Phenyliodine(III) Triflate Mediated Synthesis of 5-Benzoyldihydro-2(3*H*)-furanones

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A direct and efficient method for the preparation of 5-benzoyldihydro-2(3*H*)-furanones was realized by cyclization of 4-benzoylbutyric acids in the presence of phenyliodine(III) triflate.

Keywords: Phenyliodine(III) diacetate; Trifluoromethanesulfonic acid; α-Keto triflate.

INTRODUCTION

Lactonization methodology plays an important role in modern organic synthetic chemistry not only because lactones occur in nature in great abundance and variety,[1] but also because they constitute a particularly useful class of synthons.[2] The preparation of lactones was *via* intramolecular cyclization of acyclic olefinic carboxylic acids.[3] Recently, hypervalent iodine reagents have been extensively used in organic syntheses due to their low toxicity, ready availability, and easy handling.[4] As a continuation of our studies concerning hypervalent iodine(III) chemistry and its application to the synthesis of heterocycles, we report here a new and direct method for the conversion of 4-benzoylbutyric acids (**1**) to 5-benzoyldihydro-2(3*H*)-furanones (**3**) by the reaction with phenyliodine(III) triflate [generated *in situ* by reaction of phenyliodine(III) diacetate (PIDA) with trifluoromethanesulfonic acid] at room temperature (Scheme I).

RESULTS AND DISCUSSION

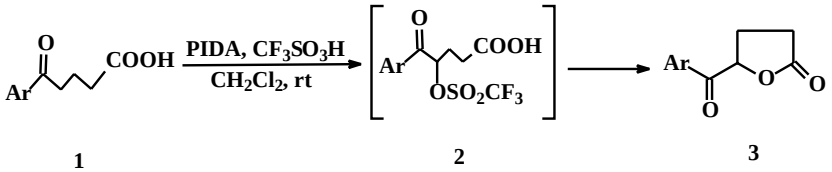
The triflate group positioned in the α position to a carbonyl group represents an increasingly important entity in both mechanistic[5] and synthetic[6] organic chemistry. One of the reasons for this is that the triflate group is a good leaving group, and this accounts for the considerable synthetic utility associated with these groups in functionalization of carbonyl compounds. Due to the triflate having better leaving ability than the corresponding halide, α-keto triflate reacts rapidly with carboxyl group without assistance of Lewis acid to give furanones.

As shown in Table 1, various 5-benzoyldihydro-2(3*H*)-furanones were prepared in good to high yields. Gratifyingly,

Table 1. Yields of 5-benzoyldihydro-2(3*H*)-furanones prepared

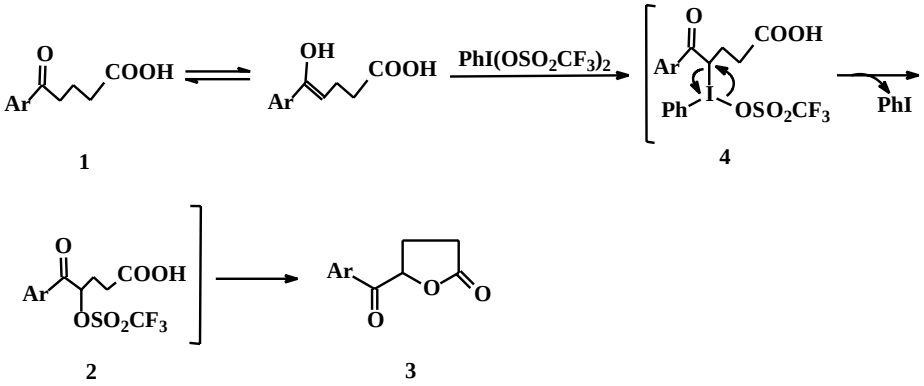
Furanone	Ar	Yield (%)
3a	Ph	81
3b	4-MeC_6H_4	78
3c	4-OMeC_6H_4	76
3d	4-ClC_6H_4	80
3e	4-BrC_6H_4	75
3f	4-i-prC_6H_4	82
3g	2,4-$Me_2C_6H_3$	72
3h	2,5-$Me_2C_6H_3$	77
3i	2,4,6-$Me_3C_6H_2$	85

Scheme I



1 **2** **3**

Scheme II



the reactions were completed at room temperature for 0.5 h and found to be clean in all cases. The structures of **3** spectral were identified by their IR, ^{1}H NMR, and MS spectral data.

A reasonable pathway of the above transformations may be explained as follows: The electrophilic addition of phenyliodine(III) triflate to the enolic form of the ketone (**1**) gave intermediate **4**. Step **4** to α-keto triflate (**2**) can occur through displacement of the iodobenzene by 1,2 shift of the $-OSO_2CF_3$ group. The preparation of 5-benzoyldihydro-2(3*H*)-furanones (**3**) was *via* intramolecular cyclization of α-keto triflates (**2**) (Scheme II).

