Table 3. Efficiency of the Photo-mutarotation by some Sensitizers at Different Wavelengths

Solvent	Sensitizers	Quantum Yields		
		254 nm	300 nm	350 nm
DMSO	DMSO	0.48[1]	0.031	0.00
DMSO	Benzophenone			0.005
DMSO	Acetophenone			0.004

[1]previous work, ref. (1).

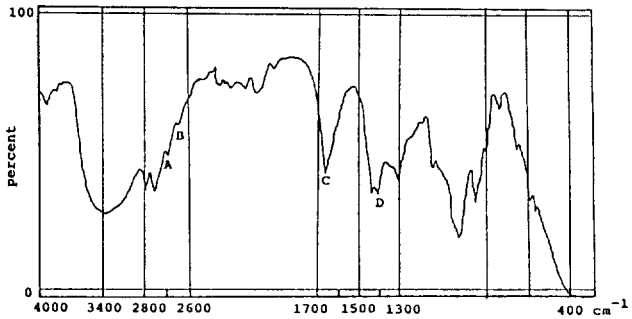

Figure 2. IR Spectrum of Glucose in DMSO. A and B. Aldehydic C-H stretch, 2800 and 2700 cm^{-1}. C. Aldehydic C=O stretch, 1675 cm^{-1}. D. Aldehydic C-H bend, 1390 cm^{-1}.

Table 4. Mutarotation of Glucose with various Sensitizers

Solvent	Sensitizers	Triplet Energy (Kcal/mol)	Mutarotation	
			300 nm	350 nm
DMSO	Fluorene	67.5	Yes	
DMSO	Naphthalene	61	No	
DMSO	2-Acetylnaphthalene	59	No	No
DMSO	1-Acetylnaphthalene	57	No	

responsible for the mutarotation on the direct irradiation at 300 nm in DMSO. The infrared spectrum of glucose in DMSO shows a typical aldehydic absorption characteristics at 1675 cm^{-1}, which is 30 cm^{-1} lower than a normal aldehyde due to the hydrogen bond between an aldehydic group and hydroxyl groups of glucose (Figure 2). The aldehydic group of glucose in DMSO was further confirmed by the doublet absorption at 2700 and 2800 cm^{-1} due to Fermi resonance with overtone of C-H bending band at 1400 cm^{-1}. The UV absorption of glucose in DMSO at 285 nm is ascribed to the aldehydic group which generally appears at 290~295 nm.

This aldehydic form of glucose would quench the phosphorescence of acetophenone and of benzophenone, and undergoes to the triplet excited state. However the possibility of hydrogen abstraction of sensitizers from anomeric hydroxide of glucose cannot be eliminated. Since benzophenone and acetophenone could abstract hydrogen from the anomeric hydroxide of glucose, mutarotations with fluorene, naphthalene, 1-acetylnaphthalene and 2-acetylnaphthalene were investigated and the results were shown in Table 4. Naphthalene (E_T = 61 Kcal), as expected, did not cause glucose to mutarotate but fluorene (E_T = 67.6 Kcal) which does not abstract hydrogen showed mutarotation, and 1-acetylnaphthalene (E_T = 57 Kcal) which could abstract hydrogen[5] also did not show mutarotation of glucose. These results could eliminate the hydrogen abstraction mechanism for the photo-mutarotation.

Based upon the sensitizations, Stern-Volmer quenching study and the wavelength discrepancy, the photochemical mechanism of the mutarotation were suggested as follows:

Sensitizer (Sen.): DMSO, Acetophenone, Benzophenone and Fluorene.

$$\alpha\text{-(D)-Glucose} \xrightarrow{\text{DMSO}} \text{Aldehydic Form (Ald-G)}$$

$$\text{Sen.} \xrightarrow{h\nu} {}^1[\text{Sen.}]^*$$

$${}^1[\text{Sen.}]^* \xrightarrow{\text{isc}} {}^3[\text{Sen.}]^*$$

$${}^3[\text{Sen.}]^* \longrightarrow \text{Sen.} + h\nu_p$$

$$\text{Ald-G} + {}^3[\text{Sen.}]^* \longrightarrow {}^3[\text{Ald-G}]^* + \text{Sen.}$$

$${}^3[\text{Ald-G}]^* \longrightarrow \alpha\text{-(D)-Glucose} + \beta\text{-(D)-Glucose}$$

A conclusion is that an efficient energy transfer occurs from the triplet state of sensitizers to the aldehydic form of glucose molecules, that results sensitized photo-mutarotations of glucose.

Acknowledgement. This work was supported by the Basic Science Research Institute Program (1989), Ministry of Education.

