

Electronic Supplementary Information- Part 1:**Amino Acid-Derived Hydroxamic Acids as Ligands in Vanadium Catalyzed Epoxidation.**

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Experimental

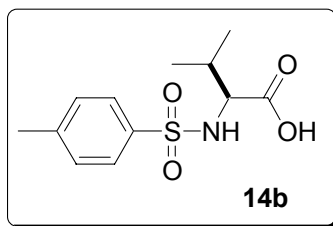
General Methods. Melting points were determined on a Kofler block and are uncorrected. Optical rotations were recorded in CHCl₃ at 25 °C unless otherwise indicated with an error of $<\pm 0.1$. The $[\alpha]_D$ values are given in 10^{-1} deg cm² g⁻¹. The NMR spectra were recorded in deuterated solvents as specified, ¹H at 400 MHz and ¹³C at 100.6 MHz. Various 2D-techniques and DEPT experiments were used to establish the structures and to assign the signals. The IR spectra were recorded for a thin film between KBr plates or for CHCl₃ solutions. The mass spectra (EI and/or CI) were measured on a dual sector mass spectrometer using direct inlet and the lowest temperature enabling evaporation. All reactions were performed under an atmosphere of dry, oxygen-free nitrogen in oven-dried glassware twice evacuated and filled with nitrogen. Solvents and solutions were transferred by syringe-septum and cannula techniques. All solvents for the reactions were of reagent grade and were dried and distilled immediately before use as follows: diethyl ether from lithium aluminum hydride; tetrahydrofuran from sodium/benzophenone; dichloromethane from calcium hydride, toluene from sodium. Petroleum ether refers to the fraction boiling in the range of 40-60 °C. Yields are given for isolated products showing one spot on a TLC plate and no impurities detectable in the NMR spectrum. The identity of the products prepared by different methods was checked by comparison of their NMR, IR and MS data and by TLC behavior.

Allylic alcohols **20**, **22**, **24**, **25** were purchased from Sigma-Aldrich and used as received. Allylic alcohols **26**,^{S1} **27**,^{S2} **28**,^{S3} **30**,^{S4} **31**,^{S5} **32**,^{S6} **33**^{S7} are known compounds and were prepared according to literature protocols.

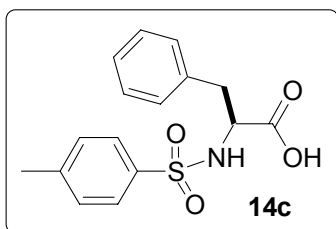
General procedure for synthesis of sulfonamide protected acids 14.

The reactions were performed on a 4-6 mmol scale. Solution of sulfonyl chloride **13** (1.2 equiv) in ether (12 mL) was added to a mechanically stirred solution of amino acid **12a-d** (1 equiv) and NaOH (2.5 equiv) in water (12 mL) at room temperature. The mixture was stirred for 16 h and then acidified to pH ~2 with 12M HCl to produce white precipitate. The precipitate was separated by filtration and washed with water. Crystallization from ether afforded acid **14** which was used in the next step without additional purification

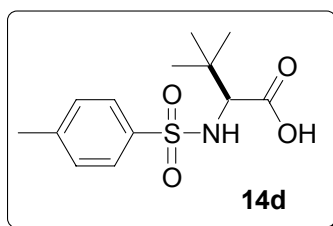
S(1) 2



N-toluenesulfonyl-L-valine (14b). Prepared from L-valine (703 mg, 6 mmol) and *p*-toluenesulfonyl chloride (1.372 g, 7.2 mmol). Crystallization from ether afforded the product as a white solid (1.26 g, 78%), which was used in the next step without further purification: ^1H NMR (400 MHz, methanol- d_4) δ 0.85 (d, $J = 6.9$ Hz, 3H), 0.90 (d, $J = 6.9$ Hz, 3H), 2.03 (m, 1H), 2.42 (s, 3H), 3.63 (d, $J = 7.5$ Hz, 1H), 7.34 (d, $J = 8.0$ Hz, 2H), 7.73 (d, $J = 8.0$ Hz, 2H).

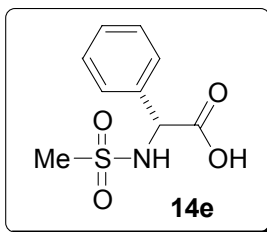


N-toluenesulfonyl-L-phenylalanine (14c). Prepared from L-phenylalanine (990 mg, 6 mmol) and *p*-toluenesulfonyl chloride (1.372 g, 7.2 mmol). Crystallization from hexane/ethyl-acetate afforded the product as a white solid (620 g, 32%), which was used in the next step without further purification: ^1H NMR (400 MHz, methanol- d_4) δ 2.35 (s, 3H), 2.99 (dd, $J = 14.8, 9.2$ Hz, 1H), 3.32 (dd, $J = 14.8, 4.0$ Hz, 1H), 3.77 (dd, $J = 9.2, 4.0$ Hz, 1H), 7.25-7.36 (m, 7H), 7.72 (d, $J = 8.0$ Hz, 2H).

