Electronic Supplementary Material (ESI) for ChemComm.

Electronic Supporting Information for

Nucleophilic ring opening of *trans*-2,3-disubstituted epoxides to β-amino alcohols with catalyst-controlled regioselectivity

Michelle Lee,[†] Jessica R. Lamb,[†] Maria J. Sanford, Anne M. LaPointe, and Geoffrey W. Coates*

Baker Laboratory, Department of Chemistry and Chemical

Biology, Cornell University,

Ithaca, New York 14853-1301, United States

*email: coates@cornell.edu

I. General Considerations

Methods and Instruments

Unless stated otherwise, all synthetic manipulations were carried out using standard Schlenk techniques under a nitrogen atmosphere or in an MBraun Unilab glovebox under an atmosphere of purified nitrogen. Reactions were carried out in oven-dried glassware cooled under vacuum. ^{1}H and $^{13}C\{^{1}H\}$ NMR Spectra were recorded on Bruker AV III HD spectrometer with a broad band Prodigy cryoprobe ((^{1}H, 500 MHz), (^{13}C, 126 MHz)), Varian INOVA 400 MHz (^{1}H, 400 MHz), or Varian INOVA 600 MHz (^{1}H, 600 MHz), spectrometer at 22 °C, unless otherwise noted, and were referenced to the residual chloroform (7.26 ppm for ^{1}H, 77.16 ppm for ^{13}C). All *J* values are given in Hertz. Deuterated chloroform was purchased from Cambridge Isotope Laboratories and stored over K_2CO_3. DART-HRMS analyses were performed on a Thermo Scientific Exactive Orbitrap MS system with an Ion Sense DART ion source.

Pre-made catalyst vials were made by dispensing stock solutions using a Freeslate Core Module 3 (CM3) robotic platform located inside an MBraun drybox. All solutions were dispensed robotically using a syringe dispense, which was designed and executed using Library Studio™ and Automation Studio™ software. The solvent was then removed *in vacuo* in a vacuum centrifuge.

Chemicals

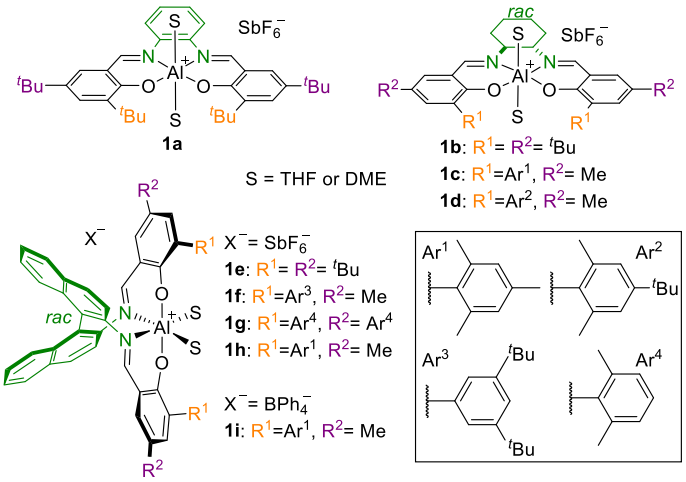
Anhydrous 1,4-dioxane was purchased from Sigma-Aldrich. It was dried over 3Å molecular sieves, filtered using a syringe filter the next day, and sparged under nitrogen for 30 minutes prior to use. Anhydrous toluene, dichloromethane (DCM), hexanes, diethyl ether, and tetrahydrofuran (THF) were purchased from Fischer Scientific and sparged vigorously with nitrogen for 40 minutes prior to first use. The solvents were further purified by passing them under nitrogen pressure through two packed columns of neutral alumina (THF was also passed through a third column packed with activated 4Å molecular sieves) or through neutral alumina and copper(II) oxide (for toluene and hexanes). THF, diethyl ether, and

dichloromethane were degassed via three freeze-pump-thaw cycles prior to use. All epoxides used in this study were dried over calcium hydride and degassed via three freeze-pump-thaw cycles prior to use. All non-dried solvents used were reagent grade or better and used as received.

All other chemicals were purchased from Aldrich, Alfa-Aesar, TCI America, Strem, or Macron and used as received. Flash column chromatography was performed with silica gel (particle size 40–64 μm, 230–400 mesh) using mixtures of ethyl acetate and hexanes as eluent.

The following compounds were prepared according to literature procedures:

a) catalysts and catalyst precursors



salphAl–Cl (precursor to **1a**, salph = 6,6'-((1*E*,1'*E*)-(1,2-phenylenebis(azanylylidene))bis(methanylylidene))bis(2,4-di-*tert*-butylphenolate))[1]

rac-salcyAl–Cl (precursor to **1b**, salcy = *N*,*N*′-*bis*(3,5-di-*tert*-butyl-salicyl-idene)-1,2-cyclohexanediamine)[2]

rac-3,3''-((1*E*,1'*E*)-((1*S*,2*S*)-Cyclohexane-1,2-diylbis(azanylylidene))bis(methanylylidene))bis(2',4',5,6'-tetramethyl-[1,1'-biphenyl]-2-olate)aluminum chloride (precursor to **1c**)[3]

rac-3,3''-((1*E*,1'*E*)-((1*S*,2*S*)-Cyclohexane-1,2-diylbis(azanylylidene))bis(methanylylidene))bis(4'-(*tert*-butyl)-2',5,6'-trimethyl-[1,1'-biphenyl]-2-olate)aluminum chloride (precursor to **1d**)[4]

rac-^{t}BuBinamAl–Cl (precursor to **1e**, *rac*-^{t}BuBinam = *rac*-*N,N'-bis*(2-hydroxy-3,5-di-*tert*-butylbenzylidene)-1,1'-binaphtyl-2,2'-diamine, *rac* complex made analogously to the *R* complex shown)[5]

3,3''-((1*E*,1'*E*)-([1,1'-Binaphthalene]-2,2'-diylbis(azanylylidene))-bis(methanylylidene))bis(3',5'-di-tert-butyl-5-methyl-[1,1'-biphenyl]-2-olate)aluminum chloride (precursor to **1f**)[6]

Rac-Xyl$_2$BinamAl–Cl (precursor to **1g**, *rac*-Xyl$_2$Binam = *rac*-5',5''''-((1*E*,1'*E*)-([1,1'-binaphthalene]2,2'-diylbis(azanylylidene))bis(methanylylidene))-bis(2,2'',6,6''-tetramethyl-[1,1',3',1''-perphenyl]-4'-olate, *rac* complex made analogously to the *R* complex shown)[7]

3,3''-((1*E*,1'*E*)-([1,1'-Binaphthalene]-2,2'-diylbis(azanylylidene))-bis(methanylylidene))bis(2',4',5,6'-tetramethyl-[1,1'-biphenyl]-2-olate)aluminum chloride (precursor to **1h** and **1i**)[7]

b) epoxides

rac-trans-2-methyl-3-pentyloxirane (**2a**)[8]

rac-trans-2-ethyl-3-methyloxirane (**2b**)[9]

rac-trans-2-methyl-3-propyloxirane (**2c**)[3]

rac-trans-2-hexyl-3-methyloxirane (**2d**)[8]

rac-trans-2-butyl-3-ethyloxirane (**2e**)[10]

rac-trans-2-methyl-3-[(4-methylphenyl)methyl]-oxirane (**2f**)[4]

rac-trans-2-methyl-3-[(3-methylphenyl)methyl]-oxirane (**2g**)[4]

rac-trans-2-methyl-3-[(2-methylphenyl)methyl]-oxirane (**2h**)[4]

rac-tert-butyldimethyl((*trans*-3-methyloxiran-2-yl)methoxy)-silane (**2i**)[11]

rac-cis-2-methyl-3-pentyloxirane (**2j**)[7]

II. Synthetic Procedures

General procedure A: Preparation of catalyst and dispensing of stock solution

In a glove box, a 20 ml scintillation vial was charged with (*rac*)-3,3''-(([1,1'-binaphthalene]-2,2'-diylbis(azanylylidene))bis(methanylylidene))bis(2',4',5,6'-tetramethyl-[1,1'-biphenyl]-2-olate))AlCl, (precursor to **1i**, 0.202 g, 0.250 mmol), $NaBPh_4$ (0.102 g, 0.297 mmol), and a magnetic stir bar. DME (2.4 ml, 0.1 M DME) was added using an automatic pipettor. The vial was sealed, taken out of the glovebox, and put in a preheated heating block (60 °C) for 18 hours. The vial was then cooled to room temperature before filtering the solution via syringe filter in the glovebox. Pentane (~2.5 ml) was layered on top of the filtered reaction solution, which was then sealed and placed in the freezer to crystallize for 24 hours. The solid was collected via filtration and dried under vacuum for 20 hours to give catalyst **1i** (0.254 g, 0.210 mmol, 86% yield). A stock solution of **1i** (16.51 mg) in DCM (4.27 ml, 0.05 M) was made. A robotic syringe dispense was used to transfer 278 μl of the stock solution (0.0165 g, 0.0139 mmol of **1i**) to several 4 ml scintillation vials equipped with magnetic stir bars. Vials were placed in a vacuum centrifuge at 40 °C for one hour to remove DCM.

General procedure B: Nucleophilic ring opening with aniline

In a glove box, an aniline stock solution (64 μl, 0.51 mmol, 8.0 M DME, 1.1 equiv) was added to a pre-made catalyst vial (see General Procedure A) using an automatic pipettor. Neat epoxide (0.46 mmol, 1.0 equiv) was added by weight using a syringe, resulting in [epoxide] = 3.6 M. The vial was sealed, taken out of the glovebox, and put in a preheated heating block (40 °C) for 6 hours. The vial was then

cooled to room temperature before loading directly onto a column for purification (silica gel, hexanes/ethyl acetate).

General procedure C: Nucleophilic ring opening of 2a using different nucleophiles and pre-made catalyst vials

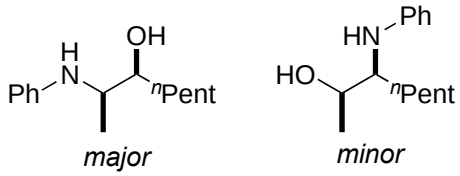
In a glove box, the nucleophile (0.51 mmol, 1.1 equiv) was added by weight to a pre-made catalyst vial (see General Procedure A). Neat *rac-trans*-2-methyl-3-pentyloxirane (0.07 ml, 0.059 g, 0.46 mmol, 1.0 equiv) was added by weight using an automatic pipettor. Solution was diluted to [epoxide] = 3.6 M using DME. The vial was sealed, taken out of the glovebox, and put in a preheated heating block (40 °C) for 20 hours. The vial was then cooled to room temperature before loading directly onto a column for purification (silica gel, hexanes/ethyl acetate).

General procedure D: Nucleophilic ring opening of 2a using different nucleophiles without pre-made catalyst vials

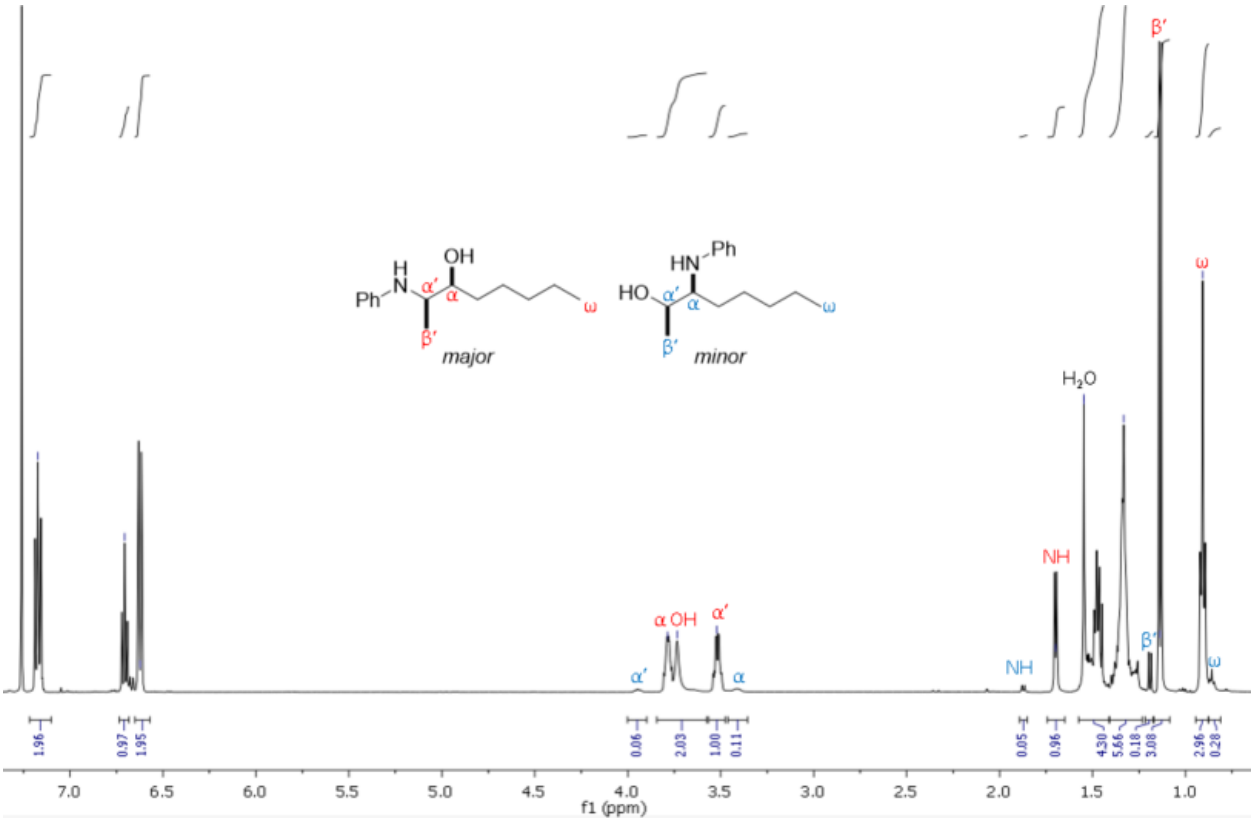
In a glove box, a 4 ml scintillation vial was charged with catalyst **1i** (0.0139 mmol, 3 mol%), the nucleophile (0.51 mmol, 1.1 equiv), and a magnetic stir bar. Neat *rac-trans*-2-methyl-3-pentyloxirane (0.07 ml, 0.059 g, 0.46 mmol, 1.0 equiv) was added by weight using an automatic pipettor. Solution was diluted to [epoxide] = 3.6 M using DME. The vial was sealed, taken out of the glovebox, and put in a preheated heating block (40 °C) for 20 hours. The vial was then cooled to room temperature before loading directly onto a column for purification (silica gel, hexanes/ethyl acetate).

III. Synthesis and Characterization of Nucleophilic Ring Opened Products

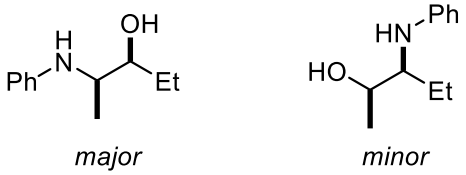
(2*R*,3*S*)-*rel*-2-(Phenylamino)-3-octanol (4a) + (2*R*,3*S*)-*rel*-3-(phenylamino)-2-octanol (5a)



Following general procedure B, **2a** (0.0593 g, 0.462 mmol), aniline (64 μl, 0.51 mmol, 8.0 M, DME), and **1i** (0.0165 g, 0.0139 mmol, 3.0 mol %) were used to produce a mixture of the title compounds (0.1007 g, 98%, 17 : 1) as a yellow oil (column conditions Hexanes : EtOAc 15 : 1). **HRMS** (DART) *m/z* calculated for $C_{14}H_{24}NO^+$ $(M+H)^+$ 222.18524, found 222.18591 (error 3.01 ppm). **$^{13}C\{^1H\}$ NMR** (126 MHz, $CDCl_3$, ppm): major- δ 147.4, 129.5, 117.8, 113.8, 73.0, 52.7, 33.7, 32.1, 26.1, 22.8, 14.2, 14.0 (minor product cannot be seen in the ^{13}C NMR spectrum). **^1H NMR** (500 MHz, $CDCl_3$, ppm): major- δ 7.17 (m (2^{nd} order pseudo t), 2H), 6.71 (m (2^{nd} order pseudo t), 1H), 6.62 (m (2^{nd} order pseudo d), 2H), 3.79 (m, 1H), 3.73 (br s, 1H), 3.52 (qd, *J* = 6.6, 3.0, 1H), 1.70 (d, *J* = 5.5, 1H), 1.23–1.58 (m, 8H), 1.14 (d, *J* = 6.6, 3H), 0.91 (t, *J* = 6.7, 3H).

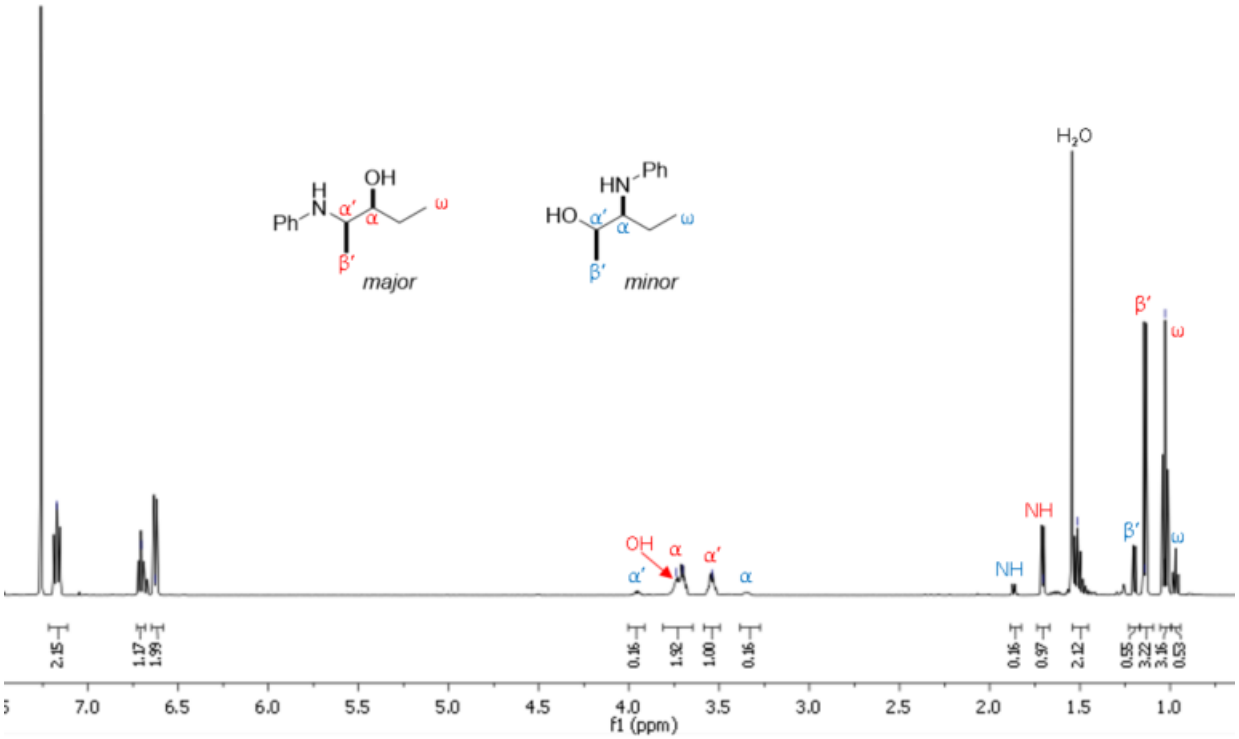


(2*R*,3*S*)-*rel*-2-(Phenylamino)-3-pentanol (4b) + (2*R*,3*S*)-*rel*-3-(phenylamino)-2-pentanol (5b)

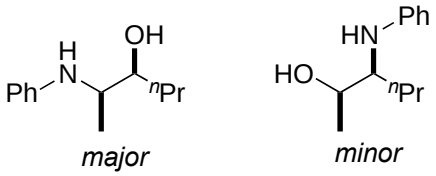


Following general procedure B, **2b** (0.0386 g, 0.448 mmol), aniline (64 µl, 0.51 mmol, 8.0 M, DME), and **1i** (0.0165 g, 0.0139 mmol, 3.1 mol %) were used to produce a mixture of the title compounds (0.0502 g, 63%, 6 : 1) as a yellow oil (column conditions Hexanes : EtOAc 15 : 1). **HRMS** (DART) *m/z* calculated for $C_{11}H_{18}NO^+$ $(M+H)^+$ 180.13829, found 180.13890 (error 3.38 ppm). **$^{13}C\{^1H\}$ NMR** (126 MHz, $CDCl_3$, ppm): major- δ 147.4, 129.5, 117.8, 113.8, 74.6, 52.4, 26.7, 14.0, 10.8; minor- δ 68.8, 60.7, 23.8, 18.6, 11.2. (minor product's aryl carbons cannot be seen in the ^{13}C NMR spectrum). **^1H NMR** (500 MHz, $CDCl_3$, ppm): major- δ 7.17 (m (2^{nd} order pseudo t), 2H), 6.70 (m (2^{nd} order pseudo t), 1H), 6.63 (m (2^{nd}

order pseudo d), 2H), 3.74 (br s, 1H), 3.70 (m, 1H), 3.54 (qd, *J* = 6.6, 3.0, 1H), 1.71 (d, *J* = 5.5, 1H), 1.45–1.56 (m, 2H), 1.14 (d, *J* = 6.6, 3H), 1.03 (t, *J* = 7.5, 3H).

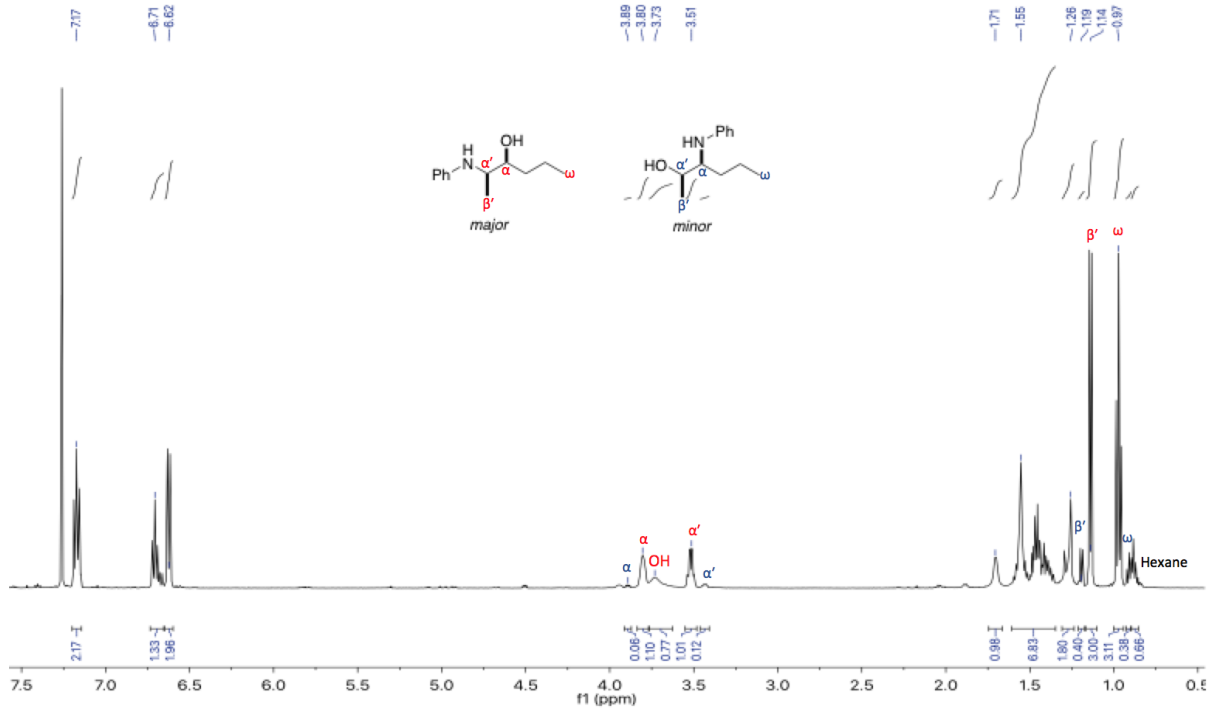


(2*R*,3*S*)-*rel*-2-(Phenylamino)-3-hexanol (4c) + (2*R*,3*S*)-*rel*-3-(phenylamino)-2-hexanol (5c)

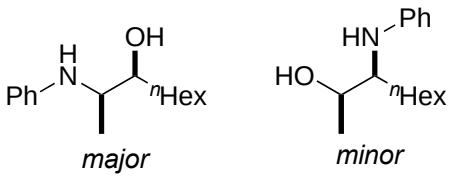


Following general procedure B, **2c** (0.0421 g, 0.42 mmol), aniline (64 µl, 0.51 mmol, 8 M, DME), and **1i** (0.0165 g, 0.0139 mmol, 3.1 mol %) were used to produce a mixture of the title compounds (0.0718 g, 88%, 8 : 1) as a yellow oil (column conditions Hexanes : EtOAc 19 : 1). **HRMS** (DART) *m/z* calculated for $C_{12}H_{19}NO^+$ $(M+H)^+$ 194.15394, found 194.15376 (error −0.93 ppm). **$^{13}C\{^1H\}$ NMR** (126 MHz, $CDCl_3$, ppm): major- δ 147.2, 129.4, 117.6, 113.6, 72.5, 52.6, 35.7, 19.5, 14.2, 13.9; minor- δ 128.5,

117.8, 113.7, 69.0, 58.8, 33.0, 29.7, 19.7, 18.3 (one of the minor product's aromatic peaks cannot be seen in the ^{13}C NMR spectrum). **^{1}H NMR** (500 MHz, $CDCl_3$, ppm): major- δ 7.17 (m (2nd order pseudo t), 2H), 6.71 (m (2nd order pseudo t), 1H), 6.63 (m (2nd order pseudo d), 2H), 3.80 (m, 1H), 3.73 (br s, 1H), 3.52 (qd, *J* = 6.7, 3.1, 1H), 1.71 (d, *J* = 3.4, 1H), 1.23–1.61 (m, 4H), 1.14 (d, *J* = 6.6, 3H), 0.97 (t, *J* = 7.3, 3H).

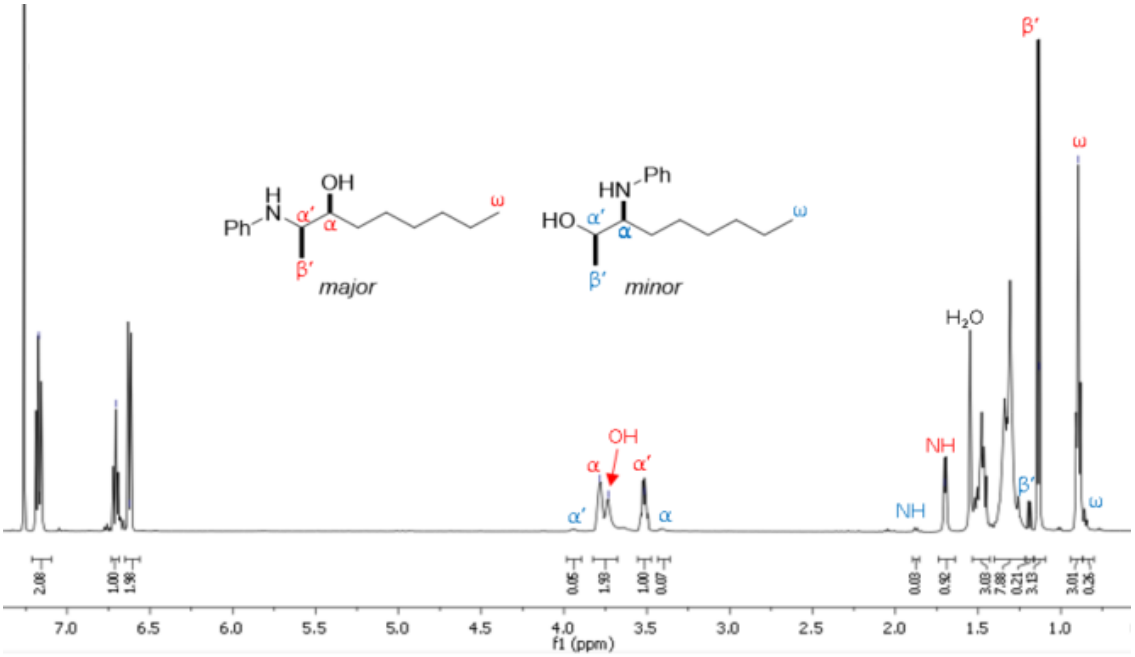


(2*R*,3*S*)-*rel*-2-(Phenylamino)-3-nonanol (4d) + (2*R*,3*S*)-*rel*-3-(phenylamino)-2-nonanol (5d)

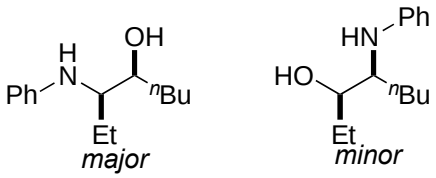


Following general procedure B, **2d** (0.0661 g, 0.464 mmol), aniline (64 µl, 0.51 mmol, 8 M, DME), and **1i** (0.0165 g, 0.0139 mmol, 3.0 mol %) were used to produce a mixture of the title compounds (0.1057 g, 97%, 15 : 1) as a yellow oil (column conditions Hexanes : EtOAc 15 : 1 → 10 : 1). **HRMS** (DART) *m/z* calculated for $C_{15}H_{26}NO^+$ $(M+H)^+$ 236.20089, found 236.20079 (error −0.41 ppm). **^{13}C{^{1}H} NMR** (126

MHz, $CDCl_3$, ppm): major- δ 147.4, 129.5, 117.7, 113.8, 73.0, 52.7, 33.8, 32.0, 29.5, 26.4, 22.8, 14.2, 14.0 (minor product can barely be seen in the ^{13}C NMR spectrum). **^{1}H NMR** (500 MHz, $CDCl_3$, ppm): major- δ 7.17 (m (2nd order pseudo t), 2H), 6.71 (m (2nd order pseudo t), 1H), 6.62 (m (2nd order pseudo d), 2H), 3.78 (m, 1H), 3.73 (br s, 1H), 3.52 (qd, *J* = 6.6, 3.0, 1H), 1.70 (d, *J* = 5.3, 1H), 1.43–1.53 (m, 3H), 1.21–1.40 (m, 7H), 1.13 (d, *J* = 6.5, 3H), 0.90 (t, *J* = 6.9, 3H).

