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Preparation and properties of amorphous Cr/Fe mixed-aluminophosphates and their catalytic application in one pot-three component synthesis of 3,4-dihydropyrimidinones by Biginelli reaction

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ABSTRACT

Amorphous aluminophosphate, Cr or Fe–aluminophosphates (2.5mol% of Cr or Fe) and Cr and Fe-aluminophosphates (2.5, 5 or 25 mol% of Cr and Fe) are prepared by co-precipitation method. These materials are characterized for their bulk, surface and acidic properties and applied as catalyst for the synthesis of biologically important 3,4-dihydropyramidinones by the Biginelli condensation of benzaldehyde, urea and ethylacetoacetate at ambient reaction conditions.The materials are found to be mesoporous, amorphous and possess high surface area and weak and strong acid sites depending on the type and concentration of the transition metals. All the materials are catalytically active with 100% selectivity towards the formation of Biginelli product. Among allthe catalysts, CrFeAlP with 5 mol % of Cr and Fe is found to be the best catalyst because of its higher concentration of weak acid sites and also higher surface area and porosity compared to other phosphate materials investigated. The material also found to be recyclable up to five cycles without losing catalytic activity significantly.

Keywords: Amorphous metal-aluminophosphate, surface properties, surface acidity, Biginelli reaction, 3,4-dihydropyramidinone

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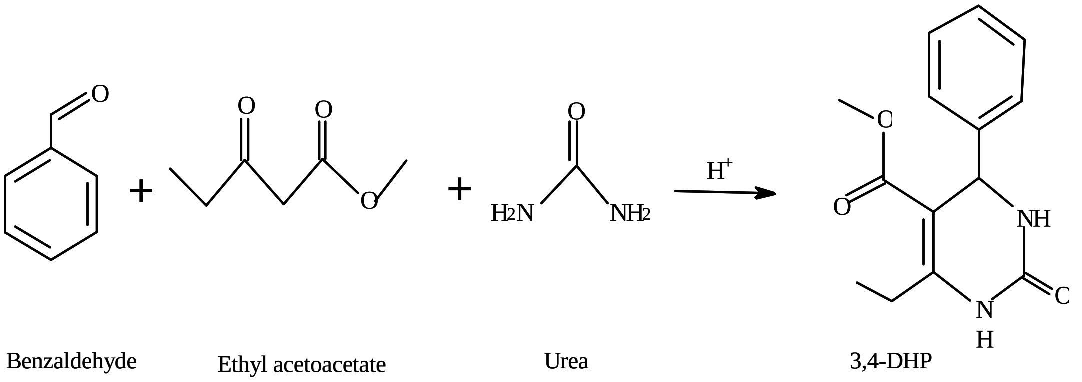
INTRODUCTION

Multi-component reactions (MCRs) have recently gained tremendous importance in medicinal and green chemistry[1]. The main advantages of these reactions are good atom economy, their applications in combinatorial chemistry and the use of diverse substrate molecules. An important MCR in the synthetic chemistry is the Biginelli type cyclocondensation reaction to produce 3,4-Dihydropyrimidinones (3,4-DHPs) [2-3]. 3,4-DHPs are an important class of biologically active heterocyclic compounds which possess a vast variety of applications in medicinal chemistry. 3,4-DHP derivatives are mainly used as calcium channel blockers, which inhibits the in-flow of calcium ions through plasma membrane channels and thereby dilate vascular muscles and minimize the force of cardio-vascular contraction [4]. The DHP derivatives are also used as anti-hypertensive agents, anti-cancer drugs, anti-batcterial and anti-viral drugs [5-7]. Another most notable fact is that 3,4-DHPs are the first low molecular weight natural products to inhibit the binding of HIV gp120 to CD4 cells, which is a landmark in the treatment of AIDS [8]. The multicomponent condensation for synthesis of 3,4-DHP was first reported by PietroBiginelli in 1891 and hence the name Biginelli reaction [9]. It involves in general the homogeneous acid catalyzed reaction of a mixture of a β-keto ester (mainly ethylacetoacetate), an aromatic aldehyde and urea (Scheme 1). The difficulties associated with the classical DHP preparation in strongly acidic medium is the low to moderate yield. Various homogeneous catalysts were employed and reported in the literature to overcome these issues. The important homogeneous catalysts reported are $AlCl_3$ [10], $[Al(H_2O)_6](BF_4)_3$ [11], $ZnCl_2$ [12], $CuCl_2.2H_2O$ [13], $FeCl_3.6H_2O$[14], Ziegler–Natta catalyst [15], polyphosphate ester [16], Baker's yeast [17], $LaCl_3\cdot 7H_2O$ [18] and $LiClO_4$[17]. Most of the processes involving above catalytic materials are either costly or eco-unfriendly, or the catalysts are non-recoverable and generate copious amount of acidic wastes.



