LETTERS

Facile Synthesis of 3,4-Dihydro-α-pyrones via Michael Reaction-O-Acylation Sequences

Shu Kobayashi,* Mitsuhiro Moriwaki

Department of Applied Chemistry, Faculty of Science, Science University of Tokyo (SUT), and CREST, Japan Science and Technology Corporation (JST), Kagurazaka, Shinjuku-ku, Tokyo 162, Japan

Fax 3-3260-4726

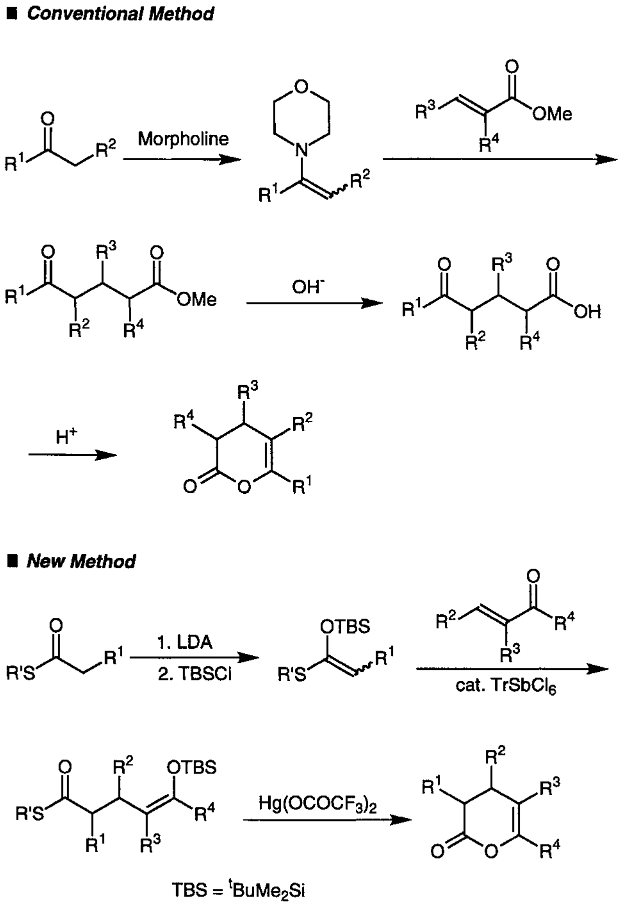
Received 27 January 1997

Abstract: 3,4-Dihydro-α-pyrones were prepared in excellent yields with high stereoselectivities by the trityl salt-catalyzed Michael reaction and sequential intramolecular O-acylation of the intermediary silyl enol ethers using a mercury (II) salt (one-pot reaction).

3,4-Dihydro-α-pyrones are useful intermediates for the synthesis of γ-lactones,[1] substituted benzenoids,[2] pyridones,[3] etc. In conventional methods, 3,4-dihydro-α-pyrones were prepared by heating the corresponding 5-keto carboxylic acids under acidic conditions (using thionyl chloride[4] or acetic anhydride[1]). The 5-keto carboxylic acids were prepared from the corresponding ketones, via enamine formation, alkylation with α,β-unsaturated esters,[5] and hydrolysis. In this paper, we describe a facile shorter synthesis of 3,4-dihydro-α-pyrones by the trityl salt-catalyzed Michael reaction and sequential lactonization (O-acylation) using a mercuric salt.

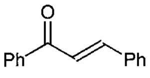
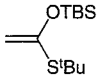
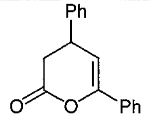
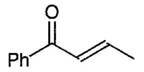
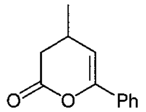
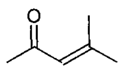
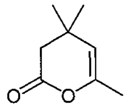
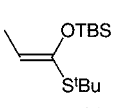
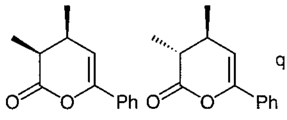
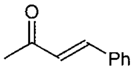
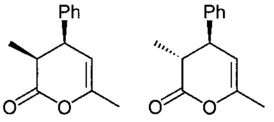
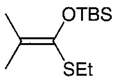
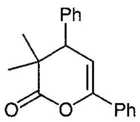
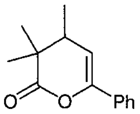
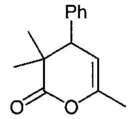
Our new route for the synthesis of 3,4-dihydro-α-pyrones is shown below. In the presence of a catalytic amount of trityl salt,[6] silyl enol ethers derived from thioesters reacted with α,β-unsaturated ketones to afford the corresponding Michael adducts as second silyl enol ethers. The enol ethers were treated with mercuric trifluoroacetate ($Hg(OCOCF_3)_2$)[7] in the same pot to produce 3,4-dihydro-α-pyrones via intramolecular O-acylation.

