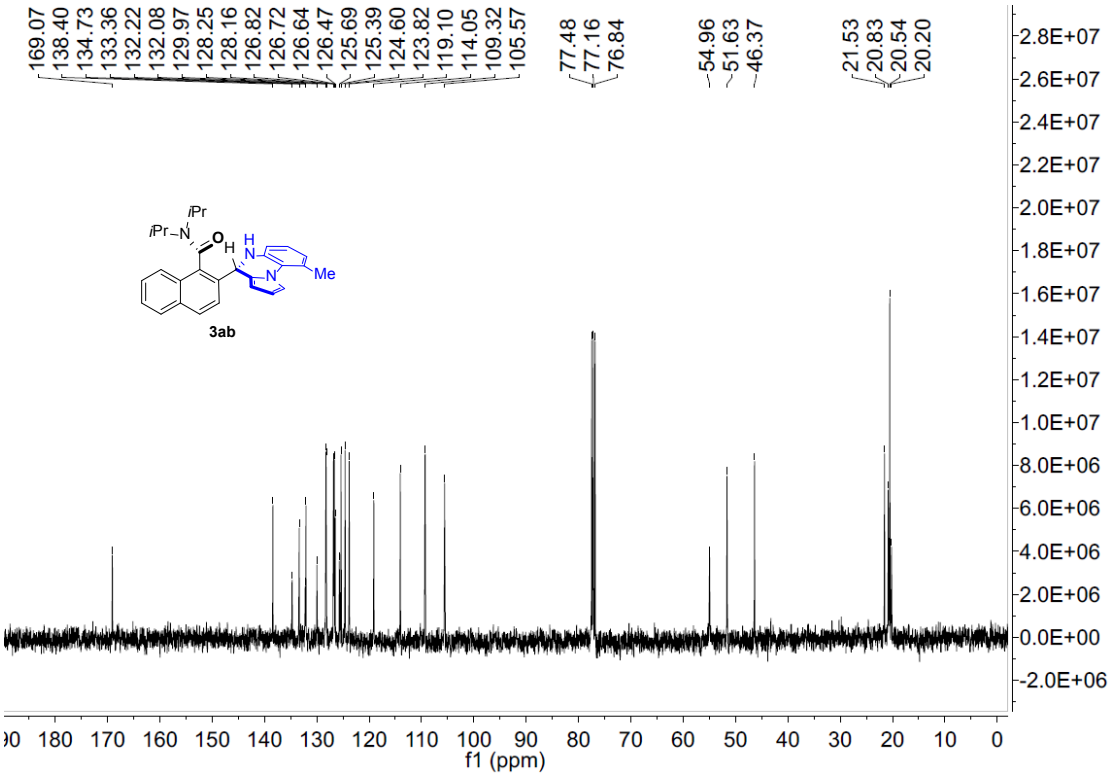
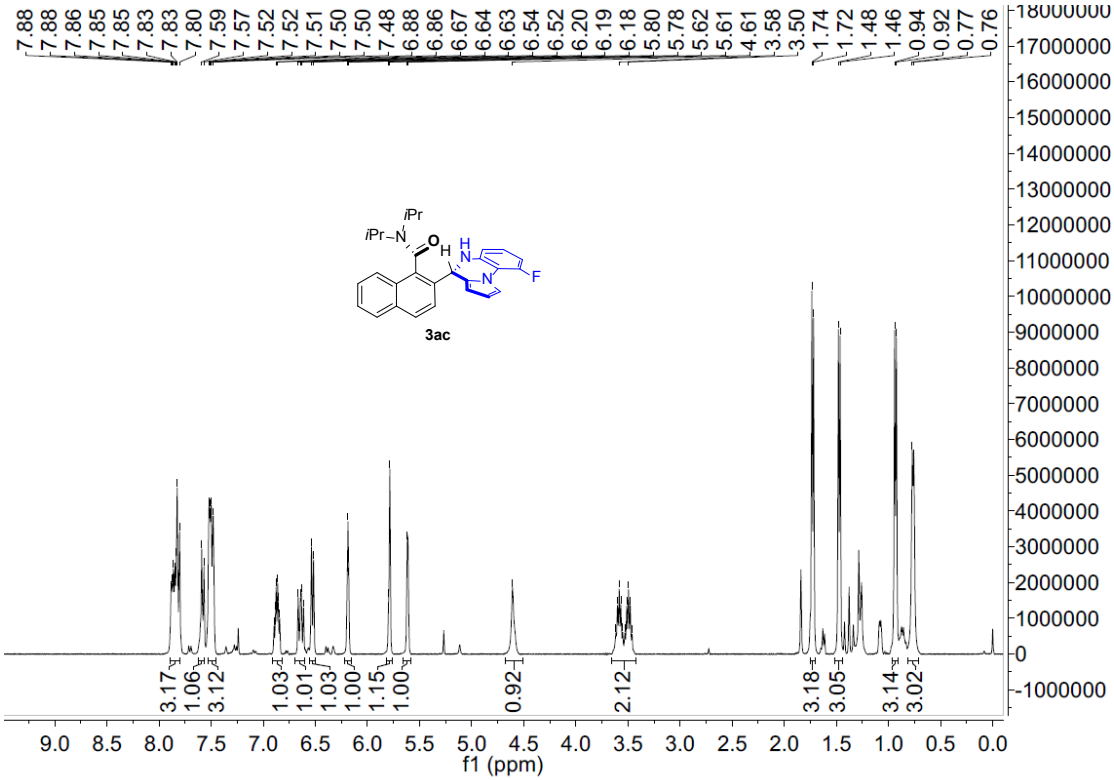
iPr
iPr–N
O
H
H
N
N
Me
3ab
3.14 1.06 2.08 1.07 1.01 1.04 1.07 1.03 1.03 1.00 0.83 1.10 1.04 3.14 3.19 3.12 3.05 3.02
f1 (ppm)


