

# Facile heteropolyacid-promoted synthesis of 14-substituted-14-H-dibenzo[*a,j*] xanthene derivatives under solvent-free conditions

Majid M. Heravi<sup>a,\*</sup>, Khadijeh Bakhtiari<sup>a</sup>, Zohreh Daroogheha<sup>a</sup>,  
Fatemeh F. Bamoharram<sup>b</sup>

<sup>a</sup> Department of Chemistry, School of Sciences, Azahra University, Vanak, Tehran, Iran

<sup>b</sup> Department of Chemistry, Azad University of Mashad, Mashad, Iran

Received 22 February 2007; accepted 15 March 2007

Available online 20 March 2007

## Abstract

An efficient and facile synthesis of biologically active 14-substituted-14-H-dibenzo[*a,j*] xanthene derivatives were reported via three-component condensation reaction of  $\beta$ -naphthol and aldehydes in the presence of a catalytic amount of Preyssler type heteropoly acid, under solvent-free conditions. This method is very easy, rapid and high yielding reaction for the synthesis of dibenzo xanthene derivatives.  
© 2007 Elsevier B.V. All rights reserved.

**Keywords:** Xanthene derivatives; Solvent-free condition; Preyssler type heteropolyacid;  $H_{14}[NaP_5W_{30}O_{110}]$

## 1. Introduction

In recent years, much attention has been directed towards the synthesis of 14-substituted-14-H-dibenzo[*a,j*] xanthene derivatives due to the fact that these compounds possess a variety of biological and therapeutic properties, such as antibacterial [1] anti-inflammatory [2] antiviral activities [3] as well as in photodynamic therapy [4] and as antagonism for paralyzing action of zoazolamine [5]. Furthermore, these heterocycles show useful spectroscopic properties and are used as dyes [6] in laser technologies [7] and in fluorescent materials for visualization of biomolecules [8]. A number of xanthene dyes are extracted naturally from soil and plants, such as Indigofera Longercacemosa [9].

In view of the importance of xanthene derivatives, many methods for the synthesis of these compounds were reported including palladium catalyzed cyclization of polycyclic aryltriflate esters [10] intermolecular trapping of benzyne by phenols [11] and condensation of  $\beta$ -naphthol and aldehydes or acetals catalyzed by concentrated HCl/CH<sub>3</sub>COOH or H<sub>3</sub>PO<sub>4</sub> [12,13].

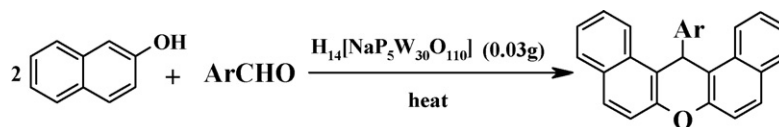
Some of these methods, however, involve long reaction times, and unsatisfactory yields. Therefore, improvements in such syntheses have been sought continuously.

More recently, the preparation of 14-substituted-14-H-dibenzo[*a,j*] xanthene derivatives in the presence of sulfamic acid under conventional heating and microwave irradiation has been reported [14]. Further, use of *p*-toluenesulfonic acid as catalyst for this transformation in solvent and under solvent-free conditions [15] as well as under microwave irradiation have been reported [16]. Molecular iodine has also been used as catalyst for the synthesis of 14-substituted-14-H-dibenzo[*a,j*] xanthene derivatives under solvent-free conditions [17].

Very recently, the synthesis of these heterocycles under conventional heating and microwave under solvent-free conditions catalyzed by amberlyst-15 [18] potassium dodecatungstocobaltate trihydrate [19a] and selectfluor [19b] has also been reported.

The application of heteropolyacids, HPAs, as catalytic materials is growing continuously in the catalytic field. These compounds possess unique properties, such as: well-defined structure, Brønsted acidity, possibility to modify their acid–base and redox properties by changing their chemical composition (substituted HPAs), ability to accept and release electrons, high proton mobility, etc [20]. In view of green chemistry, the substitution of harmful liquid acids by solid reusable HPAs as catalyst

\* Corresponding author. Tel.: +98 21 88044051; fax: +98 21 88047861.  
E-mail address: [mmh1331@yahoo.com](mailto:mmh1331@yahoo.com) (M.M. Heravi).



Scheme 1.

in organic synthesis is the most promising application of these acids.

As part of our continued interest in the development of highly expedient methods for the synthesis of heterocyclic compounds of biological importance [21] and continuation with the application of heteropolyacids as versatile catalysts for a variety of organic transformations [22] we would like to report an effective method to produce dibenzo[*a,j*] xanthene derivatives in very good yields catalyzed by Preyssler type heteropolyacid,  $H_{14}[NaP_5W_{30}O_{110}]$ , under solvent-free conditions (Scheme 1).

