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A Convenient Method for the Preparations of Carboxamides and Peptides by Using Di(2-pyridyl) Carbonate and *O*,*O*′-Di(2-pyridyl) Thiocarbonate as Dehydrating Reagents

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Preparations of carboxamides and peptides are performed in high yields from free carboxylic acids and amines by dehydration condensation using di(2-pyridyl) carbonate (DPC) or *O*,*O*′-di(2-pyridyl) thiocarbonate (DPTC) in the presence of a catalytic amount of 4-(dimethylamino)pyridine (DMAP). The formation of 2-pyridyl esters, key intermediates of the reaction, from carboxylic acids by using DPC proceeded faster than by using DPTC; therefore, the former carbonate is more efficiently employed in the above condensation reactions.

In a previous paper,[1] it was reported that carboxylic esters were synthesized in high yields by dehydration condensation where nearly equimolar amounts of carboxylic acids and alcohols including bulky ones were treated with *O*,*O*′-di(2-pyridyl) thiocarbonate (DPTC). The method was enabled esterification of 7-TES baccatin III with a side-chain, protected phenylisoserine, by which the total synthesis of Taxol[2] was completed in 1997. In 1985, Kim et al. reported that isothiocyanates or thiocarbamates were formed in high yields by treating primary or secondary amines with DPTC[3] (or 1, 1′-thiocarbonyldi-2,2′-pyridone,[4] a regioisomer of DPTC) along with 2-hydroxypyridine (2(1*H*)-pyridone). However, there have been no attempts that used DPTC as a dehydrating reagent in the synthesis of carboxamides from carboxylic acids and amines. Quite recently, it was reported from our laboratory that carboxamides were synthesized in quite high yields by the addition of amines after 2-pyridyl esters had completely been formed from carboxylic acids and DPTC.[5] It was revealed there that 2-pyridyl esters, reactive acylating reagents,[6] were in situ formed from carboxylic acids on treatment with DPTC in the presence of a catalytic amount of 4-(dimethylamino)pyridine (DMAP) for 20 min (Scheme 1).

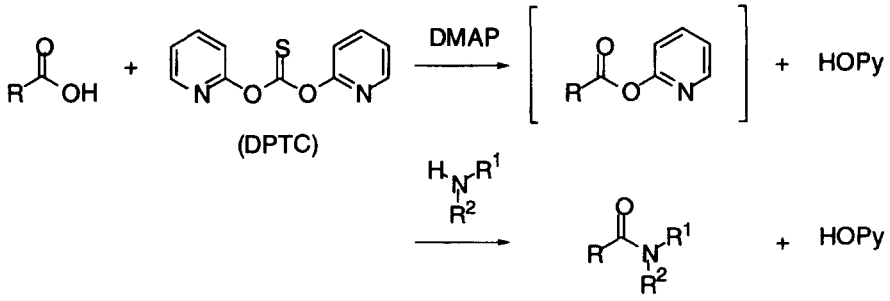
An effective method for the preparation of carboxylic esters was developed by Kim et al. in 1984 using di(2-pyridyl) carbonate (DPC).[7] This was later applied to the preparation of protected Taxol by Greene et al. in 1988.[8] Further, DPC was applied to the syntheses of carboxylic acid derivatives such as 2-pyridyl esters from carboxylic acids,[9] several active esters from carboxylic acids and alcohols with small pK_a values,[9] thiol esters from carboxylic acids and thiols,[10] nitriles from aldoximes,[11] and 2-pyridyl carbamates or ureas from amines.[12] However, concerning the synthesis of carboxamides, Kim described in his review article three examples of carboxamide formation:[13] i.e. *N*-benzyloctanamide, *N*-cyclohexylbenzamide, and 2-methyl-*N*-phenylpropanamide were prepared in 80%, 85%, and 86% yields, respectively by treating the corresponding carboxylic acids and amines with DPC and DMAP by a stepwise procedure.

In the course of our investigation on condensation reactions using DPTC, a characteristic difference of chemical behaviors between DPC and DPTC was recognized in several reactions of carboxylic acids with nucleophiles. Here, we would like to report details of the condensation reaction between nearly equimolar amounts of carboxylic acids and amines by using DPC in the presence of a catalytic amount of DMAP. Further, the difference in forming the corresponding 2-pyridyl esters from carboxylic acids by using DPC or DPTC was studied by comparing respective yields of *N*-benzyl-2-phenylpropanamide (**1**), a condensation product derived from 2-phenylpropanoic acid and benzylamine.

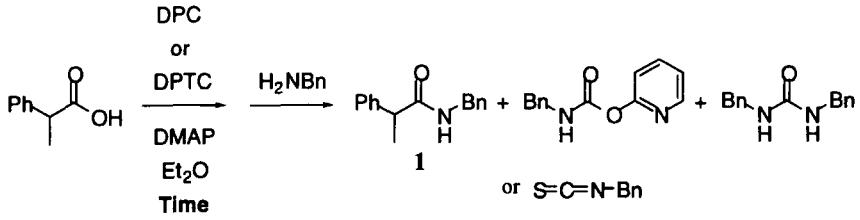
Results and Discussion

In the first place, the reaction velocity of 2-phenylpropanoic acid with DPC was determined by measuring the amounts of produced **1** by treating in situ formed 2-pyridyl 2-phenylpropanoate with benzylamine according to a time sequence by the same procedure as described in the previous paper (Scheme 2).[5]

When benzylamine was added to the above reaction mixture in the presence of a catalytic amount of DMAP after being stirred for 3 min, **1** and the corresponding 2-pyridyl carbamate were obtained in 75% and 20% yields, respectively. On the other hand, **1** and benzyl isothiocyanate were obtained in 34% and 59% yields, respectively, when DPTC was added under the same reaction conditions. It was also observed that **1** was obtained in 91% yield by the addition of benzylamine to the reaction mixture of 2-phenylpropanoic acid and DPC after being stirred for 5 min. Such results suggest that the formation of 2-pyridyl 2-phenylpropanoate from 2-phenylpropanoic acid by using DPC proceeds faster



Scheme 1.



Scheme 2.

than by DPTC, and **1** was obtained in high yield within a shorter time. When DPTC was used, however, 20 min was required before adding benzylamine to obtain **1** in high yield as shown in Fig. 1.

Thus, DPC worked quite efficiently for the preparation of carboxamides, and a variety of carboxamides were synthesized in quite high yields (Table 1). It is noteworthy that even highly hindered carboxylic acids reacted smoothly with DPC within several minutes to form the key intermediates, 2-pyridyl esters, at room temperature, and the successive addition of various amines including highly hindered ones to the reaction mixture afforded the corresponding carboxamides in excellent yields.

