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TITANIUM DIOXIDE AS AN ECO-FRIENDLY AND RECYCLABLE CATALYST FOR THE EFFICIENT SYNTHESIS OF 14-ARYL-14*h*-DIBENZO [A,J] XANTHENES

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ABSTRACT

A facile and highly efficient route has been developed for the synthesis of 14-aryl-14*H*-dibenzo[a,j] xanthenes derivatives by condensation of substituted benzaldehyde and β-naphthol were carried out in the presence of catalytic amount of titanium dioxide (TiO_2) under microwave irradiation and conventional method. The momentous advantages of the present method are short reaction time, excellent yields and green aspects by use of non-toxic, inexpensive, recyclable heterogeneous catalyst, avoiding toxic catalyst and hazardous solvent.

KEYWORDS

Dibenzoxanthene, Titanium dioxide and Aldehyde and β-naphthol.

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INTRODUCTION

Heterocyclic compounds synthesis always ever green in the field of organic chemistry, due to those compounds having broad spectrum of biological applications[1]. In recent years, much attention has been directed towards the synthesis of xanthene, especially benzoxanthene compounds due to the fact that benzoxanthene compounds possess a variety of biological and therapeutic properties like antiviral[2], antibacterial[3] and anti-inflammatory activities[4] as well as in photodynamic therapy (PDT)[5] and as antagonists of the paralyzing action of zoxazolamine[6]. Xanthenes are also available from natural sources. Popularly known, Santalin

pigments have been isolated from a number of plant species[7]. Furthermore, benzoxanthene are used as dyes[8]and in laser technologies[9]. Many procedures are disclosed to synthesize xanthenes and benzoxanthenes like cyclodehydrations[10] trapping of benzynes by phenols[11]alkylations of hetero atoms[12]. In addition, 14H-dibenzo [a,j]xanthenes and related products are prepared by reaction of β-naphthol with formamide[13]and carbon monoxide[14]. In view of the importance of benzoxanthenes derivatives, many classical methods for the synthesis of benzoxanthenes derivatives were reported[1518] by conventional heating and refluxing approaches in the presence of organic solvent. These methods, however, involve long reaction time, harsh reaction conditions, and the use of a large quantity of organic solvent and unsatisfactory yields. Therefore, improvements in such syntheses have been sought continuously.

Titanium dioxide (TiO_2) was found to be effective in certain organic transformations that include Biginelli reaction[19a], Beckmann rearrangement[19b], synthesis of dihydropyrazines[19c], quinoxalines[19d] and piperazines[19e]. Very recently, effective synthesis of 2,4,5-triarylimidazole[19f] has also been reported. Titanium dioxide has been exploited in organic synthesis as an easy handling, green, mild, inexpensive, recyclable, commercially available and highly reactive heterogeneous Lewis acid catalyst. It was therefore decided to investigate titanium dioxide as a catalyst for the synthesis of synthesis of 14-aryl-14*H*-dibenzo[a,j] xanthenes derivatives by condensation of substituted benzaldehyde and β-naphthol.

The science of green chemistry is developed to meet the increasing demand of environmentally benign chemical processes. The application of microwaves, as an efficient heating source for organic reactions and it has been reported in the literature[20a]. The main advantage of microwave assisted organic synthesis is the shorter reaction time using only small amount of energy. Many microwave-assisted transformations offer additional convenience in the field of organic synthesis because of simple experimental procedure and high yields[20b].

Experimental Section

All products are known compounds and these physical data, IR and NMR spectra were essentially identical with those of authentic samples. All the reagents and substituted benzaldehydes were obtained from commercial suppliers and were not purified. Melting points were determined in open capillaries apparatus and were uncorrected. The progress of reactions was monitored by TLC. IR spectra were recorded on Perkin-Elmer FT spectrophotometer in KBr disc. NMR spectra were recorded on Varian, 500 MHz spectrophotometer in CDCl3 as a solvent and TMS as an internal standard.

