Bulgarian Chemical Communications, Volume 46, Number 1(pp.165 – 174) 2014

Synthesis of 2,4,5-trisubstituted and 1,2,4,5-tetrasubstituted-1H-imidazole derivatives and or 2,4,5-Triaryloxazoles using of Silica-Supported Preyssler Nanoparticles

A. Gharib[1,2]*, B. R.h Hashemipour Khorasani[2], M. Jahangir[1], M. Roshani[1],
L.Bakhtiari[2], S. Mohadeszadeh[2]

[1]*Department of Chemistry, Islamic Azad University, Mashhad, IRAN*
[2]*Agricultural Researches and Services Center, Mashhad, IRAN*

Received: May 28, 2012; Revised: February 5, 2013

One-pot multi-component condensation of benzil and or benzoin, aldehydes, ammonium acetate and primary amines were used for synthesis of 2,4,5-trisubstituted and 1,2,4,5-tetrasubstituted-1H-imidazole derivatives under reflux conditions using Silica-supported Preyssler nanoparticles heteropolyacid as a catalysts. This catalyst has several advantages (simple work-up, inexpensive and reusability). These catalysts were also successfully employed in the synthesis of triaryloxazoles.

Keywords: substituted imidazole; silica-supported Preyssler nanoparticle; benzil; aromatic aldehyde; triaryloxazoles; multicomponent reaction

INTRODUCTION

Imidazole is a five-membered ring heteroaromatic compound with two nitrogen atoms at 1 and 3 [1]. This type of compound is known to exhibit a broad range of pharmaceutical and industrial applications. For instance, the imidazole core unity is present in many compounds with pronounced biologic activities such as angiotensin inhibitors [2], anti-inflammatory [3], glucagon antagonist [4], antiviral [5], fungicidal [6], and high cytotoxicity, which has indicated them as new candidates in cancer therapy [7]. Heterocyclic compounds with imidazole ring systems have many pharmaceutical activities and play important roles in biochemical processes [8]. Highly substituted imidazole derivatives are also the key intermediates in the synthesis of many therapeutic agents. Omeprazole, Pimobendan, Losarton, Olmesartan, Eprosartan and Triphenagrel are some of the leading drugs in the market with diverse functionality [9]. Triarylimidazoles are used in photography as photosensitive compound [10]. In addition, they are of interest due to their herbicidal [11], analgesic [12], fungicidal [13], antiinflammatory [14] and antithrombotic activities [15]. There are numerous methods in the literature for the synthesis of highly substituted imidazoles: (a) condensation of 1,2–diones, aldehydes, primary amines and ammonia [16], (b) *N*-alkylation of trisubstituted imidazoles [17], (c) condensation of benzoin or benzoin acetate with aldehydes, primary amines and ammonia in the presence of copper acetate [18] (d) cyclization of sulfonamides with mesoionic 1,3-oxazolium-5-olates [19], (e) four component condensation of diones, aldehydes, primary amines and ammonium acetate in acetic acid under reflux conditions [20], (f) condensation of *β*-carbonyl -*N*-acyl-*N*-alkylamines with ammonium acetate in refluxing acetic acid [21] and (g) conversion of *N*-(2-oxo)amides with ammonium trifluoroacetate under neutral conditions [22]. The synthesis of triarylimidazoles from the three component reaction of 1,2-dicarbonyl compounds, aldehyde and ammonia was independently discovered by Radziszewski [23]. However, long periods of time and harsh conditions were frequently associated with low yields of production. Davidson *et al*. [17] showed can reduce the reaction times using acetic acid as solvent and ammonium acetate instead of ammonia. This last protocol became usual and default procedure for the synthesis of triarylimidazoles [24]. Polyoxo-metalates (POMs) are metal-oxo anionic clusters whose chemical properties can be controlled by transition-metal substitution and the countercation used. POMs have wide applications in many fields such as catalysis, medicine, magnetic properties, materials, surface chemistry, photochromism, and electrochromism, owing to their so-called ‘‘valueadding properties.’’ These properties, combined with their ability to donate and accept

---

* To whom all correspondence should be sent:
E-mail: aligharib5@yahoo.com

electrons and their stability over a wide range of conditions, make them attractive candidates for catalysis. A new and efficient method for the preparation of 4(3*H*)-quinazolinones fromthe condensation of anthranilic acid, orthoester and substituted anilines, in the presence of catalytic amounts of silica-supported Preyssler nanoparticles is reported [25]. An efficient, improved, and environmentally benign procedure for catalytic oxidation of benzyl alcohols to the corresponding benzaldehdes was developed in the presence of nano-SiO_2-supported Preyssler heteropolyacid (HPA), both in thermal conditions and under microwave irradiation [26]. Silica-supported Preyssler nanoparticles appear to be a new and efficient solid acid catalyst for an economical, and environmentally benign one-pot synthesis of 3-substituted phthalides [27]. An efficient and environmentally benign procedure for the catalytic esterification of salicylic acid with aliphatic alcohols, $C_nH_{2n+1}OH$ (n = 1–5) and benzylic alcohols, $RC_6H_4CH_2OH$ (R = H, NO_2, OCH_3, Br, Cl, Me) was developed using nano-SiO_2-supported Preyssler heteropolyacid both under thermal conditions and microwave irradiation [28].

EXPERIMENTAL

Catalyst Preparation

Supported heteropolyacid catalyst was synthesized according to the literature [29,30] using a support in powder form (SiO_2) with an aqueous solution of the heteropolyacids. After stirring the mixture, the solvent was evaporated, dried at 120^{O}C and calcined at 250^{O}C in a furnace prior to use. Silica-supported Preyssler nano-structures were obtained through the microemulsion method [29].

