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Article

Efficient synthesis of pyrano[2,3-*d*]pyrimidinone and pyrido[2,3-*d*]pyrimidine derivatives in presence of novel basic ionic liquid catalyst

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ABSTRACT

A basic ionic liquid, namely 1,1'-(butane-1,4-diyl)bis(1,4-diazabicyclo [2.2.2]octan-1-ium) hydroxide, was prepared and characterized using Fourier-transform infrared spectroscopy, ^{1}H nuclear magnetic resonance spectroscopy, and pH measurements. The ionic liquid was used for efficient promotion of the synthesis of pyrano[2,3-*d*]pyrimidinone and pyrido[2,3-*d*]pyrimidine derivatives at room temperature under grinding conditions. A simple procedure, short reaction time, high yields, non-column chromatographic separation, commercial availability of the starting materials, and recyclability of the catalyst are attractive features of this process.

1. Introduction

Highly efficient, selective, and cost-effective catalytic systems are the foundation of synthetic chemistry. Ionic liquids (ILs) have emerged as eco-friendly catalysts or catalysts/solvents in various fields of chemistry because of their distinctive properties such as high thermal stability, negligible vapor pressure, high loading capacity, and easy recycling [1].

Basic ILs have attracted great interest because, compared with inorganic bases such as KOH and NaOH, they have good catalytic efficiencies, are non-corrosive, recyclable, and produce no waste [2]. This type of IL has been successfully used in the industrial production of drugs, fragrances, and chemical intermediates, and to accelerate various reactions such as Michael additions, Heck reactions, and Markovnikov additions [3,4].

Pyrano[2,3-*d*]pyrimidinones (A) and pyrido[2,3-*d*]pyrimidines (B) (Fig. 1) are two classes of nitrogen-containing heterocyclic compounds that show considerable pharmaceutical and biological activities, including anticancer, antitumor, antimalarial, antibacterial, antihypertensive, anti-inflammatory, hepatoprotective, cardiotonic, vasodilator, bronchiodilator, antifolate, and antiallergic activities [5–17]. They are also used in the preparation of dyes and pigments [18] and flavoring agents [19], and in luminescence chemistry [20].

The most simple and straightforward protocols for the preparation of pyrano[2,3-*d*]pyrimidinones and pyrido[2,3-*d*]pyrimidines are based on three-component reactions of substituted aldehydes, malononitrile, and barbituric acid or 6-amino-1,3-dimethyluracil. Various conditions for these reactions have been reported [21–31]. Although these procedures

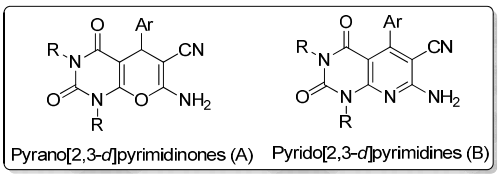

Fig. 1. The structure of pyrano[2,3-*d*]pyrimidinones (A) and pyrido[2,3-*d*]pyrimidines (B).

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are better than other methods, they have disadvantages such as long reaction time, harsh reaction conditions, the need for excess amounts of reagents, the use of organic solvents and toxic reagents, and non-recoverability of the catalyst. The development of simple, efficient, and mild procedures using easily separable and reusable solid catalysts to overcome these problems is therefore needed.

2. Experimental

2.1. General

Chemicals were purchased from Fluka, Merck, and Aldrich. The products were characterized by comparison of their melting points, and Fourier-transform infrared (FT-IR) and nuclear magnetic resonance (NMR) spectra with those of authentic samples and those reported in the literature. All yields refer to isolated products. Thin-layer chromatography (TLC; Polygram SILG/UV 254 plates) was used to determine the substrate purity and monitor the reaction. FT-IR spectra were recorded with a VERTEX 70 (Brucker, Germany) instrument using KBr disks. ^{1}H NMR and ^{13}C NMR spectra were recorded using a 400 MHz Bruker Avance instrument, with tetramethylsilane as an internal standard. Melting points were determined using an Electrothermal 9100 instrument and are uncorrected. Mass spectrometry (MS) was performed using an Agilent Technology (HP) instrument at 70 eV.

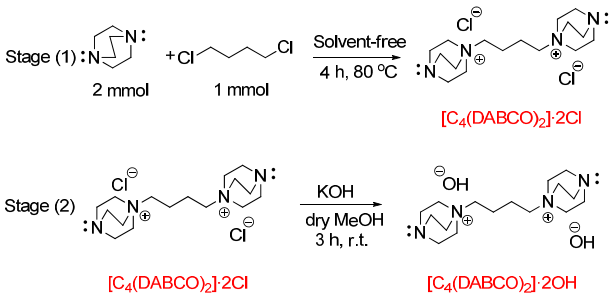
2.2. General procedure for synthesis of 1,1'-(butane-1,4-diyl)bis (1,4-diazabicyclo[2.2.2]octan-1-ium) chloride ([C$_4$(DABCO)$_2$]·2Cl)

1,4-Dichlorobutane (0.547 mL, 5.0 mmol) was added to DABCO (1.121 g, 10.0 mmol) and the mixture was stirred for 4 h at 80 °C. After completion of the reaction, the solid product was washed with diethyl ether and dried under vacuum. [C$_4$(DABCO)$_2$]·2Cl was obtained as a white solid in 98.7% yield (1.39 g).

