



## $S_4N_4 \cdot SbCl_5$ COMPLEX: A USEFUL REAGENT FOR CONVERSION OF STERICALLY LESS HINDERED $\alpha$ -BROMO KETONES TO $\alpha$ -CHLORO KETONES

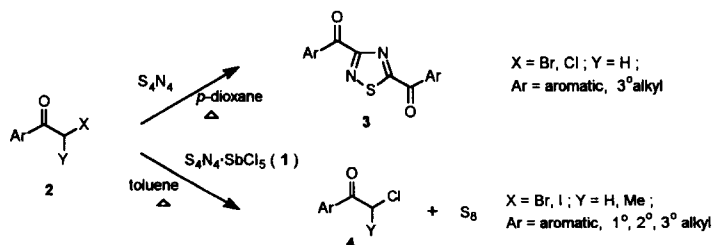
Kil-Joong Kim and Kyongtae Kim\*

Department of Chemistry, Seoul National University, Seoul 151-742, Korea

**Abstract:** The reactions of sterically less hindered  $\alpha$ -bromo alkyl and aryl ketones with tetrasulfur tetranitride-antimony pentachloride ( $S_4N_4 \cdot SbCl_5$ ) complex in toluene at reflux gave the corresponding  $\alpha$ -chloro ketones in good to excellent yields. © 1997 Elsevier Science Ltd.

It has been reported that tetrasulfur tetranitride ( $S_4N_4$ ) reacts in inert solvents with a wide variety of Lewis acids to give adducts isolable.<sup>1</sup> Although the adduct  $S_4N_4 \cdot SbCl_5$  (**1**)<sup>2</sup> which is quite stable in the air has attracted much attention and so its physical properties<sup>1</sup> including color, mp, molar conductance, and solubility as well as its structure based on X-ray crystallography<sup>3</sup> and IR spectroscopic data<sup>1,4</sup> have been studied, its chemistry has not been explored at all.

We were interested in exploiting the potential synthetic utility of the adduct **1** in view of the formation of 3,5-diacyl- and 3,5-diaroyl-1,2,4-thiadiazoles (**3**) from the reaction of  $S_4N_4$  with  $\alpha$ -haloketones (**2**) in *p*-dioxane at reflux.<sup>5</sup> In this letter, we wish to report a preliminary result in which treatment of  $\alpha$ -bromomethyl and  $\alpha$ -bromoethyl ketones (**2**) with the adduct **1** in toluene at reflux gave the corresponding



chloro compounds **4** regardless of bulkiness of the groups at  $\alpha'$ -position of ketones **2** in good to excellent yields. Yields of the products **4** are summarized in Table 1.

**Typical procedure:** A mixture of 2-bromo-1-phenylethanone (**2a**) ( $Ar = C_6H_5, X = Br, Y = H$ ) (294 mg, 2.48 mmol) and **1** (1.21 g, 2.51 mmol) in toluene (30 mL) was heated for 3 h at reflux until the spot corresponding

Table 1. Reaction times and yields of  $\alpha$ -chloro ketones (**4**)

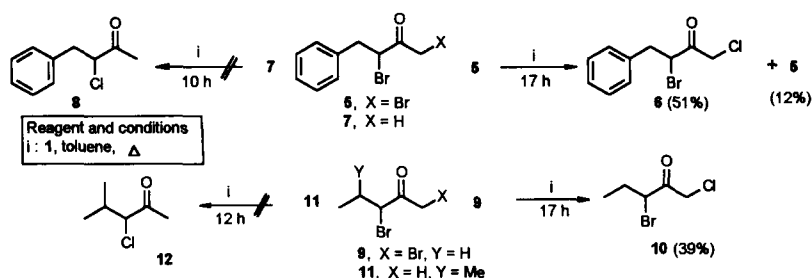
Compound	Ar	Y	Reaction time h	Yield, <sup>a</sup> (%)	
				<b>4</b>	S <sub>8</sub>
<b>4a</b>	C <sub>6</sub> H <sub>5</sub>	H	3	79	12
<b>4b</b>	4-MeC <sub>6</sub> H <sub>4</sub>	H	3	91	19
<b>4c</b>	4-ClC <sub>6</sub> H <sub>4</sub>	H	3.5	81	19
<b>4d</b>	4-FC <sub>6</sub> H <sub>4</sub>	H	3.5	79	17
<b>4e</b>	4-O <sub>2</sub> NC <sub>6</sub> H <sub>4</sub>	H	3	93	17
<b>4f</b>	2-Naphthyl	H	3	86	27
<b>4g</b>	1-Adamantyl	H	6	91	2
<b>4h</b>	C <sub>6</sub> H <sub>5</sub>	Me	9	88	15
<b>4i</b>	<i>i</i> -Pr	H	10	69	14
<b>4j</b>	<i>i</i> -Bu	H	10	83	14
<b>4k</b>	C <sub>6</sub> H <sub>5</sub>	Et	14	0	5

