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Titanocene(II)-Promoted Desulfurizative Tertiary Alkylation of 1,3-Bis(phenylthio)alk-1-enes and β,γ -Unsaturated Thioacetals

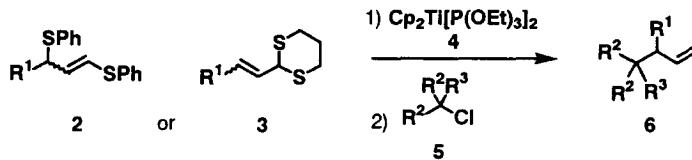
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Abstract: The desulfurization of 1,3-bis(phenylthio)alk-1-enes with the low valent titanium species $\text{Cp}_2\text{Ti}[\text{P}(\text{OEt})_3]_2$ and subsequent reaction with *tert*-alkyl chlorides gave the terminal olefins regioselectively. The similar reactions also took place when β,γ -unsaturated thioacetals were treated successively with the titanocene(II) species and *tert*-alkyl chlorides. It was suggested that the present reactions proceeded via the formation of (*E*)-vinyltitanium intermediate. © 1999 Elsevier Science Ltd. All rights reserved.

Recently we reported titanocene(II)-promoted reactions of thioacetals with various organic compounds such as carbonyls,¹ alkenes,² alkynes,³ and group 14 organometallics.⁴ We tentatively assume that all these reactions proceed via the formation of carbene complexes of titanium. Since we expected that such metal carbenes are regarded as Schrock type complexes and would behave as nucleophiles, we have examined their alkylation. Contrary to our expectation, the reactions of carbene complex formed from saturated thioacetal with alkyl halides did not proceed under the various reaction conditions. After several attempts, however, we found that the vinylcarbene complex **1**, formed by the desulfurization of 1,3-bis(phenylthio)propene derivative **2** or β,γ -unsaturated thioacetal **3** with the low-valent titanium species $\text{Cp}_2\text{Ti}[\text{P}(\text{OEt})_3]_2$ **4**, did react with *tert*-alkyl chloride **5** (Scheme 1).



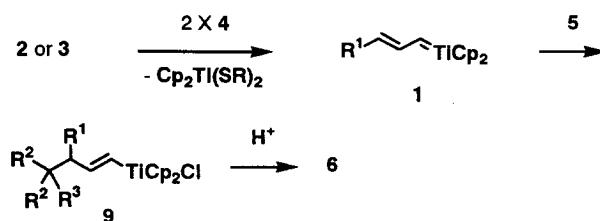
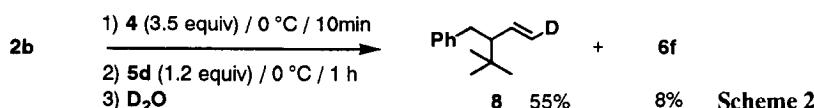
Scheme 1

The treatment of 4-phenyl-1,3-bis(phenylthio)but-1-ene (**2b**) with titanocene(II) **4** (3.5 equiv) at 0 °C for 10 min and then with 1.2 equiv of 2-chloro-2-methyl-4-phenylbutane (**5a**) for 1 h produced the alkylation product **6d** in 57% yield. The reaction proceeded with high regioselectivity in which the alkyl halide attacks only at the substituted side of the allylic system. By the use of 2 equiv of **5a**, **6d** was obtained in 73% yield along with the dehydrochlorination products, 2-methyl-4-phenylbut-1-ene (**7a**) and 2-methyl-4-phenylbut-2-ene (**7b**) (17% based on **5a** used (**7a** : **7b** = 63 : 37)). When the alkylation was carried out at room temperature, the yields of **7** increased (47% based on **5a** used (**7a** : **7b** = 85 : 15)) though **6d** was obtained in the same yield (Table 1, entry 4). It was found that an increase of the steric demand of the alkyl chloride by using 3-chloro-3-ethylpentane (**5b**) led to a drastic decrease of the yield of product **6e** (33%) when the desulfurization of **2b** and the following alkylation were carried out at 0 °C. However, **6e** was obtained in good yield by the treatment of the organotitanium species with **5b** at room temperature (entry 5).