The above results can be rationalized by the formation of phenyliodine(III) triflate *in situ* by the action of trifluoromethanesulfonic acid on PIDA (eq. 1).

$$PhI(OAc)_2 + 2CF_3SO_3H \rightarrow PhI(OSO_2CF_3)_2 + 2AcOH \quad (1)$$

In summary, the method described herein provides a good approach for the direct transformation of 5-benzoyldihydro-2(3*H*)-furanones by using the reaction of 4-benzoylbutyric acids with phenyliodine(III) triflate at room temperature.

EXPERIMENTAL SECTION

All melting points are uncorrected. The IR spectra were recorded on a Shimadzu IR-27 G spectrophotometer. ^{1}H NMR and ^{13}C NMR spectra were recorded on a Varian Unity Plus 400 MHz. Chemical shifts were measured in ppm (δ) with respect to TMS. MS were obtained on a JEOL JMS D-300 instrument.

General procedure for the preparation of 5-benzoyldihydro-2(3*H*)-furanones 3a-i

To a stirred solution of the phenyliodine diacetate (242 mg, 0.75 mmol) in CH_2Cl_2 (20 mL) was added CF_3SO_3H (225 mg, 1,50 mmol), and the mixture was stirred at room temperature for 10 min. To the reaction mixture, 4-benzoylbutyric acid (0.5 mmol) was added and stirring was continued at room temperature for 0.5 h. The reaction mixture was washed with saturated aqueous $NaHCO_3$ solution, dried over $MgSO_4$, and concentrated under reduced pressure. The residue was purified by chromatography on a silica gel column with $CHCl_3$-AcOEt (9:1) as eluent to give the products **3a-i**.

5-Benzoyldihydro-2(3*H*)-furanone (3a)

mp 77-78 °C ($CHCl_3$/hexane) (lit.,[7] 78-79 °C). IR (neat) ν: 1780, 1687, 1245, 1060 cm^{-1}. ^{1}H NMR ($CDCl_3$) δ: 2.44-2.62 (m, 4H), 5.79-5.82 (m, 1H), 7.50-7.55 (m, 2H), 7.63-7.67 (m, 1H), 7.98 (dd, *J* = 1.2, 8.8 Hz, 2H). ^{13}C NMR ($CDCl_3$) δ: 24.9, 26.6, 78.1, 128.5, 128.8, 133.3, 134.1, 176.3, 194.4. EI-MS: 105, 77.

5-(4-Methylbenzoyl)dihydro-2(3*H*)-furanone (3b)

mp 89-90 °C ($CHCl_3$/hexane) (lit.,[8] 90-91 °C). IR (neat) ν: 1768, 1689, 1229, 1066 cm^{-1}. ^{1}H NMR ($CDCl_3$) δ: 2.44 (s, 3H), 2.44-2.62 (m, 4H), 5.76-5.79 (m, 1H), 7.31 (d, *J* = 8.4 Hz, 2H), 7.88 (d, *J* = 8.4 Hz, 2H). ^{13}C NMR ($CDCl_3$) δ: 21.7, 25.0, 26.8, 78.1, 128.8, 128.9, 129.6, 129.7, 131.0, 145.4, 176.3, 193.9. EI-MS: 204 (M^+), 119, 91.

5-(4-Methoxybenzoyl)dihydro-2(3*H*)-furanone (3c)

mp 121-123 °C ($CHCl_3$/hexane) (lit.,[7] 122-124 °C). IR

(neat) ν: 1773, 1683, 1244, 1071 cm^{-1}. ^1H NMR ($CDCl_3$) δ: 2.48-2.65 (m, 4H), 3.89 (s, 3H), 5.73-5.76 (m, 1H), 6.98 (d, *J* = 8.8 Hz, 2H), 7.97 (d, *J* = 8.8 Hz, 2H). ^{13}C NMR ($CDCl_3$) δ: 25.0, 26.9, 55.6, 78.1, 114.2, 126.6, 131.2, 164.4, 176.4, 192.7. EI-MS: 220 (M^+), 135, 77.

5-(4-Chlorobenzoyl)dihydro-2(3*H*)-furanone (3d)

mp 92-93 °C ($CHCl_3$/hexane) (lit.,[8] 93-94 °C). IR (neat) ν: 1773, 1694, 1282, 1071 cm^{-1}. ^1H NMR ($CDCl_3$) δ: 2.54-2.59 (m, 4H), 5.69-5.74 (m, 1H), 7.49 (dd, *J* = 2.0, 6.4 Hz, 2H), 7.95 (dd, *J* = 2.0, 6.8 Hz, 2H). ^{13}C NMR ($CDCl_3$) δ: 24.6, 26.8, 78.2, 129.3, 130.2, 131.9, 140.9, 175.9, 193.2. EI-MS: 141, 139.

