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Cation-π Interactions in MacMillan Organocatalysis

Supporting Information

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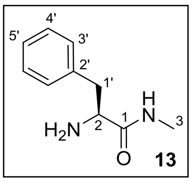
General Information

All chemicals were purchased as reagent grade and used without further purification. Solvents for purification (extraction and chromatography) were purchased as technical grade and distilled on the rotary evaporator prior to use. For column chromatography SiO_2-60 (230-400 mesh ASTM; *Fluka*) was used as stationary phase. Analytical thin layer chromatography (TLC) was performed on glass plates pre-coated with SiO_2-60 F_{254} (*Merck*) and visualized with a UV-lamp (254 nm) and $KMnO_4$ solution. Concentration *in vacuo* was performed at ~10 mbar and 40 °C, drying at ~10^{-2} mbar and rt. NMR spectra were measured by the NMR service of the Organisch-Chemisches Institut, Westfälische Wilhelms-Universität Münster on a *Bruker AV300* or an *Agilent DD2 600* spectrometer at rt. ^{1}H NMR spectra are reported as follows: chemical shift δ in ppm (multiplicity, number of protons, coupling constant *J* in Hz, assignment of proton). The deuterated solvent residual peak was used as internal reference: $C\mathit{H}Cl_3$ (δ_H 7.26) and $CD_2\mathit{H}CN$ (δ_H 1.94). ^{13}C NMR spectra are reported as follows: chemical shift δ in ppm (multiplicity if different from s due to heteronuclear couplings to fluorine, number of carbons if different from 1, coupling constant $^xJ_{CF}$ in Hz, assignment of carbon). The solvent peak was used as internal reference: $\mathit{C}DCl_3$ (δ_C 77.16) and $\mathit{C}D_3CN$ (δ_C 1.32). ^{19}F NMR spectra are reported as follows: chemical shift δ in ppm (multiplicity, number of fluorines, coupling constant $^xJ_{YF}$ in Hz, assignment of fluorine). The resonance multiplicity is abbreviated as: s (singlet), d (doublet), t (triplet), q (quadruplet), m (multiplet) and b (broad). Assignments of unknown compounds are based on DEFT, COSY (HH and FF), HMBC, HSQC and NOESY spectra. Melting points were measured on a *Büchi B-545* melting-point apparatus in open capillaries and are uncorrected. IR spectra were recorded on a *Perkin-Elmer 100 FT-IR* spectrometer, selected adsorption bands are reported in wavenumbers (cm^{-1}) and intensities are reported as: w (weak), m (medium), s (strong) and br (broad). Optical rotations were measured on a *JASCO P-2000* polarimeter or a *Perkin-Elmer 341* polarimeter. HPLC spectra were recorded on an *Agilent 1100* series (DAD, *Agilent technologies 1200* series) using a Chiralcel OJ-H (5 µm, 250·4.6 mm) and *n*-hexane/*iso*-propanol as eluent. High-resolution mass spectra (HR ESI) were measured by the MS service of the Organisch-Chemisches Institut, Westfälische Wilhelms-Universität Münster.

Experimental Section

Syntheses of (5*S*)-5-Benzyl-2,2,3-trimethyl-4-imidazolidinone (1) and (5*S*)-5-Benzyl-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium salt (1a)

L-Phenylalanine methyl amide 13[1]

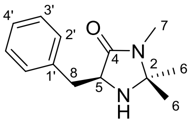


13

To a suspension of *L*-phenylalanine (6.98 g, 42.3 mmol, 1.0 equiv.) in MeOH (17.1 mL, 423 mmol, 10 equiv.) was added thionyl chloride (3.70 mL, 50.7 mmol, 1.2 equiv.) over 15 min at 0 °C and the resulting solution was allowed to come to RT before it was heated to reflux for 22 h. The solution was allowed to come to RT and evaporated *in vacuo* to give the *L*-phenylalanine methyl ester hydrochloride as a white solid. To the ester was added $MeNH_2$ (8 N in EtOH, 21.0 mL, 169 mmol, 4.0 equiv.) at RT and the solution stirred for 23 h. The reaction was concentrated *in vacuo* and a saturated aqueous solution of $NaHCO_3$ (45 mL) was added. The aqueous layer was extracted with CH_2Cl_2 (3 x 55 mL). The combined organic layers were dried over $MgSO_4$, filtrated and concentrated *in vacuo* to give the amide **13** as a yellowish solid (6.44 g, 86%).

R$_f$ = 0.37 (CH_2Cl_2/MeOH 10:1); M.p. = 58.5–59.6 °C; $[\alpha]_D^{20}$: –66.1 (*c* = 1.07, CH_2Cl_2); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.32 (2H, t, *J* = 7.2, H–C4'), 7.28–7.19 (4H, m, H–C3', H–C5', H–N^{amide}), 3.61 (1H, dd, *J* = 9.4, 3.9, H–C2), 3.29 (1H, dd, *J* = 13.7, 3.9, H–C1'), 2.82 (3H, d, *J* = 5.0, H–C3), 2.68 (1H, dd, *J* = 13.7, 9.4, H–C1'), and 1.38 (2H, b, H–N^{amine}) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 174.9 (C1), 138.2 (C2'), 129.4 (2C, C3'), 128.8 (2C, C4'), 126.9 (C5'), 56.6 (C2), 41.2 (C1'), and 26.0 (C3) ppm; IR (ATR): $\tilde{\nu}$ = 3343w, 3291w, 3033w, 2940w, 2915w, 2877w, 1644s, 1524s, 1455m, 1439m, 1399m, 1342w, 1322w, 1268w, 1229w, 1152w, 1109m, 978w, 927w, 913w, 877m, 858m, 834w, 745s, and 699s cm^{-1}, HR-ESI-MS: *m*/*z*: 179.1186 ([*M*+H]$^+$, calcd for $C_{10}H_{15}N_2O^+$: 179.1179); analytical data in agreement with the literature.[1]

(5*S*)-5-Benzyl-2,2,3-trimethyl-4-imidazolidinone (1)[2]

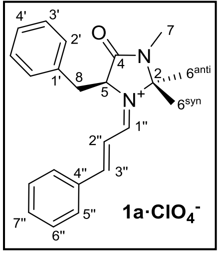


1

To a solution of amide **13** (1.00 g, 5.6 mmol, 1 equiv.) in MeOH (12.0 mL) was added acetone (2.1 mL, 28.1 mmol, 5.0 equiv.) and NEt_3 (0.6 mL, 4.5 mmol, 0.8 equiv.) at RT under an atmosphere of argon and the yellow solution was heated to reflux overnight. The reaction was allowed to come to RT and concentrated *in vacuo* to give **1** as a yellow oil (1.22 g, quant.).

R$_f$ = 0.79 (CH_2Cl_2/MeOH 10:1); $[\alpha]_D^{20}$: –33.2 (*c* = 0.94, CH_3OH); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.36–7.18 (5H, m, H–C2', H–C3', and H–C4'), 3.80 (1H, dd, *J* = 6.8, 4.5, H–C5), 3.15 (1H, dd, *J* = 14.2, 4.5, H–C8), 3.01 (1H, dd, *J* = 14.2, 6.8, H–C8), 2.76 (3H, s, H–C7), 1.70 (1H, b, H–N^{amine}), 1.27 (3H, s, H–C6), and 1.16 (3H, s, H–C6) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 173.5 (C4), 137.3 (C1'), 129.7 (2C, C2'), 128.7 (2C, C3'), 126.9 (C4'), 75.7 (C2), 59.4 (C5), 37.4 (C8), 27.4 (C6), 25.5 (C6), and 25.4 (C7) ppm; IR (ATR): $\tilde{\nu}$ = 3317b, 2979w, 2931w, 1745w, 1680s, 1602w, 1496w, 1424s, 1398s, 1367m, 1269m, 1148m, 1089w, 1030w, 922w, 904w, 748s, 701s, and 673w cm^{-1}; HR-ESI-MS: *m*/*z*: 219.1492 ([*M*+H]$^+$, calcd for $C_{13}H_{19}N_2O^+$: 219.1492); analytical data in agreement with the literature.[2]

(5*S*)-5-Benzyl-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium perchlorate ($1a\cdot ClO_4^-$):[3]

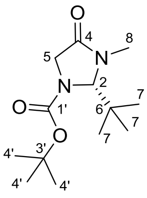


1a·ClO$_4^-$

To imidazolidinone **1** (34.9 mg, 0.16 mmol, 1 equiv.) in Et_2O (0.20 mL) was added perchloric acid (60% in H_2O, 26.80 mg, 0.16 mmol, 1 equiv.) in EtOH/Et_2O (1:1, 0.40 mL) at RT and the resulting mixture stirred for 15 min before it was evaporated *in vacuo* to give the imidazolidinone salt. The salt was redissolved in MeOH (0.40 mL) and heated to 35 °C. (*E*)-cinnamaldehyde (40.2 µL, 0.32 mmol, 2 equiv.) was added and the yellow solution stirred for 1 h. The solvent was removed *in vacuo* and the residue dissolved in a minimum amount of MeOH. From this solution the iminium salt was crashed out with Et_2O and the supernatant solution taken off. The washing procedure was repeated and the iminium salt isolated as a yellow solid (31.9 mg, 46%).

M.p. = 189.9–191.9 °C; $[\alpha]_D^{20.5}$: +2.5 (*c* = 0.45, CH_3CN); ^{1}H NMR (300 MHz, CD_3CN): δ_H = 8.73 (1H, dd, *J* = 10.7, 1.9, H–C1''), 8.18 (1H, d, *J* = 15.0, H–C3''), 7.93 (2H, d, *J* = 7.3, H–C5''), 7.77–7.68 (1H, m, H–C7''), 7.62 (2H, t, *J* = 7.6, H–C6''), 7.38–7.20 (4H, m, H–C3', H–C4', H–C2''), 7.09 (2H, dd, *J* = 7.9, 1.7, H–C2'), 5.20 (1H, s, H–C5), 3.57 (1H, dd, *J* = 14.7, 5.7, H–C8), 3.47 (1H, dd, *J* = 14.7, 3.7, H–C8), 2.78 (3H, s, H–C7), 1.70 (3H, s, H–C6anti), and 0.79 (3H, s, H–C6syn) ppm; ^{13}C NMR (151 MHz, CD_3CN): δ_C = 168.2 (C1''), 166.7 (C3''), 165.2 (C4), 136.1 (C7''), 134.8 (C1'), 134.4 (C4''), 132.5 (2C, C5''), 131.1 (2C, C2'), 130.7 (2C, C6''), 130.1 (2C, C3'), 129.2 (C4'), 118.4 (C2''), 86.5 (C2), 65.2 (C5), 37.2 (C8), 27.5 (C6anti), 26.1 (C7), and 24.8 (C6syn) ppm; IR (ATR): $\tilde{\nu}$ = 2938b, 1712s, 1620s, 1601s, 1587s, 1455m, 1438m, 1420m, 1043m, 1335w, 1311w, 1281m, 1235w, 1197m, 1179m, 1151w, 1115m, 1081m, 1051w, 1012m, 999m, 955w, 933w, 872w, 756m, 750m, 705m, 684w, 642w, and 622s cm^{-1}; HR-ESI-MS: *m/z*: 333.19602 ([*M*-ClO_4^-]$^+$, calcd for $C_{22}H_{25}N_2O^+$: 333.19614); analytical data in agreement with the literature.[3, 4]

(2*S*)-1-Boc-2-(*tert*-butyl)-3-methyl-4-imidazolidinone (*S*-Boc-BMI) 14[5]



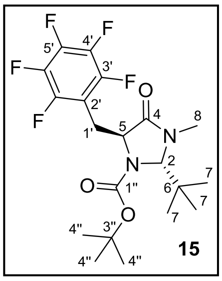
(*S*)-Boc-BMI
14

To a solution of (*R*)-BMI trifluoroacetic acid (2.00 g, 7.40 mmol, 1.00 equiv.) in CH_2Cl_2 (5.00 mL) was added aqueous NaOH (2 N, approx. 7 mL) to adjust the pH to approx. 8. The layers were separated and the aqueous phase extracted three times with CH_2Cl_2. The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. The residue was dissolved in acetone (14.0 mL) and Boc_2O (2.21 mL, 9.62 mmol, 1.3 equiv.) and DMAP (90.4 mg, 0.74 mmol, 0.1 equiv.) were added under Ar at 0 °C. The solution was allowed to come to RT and stirred for 19 h. Et_3N (1.0 mL, 7.4 mmol, 1.0 equiv.) and after another 2 h H_2O (0.7 mL) were added. After stirring for an additional 2 h, the organic solvent was evaporated *in vacuo*. Et_2O (10 mL) and an aqueous solution of HCl (1 N, 10 mL) were added to the residue, the layers were separated and the organic layer was washed with an aqueous solution of HCl (1 N, 10 mL) and with a saturated aqueous solution of $NaHCO_3$ (10 mL). The organic layer was dried over $MgSO_4$ and concentrated *in vacuo* give (*S*)-Boc-BMI (**14**) as a white solid (1.53 g, 81%).

R_f = 0.69 (SiO_2; CH_2Cl_2/MeOH 10:1); M.p. = 65.0–65.7 °C; $[\alpha]_D^{20}$: –11.6 (*c* = 1.05, CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 4.88 (bd, 1H, *J* = 55.0, H–C2), 4.08 (bd, 1H, *J* = 14.1, H–C5), 3.73 (bd, 1H, *J* = 16.0, H–C5), 2.98 (s, 3H, H–C8), 1.46 (s, 9H, H–C4'), and 0.96 (s, 9H, H–C7) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.6 (C4), 154.7 (b, C1'), 82.3 (b, C2), 81.0 (b, C3'), 59.5 (b, C5), 39.5 (C6), 31.5 (C8), 28.2 (3C, C4'), and 25.9 (3C, C7) ppm; IR (ATR): $\tilde{\nu}$ = 2968w, 2951w, 1694s, 1480w, 1450w, 1434w, 1400m, 1362s, 1301s, 1288m, 1252s, 1162s, 1118m, 1104s, 1035w, 1007w, 939m, 928m, 877m, 868m, 776m, 762w, 728w, and 664w cm^{-1}; HR-ESI-MS: *m/z*: 257.1861 ([*M*+H]$^+$, calcd for $C_{13}H_{25}N_2O_3^+$: 257.1860); analytical data in agreement with the literature.[5]

Syntheses of (5*S*)-2,2,3-Trimethyl-5-(pentafluorobenzyl)-4-imidazolidinone (2) and 5-Pentafluorobenzyl-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium salt (2a)

(2*S*,5*S*)-1-Boc-2-(*tert*-butyl)-3-methyl-5-(pentafluorobenzyl)-4-imidazolidinone 15[6]

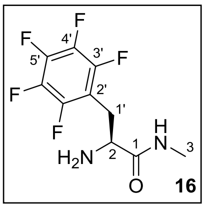


15

A solution of (*S*)-Boc-BMI **14** (128 mg, 0.50 mmol, 1.0 equiv.) in dry THF (0.70 mL) in a flame-dried Schlenck under an atmosphere of argon was cooled to –78 °C. LDA (0.28 mL, 0.55 mmol, 1.1 equiv.) was added resulting in a dark red solution. After 30 min, pentafluorobenzylbromide (131 mg, 0.50 mmol, 1.0 equiv.) in dry THF (0.25 mL) was added slowly upon which the solution turned purple. The reaction was stirred at –78 °C for 5 h and then quenched by addition of saturated aqueous solution of NH_4Cl (2 mL) and extracted with CH_2Cl_2 (3 · 5 mL). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. Purification by CC (SiO_2; CH/EtOAc 8:1) gave **15** as an off-white solid (179 mg, 82%).

R_f = 0.66 (SiO_2; CH/EtOAc 2:1); M.p. = 65.9–69.6°C; $[\alpha]_D^{23}$: –0.7 (*c* = 0.95, CH_3OH); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 4.99 (1H, bs, H–C2), 4.22 (1H, bs, H–C5), 3.89 (1H, dd, *J* = 13.9, 3.0, H–C1'), 2.95 (3H, s, H–C8), 2.91 (1H, bs, H–C1'), 1.48 (9H, s, H–C4''), and 0.95 (9H, s, H–C7) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 170.8 (C4), 152.8 (C1''), 145.6 (2C, dm, $^1J_{CF}$ = 246.8, C^{Ar}), 137.2 (dm, $^1J_{CF}$ = 268.6, C5'), 137.0 (2C, dm, $^1J_{CF}$ = 205.2, C^{Ar}), 111.1 (b, C2'), 81.8 (C2), 80.9 (C3''), 56.8 (C5), 41.1 (C6), 32.1 (C1'), 28.3 (3C, C4''), 26.6 (3C, C7), and 24.7 (b, C8) ppm; ^{19}F NMR (282 MHz, $CDCl_3$): δ = –141.7 (2F, bs, F–C3'), –157.3 (1F, bs, F–C5'), and –163.2 (2F, bs, F–C4') ppm; IR (ATR): $\tilde{\nu}$ = 2973w, 2932w, 1695s, 1658w, 1602w, 1511m, 1506m, 1478w, 1457w, 1400m, 1376s, 1364s, 1302m, 1257m, 1216m, 1178m, 1160m, 1116s, 1098m, 1035w, 1010w, 980m, 948w, 934w, 912w, 886m, 840w, 821w, 786m, 771m, and 717m cm^{-1}; HR-ESI-MS: *m/z*: 459.1662 ($[M+Na]^+$, calcd for $C_{20}H_{25}F_5N_2O_3Na^+$: 459.1678). Analytical data in agreement with the literature.[6]

L-Pentafluorophenylalanine *N*-methyl amide (16)

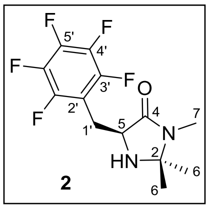


16

To a solution of **15** (100 mg, 0.23 mmol, 1.0 equiv.) in MeOH (3.0 mL) was added an aqueous solution of HCl (1 N, 3.0 mL) at RT and the mixture heated to reflux for 11 h. The reaction was allowed to come to RT and basified to a pH of 10 with an aqueous solution of NaOH (2 N) and extracted with CH_2Cl_2. The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo* to give amide **16** as a white solid (62 mg, quant.).

M.p. = 98.4–99.3 °C; $[\alpha]_D^{22}$ = –0.263 (*c* = 0.039 in $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.21 (1H, bs, H–N^{amide}), 3.58 (1H, dd, *J* = 9.1, 4.9, H–C2), 3.37 (1H, dd, *J* = 14.1, 4.4, H–C1'), 2.91–2.74 (4H, m, H–C3, H–C1'), and 1.50 (2H, s, H–N^{amine}) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 173.5 (C1), 145.6 (dm, $^1J_{CF}$ = 247.3, C^{Ar}), 139.8 (dm, $^1J_{CF}$ = 252.1, C^{Ar}), 137.3 (dm, $^1J_{CF}$ = 250.5, C^{Ar}), 111.9 (td, $^2J_{CF}$ = 18.5, $^3J_{CF}$ = 3.7, C2'), 54.8 (C2), 28.5 (C1'), and 26.1 (C3) ppm; ^{19}F NMR (377 MHz, $CDCl_3$): δ = –142.4 (2F, dd, $^3J_{FF}$ = 22.6, $^4J_{FF}$ = 8.4, F–C3'), –156.0 (1F, t, $^3J_{FF}$ = 20.9, F–C5'), and –162.1 (2F, dt, $^3J_{FF}$ = 22.5, $^4J_{FF}$ = 8.4, F–C4') ppm; IR (ATR): $\tilde{\nu}$ = 3379w, 3330m, 3298w, 2953w, 2910w, 1649s, 1540m, 1520s, 1500s, 1445m, 1423m, 1407m, 1298m, 1116s, 1098s, 1000s, 972s, 932s, 914s, 890m, 849m, 805s, 735m, 710s, and 664m cm^{-1}; HR-ESI-MS: *m/z*: 269.0718 ([*M*+H]$^+$, calcd for $C_{10}H_{10}F_5N_2O^+$: 269.0708).

(5*S*)-2,2,3-Trimethyl-5-(pentafluorobenzyl)-4-imidazolidinone (2)

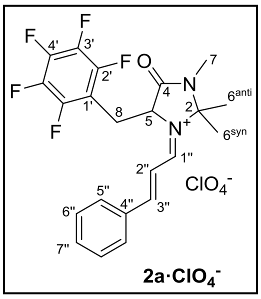


2

To a solution of amide **16** (181 mg, 0.68 mmol, 1.0 equiv.) in MeOH (4.0 mL) were added acetone (0.37 mL, 5.06 mmol, 7.5 equiv.) and NEt_3 (0.08 mL, 0.54 mmol, 0.8 equiv.) at RT under an atmosphere argon and the solution heated to reflux for 9 h. The reaction was allowed to come to RT and concentrated *in vacuo* to give imidazolidinone **2** as an off-white solid (194 mg, 93%).

M.p. = 73.0–75.3 °C; $[\alpha]_D^{20}$ = –31.5 (*c* = 0.91 in CH_3OH); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 3.78 (1H, dd, *J* = 10.3, 4.6, H–C5), 3.31 (1H, d, *J* = 14.1, H–C1'), 2.86–2.75 (4H, m, H–C1', H–C7), 1.72 (2H, b, H–N), 1.40 (3H, s, H–C6), and 1.30 (3H, s, H–C6) ppm; ^{13}C NMR (101 MHz, $CDCl_3$, racemic compound): δ = 172.3 (C4), 145.6 (2C, dm, $^1J_{CF}$ = 245.6, C^{Ar}), 139.6 (dm, $^1J_{CF}$ = 245.0, C5'), 137.4 (2C, dm, $^1J_{CF}$ = 251.8, C^{Ar}), 111.9 (td, $^2J_{CF}$ = 18.4 $^3J_{CF}$ = 3.8, C2'), 76.0 (C2), 57.7 (C5), 28.0 (C6), 26.6 (C1'), 25.6 (C6), and 25.4 (C7) ppm; ^{19}F NMR (282 MHz, $CDCl_3$): δ = (–142.3)–(–142.7) (2F, m, F-C3'), –157.2 (1F, t, $^3J_{FF}$ = 20.8, F–C5'), and –163.0 (2F, td, $^3J_{FF}$ = 22.6, $^4J_{FF}$ = 8.3, F–C4') ppm; IR (ATR): $\tilde{\nu}$ = 3318m, 2982w, 1676s, 1519s, 1499s, 1441m, 1404s, 1384m, 1371m, 1303w, 1279w, 1202w, 1182m, 1156w, 1119s, 1099m, 1042m, 1012m, 977m, 964s, 937s, 885w, 795w, 768w, 736w, and 681w cm^{-1}; HR-EI-MS: *m/z*: 309.1018 ([*M*+H]$^+$, calcd for $C_{13}H_{14}F_5N_2O^+$: 309.1021); elemental analysis (racemic compound) calcd (%) for $C_{13}H_{13}F_5N_2O$ (308.2): C 50.65, H 4.25, N 9.09, F 30.82; found: C 50.74, H 4.43, N 8.87, F 31.06.

5-Pentafluorobenzyl-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium perchlorate (2a·ClO_4^-):[3]



2a·ClO_4^-

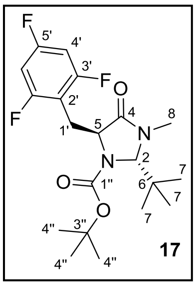
To imidazolidinone **2** (24.7 mg, 0.08 mmol, 1.0 equiv.) in Et_2O (0.10 mL) was added perchloric acid (60% in H_2O, 11.5 mg, 0.08 mmol, 1 equiv.) in Et_2O/EtOH (1:1, 0.2 mL) at RT and the resulting mixture stirred for 10 min before it was evaporated *in vacuo* to give the imidazolidinone salt. The salt was redissolved in MeOH (0.20 mL) and heated to 35 °C. (*E*)-cinnamaldehyde (20.1 µL, 0.16 mmol, 2 equiv.) was added and the yellow solution stirred for 1 h. The solvent was removed *in vacuo* and the residue dissolved in a minimum amount of MeOH. From this solution the iminium salt **2a·ClO_4^-**was crashed out as a yellow solid with Et_2O and the supernatant solution taken off. Crystals suitable for X-ray crystallographic analysis were obtained from a solution in MeOH/CH_3CN (2:1) by vapour diffusion with Et_2O.

M.p. = 185.1–186.3 °C; ^{1}H NMR (600 MHz, CD_3CN): δ_H = 8.87 (1H, dd, *J* = 10.7, 1.8, H–C1''), 8.24 (1H, d, *J* = 15.0, H–C3''), 7.89 (2H, dd, *J* = 8.2, 1.0, H–C5''), 7.76–7.71 (1H, m, H–C7''), 7.63 (2H, t, *J* = 7.9, H–C6''), 7.22 (1H, dd, *J* = 15.0, 10.7, H–C2''), 5.09–5.04 (1H, m, H–C5), 3.54 (1H, dd, *J* = 15.0, 5.2, H–C8), 3.49 (1H, dd, *J* = 15.0, 8.3, H–C8), 2.90 (3H, d, *J* = 0.5, H–C7), 1.83 (3H, s, H–C6anti), and 1.70 (3H, s, H–C6syn) ppm; ^{13}C NMR (151 MHz, CD_3CN, C1', C2', C3' and C4' not visible): δ_C = 168.8 (C1''), 167.2 (C3''), 164.1 (C4), 136.5 (C7''), 134.2 (C4''), 132.3 (2C, C5''), 130.9 (2C, C6''), 117.9 (C2''), 86.8 (C2), 61.1 (C5), 27.2 (C6syn), 26.8 (C6anti), 26.5 (C8), and 26.3 (C7) ppm; ^{19}F NMR (564 MHz, CD_3CN): δ_F = (–141.1)–(–141.2) (2F, m, F–C2'), –155.6 (1F, t, $^2J_{FF}$ = 20.1, F-C4'), and

(–163.6)–(–163.7) (2F, m, F–C3') ppm; IR (ATR): $\tilde{\nu}$ = 2997b, 1712s, 1661w, 1617m, 1603m, 1588s, 1523m, 1506s, 1455m, 1434m, 1405m, 1396m, 1334w, 1277m, 1236w, 1215w, 1181m, 1161m, 1125m, 1093s, 1074s, 1039s, 1012m, 1004m, 976m, 964m, 935m, 865m, 823w, 765s, 700w, 685w, and 621m cm^{-1}; HR-ESI-MS: *m/z*: 423.1484 ([*M*-ClO$_4^-$]$^+$, calcd for $C_{22}H_{20}F_5N_2O^+$: 423.1496).

Syntheses of (5*S*)-2,2,3-Trimethyl-5-(2,4,6-trifluorobenzyl)-4-imidazolidinone (3) and (*S*)-5-(2',4',6'-Trifluorobenzyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium salt (3a)

(2*S*,5*S*)-1-Boc-2-(*tert*-butyl)-3-methyl-5-(2,4,6-trifluorobenzyl)-4-imidazolidinone (17)

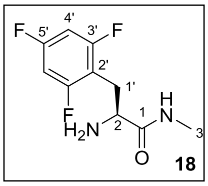


17

A solution of (*S*)-Boc-BMI (**14**) (570 mg, 2.22 mmol, 1.0 equiv.) in dry THF (3.00 mL) in a flame-dried Schlenck under an atmosphere of argon was cooled to –78 °C. LDA (2.0 N in THF/^{n}heptane/ethylbenzene, 1.22 mL, 2.44 mmol, 1.1 equiv.) was added dropwise and the solution stirred for 30 min before 2,4,6-trifluorobenzylbromide (500 mg, 2.22 mmol, 1.0 equiv.) in THF (1.00 mL) was added slowly. After 5 h, the reaction was quenched by addition of saturated aqueous solution of NH_4Cl (2 mL), diluted with water (3 mL) and extracted with CH_2Cl_2 (3 · 5 mL). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. Purification by CC (SiO_2; CH/EtOAc 10:1) gave **17** as an orange oil (757 mg, 85%).

R_f = 0.51 (SiO_2; CH/EtOAc 2:1); $[\alpha]_D^{23}$: –1.1 (c = 0.89, CH_3OH); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.62 (2H, t, J = 8.3, H–C4'), 4.99 (1H, s, H–C2), 4.22 (1H, d, J = 5.6, H–C5), 3.79 (1H, dd, J = 13.9, 3.4, H–C1'), 2.93 (4H, s, H–C8, H–C1'), 1.49 (9H, s, H–C4''), and 0.95 (9H, s, H–C7) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 171.1 (C4), 161.5 (2C, ddd, $^1J_{CF}$ = 248.4, $^3J_{CF}$ = 15.5, $^3J_{CF}$ = 14.7, C3'), 161.4 (dt, $^1J_{CF}$ = 247.4, $^4J_{CF}$ = 15.7, C5'), 152.9 (b, C1''), 109.3 (t, $^2J_{CF}$ = 21.3, C2'), 99.7 (2C, ddd, $^2J_{CF}$ = 28.4, $^2J_{CF}$ = 25.4, $^4J_{CF}$ = 2.6, C4'), 81.2 (C2), 80.6 (C3''), 57.1 (C5), 40.9 (C6), 31.8 (C1'), 28.2 (3C, C4''), 26.5 (3C, C7), and 23.9 (b, C8) ppm; ^{19}F NMR (75 MHz, $CDCl_3$): δ = –110.4 (2F, b, F–C3'), and –110.8 (b, F–C5') ppm; IR (ATR): $\tilde{\nu}$ = 3331w, 2976w, 2928w, 1682s, 1602w, 1508s, 1425m, 1398s, 1368w, 1219s, 1158m, 1098m, 1016w, 922w, 823m, and 731m cm^{-1}; HR-EI-MS: *m/z* : 423.1867 ([*M*–Na]$^+$, calcd for $C_{20}H_{27}F_3N_2O_3Na^+$: 423.1866).

L-2,4,6-Trifluorophenylalanine *N*-methyl amide (18)

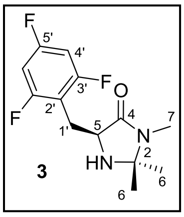


18

To a solution of **17** (680 mg, 1.70 mmol, 1.0 equiv.) in MeOH (10.0 mL) was added an aq. solution of HCl (1 N, 10.0 mL) at RT and the mixture heated to reflux overnight. The reaction was allowed to come to RT and basified to a pH of 10 with an aqueous solution of NaOH (2 N) and extracted with CH_2Cl_2 (3 · 35 mL). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo* to give amide **18** as a white solid (355 mg, 90%).

R_f = 0.56 (CH_2Cl_2/MeOH 10:1); M.p. = 50.7–52.1 °C; $[\alpha]_D^{23}$: +30.3 (c = 0.95, CH_3OH); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.26 (1H, b, H–N^{amide}), 6.65 (2H, dd, J = 8.7, 7.8, H–C4'), 3.54 (1H, dd, J = 9.6, 4.3, H–C2), 3.29 (1H, dd, J = 14.1, 4.3, H–C1'), 2.81 (3H, d, J = 5.0, H–C3), 2.74 (1H, dd, J = 14.1, 9.7, H–C1'), and 1.42 (2H, bs, H–N^{amine}) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 174.2 (C1), 161.9 (2C, ddd, $^1J_{CF}$ = 247.8, $^3J_{CF}$ = 14.7, $^3J_{CF}$ = 11.5, C3'), 161.6 (dt, $^1J_{\mathrm{CF}}$ = 248.4, $^3J_{\mathrm{CF}}$ = 15.7, H-C5'), 110.4 (td, $^2J_{\mathrm{CF}}$ = 20.4, $^4J_{\mathrm{CF}}$ = 4.6, C2'), 101.3–99.6 (2C, m, C4'), 55.0 (C2), 28.0 (C1'), and 26.0 (C3) ppm; ^{19}F NMR (282 MHz, $CDCl_3$): δ = –109.84 (1F, tt, $^3J_{\mathrm{FH}}$ = 22.6, $^4J_{\mathrm{FF}}$ = 5.8, F–C5'), and –111.26 (2F, dd, $^3J_{\mathrm{FH}}$ = 7.4, $^4J_{\mathrm{FF}}$ = 5.9, F–C3') ppm; IR (ATR): $\tilde{\nu}$ = 3302w, 3077w, 2941w, 1625s, 1601s, 1538m, 1493m, 1436m, 1412w, 1345w, 1305w, 1272w, 1224w, 1157w, 1138w, 1114s, 1021m, 993m, 950w, 838m, 779w, 723w, 707w, and 659w cm^{-1}; HR-ESI-MS: *m*/*z*: 233.0902 ([*M*+H]$^+$, calcd for $C_{10}H_{12}F_3N_2O^+$: 233.0896).

