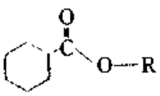
Table 1. Reduction of Cyclohexanecarboxylic Acid Esters with Light Absorbing Reducing Agents[a]

Reducing agents	R in 	Reduction(%) Thermal	Photocatalyzed (Quantum yield)
Mono-β-naphthoxyborane	Phenyl	9.0	25.8 (0.66)
	2-tolyl	8.6	23.4 (0.58)
	3-tolyl	18.3	25.1 (0.27)
	4-tolyl	19.5	39.7 (0.79)
	2-chlorophenyl	12.2	12.2 (0.00)
	4-chlorophenyl	14.0	18.9 (0.19)
	4-methoxyphenyl	25.3	27.0 (0.07)
	methyl	47.3	59.1 (0.43)
Di-β-naphthoxyborane	phenyl	10.0	21.3 (0.45)
	2-tolyl	16.8	26.3 (0.37)
	3-tolyl	9.9	27.6 (0.60)
	4-tolyl	11.3	13.5 (0.08)
	2-chlorophenyl	2.4	10.2 (0.31)
	4-chlorophenyl	2.7	12.8 (0.40)
	4-methoxyphenyl	13.2	22.9 (0.38)
	methyl	30.5	38.5 (0.31)
Lithium tri-β-naphthoxyborohydride	phenyl	2.8	11.2 (2.36)
	2-tolyl	10.1	7.7 (0.00)
	3-tolyl	13.3	9.3 (0.00)
	4-tolyl	9.7	13.4 (1.05)
	2-chlorophenyl	28.4	23.3 (0.00)
	4-chlorophenyl	27.3	24.6 (0.00)
	4-methoxyphenyl	10.0	9.5 (0.00)
	methyl	27.0	24.7 (0.00)

[a]Irradiated for 3 h at 334 nm.

the hydride anion transfer from metal atom is decreased in the singlet excited state of lithium tri-β-naphthoxyborohydride. The results offer a new method and possibility to control the reducing power of borohydride by introducing new substituents which will change the acidity of acidic borohydride or the basicity of basic borohydride in the excited state.

When the reduction of cyclohexanecarboxylic acid esters with lithium tri-β-naphthoxyborohydride was carried out with 334 nm irradiation, phenyl and 4-tolyl cyclohexanecarboxylates gave guantum yeilds of 2.36 and 1.05 as shown in Table 1. But the reduction of most of the cyclohexanecarboxylic acid esters wat not accelerated on irradiation with 334 nm light but yields were decreased on irradiation due to the increased acidity of β-naphthoxy group in the (π, π^*) singlet excited state. The ability of hydride anion transfer from metal atom is, therefore, decreased in the singlet excited state of lithium tri-β-naphthoxyborohydride.

In conclusion, the results offer a new method and possibility to control the reducing power of borohydrides by introducing appropriate light absorbing substituents into the borohydride followed by uv irradiation.

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Desulfurization of Thioamide Derivatives into Their Corresponding Amides Using Superoxide Anion ($O_2^{\bar{}}$)

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Considerable interest has recently been focused on the desulfurization of thiocarbonyl compounds using superoxide[1,2] and a related system of alkaline autoxidation[3] since oxidative desulfurization of thioamides[4,5] such as thiobarbiotal, ethionamide, or thiouracil has been known to be metabolized *in vivo* to give the corresponding carbonyl compounds without any evidence that an activated oxygen species like superoxide, which is distributed widely in living cells, is involved.

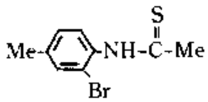
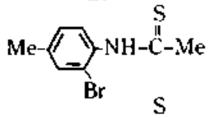
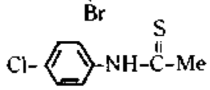
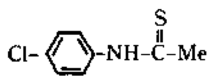
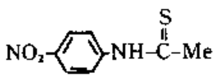
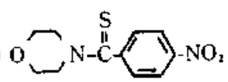
Our previous work on the oxidation of diaryl disulfide[6] and arylsulfonyl halides[7] to the corresponding sulfonates suggests that if peroxy-sulfur compounds *i.e.* peroxy-sulfinates or -sulfonates are formed, they may be useful intermediates in organic syntheses owing to their lability under alkaline conditions.

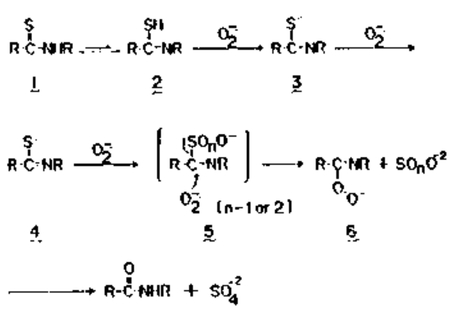
Superoxide anion is known to have quite strong basicity in the solution[8].