169.07 138.40 134.73 133.36 132.22 132.08 129.97 128.25 128.16 126.82 126.72 126.64 126.47 125.69 125.39 124.60 123.82 119.10 114.05 109.32 105.57
77.48 77.16 76.84
54.96 51.63 46.37
21.53 20.83 20.54 20.20
iPr
iPr–N
O
H
H
N
N
Me
3ab
f1 (ppm)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7.51
7.50
7.50
7.48
6.88
6.86
6.67
6.64
6.63
6.54
6.52
6.20
6.19
6.18
5.80
5.78
5.62
5.61
4.61
3.58
3.50
1.74
1.72
1.48
1.46
0.94
0.92
0.77
0.76
iPr
iPr–N
O
H
H
N
N
F
3ac
3.17
1.06
3.12
1.03
1.01
1.03
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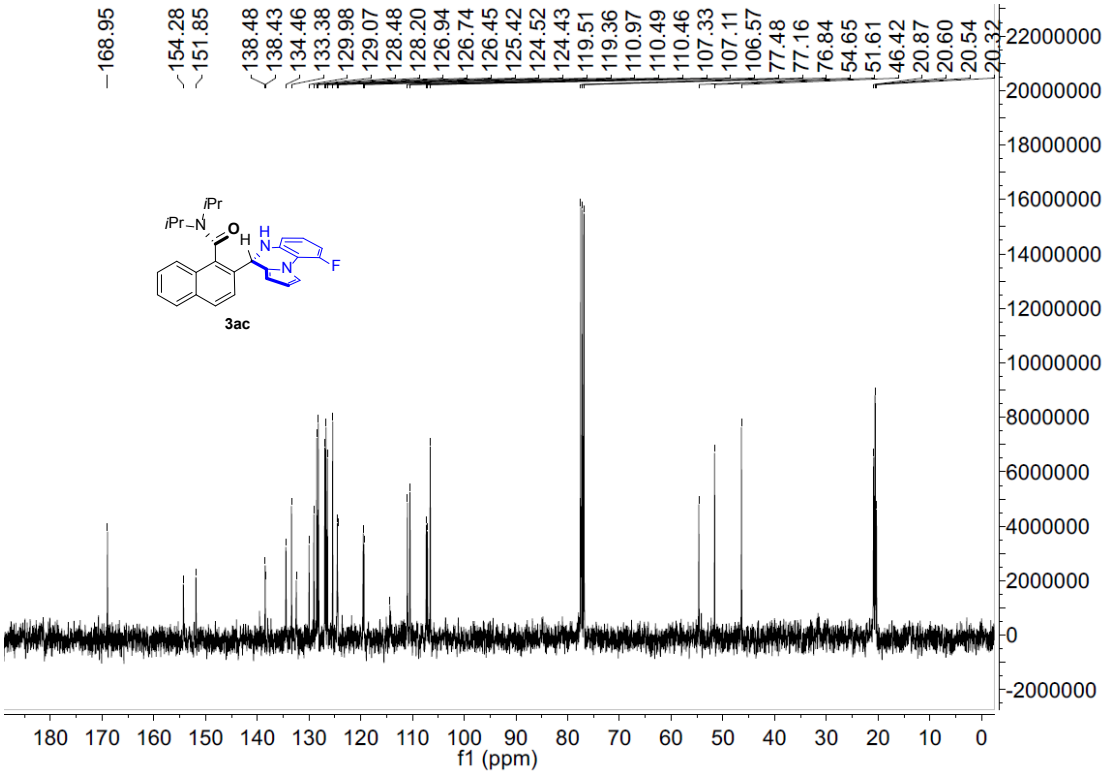
1.15
1.00
0.92
2.12
3.18
3.05
3.14
3.02
f1 (ppm)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126.74
126.45
125.42
124.52
124.43
119.51
119.36
110.97
110.49
110.46
107.33
107.11
106.57
77.48
77.16
76.84
54.65
51.61
46.42
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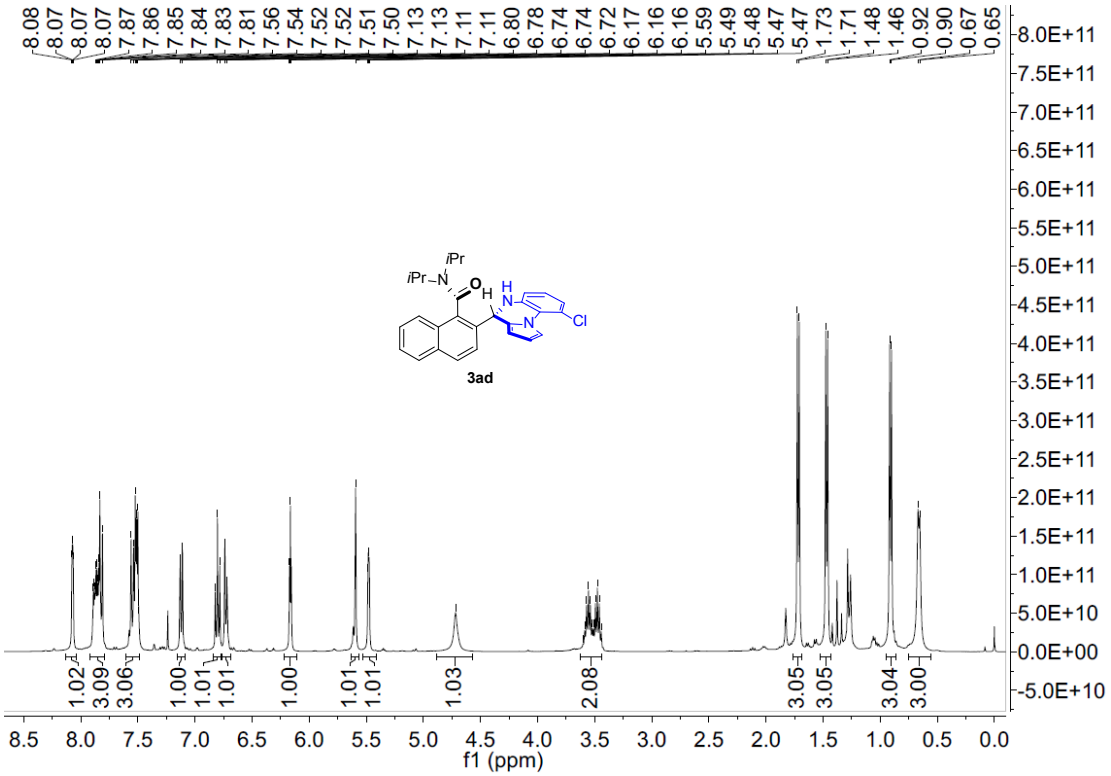
20.54
20.32
iPr
iPr–N
O
H
H
N
N
F
3ac
f1 (ppm)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7.11
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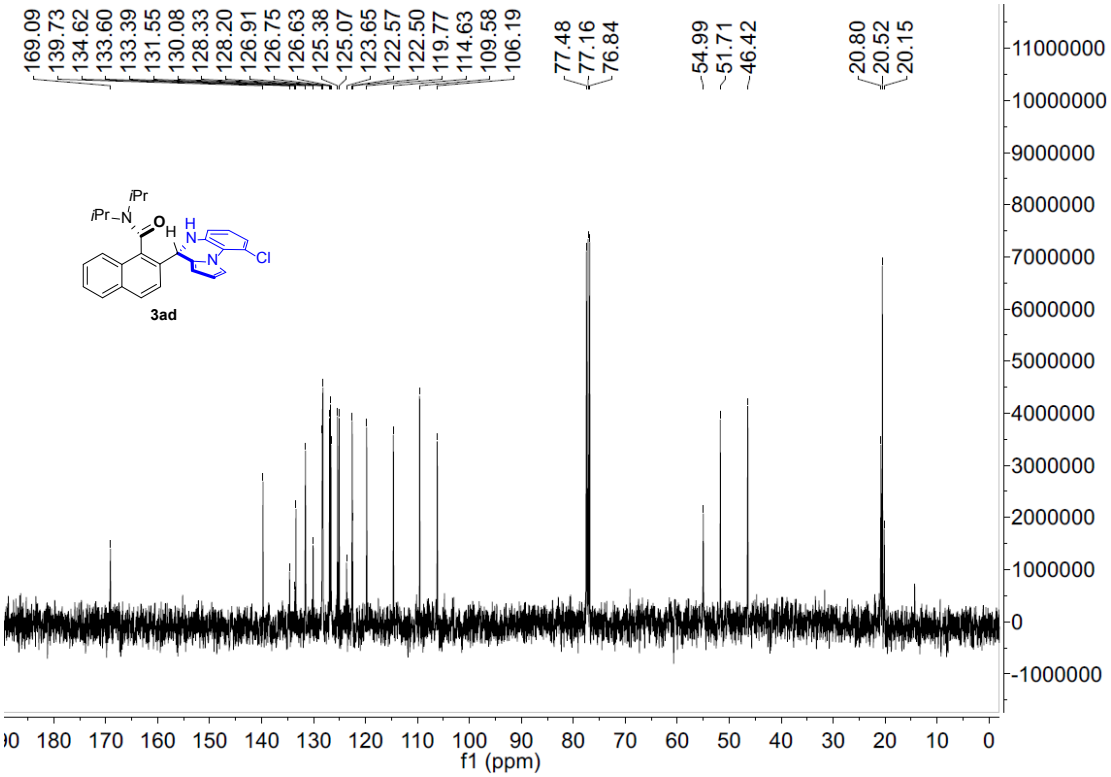
6.80
6.78
6.74
6.74
6.72
6.17
6.16
6.16
5.59
5.49
5.48
5.47
5.47
1.73
1.71
1.48
1.46
0.92
0.90
0.67
0.65
iPr
iPr–N
O
H
H
N
N
Cl
3ad
1.02
3.09
3.06
1.00
1.01
1.01
1.00
1.01
1.01
1.03
2.08
3.05
3.05
3.04
3.00
f1 (ppm)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125.38
125.07
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122.57
122.50
119.77
114.63
109.58
106.19
77.48
77.16
76.84
54.99
51.71
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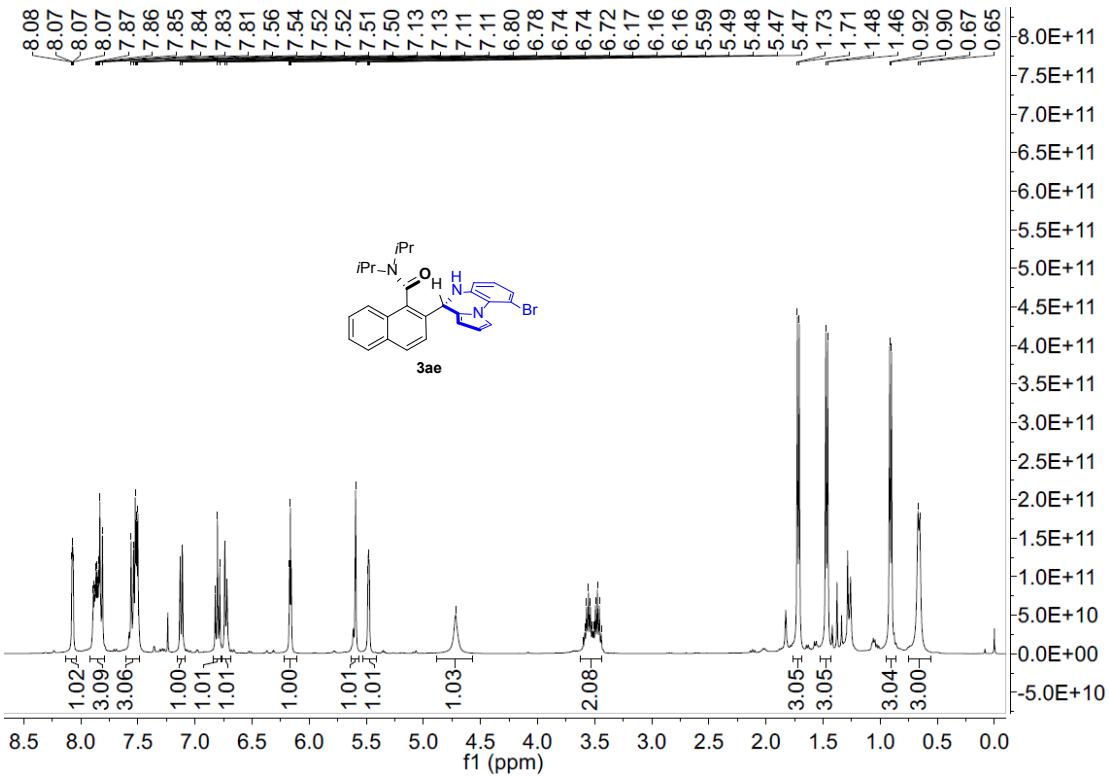
20.52
20.15
iPr
iPr–N
O
H
H
N
N
Cl
3ad
f1 (ppm)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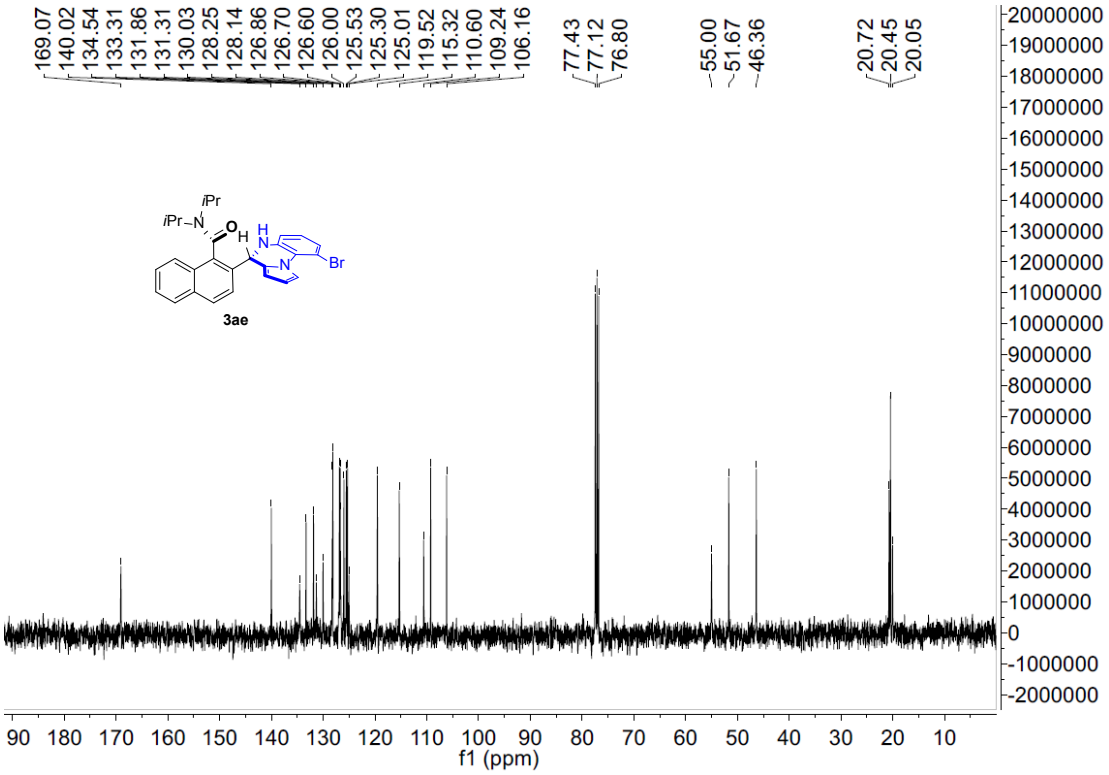
