October, 1981] © 1981 The Chemical Society of Japan NOTES Bull. Chem. Soc. Jpn., 54, 3237—3238 (1981) 3237

The Reaction of 2-Ethoxy-1,3-oxathiolane with Carbonyl Compounds in the Presence of $ZnCl_2$ or $HgCl_2$

Shigeo TANIMOTO,* Shigeo JO,* Toyonari SUGIMOTO, and Masaya OKANO
Institute for Chemical Research, Kyoto University, Uji, Kyoto 611

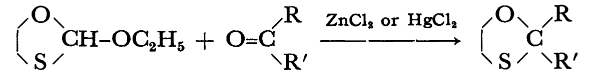
(Received February 21, 1981)

Synopsis. In the reaction of 2-ethoxy-1,3-oxathiolane with carbonyl compounds in the presence of $ZnCl_2$ or $HgCl_2$, it has been found that only the breaking of the endocyclic bond (C–O or C–S bond) occurs, while the breaking of the exocyclic C–O bond to give the 1,3-oxathiolan-2-ium ion is unfavorable. This behavior is different from that of 2-ethoxy-1,3-dithiolane, in which the breaking of the endocyclic C–S bond occurs by means of $HgCl_2$ and the exocyclic C–O bond, by means of $ZnCl_2$.

It has already been shown[1)] that the reaction of 2-ethoxy-1,3-dithiolane with acetone in the presence of $HgCl_2$ gives exclusively 2,2-dimethyl-1,3-dithiolane (**1**), whereas the employment of $ZnCl_2$, under otherwise identical conditions, yields 1-(1,3-dithiolan-2-yl)-2-propanone (**2**), along with **1**. The pathway leading to **1** involves the C–S bond fission of 2-ethoxy-1,3-dithiolane, and the breaking of the exocyclic C–O bond to give the 1,3-dithiolan-2-ium ion is necessary for the formation of **2**.

This report will describe the somewhat different behavior of 2-ethoxy-1,3-oxathiolane, in which these Lewis acids cause only the breaking of the endocyclic bond, with no evidence of the formation of the 1,3-oxathiolan-2-ium ion.

When 2-ethoxy-1,3-oxathiolane was allowed to react with aldehydes or ketones in dichloromethane at room temperature, in the presence of $ZnCl_2$, the corresponding 2-substituted or 2,2-disubstituted 1,3-oxathiolane (**3**) was produced as the main product in all cases.

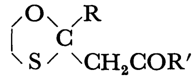


3

a: $R=C_6H_5$, $R'=H$
b: $R=CH_3(CH_2)_2$, $R'=H$
c: R, $R'=-(CH_2)_5-$
d: $R=R'=CH_3$
e: $R=C_6H_5$, $R'=CH_3$
f: $R=C_6H_5CH{=}CH$, $R'=H$

From the previously known data[1)] it seems reasonable to propose that the coordination of the O atom in the ring with $ZnCl_2$ occurs preferentially, thus bringing about the formation of the resonance-stabilized thiocarbonium ion. The employment of $HgCl_2$ instead of $ZnCl_2$, under otherwise identical conditions, also yielded **3**. This may be also explained in terms of another path involving the intial coordination of the S atom with $HgCl_2$ and the subsequent formation of the resonance-stabilized oxycarbonium ion.

Ethyl acetoacetate, methyl acetoacetate, or acetylacetone was also used for the reaction with 2-ethoxy-1,3-oxathiolane in the presence of $ZnCl_2$ or $HgCl_2$. The reaction proceeded without a solvent at room temperature, and 1,3-oxathiolane derivatives of the **4** formula were isolated.



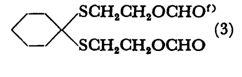
4

a: $R=CH_3$, $R'=OC_2H_5$
b: $R=CH_3$, $R'=OCH_3$
c: $R=CH_3$, $R'=CH_3$

The only product obtained was **4**; the remainder consisted of unchanged starting materials containing some resinous matter. Even in runs in which $ZnCl_2$

TABLE 1. REACTION OF 2-ETHOXY-1,3-OXATHIOLANE WITH ALDEHYDES OR KETONES

2-Ethoxy-1,3-oxathiolane, 20 mmol; Aldehyde or ketone, 20 mmol; $ZnCl_2$ or $HgCl_2$, 4 mmol; Dichloromethane, 35 ml. Reaction conditions: room temperature, 16 h.

