Supplementary Material

Phosphinamide Directed Benzylic Lithiation. Application to the Synthesis of Peptide Building Blocks

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General information

The reactions involving organolithium reagents were performed under an inert atmosphere of nitrogen using Schlenk techniques. Diethyl ether was distilled from sodium/benzophenone immediately prior use. Commercial reagents were distilled prior to their use, except t-BuLi, s-BuLi and ClSnMe₃ that were used that were used as obtained from commercial sources without further purification. TLC was performed on Merck plates with aluminum backing and silica gel 60 F₂₅₄. For column chromatography silica gel 60 (40-63 μm) from Scharlau was used. Melting points were recorder on a Büchi B-540 cAPCiIary melting point apparatus. Mass spectra were determined by atmospheric pressure chemical ionization (APCI) on a Hewlett-Packard 1100. ¹H (300 MHz), ¹³C (75.47 MHz), and ³¹P (121.47 MHz) NMR spectra were recorded on Bruker.
Avance DPX300 equipped with a QNP $^{1}$H/$^{13}$C/$^{19}$F/$^{31}$P probe. Selective 1D NMR (gTOCSY, gNOESY) and 2D (gNOESY, gHMQC and gHMBC) correlation spectra were measured in a Bruker Avance 500 spectrometer ($^{1}$H, 500 MHz; $^{13}$C, 125.7 MHz; $^{31}$P, 202.4 MHz) using an inverse TBI $^{1}$H/$^{31}$P/BB. The solvent used was CDCl$_3$, except for the identification of compounds 23 and 24 where D$_2$O was the solvent of choice and CD$_3$OD for the identification of 26. Chemical shifts are referred to internal tetramethylsilane for $^{1}$H and $^{13}$C, and to external 85% H$_3$PO$_4$ for $^{31}$P. Standard Bruker software was used for acquisition and processing routines. The enantiomeric excesses were determined by HPLC analysis on a HP 1100 instrument using a Chiralcel OD-H column (5μm, 150 x 4.6 mm) and a diode array detector. Optical rotations were measured (1-dm tube) with a Jasco P-1030 instrument.

X-Ray. Data collection was performed on a Oxford Diffraction Gemini CCD single crystal diffractometer, using MoKα ($\lambda$ = 0.71073 Å) for 6b and CuKα ($\lambda$ = 1.54180 Å) for 15. The intensities were measured using the $\omega$ scan method. An analytical method was used for the absorption correction for the compound. The crystal structures were solved by Patterson methods. The refinement was performed using full-matrix least squares on F$^2$. All non-H atoms were anisotropically refined. All H atoms were geometrically placed and isotropically refined. The absolute structure of 15 was determined with a Flack parameter, $\chi$ = 0.000(9).

Crystallographic calculations were made at the University of Oviedo, on the X-ray group computers, using the following programs: CrysAlis CCD$^2$ for data collection; CrysAlis RED$^3$ for cell refinement and data reduction; DIRDIF-99$^4$ for structure solution; SHELXL-97$^5$ for structure refinement and prepare materials for publication; PARST$^7$ for the geometrical calculations; ORTEP-3 for windows$^7$ for molecular graphics. The crystallographic data (excluding structure factors) for the structure of compound 6b and 15 have been deposited at the Cambridge Crystallographic Data Centre as supplementary publications numbers CCDC 665889 and CCDC 665890. Copies for the data can be obtained free of charge on application to CCDC, 12 Union Road, Cambridge, CB2 1EZ, UK [fax: C44 1223 336033 or e-mail: deposit@ccdc.cam.ac.uk].

Preparation of phosphinamides 1a-c

Compounds 1a and 1b have been described previously.$^8$

To a solution of diphenylphosphinic chloride (2.9 mL, 15.2 mmol) and triethylamine (5.21 mL, 38 mmol) in toluene (100 mL) at −78 ºC was added (1S)-1-phenylethanamine (2 mL, 15.2 mmol), and the mixture stirred for 30 min. The reaction was poured into ice water, extracted with ethyl acetate (3 x 15 mL), and washed with 1N NaOH (2 x 15 mL). The organic layers were dried over Na$_2$SO$_4$ and concentrated in vacuo affording $P,P$-diphenyl-$N$-[1(1S)-1-phenylethyl]phosphinic amide as a white solid. This amide (4.82 g, 14.74 mmol) was added to a stirred solution of NaH (2.36 g, 59
mmol) in THF at 0 °C. After 30 min (bromomethyl)benzene (1.78 mL, 14.74 mmol) was added, and the resulting solution was heated to reflux for 2 h. Then, the mixture was slowly cooled and extracted with ethyl acetate (3x15 mL). The organic layers were dried over Na2SO4 and concentrated in vacuo affording \((S)-1c\) as a white solid.

\[ N\text{-benzyl-}P,P\text{-diphenyl-N-[(1S)-1-phenylethyl]phosphinic amide} \]

Recrystallized from Et2O. Yield 86 % (5.37 g). Mp: 121-123 °C. \([\alpha]D^25 = +6.7 \text{ (c = 1.8, CHCl}_3)\). 1H NMR (300.13 MHz, CDCl3): \(\delta\) 1.42 (d, 3H, \(J_{HH} 7.1 \text{ Hz}\)), 3.90 (dd, 1H, \(J_{PH} 11.4, J_{HH} 16 \text{ Hz}\)), 4.21 (dd, 1H, \(J_{PH} 11.4, J_{HH} 16 \text{ Hz}\)), 4.78 (dc, 1H, \(J_{PH} 10, J_{HH} 7.1 \text{ Hz}\)), 7.52-7.03 (m, 16H, ArH), 7.95 (m, 4H, ArH). 13C NMR \(\delta\) 19.93 (d, CH3, \(J_{PC} 2.9 \text{ Hz}\)), 47.54 (d, CH2, \(J_{PC} 4.4 \text{ Hz}\)), 55.27 (d, CH, \(J_{PC} 4 \text{ Hz}\)), 128.53-126.67 (14CAr), 131.58 (d, 2CAr, \(J_{PC} 2.5 \text{ Hz}\)), 132.38 (d, 2Cipso \(1\text{ }J_{PC} 125.1 \text{ Hz}\)), 132.58 (d, 2CAr, \(J_{PC} 9.2 \text{ Hz}\)), 132.61 (d, 2CAr, \(J_{PC} 9.2 \text{ Hz}\)), 139.62 (d, Cipso, \(J_{PC} 4 \text{ Hz}\)), 140.85 (Cipso). 31P NMR \(\delta\) 31.83. MS (APCI-ES), m/z: 412 (M+1). Analysis: Calcd. (%) for C27H26NOP: C, 78.81; H, 6.37; N, 3.40. Found: C, 78.76; H, 6.42; N, 3.41.

**Preparation of phosphinamides 2-21**

Compounds 2a and 2b have been described previously.9 To a solution of 0.1 g of the appropriated phosphinamide 1a-c (0.311 mmol, 0.252 mmol and 0.243 mmol, for 1a, 1b and 1c, respectively) in diethyl ether (20 mL) was added a solution of t-BuLi (0.746 mmol, 0.605 mmol and 0.584 mmol, 0.44 mL, 0.35 mL and 0.34 mL, for 1a, 1b and 1c, respectively, of a 1.7 M solution in hexane) at −90 °C. After 120 min, the corresponding electrophile was added (0.746mmol, 0.605 mmol and 0.583 mmol, for 1a, 1b and 1c, respectively). The reaction mixture was stirred at −90 °C for 30 min and then was poured into ice water and extracted with ethyl acetate (3x15 mL). The organic layers were dried over Na2SO4 and concentrated in vacuo. 1H, 1H{31P}, and 31P NMR spectra of the crude reaction were measured in order to determine the stereoselectivity and conversion of the process. The products were isolated by flash column chromatography using different eluent mixtures based on ethyl acetate and hexane.

\[ N\text{-[(1R*)-1,2-diphenylethyl]-N-ethyl-P,P-diphenylphosphinic amide} \]

Yield after chromatography (ethyl acetate:hexane 3:1) 82 % (0.105 g). Oil. 1H NMR (300.13 MHz, CDCl3): \(\delta\) 2.51 (d, 3H, \(J_{PH} 10.5 \text{ Hz}\)), 3.30 (dd, 1H, \(J_{HH} 14, J_{HH} 6.7 \text{ Hz}\)), 3.37 (dd, 1H, \(J_{HH} 14, J_{HH} 6.7 \text{ Hz}\)), 3.37 (dd, 1H, \(J_{HH} 14,
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1H NMR δ 3.13 (dd, 1H, 2JHH 13.7, 3JHH 10.8 Hz), 3.32 (dd, 1H, 2JHH 13.7, 3JHH 4.8 Hz), 3.98 (dd, 1H, 2JHH 16, 3JPH 11.1 Hz), 4.33 (dd, 1H, 2JHH 16, 3JPH 15.6, 2JHH 10.8, 3JHH 4.8 Hz), 6.71 (m, 2H, ArH), 7.55-6.95 (m, 19H, ArH), 7.81 (m, 2H, ArH), 7.92 (m, 2H, ArH).

13C NMR δ 40.44 (d, CH2 12.6 Hz), 48.12 (d, CH2 4.4 Hz), 62.37 (d, CH 3.2 Hz), 125.82 (CAr), 127.00 (CAr), 127.58 (CAr), 127.93 (2CAr), 128.03 (2CAr), 128.08 (2CAr), 128.39 (2CAr), 128.40 (d, 2CAr, 3JPC 12.6 Hz), 128.50 (d, 2CAr, 3JPC 12.7 Hz), 129.08 (2CAr), 129.68 (2CAr), 131.64 (d, CAr, 4JPC 2.6 Hz), 131.82 (d, CAr, 4JPC 2.6 Hz), 132.42 (d, 4CAr, 1JPC 126.4 Hz), 132.40 (d, 4CAr, 1JPC 125.9 Hz), 132.63 (d, 4CAr, 2JPC 9.6 Hz), 138.10 (d, 4CAr, 3JPC 4.1 Hz), 138.78 (Cips), 139.32 (d, Cips, 3JPC 4 Hz). 31P NMR δ 33.18. MS (APCI-ES), m/z: 488 (M+1). Analysis: Calcd. (%) for C33H30NOP: C, 81.29; H, 6.20; 2.87, N. Found: C, 81.34; H, 6.18; 2.82N.

Yield after chromatography (ethyl acetate:hexane 1:1) 72 % (0.095 g). Colorless crystals. Mp 182-183 ºC. 1H NMR (300.13 MHz, CDCl3): δ 2.48 (d, 3H, 3JPH 10.4 Hz), 3.18 (bs, OH), 4.87 (dd, 1H, 3JPH 8.8, 3JHH 7.3 Hz), 5.47 (d, 1H, 3JHH 7.3 Hz), 7.51-7.23 (m, 20H, ArH). 13C NMR δ 31.85 (d, CH3, 2JPC 5.0 Hz), 65.78 (d, CH, 2JPC 2.2 Hz), 73.62 (d, CH, 3JPC 5.5 Hz), 129.54-127.37 (14CAr), 131.29 (d, Cips, 1JPC 127.7 Hz), 131.55 (d, CAr, 4JPC 2.8 Hz), 131.61 (d, CAr, 4JPC 2.8 Hz), 132.05 (d, Cips, 1JPC 125.5 Hz), 132.16 (d, 2CAr, 2JPC 9.9 Hz), 132.19 (d, 2CAr, 2JPC 9.4 Hz), 136.89 (d, Cips, 3JPC 1.7 Hz), 141.47 (Cips). 31P NMR δ 34.18. MS (APCI-ES), m/z: 428 (M+1). Analysis: Calcd. (%) for C27H26NO2P: C, 75.86; H, 6.13; N, 3.28. Found: C, 75.89; H, 6.18, N, 3.25.
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\[
N-[(1R^*,2R^*)-2-hydroxy-1,2-diphenylethyl]-N-methyl-P,P-
diphenylphosphinic amide (4a').
\]

Yield after chromatography (ethyl acetate:hexane 1:1) 24 % (0.032 g). Oil. \[^1H\text{NMR}\] (300.13 MHz, CDCl\(_3\)): \(\delta\) 2.70 (d, 3H, \(^3J_{PP}\) 10.6 Hz), 4.57 (dd, 1H, \(^3J_{PH}\) 9.5, \(^3J_{HH}\) 10.3 Hz), 5.31 (d, 1H, \(^3J_{HH}\) 10.3 Hz), 5.29 (bs, OH), 7.63-6.95 (m, 16H, ArH) , 7.81 (m, 2H, ArH), 7.92 (m, 2H, ArH). \[^{13}C\text{NMR}\] \(\delta\) 29.41 (d, CH\(_3\), \(^2J_{PC}\) 3.9 Hz), 66.54 (d, CH, \(^2J_{PC}\) 2.2 Hz), 71.10 (CH), 129.38-127.23 (14CAr), 130.55 (d, C\(_{ipso}\), \(^1J_{PC}\) 129.9 Hz), 131.07 (d, C\(_{ipso}\), \(^1J_{PC}\) 129.4 Hz), 132.10 (d, CAr, \(^4J_{PC}\) 2.8 Hz), 132.20 (d, CAr, \(^4J_{PC}\) 2.8 Hz), 132.59 (d, 2CAr, \(^2J_{PC}\) 9.4 Hz), 132.98 (d, 2CAr, \(^2J_{PC}\) 9.4 Hz), 136.49 (d, C\(_{ipso}\), \(^3J_{PC}\) 6.6 Hz), 141.44 (C\(_{ipso}\)). \[^{31}P\text{NMR}\] \(\delta\) 38.24. MS (APCI-ES), m/z: 428 (M+1). Analysis: Calcd. (%) for C\(_{27}\)H\(_{26}\)NO\(_2\)P: C, 75.86; H, 6.13; N, 3.28. Found: C, 75.89; H, 6.18, N, 3.25.

