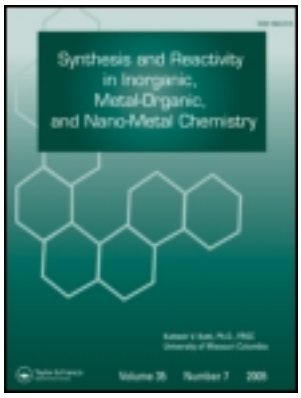

Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry

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Silica-Supported Preyssler Nanoparticles Catalyzed Simple and Efficient One-Pot Synthesis of 1,8-Dioxodecahydroacridines in Aqueous Media

Ali Javid [a] , Amir Khojastehnezhad [b] , Majid Heravi [c] & Fatemeh F. Bamoharram [b]

[a] Department of Chemistry, Ahvaz-Branch, Islamic Azad University, Ahvaz, I. R. Iran

[b] Department of Chemistry, Mashhad-Branch, Islamic Azad University, Mashhad, I. R. Iran

[c] Department of Chemistry, Alzahra University, Vanak, Tehran, I. R. Iran

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Silica-Supported Preyssler Nanoparticles Catalyzed Simple and Efficient One-Pot Synthesis of 1,8-Dioxodecahydroacridines in Aqueous Media

Ali Javid,[1] Amir Khojastehnezhad,[2] Majid Heravi,[3] and Fatemeh F. Bamoharram[2]

[1]*Department of Chemistry, Ahvaz-Branch, Islamic Azad University, Ahvaz, I. R. Iran*
[2]*Department of Chemistry, Mashhad-Branch, Islamic Azad University, Mashhad, I. R. Iran*
[3]*Department of Chemistry, Alzahra University, Vanak, Tehran, I. R. Iran*

Silica-supported Preyssler nanoparticles (SPNP) was found to be an inexpensive and effective catalyst for the rapid, one-pot three-component synthesis of N-substituted 1,8-dioxodecahydroacridines in high yields, with easy workup procedure. The nanocatalyst was easily separated from the reaction mixture and was recycled a couple of times without any appreciable loss in activity. In addition, water as a green solvent was a solvent of choice.

Keywords aqueous media, heteropolyacid, nanocatalyst, 1, 8-dioxodecahydroacridines, one-pot three-component reaction

INTRODUCTION

Xanthene and their derivatives are an important family of organic compounds because they have wide range of biological and pharmaceutical properties.[1, 2] In particular, xanthenediones constitute a structural unit in a number of natural products,[3, 4] and have been used as versatile synthons because of the inherent reactivity of the inbuilt pyran ring.[5] Acridines belong to xanthene derivatives that have a 1,4-dihydropyridine (DHP) ring skeleton. Substituted acridines have been used as antimalarials and in cancer chemotherapy.[6–10] Also, these derivatives are used in the industry, for the production of dyes.[11] Another role of acridines is to synthesize labeled conjugates with medicinals, peptides, proteins, and nucleic acids that exhibit antitumor and DNA-binding properties.[12–14] The synthesis of xanthenediones usually condenses appropriate active methylene carbonyl compounds with aldehydes. Also, the synthesis of polyfunctionalized DHP derivatives has been studied, in particular the Hantzsch reaction.[15] This method involves a three-component condensation of an aldehyde, ethyl acetoacetate, and ammonia. Further, acridinediones synthesized from aldehydes, dimedone, and different anilines or ammonium acetate *via* one-pot multicomponent reaction in the presence of different catalysts have been reported in the literature.[16–24] However, some of these methods have limitations such as low yields, long reaction times, a cumbersome workup procedure, and generation of polluting effluents. Furthermore, most of these methodologies do not meet the requirement of green chemistry, as most of these reactions tend to use expensive reagents that are difficult to recover and recycle in volatile organic solvents that are a threat to the environment due to their pyrophoric nature, volatility, and poor recovery.[25] So, a new method is needed for the synthesis of acridinedione derivatives with less waste and more facile isolation of products, with the ability to recover and reuse the catalysts as well.

