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LETTERS

$SnCl_4$-mediated reaction of ozonides with allyltrimethylsilane: formation of 1,2-dioxolanes

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Abstract: $SnCl_4$-mediated reaction of ozonides (1,2,4-trioxolanes) with allyltrimethylsilane furnishes trimethylsilylmethyl-1,2-dioxolanes via metalated carbonyl oxides. The carbonyl oxides can arise through initial ionization of either the ether or peroxide oxygens. © 1999 Elsevier Science Ltd. All rights reserved.

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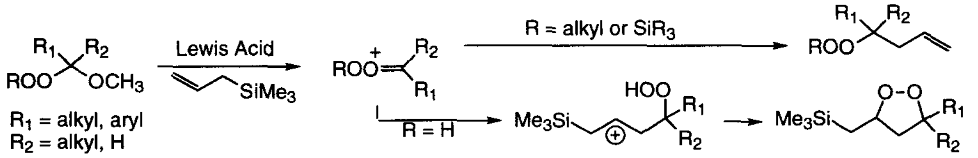
We have been exploring the synthesis of cyclic and acyclic peroxides through Lewis acid-mediated displacement of peroxyacetals with electron-rich alkenes (eq. 1 and 2).[1-3] We now report that the $SnCl_4$-mediated reaction of ozonides with allyltrimethylsilane furnishes good yields of trimethylsilylmethyl-1,2-dioxolanes (eq. 3), in at least some cases through a mechanism involving ionization of the ethereal ozonide oxygen.



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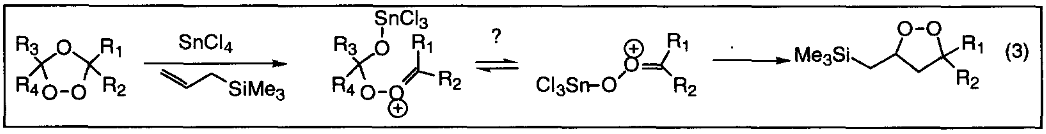

(3)

Treatment of ozonides with $ClSO_3H$- or $SbCl_5$ generates metalated or protonated carbonyl oxides, typically via ionization of peroxide oxygen followed by loss of a carbonyl (eq. 4).[4-7] In the absence of a trapping agent, self-reaction and/or attack on another ozonide produces cyclic peroxides (eq. 4). Treatment with BF_3 in the presence of 1,1-substituted alkenes, results in formation of alkyldioxolanes, presumably through a pathway similar to that described in eq. 2.[8]

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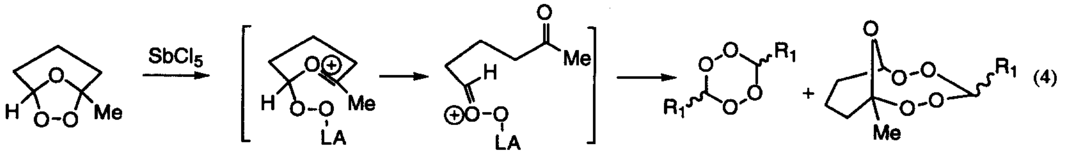
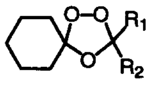


$R_1 = (CH_2)_3COMe$

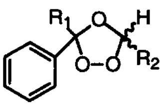
Research in our lab has found the reactivity of peroxyacetals to vary substantially with the choice of Lewis acid and we were interested in whether ozonide ionization might be manipulated by choice of reaction conditions.[9] In particular, we hoped that ozonides might represent an improved source of peroxycarbenium ions relative to hydroperoxyacetals (eq. 2), which had proven incompatible with silyl enol ethers and related nucleophiles.[2] We now report the $SnCl_4$-mediated allylation of ozonides furnishes products similar to those obtained from hydroperoxyacetals, in some cases through selective ionization of the ethereal oxygen.

Ozonides were prepared through alkene ozonolysis (method A) or through the reaction of an aldehyde or ketone with the carbonyl oxide derived from ozonolysis of either cyclohexanone methoxyoxime (method B) or methoxymethylenecyclohexane. (method C).[10-12]

Figure 1: Ozonide Substrates



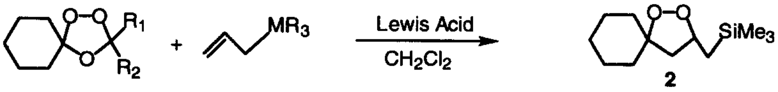
	R_1	R_2	Method	Yield (%)
1a	$-(CH_2)_4-$		B	67
1b	CH_3	C_6H_5	B	57
1c	C_4H_9	C_4H_9	C	47
1d	C_8H_{17}	H	C	47
1e	C_6H_5	H	C	65
1f	H	H	A	78



	R_1	R_2	Method	Yield
1g	H	C_3H_7	A	73
1h	H	H	A	77
1i	Me	H	A	61

Addition of allyltrimethylsilane and $TiCl_4$ to ozonide **1a** at - 78 °C led to disappearance of starting material and the appearance of caprolactone, cyclohexanone, and cycloheptanone (Table 1).[13] Reaction in the presence of $SnCl_4$, which occurred only upon warming to ~ 0 ° C, furnished