\[
N\text{-}[1R^*,2S^*]-2-hydroxy-1,2-diphenylethyl]-N\text{-}benzyl-
P,P\text{-}diphenylphosphinic amide (4b').
\]

Yield after chromatography (ethyl acetate:hexane 1:1) 79 % (0.100 g). Oil. \[^1H\text{NMR}\] (300.13 MHz, CDCl\(_3\)): \(\delta\) 3.96 (dd, 1H, \(^2J_{HH}\) 15.1, \(^3J_{PH}\) 6.8 Hz), 4.28 (dd, 1H, \(^2J_{HH}\) 15.1, \(^3J_{PH}\) 10.1 Hz), 4.38 (dd, 1H, \(^3J_{PH}\) 18.7, \(^3J_{HH}\) 2.4 Hz), 5.49 (d, 1H, \(^3J_{HH}\) 2.4 Hz), 6.41 (bs, OH), 6.76-7.51. (m, 23H, ArH), 7.82 (m, 2H, ArH). \[^{13}C\text{NMR}\] \(\delta\) 52.57 (d, CH\(_2\), \(^2J_{PC}\) 6.5 Hz), 70.91 (d, CH, \(^2J_{PC}\) 1.8 Hz), 76.16 (d, CH, \(^3J_{PC}\) 1.6 Hz), 128.68-126.51 (19CAr), 131.60 (d, C\(_{ipso}\), \(^1J_{PC}\) 127.6 Hz), 131.78 (d, CAr, \(^4J_{PC}\) 2.8 Hz, C-10), 132.07 (d, 2CAr, \(^2J_{PC}\) 9.2 Hz), 132.19 (d, CAr, \(^4J_{PC}\) 2.8 Hz), 132.94 (d, 2CAr, \(^2J_{PC}\) 9.8 Hz), 133.18 (d, C\(_{ipso}\), \(^1J_{PC}\) 122.5 Hz), 135.62 (d, C\(_{ipso}\), \(^3J_{PC}\) 0.8 Hz), 137.06 (d, C\(_{ipso}\), \(^3J_{PC}\) 4.2 Hz), 142.08 (C\(_{ipso}\)). \[^{31}P\text{NMR}\] \(\delta\) 38.48. MS (APCI-ES), m/z: 504 (M+1). Analysis: Calcd. (%) for C\(_{33}\)H\(_{30}\)NO\(_2\)P: C, 78.71; H, 6.00; N, 2.78. Found: C, 78.80; H, 5.93; N, 2.73.

\[
N\text{-}[1R^*,2S^*]-2-hydroxy-1,2-diphenylethyl]-P,P-
diphenylphosphinic amide (4b').
\]

Yield after chromatography (ethyl acetate:hexane 1:1) 10 % (0.012 g). Oil. \[^1H\text{NMR}\] (300.13 MHz, CDCl\(_3\)): \(\delta\) 4.15 (dd, 1H, \(^2J_{HH}\) 16.6, \(^3J_{PH}\) 12.3 Hz), 4.44 (dd, 1H, \(^2J_{HH}\) 16.6, \(^3J_{PH}\) 13.0 Hz), 4.66 (d, 1H, \(^3J_{HH}\) 10.4 Hz), 5.06 (dd, 1H, \(^3J_{HH}\) 5.7, \(^3J_{HH}\) 10.4 Hz), 6.41 (d, OH, \(^3J_{HH}\) 5.7Hz), 6.79-7.66. (m, 21H, ArH), 7.68 (m, 2H, ArH), 7.92 (m, 2H, ArH). \[^{13}C\text{NMR}\] \(\delta\) 48.64 (d, CH\(_2\), \(^2J_{PC}\) 5.1 Hz), 68.14

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(d, CH, $^2J_{PC}$ 2.8 Hz), 73.36 (CH), 128.68-126.51 (19CAr), 130.40 (d, C$_{ipso}$, $^1J_{PC}$ 125.3 Hz), 131.58 (d, C$_{ipso}$, $^1J_{PC}$ 128.5 Hz), 132.28 (d, CAr, $^4J_{PC}$ 2.8 Hz), 132.32 (d, CAr, $^4J_{PC}$ 2.3 Hz), 132.49 (d, 2CAr, $^2J_{PC}$ 10.2 Hz), 132.97 (d, 2CAr, $^2J_{PC}$ 10.2 Hz), 136.62 (d, C$_{ipso}$, $^3J_{PC}$ 5.1 Hz), 138.83 (d, C$_{ipso}$, $^3J_{PC}$ 2.8 Hz), 142.28 (C$_{ipso}$).

$^31$P NMR $\delta$ 39.83. MS (APCI-ES), m/z: 504 (M+1). Analysis: Calcd. (%) for C$_{33}$H$_{30}$NO$_2$P: C, 78.71; H, 6.00; N, 2.78. Found: C, 78.80; H, 5.93; N, 2.73.

P N O Me OH

$N$-[($1R^*$,$2S^*$)-2-hydroxy-1,4-diphenylbutyl]-$N$-methyl-$P,P$-diphenylphosphinic amide (5a).

Yield after chromatography (ethyl acetate:hexane 2:1) 69 % (0.098 g). Oil. 1H NMR (300.13 MHz, CDCl$_3$): $\delta$ 1.77 (m, 1H), 1.92 (m, 1H), 2.42 (d, 3H, $^3J_{PH}$ 10.4 Hz), 2,67 (m, 1H), 2.89 (ddd, 1H, $^2J_{HH}$ 14, $^3J_{HH}$ 9.1, $^3J_{HH}$ 5 Hz), 3.72 (d, 1H, $^3J_{PH}$ 4.3Hz), 4.29 (m, 1H), 4.45 (dd, 1H $^3J_{PH}$ 8.5, $^3J_{HH}$ 6.1 Hz), 7.55-7.12 (m, 16H, ArH), 7.69 (m, 4H, ArH). 13C NMR $\delta$ 32.11 (CH$_2$), 32.38 (d, CH$_3$, $^2J_{PC}$ 5.4 Hz), 35.91 (CH$_2$), 65.50 (d, CH, $^2J_{PC}$ 2.4 Hz), 70.36 (d, CH, $^3J_{PC}$ 2.9 Hz), 129.54-125.65 (14CAr), 131.80 (d, CAr, $^4J_{PC}$ 2.8 Hz), 131.82 (d, CAr, $^4J_{PC}$ 3 Hz), 132.18 (d, 4CAr, $^2J_{PC}$ 9.8 Hz), 131.74 (d, C$_{ipso}$, $^1J_{PC}$ 125.5 Hz), 131.94 (d, C$_{ipso}$, $^1J_{PC}$ 128.8 Hz), 137.43 (d, C$_{ipso}$, $^3J_{PC}$ 4 Hz), 142.08 (C$_{ipso}$).

$^31$P NMR $\delta$ 33.90. MS (APCI-ES), m/z: 456 (M+1). Analysis: Calcd. (%) for C$_{29}$H$_{30}$NO$_2$P: C, 76.46; H, 6.64; N, 3.07. Found: C, 76.54; H, 6.60; N, 3.12.

N-[($1R^*$,$2R^*$)-2-hydroxy-1,4-diphenylbutyl]-$N$-methyl-$P,P$-diphenylphosphinic amide (5a').

Yield after chromatography (ethyl acetate:hexane 2:1) 26 % (0.037 g). Oil. 1H NMR (300.13 MHz, CDCl$_3$) $\delta$ 1.44 (m, 1H), 1.57 (m, 1H), 2.52 (d, 3H, $^3J_{PH}$ 11 Hz), 2.70 (m, 1H), 2.84 (ddd, 1H, $^2J_{HH}$ 14.3, $^3J_{HH}$ 10, $^3J_{HH}$ 4.9 Hz), 4.26 (dd, 1H, $^3J_{PH}$ 10, $^3J_{HH}$ 8.5 Hz), 4.33 (m, 1H), 4.64 (d, 1H, $^3J_{HH}$ 2.9 Hz), 7.60-6.96 (m, 16H, ArH), 7.79 (m, 2H, ArH), 7.87 (m, 2H, ArH). 13C NMR $\delta$ 29.12 (d, CH$_3$, $^2J_{PC}$ 4.2 Hz), 31.70 (CH$_2$), 36.03 (CH$_2$), 65.23 (d, CH, $^2J_{PC}$ 2.5 Hz), 66.37 (CH), 129.17-125.57 (14CAr), 130.93 (d, C$_{ipso}$, $^1J_{PC}$ 129.5 Hz), 131.18 (d, C$_{ipso}$, $^1J_{PC}$ 129.5 Hz), 131.20 (d, 2CAr, $^4J_{PC}$ 3.5 Hz), 131.26 (d, CAr, $^4J_{PC}$ 3.6 Hz), 132.57 (d, CAr, $^2J_{PC}$ 9.5 Hz), 133.02 (d, 2CAr, $^2J_{PC}$ 9.7 Hz), 137.21 (d, C$_{ipso}$, $^3J_{PC}$ 6.8 Hz), 142.29 (C$_{ipso}$). $^31$P NMR $\delta$ 37.02. MS (APCI-ES), m/z: 456 (M+1). Analysis: Calcd. (%) for C$_{29}$H$_{30}$NO$_2$P: C, 76.46; H, 6.64; N, 3.07. Found: C, 76.50; H, 6.62; N, 3.13.
**N-benzyl-N-[(1R*,2S*)-2-hydroxy-1,4-diphenylbutyl]-P,P-diphenylphosphinic amide (5b).**

Yield after chromatography (ethyl acetate:hexane 2:1) 77 % (0.103 g). Oil. ¹H NMR (300.13 MHz, CDCl₃): δ 1.58 (m, 2H), 2.39 (ddd, 1H, 2 J HH 14, 3 J HH 9.5, 3 J HH 7 Hz), 2.64 (ddd, 1H, 2 J HH 14, 3 J HH 9.2, 3 J HH 6.5 Hz), 4.02 (dd, 1H, 2 J HH 15.7, 3 J PH 8.3 Hz), 4.14 (dd, 1H, 2 J HH 15.7, 3 J PH 9.6 Hz), 4.21 (d, 1H, 3 J PH 14.4 Hz), 4.22 (m, 1H), 5.41 (bs, OH), 7.60-6.93 (m, 23H, ArH), 7.76 (m, 2H, ArH).

¹³C NMR δ 32.38 (CH 2), 36.53 (CH 2), 51.66 (d, CH 2, 2 J PC 6.5 Hz), 68.48 (d, CH, 2 J PC 2.4 Hz), 72.14 (d, CH, 3 J PC 2.1 Hz), 128.61-125.51 (17CAr), 130.57 (2CAr), 131.77 (d, CAr, 4 J PC 2.9 Hz), 131.88 (d, C ipso, 1 J PC 124.3 Hz), 131.98 (d, CAr, 4 J PC 2.8 Hz), 132.07 (d, 2CAr, 2 J PC 10 Hz), 132.27 (d, 2CAr, 2 J PC 10.1 Hz), 132.96 (d, C ipso, 1 J PC 126.6 Hz), 136.70 (C ipso), 137.49 (d, C ipso, 3 J PC 4.2 Hz), 142.23 (C ipso). ³¹P NMR δ 37.30. MS (APCI-ES), m/z: 532 (M +1).

Analysis: Calcd. (%) for C₃₅H₃₄NO₂P: C, 79.07; H, 6.45; N, 2.63. Found: C, 79.05; H, 6.48; N, 2.70.

**N-benzyl-N-[(1R*,2R*)-2-hydroxy-1,4-diphenylbutyl]-P,P-diphenylphosphinic amide (5b').**

Yield after chromatography (ethyl acetate:hexane 2:1) 20 % (0.027 g). Oil. ¹H NMR (300.13 MHz, CDCl₃): δ 1.40 (m, 2H), 2.58 (m, 1H), 2.79 (ddd, 1H, 2 J HH 14.2, 3 J HH 9.5, 3 J HH 5.5 Hz), 3.99 (dd, 1H, 2 J HH 16.5, 3 J PH 11.9 Hz), 4.02 (m, 1H), 4.30 (dd, 1H, 2 J HH 16.5, 3 J PH 12.8 Hz), 4.37 (dd, 1H, 3 J PH 11, 3 J HH 10.6 Hz), 5.23 (bs, OH), 7.94-6.81 (m, 25H, ArH).

¹³C NMR δ 31.74 (CH 2), 36.74 (CH₃), 48.43 (d, CH 2, 2 J PC 4.9 Hz), 66.76 (d, CH, 2 J PC 2.9 Hz), 68.82 (CH), 128.64-125.43 (17CAr), 129.62 (2CAr), 132.52-131.41 (4CAr), 132.56 (d, 2CAr, 2 J PC 9.8 Hz), 133.04 (d, 2CAr, 2 J PC 9.7 Hz), 137.41 (d, C ipso, 3 J PC 4.9 Hz), 139.09 (d, C ipso, 3 J PC 2.5 Hz), 142.35 (C ipso). ³¹P NMR δ 38.27. MS (APCI-ES), m/z: 532 (M+1). Analysis: Calcd. (%) for C₃₅H₃₄NO₂P: C, 79.07; H, 6.45; N, 2.63. Found: C, 79.04; H, 6.49; N, 2.72.

