Supporting Information for

“Enantioselective Carboetherification/Hydrogenation for the Synthesis of Amino Alcohols via a Catalytically-Formed Chiral Auxiliary”

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A. General Information

The NMR spectra were recorded on a Brucker DPX-400 spectrometer at 400 MHz for 1H, 101 MHz for 13C, 376 MHz for 19F and 162 MHz for 31P. The chemical shift (δ) for 1H and 13C are given in ppm relative to residual signals of the solvents (chloroform-d - 7.26 ppm 1H NMR and 77.16 ppm 13C NMR; methanol-d4 3.31 ppm 1H NMR and 49.0 ppm 13C NMR; dimso-d6 2.50 ppm 1H NMR and 39.52 ppm 13C NMR). Carbon spectra have been measured using broadband [1H] decoupling. Coupling constants are given in Hertz. The following abbreviations are used to indicate the multiplicity: s, singlet; d, doublet; q, quartet; m, multiplet; bs, broad signal; app, apparent. Infrared spectra were recorded on a JASCO FT-IR B4100 spectrophotometer with an ATR PRO410-S and a ZnSe prism and are reported as cm⁻¹ (w = weak, m = medium, s = strong, br = broad). High resolution mass spectrometric measurements were performed by the mass spectrometry service of ISIC at the EPFL on a MICROMASS (ESI) Q-TOF Ultima API. The raw data obtained from the Q-TOF Waters instrument does not take into account the mass of the electron for the ion, the obtained raw data has therefore been corrected by removing the mass of the electron (5 mDa). The diffraction data for crystal structures were collected by mass spectrometry service of ISIC at the EPFL at low temperature using Cu (320) or Mo (520) Kα radiation on a Rigaku SuperNova dual system in combination with Atlas type CCD detector. The data reduction and correction were carried out by Crystals²⁶⁄²⁷ (Rigaku Oxford Diffraction, release 1.171.40.68a, 2019). The solutions and refinements were performed by SHELXT²⁸ and SHELXL³, respectively. The crystal structures were refined using full-matrix least-squares based on F² with all non-H atoms defined in anisotropic manner. Hydrogen atoms were placed in calculated positions by means of the “riding” model. Yields of isolated products refer to materials of >95% purity as determined by 1H NMR.

The authors are indebted to the team of the research support service of ISIC at EPFL, particularly to the NMR, X-Ray, and the High Resolution Mass Spectrometry Units.

General Procedures. All reactions were set up under a nitrogen atmosphere in oven-dried glassware unless otherwise stated. Synthesis grade solvents were used as purchased; anhydrous solvents (THF, EtO, Toluene and DCM) were taken from a commercial SPS solvent dispenser (H2O content < 10 ppm, Karl-Fischer titration). Chromatographic purification of products was accomplished using flash chromatography (FC) on SiliaFlash P60 silica gel (230 - 400 mesh). For thin layer chromatography (TLC) analysis throughout this work, Pre-coated TLC sheets ALUGRAM® Xtra SIL G/UV254 were employed, using UV light as the visualizing agent and basic aqueous potassium permanganate (KMcO₄) stain solutions, and heat as developing agents. Organic solutions were concentrated under reduced pressure on a Büchi rotatory evaporator.

Determination of Enantiomeric Purity: HPLC analysis on chiral stationary phase was performed on a Agilent Acquity instrument using a Daicel CHIRALPAK IA, IB-N5 and IC chiral columns. The exact conditions for the analyses are specified within the characterization section. HPLC traces were compared to racemic samples prepared by running the reactions using racemic ligands. Absolute values of enantiomeric excesses are reported.

Materials. Most of the starting materials used in this study are commercial and were purchased in the highest purity available from Sigma-Aldrich, Fluka, Alfa Aesar, Fluorochem, Enamine and used as received, without further purifications. Tris(dibenzylideneacetone)dipalladium was purchased from Fluorochem and recrystallised in 200 mg portions following a reported method.³ Pd(OH)₂/C was purchased from Fluka (humid, Assay: ~20% (Pd), Analysis Number: 3204001/1192). Pd/C was purchased from Sigma-Aldrich (~5 wt. % Pd (dry basis), matrix activated charcoal, wet support. Degussa type E105CA/W, Lot#MKBJ9424V). Deactivated silica gel was prepared by making a slurry of silica gel (230-400 mesh) with 5% Et₃N in pentane solution followed by complete removal of solvent by rotary evaporation until obtaining a free flowing powder. The synthesis of 1, 63-65, 68, 71 and 73-78 has already been described by our group. The procedures are taken from the indicated publication²⁴ for clarity and to facilitate the reproduction of the results.
B. Synthesis of the Starting Materials and Ligands

B.1. Synthesis of the Propargylic Amines Precursors 57 and 62

\[ \text{N-Benzylprop-2-yn-1-amine (57)} \]

To a flame-dried 250 mL two-necked round-bottom flask, benzylamine (55 mL, 0.50 mol, 5.0 equiv.) and DCM (60 mL) were added. The mixture was cooled to 0 °C. Then, via an addition funnel, propargyl bromide (80 wt% solution in toluene, 10.8 mL, 100 mmol, 1.0 equiv.) in DCM (40 mL) was added dropwise over 1 hour. The reaction mixture was allowed to reach room temperature and stirred for 5 h. The reaction mixture was filtered through a plug of silica and concentrated in vacuo to approx. 100 mbar. The mixture was distilled under reduced pressure to give the N-benzylprop-2-yn-1-amine 57 as a colorless oil (7.3 g, 50 mmol, ~90% purity according to \(^1\)H NMR (T = 50 – 55 °C, 0.35 mbar).

\(^1\)H NMR (400 MHz, Chloroform-d) \( \delta \) 7.41 – 7.31 (m, 4H, ArH), 7.31 – 7.24 (m, 1H, ArH), 3.90 (s, 2H, PhCH\(_2\)), 3.44 (d, \( J = 2.4 \) Hz, 2H, CH\(_2\)CH\(_2\)), 2.28 (t, \( J = 2.4 \) Hz, 1H, C≡CH), 1.49 (s, 1H, NH).

\(^13\)C[\(^1\)H] NMR (101 MHz, Chloroform-d) \( \delta \) 139.5, 128.52, 128.49, 127.2, 82.2, 72.7, 71.6, 52.4, 37.4.

Spectral data were consistent with the values reported in literature.\(^5\)

\[ \text{N-Benzyl propynyl trifluoroacetamide (62)} \]

Following a modified version of a reported procedure.\(^6\) In a flame dried round-bottom flask, to a solution of ethyl trifluoroacetate (8.0 g, 56 mmol, 1.2 equiv.) in THF (12 mL) at 0 °C was slowly added propargyl amine (2.6 g, 47 mmol, 1 equiv.). The reaction mixture was stirred at 0 °C for 10 minutes; it was then allowed to reach room temperature and stirred for a further 7 hours. The solvent was removed by rotary evaporation and the product was isolated by distillation (90 °C at 17 mbar) to afford propynyl trifluoroacetamide 61 as a colourless oil (5.5 g, 37 mmol, 78% yield).

\(^1\)H NMR (400 MHz, Chloroform-d) \( \delta \) 6.94 (br. s., 1H, NH), 4.14 (dd, \( J = 6.0, 2.5 \) Hz, 2H, CH\(_2\)=C=C), 2.32 (q, \( J = 2.2 \) Hz, 1H, C≡CH).

\(^13\)C NMR (101 MHz, Chloroform-d) \( \delta \) 157.0 (q, \( J = 38.1 \) Hz), 115.5 (q, \( J = 287.5 \) Hz), 77.0, 73.1, 29.6.

\(^19\)F NMR (376 MHz, Chloroform-d) \( \delta \) -76.3.

Spectra data was consistent with the values reported in literature.\(^6\)

To a mixture of KHCO\(_3\) (8.2 g, 59 mmol, 2 equiv.) and TBAB (0.95 g, 3.0 mmol, 1 equiv.) in MeCN (150 mL) was added propynyl trifluoroacetamide 61 (4.5 g, 30 mmol, 1 equiv.) and benzyl bromide (6.0 g, 33 mmol, 1.1 equiv.) and the reaction mixture was stirred at 60 °C. After 3 hours (progress determined by TLC (SiO\(_2\), 20% EtOAc in pentane)), the mixture was filtered through a plug of Celite, which was washed with EtO. The resulting filtrate was concentrated by rotary evaporation. Purification of the crude product by column chromatography (SiO\(_2\), 0-8% EtOAc in pentane) afforded N-Benzyl propynyl trifluoroacetamide (62) as a colourless oil (5.0 g, 21 mmol, 71% yield)

\(^1\)H NMR (400 MHz, Chloroform-d; 1:1 mixture of rotamers) \( \delta \) 7.46 – 7.23 (m, 10H, ArH), 4.79 (s, 2H, CH\(_2\)Ar), 4.77 (s, 2H, CH\(_2\)Ar), 4.12 (d, \( J = 2.5 \) Hz, 2H, CH\(_2\)=C=C), 4.06 (d, \( J = 2.4 \) Hz, 2H, CH\(_2\)=C=C), 2.37 (t, \( J = 2.4 \) Hz, 1H, C≡CH), 2.29 (t, \( J = 2.5 \) Hz, 1H, C≡CH).

\(^13\)C[\(^1\)H] NMR (101 MHz, Chloroform-d; 1:1.2 mixture of rotamers) \( \delta \) 156.7 (q, \( J = 36.5 \) Hz, 2\( \times \)C=O), 134.5, 133.8, 129.1, 129.0, 128.6, 128.6, 128.3, 127.7, 116.4 (q, \( J = 287.9 \) Hz), 116.3 (q, \( J = 288.1 \) Hz), 76.6 (overlapping with solvent), 76.5, 73.7, 73.3, 49.7 (q, \( J = 3.6 \) Hz), 48.7, 35.8 (q, \( J = 4.2 \) Hz), 34.4.

\(^19\)F NMR (376 MHz, Chloroform-d; 1:1.2 mixture of rotamers) \( \delta \) -68.5, -69.3.

HRMS (LTQ-Orbitrap) m/z: [M + H]\(^+\) Calculated for C\(_{13}\)H\(_11\)F\(_3\)NO\(_2\) 242.0787; Found 242.0783.
B.2. Synthesis of the Propargylic Amines

Scheme 3. The propargylic amines synthesized according to the general procedures reported.

General Procedure B2.A

To a flame-dried 100 mL round bottom flask equipped with a Teflon-coated magnetic stirring bar, \( \text{Pd}\left(\text{PPh}_3\right)_2\text{Cl}_2 \) (42 mg, 60 \( \mu \)mol, 2 mol%), \( \text{CuI} \) (11 mg, 60 \( \mu \)mol, 2 mol%), \( \text{Et}_3\text{N} \) (0.90 g, 1.2 mL, 9.0 mmol, 3.3 equiv.) and degassed (by bubbling dry \( \text{N}_2 \) for 10 minutes) \( \text{MeCN} \) (30 mL) were added. Then, the iodoarene (1.1 equiv.) was added and the mixture was heated to 60 °C and stirred for 5 minutes. Benzyl propargyl amine 57 (0.39 g, 2.7 mmol, 1.0 equiv.) was added and the reaction mixture was stirred for 7 hours at 60 °C. Then, the reaction mixture was cooled down to ambient temperature and concentrated in vacuo. The resulting crude was dissolved in \( \text{EtOAc} \) (20 mL), then washed with water (20 mL) and brine (20 mL). The organic layer was dried over \( \text{Na}_2\text{SO}_4 \), filtered, and concentrated in vacuo. The crude was purified with Biotage flash chromatography system using Buchi FlashPure cartridge with EcoFlex silica (10% – 40% \( \text{EtOAc} \) in pentane).
General Procedure B2.B

Following a modified version of a reported procedure. To a solution of 62 (0.80 g, 3.3 mmol, 1 equiv.), ArI (1.01 equiv.) and Et3N (2.3 mL, 17 mmol, 5 equiv.) in acetonitrile (30 mL) was added PdCl2(PPh3)2 (47 mg, 0.066 mmol, 2 mol%) and CuI (13 mg, 0.066 mmol, 2 mol%) in a single portion. The resulting mixture was stirred for 7 hours at 60 °C. Water (20 mL) was then added and the reaction mixture extracted with EtOAc (3 x 30 mL); the combined organic layers were dried over MgSO4, filtered and concentrated by rotary evaporation. The crude material was purified by flash column chromatography (SiO2, 0-5% EtOAc in pentane).

Hydrolysis: following an adapted version of a reported procedure. To the trifluoroacetamide obtained from the previous step (1 equiv.) was added a solution of KOH (3.0 equiv.) in water (15 mL) and methanol (15 mL) and the resulting mixture was stirred at 60 °C for 3 hours. The reaction was then cooled to room temperature and acidified with aq. HCl (1.0 M; 5 mL) followed by basification with sat. aq. NaHCO3 (pH >7). The resulting mixture was extracted with DCM (3 x 10 mL), dried over MgSO4, filtered and concentrated by rotary evaporation. The crude material was purified by flash column chromatography (SiO2, 10-30% EtOAc in pentane).

General Procedure B2.C

Following an adapted version of a reported procedure. To a solution of CuBr (0.20 g, 1.4 mmol, 13 mol%) in MeCN (c = 0.15 M) was added allyl amine (1.3 equiv.), formaldehyde (3 equiv.) and alkyne (1 equiv.). The reaction mixture was stirred at room temperature for 16 hours after which it was concentrated by rotary evaporation. The residue was diluted with Et2O (20 mL) and washed with sat. NaOH solution (5.0 M; 3 x 10 mL), dried over MgSO4, filtered and concentrated by rotary evaporation. The crude material was purified by flash column chromatography (SiO2, 0-2% EtOAc in pentane).

Deallylation: The tertiary amine obtained from the previous step (1 equiv.) was added to a solution of Pd(PPh3)4 (2 mol%) and 1,3-dimethylbarbituric acid (1.5 equiv.) in DCM (c = 0.18 M) under an N2 atmosphere. The reaction mixture was stirred at room temperature for 16 hours. The reaction mixture was concentrated to a quarter of its original volume and diluted with ether (40 mL) and washed with sat. NaHCO3 (3 x 15 mL). The organic layer was extracted with aq. HCl (1.0 M; 3 x 15 mL) after which the combined aqueous layers and any precipitated solids were basified with K2CO3 (pH >7) and extracted with DCM (3 x 25 mL). The combined extracts were dried over MgSO4, filtered and concentrated by rotary evaporation. The crude material was purified by flash column chromatography (SiO2, 20-50% EtOAc in pentane).
Procedure B2.D for the Synthesis of 74

\[
\begin{array}{c}
\text{BnNH}_2 \quad \text{Br} \quad \text{DCM} \quad 0^\circ \text{C} - 22^\circ \text{C} \\
\text{Scheme 7. General Procedure B2.D for the synthesis of 74.}
\end{array}
\]

A solution of benzyl amine (4–6 equiv.) in DCM (15 mL) at 0 °C was stirred vigorously while a solution of bromo-2-butynyl (2.5 mL, 27 mmol, 1 equiv.) in DCM (15 mL) was slowly added. The reaction mixture was then warmed to room temperature and stirred for 5 hours. It was then filtered through silica gel, eluting with 40% EtOAc in pentane and the resulting solution concentrated. Purification was performed by column chromatography (SiO\(_2\), 10–40% EtOAc in pentane) to afford benzyl butynylamine 71 as a straw yellow oil (3.4 g, 21 mmol, 74% yield). Further purification could be achieved by Kugelrohr distillation (86 °C at 5x10\(^{-1}\) mbar).

\([\text{1H NMR (400 MHz, Chloroform-}d\text{)} \delta 7.39 – 7.21 (m, 5H, ArH), 3.86 (s, 2H, ArCH\(_2\)), 3.38 (q, J = 2.4 Hz, 2H, CH\(_2\)C=O), 1.85 (t, J = 2.4 Hz, 3H, CH\(_3\)), 1.57 (bs, 1H NH).]

\([\text{13C NMR (101 MHz, Chloroform-}d\text{)} \delta 139.7, 138.9, 133.0, 128.4 (2C), 127.1, 115.3, 113.9, 86.0, 83.5, 55.3, 52.5, 38.3].

Spectral data was consistent with the values reported in literature.9

N-Benzyl-3-phenylprop-2-yn-1-amine (1)

Prepared following an up-scaled general procedure B2.A using N-benzylprop-2-yn-1-amine 57 (2.20 g, 13.5 mmol, 1.0 equiv.), iodobenzene (3.1 g, 1.7 mL, 15 mmol, 1.1 equiv.), Et\(_3\)N (4.5 g, 6.3 mL, 45 mmol, 3.3 equiv.), Pd(PPh\(_3\))\(_2\)Cl\(_2\) (211 mg, 300 µmol, 2 mol%) and CuI (57 mg, 300 µmol, 2 mol%). Purification was performed by Biotage flash column chromatography system with a 120 g cartridge (SiO\(_2\), 10 – 40% EtOAc in pentane) to afford N-benzyl-3-phenylprop-2-yn-1-amine (1) as an orange oil (2.5 g, 11 mmol, 75% yield).

\([\text{1H NMR (400 MHz, Chloroform-}d\text{)} \delta 7.52 – 7.20 (m, 9H, ArH), 3.96 (s, 2H, PhCH\(_2\)), 3.66 (s, 2H, CH\(_2\)C=O), 1.73 (br. s, 1H, NH)].

\([\text{13C NMR (101 MHz, Chloroform-}d\text{)} \delta 139.5, 131.7, 128.5 (2C), 128.3, 128.1, 127.2, 123.2, 87.5, 83.8, 52.5, 38.3].

Spectral data were consistent with the values reported in literature.9

N-Benzyl-3-(p-tolyl)prop-2-yn-1-amine (63)

Prepared following general procedure B2.A using p-tolyliodobenzene (667 mg, 3.06 mmol, 1.1 equiv.). Purification was performed by Biotage flash column chromatography system with a 25 g cartridge (SiO\(_2\), 10 – 40% EtOAc in pentane) to afford N-benzyl-3-(p-tolyl)prop-2-yn-1-amine (63) as an orange oil (512 mg, 2.13 mmol, 79% yield).

\([\text{1H NMR (400 MHz, Chloroform-}d\text{)} \delta 7.41 – 7.29 (m, 6H, ArH), 7.29 – 7.22 (m, 1H, ArH), 7.12 (d, J = 7.9 Hz, 2H, ArH), 3.95 (s, 2H, PhCH\(_2\)), 3.65 (s, 2H, CH\(_2\)C=O), 2.35 (s, 3H), 1.68 (br. s, 1H, NH)].

\([\text{13C NMR (101 MHz, CDCl\(_3\)) \delta 139.7, 138.3, 131.7, 129.2, 128.62, 128.59, 127.93, 127.3, 126.0, 86.7, 84.0, 52.6, 38.4, 21.6}.]

Spectral data were consistent with the values reported in literature.9

N-Benzyl-3-(4-methoxyphenyl)prop-2-yn-1-amine (64)

Prepared following modified general procedure B2.A using Pd(PPh\(_3\))\(_2\)Cl\(_2\) (90 mg, 0.13 mmol, 5 mol%), dpff (86 mg, 0.16 mmol, 6 mol%), CuI (25 mg, 0.13 mmol, 5 mol%), DABCO (0.76 g, 6.8 mmol, 2.6 equiv.) and 4-iodo-anisole (0.79 g, 6.4 mmol, 1.3 mmol) in DMSO (10 mL; degassed by bubbling N\(_2\)). The crude material was dry-loaded onto SiO\(_2\) and purified by column chromatography (SiO\(_2\), 15-30% EtOAC in pentane) affording N-benzyl-3-(4-methoxyphenyl)prop-2-yn-1-amine (64) as a light orange solid (0.28 g, 1.1 mmol, 43% yield).

\([\text{1H NMR (400 MHz, Chloroform-}d\text{)} \delta 7.42 – 7.23 (m, 7H, ArH), 6.87 – 6.81 (m, 2H, ArH), 3.95 (s, 2H, ArCH\(_2\)), 3.81 (s, 3H, CH\(_3\)), 3.64 (s, 2H, CH\(_2\)C=O), 1.64 (bs, 1H, NH)].

\([\text{13C NMR (101 MHz, Chloroform-}d\text{)} \delta 159.4, 139.6, 133.0, 128.4 (2C), 127.1, 115.3, 113.9, 86.0, 83.5, 55.3, 52.5, 38.3].

Spectral data was consistent with the values reported in literature.10
**N-Benzyl-3-(4-(trifluoromethyl)phenyl)prop-2-yn-1-amine (65)**

Prepared following modified general procedure B2.A using Pd(PPh$_3$)$_2$Cl$_2$ (90 mg, 0.13 mmol, 5 mol%), dpf (86 mg, 0.16 mmol, 6 mol%), CuI (25 mg, 0.13 mmol, 5 mol%), DABCO (0.76 g, 6.8 mmol, 2.6 equiv.) and 4-trifluoroiodobenzene (0.92 g, 3.4 mmol, 1.3 equiv.) in DMSO (10 mL; degassed by bubbling N$_2$). The crude material was dry-
dried onto SiO$_2$ and purified by column chromatography (SiO$_2$, 10-20% EtOAc in pentane) affording N-
benzyl-3-(4-(trifluoromethyl)phenyl)prop-2-yn-1-amine (65) as a dark orange oil (0.55 g, 1.9 mmol, 72%
yield).

$^1$H NMR (400 MHz, Chloroform-d) δ 7.61 – 7.24 (m, 9H, ArH), 3.95 (s, 2H, ArCH$_2$), 3.67 (s, 2H, CH$_2$-C=O), 1.76 (bs, 1H, NH).

$^{13}$C$[^1]$H NMR (101 MHz, Chloroform-d) δ 139.3, 131.9, 129.8 (q, $J = 32.7$ Hz), 128.5, 128.4, 127.2, 127.0, 125.2 (q, $J = 3.9$ Hz), 123.91 (q, $J = 272.2$ Hz), 90.2, 82.5, 52.6, 38.2.

$^{19}$F NMR (376 MHz, Chloroform-d) δ -63.2.

Spectral data was consistent with the values reported in literature.°

**N-Benzyl-3-(4-fluorophenyl)prop-2-yn-1-amine (66)**

Prepared following general procedure B2.A using 4-fluoriodobenzene (0.68 g, 0.35 mL, 3.1 mmol, 1.1 equiv.). Purification was performed by Biotage flash column chromatography system with a 25 g cartridge (SiO$_2$, 10 – 40 % EtOAc in pentane) to afford N-benzyl-3-(4-fluorophenyl)prop-2-yn-1-amine (66) as an orange oil (512 mg, 2.02 mmol, 79% yield).

$^1$H NMR (400 MHz, Chloroform-d) δ 7.48 – 7.30 (m, 6H, ArH), 7.30 – 7.22 (m, 1H, ArH), 7.07 – 6.91 (m, 2H, ArH), 3.95 (s, 2H, PhCH$_2$), 3.64 (s, 2H, CH$_2$-C=O), 1.61 (br. s., 1H, NH).

$^{13}$C$[^1]$H NMR (101 MHz, Chloroform-d) δ 162.5 (d, $J = 272.2$ Hz), 139.7, 133.6 (d, $J = 8.3$ Hz), 128.61, 128.55, 127.3, 119.4 (d, $J = 3.5$ Hz), 115.7 (d, $J = 22.0$ Hz), 87.4, 82.8, 52.7, 38.3.

$^{19}$F NMR (376 MHz, Chloroform-d) δ -111.4 (tt, $J = 8.7, 5.4$ Hz).

Spectral data were consistent with the values reported in literature.°

**N-Benzyl-3-(4-chlorophenyl)prop-2-yn-1-amine (67)**

Prepared following general procedure B2.A using 4-chloriodobenzene (730 mg, 3.06 mmol, 1.1 equiv.). Purification was performed by Biotage flash column chromatography system with a 25 g cartridge (SiO$_2$, 10 – 40 % EtOAc in pentane) to afford N-benzyl-3-(4-chlorophenyl)prop-2-yn-1-amine (67) as an orange oil (540 mg, 2.08 mmol, 77% yield).

$^1$H NMR (400 MHz, Chloroform-d) δ 7.38 – 7.28 (m, 6H, ArH), 7.27 – 7.19 (m, 3H, ArH), 3.91 (s, 2H, PhCH$_2$), 3.61 (s, 2H, CH$_2$=C=O), 2.35 (s, 3H, CH$_3$), 1.57 (br. s., 1H, NH).

$^{13}$C$[^1]$H NMR (101 MHz, Chloroform-d) δ 139.6, 134.2, 133.0, 129.1, 128.6, 128.6, 127.3, 121.9, 87.7, 82.8, 52.7, 38.3.

IR (cm$^{-1}$) 3327 (w), 3031 (m), 2840 (m), 2104 (w), 1727 (m), 1487 (s), 1335 (m), 1254 (m), 1166 (m), 1094 (s).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{18}$H$_{13}$ClN$^+$ 256.0888; Found 256.0890.

**N-Benzyl-3-(3-bromophenyl)prop-2-yn-1-amine (68)**

Prepared following general procedure B2.B using PdCl$_2$(PPh$_3$)$_2$ (47 mg, 66 µmol, 2 mol%), CuI (13 mg, 66 µmol, 2 mol%), 57 (0.80 g, 3.3 mmol, 1 equiv.), 1-bromo-3-iodobenzene (0.95 g, 3.4 mmol, 1.01 equiv.) and Et$_3$N (2.3 mL, 17 mmol, 5 equiv.) in acetonitrile (30 mL). The crude material was purified by flash column chromatography (SiO$_2$, 0-5% EtOAc in pentane) affording N-benzyl-N-(3-(3-bromophenyl)prop-2-yn-1-yl)-2,2,2-trifluoroacetamide as an yellow oil (1.2 g, 3.04 mmol, 92% yield).

Hydrolysis: the obtained trifluoroacetamide (1.2 g, 3.0 mmol, 1 equiv.) was treated with KOH (0.50 g, 9.0 mmol, 3.0 equiv.) in H$_2$O (15 mL) and MeOH (15 mL). Purification by column chromatography (SiO$_2$, 10-30% EtOAc in pentane) afforded N-benzyl-3-(3-bromophenyl)prop-2-yn-1-amine (68) as a light yellow oil (0.80 g, 2.7 mmol, 88% yield).
N-Benzyl-3-(3-chlorophenyl)prop-2-yn-1-amine (69)

Prepared following general procedure B2.A using 3-chloroiodobenzene (730 mg, 3.06 mmol, 1.1 equiv.). Purification was performed by Biotage flash column chromatography system with a 25 g cartridge (SiO$_2$, 10 – 40% EtOAc in pentane) to afford N-benzyl-3-(3-chlorophenyl)prop-2yn-1-amine (69) as an orange oil (530 mg, 2.08 mmol, 77% yield).

$^1$H NMR (400 MHz, Chloroform-$d$) δ 7.45 – 7.40 (m, 1H, ArH), 7.40 – 7.18 (m, 8H, ArH), 3.94 (s, 2H, PhCH$_2$), 3.65 (s, 2H, CH$_2$=C=), 1.60 (br. s., 1H, NH).

$^{13}$C [$^1$H] NMR (101 MHz, Chloroform-$d$) δ 139.6, 134.2, 131.7, 129.9, 129.6, 128.62, 128.56, 128.5, 127.4, 125.1, 89.1, 82.5, 52.7, 38.3.

IR (cm$^{-1}$) 3324 (m), 3030 (m), 2909 (m), 2357 (m), 2357 (w), 1589 (m), 1560 (m), 1465 (m).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{19}$H$_{19}$BrN+$^+$ 300.0382; Found 300.0384.$^4$

N-Benzyl-3-(2-fluorophenyl)prop-2-yn-1-amine (70)

Prepared following general procedure B2.A using 2-fluoroiodobenzene (0.80 g, 0.42 mL, 3.6 mmol, 1.2 equiv.). Purification was performed by Biotage flash column chromatography system with a 25 g cartridge (SiO$_2$, 10 – 40% EtOAc in pentane) to afford N-benzyl-3-(2-fluorophenyl)prop-2yn-1-amine (70) as an orange oil (520 mg, 2.17 mmol, 72% yield).

$^1$H NMR (400 MHz, Chloroform-$d$) δ 7.34 – 7.19 (m, 5H, ArH), 7.19 – 7.10 (m, 2H, ArH), 7.00 – 6.92 (m, 2H, ArH), 3.86 (s, 2H, PhCH$_2$), 3.58 (s, 2H, CH$_2$=C=), 1.48 (s, 1H, NH).