Scheme 1. The Biginelli condensation of benzaldehyde, urea and ethylacetoacdtate to synthesize 3,4-DHP

The heterogeneous catalytic process is always favorable than the homogeneous one due to ease of separation of the catalyst from the reaction mixture and the lack of possibility of reactor corrosion. Many authors have reported more economic and greener methods using heterogeneous catalysts such as bentonite clay [19], silica-chloride [20], zeolites [21], ion exchange resins [22] and heteropoly acid [23]. Though the yield and selectivity of the DHP product was superior with some of the heterogenous catalytic systems listed above, the drawbacks associated with these catalysts are the longer duration, the elevated temperatures etc.

Recently our group has reported the synthesis, characterization and catalytic applications of amorphous aluminophosphate and a few metal-aluminophosphates[24-27]. These materials possess weak acid-base as well as redox sites that can activate a number of industrially important organic reactions. These materials are much simpler to prepare compared to the crystalline ALPOs and MAPOs. The catalytic efficiency of these materials may be altered depending on the experimental conditions maintained before and after their preparation, such as pH of precipitation, precipitating agent, digestion of the precipitate, calcinations temperature etc. There is a wide scope to develop these materials as a new class of heterogeneous catalysts to affect a number of industrially important organic transformations. Most of the works reported so far on amorphous aluminophosphate relates mainly on the incorporation of one type of metal. However, few studies on the incorporation of two or more types of metals in the crystalline AlPOs are reported [28]. The study of synergic effects of two metals on the structural and surface properties of amorphous aluminophosphate will be more interesting with respect to their catalytic applications since the development of cheaper and highly efficient catalytic materials is still a challenging task in the world of sustainable and green chemistry.

In the present work, amorphous aluminophophate and Cr/Fe-aluminophosphates are prepared by co-precipitation method from the respective metal nitrates and ammonium hydroxide using ortho-phosphoric acid as the phosphorous source, without using any surfactants or structure directing organic molecules. In order to synthesis catalytic materials with low particle size and high surface area, the precipitations are carried out at ice cold temperature. According von-Weimarn relation of super saturation, Relative supersaturation, $K = (Q-S)/S$, Where, Q = molar concentration of the mixed reagents before precipitation,S = molar solubility of the precipitate at equilibrium and K = a constant[29].Since the particle size is inversely proportional to relative supersaturation, for the formation of precipitates by homogeneous nucleation, a supersaturation of growth species must be created. A reduction in temperature of an equilibrium mixture, such as saturated solution would lead to supersaturation. At high relative super saturation, materials with reduced particle size and high surface area are expected. The prepared materials are thoroughly characterized and used as catalyst for the Biginelli condensation of urea, ethyl acetoacetate and benzaldehyde to synthesize industrially and biologically important 3,4-dihydropyramidinones.

EXPERIMENTAL SECTION

Material preparation

Preparation of aluminophosphate (AlP)

The aluminophosphate was prepared as per the procedure reported in the literature [26].Calculated amount of the aluminium nitrate [$(Al(NO_3)_3 9H_2O)$] was weighed and taken in a 500mL beaker and dissolved in 200mL de-ionized water. To this solution required quantities of 85% phosphoric acid with aluminium to phosphorous mole ratio of 1:1 was added. The whole beaker was kept in an ice bath and stirred well using a magnetic stirrer. To the above clear solution 28% laboratory grade ammonia was added slowly with constant stirring over a period of 20 minutes. Initial pH was 2 and addition of ammonia was stopped at a pH of 7.5. The precipitate obtained was filtered and washed continuously with distilled water to remove the soluble salts. The precipitate was dried at 120^oC for 10h and powdered samples were calcined at 350^oC for 5h. The calcinedmaterial was abbreviated as AlP.

Preparation of Cr/Fe -aluminophosphate

Chromium –aluminophosphate (CrAlP) and iron –aluminophosphate (FeAlP) with2.5mol% of Cr or Fe, were prepared by mixing aluminium nitrate nonahydrate [$(Al(NO_3)_3 9H_2O)$], chromium nitrate nonahydrate [$Cr(H_2O)_6](NO_3)_3\ 3H_2O$] or iron nitrate nonahydrate [$Fe(NO_3)_3\ 9H_2O$] in 500 mL of de-ionized water followed by 85% of H_3PO_4 in the desired molar ratio. The beaker was kept in an ice bath, cooled and agitated on a magnetic stirrer. To the above clear and cold solution, 28% laboratory grade ammonia was added drop wise from a burette until pH reached 7.5. The resulting precipitate was processed in a similar procedure used for aluminophosphate preparation explained above. The phosphorous to total metal molar ratio was kept 1 in all the preparations with 2.5 mol percentage of the metal.

