

**Cu-CATALYZED ENANTIOSELECTIVE CONJUGATE ADDITION OF
ALKYLZINCS TO CYCLIC NITROALKENES. CATALYTIC ASYMMETRIC
SYNTHESIS OF α -SUBSTITUTED CYCLIC KETONES**

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Supporting Information

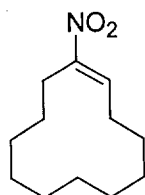
General. Infrared (IR) spectra were recorded on a Perkin-Elmer 781 spectrophotometer, ν_{\max} in cm^{-1} . Bands are characterized as broad (br), strong (s), medium (m), and weak (w). ^1H NMR spectra were recorded on a Varian INOVA AS-400 (400 MHz) spectrometer. Chemical shifts are reported in ppm from tetramethylsilane with the solvent resonance as the internal standard (CDCl_3 : δ 7.26 ppm). Data are reported as follows: chemical shift, integration, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, br = broad, m = multiplet), and coupling constants (Hz). ^{13}C NMR spectra were recorded on a Varian INOVA AS-400 (100 MHz) with complete proton decoupling. Chemical shifts are reported in ppm from tetramethylsilane with the solvent as the internal reference (CDCl_3 : δ 77.2 ppm). Enantiomer and diastereomer ratios were determined by ^1H NMR and chiral GLC analysis (Alltech Associates ChiralDex GTA (30 m x 0.25 mm)) in comparison with authentic racemic materials. Microanalyses were performed by Robertson Microlit Laboratories (Madison, NJ). High-resolution mass spectrometry was performed by the University of Illinois Mass Spectrometry Laboratories (Urbana, IL). Absolute stereochemistry is determined by optical rotation on a Rudolph Research Analytical Autopol IV polarimeter.

All reactions were conducted in oven- (135 °C) and flame-dried glassware under an inert atmosphere of dry nitrogen. Solvents are purified under a positive pressure of dry argon by a modified Advanced Chem Tech purification system – toluene is purified through Cu and alumina columns. Dimethylzinc is purchased from Aldrich and used without purification. 1,8-Diazabicyclo[5.4.0]undec-7-ene (DBU) is purchased from Aldrich and freshly distilled from CaH_2 . Diethylzinc is purchased from Strem and used without purification. Other dialkylzincs are prepared using known methods.¹ Copper (I) triflate is freshly prepared according to a known literature procedure.² 1-Nitrocyclohexene is purchased from Aldrich, distilled from CaCl_2 , passed

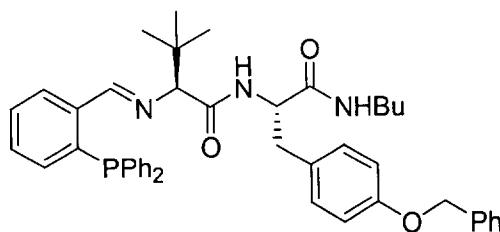
¹ Knochel, P.; Singer, R. *Chem. Rev.* **1993**, *93*, 2117-2188 and references cited therein.

² (a) Salomon, R. G.; Kochi, J. K. *J. Am. Chem. Soc.* **1973**, *95*, 1889-1897. (b) Salomon, R. G.; Kochi, J. K. *J. Am. Chem. Soc.* **1973**, *95*, 3300-3310.

through a silica gel plug, and stored over 4Å molecular sieves. 1-Nitrocyclopentene,³ 1-nitrocycloheptene,⁴ and 1-nitrocyclododecene (synthesized in an analogous fashion to the literature^{4b} procedure for 1-nitrocycloheptene, from 2-nitrocyclododecanone, obtained from Aldrich and used without purification) are prepared according to referenced procedures and stored over 4 Å molecular sieves. Amino acid ligands were prepared as reported previously.⁵



(E)-1-nitrocyclododecene (12): Colorless oil. $R_f = 0.5$ in 95/5 pentane/diethyl ether. IR (NaCl): 2936 (s), 2867 (w), 1520 (s), 1470 (w), 1344 (m). $^1\text{H NMR}$ (CDCl_3 , 400 MHz): δ 7.09 (1H, t, $J = 8.6$ Hz), 2.66 (2H, t, $J = 8.0$ Hz), 2.27 (2H, dt, $J = 8.4, 7.2$ Hz), 1.69-1.60 (4H, m), 1.41-1.26 (12H, m). $^{13}\text{C NMR}$ (CDCl_3 , 100 MHz): δ 152.3, 137.0, 26.0, 25.6, 25.1, 25.0, 24.9, 24.8, 23.7, 23.4, 22.9, 22.2. HRMS Calcd. for $\text{C}_{12}\text{H}_{21}\text{NO}_2$: 211.1572. Found: 211.1566. Anal. Calcd. for $\text{C}_{12}\text{H}_{21}\text{NO}_2$: C, 68.21; H, 10.02; N, 6.63. Found: C, 68.58; H, 9.95; N, 6.53.