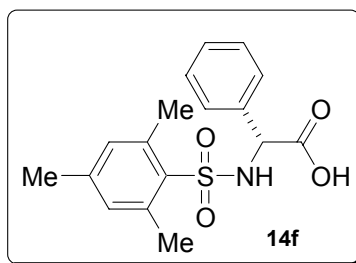


N-toluenesulfonyl-L-*t*-leucine (14d). Prepared from (*S*)-*tert*-leucine pentahydrate (1.327 g, 6 mmol) and *p*-toluenesulfonyl chloride (1.372 g, 7.2 mmol). Crystallization from ether afforded the product as a white solid (1.18 g, 69%), which was used in the next step without further purification: ^1H NMR (400 MHz, DMSO- d_6) δ 0.88 (s, 9H), 2.36 (s, 3H), 3.38 (bs, 1H), 7.34 (d, $J = 8.0$ Hz, 2H), 7.65 (d, $J = 8.4$ Hz, 2H), 7.84 (d, $J = 10.0$ Hz, 1H); HRMS (EI) m/z 285.1035 ($\text{C}_{13}\text{H}_{19}\text{O}_4\text{NS}$ requires 285.1035).

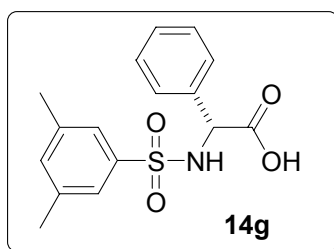
S(1) 3



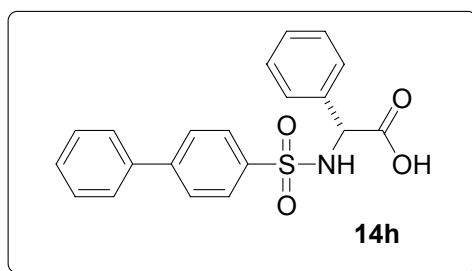
***N*-Methanesulfonyl-D-phenylglycine (14e).** Prepared from of D-(–)-phenylglycine (906.6 mg, 6 mmol) and methane sulfonyl chloride (824 mg, 7.2 mmol, 0.6 mL). Crystallization from ether afforded the product as a white solid (824 mg, 60%), which was used in the next step without further purification: ^1H NMR (400 MHz, DMSO- d_6) δ 2.86 (s, 3H), 5.08 (d, J = 8.8 Hz, 1H), 7.30-7.68 (m, 5H). 8.19 (d, J = 8.8 Hz, 1H); ^{13}C NMR (100 MHz, DMSO- d_6) δ 41.00 (CH₃), 59.4 (CH), 127.5 (CH), 128.2 (CH), 128.6 (CH), 137.0 (C), 171.6 (CO).



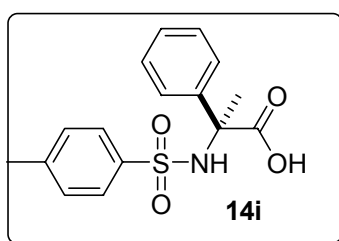
***N*-(2,4,6-Trimethyl-benzenesulfonyl)-D-phenylglycine (14f).** Prepared from D-(–)-phenylglycine (906.6 mg, 6 mmol) and mesitylene sulfonyl chloride (1.575 g, 7.2 mmol). Crystallization from ether afforded the product as a yellow solid (1.2 g, 62%), which was used in the next step without further purification: ^1H NMR (400 MHz, DMSO- d_6) δ 2.23 (s, 3H), 2.51 (s, 6H), 4.76 (d, J = 10 Hz, 1H), 6.95 (s, 2H), 7.28-7.36 (m, 5H), 8.53 (d, J = 9.6 Hz, 1H).



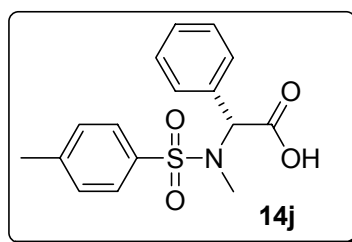
***N*-(3,5-Dimethyl-benzenesulfonyl)-D-phenylglycine (14g).** Prepared from D-(–)-phenylglycine (615 mg, 4.07 mmol) and 3,5-dimethylbenzenesulfonyl chloride (1.0 g, 4.88 mmol). Crystallization from ether afforded the product as a white solid (723 mg, 52%): ^1H NMR (400 MHz, DMSO- d_6) δ 2.32(s, 6H, CH₃), 4.95 (d, J = 8.8 Hz, 1H), 7.02-7.35 (m, 8H), 8.69 (d, J = 9.2 Hz, 1H); HRMS (CI) m/z 320.0961 (C₁₆H₁₈O₄NS requires 320.0957).



***N*-(Biphenyl-4-sulfonyl)-D-phenylglycine (14h)** Prepared from D-(–)-phenylglycine (906.6 mg, 6 mmol) and 4-biphenylsulfonyl chloride (1.820 g, 7.2 mmol). Crystallization from ether afforded the product as a white solid (2.18 g, 99%): $^1\text{H NMR}$ (400 MHz, $\text{DMSO-}d_6$) δ 4.75 (s, 1H), 7.21-7.80 (m, 14H), 8.37 (br s, 1H).



