

# Solvent-free Synthesis of Dihydropyrimidinones/Thiones and Naphthoxazinones Derivatives Using Recyclable Mesoporous Mixed Metal Oxide Nanocrystals as Robust and Efficient Heterogeneous Catalyst

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## Abstract

Mesoporous mixed metal oxide nanocrystals of Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>-V<sub>2</sub>O<sub>5</sub> and Al<sub>2</sub>O<sub>3</sub>-CuO have been applied as heterogeneous catalysts for the synthesis of series of medicinally significant dihydropyrimidinones/thiones and naphthoxazinones derivatives under solvent-free conditions. The developed method has the rewards of operational simplicity; shorter reaction times along with high yields and recyclability of the catalysts are the unique features of the heterogeneous catalysis.

**Keywords:** *Dihydropyrimidinone; Naphthoxazinone; 2-Naphthol; Aldehyde; Mesoporous mixed metal oxide; Heterogeneous catalyst.*

## 1. Introduction

3,4-Dihydropyrimidin-2-(1*H*)-ones (DHPMs) and naphthoxazinones are very vital class of heterocyclic scaffolds in the realm of natural and synthetic organic chemistry due to their incredible biological and outstanding pharmacological deeds for example, DHPMs derivatives exhibited various biological properties [1-6] such as antitumour, antibacterial, antiviral, anti-inflammatory, calcium channel modulators,  $\alpha_{1a}$ -antagonists, neuropeptide Y (NPY) antagonist and naphthoxazinone derivatives displays antibacterial properties [7], as well as these compounds have also been used as a precursor in the synthesis of chiral amino phosphine ligands for asymmetric catalysis [8]. DHPM-derived moieties are also present in the skeleton of several natural marine polycyclic guanidine alkaloids such as crambine, batzelladine B (potent HIV gp-120CD<sub>4</sub> inhibitors), and ptilomycalin alkaloids [9,10].

3,4-Dihydropyrimidin-2-(1*H*)-ones and naphthoxazinones are typically synthesized *via* Biginelli [11] and Biginelli like reactions [12-14]. These reactions are belong to the class of multi-component reactions involving the straight forward three component, one-pot condensation of  $\beta$ -ketoester (1,3-dicarbonyl compound) or 2-naphthol, arylaldehydes and urea/thiourea. Several protocols have been reported in the

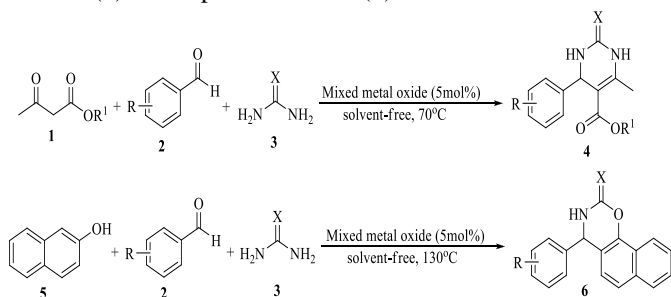
literature for the synthesis of medicinally significant dihydropyrimidinones/thiones [15] and naphthoxazinones [16-21] utilizing numerous Lewis acids and bases in order to reduce the reaction time, increase the yield of desired products and to develop the environmentally benign reaction conditions. Nevertheless, each of these methods has their own advantages but also experienced from some bottlenecks, such as prolonged reaction time drastic work-up procedures and modest yields of the title products. Therefore, these drawbacks prompted us to examine a new catalyst which suppress the limitations of previously existed protocols for the environmentally benign synthesis of 3,4-dihydropyrimidin-2-(1*H*)-ones and 1,2-dihydro-1-arylnaphtho[1,2-*e*][1,3]oxazine-3-one derivatives.