iPr
iPr–N
O
H
H
N
N
Br
3ae
1.02 3.09 3.06 1.00 1.01 1.01 1.00 1.01 1.01 1.03 2.08 3.05 3.05 3.04 3.00
f1 (ppm)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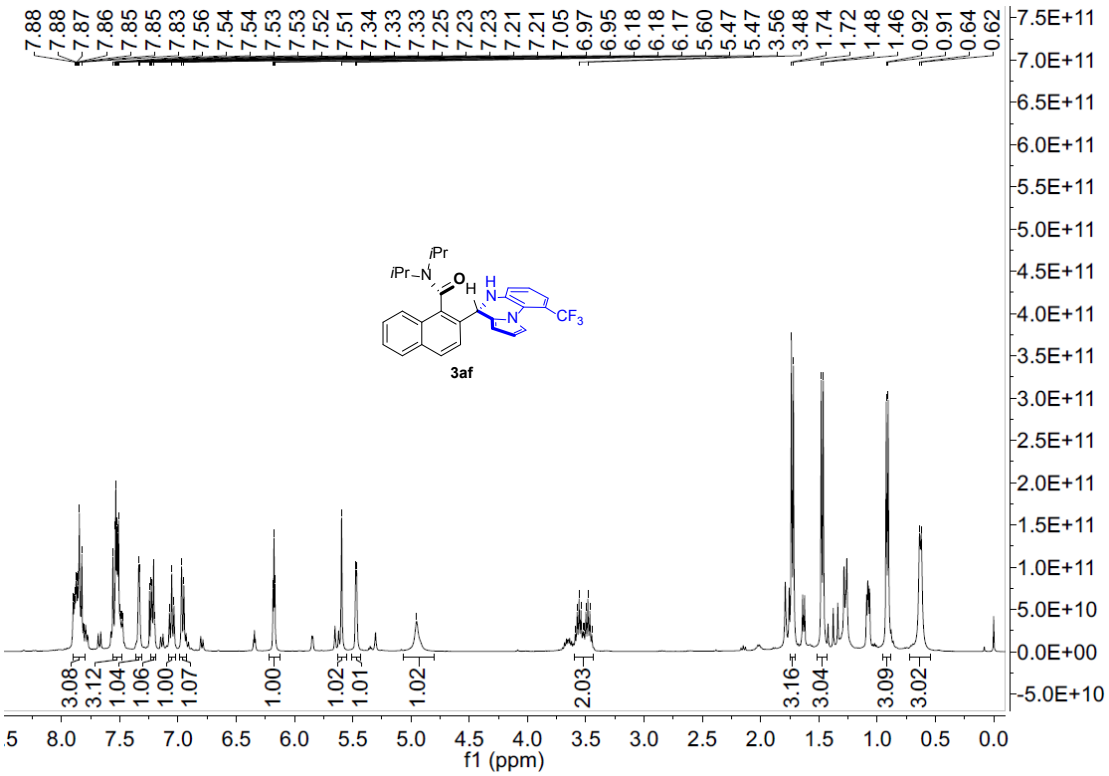
77.43 77.12 76.80
55.00 51.67 46.36
20.72 20.45 20.05
iPr
iPr–N
O
H
H
N
N
Br
3ae
f1 (ppm)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3.48
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1.72
1.48
1.46
0.92
0.91
0.64
0.62
iPr
iPr–N
O
H
H
N
N
CF3
3af
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3.12
1.04
1.06
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3.04
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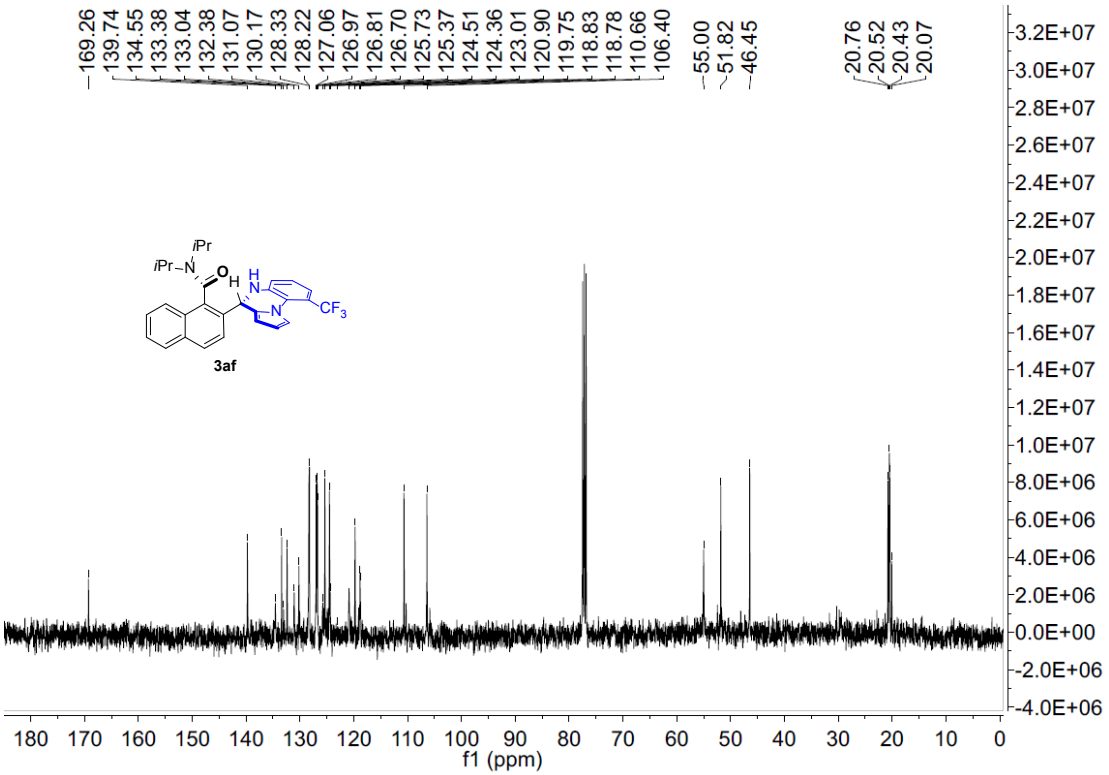
3.02
f1 (ppm)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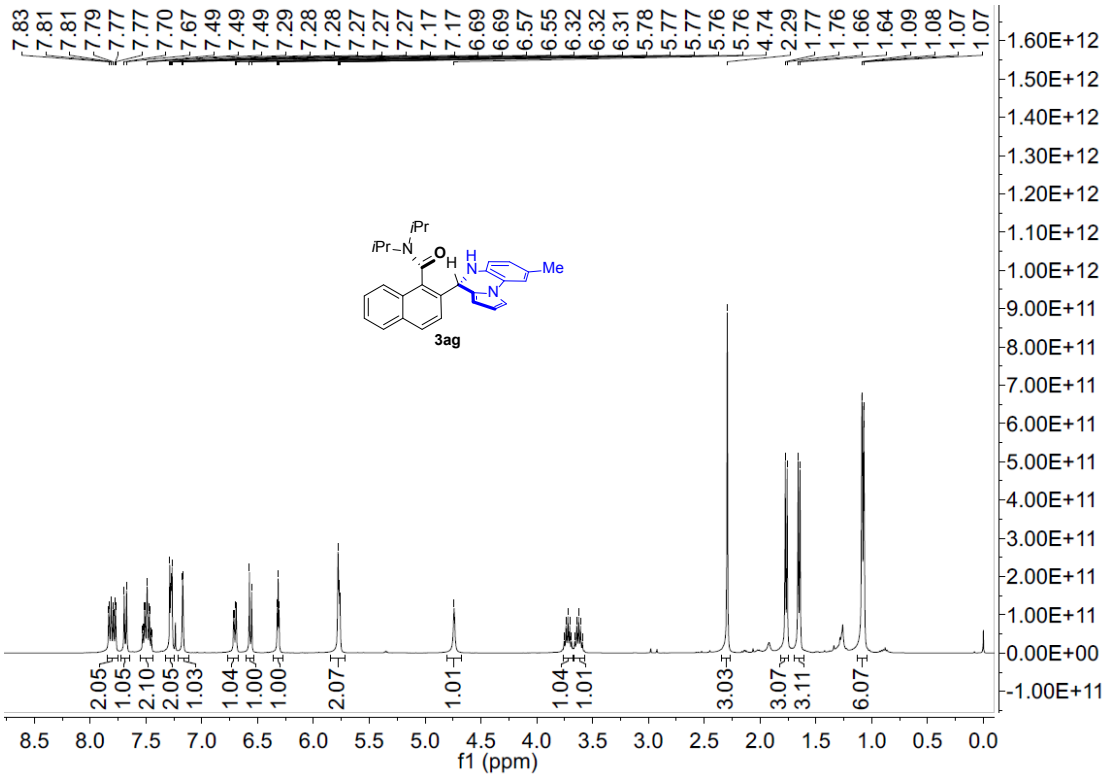
N
N
CF3
3af
f1 (ppm)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1.77
1.76
1.66
1.64
1.09
1.08
1.07
1.07
iPr
iPr
N
O
H
H
N
Me
N
3ag
2.05
1.05
2.10
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1.03
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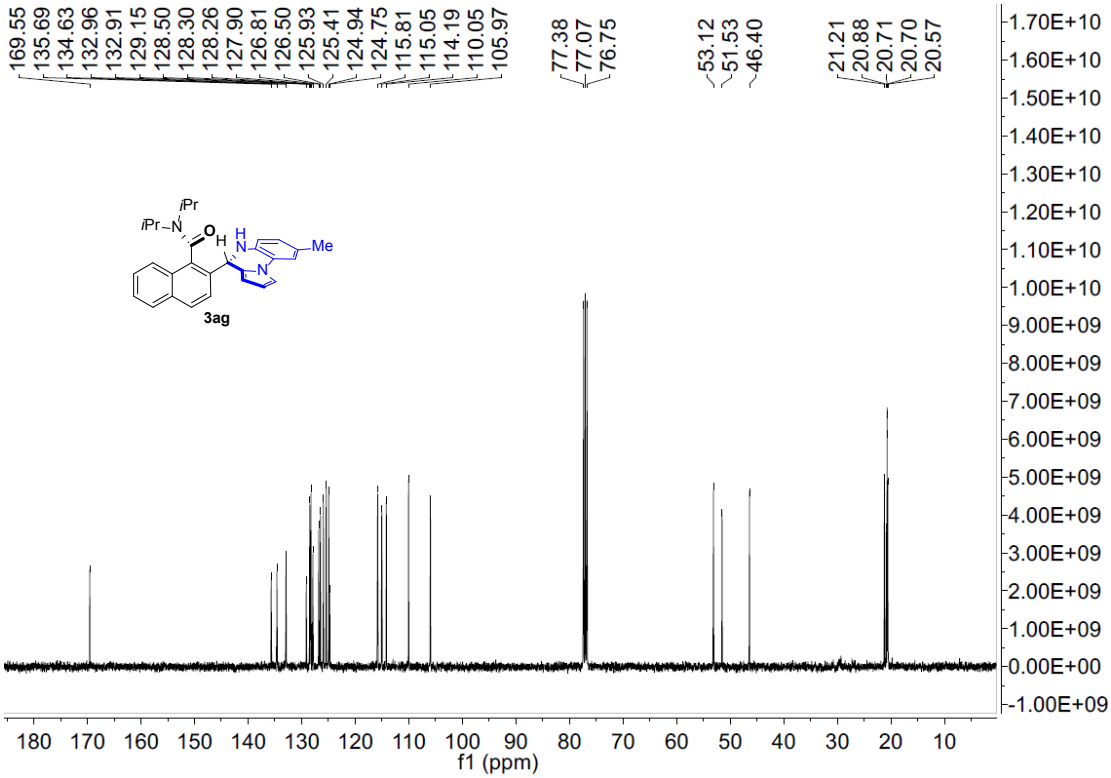
f1 (ppm)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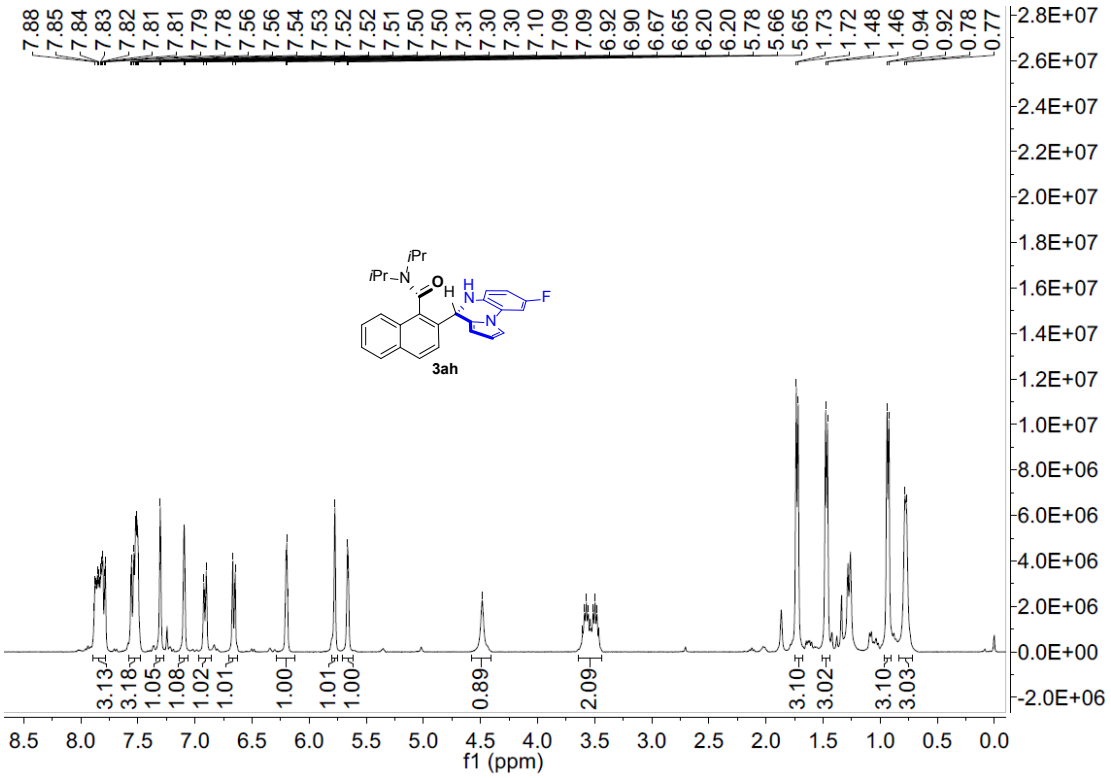
125.41
124.94
124.75
115.81
115.05
114.19
110.05
105.97
77.38
77.07
76.75
53.12
51.53
46.40
21.21
20.88
20.71
20.70
20.57
iPr
iPr
N
O
H
H
N
Me
N
3ag
f1 (ppm)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3ah
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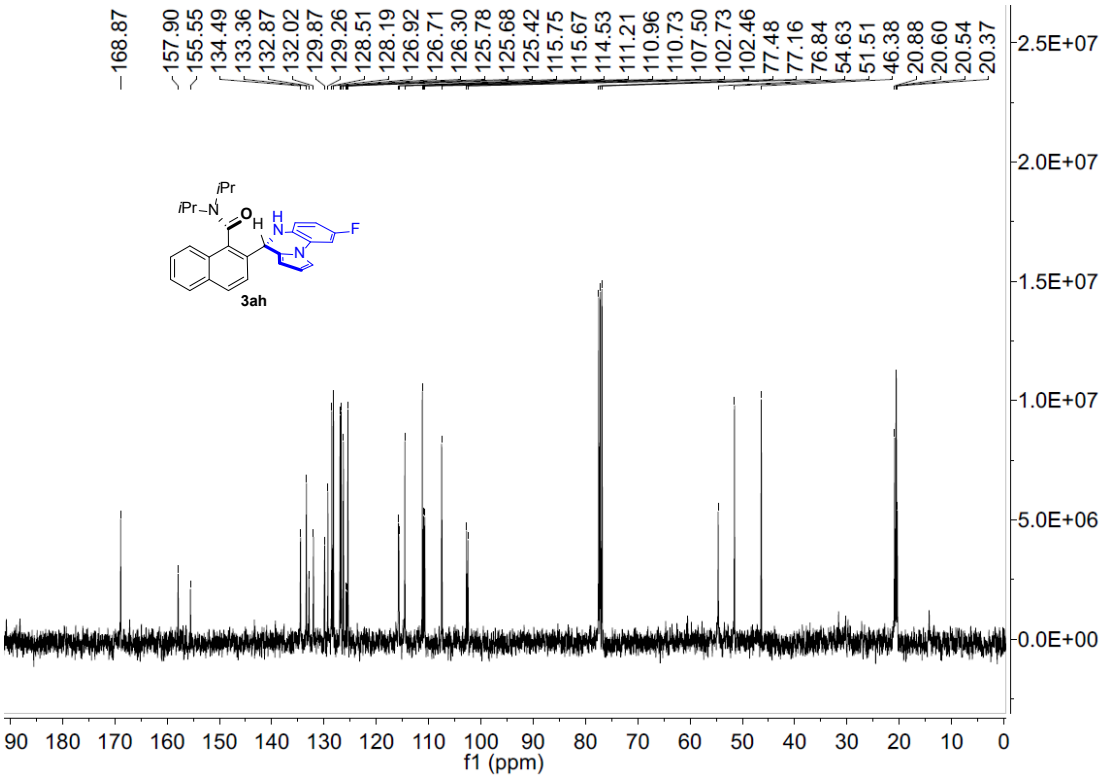
f1 (ppm)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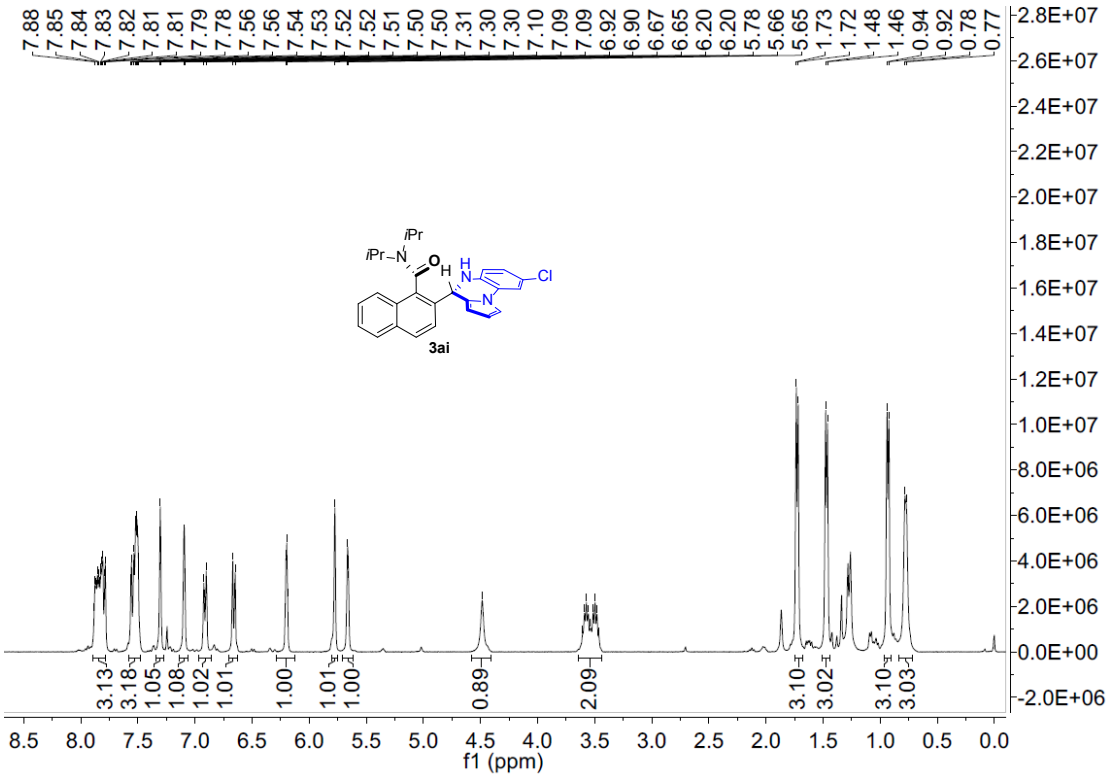
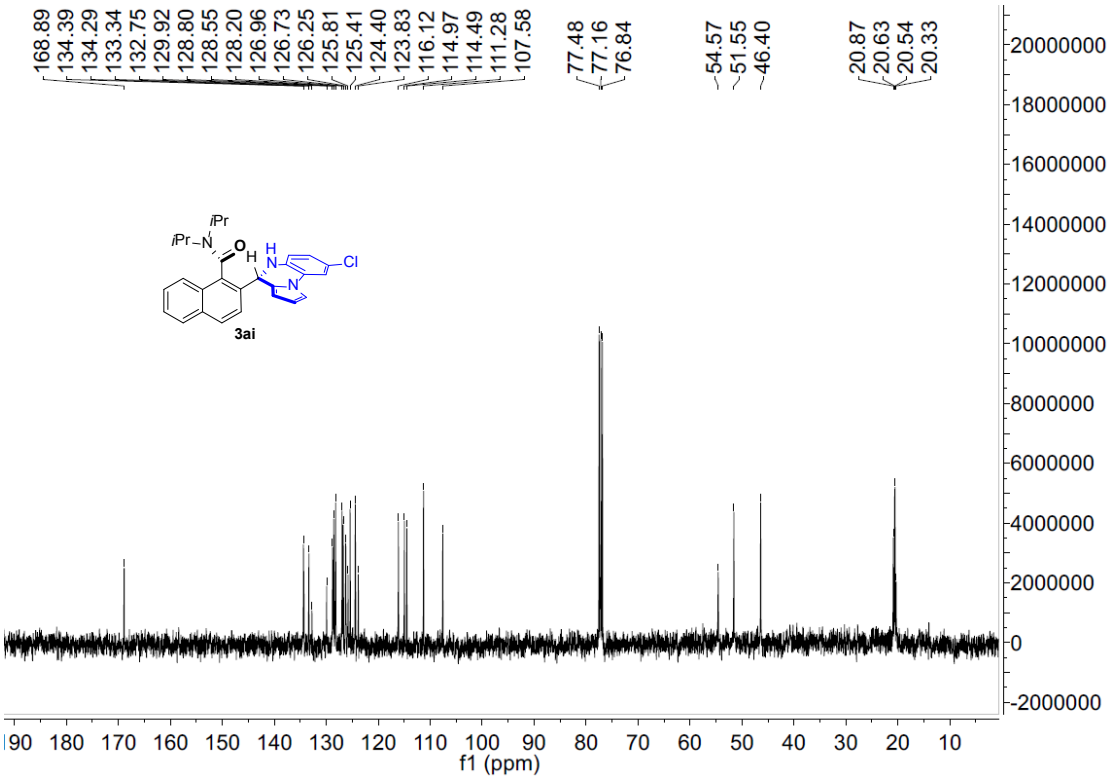
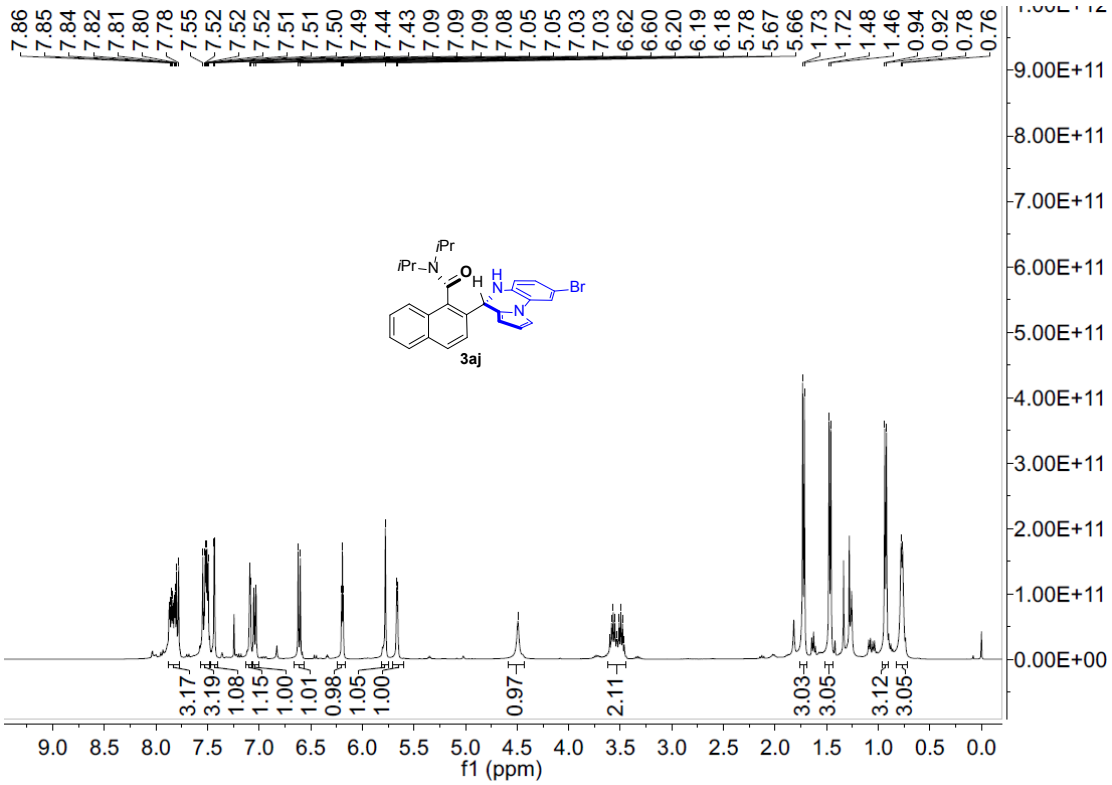
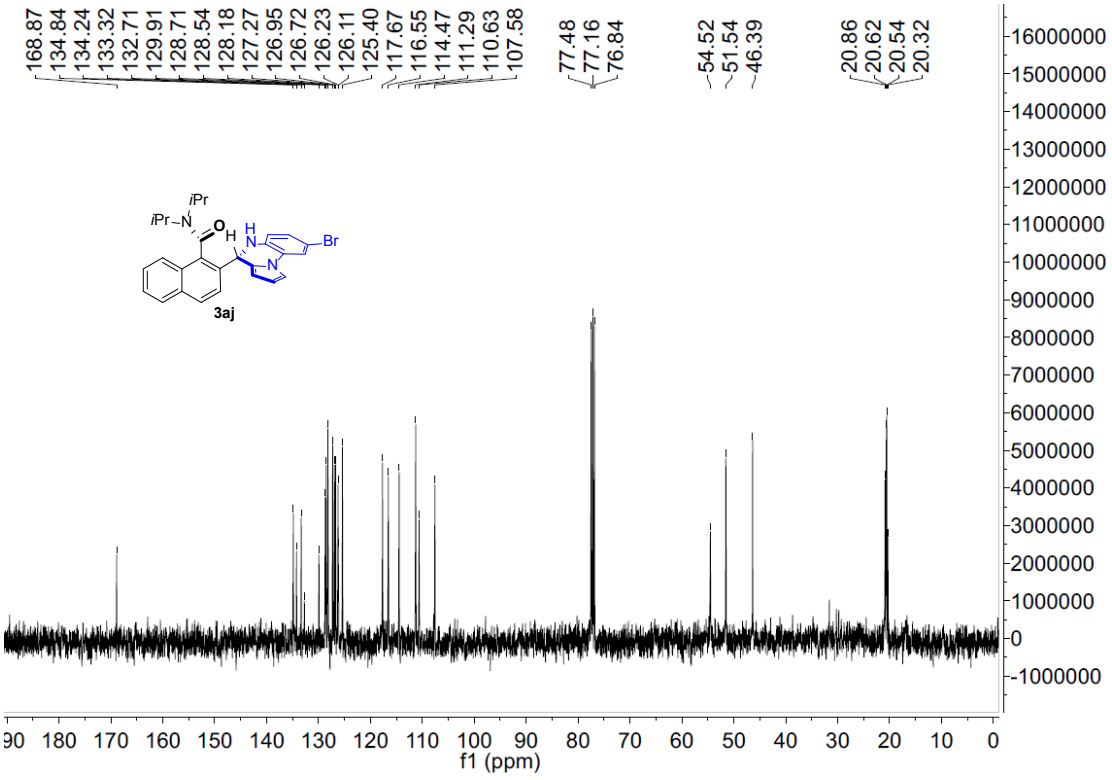
3ah
f1 (ppm)


