SHORT PAPER

J. Chem. Research (S), 2001, 394–395

Samarium (III) triiodide catalysed reaction of salicylaldehydes with active methylene compounds†

Jue Chen[a] and Yongmin Zhang*[,a,b]

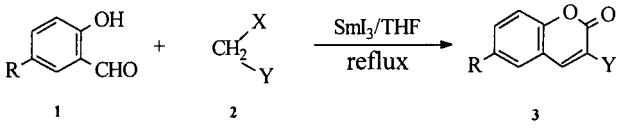
[a]*Department of Chemistry, Zhejiang University, Xixi Campus, Hangzhou, 310028, P. R. China*
[b]*Laboratory of Organometallic Chemistry, Chinese Academy of Sciences, Shanghai, 200032, P. R. China*

The unambiguous synthesis and isolation of 2-oxo-2*H*-1-benzopyran derivatives are described. The Knoevenagel condensation of 2-hydroxy benzaldehydes with active methylene compounds catalysed by samarium triiodide resulted in coumarium derivatives in fair yields under refluxing conditions.

Keywords: samarium (III) triiodide, salicylaldehydes, methylene

2-Oxo-2*H*-1-benzopyran derivatives have attracted strong interest due to their useful pharmacological properties, such as anticoagulant,[1] spasmolytic,[2] anthelmintic[3] and diuretic[4] activity. There have been many synthetic routes to 2-oxo-2*H*-1-benzopyrans, including the Perkin reaction,[5] Reformatsky reaction,[6] Michael addition[7] and Knoevenagel condensation.[8] Due to their great importance, the development of novel syntheses of benzopyrans still remains an active research area.

Organolanthanide chemistry is of great interest and recently reports on using samarium (III) in organic chemistry have rapidly increased.[9] For example, we have reported that α-haloketones could react with aldehydes to give α, β-unsaturated ketones promoted by SmI_3.[10] We also found that samarium triiodide could promote Michael addition of active methylene compounds to α, β-unsaturated esters to form δ-carbonyl esters with fair yields.[11] Mori reported that in the presence of SmI_2 or SmI_3, α-haloketones could react with α-ketocarboxylates or α-diketones to form α-hydroxy-γ-ketocarboxylates and 2-hydroxy-1, 4-diketones respectively.[12] Herein, we report a simple and convenient synthesis of 2-oxo-2H-1-benzopyrans from salicylaldehydes and active methylene compounds catalysed by samarium triiodide (Scheme 1).



1 2 3

$XCH_2Y = CH_2(CN)_2$, $CH_2(CO_2Et)_2$, $NCCH_2CO_2Et$, $CH_3COCH_2CO_2Et$
$NCCH_2SO_2Ph$, $EtCO_2CH_2SO_2Ph$

Scheme 1

The results are summarised in Table 1. When 1 mmol salicylaldehydes, 1.2 mmol active methylene compounds and 0.2 mmol SmI_3 were mixed and refluxed in dry THF under a nitrogen atmosphere for a given time (indicated in Table 1), 2-oxo-2*H*-1-benzopyrans were formed with satisfactory yields. We found that the reaction could not take place at room temperature but proceed smoothly under reflux conditions. When a stoichiometric amount of SmI_3 was used, the yields were not increased.

The present procedure has the advantage of progressing by a straightforward sequence of reactions to fair yields. It is also more convenient than the previous method[7] in that it eliminated the necessity of preparing the requisite aryllithium. Compared with condensation carried out by the Knoevenagel method using piperidine as a catalyst, this reaction was performed under neutral, mild conditions and avoided some side reaction that occurred in basic conditions. Thus, this method represents a novel complement to the traditional Knoevenagel synthesis. The mechanism should be similar to that which we proposed previously.[13]

Table 1 Synthesis of 2-oxo-2*H*-1-benzopyrans catalysed by SmI_3 in THF

Entry	R	X	Y	T(h)	Yield/%[a]
3a	H	CN	$CO_2C_2H_5$	40	68,70[b]
3b	H	CN	CN	30	66
3c	H	$CO_2C_2H_5$	$CO_2C_2H_5$	28	76[c],80[b]
3d	H	$CO_2C_2H_5$	CH_3CO	28	70
3e	H	$CO_2C_2H_5$	SO_2Ph	32	70
3f	H	CN	SO_2Ph	32	65
3g	Cl	CN	$CO_2C_2H_5$	40	68
3h	Cl	CN	CN	38	70
3i	Cl	$CO_2C_2H_5$	$CO_2C_2H_5$	28	68[c]
3j	Cl	$CO_2C_2H_5$	CH_3CO	32	72
3k	Cl	$CO_2C_2H_5$	SO_2Ph	32	65

[a]Isolated yields based on salicylaldehydes. [b]The yield was obtained when using stoichiometric amounts of SmI_3. [c] The unexpected products 3-hydroxycarbonyl-2-oxo-2*H*-1-benzopyrans were obtained.