Synthesis of 2,4,5-triaryl-1H-imidazoles (5a-Z4) from the benzils (1a-Z4): General Procedure:

A mixture of benzils (1 mmol) and aromatic aldehyde (**2a-Z4**) (1 mmol), ammonium acetate (4 mmol) and EtOH (4 mL) was heated under reflux with magnetic stirring until the mixture melted. Silica-supported Preyssler nanoparticles (0.03 mmol) were added to this mixture and stirred under reflux for 3 h. The progress of the reaction was monitored by thin-layer chromatography (TLC). After completion of reaction, the reaction mixture was cooled to room temperature and poured on 100 ml ice water and diluted with dichloromethane, and separated from the catalyst by filtration. Pure products were obtained after the addition of water to the organic layer. Two phases of solution were extracted and then the solvent was evaporated to afford 2,4,5-triaryl-1*H*-imidazoles (**5a-Z4**). The separated solid was filtered and washed with water. The residue was dried, and recrystallized from methanol: water (8:1) mixture.

Synthesis of 2,4,5-triarylimidazoles (5a-Z4) from the benzoin (5):

A mixture of benzoin (1 mmol) and aromatic aldehyde (**2a-Z4**) (1 mmol), ammonium acetate (5 mmol) and EtOH (4 mL) was heated under reflux with magnetic stirring until the mixture melted. Silica-supported Preyssler nanoparticles (0.03 mmol) were added to this mixture and stirred under reflux for 3 h. The progress of the reaction was monitored by thin-layer chromatography (TLC). After completion of reaction, the reaction mixture was cooled to room temperature and poured on 100 ml ice water and diluted with dichloromethane, and separated from the catalyst by filtration. Pure products were obtained after the addition of water to the organic layer. Two phases of solution were extracted and then the solvent was evaporated to afford 2,4,5-triaryl-1*H*-imidazoles (**5a-Z4**). The separated solid was filtered and washed with water. The residue was dried, and recrystallized from methanol: water (8:1) mixture.

Synthesis of 2,4,5-triaryloxazoles (9a-j):

A 10 mL round-bottom flask equipped with magnetic stirrer was charged with benzoin (**5**) and or benzils (**1a-Z4**) (1.0 mmol), aldehydes (**2a-j**) (1.0 mmol), NH_4OAc (**4**, 4.0 mmol) and Silica-supported Preyssler nanoparticles (0.05 mmol), followed by EtOH (4 mL). The reaction mixture was stirred and gently refluxed for 4 h. After the completion of the reaction with the monitoring of TLC, 4 mL of water were added. The solid was filtered under reduced pressure and washed with small portions of a mixture of cooled EtOH/H_2O (1:1, v:v). The crude product was recrystallized from acetone/water 9:1 or toluene.

Selected Spectra data:

2-(2,4-dichlorophenyl)-4,5-diphenyl-1H-imidazole (Table 1, entry 5):

mp 175–176 ^{O}C. IR (KBr, cm^{-1}) ν_{max}: 3425, 3069, 1590, 824, 765, 698. ^{1}H NMR (300 MHz, DMSO-d_6,) δ_H: 12.6 (s, 1H), 7.84 (d, J = 8.4 Hz, 1H), 7.80 (s, 1H), 7.45–7.65 (m, 12H). ^{13}C NMR (100 MHz, DMSO-d_6) δ_C: 126.5, 127.4, 127.4, 127.8, 128.2, 128.5, 128.4, 128.7, 128.7, 129.55, 130.6, 132.4, 132.6, 133.9, 134.8, 137.1, 142.4. EIMS *m/z* 364 (M$^+$-2, 100), 165, 123, 69, 55.

2-(4-methoxyphenyl)-4,5-diphenyl-1H-imidazole (Table 1, entry 17):

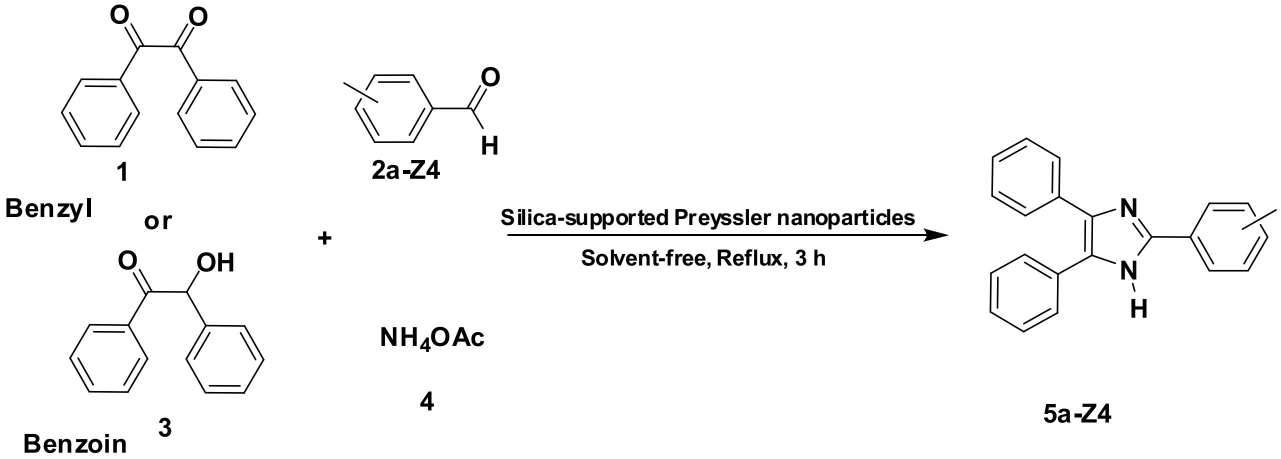
mp 231–232 ^{O}C. IR (KBr, cm^{-1}) ν_{max}: 3400, 3060, 1611, 1490, 1179, 1027, 830, 760. ^{1}H NMR (300 MHz, DMSO-d_6,) δ_H: 12.47 (s, Br, 1H), 8.00 (dt, J = 8.8Hz, 2.0 Hz, 2H), 7.50 (d, J = 7.2 Hz, 4H), 7.37 (t, J = 7.2 Hz, 4H), 7.28 (t, J = 7.2 Hz, 2H), 7.06(dt, J = 8.8 Hz, 2.0 Hz, 2H), 3.82 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ_C: 55.2, 114.2, 122.9, 126.7, 127.1, 127.7, 128.4, 145.7, 159.5. EIMS: m/z (%) = 326 (M+, 100), 311, 283, 235, 97.