The advances in nanotechnology have led to an increasing demand for multifunctional materials. Highly ordered mesoporous materials function as excellent catalysts due to their high surface area and surface functionalities. Thus, synthesis of ordered mesoporous materials has attracted great deal of research interest in the recent years [22]. Recently, we successfully explored the application of mixed metal oxide nanocrystals [23, 24] in various transformations. Mesoporous mixed oxide nanocrystals of Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>-V<sub>2</sub>O<sub>5</sub> and Al<sub>2</sub>O<sub>3</sub>-CuO were prepared by aero gel process [25] and characterized by TEM, XRD, N<sub>2</sub> BET. Inspired by the above catalytic activity of mesoporous materials, we inspected the mesoporous mixed metal oxide nanocrystals of Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>-V<sub>2</sub>O<sub>5</sub> and Al<sub>2</sub>O<sub>3</sub>-CuO as heterogeneous catalysts for the construction of dihydropyrimidinones/thiones and naphthoxazinones derivative.

In continuation of our work on the synthesis of various bioactive compounds [26-29] and in terms of environmentally benign procedures [30-31] herein, we report the efficient application of mesoporous mixed metal oxide nanocrystals of

$\text{Al}_2\text{O}_3\text{-Fe}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3\text{-V}_2\text{O}_5$  and  $\text{Al}_2\text{O}_3\text{-CuO}$  as heterogeneous catalysts for the synthesis of dihydropyrimidinones/thiones (**4**) and naphthoxazinones (**6**) derivatives by the combination of  $\beta$ -ketoester (**1**) or 2-naphthol (**5**), arylaldehydes (**2**) and urea/thiourea (**3**) in one-pot under solvent-free conditions as depicted in Scheme 1.

**Scheme1:** General synthetic approach of dihydropyrimidinons /thiones (**4**) and naphthoxazinones (**6**).

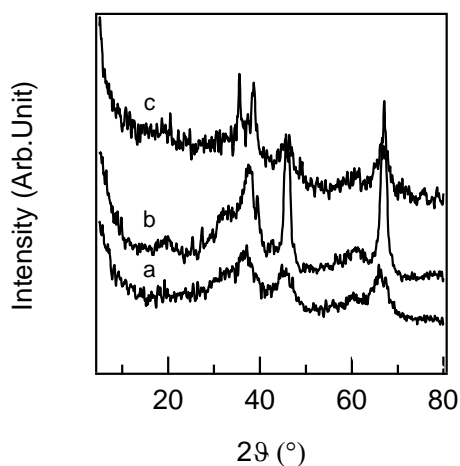


## 2. Results and Discussion

### 2.1. Characterization of catalysts

Synthesized nanocrystals were characterized by X-ray diffraction studies as per the patterns depicted in Figure 1. It was revealed from the XRD data that, these materials are less crystalline in nature and they had a completely amorphous pattern due to particle size broadening.

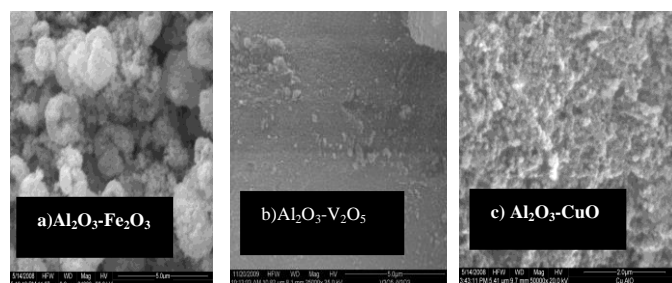
**Figure 1.** XRD pattern of a)  $\text{Al}_2\text{O}_3\text{-Fe}_2\text{O}_3$ , b)  $\text{Al}_2\text{O}_3\text{-V}_2\text{O}_5$  and c)  $\text{Al}_2\text{O}_3\text{-CuO}$ .



The crystallite size of  $\text{Al}_2\text{O}_3\text{-Fe}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3\text{-V}_2\text{O}_5$  and  $\text{Al}_2\text{O}_3\text{-CuO}$  was determined by the Scherrer equation. The values of crystallite size diameter were found to be 4.2 nm, 6.4 nm, 3.7 nm for  $\text{Al}_2\text{O}_3\text{-Fe}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3\text{-V}_2\text{O}_5$  and  $\text{Al}_2\text{O}_3\text{-CuO}$  respectively. Size of crystallites  $\text{Fe}_2\text{O}_3$ ,  $\text{V}_2\text{O}_5$  on alumina