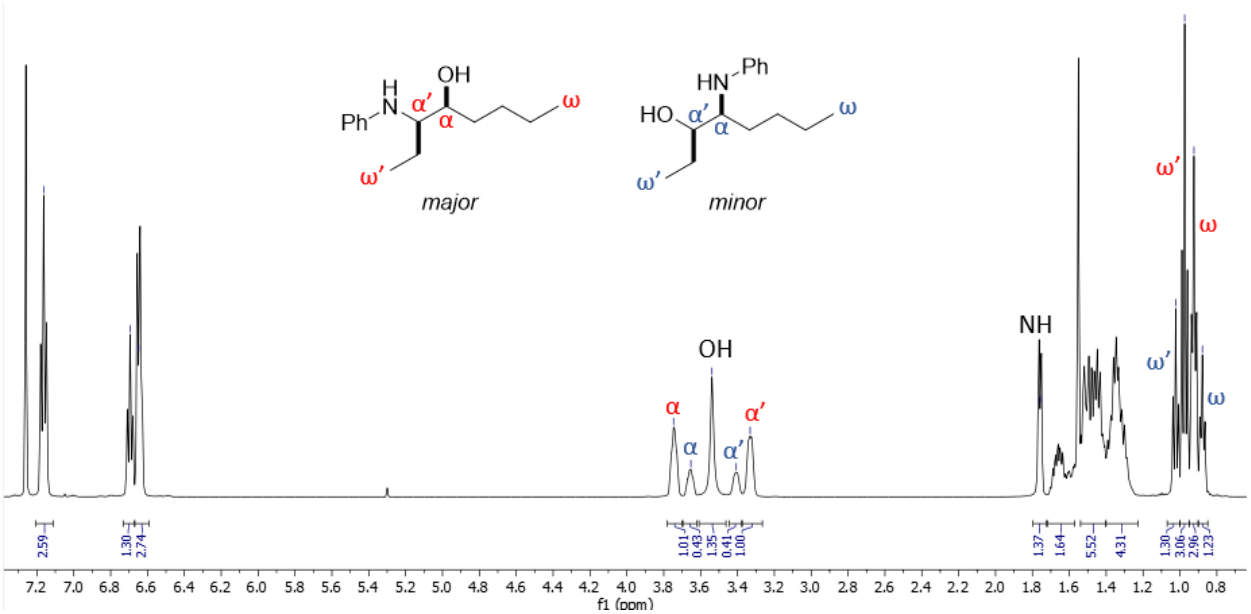


(3*R*,4*S*)-*rel*-3-(Phenylamino)-4-octanol (4e) + (3*R*,4*S*)-*rel*-4-(phenylamino)-3-octanol (5e)

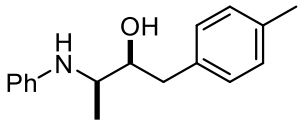


Following general procedure B, **2e** (0.0583 g, 0.455 mmol), aniline (64 µl, 0.51 mmol, 8 M, DME), and **1i** (0.0167 g, 0.0140 mmol, 3.1 mol %) were used to produce a mixture of the title compounds (0.0824 g, 82%, 2.4 : 1) as a yellow oil (column conditions Hexanes : EtOAc 15 : 1 → 10 : 1). **HRMS** (DART) *m/z* calculated for $C_{14}H_{24}NO^+$ $(M+H)^+$ 222.18524, found 222.18476 (error −2.17 ppm). **$^{13}C\{^1H\}$ NMR** (126 MHz, $CDCl_3$, ppm): major- δ 148.44, 129.5, 117.63, 113.64, 72.81, 59.78, 32.73, 28.63, 22.95, 22.94,

14.22, 11.29; minor- δ 148.35, 129.4, 117.59, 113.57, 74.51, 57.81, 29.67, 28.84, 25.96, 22.97, 14.16, 10.87. **^{1}H NMR** (500 MHz, $CDCl_3$, ppm): major- δ 7.16 (t, *J* = 7.8, 2H), 6.70 (t, *J* = 7.2, 1H), 6.65 (m (2nd order pseudo d), 2H), 3.75 (m, 1H), 3.54 (s, 1H), 3.33 (m, 1H), 1.76 (d, *J* = 6.1, 1H), 1.57–1.72 (m, 1H), 1.40–1.54 (m, 4H), 1.23–1.40 (m, 3H), 0.97 (t, *J* = 7.5, 3H), 0.92 (t, *J* = 6.9, 3H); minor- δ 7.16 (t, *J* = 7.8, 2H), 6.70 (t, *J* = 7.2, 1H), 6.65 (m (2nd order pseudo d), 2H), 3.65 (m, 1H), 3.54 (s, 1H), 3.41 (m, 1H), 1.76 (d, *J* = 6.1, 1H), 1.57–1.72 (m, 1H), 1.40–1.54 (m, 4H), 1.23–1.40 (m, 3H), 1.02 (t, *J* = 7.4, 3H), 0.88 (t, *J* = 6.9, 3H).



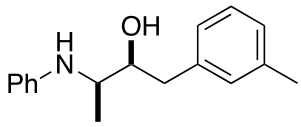
(2*R*,3*S*)-*rel*-3-(Phenylamino)-1-(*p*-tolyl)butan-2-ol (4f)



Following general procedure B, **2f** (0.0755 g, 0.465 mmol), aniline (64 µl, 0.51 mmol, 8 M, DME), and **1i** (0.0165 g, 0.0139 mmol, 3.0 mol %) were used to produce the title compound (0.1081 g, 91%) as a yellow oil (column conditions Hexanes : EtOAc 15 : 1 → 10 : 1). **HRMS** (DART) *m/z* calculated for $C_{17}H_{22}NO^+$ $(M+H)^+$ 256.16959, found 256.16937 (error −0.86 ppm). **^{13}C{^{1}H} NMR** (126 MHz, $CDCl_3$,

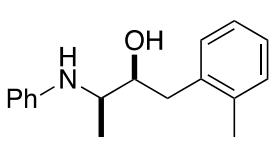
ppm): δ 147.3, 136.3, 135.3, 129.53, 129.48, 129.2, 117.7, 113.7, 74.2, 52.1, 40.2, 21.2, 14.2. **^{1}H NMR** (500 MHz, $CDCl_3$, ppm): δ 7.15 (m (2^{nd} order pseudo t), 2H), 7.14 (s, 4H), 6.69 (m (2^{nd} order pseudo t), 1H), 6.57 (m (2^{nd} order pseudo d), 2H), 4.00 (m, 1H), 3.79 (br s, 1H), 3.55 (qd, *J* = 6.5, 3.2, 1H), 2.81 (dd, *J* = 13.7, 4.6, 1H), 2.74 (dd, *J* = 13.7, 8.8, 1H), 2.34 (s, 3H), 1.75 (br d, *J* = 3.7, 1H), 1.55 (br s, 1H), 1.24 (d, *J* = 6.6, 3H).

(2*S*,3*R*)-*rel*-3-(Phenylamino)-1-(*m*-tolyl)butan-2-ol (4g)

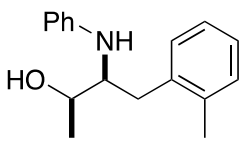


Following general procedure B, **2g** (0.0703 g, 0.460 mmol), aniline (64 μl, 0.51 mmol, 8 M, DME), and **1i** (0.0165 g, 0.0140 mmol, 3.0 mol %) were used to produce the title compound (92 mg, 78%, >20 : 1) as a yellow oil (column conditions Hexanes : EtOAc 19 : 1). **HRMS** (DART) *m/z* calculated for $C_{17}H_{22}NO^+$ $(M+H)^+$ 256.16959, found 256.16907 (error −2.02 ppm). **^{13}C{^{1}H} NMR** (126 MHz, $CDCl_3$, ppm): 147.1, 138.3, 138.2, 130.0, 129.3, 128.6, 127.4, 126.21, 117.5, 113.6, 73.9, 52.0, 40.4, 21.4, 14.1. **^{1}H NMR** (500 MHz, $CDCl_3$, ppm): δ 7.22 (m (2^{nd} order pseudo t), 1H), 7.16 (t, *J* = 7.9, 2H), 7.07 (m (2^{nd} order pseudo d), 2H), 6.70 (m (2^{nd} order pseudo t), 1H), 6.58 (m (2^{nd} order pseudo d), 2H), 4.01 (m, 1H), 3.8 (br s, 1H), 3.55 (qd, *J* = 6.4, 3.2, 1H), 2.81 (dd, *J* = 13.7, 4.6, 1H), 2.74 (dd, *J* = 13.7, 9.0, 1H), 2.35 (s, 3H), 1.78 (br s, 1H), 1.56 (br s, 1H), 1.24 (d, *J* = 6.6, 3H).

(2S,3R)-*rel*-3-(Phenylamino)-1-(o-tolyl)butan-2-ol (4h) + (2S,3R)-*rel*-2-(phenylamino)-1-(o-tolyl)butan-3-ol (5h)

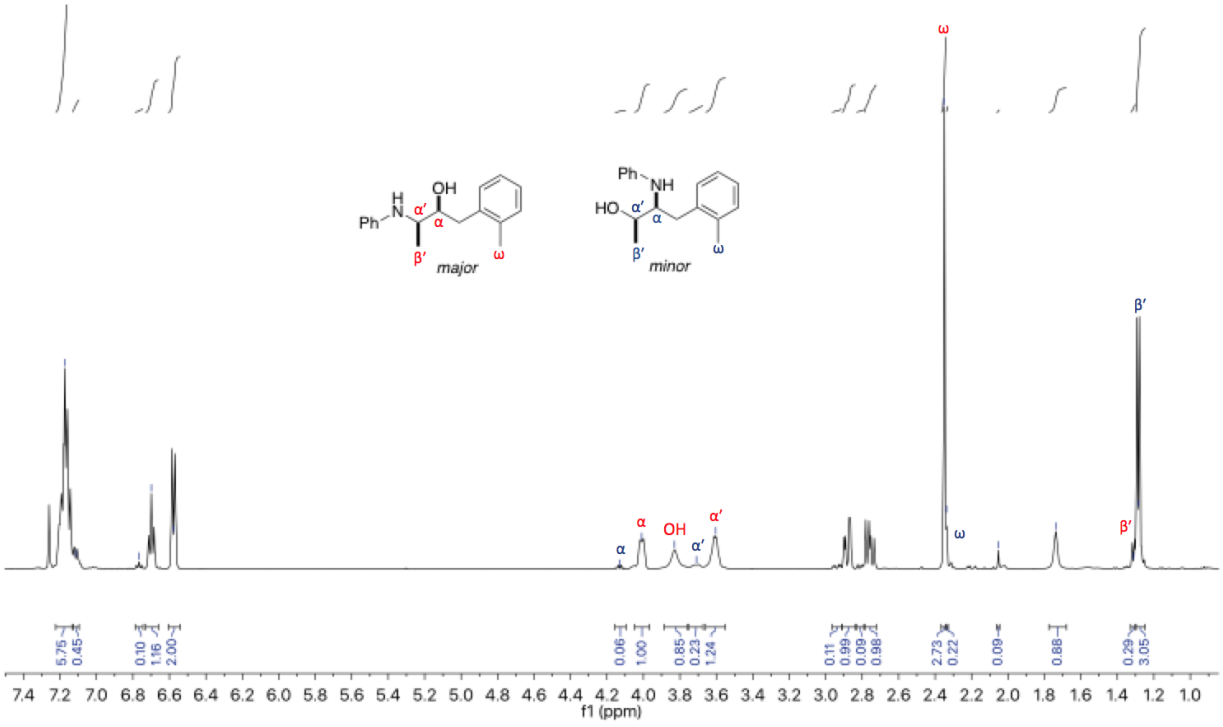


major

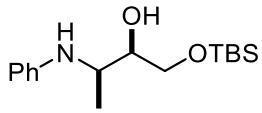


minor

Following general procedure B, **2h** (0.0739 g, 0.460 mmol), aniline (64 µl, 0.51 mmol, 8 M, DME), and **1i** (0.0165 g, 0.0140 mmol, 3.0 mol %) were used to produce the title compounds (101 mg, 86%, 14 : 1) as a yellow oil (column conditions Hexanes : EtOAc 19 : 1). **HRMS** (DART) *m/z* calculated for $C_{17}H_{22}NO^+$ $(M+H)^+$ 256.16959, found 256.17069 (error 4.28 ppm). **$^{13}C\{^1H\}$ NMR** (126 MHz, $CDCl_3$, ppm): major- δ 147.1, 136.6, 136.5, 130.6, 129.98, 129.36, 126.8, 126.1, 117.6, 113.6, 72.8, 52.6, 37.7, 19.7, 14.1; minor- δ 147.6, 146.3, 130.5, 129.42, 129.3, 129.27, 126.5, 126.06, 118.6, 115.1, 113.9, 68.1, 58.7, 33.1, 18.5. **^1H NMR** (500 MHz, $CDCl_3$, ppm): major- δ 7.17 (m, 5H), 6.70 (m (2^{nd} order pseudo t), 1H), 6.58 (m (2^{nd} order pseudo d), 2H), 4.01 (m, 1H), 3.83 (br s, 1H), 3.60 (qd, *J* = 9.3, 6.9, 1H), 2.88 (dd, *J* = 13.9, 4.1, 1H), 2.74 (dd, *J* = 13.9, 9.3, 1H), 2.35 (s, 3H), 1.74 (br s, 1H), 1.29 (d, *J* = 6.5, 3H); minor- δ 7.11 (m, 5H), 6.77 (m (2^{nd} order pseudo t), 1H), 6.58 (m (2^{nd} order pseudo d), 2H), 4.13 (m, 1H), 3.83 (br s, 1H), 3.71 (m, 1H), 2.94 (dd, *J* = 14.7, 5.0, 1H), 2.81 (m, 1H), 2.34 (s, 3H), 2.05 (br s, 1H), 1.31 (d, *J* = 6.4, 3H).

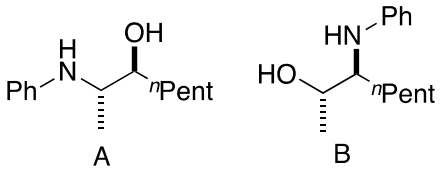


(2*R*,3*R*)-*rel*-1-((*tert*-Butyldimethylsilyl)oxy)-3-(phenylamino)butan-2-ol (4i)

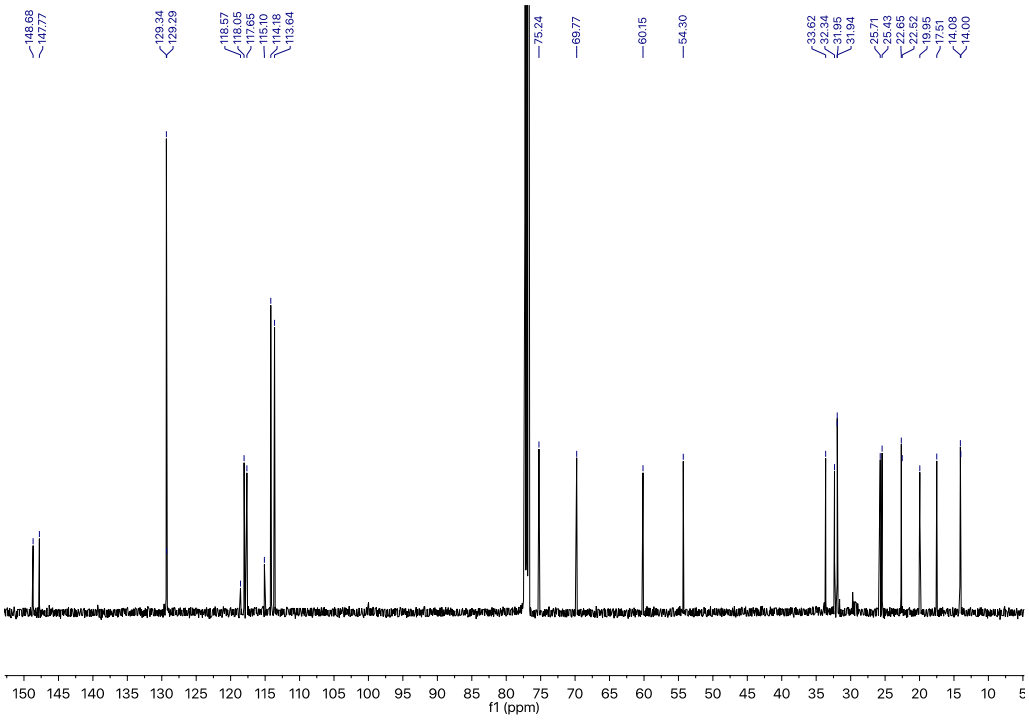


Following general procedure B, **2i** (0.0932 g, 0.460 mmol), aniline (64 µl, 0.51 mmol, 8 M, DME), and **1i** (0.0167 g, 0.0140 mmol, 3.0 mol %) were used to produce the title compound (0.115 g, 84%) as a yellow oil (column conditions Hexanes : EtOAc 20 : 1 → 10 : 1). **HRMS** (DART) *m/z* calculated for $C_{16}H_{30}NO_2Si^+$ $(M+H)^+$ 296.20403, found 296.20285 (error −3.98 ppm). **^{13}C{^{1}H} NMR** (126 MHz, $CDCl_3$, ppm): δ 147.6, 129.5, 117.7, 113.8, 73.3, 64.8, 51.1, 26.1, 18.4, 16.1, −5.28, −5.30. **^{1}H NMR** (500 MHz, $CDCl_3$, ppm): δ 7.16 (m (2nd order pseudo t), 2H), 6.70 (tt, *J* = 7.4, 1.0, 1H), 6.62 (m (2nd order pseudo d), 2H), 3.99 (br s, OH, 1H), 3.75 (overlapping d, 2H), 3.65–3.72 (m, 2H), 2.69 (d, *J* = 6.0, 1H), 1.20 (d, *J* = 6.3, 3H), 0.94 (s, 9H), 0.10 (s, 6H).

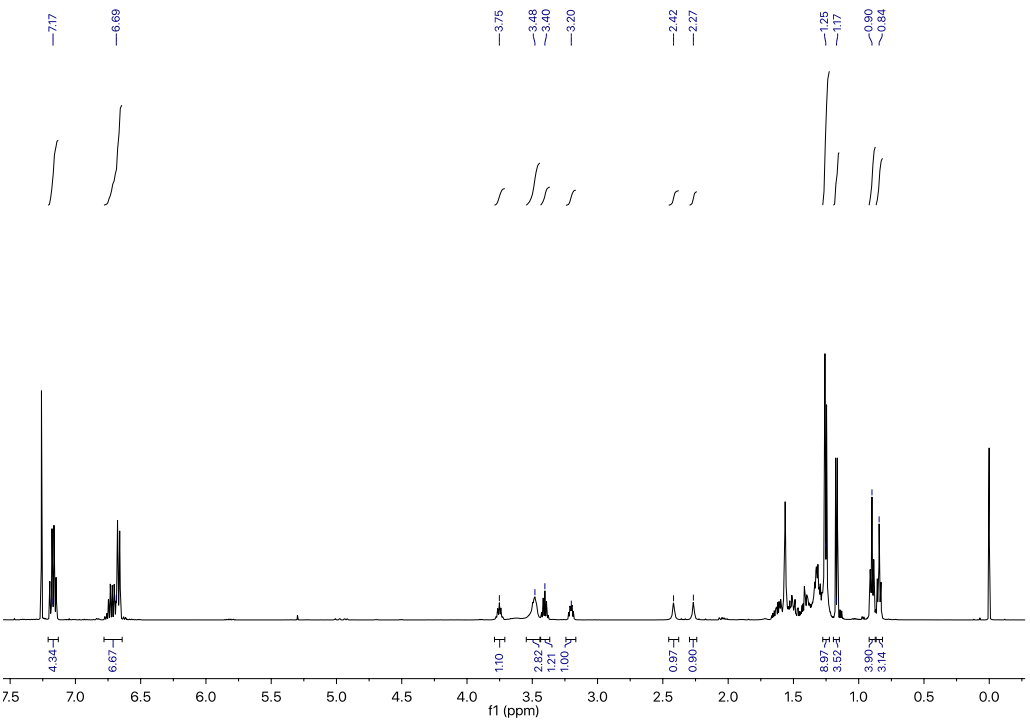
(2*S*,3*S*)-*rel*-2-(Phenylamino)-3-octanol (4j) + (2*S*,3*S*)-*rel*-3-(phenylamino)-2-octanol (5j)



Following general procedure B, **2j** (0.0577 g, 0.450 mmol), aniline (64 µl, 0.51 mmol, 8 M, DME), and **1i** (0.0165 g, 0.0139 mmol, 3.0 mol %) were used to produce a mixture of the title compounds (0.0947 g, 95%, 1 : 1) as a yellow oil (column conditions Hexanes : EtOAc 19 : 1). **HRMS** (DART) *m/z* calculated for $C_{14}H_{24}NO^+$ $(M+H)^+$ 222.18524, found 222.18504 (error –0.90 ppm). **^{13}C{^{1}H} NMR** (126 MHz, $CDCl_3$, ppm): A- δ 147.9, 129.5, 118.2, 114.3, 75.4, 54.4, 33.8, 32.1, 25.6, 22.8, 17.6, 14.2; B- δ 148.8, 129.5, 117.8, 113.8, 69.9, 60.3, 32.5, 32.1, 25.8, 22.7, 20.1, 14.1.

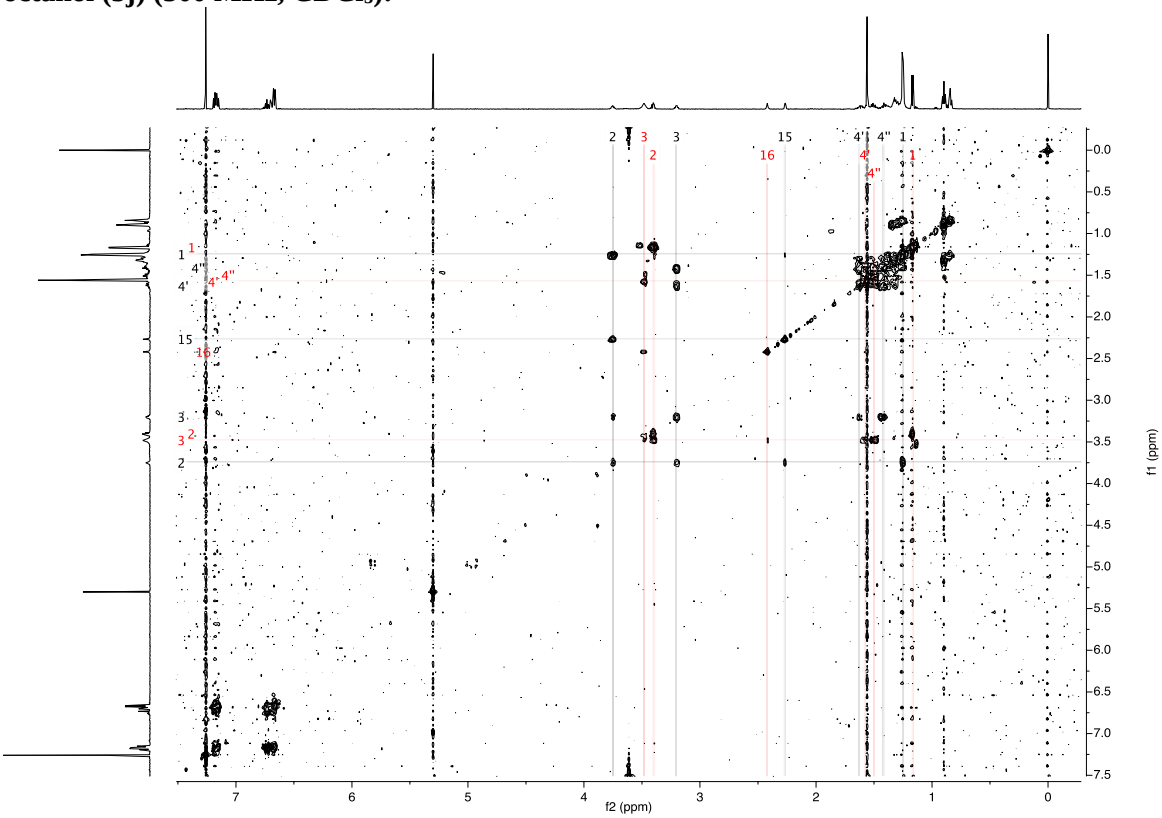


^{1}H NMR (500 MHz, $CDCl_3$, ppm): A- δ 7.17 (m (2nd order pseudo q), 2H), 6.72 (m, 1H), 6.67 (m (2nd order pseudo d), 2H), 3.48 (m, 1H), 3.40 (p, *J* = 6.4, 1H), 2.42 (s, 1H), 1.22–1.68 (m, 8H), 1.17 (d, *J* = 6.2, 3H), 0.90 (t, *J* = 6.9, 3H); B- δ 7.17 (m (2nd order pseudo q), 2H), 6.72 (m, 1H), 6.67 (m (2nd order pseudo d), 2H), 3.75 (p, *J* = 6.1, 1H), 3.20 (dt, *J* = 7.4, 4.6, 1H), 2.27 (s, 1H), 1.22–1.68 (m, 8H), 1.26 (d, *J* = 6.4, 3H), 0.84 (t, *J* = 6.7, 3H).

