Electronic Supplementary Material (ESI) for Chemical Communications.

Table of Contents

1. General information:

1.1 Analytical methods

All IR spectra were measured on a Jasco FT-IR 4600 spectrometer. The NMR spectra were recorded with a Bruker Avance NEO 400 spectrometer (^{1}H: 400 MHz, ^{13}C: 101 MHz, ^{19}F: 376 MHz, ^{31}P: 162 MHz), DMX 500 spectrometer (^{1}H: 500 MHz) and DRX 600 spectrometer (^{1}H: 600 MHz, ^{13}C: 151 MHz, ^{31}P: 243 MHz). All measurements were performed at room temperature, using [D]-chloroform ($CDCl_3$) or [D_6]-dimethylsulfoxide (DMSO-d_6) as solvents. The chemical shifts are referenced relative to the residual proton signals of the solvents in the ^{1}H-NMR ($CDCl_3$: δ = 7.26 ppm, DMSO-d_6: δ = 2.50 ppm) or relative to the solvent signal in the ^{13}C-NMR ($CDCl_3$: δ = 77.16 ppm, DMSO-d_6: δ = 39.51 ppm). The apparent coupling constants are given in Hertz. The description of the fine structure means: s = singlet, br s = broad singlet, d = doublet, t = triplet, tt = triplet of triplets, quint. = quintuplet, hept.= heptet, m = multiplet. High resolution ESI mass spectra were recorded on a Bruker Maxis 4G spectrometer or a Thermo Scientific Orbitrap LTQ-XL mass spectrometer. Chiral normal phase analytical high-performance liquid chromatography (HPLC) was used for determination of the enantiomeric purity (Erma Degasser ERC-3512, Merck Hitachi Intelligent Pump L-6200A, Knauer Smartline UV Detector 2600 (wavelength: 220 or 254 nm)). The chromatograms were recorded using a DAICEL Chiralpak AD-H column (0.46 × 25 cm) using an eluent of hexane : 2-propanol (80 : 20) at a flow of 0.5 mL/min.

The chromatograms for the rotaxanes (*S,S*)-**2**, (*S,R,S*)-**3** and (*R,R,S*)-**3** were recorded on a reversed phase analytical high-performance liquid chromatography (HPLC) with the following setup: Dionex HPLC system: P680 pump, ASI-100 automated sample injector, UVD-340U UV detector (detection wavelength: 254 nm). The chromatograms were recorded using a YMC-Pack RP-18 column (3.0 x 150 mm, 5 µm, 12 nm) using an eluent of water : MeOH (30:70 to 0:100 + 0.05% TFA).

1.2 Material and methods

Materials

For thin layer chromatography (TLC) analysis throughout this work, Polygram® SIL G/UV254 TLC plates (silica gel 0.2 mm, 40 × 80 mm) were used. Visualization of the spots was carried under a 254 nm UV light source and, if necessary, stained by permanganate, vaniline or ninhydrin solution and heated with a heat gun. The products were purified by flash column chromatography on silica

gel 60M (40-63 µm) which was purchased from MACHEREY-NAGEL GmbH & Co. KG. Some purifications were performed with the use of a Teledyne Isco CombiFlash NextGen 300+ using SiOH 40-63 µm cartridges from MACHEREY-NAGEL GmbH & Co. KG. 3-(Ethylenediamino)-propyl functionalized silica was purchased from Sigma Aldrich.

Solvents

Tetrahydrofuran was freshly distilled from sodium-benzophenone. Dichloromethane was distilled from CaH_2 and stored over molecular sieves under argon. Dimethoxyethane (DME) and aqueous sodium carbonate solution (2 M) were degassed by bubbling with argon for 15 minutes. Solvents for synthetic procedures were used in analytical grade, solvents for aqueous extraction processes or flash column chromatography were of technical grade. Technical grade ethyl acetate and cyclohexane were always distilled before being used for work-ups or columns.

Chemicals

All reactions that needed exclusion of residual air or humidity were performed under an argon inert gas atmosphere using common Schlenk-techniques. Unless otherwise stated, all commercially purchased chemicals were not purified before use.

4-Hydroxyphenylboronic acid, trifluoroacteic acid and ammonium hexafluorophosphate were purchased from Fluorochem. Cesium carbonate was purchased from Carbolution. Propargyl bromide (80% in toluene) was purchased from Alfa Aesar. Hydrogen chloride (1 mol/L in diethylether), sodium hydride, tetrakis(acetonitrile)copper(I)hexafluorophosphate and (*rac*)-Binaphthyldiyl hydrogen phosphate were purchased from TCI. Lithium hydroxide and trans-cinnamaldehyde were purchased from Acros. Dibenzylamine was purchased from ABCR. Tetrakis(triphenylphospine)palladium(0) and diethyl malonate were purchased from Sigma-Aldrich.Compounds (*S*)-**4**[2], (*S*)-**8**[3], (*R*)-**8**[3] and **9**[1,3b] were prepared according to literature procedures.

2. Synthetic procedures

2.1 Overview

Synthesis of BINOL based amine and thread

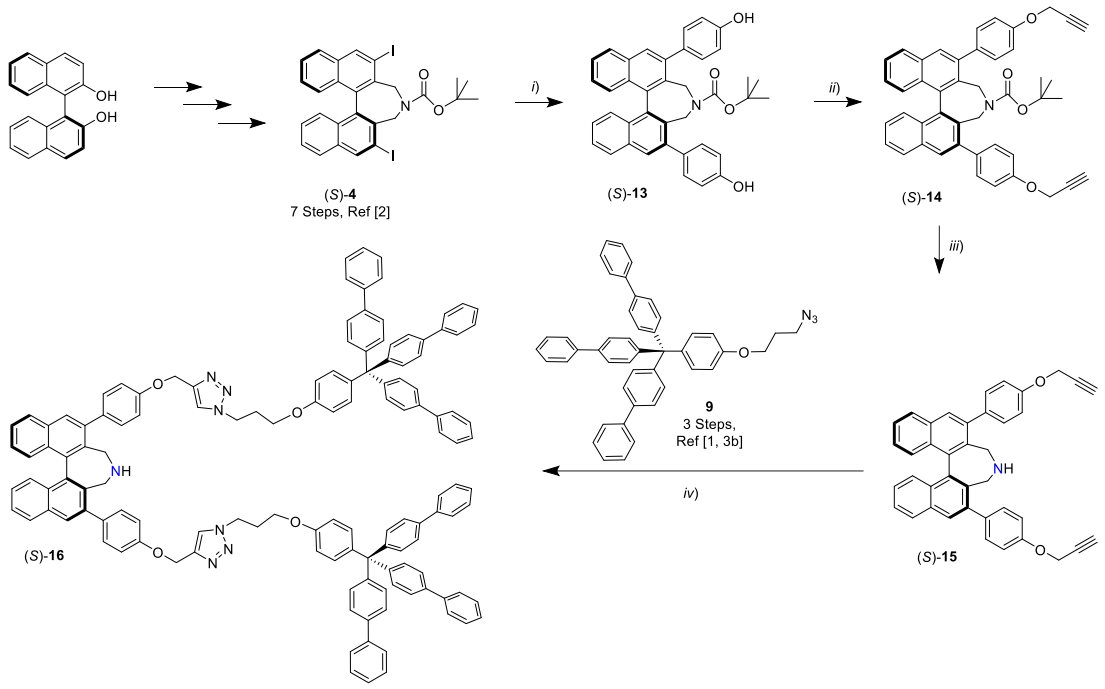


Figure S1: Synthesis of (*S*)-**16**. Reagents and conditions: *i*) 4-hydroxyphenylboronic acid, $Pd(PPh_3)_4$, 2M Na_2CO_3 (aq), DME , 90 °C, 2 h, 81%; *ii*) propargyl bromide, cesium carbonate, DMF, 80 °C, 1.5 h, 68%; *iii*) trifluoroacetic acid, DCM, r.t., 2h, then NaOH, r.t., 5 min, 96% *iv*) DCM, $[Cu(CH_3CN)_4]PF_6$, r.t., 4h, 62%.

Synthesis of BINOL based [2] rotaxanes:

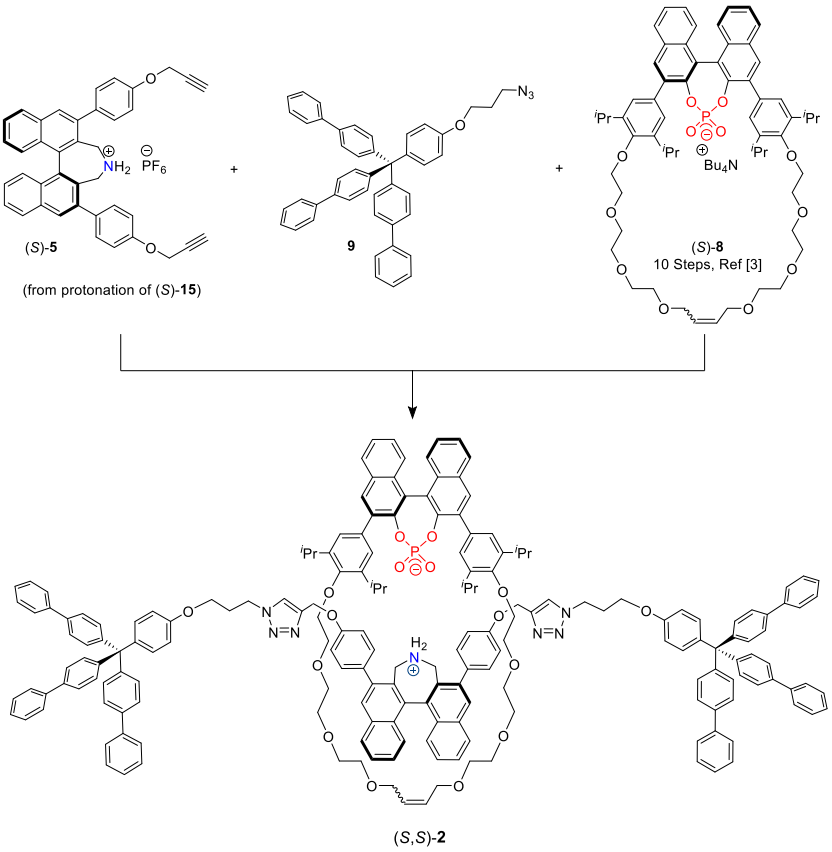


Figure S2: Synthesis of (*S,S*)-**2**. Reagents and conditions: DCM, 30 min, $[Cu(CH_3CN)_4]PF_6$, 4h, r.t., 20% .

Synthesis of PROLINOL based amine and thread:

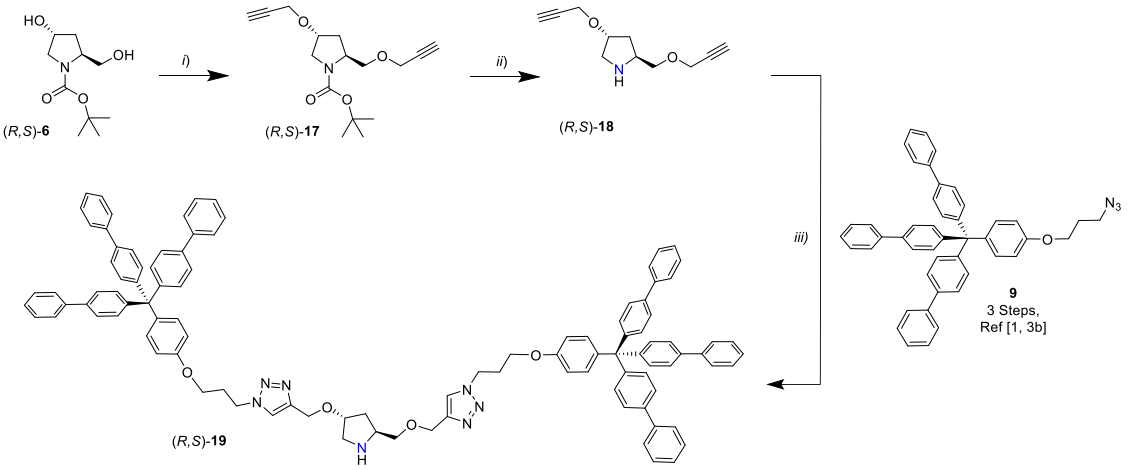


Figure S3: Synthesis of (*R,S*)-**19**. Reagents and conditions: *i*) propargyl bromide, sodium hydride, THF, r.t., 16 h, 76%; *ii*) trifluoroacetic acid, DCM, r.t., 2 h, then NaOH, r.t., 5 min, 98%; *iii*) $[Cu(CH_3CN)_4]PF_6$, DCM, 4 h, r.t., 49%.

Synthesis of PROLINOL based [2] rotaxanes:

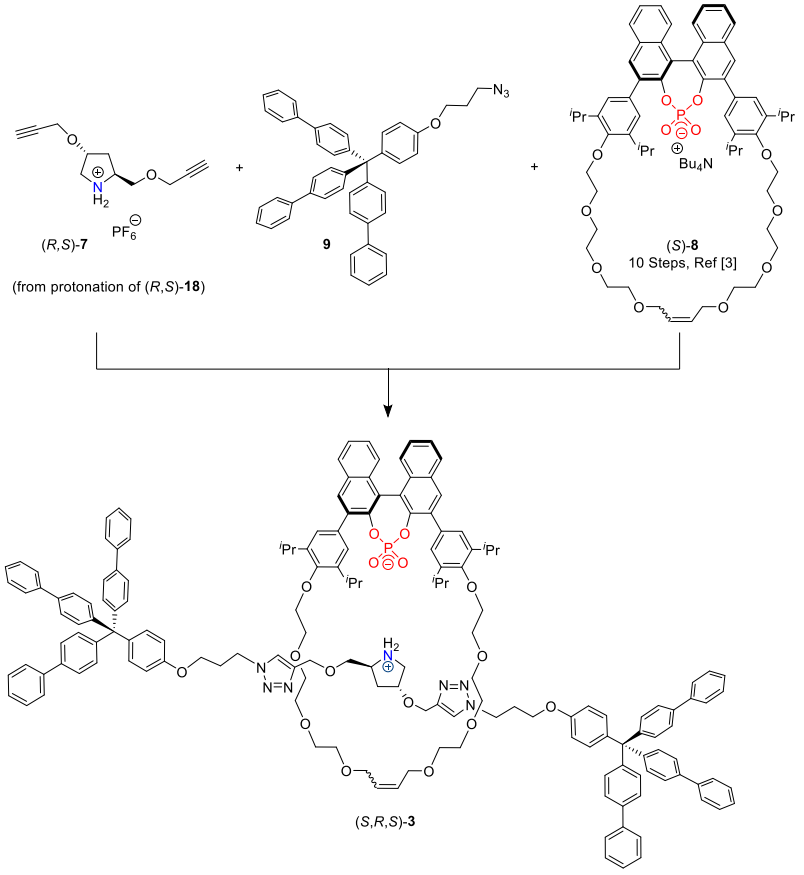


Figure S4: Synthesis of (*S,R,S*)-**3**. Reagents and conditions: DCM, 30 min, $[Cu(CH_3CN)_4]PF_6$, 4 h, r.t., 37% .

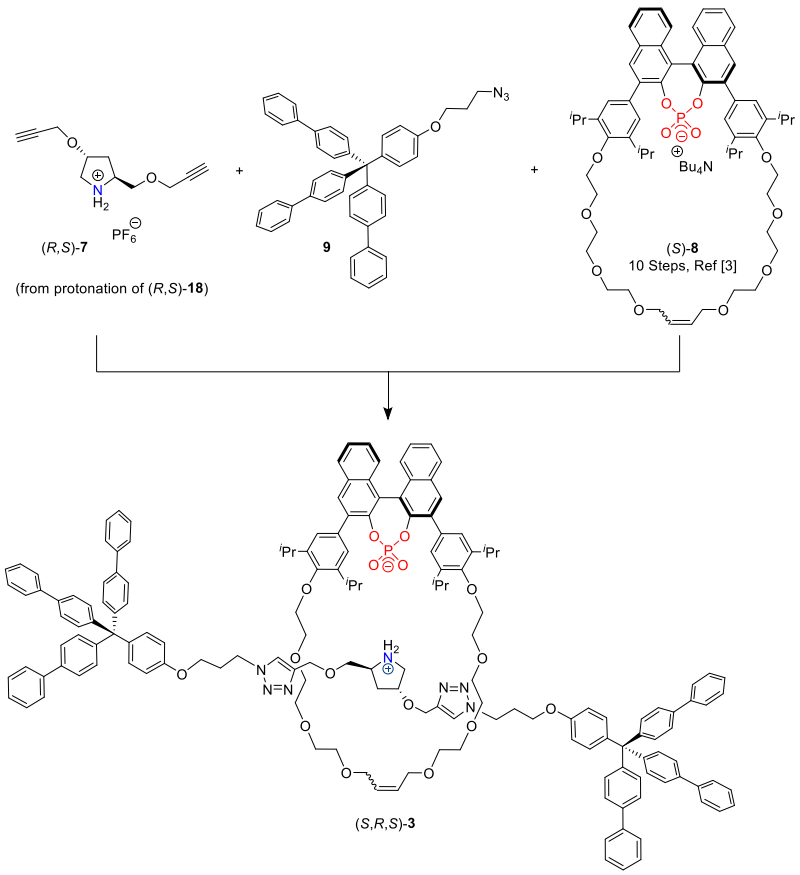
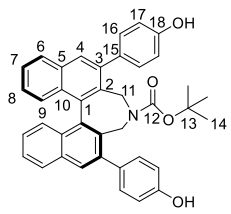


Figure S5: Synthesis of (*R*,*R*,*S*)-**3**. Reagents and conditions: DCM, 30 min, $[Cu(CH_3CN)_4]PF_6$, 4 h, r.t., 19%.

2.2 BINOL-based systems

Compound (*S*)-**13**



The diiodide (*S*)-**4** (0.321 g, 0.496 mmol, 1 eq.), 4-hydroxyphenylboronic acid (0.547 g, 3.97 mmol, 8 eq.) and tetrakis(triphenylphosphine)palladium(0) catalyst (0.143 g, 0.124 mmol, 0.25 eq.) were weighed in a Schlenk flask. The flask was evacuated and back filled with argon 3 times. Then degassed dimethoxyethane (12 mL) and degassed sodium carbonate solution (2 M, 1.2 mL) were added. The reaction mixture was refluxed at 90 °C for 2 hours. After cooling to room temperature, the organic phase was washed with water (2 x 10 mL) and concentrated *in vacuo*. After purification by column chromatography (cyclohexane/ethylacetate 6/1 + 1% triethylamine), the product was obtained as a light yellow foam (0.234 g, 0.404 mmol, 81 %).

Chemical formula: $C_{39}H_{33}NO_4$ **Molecular weight:** 579.70 g/mol.

^{1}H-NMR (600 MHz, [D$_6$]-dimethylsulfoxid, 298 K) *δ* [in ppm]: 9.59 (s, 2H, OH), 8.07 (d, *J* = 8.7 Hz, 2H, H-6), 8.00 (s, 2H, H-4), 7.53 (t, *J* = 7.7 Hz, 2H, H-7), 7.31 (t, *J* = 7.5 Hz, 2H, H-8, H-16), 7.28 (d, *J* = 8.4, 2H, H-16, H-8), 7.22 (d, *J* = 8.7 Hz, 2H, H-9), 7.21 (d, 2H, H-16' , H-9) 6.91 (d, *J* = 8.2Hz, 2H, H-17), 6.82 (d, *J* = 7.6 Hz, 2H H-17'), 5.28 (d, *J* = 12.7 Hz, 1H, H-11), 4.98 (d, *J* = 12.7 Hz, 1H, H-11'), 3.45 (d, *J* = 12.7 Hz, H-11''), 3.17 (d, *J* = 12.7 Hz, 1H, H-11'''). 1.20 (s, 9H, H-14)

^{13}C- NMR (151 MHz, [D$_6$]-dimethylsulfoxid, 298 K) *δ* [in ppm]: 157.0 (C-18), 156.8 (C-18'), 152.1 (C-12), 139.3 (C-3), 135.9 (C-1'), 135.5 (C-1), 132.4 (C-5), 131.2 (C-2), 131.0 (C-15), 130.9 (C-15'), 130.7 (C-16), 130.5 (C-9), 129.8 (C-4), 129.5 (C-10), 128.4 (C-6), 126.8 (C-16'), 126.3 (C-7), 126.0 (C-8), 115.2 (C-17), 78.8 (C-13), 43.1 (C-11), 27.6 (C-14).

^{1}H,^{1}H-COSY (600 MHz, [D$_6$]-dimethylsulfoxid, 298K) *δ* [in ppm]: 8.07/7.53 (H-6/H-7), 7.53/8.07, 7.31 (H-7/H-6, H-8), 7.31, 7.28/ 8.07, 7.53, 7.22, 6.91 (H-8 , H-16/ H-6, H-7, H-9 , H-16',H-17), 7.22/8.07, 7.53, 7.31, 6.82 (H9 , H-16'/H-6, H-7, H-8 , H-16, H-17'), 6.91/7.28, 6.82 (H-17/ H-16, H-17'), 6.82/7.22, 6.91/7.31, 6.82 (H-17/H-16, H-17'), 6.82/7.21, 6.91 (H-17'/H-16',H-17), 5.28/4.98, 3.45, 3.17 (H-11/H-11',H-11'',H-11'''),4.98/5.28, 3.45, 3.17 (H-11'/H-11, H-11'', H-11'''), 3.45/5.28, 3.45, 3.17(H-11''/H-11, H-11', H-11'''), 3.17/5.28, 4.98, 3.45 (H-11'''/H-11, H-11', H-11'').

^{1}H,^{13}C-HSQC (600 MHz/ 151 MHz, [D$_6$]-dimethylsulfoxid, 298K) [in ppm]: 8.07/128.4 (H-6/C-6), 8.00/ 129.8 (H-4/C-4), 7.53/126.3 (H-7/C-7), 7.31/ 130.7, 126.0 (H-8 und H-16/C-8 und C-16), 7.22/ 130.5, 126.8 (H-9 und H-16'/C-9 und C16), 6.91/115.2 (H-17/C-17), 6.82/115.2 (H-17'/C-17),

5.28/43.1 (H-11/C-11), 4.98/43.1 (H-11‘/C-11), 3.45/43.1 (H-11’’/C-11), 3.17/43.1 (H-11’’’/C-11), 1.20/ 27.6 (H-14/C-14)

^{1}H,^{13}C-HMBC (600 MHz/ 151 MHz, [D_6]-dimethylsulfoxid, 298K) [in ppm]: 8.07/132.4, 129.5, 129.8, 126.0 (H-6/C-5, C-10, C-4, C-8), 8.00/131.2, 130.7, 129.8, 128.4 (H-4/ C-2, C-16, C-4, C-6), 7.53/132.4 (H-7/C-5), 7.28/157.0, 139.3, 130.7, 129.8, 128.4 (H-8 ,H-16/C-18, C-3, C-16, C-4, C-6), 7.21/156.8, 135.9, 135.5, 132.4, 126.3 (H-9 , H-16’/ C-18’, C-1’, C-1, C-5, C-7), 6.91/ 131.0, 115.2 (H-17/C-15, C-17), 6.82/130.9, 115.2 (H-17’/C-15’, C-17), 5.28/135.5, 131.2, 43.1 (H-11/ C-1, C-2, C-11), 4.98/135.5, 130.9, 43.1 (H-11’/C- 1, C-15’, C-11), 1.20/78.8 (H-14/C-13).

MS (ESI-pos, MeOH): *m/z* = 602.2293 ([M+Na]$^{+}$, calcd. 602.2302 for [$C_{39}H_{33}NNaO_4$]$^{+}$).

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}): 3255 (w), 2922 (w), 2848 (w), 1648 (w), 1610 (s), 1518 (s), 1418 (m), 1365 (m), 1237 (s), 1143 (m), 893 (w), 832 (w), 748 (w), 691 (w), 646 (m), 612 (w), 566 (m), 516 (s), 497 (w), 421 (m).

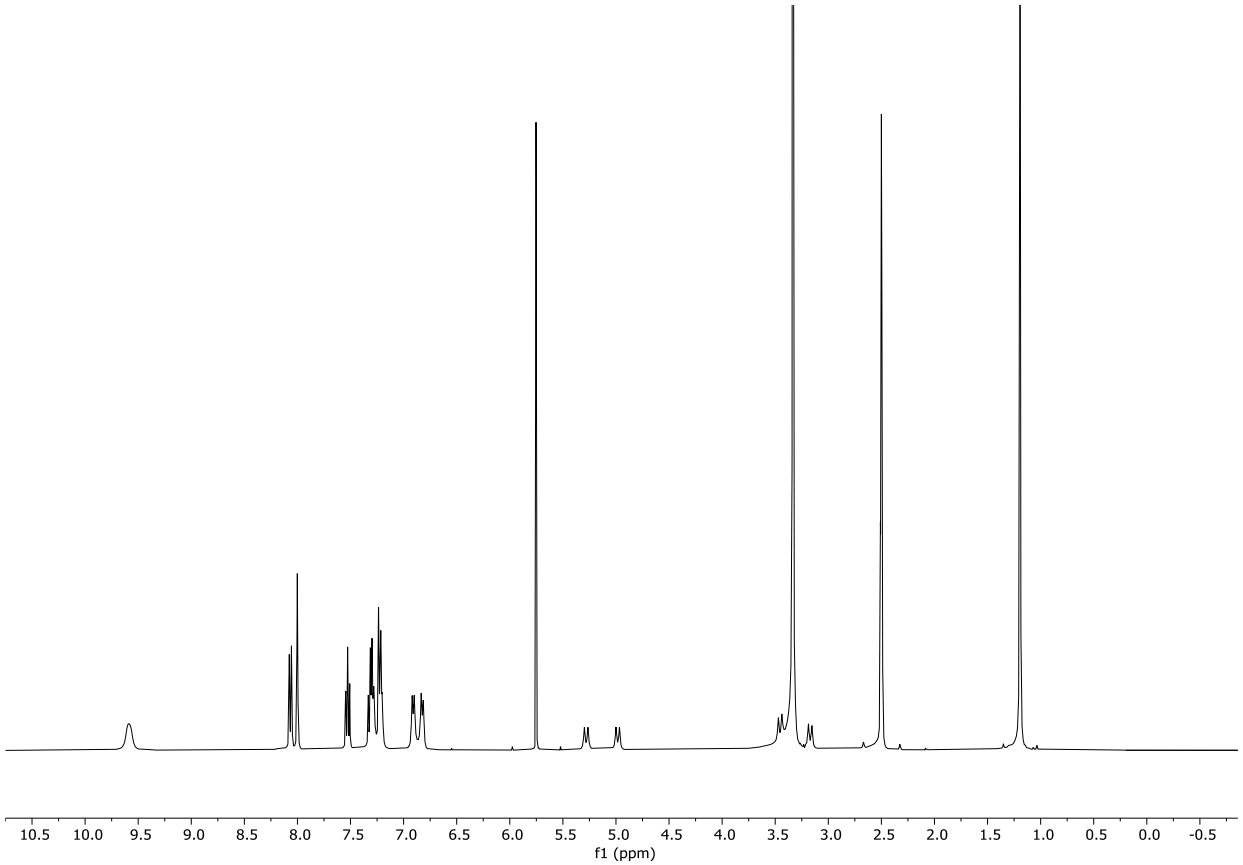


Figure S6: ^{1}H-NMR spectrum of (*R,S*)-**13** ([D_6]-dimethylsulfoxid, 298 K, 600 MHz).

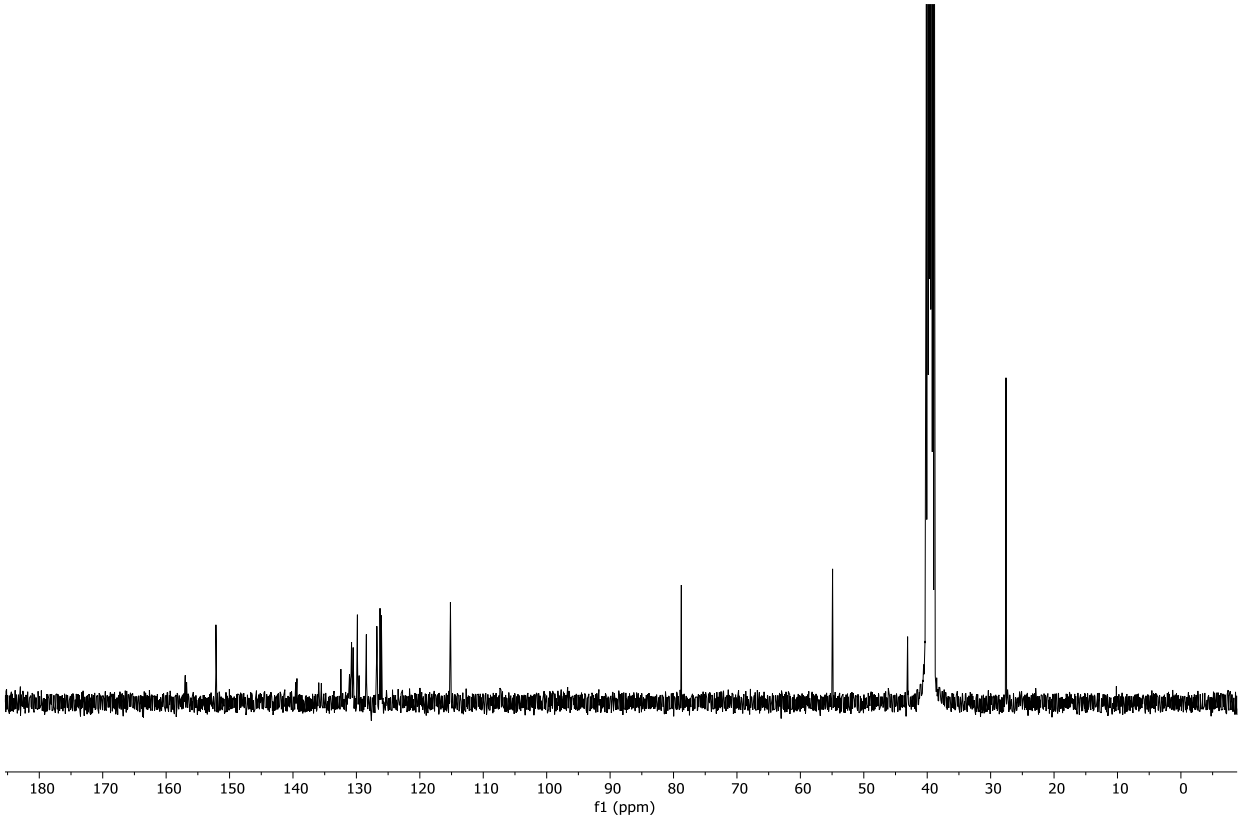
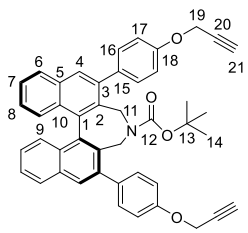


Figure S7: ^{13}C-NMR spectrum of (*R,S*)-**13** ([D_6]-dimethylsulfoxid, 298 K, 151 MHz).

