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Fe^{+3}-MONTMORILLONITE K10: AS AN EFFECTIVE AND REUSABLE CATALYST FOR THE SYNTHESIS OF 3,4-DIHYDROPYRIMIDIN-2(1H)-ONES AND –THIONES

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ABSTRACT. In this study, a novel, clean, convenient, appropriate and environmentally benign route to dihydropyrimidinone and thione derivatives has been developed using the reaction between various benzaldehydes, urea or thiourea, and ethyl acetoacetate in the presence of Fe^{+3}-montmorillonite K10 under grind condition. The present methodology has several advantages such as simple work-up, solvent-free conditions, environmental friendliness and shorter reaction time along with high yields. Several aromatic aldehydes carrying either electron-releasing or electron-withdrawing substituents in the *ortho* and *para* positions were tested in this reaction. Another important feature of this procedure is the survival of a variety of functional groups under the reaction conditions. All of synthesized compounds were characterized by IR, ^{1}HNMR, ^{13}CNMR and elemental analyses.

KEY WORDS: Grinding, K10, Urea, Thiourea, Ethyl acetoacetate, Biginelli reaction

INTRODUCTION

In the past decade, dihydropyrimidinones (DHPMs) and their derivatives have attracted considerable interest because they exhibit promising activities such as calcium channel blockers, antihypertensive agents, and a-1a-antagonists and neuropeptide Y (NPY) antagonists [1]. Furthermore, several bioactive isolated marine alkaloids were also found to contain 2-amino-1, 4-dihydropyrimidinone-5-carboxylate core [2]. Most notably among them are the batzalladine alkaloids, which have been found to be potent HIV-gp-120-CD4 inhibitors [3, 4]. Their derivatives exhibit a wide spectrum of biological effects including antifungal, antiviral, anticancer, antibacterial, anti-inflammatory, and antihypertensive effects [5-7].

In 1893, Petro Biginelli reported the first synthesis of 3,4-dihydropyrimidin-2(1*H*)-one (DHPM) by a very simple one-pot condensation reaction of an aromatic aldehyde, *β*-ketoesters and urea under strongly acidic conditions [8]. In order to improve the efficiency of Biginelli reaction, a variety of catalysts have been reported which of them $H_4PMo_{11}VO_{40}$ [9], Dowex-50W [10], $H_3PW_{12}O_{40}/SiO_2$ [11], $MgBr_2$ [12], polymer-supported 4-aminoformoyl-diphenylammonium triflate [13], $NaHSO_4/SiO_2$ [14], $FeCl_3$ [15], $ZrCl_4$ [16], $Cu(OTf)_2$ [17], $Bi(OTf)_3$ [18], yutterbium triflate [19], 12-molbdophosphoric acid [20], natural HEU type zeolite [21], $Sr(OTf)_2$ [22], covalently anchored sulfonic acid onto silica [23], $ZrOCl_{28}H_2O$ [24], silica triflate [25], $Fe(HSO_4)_3$ [26], TCICA [27], PPh_3 [28], CaF_2 [29], [bmim]BF_4-immobilized Cu(II) acetylacetonate [30], [bmim][$FeCl_4$] [31], Fe^{+3}- montmorillonite K10 [32], MCM-41 [33] and solvent free condition [34] are examples.

However, in spite of their potential utility, the practical application of most of these reagents suffers from disadvantages such as the use of expensive or less easily available reagents, vigorous reaction conditions, long reaction times, high temperatures, unsatisfactory yields and tedious manipulations to isolate the products. Therefore, the development of simple, efficient, clean, high-yielding, and environmentally friendly approaches using new catalysts for the synthesis of these compounds is an important task for organic chemists.

