July, 1985] Bull. Chem. Soc. Jpn., 58, 1991—1999 (1985)

Nucleophilic Aminomethylation of Aldehydes with α-Amino Alkylsilanes

Otohiko TSUGE,* Junji TANAKA, and Shuji KANEMASA
*Research Institute of Industrial Science, and Department of Molecular Science and Technology,
Interdisciplinary Graduate School of Engineering Sciences, Kyushu University,
Kasugakoen, Kasuga 816*
(Received March 14, 1985)

Fluoride-induced desilylation of (α-phthalimido-, α-morpholino-, and α-acetamidobenzyl)silanes and a (phthalimidomethyl)silane generates the corresponding α-amino carbanions which add to a variety of aldehydes. The conversion of phthalimido group of the adducts into amino moiety leads to β-amino alcohols. This simple reaction sequence offers a new and general method of nucleophilic aminomethylation.

Removal of a proton from a carbon adjacent to nitrogen leads to an α-amino carbanion synthon which is important for nucleophilic aminomethylation. However, deprotonation at the α-position of amines is generally quite difficult since the α-hydrogen is not highly acidic.1) When the nitrogen bears a strongly electron-withdrawing substituent or the nitrogen is incorporated in a system in which an anion formed can be stabilized by delocalization, some successful deprotonation has been achieved.2) Thus, such dipole-stabilized α-amino carbanions3,4) as α-metalated amides, *N*-nitrosoamines, amidines, amine oxides and such resonance-stabilized α-amino carbanions5,6) as α-metalated imines, isocyanides are now available and have found wide applications in organic synthesis.

Although not widely developed so far, the use of isolable organometallic compounds with an amino moiety at the α-position offers a fascinating access to the α-amino carbanions. One example is the transmetalation reaction of (α-amino alkyl)tins with alkyllithiums leading to α-amino carbanions of nonstabilized type.7,8) This method would be useful in organic synthesis if the starting α-amino organometallic compounds are readily available, because the regioselective carbanion generation that is difficult at the α-position of amino substituent could be possible even if some other more acidic hydrogens are present in the same molecule.9)

It has been recently reported that (α-alkoxybenzyl)silanes are smoothly desilylated by the action of a fluoride ion forming α-alkoxy carbanions which react with a variety of carbonyl compounds as a useful synthon for nucleophilic hydroxymethylation.10) As this method has an advantage of regioselective carbanion formation under nearly neutral conditions, its extention to other hetero-substituted silanes has been investigated.

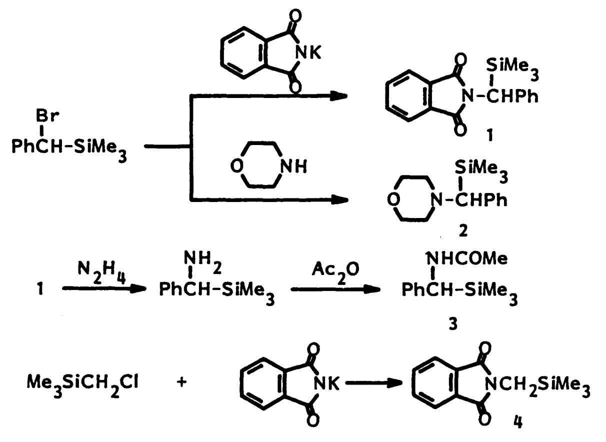
The present paper describes a new approach to nucleophilic aminomethylation using α-aminobenzylsilanes and an aminomethylsilane which carry phthalimido, morpholino, and acetamido moieties as amino substituents.

Results and Discussion

(α-Amino alkyl)silanes were synthesized by the reactions of readily available (α-halo alkyl)silanes with amines as shown in Scheme 1. Thus, (α-phthalimidobenzyl)trimethylsilane **1** and (α-morpholinobenzyl)trimethylsilane **2** were obtained in excellent yields in the reactions of (α-bromobenzyl)trimethylsilane, prepared by the bromination of benzyltrimethylsilane with *N*-bromosuccinimide,11) with potassium phthalimide and morpholine, respectively. Hydrazinolysis of **1** provided (α-aminobenzyl)trimethylsilane which was then acetylated to give (α-acetamidobenzyl)trimethylsilane **3**. Phthalimidomethyltrimethylsilane **4** was obtained from the reaction of potassium phthalimide with (chloromethyl)trimethylsilane which was commercially available.

α-Amino carbanion formation from the α-aminobenzylsilanes **1**, **2**, and **3** was accomplished by the action of a fluoride ion in such aprotic polar solvents as *N*,*N*-dimethylformamide (DMF) and hexamethylphosphoric triamide (HMPA) at room temperature, and the carbanions generated were attempted to capture with aldehydes as β-amino alcohols.

The reaction of **1** with benzaldehyde (1 equiv) in the presence of cesium fluoride (1 equiv) in dry DMF,



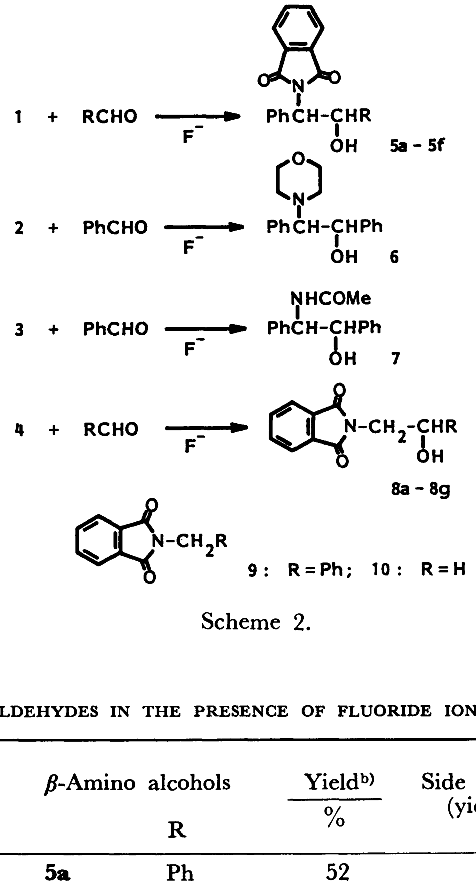
Scheme 1.

at room temperature under nitrogen, furnished a mixture of erythro and threo isomers (1:1) of 1,2-diphenyl-2-phthalimidoethanol **5a** as shown in Scheme 2 and Table 1. Each isomer of **5a** was separable from the other through a flash chromatography over silica gel, their structures being confirmed by their conversion into the known erythro and threo isomers of 2-amino-1,2-diphenylethanol as mentioned later.

The same reaction was carried out as well by the use of a catalytic amount of tetrabutylamonium fluoride (TBAF) under similar conditions. As a solvent, HMPA could be effectively employed, but separation of the solvent from the crude reaction mixture was rather annoying. The reaction in tetrahydrofuran (THF) was found not practical because only a very sluggish reaction occurred in this solvent.

Other aldehydes such as *p*-substituted benzaldehydes (*p*-methyl- and *p*-methoxybenzaldehyde), a heteroaromatic aldehyde (2-furancarbaldehyde), and an α,β-unsaturated aldehyde (cinnamaldehyde) also successfully reacted with **1** under similar conditions giving good to fair yields of the corresponding β-phthalimido-β-phenyl alcohols **5b** to **5e**. In all cases, the ratios of erythro and threo isomers were found to be 1:1, and their separation was carried out without any difficulty through a flash chromatography over silica gel. In the reaction of **1** with an aliphatic aldehyde (butanal), comparable amounts of the desired adduct **5f** and *N*-benzylphthalimide **9** were obtained. The formation of **9** as a protodesilylated product of **1** might be because the aldehyde carries acidic α-hydrogens which could protonate the carbanion species generated from **1** resulting in the formation of **9** and also the decrease of the yield of **5f**. The erythro/threo ratio in this case was 1/2, their separation being easy.

Trapping the α-amino carbanion of **1** with ketones (cyclohexanone and acetophenone), an imine (*N*-benzylideneaniline), and an α,β-unsaturated ester (methyl crotonate) was all unsuccessful. The only



Scheme 2.

