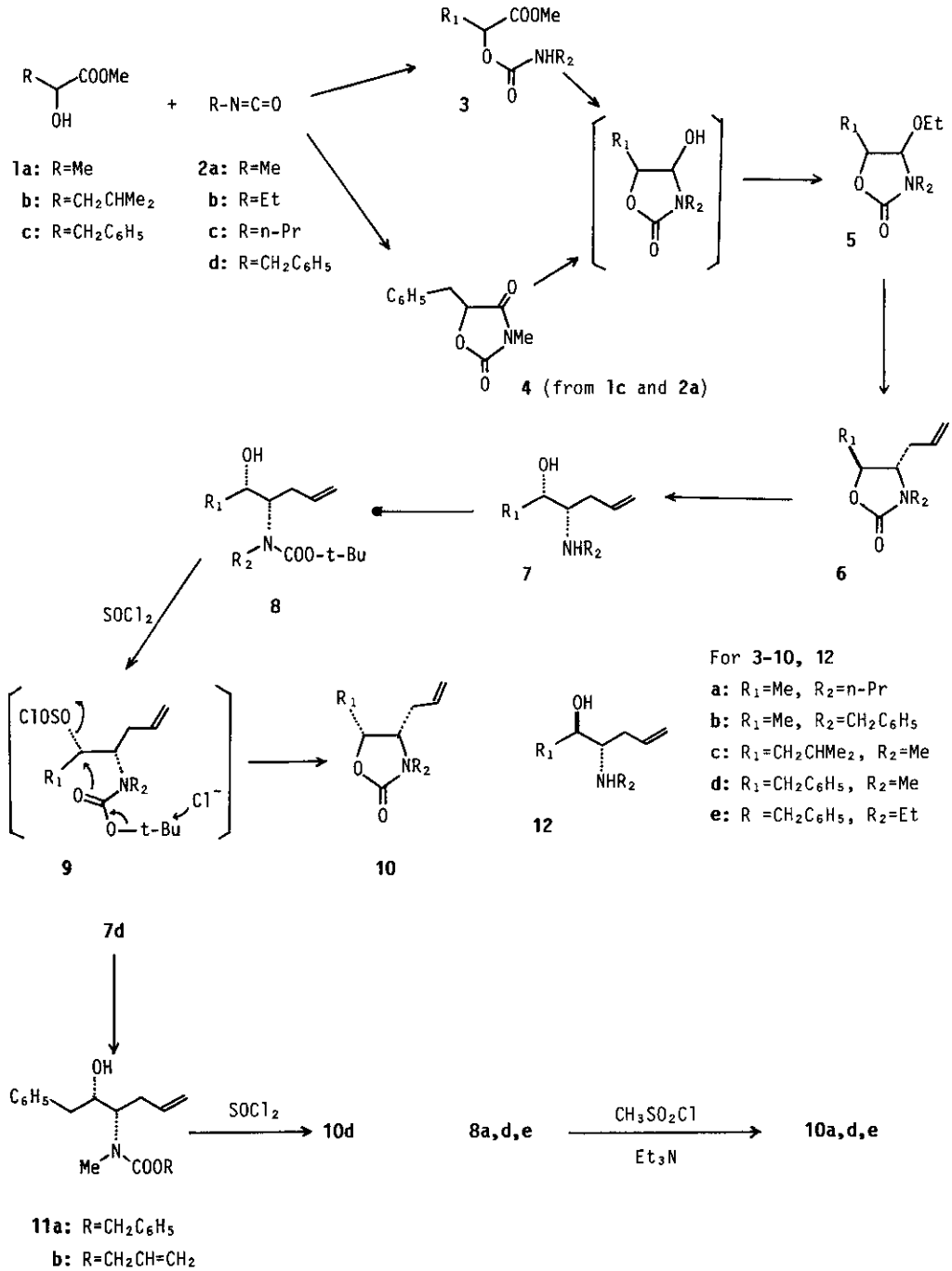
DIASTEREOCONVERSION OF THREO 2-AMINO ALCOHOLS TO ERYTHRO ISOMERS THROUGH A NEW CYCLOCARBAMATION

Shinzo Kano,* Yoko Yuasa, Tsutomu Yokomatsu, and Shiroshi Shibuya
Tokyo College of Pharmacy, 1432-1 Horinouchi, Hachioji, Tokyo 192-03, Japan

Abstract —— A diastereoconversion of threo 2-amino alcohols to erythro isomers was achieved by treatment of N-Boc derivatives with thionyl chloride or with methanesulfonyl chloride in the presence of triethylamine, hereby cis-4,5-disubstituted oxazolidin-2-ones being produced.