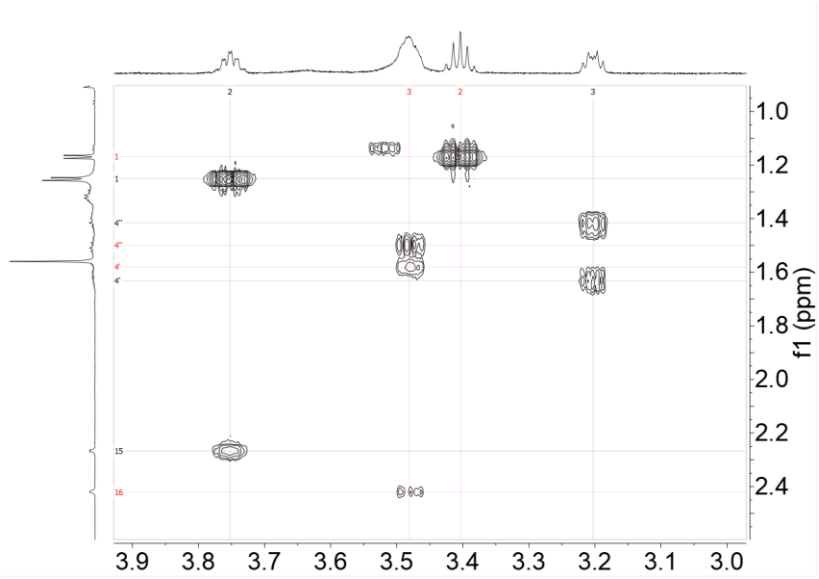


Assignments are based on 2D NMR spectra, below (A is labeled in red, B is labeled in black):

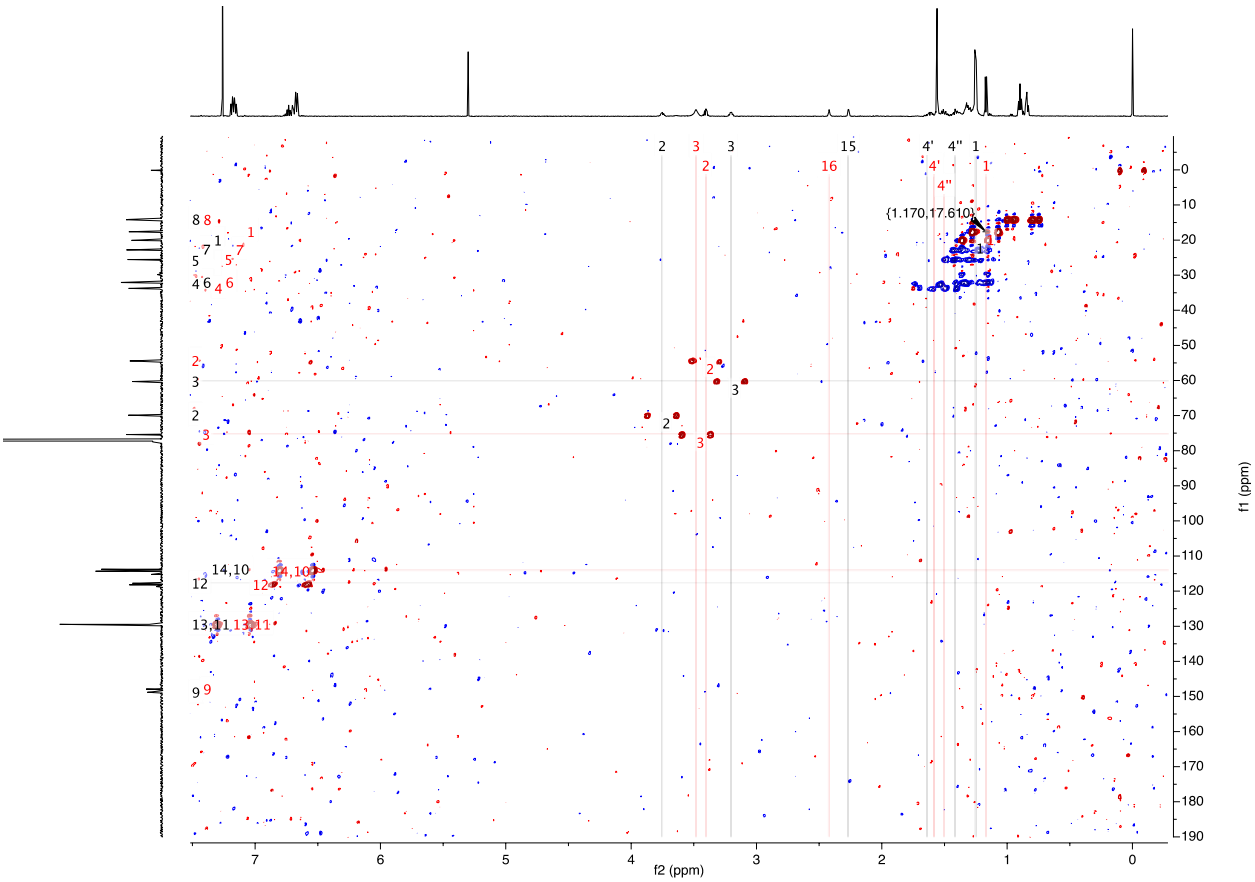
COSY NMR spectrum of **(2*S*,3*S*)-*rel*-2-(phenylamino)-3-octanol (4j) + (2*S*,3*S*)-*rel*-3-(phenylamino)-2-octanol (5j) (500 MHz, $CDCl_3$):**



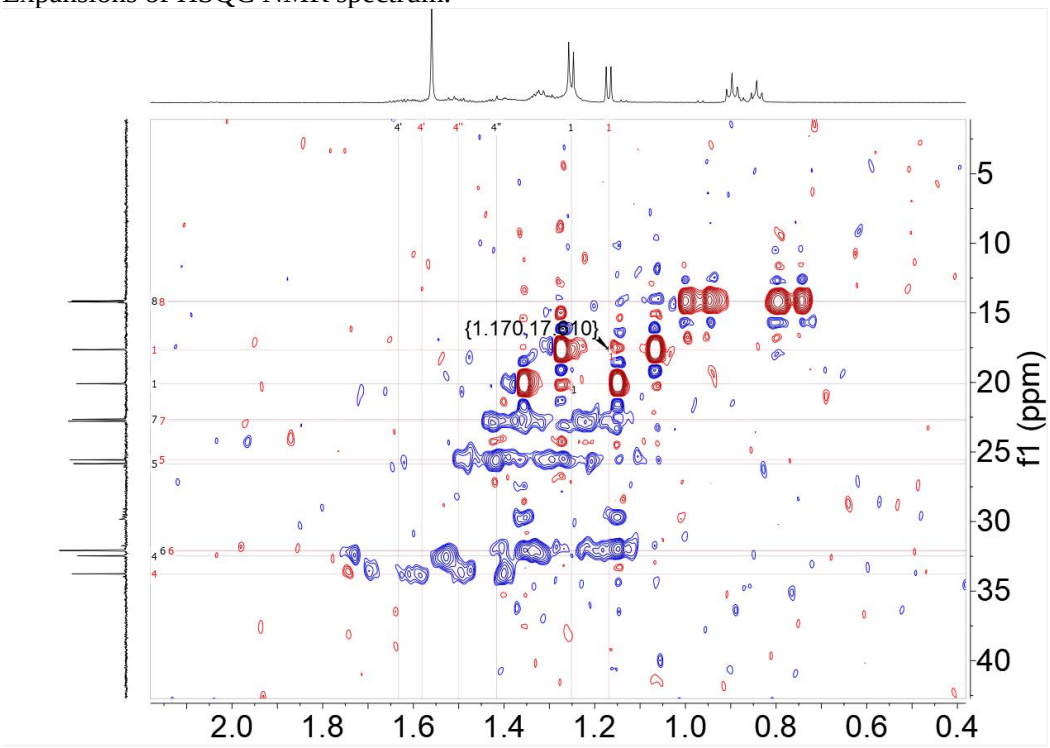
Expansion of COSY NMR spectrum:

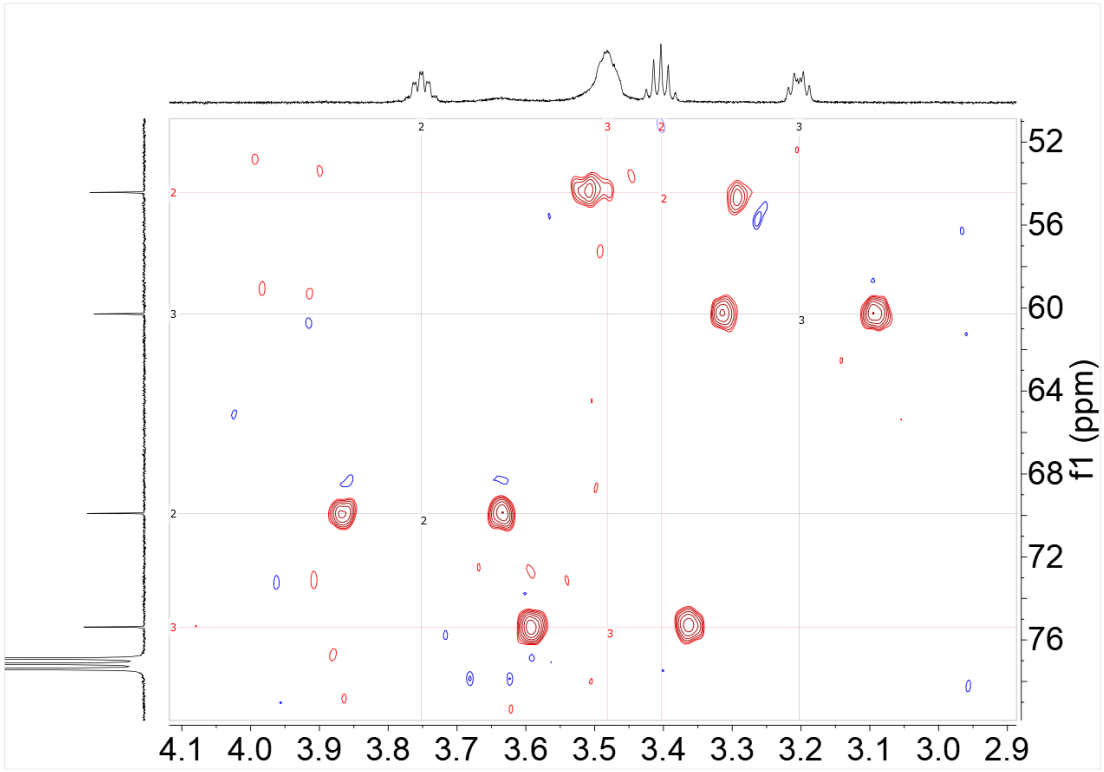


HSQC NMR spectrum of **(2*S*,3*S*)-*rel*-2-(phenylamino)-3-octanol (4j) + (2*S*,3*S*)-*rel*-3-(phenylamino)-2-octanol (5j) (500 MHz, $CDCl_3$):**

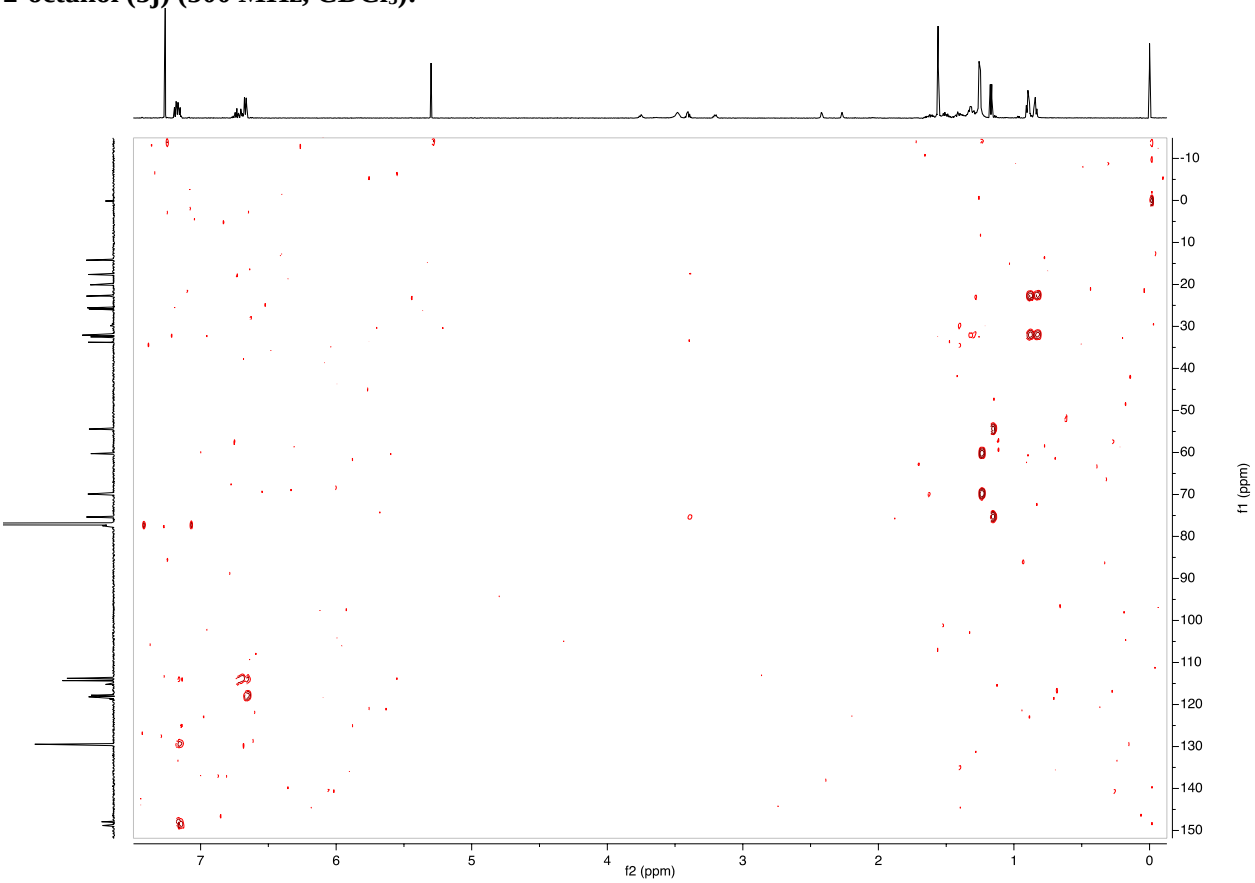


Expansions of HSQC NMR spectrum:

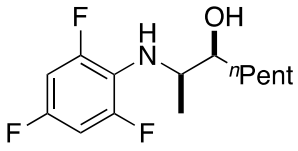




HMBC NMR spectrum of **(2*S*,3*S*)-*rel*-2-(phenylamino)-3-octanol (4j) + (2*S*,3*S*)-*rel*-3-(phenylamino)-2-octanol (5j) (500 MHz, $CDCl_3$):**



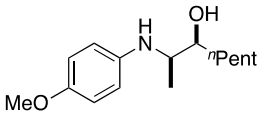
(2*R*,3*S*)-*rel*-2-(2,4,6-Trifluorophenyl)amino)octan-3-ol (6b)



Following general procedure C, **2a** (0.07 mL, 0.460 mmol), **3b** (75 mg 0.51 mmol), 0.046 mL DME, and **1i** (0.0165 g, 0.0140 mmol, 3.0 mol %) were used to produce the title compound (72 mg, 51%, >20 : 1) as a yellow oil (column conditions Hexanes : EtOAc 97 : 3 → 19 : 1). **HRMS** (DART) *m/z* calculated for $C_{14}H_{21}NOF_3^+$ $(M+H)^+$ 276.15698, found 276.15683 (error −0.54 ppm). **$^{13}C\{^1H\}$ NMR** (126 MHz, $CDCl_3$, ppm): δ 100.48, 100.32, 100.27, 100.04, 73.5, 55.4, 33.9, 31.8, 25.8, 22,6, 14.2, 14.0. **^1H NMR** (500 MHz, $CDCl_3$, ppm): δ 6.63 (t, *J* = 8.6, 2H), 3.69 (m, 1H), 3.52 (m (pseudo 2nd order d), 2H), 1.64 (d, *J* =

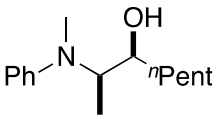
5.9, 1H), 1.23–1.53 (m, 8H), 1.09 (d, *J* = 6.4, 3H), 0.89 (t, *J* = 6.8, 3H). **^{19}F{^{1}H} NMR** (400 MHz, $CDCl_3$, ppm): major- δ 121.09 (t, *J* = 8.3, 1F), 124.7 (d, *J* = 8.6, 2F). minor- δ 121.4 (t, *J* = 8.3, 1F), 124.6 (d, *J* = 8.1, 2F).

(2*R*,3*S*)-*rel*-2-((4-Methoxyphenyl)amino)octan-3-ol (6c)



Following general procedure D, **2a** (0.07 mL, 0.450 mmol), **3c** (55.4 mg 0.45 mmol), 0.043 mL DME, and **1i** (0.0165 g, 0.0140 mmol, 3.0 mol %) were used to produce the title compound (62 mg, 55%, 12 : 1) as a brown, waxy solid (column conditions Hexanes : EtOAc 95 : 5 with 1% NEt_3 → 1 : 1 EtOAc with 1% NEt_3) → EtOAc with 1% NEt_3). **HRMS** (DART) *m/z* calculated for $C_{15}H_{26}NO_2^+$ $(M+H)^+$ 252.19581, found 252.19674 (error 3.72 ppm). **^{13}C{^{1}H} NMR** (126 MHz, $CDCl_3$, ppm): major- δ 152.5, 141.4, 115.4, 114.9, 72.7, 55.8, 53.9, 33.4, 31.9, 25.98, 22.6, 14.1, 13.97 (minor product can barely be seen in the ^{13}C NMR spectrum). **^{1}H NMR** (500 MHz, $CDCl_3$, ppm): major- δ 6.78 (d, *J* = 8.8, 2H), 6.61 (d, *J* = 8.9, 2H), 3.75 (s, 3H), 3.42 (qd, *J* = 6.6, 2.9, 2H), 2.17 (s, 1H), 1.83 (br s, 1H), 1.23–1.59 (m, 8H), 1.11 (d, *J* = 6.6, 3H), 0.90 (m (pseudo 2nd order t), 3H); minor- δ 6.78 (d, *J* = 8.8, 2H), 6.61 (d, *J* = 8.9, 2H), 3.75 (s, 3H), 3.29 (m, 2H), 2.05 (s, 1H), 1.83 (br s, 1H), 1.23–1.59 (m, 8H), 1.17 (d, *J* = 6.6, 3H), 0.86 (m (pseudo 2nd order t), 3H).

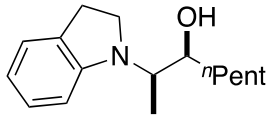
(2*R*,3*S*)-*rel*-2-(Methyl(phenyl)amino)octan-3-ol (6d)



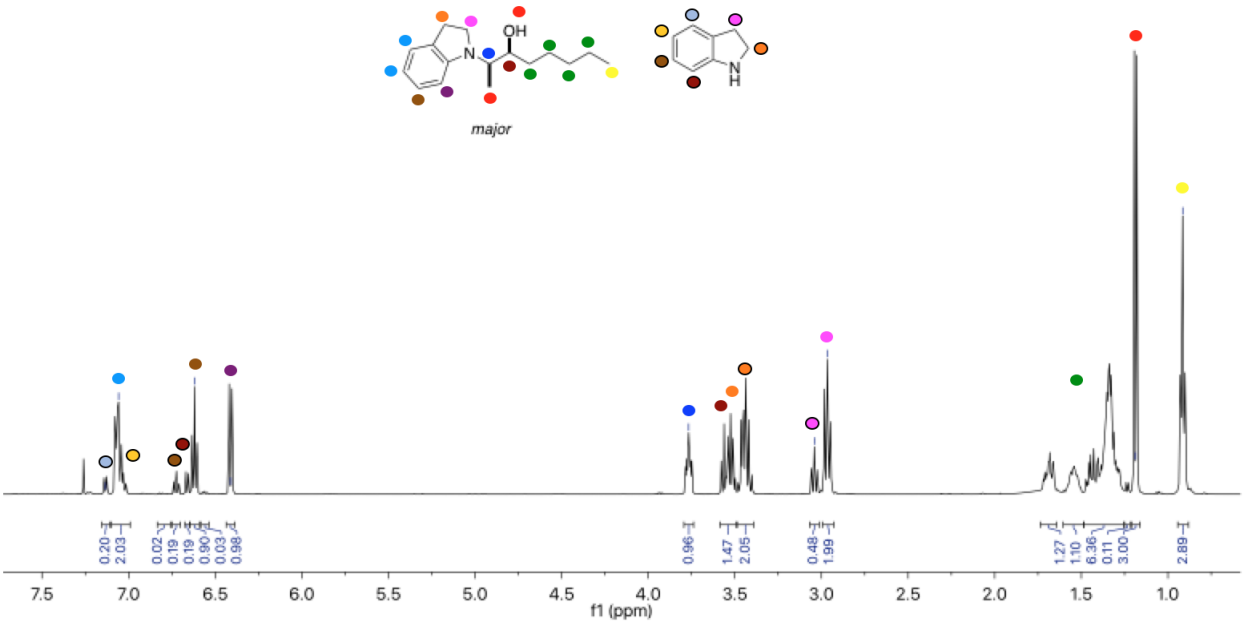
Following general procedure D, **2a** (0.07 mL, 0.450 mmol), **3d** (48 mg 0.45 mmol), 0.043 mL DME, and **1i** (0.0165 g, 0.0140 mmol, 3.0 mol %) were used to produce the title compound (34 mg, 32%) as a yellow oil (column conditions Hexanes : EtOAc 95 : 5). **HRMS** (DART) *m/z* calculated for $C_{15}H_{26}NO^+$

$(M+H)^+$ 236.20089, found 236.20085 (error −0.04 ppm). **$^{13}C\{^1H\}$ NMR** (126 MHz, $CDCl_3$, ppm): δ 150.3, 129.2, 116.7, 113.1, 74.4, 58.1, 34.5, 32.03, 31.8, 25.7, 22.65, 14.1, 12.7. **^1H NMR** (500 MHz, $CDCl_3$, ppm): δ 7.26 (m (pseudo 2nd order t), 2H), 6.81 (d, *J* = 8.2, 2H), 6.74 (d, *J* = 2.2, 1H), 3.78 (m, 2H), 2.81 (s, 3H), 1.28–1.67 (m, 8H), 6.26 (d, *J* = 6.4, 3H), 0.91 (t, *J* = 6.4, 3H).

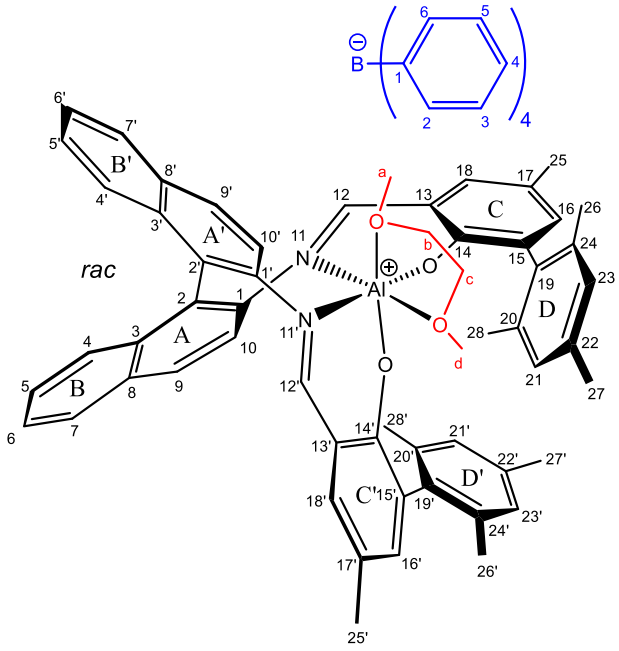
(2*R*,3*S*)-*rel*-2-(Indolin-1-yl)octan-3-ol (6e)



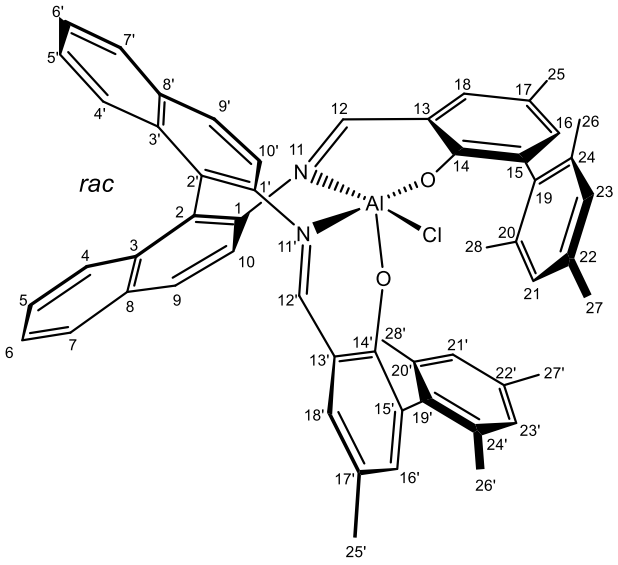
Following general procedure D, **2a** (0.07 mL, 0.450 mmol), **3e** (54 mg 0.45 mmol), 0.043 mL DME, and **1i** (0.0165 g, 0.0140 mmol, 3.0 mol %) were used to produce the title compound (66.7 mg, 60%, >20 : 1) as a yellow oil (column conditions Hexanes : EtOAc 95 : 5). There was some free indoline that co-eluted with the desired product. The mass attributed to indoline based on the ratio in the ^1H NMR spectrum (13.3 mg) was subtracted from the total isolated mass (80.0 mg) and was not included in the yield calculation of the product. **HRMS** (DART) *m/z* calculated for $C_{16}H_{26}NO^+$ $(M+H)^+$ 248.20089, found 248.20088 (error −0.06 ppm). **$^{13}C\{^1H\}$ NMR** (126 MHz, $CDCl_3$, ppm): δ 151.5, 129.7, 127.3, 124.5, 116.9, 106.4, 74.1, 55.3, 47.7, 34.4, 31.9, 28.5, 25.7, 22.7, 14.1, 10.5. **^1H NMR** (500 MHz, $CDCl_3$, ppm): δ 7.05 (m, 2H), 6.62 (t, *J* = 7.3, 1H), 6.41 (d, *J* = 7.8, 1H), 3.77 (m, 1H), 3.39–3.59 (m, 4H), 2.97 (t, *J* = 8.2, 2H), 1.26–1.73 (m, 8H), 1.18 (d, *J* = 6.6, 3H), 0.91 (t, *J* = 6.8, 3H).



IV. Characterization of complex 1i



1i



Al-Cl

Complex **1i** was characterized by 1- and 2-dimensional NMR spectroscopy in $CDCl_3$ at −55 °C to freeze out intramolecular dynamics which resulted in significant line broadening at ambient temperature.

During characterization, ~30% of the sample underwent ligand substitution with chloride from solvent to generate the neutral complex **Al-Cl**. The sample also contained minor unidentified aromatic components, dichloromethane, and excess DME. This made characterization more challenging, but we were able to unambiguously assign most ^{1}H and ^{13}C chemical shifts in both complexes based on high-resolution HSQC, HMBC and ROESY spectra (Table S1). 2D spectra were acquired on a 500 MHz Varian INOVA spectrometer, running VnmrJ 3.2A/Chempack 6.1 and using a Varian 5 mm z-PFG inverse-detection, broadband probehead. The spectra were processed and analyzed with MestReNova 12.0.2-20910 (2018, Mestrelab Research S.L.). The multiplicity-edited $^{1}H/^{13}C$ HSQC was acquired using the HSQCAD sequence optimized for 145 Hz couplings with spectral widths of 4200 and 25141 Hz in F2 and F1, respectively. 800 complex points were collected in F1 with two scans per increment and acquisition time of 0.15s. Broadband ^{13}C decoupling was applied during acquisition. Data were zero filled to 4k (F1) x 2k (F2) complex points and no window functions were applied prior to Fourier transform. The 2D-HMBC spectrum was acquired using the gHMBCAD sequence optimized for 8 Hz couplings with spectral widths of 4200 and 30167 Hz in F2 and F1, respectively. 1600 complex points were collected in F1 with two scans per increment and acquisition time of 0.3s. Data were zero filled to 8k (F1) x 2k (F2) complex points and unshifted sine bell as well as 5 Hz Gaussian window functions were applied in F2 prior to Fourier transform. The spectrum was analyzed in phase sensitive mode. A 2D ROESY was acquired using the ROESYAD sequence with a mixing time of 0.2s and spectral width of 4200 Hz. 512 complex points were collected in F1 with four scans per increment and an acquisition time of 0.4 s. Data were zero filled to 2k x 2k complex points, and Gaussian window functions were applied in both dimensions prior to Fourier transform. A diffusion-ordered NMR experiment was acquired using the convection-compensated, bipolar pulsed field-gradient double stimulated experiment (Dbppste_cc sequence modified to include a longitudinal eddy current delay) (Insert reference to https://doi.org/10.1006/jmre.1997.1123). Diffusion delay (150 ms) and bipolar gradient pulse duration (3 ms) were optimized to achieve at least 95% attenuation of all signals corresponding to four half-lives of decay. Gradient strength was varied

from 2 to 55.6 G/cm in 32 increments. Each increment was acquired with 2 steady-state scans and eight scans, acquisition time and relaxation delay were 1.2 and 2.5 s, respectively.

Chemical shift assignments were accomplished starting with C-12s and C-12', which were identified by their downfield ^{13}C chemical shifts (168–175 ppm) in the HSQC spectrum. The biphenyl portion of the ligand (C-13 to C-28) was easily assigned based on the HMBC, with aromatic hydrogens giving almost exclusively $^{3}J_{C,H}$ correlations and methyl substituents showing both $^{2}J_{C,H}$ and $^{3}J_{C,H}$ correlations. The BINAM portion of the ligand (C-1 to C-10) was more challenging due to overlap between H-9s and H-7s, but complete assignment was possible even without uniquely identifying all HMBC correlations. Assignment of the tetraphenyl borate anion was accomplished starting with the *ipso* carbon at 163.62 ppm, which appeared as a 1:1:1:1 quartet in F1 of the HMBC due to $^{1}J_{B,C}$ of 48 Hz. In addition to free dimethoxyethane (DME, CH_3: 3.44/59.46 ppm; CH_2: 3.59/71.65 ppm), we identified a complete set of resonances for a dimethoxyethane (DME) molecule—with two unique methyl resonances and two pairs of diastereotopic methylene hydrogens—that ROESY crosspeaks to the ligand of **1i** confirmed to be bound to the complex as a bidentate ligand.

The configuration of **1i** was derived from the ROESY spectrum in conjunction with molecular mechanics calculations (MM2, Chem3D Pro, 16.0.1.4, Perkin Elmer Informatics. Inc.) to visualize the complex. The stereochemistry of the Al center was constrained by the presence of inter-ring ROESY correlations H-10/H-28' and H-28/H27'. The presence of *both* of these correlations indicate that the oxygen atoms attached to C-14 and C-14' are *cis* relative to each other. This conformation creates a "cleft" surrounded by rings C, D, A' and C'. The bound DME is situated in this cleft as indicated by ROESY correlations between H-a and H-12, 18, 9', 10'; H-c' and H-10'; as well as H-d and H-23 and 28. We also observed strong ROESY correlations to the *ortho*-hydrogen of BPh_4^- from H-b', H-c'' as well as H-10' indicating that **1i** exists as a tight ion-pair in solution, with the anion located on top of the bound DME ligand. Tight ion-pairing was further confirmed by diffusion-ordered NMR that showed experimentally indistinguishable diffusion coefficients for **1i** ligand, bound DME, and PPh_4^- resonances.

