

# COMMUNICATIONS

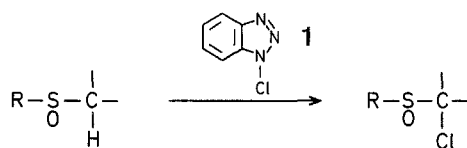
## The Reaction of Sulfoxides with 1-Chlorobenzotriazole

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Increasing interest has been devoted to the  $\alpha$ -chlorination of sulfoxides<sup>1-9</sup>. 1-Chlorobenzotriazole (**1**) has recently been used for the oxidation of sulfides to sulfoxides<sup>10</sup>. As 1-chlorobenzotriazole (**1**) is a potential source of chlorine cation ( $\text{Cl}^{\oplus}$ ), we investigated the behaviour of **1** towards sulfoxides.

The reaction of sulfoxides **2-7** with an equimolar amount of **1** in dichloromethane in the presence of excess pyridine at  $-40^\circ$  affords the corresponding  $\alpha$ -chlorosulfoxides (Table 1).



The acidity of the  $\alpha$ -hydrogen atoms does not control the course of the reaction: chlorination of benzyl methyl sulfoxide (**7**) gives both benzyl chloromethyl sulfoxide and  $\alpha$ -chlorobenzyl methyl sulfoxide in nearly equal yields. The presence of pyridine is not required in the case of alkyl

aryl sulfoxides (Table 2); it seems likely that benzotriazolate anion acts as base, abstracting the  $\alpha$ -hydrogen atom. In the case of benzyl sulfoxides, the yields of  $\alpha$ -chlorosulfoxides are strongly decreased in the absence of pyridine.

Table 2. Chlorination of Aryl Methyl Sulfoxides with 1-Chlorobenzotriazole in the Absence of Pyridine

Sulfoxide	Solvent/ Temperature	Product	Yield %
	$\text{CH}_2\text{Cl}_2 / -40^\circ$		77
			5
	$\text{CH}_2\text{Cl}_2 / -40^\circ$		70
	$\text{CH}_3\text{OH} / -40^\circ$		85
	$\text{CH}_3\text{OH} / -78^\circ$		88

In methanol as solvent, the reaction of alkyl aryl sulfoxides with **1** affords the corresponding sulfones (Table 2), as previously described by Kingsbury and Johnson<sup>10</sup> for methyl phenyl sulfoxide.

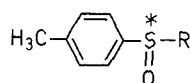
Table 1.  $\alpha$ -Chlorination of Sulfoxides with 1-Chlorobenzotriazole in the Presence of Pyridine at  $-40^\circ$

	Sulfoxide	$\alpha$ -Chlorosulfoxide	Yield %	m.p. or b.p.
2			77	m.p. 61.5–62° (Ref. <sup>7</sup> )
3			70	b.p. 78–79°/0.02 mm (Ref. <sup>3</sup> )
4			79	m.p. 64–65° (Ref. <sup>8</sup> )
5			46	m.p. 120° (Ref. <sup>1</sup> )
6			78	m.p. 122.5–123° (Ref. <sup>3</sup> )
7			44	m.p. 63.5–64° (Ref. <sup>3</sup> )
			37	m.p. 58.5–59° (Ref. <sup>3</sup> )

$\alpha$ -Halogenation by **1** is highly stereospecific. When the  $\alpha$ -carbon is a prochiral center (compounds **5**, **6**, **7**), only one of the two diastereomeric  $\alpha$ -chlorosulfoxides is obtained.

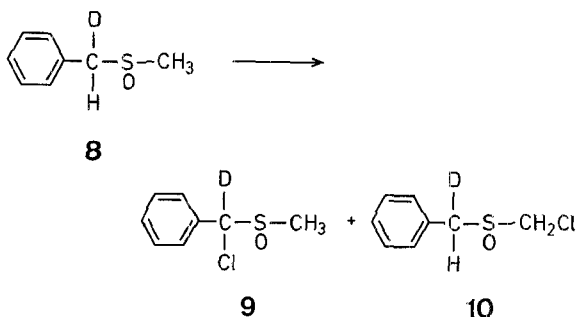
The reaction of **1** with optically active sulfoxides yields optically active  $\alpha$ -chlorosulfoxides. As in the reaction with iodobenzene dichloride<sup>4</sup>, the presence of silver(I) ions affects the stereochemical course of the chlorination (Table 3); in the case of methyl *p*-tolyl sulfoxide, the addition of silver nitrate to the reaction mixture leads to the formation of the enantiomer opposite to that obtained in the absence of silver ion. [Inversion of chirality at the sulfur atom has been proven to occur in the presence of silver(I) ion<sup>11</sup>]. In the absence of pyridine and of silver ion, the  $\alpha$ -chlorosulfoxide obtained is racemized for the most part.

