Synthesis of Optically Active $\beta$-Amino-$\gamma$-butyrolactone Derivatives from Aspartic Acid†

Masahiko SEKI, Tamon MORIYA and Kazuo MATSUMOTO*

Research Laboratory of Applied Biochemistry, Tanabe Seiyaku Co., Ltd.,
16-89, Kashima 3-chome, Yodogawa-ku, Osaka 532, Japan
Received June 8, 1987

(3S, 4R)-3-Methoxycarbonylamo-4-phenyl-4-butanolide (4a) was prepared from L-aspartic acid by stereoselective reduction of ethyl (S)-3-methoxycarbonylamo-4-oxo-4-phenylbutyrate (3a).

$\alpha$-Amino acids have recently been attracting much attention as versatile starting materials for the preparation of a variety of optically active compounds. For example, optically active $\beta$-amino alcohols and $\alpha$-amino ketones have been synthesized by the conversion of $\alpha$-carboxyl group with complete conservation of chirality on the $\alpha$-carbon of amino acids.  

In this respect, we have reported that aspartic acid can be used as the building block of a chiral molecule to produce optically active $\beta$-amino-$\gamma$-ketobutyrate. In other examples, $\beta$-amino-$\gamma$-butyrolactone was obtained by selective reduction of the $\alpha$-amino carboxyl group of the aspartic acid skeleton, which was shown to be a key intermediate for the synthesis of polyene macrolide amphotericin B. Ohno et al. employed the same aminolactone for the synthesis of cis-carbapenem, an antibiotic of current interest.

On the other hand, the synthesis of substituted $\beta$-amino-$\gamma$-butyrolactones has scarcely been undertaken: only reported have been the 4-alkyl derivatives such as 3-acetylamino-4-ethyl-4-butanolide, which is a degradation product of the $\beta$-lactam antibiotic PS-5. Nonetheless, $\beta$-amino-$\gamma$-butyrolactones bearing an aryl group at the 4-position are generally considered to be useful starting materials for the preparation of various $\beta$-amino alcohols with significant pharmaceutical activity.

Therefore, it seemed of interest to synthesize optically active 4-aryl substituted $\beta$-amino-$\gamma$-butyrolactones. The synthetic strategy was similar to that of the non-substituted parent compound, starting from aspartic acid. Thus, reduction of the aforementioned optically active $\beta$-amino-$\gamma$-ketobutyrate was carried out in the present study.

RESULTS AND DISCUSSION

Optically active $\beta$-amino-$\gamma$-ketobutyrate (3a) was prepared from L-aspartic acid via Friedel-Crafts acylation of benzene with N-methoxycarbonyl-$\alpha$-$\l$-aspartyl chloride $\beta$-ethyl ester (2a). Since $\beta$-amino-$\gamma$-butyrolactones bearing an aryl group at the 4-position are generally considered to be useful starting materials for the preparation of various $\beta$-amino alcohols with significant pharmaceutical activity,

Therefore, it seemed of interest to synthesize optically active 4-aryl substituted $\beta$-amino-$\gamma$-butyrolactones. The synthetic strategy was similar to that of the non-substituted parent compound, starting from aspartic acid. Thus, reduction of the aforementioned optically active $\beta$-amino-$\gamma$-ketobutyrate was carried out in the present study.

RESULTS AND DISCUSSION

Optically active $\beta$-amino-$\gamma$-ketobutyrate (3a) was prepared from L-aspartic acid via Friedel-Crafts acylation of benzene with N-methoxycarbonyl-$\alpha$-$\l$-aspartyl chloride $\beta$-ethyl ester (2a). Since $\beta$-amino-$\gamma$-butyrolactones bearing an aryl group at the 4-position are generally considered to be useful starting materials for the preparation of various $\beta$-amino alcohols with significant pharmaceutical activity,

Therefore, it seemed of interest to synthesize optically active 4-aryl substituted $\beta$-amino-$\gamma$-butyrolactones. The synthetic strategy was similar to that of the non-substituted parent compound, starting from aspartic acid. Thus, reduction of the aforementioned optically active $\beta$-amino-$\gamma$-ketobutyrate was carried out in the present study.