(*S*)-2-Phenyl-2-(toluene-4-sulfonylamino)-propionic acid (14i) . Prepared from (*S*)-(+)-methylphenylglycine (991 mg, 6 mmol) and *p*-toluenesulfonyl chloride (1.372 g, 7.2 mmol). The product was isolated as a colorless oil (500 g, 26%), which was used in the next step without further purification: $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 1.89 (s, 3H), 2.29 (s, 3H), 5.9 (s, 1H), 7.04-7.42 (m, 9H).

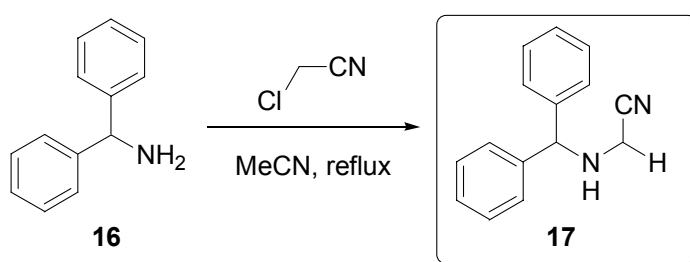


***N*-toluenesulfonyl-*N*-methyl-D-phenylglycine (14j)**. *N*-toluenesulfonyl-D-phenylglycine was prepared from D-(–)-phenylglycine (906 mg, 6 mmol) and of *p*-toluenesulfonyl chloride (1.372 g, 7.2 mmol). Crystallization from ether afforded acid **14a** as a white solid (1.2 g, 66%). Following the published protocol,^{S8} a solution of the resulting *N*-toluenesulfonyl-D-phenylglycine (700 mg, 2.3 mmol) in 2M aqueous NaOH (3 mL) and methyl iodide (0.24 ml, 547 mg, 3.8 mmol) was stirred in a sealed tube for 30 min. at 70 °C. After acidification with 2M HCl, the product was extracted with ethyl acetate and back-extracted into 1M potassium hydrogen carbonate. After acidification and extraction with ethyl acetate, the organic phase was dried over MgSO_4 and evaporated in vacuo to yield a yellow solid. Crystallization from a mixture of ethyl acetate and hexane gave the title compound as yellowish crystals (300 mg, 41 %) which was used in the next step without further purification: $^1\text{H NMR}$ (400 MHz, $\text{DMSO-}d_6$) δ 2.41 (s, 3H), 2.63 (s, 3H), 5.63 (s, 1H), 7.16-7.42 (m, 7H), 7.71 (d, $J = 8.2$ Hz, 2H).

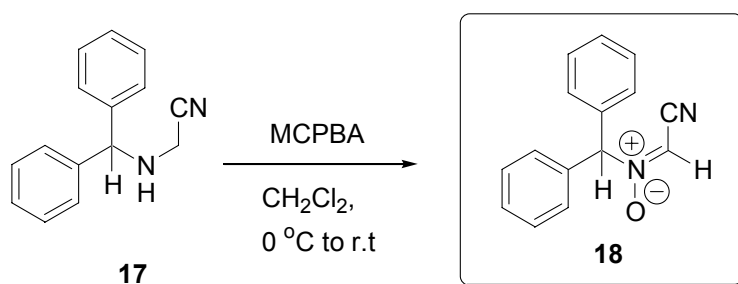
General procedure for synthesis of acid chlorides 15.

The reactions were performed on a 1-4 mmol scale. Phosphorus pentachloride (1.2 equiv) was added in one portion to a stirred solution of *N*-sulfonyl protected acid **14** (1 equiv) in anhydrous ether (8 mL) in a 100 mL round bottom flask under nitrogen atmosphere. After stirring at room temperature for 2 h, *n*-hexane (35 mL) was added and the mixture was left in a freezer overnight. The precipitated crystals were quickly separated by filtration, washed with *n*-hexane, and used immediately in the next step. In the case of *N*-(biphenyl-4-sulfonyl)-*D*-phenylglycine, 2-phenyl-2-(toluene-4-sulfonylamino)-propionic acid, and 2-phenyl-propionic acid the corresponding acid chlorides were obtained as a colorless oil.

Synthesis of hydroxylamine **19**.^{S9}

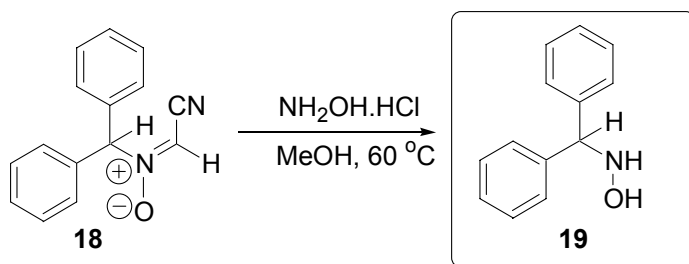


(Benzhydrylamino)-acetonitrile 17. Chloroacetonitrile (3.4 g, 45 mmol, 2.9 mL) was added to a stirred suspension of sodium carbonate (6.36 g, 60 mmol) in a solution of aminodiphenylmethane **16** (5.2 mL, 30 mmol) in anhydrous acetonitrile (20 mL) in a 100 mL flask and the mixture was stirred at 60 °C for 24 h. The reaction mixture was then filtered through Celite and the filtrate was concentrated *in vacuo* to yield an orange solid. The product was recrystallized from hexane/ethyl acetate to yield **17** as a yellow solid (3.79 g, 57%) which was used immediately in the next step: ¹H NMR (400 MHz, CDCl₃) δ = 3.56 (s, 2H), 5.10 (s, 1H), 7.26-7.53 (m, 10H), in agreement with the literature data.^{S9}



