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Potassium alum as a naturally mineral and economical catalyst for the one-pot, multi-component and clean synthesis of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines and N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates

Farzaneh Mohamadpour

School of Engineering, Apadana Institute of Higher Education, Shiraz, Iran
E-mail: mohamadpour.f.7@gmail.com

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An environmental friendly synthetic route for potassium alum catalyzed one-pot multi-component synthesis of biologically active 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines and N--aryl-3-aminodihydropyrrol-2-one-4-carboxylates has developed. The present synthetic route has the notable advantages of natural, mineral, inexpensive and non-toxic catalyst, mild reaction conditions, eco-friendly, one-pot and good to high yield of biological active products. This method is simple for work up and the compound formed filtered and purified just by simple crystallization.

Keywords: Potassium alum, 2-Oxo(thio)-1,2,3,4-tetrahydropyrimidines, N-aryl-3-aminodihydropyrrol-2-one-4-carboxylate, Naturally mineral catalyst, Multi-component synthesis.

Natural catalysts for the synthesis of organic compounds have attracted considerable interest from both environmental and eco-friendly points. Alum and its derivatives, have specially properties, which make them attractive alternatives for catalytic applications in preparation of organic compounds.

Potassium alum [potassium aluminum sulfate dodecahydrate ($KAl(SO_4)_2.12H_2O$)] is a naturally occurring mineral used in many research areas such as in food and pharmaceutical industrials[1]. Potassium alum has antiperspirant and antibacterial properties[2-3], and has used to stop bleeding in cases of hemorrhagic cystitis[4]. Also hydrated potassium aluminum sulfate is the major adjuvant used to increase the efficacy of vaccines, and has been used since the 1920s[5]. 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines and N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates are two type of the most important heterocyclic compounds because of useful biological and pharmaceutical properties for example these compounds have been used as anticancer[6], and calcium channel blockers, α-1a-antagonists[7], cardiac cAMP phosphodiestrase[8], also some of alkaloids which were found have dihydropyrimidine derivatives. They have been used as Pl-091[9], and these rings have been used as UCS1025A[10], Oteromycin[11]. Many of alkaloids with biological activities have pyrrole rings[12]. In the past few decades, due to a wide range of their properties such as atom-economy, mild and environmentally-friendly, low-cost, one-pot, simple work-up, multi-component domino reactions (MCRs)[13-17] have become one of the most attractive for the synthesis of heterocyclic compounds by organic chemists. Due to the importance of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines and N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates, various methodologies for the preparation of these compounds have developed[18-33]. Some of limitation these methodologies are low yields, toxic catalyst, long time reactions, harsh reaction conditions and expensive materials. Based on the above considerations and our interest in the development of environmental benign synthetic methodologies, attempts were described to synthesize biologically active 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines and N-aryl-3-aminodihydropyrrol-2-one-4-carboxylate by using potassium alum as the catalyst. Finally, herein, we report a simple and clean one-pot approach for the synthesis of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines using potassium alum as a naturally mineral and economical catalyst by means of three-component Biginelli[34] reaction between β-keto esters, aldehyde derivatives and urea/thiourea under thermal and solvent-free conditions and also, one-pot synthesis of N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates through a four-component reaction between amines (aromatic or aliphatic), dialkyl acetylenedicarboxylate and formaldehyde under ambient temperature in methanol with excellent yields. The notable benefits of potassium alum as catalyst in organic compounds synthesis are natural, efficient, inexpensive and non-toxic. Also, potassium alum can be successfully used in the type of carbon-carbon bonds as a naturally mineral, economical and mild catalyst[35, 36] in organic synthesis.

Results and Discussion

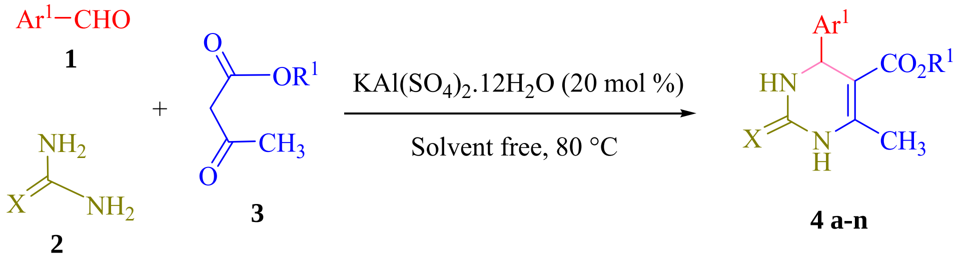
An economical, natural and efficient catalyst for clean and simple methodology to diverse synthesis of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines by using of one-pot three-component condensation Biginelli reaction of aldehydes derivatives (**1**, 1.0 mmol), urea/ thiourea (**2**, 1.5 mmol) and ethyl/methyl acetoacetate (**3,** 1.0 mmol) with potassium alum under solvent-free and thermal conditions is described (Scheme I).