2.3. General procedure for synthesis of 1,1'-(butane-1,4-diyl)bis (1,4-diazabicyclo[2.2.2]octan-1-ium) hydroxide ([C$_4$(DABCO)$_2$]·2OH)

The amount of chloride in [C$_4$(DABCO)$_2$]·2Cl was determined by potentiometric titration to calculate the amount of KOH needed for complete ion exchange. For this purpose, 10 mL of [C$_4$(DABCO)$_2$]·2Cl in water (0.05 mol/L) was titrated with $AgNO_3$ (0.55 mol/L); the end-point occurred after consumption of 20 mL of $AgNO_3$. This indicates that [C$_4$(DABCO)$_2$]·2Cl contains 2 equiv of Cl^- per mole.

In the next step, solid KOH (0.561 g, 10 mmol) was added to a solution of [C$_4$(DABCO)$_2$]·2Cl (1.44 g, 5 mmol) in dry methanol and the mixture was stirred at room temperature (r.t.) for 3 h. The produced solid (KCl) was removed by filtration, and the filtrate was evaporated under reduced pressure. The obtained viscous liquid was washed with ethyl acetate (3 × 10 mL) and dried to give the pure IL, i.e., [C$_4$(DABCO)$_2$]·2OH (1.35 g, 96.42%) (Scheme 1).



Scheme 1. Synthesis of [C$_4$(DABCO)$_2$]·2OH.

2.4. Catalyst characterization

2.4.1. FT-IR analysis

The FT-IR spectra of DABCO and [C$_4$(DABCO)$_2$]·2OH are shown in Fig. 2. The DABCO spectrum shows bands from various stretching and bending vibrations. These bands are of lower intensity in the spectrum of [C$_4$(DABCO)$_2$]·2OH, or are absent. The strong and broad band between 2700 and 3750 cm^{-1} (centered at 3424 cm^{-1}) in the spectrum of [C$_4$(DABCO)$_2$]·2OH can be attributed to the hydroxide stretching mode. The strong peak at 1407 cm^{-1} and the small shoulder peak at 702 cm^{-1} are assigned to the scissoring and rocking vibrational modes, respectively, of the CH_2 group.

2.4.2. ^{1}H NMR analysis

The ^{1}HNMR spectrum of [C$_4$(DABCO)$_2$]·2OH is show in Fig. 3. The broad multiple peak at 1.7 ppm can be attributed to chain hydrogen atoms (H_a). The triplet peaks at 3.03 and 3.33 ppm are related to the cyclic hydrogens H_d and H_c, respectively. The peak at 3.37 ppm, which can be assigned to H_c cyclic hydrogens, confirms that [C$_4$(DABCO)$_2$]·2OH was synthesized.

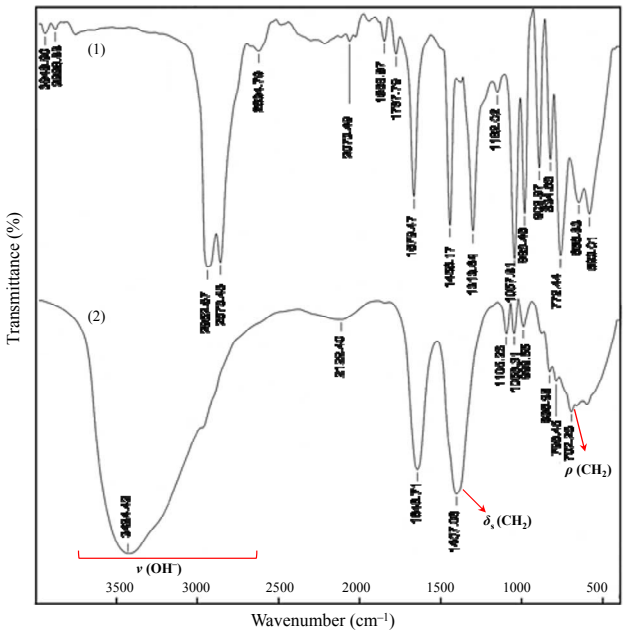


Fig. 2. FT-IR spectra of DABCO (1) and [C$_4$(DABCO)$_2$]·2OH (2).