General Procedure for the synthesis of 14-aryl-14H-dibenzo [a, j] xanthenes 3(a-l)

By microwave irradiation

A mixture of substituted benzaldehyde (1 mmol), β-naphthol (2 mmol) and titanium dioxide (1 mol %) in a Borosil beaker (50 mL) was added. The reaction mixture was mixed properly with the help of a glass rod and irradiated in a microwave oven at 720 W for an appropriate time given in Table No.1. The progresses of reactions were monitored on TLC.

After completion of the reaction, the mixture was diluted with ethyl acetate (15 mL) and shaken well to dissolve the organic components, then filtered to separate out titanium dioxide and washed with ethyl acetate. The solid residue of titanium dioxide was further washed with hot 10 ml acetone and then dried up this recovered titanium dioxide reusable. The organic layer was dried over anhydrous Na_2SO_4. The solvent was evaporated under reduced pressure to give pure 3 (a-l) in excellent yields.

By conventional method

A mixture of substituted benzaldehyde (1m mol), β-naphthol (2m mol) titanium dioxide (1 mol%) in a 50 mL round bottom flask was heated in an oil bath at 100^0C for an appropriate time given in Table No.1, worked up and purified as above (method-i) to get the desired product.

RESULTS AND DISCUSSION

In continuation of our ongoing research for the development of simple and efficient method for the

synthesis of benzoxanthenes[21] and various heterocyclic compounds[22] herein we wish to report an efficient, convenient, improved yield and novel method for condensation of substituted benzaldehyde with β-naphthol in presence of titanium dioxide as a catalyst (Figure No.1).

In an initial endeavor, we tried to the reaction of benzaldehyde and β-naphthol using titanium dioxide (1 mol %) under microwave irradiation operating at 720W power and conventional heating in an oil bath at 100^0C, the reaction proceeded smoothly and was completed within 50 sec and 20 min of reaction time and 90% and 88% conversion respectively. Further increase in the catalyst amount did not show any marked reduce the time and increase in the yield of the reaction. It was observed that 1 mol% of titanium dioxide is quite efficient for the condensation of β-naphthol and substituted benzaldehyde to produce the corresponding xanthenes using microwave irradiation as well as conventional heating. The reaction was performed with benzaldehyde containing withdrawing as well as electron donating groups, but benzaldehydes with electron donating groups are generally more reactive than their corresponding benzaldehydes with electron withdrawing groups and give the desired product at short reaction time with excellent yield (Table No.1). This observation shows clearly that the preparation of benzoxanthenes is more strongly affected by the electronic factors.

[a]All products were characterized by their physical constant, comparison with authentic samples, and IR and NMR spectroscopy.

[a]Reaction condition: benzaldehyde (1m mol), β-naphthol (2m mol) and titanium dioxide (1 mol%) under MW[b]. Reaction time-50sec[c] Isolated yield.

Further investigation was the reusability of catalyst is important for the large-scale operation and industrial point of view. Therefore, the recovery and reusability of titanium dioxide was examined. The reusability of the catalyst was investigated in the model reaction. The results illustrated in Table No.2 showed that the catalyst could be used four times without significant loss of activity.

Table No.1: Synthesis of 14-aryl-14H-dibenzo [a,j] Xanthenes catalyzed Titanium dioxide[a]

S.No	Entry	R	MW		Conventional		M.P.(^{0}C)	
			Time (sec)	Yield (%)	Time (min)	Yield (%)	Found	Ref.[15-18]
1	3a	H	50	90	20	88	182	182
2	3b	4-Cl	50	93	10	88	287	288
3	3c	3-F	40	91	10	87	260	259
4	3d	2-Cl	60	90	15	87	215	215
5	3e	4-NO_2	90	92	10	86	312	312
6	3f	2-NO_2	80	91	25	86	292	293
7	3g	3-NO_2	80	90	15	87	212	213
8	3h	4-OMe	70	90	30	85	203	205
9	3i	4-Me	50	89	15	85	226	228
10	3j	4-OH	30	90	10	88	141	141
11	3k	2-OMe, 4-OH	50	90	10	89	169	-
12	3l	2-OMe, 5-OMe	25	91	15	88	168	-