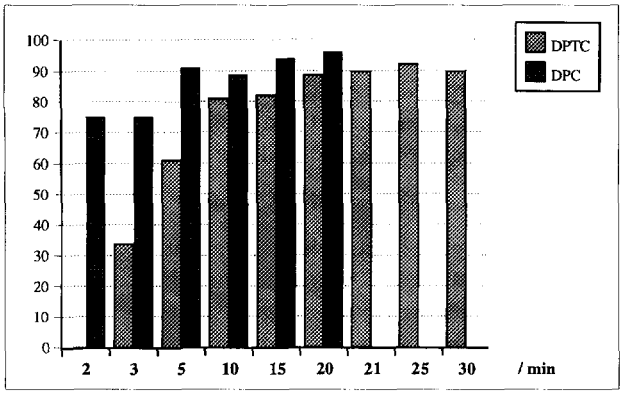
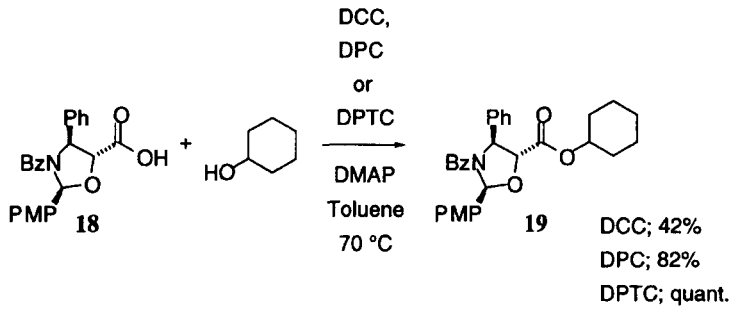


Fig. 1.

The above high-yielding preparative method of carboxamides was further applied to the formation of peptides. When *N*-benzyloxycarbonyl protected α-amino acids were treated with glycine ethyl ester, the corresponding optically active peptides were obtained in high yields without any losses of optical purities. This is probably because the intermediates, active 2-pyridyl esters, were formed rapidly in situ in the presence of a catalytic amount of DMAP (See Table 2).

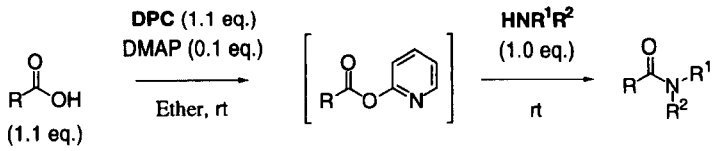
In the previous communication, an effective condensation reaction between Taxol side chains and 7-TES baccatin III or cyclohexanol by using DPTC was reported.[1] In the above reaction, DPTC-DMAP combined system gave better yields compared to DPC-DMAP combined system (Scheme 3).

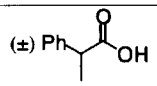
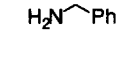
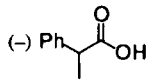
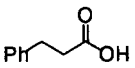
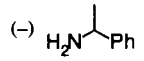
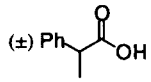
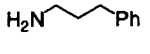
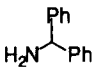
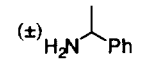
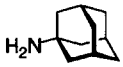
The result was explained by considering the fact that the corresponding 2-pyridyl carbonate was formed rapidly from alcohol and DPC, while little of the corresponding 2-pyridyl thiocarbonate was formed when DPTC was used. For example, as shown in Scheme 4, treatment of DPC with cyclohexanol gave a mixture of the corresponding 2-pyridyl carbonate **20**, 1-(cyclohexyloxycarbonyl)-2-pyridone (**21**) and symmetric carbonate **22** in 52%, 8%, and 2% yields, respectively, after silicagel filtration (60%, 33%, and 0.1%



Scheme 3.

Table 1. Synthesis of Several Carboxamides



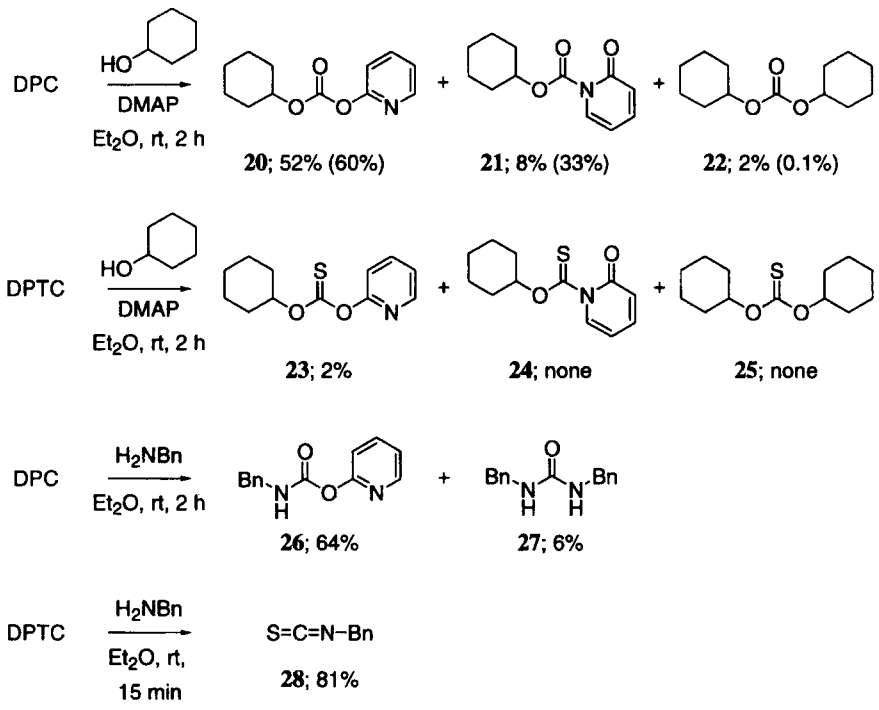
Entry	Carboxylic Acid	Amine	Yield/% [a]	Product
1			96 (91)	(±)-**1**
2	⬆	⬆	95 (81)	(±)-**1**
3	⬆	⬆	93 (86)	(±)-**1**
4		⬆	95 (89)	(−)-**1**
5		⬆	82 (83)	**2**
6		⬆	92 (73)	**3**
7		⬆	94 (98)	**4**
8	⬆		96 (94)	(−)-**5**
9			97 (94)	(±)-**6**
10	⬆		98 (75)	(±)-**7**
11	⬆	⬆	89	(±)-**7**
12	⬆		90[b] (81)[c]	(±)-**8a,8b**
13	⬆		90 (91)	(±)-**9**
14	⬆		98 (quant.)	(±)-**10**
15	⬆		89 (95)	(±)-**11**

a) Reaction using DPTC instead of DPC gave yields in parentheses.
b) **8a**/**8b** = 47/53. c) **8a**/**8b** = 54/46.

Table 2. Synthesis of Several Peptides

Entry	Z-Amino Acid	Peptide	Yield/%[a]	$[\alpha]_D$[b]	lit.
1	Z-L-Leu-OH	Z-L-Leu-Gly-OEt (**12**)	97 (90)	−26.4 (−26.1)	−26.4
2	Z-L-Ala-OH	Z-L-Ala-Gly-OEt (**13**)	93 (77)	−22.1 (−21.5)	−22.2
3	Z-L-Phe-OH	Z-L-Phe-Gly-OEt (**14**)	81 (60)	−17.2 (−16.0)	−16.9
4	Z-L-Val-OH	Z-L-Val-Gly-OEt (**15**)	95 (65)	−25.2 (−26.4)	−25.3
5	Z-L-Met-OH	Z-L-Met-Gly-OEt (**16**)	93 (79)	−19.0 (−19.4)	−19.8
6	Z-L-Pro-OH	Z-L-Pro-Gly-OEt (**17**)	99 (87)	−60.4 (−60.4)	−60.4

a) Reaction using DPTC instead of DPC gave yields in parentheses. b) Values of optical rotation of peptides prepared by DPTC were shown in parentheses.



