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Ultrasound-Promoted Synthesis of 1,5-Diarylpenta-2,4-dien-1-ones Catalyzed by Activated Barium Hydroxide

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Abstract: 1,5-Diarylpenta-2,4-dien-1-ones were synthesized with ultrasound irradiation in the presence of activated barium hydroxide as catalyst. Compared to conventional methods, the present methodology offers several advantages such as excellent yields, simple procedure, short reaction times, and milder conditions.

Keywords: Activated barium hydroxide, 1,5-diarylpenta-2,4-dien-1-ones, synthesis, ultrasound

INTRODUCTION

1,5-Diarylpenta-2,4-dien-1-ones are important intermediates and raw materials widely used as precursors to drugs,[1,2] nonlinear optical materials,[3] and so on. They also exhibited considerable biological activities.[4–8] Traditional synthesis of 1,5-diarylpenta-2,4-dien-1-ones is usually completed via Claisen–Schmidt condensation between various substituted acetophenones and cinnamaldehyde using NaOH as a basic catalyst with a longer reaction time (20 h) and poor product yields (55–81%).[9] More recently, there are some new catalysts, such as diphenyltitanocene,[10] $Yb(OPf)_3$,[11] zirconium tetrachloride,[12] and palladium/TMSCl,[13] to obtain 1,5-diarylpenta-2,4-dien-1-ones. However, despite the potential utility of these catalysts, many of these methodologies for the synthesis of 1,5-diarylpenta-2,4-dien-1-ones are associated with

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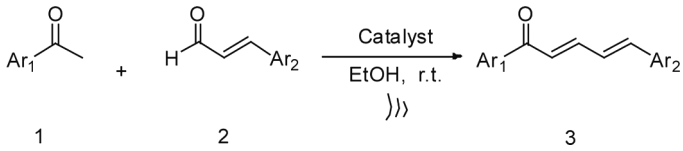

Scheme 1. Synthesis of 1,5-diarylpenta-2,4-dien-1-ones.

several shortcomings such as long reaction time, the cost of expensive catalyst, or difficult experimental operation. Thus, the development of a simple, highly effcient methodology for synthesis of 1,5-diarylpenta-2,4-dien-1-ones remains desired.

Ultrasound has increasingly been used in organic synthesis in the past three decades.[14–16] A large number of organic reactions can be carried out in greater yields, shorter reaction time, and milder conditions under ultrasound irradiation.[17–26] For example, Jin et al.[27] reported that Claisen–Schmidt condensation of various substituted acetophenones with cinnamaldehyde catalyzed by $KF–Al_2O_3$ gave (*2E,4E*)-1,5-diarylpenta-2,4-dien-1-ones in 67–92% yields in 5–60 min under ultrasound irradiation. Activated barium hydroxide have been used as catalysts in organic synthesis because these compounds are relatively nontoxic, easy to handle, low cost, and high catalytic activity.[28–30] For instance, in 1984, Sinisterra and Garcia-Raso[28] reported that Claisen–Schmidt condensation of acetophenone with benzaldehyde catalyzed by activated barium hydroxide gave 98% of (*2E*)-1,3-diphenylprop-2-en-1-one under refluence condition in 1 h. Later, Fuentes et al.[30] reported that synthesis of (*2E*)-1,3-diarylprop-2-en-1-ones using activated barium hydroxide was completed at room temperature within 10 min in 36–79% yields under ultrasound.

All of these results prompted us to study a simple, highly effcient methodology for synthesis of the Claisen–Schmidt condensation of various substituted acetophenones with cinnamaldehyde catalyzed by activated barium hydroxide under ultrasound irradiation. Here, we report for the first time a facile and effcient protocol for the synthesis of 1,5-diarylpenta-2,4-dien-1-ones in the presence of a catalytic amount of activated barium hydroxide under ultrasonication (Scheme 1).

RESULTS AND CONCLUSIONS

As shown in Table 1 and Scheme 1, 1,5-diarylpenta-2,4-dien-1-ones (**3a**–**j**) were synthesized in better yields for the condensation of various substituted acetophenones (**1**) with cinnamaldehyde (**2**), which were

Table 1. Synthesis of 1,5-diarylpenta-2,4-dien-1-ones by activated barium hydroxide under ultrasound irradiation

Entry	Ar_1	Ar_2	t (min)	Yield (%)[a]	Mp. (°C) (lit.)	Reference
a	C_6H_5	C_6H_5	40	85	102–103 (102.7–103)	27
			300	67[b]		
			300	0[c]		
b	4-FC_6H_5	C_6H_5	35	82	85–86 (85.2–86.3)	27
			270	87[b]		
c	4-ClC_6H_5	C_6H_5	30	88	141–142 (141.3–142.8)	27
			240	82[b]		
d	4-BrC_6H_5	C_6H_5	30	90	145–146 (146.2–147.3)	27
			270	84[b]		
e	4-$CH_3OC_6H_5$	C_6H_5	70	78	85–86 (85.7–85.9)	27
			420	64[b]		
f	4-$NO_2C_6H_5$	C_6H_5	20	92	172–173 (172.3–173.5)	27
			180	86[b]		
g	2,4-Cl_2	C_6H_5	35	83	178–179 (178.9–179.1)	27
			300	80[b]		
h	2-Furyl	C_6H_5	40	77	111–112 (112–113)	31
			360	76[b]		
i	2-Furyl	2-Furyl	40	73	81–82 (82)	31
			300	70[b]		
j	C_6H_5	2-Furyl	45	80	60–61 (61)	31
			300	74[b]		