In order to optimized the reaction conditions, the synthesis of compound **4a** (Table III, entry 1) was used as a model reaction. The effect of different amount of catalyst on the reaction has studied in this protocol. No product could not detect in the absence of the catalyst even after 7h (Table I, entry 1). Good yields have obtained in the presence of catalyst. The best amount of catalyst was 20 mol% (0.095 g) (Table I, entry 5). The higher amount of catalyst did not increase the yields products (Table I, entry 6).

However, the higher yield of product has obtained with 0.095 g of catalyst and the results have summarized in Table I.

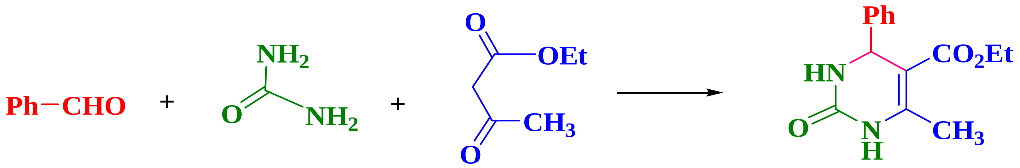
Also, the effect of temperature on the reaction has been studied. No product could be detected in room temperature conditions (Table II, entry 1). The reaction has investigated by changing temperature from 40-100°C, and the high yield of product has obtained in 80°C temperature (Table II, entry 4) and yields of product at different temperature has reported in Table II.

In order to study of this procedure, we have synthesized a series of compounds with the type of electron-donating and electron-withdrawing aldehydes derivatives such as Cl, NO_2, OH, OMe, substituted benzaldehydes which gave excellent yields and the generality of this three-condensation reaction was studied by using of potassium alum (20 mol%) via the type of aldehydes derivatives(1.0 mmol), urea or thiourea (1.5 mmol) and ethyl/methyl acetoacetate (1.0 mmol), under solvent-free conditions at 80°C temperature and the results are shown in Table III.



Scheme I — Synthesis of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines.

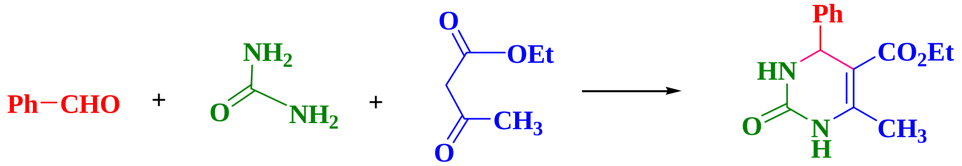
Table I — Optimization of the reaction condition [a]



Entry	Potassium alum (mol %)	Time (min)	Product	Isolated Yields (%)
1	Catalyst free	420	4a	Not product
2	5	45	4a	36
3	10	30	4a	55
4	15	20	4a	73
5	**20**	**20**	**4a**	**91**
6	25	20	4a	93

[a] Reaction conditions: benzaldehyde (1.0 mmol), ethyl acetoacetate (1.0 mmol), urea (1.5mmol) and potassium alum was heated at 80°C for the appropriate time.

Table II — Effect of temperature on the synthesis of **4a** [a]



Product	Time (min)	Temperature (°C)	Entry	Isolated Yields (%)
4a	420	rt	1	Not product
4a	85	40	2	39
4a	45	60	3	64
4a	**20**	**80**	**4**	**91**
4a	20	100	5	92

[a] Reaction conditions: benzaldehyde (1.0 mmol), ethyl acetoacetate (1.0 mmol), urea (1.5 mmol) and potassium alum (20 mol%) was heated under various temperatures for the appropriate time.

Table III — Potassium alum catalyzed synthesis of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines.