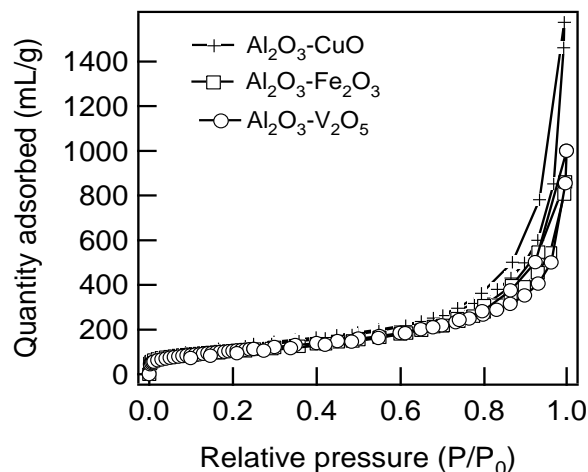
could not be calculated due to the amorphous nature of diffraction patterns. Further, the characterization was done by scanning electron microscopy (SEM) [Figure 2, (a-c)]. Scanning electron micrographs demonstrated the aggregates of nanocrystallites having size less than 50 nm. These aggregates appeared to be formed from particles of size smaller than 50 nm as indicated by XRD data. These nanoparticles were seemed to orient randomly in irregular fashion to minimize the steric, electric charge repulsions thereby resulting into a porous structure. SEM data indicated that the aggregates of  $\text{Al}_2\text{O}_3\text{-Fe}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3\text{-V}_2\text{O}_5$  and  $\text{Al}_2\text{O}_3\text{-CuO}$  were having the values of void diameters ranging approximately between 10 to 50 nm. These values come in the range of mesoporous materials.

**Figure 2.** SEM images of a)  $\text{Al}_2\text{O}_3\text{-Fe}_2\text{O}_3$ , b)  $\text{Al}_2\text{O}_3\text{-V}_2\text{O}_5$ , c)  $\text{Al}_2\text{O}_3\text{-CuO}$ .



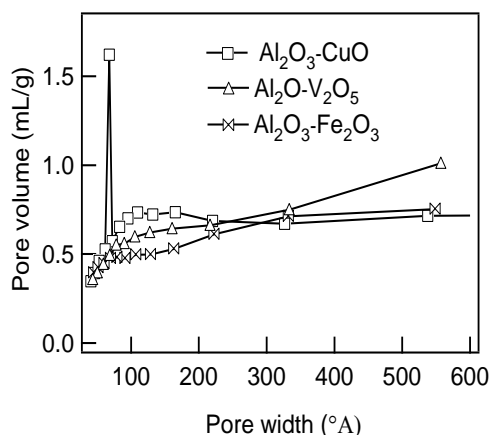
The *BET* surface areas of samples were measured by nitrogen adsorption method. A type IV isotherm with hysteresis curve was obtained by nitrogen adsorption isotherm (Figure 3), which represents characteristic feature of mesoporous materials. In the present studies adsorption isotherm data were also used to determine the pore size distribution which indicated that materials possess cylindrical pores with opening at both the ends. Additionally,  $\text{Al}_2\text{O}_3\text{-CuO}$  was found to have more number of pores than  $\text{Al}_2\text{O}_3\text{-V}_2\text{O}_5$  or  $\text{Al}_2\text{O}_3\text{-Fe}_2\text{O}_3$ .

**Figure 3.** Nitrogen adsorption isotherms



Surface area of these materials was found to be ranging from 376 to 418 m<sup>2</sup>/g. They exhibited meso and macroporosity with the pore volume ranging from 1.0 to 1.38 mL/g. The pore size distribution data is depicted in Figure 4.

**Figure 4.** Pore size distribution data of a) Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub>, b) Al<sub>2</sub>O<sub>3</sub>-V<sub>2</sub>O<sub>5</sub> and c) Al<sub>2</sub>O<sub>3</sub>-CuO



The surface area and pore volume values obtained from the above studies are presented in Table 1. Data indicate that Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub> exhibited wide meso-pore size distribution with maxima centered at 7.1 nm, whereas, Al<sub>2</sub>O<sub>3</sub>-V<sub>2</sub>O<sub>5</sub> and Al<sub>2</sub>O<sub>3</sub>-CuO exhibited wide pore size distribution unlike Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub>. The pores as understood perhaps were formed by aggregation of nanocrystals. However, during the formation of nanocrystals of Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub>, they nucleate, crystallize and aggregate in a manner to create pores of 7.1 nm width. In case of Al<sub>2</sub>O<sub>3</sub>-V<sub>2</sub>O<sub>5</sub> and Al<sub>2</sub>O<sub>3</sub>-CuO, they possibly follow a different route of crystallization and orientation followed by aggregation due to different symmetry.