7.88 7.85 7.84 7.83 7.82 7.81 7.81 7.79 7.78 7.56 7.56 7.54 7.53 7.52 7.52 7.51 7.50 7.50 7.31 7.30 7.30 7.10 7.09 7.09 6.92 6.90 6.67 6.65 6.20 6.20 5.78 5.66 5.65 1.73 1.72 1.48 1.46 0.94 0.92 0.78 0.77
iPr
iPr–N
O
H
H
N
Cl
N
3ai
3.13 3.18 1.05 1.08 1.02 1.01 1.00 1.01 1.00 0.89 2.09 3.10 3.02 3.10 3.03
f1 (ppm)


168.89 134.39 134.29 133.34 132.75 129.92 128.80 128.55 128.20 126.96 126.73 126.25 125.81 125.41 124.40 123.83 116.12 114.97 114.49 111.28 107.58
77.48 77.16 76.84
54.57 51.55 46.40
20.87 20.63 20.54 20.33
iPr
iPr–N
O
H
H
N
Cl
N
3ai
f1 (ppm)


7.86 7.85 7.84 7.82 7.81 7.80 7.78 7.55 7.52 7.52 7.52 7.51 7.51 7.50 7.49 7.44 7.43 7.09 7.09 7.09 7.08 7.05 7.05 7.03 7.03 6.62 6.60 6.20 6.19 6.18 5.78 5.67 5.66 1.73 1.72 1.48 1.46 0.94 0.92 0.78 0.76
iPr
iPr–N
O
H
H
N
N
Br
3aj
3.17 3.19 1.08 1.15 1.00 1.01 0.98 1.05 1.00 0.97 2.11 3.03 3.05 3.12 3.05
f1 (ppm)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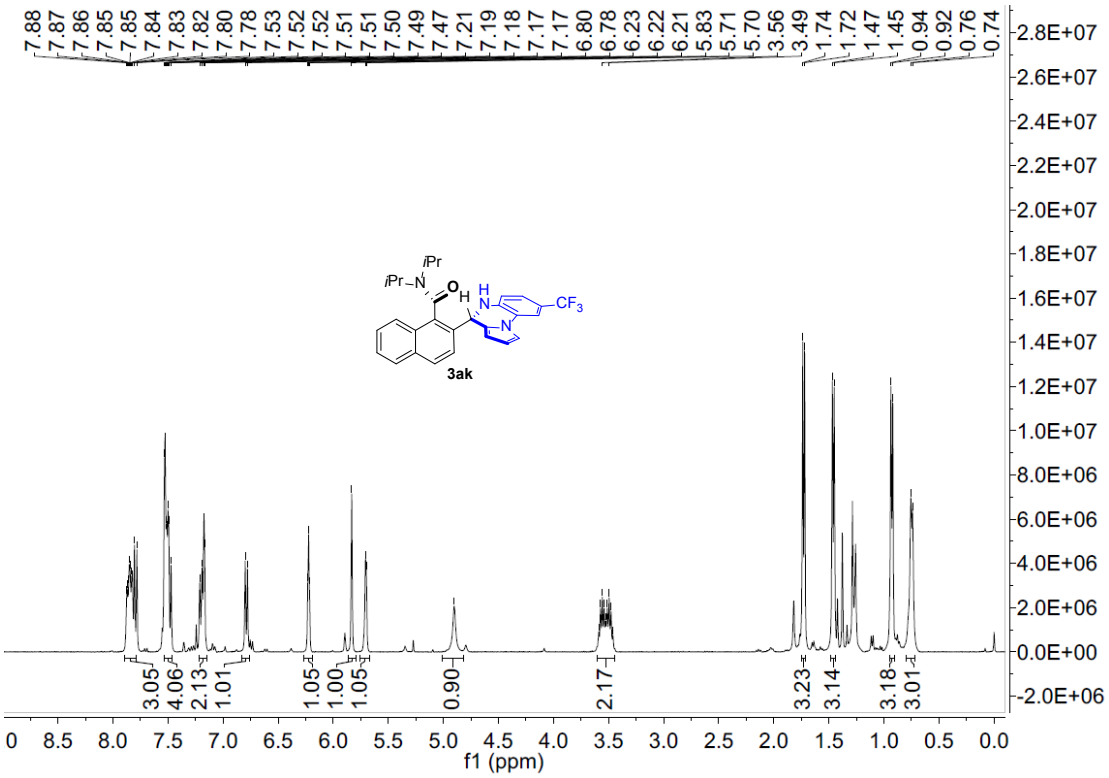
77.48 77.16 76.84
54.52 51.54 46.39
20.86 20.62 20.54 20.32
iPr
iPr–N
O
H
H
N
N
Br
3aj
f1 (ppm)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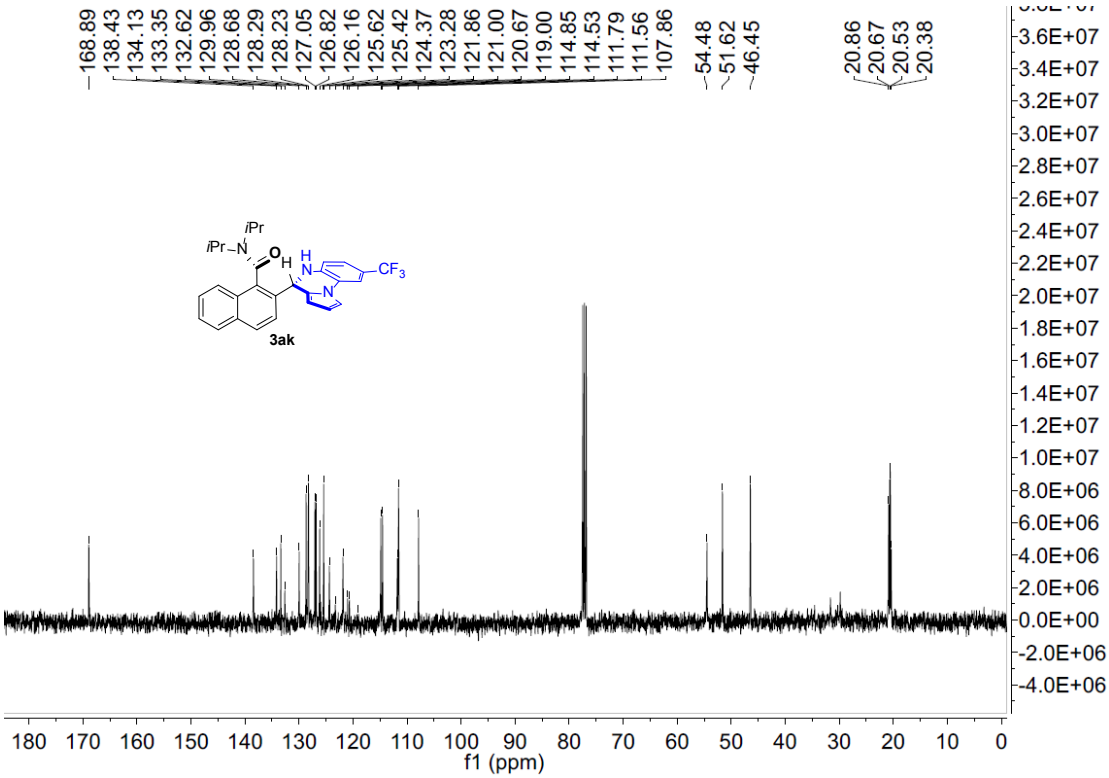
7.87
7.86
7.85
7.85
7.84
7.83
7.82
7.80
7.78
7.53
7.52
7.52
7.51
7.51
7.50
7.49
7.47
7.21
7.19
7.18
7.17
7.17
6.80
6.78
6.23
6.22
6.21
5.83
5.71
5.70
3.56
3.49
1.74
1.72
1.47
1.45
0.94
0.92
0.76
0.74
iPr
iPr–N
O
H
H
N
CF3
N
3ak
3.05
4.06
2.13
1.01
1.05
1.00
1.05
0.90
2.17
3.23
3.14
3.18
3.01
f1 (ppm)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138.43
134.13
133.35
132.62
129.96
128.68
128.29
128.23
127.05
126.82
126.16
125.62
125.42
124.37
123.28
121.86
121.00
120.67
119.00
114.85
114.53
111.79
111.56
107.86
54.48
51.62
46.45
20.86
20.67
20.53
20.38
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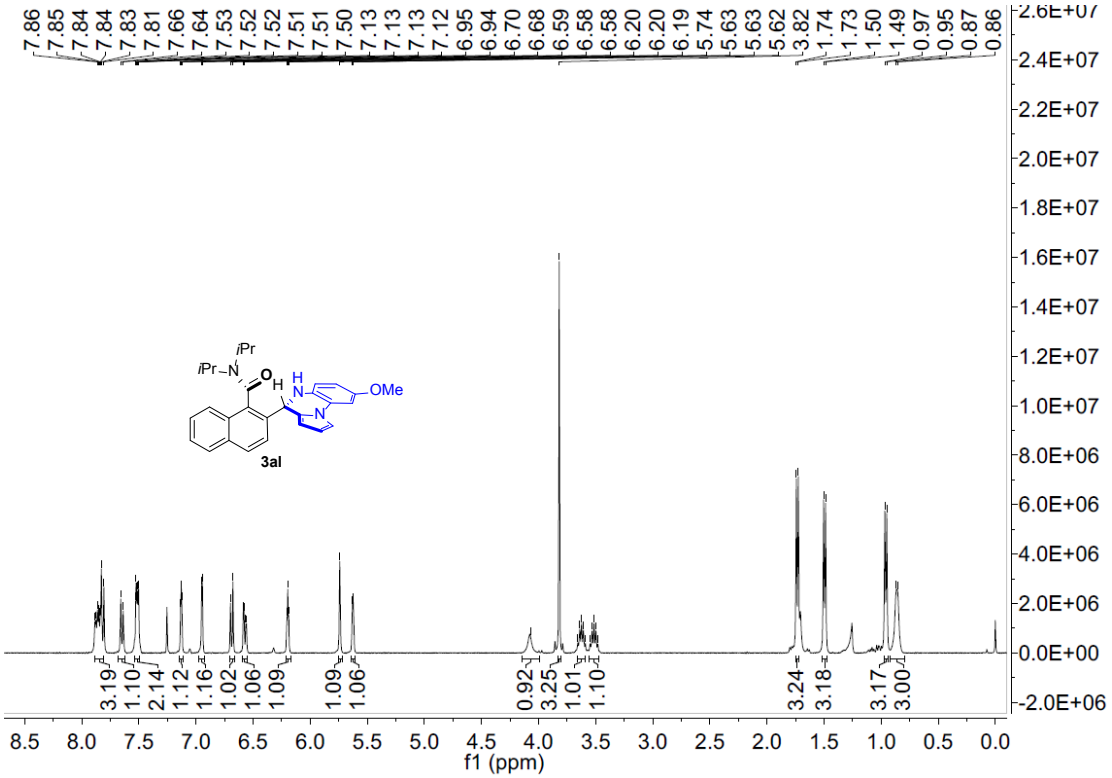
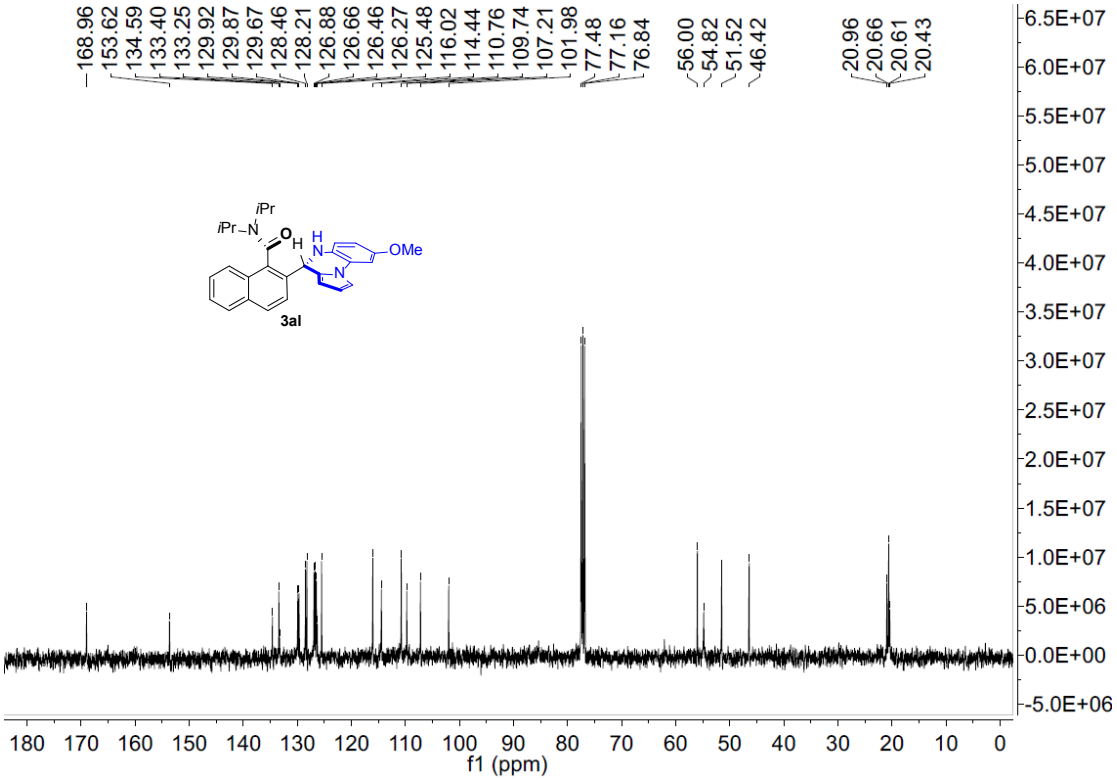
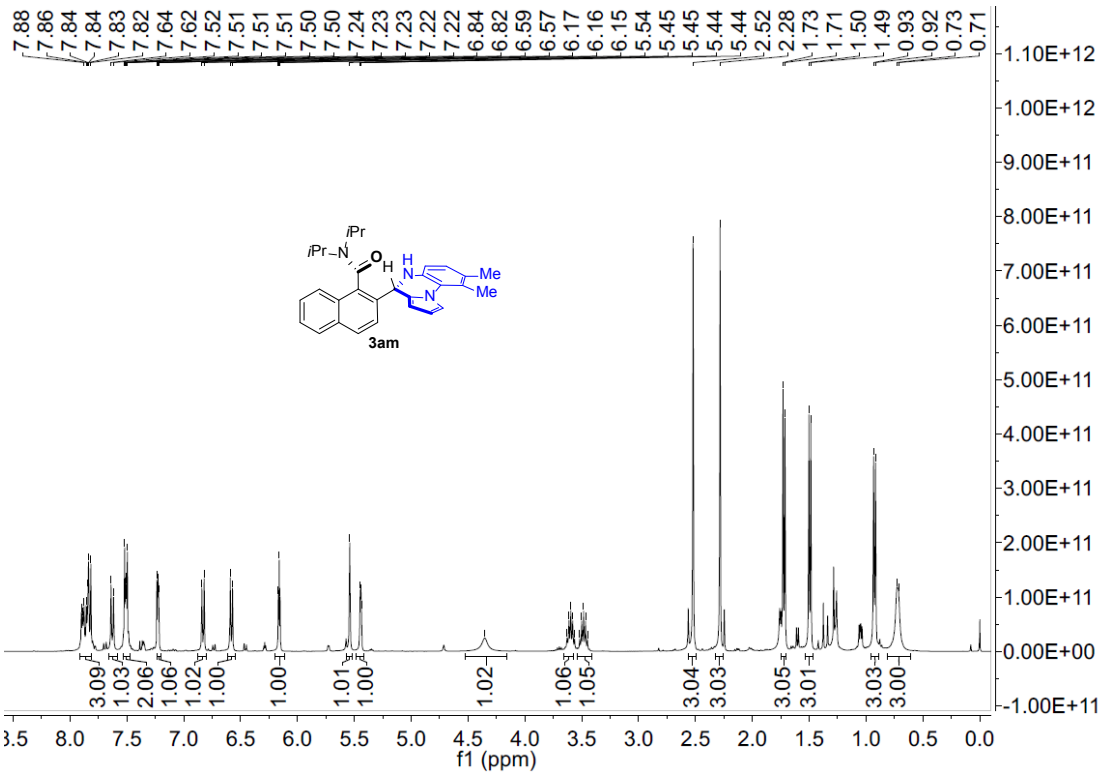
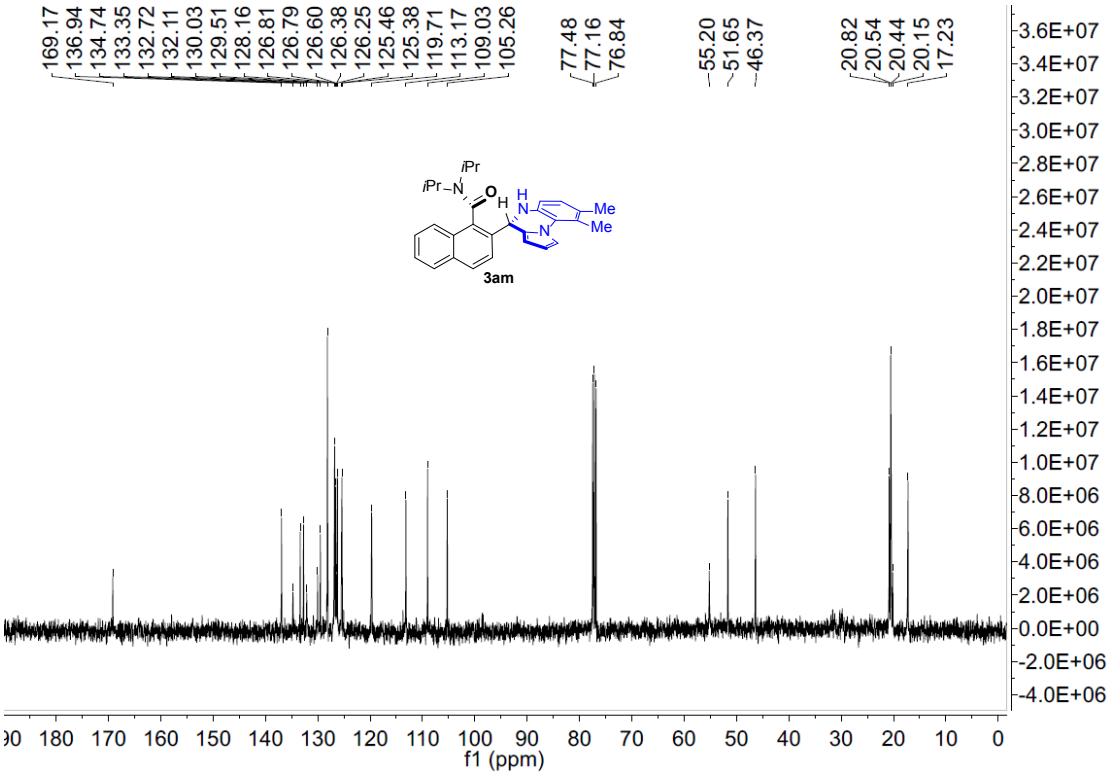
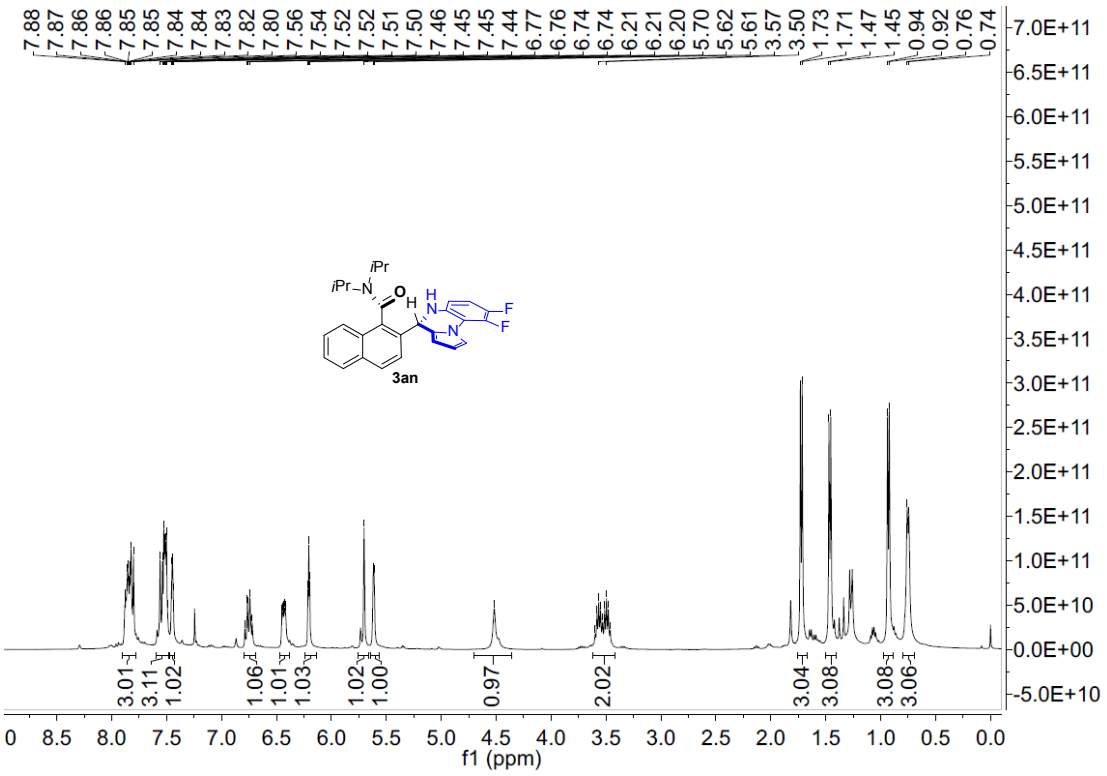
O
H
H
N
CF3
N
3ak
f1 (ppm)

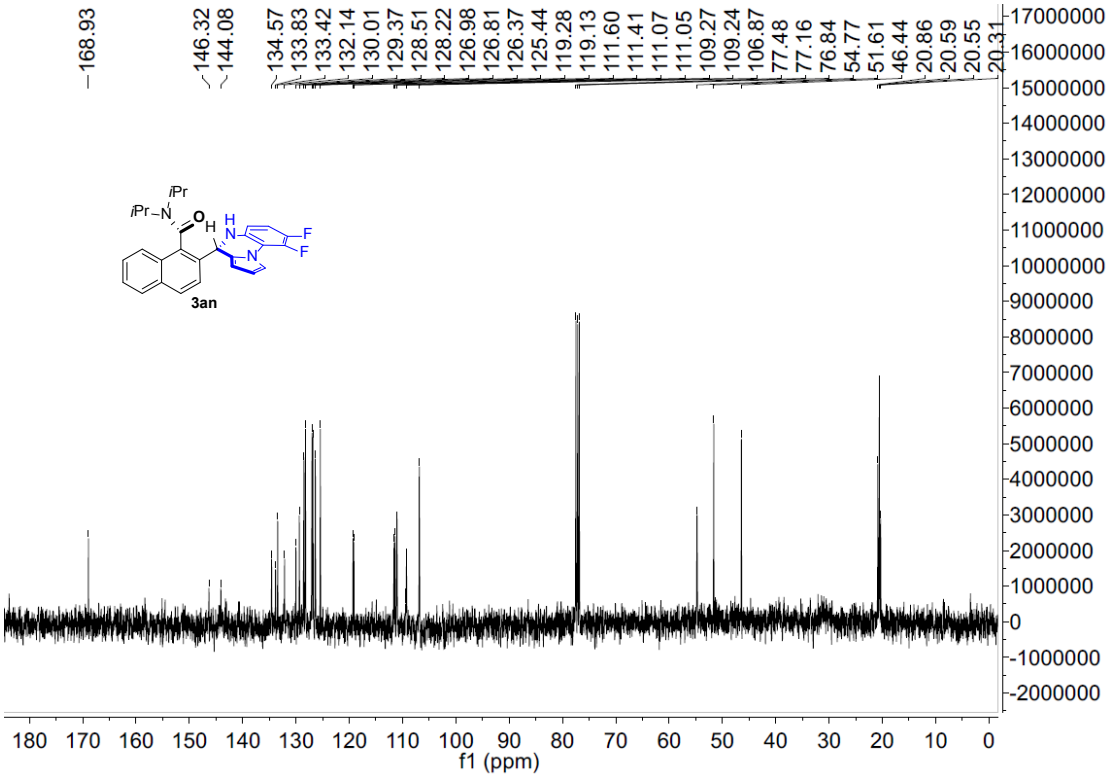

7.86 7.85 7.84 7.84 7.83 7.81 7.66 7.64 7.53 7.52 7.52 7.51 7.51 7.50 7.13 7.13 7.13 7.12 6.95 6.94 6.70 6.68 6.59 6.58 6.58 6.20 6.20 6.19 5.74 5.63 5.63 5.62 3.82 1.74 1.73 1.50 1.49 0.97 0.95 0.87 0.86
iPr
iPr–N
O
H
H
N
N
OMe
3al
3.19 1.10 2.14 1.12 1.16 1.02 1.06 1.09 1.09 1.06 0.92 3.25 1.01 1.10 3.24 3.18 3.17 3.00
f1 (ppm)

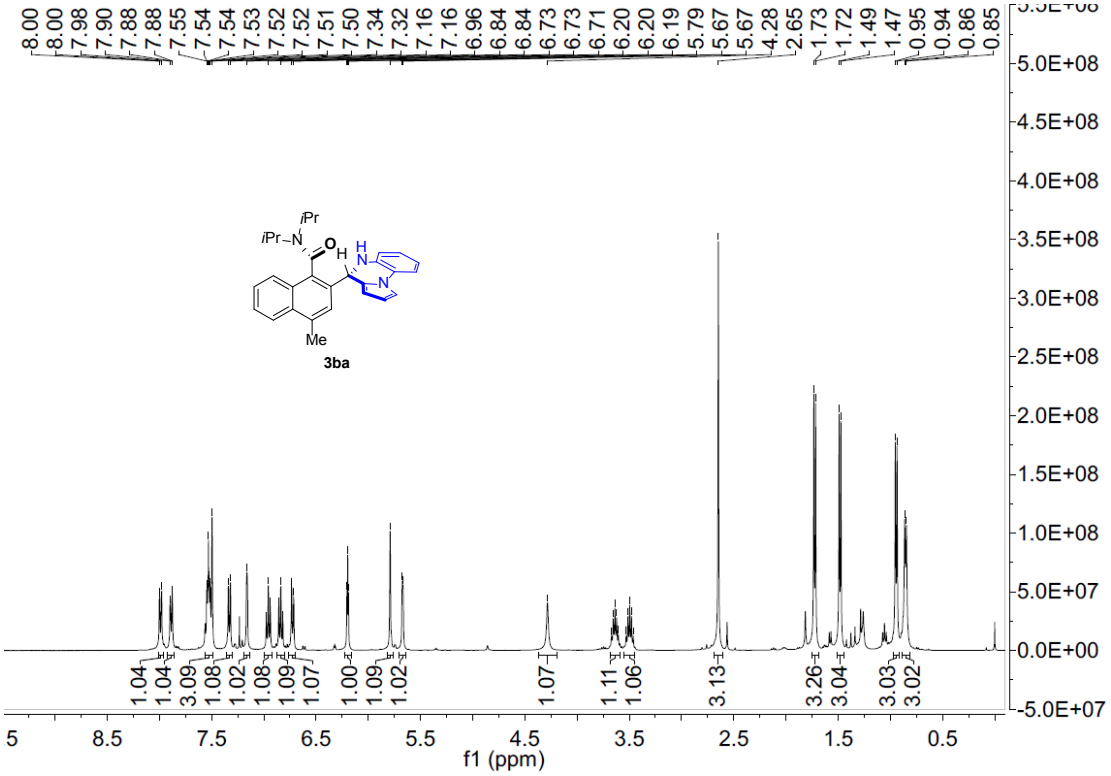

168.96 153.62 134.59 133.40 133.25 129.92 129.87 129.67 128.46 128.21 126.88 126.66 126.46 126.27 125.48 116.02 114.44 110.76 109.74 107.21 101.98 77.48 77.16 76.84 56.00 54.82 51.52 46.42 20.96 20.66 20.61 20.43
iPr
iPr–N
O
H
H
N
N
OMe
3al
f1 (ppm)

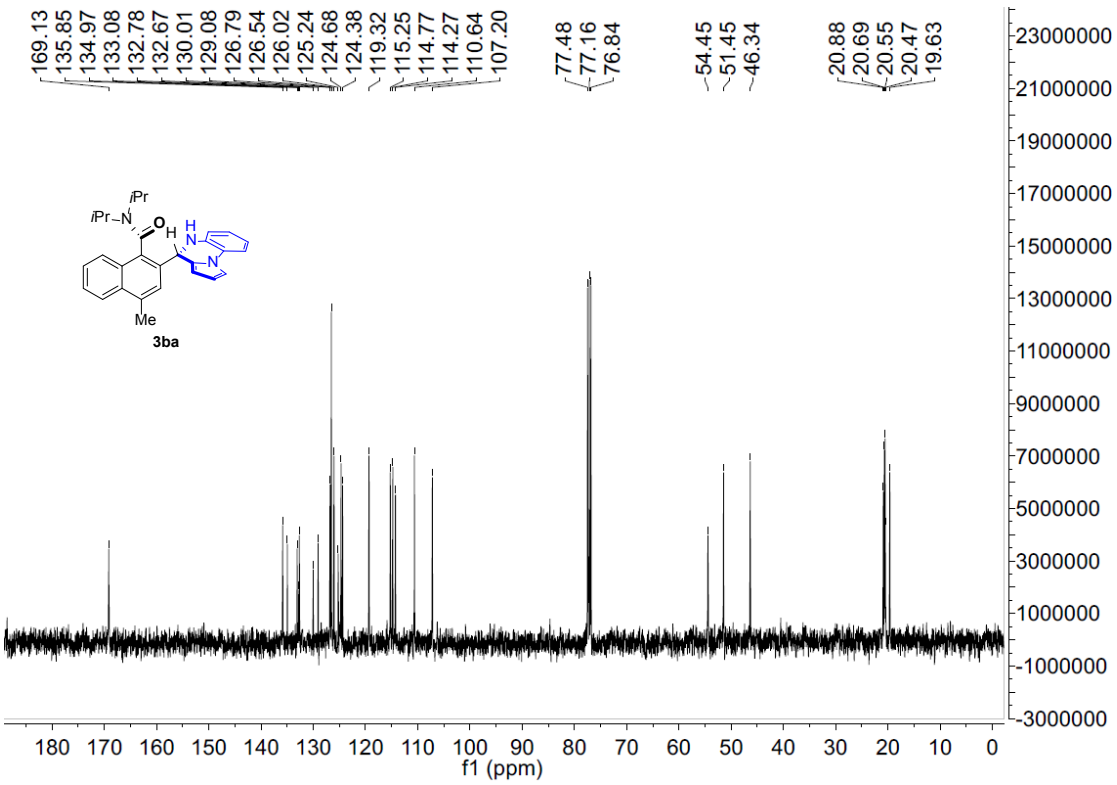

7.88 7.86 7.84 7.84 7.83 7.82 7.64 7.62 7.52 7.51 7.51 7.51 7.50 7.50 7.24 7.23 7.23 7.22 7.22 6.84 6.82 6.59 6.57 6.17 6.16 6.15 5.54 5.45 5.44 5.44 2.52 2.28 1.73 1.71 1.50 1.49 0.93 0.92 0.73 0.71
3.09 1.03 2.06 1.06 1.02 1.00 1.00 1.01 1.00 1.02 1.06 1.05 3.04 3.03 3.05 3.01 3.03 3.00
f1 (ppm)
3am