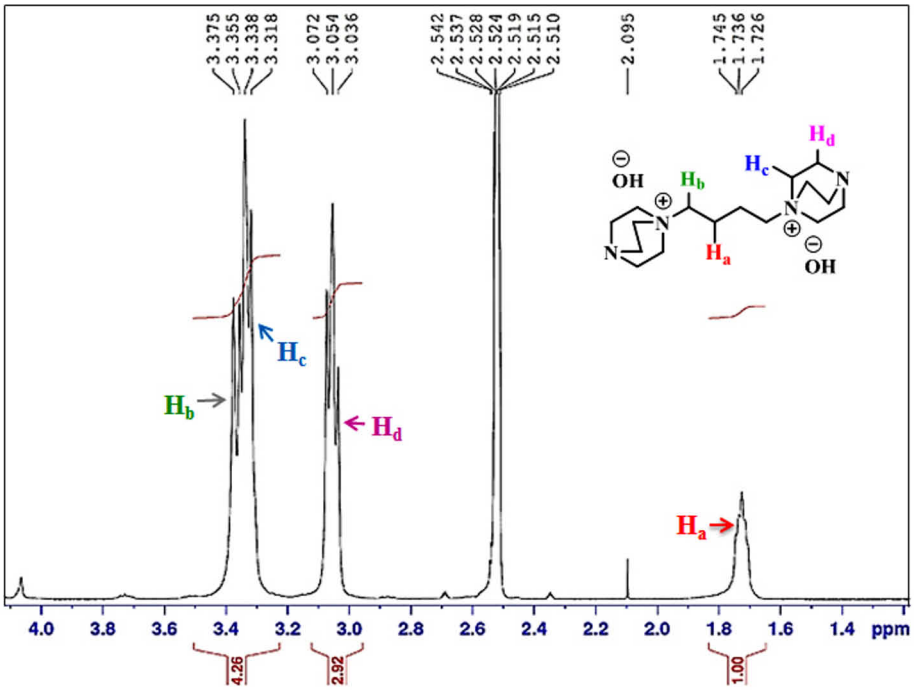


Fig. 3. ^{1}H NMR spectrum of $[C_4(DABCO)_2]\cdot 2OH$.

2.4.3. *Titration curve for $[C_4(DABCO)_2]\cdot 2OH$ with HCl*

The basicity of $[C_4(DABCO)_2]\cdot 2OH$ was determined by acid-base titration. An aqueous solution of the IL (0.05 mol/L, 10 mL) was titrated with a standard solution of HCl (0.1 mol/L) using a calibrated glass electrode pH meter at 25 °C. Fig. 4 shows that 20 mL of HCl were needed to neutralize all the basic groups in $[C_4(DABCO)_2]\cdot 2OH$. According to equation (1), 5 mL of HCl are needed to neutralize each basic group, therefore it can be concluded that this IL has four basic groups. Neutralization occurred in two stages, which indicates that $[C_4(DABCO)_2]\cdot 2OH$ has two types of basic group. These results confirm the structure of the prepared reagent.

$$M_{(acid)} \times V_{(acid)} = M_{(base)} \times V_{(base)}$$
$$0.05\ (mol/L) \times 10\ (mL) = 0.10\ (mol/L) \times V_{(acid)} \quad (1)$$
$$V_{(acid)} = 5\ mL$$

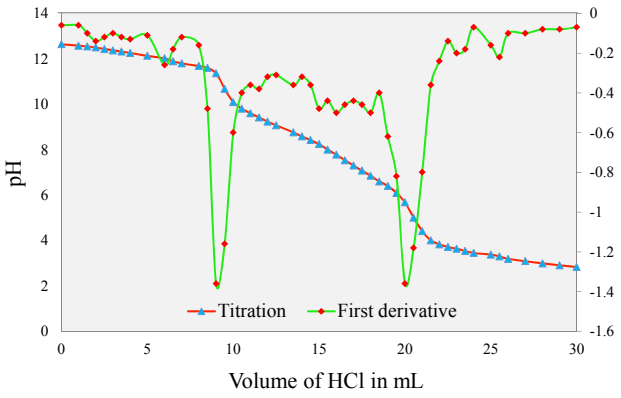


Fig. 4. Titration curve and its first derivative for IL with HCl (0.1 mol/L).

2.4.4. *Leaching test*

The probability of hydroxide groups leaching from the $[C_4(DABCO)_2]\cdot 2OH$ framework was determined using an in situ filtration technique. $[C_4(DABCO)_2]\cdot 2OH$ (50 mg) was stirred in dichloromethane (10 mL) for 24 h at room temperature. The $[C_4(DABCO)_2]\cdot 2OH$ was separated by filtration, and the filtrate was transferred to a 50 mL round-bottomed flask and evaporated to dryness. After drying, the pH values of fresh and tested $[C_4(DABCO)_2]\cdot 2OH$ were determined using pH-indicator strips. The images of the pH-indicator strips show that no leaching of the basic hydroxyl groups occurred (Fig. 5).