**Table 1.** BET Surface area and pore volume values for Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>-V<sub>2</sub>O<sub>5</sub> and Al<sub>2</sub>O<sub>3</sub>-CuO

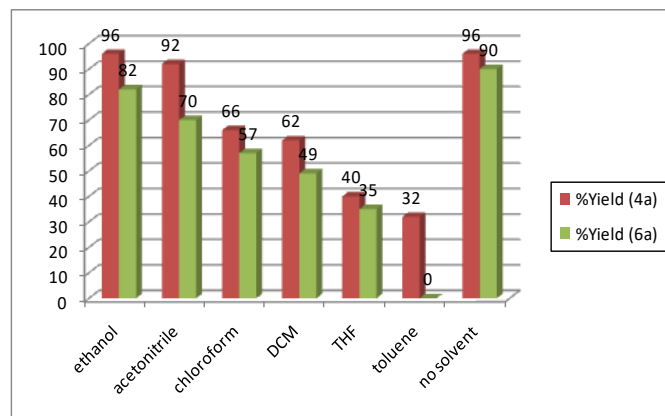
S.No.	Catalyst	BET Surface area (m <sup>2</sup> /g)	Pore volume (cm <sup>3</sup> /g)
1.	Al <sub>2</sub> O <sub>3</sub> -Fe <sub>2</sub> O <sub>3</sub>	376	1.00
2.	Al <sub>2</sub> O <sub>3</sub> -V <sub>2</sub> O <sub>5</sub>	384	1.10
3.	Al <sub>2</sub> O <sub>3</sub> -CuO	418	1.38

Due to broadening of diffraction peaks it was difficult to confirm the presence of Fe<sub>2</sub>O<sub>3</sub> or V<sub>2</sub>O<sub>5</sub> nanocrystals in the matrix of Al<sub>2</sub>O<sub>3</sub>. Therefore, samples were analyzed by energy dispersive analysis of X-rays. Data was calculated as wt% of either Al, or Fe or Cu or V or O. In Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub> sample, 39.37 wt% of Al, 34.65 wt% of O, 12.32 wt% Fe were observed. In Al<sub>2</sub>O<sub>3</sub>-V<sub>2</sub>O<sub>5</sub>, 38.21 wt% of Al, 28.12 wt% of O, 20.95 wt% V were observed. In Al<sub>2</sub>O<sub>3</sub>-CuO, 31.28 wt% of Al, 41.82 wt% of O, 5.27 wt% Cu were observed. It is inferred from these data that, either metal oxides are forming small

clusters of nanocrystallites that are located on the surface of Al<sub>2</sub>O<sub>3</sub> which are in close contact with each other and form an interface with more number of active sites or they form small crystallites that are mixed with Al<sub>2</sub>O<sub>3</sub> in a uniform manner.

Initially, we examine the different common solvents for the synthesis of dihydropyrimidinones/thiones and naphthoxazinones derivatives using mesoporous mixed metal oxide nanocrystals of Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>-V<sub>2</sub>O<sub>5</sub> and Al<sub>2</sub>O<sub>3</sub>-CuO as heterogeneous catalysts. To study the feasibility of the different solvents, the reaction of methyl β-ketoester or 2-naphthol, 4-methoxybenzaldehyde and urea was selected as model reactants for the synthesis of dihydropyrimidinones/thiones (Table 1, entry 1) and naphthoxazinones (Table 2, entry 1) derivatives. It was observed that, all the three catalytic systems efficiently accelerated the reaction towards the formation of desired product, although Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub> and Al<sub>2</sub>O<sub>3</sub>-V<sub>2</sub>O<sub>5</sub> were found to be little superior over Al<sub>2</sub>O<sub>3</sub>-CuO owing to their enhanced surface properties. However, among all the solvents, solvent-free condition was found to be the most effective for the reaction of methyl β-ketoester or 2-naphthol, 4-methoxybenzaldehyde and urea with respect to yield as shown in Figure 5.