Compound (*S*)-**14**



The bisphenol (*S*)-**13** (230 mg, 0.397 mmol, 1eq.) and cesium carbonate (1.03 g, 3.17 mmol, 8 eq) were weighed in a Schlenk flask. The flask was evacuated and back filled with argon 3 times. Then 15 mL of degassed DMF was added. The mixture was stirred for 30 minutes at room temperature. Then propargyl bromide (106 mg, 0.893 mmol, 2.25 eq) was added and the mixture was heated to 80 °C for 1.5 hours. After the reaction mixture was brought to room temperature, water (30 mL) was added. The phases were separated. The aqueous phase was extracted with ethyl acetate (3 x 30 mL). The combined organic phases were washed with brine (20 mL). It was dried over sodium sulphate anhydrous and then filtered. The solvent was removed *in vacuo* and after column chromatography (cyclohexane/ethylacetate 1:0 to 3:1) the product was obtained as a yellow foam (178 mg, 0.271 mmol, 68%).

Chemical formula: $C_{45}H_{37}NO_4$ **Molecular weight:** 655.79 g/mol.

^{1}H-NMR (600 MHz, [D$_6$]-dimethylsulfoxid, 298 K) δ [in ppm]: 8.08 (d, *J* = 8.2 Hz, 2H, H-6), 8.05 (s, 2H, H-4), 7.55 (t, *J* = 6.9 Hz, 2H, H-7), 7.45 (d, *J* = 8.5 Hz, 2H, H-16), 7.33-7.37 (m, 4H, H16' , H8), 7.25 (d, *J* = 8.5 Hz, H-9), 7.15 (d, *J* = 7.2 Hz, 2H, H-17), 7.05 (d, *J* = 7.2 Hz, 2H, H-17'), 5.26 (d, *J* = 13.2 Hz, 1H, H-11), 4.97 (d, *J* = 13.2 Hz, 1H, H-11'), 4.87 (d, *J* = 4.1 Hz, 4H, H-19), 3.61 (s, 2H, H-21), 3.49 (d, *J* = 12.4 Hz, 1H, H-11''), 3.20 (d, *J* = 12.4 Hz, 1H, H-11'''), 1.16 (s, 9H, H-14).

^{13}C- NMR (151 MHz, [D$_6$]-dimethylsulfoxid, 298 K) δ [in ppm]: 156.7 (C-18), 152.2 (C-12), 138.8 (C-3), 135.9 (C-1), 135.6 (C-1'), 133.5 (C-15), 133.2 (C-2), 132.4 (C-5), 130.8 (C-16), 130.5 (C-16'), 129.9 (C-4), 129.8 (C-10), 128.5 (C-6), 126.8 (C-9), 126.4 (C-7), 126.3 (C-8), 114.8 (C-17), 114.6 (C-17'), 79.2 (C-20), 78.9 (C-13), 78.4 (C-21), 55.5 (C-19), 43.1 (C-11), 27.7 (C-14).

^{1}H,^{1}H-COSY (600 MHz, [D$_6$]-dimethylsulfoxid, 298K) [in ppm]: 8.08/7.55 (H-6/H-7), 7.55/8.08,7.34 (H-7/,H-6, H-8), 7.45/7.15 (H-16/H-17), 7.36/7.05 (H-16'/H-17'), 7.33-7.37/7.25,7.55 (H-8, H-16'/H-9,H-7), 7 .25/7.34 (H-9/H-8), 7.15/7.45 (H-17/H-16), 7.05/7.36(H-17'/H-16'), 5.26/3.49(H-11/H-11''), 4.97/3.20(H-11'/H-1'''), 4.87/3.61(H-19/H-21), 3.61/4.87 (H-21/H-19), 3.49/5.26 (H-11''/H-11), 3.20/4.97(H-11'''/H-11').

^{1}H,^{13}C-HSQC (600 MHz/ 151 MHz, [D$_6$]-dimethylsulfoxid, 298K) [in ppm]: 8.08/128.5(H-6/C-6),8.05/129.9 (H-4/C-4), 7.55/126.4 (H-7/C-7), 7.45/130.8 (H-16/C-16), 7.33-7.37 /130.5, 126.3 (H-8, H-16'/ C-8, C-16'), 7.25/126.3(H-9/C-9), 7.15/114.8 (H-17/C-17), 7.05/114.6 (H-17'/C-17'), 5.26/43.1 (H-11/C-11), 4.97/43.1 (H-11'/C-11), 3.61/78.4 (H-21/C-21), 3.49/43.1 (H-11''/C-11), 3.20/43.1 (H-11'''/C-11), 1.16/27.7 (H-14/C-14).

^{1}H,^{13}C-HMBC (600 MHz/ 151 MHz, [D_6]-dimethylsulfoxid, 298K) [in ppm]: 8.08/132.4, 129.9,126.3 (H-6/C-5, C-4, C-8), 8.05/133.5, 133.2, 130.8, 128.5 (H-4/C-15, C-2, C-16, C-6), 7.55/132.5, 126.8 (H-7/C-5, C-9), 7.45/156.7, 130.8 (H-16/C-18, C-16), 7.33-7.37 /156.7, 130.8, 129.8, 128.5, 126.4 (H-8,16'/C-18, C-16, C-10, C-6, C-7), 7.25/135.9, 135.6, 132.4, 129.9, 126.4 (H-9/C-1, C-1', C-5, C-4, C-7), 7.15/133.5 (H-17/C-15), 7.05/133.5 (H-17'/C-15), 4.87/ 156.7, 79.2, 78.4 (H-19/C-18, C-20, C-21).

MS (ESI-pos, MeOH): *m/z* = 678.2606 ([M+Na]$^+$, calcd. 678.2615 for [$C_{45}H_{37}NNaO_4$]$^+$).

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}): 3298 (w), 3287 (m), 2922 (w), 1682 (s), 1646 (w), 1607 (m), 1509 (s), 1403 (s), 1364 (m), 1286 (w), 1215 (s), 1175 (s), 1143 (s), 1106 (m), 1024 (s), 894 (w), 830 (s), 751 (s), 647 (m).

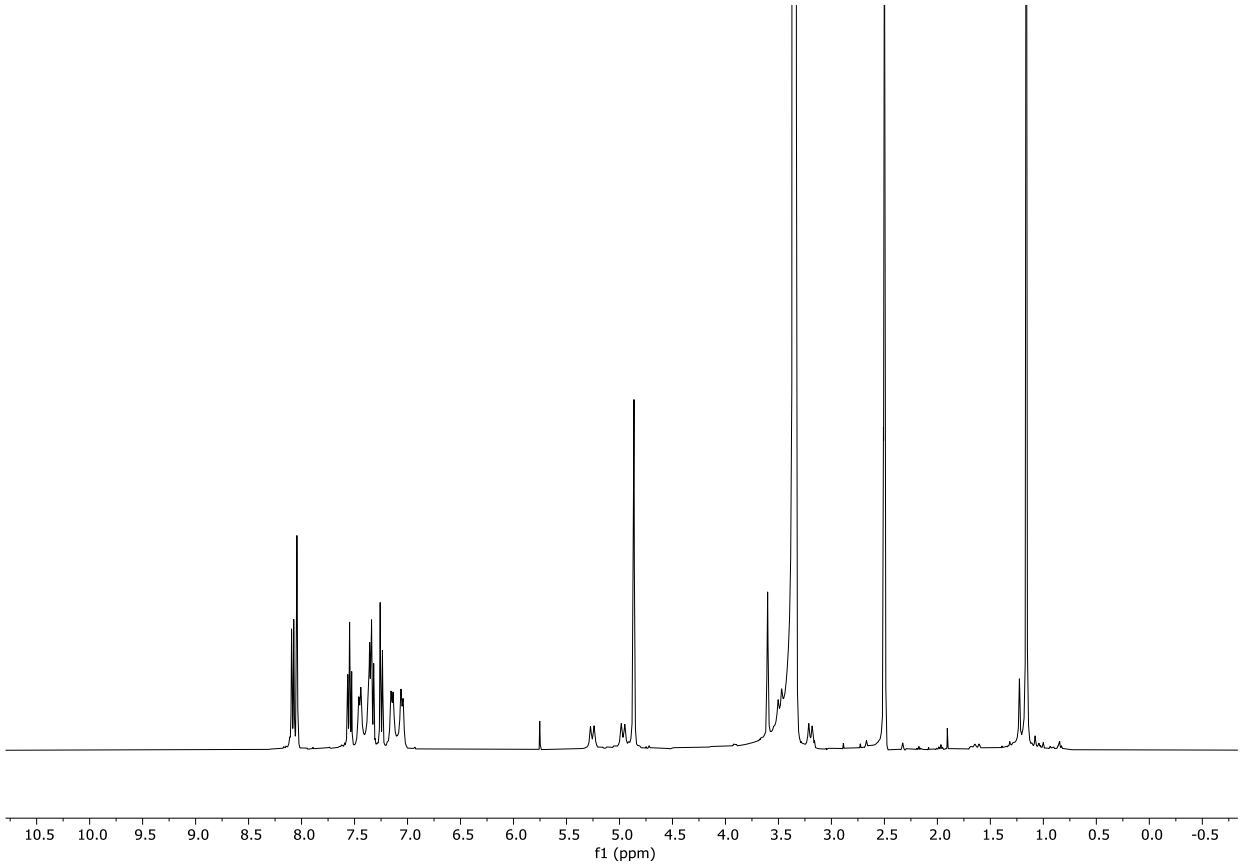


Figure S8: ^{1}H-NMR spectrum of (*R,S*)-**14** ([D_6]-dimethylsulfoxid, 298 K, 600 MHz).

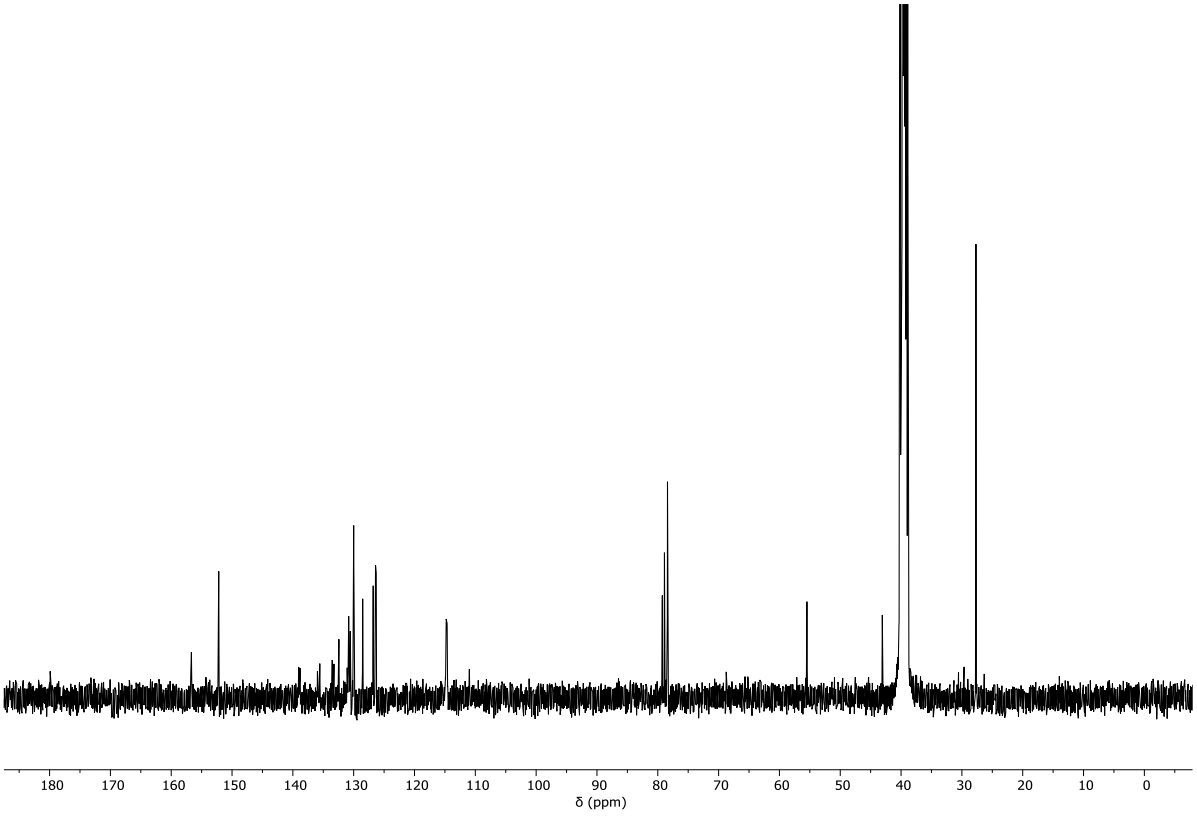
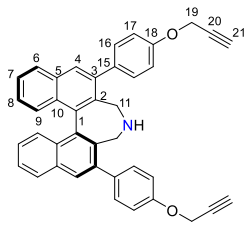


Figure S9: ^{13}C-NMR spectrum of (*R,S*)-**14** ([D_6]-dimethylsulfoxid, 298 K, 151 MHz).

Compound (*S*)-**15**



Boc-protected amine (*S*)-**14** (110 mg, 0.190 mmol, 1eq) was weighed into a flask and dissolved in dichloromethane (15 mL). Trifluoroacetic acid (146 µL, 1.89 mmol, 10 eq) was added slowly and the mixture was stirred for 2 hours at room temperature. Sodium hydroxide solution (2 M, 15 mL) was carefully added. The phases were separated. The aqueous phase was extracted with dichloromethane (3 x 10 mL). The combined organic phases were washed with brine (30 mL). The solution was dried over sodium sulfate, filtered and the solvent was removed. A yellow oil (101 mg, 0.182 mmol, 96%) was obtained.

Chemical formula: $C_{40}H_{29}NO_2$ **Molecular weight:** 555,68 g/mol.

^{1}H-NMR (600 MHz, [D$_6$]-dimethylsulfoxid, 298 K) *δ* [in ppm]: 8.05 (d, *J* = 8.5 Hz, 2H, H-6), 8.01 (s, 2H, H-4), 7.64 (d, *J* = 8.8 Hz, 4H, H-16), 7.49 (t, *J* = 7.4 Hz, 2H, H-7), 7.29 (t, *J* = 8.1 Hz, 2H, H-8), 7.20 (d, *J* = 8.5 Hz, 2H, H-9), 7.12 (d, *J* = 8.5 Hz, 4H, H-17), 4.88 (d, *J* = 2.2 Hz, 4H, H-19), 3.89 (d, *J* = 11.8 Hz, 2H, H-11), 3.62 (t, *J* = 1.8 Hz, H-21), 3.15 (d, *J* = 12.6 Hz, 1H, H-11').

^{13}C- NMR (151 MHz, [D$_6$]-dimethylsulfoxid, 298 K) *δ* [in ppm]: 156.6 (C-18), 138.8 (C-3), 135.2 (C-1), 133.7 (C-15), 133.1 (C-2), 132.1 (C-5), 130.8 (C-16), 129.9 (C-10), 129.4 (C-4), 128.5 (C-6), 126.7 (C-9), 125.8 (C-7), 125.7 (C-8), 114.6 (C-17), 79.4 (C-20), 78.4 (C-21), 55.5 (C-19), 44.3 (C-11).

^{1}H,^{1}H-COSY (600 MHz, [D$_6$]-dimethylsulfoxid, 298K) [in ppm]: 8.05/7.49 (H-6/H-7), 7.64/7.12 (H-16/H-17), 7.49/ 8.05, 7.29 (H-7/H-6, H-8), 7.29/7.49 (H-8/H-7), 7.12/7.64 (H-17/H-16), 4.88/ 3.62 (H-19/ H-21), 3.89/3.15 (H-11/H11'), 3.62/4.88 (H-21/H19), 3.15/3.89 (H11'/H-11).

^{1}H,^{13}C-HSQC (600 MHz/ 151 MHz, [D$_6$]-dimethylsulfoxid, 298K) [in ppm]: 8.05/128.5 (H-6/C-6), 8.01/129.4 (H-4/C-4), 7.64/130.8 (H-16/C-16), 7.49/125.8 (H-7/C-7), 7.29/125.7 (H-8, C-8), 7.20/126.7 (H-9/C-9), 7.12/114.6 (H-17/C-17), 4.88/55.5 (H-19/C-19), 3.89/44.3 (H-11/C-11), 3.15/44.3 (H-11'/C-11).

^{1}H,^{13}C-HMBC (600 MHz/ 151 MHz, [D$_6$]-dimethylsulfoxid, 298K) [in ppm]: 8.05/129.9 , 129.4, 125.7 (H-6/C-10, C-4, C-8), 8.01/133.7, 133.2, 129.9, 128.5 (H-4/C-15, C-2, C-10, C-6,), 7.64/156.6, 138.8, 130.8 (H-16/C-18, C-3, C-16), 7.49/132.1, 126.7 (H-7/C-5, C-9), 7.29/129.9, 128.5 (H-8/ C-10, C-6), 7.20/135.2, 132.1, 125.8 (H-9/C-1, C-5, C-7), 7.12/156.6, 133.7, 114.6 (H-17/C-18, C-15, C-17), 4.88/ 125.6, 79.4, 78.4 (H-19/C-18, C-20, C-21).

MS (ESI-pos, MeOH): *m/z* = 556.2266 ($[M+H]^+$, calcd. 556.2271 for $[C_{40}H_{30}NO_2]^+$).

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}) : 3278 (m), 3031 (s), 2918 (s), 2849 (s), 1683 (m), 1605 (m), 1507 (s), 1436 (w), 1213 (s), 1175 (s), 1024 (s), 986 (w), 924 (w), 831 (s), 781 (w), 749 (s), 632 (s).

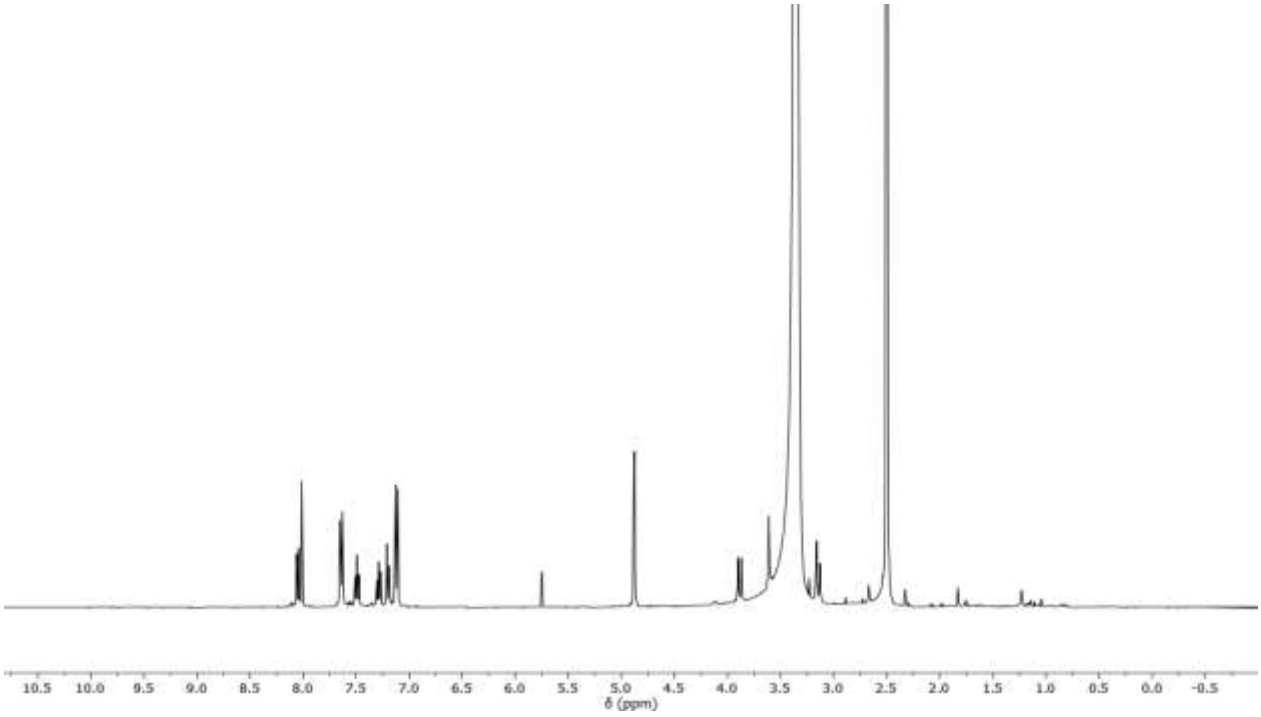


Figure S10: ^{1}H-NMR spectrum of (*S*)-**15** ([D_6]-dimethylsulfoxid, 298 K, 600 MHz).

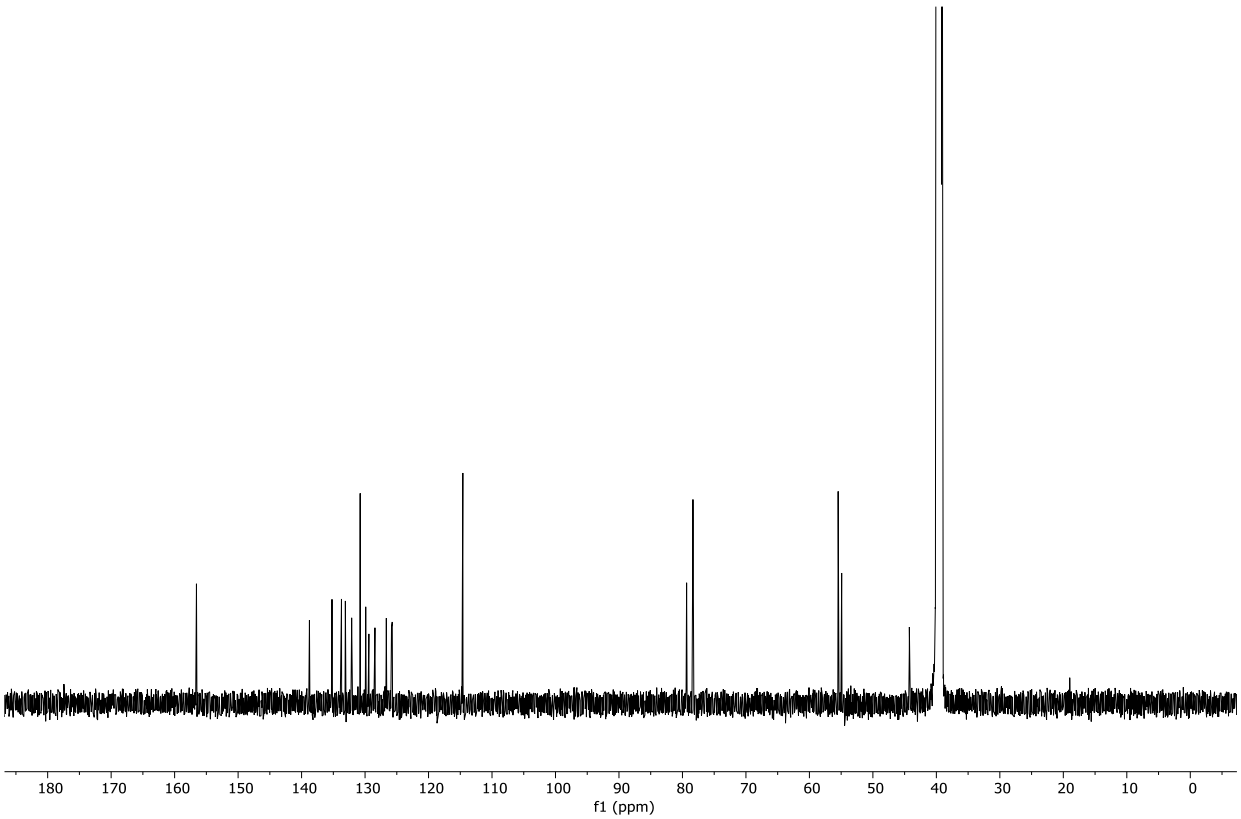
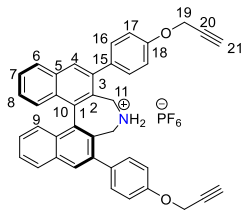


Figure S11: ^{13}C-NMR spectrum of (*S*)-**15** ([D_6]-dimethylsulfoxid, 298 K, 151 MHz)

Compound (*S*)-**5**



Amine (*S*)-**15** (100 mg, 0.179 mmol, 1 eq) was weighed in a flask and dissolved in diethyl ether (8 mL). Hydrogen chloride in diethyl ether (1M, 1.97 mL, 1.97 mmol, 11 eq) was slowly added and the mixture was stirred for 30 minutes at room temperature. The solvent was removed *in vacuo* and the residue was redissolved in dichloromethane (8 mL). Ammonium hexafluorophosphate (146 mg, 0.899 mmol, 5 eq) was added and the mixture was stirred overnight. The suspension was filtered and the filter residue was washed with dichloromethane (8 mL). The solvent was removed to give the product as a white solid (110 mg, 0.157 mmol, 88%).

Chemical formula: $C_{40}H_{30}F_6NO_2P$ **Molecular weight:** 701,65 g/mol.

^{1}H-NMR (600 MHz, [D$_6$]-dimethylsulfoxid, 298 K) δ [in ppm]: 8.10 (m, 4H, H-6 ,H-4), 7.58 (m, 6H, H-16 ,H-7), 7.35 (t, *J* = 7.4 Hz, 2H, H-8), 7.20-7.12 (m, 6H, H-9 , H-17), 4.89 (d, *J* = 2.3 Hz, 4H, H-19), 4.14 (br. s, 2H, H-11) 3.63 (t, *J* = 2.2 Hz, 2H, H-21), 3.41 (br. s, 2H, H-11', merged with water signal)

^{31}P NMR (162 MHz, [D$_6$]-dimethylsulfoxid, 298 K) δ [in ppm]: -144.2 (sept., *J* = 710 Hz)

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}): 3282 (w), 2962 (m), 1605 (m), 1508 (m), 1446 (w), 1372 (w), 1258 (w), 1216 (m), 1176 (w), 1087 (m), 1015 (s), 795 (s), 752 (w), 660 (w), 554 (w).