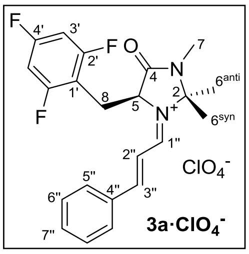
(5*S*)-2,2,3-Trimethyl-5-(2,4,6-trifluorobenzyl)-4-imidazolidinone (3)



To a solution of amide **18** (320 mg, 1.38 mmol, 1.0 equiv.) in MeOH (8.00 mL) were added aceton (0.76 mL, 10.3 mmol, 7.5 equiv.) and NEt_3 (0.15 mL, 1.10 mmol, 0.8 equiv.) at RT under an atmosphere argon and the solution heated to reflux overnight. The reaction was allowed to come to RT and concentrated *in vacuo* to give imidazolidinone **3** as yellow oil (682 mg, quant.).

$[\alpha]_D^{23}$: –32.2 (*c* = 0.48, CH_3OH); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.60 (2H, dd, *J* = 8.8, 7.7, H–C4'), 3.69 (1H, dd, *J* = 10.2, 4.1, H–C5), 3.22 (1H, dd, *J* = 14.1, 4.2, H–C1'), 2.75 (3H, s, H–C7), 2.68 (1H, dd, *J* = 14.1, 10.4, H–C1'), 1.74 (1H, b, H–N), 1.35 (3H, s, H–C6), and 1.23 (3H, s, H–C6) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 172.9 (C4), 161.7 (2C, ddd, $^1J_{\mathrm{CF}}$ = 247.7, $^3J_{\mathrm{CF}}$ = 14.8, $^3J_{\mathrm{CF}}$ = 11.6, C3'), 161.4 (dt, $^1J_{\mathrm{CF}}$ = 248.0, $^3J_{\mathrm{CF}}$ = 15.7, C5'), 110.3 (td, $^2J_{\mathrm{CF}}$ = 20.5, $^4J_{\mathrm{CF}}$ = 4.7, C2'), 100.1 (2C, ddd, $^2J_{\mathrm{CF}}$ = 28.7, $^2J_{\mathrm{CF}}$ = 25.5, $^4J_{\mathrm{CF}}$ = 2.1, C4'), 75.7 (C2), 58.0 (C5), 27.6 (C6), 25.8 (C8), 25.3 (C6), and 25.3 (C7) ppm; ^{19}F NMR (75 MHz, $CDCl_3$): δ = –110.35 (1F, t, $^3J_{\mathrm{FF}}$ = 5.7, F–C5'), and –111.45 (2F, d, $^3J_{\mathrm{FF}}$ = 5.7, F–C3') ppm; IR (ATR): $\tilde{\nu}$ = 3326w, 2976w, 1687s, 1641m, 1622m, 1605s, 1497m, 1440s, 1400m, 1268w, 1167m, 1149w, 1116s, 1058m, 998m, 940w, 839m, and 737w cm^{-1}; HR-ESI-MS: *m*/*z*: 273.1207 ([*M*+H]$^+$, calcd for $C_{13}H_{16}F_3N_2O^+$: 273.1209).

(*S*)-5-(2',4',6'-Trifluorobenzyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium perchlorate (3a ClO_4^-):[3]

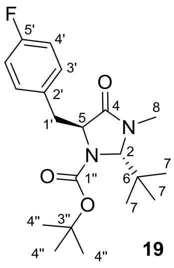


To imidazolidinone **3** (43.6 mg, 0.16 mmol, 1.0 equiv.) in Et_2O (0.2 mL) was added $HClO_4$ (60% in H_2O, 26.8 mg, 0.16 mmol, 1.0 equiv.) in $EtOH/Et_2O$ (1:1, 0.4 mL) at RT and stirred for 10 min, before the sovent was evaporated *in vacuo* to give the off-white $HClO_4$ salt as a solid. The solid was dissolved in MeOH (0.4 mL) and (*E*)-cinnamaldehyde (40.2 μL, 0.32 mmol, 2.0 equiv.) was added at 35 °C and the yellow solution stirred for 1 h. The solvent was evaporated *in vacuo*. The residue was dissolved in a minimum amount of MeOH, the iminium salt was crashed out with Et_2O and the supernatant solution taken off. This purification procedure was repeated two additional times to give **3a·ClO_4^-** as a yellow solid.

M.p. = 198.5 °C decomp.; $[\alpha]_D^{20}$ = +122.5 (*c* = 0.83 in CH_3CN); ^{1}H NMR (600 MHz, CD_3CN): δ_H = 8.87 (1H, dd, *J* = 10.7, 1.7, H–C1''), 8.20 (1H, d, *J* = 15.0, H–C3''), 7.83 (2H, dd, *J* = 8.2, 1.0, H–C5''), 7.73–7.69 (1H, m, H–C7''), 7.60 (2H, t, *J* = 7.9, H–C6''), 7.16 (1H, dd, *J* = 15.0, 10.7, H–C2''), 6.87 (2H, dd, *J* = 8.9, 7.9, H–C3'), 5.06 (1H, t, *J* = 6.0, H–C5), 3.48 (1H, dd, *J* = 15.0, 7.6, H–C8), 3.42 (1H, dd, *J* = 15.1, 5.8, H–C8), 2.89 (3H, d, *J* = 0.5, H–C7), 1.82 (3H, s, H–C6$^{\mathrm{anti}}$), and 1.64 (3H, s, H–C6$^{\mathrm{syn}}$) ppm; ^{13}C NMR (151 MHz, CD_3CN, C1', C2' and C4' assigned in CFdec spectrum): δ_C = 168.7 (C1''), 166.6 (C3''), 164.5 (C4), 163.6 (C4'), 162.9 (2C, C2'), 136.2 (C7''), 134.3 (C4''), 132.2 (2C, C5''), 130.8 (2C, C6''), 118.1 (C2''), 108.2 (C1'), 101.7 (2C, dd, $^2J_{CF}$ = 31.2, $^2J_{CF}$ = 26.0, C3'), 86.8 (C2), 61.9 (C5), 26.9 (C6^{syn}), 26.9 (C6^{anti}), 26.4 (C8), and 26.3 (C7) ppm; 19F NMR (564 MHz, CD_3CN): δ_F = –108.7 (1F, tt, $^2J_{HF}$ = 9.0, $^3J_{FF}$ = 6.7, F–C4'), and –110.4 (2F, dd, $^2J_{HF}$ = 7.8, $^3J_{FF}$ = 6.6, F–C2') ppm; IR (ATR): $\tilde{\nu}$ = 3376br, 3071w, 2985w, 1705s, 1619s, 1604s, 1588s, 1517m, 1442m, 1403m, 1392m, 1325w, 1276w, 1233w, 1198m, 1178m, 1153m, 1075s, 998s, 931w, 852w, 813w, 756m, 684w, and 621s cm^{-1}; HR-ESI-MS: *m/z*: 387.16776 ([*M*-ClO$_4^-$]$^+$, calcd for $C_{22}H_{22}F_3N_2O^+$: 387.16787).

Synthesis of (5*S*)-2,2,3-Trimethyl-5-(*para*-fluorobenzyl)-4-imidazolidinone (4)

(2*S*,5*S*)-1-Boc-2-(*tert*-butyl)-3-methyl-5-(*para*-fluoro)benzyl-4-imidazolidinone (19)[6]

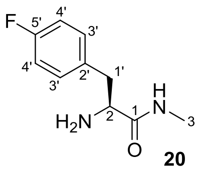


19

A solution of (*S*)-Boc-BMI (**14**) (570 mg, 2.22 mmol, 1.0 equiv.) in dry THF (3.00 mL) in a flame-dried Schlenck under an atmosphere of argon was cooled to –78 °C. LDA (2.0 N in THF/^{n}heptane/ethylbenzene, 1.22 mL, 2.44 mmol, 1.1 equiv.) was added dropwise and the solution stirred for 30 min before 4-fluorobenzylbromide (420 mg, 2.22 mmol, 1.0 equiv.) in THF (1.00 mL) was added slowly. After 4 h, the reaction was quenched by addition of a sat. aqueous solution of NH_4Cl (2 mL), diluted with water (3 mL) and extracted with CH_2Cl_2 (3 x 5 mL). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. Purification by CC (SiO_2; CH/EtOAc 8:1) gave **19** as a white solid (667 mg, 82%).

R_f = 0.49 (SiO_2; hexane/EtOAc 2:1); M.p. = 126.8 °C decomp.; $[\alpha]_D^{20}$: +26.8 (*c* = 0.91, CH_3OH); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.12 (2H, dd, *J* = 8.2, 5.8, H–C3'), 6.87 (2H, t, *J* = 8.7, H–C4'), 4.54 (1H, b, H–C2), 4.29 (1H, s, H–C5), 3.81 (1H, b, H–C1'), 3.15 (1H, dd, *J* = 14.1, 2.2, H–C1'), 2.78 (3H, b, H–C8), 1.49 (9H, s, H–C4''), and 0.91 (9H, s, H–C7) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 171.4 (C4), 162.0 (d, $^1J_{CF}$ = 252.4, C5'), 152.7 (C1''), 131.8 (C2´), 131.6 (2C, d, $^3J_{CF}$ = 3.1, C3'), 114.8 (2C, d, $^2J_{CF}$ = 20.9, C4'), 81.2 (C3''), 81.2 (C2), 60.8 (C5), 41.0 (C6), 32.8 (C1'), 31.9 (C8), 28.4 (C4''), and 26.7 (C7) ppm; ^{19}F NMR (282 MHz, $CDCl_3$): δ = –116.55 (1F, b, F–C5') ppm; IR (ATR): $\tilde{\nu}$ = 2975w, 2933w, 1694s, 1602w, 1512w, 1478w, 1457w, 1440w, 1400m, 1377s, 1364s, 1302m, 1258m, 1236w, 1216m, 1179m, 1160m, 1116s, 1098w, 1934w, 1010w, 981w, 948w, 886m, 867w, 841w, 822w, 786m, 770m, 717m, and 705w cm^{-1}; HR-ESI-MS: *m/z* (%): 387.2059 ([*M*–Na]$^+$, calcd for $C_{20}H_{29}FN_2O_3Na^+$: 387.2060). Analytical data in agreement with the literature.[6]

L-(*para*-Fluoro)-phenylalanine *N*-methyl amide (20)

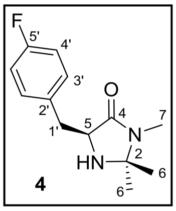


20

To a solution of **19** (575 mg, 1.58 mmol, 1.0 equiv.) in MeOH (15.0 mL) was added an aqueous solution of HCl (1 N, 15.0 mL) at RT and the mixture heated to reflux for 10 h. The reaction was allowed to come to RT and basified to a pH of 10 with an aqueous solution of NaOH (2 N) and extracted with CH_2Cl_2 (3·20.0 mL). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo* to give amide **20** as a white solid (290 mg, 94%).

M.p. = 133.7–134.5 °C; $[\alpha]_D^{23}$: +28.1 (*c* = 1.04, CH_3OH); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.23 (1H, b, H–N^{amide}), 7.16 (2H, dd, *J* = 8.6, 5.5, H–C3'), 6.98 (2H, t, *J* = 8.7, H–C4'), 3.56 (1H, dd, J = 9.1, 4.1, H–C2), 3.20 (1H, dd, J = 13.8, 4.0, H–C1'), 2.79 (3H, d, J = 5.0, H–C3), 2.69 (1H, dd, J = 13.8, 9.1, H–C1'), and 1.32 (2H, b, H–N$^{\text{amine}}$) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 174.7 (C1), 161.9 (d, $^{1}J_{CF}$ = 244.9, C5'), 133.7 (d, $^{4}J_{CF}$ = 3.3, C2'), 130.8 (2C, d, $^{3}J_{CF}$ = 7.9, C3'), 115.6 (2C, d, $^{2}J_{CF}$ = 21.2, C4'), 56.5 (d, $^{5}J_{CF}$ = 0.7, C1'), 40.3 (C2), and 25.9 (C3) ppm; ^{19}F NMR (382 MHz, $CDCl_3$): δ = –116.20 (1F, tt, $^{3}J_{HF}$ = 8.7, $^{4}J_{HF}$ = 5.4, F–C4´) ppm; IR (ATR): $\tilde{\nu}$ = 3375w, 3300m, 2943w, 1637s, 1600m, 1530m, 1507s, 1443w, 1406m, 1339w, 1311w, 1272w, 1222s, 1154m, 1110m, 1093m, 1016w, 983w, 927w, 884w, 867w, 816s, 797m, 751m, 710w, 693m, and 658w cm^{-1}; HR-ESI-MS: *m*/*z*: 197.1085 ([*M*+H]$^+$, calcd for $C_{10}H_{14}FN_2O^+$: 197.1085).

(5*S*)-2,2,3-Trimethyl-5-(*para*-fluorobenzyl)-4-imidazolidinone (4)



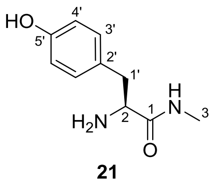
4

To a solution of amide **20** (141 mg, 0.72 mmol, 1.0 equiv.) in MeOH (4.00 mL) were added aceton (0.40 mL, 5.33 mmol, 7.5 equiv.) and NEt_3 (0.08 mL, 0.58 mmol, 0.8 equiv.) at RT under an atmosphere argon and the solution heated to reflux for 8 h. The reaction was allowed to come to RT and concentrated *in vacuo* to give imidazolidinone **4** as an orange sticky solid (172 mg, quant.).

$[\alpha]_D^{23}$: –44.0 (c = 0.50, CH_3OH); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.12 (2H, dd, J = 8.6, 5.5, H–C3'), 6.89 (2H, t, J = 8.7, H–C4'), 3.68 (1H, dd, J = 6.7, 4.6, H–C5), 3.02 (1H, dd, J = 14.2, 4.4, H–C1'), 2.87 (1H, dd, J = 14.2, 6.8, H–C1'), 2.66 (3H, s, H–C7), 1.71 (1H, b, H–N), 1.19 (3H, s, H–C6), and 1.10 (3H, s, H–C6) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 173.1 (C4), 161.7 (d, $^{1}J_{CF}$ = 244.7, C5'), 132.9 (d, $^{4}J_{CF}$ = 3.2, C2'), 130.9 (2C, d, $^{3}J_{CF}$ = 7.8, C3'), 115.2 (2C, d, $^{2}J_{CF}$ = 21.1, C4'), 75.5 (C2), 59.2 (C5), 36.4 (C1'), 27.2 (C6), 25.2 (C6), and 25.1 (C7) ppm; 19F NMR (75 MHz, $CDCl_3$): δ = –116.28 (1F, s, F–C4´) ppm; IR (ATR): $\tilde{\nu}$ = 3315w, 2978w, 2927w, 1683s, 1602w, 1509s, 1426m, 1399s, 1220s, 1158m, 1098w, 1017w, 824m, and 722w cm^{-1}; HR-ESI-MS: *m*/*z*: 237.1398 ([*M*+H]$^+$, calcd for $C_{13}H_{18}FN_2O^+$: 237.1398).

Syntheses of (5*S*)-5-*para*-Hydroxybenzyl-2,2,3-trimethyl-4-imidazolidinone (5) and 5-(4'-Hydroxybenzyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium salt (5a)

L-Tyrosine methyl amide (21)

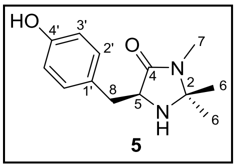


21

To *L*-tyrosine (1.00 g, 5.52 mmol, 1.0 equiv.) in EtOH (3.4 mL, 82.8 mmol, 15 equiv.) was added thionyl chloride (0.6 mL, 8.28 mmol, 1.5 equiv.) over 5 min at 0 °C and the resulting solution was allowed to come to RT before it was heated to reflux for 8 h. The solution was allowed to come to RT and evaporated *in vacuo* to give the *L*-tyrosine ethyl ester hydrochloride as a white powder. To the ester was added $MeNH_2$ (8 N in EtOH, 2.80 mL, 22.1 mmol, 4.0 equiv.) at RT and the solution stirred overnight. After evaporation *in vacuo*, THF was added and the remaining white solid filtered off ($MeNH_2 \cdot HCl$). The filtrate was concentrated *in vacuo* to give amide **21** as an orange oil (1.09 g, quant.).

R_f = 0.21 (CH_2Cl_2/MeOH 10:1); $[\alpha]_D^{20}$: +23.2 (c = 1.02, CH_3OH); ^{1}H NMR (300 MHz, CD_3OD): δ = 7.00 (2H, d, J = 8.5, H–C3'), 6.71 (2H, d, J = 8.6, H–C4'), 3.44 (1H, t, J = 6.8, H–C2), 2.87 (1H, dd, J = 13.4, 6.5, H–C1'), 2.71 (1H, dd, J = 13.4, 7.1, H–C1'), and 2.67 (3H, s, H–C3) ppm; ^{13}C NMR (75 MHz, CD_3OD): δ = 177.1 (C1), 157.4 (C5'), 131.3 (2C, C3'), 129.3 (C2'), 116.3 (2C, C4'), 57.9 (C2), 41.6 (C1'), and 26.1 (C3) ppm; IR (ATR): $\tilde{\nu}$ = 3275b, 2939w, 1644s, 1612s, 1592s, 1540m, 1513s, 1447m, 1410m, 1309w, 1234s, 1170m, 1105w, 1022w, 942w, 821s, and 696w cm^{-1}; HR-ESI-MS: *m/z*: 195.1133 ($[M+H]^+$, calculated for $C_{10}H_{15}N_2O_2^+$: 195.1128); analytical data in agreement with the literature.[7]

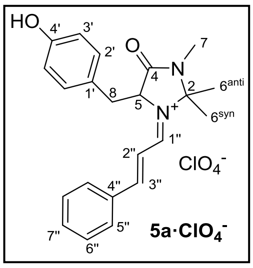
(5*S*)-5-*para*-hydroxybenzyl-2,2,3-trimethyl-4-imidazolidinone (5)



To a solution of amide **21** (985 mg, 5.07 mmol, 1.0 equiv.) in MeOH (10.0 mL) was added acetone (1.9 mL, 25.4 mmol, 5.0 equiv.) at RT under an atmosphere of argon and the yellow solution was heated to reflux overnight. The reaction was allowed to come to RT and concentrated *in vacuo* to give imidazolidinone **5** as an off-white solid (1.15 g, 97%).

R_f = 0.64 (CH_2Cl_2/MeOH 10:1); M.p. = 94.5–95.8 °C; $[\alpha]_D^{20.5}$: –57.0 (c = 1.00, CH_3OH); ^{1}H NMR (300 MHz, CD_3OD): δ = 7.06 (2H, d, J = 8.5, H–C2'), 6.72 (2H, d, J = 8.6, H–C3'), 3.73 (1H, dd, J = 6.8, 4.4, H–C5), 3.00 (1H, dd, J = 14.3, 4.3, H–C8), 2.85 (1H, dd, J = 14.3, 7.1, H–C8), 2.75 (3H, d, J = 0.4, H–C7), 1.26 (3H, s, H–C6), and 1.20 (3H, s, H–C6) ppm; ^{13}C NMR (101 MHz, CD_3OD): δ = 175.5 (C4), 157.4 (C4'), 131.5 (2C, C2'), 129.0 (C1'), 116.3 (2C, C3'), 77.4 (C2), 60.9 (C5), 37.0 (C8), 26.8 (C6), 25.6 (C7), and 24.8 (C6) ppm; IR (ATR): $\tilde{\nu}$ = 3276w, 2974w, 2939w, 1661s, 1479w, 1447m, 1427m, 1400s, 1384s, 1370s, 1331w, 1262m, 1243m, 1210w, 1147s, 1076m, 1037m, 1004w, 993w, 936s, 916m, 847s, and 757s cm^{-1}; HR-ESI-MS: *m/z* (%): 235.1444 ($[M+H]^+$, calculated for $C_{13}H_{19}N_2O_2^+$: 235.1441); analytical data in agreement with the literature.[8]

5-(4'-Hydroxybenzyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium perchlorate ($5a\cdot ClO_4^-$)[3]



To imidazolidinone **5** (37.5 mg, 0.16 mmol, 1 equiv.) in Et_2O (0.20 mL) was added perchloric acid (60% in H_2O, 26.80 mg, 0.16 mmol, 1 equiv.) in EtOH/Et_2O (1:1, 0.40 mL) at RT and the resulting mixture stirred for 10 min before it was evaporated *in vacuo* to give the imidazolidinone salt. The salt was dissolved in MeOH (0.40 mL) and heated to 35 °C. (*E*)-cinnamaldehyde (40.2 µL, 0.32 mmol, 2 equiv.) was added and the yellow solution stirred for 1 h. The solvent was removed *in vacuo* and the residue dissolved in a minimum amount of MeOH. From this solution the iminium salt was crashed out with Et_2O and the supernatant solution taken off. The washing procedure was repeated and the iminium salt $\mathbf{5a\cdot ClO_4^-}$ isolated as a yellow solid (50.3 mg, 70%).

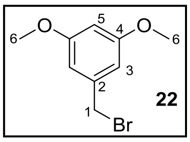
Crystals suitable for X-ray crystallographic analysis were obtained from a solution in CH_3CN by vapor diffusion with Et_2O.

M.p. = 117.3 °C decomp.; ^{1}H NMR (600 MHz, CD_3CN): δ_H = 8.71 (1H, dd, J = 10.7, 1.9, H–C1''), 8.14 (1H, d, J = 15.0, H–C3''), 7.90 (2H, dd, J = 8.4, 1.1, H–C5''), 7.73–7.69 (1H, m, H–C7''), 7.63–7.59 (2H, m, H–C6''), 7.23 (1H, dd, J = 15.0, 10.7, H–C2''), 6.92 (2H, d, J = 8.5, H–C2'), 6.72 (2H, d, J = 8.6, H–C3'), 5.13 (1H, t, J = 4.8, H–C5), 3.49 (1H, dd, J = 14.9, 5.6, H–C8), 3.36 (1H, dd, J = 14.9, 4.0, H–C8), 2.80 (3H, d, J = 0.5, H–C7), 1.71 (3H, s, H–$C6^{anti}$), and 0.93 (3H, s, H–$C6^{syn}$) ppm; ^{13}C NMR (151 MHz, CD_3CN): δ_C = 168.0 (C1''), 166.3 (C3''), 165.4 (C4), 158.0 (C4'), 136.0 (C7''), 134.4 (C4''), 132.4 (2C, C5''), 132.4

(2C, C2'), 130.7 (2C, C6''), 125.6 (C1'), 118.5 (C2''), 116.8 (2C, C3'), 86.6 (C2), 65.4 (C5), 36.7 (C8), 27.5 (C6^{anti}), 26.1 (C7), and 25.1 (C6^{syn}) ppm; IR (ATR): $\tilde{\nu}$ = 3370br, 3070w, 2985w, 1704s, 1603s, 1588s, 1517m, 1441m, 1403m, 1392m, 1325w, 1276w, 1233w, 1199m, 1178m, 1153m, 1076s, 999s, 931w, 852w, 813w, 756m, 726s, 684w, and 621s cm^{-1}; HR-ESI-MS: *m*/*z*: 349.19106 ([*M*-ClO_4^-]$^+$, calcd for $C_{22}H_{25}N_2O_2^+$: 349.19105).

Syntheses of (5*S*)-2,2,3-Trimethyl-5-(3,5-dimethoxybenzyl)imidazolidin-4-one (6) and 5-(3',3'-Dimethoxybenzyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium salt (6a)

1-Bromomethyl-3,5-dimethoxybenzene 22[9]

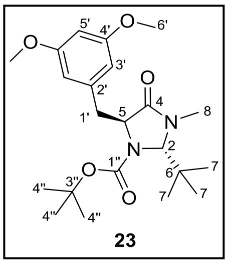


22

To a solution of 3,5-dimethoxybenzyl alcohol (500m g, 2.97 mmol, 1.00 equiv.) in Et_2O (14 mL) were added successively PBr_3 (0.28 mL, 2.97 mmol, 1.00 equiv.) and pyridine (12 µL, 0.15 mmol, 0.05 equiv.) slowly at RT. The mixture was heated to 40 °C and after completion was detected by TLC (2 h), it was allowed to cool to RT. H_2O (20 mL) was added slowly and the aqueous layer extracted Et_2O (3·15 mL). The combined organic layers were washed with H_2O and brine and dried over $MgSO_4$. Concentration *in vacuo* gave 1-bromomethyl-3,5-dimethoxybenzene (**22**) as a white crystalline solid (625 mg, 91%), which should be kept in the freezer (turns first orange then brown at RT).

R$_f$ = 0.88 (CH/EtOAc 1:1); M.p. = 71.2–71.8 °C; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.55 (2H, d, *J* = 2.3, H–C3), 6.41 (1H, d, *J* = 2.3, H–C5), 4.42 (2H, s, H–C1), and 3.79 (6H, s, H-C6) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 161.0 (2C, C4), 139.8 (C2), 107.0 (2C, C3), 100.6 (C5), 55.4 (2C, C6), and 33.7 (C1) ppm; HR-EI-MS: *m*/*z*: 151.0758 ([*M*-Br$^-$]$^+$, calcd for $C_9H_{11}O_2^+$: 151.0759); analytical data in agreement with the literature.[9]

(2*S*,5*S*)-1-Boc-2-(*tert*-butyl)-3-methyl-5-(3,5-dimethoxybenzyl)-4-imidazolidinone (23)[5]

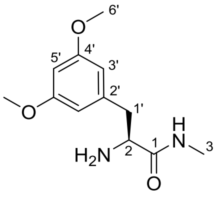


23

A solution of HMDS (0.3 mL, 1.42 mmol, 1.2 equiv.) in dry THF (1.00 mL) in a flame-dried Schlenck under an atmosphere of argon was cooled to 0 °C. ^{n}BuLi (1.6 N in ^{n}hexane, 0.9 mL, 1.42 mmol, 1.2 equiv.) was added dropwise and the solution stirred for 15 min before it was cooled to -78 °C. DMPU (0.43 mL, 3.54 mmol, 3.0 equiv.) and then (*S*)-Boc-BMI (**14**) (300 g, 1.18 mmol, 1.0 equiv.) in THF (1.00 mL) was added dropwise, the solution turned yellow during the addition. After 30 min, 1-bromomethyl-3,5-dimethoxybenzene **22** (273 g, 1.18 mmol, 1.0 equiv.) in THF (1.00 mL) was added slowly and the resulting mixture stirred for 5 h. The reaction was quenched by addition of a saturated aqueous solution of $NaHCO_3$ (4 mL) and extracted with CH_2Cl_2 (3·5 mL). The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. Purification by CC (SiO_2; CH/EtOAc 3:1) gave **23** as a colourless oil (352 mg, 73%).

R$_f$ = 0.53 (CH/EtOAc 1:1); $[\alpha]_D^{20}$: +40.0 (*c* = 1.00, CH_3OH); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.31 (2H, s, H–C3'), 6.27 (1H, bt, *J* = 2.1, H–C5'), 4.63 (1H, bs, H–C2), 4.27 (1H, bs, H–C5), 3.71 (6H, s, H–C6'), 3.66 (1H, bs, H–C1'), 3.13 (1H, dd, *J* = 14.2, 1.2, H–C1'), 2.81 (s, 3H, H–C8), 1.47 (s, 9H, H–C4'), and 0.91 (s, 9H, H–C7) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 171.5 (C4), 160.3 (2C, C4'), 152.8 (C1''), 138.0 (C2'), 108.0 (b, 2C, C3'), 99.0 (b, C5'), 81.0 (C2), 81.0 (C3''), 60.5 (C5), 55.3 (2C, C6'), 40.9 (C6), 34.4 (b, C1'), 31.9 (C8), 28.3 (3C, C4'), and 26.6 (3C, C7) ppm; IR (ATR): $\tilde{\nu}$ = 2966w, 2838w, 1698s, 1595s, 1457m, 1431m, 1407m, 1397s, 1366s, 1312w, 1251m, 1204m, 1151s, 1127s, 1067m, 1033w, 960w, 887w, 862w, 774w, 755w, 736w, and 696w cm^{-1}; HR-ESI-MS: *m*/*z*: 407.2542 ([*M*+H]$^+$, calcd for $C_{22}H_{35}N_2O_5^+$: 407.2540).

L-3,5-Dimethoxyphenylalanine *N*-methyl amide (24)[10]

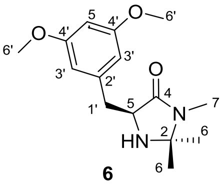


24

To a solution of **23** (300 mg, 0.74 mmol, 1.0 equiv.) in MeOH (7.0 mL) was added an aqueous solution of HCl (1 N, 7.0 mL) at RT and the mixture heated to reflux for 8 h. The reaction was allowed to come to RT and basified to a pH of 10 with an aqueous solution of NaOH (2 N, circa 4 mL) and extracted three times with CH_2Cl_2. The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo* to give amide **24** as a white solid (175 mg, 99%).

M.p. = 61.7–63.6 °C; $[\alpha]_D^{23}$: +15.1 (*c* = 0.60, CH_3OH); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.33 (1H, bd, *J* = 5.5, H–N^{amide}), 6.34 (2H, s, H–C3'), 6.31 (1H, s, H–C5'), 3.74 (6H, d, *J* = 1.2, H–C6'), 3.56 (1H, dd, *J* = 9.7, 3.9, H–C2), 3.19 (1H, dd, *J* = 13.6, 3.9, H–C1'), 2.79 (3H, d, *J* = 5.0, H–C3), 2.56 (1H, dd, *J* = 13.6, 9.6, H–C1'), and 1.45 (2H, bs, H–N^{amine}) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 174.9 (C1), 161.0 (2C, C4´), 140.4 (C2'), 107.2 (2C, C3'), 98.8 (C5'), 56.4 (C2), 55.4 (2C, C6'), 41.4 (C1'), and 25.9 (C3) ppm; IR (ATR): $\tilde{\nu}$ = 3379w, 3314w, 2958w, 2935w, 2865w, 1636m, 1595s, 1524m, 1463m, 1446m, 1428m, 1400m, 1346m, 1332w, 1291m, 1205s, 1147s, 1147s, 1097w, 1081w, 1057s, 994w, 955w, 907w, 877w, 838w, 822m, 786w, 742m, 690m, and 657w cm^{-1}; HR-ESI-MS: *m*/*z*: 239.1397 ([*M*+H]$^+$, calcd for $C_{12}H_{19}N_2O_3^+$: 239.1390).

(5*S*)-2,2,3-Trimethyl-5-(3,4,5-trimethoxybenzyl)imidazolidin-4-one (6)

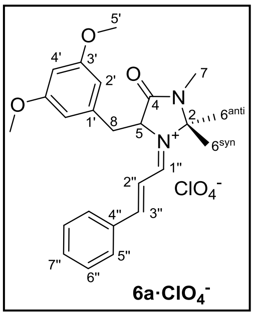


6

To a solution of amide **24** (100 mg, 0.42 mmol, 1.0 equiv.) in MeOH (2.0 mL) were added aceton (0.23 mL, 3.15 mmol, 7.5 equiv.) and NEt_3 (47 µL, 0.34 mmol, 0.8 equiv.) at RT under an atmosphere argon and the solution heated to reflux for 6 h. The reaction was allowed to come to RT and concentrated *in vacuo* to give imidazolidinone **6** as a yellow oil (122 mg, quant.).