$^{13}$C [$^1$H] NMR (101 MHz, Chloroform-$d$) δ 163.0 (d, J = 250.9 Hz), 139.6, 133.7, 129.9 (d, J = 7.9 Hz), 128.7, 128.6, 127.3, 124.0 (d, J = 3.7 Hz), 115.6 (d, J = 21.0 Hz), 111.9 (d, J = 15.7 Hz), 93.2, 77.3, 52.5, 38.4.

$^{19}$F NMR (376 MHz, Chloroform-$d$) δ -110.4 (d, 1F, J = 5.9 Hz, ArF).

IR (cm$^{-1}$) 3324 (m), 3032 (m), 2912 (m), 2833 (m), 2104 (w), 1494 (s), 1451 (s), 1327 (m), 1214 (m), 1107 (m).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{19}$H$_{19}$FHN+$^+$ 256.0888; Found 256.0886.

N-benzyl-3-(3,5-dimethylphenyl)prop-2-yn-1-amine (71)

Prepared following modified general procedure B2.B using PdCl$_2$(PPh$_3$)$_2$ (0.14 g, 0.20 mmol, 5 mol%), PPh$_3$ (0.21 g, 0.80 mmol, 20 mol%) and CuI (76 mg, 0.40 mmol, 10 mol%). 57 (0.97 g, 4.0 mmol, 1 equiv.), 1-iodo-3,5-dimethylbenzene (1.1 g, 4.8 mmol, 1.2 equiv.) in DMF (3.3 mL) and Et$_3$N (10 mL). The crude material was purified by flash column chromatography (SiO$_2$, 0-5% EtOAc in pentane) afforded N-benzyl-N-3-(3,5-dimethylphenyl)prop-2ynyl-trifluoroacetamide as an orange oil (1.2 g, 3.6 mmol, 90% yield). Hydrolysis: the obtained trifluoroacetamide (0.84 g, 2.4 mmol, 1 equiv.) was treated with KOH (0.15 g, 2.7 mmol, 1.3 equiv.) in H$_2$O (5 mL) and MeOH (5 mL). Purification by column chromatography (SiO$_2$, 10-40% EtOAc in pentane) afforded N-benzyl-3-(3,5-dimethylphenyl)prop-2ynylamine (71) as an orange oil (0.49 g, 2.0 mmol, 76% yield).

$^1$H NMR (400 MHz, Chloroform-$d$) δ 7.42 – 7.24 (m, 5H, ArH), 7.08 (m, 2H, ArH), 6.95 (m, 1H, ArH), 3.96 (s, 2H, ArCH$_2$), 3.65 (s, 2H, CH$_2$=C=), 2.29 (s, 6H, CH$_3$), 2.09 (bs, 1H, NH).

$^{13}$C [$^1$H] NMR (101 MHz, Chloroform-$d$) δ 139.3, 137.8, 130.0, 129.3, 128.5, 128.4, 127.2, 122.8, 86.5, 84.2, 52.3, 38.1, 21.1.

Spectral data was consistent with the values reported in literature.$^{11}$
**N-Benzyl-3-(pyridin-3-yl)prop-2-yn-1-amine (72)**

Prepared following general procedure B2.A using 3-bromopyridine (0.48 g, 0.30 mL, 3.06 mmol, 1.1 equiv.). Purification was performed by two sequential runs of Biotage flash column chromatography system with a 25 g cartridge (SiO₂, 0 – 10% MeOH in DCM) to afford N-benzyl-3-(pyridin-3-yl)prop-2-yn-1-amine (72) as a dark orange oil (401 mg, 1.80 mmol, 60% yield). The material was used without further purification.

¹H NMR (400 MHz, DMSO-d₆) δ 8.62 (br. s, 1H, HetArH), 8.55 (br. s, 1H, HetArH), 7.84 (dt, J = 7.9, 1.9 Hz, 1H, HetArH), 7.45 – 7.29 (m, 5H, HetArH and ArH), 7.26 – 7.19 (m, 1H, ArH), 3.82 (s, 2H, PhCH₂), 3.56 (s, 2H, CH₂=CHC=CH₂).

¹³C[¹H] NMR (101 MHz, DMSO-d₆) δ 151.6, 148.1, 139.5, 137.0, 128.5, 128.4 (2C), 127.9, 127.1, 126.6, 81.4, 80.2, 77.3, 52.3, 37.4.

IR (cm⁻¹) 3649 (m), 3276 (m), 3032 (m), 2914 (m), 2831 (m), 2233 (w), 1663 (m), 1579 (m), 1465 (m), 1382 (m), 1297 (m), 1226 (m), 1112 (m), 79.8, 51.5, 37.4.

HRMS (ESI/QTOF) m/z: [M + H]⁺ Calculated for C₁₅H₁₂N₂⁺ 223.1230; Found 223.1232.

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**N-Benzyl-3-(thiophen-2-yl)prop-2-yn-1-amine (73)**

Prepared following general procedure B2.B using PdCl₂(PPh₃)₂ (36 mg, 51 µmol, 2 mol%), CuI (12 mg, 66 µmol, 1.1 equiv.), 2-iodothiophene (0.43 g, 2.0 mmol, 1.01 equiv.) and Et₃N (1.4 mL, 10 mmol, 5 equiv.) in acetonitrile (30 mL). The crude material was purified by flash column chromatography (SiO₂, 0-5% EtOAc in pentane) afforded N-benzyl-2,2,2-trifluoro-N-(3-(thiophen-2-yl)prop-2-yn-1-yl)acetamide as an yellow oil (0.58 g, 1.8 mmol, 88% yield).

**Hydrolysis:** the obtained trifluoroacetamide (0.58 g, 1.8 mmol, 1 equiv.) was treated with KOH (0.30 g, 5.4 mmol, 3.0 equiv.) in H₂O (9 mL) and MeOH (9 mL). Purification by column chromatography (SiO₂, 10-30% EtOAc in pentane) afforded N-benzyl-3-(3-bromophenyl)prop-2-yn-1-amine (73) as an orange amorphous solid (0.38 g, 1.7 mmol, 93% yield).

¹H NMR (400 MHz, Chloroform-d) δ 7.40 – 7.27 (m, 5H, ArH), 7.24 (dd, J = 5.2, 1.2 Hz, 1H, ArH), 7.20 (dd, J = 3.6, 1.1 Hz, 1H, ArH), 6.97 (dd, J = 5.2, 3.6 Hz, 1H, ArH), 3.95 (s, 2H, ArCH₂), 3.68 (s, 2H, CH₂=CHC=CH₂), 3.00 (s, 1H NH).

¹³C[¹H] NMR (101 MHz, Chloroform-d) δ 138.8, 131.8, 128.5, 128.5, 127.3, 126.9, 126.8, 123.1, 91.0, 77.3, 52.3, 38.2.

HRMS (ESI/QTOF) m/z: [M + H]⁺ Calculated for C₁₅H₁₂NS⁺ 228.0841; Found 228.0844.

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**N-Benzyl 4-phenyl-but-2-ynylamine (75)**

Prepared following general procedure B2.C using CuBr (0.18 g, 1.3 mmol, 12 mol%), allyl benzylamine (1.9 g, 13 mmol, 1.3 equiv), formaldehyde (2.5 mL, 33 mmol 36% aq. solution, 3.1 equiv) and phenylpropyne (1.2 g, 10 mmol, 1 equiv.) in MeCN (60 mL). Purification of the crude product by column chromatography (SiO₂, 0-2% EtOAc in pentane) to afford N-allyl-N-benzyl-4-phenyl-but-2-ynylamine as a colourless oil (2.6 g, 9.3 mmol, 89% yield).

**Deallylation:** the obtained tertiary amine (1.0 g, 3.6 mmol, 1 equiv.) was treated with Pd(PPh₃)₄ (84 mg, 73 µmol, 2 mol%) and 1,3-dimethylbarbituric acid (0.85 g, 5.5 mmol, 1.5 equiv.) in DCM (22 mL). Purification by flash column chromatography (SiO₂, 20-30% EtOAc in pentane) to afford N-benzyl-4-phenyl-but-2-ynylamine (75) as a straw coloured oil (0.76 g, 3.0 mmol, 83% yield)

¹H NMR (400 MHz, Chloroform-d) δ 7.41 – 7.20 (m, 10H, ArH), 3.90 (s, 2H, ArCH₂N), 3.65 (t, J = 2.3 Hz, 2H, C≡CHPh), 3.48 (t, J = 2.3 Hz, 2H, NCH₂C≡C), 1.65 (br. s., 1H, NH).

¹³C[¹H] NMR (101 MHz, Chloroform-d) δ 139.5, 137.0, 128.5, 128.4 (2C), 127.9, 127.1, 126.6, 81.4, 80.2, 52.5, 37.9, 25.2.

Spectral data was consistent with the values reported in literature.

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**N-Benzyl 4-phenyl-but-2-ynylamine (76)**

Prepared following general procedure B2.C using CuBr (0.36 g, 2.5 mmol, 12 mol%), allyl benzylamine (3.9 mL, 25 mmol, 1.3 equiv), formaldehyde (36% aq. solution: 5.0 mL, 65 mmol, 3.3 equiv.) and ethynylcyclopropane (1.7 mL, 20 mmol, 1 equiv.) in MeCN (130 mL). Purification of the crude material by column chromatography (SiO₂, 0-2% EtOAc in pentane) afforded N-allyl-N-benzyl 3-cyclopropyl-prop-2-ynylamine as a colourless oil (4.0 g, 18 mmol, 89% yield).
Deallylation: the obtained tertiary amine (1.0 g, 4.4 mmol, 1.0 equiv.) was treated with Pd(PPh₃)₄ (0.10 g, 0.89 µmol, 2 mol%) and 1,3-dimethylbarbituric acid (1.0 g, 6.7 mmol, 1.5 equiv.) in DCM (22 mL). The crude material was purified by column chromatography (SiO₂, 20-30% EtOAc in pentane) to afford N-benzyl 3-cyclopropyl-prop-2-ynylamine (76) as a lightly straw coloured oil (0.82 g, 4.4 mmol, 99% yield).

H NMR (400 MHz, Chloroform-d) δ 7.45 – 7.19 (m, 5H, ArH), 3.84 (s, 2H, ArCH₂), 3.37 (d, J = 2.0 Hz, 2H, CH₂=CH), 1.50 (bs, 1H, NH), 1.25 (ddddd, J = 10.1, 8.6, 5.0, 2.5 Hz, 1H, CH(CH₃)₂), 0.80 – 0.63 (m, 4H, CH₂(CH₃)₂).

13C{¹H} NMR (101 MHz, Chloroform-d) δ 139.7, 128.4 (2C), 127.0, 87.0, 73.3, 52.5, 37.9, 8.1, -0.5.

Spectral data was consistent with the values reported in literature.⁹

N-methyl-3-phenylprop-2-yn-1-amine (77)

Prepared following general procedure B2.C using CuBr (0.20 g, 1.4 mmol, 13 mol%), allyl methyleneimine (0.98 g, 14 mmol, 1.3 equiv.), formaldehyde (2.5 mL, 33 mmol 36% aq. solution, 3 equiv.) and phenylpropyne (1.2 g, 11 mmol, 1 equiv.) in MeCN (70 mL).

Purification of the crude product by column chromatography (SiO₂, 20-30% EtOAc in pentane) to afford N-allyl-N-benzyl-4-phenyl-but-2-ynylamine as a colourless oil (1.8 g, 9.7 mmol, 88% yield).

Deallylation: the obtained tertiary amine (1.0 g, 3.6 mmol, 1 equiv.), Pd(PPh₃)₄ (0.37 g, 0.32 mol, 6 mol%) and 1,3-dimethylbarbituric acid (1.7 g, 11 mmol, 2 equiv.) in DCM (50 mL). Purification by flash column chromatography (SiO₂, 20-50% EtOAc in pentane) to afford N-methyl-3-phenylprop-2-yn-1-amine (77) as an orange viscous oil (0.46 g, 3.1 mmol, 58% yield).

¹H NMR (400 MHz, Chloroform-d) δ 7.49 – 7.41 (m, 2H, ArH), 7.33 (m, 3H, ArH), 3.68 (s, 2H, NCH₂=CH), 3.16 (s, 1H, NH), 2.59 (s, 3H, CH₃).

¹³C{¹H} NMR (101 MHz, Chloroform-d) δ 131.7, 128.3, 128.1, 123.0, 86.5, 84.1, 40.5, 34.9.

Spectral data was consistent with the values reported in literature.⁹

N-(3-phenylprop-2-yn-1-yl)aniline (78)

Prepared following general procedure B2.A using phenyl propargylamine (400 mg, 3.05 mmol, 1.0 equiv.), iodobenzene (684 mg, 3.35 mmol, 1.1 equiv.), PdCl₂(PPh₃)₂ (43 mg, 0.061 mmol, 2 mol%), CuI (6 mg, 0.03 mmol, 1 mol%) and Et₃N (0.31 g, 4.3 mL, 3.0 mmol, 1.0 equiv.). Purification by flash column chromatography (SiO₂, 2-6% EtOAc in pentane) afforded N-(3-phenylprop-2-yn-1-yl)aniline (78) as an orange solid (0.43 g, 1.9 mmol, 63% yield).

¹H NMR (400 MHz, Chloroform-d) δ 7.44 – 7.36 (m, 2H, ArH), 7.35 – 7.27 (m, 3H, ArH), 7.27 – 7.20 (m, 3H, ArH), 6.86 – 6.73 (m, 3H, ArH and NH), 4.17 (s, 2H, CH₂).

¹³C{¹H} NMR (101 MHz, Chloroform-d) δ 146.9, 131.9, 129.4, 128.4 (2C), 123.0, 119.0, 114.1, 86.2, 83.7, 35.0.

Spectral data was consistent with the values reported in literature.¹²

N-(4-methoxybenzyl)-3-phenylprop-2-yn-1-amine (79)

Prepared following general procedure B2.C using CuBr (0.22 g, 1.5 mmol, 13 mol%), N-(4-methoxybenzyl)prop-2-yn-1-yl)prop-2-yn-1-amine (1.2 g, 12.0 mmol, 1 equiv.) in MeCN (80 mL). Purification of the crude product by column chromatography (SiO₂, 20-50% EtOAc in pentane) afforded N-benzyl-N-(3-(4-methoxyphenyl)prop-2-yn-1-yl)prop-2-yn-1-amine as a pale yellow oil (3.40 g, 11.7 mmol, 97% yield).

Deallylation: the obtained tertiary amine (3.40 g, 11.7 mmol, 1 equiv.) was treated with Pd(PPh₃)₄ (0.270 g, 0.233 mol, 2 mol%) and 1,3-dimethylbarbituric acid (2.70 g, 17.5 mmol, 1.5 equiv.) in DCM (58 mL). Purification by flash column chromatography (SiO₂, 20-50% EtOAc in pentane) to afford N-(4-methoxybenzyl)-3-phenylprop-2-yn-1-amine (79) as an orange viscous oil (2.3 g, 9.3 mmol, 80% yield).

¹H NMR (400 MHz, Chloroform-d) δ 7.49 – 7.41 (m, 2H, ArH), 7.34 – 7.28 (m, 5H, ArH), 6.93 – 6.85 (m, 2H, ArH), 3.89 (s, 2H, ArCH₂N), 3.81 (s, 3H, OCH₃), 3.64 (s, 2H, NCH₂=CH), 1.54 (br. s., 1H, NH).

¹³C{¹H} NMR (101 MHz, Chloroform-d) δ 158.9, 131.8 (2C), 129.8, 128.4, 128.1, 123.4, 114.0, 87.8, 83.8, 55.4, 52.0, 38.2.

Spectral data was consistent with the values reported in literature.⁹
B.3. Synthesis of the Substituted Aryl Iodide 80

\[ \text{Ligand} \cdot \text{HCl} \xrightarrow{\text{EIOH reflux, } 4\text{h}} \text{Ligand} \cdot \text{Ph} \xrightarrow{\text{NaOH, EIOH/H}_2\text{O reflux, } 16\text{h}} \text{L9} \]

Scheme 8. Synthesis of arylibrary 80.

In accordance to a reported procedure, \(^{14}\) 4-iodoaniline (4.00 g, 18.5 mmol, 1 equiv.) was dissolved in acetic acid (120 mL) and degassed. To the solution was added paraformaldehyde (6.00 g, 194 mmol, 10.5 equiv.) and slowly sodium cyanoborohydride (5.5 g, 87 mmol, 4.7 equiv.). The reaction mixture was stirred at room temperature for 12 h. Then, the mixture was cooled and neutralized with adding 1M NaOH solution and pure NaOH until basicity (pH >9). The suspension was extracted with DCM (3×100 mL). The combined organic layers were washed with brine and dried over sodium sulfate. After filtration, the solvent was removed in vacuum affording the product 80 as a grey solid (4.13 g, 16.7 mmol, 91%).

\(^1\)H NMR (400 MHz, Chloroform-\(d\)) \(\delta 7.47 (d, J = 9.1 \text{ Hz, } \text{ArH}), 6.49 (d, J = 9.1 \text{ Hz, } 2\text{H, ArH}), 2.92 (s, 6\text{H, N(CH}_3)_2\)).

\(^1\)C\(^{1}\)H NMR (101 MHz, Chloroform-\(d\)) \(\delta 150.1, 137.7, 114.9, 77.6, 40.5.\)

Spectral data was consistent with the values reported in literature. \(^{14}\)

B.4. Synthesis of the Ligand L9

\[ \text{(3aS,7aS)-2-phenyl-3a,4,5,6,7a-hexahydro-1H-benzo[d]imidazole (82)} \]

\[ \text{N-((15,2S)-2-aminocyclohexyl)benzamide (83)} \]

In accordance with a reported procedure, \(^{15}\) ethyl benzimidate hydrochloride (3.3 g, 18 mmol, 1.2 equiv.) in ethanol (15 mL) was stirred at room temperature under nitrogen and (15,2S)-cyclohexane-1,2-diamine (1.70 g, 15.0 mmol, 1.0 equiv.) was added to the solution in one portion. The solution was heated to reflux and stirred for 4 hours. 1 M NaOH (50 mL) was then added and the mixture was extracted with 5% MeOH in DCM. The organic layer was dried over sodium sulfate and concentrated to afford the crude product, which was purified by silica gel chromatography (gradient from DCM to DCM/MeOH/NH\(_3\) 100:10:1) to obtain the product as a white solid (2.50 g, 12.5 mmol, 83%).

\[^{1}\)H NMR (400 MHz, Chloroform-\(d\)) \(\delta 7.84 – 7.74 (m, 2\text{H, ArH}), 7.74 (m, 3\text{H, ArH}), 7.54–7.35 (m, 5\text{H, ArH}), 3.12 (m, 2\text{H, NCH}_2\text{CH}_2), 2.36 – 2.25 (m, 2\text{H, NCH}_2\text{CH}_2), 1.92 – 1.79 (m, 2\text{H, NCH}_2\text{CH}_2), 1.62 – 1.49 (m, 2\text{H, -CH}_2\text{CH}_2\text{CH}_2), 1.45 – 1.28 (m, 2\text{H, -CH}_2\text{CH}_2\text{CH}_2).\)

\(^{13}\)C\(^{1}\)H NMR (101 MHz, Chloroform-\(d\)) \(\delta 165.5, 131.0, 130.7, 128.6, 126.7, 69.8, 31.1, 25.2.\)

Spectral data was consistent with the values reported in literature. \(^{15}\)
NH\textsubscript{2}CHCH\textsubscript{2}), 2.14 (ddd, \(J = 12.7, 4.0, 2.1\) Hz, 1H, NHCH\textsubscript{2}H\textsubscript{6}), 2.08 – 1.98 (m, 6H, NH\textsubscript{2} and 2 x -CH\textsubscript{2}CH\textsubscript{2}CH\textsubscript{2}).

\textsuperscript{13}C\textsuperscript{1}H NMR (101 MHz, Chloroform-\(d\)) \(\delta\) 167.9, 134.9, 131.5, 128.7, 127.0, 56.8, 55.8, 35.9, 32.7, 25.3, 25.2.

Spectral data was consistent with the values reported in literature.\textsuperscript{15}

\textbf{N-(1S,2S)-2-benzamidocyclohexyl)-2-(diphenylphosphino)benzamide (L9)}

To a stirred solution of 2-(diphenylphosphino)benzoic acid (1.5 g, 5.0 mmol, 1.1 equiv.) and DMAP (280 mg, 2.3 mmol, 0.5 equiv.) in DCM (20 mL) was added EDC HCl (966 mg, 5.00 mmol, 1.1 equiv.) at 0 °C. The mixture was stirred for few minutes and allowed to reach room temperature. Then, compound 83 (1.0 g, 4.6 mmol, 1 equiv.) was added followed by 8 mL of DCM. The resulting mixture was stirred at room temperature for 16 hours. The mixture was then quenched with 1 M HCl (50 mL) and extracted with DCM (2x50 mL). The combined organic layers were washed with brine and dried over sodium sulfate. The solvent was removed in vacuum and the crude mixture was purified by column chromatography (pentane/EtOAc up to 1:1) and recrystallized from boiling acetonitrile to obtain the desired compound L9 as a white solid (1.4 g, 60%).

[\(\alpha\)]\textsuperscript{D}\textsuperscript{20} = +21.3 (c = 0.5, CHCl\textsubscript{3}, >99% e.e.).

\textbf{31P NMR (162 MHz, Chloroform-\(d\)) \(\delta\) -10.97.}

HRMS (ESI/QTOF) m/z: [M + H]\textsuperscript{+} Calculated for C\textsubscript{32}H\textsubscript{32}N\textsubscript{2}O\textsubscript{2}P\textsuperscript{+} 507.2196; Found 507.2201.

IR (cm\textsuperscript{−1}) 3279 (m), 3064 (m), 2935 (m), 2860 (m), 1634 (s), 1545 (s), 1334 (m).

The (\(R\),\(R\))-L9 ligand and the \(\text{rac}\)-L9 were prepared using the same route starting from (\(R\),\(R\))-cyclohexane-1,2-diamine and racemic cyclohexane-1,2-diamine respectively.

\textsuperscript{*}The peaks are listed not accounting for C-P coupling
C. Optimization Studies

C.1. Carboetherification: Screening of Ligands

The optimization reactions were conducted on a 0.1 mmol scale (relative to the propargylic amine). Reactions were performed in 6 mL conical microwave vials equipped with Teflon-coated magnetic stirring bars. The vials were loaded with the palladium source, the base and the ligand. Part of the solvent (300 μL) was added and the mixture was stirred at the specified temperature for 10 minutes. Propargylic amine, tether, and the remaining solvent (200 μL) were then added and the reaction mixture was stirred for 16 hours. The crude mixture was filtered through a plug of deactivated silica eluting with 10 mL of pentane/EtOAc 9:1. The solvent was removed and yields were determined by 1H NMR analysis of the crude mixture using 1 equiv. of trichloroethylene as the internal standard (IS). The enantiomeric excess was determined by HPLC analysis of a pure sample of product obtained by preparative TLC purification (pentane/EtOAc 100:3). HPLC method: Daicel Chiralpak IB N-5 column, 99:1 hexane/IPA, flow rate 1 mL/min: τ₁ = 7.0 min τ₂ = 8.5 min.

The ligands used in the optimization studies are commercially available or synthesized following reported procedures (L4-L5, L16, L8, L17, L18, L19, L20, L21, L22, L23).

Scheme 10. Screen Evaluation of the JosiPhos and TaniaPhos type ligands and the corresponding P,N ligands.
Scheme 11. Screen 2 Evaluation of the Trost type ligands and analogs.

Scheme 12. Screen 3 Variations on the benzoyl amide
C.2. Carboetherification: Screening of Solvents and Temperatures

![Chemical structure](image)

| entry | Solvent (Temperature) | [%] yield 4 | ee 4 |
|-------|------------------------|-------------|------|
| 1     | DCE (45°C)             | >95         | 90   |
| 2     | MeOH (45°C)            | 25          | 48   |
| 3     | DMSO (45°C)            | 78          | 50   |
| 4     | DMF (45°C)             | 64          | 56   |
| 5     | NMP (45°C)             | 40          | 44   |
| 6     | MeCN (45°C)            | 94          | 72   |
| 7     | Acetone (45°C)         | 35          | 74   |
| 8     | EtOAc (45°C)           | 80          | 84   |
| 9     | DCM (35°C)             | >95         | 88   |
| 10    | CHCl₃ (45°C)           | 80          | 89   |
| 11    | PhCl (45°C)            | 93          | 90   |
| 12    | DME (45°C)             | 87          | 82   |
| 13    | THF (45°C)             | 84          | 89   |
| 14    | Dioxane (45°C)         | 73          | 88   |
| 15    | MTBE (45°C)            | 89          | 89   |
| 16    | Et₂O (35°C)            | >95         | 91   |
| 17    | CPME (45°C)            | 90          | 90   |
| 18    | MeTHF (45°C)           | 26          | 82   |
| 19    | PhCF₃ (45°C)           | 88          | 90   |
| 20    | Benzene (45°C)         | 93          | 90   |
| 21    | Toluene (45°C)         | 91          | 91   |
| 22    | n-hexane (45°C)        | 78          | 86   |
C.3. Carboetherification: Screening of Bases

| entry | Base          | [%] yield 4 | ee 4 |
|-------|---------------|-------------|------|
| 1     | K3PO4        | >95         | 91   |
| 2     | CsOAc        | <5          | -    |
| 3     | KH2PO4       | <5          | -    |
| 4     | Li2CO3       | <5          | -    |
| 5     | Na2CO3       | <5          | -    |
| 6     | K2CO3        | 50          | 75   |
| 7     | Cs2CO3       | 89          | 50   |
| 8     | Li3PO4       | <5          | -    |
| 9     | Na3PO4       | <5          | -    |
| 10    | Cs3PO4       | >95         | 86   |
| 11    | LiOH         | <5          | -    |
| 12    | NaOH         | 45          | 30   |
| 13    | KOH          | >95         | 82   |
| 14    | NaOMe        | 30          | 89   |
| 15    | NaOtBu       | 80          | 82   |
| 16    | KOtBu        | 56          | 40   |
| 17    | NaHMDS       | 28          | 52   |
| 18    | 2,6-lutidine | <5          | -    |
| 19    | Et3N         | <5          | -    |
| 20    | DBU          | <5          | -    |

C.4. Carboetherification: Screening of Palladium Sources

| entry | Pd source                  | [%] yield 4 | ee 4 |
|-------|----------------------------|-------------|------|
| 1     | Pd2(dba)3 + CHCl3         | >95         | 91   |
| 2     | Pd2(PhCN)2Cl2            | 89          | 91   |
| 3     | (η3-C3H5Pd)2              | 94          | 91   |
| 4     | CpPdCynnamil              | 90          | 91   |
| 5     | Pd(OAc)2                 | 68          | 88   |
| 6     | Pd(acac)2                | 80          | 91   |
| 7     | Pd(PPPh3)2               | 20          | 82   |
C.5. Carboetherification: Screening of Additives

\[ \text{Bn} \text{N} \equiv \text{Ph} + \text{Me} \text{C} = \text{I} + \text{CF}_3 \text{O} \text{Et} \rightarrow \text{F}_3 \text{C} \text{N} \equiv \text{Ph} \]

| entry | Additive | [%] yield | ee |
|-------|----------|-----------|----|
| 1     | 18-crown-6 (10 mol%) | >95 | 82 |
| 2     | TBAB (10 mol%) | >95 | 88 |
| 3     | LiCl (20 mol%) | >95 | 88 |
| 4     | NaOTf (20 mol%) | >95 | 89 |
| 5     | Perfluoroheptane (10% v/v) | 91 | 91 |
| 6     | HFIP (50 mol%) | >95 | 91 |
| 7     | H$_2$O (10% v/v) | 27 | 32 |

C.5. Asymmetric Hydrogenation: Optimization Studies

The optimization reactions were performed in 25 mL round-bottom flask equipped with Teflon-coated magnetic stir bars. The flasks were loaded with the palladium catalyst and the olefin substrate closed with a septum, and purged with nitrogen. The solvent mixture was added and the suspension was stirred under a nitrogen flow for 10 minutes. Then, a balloon of hydrogen was connected to the flask with a needle and the reaction was stirred for 16 h at room temperature. The crude mixture was degassed bubbling nitrogen for 10 minutes and filtered through a plug of celite eluting with 10 mL of MeOH. The crude extract was washed with saturated NaHCO$_3$ and extracted with DCM (3x20 mL). The combined organic layers were dried over sodium sulfate, filtered and concentrated in vacuum. Yields were determined by $^1$HNMR analysis of the crude mixture using 1 equiv. of trichloroethylene as the internal standard (IS). The enantiomeric excess was determined by HPLC analysis of a pure sample obtained by preparative TLC purification (pentane/EtOAc 100:15). HPLC method: Daicel Chiralpak IA column, 95:5 hexane/IPA, flow rate 1 mL/min. $t_1 = 8.2$ min, $t_2 = 12.5$ min.

\[ \text{F}_3 \text{C} \text{N} \equiv \text{Ph} + \text{H}_2 \text{balloon} \rightarrow \text{F}_3 \text{C} \text{N} \equiv \text{Ph} \]

| entry | Scale (mmol) | Solvent | [Pd] loading | [%] yield 5 | [%] yield 84 |
|-------|--------------|---------|--------------|-------------|-------------|
| 1     | 0.1          | MeOH/EiOAc (2:1) | 10 | 28 | 8 |
| 2     | 0.2          | MeOH/EiOAc (2:1) | 20 | 23 | 70 |
| 3     | 0.1          | MeOH/AcOH (2:1) | 20 | 77 | - |
| 4     | 0.1          | MeOH/AcOH (2:1) | 10 | 77 | - |
| 5     | 0.2          | MeOH/AcOH (2:1) | 10 | 80 (91% ee)$^a$ | - |

$^a$: ee starting material: 91%
D. Stereoselective Carboetherification of Propargylic Amines

D.1. General Procedure for the Enantioselective Carboetherification of Propargylic Amines

An oven-dried 8 mL microwave vial equipped with a Teflon coated stirring bar was charged with Pd$_2$(dba)$_3$ • CHCl$_3$ (5.2 mg, 5.0 μmol, 1.25 mol%), the ligand (7.2 mg, 14 μmol, 3.5 mol%) and K$_3$PO$_4$ (0.11 g, 0.52 mmol, 1.3 equiv.). The vial was then sealed, purged with N$_2$ and placed in a heating metal block. Propargylic amine (0.40 mmol, 1.0 equiv) and 1-ethoxy-2,2,2-trifluoroethanol (85% in EtOH, 76 μL, 0.56 mmol 1.4 equiv.) were added followed by the aryl iodide (52 mmol, 1.3 equiv.) and the remaining 0.5 mL of Et$_2$O to rinse the wall of the vial. The resulting suspension was stirred at 35 °C for 16 hours. Next, the reaction mixture was filtered through a plug of deactivated silica gel eluting with 15 mL of pentane/EtOAc 9:1 and concentrated in vacuo. The crude material was purified by flash column chromatography on silica gel to afford the corresponding product.