Scheme 4.

yields, respectively, before silicagel filtration). On the other hand, the corresponding 2-pyridyl thiocarbonate **23** was obtained in only 2% yield and the corresponding thiocarbonyl-2-pyridone **24** and symmetric thiocarbonate **25** were not obtained at all when DPTC and cyclohexanol were treated under the same reaction conditions. Therefore, the preparation of carboxylic esters from less reactive carboxylic acids and alcohols via the corresponding 2-pyridyl esters is performed smoothly just by mixing carboxylic acids, alcohols, and DPTC at once. On the other hand, benzylamine, a stronger nucleophile, affords the corresponding 2-pyridyl carbamate **26** and urea **27** from DPC[12] and the corresponding thioisocyanate **28** from DPTC[3] in 64%, 6%, and 81% yields, respectively as shown in Scheme 4. Concerning the synthesis of carboxamides, therefore, the difference in effectiveness between DPC and DPTC is the rate of initial formation of the active intermediates, 2-pyridyl esters, in the respective reactions with carboxylic acids.

Thus, an effective method for the preparation of carboxamides from nearly equimolar amounts of carboxylic acids, amines, and DPC is established. By-products such as 2-pyridyl carbamates or ureas were not formed when amines were added after the corresponding active 2-pyridyl esters had been formed completely from carboxylic acids and DPC in the presence of a catalytic amount of DMAP.

Experimental

General. All melting points were measured on a Yanaco MP-S3 micro melting point apparatus. Infrared spectra were recorded on a Horiba FT-300 infrared spectrometer. Proton and ^{13}C NMR spectra were recorded on a JEOL JNM-EX270L, a JEOL JNM-EX400, or a JEOL LAMBDA-500 spectrometer with chloroform (in chloroform-*d*) or benzene (in benzene-d_6) as an internal standard. High-resolution mass spectra were recorded on a JEOL JMS-SX102A or a JEOL JMS-AX505HA instrument using 4-nitrobenzyl alcohol as a matrix. High performance liquid chromatography was carried out using a Hitachi LC-Organizer, L-4000 UV Detector, L-6200 Intelligent Pump, and D-2500 Chromato-Integrator. Column chromatography was performed on Silica gel 60 (Merck). Thin layer chromatography was performed on Wakogel B5F.

All reactions were carried out under argon atmosphere in dried glassware, unless otherwise noted. Dichloromethane was distilled from diphosphorus pentaoxide, then calcium hydride, and dried over MS 4 Å, benzene and toluene were distilled from diphosphorus pentaoxide, and dried over MS 4 Å, and THF and diethyl ether were distilled from sodium/benzophenone immediately prior to use. All reagents were purchased from Tokyo Kasei Kogyo Co., Ltd., Kanto Chemical Co., Inc., or Aldrich Chemical Co., Inc.

Synthesis of Carboxamides. A typical experimental procedure is described for the reaction of 2-phenylpropanoic acid with benzylamine: To DMAP (4.6 mg, 0.038 mmol) were successively added a solution of 2-phenylpropanoic acid (60.1 mg, 0.40 mmol) in diethyl ether (1.2 mL) and DPC (87.1 mg, 0.40 mmol). After the reaction mixture had been stirred for 20 min under an argon atmosphere, a solution of benzylamine (40.1 mg, 0.37 mmol) in diethyl ether (1.2 mL) was added to it. This mixture was stirred for 2 h at room temperature and then the solvent was evaporated. The resulting mixture was purified by preparative TLC to afford *N*-benzyl-2-phenylpropanamide (**1**) (85.8 mg, 96%) as a white solid (Table 1, Entry 1). Various carboxamides which were prepared according to this procedure are listed in Table 1.

***N*-Benzyl-2-phenylpropanamide ((±)-1).**[5] Mp 78 °C. ^1H NMR ($CDCl_3$) δ = 7.32—7.09 (m, 10H, Ph), 6.02 (br s, 1H, NH), 4.34 (dd, J = 14.9, 5.9 Hz, 1H, Bn), 4.30 (dd, J = 14.9, 5.9 Hz, 1H, Bn), 3.57 (q, J = 7.1 Hz, 1H, 2-H), 1.51 (d, J = 7.1 Hz, 3H, 3-H). ^{13}C NMR ($CDCl_3$) δ = 174.1 (1), 141.3 (Ph), 138.4 (Ph), 128.8 (Ph), 128.5 (Ph), 127.6 (Ph), 127.4 (Ph), 127.2 (Ph), 127.2 (Ph), 47.0 (2), 43.4 (Bn), 18.5 (3).

(2*R*)-*N*-Benzyl-2-phenylpropanamide ((−)-1, 98% ee).[5] Mp 60 °C. $[\alpha]_D^{20} = -27.4°$ (*c* 1.01, EtOH).

***N*-Benzylbenzamide (2).**[5] Mp 104 °C. IR (KBr) 3270, 1640, 1550 cm^{-1}. ^1H NMR ($CDCl_3$) δ = 7.70 (d, *J* = 6.9 Hz, 2H, Ph), 7.40—7.20 (m, 8H, Ph), 6.37 (br s, 1H, NH), 4.55 (d, *J* = 5.6 Hz, 2H, Bn). ^{13}C NMR ($CDCl_3$) δ = 167.3 (1), 138.2 (Ph), 134.4 (Ph), 131.5 (Ph), 128.8 (Ph), 128.6 (Ph), 127.9 (Ph), 127.6 (Ph), 126.9 (Ph), 44.1 (Bn).

***N*-Benzyl-2,2-dimethylpropanamide (3).**[5] Mp 79 °C. IR (KBr) 3280, 2950, 1650, 1530 cm^{-1}. ^1H NMR ($CDCl_3$) δ = 7.39—7.23 (m, 5H, Ph), 5.95 (br s, 1H, NH), 4.41 (d, *J* = 5.6 Hz, 2H, Bn), 1.14 (s, 9H, 3-H). ^{13}C NMR ($CDCl_3$) δ = 178.3 (1), 138.5 (Ph), 128.7 (Ph), 127.6 (Ph), 127.4 (Ph), 43.6 (Bn), 38.7 (2), 27.6 (3).

***N*-Benzyl-3-phenylpropanamide (4).**[5] Mp 80 °C. IR (KBr) 3290, 1650, 1540 cm^{-1}. ^1H NMR ($CDCl_3$) δ = 7.30—7.09 (m, 10H, Ph), 5.68 (br s, 1H, NH), 4.36 (d, *J* = 5.6 Hz, 2H, Bn), 2.96 (t, *J* = 7.6 Hz, 2H, 3-H), 2.48 (t, *J* = 7.6 Hz, 2H, 2-H). ^{13}C NMR ($CDCl_3$) δ = 171.8 (1), 140.7 (Ph), 138.1 (Ph), 128.6 (Ph), 128.5 (Ph), 128.4 (Ph), 127.7 (Ph), 127.4 (Ph), 126.2 (Ph), 43.5 (Bn), 38.4 (2), 31.7 (3).

