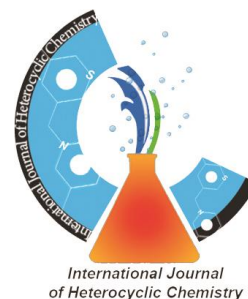

Research article

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synthesis of trisubstituted pyrimidines using iron (III) phosphate

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Abstract

Iron (III) phosphate catalyzed condensation reaction of aldehydes, 1,3-dicarbonyl compounds and ammonium acetate refluxing ethanol that remains a common theme in current literature.

Keywords: Condensation, Cyclization, Heterocycles, Pyrimidines, Iron(III) phosphate

Introduction

Pyrimidines include a large number of natural products, pharmaceuticals, and functional materials, [1] such as trimethoprim, [2] sulfadiazine, [3] Gleevec [4] and Xeloda. [5] Natural and unnatural polymers also contain pyrimidines. [6] The first report was developed by nitric acid oxidative degradation of uric acid. [7] Since this early report many important contributions describing a variety of methods for preparation of pyrimidines have been reported. [8]

2,4,6-Trisubstituted pyrimidines have been prepared using various procedures including the reaction of amidines with α,β -unsaturated ketones, [9] dimerization–oxidative fragmentation of aryl- β -arylvinyldimines, [10] one-pot condensation of β -dicarbonyl compounds, NH_4OAc and aldehydes, [11,12] condensation of phenacyldimethylsulfonium salts, aldehydes, and ammonia, [13] reaction of alkynes and nitriles in the presence of TfOH, [14] rearrangement of 2,4,5-trisubstituted imidazolines, [15] one-pot, three-component reaction of aryl halides,

terminal propargyl alcohols and amidinium salts based upon a coupling-isomerization–cyclocondensation sequence, [16] arylation of halogenated pyrimidines via a Suzuki coupling reaction, [17] reaction of α,α -dibromo oxime ethers with Grignard reagents, [18] microwave-assisted reaction of amidines and alkynes, [19] sequential assembly of aryl groups onto a pyrimidine core (2-methylthiopyrimidine), [20] the synthesis of pyrimidines using heteropolyacids [21] and Microwave-assisted synthesis of 2,4,6-triarylpyrimidines under solvent-free conditions. [22]

However, in some these methods the reactants such as amidines, unsaturated ketones, aryl-b-arylvinylimines, sulfonium salts, imidazoline derivatives, and dihalo oxime ethers have to be synthesized initially, hence these methods are relatively expensive and time consuming.

Owing to the important properties of pyrimidines, the development of synthetic methods which enable a facile access to this heterocycle are demand. In present research we report fairly greener route to the synthesis of 2,4,6-triarylpyrimidines using 1,3-dicarbonyl compounds, aldehydes and NH_4OAc in the presence of iron(III) phosphate as a reusable catalyst from green chemistry point of view (fig 1)

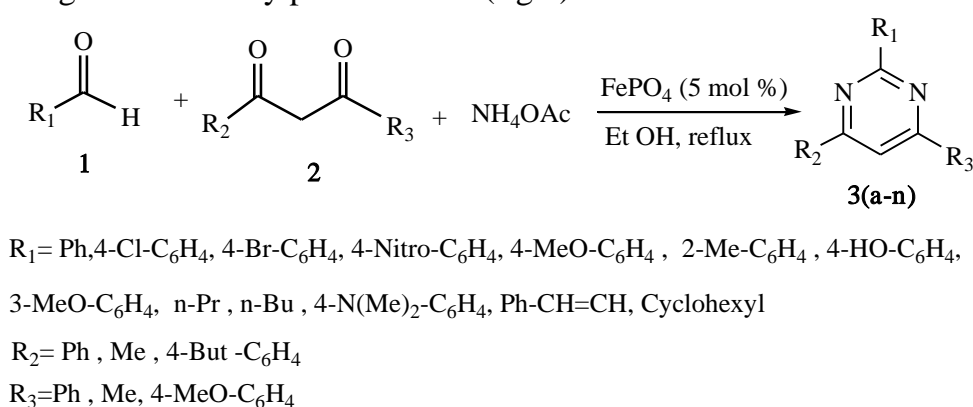


fig 1. Synthesis of 2,4,6-triarylpyrimidines

Experimental

Mps were measured by using the capillary tube method with an electro thermal 9200 apparatus. IR spectra were recorded on Perkin Elmer FT-IR spectrometer did scanning between 4000–400 cm^{-1} . ^1H NMR and ^{13}C -NMR spectra were obtained on Bruker DRX-400MHZ NMR instrument in CDCl_3 . All the products(entries 1-13, Table 2) were identified by comparison of their physical and spectroscopic data with those of authentic samples.