Preparation of Cr and Fe mixed -aluminophosphate (CrFeAlPn)

CrFeAlPn(where n = 2.5, 5 and 25 mol percentage of both Cr and Fe) were prepared using the same procedure applied for the preparation of the single metal-aluminophosphatesexcept the addition of the precursor salt of the second metal. The metal nitrates including that of aluminium are dissolved in the initial stage before the addition of phosphoric acid. After precipitation was completed, the rest of processing was done similar to the one described in former cases.

Material characterization

The elemental composition of materials was analyzed in ICP-AES instrument (ARCOS from M/s. Spectro, Germany). 0.2 g of the solid sample was dissolved in conc. HCl and made up to 100mL with distilled water in a standard measuring flask for analysis. The BET surface area, porosity and N_2 adsorption-desorption isotherms were determined using MicromeriticsTristar 3000 instrument. In a typical measurement, 0.2g of the material was screened through 40/60 mesh size and degassed at 250^oC for 2h in N_2 gas flow. After cooling the sample to room temperature, adsorption-desorption analysis was conducted using N_2 asanadsorbate. The powder X-Ray diffraction patterns of the materials were recorded using Rigaku instrument (Japan) with Cu Kα radiation. FT-IR spectra were recorded using Thermo-Scientific Nicolet IR-380 instrument by KBr pellet technique in a range of 400 cm^{-1}-4000cm^{-1}. Temperature-Programmed Desorption of ammonia (TPD-NH_3) experiments was performed on a pulse Chemisorb instrument (Micromeritics) to characterize the acidity of materials. In a typical experiment, 0.15 g of material sieved through 40/60 mesh size was heated at 250 °C for 1 hour in He gas flow, cooled to room temperature and then 5% NH_3 (balance nitrogen gas) was passed through the sample for 30 minutes. After purging with He for 10 minutes to remove excess ammonia present, the TPD-NH_3 was performed in the temperature range of 35–800 °C at a heating rate of 10 °C/min. The TCD signals were measured after 100 ^oC and a waiting time of 15 minutes to remove any physisorbed ammonia. Thermogravimetry(TG) analysis of un-calcined materials was carried out in TA Qseries-600 instrument using an aluminium pan in a temperature range 30 to 800^oC by programmed heating at rate of 10^oC/min.The SEM micrographs were obtained using a JEOL JED-2300 analysis station microscope.

Catalytic activity test

The catalytic Biginelli condensation of benzaldehyde, urea and ethylacetoacetatewas performed in a dry two necked RB flask fitted with a reflux condenser to one of the necks. The other neck of the RB flask is closed by a rubber cork and the analytical samples were removed carefully through this end. For the initial catalytic screening test, 8mmol of benzaldehyde, 8mmol of ethyl acetate and 12mmol of urea were taken in the RB flask along with 0.1g catalyst and 5mL of ethanol as solvent. The RB flask containing reactants and catalyst was heated in an oil bath and agitated on a magnetic stirrer at 90^oC for 2h. Then reaction mixture was cooled and the solvent ethanol was removed by applying vacuum under warm condition. Then ice cubes were added to precipitate 3,4-DHP formed and thoroughly mixed to remove unreacted urea from the reaction mixture. The slurry was filtered and washed with ice cold water followed by cold ethanol to remove un-reacted aldehyde or ester. The product 3,4-DHP and catalyst were separated by washing and filtration with hot ethanol. The filtrate containing the desired product dissolved in ethanol was concentrated and re-crystallized. The % yield of separated DHP was calculated with respect to the weight of input benzaldehdye. The product was also identified by GC MS analysis and melting point determination.

RESULTS AND DISCUSSION

Physico-chemical properties

The list of materialswith atomic mol percentage of Cr and Fe, surface area, total pore volume, average pore diameter and total acidity values are given in Table.1. The atomic mol percentage of Cr and Fe are found in good agreement with that of input addition. The surface area of materials is in the range 137 to 193 m^2/g. The increasing order of surface of the material is CrFeAlP25<FeAlP< CrFeAlP2.5 <AlP = CrAlP< CrFeAlP5.The variation in the surface area is related to the changes in the pore diameter and particle size due to the presence of transition metals in aluminophosphate material.

While the surface area decreased from AlP by Fe loading, it unchanged by Cr loading. In the case of chromium and iron mixedaluminophosphates, the surface area is found to be decreased first with increase in the atomic mole percentage of chromium and iron and then gradually increased by a higher metal content up to 5mol%. There is a significant increase in the total surface area from 2.5% each Fe and Cr loaded sample (167m^2/g) to 5% each Fe and Cr metal loaded sample (193m^2/g). But the surface area of CrFeAlP25 is found to be significantly decreased when compared all other materials. It may be attributed to the disturbance of porous network of aluminophosphate by high percentage of Cr and Fe.