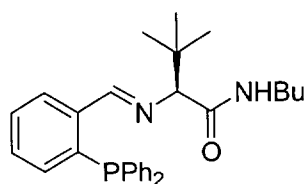


2-(Diphenylphosphino)-phenyl-L-Tle-L-Tyr(OBn)-Bu (3): Yellow solid. mp 63-70 °C; IR (NaCl): 3308 (br), 2952 (m), 2873 (w), 2366 (w), 1653 (s), 1508 (s), 1430 (m), 1242 (m), 1031 (w). $^1\text{H NMR}$ (CDCl_3 , 400 MHz): δ 8.47 (1H, d, $J = 4.0$ Hz), 7.75-7.72 (1H, m), 7.63-7.60 (1H, m), 7.46-7.23 (15H, m), 7.16-7.09 (4H, m), 6.91-6.84 (3H, m), 6.19 (1H, t, $J = 5.6$ Hz), 4.96 (2H, s), 4.57 (1H, dd, $J = 14.8, 7.6$ Hz), 3.41 (1H, s), 3.21-3.06 (4H, m), 1.32-1.09 (4H, m), 0.77 (3H, t, $J = 7.6$ Hz), 0.60 (9H, s). $^{13}\text{C NMR}$ (CDCl_3 , 100 MHz): δ 172.2, 171.1, 161.7, 161.6, 157.9, 138.6, 138.5, 137.6, 137.4, 137.3, 136.6, 136.5, 134.9, 134.7, 134.5, 133.6, 133.5, 130.9, 130.8, 130.7, 130.5, 129.9, 129.3, 129.1, 129.0, 128.9, 128.8, 128.8, 128.7, 128.6, 128.1, 127.6, 115.1, 85.0, 70.2, 55.0, 39.3, 36.5, 35.1, 31.6, 27.0, 20.1, 13.9. HRMS Calcd. for $\text{C}_{45}\text{H}_{50}\text{N}_3\text{O}_3\text{P}$: 711.3590. Found: 711.3597. Anal. Calcd. for $\text{C}_{45}\text{H}_{50}\text{N}_3\text{O}_3\text{P}$: C, 75.92; H, 7.08; N, 5.90. Found: C, 76.08; H, 6.82; N, 5.69; $[\alpha]_D^{20} +5.6^\circ$ (c 1.23, CHCl_3).

³ Corey, E. J.; Estreicher, H. *J. Am. Chem. Soc.* **1978**, *100*, 6294-6295.

⁴ (a) Kochi, J. K.; Rathore, R. *J. Org. Chem.* **1996**, *61*, 627-639. (b) Ballini, R.; Palestini, C. *Tetrahedron Lett.* **1994**, *35*, 5731-5734.

⁵ Mizutani, H.; Degrado, S. J.; Hoveyda, A. H. *J. Am. Chem. Soc.* **2002**, *124*, 779-781.

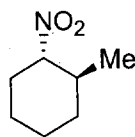


2-(Diphenylphosphino)-phenyl-L-Tle- Bu (14): Off white solid. mp 105-107 °C; IR (NaCl): 3371 (w), 3320 (w), 3062 (w), 2968 (s), 2873 (m), 1671 (s), 1520 (m), 1483 (m), 1438 (m), 1369 (w), 1300 (w), 1231 (w), 1073 (w), 1017 (w), 910 (w), 752 (s), 702 (s). ¹H NMR (CDCl₃, 400 MHz): δ 8.43 (1H, s), 7.74 (1H, br), 7.48-7.44 (1H, t, *J* = 8.0 Hz), 7.38-7.22 (10H, m), 7.18-7.14 (1H, m), 6.93-6.88 (2H, m), 3.44 (1H, s), 3.27-3.19 (1H, m), 3.04-2.96 (1H, m), 1.48-1.27 (4H, m), 0.91 (3H, t, *J* = 7.2 Hz), 0.78 (9H, s). ¹³C NMR (CDCl₃, 100 MHz): δ 171.2, 161.5, 138.3, 138.2, 137.5, 134.9, 134.4, 134.2, 133.8, 133.7, 131.8, 131.7, 130.6, 129.0, 128.9, 128.8, 128.8, 128.7, 128.6, 85.6, 39.0, 35.1, 32.0, 27.3, 20.5, 14.0. Anal. Calcd. for C₂₉H₃₅N₂OP: C, 75.95; H, 7.69; N, 6.11. Found: C, 75.70; H, 7.86; N, 6.02; [α]_D²⁰ +42.1° (c 1.93, CHCl₃).