Recently, stereoselective construction of 2-amino alcohols have been greatly stimulated[1] in peptidomimetic chemistry and pharmacological research. Several methods for a stereochemically controlled synthesis of 2-amino alcohols have been reported.[1,2] Diastereoconversion of one isomer to another[3,4] would be an important subject from both synthetic and medicinal points of view. Recently, we reported the new facile method for diastereoconversion of 2-amino alcohols without racemization.[5] We further investigated a diastereoconversion of N-alkylated threo 2-amino alcohols, obtained through an alkylation of oxazolidin-2-one at the 4-position with high diastereoselectivty. Treatment of N-t-butoxycarbonyl threo 2-amino alcohols with thionyl chloride under the conditions reported previously[5] or with methanesulfonyl chloride in the presence of triethylamine yielded 4,5-cis-oxazolidin-2-ones, which are synthetic equivalent of erythro isomers. The results of our studies are described in this paper. At first threo 2-amino alcohols (**7a-e**) were prepared according to the method reported previously[6] with high diastereoselectivity as outlined in the Scheme 1. Reduction of the carbamates (**3a-c,e**), obtained by the reaction of **1a-c** and **2a-d**, with diisobutylaluminum hydride (DIBAL-H) followed by treatment with ethanol at pH 1-2 afforded the corresponding 4-ethoxy-5-substituted oxazolidin-2-ones (**5a-c**, **5e**), respectively. 5-Benzyl-4-ethoxyoxazolidin-2-one (**5d**) was obtained by reduction of **4** with sodium borohydride followed by treatment with ethanol at pH 1-2. The compound (**4**) was in turn obtained by condensation of methyl α-hydroxyphenylpropionate (**1c**) and methyl isocyanate (**2a**). Allylation[6] of **5a-e** with allyltrimethylsilane in the presence of titanium tetrachloride gave the corresponding trans-4-allyl-5-substituted oxazolidin-2-ones (**6a-e**) in 82-88 % yield, as a single diastereomer in all cases. Cleavage of oxazolidinone ring of **6a-e** (10 % aq. EtOH-NaOH, reflux, 10 h) gave the corresponding threo 2-amino alcohols (**7a-e**), respectively in yield shown in the Table 1. t-Butoxycarbonylation

Scheme 1


1a: R=Me
b: R=CH2CHMe2
c: R=CH2C6H5
2a: R=Me
b: R=Et
c: R=n-Pr
d: R=CH2C6H5
3
4 (from 1c and 2a)
5
6
7
8
SOCl2
9
10
12
For 3-10, 12
a: R1=Me, R2=n-Pr
b: R1=Me, R2=CH2C6H5
c: R1=CH2CHMe2, R2=Me
d: R1=CH2C6H5, R2=Me
e: R =CH2C6H5, R2=Et
7d
SOCl2
10d
8a,d,e
CH3SO2Cl
Et3N
10a,d,e
11a: R=CH2C6H5
b: R=CH2CH=CH2