<sup>a</sup> Isolated yield. The structures of compounds **4a-4k** were determined on the basis of the spectroscopic (<sup>1</sup>H NMR, IR) data and m.p..

to **2a** had disappeared on TLC ( $R_f = 0.45$ , CCl<sub>4</sub> : CHCl<sub>3</sub> = 1:1). The color of the reaction mixture became dark red. After the insoluble dark red materials were filtered, the solvent of the filtrate was removed in vacuo. Chromatography of the residue on a silica gel column (Merck 230-400 mesh, 2.5 × 5.0 cm) using *n*-hexane (100 mL) gave sulfur (79 mg, 12%). Elution with a mixture of *n*-hexane and benzene (2:1, 200 mL) gave 2-chloro-1-phenylethanone (**4a**) (301 mg, 79%): m.p. 55.5 °C (*n*-hexane) (lit.<sup>6</sup> 54-56 °C).

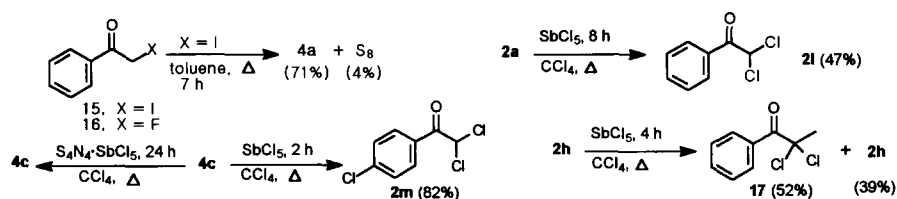
Conversion of simple alkyl bromides to the corresponding chlorides has been extensively studied.<sup>7</sup> However, to the best of our knowledge no reports are available for direct conversion of  $\alpha$ -bromo ketones to their chloro analogues.

Apart from the formation of 2-chloro-1-phenylpropanone (**4h**), 2-chloro-1-phenylbutan-1-one (**4k**) was not formed from the corresponding bromo ketone, which was recovered in 89% yield along with sulfur (5%).<sup>8</sup> Cyclic bromo ketones, i. e. 2-bromocyclohexanone, 2-bromocyclodecapentanone, and 3-bromocamphor, were not converted to chloro compounds even at elongated reaction times under the same conditions, where the reactants (31%, 89%, and 100%, respectively) were recovered along with small amounts of sulfur (3-6%). Conversion of 1,3-dibromo-4-phenylbutan-2-one (**5**)<sup>9</sup> to 3-bromo-1-chloro-4-phenylbutan-2-one (**6**) (51%), whereas failure of the formation of 3-chloro-4-phenylbutanone (**8**) with recovery of **7** (79%) and sulfur (6%) from the corresponding bromo ketone **7** supports the importance of a less sterically hindered environment at the reaction center. Similarly 3-bromo-1-chloropentan-2-one (**10**)<sup>10</sup> was obtained in 39% yield from 1,3-dibromopentan-2-one (**9**).<sup>10</sup> In contrast, chloro ketone **12** was not formed from the reaction of 3-bromo-4-methylpentan-2-one (**11**). Instead, **11** (31%) and sulfur (8%) were isolated. The formation of  $\alpha$ ,  $\alpha'$ -bromochloro ketones **6** and **10** albeit in moderate yields suggests the possibility in which **1** can be utilized for



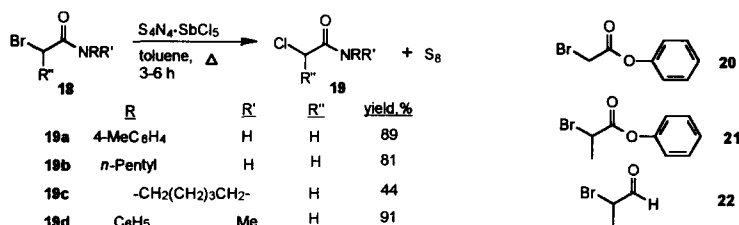
the selective conversion of  $\alpha, \alpha'$ -dibromo ketones to  $\alpha, \alpha'$ -bromochloro ketones, which are very useful in organic synthesis but seldom investigated. There has been only one report which dealt with synthesis of  $\alpha, \alpha'$ -bromochloro ketones from the reaction of  $\alpha$ -bromo carboxylic acid esters with in situ generated chloromethyl lithium in the presence of LiBr at  $-78\text{ }^\circ\text{C}$ .<sup>10</sup>

Table 1 shows that 2-chloro-1-phenylpropanone (**4h**) was obtained from its 2-bromo analogue in 83% yield. However, its structural isomer, 3-bromo-1-phenylpropan-1-one (**13**) did not give the corresponding chloro ketone in 3 h under the same conditions as with **4h**. (2-Bromoethyl)benzene (**14**) also did not react with **1**. In the meantime, 2-iodo-1-phenylethanone (**15**) was converted to **4a** (71%), whereas 2-fluoro analogue **16** was recovered in 82% yield in 5 h refluxing. The inertness of **16** might be due to the nature of fluorine atom which is a poor leaving group. The failure of the formation of chloro compounds from **13**, **14**, and **16** indicates that a carbonyl group  $\alpha$  to the carbon atom bearing a halogen atom such as bromine and iodine should be present for the success of the reactions.