**N-[(1R*,2S*)-2-hydroxy-3,3-dimethyl-1-phenylbutyl]-N-methyl-P,P-diphenylphosphinic amide (6a).**

Yield after chromatography (ethyl acetate:hexane 2:1) 58 % (0.073 g). White solid. Mp 169-170 ºC. ¹H NMR (300.13 MHz, CDCl₃): δ 0.66 (s, 9H), 2.71 (d, 3H, 3 J PH 10.3 Hz), 4.05 (d, 1H, 3 J HH 2.1 Hz), 4.58 (t, 1H, 3 J PH 9.7, 3 J HH 2.1 Hz), 7.82-7.25 (m, 15H, ArH). ¹³C NMR δ 26.80 (3CH₃), 33.28 (d, CH₃, 2 J PC 4.9 Hz), 35.44 (C), 62.04 (d, CH, 2 J PC 2.5 Hz), 83.74 (d, CH, 3 J PC 2.4 Hz), 129.52-
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127.39 (8CAr), 13174 (CAr), 131.55 (d, CAr, $^4J_{PC}$ 2.7 Hz), 131.74 (d, CAr, $^4J_{PC}$ 2.4 Hz), 132.19 (d, C$_{ipso}$, $^1J_{PC}$ 125.4 Hz), 132.22 (d, 2CAr, $^2J_{PC}$ 10.3 Hz), 133.36 (d, 2CAr, $^2J_{PC}$ 10.3 Hz), 132.40 (d, C$_{ipso}$, $^1J_{PC}$ 119.2 Hz), 133.19 (d, C$_{ipso}$, $^3J_{PC}$ 4.5 Hz). $^{31P}$ NMR δ 33.93. MS (APCI-ES), m/z: 408 (M+1). Analysis: Calcd. (%) for C$_{25}$H$_{30}$NO$_2$P: C, 73.69; H, 7.42; N, 3.44. Found: C, 73.67; H, 7.44; N, 3.50.

![Image](P NO Me OH N -[(1R*,2R*)-2-hydroxy-3,3-dimethyl-1-phenylbutyl]-N-methyl-P,P-diphenylphosphinic amide (6a†).

Yield after chromatography (ethyl acetate:hexane 2:1) 32 % (0.040 g). Oil. $^1$H NMR (300.13 MHz, CDCl$_3$): δ 0.67 (s, 9H), 2.59 (d, 3H, $^3J_{PH}$ 11 Hz), 3.99 (dd, 1H, $^3J_{HH}$ 9.7, $^3J_{HH}$ 7 Hz), 4.46 (t, 1H, $^3J_{PH}$ 9.7, $^2J_{HH}$ 9.7 Hz), 4.59 (d, OH, $^3J_{HH}$ 7 Hz), 7.62-7.09 (m, 11H, ArH), 7.70 (m, 2H, ArH), 7.88 (m, 2H, ArH). $^{13C}$ NMR δ 26.92 (3CH$_3$), 30.04 (d, CH$_3$, $^2J_{PC}$ 3.8 Hz), 35.80 (C), 61.00 (d, CH, $^2J_{PC}$ 2.1 Hz), 74.68 (CH), 127.69 (2CAr), 128.17 (2CAr), 128.42 (d, 2CAr, $^3J_{PC}$ 12.9), 128.61 (d, 2CAr, $^3J_{PC}$ 12.5), 129.46 (CAr), 130.69 (d, C$_{ipso}$, $^1J_{PC}$ 128.1 Hz), 131.64 (d, C$_{ipso}$, $^1J_{PC}$ 131.5 Hz), 131.94 (d, CAr, $^4J_{PC}$ 2.6 Hz), 132.12 (d, CAr, $^4J_{PC}$ 2.8 Hz), 132.38 (d, 2CAr, $^2J_{PC}$ 9.4 Hz), 133.11 (d, 2CAr, $^2J_{PC}$ 9.4 Hz), 138.90 (d, C$_{ipso}$, $^3J_{PC}$ 6.5 Hz). $^{31P}$ NMR δ 36.57. MS (APCI-ES), m/z: 408 (M+1). Analysis: Calcd. (%) for C$_{25}$H$_{30}$NO$_2$P: C, 73.69; H, 7.42; N, 3.44. Found: C, 73.67; H, 7.44; N, 3.50.

![Image](N-benzyl-N-[(1R*,2S*)-2-hydroxy-3,3-dimethyl-1-phenylbutyl]-P,P-diphenylphosphinic amide (6b).

Yield after chromatography (ethyl acetate:hexane 2:1) 94 % (0.114 g). Colorless crystals; mp: 153-154 °C. $^1$H NMR (300.13 MHz, CDCl$_3$): δ 0.56 (s, 9H), 4.00 (s, 1H), 4.02 (dd, 1H, $^2J_{HH}$ 15.4, $^3J_{PH}$ 5 Hz), 4.28 (dd, 1H, $^2J_{HH}$ 15.4, $^3J_{PH}$ 10.3 Hz), 4.37 (d, 1H, $^3J_{PH}$ 20.4 Hz), 6.60 (bs, OH), 7.63-6.95 (m, 18H, ArH), 7.82 (m, 2H, ArH). $^{13C}$ NMR δ 27.14 (3CH$_3$), 35.36 (C), 52.46 (d, CH$_2$, $^2J_{PC}$ 6.7 Hz), 64.84 (d, CH, $^2J_{PC}$ 1.9 Hz), 82.89 (CH), 126.61-127.34 (12CAr), 131.48 (d, 2CAr, $^4J_{PC}$ 3.4 Hz), 131.65(2CAr), 131.68 (d, C$_{ipso}$, $^1J_{PC}$ 122.2 Hz), 131.99 (d, 2CAr, $^2J_{PC}$ 10.5 Hz), 132.15 (d, 2CAr, $^2J_{PC}$ 10.5 Hz), 133.44 (d, C$_{ipso}$, $^1J_{PC}$ 128.3 Hz), 137.50 (d, C$_{ipso}$, $^3J_{PC}$ 5.1 Hz), 138.18 (C$_{ipso}$). $^{31P}$ NMR δ 37.75. MS (APCI-ES), m/z: 484 (M+1). Analysis: Calcd. (%) for C$_{31}$H$_{34}$NO$_2$P: C, 76.99, H, 7.09; N, 2.90. Found: C, 76.96; H, 7.12; N, 2.95.
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\[
N-[(1R^*,2S^*)-2-hydroxy-1-phenylbut-3-en-1-yl]-N\text{-methyl-}P,P\text{-}
diphenylphosphinic amide (7a).
\]

Yield after chromatography (ethyl acetate:hexane 2:1) 75 % (0.088 g). Mp: 168-170 °C. \(^{1}H\) NMR (300.13 MHz, CDCl\(_3\)): \(\delta\) 2.48 (d, 3H, \(J_{PH}\) 10.5 Hz), 3.85 (bs, OH), 4.68 (dd, 1H, \(J_{PH}\) 8.8, \(J_{HH}\) 6.5 Hz), 4.83 (m, 1H), 5.19 (dt, 1H, \(J_{HH}\) 1.4, \(J_{HH}\) 10.4 Hz), 5.40 (dt, 1H, \(J_{HH}\) 1.4, \(J_{HH}\) 1.4, \(J_{HH}\) 17.1 Hz), 6.07 (ddd, 1H, \(J_{HH}\) 17.1, \(J_{HH}\) 10.4, \(J_{HH}\) 6.3 Hz), 7.56-7.27 (m, 11H, ArH), 7.76 (m, 4H, ArH). \(^{13}C\) NMR \(\delta\) 31.81 (d, CH \(J_{PC}\) 4.5 Hz), 63.93 (d, CH, \(J_{PC}\) 2.8 Hz), 72.82 (d, CH, \(J_{PC}\) 3.2 Hz), 116.65 (=CH \(J_{PC}\) 12.6 Hz), 127.57 (CAr), 128.30 (2CAr), 128.47 (d, 2CAr, \(J_{PC}\) 9.5 Hz), 131.83 (d, 2CAr, \(J_{PC}\) 9.6 Hz), 137.08 (d, Cipso, \(J_{PC}\) 4 Hz), 138.54 (=CH). \(^{31}P\) NMR \(\delta\) 34.06. MS (APCI-ES), m/z: 378 (M+1). Analysis: Calcd. (%) for C\(_{23}\)H\(_{24}\)NO\(_2\)P: C, 73.19; H, 6.41; N, 3.71. Found: C, 73.22; H, 7.39; N, 3.75.

\[
N-[(1R^*,2R^*)-2-hydroxy-1-phenylbut-3-en-1-yl]-N\text{-methyl-}P,P\text{-}
diphenylphosphinic amide (7a*).
\]

Yield after chromatography (ethyl acetate:hexane 2:1) 15 % (0.017 g). Oil. \(^{1}H\) NMR (300.13 MHz, CDCl\(_3\)): \(\delta\) 2.58 (d, 3H, \(J_{PH}\) 10.6 Hz), 4.28 (dd, 1H, \(J_{PH}\) 10.1, \(J_{HH}\) 9.1 Hz), 4.92 (m, 1H), 5.00 (ddd, 1H, \(J_{HH}\) 2, 4\(^{1}HH\) 1.2, \(J_{HH}\) 17.2 Hz), 5.34 (ddd, 1H, \(J_{HH}\) 2, \(J_{HH}\) 1.2, \(J_{HH}\) 17.2 Hz), 5.55 (ddd, 1H, \(J_{HH}\) 17.2, \(J_{HH}\) 10.4, \(J_{HH}\) 5.7 Hz), 8.05-7.3 (m, 15H, ArH). \(^{13}C\) NMR \(\delta\) 33.71 (d, CH\(_{3}\), \(J_{PC}\) 2.9 Hz), 65.16 (d, CH, \(J_{PC}\) 2.4 Hz), 68.63 (CH), 116.83 (=CH\(_{2}\)), 128.74-127.54 (7CAr), 129.43 (2CAr), 131.87 (d, CAr, \(J_{PC}\) 2.5 Hz), 132.36 (d, 2CAr, \(J_{PC}\) 9.5 Hz), 132.38 (d, 2CAr, \(J_{PC}\) 9.6 Hz), 137.08 (d, Cipso, \(J_{PC}\) 4 Hz), 138.54 (=CH). \(^{31}P\) NMR \(\delta\) 37.49. MS (APCI-ES), m/z: 378 (M+1). Analysis: Calcd. (%) for C\(_{23}\)H\(_{24}\)NO\(_2\)P: C, 73.19; H, 6.41; N, 3.71. Found: C, 73.22; H, 7.39; N, 3.75.

\[
N\text{-benzyl-N-}[1(1R^*,2S^*)-2-hydroxy-1-phenylbut-3-en-1-yl]-P,P\text{-}
diphenylphosphinic amide (7b).
\]

Yield after chromatography (ethyl acetate:hexane 2:1) 85 % (0.097 g). Oil. \(^{1}H\) NMR (300.13 MHz, CDCl\(_3\)): \(\delta\) 4.11 (dd, 1H, \(J_{HH}\) 15.6, \(J_{PH}\) 8.7 Hz), 4.20 (dd, 1H, \(J_{HH}\) 15.6, \(J_{HH}\) 9.6 Hz), 4.33 (dd, 1H, \(J_{HH}\) 15.6, \(J_{HH}\) 3.8 Hz), 4.80 (m, 1H), 5.00 (dt, 1H, \(J_{HH}\) 1.5, \(J_{HH}\) 1.5, \(J_{HH}\) 10.5 Hz), 5.07 (dt, 1H, \(J_{HH}\) 1.5, \(J_{HH}\) 1.5, \(J_{HH}\) 17.3 Hz), 5.53 (bs, OH), 5.73 (ddd, 1H, \(J_{HH}\) 17.3, \(J_{HH}\) 10.5, \(J_{HH}\) 6 Hz),
7.63-6.94 (m, 18H, ArH), 7.84 (m, 2H, ArH). $^{13}$C NMR $\delta$ 51.72 (d, CH$_2$, $^2J_{PC}$ 5.9 Hz), 68.39 (CH), 74.25 (CH), 115.88 (=CH$_2$), 128.64-127.53 (12CAr), 130.70 (2CAr), 131.56 (d, C$_{ipso}$, $^1J_{PC}$ 124.6 Hz), 131.71 (d, CAr, $^4J_{PC}$ 2.9 Hz), 132.09 (d, CAr, $^4J_{PC}$ 2.5 Hz), 132.25 (d, 4CAr, $^2J_{PC}$ 9.8 Hz), 132.68 (d, C$_{ipso}$, $^1J_{PC}$ 126.8 Hz), 136.52 (d, C$_{ipso}$, $^3J_{PC}$ 1.7 Hz), 137.51 (d, C$_{ipso}$, $^3J_{PC}$ 4.1 Hz), 138.68 (=CH). $^{31}$P NMR $\delta$ 36.83. MS (APCI-ES), m/z: 454 (M+1). Analysis: Calcd. (%) for C$_{29}$H$_{28}$NO$_2$P: C, 76.80, H, 6.22; N, 3.08. Found: C, 76.76; H, 6.26; N, 3.03.

N-benzyl-N-[1(R$^*$,2R$^*$)-2-hydroxy-1-phenylbut-3-en-1-yl]-P,P-diphenylphosphinic amide (7b$^*$).