2.5. *General procedure for synthesis of 2-amino-3-cyano-4H-pyran derivatives*

A mixture of an aldehyde (1 mmol), malononitrile (1 mmol), barbituric acid or 6-amino-1,3-dimethyluracil (1 mmol), and $[C_4(DABCO)_2]\cdot 2OH$ (2 mol%) was prepared. The mixture was ground for 5–11 min at room temperature using a mortar and

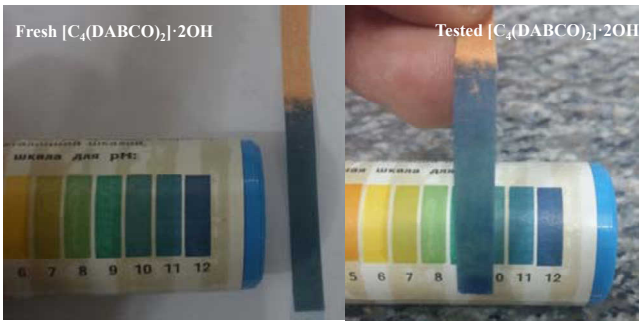


Fig. 5. Images of pH-indicator strips for fresh and tested $[C_4(DABCO)_2]\cdot 2OH$.

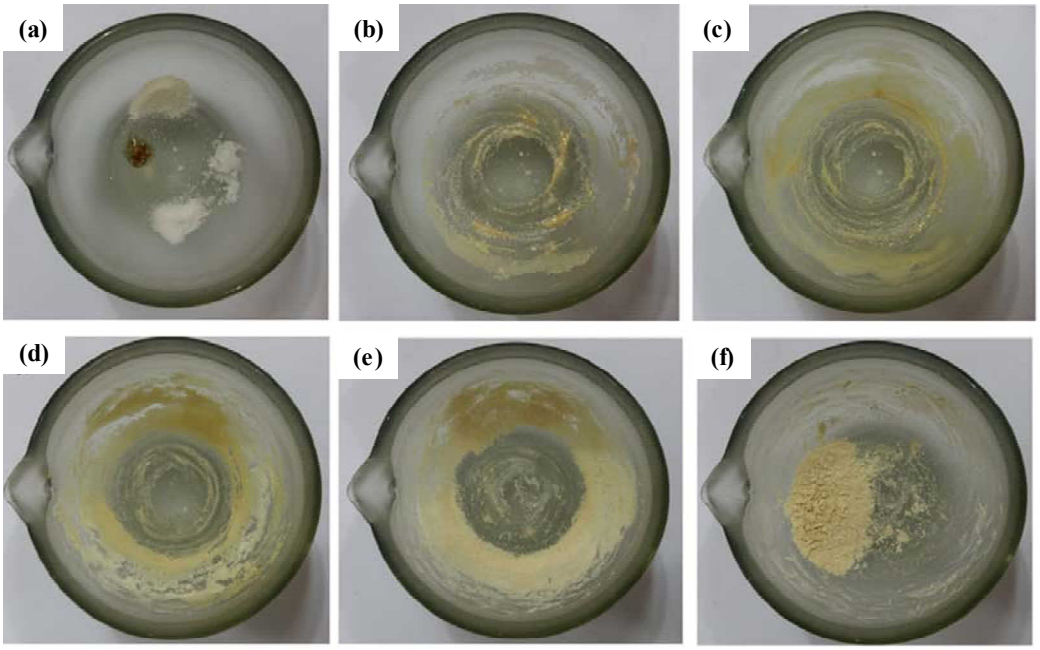


Fig. 6. Reaction process (a–f) using grinding method.

pestle; a solid mass was obtained (Fig. 6). After completion of the reaction (monitored using TLC), water (3 mL) was added to the mortar, and the mixture was filtered to separate the crude product. The product was purified by recrystallization from ethanol.

The spectral data of new compounds are as follows.

7-Amino-2,4-dioxo-5-(*o*-tolyl)-1,3,4,5-tetrahydro-2*H*-pyrano[2,3-*d*]pyrimidine-6-carbonitrile (Table 1, entry 5): m.p. = 223–225 °C; FT-IR (KBr, cm^{-1}): 3302, 3070, 2962, 2223, 1698, 1606, 1481, 1377, 1275, 1212, 1065; MS: *m/z* = 297 (M^+ + 1); ^{1}H NMR (DMSO-d_6, 400 MHz, ppm): δ = 2.45 (s, 3H, CH_3), 4.52 (s, 1H, CH), 7.10–7.16 (m, 6H, ArH and NH_2), 11.059 (s, 1H, NH), 12.080 (s, 1H, NH).

Table 1
Preparation of pyrano[2,3-*d*]pyrimidinone derivatives using $[C_4(DABCO)_2]\cdot 2OH$ as catalyst.