Entry	Ar^1	R^1	X	Product	Time (min)	Yield% [a]	m.p.°C	Lit. m.p.°C
1	C_6H_5	C_2H_5	O	**4a**	20	91	197-199	200-202[19]
2	2-Cl-C_6H_4	CH_3	O	**4b**	35	82	251-253	248-252[19]
3	3-Cl-C_6H_4	C_2H_5	O	**4c**	40	78	191-193	191-193[19]
4	C_6H_5	C_2H_5	S	**4d**	25	89	208-210	208-210[19]
5	4-OMe-C_6H_4	CH_3	O	**4e**	30	81	190-192	190-194[19]
6	4-OH-C_6H_4	C_2H_5	O	**4f**	45	76	229-231	230-232[19]
7	4-F-C_6H_4	CH_3	S	**4g**	30	83	208-210	208-210[21]
8	4-Me-C_6H_4	C_2H_5	O	**4h**	35	85	206-208	204-205[18]
9	4-O_2N-C_6H_4	CH_3	O	**4i**	30	82	215-217	214-216[19]
10	4-F-C_6H_4	C_2H_5	O	**4j**	25	85	175-177	174-176[21]
11	2-Cl-C_6H_4	C_2H_5	O	**4k**	45	76	222-224	220-223[19]
12	4-OH-C_6H_4	CH_3	O	**4l**	40	79	246-248	245-246[18]
13	4-O_2N-C_6H_4	C_2H_5	O	**4m**	35	86	207-209	207-209[19]
14	4-OMe-C_6H_4	C_2H_5	O	**4n**	35	77	200-202	202-203[20]

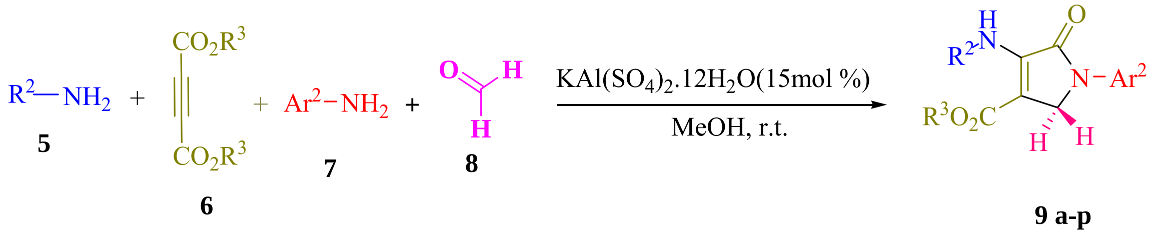
[a] Isolated yield.

After the successful synthesis of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines, we turned our attention toward the synthesis of N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates by using of a one-pot four-component domino reaction via amines (aromatic or aliphatic **5** and **7,** 2.0 mmol), dialkyl acetylenedicarboxylate (**6**, 1.0 mmol) and formaldehyde (**8**, 1.5 mmol) in the presence of potassium alum as an efficient and natural catalyst under ambient temperature with excellent yields and short reaction times (Scheme II).

The generality of this four-condensation reaction has studied under optimized conditions and the reaction between aniline, dimethyl acetylenedicarboxylate (DMAD) and formaldehyde was investigation as a model reaction and then the effect of different amount of catalyst was also studied in this protocol and in the absence of catalyst; a trace amount of this product was detected after 9h (Table IV, entry 1). Good yields were obtained in the presence of catalyst. The best amount of catalyst was 15 mol % (0.071g) (Table IV, entry 4). The higher amount of catalyst did not increase the yields products (Table IV, entry 5) and the results are summarized in Table IV.

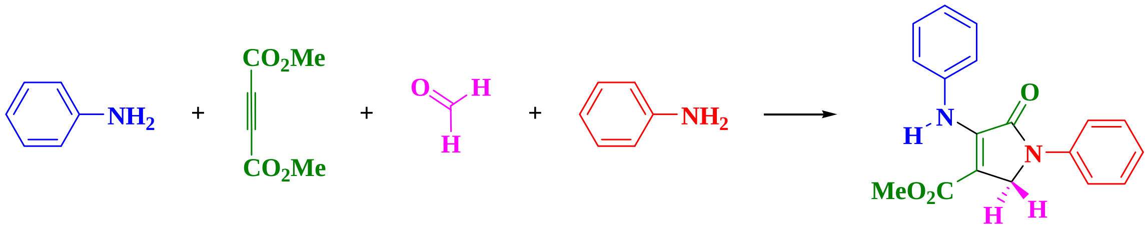
The effect of various solvents was investigated for this protocol H_2O, EtOH, MeOH, CH_3CN, $CHCl_3$, CH_2Cl_2 and among these solvents, MeOH was found to be the best solvent for this methodology (Table V, entry 4) and the results are shown in Table V.