Table 1. Various phosphate materials with atomic mol percentage of metals, BET surface area, pore volume, pore diameter and total acidity

Material	Atomic mol percentage of Cr and Fe	BET Surface area (m^2/g)	Pore Volume (cm^3/g)	BJH adsorption Pore Diameter (nm)	Total acidity (mmol/g)
AlP	Fe: Nil Cr: Nil	181	0.50	10.9	0.09
FeAlP	Fe: 2.56 Cr: Nil	153	1.00	26.4	0.06
CrAlP	Fe: Nil Cr: 2.41	181	0.90	19.6	0.13
CrFeAlP2.5	Cr: 2.35 Fe: 2.40	167	1.00	25.2	0.08
CrFeAlP5	Cr: 4.73 Fe: 4.86	193	0.80	16.3	0.12
CrFeAlP25	Cr: 23.80 Fe: 24.64	137	0.43	12.43	0.70

The average adsorption pore diameter increased with single and double metal loading in aluminophosphates only up to 2.5% percentage of metal loading. Pore diameter is slightly decreased by higher metal content (5% metals loading). The 5% Fe and Cr loaded sample possessed a pore diameter of 16.3nmversus 25.2nm of 2.5% loaded sample. Thus by higher amount Cr and Fe loading (5%), even though surface area is increased, the pore diameter is not changed significantly. An interesting observation is that due to metal loading in pure aluminium phosphates the total pore volume is increased from 0.5 to almost 1 mL/g in all samples except CrFeAlP25. It is an added advantage to aluminophosphate that the extent of intake of any reactant molecule will be higher with Fe or Cr loaded one. A high value of pore volume is obtained in the 2.5% metal loaded sample, after that there is slight decrease. It may be attributed to the blockage of pores due higher amount of hetero metals in AlP.

N_2 adsorption-desorption isotherms of the materials are presented in Figure 1. While AlP, type-V isotherm and H4 hysteresis loop with limiting adsorption, CrAlP, FeAlP and CrFeAlP materials exhibited type-V isotherm with H3 type hysteresis loop which did not exhibit any limiting adsorption at high P/P_0 value. The hysteresis loops observed is attributed to capillary condensation taking place within a narrow range of tubular pores, confirming the high dimension of the pores [30]. The H4 type hysteresis in AlP revealed the absence of large mesopores and macropores and presence of slit like pores which is complimentary to the surface area results. This fact is again substantiated by the presence of hysteresis loops at low pressure region. The H3 type hysteresis in metal-aluminophosphates and mixed metal-aluminophosphates revealed the widened pores with aggregates of plate like particles [31].

The powder XRD profiles of all materials are found to be amorphous with broad peak around 2θ of 25 degree as reported in literature (Figure 2)[26].The Fourier Transform-Infra Red (FTIR) spectra of aluminophosphate and Cu/Zn-aluminophosphates are shown in Figure 3. All the phosphates prepared showed nearly similar type of OH stretching vibration band zone (3600–3000 cm^{-1}) centered at 3500 cm^{-1}, which is attributed to the surface hydroxyl groups associated with metal, aluminum and phosphorous atoms [32]. The weak absorption bands around 1640 cm^{-1}, pointed out the presence of adsorbed carbon dioxide molecules. It is to be noted that all the samples exhibited characteristic absorption peaks due to the asymmetric vibrations of phosphate in the range of 1100 to 1140 cm^{-1}. The IR spectra also exhibited shoulder peaks at 725 and 507 cm^{-1} which are respectively assigned to the symmetric stretching mode of P-O-P and bending mode of O-P-O bonds [33].