Entry	Aldehyde	Time (min)	Yield [a] (%)	m.p. (°C)	
				Found	Reported
1	C_6H_5CHO	5	92	215–217	215–217 [30]
2	$2\text{-}ClC_6H_4CHO$	6	94	211–212	211–212 [30]
3	$2\text{-}NO_2C_6H_4CHO$	4	95	253–256	253–256 [30]
4	$2\text{-}OHC_6H_4CHO$	7	95	160–162	160–162 [30]
5	$2\text{-}CH_3C_6H_4CHO$	6	94	223–225	—
6	$3\text{-}ClC_6H_4CHO$	6	90	240–241	240–241 [30]
7	$3\text{-}NO_2C_6H_4CHO$	5	95	267–269	267–269 [30]
8	$4\text{-}ClC_6H_4CHO$	5	94	245–247	245–247 [30]
9	$4\text{-}BrC_6H_4CHO$	5	94	231–233	231–233 [30]
10	$4\text{-}OCH_3C_6H_4CHO$	4	96	280–281	280–281 [30]
11	$4\text{-}NO_2C_6H_4CHO$	6	93	236–237	237–238 [30]
12	$4\text{-}CH_3C_6H_4CHO$	6	85	225–227	225 [30]
13	$4\text{-}NMe_2C_6H_4CHO$	10	92	231–233	230–232 [30]
14	Isatin	4	95	243–245	—
15	Pyridine-4-carbaldehyde	7	94	211–212	—

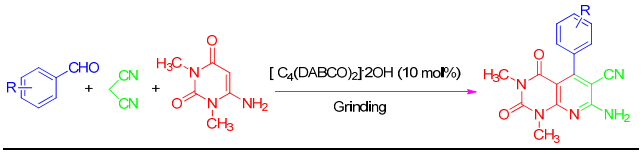
[a] Isolated yields.

7'-Amino-2,2',4'-trioxo-1',2',3',4'-tetrahydrospiro[indoline-3,5'-pyrano[2,3-*d*]pyrimidine]-6'-carbonitrile (Table 1, entry 14): m.p. = 243–245 °C; FT-IR (neat, cm^{-1}): 3352, 3303, 3140, 2202, 1723, 1672, 1531, 1389, 1333, 1108, 995, 635; MS: *m/z* = 323 (M^+); ^{1}H NMR (DMSO-d_6, 400 MHz, ppm): δ = 6.8 (d, J = 7.6 Hz, 1H), 6.9 (1H, td, J_1 = 7.6 Hz, J_2 = 0.8 Hz), 7.2 (2H, m), 7.4 (2H, s, NH_2), 10.5 (1H, s, NH), 11.145 (1H, s, NH), 12.3 (1H, s, NH); ^{13}C NMR (DMSO-d_6, 100 MHz, ppm): δ = 58, 87, 109, 117, 122, 124, 128, 133, 142, 149, 153, 158, 161, 178.

7-Amino-2,4-dioxo-5-(pyridin-4-yl)-1,3,4,5-tetrahydro-2*H*-pyrano[2,3-*d*]pyrimidine-6-carbonitrile (Table 1, entry 15): m.p. = 211–212 °C; FT-IR (neat, cm^{-1}) 3418, 3316, 3179, 2958, 2883, 2187, 1683, 1599, 1369, 1214, 1146, 1040; MS: *m/z* = 283 (M^+); ^{1}H NMR (DMSO-d_6, 500 MHz, ppm): δ = 4.38 (a, 1H, CH), 7.28 (2H, s, NH_2), 7.46–7.49 (1H, dd, ArH), 7.82–7.85 (1H, dd, ArH), 8.5–8.52 (1H, dd, ArH), 8.55–8.58 (1H, dd, ArH), 9.38 (1H, s, NH), 11.12 (1H, s, NH); ^{13}C NMR (DMSO-d_6, 100 MHz, ppm): δ = 26.02, 33.92, 57.83, 82.83, 87.6, 114.80, 115.26, 119.48, 124.93, 138.06, 138.99, 141.03, 146.68, 146.83, 150.09, 153.16, 158.31, 163.05, 164.58.

7-Amino-5-(4-cyanophenyl)-1,3-dimethyl-2,4-dioxo-1,2,3,4-tetrahydropyrido[2,3-*d*]pyrimidine-6-carbonitrile (Table 2, entry 9): m.p. > 300 °C; FT-IR (KBr, cm^{-1}): 3469, 3319, 3217, 2212, 1708, 1649, 1622, 1554, 1508, 1276, 1226, 973, 850, 806, 752; MS: *m/z* = 332 (M^+ + 1); ^{1}H NMR (DMSO-d_6, 500 MHz, ppm): δ = 3.09 (s, 3H, CH_3), 3.53 (s, 3H, CH_3), 7.28–7.31 (d, 2H), 7.36 (s, 2H, NH_2), 7.44–7.45 (d, 2H); ^{13}C NMR (DMSO-d_6, 100 MHz, ppm): δ = 24.56, 28.21, 28.31, 30.12, 34.85, 35.43, 43.05, 88.96, 99.11, 114.64, 115.76, 127.64, 128.01, 128.19, 128.73, 129.20, 134.99, 137.22, 151.36, 154.10, 158.91, 159.39, 160.75, 166.81.