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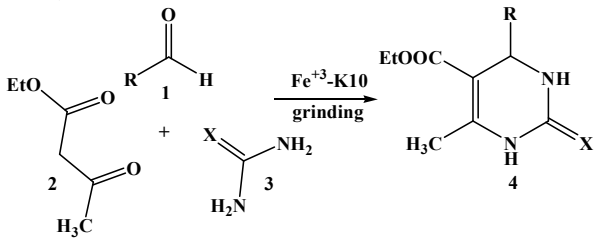
On the other hand, the application of solid acid catalysts has afforded importance in organic synthesis due to several advantages like operational simplicity, ease, recyclability, non-toxicity, and easy isolation after completion of the reaction.

Solvent free chemistry is a powerful method for the preparation of various molecules, due to their special activity, the ease of work-up and set-up, arising great interest [35]. Moreover, organic reactions in the absence of solvent are relatively faster. This solvent free reactions and low cost equipment could become an important factor in industry.

In the continuation of our researches for the synthesis of heterocyclic and pharmaceutical compound [36-40], this is the first grind mediated synthesis of some derivatives of 3,4-dihydropyrimidin-2(*1H*)-ones and -thiones using catalytic amount of Fe^{+3}-K10 montmotillonite, as shown in (Scheme 1).



Scheme 1. Synthesis of dihydropyrimidinone and thione derivatives using Fe^{+3}-montmorillonite K10 under grinding.

EXPERIMENTAL

Melting points were measured on an Electrothermal 9100 apparatus. IR spectra were determined on a Shimadzo IR-470 spectrometer. ^{1}H NMR and ^{13}C NMR spectra were recorded on a 500 MHz Bruker DRX-500 in $CDCl_3$ as solvent and TMS as internal standard. Chemicals were purchased from Merck and Fluka. Elemental analyses were done on a Carlo-Erba EA1110CNNO-S analyzer and agreed with the calculated values. All solvents used were dried and distilled according to standard procedures. Montmorillonite K10 [surface area: (200±10) m^2/g; surface acidity 0.65 meq. H^+/g (determined in our laboratory by temperature programmed desorption of ammonia gas (NH_3-TPD); chemical composition (average value): SiO_2 (73.0%), Al_2O_3 (13.4%), Fe_2O_3 (4.2%), CaO (0.2%), MgO (1.1%), Na_2O (0.6%), K_2O (1.9%) were purchased from Fluka chemical company.

General procedure for the preparation of Fe^{+3}-montmorillonite K10

Metal-exchanged montmorillonite clay catalysts were prepared by adopting the literature methods [41], and dried at 120 ^{o}C overnight. The prepared Fe^{+3}-montmorillonite K10 was titrated with a solution of NaOH 0.1 M. The surface acidity 0.65 meq. H^+/g of natural clay was changed to 0.45 meq. H^+/g in the prepared Fe^{+3}-montmorillonite K10 because of exchanging of surficial H^+ with Fe^{+3} ions. It causes the Lewis acidity of catalyst was increased.

*General procedure for the preparation of **4a-s***

A mixture of aldehyde (1mmol), ethyl acetoacetate (1mmol), urea (1mmol) or thiourea (1 mmol) and Fe^{+3}-montmorillonite K10 (0.1 g) were added to a mortar and the mixture was pulverized with a pestle. A spontaneous reaction took place (Table 2, monitored every 20 seconds by TLC EtOAc : petroleum ether 1:4 drops. After completion of reaction, as indicated

by TLC, the reaction product was extracted by $CHCl_3/H_2O$. After evaporation of organic solvent, the crude product was released and recrystallized from EtOH and dried to afford powdery compounds of **4a-s**. All of synthesized compound are known and were characterized by IR, NMR and elemental analysis.

Selected spectral data

*Ethyl 1,2,3,4-tetrahydro-6-methyl-2-oxo-4-phenylpyrimidine-5-carboxylate (**4a**)*. IR (KBr) (υ_{max}, cm^{-1}): 3242, 3114, 2925, 1726, 1643, 1525, 1460, 1421, 1224; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.18 (t, 3H, ^3J = 9.0 Hz, CH_3), 4.00 (q, 2H, ^3J = 6.0 Hz, CH_2), 5.14 (d, 1H, ^3J = 3.0 Hz, ArH), 7.35–7.12 (m, 4H, ArH), 7.71 (s, 1H, ArH), 9.16 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 165.6, 157.5, 148.0, 142.8, 128.6, 127.3, 123.2, 121.6, 59.1, 48.9, 22.7, 14.3 ppm. Anal. calcd. for $C_{14}H_{16}N_2O_3$: C, 64.60; H, 6.20; N, 10.76. Found: C, 64.68; H, 6.12; N, 10.77.