Finally, we reported potassium alum (KAl $(SO_4)_2.12H_2O$) (0.071 g) as a mild and efficient catalyst for economical, environmental benign nature one-pot four-component reaction of amines (aromatic or aliphatic), dialkyl acetylenedicarboxylate and formaldehyde in MeOH as solvent under ambient temperature.



Scheme II — Synthesis of N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates.

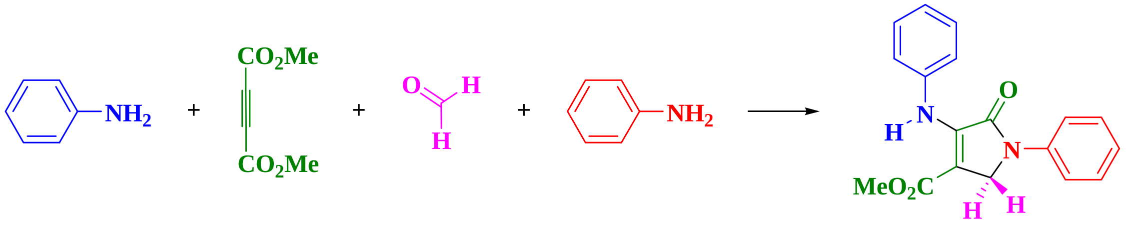
Table IV — Optimization of the reaction condition in the presence of different amounts of potassium alum[a]



Entry	Potassium alum (mol %)	Time (h)	Product	Isolated Yields (%)
1	Catalyst free	9	9a	trace
2	5	8	9a	47
3	10	6	9a	82
4	**15**	**4**	**9a**	**93**
5	20	4	9a	94

[a]Reaction conditions: aniline (2.0 mmol), dialkyl acetylenedicarboxylate (1.0 mmol) and formaldehyde (1.5 mmol) and catalyst at room temperature.

Table V — Optimization of the reaction condition in the presence of different solvents by using of $KAl(SO_4)_2.12H_2O$ (15 mol%)[a]



Entry	Solvent	Time (h)	Product	Isolated Yields (%)
1	Solvent free	9	9a	57
2	EtOH	4	9a	79
3	H_2O	7	9a	37
4	MeOH	4	9a	93
5	CH_3CN	7	9a	43
6	CH_2Cl_2	9	9a	32
7	$CHCl_3$	8	9a	29

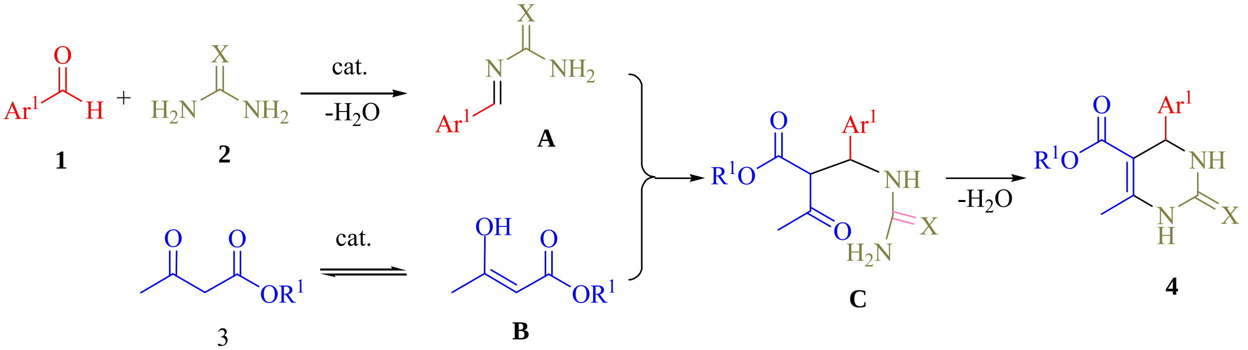
[a]Reaction conditions: aniline (2.0 mmol), dialkyl acetylenedicarboxylate (1.0 mmol) and formaldehyde (1.5 mmol) and catalyst in various solvents at room temperature.

In order to study of this procedure, we have synthesis a series of N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates with the type of aromatic or aliphatic amines with electron-donating or electron-withdrawing groups such as Cl, Br, F, Me, OMe, and dialkyl acetylenedicarboxylate with formaldehyde under ambient temperature in MeOH which gave excellent yields and the results are shown in Table VI. The proposed mechanism for the synthesis of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines and N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates are shown in Scheme III and Scheme IV.

