Supporting Information for

Enantioselective Synthesis of Tetrahydroisoquinoline Derivatives via Chiral-at-Metal Rhodium Complex Catalyzed [3+2] Cycloaddition

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General Information

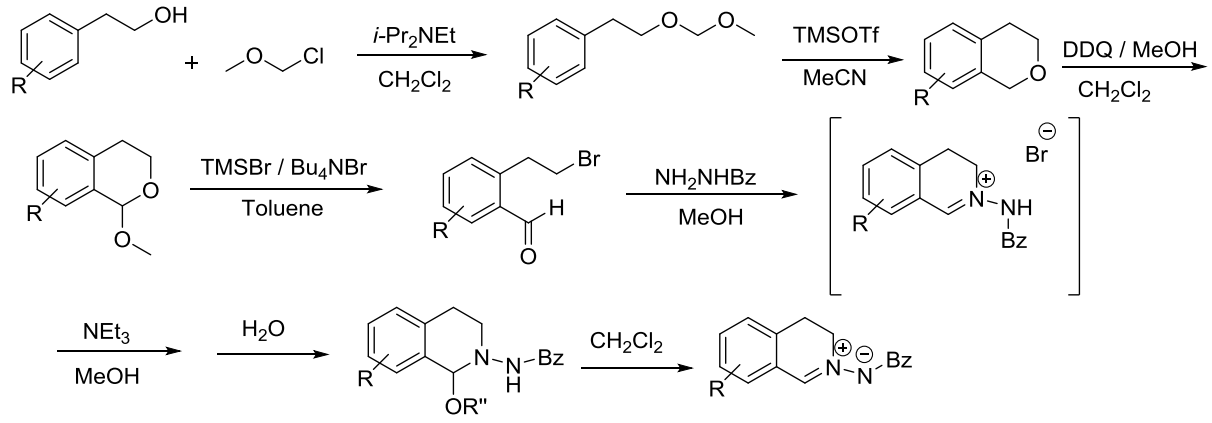
All non-aqueous reactions were performed in oven-dried glassware and standard Schlenk tubes under an atmosphere of nitrogen. 1,2-Dichloroethane (DCE) and dichloromethane (DCM) were distilled from CaH_2 under inert atmosphere. Tetrahydrofuran (THF) and toluene (PhMe) were distilled from sodium and benzophenone under inert atmosphere. Rhodium catalysts ***rac*-RhO**, **Δ-Rh1**[1], **Δ-Rh2**[2], and **Δ-Rh3**[3] were prepared according to the reported procedures. All other solvents and reagents were used as received unless otherwise noted. Thin layer chromatography was performed using silica gel 60 F-254 precoated plates (0.2~0.3 mm) and visualized by short-wave UV (254 nm) irradiation, potassium permanganate, or iodine stain. Column chromatography was performed with silica gel (200-300 mesh, Yantai Jiangyou Silica Gel Development Co., Ltd). The NMR spectra were obtained in $CDCl_3$ using a Bruker Avance III spectrometer at 400 and 100 MHz for ^1H and ^{13}C NMR, respectively. Chemical shifts (δ) for ^{1}HNMR spectra are recorded in parts per million from tetramethylsilane with the resonance of methyl group as the internal standard (δ 0.00 ppm). Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, qn = quintet, m = multiplet and br = broad, dd = double doublet, hept = heptet), coupling constant in Hz, and integration. Chemical shifts for ^{13}CNMR spectra are recorded in parts per million from tetramethylsilane using the central peak of deuterochloroform (δ 77.0 ppm) as the internal standard. The infrared spectra were recorded on a VERTEX 70 IR spectrometer as KBr pellets, with absorption reported in cm^{-1}. HRMS data were obtained on a Thermo Fisher Scientific LTQ FT Ultrasystem. Optical rotation was recorded on INESA SGW-1 polarimeter at concentrations of 0.5g/100mL or 1.0g/100mL. Enantiomeric excess was determined by HPLC analysis on Chiralpak IA column and IC column (Daicel Chemical Industries, LTD) on Shimadzu LC-20AD. The crystallographic measurement was made on an Agilent SuperNova (Dual, Cu at zero, Atlas) diffractometer. The structure was solved by direct method and refined to convergence by least squares method on F2 using the SHELXTL-2014 software suit.

Synthesis of Substrates

Preparation of α,β-Unsaturated 2-acylimidazoles (1)

α,β-Unsaturated 2-acylimidazoles **1a-1s** were prepared according to reported procedures.[4-6] Substrate **1p** was prepared according to reported procedure.[7]

Preparation of C,N-Cyclic Azomethine Imines (2)



C,N-cyclic azomethine imines were prepared according to a general procedure.[8,9] To a stirred solution of phenethylol (20 mmol) in CH_2Cl_2 (20 mL), *i*-Pr_2NEt (6.97 mL, 40 mmol) and MOMCl (2.28 mL, 30 mmol) were added to this solution at 0 ℃. The reaction solution was then allowed to warm to room temperature and stirred for 12 h. The mixture was poured into 1 N HCl and extracted with ethyl acetate. The combined organic layers were dried over Na_2SO_4 and concentrated in vacuo to give phenylethyl methoxymethyl ether.

This crude material was diluted in CH_3CN (20 mL), and TMSOTf (3.62 mL, 20 mmol) then added to this mixture at 0 ℃. The reaction solution was then allowed to warm to room temperature and stirred for 24 h. The mixture was then treated with aq. $NaHCO_3$ and evaporated in vacuo to remove CH_3CN. The residue was extracted with ethyl acetate, dried over Na_2SO_4 and concentrated in vacuo. The residue was purified by column chromatography on silica gel.

To a solution of thus-obtained isochroman (9.18 mmol) in CH_2Cl_2 were added methanol (447 μL, 11.0 mmol) and DDQ (2.08 g, 9.18 mmol) at room temperature. After stirring for 48 h at room temperature, the suspension was filtered off to remove the insoluble waste. The filtrate was washed with saturated aqueous $NaHCO_3$, extracted with CH_2Cl_2, dried over Na_2SO_4 and concentrated in vacuo. The residue was purified by column chromatography on silica gel.

To a solution of the resulting 1-methoxyisochroman (6.48 mmol) in toluene (6.5 mL) were added Bu_4NBr (2.09 g, 6.48 mmol) and TMSBr (1.71 mL, 13.0 mmol). The reaction solution was then allowed to warm to 80 ℃ and stirred for 4 h, then treated with saturated aqueous $NaHCO_3$, extracted with ethyl acetate. The combined organic layers were dried over Na_2SO_4 and concentrated in vacuo. The residue was purified by column chromatography on silica gel to give 2-(2-bromoethyl)-benzaldehyde.

To a 0.5 M solution of the corresponding 2-(2-bromoethyl)-benzaldhyde (1.05 equiv) in MeOH was added benzoylhydrazine or sulfonylhydrazine (1 equiv) at room temperature. After the immediate formation of the insoluble material, this white suspension was heated to reflux and stirred for additional 1 h to give a clear solution. After cooling to room temperature, the reaction solution was treated with Et_3N (1.5 equiv), poured into water and stirred for 30 min to give a white precipitate (tentatively assigned as a methanol and/or water adduct of the corresponding betaine). This solid material was washed with cold ether and then dissolved in CH_2Cl_2 to give a yellow solution. This colored solution was dried over Na_2SO_4 and evaporated in vacuo to give N-benzoylimino-3,4-dihydroisoquinolium betaine as a yellow solid **2a**. By the above procedure all the substituted C,N-cyclic azomethine imines were prepared without any further purification.

General Procedure for the Catalytic Reactions

Synthesis of racemic products as HPLC references

General Procedure: A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazoles **1** (0.1 mmol), C,N-cyclic azomethine imines **2** (0.12 mmol) and racemic catalyst ***rac*-RhO** (1.6 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.2 mL) was added. The reaction mixture was stirred at room temperature for indicated time (monitored by TLC) under argon. the mixture was purified by flash column chromatography on silica gel (petroleum ether/EtOAc = 5:1 to 1:1) to afford racemic products as HPLC reference for determination of enantiomeric excess.

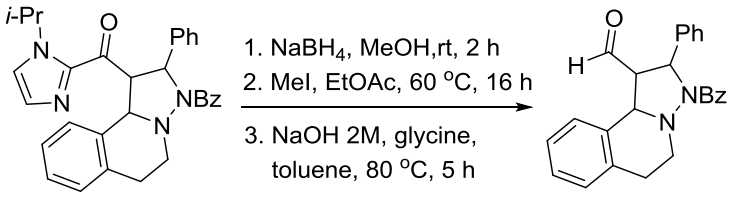
Substrate Scope

General Procedure for chiral product

A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazoles **1** (0.1 mmol), C,N-cyclic azomethine imines **2** (0.12 mmol) and chiral catalyst **Δ-Rh2** (2.1 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.2 mL) was added. The reaction mixture was stirred at room temperature for indicated time (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/EtOAc = 5:1 to 1:1) to afford chiral products.

Synthetic Transformations

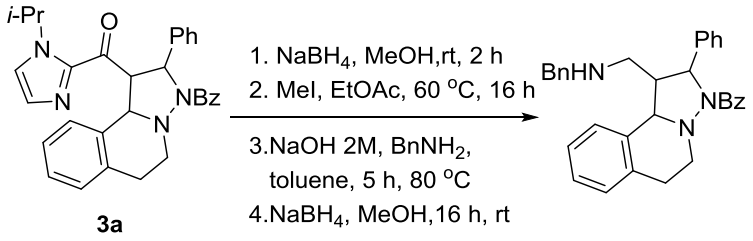
Into aldehyde



3a

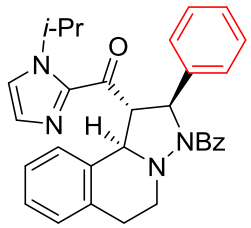
In a round bottom flask, sodium borohydride (0.16 mmol) was added portionwise to a solution of the substrate **3a** (0.06 mmol in methanol, c = 0.125 M). The reaction was stirred at room temperature for 2 h and monitored by TLC. After completion, water was added and the mixture was extracted with ethyl acetate. The organic layer was further washed with brine, dried over magnesium sulfate and concentrated under vacuum. The intermediate so obtained was dissolved with ethyl acetate (c = 0.05 M) and treated with methyl iodide (0.45 mmol). The mixture was heated at 60 ℃ for 16 h, cooled down to room temperature and concentrated to dryness. The crude residue was taken up in toluene (c = 0.17 M), glycine (0.26 mmol) and 2 M NaOH solution (0.58 mmol) were added. The mixture was heated at 80 ℃ for 5 h. At 80 ℃, 1 M HCl solution (0.58 mmol) was added and the mixture was stirred until lightening of the aqueous phase (from cloudy to clear). Then the mixture was cooled down to room temperature and ethyl acetate was added. The organic layer was washed with an aqueous solution of 1 M HCl and brine, dried over magnesium sulfate and concentrated under vacuum. The residue was purified by column chromatography to afford the desired product.

Into amine



In a round bottom flask, sodium borohydride (0.18 mmol) was added portionwise to a solution of the substrate **3a** (0.07 mmol) in methanol (0.36 mL). The mixture was stirred at room temperature for 2 h and monitored by TLC. Water was added, the mixture was extracted with ethyl acetate. The organic layer was washed with brine, dried over magnesium sulfate and concentrated under vacuum. Ethyl acetate (0.56 mL) was added to the intermediate followed by methyl iodide (0.51 mmol). The mixture was heated at 60 ℃ for 16 h, cooled down to room temperature and concentrated to dryness. The residue was taken up in toluene (0.36 mL), benzylamine (0.29 mmol) and 2 M NaOH solution (0.36 mmol) were then added. The mixture was heated at 80 ℃ for 5 h and cooled down to room temperature. The organic layer was diluted with ethyl acetate, dried with brine and concentrated under vacuum. The residue was taken up in MeOH (0.36 mL) and sodium borohydride (0.73 mmol) was added at room temperature. The mixture was stirred at room temperature for 16 h. Water was added and the mixture was extracted with ethyl acetate. The combined organic layers were washed with brine, dried over magnesium sulfate and concentrated under vacuum. The residue was purified by column chromatography (petroleum ether/EtOAc = 5:1 to 1:1) to afford desired product.

Characterization of Products



3a

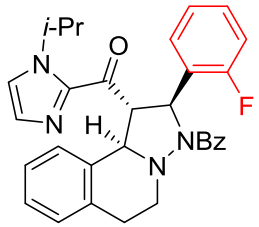
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1a** (12.0 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 3 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3a** as white solid (24.3 mg, yield: 99%). Enantiomeric excess was determined by HPLC analysis, ee = 98% (Chiralpak column IA, λ = 254 nm, *n*-hexane/*i*-PrOH = 70:30, flow rate: 1.0 mL/min, 30 ℃, tr(minor) = 10.446 min, tr(major) = 11.599 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –32.061. Mp 185–188 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 6.8 Hz, 2H), 7.50-7.15 (m, 9H), 7.04 (brs, 3H), 6.84 (m, 1H), 6.51 (d, *J* = 7.7 Hz, 1H), 6.08 (d, *J* = 7.8 Hz, 1H), 5.73 (hept, 1H), 5.32 (dd, *J* = 7.8, 10.0 Hz, 1H), 4.83 (d, *J* = 10.0 Hz, 1H), 3.30 (m, 1H), 3.20 (m, 1H), 3.02 (m, 1H), 2.71 (d, *J* = 16.0 Hz, 1H), 1.54 (t, *J* = 7.3 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 191.0, 170.9, 142.9, 141.3, 135.6, 133.3, 132.9, 130.6, 130.2, 128.6, 128.5 (2C), 128.4 (2C), 127.6 (2C), 127.2, 127.0, 126.3, 126.1 (2C), 125.7, 122.5, 68.9, 68.0, 61.2, 49.9, 49.6, 29.5, 23.8, 23.7.

IR (KBr): *v* (cm^{-1}) 2965, 1664, 1394, 989, 696.

HRMS (ESI, *m*/*z*) calcd for $C_{31}H_{30}N_4O_2Na^+$ $[M+Na]^+$: 513.2261, found: 513.2261.



3b

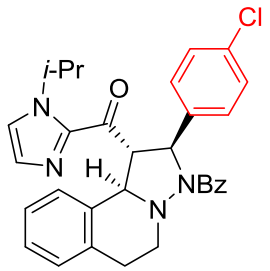
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1b** (12.9 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 4 h (monitored by TLC) under argon. the mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3b** as white solid (22.8 mg, yield: 90%). Enantiomeric excess was determined by HPLC analysis, ee = 94% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 0.6 mL/min, 30 ℃, tr(major) = 36.491 min, tr(minor) = 45.281 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –11.832. Mp 173–176 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 7.1 Hz, 2H), 7.47-7.36 (m, 4H), 7.30 (s, 1H), 7.20-7.00 (m, 4H), 6.93 (s, 1H), 6.88-6.80 (m, 2H), 6.54 (d, *J* = 7.8 Hz, 1H), 6.13 (d, *J* = 8.5 Hz, 1H), 5.75 (hept, 1H), 5.09 (dd, *J* = 8.5, 10.4 Hz, 1H), 4.88 (d, *J* = 10.4 Hz, 1H), 3.40 (m, 1H), 3.30 (m, 1H), 3.07 (m, 1H), 2.75 (d, *J* = 16.1 Hz, 1H), 1.56 (d, *J* = 8.8 Hz, 3H), 1.52 (d, *J* = 8.8 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.0 (d, *J* = 2.4 Hz), 169.6, 159.8 (d, *J* = 244 Hz), 143.1, 135.2, 132.6 (d, *J* = 3.5 Hz), 130.3, 130.0, 128.7 (d, *J* = 8.1 Hz), 128.5 (2C), 128.42, 128.35, 128.2, 127.6 (2C), 127.2, 126.5, 126.2 (d, *J* = 3.9 Hz), 125.6, 124.0 (d, *J* = 3.3 Hz), 122.0, 115.2 (d, *J* = 21.2 Hz), 68.2, 63.7, 60.4, 50.0, 49.5, 29.4, 23.7, 23.4.

IR (KBr): *v* (cm^{-1}) 2952, 1664, 1488, 1396, 1255, 991, 757, 696.

HRMS (ESI, *m*/*z*) calcd for $C_{31}H_{29}FN_4O_2Na^+$ $[M+Na]^+$: 531.2167, found: 531.2166.



3c

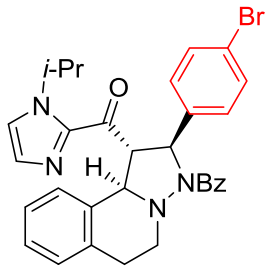
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1c** (13.7 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 4 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3c** as white solid (24.7 mg, yield: 95%). Enantiomeric excess was determined by HPLC analysis, ee = 96% (Chiralpak column IA, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 0.6 mL/min, 30 ℃, tr(minor) = 31.593 min, tr(major) = 42.447 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –28.305. Mp 169–172 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 7.2 Hz, 2H), 7.47-7.32 (m, 6H), 7.28-7.20 (m, 2H), 7.06 (m, 3H), 6.85 (m, 1H), 6.51 (d, *J* = 7.8 Hz, 1H), 6.00 (d, *J* = 8.0 Hz, 1H), 5.71 (hept, 1H), 5.29 (dd, *J* = 10.0, 8.0 Hz, 1H), 4.83 (d, *J* = 10.0 Hz, 1H), 3.29 (dd, *J* = 5.0, 10.6 Hz, 1H), 3.17 (ddd, *J* = 2.6, 10.6, 12.5 Hz, 1H), 3.03 (ddd, *J* = 5.0, 12.5, 16.0 Hz, 1H), 2.72 (d, *J* = 16.0 Hz, 1H), 1.55 (t, *J* = 6.8 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.6, 170.8, 142.8, 139.9, 135.3, 133.1, 132.9, 132.8, 130.6, 130.4, 128.6, 128.5 (2C), 127.7 (4C), 127.3, 126.2, 125.8, 122.6, 68.8, 67.6, 60.9, 50.0, 49.7, 29.4, 23.8, 23.7.

IR (KBr): *v* (cm^{-1}) 2927, 1662, 1545, 1491, 1395, 1254, 1013, 990, 764, 737.

HRMS (ESI, *m*/*z*) calcd for $C_{31}H_{29}ClN_4O_2Na^+$ $[M+Na]^+$: 547.1871, found: 547.1870.



3d

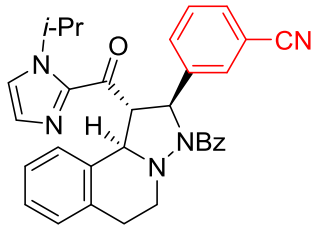
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1d** (15.96 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 5 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3d** as off white solid (26.9 mg, yield: 95%). Enantiomeric excess was determined by HPLC analysis, ee = 92% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 14.522 min, tr(minor) = 17.334 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = +25.733. Mp 170–172 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 7.1 Hz, 2H), 7.47-7.27 (m, 8H), 7.05 (m, 3H), 6.85 (m, 1H), 6.51 (d, *J* = 7.7 Hz, 1H), 5.98 (d, *J* = 8.0 Hz, 1H), 5.71 (hept, 1H), 5.29 (dd, *J* = 10.0, 8.0 Hz, 1H), 4.83 (d, *J* = 10.0 Hz, 1H), 3.29 (m, 1H), 3.17 (ddd, *J* = 3.0, 10.4, 12.0 Hz, 1H), 3.03 (ddd, *J* = 5.2, 12.0, 16.0 Hz, 1H), 2.72 (d, *J* = 16.0 Hz, 1H), 1.54 (t, *J* = 6.8 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.6, 170.8, 142.8, 140.4, 135.3, 133.1, 132.8, 131.5 (2C), 130.7, 130.4, 128.6, 128.55 (2C), 128.0 (2C), 127.7 (2C), 127.3, 126.2, 125.8, 122.7, 121.0, 68.8, 67.6, 60.8, 50.0, 49.7, 29.4, 23.8, 23.7.

IR (KBr): *v* (cm^{-1}) 2931, 1663, 1489, 1447, 1395, 1255, 1163, 1074, 1010, 990, 766, 670.

HRMS (ESI, *m*/*z*) calcd for $C_{31}H_{29}BrN_4O_2Na^+$ $[M+Na]^+$: 591.1366, found: 591.1364.



3e

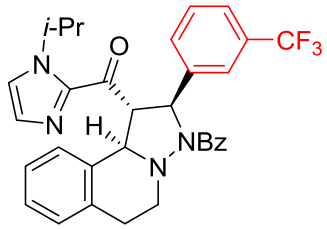
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1e** (13.2 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 4 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3e** as colorless oil (24.5 mg, yield: 96%). Enantiomeric excess was determined by HPLC analysis, ee = 93% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 70:30, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 16.823 min, tr(minor) = 28.729 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –11.193.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 7.1 Hz, 2H), 7.72 (s, 1H), 7.64 (d, *J* = 8.0 Hz, 1H), 7.54-7.34 (m, 6H), 7.07 (m, 3H), 6.86 (m, 1H), 6.53 (d, *J* = 7.7 Hz, 1H), 6.02 (d, *J* = 8.1 Hz, 1H), 5.72 (hept, 1H), 5.28 (dd, *J* = 10.0, 8.1 Hz, 1H), 4.87 (d, *J* = 10.0 Hz, 1H), 3.33 (m, 1H), 3.19-2.99 (m, 2H), 2.75 (d, *J* = 15.5 Hz, 1H), 1.57 (d, *J* = 6.6 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.1, 170.9, 143.0, 142.7, 134.8, 132.8, 132.7, 130.9, 130.8, 130.7, 129.9, 129.3, 128.7 (2C), 127.7 (2C), 127.4, 126.2, 125.9, 123.0, 118.9, 112.5, 68.6, 67.4, 60.7, 50.2, 49.8, 29.4, 23.9, 23.6.

IR (KBr): *v* (cm^{-1}) 2979, 2932, 1662, 1601, 1395, 1349, 1255, 1194, 1088, 991, 732.

HRMS (ESI, *m*/*z*) calcd for $C_{32}H_{29}N_5O_2Na^+$ $[M+Na]^+$: 538.2213, found: 538.2213.



3f

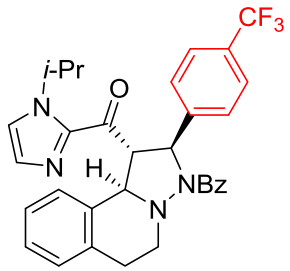
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1f** (15.4 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 4 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3f** as white solid (27.5 mg, yield: 99%). Enantiomeric excess was determined by HPLC analysis, ee = 99% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 7.534 min, tr(minor) = 9.089 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –22.6. Mp 130–133 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 7.2 Hz, 2H), 7.66 (s, 1H), 7.60 (d, *J* = 7.6 Hz, 1H), 7.50-7.32 (m, 6H), 7.05 (m, 3H), 6.87 (m, 1H), 6.57 (d, *J* = 7.8 Hz, 1H), 6.05 (d, *J* = 8.1 Hz, 1H), 5.72 (hept, 1H), 5.32 (dd, *J* = 10.0, 8.1 Hz, 1H), 4.89 (d, *J* = 10.0 Hz, 1H), 3.33 (m, 1H), 3.16 (ddd, *J* = 2.4, 10.2, 12.2 Hz, 1H), 3.04 (ddd, *J* = 5.0, 12.2, 16.0 Hz, 1H), 2.73 (d, *J* = 16.0 Hz, 1H), 1.54 (t, *J* = 6.8 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.4, 170.9, 142.6, 142.2, 135.0, 132.9, 132.7, 130.6, 130.48 (q, *J* = 32 Hz), 130.46, 129.3, 128.9, 128.53, 128.51 (2C), 127.6 (2C), 127.2, 126.1, 125.8, 124.0 (q, *J* = 271 Hz), 123.9 (q, *J* = 3.6 Hz), 123.0 (q, *J* = 3.8 Hz), 122.8, 68.3, 67.8, 60.7, 49.9, 49.6, 29.3, 23.7, 23.5.

IR (KBr): *v* (cm^{-1}) 2985, 1656, 1397, 1325, 1165, 113, 1068, 768.

HRMS (ESI, *m*/*z*) calcd for $C_{32}H_{29}F_3N_4O_2Na^+$ $[M+Na]^+$: 581.2135, found: 581.2134.



3g

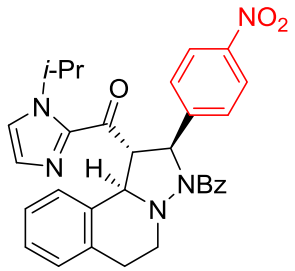
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1g** (15.4 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 5 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3g** as colorless oil (26.9 mg, yield: 97%). Enantiomeric excess was determined by HPLC analysis, ee = 99% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 8.987 min, tr(minor) = 10.657 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –22.786.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 7.2 Hz, 2H), 7.58-7.35 (m, 8H), 7.05 (m, 3H), 6.85 (m, 1H), 6.51 (d, *J* = 7.8 Hz, 1H), 6.10 (d, *J* = 8.0 Hz, 1H), 5.72 (hept, 1H), 5.32 (dd, *J* = 10.0, 8.0 Hz, 1H), 4.85 (d, *J* = 10.0 Hz, 1H), 3.32 (dd, *J* = 3.5, 10.2 Hz, 1H), 3.15 (ddd, *J* = 2.6, 10.2, 12.2 Hz, 1H), 3.04 (ddd, *J* = 4.8, 12.2, 16.0 Hz, 1H), 2.73 (d, *J* = 16.0 Hz, 1H), 1.56 (d, *J* = 6.4 Hz, 3H), 1.54 (d, *J* = 6.4 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.4, 170.8, 145.3, 142.7, 135.1, 132.9, 132.7, 130.7, 130.5, 129.3 (q, *J* = 32 Hz), 128.6 (2C), 127.7 (2C), 127.3, 126.5 (2C), 126.2, 125.8, 125.4 (q, *J* = 3.7 Hz), 124.1 (q, *J* = 270 Hz), 122.7, 68.8, 67.6, 60.8, 50.0, 49.7, 29.4, 23.8, 23.6.

IR (KBr): *v* (cm^{-1}) 2980, 1751, 1395, 1324, 1258, 1068, 764.

HRMS (ESI, *m*/*z*) calcd for $C_{32}H_{29}F_3N_4O_2Na^+$ $[M+Na]^+$: 581.2135, found: 581.2134.



3h

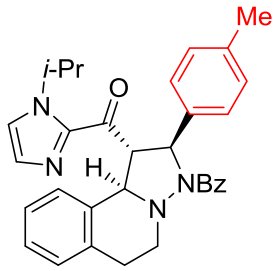
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1h** (14.2 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 4 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3h** as yellow oil (25.0 mg, yield: 94%). Enantiomeric excess was determined by HPLC analysis, ee = 93% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 70:30, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 24.444 min, tr(minor) = 27.461 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = +22.307.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 (d, *J* = 8.8 Hz, 2H), 7.93 (d, *J* = 7.1 Hz, 2H), 7.58 (d, *J* = 8.6 Hz, 2H), 7.49-7.35 (m, 4H), 7.12-7.02 (m, 3H), 6.86 (m, 1H), 6.53 (d, *J* = 7.8 Hz, 1H), 6.08 (d, *J* = 8.2 Hz, 1H), 5.72 (hept, 1H), 5.31 (dd, *J* = 10.0, 8.2 Hz, 1H), 4.88 (d, *J* = 10.0 Hz, 1H), 3.33 (m, 1H), 3.20-3.00 (m, 2H), 2.75 (m, 1H), 1.57 (d, *J* = 6.6 Hz, 3H), 1.56 (d, *J* = 6.6 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.0, 170.8, 148.8, 147.1, 142.7, 134.8, 132.7, 130.8, 130.7, 128.7 (2C), 127.8 (2C), 127.5, 127.2 (2C), 126.2, 125.9, 123.8 (2C), 123.0, 68.7, 67.7, 60.5, 50.2, 49.8, 29.4, 23.8, 23.7.

IR (KBr): *v* (cm^{-1}) 2932, 1663, 1601, 1520, 1493, 1396, 1345, 1254, 1109, 990, 816, 748, 736, 696.

HRMS (ESI, *m*/*z*) calcd for $C_{31}H_{29}N_5O_4Na^+$ $[M+Na]^+$: 558.2112, found: 558.2112.



3i

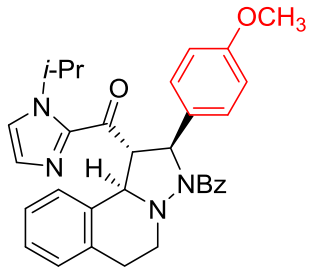
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1i** (12.7 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 4 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3i** as white solid (24.6 mg, yield: 98%). Enantiomeric excess was determined by HPLC analysis, ee = 97% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 0.8 mL/min, 30 ℃, tr(minor) = 27.737 min, tr(major) = 35.721 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –28.152. Mp 166–168 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.1 Hz, 2H), 7.45-7.25 (m, 6H), 7.10-7.02 (m, 5H), 6.84 (m, 1H), 6.51 (d, *J* = 7.8 Hz, 1H), 6.02 (d, *J* = 8.0 Hz, 1H), 5.72 (hept, 1H), 5.32 (dd, *J* = 10.0, 8.0 Hz, 1H), 4.82 (d, *J* = 10.0 Hz, 1H), 3.34-3.18 (m, 2H), 3.01 (ddd, *J* = 5.5, 12.2, 16.0 Hz, 1H), 2.71 (d, *J* = 16.0 Hz, 1H), 2.28 (s, 3H), 1.55 (d, *J* = 6.7 Hz, 3H), 1.53 (d, *J* = 6.7 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 191.1, 170.8, 142.9, 138.3, 136.6, 135.7, 133.3, 132.9, 130.5, 130.2, 129.1 (2C), 128.6, 128.5 (2C), 127.6 (2C), 127.2, 126.3, 126.1 (2C), 125.7, 122.4, 68.8, 67.9, 61.1, 49.9, 49.6, 29.5, 23.8, 23.7, 21.0.

IR (KBr): *v* (cm^{-1}) 2948, 1661, 1395, 1254, 990, 766.

HRMS (ESI, *m*/*z*) calcd for $C_{32}H_{32}N_4O_2Na^+$ $[M+Na]^+$: 527.2417, found: 527.2417.