$[\alpha]_D^{23}$: –39.3 (*c* = 1.02, CH_3OH); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.37 (2H, d, *J* = 2.3, H–C3'), 6.31 (1H, d, *J* = 2.3, H–C5'), 3.73 (7H, m, H–C5, H–C6'), 3.06 (1H, dd, *J* = 14.1, 4.5, H–C1'), 2.91 (1H, dd, *J* = 14.0, 6.9, H–C1'), 2.74 (3H, s, H–C7), 1.24 (3H, s, H–C6), and 1.18 (3H, s, H–C6) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 173.5 (C4), 160.9 (2C, C4'), 139.6 (C2'), 107.4 (2C, C3'), 99.0 (C5'), 75.6 (C2), 59.2 (C5), 55.4 (2C, C6'), 37.7 (C1'), 27.4 (C6), 25.4 (C6), and 25.3 (C7) ppm; IR (ATR): $\tilde{\nu}$ = 2933w, 2839w, 1684s, 1595s, 1461m, 1429s, 1398m, 1368w, 1315w, 1294w, 1205s, 1151s, 1066m, 931w, 832w, and 698w cm^{-1}; HR-ESI-MS: *m*/*z*: 279.1708 ([*M*+H]$^+$, calcd for $C_{15}H_{23}N_2O_3^+$: 279.1703).

5-(3',3'-Dimethoxybenzyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium perchlorate (**6a·ClO$_4^-$**):

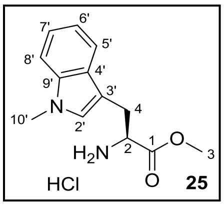


To racemic imidazolidinone **6** (3.3 mg, 12 µmol, 1.0 equiv.) in Et_2O (20 µL) was added $HClO_4$ (70% in H_2O, 1.7 mg, 12 µmol, 1.0 equiv.) in EtOH/Et_2O (1:1, 40 µL) at RT and stirred for 10 min, before the yellow solution was evaporated *in vacuo* to give the off-white $HClO_4$ salt as a solid. The solid was dissolved in MeOH (20 µL) and (*E*)-cinnamaldehyde (3.0 µL, 24 µmol, 2.0 equiv.) was added at 35 °C and the yellow solution stirred for 1 h. The solvent was evaporated *in vacuo*. The residue was dissolved in a minimum amount of MeOH, the iminium salt was crashed out with Et_2O and the supernatant solution taken off. The iminium salt **6a·ClO$_4^-$** was isolated as a yellowish solid contaminated with (*E*)-cinnamaldehyde (P/(*E*)-cinnamaldehyde 1:1.3).

^{1}H NMR (300 MHz, CD_3CN): δ_H = 8.73 (1H, dd, *J* = 10.7, 1.7, H–C1''), 8.10 (1H, d, *J* = 14.8, H–C3''), 7.88–7.82 (2H, m, H–C5''), 7.72–7.58 (3H, m, H–C7'', H–C6''), 7.11 (1H, dd, *J* = 15.1, 10.6, H–C2''), 6.34–6.27 (3H, m, H–C2', H–C4'), 5.16 (1H, b, H–C5), 3.67 (6H, s, H–C5'), 3.50 (1H, dd, *J* = 14.5, 5.3, H–C8), 3.30 (1H, dd, *J* = 14.5, 5.1, H–C8), 2.84 (3H, d, *J* = 0.7, H–C7), 1.74 (3H, s, H–C6^{anti}), and 1.13 (3H, s, H–C6^{syn}) ppm; HR-ESI-MS: *m*/*z*: 393.2170 ([*M*–ClO_4^-]$^+$, calcd for $C_{24}H_{29}N_2O_3^+$: 393.2173).

Syntheses of (*S*)-5-(1-Methylindol-3-ylmethyl)-2,2,3-trimethylimidazolidin-4-one (7) and (*S*)-5-(1-Methylindol-3-ylmethyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium salt (7a·ClO$_4^-$)

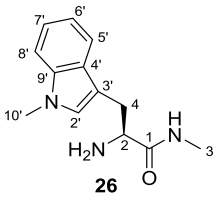
1-Methyl-L-tryptophan methyl ester (25)



To 1-methyl-L-tryptophan (500 mg, 2.29 mmol, 1.0 equiv.) in MeOH (1.86 mL, 45.8 mmol, 20 equiv.) was added thionyl chloride (0.20 mL, 2.75 mmol, 1.2 equiv.) over 10 min at 0 °C and the resulting mixture was allowed to come to RT before it was heated to reflux overnight. The solution was allowed to come to RT and evaporated *in vacuo* to give 1-methyl-L-tryptophan methyl ester hydrochloride (**25**) as an off-white solid (615 mg, quant.).

M.p. = 197.6–198.4 °C; $[\alpha]_D^{23}$: +14.5 (*c* = 0.89, CH_3OH); ^{1}H NMR (300 MHz, CD_3OD): δ = 7.54 (1H, dt, *J* = 7.9, 1.0, H–C5'), 7.39 (1H, dt, *J* = 8.3, 0.8, H–C8'), 7.21 (1H, ddd, *J* = 8.2, 7.1, 1.1, H–C7'), 7.14–7.07 (2H, m, H–C6', H–C2'), 4.32 (1H, dd, *J* = 7.3, 5.5, H–C2), 3.80 (6H, s, H–C3, H–C10'), 3.45 (1H, ddd, *J* = 15.1, 5.5, 0.6, H–C4), and 3.36 (1H, dd, *J* = 9.6, 5.6, H–C4) ppm; ^{13}C NMR (75 MHz, CD_3OD): δ = 170.8 (C1), 138.8 (C9'), 129.9 (C2'), 128.7 (C4'), 123.1 (C7'), 120.4 (C6'), 119.1 (C5'), 110.7 (C8'), 106.8 (C3'), 54.6 (C2), 53.7 (C3), 32.9 (C10'), and 27.4 (C4) ppm; IR (ATR): $\tilde{\nu}$ = 3009w, 2837m, 2637w, 2010w, 1746s, 1613w, 1575w, 1542w, 1505m, 1474m, 1445m, 1377w, 1359w, 1327w, 1284w, 1251w, 1228s, 1186w, 1159w, 1123w, 1074m, 1047w, 1011w, 9909w, 945w, 919w, 890w, 864w, 833w, 739m, 727s, and 657w cm^{-1}; HR-ESI-MS: *m*/*z*: 233.1283 ([*M*–Cl]$^+$, calcd for $C_{13}H_{17}N_2O_2^+$: 233.1285); analytical data in agreement with the literature.[11]

1-Methyl-L-tryptophan methyl amide (26)

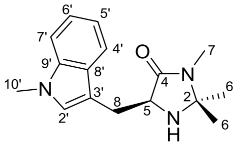


26

To 1-methyl-L-tryptophan methyl ester **25** (584 mg, 2.17 mmol, 1.0 equiv.) was added MeNH$_2$ (8 N in EtOH, 1.10 mL, 8.70 mmol, 4.0 equiv.) at RT and the solution stirred overnight. After evaporation *in vacuo*, the crude product was dissolved in a saturated aqueous solution of NaHCO$_3$ (20 mL) and CHCl$_3$ (15 mL), the aqueous layer was extracted twice with CHCl$_3$ (2 · 15 mL), the combined organic layers were dried over MgSO$_4$ and concentrated *in vacuo* to give amide **26** as a sticky oil (502 mg, quant.).

$[\alpha]_D^{23}$: +6.7 (c = 0.95, CH$_3$OH); ^{1}H NMR (300 MHz, CDCl3): δ = 7.67 (1H, dt, *J* = 7.9, 1.1, H–C5'), 7.31 (1H, dt, *J* = 8.2, 1.2, H–C8'), 7.23 (1H, dd, *J* = 8.2, 1.1, H–C7'), 7.12 (1H, ddd, *J* = 8.0, 6.8, 1.2, H–C6'), 6.92 (1H, s, H–C2'), 3.76 (3H, s, H–C10'), 3.70 (1H, dd, *J* = 8.9, 4.1, H–C2), 3.38 (1H, ddd, *J* = 14.4, 4.1, 0.6, H–C4), 2.90 (1H, dd, *J* = 14.4, 9.0, H–C4), 2.81 (3H, d, *J* = 5.0, H–C3), and 1.46 (2H, bs, H–N$^{\text{amine}}$) ppm; ^{13}C NMR (75 MHz, CD$_3$OD): δ = 175.4 (C1), 137.2 (C9'), 128.1 (C4'), 127.9 (C2'), 121.9 (C7'), 119.2 (2C, C5', C6'), 110.3 (C3'), 109.4 (C8'), 55.8 (C2), 32.8 (C10'), 30.7 (C3), and 25.9 (C4) ppm; IR (ATR): $\tilde{\nu}$ = 3300w, 3052w, 2934w, 1652s, 1532m, 1471m, 1409w, 1375w, 1326m, 1250w, 1156w, 1130w, 1012w, 909w, 846w, and 735s cm^{-1}; HR-ESI-MS: *m*/*z*: 232.1445 ([*M*+H]$^+$, calcd for C$_{13}$H$_{18}$N$_3$O$^+$: 232.1444).

(*S*)-5-(1-Methylindol-3-ylmethyl)-2,2,3-trimethylimidazolidin-4-one (7):

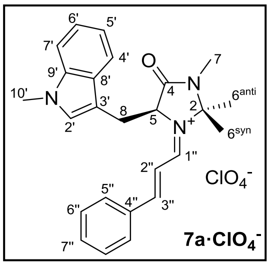


7

To a solution of amide **26** (502 mg, 2.17 mmol, 1.0 equiv.) in MeOH (10.0 mL) was added acetone (1.20 mL, 16.3 mmol, 7.5 equiv.) and NEt$_3$ (0.24 mL, 1.74 mmol, 0.8 equiv.) at RT under an atmosphere of argon and the yellow solution was heated to reflux overnight. The reaction was allowed to come to RT and concentrated *in vacuo*. Purification by CC (SiO$_2$; CH$_2$Cl$_2$/MeOH/NH$_3$ (25% in H$_2$O) 20:1:0.2) gave imidazolidinone **7** as a yellow oil (484 mg, 82%).

R_f = 0.46 (CH$_2$Cl$_2$/MeOH 10:1); $[\alpha]_D^{23}$: –37.8 (*c* = 0.31, CH$_3$OH); ^{1}H NMR (600 MHz, CDCl$_3$): δ = 7.64 (1H, dt, *J* = 7.8, 0.9, H–C4'), 7.27 (1H, dt, *J* = 8.2, 0.9, H–C7'), 7.21 (1H, ddd, *J* = 8.2, 7.0, 1.1, H–C6'), 7.10 (1H, ddd, *J* = 8.0, 7.0, 1.0, H–C5'), 6.95 (1H, s, H–C2'), 3.82 (1H, ddd, *J* = 5.9, 4.7, 0.5, H–C5), 3.73 (3H, s, H–C10'), 3.32 (1H, ddd, *J* = 15.1, 4.6, 0.7, H–C8), 3.17 (1H, ddd, *J* = 15.1, 6.1, 0.7, H–C8), 2.73 (3H, d, *J* = 0.6, H–C7), 1.25 (3H, s, H–C6), and 1.09 (3H, s, H–C6) ppm; ^{13}C NMR (151 MHz, CDCl$_3$): δ = 174.1 (C4), 136.9 (C9'), 128.4 (C8'), 128.0 (C2'), 121.6 (C6'), 119.1 (C5'), 119.0 (C4'), 109.1 (C7'), 109.0 (C3'), 75.4 (C2), 59.1 (C5), 32.7 (b, C10'), 27.0 (C6), 26.3 (C8), 25.2 (C7), and 25.1 (C6) ppm; IR (ATR): $\tilde{\nu}$ = 3295b, 2921w, 2239w, 1682s, 1615w, 1526w, 1472m, 1425m, 1397m, 1379m, 1327w, 1253w, 1205w, 1150w, 1086w, 1013w, 921w, 799w, and 738s cm^{-1}; HR-ESI-MS: *m*/*z*: 272.1763 ([*M*+H]$^+$, calcd for C$_{16}$H$_{22}$N$_3$O$^+$: 272.1757).

(*S*)-5-(1-Methylindol-3-ylmethyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium perchlorate ($\mathbf{7a\cdot ClO_4^-}$):[3]



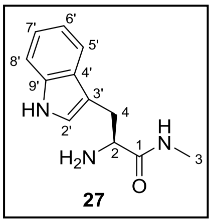
7a·ClO$_4^-$

To imidazolidinone **7** (43.4 mg, 0.16 mmol, 1.0 equiv.) in Et_2O (0.2 mL) was added $HClO_4$ (60% in H_2O, 26.8 mg, 0.16 mmol, 1.0 equiv.) in EtOH/Et_2O (1:1, 0.4 mL) at RT and stirred for 10 min, before the solution was evaporated *in vacuo* to give the $HClO_4$ salt as a solid. The solid was dissolved in MeOH (0.4 mL) and (*E*)-cinnamaldehyde (40.2 µL, 0.32 mmol, 2.0 equiv.) was added at 35 °C and the solution stirred for 1 h. The solvent was evaporated *in vacuo*. The residue was dissolved in a minimum amount of MeOH, the iminium salt was crashed out with Et_2O and the supernatant solution taken off. This purification procedure was repeated two additional times to give iminium salt $\mathbf{7a\cdot ClO_4^-}$ as a red solid.

M.p. = 137.8 °C decomp.; $[\alpha]_D^{20} = +195.3$ ($c = 0.43$ in CD_3CN); ^{1}H NMR (600 MHz, CD_3CN): δ_H = 8.67 (1H, d, J = 10.7, H–C1''), 7.94 (1H, d, J = 15.1, H–C3''), 7.66–7.62 (1H, m, H–C7''), 7.59 (1H, dt, J = 8.0, 0.9, H–C4'), 7.50 (2H, t, J = 7.8, H–C6''), 7.40 (2H, dd, J = 8.2, 1.0, H–C5''), 7.24–7.18 (2H, m, H–C6', H–C7'), 7.14 (1H, ddd, J = 8.0, 6.5, 1.5, H–5'), 6.93 (1H, s, H–C2'), 6.68 (1H, dd, J = 15.0, 10.6, H–C2''), 5.08 (1H, t, J = 5.0, H–C5), 3.81 (1H, dd, J = 15.5, 5.0, H–C8), 3.59 (3H, s, H–C10'), 3.43 (1H, dd, J = 17.8, 6.6, H–C8), 2.78 (3H, d, J = 0.4, H–C7), 1.72 (3H, s, H–C6^{anti}), and 1.14 (3H, s, H–C6^{syn}) ppm; ^{13}C NMR (151 MHz, CD_3CN): δ_C = 167.7 (C1''), 166.0 (C4), 164.6 (C3''), 138.1 (C9'), 135.5 (C7''), 134.2 (C4''), 131.9 (2C, C5''), 130.8 (C2'), 130.6 (2C, C6''), 128.3 (C3'), 123.4 (C8'), 120.6 (C5'), 119.6 (C4'), 118.5 (C2''), 111.0 (C7'), 107.0 (C3'), 86.5 (C2), 64.7 (C5), 33.1 (C10'), 29.3 (C8), 27.3 (C6^{anti}), 26.1 (C7), and 25.6 (C6^{syn}) ppm; IR (ATR): $\tilde{\nu}$ = 3058w, 2939w, 1712s, 1621m, 1604m, 1589s, 1474m, 1455m, 1429m, 1390m, 1324w, 1282w, 1197m, 1180m, 1073s, 1011m, 999m, 932w, 743s, 686m, and 621s cm^{-1}; HR-ESI-MS: *m*/*z*: 386.22284 ($[M\text{-}ClO_4^-]^+$, calcd for $C_{25}H_{28}N_3O^+$: 386.22324).

Syntheses of (5*S*)-5-(Indol-3-ylmethyl)-2,2,3-trimethyl-4-imidazolidinone (8) and (*S*)-5-(Indol-3-ylmethyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium salt (8a)

L-Tryptophan methyl amide (27)

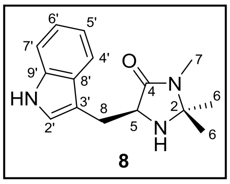


27

To *L*-tryptophan (1.00 g, 4.90 mmol, 1.0 equiv.) in MeOH (5.00 mL, 123 mmol, 25 equiv.) was added thionyl chloride (0.43 mL, 5.88 mmol, 1.2 equiv.) over 10 min at 0 °C and the resulting mixture was allowed to come to RT before it was heated to reflux for 19 h. The solution was allowed to come to RT and evaporated *in vacuo* to give the tryptophan methyl ester hydrochloride as an off-white solid. To the ester was added $MeNH_2$ (8 N in EtOH, 2.50 mL, 19.6 mmol, 4.0 equiv.) at RT and the solution stirred for 42.5 h. After evaporation *in vacuo*, the crude product was dissolved in sat. aq. solution of $NaHCO_3$ (20 mL) and $CHCl_3$, the aqueous layer was extracted with $CHCl_3$ (3·30 mL), the combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo* to give amide **27** as an orange sticky solid (868 mg, 82%).

M.p. = 96.2–99.1 °C; $[\alpha]_D^{23}$: +11.0 (c = 0.75, CH_3OH); ^{1}H NMR (400 MHz, CDCl3): δ = 8.31 (1H, b, H–N^{Ar}), 7.67 (1H, d, J = 7.6, H–C5'), 7.38 (1H, d, J = 7.9, H–C8'), 7.26 (1H, b, H–N^{amide}), 7.20 (1H, t, *J* = 7.4, H–C7'), 7.12 (1H, t, *J* = 7.2, H–C6'), 7.06 (1H, s, H–C2'), 3.72 (1H, dd, *J* = 8.4, 3.4, H–C2), 3.40 (1H, dd, *J* = 14.4, 3.2, H–C4), 2.92 (1H, dd, *J* = 14.3, 9.1, H–C4), 2.81 (3H, d, *J* = 4.4, H–C3), and 1.45 (2H, b, H–N^{amine}) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 175.59 (C1), 136.56 (C9'), 127.67 (C4'), 123.18 (C2'), 122.38 (C7'), 119.72 (C6'), 119.12 (C5'), 112.03 (C3'), 111.38 (C8'), 55.78 (C2), 30.95 (C4), and 25.97 (C3) ppm; IR (ATR): $\tilde{\nu}$ = 3274m, 2922w, 1643s, 1533s, 1456m, 1436m, 1409m, 1232w, 1158w, 1101w, 1010w, 908w, 848, and 739s cm^{-1}; HR-EI-MS: *m/z*: 218.1278 ($[M+H]^+$, calcd for $C_{12}H_{16}N_3O^+$: 218.1288); analytical data in agreement with the literature.[12]

(5*S*)-5-(Indol-3-ylmethyl)-2,2,3-trimethyl-4-imidazolidinone (8)

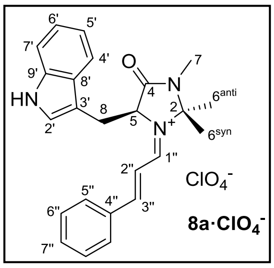


8

To a solution of amide **27** (432 mg, 2.0 mmol, 1.0 equiv.) in MeOH (8.0 mL) was added acetone (1.1 mL, 14.9 mmol, 7.5 equiv.) and NEt_3 (0.22 mL, 1.59 mmol, 0.8 equiv.) at RT under an atmosphere of argon and the yellow solution was heated to reflux overnight. The reaction was allowed to come to RT and concentrated *in vacuo* to give imidazolidinone **8** as a yellow sticky solid (516 mg, quant.).

M.p. = 109.6–110.8 °C; $[\alpha]_D^{20}$: – 66.3 (c = 0.98, CH_3OH); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.07 (1H, b, H–N^{Ar}), 7.67 (1H, d, *J* = 7.8, H–C4'), 7.36 (1H, d, *J* = 8.1, H–C7'), 7.19 (1H, dd, *J* = 7.5, 0.9, H–C6'), 7.16–7.09 (2H, m, H–C5', H–C2'), 3.85 (1H, t, *J* = 5.2, H–C5), 3.33 (1H, dd, *J* = 15.1, 4.6, H–C8), 3.21 (1H, dd, *J* = 15.0, 5.8, H–C8), 2.73 (3H, s, H–C7), 1.25 (3H, s, H–C6), and 1.07 (3H, s, H–C6) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 174.2 (C4), 136.3 (C9'), 128.1 (C8'), 123.4 (C2'), 122.3 (C6'), 119.8 (C5'), 119.1 (C4'), 111.2 (C7'), 110.9 (C3'), 75.6 (C2), 59.1 (C5), 27.1 (C6), 26.5 (C8), 25.4 (C7), and 25.3 (C6); IR (ATR): $\tilde{\nu}$ = 3262bw, 2976w, 2926w, 1668s, 1429m, 1400m, 1367w, 1339w, 1257w, 1208w, 1185w, 1148w, 1090w, 1010w, 923w, 878w, 796w, and 739s cm^{-1}; HR-ESI-MS: *m/z*: 258.1597 ($[M+H]^+$, calcd for $C_{15}H_{20}N_3O^+$: 258.1601).

(*S*)-5-(Indol-3-ylmethyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium perchlorate (8a·ClO_4^-)



8a·ClO_4^-

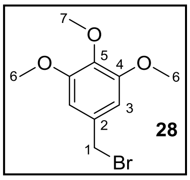
To imidazolidinone **8** (20.3 mg, 0.08 mmol, 1.0 equiv.) in Et_2O (0.1 mL) was added $HClO_4$ (70% in H_2O, 11.5 mg, 0.08 mmol, 1.0 equiv.) in EtOH/Et_2O (1:1, 0.2 mL) at RT and stirred for 10 min, before the solution was evaporated *in vacuo* to give the $HClO_4$ salt as a solid. The solid was dissolved in MeOH (0.2 mL) and (*E*)-cinnamaldehyde (20.1 µL, 0.16 mmol, 2.0 equiv.) was added at 35 °C and the solution stirred for 1 h. The solvent was evaporated *in vacuo*. The residue was dissolved in a minimum amount of MeOH, the iminium salt was crashed out with Et_2O and the supernatant solution taken off. This purification procedure was repeated two additional times to give iminium salt **8a·ClO_4^-** as a red solid.

M.p. = 135.1 °C decomp.; $[\alpha]_D^{23}$ = +522.9 (*c* = 0.77 in CH_3CN); ^{1}H NMR (400 MHz, CD_3CN): δ = 9.30 (1H, bs, H–N^{Ar}), 8.65 (1H, dd, *J* = 10.7, 1.8, H–C1''), 7.95 (1H, d, *J* = 15.1, H–C3''), 7.67–7.57 (2H, m, H–C7'', H–C4'), 7.50 (2H, t, *J* = 7.8, H–C6''), 7.43 (2H, d, *J* = 7.4, H–C5''), 7.29 (1H, d, *J* = 8.0, H–7'), 7.21–7.10 (2H, m, H–C6', H–C5'), 7.00 (1H, d, *J* = 2.5, H–2'), 6.78 (1H, dd, *J* = 15.0, 10.7, H–C2''), 5.11 (1H, t, *J* = 5.0, H–C5), 3.83 (1H, dd, *J* = 15.4, 5.1, H^{si}–C8), 3.47 (1H, dd, *J* = 15.4, 6.0, H^{re}–C8), 2.78 (3H, s, H–C7), 1.71 (3H, s, H–

C6^{anti}), and 1.07 (3H, s, H–C6^{syn}) ppm; ^{13}C NMR (151 MHz, CD_3CN): δ = 167.7 (C1''), 166.0 (C4), 164.9 (C3''), 137.5 (C9'), 135.6 (C7''), 134.2 (C4''), 132.0 (2C, C5''), 130.6 (2C, C6''), 127.9 (C8'), 126.7 (C2'), 123.5 (C7'), 120.8 (C5'), 119.4 (C4'), 118.3 (C2''), 112.9 (C7'), 108.0 (C3'), 86.5 (C2), 64.6 (C5), 29.3 (C8), 27.3 (C6^{anti}), 26.1 (C7), and 25.5 (C6^{syn}) ppm; IR (ATR): $\tilde{\nu}$ = 3359w, 3059w, 1709m, 1621m, 1603m, 1588s, 1456w, 1429w, 1390m, 1341w, 1312w, 1281w, 1233w, 1155w, 1197m, 1179m, 1071s, 999m, 931w, 866w, 745s, and 684w cm^{-1}; HR-ESI-MS: *m*/*z*: 372.2073 ([*M*–ClO_4^-]$^+$, calcd for $C_{24}H_{26}N_3O^+$: 372.2070).

Syntheses of (5*S*)-2,2,3-Trimethyl-5-(3,4,5-trimethoxybenzyl)imidazolidin-4-one (9) and 5-(3',3',4'-Trimethoxybenzyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium salt (9a)

1-Bromomethyl-3,4,5-trimethoxybenzene (28)[9]

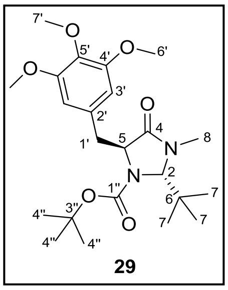


28

To a solution of 3,4,5-trimethoxybenzyl alcohol (4.00 g, 20.2 mmol, 1.00 equiv.) in Et_2O (1.00 L) were added successively PBr_3 (5.46 g, 20.2 mmol, 1.00 equiv.) and pyridine (79.8 mg, 1.01 mmol, 0.05 equiv.) slowly at RT. The mixture was heated to 40 °C and after completion was detected by TLC (3 h), it was allowed to cool to RT. H_2O was added and the aqueous layer extracted twice with Et_2O. The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo* to give 1-bromomethyl-3,4,5-trimethoxybenzene (**28**) as a white solid (5.27 g, quant.), which should be kept in the freezer (turns first orange then brown at RT).

R_f = 0.76 (CH/EtOAc 1:1); M.p. = 72.3–73.4 °C (Lit. 74–75 °C); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.62 (2H, s, H–C3), 4.47 (2H, s, H–C1), 3.88 (6H, d, *J* = 0.7, H-C6), and 3.85 (3H, d, *J* = 0.8 Hz, H-C7) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 153.5 (2C, C4), 138.3 (C5), 133.3 (C2), 106.3 (2C, C3), 61.0 (C7), 56.3 (2C, C6), and 34.4 (C1) ppm; HR-EI-MS: *m*/*z*: 181.0866 ([*M*-Br^-]$^+$, calcd for $C_{10}H_{13}O_3^+$: 181.0859); analytical data in agreement with the literature.[13]

(2*S*,5*S*)-1-Boc-2-(*tert*-butyl)-3-methyl-5-(3,4,5-trimethoxybenzyl)-4-imidazolidinone (29)[5]



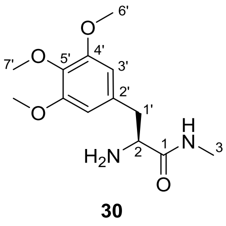
29

A solution of HMDS (1.28 mL, 6.16 mmol, 1.2 equiv.) in dry THF (4.00 mL) in a flame-dried Schlenck under an atmosphere of argon was cooled to 0 °C. ^{n}BuLi (1.6 N in ^{n}hexane, 3.85 mL, 6.16 mmol, 1.2 equiv.) was added dropwise and the solution stirred for 15 min before it was cooled to –78 °C. DMPU (1.86 mL, 15.4 mmol, 3.0 equiv.) and then (*S*)-Boc-BMI (**14**) (1.30 g, 5.13 mmol, 1.0 equiv.) in THF (4.00 mL) was added dropwise to the orange solution that turned darker upon addition. After 30 min, 1-bromomethyl-3,4,5-trimethoxybenzene (**28**) (1.34 g, 5.13 mmol, 1.0 equiv.) in THF (4.00 mL) was added slowly and the resulting mixture stirred for 3 h during which time a brown solid formed. The reaction was quenched by addition of a saturated aqueous solution of NH_4Cl and extracted three times with CH_2Cl_2. The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo*. Purification by CC (SiO_2; CH/EtOAc 3:1) gave **29** as a white solid (1.93 g, 86%).

R_f = 0.40 (CH/EtOAc 1:1); M.p. = 69.6–71.2 °C; $[\alpha]_D^{23}$: +34.4 (*c* = 0.83, CH_3OH); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.38 (2H, s, H–C3'), 4.65 (1H, d, *J* = 1.5, H–C2), 4.28 (1H, dd,

J = 4.4, 2.2, H–C5), 3.80 (6H, s, H–C6'), 3.79 (3H, s, H–C7'), 3.65 (1H, bs, H–C1'), 3.13 (1H, bd, *J* = 12.8, H–C1'), 2.80 (s, 3H, H–C8), 1.47 (s, 9H, H–C4'), and 0.93 (s, 9H, H–C7) ppm; ^{13}C NMR (100 MHz, $CDCl_3$, racemic compound, C4 and C1" not visible): δ = 152.8 (C4'), 136.9 (C2'), 131.7 (b, C5'), 107.4 (2C, C3'), 81.1 (C2), 77.4 (C3"), 61.0 (C7'), 60.9 (C5), 56.4 (2C, C6'), 41.1 (C6), 32.0 (C1'), 28.4 (3C, C4"), 26.8 (3C, C7), and 25.9 (C8) ppm; IR (ATR): $\tilde{\nu}$ = 2966w, 2931w, 2840w, 1693s, 1588w, 1509w, 1456w, 1433w, 1407w, 1380m, 1363m, 1339w, 1325w, 1302w, 1254m, 1239m, 1165m, 1126s, 1112s, 1050w, 1019m, 966w, 956w, 930w, 889w, 859w, 835w, 787w, 764m, 713w, and 668w cm^{-1}; HR-ESI-MS: *m*/*z*: 459.2464 ([*M*+Na]$^+$, calcd for $C_{23}H_{36}N_2O_6Na^+$: 459.2466).

L-3,4,5-Trimethoxyphenylalanine *N*-methyl amide (30)[10]

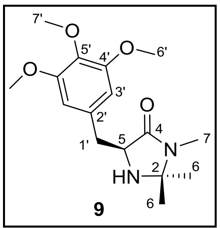


30

To a solution of **29** (1.75 g, 4.01 mmol, 1.0 equiv.) in MeOH (45.0 mL) was added an aqueous solution of HCl (1 N, 45.0 mL) at RT and the mixture heated to reflux for 11 h. The reaction was allowed to come to RT and basified to a pH of 10 with an aqueous solution of NaOH (2 N) and extracted three times with CH_2Cl_2. The combined organic layers were dried over $MgSO_4$ and concentrated *in vacuo* to give amide **30** as an off-white solid (812 mg, 75%).

R_f = 0.26 (CH_2Cl_2/MeOH 10:1); M.p. = 127.8–128.6 °C; $[\alpha]_D^{20}$: +16.6 (*c* = 0.98, CH_3OH); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.30 (1H, b, H–N^{amide}), 6.43 (2H, s, H–C3'), 3.83 (6H, s, H–C6'), 3.81 (3H, s, H–C7'), 3.59 (1H, dd, *J* = 9.4, 3.9, H–C2), 3.19 (1H, dd, *J* = 13.6, 3.9, H–C1'), 2.82 (3H, d, *J* = 5.0, H–C3), 2.61 (1H, dd, *J* = 13.6, 9.4, H–C1'), and 1.48 (2H, bs, H–N^{amine}) ppm; ^{13}C NMR (101 MHz, $CDCl_3$): δ = 174.8 (C1), 153.3 (2C, C4´), 136.7 (C2'), 133.6 (C5'), 106.0 (2C, C3'), 60.8 (C7'), 56.6 (C2), 56.1 (2C, C6'), 41.4 (C1'), and 25.9 (C3) ppm; IR (ATR): $\tilde{\nu}$ = 3390w, 3311w, 2998w, 2945w, 2841w, 1648m, 1589m, 1507m, 1454m, 1420w, 1402w, 1328m, 1232s, 1185w, 1149w, 1123s, 1040w, 1002m, 972w, 920w, 857w, 812s, 783w, 760m, 739m, and 686w cm^{-1}; HR-ESI-MS: *m*/*z*: 269.1497 ([*M*+H]$^+$, calculated for $C_{13}H_{21}N_2O_4^+$: 269.1496).