Aldehyde or ketone		Catalyst	Product (yield/%)
R	R′		
C_6H_5	H	$ZnCl_2$	**3a**[a)] (60), $C_6H_5CH(SCH_2CH_2OCHO)_2$[b)] (14)
C_6H_5	H	$HgCl_2$	**3a**[a)] (74), $C_6H_5CH(SCH_2CH_2OCHO)_2$[b)] (4)
$CH_3(CH_2)_2$	H	$ZnCl_2$	**3b**[c)] (53), $CH_3(CH_2)_2CH(SCH_2CH_2OCHO)_2$[d)] (12)
$CH_3(CH_2)_2$	H	$HgCl_2$	**3b**[c)] (72), $CH_3(CH_2)_2CH(SCH_2CH_2OCHO)_2$[d)] (4)
$-(CH_2)_5-$		$ZnCl_2$	**3c**[e)] (82),  (3)
$-(CH_2)_5-$		$HgCl_2$	**3c**[e)] (92)
CH_3	CH_3	$HgCl_2$	**3d**[g)] (72)
C_6H_5	CH_3	$ZnCl_2$	**3e**[h)] (43)
C_6H_5	CH_3	$HgCl_2$	**3e**[h)] (42)
$C_6H_5CH{=}CH$	H	$HgCl_2$	**3f**[i)] (39)

a) Bp 94.5—95 °C/2 Torr (lit,[2)] 86—87 °C/5 Torr). NMR ($CDCl_3$): δ 7.5—7.1 (m, 5H), 5.97 (s, 1H), 4.6—4.3 (m,1H), 4.0—3.6 (m, 1H), 3.22—3.17 (m, 2H). b) Bp 170—171 °C/2 Torr. NMR ($CDCl_3$): δ 7.97 (s, 2H), 7.5—7.2 (m, 5H), 5.03 (s, 1H), 4.23 (t, 4H), 2.78 (d of t, 4H). c) Bp 83 °C/35 Torr (lit,[3)] 84 °C/34 Torr). NMR ($CDCl_3$): δ 5.05 (t, 1H), 4.7—4.2 (m, 1H), 4.0—3.5 (m, 1H), 3.1—2.9 (m, 2H), 2.0—0.8 (m, 7H). d) Bp 119.5—120.5 °C/3 Torr. NMR ($CDCl_3$): δ 8.05 (s, 2H), 4.33 (t, 4H), 3.88 (t, 1H), 2.55 (d of t, 4H), 1.9—0.8 (m, 7H). e) Bp 59 °C/2.5 Torr (lit,[4)] 47 °C/0.6 Torr). NMR ($CDCl_3$): δ 4.13 (t , 2H), 3.00 (t, 2H), 2.0—1.3 (m, 10H). f) Bp 153—154 °C/2 Torr. NMR ($CDCl_3$): δ 8.02 (s, 2H), 4.28 (t, 4H), 2.87 (t, 4H), 2.0—1.3 (m, 10H). g) Bp 44.5 °C/25 Torr (lit,[4)] 70 °C/65 Torr). NMR ($CDCl_3$): δ 4.12 (t, 2H), 3.08 (t, 2H), 1.60 (s, 6H). h) Bp 78 °C/1.5 Torr (lit,[4)] 96 °C/2 Torr). NMR ($CDCl_3$): δ 7.5—6.8 (m, 5H), 4.5—3.7 (m, 2H), 3.3—2.9 (m, 2H), 1.87 (s, 3H). i) Bp 98—101 °C/2.2 Torr. NMR ($CDCl_3$): δ 7.4—7.2 (m, 5H), 6.63 (d, 1H), 6.23 (d of d, 1H), 5.63 (d, 1H), 4.5—3.6 (m, 2H), 3.1—3.0 (m, 2H).