Peroxysulfinate Peroxysulfonate

During the study of model metabolic reactions for desulfurization, we found that thioamide derivatives reacted with potassium superoxide in acetonitrile or tetrahydrofuran under mild conditions to form their corresponding amides together

Table 1. Desulfurization of thioamide derivatives with KO_2 at 20°C

Run	Substrate	Solvent	Time (h)	Yield (%)	Recovery(%) of Thioamides
1		CH_3CN	48	80	13
2		THF	48	85	8
3		CH_3CN	24	65	35
4		THF	24	71	29
5		THF	24	89	5
6	PhNH-C(=S)-Ph	THF	24	63	30
7	PhNH-C(=S)-OMe	THF	24	40	51
8	MeNH-C(=S)-Ph	THF	24	50	42
9	n-Pr NH-C(=S)-Ph	THF	24	45	52
10		THF	24	0	100



Scheme 1

with potassium sulfate.

In a typical experiment, a solution of 1-bromo-4-methylthioamide (132 mg, 0.5 mmole; THF, 2 m*l*) was added to a heterogeneous solution of potassium superoxide (148 mg, 2 mmole; THF, 1 m*l*) at 20°C under dry nitrogen atmosphere. After being stirred for ca. 48 h at 20°C, the reaction mixture was poured into cold water, and then extracted with chloroform. The chloroform solution was dried over anhydrous magnesium sulfate, filtered, and concentrated under reduced pressure to give highly pure 2-bromo-4-methylacetanilide (105.4 mg, 85%), which was purified by preparative thin layer chromatography. Potassium sulfate (70%) was obtained from the water layer. The products obtained were identified by comparing their IR and ^{1}H NMR spectra, and mp with those of authentic samples.

The results are summarized in Table 1.

2-Bromo-4-methylthioacetanilide was reacted with O_2^- to yield the corresponding amide (85%) in tetrahydrofuran (Run 2), but no oxidation occurred with p-nitrothiobenzoyl morpholine which has no proton on the nitrogen atom; starting material was recovered quantitatively under same reaction conditions (Run 10). The possibility of the formation of a tetrahedral intermediate formed by a direct nucleophilic attack of O_2^- on the thiocarbonyl carbon like the nucleophilic attack of O_2^- to phenylacetate[9] can be rule out because p-nitrothiobenzoyl morpholine, whose more electrophilic thiocarbonvl carbon expected to be more readily attack by O_2^- than 2-bromo-4-methylthioacetanilide was not observed to react with O_2^- under the same conditions. Thus, the oxidation reaction of thioamide derivatives appears to be required at least, one proton which is necessary for the tautomeric change from thioamides to the thiol form(**2**). The thiolate ion(**3**) may be converted to the thiyl radical(**4**) by one electron transfer. The thiyl radical(4), then couples with O_2^- to form peroxysulfur intermediate(**5**). A nucleophilic attack by O_2^- on peroxysulfur intermediate carbon produced amide together with SO_2^{2-} or SO_3^{2-} which is a good leaving group and further oxidized to SO_4^{2-}.[10]

In the previous paper, it was reported that diaryl thioureas reacted with superoxide in tetrahydrofuran or in acetonitrile to give triaryl guanidines as the main product, but to give diarylureas in dimethylsulfoxide solvent as the main product[1,2]. However, thioamides converted into the corresponding amides in both tetrahydrofuran and dimethylsulfoxide[11] solvent: no different solvent effects between tetrahydrofuran and dimethylsulfoxide were observed. Any formation of amidine derivatives colud not be detected through Run 1-9.

Usually, the reaction using potassium superoxide needs 18-crown-6-ether for the solubility of KO_2, but this method does not require the crown ether in both acetonitrile and tetrahydrofuran solvent at room temperature though the desulfurization reactions in the presence of 18-crown-6-ether were observed to be accelerated.

Acknowledgement. This work was supported by the grants from Korea Science and Engineering Foundation, and Korea Advanced Institute of Science and Technology.

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10. Actually, sodium sulfite was oxidized with O_2^{-} to sodium sulfate in quantitative yield.
11. 2-Bromo-4-methylthioacetanilide reacted with O_2^{-} in DMSO at 20°C for 24 h to give the corresponding amide in 5% yield together with the 90% recovery of th starting material, and in 25% yield of amide in the presence of 18-crown-6-ether under the same reaction condition.