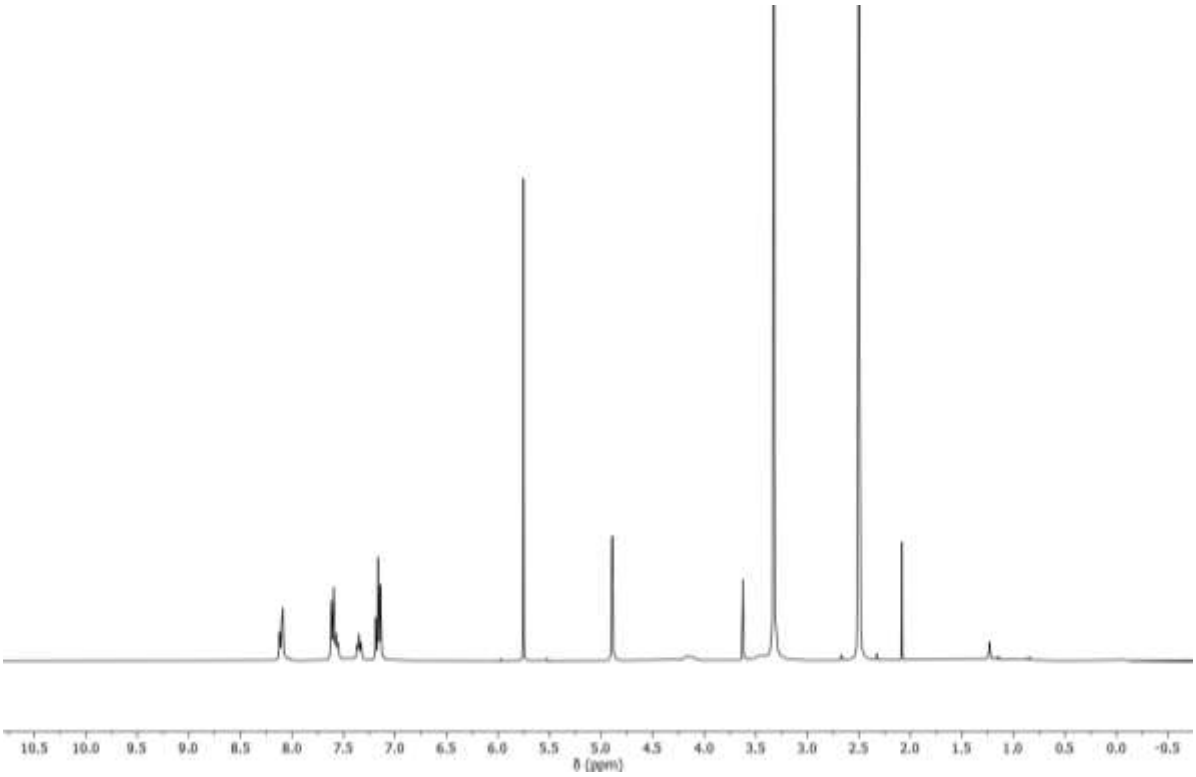


Figure S12: ^{1}H-NMR spectrum of (*S*)-**5** ([D$_6$]-dimethylsulfoxid, 298 K, 600 MHz).

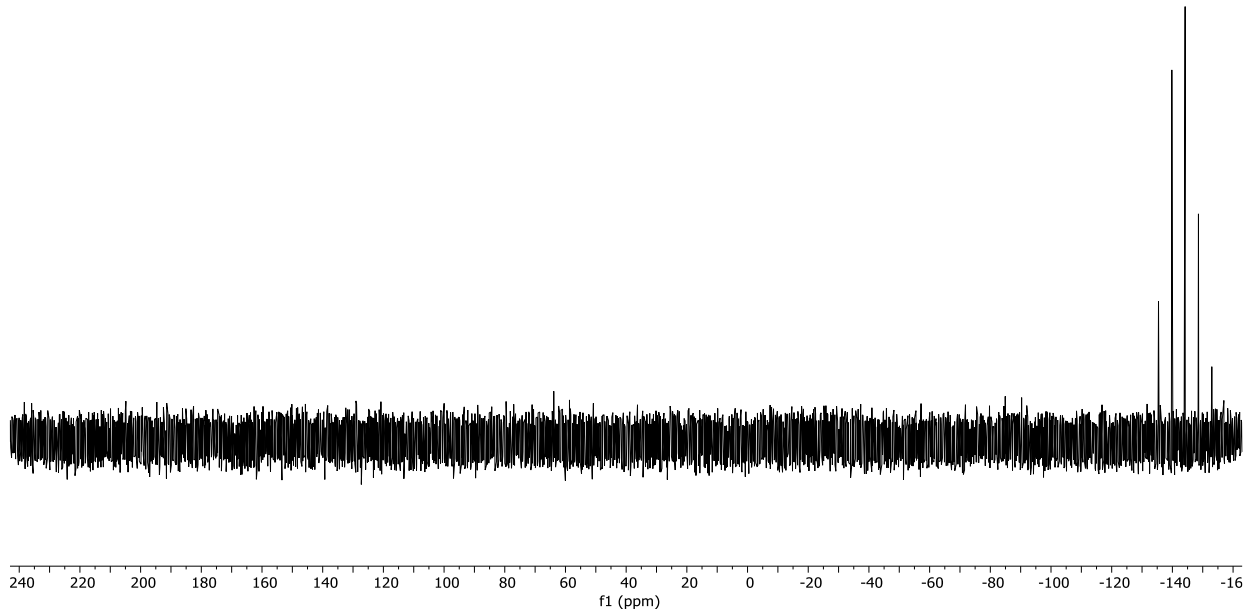
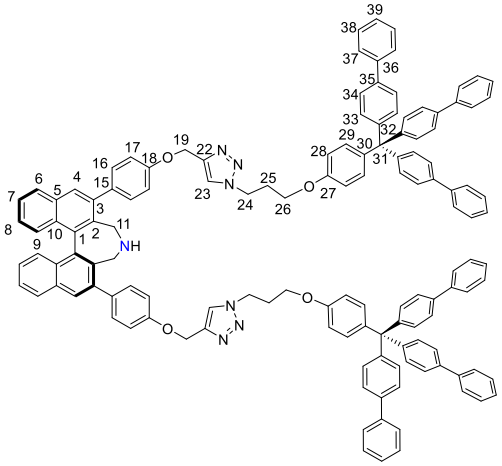


Figure S13: ^{31}P-NMR of (*S*)-**5** ([D_6]-dimethylsulfoxid, 298 K, 243 MHz)

Compound (*S*)-**16**



The bisalkyne (*S*)-**15** (8.00 mg, 0.0114 mmol, 1 eq) and stopper **9** (16.2 mg, 0.0251 mmol, 2.2 eq) were weighed in a Schlenk flask and dried *in vacuo* for 3 hours. Dry and degassed dichloromethane (1 ml) was added. The mixture was stirred for 30 minutes. Then tetrakis(acetonitrile)copper(I) hexafluorophosphate catalyst (2.97 mg, 0.00798 mmol, 0.7 eq.) was added and the mixture was stirred for 4 hours. 3-(Ethylenediamino)-propyl functionalized silica (1.4 mmol/g, 20mg) was added and the mixture was stirred for another 2 hours. The mixture was filtered and the solvent was removed. After column chromatography (dichloromethane/ethyl acetate 1/0 to 1/1) the product was obtained as a light yellow foam (13.2 mg, 0.00714 mmol, 62%).

Chemical formula: $C_{132}H_{103}N_7O_4$ **Molecular weight:** 1849.81 g/mol.

^{1}H-NMR (600 MHz, [D]-chloroform, 298 K) δ [in ppm]: 7.92-7.87 (m, 4H, H-6 , H-4), 7.67 (s, 2H, H-23), 7.59 (d, *J* = 7.5 Hz, 12H, H-37), 7.51 (d, *J* = 8.2 Hz, 12H, H-34), 7.50-7.44 (m, 8H, H-16 und H-7), 7.40 (t, *J* = 7.0 Hz, 14H, H-38, H-9), 7.36-7.32 (m, 12H, H-33), 7.32-7.28 (m, 6H, H-39), 7.26-7.20 (m, 6H, H-29 und H-8), 7.07 (d, *J* = 7.9 Hz, 4H, H-17), 6.81 (d, *J* = 7.9 Hz, 4H, H-28), 5.27 (s, 4H, H-19), 4.61 (t, J = 6.5 Hz, 4H, H-24), 3.99 (t, *J* = 5.5 Hz, 6H, H-26 und H-11), 3.29 (d, *J* = 6.5 Hz 2H, H-11'), 2.46-2.37 (m, 4H, H-25).

^{13}C- NMR (151 MHz, [D]-chloroform, 298 K) δ [in ppm]: 157.7 (C-18), 156.6 (C-30), 146.1 (C-32), 140.7 (C-36), 139.6 (C-27), 138.7 (C-35),134.5 (C-15), 132.4 (C-29), 131.6 (C-33), 130.9 (C-16), 129.7 (C-4), 128.9 (C-38), 128.4 (C-6), 127.7 (C-9), 127.4 (C-39),127.1 (C-37), 126.3 (C-34), 125.9 (C-7), 125.8 (C-8), 123.4 (C-23), 114.7 (C-17), 113.5 (C-28), 64.8 (C-26), 63.8 (C-31), 62.3 (C-19), 47.5 (C-24), 44.6 (C-11), 30.1 (C-25).

C-1, C-2 and C-3 could not be observed.

^{1}H,^{1}H-COSY (600 MHz, [D]-chloroform, 298K) [in ppm]: 7.92-7.87/7.50-7.44 (H-6, H-4/H-7,H-16), 7.59/7.51, 7.40, 7.36-7.32 (H-37/H-34, H-38, H-33), 7.51/ 7.59, 7.40, 7.36-7.32 (H-34/H-37, H-38, H-33), 7.50-7.44/7.92-7.87, 7.07 (H-16, H-7/H-6, H-17), 7.40/7.59, 7.51, 7.36-7.32, 7.26-7.20 (H-38/H-37, H-34), 7.36-7.32/7.59, 7.51, 7.40, 7.26-7.20 (H-33/H-37, H-34, H-38, H-29), 7.26-7.20/ 7.36-7.32, 6.81 (H-29/ H-33, H-28), 7.07/7.50-7.44 (H17/H-16), 6.81/7.26-7.20 (H-28/H-29), 4.61/2.46-2.37 (H-24/H-25), 3.99/3.29, 2.46-2.37 (H-26, H-11/H-11', H-25), 3.29/3.99 (H-11'/H-11), 2.46-2.37/4.61, 3.99 (H-25/ H-24, H-26).

^{1}H,^{13}C-HSQC (600 MHz/ 151 MHz, [D]-chloroform, 298K) [in ppm]: 7.92-7.87/129.7, 128.4 (H-6, H-4/C-4, C-6), 7.59/127.1(H-37/C-37), 7.51/126.3 (H-34/C-34), 7.50-7.44/130.9, 125.9 (H-16, H-7/C-16, C-7), 7.40/128.9, 127.7 (H-38, H-9/C-38, C-9), 7.36-7.32/131.6 (H-33/C-33), 7.32-7.28/127.4 (H-39/C-39), 7.26-7.20/125.8, 132.4 (H-29, H-8/C-8, C-29), 7.07/114.7 (H-17/C-17), 6.81/113.5 (H-28/C-28), 5.27/62.3 (H-19/C-19), 4.61/47.5 (H-24/C-24), 3.99/ 64.8, 44.6 (H-26, H-11/ C-26, C-11), 3.29/44.6 (H11'/C-11), 2.46-2.37/30.1 (H-25/C-25).

^{1}H,^{13}C-HMBC (600 MHz/ 151 MHz, [D]-chloroform, 298K) [in ppm]: 7.92-7.87/130.9, 128.4, 125.8 (H-6, H-4/ C-16, C-6, C-8), 7.59/138.7, 127.4 (H-37/C-35, C-39), 7.51/146.1, 140.7, 126.3 (H-34/C-32, C-36, C-34), 7.40/140.7,128.9 (H-38/C-36, C-38), 7.36-7.32/138.7, 131.6, 63.8 (H-33/C-35, C-33, C-31), 7.32-7.28/128.9, 127.1 (H-39/C-38, C-37), 7.26-7.20/156.6, 132.4, 63.8 (H-29/C-30, C-29, C-31), 7.07/134.5 (H-17/C-15), 6.81/139.6, 113.5 (H-28/C-27, C-28), 4.61/64.8, 30.1 (H-24/C-26, C-25), 3.99/47.5 (H-26/C-24), 2.46-2.37/64.1 (H-25/C-26).

MS (ESI-pos, MeOH): *m/z* = 1851.8138* ($[M+H]^+$, calcd. 1851.8144 for $[C_{132}H_{104}N_7O_4]^+$).

*Due to the very low intensity of the mass spectrum, the signal with highest intensity (not the lowest monoisotopic signal) was used for evaluation.

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}): 3053 (w), 3027 (m), 2956 (m), 2927 (m), 2868 (w), 1654 (m), 1604 (m), 1508 (s), 1483 (s), 1393 (w), 1363 (w), 1241 (s), 1180 (s), 1042 (m), 1006 (m), 827 (s), 764 (s), 747 (s), 734 (s), 697 (s), 613 (w), 560 (w), 539 (w), 503 (w).

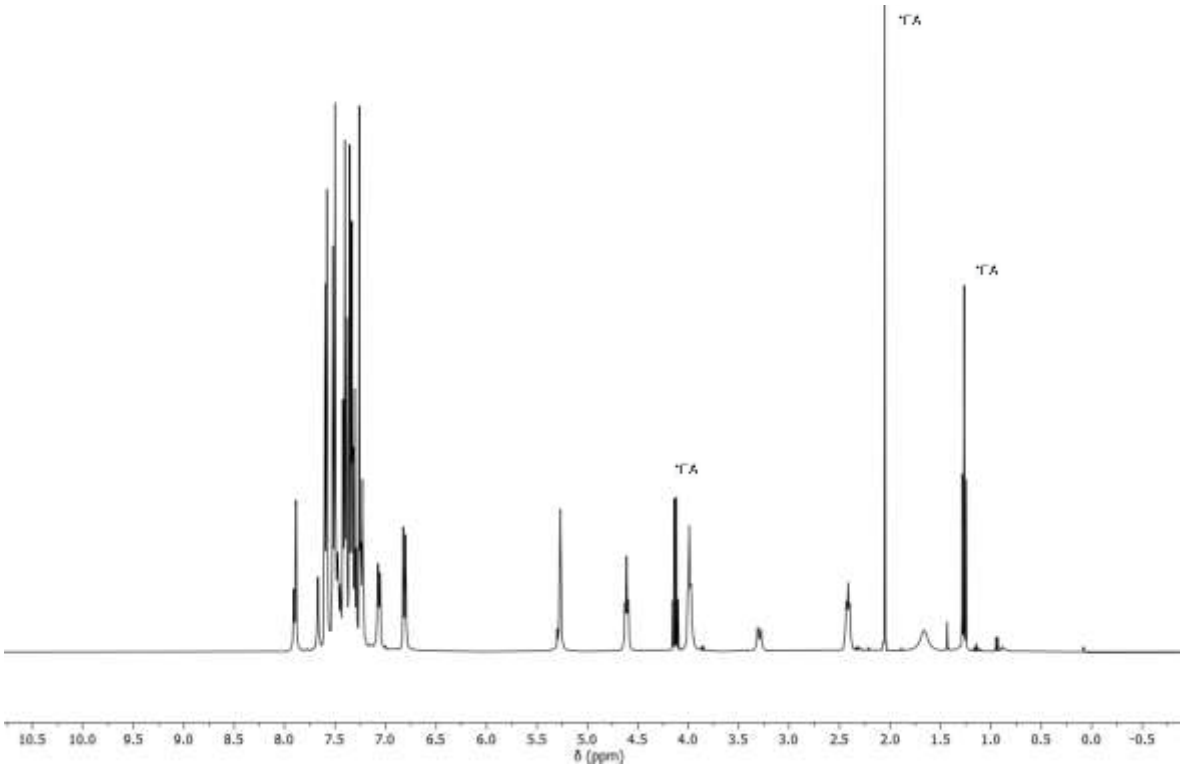


Figure S14: ^{1}H-NMR of the compound (*S*)-**16** ([D]-chloroform, 298 K, 400 MHz)

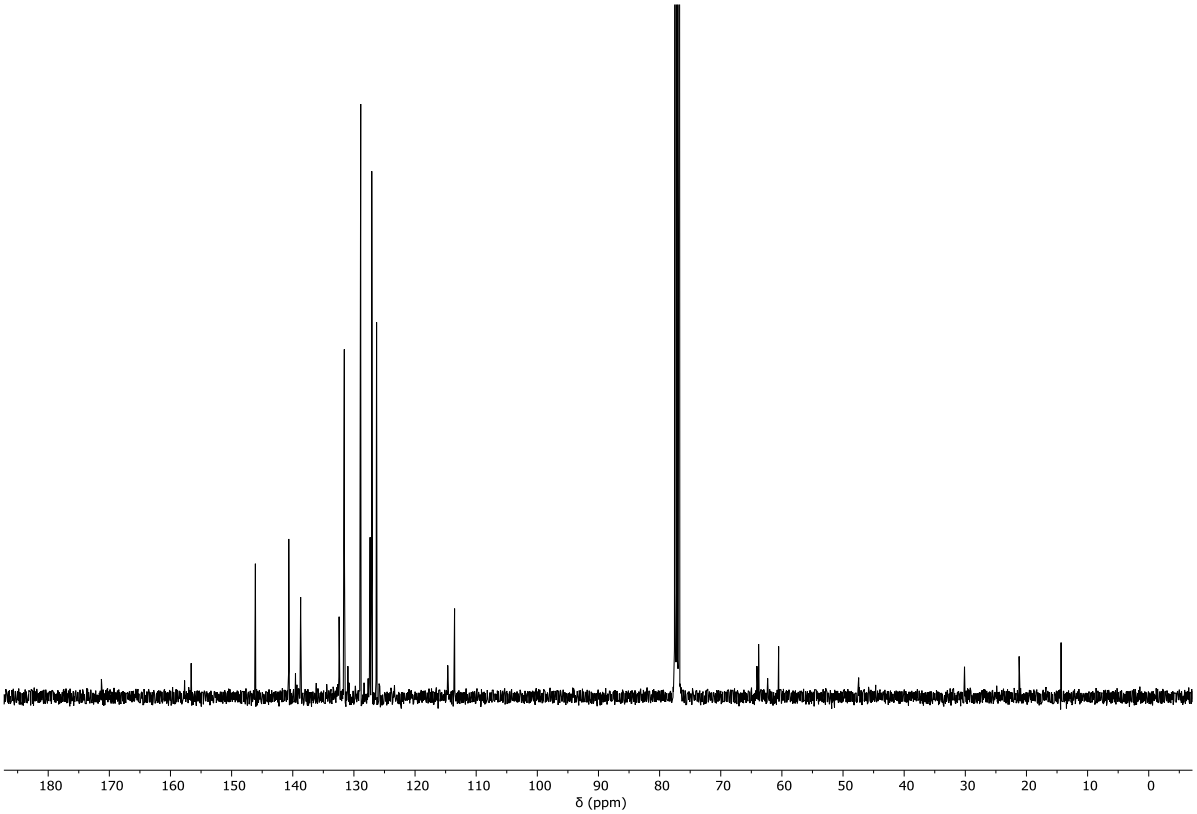
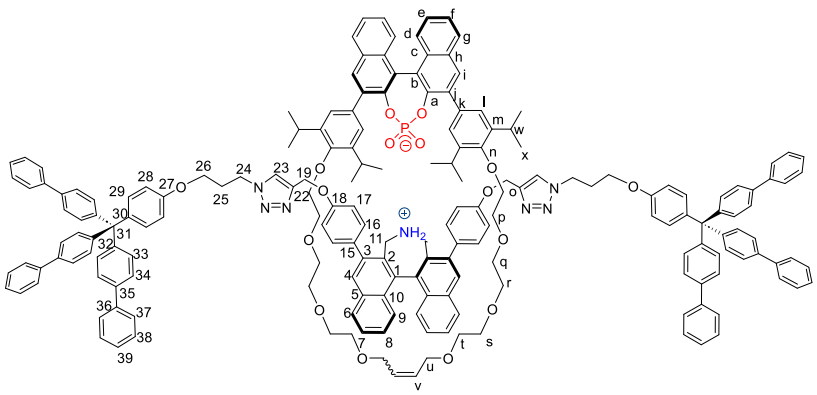


Figure S15: ^{13}C-NMR of the compound (*S*)-**16** ([D]-chloroform, 298 K, 151 MHz)

Compound (*S,S*)-**2**



The amine (*S*)-**5** (18.8 mg, 0.0268 mmol, 1 eq), the stopper **9** (38.2 mg, 0.0589 mmol, 2.2 eq) and the macrocycle (*S*)-**8** (33.7 mg, 0.0268 mmol, 1 eq) were weighed in a Schlenk flask and dried *in vacuo* for 3 hours. Dry and degassed dichloromethane (2.5 mL) was added and the mixture was stirred for 2 hours. Tetrakis (acetonitrile) copper(I) hexafluorophosphate catalyst (6.99 mg, 0.0188 mmol, 0.7 eq) was added and the mixture was stirred overnight. 3-(Ethylenediamino)-propyl functionalized silica gel (1.4 mmol/g, 40 mg) was added and the mixture was stirred for 2 hours. The mixture was filtered and the solvent was removed *in vacuo*. After purification by column chromatography (dichloromethane/methanol 100/0 to 100/1 performed with NextGen), the product was obtained as a white foam (15.4 mg, 0.00537 mmol, 20%).

Chemical formula: $C_{192}H_{176}N_7O_{16}P$ **Molecular weight:** 2868.53 g/mol.

^{1}H-NMR (600 MHz, [D]-chloroform, 298 K) δ [in ppm]: 9.77 (br s, 1H, NH_2), 9.50 (br s, 1H, NH_2), 8.21 (s, 1H, H-23), 8.07-8.02 (m, 2H, Ar-H), 7.96 (s, 2H, H-l),7.94-7.89 (m, 4H, Ar-H), 7.61-7.58 (m, 14H, H-37, Ar-H), 7.54-7.49 (m, 17H, H-34, BINOL-Backbone), 7.46 (s, 2H, H-l), 7.44-7.37 (m, 17H, H-38, Ar-H), 7.35-7.29 (m, 21H, H-33, H-39, Ar-H), 7.25-7.18 (m, 8H, H-29, Ar-H), 7.05-7.02 (m, 2H; Ar-H), 6.96 (m, 1H, Ar-H), 6.77-6.73 (m, 4H, Ar-H), 5.42-5.38 (m, 2H, H-v), 5.29-5.26 (m, 2H, Thread), 5.21-5.07 (m, 2H, H-11), 4.50-4.42 (m, 4H, Thread), 4.31-4.17 (m, 2H, H-11'), 3.94-3.88 (m, 4H, Ethylene glycol-Chain), 3.78-3.56 (m, 12H, Ethylene glycolEthylene glycol-Chain), 3.55- 3.48 (m, 12H,Ethylene glycol-Chain), 3.46-3.40 (m, 6H, Thread), 3.25- 3.18 (m, 2H, H-w), 3.15-3.09 (m, 2H, H-w'), 2.30-2.24 (m, 4H, H-25) 1.27-1.17 (m, 6H, H-x), 1.16-0.94 (m, 18H, H-x'). Ar-H contains the signals for the BINOL-backbones, the second signal for H-23 and the signals for H-28.

^{13}C- NMR (151 MHz, [D]-chloroform, 298 K) δ [in ppm]: 157.9, 157.5, 156.3, 152.9, 152.4, 146.2, 146.0, 145.9, 145.3, 143.8, 142.9, 141.1, 140.7, 139.8, 139.7, 139.4, 138.7, 136.7, 136.5, 134.8, 134.6, 133.6, 132.4, 132.2, 131.6 (C-33), 131.2, 130.9, 130.8, 130.6 (C-v), 130.5, 130.46, 129.4 (C-v'), 128.9 (C-38), 128.6, 127.47, 127.4 (C-39), 127.1 (C-37), 126.6 (C-34), 126.3, 125.7, 123.4, 123.0, 115.0, 113.5, 113.48, 73.3, 73.0, 71.3, 71.1, 71.0, 70.8, 70.6, 70.0, 69.7, 64.4, 64.2, 63.8, 62.0, 60.5, 53.6, 48.5, 47.5, 42.7, 42.2, 32.1, 30.1, 30.0, 29.8, 29.66, 29.5 (C-25), 29.3, 26.6 (C-w), 26.5 (C-w'), 24.3, 24.0, 23.96, 22.8, 20.4, 14.4.

^{1}H,^{1}H-COSY (600 MHz, [D]-chloroform, 298K) [in ppm]: 7.54-7.49/ 7.44-7.37; 7.61-7.58/7.44-7.37; 7.54-7.49/7.94-7.89, 7.35-7.29; 7.44-7.37/7.94-7.89, 7.61-7.58, 7.35-7.29, 7.25-7.18; 7.35-7.29/ 7.54-7.49, 7.44-7.37; 7.25-7.18/7.44-7.37, 6.77-6.73; 6.77-6.73/7.25-7.18; 5.42-5.38/3.78-3.56, 3.46-3.40; 5.29-5.26/5.16, 3.78- 3.56; 5.21-5.07/5.29-5.26; 4.50-4.42/2.30-2.24; 4.31-4.17/3.78- 3.56; 4.50-4.42/2.41; 3.98/2.30-2.24; 3.94-3.88/2.30-2.24; 3.78- 3.56/5.42-5.38, 4.50-4.42; 3.78- 3.56/4.31-4.17, 5.29-5.26; 3.46-3.40/5.42-5.38, 1.27-1.17; 3.25-3.18, 1.16-0.94; 3.15-3.09 /1.16-0.94; 2.30-2.24/4.62; 2.27/4.50-4.42, 3.94-3.88; 1.27-1.17/3.25- 3.18; 3.15-3.09/1.16-0.94; 1.16-0.94/3.15-3.09.

^{1}H,^{13}C-HSQC (600 MHz/ 151 MHz, [D]-chloroform, 298K) [in ppm]: 8.21/127.1; 8.07-8.02/126.3, 130.5; 7.94-7.89/128.6, 130.8, 131.2, 131.6; 7.61-7.58/ 127.1, 128.9; 7.54-7.49/131.6, 127.4; 7.46 /126.3; 7.44-7.37/125.7, 127.1, 128.9; 7.35-7.29/ 131.6, 128.9, 127.4, 126.3; 7.25-7.18/ 132.4, 27.5, 126.6, 126.3; 7.05-7.02/127.1, 115.0; 6.77-6.73/ 113.5; 5.42-5.38/ 129.4, 130.6; 5.29-5.26/ 62.0, 60.5; 5.21-5.07/ 62.0, 60.5; 4.50-4.42/47.5, 48.5; 4.31-4.17/ 42.2; 3.94- 3.88/ 64.4; 3.78-3.56/ 71.3, 70.8, 70.0, 69.7; 3.55- 3.48/ 70.6; 3.46-3.40/ 26.5; 3.25- 3.18/ 26.5; 3.15-3.09/ 26.5; 2.30-2.24/ 30.2, 29.8; 1.27-1.17/29.4; 24.0; 1.16-0.94/ 24.0, 23.9.

^{1}H,^{13}C-HMBC (600 MHz/ 151 MHz, [D]-chloroform, 298K) [in ppm]: 7.94-7.89/ 130.9, 126.6; 7.61-7.58/ 138.5, 129.4, 127.4, 127.1, 126.3; 7.54-7.49/ 146.2, 140.7, 131.6, 128.9, 126.3; 7.46/131.6; 7.44-7.37/ 140.7, 128.9, 126.6; 7.35-7.29/ 138.7, 131.6, 127.1, 126.3, 63.8; 6.77-6.73/ 139.4; 1.27-1.17/ 141.0, 26.5, 23.9, 24.3.

MS (ESI-pos, MeOH): *m/z* = 2867.2963 ($[M+H]^+$, calc. 2867.2984 for $[C_{192}H_{177}N_7O_{16}P]^+$), 2889.2963 ($[M+Na]^+$, calc. 2889.2803 for $[C_{192}H_{176}N_7NaO_{16}P]^+$).

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}): 3406 (w), 3054 (m), 3027 (m), 2957 (m), 2924 (m), 2868 (m), 1605 (s), 1579 (w), 1559 (w), 1507 (s), 1484 (s), 1447 (w), 1398 (w), 1245 (s), 1182 (m), 1091 (s), 1042 (m), 1006 (m), 995 (w), 960 (w), 925 (w), 827 (s), 764 (s), 747 (s), 697 (s), 653 (w), 615 (w), 562 (w).