TABLE 1. REACTIONS OF α-AMINOALKYLSILANES 1—4 WITH ALDEHYDES IN THE PRESENCE OF FLUORIDE ION

α-Amino-silanes	Aldehydes	Reaction conditions[a] Fluoride (equiv)	Temp °C	Time h	β-Amino alcohols	R	Yield[b] %	Side products (yield/%)
1	PhCHO	CsF (1)	rt	8	**5a**	Ph	52	
1	PhCHO	TBAF (0.05)	rt	12	**5a**	Ph	62	
1	*p*-MeC_6H_4CHO	CsF (0.1)	rt	12	**5b**	*p*-MeC_6H_4	59	
1	*p*-$MeOC_6H_4CHO$	TBAF (0.05)	rt	16	**5c**	*p*-$MeOC_6H_4$	67	
1	2-furyl-CHO	TBAF (0.05)	rt	6	**5d**	2-furyl	75	
1	PhCH=CHCHO (t)	TBAF (0.05)	rt	12	**5e**	PhCH=CH (t)	74	
1	*n*-PrCHO	TBAF (0.05)	rt	18	**5f**	*n*-Pr	37	**9** (39)
2	PhCHO	CsF (1)	rt	16	**6**		67	
3	PhCHO	TBAF (1)	rt	16	**7**		57	
4	PhCHO	TBAF (0.05×2)	100	6+2	**8a**	Ph	60	**10** (16)
4	*p*-MeC_6H_4CHO	TBAF (0.05×2)	100	2+6	**8b**	*p*-MeC_6H_4	41	**10** (20)
4	*p*-$MeOC_6H_4CHO$	TBAF (0.05×2)	100	2+16	**8c**	*p*-$MeOC_6H_4$	38	**10** (22)
4	2-furyl-CHO	TBAF (0.05×2)	100	2+16	**8d**	2-furyl	49	**10** (20)
4	PhCH=CHCHO (t)	TBAF (0.05×2)	100	2+2	**8e**	PhCH=CH (t)	24	**10** (31)
4	*n*-PrCHO	TBAF (0.05×2)	100	2+8	**8f**	*n*-Pr	36	**10** (26)
4	Me_3CCHO	TBAF (0.05×2)	100	2+2	**8g**	Me_3C	28	**10** (39)

a) In the reactions of **4**, TBAF was added in two portions at the time intervals shown in Table. b) Isolated yields as mixtures of erythro and threo isomers with the ratio of 1:1 in all cases of **5** to **7** except for **5f** which is composed of 1:2 erythro/threo isomers.

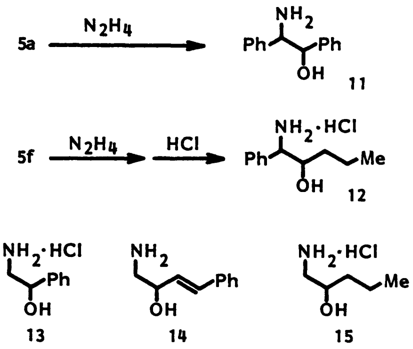
isolated product from **1** was **9** in each case.

The phthalimido moiety as an amino substituent could be replaced with others such as a morpholino and an acetamido moiety as well. Thus, the reactions of (α-morpholinobenzyl)- **2** and (α-acetamidobenzyl)-trimethylsilane **3** with benzaldehyde under similar conditions gave satisfied yields of 2-aminoethanols **6** and **7**, respectively, which were unseparable mixtures of erythro and threo isomers (1:1). From these results, it is easily indicated that other dialkylamino substituents might be able to use in the present reaction since the easiness of desilylation of (α-amino-substituted benzyl)silanes seems independent upon the carbanion-stabilizing ability of the amino substituents. Surprising was that even a secondary amide group with a highly acidic NH hydrogen has led to the smooth generation and longtime survival of the α-acetamido carbanion which reacted with the aldehyde leading to **7** with no trace of the corresponding protodesilylated product.

The phthalimidomethylsilane **4**, carrying no anion-stabilizing substituent such as a phenyl in **1**, was only desilylated very slowly at room temperature as shown in Table 2. In addition, the α-amino carbanion generated from **4** showed the preference for the proton abstraction from somewhere forming *N*-methylphthalimide **10** rather than the addition to benzaldehyde giving the 2-aminoethanol **8a**. Although it was certain that the reaction using a catalytic amount of fluoride was more favored for the formation of **8a**, a trouble was that some of the starting **4** remained unchanged even if the reaction time was prolonged. This problem was resolved by the addition of another portion of fresh catalyst (fluoride) sometime in the course of reaction. In this way the yield of **8a** increased up to 60% and that of the undesired product **10** was suppressed down to 16% (Table 2). As the formyl hydrogen in DMF which was used as a solvent was suspected to be a possible proton source for the formation of side-product **10**,[12] a similar reaction in dry HMPA was carried out. However, only nearly identical results were obtained providing no solution to our concern on the proton source.

Table 1 shows the results of reactions of **4** with a variety of aldehydes. Every reaction was performed at 100 °C using two portions of catalytic amounts of TBAF which were added in the intervals of reaction times shown in Table 1. The α-phthalimido carbanion generated from **4** was found also unreactive toward ketones, α,β-unsaturated esters, and imines.

The removal of the phthalimido protecting group of **5** and **8** permits the establishment of a synthetic route of β-amino alcohols *via* a nucleophilic aminoalkylation onto aldehydes. In fact it was found easy to convert the phthalimido group into amino moiety through a hydrazinolysis using hydrazine hydrate. Thus, some of the 2-phthalimidoethanols **5** and **8** that were listed in Table 1 were subjected to the hydrazynolysis (Scheme 3 and Table 3). Both erythro and threo isomers of **5a** and **5f** were separately deprotected giving the erythro and threo isomers of β-amino alcohols **11** and **12**, respectively, in almost quantitative yields. The structures of *erythro*-**11** and *threo*-**11** were confirmed by the comparison of the spectral data and physical properties with those of the authentic samples.



Scheme 3.

TABLE 2. REACTIONS OF **4** WITH BENZALDEHYDE UNDER VARIOUS CONDITIONS

Reaction conditions[a]				Products (yield/%)[b]		
Fluoride (equiv)	Solvent	Temp/°C	Time/h	**8a**	**10**	Recovered **4**
TBAF (0.2)	THF	rt	60	2	12	63
TBAF (0.2)	DMF	rt	60	5	37	52
TBAF (1)	DMF	rt	48	10	35	0
TBAF (0.05)	DMF	100	36	41	11	34
TBAF (0.05)	DMF	150	18	30	17	30
CsF (0.05)	DMF	130	4	29	18	0
TBAF (1)	DMF	100	15	38	56	0
TBAF (0.05×2)	DMF	100	6+2	60	16	0
TBAF (0.05×2)	HMPA	100	2+2	58	15	0

a) **4**: benzaldehyde = 1 : 1.5 in 2 ml of solvents per 1 mmol of **4**. b) All isolated yields.

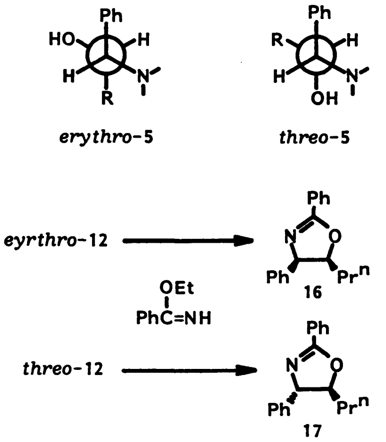
Similarly other 2-phthalimidoethanols **8a**, **8e**, and **8f** were treated with hydrazine hydrate under reflux in ethanol giving excellent yields of **13**, **14**, and **15**, respectively.

As mentioned above, the reactions of **1** with a variety of aldehydes gave mixtures of comparable amounts of erythro and threo isomers of **5** and these isomers were readily separable by a flash chromatography. The only remarkable difference in the spectral data of *erythro*-**5a** and *threo*-**5a**, whose structures were confirmed by their derivation to the known β-amino alcohols, *erythro*-**11** and *threo*-**11**, is that the hydroxyl proton appears considerably lower in *erythro*-**5a** than in *threo*-**5a** (Table 4).

Table 3. Hydrazinolysis of 2-phthalimidoethanols 5 and 8

2-Phthalimido-ethanols	Reaction time/h[a]	Products	Yield[b] %
erythro-**5a**	3	*erythro*-**11**	75
threo-**5a**	3	*threo*-**11**	88
erythro-**5f**	2	*erythro*-**12**	96
threo-**5f**	2	*threo*-**12**	95
8a	4	**13**	82
8e	4	**14**	97
8f	2	**15**	99

a) The time for hydrazinolysis under reflux in ethanol. b) All isolated yields.



Scheme 4.