Nitron 18. A solution of cyanomethylated amine **17** (3.79 g, 17 mmol) in anhydrous dichloromethane (30 mL) in a 250 mL flask was cooled to 0 °C in an ice-bath. In another 250 mL flask, 70% MCPBA (7.33 g, 42.5 mmol) was dissolved in dry dichloromethane (60 mL), then magnesium sulfate (4 g) was added, and the mixture was stirred for 10 min. The solid was removed by filtration and washed with anhydrous dichloromethane (60 mL). The organic solution was then transferred to a 250 mL dropping funnel and slowly added to the mixture containing cyanomethylated amine **17** at 0 °C. After all the solution had been added, the flask was removed from the cooling bath and stirred at room temperature for 2 h. The reaction mixture was then successively washed with aqueous saturated solutions of sodium thiosulfite (2 × 100 mL), sodium carbonate (2 × 100 mL) and water (2 × 100 mL), and the aqueous layer

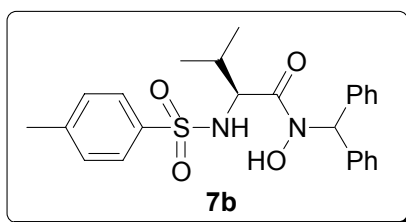
was extracted with dichloromethane. The combined organic phase was dried over MgSO_4 and evaporated *in vacuo* to yield **18** as a yellow solid (2.75 g, 68%), which was used immediately in the next step: $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 6.26 (s, 1H), 6.64 (s, 1H), 7.23-7.42 (m, 10H); NMR data consistent with the literature.^{S9}



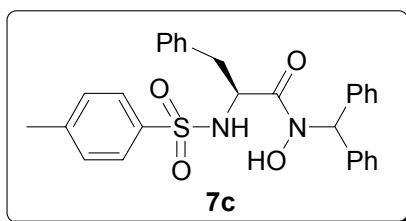
N-Benzhydryl-hydroxylamine 19. Hydroxylamine hydrochloride (4.04 g, 58.2 mmol) was added to a stirred solution of nitrone **18** (2.75g, 11.64 mmol) in methanol (60 mL) and the mixture was stirred at 60 °C for 24 h. The solution was allowed to cool to room temperature and then concentrated *in vacuo*. Dichloromethane (40 mL) was added and the solution was filtered through Celite. The filtrate was washed with an aqueous saturated solution of sodium carbonate (2×50 mL) and the aqueous layer was extracted with dichloromethane. The organic phase was dried over MgSO_4 and concentrated *in vacuo* to give a yellow oil which was purified by column chromatography on silica (20 × 3 cm) using a 4:1 mixture petroleum-ether/ethyl-acetate as eluent to furnish the target product **19** (1.24 g, 53%) as white plate crystals, which gave a white stain with iodoplatinate reagent on TLC: $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 4.71 (bs, 1H), 5.25 (s, 1H), 7.28-7.41(m, 10H), consistent with the literature data.^{S9}

General procedure for synthesis of hydroxamic acids 7b-d, 8a-d, 9-11.^{S10}

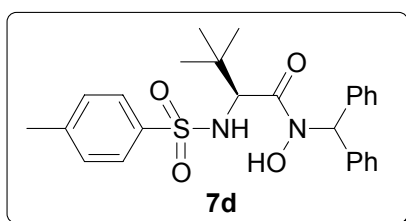
The reactions were performed on a 0.3-1.0 mmol scale. A solution of acid chloride **15** (323 mg, 1 mmol) in dry dichloromethane (3 mL) in a 50 mL round bottom flask under argon atmosphere, was cooled to -10 °C (cryocooler) and a solution of hydroxylamine **19** (200 mg, 1 mmol) in dry dichloromethane (3 mL) was added. The resulting mixture was stirred at -10 °C for 30 min, then the cooling was discontinued and the mixture was allowed to warm to room temperature. After 2 h of stirring, the reaction was quenched with triethylamine (150 μL) or 10% aqueous solution of Na_2CO_3 . A saturated solution of ammonium chloride was added and the mixture was extracted with dichloromethane. The organic extracts were dried over MgSO_4 and concentrated *in vacuo* to afford a brown oil. Purification using column chromatography on silica gel (20 g) with *n*-hexane-ethyl acetate mixture (4:1) yielded the product **25a** (115 mg, 24%) as white crystals, which gave positive red-wine colored stain with FeCl_3 reagent on TLC.