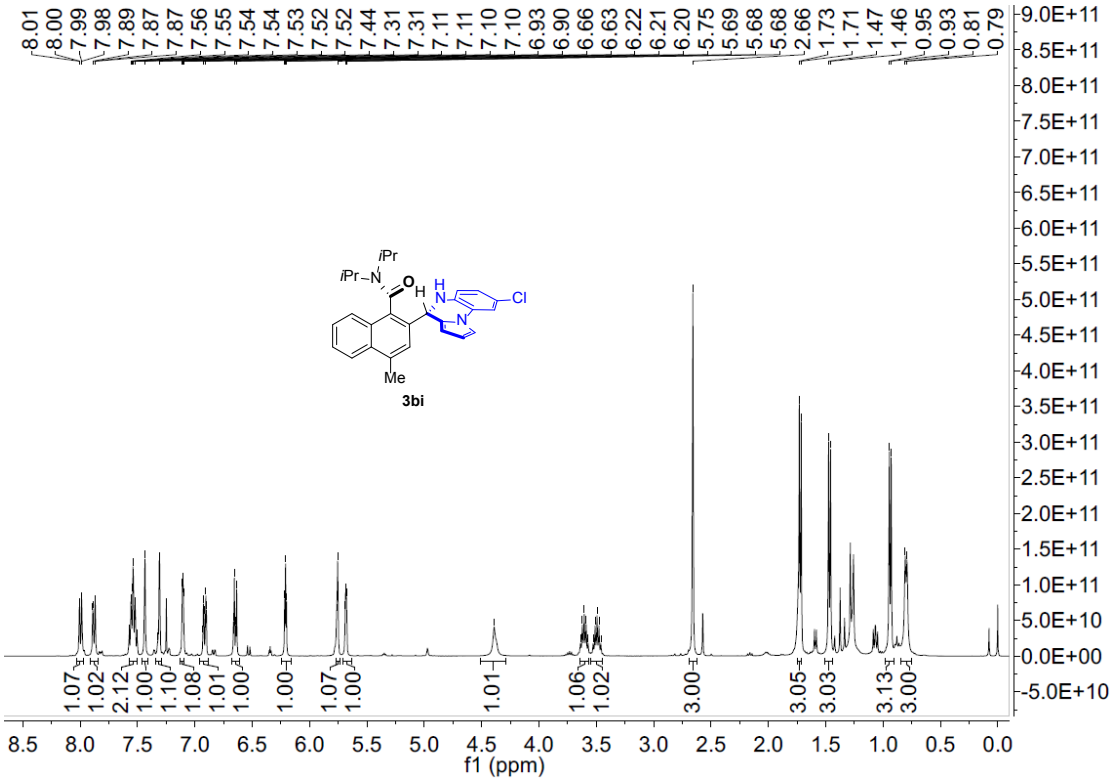

169.17 136.94 134.74 133.35 132.72 132.11 130.03 129.51 128.16 126.81 126.79 126.60 126.38 126.25 125.46 125.38 119.71 113.17 109.03 105.26
77.48 77.16 76.84
55.20 51.65 46.37
20.82 20.54 20.44 20.15 17.23
f1 (ppm)
3am

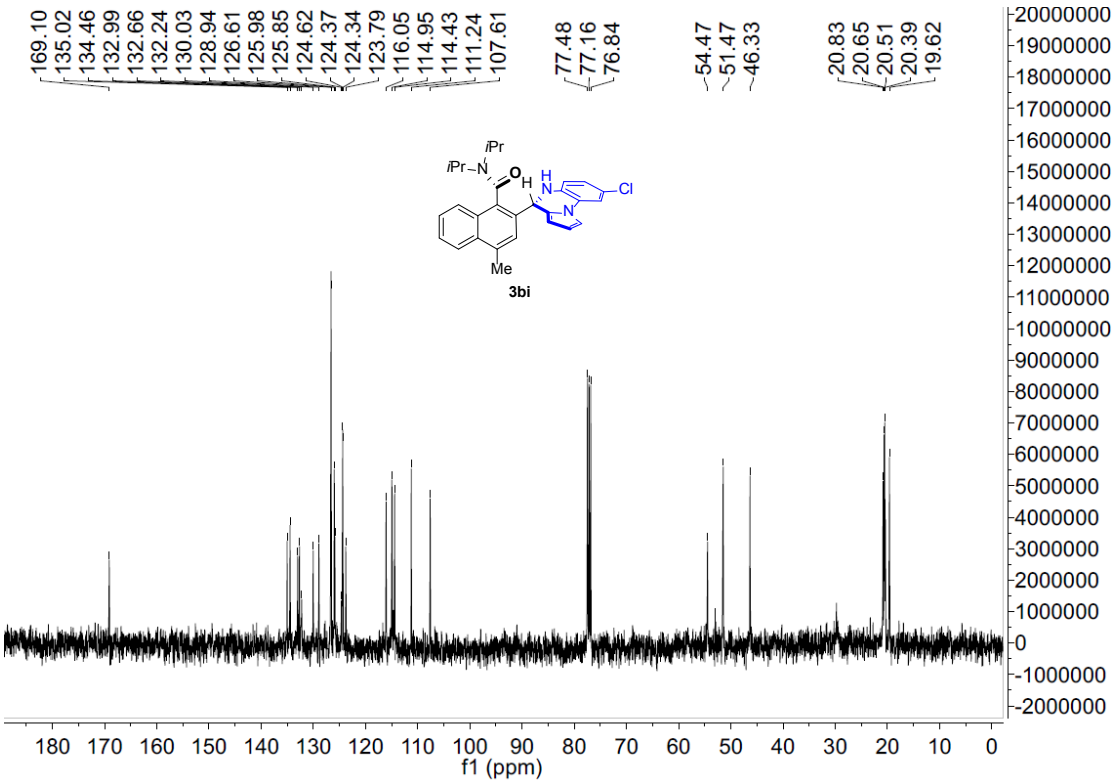

7.88 7.87 7.86 7.86 7.85 7.85 7.84 7.84 7.83 7.82 7.80 7.56 7.54 7.52 7.52 7.51 7.50 7.46 7.45 7.45 7.44 6.77 6.76 6.74 6.74 6.21 6.21 6.20 5.70 5.62 5.61 3.57 3.50 1.73 1.71 1.47 1.45 0.94 0.92 0.76 0.74
3an
3.01 3.11 1.02 1.06 1.01 1.03 1.02 1.00 0.97 2.02 3.04 3.08 3.08 3.06
f1 (ppm)

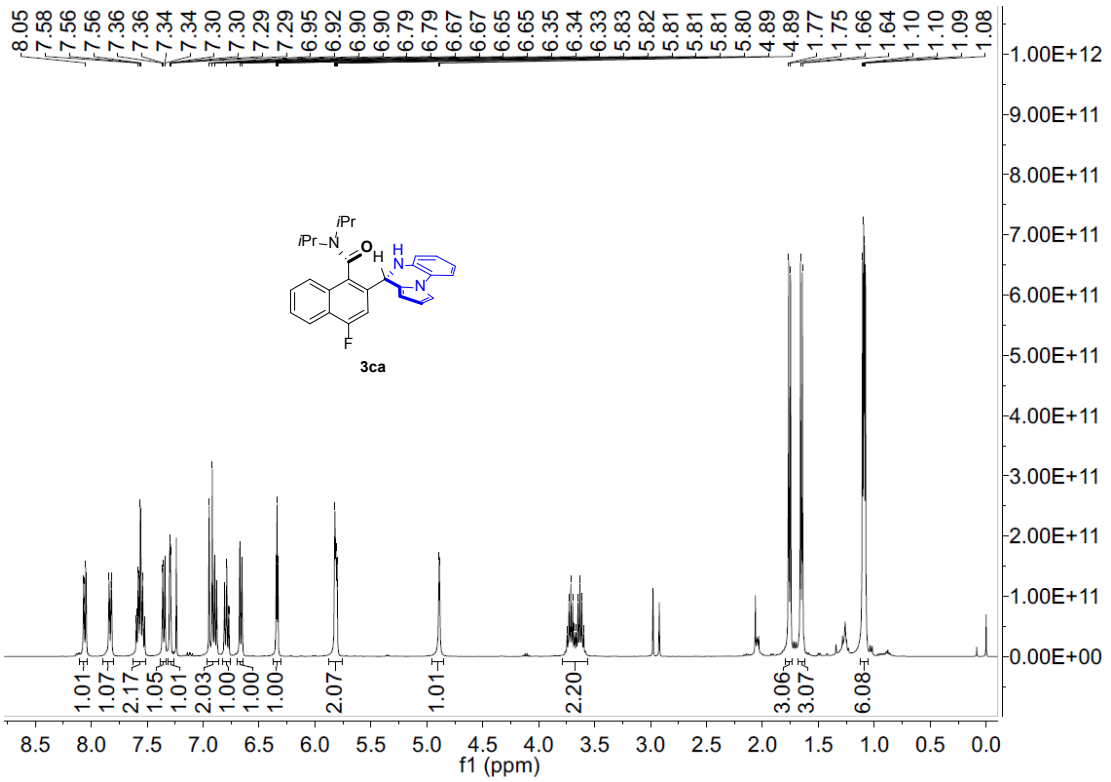

168.93 146.32 144.08 134.57 133.83 133.42 132.14 130.01 129.37 128.51 128.22 126.98 126.81 126.37 125.44 119.28 119.13 111.60 111.41 111.07 111.05 109.27 109.24 106.87 77.48 77.16 76.84 54.77 51.61 46.44 20.86 20.59 20.55 20.31
3an
f1 (ppm)

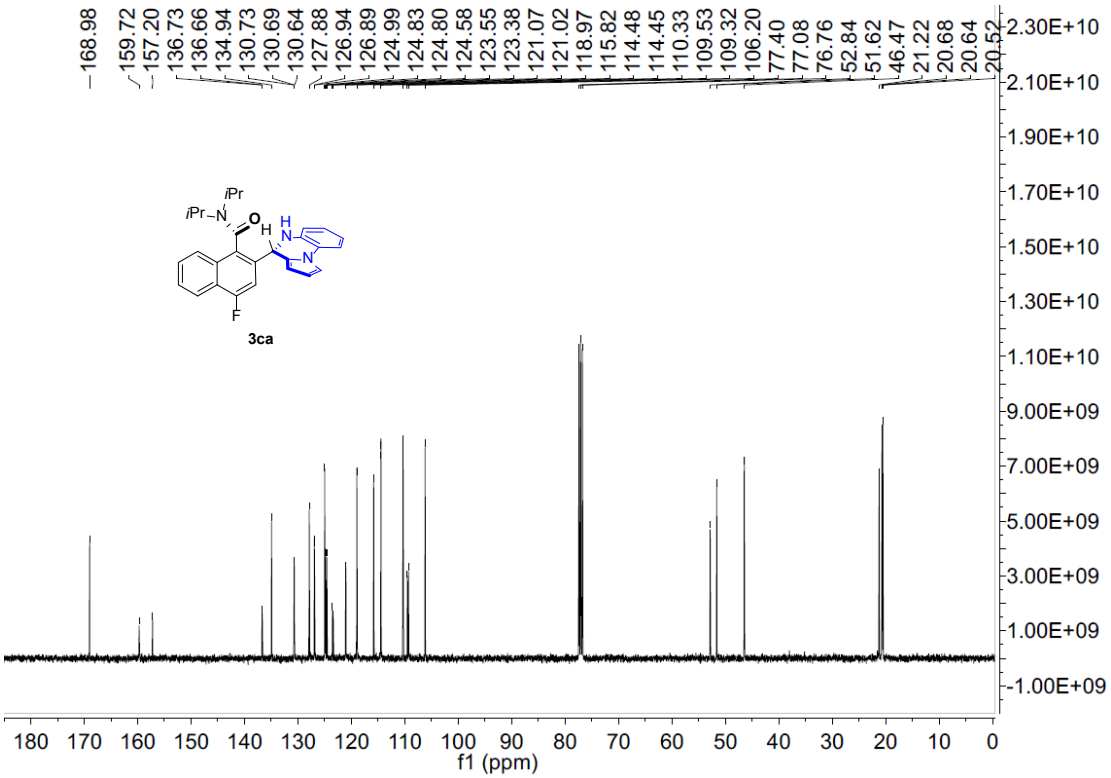

8.00 8.00 7.98 7.90 7.88 7.88 7.55 7.54 7.54 7.53 7.52 7.52 7.51 7.50 7.34 7.32 7.16 7.16 6.96 6.84 6.84 6.73 6.73 6.71 6.20 6.20 6.19 5.79 5.67 5.67 4.28 2.65 1.73 1.72 1.49 1.47 0.95 0.94 0.86 0.85
iPr
iPr
N
O
H
H
N
N
Me
3ba
1.04 1.04 3.09 1.08 1.02 1.08 1.09 1.07 1.00 1.09 1.02 1.07 1.11 1.06 3.13 3.26 3.04 3.03 3.02
5.0E+08
4.5E+08
4.0E+08
3.5E+08
3.0E+08
2.5E+08
2.0E+08
1.5E+08
1.0E+08
5.0E+07
0.0E+00
-5.0E+07
5 8.5 7.5 6.5 5.5 4.5 3.5 2.5 1.5 0.5
f1 (ppm)

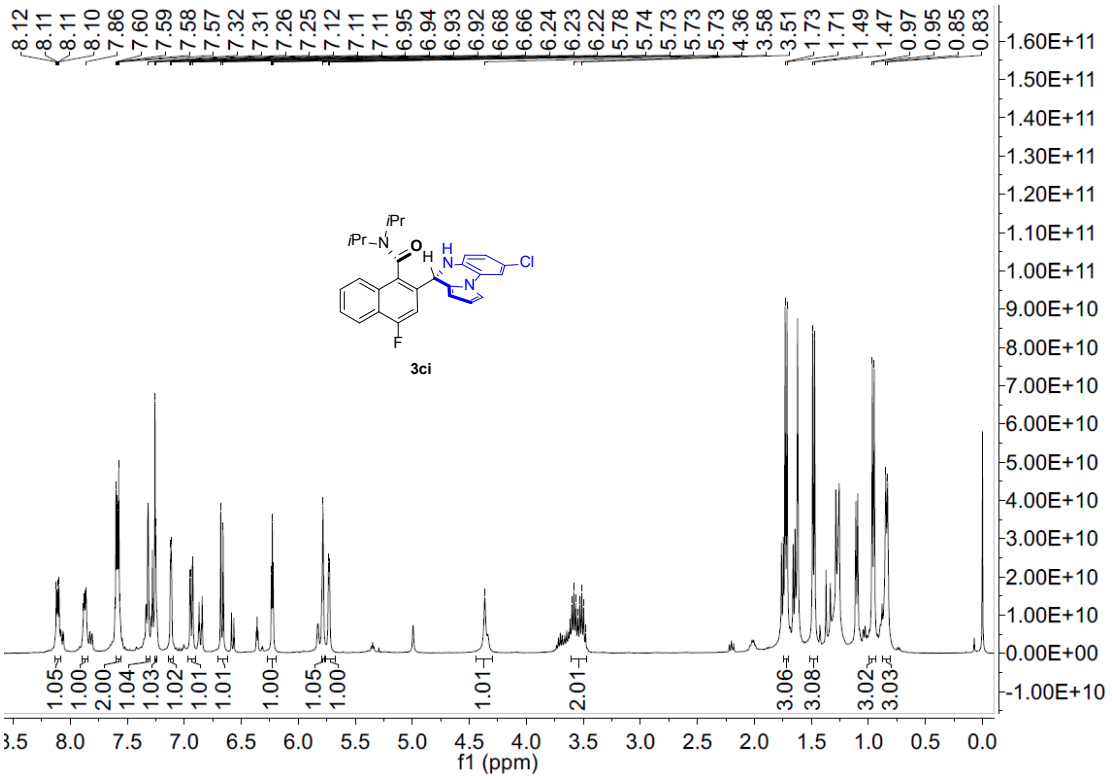

169.13 135.85 134.97 133.08 132.78 132.67 130.01 129.08 126.79 126.54 126.02 125.24 124.68 124.38 119.32 115.25 114.77 114.27 110.64 107.20
77.48 77.16 76.84
54.45 51.45 46.34
20.88 20.69 20.55 20.47 19.63
iPr
iPr
N
O
H
H
N
N
Me
3ba
23000000
21000000
19000000
17000000
15000000
13000000
11000000
9000000
7000000
5000000
3000000
1000000
-1000000
-3000000
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

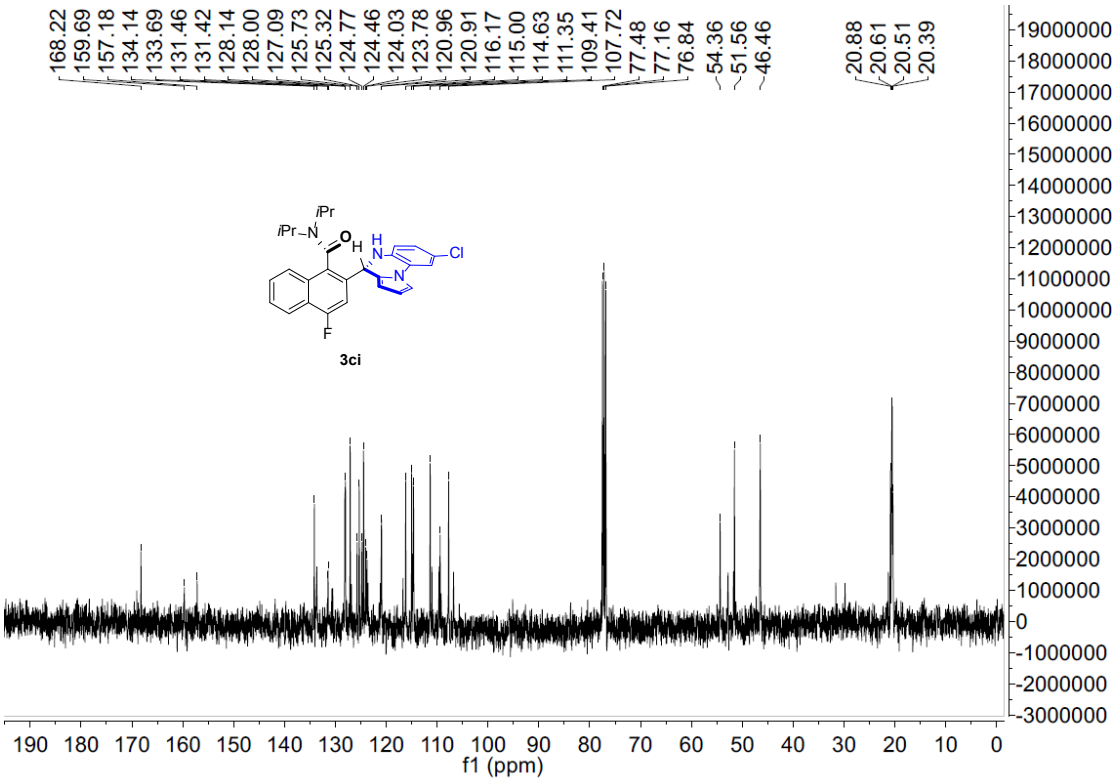

8.01 8.00 7.99 7.98 7.89 7.87 7.87 7.56 7.55 7.54 7.54 7.53 7.52 7.52 7.44 7.31 7.31 7.11 7.11 7.10 7.10 6.93 6.90 6.66 6.63 6.22 6.21 6.20 5.75 5.69 5.68 5.68 2.66 1.73 1.71 1.47 1.46 0.95 0.93 0.81 0.79
iPr
iPr–N
O
H
H
N
Cl
N
Me
3bi
1.07 1.02 2.12 1.00 1.10 1.08 1.01 1.00 1.00 1.07 1.00 1.01 1.06 1.02 3.00 3.05 3.03 3.13 3.00
f1 (ppm)