In Scheme 4, the most stable conformers for *erythro*-**5** and *threo*-**5** were illustrated. These models show that both the methine hydrogens α and β to the hydroxyl group of *erythro*-**5** look magnetically almost equivalent to those of *threo*-**5**. However, the hydroxyl proton of *threo*-**5** is located close to the adjacent phthalimido moiety so that it may be deshielded to some extent. This is the case observed for *erythro*-**5a** and *threo*-**5a** (R=Ph). Other erythro and threo structures for the similar products **5b** to **5e** were tentatively assigned on the basis of the ^{1}H-NMR spectral data shown in Table 4.

The possibility for intramolecular hydrogen bonding in *threo*-**5a** was confirmed on the basis of the IR spectra taken as the solution in chloroform. For *threo*-**5a**, no essential change of OH stretching vibration was observed between two kinds of solutions of different concentrations: for the solution containing 30 mg of *threo*-**5a** in 1 ml of chloroform, 3728, 3704 (free OH), 3604, and 3464 cm^{-1} (hydrogen-bonded OH); for the solution containing 0.6 mg in 1 ml, 3728, 3705 (free OH), 3516, and 3448 cm^{-1} (hydrogen-bonded OH). However, the last two of four OH absorptions which were observed in the solution containing 30 mg of *erythro*-**5a** in 1 ml of chloroform (3728, 3705 (free OH), 3602, and 3466 cm^{-1} (hydrogen-bonded OH) dissapeared in the spectrum of a diluted solution (0.3 mg in 1 ml, 3730 and 3705 cm^{-1}).

As the ^{1}H-NMR spectra for the two isomers of **5f** were found too close each other, it was impossible to determine the stereostructures only on the basis of the spectral data. Therefore each isomer of **5f** was first converted into **12** (Scheme 3 and Table 3) and then cyclized into each isomeric 2-oxazoline **16** or **17** by the reaction with an imino ether. The isomer **16** showed a coupling constant of 9.7 Hz for J_{4-5} and the other **17** 7.2 Hz, **16** and **17** being assigned as cis and trans isomers, respectively. The propyl hydrogens

Table 4. ^{1}H-NMR data for erythro and threo isomers of 5[a]

5	*erythro*-**5** (δ, ppm)			*threo*-**5** (δ, ppm)		
	α-CH[b]	β-CH[b]	OH	α-CH[b]	β-CH[b]	OH
5a	5.49 d	5.92 d	2.77 br. s	5.55 d	5.75—5.90m	3.29m
5b	5.29 d	5.92 dd	2.69 d [c]	5.53 d	5.73—5.98m	3.32m [d]
5c	5.49 d	5.95 d	2.64 br. s [e]	5.55 d	5.87 dd	3.18 d [f]
5d	5.70 d	6.06 dd	2.80 d	5.78 d	5.90 dd	3.40 d
5e	5.33 d	5.56 dd	2.10 br. s [g]	5.30—5.62m		3.20m [h]
5f	5.14 d	4.60—4.87m	2.64 br. s [i]	5.19 d	4.52—4.90m	2.79 br. d [j]

a) Measured in $CDCl_3$. b) α-CH and β-CH: methine hydrogens α and β to the hydroxyl group. c) 2.21 s (Me). d) 2.21 s (Me). e) 3.64 s (OMe). f) 3.70 s (OMe). g) 6.20 dd and 6.72 d (PhCH=CH). h) 6.10 dd and 6.68 d (PhCH=CH). i) 0.73—1.05m and 1.20—1.70m (*n*-Pr). j) 0.72—1.05m and 1.16—1.78m (*n*-Pr).

at the 5-position of **16** as well as the methine hydrogen at the 5-position of **17** are both suffering from shielding from the adjacent phenyl plane. As it is known that 2-oxazoline formation from β-amino alcohols and imidic esters takes place with the retention of stereochemistry of the alcohols,[13] one isomer of **5f** which provided **16** can be assigned as *erythro*-**12**, and hence the other of **5f** leading to **17** is *threo*-**12**.

Experimental

General. Melting points were determined on a Yanagimoto micro melting point apparatus and uncorrected. IR spectra were taken with a JASCO A-702 or a JEOL JIR-100 spectrometer. ^{1}H-NMR spectra were recorded on a Hitachi R-40 or a JEOL FX-100 instrument and ^{13}C-NMR spectra were obtained on a JEOL FX-100 spectrometer at 25.05 MHz. Chemical shifts are expressed in parts per million downfield from tetramethylsilane. Mass spectra were measured with a JEOL JMS-01SG-2 spectrometer at 70 eV of ionization energy. Elementary analyses were performed on a Hitachi 026 CHN analyzer. Thin-layer chromatography (TLC) was accomplished on 0.2 mm precoated plates of silica gel 60 F-254 (Merck). Visualization was with ultraviolet light (254 and 365 nm) and iodine. Wakogel C 300 (Wako) and Silicagel 60 (Merck, size: 0.063—0.200 mm) were used for preparative column chromatography. Flash chromatography was carried out on an EYELA EF-10 apparatus using a column (20×180 mm) packed with Silicagel 60 (Merck, size: 0.040—0.063 mm). Micro vacuum distillation was accomplished with a Sibata GTO-250R Kugelrohr distilling apparatus. Solvents were evaporated with a Tokyo Rikakikai rotary evaporator type V.

DMF was purified by a vacuum distillation over alumina under nitrogen and stored on molecular sieves MS-5A. HMPA was also distilled *in vacuo* over calcium hydride under nitrogen and stored on molecular sieves MS-13X. THF was distilled over lithium aluminum hydride immediately prior to its use. Other solvents for reactions as well as for chromatography were used without further purification.

Materials. (α-Bromobenzyl)trimethylsilane (bp 88—92 °C (266 Pa), lit,[11] bp 98—99 °C (532 Pa)) was prepared by the reaction of benzyltrimethylsilane[14] with *N*-bromosuccinimide according to the reported method.[11] (Phthalimidomethyl)trimethylsilane **4** (bp 95—97 °C (100 Pa), lit,[15] bp 117 °C (266 Pa)) was synthesized from both commercially available (chloromethyl)trimethylsilane and potassium phthalimide. Morpholine was used without further purification. Commercial cesium fluoride was dried in a reaction flask under vacuum by heating at about 100 °C. TBAF solution in THF (1 mol dm^{-3}) was dried over molecular sieves MS-5A under nitrogen. Benzaldehyde, butanal, and cinnamaldehyde were purified by distillation. 2-Furancarbaldehyde was passed through a short column packed with alumina immediately before use. Other aldehydes were all used without further purification.

(α-Phthalimidobenzyl)trimethylsilane 1. A mixture of (α-bromobenzyl)trimethylsilane (12.15 g, 0.05 mol) and potassium phthalimide (10.2 g, 0.055 mol) in dry DMF (50 ml) was heated at 140 °C for 3 h. After cooled to room temperature, the reaction mixture was poured into ice-water and extracted with ether (50 ml×2). The ether was dried over magnesium sulfate and evaporated *in vacuo*. The residue was chromatographed over silica gel using hexane-benzene (2:1) as an eluent to give 12.96 g (84%) of **1**: Colorless prisms from hexane; mp 106—107 °C; IR (KBr) 1768, 1712 (CO), 1252, and 845 cm^{-1} (TMS); ^{1}H-NMR (CDCl$_3$) δ=0.15 (9H, s, Me$_3$Si), 4.66 (1H, s, CH), 7.08—7.30 (5H, m, Ph), and 7.53—7.85 (4H, m, Ar); MS *m/z* (rel. intensity, %) 309 (M$^+$, 44) and 73 (base peak).

Found: C, 70.04; H, 6.21; N, 4.46%. Calcd for $C_{18}H_{19}NO_2Si$: C, 69.86; H, 6.12; N, 4.53%.

(α-Morpholinobenzyl)trimethylsilane 2. A mixture of (α-bromobenzyl)trimethylsilane (1.2 g, 4.9 mmol) and morpholine (1.3 g, 14.9 mmol) was heated under reflux for 6 h. After cooled to room temperature, the reaction mixture was poured into aqueous potassium hydroxide solution and extracted with ether (10 ml×2). The ether was dried and evaporated *in vacuo*. The residue was distilled on a micro distilling apparatus to give 0.932 g (76%) of **2**: Pale yellow oil; bp 210—215 °C (3325 Pa) (bulb-to-bulb); IR (neat) 1250, 858, and 841 cm^{-1} (TMS); ^{1}H-NMR (CDCl$_3$) δ=−0.09 (9H, s, Me$_3$Si), 2.35—2.64 (4H, m, CH$_2$N), 2.79 (1H, s, CH), 3.53—3.78 (4H, m, OCH$_2$), and 7.01—7.32 (5H, m, Ph); ^{13}C-NMR (CDCl$_3$) δ=−1.17 (q, Me$_3$Si), 54.82 (t, CH$_2$N), 66.71 (d, CH), 67.25 (t, NCH$_2$), 125.58, 127.96 (each d, *o*-, *m*-, and *p*-C of Ph), and 142.00 (s, 1-C of Ph); MS *m/z* (rel. intensity, %) 249 (M$^+$, 8) and 176 (base peak).