Table 1

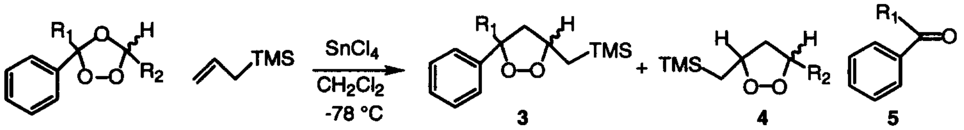


Ozonide	MR_3	R_1	R_2	Lewis Acid	T (°C)	Yield **2** (%)
1a	$-SiMe_3$	$-(CH_2)_4-$		$TiCl_4$	-78	0
1a	$-SiMe_3$	$-(CH_2)_4-$		$SnCl_4$	-78 -> 0	57
1a	$-SiMe_3$	$-(CH_2)_4-$		TMSOTf	-78 -> 0	NR
1a	$-SiMe_3$	$-(CH_2)_4-$		$SbCl_5$	-78 -> 0	dec.
1a	$-SnBu_3$	$-(CH_2)_4-$		$SnCl_4$	-78	20 (50% conv)
1b	$-SiMe_3$	CH_3	C_6H_5	$SnCl_4$	-78 -> 0	61
1c	$-SiMe_3$	C_4H_9	C_4H_9	$SnCl_4$	-78 -> 0	14
1d	$-SiMe_3$	C_8H_{17}	H	$SnCl_4$	-78 -> 0	56
1e	$-SiMe_3$	C_6H_5	H	$SnCl_4$	-78 -> 0	79
1f	$-SiMe_3$	H	H	$SnCl_4$	-78 -> 0	10

spirodioxolane **2** accompanied by small amounts of cycloheptanone.[14] No reaction was observed in the presence of TMSOTf. $SbCl_5$, a catalyst previously observed to promote ozonide ionization, failed to promote reaction at low temperature and led to decomposition at higher temperatures. The replacement of allyltrimethylsilane by allylstannane resulted in a considerably reduced yield of dioxolane, demonstrating that the displacement is slow relative to metathesis of the stannane.[15] We next applied the most favorable conditions ($SnCl_4$, -78 to 0 °C, allyltrimethylsilane) to a series of tri- and tetrasubstituted ozonides (**1b** - **1f**); in each case the allylated spirodioxolane (**2**) was the only product observed.

The allylation of several acyclic ozonides (**1g** - **1i**) allowed an assessment of regioselectivity in the absence of the spirocyclohexylidene unit (Table 2). For volatile dioxolanes, the yield was inferred from the isolated amount of benzaldehyde or acetophenone. In each case, the product distribution demonstrates reaction through both possible ionization modes.

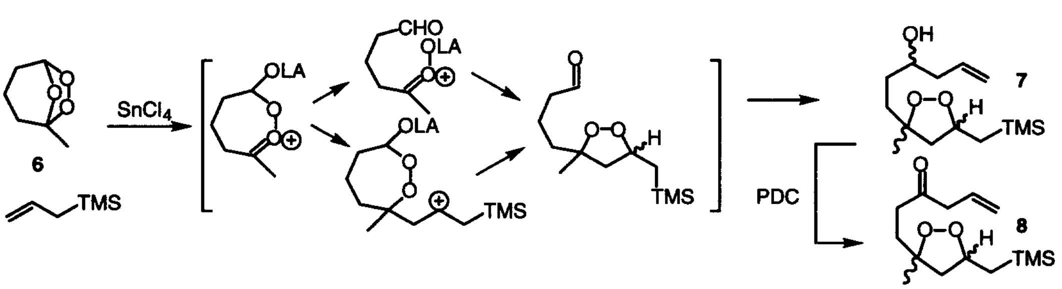
Table 2



	R1	R2	Yield 3	Yield 4	Yield 5
1g	H	C_3H_7	15	7 (volatile)	39
1h	H	H	15	volatile	22
1i	Me	H	9	volatile	43

Allylation of methylcyclopentene ozonide (**6**) with $SnCl_4$ and excess allyltrimethylsilane resulted in formation of 3,5,5-trisubstituted 1,2-dioxolane (**7**) as a single regioisomer derived from allylation at the least substituted ozonide carbon. The dioxolane was formed as a 30:70 mixture of cis/trans isomers, each a 1:1 mixture of epimers at the exocyclic carbinol (Scheme 1). This stereochemical assignment was supported by the observation of only two diastereomers in an 30:70 ratio following oxidation of the alcohol to the corresponding ketone (**8**). The regioselectivity of ring opening supports a mechanism involving ionization of the alkoxide followed by trapping of a derived peroxycarbenium ion.

Scheme 1



Conclusions: $SnCl_4$-mediated ozonide displacement provides a useful pathway for the synthesis of functionalized 1,2-dioxolanes. Whereas decomposition of ozonides in the presence of $SbCl_5$ or

$ClSO_3H$- proceeds via peroxide ionization, $SnCl_4$-mediated displacements proceed, in at least some cases, through initial ionization of the ethereal oxygen to form a peroxycarbenium ion. Depending upon whether the neutral carbonyl is lost prior to allylation, it may be possible to employ the substituents on this fragment to influence reactions at the developing carbenium ion. Further investigations will be reported in due course.

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Caution: Although no safety problems were encountered during these studies, the observance of standard precautions is strongly recommended.[16-18]

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