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ORGANIC SULFUR CHEMISTRY. XXI. TRISULFIDE FORMATION BY ALKOXIDE DECOMPOSITION OF SULFENYLTHIOCARBONATES[1a]

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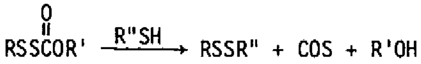
While sulfenylthiocarbonates (1) are easily prepared and stored[2] they have received

$$RSSCO_2R'$$

1

very little attention in spite of the fact that they appear to be highly reactive towards a variety of nucleophilic reagents[1b]. One of their reactions which has been explored in some detail by Brois[3] involves their use as precursors to unsymmetrical disulfides 2. This approach has enabled Hiskey and co-workers to use this functionality as a useful protective group in the synthesis of complex peptide disulfides[4]. The reaction has been

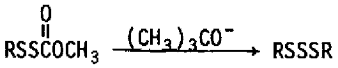


$$RSS\overset{O}{\overset{\|}{C}}OR' \xrightarrow{R''SH} RSSR'' + COS + R'OH$$

1 2

suggested[3] to proceed *via* attack of the thiol on the aryl /alkyl sulfur atom with concomitant displacement of COS and R'OH. We felt that it might be possible to effect a synthesis of sulfenate esters (RSOR")[5] by a similar reaction using an alkoxide or alcohol as a nucleophile.

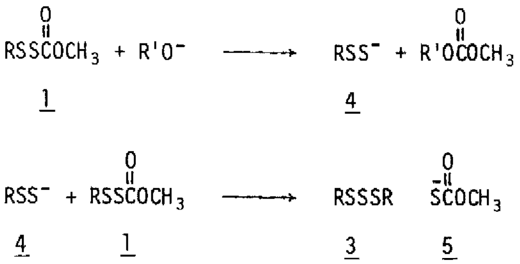
Surprisingly, when equimolar amounts of sulfenylthiocarbonate 1a (R = C_2H_5; R' = CH_3; ethylsulfenylmethylthiocarbonate) and sodium methoxide[6] were allowed to react, both ethyl di-and trisulfide were produced in a ratio of approximately 1:1. Similar results were obtained using 1c and 1d (R = ipr, t-Bu). That the nature of the base influences the reaction pathway was demonstrated by the observation that as the alkoxide was varied from methoxide, ethoxide, isopropoxide to t-butoxide, the ratio of trisulfide to disulfide was increased considerably. Thus, the decomposition of 1 proceeds cleanly in the presence of a molar amount of t-butoxide to give trisulfide in good yield (Table).



$$RSS\overset{O}{\overset{\|}{C}}OCH_3 \xrightarrow{(CH_3)_3CO^-} RSSSR$$

1 3

The mechanism of the reaction may be formulated by attack of the base on the carbonyl carbon to displace the thiomercaptide anion. The latter then reacts with



$$RSS\overset{O}{\overset{\|}{C}}OCH_3 + R'O^- \longrightarrow RSS^- + R'O\overset{O}{\overset{\|}{C}}OCH_3$$

1 4

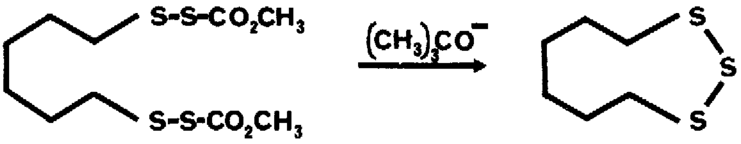
$$RSS^- + RSS\overset{O}{\overset{\|}{C}}OCH_3 \longrightarrow RSSSR \quad {}^-S\overset{O}{\overset{\|}{C}}OCH_3$$

4 1 3 5

another molecule of 1 to give trisulfide displacing potassium thiocarbonate. In each reaction a solid was isolated which contained salt 5. Evidence as to its identity[7] was gained by its reaction with C_6H_5SCl to give sulfenylthiocarbonate 1f in reasonable yield.