Reusing the Catalyst

The reusability of the catalyst was also investigated. The synthesis of 3a was selected as the model reaction (Scheme 1). After completion, the catalyst was filtered off and washed three times with 10 ml of dichloromethane, dried at 80^{O}C under reduced pressure (2 h), and subjected to the second run of the model reaction.

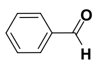
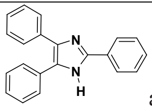
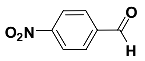
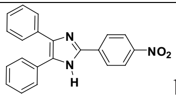
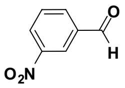
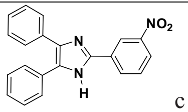
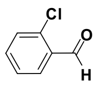
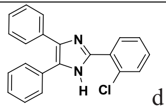
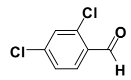
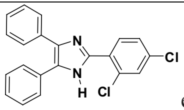
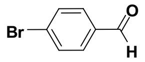
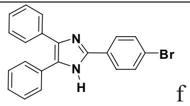
RESULTS AND DISCUSSION

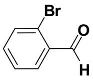
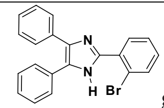
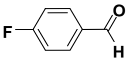
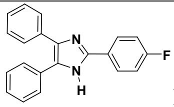
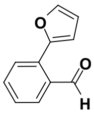
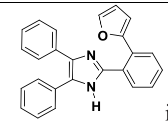
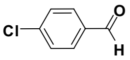
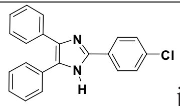
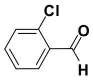
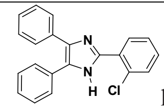
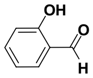
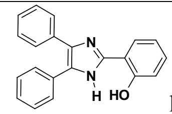
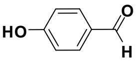
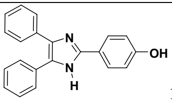
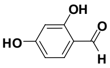
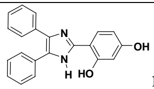
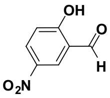
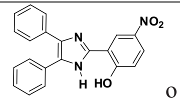
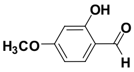
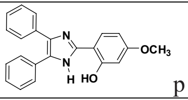
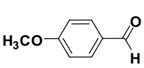
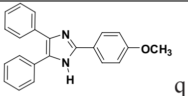
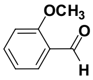
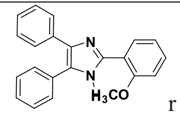
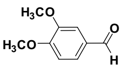
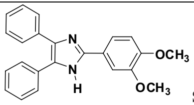
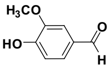
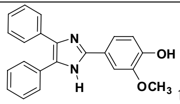
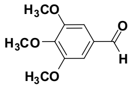
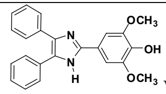
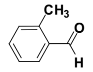
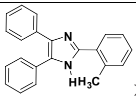
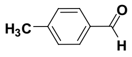
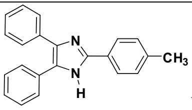
We report for the first time a direct and efficient method for the preparation of substituted 2,4,5-triaryl-1*H*-imidazole derivatives by the condensation of benzil or 1,2-diketones (1) and or benzoin, aromatic aldehyde (2) and ammonium acetate using silica-supported Preyssler nanoparticles as a novel and efficient catalytic system (Scheme 1), (entries 5a-Z4, Table 1).

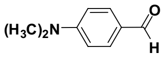
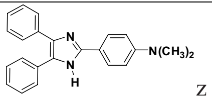
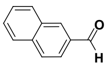
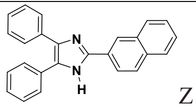
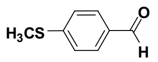
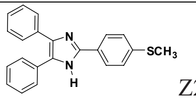
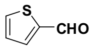
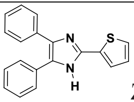
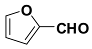
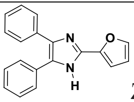


Scheme 1 Synthesis of 2,4,5-trisubstituted-1*H*-imidazole derivatives (5a-Z4) in the presence of Silica-Supported Preyssler Nanoparticles under Solvent-Free Conditions at reflux conditions and in proper times.

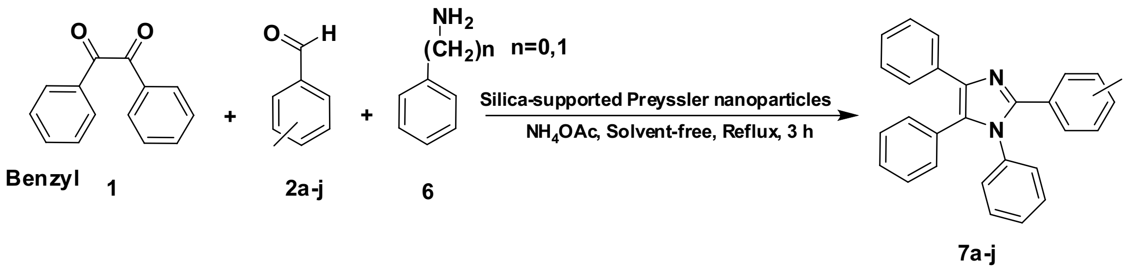
Table 1. Synthesis of 2,4,5-Trisubstituted Imidazoles via condensation of benzil, aldehydes, ammonium acetate and using silica-supported Preyssler nanoparticles under solvent-free conditions at reflux conditions and in proper times.