Representative experimental procedure for conjugate addition of dialkylzinc reagents to cyclic nitroalkenes. (CAUTION: Me₂Zn IS PYROPHORIC! USE EXTREME CAUTION!) A flame-dried 13 mm x 100 mm test tube under N₂ atmosphere is charged with 4.0 x 10¹ mg (8.0 x 10⁻³ mmol) of (CuOTf)₂ • C₆H₆, and 11 mg (1.6 x 10⁻² mmol) of **3**; the mixture is dissolved in 2.0 x 10¹ mL of toluene at 22 °C to yield a homogeneous yellow solution. The reaction mixture is stirred at 22 °C for 15 min, then cooled to 0 °C. After equilibration of the solution to 0 °C for 5 minutes, Me₂Zn (2.5 x 10⁻¹ mL of a 2M solution in toluene, 0.49 mmol) is added dropwise. The mixture is stirred at 0 °C for 15 min. 18 μL (0.16 mmol) of **1** is added via syringe, and the reaction is stirred at 4 °C. After 12 h, the reaction is treated with 2.0 x 10¹ mL of a saturated aqueous NH₄Cl solution to obtain **2b** or alternatively, a 20% H₂SO₄ solution for 15 minutes at 0 °C followed by 15 minutes at 22 °C to obtain **10**. The aqueous layer is washed with CH₂Cl₂ (3 x 2.0 x 10¹ mL) (**2b**) or alternatively Et₂O (3 x 2.0 x 10¹ mL) (**10**). The combined organic layers are passed through a plug of silica gel, concentrated in vacuo to remove CH₂Cl₂ and purified through chromatography on silica (100% pentane to remove toluene followed by 95 : 5 pentane : diethyl ether to elute product) affords (*R,S*)-**2b** (17 mg, 72% yield). GLC analysis indicated that the enantiomeric ratio of the product is 97.5 : 2.5 (95% ee) and the diastereomeric ratio is 83 : 17 syn : anti.

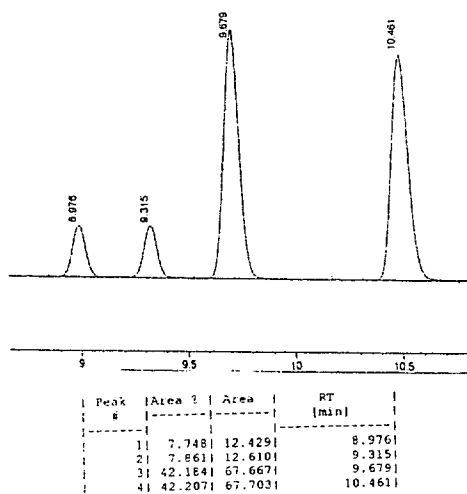
Representative experimental procedure for equilibration of diastereomeric mixtures. A flame-dried 6 dram vial with a Teflon cap is charged with 16.2 mg (0.110 mmol) of **2b** and dissolved in 1.50 mL dry Et₂O. To the mixture is added 17.0 x 10¹ μL (0.110 mmol) of DBU, and the reaction is stirred at 22 °C for 12 h. The reaction is then treated with 1.50 mL of a 0.5M aqueous CuSO₄ solution. The aqueous layer is washed with CH₂Cl₂ (3 x 2.00 x 10¹ mL), the combined organic layers are passed through a plug of silica gel and concentrated in vacuo to

afford (*S,S*)-**anti-2b** (14.9 mg, 92% yield). GLC analysis indicated that the enantiomeric ratio of the product is 97.5 : 2.5 (95% ee) and the diastereomeric ratio is 7 : 93 syn : anti.

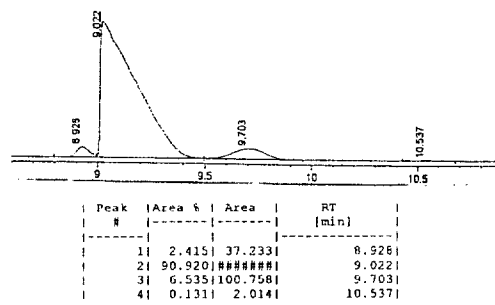


(*S,S*)-2-Methyl-1-nitrocyclohexane (2b): Colorless oil recovered in 72% yield. $R_f = 0.7$ in 95 : 5 pentane : diethyl ether. IR (NaCl): 2941 (m), 2865 (w), 1547 (s), 1459 (w), 1382 (w). ^1H NMR (CDCl_3 , 400 MHz): δ 4.54-4.50 (1H_{syn} diastereomer, m), 4.14-4.07 (1H_{anti} diastereomer, m), 2.44-2.37 (1H, m), 2.13-2.00 (1H, m), 1.93-1.81 (2H, m), 1.77-1.68 (1H, m), 1.63-1.51 (2H, m), 1.45-1.23 (2H, m), 0.95 (3H_{syn} diastereomer, d, $J = 7.2$ Hz), 0.94 (3H_{anti} diastereomer, d, $J = 6.4$ Hz). ^{13}C NMR (CDCl_3 , 100 MHz): δ 92.9, 87.4, 36.5, 33.4, 33.2, 31.9, 30.5, 26.0, 25.1, 24.6, 23.0, 21.2, 18.9, 14.3. HRMS Calcd. for $\text{C}_7\text{H}_{13}\text{NO}_2$: 97.1017 (M- NO_2). Found: 97.1021 (M- NO_2). Anal. Calcd. for $\text{C}_7\text{H}_{13}\text{NO}_2$: C, 58.72; H, 9.15; N, 9.78. Found: C, 58.75; H, 9.14; N, 10.06; $[\alpha]_D^{20} +25.0^\circ$ (c 0.83, CHCl_3) for a sample of 95% ee and 86% de giving product with (*S,S*) stereochemistry determined by comparison of the corresponding ketone reported herein.