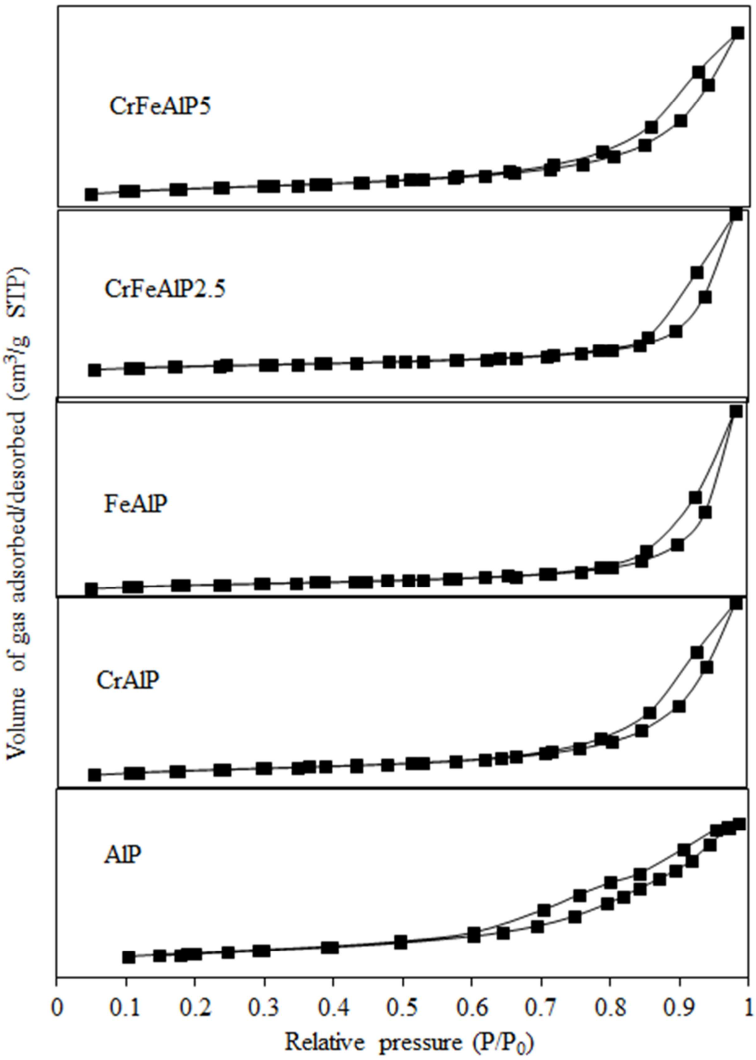


Figure 1. N_2adsorption-desorption isotherms of materials

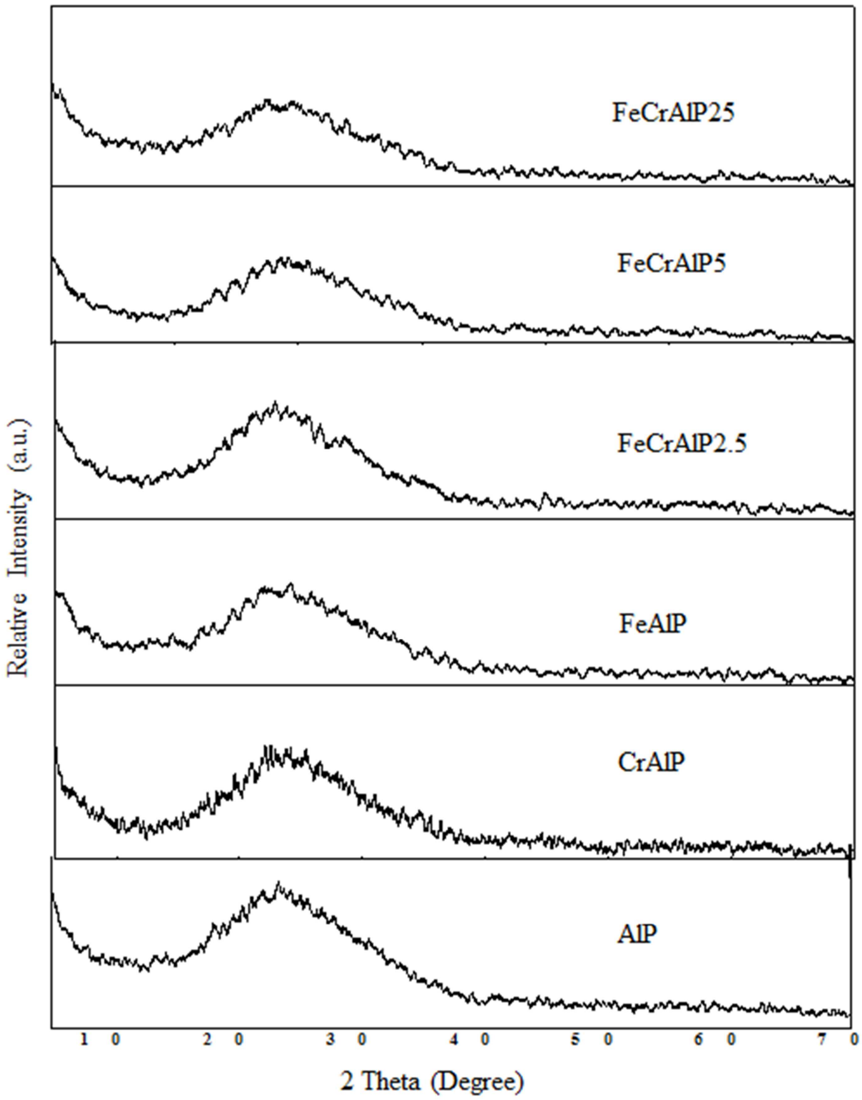


Figure 2. PXRD profiles of AlP and Cr/FeAlP materials

Since Biginelli type condensation is catalyzed by acid sites, the type and strength of acidic sites of pure and metal loaded aluminophosphates has an important role to play in the reaction. Ammonia temperature programmed desorption (NH_3-TPD) profiles of the AlP, Cr/FeAlP materials are presented in Figure 4. The acidic properties of pure aluminophosphate are significantly affected by Cr and Fe incorporation during its precipitation. Generally weak acid sites are observed in aluminophosphates at around the T_{max} of 170°C temperature. It is observed from Figure 4 that the peak is shifted to higher temperature side by the incorporation of metals such as Cr and Fe.The amount of strong acid sites is increased in aluminophosphates with increasing amount of Cr and Fe. A clear shift from weak to medium and then to strong acidic sites is observed from pure aluminophosphate to CrFeAlPn samples. A predominant amount of strong acidic sites are found to be formed in the CrFeAlP25.