5-(4-Bromobenzoyl)dihydro-2(3*H*)-furanone (3e)

mp 71-73 °C ($CHCl_3$/hexane) (lit.,[8] 70-72 °C). IR (neat) ν: 1780, 1690, 1244, 1064 cm^{-1}. ^1H NMR ($CDCl_3$) δ: 2.45-2.63 (m, 4H), 5.79-5.82 (m, 1H), 7.63-7.68 (m, 2H), 7.97-8.00 (m, 2H). ^{13}C NMR ($CDCl_3$) δ: 24.9, 26.7, 78.2, 128.7, 128.9, 130.2, 132.3, 133.4, 134.2, 176.3, 194.3. EI-MS: 271, 269 (M^+), 185, 183, 155, 77.

5-(4-Isopropylbenzoyl)dihydro-2(3*H*)-furanone (3f)

mp 81-83 °C ($CHCl_3$/hexane). IR (KBr) ν: 1770, 1687, 1601, 1225, 1072 cm^{-1}. ^1H NMR ($CDCl_3$) δ: 1.28 (d, *J* = 6.8 Hz, 6H), 2.45-2.64 (m, 4H), 2.95-3.02 (m, 1H), 5.77-5.80 (m, 1H), 7.36 (d, *J* = 8.4 Hz, 2H), 7.91 (d, *J* = 8.4 Hz, 2H). ^{13}C NMR ($CDCl_3$) δ: 23.4, 24.9, 26.7, 34.2, 78.1, 126.9, 128.9, 131.2, 176.2, 193.8. EI-MS: 147, 91. Anal. Calcd for $C_{14}H_{16}O_3$: C, 72.39; H, 6.94. Found: C, 72.43; H, 6.85.

5-(2,4-Dimethylbenzoyl)dihydro-2(3*H*)-furanone (3g)

mp 145-146 °C ($CHCl_3$/hexane) (lit.,[8] 146 °C). IR (neat) ν: 1783, 1688, 1245, 1063 cm^{-1}. ^1H NMR ($CDCl_3$) δ: 2.33-2.62 (m, 4H), 2.38 (s, 3H), 2.52 (s, 3H), 5.69-5.72 (m, 1H), 7.11 (d, *J* = 8.0 Hz, 1H), 7.12 (s, 1H), 7.59 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR ($CDCl_3$) δ: 21.4, 21.5, 25.2, 26.8, 78.9, 128.5, 129.4, 130.5, 133.3, 140.4, 143.5, 176.5, 196.8. EI-MS: 218 (M^+), 133, 105.

5-(2,5-Dimethylbenzoyl)dihydro-2(3*H*)-furanone (3h)

Oily compound. IR (neat) ν: 1783, 1692, 1244, 1063 cm^{-1}. ^1H NMR ($CDCl_3$) δ: 2.38 (s, 3H), 2.47 (s, 3H), 2.49-2.64 (m, 4H), 5.68-5.72 (m, 1H), 7.18 (d, *J* = 8.0 Hz, 1H), 7.26-7.27 (m, 1H), 7.44 (s, 1H). ^{13}C NMR ($CDCl_3$) δ: 20.6, 20.7, 25.0, 26.7, 79.1, 129.3, 132.1, 133.2, 135.4, 136.5, 137.2, 176.4, 197.8. EI-MS: 218 (M^+), 133, 105. HRMS (EI) Calcd for $C_{13}H_{14}O_3$: 218.0943. Found: 218.0946.

5-(2,4,6-Trimethylbenzoyl)dihydro-2(3*H*)-furanone (3i)

Oily compound. IR (neat) ν: 1787, 1707, 1609, 1251, 1063 cm^{-1}. ^1H NMR ($CDCl_3$) δ: 2.17 (s, 6H), 2.24 (s, 3H), 2.16-2.61 (m, 4H), 5.23-5.26 (m, 1H), 6.78 (s, 2H). ^{13}C NMR ($CDCl_3$) δ: 19.5, 21.0, 24.5, 24.6, 26.9, 81.8, 128.8, 130.6, 134.0, 134.9, 137.3, 139.9, 176.0, 205.6. EI-MS: 232 (M^+), 149, 147, 121, 105. HRMS (EI) Calcd for $C_{14}H_{16}O_3$: 232.1099. Found: 232.1097.

ACKNOWLEDGEMENT

We gratefully acknowledge the National Science Council of the Republic of China for the financial support of this work (Grant No. 93-2113-M-037-010).

Received January 26, 2005.

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