

Substitution Reaction of Ketene Dithioacetals with Carbon Electrophiles
by the Promotion of Trityl Chloride-Tin(II) Chloride or
Trimethylsilyl Chloride-Tin(II) Chloride Catalyst System

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In the presence of catalytic amounts of trityl chloride or trimethylsilyl chloride and tin(II) chloride, ketene dithioacetals smoothly react with allyl methyl ethers or α,β -unsaturated orthoesters to afford the corresponding allyl or alkoxy-carbonyl-ethyl substituted ketene dithioacetals in good yields.

Ketene dithioacetals are synthetically useful intermediates and a number of preparative methods have been reported.¹⁾ Since neighbouring positively or negatively charged atom is electronically stabilized by sulfur atom, the double bond of ketene dithioacetals is reactive towards nucleophiles as well as electrophiles. However, there were few examples of direct substitution reaction of ketene dithioacetals with electrophiles except in the cases of bromonium,^{2a)} chloronium,^{2a)} and trihaloacylium^{2b)} ions. Further, as far as we know, concerning the direct and effective reaction of ketene dithioacetals with carbon electrophiles possessing synthetically useful functional groups, there has been reported only one example, which is the reaction of the lithiated ketene dithioacetals (vinylolithium derivatives) with electrophiles.³⁾ In considering the usefulness of ketene dithioacetals in organic synthesis, a development of convenient and effective method to convert a simple ketene dithioacetal into a more highly functionalized one has been studied.

Recently we have reported that allyl methyl ethers⁴⁾ or α,β -unsaturated orthoesters⁵⁾ activated by trityl salts, such as TrClO_4 , TrSbCl_6 , TrOTf , etc., smoothly react with silyl nucleophiles, and the combination of a neutral molecule and a weak Lewis acid, such as trityl chloride or trimethylsilyl chloride and tin(II) chloride, also generate active species similar to trityl salts.⁶⁾ In these reactions, cationic species would be produced by the activation with the catalysts, which smoothly react with various nucleophiles. Therefore, it is expected that these active intermediates react with ketene dithioacetals, which are regarded as electron-rich olefins by the effect of two sulfur atoms. In this communication, we wish to describe the direct substitution reaction of ketene dithioacetals with the cationic carbon electrophiles produced from allyl methyl

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Table 1. Effect of activator on the reaction of 2-(2-phenylethylidene)-1,3-dithiolane with 4-methoxy-2-pentene

Activator	Time/h	Yield/%
15 mol% SnCl ₂	23	19
10 mol% TrCl-SnCl ₂	24	40
10 mol% TMSCl-SnCl ₂	21	58

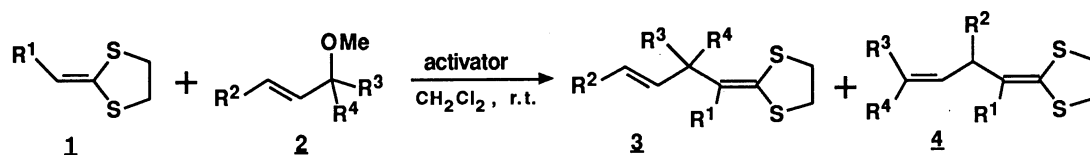
ethers or α,β -unsaturated orthoesters by the activation with a combined catalyst system, trityl chloride or trimethylsilyl chloride and tin(II) chloride.

At first, the reaction of 2-(2-phenylethylidene)-1,3-dithiolane with 4-methoxy-2-pentene was examined by the use of catalytic amounts of trityl chloride and tin(II) chloride as a catalyst system, and the corresponding allylated ketene dithioacetal was obtained in 40% yield. In this reaction, the use of catalytic amounts of trimethylsilyl chloride and tin(II) chloride afforded the almost same product in 58% yield, while the use of tin(II) chloride alone was not effective (19% yield, Table 1). Therefore, it is proved that combined use of tin(II) chloride and trityl chloride or trimethylsilyl chloride promotes the present reaction. Several examples of the reaction of allyl methyl ethers with ketene dithioacetals are summarized in Table 2.

Next, α,β -unsaturated orthoesters were examined as carbon electrophiles with the expectation that α,β -unsaturated orthoesters would generate active cationic species by the catalyst system to result in the formation of substituted products on treatment with ketene dithioacetals. α,β -Unsaturated orthoesters were strongly activated by the above catalyst system, so the reaction was carried out under rather low temperature. The results of the reaction of various ketene dithioacetals with α,β -unsaturated orthoesters are summarized in Table 3.