RESULTS AND DISCUSSION

Optically active $\beta$-amino-$\gamma$-ketobutyrate (3a) was prepared from L-aspartic acid via Friedel-Crafts acylation of benzene with N-methoxycarbonyl-$\alpha$-$\l$-aspartyl chloride $\beta$-ethyl ester (2a). Since $\beta$-amino-$\gamma$-butyrolactones bearing an aryl group at the 4-position are generally considered to be useful starting materials for the preparation of various $\beta$-amino alcohols with significant pharmaceutical activity,

Therefore, it seemed of interest to synthesize optically active 4-aryl substituted $\beta$-amino-$\gamma$-butyrolactones. The synthetic strategy was similar to that of the non-substituted parent compound, starting from aspartic acid. Thus, reduction of the aforementioned optically active $\beta$-amino-$\gamma$-ketobutyrate was carried out in the present study.

RESULTS AND DISCUSSION

Optically active $\beta$-amino-$\gamma$-ketobutyrate (3a) was prepared from L-aspartic acid via Friedel-Crafts acylation of benzene with N-methoxycarbonyl-$\alpha$-$\l$-aspartyl chloride $\beta$-ethyl ester (2a). Since $\beta$-amino-$\gamma$-butyrolactones bearing an aryl group at the 4-position are generally considered to be useful starting materials for the preparation of various $\beta$-amino alcohols with significant pharmaceutical activity,

Therefore, it seemed of interest to synthesize optically active 4-aryl substituted $\beta$-amino-$\gamma$-butyrolactones. The synthetic strategy was similar to that of the non-substituted parent compound, starting from aspartic acid. Thus, reduction of the aforementioned optically active $\beta$-amino-$\gamma$-ketobutyrate was carried out in the present study.

RESULTS AND DISCUSSION

Optically active $\beta$-amino-$\gamma$-ketobutyrate (3a) was prepared from L-aspartic acid via Friedel-Crafts acylation of benzene with N-methoxycarbonyl-$\alpha$-$\l$-aspartyl chloride $\beta$-ethyl ester (2a). Since $\beta$-amino-$\gamma$-butyrolactones bearing an aryl group at the 4-position are generally considered to be useful starting materials for the preparation of various $\beta$-amino alcohols with significant pharmaceutical activity,

Therefore, it seemed of interest to synthesize optically active 4-aryl substituted $\beta$-amino-$\gamma$-butyrolactones. The synthetic strategy was similar to that of the non-substituted parent compound, starting from aspartic acid. Thus, reduction of the aforementioned optically active $\beta$-amino-$\gamma$-ketobutyrate was carried out in the present study.

RESULTS AND DISCUSSION

Optically active $\beta$-amino-$\gamma$-ketobutyrate (3a) was prepared from L-aspartic acid via Friedel-Crafts acylation of benzene with N-methoxycarbonyl-$\alpha$-$\l$-aspartyl chloride $\beta$-ethyl ester (2a). Since $\beta$-amino-$\gamma$-butyrolactones bearing an aryl group at the 4-position are generally considered to be useful starting materials for the preparation of various $\beta$-amino alcohols with significant pharmaceutical activity,

Therefore, it seemed of interest to synthesize optically active 4-aryl substituted $\beta$-amino-$\gamma$-butyrolactones. The synthetic strategy was similar to that of the non-substituted parent compound, starting from aspartic acid. Thus, reduction of the aforementioned optically active $\beta$-amino-$\gamma$-ketobutyrate was carried out in the present study.

RESULTS AND DISCUSSION

Optically active $\beta$-amino-$\gamma$-ketobutyrate (3a) was prepared from L-aspartic acid via Friedel-Crafts acylation of benzene with N-methoxycarbonyl-$\alpha$-$\l$-aspartyl chloride $\beta$-ethyl ester (2a). Since $\beta$-amino-$\gamma$-butyrolactones bearing an aryl group at the 4-position are generally considered to be useful starting materials for the preparation of various $\beta$-amino alcohols with significant pharmaceutical activity,

Therefore, it seemed of interest to synthesize optically active 4-aryl substituted $\beta$-amino-$\gamma$-butyrolactones. The synthetic strategy was similar to that of the non-substituted parent compound, starting from aspartic acid. Thus, reduction of the aforementioned optically active $\beta$-amino-$\gamma$-ketobutyrate was carried out in the present study.