Among various solid acids, heteropolyacids (HPAs) have specific physical and chemical properties. HPAs have very strong Brønsted acidity and are several times more active than mineral acids.[26] Furthermore, they are capable of protonating and activating the substrate, and in some cases they are more effective than usual inorganic acid and the traditional acid catalysts and can improve and reduce reaction time. Therefore, they are widely used as solid acid catalysts either indirectly as a bulk material or in supported form in homogeneous and heterogeneous systems for the synthetic reactions.[27] HPAs are non-toxic, non-corrosive, very stable toward humidity, air stable, recyclable, eco-friendly, compatible with green chemistry, easy to handle, and experimentally simple. Also, they are usually solids that are insoluble in non-polar solvents but highly soluble in polar ones.[28] They can be used in low concentrations. Of course, the need for character development and optimization of catalytic efficiency of heteropolyacids to be felt. Recently, because of the unique properties of nanoparticles along with their novel properties and potential applications in different fields, synthetic chemists focused on nanocatalysts. Therefore, synthesis and characterization of new catalysts with lower dimensions has become the most interesting topic of

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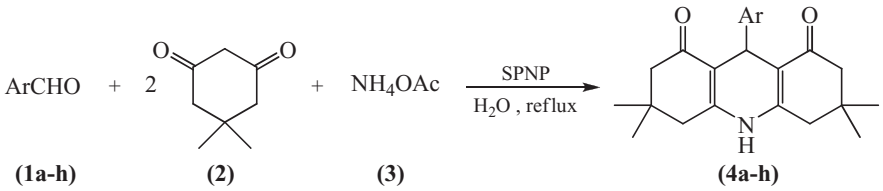
Address correspondence to Ali Javid, Department of Chemistry, Ahvaz Branch, Islamic Azad University, Ahvaz, I. R. Iran. E-mail: alijavids@yahoo.com



SCH. 1.

research. We know that as the particle size decreases, the relative number of surface atoms increases and thus the activity increases.[29] Moreover, due to quantum size effects, nanometer-sized particles may exhibit unique properties for a wide range of applications.[30]

Recently, these considerations raised the interest for synthesis of Keggin nanocatalysts,[31–33] but the synthesis and catalytic activity of Preyssler nanocatalysts has been largely overlooked. For this reason, we have reported the synthesis and characterization of silica-supported Preyssler nanoparticles (SPNP).[34] A Preyssler acid is a highly acidic catalyst from heteropolyacid family with excellent catalytic activity in a variety of acid-catalyzed reactions.[35] Therefore, we hope that to get better the behaviors of this catalyst with nanoparticle size in organic reactions and synthesizes. So, in continuation of our work with application of HPA in organic reactions,[36–47] in this article we wish to describe the synthesis of 1,8-dioxodecahydroacridines by use of SPNP as heterogeneous catalyst under mild reaction conditions. The novelty of this work lies in the shorter time period than in earlier works,[16–25] reusable new derivatives, and greenness of the used catalyst.

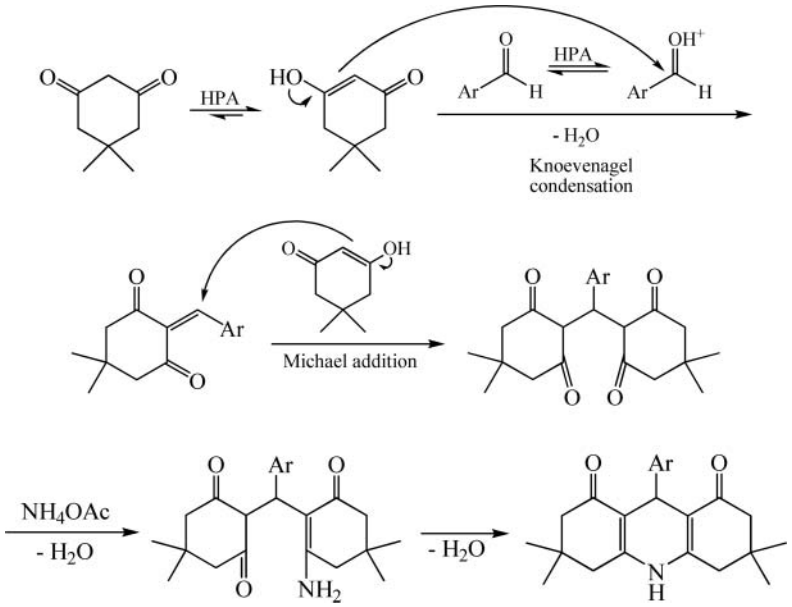
RESULTS AND DISCUSSION

In our continued interest in the development of a highly expedient methodology for the synthesis of fine chemicals and heterocyclic compounds of biological importance by usage of heteropoly and nanoheteropolyacids as catalyst,[36–47] we report here the synthesis of 1,8-dioxodecahydroacridines in the presence of SPNP as an acidic catalyst, in water as a green solvent at reflux condition (Scheme 1).