Several examples of the 3,4-dihydro-α-pyrone synthesis are shown in Table 1. In all cases, the desired unsaturated lactones were obtained in



Scheme 1

Table 1. The synthesis of 3,4-dihydro-α-pyrone derivatives[a]

α,β-Unsaturated Ketone	Silyl Enol Ether	Product	Yield (%)
 1	 4		quant
 2	4		quant
	4		quant
2	 (E/Z = 94/6) 5	 (90 : 10)	quant
 3	5	 (96 : 4)	quant
1	 6		quant
2	6		quant
3	6		96

a) All products gave satisfactory ^1H NMR, ^{13}C NMR, and/or HRMS.

excellent yields with high diastereoselectivities.[8] Silyl enol ethers derived from both S-ethyl and S-*t*-butyl thioesters were available in these reactions. When trimethylsilyl enol ethers instead of *t*-butyldimethylsilyl (TBS) enol ethers were used, lower yields were obtained. It should be noted that the Michael reaction and sequential lactonization can be carried out in the same pot.

A typical experimental procedure is described for the reaction of chalcone (**1**) with 1-*t*-butyldimethylsiloxy-1-*t*-butylthioethene (**4**); a mixture of **1** (0.4 mmol), **4** (0.44 mmol), and trityl hexachloroantimonate (0.02 mmol, 5 mol%) in dichloromethane (4 ml) was stirred for 15 h at -78 °C. Pyridine in methanol solution (1 M, 1 ml) was added at the same temperature and the reaction mixture was allowed to warm to room temperature. After the solvents were removed under reduced pressure, mercuric trifluoroacetate (0.8 mmol) and acetonitrile (4 ml) were added to the same pot at 0 °C and the mixture was stirred for 30 min. The reaction mixture was passed through a silica gel column directly to afford 3,4-dihydro-3,5-diphenyl-α-pyrone (quant).

3,4-dihydro-3,5-diphenyl-α-pyrone: IR (neat) 1768 cm^{-1}; ^1H NMR ($CDCl_3$) $\delta = 2.78$ (dd, 1H, $J = 8.6, 16.0$ Hz), 3.02 (dd, 1H, $J = 6.6, 16.0$ Hz), 3.91-3.99 (m, 1H), 5.95 (d, 1H, $J = 4.3$ Hz), 7.24-7.43 (m, 8H), 7.65-7.68 (m, 2H); ^{13}C NMR ($CDCl_3$) $\delta = 36.8$, 37.2, 104.2, 124.6, 127.0, 127.5, 128.5, 129.1, 129.2, 132.1, 141.5, 150.7, 167.6; HRMS Calcd for $C_{17}H_{14}O_2$: (M^+), 250.0994. Found: m/z 250.0988.

In summary, 3,4-dihydro-α-pyrones have been prepared in excellent yields with high stereoselectivities by the trityl salt-catalyzed Michael reaction and sequential lactonization (O-acylation) using a mercuric salt. The present method is superior over the conventional methods in its high yields and diastereoselectivities, short steps, and mild reaction conditions. In addition to the synthetic utilities, it is noteworthy that this is the first example of *intramolecular* O-acylation of silyl enol ethers,[9] to the best of our knowledge.

Acknowledgment. This work was partially supported by a Grant-in-Aid for Scientific Research from the Ministry of Education, Science, Sports, and Culture, Japan.

References and Notes

(1) Mandal, A. K.; Jawalkar, D. G. *J. Org. Chem.* **1989**, *54*, 2364.

(2) Robl, J. A. *Tetrahedron Letters,* **1990**, *31*, 3421.

(3) Katritzky, A. R.; Molina-Buendia, P. *J. Chem. Soc., Perkin I*, **1978**, 1957.

(4) Belmont, D. T.; Paquette, L. A. *J. Org. Chem.* **1985**, *50*, 4102. Shiiroyan, F. R.; Khazhakyan, L. V.; Mkrtchyan, A. R.; Terzyan, A. G.; Tatevsyan, G. T. *Arm. Khim. Zh.* **1967**, *20*, 649; Chem. Abstr. **1968,** 69, 10387v.

(5) Stork, G.; Brizzolara, A.; Landesman, H.; Szmuszkovicz, J.; Terrell, R. *J. Am. Chem. Soc.* **1963**, *85*, 207.

(6) (a) Kobayashi, S.; Mukaiyama, T. *Chem. Lett.* **1986**, 1805.
(b) Mukaiyama, T.; Tamura, M.; Kobayashi, S. *ibid.* **1986**, 1817.
(c) Mukaiyama, T.; Tamura, M.; Kobayashi, S. *ibid.* **1987**, 743.

(7) Cf. Msamune, S.; Yamamoto, H.; Kamata, S.; Fukuzawa, A. *J. Am. Chem. Soc.* **1975**, *97*, 3515.

(8) Higher yields compared to those of the Michael reactions reported[6] should be noted. These results show that the trityl salt-catalyzed Michael reactions proceed almost quantitatively, but that there may be some loss in the isolation steps of the corresponding Michael adducts (1,5-diketone or intermediary silyl enol ether derivatives).

(8) Cf. Kramarova, E. N.; Baukov, Y. I.; Lutsenko, I. F. *Zh. Obshch. Khim.* **42**, 1857 (1973).