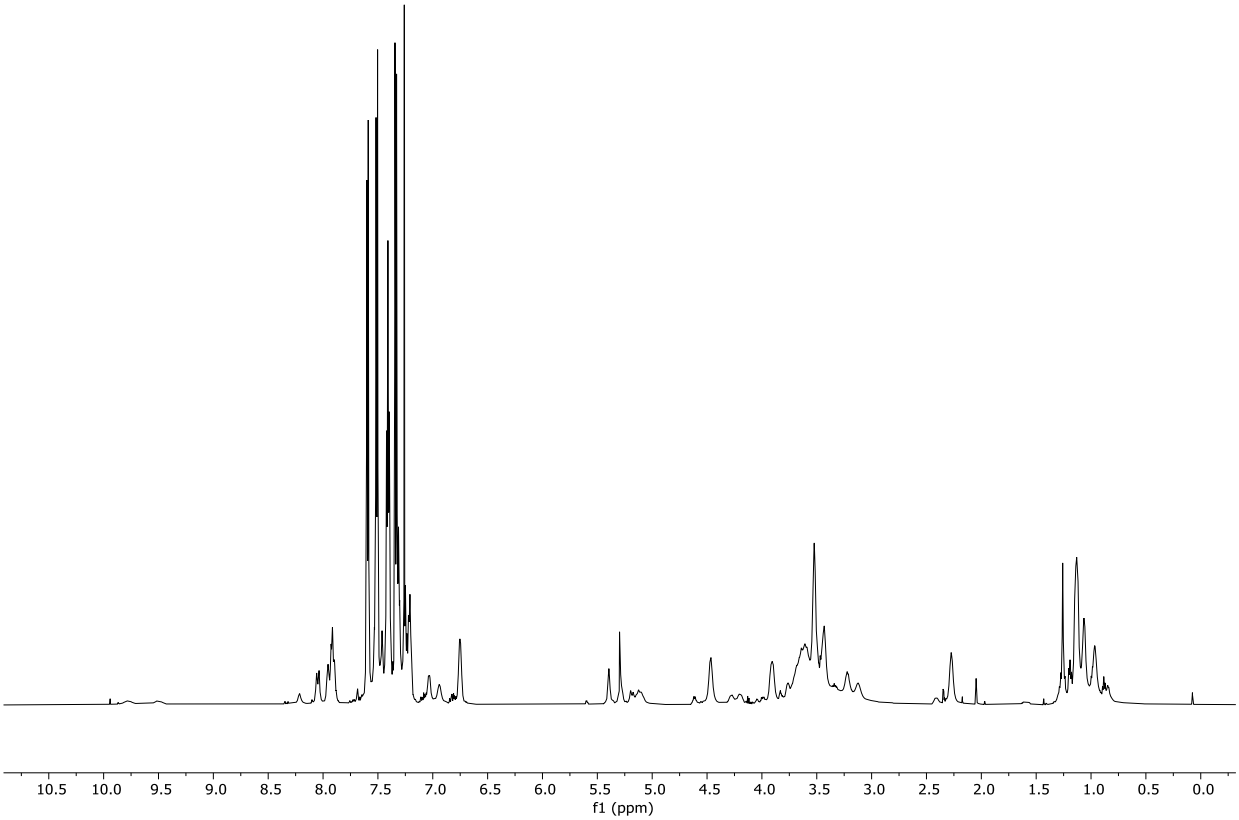


Figure S16: ^{1}H-NMR of the compound (*S,S*)-**2** ([D]-chloroform, 298 K, 600 MHz)

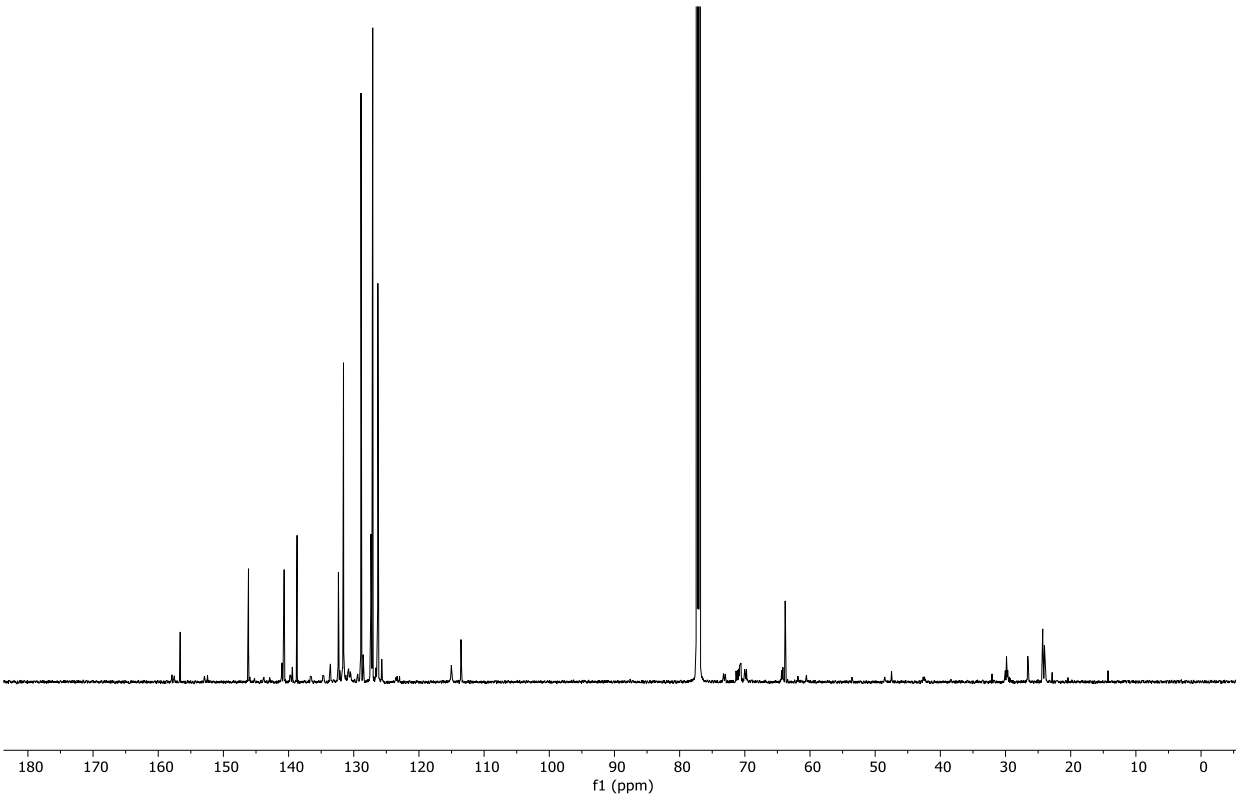
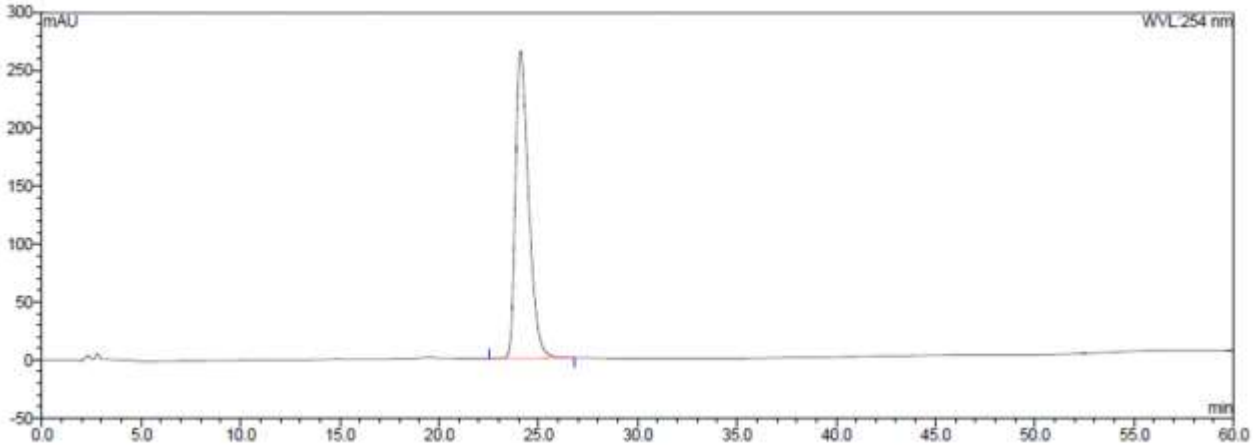


Figure S17: ^{13}C-NMR of the compound (*S,S*)-**2** ([D]-chloroform, 298 K, 151 MHz)

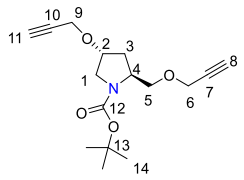


No.	*Ret. Time*	*Height*	*Area*	*Percent*
1	24.102	265.509	204.9323	100

Figure S18*:* Reversed phase HPLC of the rotaxane (*S,S*)-**2**.

2.3 Prolinol-based systems

Compound (*R,S*)-**17**



N-Boc-*trans*-hydroxy-L-prolinol (*R,S*)-**6** (500 mg, 2.31 mmol, 1 eq) was dissolved in anhydrous tetrahydrofuran (50 ml) and cooled to 0 °C. Sodium hydride (276 mg, 6.90 mmol, 3 eq) was added. After stirring for 10 minutes, propargyl bromide (0.77 ml, 6.90 mmol, 3 eq) was added, the solution was warmed to room temperature and stirred overnight. Saturated ammonium chloride solution (50 ml) was added. The phases were separated and the aqueous phase was extracted with ethyl acetate (3 x 30 ml). The combined organic phases were washed with brine (30 ml), dried with magnesium sulfate, filtered and the solvent removed *in vacuo*. The residue was purified by silica flash column chromatography (cyclohexane/ethyl acetate 3/1) to give the product as a yellow oil (515 mg, 1.76 mmol, 76%).

Chemical formula: $C_{16}H_{23}NO_4$ **Molecular weight:** 293.36 g/mol

^{1}H NMR (400 MHz, [D]-chloroform, 298 K) *δ* [in ppm]: 4.30-4.26 (m, 1H, H-2), 4.20 – 4.08 (m, 4H, H-6 and H-9), 4.04 (br. s, 1H, H-4), 3.77 – 3.51 (m, 2H, H-5), 3.51 – 3.40 (m, 2H, H-1), 2.42 (t, *J* = 2.4 Hz, 1H, H-8 or H-11), 2.41 (t, *J* = 2.4 Hz, 1H, H-8 or H-11), 2.21 – 2.04 (m, 2H, H-3), 1.46 (s, 9H, H-14).

^{13}C NMR (101 MHz, [D]-chloroform, 298 K) *δ* [in ppm]: 154.6 (C-11), 79.9, 79.8 (C-7 and C-10 and C-12), 76.4 (broad, C-2), 74.6, 74.5 (C-11 and C-8), 71.0 (broad, C-5), 58.7, 56.5 (C-6 and C-9), 55.6 (C-4), 51.6 (broad, C-1), 28.6 (C-14).

COSY (400 MHz / 400 MHz, [D]-chloroform, 298 K) δ [in ppm]:4.29 / 3.51 – 3.40, 2.21 – 2.04 (H-2/H-1, H-3), 4.20 – 4.08 / 2.42, 2.41 (H-9,H-6 /H-11,H-8), 4.04 / 3.77 – 3.51 (H-4/H-5), 3.77 – 3.51 / 4.04 (H-5/H-4), 3.51 – 3.40 / 4.29 (H-1/H-2), 2.42 / 4.20-4.08 (H-8,H-11/H6, H9), 2.41 / 4.20-4.08 (H-8, H-11 / H-6,H-9), 2.21 – 2.04 / 4.04, 3.51 – 3.40 (H-3/H-2, H-1).

HSQC (400 MHz / 101 MHz, [D]-chloroform, 298 K) δ [in ppm]:4.29 / 76.4 (H-2/C-2), 4.20 – 4.08 / 58.7, 56.5 (H-6/ C-6 and H-9/C-9), 4.04 / 55.6 (H-4/ C-4), 3.77 – 3.51 / 71.0 (H-5/ C-5), 3.51 – 3.40 / 51.6 (H-1/C-1), 1.46 / 28.6 (H-31/ C-31).

HMBC (400 MHz / 101 MHz, [D]-chloroform, 298 K) δ [in ppm]:4.20 – 4.08 / 79.9, 79.8, 76.4, 74.6, 74.5, 71.0 (H-6/ C-5, C-7, C-8 and H-9/C-10, C-11, C-2), 2.21 – 2.04 / 71.0, 55.6 (H-3/C-5, C-4), 1.46 / 154.6, 79.9, 28.6 (H-31/C-11, C-12, C-31').

MS (ESI-pos, MeOH): m/z = 316.1520 ([M+Na]$^+$, calcd. 316.1519 for [$C_{16}H_{23}NNaO_4$]$^+$)

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}): 3282 (m), 2975 (m), 2931 (m), 1681 (s), 1478 (w), 1403 (s), 1367 (s), 1253 (w), 1161 (s), 1131 (m), 1087 (m), 925 (w), 858 (w), 773 (w), 671 (w), 551 (w).

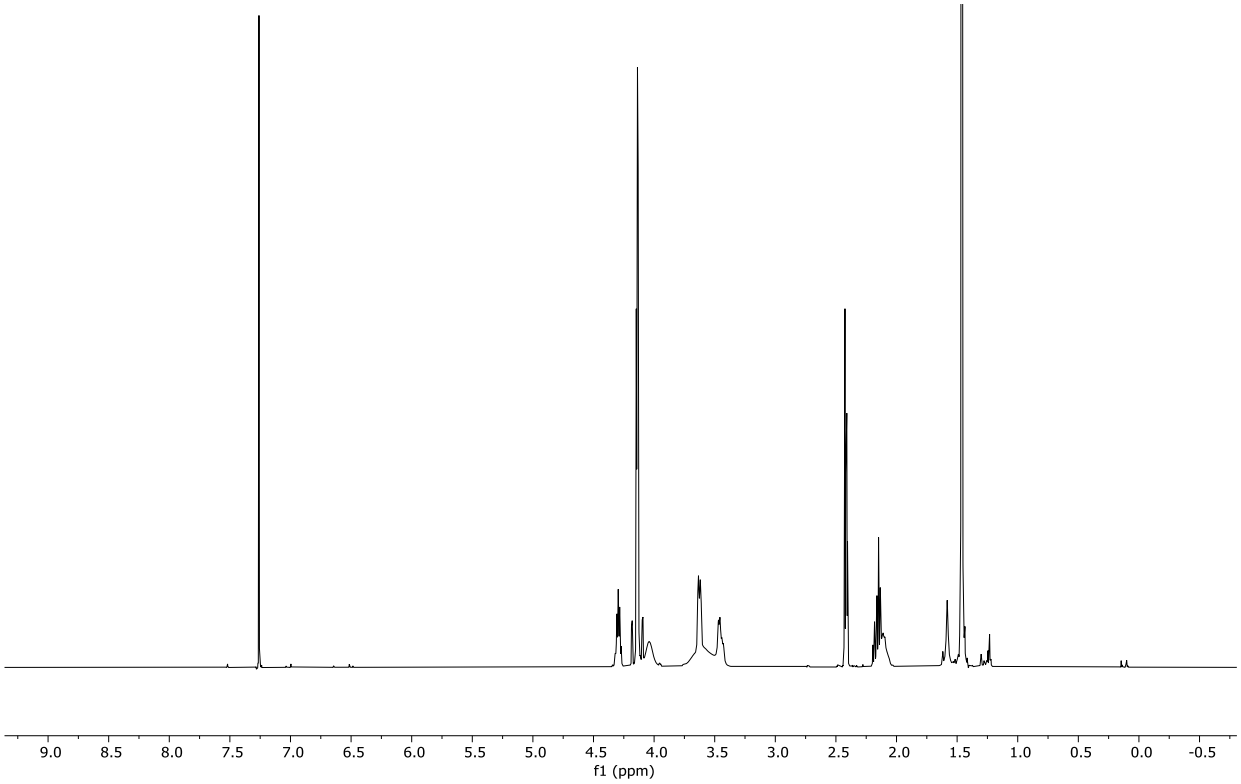


Figure S19: ^{1}H-NMR spectrum of (*R,S*)-**17** ([D]-chloroform, 298 K, 400 MHz).

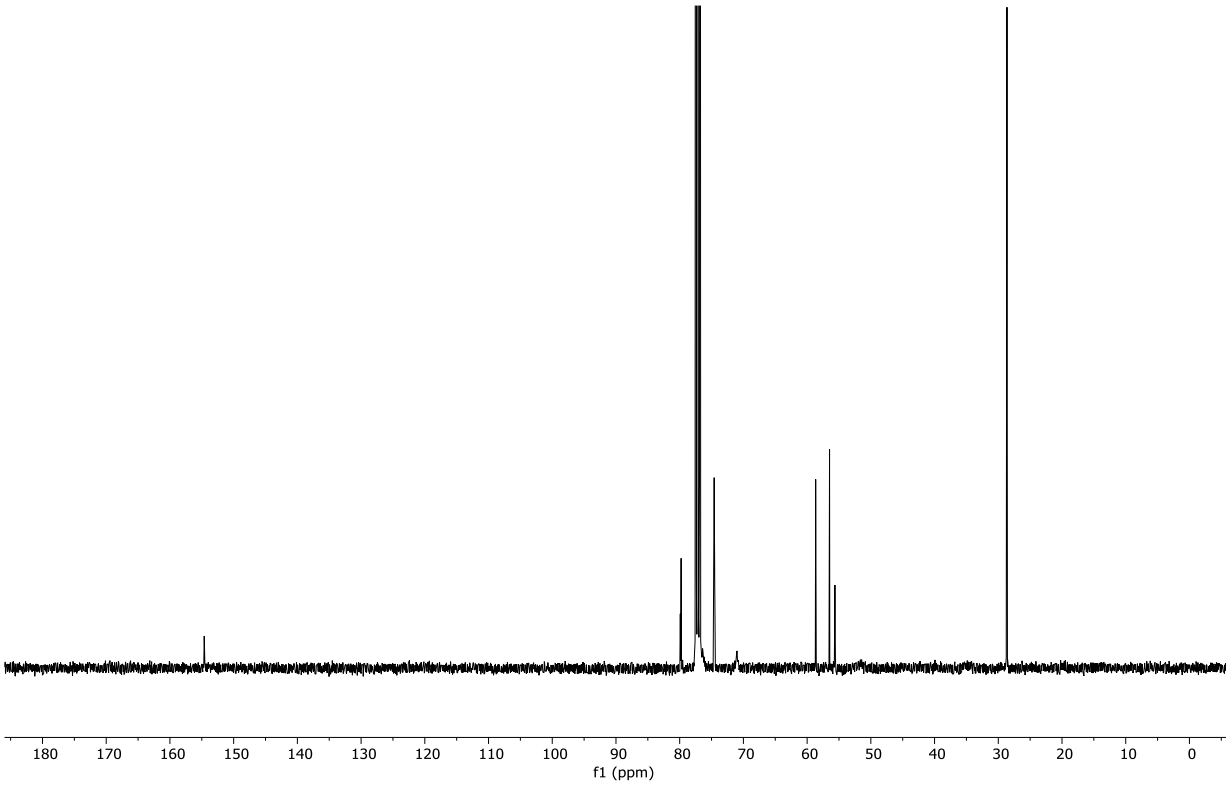
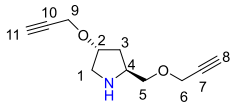


Figure S20: ^{13}C-NMR spectrum of (*R,S*)-**17** ([D]-chloroform, 298 K, 101 MHz).

Compound (*R*,*S*)-**18**



The Boc-protected amine (*R*,*S*)-**17** (340 mg, 1.16 mmol, 1 eq) was dissolved in dichloromethane (25 mL). Trifluoroacetic acid (2.20 mL, 28.9 mmol, 25 eq) was added and the reaction mixture was stirred overnight at room temperature. Sodium hydroxide (2 M, 20 mL) was added carefully. The phases were separated and the aqueous phase was extracted with dichloromethane (3 x 15 mL). The combined organic phases were washed with brine (1 x 20 mL). The solvent was removed *in vacuo* to give the product as a light orange oil (220 mg, 1.14 mmol, 98%).

Chemical formula: $C_{11}H_{15}NO_2$ **Molecular weight:** 193.25 g/mol

^{1}H NMR (400 MHz, [D]-chloroform, 298 K) *δ* [in ppm]: 4.23 (ddd, *J* = 7.2, 4.8, 2.2 Hz, 1H, H-2), 4.17 (t, *J* = 2.0 Hz, 2H, H-6), 4.11 (d, *J* = 2.4, 2H, H-9), 3.57 – 3.49 (m, 2H, H-4 and H-5), 3.43 (dd, *J* = 10.5, 8.0 Hz, 1H, H-5'), 3.08 (dd, *J* = 12.1, 4.6 Hz, 1H, H-1), 3.05 – 2.98 (m, 1H, H-1'), 2.40 – 2.43 (m, 2H, H8 and H11), 1.95 – 2.02 (m, 1H, H-3), 1.68 – 1.58 (m, 1H, H-3') .

^{13}C NMR (101 MHz, [D]-chloroform, 298 K) *δ* [in ppm]: 80.0 (C-11), 79.8 (C-7), 79.7 (C-2), 74.6 (C-8), 74.3 (C-10), 72.8 (C-5), 58.6 (C-6), 56.6 (C-4), 56.3 (C-9), 52.1 (C-1), 34.8 (C-3).

^{1}H,^{1}H-COSY (400 MHz / 400 MHz, [D]-chloroform, 298 K) δ [in ppm]: 4.23 / 3.08, 3.05 – 2.98, 1.68 – 1.58 (H-2/H-1, H-1', H-3), 4.17 / 2.41 (H-6/H-8), 4.11 / 2.41 (H-9/H-11), 3.57 – 3.49 / 3.43, 3.08, 1.99, 1.68 – 1.58 (H-4,H-5/H-5', H-1, H-3, H-3'), 3.43 / 3.57 – 3.49 (H-5'/H-5), 3.08 / 4.23, 3.05 – 2.98 (H-1/H-2, H-1'), 3.05 – 2.98 / 4.23, 3.08 (H-1'/H-2, H-1), 2.40-2.43 / 4.17, 4.11 (H-8, H-11/H-6, H-9), 1.99 / 3.57 – 3.49, 1.68 – 1.58 (H-3/ H-4, H-5, H-3'), 1.68 – 1.58 / 4.29, 3.57 – 3.49, 1.99 (H-3'/H-2, H-4, H-3).

^{1}H,^{13}C-HSQC (400 MHz / 101 MHz, [D]-chloroform, 298 K) δ [in ppm]: 4.23 / 79.7 (H-2/C-2), 4.17 / 58.6 (H-6/C-6), 4.11 / 56.3 (H-9/C-9), 3.57 – 3.49 / 72.8, 56.6 (H-5/C-5 and H-4/C-4), 3.43 / 72.8 (H-5'/C-5), 3.08 / 52.1 (H-1/C1), 3.05 – 2.98 / 52.1 (H1'/C-1), 2.40-2.43 / 80.0, 74.6 (H-8/C-8 and H-11/C-11), 1.99 / 34.8 (H- 3/C- 3), 1.68 – 1.58 / 34.8 (H-3'/C-3).

^{1}H,^{13}C-HMBC (400 MHz / 101 MHz, [D]-chloroform, 298 K) δ [in ppm]:4.17 / 79.8, 74.6, 72.8 (H-6/C-7, C-8, C-5), 4.11 / 80.0, 74.3 (H-9/C-11, C-10), 3.57 – 3.49 / 58.6, 56.6, 34.8 (H-5 and H-4/C-6, C-4, C-3), 3.43 / 58.6, 56.6, 34.8 (H-5'/C-6, C-4, C-3), 3.08 / 56.6, 34.8 (H-1/C-4, C-3), 3.05 – 2.98 / 79.7, 56.6, 34.8 (H-1'/ C-2, C-4, C-3), 2.40-2.43 / 58.6, 56.3 (H-11 and H-8/C-10, C-9), 1.99 / 79.7, 72.8, 52.1 (H-3/C-2, C-5, C-1), 1.68 – 1.58 / 72.8, 56.6 (H-3'/C-5, C-4).

MS (ESI-pos, MeOH): m/z = 216.1001 ([M+Na]$^+$, calcd. 216.0995 for $[C_{11}H_{15}NNaO_2]^+$).

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}): 3278 (m), 2923 (m), 2854 (m), 1604 (s), 1439 (m), 1359 (w), 1336 (w), 1233 (w), 1199 (w), 1079 (s), 918 (w), 901 (w), 664 (w).

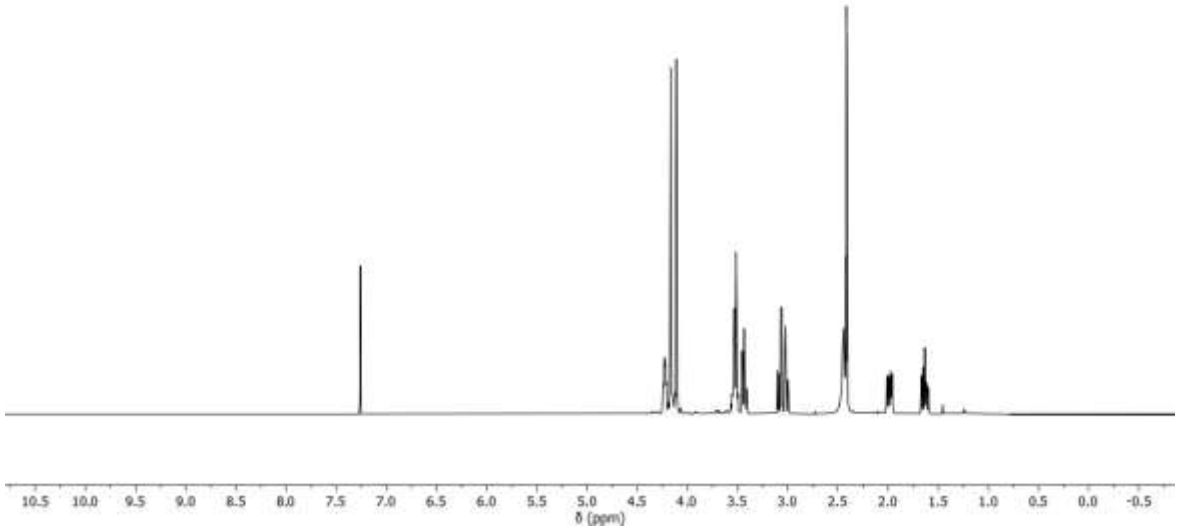


Figure S21: ^{1}H-NMR spectrum of *(R,S)*-**18** ([D]-chloroform, 298 K, 400 MHz).

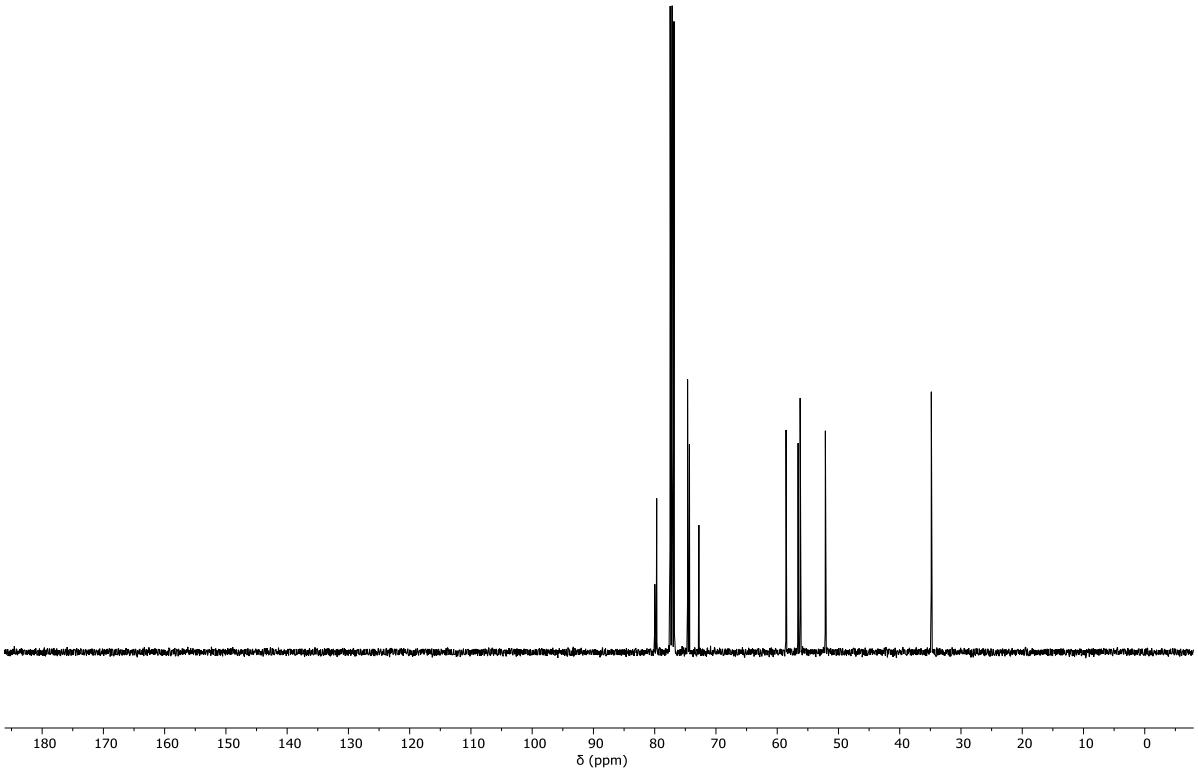
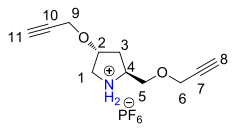


Figure S22: ^{13}C-NMR spectrum of (*R,S*)-**18** ([D]-chloroform, 298 K, 101 MHz).

Compound (*R,S*)-**7**



Amine (*R,S*)-**18** (120 mg, 0.621 mmol, 1 eq) was weighed in a flask and dissolved in diethyl ether (10 mL). Hydrogen chloride in diethyl ether (1 M, 6.83 mL, 6.83 mmol, 11 eq) was slowly added and the mixture was stirred for 30 minutes at room temperature. The solvent was removed *in vacuo* and the residue was redissolved in dichloromethane (10 mL). Ammonium hexafluorophosphate (521 mg, 3.11 mmol, 5 eq) was added and the mixture was stirred overnight. The suspension was filtered and the filter residue was washed with DCM (10 mL). The filtrate was dried to give the product as a white solid (170 mg, 0.503 mmol, 81%).

Chemical formula: $C_{11}H_{15}F_6NO_2P$ **Molecular weight:** 338.21 g/mol

^{1}H NMR (400 MHz, [D]-chloroform, 298 K), δ [in ppm]: 8.76 (br s, 2H, NH_2), 4.49-4.55 (m, 1H, H-2), 4.27 (d, *J* = 2.4 Hz, 1H, H-9), 4.24 (d, *J* = 2.3, 1H, H-9'), 4.20 (t, *J* = 2.1 Hz, 2H, H-6), 4.09-4.17 (m, 1H, H-4), 3.88 (dd, *J* = 10.7, 3.8 Hz, 1H, H-5), 3.78 (dd, *J* = 10.7, 5.8 Hz, 1H, H-5'), 3.54-3.57 (m, 2H, H-1), 2.49 (2t, *J* = 2.5 Hz, 2H, H-8, H-11), 2.28 (dd,*J* = 14.4, 6.9 Hz, 1H, H-3), 2.09 (ddd, *J* = 15.3, 10.7, 5.0 Hz, 1H, H-3').