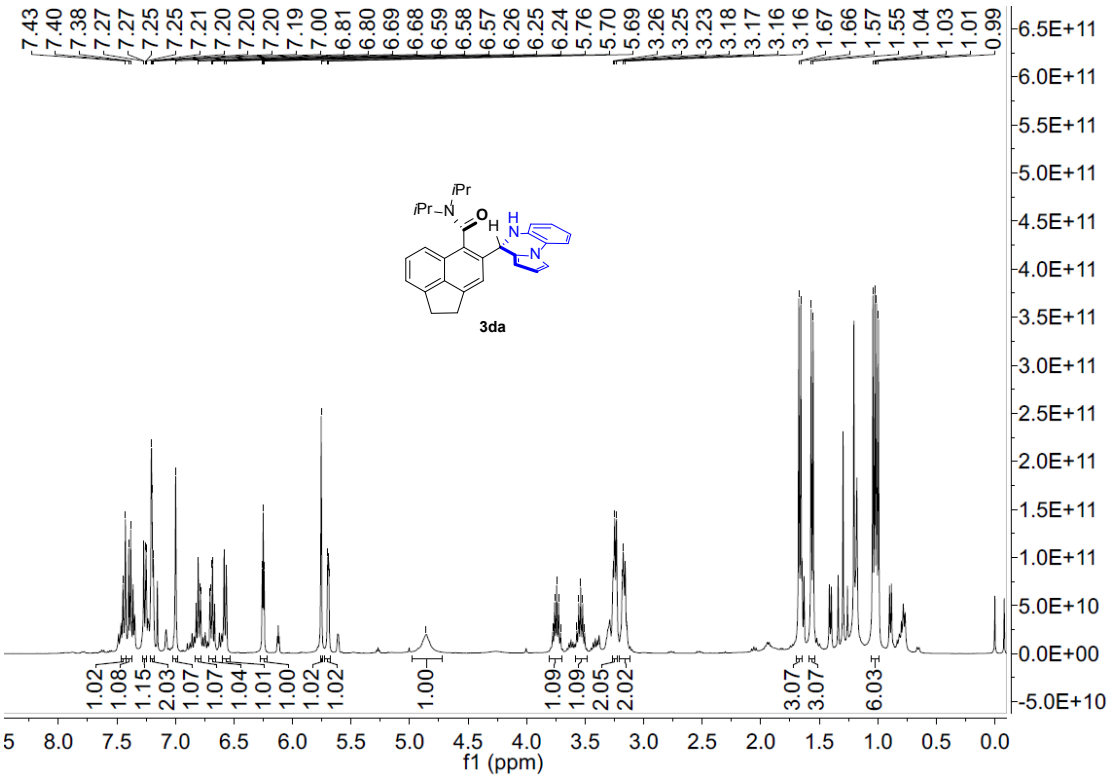

169.10 135.02 134.46 132.99 132.66 132.24 130.03 128.94 126.61 125.98 125.85 124.62 124.37 124.34 123.79 116.05 114.95 114.43 111.24 107.61
77.48 77.16 76.84
54.47 51.47 46.33
20.83 20.65 20.51 20.39 19.62
iPr
iPr–N
O
H
H
N
Cl
N
Me
3bi
f1 (ppm)

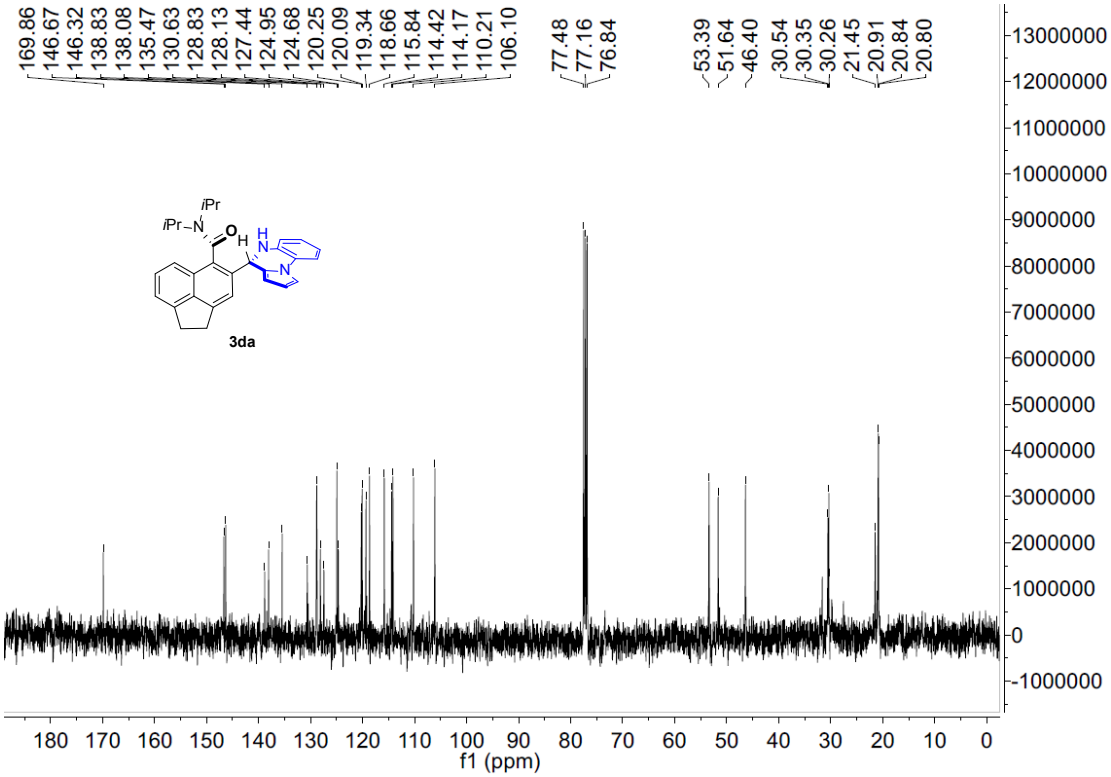

8.05 7.58 7.56 7.56 7.36 7.36 7.34 7.34 7.30 7.30 7.29 7.29 6.95 6.92 6.90 6.90 6.79 6.79 6.67 6.67 6.65 6.65 6.35 6.34 6.33 5.83 5.82 5.81 5.81 5.81 5.80 4.89 4.89 1.77 1.75 1.66 1.64 1.10 1.10 1.09 1.08
iPr
iPr–N
O
H
H
N
N
F
3ca
1.01 1.07 2.17 1.05 1.01 2.03 1.00 1.00 1.00 2.07 1.01 2.20 3.06 3.07 6.08
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)
1.00E+12
9.00E+11
8.00E+11
7.00E+11
6.00E+11
5.00E+11
4.00E+11
3.00E+11
2.00E+11
1.00E+11
0.00E+00

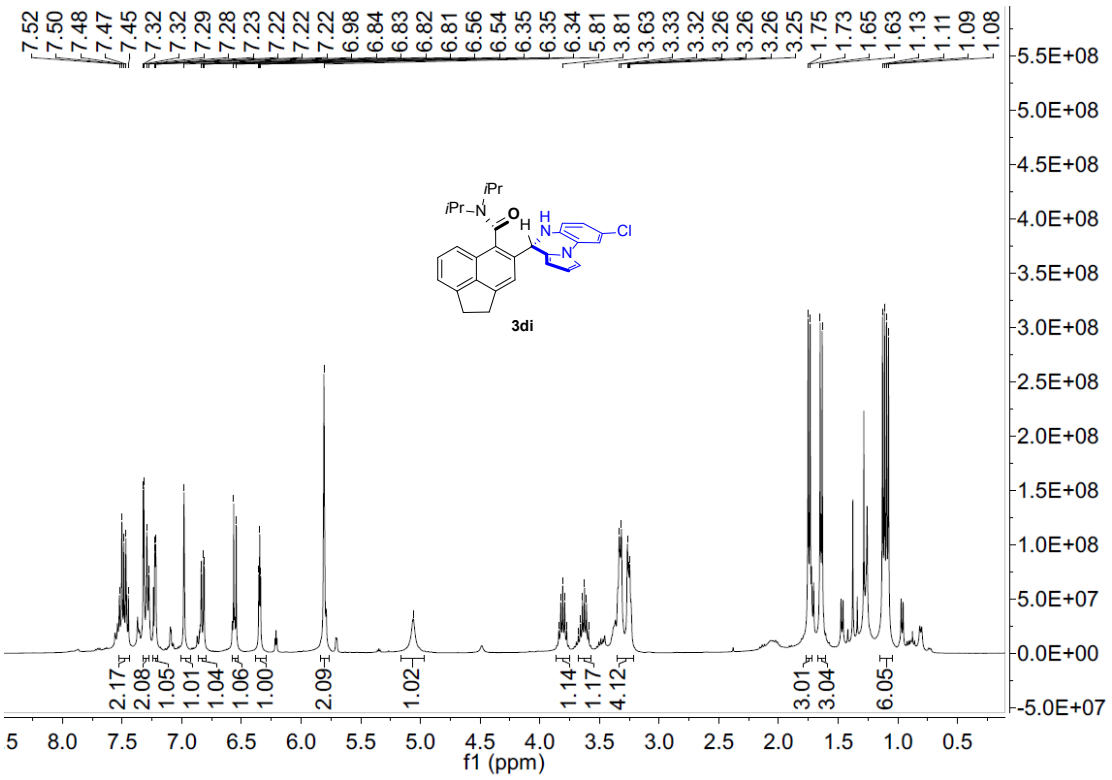

168.98 159.72 157.20 136.73 136.66 134.94 130.73 130.69 130.64 127.88 126.94 126.89 124.99 124.83 124.80 124.58 123.55 123.38 121.07 121.02 118.97 115.82 114.48 114.45 110.33 109.53 109.32 106.20 77.40 77.08 76.76 52.84 51.62 46.47 21.22 20.68 20.64 20.52
iPr
iPr–N
O
H
H
N
N
F
3ca
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)
2.30E+10
2.10E+10
1.90E+10
1.70E+10
1.50E+10
1.30E+10
1.10E+10
9.00E+09
7.00E+09
5.00E+09
3.00E+09
1.00E+09
-1.00E+09

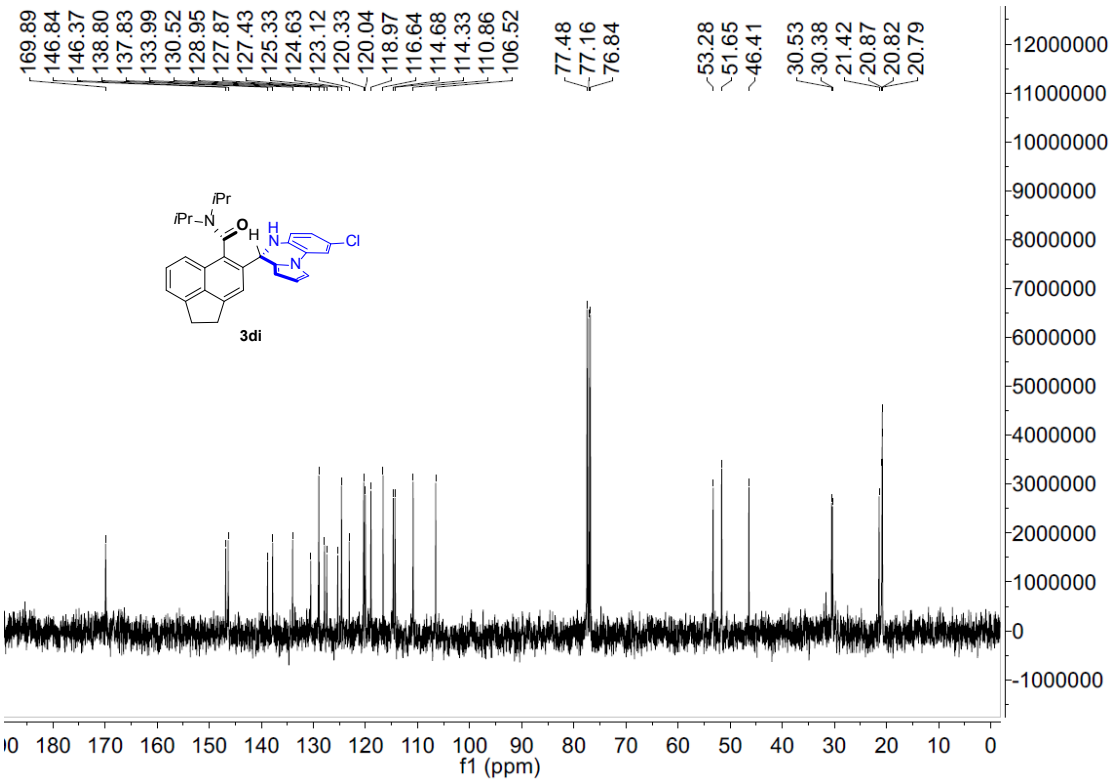

8.12
8.11
8.11
8.10
7.86
7.60
7.59
7.58
7.57
7.32
7.31
7.26
7.25
7.12
7.11
7.11
6.95
6.94
6.93
6.92
6.68
6.66
6.24
6.23
6.22
5.78
5.74
5.73
5.73
5.73
4.36
3.58
3.51
1.73
1.71
1.49
1.47
0.97
0.95
0.85
0.83
iPr
iPr
N
O
H
H
N
N
Cl
F
3ci
1.05
1.00
2.00
1.04
1.03
1.02
1.01
1.01
1.00
1.05
1.00
1.01
2.01
3.06
3.08
3.02
3.03
f1 (ppm)


168.22
159.69
157.18
134.14
133.69
131.46
131.42
128.14
128.00
127.09
125.73
125.32
124.77
124.46
124.03
123.78
120.96
120.91
116.17
115.00
114.63
111.35
109.41
107.72
77.48
77.16
76.84
54.36
51.56
46.46
20.88
20.61
20.51
20.39
iPr
iPr
N
O
H
H
N
N
Cl
F
3ci
f1 (ppm)


7.43 7.40 7.38 7.27 7.27 7.25 7.25 7.21 7.20 7.20 7.20 7.19 7.00 6.81 6.80 6.69 6.68 6.59 6.58 6.57 6.26 6.25 6.24 5.76 5.70 5.69 3.26 3.25 3.23 3.18 3.17 3.16 3.16 1.67 1.66 1.57 1.55 1.04 1.03 1.01 0.99
iPr
iPr–N
O
H
H
N
N
3da
1.02 1.08 1.15 2.03 1.07 1.07 1.04 1.01 1.00 1.02 1.02 1.00 1.09 1.09 2.05 2.02 3.07 3.07 6.03
f1 (ppm)


169.86 146.67 146.32 138.83 138.08 135.47 130.63 128.83 128.13 127.44 124.95 124.68 120.25 120.09 119.34 118.66 115.84 114.42 114.17 110.21 106.10
77.48 77.16 76.84
53.39 51.64 46.40 30.54 30.35 30.26 21.45 20.91 20.84 20.80
iPr
iPr–N
O
H
H
N
N
3da
f1 (ppm)


7.52
7.50
7.48
7.47
7.45
7.32
7.32
7.29
7.28
7.23
7.22
7.22
7.22
6.98
6.84
6.83
6.82
6.81
6.56
6.54
6.35
6.35
6.34
5.81
3.81
3.63
3.33
3.32
3.26
3.26
3.26
3.25
1.75
1.73
1.65
1.63
1.13
1.11
1.09
1.08
iPr
iPr–N
O
H
H
N
Cl
N
3di
2.17
2.08
1.05
1.01
1.04
1.06
1.00
2.09
1.02
1.14
1.17
4.12
3.01
3.04
6.05
f1 (ppm)