(S)-(+)-N-Benzhydryl-N-hydroxy-3-methyl-2-(toluene-4-sulfonylamino)-butyramide 7b. Prepared from acid chloride **15b** (275 mg, 0.95 mmol) and hydroxylamine **19** (200 mg, 1.0 mmol) as a white solid (200 mg, 47%): m.p. 166-169 °C (hexane/ethyl acetate); $[\alpha]_D^{25} +83.3$ (*c* 1.00, CHCl₃); ¹H NMR (400 MHz, CDCl₃) δ 0.74 (d, *J* = 6.8 Hz, 3H), 0.96 (d, *J* = 6.4 Hz, 3H), 2.06 (d sept, *J* = 6.4, 5.2 Hz; 1H), 2.43 (s, 3H, CH₃), 4.34 (dd; *J* = 9.6, 4.8 Hz; 1H), 5.52 (d, *J* = 10 Hz, 1H), 6.19 (s, 1H), 6.74 (s, 1H), 6.91-7.75 (m, 14H); ¹³C NMR (100 MHz, CDCl₃) δ 16.5 (CH₃), 19.6 (CH₃), 30.4 (CH), 57.9 (CH), 62.6 (CH), 127.3 (CH), 127.9 (CH), 128.0 (CH), 128.4 (CH), 128.59 (CH), 128.6 (CH), 128.8 (CH), 129.6 (CH), 136.9 (C), 137 (C), 137.6 (C), 143.5 (C), 170.8 (CO); IR (KBr) ν_{\max} 3431, 1620, 1447, 1409, 1164, 1093, 1043, 719, 700 cm⁻¹; HRMS (EI) *m/z* 452.1774 (C₂₅H₂₈O₄N₂S requires 452.1770).

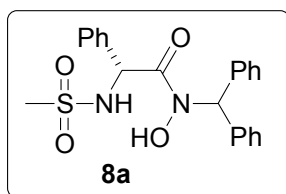


(S)-(+)-N-Benzhydryl-N-hydroxy-3-phenyl-2-(toluene-4-sulfonylamino)-propionamide 7c. Prepared from acid chloride **15c** (560 mg, 1.66 mmol) and hydroxylamine **19** (330 mg, 1.66 mmol) as a white solid (465 mg, 56%): m.p. 158-160 °C (hexane/ethyl acetate); $[\alpha]_D^{25} +47.6$ (*c* 1.00, CHCl₃); ¹H NMR (400 MHz, CDCl₃) δ 2.40 (s, 3H), 2.99 (d, *J* = 7.2 Hz, 2H), 4.85 (q, *J* = 7.2 Hz, 1H), 5.63 (d, *J* = 9.6 Hz, 1H), 6.75 (s, 1H), 7.01-7.69 (m, 19H); ¹³C NMR (100 MHz, CDCl₃) δ 21.6 (CH₃), 40.1 (CH₂), 53.8 (CH), 62.5 (CH), 127.0 (CH), 127.8 (CH), 128.0 (CH), 128.5 (CH), 128.56 (CH), 128.6 (CH), 128.9 (CH), 129.4 (CH), 129.7 (CH), 135.6 (C), 136.9 (C), 137.2 (C), 137.3 (C), 143.4 (C), 170.83 (CO); IR (KBr) ν_{\max} 3427, 1616, 1450, 1406, 1336, 1162, 1091, 713, 701 cm⁻¹; HRMS (FAB) *m/z* 501.1850 (C₂₉H₂₉O₄N₂S requires 501.1848).



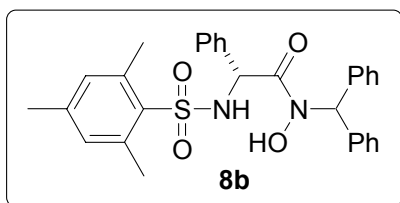
(S)-(+)-N-Benzhydryl-N-hydroxy-3,3-dimethyl-2-(toluene-4-sulfonylamino)-butyramide 7d. Prepared from acid chloride **15d** (151 mg, 0.5 mmol) and hydroxylamine **19** (100 mg, 0.5 mmol) as a beige solid (163 mg, 70%): m.p. 82-85 °C (hexane/ethyl acetate); $[\alpha]_D^{25} +41.3$ (*c* 1.00, CHCl₃); ¹H NMR (400 MHz, CDCl₃) δ 0.76 (s, 9H), 2.34 (s, 3H), 4.30 (d, *J* = 10.8 Hz, 1H), 5.38 (d, *J* = 10.8 Hz, 1H), 5.94 (s, 1H), 6.83 (s, 1H), 6.93-7.67 (m, 14H);

^{13}C NMR (100 MHz, CDCl_3) δ 21.7 (CH_3), 26.1 (CH_3), 35.7 ($\text{C}(\text{CH}_3)_2$), 58.3 (CH), 62.3 (CH), 127.3 (CH), 127.9 (CH), 128.0 (CH), 128.5 (CH), 128.6 (CH), 128.7 (CH), 128.9 (CH), 129.7 (CH), 137.0 (C), 137.7 (C), 143.7 (C), 171.0 (CO); IR (KBr) ν_{max} 3339, 1627, 1597, 1495, 1449, 1407, 1336, 1167, 1090, 815, 717, 704 cm^{-1} ; HRMS (EI) m/z 466.1923 ($\text{C}_{26}\text{H}_{30}\text{O}_4\text{N}_2\text{S}$ requires 466.1926).