3j

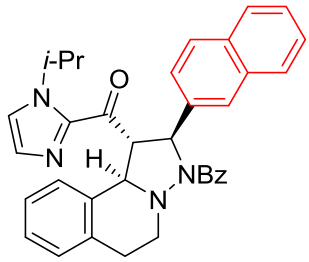
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1j** (13.5 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 4 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3j** as off white solid (25.4 mg, yield: 98%). Enantiomeric excess was determined by HPLC analysis, ee = 96% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 28.347 min, tr(minor) = 32.594 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –9.034. Mp 173–175 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.1 Hz, 2H), 7.45-7.30 (m, 6H), 7.05 (m, 3H), 6.88-6.77 (m, 3H), 6.52 (d, *J* = 7.8 Hz, 1H), 5.99 (d, *J* = 8.0 Hz, 1H), 5.71 (hept, 1H), 5.33 (dd, *J* = 10.0, 8.0 Hz, 1H), 4.83 (d, *J* = 10.0 Hz, 1H), 3.75 (s, 3H), 3.36-3.18 (m, 2H), 3.02 (ddd, *J* = 5.7, 12.0, 16.2 Hz, 1H), 2.71 (d, *J* = 16.2 Hz, 1H), 1.55 (d, *J* = 6.6 Hz, 3H), 1.52 (d, *J* = 6.6 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 191.1, 170.8, 158.6, 142.9, 135.7, 133.4, 133.3, 132.9, 130.5, 130.2, 128.6, 128.5 (2C), 127.6 (2C), 127.5 (2C), 127.2, 126.3, 125.7, 122.4, 113.8 (2C), 68.7, 67.8, 61.1, 55.3, 49.95, 49.6, 29.5, 23.8, 23.7.

IR (KBr): *v* (cm^{-1}) 2932, 1662, 1512, 1394, 1250, 1032, 669.

HRMS (ESI, *m*/*z*) calcd for $C_{32}H_{32}N_4O_3Na^+$ $[M+Na]^+$: 543.2367, found: 543.2364.



3k

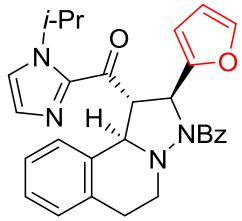
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1k** (14.5 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 5 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3k** as yellow solid (25 mg, yield: 93%). Enantiomeric excess was determined by HPLC analysis, ee = 95% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 0.8 mL/min, 30 ℃, tr(major) = 25.076 min, tr(minor) = 32.961 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = +38.135. Mp 180–183 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (m, 3H), 7.76 (m, 3H), 7.52 (d, *J* = 8.5 Hz, 1H), 7.48-7.35 (m, 5H), 7.33 (s, 1H), 7.05 (m, 3H), 6.86 (m, 1H), 6.55 (d, *J* = 7.8 Hz, 1H), 6.23 (d, *J* = 8.0 Hz, 1H), 5.74 (hept, 1H), 5.47 (dd, *J* = 10.0, 8.0 Hz, 1H), 4.89 (d, *J* = 10.0 Hz, 1H), 3.42-3.22 (m, 2H), 3.04 (ddd, *J* = 5.3, 12.2, 16.2 Hz, 1H), 2.71 (d, *J* = 16.2 Hz, 1H), 1.57 (d, *J* = 6.8 Hz, 3H), 1.54 (d, *J* = 6.8 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 191.0, 171.1, 142.9, 138.8, 135.6, 133.3, 132.9, 132.7, 130.6, 130.3, 128.6, 128.57 (2C), 128.2, 128.1, 127.6 (2C), 127.5, 127.2, 126.3, 126.0, 125.8, 125.7, 124.8 (2C), 122.5, 68.9, 68.3, 61.0, 50.0, 49.7, 29.5, 23.8, 23.7.

IR (KBr): *v* (cm^{-1}) 2931, 1660, 1493, 1448, 1395, 1255, 1163, 1075, 991, 916, 838, 766, 697, 667, 477.

HRMS (ESI, *m*/*z*) calcd for $C_{35}H_{32}N_4O_2Na^+$ $[M+Na]^+$: 563.2417, found: 563.2416.



3l

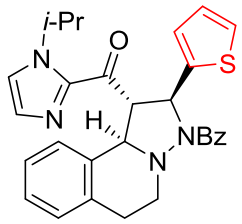
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1l** (11.5 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 5 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3l** as light brown solid (22.9 mg, yield: 96%). Enantiomeric excess was determined by HPLC analysis, ee = 96% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 60:40, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 7.842 min, tr(minor) = 12.669 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –31.422. Mp 195–198 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 6.9 Hz, 2H), 7.48-7.26 (m, 5H), 7.08 (brs, 2H), 7.01 (s, 1H), 6.88 (m, 1H), 6.59 (d, *J* = 7.7 Hz, 1H), 6.39 (s, 1H), 6.27 (s, 1H), 5.92 (d, *J* = 8.1 Hz, 1H), 5.66 (hept, 1H), 5.50 (dd, *J* = 8.1, 10.2 Hz, 1H), 4.84 (d, *J* = 10.2 Hz, 1H), 3.61 (m, 1H), 3.25 (m, 1H), 3.03 (m, 1H), 2.78 (d, *J* = 16.1 Hz, 1H), 1.53 (d, *J* = 6.6 Hz, 3H), 1.49 (d, *J* = 6.6 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.2, 170.0, 152.3, 142.8, 142.1, 135.3, 133.3, 133.0, 130.5, 130.3, 128.6, 128.5 (2C), 127.6 (2C), 127.2, 126.4, 125.8, 122.4, 110.5, 108.4, 67.6, 61.5, 58.4, 49.6, 49.3, 29.4, 23.80, 23.6.

IR (KBr): *v* (cm^{-1}) 2968, 1662, 1448, 1396, 1255, 1011, 768.

HRMS (ESI, *m*/*z*) calcd for $C_{29}H_{28}N_4O_3Na^+$ $[M+Na]^+$: 503.2054, found: 503.2054.



3m

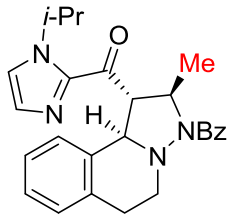
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1m** (12.3 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 5 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3m** as white solid (23.2 mg, yield: 94%). Enantiomeric excess was determined by HPLC analysis, ee = 95% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 0.8 mL/min, 30 ℃, tr(major) = 21.846 min, tr(minor) = 26.315 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –31.661. Mp 200–202 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 6.9 Hz, 2H), 7.45-7.32 (m, 4H), 7.24-7.16 (m, 2H), 7.12-7.04 (m, 3H), 6.92-6.83 (m, 2H), 6.54 (d, *J* = 7.7 Hz, 1H), 6.17 (d, *J* = 8.0 Hz, 1H), 5.68 (hept, 1H), 5.56 (dd, *J* = 10.1, 8.0 Hz, 1H), 4.82 (d, *J* = 10.1 Hz, 1H), 3.41 (ddd, *J* = 3.3, 10.8, 12.5 Hz, 1H), 3.31 (ddd, *J* = 1.8, 5.4, 10.8 Hz, 1H), 3.02 (ddd, *J* = 5.4, 12.5, 16.0 Hz, 1H), 2.75 (d, *J* = 16.0 Hz, 1H), 1.55 (d, *J* = 6.6 Hz, 3H), 1.51 (d, *J* = 6.6 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.3, 170.5, 145.6, 142.9, 135.3, 133.2, 132.9, 130.6, 130.3, 128.7, 128.5 (2C), 127.6 (2C), 127.3, 126.6, 126.3, 125.8, 125.0, 124.9, 122.6, 68.6, 64.0, 60.9, 50.0, 49.6, 29.5, 23.8, 23.6.

IR (KBr): *v* (cm^{-1}) 2932, 1661, 1493, 1447, 1396, 1164, 988, 917, 847, 767, 698.

HRMS (ESI, *m*/*z*) calcd for $C_{29}H_{28}N_4O_2SNa^+$ $[M+Na]^+$: 519.1825, found: 519.1822.



3n

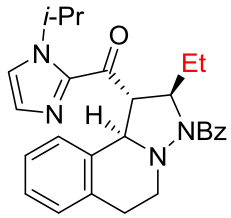
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1n** (8.9 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15.0 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 5 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3n** as colorless oil (19.6 mg, yield: 95%). Enantiomeric excess was determined by HPLC analysis, ee = 99.6% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 15.490 min, tr(minor) = 21.922 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –25.836.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 6.7 Hz, 2H), 7.43-7.32 (m, 4H), 7.16-7.04 (m, 3H), 6.95 (m, 1H), 6.78 (d, *J* = 7.8 Hz, 1H), 5.67 (hept, 1H), 4.96 (d, *J* = 10.4 Hz, 1H), 4.90 (dd, *J* = 7.7, 10.4 Hz, 1H), 4.62 (dq, *J* = 7.7, 6.5 Hz, 1H), 3.34 (m, 1H), 3.20 (m, 1H), 2.95 (ddd, *J* = 5.2, 12.4, 16.0 Hz, 1H), 2.70 (d, *J* = 16.0 Hz, 1H), 1.73 (d, *J* = 6.5 Hz, 3H), 1.54 (d, *J* = 6.7 Hz, 3H), 1.52 (d, *J* = 6.7 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.8, 168.9, 143.0, 135.7, 134.3, 133.0, 130.4, 130.0, 128.5, 128.4 (2C), 127.6 (2C), 127.1, 126.2, 126.1, 122.4, 65.4, 61.6, 60.8, 50.3, 49.6, 29.6, 23.8, 23.6, 22.7.

IR (KBr): *v* (cm^{-1}) 2974, 2931, 1665, 1573, 1449, 1395, 1255, 1127, 1019, 916, 829, 766, 712, 669.

HRMS (ESI, *m*/*z*) calcd for $C_{26}H_{28}N_4O_2Na^+$ $[M+Na]^+$: 451.2104, found: 451.2104.



3o

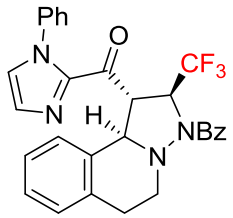
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1o** (9.6 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15.0 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 5 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3o** as colorless oil (19.8 mg, yield: 90%). Enantiomeric excess was determined by HPLC analysis, ee = 99% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 12.521 min, tr(minor) = 13.649 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –50.371.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 6.6 Hz, 2H), 7.43-7.30 (m, 4H), 7.13-7.03 (m, 3H), 6.87 (m, 1H), 6.57 (d, *J* = 7.7 Hz, 1H), 5.68 (hept, 1H), 4.97 (dd, *J* = 8.0, 10.2 Hz, 1H), 4.75 (d, *J* = 10.2 Hz, 1H), 4.70 (dt, *J* = 5.6, 8.2 Hz, 1H), 3.34 (m, 1H), 3.22 (m, 1H), 2.95 (ddd, *J* = 5.1, 12.3, 16.1 Hz, 1H), 2.71 (d, *J* = 16.1 Hz, 1H), 2.22 (m, 1H), 1.91 (m, 1H), 1.54 (d, *J* = 6.7 Hz, 3H), 1.51 (d, *J* = 6.7 Hz, 3H), 0.93 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 191.4, 170.5, 142.9, 136.1, 133.8, 133.0, 130.3, 129.9, 128.5, 128.2 (2C), 127.5 (2C), 127.1, 126.3, 125.8, 122.3, 67.6, 67.5, 59.5, 49.9, 49.6, 30.9, 30.3, 29.6, 23.7, 11.3.

IR (KBr): *v* (cm^{-1}) 2963, 1678, 1550, 1396, 1092, 850, 730.

HRMS (ESI, *m*/*z*) calcd for $C_{27}H_{30}N_4O_2Na^+$ $[M+Na]^+$: 465.2261, found: 465.2260.



3p

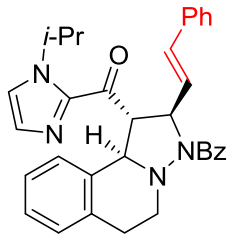
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1p** (13.3 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 5 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3p** as white solid (25.4 mg, yield: 99%). Enantiomeric excess was determined by HPLC analysis, ee = 97% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 8.206 min, tr(minor) = 9.840 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –203.00. Mp 165–167 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (m, 2H), 7.54 (m, 3H), 7.46-7.32 (m, 5H), 7.26 (d, *J* = 0.8 Hz, 1H), 7.21 (d, *J* = 0.8 Hz, 1H), 7.10 (m, 2H), 6.90 (m, 1H), 6.47 (d, *J* = 7.8 Hz, 1H), 5.56 (qn, 1H), 5.38 (dd, *J* = 10.2, 8.7 Hz, 1H), 4.46 (d, *J* = 10.2 Hz, 1H), 3.48-3.35 (m, 2H), 2.98 (ddd, *J* = 7.5, 10.6, 16.2 Hz, 1H), 2.81 (dt, *J* = 16.2, 2.5 Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 187.3, 173.9, 143.0, 138.0, 134.7, 133.2, 131.9, 130.87, 130.85, 129.3 (2C), 128.8, 128.6, 128.3 (2C), 127.7 (2C), 127.6, 126.3, 126.0 (2C), 125.8, 124.7 (q, *J* = 278 Hz), 68.6, 64.7 (q, *J* = 33.5 Hz), 53.8, 48.9, 29.5.

IR (KBr): *v* (cm^{-1}) 2958, 1680, 1597, 1491, 1446, 1411, 1391, 1328, 1283, 1257, 1170, 1126, 976, 802, 739, 692.

HRMS (ESI, *m*/*z*) calcd for $C_{29}H_{23}F_3N_4O_2Na^+$ $[M+Na]^+$: 539.1665, found: 539.1664.



3q

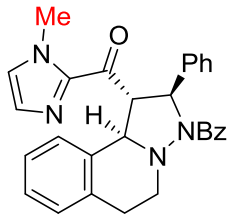
A dried 25 mL Schlenk tube was charged with styryl-substituted α,β-unsaturated 2-acyl imidazole **1q** (13.3 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15.0 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 4 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3q** as yellow oil (25.0 mg, yield: 97%). Enantiomeric excess was determined by HPLC analysis, ee = 98% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 14.530 min, tr(minor) = 15.653 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = +26.225.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 7.0 Hz, 2H), 7.45-7.04 (m, 12H), 6.92 (m, 1H), 6.80-6.50 (m, 3H), 5.67 (hept, 1H), 5.42 (t, *J* = 6.0 Hz, 1H), 5.16 (dd, *J* = 10.1, 8.0 Hz, 1H), 4.90 (d, *J* = 10.1 Hz, 1H), 3.42-3.24 (m, 2H), 3.02 (ddd, *J* = 5.4, 12.2, 16.2 Hz, 1H), 2.74 (d, *J* = 16.2 Hz, 1H), 1.53 (d, *J* = 6.7 Hz, 3H), 1.50 (d, *J* = 6.7 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.5, 169.9, 142.9, 136.8, 135.5, 133.8, 132.9, 131.4, 130.5, 130.2, 129.5, 128.6, 128.5 (2C), 128.4 (2C), 127.6 (2C), 127.55, 127.2, 126.7 (2C), 126.3, 126.0, 122.5, 66.5, 66.2, 59.4, 50.2, 49.6, 29.5, 23.8, 23.6.

IR (KBr): *v* (cm^{-1}) 2975, 1751, 1505, 1436, 1259, 749.

HRMS (ESI, *m*/*z*) calcd for $C_{33}H_{32}N_4O_2Na^+$ $[M+Na]^+$: 539.2417, found: 539.2416.



3r

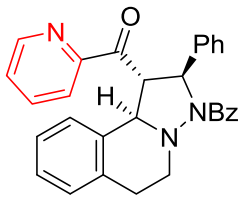
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1r** (10.6 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 3 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3r** as white solid (22.8 mg, yield: 99%). Enantiomeric excess was determined by HPLC analysis, ee = 97% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 70:30, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 14.863 min, tr(minor) = 27.742 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –8.074. Mp 235–238 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 7.1 Hz, 2H), 7.45-7.35 (m, 5H), 7.30-7.15 (m, 3H), 7.13-7.00 (m, 4H), 6.86 (m, 1H), 6.51 (d, *J* = 7.7 Hz, 1H), 6.08 (d, *J* = 7.9 Hz, 1H), 5.27 (dd, *J* = 10.0, 7.9 Hz, 1H), 4.84 (d, *J* = 10.0 Hz, 1H), 4.15 (s, 3H), 3.31 (m, 1H), 3.20 (ddd, *J* = 3.2, 10.6, 12.2 Hz, 1H), 3.02 (ddd, *J* = 5.2, 12.2, 16.0 Hz, 1H), 2.71 (d, *J* = 16.0 Hz, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 191.0, 170.9, 143.5, 141.2, 135.6, 133.2, 132.9, 130.3, 130.1, 128.6, 128.5 (2C), 128.4 (2C), 128.2, 127.6 (2C), 127.2, 127.1, 126.3, 126.1 (2C), 125.8, 68.8, 68.0, 60.7, 49.9, 36.6, 29.4.

IR (KBr): *v* (cm^{-1}) 2923, 1662, 1404, 991, 669.

HRMS (ESI, *m*/*z*) calcd for $C_{29}H_{26}N_4O_2Na^+$ $[M+Na]^+$: 485.1948, found: 485.1948.



3s

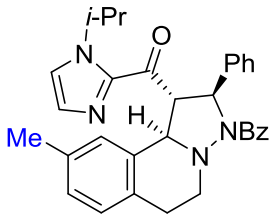
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylpyridine **1s** (10.4 mg, 0.05 mmol), C,N-cyclic azomethine imine **2a** (15.0 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 5 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3s** as white solid (21.6 mg, yield: 95%). Enantiomeric excess was determined by HPLC analysis, ee = 94% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 26.625 min, tr(minor) = 48.838 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –13.192. Mp 210–213 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (d, *J* = 4.2 Hz, 1H), 8.22 (d, *J* = 7.8 Hz, 1H), 8.00-7.80 (m, 3H), 7.50-7.12 (m, 9H), 7.04 (m, 2H), 6.76 (m, 1H), 6.50 (d, *J* = 7.8 Hz, 1H), 6.11 (d, *J* = 8.1 Hz, 1H), 5.53 (dd, *J* = 10.1, 8.1 Hz, 1H), 4.94 (d, *J* = 10.1 Hz, 1H), 3.40-3.23 (m, 2H), 3.04 (ddd, *J* = 5.5, 12.3, 16.0 Hz, 1H), 2.74 (d, *J* = 16.0 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 200.9, 170.6, 152.9, 149.0, 141.3, 137.1, 135.6, 133.3, 132.9, 130.3, 128.5 (2C), 128.48, 128.4 (2C), 127.7 (2C), 127.6, 127.2, 127.0, 126.5, 126.0 (2C), 125.8, 122.9, 68.9, 68.4, 58.8, 50.0, 29.5.

IR (KBr): *v* (cm^{-1}) 3057, 3027, 2930, 1687, 1648, 1601, 1579, 1494, 1446, 1381, 1348, 1279, 1250, 995, 937, 868, 769, 748, 695, 669, 618, 550.

HRMS (ESI, *m*/*z*) calcd for $C_{30}H_{25}N_3O_2Na^+$ $[M+Na]^+$: 482.1839, found: 482.1836.



3t

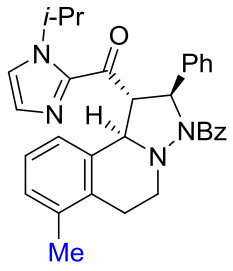
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1a** (12.0 mg, 0.05 mmol), C,N-cyclic azomethine imine **2t** (15.8 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 4 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3t** as white solid (24.4 mg, yield: 97%). Enantiomeric excess was determined by HPLC analysis, ee = 91% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 18.996 min, tr(minor) = 29.639 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –13.352. Mp 160–162 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (d, *J* = 7.1 Hz, 2H), 7.45-7.15 (m, 9H), 7.04 (s, 1H), 6.88 (m, 2H), 6.24 (s, 1H), 6.10 (d, *J* = 8.0 Hz, 1H), 5.77 (hept, 1H), 5.31 (dd, *J* = 10.0, 8.0 Hz, 1H), 4.72 (d, *J* = 10.0 Hz, 1H), 3.29 (m, 1H), 3.18 (m, 1H), 2.96 (ddd, *J* = 5.1, 12.0, 16.0 Hz, 1H), 2.66 (d, *J* = 16.0 Hz, 1H), 1.96 (s, 3H), 1.57 (d, *J* = 6.5 Hz, 3H), 1.55 (d, *J* = 6.5 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 191.0, 170.8, 142.9, 141.3, 135.6, 135.0, 132.9, 130.6, 130.2, 129.7, 128.5 (2C), 128.4 (2C), 128.3, 128.0, 127.6 (2C), 127.1, 127.0, 126.1 (2C), 122.3, 69.2, 67.8, 61.3, 50.1, 49.6, 29.0, 24.0, 23.6, 20.8.

IR (KBr): *v* (cm^{-1}) 2951, 1751, 1664, 1563, 1395, 1215, 988, 758.

HRMS (ESI, *m*/*z*) calcd for $C_{32}H_{32}N_4O_2Na^+$ $[M+Na]^+$: 527.2417, found: 527.2417.



3u

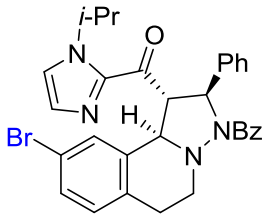
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1a** (12.0 mg, 0.05 mmol), C,N-cyclic azomethine imine **2u** (15.8 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 5 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3u** as white solid (24.1 mg, yield: 96%). Enantiomeric excess was determined by HPLC analysis, ee = 99% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 19.252 min, tr(minor) = 28.024 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –21.504. Mp 160–163 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 7.0 Hz, 2H), 7.45-7.15 (m, 9H), 7.04 (s, 1H), 6.91 (d, *J* = 7.5 Hz, 1H), 6.76 (t, *J* = 7.5 Hz, 1H), 6.36 (d, *J* = 7.7 Hz, 1H), 6.10 (d, *J* = 8.0 Hz, 1H), 5.72 (hept, 1H), 5.37 (dd, *J* = 10.0, 8.0 Hz, 1H), 4.79 (d, *J* = 10.0 Hz, 1H), 3.35 (m, 1H), 3.18 (m, 1H), 2.84-2.64 (m, 2H), 2.14 (s, 3H), 1.53 (t, *J* = 6.8 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 191.0, 170.8, 142.8, 141.3, 136.0, 135.6, 132.9, 131.4, 130.4, 130.1, 128.5, 128.4 (2C), 128.3 (2C), 127.5 (2C), 126.9, 126.0 (2C), 125.5, 124.0, 122.4, 69.2, 67.8, 61.0, 49.7, 49.5, 26.9, 23.7, 23.6, 19.3.

IR (KBr): *v* (cm^{-1}) 2929, 1663, 1576, 1495, 1448, 1396, 1351, 1255, 1163, 1076, 990, 917, 779, 696, 670, 552.

HRMS (ESI, *m*/*z*) calcd for $C_{32}H_{32}N_4O_2Na^+$ $[M+Na]^+$: 527.2417, found: 527.2417.



3v

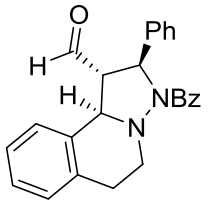
A dried 25 mL Schlenk tube was charged with α,β-unsaturated 2-acylimidazole **1a** (12.0 mg, 0.05 mmol), C,N-cyclic azomethine imine **2v** (19.75 mg, 0.06 mmol) and chiral catalyst **Δ-Rh2** (1.03 mg, 2.0 mol%). The tube was purged with argon and anhydrous DCE (0.1 mL) was added. The reaction mixture was stirred at room temperature for 5 h (monitored by TLC) under argon. The mixture was purified by flash column chromatography on silica gel (petroleum ether/ EtOAc = 5:1 to 1:1) to afford chiral product **3v** as white solid (26.6 mg, yield: 94%). Enantiomeric excess was determined by HPLC analysis, ee = 91% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 80:20, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 17.280 min, tr(minor) = 24.890 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –18.229. Mp 130–133 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, *J* = 7.1 Hz, 2H), 7.46-7.13 (m, 10H), 7.06 (s, 1H), 6.91 (d, *J* = 8.2 Hz, 1H), 6.55 (d, *J* = 1.8 Hz, 1H), 6.12 (d, *J* = 8.1 Hz, 1H), 5.74 (hept, 1H), 5.33 (dd, *J* = 10.1, 8.1 Hz, 1H), 4.66 (d, *J* = 10.1 Hz, 1H), 3.33 (m, 1H), 3.20 (m, 1H), 2.94 (ddd, *J* = 5.2, 12.2, 16.2 Hz, 1H), 2.68 (d, *J* = 16.2 Hz, 1H), 1.59 (d, *J* = 6.7 Hz, 3H), 1.56 (d, *J* = 6.7 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 190.2, 170.9, 142.8, 141.1, 135.5, 135.2, 131.9, 130.8, 130.3, 130.2, 130.1, 129.6, 128.5 (2C), 128.4 (2C), 127.7 (2C), 127.1, 126.0 (2C), 122.8, 119.1, 68.5, 67.5, 61.1, 49.7, 49.6, 29.0, 23.9, 23.7.

IR (KBr): *v* (cm^{-1}) 2929, 1664, 1576, 1486, 1449, 1396, 1351, 1255, 1192, 1165, 1078, 990, 935, 844, 760, 698, 669, 517.

HRMS (ESI, *m*/*z*) calcd for $C_{31}H_{29}BrN_4O_2Na^+$ $[M+Na]^+$: 591.1366, found: 591.1365.



4

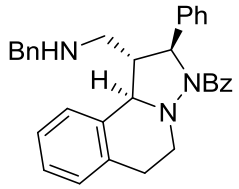
In a round bottom flask, sodium borohydride (6.15 mg, 0.16 mmol) was added portionwise to a solution of the substrate **3a** (32.2mg, 0.06 mmol in methanol, c = 0.125 M). The reaction was stirred at room temperature for 2 h and monitored by TLC. After completion, water was added and the mixture was extracted with ethyl acetate. The organic layer was further washed with brine, dried over magnesium sulfate and concentrated under vacuum. The intermediate so obtained was dissolved with ethyl acetate (c = 0.05 M) and treated with methyl iodide (28 μL, 0.45 mmol). The mixture was heated at 60 ℃ for 16 h, cooled down to room temperature and concentrated to dryness. The crude residue was taken up in toluene (c = 0.17 M), glycine (19.51 mg, 0.26 mmol) and 2 M NaOH solution (0.29 mL, 0.58 mmol) were added. The mixture was heated at 80 ℃ for 5 h. At 80 ℃, 1 M HCl solution (0.6 mL, 0.58 mmol) was added and the mixture was stirred until lightening of the aqueous phase (from cloudy to clear). Then the mixture was cooled down to room temperature and ethyl acetate was added. The organic layer was washed with an aqueous solution of 1M HCl and brine, dried over magnesium sulfate and concentrated under vacuum. The residue was purified by column chromatography (petroleum ether/ EtOAc = 7:1 to 3:1) to afford the chiral product **4** as white solid (15.5 mg, yield: 62%). Enantiomeric excess was determined by HPLC analysis, ee = 97% (Chiralpak column IC, λ = 254 nm, *n*-hexane/*i*-PrOH = 70:30, flow rate: 1.0 mL/min, 30 ℃, tr(major) = 13.258 min, tr(minor) = 22.896 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = +44.853. Mp 155–158 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 10.16 (d, *J* = 3.3 Hz, 1H), 7.88 (d, *J* = 7.1 Hz, 2H), 7.48-7.07 (m, 11H), 6.96 (m, 1H), 6.11 (d, *J* = 8.1 Hz, 1H), 4.67 (d, *J* = 10.2 Hz, 1H), 3.73 (ddd, *J* = 10.2, 8.1, 3.3 Hz, 1H), 3.37 (m, 1H), 3.06 (m, 2H), 2.74 (m, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 199.3, 170.8, 140.6, 134.9, 133.0, 132.6, 130.7, 128.8 (2C), 128.6 (2C), 127.8 (2C), 127.7, 127.5, 126.9, 126.6, 125.5 (2C), 66.8, 64.9, 63.0, 50.1, 29.3.

IR (KBr): *v* (cm^{-1}) 2985, 1720, 1394, 1028, 749.

HRMS (ESI, *m*/*z*) calcd for $C_{25}H_{22}N_2O_2Na^+$ $[M+Na]^+$: 405.1573, found: 405.1573.



5

In a round bottom flask, sodium borohydride (6.9 mg, 0.18 mmol) was added portionwise to a solution of the substrate **3a** (36.0 mg, 0.07 mmol,) in methanol (0.36 mL). The mixture was stirred at room temperature for 2 h and monitored by TLC. Water was added, the mixture was extracted with ethyl acetate. The organic layer was washed with brine, dried over magnesium sulfate and concentrated under vacuum. Ethyl acetate (0.56 mL) was added to the intermediate followed by methyl iodide (31.8 μL, 0.51 mmol). The mixture was heated at 60 ℃ for 16 h, cooled down to room temperature and concentrated to dryness. The residue was taken up in toluene (0.36 mL), benzylamine (31.8 μL, 0.29 mmol) and 2 M NaOH solution (0.18 mL, 0.36 mmol) were then added. The mixture was heated at 80 ℃ for 5 h and cooled down to room temperature. The organic layer was diluted with ethyl acetate, dried with brine and concentrated under vacuum. The residue was taken up in MeOH (0.36 mL) and sodium borohydride (27.6 mg, 0.73 mmol) was added at room temperature. The mixture was stirred at room temperature for 16 h. Water was added and the mixture was extracted with ethyl acetate. The combined organic layers were washed with brine, dried over magnesium sulfate and concentrated under vacuum. The residue was purified by column chromatography (petroleum ether/ EtOAc = 6:1 to 1:1) to afford chiral product **5** as white solid (13.5 mg, yield: 39%). Enantiomeric excess was determined by HPLC analysis, ee = 97% (Chiralpak column IA, λ = 254 nm, *n*-hexane/*i*-PrOH = 70:30, flow rate: 1.0 mL/min, 30 ℃, tr(minor) = 10.805 min, tr(major) = 18.467 min). $[\alpha]_D^{25}$ (*c* 0.5, $CHCl_3$) = –25.549. Mp 110–113 ℃.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 6.7 Hz, 2H), 7.45-7.20 (m, 13H), 7.15 (dt, *J* = 1.2, 7.3 Hz, 1H), 7.09 (t, *J* = 7.3 Hz, 2H), 6.98 (d, *J* = 7.6 Hz, 1H), 5.45 (d, *J* = 8.6 Hz, 1H), 4.34 (d, *J* = 10.6 Hz, 1H), 3.88 (AB, *J* = 13.2 Hz, 2H), 3.32-3.14 (m, 3H), 3.07-2.96 (m, 2H), 2.82-2.67 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.4, 142.0, 140.1, 135.5, 134.2, 133.2, 130.1, 128.6 (2C), 128.5 (2C), 128.47 (2C), 128.44 (2C), 127.6 (2C), 127.2, 127.17, 127.05, 127.03, 126.4 (2C), 126.1, 66.0, 64.1, 54.3, 53.7, 49.9, 47.4, 29.6.

IR (KBr): *v* (cm^{-1}) 3026, 2964, 1639, 1493, 1451, 1397, 1028, 744, 697.