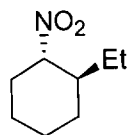
The optical purity of the conjugate addition was established by chiral GLC analysis (Chiraldex GTA column); chromatograms are illustrated below for a 95% ee sample after treatment with DBU:



authentic racemic
(*syn* is major diastereomer)

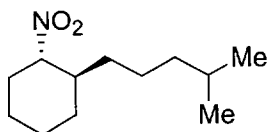
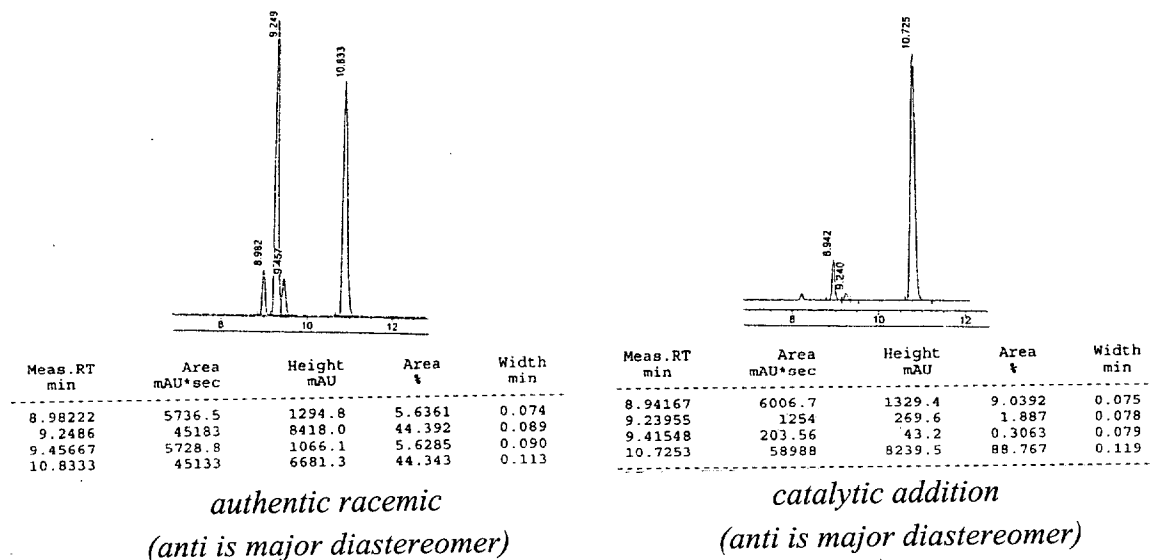


catalytic addition
(*anti* is major diastereomer)



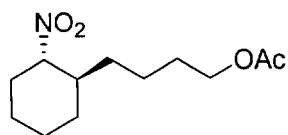
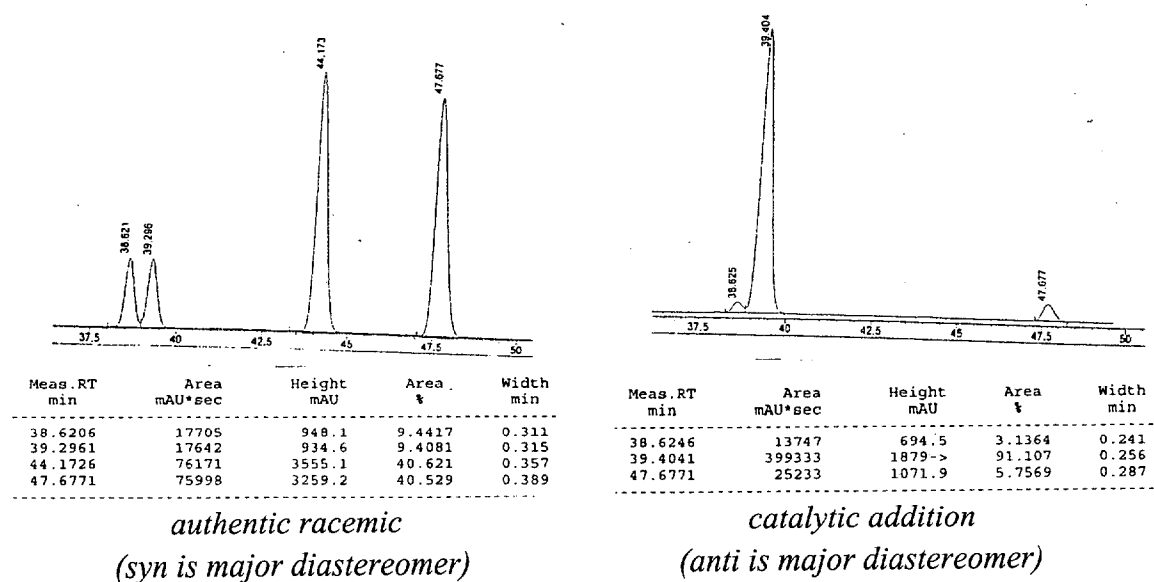
(*S,S*)-2-Ethyl-1-nitrocyclohexane (2a): Colorless oil recovered in 92% yield. $R_f = 0.7$ in 95 : 5 pentane : diethyl ether. IR (NaCl): 2936 (m), 2861 (w), 1545 (s), 1464 (w), 1376 (w). ^1H NMR (CDCl_3 , 400 MHz): δ 4.65-4.61 (1H_{syn} diastereomer, m), 4.26-4.20 (1H_{anti} diastereomer, m), 2.22-2.07 (1H, m), 1.98-1.74 (4H, m), 1.66-1.14 (6H, m), 0.92 (3H, t, $J = 7.2$ Hz). ^{13}C NMR (CDCl_3 , 100 MHz): δ 91.3, 86.6, 42.3, 40.9, 32.2, 29.2, 27.5, 26.7, 25.4, 25.0, 24.7, 22.4, 22.1, 11.8, 10.4. HRMS Calcd. for $\text{C}_8\text{H}_{15}\text{NO}_2$: 111.1174 (M- NO_2): Found: 111.1175 (M- NO_2). Anal. Calcd. for $\text{C}_8\text{H}_{15}\text{NO}_2$: C, 61.12; H, 9.62; N, 8.91. Found: C, 61.40; H, 9.49; N, 8.90; $[\alpha]_D^{20} +30.5^\circ$ (c 0.68, CHCl_3) for a sample of 96% ee and 82% de giving product with (*S,S*) stereochemistry as determined by comparison with the corresponding ketone reported herein.