3-Phenyl-*N*-[(1*S*)-1-phenylethyl]propanamide ((−)-5, 98% ee).[5] Mp 92 °C. $[\alpha]_D^{21} = -63.6°$ (*c* 1.03, EtOH). ^1H NMR ($CDCl_3$) δ = 7.21—7.00 (m, 12H, Ph), 5.90 (br s, 1H, NH), 4.97 (quin, *J* = 7.6 Hz, 1H, 1′-H), 2.83 (t, *J* = 7.3 Hz, 2H, 3-H), 2.35 (t, *J* = 7.3 Hz, 2H, 2-H), 1.28 (d, *J* = 7.6 Hz, 3H, 2′-H). ^{13}C NMR ($CDCl_3$) δ = 171.1 (1), 143.1 (Ph), 140.7 (Ph), 128.4 (Ph), 128.4 (Ph), 128.3 (Ph), 127.1 (Ph), 126.1 (Ph), 126.0 (Ph), 48.4 (1′), 38.4 (2), 31.7 (3), 21.5 (2′). HR MS (FAB) Found: 254.1542. Calcd for $C_{17}H_{20}NO$ $[M+H]^+$: 254.1545.

2-Phenyl-*N*-(3-phenylpropyl)propanamide ((±)-6).[5] Mp 93 °C. ^1H NMR ($CDCl_3$) δ = 7.34—7.05 (m, 10H, Ph), 5.44 (br s, 1H, NH), 3.50 (q, *J* = 7.3 Hz, 1H, 2-H), 3.24—3.15 (m, 2H, 1′-H), 2.51 (br t, 2H, 3′-H), 1.76—1.69 (m, 2H, 2′-H), 1.50 (d, *J* = 7.3 Hz, 3H, 3-H). ^{13}C NMR ($CDCl_3$) δ = 174.1 (1), 141.4 (Ph), 141.3 (Ph), 128.8 (Ph), 128.3 (Ph), 128.2 (Ph), 127.5 (Ph), 127.2 (Ph), 125.9 (Ph), 47.0 (2), 39.1 (1′), 33.0 (3′), 31.0 (2′), 18.4 (3).

***N*-(Diphenylmethyl)-2-phenylpropanamide ((±)-7).**[5] Mp 134 °C. ^1H NMR ($CDCl_3$) δ = 7.37—6.95 (m, 15H, Ph), 6.19—6.00 (m, 2H, 1′-H), 3.59 (q, *J* = 7.1 Hz, 1H, 2-H), 1.48 (d, *J* = 7.1 Hz, 3H, 3-H). ^{13}C NMR ($CDCl_3$) δ = 173.1 (1), 141.5 (Ph), 141.3 (Ph), 141.2 (Ph), 128.8 (Ph), 128.5 (Ph), 128.3 (Ph), 127.5 (Ph), 127.4 (Ph), 127.3 (Ph), 127.2 (Ph), 127.1 (Ph), 127.0 (Ph), 56.7 (1′), 46.8 (2), 18.3 (3).

(2*RS*)-2-Phenyl-*N*-[(1*SR*)-1-phenylethyl]propanamide ((±)-8a).[5] Mp 127 °C. ^1H NMR ($CDCl_3$) δ = 7.37—7.19 (m, 10H, Ph), 5.56 (br d, 1H, NH), 5.09 (quin, *J* = 6.9 Hz, 1H, 1′-H), 3.53 (q, *J* = 7.1 Hz, 1H, 2-H), 1.51 (d, *J* = 7.1 Hz, 3H, 3-H), 1.34 (d, *J* = 6.9 Hz, 3H, 2′-H). ^{13}C NMR ($CDCl_3$) δ = 173.2 (1), 143.2 (Ph), 141.4 (Ph), 128.9 (Ph), 128.6 (Ph), 127.6 (Ph), 127.2 (Ph), 127.2 (Ph), 126.0 (Ph), 48.7 (1′), 47.1 (2), 21.5 (2′), 18.6 (3).

(2*RS*)-2-Phenyl-*N*-[(1*RS*)-1-phenylethyl]propanamide ((±)-8b).[5] Mp 127 °C. ^1H NMR ($CDCl_3$) δ = 7.34—7.17 (m, 8H, Ph), 7.08 (dd, *J* = 7.7, 1.2 Hz, 2H, Ph), 5.59 (d, *J* = 7.1 Hz, 1H, NH), 5.08 (quin, *J* = 7.1 Hz, 1H, 1′-H), 3.57 (q, *J* = 7.3 Hz, 1H, 2-H), 1.51 (d, *J* = 7.3 Hz, 3H, 3-H), 1.39 (d, *J* = 7.1 Hz, 3H, 2′-H). ^{13}C NMR ($CDCl_3$) δ = 173.1 (1), 143.2 (Ph), 141.3 (Ph), 128.8 (Ph), 128.5 (Ph), 127.6 (Ph), 127.2 (Ph), 127.1 (Ph), 125.7 (Ph), 48.6 (1′), 47.1 (2), 21.9 (2′), 18.4 (3).

***N*-1-Adamantyl-2-phenylpropanamide ((±)-9).**[5] Mp 136 °C. ^1H NMR ($CDCl_3$) δ = 7.34—7.22 (m, 5H, Ph), 5.11 (br s, 1H, NH), 3.45 (q, *J* = 7.1 Hz, 1H, 2-H), 2.02 (br s, 3H, 3′-H), 1.90 (br d, 6H, 2′-H), 1.63 (br t, 6H, 4′-H), 1.46 (d, *J* = 7.1 Hz, 3H, 3-H). ^{13}C NMR ($CDCl_3$) δ = 173.2 (1), 142.1 (Ph), 128.7 (Ph), 127.5 (Ph), 127.0 (Ph), 51.7 (1′), 47.8 (2), 41.4 (2′), 36.3 (4′), 29.4 (3′), 18.7 (3).

***N*-Benzyl-*N*-methyl-2-phenylpropanamide ((±)-10).**[5] (a mixture of two conformational isomers A and B). ^1H NMR ($CDCl_3$) δ = 7.31—7.15 (m, 8H, Ph), 7.01 (d, *J* = 7.3 Hz, 2H, Ph), 4.66 (d, *J* = 14.6 Hz, 1aH, Bn of A), 4.65 (d, *J* = 16.7 Hz, 1bH, Bn of B), 4.54 (d, *J* = 14.6 Hz, 1aH, Bn of A), 4.24 (d, *J* = 16.7 Hz, 1bH, Bn of B), 3.92 (q, *J* = 6.8 Hz, 1aH, 2-H of A), 3.87 (q, *J* = 6.8 Hz, 1bH, 2-H of B), 2.93 (s, 3H, MeN of B), 2.79 (s, 3H, MeN of A), 1.49 (d, *J* = 6.8 Hz, 3aH, 3-H of A), 1.46 (d, *J* = 6.8 Hz, 3bH, 3-H of B). ^{13}C NMR ($CDCl_3$) δ = 174.1 (1 of B), 173.7 (1 of A), 141.9 (Ph of B), 141.7 (Ph of A), 137.4 (Ph of A), 136.6 (Ph of B), 128.8 (Ph), 128.8 (Ph), 128.8 (Ph), 128.4 (Ph), 127.8 (Ph), 127.4 (Ph), 127.3 (Ph), 127.2 (Ph), 127.1 (Ph), 126.8 (Ph), 126.7 (Ph), 126.2 (Ph), 52.9 (Bn of B), 51.1 (Bn of A), 43.4 (2 of A), 43.1 (2 of B), 34.7 (MeN of A), 34.2 (MeN of B), 20.9 (3 of B), 20.8 (3 of A).

