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Ceria/vinylpyridine polymer nanocomposite: an ecofriendly catalyst for the synthesis of 3,4-dihydropyrimidin-2(1*H*)-ones☆

Gowravaram Sabitha,[a,*] K. Bhaskar Reddy,[a] J. S. Yadav,[a] D. Shailaja[b,*] and K. Samba Sivudu[b]

[a]*Organic Division I, Indian Institute of Chemical Technology, Hyderabad 500 007, India*
[b]*Organic Coatings and Polymers Division, Indian Institute of Chemical Technology, Hyderabad 500 007, India*

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Abstract—The three-component condensation of aldehydes, β-ketoesters and urea has been carried out in water using ceria (cerium oxide, CeO_2) nanoparticles supported on poly(4vp-co-dvb) as a catalyst for the preparation of 3,4-dihydropyrimidin-2(1*H*)-ones in good yields. The catalyst was recovered easily and reused without loss of its activity.

The development of efficient and environmentally acceptable synthetic methods is an important task of modern chemistry. Conventional organic syntheses are generally based on homogeneous catalysts. However, homogeneous reactions suffer disadvantages in separation, regeneration, etc. From the viewpoint of green chemistry, the use of heterogeneous catalysts is desirable. The consequent advantages of heterogeneous catalysts from the environmental and economic points of view are clearly understandable, since these procedures allow money to be saved and the production of waste at source to be minimized. In addition to this, the use of water as a reaction medium represents a remarkable benefit. In recent years, metal nanoparticles supported on polymers[1] have attracted much attention in organic transformations.

The Biginelli reaction[2] was first reported more than a century ago and involves the synthesis of 3,4-dihydropyrimidin-2(1*H*)-ones by a one-pot condensation reaction of ethyl acetoacetate, benzaldehyde and urea in ethanol. The synthesis of dihydropyrimidinones has gained much attention due to their wide range of pharmacological and biological properties.[3] They have emerged as potent calcium channel blockers,[4] antihypertensive agents,[5] adrenergic[6] and neuropeptide Y antagonists.[7] Apart from this they are also of interest as agents for treating anxiety,[8] and optic nerve dysfunction.[9] Therefore, many research groups have focused their attention on the synthesis of these compounds. However, this one-pot, one-step protocol often provides low yields of the products, when substituted aromatic or aliphatic aldehydes are employed. Therefore, the use of catalysts has become essential to obtain higher yields.

3,4-Dihydropyrimidines have previously been synthesized by Biginelli reaction in the presence of strong acids and Lewis acids. These have included $BF_3{\cdot}Et_2O/CuCl$,[10] $InCl_3$,[11] $LaCl_3{\cdot}H_2O$,[12] $ZrCl_4$,[13] $Yb(OTf)_4$,[14] boric acid[15] and silica-sulfuric acid.[16] However, many of these reagents are expensive, harmful and difficult to handle especially on a large scale and moreover are homogeneous in nature. Recently, we have reported a room temperature protocol using and a library generation using TMSI[17] and VCl_3,[18] respectively, for the synthesis of Biginelli compounds. We now report the three-component synthesis of dihydropyrimidines in water in the presence of a heterogeneous catalyst [ceria (cerium oxide, CeO_2) nanoparticles supported on poly(4vp-co-dvb) via in situ polymerization],[19] under mild conditions (Scheme 1). The catalyst can be prepared easily and has added advantages of recovery, reusability and high activity.

Keywords: Biginelli reaction; Water; Heterogeneous catalysis; Ceria nanoparticles; Reusability.
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* Corresponding authors. Tel./fax: +91 40 27160512; e-mail: sabitha@iictnet.org

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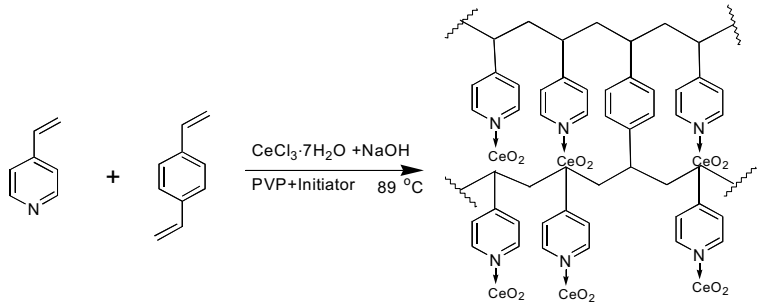
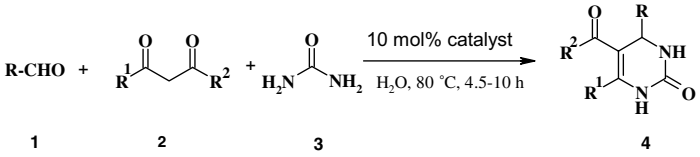
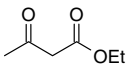
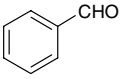
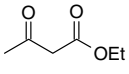
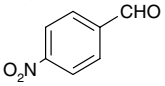
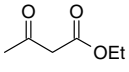
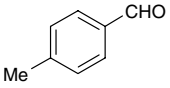
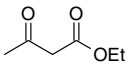
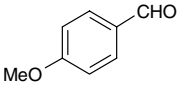
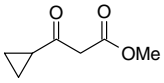
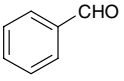
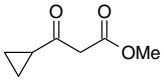
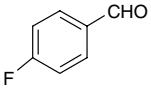
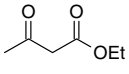
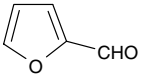
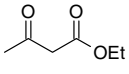
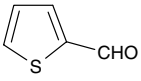
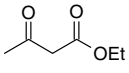
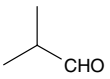
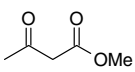
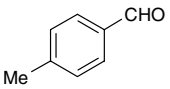
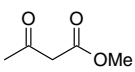
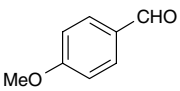
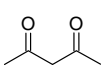
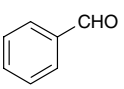


Catalyst : Ceria nanoparticles supported on poly(4vp-co-dvb) via *in situ* polymerization



Scheme 1.

Table 1. Polymer supported ceria nanoparticles-catalyzed synthesis of dihydropyrimidinones **4**[a]

Entry	Esters **2**	Aldehydes **1**	Time (h)	Yield (%)[b] **4**
a			4.5	92
b			5.0	84
c			5.0	88
d			5.0	86
e			10	55
f			10	51
g			6.0	82
h			6.0	78
i			5.5	76
j			4.5	89
k			5.0	87
l			5.0	78

[a] All products are characterized by IR, ^{1}H NMR and mass spectroscopy.
[b] Isolated yields after purification.