169.89
146.84
146.37
138.80
137.83
133.99
130.52
128.95
127.87
127.43
125.33
124.63
123.12
120.33
120.04
118.97
116.64
114.68
114.33
110.86
106.52
77.48
77.16
76.84
53.28
51.65
46.41
30.53
30.38
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20.82
20.79
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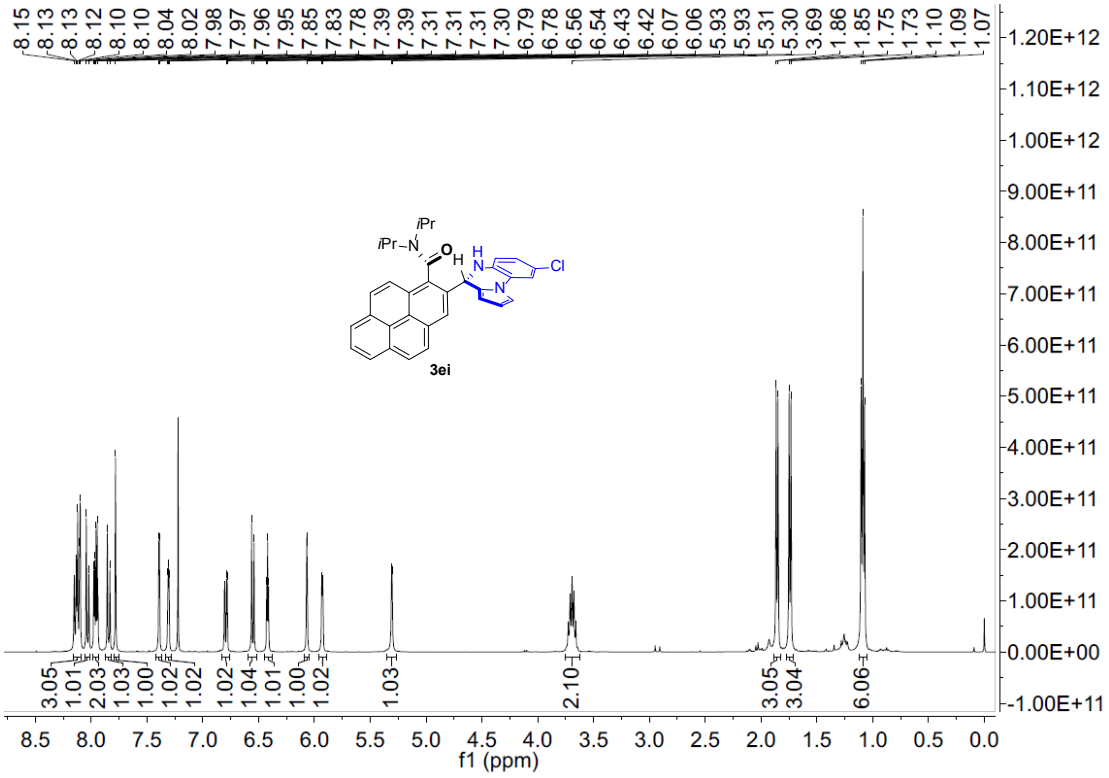
iPr–N
O
H
H
N
Cl
N
3di
f1 (ppm)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7.83
7.78
7.39
7.39
7.31
7.31
7.31
7.30
6.79
6.78
6.56
6.54
6.43
6.42
6.07
6.06
5.93
5.93
5.31
5.30
3.69
1.86
1.85
1.75
1.73
1.10
1.09
1.07
iPr
iPr–N
O
H
H
N
Cl
N
3ei
3.05
1.01
2.03
1.03
1.00
1.02
1.02
1.02
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3.05
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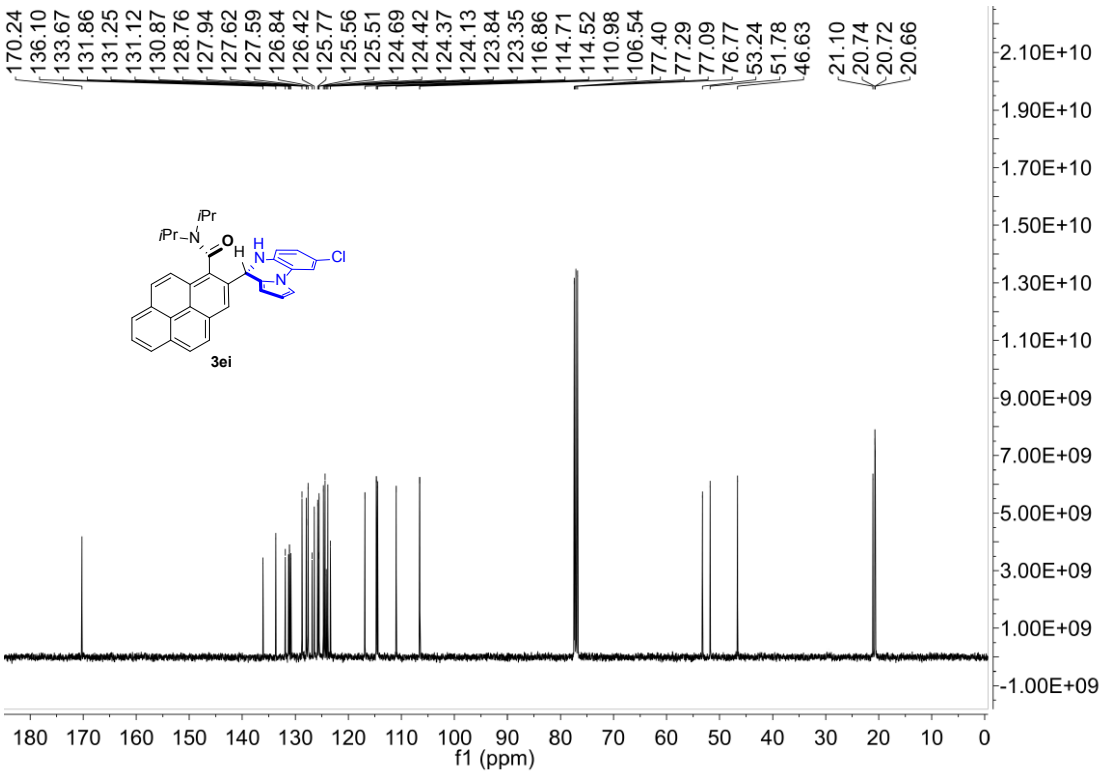
6.06
f1 (ppm)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128.76
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126.42
125.77
125.56
125.51
124.69
124.42
124.37
124.13
123.84
123.35
116.86
114.71
114.52
110.98
106.54
77.40
77.29
77.09
76.77
53.24
51.78
46.63
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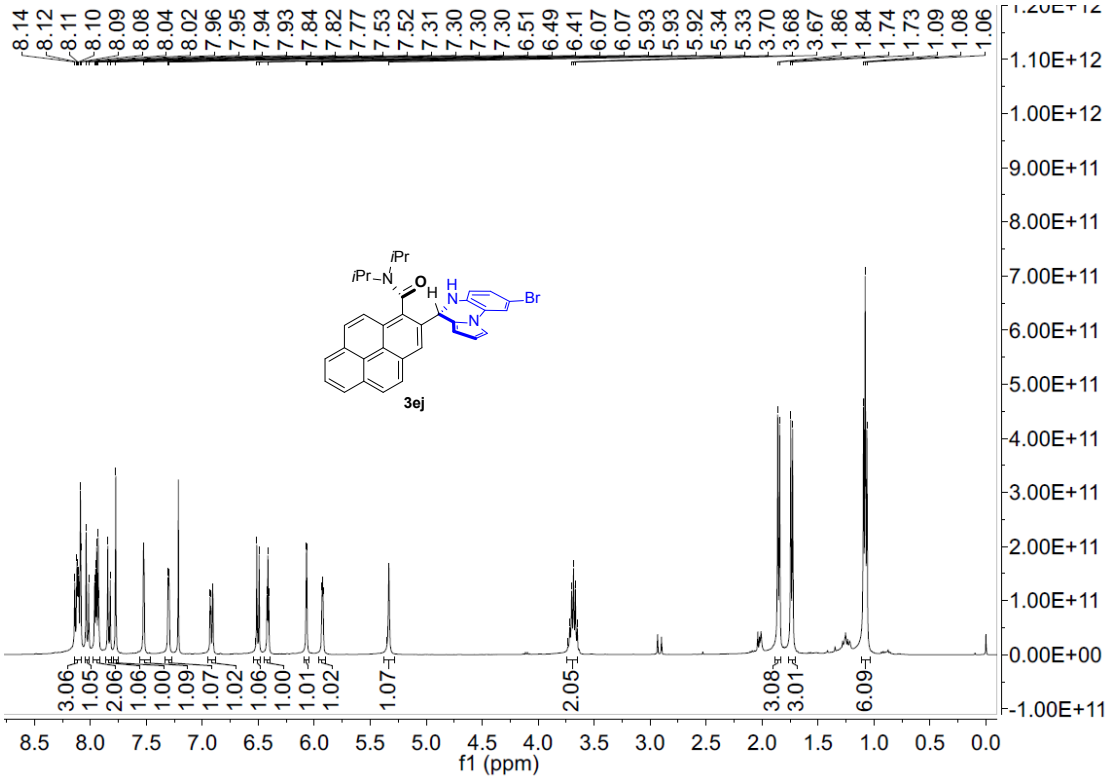
20.72
20.66
iPr
iPr–N
O
H
H
N
Cl
N
3ei
f1 (ppm)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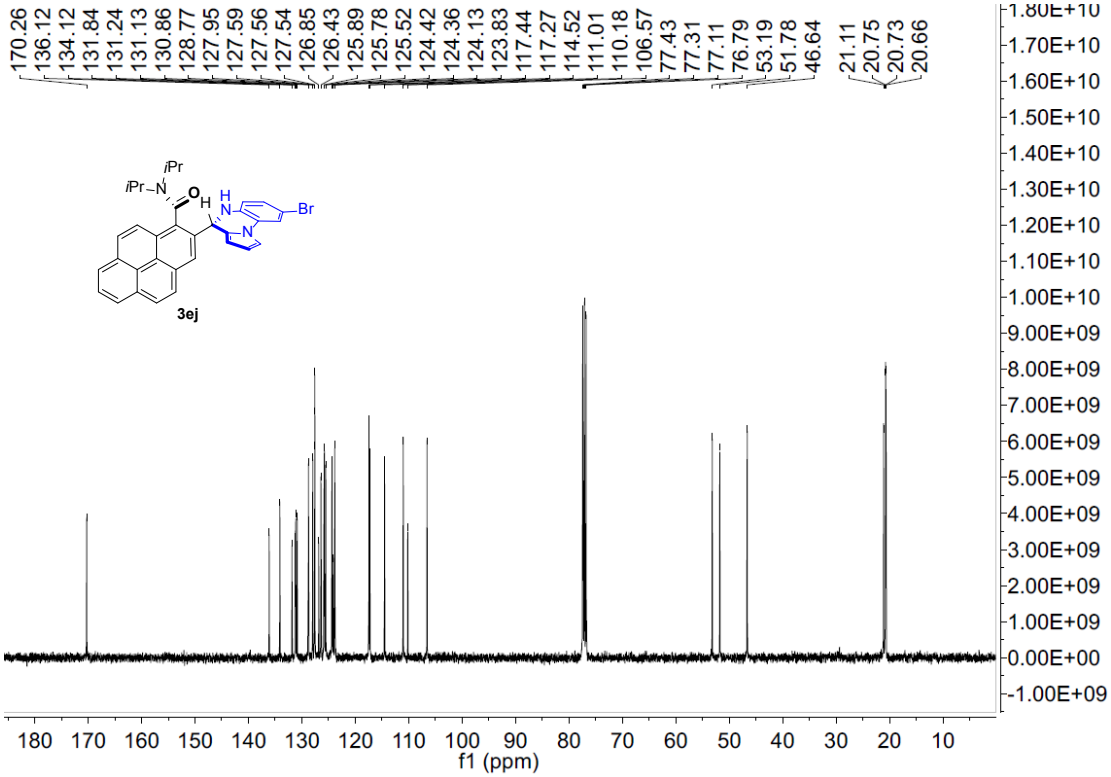
iPr
iPr
N
O
H
H
N
N
Br
3ej
3.06 1.05 2.06 1.06 1.00 1.09 1.07 1.02 1.06 1.00 1.01 1.02 1.07 2.05 3.08 3.01 6.09
f1 (ppm)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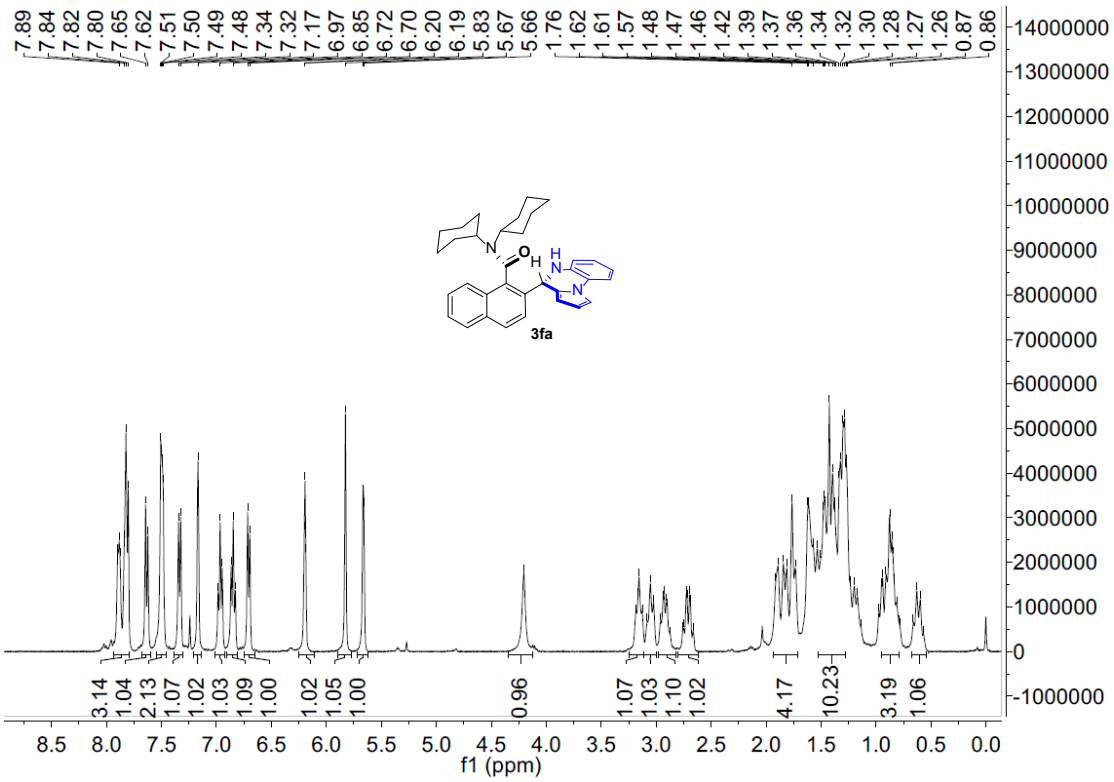
iPr
iPr
N
O
H
H
N
N
Br
3ej
f1 (ppm)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7.32
7.17
6.97
6.85
6.72
6.70
6.20
6.19
5.83
5.67
5.66
1.76
1.62
1.61
1.57
1.48
1.47
1.46
1.42
1.39
1.37
1.36
1.34
1.32
1.30
1.28
1.27
1.26
0.87
0.86
3fa
3.14
1.04
2.13
1.07
1.02
1.03
1.09
1.00
1.02
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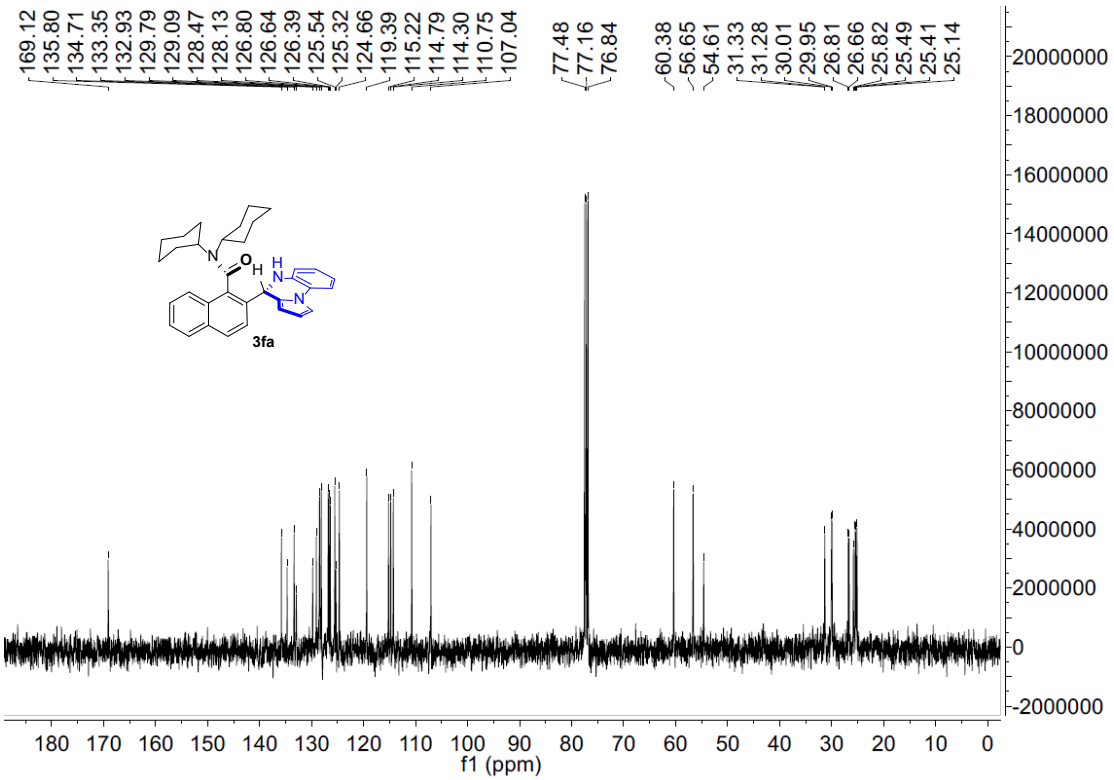
1.10
1.02
4.17
10.23
3.19
1.06
f1 (ppm)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126.39
125.54
125.32
124.66
119.39
115.22
114.79
114.30
110.75
107.04
77.48
77.16
76.84
60.38
56.65
54.61
31.33
31.28
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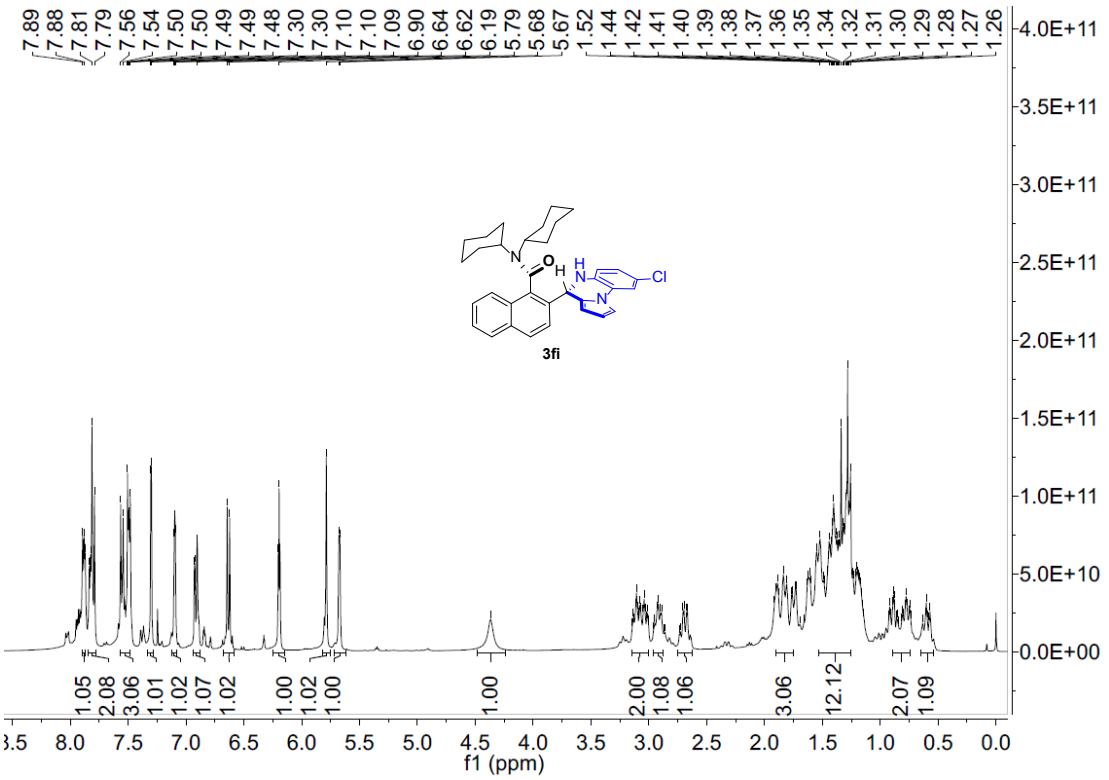
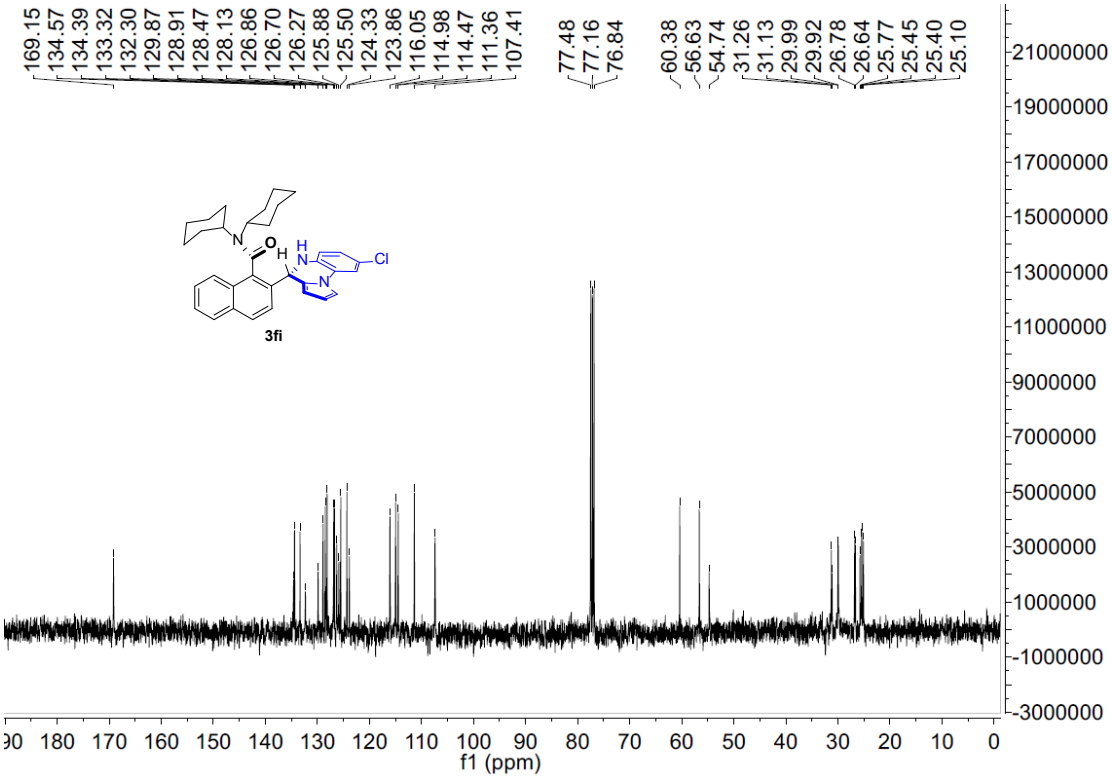
29.95
26.81
26.66
25.82
25.49
25.41
25.14
3fa
f1 (ppm)