of **7a-e** (Boc_2O, Et_3N, CH_2Cl_2, 0°, 4 h) gave **8a-e**, respectively. Treatment of **8a-e** with thionyl chloride (0°C → room temperature, 14 h) yielded the corresponding cis-4,5-disubstituted oxazolidin-2-ones (**10a-e**) with high diastereoselectivity. The relative configuration at 4- and 5-positions of **10a-e** was clearly determined[7] by comparison of the chemical shifts and coupling constants[7] for 4-H (δ 3.19, dt, J=5.5, 6 Hz) and 5-H (δ 4.29, dq, J=5.5, 6 Hz) of **6b** with those for 4-H (δ 3.61, dt, J=7, 6 Hz) and 5-H (δ 4.81, dq, J=7, 7 Hz) of **10b** in their ^{1}H-nmr ($CDCl_3$) spectra (see Table 1). The relative configuration of **10a,c-e** also determined as 4,5-cis without ambiguity by comparison of chemmical shifts for 4-H and 5-H of **6a,c-e** with those of **10a,c-e**, though their coupling constants are not determined precisely (see Table 1). Apparently this new cyclocarbamation reaction proceeded through S_N2 type C-O bond formation as depicted in **9**. The same reaction by the use of carbamates (**11a,b**), derived from **7d**, also afforded **10d** in 92% yield. Thus, allyl carbamate was also found to be effective for this S_N2 type cyclocarbamation as well as N-Cbz[5] and N-Boc derivatives. Next, we examined the similar diastereoconversion under non-acidic conditions. Treatment of **8a,d,e** with methanesulfonyl chloride in the presence of triethylamine (CH_2Cl_2, 0°C → room temperature, 14 h) also afforded **10a,d,e** in 85, 83 and 80 % yield, respectively. Since 4,5-cis-oxazolidin-2-ones are synthetic equivalents of erythro 2-amino alcohols (**12a-e**), this reaction establishes a new and facile method for diastereoconversion of 2-amino alcohols. The reaction described in this paper would be widely applicable to a diastereoconversion of a variety of 2-amino alcohols and the method would be superior to the other existing methods.[3,4,8]

EXPERIMENTAL

All melting points are uncorrected. ^{1}H-nmr are determined on a Varian EM-390 instrument with tetramethylsilane as an internal standard. Mass spectra (ms) are determined with a Hitachi RMU-7L instrument. Ir spectra are taken on a Hitachi 260-30 infrared spectrophotometer.

General Procedure for a Synthesis of Carbamates (3a-c,e) —— A mixture of α-hydroxy ester (**1a-c**) (50 mmol), isocyanate (**2a-d**)(55 mmol) and toluene (30 mL) was heated at 100°C for 4 h. The solvent was removed and the residual oil was purified by distillation for **3a,c** and **3b,e** were purified by column chromatography on silica gel by using benzene as an eluant. EI ms did not give M^+ ion peak but CI ms gave M^++1 ions. Yields and physical data are as follows.

Carbamate (3a) —— 95 % yield, bp 150-160°C (3 mmHg), ir ($CHCl_3$) 1720, 1750 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 0.93 (3H, t, J=7 Hz), 1.46 (3H, d, J=7 Hz), 1.34-1.74 (2H, m), 3.16 (2H, q, J=7 Hz), 3.74 (3H, s), 5.08 (1H, q, J=7 Hz).

Carbamate (3b) —— 88 % yield, ir ($CHCl_3$) 1720, 1750 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 1.41 (3H, d, J=7 Hz), 3.68 (3H, s), 4.41 (2H, d, J=6 Hz), 5.06 (1H, q, J=7 Hz), 7.27 (5H, broad s).

Carbamate (3c) —— 85 % yield, bp 110-115°C (3 mmHg), ir ($CHCl_3$) 1720, 1740 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 0.96 (6H, d, J=6 Hz), 1.33 (3H, m), 2.79 (3H, d, J=6 Hz), 3.77 (3H, s), 4.94-5.09 (1H, m).

Carbamate (3e) —— 90 % yield, ir ($CHCl_3$) 1720, 1750 cm^{-1}, ^{1}H-nmr ($CDCl_3$) 1.08 (3H, t, J=7 Hz), 3.28-3.31 (2H, m), 3.70 (3H, s), 5.14-5.29 (1H, m), 7.13-7.27 (5H, m).

5-Benzyl-3-methyloxazolidine-2,4-dione (4) —— A mixture of methyl α-hydroxyphenylpropionate (**1c**) (9 g, 50 mmol), methyl isocyante (**2a**)(8.55 g, 0.15 mmol), and toluene (25 ml) was heated at 100°C for 4 h and then pyridine (20 ml) was added to the reaction mixture and further heated at 145°C for 10 h. The solvent was evaporated and the remaining residue was chromatographed on silica gel (30 g) by using benzene as an eluant. Removal of the solvent gave **4** (8.55 g, 83 % yield) as an oil, CI ms 206 (M^++1), ir ($CHCl_3$) 1740 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 2.87 (3H, s), 3.07 (1H, dd, J=5.5, 15 Hz), 3.31 (1H, dd, J=4.5, 15 Hz), 4.98 (1H, dd, J=4.5, 5.5 Hz), 7.26 (5H, broad s).