2-Phenylpropanoylpiperidine ((±)-11).[5] ^1H NMR ($CDCl_3$) δ = 7.33—7.19 (m, 5H, Ph), 3.88 (q, *J* = 6.8 Hz, 1H, 2-H), 3.70—3.35 (br m, 4H, 1′-H), 1.52—1.37 (m, 6H, 2′-H, 3′-H), 1.44 (d, *J* = 6.8 Hz, 3H, 3-H). ^{13}C NMR ($CDCl_3$) δ = 171.7 (1), 142.4 (Ph), 128.8 (Ph), 127.2 (Ph), 126.6 (Ph), 43.2 (2), 43.2 (1′), 25.7 (3′), 24.5 (2′), 20.8 (3).

Synthesis of Peptides. A typical experimental procedure is described for the reaction of *Z*-L-leucine with glycine ethyl ester hydrochloride: To a solution of *Z*-L-leucine (144.5 mg, 0.54 mmol) in dichloromethane (1.5 mL) were successively added DPC (117.2 mg, 0.54 mmol) and DMAP (5.3 mg, 0.043 mmol). After the reaction mixture had been stirred for 2 h under an argon atmosphere, glycine ethyl ester hydrochloride (67.1 mg, 0.48 mmol) and a solution of triethylamine (50.3 mg, 0.50 mmol) in dichloromethane (1.5 mL) were successively added to it. This mixture was stirred for 2 h at room temperature and then the solvent was evaporated. The resulting mixture was purified by preparative TLC to afford ethyl [(2*S*)-2-(benzyloxycarbonylamino)-4-methylpentanoylamino]acetate (**12**) (163.5 mg, 97%) as a white solid (Table 2, Entry 1). Various peptides which were prepared according to this procedure are listed in Table 2.

Ethyl [(2*S*)-2-(Benzyloxycarbonylamino)-4-methylpentanoylamino]acetate (12).[14] Mp 101 °C (prepared by DPC-DMAP). Mp 103 °C (prepared by DPTC–DMAP). $[\alpha]_D^{14} = -26.4°$ (*c* 1.94, EtOH) (prepared by DPC–DMAP). $[\alpha]_D^{18} = -26.1°$ (*c* 1.67, EtOH) (prepared by DPTC–DMAP). ^1H NMR ($CDCl_3$) δ = 7.38—7.29 (m, 5H, Ph), 6.54 (br s, 1H, 2-NH), 5.17 (br d, *J* = 8.3 Hz, 1H, 2′-NH), 5.13 (d, *J* = 12.2 Hz, 1H, Bn), 5.09 (d, *J* = 12.2 Hz, 1H, Bn), 4.25—4.20 (m, 1H, 2′-H), 4.21 (q, *J* = 7.2 Hz, 2H, EtO), 4.04 (dd, *J* = 18.1, 4.4 Hz, 1H, 2-H), 3.99 (dd, *J* = 18.1, 4.9 Hz, 1H, 2-H), 1.73—1.63 (m, 1H, 2′-H), 1.69 (ddd, *J* = 16.2, 7.4, 7.0 Hz, 1H, 3′-H), 1.52 (ddd, *J* = 16.2, 9.2, 8.9 Hz, 1H, 3′-H), 1.28 (t, *J* = 7.2 Hz, 3H, EtO), 0.94 (d, *J* = 6.1 Hz, 6H, 5′-H, 5′-H). ^{13}C NMR ($CDCl_3$) δ = 172.3 (1′), 169.6 (1), 156.2 (Z), 136.0 (Ph), 128.6 (Ph), 128.2 (Ph), 128.1 (Ph), 67.2 (Bn), 61.6 (EtO), 53.4 (2′), 41.3 (2), 41.3 (3′), 24.6 (4′), 22.9 (5′), 21.9 (5′), 14.1 (EtO).

Ethyl [(2*S*)-2-(Benzyloxycarbonylamino)propanoylamino]-acetate (13).[15] Mp 98 °C (prepared by DPC–DMAP). Mp 96 °C (prepared by DPTC-DMAP). $[\alpha]_D^{18} = -22.1°$ (*c* 1.81, EtOH) (prepared by DPC–DMAP). $[\alpha]_D^{20} = -21.5°$ (*c* 1.97, EtOH) (prepared by DPTC–DMAP). ^1H NMR ($CDCl_3$) δ = 7.56—7.20 (m, 5H, Ph), 6.76 (br s, 1H, 2-NH), 5.54 (br d, *J* = 7.4 Hz, 1H, 2′-NH), 5.06 (d, *J* = 12.3 Hz, 1H, Bn), 5.00 (d, *J* = 12.3 Hz, 1H, Bn), 4.24 (br dq, *J* = 7.4, 6.9 Hz, 1H, 2′-H), 4.12 (q, *J* = 7.1 Hz, 2H,

EtO), 3.92 (d, J = 5.3 Hz, 2H, 2-H), 1.32 (d, J = 6.9 Hz, 3H, 3′-H), 1.19 (t, J = 7.1 Hz, 3H, EtO). ^{13}C NMR ($CDCl_3$) δ = 172.6 (1′), 169.6 (1), 155.9 (Z), 136.1 (Ph), 128.5 (Ph), 128.1 (Ph), 128.0 (Ph), 67.0 (Bn), 61.5 (EtO), 50.4 (2′), 41.2 (2), 18.5 (3′), 14.0 (EtO).