Entry	Substrate 2	Product 3	Time (h)		^{a}Yield (%)		MP (°C)	
			Benzil	Benzoin	Benzil	Benzoin	Found	Reported (lit.)
1		 a	1	1.5	96	92	269-270	(274–276)[19]
2		 b	1.5	2.5	98.5	96	240-241	240–242
3		 c	1.5	2	93	96	>262	>260 [18]
4		 d	1.5	2	96	92	180-182	(183–184)[20]
5		 e	1	1.5	91	94	175-176	176.5-177 [31]
6		 f	1	1.5	93	98	260-262	261.5-263.5 [21]

7		 g	1	2	90	95	202-203	201-202 [32]
8		 h	2	2.5	97	91	188-189	189-190 [33]
9		 i	1.5	2	91	96	200-201	202-203 [32]
10		 j	1.5	2	96	98	261-263	262-264 [21]
11		 k	1.5	2	94	95	196-198	195-197 [31]
12		 l	1	1.5	96	98	271	272 [17]
13		 m	1.5	2	91	95	234	233 [19]
14		 n	1.5	2	96	97	272	272 [17]
15		 o	2	2.5	96	98	261-263	260.5-262 [24]
16		 p	1.5	2	95	97	242	243 [17]
17		 q	2	2.5	86	92	231-233	230-232 [21]
18		 r	1	2	81	84	209-211	210-210.5 [21]
19		 s	2	3	84	89	217-219	216-218 [22]
20		 t	1	2	93	96	196	197 [34]
21		 w	2	4	86	84	261-262	261 [17]
22		 x	2	3	90	91	207-208	205-207 [21]
23		 y	1	2	88	88	234-236	232-235 [20]

24		 z	1	2	92	96	257-259	257-258 [33]
25		 Z1	2	3	90	91	292-293	291.5-292 [21]
26		 Z2	1	2.5	98	98	241-243	242-244 [35]
27		 Z3	1.5	2.5	94	94	259-260	260-261 [33]
28		 Z4	1	3	92	96	199-200	200-201 [33]

[a]Isolated yield.



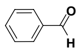
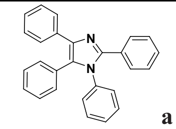
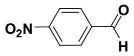
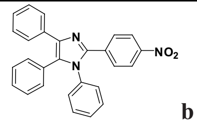
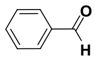
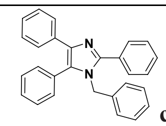
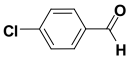
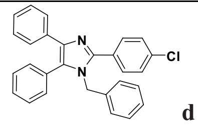
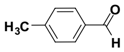
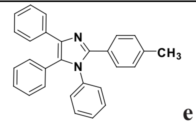
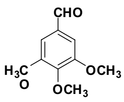
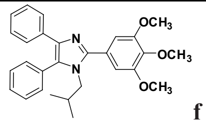
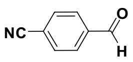
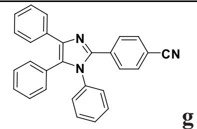
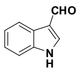
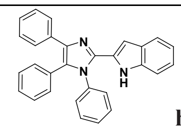
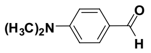
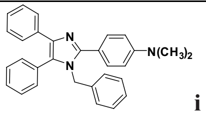
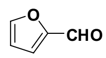
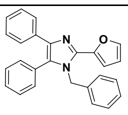
Scheme 2. Synthesis of 1,2,4,5-tetrasubstituted-1*H*-imidazole derivatives (7a-j) in the presence of Silica-Supported Preyssler Nanoparticles under Solvent-Free Conditions at reflux conditions and in proper times

Similar methodology was applied for the synthesis of 1,2,4,5-tetrasubstituted-1*H*-imidazole derivatives (7a-j) which were also obtained in good to excellent yields by the condensation of benzil (1), aldehydes (2), aromatic amines (4) and ammonium acetate (Table 2) in presence of nano-structured Preyssler supported on silica as catalyst under solvent-free conditions. (Scheme 2).

The effect of solvent on the model reaction was studied by carrying out the reaction in a solvent-free system and in a variety of solvents including ethanol, methanol and acetonitrile at reflux conditions. As shown in Table 3 the best results in terms of yield and time have been achieved in free-solvent and ethanol conditions. Thus it was applied as solvent of choice. It is noteworthy to mention that in the absence of the catalyst and just refluxing the substrate in free-solvent and ethanol, no reaction took place.

To determine the most appropriate reaction conditions and evaluate the catalytic efficiency of silica-supported Preyssler nanoparticles, the synthesis of **5a** (as model reaction) was carried out in various conditions. First, we tried the reaction without catalyst. When a mixture of benzil, aromatic aldehyde and ammonium acetate was stirred under reflux conditions for 14 h in the absence of silica-supported Preyssler nanoparticles, no conversion was detected. This observation indicated that a catalyst is necessary for this transformation. To study the effect of solvent on the yield of this reaction, the model reaction was carried out in various solvents and a solvent-free system using 0.03 mmol of silica-supported Preyssler nanoparticles as the catalyst. As shown in Table 1, the best results in terms of yield and time were achieved in solvent-free conditions and in the presence of EtOH as solvent, too. To investigate the effect of silica-supported Preyssler nanoparticles, we carried out comparative experiments with some silica-gel-supported heteropolyacids, and the comparative results are summarized in Tables 1 and 2 for the synthesis of 2,4,5-triphenyl-1*H*-imidazole (**5a**) and 1,2,4,5-tetrasubstituted-1*H*-imidazole (**7a**). We have performed aldehydes consisting electron withdrawing groups or electron donating groups at different positions but it did not show any remarkable difference in the yield of product and time of the reactions. Different mechanistic pathways have been proposed for this multicomponent reaction having the benzil or benzoin as starting materials [30]. The proposed rationale by Kokare *et al.* [31] seems to be in

Table 2. Synthesis of 1,2,4,5-tetrasubstituted-1*H*-imidazole via condensation of benzil, aldehydes, ammonium acetate and amine using Silica-Supported Preyssler Nanoparticles under reflux conditions and in proper times.