We propose the possible following mechanism to account for the reaction (Scheme 2). As can be seen, reaction proceeds *via* one-pot Knoevenagel condensation, Michael addition, and cyclodehydration. We think that acid catalysts such as HPAs might promote the reaction by accelerating the formation of enol from the 1,3-dicarbonyls, such as dimedone, in the rate-determining step.

We first examined the reaction of benzaldehyde (**1a**), dimedone (**2**), and ammonium acetate (**3**) in the presence of catalytic amount of several acids. The results are summarized in Table 1.

As it is observable, the reaction was carried out when heteropolyacids used as catalyst. Apparently, SPNP acid catalyst was more effective regarding time consumption and in light of



SCH. 2.

TABLE 1
Effect of various acid catalysts amount on 1,8-dioxodecahydroacridines synthesis

Entry	Catalyst	Conditions	Time (h)	Isolated yield (%) [Ref.]
1	$B(C_6F_5)_3$	solvent free	3.5	80[20]
2	L-Proline	H_2O, reflux	3	82[23]
3	$Zn(OAc)_2$	H_2O, reflux	3	84[23]
4	$H_3[PW_{12}O_{40}]$	H_2O, reflux	6	75[a]
5	$H_4[SiW_{12}O_{40}]$	H_2O, reflux	8	67[a]
6	$H_4[PW_{11}VO_{40}]$	H_2O, reflux	10	36[a]
7	$H_{14}[NaP_5W_{30}O_{110}]$	H_2O, reflux	3	76[a]
8	SPNP	H_2O, reflux	2	91[a]

Reaction of benzaldehyde (1 mmol), dimedone (2 mmol), and ammonium acetate (1 mmol) in presence of different amount of acid catalysts. [a]Finding reported in the present article.

yields of reactions in comparison with neat Preyssler, Keggin heteropolyacids, and other reported catalysts.

The best ratio of aromatic aldehyde, dimedone, ammonium acetate, and SPNP catalyst at mole is 1:2:1:0.03. It is noteworthy that the reactions were completed after about 2 h, and more time did not affect on the reaction process.

Also, the effect of various solvents on the rate of the reaction was studied (Table 2). As can be seen, ethanol and water were favorable solvents under reflux conditions for this synthesis. But water was chosen because it is acceptable solvent for green chemistry and environment.

After optimizing the conditions, we next examined the generality of these conditions to other substrates (aldehydes). The results are summarized in Table 3. It could be seen that by using this nanocatalyst, the aromatic aldehydes containing electron-donating and electron withdrawing groups afforded the products with excellent yields.

TABLE 2
Effect of various solvents and conditions on 1,8-dioxodecahydroacridines synthesis

Entry	Solvent/Conditions	Time (h)	Isolated yield (%)
1	Acetonitrile/reflux	10	32
2	Ethyl acetate/reflux	20	0
3	Ethanol/reflux	3	92
4	H_2O/25°C	20	0
5	H_2O/50°C	10	27
6	H_2O/reflux	2	91

Reaction of benzaldehyde (1 mmol), dimedone (2 mmol), and ammonium acetate (1 mmol) in presence of SPNP catalyst (0.03 mmol), in various solvents (15 mL) and different conditions.

This nanocatalyst also showed excellent reusability in these reactions. We recycled the catalyst four times without any appreciable loss in activity.