^{31}P NMR (162 MHz, [D]-chloroform, 298 K), δ [in ppm]: -142.04 (sept, *J* = 714 Hz).

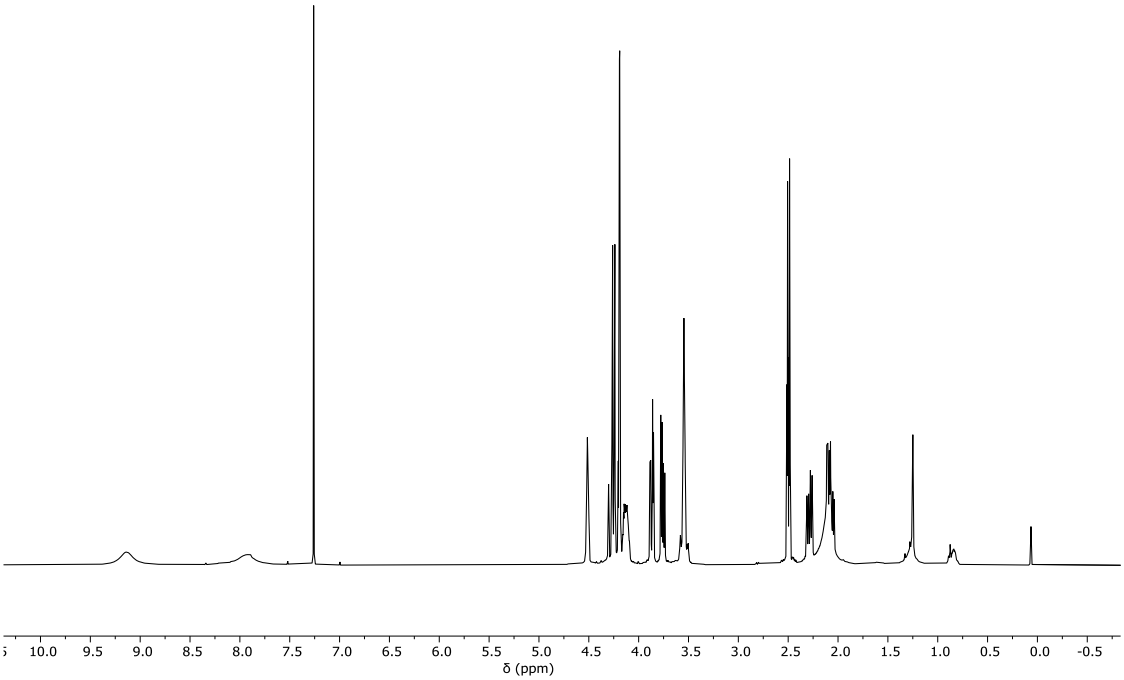


Figure S23: ^{1}H-NMR spectrum of (*R,S*)-**7** ([D]-chloroform, 298 K, 400 MHz).

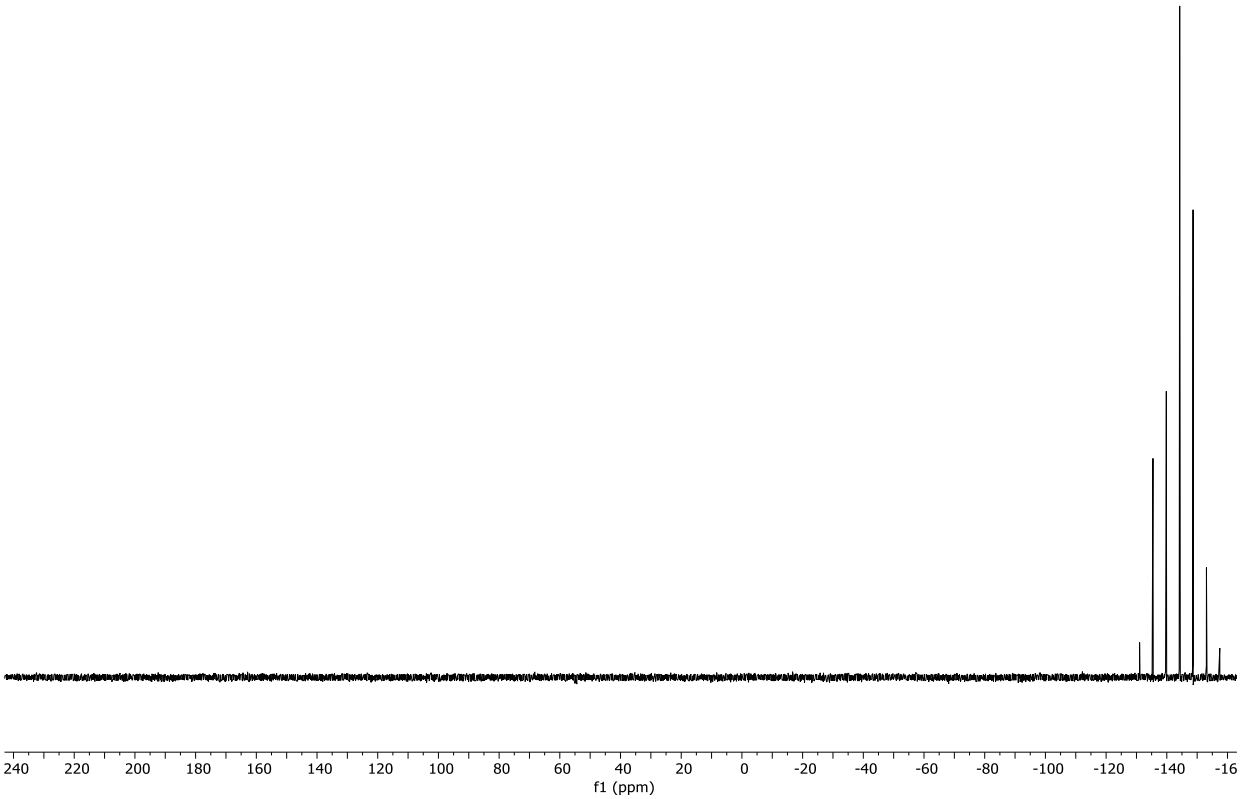
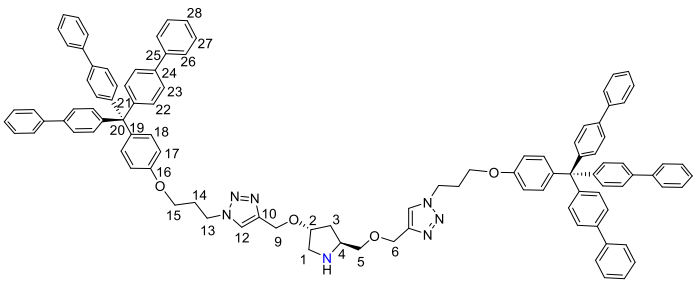


Figure S24: ^{31}P-NMR spectrum of (*R,S*)-**7** ([D]-chloroform, 298 K, 162 MHz).

Compound (*R,S*)-**19**



The bisalkyne (*R,S*)-**18** (15.0 mg, 0.0776 mmol, 1 eq.) and the stopper **9** (105 mg, 0.163 mmol, 2.1 eq.) were weighed in a Schlenk flask and dried for 3 hours *in vacuo*. Dry and degassed dichloromethane (1.7 mL) was added and the mixture was stirred for 30 minutes. Tetrakis(acetonitrile)copper(I) hexafluorophosphate catalyst (14.5 mg, 0.0388 mmol, 0.5 eq.) was added and the mixture was stirred for 4 hours at room temperature. 3-(Ethylenediamino)-propyl functionalized silica gel (1.4 mmol/g, 30 mg) was added and the mixture as stirred for 1 hour. The mixture was then filtered and the filtrate was concentrated *in vacuo*. After purification by column chromatography (cyclohexane/ethyl acetate/methanol = 4/4/1), the product was obtained as a beige foam (56.8 mg, 0.0381 mmol, 49%).

Chemical formula: $C_{103}H_{89}N_7O_4$ **Molecular weight:** 1488.89 g/mol

^{1}H NMR (400 MHz, [D]-chloroform, 298 K) δ [in ppm]: 7.69 (s, 2H, H-12), 7.64 – 7.56 (m, 12H, H-26), 7.55 – 7.46 (m, 12H, H-23), 7.46 – 7.38 (m, 12H, H-27), 7.37 – 7.27 (m, 18H, H-22 and H-28), 7.25 – 7.16 (m, 4H, H-18), 6.85 – 6.72 (m, 4H, H-17), 4.66 (s, 2H, H-6), 4.61 – 4.47 (m, 6H, H-9 and H-13), 4.28 – 4.20 (m, 1H, H-2), 4.01 – 3.91 (m 4H, H-15), 3.90 – 3.81 (m, 1H, H-4), 3.75 – 3.63 (m, 2H, H-5), 3.37 – 3.23 (m, 2H, H-1), 2.44 – 2.30 (m 4H, H-14), 2.13 – 2.02 (m, 1H, H-3), 1.89 – 1.77 (m, 1H, H-3').

^{13}C NMR (101 MHz, [D]-chloroform, 298 K) δ [in ppm]: 156.6 (C-16), 146.1 (C-21), 144.6 (C-10) 140.7 (C-25), 139.49 and 139.45 (C-19), 138.7 (C-24), 132.4 (C-18), 131.6 (C-22), 128.9 (C-27), 127.4 (C-28), 127.1 (C-26), 126.3 (C-23), 123.5 (C-12), 113.5 (C-17), 77.4 (C-2), 70.2 (C-5, broad) 64.2 (C-6), 63.8 (C-15 and C-20), 62.5 (C-9) 57.7 (C-4), 50.9 (C-1, broad), 47.4 (C-13), 34.1 (C-3), 30.1 (C-14).

COSY (400 MHz / 400 MHz, [D]-chloroform, 298 K) δ [in ppm]: 7.64 – 7.56 / 7.46 – 7.38 (H-26/H-27), 7.55 – 7.46 / 7.37 – 7.27 (H-23/H-22), 7.46 – 7.38 / 7.64 – 7.56, 7.37 – 7.27 (H-27/H-26, H-28), 7.37 – 7.27 / 7.55 – 7.46, 7.46 – 7.38 (H-22, H-28/H-23, H-27), 7.25 – 7.16 / 6.85 – 6.72 (H-18/H-17), 6.85 – 6.72 / 7.25 – 7.16 (H-17/H-18), 4.61 – 4.47 / 2.44 – 2.30 (H-13/H-14), 4.28 – 4.20 / 3.37 – 3.23, 1.89 – 1.77 (H-2/H-1, H3'), 4.01 – 3.91 / 2.44 – 2.30 (H-15/H-14), 3.90 – 3.81 / 2.13 – 2.02, 1.89 – 1.77 (H-4/H-3, H-3'), 3.37 – 3.23 / 4.28 – 4.20 (H-1/H-2), 2.44 – 2.30 / 4.61 –

4.47, 4.01 – 3.91 (H-14/H-13, H-15), 2.13 – 2.02 / 3.90 - 3.81, 1.89 – 1.77 (H-3/H-4, H-3'), 1.89 – 1.77 / 4.20, 2.13 – 2.02 (H-3'/H-2, H-3).

HSQC (400 MHz / 101 MHz, [D]-chloroform, 298 K) *δ* [in ppm]: 7.69 / 123.5 (H-12/C-12), 7.64 – 7.56 / 127.1 (H-26/C-26), 7.55 – 7.46 / 126.3 (H-23/C-23), 7.46 – 7.38 / 128.9 (H-27/C-27), 7.37 – 7.27 / 131.6, 127.4 (H-22, H-28/C-22 andC-28), 7.25 – 7.16 / 132.4 (H-18/C-18), 6.85 – 6.72 / 113.5 (H-17/C-17), 4.66 / 64.2 (H-6/C-6), 4.61 – 4.47 / 62.5, 47.4 (H-9, H-13/C-9, C-13), 4.28 – 4.20 / 77.4 (H-2/C-2), 4.01 – 3.91 / 63.8 (H-15/C-15), 3.90 – 3.81 / 57.7 (H-4/C-4), 3.75 – 3.63 / 70.2 (H-5/C-5) 3.37 – 3.23 / 50.9 (H-1/C-1), 2.44 – 2.30 / 30.1 (H-14/C-14), 2.13 – 2.02 / 34.1 (H-3/C-3), 1.89 – 1.77 / 34.1 (H-3'/C-3).

HMBC (400 MHz / 101 MHz, [D]-chloroform, 298 K) *δ* [in ppm]: 7.64 – 7.56 / 138.7, 128.9, 127.4, (H- 26/C-24, C-27, C-28), 7.55 – 7.46 / 146.1, 140.7, 131.6, 126.3 (H-23/C-21, C-25, C-22, C-23'), 7.46 – 7.38 / 140.7, 128.9, 127.1 (H-27/C-25, C-27', C-26), 7.37 – 7.27 / 138.7, 131.6, 128.9, 126.3, 63.8 (H-22 and H-28 /C-24, C-22, C-27,C-23, C-20), 7.25 – 7.16 / 156.6, 132.4, 63.8 (H-18/C-16, C-18', C-20), 6.85 – 6.72 / 156.6, 139.5, 113.5 (H-17/ C-16, C-19, C-17'), 4.66 / 144.6, 123.5, 70.2 (H-6/C-10', C-12', C- 5), 4.61 – 4.47 / 144.6, 123.5, 63.8, 30.1 (H-9 and H-13/C-10, C-12, C-15, C-14), 44.01 – 3.91 / 47.4 (H-15/C-13).

MS (ESI-pos, MeOH): m/z = 1488.7084 ($[M+H]^+$, calcd. 1488.7048 for $[C_{103}H_{90}N_7O_4]^+$).

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}): = 3030 (w), 2442 (w), 2160 (s), 2031 (m), 1977 (s), 1601 (w), 1582 (w), 1506 (w), 1483 (m), 1447 (w), 1294 (w), 1244 (m) 1182 (m), 1094 (w), 1042 (w), 1007 (m), 826 (s), 764 (m), 746 (s), 694 (s), 665 (w), 652 (w), 613 (w) cm^{-1}.

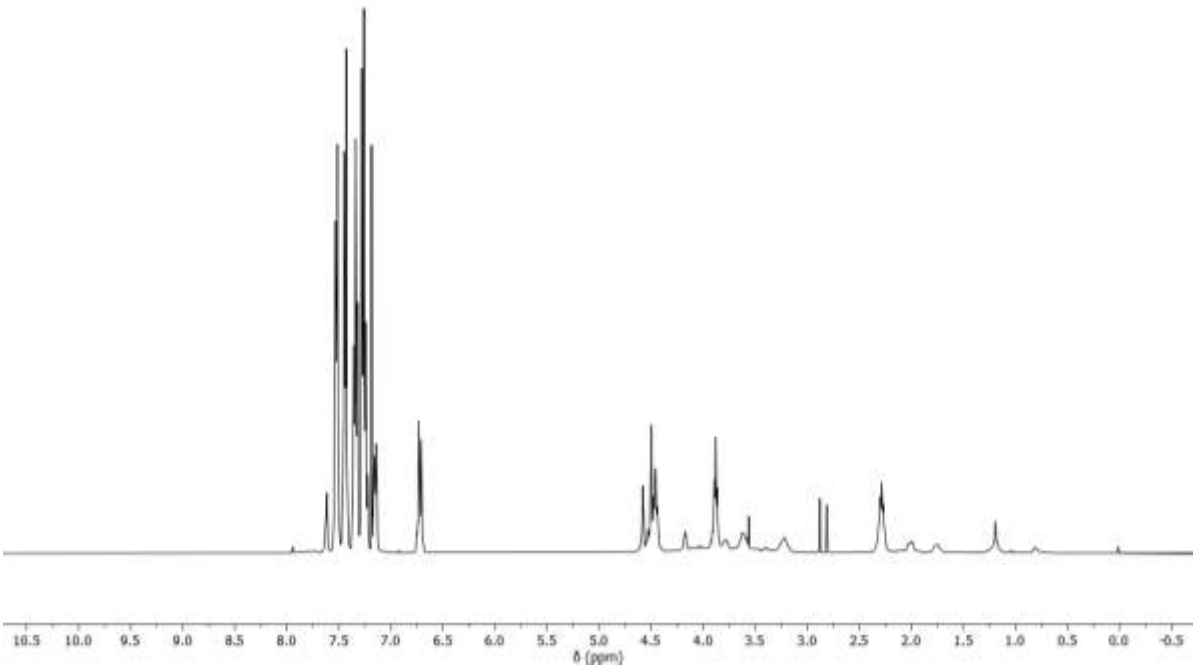


Figure S25: ^{1}H-NMR spectrum of (*R,S*)-**19** ([D]-chloroform, 298 K, 400 MHz).

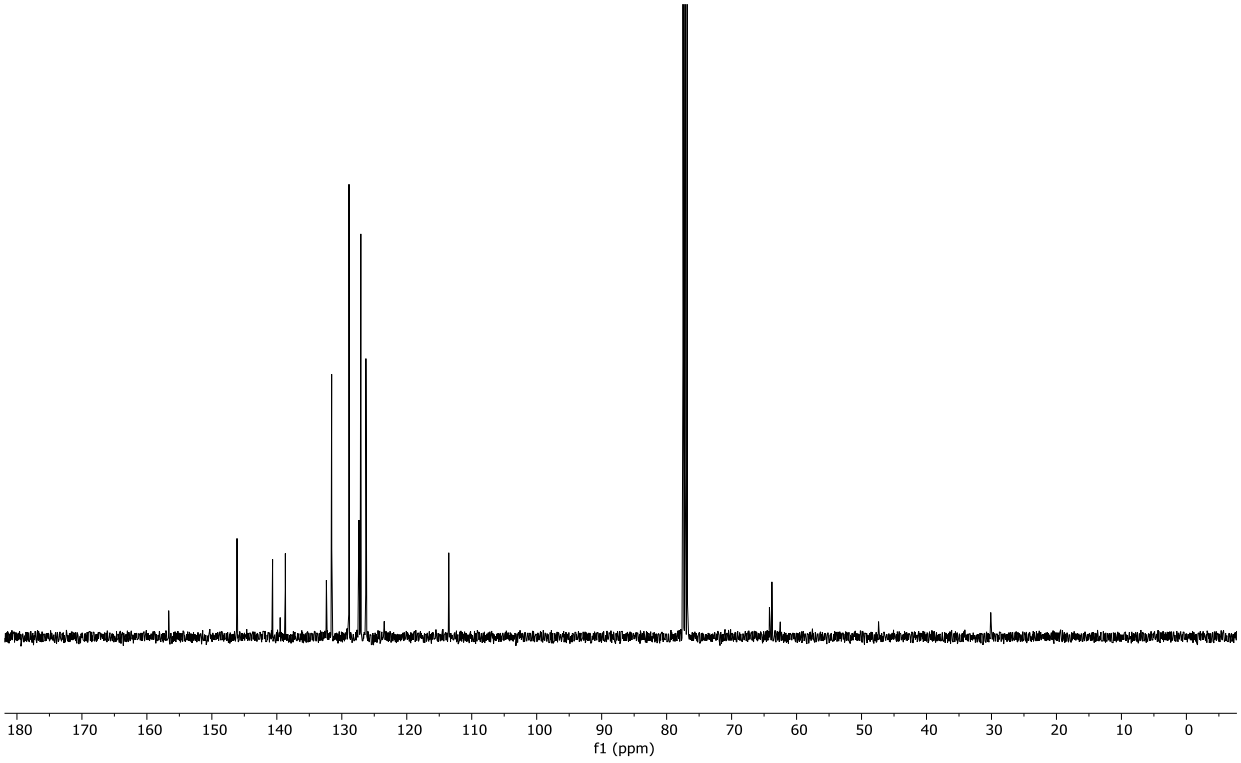
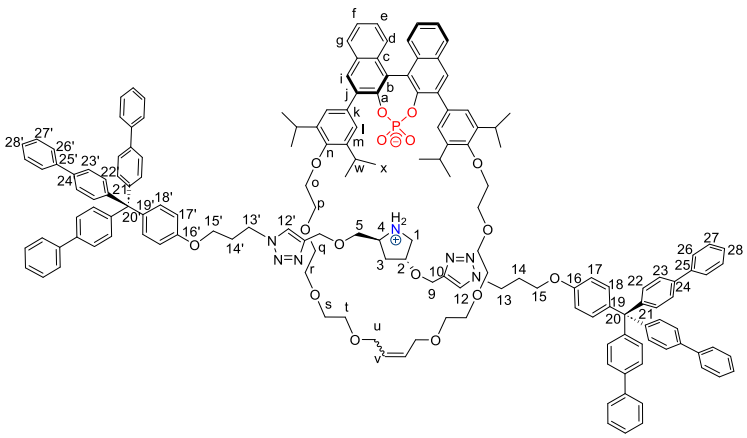


Figure S26: ^{13}C-NMR spectrum of (*R,S*)-**19** ([D]-chloroform, 298 K, 101 MHz).

Compound (*S,R,S*)-**3**



The amine (*R,S*)-**7** (31.0 mg, 0.0914 mmol, 2.3 eq), the stopper **9** (119 mg, 0.183 mmol, 4.6 eq) and the macrocycle (*S*)-**8** (50.0 mg, 0.0397 mmol, 1 eq) were weighed in a Schlenk flask and dried for 3 hours *in vacuo*. Dry and degassed dichloromethane (4 mL) was added and the mixture was stirred for 2 hours. Tetrakis(acetonitrile)copper(I) hexafluorophosphate catalyst (10.4 mg, 0.0278 mmol, 0.7 eq) was then added and the mixture was stirred overnight at room temperature. 3-(Ethylenediamino)-propyl functionalized silica gel (1.4 mmol/g, 60 mg) was added and the mixture was stirred for 2 hours. The mixture was then filtered and the filtrate was concentrated in vacuo. After purification by column chromatography (1st column: chloroform/methanol 100/1, 2nd column: dichloromethane/ethylacetate 1/1 + 1-10% methanol performed with NextGen), the product was obtained as a white foam (37.2 mg, 0.0148 mmol, 37%).

Chemical formula: $C_{163}H_{162}N_7O_{16}P$ **Molecular weight:** 2506.10 g/mol

^{1}H-NMR (600 MHz, [D]-chloroform, 298 K) δ [in ppm]: 9.78 (br s, 1H, NH_2), 8.46 (br s, 1H, NH_2), 8.04 (s, 1H, H-12), 7.98 (s, 2H, H-l), 7.89-7.84 (m, 2H, BINOL-Backbone), 7.75 (s, 1H, H-12'), 7.61 (d, *J* = 6.80 Hz, 12H, H-26), 7.55 (s, 2H, H-l'), 7.54-7.48 (m, 14H, H-23, BINOL-Backbone), 7.47-7.39 (m, 13H, H-27, BINOL-Backbone), 7.38-7.30 (m, 21H, H-22, H-28, BINOL-Backbone), 7.22-7.10 (m, 6H, H-18, H-18', BINOL-Backbone), 6.72 (d, *J* = 9.58Hz, 2H, H-17), 6.68-6.60 (m, 2H, H-17'), 5.63 (s, 2H, H-v), 4.54-4.45 (m, 3H, Prolinol-Thread), 4.42-4.31 (m, 3H, Prolinol-Thread), 4.24-4.19 (m, 2H, Prolinol Thread), 4.14-4.03 (m, 3H, Prolinol-Thread), 3.97-3.91 (m, 2H, Prolinol-Thread), 3.88-3.82 (m, 7H, Ethylene glycol-Chain, Prolinol-Thread), 3.82-3.74 (m, 6H, Ethylene glycol-Chain), 3.74-3.56 (m, 12H, Ethylene glycol-Chain), 3.56-3.45 (m, 8H, Ethylene glycol-Chain), 3.40-3.29 (m, 4H, H-w), 3.23-3.15 (m, 1H, Prolinol-Thread), 2.89-2.66 (m, 1H, Prolinol-Thread, water), 2.28-2.19 (m, 2H, Prolinol-Thread), 1.96-1.90 (m, 1H, Prolinol-Thread), 1.71-1.62 (m, 1H, Prolinol-Thread), 1.25-1.11 (m, 24H, H-x).

^{13}C- NMR (151 MHz, [D]-chloroform, 298 K) δ [in ppm]: 156.58, 146.18, 146.12, 140.86, 140.71, 140.67, 138.74, 138.70, 138.66, 132.42, 132.29, 132.18, 131.56 (C-22, C-28), 130.29, 130.13 (C-l), 129.47, 129.25 (C-v), 129.18, 128.89 (C-27), 128.35, 127.36 (C-22, C-28), 127.09 (C-26), 126.47, 126.28 (C-23), 113.48 (C-17), 73.70, 73.64, 71.26, 71.18, 71.14, 70.96, 70.92, 70.78,

70.72, 70.68, 70.54, 70.39, 70.31, 70.23, 69.99, 69.73, 64.16, 63.78, 62.45, 58.11, 50.04, 32.86, 30.09, 29.53, 26.68 (C-w), 24.50 (C-x), 24.34 (C-x'), 24.19 (C-x''), 23.97 (C-x''').

^{1}H,^{1}H-COSY (600 MHz, [D]-chloroform, 298K) [in ppm]: 7.98/ 130.13; 7.89-7.84/ 128.35; 7.75/ 123.7; 7.61/127.06; 7.55/126.28; 7.54-7.48/128.89; 7.47-7.39/ 131.56, 127.36, 125.3; 7.22-7.10/ 132.3, 125.9; 6.72/113.5; 6.68-6.60/113.49; 5.63/129.41; 4.54-4.45/ 62.39; 4.42-4.31/ 62.39, 47.13; 4.14-4.03/73.7; 3.97-3.91/73.7; 3.88-3.82/71.2, 64.2, 50.8; 3.74-3.56/70.8, 63.8; 3.56-3.45/70.4; 3.40-3.29/26.67; 3.23-3.15/50.0; 2.89-2.66/50.0; 2.28-2.19/30.0; 1.96-1.90/32.8; 1.60/32.8; 1.25-1.11/ 24.51,24.29,24.25,23.98.

^{1}H,^{13}C-HSQC (600 MHz/ 151 MHz, [D]-chloroform, 298K) [in ppm]: 7.89-7.84/7.38-7.30; 7.61/7.54-7.48, 7.47-7.39, 7.38-7.30; 7.54-7.48/7.75, 7.47-7.39, 7.22-7.10; 7.47-7.39/ 7.75, 7.54-7.48, 7.38-7.30; 7.38-7.30/ 7.89-7.84, 7.75, 7.47-7.39, 7.54-7.48, 7.22-7.10; 7.22-7.10/7.47-7.39, 6.72, 6.68-6.60; 6.72/7.22-7.10; 6.68-6.60/7.22-7.10; 5.63 / 3.82-3.74; 4.42-4.31/2.17; 3.82-3.74 /5.63, 2.28-2.19; 3.40-3.29/ 1.25-1.11; 2.89-2.66/ 3.23-3.15; 2.28-2.19/4.42-4.31, 3.82-3.74; 1.96-1.90/ 1.71-1.62; 1.71-1.62/4.24-4.19, 3.74-3.56, 1.96-1.90; 1.25-1.11 /3.40-3.29.

^{1}H,^{13}C-HMBC (600 MHz/ 151 MHz, [D]-chloroform, 298K) [in ppm]: 7.98/146.18, 132.31; 7.89-7.84/ 132.3; 7.75/144.44, 127.36; 7.61/138.68, 128.89, 127.06; 7.54-7.48/152.52, 146.15, 140.71, 134.94, 131.56, 126.28,26.67; 7.47-7.39/140.71, 128.89, 127.06; 7.38-7.30/ 138.68,131.56, 128.89; 6.72/139.34; 5.63 /71.3; 3.82-3.74/129.41; 1.25-1.11/140.71, 26.67, 23.38.

MS (ESI-pos, MeOH): *m/z* = 1253.0875 ($[M+2H]^{2+}$, calcd. 1253.0981 for $[C_{163}H_{164}N_7O_{16}P]^{2+}$)

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}): 3029 (m), 2866 (m), 1484 (s), 1248 (m), 1095 (s), 830 (m), 763 (m), 747 (m), 697 (m), 626 (w), 570 (w), 537 (w), 507 (w), 492 (w).