In this reaction, the effect of the substituents of α,β -unsaturated orthoesters strongly influences on the reactivity; for example, 1,1,1-triethoxy-2-butene ($R^2=Me$, $R^3=Et$) did not react with 2-(2-phenylethylidene)-1,3-dithiolane under the conditions described above, while 1,1,1-triethoxy-2-propene ($R^2=H$, $R^3=Et$) did, and 1,1,1-trimethoxy-2-butene ($R^2=Me$, $R^3=Me$) reacted with 2-(2-phenylethylidene)-1,3-dithiolane to give the corresponding substituted product in high yield (72%).

The following experimental procedure is representative; trityl chloride (8.0 mg, 0.0287 mmol) and tin(II) chloride (8.3 mg, 0.0438 mmol) were stirred for 1.5 h in 1 ml of dichloromethane at room temperature. Then, to a stirred suspension of above mixture was added a dichloromethane (2 ml) solution of 4-

Table 2. The reaction of ketene dithioacetals with allyl methyl ethers^{a)}

Ketene dithioacetal	Allyl methyl ether	Activator ^{b)}	Time/h	Yield/%	(<u>3</u> : <u>4</u>) ^{c)}
 (<u>1a</u>)	 (<u>2a</u>)	A	21	58 (75) ^{d)}	
		B	24	40	
	 (<u>2b</u>)	A	2	86	(32:68)
		B	4	83	(32:68)
 (<u>2c</u>)	A	2	81	(70:30)	
	B	1.5	84	(72:28)	
 (<u>2d</u>)	A	2	74	(<5:>95)	
	B	1	80	(<5:>95)	
 (<u>1b</u>)	(<u>2a</u>)	B	4	82	(9:91) ^{e)}
 (<u>1c</u>)	(<u>2a</u>)	B	4	92	(<5:>95)
 (<u>1d</u>)	(<u>2a</u>)	B	24	46	(<5:>95)

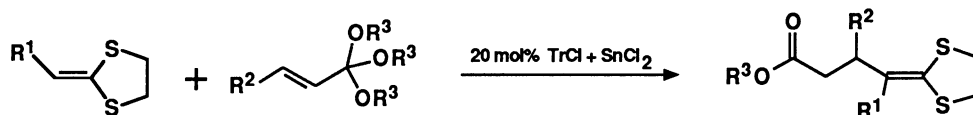
a) All the products gave satisfactory NMR and IR spectral data.

b) Activator; A: 10 mol% TMSCl-SnCl₂, B: 10 mol% TrCl-SnCl₂.

c) The ratio was determined by ¹H NMR.

d) One equivalent of TMSCl and 15 mol% of SnCl₂ were used as a catalyst system.

e) The reaction was quenched with triethylamine.

Table 3. The reaction of ketene dithioacetals with a,b-unsaturated orthoesters^{a)}

R ¹	R ²	R ³	Solvent	Temp / °C	Time/h	Yield/%
PhCH ₂	H	Et	CH ₂ Cl ₂	-78	6	81
Me	H	Et	CH ₂ Cl ₂	-78	6	64
Ph	H	Et	CH ₂ Cl ₂	-78	6	79
PhCH ₂	Me	Me	toluene	-23	21	72
Me	Me	Me	toluene	-23	21	83
Ph	Me	Me	toluene	-23	21	trace

a) All the products gave satisfactory NMR and IR spectral data.

methoxy-4-phenyl-2-butene (47.8 mg, 0.295 mmol) and 2-(2-phenylethylidene)-1,3-dithiolane (77.6 mg, 0.372 mmol) at room temperature. The mixture was stirred at the same temperature for 4 h. The reaction was quenched by adding aqueous sodium hydrogen carbonate (or triethylamine) and organic materials were extracted with dichloromethane. After the organic layer was dried and evaporated, the residue was purified by thin layer chromatography (silica gel) to give the mixture of the corresponding substituted products in 83% yield (82.9 mg, 0.245 mmol). In the case of the reaction of ketene dithioacetals with α,β -unsaturated orthoesters, trityl chloride and tin(II) chloride were stirred for 1.5 h in 1 ml of dichloromethane (or toluene) at room temperature, and the mixture was cooled to an appropriate temperature (see Table 3), then an α,β -unsaturated orthoester and a ketene dithioacetal were added, and the reaction mixture was subjected to usual work-up.

It is noted that ketene dithioacetals smoothly react with allyl methyl ethers or α,β -unsaturated orthoesters under mild conditions to afford the corresponding allyl or alkoxy-carbonyl ethyl substituted ketene dithioacetals, more highly functionalized acetals, by the combined use of catalytic amounts of trityl chloride or trimethylsilyl chloride and tin (II) chloride under especially mild conditions.

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