A typical preparation is as follows. Potassium t-butoxide (1.8g, 0.015 mol) is dissolved in 10 ml of methanol and added dropwise to 2.8g (0.0155 mol) of t-butyl sulfenylthiocarbonate (1d). During the addition the temperature of the reaction is maintained between 0-10°. The reaction mixture is then warmed to room temperature and stirred overnight. The solvent is then evaporated and the t-butyl trisulfide collected as the fraction boiling at 75-8° (0.3 mm); yield: 14g (86%).

From the above, bis sulfenylthiocarbonates were suggested to be precursors for cyclic trisulfides. Such cycles have proved difficult to synthesize by a variety of means[8]. When 1,6-hexanedithiol was treated with $ClSCO_2CH_3$, the bis derivative 6 was obtained in 95% yield. Treatment of this material with potassium t-butoxide in methanol gave a semisolid which was chromatographed (silica gel, hexane/chloroform). Solvents were removed from the early fractions giving a solid which was thoroughly leached with hot ethanol. On cooling, a crystalline solid resulted (7, mp 75.5°-77.5°). The later fractions from the column provided an oil which became more viscous in time. The pmr properties of the two substances are similar, however the solid gave a correct combustion analysis and an exact mass measurement for the cyclic 9-membered trisulfide[9].



6 7

Finally, ^{13}C analysis of 7 showed three clean signals at 40.29, 29.03 and 27.80 ppm (TMS) consistent with the structure.

The scope and mechanism of this reaction are under further investigation.

TABLE

$$RSSCO_2CH_3 + (CH_3)_3CO^- \longrightarrow RSSSR$$

No	$RSSCO_2CH_3$	bp/mm °C	lit bp	No	% RSSSR	bp/mm (mp) °C	lit bp(mp)
1a	CH_3CH_2-	91-3/14	53-4/1[3]	3a	67	60-1/3	57/3[10]
b	$CH_3CH_2CH_2$-	70/1		b	70	65/0.5	68-9/0.9[11]
c	$(CH_3)_2CH$-	99/13	-	c	78	56/2	75-6/5[11]
d	$(CH_3)_3C$-	100/5	-	d	86	75-8/3	86/4[10]
e	$C_6H_5CH_2$-	140/3	-	e	46	(49-50)	(49)[12]
f	C_6H_5-	120/1.5	-	f	98	oil	[13]
4	$(CH_2)_6$ [14]		-	5	16	(75.5-77.5)	

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3. S.J. Brois, J.F. Pilot and H.W. Barnum, J. Amer. Chem. Soc., 92, 7629 (1970).
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5. At present no widely useful procedure is available for the synthesis of this class of compounds.
6. There is no reaction between 1 and alcohols.
7. It was further noted that salt 5 showed an ultra violet absorption at 221 nm, in excellent agreement with that published for 5 (222 nm); C.N. Murphy and G. Winter, Aust. J. Chem., 26, 755 (1973).

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9. Calc'd: C,40.0; H,6.7; S,53.3; found: C,40.2; H,7.1; S;52.9; ms: Calc'd for $C_6H_{12}S_3$ 180.0093; found: 180.0103; Rast molecular weight determination (camphor) 196 , 213 . Attempts to purify 7 without column chromatography resulted in a much lower yield of monomer. To our knowledge, compound 7 is the largest monocyclic trisulfide reported to date: *cf*. H. Fritz and C.D. Weis, Tetrahedron Lett., 1659 (1974) for an unsaturated bicyclic case.

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13. Decomposed to diphenyl disulfide on distillation; yellow oil collected, bp 156-171°/0.5; crystallized mp 59-61°; this decomposition has been reported: H. Lecher, *Chem Ber.*, **58**, 417 (1925).

14. After column chromatography, 6 gave a homogeneous tlc as well as a pmr spectrum consistent with its structure.

ACKNOWLEDGEMENT

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