HRMS (ESI, *m*/*z*) calcd for $C_{32}H_{31}N_3ONa^+$ $[M+Na]^+$: 496.2359, found: 496.2356.

NMR Spectra

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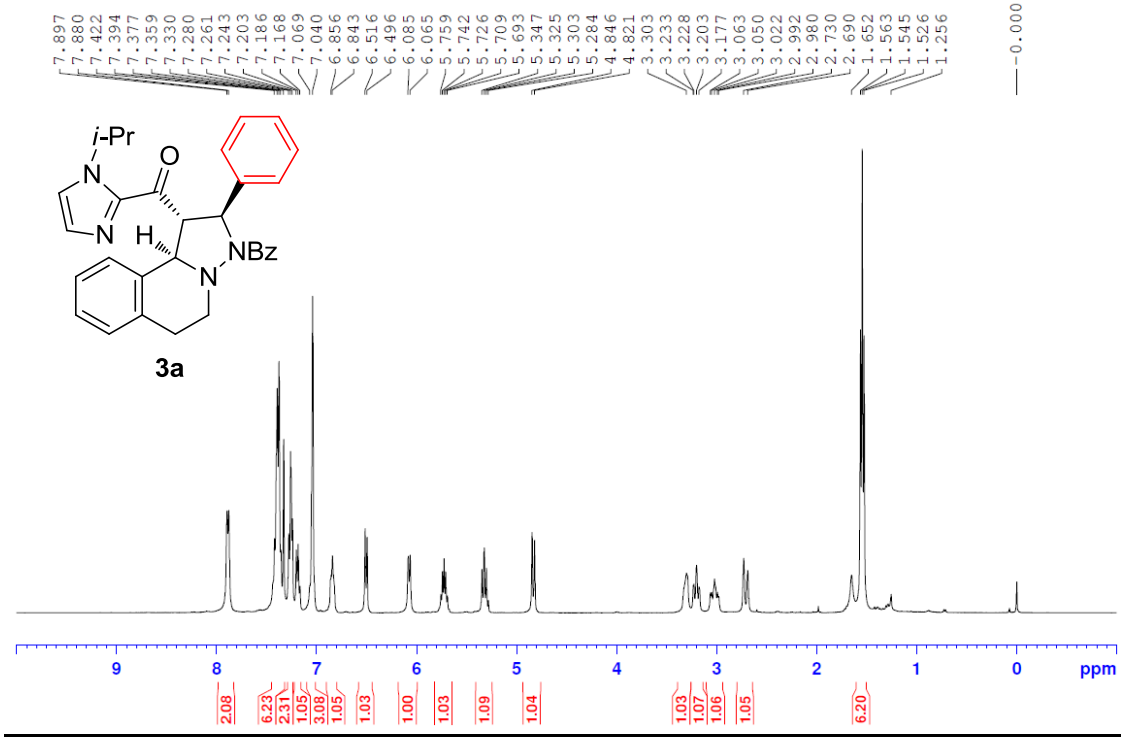
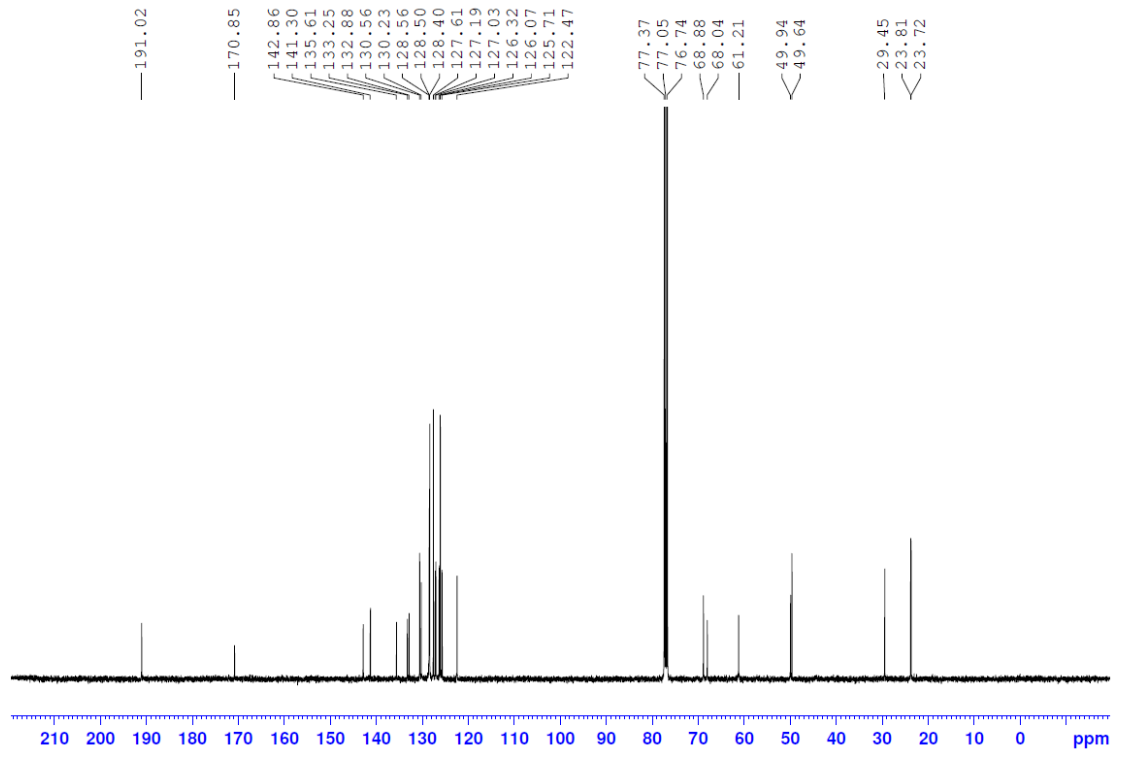
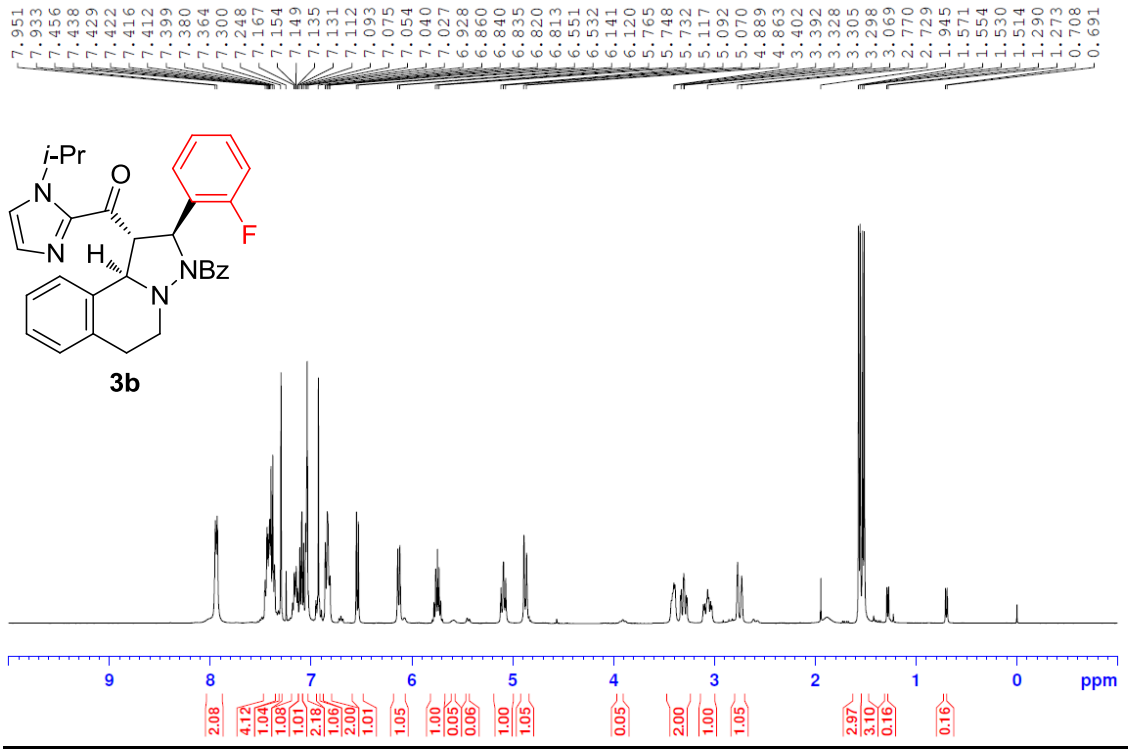




Compound 3b: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H
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N
F
3b
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8
7
6
5
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3
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ppm
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1.08
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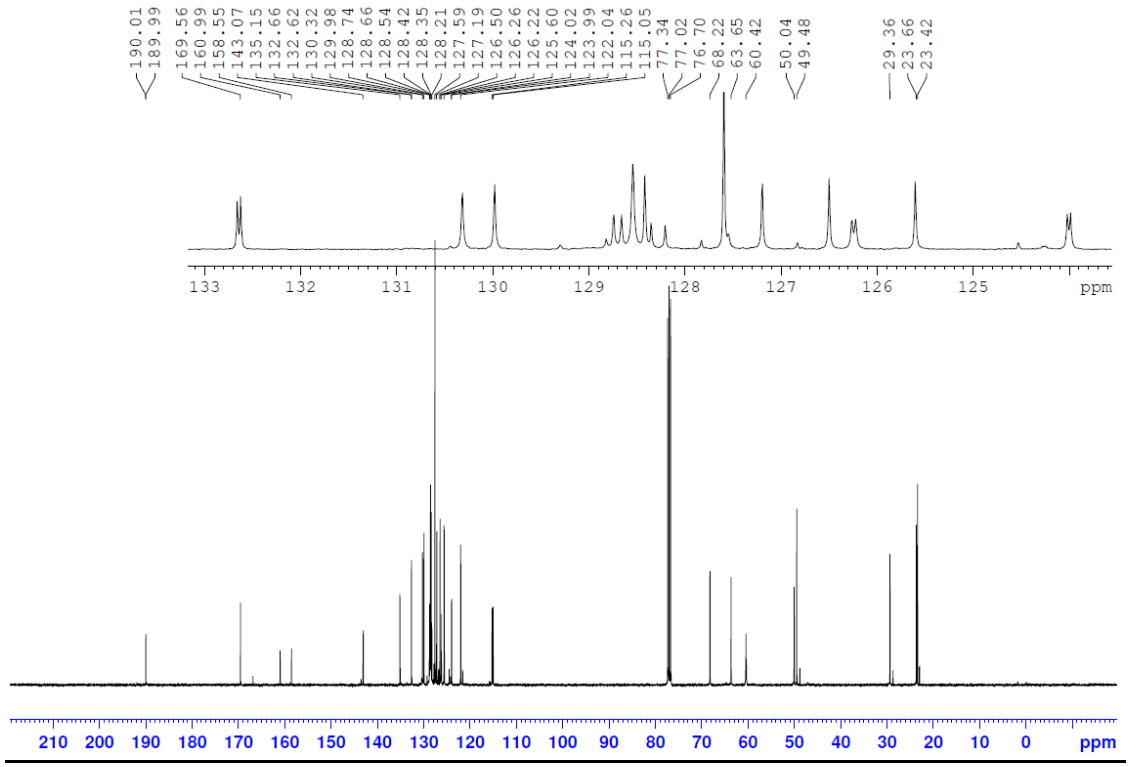
0.16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128.21
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126.26
126.22
125.60
124.02
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115.05
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77.02
76.70
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132
131
130
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127
126
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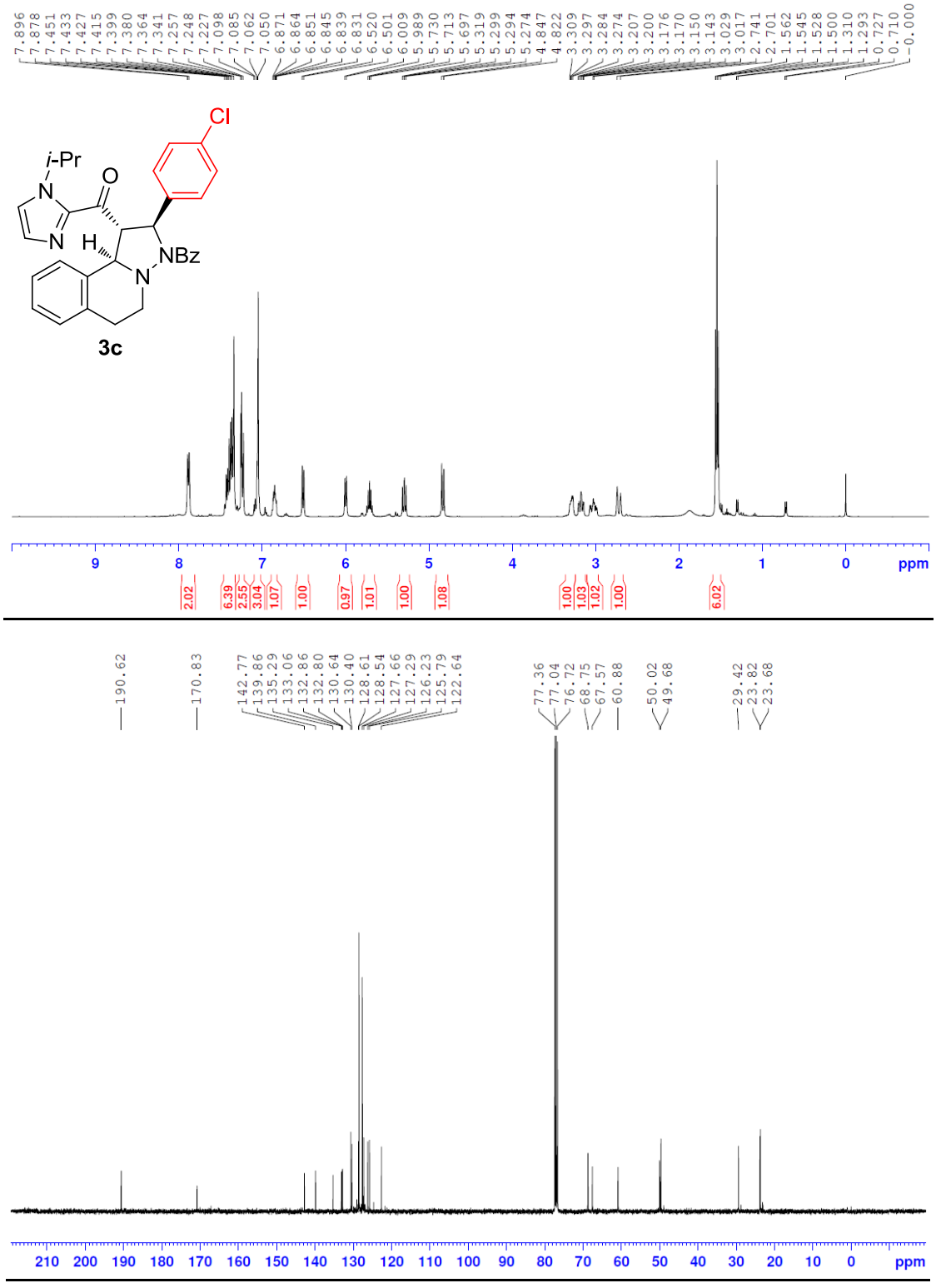
Compound 3c: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H
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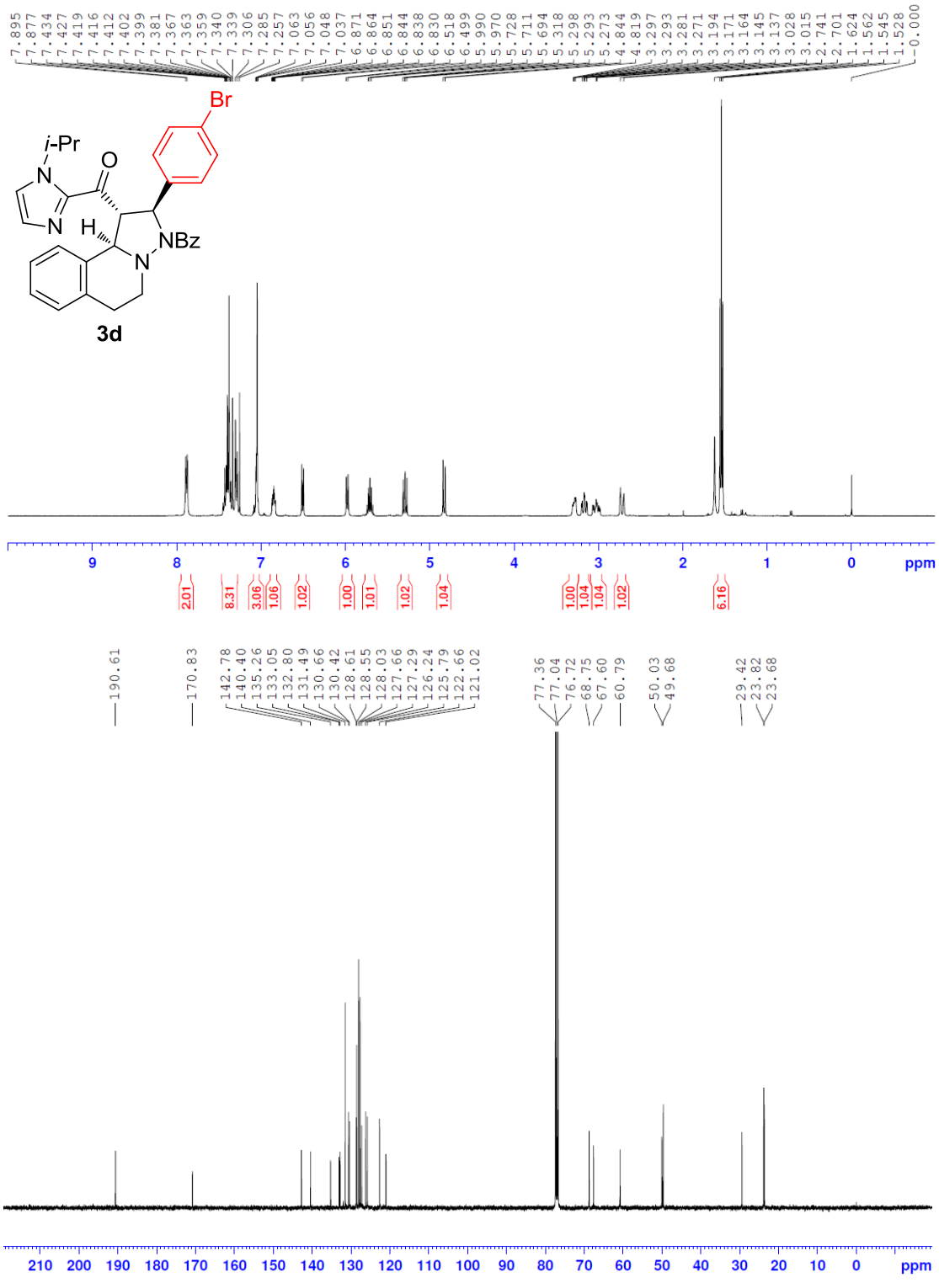
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N
H
NBz
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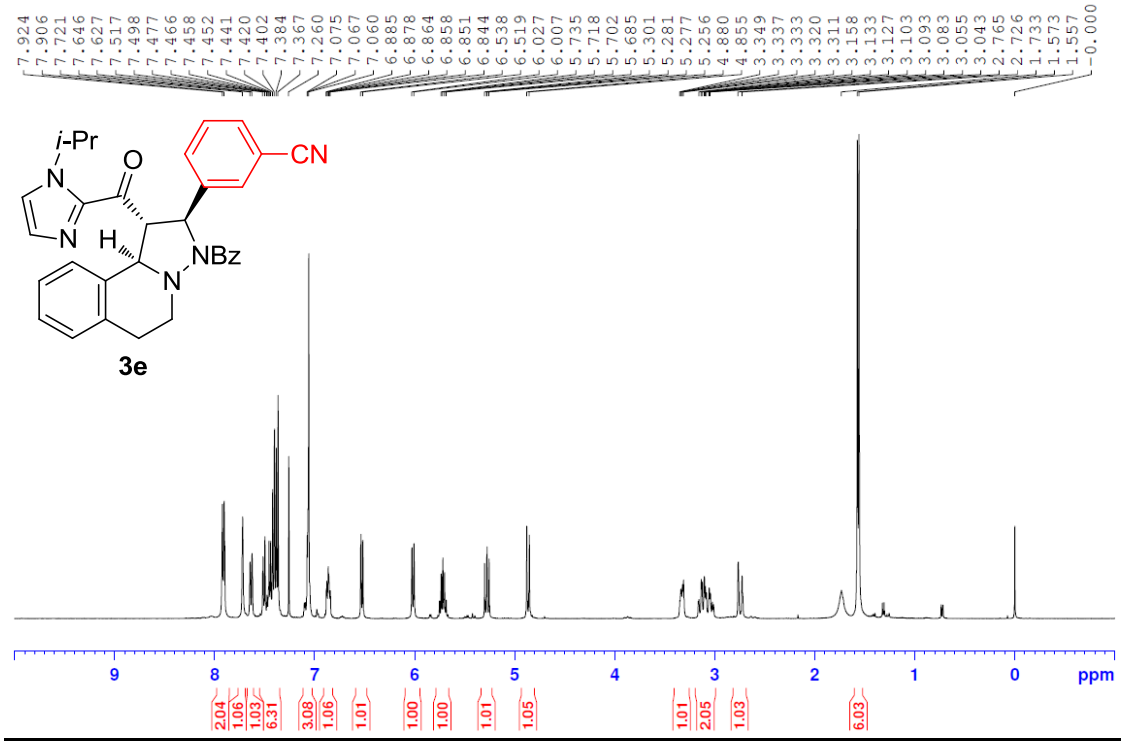
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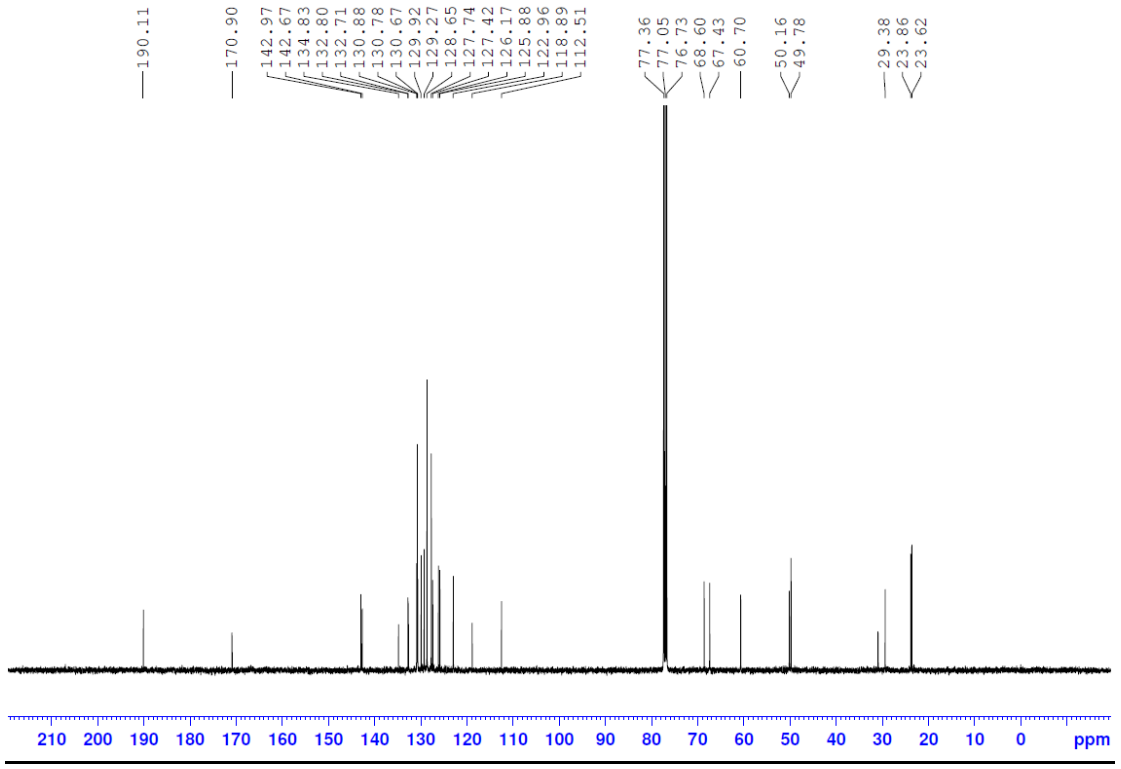
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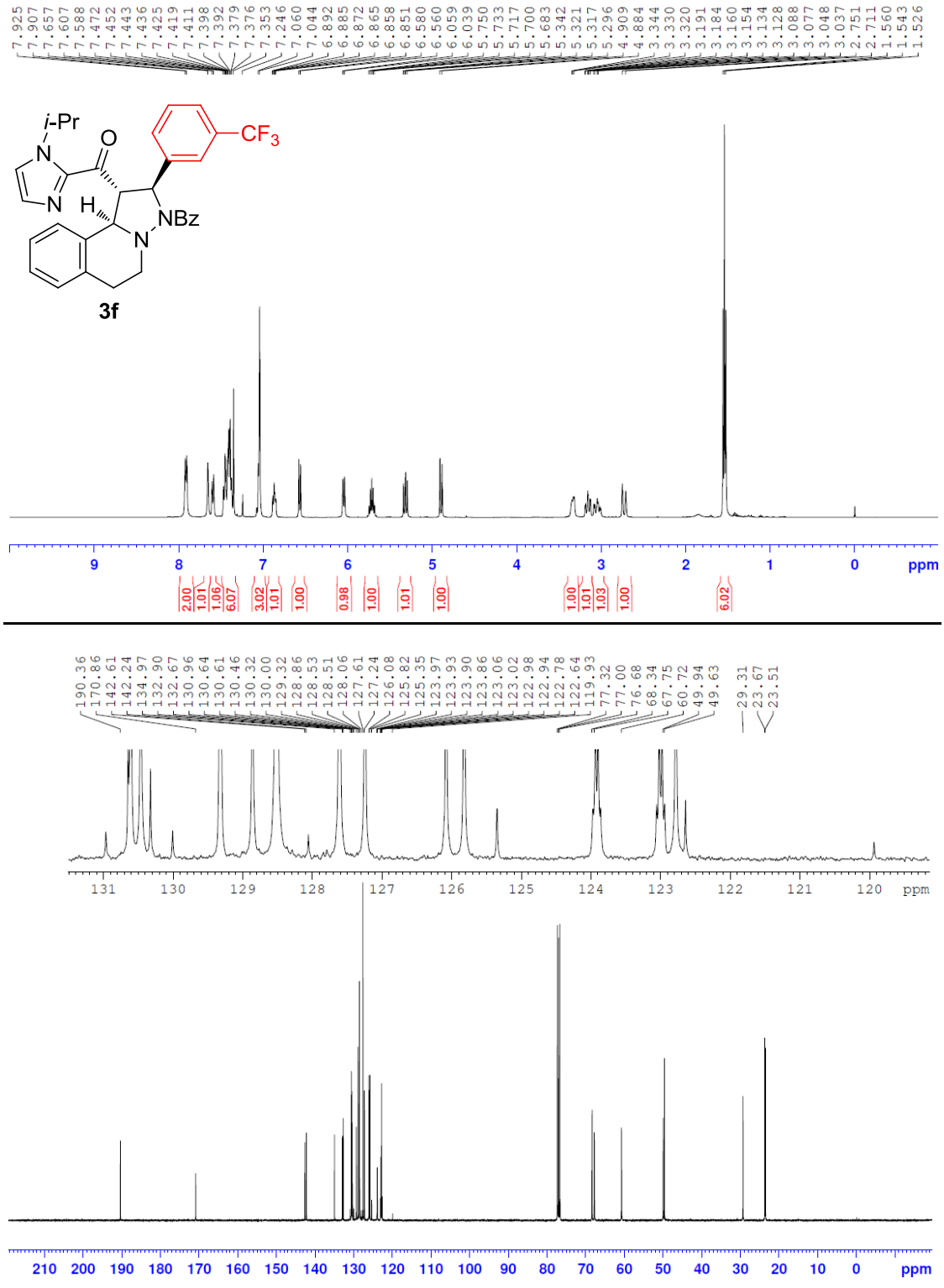
Compound 3f: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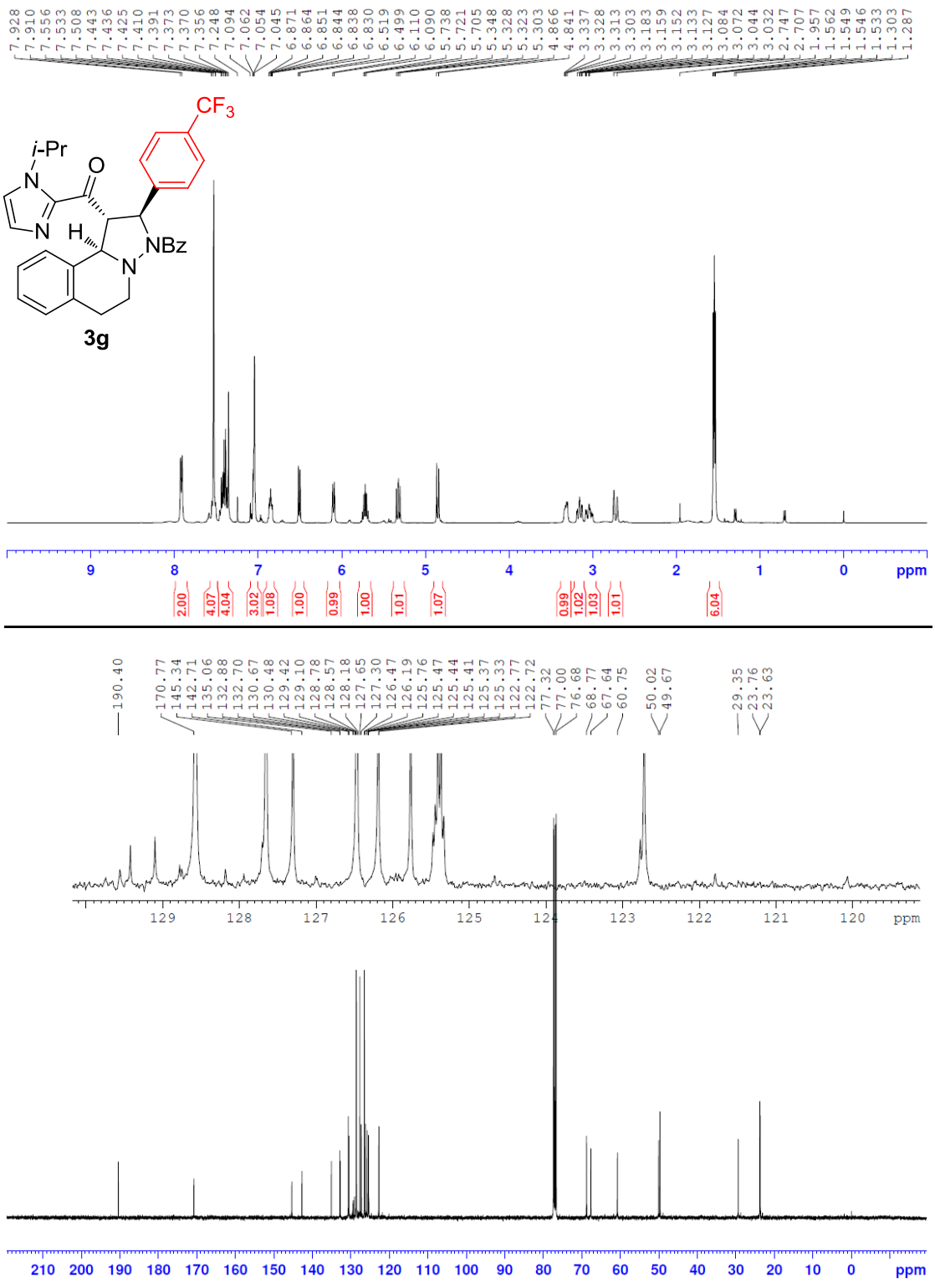
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180
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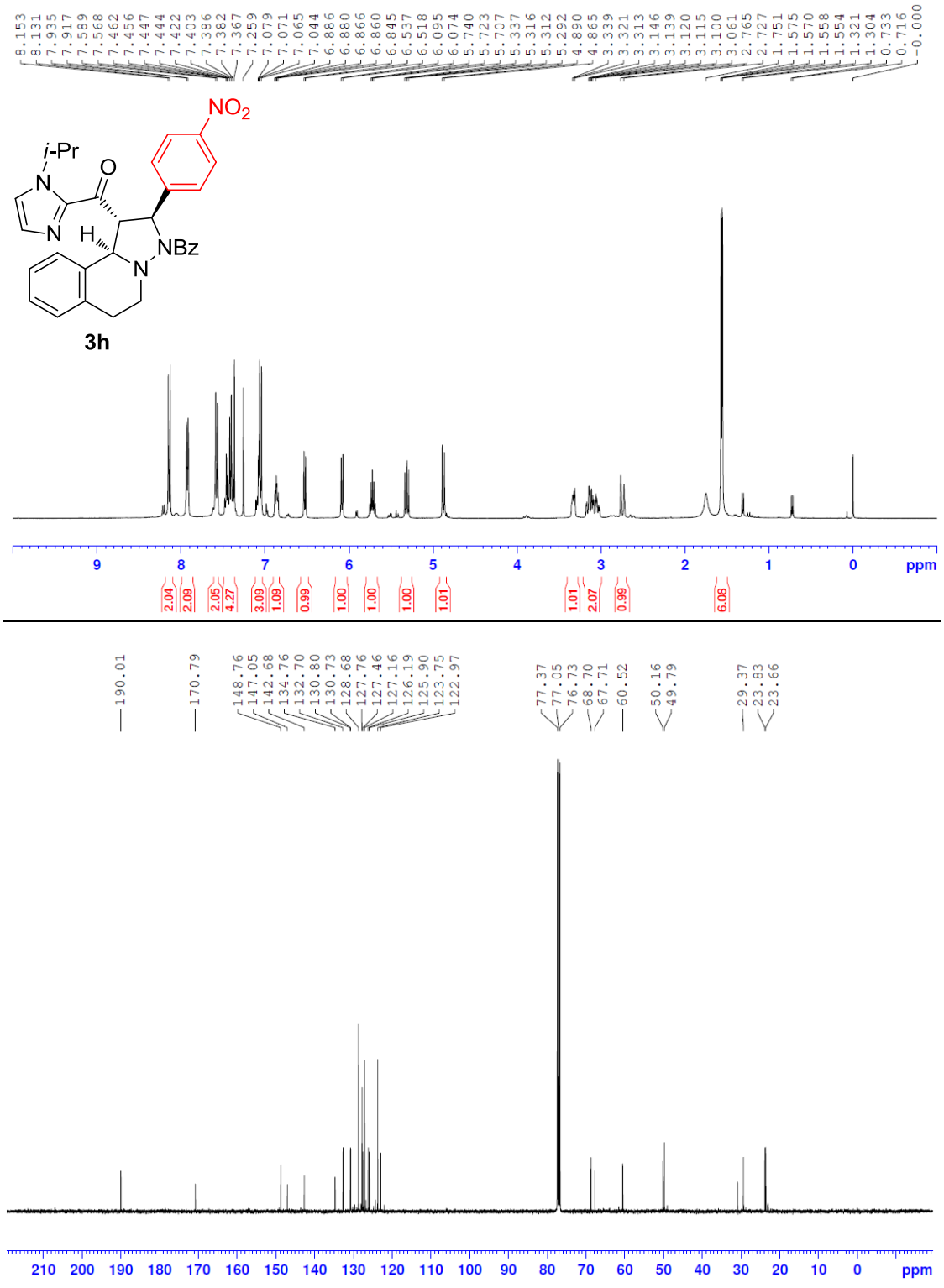
Compound 3h: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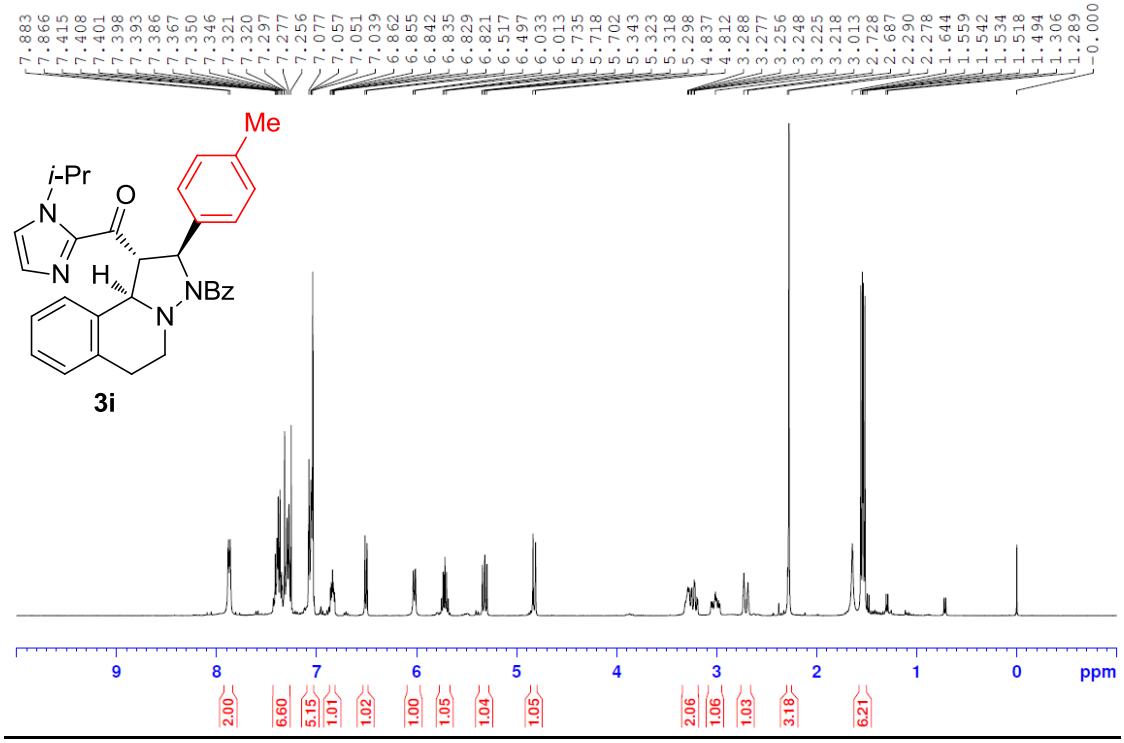
O
N
N
H
NBz
N
3h
9
8
7
6
5
4
3
2
1
0
ppm
2.04
2.09
2.05
4.27
3.09
1.09
0.99
1.00
1.00
1.00
1.01
1.01
2.07
0.99
6.08
190.01
170.79
148.76
147.05
142.68
134.76
132.70
130.80
130.73
128.68
127.76
127.46
127.16
126.19
125.90
123.75
122.97
77.37
77.05
76.73
68.70
67.71
60.52
50.16
49.79
29.37
23.83
23.66
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