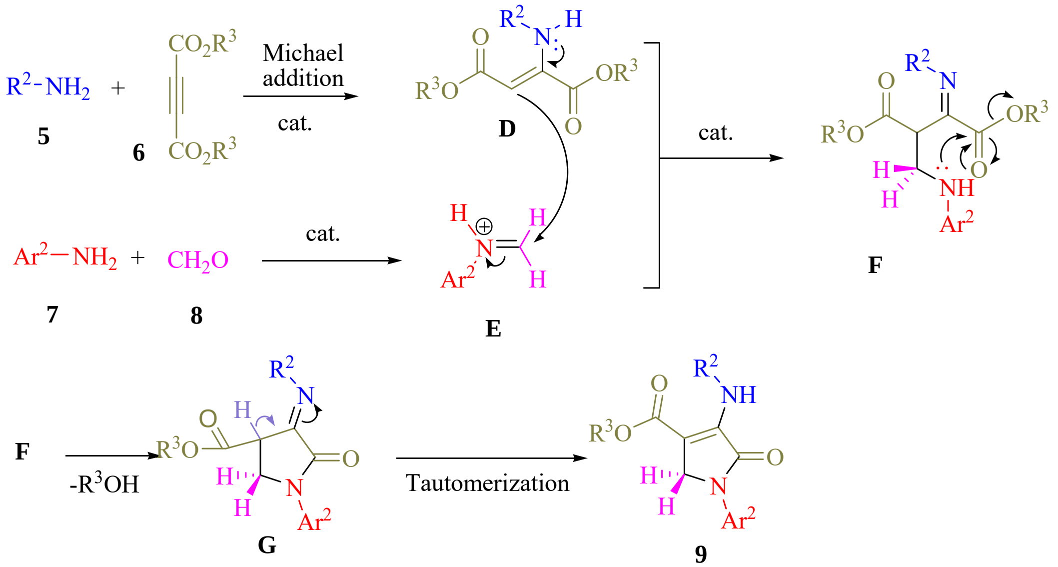
Table VI — Potassium alum catalyzed synthesis of N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates.

Entry	R^2	R^3	Ar^2	Product	Time (h)	Yield (%)^a	m.p.°C	Lit. M.p. °C
1	Ph	Me	Ph	**9a**	4	93	153-155	155-156[24]
2	4-F-C_6H_4	Me	4-F-C_6H_4	**9b**	3.5	94	161-163	163-165[28]
3	4-Br-C_6H_4	Me	4-Br-C_6H_4	**9c**	5	82	174-176	175-177[26]
4	4-Me-C_6H_4	Me	4-Me-C_6H_4	**9d**	4	92	177-179	177-178[24]
5	4-OMe-C_6H_4	Me	4-OMe-C_6H_4	**9e**	4	89	171-173	172-175[26]
6	4-Cl-C_6H_4	Me	4-Cl-C_6H_4	**9f**	4.5	86	173-175	171-173[26]
7	Ph	Et	Ph	**9g**	4	90	140-142	138-140[25]
8	4-F-C_6H_4	Et	4-F-C_6H_4	**9h**	3.5	96	173-175	172-174[26]
9	4-Br-C_6H_4	Et	4-Br-C_6H_4	**9i**	5	79	171-173	169-171[25]
10	4-Me-C_6H_4	Et	4-Me-C_6H_4	**9j**	4.5	89	131-133	131-132[25]
11	4-OMe-C_6H_4	Et	4-OMe-C_6H_4	**9k**	4	91	151-153	152-154[27]
12	4-Cl-C_6H_4	Et	4-Cl-C_6H_4	**9l**	5.5	83	168-170	168-170[26]
13	PhCH_2	Me	Ph	**9m**	3	86	140-142	140-141[25]
14	PhCH_2	Me	4-F-C_6H_4	**9n**	2.5	92	165-167	166-168[27]
15	PhCH_2	Et	Ph	**5o**	4	89	130-132	130-132[25]
16	n-C_4H_9	Et	4-Br-C_6H_4	**9p**	4.5	82	93-95	94-96[27]

^{a} Isolated yield.



Scheme III — Proposed mechanistic route for the synthesis of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines.



Scheme IV — Proposed mechanistic route for the synthesis of N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates.