Table 2
Preparation of pyrido[2,3-*d*]pyrimidine derivatives using $[C_4(DABCO)_2]\cdot 2OH$ as catalyst.



Entry	Aldehyde	Time (min)	Yield [a] (%)	m.p. (°C)	
				Found	Reported
1	C_6H_5CHO	8	92	>300	>300 [31]
2	$2\text{-}ClC_6H_4CHO$	11	93	>300	>300 [31]
3	$3\text{-}ClC_6H_4CHO$	8	92	>300	>300 [31]
4	$4\text{-}ClC_6H_4CHO$	7	94	>300	>300 [31]
5	$3\text{-}NO_2C_6H_4CHO$	7	93	>300	>300 [31]
6	$4\text{-}NO_2C_6H_4CHO$	8	95	>300	>300 [31]
7	$3\text{-}BrC_6H_4CHO$	8	92	>300	>300 [31]
8	$4\text{-}FC_6H_4CHO$	10	91	>300	>300 [31]
9	$4\text{-}CNC_6H_4CHO$	10	93	>300	—
10	2-Naphthaldehyde	8	91	>300	—

[a] Isolated yields.

7-Amino-1,3-dimethyl-5-(naphthalen-2-yl)-2,4-dioxo-1,2,3,4-tetrahydropyrido[2,3-*d*]pyrimidine-6-carbonitrile (Table 2, entry 10): m.p. >300 °C; FT-IR (KBr, cm^{-1}): 3431, 3047, 3229, 2908, 2202, 1658, 1621, 1575, 1372, 1264, 741; MS: m/z = 357 (M^+); ^1H NMR (DMSO-d_6, 500 MHz, ppm): δ = 3.07 (s, 3H, CH_3), 3.55 (s, 3H, CH_3), 7.35–7.37 (dd, 2H), 7.57–7.63 (m, 2H), 7.81 (s, 1H), 7.92–8.01 (m, 3H); ^{13}C NMR (DMSO-d_6, 100 MHz, ppm): δ = 19.05, 28.16, 30.14, 56.51, 89.11, 99.30, 115.95, 126.29, 126.33, 126.78, 126.98, 127.57, 128.11, 128.54, 132.90, 133.10, 135.53, 151.39, 154.16, 159.01, 159.70, 160.79.

3. Results and discussion

The structure of $[C_4(DABCO)_2]\cdot 2OH$ suggests that this reagent has good potential as a basic catalyst for reactions that are accelerated by this type of catalyst. We therefore investigated the use of this reagent for promotion of the synthesis of pyrano[2,3-*d*]pyrimidinone and pyrido[2,3-*d*]pyrimidine derivatives.

First, we optimized the reaction conditions in the synthesis of pyrano[2,3-*d*]pyrimidinone derivatives by performing the condensation of 4-chlorobenzaldehyde, barbituric acid, and malononitrile in the absence or presence of $[C_4(DABCO)_2]\cdot 2OH$ under various conditions (Table 3). The best results were obtained using a grinding method with 10 mol% of $[C_4(DABCO)_2]\cdot 2OH$ at room temperature under solvent-free conditions.

After optimization of the reaction conditions, the effectiveness and suitability of this method were investigated by performing the reaction using a variety of simple and readily available substrates under the optimal conditions.

For this purpose, various aromatic aldehydes containing electron-withdrawing and electron-donating groups, i.e., Cl, Br, CH_3, OCH_3, and NO_2, in the *ortho*, *meta*, and *para* positions of the benzene ring were reacted with barbituric acid and malononitrile under the optimal conditions. The corresponding

Table 3
Optimization of conditions for reactions catalyzed by $[C_4(DABCO)_2]\cdot 2OH$ [a].

Entry	Catalyst (mol%)	Solvent	Temperature (°C)	Time (min)	Yield [b] (%)
1	—	EtOH	r.t.	60	Trace
2	—	H_2O	r.t.	60	Trace
3	—	Grinding	r.t.	60	Trace
4	10	EtOH	r.t.	60	70
5	10	H_2O	r.t.	60	80
7	10	Grinding	r.t.	5	94
8	15	Grinding	r.t.	5	95
9	5	Grinding	r.t.	25	85

[a] Reaction conditions: 4-chlorobenzaldehyde (1 mmol), barbituric acid (1 mmol), malononitrile (1 mmol), in the presence of $[C_4(DABCO)_2]\cdot 2OH$ as the catalyst.
[b] Isolated yields.