[a]Isolated yield based on cinnamaldehyde.
[b]Stirred with activated barium hydroxide without ultrasound.
[c]Stirred without activated barium hydroxide without ultrasound.

catalyzed by activated barium hydroxide under ultrasound irradiation at room temperature within 20–70 min. In the absence of ultrasound, the time of the condensation reaction was within 180–420 min. For example, the mixture of acetophenone (**1a**), cinnamaldehyde, and activated barium hydroxide was stirred at room temperature for 300 min to produce 1,5-diphenylpenta-2,4-dien-1-one in 67% yield. The reaction was carried out in 85% yield at room temperature for 40 min under ultrasonication. Therefore, with treatment of ultrasonication, results show that the yields of condensation reaction are similar or even more than those without such treatments as described in Table 1, as well as having short reaction times.

Catalyst-activated barium hydroxide is imperative for the condensation reaction. For example, the condensation of acetophenone (**1a**) with cinnamaldehyde under ultrasound was studied. In the absence of activated barium hydroxide, the condensation did not

take place at room temperature. Therefore, we must say that the active sites of the catalyst are activated by ultrasound, favoring their catalytic activity.

In conclusion, synthesis of 1,5-diarylpenta-2,4-dien-1-ones was carried out for the condensation between various substituted acetophenones with cinnamaldehyde catalyzed by activated barium hydroxide under ultrasound. The present procedure was carried out in a shorter reaction time with easier operation and greater yield.

EXPERIMENTAL

Liquid acetophenones and cinnamaldehyde were purified by distillation prior to use. Melting points were uncorrected. ^{1}H NMR spectra were measured on a Bruker (400 MHz) spectrometer using tetramethylsilane (TMS) as internal standard and $CDCl_3$ as solvent. Sonication was performed in a KQ-100E ultrasonic cleaner with a frequency of 40 kHz and a nominal power 100 W. The reaction flask was placed with the maximum energy area in the cleaner, and the reaction temperature was controlled by a water bath.

Preparation of the Catalyst (Activated Barium Hydroxide)[32]

The barium hydroxide catalyst was prepared by heating commercial barium hydroxide octahydrate at 200°C for 3 h. The catalyst was stored in a desiccator over sodium hydroxide pellets.

General Experimental Procedure for the Preparation of 1,5-Diarylpenta-2,4-dien-1-ones (3)

Substituted acetophenones (**1**, 2.0 mmol), cinnamaldehyde (**2**, 2.0 mmol), absolute ethanol (5 ml), and activated barium hydroxide (0.30 g) were added in a Pyrex flask (25 ml). The mixture was irradiated in the water bath of an ultrasonic cleaner at room temperature for the period as indicated in Table 1. [Sonication was continued until cinnamaldehyde disappeared as indicated by thin-layer chromatography (TLC).] Then the mixture was dissolved in diethyl ether. The catalyst was removed by filtration and washed with diethyl ether. The solvent was evaporated under reduced pressure, and the residue was crystallized with absolute ethanol to give 1,5-diarylpenta-2,4-dien-1-ones.

The authenticity of the products was established by comparing their melting points with the literature as well as the spectra data of ^{1}H NMR.

Data

1-(2-Furanyl)-5-phenylpenta-2,4-dien-1-one (**3h**)

Pale yellow needles; δ_H (400 MHz): 6.58–6.59 (1H, m), 6.99 (1H, d, $J = 15.6$ Hz), 7.02 (2H, d, $J = 2.8$ Hz), 7.27 (1H, d, $J = 3.6$ Hz), 7.32–7.40 (3H, m), 7.50 (2H, d, $J = 8.0$ Hz), 7.65 (1H, s), 7.66–7.70 (1H, m) ppm.

1,5-Di(2-furanyl)penta-2,4-dien-1-one (**3i**)

Yellow slice; δ_H (400 MHz): 6.46 (1H, d, $J = 1.6$ Hz), 6.50 (1H, d, $J = 3.2$ Hz), 6.57–6.58 (1H, m), 6.78 (1H, d, $J = 15.2$ Hz), 6.87–6.94 (1H, m), 6.98 (1H, d, $J = 14.8$ Hz), 7.25 (1H, d, $J = 4.0$ Hz), 7.46 (1H, s), 7.56–7.60 (1H, m), 7.63 (1H, s) ppm.

5-(2-Furanyl)-1-phenylpenta-2,4-dien-1-one (**3j**)

Pale yellow slice; δ_H (400 MHz): 6.46–6.50 (2H, m), 6.78 (1H, d, $J = 15.2$ Hz), 6.90–6.96 (1H, m), 7.08 (1H, d, $J = 14.8$ Hz), 7.47–7.58 (5H, m), 7.97 (2H, $J = 8.0$ Hz) ppm.

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