## 2. Experimental

Melting points were measured by using the capillary tube method with an electro thermal 9200 apparatus.  $^1H$ NMR spectra were recorded on a Bruker AQS AVANCE-300 MHz spectrometer using TMS as an internal standard ( $CDCl_3$  solution). IR spectra were recorded from KBr disk on the FT-IR Bruker Tensor 27. All products were well characterized by comparison with authentic samples by TLC, spectral and physical data. [15,19b].

### 2.1. General procedure

A mixture of an aldehyde (1 mmol),  $\beta$ -naphthol (2 mmol) and heteropolyacid  $H_{14}[NaP_5W_{30}O_{110}]$  (0.42 mol%, 0.03 g) was heated at  $90^\circ C$ . The progress of the reaction was monitored by TLC. After completion of the reaction, hot ethanol was added to the mixture and the catalyst was filtered off. The pure product was obtained by recrystallization from the solvent.

### 2.2. Reusability of the catalyst

At the end of the reaction, the catalyst was filtered, washed with diethyl ether, dried at  $130^\circ C$  for 1 h, and reused in another reaction. We have found that the catalyst can be reused several times without any appreciable loss of activity.

## 3. Results and discussion

In a typical general experimental procedure, a mixture of  $\beta$ -naphthol and aldehyde was heated in the presence of a catalytic amount of  $H_{14}[NaP_5W_{30}O_{110}]$ , the corresponding products were obtained in good to excellent yields. The results are summarized in Table 1.

As shown in Table 1, electronic effects and the nature of the substituents on the aromatic ring showed relatively strong obvious effects in terms of yields under reaction conditions. Benzaldehyde and other aromatic aldehydes containing electron-withdrawing and electron-donating groups as well as aliphatic aldehydes were employed and reacted to give the cor-

responding dibenzoxanthenes in very good yields. In the cases of 4-methoxy and 4-hydroxybenzaldehyde, the reactions were not completed even after prolonged times and the product yields were moderate.

The catalyst plays a crucial role in the success of the reaction in terms of time and the yields. In the absence of the catalyst, the reaction of 4-chlorobenzaldehyde with  $\beta$ -naphthol as an example, could be carried out but the product was obtained in very low yield after prolonged time.

We also studied the effect of the amount of the catalyst on this reaction. Upon heating the mixture of 4-chlorobenzaldehyde with  $\beta$ -naphthol as a model for 3 h in the presence of 0.14 mol% of  $H_{14}[NaP_5W_{30}O_{110}]$ , the product was obtained in 52%. Increasing the quantity of the catalyst to 0.42 mol% the product could be obtained in 99% yield. Use of 0.42 mol%  $H_{14}[NaP_5W_{30}O_{110}]$  is sufficient to push the reaction forward. Larger amounts of the catalyst did not improve the results to a greater extent.

All reactions were carried out under solvent-free condition at  $90^\circ C$  and the desired products were characterized by melting points,  $^1H$ NMR, and IR spectroscopic analyses.

We found that  $H_{14}[NaP_5W_{30}O_{110}]$  showed high catalytic activity and could be recovered and recycled several times without significant loss of activity.

Table 1  
Solvent-free synthesis of 14-substituted-14-H-dibenzo[*a,j*] xanthene derivatives catalyzed by  $H_{14}[NaP_5W_{30}O_{110}]$

Entry	Aldehyde	Time (min)	Yield (%) <sup>a</sup>	m.p. ( $^\circ C$ )	
				Found	Reported
1		30	98	189	183 [15]
2		45	99	297	289 [15]
3		60	99	324	310 [15]
4		60	98	212–220	213 [15]
5		60	98	221–228	228 [15]
6		120	50	206–208	204 [15]
7		120	50	140	140 [19b]
8		80	96	263–265	260 [15]
9		105	98	188–192	–
10		90	97	154–158	152 [15]

<sup>a</sup> Yields refer to isolated products.

#### 4. Conclusion

In conclusion, we have described a very simple and convenient procedure for the synthesis of 14-substituted-14-H-dibenzo[*a,j*] xanthene derivatives catalyzed by non-corrosive green and environmentally benign Preyssler type heteropolyacid under solvent-free conditions. In addition, it is possible to apply the tenets of green chemistry to the generation of biologically interesting products under solvent-free media that is less expensive and less toxic than those with organic solvents. Also, the catalyst is recyclable and could be reused without significant loss of activity. Even after three runs for the reaction, the catalytic activity of H<sub>14</sub>[NaP<sub>5</sub>W<sub>30</sub>O<sub>110</sub>] was almost the same as that of the freshly used catalyst.

#### Acknowledgment

The authors are thankful to Azzahra University Council for the partial financial support.