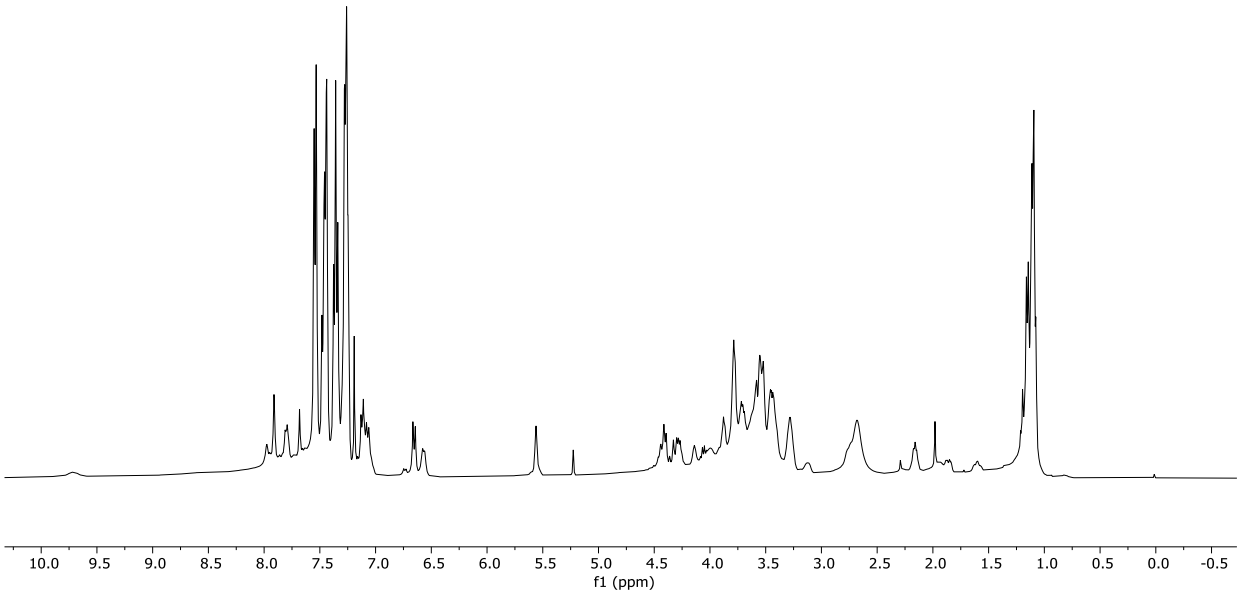


Figure S27: ^{1}H-NMR spectrum of (*S,R,S*)-**3** ([D]-chloroform, 298 K, 600 MHz).

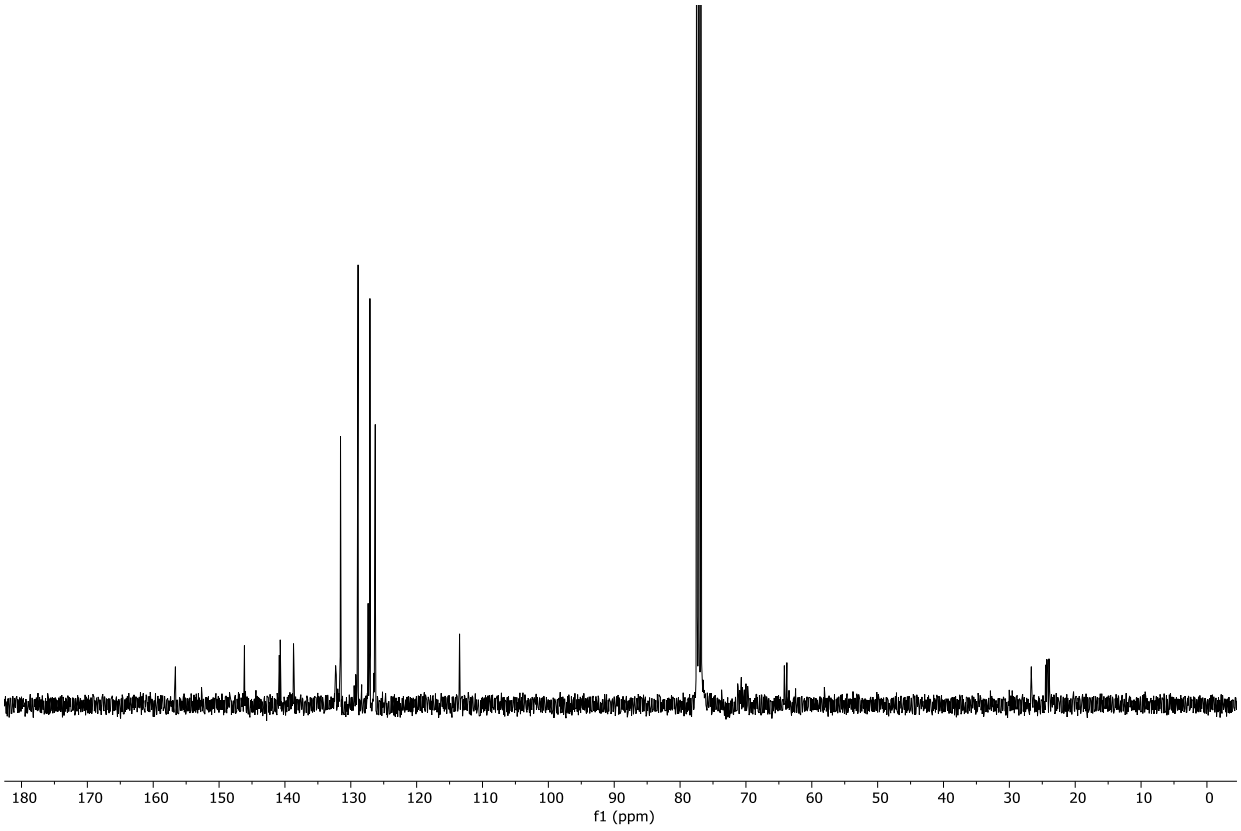
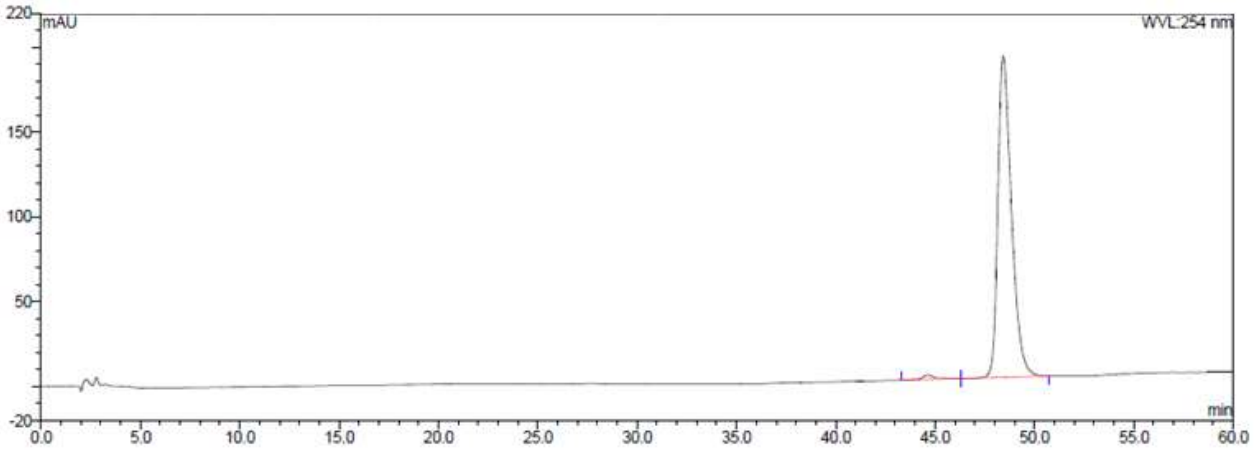


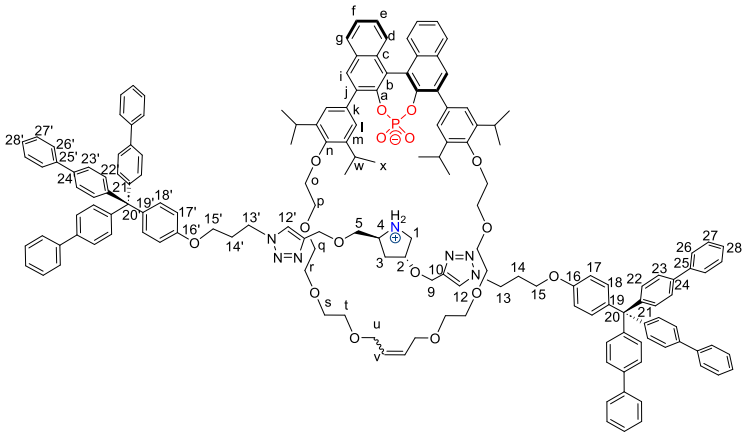
Figure S28: ^{13}C-NMR spectrum of (*S,R,S*)-**3** ([D]-chloroform, 298 K, 151 MHz).



No.	*Ret. Time*	*Height*	*Area*	*Percent*
1	44.645	2.533	1.8797	1.23
2	48.424	189.644	150.6349	98.77

Figure S29: Reversed phase HPLC of the rotaxane (*S,R,S*)-**3**.

Compound (*R,R,S*)-**3**



The amine (*R,S*)-**7** (31.0 mg, 0.0914 mmol, 2.3 eq), the stopper **9** (119 mg, 0.183 mmol, 4.6 eq) and the macrocycle (*R*)-**8** (50.0 mg, 0.0397 mmol, 1 eq) were weighed in a Schlenk flask and dried for 3 hours *in vacuo*. Dry and degassed dichloromethane (4 mL) was added and the mixture was stirred for 2 hours. Tetrakis(acetonitrile)copper(I) hexafluorophosphate catalyst (10.4 mg, 0.0278 mmol, 0.7 eq) was added and the mixture was stirred overnight at room temperature. 3-(Ethylenediamino)-propyl functionalized silica gel (1.4 mmol/g, 60mg) was added and the mixture was stirred for 2 hours. The mixture was then filtered and the filtrate was concentrated *in vacuo*. After purification by column chromatography (1st column: chloroform/methanol 100/1, 2nd column: dichlormethane/ethylacetate 1/1 + 1-10% methanol performed with NextGen), the product was obtained as a white foam (18.9 mg, 0.00754 mmol, 19%).

Chemical formula: $C_{163}H_{162}N_7O_{16}P$ **Molecular weight:** 2506.10 g/mol

^{1}H-NMR (600 MHz, [D]-chloroform, 298 K) δ [in ppm]: 9.79 (br s, 1H, NH_2), 8.50 (br s, 1H, NH_2), 8.01 (s, 1H, H-12), 7.97 (s, 2H, H-l), 7.88-7.82 (m, 2H, BINOL-Backbone), 7.75 (s, 1H, H-12'), 7.61 (d, *J* = 6.7 Hz, 12H, H-26), 7.56 (s, 2H, H-l'), 7.54-7.49 (m, 14H, H-23, BINOL-Backbone), 7.45-7.39 (m, 13H, H-27, BINOL-Backbone), 7.36-7.30 (m, 21H, H-22, H-28, BINOL-Backbone), 7.20-7.15 (m, 6H, H-18, H-18', BINOL-Backbone), 7.15-7.07 (m, 2H, H-17), 6.74-6.69 (m, 2H, H-17'), 5.65-5.61 (m, 2H, H-v), 4.53-4.45 (m, 3H, Prolinol-Thread), 4.41-4.31 (m, 3H, Prolinol-Thread), 4.24-4.20 (m, 2H, Prolinol Thread), 4.12-4.05 (m, 3H, Prolinol-Thread), 3.97-3.92 (m, 2H, Prolinol-Thread), 3.88-3.82 (m, 7H, Ethylene glycol-Chain, Prolinol-Thread), 3.80-3.74 (m, 6H, Ethylene glycol-Chain), 3.67-3.57 (m, 12H, Ethylene glycol-Chain), 3.56-3.44 (m, 8H, Ethylene glycol-Chain), 3.38-3.30 (m, 4H, H-w), 3.21-3.15 (m, 1H, Prolinol-Thread), 2.84-2.77 (m, 1H, Prolinol-Thread, water), 2.27-2.16 (m, 2H, Prolinol-Thread), 1.96-1.88 (m, 1H, Prolinol-Thread), 1.72-1.63 (m, 1H, Prolinol-Thread), 1.24-1.13 (m, 24H, H-x).

^{13}C- NMR (151 MHz, [D]-chloroform, 298 K) δ [in ppm]: 156.6, , 146.2, 146.1, 140.7, 140.6 , 139.3, 138.7, 138.6, 132.4, 132.3 (C-e), 132.2 (C-18), 131.6 (C-22, C-28), 131.2, 130.0 (C-l), 129.5, 129.3 (C-v), 128.9, 128.3, 127.4 (C-28), 127.1 (C-26), 126.4, 126.3 (C-23), 113.5 (C-17), 73.7, 71.3, 71.2, 71.1, 70.9 , 70.8, 70.7, 70.5, 70.3, 70.0 (C-u), 64.1 , 63.8, 63.7, 62.2 , 47.4, 41.1, 30.1, 29.7 , 29.5, 26.7, 26.6 (C-w), 24.5 (C-x), 24.4 (C-x'), 24.3 (C-x''), 24.0 (C-x''').

^{1}H,^{1}H-COSY (600 MHz, [D]-chloroform, 298K) [in ppm]: 7.88-7.82/7.36-7.30; 7.61/7.54-7.49, 7.45-7.39, 7.36-7.30; 7.56/7.61, 7.45-7.39, 7.36-7.30; 7.54-7.49/ 7.61, 7.45-7.39, 7.36-7.30; 7.45-7.39/7.61, 7.54-7.49, 7.36-7.30; 7.36-7.30/ 7.88-7.82, 7.61, 7.54-7.49, 7.45-7.39; 7.20-7.15/ 6.74-6.69; 6.74-6.69 /7.20-7.15; 4.41-4.31/ 2.27-2.16; 3.97-3.92/3.80-3.74; 3.88-3.82/3.80-3.74, 2.27-2.16; 3.80-3.74/3.97-3.92, 3.67-3.57; 3.67-3.57/3.56-3.44; 3.56-3.44/3.67-3.57; 3.38-3.30/1.24-1.13; 3.21-3.15/2.84-2.77; 2.84-2.77/3.21-3.15; 2.27-2.16/ 4.41-4.31, 3.88-3.82; 1.24-1.13/ 3.38-3.30.

^{1}H,^{13}C-HSQC (600 MHz/ 151 MHz, [D]-chloroform, 298K) [in ppm]: 7.97/ 130.0; 7.88-7.82/128.3; 7.61/ 127.1; 7.56/ 126.4; 7.54-7.49/126.3; 7.45-7.39/129.3; 7.36-7.30/131.6, 127.4; 7.20-7.15/132.3; 7.15-7.07/132.2; 6.74-6.69 /113.5; 5.65-5.61/129.3; 4.53-4.45/62.2; 4.41-4.31/62.2; 4.24-4.20/47.4; 3.97-3.92/73.7; 3.88-3.82/71.3; 3.80-3.74/70.3; 3.67-3.57/71.3-70.7; 3.56-3.44/70.0; 3.38-3.30/26.7; 2.27-2.16/30.1; 1.24-1.13/24.5-24.0.

^{1}H,^{13}C-HMBC (600 MHz/ 151 MHz, [D]-chloroform, 298K) [in ppm]: 7.97/132.4; 7.75/144.7; 7.61/126.4, 238.7, 128.5; 7.56/ 152.7, 124.9, 126.3, 26.6; 7.54-7.49/152.7, 126.2, 140.9, 134.9, 131.6, 126.42, 26.56; 7.45-7.39/140.64, 129.25, 127.36; 7.36-7.30/138.66, 131.57, 126.42, 63.79; 7.20-7.15/156.6, 128.90; 7.15-7.07/132.16; 5.65-5.61/71.08; 3.88-3.82/129.25; 3.67-3.57/70.54; 3.38-3.30/156.6, 140.86, 126.42, 24.26; 1.24-1.13 /140.8, 26.66, 24.26.

MS (ESI-pos, MeOH): *m/z* = 1253.0979 ([M+2H]$^{2+}$, calcd. 1253.0981 for [$C_{163}H_{164}N_7O_{16}P$]$^{2+}$).

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}): 3026 (w), 2957 (m), 2931 (m), 1478 (w), 1403 (m), 1367 (m), 1253 (s), 1161 (w), 1131 (s), 1087 (w), 925 (w), 858 (s), 773 (m), 671 (s), 551 (w), 491 (w).

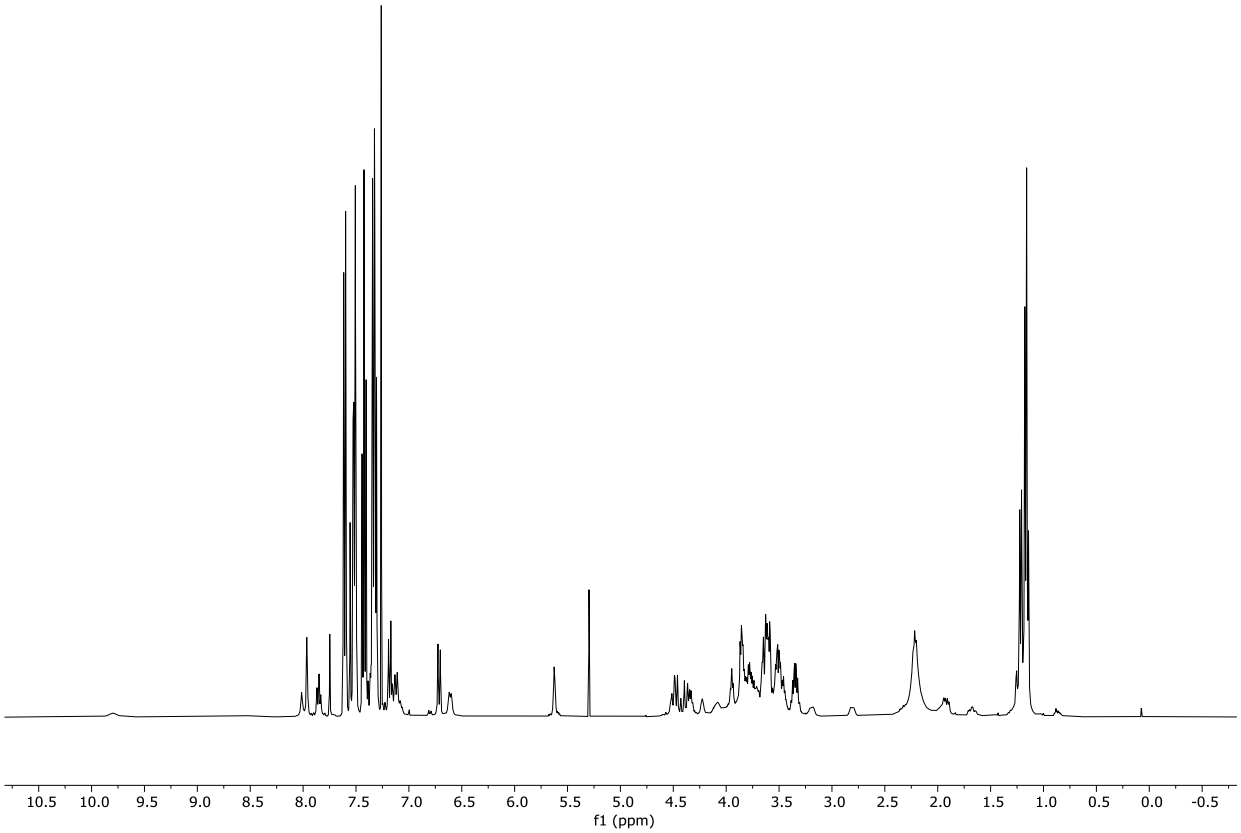


Figure S30: ^{1}H-NMR spectrum of (*R,R,S*)-**3** ([D]-chloroform, 298 K, 600 MHz).

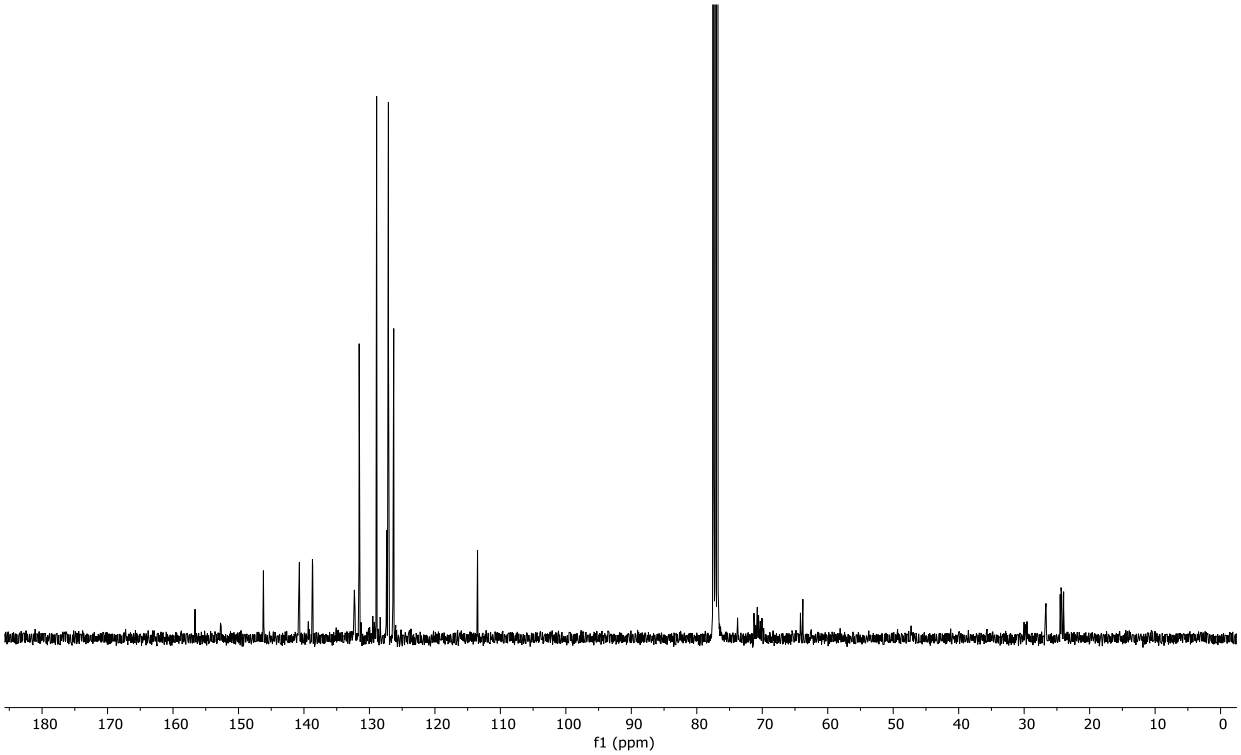
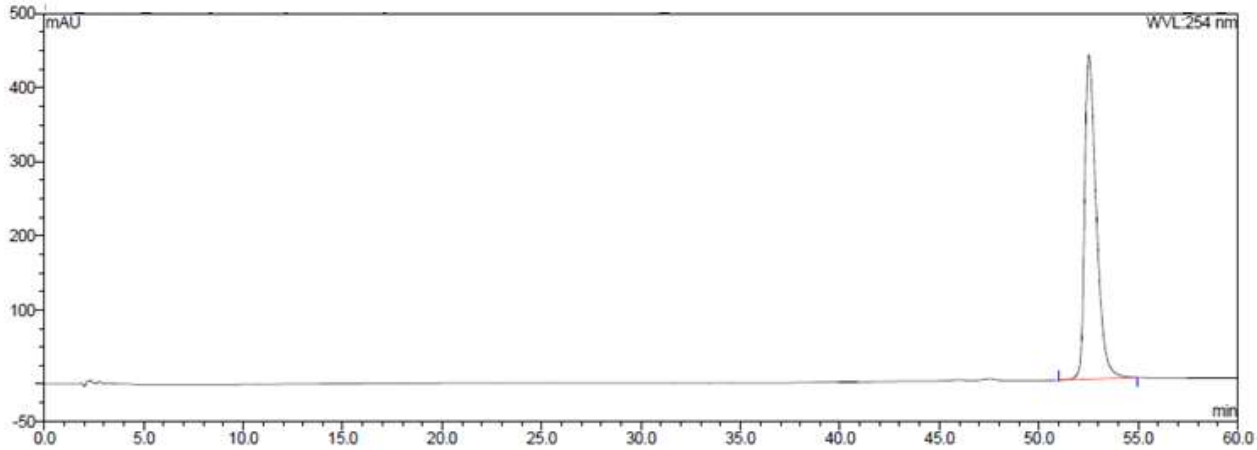


Figure S31: ^{13}C-NMR spectrum of (*R,R,S*)-**3** ([D]-chloroform, 298K, 151 MHz)



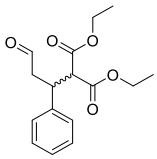
No.	*Ret. Time*	*Height*	*Area*	*Percent*
1	52.513	437.966	299.5492	100

Figure S32*:* Reversed phase HPLC of the rotaxane (*R,R,S*)-**3**.

3. Catalysis experiments

3.1 Synthesis of the racemates

Michael product (*rac*)-**12a**

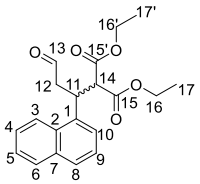


The aldehyde **10a** (126 µL, 0.953 µmol, 1eq.) and diethyl malonate (152 µL, 1.00 µmol, 1.1eq) were weighed into a Schlenk flask and dissolved in tetrahydrofuran under argon atmosphere. Pyrrolidine (7.88 µL, 0.0953 µmol, 0.1eq) was added and the mixture was stirred for 3 days at room temperature. The solvent was removed and the crude product was purified by column chromatography (cyclohexane/ethyl acetate = 4/1). The product was obtained as a colorless film (no yield was determined).

Chemical formula: $C_{16}H_{20}O_5$ **Molecular weight:** 292.33 g/mol

The NMR data corresponds to the literature.[3b]

Michael product (*rac*)-**12b**



(*rac*)-Binaphthyldiyl hydrogen phosphate (5.7 mg, 0.0164 mmol, 0.1eq.) and dibenzylamine (1.76 mg, 0.0164 mmol, 0.1eq.) were dissolved in tetrahydrofuran/ethanol (4/1, 600 µL) and a freshly prepared aqueous solution of lithium hydroxide (1 M, 16.4 µL, 0.0164 mmol, 0.1 eq.) was added. The solution was placed in a sonicator bath for 30 seconds and then left standing for 30 minutes. α,β-unsaturated aldehyde **10b** (29.9 mg, 0.164 mmol, 1 eq.) and diethyl malonate (27.5 µL, 0.180 mmol, 1.1 eq.) were added. The reaction mixture was stirred for 3 days at room temperature. The solvent was removed and the crude product was purified by column chromatography (cyclohexane/ethyl acetate = 4/1). The product was obtained as a light yellow oil (no yield was determined).

Chemical formula: $C_{20}H_{22}O_5$ **Molecular weight:** 342.39 g/mol.

^{1}H-NMR (600 MHz, [D]-chloroform, 298 K) *δ* [in ppm]: 9.60 (s, 1H, H-13), 8.26 (d, *J* = 8.2 Hz, 1H, H-6), 7.85 (d, *J* = 7.4 Hz, 1H, H-3), 7.74 (d, *J* = 8.3 Hz, 1H, H-8), 7.59 (t, *J* = 7.4 Hz, 1H, H-5), 7.50 (t, *J* = 6.5 Hz, 1H, H-4), 7.44-7.38 (m, 2H, H-9 and H-10), 4.96 (br. s, 1H, H-11), 4.19 (q, *J* = 6.6 Hz, 2H, H-16), 3.96 (br. s, 1H, H-14), 3.86 (q, *J* = 6.8 Hz, 2H, H-16'), 3.14-3.07 (m, 2H, H-12), 1.24 (t, *J* = 6.6 Hz, 3H, H-17), 0.86 (t, *J* = 7.2 Hz, 3H, H-17').

^{13}C- NMR (151 MHz, [D]-chloroform, 298 K) *δ* [in ppm]: 200.3 (C-13), 168.3 (C-15), 167.7 (C-15'), 136.4 (C-1), 134.2 (C-2), 131.4 (C-7), 129.2 (C-3), 128.2 (C-8), 126.7 (C-5), 126.0 (C-4), 125.4 (C-10 or C-9), 124.5 (C-10 or C-9), 123.1 (C-6), 61.9 (C-16), 61.7 (C-16'), 57.1 (C-14), 47.5 (C-12), 14.2 (C-17), 13.7 (C-17'). The signal for C-11 was not found.

^{1}H,^{1}H-COSY (600 MHz, [D]-chloroform, 298K) [in ppm]: 9.60/3.14-3.07 (H-13/H-12), 8.26/7.59 (H-6/H-5), 7.75/7.44-7.38 (H-8/H-10 or H-9), 7.59/8.26, 7.50 (H-5/H-6, H-4), 7.50/7.84, 7.59 (H-4/H-3, H-5), 7.44-7.38/7.75 (H-10 or H-9/H-8), 4.96/3.96, 3.14-3.07 (H-11/H-14, H-12), 4.19/1.24 (H-16/H-17), 3.96/4.96 (H-14/H-11), 3.86/0.86 (H-16'/H-17'), 3.14-3.07/9.60, 4.96 (H-12/H-13, H-11), 1.24/4.19 (H-17/H-16), 0.86/3.86 (H-17'/H-16').

^{1}H,^{13}C-HSQC (600 MHz/ 151 MHz, [D]-chloroform, 298K) [in ppm]: 9.60/200.3 (H-13/C-13), 8.26/123.1 (H-6/C-6), 7.84/129.2 (H-3/C-3), 7.75/128.24 (H-8/C-8), 7.59/126.70 (H-5,C-5), 7.50/125.98 (H-4/C-4), 7.44-7.38/125.38, 124.53 (H-10,H-9/C-10/C-9), 4.19/61.91 (H-16/C-16), 3.96/57.14 (H-14/C-14), 3.86/61.66 (H-16'/C-16'), 3.14-3.07/47.49 (H-12/C-12), 1.24/14.16 (H-17/C-17), 0.86/13.72 (H-17'/C-17').