Compound 3i: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7.401
7.398
7.393
7.386
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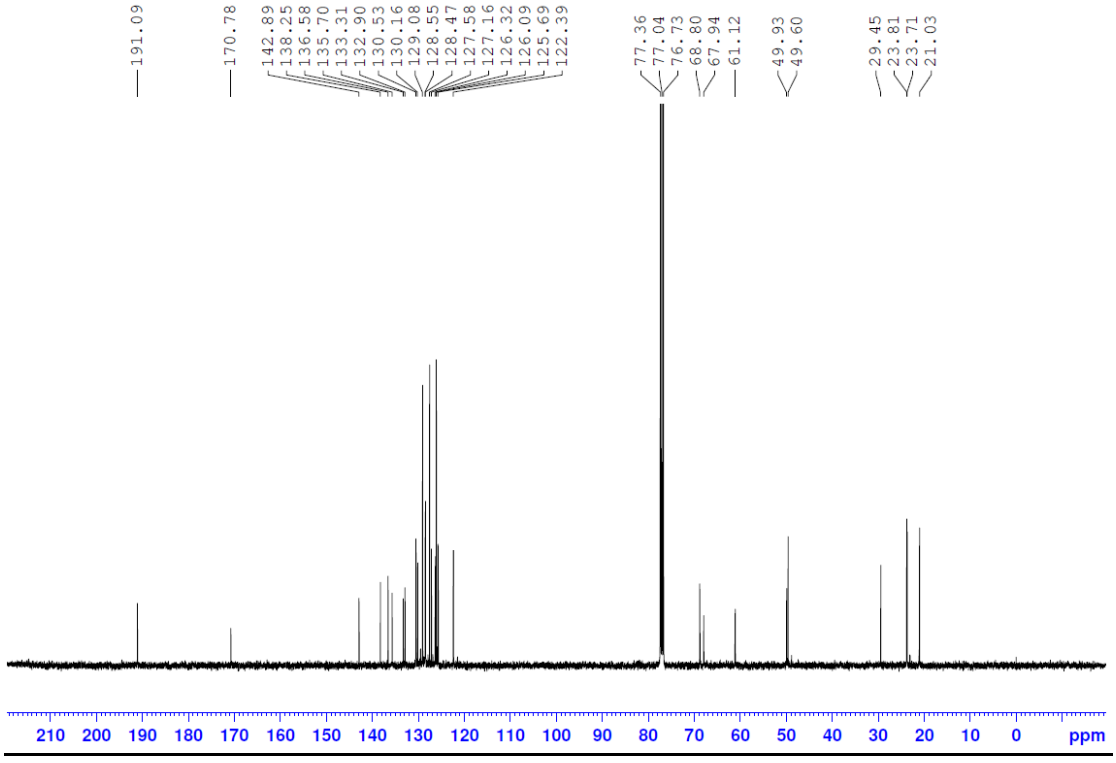
7.350
7.346
7.321
7.320
7.297
7.277
7.256
7.077
7.057
7.051
7.039
6.862
6.855
6.842
6.835
6.829
6.821
6.517
6.497
6.033
6.013
5.735
5.718
5.702
5.343
5.323
5.318
5.298
4.837
4.812
3.288
3.277
3.256
3.248
3.225
3.218
3.013
2.728
2.687
2.290
2.278
1.644
1.559
1.542
1.534
1.518
1.494
1.306
1.289
0.000
Me
i-Pr
O
N
N
H
NBz
N
3i
9
8
7
6
5
4
3
2
1
0
ppm
2.00
6.60
5.15
1.01
1.02
1.00
1.05
1.04
1.05
2.06
1.06
1.03
3.18
6.21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170.78
142.89
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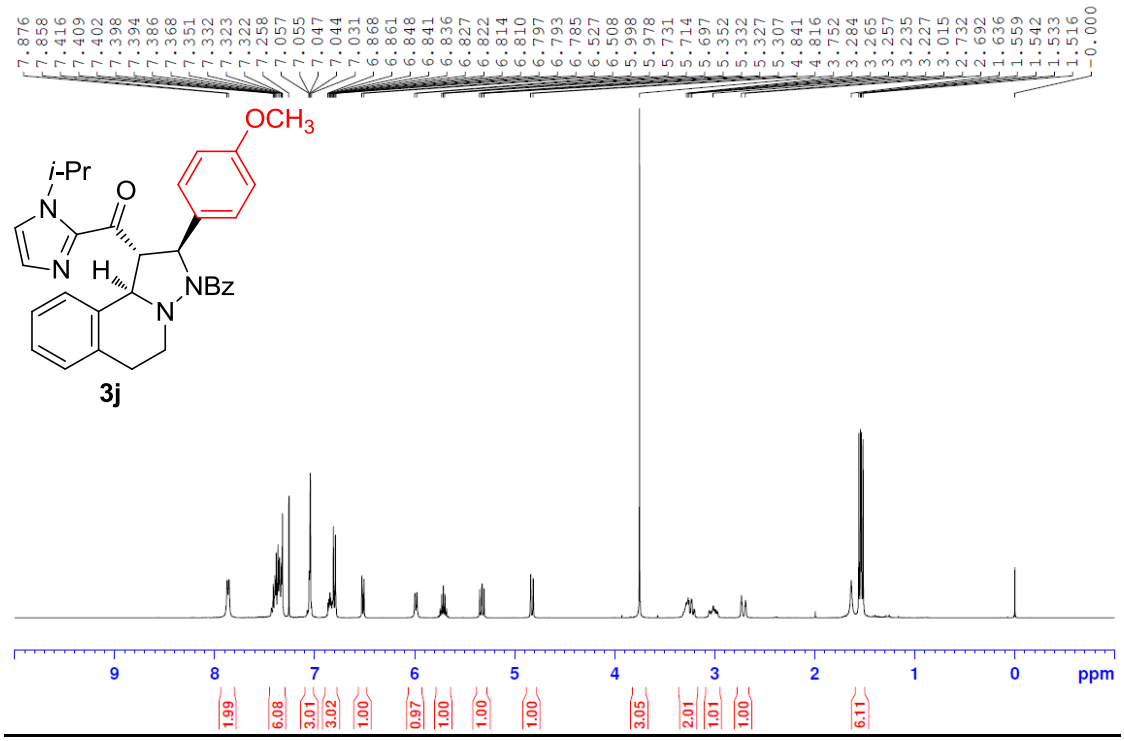
136.58
135.70
133.31
132.90
130.53
130.16
129.08
128.55
128.47
127.58
127.16
126.32
126.09
125.69
122.39
77.36
77.04
76.73
68.80
67.94
61.12
49.93
49.60
29.45
23.81
23.71
21.03
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

Compound 3j: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7.409
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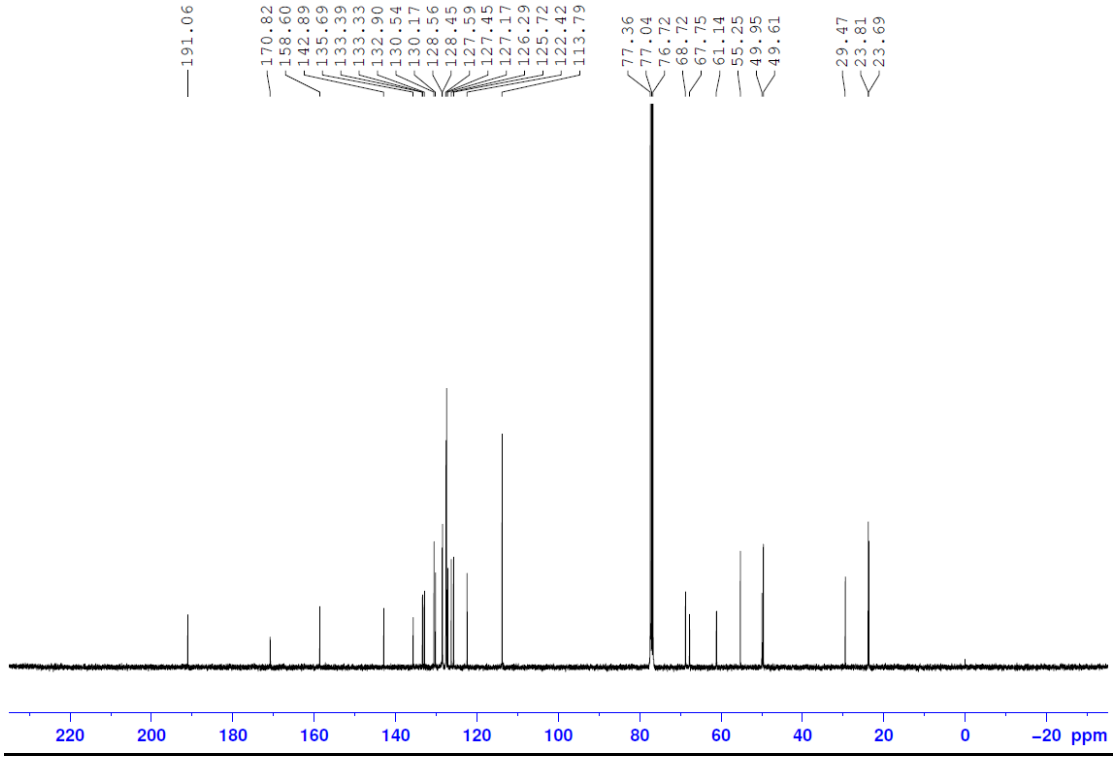
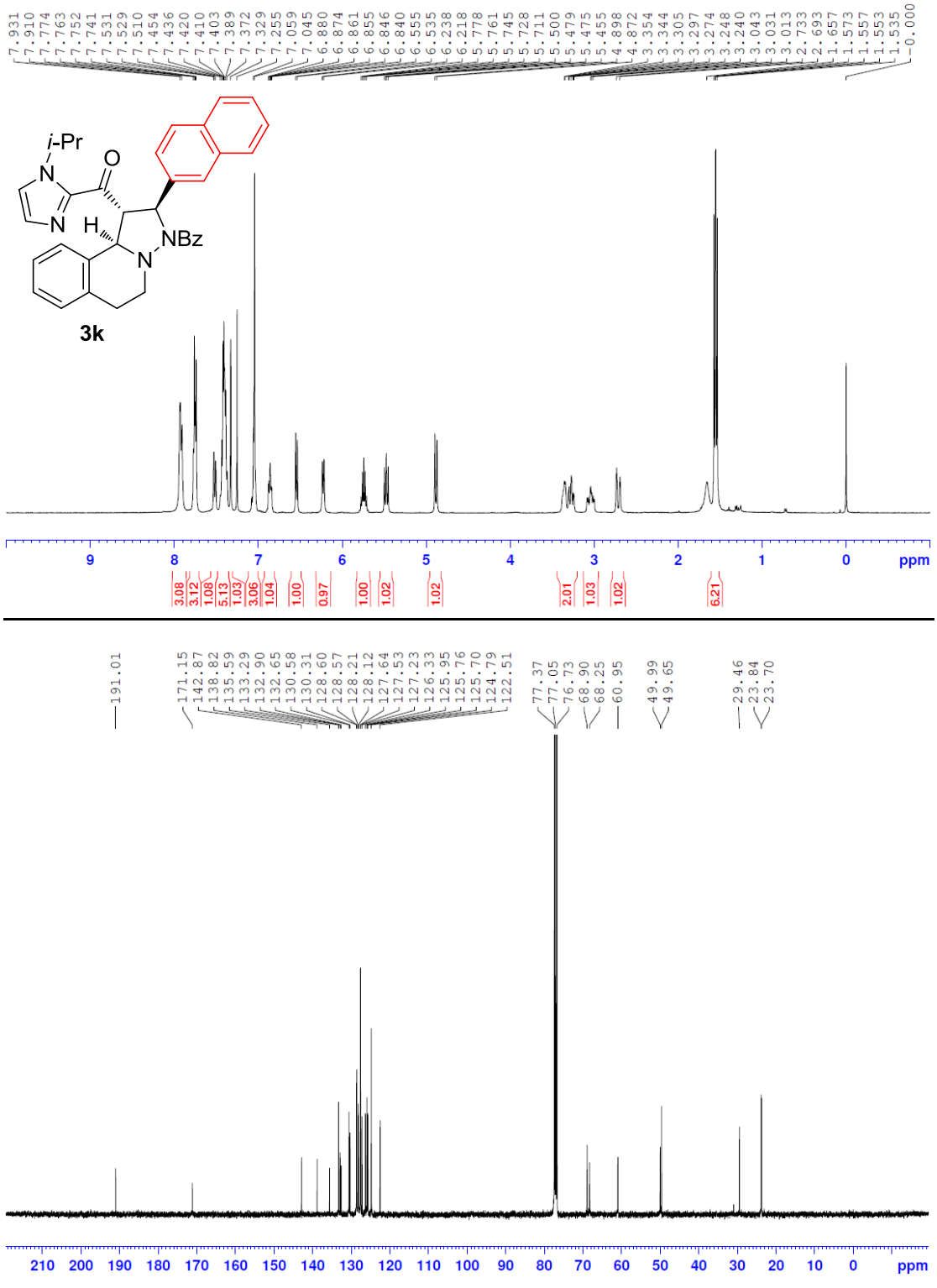
7.398
7.394
7.386
7.368
7.351
7.332
7.323
7.322
7.258
7.057
7.055
7.047
7.044
7.031
6.868
6.861
6.848
6.841
6.836
6.827
6.822
6.814
6.810
6.797
6.793
6.785
6.527
6.508
5.998
5.978
5.731
5.714
5.697
5.352
5.332
5.327
5.307
4.841
4.816
3.752
3.284
3.265
3.257
3.235
3.227
3.015
2.732
2.692
1.636
1.559
1.542
1.533
1.516
0.000
OCH3
i-Pr
O
N
N
H
NBz
N
3j
9
8
7
6
5
4
3
2
1
0
ppm
1.99
6.08
3.01
3.02
1.00
0.97
1.00
1.00
1.00
3.05
2.01
1.01
1.00
6.11


191.06
170.82
158.60
142.89
135.69
133.39
133.33
132.90
130.54
130.17
128.56
128.45
127.59
127.45
127.17
126.29
125.72
122.42
113.79
77.36
77.04
76.72
68.72
67.75
61.14
55.25
49.95
49.61
29.47
23.81
23.69
220
200
180
160
140
120
100
80
60
40
20
0
-20
ppm

Compound 3k: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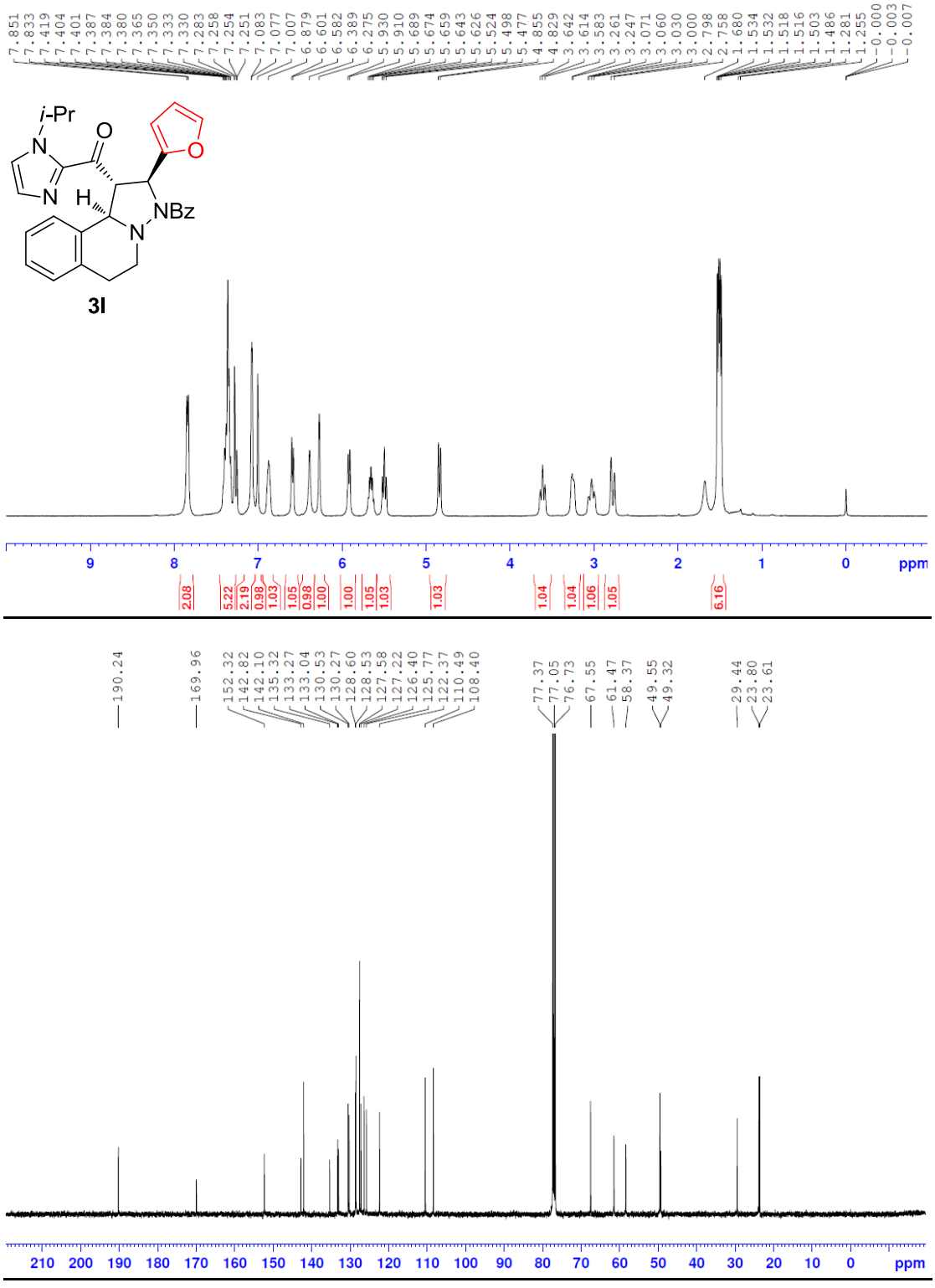
7.910
7.774
7.763
7.752
7.741
7.531
7.529
7.510
7.454
7.436
7.420
7.410
7.403
7.389
7.372
7.329
7.255
7.059
7.045
6.880
6.874
6.861
6.855
6.846
6.840
6.555
6.535
6.238
6.218
5.778
5.761
5.745
5.728
5.711
5.500
5.479
5.475
5.455
4.898
4.872
3.354
3.344
3.305
3.297
3.274
3.248
3.240
3.043
3.031
3.013
2.733
2.693
1.657
1.573
1.557
1.553
1.535
0.000
i-Pr
O
N
N
H
NBz
N
3k
9
8
7
6
5
4
3
2
1
0
ppm
3.08
3.12
1.08
5.13
1.03
3.06
1.04
1.00
0.97
1.00
1.02
1.02
2.01
1.03
1.02
6.21
191.01
171.15
142.87
138.82
135.59
133.29
132.90
132.65
130.58
130.31
128.60
128.57
128.21
128.12
127.64
127.53
127.23
126.33
125.95
125.76
125.70
124.79
122.51
77.37
77.05
76.73
68.90
68.25
60.95
49.99
49.65
29.46
23.84
23.70
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

Compound 3l: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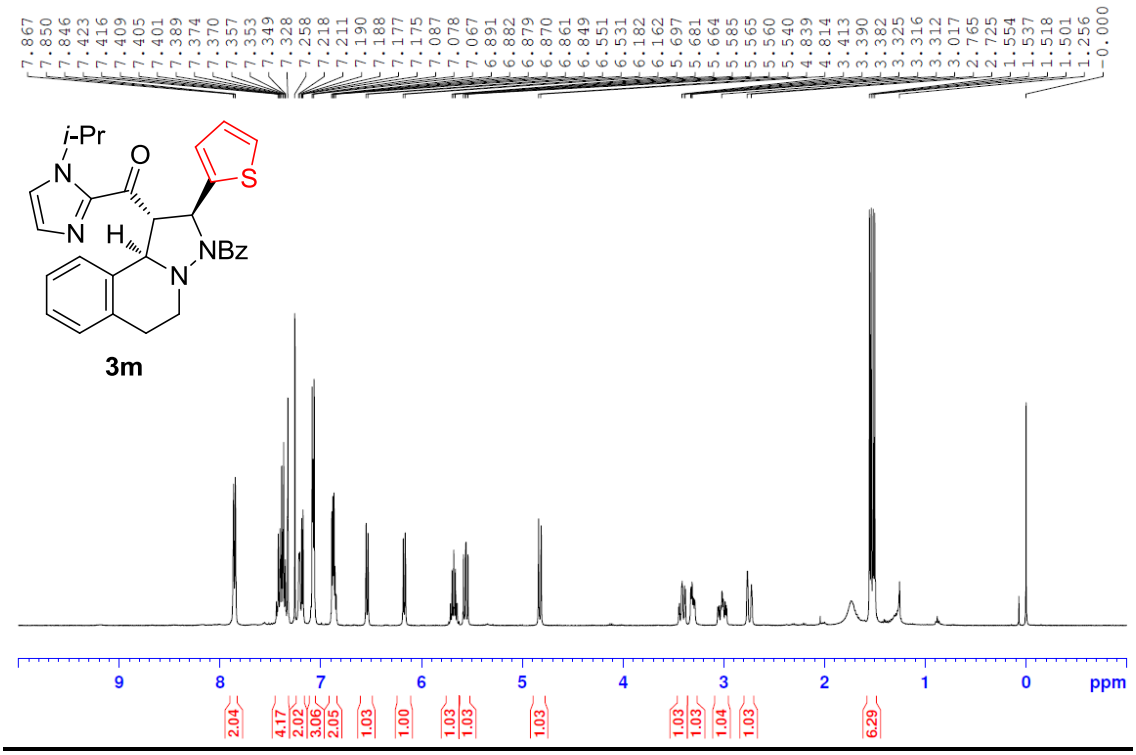
7.833
7.419
7.404
7.401
7.387
7.384
7.380
7.365
7.350
7.333
7.330
7.283
7.258
7.254
7.251
7.083
7.077
7.007
6.879
6.601
6.582
6.389
6.275
5.930
5.910
5.689
5.674
5.659
5.643
5.626
5.524
5.498
5.477
4.855
4.829
3.642
3.614
3.583
3.261
3.247
3.071
3.060
3.030
3.000
2.798
2.758
1.680
1.534
1.532
1.518
1.516
1.503
1.486
1.281
1.255
0.000
-0.003
-0.007
i-Pr
O
N
N
H
O
NBz
N
3l
9
8
7
6
5
4
3
2
1
0
ppm
2.08
5.22
2.19
0.98
1.03
1.05
0.98
1.00
1.00
1.05
1.03
1.03
1.04
1.04
1.06
1.05
6.16
190.24
169.96
152.32
142.82
142.10
135.32
133.27
133.04
130.53
130.27
128.60
128.53
127.58
127.22
126.40
125.77
122.37
110.49
108.40
77.37
77.05
76.73
67.55
61.47
58.37
49.55
49.32
29.44
23.80
23.61
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