EXPERIMENTAL

All chemicals were obtained from Merck Company and used as received. SPNP were synthesized according to a previous report.[34] For synthesis of this catalyst to a solution of surfactant in cyclohexane (0.2 M), a solution of Preyssler acid in a specified amount of water was added. The molar ratio of water to surfactant selected was 3, 5, and 7. Then, tetraethoxysilane was added into the micro emulsion phase. After mixing for various times (8, 12, 18, 25, and 30 h) at room temperature, dispersed Preyssler acid/SiO_2 nanostructures were centrifuged (1500 rpm) and the particles were rinsed with acetone (4 times) and dried in a vacuum oven. The optimum ratio of water to surfactant was 3:1 and the optimum time was 30 h.

Preparation of 1,8-Dioxodecahydroacridines

SPNP catalyst (0.03 mmol) was added to a solution of aromatic aldehyde (1 mmol), dimedone (2 mmol), and ammonium acetate (1 mmol) in water (15 mL). The mixture was refluxed for 2 h. After completion of the reaction (the progress of the reaction was monitored by TLC), the mixture was cooled and the solid residue was separated and dissolved in dichloromethane. The solution was filtered and solid SPNP catalyst was isolated and could be reused (the solvent was evaporated and the crude catalyst was washed with diethyl ether and dried at 100°C for 1 h). The organic phase was evaporated and the reaction mixture was recrystallized in ethanol to give pure product. All the products are known compounds and the spectral properties and melting points of them matched well with those reported previously.[16–24]

Spectroscopic and physical data of some representative compounds are given subsequently.

3,3,6,6-tetramethyl-9-(4-bromophenyl)-3,4,6,7,9,10-hexahydroacridine-1,8(2H,5H)-dione (**4c**)

^{1}H NMR (300 MHz, $CDCl_3$) δ: 0.95(s, 6H, $2CH_3$), 1.06(s, 6H, $2CH_3$), 2.18–2.37(m, 8H, $4CH_2$), 5.11(s, 1H, CH), 7.13(s, 1H, NH), 7.20(d, J = 8.3 Hz, 2H, Ar), 7.36(d, 2H, J = 8.3 Hz, Ar) ppm; IR (KBr) ν: 3394, 3073, 2949, 1740, 1612 cm^{-1}; MS (20 eV) m/z: 429(M^++2), 427(M^+); Anal. Calcd. for $C_{23}H_{26}NO_2Br$: C, 64.49; H, 6.12; N, 3.27. Found: C, 64.42; H, 6.09; N, 3.35.

3,3,6,6-tetramethyl-9-(3-nitrophenyl)-3,4,6,7,9,10-hexahydroacridine-1,8(2H,5H)-dione (**4f**)

^{1}H NMR (300 MHz, $CDCl_3$) δ: 0.97(s, 6H, $2CH_3$), 1.09(s, 6H, $2CH_3$), 2.15–2.40(m, 8H, $4CH_2$), 5.15(s, 1H, CH), 7.04(s, 1H, NH), 7.33–8.07(m, 4H, Ar) ppm; IR (KBr) ν: 3356, 3042, 2966, 1742, 1640, 1553, 1358 cm^{-1}; MS (20 eV) m/z: 394(M^+); Anal. Calcd. for $C_{23}H_{26}N_2O_4$: C, 70.03; H, 6.64; N, 7.10. Found: C, 69.63; H, 6.67; N, 7.24.

TABLE 3
One-pot synthesis of 1,8-dioxodecahydroacridines in the presence of SPNP as catalyst

Entry	Aldehyde	Product	Yield (%)[a]	Mp (°C)	Lit. (°C)
1	C_6H_5CHO	4a	91	191–193	192 (9)
2	4-$CH_3OC_6H_4CHO$	4b	93	274–276	270 (9)
3	4-BrC_6H_4CHO	4c	88	241–243	241 (9)
4	4-ClC_6H_4CHO	4d	87	>300	299 (9)
5	4-$NO_2C_6H_4CHO$	4e	90	279–281	286 (9)
6	3-$NO_2C_6H_4CHO$	4f	85	286–288	288 (9)
7	4-CNC_6H_4CHO	4g	88	>300	>300 (9)
8	4-$CH_3C_6H_4CHO$	4h	92	274–276	269 (9)

[a]Isolated yield after 2 h.