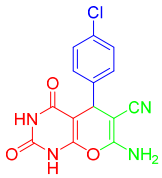
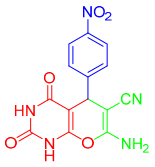
products were obtained in high isolated yields in short reaction times (Table 1, entries 1–13). The heterocyclic aldehydes isatin and pyridine-4-carbaldehyde were also used under these conditions, and the desired products were obtained in high yields (Table 1, entries 14 and 15).

Next, $[C_4(DABCO)_2]\cdot 2OH$ was used to promote the condensation of aldehydes, malononitrile, and 6-amino-1,3-dimethyluracil to give pyrido[2,3-*d*]pyrimidines. The reaction conditions were optimized using the reaction between 4-chlorobenzaldehyde, malononitrile, and 6-amino-1,3-dimethyluracil as a model reaction. The best results were obtained by grinding 1 mmol of aldehyde, 1 mmol of malononitrile, 1 mmol of 6-amino-1,3-dimethyluracil, and 10 mol% $[C_4(DABCO)_2]\cdot 2OH$ at room temperature. Under the optimal conditions, various aromatic aldehydes containing electron-releasing and electron-withdrawing substituents on the aromatic ring gave the corresponding products in high yields in short reaction time (Table 2).

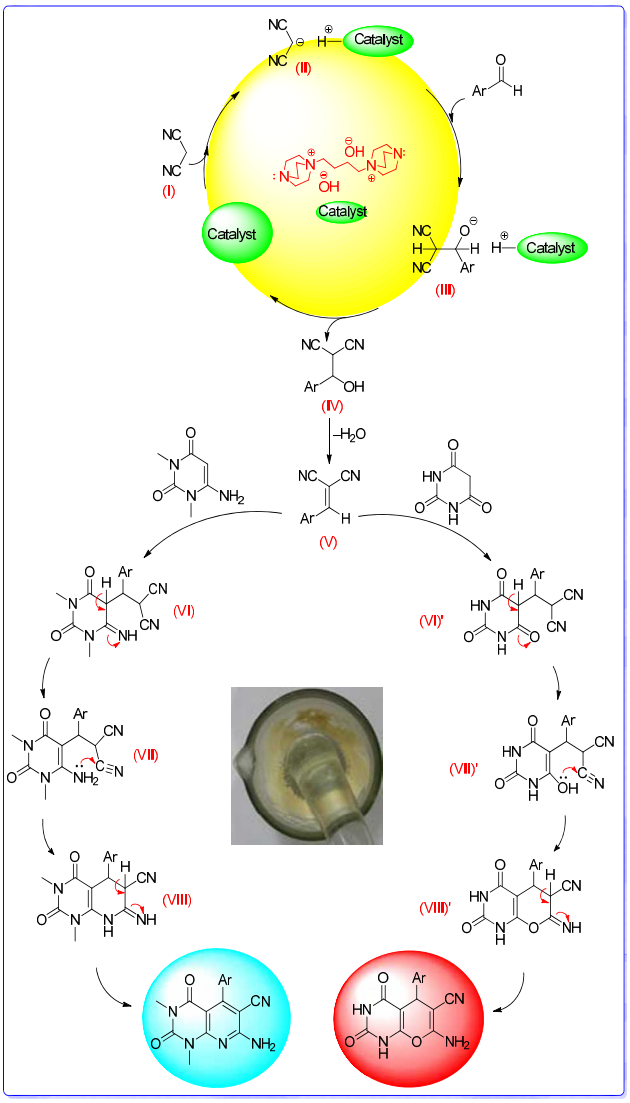
We compared the results obtained using our newly developed method for the $[C_4(DABCO)_2]\cdot 2OH$-catalyzed synthesis of 7-amino-5-(4-chlorophenyl)-2,4-dioxo-1,3,4,5-tetrahydro-2*H*-pyrano[2,3-*d*]pyrimidine-6-carbonitrile (Table 1, entry 8) and 7-amino-5-(4-nitrophenyl)-2,4-dioxo-1,3,4,5-tetrahydro-2*H*-pyrano[2,3-d]pyrimidine-6-carbonitrile (Table 1, entry 11) with the results reported in the literature for other synthetic methods (Table 4). The data in Table 4 show that this method avoids some of the difficulties associated with other procedures such as long reaction time, low yields, harsh conditions for catalyst preparation, e.g., IR or microwave irradiation, and high catalyst loadings.