Compound 3m: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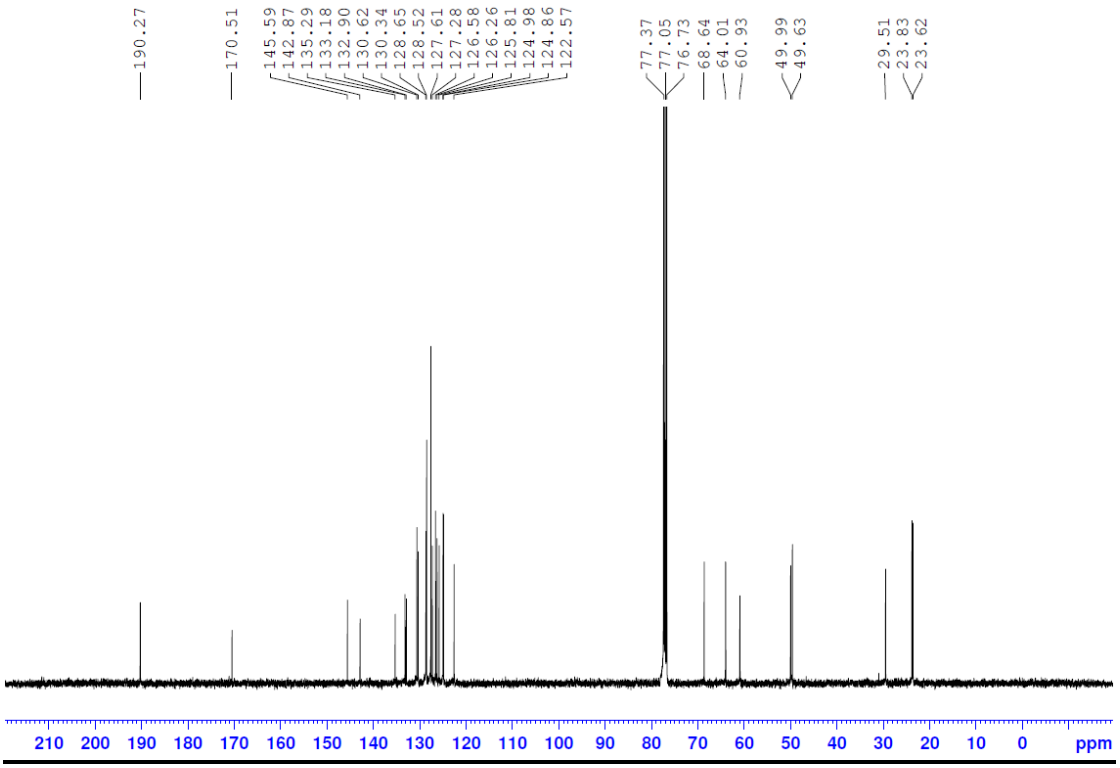
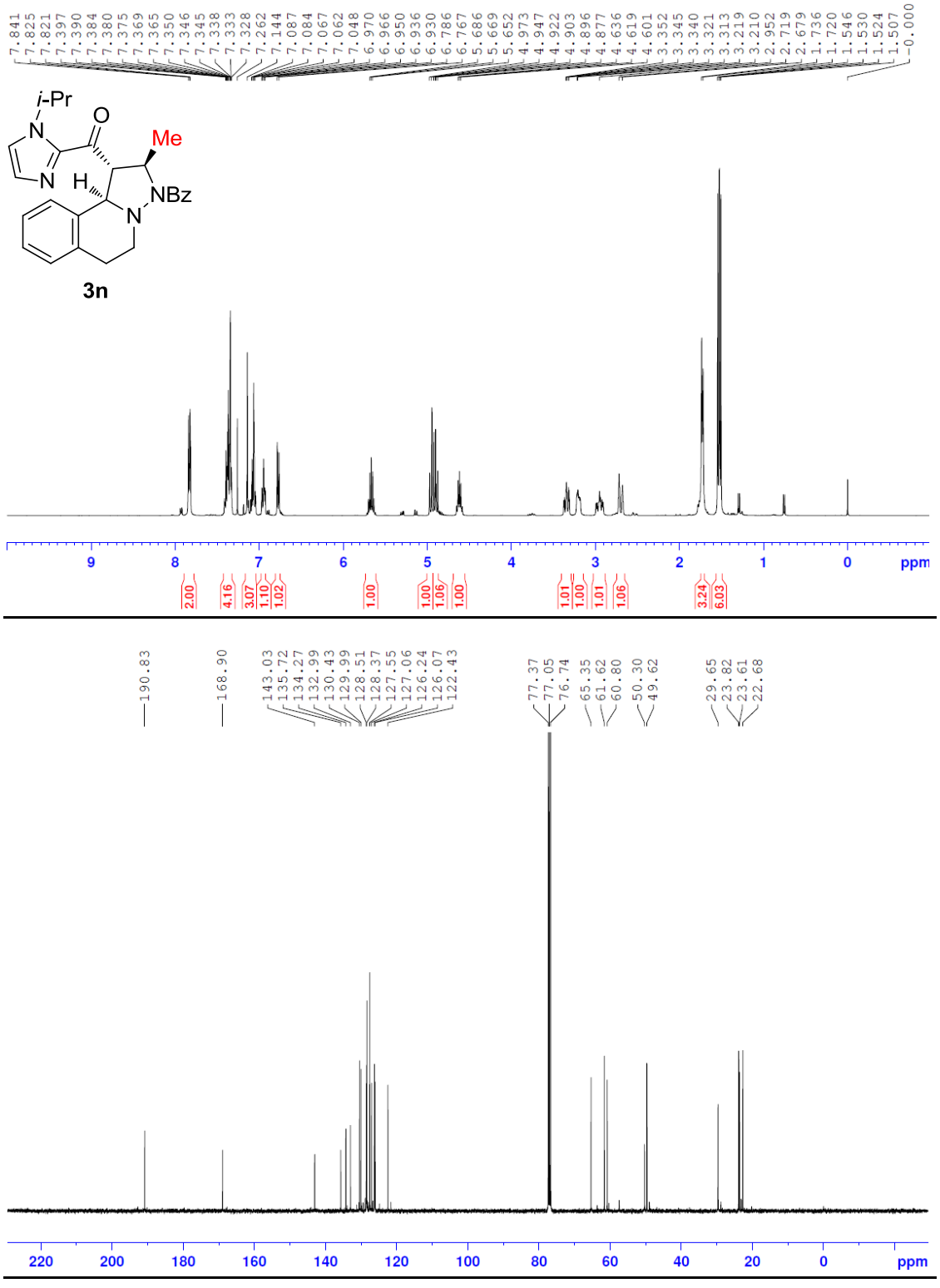
7.416
7.409
7.405
7.401
7.389
7.374
7.370
7.357
7.353
7.349
7.328
7.258
7.218
7.211
7.190
7.188
7.177
7.175
7.087
7.078
7.067
6.891
6.882
6.879
6.870
6.861
6.849
6.551
6.531
6.182
6.162
5.697
5.681
5.664
5.585
5.565
5.560
5.540
4.839
4.814
3.413
3.390
3.382
3.325
3.316
3.312
3.017
2.765
2.725
1.554
1.537
1.518
1.501
1.256
0.000
i-Pr
O
S
N
N
H
NBz
N
3m
9
8
7
6
5
4
3
2
1
0
ppm
2.04
4.17
2.02
3.06
2.05
1.03
1.00
1.03
1.03
1.03
1.03
1.03
1.04
1.03
6.29


190.27
170.51
145.59
142.87
135.29
133.18
132.90
130.62
130.34
128.65
128.52
127.61
127.28
126.58
126.26
125.81
124.98
124.86
122.57
77.37
77.05
76.73
68.64
64.01
60.93
49.99
49.63
29.51
23.83
23.62
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

Compound 3n: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7.390
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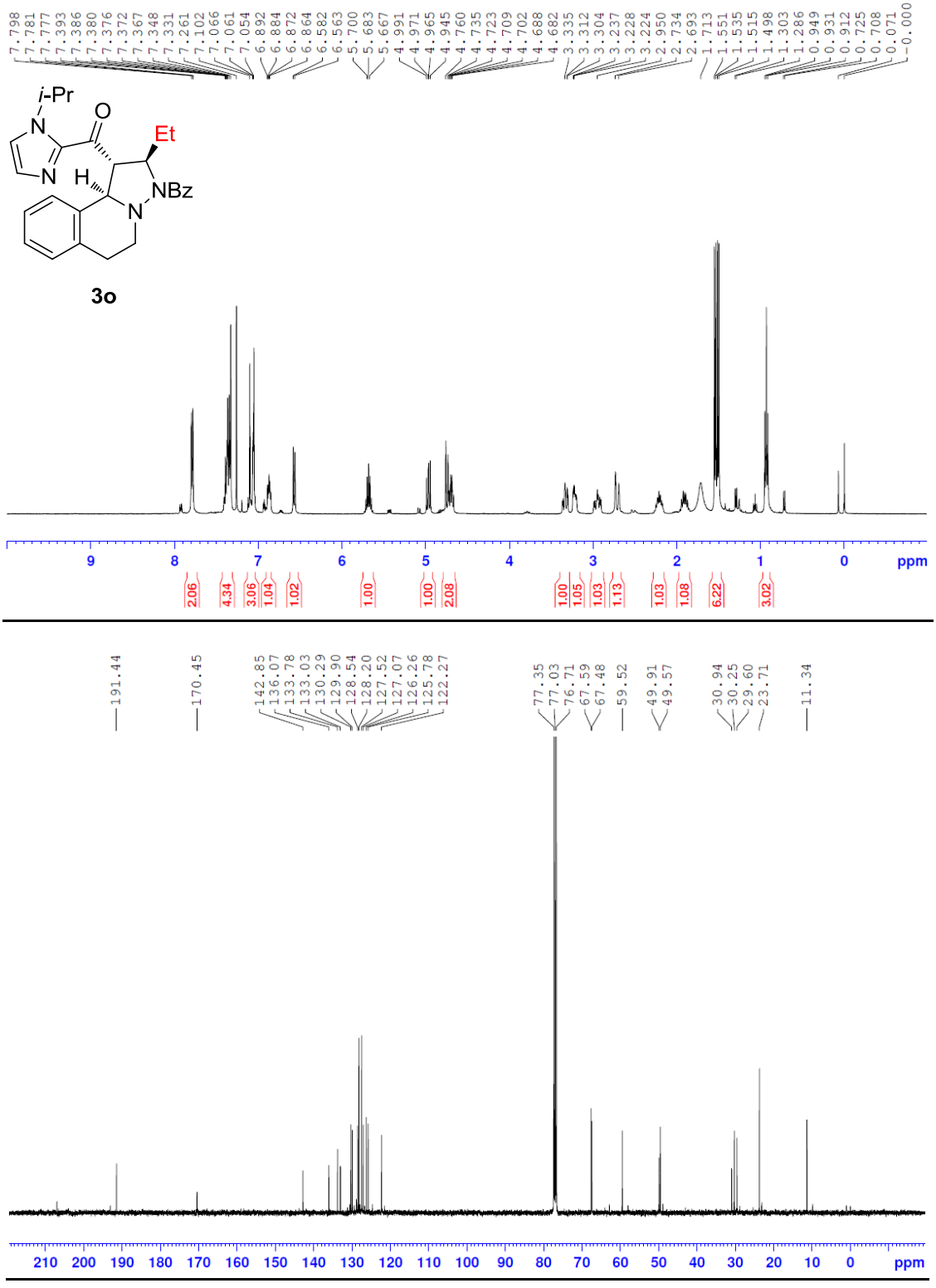
7.380
7.375
7.369
7.365
7.350
7.346
7.345
7.338
7.333
7.328
7.262
7.144
7.087
7.084
7.067
7.062
7.048
6.970
6.966
6.950
6.936
6.930
6.786
6.767
5.686
5.669
5.652
4.973
4.947
4.922
4.903
4.896
4.877
4.636
4.619
4.601
3.352
3.345
3.340
3.321
3.313
3.219
3.210
2.952
2.719
2.679
1.736
1.720
1.546
1.530
1.524
1.507
0.000
i-Pr
O
N
Me
N
H
NBz
N
3n
9
8
7
6
5
4
3
2
1
0
ppm
2.00
4.16
3.07
1.10
1.02
1.00
1.00
1.06
1.00
1.01
1.00
1.01
1.06
3.24
6.03
190.83
168.90
143.03
135.72
134.27
132.99
130.43
129.99
128.51
128.37
127.55
127.06
126.24
126.07
122.43
77.37
77.05
76.74
65.35
61.62
60.80
50.30
49.62
29.65
23.82
23.61
22.68
220
200
180
160
140
120
100
80
60
40
20
0
ppm

Compound 3o: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7.380
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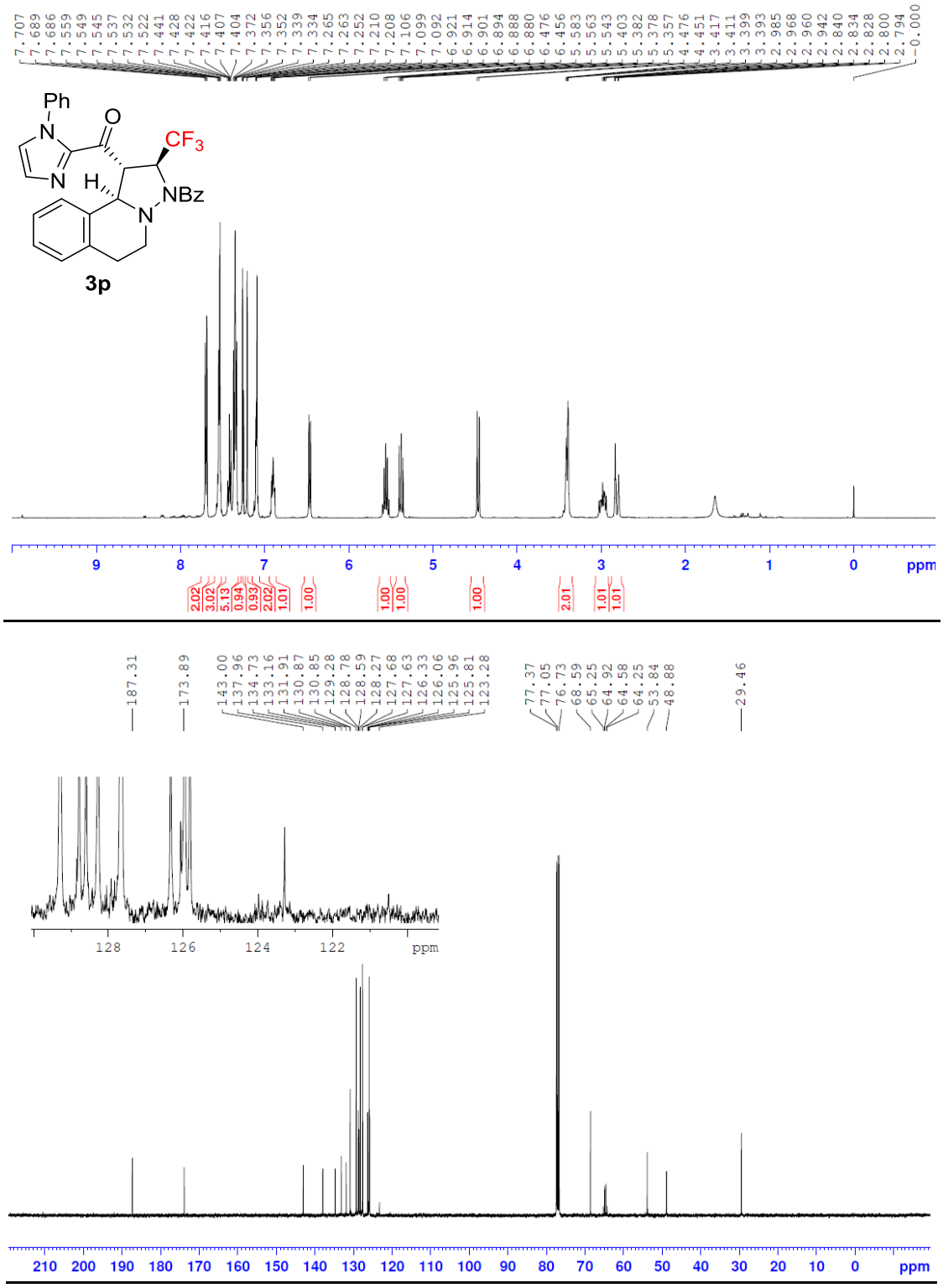
7.372
7.367
7.348
7.331
7.261
7.102
7.066
7.061
7.054
6.892
6.884
6.872
6.864
6.582
6.563
5.700
5.683
5.667
4.991
4.971
4.965
4.945
4.760
4.735
4.723
4.709
4.702
4.688
4.682
3.335
3.312
3.304
3.237
3.228
3.224
2.950
2.734
2.693
1.713
1.551
1.535
1.515
1.498
1.303
1.286
0.949
0.931
0.912
0.725
0.708
0.071
0.000
i-Pr
O
N
Et
N
H
NBz
N
3o
9
8
7
6
5
4
3
2
1
0
ppm
2.06
4.34
3.06
1.04
1.02
1.00
1.00
2.08
1.00
1.05
1.03
1.13
1.03
1.08
6.22
3.02
191.44
170.45
142.85
136.07
133.78
133.03
130.29
129.90
128.54
128.20
127.52
127.07
126.26
125.78
122.27
77.35
77.03
76.71
67.59
67.48
59.52
49.91
49.57
30.94
30.25
29.60
23.71
11.34
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

Compound 3p: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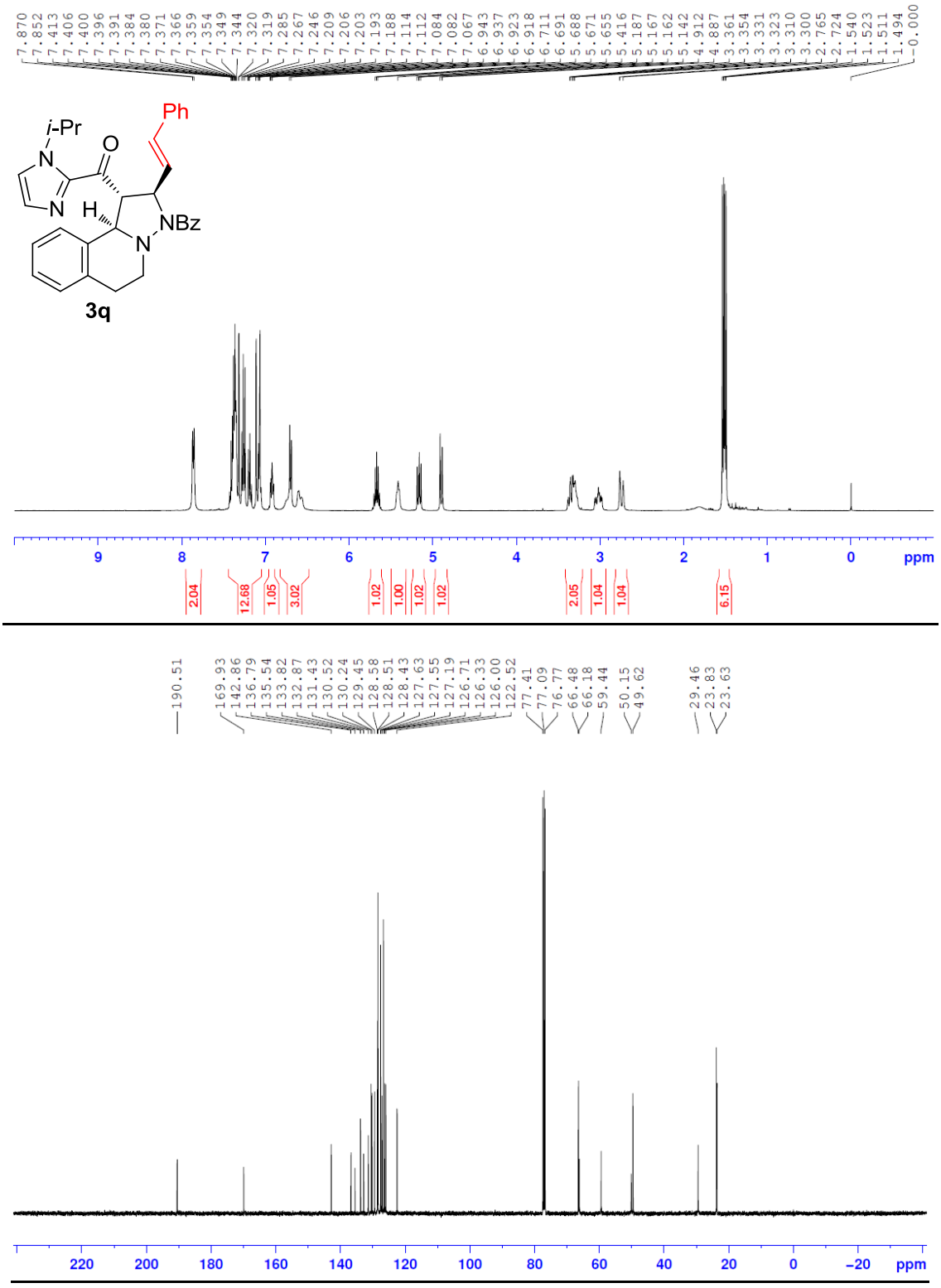
7.537
7.532
7.522
7.441
7.428
7.422
7.416
7.407
7.404
7.372
7.356
7.352
7.339
7.334
7.265
7.263
7.252
7.210
7.208
7.106
7.099
7.092
6.921
6.914
6.901
6.894
6.888
6.880
6.476
6.456
5.583
5.563
5.543
5.403
5.382
5.378
5.357
4.476
4.451
3.417
3.411
3.399
3.393
2.985
2.968
2.960
2.942
2.840
2.834
2.828
2.800
2.794
0.000
Ph
N
O
CF3
N
H
NBz
N
3p
9
8
7
6
5
4
3
2
1
0
ppm
2.02
3.02
5.13
0.94
0.93
2.02
1.01
1.00
1.00
1.00
1.00
2.01
1.01
1.01
187.31
173.89
143.00
137.96
134.73
133.16
131.91
130.87
130.85
129.28
128.78
128.59
128.27
127.68
127.63
126.33
126.06
125.96
125.81
123.28
77.37
77.05
76.73
68.59
65.25
64.92
64.58
64.25
53.84
48.88
29.46
128
126
124
122
ppm
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

Compound 3q: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7.396
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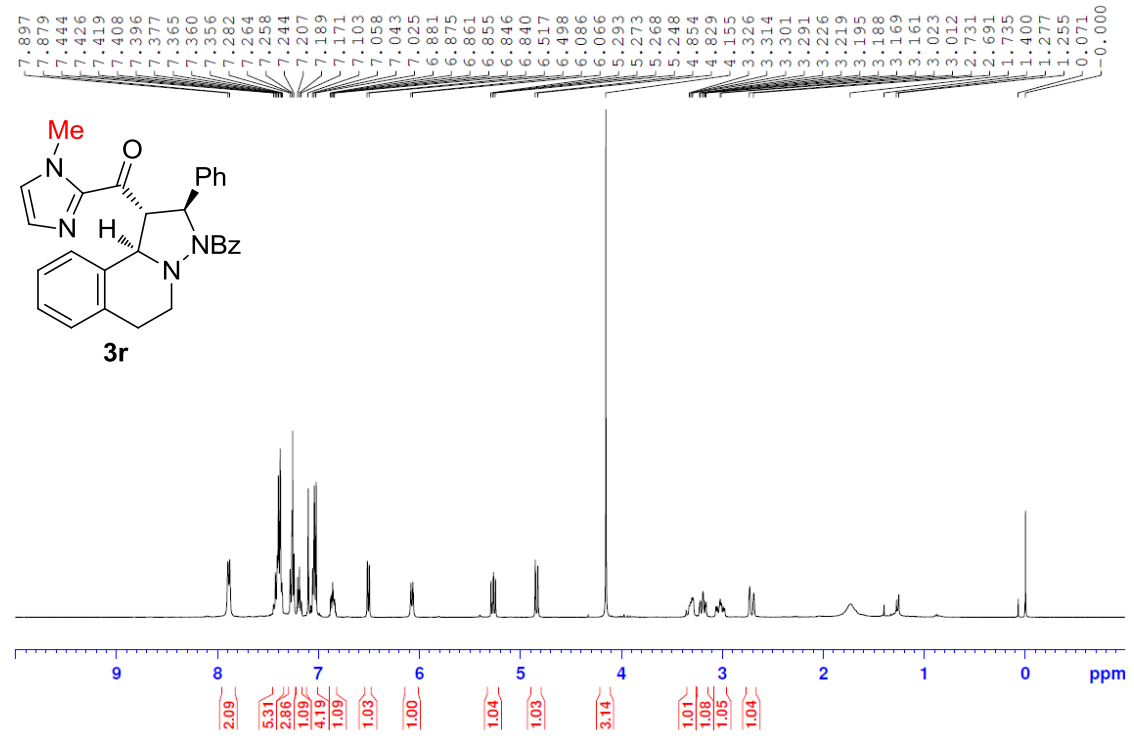
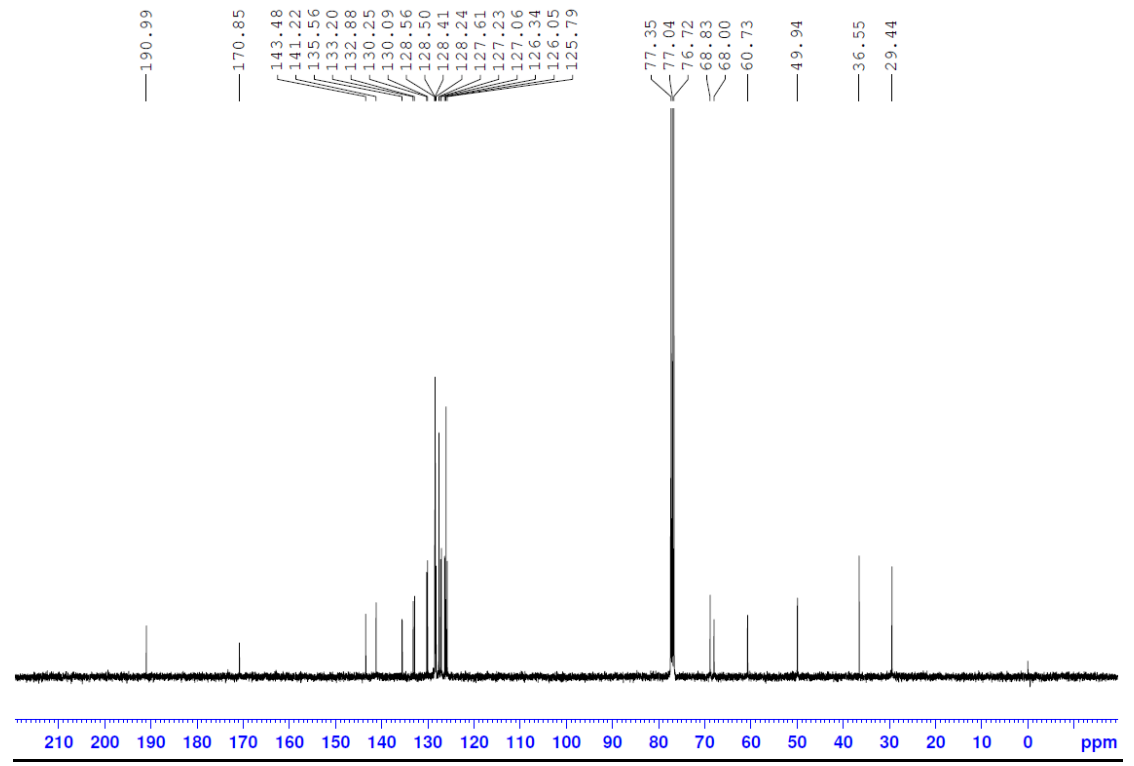
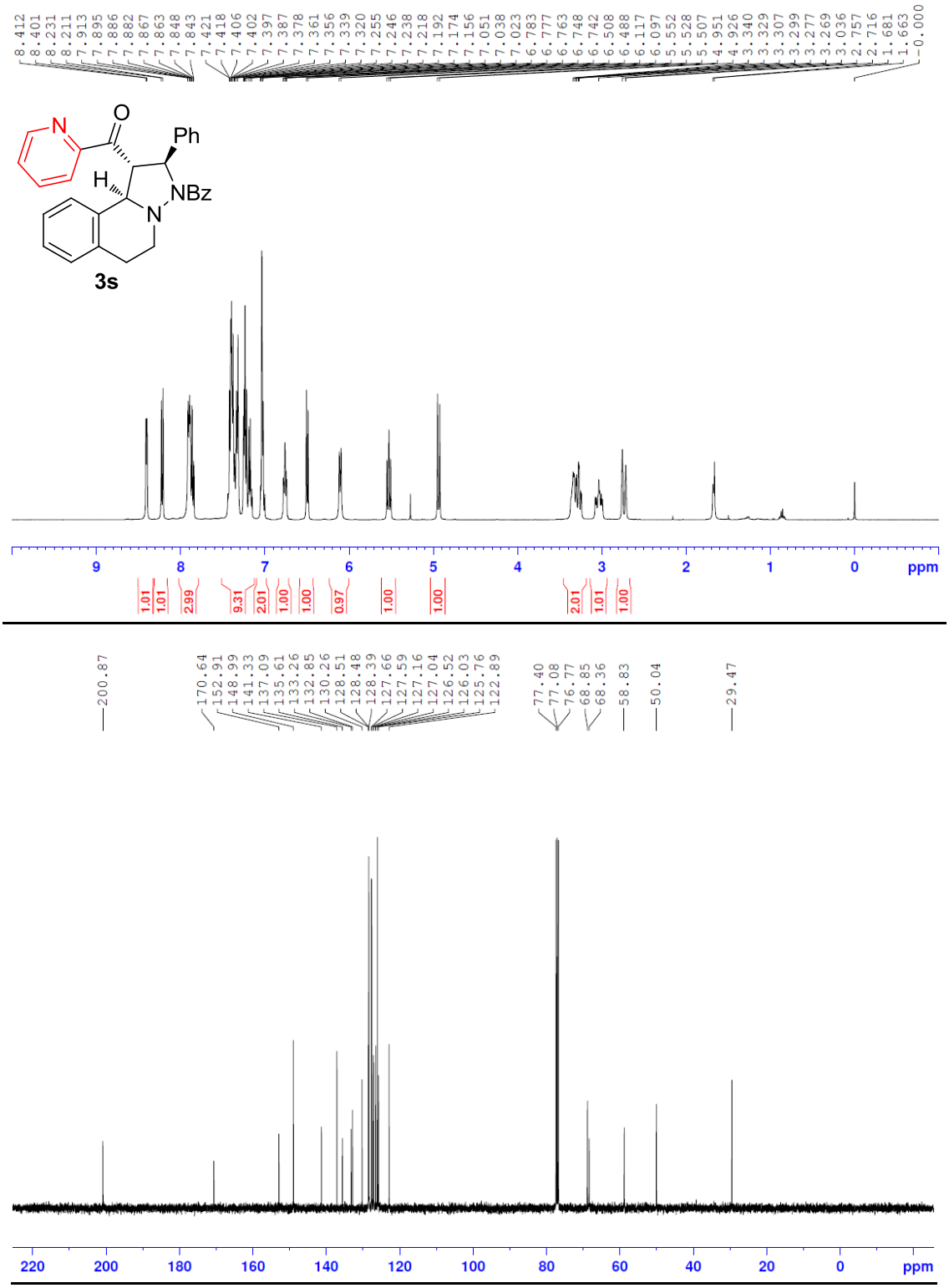
7.384
7.380
7.371
7.366
7.359
7.354
7.349
7.344
7.320
7.319
7.285
7.267
7.246
7.209
7.206
7.203
7.193
7.188
7.114
7.112
7.084
7.082
7.067
6.943
6.937
6.923
6.918
6.711
6.691
5.688
5.671
5.655
5.416
5.187
5.167
5.162
5.142
4.912
4.887
3.361
3.354
3.331
3.323
3.310
3.300
2.765
2.724
1.540
1.523
1.511
1.494
0.000
i-Pr
Ph
O
N
N
H
NBz
N
3q
9
8
7
6
5
4
3
2
1
0
ppm
2.04
12.68
1.05
3.02
1.02
1.00
1.02
1.02
2.05
1.04
1.04
6.15
190.51
169.93
142.86
136.79
135.54
133.82
132.87
131.43
130.52
130.24
129.45
128.58
128.51
128.43
127.63
127.55
127.19
126.71
126.33
126.00
122.52
77.41
77.09
76.77
66.48
66.18
59.44
50.15
49.62
29.46
23.83
23.63
220
200
180
160
140
120
100
80
60
40
20
0
-20
ppm