Table No.2: Recycling of titanium dioxide for the 14-aryl-14H-dibenzo [a,j] xanthenes[a]

S.No	Entry	1	2	3	4	5
1	Cycle[b]	Fresh	First reuse	Second reuse	Third reuse	Fourth reuse
2	Yield (%)[c]	90	90	89	88	88

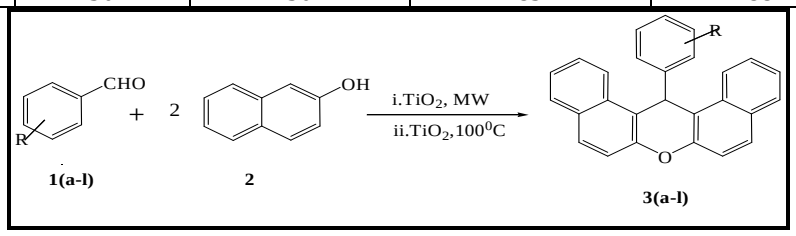

Figure No.1: Benzaldehyde with B-Naphthol in Presence of Titanium Dioxide as a Catalyst

CONCLUSION

In conclusion, we have achieved an facile, efficient, and environment-friendly method for synthesis of 14-aryl-14H-dibenzo [a,j] xanthenes derivatives using substituted benzaldehyde with β-naphthol in presence of catalytic amount of titanium dioxide. The salient features offered by this method are shorter reaction time, easy for product isolation, excellent yield of product and easy recovery and reusability of catalyst.

Spectral data for selected compounds

(3k). ^{1}H NMR ($CDCl_3$, 500 MHz): δ=8.40 (2H, d, *J* = 8.2 Hz), 7.83 (2H, d, *J* = 7.8 Hz), 7.79 (2H, d, *J* = 8.7 Hz), 7.58 (2H, t, *J* = 7.2 Hz), 7.48 (2H, d, *J* = 8.7 Hz), 7.42 (2H, t , *J* = 7.2 Hz), 7.15 (1H, d, *J* = 8.0 Hz), 6.85 (1H, s), 6.73 (1H, d, *J* = 8.0 Hz), 6.44 (1H, s), 5.34 (1H, s), 3.65 (3H, s) ppm; ^{13}C NMR ($CDCl_3$): δ= 148.7, 146.7, 144.1, 137.1, 131.4, 131.1, 128.8, 128.7, 126.7, 124.2, 122.7, 121.0, 117.9, 117.5, 113.7,110.7, 55.6, 37.5 ppm; IR (KBr, cm^{-1}): 3477, 2963, 1591, 1509, 1458, 1430, 1401, 1240, 1032, 959, 805, 781, 749.

(3l). ^{1}H NMR ($CDCl_3$, 500 MHz): δ= 8.62 (2H, d, *J* = 8.4 Hz), 7.82 (2H, d, *J* = 8.0 Hz), 7.78 (2H, d, *J* = 8.9 Hz), 7.59 (2H, t, *J* = 7.3 Hz), 7.50 (2H, d, *J* = 8.8 Hz), 7.45(2H, t , *J* = 7.4 Hz), 6.9 (1H, s), 6.84 (1H, s), 6.78 (1H, d, *J* = 9.0 Hz), 6.48 (1H, d, *J* = 6.0 Hz), 4.24 (3H, s), 3.47 (3H, s) ppm; ^{13}C NMR ($CDCl_3$): δ= 154.1, 148.8, 148.2, 135.6, 132.0, 129.9, 129.7, 128.6, 128.5, 126.7, 124.2, 123.4, 118.3, 117.0, 111.9, ,111.3, 56.1, 55.2, 30.5 ppm; IR (KBr, cm^{-1}): 2925, 2831, 1622, 1594, 1496, 1461, 1430, 1407, 1256, 1207, 1173, 1043, 965, 849, 813, 800, 746, 702.

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CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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