Entry	Substrate 2	Product 3	Time (min.)	[a]Yielda (%)	MP (°C)	
			Benzil	Benzil	Found	Reported
1		 a	30	91	256–257	(261–262)[19]
2		 b	20	97	222-225	219-220 [33]
3		 c	25	91	161-163	158-160 [33]
4		 d	20	96	149-152	146-148 [24]
5		 e	30	81	192-193	189 [36]
6		 f	60	92	117-119	112-115 [33]
7		 g	25	93	205-207	198-201 [24]
8		 h	30	86	219-221	218-220 [24]
9		 i	30	94	180-182	183-185[23, 24]
10		 j	17	91	156-158	156-157 [24]

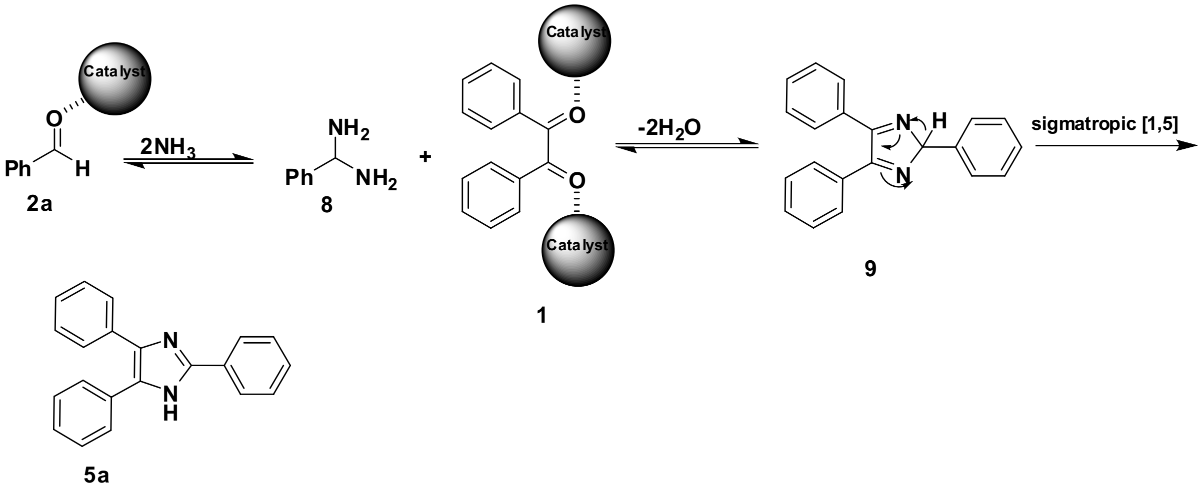
[a]Isolated yield.

accordance with the results in Table 1 (Scheme 3). The authors suggested the initial formation of *N*,*N*-ketal (**10**) under heteropolyacid acidic catalysis from benzaldehyde (**2a**) and 2 equivalents of NH_4OAc (**4**). It was assumed that the same activation occurs in the heteropolyacid catalysis. Therefore, the condensation of **8** with benzil (**1**) after losing 2 equivalents of water, leads to the conjugate intermediate **9** which rearranges via a [1,5]-sigmatropic proton shift to afford the corresponding lophine (**5a**). On the other hand, starting from benzoin, the cyclization of intermediate imino-alcohol (**10**) should occur by an intramolecular attack of nitrogen in a more hindered and saturated carbon to afford the dihydroimidazole intermediate (**11**) (Scheme 4). Additionally, the needed oxidation step to produce the conjugated intermediate (**12**) could explain the minor reactivity that is observed in the reactions starting from benzoin. The intermediate (**12**) is suggested as common specie in both mechanistic pathways.

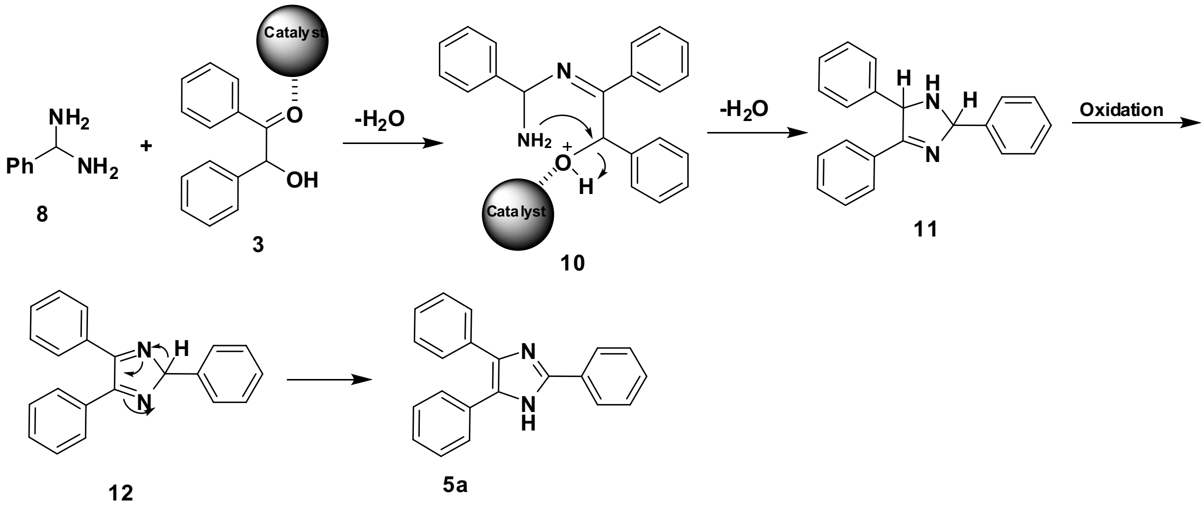
Table 3. Synthesis of 2,4,5-triphenyl-1*H*-imidazole (**3a**) in the presence of various silica-supported heteropolyacids in different solvents and proper times.