(Figure S1) This diffusion coefficient was also found to be significantly slower than that of the **Al-Cl** complex. Tight ion-pairing in a specific orientation likely explains the low rate of DME exchange. We also believe this tight ion pairing assists with the observed high regioselectivity and may explain why other bulky anions result in lower selectivity (ie. if other anions do not have a tight ion pair the selectivity may be lower).

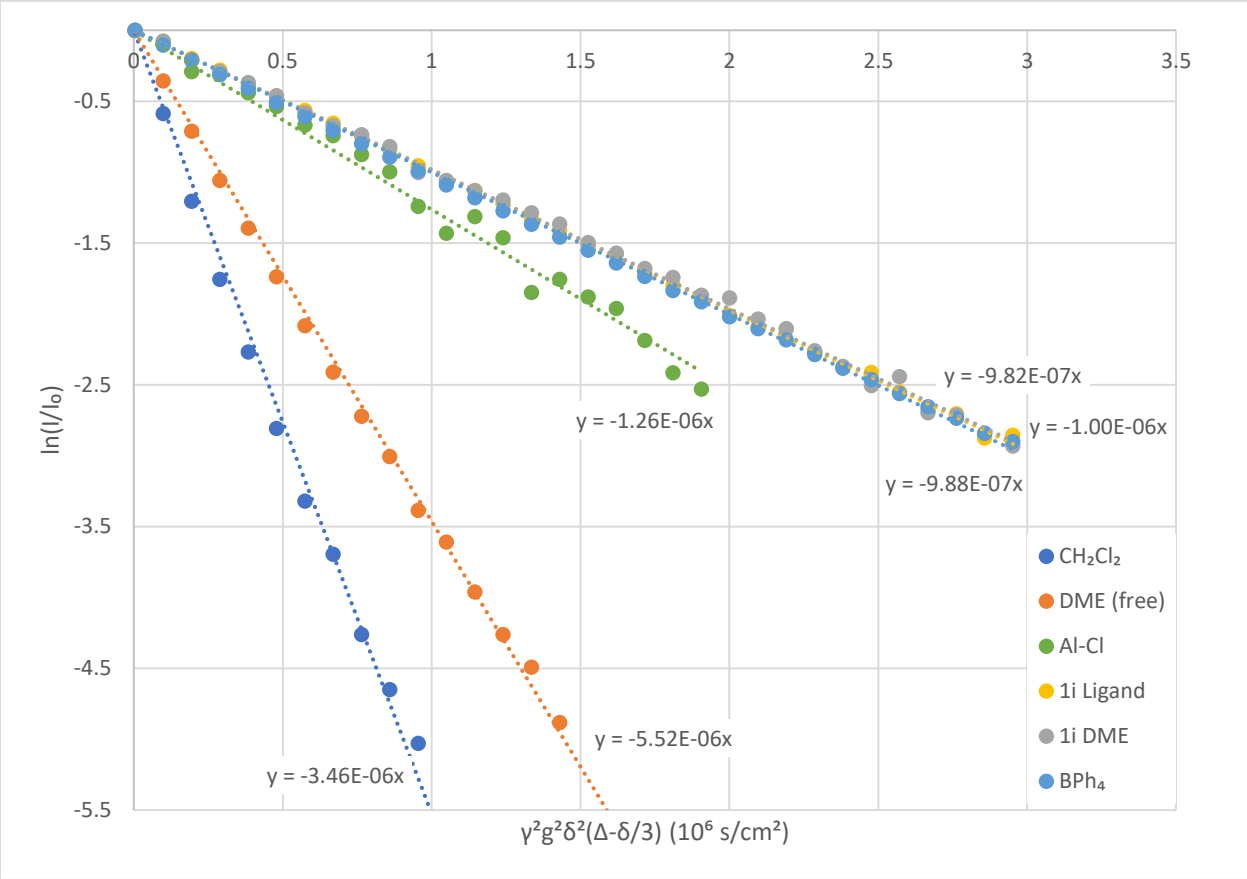


Figure S1 Stejskal-Tanner plot of a 500 MHz ^{1}H diffusion NMR experiment of **1i** in $CDCl_3$ at −55°C. The slope of each line corresponds to the negative of the diffusion coefficient. With the exception of CH_2Cl_2, each data point represents the average of two or three well-resolved resonances.

Table S1. Chemical shifts for **1i** and **Al-Cl** determined at −55 °C in $CDCl_3$

	1i		**Al–Cl**	
Atom #	^{13}C (ppm)	^{1}H (ppm)	^{13}C (ppm)	^{1}H (ppm)
1	144.62	–	143.8	–
2	124.9	–	126.1	–
3	131.57	–	131.81	–

	1i		Al–Cl	
Atom #	^{13}C (ppm)	^{1}H (ppm)	^{13}C (ppm)	^{1}H (ppm)
4	126.67	6.83	126.93	7.04
5	127.49	7.27	126.98	7.27
6	126.56	7.5	126.18	7.5
7	128.33	7.89	128.13	7.93
8	132.25	–	132.35	–
9	130.73	7.95	129.96	7.92
10	125.2	7.21	125.51	7.42
12	173.44	8.48	174.09	8.4
13	118.2	–	118.92	–
14	160.26	–	163.15	–
15	n/d	–	n/d	–
16	140.6	7.12	140.99	7.03
17	126.37	–	125.8	–
18	133.07	7	132.56	6.92
19	133.71	–	135.06	–
20	134.5	–	137.62	–
21	128.1	7.09	127.74	6.98
22	136.94	–	135.88	–
23	127.33	6.67	127.54	7.11
24	138.64	–	136.85	–
25	20.42	2.22	20.41	2.15
26	21.61	2.00	21.26	2.05
27	21.33	2.38	21.43	2.46
28	18.45	1.22	20.47	1.89
1'	143.76	–	144.02	–
2'	125.59	–	125.16	–
3'	131.92	–	131.82	–
4'	126.49	7.10	126.5	7.13
5'	127.68	7.34	126.82	7.31
6'	126.65	7.55	125.96	7.53
7'	128.52	8.00	128.46	7.98
8'	131.51	–	132.11	–
9'	131.3	8.00	129.42	8.04
10'	121.94	6.27	126.21	7.61
12'	171.22	8.01	169.12	8.26
13'	118.23	–	118.48	–
14'	159.85	–	159.13	–
15'	n/d	–	n/d	–
16'	140.87	7.04	139.91	7.07
17'	126.63	–	126.29	–
18'	133.51	6.95	132.68	6.96

	1i		Al–Cl	
Atom #	^{13}C (ppm)	^{1}H (ppm)	^{13}C (ppm)	^{1}H (ppm)
19'	133.82	–	133.76	–
20'	134.89	–	135.22	–
21'	128.2	7.05	127.79	6.86
22'	136.51	–	135.69	–
23'	127.66	6.82	127.78	6.79
24'	137.44	–	138.9	–
25'	20.34	2.20	20.31	2.19
26'	20.9	2.01	21.73	1.93
27'	21.15	2.31	21.32	2.38
28'	20.69	1.80	19.06	1.63
a	59.5	1.99	–	–
b	68.27	2.56, 2.73	–	–
c	68.01	0.90, 2.97	–	–
d	61.1	2.11	–	–
BPh_4-1	163.62	–	–	–
BPh_4-2	136.01	7.40	–	–
BPh_4-3	125.75	7.05	–	–
BPh_4-4	122.09	6.95	–	–

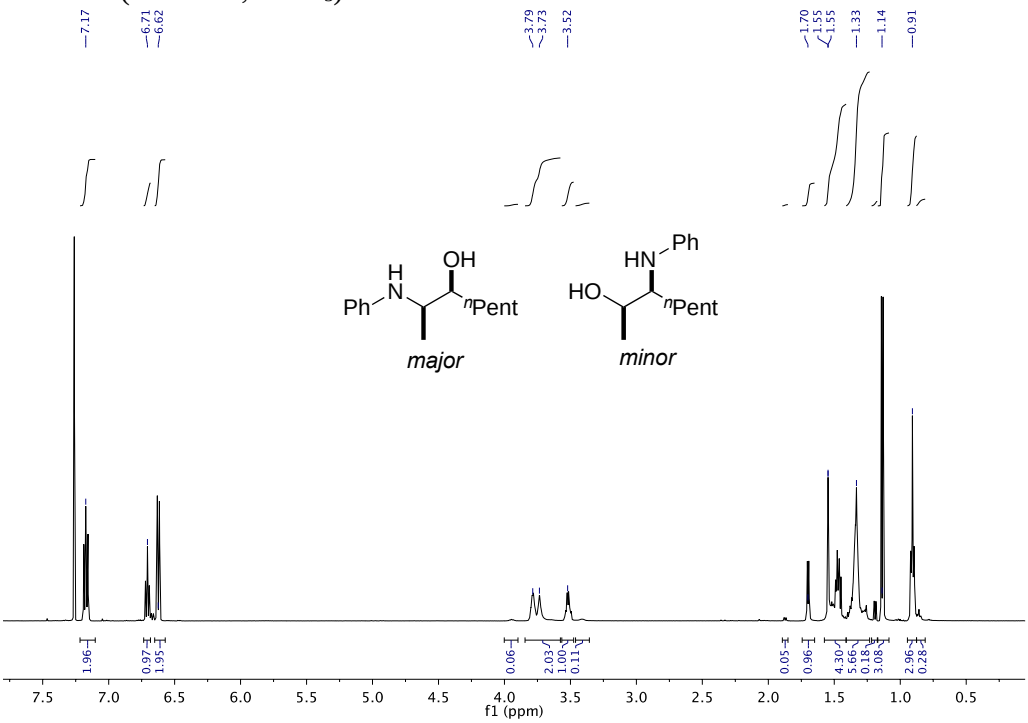
References

1) Getzler, Y. D. Y. L.; Mahadevan, V.; Lobkovsky, E. B.; Coates, G. W. *J. Am. Chem. Soc.* **2002**, *124*, 1174–1175.
2) Getzler, Y. D. Y. L.; Mahadevan, V.; Lobkovsky, E. B.; Coates, G. W. *Pure Appl. Chem.* **2004**, *76*, 557–564.
3) Mulzer, M.; Whiting, B. T.; Coates, G. W. *J. Am. Chem. Soc.* **2013**, *135*, 10930–10933.
4) Lamb, J. R.; Mulzer, M.; LaPointe, A. M.; Coates, G. W. *J. Am. Chem. Soc.* **2015**, *137*, 15049–15054.
5) Evans, D. A.; Janey, J. M.; Magomedov, N.; Tedrow, J. S. *Angew. Chem., Int. Ed.* **2001**, *113*, 1936–1940.
6) Mulzer, M.; Coates, G. W. *J. Org. Chem.* **2014**, *79*, 11851–11862.
7) Mulzer, M.; Ellis, W. C.; Lobkovsky, E. B.; Coates, G. W. *Chem. Sci.* **2014**, *5*, 1928–1933.
8) Kroutil, W.; Mischitz, M.; Faber, K. *J. Chem. Soc., Perkin Trans. 1* **1997**, 3629–3636.
9) Hobson, L. A.; Thomas, E. J. *Org. Biomol. Chem.* **2012**, *10*, 7510–7526.
10) Cornforth, J. W.; Cornforth, R. H.; Mathew, K. K. *J. Chem. Soc.* **1959**, 112–127.
11) Gao, Y.; Hanson, R. M.; Klunder, J. M.; Ko, S. Y.; Masamune, H.; Sharpless, K. B. *J. Am. Chem. Soc.* **1987**, *109*, 5765–5780.

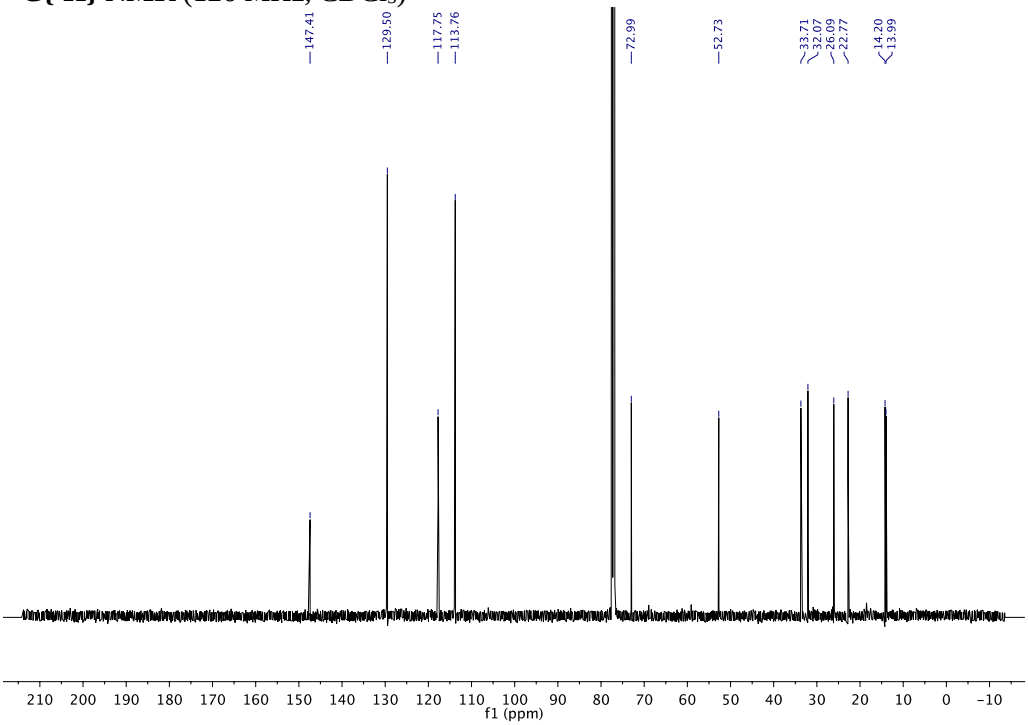
Copies of ^{1}H and ^{13}C{^{1}H} NMR spectra

(2*R*,3*S*)-*rel*-2-(Phenylamino)-3-octanol (4a) + (2*R*,3*S*)-*rel*-3-(phenylamino)-2-octanol (5a)

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

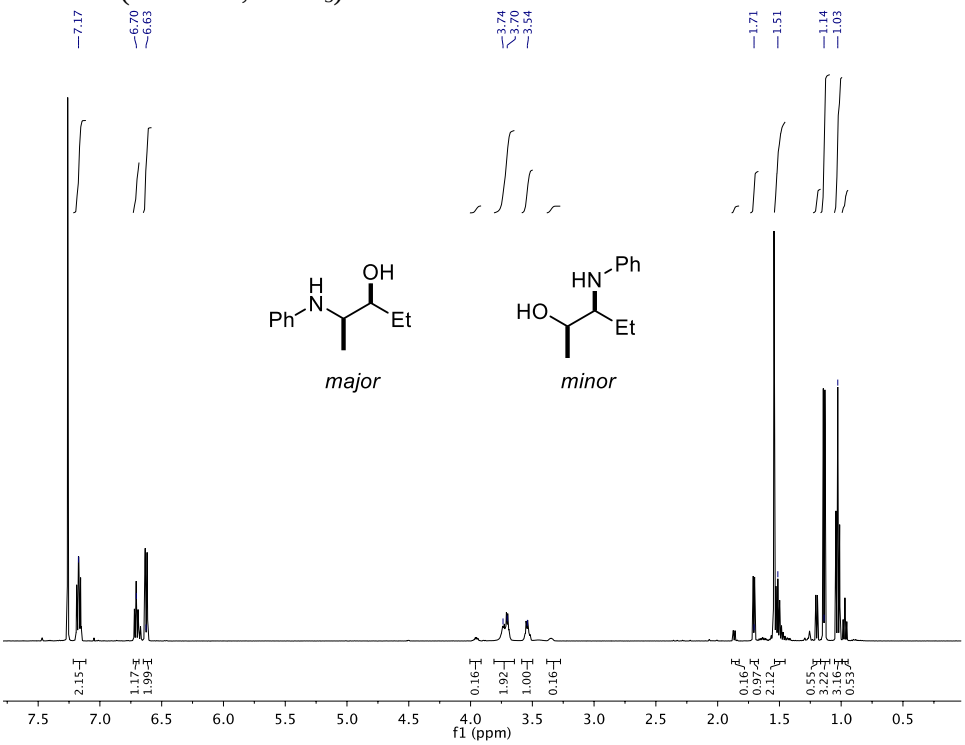


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

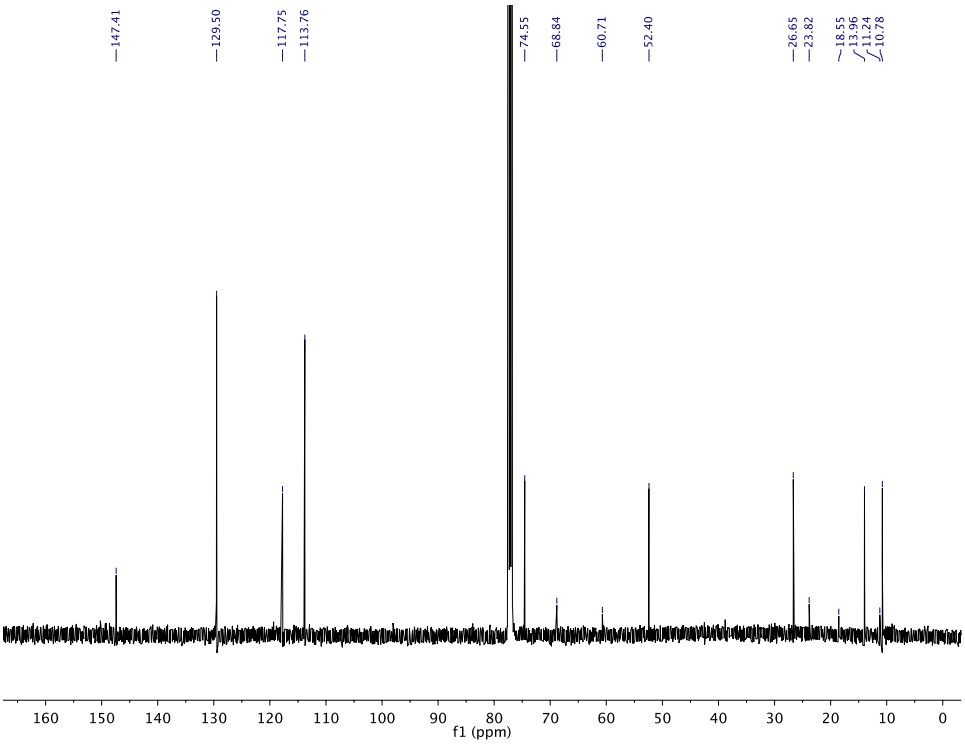


(2*R*,3*S*)-*rel*-2-(Phenylamino)-3-pentanol (4b) + (2*R*,3*S*)-*rel*-3-(phenylamino)-2-pentanol (5b)

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

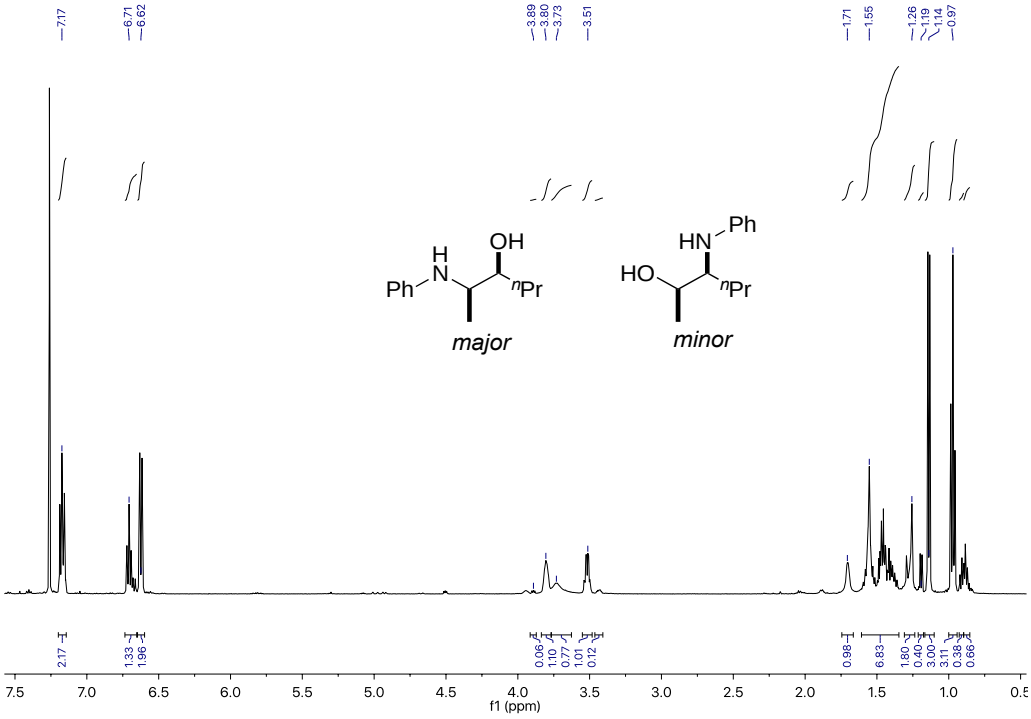


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

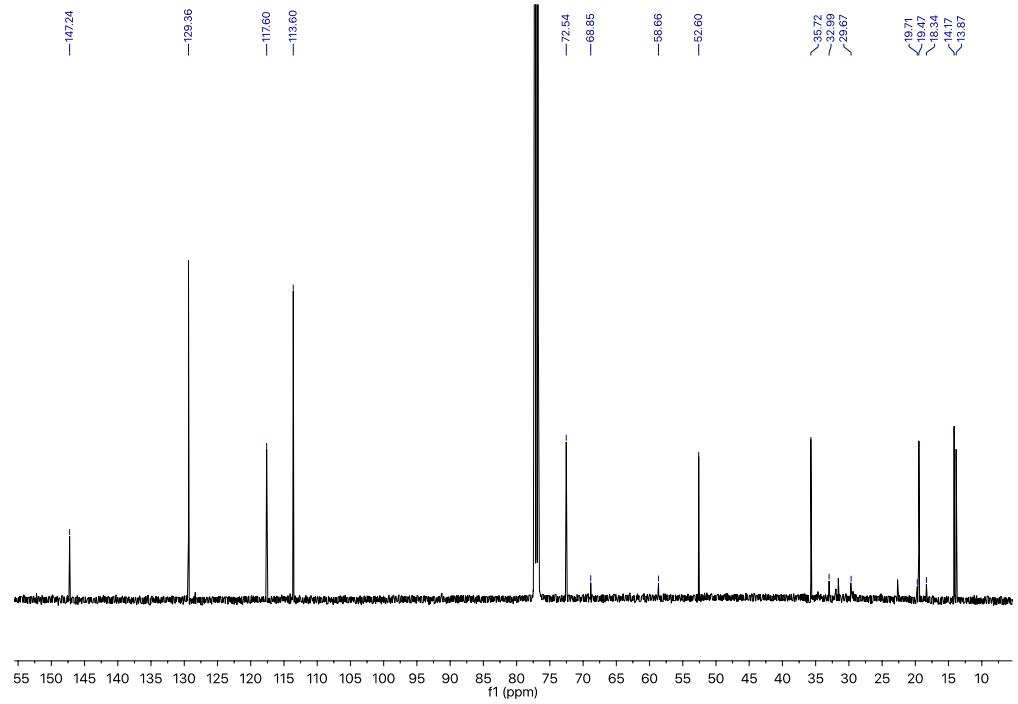


(2*R*,3*S*)-*rel*-2-(Phenylamino)-3-hexanol (4c) + (2*R*,3*S*)-*rel*-3-(phenylamino)-2-hexanol (5c)

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

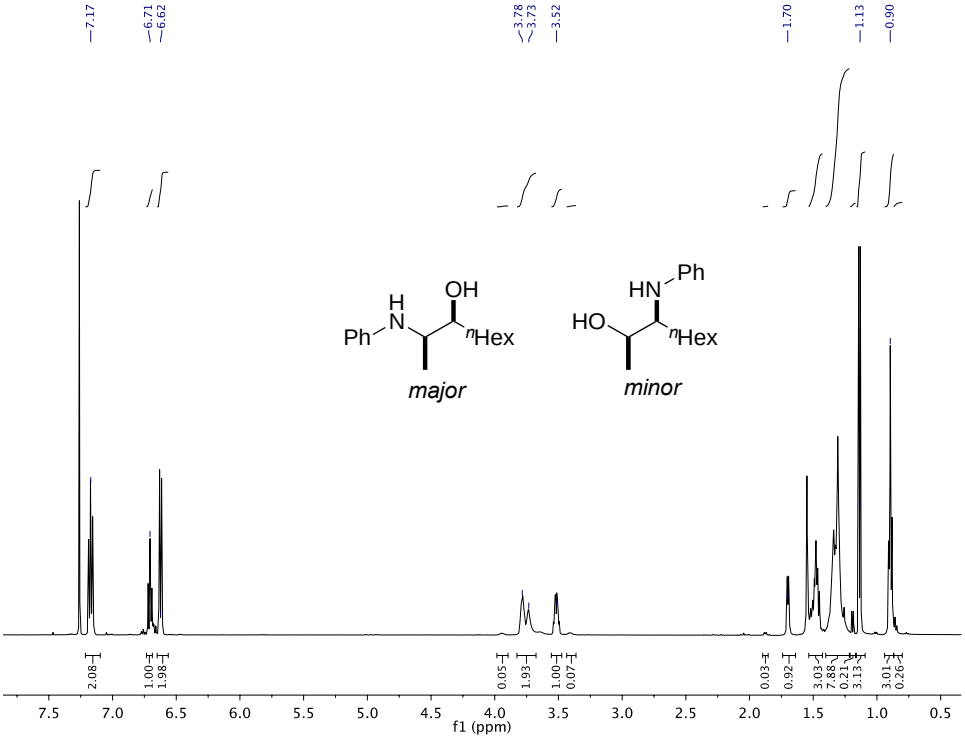


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

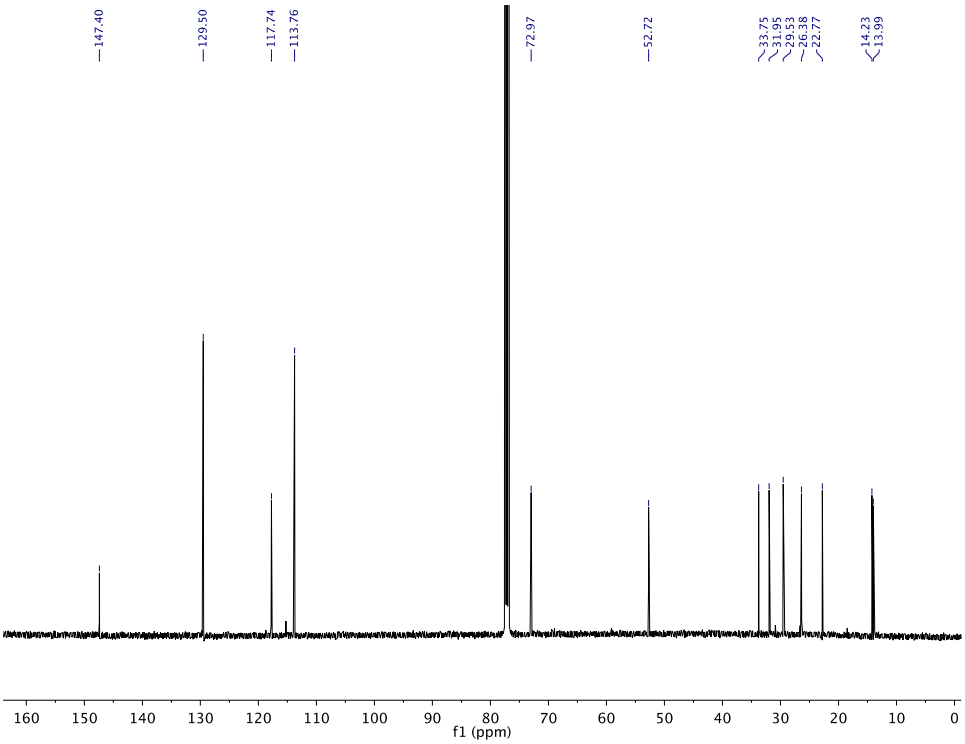


(2*R*,3*S*)-*rel*-2-(Phenylamino)-3-nonanol (4d) + (2*R*,3*S*)-*rel*-3-(phenylamino)-2-nonanol (5d)