(5*S*)-2,2,3-Trimethyl-5-(3,4,5-trimethoxybenzyl)imidazolidin-4-one (9)



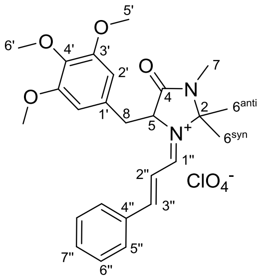
9

To a solution of amide **30** (300 mg, 1.12 mmol, 1.0 equiv.) in MeOH (5.0 mL) were added aceton (0.62 mL, 8.40 mmol, 7.5 equiv.) and NEt_3 (0.12 mL, 0.90 mmol, 0.8 equiv.) at RT under an atmosphere argon and the solution heated to reflux for 7 h. The reaction was allowed to come to RT and concentrated *in vacuo* to give imidazolidinone **9** as an off-white solid (345 mg, quant.).

R_f = 0.73 (CH_2Cl_2/MeOH 10:1); M.p. = 116.8–118.2 °C; $[\alpha]_D^{20}$: –37.2 (*c* = 0.94, CH_3OH); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.44 (2H, s, H–C3'), 3.81 (6H, s, H–C6'), 3.80 (3H, s, H–C7'), 3.75 (1H, t, *J* = 5.3, H–C5), 3.02 (2H, d, *J* = 5.3, H–C1'), 2.74 (3H, s, H–C7), 1.26 (3H, s, H–C6), and 1.16 (3H, s, H–C6) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 173.5 (C4), 153.3 (2C, C4'), 136.9 (C2'), 132.8 (C5'), 106.5 (2C, C3'), 75.7 (C2), 61.0 (C7'), 59.4 (C5), 56.2 (2C, C6'), 37.4 (C1'), 27.3 (C6), 25.4 (C6), and 25.4 (C7) ppm; IR (ATR): $\tilde{\nu}$ = 3291w, 2920w, 2686w, 2565w, 2432w, 1702s, 1673w, 1590m, 1508w, 1459m, 1424s, 1396s, 1385m, 1328m, 1315w, 1234m, 1154w, 1113s, 1064w, 1000m, 967w, 875w, 831w, 789w, and 771w cm^{-1}; HR-ESI-MS: *m*/*z*: 309.1814 ([*M*+H]$^+$, calcd for $C_{16}H_{25}N_2O_4^+$: 309.1809);

elemental analysis calcd (%, racemic compound) for $C_{16}H_{24}N_2O_4$ (308.2): C 62.32, H 7.84, N 9.08, O 20.75; found: C 62.02, H 7.68, N 8.96, O 20.82.

5-(3',3',4'-Trimethoxybenzyl)-2,2,3-trimethyl-4-oxo-1-[(*E*)-3-phenylallylidene]-imidazolidin-1-ium perchlorate (9a·ClO_4^-):[3]



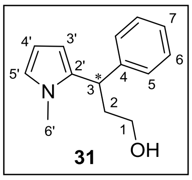
9a·ClO_4^-

To racemic imidazolidinone **9** (49.6 mg, 0.16 mmol, 1.0 equiv.) in Et_2O (0.2 mL) was added $HClO_4$ (60% in H_2O, 26.8 mg, 0.16 mmol, 1.0 equiv.) in EtOH/Et_2O (1:1, 0.4 mL) at RT and stirred for 10 min, before the yellow solution was evaporated *in vacuo* to give the off-white $HClO_4$ salt as a solid. The solid was dissolved in MeOH (0.4 mL) and *E*-cinnamaldehyde (40.2 μL, 0.32 mmol, 2.0 equiv.) was added at 35 °C and the yellow solution stirred for 1 h. The solvent was evaporated *in vacuo*. The residue was dissolved in a minimum amount of MeOH, the iminium salt was crashed out with Et_2O and the supernatant solution taken off. This purification procedure was repeated two additional times to give iminium salt **9a·ClO_4^-** as a yellow solid.

M.p. = 116.1 °C decomp.; ^{1}H NMR (600 MHz, CD_3CN): δ_H = 8.77 (1H, dd, J = 10.7, 1.9, H–C1''), 8.13 (1H, d, J = 15.0, H–C3''), 7.87–7.83 (2H, m, H–C5''), 7.71–7.67 (1H, m, H–C7''), 7.59 (2H, t, J = 7.9, H–C6''), 7.11 (1H, dd, J = 15.0, 10.7, H–C2''), 6.38 (2H, s, H–C2'), 5.17 (1H, td, J = 5.3, 1.6, H–C5), 3.73 (6H, s, H–C5'), 3.52 (1H, dd, J = 14.7, 5.4, H–C8), 3.47 (3H, s, H–C6'), 3.31 (1H, dd, J = 14.7, 5.2, H–C8), 2.86 (3H, d, J = 0.5, H–C7), 1.75 (3H, s, H–C6^{anti}), and 1.13 (3H, s, H–C6^{syn}) ppm; ^{13}C NMR (151 MHz, CD_3CN): δ_C = 168.2 (C1''), 165.9 (C4), 165.4 (C3''), 154.8 (2C, C3'), 139.0 (C4'), 136.0 (C7''), 134.4 (C4''), 132.4 (2C, C5''), 130.6 (2C, C6''), 130.3 (C1'), 118.6 (C2''), 108.2 (2C, C2'), 86.6 (C2), 65.1 (C5), 60.7 (C6'), 56.8 (2C, C5'), 38.2 (C8), 27.3 (C6^{anti}), 26.2 (C7), and 25.5 (C6^{syn}) ppm; IR (ATR): $\tilde{\nu}$ = 3382br, 3068w, 2984w, 1704s, 1622s, 1588s, 1517m, 1441m, 1403m, 1392m, 1325w, 1277w, 1233w, 1198m, 1178m, 1153w, 1073s, 999s, 931m, 852w, 813w, 756m, 726w, 684m, and 621s cm^{-1}; HR-ESI-MS: *m*/*z*: 423.22755 ([*M*-ClO_4^-]$^+$, calcd for $C_{25}H_{31}N_2O_4^+$: 423.22838).

Catalysis with HPLC Data

General Procedure for the Friedel-Crafts Reaction of 1-Methyl-1*H*-pyrrole (11) and (*E*)-Cinnamaldehyde to give 3-(1-Methyl-1*H*-pyrrol-2-yl)-3-phenylpropan-1-ol (31)[3]

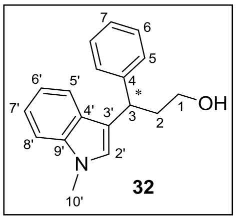


31

To the corresponding imidazolidinone catalyst (33.0 µmol, 0.2 equiv.) was added TFA (3.76 mg, 33.0 µmol, 0.2 equiv.) in THF (0.33 mL) and H_2O (0.05 mL) and the solution was stirred for 5 min at the given temperature before (*E*)-cinnamaldehyde was added (63 µL, 0.50 mmol, 3.0 equiv.). After an additional 30 min, 1-methyl-1*H*-pyrrole (**11**) (15 µL, 0.17 mmol, 1.0 equiv.) was added and the yellow solution stirred for the given time, after which complete conversion of the starting material was observed by TLC. EtOH (0.5 mL) and $NaBH_4$ (19.0 mg, 0.50 mmol, 3.0 equiv.) were added (and the mixture warmed to RT). The reduction was quenched with aqueous saturated $NaHCO_3$ after 30 min and extracted three times with CH_2Cl_2. The combined organic layers were dried over $MgSO_4$ and evaporated *in vacuo*. The crude product **31** was purified by column chromatography (CH/EtOAc 4:1). The enantioselectivities were determined by chiral HPLC on a *Chiracel OJ-H* column, using *n*-hexane/*i*-PrOH 85:15 as eluent (1.0 mL/min). Retention times of the two enantiomers are: 11 min (*R*) and 18 min (*S*).

R_f = 0.58 (CH/EtOAc 1:1); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.33–7.23 (2H, m, H–C6), 7.23–7.09 (3H, m, H–C5, H–C7), 6.53 (1H, t, *J* = 2.3, H–C5'), 6.19–6.14 (1H, m, H–C3'), 6.14–6.07 (1H, m, H–C4'), 4.12 (1H, t, *J* = 7.5, H–C3), 3.75–3.56 (2H, m, H–C1), 3.30 (3H, s, H–C6'), 2.34 (1H, dq, *J* = 13.4, 7.1, H–C2), 2.10 (1H, ddt, *J* = 14.0, 8.5, 5.7, H–C2), and 1.45 (1H, b, H–O) ppm; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 143.6 (C4), 135.0 (C2'), 128.7 (2C, C6), 128.0 (2C, C5), 126.5 (C7), 122.0 (C5'), 106.4 (C4'), 105.8 (C3'), 60.8 (C1), 39.6 (C2), 39.1 (C6'), and 34.0 (C3) ppm; HR-ESI-MS: *m*/*z*: 238.1208 ([*M*+Na]$^+$, calcd for $C_{14}H_{17}NONa^+$: 238.1202); analytical data in agreement with the literature.[15]

General Procedure for the Friedel-Crafts Reaction of 1-Methyl-1*H*-indole (10) and (*E*)-Cinnamaldehyde to give 3-(1-Methyl-1*H*-indole-3-yl)-3-phenylpropan-1-ol (32)



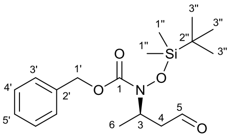
32

To the corresponding imidazolidinone catalyst (33.0 µmol, 0.2 equiv.) was added TFA (3.76 mg, 33.0 µmol, 0.2 equiv.) in CH_2Cl_2 (0.28 mL) and *i*-PrOH (0.05 mL) and the solution was stirred for 5 min at the given temperature before (*E*)-cinnamaldehyde was added (63 µL, 0.50 mmol, 3.0 equiv.). After an additional 30 min, 1-methyl-1*H*-indole (**10**) (15 µL, 0.17 mmol, 1.0 equiv.) was added and the yellow solution stirred for the given time, after which complete conversion of the starting material was observed by TLC. EtOH (0.5 mL) and $NaBH_4$ (19.0 mg, 0.50 mmol, 3.0 equiv.) were added (and the mixture warmed to RT). The reduction was quenched with aqueous saturated $NaHCO_3$ after 30 min and extracted three times with CH_2Cl_2. The combined organic layers were dried over $MgSO_4$ and evaporated *in vacuo*. The crude product **32** was purified by column chromatography (CH/EtOAc 5:1). The enantioselectivities were determined by chiral HPLC on a *Reprosil Chiral-OM* column, using *n*-hexane/*i*-PrOH 85:15 as eluent (1.0 mL/min). Retention times of the two enantiomers are: 15 min (*R*) and 21 min (*S*).

R_f = 0.17 (CH/EtOAc 3:1); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.39 (1H, d, *J* = 7.8, H–C5'), 7.28–7.16 (5H, m, H–C5, H–C6, H–C7), 7.14–7.05 (2H, m, H–C7', H–C8'), 6.94 (1H, t,

J = 7.8, H–C6'), 6.82 (1H, s, H–C2'), 4.31 (1H, t, *J* = 7.8, H–C3), 3.67 (3H, s, H–C10'), 3.59 (2H, td, *J* = 6.4, 2.2, H–C1), 2.48–2.30 (1H, m, H–C2), 2.27–2.13 (1H, m, H–C2), and 1.46 (1H, s, H–O) ppm; HR-ESI-MS: *m*/*z*: 288.1361 ([*M*+Na]$^+$, calcd for $C_{18}H_{19}NONa^+$: 288.1359); analytical data in agreement with the literature.[16]

General Procedure for the Conjugate Addition of Benzyl-(*tert*-butyldimethylsilyloxy)carbamate (12) and (*E*)-Crotonaldehyde to give *N*-*tert*-Butyldimethylsilyloxy[benzyl-(S)-1-formylpropan-2-ylcarbamate] (33)[17]

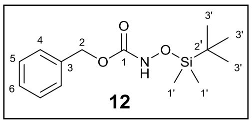


33

The corresponding imidazolidinone (0.05 mmol, 0.2 equiv.) and *p*TSA·H_2O (0.05 mmol, 0.2 equiv.) were dissolved in $CHCl_3$ (1.0 mL), stirred for 10 min and the solvent was removed to yield an off-white solid. After dissolving the solid in $CHCl_3$ (0.75 mL) and cooling to –20 °C, crotonaldehyde (0.75 mmol, 3.0 equiv.) and benzyl-(*tert*-butyldimethylsilyloxy)carbamate (**12**) (0.25 mmol, 1.0 equiv., in 0.25 mL $CHCl_3$) were added. The reaction occurred within 5 days at –20 °C. The crude reaction mixture was filtered through a silica plug, eluted with Et_2O (5 mL) and purified by column chromatography (SiO_2, *n*-pentane/Et_2O 95:5→90:10) to give the product **33**. Determination of the enantiomeric excess was accomplished by HPLC analysis (Reprosil Chiral OM 5 µm 250·4.6 mm column, *n*-hexane/*i*-PrOH 95:5, 1.0 mL/min) of the corresponding alcohol after reduction with $NaBH_4$ with the minor enantiomer at 6 min and the major enantiomer between 7 min.

R_f = 0.60 (*n*-pentane/Et_2O 7:3); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 9.64 (1H, t, *J* = 1.8, H–C5), 7.26 (5H, m, H–C^{Ar}), 5.05 (2H, s, H–C1'), 4.41 (1H, h, *J* = 6.8, H–C3), 2.71 (1H, ddd, *J* = 16.8, 6.8, 1.8, H–C9), 2.51(1H, ddd, *J* = 16.8, 6.8, 1.8, H–C9), 1.17 (3H, d, *J* = 6.8, 3H, H–C6), 0.81 (9H, s, H–C3''), 0.00 (3H, s, H–C1''), and –0.01 (3H, s, H–C1'') ppm; HR-ESI-MS: *m/z*: 352.1939 ([*M*+H]$^+$, calcd for $C_{18}H_{30}NO_4Si^+$: 352.1944); analytical data in agreement with the literature.[17]

Preparation of Benzyl-(*tert*-butyldimethylsilyloxy)carbamate (12)[17]



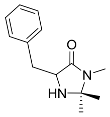
12

N-(Benzyloxycarbonyl)hydroxylamine (5 mmol, 1.0 eq.) was dissolved in CH_2Cl_2 (25 mL) and triethylamine (5.5 mmol, 1.1 eq.), cooled to 0 °C and *tert*-butylchlorodimethylsilane (5.0 mmol, 1.0 eq.) was added. The reaction mixture was stirred at 0 °C for 10 min, gradually warmed to RT and stirred for 12 h. The crude solution was washed with H_2O (25 mL), brine (25 mL) and was dried over $MgSO_4$. Purification by CC (SiO_2; pentane/Et_2O 9:1) yielded a clear oily product which crystallized to a white solid at –4 °C (70%).

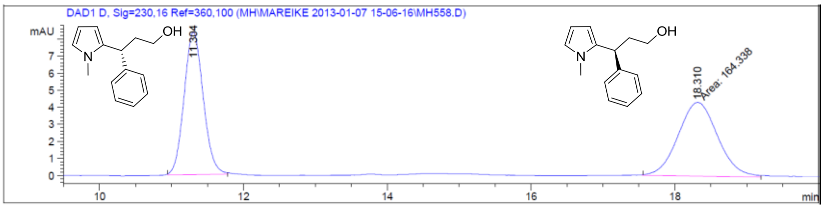
R_f = 0.67 (*n*-pentane/Et_2O 7:3); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.31–7.20 (5H, m, H–C^{Ar}), 6.88 (1H, s, H–N^{amide}), 5.08 (2H, s, H–C2), 0.85 (9H, s, H–C3'), and 0.06 (6H, s, H–C1') ppm; HR-ESI-MS: *m/z*: 304.1350 ([*M*+H]$^+$, calcd for $C_{14}H_{23}NO_3SiNa^+$: 304.1344); analytical data in agreement with the literature.[17]

HPLC data for the Friedel-Crafts reaction of 1-methyl-1*H*-pyrrole (11) and (*E*)-cinnamaldehyde to give 3-(1-methyl-1*H*-pyrrole-3-yl)-3-phenylpropan-1-ol (31)

Catalyst:



Column: Chiracel OJ-H
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: -1%



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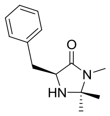
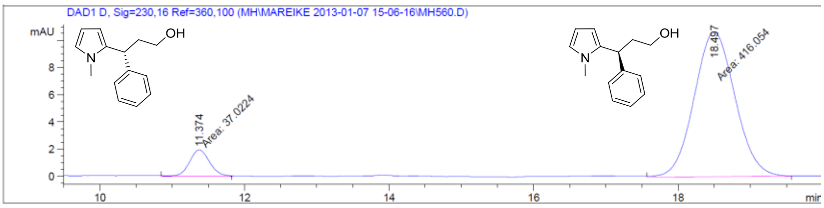
Signal 2: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  11.304 BB    0.2978  159.65663    8.39855  49.2776
   2  18.311 MM    0.6349  164.33765    4.31425  50.7224
```

Catalyst:



Column: Chiracel OJ-H
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 84%



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Signal 2: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  11.374 MM    0.3197   37.02241    1.93008   8.1713
   2  18.497 MM    0.6534  416.05359   10.61296  91.8287
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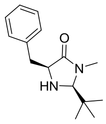
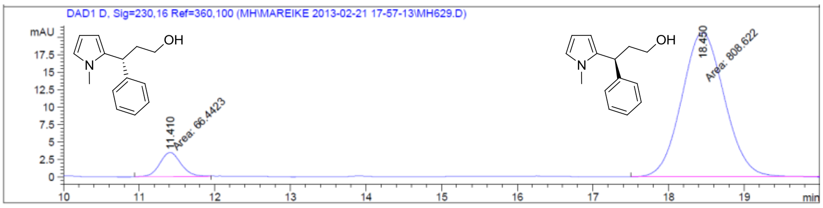
Catalyst:



Column: Chiracel OJ-H
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 85%



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Signal 2: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  11.410 MM    0.3221   66.44230    3.43754   7.5928
   2  18.450 MM    0.6536  808.62244   20.61821  92.4072
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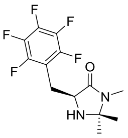
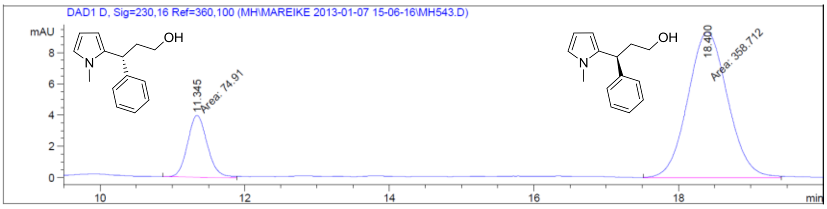
Catalyst:



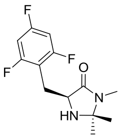
Column: Chiracel OJ-H
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 65%



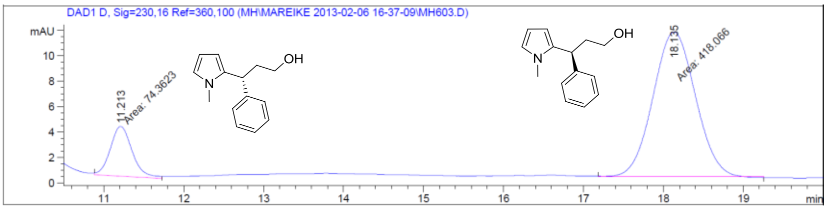
```
Signal 2: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  11.345 MM    0.3154   74.91003    3.95791  17.2754
   2  18.400 MM    0.6400  358.71158    9.34160  82.7246
```

Catalyst:



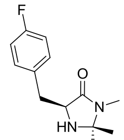
Column: Chiracel OJ-H
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 70%



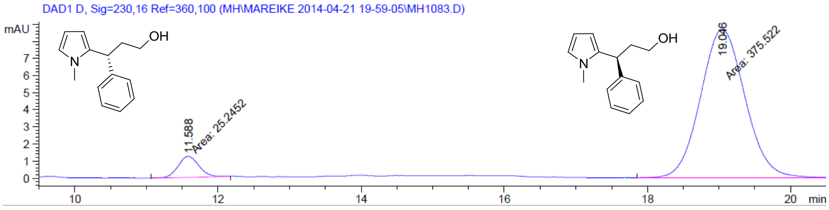
```
Signal 2: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  11.213 MM    0.3169   74.36226    3.91120  15.1011
   2  18.135 MM    0.6144  418.06561   11.34137  84.8989
```

Catalyst:



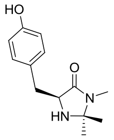
Column: Chiracel OJ-H
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 87%



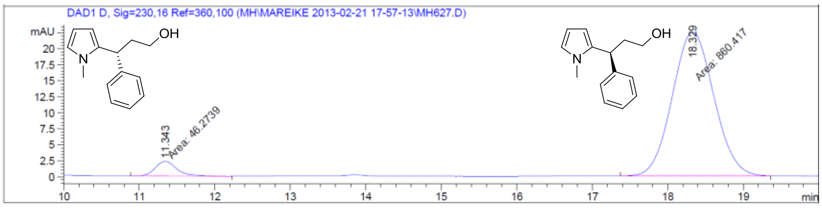
```
Signal 3: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  11.588 MM    0.3394   25.24517    1.23982   6.2992
   2  19.046 MM    0.7201  375.52176    8.69086  93.7008
```

Catalyst:



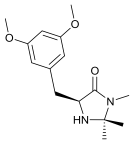
Column: Chiracel OJ-H
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 90%



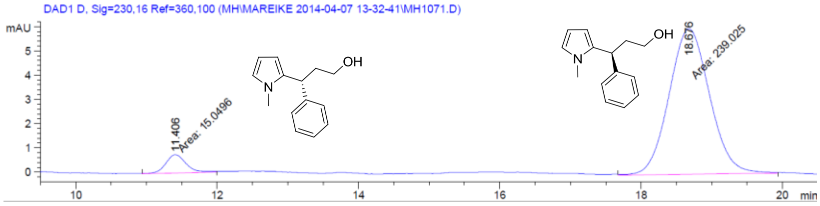
```
Signal 2: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  11.343 MM    0.3343   46.27386    2.30669   5.1036
   2  18.329 MM    0.6373  860.41650   22.50143  94.8964
```

Catalyst:



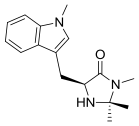
Column: Chiracel OJ-H
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 88%



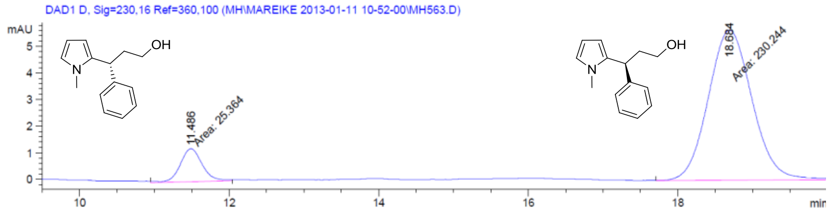
```
Signal 3: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  11.406 MM    0.3320   15.04963 7.55398e-1   5.9233
   2  18.676 MM    0.6640  239.02528    5.99975  94.0767
```

Catalyst:



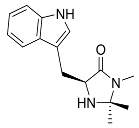
Column: Chiracel OJ-H
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 80%



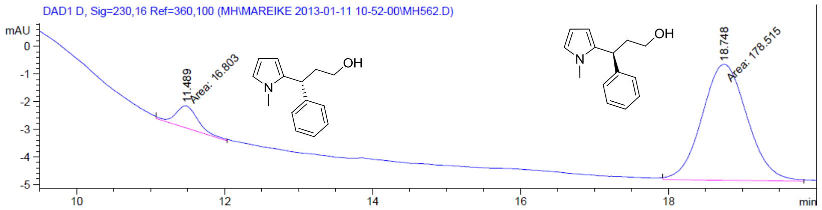
```
Signal 2: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  11.486 MM    0.3410   25.36401    1.23985   9.9230
   2  18.684 MM    0.6797  230.24394    5.64561  90.0770
```

Catalyst:



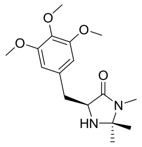
Column: Chiracel OJ-H
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 83%



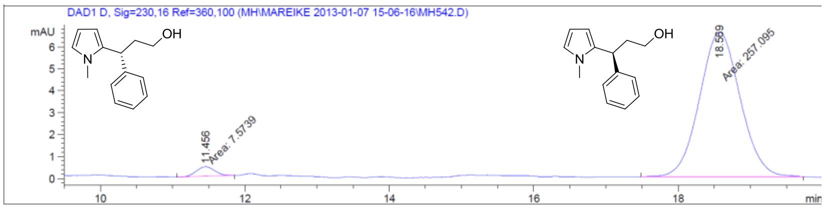
```
Signal 2: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  11.489 MM    0.3506   16.80299 7.98853e-1   8.6029
   2  18.748 MM    0.7081  178.51518    4.20154  91.3971
```

Catalyst:



Column: Chiracel OJ-H
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 94%

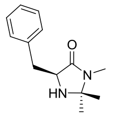


```
Signal 2: DAD1 D, Sig=230,16 Ref=360,100

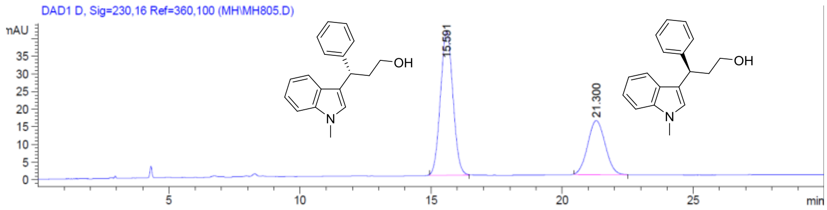
Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  11.456 MM    0.2922    7.57390 4.32039e-1   2.8617
   2  18.569 MM    0.6513  257.09509    6.57883  97.1383
```

HPLC data for the Friedel-Crafts reaction of 1-methyl-1*H*-indole (10) and (*E*)-cinnamaldehyde to give 3-(1-methyl-1*H*-indole-3-yl)-3-phenylpropan-1-ol (32)

Catalyst:



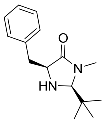
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 31%



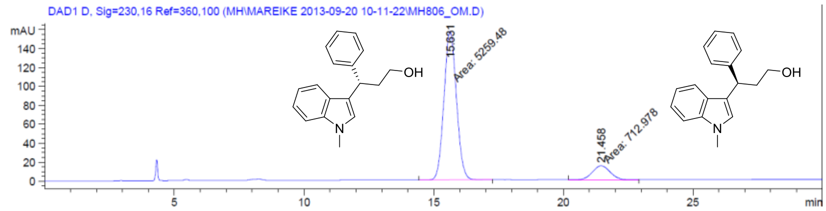
```
Signal 3: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  15.591 BB    0.5127 1350.40784   40.95087  65.7272
   2  21.300 BB    0.7040  704.15778   15.26964  34.2728
```

Catalyst:



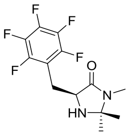
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 76%



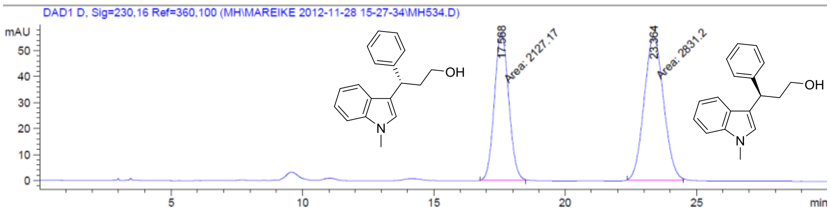
```
Signal 3: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  15.631 MM    0.5583 5259.48438  157.01529  88.0622
   2  21.458 MM    0.8030  712.97803   14.79892  11.9378
```

Catalyst:



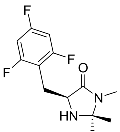
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: –14%



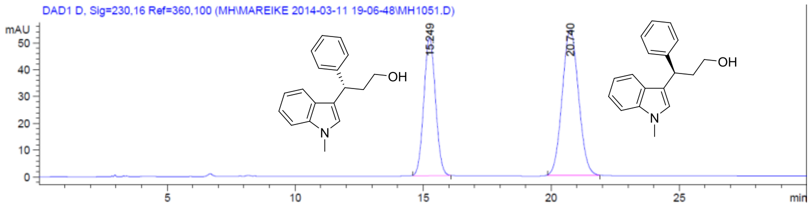
```
Signal 3: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  17.568 MM    0.6245 2127.17017   56.76834  42.9006
   2  23.364 MM    0.8567 2831.20044   55.07951  57.0994
```

Catalyst:



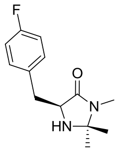
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: –20%



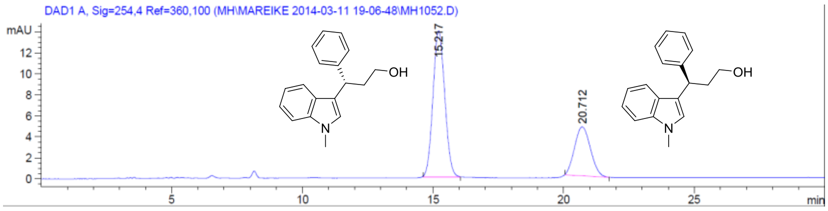
```
Signal 3: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  15.249 BB    0.4924 1622.92798   51.40039 40.2419
   2  20.740 BB    0.6927 2410.00195   54.20600 59.7581
```

Catalyst:



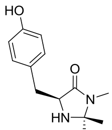
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 37%



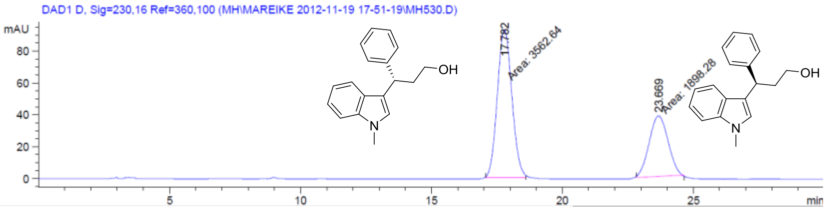
```
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  15.217 BB    0.4909  435.55875   13.92667 68.9456
   2  20.712 BB    0.6092  196.18393    4.66004 31.0544
```

Catalyst:



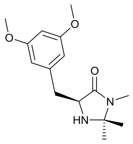
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 30%



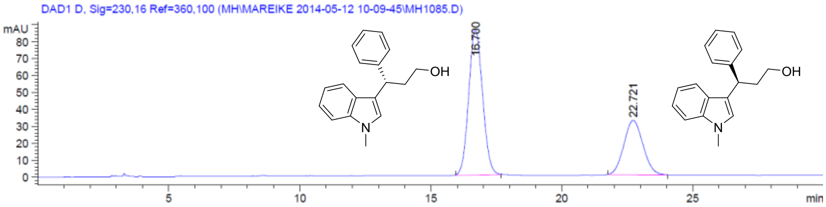
```
Signal 3: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  17.782 MM    0.6408 3562.63770   92.65876 65.2388
   2  23.669 MM    0.8344 1898.28137   37.91484 34.7612
```

Catalyst:



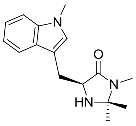
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 32%



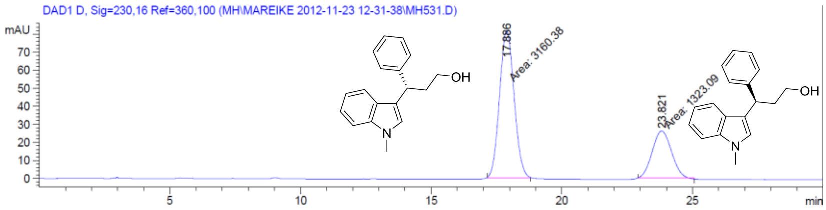
```
Signal 3: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  16.700 BB    0.5718 3155.68799   86.05006 65.9419
   2  22.721 BB    0.7818 1629.86987   32.13181 34.0581
```

Catalyst:



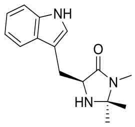
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 41%



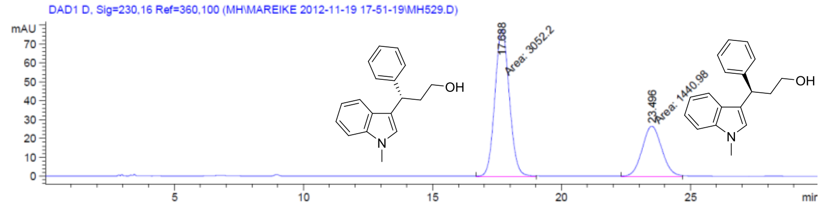
```
Signal 3: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  17.886 MM    0.6447 3160.37720   81.69723  70.4896
   2  23.821 MM    0.8485 1323.08850   25.98728  29.5104
```

Catalyst:



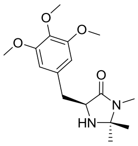
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 36%



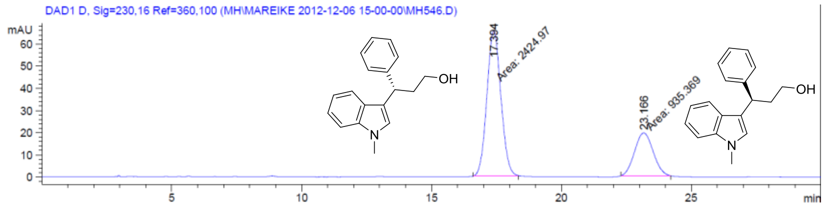
```
Signal 3: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  17.688 MM    0.6512 3052.19995   78.11877  67.9297
   2  23.496 MM    0.8946 1440.97632   26.84441  32.0703
```

Catalyst:



Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 15:85
1.0 mLmin^{-1}
ee: 44%

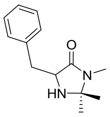