General Procedure for a Synthesis of 4-Ethoxy-5-substituted Oxazolidin-2-ones (5a-e) —— For **5a-c,e**, to a stirred solution of **3a-c,e** (33 mmol) in toluene (50 ml) was added a solution of DIBAL-H (56 ml of 1M hexane solution, 56 mmol) at -78°C. After the stirring had been continued for 40 min at the same temperature, the mixture was decomposed with water. Inorganic precipitate was removed by filtration and the filtrate was extracted with $CHCl_3$. The extract was dried (Na_2SO_4) and evaporated. To a stirred solution of the remaining residue in EtOH (100 ml) was added conc. HCl (6 ml) at room temperature. After the stirring had been continued for 4 h, the mixture was made basic with sat. $NaHCO_3$. The solvent was evaporated and the resulting residue was extracted with $CHCl_3$. Removal of the solvent gave 4-ethoxyoxazolidin-2-ones as a 1:1 mixture of 4,5-cis- and trans-isomer; this was used for the following reaction without purificaiton. For **5d**, to a stirred solution of **4** (7 g, 34 mmol) in MeOH (100 ml) was added $NaBH_4$ (2 g, 61 mmol) in small portions under cooling below 0°C. After the stirring had been continued for 2 h, the solvent was evaporated below 40°C and the resulting residue was diluted with water and extracted with $CHCl_3$. The solvent was dried (Na_2SO_4) and evaporated. The resulting residue was treated with EtOH as above to yield the 4-ethoxy derivative which was used for the following reaction without purificaiton.

General Procedrue for a Synthesis of trans-4-Allyl-5-substituted Oxazolidin-2-ones (6a-e) —— To a solution of **5** (20 mmol) in CH_2Cl_2 (20 ml) was added $TiCl_4$ (7.3 ml of 3 M solution in Cl_2Cl_2, 22 mmol) under ice-cooling. After 3 min, allyltrimethylsilane (7.5 g, 30 mmol) was added at the same temperature. After the stirring had been continued for 12 h at room temperature, the mixture was poured onto ice-water and made basic with 28 % ammonia and extracted with $CHCl_3$. The extract was dried (Na_2SO_4) and evaporated. The resulting residue was chromatographed on silica gel (30 g). Elution with hexane-AcOEt (5:1) gave **6a-e** as an oil in all the entries. EI ms did not give M^+ ion peaks, but CI ms gave M^++1 ion. Yields and physical data are given in the Table 1.

Table 1. Yields and Physical Properties of **6a-e**, **7a-e**, **8a-e** and **10a-e**

6a 88 % yield, CI ms m/z 184 (M^++1), ir ($CHCl_3$) 1730 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 0.89 (3H, t, J=7 Hz), 1.32 (3H, d, J=6 Hz), 1.12-1.78 (2H, m), 2.14-2.60 (2H, m), 2.83-3.14 (1H, m), 3.24-3.58 (1H, m, 4-H), 4.10-4.38 (1H, m, 5-H), 5.06-5.24 (2H, m), 5.50-5.94 (1H, m)

6b 82 % yield, CI ms m/z 232 (M^++1), ir ($CHCl_3$) 1730 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 1.28 (3H, d, J=6 Hz), 2.22-2.42 (2H, m), 3.19 (1H, dt, J=5.5, 6 Hz, 4-H), 4.10 (1H, d, J=16 Hz), 4.29 (1H, d,q, J=5.5, 6 Hz, 5-H), 4.83 (1H, d, J=16 Hz), 5.03-5.23 (2H, m), 7.38 (5H, broad s).

6c 87 % yield, CI ms m/z 198 (M^++1), ir ($CHCl_3$) 1740 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 0.97 (6H, d, J=6 Hz), 1.19-2.03 (3H, m), 2.29-2.53 (2H, m), 2.85 (3H, s), 3.19-3.38 (1H, m, 4-H), 4.10-4.31 (1H, m, 5-H), 5.07-5.34 (2H, m), 5.53-5.99 (1H, m)

6d 86 % yield, CI ms m/z 232 (M^++1), ir ($CHCl_3$) 1740 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 2.14-2.30 (2H, m), 2.76 (3H, s), 2.88-2.99 (2H, m), 3.29-3.47 (1H, m, 4-H), 4.26-4.46 (1H, m, 5-H), 4.94-5.17 (2H, m), 5.36-6.13 (1H, m), 7.27 (5H, broad s).