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

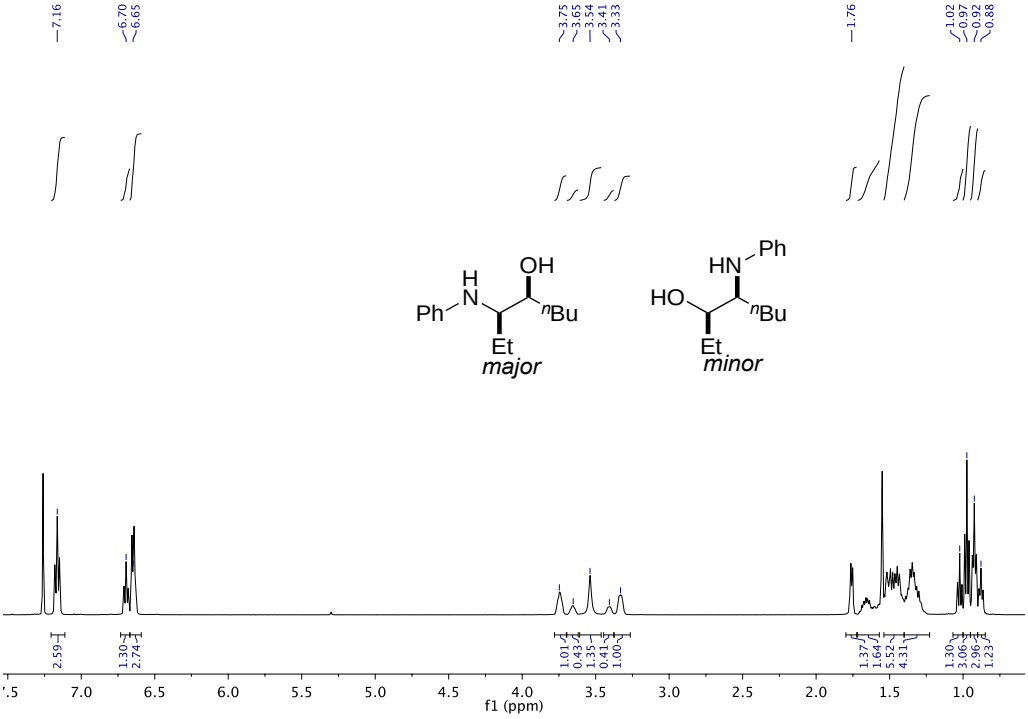


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

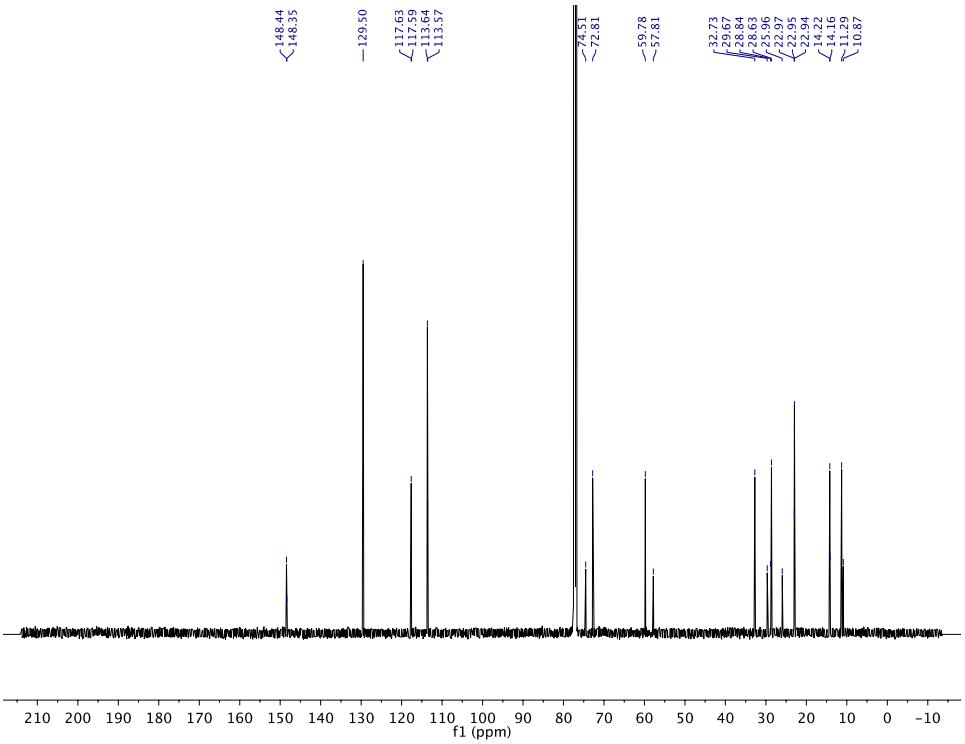


(3*R*,4*S*)-*rel*-3-(Phenylamino)-4-octanol (4e) + (3*R*,4*S*)-*rel*-4-(phenylamino)-3-octanol (5e)

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

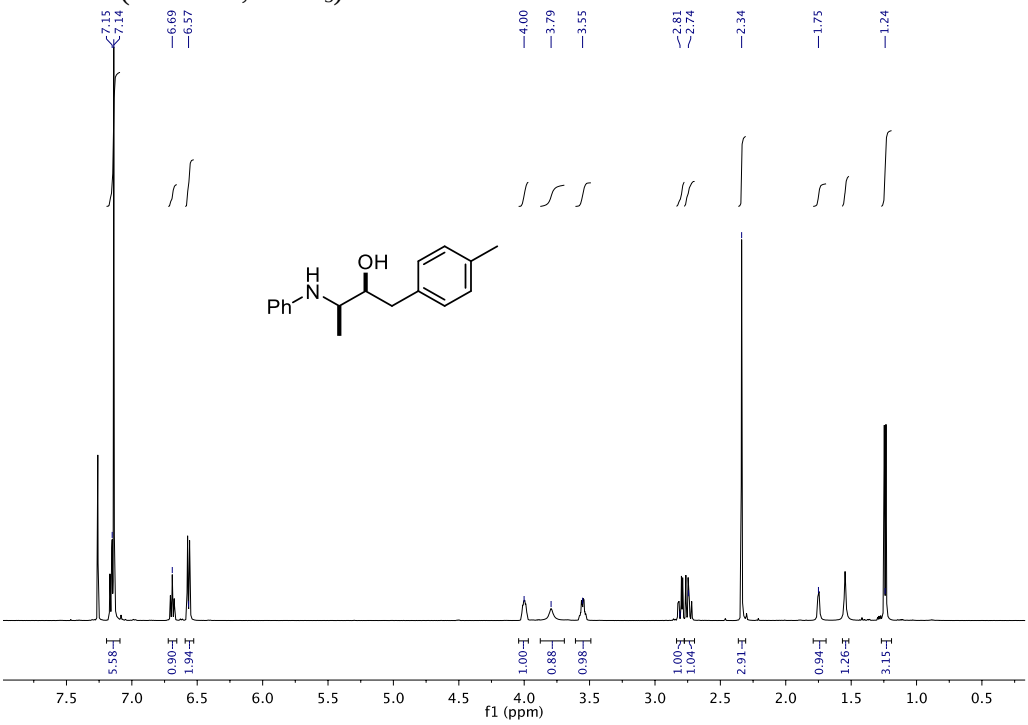


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

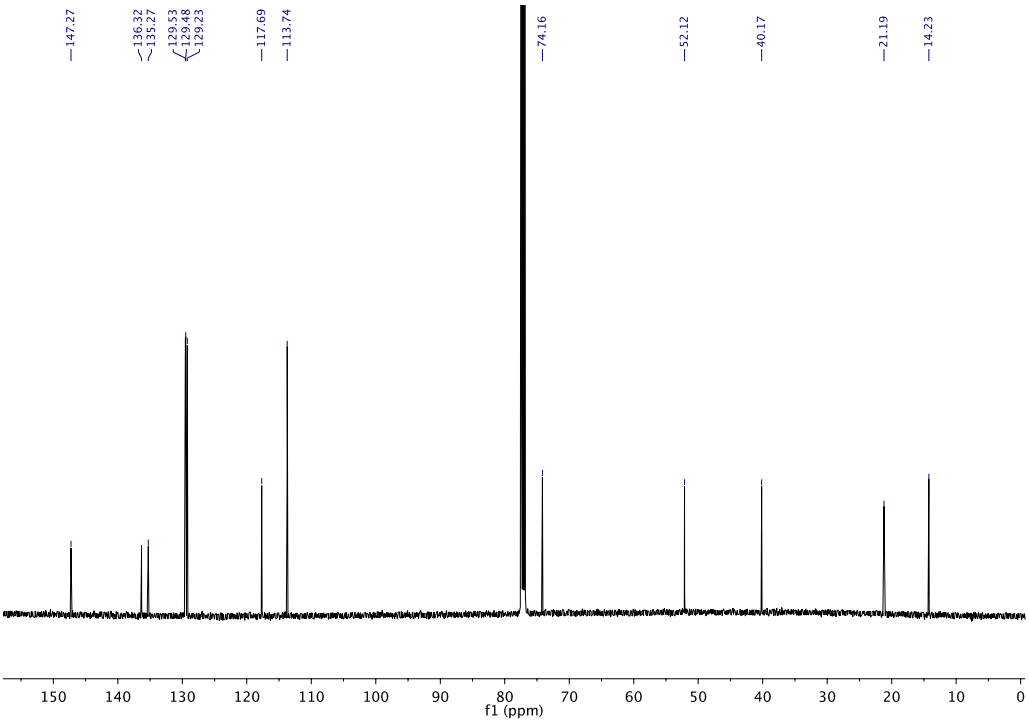


(2*R*,3*S*)-*rel*-3-(Phenylamino)-1-(*p*-tolyl)butan-2-ol (4f)

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

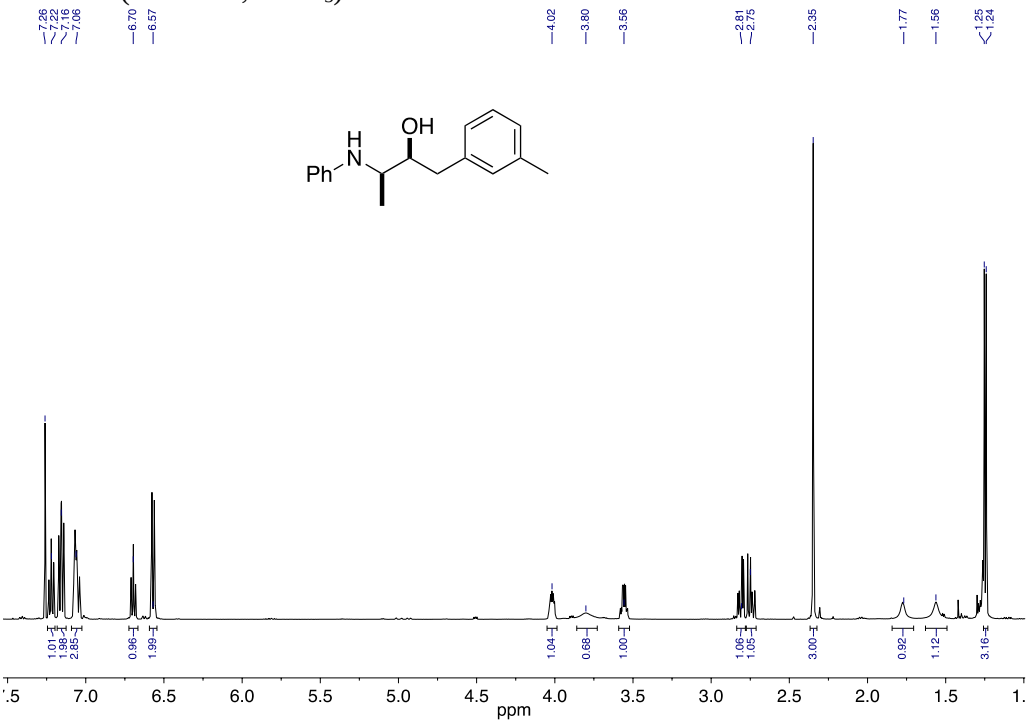


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

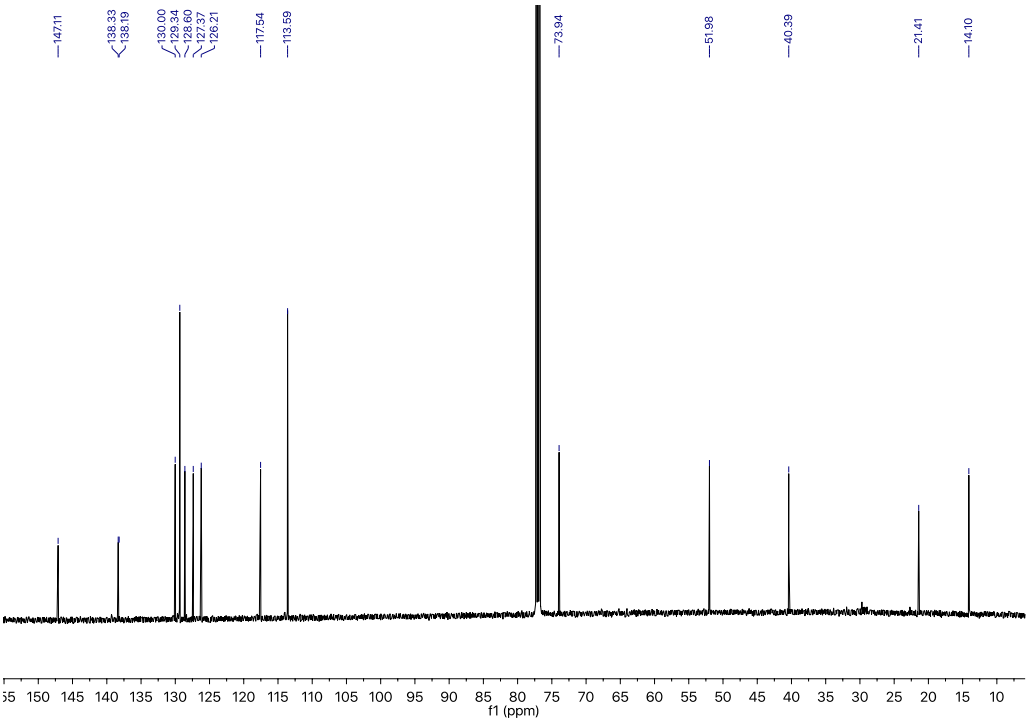


(2*S*,3*R*)-*rel*-3-(Phenylamino)-1-(*m*-tolyl)butan-2-ol (4g)

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

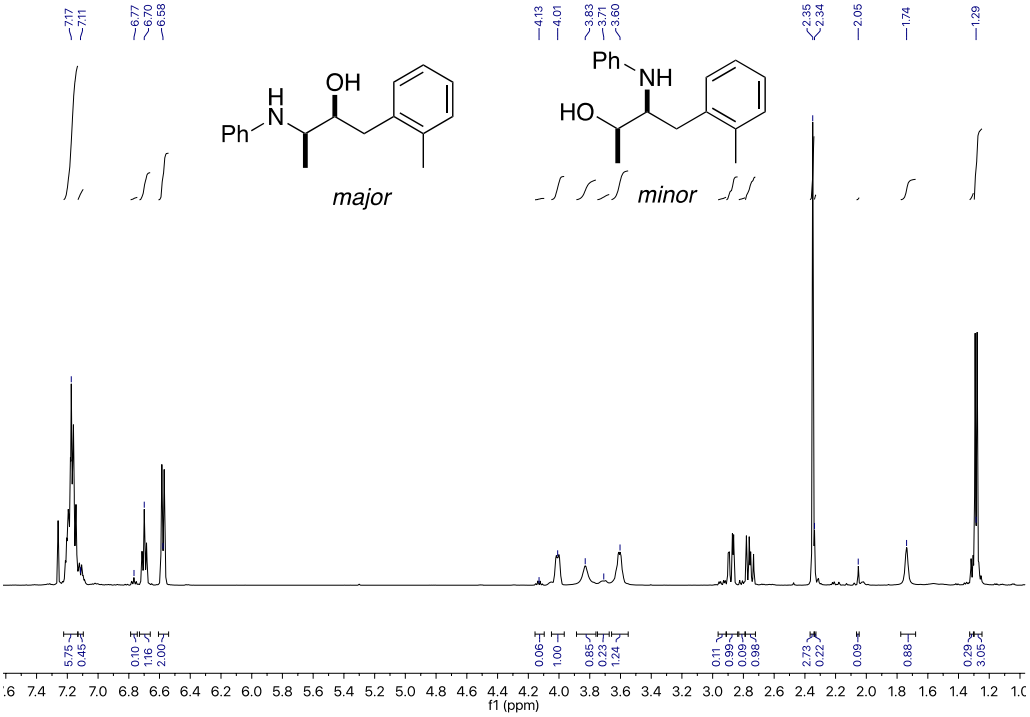


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

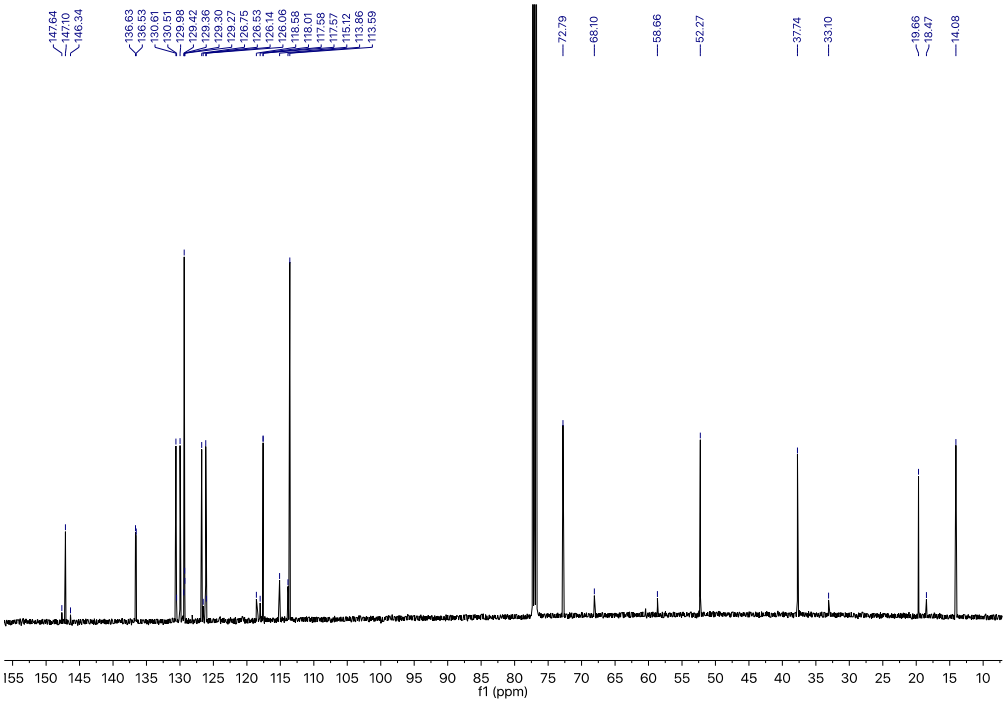


((2S,3R)-*rel*-3-(Phenylamino)-1-(o-tolyl)butan-2-ol (4h) + (2S,3R)-*rel*-2-(phenylamino)-1-(o-tolyl)butan-3-ol (5h)

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

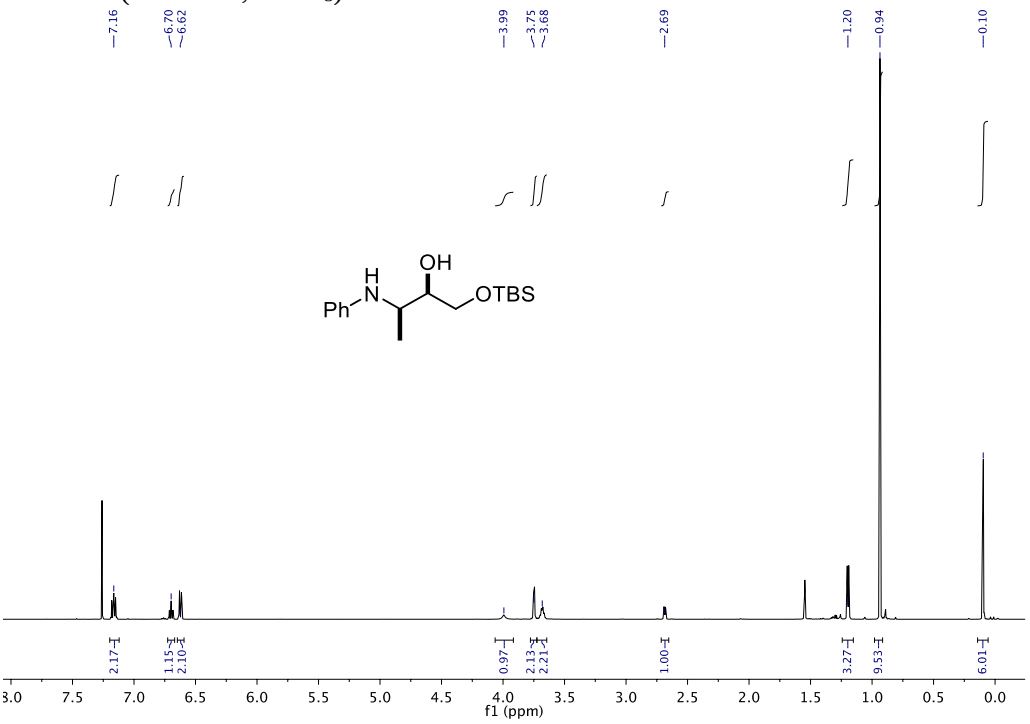


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

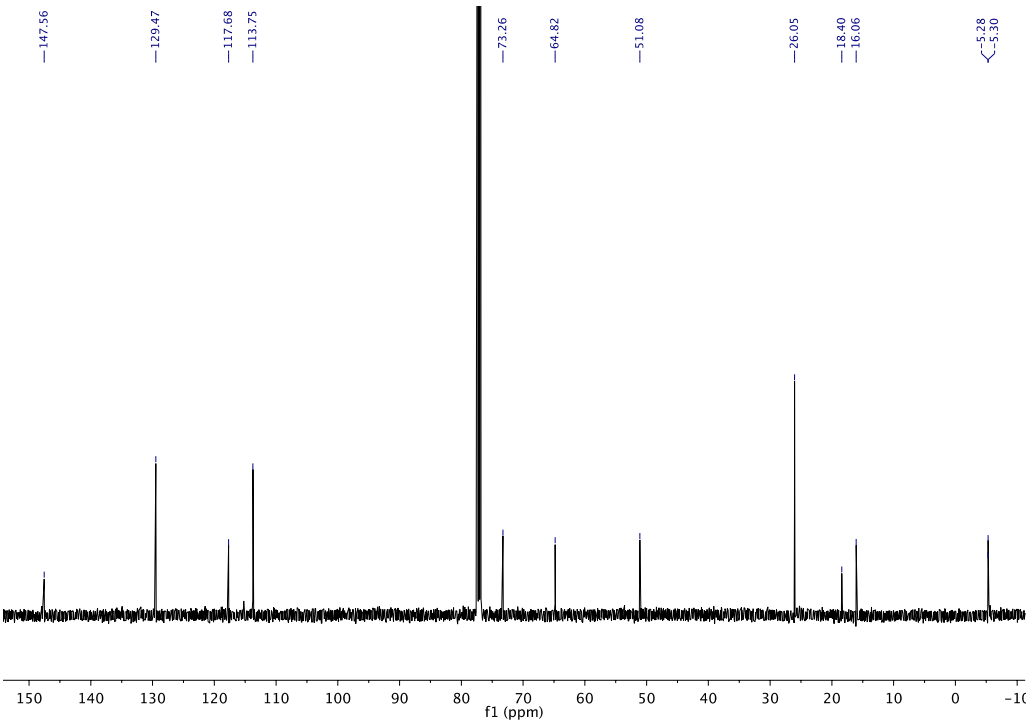


(2*R*,3*R*)-*rel*-1-((*tert*-Butyldimethylsilyl)oxy)-3-(phenylamino)butan-2-ol (4i)

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

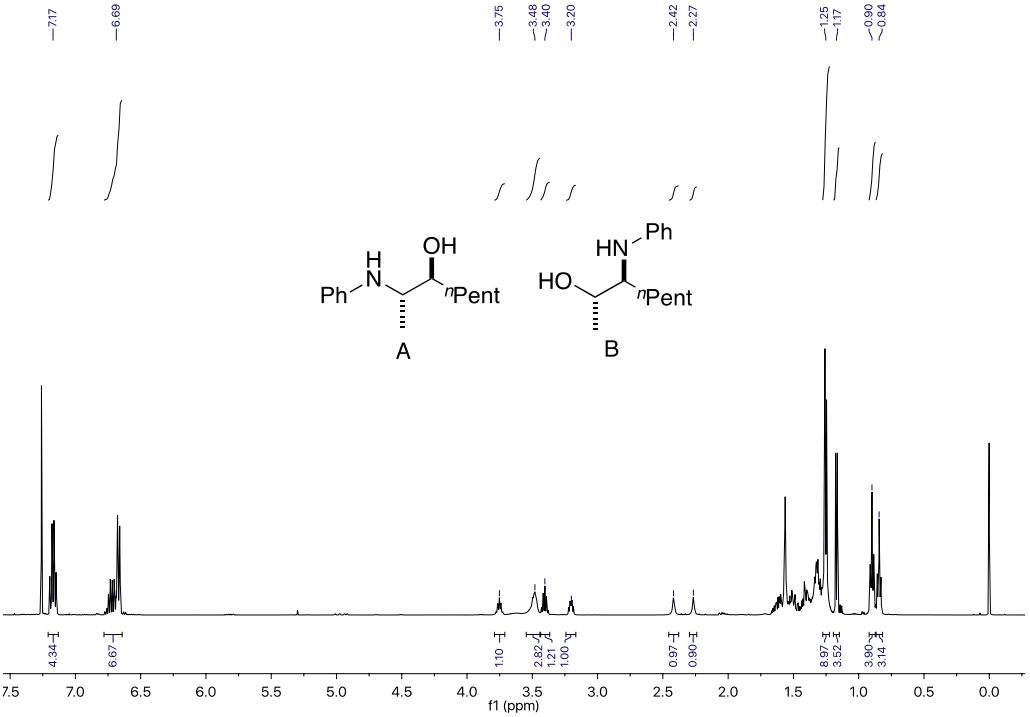


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

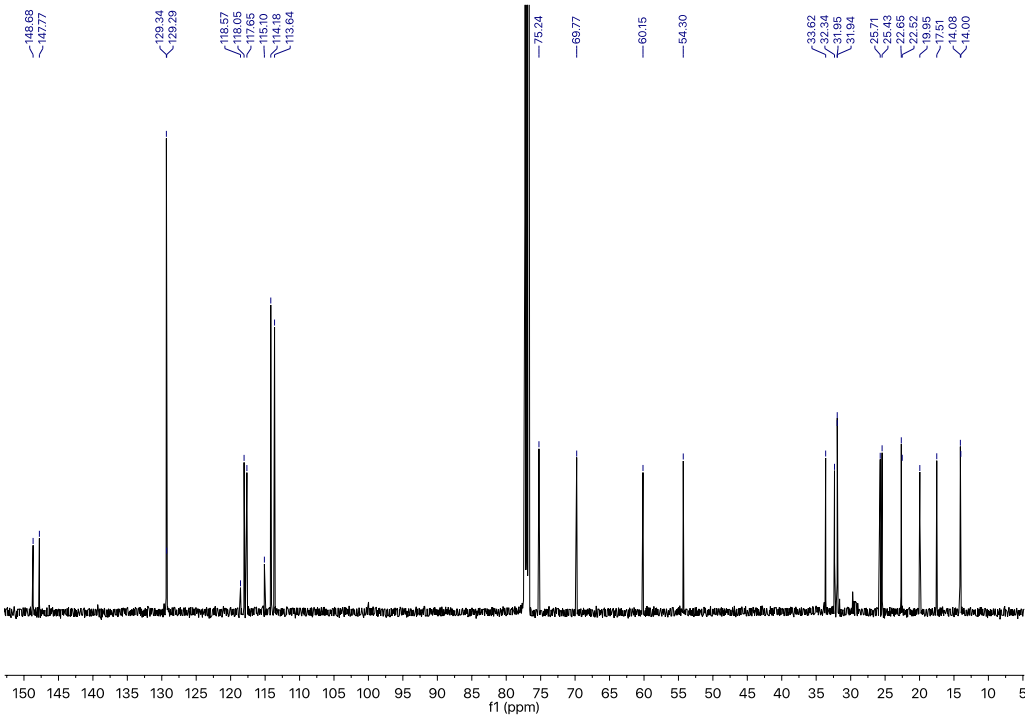


(2*S*,3*S*)-*rel*-2-(Phenylamino)-3-octanol (4j) + (2*S*,3*S*)-*rel*-3-(phenylamino)-2-octanol (5j)