^{1}H,^{13}C-HMBC (600 MHz/ 151 MHz, [D]-chloroform, 298K) [in ppm]: 9.60/47.5 (H-13/C-12), 7.84/134.2, 131.4, 128.2, 126.7 (H-3/C-2, C-7, C-8, C-5), 7.75/134.2, 131.4, 129.2, 124.5 (H-8/C-2, C-7, C-3, C-10 and C-9), 7.59/131.4, 129.2 (H-5/ C-7, C-3), 7.50/ 134.2, 123.1 (H-4/C-2, C-6), 7.44-7.38/136.4, 134.2, 131.4, 128.2 (H-10 and H-9/C-1, C-2, C-7, C-8), 4.19/168.3, 14.16 (H-16/C-15, C-17), 3.86/167.7, 13.7 (H-16'/C-15', C-17'), 3.14-3.07/200.3, 136.4, 57.1 (H-12/C-13, C-1, C-14), 1.24/61.9 (H-17/C-16), 0.86/61.7 (H-17'/C-16').

MS (ESI-pos, MeOH): *m/z* = 365.1387 ([M+Na]$^{+}$, calcd. 365.1359 for [$C_{20}H_{22}NaO_5$]$^{+}$).

IR (ATR-FT): $\tilde{\nu}$ (cm^{-1}): 2983 (w), 1725 (s), 1368 (w), 1301 (w), 1251 (m), 1228 (m), 1176 (m), 1155 (m), 1030 (m), 799 (w), 780 (m).

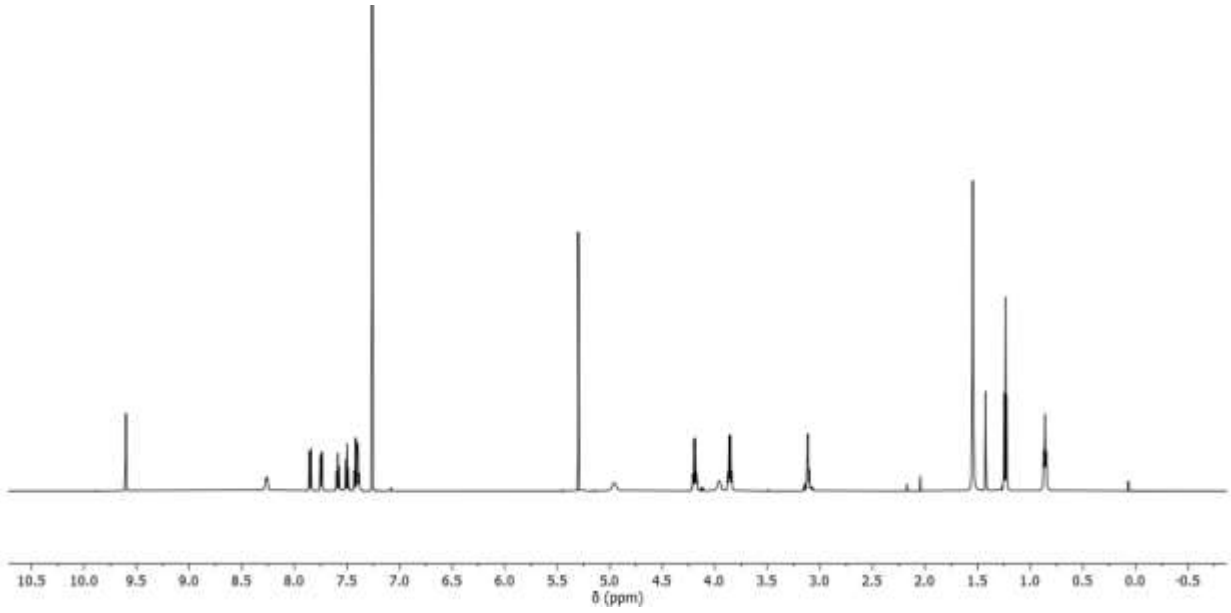


Figure S33: ^{1}H-NMR spectrum of **12b** ([D]-chloroform, 298 K, 600 MHz).

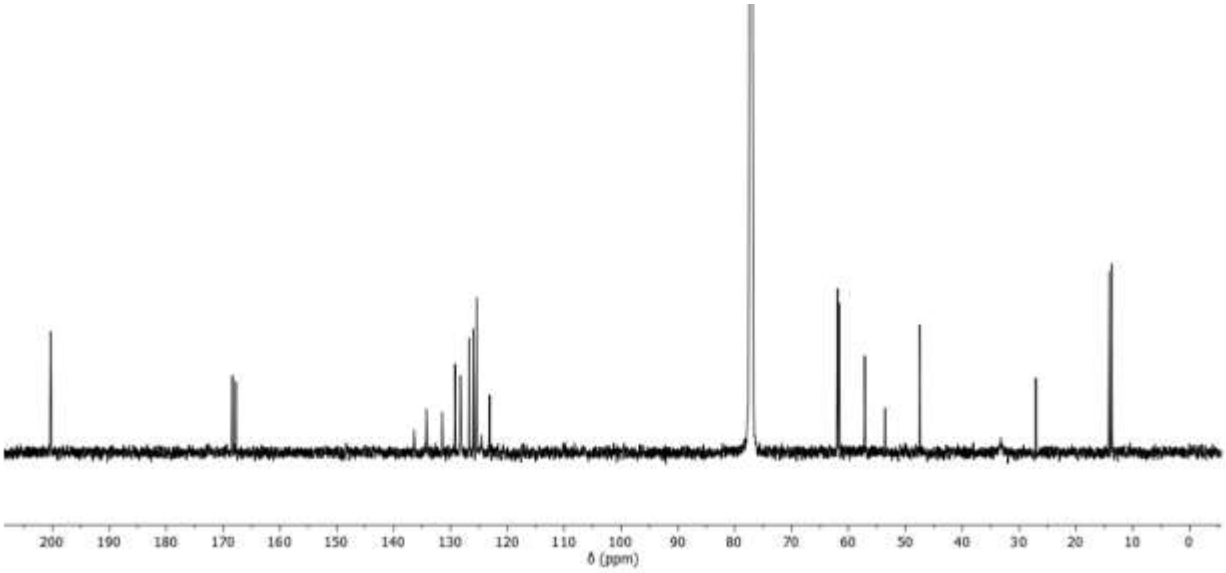


Figure S34: ^{13}C-NMR spectrum of **12b** ([D]-chloroform, 298K, 151 MHz)

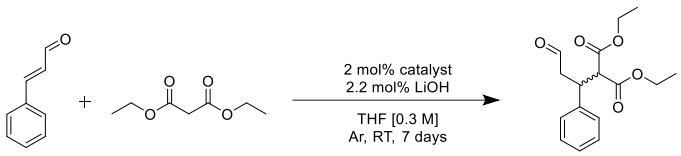
3.2 Procedure for the stereoselective catalytic reactions

Each catalyst was preliminarily prepared by the following procedure: In a test tube, catalyst (1.2 μmol, 1 eq.) was dissolved in THF (500 μL) and a freshly prepared aqueous solution of lithium hydroxide (1 M, 1.32 μL, 1.32 μmol, 1.1 eq.) was added. The solution was placed in a sonicator bath for 30 seconds and then left standing for 30 minutes. Then the solvent was removed by a flow of argon and the remaining catalyst dried overnight under high vacuum before use.

Catalyst (1.20 μmol, 0.02 eq.) was dissolved in deuterated tetrahydrofuran (200 mL) and successively α,β-unsaturated aldehyde (90.0 μmol, 1.5 eq.) and diethyl malonate (60.0 μmol, 1 eq.) were added. The solution was transferred to a 3 mm diameter NMR tube previously flushed with argon. The reaction was performed at room temperature and conversion controlled by NMR spectroscopy on a BRUKER 400 MHz NMR spectrometer, based on appearance of the aldehyde proton of Michael product (9.51 ppm) and central methylene proton of diethyl malonate (3.32 ppm). After 7 days, the solvent was removed and the crude was purified by silica gel column chromatography (1 cm x 35 cm, cyclohexane/ethylacetate 8/1) to isolate the Michael-addition product.

Comment: The deuterated tetrahydrofuran was used as obtained and not dried prior to the reaction.

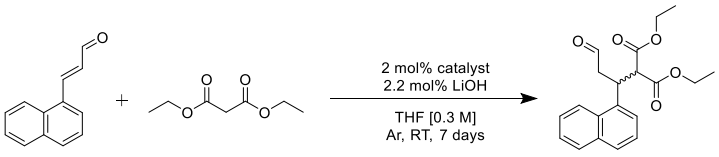
Table S1: Michael addition of diethyl malonate to *trans*-cinnamaldehyde **10a** by different rotaxanes in comparison to non-interlocked catalysts.



Entry	**Catalyst[a]**	**Conversion[b] (%)**	**Enantiomeric excess[c] (%)**
1	Rotaxane (*S*)-**1**[d]	88	53
2	Thread + *(S)*-macrocycle[d]	76	9
3	(*R,S*)-prolinol-thread	12	17
4	(*S*)-macrocycle + (*R,S*)-thread	30	37
5	Rotaxane (*S,R,S*)-**3**	84	-8
6	(*R*)-macrocycle + (*R,S*)-thread	7	21
7	Rotaxane (*R,R,S*)-**3**	82	30
8	Rotaxane (*R,R,S*)-**3**[e]	62[e]	40

Reaction and reagents: Malonate (1 eq), aldehyde (1.5 eq), 0.3 M, r.t., 7 days; (a) 2 mol% catalyst loading; (b) Determined by ^{1}H-NMR; (c) determined after purification on a DAICEL Chiralpak AD-H column, 20/80 isopropanol/*n*-hexane, 0.5 mL/min; (d) data taken from reference 3b. (e) After addition of LiOH (2.2 mol%) and storage of the deprotonated catalyst in thf-d_8 solution for 8 days, followed by addition of starting materials, conversion determined after 6 days.

Table S2: Michael addition of diethyl malonate to naphthyl-derivate **10b** by different rotaxanes in comparison to non-interlocked catalysts.



Entry	**Catalyst[a]**	**Conversion[b] (%)**	**Enantiomeric excess[c] (%)**
1	Rotaxane (*S*)-**1**	54	32
2	Thread + (*S*)-macrocycle	11	5
3	(*R,S*)-prolinol-thread	34	10
4	(*S*)-macrocycle + (*R,S*)-thread	18	16
5	Rotaxane (*S,R,S*)-**3**	71	-30
6	(*R*)-macrocycle + (*R,S*)-thread	30	17
7	Rotaxane (*R,R,S*)-**3**	82	0

Reaction and reagents: Malonate (1 eq), aldehyde (1.5 eq), 0.3 M, r.t., 7 days; (a) 2 mol% catalyst loading; (b) Determined by ^{1}H-NMR; (c) determined after purification on a DAICEL Chiralpak AD-H column, 20/80 isopropanol/*n*-hexane, 0.5 mL/min;

3.3 Conversion curves

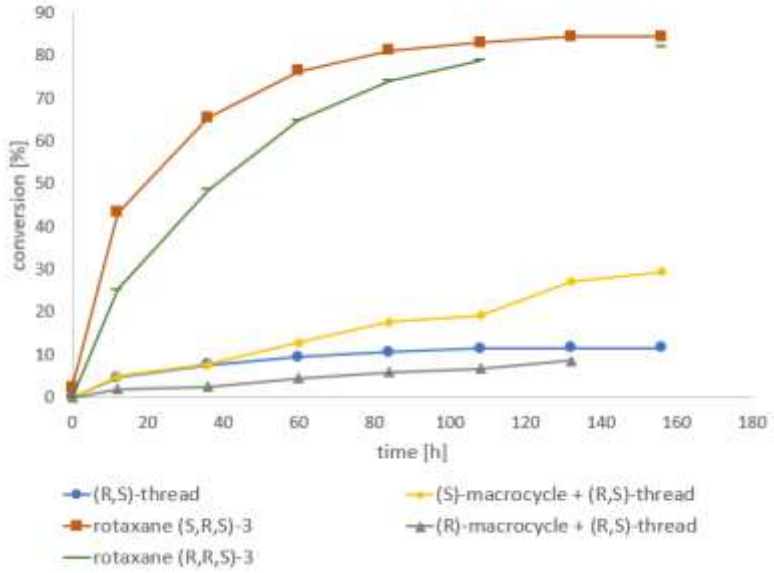


Figure S35: Conversion curves from reaction using **10a** (entry 3 to 7, Table 1)

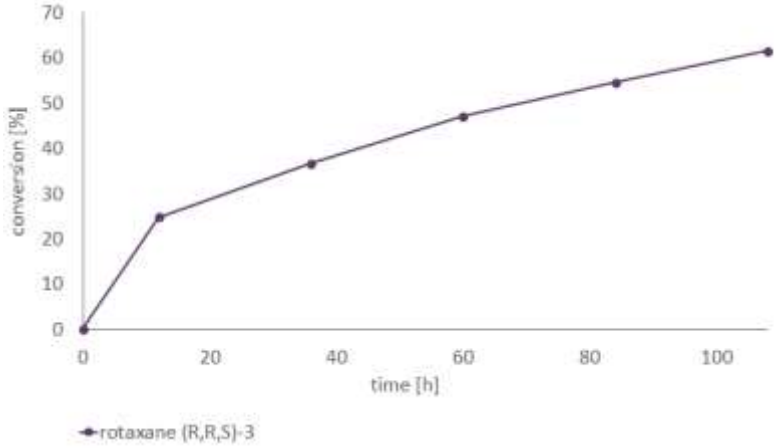


Figure S36: Test for catalyst stability: Conversion curve from reaction using **10a** with rotaxane (*R,R,S*)-**3** (2 mol%) after addition of LiOH (2.2 mol%) and storage of the deprotonated catalyst in thf-d_8 solution for 8 days, followed by addition of starting materials (t = 0).

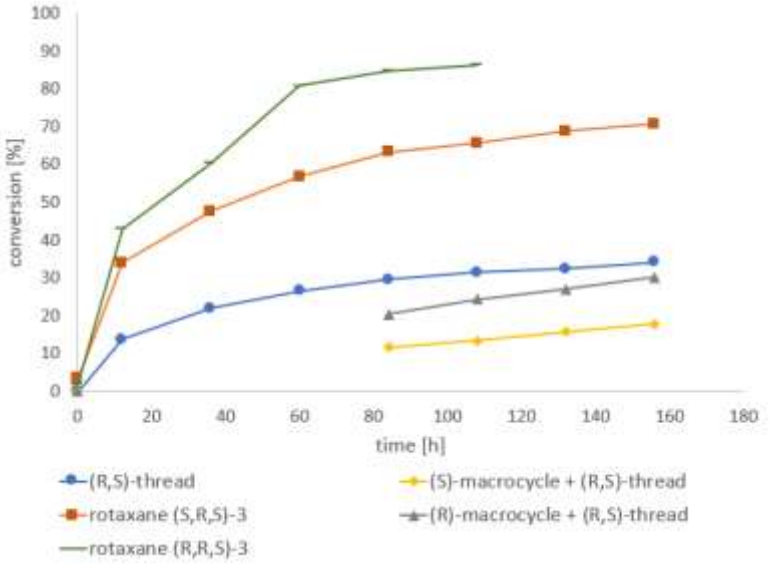


Figure S37: Conversion curves from reaction using **10b** (entry 3 to 7, Table 2)

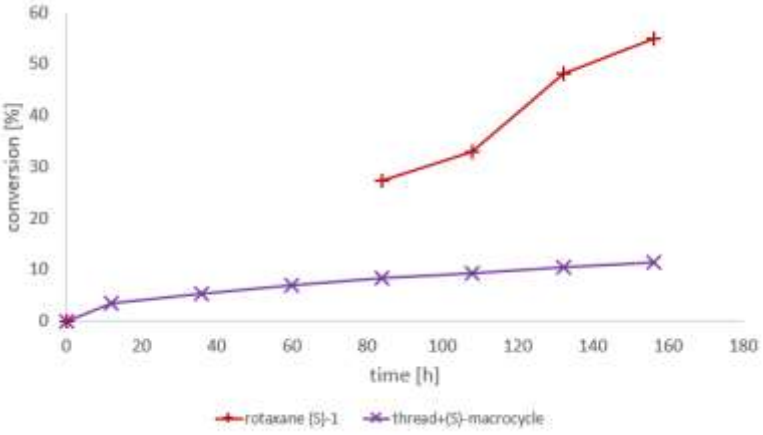
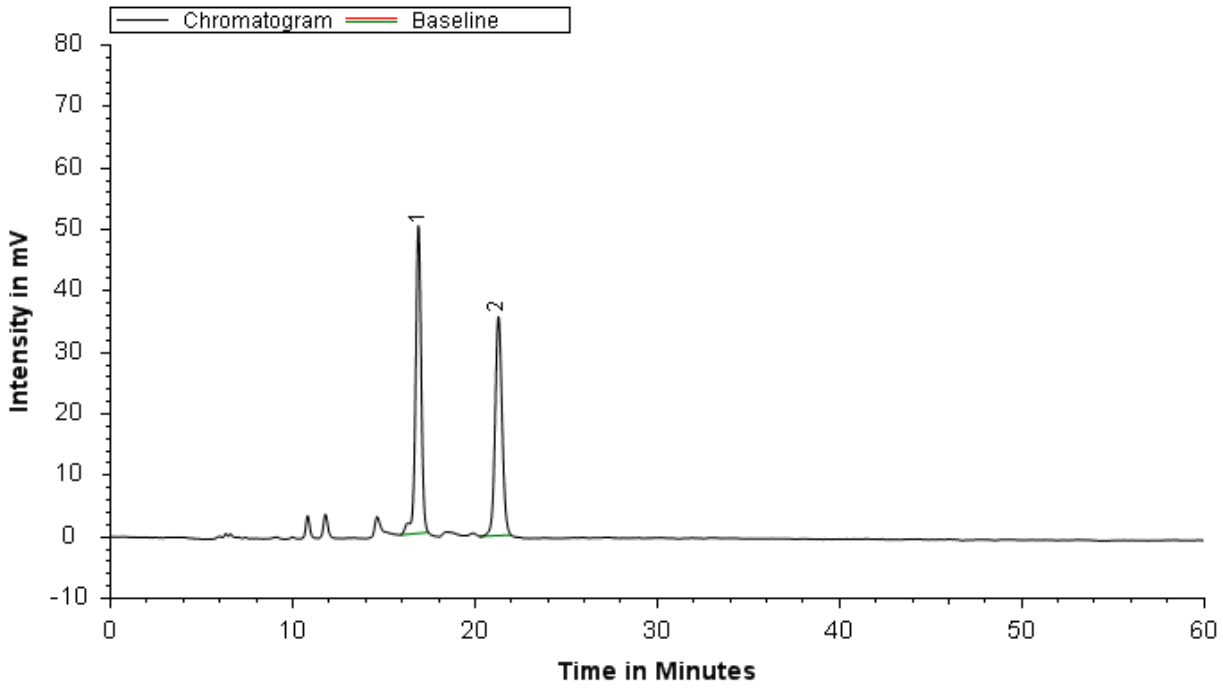


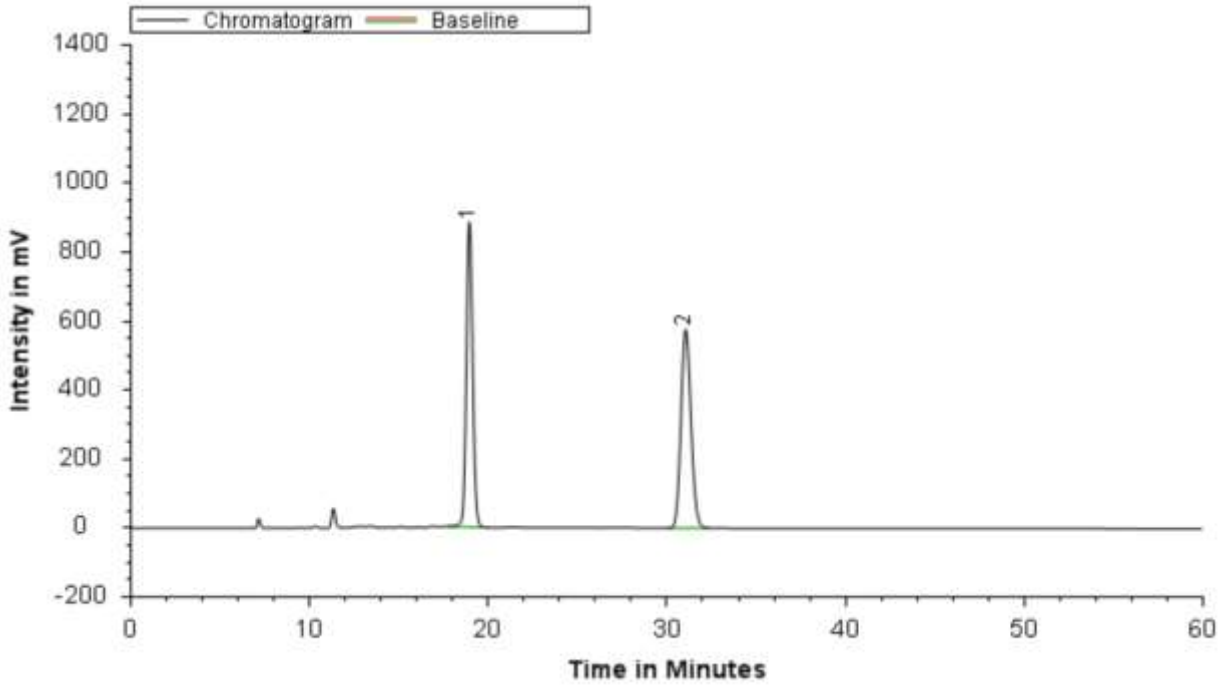
Figure S38: Conversion curves from reaction using **10b** (entry 1 and 2, Table 2)

3.4 Chiral HPLC profiles



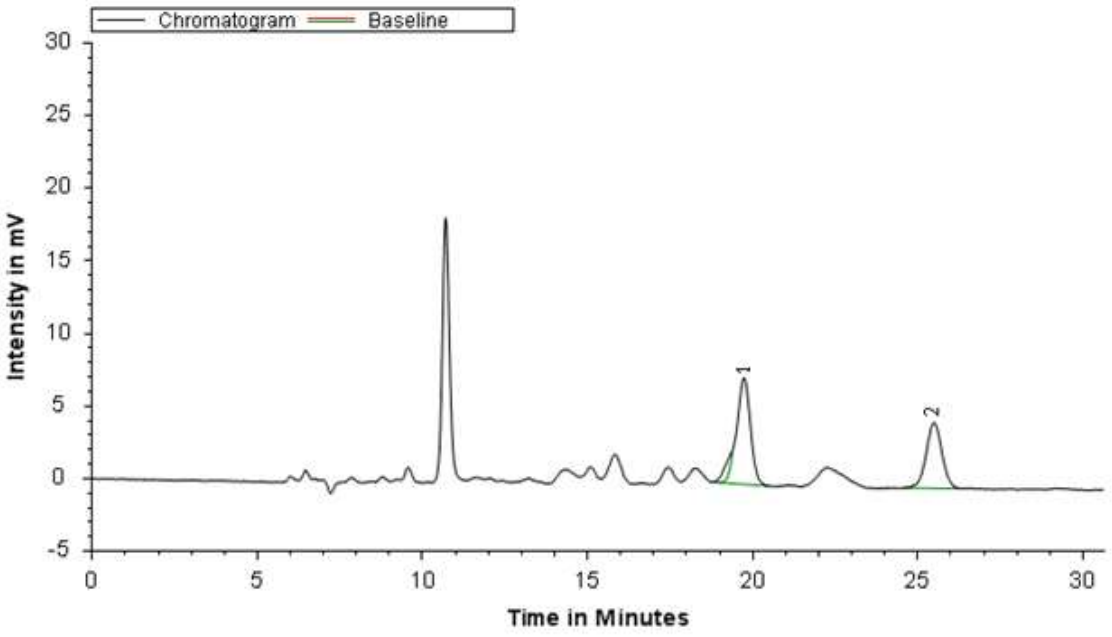
No.	*Ret. Time*	*Height*	*Area*	*Percent*
1	17.04167	51.5724	1340587.49	50.823
2	21.6667	35.6218	1297170	49.177

Figure S39: Chiral HPLC of Michael product (*rac*)-**12a**.



No.	*Ret. Time*	*Height*	*Area*	*Percent*
1	18.925	883.9421	2.182782E+07	49.311
2	31.04167	574.601	2.243791E+07	50.689

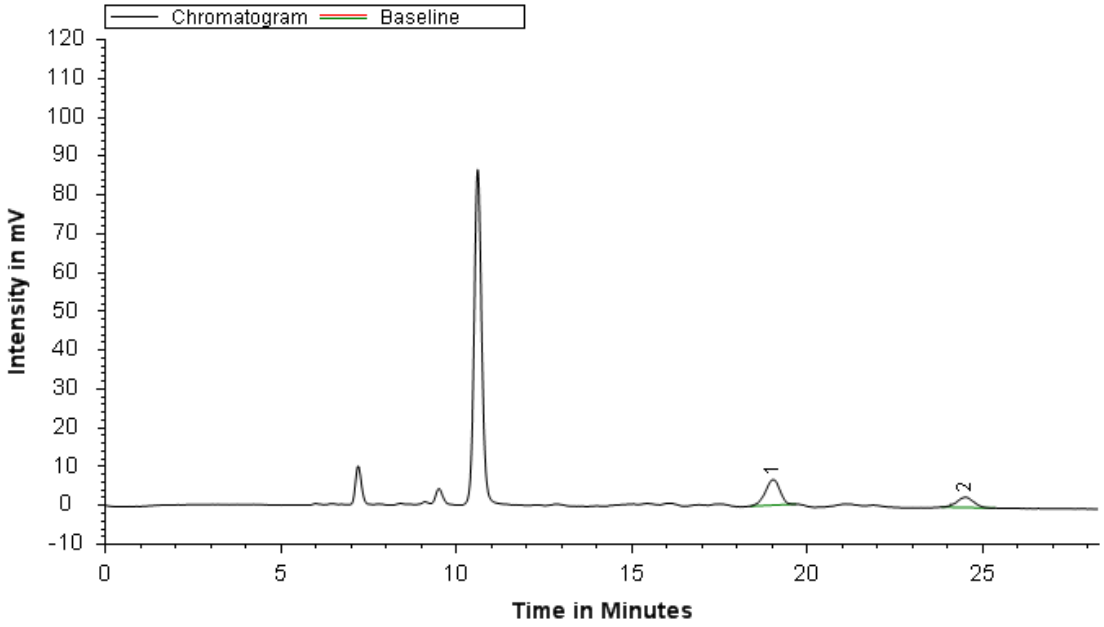
Figure S40: Chiral HPLC of Michael product (*rac*)-**12b**.



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	19.742	7.325572	213583	55.670	
2	25.483	4.522574	150677.9	39.273	
					17%

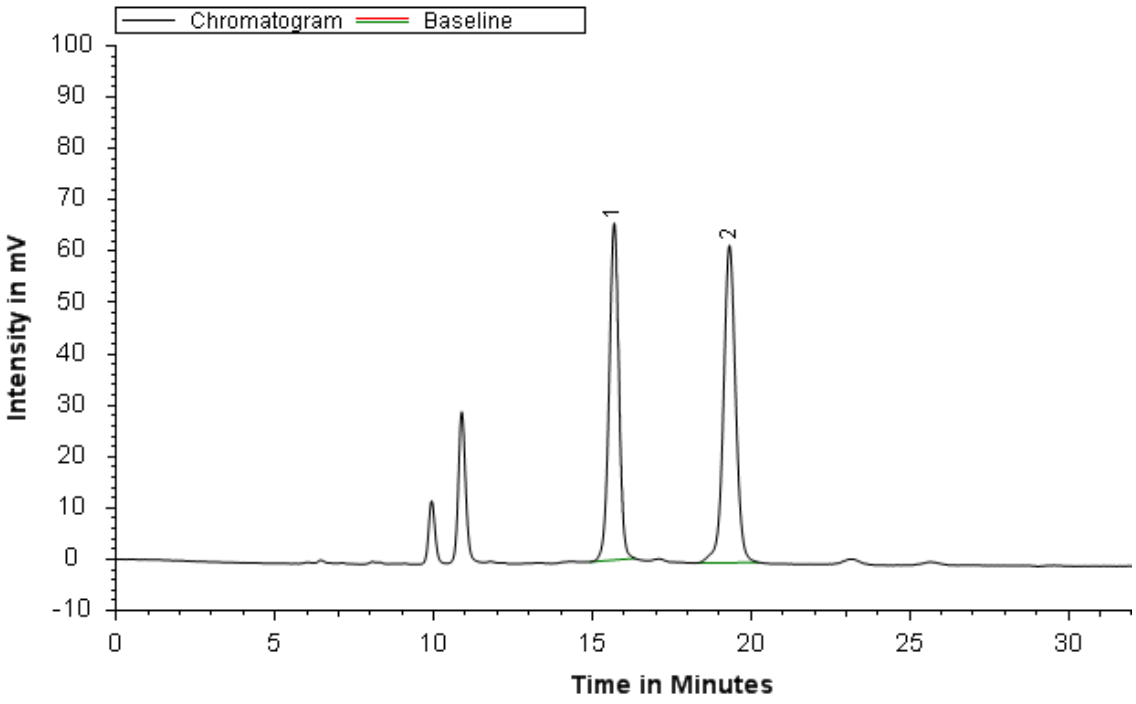
Figure S41: Chiral HPLC of Michael product **12a** using (*R*,*S*)-prolinol-thread as catalyst (Entry 3, Table 1). Due to the low conversion, product isolation was difficult and the mixture contained starting material (peak at 11 min.).