Comparison of catalytic ability some of catalysts reported in the literature for synthesis of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines and N-aryl-3-amino-dihydropyrrol-2-one-4-carboxylates are shown in Table VII and Table VIII. This study reveals that potassium alum ($KAl(SO_4)_2.12H_2O$) has shown its extraordinary potential to be an alternative naturally mineral, cost effective, cheap, eco-friendly and efficient catalyst for the one-pot synthesis of these heterocyclic compounds, in addition to excellent yields and short reaction times are the notable advantages this present methodology.

Experimental Section

General

Melting points and IR spectra all compounds were determined using an Electro thermal 9100 apparatus and a JASCO FTIR 460 Plus spectrometer. Also, nuclear magnetic resonance, ^{1}H NMR spectra were recorded on a Bruker DRX-400 Avance instruments with DMSO-d_6 and $CDCl_3$ as solvents. In the present literature, all reagents and solvents were purchased from Merck, Fluka and Acros chemical companies were used without further purification.

General procedure for preparation of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines (4a-n)

A mixture of aldehydes derivatives (**1**, 1.0 mmol) and urea/thiourea (**2**, 1.5 mmol), ethyl/methyl acetoacetate (**3**, 1.0 mmol) under solvent-free conditions was heated for appropriate time in the presence of potassium alum (20 mol %) at 80°C. After completion of the reaction (by thin layer chromatography TLC) the mixture was cooled to rt and cold water was added and the precipitated was separated with filtration and solid was recrystallized from ethanol to afford the pure products (**4a- n**). Spectra data some of products are represented below:

5-Ethoxycarbonyl-6-methyl-4-phenyl-3,4-dihydropyrimidin-2(1*H*)-one (**4a**): m.p.197-199; ^{1}H NMR (400 MHz, DMSO-d_6): 1.10 (3H, t, *J* = 7.2 Hz, CH_3CH_2), 2.26 (3H, s, CH_3), 3.99 (2H, q, *J* = 7.2 Hz, CH_2O), 5.15 (1H, s, CHN), 7.26 (3H, d, *J* = 7.2 Hz, ArH), 7.33 (2H, t, *J* = 7.2 Hz, ArH), 7.76 and 9.21 (2H, 2s, 2NH).

5-Methoxycarbonyl-6-methyl-4-(2-chlorophenyl)-3,4-dihydropyrimidin-2(1*H*)-one (**4b**): m.p. 251-253°C; ^{1}H NMR (400 MHz, DMSO-d_6): 2.31 (3H, s, CH_3), 3.46 (3H, s, OCH_3), 5.62 (1H,

Table VII — Comparison of catalytic ability some of catalysts reported in the literature for synthesis of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines[a].

Entry	Catalyst	Conditions	Time/Yield (%)	References
1	bakers' yeast	Room temperature	24h/84	[18]
2	$Cu(BF_4)_2.xH_2O$	Room temperature	30 min/90	[19]
3	Hydrotalcite	Solvent-free, 80°C	35 min/84	[20]
4	$[Al(H_2O)_6](BF_4)_3$	MeCN, Reflux	20 h/81	[22]
5	[Btto][*p*-TSA]	Solvent-free, 90°C	30 min/96	[23]
6	triethylammonium acetate	70°C	45min/90	[24]
7	*p*-dodecylbenzenesulfonic acid	Solvent-free, 80°C	3 h/94	[25]
8	$KAl(SO_4)_2.12H_2O$	Solvent-free, 80°C	20 min/91	This work

[a] Based on the three-component reaction of benzaldehyde, ethyl acetoacetate and urea.

Table VIII — Comparison of catalytic ability some of catalysts reported in the literature for synthesis of N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates[a]

Entry	Catalyst	Conditions	Time/Yield (%)	References
1	I_2	MeOH, r.t.	1 h/82	[26]
2	$[n\text{-}Bu_4N][HSO_4]$	MeOH, r.t.	4 h/88	[28]
3	$Al(H_2PO_4)_3$	MeOH, r.t.	5 h/81	[29]
4	$InCl_3$	MeOH, r.t.	3h/85	[31]
5	$ZrCl_4$	MeOH, r.t.	4 h/84	[32]
6	$Cu(OAC)_2.H_2O$	MeOH, r.t.	6 h/91	[33]
7	$KAl(SO_4)_2.12H_2O$	MeOH, r.t.	4 h/93	This work

[a] Based on the four-component reaction of aniline, dimethylacetylenedicarboxylate, formaldehyde.

s, CHN), 7.28-7.34 (3H, m, ArH), 7.42 (1H, d, *J* = 7.2 Hz, ArH), 7.72 and 9.36 (2H, 2s, 2NH).