Synthesis of 2,4,6-triaryl pyrimidines. A mixture of 1,3-diketone, (10 mmol), benzaldehyde (10 mmol), ammonium acetate (20 mmol) and catalytic amount of FePO_4 (5.0 mol%) was refluxed in ethanol (10 ml). The progress of the reaction was monitored by TLC and the spot were detected either UV light or by placing in iodine chamber. Upon completion of the reaction, the catalyst was filtered off and the crude product recrystallized from ethanol/water.

Results and discussion

In continuing our own study using iron(III) phosphate[23,24] we interest to employ the oxidative potential of FePO_4 [25] as well as their acidic properties as catalyst for a simple and efficient synthesis of 2,4,6-trisubstituted pyrimidines. We investigated the reaction of 1,3-diketones, aldehydes and ammonium acetate in the presence of catalytic amounts of FePO_4 . Various parameters were investigated to obtain the optimum reaction conditions.

To study the effect of the catalyst amount on this reaction, the synthesis of 2,4,6-triphenyl pyrimidine was selected as model reaction using FePO_4 . The results are reported in Table 1.

Table 1. Synthesis of 2,4,6-triphenyl pyrimidine using different amount of FePO_4

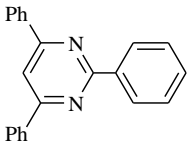
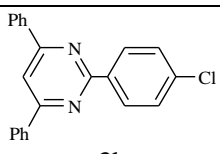
Entry	Catalyst(mol %)	Time(h)	Yield (%)
1	0	24	10
2	2	4.0	45
3	5	4.0	80
4	10	4.0	80

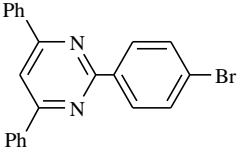
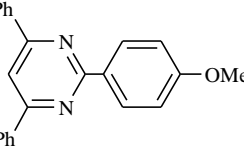
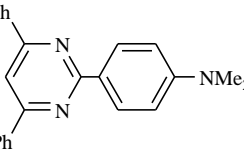
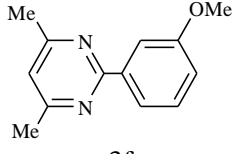
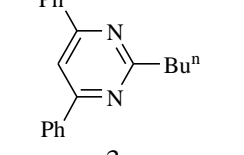
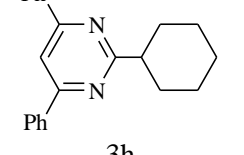
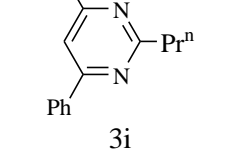
It is clear that the yield depend on the amount of catalyst, the optimum amount of which was 5.0 mol% for all derivatives.

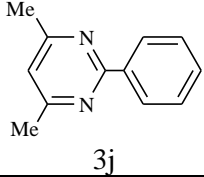
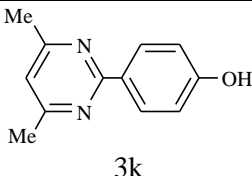
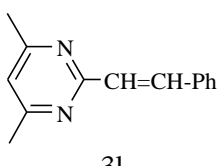
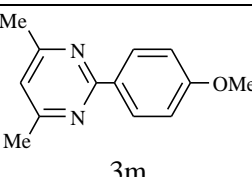
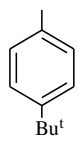
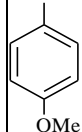
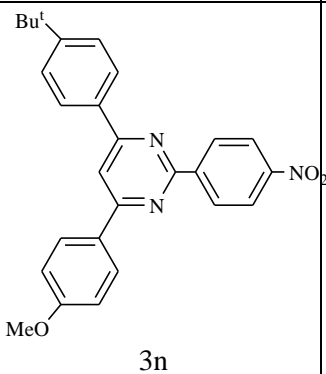
On the basis of the above results, a facile three component one synthesis of trisubstituted pyrimidines was envisaged using various aldehydes, 1,3-diketones and ammonium acetate in the presence of 5 mol% of iron (III) phosphate and ethanol under reflux condition in a green organic reaction.