The elementary analysis was carried out with an authentic sample of hydrochloride of **2** (mp 211—212 °C).

Found: C, 58.87; H, 8.70; N, 4.93%. Calcd for $C_{14}H_{24}NOClSi$: C, 58.82; H, 8.46; N, 4.90%.

(α-Acetamidobenzyl)trimethylsilane 3. A mixture of **1** (8.3 g, 0.027 mol) and hydrazine hydrate (100%, 1.5 g, 0.03 mol) in ethanol (100 ml) was heated under reflux for 3 h. Concd hydrochloric acid (3 ml) was added and the resulting mixture was again refluxed for 1 h. After cooled to room temperature, the precipitate separated was removed by filtration and the filtrate was evaporated *in vacuo*. The residue was treated with water, the insoluble material was removed off by filtration, the filtrate was made alkaline with aqueous potassium hydroxide solution, and extracted with dichloromethane (25 ml×2). The dichloromethane was dried and evaporated *in vacuo*. The residue was distilled under vacuum to give 2.9 g (61%) of (α-aminobenzyl)trimethylsilane: Pale yellow oil; bp 114—117 °C (2660 Pa) (bulb-to-bulb); IR (neat) 3380 (NH), 1250, and 840 cm^{-1} (TMS); ^{1}H-NMR (CDCl$_3$) δ=0.03 (9H, s, Me$_3$Si), 1.56 (2H, br. s, NH$_2$), 3.52 (1H, s, CH), and 7.04—7.38 (5H, m, Ph); MS *m/z* (rel. intensity, %) 179 (M$^+$, 22), 106 (98), 105 (62), and 73 (base peak).

The elementary analysis was performed with an authentic sample of hydrochloride of the amine (mp 239—241 °C).

Found: C, 55.87; H, 8.66; N, 6.56%. Calcd for $C_{10}H_{18}NClSi$: C, 55.66; H, 8.41; N, 6.49%.

A mixture of the above amine (0.5 g, 2.8 mmol), triethylamine (0.5 ml), and acetic anhydride (0.5 ml) in dichloromethane (5 ml) was stirred overnight at room temperature and poured into water. The organic material was extracted with dichloromethane (25 ml), the dichloromethane was dried, and evaporated *in vacuo*. The residue was chromatographed over silica gel using hexane–ethyl acetate (2:1) as an eluent to give 0.41 g (66%) of **3**: Colorless needles from benzene–hexane; mp 137.5—139 °C; IR (KBr) 3270 (NH), 1633 (CO), 1250, 865, and 840 cm^{-1} (TMS); ^{1}H-NMR (CDCl$_3$) δ=0.02 (9H, s, Me$_3$Si), 2.00 (3H, s, MeCO), 3.60 (1H, d, J=9.0 Hz, CH), 6.00 (1H, br. d, NH), and 6.97—7.32 (5H, m, Ph); MS *m/z* (rel. intensity, %) 221 (M$^+$, 30), 178 (20), 106 (41), 104 (19), 79 (20), 77 (21), and 73 (base peak).

Found: C, 65.29; H, 8.61; N, 6.40%. Calcd for $C_{12}H_{19}NOSi$: C, 65.10; H, 8.65; N, 6.33%.

General Procedure for the Reactions of **1** *with Aldehydes.* The reagents were charged in a reaction flask in the following manner: When cesium fluoride was used, a weighed quantity of cesium fluoride (1—0.1 mmol) was placed in a reaction flask and dried at 100 °C under vacuum. After it was cooled to room temperature, dry DMF (2 ml), aldehydes (1—1.4 mmol), and then **1** (1 mmol) were added. When TBAF was used as a catalyst, to a mixture of **1** (1 mmol) and aldehydes (1—1.4 mmol) in dry DMF (2 ml) was added TBAF (0.05 ml, 0.05 mmol). The resulting mixture was stirred at room temperature under nitrogen for the period of time shown in Table 1. The solvents were all evaporated to dryness under vacuum. The residue was filtered through a short column packed with silica gel using hexane–ethyl acetate (2:1) to give a mixture of two isomeric 2-aminoethanols **5a** to **5f**. The yields as well as the erythro/threo ratios were measured at this stage, the formers of which were listed in Table 1. The separation of isomers was carried out by a flash chromatography over silica gel using hexane–ethyl acetate (5:1) as an eluent.

1,2-Diphenyl-2-phthalimidoethanol **5a**. *erythro*-**5a**: Colorless leaflets from benzene–hexane; mp 184—186 °C; IR (KBr) 3523, 3469, 3425 (OH), and 1708 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=2.77 (1H, br. s, OH), 5.49 (1H, d, J_{2-1}=9.0 Hz, 2-CH), 5.92 (1H, d, J_{1-2}=9.0 Hz, 1-CH), and 7.10—7.71 (14H, m, Ph and Ar); MS *m/z* (rel. intensity, %) 237 (43), 236 (40), 130 (30), 104 (21), 79 (55), and 77 (base peak).

Found: C, 77.05, H; 5.06; N, 4.26%. Calcd for $C_{22}H_{17}NO_3$: C, 76.94; H, 4.99; N, 4.08%.

threo-**5a**: Colorless needles from benzene–hexane; mp 182—184 °C; IR (KBr) 3425 (OH), 1709, and 1697 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=3.29 (1H, m, OH), 5.55 (1H, d, J_{2-1}=9.0 Hz, 2-CH), 5.75—5.90 (1H, m, 1-CH), and 7.04—7.90 (14H, m, Ph and Ar); MS *m/z* (rel. intensity, %) 237 (17), 236 (29), 130 (26), 107 (38), 105 (32), 104 (31), 79 (74), and 77 (base peak).

Found: C, 77.17; H, 4.89; N, 4.11%. Calcd for $C_{22}H_{17}NO_3$: C, 76.94; H, 4.99; N, 4.08%.

^{13}C-NMR (CDCl$_3$) of the mixture of *erythro*-**5a** and *threo*-**5a**: δ=60.86, 62.63 (each d, 2-C), 72.60, and 73.00 (each d, 1-C).

*1-(*p*-Methylphenyl)-2-phenyl-2-phthalimidoethanol* **5b**. *erythro*-**5b**: Colorless prisms from benzene–hexane; mp 163—164 °C; IR (KBr) 3545 (OH) and 1709 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=2.21 (3H, s, Me), 2.69 (1H, d, J=2.5 Hz, OH), 5.29 (1H, d, J_{2-1}=9.0 Hz, 2-CH), 5.92 (1H, dd, J_{1-2}=9.0 and J_{1-OH}=2.5 Hz, 1-CH), and 6.91—7.74 (13H, m, Ar); MS *m/z* (rel. intensity, %) 357 (M$^+$, 5), 238 (17), 237 (base peak), 236 (19), 219 (17), 209 (12), 130 (9), 121 (14), 119 (12), 105 (19), 104 (48), and 91 (38).

Found: C, 77.39; H, 5.39; N, 3.91%. Calcd for $C_{23}H_{19}NO_3$: C, 77.29; H, 5.36; N, 3.92%.

threo-**5b**: Colorless leaflets from benzene–hexane; mp 161—162 °C; IR (KBr) 3450 (OH), 1711, and 1699 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=2.21 (3H, s, Me), 3.32 (1H, m, OH), 5.53 (1H, d, J_{2-1}=9.0 Hz, 2-CH), 5.73—5.98 (1H, m, 1-CH), and 6.88—7.82 (13H, m, Ar); MS *m/z* (rel. intensity, %) 357 (M$^+$, 4), 238 (17), 237 (base peak), 236 (23), 219 (18), 209 (13), 208 (10), 133 (11), 130 (29), 121 (18), 105 (19), 104 (46), 93 (16), and 91 (25).

Found: C, 77.33; H, 5.38; N, 3.91%. Calcd for $C_{23}H_{19}NO_3$: C, 77.29; H, 5.36; N, 3.92%.