TABLE 2. REACTION OF 2-ETHOXY-1,3-OXATHIOLANE WITH SOME ACTIVE METHYLENE COMPOUNDS

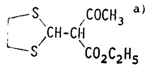
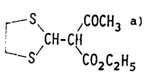
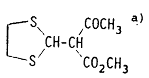
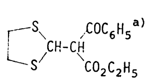
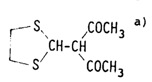
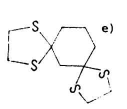
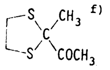
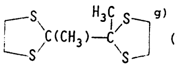
2-Ethoxy-1,3-oxathiolane, 45 mmol; Active methylene compound, 30 mmol; Lewis acid catalyst: described in individual cases. Reaction conditions: room temperature, 24 h.

Active methylene compound		Catalyst (mmol)	Product (yield/%)
R	R′		
CH_3	OC_2H_5	$ZnCl_2$(7)	**4a**[a)] (37)
CH_3	OC_2H_5	$HgCl_2$(11)	**4a**[a)] (9)
CH_3	OC_2H_5	$FeCl_3$(6)	**4a**[a)] (44)
CH_3	OCH_3	$ZnCl_2$(7)	**4b**[b)] (66)
CH_3	CH_3	$ZnCl_2$(7)	**4c**[c)] (28)

a) Bp 131—134 °C/25.5 Torr (lit,[4)] 117 °C/20 Torr). NMR ($CDCl_3$): δ 4.17 (t, 2H), 4.13 (q, 2H), 3.06 (t, 2H), 2.87 (bs, 2H), 1.72 (s, 3H), 1.25 (t, 3H). b) Bp 82—83 °C/3 Torr. NMR (CCl_4): δ 3.98 (t, 2H), 3.53 (s, 3H), 2.92 (t, 2H), 2.70 (s, 2H), 1.62 (s, 3H). c) Bp 74—77 °C/2.5 Torr. NMR (CCl_4): δ 3.94 (t, 2H), 2.88 (t, 2H), 2.81 (s, 2H), 2.02 (s, 3H), 1.51 (s, 3H).

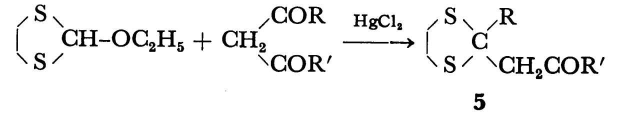
Table 3. Reaction of 2-ethoxy-1,3-dithiolane with some active methylene compounds using the $HgCl_2$ catalyst

2-Ethoxy-1,3-dithiolane, 33 mmol; Active methylene compound, 38 mmol; $HgCl_2$ (or $HgBr_2$) catalyst, 15 mmol. Reaction conditions: room temperature, 24 h.

Active methylene compound R	 R	Catalyst	Product (yield/%)
CH_3	OC_2H_5	$HgCl_2$	**5a**[a] (35),  [a] (5)
CH_3	OC_2H_5	$HgBr_2$	**5a**[a] (36),  [a] (3)
CH_3	OCH_3	$HgCl_2$	**5b**[a] (37),  [a] (0.5)
C_6H_5	OC_2H_5	$HgCl_2$	**5c**[b] (35),  [a] (1)
C_6H_3	CH_3	$HgCl_2$	**5d**[a] (30),  [a] (9)
$-(CH_2)_3-$		$HgCl_2$[c]	**5e**[d] (7),  [e] (5)
Diacetyl		$HgCl_2$	 [f] (28),  [g] (9)

a) The data of these compounds can be seen in the literature.[5] b) Bp 163—165 °C/2 Torr. NMR ($CDCl_3$): δ 7.8—7.2 (m, 5H), 3.93 (q, 2H), 3.46 (s, 2H), 3.28 (s, 4H), 1.01 (t, 3H). c) Dichloromethane was used as the reaction solvent. d) Bp 134—136 °C/2 Torr (lit,[6] 130—136 °C/0.6 Torr). NMR ($CDCl_3$): δ 3.30 (s, 4H), 2.87 (bs, 2H), 2.5—1.9 (m, 6H). e) After the evaporation of **5e** from the crude product, the residue was column-chromatographied on silica gel, using 20% ether–hexane as the eluent, to afford this product. Mp 155—156 °C (ethanol) (lit,[7] 158—158.5 °C). NMR ($CDCl_3$): δ 3.28 (s, 8H), 2.71 (bs, 2H), 2.1—1.8 (m, 6H). f) Bp 82—84 °C/2 Torr. NMR ($CDCl_3$): δ 3.43 (bs, 4H), 2.39 (s, 3H), 1.81 (s, 3H). g) Mp 83—84 °C (ethanol) (lit,[8] 83 °C). NMR ($CDCl_3$): δ 3.5—3.3 (m, 8H), 2.03 (s, 6H).