5-Ethoxycarbonyl-6-methyl-4-phenyl-3,4-dihydropyrimidin-2(1*H*)-thione (4d): m.p. 208-210°C; ^{1}H NMR (400 MHz, DMSO-d$_6$): 1.11 (3H, t, *J* = 7.2 Hz, *CH*$_3$CH$_2$), 2.31 (3H, s, CH$_3$), 4.02 (2H, q, *J* = 7.2 Hz, CH$_2$O), 5.19 (1H, s, CHN), 7.23 (2H, d, *J* = 7.2 Hz, ArH), 7.28 (1H, t, *J* = 7.2 Hz, ArH), 7.36 (2H, t, *J* = 7.2 Hz, ArH), 9.68 and 10.36 (2H, 2s, 2NH).

5-Ethoxycarbonyl-6-methyl-4-(4-hydroxyphenyl)-3,4-dihydropyrimidin-2(1*H*)-one (4f): m.p. 229-231°C; ^{1}H NMR (400 MHz, DMSO-d$_6$): 1.11 (3H , t, *J* = 9.6 Hz, *CH*$_3$CH$_2$), 2.50 (3H, s, CH$_3$), 3.98 (2H, q, *J* = 9.2 Hz, CH$_2$O), 5.04 (1H, s, CHN), 6.68-7.04 (4H, m, ArH), 7.64 and 9.13 (2H, 2s, 2NH), 9.35 (1H, s, OH).

5-Methoxycarbonyl-6-methyl-4-(4-fluorophenyl)-3,4-dihydropyrimidin-2(1*H*)-thione (4g): m.p.208-210°C; ^{1}H NMR (400 MHz, DMSO-d$_6$): 2.30 (3H, s, CH$_3$), 3.56 (3H, s, OCH$_3$), 5.18 (1H, s, CHN), 7.13-7.28 (4H, m, ArH), 9.71 and 10.42 (2H, 2s, 2NH).

5-Ethoxycarbonyl-6-methyl-4-(4-methylphenyl)-3,4-dihydropyrimidin-2(1*H*)-one (**4h**): m.p. 206-208°C; ^{1}H NMR (400 MHz, DMSO-d$_6$): 1.11 (3H, t, *J* = 7.2 Hz, *CH*$_3$CH$_2$), 2.26 (6H, d, *J* = 9.2 Hz, 2CH$_3$), 3.99 (2H, q, *J* = 7.2 Hz, CH$_2$O), 5.11 (1H, s, CHN), 7.13 (4H, s, ArH), 7.70 and 9.17 (2H, 2s, 2NH).

5-Methoxycarbonyl-6-methyl-4-(4-nitrophenyl)-3,4-dihydropyrimidin-2(1*H*)-one (4i): m.p. 215-217°C; ^{1}H NMR (400 MHz, DMSO-d$_6$): 2.2 8 (3H, s, CH$_3$), 3.55 (3H, s, OCH$_3$), 5.28 (1H, s, CHN), 7.52 (2H, d, *J* = 8.4Hz, ArH), 7.22 (2H, d, *J* = 8.8Hz, ArH), 7.93 and 9.40 (2H, 2s, 2NH).

5-Ethoxycarbonyl-6-methyl-4-(4-fluorophenyl)-3,4-dihydropyrimidin-2(1*H*)-one (4j): m.p.175-177°C; ^{1}H NMR (400 MHz, DMSO-d$_6$): 1.11 (3H, t, *J* = 9.6 Hz, *CH*$_3$CH$_2$), 2.25 (3H, s, CH$_3$), 3.99 (2H, q, *J* = 9.6 Hz, CH$_2$O), 5.14 (1H, s, CHN), 7.13-7.20 (2H, m, ArH), 7.24-7.29 (2H, m, ArH), 7.78 and 9.25 (2H, 2s, 2NH).

5-Ethoxycarbonyl-6-methyl-4-(4-methoxyphenyl)-3,4-dihydropyrimidin-2(1*H*)-one (4n): m.p.200-202°C; ^{1}H NMR (400 MHz, DMSO-d$_6$): 1.11 (3H, t, *J* = 9.6 Hz, *CH*$_3$CH$_2$), 2.24 (3H, s, CH$_3$), 3.73 (3H, s, OCH$_3$), 3.99 (2H, q, *J* = 9.6 Hz, CH$_2$O), 5.09 (1H, s, CHN), 6.89 (2H, d, *J* = 8.4Hz, ArH), 7.15(2H, d, *J* = 8.8Hz, ArH), 7.70 and 9.18 (2H, 2s, 2NH).

