CHEMISTRY LETTERS, pp. 1909-1912, 1989.

[1,2-Benzenediolato(2-)-O-O']oxotitanium. A Chemoselective and Efficient Catalyst for Aldol-type Reaction of Ketene Silyl Acetals with Aldehydes

Ryuichiro HARA and Teruaki MUKAIYAMA
Department of Applied Chemistry, Faculty of Science,
Science University of Tokyo, Kagurazaka, Shinjuku-ku, Tokyo 162

In the presence of a catalytic amount of [1,2-benzenediolato(2-)-O,O']oxotitanium, ketene silyl acetals smoothly react with aldehydes to afford the corresponding β-hydroxy carboxylic esters in good yields under mild conditions. According to this procedure, an aldehyde group is selectively activated, while an acid labile acetal group remains intact.

In the previous paper, we reported an efficient catalytic action of titanate derivatives in the Michael reaction of ketene silyl acetals with α,β-unsaturated ketones.[1)] Among the titanate compounds studied, [1,2-benzenediolato(2-)-O,O']oxotitanium 1 was found to be most promising. In the present communication, we would like to describe its application to aldol-type reaction of ketene silyl acetals with aldehydes as well as the characteristic behavior of this catalyst.

First, several reaction conditions were screened by taking the reaction of benzaldehyde with t-butyldimethylsiloxy-1-ethoxyethene in the presence of 0.2 equiv. of 1 as a model.

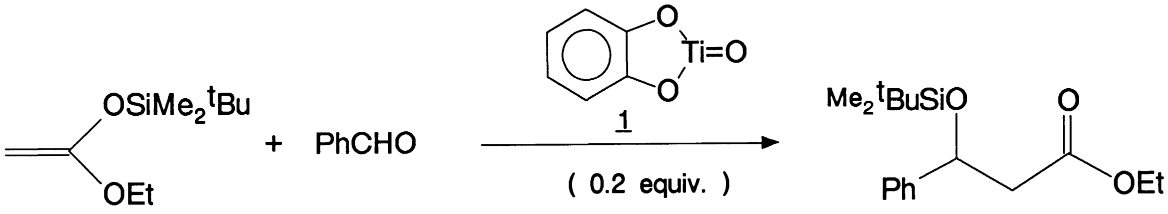


Table 1. Effect of solvent

Solvent	Temperature/^{o}C	Reaction time/h	Yield/%
CH_2Cl_2	-78	3	97
Et_2O	-78	3	71
Toluene	-78	3	45
AcOMe	-78	3	61
$CH_3CN$$^{a)}$	-23	1	87

a) No reaction occurred at this temperature without 1.$^{2)}$

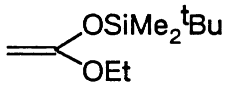
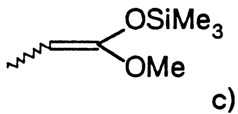
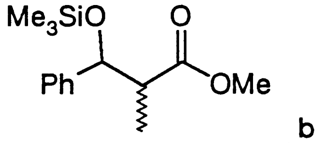
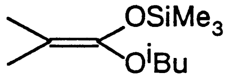
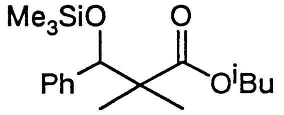
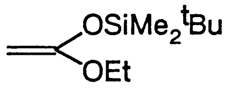
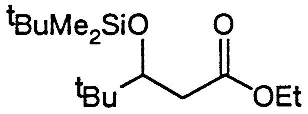
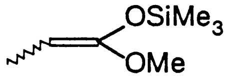
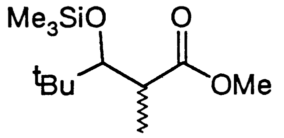
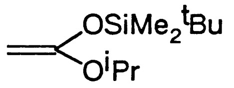
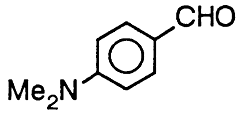
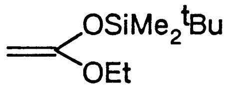
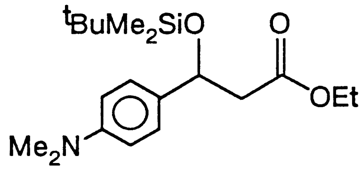
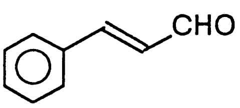
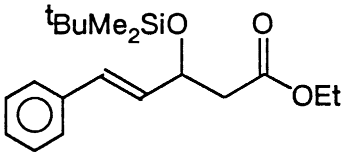
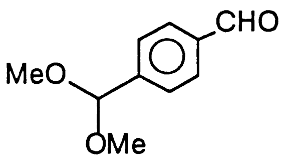
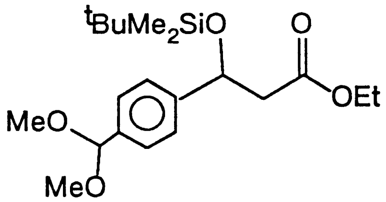
As listed in Table 1, the reaction took place in a wide variety of solvents at low temperature. Among them, dichloromethane was the most suitable solvent and, as shown in Table 2, non-, mono-, di-substituted ketene silyl acetals smoothly react with aldehydes to give the corresponding adducts at -78 ^{o}C.