CONCLUSION

In conclusion, we have used SPNP as an efficient, reusable, and green solid acid catalyst for synthesis of 1,8-dioxodecahydroacridines that were prepared *via* one-pot three-component reaction of aryl aldehydes, dimedone, and ammonium acetate in water as green solvent and reflux conditions. Excellent yields, enhanced reaction rates and short reaction times, simplicity of operation, and easy workup are some advantages of this protocol.

REFERENCES

1. Poupelin, J.P.; Saint-Rut, G.; Fussard-Blanpin, O.; Narcisse, G.; Uchida-Ernouf, G.; Lakroix, R. *Eur. J. Med. Chem.* **1978**, *13*, 67–71.
2. Chibale, K.; Visser, M.; Schalkwyk, D.V.; Smith, P.J.; Saravanamuthu, A.; Fairlamb, A.H. *Tetrahedron* **2003**, *59*, 2289–2296.
3. Hatakeyma, S.; Ochi, N.; Numata, H.; Takano, S. *J. Chem. Soc. Chem. Commun.* **1988**, 1202–1204.
4. Cingolant, G.M.; Pigini, M. *J. Med. Chem.* **1988**, *12*, 531–534.
5. O'Callaghan, C.N.; McMurry, T.B. H. *J. Chem. Res. (S)* **1995**, 214–218.
6. Girault, S.; Grellier, P.; Berecibar, A.; Maes, L.; Mouray, E.; Lemiere, P.; Debreu, M.; Davioud-Charvet, E.; Sergheraet, C. *J. Med. Chem.* **2000**, *43*, 2646–2654.
7. Cholody, W.; Horowska, B.; Paradziej-Lukowicz, J.; Martelli, S.; Konopa, J. *J. Med. Chem.* **1996**, *39*, 1028–1033.
8. Chen, T.; Fico, R.; Cancellakis, E.S. *J. Med. Chem.* **1978**, *21*, 868–874.
9. Denny, W.; Atwell, G.J.; Baguley, B.C.; Wakelin, L.P.G. *J. Med. Chem.* **1985**, *28*, 1568–1574.
10. Rewcastle, G.; Atwell, G.J.; Chambers, D.; Baguley, B.C.; Denny, W.A. *J. Med. Chem.* **1986**, *29*, 472–477.
11. Albert, A. *The Acridines*; Edward Arnold: London, **1966**.
12. Delfourne, E.; Roubin, C.; Bastide, J. *J. Org. Chem.* **2000**, *65*, 5476–5479.
13. Antonini, J.; Polucci, P.; Magnano, A.; Martelli, S. *J. Med. Chem.* **2001**, *44*, 3329–3333.
14. Ferlin, M.G.; Marzano, C.; Chiarelotto, G.; Baccichetti, F.; Bordin, F. *Eur. J. Med. Chem.* **2000**, 827–837.
15. Hantzsch, A. *Liebigs Ann. Chem.* **1882**, *215*, 1–82.
16. Tu, S.; Miao, C.; Gao, Y.; Fang, F.; Zhuang, Q.; Feng, Y.; Shi, D. *Synlett* **2004**, *2*, 255–258.
17. Jin, T.S.; Zhang, J.S.; Guo, T.T.; Wang, A.Q.; Li, T.S. *Synthesis* **2004**, *12*, 2001–2005.
18. Tu, S.; Li, T.; Zhang, Y.; Shi, F.; Xu, J.; Wang, Q.; Zhang, J. *J. Heterocyclic Chem.* **2007**, *44*, 83–88.
19. Dabiri, M.; Baghbanzadeh, M.; Arzroomchilar, E. *Catal. Commun.* **2008**, *9*, 939–942.
20. Chandrasekhar, S.; Srinivasa Rao, Y.; Sreelakshmi, L.; Mahipal, B.; Reddy, C.R. *Synthesis* **2008**, *11*, 1737–1740.
21. Shen, W.; Wang, L.M.; Tian, H.; Tang, J.; Yu, J.J. *J. Fluorine Chem*. **2009**, *130*, 522–527.
