Reaction of Tri-*n*-butyltin ω-Haloalkoxide (*n*-$Bu_3SnO(CH_2)_nX$) with Isothiocyanate

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(Received August 8, 1985)

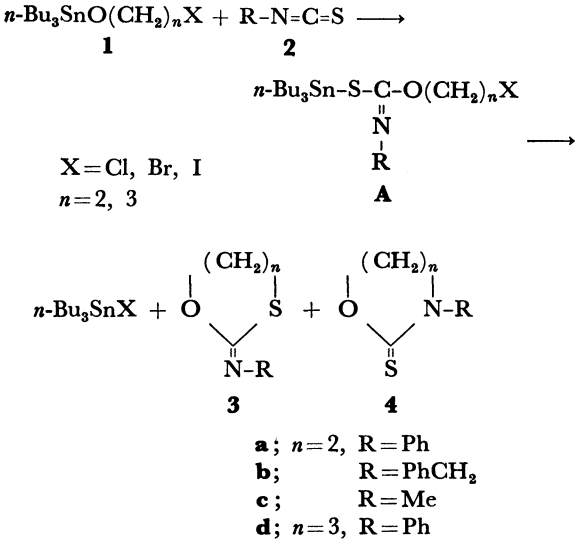
Synopsis. Tri-*n*-butyltin ω-haloalkoxides are useful reagents for the preparation of sulfur-containing five- and six-membered cyclic compounds combined with isothiocyanates.

We have recently reported the novel use of tri-*n*-butyltin ω-haloalkoxides (*n*-$Bu_3SnO(CH_2)_nX$ n=2,3 X=Cl, Br, I) (**1**). They are useful reagents yielding a variety of five- and six-membered heterocyclic compounds by combination with isocyanates or carbodiimides.[1] An important feature of this reaction is that **1** can be regarded as a synthon of oxiranes or oxetanes.[2] Nevertheless, in some cases, several types of compounds different from the cycloadducts of heterocumulenes with oxiranes can be obtained.

The cycloaddition of isothiocyanates to oxiranes has been investigated,[3] but in these cases, cycloadducts were obtained only by using activated isothiocyanates such as benzoyl and acetyl isothiocyanate. In other isothiocyanates such as aromatic and aliphatic isothiocyanates, no sulfur-containing cycloadduct has been obtained because of the isomerization from oxathiolanimines to oxazolidinones in the presence of oxiranes, moreover, the formation of by-products was often a problem.[4]

As a part of continuing study on synthetic use of **1**, we wish herein to report the reaction of **1** with isothiocyanates (**2**), thereby preparing five- and six-membered sulfur- containing cyclic compounds under mild condition (Scheme 1).

Treatment of *n*-$Bu_3SnO(CH_2)_2X$ with PhNCS gave a mixture of *N*-phenyl-1,3-oxathiolan-2-imine **3** and 3-phenyl-1,3-oxazolidin-2-thione **4**. The proportion of these products appeared to be dependent on the nature of substrates and solvents as shown in Table 1. The order of the reactivity of halogen species in **1** was Cl<Br<I, and the proportion of **4** was decreased in this order (entries 1, 3, and 4). The use of the chloride in hexane induced the predominant formation of **4a** (entry 1), which has not been obtained even from the cycloaddition of activated isothiocyanates to oxiranes.[3] Meanwhile, DMF, when used as a solvent,



Scheme 1.

Table 1. Reactions between *n*-$Bu_3SnO(CH_2)_nX$ and Isothiocyanates[a]

Entry	1		2	Solv. (ml)	Isolated yield/ %	3/4 Ratio[b]
	n	X	R			
1	2	Cl	Ph	Hexane (10)	43	7/93
2	2	Cl	Ph	DMF (5)	90[c]	49/51
3	2	Br	Ph	Hexane (10)	68	17/83
4	2	I	Ph	Hexane (10)	80	34/66
5	2	I	Ph	DMF (5)	100[c]	83/17
6	2	Br	$PhCH_2$	Hexane (10)	41	68/32
7	2	Br	$PhCH_2$	DMF (5)	91	77/23
8	2	Br	Me	Hexane (10)	15	20/80
9	2	Br	Me	DMF (5)	33	90/10
10	2	I	Me	DMF (5)	56	100/0
11	3	Br	Ph	Hexane (10)	14	0/100
12	3	Br	Ph	DMF (5)	57	0/100
13	3	I	Ph	Hexane (15)	73	0/100

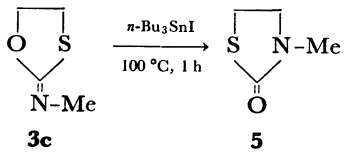
a) **1** 10 mmol, **2** 8 mmol, Temp. 40 °C, Time 1 h, b) Determined by GLC, c) 25 °C.

accelerated the reaction, and the proportion of **3a** was greater than in hexane (entries 2 and 5). Similar effects of DMF were observed in the reactions with alkyl isothiocyanates, although, the reactivity of which was low (entries 6—10).