The optical purity of the conjugate addition was established by chiral GLC analysis (Chiraldex GTA column); chromatograms are illustrated below for a 96% ee sample after treatment with DBU:



2-(4-Methylpentyl)-1-nitrocyclohexane (2c): Colorless oil recovered in 89% yield. $R_f = 0.8$ in 95 : 5 pentane : diethyl ether. IR (NaCl): 2931 (m), 2862 (w), 1548 (s), 1473 (w), 1375 (w). ^1H NMR (CDCl_3 , 400 MHz): δ 4.62-4.58 (1H_{syn} diastereomer, m), 4.24-4.18 (1H_{anti} diastereomer, m), 2.15-2.02 (1H, m), 1.90-1.78 (2H, m), 1.64-1.11 (13H, m), 0.87 (3H, d, $J = 1.2$ Hz), 0.85 (3H, d, $J = 1.2$ Hz). ^{13}C NMR (CDCl_3 , 100 MHz): δ 91.8, 86.8, 41.1, 33.0, 32.3, 29.9, 29.2, 28.0, 27.4, 27.2, 25.1, 24.7, 23.8, 22.9, 22.7, 22.4, 22.3. HRMS Calcd. for $\text{C}_{12}\text{H}_{23}\text{NO}_2$: 167.1799. Found: 167.1797. Anal. Calcd. for $\text{C}_{12}\text{H}_{23}\text{NO}_2$: C, 67.57; H, 10.87; N, 6.57. Found: C, 67.85; H, 10.76; N, 6.80; $[\alpha]_{\text{D}}^{20} +34.7^\circ$ (c 1.93, CHCl_3) for a sample of 93% ee and 88% de.

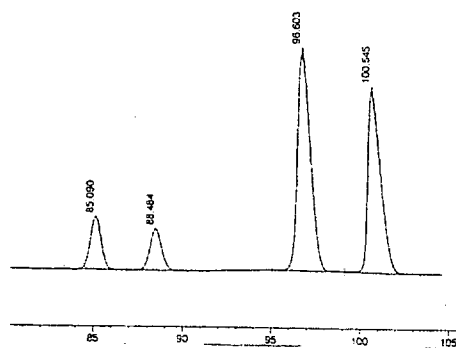
The optical purity of the conjugate addition was established by chiral GLC analysis (Chiraldex GTA column); chromatograms are illustrated below for a 93% ee sample after treatment with DBU:



2-(4-Acetoxybutyl)-1-nitrocyclohexane (2d): Colorless oil recovered in 76% yield. $R_f = 0.5$ in 2 : 1 pentane : diethyl ether. IR (NaCl): 2947 (m), 2859 (w), 1741 (s), 1547 (s), 1459 (w), 1377 (w), 1247 (m), 1047 (w). ^1H NMR (CDCl_3 , 400 MHz): δ 4.61-4.57 (1H_{syn} diastereomer, m), 4.23-4.17 (1H_{anti} diastereomer, m), 4.03 (2H, t, $J = 6.4$ Hz), 2.13-2.05 (1H, m), 2.03 (3H, s), 1.89-1.75 (4H, m), 1.63-1.49 (4H, m), 1.46-1.18 (6H, m). ^{13}C NMR (CDCl_3 , 100 MHz): δ 171.3, 91.5, 86.6, 64.4, 40.9, 39.0, 32.4, 32.2, 29.8, 28.8, 27.4, 27.1, 25.0, 24.6, 23.8, 22.6, 22.3, 21.2. HRMS

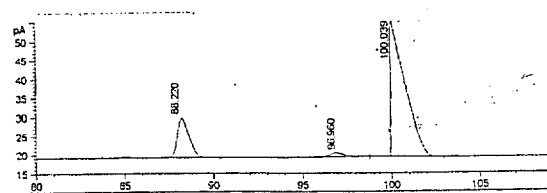
Calcd. for $C_{12}H_{23}NO_2$: 244.1549 (M+1). Found: 244.1549 (M+1). Anal. Calcd. for $C_{12}H_{23}NO_2$: C, 59.24; H, 8.70; N, 5.76. Found: C, 59.51; H, 8.81; N, 5.56; $[\alpha]_D^{20} +30.7^\circ$ (c 1.49, $CHCl_3$) for a sample of 95% ee and 88% de (determined by 1H NMR).