6e 85 % yield, CI ms m/z 246 (M^++1), ir ($CHCl_3$) 1740 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 0.96 (3H, t, J=7 Hz), 2.17-2.31 (2H, m), 2.73-3.13 (3H, m), 3.27-3.67 (1H, m), 3.41-3.60 (1H, m, 4-H), 4.31-4.50 (1H, m, 5-H), 4.97-5.23 (2H, m), 5.40-5.83 (1H, m), 7.31 (5H, broad s).

7a 85 % yield, CI ms m/z 158 (M^++1), ^{1}H-nmr ($CDCl_3$) δ 0.93 (3H, t, J=7 Hz), 1.17 (3H,d, J 6 Hz), 1.26-1.62 (2H, m), 2.12-2.49 (2H, m), 2.33-2.51 (3H, m), 3.88-4.14 (1H, m), 5.03-5.26 (2H, m), 5.60-6.06 (1H, m)

7b 97 % yield, CI ms m/z 206 (M^++1), ^{1}H-nmr ($CDCl_3$) δ 1.20 (3H, d, J=6 Hz), 2.09-2.59 (3H, m), 3.33-3.59 (1H, m), 3.67 (1H, d, J=12 Hz), 3.89 (1H, d, J=12 Hz), 5.57-6.02 (1H, m),7.31 (5H, broad s)

7c 87 % yield, CI ms m/z 172 (M^++1), ^{1}H-nmr ($CDCl_3$) δ 0.90 (3H, d, J=6 Hz), 0.94 (3H, d, J 6 Hz), 1.21-1.40 (2h, m), 1.48-2.43 (3H, m), 3.23-3.50 (2H, m), 4.93-5.20 (2H, m), 5.52-5.98 (1H, m)

7d 96 % yield, CI ms m/z 206 (M^++1), ^{1}H-nmr ($CDCl_3$) δ 2.17-2.53 (2H, m), 2.41 (3H, s), 2.67-2.87 (2H, m), 3.50-3.70 (1H, m), 4.94-5.23 (2H, m), 5.56-6.03 (1H, m), 7.26 (5H, broad s).

7e 96 % yield, CI ms m/z 220 (M^++1), ^{1}H-nmr ($CDCl_3$) δ 1.08 (3H, t, J=7 Hz), 2.10-3.03 (5H, m), 3.49-3.70 (1H, m), 5.02-5.18 (2H, m), 5.59-6.06 (1H, m), 7.28 (5H, broad s)