Yield after chromatography (ethyl acetate:hexane 2:1) 13 % (0.015 g). Oil. $^1$H NMR (300.13 MHz, CDCl$_3$): $\delta$ 4.05 (dd, 1H, $^2J_{HH}$ 16.6, $^3J_{PH}$ 12.2 Hz), 4.38 (dd, 1H, $^2J_{HH}$ 16.6, $^3J_{PH}$ 3.8 Hz), 4.41 (t, 1H, $^3J_{PH}$ 10.3, $^3J_{HH}$ 10.4 Hz), 4.53 (m, 1H), 4.91 (dt, 1H, $^2J_{HH}$ 1.5, $^4J_{HH}$ 1.5, $^3J_{HH}$ 10.4 Hz), 5.25 (dt, 1H, $^2J_{HH}$ 1.5, $^4J_{HH}$ 1.5, $^3J_{HH}$ 16.9 Hz), 5.46 (ddd, 1H, $^3J_{HH}$ 16.9, $^3J_{HH}$ 10.4, $^3J_{HH}$ 5.5 Hz), 7.70-7.16 (m, 18H, ArH), 7.89 (m, 2H, ArH). $^{13}$C NMR $\delta$ 48.48 (d, CH$_2$, $^2J_{PC}$ 5.9 Hz), 66.64 (d, CH, $^2J_{PC}$ 3.1 Hz), 71.03 (CH), 116.17 (=CH$_2$), 128.65-127.04 (12CAr), 130.02 (2CAr), 132.89-131.75 (4CAr), 133.09 (d, 2CAr, $^2J_{PC}$ 9.7 Hz), 136.77 (d, C$_{ipso}$, $^3J_{PC}$ 5 Hz), 138.19 (=CH), 138.90 (d, C$_{ipso}$, $^3J_{PC}$ 2.5 Hz). $^{31}$P NMR $\delta$ 39.00. MS (APCI-ES), m/z: 454 (M+1). Analysis: Calcd. (%) for C$_{29}$H$_{28}$NO$_2$P: C, 76.80; H, 6.22; N, 3.08. Found: C, 76.74; H, 6.24; N, 3.12.

N-methyl-N-[1(R$^*$)-4-oxo-1-phenylpentyl]-P,P-diphenylphosphinic amide (8a).

Yield after chromatography (ethyl acetate:hexane 2:1) 70 % (0.085 g). Oil. $^1$H NMR (300.13 MHz, CDCl$_3$): $\delta$ 2.12 (s, 3H), 2.25 (m, 2H), 2.41 (d, 3H, $^3J_{PH}$ 10.5 Hz), 2.54 (m, 2H), 4.63 (dt, 1H, $^3J_{PH}$ 8.9, $^3J_{HH}$ 7.5 Hz), 7.55-7.25 (m, 11H, ArH), 7.67 (m, 2H, ArH), 7.81 (m, 2H, ArH). $^{13}$C NMR $\delta$ 24.14 (CH$_3$), 29.27 (d, CH$_3$, $^2J_{PC}$ 4.5 Hz), 30.04 (CH$_2$), 40.73 (CH$_2$), 57.15 (d, CH, $^2J_{PC}$ 3 Hz), 127.41 (CAr), 128.61-128.22 (8CAr), 131.72 (d, CAr, $^4J_{PC}$ 2.7 Hz), 131.73 (d, C$_{ipso}$, $^1J_{PC}$ 126.4 Hz), 131.76 (d, CAr, $^4J_{PC}$ 3 Hz), 132.24 (d, C$_{ipso}$, $^1J_{PC}$ 128.5 Hz), 132.27 (d, 2CAr, $^2J_{PC}$ 9.3 Hz), 132.33 (d, 2CAr, $^2J_{PC}$ 9.6 Hz), 139.51 (d, C$_{ipso}$, $^3J_{PC}$ 4.2 Hz), 208.14 (C=O). $^{31}$P NMR $\delta$ 32.22. MS (APCI-ES), m/z: 392 (M+1). Analysis: Calcd. (%) for C$_{24}$H$_{26}$NO$_2$P: C, 73.64; H, 6.69; N, 3.58. Found: C, 76.96; H, 7.12; N, 3.61.
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N-bezyl-N-[(1R*)-4-oxo-1-phenylpentyl]-P,P-diphenylphosphinic amide (8b).

Yield after chromatography (ethyl acetate:hexane 3:2) 68 % (0.080 g). Oil. $^1$H NMR (300.13 MHz, CDCl$_3$): δ 1.97 (s, 3H), 2.08 (m, 2H), 2.22 (ddd, 1H, $^2$J$_{HH}$ 17.2, $^3$J$_{HH}$ 9.2, $^3$J$_{HH}$ 5.8 Hz), 2.32 (ddd, 1H, $^2$J$_{HH}$ 17.2, $^3$J$_{HH}$ 9.5, $^3$J$_{HH}$ 5.8 Hz), 3.90 (dd, 1H, $^2$J$_{HH}$ 16.2, $^3$J$_{HH}$ 9.2, $^3$J$_{HH}$ 5.8 Hz), 4.25 (dd, 1H, $^2$J$_{HH}$ 16.2, $^3$J$_{PP}$ 11.5 Hz), 4.58 (ddd, 1H, $^3$J$_{HH}$ 10.3, $^3$J$_{HH}$ 8.4, $^3$J$_{HH}$ 7.4 Hz), 7.55-7.09 (m, 16H, ArH), 7.83 (m, 4H). $^{13}$C NMR δ 27.29 (d, CH$_2$, $^3$J$_{PC}$ 2.4 Hz), 29.69 (CH$_3$), 41.10 (CH$_2$), 47.81 (d, CH$_2$, $^2$J$_{PC}$ 4.8 Hz), 59.82 (d, CH, $^2$J$_{PC}$ 3.9 Hz), 128.48-126.99 (12CAr), 129.17 (2CAr), 131.66 (d, CAr, $^4$J$_{PC}$ 2.7 Hz), 131.79 (d, CAr, $^4$J$_{PC}$ 2.7 Hz), 132.29 (d, C$_{ipso}$, $^1$J$_{PC}$ 125.7 Hz), 132.35 (d, C$_{ipso}$, $^1$J$_{PC}$ 127.2 Hz), 132.51 (d, 2CAr, $^2$J$_{PC}$ 9.0 Hz), 132.63 (d, 2CAr, $^2$J$_{PC}$ 9.0 Hz), 138.64 (d, C$_{ipso}$, $^3$J$_{PC}$ 3.9 Hz), 139.32 (d, C$_{ipso}$, $^3$J$_{PC}$ 3.7 Hz), 207.83 (C=O). $^{31}$P NMR δ 33.22. MS (APCI-ES), m/z: 468 (M+1). Analysis: Calcd. (%) for C$_{30}$H$_{30}$NO$_2$P: C, 77.07, H, 6.47; N, 3.00. Found: C, 76.96; H, 6.55; N, 3.10.

Methyl (4R*)-4-[[diphenylphosphoryl](methyl)amino]-4-phenylbutanoate (9a).

Yield after chromatography (ethyl acetate:hexane 2.5:1) 78 % (0.098 g). Oil. $^1$H NMR (300.13 MHz, CDCl$_3$): δ 2.34 (m, 2H), 2.35(m, 2H), 2.43 (d, 3H, $^3$J$_{PH}$ 10.3 Hz), 3.62 (s, 3H), 4.61 (dt, 1H, $^3$J$_{PH}$ 8.4, $^3$J$_{HH}$ 7.3 Hz), 7.49-6.22 (m, 11H, ArH), 7.73 (m, 4H, ArH). $^{13}$C NMR δ 25.5 (d, CH$_2$, $^3$J$_{PC}$ 3.3 Hz), 28.18 (d, CH$_3$, $^2$J$_{PC}$ 4.2 Hz), 31.34 (CH$_2$), 51.55 (OCH$_3$), 57.38 (d, CH, $^2$J$_{PC}$ 3 Hz), 127.51 (CAr), 128.67-128.30 (8CAr), 131.72 (d, CAr, $^4$J$_{PC}$ 2.7 Hz), 131.74 (d, CAr, $^4$J$_{PC}$ 3 Hz), 131.76 (d, C$_{ipso}$, $^1$J$_{PC}$ 126.8 Hz), 132.01 (d, C$_{ipso}$, $^1$J$_{PC}$ 127.6 Hz), 132.29 (d, 2CAr, $^2$J$_{PC}$ 9.6 Hz), 132.39 (d, 2CAr, $^2$J$_{PC}$ 9.3 Hz), 139.01 (d, C$_{ipso}$, $^3$J$_{PC}$ 3.6 Hz), 173.55 (C=O). $^{31}$P NMR δ 32.23. MS (APCI-ES), m/z: 408 (M+1). Analysis: Calcd. (%) for C$_{24}$H$_{26}$NO$_3$P: C, 70.75, H, 6.43; N, 3.44. Found: C, 70.72; H, 6.45; N, 3.50.

Methyl (4R*)-4-[(benzyl)(diphenylphosphoryl)amino]-4-phenylbutanoate (9b).

Yield after chromatography (ethyl acetate:hexane 2:1) 84 % (0.102 g). Oil. $^1$H NMR (300.13 MHz, CDCl$_3$): δ 2.11 (m, 1H), 2.12 (m, 2H), 2.20 (m, 1H), 3.52 (s, 3H), 3.91 (dd, 1H, $^2$J$_{HH}$ 16.1, $^3$J$_{PH}$ 10.4
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Hz), 4.24 (dd, 1H, $^2J_{\text{HH}}$ 16.1, $^3J_{\text{PH}}$ 11.5 Hz), 4.59 (m, 1H), 7.54-7.10 (m, 16H, ArH), 7.85 (m, 4H).

$^{13}$C NMR $\delta$ 28.74 (d, CH$_2$, $^2J_{\text{PC}}$ 2.8 Hz), 31.65 (CH$_2$), 47.91 (d, CH$_2$, $^2J_{\text{PC}}$ 4.7 Hz), 51.40 (OCH$_3$), 60.00 (d, CH, $^2J_{\text{PC}}$ 4 Hz), 128.52-127.03 (12CAr), 129.31 (2CAr), 131.70 (d, CAr, $^4J_{\text{PC}}$ 3.1 Hz), 131.83 (d, CAr, $^4J_{\text{PC}}$ 3.1 Hz), 132.34 (d, C$_{\text{ipso}}$, $^1J_{\text{PC}}$ 126.6 Hz), 132.39 (d, C$_{\text{ipso}}$, $^1J_{\text{PC}}$ 127.4 Hz), 132.57 (d, 2CAr, $^2J_{\text{PC}}$ 9.4 Hz), 132.66 (d, 2CAr, $^2J_{\text{PC}}$ 9.6 Hz), 138.30 (d, C$_{\text{ipso}}$, $^3J_{\text{PC}}$ 3.8 Hz), 139.32 (d, C$_{\text{ipso}}$, $^3J_{\text{PC}}$ 3.6 Hz), 173.27 (C=O).

$^{31}$P NMR $\delta$ 33.37. MS (APCI-ES), m/z: 484 (M+1). Analysis: Calcd. (%) for C$_{30}$H$_{30}$NO$_2$P: C, 74.52, H, 6.25; N, 2.90. Found: C, 74.60; H, 6.15; N, 2.87.

**Methyl (2R*)-2-[(diphenylphosphoryl)(methyl)amino]-2-phenyletanoate (10a).**

Yield after chromatography (ethyl acetate:hexane 2:1) 72 % (0.085 g). Oil. $^1$H NMR (300.13 MHz, CDCl$_3$): $\delta$ 2.50 (d, 3H, $^3J_{\text{PH}}$ 10.2 Hz), 3.74 (s, 3H), 5.56 (d, 1H, $^3J_{\text{PH}}$ 10 Hz), 7.59-7.30 (m, 11H, ArH), 7.87 (m, 4H, ArH).

$^{13}$C NMR $\delta$ 30.68 (d, CH$_3$, $^2J_{\text{PC}}$ 4.5 Hz), 51.87 (OCH$_3$), 61.09 (d, CH, $^2J_{\text{PC}}$ 5 Hz), 128.05 (CAr), 128.63-128.43 (6CAr), 129.07 (2CAr), 130.55 (d, C$_{\text{ipso}}$, $^1J_{\text{PC}}$ 129.9 Hz), 131.07 (d, C$_{\text{ipso}}$, $^1J_{\text{PC}}$ 129.4 Hz), 131.85 (d, CAr, $^4J_{\text{PC}}$ 2.5 Hz), 131.98 (d, CAr, $^4J_{\text{PC}}$ 2.5 Hz), 132.29 (d, 2CAr, $^2J_{\text{PC}}$ 9.9 Hz), 132.38 (d, 2CAr, $^2J_{\text{PC}}$ 9.5 Hz), 135.06 (d, C$_{\text{ipso}}$, $^3J_{\text{PC}}$ 3 Hz), 172.16 (d, C=O, $^3J_{\text{PC}}$ 5.1 Hz). $^{31}$P NMR $\delta$ 33.03. MS (APCI-ES), m/z: 380 (M+1). Analysis: Calcd. (%) for C$_{22}$H$_{22}$NO$_3$P: C, 69.65, H, 5.84; N, 3.69. Found: C, 69.66; H, 5.83, N, 3.73.