The results on the synthesis of pyrimidines in the presence of catalytic amounts of FePO_4 are summarized in Table 2. One can see Table 2 demonstrates that good to high yields of trisubstituted pyrimidines are obtained across the selected aldehydes including those that bear an electron-withdrawing group. The use of electron-rich aromatic aldehydes also leads to good yields of products.

Table 2. FePO_4 -catalyzed synthesis of 2,4,6-trisubstituted pyrimidines

Entry	R ₁	R ₂	R ₃	Product	Time (h)	Yield ^a (%)	MP(°C) Found Reported
1	Ph	Ph	Ph	 3a	5.0	80	177-186 184-185[1]
2	4-Cl-C ₆ H ₄	Ph	Ph	 3b	6	78	200-205 219-220[1]

3	4-Br-C ₆ H ₄	Ph	Ph	 <p>3c</p>	5	77	228-234 237[2]
4	4-OMe-C ₆ H ₄	Ph	Ph	 <p>3d</p>	4	79	95-110 128[2]
5	4-NMe ₂ -C ₆ H ₄	Ph	Ph	 <p>3e</p>	5	89	34-38 [3]
6	3-OMe-C ₆ H ₄	Ph	Ph	 <p>3f</p>	6	75	106-111 [3]
7	Bu ⁿ	Ph	Ph	 <p>3g</p>	10	69	60-65 73[2]
8	Cyclohexyl	Ph	Ph	 <p>3h</p>	9	72	107-112 120[2]
9	Pr ⁿ	Ph	Ph	 <p>3i</p>	11	70	49-53 56[2]

10	Ph	CH ₃	CH 3	 3j	7	70	80-87 80[4]	79-
11	2-HO- C ₆ H ₄	CH ₃	CH 3	 3k	8	77	68-73	81[5]
12	Ph- CH=CH	CH ₃	CH 3	 3l	6	75	39-46 50[6]	47-
13	4-OMe- C ₆ H ₄	CH ₃	CH 3	 3m	4	79	84-92 92[7]	91-
14	4-NO ₂ - C ₆ H ₄	 		 3n	4	88	65-70	NEW

a) Yields refer to isolated yield.

The overall greenness of this reaction was high as minimum amount of environmentally benign ethanol and FePO₄ were used during the course of reaction. Moreover, it is important to note that in all cases, after completion of the reaction FePO₄ filtrated off and reused for another run.

Trisubstituted primidines were also precipitated on dilution of the reaction mixture with water and were isolated by a simple filtration. The dried product that obtained showed a single spot on TLC and was pure enough for all practical purposes. Another advantage of this research is synthesis of 4-(4-tert-butylphenyl)-6-(4-methoxyphenyl)-2-(4-nitrophenyl) pyrimidine for first time as a new primidine (entries 14, Table 2). We are willing to survey their biological properties in future.

A plausible mechanism²¹ for the formation of trisubstituted pyrimidines is proposed as shown in Scheme 2.