In a similar manner, the reactions of several 1,3-bis(phenylthio)propene derivatives **2** with *tert*-alkyl chlorides **5** were performed. As the results listed in Table 1 indicate, the present alkylation regioselectively affords the terminal olefins **6** in good yields even when highly sterically hindered tertiary halides are employed. The typical experimental procedure is as follows; magnesium turnings (51 mg, 2.1 mmol; purchased from Nakarai Tesque Inc. Kyoto, Japan), finely powdered molecular sieves 4 A (175 mg), and Cp_2TiCl_2 (436 mg, 1.75 mmol) were placed in a flask and dried by heating with a heat gun under reduced pressure (2-3 mmHg). Care was taken not to sublimate Cp_2TiCl_2 . After cooling, THF (3.5 ml) and $\text{P}(\text{OEt})_3$ (0.60 ml, 3.5 mmol) were added successively with stirring at room temperature under argon. After 3 h, **2b** (174 mg, 0.5 mmol) in THF (1.5 ml) was added to the mixture at 0 °C, and stirring was continued for 10 min. Then 2-chloro-2-methylpropane (**5d**) (93 mg, 1 mmol) in THF (1.5 ml) was added and the reaction mixture was stirred for 30 min at the same temperature. The cooling bath was removed, and the mixture was further stirred for 1.5 h. The reaction was quenched by addition of 1 M NaOH, and the resulting insoluble materials were filtered off through Celite. The organic materials were extracted with ether, and the extract was dried over Na_2SO_4 . After removal of solvent, the residue was purified by using PTLC (hexane) to give 3-benzyl-4,4-dimethylpent-1-ene (**6f**) (78 mg, 83%).

Since the vinylcarbene complexes **1** are produced also from β,γ -unsaturated thioacetals **3**, we next examined the desulfurizative alkylation of **3** under the similar reaction conditions. Due to the low reactivity of **3** toward the low-valent titanium species **4**, the alkylation products **6** were produced in poor yields when the desulfurization and alkylation of **3** were performed at 0 °C (see entry 1, Table 2). On the other hand, the terminal olefins **6** were obtained in good yields when all the reaction steps took place at room temperature.

In order to prove the reaction pathway, **2b** was successively treated with **4** and 1.2 equiv of **5d** at 0 °C, and the reaction was quenched with excess D_2O (Scheme 2). The formation of the *trans*-deutero olefin **8** indicates that the present reaction proceeds via the *trans*-vinyltitanium compound **9** as shown in Scheme 3. On the other hand, no deuterio olefin was produced when the alkylation was performed at room temperature using 2 equiv of **5d** and was quenched with D_2O . This result suggests that the formation of olefin **7** during the alkylation at room temperature is due, to a large extent, to the dehydrochlorination of the halide **5** with **9**.



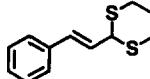
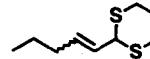
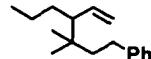
Scheme 3

Table 1. Desulfurizative Alkylation of 1,3-Bis(phenylthio)alk-1-enes **2**^a

Entry	1,3-Bis(phenylthio)alk-1-ene 2	Alkyl Halide 5	Product 6	Yield (%)	
1		2a 	5a 	6a 	78
2		2a 	5b 	6b 	72
3		2a 	5c 	6c 	73
4		2b 	5a 	6d 	73
5		2b 	5b 	6e 	70
6		2b 	5d 	6f 	83
7		2c 	5b 	6g 	74
8		2c 	5c 	6h 	76
9		2c 	5d 	6i 	78
10		2d 	5a 	6j 	82
11		2d 	5b 	6k 	81
12		2d 	5c 	6l 	85

a) All reactions were performed following the procedure described in the text.

Table 2. Desulfurizative Alkylation of β,γ -Unsaturated Thioacetals 3^a

Entry	β,γ -Unsaturated Thioacetal 3	Alkyl Halide 5	Product 6	Yield (%)
1		3a	5a	6a
	(E only)			
2	3a	5b	6b	57
3	3a	5c	6c	59
4		3b	5a	6m
	(E : Z = 89 : 11)			65

a) All reactions were performed at room temperature with the similar procedure as described in the text, unless otherwise noted. b) The reaction was performed at 0 °C.

It is well known that organotitanium species such as methyltitanium reagents or titanium enolates react with tertiary halides to afford the substitution products.⁵ The titanium tetrachloride-promoted reaction of allyl-silanes with tertiary halides was also reported.⁶ It should be noted that the present tertiary alkylation of the vinylcarbene complexes 1 provides an alternative way for the construction of quaternary carbon center. Further study on the reaction of vinylcarbene complexes with electrophiles and the subsequent reaction of the resulting vinyltitanium species is now in progress.

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