An Efficient Route for the Synthesis of Glorin

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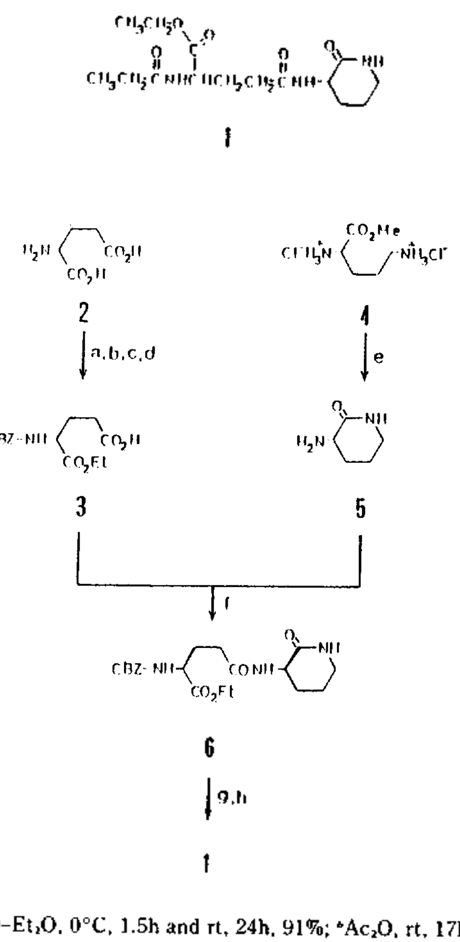
Chemotaxis is referred to the directed movement of cells toward an attractant along a concentration gradient. Many di- or tripeptides with N-formyl-methionine, which are related to inflammation mechanisms of body are well known examples of chemoattractant for neutrophiles and macrophages[1].

Recently, Shimomura *et al.*[2,3] has isolated a chemotactic peptide, N-propionyl-γ-L-glutamyl-L-ornithine-δ-lactam α-ethyl ester (**1**) (glorin) for social amoeba *Polysphondylium violaceum*, and conformed the structure by comparing it with synthetic glorin for its chemotactic activity. To study the relationship between the structures of various derivatives of glorin and their chemotactic activities on amoeba or leukocytes, we had to synthesize them in large quantity. However the reported route for the synthesis of glorin[4] appeared somewhat crude without mentioning of reaction condition. Furthermore, no physical data were available except MS and IR spectra[2].

We now wish to report here a simple and efficient route for the synthesis of glorin and its derivatives. L-Glutamic acid (**2**) was first transformed into N-benzyloxycarbonyl-L-glutamic acid α-ethyl ester (**3**) in the usual manner.[5,6] L-Ornithine-δ-lactam (**5**) was prepared from L-ornithine methyl ester dihydrochloride (**4**)[7] by the known procedures[8]. The two fragments, **3** and **5** were coupled by mixed anhydride method[9] affording N-benzyloxycarbonyl-γ-L-glutamyl-L-ornithine-δ-lactam α-ethyl ester (**6**) in 70% yield. Since **5** was known to be hygroscopic and unstable, 3 eq of **5** was used in the coupling step, and excess of **5** could be removed by washing it with water. The coupled product, **6** was very stable as nice crystalline form[10] and gave satisfactory H-nmr spectral data; NMR ($CDCl_3$): δ 7.35 (5H, 2, phenyl), 6.64 (1H, d, amide), 5.93 (1H, br, amide), 5.74(1H, d, amide), 5.11 (2H, s, $-CH_2-$of benzyl), 4.4-4.0(2H, m, two methines), 4.20 (2H, q, $-OCH_2-$), 3.32 (2H, d of t, $-CH_2$ NH- of lactam), 2.57-1.64 (8H, m, four $-CH_2-$), 1.27 (3H, t, $-CH_3$). Treatment of **6** with H_2/Pd in methanol for 7 h, and evaporation of the solvent gave oily product. It was reacted without further purification with 10 eq of propionic anhydride in CH_2Cl_2 for 10 h at room temperature. Removal of the solvent in high vacuum and crystallization of the resulting solid in EtOH-EtOAc afforded **1** in quantitative yield; MP 139-140°C, TLC, Rf 0.69, silica gel (2-butanone-H_2O-HOAc = 7:1.5:1.5), $[\alpha]_D^{22} = +37.77$ (c = 0.4, $CHCl_3$); NMR($CDCl_3$), δ 6.93 (1H, br, amide), 6.70 (1H, br, amide), 6.15 (1H, br, amide), 4.7-4.0 (2H, br, two methines), 4.20 (2H, q, $-OCH_2-$), 3.37 (2H, m, $-CH_2NH-$ of lactam), 2.6-1.6 (10H, m, five $-CH_2-$), 1.28 (3H, t, $-CH_3$), 1.16(3H, t, $-CH_3$); Anal. calcd. for $C_{15}H_{25}N_3O_5$: C 55.03, H 7.70, N 12.84; found: C 55.26, H 8.13, N 12.52. Unlike the result of Shimomura *et al.*[2], **1** was recovered from the reaction mixture in a highly purified



[a]Z-Cl, H_2O-Et_2O, 0°C, 1.5h and rt, 24h, 91%; [b]Ac_2O, rt, 17h, 80%; [c]EtOH, dicyclohexyl amine, rt, 15h, 70%; [d]Dowex 50 WX4, H_2O-MeOH(1:1), rt, 30 min; [e]NaOMe, MeOH, rt, 3h, 91%; [f]for activation, N-methylmorpholine, $ClCO_2$-isobutyl, −15°C, 5 min; for coupling, −15°C, 30 min and rt, 10h, 70%; [g]H_2, Pd-C, rt, 7h; [h]propionyl anhydride, CH_2Cl_2, rt, 10h.