Synthesis of 1,8-dioxo-octahydroxanthenes under solvent-free conditions via Phosphorus pentoxide supported on alumina (P_2O_5/Al_2O_3) catalyzed tandem reaction of Aldehyde with dimedone

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Abstarct- Phosphorus pentoxide used on alumina (P_2O_5/Al_2O_3) as an inexpensive, eco-friendly and non-toxic acid catalyst for the one-pot synthesis of 1,8-dioxo-octahydroxanthenes via multi-component reactions under solvent-free conditions. The present approach offers several advantages such as short reaction times, high yields, easy purification, recovery and reusability of the catalyst.

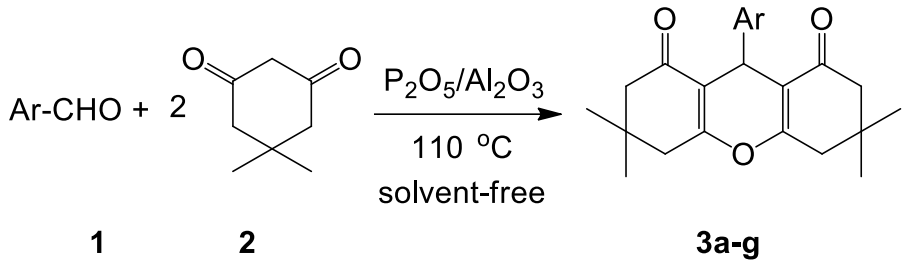
Keywords: 1,8-Dioxo-octahydroxanthenes, Solvent-free, Multicomponent reactions, Phosphorus pentoxide used on alumina

Introduction

The synthesis of xanthenes is important in organic synthesis because of their wide range of biological and pharmaceutical properties, such as agricultural bactericide activity, anti-inflammatory [1]. They have also been used for photodynamic therapy, used as dyes [2]. Fortunately, there have been extensive praiseworthy achievements in this field, especially those successful reactions achieved under solvent free conditions, which demonstrate various obvious and significant advantages [3].

For this purpose, react two molecules of dimedone with various aromatic aldehydes, by using of different Lewis acid catalysts such as Fe_3O_4NPS [4], PFPAT [5], Dowex-50W ion exchange resin under solvent-free conditions [6], phosphomolybdic acid supported on silica gel DABCO [7], $HClO_4$–SiO_2 [8], P_2O_5/SiO_2 or Silphos [9], , ZnO and ZnO acetyl chloride [10].

We wish to report a novel and efficient method for the Knoevenagel condensation of dimedone and various aromatic aldehydes on Phosphorus pentoxide used on alumina in the absence of organic solvents in good yield (Scheme 1).



Scheme 1

Result and Discussion

In the initial experiments, the effect of reaction temperature was examined using the reaction of aromatic aldehydes and dimedone in the presence of 10 mol% of Phosphorus pentoxide used on alumina under solvent-free conditions. As can be seen from table 1, the optimum temperature was at 110 °C. The effect of the amount of catalyst was also examined.

Table 1. Effect of different reaction conditions for the condensation of aromatic aldehydes and dimedone under solvent free

Entry	Temperature (°C)	Amount of catalyst (%mol)	Time (min)	Yield (%)
1	60	10	15	68
2	70	10	10	73
3	80	10	5	92
4	110	10	2	95
5	110	5	2	90
6	110	15	2	80
7	110	20	4	85

As can be seen from table 2, dimedone with various aromatic aldehydes at 110 °C using 10 mol% of Phosphorus pentoxide used on alumina as catalyst, carrying either electorn-donating or electron-withdrawing substituents, gave the corresponding xanthene under solvent-free condition in excellent yields after 2 min.

Table 2. Synthesis of substituted xanthene

Entry	Ar	Product	Yield/%	m.p/˚C	Ref.m.p/ ˚C
1	C_6H_5	**3a**	90	200-202	203-205[8]
2	3-$NO_2C_6H_4$	**3b**	91	162-164	
3	4-$NO_2C_6H_4$	**3c**	95	228-230	166-168[3]
4	4-ClC_6H_4	**3d**	95	228-231	
5	4-$CH_3C_6H_4$	**3e**	89	216-218	228-230[8]
6	4-$OCH_3C_6H_4$	**3f**	80	246-248	
7	4-BrC_6H_4	**3g**	92	228-231	231-233[8]
					219-221[8]
					248-250[8]
					231-233[8]

Experimental

All chemicals were purchased from Merck and used without further purification. IR spectra were recorded on a Shimadzu IR-460 spectrometer. ^{1}H spectra were recorded on a Bruker DRX-300 AVANCE instrument with DMSO as solvent**.**

General procedure for the synthesis of xanthene

A mixture of dimedone (2 mmol) and aromatic aldehyde (1 mmol) was added Phosphorus pentoxide used on alumina (10 mol%) under solvent-free conditions at 110 ˚C. After completion of the reaction (the progress of the reaction was monitored by TLC using n-hexan: ethylacetate), the mixture was cooled and the solid residue was separated and dissolved in dichloromethane. The product was filtered and then solvent was evaporated. A solid was obtained which was recrystallized in ethanol to give pure product.