Treatment of **2a** and **2h** ( $\text{Ar} = \text{C}_6\text{H}_5$ ,  $\text{X} = \text{Br}$ ,  $\text{Y} = \text{Me}$ ) with  $\text{SbCl}_5$  itself for 8 h and 4 h in refluxing  $\text{CCl}_4$  gave 2,2-dichloro-1-phenylethanone (**2l**) ( $\text{Ar} = \text{C}_6\text{H}_5$ ,  $\text{X} = \text{Y} = \text{Cl}$ ) and 2,2-dichloro-1-phenylpropanone (**17**) in 47% and 52% yields, respectively. Furthermore, the reaction of **4c** with  $\text{SbCl}_5$  for 2 h in refluxing  $\text{CCl}_4$  gave 2,2-dichloro-1-(4-chlorophenyl)ethanone (**2m**) ( $\text{Ar} = 4\text{-ClC}_6\text{H}_4$ ,  $\text{X} = \text{Y} = \text{Cl}$ ) in 82% yield, whereas from the same reaction with **1** for 24 h was recovered only **4c** (97%). The results clearly show that  $\alpha$ -monobromo and  $\alpha$ -monochloro ketones are readily converted to  $\alpha, \alpha$ -dichloro ketones by treatment with  $\text{SbCl}_5$ . However,  $\alpha$ -monochloro ketones are not converted to  $\alpha, \alpha$ -dichloro ketones by the reaction with **1**.

Similarly, the reactions of *N*-alkyl- and *N*-arylbromoacetamides (**18**) with the adduct **1** afforded the corresponding chloro amides (**19a-19d**) along with sulfur (10-21%). However, the reaction with *N*-(4-tolyl)-2-bromopropanamide (**18**) ( $\text{R} = 4\text{-MeC}_6\text{H}_4$ ,  $\text{R}' = \text{H}$ ,  $\text{R}'' = \text{Me}$ ) under the same conditions gave a mixture



of the reactant **18** and its chloro analogue **19** with 86 : 14 ratio.<sup>11</sup>

On the other hand, the reactions of phenyl bromoacetate (**20**), phenyl 2-bromopropanoate (**21**), and 2-bromopropanal (**22**) with the adduct **1** under the same conditions did not give the corresponding chloro esters and aldehyde. Instead, from the former reactions were recovered the bromo ester **20** (22%) and **21** (61%) and from the latter was obtained only complex solid mixtures with a trace amount of sulfur.

In summary, the adduct **1** can be utilized for the conversion of  $\alpha$ -bromomethyl and  $\alpha$ -bromoethyl ketones to  $\alpha$ -chloro analogues and for the conversion of *N*-alkyl- and *N*-aryl bromoacetamides to their chloro analogues. Moreover, it has been found that a selective conversion of  $\alpha, \alpha'$ -dibromo ketones to  $\alpha, \alpha'$ -bromochloro ketones using adduct **1** may be effective when  $\alpha'$ -bromoalkyl group is bigger than  $\alpha$ -bromomethyl or  $\alpha$ -bromoethyl group.

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- Percent yields of sulfur through the paper are based on **1**.
- <sup>1</sup>H NMR (CDCl<sub>3</sub>, 80 MHz). **5**:  $\delta$  3.00-3.60 (m, 2H, PhCH<sub>2</sub>), 4.04 (q, 2H, J = 12 Hz, CH<sub>2</sub>Br), 4.84 (t, 1H, J = 7 Hz, CHBr), 7.23 (s, 5H, Ph). **6**:  $\delta$  2.93-3.50 (m, 2H, PhCH<sub>2</sub>), 4.24 (s, 2H, CH<sub>2</sub>Cl), 4.68 (t, 1H, J = 7 Hz, CHBr), 7.24 (s, 5H, Ph). IR (neat) 3024, 2928, 1728, 1596, 1488, 1388, 1068, 1027, 940, 787, 748, and 700 cm<sup>-1</sup>; Anal. Calcd for C<sub>10</sub>H<sub>10</sub>BrClO: C, 45.91; H, 3.85. Found. C, 45.60, H, 3.81.
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- The ratio was obtained on the basis of the intensities of the peaks at  $\delta$  1.81 and  $\delta$  1.66 which are respectively assignable to CH<sub>3</sub>CH(Br)- and CH<sub>3</sub>CH(Cl)- of each amide.

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