RESULTS AND DISCUSSION

Optically active $\beta$-amino-$\gamma$-ketobutyrate (3a) was prepared from L-aspartic acid via Friedel-Crafts acylation of benzene with N-methoxycarbonyl-$\alpha$-$\l$-aspartyl chloride $\beta$-ethyl ester (2a). Since $\beta$-amino-$\gamma$-butyrolactones bearing an aryl group at the 4-position are generally considered to be useful starting materials for the preparation of various $\beta$-amino alcohols with significant pharmaceutical activity,
In general, N-benzyloxy carbonyl derivatives are more versatile and practical than the N-methoxy carbonyl derivatives. Regarding the synthesis of the N-benzyloxy carbonyl derivative, Buckley and Rapoport have already examined the Friedel–Crafts acylation using N-benzyloxy carbonyl-L-alanyl chloride and its N-methyl derivative. They demonstrated the process to be very sluggish, being accompanied by complete cleavage of the benzyloxy carbonyl group. Moreover, the integrity of the product was not established.

We then also examined the Friedel–Crafts reaction using the N-benzyloxy carbonyl-α-D-aspartyl chloride β-methyl ester. The acid chloride was generated by a similar procedure to that for the N-methoxy carbonyl derivative and subjected to Friedel–Crafts reaction using aluminum chloride and benzene. In this case, the N-benzyloxy carbonyl group was completely cleaved, the deblocked product bearing the free amino group being monitored by TLC. It was then treated with benzyloxy carbonyl chloride and sodium bicarbonate to afford the target (3d) in a 20% yield. The optical purity of 3d was estimated to be 62% e.e. by 1H-NMR, using (-)-PrDPPM as a shift reagent. This low yield of the product was due to decarboxylation, considerable foaming being observed during the reaction.

The reduction of the optically active ketone compound (3a) was investigated using four different reducing agents, the results being summarized in Table II. Using phenyl(dimethyl)silane in trifluoroacetic acid as a reducing agent, trans-β-methoxycarbonylamino-γ-butyrolactone (4a) was directly obtained with high stereoselectivity from 3a (trans/cis = 92/8) in an 87% yield; the intermediate γ-hydroxy-β-amino ester corresponding to 4a was spontaneously cyclized. The diastereomer ratio was clearly determined by 1H-NMR spectra, in which the benzylic proton of the trans isomer appeared at 5.42 ppm as a doublet with a coupling constant of 3.6 Hz, while the signal of the cis isomer appeared at 5.64 ppm as a doublet with a coupling constant of 6.0 Hz.

On the other hand, reduction with phenyl(dimethyl)silane in hexamethyldisilazane triamine (HMPA) and tetra-n-butylammonium fluoride7 did not show such high selectivity. In the case of sodium borohydride or catalytic hydrogenation, selectivity was hardly observed as shown in Table II.

Estimation of the e.e. of the aminolactone (4a) was carried out by conversion to (+)-α-methoxy-α-(trifluoromethyl)phenylacetamide (MTPA amide). The methoxycarbonyl group was deblocked to an aminolactone (9) by...
refluxing in 6 N-hydrochloric acid for 1 hr in a 46.2% yield. Subsequently, this was converted to an MTPA amide (10) by the reported method.\(^8\) The standard racemic trans derivative (8) was prepared via highly stereoselective hydrogenation of racemic β-benzylloxy-carbonylamino-γ-ketobutyrate (6). In the case of the \(^1\)H-NMR spectrum of the MTPA amide of the racemic standard (8), two pairs of signals of benzylic methine and methylene protons were clearly observed. On the other hand, the MTPA amide (10) showed only one pair of signals. Thus, the aminolactone (9) was shown to be >95% enantiomerically pure.

Thus, aspartic acid was recognized as one of the most efficient materials for the synthesis of optically active 4-phenyl substituted β-amino-γ-butyrolactone via β-amino-γ-ketobutyrate with high stereoselectively.