Entry	Solvent	Catalyst	Reaction Time (h)		ªYield (%)	
			Benzil	Benzoin	Benzil	Benzoin
1	Free	$H_3[PMo_{12}O_{40}]/SiO_2(50\%)$	1.5	2	84	82
2	Free	$H_4[PMo_{11}VO_{40}]/SiO_2(50\%)$	1.5	2	91	88
3	Free	$H_3[PW_{12}O_{40}]/SiO_2(50\%)$	1.5	2	87	85
4	Free	$H_{14}[NaP_5W_{30}O_{110}]/SiO_2$ Nanoparticles	1	1.5	96	92
5	Free	$H_{14}[NaP_5W_{30}O_{110}]/SiO_2(50\%)$	1	1.5	94	90
6	EtOH	$H_3[PMo_{12}O_{40}]/SiO_2(50\%)$	1.5	2	83	80.5
7	EtOH	$H_4[PMo_{11}VO_{40}]/SiO_2(50\%)$	1.5	2	89.5	87
8	EtOH	$H_3[PW_{12}O_{40}]/SiO_2(50\%)$	1.5	2	85.5	84
9	EtOH	$H_{14}[NaP_5W_{30}O_{110}]/SiO_2$ Nanoparticles	1	1.5	95	91
10	EtOH	$H_{14}[NaP_5W_{30}O_{110}]/SiO_2(50\%)$	1	1.5	91.5	87.5
11	MeOH	$H_3[PMo_{12}O_{40}]/SiO_2(50\%)$	2	2	83	80
12	MeOH	$H_4[PMo_{11}VO_{40}]/SiO_2(50\%)$	2	2	88.5	86
13	MeOH	$H_3[PW_{12}O_{40}]/SiO_2(50\%)$	2	2	84.5	84
14	MeOH	$H_{14}[NaP_5W_{30}O_{110}]/SiO_2$ Nanoparticles	2	2	93	90
15	Acetonitrile	$H_{14}[NaP_5W_{30}O_{110}]/SiO_2(50\%)$	2	2	89.5	86
16	Acetonitrile	$H_3[PMo_{12}O_{40}]/SiO_2(50\%)$	2.5	3	80	77
17	Acetonitrile	$H_4[PMo_{11}VO_{40}]/SiO_2(50\%)$	2.5	3	85	84.5
18	Acetonitrile	$H_3[PW_{12}O_{40}]/SiO_2(50\%)$	2.5	3	82	82
19	Acetonitrile	$H_{14}[NaP_5W_{30}O_{110}]/SiO_2$, Nanoparticles	2	2.5	92	88.5
20	Acetonitrile	$H_{14}[NaP_5W_{30}O_{110}]/SiO_2(50\%)$	2	2.5	87.5	85

ªIsolated yield.



Scheme 3. Suggested mechanistic pathway starting from benzil (**5a**).



Scheme 4. Suggested mechanistic pathway starting from benzoin (**5a**).

Table 4. Comparative study of various supported heteropolyacid catalysts for the preparation of 2,4,5-trisubstituted (**5a**) under reflux conditions and solvent-free

Entry	Catalyst	Amount of catalyst (mmol)	Time (h)	Yield (%)
			Benzil	Benzil
1	$H_{14}[NaP_5W_{30}O_{110}]/SiO_2$ nanoparticles	0.08	8	96
2	$H_{14}[NaP_5W_{30}O_{110}]/SiO_2$(50%)	0.09	10	94
3	$H_3[PMo_{12}O_{40}]/SiO_2$(50%)	0.09	10	84
4	$H_4[PMo_{11}VO_{40}]/SiO_2$(50%)	0.09	10	91
5	$H_3[PW_{12}O_{40}]/SiO_2$(50%)	0.09	10	87
6	Free	-	-	-

The generality of this process was demonstrated by the wide range of substituted and structurally divers aldehydes to synthesize the corresponding products in high to excellent yields (Table 1). The high yield transformations were carried out without any significant amounts of undesirable side products. Unlike some previously reported methods, the present method does not require toxic or anhydrous organic solvents to produce the 2,4,5-trisubstituted imidazole derivatives. Comparison of silica-supported Preyssler nanoparticles, $H_3[PMo_{12}O_{40}]/SiO_2$ (50%), $H_4[PMo_{11}VO_{40}]/SiO_2$ (50%), $H_{14}[NaP_5W_{30}O_{110}]/SiO_2$ (50%) and $H_3[PW_{12}O_{40}]/SiO_2$ (50%) shows that silica-supported Preyssler nanoparticles led to greater yields and the higher activity. The results are represented in Table 3. Although it is difficult to offer an explanation for the different activity between these heteropolyacids, certainly there is a complex relationship between the activity and structure of polyanion. By changing the constituent elements of polyanion (both hetero and addenda atoms), the acid strength of HPA as well as its catalytic activity is able to vary in a wide range [34]. This observation can be explained by considering the reaction mechanism. As shown in Schemes 3, 4 the first stage of the reaction is the activation of the carbonyl group by an acidic catalyst. According to previous reports, the acidic property of the Preyssler type of heteropolyacids is greater than the Keggins [35].