continue

continued

8a	92 % yield, ^{1}H-nmr ($CDCl_3$) δ 0.87 (3H, t, J=7 Hz), 1.19 (3H, d, J=6 Hz), 1.46 (9H, s), 1.28-1.78 (2H, m), 2.41-2.64 (2H, m), 2.99-3.34 (3H, m), 3.71-4.00 (1H, m), 5.00-5.19 (2H, m), 5.60-6.06 (1H, m).
8b	90 % yield, ^{1}H-nmr ($CDCl_3$) δ 1.04 (3H, d, J=6 Hz), 1.50 (9H, s), 2.33-2.54 (2H, m), 3.20-3.63 (1H, m), 3.63-3.97 (1H, m), 4.37 (2H, s), 4.88-5.10 (2H, m), 4.90-5.31 (1H, m), 7.30 (5H, broad s)
8c	93 % yield, ^{1}H-nmr (CDl_3) δ 0.90 (3H, d, J=6 Hz), 0.96 (3H, d, J=6 Hz), 1.19-1.39 (2H, m), 1.46 (9H, s), 1.53-1.94 (1H, m), 2.26-2.49 (2H, m), 2.67-2.83 (1H, m), 2.78 (3H, s), 3.49-3.79 (1H, m), 4.92-5.19 (2H, m), 5.49-6.00 (1H,)
8d	92 % yield, ^{1}H-nmr ($CDCl_3$) δ 1.43 (9H, s), 2.28-2.58 (2H, m), 2.64-2.94 (1H, m), 2.79 (3H, s), 3.68-3.98 (1H, m), 4.92-5.20 (2H,m), 5.53-5.98 (1H, m), 7.27 (5H, broad s)
8e	90 % yield, ^{1}H-nmr ($CDCl_3$) δ 1.14 (3H, t, J=7 Hz), 1.48 (9H, s), 2.39-2.84 (2H,m), 3.04-3.62 (3H, m), 3.76-4.03 (1H, m), 4.97-5.19 (2H, m), 5.58-6.03 (1H, m), 7.24 (5H, broad s)
10a	90 % yield, CI ms m/z 184 (M^++1), ir ($CHCl_3$) 1730 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 0.92 (3H, t, J=7 Hz), 1.37 (3H, d, J=6 Hz), 1.18-1.70 (2H, m), 2.32-2.47 (2H, m), 2.84-3.16 (1H, m), 3.28-3.61 (1H, m), 3.70-3.97 (1H, m, 4-H), 4.50-4.80 (1H, m, 5-H), 4.62-5.04 (2H, m), 5.57-6.02 (1H, m)
10b	85 % yield, CI ms m/z 232 (M^++1), ir ($CHCl_3$) 1730 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 1.36 (3H, d, J=6 Hz), 2.24-2.41 (2H, m), 3.61 (1H, dt, J=7, 6 Hz, 4-H), 4.08 (1H, d, J 16 Hz), 4. 60 (1H, dq, J=7, 7 Hz, 5-H), 4.81 (1H, d, J=16 Hz), 4.98-5.23 (2H, m), 5.40-5.91 (1H, m), 7.30 (5H, braod s)
10c	90 % yield, CI ms m/z 198 (M^++1), ir ($CHCl_3$) 1740 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 0.93 (3H, d, J=6 Hz), 0.97 (3H, d, J=6 Hz), 1.19-2.01 (3H, m), 2.26-2.50 (2H, m), 2.83 (3H, s), 3.59-3.81 (1H, m, 4-H), 4.44-4.68 (1H, m, 5-H), 5.02-5.30 (2H, m), 5.57-6.02 (1H, m)
10d	92 % yield, CI ms m/z 232 (M^++1), ir ($CHCl_3$) 1740 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 2.40-2.57 (2H, m), 2.87 (3H, s), 2.98-3.07 (2H, m), 3.67-3.88 (1H, m, 4-H), 4.61-4.84 (1H, m, 5-H), 5.12-5.33 (2H, m), 5.64-6.10 (1H, m), 7.29 (5H, broad s)
10e	90 % yield, CI ms m/z 246 (M^++1), ir ($CHCl_3$) 1740 cm^{-1}, ^{1}H-nmr ($CDCl_3$) δ 1.17 (3H, t, J=7 Hz), 2.41-2.54 (2H, m), 2.97-3.30 (3H, m), 3.39-3.78 (1H, m), 3.79-3.98 (1H, m, 4-H), 4.58-4.81 (1H, m, 5-H), 5.09-5,31 (2H, m), 5.63-6.08 (1H, m), 7.28 (5H, broad s)

General Procedure for a Synthesis of threo 2-Amino Alcohols (7a-e) —— A mixture of **6a-e** (10 mmol), EtOH (27 ml) and 50 % NaOH (6 g) was heated under reflux for 10 h. After removal of the solvent, the remaining residue was diluted with water and extracted with $CHCl_3$. The extract was dried (Na_2SO_4) and evaported. The residual oil was chromatographed on silica gel by using $CHCl_3$ as an eluant. Removal of the solvent gave **7a-e** as an oil. Yields and physical properties of **7a-e** are listed in Table 1.

General Procedure for t-Butoxycarbonylation of 7a-e —— To a mixture of **7** (7 mmol), Et_3N (1.41 g, 14 mmol), and CH_2Cl_2 (5 ml) was added di-t-butyl dicarbonate (1.31 g, 7 mmol) under ice-cooling. After 2 h, the mixture was decomposed with water and extracted with $CHCl_3$. The extract was washed with water, dried (Na_2SO_4) and evaporated. The resulting residue was chromatographed on silica gel (15 g). Elution with hexane afforded uncharacterized product which was discarded. Successive elution with hexane-AcOEt (7:1) gave **8a-e** as an oil in all entry, ^{1}H-nmr spectral data of which were listed in the Table 1.