D.2. Characterization of Products of the Enantioselective Carboetherification

(S,E)-3-Benzyl-5-(phenyl(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine ((S)-4)
Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 μL, 0.40 mmol, 1.0 equiv.) and 1-iodo-4-methylbenzene (113 mg, 0.52 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:3) to give the corresponding olefin (S)-4 (161 mg, 0.393 mmol, 98% yield) as a white solid (m.p. 118 °C). The enantiomeric excess was determined to be 94% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: t$_{Major}$ = 6.9 min t$_{Minor}$ = 8.4 min. Absolute configuration was determined by X-Ray diffraction analysis of a single crystal of (S)-4 (details in section F).

[a]D$_{20}^{o}$ = +67.5 (c = 0.37, CHCl$_3$, 94% ee).

$^1$H NMR (400 MHz, Chloroform-d) δ 7.39 – 7.26 (m, 9H, ArH), 7.22 – 7.16 (m, 1H, ArH), 7.14 (d, J = 7.8 Hz, 2H, ArH), 7.05 (d, J = 8.1 Hz, 2H, ArH), 5.13 (q, J = 5.3 Hz, 1H, CHCF$_3$), 3.99 (d, J = 13.3 Hz, 1H, PhCH$_2$H$_2$), 3.94 (d, J = 16.0 Hz, 1H, NCH$_2$H$_2$C=C), 3.89 (d, J = 13.2 Hz, 1H, PhCH$_2$H$_2$), 3.54 (d, J = 16.0 Hz, 1H, NCH$_2$CH$_2$C=C)), 2.35 (s, 3H, CH$_3$).

$^{13}$C[$^1$H] NMR (101 MHz, Chloroform-d) δ 148.4, 138.8, 137.2, 137.1, 136.7, 130.0, 129.4, 129.1, 128.8 (2C), 128.04, 128.02, 126.3, 122.9 (q, J$_{C\text{-}F} = 283.9$ Hz), 112.9, 94.00 (q, J$_{C\text{-}F} = 34.4$ Hz), 60.5, 54.9, 21.3.

$^{19}$F NMR (376 MHz, Chloroform-d) δ -80.3.

IR (cm$^{-1}$) 3031 (w), 1665 (w), 1503 (w), 1451 (w), 1293 (m), 1175 (s), 1153 (s).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{25}$H$_{27}$F$_3$NO$^+$ 410.1726; Found 410.1728.

5 mmol scale reaction. The model reaction was repeated on 5 mmol scale. An oven dried 50 mL round-bottom flask equipped with a Teflon stir bar was charged with Pd$_2$(dba)$_3$ • CHCl$_3$ (65 mg, 63 μmol, 1.25 mol%), the ligand (90 mg, 0.18 mmol, 3.5 mol%) and K$_3$PO$_4$ (1.38 g, 6.50 mmol, 1.3 equiv.). The flask was then purged with N$_2$ and placed in a heating metal block. 20 mL of Et$_2$O were added and the suspension was stirred at 35 °C for 10 minutes N-benzyl-3-phenylprop-2-yn-1-amine (1.11 g, 5.00 mmol, 1.0 equiv) and 1-ethoxy-2,2,2-trifluoroethanol (85% in EtOH, 0.96 mL, 7.0 mmol, 1.4 equiv.) were added followed by 1-iodo-4-methylbenzene (1.42 g, 6.50 mmol, 1.3 equiv.) and the remaining 5 mL of Et$_2$O to rinse the wall. The resulting suspension was stirred at 35 °C for 16 hours. Then, the reaction mixture was filtered through a plug of deactivated silica gel eluting with 50 mL of pentane/EtOAc 9:1 and concentrated in vacuo and analyzed by $^1$H NMR with an internal standard (trichloroethylene, 0.1 equiv., NMR yield: >99%). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:3) to give the corresponding product (S)-4 (2.04 g, 4.98 mmol, >99% yield) as a white solid. The enantiomeric
excess was determined to be 94% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: δ_{major} = 6.9 min δ_{major} = 8.6 min.

(R,E)-3-Benzyl-5-(phenyl(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine ((R)-4)

Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 µL, 0.40 mmol, 1.0 equiv.), 1-iodo-4-methylenbenzene (113 mg, 0.520 mmol, 1.3 equiv) and the (R,R)-L9 ligand. The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:3) to give the corresponding olefin (160 mg, 0.390 mmol, 98% yield) as a white solid. The enantiomeric excess was determined to be 92% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: δ_{major} = 7.0 min δ_{major} = 8.6 min. [α]D^{20} = -52.3 (c = 0.50, CHCl3, 92% ee). Absolute configuration determined in comparison to compound (S)-4.

(S,Z)-3-Benzyl-5-(phenyl(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine ((S)-6)

Prepared according to the general procedure D1 using N-benzyl-3-(p-tolyl)prop-2-yn-1-amine (94 mg, 0.40 mmol, 1.0 equiv.) and iodobenzene (108 mg, 58 µL, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin (S)-6 (152 mg, 0.372 mmol, 93% yield) as colorless oil. The enantiomeric excess was determined to be 89% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: δ_{minor} = 7.0 min δ_{major} = 8.1 min. Absolute configuration determined in comparison to compound (S)-4.

[α]D^{20} = 45.6 (c = 0.55, CHCl3, 89% ee).

^1H NMR (400 MHz, Chloroform-d) δ 7.36 – 7.28 (m, 7H, ArH), 7.27 – 7.21 (m, 3H, ArH), 7.18 – 7.13 (m, 2H, ArH), 7.10 (d, J = 8.0 Hz, 2H, ArH), 5.11 (q, J = 5.3 Hz, 1H, CHCF3), 4.03 – 3.83 (m, 3H, PhCH2 and NCH3H3C=C), 3.52 (d, J = 15.7 Hz, 1H, NCH3H3C=C), 2.33 (s, 3H, ArCH3).

^13C[^1H] NMR (101 MHz, Chloroform-d) δ 148.1, 140.3, 137.1, 136.1, 135.8, 130.2, 129.0, 128.81, 128.77 (2C), 128.7, 128.0, 127.0, 122.9 (q, J = 284.0 Hz), 113.0, 93.9 (q, J = 34.3 Hz), 60.5, 54.8, 21.3.

^19F NMR (376 MHz, Chloroform-d) δ -80.4 (d, 3F, J = 5.3 Hz).

IR (cm⁻¹) 3024 (w), 3023 (w), 1664 (w), 1505 (w), 1295 (m), 1214 (m), 1154 (m).

HRMS (ESI/QTOF) m/z: [M + Na]^+ Calculated for C_{27}H_{22}F_{3}N_{Na}O: 432.1546; Found 432.1547.

(R,Z)-3-Benzyl-5-(phenyl(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine ((R)-6)

Prepared according to the general procedure D1 using N-benzyl-3-(p-tolyl)prop-2-yn-1-amine (94 mg, 0.40 mmol, 1.0 equiv.), iodobenzene (108 mg, 58 µL, 0.520 mmol, 1.3 equiv.) and the (R,R)-L9 ligand. The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin (R)-6, (142 mg, 0.347 mmol, 87% yield) as colorless oil. The enantiomeric excess was determined to be 89% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: δ_{major} = 7.6 min δ_{major} = 9.0 min. [α]D^{20} = -45.1 (c = 0.58, CHCl3, 89% ee). Absolute configuration determined in comparison to compound (S)-4.

(S)-3-Benzyl-5-((4-methoxyphenyl)(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine (7)

Prepared according to the general procedure D1 using N-benzyl-3-(4-(methoxy)phenyl)prop-2-yn-1-amine (101 mg, 0.400 mmol, 1.0 equiv.) and p-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin (154 mg, 0.352 mmol, 88% yield) as amorphous white solid. The enantiomeric excess was determined to be 92% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: δ_{minor} = 10.9 min δ_{major} = 22.6 min. Absolute configuration determined in comparison to compound (S)-4.

[α]D^{20} = 54.5 (c = 0.52, CHCl3, 92% ee).
$^1$H NMR (400 MHz, Chloroform-d) δ 7.36 – 7.27 (m, 7H, ArH), 7.16 – 7.09 (m, 2H, ArH), 7.07 – 7.00 (m, 2H, ArH), 6.87 – 6.78 (m, 2H, ArH), 5.10 (q, J = 5.3 Hz, 1H, CHCF$_3$), 4.03 – 3.85 (m, 3H, PhCH$_2$ and NCH$_2$H$_2$C=O), 3.80 (s, 3H, OCH$_3$), 3.52 (dd, J = 15.7, 0.9 Hz, 1H, NCH$_2$H$_2$C=O), 2.34 (s, 3H, ArCH$_3$).

$^{13}$C($^1$H) NMR (101 MHz, Chloroform-d) δ 158.0, 147.3, 147.3, 137.4, 137.1, 136.7, 131.4, 130.2, 130.0, 129.4, 128.8, 128.0, 122.9 (q, J = 283.9 Hz), 113.5, 112.5, 93.8 (q, J = 34.2 Hz), 60.5, 55.4, 54.8, 21.3.

$^{19}$F NMR (376 MHz, Chloroform-d) δ -80.3 (d, 3F, J = 5.3 Hz).

IR (cm$^{-1}$) 2941 (w), 2835 (w), 1664 (m), 1607 (m), 1512 (m), 1293 (m), 1247 (m), 1176 (s), 1155 (s), 1033 (m).

HRMS (ESI/QTOF) m/z: [M + Na]$^+$ Calculated for C$_{29}$H$_{35}$F$_3$NaO$_4$: 462.1651; Found 462.1661.

(S,Z)-3-Benzyl-5-(p-tolyl)(4-trifluoromethyl)(phenyl)methylene)-2-(trifluoromethyl)oxazolidine (8)

Prepared according to the general procedure D1 using N-benzyl-3-(4-(trifluoromethyl)phenyl)prop-2-yn-1-amine (116 mg, 0.40 mmol, 1.0 equiv.) and p-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentene/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 8 (165 mg, 0.346 mmol, 86% yield) as colorless oil. The enantiomeric excess was determined to be 88% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: τ$_{\text{minor}}$ = 6.8 min, τ$_{\text{major}}$ = 9.5 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D$_{20}^0$ = 37.9 (c = 0.51, CHCl$_3$, 88% ee).

$^1$H NMR (400 MHz, Chloroform-d) δ 7.51 (d, J = 8.5 Hz, 2H, ArH), 7.46 (d, J = 8.5 Hz, 2H, ArH), 7.36 – 7.27 (m, 5H, ArH), 7.15 (d, J = 8.0 Hz, 2H, ArH), 7.02 (d, J = 8.0 Hz, 2H, ArH), 5.17 (q, J = 5.2 Hz, 1H, CHCF$_3$), 3.99 (d, J = 13.3 Hz, 1H, PhCH$_2$H$_{\text{ar}}$), 3.95 (d, J = 16.2 Hz, 1H, NCH$_2$H$_2$C=O), 3.90 (d, J = 13.3 Hz, 1H, PhCH$_2$H$_{\text{ar}}$), 3.54 (d, J = 16.2 Hz, 1H, NCH$_2$H$_2$C=O), 2.36 (s, 3H, ArCH$_3$).

$^{13}$C($^1$H) NMR (101 MHz, Chloroform-d) δ 150.2, 142.4, 137.3, 138.8, 136.3, 130.0, 129.7, 129.1, 128.83, 128.78, 128.2, 127.9 (q, J = 32.0 Hz), 124.9 (q, J = 3.7 Hz), 124.5 (q, J = 272 Hz), 122.7 (q, J = 284.0 Hz) 111.7, 94.4 (q, J = 34.4 Hz), 60.6, 55.1, 21.3.

$^{19}$F NMR (376 MHz, Chloroform-d) δ -62.4 (s, 3F, ArCF$_3$), -80.4 (d, 3F, J = 5.2 Hz, CHCF$_3$).

IR (cm$^{-1}$) 2979 (m), 2901 (m), 1662 (m), 1616 (m), 1516 (m), 1329 (s), 1157 (s), 1122 (s), 1075 (m).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{29}$H$_{35}$F$_3$NO$_4$: 478.1600; Found 478.1607.

(S,Z)-3-Benzyl-5-(4-fluorophenyl)(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine (9)

Prepared according to the general procedure D1 using N-benzyl-3-(4-(fluorophenyl)prop-2-yn-1-amine (96 mg, 0.40 mmol, 1.0 equiv.) and p-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 9 (168 mg, 0.392 mmol, 98% yield) as amorphous white solid. The enantiomeric excess was determined to be 91% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: τ$_{\text{minor}}$ = 6.5 min, τ$_{\text{major}}$ = 8.2 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D$_{20}^0$ = 56.3 (c = 0.50, CHCl$_3$, 91% ee).

$^1$H NMR (400 MHz, Chloroform-d) δ 7.36 – 7.27 (m, 7H, ArH), 7.13 (d, J = 7.8 Hz, 2H, ArH), 7.06 – 6.99 (m, 2H, ArH), 6.99 – 6.92 (m, 2H, ArH), 5.12 (q, J = 5.3 Hz, 1H, CHCF$_3$), 4.02 – 3.83 (m, 3H, PhCH$_2$ and NCH$_2$H$_2$C=O), 3.52 (dd, J = 15.8, 1.0 Hz, 1H, NCH$_2$H$_2$C=O), 2.35 (s, 3H, ArCH$_3$).

$^{13}$C($^1$H) NMR (101 MHz, Chloroform-d) δ 161.3 (d, J = 245.8 Hz), 148.25, 148.24, 137.0 (2C), 136.9, 134.8 (d, J = 3.2 Hz), 130.7, 130.6, 129.9, 129.5, 128.79, 128.76, 122.82 (d, J = 284.0 Hz), 114.9 (d, J = 22.1 Hz), 94.0 (q, J = 34.2 Hz), 60.5, 54.8, 21.3.

$^{19}$F NMR (376 MHz, Chloroform-d) δ -80.4 (d, 3F, J = 5.3 Hz, CHCF$_3$), -116.2 (tt, 1F, J = 8.8, 5.5 Hz, ArF).

IR (cm$^{-1}$) 2979 (m), 2908 (m), 1665 (w), 1508 (m), 1402 (m), 1229 (s), 1154 (s), 1066 (s).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{29}$H$_{35}$F$_3$NO$_4$: 428.1632; Found 428.1627.
(S,Z)-3-Benzyl-5-((4-chlorophenyl)(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine (10)

Prepared according to the general procedure D1 using N-benzyl-3-(4-chlorophenyl)prop-2-yn-1-amine (102 mg, 0.400 mmol, 1.0 equiv.) and p-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 10 (159 mg, 0.360 mmol, 90% yield) as colorless oil. The enantiomeric excess was determined to be 90% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: t<sub>Minor</sub> = 6.9 min, t<sub>Major</sub> = 9.1 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D<sup>20</sup> = 34.7 (c = 0.38, CHCl<sub>3</sub>, 90% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.36 – 7.20 (m, 9H, ArH), 7.14 (d, J = 7.9 Hz, 2H, ArH), 7.01 (d, J = 7.9 Hz, 2H, ArH), 5.14 (q, J = 5.3 Hz, 1H, CH(CF<sub>3</sub>)), 4.03 – 3.81 (m, 3H, PhCH<sub>2</sub> and NCH<sub>2</sub>H<sub>2</sub>C=C), 3.52 (dd, J = 15.9, 0.9 Hz, 1H, NCH<sub>2</sub>H<sub>2</sub>C=C), 2.35 (s, 3H, ArCH<sub>3</sub>).

13C{1H} NMR (101 MHz, Chloroform-d) δ 148.9, 137.3, 137.0, 136.9, 136.7, 131.9, 130.3, 130.0, 129.6, 128.80, 128.76, 128.2, 128.1, 128.2 (J = 283.9 Hz), 111.8, 91.2 (q, J = 34.4 Hz), 60.5, 55.0, 21.3.

19F NMR (376 MHz, Chloroform-d) δ -80.4 (d, 3F, J = 5.3 Hz).

IR (cm<sup>-1</sup>) 2927 (w), 2850 (w), 1664 (m), 1480 (m), 1465 (m), 1422 (m), 1343 (m), 1304 (s), 1292 (s), 1237 (s), 1179 (s), 1154 (s), 1096 (s).

HRMS (ESI/QTOF) m/z: [M + H]<sup>+</sup> Calculated for C<sub>25</sub>H<sub>22</sub>BrF<sub>5</sub>NO<sub>3</sub> 444.1337; Found 444.1332.

(S,Z)-3-Benzyl-5-((3-bromophenyl)(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine (11)

Prepared according to the general procedure D1 using N-benzyl-3-(3-bromophenyl)prop-2-yn-1-amine (120 mg, 0.400 mmol, 1.0 equiv.) and p-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 11 (149 mg, 0.304 mmol, 76% yield) as colorless oil. The enantiomeric excess was determined to be 82% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: t<sub>Minor</sub> = 8.4 min, t<sub>Major</sub> = 10.4 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D<sup>20</sup> = 21.4 (c = 0.64, CHCl<sub>3</sub>, 82% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.49 (t, J = 1.7 Hz, 1H, ArH), 7.36 – 7.26 (m, 7H, ArH), 7.17 - 7.09 (m, 3H, ArH), 7.01 (d, J = 8.0 Hz, 2H, o-Me-ArH), 5.15 (q, J = 5.3 Hz, 1H, CH(CF<sub>3</sub>)), 4.01 – 3.81 (m, 3H, PhCH<sub>2</sub> and NCH<sub>2</sub>H<sub>2</sub>C=C), 3.50 (d, J = 16.1 Hz, 1H, NCH<sub>2</sub>H<sub>2</sub>C=C), 2.35 (s, 3H, ArCH<sub>3</sub>).

13C{1H} NMR (101 MHz, Chloroform-d) δ 149.5, 140.9, 137.1, 136.9, 136.4, 131.9, 130.0, 129.6, 129.5, 129.2, 128.81, 128.78, 128.1, 127.7, 122.7 (q, J = 284.1 Hz), 122.3, 111.6, 94.2 (q, J = 34.5 Hz), 60.6, 55.0, 21.3.

19F NMR (376 MHz, Chloroform-d) δ -80.3 (d, 3F, J = 5.3 Hz).

IR (cm<sup>-1</sup>) 2927 (w), 2850 (w), 1664 (m), 1593 (m), 1480 (m), 1465 (m), 1292 (m), 1179 (s), 1154 (s), 1082 (m).

HRMS (ESI/QTOF) m/z: [M + H]<sup>+</sup> Calculated for C<sub>25</sub>H<sub>22</sub>Br<sub>5</sub>F<sub>5</sub>NO<sub>3</sub> 488.0831; Found 488.0830.

(S,Z)-3-Benzyl-5-((3-chlorophenyl)(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine (12)

Prepared according to the general procedure D1 using N-benzyl-3-(3-chlorophenyl)prop-2-yn-1-amine (102 mg, 0.400 mmol, 1.0 equiv.) and p-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 12 (168 mg, 0.380 mmol, 95% yield) as amorphous white solid. The enantiomeric excess was determined to be 84% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: t<sub>Minor</sub> = 8.2 min, t<sub>Major</sub> = 10.5 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D<sup>20</sup> = 33.0 (c = 0.48, CHCl<sub>3</sub>, 84% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.36 – 7.27 (m, 6H, ArH), 7.25 – 7.16 (m, 2H, ArH), 7.17 – 7.10 (m, 3H, ArH), 7.04 – 6.97 (m, 2H, ArH), 5.16 (q, J = 5.3 Hz, 1H, CH(CF<sub>3</sub>)), 4.01 – 3.80 (m, 3H, PhCH<sub>2</sub> and NCH<sub>2</sub>H<sub>2</sub>C=C), 3.50 (dd, J = 16.0, 1.0 Hz, 1H, NCH<sub>2</sub>H<sub>2</sub>C=C), 2.35 (s, 3H, ArCH<sub>3</sub>).
13C(1H) NMR (101 MHz, Chloroform-d) δ 149.4, 140.6, 137.1, 136.9, 136.4, 134.0, 130.0, 129.6, 129.2, 129.0, 128.80, 128.78, 128.1, 127.2, 126.3, 122.7 (q, J = 284.0 Hz), 111.7, 94.3 (q, J = 34.2 Hz), 60.6, 55.0, 21.3.

19F NMR (376 MHz, Chloroform-d) δ -80.3 (d, 3F, J = 5.3 Hz).

IR (cm⁻¹) 2842 (w), 1665 (m), 1589 (m), 1467 (w), 1293 (m), 1179 (s), 1154 (s), 1014 (m).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C₃₅H₃₁ClF₅NO 444.1337; Found 444.1337.

(S,Z)-3-benzyl-5-((2-fluorophenyl)(p-toly)methylene)-2-((trifluoromethyl)oxazolidine (13)

Prepared according to the general procedure D1 using N-benzyl-3-(2-fluorophenyl)prop-2-yn-1-amine (96 mg, 0.40 mmol, 1.0 equiv.) and p-iiodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 13 (165 mg, 0.380 mmol, 97% yield) as amorphous white solid. The enantiomeric excess was determined to be 80% by HPLC analysis on a Daicel Chiralpak IB N-5 column; 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: εmin = 6.6 min, εmax = 7.4 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D^20 = 6.2 (c = 0.54, CHCl₃, 80% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.41 – 7.27 (m, 5H, ArH), 7.26 – 7.16 (m, 2H, ArH), 7.13 – 7.03 (m, 4H, ArH), 7.04 – 6.94 (m, 2H, ArH), 5.00 (q, J = 5.3 Hz, 1H, CHF₃), 4.12 (dd, J = 15.6, 1.1 Hz, 1H, N(CH₃)₂H₂C=C), 3.99 (d, J = 13.3 Hz, 1H, PhCH₂H₂), 3.91 (d, J = 13.3 Hz, 1H, PhCH₂H₂), 3.72 (dd, J = 15.6, 1.3 Hz, 1H, NCH₂H₂C=O, 2.32 (s, 3H, ArCH₃)).

13C(1H) NMR (101 MHz, Chloroform-d) δ 160.4 (d, J = 248.0 Hz), 149.5, 136.7 (d, J = 57.4 Hz, 136.6, 133.2 (d, J = 3.8 Hz), 129.2, 128.9, 128.82, 127.9, 128.6, 128.0, 126.6 (d, J = 15.8 Hz), 124.1, 123.91 (d, J = 3.5 Hz), 122.7 (q, J = 283.9 Hz), 115.8 (d, J = 22.5 Hz), 107.8, 93.2 (q, J = 34.3 Hz), 60.5, 54.0, 21.3.

19F NMR (376 MHz, Chloroform-d) δ -80.2 (d, 3F, J = 5.3 Hz, CHF₃) –112.63 – 112.82 (m, 1F, ArF).

IR (cm⁻¹) 2927 (w), 2858 (w), 1675 (m), 1492 (m), 1452 (m), 1294 (m), 1223 (m), 1176 (s), 1155 (s), 1021 (m).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C₃₅H₃₁F₅NO 428.1632; Found 428.1640.

(S,Z)-3-Benzyl-5-((3,5-dimethylphenyl)(p-toly)methylene)-2-(trifluoromethyl)oxazolidine (14)

Prepared according to the general procedure D1 using N-benzyl-3-(3,5-dimethylphenyl)prop-2-yn-1-amine (100 mg, 0.400 mmol, 1.0 equiv.) and p-iiodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 14 (155 mg, 0.356 mmol, 89% yield) as colorless oil. The enantiomeric excess was determined to be 91% by HPLC analysis on a Daicel Chiralpak IB N-5 column; 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: εmin = 5.8 min, εmax = 7.2 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D^20 = 56.7 (c = 0.52, CHCl₃, 91% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.36 – 7.32 (m, 4H, ArH), 7.32 – 7.27 (m, 1H, ArH), 7.11 (d, J = 7.8 Hz, 2H, ArH), 7.05 – 6.99 (m, 2H, ArH), 6.96 (s, 2H, ArH), 6.84 (s, 1H, ArH), 5.09 (q, J = 5.3 Hz, 1H, CHF₃), 4.04 – 3.81 (m, 3H, PhCH₂ and N(CH₃)₂H₂C=C), 3.53 (dd, J = 15.7, 0.9 Hz, 1H, NCH₂H₂C=C), 2.34 (s, 3H, ArCH₃), 2.26 (s, 6H, 2×ArCH₃).

13C(1H) NMR (101 MHz, Chloroform-d) δ 148.1, 138.7, 137.4 (2C), 137.2, 136.5, 129.9, 129.3, 128.8 (2C), 128.2, 128.0, 127.0, 122.9 (q, J = 284.1 Hz), 113.2, 93.8 (q, J = 34.2 Hz), 60.5, 54.8, 21.6, 21.3.

19F NMR (376 MHz, Chloroform-d) δ -80.3 (d, 3F, J = 5.3 Hz).

IR (cm⁻¹) 2925 (m), 2865 (w), 1664 (m), 1600 (m), 1506 (m), 1453 (m), 1295 (m), 1154 (s), 1077 (m).

HRMS (ESI/QTOF) m/z: [M + Na]+ Calculated for C₃₅H₃₁F₅NaO 460.1859; Found 460.1863.

(S,Z)-3-benzyl-5-(pyridin-3-yl)(p-toly)methylene)-2-(trifluoromethyl)oxazolidine (15)

Prepared according to the general procedure D1 using N-benzyl-3-(pyridin-3-yl)prop-2-yn-1-amine (89 mg, 0.40 mmol, 1.0 equiv.) and p-iiodotoluene (113 mg, 0.520 mmol,
1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 90:10 to 60:40) to give the corresponding olefin 15 (103 mg, 0.251 mmol, 63% yield) as orange oil. The enantiomeric excess was determined to be 52% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 90:10 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: \( \tau_{\text{minor}} \) = 10.4 min, \( \tau_{\text{major}} \) = 11.2 min. Absolute configuration determined in comparison to compound (S)-4.

[\text{a}]^{20} \text{D} = 18.5 (c = 0.80, CHCl\text{c}, 52\% ee).