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

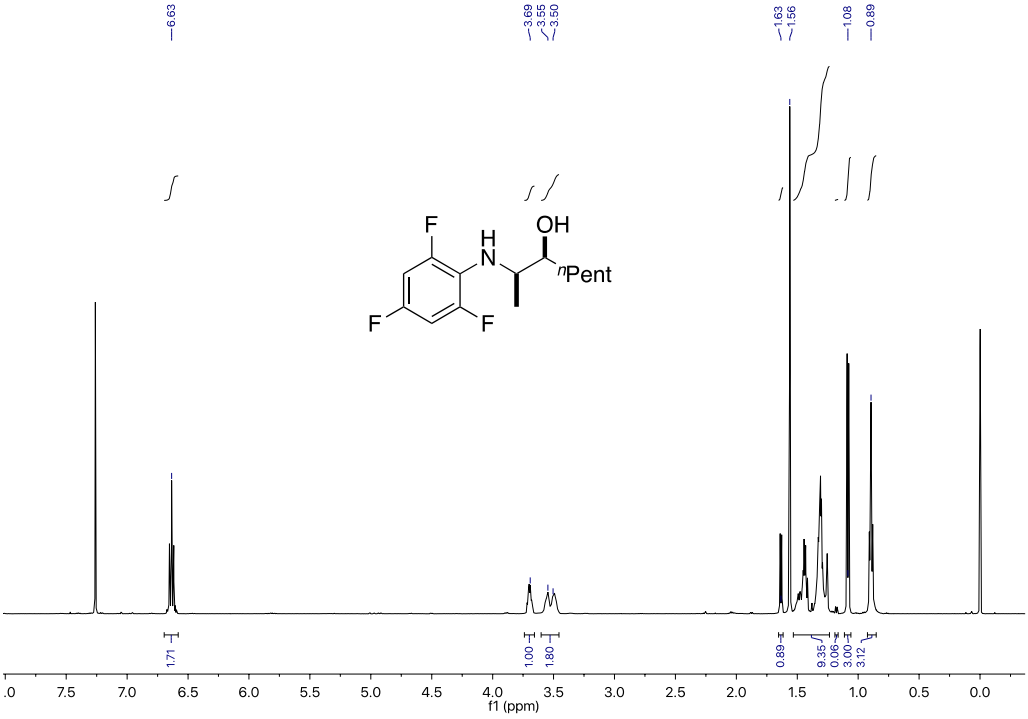


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

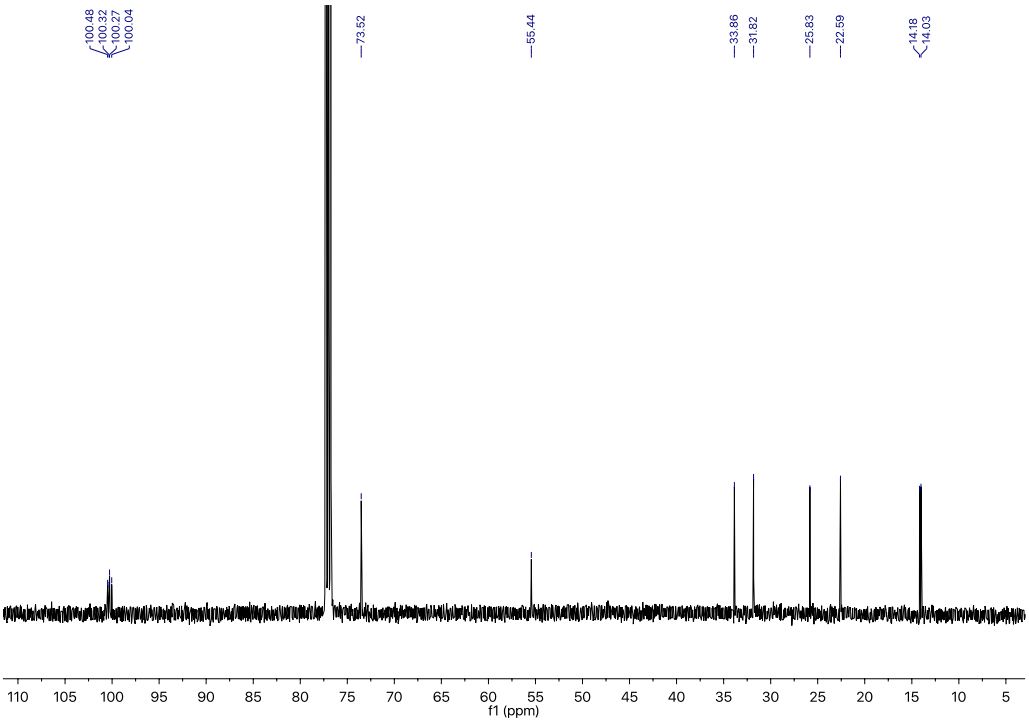


(2*R*,3*S*)-*rel*-2-(2,4,6-Trifluorophenyl)amino)octan-3-ol (6b)

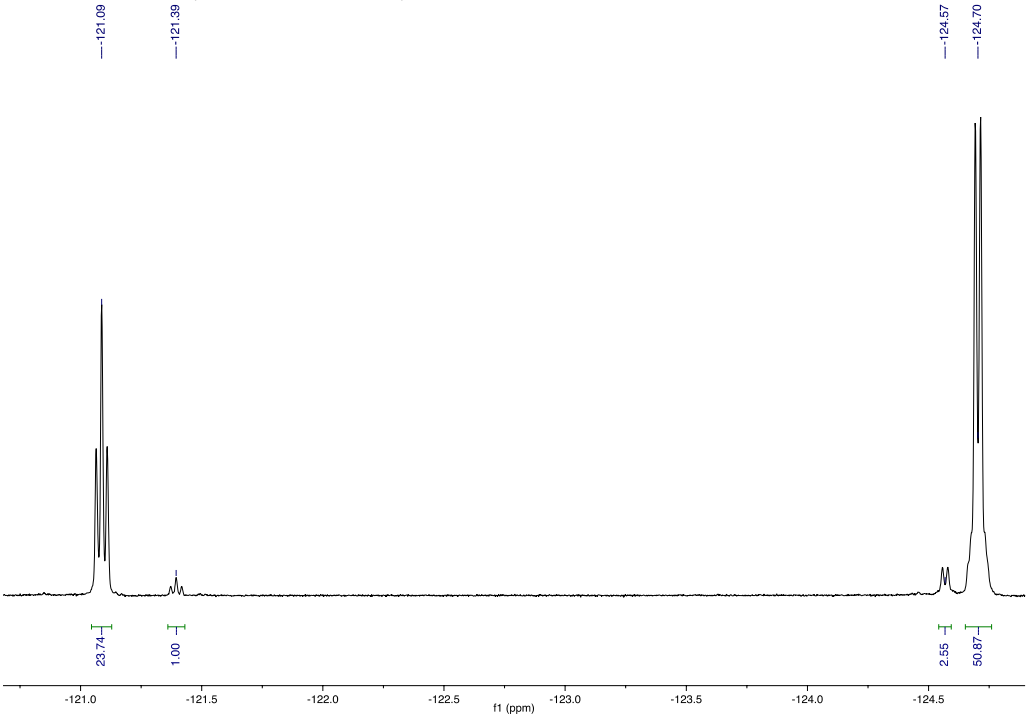
^{1}H NMR (500 MHz, $CDCl_3$)



^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

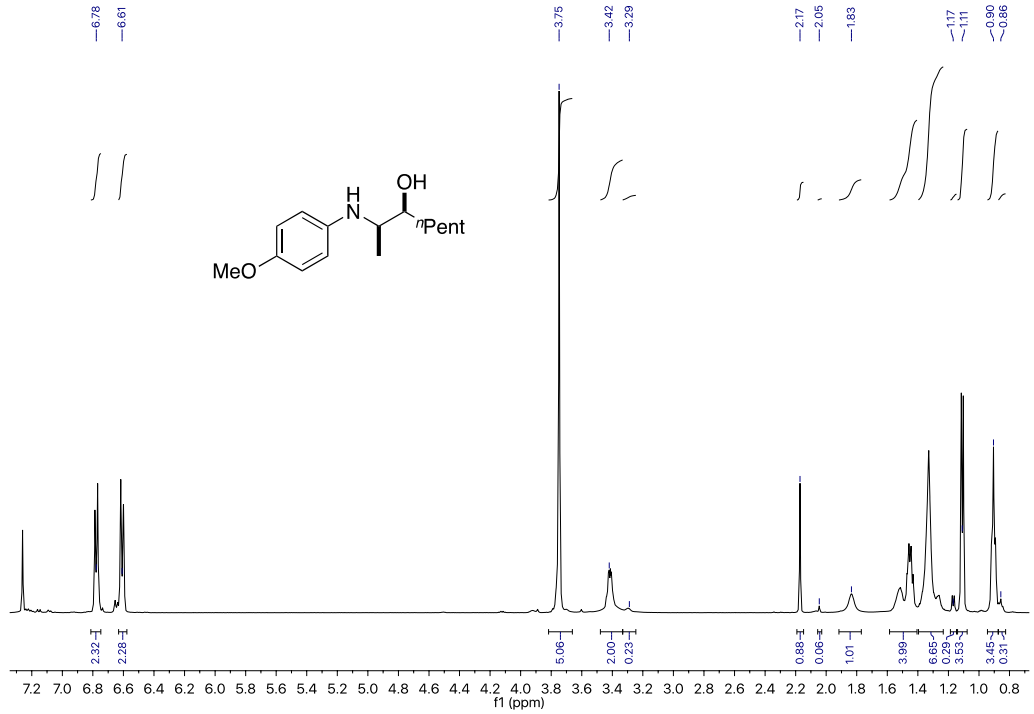


^{19}F {^{1}H} NMR (400 MHz, $CDCl_3$)

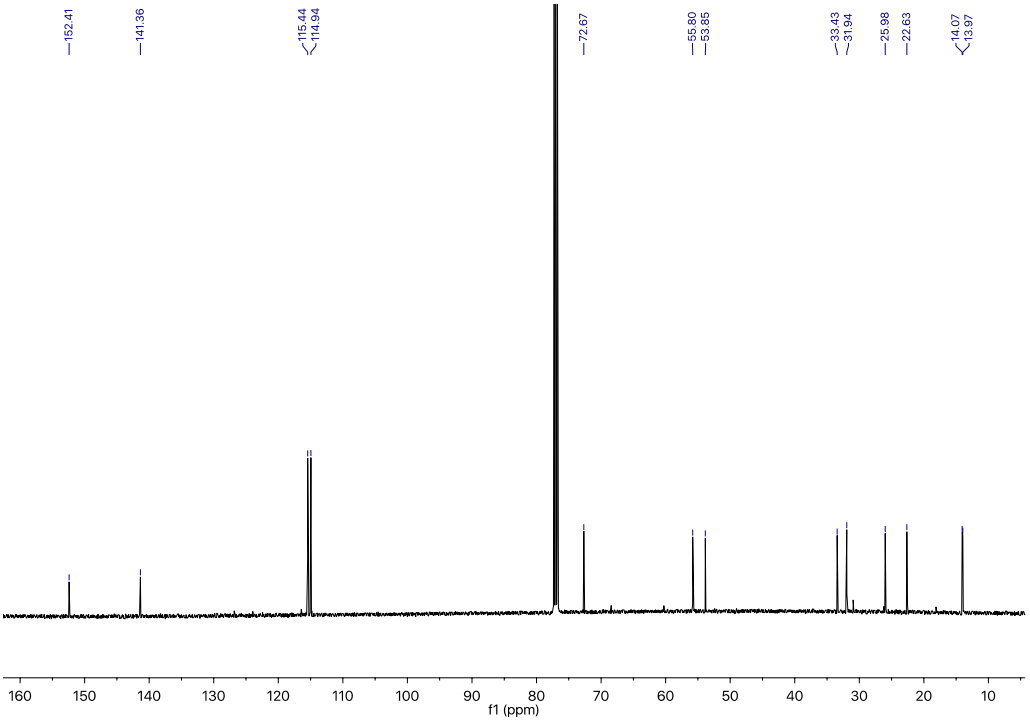


(2*R*,3*S*)-*rel*-2-((4-Methoxyphenyl)amino)octan-3-ol (6c)

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

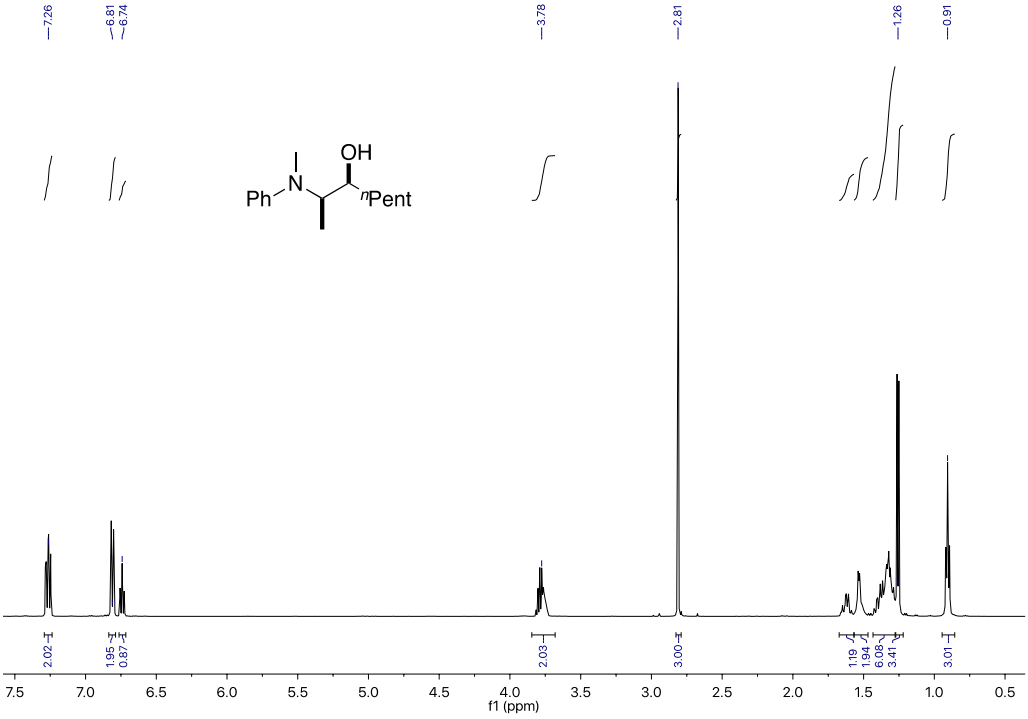


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

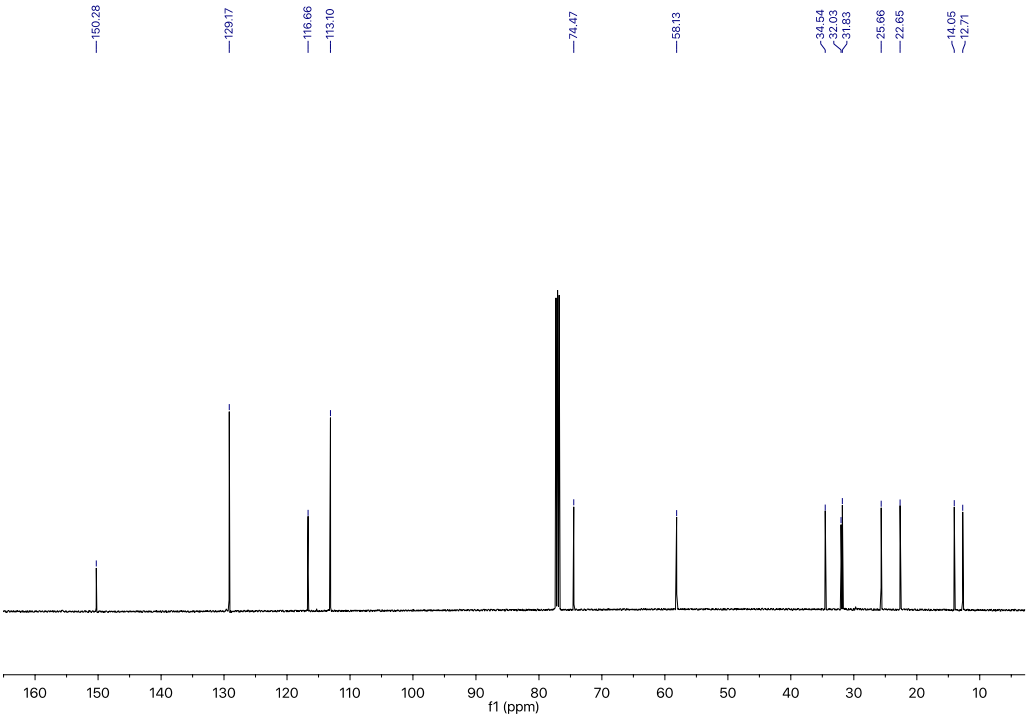


(2*R*,3*S*)-*rel*-2-(Methyl(phenyl)amino)octan-3-ol (6d)

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

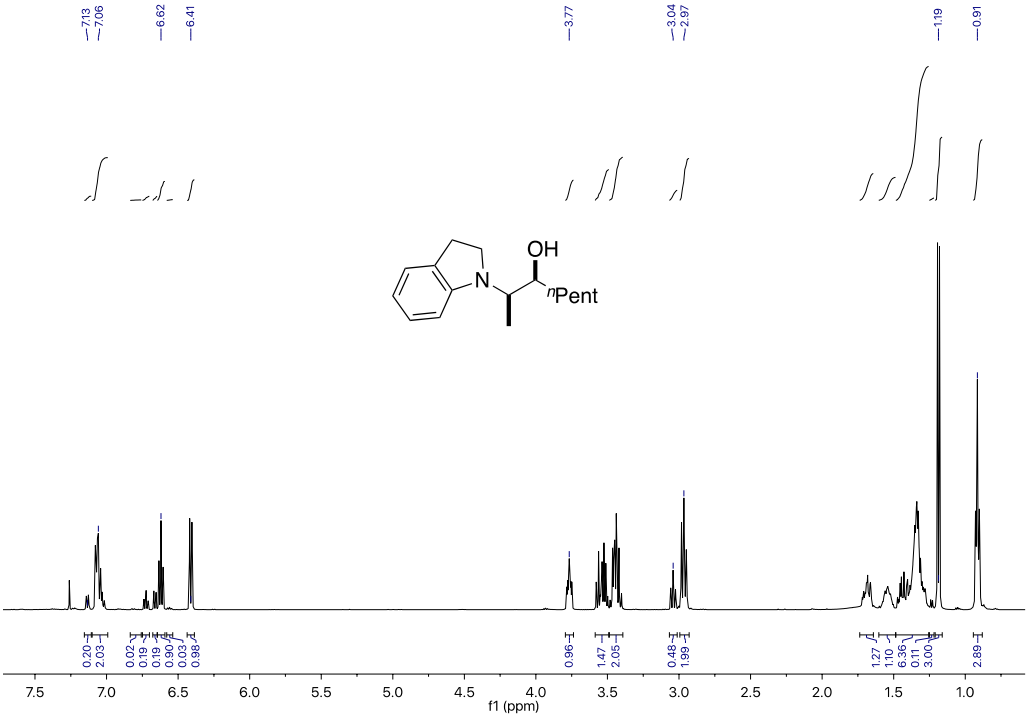


^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)

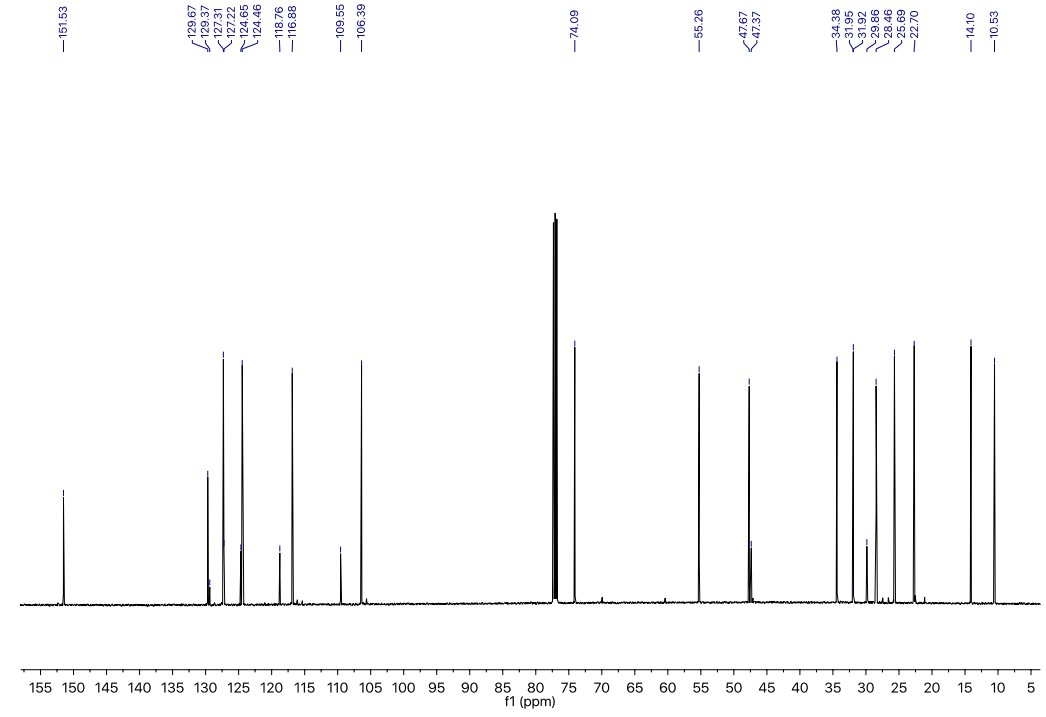


(2*R*,3*S*)-*rel*-2-(Indolin-1-yl)octan-3-ol (6e)

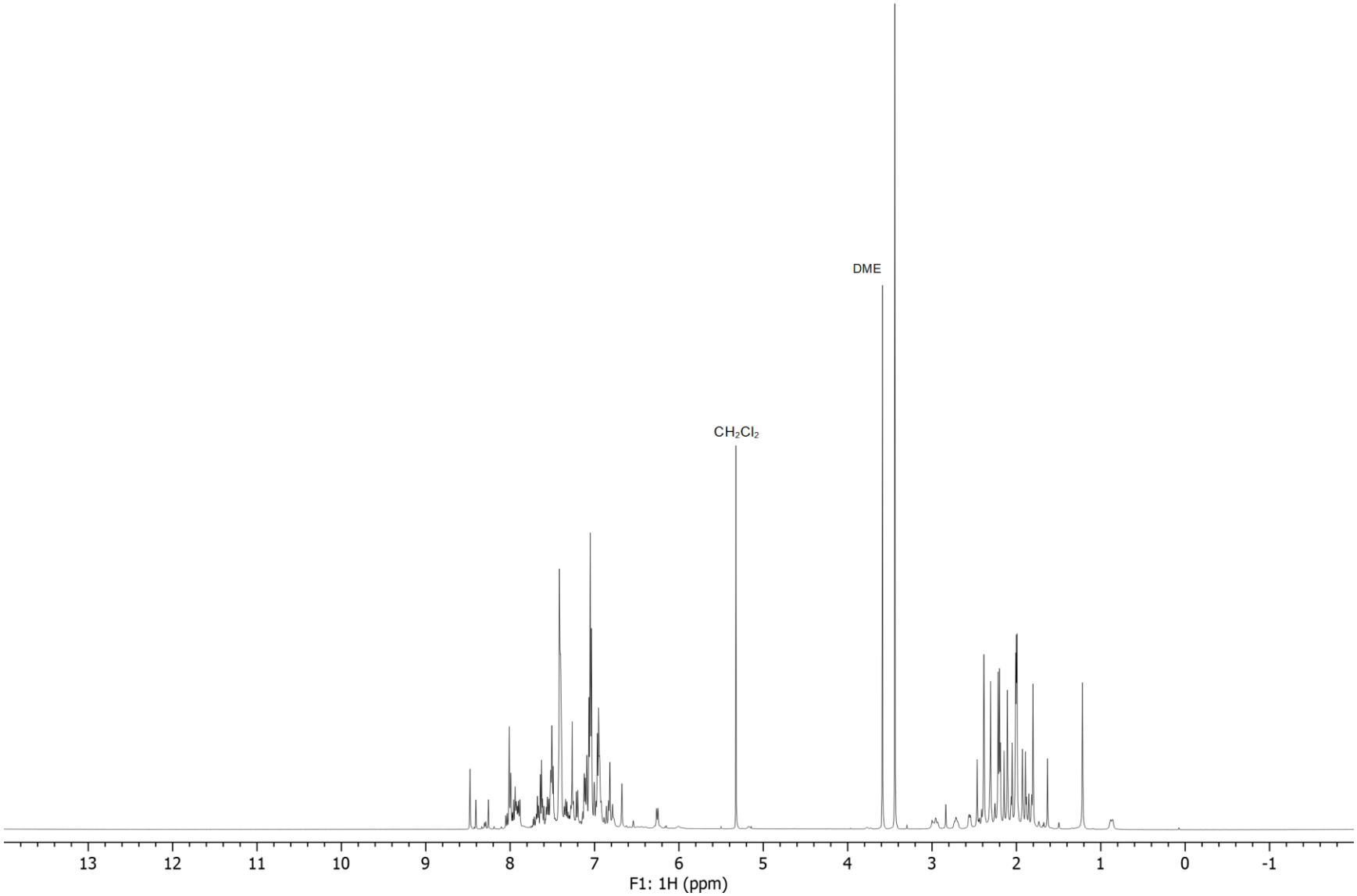
^{1}H NMR (500 MHz, $CDCl_3$)



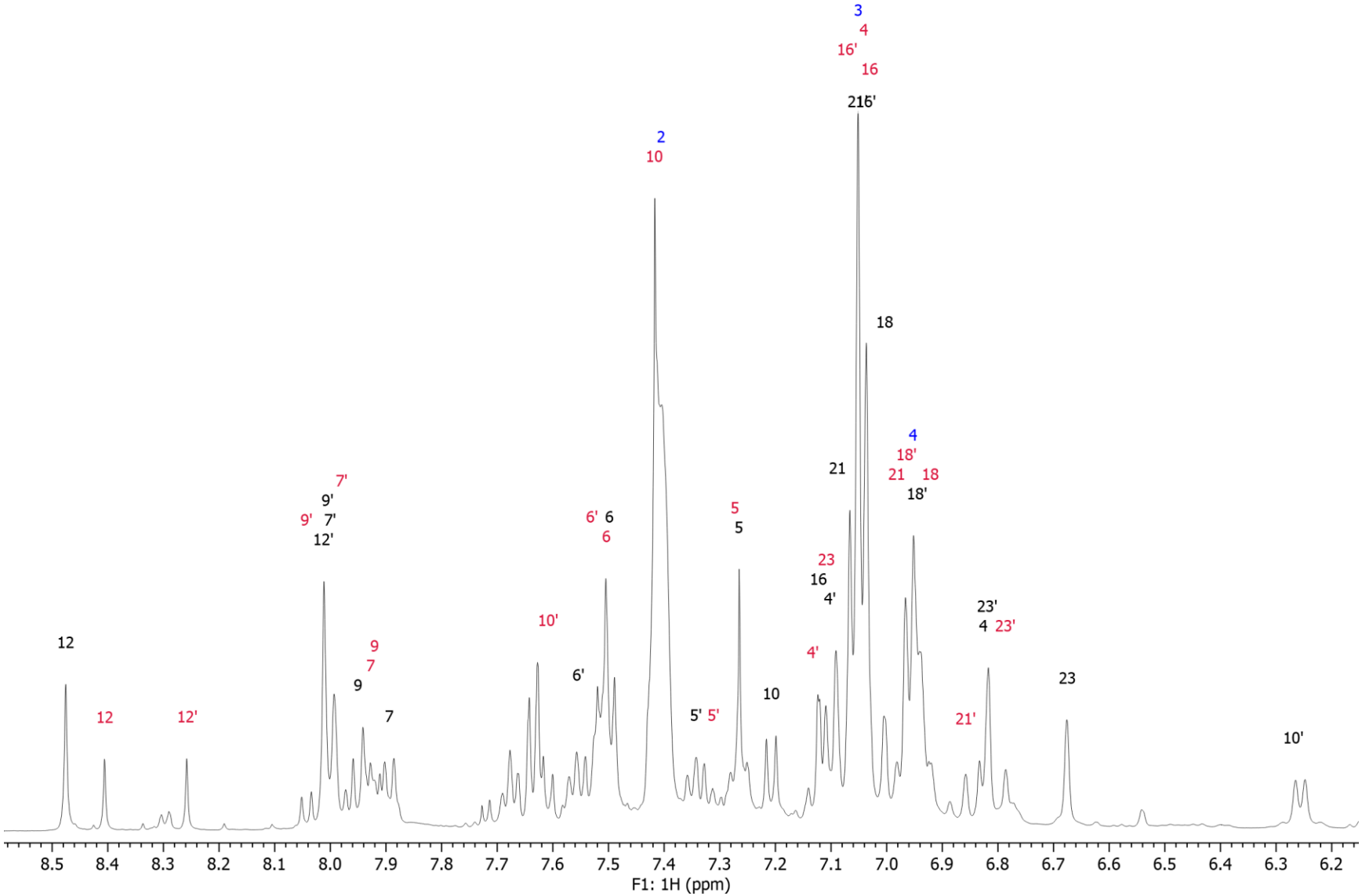
^{13}C{^{1}H} NMR (126 MHz, $CDCl_3$)