At the initial stage of the reaction, isothiocyanates were added to **1** exothermically, and the IR absorption band of ν NCS immediately disappeared and the new band around 1600 cm^{-1} (C=N) was recognized.[5] In the case of isocyanates, two types of adducts were considered.[1] However, because of the great affinity of tin toward sulfur atoms,[6] the addition of **1** may take place only across the C=S group of RNCS as described by Davies et al.,[7] giving **A** as an intermediate (Scheme 1). In next stage, the intramolecular alkylation at the sulfur atom and at the nitrogen atom gives **3** and **4**, respectively. Although the formation of **4** was generally predominant, DMF increased the proportion of **3**. This is explained by the coordination of DMF to the tin atom in **A** as a Lewis base. The basicity of the sulfur atom adjacent to the tin is thus increased, therefore, the intramolecular S-alkylation is accelerated, giving **3** predominantly. This is not the case, however, in the case of tri-*n*-butyltin γ-halopropoxides (*n*-$Bu_3SnO(CH_2)_3X$). Compound **4d** was produced in a higher selectivity than *n*-$Bu_3SnO(CH_2)_2X$ even when DMF was used (entries 11—13).

Alternatively, the isomerization of initially formed **3** to **4** catalyzed by *n*-Bu_3SnI which is a by-product of the reaction of **1** with **2**, can be considered. However, no isomerization was recognized by the treatment of **3c** with an equimolar *n*-Bu_3SnI at 40 °C for 1 h, and **3c** was recovered quantitatively.

On the other hand, treatment of **3c** with an equimolar *n*-Bu_3SnI at 100 °C for 1 h induced the formation of the thiazolidinone **5** in 50% yield as described by Sakai et al.[8]



3c **5**

In this case, formation of **4c** could not be recognized. We thus conclude that no isomerization of **3** to **4** occurred under present conditions.

Experimental

***N*-Phenyl-1,3-oxathiolan-2-imine (3a).** *n*-$Bu_3SnO(CH_2)_2I$ (4.61 g, 10 mmol) and PhNCS (1.08 g, 8 mmol) were stirred under dry N_2 on cooling, then heat was evolved about 40 °C. The infrared spectrum showed the disappearance of the characteristic absorption band of ν NCS at 2100 cm^{-1} and the presence of a new band around 1600 cm^{-1}. After additional 5 min, DMF (5 ml) was added and the stirring was continued for 1 h at 25 °C. The addition of excess amounts of hexane on cooling induced 1.79 g of white precipitates immediately, which were filtered, washed with hexane and dried in vacuo. The precipitates contained *N*-phenyl-1,3-oxathiolan-2-imine **3a** as a mixture with **4a** (100%, **3a**:**4a**=83:17, entry 5). The **3**/**4** ratio was determined by GLC. Analytically pure sample of **3a** was obtained by column chromatography (Silica gel, $CHCl_3$). Compound **4a** was obtained as the major product from the reaction of *n*-$Bu_3SnO(CH_2)_2Cl$ (entry 1). Spectral data for **3a** was as follows; mp 65—67 °C (lit,[8] mp 65—65.5 °C); IR (KBr) 1035, 1110, 1640 cm^{-1}; ^1H NMR ($CDCl_3$) δ=3.40 (t, 2H, $C\underline{H}_2S$), 4.50 (t, 2H, $C\underline{H}_2O$), 6.90—7.50 (m, 5H, phenyl).

Following compounds were isolated similarly.

***N*-Benzyl-1,3-oxathiolan-2-imine (3b)**: Bp 113—115 °C/10^{-3} mmHg; IR (neat) 1060, 1660 cm^{-1}; MS *m/z* 193 (M^+); ^1H NMR ($CDCl_3$) δ=3.40 (t, 2H, $C\underline{H}_2S$), 4.40 (t, 4H, $C\underline{H}_2N$, $C\underline{H}_2O$), 7.20—7.40 (m, 5H, phenyl); ^{13}C NMR ($CDCl_3$) δ=31.7, 58.0, 68.8, 126.7, 127.5, 128.2, 139.4, 163.1.

***N*-Methyl-1,3-oxathiolan-2-imine (3c)**: Bp 66—67 °C/2 mmHg(1 mmHg=133.322 Pa) (lit,[9] bp 117—118 °C/20 mmHg); IR (neat) 1050, 1670 cm^{-1}; ^1H NMR ($CDCl_3$) δ=3.00 (s, 3H, $C\underline{H}_3N$), 3.40 (t, 2H, $C\underline{H}_2S$), 4.30 (t, 2H, $C\underline{H}_2O$).

3-Phenyl-1,3-oxazolidin-2-thione (4a): Mp 97 °C (lit,[9] 95.5 °C); IR (KBr) 1180, 1300, 1430, 1495 cm^{-1}; ^1H NMR ($CDCl_3$) δ=4.20 (t, 2H, $C\underline{H}_2N$), 4.60 (t, 2H, $C\underline{H}_2O$), 7.20—7.60 (m, 5H, phenyl).