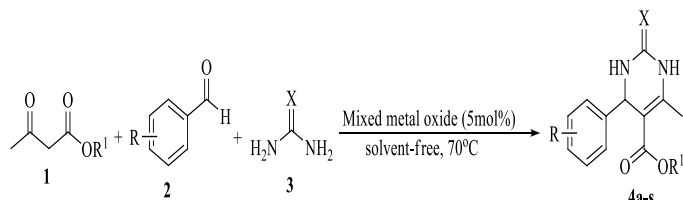
**Figure 5.** Effect of solvent on synthesis of dihydropyrimidinones (4a) and naphthoxazinones (12) using mesoporous mixed metal oxide nanocrystals as heterogeneous catalysts. Reaction conditions: methyl β-ketoester (1.0 mmol) or 2-naphthol (1.0 mmol), 4-methoxybenzaldehyde (1.0 mmol), urea (1.2 mmol) and mixed metal oxide nanocrystals (5 mmol% of aldehyde).



Thereafter, the reaction was carried out by varying the amount of mesoporous mixed metal oxide nanocrystals of Al<sub>2</sub>O<sub>3</sub>-Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>-V<sub>2</sub>O<sub>5</sub> and Al<sub>2</sub>O<sub>3</sub>-CuO as heterogeneous catalysts. The best result observed when 1:1:1.2 mole ratios of methyl/ethyl β-ketoester or 2-naphthol, arylaldehyde and urea/thiourea with mesoporous mixed metal oxide nanocrystals (5 mol% of aldehyde) was used. Further we extended the optimized reaction conditions to various

arylaldehydes for the synthesis of dihydropyrimidinones/thiones (Table 2, 4a-s) derivatives.

**Table 2.** Synthesis of 3,4-dihydropyrimidin-2-(1H)-ones using mesoporous mixed metal oxide nanocrystals as catalyst<sup>a</sup>



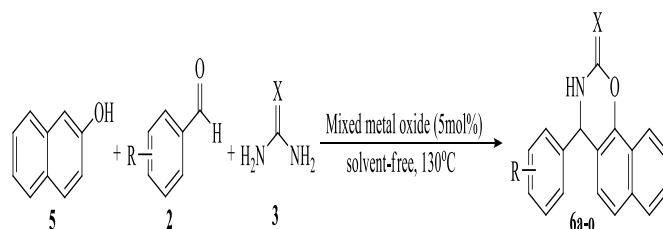
Entry	R	R <sup>1</sup>	X	Product	% Yield <sup>b</sup>
1	4-OCH <sub>3</sub>	CH <sub>3</sub>	O	4a	96
2	4-OCH <sub>3</sub>	CH <sub>3</sub>	S	4b	90
3	4-OCH <sub>3</sub>	C <sub>2</sub> H <sub>5</sub>	O	4c	91
4	4-OCH <sub>3</sub>	C <sub>2</sub> H <sub>5</sub>	S	4d	88
5	4-CH <sub>3</sub>	C <sub>2</sub> H <sub>5</sub>	S	4e	85
6	4-CH <sub>3</sub>	CH <sub>3</sub>	S	4f	90
7	3-OCH <sub>3</sub>	CH <sub>3</sub>	O	4g	90
8	H	C <sub>2</sub> H <sub>5</sub>	S	4h	85
9	H	C <sub>2</sub> H <sub>5</sub>	O	4i	89
10	4-NO <sub>2</sub>	C <sub>2</sub> H <sub>5</sub>	O	4j	92
11	4-NO <sub>2</sub>	CH <sub>3</sub>	O	4k	90
12	4-F	C <sub>2</sub> H <sub>5</sub>	O	4l	91
13	4-F	CH <sub>3</sub>	O	4m	89
14	4-Cl	CH <sub>3</sub>	O	4n	91
15	3-Cl	C <sub>2</sub> H <sub>5</sub>	O	4o	88
16	4-OH	C <sub>2</sub> H <sub>5</sub>	O	4p	85
17	4-OH	CH <sub>3</sub>	O	4q	89
18	4-N(CH <sub>3</sub> ) <sub>2</sub>	C <sub>2</sub> H <sub>5</sub>	O	4r	90
19	4-N(CH <sub>3</sub> ) <sub>2</sub>	CH <sub>3</sub>	S	4s	82

<sup>a</sup>Reaction conditions: **1** (1.0 mmol), **2** (1.0 mmol), **3** (1.2 mmol) and mixed metal oxide nanocrystals (5 wt% of aldehyde) at 70°C.