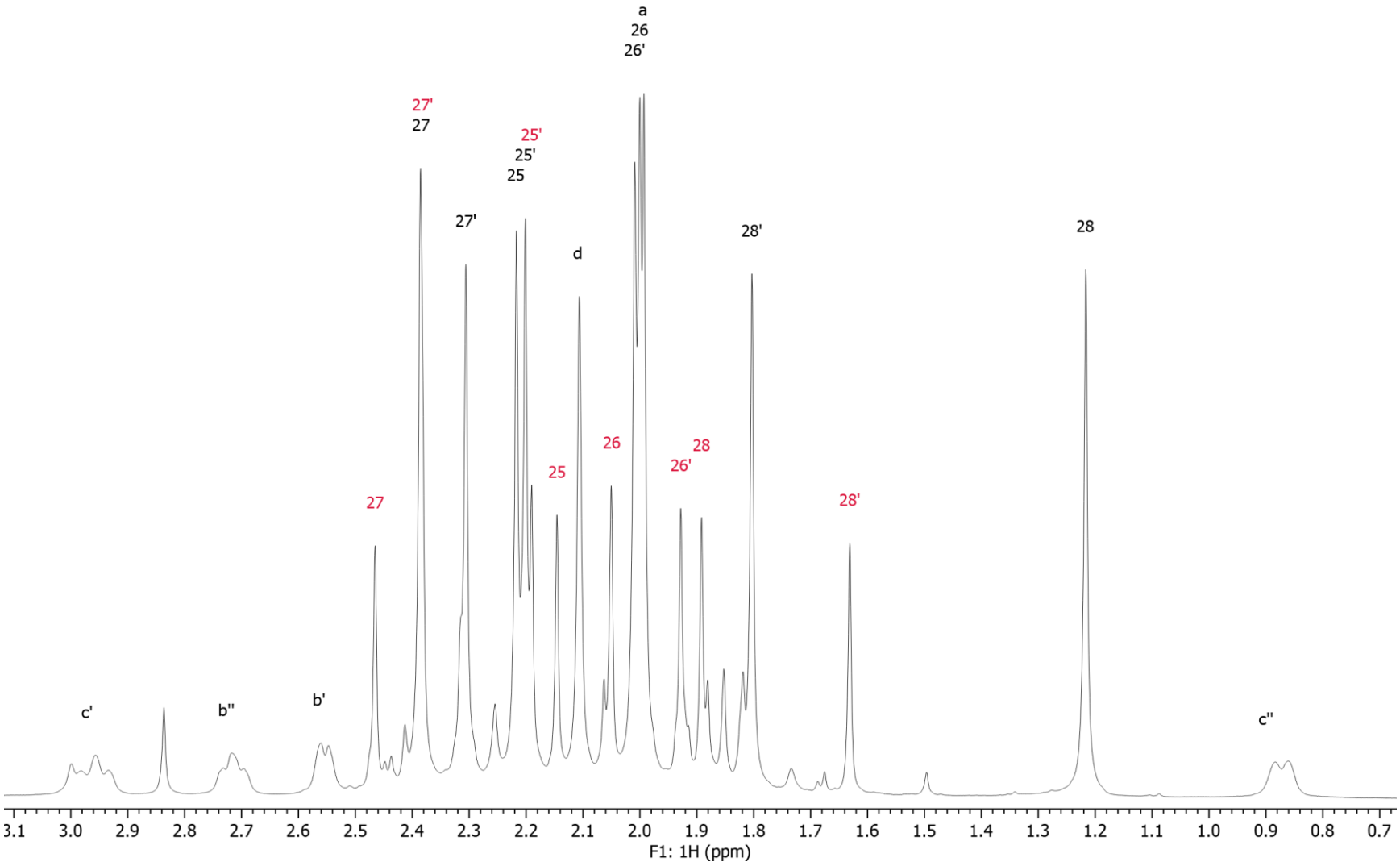
NMR spectra for **1i** in $CDCl_3$ at −55°C on a 500 MHz spectrometer



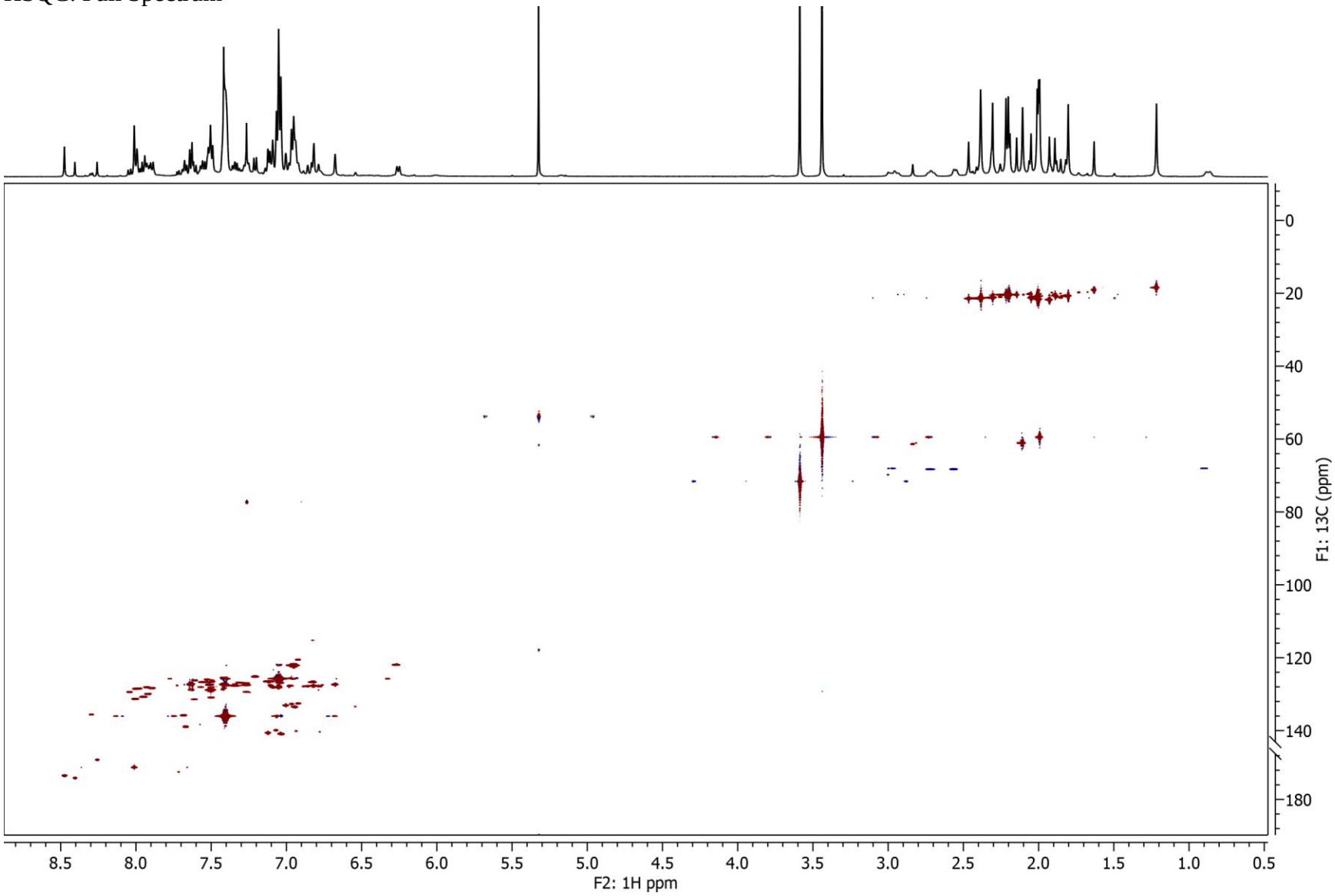
^{1}H NMR: Expansion or aromatic region. Numbers in black, blue and red indicate assignments for **1j**, BPh_4^- and **Al–Cl**, respectively.



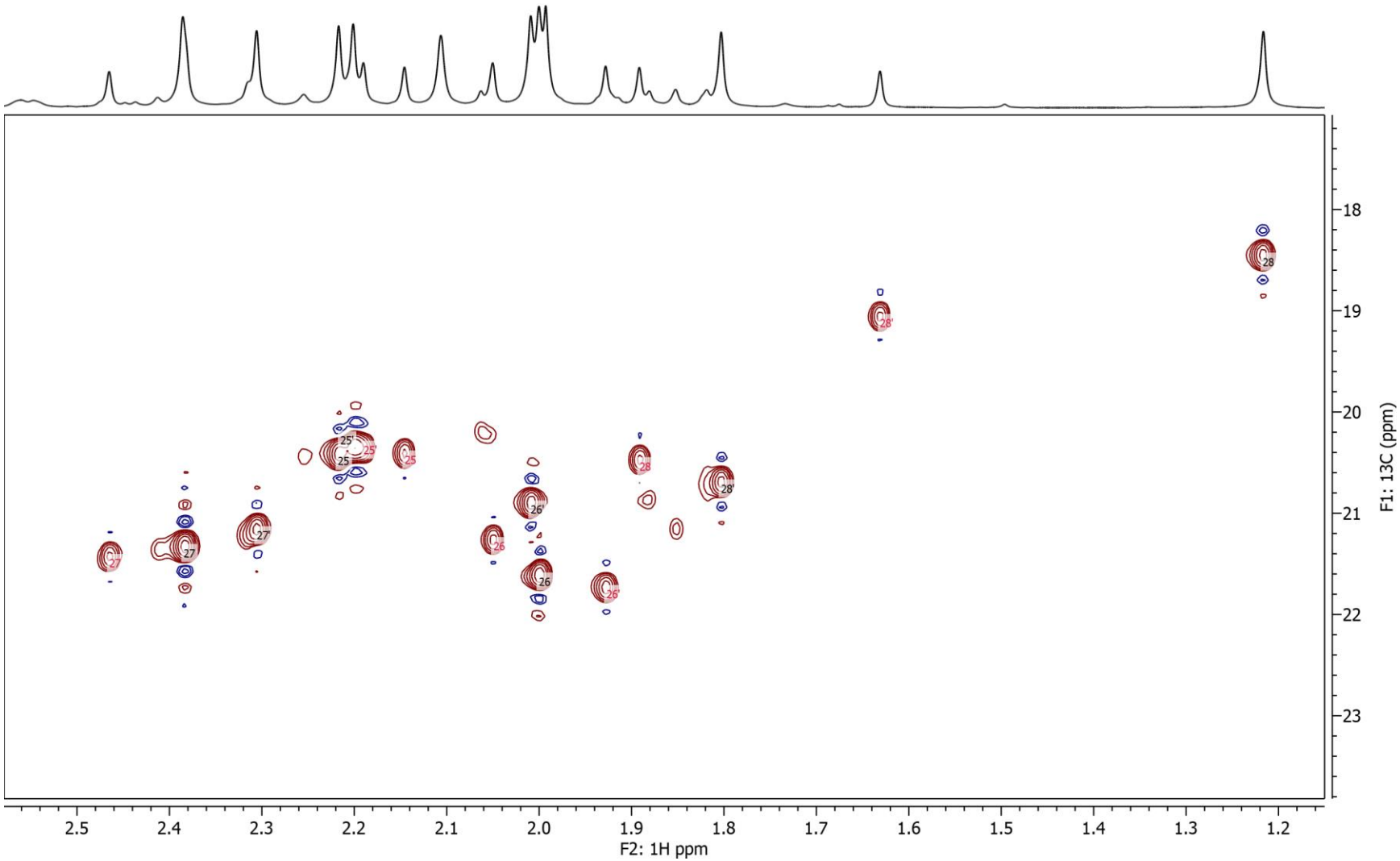
^{1}H NMR: Expansion or aliphatic region. Numbers in black and red indicate assignments for **1j** and **Al−Cl**, respectively.



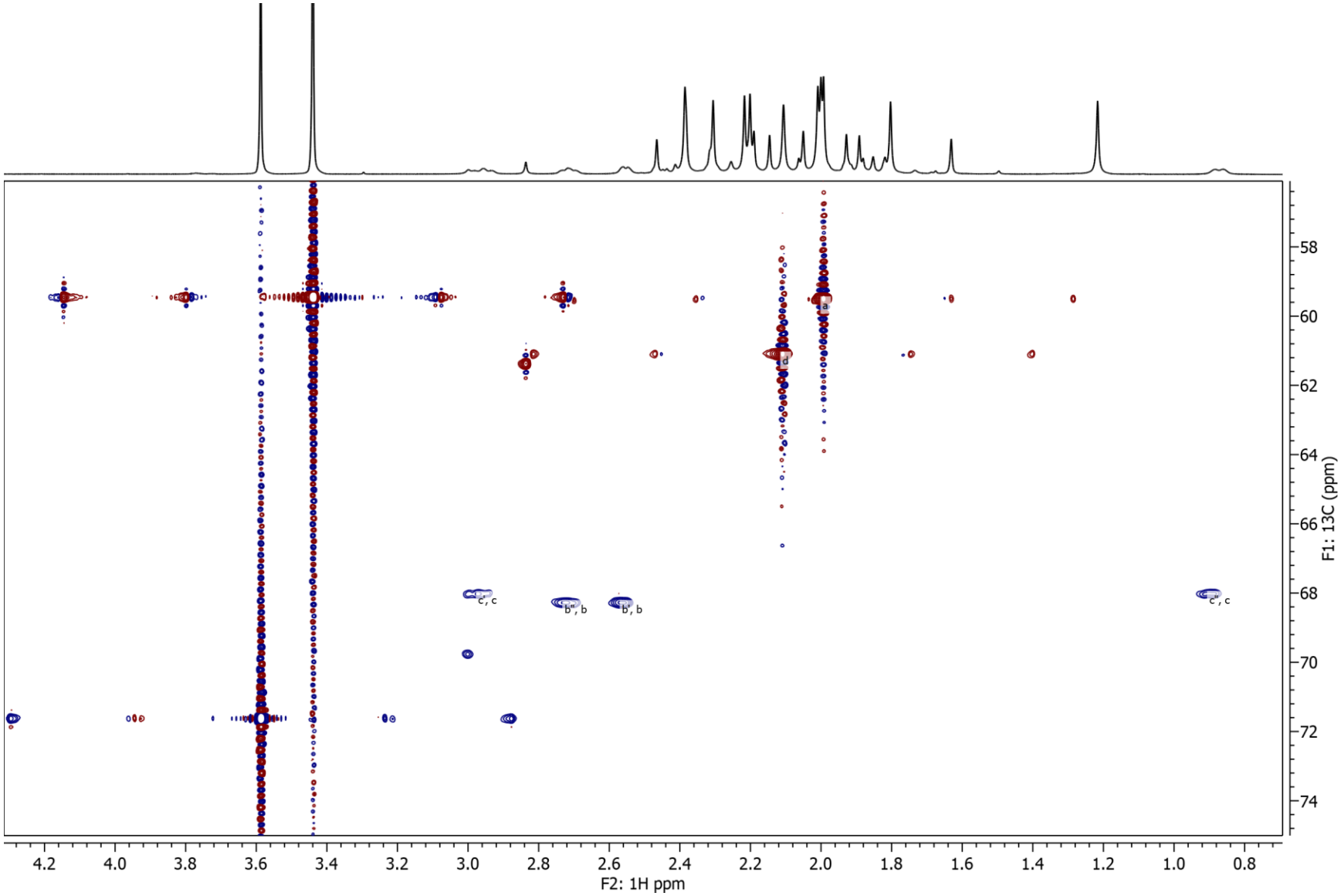
HSQC: Full Spectrum



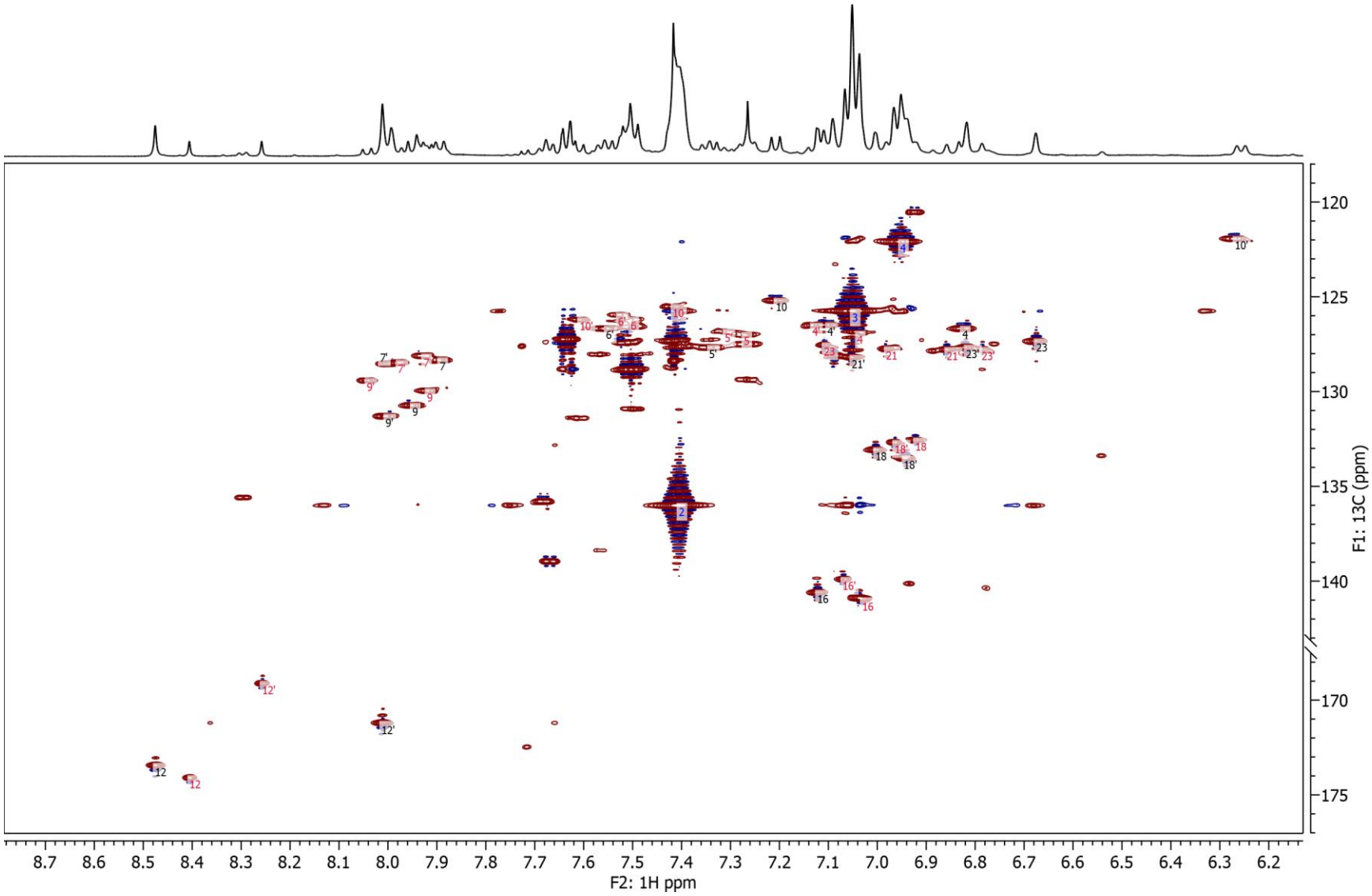
HSQC: Expansion of aliphatic methyl region. Numbers in black and red indicate assignments for **1j** and **Al–Cl**, respectively.



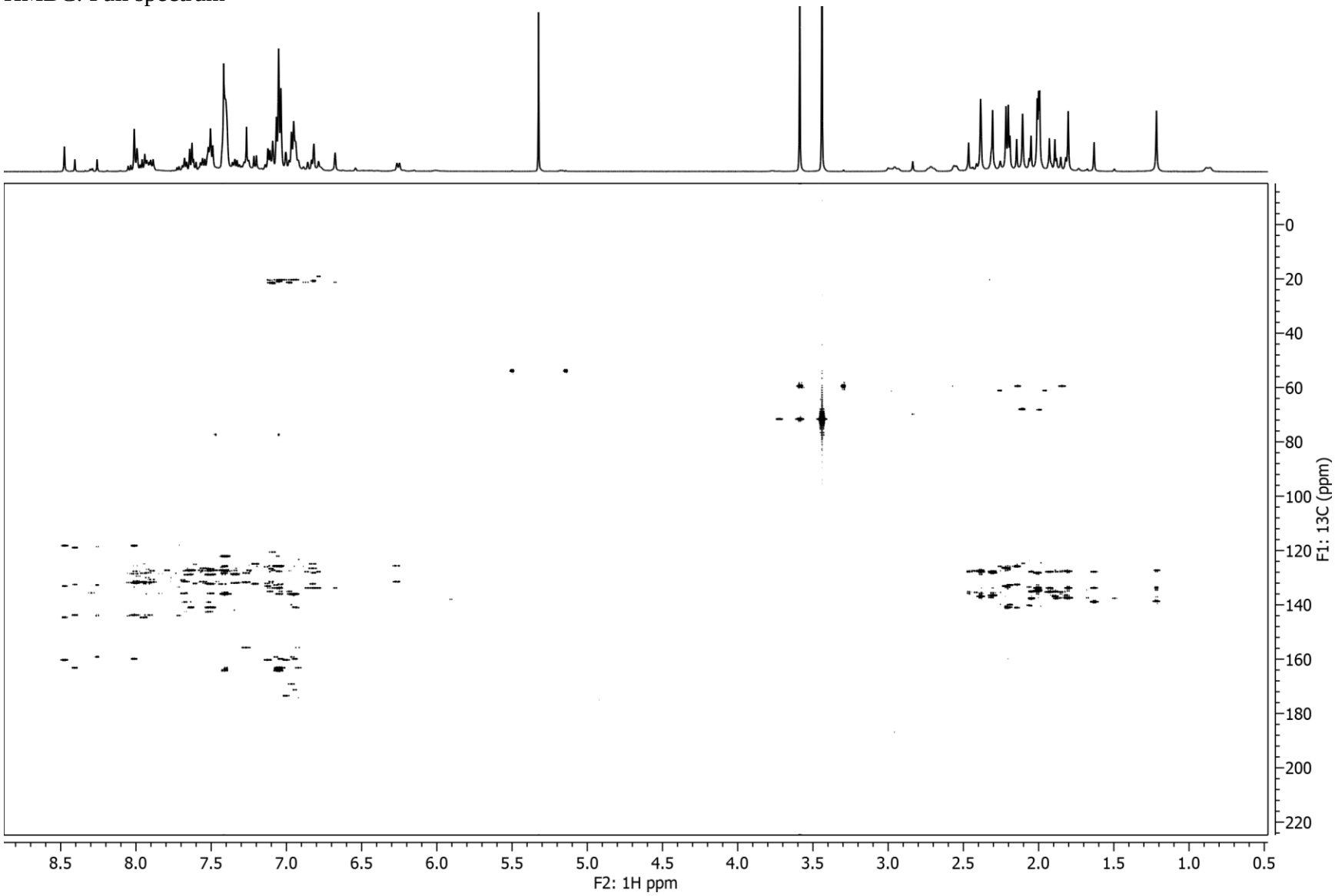
HSQC: Expansion of dimethoxyethane region. Numbers in black and red indicate assignments for **1j** and **Al–Cl**, respectively.



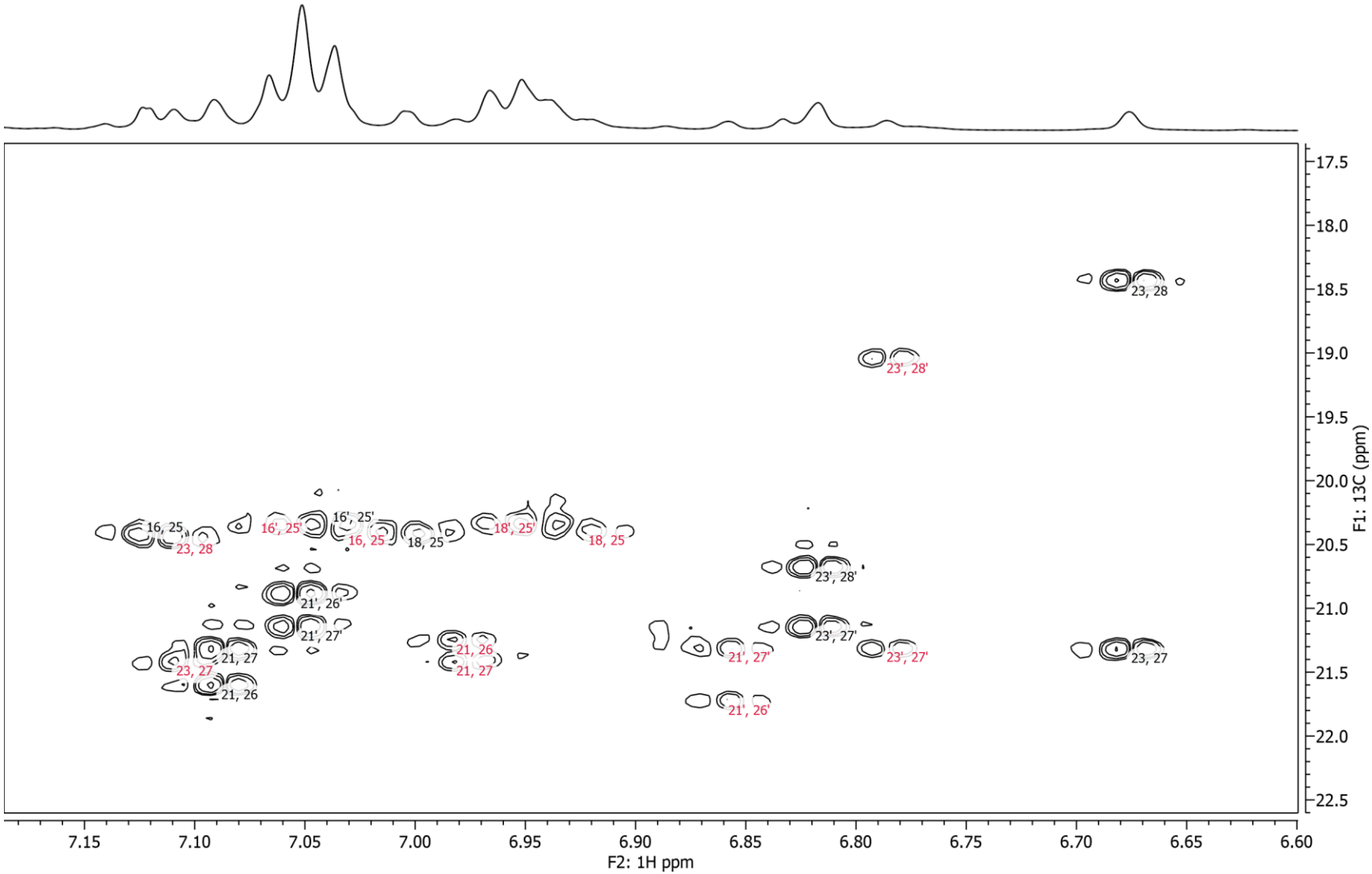
HSQC: Expansion of aromatic region. Numbers in black and red indicate assignments for **1j** and **Al−Cl**, respectively.