Compound 3r:





Compound 3s: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8.231
8.211
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7.882
7.867
7.863
7.848
7.843
7.421
7.418
7.406
7.402
7.397
7.387
7.378
7.361
7.356
7.339
7.320
7.255
7.246
7.238
7.218
7.192
7.174
7.156
7.051
7.038
7.023
6.783
6.777
6.763
6.748
6.742
6.508
6.488
6.117
6.097
5.552
5.528
5.507
4.951
4.926
3.340
3.329
3.307
3.299
3.277
3.269
3.036
2.757
2.716
1.681
1.663
0.000
O
N
Ph
H
NBz
N
3s
9
8
7
6
5
4
3
2
1
0
ppm
1.01
1.01
2.99
9.31
2.01
1.00
1.00
0.97
1.00
1.00
2.01
1.01
1.00
200.87
170.64
152.91
148.99
141.33
137.09
135.61
133.26
132.85
130.26
128.51
128.48
128.39
127.66
127.59
127.16
127.04
126.52
126.03
125.76
122.89
77.40
77.08
76.77
68.85
68.36
58.83
50.04
29.47
220
200
180
160
140
120
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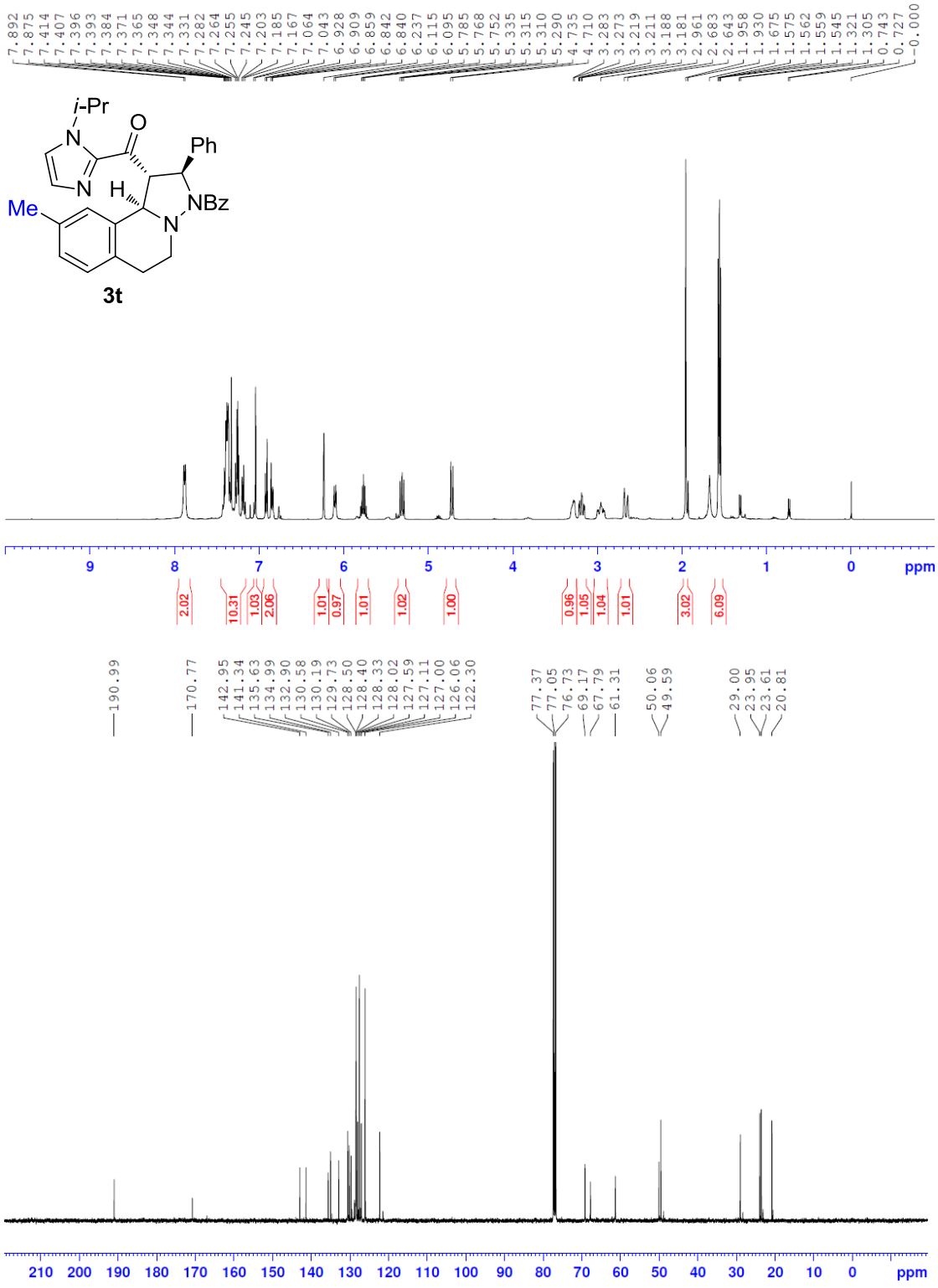
80
60
40
20
0
ppm

Compound 3t: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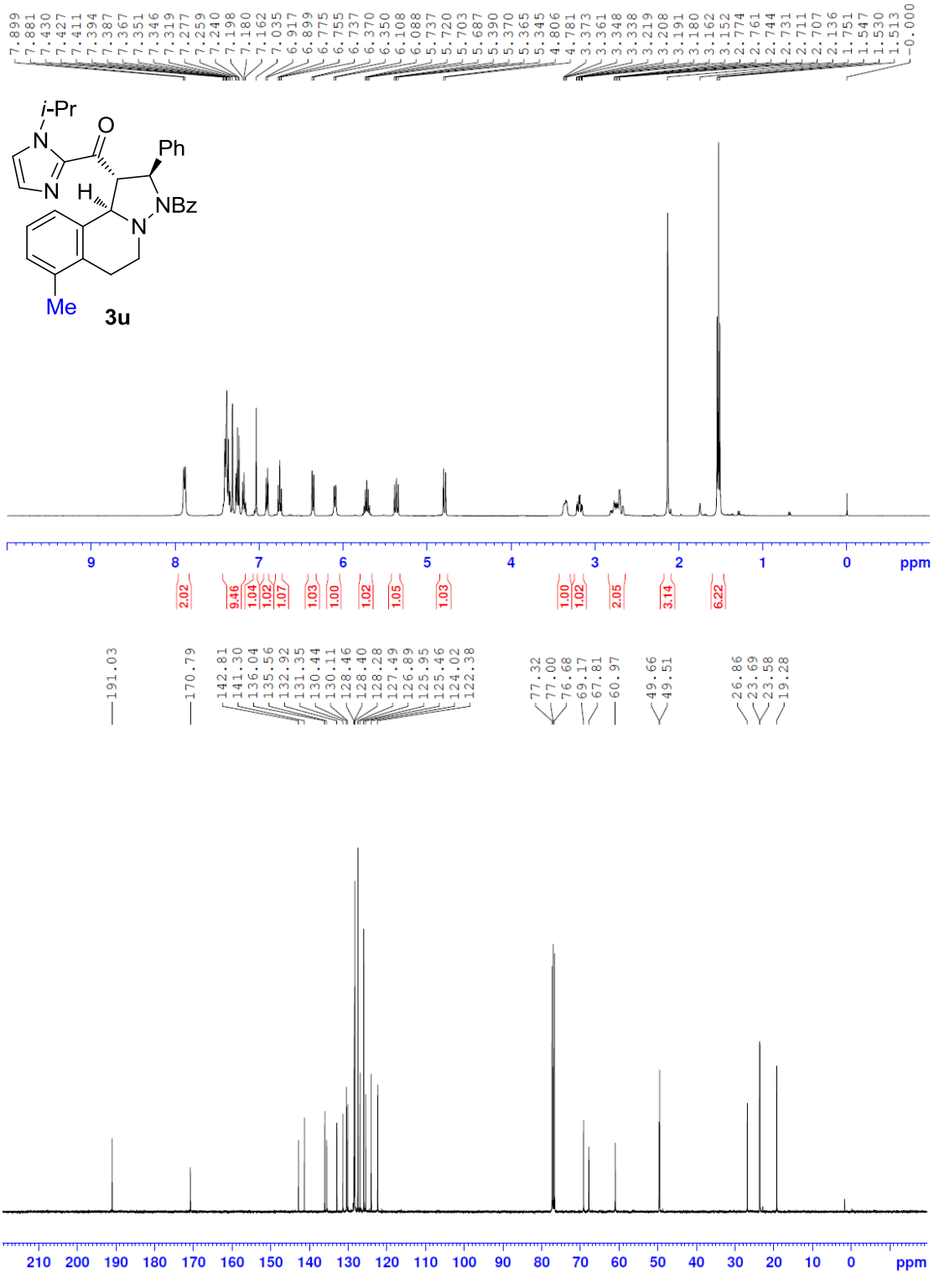
7.384
7.371
7.365
7.348
7.344
7.331
7.282
7.264
7.255
7.245
7.203
7.185
7.167
7.064
7.043
6.928
6.909
6.859
6.842
6.840
6.237
6.115
6.095
5.785
5.768
5.752
5.335
5.315
5.310
5.290
4.735
4.710
3.283
3.273
3.219
3.211
3.188
3.181
2.961
2.683
2.643
1.958
1.930
1.675
1.575
1.562
1.559
1.545
1.321
1.305
0.743
0.727
0.000
i-Pr
O
Ph
N
N
H
NBz
Me
N
3t
9
8
7
6
5
4
3
2
1
0
ppm
2.02
10.31
1.03
2.06
1.01
0.97
1.01
1.02
1.00
0.96
1.05
1.04
1.01
3.02
6.09
190.99
170.77
142.95
141.34
135.63
134.99
132.90
130.58
130.19
129.73
128.50
128.40
128.33
128.02
127.59
127.11
127.00
126.06
122.30
77.37
77.05
76.73
69.17
67.79
61.31
50.06
49.59
29.00
23.95
23.61
20.81
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

Compound 3u: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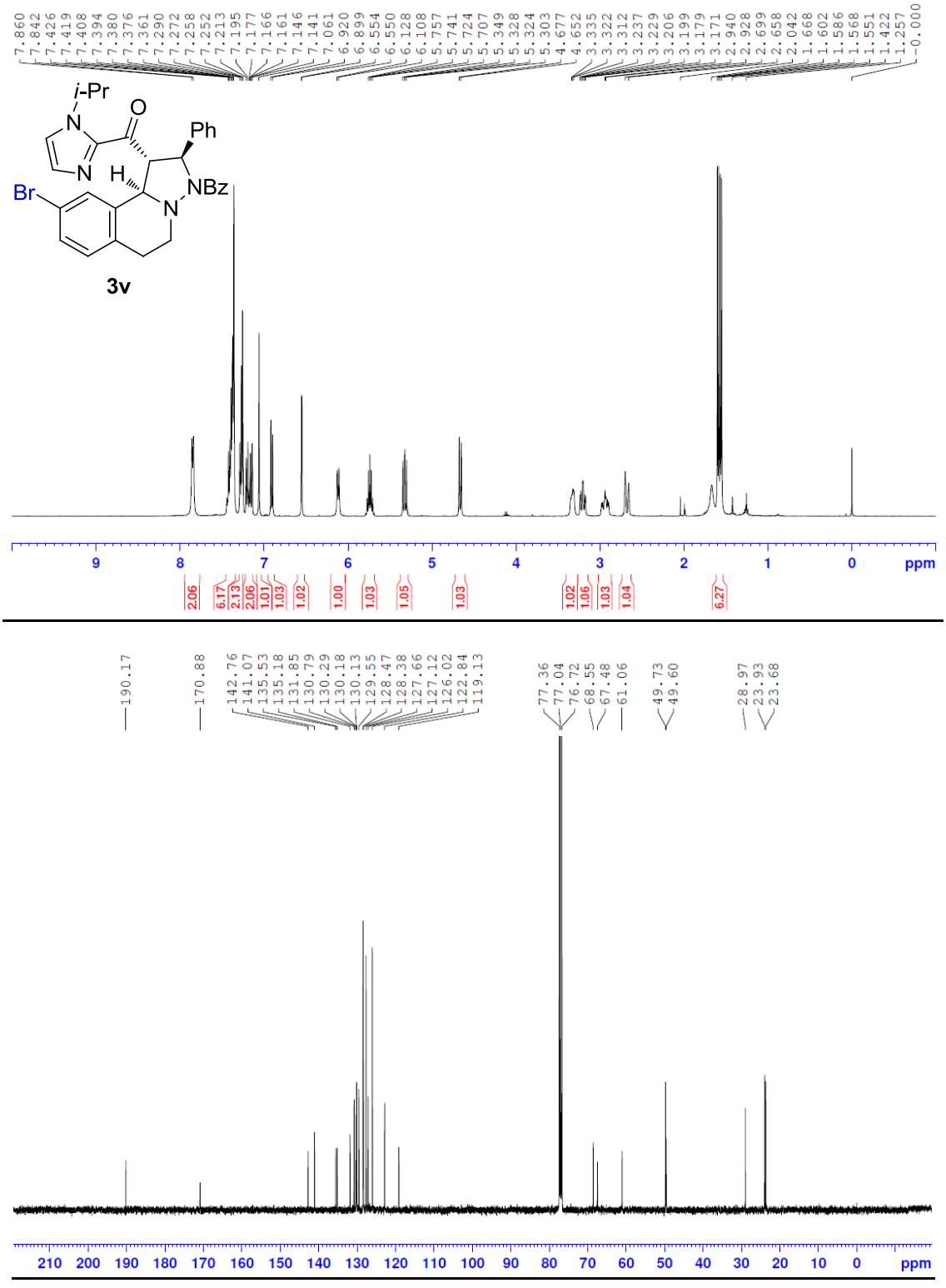
7.387
7.367
7.351
7.346
7.319
7.277
7.259
7.240
7.198
7.180
7.162
7.035
6.917
6.899
6.775
6.755
6.737
6.370
6.350
6.108
6.088
5.737
5.720
5.703
5.687
5.390
5.370
5.365
5.345
4.806
4.781
3.373
3.361
3.348
3.338
3.219
3.208
3.191
3.180
3.162
3.152
2.774
2.761
2.744
2.731
2.711
2.707
2.136
1.751
1.547
1.530
1.513
0.000
i-Pr
O
Ph
N
N
H
NBz
N
Me
3u
9
8
7
6
5
4
3
2
1
0
ppm
2.02
9.46
1.04
1.02
1.07
1.03
1.00
1.02
1.05
1.03
1.00
1.02
2.05
3.14
6.22
191.03
170.79
142.81
141.30
136.04
135.56
132.92
131.35
130.44
130.11
128.46
128.40
128.28
127.49
126.89
125.95
125.46
124.02
122.38
77.32
77.00
76.68
69.17
67.81
60.97
49.66
49.51
26.86
23.69
23.58
19.28
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

Compound 3v: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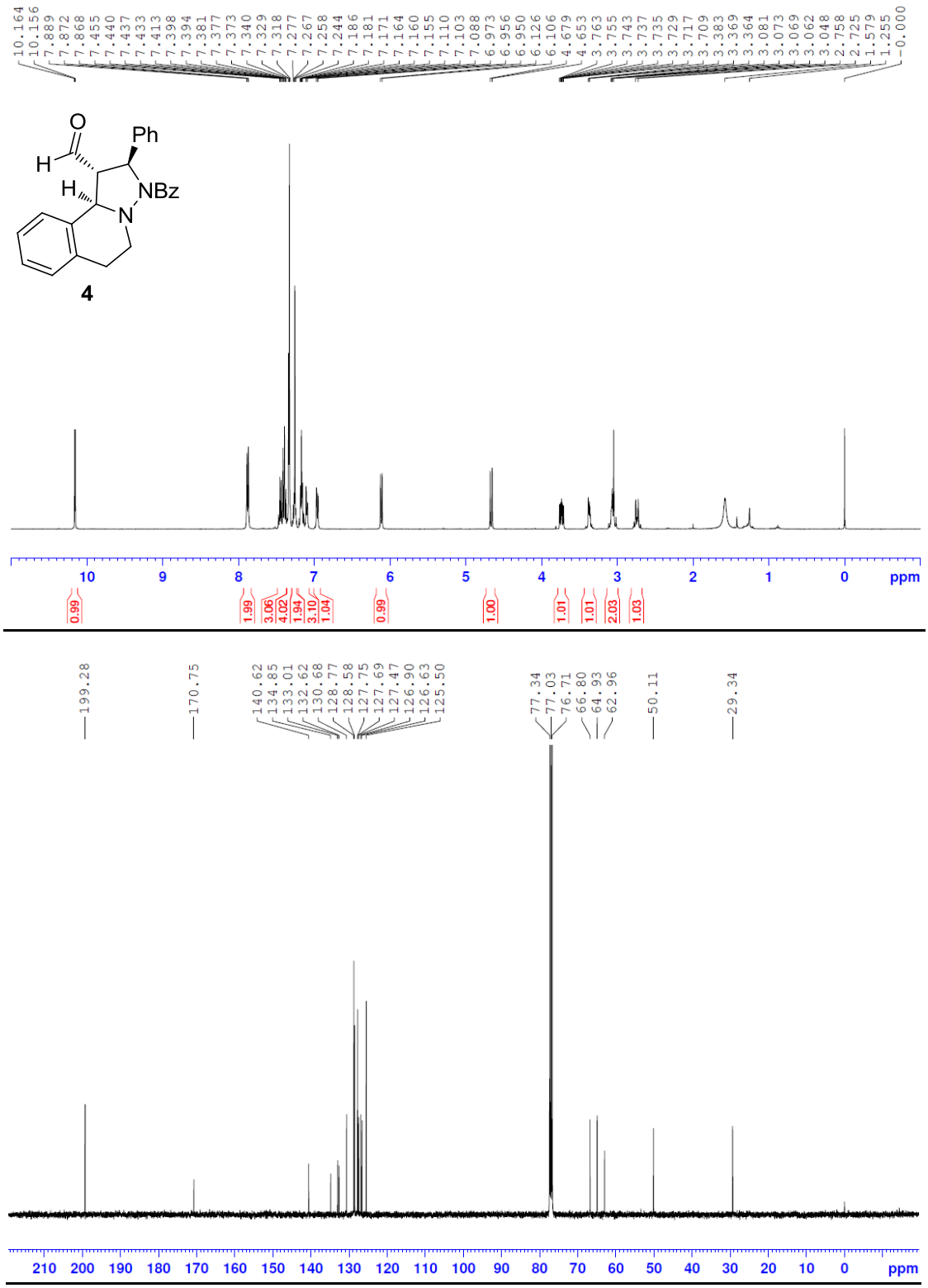
7.394
7.380
7.376
7.361
7.290
7.272
7.258
7.252
7.213
7.195
7.177
7.166
7.161
7.146
7.141
7.061
6.920
6.899
6.554
6.550
6.128
6.108
5.757
5.741
5.724
5.707
5.349
5.328
5.324
5.303
4.677
4.652
3.335
3.322
3.312
3.237
3.229
3.206
3.199
3.179
3.171
2.940
2.928
2.699
2.658
2.042
1.668
1.602
1.586
1.568
1.551
1.422
1.257
0.000
i-Pr
O
Ph
N
N
H
NBz
Br
N
3v
9
8
7
6
5
4
3
2
1
0
ppm
2.06
6.17
2.13
2.06
1.01
1.03
1.02
1.00
1.03
1.05
1.03
1.02
1.06
1.03
1.04
6.27
190.17
170.88
142.76
141.07
135.53
135.18
131.85
130.79
130.29
130.18
130.13
129.55
128.47
128.38
127.66
127.12
126.02
122.84
119.13
77.36
77.04
76.72
68.55
67.48
61.06
49.73
49.60
28.97
23.93
23.68
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

Compound 4: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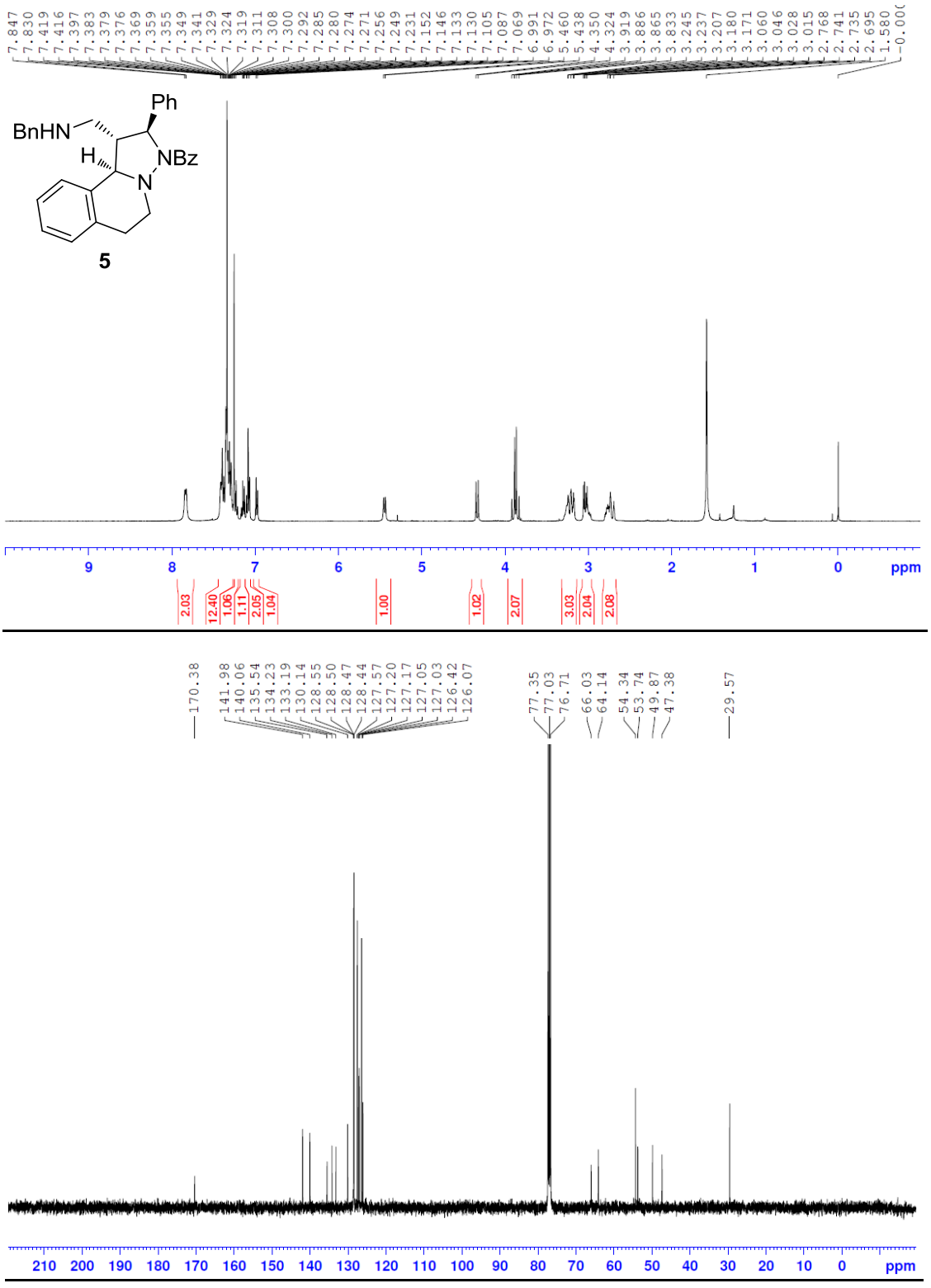
7.394
7.381
7.377
7.373
7.340
7.329
7.318
7.277
7.267
7.258
7.244
7.186
7.181
7.171
7.164
7.160
7.155
7.110
7.103
7.088
6.973
6.956
6.950
6.126
6.106
4.679
4.653
3.763
3.755
3.743
3.737
3.735
3.729
3.717
3.709
3.383
3.369
3.364
3.081
3.073
3.069
3.062
3.048
2.758
2.725
1.579
1.255
0.000
O
H
Ph
H
NBz
N
4
10
9
8
7
6
5
4
3
2
1
0
ppm
0.99
1.99
3.06
4.02
1.94
3.10
1.04
0.99
1.00
1.01
1.01
2.03
1.03
199.28
170.75
140.62
134.85
133.01
132.62
130.68
128.77
128.58
127.75
127.69
127.47
126.90
126.63
125.50
77.34
77.03
76.71
66.80
64.93
62.96
50.11
29.34
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

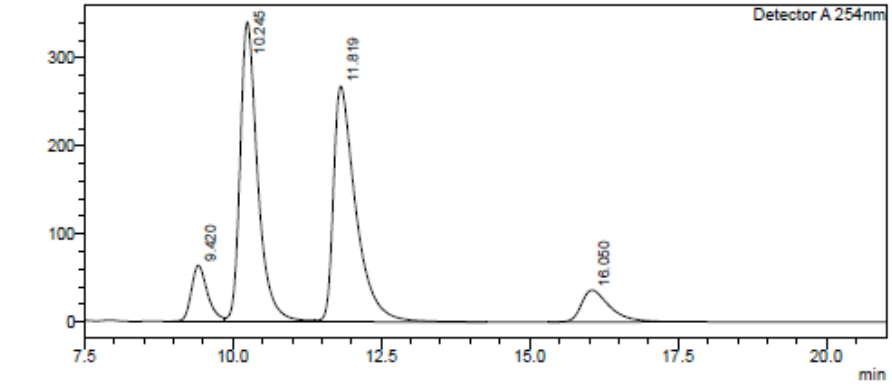
Compound 5:



HPLC Spectra

Racemic **3a**

<Chromatogram>



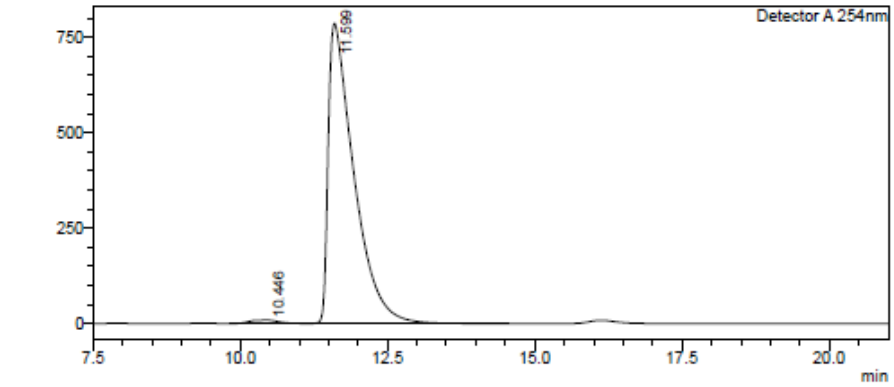
<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	9.420	1212094	63707	7.378			
2	10.245	7007072	340118	42.650		V	
3	11.819	7008989	267531	42.662		V	
4	16.050	1201053	36086	7.310			
Total		16429209	707442				

Chiral **3a**

<Chromatogram>

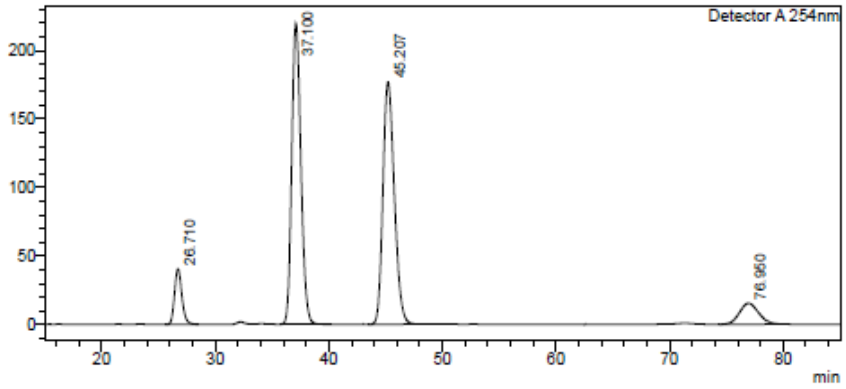


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	10.446	295584	8700	1.224			
2	11.599	23862169	785701	98.776		V	
Total		24157763	794401				