7.89 7.88 7.81 7.79 7.56 7.54 7.50 7.50 7.49 7.48 7.30 7.30 7.10 7.10 7.09 6.90 6.64 6.62 6.19 5.79 5.68 5.67 1.52 1.44 1.42 1.41 1.40 1.39 1.38 1.37 1.36 1.35 1.34 1.32 1.31 1.30 1.29 1.28 1.27 1.26
4.0E+11 3.5E+11 3.0E+11 2.5E+11 2.0E+11 1.5E+11 1.0E+11 5.0E+10 0.0E+00
3fi
1.05 2.08 3.06 1.01 1.02 1.07 1.02 1.00 1.02 1.00 1.00 2.00 1.08 1.06 3.06 12.12 2.07 1.09
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)


169.15 134.57 134.39 133.32 132.30 129.87 128.91 128.47 128.13 126.86 126.70 126.27 125.88 125.50 124.33 123.86 116.05 114.98 114.47 111.36 107.41 77.48 77.16 76.84 60.38 56.63 54.74 31.26 31.13 29.99 29.92 26.78 26.64 25.77 25.45 25.40 25.10
21000000 19000000 17000000 15000000 13000000 11000000 9000000 7000000 5000000 3000000 1000000 -1000000 -3000000
3fi
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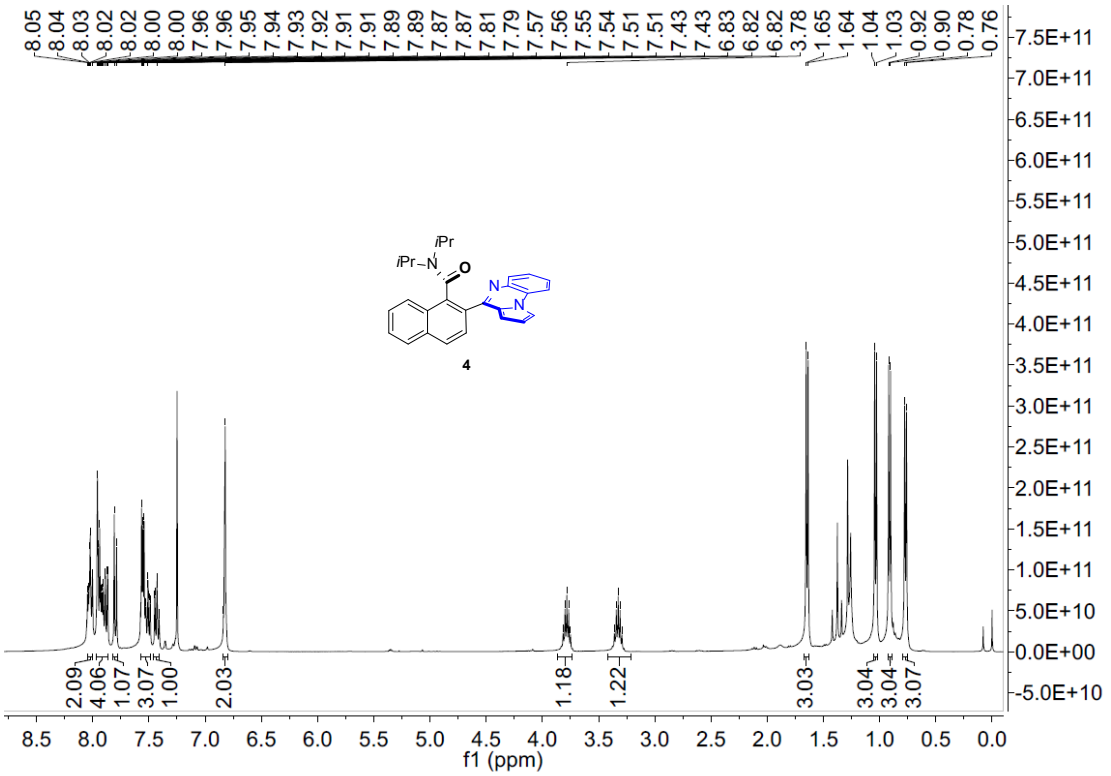
f1 (ppm)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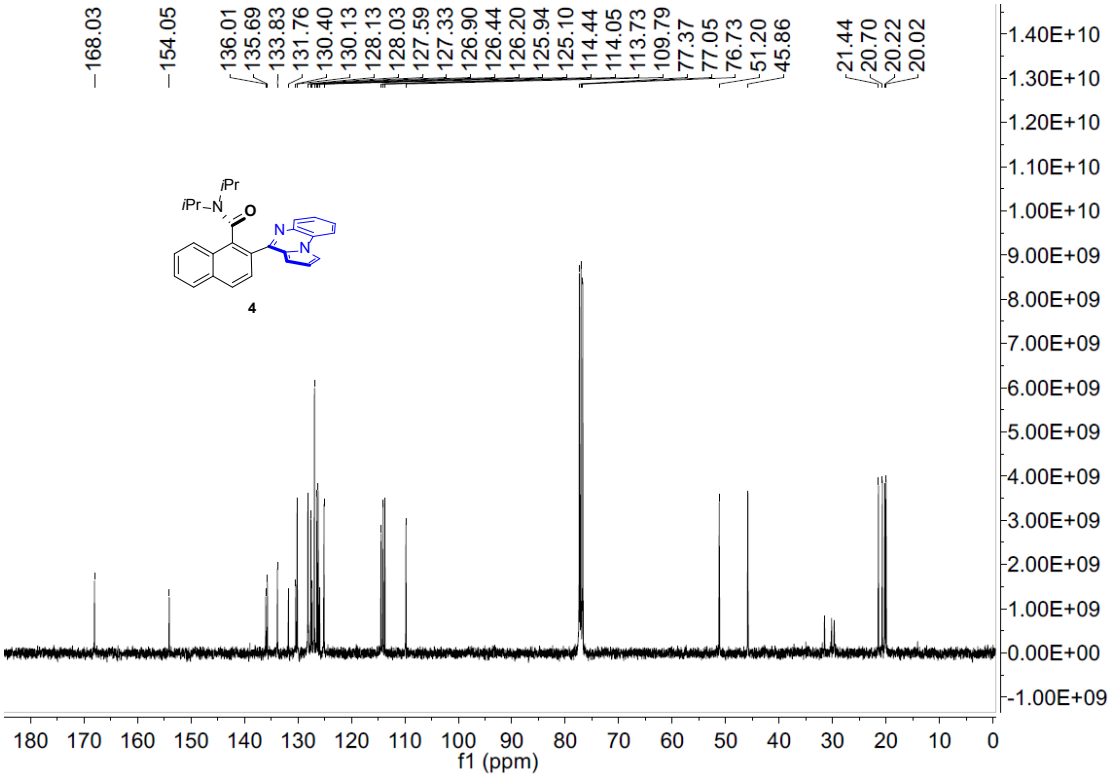
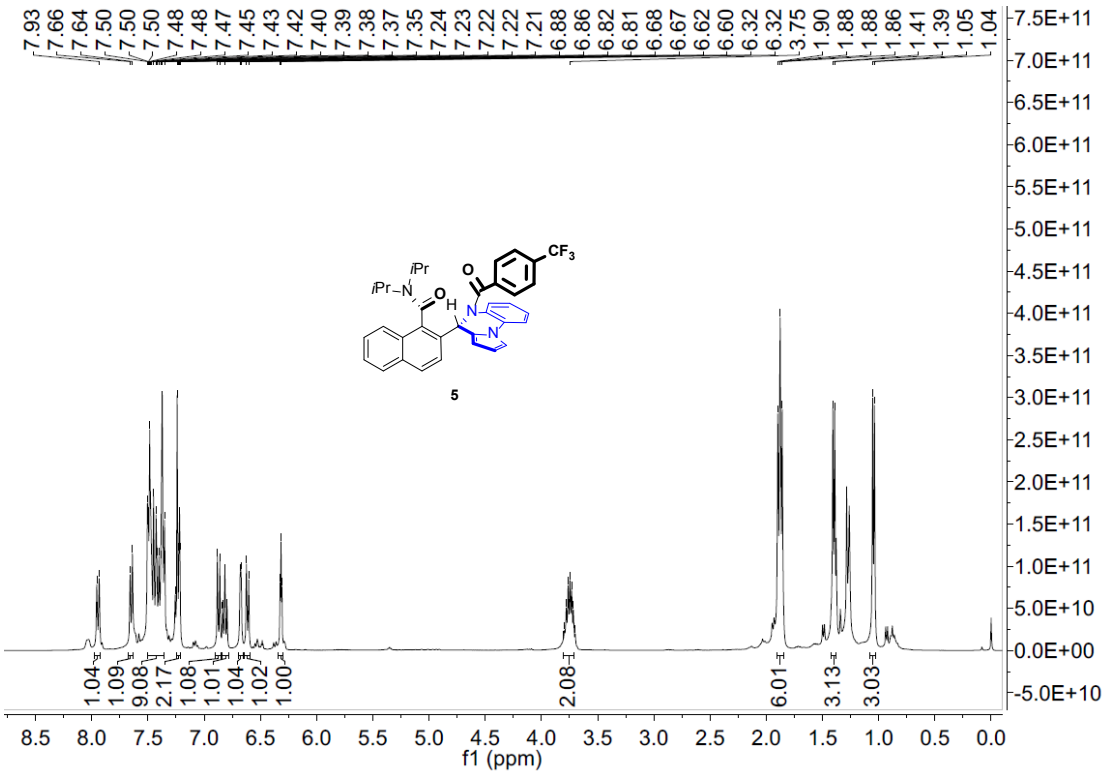
iPr
iPr–N
O
N
N
4
2.09 4.06 1.07 3.07 1.00 2.03 1.18 1.22 3.03 3.04 3.04 3.07
f1 (ppm)


168.03 154.05 136.01 135.69 133.83 131.76 130.40 130.13 128.13 128.03 127.59 127.33 126.90 126.44 126.20 125.94 125.10 114.44 114.05 113.73 109.79 77.37 77.05 76.73 51.20 45.86 21.44 20.70 20.22 20.02
iPr
iPr–N
O
N
N
4
f1 (ppm)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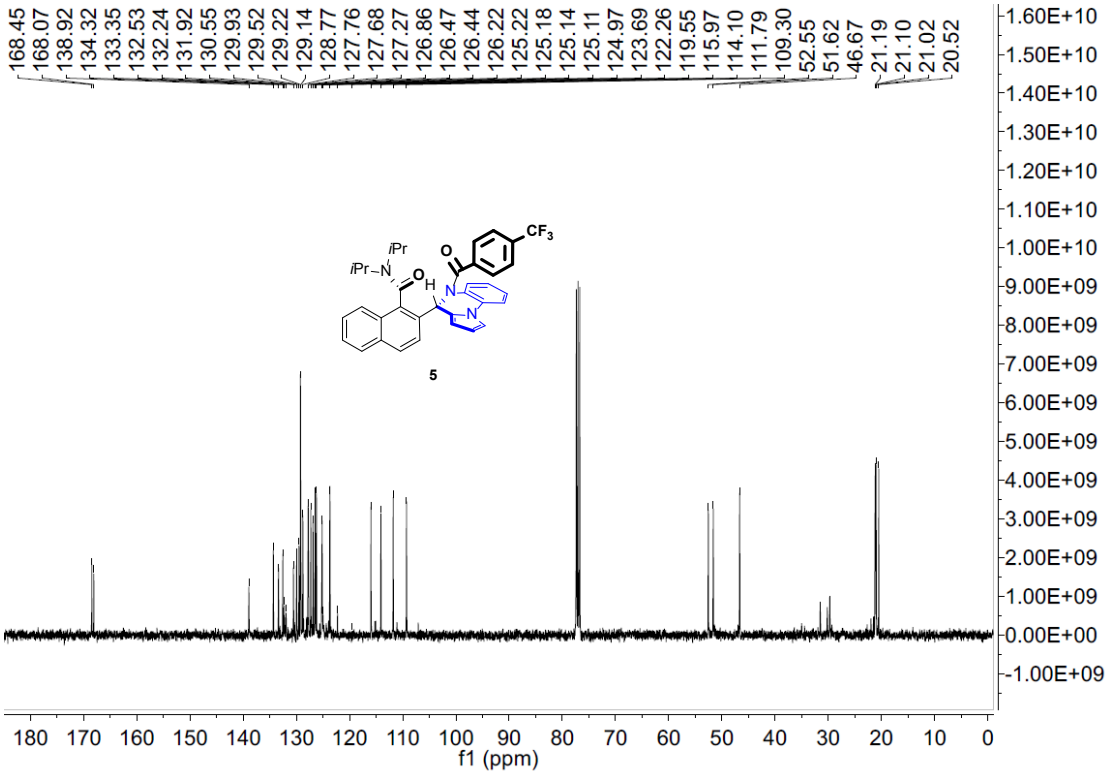
1.04 1.09 9.08 2.17 1.08 1.01 1.04 1.02 1.00 2.08 6.01 3.13 3.03
f1 (ppm)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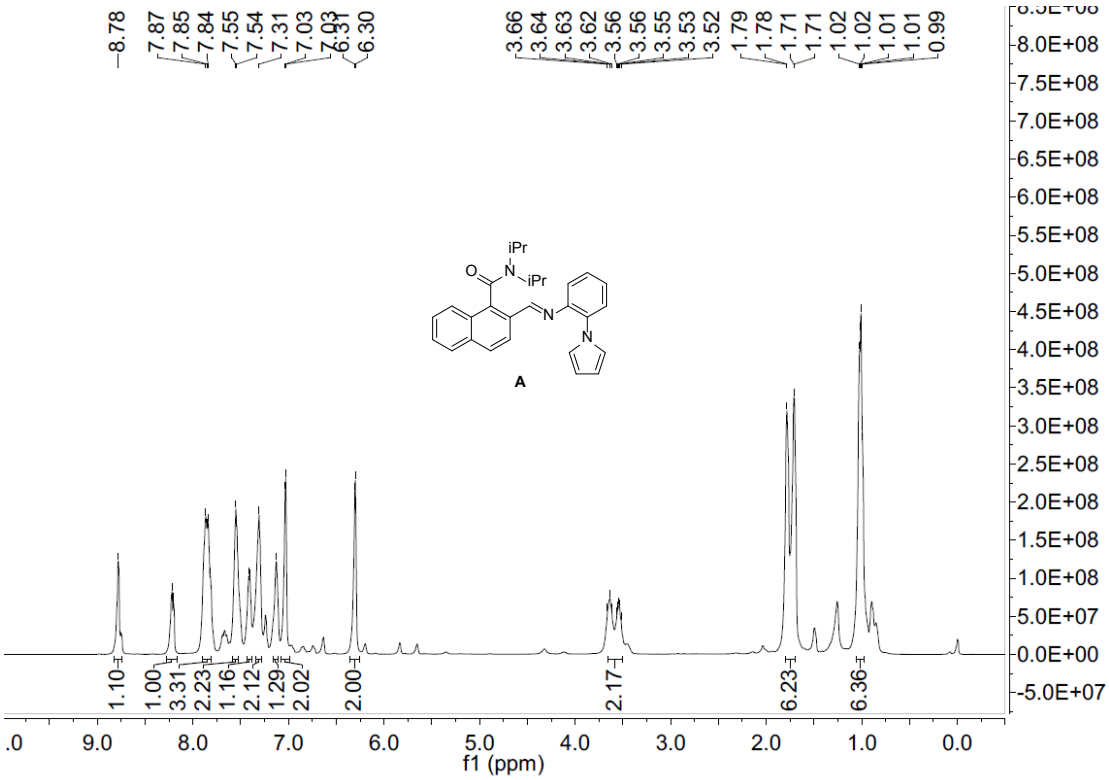
f1 (ppm)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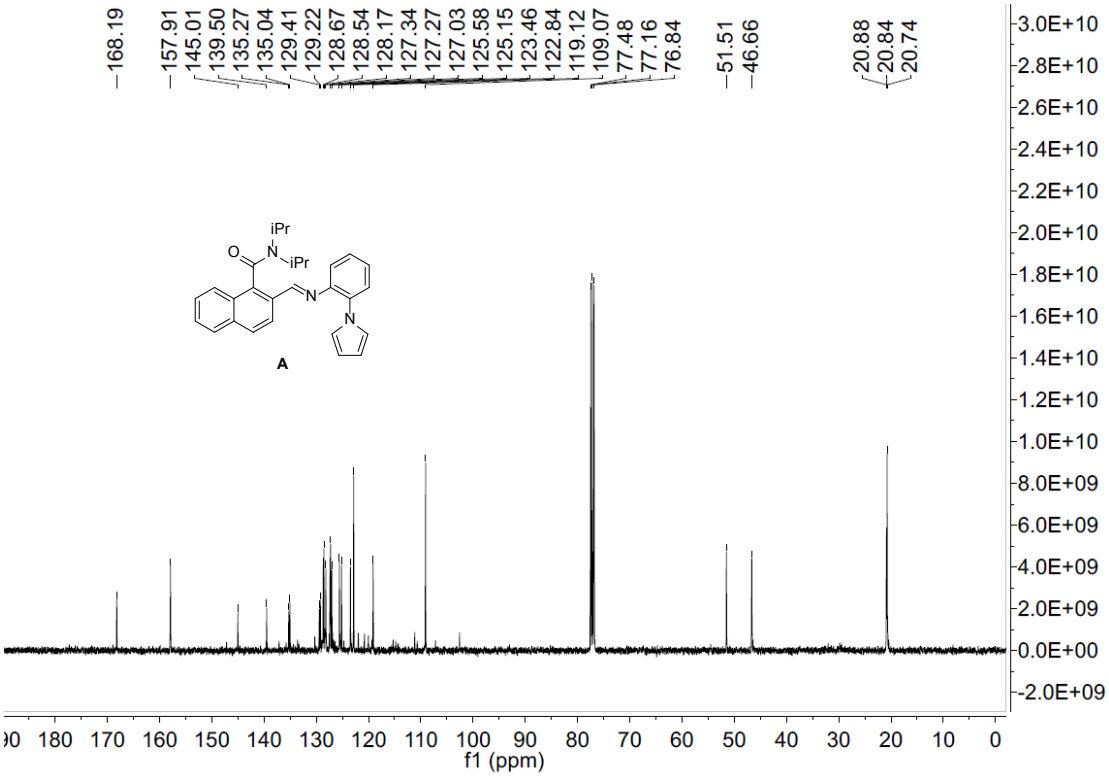
7.84
7.55
7.54
7.31
7.03
6.31
6.30
3.66
3.64
3.63
3.62
3.56
3.56
3.55
3.53
3.52
1.79
1.78
1.71
1.71
1.02
1.02
1.01
1.01
0.99
iPr
iPr
A
1.10
1.00
3.31
2.23
1.16
2.12
1.29
2.02
2.00
2.17
6.23
6.36
f1 (ppm)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135.04
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128.54
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127.03
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125.15
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109.07
77.48
77.16
76.84
51.51
46.66
20.88
20.84
20.74
iPr
iPr
A
f1 (ppm)