*1-(*p*-Methoxyphenyl)-2-phenyl-2-phthalimidoethanol* **5c**. *erythro*-**5c**: Colorless prisms from benzene–hexane; mp 147.5—148.5 °C; IR (KBr) 3460 (OH), 1767, and 1705 cm^{-1}; ^{1}H-NMR (CDCl$_3$) δ=2.64 (1H, br. s, OH), 3.64 (3H, s, MeO), 5.49 (1H, d, J_{2-1}=9.3 Hz, 2-CH), 5.95 (1H, d, J_{1-2}=9.3 Hz, 1-CH), 6.65—6.85, and 7.20—7.78 (13H, m, Ar); MS *m/z* (rel. intensity, %) 373 (M$^+$, 4), 356 (13), 238 (15), 237 (89), 236 (17), 219 (22), 209 (13), 137 (base peak), 130 (18), 109 (20), 104 (24), and 94 (14).

Found: C, 74.27; H, 5.17; N, 3.86%. Calcd for $C_{23}H_{19}NO_4$: C, 73.98; H, 5.13; N, 3.75%.

threo-**5c**: Colorless leaflets from benzene–hexane; mp 151—152.5 °C; IR (KBr) 3430 (OH), 1765, and 1700 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=3.18 (1H, d, J=6.0 Hz, OH), 3.70 (3H, s, OMe), 5.55 (1H, d, J_{2-1}=8.7 Hz, 2-CH), 5.87 (1H, dd, J_{1-2}=8.7 and J_{1-OH}=6.0 Hz, 1-CH), 6.65—6.81, 7.10—7.43, and 7.56—7.85 (13 H, m, Ar); MS *m/z* (rel. intensity, %) 373 (M$^+$, 4), 238 (11), 237 (69), 236 (32), 219 (18), 209 (13), 208 (11), 152 (10), 137 (base peak), 135 (12), 133 (12), 130 (36), 109 (31), 105 (20), 104 (45), and 94 (32).

Found: C, 74.15; H, 5.21; N, 4.01%. Calcd for $C_{23}H_{19}NO_4$: C, 73.98; H, 5.13; N, 3.75%.

1-(2-Furyl)-2-phenyl-2-phthalimidoethanol **5d**. *erythro*-**5d**: Colorless prisms from benzene–hexane; mp 133—134 °C; IR (KBr) 3510 (OH), 1765, and 1708 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=2.80 (1H, d, J=4.8 Hz, OH), 5.70 (1H, d, J_{2-1}=9.3 Hz, 2-CH), 6.06 (1H, dd, J_{1-2}=9.3 and J_{1-OH}= 4.8 Hz, 1-CH), 6.18 (1H, dd, J=3.6 and 2.2 Hz, 4-H of furyl), 6.31 (1H, br. d, J=3.6 Hz, 3-H of furyl), and 7.20—7.80 (10H, m, Ar and 5-H of furyl); MS *m/z* (rel. intensity, %) 333 (M$^+$, 3), 238 (17), 237 (base peak), 236 (40), 219 (14), 130 (16), 104 (16), and 77 (14).

Found: C, 72.33; H, 4.56; N, 4.38%. Calcd for $C_{20}H_{15}NO_4$: C, 72.06; H, 4.54; N, 4.20%.

threo-**5d**: Colorless prisms from benzene–hexane; mp 170—171.5 °C; IR (KBr) 3592 (OH), 1765, and 1704 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=3.40 (1H, d, J=6.8 Hz, OH), 5.78 (1H, d, J_{2-1}=8.5 Hz, 2-CH), 5.90 (1H, dd, J_{1-2}=8.5 and J_{1-OH}=6.8 Hz, 1-CH), 6.17 (2H, d, J=2.0 Hz, 3- and 4-H of furyl), and 7.13—7.90 (10H, m, Ar and 5-H of furyl); MS *m/z* (rel. intensity, %) 237 (50), 236 (63), 219 (12), 209 (14), 208 (14), 180 (11), 153 (17), 133 (29), 132 (13), 131 (10), 130 (88), 105 (42), 104 (base peak), 102 (25), 97 (78), and 77 (91).

Found: C, 72.26; H, 4.62; N, 4.33%. Calcd for $C_{20}H_{15}NO_4$: C, 72.06; H, 4.54; N, 4.20%.

*(*E*)-1,4-Diphenyl-1-phthalimido-3-buten-2-ol* **5e**. *erythro*-**5e**: Colorless prisms from benzene–hexane; mp 146—147 °C; IR (KBr) 3473 (OH), 1709, and 1703 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=2.10 (1H, br. s, OH), 5.33 (1H, d, J_{1-2}=8.3 Hz, 1-CH), 5.56 (1H, dd, J_{2-1}=8.3 and J_{2-3}= 6.8 Hz, 2-CH), 6.20 (1H, dd, J_{3-2}=6.8 and J_{3-4}=15.8 Hz, 3-CH=),

6.72 (1H, d, J_{4-3}=15.8 Hz, 4-CH=), and 6.90—7.88 (14H, m, Ph and Ar); MS *m/z* (rel. intensity, %) 369 (M^+, 3), 238 (12), 237 (78), 236 (base peak), 219 (12), 133 (29), 130 (38), 116 (11), 105 (19), 104 (28), 103 (12), and 77 (38).

Found: C, 79.26; H, 5.46; N, 3.57%. Calcd for $C_{24}H_{19}NO_3$+ 1/2 C_6H_6: C, 79.39; H, 5.43; N, 3.43%.

threo-**5e**: Colorless leaflets from benzene-hexane; mp 184—186 °C; IR (KBr) 3412 (OH), 1713, and 1697 cm^{-1} (CO); ^1H-NMR ($CDCl_3$) δ=3.20 (1H, M, OH), 5.30—5.62 (2H, m, 1- and 2-CH), 6.10 (1H, dd, J_{3-2}=5.4 and J_{3-4}= 16.0 Hz, 3-CH=), 6.68 (1H, d, J_{4-3}=16.0 Hz, 4-CH=), and 7.08—7.92 (14H, m, Ph and Ar); MS *m/z* (rel. intensity, %) 369 (M^+, 4), 238 (14), 237 (87), 236 (base peak), 219 (10), 133 (27), 130 (22), 105 (11), 104 (18), and 77 (23).

Found: C, 78.24; H, 5.26; N, 3.85%. Calcd for $C_{24}H_{19}NO_3$: C, 78.03; H, 5.18; N, 3.79%.

1-Phenyl-1-phthalimido-2-pentanol **5f**. *erythro*-**5f**: Colorless needles from benzene-hexane; mp 115.5—117 °C; IR (KBr) 3493 (OH) and 1705 cm^{-1} (CO); ^1H-NMR ($CDCl_3$) δ=0.73—1.05 (3H, m, Me), 1.20—1.70 (4H, m, CH_2), 2.64 (1H, br. s, OH), 4.60—4.87 (1H, m, 2-CH), 5.14 (1H, d, J_{1-2}=6.8 Hz, 1-CH), and 7.12—7.90 (9H, m, Ph and Ar); MS *m/z* (rel. intensity, %) 237 (base peak), 236 (16), 219 (17), 209 (12), 130 (10), 105 (10), 104 (26), and 77 (15).

Found: C, 73.69; H, 6.22; N, 4.55%. Calcd for $C_{19}H_{19}NO_3$: C, 73.77; H, 6.19; N, 4.53%.

threo-**5f**: Colorless needles from benzene-hexane; mp 146.5—148 °C; IR (KBr) 3529, 3490 (OH), 1707, and 1699 cm^{-1} (CO); ^1H-NMR ($CDCl_3$) δ=0.72—1.05 (3H, m, Me), 1.16—1.78 (4H, m, CH_2), 2.79 (1H, br. d, J=8.0 Hz, OH), 4.52—4.90 (1H, m, 2-CH), 5.19 (1H, d, J_{1-2}=8.7 Hz, 1-CH), and 7.10—7.90 (9H, m, Ph and Ar); MS *m/z* (rel. intensity, %) 237 (base peak), 236 (13), 219 (17), and 104 (12).

Found: C, 73.83; H, 6.28; N, 4.69%. Calcd for $C_{19}H_{19}NO_3$: C, 73.77; H, 6.19; N, 4.53%.