3,3,6,6-Tetramethyl-9-phenyl-1,8-dioxooctahydroxanthene (**3a**)

IR (KBr) (ν_{max}/cm^{-1}): 2959, 1662, 1624, 1360, 1197, 1166, 1139, 1001; ^{1}H NMR (300 MHz, DMSO-d_6): δ = 0.86 (s, 6 H, 2 CH_3), 1.00 (s, 6 H, 2 CH_3), 2.11-2.25 (d, 4 H, 2 CH_2), 2.42 (s, 4 H, 2 CH_2), 4.53 (s, 1 H, CH), 7.29 -7.42 (m, 5 H, Ph).

3,3,6,6-Tetramethyl-9-(4-chlorophenyl)-1,8-dioxooctahydroxanthene (**3d**)
IR (KBr) (ν_{max}/cm^{-1}): 2952, 1661, 1618, 1361, 1198, 1166, 1140, 1003; ^{1}H NMR(300 MHz, DMSO-d_6): δ = 0.86 (s, 6 H, 2 CH_3), 1.00 (s, 6 H, 2 CH_3), 2.12-2.22 (d, 4 H, 2 CH_2), 2.39 (s, 4 H, 2 CH_2), 4.48 (s, 1 H, CH), 7.18-7.54 (dd, 4 H, Ph).

Conclusions

Phosphorus pentoxide used on alumina is a highly efficient solid acid catalyst for the synthesis of 1,8-dioxo-octahydroxanthenes via a one-pot condensation reaction of aromatic aldehydes and dimedone. Excellent yields, enhanced reaction rates and short reaction times, simplicity of operation and easy work-up are some advantages of this protocol. Hence, we believe that this method will find wide application in organic synthesis.

Reference

[1] Eshghi, H.; Hassankhani, A. Synthesis of nanostructured AlN by solid state reaction of Al and diaminomaleonitrile, *J Iran Chemsoc*, 2012, **9**, 467-482.

[2] Olyawi, A.; Derikvand, Z.; Razeghi, R.; Sadeghpoor, M.; Vaziri, M. Zr-MCM-41 Nanoreactors: A Highly Efficient and Reusable Catalyst for the Synthesis of 14-Aryl-14H-dibenzo[*a*,*j*]xanthenes under Solvent-Free Conditions, *Open Journal of Organic Chemistry*, 2013, **2**, 22-26.

[3] Wang, G.W.; Shen, Y. B.; Solvent-free synthesis of xanthenediones and acridinediones, Arkovoc, 2008, 1-8.

[4] Ghasemzadeh, M. A.; Safaei-Ghomi, J.; Zahedi, S. Fe_3O_4 nanoparticles: a highly efficient and conditions, *J. Serb. Chem. Soc*, 2013, **6**, 769-779.

[5] Khaksar, S.; Behzadi, N. Mild and highly efficient method for synthesis of 14-aryl(alkyl)-14H-dibenzo[a.j]xanthenes and 1,8-dioxooctahydroxanthene drivative using pentafluorophenyl ammonium triflate as a novel organo catalyst, *Chin. J. Cat*., 2012, **33**, 982-985.

[6] Imani Shakibaei, G.; Mirzaei, P.; Bazgir, A. Dowex-50w promoted synthesis of 14-aryl-14H-dibenzo[a.j]xanthene and 1,8-dioxo-octahydroxanthene derivatives under solvent-free conditions, *Applied Catalysis A*, 2007,188-192.

[7] Jiao, C.; Jian, S.; Chao-guo, Y. Synthesis of spiro dihydrofurans and 1,8-dioxo-xanthenes via DABCO catalyzed tandem reaction of aldehyde with cyclohexane-1,3-dione and dimedone, *Chem. Res. Chin. Uni.*, 2011,**1**,49-53.

[8]. Shaterian, H. R.; Hoseinian, A.; Ghashang, M. Ferric hydrogen sulfate as an efficient heterogeneous catalyst for environmentally friendly greener synthesis of 1,8-dioxo-octahydroxanthenes, *Turk. J. Chem*., 2009, **33**, 233-240.

[9] Hasaninejad, A.; Dadar, M.; Zare, A. silica-supported phosphorus-containing catalysts efficiently promoted synthesis of 1,8-dioxo-octahydroxanthene under solvent-free conditions, *Chem. Sci. Trans,* 2012, **2**, 233-238.

[10] Safaei-Ghomi, J.; Ghasemzadeh, M. A.; Zahedi, S. ZnO Nanoparticles: A highly effective and readily recyclable catalyst for the one-pot synthesis of 1,8-dioxo decahydroacridine and 1,8-dioxooctahydro-xanthene derivatives, *J. Mex. Chem. Soc.*, 2013, **1**, 1-7.