The optical purity of the conjugate addition was established by chiral GLC analysis (Chiraldex GTA column); chromatograms are illustrated below for a 95% ee sample:



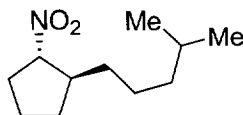
Peak #	Area 1	Area 2	RT (min)
1	5.415	169.811	85.090
2	7.740	164.192	88.484
3	45.636	166.088	96.603
4	37.205	185.233	100.545

authentic racemic
(*syn* is major diastereomer)



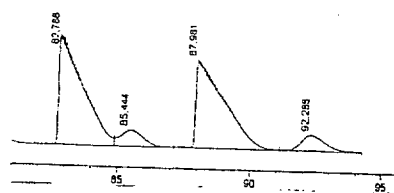
Peak #	Area 1	Area 2	RT (min)
1	18.932	493.961	88.220
2	2.104	54.893	96.560
3	70.964	#####	100.039

catalytic addition
(*syn* is major diastereomer)



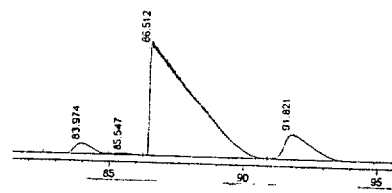
2-(4-Methylpentyl)-1-nitrocyclopentane (7): Colorless oil recovered in 61% yield. $R_f = 0.7$ in 95 : 5 pentane : diethyl ether. IR (NaCl): 2949 (s), 2880 (w), 1545 (s), 1470 (w), 1376 (m). 1H NMR ($CDCl_3$, 400 MHz): δ 4.96-4.92 ($1H_{syn}$ diastereomer, m), 4.51-4.48 ($1H_{anti}$ diastereomer, m), 2.50-2.41 (1H, m), 2.32-2.23 (1H, m), 2.15-2.02 (2H, m), 1.93-1.71 (2H, m), 1.57-1.49 (2H, m), 1.39-1.13 (6H, m), 0.86 (6H, d, $J = 6.4$ Hz). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 92.2, 90.9, 47.1, 46.6, 39.1, 39.0, 34.5, 32.3, 31.7, 31.3, 30.1, 30.0, 28.0, 27.9, 26.2, 25.6, 24.1, 23.4, 22.8, 22.7. Anal. Calcd. for $C_{11}H_{21}NO_2$: C, 66.29; H, 10.62; N, 7.03. Found: C, 66.53; H, 10.60; N, 7.02; $[\alpha]_D^{20} +29.0^\circ$ (c 1.18, $CHCl_3$) for a sample of 93% ee and 74% de.

The optical purity of the conjugate addition was established by chiral GLC analysis (Chiraldex GTA column); chromatograms are illustrated below for a 93% ee sample:



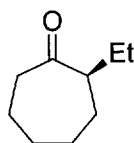
Peak #	Area %	Area	RT [min]
11	44.617	#####	82.788
21	6.519	195.769	85.444
31	42.055	#####	87.981
41	6.809	1204.464	92.288

authentic racemic
(*syn* : *anti* is 1 : 1)



Peak #	Area %	Area	RT [min]
11	3.476	145.526	83.974
21	0.457	19.155	85.547
31	83.804	#####	86.512
41	12.263	513.458	91.821

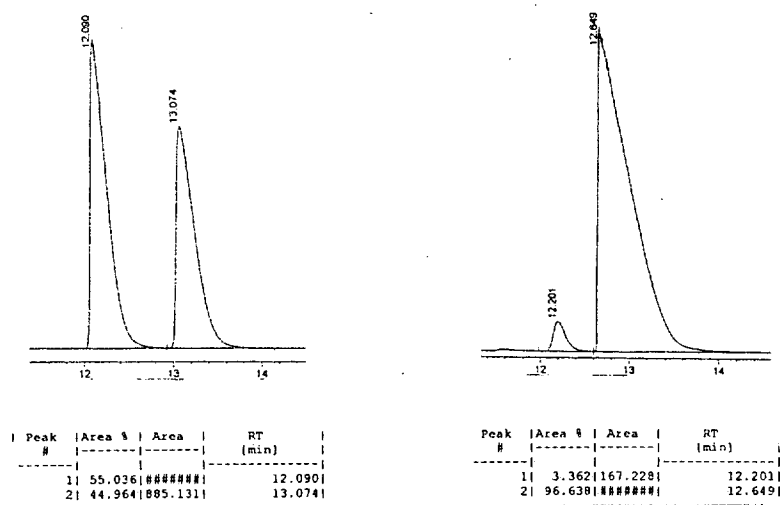
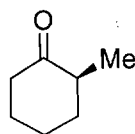
catalytic addition
(*anti* is major diastereomer)



