Angewandte Chemie
Eine Zeitschrift der Gesellschaft Deutscher Chemiker

Supporting Information

69451 Weinheim, Germany

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Asymmetric Michael Reaction of Acetaldehyde Catalyzed by Diphenylprolinol Silyl Ether

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Experimental Section

General Remarks

All reactions were carried out under argon atmosphere and monitored by thin-layer chromatography using Merck 60 F254 precoated silica gel plates (0.25 mm thickness). FT-IR spectra were recorded on a JASCO FT/IR-410 spectrometer. ^{1}H and ^{13}C NMR spectra were recorded on a Brucker AM400 (400 MHz for ^{1}H NMR, 100 MHz for ^{13}C NMR) instrument. Data for ^{1}H NMR are reported as chemical shift (δ ppm), coupling constant (Hz), integration, and assignment. Data for ^{13}C NMR are reported as chemical shift. High-resolution mass spectral analyses (HRMS) were carried out using Bruker ESI-TOF MS. Preparative thin layer chromatography was performed using Wakogel B-5F purchased from Wako Pure Chemical Industries, Tokyo, Japan. Flash chromatography was performed using silica gel 60N of Kanto Chemical Co. Int., Tokyo, Japan. GC-MS was performed on Shimazu GC-MS QP2010, equipped with a split-mode capillary injecton system and electron ionization detectors using Bodman Chiraldex Γ-TA (30 m x 0.25 mm). HPLC analysis was performed on a HITACHI Elite LaChrom Series HPLC, UV detection monitered at appropriate wavelength respectively, using Chiralcel OJ-H (0.46 cm x 25 cm), Chiralpak IC (0.46 cm x 25 cm) or Chiralpak AS-H (0.46 cm x 25 cm).

Typical procedure of asymmetric Michael addition of acetaldehyde (Table 2. entry 1)

To a mixture of (*S*)-diphenyltrimethylsiloxymethylpyrrolidine (24.4 mg, 0.075 mmol) and nitrostyrene (111.8 mg, 0.75 mmol) in 1,4-dioxane (0.15 mL) was added acetaldehyde (420 mL, 7.5 mmol) in a sealed tube (ACE GLASS, product number 5027-05) at 4 ^{o}C. After the reaction mixture was stired at room temperature for 18 h, the reaction was quenched with aq. 1N-HCl. The organic materials were extracted with ethyl acetate three times. The combined organic extracts were dried over anhydrous Na_2SO_4, and concentrated *in vacuo* after filtration. Purification by column chromatography (ethyl acetate : hexane = 1 : 20 - 1 : 6) gave (*S*)-4-nitro-3-phenylbutanal (108.1 mg, 0.56 mmol) in 75% yield. Enantiometric excess was 96% *ee*.

(*S*)-4-Nitro-3-phenylbutanal[1,2] (5a)

was known conpound.

Enantiomeric excess was determined by GLC (Bodman Chiraldex Γ-TA column, 40 °C, 10 °C /min gradient, 60 kPa), TR1 = 47.5 (minor), TR2 = 49.5 (major) min.

(*S*)-3-(2-Naphthyl)-4-nitrobutanal[1,3] (5b)

was known conpound.

The product was converted to the corresponding alcohol with $NaBH_4$ and enantiomeric excess was determined by HPLC using a Chiralpak AS-H column (10/1 hexane/*i*-PrOH; flow rate 1.0 ml/min, TR1 = 10.3 (major), TR2 = 11.3 (minor) min).

(*S*)-3-(4-Methoxyphenyl)-4-nitrobutanal[1,3] (5c)

was known conpound.

The product was converted to the corresponding alcohol with $NaBH_4$ and enantiomeric excess was determined by HPLC using a Chiralpak AS-H column (10/1 hexane/*i*-PrOH; flow rate 1.0 ml/min, TR1 = 17.4 (major), TR2 = 22.9 (minor) min).

(*S*)-3-(4-Bromophenyl)-4-nitrobutanal[1] (5d)

was known conpound.

The product was converted to the corresponding alcohol with $NaBH_4$ and enantiomers were separated by HPLC using a Chiralpak IC column (10/1 hexane/*i*-PrOH; flow rate 1.0 ml/min, TR1 = 15.5 (minor), TR2 = 16.2 (major) min).

(*S*)-3-(4-Chlorophenyl)-4-nitrobutanal[1,3] (5e)

was known conpound.

The product was converted to the corresponding alcohol with NaBH4 and enantiomeric excess was determined by HPLC using a Chiralpak IC column (10/1 hexane/*i*-PrOH; flow rate 1.0 ml/min, TR1 = 15.0 (minor), TR2 = 15.9 (major) min).