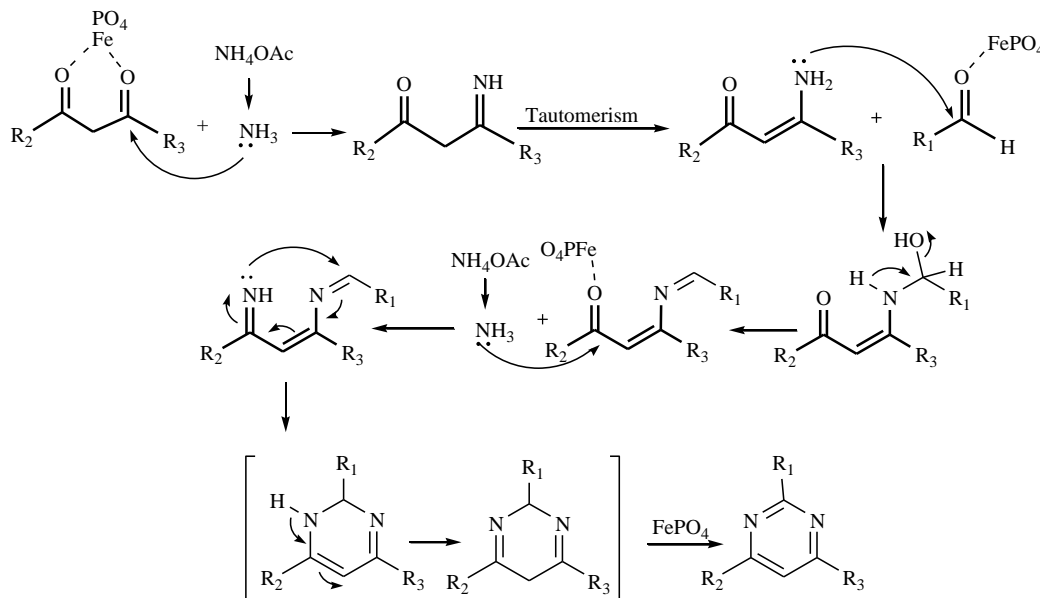


Fig 2. A plausible mechanism for the formation of trisubstituted pyrimidines

FePO_4 is Lewis acid because of the hard character of its metal cation, so that it can activate the carbonyl group ($\text{C}=\text{O}$) to decrease the energy of transition state. This reaction involves the initial imination/enamination tautomerization of the 1,3-diketone followed by nucleophilic attack of the ketenamine on the aldehyde. Dehydration/iminization and cyclization/aromatization afforded trisubstituted pyrimidines.

4-(4-*tert*-butylphenyl)-6-(4-methoxyphenyl)-2-(4-nitrophenyl)pyrimidine (entry 14)

IR(KBr.) 3393.05, 3071.42, 2959.60, 2901.09, 1925.92, 1604.24, 1509.01, 1509.01, 1456.81 1434.86, 1306.55, 1259.82, 1232.12, 1172.28, 1109.99, 1028.40, 842.91, 752.83, 698.26, 633.42 cm^{-1} ; ^1H NMR(CDCl_3 , 400MHz) 1.37 (s, 9H), 3.89 (s, 3H), 6.78(s, 1H), 6.98 (d, $J=8.67$ Hz, 2H), 7.50 (d, $J=8.28$ Hz, 2H), 7.69 (d, $J=8.43$ Hz, 2H), 7.91 (d, $J=8.28$ Hz, 2H), 7.97(d, $J=8.67$ Hz, 2H), 8.15(d, $J=8.43$ Hz, 2H) ppm; ^{13}C NMR (CDCl_3 , 400MHz) 164.7, 162.5, 161.5, 160.7, 150.0, 136.8, 130.0, 128.5, 127.1, 125.6, 121.6, 114.8, 102.5, 55.9, 40.7, 31.4 ppm; GC/Mass: 439; Elemn. Anal. Calcd. for $\text{C}_{27}\text{H}_{25}\text{N}_3\text{O}_3$: C, 73.78; H, 5.73; N, 9.56; Found: C, 73.58; H, 5.59; N, 9.45.

At the end of the reaction, the catalyst could be recovered by filtration. The recycled catalyst was washed with ethyl acetate and subjected to a several reaction process. Table 3 compares the efficiency of FePO_4 in the synthesis of triphenyl pyrimidine over 4 runs.

Entry	Aldehyde	Run/ Yield (%)
1	Benzaldehyde	1st/80
2	"	2nd/78
3	"	3th/78
4	"	4th/77

Table 3. Recycling and reusing of the catalyst for the synthesis of 2,4,6-triphenyl pyrimidine has been shown.

Conclusion

In conclusion, we have developed a simple, one-pot, four-component procedure for the preparation of 2,4,6-trisubstituted pyrimidines of potential synthetic and pharmacological interest. The use of commercial materials, the green one-pot reaction, easy work up and simple purification of the products are the main advantages of this method. This method appears to have a broad scope with respect to variation in substitution at the 2-, 4-, and 6-position of pyrimidine. Thus it could be a novel methodology besides previous procedures.