### Table II: Synthesis of Optically Active β-Amino-γ-butyrolactone (4)

<table>
<thead>
<tr>
<th>Reducing agent</th>
<th>Temp (°C)</th>
<th>Period (hr)</th>
<th>4a/4b</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhMe₂SiH/TFA</td>
<td>0</td>
<td>16</td>
<td>92/8</td>
<td>87</td>
</tr>
<tr>
<td>PhMe₂SiH/n-Bu₄NF, HMPA</td>
<td>0</td>
<td>16</td>
<td>74/26</td>
<td>24</td>
</tr>
<tr>
<td>NaBH₄</td>
<td>5</td>
<td>1</td>
<td>64/36</td>
<td>77</td>
</tr>
<tr>
<td>H₂/Pd-C</td>
<td>20</td>
<td>11</td>
<td>47/53</td>
<td>93</td>
</tr>
</tbody>
</table>

**Scheme 2.**

**Scheme 3.**
EXPERIMENTAL

Melting points (mp) were measured on a Yamato melting point apparatus and are uncorrected. IR spectra were recorded on a Shimadzu IR-27G infrared spectrophotometer. NMR spectra were obtained using Hitachi R-40 and JEOL FX-100S NMR spectrometers with Me$_4$Si as the internal standard. Mass spectra were taken on a Hitachi RMU-6M spectrometer at an ionizing potential of 30 eV. Optical rotations were taken on a Perkin-Elmer 241 polarimeter, and column chromatography was accomplished using Kieselgel 60 (230~400 mesh, Merck).

**Ethyl (S)-3-methoxycarbonylamo-4-oxo-4-phenylbutyrate** (3a). This was prepared from 1a in a 40% yield by following the reported procedure.$^{14}$ mp 57~59°C (lit.$^{14}$ mp 57~59°C). [α]$^2_0^{\text{D}}$ = 88.9° (c = 2, MeOH) (lit.$^{14}$ [α]$^2_0^{\text{D}}$ = 88.3° (c = 2, MeOH)).

**Ethyl (R)-3-methoxycarbonylamino-4-oxo-4-phenylbutyrate** (3b). According to the procedure described for the preparation of 3a, 3b was obtained from 1b in a 52% yield. The IR, NMR and mass spectra were the same as those of 3a. [α]$^2_0^{\text{D}}$ = 88.9° (c = 2, MeOH).

**Ethyl (S)-3-methoxycarbonylamino-4-oxo-4-tolylbutyrate** (3c). The acid chloride (2a) prepared from 1a (7.44 g, 0.034 mol) and PCl$_5$ (7.07 g, 0.034 mol) in Et$_2$O (100 ml) by the same procedure as that mentioned for 3a was dissolved in toluene (80 ml), and then AlCl$_3$ (12.5 g, 0.102 mol) was added with ice-cooling. The mixture was stirred overnight at room temperature and subjected to a similar work-up to that for 3a to afford 3c (2.99 g, 30%) mp 78~79°C. IR $v_{\max}$ (Nujol) cm$^{-1}$: 3320, 1790, 1690; NMR δ (CDCl$_3$): 1.21 (3H, t, J = 7.0 Hz), 2.41 (3H, s), 2.60~3.05 (2H, m), 3.69 (3H, s), 4.10 (2H, q, J = 7.0 Hz), 5.18~5.62 (1H, m), 5.62~6.00 (1H, br.), 7.24 (2H, d, J = 8.1 Hz), 7.84 (2H, d, J = 8.1 Hz); MS m/z: 293 (M$^+$), [α]$^2_0^{\text{D}}$ = 82.2° (c = 2, MeOH). Anal. Found: C, 61.24; H, 6.48; N, 4.83. Calcd. for C$_{18}$H$_{19}$NO$_3$: C, 61.42; H, 6.53; N, 4.78%.

**Ethyl (R)-3-benzoxycarbonylamino-4-oxo-4-phenylbutyrate** (3d). The acid chloride (2c) was generated from 1c (11.2 g, 0.04 mol), PCl$_5$ (8.33 g, 0.04 mol) and Et$_2$O (120 ml) by a similar procedure to that for 3a. Then, 2c was dissolved in abs. benzene, and AlCl$_3$ (10.7 g, 0.08 mol) was added with ice-cooling. The mixture was stirred overnight at room temperature. The reaction was quenched with dil. HCl (the product bearing a free amino group, TLC Rf: 0.4 (CHCl$_3$; MeOH : AcOH = 85 : 15 : 3)). The aqueous layer was separated, washed with EtOAc and neutralized by adding 2N-NaOH with ice-cooling. Into the aqueous solution, NaHCO$_3$ (10 g, 0.12 mol) and benzoxycarbonyl chloride (6.82 g, 0.04 mol) were added with ice-cooling, and the mixture was vigorously stirred for 1 hr. After acidifying the reaction mixture to pH 4.0 with dil. HCl, the product was extracted with EtOAc. The crude product was chromatographed on SiO$_2$-gel (n-hex : EtOAc = 1 : 1) to afford 3d (2.73 g, 20%), mp 51~52°C. IR $v_{\max}$ (Nujol) cm$^{-1}$: 3320, 1730, 1690; NMR δ (CDCl$_3$): 2.60~3.40 (2H, m), 3.62 (3H, s), 5.06 (2H, s), 5.41~5.64 (1H, m), 5.70~6.02 (1H, br.), 7.02~7.64 (3H, m), 7.84~8.02 (2H); MS m/z: 341 (M$^+$), [α]$^2_0^{\text{D}}$ + 51.8° (c = 0.5, MeOH).