**Methyl (2R*)-2-[(benzyl)(diphenylphosphoryl)amino]-2-phenyletanoate (10b).**

Yield after chromatography (ethyl acetate:hexane 2:1) 76 % (0.087 g). Oil. $^1$H NMR (300.13 MHz, CDCl$_3$): $\delta$ 3.66 (s, 3H), 4.34 (dd, 1H, $^2J_{\text{HH}}$ 16.7, $^3J_{\text{PH}}$ 9.1 Hz), 4.53 (t, 1H, $^2J_{\text{HH}}$ 16.7, $^3J_{\text{PH}}$ 16.7 Hz), 5.37 (d, 1H, $^3J_{\text{PH}}$ 10.1 Hz), 7.51-6.72 (m, 16H, ArH), 7.87 (m, 4H, ArH). $^{13}$C NMR $\delta$ 49.37 (d, CH$_2$, $^2J_{\text{PC}}$ 3.8 Hz), 51.94 (OCH$_3$), 62.21 (d, CH, $^2J_{\text{PC}}$ 5.3 Hz), 128.48-126.22 (12CAr), 129.76 (2CAr), 131.26 (d, C$_{\text{ipso}}$, $^1J_{\text{PC}}$ 127.4 Hz), 131.75 (d, CAr, $^4J_{\text{PC}}$ 3 Hz), 131.81 (d, C$_{\text{ipso}}$, $^1J_{\text{PC}}$ 127 Hz), 131.89 (d, CAr, $^4J_{\text{PC}}$ 2.9 Hz), 132.54 (d, 2CAr, $^2J_{\text{PC}}$ 9.9 Hz), 132.66 (d, 2CAr, $^2J_{\text{PC}}$ 9.8 Hz), 135.14 (d, C$_{\text{ipso}}$, $^3J_{\text{PC}}$ 4.3 Hz), 138.53 (d, C$_{\text{ipso}}$, $^3J_{\text{PC}}$ 1.3 Hz), 172.41 (d, C=O, $^3J_{\text{PC}}$ 3.1 Hz). $^{31}$P NMR $\delta$ 32.33. MS (APCI-ES), m/z: 456 (M+1). Analysis: Calcd. (%) for C$_{28}$H$_{26}$NO$_3$P: C, 73.83, H, 5.75; N, 3.08. Found: C, 73.85; H, 5.73; N, 3.12.
Methyl (3R*)-3-[(diphenylphosphoryl)(methyl)amino]-3-phenylpropanoate (11a).

Yield after chromatography (ethyl acetate:hexane 2:1) 63 % (0.077 g). Oil. \textbf{1H NMR} (300.13 MHz, CDCl$_3$): $\delta$ 2.45 (d, 3H, $J_{PH}$ 10.4 Hz), 3.07 (dd, 1H, $J_{HH}$ 14.8, $J_{HH}$ 7.7 Hz), 3.15 (dd, 1H, $J_{PH}$ $\approx J_{HH}$ 7.7 Hz), 3.60 (s, 3H), 5.17 (c, 1H, $J_{PH}$ $\approx J_{HH}$ 7.7 Hz), 7.63-6.95 (m, 11H, ArH), 7.81 (m, 4H, ArH).

\textbf{13C NMR} $\delta$ 28.72 (d, CH$_3$, $J_{PC}$ 3.7 Hz), 36.80 (d, CH$_2$, $J_{PC}$ 2.9 Hz), 51.75 (OCH$_3$), 55.17 (d, CH, $J_{PC}$ 3.3 Hz), 127.59 (CAr), 127.77 (2CAr), 128.40 (2CAr), 128.46 (d, 4CAr, $J_{PC}$ 12.5 Hz), 131.71 (d, C$_{ipso}$, $J_{PC}$ 128.1 Hz), 131.78 (d, 2CAr, $J_{PC}$ 2.3 Hz), 131.85 (d, C$_{ipso}$, $J_{PC}$ 127.6 Hz), 132.36 (d, 2CAr, $J_{PC}$ 9.2 Hz), 132.43 (d, 2CAr, $J_{PC}$ 9.2 Hz), 138.76 (d, C$_{ipso}$, $J_{PC}$ 4.1 Hz), 171.22 (C=O).

\textbf{31P NMR} $\delta$ 32.32. MS (APCI-ES), m/z: 394 (M+1). Analysis: Calcd. (%) for C$_{23}$H$_{24}$NO$_3$P: C, 70.22, H, 6.15; N, 3.56. Found: C, 70.21; H, 6.16; N, 3.60.

Methyl (3R*)-3-[(benzyl)(diphenylphosphoryl)amino]-3-phenylpropanoate (11b).

Yield after chromatography (ethyl acetate:hexane 3:2) 25 % (0.028 g). Oil. \textbf{1H NMR} (300.13 MHz, CDCl$_3$): $\delta$ 2.84 (dd, 1H, $J_{HH}$ 16, $J_{HH}$ 10.7 Hz), 3.02 (dd, 1H, $J_{HH}$ 16, $J_{HH}$ 5 Hz), 3.42 (s, 3H), 3.85 (dd, 1H, $J_{HH}$ 16, $J_{PH}$ 11.5 Hz), 4.24 (dd, 1H, $J_{HH}$ 16, $J_{PH}$ 10.6 Hz), 5.11 (ddd, 1H, $J_{PH}$ $\approx J_{HH}$ 10.7, $J_{HH}$ 5 Hz), 7.60-7.07 (m, 16H, ArH), 7.84 (m, 2H, ArH), 7.96 (m, 2H, ArH).

\textbf{13C NMR} $\delta$ 39.11 (d, CH$_2$, $J_{PC}$ 1.6 Hz), 48.21 (d, CH$_2$, $J_{PC}$ 4.1 Hz), 51.39 (OCH$_3$), 56.79 (d, CH, $J_{PC}$ 4.1 Hz), 128.63-127.17 (14CAr), 131.73 (d, C, $J_{PC}$ 2.8 Hz), 131.83 (d, C$_{ipso}$, $J_{PC}$ 126.7 Hz), 131.89 (d, C, $J_{PC}$ 2.8 Hz), 132.07 (d, C$_{ipso}$, $J_{PC}$ 127.2 Hz), 132.53 (d, 2CAr, $J_{PC}$ 9.2 Hz), 132.60 (d, 2CAr, $J_{PC}$ 9.7 Hz), 138.11 (d, C$_{ipso}$, $J_{PC}$ 4.6 Hz), 138.84 (d, C$_{ipso}$, $J_{PC}$ 3.2 Hz), 171.01 (C=O).

\textbf{31P NMR} $\delta$ 33.09. MS (APCI-ES), m/z: 470 (M+1). Analysis: Calcd. (%) for C$_{28}$H$_{26}$NO$_3$P: C, 74.19, H, 6.01; N, 2.98. Found: C, 74.21; H, 6.09; N, 3.00.


Yield after chromatography (ethyl acetate:hexane 1:4) 70 % (0.105 g). Oil. \textbf{1H NMR} (300.13 MHz, CDCl$_3$): $\delta$ 0.08 (s, 9H), 2.71 (d, 3H, $J_{PH}$ 9.9 Hz), 4.16 (d, 1H, $J_{PH}$ 10.4 Hz), 7.55-7.08 (m, 11H, ArH), 7.75 (m, 4H, ArH).

\textbf{13C NMR} $\delta$ -6.46 (3CH$_3$), 37.16 (d, CH$_3$, $J_{PC}$ 7.4 Hz, C-6), 55.51 (d,
Yield after chromatography (ethyl acetate:hexane 1:3) 86 % (0.121 g). Mp: 157-159 ºC. 

**1H NMR** (300.13 MHz, CDCl 3): δ 0.05 (s, 9H), 3.67 (d, 1H, 3JHH 16.1 Hz), 3.97 (dd, 1H, 2JHH 15, 3JPH 7.1 Hz), 4.31 (dd, 1H, 2JHH 15, 3JPH 9.4 Hz), 7.55-6.86 (m, 16H, ArH), 7.75 (m, 4H, ArH). 

**13C NMR** δ -5.37 (3CH 3), 49.77 (d, CH, 2JPC 8.6 Hz), 50.79 (d, CH2, 2JPC 9.6 Hz), 128.52-125.29 (14CAr), 131.81 (d, 2CAr, 3JPH 9.4 Hz), 132.14 (d, 2CAr, 2JPC 10.3 Hz), 132.35 (d, 2CAr, 2JPC 9.7 Hz), 133.07 (d, Cipso, 1JPC 119.6 Hz), 133.69 (d, Cipso, 1JPC 123.9 Hz), 136.56 (d, Cipso, 3JPC 3.6 Hz), 142.72 (Cipso).


**P,P-diphenyl-N-[(R*)]-phenyl(trimethylstannyl)methyl|phosphinic amide (12b).**

**N-benzyl-P,P-diphenyl-N-[(R*)]-phenyl(trimethylstannyl)methyl|phosphinic amide (12b).**

Yield after chromatography (ethyl acetate:hexane 1:3) 86 % (0.121 g). Mp: 157-159 ºC. 

**1H NMR** (300.13 MHz, CDCl 3): δ 0.05 (s, 9H), 3.67 (d, 1H, 3JPH 16.1 Hz), 3.97 (dd, 1H, 2JHH 15, 3JPH 7.1 Hz), 4.31 (dd, 1H, 2JHH 15, 3JPH 9.4 Hz), 7.55-6.86 (m, 16H, ArH), 7.75 (m, 4H, ArH). 

**13C NMR** δ -5.37 (3CH 3), 49.77 (d, CH, 2JPC 8.6 Hz), 50.79 (d, CH2, 2JPC 9.6 Hz), 128.52-125.29 (14CAr), 131.81 (d, 2CAr, 3JPH 9.4 Hz), 132.14 (d, 2CAr, 2JPC 10.3 Hz), 132.35 (d, 2CAr, 2JPC 9.7 Hz), 133.07 (d, Cipso, 1JPC 119.6 Hz), 133.69 (d, Cipso, 1JPC 123.9 Hz), 136.56 (d, Cipso, 3JPC 3.6 Hz), 142.72 (Cipso).

**31P NMR** δ 33.09. MS (APCI-ES), m/z: 546 (M-15). Analysis: Calcd. (%) for C29H32NOPSn: C, 62.17, H, 5.76; N, 2.50. Found: C, 62.16; H, 5.77; N, 2.55. 57.04; H, 5.85; N, 2.92.

**P,P-diphenyl-N-[(1R)-1-phenylethyl]-N-[(1S)-1-phenylethyl]-phosphinic amide (13).**

Yield after chromatography (ethyl acetate:hexane 1:4) 71 % (0.073 g). Oil. 

**1H NMR** (300.13 MHz, CDCl 3): δ 1.42 (d, 3H, 3JHH 7 Hz), 4.61 (d, 1H, 3JPH 7 Hz), 7.47-7.16 (m, 8H, ArH), 7.76 (m, 2H, ArH). 

**13C NMR** δ 20.16 (d, CH3, 3JPC 4.1 Hz), 54.39 (d, CH, 2JPC 3.7 Hz), 126.79 (CAr), 127.84 (d, 2CAr, 3JPC 12.8 Hz), 127.97 (2CAr), 128.08 (2CAr), 130.97 (d, CAr, 4JPC 2.9 Hz), 132.60 (d, 2CAr, 2JPC 9.5 Hz), 133.33 (d, Cipso, 1JPC 127.5 Hz), 142.63 (Cipso). 

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\text{N-[(1S,2R)-2-hydroxy-1,2-diphenylethyl]-P,P-diphenyl-N-[(1S)-phenylethyl]-phosphinic amide (14).}
\]

Yield after chromatography (ethyl acetate:hexane 3:1) 76 % (0.095 g). mp: 73 °C. \([\alpha]_{D}^{24} = -55.7 \text{ (c = 3.2, CHCl}_3\). \[^1H\text{ NMR (300.13 MHz, CDCl}_3\): } \delta \text{ 1.38 (d, 3H, } 3^J_{HH} 6.9 \text{ Hz)}, 1.75 \text{ (bs, OH), 4.48 (dd, 1H, } 3^J_{PH} 20.8, 3^J_{HH} 0.7 \text{ Hz), 4.75 (dc, 1H, } 3^J_{PH} 10.7, 3^J_{HH} 6.9 \text{ Hz), 5.02 (d, 1H, } 3^J_{HH} 0.7 \text{ Hz), 6.47 (m, 2H, ArH), 7.65-6.91. (m, 21H, ArH).} \]

\[^{13}C\text{ NMR } \delta \text{ 18.98 (d, CH}_3\text{, } 3^J_{PC} 2.2 \text{ Hz), 56.50 (d, CH, } 2^J_{PC} 7.3 \text{ Hz), 69.25 (d, CH, } 2^J_{PC} 2.2 \text{ Hz), 77.11 (d, CH, } 3^J_{PC} 1.7 \text{ Hz), 128.73-126.28 (17CAr), 131.14 (2CAr), 131.70 (d, CAr, } 4^J_{PC} 2.9 \text{ Hz), 132.21 (d, CAr, } 4^J_{PC} 2.9 \text{ Hz), 132.23 (d, C}_\text{ipso}, 1^J_{PC} 126.0 \text{ Hz), 132.46 (d, 2CAr, } 2^J_{PC} 9.5 \text{ Hz), 132.59 (d, 2CAr, } 2^J_{PC} 10.9 \text{ Hz), 132.95 (d, C}_\text{ipso}, 1^J_{PC} 124.4 \text{ Hz), 137.78 (C}_\text{ipso}, 140.73 (d, C}_\text{ipso}, 3^J_{PC} 3.3 \text{ Hz), 142.34 (C}_\text{ipso}.} \]

\[^{31}P\text{ NMR } \delta \text{ 38.35. MS (APCI-ES), m/z: 518 (M+1). Analysis: Calcd. (%) for C}_{34}\text{H}_{32}\text{NO}_2\text{P: C, 78.90, H, 6.23; N, 2.71. Found: C, 78.88; H, 6.25; N, 2.76.} \]

\[
\text{N-[(1S,2S)-2-hydroxy-1,2-diphenylethyl]-P,P-diphenyl-N-[(1S)-phenylethyl]-phosphinic amide (14').}
\]