Ethyl [(2*S*)-2-(Benzyloxycarbonylamino)-3-phenylpropanoylamino]acetate (14).[16] Mp 104 °C (prepared by DPC–DMAP). Mp 104 °C (prepared by DPTC–DMAP). $[\alpha]_D^{18}$ = −17.2° (*c* 1.97, EtOH) (prepared by DPC–DMAP). $[\alpha]_D^{19}$ = −16.0° (*c* 2.49, EtOH) (prepared by DPTC–DMAP). ^{1}H NMR ($CDCl_3$) δ = 7.39—7.21 (m, 10H, Ph), 6.61 (br s, 1H, 2-NH), 5.55 (br d, J = 7.8 Hz, 1H, 2′-NH), 5.11 (d, J = 12.4 Hz, 1H, Bn), 5.06 (d, J = 12.4 Hz, 1H, Bn), 4.55 (br ddd, J = 7.8, 6.8, 6.6 Hz, 1H, 2′-H), 4.20 (q, J = 7.1 Hz, 2H, EtO), 4.03 (dd, J = 18.1, 5.4 Hz, 1H, 2-H), 3.92 (dd, J = 18.1, 4.8 Hz, 1H, 2-H), 3.16 (dd, J = 13.9, 6.6 Hz, 1H, 3′-H), 3.08 (dd, J = 13.9, 6.8 Hz, 3H, 3′-H), 1.29 (t, J = 7.1 Hz, 3H, EtO). ^{13}C NMR ($CDCl_3$) δ = 171.2 (1′), 169.4 (1), 156.0 (*Z*), 136.3 (Ph), 136.0 (Ph), 129.2 (Ph), 128.6 (Ph), 128.5 (Ph), 128.1 (Ph), 127.9 (Ph), 127.0 (Ph), 67.0 (Bn), 61.5 (EtO), 56.0 (2′), 41.2 (2), 38.3 (3′), 14.0 (EtO).

Ethyl [(2*S*)-2-(Benzyloxycarbonylamino)-3-methylbutanoylamino]acetate (15).[17] Mp 166 °C (prepared by DPC–DMAP). Mp 165 °C (prepared by DPTC–DMAP). $[\alpha]_D^{21}$ = −25.2° (*c* 0.973, EtOH) (prepared by DPC–DMAP). $[\alpha]_D^{22}$ = −26.4° (*c* 0.913, EtOH) (prepared by DPTC–DMAP). ^{1}H NMR ($CDCl_3$) δ = 7.41—7.28 (m, 5H, Ph), 6.63 (br dd, J = 5.4, 5.0 Hz, 1H, 2-NH), 5.47 (br d, J = 8.8 Hz, 1H, 2′-NH), 5.11 (d, J = 12.2 Hz, 1H, Bn), 5.07 (d, J = 12.2 Hz, 1H, Bn), 4.19 (q, J = 7.2 Hz, 2H, EtO), 4.09 (dd, J = 8.8, 6.6 Hz, 1H, 2′-H), 4.07 (dd, J = 18.2, 5.4 Hz, 1H, 2-H), 3.96 (dd, J = 18.2, 5.0 Hz, 1H, 2-H), 2.15 (qqd, J = 6.8, 6.8, 6.6 Hz, 1H, 3′-H), 1.27 (t, J = 7.2 Hz, 3H, EtO), 0.98 (d, J = 6.8 Hz, 1H, 4′-H), 0.93 (d, J = 6.8 Hz, 1H, 4′-H). ^{13}C NMR ($CDCl_3$) δ = 171.7 (1′), 169.6 (1), 156.4 (Z), 136.1 (Ph), 128.4 (Ph), 128.1 (Ph), 127.9 (Ph), 66.9 (Bn), 61.4 (EtO), 60.2 (2′), 41.2 (2), 31.0 (3′), 19.1 (4′), 17.7 (4′), 14.0 (EtO).

Ethyl [(2*S*)-2-(Benzyloxycarbonylamino)-4-methylthiobutanoylamino]acetate (16).[18] Mp 94 °C (prepared by DPC–DMAP). Mp 94 °C (prepared by DPTC–DMAP). $[\alpha]_D^{18}$ = −19.0° (*c* 3.40, EtOH) (prepared by DPC–DMAP). $[\alpha]_D^{18}$ = −19.4° (*c* 3.90, EtOH) (prepared by DPTC–DMAP). ^{1}H NMR ($CDCl_3$) δ = 7.36–7.28 (m, 5H, Ph), 6.84 (br s, 1H, 2-NH), 5.70 (br d, J = 6.4 Hz, 1H, 2′-NH), 5.12 (d, J = 12.2 Hz, 1H, Bn), 5.08 (d, J = 12.2 Hz, 1H, Bn), 4.44 (br td, J = 6.7, 6.4 Hz, 1H, 2′-H), 4.19 (q, J = 7.2 Hz, 2H, EtO), 4.05 (ddd, J = 18.0, 4.0, 1.2 Hz, 1H, 2-H), 3.95 (dd, J = 18.0, 4.9 Hz, 1H, 2-H), 2.58 (t, J = 7.0 Hz, 1H, 4′-H), 2.11 (ddt, J = 7.3, 7.0, 6.7 Hz, 1H, 3′-H), 2.09 (s, 3H, MeS), 1.98 (ddt, J = 7.3, 7.0, 6.7 Hz, 1H, 3′-H), 1.26 (td, J = 7.2, 1.2 Hz, 3H, EtO). ^{13}C NMR ($CDCl_3$) δ = 171.5 (1′), 169.5 (1), 156.2 (Z), 136.1 (Ph), 128.5 (Ph), 128.2 (Ph), 128.0 (Ph), 67.1 (Bn), 61.5 (EtO), 53.7 (2′), 41.3 (2), 31.6 (3′), 29.9 (4′), 15.1 (MeS), 14.1 (EtO).

Ethyl {[(2*S*)-1-(Benzyloxycarbonyl)pyrrolidin-2-yl]carbonylamino}acetate (17).[19] $[\alpha]_D^{16}$ = −60.4° (*c* 1.76, AcOEt) (prepared by DPC–DMAP). $[\alpha]_D^{19}$ = −60.4° (*c* 1.97, AcOEt) (prepared by DPTC–DMAP). ^{1}H NMR ($CDCl_3$) δ = 7.26—7.20 (m, 5H, Ph), 7.09 (br s, 1H, 2-NH), 6.48 (br s, 1H, 2′-NH), 5.12 (d, J = 12.4 Hz, 1H, Bn), 5.04 (d, J = 12.4 Hz, 1H, Bn), 4.40—4.20 (br m, 1H, 2″-H), 4.10 (q, J = 7.1 Hz, 2H, EtO), 4.00—3.85 (br m, 1H, 2-H), 3.85—3.61 (br m, 1H, 2-H), 3.57—3.36 (br m, 1H, 5″-H), 3.51—3.29 (br m, 1H, 5″-H), 2.33—2.11 (br m, 1H, 3″-H), 2.21—2.00 (br m, 1H, 3″-H), 1.95—1.73 (m, 2H, 4″-H), 1.18 (td, J = 7.1, 3.3 Hz, 3H, EtO). ^{13}C NMR ($CDCl_3$) δ = 171.9 (1′), 169.5 (1), 155.9 (Z), 136.3 (Ph), 128.3 (Ph), 127.9 (Ph), 127.8 (Ph), 67.1 (Bn), 61.2 (EtO), 60.4 (2″), 46.9 (2), 41.2 (5″), 28.5 (3″), 24.3 (4″), 14.0 (EtO).