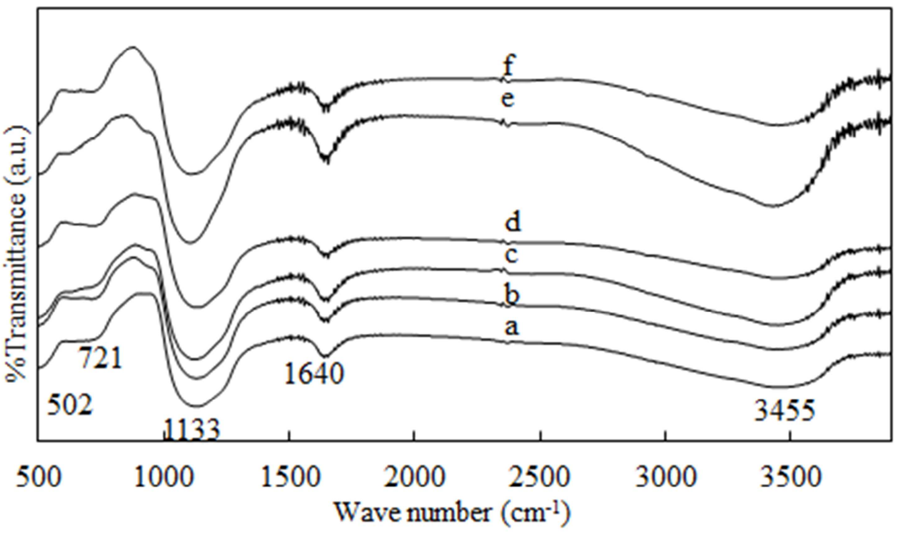


Figure 3. FT-IR spectra of (a) AlP, (b) CrAlP, (c) FeAlP, (d) CrFeAlP2.5, (e) CrFeAlP5 and (f) CrFeAlP25

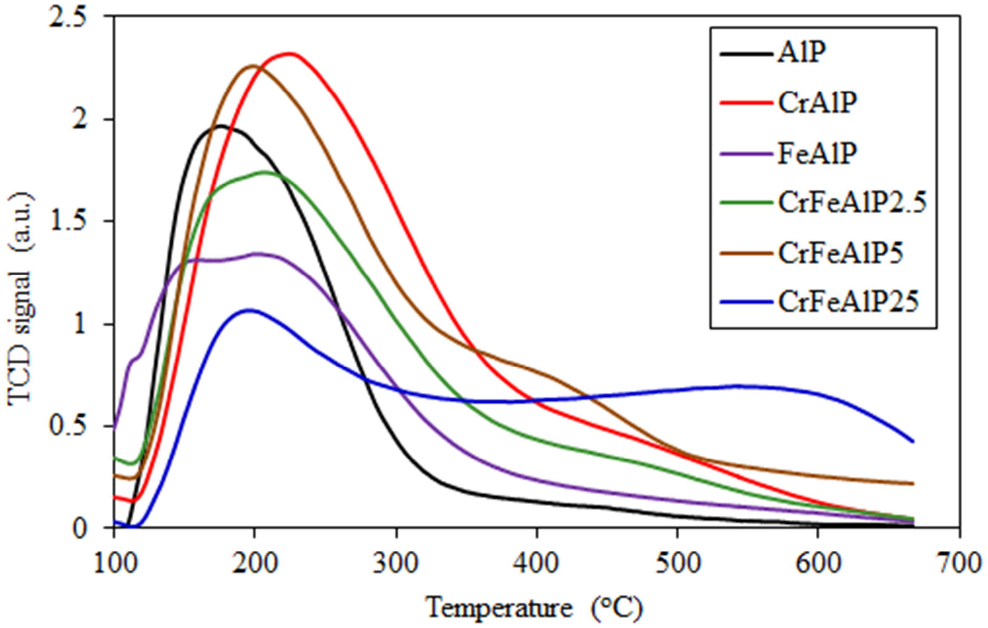


Figure 4. NH_3-TPD profiles of aluminophosphates and Cr/Fe-AlPs

The Scanning Electron Micrographs of AlP and CrFeAlP2.5 are given Figure 5. In general all the materials are characterized by irregular aggregates of plate like shapes with non-uniform porous nature, with the inter particle spaces which is also considered as the reason for porosity of these materials.