Racemic **3b**

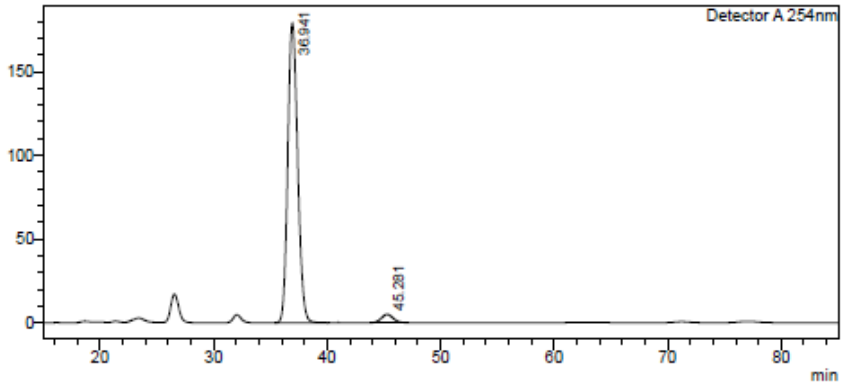


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	26.710	1817729	40580	6.434			
2	37.100	12293983	219561	43.512		S	
3	45.207	12331455	177015	43.645			
4	76.950	1810858	15283	6.409			
Total		28254024	452439				

Chiral **3b**

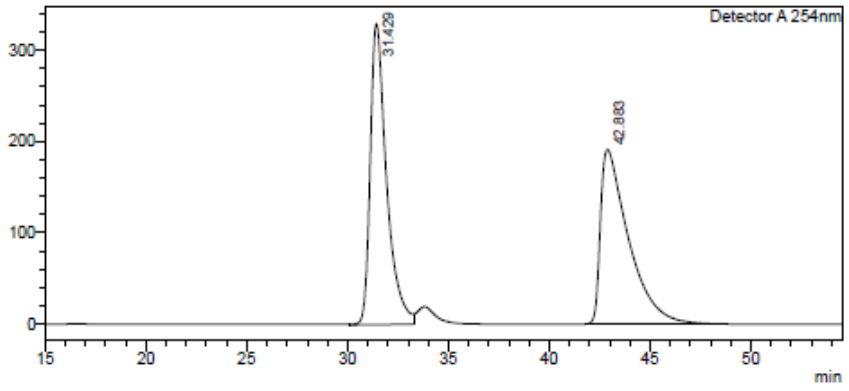


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	36.941	10822566	178831	96.757			
2	45.281	362776	5029	3.243			
Total		11185342	183859				

Racemic **3c**

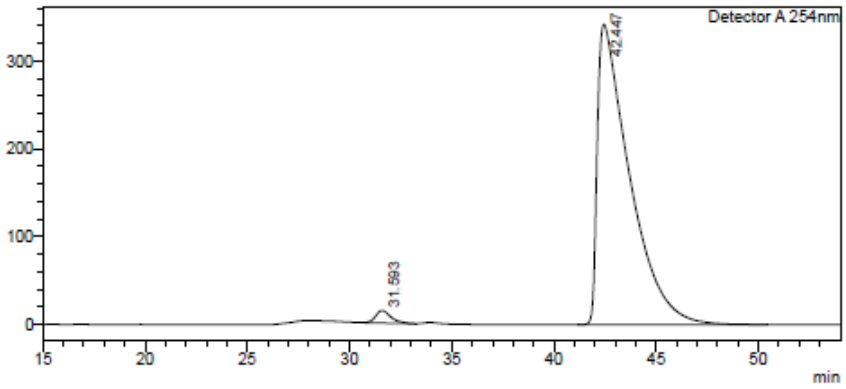


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	31.429	18532489	329554	50.099		M	
2	42.883	18459181	191352	49.901		M	
Total		36991669	520907				

Chiral **3c**

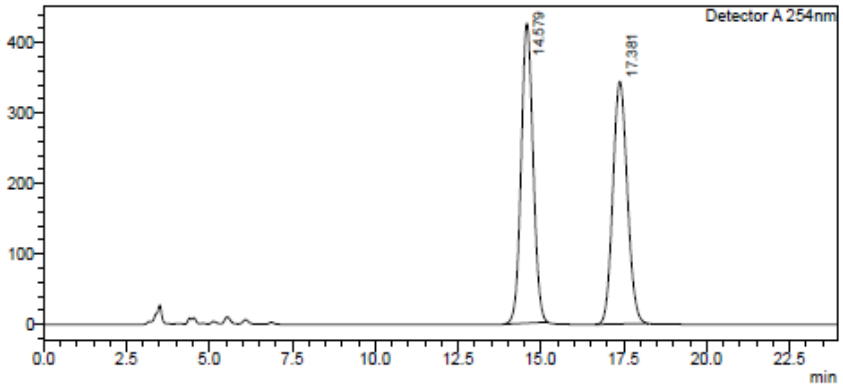


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	31.593	725694	14104	1.898			
2	42.447	37508883	341750	98.102			
Total		38234577	355854				

Racemic **3d**

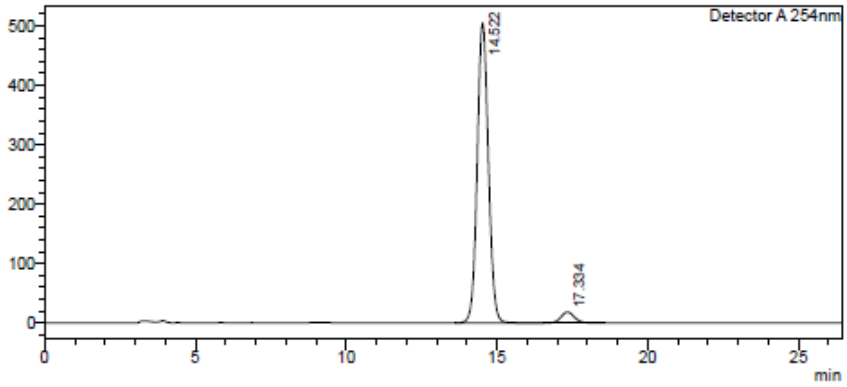


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	14.579	10641537	425624	50.527		M	
2	17.381	10419644	344335	49.473		M	
Total		21061181	769959				

Chiral **3d**

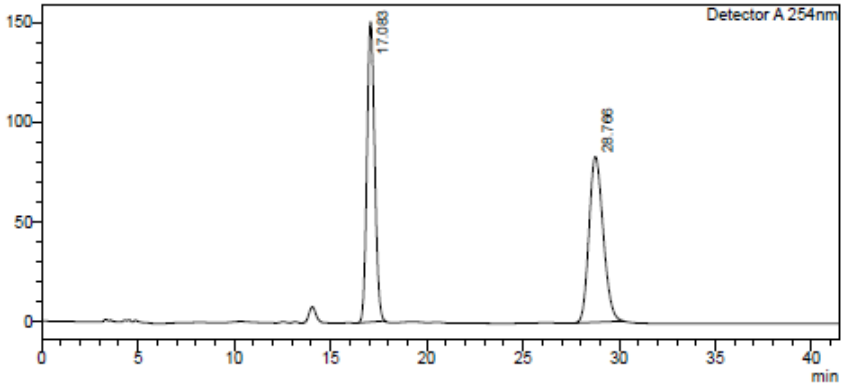


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	14.522	13013488	504614	95.826			
2	17.334	566849	18389	4.174		V	
Total		13580337	523003				

Racemic **3e**

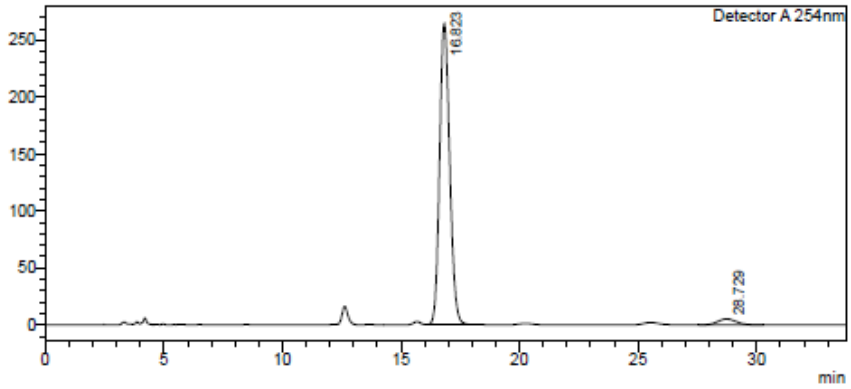


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	17.083	4220496	150536	49.731		M	
2	28.766	4266087	83178	50.269		M	
Total		8486583	233714				

Chiral **3e**

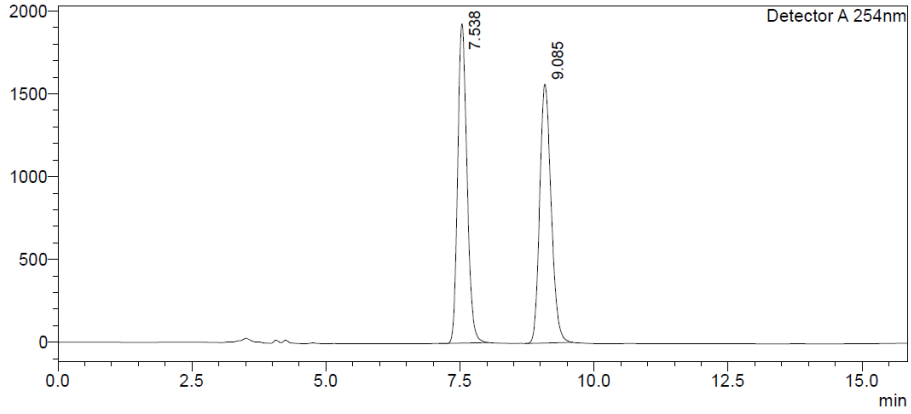


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	16.823	7833131	264536	96.495			
2	28.729	284491	5331	3.505			
Total		8117621	269867				

Racemic **3f**

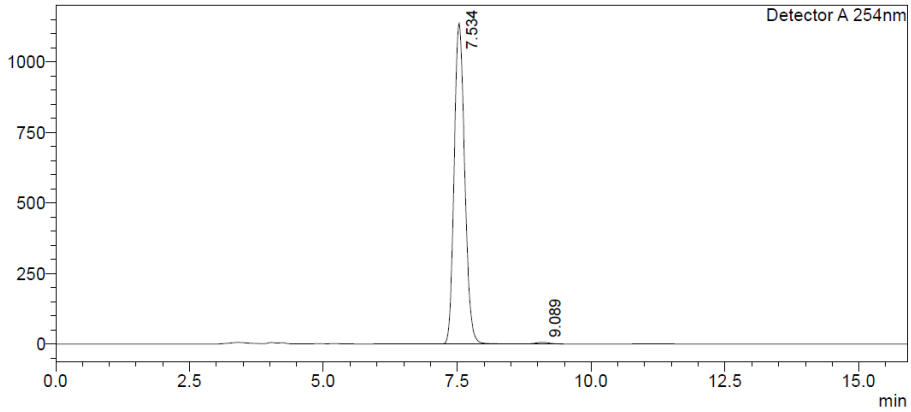


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	7.538	23266400	1926773	50.116		M	
2	9.085	23159016	1561249	49.884		M	
Total		46425415	3488022				

Chiral **3f**

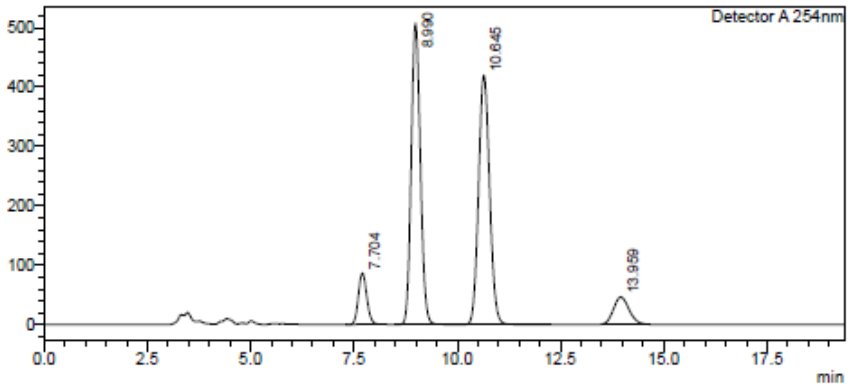


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	7.534	15572972	1136332	99.332		M	
2	9.089	104732	6294	0.668		M	
Total		15677704	1142625				

Racemic **3g**

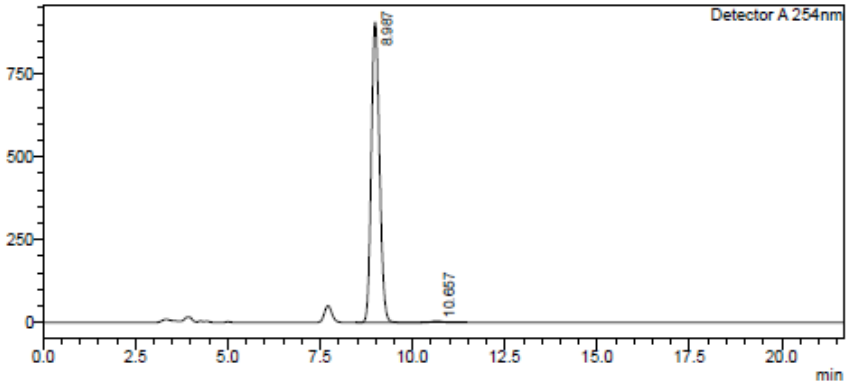


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	7.704	1214667	86242	6.751		M	
2	8.990	7797562	505882	43.336			
3	10.645	7804914	419514	43.377		V	
4	13.959	1176043	45587	6.536		M	
Total		17993186	1057224				

Chiral **3g**

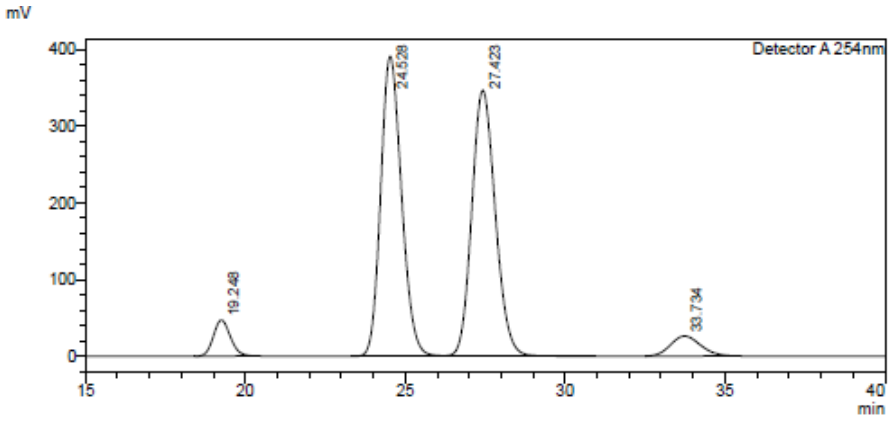


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	8.987	14050240	905794	99.406			
2	10.657	83900	4421	0.594		V	
Total		14134140	910215				

Racemic **3h**

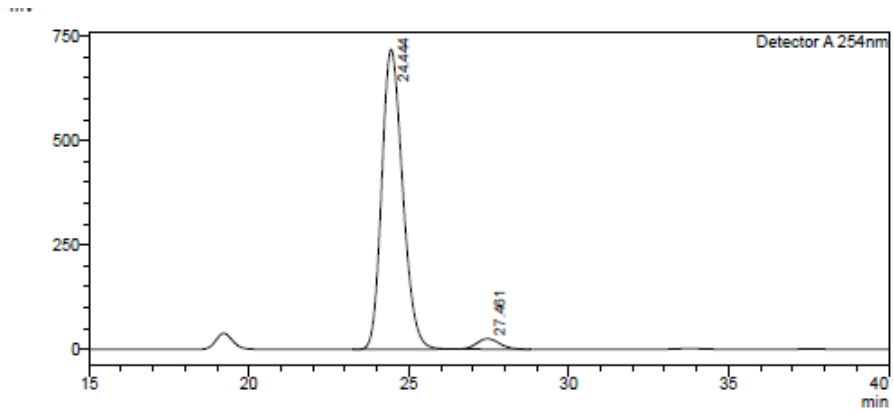


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	19.248	1736756	47039	4.461		M	
2	24.528	17743828	390806	45.579			
3	27.423	17758671	346644	45.617		V	
4	33.734	1690702	26019	4.343		M	
Total		38929957	810508				

Chiral **3h**



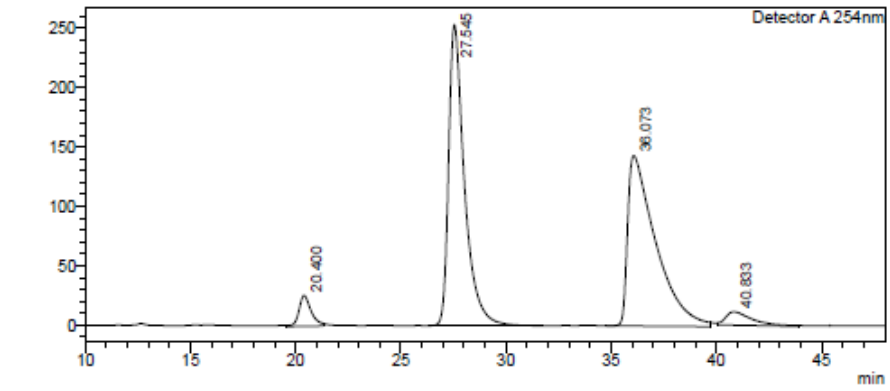
<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	24.444	32700791	717984	96.310			
2	27.461	1252873	25139	3.690		M	
Total		33953664	743123				

Racemic **3i**

<Chromatogram>



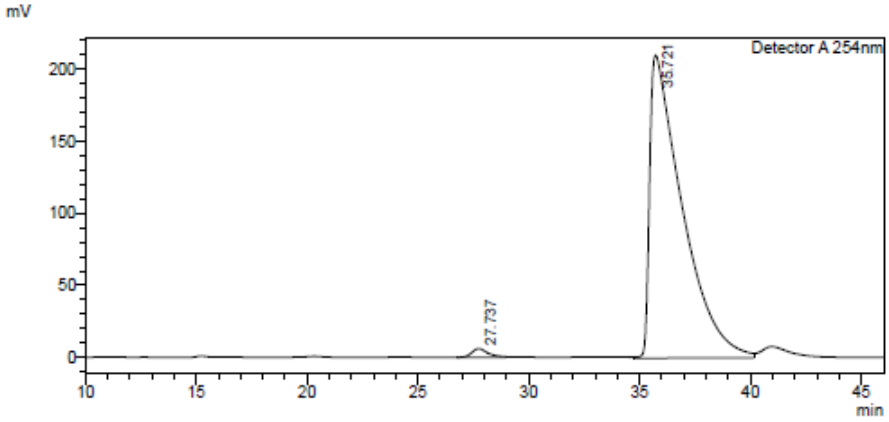
<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	20.400	1039973	25886	3.641		M	
2	27.545	13276421	253265	46.486			
3	36.073	13266844	143439	46.452		M	
4	40.833	976849	11133	3.420		M	
Total		28560087	433723				

Chiral **3i**

<Chromatogram>

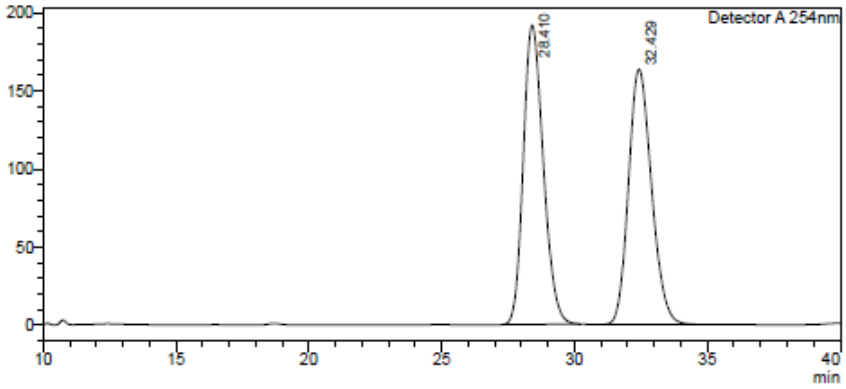


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	27.737	308737	5969	1.417			
2	35.721	21474013	210373	98.583		M	
Total		21782750	216342				

Racemic **3j**

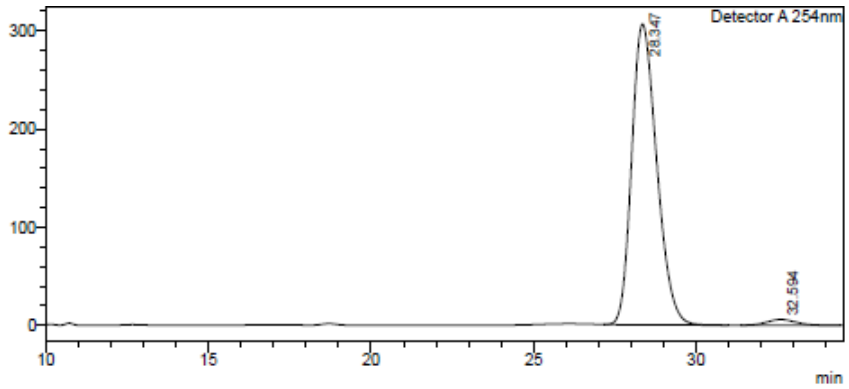


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	28.410	10072967	191404	50.422		M	
2	32.429	9904496	163440	49.578		M	
Total		19977464	354844				

Chiral **3j**

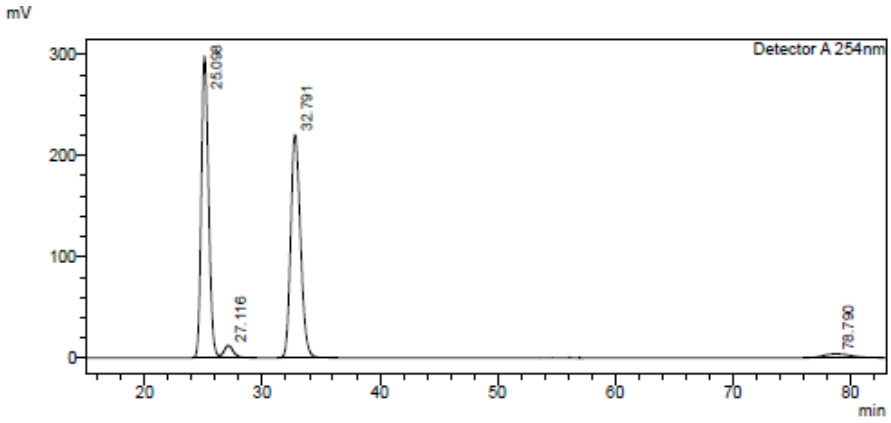


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	28.347	16370866	306101	97.836			
2	32.594	362081	5959	2.164			
Total		16732947	312061				

Racemic **3k**

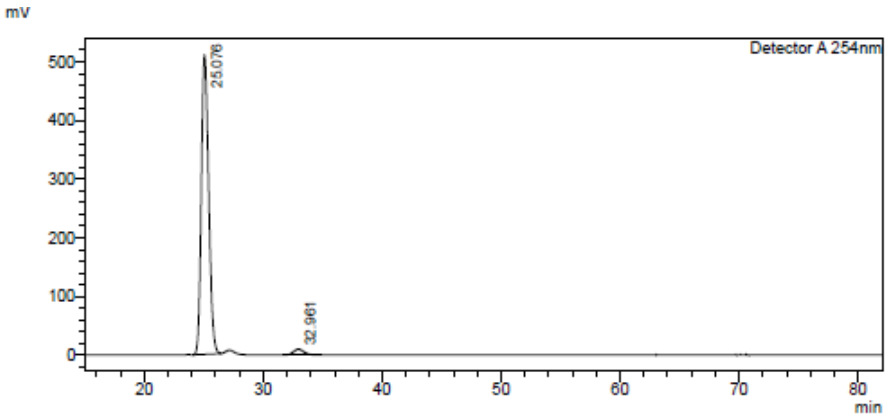


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	25.098	12775713	297254	47.559			
2	27.116	674313	12093	2.510		V	
3	32.791	12790626	220536	47.614			
4	78.790	622299	4004	2.317			
Total		26862950	533886				

Chiral **3k**

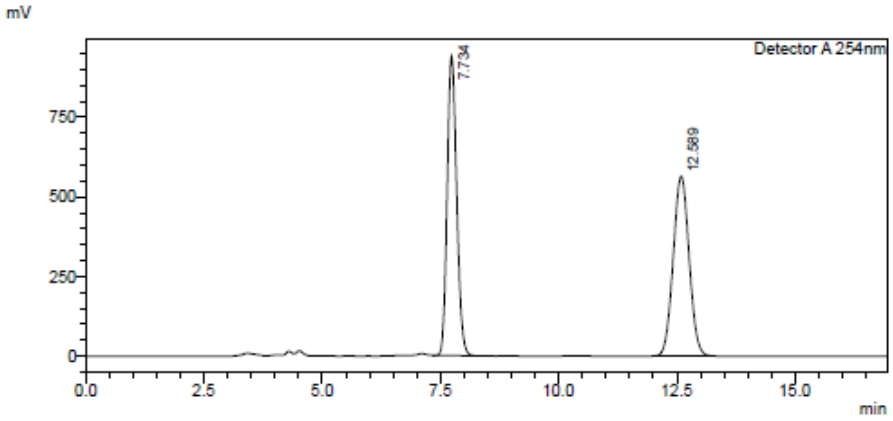


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	25.076	21858503	509190	97.399			
2	32.961	583685	9955	2.601			
Total		22442189	519145				

Racemic **3l**

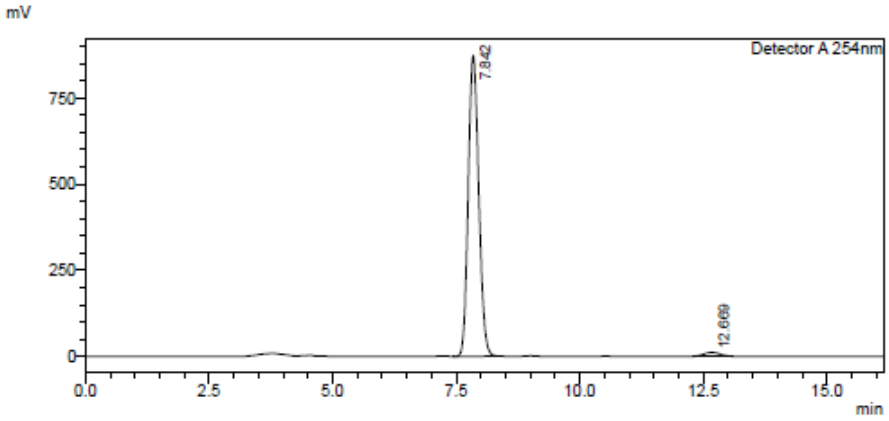


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	7.734	13147305	940182	50.005		M	
2	12.589	13144465	563701	49.995		M	
Total		26291770	1503883				

Chiral **3l**

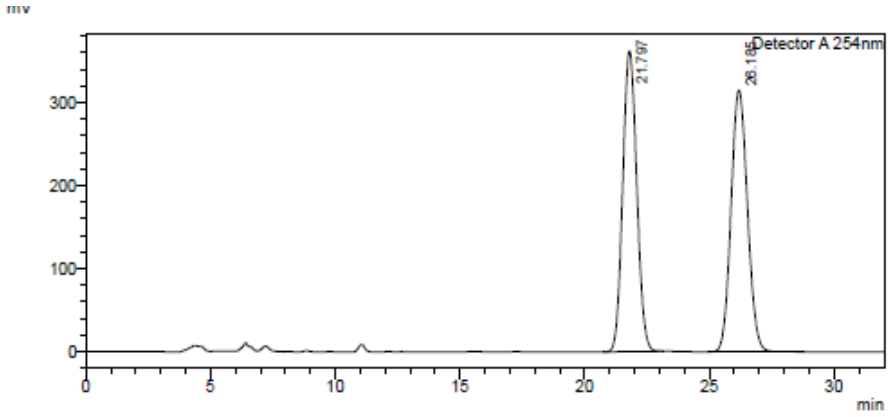


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	7.842	12910525	871218	98.057		M	
2	12.669	255853	11536	1.943		M	
Total		13166379	882754				

Racemic **3m**

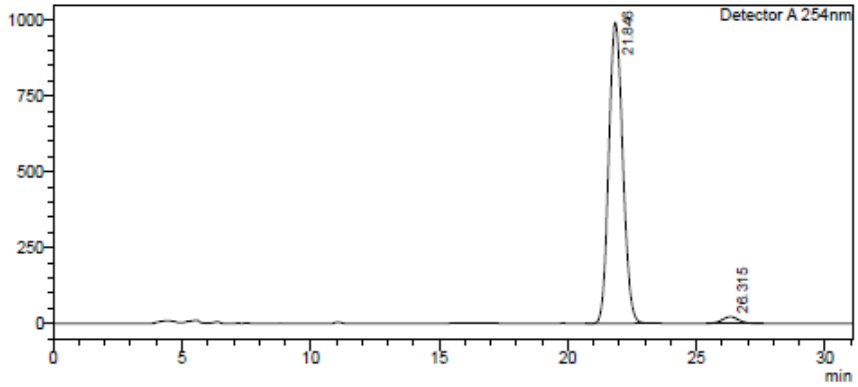


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	21.797	14154951	361742	49.528			
2	26.185	14424975	315075	50.472			
Total		28579926	676817				

Chiral **3m**

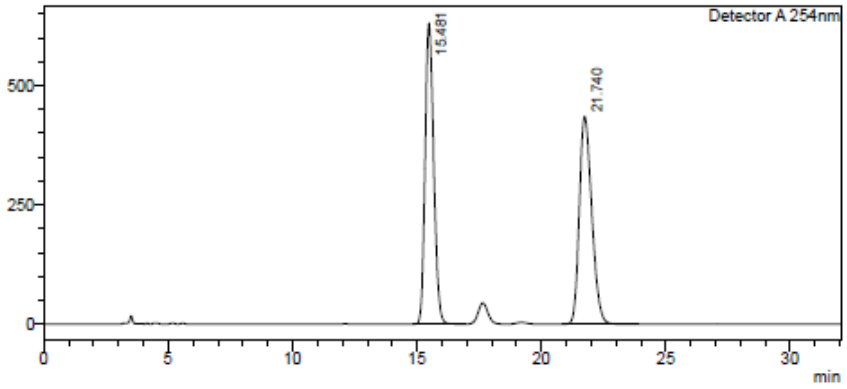


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	21.846	37498577	991174	97.473		M	
2	26.315	972266	21944	2.527		M	
Total		38470843	1013119				