1H NMR (400 MHz, Chloroform-d) 8 8.57 (br. s, 1H, HetArH), 8.38 (br. s, 1H, HetArH), 7.66 (dt, J = 8.1, 1.9 Hz, 1H, HetArH), 7.37 – 7.25 (m, 5H, ArH), 7.21 (dd, J = 8.1, 4.7 Hz, 1H, HetArH), 7.15 (d, J = 7.8 Hz, 2H, ArH), 7.06 – 6.99 (m, 2H, ArH), 5.17 (q, J = 5.3 Hz, 1H, CHCF\text{c}), 4.03 – 3.93 (m, 2H, NCH\text{H}\text{H}_2\text{C}=C\text{H}_2\text{H}), 3.90 (d, J = 13.3 Hz, 1H, PhCH\text{H}_2), 3.54 (dd, J = 16.1, 1.4 Hz, 1H, NCH\text{H}_2\text{H}_2\text{C}=C\text{H}_2), 2.35 (s, 3H, ArHc).

13C\text{[}\text{1}\text{H}\text{]}\text{NMR} (101 MHz, Chloroform-d) 8 150.6, 149.8, 146.6, 137.3, 136.8, 136.3, 135.7, 129.9, 129.7, 128.83, 128.78, 128.2, 126.4, 123.2, 122.7 (q, J = 283.9 Hz), 109.5, 94.3 (q, J = 34.5 Hz), 60.5, 54.9, 21.3.

19F NMR (376 MHz, Chloroform-d) 8 -80.3 (d, 3F, J = 5.3 Hz).

IR (cm\text{^{-1}}) 3035 (m), 1664 (m), 1569 (m), 1412 (m), 1292 (m), 1155 (s), 1076 (m).

HRMS (ESI/QTOF) m/z: [M + H]\text{^+} calculated for C\text{\textsubscript{2}}H\text{\textsubscript{2}}F\text{\textsubscript{3}}N\text{O\textsubscript{3}} 411.1679; found 411.1679.

\chem{\text{(S,Z)-3-Benzyl-5-(thiophen-2-yl-(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine}}(16)

Prepared according to the general procedure D1 using N-benzyl-3-(thiophen-2-yl)prop-2-yn-1-amine (91 mg, 0.40 mmol, 1.0 equiv.) and \( p \)-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 16 (142 mg, 0.340 mmol, 85% yield) as brown oil. The enantiomeric excess was determined to be 76% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, \( \lambda = 254 \text{ nm} \): \( \tau_{\text{minor}} \) = 8.3 min, \( \tau_{\text{major}} \) = 13.9 min. Absolute configuration determined in comparison to compound (S)-4.

[\text{a}]^{20} \text{D} = 9.4 (c = 0.68, CHCl\text{c}, 76\% ee).

1H NMR (400 MHz, Chloroform-d) 8 7.35 – 7.26 (m, 5H, ArH), 7.24 – 7.13 (m, 5H, ArH), 6.94 (dd, J = 5.1, 3.7 Hz, 1H, HetArH), 0.79 (dd, J = 3.7, 1.0 Hz, 1H, HetArH), 5.26 (q, J = 5.3 Hz, 1H, CHCF\text{c}), 4.02 – 3.82 (m, 3H, PhCH\text{H}_2 and NCH\text{H}_2\text{H}_2\text{C}=C\text{H}_2), 3.39 (dd, J = 16.1, 0.9 Hz, 1H, NCH\text{H}_2\text{H}_2\text{C}=C\text{H}_2), 2.38 (s, 3H, ArCH\text{H}_2).

13C\text{[}\text{1}\text{H}\text{]}\text{NMR} (101 MHz, Chloroform-d) 8 147.0, 142.2, 137.5, 137.0, 135.6, 130.2, 129.6, 128.8, 128.7, 128.0, 126.5, 125.3, 124.5, 122.7 (q, J = 283.7 Hz), 108.3, 94.7 (q, J = 34.5 Hz), 60.6, 54.6, 21.4.

19F NMR (376 MHz, Chloroform-d) 8 -80.5 (d, 3F, J = 5.3 Hz).

IR (cm\text{^{-1}}) 2937 (m), 2834 (m), 1663 (m), 1512 (m), 1453 (m), 1294 (m), 1223 (s), 1170 (s), 1153 (s), 1077 (m).

HRMS (ESI/QTOF) m/z: [M + H]\text{^+} calculated for C\text{\textsubscript{2}}H\text{\textsubscript{2}}F\text{\textsubscript{3}}N\text{O\textsubscript{3}} 411.1280; found 411.1289.

\chem{\text{(S,E)-3-Benzyl-5-(1-(p-tolyl)ethylidene)-2-(trifluoromethyl)oxazolidine}}(17)

Prepared according to the general procedure D1 using N-benzylbut-2-yn-1-amine (64 mg, 0.40 mmol, 1.0 equiv.) and \( p \)-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 17 (114 mg, 0.328 mmol, 82% yield) as amorphous white solid. The enantiomeric excess was determined to be 72% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, \( \lambda = 254 \text{ nm} \): \( \tau_{\text{minor}} \) = 5.5 min, \( \tau_{\text{major}} \) = 6.4 min. Absolute configuration determined in comparison to compound (S)-4.

[\text{a}]^{20} \text{D} = 27.5 (c = 0.54, CHCl\text{c}, 72\% ee).

1H NMR (400 MHz, Chloroform-d) 8 7.35 – 7.26 (m, 5H, ArH), 7.10 (d, J = 8.0 Hz, 2H, \text{-Me-ArH}), 7.07 – 7.02 (m, 2H, \text{-Me-ArH}), 4.96 (q, J = 5.3 Hz, 1H, CHCF\text{c}), 3.97 (d, J = 14.9 Hz, 1H, NCH\text{H}_2\text{H}_2\text{C}=C\text{H}_2), 3.92 (d, J = 13.3 Hz, 1H, PhCH\text{H}_2), 3.81 (d, J = 13.3 Hz, 1H, PhCH\text{H}_2), 3.45 (dt, J = 14.9, 1.3 Hz, 1H, NCH\text{H}_2\text{H}_2\text{C}=C\text{H}_2), 2.32 (s, 3H, ArCH\text{H}_2), 2.07 (t, J = 1.7 Hz, 3H, C—CH\text{H}_2).

13C\text{[}\text{1}\text{H}\text{]}\text{NMR} (101 MHz, Chloroform-d) 8 146.9, 138.3, 137.3, 136.0, 129.1, 128.7 (2C), 127.9, 127.4, 123.0 (q, J = 283.9 Hz), 107.6, 94.6 (q, J = 34.0 Hz), 60.3, 53.3, 21.2, 16.6.

19F NMR (376 MHz, Chloroform-d) 8 -80.6 (d, 3F, J = 5.3 Hz).
IR (cm⁻¹) 2979 (s), 2910 (m), 1689 (w), 1508 (w), 1451 (m), 1386 (m), 1292 (m), 1233 (m), 1157 (s), 1067 (s).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C_{26}H_{32}F_{2}NO+ 348.1570; Found 348.1567.

(S,E)-3-Benzyl-5-(2-phenyl-1-(p-toly)ethylidene)-2-(trifluoromethyl)oxazolidine (18)
Prepared according to the general procedure D1 using N-benzyl-4-phenylbut-2-yn-1-amine (94 mg, 0.40 mmol, 1.0 equiv.) and p-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 18 (142 mg, 0.336 mmol, 84% yield) as amorphous white solid. The enantiomeric excess was determined to be 86% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: t_{minor} = 6.3 min, t_{major} = 6.9 min. Absolute configuration determined in comparison to compound (S)-4.

\( [\alpha]^{20}_D = 21.4 \ (c = 0.39, \text{CHCl}_3, 86\% \text{ ee}) \)

'H NMR (400 MHz, Chloroform-d) 0.739 – 7.28 (m, 5H, ArH), 7.25 – 7.18 (m, 2H, ArH), 7.18 – 7.10 (m, 3H, ArH), 3.03 (d, J = 8.0 Hz, 2H, m-Me-ArH), 6.95 (d, J = 8.0 Hz, 2H, o-Me-ArH), 5.02 (q, J = 5.3 Hz, 1H, CHCF$_3$), 4.03 – 3.94 (m, 2H, NCH$_2$H$_2$C=CHPh), 3.94 – 3.73 (m, 3H, PhCH$_2$H$_2$N and C=CCF$_2$Ph), 3.47 (d, J = 15.2 Hz, 1H, NCH$_2$H$_2$C=C), 2.28 (s, 3H, ArCH$_3$).

'C [1H] NMR (101 MHz, Chloroform-d) δ 148.0, 140.5, 137.2, 136.8, 136.2, 129.1, 128.74, 128.71, 128.6, 128.4, 128.3, 128.2, 127.9, 123.0 (q, J = 283.9 Hz), 111.4, 92.8 (q, J = 34.1 Hz), 60.4, 53.3, 37.2, 21.2.

'F NMR (376 MHz, Chloroform-d) δ -80.5 (d, 3F, J = 5.3 Hz).

IR (cm⁻¹) 2927 (m), 2851 (m), 1690 (m), 1504 (m), 1452 (m), 1293 (m), 1173 (s), 1154 (s), 1025 (m) (376 MHz, Chloroform).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C$_{32}$H$_{37}$F$_{2}$N$_{2}$O+ 424.1883; Found 424.1886.

(S,E)-3-Benzyl-5-(cyclopropyl(p-toly)methylene)-2-(trifluoromethyl)oxazolidine (19)
Prepared according to the general procedure D1 using N-benzyl-3-cyclopropylprop-2-yn-1-amine (74 mg, 0.40 mmol, 1.0 equiv.) and p-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 19 (80 mg, 0.22 mmol, 54% yield) as amorphous white solid. The enantiomeric excess was determined to be 78% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: t_{minor} = 5.0 min, t_{major} = 5.8 min. [\alpha]^{20}_D = 22.6 (c = 0.53, CHCl$_3$, 78% ee). Absolute configuration determined in comparison to compound (S)-4.

'H NMR (400 MHz, Chloroform-d) δ 7.33 – 7.24 (m, 5H, ArH), 7.07 (d, J = 7.9 Hz, 2H, ArH), 6.95 (d, J = 7.9 Hz, 2H, Me-ArH), 5.02 (q, J = 5.3 Hz, 1H, CHCF$_3$), 3.95 (d, J = 13.3 Hz, 1H, PhCH$_2$H$_2$N), 3.81 (d, J = 13.3 Hz, 1H, PhCH$_2$H$_2$O), 3.71 (d, J = 15.2 Hz, 1H, NCH$_2$H$_2$C=C), 3.21 (d, J = 15.2 Hz, 1H, NCH$_2$H$_2$C=C), 2.31 (s, 3H, ArCH$_3$), 2.01 – 1.88 (m, 1H, CH(CH$_2$)$_2$), 0.68 – 0.58 (m, 2H, CH(CH$_2$)$_2$), 0.37 – 0.18 (m, 2H, CH(CH$_2$)$_2$).

'C [1H] NMR (101 MHz, Chloroform-d) δ 147.6, 137.4, 136.5, 134.5, 129.7, 129.0, 128.69, 128.67, 127.8, 123.0 (q, J = 284.0 Hz), 112.7, 93.2 (q, J = 34.0 Hz), 60.4, 53.5, 21.3, 11.6, 4.8, 4.4.

'F NMR (376 MHz, Chloroform-d) δ -80.5 (d, 3F, J = 5.3 Hz).

IR (cm⁻¹) 3022 (w), 2946 (w), 2863 (w), 1665 (w), 1523 (w), 1425 (w), 1216 (m).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C$_{32}$H$_{37}$F$_{2}$N$_{2}$O+ 374.1726; Found 374.1725.

(S,E)-3-Benzyl-5-((4-methoxyphenyl)(phenyl)methylene)-2-(trifluoromethyl)oxazolidine (20)
Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 µL, 0.40 mmol, 1.0 equiv.) and 4-iodoanisole (122 mg, 0.520 mmol, 1.3 equiv), 2.5 mol% of Pd$_2$(dba)$_3$ • CHCl$_3$ (10.4 mg, 0.10 µmol) and 7 mol% of ligand (14.2 mg, 28.0 µmol) were used. The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:3) to give the corresponding olefin 20 (156 mg, 92% yield) as a white solid. The enantiomeric excess was determined to be 88% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: t_{minor} = 9.9 min, t_{major} = 14.7 min. Absolute configuration determined in comparison to compound (S)-4.

S25
[α]D20 = +63.5 (c = 0.48, CHCl3, 88% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.40 – 7.25 (m, 9H, ArH), 7.22 – 7.15 (m, 1H, ArH), 7.08 (d, J = 8.7 Hz, 2H, ArH), 6.86 (d, J = 8.7 Hz, 2H, ArH), 5.13 (q, J = 5.3 Hz, 1H, CHCF3), 4.00 (d, J = 13.3 Hz, 1H, PhCH2H6), 3.96 – 3.85 (m, 2H, PhCH2H6 and NCH2H6,C=C), 3.81 (s, 3H, OCH3), 3.52 (dd, J = 15.6, 1.5 Hz, 1H, NCH2H6,C=C).

13C[1H] NMR (101 MHz, Chloroform-d) δ 158.4, 148.4, 138.9, 137.1, 132.4, 131.3, 129.0, 128.77, 128.6, 128.0 (2C), 126.3, 122.9 (q, J = 284.0 Hz), 114.1, 112.5, 94.0 (q, J = 34.4 Hz), 60.5, 55.4, 54.9.

IR (cm−1) 3032 (w), 2943 (w), 2841 (w), 1665 (m), 1606 (m), 1502 (m), 1455 (m), 1351 (m), 1295 (m), 1223 (m), 1145 (m).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C25H26F3NO5 426.1675; Found 426.1678.

(S,E)-4-((3-Benzyl-2-(trifluoromethyl)oxazolidin-5-ylidene)(phenyl)methyl)-N,N-dimethylaniline (21)
Prepared according to the modified general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 μL, 0.40 mmol, 1.0 equiv.) and 4-iodo-N,N-dimethylaniline (128 μL, 0.520 mmol, 1.3 equiv). 2.5 mol% of Pd2(dba)3 • CHCl3 (10.4 μL, 0.10 mmol) and 7 mol% of ligand (14.2 μg, 0.280 μmol) were used. The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:5) to give the corresponding olefin 21 (132 mg, 0.301 mmol, 75% yield) as a pale yellow solid. The enantiomeric excess was determined to be 94% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: τminor = 9.9 min, τmajor = 14.6 min. Absolute configuration determined in comparison to compound (S)-4.

[q]D20 = +79.1 (c = 0.64, CHCl3, 94% ee)

1H NMR (400 MHz, Chloroform-d) δ 7.42 – 7.27 (m, 9H, ArH), 7.20 – 7.14 (m, 1H, ArH), 7.05 – 6.94 (m, 2H, ArH), 6.73 – 6.64 (m, 2H, ArH), 5.10 (q, J = 5.3 Hz, 1H, CHCF3), 4.03 – 3.92 (m, 2H, PhCH2H6 and NCH2H6,C=C), 3.89 (d, J = 13.4 Hz, 1H, PhCH2H6), 3.57 (dd, J = 15.7, 1.3 Hz, 1H, NCH2H6,C=C), 2.96 (s, 6H, N(CH2)2).

13C[1H] NMR (101 MHz, Chloroform-d) δ -80.3.

IR (cm−1) 3030 (w), 2943 (w), 2855 (w), 2809 (w), 1662 (w), 1611 (m), 1522 (m), 1455 (w), 1351 (m), 1295 (m), 1223 (m), 1151 (s).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C25H26F3N3O6 426.1675; Found 426.1678.

(S,E)-3-Benzyl-5-(phenyl(4-(trifluoromethyl)phenyl)methyl)oxazolidine (22)
Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 μL, 0.40 mmol, 1.0 equiv.) and 4-iodobenzotri fluoride (76 μL, 0.52 mmol, 1.3 equiv). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:3) to give the corresponding olefin 22 (168 mg, 0.363 mmol, 91% yield) as a colorless oil. The enantiomeric excess was determined to be 82% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: τminor = 10.7 min, τmajor = 12.1 min. Absolute configuration determined in comparison to compound (S)-4.

[q]D20 = +47.8 (c = 0.77, CHCl3, 82% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.58 (d, J = 8.1 Hz, 2H, ArH), 7.40 – 7.17 (m, 12H, ArH), 5.16 (q, J = 5.2 Hz, 1H, CHCF3), 4.01 (d, J = 13.3 Hz, 1H, PhCH2H6), 3.99 – 3.93 (m, 1H, NCH2H6,C=C), 3.91 (d, J = 13.3 Hz, 1H, PhCH2H6), 3.54 (dd, J = 15.8, 1.4 Hz, 1H, NCH2H6,C=C).

13C[1H] NMR (101 MHz, Chloroform-d) δ 149.4, 144.0, 138.0, 136.7, 130.4, 129.3 (q, J = 32.2 Hz), 129.2, 128.9, 128.8, 128.3, 128.2, 126.8, 125.7 (q, J = 3.8 Hz), 124.3 (q, J = 275.6 Hz) 122.73 (q, J = 283.9 Hz), 112.2, 94.1 (q, J = 34.5 Hz), 60.5, 54.8.

IR (cm−1) 3042 (w), 2929 (w), 1664 (m), 1610 (w), 1404 (w), 1328 (s), 1293 (m), 1158 (s), 1130 (s), 1073 (m).
(S,E)-3-Benzyl-5-((4-fluorophenyl)(phenyl)methylene)-2-(trifluoromethyl)oxazolidine (23)

Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 μl, 0.40 mmol, 1.0 equiv.) and 4-fluoriodobenzene (60 μL, 0.52 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:3) to give the corresponding olefin 23 (154 mg, 0.373 mmol, 93% yield) as a colorless oil. The enantiomeric excess was determined to be 84% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: t<sub>Minor</sub> = 10.0 min, t<sub>Major</sub> = 11.9 min. Absolute configuration determined in comparison to compound (S)-4.

[α]D<sup>20</sup> = +45.5 (c = 0.41, CHCl<sub>3</sub>, 84% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.41 – 7.25 (m, 9H, ArH), 7.24 – 7.17 (m, 1H, ArH), 7.16 – 7.10 (m, 2H, ArH), 7.02 (td, J = 8.3, 1.5 Hz, 2H, ArH), 5.18 – 5.12 (m, 1H, CHCF<sub>3</sub>), 4.00 (d, J = 13.4 Hz, 1H, PhCH=CH<sub>2</sub>), 3.95 – 3.85 (m, 2H, PhCH<sub>2</sub>H<sub>5</sub> and NCH<sub>2</sub>H<sub>5</sub>C=C), 3.49 (d, J = 15.4 Hz, 1H, NCH<sub>2</sub>H<sub>5</sub>C=C).

13C[1H] NMR (101 MHz, Chloroform-d) δ 162.0 (d, J = 246.3 Hz), 148.8, 138.4, 136.9, 136.0 (d, J = 3.4 Hz), 131.8 (d, J = 8.0 Hz), 128.9, 128.8, 128.76, 128.14, 126.12, 126.5, 122.8 (q, J = 283.9 Hz), 115.7 (d, J = 21.3 Hz), 112.0, 94.1 (q, J = 34.4 Hz), 60.5, 54.9.

19F NMR (376 MHz, Chloroform-d) δ -80.3 (d, J = 4.2 Hz), -115.2.

IR (cm<sup>-1</sup>) 3034 (w), 2929 (w), 2103 (w), 1665 (m), 1602 (m), 1503 (m), 1293 (m), 1226 (m), 1176 (s), 1153 (s).

HRMS (ESI/QTOF) m/z: [M + H]<sup>+</sup> Calculated for C<sub>22</sub>H<sub>20</sub>F<sub>2</sub>NO<sup>+</sup> 414.1476; Found 414.1476.

(S,E)-3-Benzyl-5-((4-chlorophenyl)(phenyl)methylene)-2-(trifluoromethyl)oxazolidine (24)

Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 μl, 0.40 mmol, 1.0 equiv.) and 1-chloro-4-iodybenzene (124 mg, 0.520 mmol, 1.3 equiv.) as a pale yellow oil. The enantiomeric excess was determined to be 81% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: t<sub>Minor</sub> = 10.4 min, t<sub>Major</sub> = 11.9 min. Absolute configuration determined in comparison to compound (S)-4.

[α]D<sup>20</sup> = +55.1 (c = 0.49, CHCl<sub>3</sub>, 81% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.39 – 7.26 (m, 11H, ArH), 7.23 – 7.17 (m, 1H, ArH), 7.09 (d, J = 8.4 Hz, 2H, ArH), 5.14 (q, J = 5.3 Hz, 1H, CHCF<sub>3</sub>), 4.00 (d, J = 13.3 Hz, 1H, PhCH=CH<sub>2</sub>), 3.96 – 3.85 (m, 2H, PhCH<sub>2</sub>H<sub>5</sub> and NCH<sub>2</sub>H<sub>5</sub>C=C), 3.51 (dd, J = 15.8, 1.5 Hz, 1H, NCH<sub>2</sub>H<sub>5</sub>C=C).

13C[1H] NMR (101 MHz, Chloroform-d) δ 148.9, 138.6, 138.2, 136.8, 133.0, 131.5, 129.03, 128.97, 128.84, 128.75, 128.18, 126.5, 122.8 (q, J = 283.8 Hz), 112.0, 94.1 (q, J = 34.5 Hz), 60.5, 54.8.

19F[1H] NMR (376 MHz, Chloroform-d) δ -80.3.

IR (cm<sup>-1</sup>) 3062 (w), 3032 (w), 2845 (w), 1664 (m), 1598 (w), 1494 (m), 1293 (m), 1176 (s), 1153 (s).

HRMS (ESI/QTOF) m/z: [M + H]<sup>+</sup> Calculated for C<sub>23</sub>H<sub>20</sub>ClF<sub>2</sub>NO<sup>+</sup> 430.1180; Found 430.1182.

(S,E)-4-((3-Benzyl-2-(trifluoromethyl)oxazolidin-5-ylidene)(phenyl)methyl)benzonitrile (25)

Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 μl, 0.40 mmol, 1.0 equiv.) and 4-iodobenzonitrile (119 mg, 0.520 mmol, 1.3 equiv.) as a white foam. The enantiomeric excess was determined to be 74% by HPLC analysis on a Daicel Chiralpak 1A column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: t<sub>Major</sub> = 6.8 min, t<sub>Minor</sub> = 7.5 min. Absolute configuration determined in comparison to compound (S)-4.

[α]D<sup>20</sup> = +50.3 (c = 0.52, CHCl<sub>3</sub>, 74% ee).
\[ \text{(S,E)-Methyl-4-((3-benzyl-2-((trifluoromethyl)oxazolidin-5-}
\text{yldiene)(phenyl)methyl)benzene (26)} \]

Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 \( \mu \)L, 0.40 mmol, 1.0 equiv.) and methyl 4-iodobenzoate (136 mg, 0.52 mmol, 1.3 equiv). The crude material was purified by flash column chromatography (pentane/ EtOAc gradient 100:0 to 100:10) to give the corresponding olefin 26 (175 mg, 0.386 mmol, 95% yield) as a white foam. The enantiomeric excess was determined to be 82% ee.

\[ \text{[a]D}^20 = +49.8 (c = 0.76, \text{CHCl}_3, 82\% \text{ ee).} \]

\[ \text{[a]D}^20 = +46.3 (c = 0.45, \text{CHCl}_3, 80\% \text{ ee).} \]

\[ \text{[a]D}^20 = +49.8 (c = 0.76, \text{CHCl}_3, 82\% \text{ ee).} \]

\[ \text{[a]D}^20 = +46.3 (c = 0.45, \text{CHCl}_3, 80\% \text{ ee).} \]

\[ \text{[a]D}^20 = +49.8 (c = 0.76, \text{CHCl}_3, 82\% \text{ ee).} \]

\[ \text{[a]D}^20 = +46.3 (c = 0.45, \text{CHCl}_3, 80\% \text{ ee).} \]
1.3 equiv). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:3) to give the corresponding olefin 28 (158 mg, 0.382 mmol, 96% yield) as a colorless oil. The enantiomeric excess was determined to be 82% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: τ_{Minor} = 8.5 min, τ_{Major} = 10.5 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D^{20} = +47.3 (c = 0.69, CHCl₃, 82% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.41 – 7.26 (m, 10H, ArH), 7.24 – 7.17 (m, 1H, ArH), 7.02 – 6.91 (m, 2H, ArH), 6.86 (ddd, J = 9.8, 2.5, 1.6 Hz, 1H, ArH), 5.15 (q, J = 5.2 Hz, 1H, CHCF₃), 4.00 (d, J = 13.3 Hz, 1H, PhCH₂H₂), 3.95 (d, J = 16.0 Hz, 1H, NCH₂H₂C=C(C)), 3.90 (d, J = 13.3 Hz, 1H, PhCH₂H₂), 3.55 (dt, J = 16.0, 1.4 Hz, 1H, NCH₂H₂C=C(C).

13C[^1]H NMR (101 MHz, Chloroform-d) δ 163.0 (d, J = 246.6 Hz), 149.1, 142.4 (d, J = 7.8 Hz), 138.1, 136.8, 130.2 (d, J = 8.5 Hz), 129.0, 128.83, 128.78, 128.19, 126.7, 125.87 (d, J = 2.9 Hz), 122.8 (q, J = 283.8 Hz), 117.1 (d, J = 21.0 Hz), 114.1 (d, J = 21.0 Hz), 112.2 (d, J = 2.0 Hz), 94.1 (q, J = 34.4 Hz), 60.5, 54.8.

IR (cm⁻¹) 3064 (w), 3031 (w), 1668 (m), 1491 (m), 1451 (m), 1294 (m), 1179 (s), 1155 (s).

HRMS (ESI/QTOF) m/z: [M + H]^+ Calculated for C₂₃H₂₉F₃NO+ 414.1476; Found 414.1480.

(S,E)-3-Benzyl-5-((2-fluorophenyl)(phenyl)methylene)-2-(trifluoromethyl)oxazolidine (29)

Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 μL, 0.40 mmol, 1.0 equiv.) and 2-iodoanisole (61 μL, 0.52 mmol, 1.3 equiv). The reaction was conducted at 60 °C using 1,2-dichloroethane as the solvent. The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:3) to give the corresponding olefin 29 which was further purified using a chiral preparative HPLC (103 mg, 0.249 mmol, 62% yield) as a colorless oil (Chiral prep method: Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: τ = 1.3 min). The enantiomeric excess was determined to be 74% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: τ_{Minor} = 7.3 min, τ_{Major} = 8.5 min. The e.e. was no affected by the preparative chiral HPLC purification. Absolute configuration determined in comparison to compound (S)-4.

[a]D^{20} = +60.9 (c = 0.32, CHCl₃, 74% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.43 – 7.26 (m, 10H, ArH), 7.21 – 7.06 (m, 4H, ArH), 5.19 (q, J = 5.4 Hz, 1H, CHCF₃), 3.98 (d, J = 13.2 Hz, 1H, PhCH₂H₂), 3.90 (d, J = 13.3 Hz, 1H, PhCH₂H₂), 3.85 (d, J = 16.1 Hz, 1H, NCH₂H₂C=C(C), 3.43 (dd, J = 16.0, 1.4 Hz, 1H, NCH₂H₂C=C(C).

13C[^1]H NMR (101 MHz, Chloroform-d) δ 165.0 (d, J = 246.1 Hz), 149.8, 137.7, 137.0, 132.9 (d, J = 3.2 Hz), 129.5 (d, J = 8.0 Hz), 128.9, 128.8, 128.4, 128.2, 128.1, 127.1 (d, J = 16.4 Hz), 126.5, 124.6 (d, J = 3.6 Hz), 122.74 (q, J = 283.8 Hz), 116.2 (d, J = 22.5 Hz), 106.0, 94.8 (q, J = 34.5 Hz), 60.7, 55.1.

IR (cm⁻¹) 3064 (w), 3031 (w), 1668 (m), 1491 (m), 1451 (m), 1294 (m), 1179 (s), 1155 (s).

HRMS (ESI/QTOF) m/z: [M + H]^+ Calculated for C₂₃H₂₉F₃NO+ 414.1476; Found 414.1482.

(S,E)-3-Benzyl-5-((3,5-dimethylphenyl)(phenyl)methylene)-2-(trifluoromethyl)oxazolidine (30)

Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 μL, 0.40 mmol, 1.0 equiv.) and 1-iodo-3,5-dimethylbenzene (121 mg, 0.520 mmol, 1.3 equiv). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:3) to give the corresponding olefin 30 (162 mg, 0.383 mmol, 96% yield) as a colorless oil. The enantiomeric excess was determined to be 92% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: τ_{Minor} = 5.0 min, τ_{Major} = 6.2 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D^{20} = +53.5 (c = 0.57, CHCl₃, 92% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.42 – 7.26 (m, 9H, ArH), 7.22 – 7.14 (m, 1H, ArH), 6.90 (s, 1H, ArH), 6.78 (d, J = 1.6 Hz, 2H, ArH), 5.13 (q, J = 5.3 Hz, 1H, CHCF₃), 3.99 (d, J = 13.3 Hz, 1H, PhCH₂H₂),
3.95 – 3.86 (m, 2H, PhCH$_2$H$_2$ and NCH$_2$H$_2$C=C), 3.53 (dd, $J = 15.9, 1.5$ Hz, 1H, NCH$_2$H$_2$C=C), 2.28 (s, 6H, 2 × ArCH$_3$).