*Ethyl 4-(4-chlorophenyl)-1,2,3,4-tetrahydro-6-methyl-2-oxopyrimidine-5-carboxylate (**4b**)*. IR (KBr) (υ_{max}, cm^{-1}): 3242, 3114, 2970, 1712, 1647, 1460, 1224, 1091; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.19 (t, ^3J = 6.8 Hz, 3H, CH_3), 2.39 (s, 3H, CH_3), 4.09 (q, ^3J = 1.6 Hz, 2H, CH_2), 5.83 (s, 1H, CH), 7.27 (d, ^3J = 8.8 Hz, 2H, ArH), 7.30 (d, ^3J = 8.8 Hz, 2H, ArH), 8.07 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 168.1, 158.7, 146.7, 142.9, 145.2, 131.8, 128.8, 116.9, 61.3, 51.5, 22.2, 18.4 ppm. Anal. calcd. for $C_{14}H_{15}ClN_2O_3$: C, 57.05; H, 5.13; N, 9.50. Found: C, 57.08; H, 5.12; N, 9.56.

*Ethyl 1,2,3,4-tetrahydro-6-methyl-2-oxo-4-p-tolylpyrimidine-5-carboxylate (**4c**)*. IR (KBr) (υ_{max}, cm^{-1}): 3200, 3100, 2950, 1620, 1600, 1540, 1220; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.23 (t, 3H, ^3J = 7.9 Hz, CH_3), 2.57 (s, 3H, CH_3), 4.43 (q, 2H, ^3J = 1.8 Hz, CH_2), 5.67 (s, 1H, CH), 7.57 (d, 2H, ^3J = 8.5 Hz, ArH), 7.76 (d, 2H, $3J$ = 8.5 Hz, ArH), 8.46 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 167.4, 158.0, 146.3, 135.3, 131.0, 123.2, 123.0, 115.2, 61.3, 51.2, 32.4, 26.5, 17.2 ppm. Anal. calcd. for $C_{15}H_{18}N_2O_3$: C, 65.68; H, 6.61; N, 10.21. Found: C, 65.72; H, 6.62; N, 10.24.

*Ethyl 1,2,3,4-tetrahydro-4-(4-methoxyphenyl)-6-methyl-2-oxopyrimidine-5-carboxylate (**4d**)*. IR (KBr) (υ_{max}, cm^{-1}): 3250, 3100, 2950, 1700, 1640, 1510, 1460, 1220; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.11 (t, 3H, ^3J = 6.8 Hz, CH_3), 2.25 (s, 3H, CH_3), 3.37 (s, 3H, OCH_3), 3.99 (q, , 2H, ^3J = 6.8 Hz, CH_2), 5.09 (s, 1H, CH), 6.89 (d, 2H, ^3J = 8.8 Hz, ArH),7.15 (d, 2H, ^3J = 8.8 Hz, ArH), 7.70 (s, 1H, NH), 9.17 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 167.0, 158.1, 152.5, 149.3, 136.5, 129.9, 123.1, 118.9, 62.2, 60.0, 49.6, 25.8, 19.6 ppm. Anal. calcd. for $C_{15}H_{18}N_2O_4$: C, 62.06; H, 6.25; N, 9.65. Found: C, 62.11; H, 6.23; N, 9.68.