(*S*)-4-Nitro-3-(4-nitrophenyl)butanal[1,3] (5f)

was known conpound.

The product was converted to the corresponding alcohol with $NaBH_4$ and enantiomeric excess was determined by HPLC using a Chiralcel OJ-H column (10/1 hexane/*i*-PrOH; flow rate 1.0 ml/min, TR1 = 78.4 (major), TR2 = 97.1 (minor) min).

(*S*)-4-Nitro-3-(4-trifluoromethylphenyl)butanal[1] (5g)

^{1}H NMR ($CDCl_3$): δ 2.99 (2H, d, *J* = 6.8 Hz), 4.16 (1H, quint, *J* = 7.2 Hz), 4.65 (1H, dd, *J* = 4.8, 8.0 Hz), 4.72 (1H, dd, *J* = 5.6, 7.2 Hz), 7.38 (2H, d, *J* = 8.4 Hz), 7.61 (2H, d, *J* = 8.4 Hz), 9.73 (1H, s);

^{13}C NMR ($CDCl_3$): δ 37.6, 46.2, 78.8, 125.1, 126.1 (2C), 127.9 (2C), 130.3, 142.4, 197.9;

IR (neat): ν 2385, 2311, 1724, 1554, 1379, 1326, 1165, 1117, 1068, 840 cm^{-1};

HRMS (ESI): [M-H] calculated for $C_{11}H_9F_3NO_3$: 260.0529, found: 260.0527;

$[\alpha]_D^{21} = -6.9$ (*c* 0.79, MeOH).

The product was converted to the corresponding alcohol with $NaBH_4$ and enantiomeric excess was determined by HPLC using a Chiralcel OJ-H column (10/1 hexane/*i*-PrOH; flow rate 1.0 ml/min, TR1 = 13.6 (major), TR2 = 15.2 (minor) min).

(*S*)-3-(2-Furyl)-4-nitrobutanal[1,3] (5h)

was known conpound.

Enantiomeric excess was determined by GLC (Bodman Chiraldex Γ-TA column, 40 °C, 10 °C /min gradient, 60 kPa, TR1 = 20.8 (minor), TR2 = 21.3 (major) min).

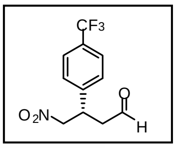
(*R*)-3-(Nitromethyl)heptanal[1] (5i)

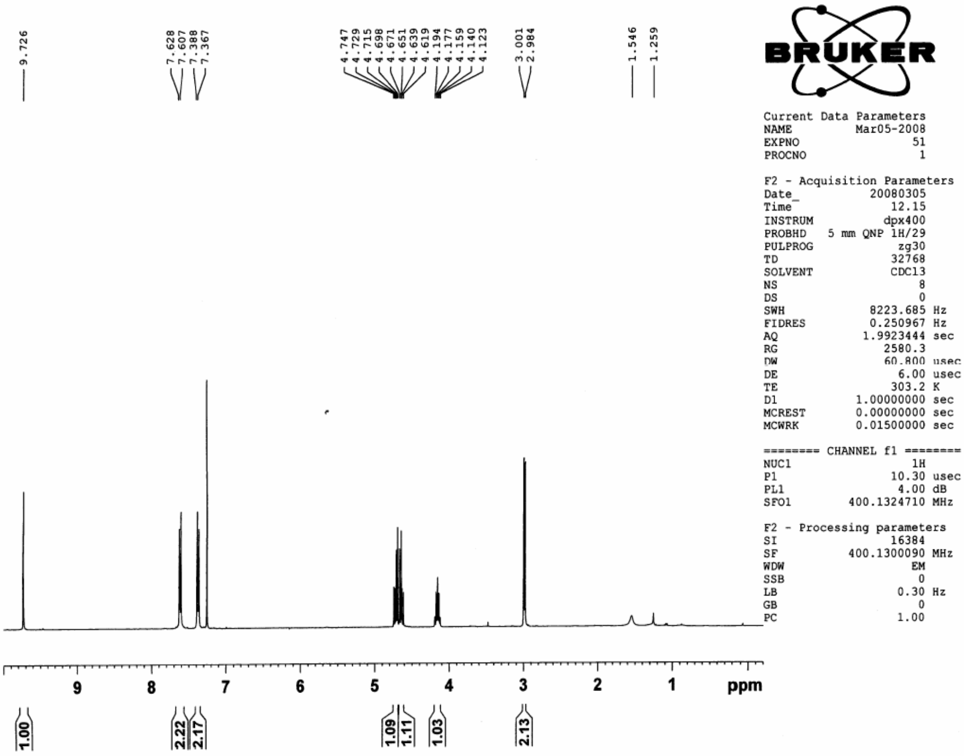
was known conpound.