The efficiency of $H_{14}[NaP_5W_{30}O_{110}]/SiO_2$(50%) and $H_{14}[NaP_5W_{30}O_{110}]/SiO_2$ nanoparticles as catalyst was also studied for this reaction, but the model reaction (reaction of benzil, aromatic aldehyde and ammonium acetate) did not go to completion in the presence of these catalysts even after long reaction times (8 h) and more amounts of catalyst (Table 4). The reactions were carried out as described in the synthesis of lophine (see Table 1). In the absence of the catalyst (Table 4, entry 6), **9** was only isolated in a poor yield.In $H_{14}[NaP_5W_{30}O_{110}]/SiO_2$ nanoparticles, the catalyst is supported into silica nano-particles. As the particle size decreases, the relative number of surface atoms increases, and thus activity increases. Moreover, because of quantum size effects, nanometer-sized particles can exhibit unique properties. There are several advantages for the use of nano-structured Preyssler supported on silica as catalyst for this transformation, which include high conversions, low cost, and reusability of the catalyst. In addition, the use of supported catalyst under heterogeneous conditions facilitates ease of separation and recovery of the catalyst. The insolubility of the catalyst in different organic solvents provided an easy method for its separation from the product. The catalyst was easily separated by filtration and reused with only a gradual decrease in its activity. The synthesis of 2,4,5-trisubstituted and 1,2,4,5-tetrasubstituted-1*H*imidazole derivatives using acetic acid for few hours is a well-established procedure [36,37]. However, this method suffering by several drawbacks such as drastic reaction conditions, difficult to handle, longer reaction time, tedious work-up, low yields, All such drawbacks were overcome in the present procedure as silica-supported Preyssler nanoparticles is easy to handle, short reaction time, yields are good, simple work-up procedure (Scheme 1). We have carried out aldehydes consisting electron withdrawing groups or electron donating groups at different positions but it did not show any remarkable difference in the yield of product and time of the reactions. All the reactions proceeded very efficiently and the results are summarized in Table 1. Similarly, we have studied the condensation of benzil, aldehydes, ammonium acetate with primary aromatic amines. The neat reactions were also attempted under conventional heating, keeping similar reaction conditions. The direct heating of reactants without solvent took more time for completion of reactions and gave the products with low yields. In some reactions decomposition of reactants took place.

CONCLUSION

In conclusion we have presented use of Silica-supported Preyssler nanoparticles as a catalyst for efficient synthesis of 2,4,5-triaryl-1*H*-imidazoles and 1,2,4,5-tetrasubstituted imidazoles with moderate to excellent yields from benzil as well as benzoin. For all the presented reactions, the ethanol-water solvent was used which is relatively environmentally benign and supporting to green Chemistry. The advantages of the reported method are the use of cheap, mild, and easily available catalyst, easy work-up, and better yields. Further studies on the application of this method for the synthesis of highly functionalized biologically active imidazoles are underway.