Experimental

Tetrahydrofuran was distilled from sodium-benzophenone immediately prior to use. All reactions were conducted under a nitrogen atmosphere. Melting points were uncorrected. Infrared spectra were recorded on a Bruker Vector 22 spectrometer in KBr with absorptions in cm^{-1}. ^1H NMR spectra were determined on a Bruker AC-80 spectrometer as $CDCl_3$ solutions. Chemical shifts were expressed in ppm downfield from internal tetramethylsilane. Mass spectra were recorded on a HP5989B Mass spectrometer.

General procedure for synthesis of the 2-oxo-2H-1-benzopyrans **3:** A solution of salicylaldehydes **1** (1 mmol) and active methylene compounds **2** (1.2 mmol) in anhydrous THF (3 ml) was added to a solution of SmI_3 (0.2 mmol) in THF (20 ml) and the reaction mixture was stirred at 65°C under a dry nitrogen atmosphere. At completion, the reaction mixture was quenched with 1mol/l HCl (5 ml) and extracted with diethyl ether (3 × 15 ml). The combined extracts were washed with a saturated solution of $Na_2S_2O_3$ (15 ml) and a saturated solution of NaCl (15 ml) and then dried with anhydrous Na_2SO_4. After evaporating the solvent under reduced pressure, the crude product was purified by preparative TLC on silica gel using ethylacetate-cyclohexane (1:6) as eluent.

3-ethoxycarbonyl-2-oxo-2H-1-benzopyran **3a**: m.p. 92–93°C (lit.,[14] 91–92 °C); ν_{max} (KBr) /(cm^{-1}) 1765 (C=O), 1610 (C=C);

* To receive any correspondence.
† This is a Short Paper, there is therefore no corresponding material in *J Chem. Research (M).*

δ_H ($CDCl_3$) 1.43 (3 H, t, *J* = 7.0Hz, CH_3), 4.37–4.46 (2H, m, CH_2), 7.27–7.57 (4H, m, ArH), 8.52 (1H, s, CH).

3-cyano-2-oxo-2H-1-benzopyran **3b**: m.p. 181-183°C (lit.,[14] 182–184°C); ν_{max} (KBr) /(cm^{-1}) 2235 (CN), 1730 (C=O), 1605 (C=C); δ_H ($CDCl_3$) 7.29–7.68 (4H, m, ArH), 8.56 (1H, s, CH).

3-hydroxycarbonyl-2-oxo-2H-1-benzopyran **3c**: m.p. 187°C (lit.,[15] 187°C); ν_{max} (KBr) /(cm^{-1}) 1735 (C=O), 1610 (C=C); δ_H ($CDCl_3$) 7.55–7.82 (4H, m, ArH), 8.85 (1H, s, CH), 13.80 (1H, s COOH exchange deuterium oxide).

3-acetyl-2-oxo-2H-1-benzopyran **3d**: m.p. 123°C (lit.,[15] 124°C); ν_{max} (KBr) /(cm^{-1}) 1730 (C=O), 1604 (C=C); δ_H ($CDCl_3$) 1.83 (3H, s, CH_3) 7.33–7.65 (4H, m, ArH), 8.86 (1H, s, CH).

3-phenylsulfonyl-2-oxo-2H-1-benzopyran **3e**: m.p. 214–216°C (lit.,[16] 214–215°C); ν_{max} (KBr) /(cm^{-1}) 1725 (C=O), 1320, 1140 (SO_2), 1600 (C=C); δ_H ($CDCl_3$) 7.26–8.17 (9H, m, ArH), 8.80 (1H, s, CH).

3-phenylsulfonyl-2-oxo-2H-1-benzopyran **3f**: m.p. 214–216°C (lit.,[16] 214–215°C); ν_{max} (KBr) /(cm^{-1}) 1725(C=O), 1320, 1140 (SO_2), 1600 (CH=); δ_H ($CDCl_3$) 7.26–8.17 (9H, m, ArH), 8.80 (1H, s, CH).

6-chloro-3-ethoxycarbonyl-2-oxo-2H-1-benzopyran **3g**: m.p. 146°C. (lit.,[17] 145–147°C); ν_{max} (KBr) /(cm^{-1}): 1765 (C=O), 1610 (C=C); δ_H ($CDCl_3$) 1.42 (3H, t, *J* = 7.2Hz, CH_3), 4.37–4.46 (2H, m, CH_2), 7.27–7.57 (3H, m, ArH), 8.52 (1H, s, CH).