(S)-2-Ethylcycloheptanone (9): Colorless oil recovered in 42% yield. $R_f = 0.3$ in 95 : 5 pentane : diethyl ether. IR (NaCl): 2933 (s), 2848 (m), 1713 (s), 1562 (w), 1465 (w). $^1\text{H NMR}$ (CDCl_3 , 400 MHz): δ 2.54-2.36 (3H, m), 1.88-1.83 (4H, m), 1.74-1.63 (2H, m), 1.43-1.29 (4H, m), 0.87 (3H, t, $J = 7.6$ Hz). $^{13}\text{C NMR}$ (CDCl_3 , 100 MHz): δ 216.8, 54.3, 43.0, 31.2, 29.8, 28.7, 25.6, 24.8, 12.0. HRMS Calcd. for $\text{C}_9\text{H}_{16}\text{O}$: 140.1201. Found: 140.1202. $[\alpha]_D^{20} +76.2^\circ$ (c 0.79, MeOH) for a sample of 93% ee giving product with (*S*) stereochemistry. Literature⁶ value: $[\alpha]_D^{22} -78.1^\circ$ (c 1.05, MeOH) for (*R*) product.

The optical purity of the conjugate addition was established by chiral GLC analysis (Chiraldex GTA column); chromatograms are illustrated below for a 93% ee sample:

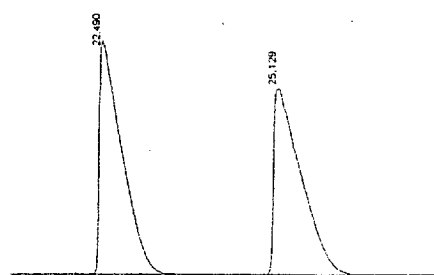
⁶ Burton, J. W.; Clark, J. S.; Derrer, S.; Stork, T. C.; Bendall, J. G.; Holmes, A. B. *J. Am. Chem. Soc.* **1997**, *119*, 7483-7498 and references cited therein.

*authentic racemic**from catalytic addition*

(S)-2-Methylcyclohexanone (10): Colorless oil recovered in 90% yield by GC (decane standard). $R_f = 0.3$ in 95 : 5 pentane : diethyl ether. IR (NaCl): 2918 (s), 2853 (m), 1737 (m), 1471 (m). ^1H NMR (CDCl_3 , 400 MHz): δ 2.44-2.25 (3H, m), 2.12-2.03 (2H, m), 1.88-1.80 (1H, m), 1.74-1.60 (2H, m), 1.44-1.19 (1H, m), 1.03 (3H, d, $J = 6.4$ Hz). ^{13}C NMR (CDCl_3 , 100 MHz): δ 213.8, 45.6, 42.1, 36.4, 28.2, 25.4, 14.9. HRMS Calcd. for $\text{C}_7\text{H}_{12}\text{O}$: 112.0888. Found: 112.0892. Anal. Calcd. for $\text{C}_7\text{H}_{12}\text{O}$: C, 74.95; H, 10.78. Found: C, 75.21; H, 10.85; $[\alpha]_D^{20} +7.8^\circ$ (c 0.48, MeOH) for a sample of 93% ee giving product with (*S*) stereochemistry. Literature⁷ value: $[\alpha]_D^{22} +12.2^\circ$ (c 4.0, MeOH) for 87% ee of (*S*) product.

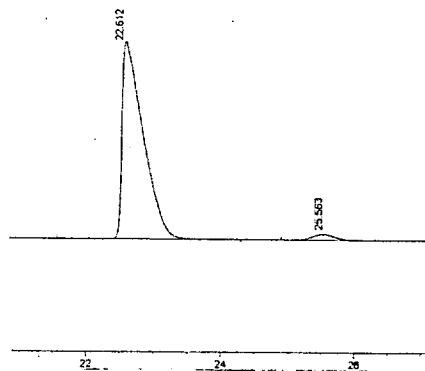
The optical purity of the conjugate addition was established by chiral GLC analysis (Chiraldex GTA column); chromatograms are illustrated below for a 93% ee sample:

⁷ Meyers, A. I.; Williams, D. R.; Erickson, G. W.; White, S.; Druehler, M. *J. Am. Chem. Soc.* **1981**, *103*, 3081-3087.



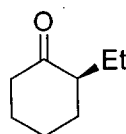
Peak #	RT [min]	Type	Width [min]	Area	Area %
11	22.490	MF	0.380	46552.168	49.826
21	25.129	FM	0.475	46877.930	50.174