<sup>b</sup>Isolated yields

In order to demonstrate the synthetic potential of this protocol the same procedure was extended for one-pot synthesis of naphthoxazinones class of compounds and depicted in Table 3 (6a-o). From these experiments we found that, arylaldehydes bearing electron-releasing or electron-withdrawing substituents underwent reaction smoothly with methyl/ethyl β-ketoester or 2-naphthol and urea/thiourea.

**Table 3.** Synthesis of 1,2-dihydro-1-arylnaphtho[1,2-e][1,3]oxazine-3-one derivatives using mixed metal oxide nanocrystals as catalyst<sup>a</sup>



Entry	R	X	Product	M.P(°C)	% Yield <sup>b</sup>
1	4-OCH <sub>3</sub>	O	6a	186-188	90
2	4-OC <sub>2</sub> H <sub>5</sub>	O	6b	218-220	88
3	4-OCF <sub>3</sub>	O	6c	168-170	92
4	4-OH	O	6d	184-186	85
5	4-F	O	6e	198-200	94
6	4-Cl	O	6f	212-214	90
7	4-Br	O	6g	220-222	85
8	4-CH <sub>3</sub>	O	6h	164-166	90
9	4-CF <sub>3</sub>	O	6i	232-234	94
10	4-H	O	6j	218-220	86
11	4-NO <sub>2</sub>	O	6k	204-206	84
12	4-(CH <sub>3</sub> ) <sub>3</sub> C	O	6l	178-180	78
13	3-F	O	6m	218-220	90
14	3-Cl	O	6n	196-198	87
15	3-OCH <sub>3</sub>	O	6o	170-172	85

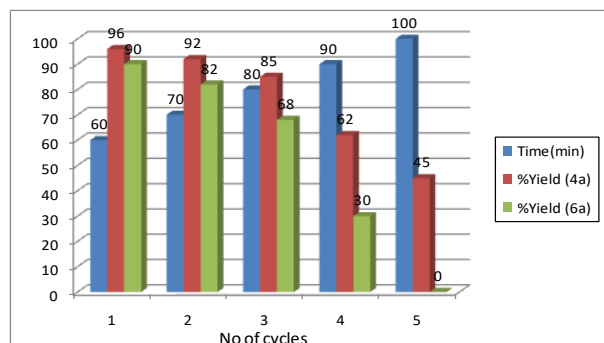
<sup>a</sup>Reaction conditions: **5** (1.0 mmol), **2** (1.0 mmol), **3** (1.2 mmol) and mixed metal oxide nanocrystals (5 wt% of aldehyde) at 130°C.