6-chloro-3-cyano-2-oxo-2H-1-benzopyran **3h**: m.p. 192°C; ν_{max} (KBr) /(cm^{-1}) 2240 (CN), 1735 (C=O), 1615 (C=C); δ_H ($CDCl_3$) 7.29–7.71 (3H, m, ArH), 8.45 (1H, s, CH); *m/z* 207 (^{37}Cl-M^+, 31.9), 205 (^{35}Cl-M^+, 100), 209 (34.8), 179 (28.2), 177 (85.4), 114 (78.2), 87 (17.3), 63 (17.1).

6-chloro-3-hydroxycarbonyl-2-oxo-2H-1-benzopyran **3i**: m.p. 198-200°C(lit.,[17] 198–199°C); ν_{max} (KBr) /(cm^{-1}) 1760 (C=O), 1600 (C=C); δ_H ($CDCl_3$) 7.55–7.82 (4H, m, ArH), 8.85 (1H, s, CH), 13.70 (1H, s, COOH exchange deuterium oxide).

6-chloro-3-acetyl-2-oxo-2H-1-benzopyran **3j**: m.p. 148–150°C; ν_{max} (KBr) /(cm^{-1}) 1745 (C=O), 1604 (C=C); δ_H ($CDCl_3$) 1.82 (3H, s, CH_3), 7.26–7.65 (3H, m, ArH), 8.41 (1H, s, CH); *m/z* 224 (^{37}Cl-M^+, 17.1), 222 (^{35}Cl-M^+, 49.4), 209 (34.8), 207 (100), 179 (12.6), 123 (19.5), 57 (41.6).

6-chloro-3-phenylsulfonyl-2-oxo-2H-1-benzopyran **3k**: m.p. 242°C (lit.,[16] 242°C); ν_{max} (KBr) /(cm^{-1}) 1725 (C=O), 1320, 1130 (SO_2), 1605 (C=C); δ_H ($CDCl_3$) 7.26–8.17 (8H, m, ArH), 8.78 (1H, s, CH).

We thank the National Natural Science Foundation of China (Project No.29872010 and 294938004) for financial support.

Received 6 January 2000; accepted 2 May 2001
Paper 01/694

References

1 W.O. Foye, *Prinicipi di Chimica Farmaceutica*, Piccin, Padova, Italy, 1991, 416.
2 L.L. Andreani and E. Lapi, *Boll. Chim. Farm.*, 1960, **99**, 583.
3 Y.L. Zhang, B. Chen, K. Zheng, M. Xu, L. Zhang and X. Lei, *YaoXue XueBao*, 1982, **17**, 17 (*Chem Abstr.*, 1982, **96**, 135383e).
4 L. Bonsignore, G. Loy, D. Secci and A. Calignano, *Eur. J. Med. Chem*., 1993, **28**, 517.
5 (a) E. Spath, *Ber.*, 1937, **70**, 83; (b) H. Yanagisawa and H. Kondo, *Yakugaku Zasshi*, 1921, **472**, 498.
6 R.L. Shriner, *Org. React.*, 1942, **1**, 1.
7 A.K. George and O. P. John, *J. Org. Chem*., 1979, **44**, 2480.
8 (a) E. Knoevenagel, *Ber*., 1904, **37**, 4461; (b) G. Jones, *Org. React.*, 1967, **15**, 204.
9 G.A. Molander, In *Comprehensive Organic Synthesis*, B.M. Trost, I. Fleming, Eds. Pergamons, Oxford, 1991, **1**, 251-282.
10 Y. Yu, R. Lin and Y. Zhang, *Teteahedron Lett.*,1993, **34,** 4547.
11 X.Y. Chen, W.L. Bao and Y.M. Zhang, *Chin. Chem. Lett.*, 2000, **11**, 483.
12 T. Arime, N. Kato, F. Komadate, H. Sacgusa and N. Mori, *Synth. Commun.*, 1994, **24**, 3315.
13 W.L. Bao and Y.M. Zhang, *Chin. J. Org. Chem.(in Chinese)*, 1998, **18**, 272.
14 A.C. Jose, M.C. Juan, G. Angel, D. Luna and M.M. Jose, *J. Org. Chem.*, 1984, **49**, 5195.
15 J. Buckingham, *Dictionary of Organic compounds*, Chapman and Hall, New York, 5th edn, 1982, 4435.
16 J.R. Merchant and P.J. Shah, *J. Heterocyclic Chem.*, 1981, **18**, 441.
17 L. Bonsignore, F. Cottiglia, A.M. Maccioni and D. Secci, *J. Heterocyclic Chem.*,1995, **32**, 573.