*Reaction of **2** with Benzaldehyde.* Cesium fluoride (152 mg, 1 mmol) was dried in a reaction flask under vacuum at 100 °C. To the falsk, after cooled to room temperature, were added dry DMF (2 ml), **2** (249 mg, 1 mmol), and then benzaldehyde (106 mg, 1 mmol). The mixture was stirred under nitrogen at room temperature for 24 h and then poured into ice-water. The products were extracted with ether (25 ml×2), the ether was dried over magnesium sulfate, and finally evaporated *in vacuo*. The residue was chromatographed over silica gel using hexane-ethyl acetate (3:1) as an eluent to give 190 mg (67%) of the erythro and threo mixture of 2-morpholino-1,2-diphenylethanol **6**, whose separation by a flash chromatography was unsuccessful. The following data were given for the mixture of *erythro*-**6** and *threo*-**6** (1:1) Colorless prisms from benzene-hexane; mp 110—118 °C; IR (KBr) 3500, 3380 (OH), 3100—2800 (CH), 1126, 882, and 712 cm^{-1}; ^1H-NMR ($CDCl_3$) δ=2.19—2.80 (4H, m, CH_2N), 4.32 (0.5H, d, J_{2-1}=2.5 Hz, 2-CH), 4.52 (0.5 H, d, J_{2-1}=5.2 Hz, 2-CH), 4.40—4.80 (5H, m, CH_2O and OH), 5.02 (0.5 H, d, J_{1-2}=5.2 Hz, 1-CH), 5.30 (0.5 H, d, J_{1-2}=2.5 Hz, 1-CH), and 6.80—7.38 (10H, m, Ph); ^{13}C-NMR ($CDCl_3$) δ=49.32, 51.90 (each t, CH_2N), 67.00, 67.15 (each t, CH_2O), 70.27, 71.19 (each d, 2-C), 76.46, 76.70 (each d, 1-C), 126.11, 127.28, 127.47, 129.52, 129.61, 132.59, 135.61, and 141.02; MS *m/z* (rel. intensity, %) 177 (13), 176 (base peak), 105 (12), and 91 (13).

Found: C, 76.57; H, 7.47; N, 4.98%. Calcd for $C_{18}H_{21}NO_2$: C, 76.29; H, 7.47; N, 4.94%.

*Reaction of **3** with Benzaldehyde.* To a mixture of **3** (130 mg, 0.59 mmol) and benzaldehyde (70 mg, 0.66 mmol) in dry DMF (1 ml) was added TBAF (0.6 ml, 0.6 mmol). The mixture was stirred under nitrogen at room temperature for 16 h and then poured into ice-water. The products were extracted with ether (25 ml×2), the ether was dried, and evaporated *in vacuo* to give a viscous oily material which solidified on trituration with ether-hexane. Thus obtained colorless solid was found to be the mixture of erythro and threo isomers (1:1) of 2-acetamido-1,2-diphenylethanol **7** (86 mg, 57%), which could not be separated by a flash chromatography. The following data were given for the mixture of *erythro*-**7** and *threo*-**7** (1:1): Colorless solid; IR (KBr) 3360 (OH) and 1650 cm^{-1} (CO); ^1H-NMR ($CDCl_3$) δ=1.89, 1.95 (each 0.5×3H, s, COMe), 3.19 (1H, br. s, OH), 4.85—5.30 (2H, m, 1- and 2-CH), 6.42 (1H, br. s, NH), and 6.88—7.32 (10H, m, Ph); MS *m/z* (rel. intensity, %) 149 (83), 148 (18), 107 (22), 106 (base peak), 104 (10), 79 (27), and 77 (25).

Found: C, 75.24; H, 6.73; N, 5.49%. Calcd for $C_{16}H_{17}NO_2$: C, 75.26; H, 6.71; N, 5.49%.

*General Procedure for the Reactions of **4** with Aldehydes.* To a mixture of **4** (1 mmol) and aldehydes (1.5 mmol) in dry DMF (1 ml) was added TBAF (0.05ml, 0.05 mmol) by use of a syringe. The mixture was heated at 100 °C under nitrogen for the time period shown in Table 1 and cooled to room temperature. Another portion of TBAF (0.05 ml) was added and this mixture was again heated under the conditions listed in Table 1. After cooled to room temperature, ice-cold water was added to the mixture which was then extracted with ether (25 ml×2), the ether was dried, and evaporated *in vacuo*. The residue obtained was dissolved in benzene (5 ml) to separate the precipitation of *N*-benzylphthalimide **10** which was filtered off. The filtrate was condensed *in vacuo* and chromatographed over silica gel using hexane-ethyl acetate (2:1) to give 1-substituted 2-phthalimidoethanol **8a** to **8g**. The yields of **8** as well as **10** are listed in Table 1.

1-Phenyl-2-phthalimidoethanol **8a**: Colorless leaflets from benzene-hexane; mp 166—168 °C (lit,[16] mp 164—165 °C); IR (KBr) 3467 (OH) and 1701 cm^{-1} (CO); ^1H-NMR ($CDCl_3$) δ=2.92 (1H, d, J=5.1 Hz, OH), 3.89 (1H, dd, J_{2-1}=5.0 and J_{gem}=14.0 Hz, one of 2-CH_2), 4.05 (1H, dd, J_{2-1}=7.1 and J_{gem}=14.0 Hz, the other of 2-CH_2), 5.04 (1H, ddd, J_{1-2}=5.0, 7.1 and J_{1-OH}=5.1 Hz, 1-CH), and 7.20—7.92 (9H, m, Ph and Ar).

1-(p-Methylphenyl)-2-phthalimidoethanol **8b**: Colorless needles from benzene-hexane; mp 155—156.5 °C; IR (KBr) 3379 (OH), 1768 and 1711 cm^{-1} (CO); ^1H-NMR ($CDCl_3$) δ=2.33 (3H, s, Me), 2.82 (1H, d, J=5.0 Hz, OH), 3.85 (1H, dd, J_{2-1}=5.0 and J_{gem}=14.0 Hz, one of 2-CH_2), 4.02 (1H dd, J_{2-1}=7.5 and J_{gem}=14.0 Hz, the other of 2-CH_2), 5.02 (1H, dt, J_{1-2}=5.0, 7.5 and J_{1-OH}=5.0 Hz, 1-CH), 7.04—7.40, and 7.60—7.92 (each 4H, m, Ar); MS *m/z* (rel. intensity, %) 281 (M^+, 7), 190 (15), 162 (15), 161 (base peak), 160 (14), 133 (10), 121 (28), 117 (15), 105 (13), 104 (19), and 91 (15).

Found: C, 72.75; H, 5.46; N, 5.06%. Calcd for $C_{17}H_{15}NO_3$: C, 72.58; H, 5.38; N, 4.98%.

1-(p-Methoxyphenyl)-2-phthalimidoethanol **8c**: Colorless leaflets from benzene-hexane; mp 172—174 °C; IR (KBr) 3470 (OH), 1770, and 1695 cm^{-1} (CO); ^1H-NMR ($CDCl_3$)

δ=2.77 (1H, d, J=5.0 Hz, OH), 3.78 (3 H, s, OMe), 3.86 (1H, dd, J_{2-1}=5.0 and J_{gem}=14.5 Hz, one of 2-CH$_2$), 4.03 (1H, dd, J_{2-1}=7.6 and J_{gem}=14.5 Hz, the other of 2-CH$_2$), 6.02 (1H, dt, J_{1-2}=5.0, 7.6 and $J_{1-\text{OH}}$=5.0 Hz, 1-CH), 6.85, 7.36 (each 2H, d, J=9.5 Hz, p-MeOC$_6$H$_4$), and 7.63—7.90 (4H, m, Ar); MS m/z (rel. intensity, %) 297 (M$^+$, 4), 161 (18), 160 (68), 137 (base peak), 135 (17), 133 (18), 117 (18), 109 (60), 105 (24), 104 (34), and 94 (46).

Found: C, 68.88; H, 5.16; N, 4.96%. Calcd for $C_{17}H_{15}NO_4$: C, 68.68; H, 5.09; N, 4.71%.

1-(2-Furyl)-2-phthalimidoethanol **8d**: Colorless prisms from benzene-hexane; mp 86—87 °C; IR (KBr) 3400 (OH), 1775, and 1708 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=2.80 (1H, d, J=7.0 Hz, OH), 4.00 (1H, dd, J_{2-1}=5.3 and J_{gem}=14.2 Hz, one of 2-CH$_2$), 4.18 (1H, dd, J_{2-1}=7.6 and J_{gem}=14.2 Hz, the other of 2-CH$_2$), 5.05 (1H, ddd, J_{1-2}=5.3, 7.6 and $J_{1-\text{OH}}$=7.0 Hz, 1-CH), 6.32 (2H, m, 3- and 4-H of furyl), 7.37 (1H, dd, J=1.8 and 1.2 Hz, 5-H of furyl), and 7.62—7.95 (4H, m, Ar); MS m/z (rel. intensity, %) 257 (M$^+$, 13), 162 (13), 161 (base peak), 160 (50), 133 (43), 132 (23), 117 (42), 110 (83), 105 (29), 104 (48), and 97 (84).