Yield after chromatography (ethyl acetate:hexane 3:1) 4 % (0.005 g). Oil. \[^1H\text{ NMR (300.13 MHz, CDCl}_3\): } \delta \text{ 1.25 (d, 3H, } 3^J_{HH} 7.2 \text{ Hz), 4.71 (dd, 1H, } 3^J_{PH} 14, 3^J_{HH} 9.8 \text{ Hz), 4.94 (dc, 1H, } 2^J_{PH} 14.4, 3^J_{HH} 7.2 \text{ Hz), 5.41 (d, 1H, } 3^J_{HH} 9.8 \text{ Hz), 6.10 (bs, OH), 7.55-6.91. (m, 23H, ArH), 7.83 (m, 2H, ArH).} \]

\[^{13}C\text{ NMR } \delta \text{ 20.99 (CH}_3\text{), 55.29 (d, CH, } 2^J_{PC} 1.5 \text{ Hz), 68.60 (d, CH, } 2^J_{PC} 3.3 \text{ Hz), 74.21 (CH), 128.42-126.95 (17CAr), 130.11 (2CAr), 133.01-132 (2CAr), 131.47 (d, CAr, } 4^J_{PC} 3.1 \text{ Hz), 132.16 (d, CAr, } 4^J_{PC} 2.6 \text{ Hz), 132.30 (d, 2CAr, } 2^J_{PC} 9.5 \text{ Hz), 132.84 (d, 2CAr, } 2^J_{PC} 10.6 \text{ Hz), 139.19 (C}_\text{ipso}, 142.21 (d, C}_\text{ipso}, 3^J_{PC} 5.8 \text{ Hz), 146.20 (C}_\text{ipso}.} \]

\[^{31}P\text{ NMR } \delta \text{ 34.76. MS (APCI-ES), m/z: 518 (M+1). Analysis: Calcd. (%) for C}_{34}\text{H}_{32}\text{NO}_2\text{P: C, 78.90, H, 6.23; N, 2.71. Found: C, 78.89; H, 6.24; N, 2.74.} \]

\[
\text{N-[(1S,2R)-2-hydroxy-3,3-dimethyl-1-phenylbutyl]-P,P-diphenyl-N-[(1S)-1-phenylethyl] phosphinic amide (15).}
\]

S16
Yield 95 % (0.115 g). Mp: 160-162 °C. [α]D²⁷ = -13.1 (c = 1, CHCl₃). ¹H NMR (300.13 MHz, CDCl₃): δ 0.40 (s, 9H), 1.49 (d, 3H, 3JHH 7.1 Hz), 3.49 (dd, 1H, 3JHH 1.2 Hz), 4.54 (dd, 1H, 3JPH 20.5, 3JHH 1.2 Hz), 4.69 (dc, 3H, 3JPH 11.2, 3JHH 7.1 Hz), 6.89 (d, 1H, 3JHH 2 Hz), 7.60-7.07 (m, 18H, ArH), 7.91 (m, 2H, ArH). ¹³C NMR δ 18.81 (CH₃), 27.02 (CH₃), 35.05 (C), 56.69 (d, CH, 2JPC 7.8 Hz), 62.90 (CH), 82.14 (CH), 128.60-127.10 (12CAr), 131.13 (d, CAr, 4JPC 3 Hz), 131.94 (d, 2CAr, 4JPC 9.7 Hz), 132.40 (d, CAr, 4JPC 10.6 Hz), 132.78 (d, 2CAr, 4JPC 10.6 Hz), 139.46 (Cipso), 140.76 (Cipso), 142.33 (Cipso). ³¹P NMR δ 37.74. MS (APCI-ES), m/z: 498 (M+1). Analysis: Calcd. (%) for C₃₂H₃₆NO₂P: C, 77.24, H, 7.29; N, 2.81. Found: C, 77.25; H, 7.28; N, 2.85.

N-[(1S,2R)-2-hydroxy-1,4-diphenylbutyl]-P,P-diphenyl-N-[(1S)-1-phenylethyl]phosphinic amide (16).

Yield after chromatography (ethyl acetate:hexane 1:2) 81 % (0.107 g). Oil. [α]D²⁵ = -14.3 (c = 1.1, CHCl₃). ¹H NMR (300.13 MHz, CDCl₃): δ 1.31 (m, 1H), 1.37 (d, 3H, 3JHH 7 Hz), 1.57 (m, 1H), 2.38 (ddd, 1H, 2JHH 14.1, 3JHH 9.3, 3JHH 7.3 Hz), 2.56 (ddd, 1H, 2JHH 14.1, 3JHH 9.5, 3JHH 5.3 Hz), 3.85 (dd, 1H, 3JHH 9.5, 3JHH 4.1 Hz), 4.34 (d, 1H, 3JPH 20.2 Hz), 4.66 (dc, 1H, 3JPH 10.8, 3JHH 7 Hz), 7.71-6.98 (m, 21H, ArH), 7.81 (m, 2H, ArH). ¹³C NMR δ 20.00 (d, CH₃, 2JPC 2.9 Hz), 32.40 (CH₂), 37.00 (CH₂), 56.84 (d, CH, 2JPC 7.5 Hz), 66.84 (d, CH, 2JPC 6.7 Hz), 73.30 (d, CH, 3JPC 1.9 Hz), 128.56-125.53 (17CAr), 130.72 (CAr), 131.74 (d, CAr, 4JPC 2.8 Hz), 131.97 (d, CAr, 4JPC 2.8 Hz), 132.26 (d, 2CAr, 2JPC 9.7 Hz), 132.40 (d, Cipso, 1JPC 127.1 Hz), 132.49 (d, 2CAr, 2JPC 10.6 Hz), 132.78 (d, Cipso, 1JPC 123.5 Hz), 139.46 (Cipso), 140.76 (d, Cipso, 3JPC 2.6 Hz), 142.33 (Cipso). ³¹P NMR δ 37.74. MS (APCI-ES), m/z: 546 (M+1). Analysis: Calcd. (%) for C₃₆H₃₆NO₂P: C, 79.24, H, 6.65; N, 2.57. Found: C, 79.23; H, 6.66; N, 2.61.

N-[(1S,2S)-2-hydroxy-1,4-diphenylbutyl]-P,P-diphenyl-N-[(1S)-1-phenylethyl]phosphinic amide (16').

Yield after chromatography (ethyl acetate:hexane 1:2) 6 % (0.008 g). Oil. ¹H NMR (300.13 MHz, CDCl₃): δ 1.31 (d, 3H, 3JHH 7 Hz), 1.47 (m, 2H), 2.71 (m, 1H), 2.82 (m, 1H), 4.44 (d, 1H, 3JPH 8.1 Hz), 4.45 (m, 1H), 4.85 (dc, 1H, 3JPH 11, 3JHH 7 Hz), 7.92-7.00 (m, 25H, ArH). ¹³C NMR δ 20.95 (CH₃), 31.68 (CH₂), 36.64 (CH₂), 58.39 (CH), 67.32 (d, CH, 2JPC 4.4 Hz), 79.35 (CH), 133.29-125.53 (27CAr), 140.36 (Cipso), 142.53 (Cipso), 142.55 (d, Cipso, 3JPC 3.6 Hz). ³¹P NMR δ: 34.59. MS
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(APCI-ES), m/z: 546 (M+1). Analysis: Calcd. (%) for C\textsubscript{38}H\textsubscript{36}NO\textsubscript{2}P: C, 79.24, H, 6.65; N, 2.57. Found: C, 79.22; H, 6.67; N, 2.62.

\[
N\-\{(1\text{S},2\text{R})\-2\text{hydroxy}-1\-\text{phenylbut-3-en-1-yl})\-P,\text{P}\-\text{diphenyl-N-}\[
\{1\text{S})\-1\-\text{phenylethyl}\}\text{phosphinic amide (17).}
\]

Yield after chromatography (ethyl acetate:hexane 2:1) 78 % (0.088 g). Oil. \([\alpha]\)\textsubscript{D}\textsubscript{25} = -3.4 (c = 1, CHCl\textsubscript{3}). \(\text{1H NMR}\) (300.13 MHz, CDCl\textsubscript{3}): \(\delta\) 1.50 (d, 3H, \(3\text{J}_{\text{HH}}\) 6.8 Hz), 1.69 (bs, OH), 4.19 (dc, 1H, \(3\text{J}_{\text{HH}}\) 6.1, \(3\text{J}_{\text{HH}}\) = 1.5, \(3\text{J}_{\text{HH}}\) = \(4\text{J}_{\text{HH}}\) 1.4 Hz), 4.41 (dd, 1H, \(3\text{J}_{\text{PH}}\) 20.8, \(3\text{J}_{\text{HH}}\) 1.4 Hz), 4.72 (dc, 1H, \(3\text{J}_{\text{PH}}\) 10.8, \(3\text{J}_{\text{HH}}\) 6.8 Hz), 4.73 (dt, 1H, \(3\text{J}_{\text{HH}}\) 16.8, \(2\text{J}_{\text{HH}}\) 1.4, \(4\text{J}_{\text{HH}}\) 1.4 Hz), 4.83 (dt, 1H, \(3\text{J}_{\text{HH}}\) 10.5, \(2\text{J}_{\text{HH}}\) 1.4, \(4\text{J}_{\text{HH}}\) 1.4 Hz), 5.44 (ddd, 1H, \(3\text{J}_{\text{HH}}\) 16.8, \(3\text{J}_{\text{HH}}\) 10.5, \(3\text{J}_{\text{HH}}\) 6.2 Hz), 7.63-7.18 (m, 18H, ArH), 7.92 (m, 2H, ArH).

\(\text{13C NMR}\) \(\delta\) 19.59 (d, CH\textsubscript{3}, \(3\text{J}_{\text{PC}}\) 2.9 Hz), 56.65 (d, CH, \(2\text{J}_{\text{PC}}\) 7.0 Hz), 66.54 (d, CH, \(2\text{J}_{\text{PC}}\) 2.5 Hz), 75.82 (d, CH, \(3\text{J}_{\text{PC}}\) 1.6 Hz), 115.14 (=CH\textsubscript{2}), 128.65-127.08 (12CAr), 130.85 (2CAr), 131.40 (d, CAr, \(4\text{J}_{\text{PC}}\) 3.0 Hz), 132.06 (d, CAr, \(4\text{J}_{\text{PC}}\) 2.5 Hz), 132.11 (d, C\textsubscript{ipso}, \(1\text{J}_{\text{PC}}\) 126.6 Hz), 132.29 (d, 2CAr, \(2\text{J}_{\text{PC}}\) 9.5 Hz), 132.35 (d, 2CAr, \(2\text{J}_{\text{PC}}\) 10.3 Hz), 132.79 (d, C\textsubscript{ipso}, \(1\text{J}_{\text{PC}}\) 124.2 Hz), 138.32 (C\textsubscript{ipso}), 138.69 (=CH), 140.73 (C\textsubscript{ipso}). \(\text{31P NMR}\) \(\delta\) 34.68. MS (APCI-ES), m/z: 468 (M+1). Analysis: Calcd. (%) for C\textsubscript{30}H\textsubscript{30}NO\textsubscript{2}P: C, 77.07, H, 6.47; N, 3.00. Found: C, 77.05; H, 6.49; N, 3.03.

\[
N\-\{(1\text{S},2\text{S})\-2\text{hydroxy}-1\-\text{phenylbut-3-en-1-yl})\-P,\text{P}\-\text{diphenyl-N-}\[
\{1\text{S})\-1\-\text{phenylethyl}\}\text{phosphinic amide (17').}
\]

Yield after chromatography (ethyl acetate:hexane 2:1) 4 % (0.004 g). Oil. \([\alpha]\)\textsubscript{D}\textsubscript{25} = -3.4 (c = 1, CHCl\textsubscript{3}). \(\text{1H NMR}\) (300.13 MHz, CDCl\textsubscript{3}): \(\delta\) 1.18 (d, 3H, \(3\text{J}_{\text{HH}}\) 6.5 Hz), 4.42 (t, 1H, \(3\text{J}_{\text{PH}}\) 10, \(3\text{J}_{\text{HH}}\) 10 Hz), 4.97 (m, 1H), 4.94 (dc, 1H, \(3\text{J}_{\text{PH}}\) 9.9, \(3\text{J}_{\text{HH}}\) 6.5 Hz), 4.96 (dt, 1H, \(3\text{J}_{\text{HH}}\) 17, \(2\text{J}_{\text{HH}}\) 1.4, \(4\text{J}_{\text{HH}}\) 1.4 Hz), 5.37 (dt, 1H, \(3\text{J}_{\text{HH}}\) 10.5, \(2\text{J}_{\text{HH}}\) 1.4, \(4\text{J}_{\text{HH}}\) 1.4 Hz), 5.51 (ddd, 1H, \(3\text{J}_{\text{HH}}\) 17, \(3\text{J}_{\text{HH}}\) 10.5, \(3\text{J}_{\text{HH}}\) 5.8 Hz), 7.63-7.18 (m, 18H, ArH), 7.96 (m, 2H, ArH). \(\text{13C NMR}\) \(\delta\) 20.59 (CH\textsubscript{3}), 53.57 (d, CH, \(2\text{J}_{\text{PC}}\) 4.3 Hz), 67.22 (d, CH, \(2\text{J}_{\text{PC}}\) 4.3 Hz), 71.42 (CH), 116.55 (=CH\textsubscript{2}), 128.68-126.62 (12CAr), 130.06 (2CAr), 131.07 (d, CAr, \(4\text{J}_{\text{PC}}\) 3.1 Hz), 131.10 (d, CAr, \(4\text{J}_{\text{PC}}\) 3.9 Hz), 132.55 (d, 2CAr, \(2\text{J}_{\text{PC}}\) 10.5 Hz), 132.67 (d, 2CAr, \(2\text{J}_{\text{PC}}\) 9.7 Hz), 133.65-131.56 (2CAr), 138.06 (=CH), 138.77 (C\textsubscript{ipso}), 142.22 (C-18) (C\textsubscript{ipso}). \(\text{31P NMR}\) \(\delta\) 34.68. MS (APCI-ES), m/z: 468 (M+1). Analysis: Calcd. (%) for C\textsubscript{30}H\textsubscript{30}NO\textsubscript{2}P: C, 77.07, H, 6.47; N, 3.00. Found: C, 77.05; H, 6.49; N, 3.02.
Methyl (2S)-2-{(diphenylphosphoryl)[(1S)-1-phenylethyl]amino}(phenyl)acetate (18).