$^{13}$C($^1$H) NMR (101 MHz, Chloroform-$_d$) $\delta$ 148.4, 140.0, 138.8, 138.1, 137.1, 129.03, 128.83, 128.75 (2C), 128.03 (2C), 127.97, 126.3, 122.8 (q, $J = 283.9$ Hz), 113.1, 94.2 (q, $J = 34.2$ Hz), 60.6, 54.8, 21.4.

$^{19}$F($^1$H) NMR (376 MHz, Chloroform-$_d$) $\delta$ -80.3.

IR (cm$^{-1}$) 3082 (w), 2925 (w), 2862 (w), 1665 (m), 1600 (w), 1491 (w), 1453 (w), 1294 (m), 1174 (s), 1152 (s).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{25}$H$_{30}$F$_3$NO$^+$ 424.1883; Found 424.1885.

(31)

(S,E)-3-Benzyl-5-(phenyl(pyridin-3-yl)methylene)-2-(trifluoromethyl)oxazolidine

Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 $\mu$L, 0.40 mmol, 1.0 equiv.) and 3-iodopyridine (107 mg, 0.520 mmol, 1.3 equiv). The reaction was conducted at 60 $^\circ$C using 1,2-dichloroethane as the solvent. The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 50:50) to give the corresponding olefin 31 (122 mg, 0.308 mmol, 77% yield) as an orange solid. The enantiomeric excess was determined to be 80% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 90:10 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm: $\tau_{\text{minor}} = 10.6$ min, $\tau_{\text{major}} = 19.8$ min. Absolute configuration determined in comparison to compound (S)-4.

$^{[\alpha]}D^{20} = +47.3$ (c = 0.55, CHCl$_3$, 80% ee).

$^1$H NMR (400 MHz, Chloroform-$_d$) $\delta$ 8.49 (m, 2H, ArH), 7.45 (dt, $J = 7.9, 1.9$ Hz, 1H, ArH), 7.39 – 7.12 (m, 11H, ArH), 5.17 (q, $J = 5.2$ Hz, 1H, CHCF$_3$), 4.01 (d, $J = 13.3$ Hz, 1H, PhCH$_2$H$_2$), 3.97 – 3.85 (m, 2H, PhCH$_2$H$_2$ and NCH$_2$H$_2$C=C), 3.55 (dd, $J = 15.7, 1.4$ Hz, 1H, NCH$_2$H$_2$C=C).

$^{13}$C($^1$H) NMR (101 MHz, Chloroform-$_d$) $\delta$ 150.8, 149.7, 148.4, 137.8, 137.7, 136.7, 136.0, 129.1, 128.9, 128.8, 128.3, 128.2, 126.8, 123.7, 122.7 (q, $J = 283.8$ Hz), 109.8, 94.2 (q, $J = 34.5$ Hz), 60.5, 54.8.

$^{19}$F($^1$H) NMR (376 MHz, Chloroform-$_d$) $\delta$ -80.3.

IR (cm$^{-1}$) 3345 (w), 3033 (w), 2970 (w), 1663 (m), 1488 (w), 1451 (w), 1409 (w), 1292 (m), 1173 (s), 1152 (s).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{25}$H$_{30}$F$_3$NO$^+$ 397.1522; Found 397.1524.

(32)

(S,E)-3-Benzyl-5-(phenyl(thiophen-2-yl)methylene)-2-(trifluoromethyl)oxazolidine

Prepared according to the general procedure D1 using N-benzyl-3-phenylprop-2-yn-1-amine (76 $\mu$L, 0.40 mmol, 1.0 equiv.) and 2-iodothiophene (57 $\mu$L, 0.520 mmol, 1.3 equiv). The reaction was conducted at 60 $^\circ$C using DCE as the solvent. The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:3) to give the corresponding olefin 32 (154 mg, 0.384 mmol, 96% yield) as a brown solid. The enantiomeric excess was determined to be 87% by HPLC analysis on a Daicel IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm: $\tau_{\text{minor}} = 9.1$ min, $\tau_{\text{major}} = 10.2$ min.). Absolute configuration determined in comparison to compound (S)-4.

$^{[\alpha]}D^{20} = +46.9$ (c = 0.65, CHCl$_3$, 87% ee).

$^1$H NMR (400 MHz, Chloroform-$_d$) $\delta$ 7.44 – 7.29 (m, 9H, ArH), 7.28 – 7.23 (m, 2H, ArH), 6.97 (dd, $J = 5.2, 3.5$ Hz, 1H, ArH), 6.76 (dd, $J = 3.6, 1.2$ Hz, 1H, ArH), 5.11 (q, $J = 5.3$ Hz, 1H, CHCF$_3$), 4.12 (dd, $J = 16.1, 1.0$ Hz, 1H, NCH$_2$H$_2$C=C), 4.01 (d, $J = 13.3$ Hz, 1H, PhCH$_2$H$_2$), 3.94 (d, $J = 13.3$ Hz, 1H, PhCH$_2$H$_2$), 3.80 (dd, $J = 16.1, 1.4$ Hz, 1H, NCH$_2$H$_2$C=C).

$^{13}$C($^1$H) NMR (101 MHz, Chloroform-$_d$) $\delta$ 149.8, 142.3, 138.3, 136.9, 129.1, 128.8, 128.2 (2C), 128.1, 127.1, 126.98, 126.91, 125.1, 122.7 (q, $J = 283.6$ Hz), 107.1, 94.1 (q, $J = 34.5$ Hz), 60.7, 55.2.

$^{19}$F($^1$H) NMR (376 MHz, Chloroform-$_d$) $\delta$ -80.4.

IR (cm$^{-1}$) 3064 (w), 3031 (w), 2935 (w), 2848 (w), 1658 (m), 1493 (w), 1449 (w), 1293 (m), 1226 (m), 1175 (s), 1150 (s).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{25}$H$_{30}$F$_3$NO$^+$ 402.1134; Found 402.1134.
(S,E)-3-Methyl-5-(phenyl(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine (33)
Prepared according to the general procedure D1 using N-methyl-3-phenylprop-2-yn-1-amine (58 mg, 0.40 mmol, 1.0 equiv.) and p-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 33 (74 mg, 0.22 mmol, 55% yield) as colorless oil. The enantiomeric excess was determined to be 92% by HPLC analysis on a Daicel Chiralpak IA column: 99.75:0.25 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: τminor = 5.1 min, τmajor = 5.4 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D²⁰ = 30.0 (c = 0.50, CHCl₃, 92% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.41 – 7.34 (m, 2H, ArH), 7.32 – 7.26 (m, 2H, ArH), 7.21 – 7.12 (m, 3H, ArH), 7.09 – 7.01 (q, J = 5.0 Hz, 1H, CHCF₃), 6.94 (d, J = 15.1 Hz, 1H, NCH₂H,C=), 3.43 (d, J = 15.1 Hz, 1H, NCH₂H,C=), 2.60 (s, 3H, Ar(CH₃)).

13C [¹H] NMR (101 MHz, Chloroform-d) δ 148.2, 138.6, 137.2, 136.8, 130.0, 129.4, 129.1, 128.1, 126.4, 122.8 (q, J = 283.4 Hz), 113.0, 95.7 (q, J = 34.2 Hz), 56.8, 43.4, 21.3.

19F NMR (376 MHz, Chloroform-d) δ -80.8 (d, J = 4.8 Hz).

IR (cm⁻¹) 2910 (w), 1660 (m), 1605 (m), 1451 (m), 1401 (m), 1284 (s), 1155 (s), 1064 (s).

HRMS (APCI/QTOF) m/z: [M + H]+ Calculated for C₁₉H₁₅F₃NO+ 334.1413; Found 334.1410.

(3S,5R)-3-Phenyl-5-(phenyl(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine (34)
Prepared according to the general procedure D1 using N-(3-phenylprop-2-yn-1-yl)aniline (83 mg, 0.40 mmol, 1.0 equiv.) and p-iodotoluene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding olefin 34 (91 mg, 0.23 mmol, 58% yield) as amorphous white solid. The enantiomeric excess was determined to be 54% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: τminor = 6.2 min, τmajor = 11.6 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D²⁰ = 68.0 (c = 0.69, CHCl₃, 54% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.42 – 7.36 (m, 2H, ArH), 7.34 – 7.27 (m, 4H, ArH), 7.25 – 7.17 (m, 3H, ArH), 7.17 – 7.10 (m, 2H, ArH), 6.97 – 6.89 (m, 1H, ArH), 6.79 – 6.67 (m, 2H, ArH), 5.90 (q, J = 4.1 Hz, 1H, CHCF₃), 4.35 (d, J = 14.0 Hz, 1H, NCH₂H,C=), 4.21 (d, J = 14.0 Hz, 1H, NCH₂H,C=), 2.41 (s, 3H, Ar(CH₃)).

13C [¹H] NMR (101 MHz, Chloroform-d) δ 147.1, 144.6, 138.2, 137.2, 136.6, 123.0, 129.64, 129.62, 129.1, 128.2, 126.7, 123.3 (q, J = 287.4 Hz), 120.4, 114.0, 113.7, 88.2 (q, J = 35.4 Hz), 50.2, 21.4.

19F NMR (376 MHz, Chloroform-d) δ -80.5 (d, J = 4.1 Hz).

IR (cm⁻¹) 3051 (m), 2926 (w), 1674 (m), 1602 (m), 1503 (s), 1358 (m), 1317 (m), 1183 (s), 1155 (s), 1077 (m).

HRMS (APCI/QTOF) m/z: [M + H]+ Calculated for C₂₄H₂₃F₃NO⁺ 396.1570; Found 396.1562.

(S,E)-3-(4-Methoxybenzyl)-5-(phenyl(p-tolyl)methylene)-2-(trifluoromethyl)oxazolidine (35)
Prepared according to the general procedure D1 using N-(4-methoxybenzyl)-3-phenylprop-2-yn-1-amine (101 mg, 0.400 mmol, 1.0 equiv.) and 1-iodo-4-methylbenzene (113 mg, 0.520 mmol, 1.3 equiv.). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 100:3) to give the corresponding olefin 35 (92 mg, 0.21 mmol, 52% yield) as a colorless oil. The enantiomeric excess was determined to be 89% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: τminor = 9.4 min, τmajor = 13.1 min. Absolute configuration determined in comparison to compound (S)-4.

[a]D²⁰ = +55.0 (c = 0.60, CHCl₃, 89% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.40 – 7.34 (m, 2H, ArH), 7.32 – 7.22 (m, 4H, ArH), 7.21 – 7.09 (m, 3H), 7.07 – 7.00 (m, 2H, ArH), 6.90 – 6.83 (m, 2H, ArH), 5.11 (q, J = 5.4 Hz, 1H, CHCF₃), 3.94 – 3.81 (m, 3H, ArCH₂) and NCH₂H,C=), 3.80 (s, 3H, OCH₃), 3.53 (d, d, J = 15.9, 1.4 Hz, 1H, NCH₂H,C=), 2.35 (s, 3H, ArCH₃).
\(^{13}\text{C}[^1\text{H}]\text{ NMR}\) (101 MHz, Chloroform-\(d\)) \(\delta\) 159.4, 148.5, 138.8, 137.2, 136.7, 130.09, 130.05, 129.4, 129.06, 129.04, 128.0, 126.3, 122.9 (q, \(J = 284.1\) Hz), 114.12, 112.8, 93.8 (q, \(J = 34.2\) Hz), 59.9, 55.4, 54.8, 21.3.

\(^{19}\text{F}[^1\text{H}]\text{ NMR}\) (376 MHz, Chloroform-\(d\)) \(\delta\) -80.3.

\(\text{IR}\) (cm\(^{-1}\)) 3024 (w), 2931 (w), 2844 (w), 1665 (m), 1609 (m), 1514 (m), 1454 (m), 1295 (m), 1250 (s), 1175 (s), 1153 (s).

\(\text{HRMS}\) (ESI/QTOF) \(m/z\): [M + H]\(^+\) Calulated for \(\text{C}_{26}\text{H}_{25}\text{F}_3\text{NO}_2\)\(^+\) 440.1832; Found 440.1842.
D.3. General Procedure for the Asymmetric Hydrogenation of the Tetrasubstituted Olefins.

An oven-dried 25 mL round-bottom flask equipped with a Teflon coated stirring bar was charged with Pd(OH)$_2$/C (10 mol%, 14 mg). The flask was sealed and evacuated and back-filled with N$_2$ three times. MeOH (2.7 mL) and AcOH (1.3 mL) were added and the suspension was stirred at room temperature for 10 minutes under a nitrogen flow. Then, a hydrogen balloon was connected to the flask through a needle and the mixture was vigorously stirred at room temperature for 16 hours. Then, the reaction mixture was degassed by bubbling nitrogen for 10 minutes and filtered through a plug of celite eluting with 10 mL of MeOH. The crude extract was washed with saturated NaHCO$_3$ and extracted with DCM (3 x 25 mL). The combined organic layer was dried over sodium sulfate, filtered and concentrated in vacuo. The crude material was purified by flash column chromatography on silica gel to afford the corresponding product as a single diastereoisomer.

D.4. Characterization of Hydrogenated Products

(2S,5R)-5-(S)-Phenyl(p-tolyl)methyl)-2-(trifluoromethyl)oxazolidine ((R,R)-5)
Prepared according to the general procedure D5 using (S)-4 (82 mg, 0.20 mmol, 1.0 equiv., 94% ee) and Pd(OH)$_2$/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product (R,R)-5 (51 mg, 0.16 mmol, 79% yield) as a pale yellow solid (m.p. 72 °C). The enantiomeric excess was determined to be 94% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm; τ$_{major}$ = 8.2 min, τ$_{minor}$ = 12.5 min. Absolute and relative configuration were determined by X-Ray diffraction analysis of a single crystal of (R,R)-5 (Details in section F)

$\{\lambda\}[D]^{20}$ = +6.9 (c = 0.36, CHCl$_3$, 94% ee).

$^1$H NMR (400 MHz, Chloroform-d) δ 7.34 – 7.18 (m, 7H, ArH), 7.12 (d, J = 7.9 Hz, 2H, ArH), 4.97 (dq, J = 8.2, 5.6 Hz, 1H, CH$_2$F$_2$), 4.62 (td, J = 9.4, 5.5 Hz, 1H, OCH$_3$), 3.97 (d, J = 9.5 Hz, 1H, Ar$^1$Ar$^2$CH), 3.15 (dt, J = 12.3, 6.2 Hz, 1H, NCH$_2$H$_2$), 2.80 (q, J = 11.0 Hz, 1H, NCH$_2$H$_2$), 2.72 – 2.58 (br. s., 1H, NH$_2$), 2.31 (s, 3H, CH$_3$).

$^{13}$C$[^1]$H NMR (101 MHz, Chloroform-d) δ 141.5, 139.2, 136.3, 129.3, 128.9, 128.3, 128.2, 127.1, 123.4 (q, J = 282.9 Hz), 88.4 (q, J = 33.9 Hz), 82.2, 55.3, 50.7, 21.2.

$^{19}$F$[^1]$H NMR (376 MHz, Chloroform-d) δ -81.0.

IR (cm$^{-1}$) 3351 (w), 3024 (w), 2925 (m), 2861 (w), 1524 (w), 1454 (w), 1290 (m), 1166 (s), 1150 (s).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{19}$H$_{28}$F$_3$NO$^+$ 322.1413; Found 322.1413.

1.2 mmol scale reduction. The model reduction was repeated on 1.2 mmol scale. An oven dried 50 mL round-bottom flask equipped with a Teflon stir bar was charged with Pd(OH)$_2$/C (10 mol%, 86 mg, 0.12 mmol) and olefin (S)-4 (500 mg, 1.22 mmol, 1.0 equiv.). MeOH (16 mL) and AcOH (8 mL) were added and the suspension was stirred at 22 °C for 20 minutes under a nitrogen flow. Then, a hydrogen balloon was connected to the flask through a needle and the mixture was vigorously stirred at 22 °C for 16 hours. Then, the reaction mixture was degassed by bubbling nitrogen for 10 minutes and filtered through a plug of celite eluting with 20 mL of MeOH. The crude extract was washed with saturated NaHCO$_3$ and extracted with DCM (3x50 mL). The combined organic layer was dried over sodium sulfate, filtered and concentrated in vacuo. The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product (R,R)-5 (284 mg, 0.884 mmol, 72% yield) as a colorless oil, which solidified upon vigorous scratching with a spatula. The enantiomeric excess was determined to be 94% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm: τ$_{major}$ = 8.2 min, τ$_{minor}$ = 12.6 min.
Prepared according to the general procedure D5 using (R)-4 (82 mg, 0.20 mmol, 1.0 equiv., 92% ee) and Pd(OH)$_2$/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product (S,S)-5 (51 mg, 0.16 mmol, 79% yield) as a pale yellow solid. The enantiomeric excess was determined to be 92% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm: $\tau_{\text{minor}} = 7.8$ min, $\tau_{\text{major}} = 11.6$ min. [a]D$^{20}$ = -2.0 (c = 0.50, CHCl$_3$, 92% ee). Absolute configuration was determined in comparison to compound (R,R)-5.

Prepared according to the general procedure D5 using (S)-6 (82 mg, 0.20 mmol, 1.0 equiv., 89% ee) and Pd(OH)$_2$/C (20 mol%, 28 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product (R,S)-36 (52 mg, 0.16 mmol, 82% yield) as colorless oil. The enantiomeric excess was determined to be 89% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm: $\tau_{\text{minor}} = 10.9$ min. [a]D$^{20}$ = 2.7 (c = 0.50, CHCl$_3$, 89% ee). Absolute configuration was determined in comparison to compound (R,R)-5.

Prepared according to the general procedure D3 using (R)-6 (82 mg, 0.20 mmol, 1 equiv., 92% ee) and Pd(OH)$_2$/C (20 mol%, 28 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product (S,R)-36 (50 mg, 0.16 mmol, 78% yield) as colorless oil. The enantiomeric excess was determined to be 89% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm: $\tau_{\text{minor}} = 7.7$ min, $\tau_{\text{major}} = 10.9$ min. [a]D$^{20}$ = 2.7 (c = 0.50, CHCl$_3$, 89% ee). Absolute configuration was determined in comparison to compound (R,R)-5.

Prepared according to the general procedure D5 using 7 (88 mg, 0.20 mmol, 1 equiv., 92% ee) and Pd(OH)$_2$/C (20 mol%, 28 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product 37 (60 mg, 0.17 mmol, 85% yield) as colorless oil The enantiomeric excess was determined to be 92% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm: $\tau_{\text{minor}} = 15.7$ min. Absolute configuration was determined in comparison to compound (R,R)-5.

[a]D$^{20}$ = -0.8 (c = 0.44, CHCl$_3$, 92% ee).

H NMR (400 MHz, Chloroform-d) b 7.21 (d, J = 8.1 Hz, 2H, ArH), 7.17 – 7.12 (m, 2H, ArH), 7.11 (d, J = 8.0 Hz, 2H, ArH), 6.87 – 6.78 (m, 2H, ArH), 4.97 (q, J = 5.6 Hz, 1H, CHF), 4.56 (dt, J = 9.6, 5.2 Hz, 1H, OCH), 3.91 (d, J = 9.6 Hz, 1H, Ar=CH$_2$), 3.77 (s, 3H, OCH$_3$), 3.15 (dd, J = 11.6, 5.2 Hz, 1H, NCH$_2$H$_3$), 2.81 (dd, 1H, J = 11.6, 9.6, NCH$_3$H$_3$), 2.67 (br. s, 1H, NH), 2.50 (s, 3H, ArCH$_3$).

[a]D$^{19}$H NMR (101 MHz, Chloroform-d) b 158.6, 139.5, 136.2, 133.7, 129.28, 129.25, 128.1, 123.5 (q, J = 282.9 Hz), 114.3, 88.4 (q, J = 33.9 Hz), 82.4, 55.4, 54.4, 50.8, 21.2.
$^{19}$F NMR (376 MHz, Chloroform-d) $\delta$ -81.1 (d, 3F, $J = 5.6$ Hz).

IR (cm$^{-1}$) 3349 (m), 3010 (m), 2926 (m), 2839 (w), 1612 (m), 1513 (s), 1456 (m), 1293 (m), 1254 (s), 1171 (s), 1150 (s), 1083 (m).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{19}$H$_{13}$F$_{3}$NO$_2$ 352.1519; Found 352.1515.

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((2S,5R)-5-((S)-p-Tolyl(4-(trifluoromethyl)phenyl)methyl)-2-(trifluoromethyl)oxazolidine (38)
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Prepared according to the general procedure D5 using 8 (95 mg, 0.20 mmol, 1.0 equiv., 88% ee) and Pd(OH)$_2$/C (20 mol%, 28 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product 38 (59 mg, 0.15 mmol 76% yield) as colorless oil. The enantiomeric excess was determined to be 88% by HPLC analysis on a Daicel Chiralpak IA column: 95.5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm: $\tau_{major} = 9.3$ min, $\tau_{minor} = 11.8$ min. Absolute configuration was determined in comparison to compound (R,R)-5.

[a]D$^{20}$ = 0.9 ($c = 0.88$, CHCl$_3$, 88% ee).

$^1$H NMR (400 MHz, Chloroform-d) $\delta$ 7.55 (d, $J = 8.1$ Hz, 2H, ArH), 7.37 (d, $J = 8.1$ Hz, 2H, ArH), 7.19 (d, $J = 8.0$ Hz, 2H, ArH), 7.13 (d, $J = 8.0$ Hz, 2H, ArH), 4.98 (q, $J = 5.3$ Hz, 1H, CHF$_2$), 4.62 (ddd, $J = 11.5$, 9.1, 5.6 Hz, 1H, OCH$_2$), 4.04 (d, $J = 9.1$ Hz, 1H, Ar$^1$Ar$^2$CH), 3.17 (ddd, $J = 11.5$, 5.6 Hz, 1H, NCH$_2$H$_2$), 2.78 (t, $J = 11.5$ Hz, 1H, NCH$_2$H$_2$), 2.68 (br. s, 1H, NH), 2.31 (s, 3H, CH$_3$).

$^{13}$C$^{(1)}$H NMR (101 MHz, Chloroform-d) $\delta$ 145.6, 138.0, 136.8, 129.5, 129.4 (q, $J = 32.5$ Hz) 128.7, 128.3, 125.9 (q, $J = 3.7$ Hz), 124.2 (q, $J = 271.9$ Hz), 123.3 (q, $J = 282.8$ Hz), 88.4 (q, $J = 34.0$ Hz), 81.6, 55.0, 50.5, 21.2.

$^{19}$F NMR (376 MHz, Chloroform-d) $\delta$ -62.6 (s, 3F, ArF$_3$), -81.0 (d, 3F, $J = 5.3$ Hz, CHF$_3$).

IR (cm$^{-1}$) 3351 (w), 3017 (w), 2932 (w), 1620 (w), 1516 (w), 1421 (w), 1328 (s), 1165 (s), 1125 (s), 1074 (m).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{19}$H$_{13}$F$_{3}$NO$^+$ 390.1287; Found 390.1298.

(2S,5R)-5-((S)-(4-Fluorophenyl)(p-tolyl)methyl)-2-(trifluoromethyl)oxazolidine (39)

Prepared according to the general procedure D5 using 9 (85 mg, 0.20 mmol, 1.0 equiv., 91% ee) and Pd/C (20 mol%, 85 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product 39 (52 mg, 0.16 mmol, 83% yield) as colorless oil. The enantiomeric excess was determined to be 91% by HPLC analysis on a Daicel Chiralpak IA column: 95.5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm: $\tau_{major} = 9.7$ min, $\tau_{minor} = 12.8$ min. Absolute configuration was determined in comparison to compound (R,R)-5.

[a]D$^{20}$ = 1.5 ($c = 0.92$, CHCl$_3$, 91% ee).

$^1$H NMR (400 MHz, Chloroform-d) $\delta$ 7.24 – 7.15 (m, 4H, ArH), 7.15 – 7.08 (m, 2H, ArH), 7.02 – 6.94 (m, 2H, ArH), 4.97 (q, $J = 5.5$ Hz, 1H, CHF$_2$), 4.57 (td, $J = 9.3$, 5.5 Hz, 1H, OCH$_2$), 3.96 (d, $J = 9.3$ Hz, 1H, Ar$^1$Ar$^2$CH), 3.15 (ddd, $J = 12.3$, 5.5, 1.5 Hz, 1H, NCH$_2$H$_2$), 2.78 (ddd, $J = 12.3$, 9.3, 1.5 Hz, 1H, NCH$_2$H$_2$), 2.30 (s, 3H, ArCH$_3$).

$^{13}$C$^{(1)}$H NMR (101 MHz, Chloroform-d) $\delta$ 161.9 (d, $J = 245.8$ Hz), 138.9, 137.4 (d, $J = 3.5$ Hz), 136.5, 129.8 (d, $J = 7.8$ Hz), 129.4, 128.2, 123.4 (q, $J = 282.8$ Hz), 115.8 (d, $J = 21.2$ Hz), 88.4 (q, $J = 33.8$ Hz), 82.1, 54.4, 50.6, 21.2.

$^{19}$F NMR (376 MHz, Chloroform-d) $\delta$ -180.0 (d, 3F, $J = 5.5$ Hz, CHF$_3$), -115.7 (tt, 1F, $J = 8.3$, 5.4 Hz, ArF).

IR (cm$^{-1}$) 3350 (w), 3016 (w), 2925 (w), 1611 (w), 1512 (m), 1329 (m), 1291 (m), 1226 (m), 1168 (s), 1137 (s).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{18}$H$_{12}$F$_2$NO$^+$ 336.1570; Found 336.1576.

(2S,5R)-5-((S)-(2-Fluorophenyl)(p-tolyl)methyl)-2-(trifluoromethyl)oxazolidine (40)

Prepared according to the general procedure D5 using 13 (85 mg, 0.20 mmol, 1.0 equiv., 80% ee) and Pd/C (20 mol%, 85 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product 40 (44 mg, 0.13 mmol, 65% yield) as colorless oil. The enantiomeric excess was determined to be 80% by HPLC analysis on a Daicel Chiralpak IA column: 95.5 hexane/IPA, flow rate 1
mL/min, λ = 230 nm: τ_{Major} = 9.0 min, τ_{Minor} = 13.8 min. Absolute configuration was determined in comparison to compound (R,R)-5.

[a]D^{20} = 8.1 (c = 0.74, CHCl₃, 80% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.29 (td, J = 7.5, 1.8 Hz, 1H, ArH), 7.27 – 7.16 (m, 3H, ArH), 7.15 – 7.05 (m, 3H, ArH), 7.02 (dd, J = 10.5, 8.2, 1.3 Hz, 1H, ArH), 4.98 (q, J = 5.6 Hz, 1H, CHCF₃), 4.68 (dd, J = 9.2, 6.8, 5.9, 3.1 Hz, 1H, OCH₂), 4.28 (d, J = 9.4 Hz, 1H, Ar¹Ar²CH₂), 3.22 (dd, J = 12.2, 5.1 Hz, 1H, NCH₂H₃), 2.80 (dd, J = 12.2, 9.3 Hz, 1H, NCH₂H₃), 2.30 (s, 3H, Ar¹CH₃).

13C{[1H]} NMR (101 MHz, Chloroform-d) δ 160.5 (d, J = 245.9 Hz), 138.1, 136.6, 129.8 (d, J = 4.5 Hz), 129.3, 128.7 (d, J = 8.4 Hz), 128.7 (d, J = 15.0 Hz), 128.3, 124.54 (d, J = 3.5 Hz), 123.4 (d, J = 283.0 Hz), 116.1 (d, J = 23.0 Hz), 88.5 (q, J = 34.1 Hz), 81.7 (d, J = 2.8 Hz), 50.4, 48.7, 21.2.

19F NMR (376 MHz, Chloroform-d) δ −81.0 (d, 3F, J = 5.6 Hz, CHCF₃), −115.9 (dt, 1F, J = 12.1, 6.5 Hz, ArF).

IR (cm⁻¹) 3356 (w), 3039 (w), 2929 (w), 1496 (m), 1454 (m), 1290 (m), 1225 (m), 1169 (s).