Dehydration Condensation between (2*S*,4*S*,5*R*)-3-Benzoyl-2-(4-methoxyphenyl)-4-phenyl-1,3-oxazolidine-5-carboxylic Acid and Cyclohexanol Using DCC in the Presence of DMAP. To a solution of (2*S*,4*S*,5*R*)-3-benzoyl-2-(4-methoxyphenyl)-4-phenyl-1,3-oxazolidine-5-carboxylic acid (12.0 mg, 0.030 mmol) and DCC (6.2 mg, 0.030 mmol) in toluene (0.1 mL) were successively added a solution of cyclohexanol in toluene (0.043 mol dm^{-3}, 0.116 mL, 0.0050 mmol) and DMAP (1.2 mg, 0.010 mmol). The reaction mixture was stirred for 7 h at 70 °C and then the mixture was filtered through a short pad of Celite with ethyl acetate. The filtrate was evaporated and the resulting mixture was purified by preparative TLC to afford the corresponding ester **19** (1.0 mg, 42%) as a colorless oil.

Dehydration Condensation between (2*S*,4*S*,5*R*)-3-Benzoyl-2-(4-methoxyphenyl)-4-phenyl-1,3-oxazolidine-5-carboxylic Acid and Cyclohexanol Using DPC in the Presence of DMAP. To a mixture of (2*S*,4*S*,5*R*)-3-benzoyl-2-(4-methoxyphenyl)-4-phenyl-1,3-oxazolidine-5-carboxylic acid (12.1 mg, 0.030 mmol) and DMAP (1.2 mg, 0.010 mmol) were successively added a solution of cyclohexanol in toluene (0.040 mol dm^{-3}, 0.124 mL, 0.0050 mmol) and DPC (6.6 mg, 0.031 mmol). The reaction mixture was stirred for 23 min at 70 °C and then the mixture was purified by preparative TLC to afford the corresponding ester **19** (2.0 mg, 82%) as a colorless oil.

Dehydration Condensation between (2*S*,4*S*,5*R*)-3-Benzoyl-2-(4-methoxyphenyl)-4-phenyl-1,3-oxazolidine-5-carboxylic Acid and Cyclohexanol Using DPTC in the Presence of DMAP. To a mixture of (2*S*,4*S*,5*R*)-3-benzoyl-2-(4-methoxyphenyl)-4-phenyl-1,3-oxazolidine-5-carboxylic acid (11.8 mg, 0.029 mmol) and DMAP (1.2 mg, 0.010 mmol) were successively added a solution of cyclohexanol in toluene (0.041 mol dm^{-3}, 0.119 mL, 0.0049 mmol) and DPTC (7.0 mg, 0.030 mmol). The reaction mixture was stirred for 20 min at 70 °C and then the mixture was purified by preparative TLC to afford the corresponding ester **19** (2.4 mg, quant.) as a colorless oil.

Cyclohexyl (2*S*,4*S*,5*R*)-3-Benzoyl-2-(4-methoxyphenyl)-4-phenyl-1,3-oxazolidine-5-carboxylate (19). $[\alpha]_D^{24}$ = −45.3° (*c* 0.324, benzene). IR (neat) 1740, 1650 cm^{-1}. ^{1}H NMR ($CDCl_3$) δ = 7.50—7.00 (m, 12H, Ph), 6.85 (br s, 1H, CHPMP), 6.79 (d, J = 8.6 Hz, 2H, PMP), 5.29 (br s, 1H, CHPh), 4.89—4.75 (m, 1H, CH in *c*-Hex), 4.75 (s, 1H, 5-H), 3.80 (s, 3H, MeO), 1.86—1.11 (10H, CH_2 in *c*-Hex). ^{13}C NMR ($CDCl_3$) δ = 171.8 (1), 169.6 (Bz), 159.8 (PMP), 135.9 (Ph), 135.6 (Ph), 130.6 (Ph), 130.1 (Ph), 128.7 (Ph), 128.6 (Ph), 128.2 (Ph), 128.0 (Ph), 127.0 (Ph), 127.0 (Ph), 113.4 (PMP), 91.3 (2′), 82.6 (5′), 74.4 (CH in *c*-Hex), 70.1 (4′), 55.3 (MeO), 31.3 (CH_2 in *c*-Hex), 25.2 (CH_2 in *c*-Hex), 23.5 (CH_2 in *c*-Hex). HR MS (FAB) Found: 486.2276. Calcd for $C_{30}H_{32}NO_5$ $[M+H]^+$: 486.2280.

Reaction between DPC and Cyclohexanol. To DPC (305.0 mg, 1.40 mmol) were successively added a solution of cyclohexanol (140.5 mg, 1.40 mmol) in diethyl ether (10 mL) and DMAP (20.4 mg, 0.17 mmol). The reaction mixture was stirred for 2 h at room temperature, and then saturated aqueous ammonium chloride was added. The mixture was extracted with diethyl ether, and the organic layer was washed with brine and dried over sodium sulfate. After filtration of the mixture and evaporation of the solvent, the crude product was filtered though a short pad of silica gel with dichloromethane to afford a mixture (210.3 mg) of the corresponding 2-pyridyl carbonate **20**, pyridone **21**, and carbonate **22** (52%, 8%, and 2%, respectively, determined by ^{1}H NMR) as a colorless oil. Though 2-pyridyl carbonate **20** and carbonate **22** were sepa-

rated by preparative TLC, pyridone **21** was relatively unstable and could not be isolated by preparative TLC. Therefore, the following experiment was carried out. To DPC (30.7 mg, 0.140 mmol) were successively added a solution of cyclohexanol (13.9 mg, 0.140 mmol) in diethyl ether (1.0 mL) and DMAP (1.9 mg, 0.016 mmol). The reaction mixture was stirred for 2 h at room temperature and then the solvent was evaporated. Proton NMR showed that the residue was a mixture of 2-pyridyl carbonate **20**, pyridone **21**, and carbonate **22** (60%, 33%, and 0.1%, respectively).

Cyclohexyl 2-Pyridyl Carbonate (20). IR (neat) 1750 cm^{-1}. ^1H NMR ($CDCl_3$) δ = 8.34—8.32 (m, 1H, Ph), 7.76—7.69 (m, 1H, Ph), 7.20—7.14 (m, 1H, Ph), 7.07—7.04 (m, 1H, Ph), 4.74—4.64, (m, 1H, CH in *c*-Hex), 1.90—1.89 (m, 2H, CH_2 in *c*-Hex), 1.74—1.69 (m, 2H, CH_2 in *c*-Hex), 1.59—1.18 (m, 6H, CH_2 in *c*-Hex). ^{13}C NMR ($CDCl_3$) δ = 157.8 (Py), 152.2 (CO), 148.4 (Py), 139.6 (Py), 122.0 (Py), 115.6 (Py), 78.0 (CH in *c*-Hex), 31.3 (CH_2 in *c*-Hex), 25.1 (CH_2 in *c*-Hex), 23.4 (CH_2 in *c*-Hex). HR MS (FAB) Found: 222.1133. Calcd for $C_{12}H_{16}NO_3$ $[M+H]^+$: 222.1130.

Di(cyclohexyl) Carbonate (22).[20] IR (neat) 1740 cm^{-1}. ^1H NMR ($CDCl_3$) δ = 4.61—4.55, (m, 2H, CH in *c*-Hex), 1.95—1.92 (m, 4H, CH_2 in *c*-Hex), 1.78—1.67 (m, 4H, CH_2 in *c*-Hex), 1.56—1.19 (m, 12H, CH_2 in *c*-Hex). ^{13}C NMR ($CDCl_3$) δ = 154.2 (CO), 76.4 (CH in *c*-Hex), 31.7 (CH_2 in *c*-Hex), 25.2 (CH_2 in *c*-Hex), 23.8 (CH_2 in *c*-Hex).