<sup>b</sup>Isolated yields

## 2.2 Reusability of the Catalyst

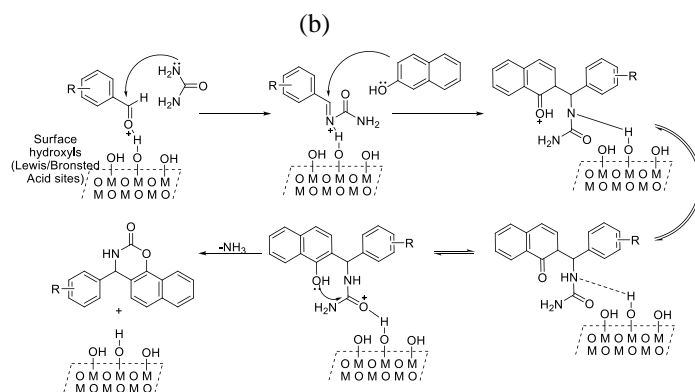
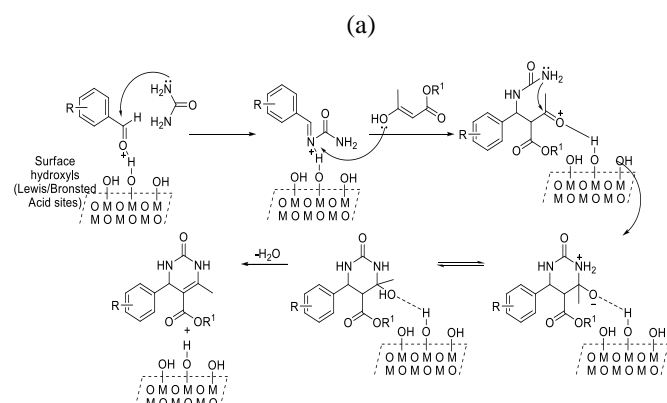
In order to explore the recyclability of catalyst, it was filtered off at the end of the reaction and washed with ethyl acetate, dried at 100 °C for 3 hr. Catalyst was reused as such for the same reaction (**4a** and **12**) under solvent-free condition repeatedly and the change in their catalytic activity was studied w.r.t time. The relation between the number of cycles of the reaction and the catalytic activity in terms of yield of the title products is presented in the Figure 6. It was found that mesoporous mixed metal oxide nanocrystal could be reused for four cycles with negligible loss of their activity under solvent-free conditions.

**Figure 6.** Recyclability of catalyst for the synthesis of dihydropyrimidinones (**4a**) and naphthoxazinones (**12**) using mesoporous mixed metal oxide nanocrystals. Reaction conditions: methyl  $\beta$ -ketoester (1.0 mmol) or 2-naphthol (1.0 mmol), 4-methoxybenzaldehyde (1.0 mmol), urea (1.2 mmol) and mixed metal oxide nanocrystals (5 mmol% of aldehyde).



The possible mechanistic path for the synthesis of 3,4-dihydropyrimidin-2-(1*H*)-ones and 1,2-dihydro-1-arylnaphtho[1,2-*e*][1,3]oxazine-3-one derivatives is given in Scheme 2. The used metal oxides species contains Lewis acid sites and Bronsted acid sites in addition to basic surface sites. Surface of nanocrystalline  $\text{Al}_2\text{O}_3$  was found to be basic in nature. Further addition of transition metal oxides would increase the number of Lewis acid sites, Bronsted acid sites and basic sites thereby increasing the reactivity of metal oxides as catalyst. These acidic sites react with carbonyl intermediate undertakes a cyclization with  $\beta$ -ketoester affording the corresponding title 3,4-dihydropyrimidin-2-(1*H*)-ones pursued by the abolition of water molecule (Scheme 2, a). The desired 1,2-dihydro-1-arylnaphtho[1,2-*e*][1,3]oxazine-3-one product is fashioned by the cyclization of acylimine intermediate with 2-naphthol followed by the removal of ammonia molecule (Scheme 2, b).

**Scheme 2:** Proposed mechanism for the synthesis of dihydropyrimidinone (**a**) and naphthoxazinone (**b**) derivatives



### 3. Experimental Section

#### 3.1. Materials

Aluminium-sec-butoxide, vanadyl acetylacetonate, copper acetylacetonate, iron acetylacetonate, methyl/ethyl  $\beta$ -ketoesters, 2-naphthol, various aromatic aldehydes and urea/thiourea were purchased from Sigma Aldrich, India.

#### 3.2. Catalyst preparation

Mesoporous mixed oxide nanocrystals of  $\text{Al}_2\text{O}_3\text{-Fe}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3\text{-V}_2\text{O}_5$  and  $\text{Al}_2\text{O}_3\text{-CuO}$  were prepared by aero gel process: A 1000 mL round bottom flask was charged with aluminium-sec-butoxide (10.0 g) under constant nitrogen flow. It was dissolved in 100 mL of butan-2-ol to form a clear solution. To this solution, copper acetylacetonate / iron acetylacetonate / vanadyl acetylacetonate was added and the solution was stirred for 2 hours. Now a mixture of 500 mL of toluene and 150 mL of butan-2-ol was added and the contents were allowed to stir for 30 minutes. To this solution, 2.0 mL of ultrapure water was added and the stirring was continued for overnight period in order to obtain the soft gel. This soft gel was then transferred to a Parr autoclave which was flushed initially with nitrogen and pressurized to 100 psi under continuous shaking. The reactor was slowly heated to  $300^\circ\text{C}$  and the pressure raised to 1000 psi. As soon as the autoclave has acquired  $300^\circ\text{C}$  the reactor was vented to ambient pressure. The autoclave was then allowed to cool and flushed with nitrogen. Mesoporous mixed oxide alumina thus obtained was heated at  $500^\circ\text{C}$  under vacuum [12].