```
Signal 3: DAD1 D, Sig=230,16 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1  17.394 MM    0.6195 2424.97070   65.24243  72.1644
   2  23.166 MM    0.8157  935.36932   19.11241  27.8356
```

HPLC data for the conjugate addition of benzyl-(*tert*-butyldimethylsilyloxy)carbamate (12) and (*E*)-crotonaldehyde to give *N*-*tert*-butyldimethylsilyloxy[benzyl-(S)-1-formylpropan-2-ylcarbamate] (33)

Catalyst:

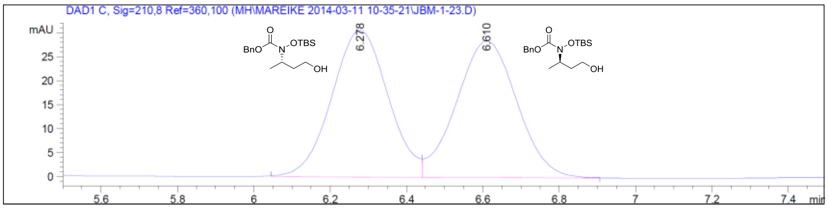


Column: Reprosil Chiral OM

^{i}PrOH : ^{n}Hexane: 5:95

1.0 mLmin^{-1}

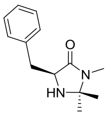
ee: 0%



```
Signal 2: DAD1 C, Sig=210,8 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1   6.278 BV     0.1596  313.84799   30.61647  49.9951
   2   6.610 VB     0.1726  313.91000   28.47799  50.0049
```

Catalyst:

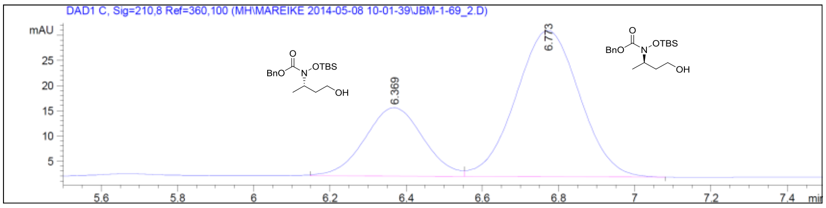


Column: Reprosil Chiral OM

^{i}PrOH : ^{n}Hexane: 5:95

1.0 mLmin^{-1}

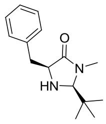
ee: 40%



```
Signal 2: DAD1 C, Sig=210,8 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1   6.369 BV     0.1644  145.51826   13.64414  30.0197
   2   6.773 VB     0.1819  339.22412   29.11581  69.9803
```

Catalyst:

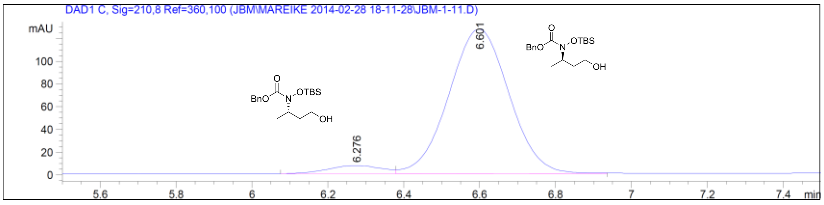


Column: Reprosil Chiral OM

^{i}PrOH : ^{n}Hexane: 5:95

1.0 mLmin^{-1}

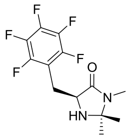
ee: 91%



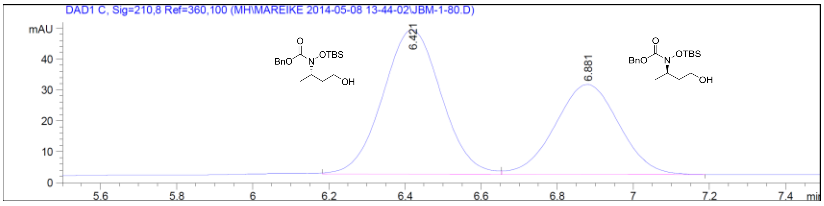
```
Signal 2: DAD1 C, Sig=210,8 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1   6.276 BV     0.1508   68.67981    7.10323   4.6890
   2   6.601 VB     0.1722 1396.02209  126.99470  95.3110
```

Catalyst:



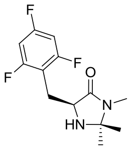
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 55:95
1.0 mLmin^{-1}
ee: –19%



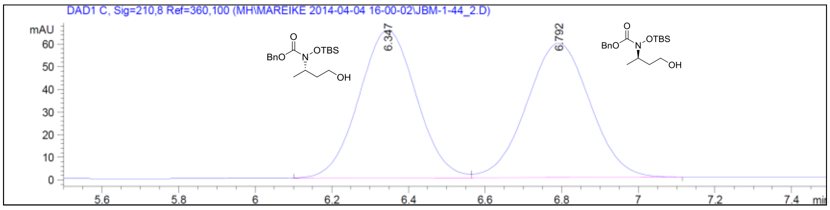
```
Signal 2: DAD1 C, Sig=210,8 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1   6.421 BV    0.1663  498.05579   46.73677  59.4626
   2   6.881 VB    0.1822  339.53918   29.08496  40.5374
```

Catalyst:



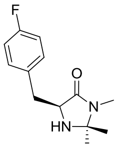
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 5:95
1.0 mLmin^{-1}
ee: 1%



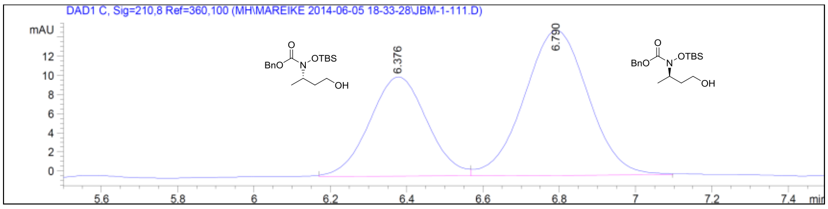
```
Signal 2: DAD1 C, Sig=210,8 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1   6.347 BV    0.1633  678.10547   65.20390  49.8058
   2   6.792 VB    0.1804  683.39441   59.31758  50.1942
```

Catalyst:



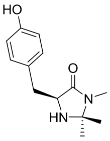
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 5:95
1.0 mLmin^{-1}
ee: 24%



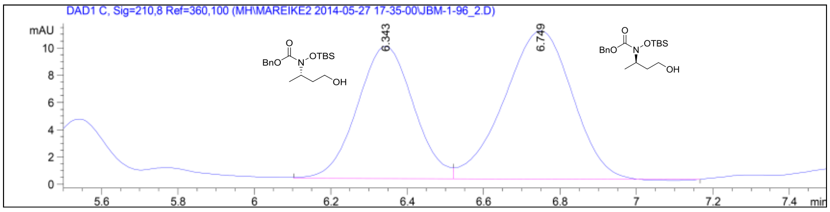
```
Signal 2: DAD1 C, Sig=210,8 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1   6.376 BV    0.1623  108.75533   10.37627  38.0745
   2   6.790 VB    0.1820  176.88301   15.17692  61.9255
```

Catalyst:



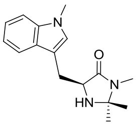
Column: Reprosil Chiral OM
^{i}PrOH : ^{n}Hexane: 5:95
1.0 mLmin^{-1}
ee: 15%



```
Signal 2: DAD1 C, Sig=210,8 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1   6.343 BV    0.1597   99.64043    9.71378  42.5490
   2   6.749 VB    0.1922  134.53789   10.88380  57.4510
```

Catalyst:

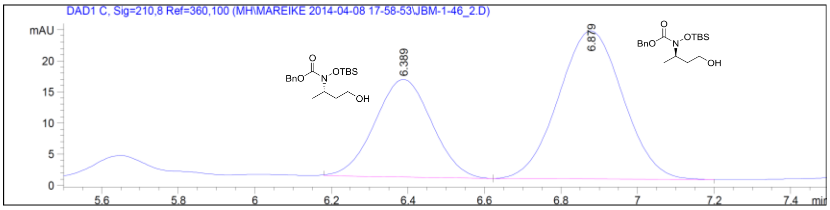


Column: Reprosil Chiral OM

^{i}PrOH : ^{n}Hexane: 5:95

1.0 mLmin^{-1}

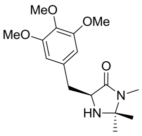
ee: 26%



```
Signal 2: DAD1 C, Sig=210,8 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1   6.389 BV    0.1605  161.93213   15.67273  36.8641
   2   6.879 VB    0.1841  277.33594   23.77788  63.1359
```

Catalyst:

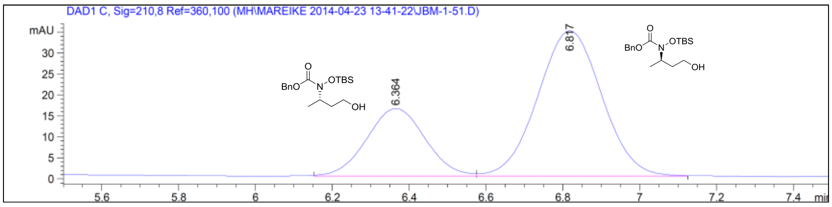


Column: Reprosil Chiral OM

^{i}PrOH : ^{n}Hexane: 5:95

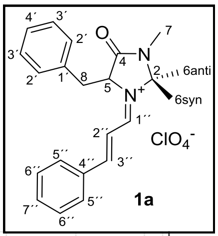
1.0 mLmin^{-1}

ee: 40%