General procedure for preparation of N-aryl-3-aminodihydropyrrol-2-one-4-carboxylates (9a-p)

A mixture of amine (**5**, 1.0 mmol) and dialkyl acetylenedicarboxylate **(6**, 1.0 mmol) was stirred in MeOH (3 mL) for 15 min. next, amine **(7**, 1.0 mmol) and formaldehyde **(8**, 1.5 mmol) and potassium alum (0.071g) were added and the reaction was stirred for appropriate time. After completion of the reaction (by thin layer chromatography TLC), the mixture was separated with filtration and the solid washed with ethanol (3×2 mL) with no column chromatographic separation to give pure compounds (**9a-p**). All products were characterized by comparison of spectroscopic data (FT-IR, ^{1}HNMR). Spectra data some of products are represented below:

Methyl4-(4-fluoroyphenylamino)-1-(4-fluorophenyl)-2,5-dihydro-5-oxo-1*H*-pyrrole-3-carboxylate (9b): Yield: 94%; m.p. 161-163°C; ^{1}H NMR (400 MHz, CDCl$_3$): 3.79 (3H, s, OCH$_3$), 4.52 (2H, s, C*H*$_2$-N), 7.04 (2H, t, *J* = 8.4 Hz, ArH), 7.08-7.16 (4H, m, ArH), 7.73-7.76 (2H, m, ArH), 8.05 (1H, s, NH).

Methyl4-(4-methylphenylamino)-1-(4-methylphenyl)-2,5-dihydro-5-oxo-1*H*-pyrrole-3-carboxylate (9d): Yield: 92%; m.p. 177-179°C; ^{1}H NMR (400 MHz, CDCl$_3$): 2.36 (6H, s, 2CH$_3$), 3.77 (3H, s, OCH$_3$), 4.52 (2H, s, C*H*$_2$-N), 7.06 (2H, d, *J* = 8.4 Hz, ArH), 7.14 (2H, d, *J* = 8.4 Hz, ArH), 7.21 (2H, d, *J* = 8.4 Hz, ArH), 7.68 (2H, d, *J* = 8.8 Hz, ArH), 8.03 (1H, s, NH).

Methyl4-(4-methoxyphenylamino)-1-(4-methoxyphenyl)-2,5-dihydro-5-oxo-1*H*-pyrrole-3-carboxylate (9e): Yield: 89%; m.p. 171-173°C; ^{1}H NMR (400 MHz, CDCl$_3$): 3.77 (3H, s, CH$_3$), 3.83 (6H, s, 2OCH$_3$), 4.50 (2H, s, C*H*$_2$-N), 6.89 (4H, d, *J* = 17.6 Hz, ArH), 7.13 (1H, s, ArH) ,7.68 (1H, s, ArH), 8.03 (1H, s, NH).

Ethyl4-(4-methoxyphenylamino)-1-(4-methoxyphenyl)-2,5-dihydro-5-oxo-1*H*-pyrrole-3-carboxylate (9k): Yield: 91%; m.p. 151-153°C; ^{1}H NMR (400 MHz, CDCl$_3$): 1.26 (3H, t, *J* = 7.2Hz, CH$_2$*CH*$_3$), 3.83 (6H, s, 2OCH$_3$), 4.23 (2H, q, *J* = 7.2 Hz, *CH*$_2$CH$_3$), 4.50 (2H, s, C*H*$_2$-N), 6.87 (2H, d, *J* = 8.8 Hz, ArH), 6.93 (2H, d, *J* = 8.8 Hz, ArH), 7.12 (2H, d, *J* = 8.8 Hz, ArH), 7.69 (2H, d, *J* = 8.8 Hz, ArH), 8.02 (1H, s, NH).

Conclusion

In summary, potassium alum as a naturally mineral, economical and efficient catalyst that has been successfully used in the synthesis of 2-oxo(thio)-1,2,3,4-tetrahydropyrimidines and N-aryl-3-amino-dihydropyrrol-2-one-4-carboxylates with excellent yields and short reaction times. This procedure has lot of advantages such as mild, non-toxic and low-cost catalyst, easily operation and simple work up with no column chromatographic separation and environmental friendly.

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