Yield after chromatography (ethyl acetate:hexane 2:1) 60 % (0.068 g). Oil. $[\alpha]_	ext{D}^{25} = -14 \ (c = 0.8, \ \text{CHCl}_3)$. $^1\text{H NMR}$ (300.13 MHz, CDCl$_3$): $\delta$ 1.51 (d, 3H, $^3J_{HH}$ 7 Hz), 3.47 (s, 3H), 4.88 (dc, 1H, $^3J_{PH}$ 14.2, $^3J_{HH}$ 7 Hz), 5.28 (d, 1H, $^3J_{PH}$ 14.5 Hz), 7.55-7.15 (m, 16H, Ar H), 7.67 (m, 2H, ArH), 7.92 (m, 2H, ArH). $^{13}\text{C NMR}$ $\delta$ 19.49 (d, CH$_3$, $^3J_{PC}$ 2 Hz), 51.61 (OCH$_3$), 55.41 (d, CH, $^2J_{PC}$ 3.5 Hz), 62.01 (d, CH, $^2J_{PC}$ 4 Hz), 128.59-126.68 (12CAr), 129.21 (2CAr), 130.70 (d, CAr, $^4J_{PC}$ 2.7 Hz), 131.39 (d, CAr, $^4J_{PC}$ 2.3 Hz), 132.71-131.42 (2CAr), 132.72 (d, 2CAr, $^2J_{PC}$ 9.8 Hz), 132.90 (d, 2CAr, $^2J_{PC}$ 9.5 Hz), 135.90 (d, C$_\text{ipso}$, $^3J_{PC}$ 2 Hz), 140.01 (d, C$_\text{ipso}$, $^3J_{PC}$ 3 Hz), 172.31 (d, C=O, $^3J_{PC}$ 4.1 Hz).

$^{31}\text{P NMR}$ $\delta$ 28.92. MS (APCI-ES), m/z: 470 (M$^+$1). Analysis: Calcd. (%) for C$_{28}$H$_{28}$NOP: C, 74.19, H, 6.01; N, 2.98. Found: C, 74.09; H, 6.10; N, 2.93.

Methyl (4R)-4-{(diphenylphosphoryl)[(1S)-1-phenylethyl]amino}-4-phenylbutanoate (19).

Yield after chromatography (ethyl acetate:hexane 2:1) 74 % (0.089 g). Oil. $[\alpha]_	ext{D}^{25} = -6.5 \ (c = 1, \ \text{CHCl}_3)$. $^1\text{H NMR}$ (300.13 MHz, CDCl$_3$): $\delta$ 1.30 (d, 3H, $^3J_{HH}$ 7.1 Hz), 1.77 (ddd, 1H, $^2J_{HH}$ 16, $^3J_{HH}$ 9.4, $^3J_{HH}$ 6.8 Hz), 1.95 (ddd, 1H, $^2J_{HH}$ 16, $^3J_{HH}$ 9.7, $^3J_{HH}$ 4.7 Hz), 2.16 (m, 1H), 2.64 (m, 1H), 3.51 (s, 3H), 4.37 (ddd, 1H, $^3J_{PH}$ 15.2, $^3J_{HH}$ 12, $^3J_{HH}$ 4.1 Hz), 4.60 (dc, 1H, $^3J_{PH}$ 16.6, $^3J_{HH}$ 7.1 Hz), 7.45-7.21 (m, 16H, Ar H), 7.75 (m, 4H, ArH). $^{13}\text{C NMR}$ $\delta$ 20.36 (d, CH$_3$, $^3J_{PC}$ 3.6 Hz), 29.65 (d, CH$_2$, $^3J_{PC}$ 3.6 Hz), 31.77 (CH$_2$), 51.38 (OCH$_3$), 54.86 (d, CH, $^2J_{PC}$ 3.7 Hz), 59.90 (d, CH, $^2J_{PC}$ 3.6 Hz), 128.52-126.82 (12CAr), 129.23 (2CAr), 131.08 (d, CAr, $^4J_{PC}$ 3 Hz), 131.13 (d, CAr, $^4J_{PC}$ 3 Hz), 132.43 (d, 2CAr, $^2J_{PC}$ 9.5 Hz), 132.60 (d, 2CAr, $^2J_{PC}$ 9.5 Hz), 133.27 (d, C$_\text{ipso}$, $^1J_{PC}$ 125.4 Hz), 133.74 (d, C$_\text{ipso}$, $^1J_{PC}$ 127.8 Hz), 139.32 (d, C$_\text{ipso}$, $^3J_{PC}$ 1.8 Hz), 142.62 (d, C$_\text{ipso}$, $^3J_{PC}$ 1.8 Hz), 173.04 (C=O). $^{31}\text{P NMR}$ $\delta$ 29.89. MS (APCI-ES), m/z: 498 (M+1). Analysis: Calcd. (%) for C$_{28}$H$_{28}$NOP: C, 74.19, H, 6.01; N, 2.98. Found: C, 74.49; H, 6.39; N, 2.86.

Yield after chromatography (ethyl acetate:hexane 1:25) 35 % (0.049 g). Oil. \([\alpha]_D^{23} = -85\) (c = 2.9, CHCl3).

\[^1H\,\text{NMR}\, (300.13\,\text{MHz, CDCl}_3): \delta\,0.02\,\text{(s, 9H)}, 1.09\,\text{(d, 3H, }^{3}J_{HH}\,7.1\,\text{Hz), 3.98\,\text{(d, 1H, }^{3}J_{PH}\,17.1\,\text{Hz}), 4.72\,\text{(dc, 1H, }^{3}J_{PH}\,9.7, \,^{3}J_{HH}\,7.1\,\text{Hz), 7.65-7.03\,\text{(m, 18H, ArH), 7.94\,\text{(m, 2H, ArH).}}}

\[^{13}C\,\text{NMR}\, \delta\,-5.03\,\text{(d, 3CH}_3\), 18.89\,\text{(CH}_3\), 48.88\,\text{(d, CH, }^{3}J_{PC}\,7.9\,\text{Hz), 57.33\,\text{(d, CH, }^{4}J_{PC}\,8.5\,\text{Hz), 128.28-124.40\,\text{(14CAr), 131.55\,\text{(d, CAr, }^{4}J_{PC}\,2.6\,\text{Hz), 131.65\,\text{(d, CAr, }^{4}J_{PC}\,2.8\,\text{Hz), 132.51\,\text{(d, 2CAr, }^{2}J_{PC}\,10.2\,\text{Hz), 132.99\,\text{(d, 2CAr, }^{2}J_{PC}\,10.2\,\text{Hz), 133.67\,\text{(d, }^{1}J_{PC}\,133.1\,\text{Hz), 133.80\,\text{(d, }^{1}J_{PC}\,136.2\,\text{Hz), 141.63\,\text{(d, }^{3}J_{PC}\,4.2\,\text{Hz), 144.28\,\text{(C}_\text{ipso).}}}

\[^{31}P\,\text{NMR}\, \delta\,35.46.\,\text{MS (APCI-ES), }m/z: 560\,(M-15).\,\text{Analysis: Calcd. (\%) for }C_{30}H_{34}NOPSn:\,C,\,62.74;\,H,\,5.97;\,N,\,2.44.\,\text{Found: }C,\,62.79;\,H,\,6.04;\,N,\,2.36.

\[P,P\text{-diphenyl-N-[(1S)-1-phenylethyl]-N-[(S)-phenyl(trimethylstannyl)methyl]phosphinic amide (21).}\]

Yield after chromatography (ethyl acetate:hexane 1:25) 34 % (0.047 g). Oil. \([\alpha]_D^{25} = +17.8\) (c = 2, CHCl3).

\[^1H\,\text{NMR}\, (300.13\,\text{MHz, CDCl}_3): \delta\,0.02\,\text{(s, 9H), 1.45\,\text{(d, 3H, }^{3}J_{HH}\,7.0\,\text{Hz), 4.62\,\text{(d, 1H, }^{3}J_{PH}\,15.7\,\text{Hz), 4.72\,\text{(dc, 1H, }^{3}J_{PH}\,10.0, \,^{3}J_{HH}\,7.0\,\text{Hz), 7.57-6.77\,\text{(m, 16H, ArH), 7.72\,\text{(m, 2H, ArH),}}}

\[^{13}C\,\text{NMR}\, \delta\,-5.02\,\text{(3CH}_3\), 18.89\,\text{(CH}_3\), 48.88\,\text{(d, CH, }^{2}J_{PC}\,7.9\,\text{Hz), 57.33\,\text{(d, CH, }^{3}J_{PC}\,8.5\,\text{Hz), 128.28-124.40\,\text{(14CAr), 131.55\,\text{(d, CAr, }^{4}J_{PC}\,2.6\,\text{Hz), 131.65\,\text{(d, CAr, }^{4}J_{PC}\,2.8\,\text{Hz), 132.51\,\text{(d, 2CAr, }^{2}J_{PC}\,10.2\,\text{Hz), 132.99\,\text{(d, 2CAr, }^{2}J_{PC}\,10.2\,\text{Hz), 133.67\,(d, }^{1}J_{PC}\,133.1\,\text{Hz), 133.80\,\text{(d, }^{1}J_{PC}\,136.2\,\text{Hz), 141.63\,\text{(d, }^{3}J_{PC}\,4.2\,\text{Hz), 144.28\,(C}_\text{ipso).}}}

\[^{31}P\,\text{NMR}\, \delta\,35.28.\,\text{MS (APCI-ES), }m/z: 560\,(M-15).\,\text{Analysis: Calcd. (\%) for }C_{30}H_{34}NOPSn:\,C,\,62.74;\,H,\,5.97;\,N,\,2.44.\,\text{Found: }C,\,62.71;\,H,\,6.01;\,N,\,2.40.

**Transmetalation and electrophilic quench sequence of 20.**

To a solution of 20 (0.1 g, 0.174 mmol) in diethyl ether (0.1 M) at – 90 ºC was added s-BuLi (1.7 equiv). The reaction mixture was stirred for 10 min at the same temperature, and then pivalaldehyde (1.9 equiv) was added. After stirring 5 min the solution was quenched with MeOH, extracted with ethyl acetate (3 x 15 mL), and washed with 1N NaOH (2 x 15 mL). The organic layers were dried over Na2SO4 and concentrated in vacuo. 31P NMR spectrum of the crude showed complete conversion into 15.

**Preparation of N-benzyl-N-(1R*-)phenylethylamine 22.**

To a solution of 2b (0.3 x 10^-3 mol) in THF (0.1 mL), 0.2 mL of HCl (aq) conc. was added. After stirring for 30 min, the reaction mixture was diluted with H2O (10 mL) and extracted with ethyl acetate (3x15 mL). The combined organic layers were dried over Na2SO4, filtered and concentrated
to give diphenylphosphinic chloride that was recycled (yield 85%). Immediately after, the aqueous layer was treated with 5N NaOH until neutral pH, and then extracted with ethyl acetate (3x15 mL). The combined organic layers were dried over Na₂SO₄, filtered and concentrated in vacuo to afford amine 22, as a pale yellow oil.

![Amine 22](image)

Yield 96 % (0.060 g). ¹H NMR (300.13 MHz, CDCl₃): δ 1.41 (d, 3H, J₃H 6.5 Hz), 3.63 (d, 1H, J₂H 13.6 Hz), 3.71 (d, 1H, J₂H 13.6 Hz), 3.85 (c, 1H, J₃H 6.5 Hz), 7.33-7.46 (m, 10H, ArH). NMR data match those of the commercially available amine.

**Preparation of α, β and γ-amino acids 23, 24, 25 and 26**

To a solution of (10a, 11a, 9a or 19) (0.3 x 10⁻³ mol) in THF (0.1 mL), 0.2 mL of HCl (aq) conc. was added. After stirring for 30 min, the reaction mixture was diluted with H₂O (10 mL) and extracted with EtOAc (3x15 mL). The combined organic layers were dried over Na₂SO₄, filtered and concentrated to give diphenylphosphinic chloride that was recycled. Immediately after, the aqueous layer was treated with 5N NaOH until neutral pH and extracted with EtOAc (3x15 mL). The combined organic layers were dried over Na₂SO₄, filtered and concentrated in vacuo to afford the corresponding 23, 24, 25, or 26, as pale yellow oils.

![Amine 22](image)

Yield 90 % (0.044 g). ¹H NMR (300.13 MHz, D₂O): δ 2.50 (s, 3H), 4.40 (s, 1H), 7.30-7.48 (m, 5H, ArH). NMR data are in agreement with published data.

![Amine 22](image)

Yield 92 % (0.050 g). ¹H NMR (500.13 MHz, D₂O): δ 2.57 (s, 3H), 3.12 (dd, 1H, J₁H 16.8 Hz, J₃H 7.6 Hz), 3.26 (dd, 1H, J₁H 16.8 Hz, J₃H 6.8 Hz), 4.61 (t, 1H, J₁H 7.1 Hz), 7.49 (m, 5H, ArH). NMR data are in agreement with published data.
(4R*)-4-(methylamino)-4-phenylbutanoic acid (25).

Yield 96 % (0.056 g). \( ^1\)H NMR (300.13 MHz, CDCl\(_3\)): \( \delta \) 1.24 (m, 1H), 2.46-2.64 (m, 3H), 2.70 (s, 3H), 4.53 (t, 1H, \( ^3\)J\(_{HH} \) 6.9 Hz), 7.22 (m, 2H, ArH), 7.40 (m, 3H, ArH). \( ^{13}\)C NMR \( \delta \) 28.17 (CH\(_3\)), 28.41 (CH\(_2\)), 30.09 (CH\(_2\)), 64.59 (CH), 126.32 (2Car), 128.07 (Car), 129.06 (2Car), 141.17 (C\(_{ipso}\)), 175.57 (C=O). MS (APCI-ES), m/z: 194 (M+1), 176 (M-OH). Analysis: Calcd. (%) for C\(_{11}\)H\(_{15}\)NO\(_2\): C, 68.37, H, 7.82; N, 7.25. Found: C, 68.40; H, 7.90; N, 7.22.