#### References

- [1] T. Hideo, Chem. Abstr. 95 (1981) 80922b; T. Hideo, Jpn. Tokkyo Koho JP 56005480 (1981).
- [2] J.P. Poupelin, G. Saint-Rut, O. Foussard-Blanpin, G. Narcisse, G. Uchida-Ernouf, R. Lacroix, Eur. J. Med. Chem. 13 (1978) 67.
- [3] R.W. Lambert, J.A. Martin, J.H. Merrett, K.E.B. Parkes, G. Thomas, J. Chem. Abstr. 126 (1997) 212377y; R.W. Lambert, J.A. Martin, J.H. Merrett, K.E.B. Parkes, G. Thomas, PCT Int. Appl. WO 9706178 (1997).
- [4] R.M. Ion, D. Frackowiak, A. Planner, K. Wiktorowicz, Acta Biochim. Pol. 45 (1998) 833.
- [5] (a) G. Saint-Ruf, A. De, H.T. Hieu, Bull. Chim. Ther. 7 (1972) 83; (b) G. Saint-Ruf, H.T. Hieu, J.P. Poupelin, Naturwissenschaften 62 (1975) 584.
- [6] M.F. Gordeev, D.V. Patel, E.M. Gordon, J. Org. Chem. 61 (1996) 924.
- [7] J.G. Breitenbucher, G. Figliozzi, Tetrahedron Lett. 41 (2000) 4311.
- [8] G. Sabitha, G.S. Reddy, C.S. Reddy, J.S. Yadav, Tetrahedron Lett. 44 (2003) 4129.
- [9] P.J.A. Licudine, M.K. Kawate, Q.X.J. Li, Agric. Food Chem. 45 (1997) 766.
- [10] J.Q. Wang, R.G. Harvey, Tetrahedron 58 (2002) 5927.
- [11] (a) D.W. Knight, P.B. Little, J. Chem. Soc. Perkin Trans. 1. (14) (2001) 1771; (b) D.W. Knight, P.B. Little, Synlett (1998) 1141.
- [12] N.P. Buu-Hoi, N.D. Xuong, J. Org. Chem. 16 (1951) 1633.
- [13] A.K. Zad, Z. Kazemi, H.A. Rudbari, J. Korean Chem. Soc. 46 (2002) 541.
- [14] Y.T. Reddy, P.N. Reddy, N. Sreenivasulu, Tetrahedron Lett. 46 (2005) 8691.
- [15] M.M. Khodaei, A.R. Khosropour, H. Moghanian, Synlett (2006) 916.
- [16] K.Z. Ahmad, S.A. Akbari, S. Azam, V. Hojat, J. Chem. Res. (S) (2005) 277.
- [17] (a) B. Das, B. Ravikantha, R. Ramu, K. Laxminarayana, B.V. Rao, J. Mol. Catal. A 255 (2006) 74; (b) M.A. Pasha, V.P. Jayashankara, Bioorg. Med. Chem. Lett. 17 (2007) 621.
- [18] S. Ko, Ch.-F. Yao, Tetrahedron Lett. 47 (2006) 8827.
- [19] (a) L. Nagarapu, S. Kantevari, V.C. Mahankhali, S. Apuri, Catal. Commun. (in press); (b) P.S. Kumar, B.S. Kumar, B. Rajitha, P.N. Reddy, N. Sreenivasula, Y.T. Reddy, Arkivoc xii (2006) 46.
- [20] L.E. Briand, G.T. Baronelti, H.J. Thomas, Appl. Catal. A: Gen. 256 (2003) 37.
- [21] (a) M.M. Heravi, M. Rahimzadeh, M. Bakavoli, M. Ghassemzadeh, Tetrahedron Lett. 45 (2004) 5747; (b) M.M. Heravi, M. Rahimzadeh, M. Bakavoli, M. Ghassemzadeh, Tetrahedron Lett. 46 (2005) 1607; (c) M.M. Heravi, M. Tajbakhsh, A.N. Ahmadi, B. Mohajerani, Monatsh. Chem. 137 (2006) 175; (d) M.M. Heravi, Sh. Taheri, Kh. Bakhtiari, H.A. Oskooie, Catal. Commun. 8 (2007) 211; (e) M.M. Heravi, Kh. Bakhtiari, M.H. Tehrani, N.M. Javadi, H.A. Oskooie, Arkivoc xvi (2006) 16.
- [22] (a) M.M. Heravi, Kh. Bakhtiari, F.F. Bamoharram, Catal. Commun. 7 (2006) 499; (b) M.M. Heravi, Kh. Bakhtiari, F.F. Bamoharram, Catal. Commun. 7 (2006) 373; (c) M.M. Heravi, F. Derikvand, F.F. Bamoharram, J. Mol. Catal. A Chem. 242 (2005) 173; (d) H.A. Oskooie, M.M. Heravi, Kh. Bakhtiari, V. Zadsirjan, F.F. Bamoharram, Synlett (2006) 1768; (e) F.F. Bamoharram, M.M. Heravi, M. Roshani, M. Jahangir, A. Gharib, Appl. Catal. A Gen. 302 (2006) 42; (f) F.F. Bamoharram, M.M. Heravi, M. Roshani, M. Jahangir, A. Gharib, J. Mol. Catal. A Chem. 252 (2006) 90; (g) M.M. Heravi, R. Motamedi, N. Seifi, F.F. Bamoharram, J. Mol. Catal. A Chem. 249 (2006) 1.