```
Signal 2: DAD1 C, Sig=210,8 Ref=360,100

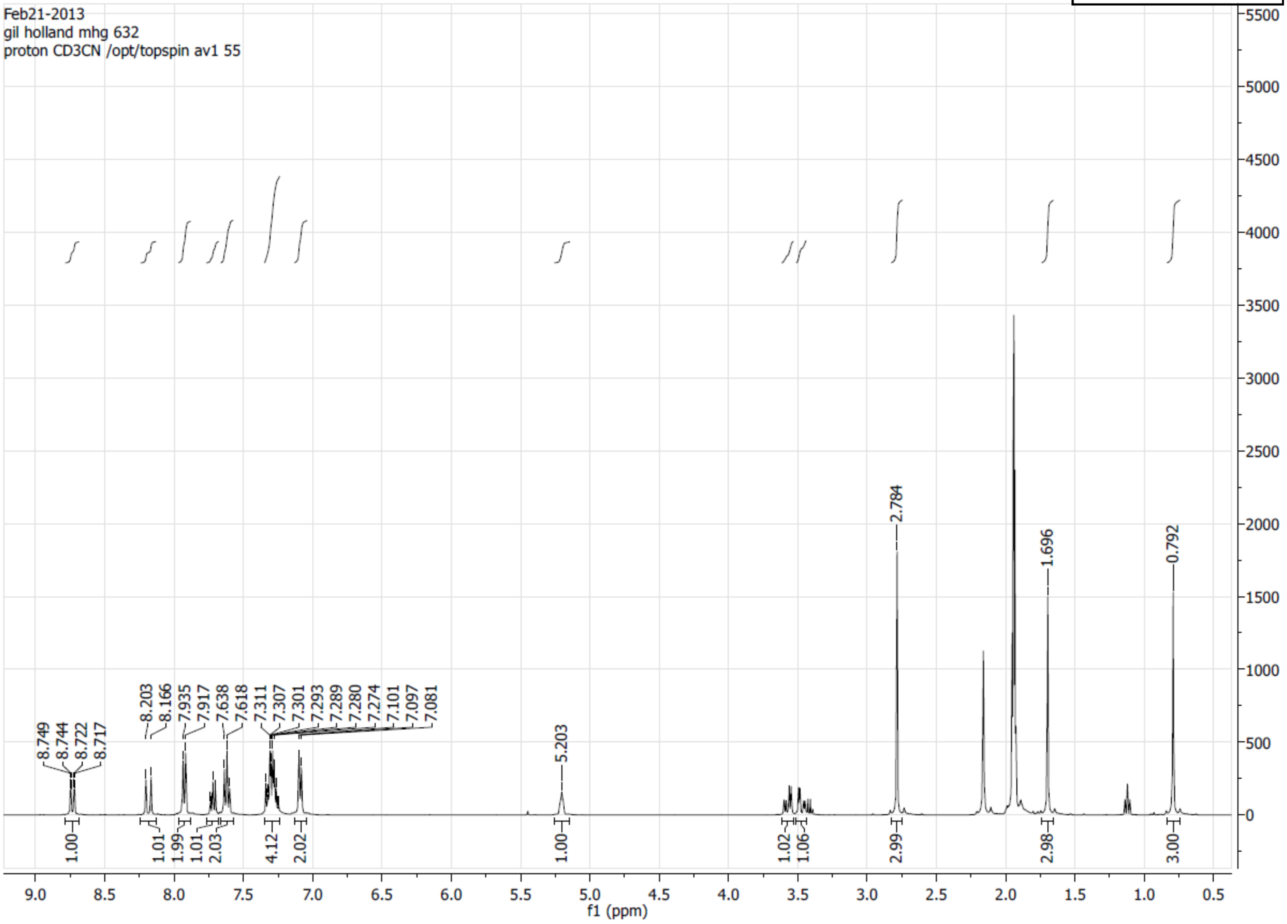
Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]        %
----|-------|----|-------|----------|----------|--------|
   1   6.364 BV    0.1651  170.19603   16.13466  29.7590
   2   6.817 VB    0.1812  401.71808   34.66341  70.2410
```



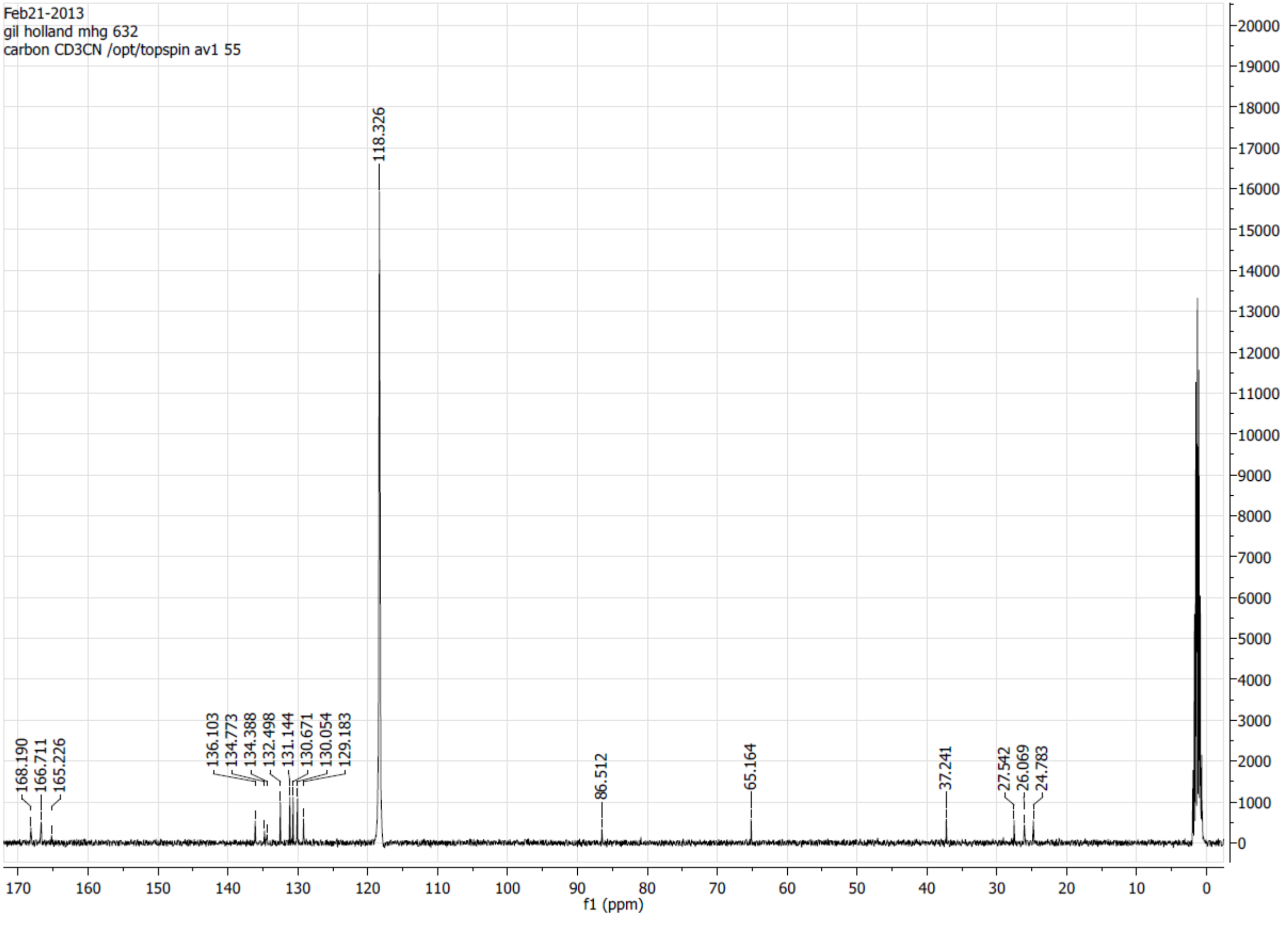
1a

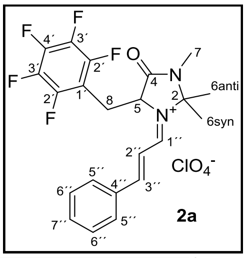
NMR-Spectra of Key Compounds

^{1}H NMR (400 MHz,



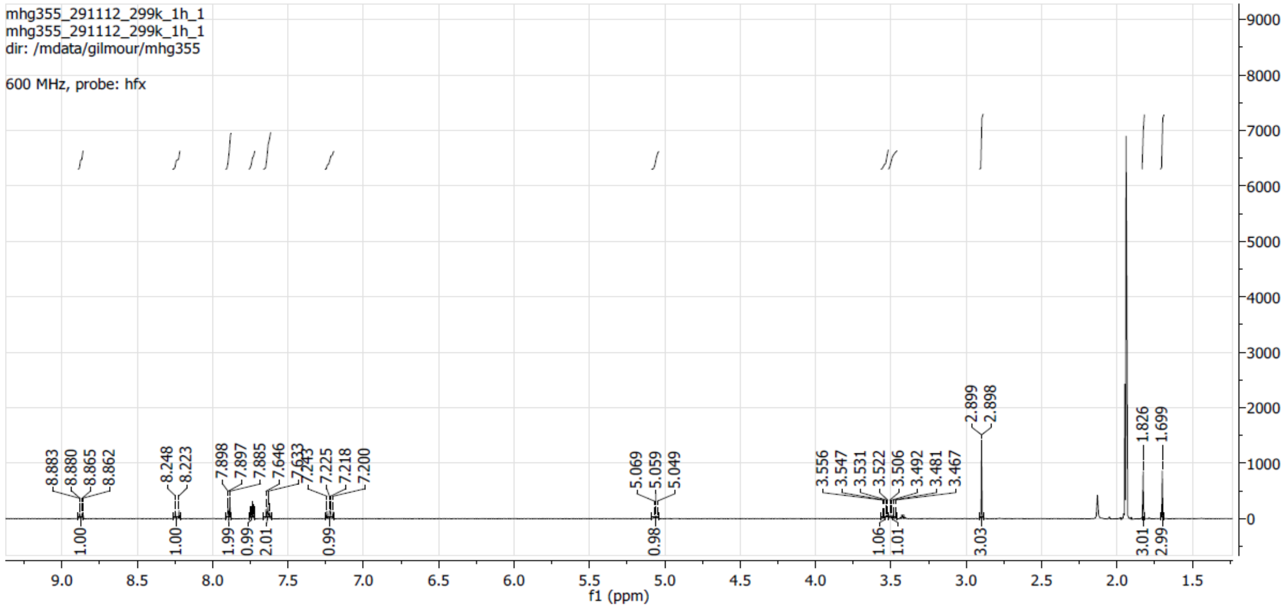
^{13}C NMR (101 MHz,



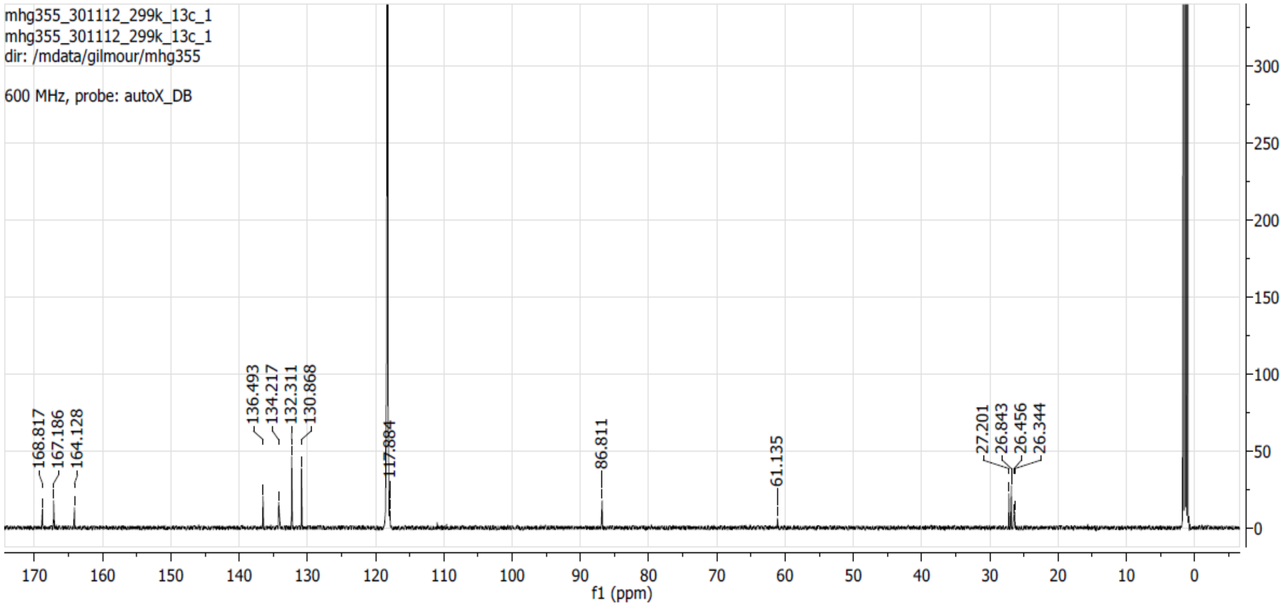


2a

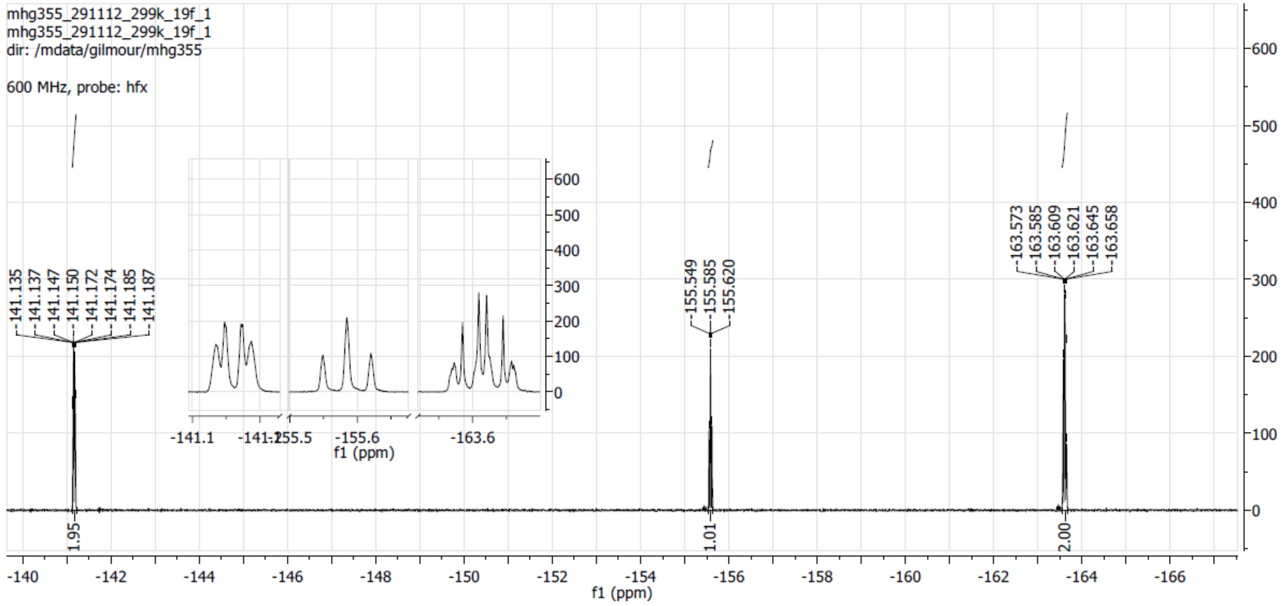
^{1}H NMR (600 MHz,

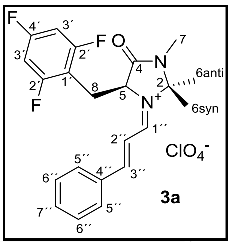


^{13}C NMR (151 MHz,



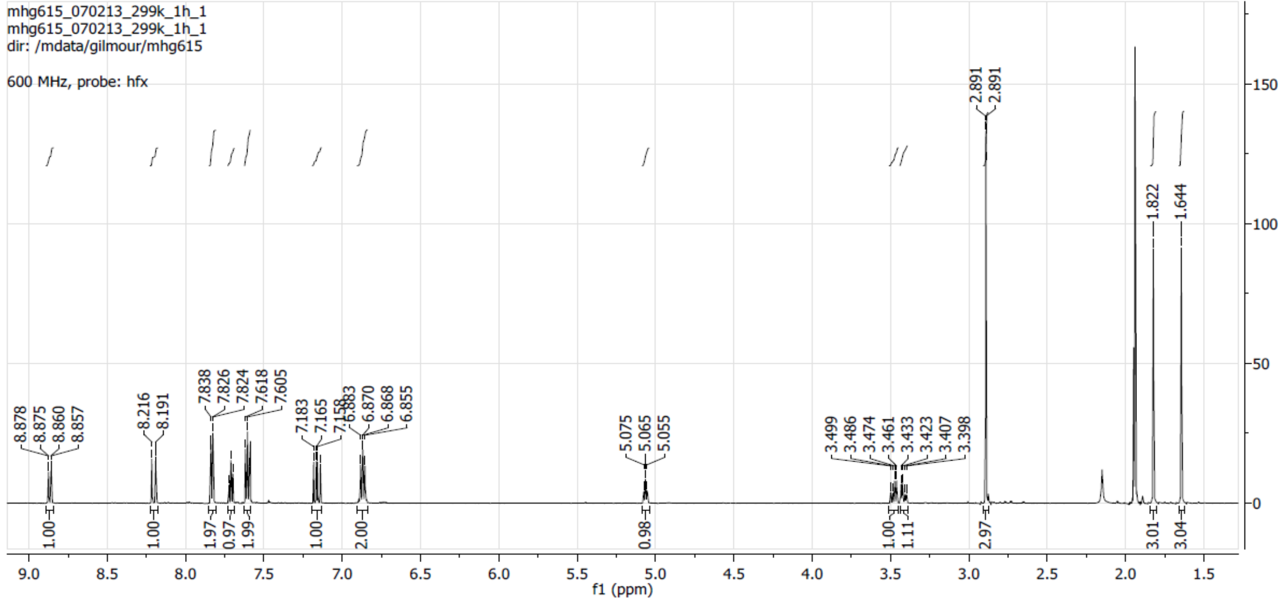
^{19}F NMR (564 MHz,



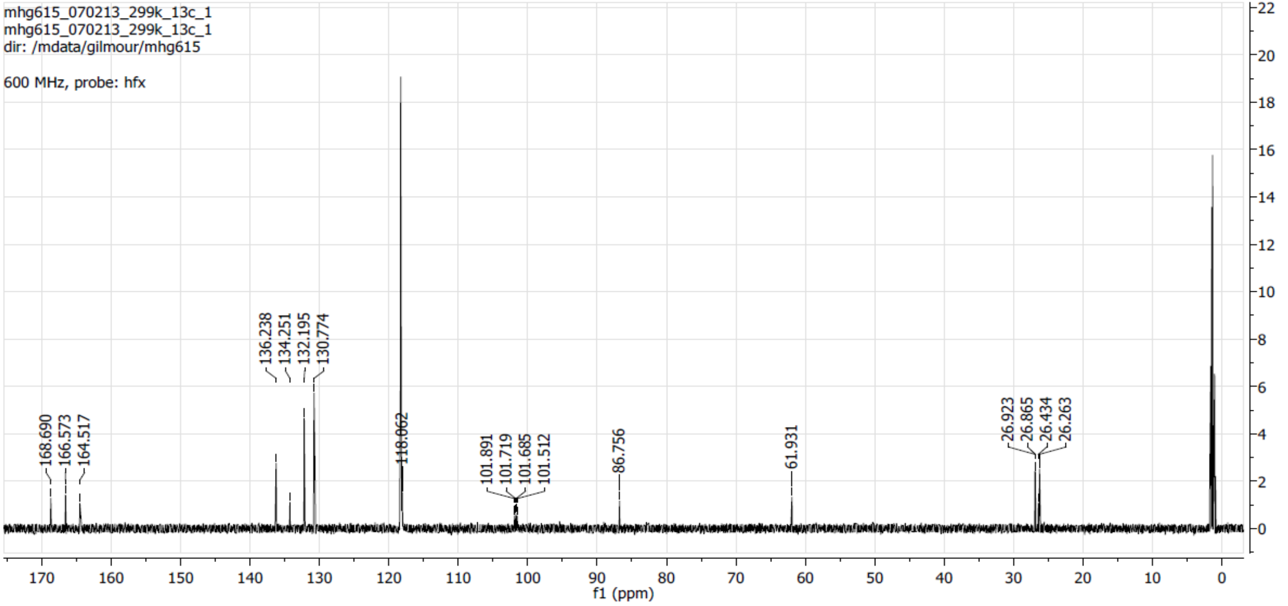


3a

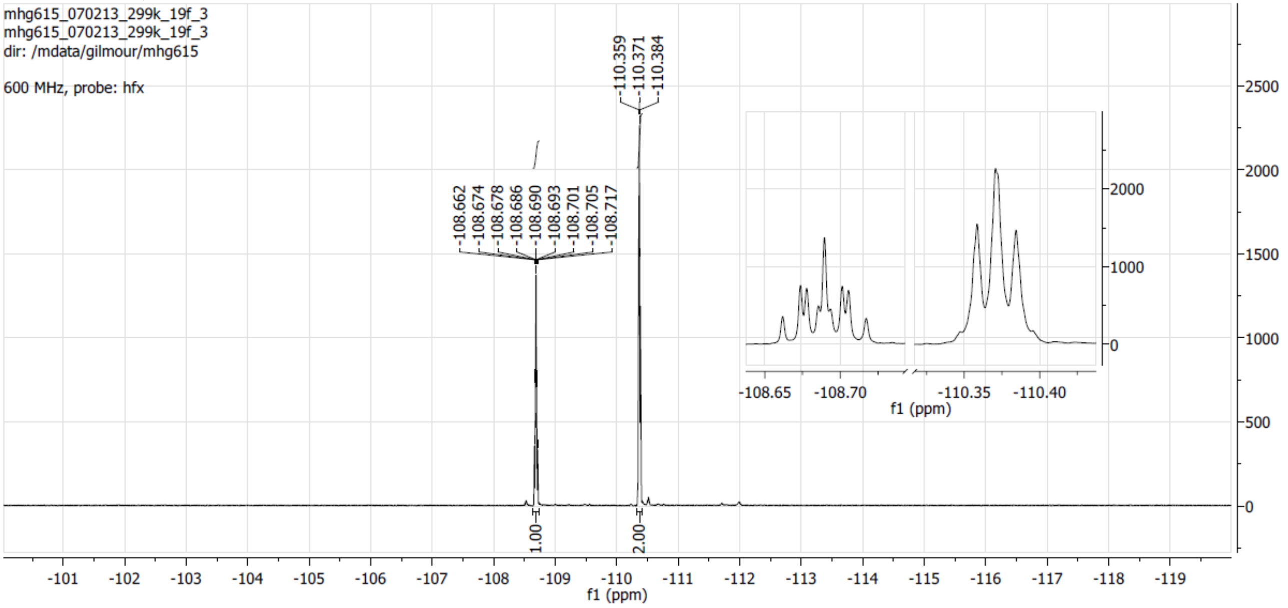
^{1}H NMR (600 MHz,

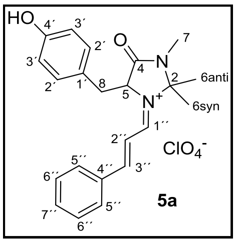


^{13}C NMR (151 MHz,



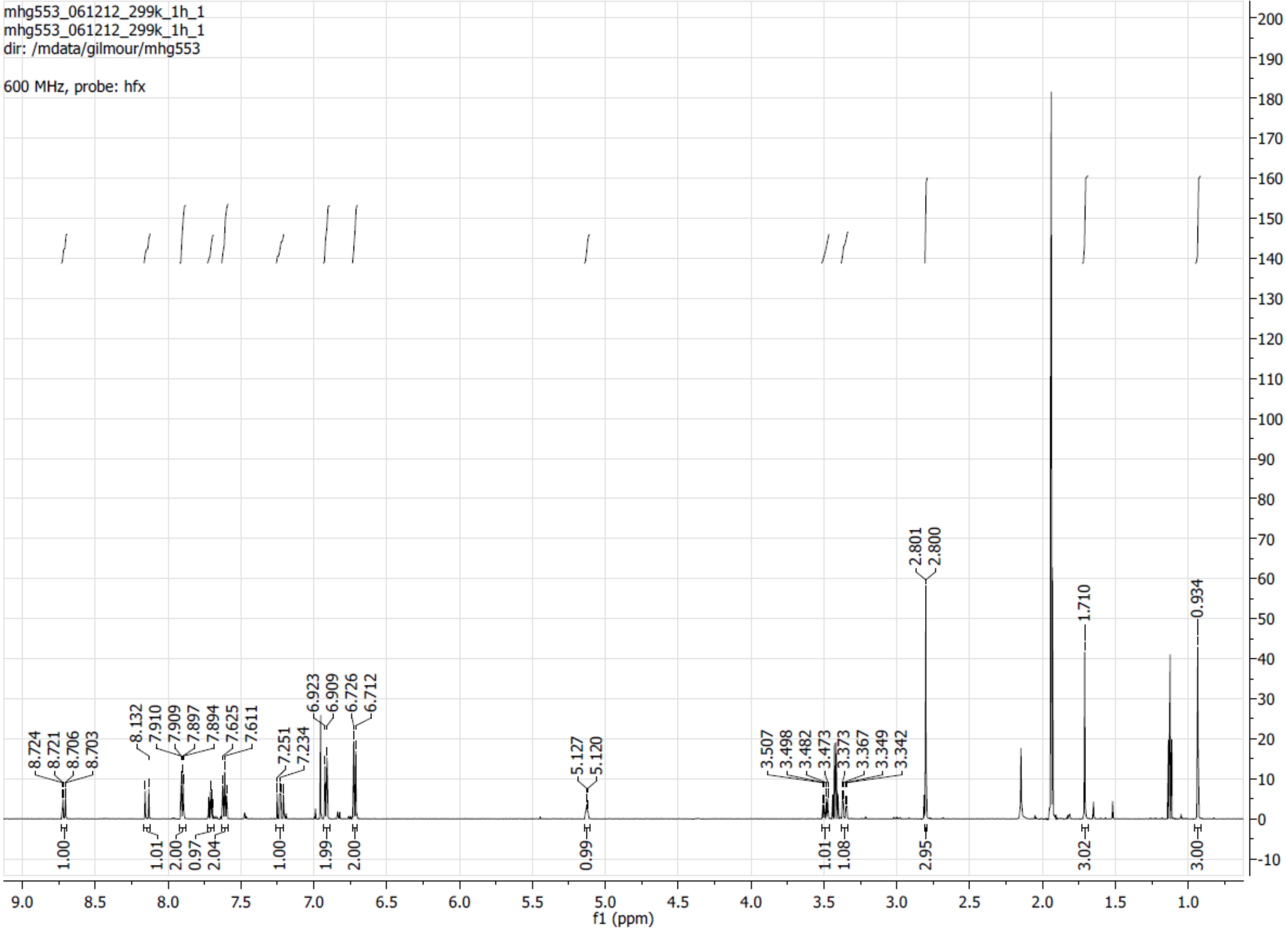
^{19}F NMR (564 MHz,



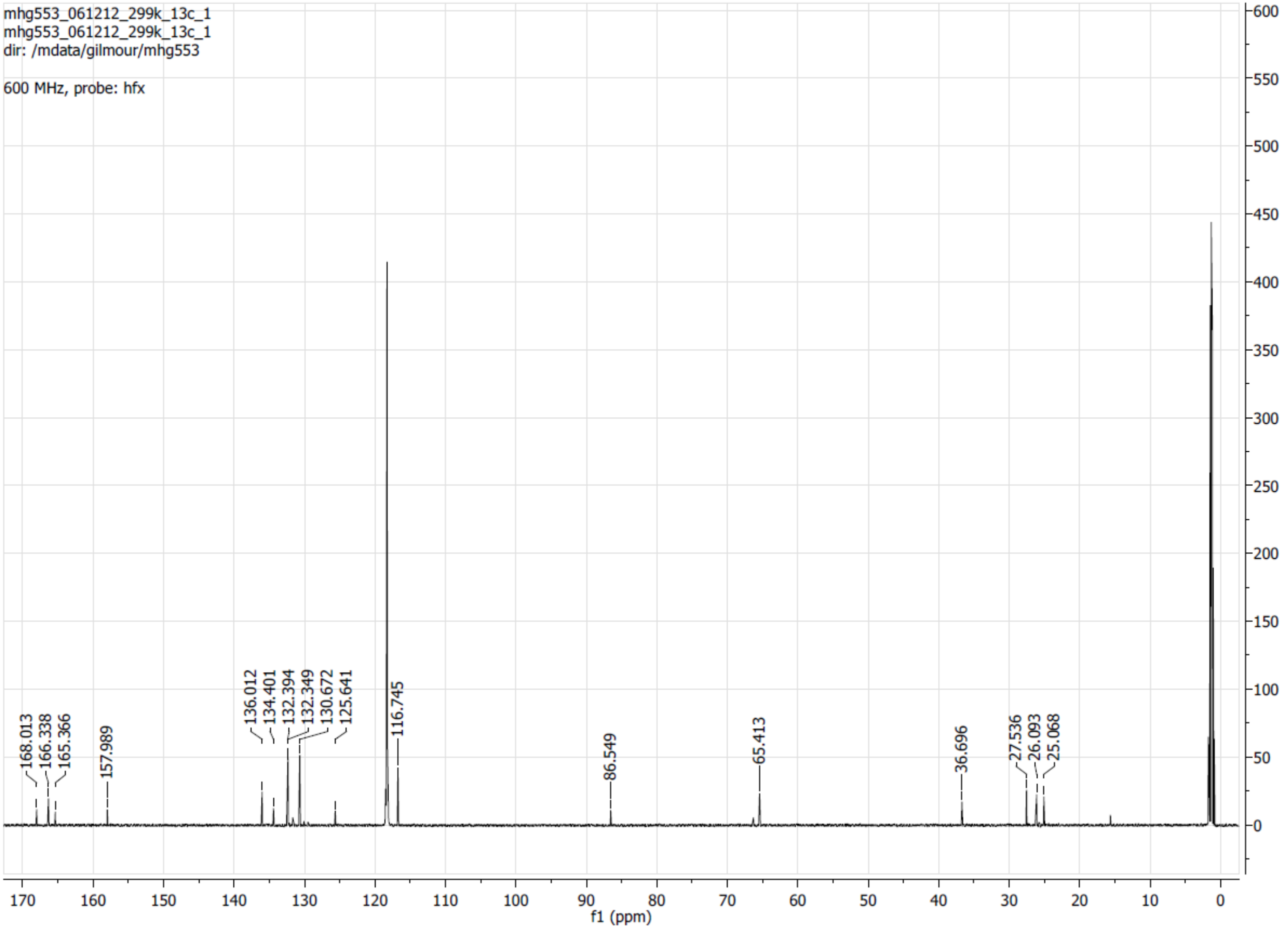


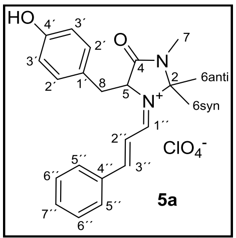
5a

^{1}H NMR (600 MHz,

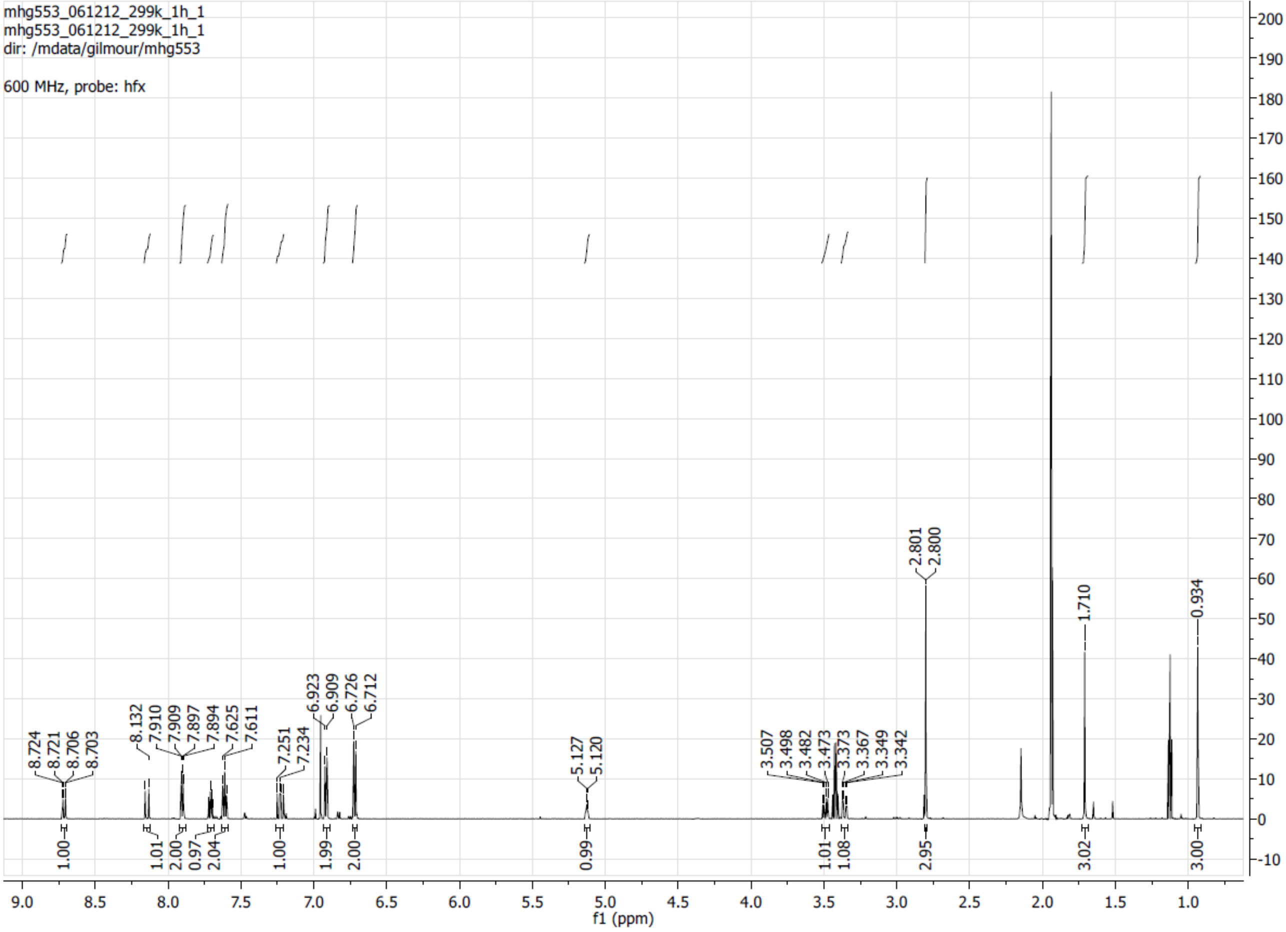


^{13}C NMR (151 MHz,

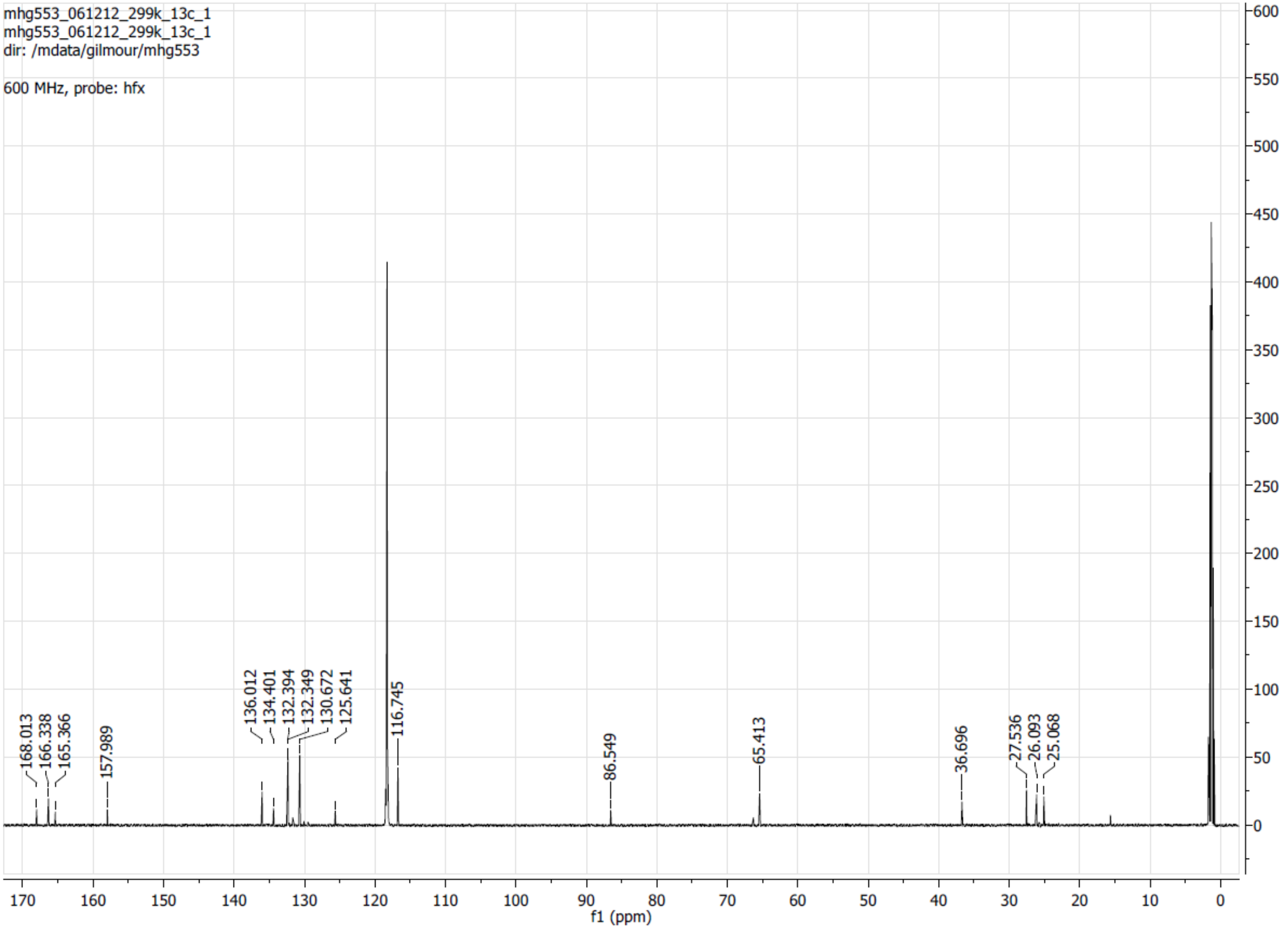


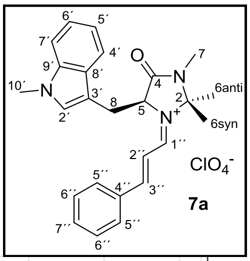


^{1}H NMR (600 MHz,



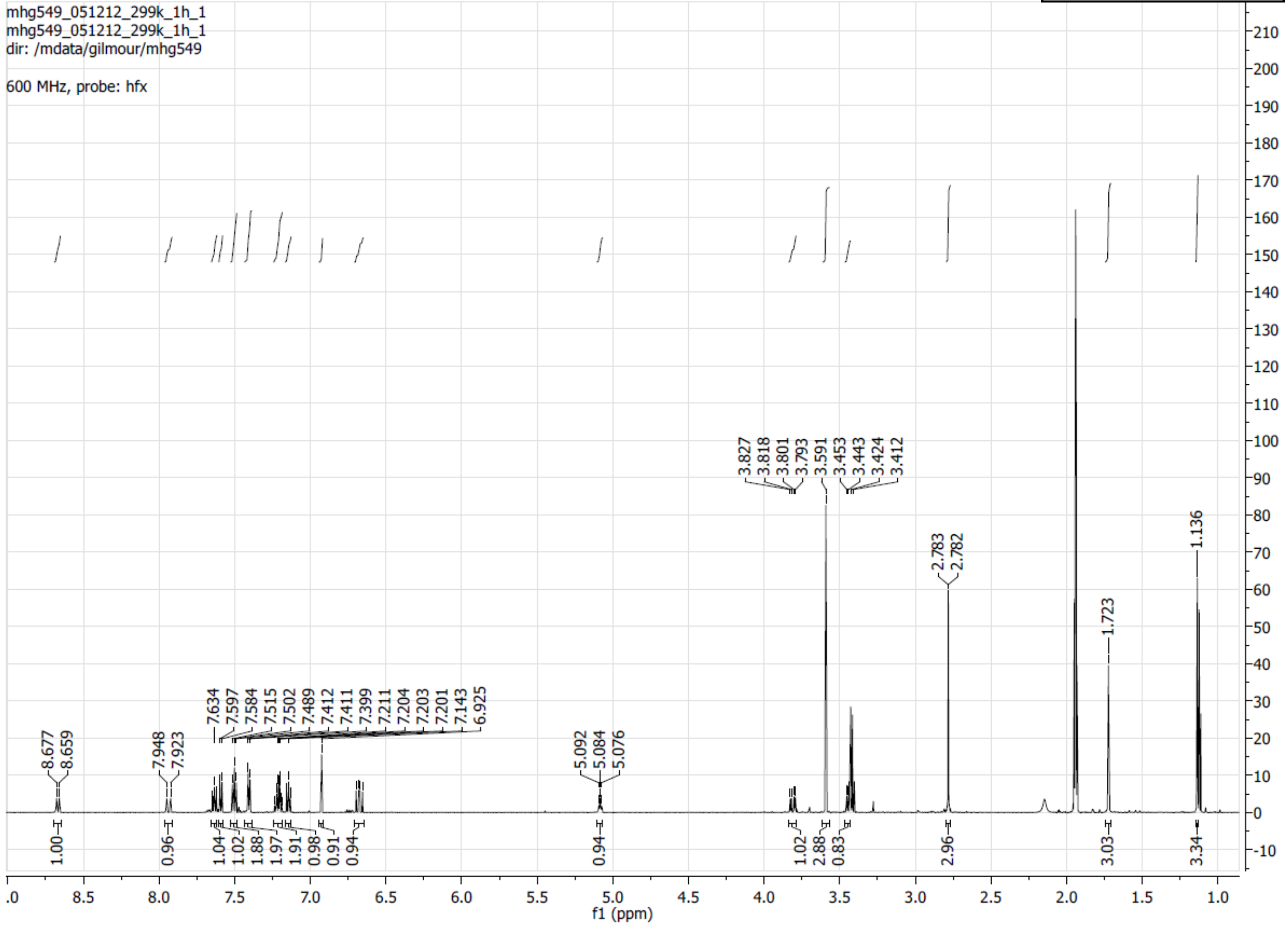
^{13}C NMR (151 MHz,



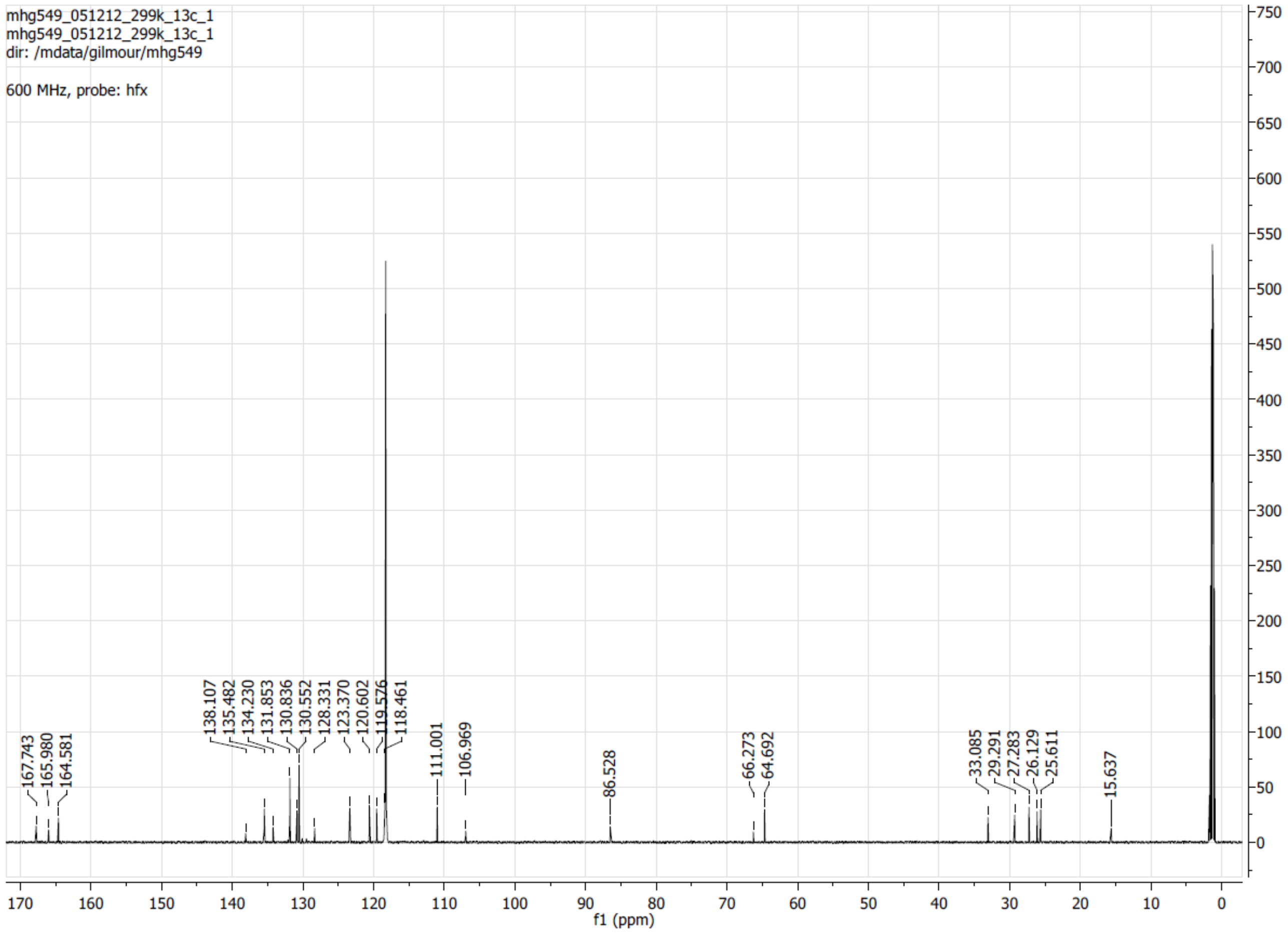


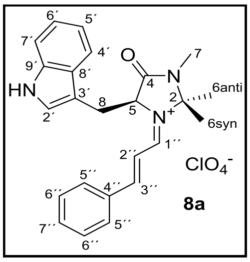
7a

^{1}H NMR (600 MHz,



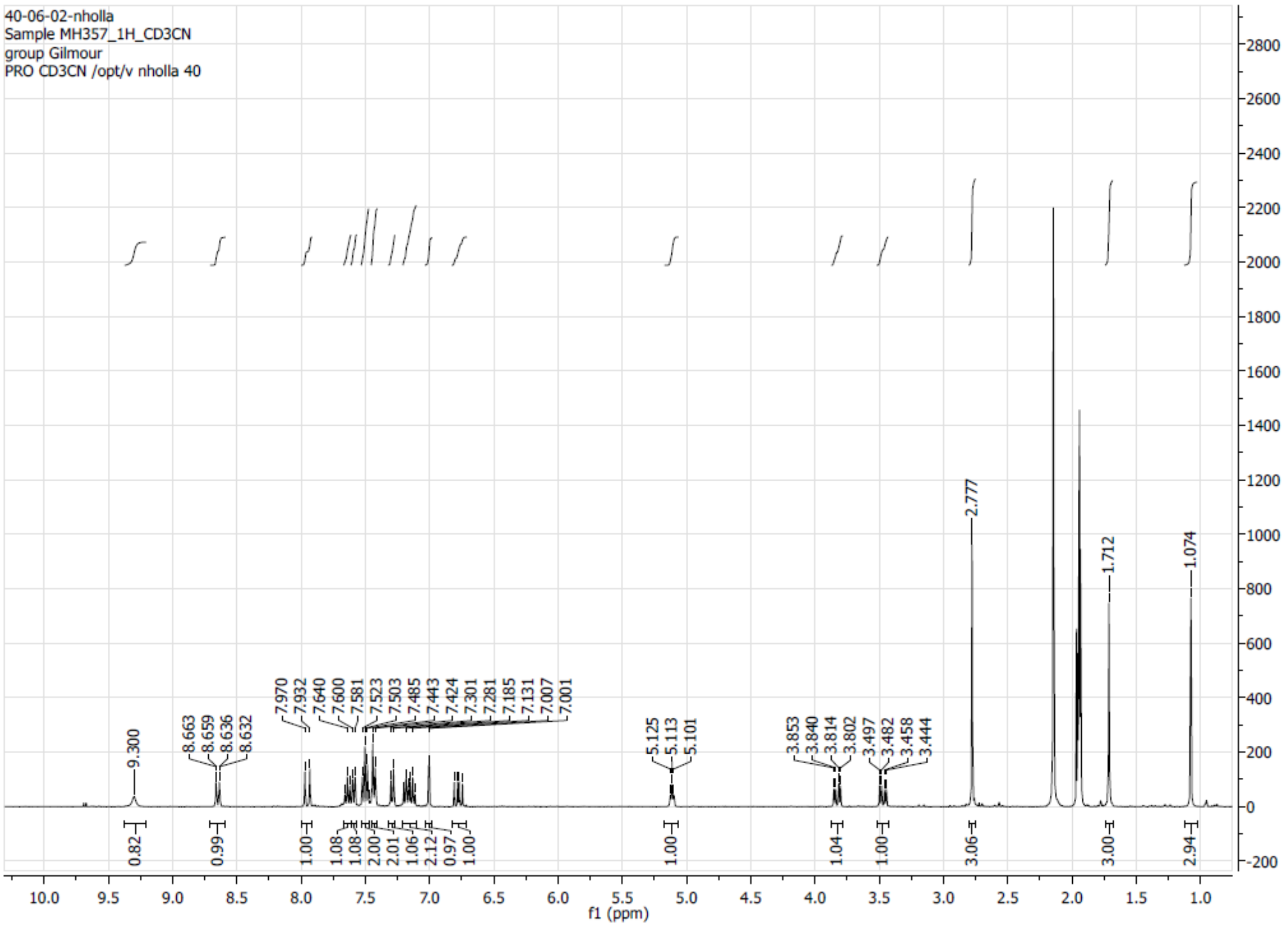
^{13}C NMR (151 MHz,



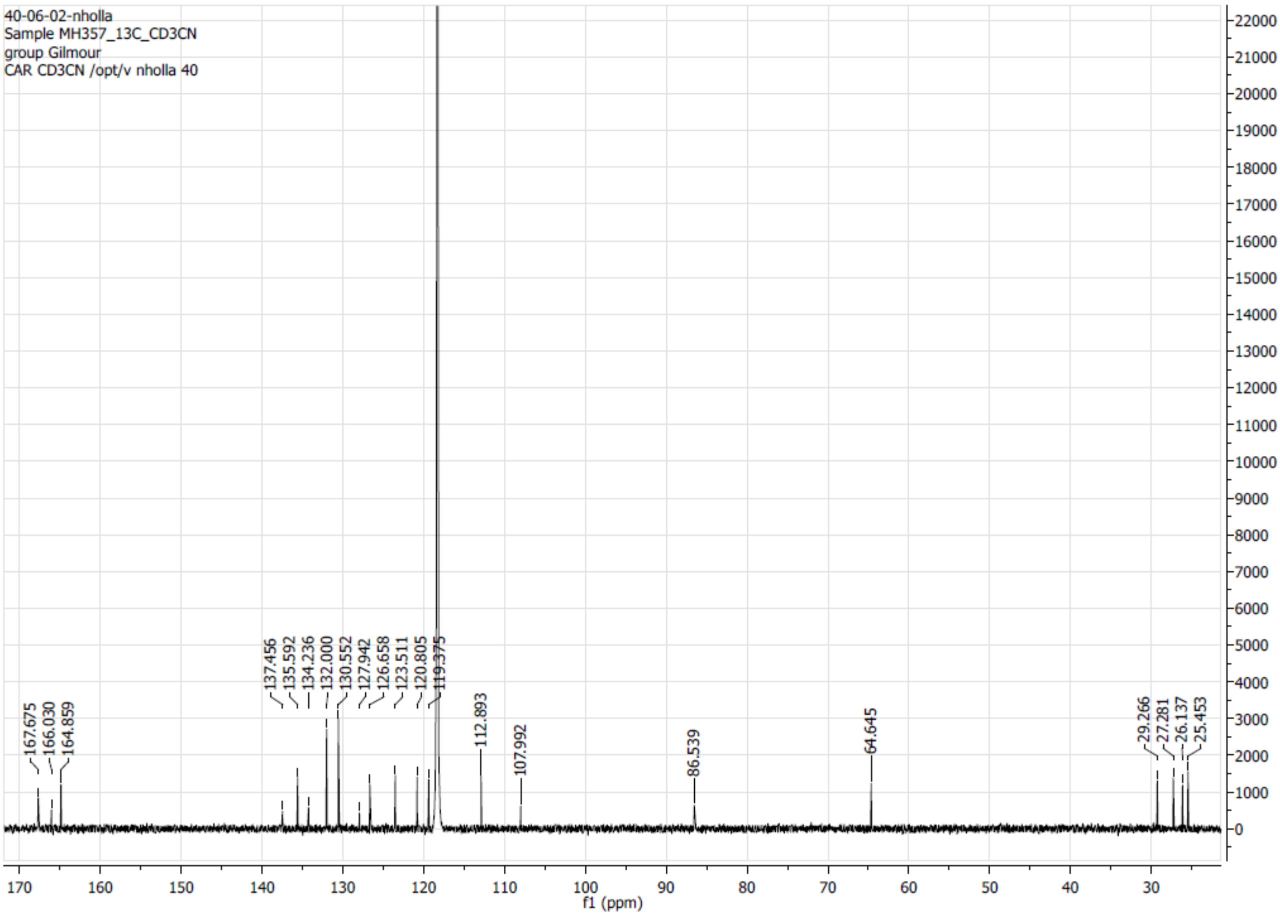


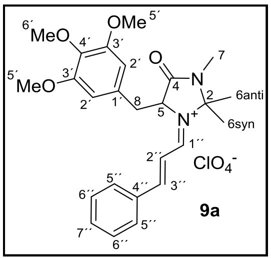
8a

^{1}H NMR (600 MHz,



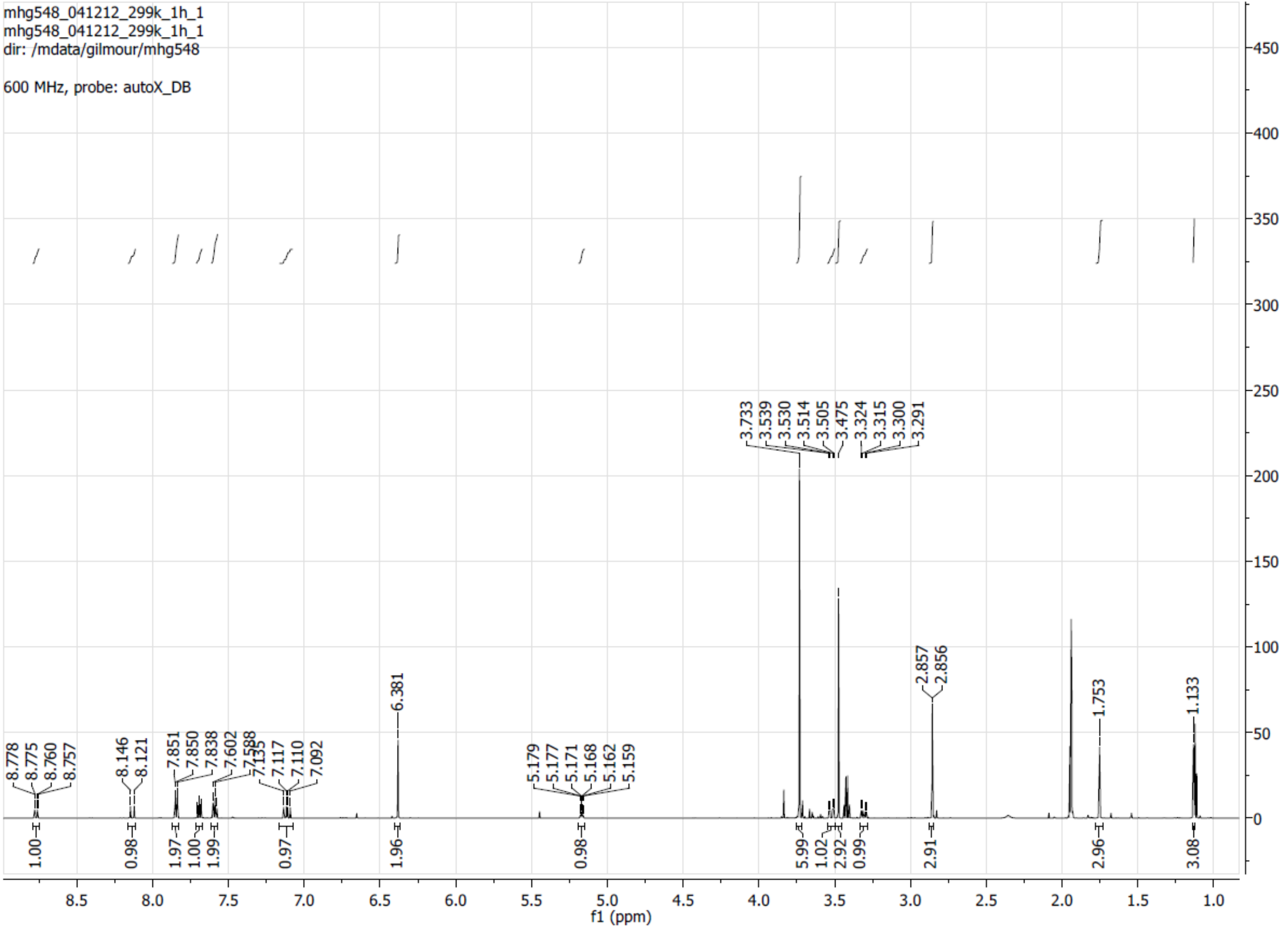
^{13}C NMR (151 MHz,



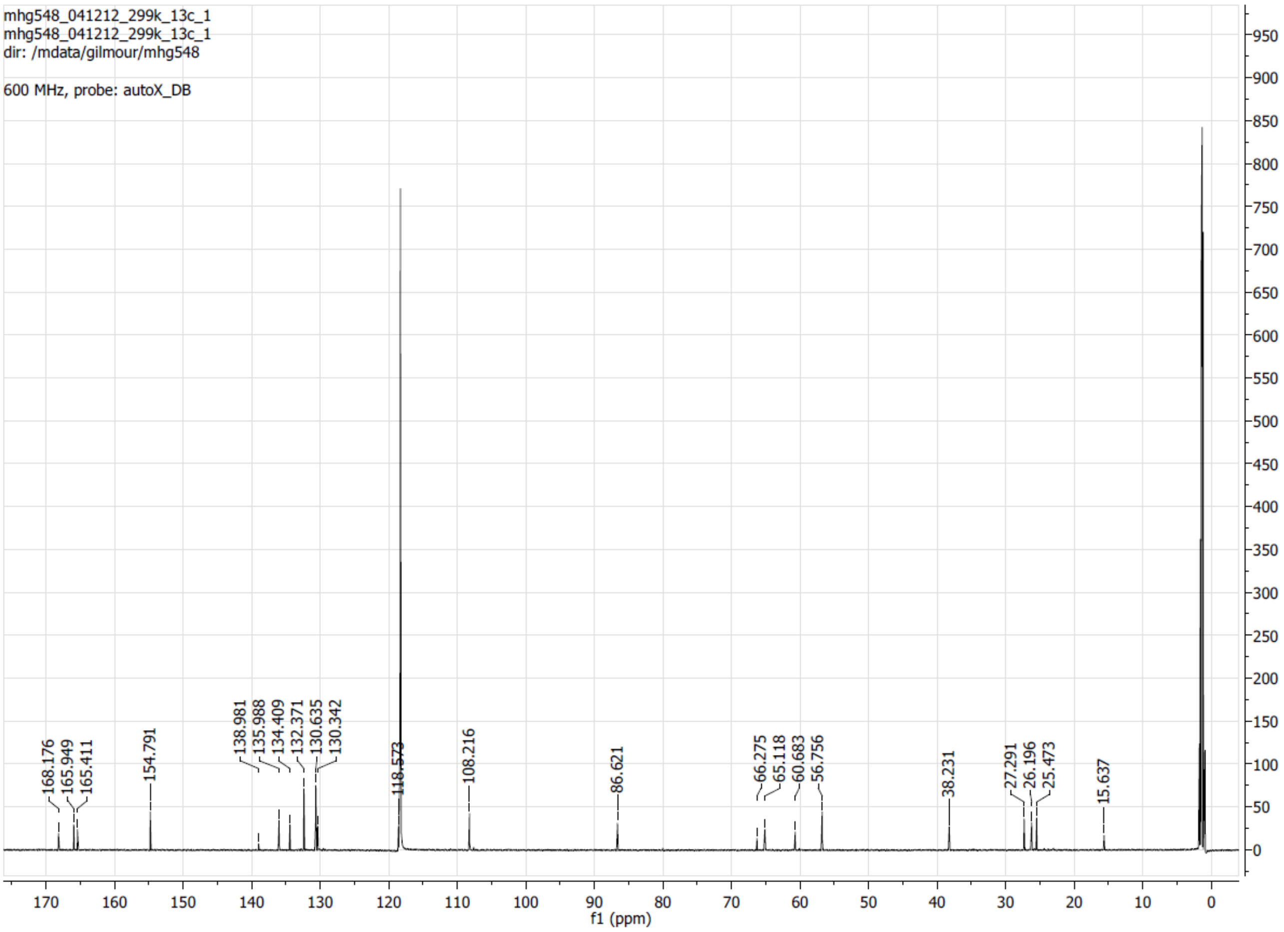


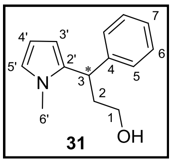
9a

^{1}H NMR (600 MHz,



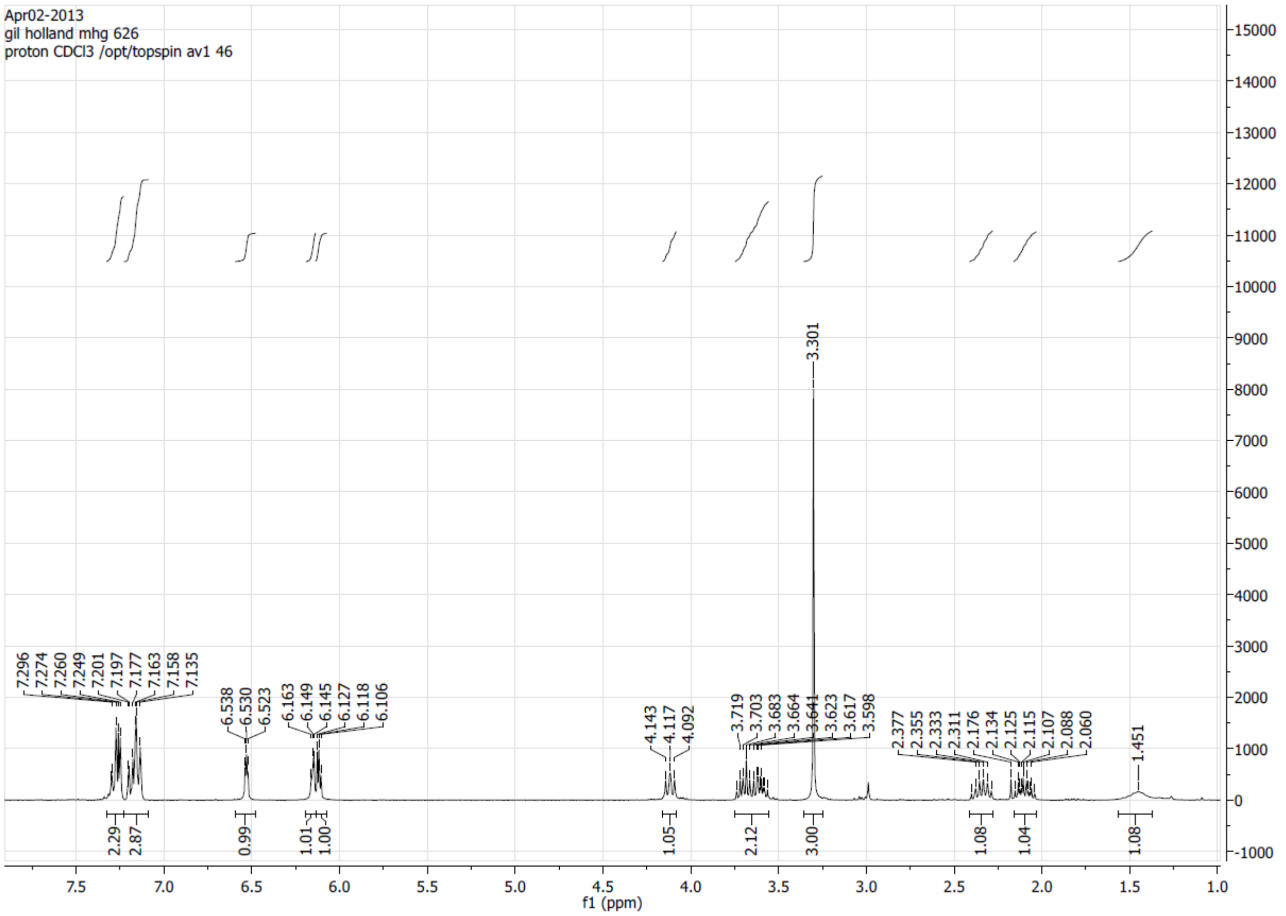
^{13}C NMR (151 MHz,

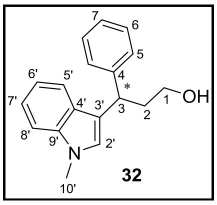




31

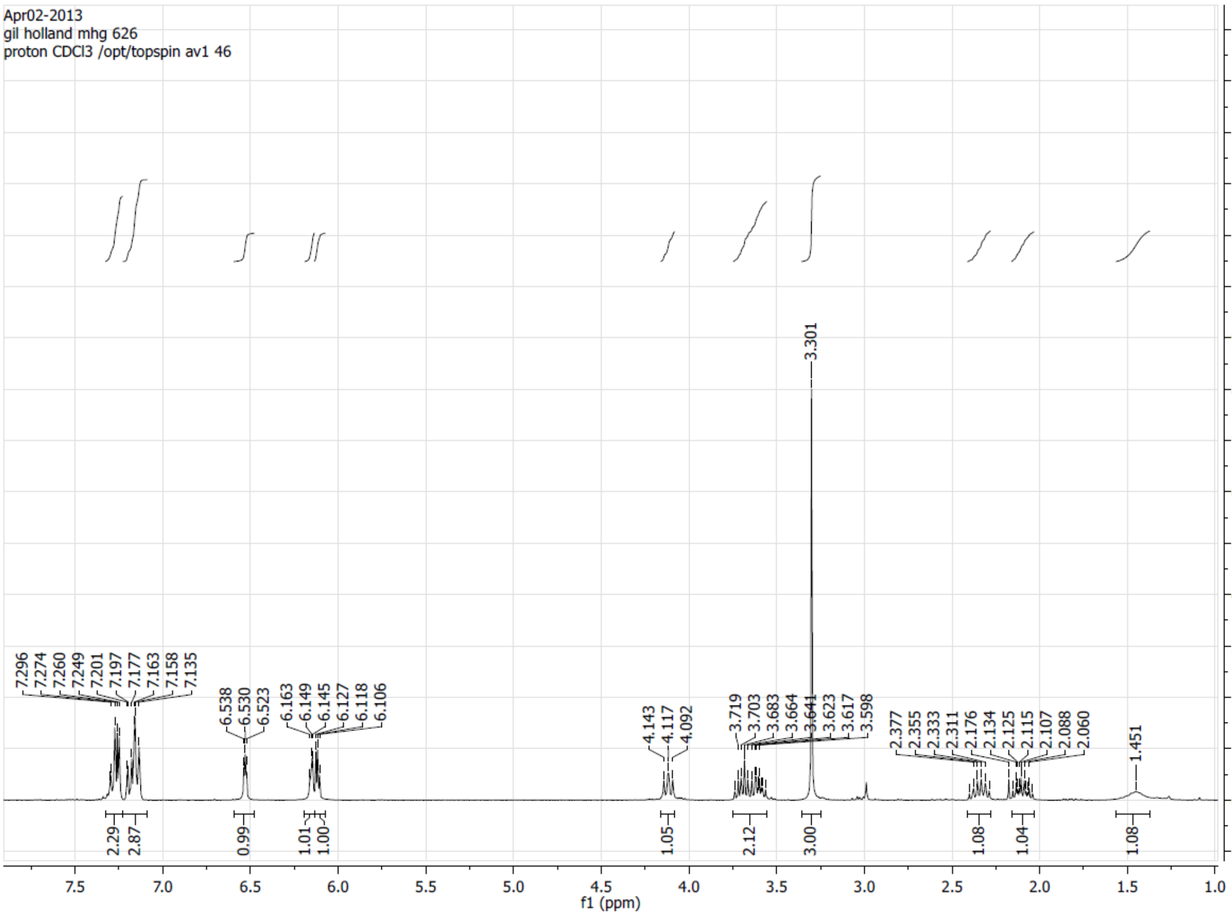
^{1}H NMR (300 MHz,

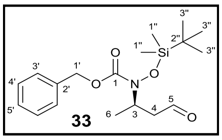




32

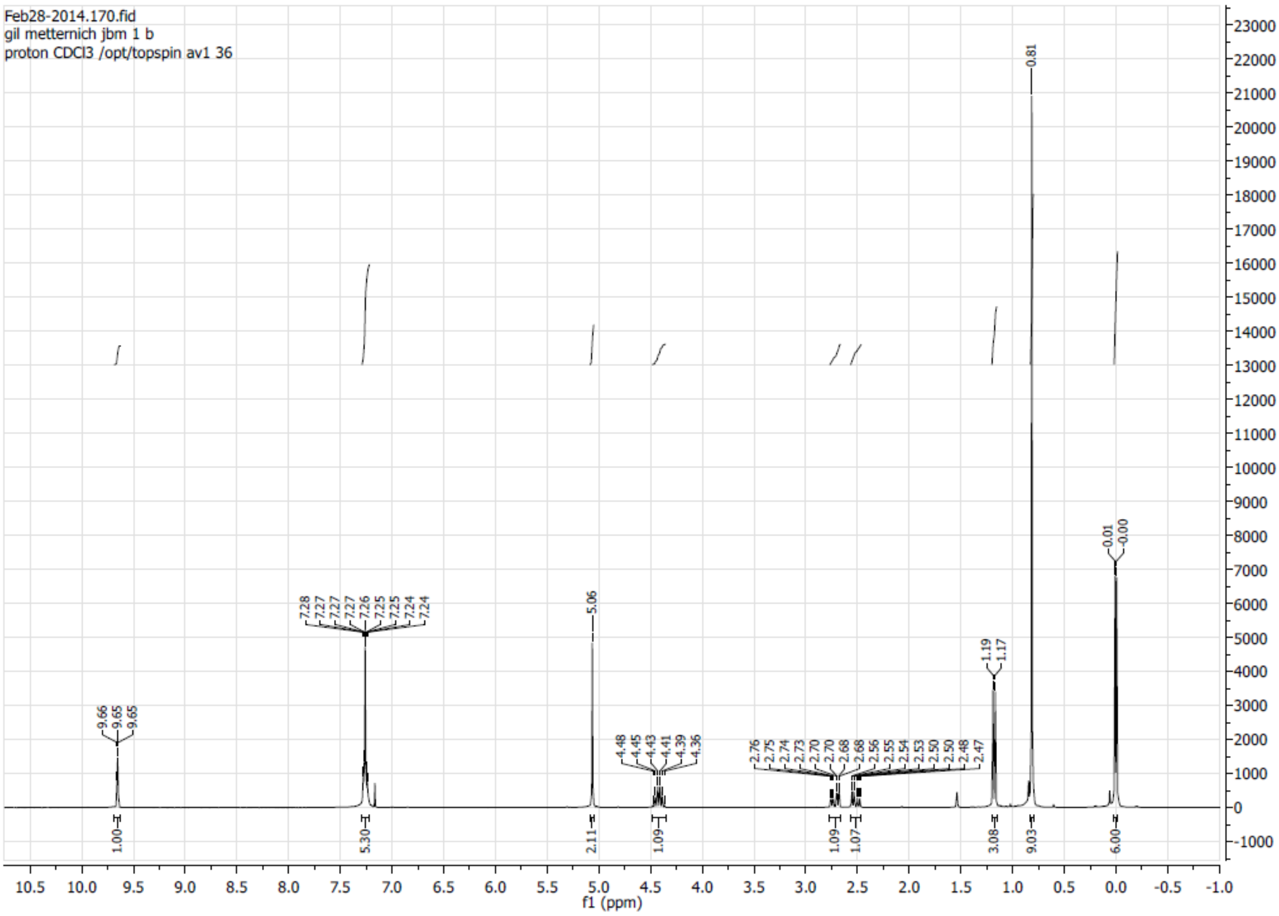
^{1}H NMR (300 MHz,





33

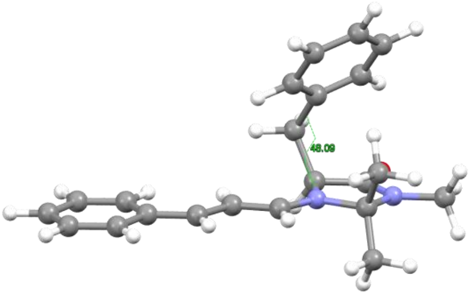
^{1}H NMR (300 MHz,



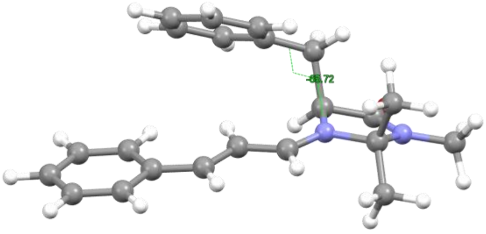
DFT Calculations

All calculations were performed with the TURBOMOLE 6.5 program.[18] The structures were optimized without any geometry constraints using the TPSS functional[19], which has been successfully applied to supramolecular thermochemistry,[23] and an atom-pairwise dispersion correction (D3).[20, 21] A flexible triple zeta basis set (def2-TZVP)[22] was used in all calculations. For the calculation of zero point vibrational energies and free enthalpy contributions, a rotor approximation was applied for vibrational modes with wave numbers below 100 cm^{-1}.[23] Solution energies were obtained with the COSMO model[24] as implemented in Turbomole with ε = 37.5.

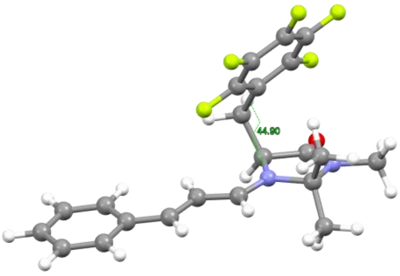
Structures of conformers of iminium cations **1** and **2**. The Ar-C-C-N$^+$ torsional angle is printed with each conformer.



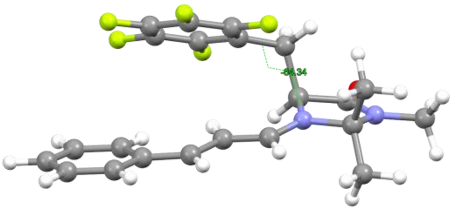
1 (I)



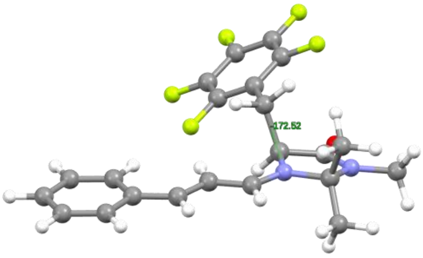
1 (II)



2 (I)



2 (II)



2 (III)

Calculated electronic energies, COSMO single point energies, zero point vibrational energies (ZPVE) and free enthalpy corrections (G298K) of the conformers of iminium cations **1** and **2**.

	E [E_h]	ZPVE [kcal mol^{-1}]	G(298K) [kcal mol^{-1}]	E(COSMO, ε=37.5) [E_h]
1 (I)	-1038,5608195	262,273	231,150	-1038,6352690
1 (II)	-1038,5599768	262,194	230,933	-1038,6347469
1 (III)	-[a]	-[a]	-[a]	-[a]
2 (I)	-1534,9658731	236,590	202,274	-1535,0444704
2 (II)	-1534,9697294	236,671	202,503	-1535,0466940

2 (III)	-1534,9667378	236,541	201,985	-1535,0433049

[a] no local minimum for III found, optimization converges to conformer II

Calculated relative energies (vacuum and solution), ZPVE-corrected relative energies and relative free enthalpies (T=298K) of the conformers of iminium cations **1** and **2**.

	ΔE_{rel} [kcal mol^{-1}]	$\Delta(E+ZPVE)_{rel}$ [kcal mol^{-1}]	$\Delta\ G_{rel}$(298K) [kcal mol^{-1}]	ΔE_{rel}(COSMO, ε=37.5) [kcal mol^{-1}]
1 (I)	**0,0**	**0,0**	**0,0**	**0,0**
1 (II)	0,53	0,45	0,31	0,33
1 (III)	-[a]	-[a]	-[a]	-[a]
2 (I)	2,42	2,34	2,19	1,40
2 (II)	**0,0**	**0,0**	**0,0**	**0,0**
2 (III)	1,88	1,75	1,36	2,13

[a] no local minimum for III found, optimization converges to conformer II

The values of Q_{zz} for the aromatic substituents reported in the manuscript were obtained by orienting the molecule such that the center of the methyl-substituted ring was located at the origin of the coordinate system. The component of the quadrupole moment tensor perpendicular to the aromatic plane (q_{zz}) was then used to obtain the traceless quadrupole moment $Q_{zz} = q_{zz} - (1/3\ \mathrm{tr}(\mathbf{q}))$.

Cartesian Coordinates (in Å) of DFT-optimized Structures (TPSS-D3/def2-TZVP)

1 (Conformer I)

C	1.9141343	1.2246182	-2.1636464
O	2.0594090	2.0829943	-3.0159083
N	2.8928565	0.6102706	-1.4392791
C	2.4401998	-0.3836142	-0.4697891
N	0.9474527	-0.3307079	-0.7069165
C	0.5626880	0.6945414	-1.6916393
C	0.1246380	-1.1475861	-0.0960103
C	4.2981931	0.9678429	-1.5926991
C	2.7704872	0.0151468	0.9716687
C	2.9676064	-1.7816804	-0.8162314
C	-0.2963123	1.8538122	-1.1151090
C	-1.2656161	-1.2371158	-0.3068974
C	-2.0040896	-2.1353125	0.4221992
C	-3.4167060	-2.3745754	0.3432909
C	-4.2684743	-1.6751612	-0.5438799
C	-5.6246725	-1.9519557	-0.5725779
C	-6.1612825	-2.9279908	0.2786695
C	-5.3361173	-3.6287844	1.1618709
C	-3.9761100	-3.3552015	1.1946568
C	-0.2207643	2.0127994	1.4003875
C	0.3421891	2.4874678	2.5852923
C	1.4106437	3.3834897	2.5382434
C	1.9015353	3.8128144	1.3033994
C	1.3360915	3.3397600	0.1195995
C	0.2738803	2.4262213	0.1576257
H	0.0403497	0.2191923	-2.5291666
H	0.5801643	-1.8207700	0.6270640
H	4.3419352	1.7244001	-2.3771695
H	4.6943045	1.3833833	-0.6615070
H	4.8923757	0.0995159	-1.8911202
H	2.3940701	1.0144815	1.1954807
H	2.3342597	-0.7016989	1.6736019
H	3.8542356	-0.0050177	1.1121890
H	2.6882585	-2.0585672	-1.8358644

H	4.0571661	-1.7883638	-0.7326197
H	2.5827378	-2.5295053	-0.1169399
H	-1.3198749	1.5073121	-0.9485704
H	-0.3228313	2.6029589	-1.9132493
H	-1.7331094	-0.6020550	-1.0504603
H	-1.4674764	-2.7413872	1.1534359
H	-3.8640692	-0.9177068	-1.2081831
H	-6.2742847	-1.4132587	-1.2548139
H	-7.2257281	-3.1399509	0.2499990
H	-5.7564904	-4.3831725	1.8187551
H	-3.3262266	-3.8949691	1.8784068
H	1.7128391	3.6860329	-0.8391267
H	2.7185526	4.5269603	1.2619754
H	1.8477336	3.7587253	3.4584642
H	-0.0578529	2.1664485	3.5425179
H	-1.0628986	1.3249193	1.4405810

1 (Conformer II)

C	3.1803798	0.9852721	-1.3717347
O	3.6310967	1.6407158	-2.2920546
N	3.8846185	0.2658268	-0.4457501
C	3.0773159	-0.4158324	0.5670049
N	1.6946568	-0.1718659	0.0095033
C	1.7013345	0.8943890	-1.0020401
C	0.6664287	-0.9271224	0.3312613
C	5.3436303	0.2401139	-0.4394508
C	3.2060981	0.2316298	1.9531517
C	3.3999562	-1.9116746	0.6138264
C	1.2310918	2.2821999	-0.4810674
C	-0.6324498	-0.8623301	-0.2053938
C	-1.5794545	-1.7505091	0.2390988
C	-2.9424183	-1.8621666	-0.1972124
C	-3.4904676	-1.0492626	-1.2160684
C	-4.8134495	-1.2021641	-1.5938095
C	-5.6181202	-2.1642171	-0.9674685
C	-5.0931946	-2.9781074	0.0392160
C	-3.7667181	-2.8298351	0.4205030
C	-1.2190670	2.5063350	-1.0334319
C	-2.5641178	2.4634053	-0.6701407
C	-2.9242319	2.2170968	0.6566944
C	-1.9335270	2.0378853	1.6215933
C	-0.5877935	2.0883348	1.2574979
C	-0.2162454	2.3087410	-0.0735649
H	1.1011210	0.5877757	-1.8622380
H	0.8708488	-1.6949146	1.0734454
H	5.6703327	0.9293412	-1.2192667
H	5.7311780	0.5721987	0.5281665
H	5.7213159	-0.7619540	-0.6623579
H	3.0081977	1.3042658	1.9038603
H	2.5042239	-0.2319363	2.6526882
H	4.2170687	0.0787169	2.3397601
H	3.2227844	-2.3787439	-0.3582437
H	4.4528035	-2.0359507	0.8786487
H	2.8167784	-2.4253083	1.3825954
H	1.4268567	2.9737961	-1.3068315
H	1.8750706	2.5783129	0.3526820
H	-0.8735815	-0.1052677	-0.9424305
H	-1.2780658	-2.4551599	1.0154827
H	-2.8766695	-0.2976560	-1.7007833
H	-5.2297946	-0.5771395	-2.3774614
H	-6.6551142	-2.2775662	-1.2685952
H	-5.7182857	-3.7241276	0.5189231
H	-3.3497306	-3.4586669	1.2028626
H	0.1817949	1.9642533	2.0161477
H	-2.2080129	1.8703619	2.6587808
H	-3.9719947	2.1839796	0.9388989
H	-3.3318565	2.6352002	-1.4190011
H	-0.9426212	2.7093314	-2.0658965

2 (Conformer I)

C	1.8839219	1.1251716	-2.2264726
O	2.0207506	1.8603309	-3.1845380
N	2.8678811	0.5754023	-1.4531375
C	2.4217744	-0.3828299	-0.4442308
N	0.9230796	-0.3133759	-0.6502864
C	0.5371989	0.6980430	-1.6462637
C	0.1029538	-1.1697793	-0.0826520
C	4.2793491	0.8460023	-1.7075234
C	2.7921309	0.0484427	0.9779224
C	2.9268540	-1.7970901	-0.7578743
C	-0.2421892	1.9204121	-1.0827964
C	-1.2824889	-1.2590596	-0.3017190
C	-2.0138180	-2.2021932	0.3785259
C	-3.4248852	-2.4393779	0.2976738
C	-4.2860655	-1.6903892	-0.5392043
C	-5.6422793	-1.9651992	-0.5686237
C	-6.1697294	-2.9881773	0.2321193
C	-5.3355451	-3.7386033	1.0649534
C	-3.9753772	-3.4676960	1.0979968
C	-0.1342377	2.0974141	1.4386768
C	0.3800007	2.5966497	2.6310173
C	1.4031880	3.5440683	2.5862111
C	1.8868999	3.9819472	1.3527103
C	1.3472837	3.4605361	0.1778482
C	0.3326846	2.4987099	0.1854931
H	-0.0612653	0.2269118	-2.4326534
H	0.5616946	-1.8706684	0.6110763
H	4.3133069	1.6249933	-2.4701313
H	4.7694085	1.2016332	-0.7971433
H	4.7936551	-0.0453133	-2.0792543
H	2.4602210	1.0693742	1.1712770
H	2.3376364	-0.6243585	1.7111958
H	3.8761981	-0.0057728	1.1053365
H	2.6109497	-2.1078468	-1.7569544
H	4.0185566	-1.8074977	-0.7124369
H	2.5657011	-2.5184592	-0.0195942
H	-1.2823739	1.6394332	-0.9055457
H	-0.2229737	2.6671629	-1.8821610
H	-1.7592994	-0.5770821	-0.9965021
H	-1.4696471	-2.8480861	1.0687024
H	-3.8884965	-0.8958025	-1.1628532
H	-6.2995369	-1.3885835	-1.2113498
H	-7.2347390	-3.1974331	0.2040094
H	-5.7495767	-4.5285122	1.6828816
H	-3.3182385	-4.0448292	1.7431102
F	-1.1293663	1.1817395	1.5148808
F	-0.0929819	2.1714214	3.8085236
F	1.9138516	4.0306262	3.7171964
F	2.8604439	4.8954695	1.3045652
F	1.8275362	3.9121209	-0.9920017

2 (Conformer II)

C	2.5977273	1.8464996	-1.7437509
O	2.6963242	2.7455538	-2.5567247
N	3.6114236	1.1652829	-1.1308568
C	3.1977249	0.1455796	-0.1652451
N	1.7031278	0.1546716	-0.3985538
C	1.2783622	1.3321180	-1.1673070
C	0.9269050	-0.8385255	-0.0211862
C	5.0132463	1.4875057	-1.3812683
C	3.5127019	0.5467766	1.2815800
C	3.7919764	-1.2212835	-0.5159941
C	0.6476334	2.4660313	-0.3093902
C	-0.4407078	-0.9843154	-0.3140839
C	-1.1549399	-2.0174262	0.2409987

C	-2.5537207	-2.2864804	0.0725009
C	-3.3756792	-1.5518303	-0.8147508
C	-4.7284775	-1.8288298	-0.9042766
C	-5.2912400	-2.8437487	-0.1171969
C	-4.4936779	-3.5881979	0.7555049
C	-3.1360352	-3.3156730	0.8476585
C	-1.8604206	2.1353640	-0.3148502
C	-3.0570394	1.7323124	0.2699144
C	-3.0486236	1.2469973	1.5784225
C	-1.8505661	1.1894283	2.2902001
C	-0.6743223	1.6107900	1.6767014
C	-0.6403348	2.0825411	0.3643367
H	0.5974629	1.0330957	-1.9678517
H	1.4144724	-1.6158660	0.5619209
H	5.0198452	2.3458483	-2.0542966
H	5.5210440	1.7497559	-0.4486171
H	5.5290067	0.6495170	-1.8584220
H	3.1097970	1.5342202	1.5128624
H	3.0875601	-0.1815119	1.9779702
H	4.5955470	0.5615748	1.4291748
H	3.4994197	-1.5257807	-1.5240234
H	4.8816710	-1.1562380	-0.4682824
H	3.4870348	-1.9858616	0.2034099
H	0.4857070	3.2959250	-1.0026627
H	1.3735372	2.7917782	0.4385002
H	-0.9269928	-0.2576437	-0.9532336
H	-0.6217084	-2.6926511	0.9112568
H	-2.9497366	-0.7705970	-1.4361586