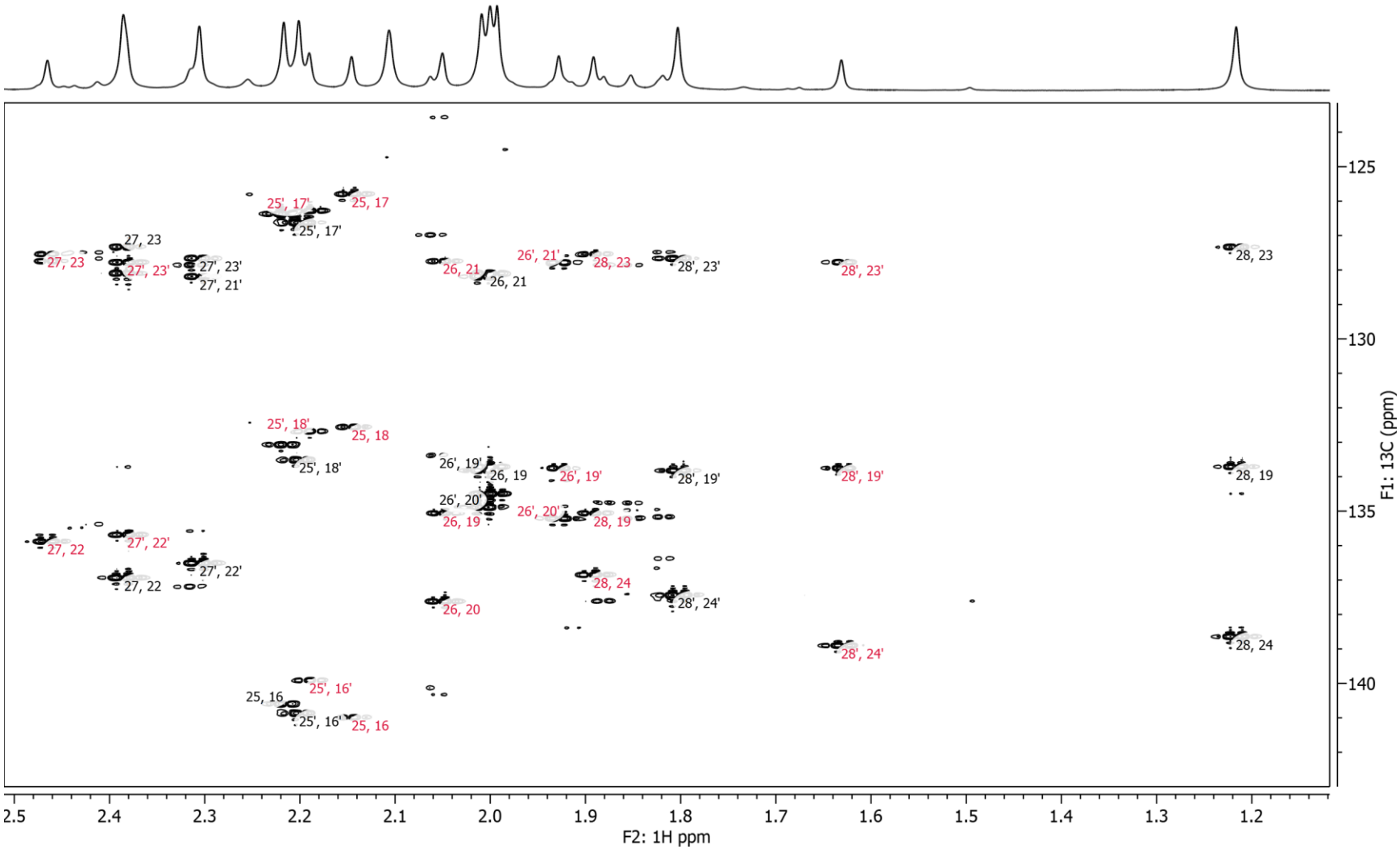
HMBC: Full spectrum



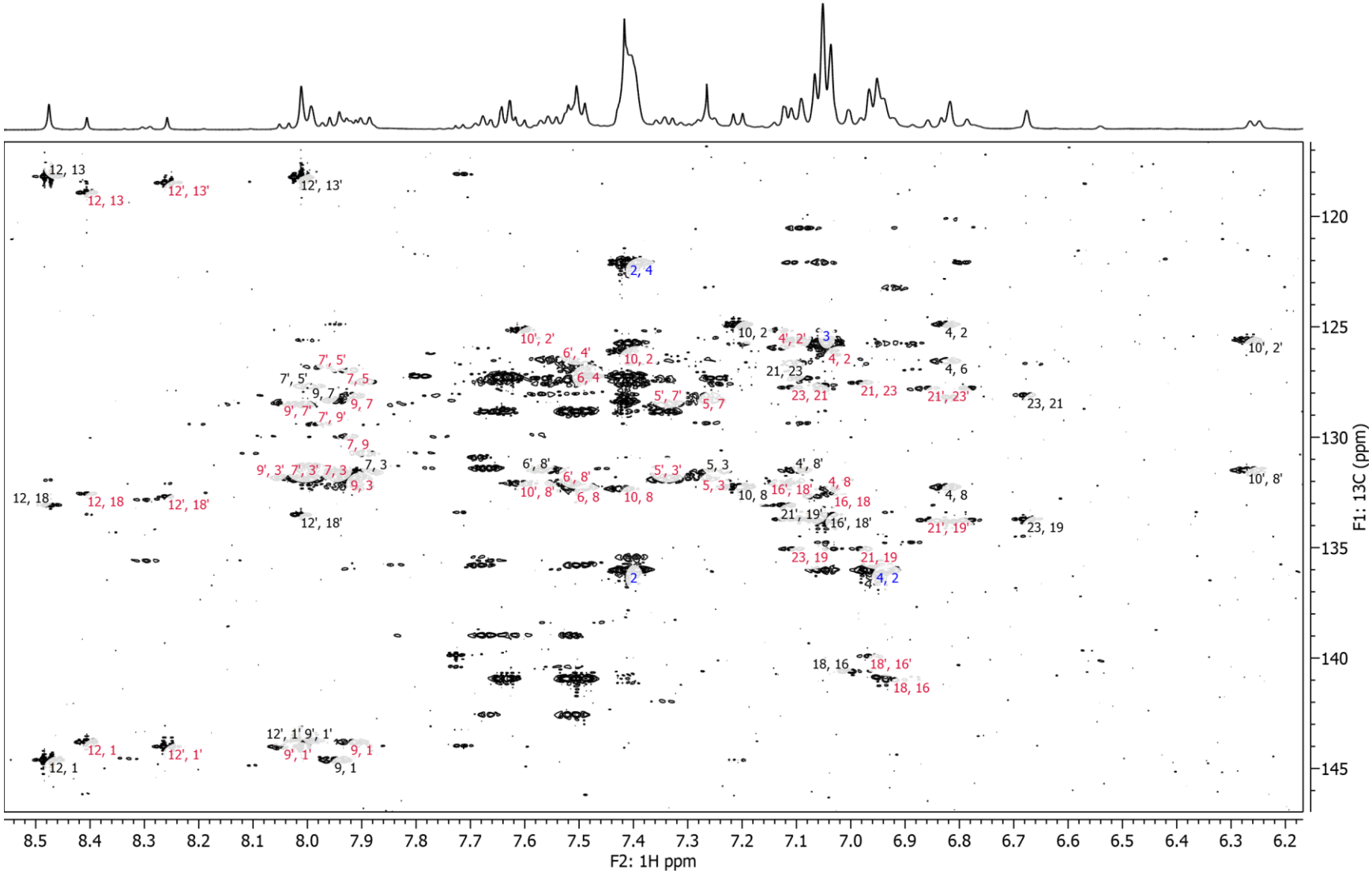
HMBC: Expansion of aromatic to aliphatic region. Numbers in black and red indicate assignments for **1j** and **Al–Cl**, respectively.



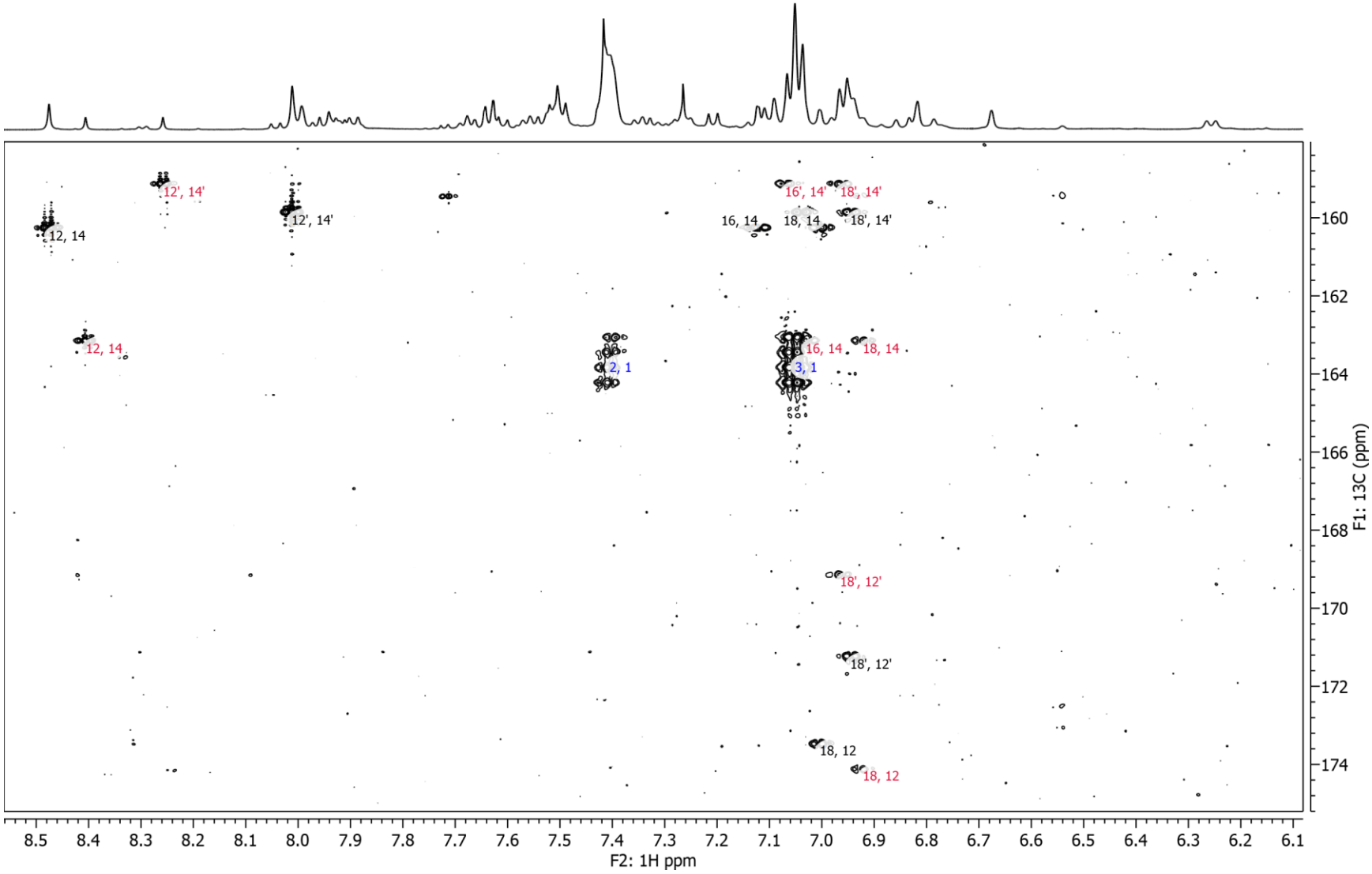
HMBC: Expansion of aliphatic to aromatic region. Numbers in black and red indicate assignments for **1j** and **Al–Cl**, respectively.



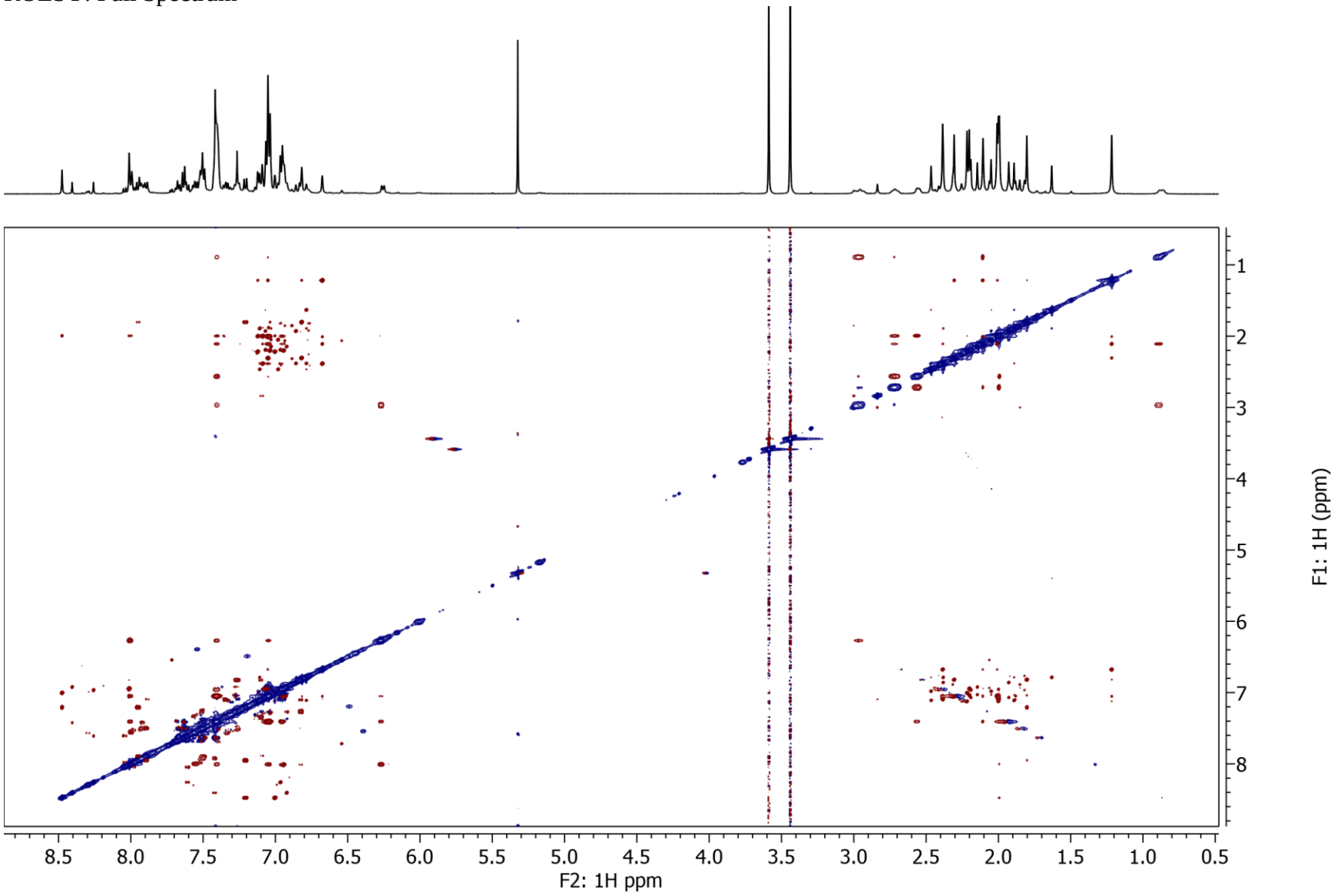
HMBC: Expansion of aromatic to low aromatic region. Numbers in black and red indicate assignments for **1j** and **Al–Cl**, respectively.



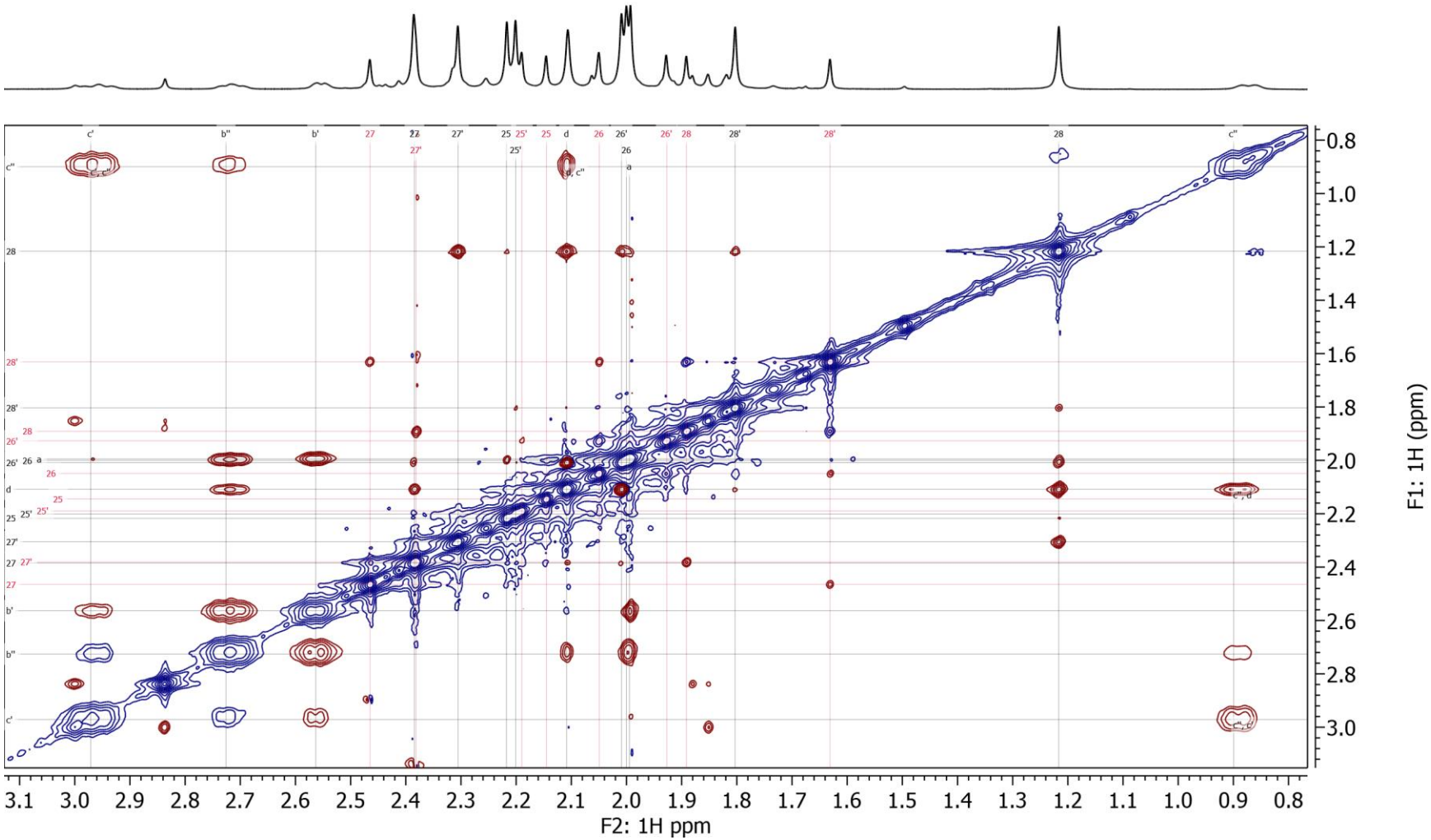
HMBC: Expansion of aromatic to high aromatic region. Numbers in black and red indicate assignments for **1j** and **Al–Cl**, respectively.



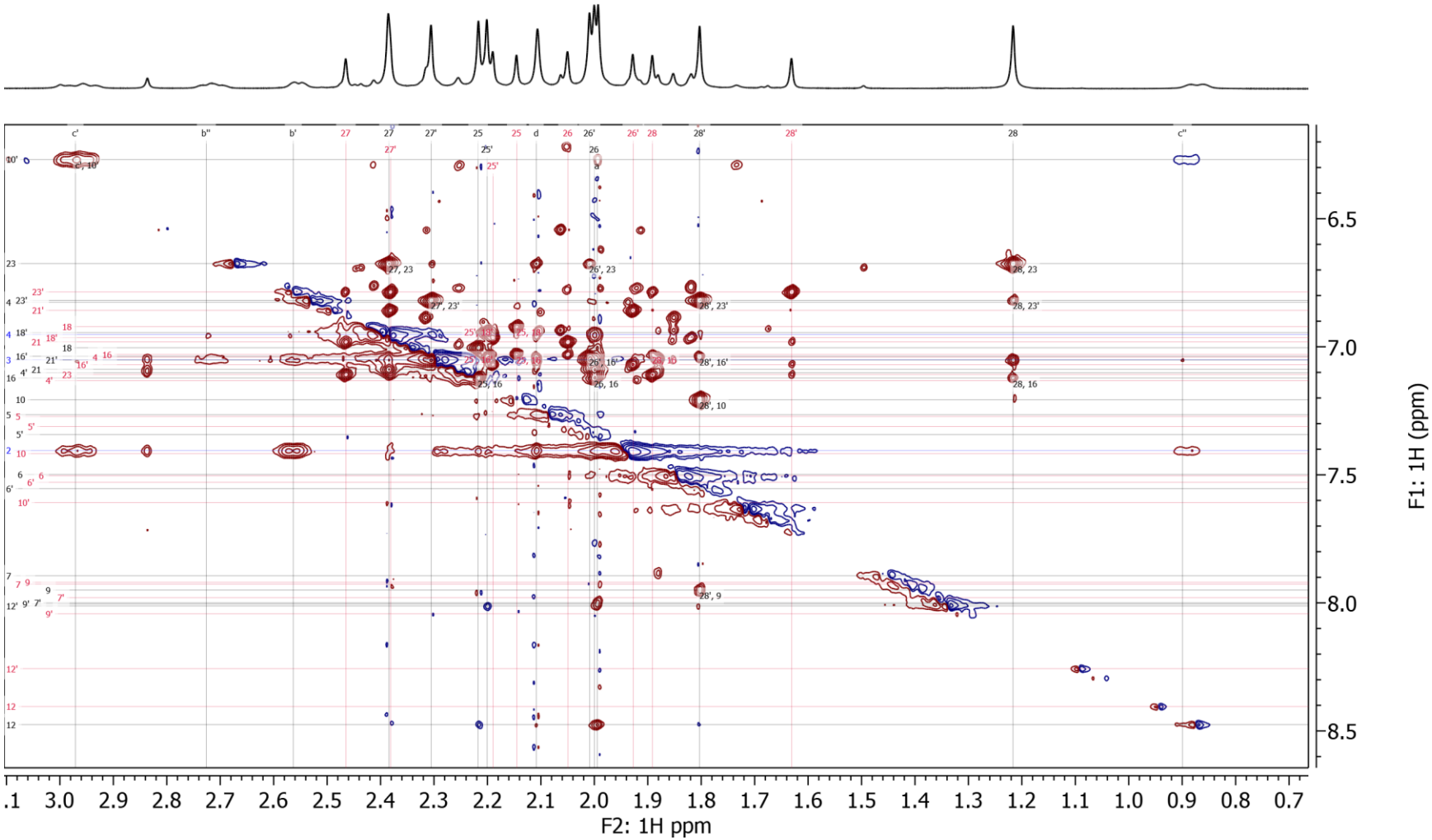
ROESY: Full Spectrum



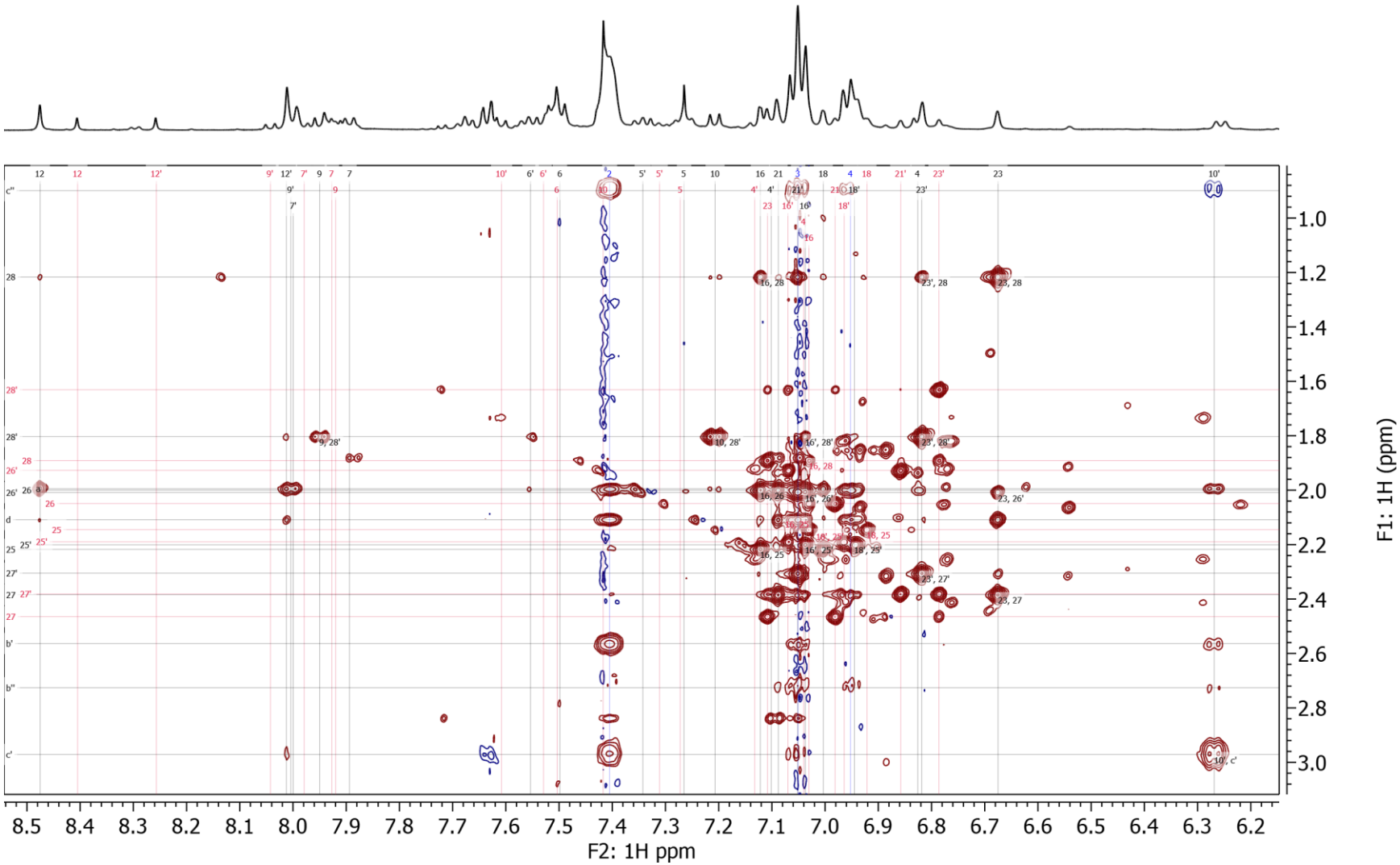
ROESY: Expansion of aliphatic region. Numbers in black and red indicate assignments for **1j** and **Al–Cl**, respectively.



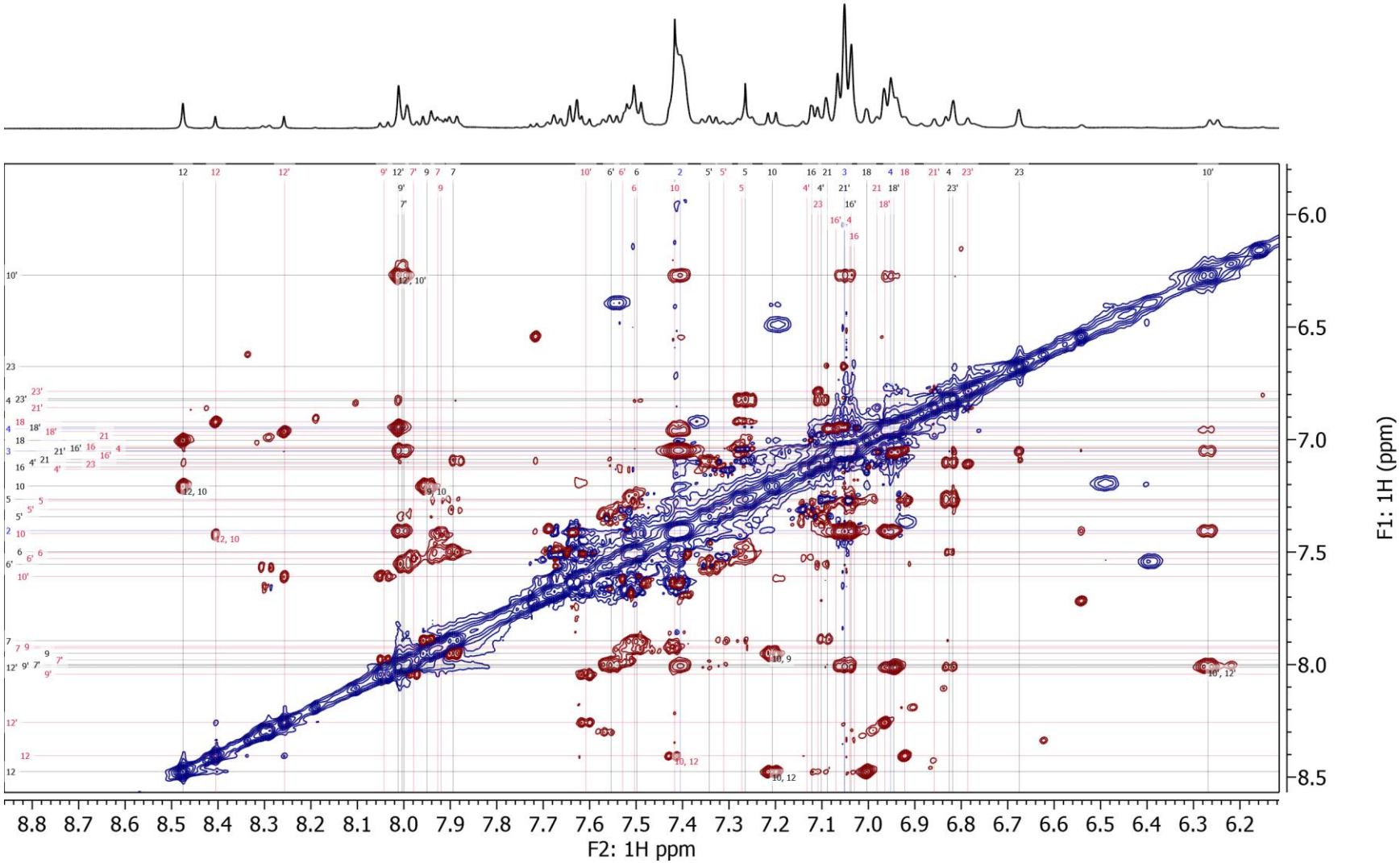
ROESY: Expansion of aliphatic to aromatic region. Numbers in black, blue and red indicate assignments for **1j**, BPh_4^- and **Al–Cl**, respectively.



ROESY: Expansion of aromatic to aliphatic region. Numbers in black, blue and red indicate assignments for **1j**, BPh_4^- and **Al–Cl**, respectively.



ROESY: Expansion of aromatic region. Numbers in black, blue and red indicate assignments for **1j**, BPh_4^- and **Al–Cl**, respectively.



Diffusion NMR: Stack plot of full spectrum