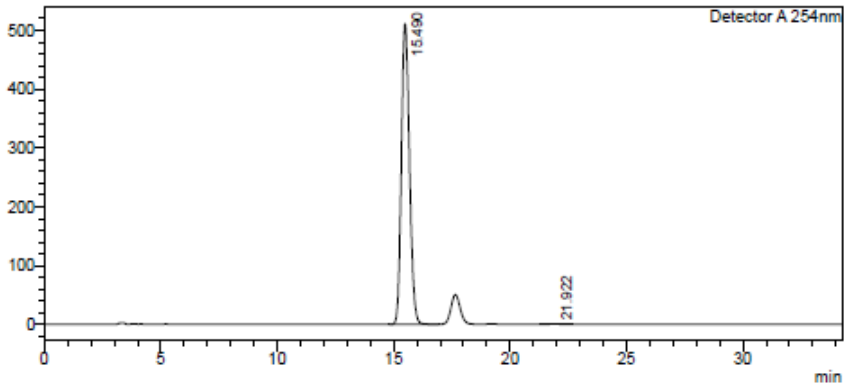
Racemic **3n**



<Peak Table>
Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	15.481	15161829	630208	49.989			
2	21.740	15168703	434988	50.011			
Total		30330532	1065196				

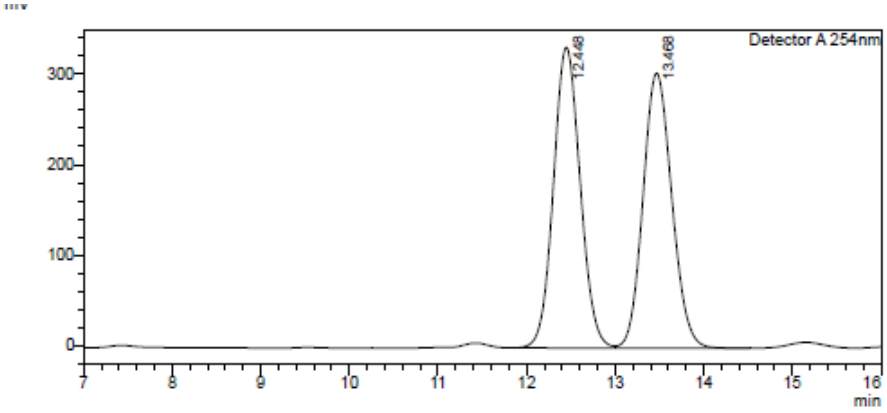
Chiral **3n**



<Peak Table>
Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	15.490	12354161	510442	99.827			
2	21.922	21360	621	0.173			
Total		12375520	511063				

Racemic **3o**

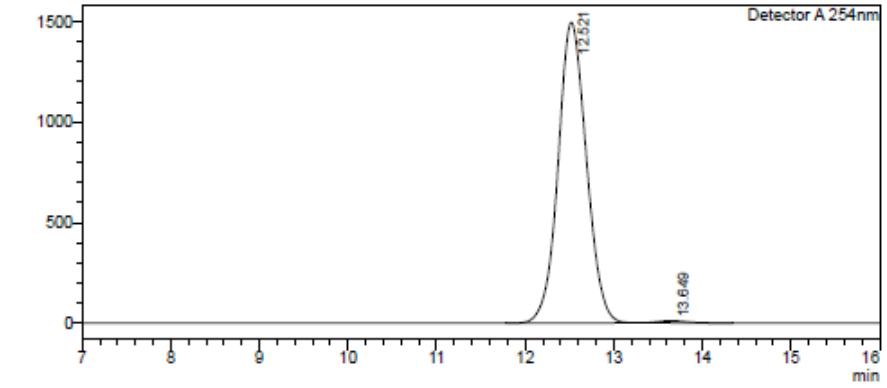


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	12.448	6991643	332241	50.441			
2	13.468	6869433	304050	49.559		V	
Total		13861075	636291				

Chiral **3o**

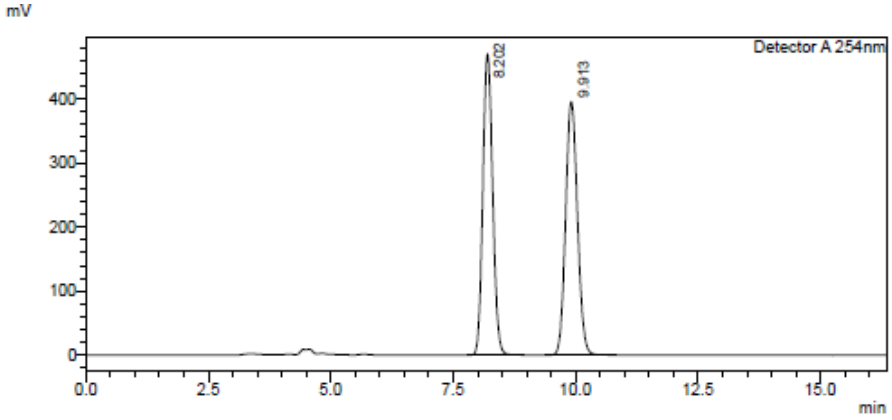


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	12.521	33290078	1494128	99.345			
2	13.649	219561	10303	0.655		M	
Total		33509639	1504432				

Racemic **3p**

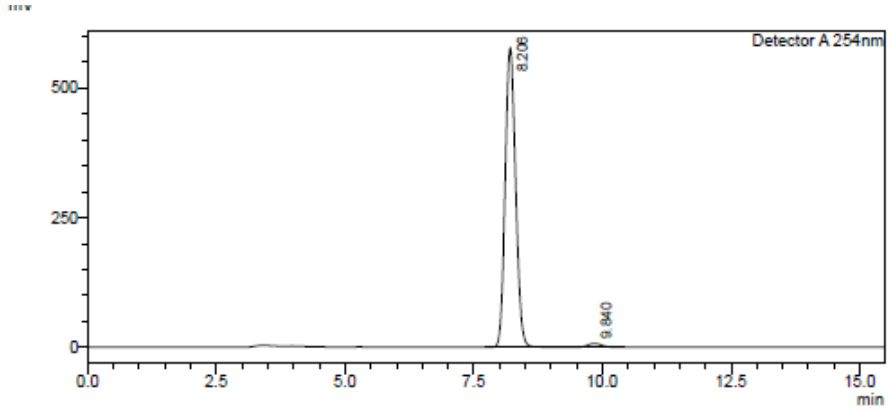


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	8.202	6555170	468992	49.622		M	
2	9.913	6655070	395601	50.378		M	
Total		13210240	864593				

Chiral **3p**

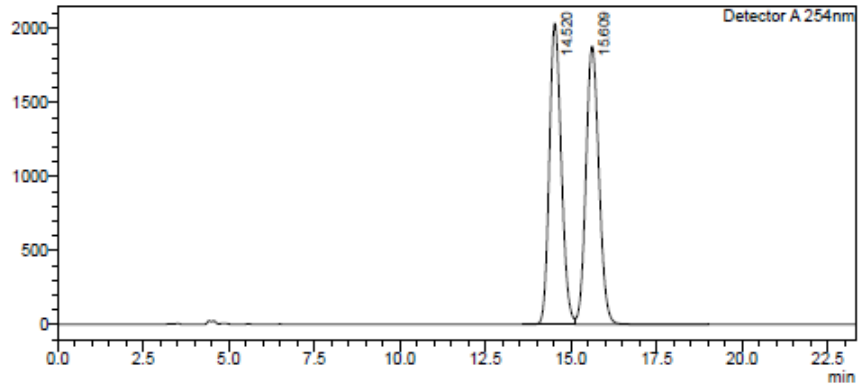


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	8.206	8143373	576870	98.387			
2	9.840	133487	7375	1.613		V	
Total		8276860	584245				

Racemic **3q**

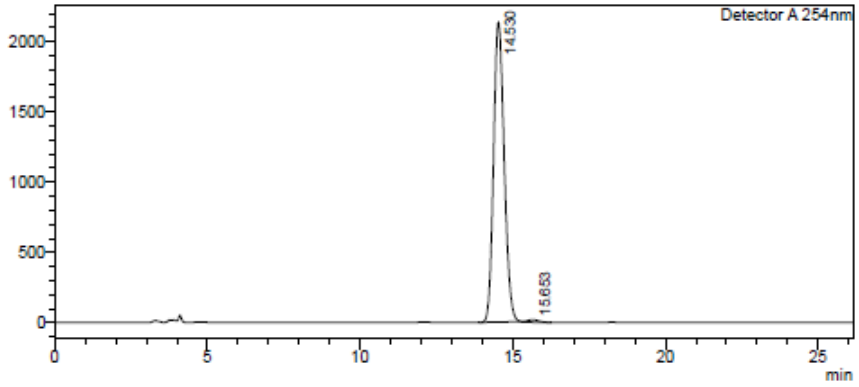


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	14.520	49369171	2035134	49.818			
2	15.609	49729700	1882139	50.182		SV	
Total		99098872	3917273				

Chiral **3q**

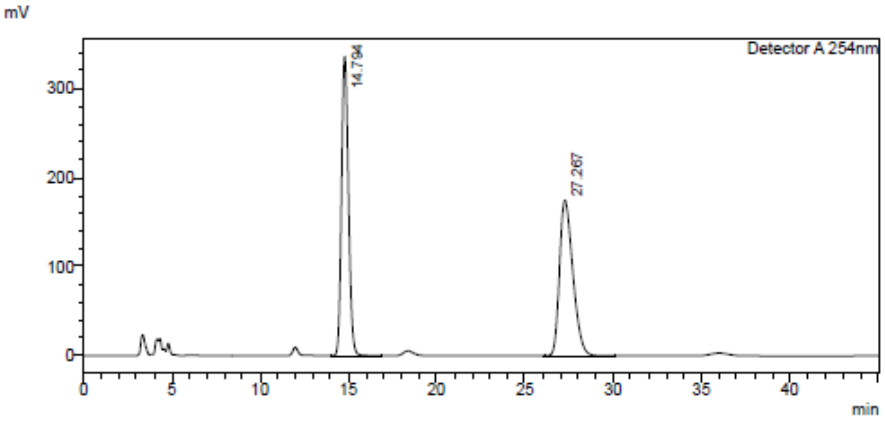


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	14.530	51735126	2132998	99.119			
2	15.653	460022	17966	0.881		M	
Total		52195147	2150964				

Racemic **3r**



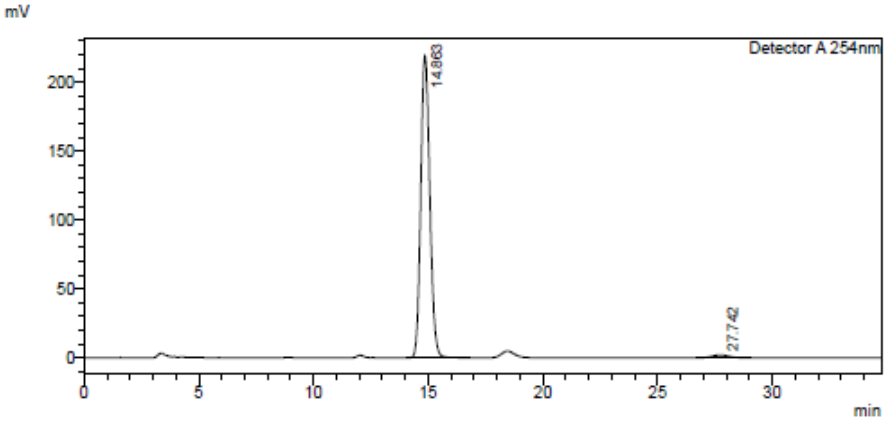
<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.
1	14.794	9143670	336072	49.928
2	27.267	9169908	174446	50.072
Total		18313578	510517	

Chiral **3r**

<Chromatogram>

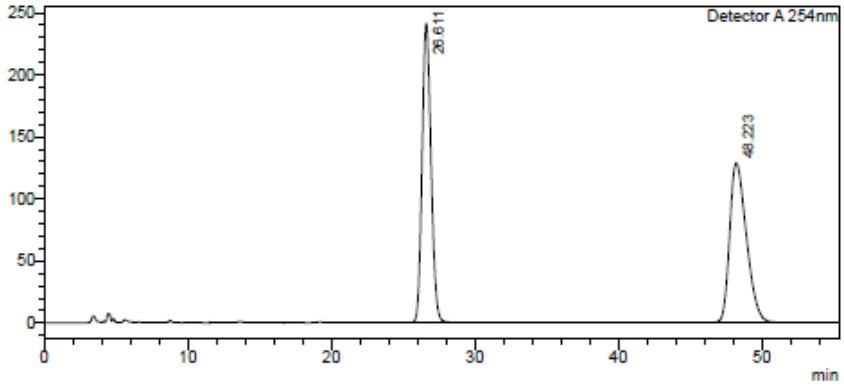


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	14.863	6021519	219315	98.281			
2	27.742	105317	2055	1.719			
Total		6126836	221370				

Racemic **3s**

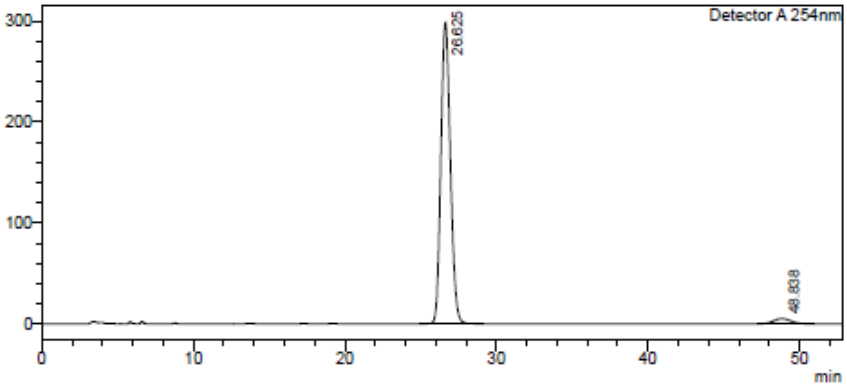


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	26.611	10435161	240940	50.018			
2	48.223	10427519	128551	49.982			
Total		20862680	369491				

Chiral **3s**

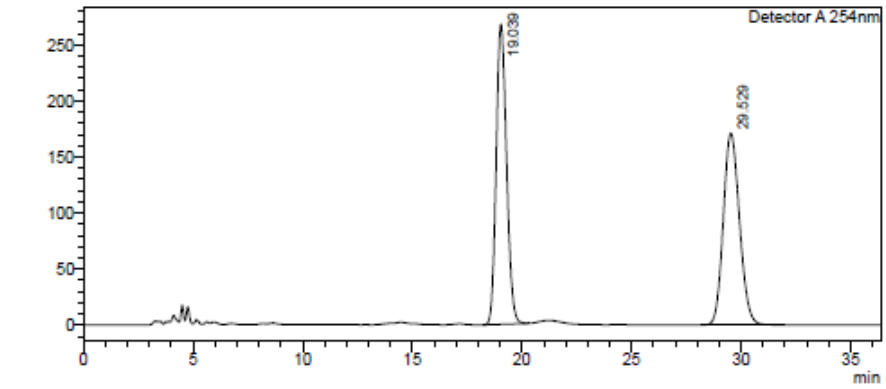


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	26.625	13022774	298359	96.906			
2	48.838	415795	5334	3.094			
Total		13438569	303693				

Racemic **3t**

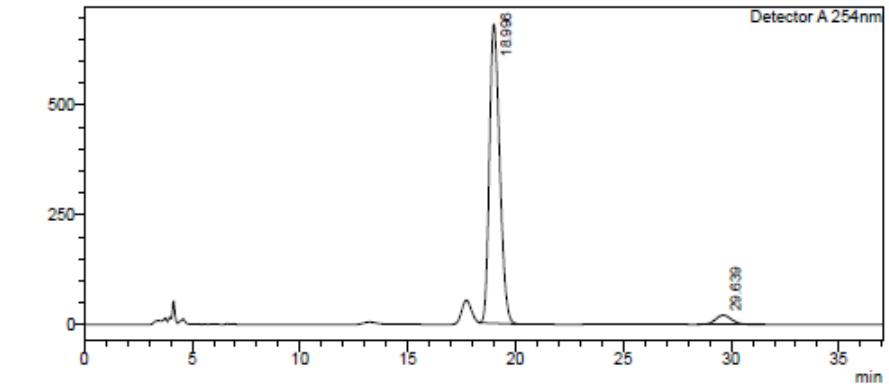


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	19.039	8792306	267478	50.020			
2	29.529	8785259	170958	49.980			
Total		17577564	438436				

Chiral **3t**

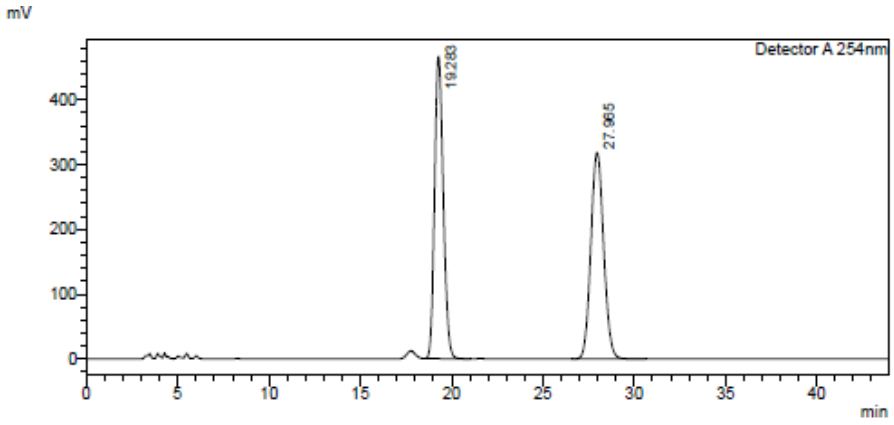


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	18.996	22574653	681453	95.452			
2	29.639	1075624	21046	4.548			
Total		23650277	702499				

Racemic **3u**

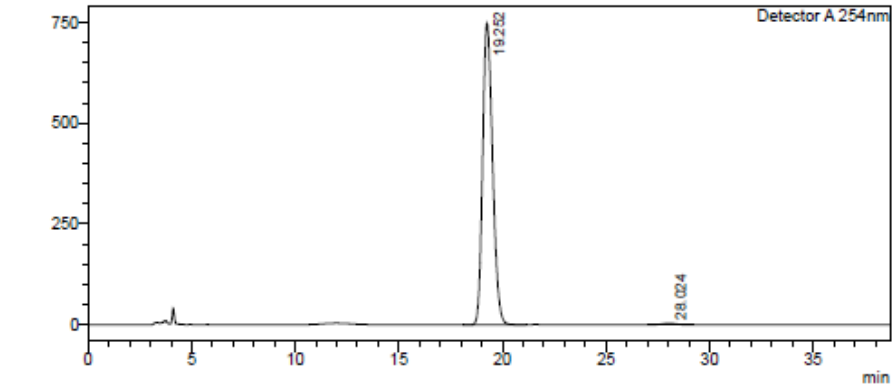


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	19.283	15515173	466134	49.914			
2	27.965	15568560	318680	50.086			
Total		31083733	784814				

Chiral **3u**

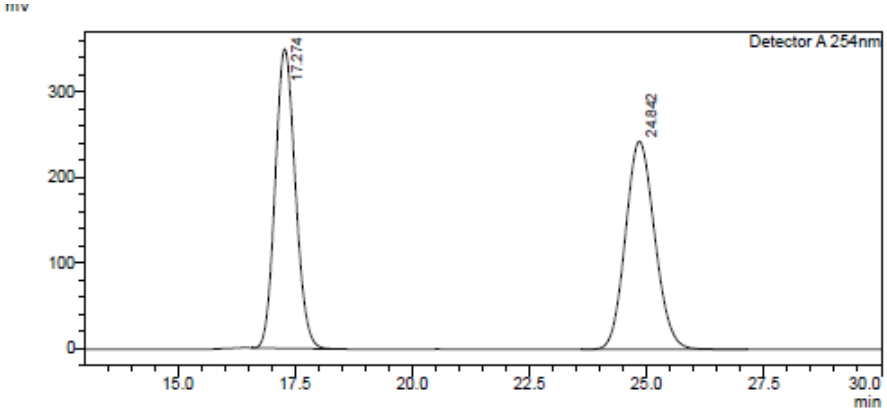


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	19.252	25036740	747159	99.350		M	
2	28.024	163689	3380	0.650		M	
Total		25200430	750538				

Racemic **3v**

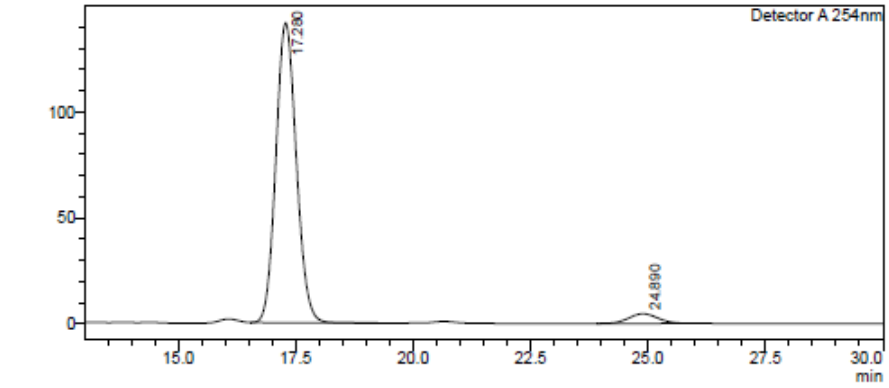


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	17.274	10494930	350350	49.742			
2	24.842	10603628	243529	50.258			
Total		21098558	593879				

Chiral **3v**

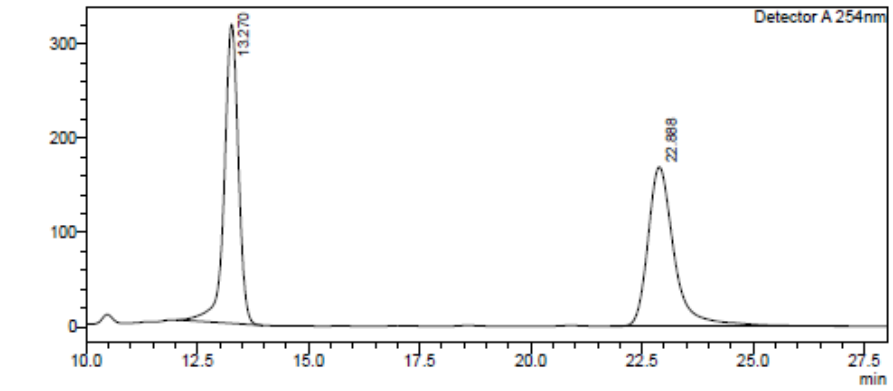


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	17.280	4288233	141304	95.589		S	
2	24.890	197905	4579	4.411			
Total		4486138	145882				

Racemic **4**

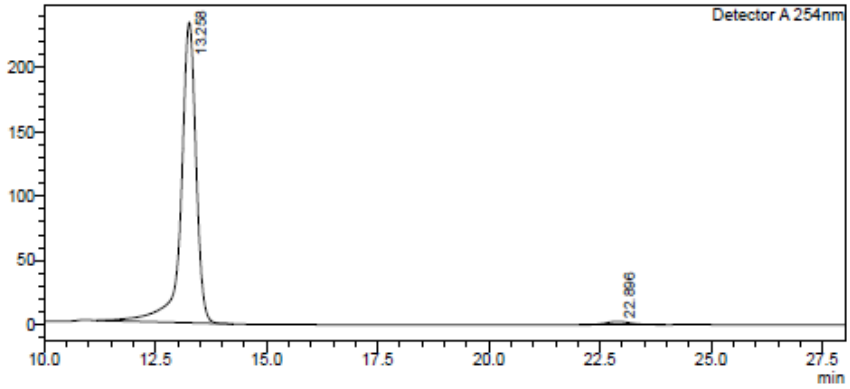


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	13.270	7022584	316642	50.272			
2	22.888	6946465	168729	49.728			
Total		13969049	485371				

Chiral **4**

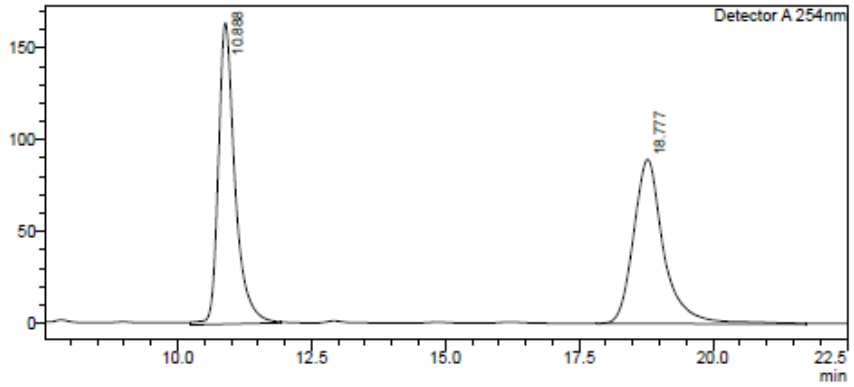


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	13.258	5497244	233489	98.298			
2	22.896	95160	2477	1.702			
Total		5592404	235966				

Racemic **5**

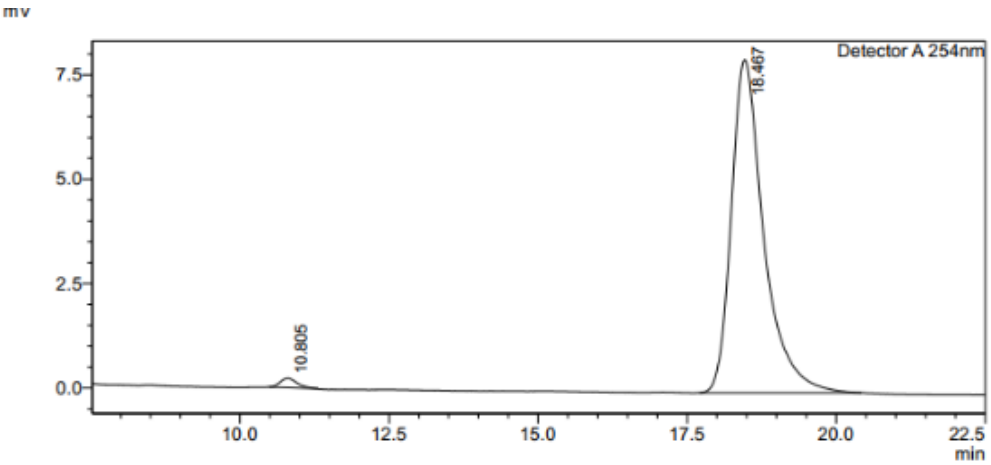


<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	10.888	3553127	164056	50.162		M	
2	18.777	3530147	89441	49.838		M	
Total		7083274	253497				

Chiral **5**



<Peak Table>

Detector A 254nm

Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	10.805	4341	223	1.416			
2	18.467	302268	7981	98.584			
Total		306609	8204				

Stereochemistry Determination via Single Crystal X-Ray Diffraction

The data have been assigned to the Cambridge Crystallographic Data Centre with a deposition number CCDC 1837253.

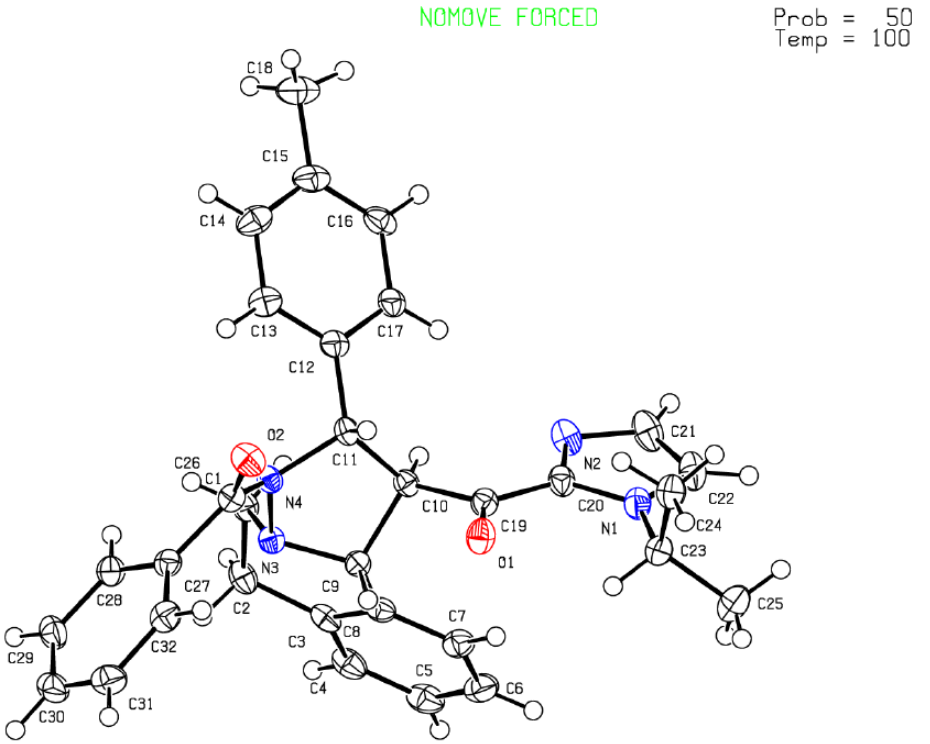


Table 1. Crystal data and structure refinement for **3i**.

Identification code	**3i**	
Empirical formula	$C_{32}H_{32}N_4O_2$	
Formula weight	504.61	
Temperature (K)	100.0(3)	
Wavelength (Å)	1.54184	
Crystal system	orthorhombic	
Space group	$P2_12_12_1$	
Unit cell dimensions (Å, °)	a = 9.57270(10)	α = 90
	b = 15.8631(2)	β = 90
	c = 17.8255(2)	γ = 90
Volume (Å^3)	2706.85(5)	

Z	4
Calculated density (g cm^{-3})	1.238
Absorption coefficient (mm^{-1})	0.620
F_{000}	1072
Crystal size (mm^3)	0.13 × 0.12 × 0.10
θ range for data collection (°)	3.730 to 73.289
Miller index ranges	$-11 \leq h \leq 11$, $-19 \leq k \leq 19$, $-19 \leq l \leq 21$
Reflections collected	20157
Independent reflections	5366 [R_{int} = 0.0276]
Completeness to θ_{max} (%)	0.994
Max. and min. transmission	0.77458 and 1.00000
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	5366 / 0 / 346
Goodness-of-fit on F^2	1.043
Final R indices [$I > 2\sigma(I)$]	$R1$ = 0.0284, $wR2$ = 0.0712
R indices (all data)	$R1$ = 0.0301, $wR2$ = 0.0726
Largest diff. peak and hole (e Å^{-3})	0.133 and -0.150
Absolute structure parameter	.01(8)

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