**PhMe$_3$SiH/TFA.** Into the α-amino ketone (3a, 1.5 g, 5.38 mmol) in CF$_3$CO$_2$H (9 ml) was added PhMe$_3$SiH (890 mg, 6.53 mmol) at 0°C, and the mixture was stirred at 0°C for 16 hr. After evaporating the solvent, the product was extracted with EtOAc. The combined EtOAc solution was successively washed with H$_2$O, sat. aq. NaHCO$_3$ and H$_2$O, dried over MgSO$_4$, and evaporated to afford a mixture of 4a and 4b (1.1 g, 87%). 4a and 4b (92:8). The mixture was separated by SiO$_2$-column chromatography (n-hex : EtOAc = 1 : 1). 4a, mp 107~109°C. IR $v_{\max}$ (Nujol) cm$^{-1}$: 3320, 1790, 1690; NMR δ (CDCl$_3$): 2.54 (1H, dd, J = 4.5 and 18 Hz), 2.90 (1H, dd, J = 7.5 and 18 Hz, 3.65 (3H, s), 4.10~4.30 (1H, m), 5.42 (1H, d, J = 3.6 Hz), 5.68 (1H, d, J = 6.0 Hz), 7.28 (5H, s), MS m/z: 235 (M$^+$), [α]$^2_0^{\text{D}}$ = 28.9° (c = 1, EtOH).

**PhMe$_3$SiH/n-Bu$_4$NF.** HMPA. To a solution of 3a (700 mg, 2.51 mmol) in HMPA (5 ml) were added n-Bu$_4$NF (1 N in hexane, 0.126 ml, 0.126 mmol) and PhMe$_3$SiH (411 mg, 3.01 mmol). The mixture was stirred at 0°C for 16 hr, before the reaction was quenched with H$_2$O and the product was extracted with EtO$_2$O. The combined EtO$_2$O solution was washed with H$_2$O, dried over MgSO$_4$, and evaporated. The residue was dissolved in CF$_3$CO$_2$H (5 ml) and evaporated. The crude product was chromatographed on SiO$_2$-gel (n-hex : EtOAc = 1 : 1) to afford a mixture of 3a and 4b (140 mg, 24%). 4a and 4b (74:26).

**NaBH$_4.$** Into a solution of 3a (1.5 g, 5.38 mmol) in MeOH (20 ml) was added portionwise NaBH$_4$ (305 mg, 8.07 mmol) with ice-cooling. After stirring for 5°C for 1 hr,
AcOH was added and the mixture was evaporated. The product was extracted with EtOAc, before the combined EtOAc solution was washed with H2O, dried over MgSO4 and evaporated. The residue was treated with CF3CO2H (5 ml) and evaporated. The crude product was chromatographed on SiO2-gel (n-hex : EtOAc = 1:1) to afford a mixture of 4a and 4b (970 mg, 77%. a/b = 64/36).

H2/Pd-C. A mixture of 3a (1 g, 3.58 mmol) and 10% Pd-C (200 mg) in EtOH (10 ml) was shaken under 3.5 kgf/cm2 of H2 at 20°C for 11 hr. The mixture was then filtered and the filtrate was evaporated. The residue was treated with CF3CO2H (5 ml) and evaporated. The crude product was chromatographed on SiO2-gel (n-hex : EtOAc = 1:1) to afford 4a and 4b (780 mg, 93%. a/b = 47/53).