H	-5.3542502	-1.2604806	-1.5844871
H	-6.3539556	-3.0535796	-0.1900507
H	-4.9336162	-4.3752237	1.3590609
H	-2.5084078	-3.8865023	1.5268748
F	-1.8804623	2.5551782	-1.5963491
F	-4.2035655	1.7777912	-0.4184132
F	-4.1819219	0.8236035	2.1396780
F	-1.8357891	0.7133926	3.5400858
F	0.4769330	1.5191139	2.3796709

2 (Conformer III)

C	2.2968079	1.2035072	-1.1064831
O	2.3699708	2.1559538	-1.8600717
N	3.3356803	0.4835417	-0.5827181
C	2.9614629	-0.6263581	0.2935301
N	1.4608876	-0.5842212	0.1459505
C	1.0027131	0.6315549	-0.5364091
C	0.6649921	-1.5472732	0.5579666
C	4.7255288	0.8271799	-0.8663394
C	3.3499449	-0.3688321	1.7557018
C	3.5162176	-1.9582518	-0.2197206
C	0.3227737	1.6323674	0.4416247
C	-0.7323351	-1.5668901	0.3969272
C	-1.4619339	-2.6340065	0.8649998
C	-2.8802683	-2.8176335	0.7755855
C	-3.7420713	-1.8711286	0.1697617
C	-5.1047432	-2.1077664	0.1137722
C	-5.6378316	-3.2854744	0.6566260
C	-4.8029108	-4.2307899	1.2588947
C	-3.4364830	-3.9999158	1.3184725
C	0.2782048	4.0535005	-0.3120413
C	-0.2888410	5.1117678	-1.0171459
C	-1.4670635	4.9048040	-1.7360347
C	-2.0701354	3.6453443	-1.7414977
C	-1.4740029	2.6153942	-1.0260816
C	-0.2984404	2.7834101	-0.2974047
H	0.3148226	0.3635152	-1.3426420
H	1.1498602	-2.3880655	1.0483324
H	4.7031214	1.7306892	-1.4770812
H	5.2712214	1.0262741	0.0604919

H	5.2222817	0.0265840	-1.4217436
H	2.9519865	0.5881472	2.1009259
H	2.9699775	-1.1694897	2.3971562
H	4.4386277	-0.3522583	1.8506229
H	3.1880715	-2.1442434	-1.2453555
H	4.6081471	-1.9244899	-0.1969304
H	3.2069994	-2.7888199	0.4206167
H	1.0652312	2.0046684	1.1501773
H	-0.4442959	1.0940359	1.0071250
H	-1.2208142	-0.7403714	-0.1072917
H	-0.9139895	-3.4357638	1.3617541
H	-3.3417715	-0.9557434	-0.2540553
H	-5.7623897	-1.3807235	-0.3515117
H	-6.7078490	-3.4632992	0.6080842
H	-5.2214603	-5.1401439	1.6773504
H	-2.7783112	-4.7287313	1.7841309
F	1.4142056	4.2734918	0.3743368
F	0.2860732	6.3171375	-1.0129201
F	-2.0209242	5.9096091	-2.4149843
F	-3.2030695	3.4413181	-2.4240605
F	-2.0638761	1.3868887	-1.0403936

Fragmented Iminium Cation, derived from **1** (Ar = Ph)

C	2.3698390	1.5978570	-2.1537469
O	2.6310789	2.5411506	-2.8791492
N	3.2404215	0.8905881	-1.3779331
C	2.6583876	-0.1945631	-0.5928873
N	1.2111376	-0.0890145	-1.0190865
C	0.9654761	1.0441949	-1.9270200
C	0.3110074	-0.9524626	-0.6169146
C	4.6548531	1.2371260	-1.3027328
C	2.7936781	0.0387855	0.9148074
C	3.2227026	-1.5559457	-1.0182716
C	-1.0386867	-0.9931992	-1.0193585
C	-1.8713722	-1.9518728	-0.4985324
C	-3.2614447	-2.1553911	-0.7904789
C	-3.9840910	-1.3481579	-1.7003771
C	-5.3251204	-1.5954736	-1.9395091
C	-5.9744238	-2.6484788	-1.2801206
C	-5.2776119	-3.4561702	-0.3778208
C	-3.9333689	-3.2125609	-0.1345120
C	3.3214380	3.1971042	2.6961682
C	2.6570954	3.8481576	1.6564644
C	1.2831141	3.6717929	1.4900012
C	0.5766204	2.8553637	2.3756796
C	1.2413843	2.2073023	3.4163359
C	2.6242901	2.3651733	3.5804189
H	0.5585908	0.6724533	-2.8738564
H	0.6630996	-1.7085529	0.0815647
H	4.8060374	2.0736877	-1.9861031
H	4.9238830	1.5415203	-0.2870256
H	5.2807177	0.3958017	-1.6134857
H	2.3940695	1.0144816	1.1954808
H	2.2647688	-0.7421841	1.4690775
H	3.8487011	-0.0162637	1.1950850
H	3.0817208	-1.7150263	-2.0902642
H	4.2911661	-1.5915053	-0.7917854
H	2.7449372	-2.3683520	-0.4631934
H	-1.4000194	-0.2725500	-1.7438157
H	-1.4397924	-2.6436278	0.2261729
H	-3.4916251	-0.5303476	-2.2173328
H	-5.8754825	-0.9739668	-2.6384107
H	-7.0261188	-2.8366679	-1.4732781
H	-5.7848964	-4.2698403	0.1300400
H	-3.3829432	-3.8353055	0.5658009
H	0.6857817	1.5828638	4.1108654
H	-0.4964633	2.7325597	2.2632517
H	0.7621938	4.1809867	0.6850118
H	3.2082820	4.4986787	0.9839000

H	4.3905138	3.3477725	2.8316137
H	0.4201026	1.8229621	-1.3737675
H	3.1533756	1.8380785	4.3880219

Fragmented Iminium Cation, derived from **2** (Ar = C_6F_5)

C	1.8839217	1.1251717	-2.2264728
O	2.0207504	1.8603310	-3.1845378
N	2.8678809	0.5754023	-1.4531377
C	2.4217746	-0.3828300	-0.4442309
N	0.9230795	-0.3133760	-0.6502866
C	0.5371989	0.6980433	-1.6462635
C	0.1029540	-1.1697792	-0.0826522
C	4.2793496	0.8460022	-1.7075237
C	2.7921308	0.0484425	0.9779224
C	2.9268540	-1.7970901	-0.7578742
C	-1.2824887	-1.2590593	-0.3017188
C	-2.0138182	-2.2021931	0.3785256
C	-3.4248853	-2.4393777	0.2976737
C	-4.2860654	-1.6903894	-0.5392044
C	-5.6422795	-1.9651990	-0.5686235
C	-6.1697293	-2.9881771	0.2321193
C	-5.3355452	-3.7386036	1.0649535
C	-3.9753770	-3.4676962	1.0979969
C	2.7017812	2.6315647	3.4866244
C	3.2652040	3.5410280	2.5973619
C	2.4725481	4.0814744	1.5843736
C	1.1308498	3.7112881	1.4840628
C	0.5994851	2.7978565	2.3932720
C	1.3683153	2.2246101	3.4105567
H	-0.0612655	0.2269117	-2.4326534
H	0.5616945	-1.8706684	0.6110762
H	4.3133069	1.6249932	-2.4701313
H	4.7694083	1.2016330	-0.7971433
H	4.7936552	-0.0453134	-2.0792541
H	2.4602209	1.0693742	1.1712768
H	2.3376365	-0.6243586	1.7111956
H	3.8761982	-0.0057728	1.1053366
H	2.6109496	-2.1078472	-1.7569546
H	4.0185563	-1.8074979	-0.7124369
H	2.5657012	-2.5184595	-0.0195944
H	-1.7592994	-0.5770824	-0.9965023
H	-1.4696469	-2.8480860	1.0687022
H	-3.8884968	-0.8958026	-1.1628534
H	-6.2995370	-1.3885834	-1.2113498
H	-7.2347389	-3.1974328	0.2040094
H	-5.7495770	-4.5285126	1.6828815
H	-3.3182386	-4.0448294	1.7431103
F	3.4956971	2.1273473	4.4613129
F	4.5525515	3.8908664	2.7042011
F	2.9945632	4.9499302	0.7183854
F	0.3655693	4.2327492	0.5212166
F	-0.6979179	2.4722470	2.2755714
H	0.9439450	1.4897424	4.1104744
H	0.1421587	1.5853171	-1.1298449

Cartesian Coordinates (in Å) of DFT-optimized Toluene Derivatives **1-9** (cf. Figure 4) (TPSS-D3/def2-TZVP)

1 (Me-Ph)

C	-0.7258839	-0.0320580	0.0000000
C	-0.0071598	-0.0230995	-1.2018661
C	1.3873556	0.0005608	-1.2048560
C	2.0906122	0.0136559	-0.0000000
C	1.3873556	0.0005608	1.2048560
C	-0.0071598	-0.0230995	1.2018661
C	-2.2355186	-0.0265516	-0.0000000

H	-0.5475805	-0.0378004	-2.1459965
H	1.9251214	0.0046215	-2.1492049
H	3.1768108	0.0290879	-0.0000000
H	1.9251214	0.0046215	2.1492049
H	-0.5475805	-0.0378004	2.1459965
H	-2.6337660	-0.5277290	0.8876717
H	-2.6221455	1.0007222	-0.0000000
H	-2.6337660	-0.5277290	-0.8876717

2 (Me-C_6F_5)

C	-0.7550270	0.0256081	0.0000000
C	-0.0189840	0.0146870	-1.1853584
C	1.3733425	-0.0003970	-1.2045158
C	2.0735925	-0.0087399	0.0000000
C	1.3733427	-0.0003811	1.2045158
C	-0.0189842	0.0146747	1.1853584
C	-2.2608919	0.0373949	0.0000000
F	-0.6687350	0.0213680	-2.3699625
F	2.0426972	-0.0076219	-2.3687546
F	3.4144915	-0.0245794	-0.0000000
F	2.0426979	-0.0075603	2.3687546
F	-0.6687356	0.0213114	2.3699625
H	-2.6381936	0.5437646	0.8905380
H	-2.6565449	-0.9849160	-0.0000054
H	-2.6381935	0.5437739	-0.8905327

3 (Me-$C_6F_3H_2$)

C	-0.7413205	0.0120249	0.0000000
C	0.0133739	0.0010227	-1.1747142
C	1.4017957	-0.0132502	-1.2186362
C	2.0667029	-0.0203394	0.0000000
C	1.4017957	-0.0132502	1.2186362
C	0.0133739	0.0010227	1.1747142
C	-2.2460467	0.0248277	0.0000000
F	-0.6544658	0.0070441	-2.3576197
F	3.4220369	-0.0351946	0.0000000
F	-0.6544658	0.0070441	2.3576197
H	-2.6244494	0.5315475	0.8901786
H	-2.6466698	-0.9959207	0.0000000
H	-2.6244494	0.5315475	-0.8901786
H	1.9363950	-0.0190225	2.1603171
H	1.9363950	-0.0190225	-2.1603171

4 (Me-C_6FH_4)

C	-0.7397549	-0.0204227	0.0000000
C	-0.0197824	-0.0113613	-1.2011032
C	1.3748535	0.0122877	-1.2144149
C	2.0465957	0.0253101	0.0000000
C	1.3748535	0.0122877	1.2144149
C	-0.0197824	-0.0113613	1.2011032
C	-2.2495103	-0.0137252	0.0000000
H	-0.5563941	-0.0255312	-2.1467143
H	1.9355132	0.0161529	-2.1433701
H	1.9355132	0.0161529	2.1433701
H	-0.5563941	-0.0255312	2.1467143
H	-2.6479683	-0.5160437	0.8868185
H	-2.6380799	1.0126772	0.0000000
H	-2.6479683	-0.5160437	-0.8868185
F	3.4083054	0.0451516	0.0000000

5 (Me-$C_6H_4(OH)$)

C	-0.1685501	0.9697370	-0.0078386
C	-1.2672311	0.0981335	-0.0057661
C	-1.1055188	-1.2832152	-0.0000649
C	0.1816030	-1.8276208	0.0030026
C	1.2913905	-0.9814347	-0.0016923
C	1.1083019	0.4021411	-0.0075071

C	-0.3621507	2.4669162	0.0040893
O	0.2913883	-3.1998352	0.0072390
H	-2.2745484	0.5089527	-0.0101911
H	-1.9623980	-1.9497669	-0.0005924
H	2.2966486	-1.3996168	-0.0036936
H	1.9819732	1.0498977	-0.0131485
H	0.5816947	2.9863995	-0.1862880
H	-0.7430248	2.8114239	0.9737630
H	-1.0829142	2.7819761	-0.7587880
H	1.2333360	-3.4340883	0.0074766

6 (Me-$C_6H_3(OMe)_2$)

C	0.0033148	1.4001237	-0.0080557
C	-1.1960063	0.6847308	-0.0405313
C	-1.1683425	-0.7179107	-0.0316808
C	0.0435973	-1.4038475	0.0091791
C	1.2368672	-0.6804137	0.0414240
C	1.2257381	0.7194707	0.0330931
C	-0.0144100	2.9106659	-0.0172194
O	-2.2920484	-1.5042260	-0.0614465
O	2.3806972	-1.4368591	0.0806101
C	-3.5555179	-0.8392245	-0.1037568
C	3.6258911	-0.7380718	0.1145785
H	-2.1352866	1.2251491	-0.0722485
H	2.1502485	1.2857262	0.0580428
H	0.4706707	3.3159187	0.8786001
H	-1.0385401	3.2927974	-0.0506195
H	0.5244737	3.3058448	-0.8863943
H	-4.3024598	-1.6337585	-0.1219907
H	-3.7027270	-0.2124958	0.7850151
H	-3.6481001	-0.2227259	-1.0069350
H	4.3938783	-1.5119853	0.1424074
H	3.7561633	-0.1183489	-0.7817538
H	3.7015411	-0.1081215	1.0100535
H	0.0604310	-2.4880196	0.0158811

7 (Me-N-Methyl-Indole)

C	-1.3415212	0.8556560	0.0000000
C	-2.4775356	0.0558335	0.0000000
C	-2.3789301	-1.3498761	0.0000000
C	-1.1424513	-1.9866727	0.0000000
C	-0.0026753	-1.1788151	0.0000000
C	-0.0763898	0.2442077	0.0000000
N	1.3363366	-1.5123508	0.0000000
C	1.2728701	0.7484169	0.0000000
C	2.0961443	-0.3520900	0.0000000
C	1.6887559	2.1869677	0.0000000
H	-1.4304286	1.9388942	0.0000000
H	-3.4608995	0.5172967	0.0000000
H	-3.2856689	-1.9478870	0.0000000
H	-1.0700728	-3.0711160	0.0000000
H	3.1762110	-0.4074195	0.0000000
H	2.7788486	2.2810677	0.0000000
H	1.3055410	2.7140894	0.8827429
H	1.3055410	2.7140894	-0.8827429
H	1.7063245	-2.4502918	0.0000000

8 (Me-Indole)

C	-2.5120739	0.5404681	0.1323922
C	-3.3677066	-0.5527138	0.1880531
C	-2.8677481	-1.8702049	0.1849151
C	-1.5014600	-2.1235754	0.1260621
C	-0.6445493	-1.0216123	0.0702107
C	-1.1256988	0.3196298	0.0721289
N	0.7322842	-0.9550725	0.0060686
C	0.0191816	1.1912300	0.0065311

C	1.1241102	0.3747992	-0.0318776
C	0.0017844	2.6884375	-0.0151609
H	-2.9096991	1.5520054	0.1354328
H	-4.4413249	-0.3942771	0.2349102
H	-3.5623475	-2.7040927	0.2292961
H	-1.1192963	-3.1410257	0.1238195
H	2.1730116	0.6330873	-0.0838608
H	1.0171540	3.0926875	-0.0677992
H	-0.4763858	3.0959425	0.8844189
H	-0.5572584	3.0694513	-0.8790192
H	1.3567930	-1.7464833	-0.0106841

9 (Me-$C_6H_2(OMe)_3$)

C	-0.4040767	1.7741607	-0.0001303
C	-1.5016886	0.9125034	-0.0001204
C	-1.3172256	-0.4723279	0.0001397
C	-0.0242078	-1.0398876	-0.0000152
C	1.0771690	-0.1606026	0.0001735
C	0.8786836	1.2253190	0.0001623
C	-0.5972762	3.2718173	-0.0005535
O	-0.0169235	-2.4078097	-0.0004118
O	-2.3437084	-1.3794411	0.0005147
O	2.3350616	-0.7272695	0.0003398
C	1.1927312	-3.1787447	-0.0007826
C	-3.6704557	-0.8560521	0.0005850
C	3.4548280	0.1556464	0.0007063
H	-2.5038446	1.3262482	-0.0002843
H	1.7372383	1.8876953	0.0001010
H	-0.1395657	3.7335948	0.8826935
H	-1.6605637	3.5288696	-0.0009927
H	-0.1389411	3.7331520	-0.8837032
H	0.8473561	-4.2146915	-0.0011064
H	1.7918135	-2.9839544	-0.8941513
H	1.7920417	-2.9845797	0.8925586
H	-4.3256367	-1.7280952	0.0013995
H	-3.8587306	-0.2500024	0.8964461
H	-3.8593237	-0.2512244	-0.8959759
H	4.3330431	-0.4916676	0.0008168
H	3.4615728	0.7891989	-0.8954479
H	3.4611727	0.7889482	0.8970389

Calculated Quadrupole Moments of Toluene Derivatives **1**-**9** (cf. Figure 4)
(in some cases, the y- or x-axis is perpendicular to the aromatic plane and has been used for the calculation of Q_{zz})

1 Me-Ph_tpss-d3.def2-TZVP