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2. A solution of 1.440 g of α-(D)-glucose in 80 m*l* of anhydrous DMSO was equally devided into four portions. Acetophenone, 260 mg, was dissolved in the first portion and benzophenone, 400 mg, was dissolved in the second portion. One of the remaining portions was wrapped by aluminum foil to protect from the irradiation. Each portion was poured into Pyrex tubes and degassed with purified nitrogen. After degassing, the samples were irradiated with 16 RPR-3500 Å lamps. The change in the optical rotation during the photo-mutarotation was determined by Polarax-ATAGO polarimeter.
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4. Light output was monitored by potassium ferrioxalate actinometry according to the method of Hatchard and Parker, *Proc. Roy. Soc. Ser.*, A235, 518 (1956).
5. Configuration of the lowest excited triplet states for 1- and 2-acetylnaphthalene are n, π^*, however, the hydrogen abstraction from glucose is throught not to be eliminated.

α-Chlorination of Ketones Using *m*-Chloroperbenzoic Acid / Hydrogen Chloride / N,N-Dimethylformamide System

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A number of methods of α-chlorination[1] of ketones have been reported using various chlorination reagents, such as chlorine[2], sulfuryl chloride[3], selenium oxychloride[4], hypochlorites[5], N-chlorosuccinimide[6], cupric chloride[7], quarternary ammonium polychlorides[8], and hexachloro-2,4-cyclohexadienone[9]. α-Chloroketones synthesized from direct chlorination of methylketones are normally contaminated with α-dichloroketones whose separation by distillation is tedious leading to low to moderate yields of pure α-chloroketones[1]. Therefore, much efforts have been devoted to the synthesis of α-chloroacetophenone derivatives using alternative methodologies including Arndt-Eistert reaction[10] of acid chloride with diazomethane, or by the Friedel-Crafts acylation[11] of chloroacetyl chloride.

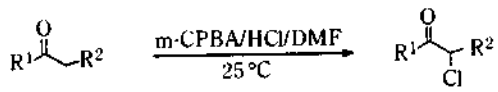
In the course of our studies on the oxidative chlorination[12] of pyrimidine and purine bases, and nucleosides, we have found that treatment of ketones with *m*-chloroperbenzoic acid (*m*-CPBA) in the presence of dry HCl in N,N-dimethylformamide (DMF) at 25 °C afforded good yields of the corresponding α-chloroketones.

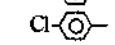
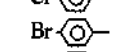
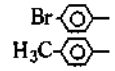
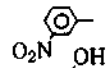
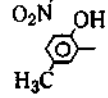
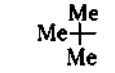
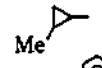
Now we wish to report a facile method of α-chlorination of various ketones using *m*-CPBA (2 eq.) and HCl (3.3 eq.) in DMF.

There have been reported only a few papers dealing with the chlorination of ketones under similar reaction conditions: acetic acid/conc. HCl/hydrogen peroxide[13] and *m*-CPBA/metal halide/tetrahydrofuran-ethyl ether[14]. Under these conditions, however, the substrates for chlorination were very specific and the yields of α-chloroketones were not always satisfactory.

In a typical run, *m*-CPBA (0.69 g, 2 mmol, Aldrich 80-85% purity) was added at once to the solution of acetophenone (0.120 g, 1 mmol) and HCl-DMF (2.55 m*l*, 1M solution of dry HCl in DMF) in DMF (2.5 m*l*) at 25 °C. The reaction mixture was stirred for 6 h at 25 °C and poured into cold 5% aq K_2CO_3 (30 m*l*). The organic layer was extracted with ethyl ether (20 m*l* × 2), washed with 5% aq K_2CO_3 solution (15 m*l* × 2), dried ($MgSO_4$), and concentrated to give 0.142g of crude 2-chloroacetophenone. The oily product was purified by a silica gel column chromatography (Merck Lichroprep™ Si60, solvent: *n*-hexane-CH_2Cl_2) to give a white solid (0.127g, 82%, m.p. 53-56 °C).

Table 1. α-Chlorination of Ketones by m-CPBA/HCl/DMF system.



Entry	R^1	R^2	Reaction time (h)	Yield(%)[a]
1		H	6	96(82)[b]
2		H	6	80
3		H	6	85
4		H	6	84
5		H	6	86
6		H	6	85
7		H	6	80
8		$CH_2CH_2CH_3$	6	98(85)[b]
9		H	6	81
10		H	6	84
11			6	80

[a] Yield were determined by GC using HP-1 column. [b] Isolated yields.

The results of representative experiments are summarized in Table 1. When the reaction temperature or the ratio of HCl-DMF to the substrate was raised, the side product[15] was increased and subsequently the yield of α-chloroketone was decreased. If *m*-CPBA was added to the reaction mixture not at once but portionwisely, the formation of the side product was also increased. Use of acyl chloride as a chlorine source in place of HCl afforded moderate yields (50-60%) of α-chloroketones.

The chlorinations of hydroxy or alkoxyacetophenone derivatives except 2'-hydroxy-5'-methylacetophenone (Entry 7 in Table 1) afforded very complicated results, and attempted separation of α-chloroketones were unsuccessful.

Acknowledgement. We wish to thank the Korea Science and Engineering Foundation for financial support of this work.

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15. The side product of the reaction of 4'-methylacetophenone (entry 5 in Table) was identified as 2,2-dichloro-4'-methylacetophenone by G.C.-M.S. and ^{1}H nmr (300 MHz).