authentic racemic



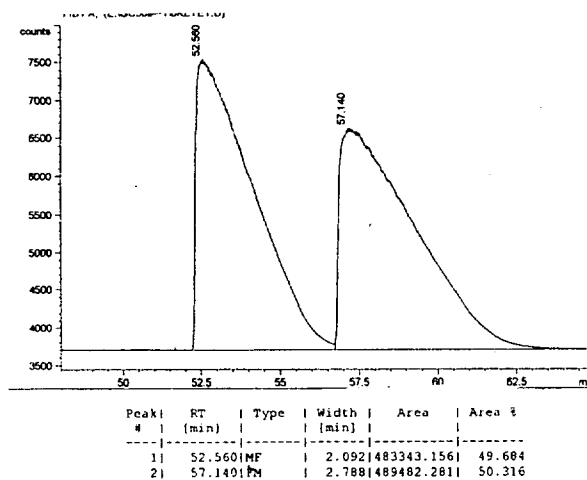
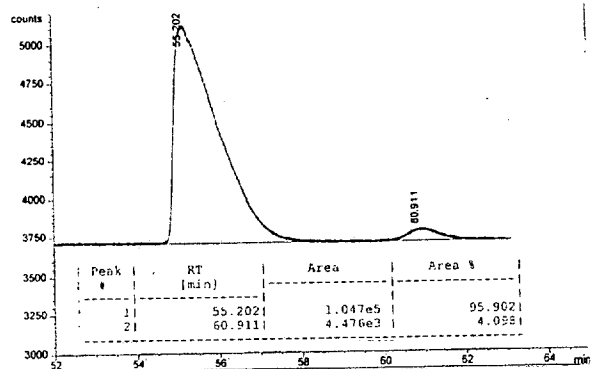
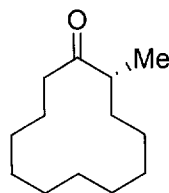
Peak #	RT [min]	Type	Width [min]	Area	Area %
11	22.612	MF	0.352	28023.805	96.532
21	25.563	MM	0.379	1006.816	3.468

from catalytic addition



(S)-2-Ethylcyclohexanone (11): Colorless oil recovered in 58% yield. $R_f = 0.3$ in 95 : 5 pentane : diethyl ether. IR (NaCl): 2928 (s), 2860 (m), 1726 (s), 1454 (w). ^1H NMR (CDCl_3 , 400 MHz): δ 2.40-1.99 (5H, m), 1.89-1.59 (4H, m), 1.43-1.20 (2H, m), 0.89 (3H, t, $J = 7.6$ Hz). ^{13}C NMR (CDCl_3 , 100 MHz): δ 213.7, 52.5, 42.2, 33.6, 28.2, 25.0, 22.6, 11.9. HRMS Calcd. for $\text{C}_8\text{H}_{14}\text{O}$: 126.1045. Found: 126.1049. $[\alpha]_D^{20} +16.7^\circ$ (c 0.79, MeOH) for a sample of 89% ee giving product with (*S*) stereochemistry. Literature⁸ value: $[\alpha]_D^{22} +24.1^\circ$ (c 4.0, MeOH) for 94% ee of (*S*) product.

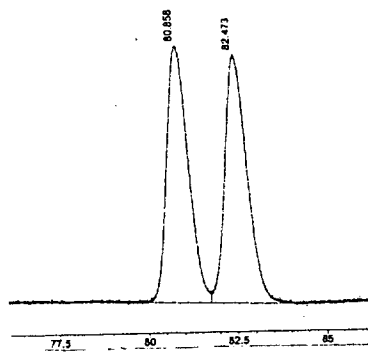
The optical purity of the conjugate addition was established by chiral GLC analysis (Chiraldex GTA column); chromatograms are illustrated below for a 92% ee sample:

*authentic racemic**from catalytic addition*

(R)-2-Methylcyclododecanone (13): Colorless oil recovered in 86% yield. $R_f = 0.5$ in 95 : 5 pentane : diethyl ether. IR (NaCl): 2939 (s), 2865 (w), 2865 (w), 1707 (m), 1468 (w). ^1H NMR (CDCl_3 , 400 MHz): δ 2.77-2.68 (1H, m), 2.62 (1H, AB, $J_{ab} = 16.2$ Hz), 2.37 (1H, AB, $J_{ab} = 16.4$ Hz), 1.75-1.68 (3H, m), 1.57-1.48 (2H, m), 1.35-1.17 (13H, m), 1.06 (3H, d, $J = 6.8$ Hz). ^{13}C NMR (CDCl_3 , 100 MHz): δ 215.8, 45.7, 37.2, 31.7, 26.0, 25.6, 24.3, 24.2, 24.0, 22.9, 22.5, 22.3, 16.9. HRMS Calcd. for $\text{C}_{13}\text{H}_{24}\text{O}$: 196.1827. Found: 196.1830. $[\alpha]_D^{20} +9.8^\circ$ (c 0.49, CHCl_3) for a sample that is of 83% ee giving product with (*R*) stereochemistry. Literature⁸ value: $[\alpha]_D^{25} +10.3^\circ$ (c 4.7, CHCl_3) for 81% ee of (*R*) product.

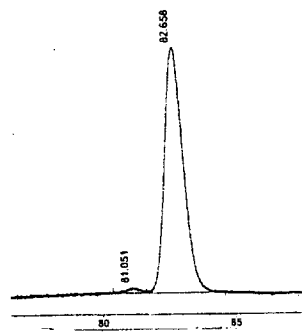
The optical purity of the conjugate addition was established by chiral GLC analysis (Chiraldex GTA column); chromatograms are illustrated below for a 96% ee sample:

⁸ Meyers, A. I.; Williams, D. R.; White, S.; Erickson, G. W. *J. Am. Chem. Soc.* **1981**, *103*, 3088-3093.



Peak #	RT [min]	Area	Area %
1	80.858	3.432e4	49.819
2	82.473	3.457e4	50.181

authentic racemic



Peak #	RT [min]	Area	Area %
1	81.051	680.358	1.526
2	82.658	4.391e4	98.474

from catalytic addition