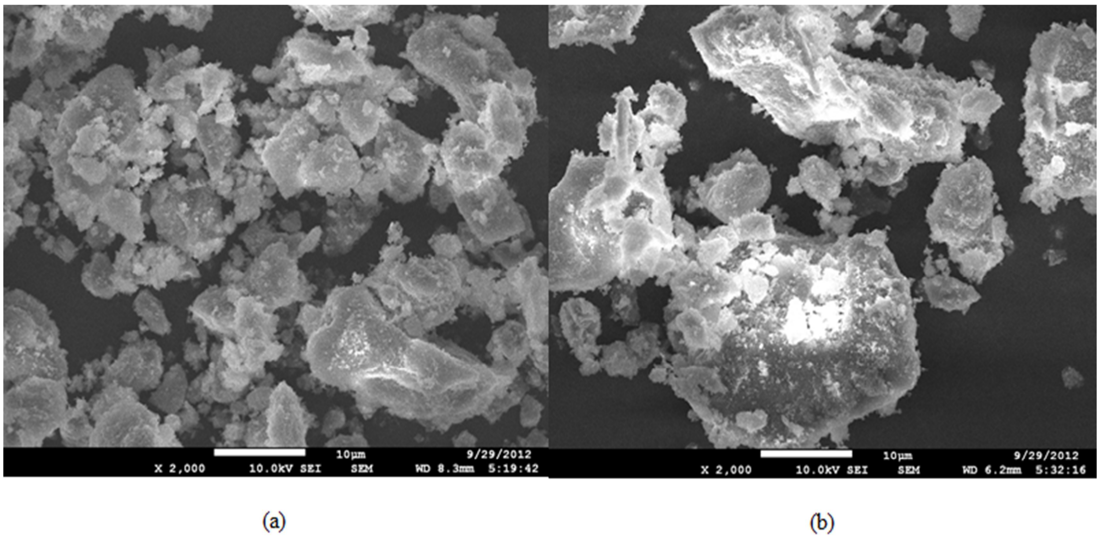


Figure 5. The SEM images of AlP and CrFeAlP2.5

Catalytic activity of AlP, Cr/FeAlP in Biginelli condensation

The catalytic activity of AlP, CrAlP, FeAlP and CrFeAlPn materials are investigated in Biginellicondensation of benzaldehyde, urea and ethyl acetoacetate and the results are presented in Table 2. Pure aluminophosphate (AlP) possessed a yield of 47% of the isolated product. AlP is characterized by weak acidic sites from ammonia TPD studies and this is the reason for the comparatively low yield of the product. The FeAlPshowed slightly increased yield than AlP. FeAlP is characterized by weak acidic sites but with higher concentration of these sites than in AlP and thus the activity is also affected marginally. But a good yield of DHP is achieved with CrAlP and CrFeAlPn catalysts, which is attributed due a higher concentration of moderate strength acidic sites in these catalysts. A high yield of 74% was achieved using CrFeAlP5 with the initial experimental conditions, which possessed not only a high surface area, porosity but also high acidic strength. An interesting observation with CrFeAlP25 catalyst is that the yield of the product is low (61%) even though it contains a good amount of moderate and strong acidic sites. This may be attributed to the low surface area, low pore volume and pore diameter of this material. The low pore size in this catalyst will limit the formation bulky product molecule DHP and the less dispersion and interaction of substrates and active sites. Thus the catalyst CrFeAlP5 is identified as the best catalyst out of the selected ones and further optimization studies are conducted using the same.

Table 2. The yield of DHP using different aluminophosphate catalysts

Catalyst used	% Yield of DHP
AlP	47
FeAlP	55
CrAlP	63
CrFeAlP2.5	65
CrFeAlP5	74
CrFeAlP25	61

Reaction condition: temperature 80^{o}C, duration 2h, mol ratio of benzaldehyde:EAA:urea 1:1:1.5, catalyst amount 10% w.r.t benzaldehyde, solvent ethanol (5ml).

Optimization of reaction conditions

Since CrFeAlP5 is identified as the best catalyst forBiginelli condensation of benzaldehyde, urea and ethyl acetoacetate to synthesis 3,4 DHP, the optimisation of reaction condition is carried out using this catalyst. The experimental conditions studied are temperature, duration, damount of catalyst and use of solvents for the same reaction. The resultswith respect to the yield of isolated product are discussed below.

Effect of Temperature

The effect of reaction temperature in the range of 30-100 ^{o}C on the catalyst performance in Biginelli condensation is studied using CrFeAlP5 catalyst keeping all remaining conditions the same. The results are tabulated in Table 3. A significant increase in the separated product yield is noted by increasing temperature from normal to 80 °C. After this temperature, there found only marginal increase in the yield of the product. Thus 80°C is considered to be the optimum temperature and safe condition for the activation of the substrates and for a satisfactory catalyst performance. Beyond this temperature a slight yellowish to green coloration is formed in the reaction mixture and it may be due to the formation of Hantzsch reaction product between ethylacetoacetate, aldehyde and ammonia formed from urea and water. The Hantzsch pyridine synthesis is a multi-component reaction between an aldehyde, two equivalents of a beta keto ester and a nitrogen donor such as ammonium acetate or ammonia and the product is 1,4-dihydropyridine, which is also a medicinally important organic compound[34].