*Ethyl 1,2,3,4-tetrahydro-6-methyl-4-(4-nitrophenyl)-2-oxopyrimidine-5-carboxylate (**4e**)*. IR (KBr) (υ_{max}, cm^{-1}): 3234, 3116, 2981, 1730, 1701, 1641, 1598, 1461, 1521, 1348, 1215; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.20 (t, 3H, ^3J = 7.2 Hz, CH_3), 2.38 (s, 3H, CH_3), 4.12 (q, 2H, ^3J = 6.0 Hz, CH_2), 5.99 (s, 1H, CH), 7.52 (d, 2H, ^3J = 8.8 Hz, ArH), 8.07 (s, 1H, NH), 8.19 (d, 2H, ^3J = 8.8 Hz, ArH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 164.5, 157.9, 151.0, 146.5, 131.6, 127.0, 123.9, 119.4, 60.5, 50.2, 24.9, 18.6 ppm. Anal. calcd. for $C_{14}H_{15}N_3O_5$: C, 55.08; H, 4.95; N, 13.76. Found: C, 55.09; H, 4.93; N, 13.78.

*Ethyl 1,2,3,4-tetrahydro-6-methyl-4-(3-nitrophenyl)-2-oxopyrimidine-5-carboxylate (**4f**)*. IR (KBr) (υ_{max}, cm^{-1}): 3400, 3100, 2950, 1660, 1600, 1580, 1520, 1340, 1220; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.23 (t, 3H, ^3J = 9.2 Hz, CH_3), 2.52 (s, 3H, CH_3), 4.34 (q, 2H, ^3J = 6.7 Hz, CH_2), 5.19 (s, 1H, CH), 7.16-7.23 (m, 2H, ArH), 7.86 (d, 2H, ^3J = 8.6 Hz, ArH), 8.15 (s, 1H, NH), 8.79 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 165.4, 158.3, 149.5, 148.0, 130.9, 130.3,

129.1, 125.6, 121.5, 118.6, 61.2, 53.2, 24.8, 17.4 ppm. Anal. calcd for $C_{14}H_{15}N_3O_5$: C, 55.08; H, 4.95; N, 13.76. Found: C, 55.11; H, 4.97; N, 13.73.

Ethyl 4-(2,4-dichlorophenyl)-1,2,3,4-tetrahydro-6-methyl-2-oxopyrimidine-5-carboxylate ***(4g)***. IR (KBr) (υ_{max}, cm^{-1}): 3353, 3006, 2945, 1698, 1634, 1604, 1486; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.21 (t, 3H, ^3J = 7.6 Hz, CH_3), 2.18 (s, 3H, CH_3), 3.85 (q, 2H, ^3J = 7.6 Hz, CH_2), 5.60 (s, 1H, CH), 7.32 (d, 1H, ^3J = 8.2 Hz, ArH),7.42 (d, 1H, ^3J = 8.2 Hz, ArH), 7.70 (s, 1H, ArH), 9.38 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 166.0, 158.9, 148.5, 147.9, 137.2, 133.2, 130.7, 128.3, 126.0, 122.1, 59.9, 53.5, 25.8, 20.0 ppm. Anal. calcd for $C_{14}H_{14}Cl_2N_2O_3$: C, 51.08; H, 4.29; N, 8.51. Found: C, 51.14; H, 4.24; N, 8.51.

Ethyl 1,2,3,4-tetrahydro-4-(3-hydroxyphenyl)-6-methyl-2-oxopyrimidine-5-carboxylate ***(4i)***. IR (KBr) (υ_{max}, cm^{-1}): 3500, 3315, 3100, 2950, 1720, 1640, 1600, 1460, 1220; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.13 (t, 3H, ^3J = 7.2 Hz, CH_3), 2.24 (s, 3H, CH_3), 4.00 (q, 2H, ^3J = 7.2 Hz, CH_2), 5.06 (s, 1H, CH), 6.62 (d, 1H, J = 1.2 Hz, ArH), 6.68 (d, 2H, J = 6.8 Hz, ArH), 7.10 (t, 2H, ^3J = 8.0 Hz, ArH), 9.11 (s, 1H, NH), 9.31 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 163.6, 157.7, 149.9, 146.4, 133.7, 131.8, 129.8, 124.7, 121.2, 115.9, 60.8, 54.6, 26.5, 18.4 ppm. Anal. calcd for $C_{14}H_{16}N_2O_4$: C, 60.86; H, 5.84; N, 10.14. Found: C, 60.83; H, 5.87; N, 10.11.