Interestingly, acetals such as benzaldehyde dimethyl acetal and cinnamaldehyde dimethyl acetal were not activated under these conditions different from the generally known acid mediated reactions. Actually 4-(dimethoxymethyl)-benzaldehyde reacted only at the aldehyde side to give the corresponding adduct in 82% yield(Entry 9).

A typical procedure is described for the reaction of t-butyldimethylsiloxy-1-ethoxyethene with benzaldehyde; [1,2-benzenediolato(2-)-O,O']oxotitanium 1 (18 mg; 0.1 mmol) was dissolved in dichloromethane (2 cm^3) and cooled to -78 ^{o}C. t-Butyldimethylsiloxy-1-ethoxyethene (123 mg; 0.6 mmol) and benzaldehyde (51.2 mg; 0.48 mmol) in dichloromethane (3 cm^3) were added dropwise and a mixture was stirred for 3 h. The reaction was quenched with phosphate buffer(pH=7). After removal of insoluble materials by filtration, the aqueous layer was extracted with dichloromethane. The organic layer was dried and the solvent was removed under reduced pressure. The residue was purified by preparative thin layer chromatography on silica gel (10:1=hexane:ethyl acetate as developing solvent) to give the product 144 mg (96%).

Thus, [1,2-benzenediolato(2-)-O-O']oxotitanium efficiently catalyzes aldol-type reaction of ketene silyl acetals with various aldehydes at low temperature. Adducts are obtained in their O-silyl ether forms, different from the same reaction promoted by commonly used Lewis acids ($SnCl_4$,$^{3)}$ $TiCl_4$,$^{4)}$ BF_3 Et_2O,$^{5)}$ etc.). Also, it should be noted that the reaction proceeds regioselectively

Table 2. Aldol - type reaction of various aldehydes in the presence of 1

Entry	Aldehyde	Ketene silyl acetal	Product	Yield / %
1	PhCHO			97
2		 (E / Z = 89 / 11) c)	 b) (Syn / Anti = 50 / 50)	90
3				83
4	^{t}BuCHO			85
5			 b) (Syn / Anti = 70 / 30)	69
6	^{i}PrCHO			86
7				83
8				97
9				82

a) The reaction was carried out in the presence of 1 (0.2 equiv.) in CH_2Cl_2 at - 78 °C for 2-3 h. All products gave satisfactory NMR and IR data.

b) Determined by ^{1}H -NMR.

c) Determined by GC.

concerning aldehydes, while acetals remain intact under the present condition. This is a characteristic point of this catalyst in comparison with previously known catalysts such as trimethylsilyl triflate$^{6)}$ and trityl perchlorate.$^{7)}$

References

1) T. Mukaiyama and R. Hara, Chem. Lett., 1989, 1171.

2) Y. Kita, H. Yasuda, O. Tamura, F. Itoh, Y. Y. Ke, and Y. Tamura, Tetrahedron Lett., 26, 5777 (1985).

3) M. Asaoka, N. Yanagida, and H. Takei, Tetrahedron Lett., 48, 4611 (1980); M. T. Reetz, K. Kesseler, and A. Jung, Tetrahedron, 40, 4327 (1984); M. Fiorenza, G. Reginato, A. Ricci, and M. Taddei, J. Org. Chem., 49, 551 (1984); C. Gennari, A. Bernardi, G. Poli, and C. Scolastico, Tetrahedron Lett., 26, 2373 (1985).

4) T. H. Chan, T. Aida, P. W. K. Lau, V. Gorys, and D. N. Harpp, Tetrahedron Lett., 1979, 4029; P. Brownbridge and T. H. Chan, ibid., 21, 3427 (1980); I. Matsuda, Y. Izumi, ibid., 22, 1805 (1981); G. Helmchen, U. Leikauf, and I. T. Knopfel, Angew. Chem., Int. Ed. Engl., 24, 874 (1985); C. Gennari, A. Bernardi, L. Colombo, and C. Scolastico, J. Am. Chem. Soc., 107, 5812 (1985); G. Guanti, L. Banfi, and E. Narisano, Tetrahedron Lett., 26, 3517 (1985).

5) C. H. Heathcock, K. T. Hug, and L. A. Flippin, Tetrahedron Lett., 25, 5973 (1984); C. Gennari, A. Bernardi, S. Cardani, and C. Scolastico, ibid., 26, 797 (1985); C. H. Heathcock, and L. A. Flippin, J. Am. Chem. Soc., 105, 1667 (1983); M. T. Reetz, and K. Kesseler, J. Chem. Soc., Chem. Commun., 1984, 1079; M. T. Reetz, K. Kesseler, and A. Jung, Tetrahedron Lett., 25, 729 (1984).

6) S. Murata, M. Suzuki, and R. Noyori, J. Am. Chem. Soc., 102, 3248 (1980); R. Noyori, S. Murata, and M. Suzuki, Tetrahedron, 37, 3899 (1981); T. Oesterle, and G. Simchen, Liebigs, Ann. Chem., 1987, 693.

7) S. Kobayashi, M. Murakami, and T. Mukaiyama, Chem. Lett., 1985, 1535.

(Received August 30, 1989)