Benzyl Carbamate (11a) —— To a stirred mixture of **7d** (1 g, 4.88 mmol), Et_3N (1.0 g, 9.9 mmol), CH_2Cl_2 (5 ml) was added benzyl chloroformate (3.5 ml of 30 % toluene solution) under ice-cooling. After the stirring had been continued for 40 min at the same temperature, the mixture was poured onto ice-water and extracted with $CHCl_3$. The mixture was washed with 5 % HCl, water and dried (Na_2SO_4) and evaporated. The remaining oil was chromatographed on silica gel (10 g) by using hexane-AcOEt (9:1) as an eluant. Removal of the solvent gave **11a** as an oil (1.46 g, 88 % yield), ^{1}H-nmr ($CDCl_3$) δ 2.27-3.00 (5H, m), 2.89 (3H, s), 3.70-4.00 (1H, m), 4.96-5.33 (2H, m), 5.15 (2H, s), 5.51-6.00 (1H, m), 7.25 (5H, braod s), 7.36 (5H, broad s).

Allyl Carbamate (11b) —— To a stirred mixture of **7d** (1 g, 4.88 mmol), Et_3N (1.0 g, 9.9 mmol), CH_2Cl_2 (5 ml) was added a solution of allyl chloroforamte (0.62 g, 5.12 mmol) in CH_2Cl_2 (5 ml) under ice-cooling. After the stirring had been conitnued at the same temperature for 1 h, the mixture was poured onto water and extracted with $CHCl_3$. The extract was washed with 5 % HCl, water, dried (Na_2SO_4) and evaporated. The remaining residue was chromatographed on silica gel (10 g) by using hexane-AcOEt (9:1) as an eluent. Removal of the solvent gave **11b** (1.20 g, 85 % yield). ^{1}H nmr ($CDCl_3$) δ 2.31-2.58 (2H, m), 2.61-3.18 (3H, m), 2.88 (3H, s), 3.70-4.01 (1H, m), 4.52-4.66 (2H, m), 4.94-5.41 (4H, m), 5.53-6.16 (2H, m), 7.26 (5H, broad s).

General Procedure for the Reaction of 8a-e with Thionyl Chloride —— To a solution of **8a-e** (2.53 mmol) in CH_2Cl_2 (5 ml) was added $SOCl_2$ (3 g, 25.3 mmol) under ice-cooling. After the stirring had been continued for 10 h at room temperature, the mixture was poured onto ice-water and made basic with 28 % ammonia. The mixture was extracted with $CHCl_3$. The extract was washed with water, dried (Na_2SO_4) and concentrated. The remaining residue was chromatographed on silica gel. (15 g) by using

hexane-AcOEt (5:1). Removal of the solvent gave **10a-e.** These compounds were obtained as an oil except **10d**: **10d**, mp 81-82°C, Anal. Calcd for $C_{14}H_{17}NO_2$: C, 72.70; H, 7.41; N, 6.06. Found:C, 72.46; H, 7.35; N, 6.04. Yields and physical data were listed in the Talbe 1.

General Procedure for the Reaction of 11a,b with Thionyl Chloride —— To a stirred solution of **11a** (or **11b**) (2.5 mmol) in CH_2Cl_2 (5 ml) was added $SOCl_2$ (3 g, 25.3 mmol) under ice-cooling. After the stirring had been continued for 10 h at room temperature, the mixture was worked up as above to give **10d** (450 mg (78 % yield) from **11a** and 530 mg (92 % yield) from **11b**).

General Procedrue for the Reaction of 8a,d,e with Methanesulfnonyl Chloride-Triethylamine —— To a stirred solution of **8a,d,e** (5 mmol), Et_3N (1.01 g, 10 mmol), CH_2Cl_2 (5 ml) was added a solution of CH_3SO_2Cl (0.63 g, 5.5 mmol) in CH_2Cl_2 (5 ml) under ice-cooling. After the stirring had been continued for 14 h, the mixture was poured onto water and extracted with $CHCl_3$. The extract was washed with 5 % HCl, dried (Na_2SO_4) and evaporated. The remaining residue was chromatographed on silica gel (10 g) by using hexane-AcOEt (5:1) as an eluant. Removal of the solvent gave **10a** (0.76 g, 83 % yield), **10d** (0.96 g, 83 % yield), **10e** (0.98 g, 80 % yield), respectively, which were identical with those of authentic samples obtained from **8a,d,e**.

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Received, 25th January, 1988