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	19.042	6.56	189829.9	68.604	
2	24.517	2.62	86872.9	31.396	
					37%

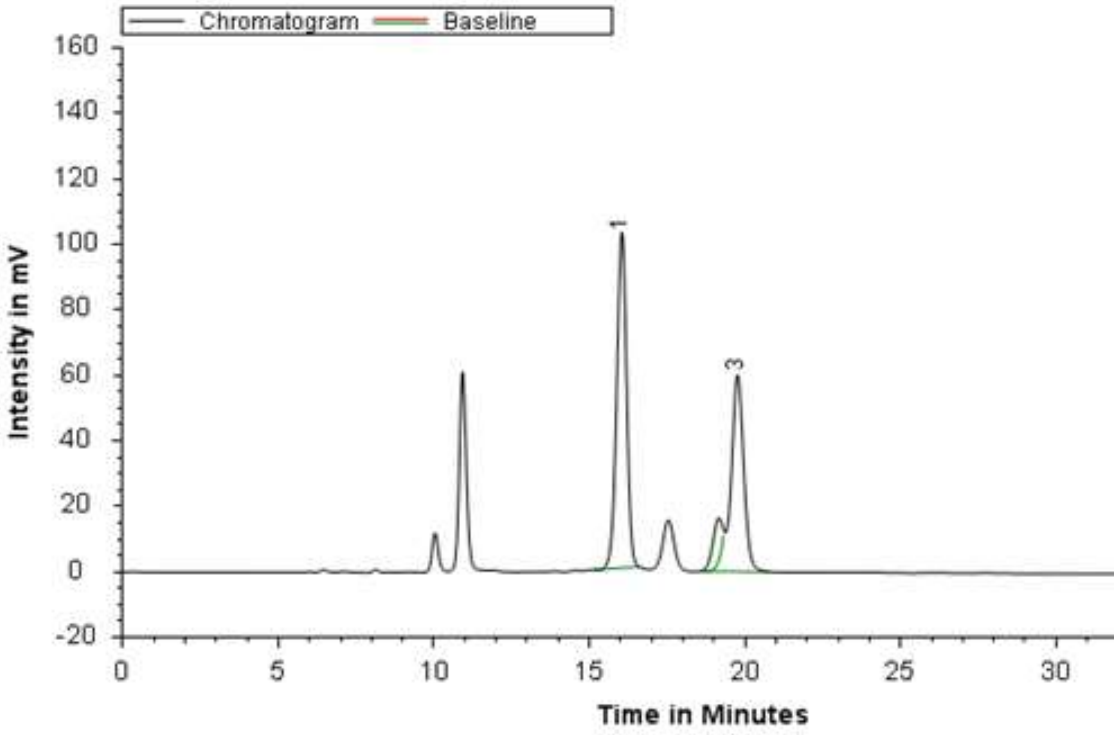
Figure S42: Chiral HPLC of Michael product **12a** using (*R*,*S*)-prolinol-thread and (S)-macrocycle as catalyst (Entry 4, Table 1). Due to the low conversion, product isolation was difficult and the mixture contained starting material (peak at 11 min).



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	15.692	65.59	1406220.00	46.032	
2	19.325	61.75	1648632.00	53.968	
					-8%

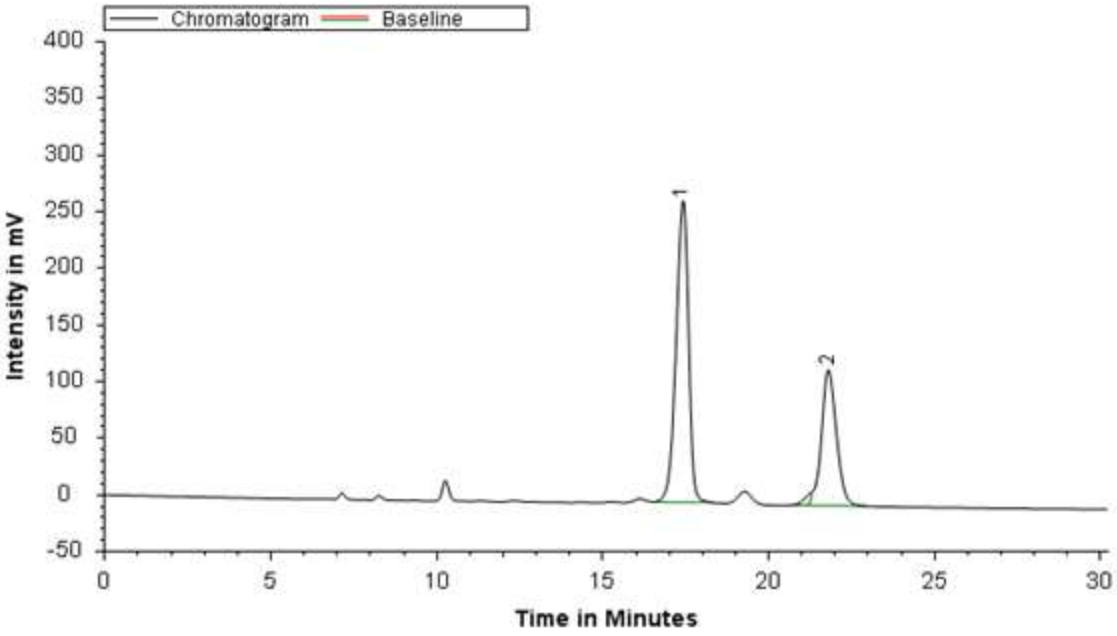
Figure S43: Chiral HPLC of Michael product **12a** using rotaxane (*S*,*R*,*S*)-**3** as catalyst (Entry 5, Table 1)



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	16.033	102.33	2254103.0	52.855	
2	19.767	59.91	1737519.0	40.742	
					21%

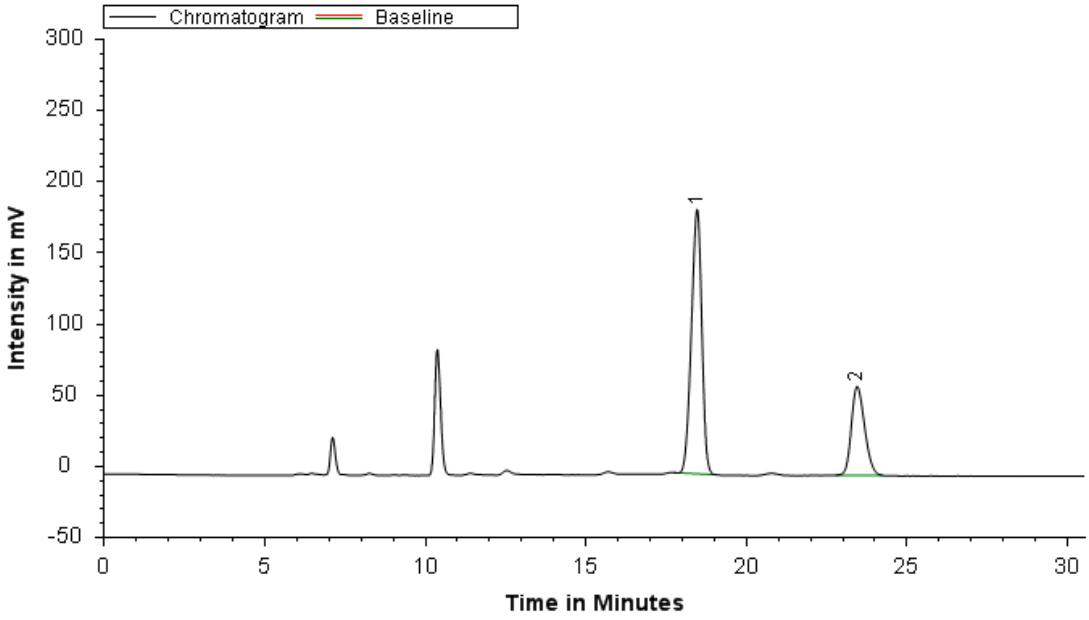
Figure S44: Chiral HPLC of Michael product **12a** using (*R*,*S*)-prolinol-thread and (*R*)-macrocycle as catalyst (Entry 6, Table 1). The product contained some product of aldehyde oxidation (peaks at 17.5 and 19.5 mins).



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	17.417	265.88	6945118.00	64.109	
2	21.800	119.44	3750080	34.616	
					30%

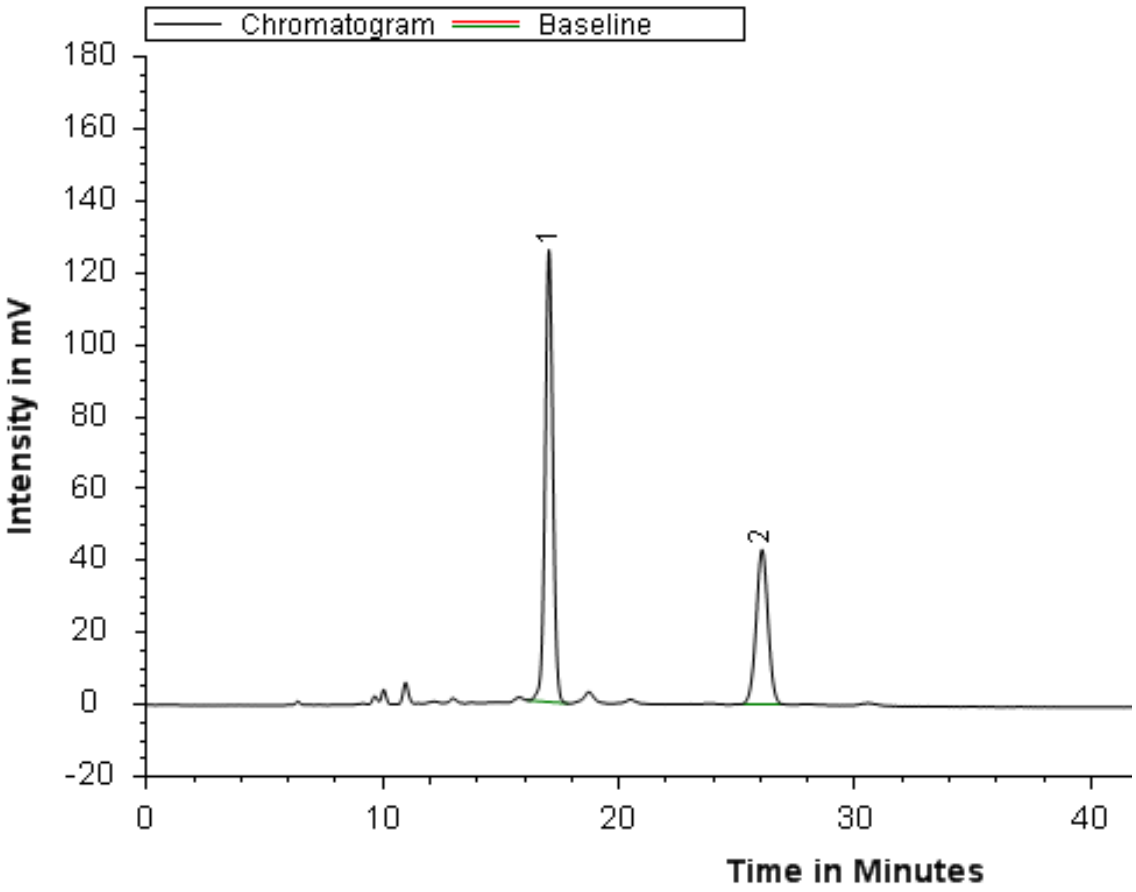
Figure S45: Chiral HPLC of Michael product **12a** using rotaxane (*R*,*R*,*S*)-**3** as catalyst (Entry 7, Table 1)



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	18.458	185.79	4183762	69.99	
2	23.441	62.42	1793738	30.01	
					40%

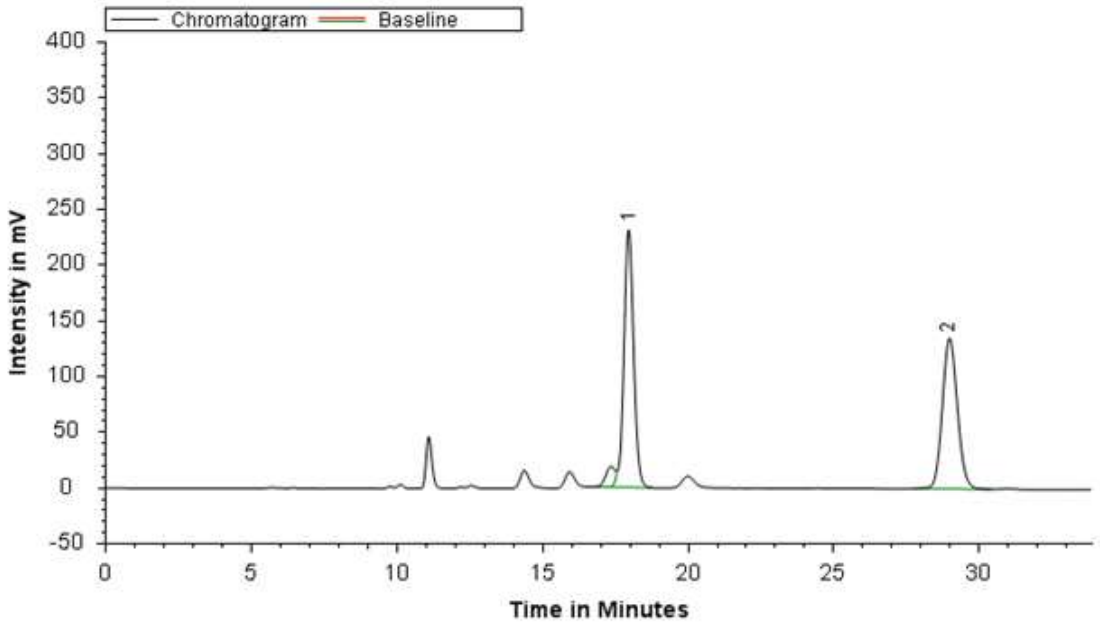
Figure S46: Chiral HPLC of Michael product **12a** using rotaxane (*R*,*R*,*S*)-**3** as catalyst (Entry 8, Table 1)



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	17.042	125.56	2880939	65.78	
2	26.067	42.92	1498570	34.22	
					32%

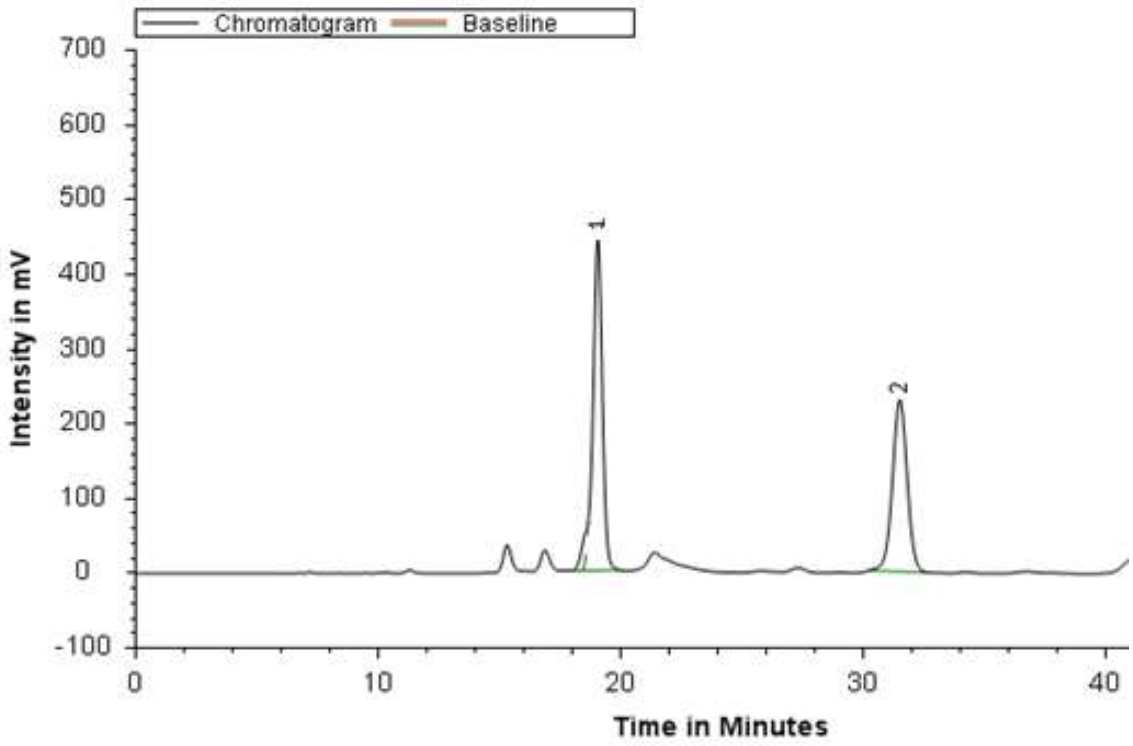
Figure S47: Chiral HPLC of Michael product **12b** using rotaxane (*S*)-**1** as catalyst (Entry 1, Table 2)



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	17.958	230.85	5349968	50.56	
2	28.992	135.11	4853529	45.87	
					5%

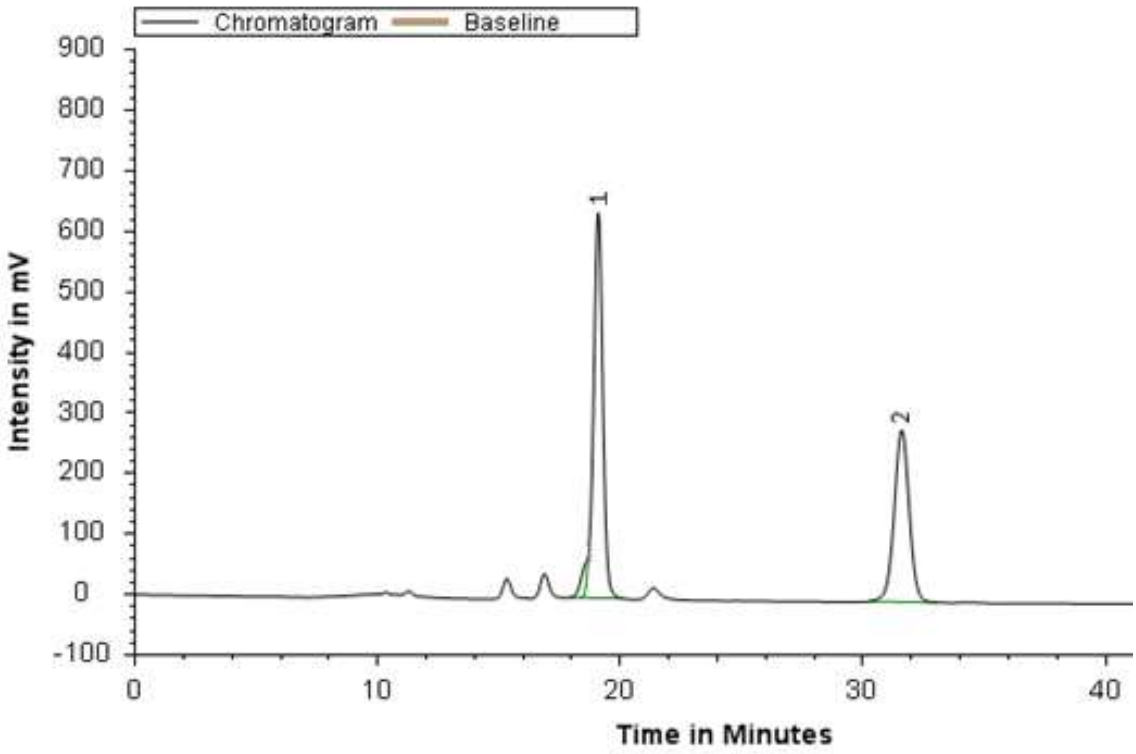
Figure S48: Chiral HPLC of Michael product **12b** using achiral thread and (*S*)-macrocycle as catalyst (Entry 2, Table 2)



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	19.058	445.06	1.190147E+07	53.32	
2	31.508	229.77	9724914	43.57	
					10%

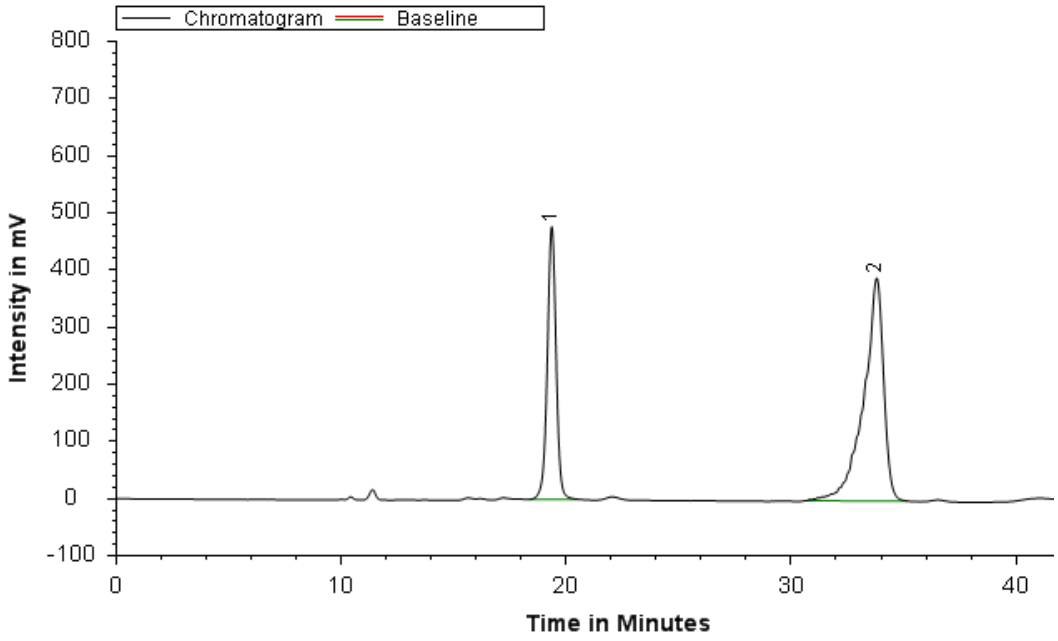
Figure S49: Chiral HPLC of Michael product from naphthyl-derivative **10b** using prolinol based thread (Entry 3, Table 2)



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	19.1	635.35	1.688363E+07	56.17	
2	31.608	283.43	1.224387E+07	40.74	
					16%

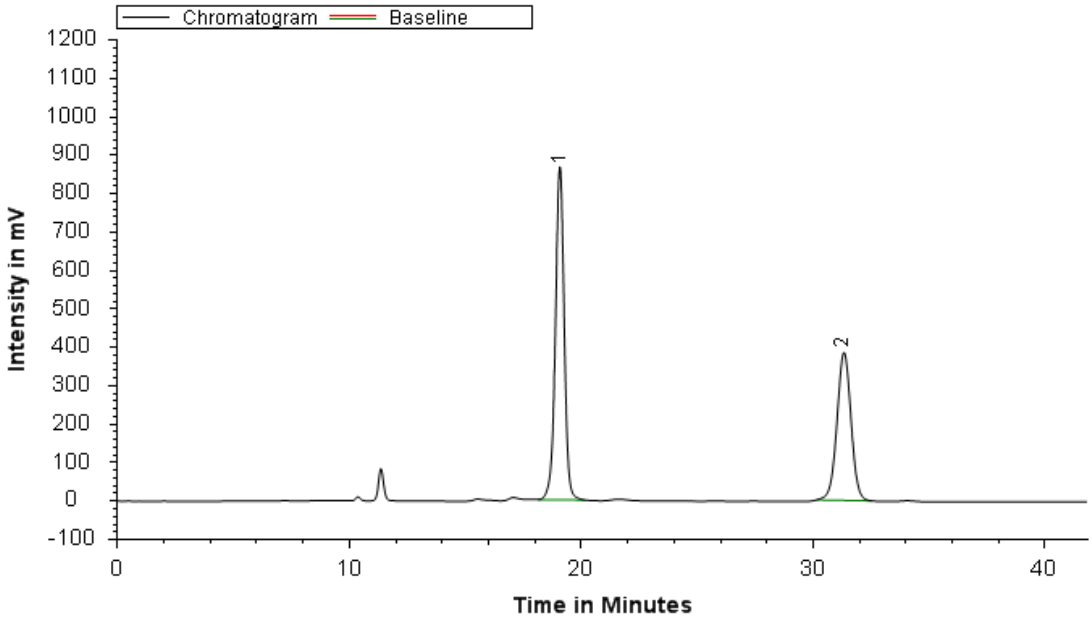
Figure S50: Chiral HPLC of Michael product **12b** using (*R*,*S*)-prolinol-thread and (*S*)-macrocycle as catalyst (Entry 4, Table 2)



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	19.358	476.92	1.293613E+07	34.93	
2	33.808	389.93	2.40997E+07	65.07	
					-30%

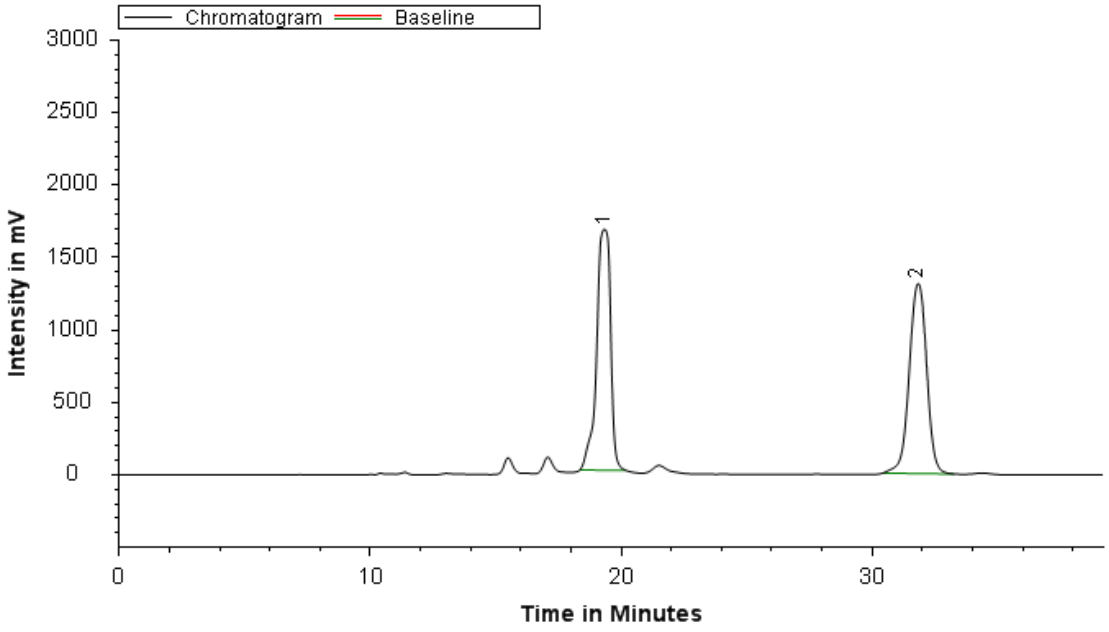
Figure S51: Chiral HPLC of Michael product **12b** using rotaxane (*S*,*R*,*S*)-**3** as catalyst (Entry 5, Table 2)



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	19.083	865.91	2.283589E+07	58.51	
2	31.325	384.56	1.619163E+07	41.49	
					17%

Figure S52: Chiral HPLC of Michael product **12b** using (*R*,*S*)-prolinol-thread and (*R*)-macrocycle as catalyst (Entry 6, Table 2).



Result Table

No.	*Ret. Time*	*Height*	*Area*	*Percent*	*ee*
1	19.317	1662	6.436755E+07	50.43	
2	31.825	1310.82	6.326414E+07	49.57	
					1%

Figure S53: Chiral HPLC of Michael product **12b** using rotaxane (*R*,*R*,*S*)-**3** as catalyst (Entry 7, Table 2)

4. References:

[1] C. Wang, H. Yamamoto, *J. Am. Chem. Soc*. **2014**, *136*, 1222-1225.

[2] a) A. Manaprasertsak, S. Tharamak, C. Schedl, A.Roller, M. Widhalm, *Molecules*, **2019**, *24*, 3844.

b) S. B. J. Kan, H. Maruyama, M. Akaura, T. Kano, K. Maruoka, *Angew. Chem. Int. Ed.*, **2017**, *56*, 9487-9491.

c) M. Thiele, F. Octa-Smolin, S. Thölke, C. Wölper, J. Linders, C. Mayer, G. Haberhauer, J. Niemeyer, *Chem. Commun.* **2021**, *57*, 9842-9845.

[3] a) R. Mitra, M. Thiele, F. Octa-Smolin, M. C. Letzel, J. Niemeyer, *Chem. Commun*. **2016**, 5977-5980.

b) N. Pairault, H. Zhu, D. Jansen, A. Huber, C. G. Daniliuc, S. Grimme, J. Niemeyer, *Angew. Chem. Int. Ed.* **2020**, *59*, 5102-5107.