REFERENCES

1. Grimmett, M. R. In *Comprehensive Heterocyclic Chemistry*, vol. 5; Katritzky, A. R.; Rees, C. W., eds.; Pergamon: Oxford, 1984; Grimmett, M. R. In *Science of Synthesis*, vol. 12; Neier R., ed.; Thieme: Stuttgart, 2002.
2. J. I. Trujillo, J. R. Kiefer, W. Huang, A. Thorarensen, L. Xing, N. L. Caspers, J. E. Day, K. J. Mathis, K. K. Kretzmer, B. A. Reitz, R. A. Weinberg, R. A. Stegeman, A. Wrightstone, L. Christine, R. Compton, X. Li, *Bioorg. Med. Chem. Lett.*, **19**, 908 (2009).
3. A. D. Palkowitz, M. I. Steinberg, K. J. Thrasher, J. K. Reel, K. L. Hauser, K. M. Zimmerman, S. A. Wiest, C. A. Whitesitt, R. L. Simon, W. Pfeifer, S. L. Lifer, D. B. Boyd, D. J. Barnett, T. M. Wilson, J. B. Deeter, K. Kakeuchi, R. E. Riley, W. D. Miller, W. S. Marshall, *J. Med. Chem.,* **37,** 4508 (1994).
4. L. Linda, L. Chang, K. L. Sidler, M. A. Cascieri, S. Laszlo, G. Koch, B. Li, M. MacCoss, N. Mantlo, S. O'Keefe, M. Pang, A. Rolandoc, W. K. Hagmanna, *Bioorg. Med. Chem. Lett.*, **11**, 2549 (2001).
5. D. Sharma, B. Narasimhan, P. Kumar, V. Judge, R. Narang, E. Clercq, J. Balzarini, *Eur. J. Med. Chem.* **44**, 2347 (2009).
6. a) S. Laufer, P. Koch, *Org. Biomol. Chem.,* **6** (2008) 437 b) S. Kumar, J. Boehm, J. C. Lee, *Nat. Rev. Drug Disc.* **2**, 717 (2003).
7. A. J. King, D. R. Patrick, R. S. Batorsky, M. L. Ho, H. T. Do, S. Y. Zhang, R. Kumar, A. K. Rusnak, D. M. Wilson, E. Hugger, L. Wang, F. Karreth, J. C. Lougheed, J. Lee, D. Chau, T. J. Stout, E. W. May, C. M. Rominger, M. D. Schaber, L. Luo, A. S. Lakdawala, J. L. Adams, R. G. Contractor, K. S. M. Smalley, M. Herlyn, M. M. Morrissey, D. A. Tuveson, P. S. Huang, *Cancer Res.,* **66,** 11100 (2006).
8. R. J. Sundberg, R. B. Martin, *Chem. Rev.,* **74,** 471 (1974).
9. M. Ghudamassi, J. Barasent, J. Imbach, P. Gayral, *Eup. J. Med. Chem.,* **23,** 225 (1988).
10. H. Sensui, J. Ichikawa, S. Sato, *Japan Kokkai Tokyo Koho JP*, 62 **94** 841: *Chem Abstr.* **107** 187436q.
11. R. Liebi, R. Randte, H. Mildenberger, K. Bauer, H. Bieringer, *Chem. Abst.* **108,** 6018 g (1987).
12. S. E. Wolkenberg, D. D. Wisnosk, W. B. Liester, Y. Wang, Z. Zhao, C. W. Lindsley, *Org. Lett.,* **6,** 1453 (2004).
13. A. F. Pozherskii, A. T. Soldalenko, A. R. Katritzky, *Heterocycles in Life, Society*; (New York: Wiley) 179, 1997.
14. J. G. Lombardino, E. H. Wiseman, *J. Med. Chem.,* **17,** 1182 (1974).
15. A. P. Philips, H. L. White, S. Rosen, *Eur. Pat. Appl,.* **58,** 890 (1983).
16. V. Stocek, W. Schunack, *Arch. Pharmaz,* **307,** 922 (1974).
17. D. Davidson, M. Weiss, M. Jelling, *J. Org. Chem.* ,**2,** 319 (1937).
18. V. Stocek, W. Schunack, *Arch. Pharmaz.,* **309,** 421 (1976).
19. R. Consoni, P. D. Croce, R. Ferraccioli, R. Rosa, *J. Chem. Res.,* (s) 188 (1991).
20. H. Schubert, J. Stodolka, *Prakt. Chem.,* **22,** 130 (1963).
21. D. A. Evans, K. M. Lundy, *J. Am. Chem. Soc.,* **114,** 1495 (1992).
22. C. F. Claiborne, N. J. Liverton, K. T. Nguyen, *Tetrahedron Lett.,* **39,** 8939 (1998).
23. B. Radziszewski, *Ber. Dtsch. Chem. Ges.,* **15**, 1493 (1882).
24. P. Lindberg, P. Nordberg, T. Alminger, A. Brandstorm, B. Wallmark*, J. Med. Chem.,* **29,** 1327 (1986).
25. M. M. Heravi, S. Sadjadi, S. Sadjadi, H. A. Oskooie, R. H. Shoar, F. F. Bamoharram, *S. Afr. J. Chem.,* 2009, **62**, 1 (2009).
26. F. F. Bamoharram, M. M. Heravi, H. Teymouri, M. Zebarjad, A. Ahmadpour *,Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry.*, **41**,1221, (2011).
27. M. M. Heravi, V. Rasmi, F. F. Bamoharram, S. Sadjadi, L. Fotouhi, S. Sadjadi, M. Bakavoli, *Synthetic Communications.,* **1**, 39, 4109 (2009).
28. F. F. Bamoharram, M. M. Heravi, J. Ebrahimi, A. Ahmadpour, M. Zebarjad*, Chinese Journal of Catalysis.,* **32**, 5, 782 (2011).
29. F. F. Bamoharram, M. M. Heravi, M. Roshani, A. Gharib, M. Jahangir, *J. Mol. Catal.,* **252**, 90 (2006).
30. M. M. Heravi, S. Sadjadi, S. Sadjadi, H. A. Oskooie, R. Hekmat Shoar, F. F. Bamoharram, *S. Afr. J. Chem.,* **62**, 1 (2009).
31. N. D. Kokare, J. N. Sangshetti, D. B. Shinde, *Synthesis.*, 2829 (2007).
32. L.-M. Wang, Y.-H. Wang, H. Tian, Y.-F. Yao, J.-H. Shao, B. Liu, *J. Fluorine Chem.,* **127**, 1570 (2006).
33. S. A. Siddiqui, U. C. Narkhed, S. S. Palimkar, T. Daniel, R. J. Lahoti, K. V. Srinivasan, *Tetrahedron.,* **61**, 3539 (2005).

34. M. M. Heravi, S. Sadjadi, H. A. Oskooie, R. Hekmat Shoar, F. F. Bamoharram, *Catal. Commun.* **9**, 470 (2008).
35. M. Misono, *Chem. Commun.,* 1141 (2001).
36. M. R. Grimett, *In Comprehensive Heterocyclic Chemistry II*; A. R. Katritzky, C. W. Rees, E. F. Scriven, E. F. V. Eds. (New York: Pergamon) Vol. 3 P77, 1996.
37. D. Davidson, M. Weiss, M. Jelling, *J. Org. Chem.,* **2**, 328 (1937).

СИНТЕЗА НА 2,4,5-ТРИЗАМЕСТЕНИ И 1,2,4,5-ЧЕТИРИЗАМЕСТЕНИ-1Н-ИМИДАЗОЛОВИ ПРОИЗВОДНИ И/ИЛИ 2,4,5-ТРИАРИЛОКСАЗОЛИ С ПОМОЩТА НА НАНОЧАСТИЦИ ОТ PREYSSLER‘ОВ КАТАЛИЗАТОР ВЪРХУ ПОДЛОЖКА ОТ СИЛИЦИЕВ ДИОКСИД

А. Гариб[1,2]*, Б.Х. Хашемипур Хорасани[2], М. Джахангир[1], М. Рошаниа[1],
Л. Бахтиари[2], С. Мохадесзаде[2]

[1]*Департамент по химия, Ислямски университет Азад, Машхад, Иран*

[2]*Земеделски център за изследвания и услуги, Машхад, Иран*

Получена на 28 май, 2012 г.; коригирана на 5 февруари, 2013 г.

(Резюме)

Използвана е едно-степенна синтеза на многокомпонентна кондензация на бензил (и/или бензоин), алдехиди, амониев ацетат и първични амини за получаването на 2,4,5-тризаместени и 1,2,4,5-четиризаместени-1Н-имидазолови производни при рефлукс катализирана от Preyssler‘ова хетерополикиселина във вид на наночастици, фиксирани върху подложка от силициев диоксид. Този катализатор има няколко предимства: проста процедура, ниска цена и многократна употреба. Този катализатор е използван успешно и при синтезата на триарилоксазоли.