A proposed mechanism for the synthesis of pyrano[2,3-*d*]pyrimidinone and pyrido[2,3-*d*]pyrimidine derivatives is shown in Scheme 2. In this procedure, $[C_4(DABCO)_2]\cdot 2OH$ effectively catalyzes the formation of olefin (V), which is readily prepared by Knoevenagel condensation of an aldehyde and active methylene nitrile (I), via intermediate (IV). Barbituric acid or 6-amino-1,3-dimethyluracil then reacts with V to give VII or VII', followed by intermolecular cyclization to VIII or VIII'. Finally, the products are formed by tautomerization.

Table 4
Comparison of results obtained for synthesis of selected compounds in presence of $[C_4(DABCO)_2]\cdot 2OH$ with those obtained using other catalysts.

Product	Catalyst (mol%)	Reaction condition	Time (min)	Yield [a] (%)	Ref.
	$Zn[(L)proline]_2$ (17)	EtOH / reflux	50	90	[22]
	$[BMIm]BF_4$ (1.5 g)	90 °C	180	92	[23]
	DABCO`(10)	Ethanol-H_2O (1:1) / r.t.	120	89	[25]
	SBA-Pr-SO_3H (0.02 g)	Neat / 140 °C	45	30	[26]
	KBr (100)	Electrolysis	20	77	[29]
	$[C_4(DABCO)_2]\cdot 2OH$ (10)	Grinding/ r.t.	5	94	This work
	L-proline (5)	aq. EtOH, r.t.	45	73	[21]
	$Zn[(L)proline]_2$ (17)	EtOH / reflux	30	92	[22]
	DAHP (10)	aq. EtOH / r.t.	120	72	[24]
	DABCO`(10)	Ethanol-H_2O (1:1) / r.t	120	92	[25]
	SBA-Pr-SO_3H (0.02 g)	Neat / 140 °C	15	90	[26]
	TBAB (10)	H_2O / reflux	35	80	[27]
	KBr (100)	Electrolysis	20	73	[29]
	$[C_4(DABCO)_2]\cdot 2OH$ (10)	Grinding/ r.t.	6	93	This work

[a] Isolated yields.



Scheme 2. Proposed mechanism for synthesis of pyrano[2,3-*d*]pyrimidinone and pyrido[2,3-*d*]pyrimidine derivatives using $[C_4(DABCO)_2]\cdot 2OH$ as catalyst.

4. Conclusions

In summary, we synthesized pyrano[2,3-*d*]pyrimidinone and pyrido[2,3-*d*]pyrimidine derivatives using 1,1'-(butane-1,4-diyl)bis(1,4-diazabicyclo[2.2.2]octan-1-ium) hydroxide as an effective IL catalyst with dual basic functional groups. This synthesis has various advantages: preparation of the basic IL catalyst is simple, and the IL is not harmful to the environment; the starting materials are readily available; mild reaction conditions can be used; the reaction profile is clean; high reaction rates and excellent yields are achieved; and column chromatographic separation of the products is not needed.

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Graphical Abstract

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Efficient synthesis of pyrano[2,3-*d*]pyrimidinone and pyrido[2,3-*d*]pyrimidine derivatives in presence of novel basic ionic liquid catalyst

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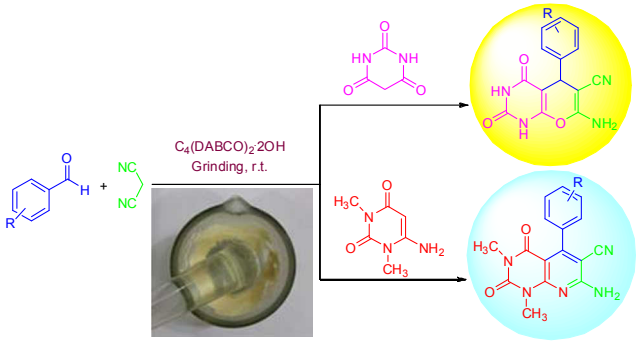
1,1'-(Butane-1,4-diyl)bis(1,4-diazabicyclo[2.2.2]octan-1-ium) hydroxide, which is a basic ionic liquid, efficiently promoted the synthesis of pyrano[2,3-*d*]pyrimidinones and pyrido[2,3-*d*]pyrimidines at room temperature under grinding conditions.



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新型碱性离子液体催化剂高效催化合成吡喃酮[2,3-*d*]嘧啶酮和[2,3-*d*]嘧啶衍生物

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摘要: 制备了碱性离子液体1,1'-(丁烷-1,4-二基)双(1,4-二氮杂二环[2.2.2]辛烷-1-ium)羟化物, 并采用红外光谱、^{1}H核磁共振谱和pH值分析对其进行了表征. 然后将它用于室温研磨条件下高效催化合成吡喃酮[2,3-*d*]嘧啶酮和[2,3-*d*]嘧啶. 该法步骤简单, 反应时间短, 产物收率高, 无需柱色谱分离, 原料易得, 且可回收利用.

关键词: 碱性催化剂; 多组分反应; 嘧啶衍生物; 研磨

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