HRMS (ESI/QTOF) m/z: [M + H]^+ Calculated for C₁₃H₁₂F₃NO^+ 340.1319; Found 340.1318.

(2S,5R)-5-((S)-(3,5-Dimethylphenyl)(p-toly)methyl)-2-(trifluoromethyl)oxazolidine (41)

Prepared according to the general procedure D5 using 14 (87 mg, 0.20 mmol, 1.0 equiv., 91% ee) and Pd(OH)₃/C (20 mol%, 28 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product 41 (41 mg, 0.12 mmol, 59% yield) as colorless oil. The enantiomeric excess was determined to be 91% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 230 nm: τ_{Major} = 5.8 min, τ_{Minor} = 8.9 min. Absolute configuration was determined in comparison to compound (R,R)-5.

[a]D^{20} = 5.9 (c = 0.62, CHCl₃, 91% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.22 (d, J = 8.0 Hz, 2H, ArH), 7.11 (d, J = 8.0 Hz, 2H, ArH), 6.84 (s, 1H, ArH), 6.84 (s, 2H, ArH), 4.98 (q, J = 5.6 Hz, 1H, CHCF₃), 4.62 (td, J = 9.7, 5.6 Hz, 1H, OCH₂), 3.87 (d, J = 9.7 Hz, 1H, Ar¹Ar²CH₂), 3.19 (ddd, J = 12.2, 5.5, 1.0 Hz, 1H, NCH₂H₃), 2.80 (dd, J = 12.2, 9.7 Hz, 1H, NCH₂H₃), 2.79 (br. s, 1H, NH), 2.29 (s, 3H, Ar¹CH₃), 2.27 (s, 6H, Ar¹CH₃).

13C{[1H]} NMR (101 MHz, Chloroform-d) δ 141.3, 139.3, 138.3, 136.2, 129.3, 128.8, 128.1, 126.1, 123.3 (q, J = 283.0 Hz), 88.2 (q, J = 33.9 Hz), 82.3, 55.2, 50.6, 21.5, 21.2.

19F NMR (376 MHz, Chloroform-d) δ −81.8 (d, 3F, J = 5.6 Hz).

IR (cm⁻¹) 3353 (m), 3018 (m), 2923 (m), 1606 (m), 1515 (m), 1456 (m), 1290 (m), 1168 (s), 1043 (m).

HRMS (ESI/QTOF) m/z: [M + H]^+ Calculated for C₁₃H₁₂F₃NO^+ 350.1726; Found 350.1733.

(2S,5R)-5-((R)-(1-(p-Toly)ethyl)-2-(trifluoromethyl)oxazolidine (42)

Prepared according to the general procedure D5 using 17 (70 mg, 0.20 mmol, 1.0 equiv., 72% ee) and Pd(OH)₃/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product 42 (43 mg, 0.16 mmol, 82% yield) as colorless oil. The enantiomeric excess was determined to be 72% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm: τ_{Major} = 7.7 min, τ_{Minor} = 9.3 min. Absolute configuration was determined in comparison to compound (R,R)-5.

[a]D^{20} = 2.7 (c = 0.43, CHCl₃, 72% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.14 (s, 4H, ArH), 4.87 (q, J = 5.6 Hz, 1H, CHCF₃), 3.93 (td, J = 8.8, 5.6 Hz, 1H, OCH₂), 3.32 (dd, J = 11.4, 5.6 Hz, 1H, NCH₂H₃), 2.94 – 2.79 (m, 2H, NCH₂H₃ and ArCHCH₂), 2.67 (br. s, 1H, NH), 2.33 (s, 3H, ArCH₃), 1.24 (d, J = 7.1 Hz, 3H, ArCHCH₃).

13C{[1H]} NMR (101 MHz, Chloroform-d) δ 140.6, 136.4, 129.3, 127.5, 123.5 (q, J = 282.9 Hz), 87.9 (q, J = 33.8 Hz), 84.7, 49.4, 42.9, 21.2, 16.9.

19F NMR (376 MHz, Chloroform-d) δ −81.1 (d, 3F, J = 5.6 Hz).

IR (cm⁻¹) 3348 (w), 2928 (w), 2887 (w), 1514 (m), 1456 (m), 1291 (m), 1166 (s).

HRMS (ESI/QTOF) m/z: [M + H]^+ Calculated for C₁₃H₁₄F₂NO^+ 260.1257; Found 260.1259.
(2S,5R)-5-((R)-2-Phenyl-1-(p-toly)ethyl)-2-(trifluoromethyl)oxazolidine (43)

Prepared according to the general procedure D5 using 18 (85 mg, 0.20 mmol, 1.0 equiv., 86% ee) and Pd(OH)₂/C (20 mol%, 28 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product 43 (47 mg, 0.14 mmol, 70% yield) as colorless oil. The enantiomeric excess was determined to be 86% by HPLC analysis on a Daicel Chiralpak IA column: 95.5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm: τ_major = 7.1 min, τ_minor = 11.4 min. Absolute configuration was determined in comparison to compound (R,R)-5.

[a]D²⁰ = −49.3 (c = 0.74, CHCl₃, 86% ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.23 – 7.17 (m, 2H, ArH), 7.17 – 7.11 (m, 1H, ArH), 7.11 – 7.02 (m, 6H, ArH), 4.84 (q, J = 5.5 Hz, 1H, CHCF₃), 4.04 (dt, J = 9.5, 5.6 Hz, 1H, OCH), 3.20 (dd, J = 12.0, 5.5 Hz, 1H, NCH₂H₃), 3.11 – 2.91 (m, 3H, PhCH₂CH and PhCH₂CH), 2.75 (t, J = 12.0, 9.5 Hz, 1H, NCH₂H₃), 2.46 (br. s, 1H, NH), 2.30 (s, 3H, ArCH₃).

¹³C¹H NMR (101 MHz, Chloroform-d) δ 139.7, 137.6, 136.4, 129.2, 129.1, 128.6, 128.4, 126.2, 123.3 (q, J = 282.8 Hz), 87.5 (q, J = 33.9 Hz), 82.5, 50.4, 49.1, 38.5, 21.2.

¹⁹F NMR (376 MHz, Chloroform-d) δ −80.8 (d, 3F, J = 5.4 Hz, CHCF₃).

IR (cm⁻¹) 3349 (w), 3027 (w), 2927 (w), 1508 (m), 1451 (m), 1292 (m), 1165 (s), 1115 (s).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C₁₅H₂₃F₂NO⁺ 336.1570; Found 336.1575.

(2S,5R)-5-((R)-(Cyclopropyl(p-toly)methyl)-2-(trifluoromethyl)oxazolidine (44)

Prepared according to the general procedure D5 using 19 (75 mg, 0.20 mmol, 1.0 equiv., 78% ee) and Pd(OH)₂/C (20 mol%, 28 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product 44 (32 mg, 0.11 mmol, 56% yield) as colorless oil. The enantiomeric excess was determined to be 78% by HPLC analysis on a Daicel Chiralpak IA column: 95.5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm: τ_major = 7.1 min, τ_minor = 9.2 min.). Absolute configuration was determined in comparison to compound (R,R)-5.

[a]D²⁰ = −21.6 (c = 0.57, CHCl₃, 78% ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.14 (s, 4H, ArH), 4.85 (q, J = 5.6 Hz, 1H, CHCF₃), 4.10 (td, J = 8.9, 5.5 Hz, 1H, OCH), 3.45 (ddd, J = 12.0, 5.5, 1.4 Hz, 1H, NCH₂H₃), 2.96 (dd, J = 12.0, 8.9 Hz, 1H, NCH₂H₃), 2.33 (s, 3H, ArCH₃), 1.93 (dd, J = 10.1, 8.3 Hz, 1H, Ar(CPy)CH), 1.04 (dtt, J = 10.1, 8.1, 4.8 Hz, 1H, CH(CH₂H₃)CH₂H₃), 0.65 (ddd, J = 9.2, 8.1, 5.8, 4.5 Hz, 1H, CH(CH₂H₃)CH₂H₃), 0.44 (ddd, J = 9.2, 8.1, 5.6, 4.5 Hz, 1H, CH(CH₂H₃)CH₂H₃), 0.33 (ddt, J = 9.2, 5.6, 4.8 Hz, 1H, CH(CH₂H₃)CH₂H₃), 0.06 (ddt, J = 9.2, 5.8, 4.8 Hz, 1H, CH(CH₂H₃)CH₂H₃).

¹³C¹H NMR (101 MHz, Chloroform-d) δ 139.4, 136.3, 129.2, 128.1, 123.4 (q, J = 282.8 Hz), 87.6 (q, J = 33.8 Hz), 84.3, 53.6, 49.6, 21.2, 13.4, 6.3, 3.3.

¹⁹F NMR (376 MHz, Chloroform-d) δ −81.1 (d, 3F, J = 5.5 Hz, CHCF₃).

IR (cm⁻¹) 3343 (w), 3010 (w), 2927 (w), 2897 (w), 1515 (m), 1327 (m), 1291 (m), 1167 (s), 1116 (m).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C₁₅H₂₁F₂NO⁺ 286.1413; Found 286.1416.

(2S,5R)-5-((R)-(Phenyl-4-(trifluoromethyl)phenyl)methyl)-2-(trifluoromethyl)oxazolidine (45)

Prepared according to the general procedure D5 using 20 (85 mg, 0.20 mmol, 1.0 equiv., 88% ee) and Pd(OH)₂/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product 45 (55 mg, 0.16 mmol, 82% yield) as colorless oil. The enantiomeric excess was determined to be 90% by HPLC analysis on a Daicel Chiralpak IA column: 95.5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm: τ_major = 12.6 min, τ_minor = 20.2 min.). Absolute configuration was determined in comparison to compound (R,R)-5.

[a]D²⁰ = +13.0 (c = 0.32, CHCl₃, 90% ee)

¹H NMR (400 MHz, Chloroform-d) δ 7.34 – 7.20 (m, 7H, ArH), 6.88 – 6.82 (m, 2H, ArH), 4.98 (br. s., 1H, CHCF₃), 4.58 (td, J = 9.3, 5.5 Hz, 1H, OCH), 3.95 (d, J = 9.4 Hz, 1H, Ar¹Ar²CH₂), 3.77 (s, 3H, OCH₃), 3.14 (br.s.,1H, NCH₂H₃), 2.79 (br. s., 1H, NCH₂H₃), 2.65 (br. s., 1H, NH).

¹³C¹H NMR (101 MHz, Chloroform-d) δ 158.4, 141.7, 134.3, 129.4, 128.9, 128.3, 127.1, 123.5 (q, J = 282.9 Hz), 113.9, 88.4 (q, J = 33.8 Hz), 82.3, 55.3, 54.8, 50.7.
(2S,5R)-5-((R)-4-(trifluoromethyl)phenyl)methyl)-2-(trifluoromethyl)oxazolidine (46)

Prepared according to the general procedure D5 using 22 (93 mg, 0.20 mmol, 1.0 equiv., 82% ee) and Pd(OH)$_2$/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product 46 (46 mg, 0.12 mmol, 61% yield) as colorless oil. The enantiomeric excess was determined to be 82% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm: $\tau_{major} = 12.0$ min, $\tau_{minor} = 14.2$ min. Absolute configuration was determined in comparison to compound (R,R)-5.

[α]$^D_{20} = +5.0$ (c = 0.30, CHCl$_3$, 82% ee).

$^1$H NMR (400 MHz, Chloroform-d) $\delta$ 7.54 (d, $J = 8.1$ Hz, 2H, ArH), 7.44 (d, $J = 8.1$ Hz, 2H, ArH), 7.34 – 7.27 (m, 2H, ArH), 7.27 – 7.19 (m, 3H, ArH), 4.98 (dq, $J = 8.5$, 5.6 Hz, 1H, CHCF$_3$), 4.62 (td, $J = 9.3$, 5.5 Hz, 1H, OCH$_3$), 4.03 (d, $J = 9.6$ Hz, 1H, Ar, Ar=CH), 3.17 (ddd, $J = 13.0$, 7.2, 5.6, 1.5 Hz, 1H, NCH$_3$H$_2$), 2.89 – 2.75 (m, 1H, NCH$_3$H$_2$), 2.65 (br.s., 1H, NH).

$^{13}$C($^1$H) NMR (101 MHz, Chloroform-d) $\delta$ 146.1, 140.4, 129.2, 129.0 (q, $J = 32.2$ Hz) 128.8, 128.4, 127.6, 125.5 (q, $J = 3.7$ Hz), 124.3 (q, $J = 271.6$ Hz), 123.3 (q, $J = 281.5$ Hz), 88.6 (q, $J = 34.0$ Hz), 81.6, 55.5, 50.7.

[α]$^F_{20} = +62.5$, -81.1.

IR (cm$^{-1}$) 2928 (w), 1613 (w), 1495 (w), 1455 (w), 1329 (s), 1292 (m), 1167 (s), 1136 (s).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{18}$H$_{19}$F$_3$NO$_2$: 376.1131; Found 376.1141.

(2S,5R)-5-((R)-(4-Fluorophenyl)phenyl)methyl)-2-(trifluoromethyl)oxazolidine (47)

Prepared according to the general procedure D5 using 23 (83 mg, 0.20 mmol, 1.0 equiv., 84% ee) and Pd(OH)$_2$/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 85:15) to give the corresponding product 47 (47 mg, 0.14 mmol, 72% yield) as colorless oil. The enantiomeric excess was determined to be 84% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm: $\tau_{major} = 10.7$ min, $\tau_{minor} = 14.2$ min. Absolute configuration was determined in comparison to compound (R,R)-5.

[α]$^D_{20} = +8.1$ (c = 0.37, CHCl$_3$, 84% ee).

$^1$H NMR (400 MHz, Chloroform-d) $\delta$ 7.39 – 7.19 (m, 7H, ArH), 6.99 (t, $J = 8.7$ Hz, 2H, ArH), 4.99 (dq, $J = 8.5$, 5.6 Hz, 1H, CHCF$_3$), 4.58 (td, $J = 9.2$, 5.5 Hz, 1H, OCH$_3$), 3.98 (d, $J = 9.4$ Hz, 1H, Ar=Ar=CH), 3.22 – 3.11 (m, 1H, NCH$_3$H$_2$), 2.87 – 2.72 (m, 1H, NCH$_3$H$_2$), 2.65 (br.s., 1H, NH).

$^{13}$C($^1$H) NMR (101 MHz, Chloroform-d) $\delta$ 161.7 (d, $J = 244.9$ Hz), 141.2, 137.8 (d, $J = 3.3$ Hz), 130.0 (d, $J = 8.0$ Hz), 129.0, 128.3, 127.3, 123.4 (q, $J = 282.9$ Hz), 115.3 (d, $J = 21.2$ Hz), 88.5 (q, $J = 34.1$ Hz), 82.1, 54.8, 50.7.

$^{19}$F($^1$H) NMR (376 MHz, Chloroform-d) $\delta$ –81.1, -116.6.

IR (cm$^{-1}$) 3357 (w), 2928 (w), 1605 (w), 1508 (m), 1454 (w), 1290 (m), 1226 (m), 1167 (s), 1154 (s).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{18}$H$_{18}$F$_3$NO$^+$: 326.1163; Found 326.1164.

(4-(R)-Phenyl(2S,5R)-2-(trifluoromethyl)oxazolidin-5-yl)methyl)phenyl)methanamine (48)

Prepared according to the general procedure D5 using 25 (84 mg, 0.20 mmol, 1.0 equiv., 73% ee) and Pd(OH)$_2$/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (DCM/MeOH gradient 100:0 to 90:10) to give the corresponding product 48 (32 mg, 95 µmol, 48% yield) as colorless oil. The enantiomeric excess was determined to be 74% by HPLC analysis on a Daicel Chiralpak IC column: 85:15 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm: $\tau_{major} = 17.4$ min, $\tau_{minor} = 24.7$ min. Absolute configuration was determined in comparison to compound (R,R)-5.

S38
(q, 3H, OCH3, 3.59 (dd, J = 9.5 Hz, 1H, ArCH(CH3))
3.47 (d, J = 3.9 Hz, 2H, ArCH2NH2), 3.21 – 2.88 (m, 4H, NCH2CH2, NCH3H6, and NH2), 2.84 – 2.70 (br. s., 1H, NH).

13C NMR (101 MHz, Chloroform-d) δ 141.3, 141.2, 129.9, 129.1, 128.9, 128.6, 128.3, 127.8, 127.7, 127.2, 123.4 (q, J = 282.9 Hz).

IR (cm−1) 3354 (w), 3027 (m), 2928 (m), 2865 (s), 1602 (w), 1505 (m), 1455 (w), 1291 (m), 1151 (s), 1092 (m).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C18H20F3N5O+ 337.1522; Found 337.1518.

Methyl-4-((R)-phenyl(2S,5R)-2-(trifluoromethyl)oxazolidin-5-yl)methyl)benzoate (49)
Prepared according to the general procedure D5 using 26 (91 mg, 0.20 mmol, 1.0 equiv., 82% ee) and Pd(OH)2/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 80:20) to give the corresponding product 49 (44 mg, 0.12 mmol, 60% yield) as colorless oil. The enantiomeric excess was determined to be 82% by HPLC analysis on a Daicel Chiralpak IA column: 90:10 hexane/IPA, flow rate 1 mL/min, λ = 210 nm; tMajor = 13.4 min, tMinor = 19.6 min. Absolute configuration was determined in comparison to compound (R,R)-5.

[q]D20 = +6.8 (c = 0.39, CHCl3, 82% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.97 (d, J = 8.4 Hz, 2H, ArH), 7.41 (d, J = 8.3 Hz, 2H, ArH), 7.35 – 7.19 (m, 5H, ArH), 4.99 (dq, J = 7.9, 5.6 Hz, 1H, CHCF3), 4.64 (td, J = 9.3, 5.5 Hz, 1H, OCH), 4.05 (d, J = 9.5 Hz, 1H, Ar′Ar2CH), 3.88 (s, 3H, COOC2H5), 3.22 – 3.12 (m, 1H, NCH2H6), 2.82 (q, J = 10.9 Hz, 1H, NCH3CH2), 2.68 (br. s., 1H, NH).

13C NMR (101 MHz, Chloroform-d) δ 167.1, 147.3, 140.6, 129.9, 129.1, 128.6, 128.5, 128.4, 127.5, 123.4 (q, J = 282.8 Hz), 88.5 (q, J = 34.0 Hz), 81.6, 55.6, 52.2, 50.7.

19F NMR (376 MHz, Chloroform-d) δ -81.1.

IR (cm−1) 3349 (w), 2953 (w), 1718 (s), 1607 (w), 1444 (m), 1286 (s), 1169 (s), 1151 (s).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C18H20F3N5O+ 366.1312; Found 366.1320.

((4-((R)-Phenyl(2S,5R)-2-(trifluoromethyl)oxazolidin-5-yl)methyl)phenyl)methanol (50)
Prepared according to the general procedure D5 using 27 (85 mg, 0.20 mmol, 1.0 equiv., 80% ee) and Pd(OH)2/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 60:40) to give the corresponding product 50 (10 mg, 30 µmol, 15% yield) as colorless oil. The enantiomeric excess was determined to be 80% by HPLC analysis on a Daicel Chiralpak IA column: 80:20 hexane/IPA, flow rate 1 mL/min, λ = 210 nm; tMajor = 9.1 min, tMinor = 13.0 min. Absolute configuration was determined in comparison to compound (R,R)-5.

[q]D20 = +9.4 (c = 0.39, CHCl3, 80% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.37 – 7.19 (m, 9H, ArH), 4.97 (q, J = 5.7 Hz, 1H, CHCF3), 4.64 (m, 3H, OCH and ArCH2OH), 3.99 (d, J = 9.5 Hz, 1H, Ar′Ar2CH), 3.16 (dd, J = 12.2, 5.4 Hz, 1H, NCH2H6), 2.81 (br. s., 1H, NCH2H6), 2.66 (br. s., 1H, NH).

13C NMR (101 MHz, Chloroform-d) δ 141.7, 141.2, 139.3, 129.0, 128.6, 128.3, 127.3, 127.2, 123.4 (q, J = 282.8 Hz), 88.4 (q, J = 34.2 Hz), 82.0, 65.3, 55.4, 50.7.

19F NMR (376 MHz, Chloroform-d) δ -81.1.

IR (cm−1) 3339 (m), 2925 (m), 1596 (w), 1454 (m), 1291 (m), 1151 (s).

HRMS (ESI/QTOF) m/z: [M + H]+ Calculated for C18H19F3N5O+ 338.1362; Found 338.1372.
(2S,5R)-5-((R)-(3-Fluorophenyl)(phenyl)methyl)-2-((trifluoromethyl)oxazolidine (51)

Prepared according to the general procedure D using 28 (83 mg, 0.20 mmol, 1.0 equiv., 82% ee) and Pd(OH)$_2$/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 80:15) to give the corresponding product 51 (43 mg, 0.14 mmol, 66% yield) as colorless oil. The enantiomeric excess was determined to be 82% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm: $\tau_{\text{major}} = 9.2$ min, $\tau_{\text{minor}} = 13.4$ min. Absolute configuration was determined in comparison to compound (R,R)-5.

$[\alpha]D^{20} = +3.3$ (c = 0.25, CHCl$_3$, 82% ee).

$^1$H NMR (400 MHz, Chloroform-d) $\delta$ 7.39 – 7.19 (m, 6H, ArH), 7.11 (dt, $J = 7.8, 1.2$ Hz, 1H, ArH), 7.05 (dt, $J = 10.3, 2.2$ Hz, 1H, ArH), 6.90 (dd, $J = 8.3, 2.6, 1.0$ Hz, 1H, ArH), 5.00 (dq, $J = 8.4, 5.6$ Hz, 1H, CHCF$_3$), 4.59 (td, $J = 9.3, 5.5$ Hz, 1H, OCH$_3$), 3.99 (d, $J = 9.5$ Hz, 1H, Ar$^1$Ar$^2$CH), 3.25 – 3.05 (br. s, 1H, NCH$_2$CH$_3$), 2.89 – 2.74 (br. s, 1H, NCH$_2$CH$_3$), 2.66 (br. s, 1H, NH).

$^{13}$C$^1$(H) NMR (101 MHz, Chloroform-d) $\delta$ 162.9 (d, $J = 245.4$ Hz), 144.6 (d, $J = 7.0$ Hz), 140.7, 129.9 (d, $J = 8.3$ Hz), 129.1, 128.4, 127.5, 124.2 (d, $J = 2.8$ Hz), 123.4 (q, $J = 282.9$ Hz), 115.4 (d, $J = 21.9$ Hz), 113.7 (d, $J = 21.1$ Hz), 88.5 (q, $J = 34.0$ Hz), 81.8, 55.3 (d, $J = 1.8$ Hz), 50.7.

$^{19}$F$^1$(H) NMR (376 MHz, Chloroform-d) $\delta$ -81.1, -113.2.

IR (cm$^{-1}$) 3354 (w), 2925 (w), 1597 (m), 1493 (m), 1451 (m), 1291 (m), 1168 (s), 1151 (s).

HRMS (APCI/QTOF) m/z: [M + H]$^+$ Calculated for C$_{17}$H$_{16}$F$_4$NO$^+$ 326.1163; Found 326.1163.

(2S,5R)-5-((R)-(2-Fluorophenyl)(phenyl)methyl)-2-((trifluoromethyl)oxazolidine (52)

Prepared according to the general procedure D using 29 (83 mg, 0.20 mmol, 1.0 equiv., 74% ee) and Pd(OH)$_2$/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 80:15) to give the corresponding product 52 (45 mg, 0.14 mmol, 69% yield) as colorless oil. The enantiomeric excess was determined to be 72% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 254 nm: $\tau_{\text{major}} = 8.1$ min, $\tau_{\text{minor}} = 14.0$ min. Absolute configuration was determined in comparison to compound (R,R)-5.

$[\alpha]D^{20} = -12.8$ (c = 0.26, CHCl$_3$, 72% ee).

$^1$H NMR (400 MHz, Chloroform-d) $\delta$ 7.45 (td, $J = 7.6, 1.9$ Hz, 1H, ArH), 7.33 – 7.15 (m, 6H, ArH), 7.12 (td, $J = 7.5, 1.4$ Hz, 1H, ArH), 7.01 (dd, $J = 10.5, 8.0, 1.4$ Hz, 1H, ArH), 4.97 (br. s., 1H, CHCF$_3$), 4.71 (td, $J = 9.1, 5.5$ Hz, 1H, OCH$_3$), 4.34 (d, $J = 9.2$ Hz, 1H, Ar$^1$Ar$^2$CH), 3.18 (br. s, 1H, NCH$_2$CH$_3$), 2.85 (br. s, 1H, NCH$_2$CH$_3$), 2.66 (br. s, 1H, NH).

$^{13}$C$^1$(H) NMR (101 MHz, Chloroform-d) $\delta$ 160.9 (d, $J = 245.8$ Hz), 140.5, 129.3 (d, $J = 4.3$ Hz), 129.0, 128.9, 128.4, 128.3, 127.3, 124.2 (d, $J = 3.5$ Hz), 123.3 (q, $J = 282.8$ Hz), 115.7 (d, $J = 22.6$ Hz), 88.4 (q, $J = 34.0$ Hz), 80.9, 50.6, 48.5 (d, $J = 2.1$ Hz).

$^{19}$F$^1$(H) NMR (376 MHz, Chloroform-d) $\delta$ -81.1, -117.2.

IR (cm$^{-1}$) 3067 (w), 3025 (w), 2945 (w), 2891 (w), 2109 (w), 1715 (w), 1592 (w), 1494 (m), 1455 (m), 1291 (m), 1226 (m), 1167 (s), 1153 (s).

HRMS (ESI/QTOF) m/z: [M + H]$^+$ C$_{17}$H$_{16}$F$_4$NO$^+$ 326.1163; Found 326.1163.

(2S,5R)-5-((R)-(3,5-Dimethylphenyl)(phenyl)methyl)-2-((trifluoromethyl)oxazolidine (53)

Prepared according to the general procedure D using 30 (85 mg, 0.20 mmol, 1.0 equiv., 92% ee) and Pd(OH)$_2$/C (10 mol%, 14 mg). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 80:15) to give the corresponding product 53 (51 mg, 0.15 mmol, 76% yield) as colorless oil. The enantiomeric excess was determined to be 92% by HPLC analysis on a Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm: $\tau_{\text{major}} = 6.8$ min, $\tau_{\text{minor}} = 8.3$ min. Absolute configuration was determined in comparison to compound (R,R)-5.

$[\alpha]D^{20} = -2.1$ (c = 0.47, CHCl$_3$, 92% ee).

$^1$H NMR (400 MHz, Chloroform-d) $\delta$ 7.35 – 7.17 (m, 5H, ArH), 6.95 (s, 2H, ArH), 6.85 (s, 1H, ArH), 4.97 (dq, $J = 8.5, 5.6$ Hz, 1H, CHCF$_3$), 4.63 (td, $J = 9.3, 5.5$ Hz, 1H, OCH$_3$), 3.91 (d, $J = 9.4$ Hz, 1H, Ar$^1$Ar$^2$CH), 3.21 – 3.09 (m, 1H, NCH$_2$CH$_3$), 2.85 – 2.71 (m, 1H, NCH$_2$CH$_3$), 2.63 (br. s., 1H, NH), 2.28 (s, 6H, ArCH$_3$).

$^{13}$C$^1$(H) NMR (101 MHz, Chloroform-d) $\delta$ 141.9, 141.6, 137.9, 128.9, 128.6, 128.3, 127.0, 126.2, 123.4 (q, $J = 283.1$ Hz), 88.4 (q, $J = 33.9$ Hz), 82.1, 55.6, 50.7, 21.6.

S40
(2S,5R)-3-Methyl-5-((R)-phenyl(p-tolyl)methyl)-2-(trifluoromethyl)oxazolidine (54)

Prepared according to the general procedure D5 using 33 (33 mg, 0.10 mmol, 1.0 equiv., 92% ee) and Pd/C (20 mol%, 43 mg) in MeOH (1.3 mL) and AcOH (0.7 mL). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding product 54 (10 mg, 0.030 mmol, 30% yield) as colorless oil. The enantiomeric excess was determined to be 92% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 210 nm: τ\text{Major} = 5.2 min, τ\text{Minor} = 6.1 min. Absolute configuration was determined in comparison to compound (R,R)-5.