Table 3. The effect of temperature on the yield of product

Temperature (°C)	%Yield of 3,4-DHP
30	24
50	41
60	54
70	60
80	74
90	76
100	79

Reaction condition: Catalyst CrFeAlP5, duration 2h, mol ratio of benzaldehyde:EAA:urea 1:1:1.5, catalyst amount 10% w.r.t benzaldehyde, solvent ethanol 5ml.

Effect of duration of the reaction

Catalytic condensation experiments of benzaldehyde, urea and ethyl acetoacetate are conducted at different reaction duration (10 min-4h) and the corresponding percentage yield of separated product are calculated. The results are presented in Table 4. It is observed that high yield is obtained by duration of 3 hours and after that there found no notable change. Thus 3 hour duration is concluded as the optimum for the reaction using CrFeAlP5 catalyst.

Table 4. The effect of duration of the reaction on the yield of product

Reaction time	% Yield of 3,4-DHP
10 min	23
30min	35
1h	51
2h	74
3h	82
4h	85

Reaction condition: Catalyst CrFeAlP5, temperature 80°C, mol ratio of benzaldehyde:EAA:urea 1:1:1.5, catalyst amount 10% w.r.t benzaldehyde, solvent ethanol (5ml).

Table 5. Effect of the solvent on the yield of the DHP

Solvent used	% Yield of 3,4-DHP
Nil	45
Ethanol	82
Ethyl acetate	84
Acetonitrile	71
Hexane	47

Reaction condition: Catalyst CrFeAlP5, temperature 80°C, duration 3h, mol ratio of benzaldehyde:EAA:urea 1:1:1.5, catalyst amount 10% w.r.t benzaldehyde, solvent 5mL.

Effect of solvent

The Biginelli condensation experiments using CrFeAlP5 catalyst are conducted without any solvents and with polar and non-polar solvents. Solvents selected for the studies are ethanol, ethyl acetate, acetonitrile and hexane. The results in terms of percentage yield of Biginelli product is given in Table 5. It is interesting to note that without using any solvents a thick greenish-yellow color product formed in the reaction medium within 10 minutes. But the yield of desired product 3,4-DHP is found to be too low, ie 20%. It may be attributed to occlusion of un-reacted substrates in the solid product mass with interruption of agitation in the reaction mixture and also due to formation of Hantzsch reaction product, which is not desired. The probability of reaction of urea and water (which is formed as byproduct of the Biginelli reaction) to form ammonia is higher in absence of any solvent and hence higher probability for formation Hantzsch reaction product by condensation of aldehyde, ethylacetoacetate and ammonia. Almost a similar conversion is achieved in all the solvents other than hexane. Thus a selection of polar solvent is desirable for the Biginelli reaction using aluminophosphate catalyst because the solvation of reactants is good in this case.

Effect of amount of catalyst

Biginelli condensation experiments are carried out by varying the amount of catalyst CrFeAlP5 used to optimize the quantity of catalyst needed. The results are tabulated in Table 6, where the result of a reaction without using any catalyst is also given. While the results are negligible in the absence of the catalyst, the yield is increased by increasing the weight percentage of the catalyst to 20 from 10. A maximum conversion and high yield of more than 95% towards the desired product is obtained using 20 weight percentage of the catalyst with respect to benzaldehyde.

Table 6. Effect of catalyst amount on the yield of the DHP

Weight % of the catalyst used	% Yield of 3,4-DHP
Without catalyst	Nil
10	82
20	>95

Reaction condition: Catalyst CrFeAlP5, temperature 80^{o}C, duration 3h, mol ratio of benzaldehyde:EAA:urea 1:1:1.5, solvent ethanol 5mL.

CONCLUSION

Amorphous AlP, CrAlP, FeAlP and CrFeAlPn materials (where n = 2.5, 5 or 25) are prepared by co-precipitation method without using any surfactant or structure directing molecules. These materials are characterized by various analytical methods. The surface and acid properties of aluminophosphate is found to be affected significantly by incorporation of Cr/Fe. These materials are used as catalysts for the Biginelli type condensation reaction to synthesize highly important pharmacological compound 3,4-dihydropyrimidinone under ambient reaction conditions. Among the various Cr/Fe -aluminophosphates, CrFeAlP5 has been found to be an efficient catalyst for the synthesis of 3,4-dihydropyramidinone via Biginelli condensation of benzaldehyde, ethylacetoacetate and urea with 100 % selectivity. The catalytic activity is attributed the presence of high concentration of week acid sites along with a high surface area and porosity. Incorporation of Cr and Fe in aluminophosphate by co-precipitation method resulted in design of highly efficient catalyst for application in the synthesis of 3,4-dihydropyrimidinones

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