Ethyl 1,2,3,4-tetrahydro-4-(4-hydroxyphenyl)-6-methyl-2-oxopyrimidine-5-carboxylate ***(4l)***. IR (KBr) (υ_{max}, cm^{-1}): 3500, 3280, 3100, 2960, 1660, 1520, 1460, 1220; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.11(t, 3H, ^3J = 6.8 Hz, CH_3), 2.24 (s, 3H, CH_3), 3.98 (q, 2H, ^3J = 6.8 Hz, CH_2), 5.05 (s, 1H, CH), 6.70 (d, 2H, ^3J = 8.4, ArH), 7.03 (d, 2H, ^3J = 8.4 Hz, ArH), 9.13 (s, 1H, NH), 9.36 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6): 166.3, 159.3, 153.6, 148.6, 136.6, 125.7, 124.5, 116.4, 62.7, 49.0, 23.9, 19.5 ppm. Anal. calcd for $C_{14}H_{16}N_2O_4$: C, 60.86; H, 5.84; N, 10.14. Found: C, 60.87; H, 5.80; N, 10.19.

Ethyl 4-(furan-2-yl)-1,2,3,4-tetrahydro-6-methyl-2-oxopyrimidine-5-carboxylate ***(4m)***. IR (KBr) (υ_{max}, cm^{-1}): 3512, 3289, 3114, 2955, 1665, 1510, 1466, 1220; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.13 (t, 3H, J = 7.2 Hz, CH_3), 2.24 (s, 3H, CH_3), 3.69 (q, 2H, J = 7.2 Hz, CH_2), 5.12 (s, 1H, CH), 6.65 (d, 1H, J = 8.2, ArH), 7.09 (d, 1H, J = 8.2 Hz, ArH), 7.68 (s, 1H, ArH), 9.22 (s, 1H, NH), 9.42 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 166.0, 159.5, 156.8, 148.4, 143.5, 132.3, 121.3, 119.4, 59.9, 53.0, 25.0, 19.2 ppm. Anal. calcd for $C_{12}H_{14}N_2O_4$: C, 57.59; H, 5.64; N, 11.19. Found: C, 57.63; H, 5.65; N, 11.21.

Ethyl 1,2,3,4-tetrahydro-6-methyl-2-oxo-4-(pyridin-4-yl)pyrimidine-5-carboxylate ***(4n)***. IR (KBr) (υ_{max}, cm^{-1}): 3500, 3354, 3110, 2952, 1672, 1520, 1465, 1208; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.15 (t, 3H, ^3J = 6.7 Hz, ^3J = 8.2, ArH), 7.09 (d, 2H, ^3J = 8.2 Hz, ArH), 9.21(s, 1H, NH), 9.39 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 168.5, 158.7, 154.1, 143.1, 138.8, 121.6, 118.9, 61.0, 52.9, 21.5, 18.7 ppm. Anal. calcd for $C_{13}H_{15}N_3O_3$: C, 59.76; H, 5.79; N, 16.08. Found: C, 59.77; H, 5.78; N, 16.11.

Ethyl 1,2,3,4-tetrahydro-6-methyl-2-oxo-4-propylpyrimidine-5-carboxylate ***(4o)***. IR (KBr) (υ_{max}, cm^{-1}): 3500, 3326, 3127, 2970, 1665, 1535, 1467, 1225; ^{1}H NMR (400 MHz, DMSO-d_6) δ: 1.02 (d, 6H, ^3J = 9.6 Hz, CH_3), 1.15 (t, 3H, ^3J = 6.8 Hz, CH_3), 1.43 (dd, 3H, ^3J = 9.8 Hz, 8.4 Hz, CH), 2.28 (s, 3H, CH_3), 5.12 (d, 1H, ^3J = 8.4, CH), 9.15 (s, 1H, NH), 9.38 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 166.6, 155.4, 148.7, 61.7, 54.8, 42.3, 40.6, 32.5, 21.8, 19.3 ppm. Anal. calcd for $C_{11}H_{18}N_2O_3$: C, 58.39; H, 8.02; N, 12.38. Found: C, 58.33; H, 8.08; N, 12.34.