[α]D<sup>20</sup> = 10.3 (c = 0.50, CHCl₃, 92% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.33 – 7.27 (m, 2H, ArH), 7.25 – 7.20 (m, 5H, ArH), 7.11 (d, J = 8.0 Hz, 2H, ArH), 4.86 (ddd, J = 9.9, 8.1, 5.8 Hz, 1H, OCH₃), 4.51 (q, J = 5.3 Hz, 1H, CH₂CF₃), 3.98 (d, J = 9.9 Hz, 1H, Ar₅Ar₂CH₂), 3.02 (ddd, J = 11.7, 8.1, 1.3 Hz, 1H, NCH₂CH₂H₂), 2.77 (ddd, J = 11.7, 5.8, 1.2 Hz, 1H, NCH₂CH₂H₂), 2.58 (s, 3H, NCH₂CH₂H₂), 2.30 (s, 3H, ArCH₂).

13C[1H] NMR (101 MHz, Chloroform-d) δ 141.6, 139.2, 136.3, 129.3, 128.9, 128.4, 128.2, 127.0, 123.4 (q, J = 232.3 Hz), 94.7 (q, J = 33.6 Hz), 79.6, 58.7, 55.3, 43.3, 21.2.

19F NMR (376 MHz, Chloroform-d) δ -80.4 (d, 3F, J = 5.2 Hz, CHCF₂).

IR (cm⁻¹) 3023 (w), 2924 (m), 2867 (w), 1510 (w), 1459 (m), 1294 (m), 1161 (s), 1068 (m).

HRMS (ESI/QTOF) m/z: [M + H]<sup>+</sup> Calculated for C₁₅H₂₁F₃NO⁺ 336.1570; Found 336.1564.

(2S,5R)-3-Phenyl-5-((R)-phenyl(p-tolyl)methyl)-2-(trifluoromethyl)oxazolidine (55)

Prepared according to the general procedure D5 using 34 (40 mg, 0.10 mmol, 1.0 equiv., 54% ee) and Pd/C (20 mol%, 43 mg) in MeOH (1.3 mL) and AcOH (0.7 mL). The crude material was purified by flash column chromatography (pentane/EtOAc gradient 100:0 to 97:3) to give the corresponding product 55 (14 mg, 0.035 mmol, 35% yield) as colorless oil. The enantiomeric excess was determined to be 73% by HPLC analysis on a Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 210 nm: τ\text{Major} = 8.1 min, τ\text{Minor} = 11.8 min. Absolute configuration was determined in comparison to compound (R,R)-5. The olefin 34 was recovered (17 mg, 0.043 mmol, 43%, 24% e.e.).

[α]D<sup>20</sup> = -23.7 (c = 0.50, CHCl₃, 73% ee).

1H NMR (400 MHz, Chloroform-d) δ 7.37 – 7.30 (m, 2H, ArH), 7.30 – 7.26 (m, 5H, ArH), 7.26 – 7.21 (m, 4H, ArH), 7.13 (d, J = 8.0 Hz, 2H, ArH), 6.88 (tt, J = 7.3, 1.1 Hz, 1H, ArH), 6.77 – 6.70 (m, 2H, ArH), 5.58 (q, J = 4.5 Hz, 1H, CH₂CF₃), 4.88 (dd, J = 9.9, 6.1 Hz, 1H, OCH₃), 4.11 (d, J = 9.9 Hz, 1H, Ar₅Ar₂CH₂), 3.74 (ddd, J = 10.8, 6.1, 1.4 Hz, 1H, NCH₂CH₂H₂), 3.33 (ddd, J = 10.8, 9.9 Hz, 1H, NCH₂CH₂H₂), 2.31 (s, 3H, ArCH₂).

13C[1H] NMR (101 MHz, Chloroform-d) δ 145.3, 141.2, 138.6, 136.5, 129.5, 129.4, 129.1, 128.3, 128.2, 127.3, 123.7 (q, J = 286.8 Hz), 120.2, 114.5, 87.5 (q, J = 34.5 Hz), 80.5, 55.4, 52.3, 21.2.

19F NMR (376 MHz, Chloroform-d) δ -79.6 (d, 3F, J = 4.6 Hz, CHCF₂).

IR (cm⁻¹) 3036 (w), 2924 (w), 1604 (m), 1506 (s), 1362 (m), 1323 (m), 1284 (m), 1168 (s), 1150 (s).

HRMS (ESI/QTOF) m/z: [M + H]<sup>+</sup> Calculated for C₁₅H₂₁F₃NO⁺ 398.1726; Found 398.1723.

(1R,2R)-3-Amino-1-phenyl-1-(p-tolyl)propan-2-ol trifluoroacetic acid salt (56)

Scheme 15. Acidic hydrolysis of the hemiaminal, synthesis of 56

In 5 mL round bottom flask 5 (53 mg, 0.20 mmol, 94% ee) was dissolved in a mixture of THF (3.6 mL) and H₂O (0.4 mL). Tosylsulfonic acid (266 mg, 1.40 mmol, 7.0 equiv) was added and the mixture was stirred at room temperature for 16 hours. The reaction was diluted with DCM (5 mL) and quenched by
adding 1 M NaOH (4 mL). The layers were separated and the aqueous layer was extracted with DCM (2 x 5 mL). The combined organic layers were washed with brine, dried over Na2SO4, filtered and concentrated. The crude material was purified by preparative RP-HPLC on an Agilent 1260 HPLC system with a G2260A 1260 Prep ALS Autosampler, a G1361a 1260 Prep Pump, a G1365C 1260 MWD detector and a G1364B 1260 FC-PS collector, coupled with a Waters XBridge semi-preparative C18 column (19 x 150 mm, 5 μm). Water (solvent A) and water:acetonitrile 5:95 (solvent B), each containing 0.1% TFA, were used as the mobile phase at a flow rate of 20 mL/min-1. The following method was used: 100% A to 100% B in 20 minutes. The desired product (1R,2R)-3-amino-1-phenyl-1-(p-tolyl)propan-2-ol trifluoroacetic acid salt \( \text{56} \) was obtained as gummy solid (56 mg, 0.15 mmol, 76%). The enantiomeric excess was determined to be 94% by HPLC analysis on a Daicel Chiralpak IA column: 80:20 hexane/IPA, flow rate 1 mL/min, \( \lambda = 210 \) nm; \( t_{\text{Major}} = 8.2 \) min, \( t_{\text{Minor}} = 11.4 \) min. Absolute configuration was determined in comparison to compound \((R,R) - \text{5} \). 

\[ [\alpha]_D^{20} = -28.3 \ (c = 0.50, \ \text{CHCl}_3, \ 94\% \ ee). \]

\( ^1H \text{NMR} \) (400 MHz, Methanol-\( d_4 \)) \( \delta \) 7.35 – 7.26 (m, 6H, ArH), 7.24 – 7.17 (m, 1H, ArH), 7.17 – 7.08 (m, 2H, ArH), 4.53 (td, \( J = 9.8, 3.0 \) Hz, 1H, HOCH), 3.90 (d, \( J = 9.4 \) Hz, 1H, Ar\( ^1\)Ar\( ^2\)CH), 2.85 (dd, \( J = 12.8, 2.9 \) Hz, 1H, H\( _2\)NCH\( _2\)H\(_3\)), 2.75 (dd, \( J = 12.8, 9.9 \) Hz, 1H, H\( _2\)NCH\( _2\)H\(_3\)), 2.29 (s, 3H, ArCH\(_3\)).

\( ^13C\{^1H\} \text{NMR} \) (101 MHz, Methanol-\( d_4 \)) \( \delta \) 162.7 (q, \( J = 34.9 \) Hz), 143.1, 139.5, 137.4, 130.2, 129.9, 129.6, 129.2, 128.0, 118.1 (q, \( J = 292.3 \) Hz), 71.1, 57.8, 45.3, 21.0.

\( ^19F \text{NMR} \) (376 MHz, Methanol-\( d_4 \)) \( \delta \) -77.0 (s, 3F, -OOCCF\(_3\)).

IR (cm\(^{-1}\)) 3031 (m), 2922 (m), 1679 (s), 1518 (m), 1200 (s), 1137 (s).

HRMS (ESI/QTOF) \( m/z \): [M + H]\(^+\) Calculated for C\(_{16}\)H\(_{20}\)NO\(^+\) 242.1539; Found 242.1542.

D.5. Unsuccessful Substrates

Unreactive propargylic amines, aryl iodides and failed hydrogenations are reported in the following scheme. Yields are reported in the case of low conversions.

![Propargylic Amines](image)

**Failed Hydrogenations**

![Failed Hydrogenations](image)

Scheme 16. Unsuccessful substrates and scope limitations.
E. Mechanistic Considerations

E.1. Proposed Reaction Mechanism

In the proposed reaction mechanism, the propargyl amine 1 condenses with the ethoxy trifluoroethanol 3 to give hemiaminal I. Then a ligand exchange onto the ArPdX species, obtained by oxidative addition of the Pd(0) catalyst with the aryl iodide, would provide the diastereomeric complexes IV. After a trans-oxypalladation step, (based on the observed geometry of the products), the vinyl palladium species V could be obtained. Finally, a reductive elimination step would regenerate Pd(0) and provide the desired products II.

The origin of the asymmetric induction can be explained considering that the propargyl amine 1 and ethoxy trifluoroethanol 3 are in equilibrium with the hemiaminal I. This equilibrium provide the source of the racemization of the stereocenter in α to the CF₃-group. This racemization pathway is key for the development of a dynamic kinetic asymmetric transformation (DYKAT). In the presence of a chiral palladium complex, the two enantiomers of IV undergoes coordination, oxopalladation and reductive elimination with different kinetics ($K_{1(S)} \neq K_{1(R)}$, $K_{2(S)} \neq K_{2(R)}$, $k_{3(S)} \neq k_{3(R)}$) leading to the enantioenriched product II. Most likely, coordination proceed in a reversible fashion while the oxypalladation and/or the reductive elimination are irreversible thus constituting the enantiodeterming steps.

Scheme 17. Proposed reaction mechanism.

*An alternative cis-oxypalladation followed by isomerization cannot be excluded*
E.2. NMR analysis of the equilibrium between Propargyl Amine 1, Tether 3 and hemiaminal I

Scheme 18. Equilibrium between 1, 3 and I.

An NMR tube (180x5 mm) was charged with propargyl amine 1 (21.5 µL, 22.0 mg, 0.10 mmol, 1.0 equiv) and 1-ethoxy-2,2,2-trifluoroethanol 3 (85% in EtOH, 19 uL, 0.14 mmol, 1.4 equiv.) and CDCl₃ (1.0 mL).

1H NMR spectra was obtained using the following acquisition parameters: pulse program zg30, TD 65536, NS 16, D1 1.00000000 s, TE 298.0 K.

The integral ratio between the CHCF₃ protons of the heminal I and 3 was found to be 1.00:2.41. By simple calculation:

\[
\begin{align*}
[3] + [I] &= 140 \mu M \\
[3] &= 2.41 \cdot [I]
\end{align*}
\]

This corresponds to approx. 41% conversion of the propargyl amine 1 to the hemiaminal I.

Scheme 19. 1H-NMR spectrum of the equilibrium between 1, 3 and I
F. X-Ray Crystallographic Data

F.1. Single Crystal X-Ray Diffraction for the chiral compound (S)-4
Crystals of the compound (S)-4 were obtained by slow evaporation of a diethyl ether solution.

Data acquisition: Single clear pale colourless needle crystals of (S)-4 were used as supplied. A suitable crystal with dimensions 0.78 × 0.13 × 0.07 mm³ was selected and mounted on a SuperNova, Dual, Cu at home/near, Atlas diffractometer. The crystal was kept at a steady $T = 140.01(10)$ K during data collection. The structure was solved with the ShelXT (Sheldrick, 2015) solution program using dual methods and by using Olex 2 as the graphical interface. The model was refined with ShelXL 2018/3 (Sheldrick, 2015) using full matrix least squares minimisation on $F^2$.

\[ \text{Scheme 20: Crystal data and structure refinement for (S)-4. CCDC 2020478} \]
| Property                  | Value                  |
|--------------------------|------------------------|
| **Compound**             | *(S)-4*                |
| Formula                  | C_{25}H_{22}F_{3}NO    |
| Density calc. g cm^{-3}  | 1.354                  |
| μ/mm^{-1}                | 0.843                  |
| Formula Weight           | 409.43                 |
| Colour                   | clear pale colourless  |
| Shape                    | needle                 |
| Size/mm^{3}              | 0.78×0.13×0.07         |
| T/K                      | 140.01(10)             |
| Crystal System           | orthorhombic           |
| Flack Parameter          | 0.02(5)                |
| Hooft Parameter          | 0.04(4)                |
| Space Group              | P_{2_{1}}2_{1}2_{1}     |
| a/Å                      | 5.80938(12)            |
| b/Å                      | 17.8312(3)             |
| c/Å                      | 19.3852(4)             |
| α/°                      | 90                     |
| β/°                      | 90                     |
| γ/°                      | 90                     |
| V/Å^{3}                  | 2008.09(7)             |
| Z                         | 4                      |
| Z'                        | 1                      |
| Wavelength/Å              | 1.54184                |
| Radiation type           | Cu Kα                  |
| θ_{min}/°                | 3.368                  |
| θ_{max}/°                | 72.663                 |
| Measured Refl's.         | 14345                  |
| Ind't Refl's             | 3929                   |
| Refl's with I > 2σ(I)    | 3826                   |
| R_{int}                  | 0.0255                 |
| Parameters               | 273                    |
| Restraints               | 0                      |
| Largest Peak             | 0.180                  |
| Deepest Hole             | -0.155                 |
| Goof                     | 1.048                  |
| wR_{2} (all data)        | 0.0761                 |
| wR_{2}                   | 0.0750                 |
| R_{1} (all data)         | 0.0301                 |
| R_{1}                     | 0.0291                 |
F.2. Single Crystal X-Ray Diffraction for the chiral compound (R,R)-5

Crystals of the compound (R,R)-5 were obtained by slow evaporation of an hexane/diethyl ether (10:1) solution.

Data Acquisition: Single clear pale colourless prism crystals of (R,R)-5 were used as supplied. A suitable crystal with dimensions 0.23 \times 0.17 \times 0.09 \text{ mm}^3 was selected and mounted on a SuperNova, Dual, Cu at home/near, AtlasS2 diffractometer. The crystal was kept at a steady $T = 140.00(10)$ K during data collection. The structure was solved with the SherXT (Sheldrick, 2015) solution program using dual methods and by using Olex2 (Dolomanov et al., 2009) as the graphical interface. The model was refined with ShelXL 2018/3 (Sheldrick, 2015) using full matrix least squares minimisation on $F^2$.

Scheme 21: Crystal data and structure refinement for 5. CCDC2020479
**Compound**  
$(R,R)$-5

| Property                        | Value                          |
|--------------------------------|--------------------------------|
| Formula                        | $C_{18}H_{18}F_3NO$            |
| $D_{calc}$ (g cm$^{-3}$)        | 1.357                          |
| $\mu$ (mm$^{-1}$)               | 0.916                          |
| Formula Weight                 | 321.33                         |
| Colour                         | clear pale colourless          |
| Shape                          | prism                          |
| Size (mm$^3$)                  | 0.23×0.17×0.09                 |
| $T$ (K)                        | 140.00(10)                     |
| Crystal System                 | orthorhombic                   |
| Flack Parameter                | 0.01(7)                        |
| Hooft Parameter                | 0.05(5)                        |
| Space Group                    | $P2_12_12_1$                   |
| $a$ (Å)                        | 5.83034(13)                    |
| $b$ (Å)                        | 8.00767(18)                    |
| $c$ (Å)                        | 33.6790(7)                     |
| $\alpha$ (°)                   | 90                             |
| $\beta$ (°)                    | 90                             |
| $\gamma$ (°)                   | 90                             |
| $V$ (Å$^3$)                    | 1572.38(6)                     |
| $Z$                             | 4                              |
| $Z'$                           | 1                              |
| Wavelength (Å)                 | 1.54184                        |
| Radiation type                 | Cu Kα                         |
| $\theta_{min}$ (°)             | 5.253                          |
| $\theta_{max}$ (°)             | 72.678                         |
| Measured Refl's.               | 3094                           |
| Ind't Refl's.                  | 3094                           |
| Refl's with $I > 2\sigma(I)$   | 2974                           |
| $R_{int}$                      |                                |
| Parameters                     | 218                            |
| Restraints                     | 0                              |
| Largest Peak                   | 0.336                          |
| Deepest Hole                   | -0.220                         |
| GoOF                           | 1.120                          |
| $wR_2$ (all data)              | 0.1374                         |
| $wR_2$                         | 0.1360                         |
| $R_1$ (all data)               | 0.0468                         |
| $R_1$                          | 0.0454                         |
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H. NMR Spectra

H.1. Starting Materials

[Diagram of NMR spectra with chemical structures]
H.2. Carboetherification Products
$^1$H NMR (300 MHz, Chloroform-d)

$^13$C NMR (75 MHz, Chloroform-d)

21

F3C12

O

Ph

Br

NMe2
H.3. Asymmetric Hydrogenation Products
3F NMR (376 MHz, Chloroform)

1H NMR (400 MHz, Chloroform)
$\text{HF NMR (376 MHz, Methanol)}$
I. HPLC Traces

I.1. Carboetherification Products

Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

![HPLC Trace 1]

| Peak | Ret Time | Type | Width | Area   | Height | Area % |
|------|----------|------|-------|--------|--------|--------|
| 1    | 6.958    | MM   | 0.161 | 3628.49634 | 374.27448 | 49.9733 |
| 2    | 8.491    | MM   | 0.1942 | 3632.37891 | 311.69940 | 50.0267 |

![HPLC Trace 2]

| Peak | Ret Time | Type | Width | Area   | Height | Area % |
|------|----------|------|-------|--------|--------|--------|
| 1    | 6.921    | MM   | 0.1587 | 354.93954 | 37.28573 | 3.2628 |
| 2    | 8.389    | MM   | 0.1949 | 1.05236e4 | 900.04584 | 96.7372 |
### Table 1

| # | RetTime [min] | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---------------|-------------|--------------|--------------|--------|
| 1 | 6.947 MM      | 0.1581      | 571.80402    | 60.28956     | 3.3226 |
| 2 | 8.572 MM      | 0.1961      | 1.66379e4    | 1414.37622   | 96.6774 |

### Table 2

| # | RetTime [min] | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---------------|-------------|--------------|--------------|--------|
| 1 | 6.980 MM      | 0.1634      | 1.51288e4    | 1543.46191   | 96.1531 |
| 2 | 8.605 MM      | 0.1957      | 605.27081    | 51.55163     | 3.8469  |
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm

| Peak | RetTime | Type | Width | Area    | Height | Area   |
|------|---------|------|-------|---------|--------|--------|
| 1    | 7.525   | MM   | 0.1801| 9505.87305 | 879.81122 | 49.8789 |
| 2    | 8.831   | MM   | 0.2139| 9552.04980  | 744.29962  | 50.1211 |

| Peak | RetTime | Type | Width | Area    | Height | Area   |
|------|---------|------|-------|---------|--------|--------|
| 1    | 6.985   | MM   | 0.1651| 925.22040 | 93.38676 | 5.2942  |
| 2    | 8.079   | MM   | 0.1962| 1.65508e4 | 1406.06726 | 94.7058 |
| Peak | RetTime | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area %   |
|------|---------|------|-------------|--------------|--------------|----------|
| 1    | 7.557   | MM   | 0.1836      | 1.20346e4    | 1092.29956   | 94.4177  |
| 2    | 8.978   | MM   | 0.2149      | 711.52716    | 55.18419    | 5.5823   |
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| Peak | RetTime | Type | Width | Area | Height | Area % |
|------|---------|------|-------|------|--------|-------|
| 1    | 10.669  | MM   | 0.2940| 6369.04639 | 361.04782 | 50.2446 |
| 2    | 22.154  | MM   | 0.6692| 6307.02979 | 157.08136 | 49.7554 |

| Peak | RetTime | Type | Width | Area | Height | Area % |
|------|---------|------|-------|------|--------|-------|
| 1    | 10.867  | MM   | 0.2815| 350.62244 | 20.76242 | 4.1984 |
| 2    | 22.624  | MM   | 0.7010| 8000.62646 | 190.21245 | 95.8016 |
**Chiral HPLC** Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

### Peak RetTime Type Width Area Height Area

| #   | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area [%] |
|-----|---------------|------|-------------|--------------|--------------|---------|
| 1   | 6.761         | MM   | 0.1538      | 2071.27759   | 224.46736    | 50.3244 |
| 2   | 9.460         | MM   | 0.2180      | 2044.57129   | 156.34639    | 49.6756 |

---

### Peak RetTime Type Width Area Height Area

| #   | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area [%] |
|-----|---------------|------|-------------|--------------|--------------|---------|
| 1   | 6.771         | MM   | 0.1575      | 497.08813    | 52.59796     | 6.1878  |
| 2   | 9.413         | MM   | 0.2209      | 7536.27637   | 568.60547    | 93.8122 |
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm

Peak RetTime Type Width Area Height Area %
---|------|--------|--------|---------|
1 6.484 MM 0.1503 7136.85303 791.44922 50.4404
2 8.172 MM 0.1881 7012.22314 621.23798 49.5596
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

Peak RetTime Type Width Area Height Area %
# [min] [min] [mAU*s] [mAU] %
---|-----|-----|--------|--------|-----|
1 6.847 MM 0.1595 8062.17871 842.56726 49.3697
2 9.145 MM 0.2182 8268.05176 631.66949 50.6303

Peak RetTime Type Width Area Height Area %
# [min] [min] [mAU*s] [mAU] %
---|-----|-----|--------|--------|-----|
1 6.851 MM 0.1575 590.49353 62.46822 5.1965
2 9.125 MM 0.2194 1.07729e4 818.30353 94.8035
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| Peak | RetTime | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|------|---------|------|-------------|--------------|--------------|--------|
| 1    | 8.326   | MM   | 0.2000      | 7839.51660   | 653.35144    | 50.0597|
| 2    | 10.472  | MM   | 0.2542      | 7820.83252   | 512.85229    | 49.9403|

| Peak | RetTime | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|------|---------|------|-------------|--------------|--------------|--------|
| 1    | 8.354   | MM   | 0.1947      | 1899.26680   | 162.59052    | 9.0407 |
| 2    | 10.425  | MM   | 0.2634      | 1.91087e4    | 1209.06799   | 90.9593|
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

Peak RetTime Type Width Area Height Area %
# [min] [min] [mAU*s] [mAU] %
--- | ------ | ------ | ---------------- | -------------- | ------ |
1 7.742 MM 0.1828 9203.80078 839.20245 50.1310
2 9.971 MM 0.2326 9155.71582 656.00647 49.8690
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm

| Peak | RetTime | Width  | Area          | Height         | Area%  |
|------|---------|--------|---------------|----------------|--------|
| 1    | 6.622   | MM     | 0.1556        | 4245.32275     | 454.70941 | 50.0146 |
| 2    | 7.398   | MM     | 0.1721        | 4242.84326     | 411.00439 | 49.9854 |

Peak RetTime Type Width Area Height Area

| Peak | RetTime | Width  | Area          | Height         | Area%  |
|------|---------|--------|---------------|----------------|--------|
| 1    | 6.620   | MM     | 0.1539        | 350.33701      | 37.93580 | 9.9967  |
| 2    | 7.375   | MM     | 0.1714        | 3154.18433     | 306.79001 | 90.0033 |
**Chiral HPLC** Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

### Peak RetTime Type Width Area Height Area %

| #  | RetTime | Width | Area     | Height   | Area     | %     |
|----|---------|-------|----------|----------|----------|-------|
| 1  | 5.830   | MM    | 0.1392   | 2834.70654 | 339.38593 | 49.8758 |
| 2  | 7.180   | MM    | 0.1670   | 2848.82788 | 284.33942 | 50.1242 |

### Peak RetTime Type Width Area Height Area %

| #  | RetTime | Width | Area     | Height   | Area     | %     |
|----|---------|-------|----------|----------|----------|-------|
| 1  | 5.840   | MM    | 0.1439   | 615.85376 | 71.33194 | 4.5763 |
| 2  | 7.177   | MM    | 0.1698   | 1.28417e4 | 1260.57019 | 95.4237 |
Chiral HPLC Daicel Chiralpak IB N-5 column: 90:10 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area [%]   |
|---|---------------|------|-------------|--------------|--------------|------------|
| 1 | 10.416        | BV   | 0.2408      | 7469.38916   | 471.64029    | 50.2664    |
| 2 | 11.161        | VB   | 0.2802      | 7390.22656   | 402.44556    | 49.7336    |

![Chiral HPLC graph 1](image1)

| # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area [%]   |
|---|---------------|------|-------------|--------------|--------------|------------|
| 1 | 10.418        | BV   | 0.2360      | 8751.86426   | 561.00800    | 75.8087    |
| 2 | 11.197        | VB   | 0.2798      | 2792.81055   | 152.41017    | 24.1913    |

![Chiral HPLC graph 2](image2)
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

**Table 1:**

| Peak | Ret Time | Type | Width | Area | Height | Area % |
|------|----------|------|-------|------|--------|-------|
| 1    | 8.072    | MM   | 0.1940 | 3102.10669 | 266.51071 | 49.9286 |
| 2    | 13.678   | MM   | 0.3301 | 3110.97852 | 157.06339 | 50.0714 |

**Table 2:**

| Peak | Ret Time | Type | Width | Area | Height | Area % |
|------|----------|------|-------|------|--------|-------|
| 1    | 8.264    | MM   | 0.1699 | 899.26599 | 88.19818 | 11.7464 |
| 2    | 13.929   | MM   | 0.4756 | 6756.37939 | 236.79008 | 88.2536 |
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

### Table 1

| # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area [%] |
|---|---------------|------|-------------|--------------|--------------|----------|
| 1 | 5.561         | MM   | 0.1247      | 7885.49609   | 1054.21460   | 49.5335  |
| 2 | 6.366         | MM   | 0.1383      | 8034.02002   | 968.16638    | 50.4665  |

### Table 2

| # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area [%] |
|---|---------------|------|-------------|--------------|--------------|----------|
| 1 | 5.548         | MM   | 0.1183      | 2105.70093   | 296.70862    | 13.9735  |
| 2 | 6.338         | MM   | 0.1413      | 1.29635e4    | 1529.33142   | 86.0265  |
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| Peak | RetTime | Type | Width | Area [mAU*s] | Height [mAU] | Area % |
|------|---------|------|-------|--------------|--------------|-------|
| 1    | 6.351   | MM   | 0.1471| 4125.28027   | 467.41537    | 49.3017 |
| 2    | 7.021   | MM   | 0.1588| 4242.14063   | 445.31125    | 50.6983 |

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| Peak | RetTime | Type | Width | Area [mAU*s] | Height [mAU] | Area % |
|------|---------|------|-------|--------------|--------------|-------|
| 1    | 6.303   | MM   | 0.1435| 530.75311    | 61.65509     | 6.8972 |
| 2    | 6.922   | MM   | 0.1580| 7164.47070   | 755.93610    | 93.1028 |
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

### Peak RetTime Type Width Area Height Area

| # | RetTime [min] | Width [min] | Area [mAU*s] | Height [mAU] | Area [%] |
|---|---------------|-------------|--------------|--------------|---------|
| 1 | 5.000 MM      | 0.1132      | 4348.69385   | 640.41498    | 49.3970 |
| 2 | 5.784 MM      | 0.1271      | 4454.86377   | 584.20685    | 50.6030 |

### Peak RetTime Type Width Area Height Area

| # | RetTime [min] | Width [min] | Area [mAU*s] | Height [mAU] | Area [%] |
|---|---------------|-------------|--------------|--------------|---------|
| 1 | 4.993 MM      | 0.1057      | 657.39233    | 103.61166    | 10.9158 |
| 2 | 5.755 MM      | 0.1275      | 5365.02002   | 701.19641    | 89.0842 |
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area [%] |
|---|---------------|------|-------------|--------------|--------------|----------|
| 1 | 9.849         | MF   | 0.2581      | 1.45062e4    | 936.69727    | 50.2952  |
| 2 | 14.916        | FM   | 0.3703      | 1.43360e4    | 645.21008    | 49.7048  |

Peak RetTime Type Width Area Height Area
# [min] [min] [mAU*s] [mAU] %
---|------|-----|--------|--------|----------|
1 9.878 MF 0.2531 1334.90137 87.88715 5.6204 |
2 14.727 FM 0.3773 2.24159e4 990.31799 94.3796 |
**Chiral HPLC** Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

Peak RetTime Type Width Area Height Area %

| # | RetTime | Width | Area     | Height   | Area     | %  |
|---|---------|-------|----------|----------|----------|----|
| 1 | 9.850   | MM    | 0.2668   | 6702.1850| 418.64359| 50.1204|
| 2 | 14.847  | MM    | 0.3783   | 6669.9780| 293.84787| 49.8796|