Table 3.  $\alpha$ -Halogenation of (+)-Alkyl *p*-Tolyl Sulfoxides with 1-Chlorobenzotriazole;  $[\alpha]_D^{20}$  in Acetone



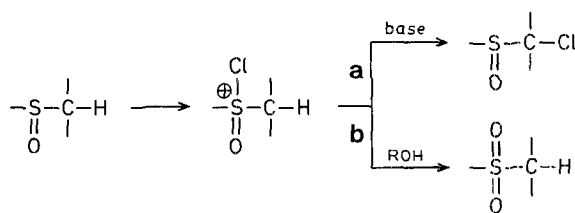
Sulfoxide		$[\alpha]_D^{20}$ of $\alpha$ -Chlorosulfoxide	
R	$[\alpha]_D^{20}$	in the absence of Ag <sup>+</sup>	in the presence of Ag <sup>+</sup>
CH <sub>3</sub>	+144°	+104°	-134°
<i>i</i> -C <sub>3</sub> H <sub>7</sub>	+176°	-20°	-97°

Chlorination of  $\alpha$ -deuteriobenzyl methyl sulfoxide (**8**; obtained from **7** via stereoselective H/D exchange<sup>12</sup>) gave only  $\alpha$ -chloro- $\alpha$ -deuteriobenzyl methyl sulfoxide (**9**) and chloromethyl  $\alpha$ -deuteriobenzyl sulfoxide (**10**).



In other words, as in the  $\alpha$ -chlorination with iodobenzene dichloride<sup>2</sup> and in the  $\alpha$ -bromination<sup>13</sup>, the reaction involves the proton diastereotopic to that preferentially exchanged by deuterium in NaOD/D<sub>2</sub>O.

It is likely that both  $\alpha$ -chlorination (in dichloromethane) and oxidation (in methanol) involve a common chloro-oxo-sulfonium salt intermediate<sup>14</sup>; in the first case, the chloro-oxo-sulfonium salt collapses by attack of base to give the  $\alpha$ -chlorosulfoxide (Path a), whereas in the second case the intermediate is converted into the sulfone by nucleophilic attack of the protic solvent (Path b).



A study of the reaction mechanism is in progress.

#### $\alpha$ -Chlorination of Sulfoxides; General Procedure:

To a stirred solution of the sulfoxide (10 mmol) and anhydrous pyridine (10 ml) in dichloromethane (15 ml) was added dropwise and with cooling at  $-40^\circ$  a solution of 1-chlorobenzotriazole (1.53 g, 10 mmol) in dichloromethane (10 ml). The reaction mixture was stirred for 1 hr at  $-40^\circ$ , diluted with dichloromethane, washed with aqueous sulfuric acid to remove pyridine, and then washed with aqueous sodium hydroxide to remove the benzotriazole. The chloroform solution was dried with sodium sulfate, the solvent evaporated, and the residue chromatographed on silica gel using ether/light petroleum 1:1 as eluent. Yields and physical properties are reported in Table 1.

A similar procedure was used in the chlorination of sulfoxides in the absence of pyridine. In the case of methyl *p*-tolyl sulfoxide, along with the expected chloromethyl *p*-tolyl sulfoxide there was obtained a small amount of dichloromethyl *p*-tolyl sulfoxide; m.p.  $68^\circ$ .

C<sub>8</sub>H<sub>8</sub>Cl<sub>2</sub>OS calc. C 43.11 H 3.61  
(222.21) found 43.03 3.55

#### Chlorination of Optically Active Sulfoxides:

The reactions were carried out as previously described. In the absence of silver nitrate, (+)-chloromethyl *p*-tolyl sulfoxide,  $[\alpha]_D^{20}$ :  $+104^\circ$  ( $c=1$ , acetone), m.p.  $62-63^\circ$ , and (-)-2-chloro-2-propyl *p*-tolyl sulfoxide,  $[\alpha]_D^{20}$ :  $-20^\circ$  ( $c=1$ , acetone), m.p.  $65^\circ$ , were obtained in 77% and 70% yields, respectively.

C<sub>10</sub>H<sub>13</sub>ClOS calc. C 55.42 H 6.05  
(216.71) found 55.43 6.15

In the presence of silver nitrate (20 mmol), (-)-chloromethyl *p*-tolyl sulfoxide,  $[\alpha]_D^{20}$ :  $-134^\circ$  ( $c=1$ , acetone), m.p.  $62-63^\circ$ , and (-)-2-chloro-2-propyl *p*-tolyl sulfoxide,  $[\alpha]_D^{20}$ :  $-97^\circ$  ( $c=1$ , acetone), m.p.  $65^\circ$ , were obtained in 50% and 68% yields, respectively.

In the absence of pyridine, (-)-chloromethyl *p*-tolyl sulfoxide,  $[\alpha]_D^{20}$ :  $-6.9^\circ$  ( $c=1$ , acetone), m.p.  $62^\circ$ , was obtained in 50% yield.

#### Oxidation of Sulfoxides to Sulfones with 1-Chlorobenzotriazole:

The reaction was carried out as described by Kingsbury and Johnson<sup>10</sup>; methyl *p*-tolyl sulfone had m.p.  $88-89^\circ$  (Ref.<sup>15</sup>, m.p.  $89-90^\circ$ ).

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