Enantiomeric excess was determined by GLC (Bodman Chiraldex Γ-TA column, 40 °C, 10 °C /min gradient, 60 kPa, TR1 = 14.6 (minor), TR2 = 15.2 (major) min.)

References

1) H. Gotoh, H. Ishikawa, Y. Hayashi, *Org. Lett.* **2007**, *9*, 5307.
2) C. Palomo, R. Pazos, M. Oiarbide, J. M. Garcia, *Adv. Synth. Catal.* **2006**, *348*, 1161.
3) L. Zu, H. Xie, H. Li, J. Wang, W. Wang, *Adv. Synth. Catal.* **2007**, *349*, 2660.





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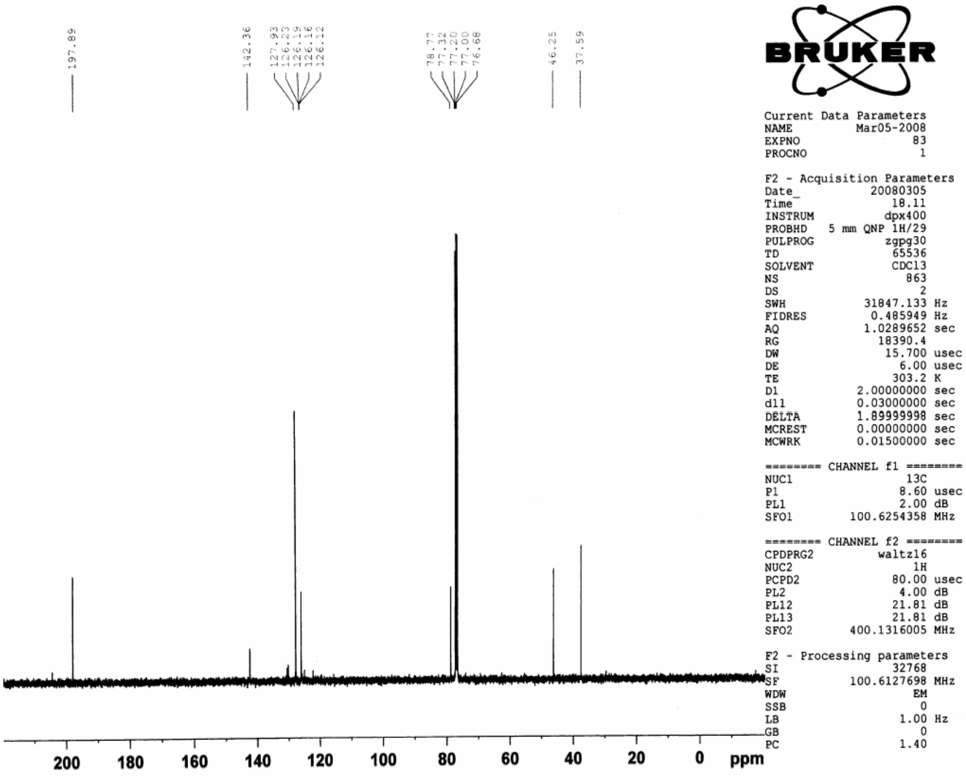

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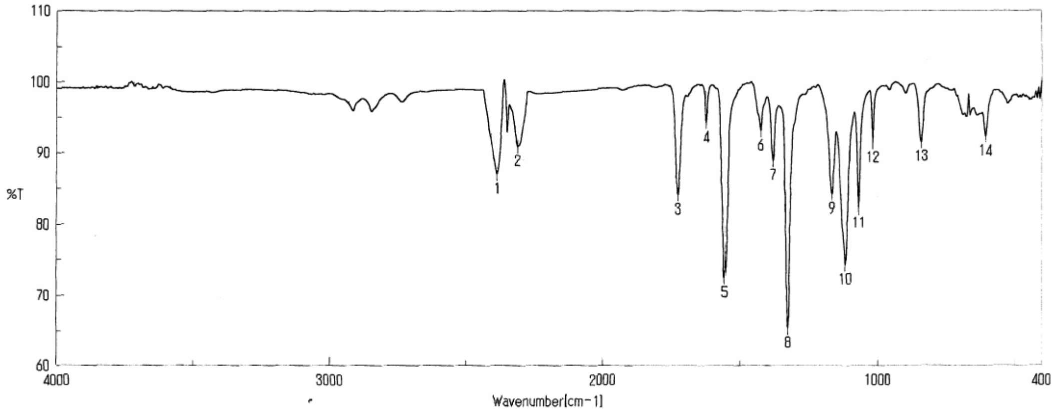

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