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Peak RetTime Type Width Area Height Area %

| # | RetTime | Width | Area     | Height   | Area     | %  |
|---|---------|-------|----------|----------|----------|----|
| 1 | 9.895   | MM    | 0.2570   | 477.36749| 30.95416| 3.1052|
| 2 | 14.639  | MM    | 0.3806   | 1.48958e4| 652.33496| 96.8948|
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254 \text{ nm}$

| #  | RetTime [min] | Width [min] | Area [mAU*s] | Height [mAU] | Area %  |
|----|---------------|------------|--------------|--------------|---------|
| 1  | 10.898        | MM         | 0.2708       | 1.09375e4    | 673.26398 | 49.1741 |
| 2  | 12.293        | MM         | 0.2970       | 1.13049e4    | 634.33032 | 50.8259 |

Peaks RetTime Type Width Area Height Area

| #  | RetTime [min] | Width [min] | Area [mAU*s] | Height [mAU] | Area %  |
|----|---------------|------------|--------------|--------------|---------|
| 1  | 10.670        | MM         | 0.2543       | 976.98279    | 64.04114 | 8.6508  |
| 2  | 12.127        | MM         | 0.2817       | 1.03166e4    | 610.32190 | 91.3492 |
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

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**Peak RetTime Type Width Area Height Area %**

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1. 9.909  MM  0.2343  7573.24756  538.81549  50.5310
2. 11.692  MM  0.2657  7414.08154  465.09402  49.4690

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**Peak RetTime Type Width Area Height Area %**

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1. 10.058  MM  0.2288  1460.80383  106.40328  8.2881
2. 11.880  MM  0.2883  1.61644e4  934.54388  91.7119
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| Peak | RetTime | Type | Width | Area   | Height | Area %  |
|------|---------|------|-------|--------|--------|---------|
| #    | [min]   | [min]| [mAU*s] | [mAU]   |        |         |
| 1    | 11.016  | MM   | 0.2752 | 6545.02051 | 396.44269 | 50.8179 |
| 2    | 12.942  | MM   | 0.3037 | 6334.33740 | 347.65237 | 49.1821 |

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| Peak | RetTime | Type | Width | Area   | Height | Area %  |
|------|---------|------|-------|--------|--------|---------|
| #    | [min]   | [min]| [mAU*s] | [mAU]   |        |         |
| 1    | 10.384  | MM   | 0.2560 | 972.89252 | 63.33549 | 9.6901  |
| 2    | 11.899  | MM   | 0.2822 | 9067.21387 | 535.55524 | 90.3099 |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|--------------|------|-------------|--------------|--------------|-------|
| 1 | 6.756        | MM   | 0.1527      | 5149.52881   | 562.19830    | 49.8628 |
| 2 | 7.461        | MM   | 0.1722      | 5177.86914   | 501.17307    | 50.1372 |

| # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|--------------|------|-------------|--------------|--------------|-------|
| 1 | 6.781        | MM   | 0.1547      | 1.11928e4    | 1205.74072   | 86.6054 |
| 2 | 7.501        | MM   | 0.1699      | 1731.10864   | 169.82246    | 13.3946 |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| Peak | RetTime | Type | Width | Area [mAU*s] | Height [mAU] | Area [%] |
|------|---------|------|-------|--------------|--------------|----------|
| 1    | 6.225   | MM   | 0.1430| 9288.00586   | 1082.22388   | 50.0764  |
| 2    | 7.087   | MM   | 0.1676| 9259.65234   | 920.65900    | 49.9236  |

| Peak | RetTime | Type | Width | Area [mAU*s] | Height [mAU] | Area [%] |
|------|---------|------|-------|--------------|--------------|----------|
| 1    | 6.221   | MM   | 0.1443| 8288.71094   | 957.65491    | 91.0758  |
| 2    | 7.091   | MM   | 0.1652| 812.18579    | 81.92288     | 8.9242   |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, \( \lambda = 254 \) nm

| Peak RetTime Type Width Area Height Area |
|---|---|---|---|---|
| # | [min] | [min] | [mAU*s] | [mAU] | % |
| 1 | 6.983 | MM | 0.1613 | 6178.28027 | 638.23871 | 49.8401 |
| 2 | 7.860 | MM | 0.1855 | 6217.93066 | 558.66156 | 50.1599 |

| Peak RetTime Type Width Area Height Area |
|---|---|---|---|---|
| # | [min] | [min] | [mAU*s] | [mAU] | % |
| 1 | 6.796 | MM | 0.1566 | 2.09868e4 | 2233.08179 | 90.0551 |
| 2 | 7.546 | MM | 0.1697 | 2317.60913 | 227.63397 | 9.9449 |
**Chiral HPLC** Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| Peak | RetTime | Type | Width | Area   | Height | Area %  |
|------|---------|------|-------|--------|--------|---------|
| 1    | 8.382   | MF   | 0.1941| 8492.19434| 729.13214| 48.7614 |
| 2    | 10.453  | FM   | 0.2488| 8923.62988| 597.71075| 51.2386 |

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**Chiral HPLC** Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| Peak | RetTime | Type | Width | Area   | Height | Area %  |
|------|---------|------|-------|--------|--------|---------|
| 1    | 8.453   | MM   | 0.1913| 1344.32251| 117.11890| 9.0544  |
| 2    | 10.506  | MM   | 0.2481| 135029e4 | 907.05493| 90.9456 |
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm

| #  | RetTime | Type | Width  | Area  | Height | Area % |
|----|---------|------|--------|-------|--------|--------|
| 1  | 7.239   | MM   | 0.1648 | 7700.02246 | 778.92145 | 47.5347 |
| 2  | 8.458   | MM   | 0.1905 | 8498.70996 | 743.38043 | 52.4653 |

Peak RetTime Type Width Area Height Area %
1 7.278 MM 0.1668 1660.55542 165.88861 13.2315
2 8.475 MM 0.1903 1.08894e4 953.67273 86.7685
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm

| Peak | RetTime | Type | Width | Area  | Height | Area % |
|------|---------|------|-------|-------|--------|--------|
| 1    | 5.126   | MM   | 0.1181| 8020.22705| 1132.02124| 49.8614 |
| 2    | 6.461   | MM   | 0.1543| 8064.80762| 871.38739 | 50.1386 |

Peak RetTime Type Width Area  Height Area %
#   [min]   [min] [mAU*s] [mAU]    %
---|--------|------|-------|--------|--------|
1  5.005 MM  0.0972  439.42377  75.32863  3.9253
2  6.188 MM  0.1534  1.07553e4 1168.46960 96.0747
Chiral HPLC Daicel Chiralpak IB N-5 column: 90:10 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| Peak | RetTime | Type | Width | Area     | Height | Area % |
|------|---------|------|-------|----------|--------|--------|
| 1    | 10.613  | MM   | 0.2771| 6940.34229| 417.39124| 49.8338|
| 2    | 19.866  | MM   | 0.5154| 6986.64111| 225.94112| 50.1662|

| Peak | RetTime | Type | Width | Area     | Height | Area % |
|------|---------|------|-------|----------|--------|--------|
| 1    | 10.661  | MM   | 0.2700| 2962.23584| 182.83882| 10.2550|
| 2    | 19.789  | MM   | 0.5373| 2.59234e4 | 804.11737| 89.7450|
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm

| Peak | RetTime | Type | Width | Area  | Height | Area % |
|------|---------|------|-------|-------|--------|--------|
| 1    | 9.255   | MM   | 0.2170| 6108.25830 | 469.16779 | 50.2505 |
| 2    | 10.580  | MM   | 0.2339| 6047.34961 | 430.89670 | 49.7495 |

| Peak | RetTime | Type | Width | Area  | Height | Area % |
|------|---------|------|-------|-------|--------|--------|
| 1    | 9.061   | MM   | 0.2129| 957.70569 | 74.95567 | 6.5349 |
| 2    | 10.218  | MM   | 0.2336| 1.36975e4 | 977.10193 | 93.4651 |
Chiral HPLC Daicel Chiralpak IA column: 99.75:0.25 hexane/IPA, flow rate 1 mL/min, $\lambda = 254$ nm

| Peak | RetTime | Type | Width [min] | Area [mAU*] | Height [mAU] | Area % |
|------|---------|------|-------------|-------------|--------------|--------|
| 1    | 5.144   | BV   | 0.1056      | 4701.87695  | 672.19818    | 48.8437|
| 2    | 5.470   | VB   | 0.1260      | 4924.50293  | 586.52747    | 51.1563|

| Peak | RetTime | Type | Width [min] | Area [mAU*] | Height [mAU] | Area % |
|------|---------|------|-------------|-------------|--------------|--------|
| 1    | 5.140   | MM   | 0.1166      | 486.41333   | 69.51125     | 3.7468 |
| 2    | 5.436   | MM   | 0.1384      | 1.24958e4   | 1505.25439   | 96.2532|
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm

| Peak | RetTime | Type | Width | Area  | Height | Area   | %     |
|------|---------|------|-------|-------|--------|--------|-------|
| 1    | 6.199   | MM   | 0.164 | 1.42175e4 | 1439.49976 | 50.2965 |       |
| 2    | 11.281  | MM   | 0.3992 | 1.40499e4 | 586.51587 | 49.7035 |       |

![Chiral HPLC Peaks](image1)

| Peak | RetTime | Type | Width | Area  | Height | Area   | %     |
|------|---------|------|-------|-------|--------|--------|-------|
| 1    | 6.153   | MM   | 0.1642 | 1.26317e4 | 1282.25012 | 77.0484 |       |
| 2    | 11.595  | MM   | 0.3531 | 3762.79053 | 177.60005 | 22.9516 |       |

![Chiral HPLC Peaks](image2)
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, λ = 254 nm

### Peak RetTime Type Width Area Height Area %

| # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|--------------|------|-------------|--------------|--------------|--------|
| 1 | 9.517        | VB    | 0.2123      | 4588.63281   | 329.88892    | 49.5091 |
| 2 | 13.419       | BB    | 0.3125      | 4679.63574   | 228.90796    | 50.4909 |

### Peak RetTime Type Width Area Height Area %

| # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|--------------|------|-------------|--------------|--------------|--------|
| 1 | 9.422        | MM    | 0.2281      | 649.89478    | 47.48665     | 5.4671 |
| 2 | 13.079       | BB    | 0.3096      | 1.12374e4    | 547.06708    | 94.5329 |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, \( \lambda = 210 \text{ nm} \)

| Peak | RetTime | Type | Width | Area    | Height | Area % |
|------|---------|------|-------|---------|--------|--------|
| 1    | 8.139   | MM   | 0.1870| 6750.12305 | 601.65063 | 50.1801 |
| 2    | 12.438  | MM   | 0.2923| 6701.67676 | 382.18515 | 49.8199 |

| Peak | RetTime | Type | Width | Area    | Height | Area % |
|------|---------|------|-------|---------|--------|--------|
| 1    | 8.162   | MM   | 0.1971| 2.09826e4 | 1773.85559 | 97.2537 |
| 2    | 12.513  | MM   | 0.2945| 592.52631 | 33.52852  | 2.7463  |

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| Peak | RetTime | Type | Width | Area   | Height  | Area   | %     |
|------|---------|------|-------|--------|---------|--------|-------|
| 1    | 7.788   | MM   | 0.1788| 1121.83972 | 104.57675 | 4.1191 |       |
| 2    | 11.646  | MM   | 0.2773| 2.61135e4  | 1569.22839 | 95.8809 |       |

| Peak | RetTime | Type | Width | Area   | Height  | Area   | %     |
|------|---------|------|-------|--------|---------|--------|-------|
| 1    | 8.223   | MM   | 0.1898| 1.09941e4 | 965.64703 | 96.3288 |       |
| 2    | 12.596  | MM   | 0.2552| 419.00122 | 27.36468  | 3.6712  |       |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm

| Peak | RetTime | Type | Width  | Area       | Height      | Area%  |
|------|---------|------|--------|------------|-------------|--------|
| #    | [min]   |      | [min]  | [mAU*s]    | [mAU]       |        |
| 1    | 7.707   | BB   | 0.1689 | 1.66268e4  | 1505.27429  | 49.6362 |
| 2    | 10.929  | MM   | 0.2652 | 1.68705e4  | 1060.31323  | 50.3638 |

| Peak | RetTime | Type | Width  | Area       | Height      | Area%  |
|------|---------|------|--------|------------|-------------|--------|
| #    | [min]   |      | [min]  | [mAU*s]    | [mAU]       |        |
| 1    | 7.722   | BB   | 0.1670 | 1.10836e4  | 1018.06122  | 94.4899 |
| 2    | 10.969  | BB   | 0.2390 | 646.32837  | 41.20693   | 5.5101  |
| Peak RetTime | Type | Width   | Area   | Height  | Area % |
|------------|------|---------|--------|---------|--------|
| #          | [min]| [min]   | [mAU*s]| [mAU]   |        |
|-------------|------|---------|--------|---------|--------|
| 1           | 7.749| BB      | 0.1644 | 492.49951| 45.44075| 5.3055 |
| 2           | 10.913| MM     | 0.2449 | 8790.36035| 598.13947| 94.6945 |
I.2. Asymmetric Hydrogenation Products

**Chiral HPLC** Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

### Peak RetTime Type Width Area Height Area

| # | RetTime [min] | Type | Width [min] | Area [mAU*sec] | Height [mAU] | Area % |
|---|--------------|------|-------------|----------------|--------------|-------|
| 1 | 10.209       | BB   | 0.2240      | 3224.11084    | 218.68341    | 49.4854 |
| 2 | 15.667       | BB   | 0.3679      | 3291.16724    | 136.19072    | 50.5146 |

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### Peak RetTime Type Width Area Height Area

| # | RetTime [min] | Type | Width [min] | Area [mAU*sec] | Height [mAU] | Area % |
|---|--------------|------|-------------|----------------|--------------|-------|
| 1 | 10.158       | BB   | 0.2291      | 1.84721e4     | 1230.68018   | 95.9072 |
| 2 | 15.671       | BB   | 0.3723      | 788.29559     | 32.34998     | 4.0928  |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

### Peak RetTime Type Width Area Height Area %
| #  | RetTime [min] | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|----|---------------|-------------|--------------|--------------|-------|
| 1  | 9.466         | 0.2144      | 1396.00537   | 99.07581     | 49.9158 |
| 2  | 11.840        | 0.2922      | 1400.71436   | 79.88445     | 50.0842 |

### Peak RetTime Type Width Area Height Area %
| #  | RetTime [min] | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|----|---------------|-------------|--------------|--------------|-------|
| 1  | 9.270         | 0.2330      | 1.59401e4    | 1005.11450   | 94.0368 |
| 2  | 11.813        | 0.2631      | 1010.81848   | 59.24051     | 5.9632 |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

| Peak | RetTime | Type | Width | Area   | Height | Area % |
|------|---------|------|-------|--------|--------|--------|
| 1    | 9.808   | BV R | 0.2199| 5136.28760 | 345.08109 | 50.4463 |
| 2    | 12.988  | BB   | 0.2750| 5045.40527 | 281.61697 | 49.5537 |

| Peak | RetTime | Type | Width | Area   | Height | Area % |
|------|---------|------|-------|--------|--------|--------|
| 1    | 9.698   | BB   | 0.2234| 9107.40918 | 612.70685 | 95.5348 |
| 2    | 12.799  | MM   | 0.2844| 425.66833 | 24.94544  | 4.4652  |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 230$ nm

| Peak | RetTime | Type | Width | Area     | Height  | Area % |
|------|---------|------|-------|----------|---------|--------|
| 1    | 8.446   | BB   | 0.2156| 3278.09863| 230.99530| 49.7995 |
| 2    | 13.375  | BB   | 0.3207| 3304.48853| 157.54460| 50.2005 |

Peaks at 8.979 min (MM) and 13.838 min (BB) with areas and heights.

Percentages of areas and heights calculated.
**Chiral HPLC** Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 230 nm

| Peak | RetTime | Type | Width | Area  | Height | Area     |
|------|---------|------|-------|-------|--------|----------|
| #    | [min]   |      | [min] | [mAU*s] | [mAU] | %        |
|------|---------|------|-------|--------|--------|----------|
| 1    | 5.853   | MM   | 0.1374 | 1623.43127 | 196.94261 | 49.7401  |
| 2    | 9.206   | BB   | 0.2001 | 1640.39392 | 125.81128 | 50.2599  |

**Chiral HPLC** Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 230 nm

| Peak | RetTime | Type | Width | Area  | Height | Area     |
|------|---------|------|-------|-------|--------|----------|
| #    | [min]   |      | [min] | [mAU*s] | [mAU] | %        |
|------|---------|------|-------|--------|--------|----------|
| 1    | 5.787   | BB   | 0.1268 | 4301.36572 | 518.57843 | 95.3091  |
| 2    | 8.947   | BB   | 0.1915 | 211.70566 | 16.97226  | 4.6909   |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

| Peak | RetTime | Type | Width | Area  | Height | Area % |
|------|---------|------|-------|-------|--------|--------|
| 1    | 7.750   | BB   | 0.1816| 5410.29150 | 445.90652 | 49.7336 |
| 2    | 9.316   | BB   | 0.2174| 5468.25977 | 376.52570 | 50.2664 |

Peak RetTime | Width | Area  | Height | Area % |
|--------------|-------|-------|--------|--------|
| 1            | 7.749 | 0.2013| 1.02085e4 | 845.34601 | 86.1001 |
| 2            | 9.276 | 0.2287| 1648.04089 | 120.09613 | 13.8999 |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm

| Peak | RetTime | Type | Width | Area   | Height | Area %  |
|------|---------|------|-------|--------|--------|---------|
| 1    | 7.169   | VB   | 0.1568| 7981.02490| 768.78271| 51.1646 |
| 2    | 11.368  | BB   | 0.2398| 7617.70557| 488.75272| 48.8354 |

| Peak | RetTime | Type | Width | Area   | Height | Area %  |
|------|---------|------|-------|--------|--------|---------|
| 1    | 7.108   | MM   | 0.1670| 9389.86133| 937.36621| 93.2531 |
| 2    | 11.430  | BB   | 0.2440| 679.36102 | 43.07292 | 6.7469  |
**Chiral HPLC** Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

| Peak | RetTime | Type | Width | Area  | Height | Area  | %   |
|------|---------|------|-------|-------|--------|-------|-----|
| 1    | 7.097   | MM   | 0.1538| 3227.70947 | 349.74594 | 50.4548 |
| 2    | 9.207   | MM   | 0.1955| 3169.52344 | 270.25354 | 49.5452 |

| Peak | RetTime | Type | Width | Area  | Height | Area  | %   |
|------|---------|------|-------|-------|--------|-------|-----|
| 1    | 7.074   | BB   | 0.1532| 1.54350e4 | 1536.66870 | 89.0161 |
| 2    | 9.182   | MM   | 0.1983| 1904.55652 | 160.07146 | 10.9839 |
**Chiral HPLC** Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

| Peak | RetTime | Type | Width | Area | Height | Area % |
|------|---------|------|-------|------|--------|--------|
| 1    | 12.627  | MM   | 0.3064| 9387.59863 | 510.63348 | 50.3461 |
| 2    | 20.072  | MM   | 0.4830| 9258.51465 | 319.47153 | 49.6539 |

**Chiral HPLC** Daicel Chiralpak EN TIA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

| Peak | RetTime | Type | Width | Area | Height | Area % |
|------|---------|------|-------|------|--------|--------|
| 1    | 12.589  | MM   | 0.3296| 3.47421e4 | 1756.78882 | 94.8740 |
| 2    | 20.193  | MM   | 0.4811| 1877.10913 | 65.03127 | 5.1260 |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

| #  | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area %  |
|----|---------------|------|-------------|--------------|--------------|--------|
| 1  | 12.067        | MM   | 0.3187      | 1.26426e4    | 661.17914    | 51.5451|
| 2  | 14.119        | MM   | 0.3477      | 1.18847e4    | 569.64447    | 48.4549|

| #  | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area %  |
|----|---------------|------|-------------|--------------|--------------|--------|
| 1  | 12.025        | MM   | 0.3504      | 2.61111e4    | 1241.86218   | 91.5866|
| 2  | 14.186        | MM   | 0.3529      | 2398.63330   | 113.26971    | 8.4134 |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm

| Peak | RetTime | Type | Width | Area   | Height | Area     | %   |
|------|---------|------|-------|--------|--------|----------|-----|
| 1    | 10.749  | MM   | 0.2663| 2.00608e4 | 1255.35925 | 49.4333 |     |
| 2    | 14.183  | MM   | 0.3381| 2.05208e4 | 1011.62799 | 50.5667 |     |

| Peak | RetTime | Type | Width | Area   | Height | Area     | %   |
|------|---------|------|-------|--------|--------|----------|-----|
| 1    | 10.737  | MM   | 0.2706| 2.18301e4 | 1344.68372 | 91.7114 |     |
| 2    | 14.224  | MM   | 0.3314| 1972.94580 | 99.23210  | 8.2886  |     |
Chiral HPLC Daicel Chiralpak IC column: 85:15 hexane/IPA, flow rate 1 mL/min, λ = 210 nm

| Peak | RetTime | Type | Width | Area [mAU*s] | Height | Area [mAU] | %   |
|------|---------|------|-------|--------------|--------|------------|-----|
| 1    | 17.999  | MM   | 1.7199| 9523.80566   | 92.28851 | 50.0670    |     |
| 2    | 24.066  | MM   | 1.8980| 9498.33203   | 83.40444 | 49.9330    |     |

| Peak | RetTime | Type | Width | Area [mAU*s] | Height | Area [mAU] | %   |
|------|---------|------|-------|--------------|--------|------------|-----|
| 1    | 17.354  | MM   | 1.5701| 1.94089e4    | 206.02518| 86.8817    |     |
| 2    | 24.704  | MM   | 1.9329| 2930.55688   | 25.26850 | 13.1183    |     |
**Chiral HPLC**
Daicel Chiralpak IA column: 90:10 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

| Peak | Ret Time [min] | Type | Width [min] | Area [mAU^*s] | Height [mAU] | Area % |
|------|----------------|------|-------------|---------------|-------------|--------|
| 1    | 13.466         | MM   | 0.3438      | 7898.64893    | 382.90601   | 49.6461 |
| 2    | 19.519         | MM   | 0.5082      | 8011.26758    | 262.71729   | 50.3539 |

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**Chiral HPLC**
Daicel Chiralpak IA column: 90:10 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

| Peak | Ret Time [min] | Type | Width [min] | Area [mAU^*s] | Height [mAU] | Area % |
|------|----------------|------|-------------|---------------|-------------|--------|
| 1    | 13.424         | MM   | 0.3626      | 2.62948e4     | 1208.62793  | 90.7176 |
| 2    | 19.601         | MM   | 0.4899      | 2690.53101    | 91.53439    | 9.2824  |
Chiral HPLC Daicel Chiralpak IA column: 80:20 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

| Peak | RetTime Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|------|--------------|-------------|--------------|--------------|--------|
| 1    | 9.073 MM     | 0.2309      | 1.41541e4    | 1021.64856   | 49.9457|
| 2    | 12.924 MM    | 0.3274      | 1.41849e4    | 721.98901    | 50.0543|

| Peak | RetTime Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|------|--------------|-------------|--------------|--------------|--------|
| 1    | 9.075 MM     | 0.2432      | 2.93592e4    | 2011.60852   | 89.7626|
| 2    | 12.950 MM    | 0.3294      | 3348.38770   | 169.44325    | 10.2374|
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 210 nm

| Peak | RetTime | Type | Width | Area [mAU*s] | Height [mAU] | Area [%] |
|------|---------|------|-------|--------------|--------------|---------|
| 1    | 9.269   | MM   | 0.2174| 4628.32080   | 354.86615    | 50.0306 |
| 2    | 13.428  | MM   | 0.3182| 4622.65576   | 242.15567    | 49.9694 |

| Peak | RetTime | Type | Width | Area [mAU*s] | Height [mAU] | Area [%] |
|------|---------|------|-------|--------------|--------------|---------|
| 1    | 9.222   | MM   | 0.2491| 3.36605e4    | 2252.25830   | 90.6442 |
| 2    | 13.428  | MM   | 0.3055| 3474.27246   | 189.52641    | 9.3558  |
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, λ = 254 nm

Peak RetTime Type Width Area Height Area
# [min] [min] [mAU*s] [mAU] %
---|------|-----|-------|-----|-----|
1 8.166 MM 0.1788 631.96338 58.90281 52.1335
2 14.122 MM 0.3250 580.23975 29.75735 47.8665

Peak RetTime Type Width Area Height Area
# [min] [min] [mAU*s] [mAU] %
---|------|-----|-------|-----|-----|
1 8.096 MM 0.1890 5202.46631 458.81155 86.2147
2 14.014 MM 0.3175 831.84991 43.66858 13.7853
Chiral HPLC Daicel Chiralpak IA column: 95:5 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

### Peak RetTime Type Width Area Height Area

| #  | RetTime | Type | Width  | Area  | Height | Area  |
|----|---------|------|--------|-------|--------|-------|
| 1  | 6.773   | MM   | 0.1634 | 1.69449e4 | 1728.24072 | 49.3852 |
| 2  | 8.299   | MM   | 0.1987 | 1.73668e4 | 1456.82104 | 50.6148 |

### Peak RetTime Type Width Area Height Area

| #  | RetTime | Type | Width  | Area  | Height | Area  |
|----|---------|------|--------|-------|--------|-------|
| 1  | 6.765   | MM   | 0.1844 | 2.66889e4 | 2411.76831 | 95.9741 |
| 2  | 8.313   | MM   | 0.1797 | 1119.54456 | 103.83485 | 4.0259 |


Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

| Peak | RetTime | Type | Width | Area     | Height   | Area% |
|------|---------|------|-------|----------|----------|-------|
| 1    | 5.196   | BB   | 0.1356| 4445.54395| 500.47305| 50.0060|
| 2    | 6.121   | BB   | 0.1365| 4444.47119| 496.40112| 49.9940|

| Peak | RetTime | Type | Width | Area     | Height   | Area% |
|------|---------|------|-------|----------|----------|-------|
| 1    | 5.178   | MM   | 0.1481| 1.40426e4| 1580.53882| 95.9190|
| 2    | 6.071   | MM   | 0.1387| 597.46625| 71.80195 | 4.0810 |
Chiral HPLC Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

**Peak RetTime Type Width Area Height Area %**

| # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---------------|------|-------------|--------------|--------------|-------|
| 1 | 8.174         | BB   | 0.1844      | 5805.73877   | 475.57748    | 50.2076 |
| 2 | 11.867        | BB   | 0.2702      | 5757.73145   | 322.67889    | 49.7924 |

**Peak RetTime Type Width Area Height Area %**

| # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---------------|------|-------------|--------------|--------------|-------|
| 1 | 8.108         | MM   | 0.2087      | 1.88300e4    | 1504.10010   | 86.7448 |
| 2 | 11.786        | BB   | 0.2707      | 2877.36133   | 160.87352    | 13.2552 |
**Chiral HPLC** Daicel Chiralpak IB N-5 column: 99:1 hexane/IPA, flow rate 1 mL/min, $\lambda = 210$ nm

(Recovered from the reduction)

![Chiral HPLC Chart]

| Peak | RetTime | Width | Area     | Height | Area %  |
|------|---------|-------|----------|--------|---------|
| 1    | 6.011   | MM    | 0.1628   | 9370   | 93945   | 959.58252 | 62.3142   |
| 2    | 11.323  | MM    | 0.3742   | 5667   | 27588   | 252.38786 | 37.6858   |
Chiral HPLC Daicel Chiralpak IA column: 80:20 hexane/IPA, flow rate 1 mL/min, \( \lambda = 210 \text{ nm} \)

| Peak RetTime | Type | Width | Area   | Height  | Area   | %     |
|--------------|------|-------|--------|---------|--------|-------|
| #            | [min]| [min]| [mAU*s]| [mAU]   |        | %     |
|---------------|------|-------|--------|---------|--------|-------|
| 1             | 8.330| MM    | 0.4435 | 4421.77979 | 166.16771 | 49.5875 |
| 2             | 11.197| MM   | 0.4967 | 4495.35107 | 150.85443 | 50.4125 |

| Peak RetTime | Type | Width | Area   | Height  | Area   | %     |
|--------------|------|-------|--------|---------|--------|-------|
| #            | [min]| [min]| [mAU*s]| [mAU]   |        | %     |
|---------------|------|-------|--------|---------|--------|-------|
| 1             | 8.174| MM    | 0.4213 | 1.84004e4 | 727.84509 | 96.9100 |
| 2             | 11.355| MM   | 0.5534 | 586.70251 | 17.67097 | 3.0900 |

S200