References

- [1] (a) K. Undheim, T. Benneche, *Pergamon, Oxford* 1996, **6**, 93. (b) I.M. Lagoja, *Chem. Biodiversity* 2005, **2**, 1. (c) J.P. Michael, *Nat. Prod. Rep* 2005, **22**, 627. (d) J.A. Joule, K. Mills, in *Heterocyclic Chemistry, 4th ed.* Blackwell, Cambridge 2000, 194. (e) A.W. Erian, *Chem. Rev* 1993, **93**, 1991.
- [2] A.M. Joffe, J.D. Farley, D. Linden and G. Goldsand, *Am. J. Med.* 87(1989) 332.
- [3] E. Petersen and D.R. Schmidt, *Expert Rev. Anti-Infect. Ther.* 1(2003) 175.
- [4] E. Nadal, E. Olavarria, *Int. J. Clin. Pract.* 58 (2004) 511.
- [5] J.L. Blum, *Oncologist.* 6(2001) 56.
- [6] (a) S. Kçytepe, A. Pasahan, E. Ekinici and T. Selkin, *Eur. Polym.J.* 41 (2005) 121. (b) R. Gompper, H-J. Mair and K. Polborn, *Synthesis.* 79 (1997) 696. (c) T. Kanbara, T. Kushida, N. Saito, I. Kuwajima, K. Kubota and T. Yamamoto, *Chem. Lett.* 23(1992) 583.
- [7] (a) G. Brugnatelli, *Giornale, difisica. chimica, etstoria Naturale (Pavia) decada secunda 1818*, **1**, 117. (b) G. Brugnatelli, *Ann. Chim. Phys* 8(1918) 201.
- [8] D.H. Matthew and M. Movassaghi, *Chem. Eur. J.* 14 (2008) 6836.
- [9] A.L. Marzinzik and E.R. Felder, *J. Org. Chem.* 63 (1998) 723.
- [10] A.R. Forrester, M. Gill and R.H. Thomson, *J. Chem. Soc., Perkin Trans.* 1 (1979) 616.
- [11] A.L. Weis and V. Rosenbach, *Tetrahedron Lett.* 22 (1981) 1453.
- [12] M.M. Heravi, S. Sadjadi, H.A. Oskooie, R.H. Shoar and F.F. Bamoharram, *Tetrahedron Letters.* 50(2009) 662.
- [13] K.C. Gupta and P. Manglum, *Curr. Sci.* 58(1989) 1196.
- [14] A.G. Martınez, A.H. Fernandez, R.M. Alvarez, M.C.S. Losada, D.M. Vilchez, L.R. Subramanian and M. Hanack, *Synthesis.* 22 (1990) 881.
- [2] M. Seki, H. Kubota, K. Matsumoto, A. Kinumaki, T. Da-te and K. Okamura, *J. Org. Chem.* 58 (1993) 6354.
- [15] T.J.J. Muller, R. Braun and M. Ansorge, *Org. Lett.* 2(2000) 1967.
- [16] J.M. Schomaker and T.J. Delia, *J. Org. Chem.* 66 (2001) 7125.
- [17] H. Kakiya, K. Yagi, H. Shinokubo and K. Oshima, *J. Am. Chem. Soc.* 124 (2002) 9032.
- [18] M.C. Bagley, D.D. Hughes and P.H. Taylor, *Synlett.* 2 (2003) 259.
- [19] K. Itami, D. Yamazaki and J. Yoshida, *J. Am. Chem. Soc.* 126 (2004) 15396.
- [20] M.M. Heravi, S. Sadjadi, H.A. Oskooie, R.H. Shoar and F.F. Bamoharram, *Tetrahedron Letters.* 50 (2009) 662.
- [21] M. Adib, N. Mahmoodi, M. Mahdavi and H.R. Bijanzadeh, *Tetrahedron Letters.* 47 (2006) 9365.
- [22] M.M. Heravi, F.K. Behbahani, V. Zadsirjan and H.A. Oskooie, *Heterocyclic Commun.* 12 (2006) 369.
- [23] F.K. Behbahani, T. Yektanezhad and A.R. Khorrami, *Heterocycles.* 81 (2010) 2313.
- [24] K. Otsuka and Y. Wang, *Appl. Catal. A: Gen.* 222 (2001) 145.