1-Butyl 3-benzoyloxy carbonyl amino-4-oxo-4-phenylbutyrate (6). Into a suspension of 61.4% NaH (17.2 g, 0.456 mol) in DMF (300 ml) was added dropwise a solution of 5 (81 g, 0.423 mol) and 1-butyl bromoacetate (86.8 g, 0.445 mol) in DMF (610 ml) at -40 to -50°C. After stirring for 1 hr at 10°C, the mixture was poured into ice-cooled water. The product was extracted with Et2O. The combined ether solution was washed with H2O, dried over MgSO4 and evaporated. The crude product was chromatographed on SiO2-gel (n-hex : CHCl3 : EtOAc = 5:5:1) to afford 6 (96 g, 59.2%). mp 69-70°C. IR (Nujol) cm⁻¹: 3250, 1715, 1680; NMR δ (CDCl3): 1.38 (9H, s), 2.65 (1H, dd, J = 6.0 and 15Hz), 2.92 (1H, dd, J = 6.0 and 15Hz), 5.12 (2H, s), 5.40 ~ 5.70 (1H, m), 5.70 ~ 6.10 (1H, br.), 7.80 ~ 8.15 and 7.20 ~ 7.70 (10H, m); MS m/z: 384 (M⁺). Anal. Found: C, 68.75; H, 6.52; N, 3.68. Calcd. for C22H25NO5: C, 68.91; H, 6.57; N, 3.65%.

trans-3-Amino-4-phenyl-4-butanolid hydrochloride (7). To a solution of 6 (1.7 g, 4.4 mmol) in EtOH (30 ml) were added conc. HCl (1.1 ml) and 10% Pd-C (500 mg), the whole being shaken under 3.5 kgf/cm2 of H2 for 1 hr. The mixture was filtered and the filtrate was evaporated. The resulting solid was recrystallized from MeOH-Et2O to afford 7 (780 mg, 82%). mp 231 ~ 232°C (dec.). IR (Nujol) cm⁻¹: 1780, 1690, NMR δ (DMSO-d6): 2.72 (1H, dd, J = 4.5 and 18 Hz), 3.18 (1H, dd, J = 4.5 and 18 Hz), 3.82 ~ 4.10 (1H, m), 5.66 (1H, d, J = 3.0 Hz), 7.15 ~ 7.50 (5H, m), 8.60 ~ 9.25 (3H, br.). MS m/z: 177 (M⁺ - HCl). Anal. Found: C, 56.29; H, 5.54; N, 6.55; Cl, 16.49. Calcd. for C10H12ClNO2: C, 56.21; H, 5.66; N, 6.56; Cl, 16.59%.

(3S,4R)-3-Amino-4-phenyl-4-butanolid hydrochloride (9). A mixture of 4a (0.6 g, 2.55 mmol) and 6N HCl (10 ml) was refluxed for 2 hr. After evaporating the mixture, the product was crystallized by adding Et2O to afford 9 (250 mg, 46%). mp 245 ~ 248°C (dec). IR (Nujol) cm⁻¹: 1775. The NMR and mass spectra were identical with 7. [α]D²⁰ +29.4° (c = 0.5, EtOH). Anal. Found: C, 56.17; H, 5.57; N, 6.53; Cl, 16.43. Calcd. for C10H12ClNO2: C, 56.21; H, 5.66; N, 6.56; Cl, 16.59%.

General procedure for the preparation and analysis of (+)-x-methoxy-x-(trifluoromethyl)phenylacetamides (8, 10). Into a suspension of aminoalcohol (7 or 9, 31.6 mg, 0.148 mmol) in CCl4 (0.45 ml) were added (+)-MTPA-chloride (37.9 mg, 0.15 mmol) and pyridine (0.3 ml). After standing at room temperature overnight, H2O (1 ml) and Et2O (20 ml) were added, and the Et2O layer was successively washed with dil. HCl, sat. aq. NaHCO3 and H2O, dried over MgSO4 and finally evaporated. The residue was dissolved in CDCl3 (0.3 ml) and subjected to 1H-NMR measurement.

REFERENCES


6) (+) or (-)-Tris[di(perfluoro-2-propoxypropionyl) methanate]praseodymium (III) ((+) or (-)-PrDP- PM) was purchased from Daiichi Kagakuyakuhin Co., Ltd., $[\alpha]_D^{17} + 51.1^\circ$ ($c = 3.08$, $C_2Cl_3F_3$).