H\(_2\)N
\[\begin{array}{c}
\text{HO} \\
\text{Cl}
\end{array}\]

(4R)-4-Amino-4-phenylbutyric acid hydrochloride (26).

Yields after work-up 92 % (0.059 g). \([\alpha]_D^{35} = -39.4 \ (c = 0.2, \text{CD}_3\text{OD}) \) [lit. \([\alpha]_D^{35} = +31.6 \ (c = 1.33)\) for the (S) isomer]. \( ^1\)H NMR (300.13 MHz, MeOD): \( \delta \) 2.20 (m, 1H), 2.28 (m, 2H), 2.38 (m, 1H), 4.38 (t, \( ^3\)J\(_{HH} \) 5.3 Hz), 7.49 (m, 5H, ArH). MS (APCI-ES), m/z: 180 (M+1), \text{CD}_3\text{OD}). NMR data are in agreement with published data.\(^{12}\)

Preparation of 1,2-aminoalcohols rac-27 and (1R,2S,3S)-28.

To a solution of the appropriate phosphinamide (6b or 15) (0.3 mmol) in THF (0.1 mL) LAH (0.8 mmol) at \(-10 \) °C was added. The reaction mixture was allowed to reach room temperature in 120 min. Then, the reaction was quenched with MeOH at \(-20 \) °C, filtered and concentrated in vacuo to afford 1,2-aminoalcohols 27 and 28.

(1S*,2R*)-1-(benzylamino)-3,3-dimethyl-1-phenylbutan-2-ol (27).

Yield after chromatography (ethyl acetate:hexane 1:4) 92 % (0.078 g). Oil. \( ^1\)H NMR (300.13 MHz, CDCl\(_3\)): \( \delta \) 0.78 (s, 9H), 3.64 (d, 1H, \( ^2\)J\(_{HH} \) 12.8 Hz), 3.67 (d, 1H, \( ^3\)J\(_{HH} \) 5.3 Hz), 3.69 (d, 1H, \( ^2\)J\(_{HH} \) 12.8 Hz), 3.83 (d, 1H, \( ^2\)J\(_{HH} \) 5.3 Hz), 7.23-7.48 (m, 10H, ArH). \( ^{13}\)C NMR \( \delta \) 26.56 (3CH\(_3\)), 34.51 (C), 51.17 (CH\(_2\)), 63.61 (CH), 80.53 (CH), 127.05 (Car), 127.58 (Car), 128.21 (2Car), 128.29 (2Car), 128.37 (2Car), 129.19 (2Car), 139.78 (C\(_{ipso}\)), 140.40 (C\(_{ipso}\)). MS (APCI-ES), m/z: 284 (M+1). Analysis: Calcd. (%) for C\(_{20}\)H\(_{27}\)NO: C, 80.52, H, 8.89; N, 4.94. Found: C, 80.57; H, 8.84; N, 4.90.
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(1S,2R)-3,3-dimethyl-1-phenyl-1-[(1S)-1-phenylethyl]amino]butan-2-ol (28).

Yield after chromatography (ethyl acetate:hexane 1:3) 92 % (0.082 g). Oil. [α]D

$^25 = +13 \ (c= 1.9, \ \text{CHCl}_3)$. $^1$H NMR (300.13 MHz, CDCl$_3$): δ 0.75 (s, 9H), 1.38 (d, 3H, $^3J_{HH} 6.4$ Hz), 3.66 (d, 1H, $^3J_{HH} 3.4$ Hz), 3.73 (d, 1H, $^3J_{HH} 3.4$ Hz), 3.80 (c, 1H, $^3J_{HH} 6.4$ Hz), 7.21-7.52 (m, 10H, ArH).

$^{13}$C NMR δ 23.19 (CH$_3$), 26.65 (CH$_3$), 34.29 (C), 54.58 (CH), 60.96 (CH), 79.41 (CH), 126.43 (2CAr), 127.02 (CAr), 127.43 (CAr), 128.26 (2CAr), 128.48 (2CAr), 129.04 (2CAr), 141.13 (C$_{ipso}$), 145.36 (C$_{ipso}$).

MS (APCI-ES), m/z: 298 (M+1). Analysis: Calcd. (%) for C$_{30}$H$_{30}$NO$_2$P: C, 80.76, H, 9.15; N, 4.71. Found: C, 80.80; H, 9.11; N, 4.74.

Preparation of 1,2-aminophosphinate rac-29.

To a stirring solution of 6b (0.3 mmol) in THF (5 mL) at −78 ºC, was added $n$-BuLi (0.3 mmol). Immediately after the solution was warmed up to −10 ºC and stirred at this temperature for 1h. The temperature of the solution was reduced down to −20 ºC, where was quenched with MeOH and allowed to reach room temperature. The solution was then diluted with CH$_2$Cl$_2$ (15 mL) and washed with H$_2$O (30 mL). The organic phase was separated and the aqueous layer extracted with CH$_2$Cl$_2$ (3x15 mL). The combined organic layers were dried over Na$_2$SO$_4$, filtered and concentrated in vacuo to afford diphenylphosphinate 29, as a pale yellow oil.

(1R$^*$)-1-[(S$^*$)-(benzylamino)(phenyl)methyl]-2,2-dimethylpropyl diphenylphosphinate (rac-29).

Yield after chromatography (ethyl acetate:hexane 1:3) 89 % (0.129 g). Oil. $^1$H NMR (300.13 MHz, CDCl$_3$): δ 0.71 (s, 9H), 2.94 (m, NH), 3.38 (dd, 1H, $^2J_{HH} 13.3$ Hz, $^3J_{HH} 7$ Hz), 3.62 (dd, 1H, $^2J_{HH} 13.3$ Hz, $^3J_{HH} 5.2$ Hz), 3.88 (d, 1H, $^3J_{HH} 9.5$ Hz), 4.58 (d, 1H, $^3J_{PH} 9.9$ Hz), 7.53-7.17 (m, 16H, ArH), 7.84 (m, 4H, ArH). $^{13}$C NMR δ 27.25 (3CH$_3$), 35.70 (d, C, $^2J_{PC} 5.3$ Hz), 50.59 (CH$_2$), 62.04 (CH), 88.81 (d, CH, $^2J_{PC}$ 9 Hz), 128.39-126.42 (12CAr), 129.74 (2CAr), 131.70 (d, 2CAr, $^2J_{PC}$ 9.9 Hz), 131.87 (d, CAr, $^4J_{PC}$ 2.9 Hz), 131.98 (d, CAr, $^4J_{PC}$ 2.5 Hz), 131.19 (d, C$_{ipso}$, $^1J_{PC}$ 132.8 Hz), 132.30 (d, 2CAr, $^2J_{PC}$ 10.3 Hz), 132.44 (d, C$_{ipso}$, $^1J_{PC}$ 117.2 Hz), 140.30 (C$_{ipso}$) 145.36 (C$_{ipso}$).

$^{31}$P NMR δ 32.64. MS (APCI-ES), m/z: 484 (M+1). Analysis: Calcd. (%) for C$_{36}$H$_{34}$NO$_2$P: C, 76.99, H, 7.09; N, 2.90. Found: C, 76.96; H, 7.12; N, 2.95.

References


(5) Sheldrick, G. M. SHELXL-97, Program for refinement of crystal structures, University of Göttingen, Germany, 1997.


Figure S1. $^1$H NMR (300.13 MHz) spectrum of 3b in CDCl$_3$. 
Figure S2. $^1$H, $^{13}$C 2D gHMOC NMR spectrum (300.13 MHz) of 3b in CDCl$_3$. 
Figure S3. $^1$H NMR (300.13 MHz) spectrum of of 14 in CDCl$_3$. 
Figure S4. $^{13}$C and DEPT135 NMR spectra of 14 in CDCl$_3$. 
Figure S5. NMR spectra of 20 in CDCl₃: A) ¹H (300.10 MHz), B) Selective 1D gNOESY, C) Selective 1D gNOESY.
Figure S6. NMR spectra of 21 in CDCl₃: A) $^1$H (300.10 MHz), B) Selective 1D gNOESY, C) Selective 1D gNOESY.
Figure S7. Selected NOE’s, (normalized to 100%) extracted from selective 1D gNOESY, highlighting their relative intensities. A) Compound 20, B) Compound 21.
**Figure S8.** A) $^{31}$P NMR spectrum (121.50 MHz) of 20 in CDCl$_3$. B) $^{31}$P NMR spectrum (121.50 MHz) of the crude resulting from the trasmetalation and electrophilic quench of 20.
Figure S9. A) $^{31}$P NMR spectrum (121.50 MHz) of (1$R$,2$S$,3$S$)-15 in CDCl$_3$. B) $^{31}$P NMR spectrum (121.50 MHz) of the crude resulting from the treatment of (1$R$,2$S$,3$S$)-15 with LAH.
Figure S10. $^1$H NMR (300.13 MHz) spectrum of (1R,2S,3S)-28 in CDCl$_3$. 
Figure S11. $^{13}$C and DEPT135 NMR spectra of ($1R,2S,3S$)-28 in CDCl$_3$. 
Figure S12. $^1$H NMR (500.13 MHz) spectrum of 24 in D$_2$O.
Figure S13. NMR spectra of 25 in CDCl3. A) 1H (500.13 MHz); B) 1D gTOCSY.
Figure S14. NMR spectra of 25 in CDCl₃: A) $^{13}$C (75.47 MHz), B) DEPT135.
Figure S15. $^1$H NMR (300.13 MHz) spectrum of $(R)$-26·HCl in CD$_3$OD.
Figure S16. $^{13}$C NMR (75.47 MHz) spectrum of (R)-26-HCl in CD$_3$OD.
Figure S17. DEPT135 (75.47 MHz) spectrum of (R)-26·HCl in CD$_3$OD.
Figure S18. HPLC chromatograms of (4R,5S)-19 and (rac)-19

Conditions: t = 0 min. 98 % hexane; t = 40 min. 95% hexane; t = 50 min. 95% hexane; t = 55 min. 98% hexane.
Table S1. Crystal data and structure refinement for 6b.

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Table S2. Hydrogen-bonding geometry for 6b (Å, °).

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$^a$Symmetry codes: (1) x, y, z ; (2) –x+1/2, +y-1/2, -z+1/2+1
Figure S19. ORTEP draw for 6b.
Table S3. Crystal data and structure refinement for 15.

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<th></th>
<th>Compound 15</th>
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<tr>
<td>CCDC [8]</td>
<td>665890</td>
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<tr>
<td>Empirical formula</td>
<td>C_{32}H_{36}NO_{2}P</td>
</tr>
<tr>
<td>Formula weigh</td>
<td>497.59</td>
</tr>
<tr>
<td>Crystal system</td>
<td>Monoclinic</td>
</tr>
<tr>
<td>Space group</td>
<td>P2_1</td>
</tr>
<tr>
<td>a (Å)</td>
<td>18.6667 (1)</td>
</tr>
<tr>
<td>b (Å)</td>
<td>8.2209 (1)</td>
</tr>
<tr>
<td>c (Å)</td>
<td>18.7079 (1)</td>
</tr>
<tr>
<td>α (°)</td>
<td>104.9002 (6)</td>
</tr>
<tr>
<td>V (Å³)</td>
<td>2774.33 (4)</td>
</tr>
<tr>
<td>Z</td>
<td>4</td>
</tr>
<tr>
<td>μ (mm⁻¹)</td>
<td>1.090</td>
</tr>
<tr>
<td>F(000)</td>
<td>1064</td>
</tr>
<tr>
<td>Temperature (K)</td>
<td>293 (2)</td>
</tr>
<tr>
<td>Wave length (Å)</td>
<td>1.54180</td>
</tr>
<tr>
<td>Reflection collected</td>
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</tr>
<tr>
<td>Unique reflection</td>
<td>20809</td>
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<td>R_{int}</td>
<td>0.0232</td>
</tr>
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<td>R_{I}[I&gt;σ(I)]</td>
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<td>wR² (all data)</td>
<td>0.0836</td>
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Table S4. Hydrogen-bonding geometry for 15 (Å, °).

<table>
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<tr>
<th>D-H···A</th>
<th>D-H (Å)</th>
<th>H···A (Å)</th>
<th>D···A (Å)</th>
<th>D-H···A (°)</th>
<th>Symmetry&lt;sup&gt;a&lt;/sup&gt;</th>
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<tbody>
<tr>
<td>O2-H30···O1</td>
<td>0.82</td>
<td>1.86</td>
<td>2.6476</td>
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<tr>
<td>O4-H40···O3</td>
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<td>1.84</td>
<td>2.6053</td>
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<tr>
<td>C8-H3···N1</td>
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<td>2.85</td>
<td>3.2242</td>
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<tr>
<td>C47-H8···N2</td>
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<td>2.97</td>
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<tr>
<td>C60-H13···O3</td>
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<tr>
<td>C6-H36···O1</td>
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<td>2.8460</td>
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<tr>
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<tr>
<td>C19-H55···O2</td>
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<td>2.73</td>
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<td>C20-H16B···O1</td>
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<td>3.3443</td>
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<sup>a</sup>Symmetry codes: (1) x, y, z ; (2) x, +y-1, +z ; (3) –x+1, +y-1/2, -z+1 ; (4) –x+1, +y-1/2, -z+2
Figure S20. ORTEP draw for one molecule of 15.
**Figure S21.** ORTEP draw for the asymmetric unit of 15.