22. Venkatesan, K.; Pujari, S.S.; Srinivasan, K.V. *Synth. Commun.* **2009**, *39*, 228–241.
23. Balalaie, S.; Chadegani, F.; Darviche, F.; Bijanzadeh, H.R. *Chin. J. Chem.* **2009**, *27*, 1953–1956.
24. Niknam, K.; Panahi, F.; Saberi, D.; Mohagheghnejad, M. *J. Heterocyclic Chem.* **2010**, *47*, 292–300.
25. Kidwai, M.; Bhatnagar, D. *Tetrahedron Lett*. **2010**, *51*, 2700–2703.
26. Mizuno, N.; Misono, M. *Chem. Rev.* **1998**, *98*, 199–217.
27. Heravi, M.M.; Sadjadi, S. *J. Iran. Chem. Soc.* **2009**, *6*, 1–54.
28. Kozhevnikov, I.V. *Chem. Rev.* **1998**, *98*, 171–198.
29. Alivisatos, A.P. *Science* **1996**, *271*, 933–937.
30. Michalet, X.; Pinaud, F.F.; Bentolia, L.A.; Tsay, J.M.; Doose, S.; Li, J.J.; Sundaresan, G.A.; Wu, M.; Gambhir, S.S.; Weiss, S. *Science* **2005**, *307*, 538–544.
31. Sawant, D.P.; Vinu, A.; Jacob, N.E.; Lefebvre, F.; Halligudi, S.B. *J. Catal.* **2005**, *235*, 341–352.
32. Uchida, S.; Mizuno, N. *Coord. Chem. Rev.* **2007**, *251*, 2537–2546.
33. Rahimizadeh, M.; Rajabzadeh, G.; Khatami, S.M.; Eshghi, H.; Shiri, A. *J. Mol. Catal. A: Chem.* **2010**, *323*, 59–64.
34. Bamoharram, F.F.; Heravi, M.M.; Roushani, M.; Toosi, M.; Jodeyre, L. *Green Chem. Lett. Rev.* **2009**, *2*, 35–41.
35. Heravi, M.M.; Sadjadi, S.; Oskooie, H.A.; Hekmat Shoar, R.; Bamoharram, F.F. *Catal Commun*. **2008**, *9*, 470–474.
36. Javid, A.; Heravi, M.M.; Bamoharram, F.F. *E-J. Chem.* **2011**, *8*, 910–916.
37. Javid, A.; Heravi, M.M.; Bamoharram, F.F.; Nikpour, M. *E-J. Chem.* **2011**, *8*, 547–552.
38. Heravi, M.M.; Nahavandi, F.; Sadjadi, S.; Oskooie, H.A.; Bamoharram, F.F. *Synth. Commun.* **2010**, *40*, 498–503.
39. Bamoharram, F.F. *Molecules* **2010**, *15*, 2509–2519.
40. Heravi, M.M.; Ghods, A.; Derikvand, F.; Bakhtiari, K.; Bamoharram, F.F. *J. Iran. Chem. Soc.* **2010**, *7*, 615–620.
41. Bamoharram, F.F.; Heravi, M.M.; Mehdizadeh, S. *Synth. React. Inorg. Met.-Org. Chem.* **2009**, *39*, 746–750.
42. Bamoharram, F.F.; Heravi, M.M.; Heravi, H.M.; Dehghan, M. *Synth. React. Inorg. Met.-Org. Chem.* **2009**, *39*, 394–399.
43. Heravi, M.M.; Sadjadi, S.; Mokhtari Haj, N.; Oskooie, H.A.; Bamoharram, F.F. *Catal Commun.* **2009**, *10*, 1643–1646.
44. Heravi, M.M.; Sadjadi, S.; Mokhtari Haj, N.; Oskooie, H.A.; Hekmat Shoar, R.; Bamoharram, F.F. *Tetrahedron Lett*. **2009**, *50*, 943–945.
45. Heravi, M.M.; Sadjadi, S.; Oskooie, H.A.; Bamoharram, F.F. *Ultrasonics Sonochem.* **2009**, *16*, 708–710.
46. Heravi, M.M.; Sadjadi, S.; Sadjadi, S.; Oskooie, H.A.; Bamoharram, F.F. *Ultrasonics Sonochem.* **2009**, *16*, 718–720.
47. Heravi, M.M.; Sadjadi, S.; Oskooie, H.A.; Hekmat Shoar, R.; Bamoharram, F.F. *Tetrahedron Lett.* **2009**, *50*, 662–666.