(R)-(-)-N-Benzhydryl-N-hydroxy-2-methanesulfonylamino-2-phenyl-acetamide

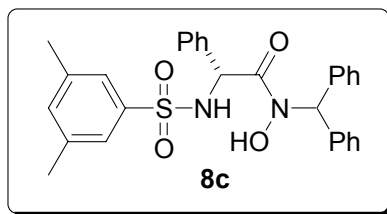
8a. Prepared from acid chloride **15e** (97 mg, 0.39 mmol) and hydroxylamine **19** (78 mg, 0.39 mmol) as beige solid (64 mg, 40%): m.p. 174-177 $^{\circ}\text{C}$ (hexane/ethyl acetate); $[\alpha]_{\text{D}} -45.2$ (c 0.5, CHCl_3); ^1H NMR (400 MHz, CDCl_3) δ 2.54 (s, 3H), 5.24 (d, $J = 4.0$ Hz, 1H), 5.64 (d, $J = 7.6$ Hz, 1H), 5.77 (d, $J = 7.2$ Hz, 1H), 6.81 (s, 1H), 6.84-7.45 (m, 15H); ^{13}C NMR (100 MHz, CDCl_3) δ 41.9 (CH_3), 57.9 (CH), 63.5 (CH), 127.9 (CH), 128.2 (CH), 128.3 (CH), 128.6 (CH), 128.8 (CH), 128.9 (CH), 129.3 (CH), 136.1 (C), 136.9 (C), 169.6 (CO); IR (NaCl) ν_{max} 3020, 2400, 1871, 1655, 1497, 1421, 1328, 1215, 769 cm^{-1} ; HRMS (EI) m/z 393.1272 ($\text{C}_{22}\text{H}_{21}\text{O}_3\text{N}_2\text{S}$ requires 393.1273).



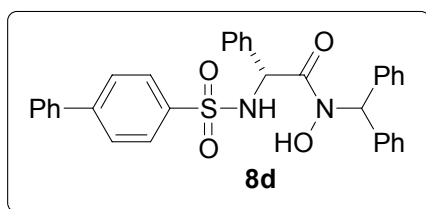
(R)-(-)-N-Benzhydryl-N-hydroxy-2-phenyl-2-(2,4,6-trimethylbenzenesulfonyl-

amino)-acetamide 8b. Prepared from acid chloride **15f** (174 mg, 0.5 mmol) and hydroxylamine **19** (100 mg, 0.5 mmol) as a yellow solid (88 mg, 34%): m.p. 148-150 $^{\circ}\text{C}$ (hexane/ethyl acetate); $[\alpha]_{\text{D}} -52.6$ (c 0.5, CHCl_3); ^1H NMR (400 MHz, CDCl_3) δ 2.50 (s, 3H), 5.49 (d, $J = 8.7$ Hz, 1H), 6.10 (d, $J = 7.6$ Hz, 1H), 6.71 (s, 1H), 6.81 (d, $J = 7.2$ Hz, 1H), 6.92-7.33 (m, 17 H); ^{13}C NMR (100 MHz, CDCl_3) δ 20.9 (CH_3), 22.9 (CH_3), 57.0 (CH), 63.2 (CH), 127.5 (CH), 127.7 (CH), 127.9 (CH), 128.1 (CH), 128.3 (CH), 128.4 (CH), 128.6 (CH), 128.7 (CH), 131.7 (CH), 135.8 (C), 136.2 (C), 137.0 (C), 138.9 (C), 142.0 (C), 169.5 (CO); IR (KBr) ν_{max} 3376, 3062, 3030, 2925, 2854, 1653, 1603, 1495, 1454, 1187, 1098, 849 cm^{-1} ; HRMS (EI) m/z 514.1927 ($\text{C}_{30}\text{H}_{30}\text{O}_4\text{N}_2\text{S}$ requires 514.1926).

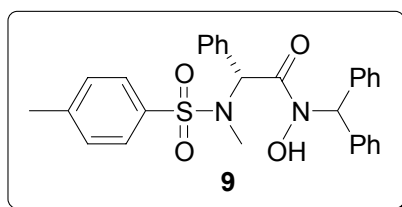
S(1) 9



(R)-(-)-N-Benzhydryl-2-(3,5-dimethyl-benzenesulfonylamino)-N-hydroxy-2-phenylacetamide 8c. Prepared from acid chloride **15g** (99 mg, 0.28 mmol) and hydroxylamine **19** (56 mg, 0.28 mmol) as a white solid (42 mg, 30%): m.p. 168-170 °C (hexane/ethyl acetate); $[\alpha]_D -53.9$ (*c* 0.5, CHCl₃); ¹H NMR (400 MHz, CDCl₃) δ 2.15 (s, 6H), 5.30 (bs, 1H), 5.53 (d, *J* = 8.0 Hz, 1H), 6.06 (d, *J* = 7.6 Hz, 1H), 6.72 (s, 1H), 6.77-7.38 (m, 18H); ¹³C NMR (100 MHz, CDCl₃) δ 21.1 (CH₃), 57.4 (CH), 63.1 (CH), 124.6 (CH), 127.7 (CH), 127.9 (CH), 128.1 (CH), 128.3 (CH), 128.4 (CH), 128.6 (CH), 128.7 (CH), 128.8 (CH), 134.13 (CH), 135.9 (C), 136.9 (C), 138.7 (C), 139.8 (C), 169.2 (CO); IR (KBr) ν_{\max} 3386, 3248, 1667, 1495, 1453, 1404, 1310, 1304, 1272, 1160, 717, 698 cm⁻¹; HRMS (EI) *m/z* 500.1771 (C₂₉H₂₈O₄N₂S requires 500.1770).