Ethyl 1,2,3,4-tetrahydro-6-methyl-4-phenyl-2-thioxopyrimidine-5-carboxylate ***(4q)***. IR (KBr) (υ_{max}, cm^{-1}): 3392, 3239, 2954, 1693, 1525, 1465, 1425, 1220; ^{1}H NMR (400 MHz, DMSO-d_6)

δ: 1.19 (t, 3H, ^3J = 8.6 Hz, CH_3) 2.38 (s, 1H, CH_3), 4.19 (q, 2H, ^3J = 6.8 Hz, CH_2), 5.38 (s, 1H, CH), 7.52–7.72 (m, 5H, ArH), 8.89 (s, 1H, NH); ^{13}C NMR (100MHz, DMSO-d_6) δ: 169.3, 159.1, 148.3, 142.5, 132.3, 125.3, 121.4, 119.7, 62.9, 53.0, 24.2, 19.7 ppm. Anal. calcd for $C_{14}H_{16}N_2O_2S$: C, 60.85; H, 5.84; N, 10.14. Found: C, 60.80; H, 5.78; N, 10.17.

RESULTS AND DISCUSSION

The research was started with three-component Biginelli condensation using Fe^{+3}-K10 as the catalyst (Scheme 1). As the model reaction of ethyl acetoacetate **2** (1 mmol), benzaldehyde **1a** (1 mmol), urea **3** (5 mmol), and Fe^{+3}-K10 (0.1 g) gave the product in 92% yield and 10 min. To release the efficiency and generality of the reaction, various aldehydes were treated with ethyl acetoacetate and urea in this reaction condition in the presence of Fe^{+3}-montmorillonite K10. The results are summarized in Table 1. It is seen that several aromatic aldehydes carrying either electron-releasing or electron-withdrawing substituents in the *ortho* and *para* positions afford high yields of the products. Another important feature of this procedure is the survival of a variety of functional groups under the reaction conditions.

After the reaction was completed, the mixture was dissolved in $CHCl_3$ and the catalyst was separated by filtration. It was washed with $CHCl_3$/acetone and activated at 120 ^oC. The recycled catalyst has been examined in next run. Studies on the synthesis of **3a** as model substrate showed that the recovered catalyst could be successively recycled in five rounds without any decrease of yields.

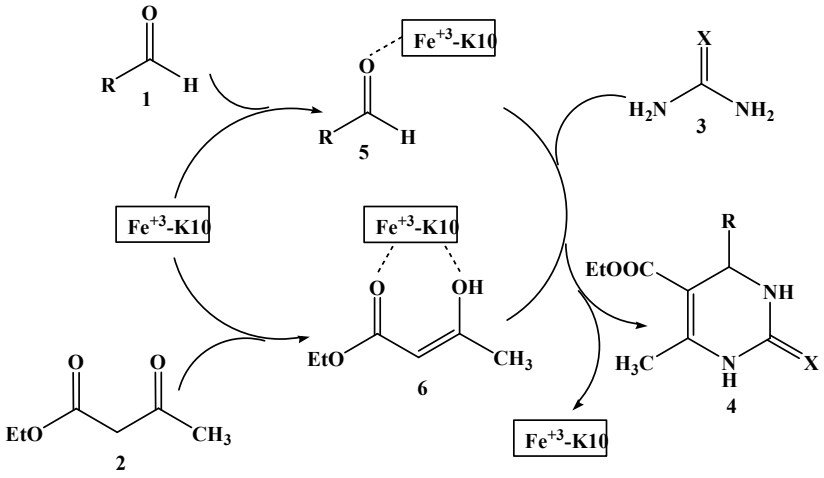
Table 1. Synthesis of dihydropyrimidinones and thiones and comparison of efficiency Fe^{+3}-montmorillonite K10.[a]