was employed, none of the product which would arise from the intermediate 1,3-oxathiolan-2-ium ion was detected. On the other hand, in our previous work[5] on the reaction of 2-ethoxy-1,3-dithiolane with active methylene compounds in the presence of $ZnCl_2$, the exclusive formation of the intermediate 1,3-dithiolan-2-ium ion was observed. When $HgCl_2$ was used instead of $ZnCl_2$, the reaction with the dithiolane proceeded *via* a resonance-stabilized thiocarbonium ion. The formation of 1,3-dithiolane derivatives with the formula of **5** in this reaction suggests that the coordination of $HgCl_2$ with the S atom in the 1,3-dithiolane ring is favorable. The products obtained in the reaction are summarized in Table 3.



5

a: $R=CH_3$, $R'=OC_2H_5$ **d**: $R=R'=CH_3$
b: $R=CH_3$, $R'=OCH_3$ **e**: R, $R'=-(CH_2)_3-$
c: $R=C_6H_5$, $R'=OC_2H_5$

Experimental

Reaction of 2-Ethoxy-1,3-oxathiolane with Aldehydes or Ketones. To a mixture of 2-ethoxy-1,3-oxathiolane (20 mmol) and an aldehyde (or a ketone) (20 mmol) in dichloromethane (35 ml), we added $HgCl_2$ (or $ZnCl_2$) (4 mmol) at 0—5 °C. The mixture was stirred for 16 h at room temperature and then poured into a mixture of water and dichloromethane. The organic layer was separated, and then it was combined with a dichloromethane extract of the aqueous phase. The dichloromethane solution was washed with dilute aqueous $NaHCO_3$, and then with water, dried over $MgSO_4$, and distilled.

Reaction of 2-Ethoxy-1,3-oxathiolane with Active Methylene Compoundes. To a mixture of 2-ethoxy-1,3-oxathiolane (45 mmol) and an active methylene compound (30 mmol), we added a Lewis-acid catalyst (as is shown in Table 2) at 0—5 °C. The mixture was stirred for 24 h at room temperature and then worked up as above.

Reaction of 2-Ethoxy-1,3-dithiolane with Active Methylene Compounds in the Presence of $HgCl_2$. To a mixture of 2-ethoxy-1,3-dithiolane (33 mmol) and an active methylene compound (38 mmol), we added $HgCl_2$ (or $HgBr_2$) (15 mmol) at 0—5 °C. The mixture was stirred for 24 h at room temperature and then poured into a mixture of ice water and ether. The organic layer was separated and combined with an ethereal extract of the aqueous phase. The ethereal solution was washed with dilute aqueous $NaHCO_3$, and then with water, dried over $MgSO_4$, and distilled. The product was further purified by column chromatography on silica gel, if necessary (the eluent in most cases was 50% hexane–ether).

References

1) S. Jo, S. Tanimoto, T. Oida, and M. Okano, *Bull. Chem. Soc. Jpn.*, in press.

2) F. Kipnis and J. Ornfelt, *J. Am. Chem. Soc.*, **71**, 3555 (1949).

3) B. E. Leggetter and R. K. Brown, *Can. J. Chem.*, **41**, 2671 (1963).

4) C. Djerassi and M. Gorman, *J. Am. Chem. Soc.*, **75**, 3704 (1953).

5) S. Tanimoto, Y. Matsumura, T. Sugimoto, and M. Okano, *Bull. Chem. Soc. Jpn.*, **51**, 665 (1978).

6) M. P. Mertes, *J. Org. Chem.*, **26**, 5236 (1961).

7) E. E. Smissman and J. L. Diebold, *J. Org. Chem.*, **33**, 1466 (1968).

8) F. Chastrette, M. Hassambay, and M. Chastrette, *Bull. Soc. Chim. Fr.*, **1976**, 601.