Found: C, 65.16; H, 4.51; N, 5.62%. Calcd for $C_{14}H_{11}NO_4$: C, 65.36; H, 4.31; N, 5.45%.

(E)-4-Phenyl-1-phthalimido-3-buten-2-ol **8e**: Pale yellow needles from benzene-hexane; mp 184—186 °C; IR (KBr) 3454 (OH) and 1701 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=2.63 (1H, d, J=5.3 Hz, OH), 3.91 (2H, d, J_{1-2}=5.8 Hz, 1-CH$_2$), 4.65 (1H, dddt, J_{2-1}=5.8, J_{2-3}=6.0, $J_{2-\text{OH}}$=5.3, and J_{2-4}=1.2 Hz, 2-CH), 6.21 (1H, dd, J_{3-2}=6.0 and J_{3-4}=15.8 Hz, 3-CH), 6.68 (1H, dd, J_{4-3}=15.8 and J_{4-2}=1.2 Hz, 4-H), 7.10—7.42 (5H, m, Ph), and 7.58—7.92 (4H, m, Ar); MS m/z (rel. intensity, %) 293 (M$^+$, 12) 161 (34), 160 (20), 146 (24), 134 (12), 133 (base peak), 115 (14), 105 (12), 104 (12), and 77 (22).

Found: C, 73.56; H, 5.18; N, 4.93%. Calcd for $C_{18}H_{15}NO_3$: C, 73.70; H, 5.16; N, 4.78%.

1-Phthalimido-2-pentanol **8f**: Colorless prisms from benzene-hexane; mp 86—87.5 °C; IR (KBr) 3508 (OH), 1774, and 1711 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=0.76—1.08 (3H, m, Me), 1.21—1.70 (4H, m, 3- and 4-CH$_2$), 2.52 (1H, br. s, OH), 3.61—4.02 (3H, m, 1-CH$_2$ and 2-CH), and 7.48—7.83 (4H, m, Ar); MS m/z (rel. intensity, %) 233 (M$^+$, 2), 190 (14), 162 (11), 161 (base peak), 160 (22), 133 (30), 132 (15), 117 (30), 105 (33), 104 (46), and 77 (36).

Found: C, 67.08; H, 6.39; N, 6.14%. Calcd for $C_{13}H_{15}NO_3$: C, 66.93; H, 6.48; N, 6.00%.

3,3-Dimethyl-1-phthalimido-2-butanol **8g**: Colorless needles from benzene-hexane; mp 94—95.5 °C; IR (KBr) 3400 (OH), 1770, and 1713 cm^{-1} (OH); ^{1}H-NMR (CDCl$_3$) δ=1.01 (9H, s, Me), 2.47 (1H, d, J=5.8 Hz, OH), 3.46—4.02 (3H, m, 1-CH$_2$ and 2-CH), and 7.62—7.90 (4H, m, Ar); MS m/z (rel. intensity, %) 247 (M$^+$, 1), 190 (58), 162 (14), 161 (base peak), 160 (20), 133 (23), 132 (13), 104 (25), and 77 (23).

Found: C, 68.02; H, 6.93; N, 5.78%. Calcd for $C_{14}H_{17}NO_3$: C, 67.99; H, 6.93; N, 5.66%.

General Procedure for the Hydrazinolysis of **5** *and* **8**. A mixture of **5** or **8** (1 mmol) and hydrazine hydrate (100%, 1.5 mmol) in 4 ml of ethanol was heated unnder reflux for a few hours. After a slight excess of concd hydrochloric acid was added, the resulting mixture was again heated under reflux for 0.5 h and then cooled to room temperature. The precipitate separated was filtered off and the filtrate was evaporated *in vacuo*. The residue was dissolved in water (5 ml) to separate some insoluble material which was removed by filtration. Evaporation of the filtrate *in vacuo* gave the hydrochloride of 2-aminoethanols (*erythro*-**12**, *threo*-**12**, **13**, and **15**). Treatment of the filtrate with aqueous potassium hydroxide afforded the free bases (*erythro*-**11**, *threo*-**11**, and **14**). The reaction times and the yields were listed in Table 3.

Identification of the products was accomplished by the comparison of the melting points with those of authentic samples or on the basis of the spectral data of 2-oxazoline derivatives.

erythro-*2-Amino-1,2-diphenylethanol.* erythro-**11**: Colorless needles from ethanol; mp 166.5—168 °C (lit,[17] mp 163 °C); IR (KBr) 3365 and 3298 cm^{-1} (NH and OH); ^{1}H-NMR (CDCl$_3$) δ=1.70 (3H, br. s, NH$_2$ and OH), 4.15 (1H, d, J_{1-2}=6.2 Hz, 1-H), 4.73 (1H, d, J_{2-1}=6.2 Hz, 2-H), and 7.05—7.20 (10H, m, Ph).

threo-*2-Amino-1,2-diphenylethanol.* threo-**11**: Colorless needles from benzene-hexane; mp 129—131 °C (lit,[17] mp 129 °C); IR (KBr) 3363, 3302, and 3159 cm^{-1} (NH and OH); ^{1}H-NMR (CDCl$_3$) δ=2.00 (3H, br. s, NH$_2$ and OH), 3.97 (1H, d, J_{1-2}=6.5 Hz, 1-H), 4.63 (1H, d, J_{2-1}=6.5 Hz, 2-H), and 7.00—7.30 (10H, m, Ph).

2-Amino-1-phenylethanol Hydrochloride **13**: Colorless prisms from ethanol-ether; mp 179—181 °C (lit,[18] mp 176—177 °C); IR (KBr) 3350 and 3000 cm^{-1} (NH and OH); ^{1}H-NMR (DMSO-d_6) δ=2.86 (2H, br. s, CH$_2$), 4.30 (1H, br. s, OH), 4.63—4.92 (1H, m, 1-H), 7.21 (5H, br. s, Ph), and 8.15 (3H, br. s, NH$_3^+$).

(E)-1-Amino-4-phenyl-3-buten-2-ol **14**: This compound **14** was converted into the oxalate whose appearance and melting point are given as follows: colorless prisms from ethanol; mp 235—238 °C (lit,[19] mp 238 °C). The IR and ^{1}H-NMR spectral data are shown for the free base: IR (KBr) 3360 cm^{-1} (NH and OH); ^{1}H-NMR (CDCl$_3$) δ=2.67 (5H, br. s, $C\underline{H}_2N\underline{H}_2$ and OH), 3.95—4.28 (1H, m, 2-H), 6.02 (1H, dd, J_{3-2}=6.0 and J_{3-4}=15.0 Hz, 3-H), 6.50 (1H, d, J_{4-3}=15.0 Hz, 4-H), and 6.95—7.40 (5H, m, Ph).

1-Amino-2-pentanol Hydrochloride **15**: This compound **15** was converted into 1-benzamido-2-pentanol by the reaction of **15** with benzoyl chloride in the presence of triethylamine. The following data are for the *N*-benzoyl derivative. Colorless leaflets from benzene; mp 111—113 °C (lit,[20] mp 112—113.5 °C); IR (KBr) 3373, 3329 (NH and OH), and 1633 cm^{-1} (CO); ^{1}H-NMR (CDCl$_3$) δ=0.80—1.08 (3H, m, Me), 1.22—1.64 (4H, m, 3- and 4-CH$_2$), 2.65 (1H, d, $J_{\text{OH}-2}$=4.7 Hz, OH), 3.25 (1H, ddd, $J_{1-\text{NH}}$=4.8, J_{1-2}=8.0, and J_{gem}=13.8 Hz, one of 1-H), 3.70 (1H, ddd, $J_{1-\text{NH}}$=6.5, J_{1-2}=2.7, and J_{gem}=13.8 Hz, the other of 1-H), 3.70—3.95 (1H, m, 2-H), 6.66 (1H, br. s, NH), and 7.26—7.84 (5H, m, Ph).

cis-*2,4-Diphenyl-5-propyl-2-oxazoline* **16**: The hydrochloride *erythro*-**12** which was obtained according to the general procedure described above was converted into **16** by the following reaction. A mixture of *erythro*-**12** (38 mg, (0.18mmol) and ethyl benzimidate[21] (70 mg, 0.46 mmol) was heated under reflux in 1,2-dichloroethane (5 ml) for 24 h. After cooled to room temperature, the mixture was washed with water twice and the organic layer was dried over magnesium sulfate. The residue which was given by the evaporation of the solution was chromatographed over silica gel using hexane-ethyl acetate (5:1) as an eluent. Colorless oil of **16** (46 mg, 94%) gave the following spectral data: IR (neat) 1647 cm^{-1} (C=N); ^{1}H-NMR (CDCl$_3$) δ=0.83 (3H, t, J=7.0 Hz, Me), 0.90—1.68 (4H, m, MeC$\underline{H}_2$C$\underline{H}_2$), 4.88 (1H, ddd, J_{5-4}=9.7, J_{5-CH_2}=4.3, and J_{5-CH_2}=9.7 Hz, 5-H), 5.20 (1H, d, J_{4-5}=9.7 Hz, 4-H), and 7.06—7.92 (10H, m, Ph); MS m/z (rel. intensity, %) 265 (M$^+$, 4), 194 (19), 193 (base peak), 90 (18), 89 (17), and 77 (11).