Compound	R	X	Time (min)	Yield (%)[b]	Mp (^oC)		Ref.
					Found	Reported	
4a	C_6H_5	O	10	92	202-203	202-203	[42]
4b	4-ClC_6H_4	O	10	96	216-218	215-216	[42]
4c	4-MeC_6H_4	O	15	90	171-172	170	[42]
4d	4-$CH_3OC_6H_4$	O	15	91	200-202	201-202	[42]
4e	4-$NO_2C_6H_4$	O	7	97	207-208	208-209	[42]
4f	3-$NO_2C_6H_4$	O	8	96	225-226	227-228	[42]
4g	2,4-$(Cl)_2C_6H_3$	O	8	95	250-251	248-250	[42]
4h	4-FC_6H_4	O	7	94	183-184	185-186	[42]
4i	3-OHC_6H_4	O	15	91	165-166	167-170	[42]
4j	4-Br C_6H_4	O	9	97	200-201	197	[42]
4k	4-$N(CH_3)_2C_6H_4$	O	16	90	254-255	256-258	[42]
4l	4-OHC_6H_4	O	20	87	237-238	237-238	[43]
4m	2-Furyl	O	15	85	208-209	206-208	[44]
4n	4-pyridyl	O	15	84	179-180	178-180	[45]
4o	n-propyl	O	13	91	155-156	152-154	[42]
4p	isopropyl	O	15	88	197-199	-	-
4q	C_6H_5	S	10	95	208-210	209-211	[46]
4r	4-ClC_6H_4	S	8	96	188-189	191-195	[46]
4s	4-OHC_6H_4	S	15	93	200-201	202-203	[43]

[a]All products were characterized by their physical constant, comparison with authentic samples, IR and NMR spectroscopy. [b]Yields based upon starting aldehyde.

The reaction may proceed through acylimine formation between an aldehyde and urea in the presence of Lewis acid Fe^{+3}-K10. Subsequent addition of the enolate of the β-ketoester to the

acylimine followed by cyclodehydration would afford dihydropyrimidinone-(1*H*)-one or thione **4** as shown in Scheme 2.



Scheme 2. Proposed mechanistic pathway for the synthesis dihydropyrimidinoes and-thiones using Fe^{+3}-montmorillonite K10.

Table 2. Yields of dihydropyrimidin-2(1*H*)-one **4a** for successive runs.

Run	Amount of catalyst/1 mmol of substrate	Time (min)	Yield (%)	Mp (^{o}C)
1	0.1 g	10	92	202-203
2	0.1 g	10	92	202-203
3	0.1 g	10	92	202-204
4	0.1 g	10	91	203-204
5	0.1 g	11	91	203-205

To investigate the efficiency of this method, the comparison between this method and some of previous reported methods for the synthesis of **4a** was carried out (Table 3).

Table 3. Comparison of synthesis of compound **4a** in this method with some of previous reported methods.

Catalyst	Condition	Time (min)	Yield (%)	Ref.
PPA-SiO_2	Reflux	60	88	[47]
Chloroacetic acid	90 ^{o}C/Solvent-free	180	92	[48]
Copper(II) sulfamate	AcOH, 100 ^{o}C	300	79	[49]
$Mn(OAc)_3 \cdot 2H_2O$	Reflux, CH_3CN	120	96	[50]
Fe^{+3}-montmorillonite K10	Grinding	10	92	This work

CONCLUSIONS

In conclusion, the Fe^{+3}-montmorillonite K10 under grind condition was used as a mild and efficient method for the synthesis of substituted dihydropyrimidinones and thiones. The remarkable advantages offered by this method are: catalyst is inexpensive, non-toxic, easy

handling and reusable, simple work-up procedure, short reaction time, high yields of product with better purity and green aspect by avoiding toxic catalyst and hazardous solvent.

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