#### 3.3. Catalyst characterization techniques

XRD patterns were obtained in an X Pert Pro Diffractometer, Panalytical, Netherlands, using  $\text{Cu K}\alpha$  radiation. The Scherer formula was used to calculate the crystallite size of the materials:

$$\text{Crystallite size} = (0.9 \lambda / 180) / (B \cos \theta \pi) \text{ Angstroms}$$

Where,  $B = \sqrt{(\text{FWHM}^2 - 0.3^2)}$  and  $\lambda$  is X-ray wave length ( $1.54 \text{ \AA}$ ).

FWHM is full width half maxima of the peak and  $\theta$  is Bragg's angle.

FWHM was calculated from the peak having highest intensity in all the samples using X Pert high score plus LTU software.

SEM-EDAX measurements were done on a FEI instrument.  $N_2$  BET measurements were done on ASAP 2020 of Micrometrics, USA.

### 3.4. Catalytic activity:

#### a) Synthesis of 3,4-dihydropyrimidin-2-(1*H*)-ones derivatives

A 25ml round bottom flask was charged with arylaldehyde (1.0 mmol), urea/thiourea (1.2 mmol) and catalytic amount of mesoporous mixed metal oxide nanocrystals (5 wt% of aldehyde). The reactants are finely powdered and mixed together and allowed to stir for 30 min at room temperature. The methyl/ethyl  $\beta$ -ketoester (1.0 mmol) was added to the above mixture and the resulting reaction mixture was refluxed at 70°C (water bath) with constant stirring till the reaction was complete. After completion of reaction as indicated on TLC, the reaction mixture was cooled to room temperature and the crude reaction mixture was dissolved in ethylacetate and the catalyst was separated out by simple filtration. The reaction mixture in ethylacetate was washed with water and excess of solvent was removed under reduced pressure. The solid mass was washed with cold diethylether (20ml  $\times$  2) and dried. The pure dihydropyrimidinone title product was obtained in 82 - 96% yield.

#### b) Synthesis of 1,2-dihydro-1-arylnaphtho[1,2-*e*][1,3]oxazine-3-one derivatives

A 25ml round bottom flask was charged with arylaldehyde (1.0 mmol), urea (1.2 mmol) and catalytic amount of mesoporous mixed metal oxide nanocrystals (5 wt% of aldehyde). The reactants are finely powdered and mixed together and allowed to stir for 30 min at room temperature. The 2-naphthol (1.0 mmol) was added to the above mixture and the resulting reaction mixture was refluxed at 130°C (oil bath) with constant stirring till the reaction was complete. After completion of reaction as indicated on TLC, the reaction mixture was cooled to room temperature and the crude reaction mixture was dissolved in ethylacetate and the catalyst was separated out by simple filtration. The reaction mixture in ethylacetate was washed with water and excess of solvent was removed under reduced pressure. The solid mass was washed with cold diethylether (20ml  $\times$  2) and dried. The pure naphthoxazinone title product was obtained in 78 - 94% yield.

## 4. Conclusions

In conclusion, a simple, efficient and environmentally benign method has been developed for the synthesis of 3,4-

dihydropyrimidin-2-(1*H*)-ones and 1,2-dihydro-1-arylnaphtho[1,2-*e*][1,3]oxazine-3-one derivatives by using mesoporous mixed metal oxide nanocrystals having high surface area and high catalytic activity under solvent-free condition. This one-pot, mixed metal oxide catalyzed synthetic method is an unprecedented, inexpensive and rapid alternative for the generation of structurally diversified dihydropyrimidinones and naphthoxazinone derivatives. The environmental compatibility and excellent reusability of the catalyst and ease of isolation of product are among the other added advantages that make this approach an attractive alternative for the synthesis of these heterocycles.

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