Found: m/z 265.1466. Calcd for C$_{18}$H$_{19}$NO: M, 265.1466.

trans-2,4-Diphenyl-5-propyl-2-oxazoline **17**: According to the similar procedure mentioned above, colorless oil of **17** was obtained in 92% yield: IR (neat) 1647 cm^{-1} (C=N); ^{1}H-NMR (CDCl$_3$) δ=0.98 (3H, t, J=7.0 Hz, Me), 1.30—2.03 (4H, m, MeC$\underline{H}_2$C$\underline{H}_2$), 4.48 (1H, ddd, J_{5-4}=7.2, J_{5-CH_2}=5.1, and J_{5-CH_2}=7.2 Hz, 5-H), 4.88 (1H, d, J_{4-5}=7.2 Hz, 4-H), and 7.15—8.12 (10H, m, Ph); MS m/z (rel. intensity, %) 265 (M$^+$, 9), 194 (14), and 193 (base peak).

Found: C, 81.69; H, 7.29; N, 5.52%. Calcd for C$_{18}$H$_{19}$NO: C, 81.47; H 7.22; N, 5.28%.

References

1) A. I. Shatenshtein and H. A. Gvozdeva, *Tetrahedron,* **25**, 2749 (1969).

2) Recent reviews on α-amino carbanions: D. Seebach, *Angew. Chem.*, **91**, 259 (1979); A. Krief, *Tetrahedron,* **36**, 2531 (1980); J.-F. Biellmann and J.-B. Bucep, *Org. React.*, **27**, 1 (1982).

3) Reviews on dipole-stabilized α-amino carbanions: D. Seebach and D. Enders, *Angew. Chem.*, **87**, 1 (1975); P. Beak and D. B. Reitz, *Chem. Rev.*, **78**, 275 (1978).

4) Related papers published later than 1980: W. Lubosch and D. Seebach, *Helv. Chim. Acta,* **63**, 102 (1980); W. Wykypiel and D. Seebach, *Tetrahedron Lett.*, **21**, 1927 (1980); A. I. Meyers and W. T. Hoeve, *J. Am. Chem. Soc.*, **102**, 7125 (1980); D. Seebach and M. Yoshifuji, *Helv. Chim. Acta,* **64**, 643 (1981); W. Wykypiel, J.-J. Lohmann, and D. Seebach, *ibid.*, **64**, 1337 (1981); N. G. Rodan, K. N. Houk, P. Beak, W. J. Zajdel, J. Chandrasekhar, and P. von R. Schleyer, *J. Org. Chem.*, **46**, 4108 (1981); D. B. Reitz, P. Beak, and A. Tse, *ibid.*, **46**, 4317 (1981); A. I. Meyers, S. Hellring, and W. T. Hoeve, *Tetrahedron Lett.*, **22**, 5115 (1981); A. I. Meyers and S. Hellring, *ibid.*, **22**, 5119 (1981); A. I. Meyers and G. E. Jagdmann Jr., *J. Am. Chem. Soc.*, **104**, 877 (1982); A. I. Meyers and S. Hellring, *J. Org. Chem.*, **47**, 2229 (1982); A. I. Meyers and L. M. Fuentes, *J. Am. Chem. Soc.*, **105**, 117 (1983); M. Al-Asser, P. Beak, D. Hay, D. J. Kempf, S. Mills, and S. G. Smith, *ibid.*, **105**, 2080 (1983); A. I. Meyers, W. F. Rieker, and L. M. Fuentes, *ibid.*, **105**, 2082 (1983); P. D. Edwards and A. I. Meyers, *Tetrahedron Lett.*, **25**, 939 (1984); P. Beak and W. J. Zajdel, *J. Am. Chem. Soc.*, **106**, 1010 (1984); A. I. Meyers, L. M. Fuentes, and Y. Kubota, *Tetrahedron,* **40**, 1361 (1984); A. I. Meyers, P. D. Edwards, W. F. Rieker, and T. R. Bailey, *J. Am. Chem. Soc.*, **106**, 3270 (1984).

5) Reviews on resonance-stabilized α-amino carbanions: U. Schöllkopf, *Angew. Chem.*, **82**, 795 (1970); Th. Kauffmann, *ibid.*, **86**, 715 (1974); D. Hoppe, *ibid.*, **86**, 878 (1974); U. Schöllkopf, *ibid.*, **89**, 351 (1977).

6) Related papers published later than 1980: D. Stafforst and U. Schöllkopf, *Justus Liebigs Ann. Chem.*, **1980**, 28; R. Grigg, J. Kemp, J. Malone, and A. Tangthongkum, *J. Chem. Soc., Chem. Commun.*, **1980**, 648; D. Hoppe and L. Beckmann, *Justus Liebigs Ann. Chem.*, **1980**, 1751; D. Hoppe, R. Follmann, and L. Beckmann, *ibid.*, **1980**, 1765; P. Bey and J. P. Vevert, *J. Org. Chem.*, **45**, 3249 (1980); L. Casella, M. Gullotti, and E. Melani, *J. Chem. Soc., Perkin Trans. 1,* **1982**, 1827.

7) D. J. Peterson, *J. Am. Chem. Soc.*, **93**, 4027 (1971); D. J. Peterson and J. F. Ward, *J. Organomet. Chem.*, **66**, 209 (1974).

8) Generation of a nonstabilized α-amino carbanion by deprotonation with a strong base (*s*-BuLi and *t*-BuOK): H. Ahlbrecht and H. Dollinger, *Tetrahedron Lett.*, **25**, 1353 (1984).

9) It is known that the deprotonation of *N,N*-dialkylbenzylamines with butyllithium occurs at the ortho position of the phenyl ring (F. N. Jones, R. L. Vaulx, and C. R. Hauser, *J. Org. Chem.*, **28**, 3461 (1963) ; W. H. Puterbaugh and C. R. Hauser, *ibid.*, **28**, 3465 (1963)).

10) O. Tsuge, S. Kanemasa, H. Nagahama, and J. Tanaka, *Chem. Lett.*, **1984**, 1803.

11) C. R. Hauser and C. R. Hance, *J. Am. Chem. Soc.*, **74**, 5091 (1952).

12) B. Banhidai and U. Schöllkopf, *Angew. Chem., Int. Ed Engl.*, **12**, 836 (1973); U. Schöllkopf and H. Beckhaus, *ibid.*, **15**, 293 (1976); R. R. Fraser and P. R. Hubert, *Can. J. Chem.*, **52**, 185 (1974); K. Smith and K. Swaminathan, *J. Chem. Soc., Chem. Commun.*, **1976**, 387.

13) W. S. Johnson and E. N. Schubert, *J. Am. Chem. Soc.*, **72**, 2187 (1950).

14) D. Tzeng and W. P. Weber, *J. Org. Chem.*, **46**, 265 (1981).

15) L. H. Sommer and J. Rockett, *J. Am. Chem. Soc.*, **73**, 5130 (1951).

16) A. Terada, *Nippon Kagaku Zasshi*, **77**, 1265 (1956).

17) J. Weijlard, K. Pfister III, E. F. Swanezy, C. A. Robinson, and M. Tishler, *J. Am. Chem. Soc.*, **73**, 1216 (1951).

18) A. Dornow and H. Eichholtz, *Chem. Ber.*, **86**, 384 (1953).

19) S. Kanao, *Yakugaku Zasshi*, **50**, 911 (1930).

20) G. Fort and A. McLean, *J. Chem. Soc.*, **1948**, 1907.

21) Prepared according to the method of Dox (A. W. Dox, *Org. Syn.*, Coll. Vol. **I**, 6 (1932)). See also Ref. 13.