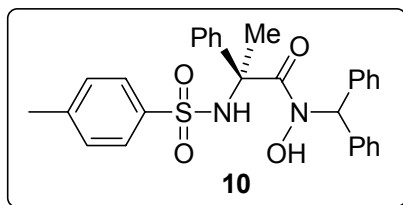


(R)-(-)-N-Benzhydryl-2-(biphenyl-4-sulfonylamino)-N-hydroxy-2-phenylacetamide 8d. Prepared from acid chloride **15h** (232 mg, 0.6 mmol) and hydroxylamine **19** (120 mg, 0.6 mmol) as a yellow solid (55 mg, 17%): m.p. 154-157 °C (hexane/ethyl acetate); $[\alpha]_D -77.3$ (*c* 0.5, CHCl₃); ¹H NMR (400 MHz, CDCl₃) δ 5.51 (s, 1H), 5.6 (d, *J* = 8.0 Hz, 1H), 6.15 (d, *J* = 8.0 Hz, 1H), 6.67 (s, 1H), 6.75-7.64 (m, 24H); ¹³C NMR (100 MHz, CDCl₃) δ 57.6 (CH), 63.2 (CH), 127.3 (CH), 127.4 (CH), 127.5 (CH), 127.8 (CH), 127.9 (CH), 128.1 (CH), 128.2 (CH), 128.4 (CH), 128.5 (CH), 128.6 (CH), 128.9 (CH), 129.0 (CH), 135.7 (C), 136.9 (C), 137.0 (C), 138.8 (C), 139.4 (C), 145.2 (C), 169.2 (CO); IR (KBr) ν_{\max} 3426, 3283, 1647, 1620, 1597, 1495, 1400, 1341, 1164, 1094, 841, 764, 697 cm⁻¹; HRMS (FAB) *m/z* 549.1841 (C₃₃H₂₉O₄N₂S requires 549.1848).

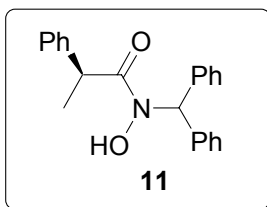


(R)-(-)-N-Benzhydryl-N-hydroxy-2-[methyl-(toluene-4-sulfonyl)-amino]-2-phenylacetamide 9. Prepared from acid chloride **15j** (200 mg, 0.6 mmol) and hydroxylamine **19** (120 mg, 0.6 mmol) as a beige solid (70 mg, 23%): m.p. 84-86 °C (hexane/ethyl acetate); $[\alpha]_D -18.9$ (*c* 1.00, MeOH); ¹H NMR (400 MHz, CDCl₃) δ 2.41 (s, 3H), 2.83 (s, 3H), 6.50 (s, 1H), 6.88 (s, 1H), 7.02-7.84 (m, 19H); ¹³C NMR (100 MHz, CDCl₃) δ 21.6 (CH₃), 31.5 (CH₃), 60.0 (CH), 62.4 (CH), 127.3 (CH), 127.9 (CH), 127.94

(CH), 128.0 (CH), 128.2 (CH), 128.3 (CH), 128.4 (CH), 128.6 (CH), 128.7 (CH), 128.8 (CH), 128.9 (CH), 129.2 (CH), 129.3 (CH), 129.6 (CH), 130.1 (CH), 130.9 (CH), 132.5 (CH), 134.1 (C), 136.2 (C), 137.6 (CH), 137.7 (C), 137.8 (C), 143.2 (C), 170.0 (CO); IR (KBr) ν_{\max} 3440, 1633, 1598, 1495, 1454, 1342, 1151, 1089, 811, 698 cm^{-1} ; HRMS (EI) m/z 500.1768 ($\text{C}_{29}\text{H}_{28}\text{O}_4\text{N}_2\text{S}$ requires 500.1770).

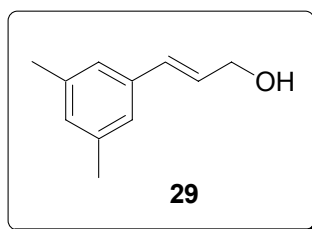


(S)-(-)-N-Benzhydryl-N-hydroxy-2-phenyl-2-(toluene-4-sulfonylamino)propionamide 10. Prepared from acid chloride **15i** (287 mg, 0.85 mmol) and hydroxylamine **19** (170 mg, 0.85 mmol) as a white solid (80 mg, 19%): m.p. 160-163 °C (hexane/ethyl acetate); $[\alpha]_{\text{D}} -67.1$ (c 0.5, CHCl_3); ^1H NMR (400 MHz, CDCl_3) δ 1.96 (s, 3H), 2.26 (s, 3H), 4.59 (bs, 1H), 6.56 (s, 1H), 6.85 (s, 1H), 6.92-7.43 (m, 19H); ^{13}C NMR (100 MHz, CDCl_3) δ 21.5 (CH_3), 23.4 (CH_3), 63.7 (CH), 125.9 (CH), 126.6 (CH), 127.6 (CH), 128.0 (CH), 128.1 (CH), 128.39 (CH), 128.41 (CH), 128.61 (CH), 128.64 (CH), 128.9 (CH), 129.1 (CH), 137.0 (C), 137.2 (C), 139.0 (C), 139.5 (C), 142.3 (C), 171.8 (CO); IR (KBr) ν_{\max} 3425, 1635, 1600, 1496, 1449, 1362, 1322, 1304, 1155, 1093, 813, 699 cm^{-1} ; HRMS (FAB) m/z 501.1844 ($\text{C}_{29}\text{H}_{29}\text{O}_4\text{N}_2\text{S}$ requires 501.1848).