3-Benzyl-1,3-oxazolidin-2-thione (4b): Mp 90—91 °C; IR (KBr) 1160, 1330, 1520 cm^{-1}; MS *m/z* 193 (M^+); ^1H NMR ($CDCl_3$) δ=3.60 (t, 2H, $C\underline{H}_2N$), 4.50 (t, 2H, $C\underline{H}_2O$), 4.82 (s, 2H, $PhC\underline{H}_2N$), 7.30—7.40 (m, 5H, phenyl); ^{13}C NMR ($CDCl_3$) δ=47.2, 52.0, 65.9, 128.1, 128.3, 128.8, 134.5, 188.0.

3-Methyl-1,3-oxazolidin-2-thione (4c): Bp 120 °C/0.3 mmHg (lit,[10] bp 127 °C/0.4 mmHg); IR (neat) 1180 cm^{-1}; ^1H NMR ($CDCl_3$) δ=3.21 (s, 3H, $C\underline{H}_3N$), 3.82 (t, 2H, $C\underline{H}_2N$), 4.52 (t, 2H, $C\underline{H}_2O$).

3-Phenyl-1,3-oxazine-2-thione (4d): Mp 138—139 °C; MS *m/z* 193 (M^+); IR (KBr) 1300, 1320, 1480, 1500 cm^{-1}; ^1H NMR ($CDCl_3$) δ=2.10—2.40 (m, 2H, $C\underline{H}_2$), 3.70 (t, 2H, $C\underline{H}_2N$), 4.50 (t, 2H, $C\underline{H}_2O$), 7.20—7.50 (m, 5H, phenyl); ^{13}C NMR ($CDCl_3$) δ=21.4, 50.7, 67.7, 126.6, 127.8, 129.4, 145.5, 187.1.

The Isomerization of 3: Oxathiolanimine **3c** (0.56 g, 5 mmol) and *n*-Bu_3SnI (2.08 g, 5 mmol) were stirred under N_2 in a 50 ml round bottomed flask, after 1 h at 100 °C, the GLC analysis showed the disappearance of **3c**, and 3-methyl-1,3-thiazolidin-2-one **5** was formed in 50% yield, this was purified by column chromatography (silica gel, $CHCl_3$) and distillation: bp 65 °C/10^{-3} mmHg (lit,[8] 73—75 °C/0.2 mmHg); IR (neat) 1240, 1690 cm^{-1}; ^1H NMR ($CDCl_3$) δ=2.88 (s, 3H, $C\underline{H}_3N$), 3.30 (t, 2H, $C\underline{H}_2S$), 3.60 (t, 2H, $C\underline{H}_2N$).

References

1) A. Baba, H. Kishiki, I. Shibata, and H. Matsuda, *Organometallics*, **4**, 1329 (1985).

2) B. Delmond, J. C. Pommier, and J. Valade, *J. Organomet. Chem.*, **35**, 91, (1972); B. Delmond, J. C. Pommier, and J. Valade, *J. Organomet. Chem.*, **47**, 337 (1973).

3) R. Feinauer, M. Jacobi, and K. Hamann, *Chem. Ber.*, **98**, 1782 (1965).

4) V. S. Etlis, A. P. Sineokov, and G. A. Razuvaev, *Zh. Obshch. Khim.*, **34**, 4018 (1964); *Chem. Abstr.*, **62**, 9132 (1965); V. S. Etlis, A. P. Sineokov, and G. A. Razuvaev, *Zh, Obshch. Khim.*, **34**, 4090 (1964); *Chem. Abstr.*, **62**, 10423 (1965).

5) The intermediate **A** may also exist in the presence of DMF, because the IR absorption around 1600 cm^{-1} (C=N) was confirmed even in the presence of bases.

6) See, for example; A. K. Sawyer, "Organotin Compounds Vol. 2," Marcel Dekker, New York (1971), p. 297; E. Negishi,

"Organometallics in Organic Synthesis Vol. 1," John Wiley & Sons, New York (1980), p. 394; A. G. Davies and P. J. Smith, "Comprehensive Organometallic Chemistry Vol. 2," Pergamon Press (1982), p. 519.

7) A. J. Bloodworth, A. G. Davies, and S. C. Vasishtha, *J. Chem. Soc. (C)*, **1967**, 1309.

8) S. Sakai, H. Niimi, Y. Kobayashi, and Y. Ishii. *Bull. Chem. Soc. Jpn.*, **50**, 3271 (1977).

9) T. Mukaiyama, I. Kuwajima, and K. Mizui, *J. Org. Chem.*, **31**, 32 (1966).

10) S. Sakai, Y. Asai, Y. Kiyohara, K. Itoh, and Y. Ishii, *Organometal. Chem. Synth.*, **1**, 45 (1970/1971).