Synthesis of 1,2,4-Thiadiazetidin-1-oxide-3-ones by Reaction of Ureas with Di-2-pyridyl Sulfite

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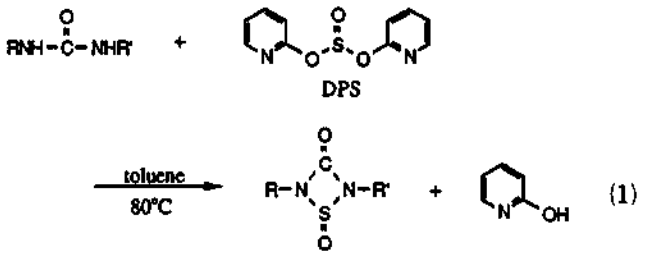
In the course of studies on the synthetic utilities of di-2-pyridyl sulfite (DPS),[1,2] we have had an occasion to examine the reaction of ureas with di-2-pyridyl sulfite. Surprisingly, the reaction of N,N'-di-tert-butylurea with an equimolar amount of DPS in toluene at 80 °C did not yield N,N'-di-tert-butylcarbodiimide. Instead the product showing a strong IR absorption at 1785 cm^{-1} was isolated in 32% yield. Based on ^{13}C NMR data as well as ^{1}H NMR and mass spectral data,[3] it seems reasonable to assign the product into a new 4-membered heterocyclic compound, 2,4-di-tert-butyl-2,4-thiadiazetidin-1-oxide-3-one, as shown in Eq. 1.

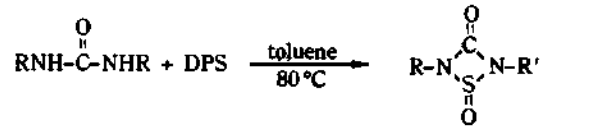


(1)

Although 1,2,4-thiadiazetidin-1-oxide-3-ones were once reported as reactive intermediates in exchange reaction of N-sulfinylamine with isocyanate,[4,5] their preparation and structure determination have not been reported.

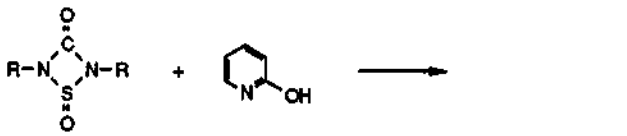
The preparation of 1,2,4-thiadiazetidin-1-oxide-3-ones was performed on several structurally different N,N'-disubstituted ureas using. 1.1 equiv of DPS in toluene at 80 °C and some of experimental results are shown in Table 1. The reaction occurred cleanly and was complete within 30 min. However, the products turned out to be very hygroscopic and unstable. Thus, the products were isolated by passing through a short column of silica gel to remove 2-hydroxypyridine but the products were decomposed to significant extent during isolation. Particularly, the products from N,N'-diphenylurea and N-phenyl-N'-cyclohexylurea were too unstable to be isolated. When N,N'-di-*n*-butylurea was treated with di-2-pyridyl sulfite in toluene at 80 °C for 20 min, 20% of 2,4-di-*n*-butyl-1,2,4-thiadiazetidin-1-oxide-3-one was isolated together with 22% of 2-pyridyl carbamate. Furthermore, only 2-pyridyl carbamate was obtained in 1h, indicating ring-opening by 2-hydroxypyridine, as shown in Eq. 2. Similar results were realized with N,N'-diphenethylurea.

Table 1. Preparation of 1,2,4-Thiadiazetidin-1-oxide-3-ones from N,N'-Disubstituted Ureas with DPS[a]



R	R'	time, h	isolated yield, %
C_6H_5	$(CH_3)_3C$	0.5	55
$(CH_3)_3C$	$(CH_3)_3C$	0.5	32
$CH_3CH_2CH(CH_3)_2$	$CH_3CH_2CH(CH_3)_2$	0.5	33
c-C_6H_{11}	$(CH_3)_3C$	0.3	71
c-C_6H_{11}	*c*-C_6H_{11}	0.5	37
c-C_6H_{11}	$CH_3(CH_2)_2CH_2$	0.5	22
$CH_3(CH_2)_2CH_2$	$CH_3(CH_2)_2CH_2$	0.3	20(22)[b]
		1	0(65)[b]
$C_6H_5CH_2CH_2$	$C_6H_5CH_2CH_2$	1	0(73)[b]

[a] 1.1 equiv of DPS was used. [b] Isolated yield of 2-pyridyl carbamate.



(2)

R = primary alkyl

The typical procedure is illustrated as follows. Di-2-pyridyl sulfite (520 mg, 2.2 mmol) was added to a solution of N,N'-di-tert-butylurea (345 mg, 2.0 mmol) in toluene (6 m*l*). After being stirred at 80 °C for 0.5 h under nitrogen, the reaction mixture was allowed to cool to room temperature and concentrated to dryness. The residue was immediately subjected to short column chromatography with hexane and ethyl acetate (6:1) as an eluant, yielding the product (140 mg) in 32% yield.

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