Reaction between DPTC and Cyclohexanol. To DPTC (32.0 mg, 0.14 mmol) were successively added a solution of cyclohexanol (13.9 mg, 0.14 mmol) in diethyl ether (1.0 mL) and DMAP (2.2 mg, 0.018 mmol). The reaction mixture was stirred for 2 h at room temperature and then the solvent was evaporated. The resulting mixture was purified by preparative TLC to afford the corresponding 2-pyridyl thiocarbonate **23** (0.4 mg, 2%) as a colorless oil. In order to obtain pyridone **24**, the following experiment was carried out. To DPTC (300.0 mg, 1.29 mmol) were successively added a solution of cyclohexanol (256.7 mg, 2.56 mmol) in benzene (9.3 mL) and DMAP (14.9 mg, 0.122 mmol). The reaction mixture was stirred for 2 h at 70 °C and then the solvent was evaporated. The resulting mixture was purified by preparative TLC to afford the corresponding 2-pyridyl thiocarbonate **23** (64.3 mg, 21%) as a colorless oil and pyridone **24** (187.4 mg, 61%) as a pale yellow oil.

***O*-Cyclohexyl *O'*-2-pyridyl Thiocarbonate (23).** IR (neat) 1590 cm^{-1}. ^1H NMR ($CDCl_3$) δ = 8.39—8.36 (m, 1H, Ph), 7.80—7.73 (m, 1H, Ph), 7.23—7.19 (m, 1H, Ph), 7.05—7.01 (m, 1H, Ph), 5.22—5.16, (m, 1H, CH in *c*-Hex), 2.02—1.95 (m, 2H, CH_2 in *c*-Hex), 1.74—1.18 (m, 8H, CH_2 in *c*-Hex). ^{13}C NMR ($CDCl_3$) δ = 193.2 (CS), 159.5 (Py), 148.6 (Py), 139.6 (Py), 122.6 (Py), 117.0 (Py), 83.6 (CH in *c*-Hex), 30.7 (CH_2 in *c*-Hex), 25.1 (CH_2 in *c*-Hex), 23.5 (CH_2 in *c*-Hex). HR MS (FAB) Found: 238.0896. Calcd for $C_{12}H_{16}NO_2S$ $[M+H]^+$: 238.0896.

1-(Cyclohexyloxythiocarbonyl)-2-pyridone (24). IR (neat) 1680, 1600 cm^{-1}. ^1H NMR ($CDCl_3$) δ = 7.56—7.52 (m, 1H, Ph), 7.24—7.17 (m, 1H, Ph), 6.43—6.39 (m, 1H, Ph), 6.09—6.04 (m, 1H, Ph), 5.38—5.32 (m, 1H, CH in *c*-Hex), 2.04—1.95 (m, 2H, CH_2 in *c*-Hex), 1.88—1.65 (m, 4H, CH_2 in *c*-Hex), 1.52—1.30 (m, 4H, CH_2 in *c*-Hex). ^{13}C NMR ($CDCl_3$) δ = 192.1 (CS), 159.9 (CO), 139.9 (Py), 135.3 (Py), 122.6 (Py), 105.3 (Py), 85.0 (CH in *c*-Hex), 30.2 (CH_2 in *c*-Hex), 25.1 (CH_2 in *c*-Hex), 23.3 (CH_2 in *c*-Hex). HR MS (FAB) Found: 238.0895. Calcd for $C_{12}H_{16}NO_2S$ $[M+H]^+$: 238.0902.

Reaction between DPC and Benzylamine. To a solution of benzylamine (49.3 mg, 0.46 mmol) in diethyl ether (3.3 mL) was added DPC (100.9 mg, 0.46 mmol). The reaction mixture was stirred for 2 h at room temperature and then the solvent was evaporated. The resulting mixture was purified by preparative TLC to afford a mixture (74.2 mg) of the corresponding carbamate **26** (64%) and urea **27** (6%) as a white solid. The above ratio of **26** to **27** was determined by ^1H NMR because these compounds could not be separated by preparative TLC.

2-Pyridyl Benzylcarbamate (26).[12] IR (KBr) 1620, 1570 cm^{-1}. ^1H NMR ($CDCl_3$) δ = 11.03 (br s, NH), 8.46—8.42 (m, 1H, Ph), 7.45—7.21 (m, 6H, Ph), 6.63—6.59 (m, 1H, Ph), 6.37—6.27 (m, 1H, Ph), 4.66 (d, J = 14.1 Hz, 1H, Bn), 4.59 (d, J = 14.1 Hz, 1H, Bn). ^{13}C NMR ($CDCl_3$) δ = 164.9 (Py), 152.5 (CO), 141.4 (Py), 137.3 (Ph), 132.2 (Py), 128.7 (Ph), 127.6 (Ph), 127.3 (Ph), 122.6 (Py), 107.1 (Py), 44.9 (Bn).

***N,N'*-Dibenzylurea (27).**[21] Mp 170—171 °C. ^1H NMR ($CDCl_3$) δ = 7.32—7.23 (m, 10H, Ph), 4.78 (br s, 2H, NH), 4.35 (s, 4H, Bn). ^{13}C NMR ($CDCl_3$) δ = 198.1 (CO), 139.0 (Ph), 128.6 (Ph), 127.4 (Ph), 127.3 (Ph), 44.6 (Bn).

Reaction between DPTC and Benzylamine. To a solution of benzylamine (32.6 mg, 0.14 mmol) in diethyl ether (1.0 mL) was added DPC (15.1 mg, 0.14 mmol). The reaction mixture was stirred for 15 min at room temperature and then the solvent was evaporated. The resulting mixture was purified by preparative TLC to afford the corresponding isothiocyanate **28** (16.9 mg, 81%) as a colorless oil.

Benzyl Isothiocyanate (28).[21b,22] IR (neat) 2180, 2080 cm^{-1}. ^1H NMR ($CDCl_3$) δ = 7.56—7.31 (m, 5H, Ph), 4.72 (s, 2H, Bn). ^{13}C NMR ($CDCl_3$) δ = 134.2 (Ph), 132.2 (NCS), 128.9 (Ph), 128.4 (Ph), 126.8 (Ph), 48.6 (Bn).

Registry Nos. (±)-**1**; 58265-34-2. (−)-**1**; 116342-25-7. **2**; 1485-70-7. **3**; 26209-45-0. **4**; 10264-10-5. (−)-**5**; 200803-30-1. (±)-**11**; 81860-77-7. (−)-**12**; 2867-06-3. (−)-**13**; 2503-32-4. (−)-**14**; 2778-34-9. (−)-**15**; 2766-17-8. (−)-**16**; 27482-82-2. (−)-**17**; 2766-31-6. (−)-**18**; 202390-86-1. **22**; 4427-97-8. **25**; 57024-84-7. **26**; 100906-76-1. **27**; 1466-67-7. **28**; 622-78-6.

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