```
                    quadrupole moment
 ------------------------------------------------------------------------------
  xx     433.246968    -461.974545     -28.727576
  yy       5.642676     -39.623933     -33.981257
  zz     195.618074    -224.474397     -28.856323
  xy       3.520237      -3.483531       0.036707
  xz       0.000000       0.000000       0.000000
  yz       0.000000       0.000000       0.000000

     1/3  trace=      -30.521719
     anisotropy=        5.190894
```

2 Me-C6F5_tpss-d3.def2-TZVP

```
                    quadrupole moment
 ------------------------------------------------------------------------------
  xx    1041.283680   -1090.086600     -48.802920
  yy       5.683254     -52.319789     -46.636535
  zz     849.757768    -903.256997     -53.499228
  xy      -8.162603       8.181365       0.018762
  xz       0.000013      -0.000011       0.000002
  yz       0.000477      -0.000473       0.000004
```

```
    1/3  trace=     -49.646228
    anisotropy=       6.076480
```

3 Me-C6F3H2_tpss-d3.def2-TZVP

```
                      quadrupole moment
 ------------------------------------------------------------------------------
  xx     800.484089    -842.151496     -41.667406
  yy       5.638271     -47.214789     -41.576518
  zz     519.053790    -561.331613     -42.277823
  xy      -8.062614       8.071414       0.008800
  xz       0.000000       0.000000       0.000000
  yz       0.000000       0.000000       0.000000

    1/3  trace=     -41.840582
    anisotropy=       0.660743
```

4 Me-PhF_tpss-d3.def2-TZVP

```
                      quadrupole moment
 ------------------------------------------------------------------------------
  xx     768.162598    -805.547806     -37.385208
  yy       5.674882     -42.171577     -36.496695
  zz     196.362822    -227.123694     -30.760872
  xy       8.318732      -8.367093      -0.048361
  xz      -0.000000       0.000000       0.000000
  yz       0.000000       0.000000       0.000000

    1/3  trace=     -34.880925
    anisotropy=       6.228361
```

5 Me-PhOH_tpss-d3.def2-TZVP

```
                      quadrupole moment
 ------------------------------------------------------------------------------
  xx     207.088265    -237.813642     -30.725376
  yy     729.473386    -763.346511     -33.873125
  zz       5.572723     -43.433538     -37.860815
  xy     -67.925935      64.134476      -3.791459
  xz      -0.038360       0.043759       0.005398
  yz      -0.651011       0.659836       0.008825

    1/3  trace=     -34.153105
    anisotropy=       9.027072
```

6 Me-diOMePh_tpss-d3.def2-TZVP

```
                      quadrupole moment
 ------------------------------------------------------------------------------
  xx    1358.753997   -1396.380023     -37.626026
  yy     626.745929    -676.515676     -49.769748
  zz      18.307726     -69.339131     -51.031405
  xy      10.161769      -9.894614       0.267155
  xz      40.840424     -40.433195       0.407229
  yz      -3.165321       3.165982       0.000660

    1/3  trace=     -46.142393
    anisotropy=      12.848914
```

7 Me-NMeIndole_tpss-d3.def2-TZVP

```
                      quadrupole moment
 ------------------------------------------------------------------------------
  xx     842.208673    -886.930466     -44.721793
  yy     704.029467    -746.879669     -42.850201
  zz      11.239894     -63.183269     -51.943376
  xy      23.410024     -25.339496      -1.929472
  xz       0.000000       0.000000       0.000000
  yz       0.000000       0.000000       0.000000

    1/3  trace=     -46.505123
    anisotropy=       8.963178
```

8 Me-NHIndole_tpss-d3.def2-TZVP

```
                     quadrupole moment
 -----------------------------------------------------------------------------
  xx     732.928167    -772.142347     -39.214180
  yy     499.563306    -536.802622     -37.239316
  zz       5.565401     -52.975844     -47.410443
  xy     169.441863    -171.921033      -2.479170
  xz       0.000000      -0.000000      -0.000000
  yz       0.000000       0.000000       0.000000

     1/3  trace=     -41.287980
     anisotropy=      10.281253
```

9 Me-triOMePh_tpss-d3.def2-TZVP

```
                     quadrupole moment
 -----------------------------------------------------------------------------
  xx    1420.089633   -1466.040119     -45.950486
  yy    1149.632240   -1205.754992     -56.122752
  zz      22.744701     -82.302395     -59.557694
  xy     -40.971818      39.576093      -1.395725
  xz      -0.010501       0.010533       0.000032
  yz       0.005879      -0.005330       0.000549

     1/3  trace=     -53.876977
     anisotropy=      12.492362
```

References

1. Li, J.; Luo, S.; Cheng, J.-P., Chiral Primary−Tertiary Diamine Catalysts Derived From Natural Amino Acids for syn-Aldol Reactions of Hydroxy Ketones. *J. Org. Chem.* **2009,** *74,* 1747-1750.
2. Macmillan, D.; Ahrendt, K. Acid Addition Salts of Imidazolidinones as Reaction Catalysts. WO0153269 (A1), 2001/07/26/, 2001.
3. Holland, M. C.; Paul, S.; Schweizer, W. B.; Bergander, K.; Mück-Lichtenfeld, C.; Lakhdar, S.; Mayr, H.; Gilmour, R., Noncovalent Interactions in Organocatalysis: Modulating Conformational Diversity and Reactivity in the MacMillan Catalyst. *Angew. Chem. Int. Ed.* **2013,** *52*, 7967-7971.
4. Brazier, J. B.; Evans, G.; Gibbs, T. J. K.; Coles, S. J.; Hursthouse, M. B.; Platts, J. A.; Tomkinson, N. C. O., Solution Phase, Solid State, and Theoretical Investigations on the MacMillan Imidazolidinone. *Org. Lett.* **2009,** *11*, 133-136.
5. Fitzi, R.; Seebach, D., Resolution and use in α-amino acid synthesis of imidazolidinone glycine derivatives. *Tetrahedron* **1988,** *44*, 5277-5292.
6. Seebach, D.; Dziadulewicz, E.; Behrendt, L.; Cantoreggi, S.; Fitzi, R., Synthesis of Nonproteinogenic (R)- or (S)-Amino Acids Analogues of Phenylalanine, Isotopically Labelled and Cyclic Amino Acids from tert-Butyl 2-(tert-Butyl)-3-methyl-4-oxo-1-imidazolidinecarboxylate (Boc-BMI). *Liebigs Ann. Chem.* **1989,** *1989*, 1215-1232.
7. Gang, s.; Shen, C.; Yang, X.; Tang, J.; Zhang, R.; Zou, G. Preparing method and application of chiral imidazolinone fungicide decorated by peptide loded with silica gel. CN101036894 (A), 2007/09/19/, 2007.
8. Zhang, Y.; Zhao, L.; Lee, S. S.; Ying, J. Y., Enantioselective Catalysis over Chiral Imidazolidin-4-one Immobilized on Siliceous and Polymer-Coated Mesocellular Foams. *Adv. Synth. Catal.* **2006,** *348*, 2027-2032.
9. Snyder, S. A.; Zografos, A. L.; Lin, Y., Total Synthesis of Resveratrol-Based Natural Products: A Chemoselective Solution. *Angew. Chem. Int. Ed.* **2007,** *46*, 8186-8191.
10. Zheng, H.; Comeforo, K.; Gao, J., Expanding the Fluorous Arsenal: Tetrafluorinated Phenylalanines for Protein Design. *J. Am. Chem. Soc.* **2009,** *131*, 18-19.
11. Crich, D.; Huang, X., On the Reaction of Tryptophan Derivatives with N-Phenylselenyl Phthalimide: The Nature of the Kinetic and Thermodynamic Hexahydropyrrolo[2,3-b]indole Products. Alkylation of Tryptophan with Inversion of Configuration. *J. Org. Chem.* **1999,** *64*, 7218-7223.
12. Samulis, L.; Tomkinson, N. C. O., Preparation of the MacMillan imidazolidinones. *Tetrahedron* **2011,** *67*, 4263-4267.
13. Alonso, F.; Riente, P.; Yus, M., Wittig-Type Olefination of Alcohols Promoted by Nickel Nanoparticles: Synthesis of Polymethoxylated and Polyhydroxylated Stilbenes. *Eur. J. Org. Chem.* **2009,** *2009*, 6034-6042.
14. Hubert, C.; Garrigues, B., Influence des ultrasons sur la diastéréosélectivité. Synthèse d'imidazolidine-4-one chirales. *Can. J. Chem.* **1998,** *76*, 234-237.
15. Paras, N. A.; MacMillan, D. W. C., New Strategies in Organic Catalysis: The First Enantioselective Organocatalytic Friedel−Crafts Alkylation. *J. Am. Chem. Soc.* **2001,** *123,* 4370-4371.
16. Austin, J. F.; MacMillan, D. W. C., Enantioselective Organocatalytic Indole Alkylations. Design of a New and Highly Effective Chiral Amine for Iminium Catalysis. *J. Am. Chem. Soc.* **2002,** *124*, 1172-1173.
17. Chen, Y. K.; Yoshida, M.; MacMillan, D. W. C., Enantioselective Organocatalytic Amine Conjugate Addition. *J. Am. Chem. Soc.* **2006,** *128,* 9328-9329.

18. Furche, F.; Ahlrichs, R.; Hättig, C.; Klopper, W.; Sierka, M.; Weigend, F., Turbomole: Turbomole. *Wiley Interdisciplinary Reviews: Computational Molecular Science* **2014,** *4*, 91-100; TURBOMOLE V6.5 2013, a development of University of Karlsruhe and Forschungszentrum Karlsruhe GmbH, 1989-2007, TURBOMOLE GmbH, since 2007; available from http://www.turbomole.com.

19. Tao, J.; Perdew, J. P.; Staroverov, V. N.; Scuseria, G. E., Climbing the Density Functional Ladder: Nonempirical Meta–Generalized Gradient Approximation Designed for Molecules and Solids. *Phys. Rev. Lett.* **2003,** *91*.

20. Grimme, S.; Antony, J.; Ehrlich, S.; Krieg, H., A consistent and accurate ab initio parametrization of density functional dispersion correction (DFT-D) for the 94 elements H-Pu. *The Journal of Chemical Physics* **2010,** *132*.

21. Grimme, S.; Ehrlich, S.; Goerigk, L., Effect of the damping function in dispersion corrected density functional theory. *J. Comput. Chem.* **2011,** *32*, 1456-1465.

22. Weigend, F.; Ahlrichs, R., Balanced basis sets of split valence, triple zeta valence and quadruple zeta valence quality for H to Rn: Design and assessment of accuracy. *Phys. Chem. Chem. Phys.* **2005,** *7*, 3297-3305.

23. Grimme, S., Supramolecular Binding Thermodynamics by Dispersion-Corrected Density Functional Theory. *Chem. Eur. J.* **2012,** *18*, 9955-9964.

24. Klamt, A.; Schüürmann, G., COSMO: a new approach to dielectric screening in solvents with explicit expressions for the screening energy and its gradient. *J. Chem. Soc., Perkin Trans. 2* **1993**, 799-805.