(R)-(-)-N-Benzhydryl-N-hydroxy-2-phenylpropionamide 11. Prepared from acid chloride **15k** (183 mg, 1.09 mmol) and hydroxylamine **19** (218 mg, 1.09 mmol) as a beige solid (77 mg, 21%): m.p. 38-41 °C (hexane/ethyl acetate); $[\alpha]_{\text{D}} -17.9$ (c 1.00, CHCl_3); ^1H NMR (400 MHz, CDCl_3) δ 1.36 (bs, 3H), 3.79 and 4.16 (2 \times bs, 1H), 5.27 (bs, 1H), 6.16 and 6.59 (2 \times bs, 1H), 6.87-7.40 (m, 15H); ^{13}C NMR (100 MHz, CDCl_3) δ 19.1 (CH_3), 42.9 (CH), 62.5 (CH), 127.7 (CH), 127.8 (CH), 128.5 (CH), 128.7 (CH), 128.8 (CH), 129.1 (CH), 138.0 (C), 141.4 (C), 174.9 (CO); IR (KBr) ν_{\max} 3444, 1618, 1583, 1496, 1452, 1419, 1270, 1030, 735, 698 cm^{-1} ; HRMS (CI/ISO) m/z 332.1653 ($\text{C}_{22}\text{H}_{22}\text{O}_2\text{N}$ requires 332.1651).

Synthesis of allylic alcohols 29.



(2E)-3-(3,5-Dimethyl-phenyl)-acrylic acid ethyl ester. A solution of 3,5-dimethylbenzaldehyde (1.0 g, 7.45 mmol) in dry dichloromethane (15 mL) was added to a solution of ethyl(triphenylphosphoranyl)acetate (2.855 g, 8.2 mmol) in dry dichloromethane (15 mL) and the mixture was heated under reflux for 24 h. The solvent was then removed under reduced pressure, the residue was purified by column chromatography on silica gel (25 × 4 cm) using a 10:1 mixture petroleum-ether/ethyl-acetate as eluent to furnish the title product as a colorless oil (1.521 g, 99%): ^1H NMR (400 MHz, CDCl_3) δ 1.23 (t, $J = 7.1$ Hz, 3H), 2.22 (s, 6H), 4.16 (q, $J = 7.1$ Hz, 2H), 6.32 (d, $J = 16.0$ Hz, 1H), 6.91 (s, 1H), 7.04 (s, 2H), 7.54 (d, $J = 16.0$ Hz, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 14.7 (CH₃), 21.6 (CH₃), 60.8 (CH₂), 118.2 (CH), 126.3 (CH), 132.4 (CH), 134.8 (C), 138.8 (C), 145.3 (CH), 167.5 (CO); HRMS (EI) m/z 204.1150 (C₁₃H₁₆O₂ requires 204.1150).

(E)-3-(3,5-Dimethyl-phenyl)-prop-2-en-1-ol 29. A 1M solution of DIBAL-H in hexanes (14.9 mL, 14.9 mmol) was added to a solution of (2E)-3-(3,5-Dimethyl-phenyl)-acrylic acid ethyl ester (1.521 g, 7.45 mmol) in dry ether (25 mL) at 0 °C. The mixture was allowed to warm to room temperature and stirred for 20 h. Then, the mixture was diluted with ether (25 mL), cooled to 0 °C, and quenched by a careful addition of brine (25 mL), followed by a dropwise addition of 4M HCl (25 mL). The aqueous layer was extracted with ether (3×150 mL), the combined organic phase was dried over MgSO₄ and concentrated under reduced pressure. Purification by column chromatography on silica gel (25 × 4 cm) using a 10:1 mixture petroleum ether - ethyl acetate as eluent furnished allylic alcohol **29** as a colorless oil (883 mg, 74%): ^1H NMR (400 MHz, CDCl_3) δ 1.75 (bs, 1H), 2.34 (s, 6H), 4.33 (d, $J = 5.6$ Hz, 2H), 6.36 (dt, $J = 15.9, 5.7$ Hz, 1H), 6.57 (d, $J = 15.9$ Hz, 1H), 6.86 (s, 1H), 7.01 (s, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 21.6 (CH₃), 64.2 (CH₂), 124.8 (CH), 128.5 (CH), 129.8 (CH), 131.8 (CH), 136.97 (C), 138.4 (C); IR (NaCl) ν_{max} 3328, 2918, 2863, 1679, 1602, 1458, 1377, 1094, 1037, 967, 851, 687 cm^{-1} ; HRMS (EI) m/z 162.1044 (C₁₁H₁₄O requires 162.1045).

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