MCM-41 Catalyzed Efficient Regioselective Synthesis of β-Aminoalcohol under Solvent-free Conditions

Heravi, Majid M.*[a] Bakhtiari, Khadijeh*[a] Alinejhad, Hamideh[a]
Saeedi, Mina[a] Malakooti, Reihane[b]

[a] *Department of Chemistry, School of Science, Azzahra University, Vanak, Tehran, Iran*
[b] *Nanochemistry Research Laboratory, Department of Chemistry, University of Birjand, Birjand, Iran*

β-Aminoalcohols were synthesized in high yields by reaction of epoxides with amines in the presence of MCM-41 as a green and reusable catalyst under solvent-free conditions.

Keywords *β*-aminoalcohol, solvent-free condition, MCM-41, aromatic amine, aliphatic amine

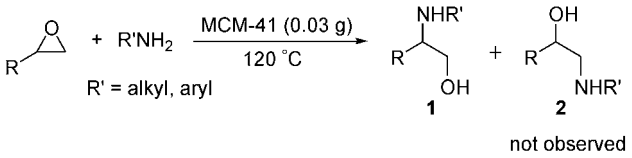
Introduction

β-Aminoalcohols are flexible intermediates in the synthesis of a broad range of biologically active natural and synthetic products and used as building blocks for the synthesis of pharmaceuticals.[1] Also they are present in unnatural amino acids, chiral auxiliaries, as chiral catalysts in asymmetric synthesis.[2] Thus, developing various methodologies for their synthesis always is demanding. These compounds are conventionally synthesized by reaction of epoxides with excessive amounts of amines at elevated temperatures.[3] Classical methodologies suffer from one or more disadvantages such as long reaction time, elevated temperature, high pressure, moderate yields and poor regioselectivities.[4] Up till now, different protocols have been reported for the synthesis of *β*-aminoalcohols including practical methods like utilizing microwave[5] and ultrasound[6] as well as efficient catalysts such as sulfamic acid,[7] amberlyst-15,[8] metal triflates,[9] metal alkoxides,[10] metal halides,[11,12] transition metal salts,[13,14] heteropolymolybdate or tungstate,[15] monodispersed silica nanoparticles,[16] zeolites,[17] montmorillonite,[18] ionic liquids,[19] sulfated zirconia and SZ/MCM-41,[20] $Er(OTf)_3$,[21] $Y(NO_3)_3$[22] and ZnO.[23] MCM-41 is a mesoporous inorganic solid with pore diameters of 2—50 Å, which has attracted much attention because of its large internal surface, regular arrays of uniform channels, long range ordered framework with uniform mesopores and sharply distributed pore dimensions. Since MCM-41 was synthesized by Kresege *et al*.,[24] its role as catalyst and support in organic reactions has been established.[25] In this work, in view of great catalytic effect of MCM-41 in literature, it was selected for synthesis of *β*-aminoalcohols.

Results and discussion

In continuation of our interest in synthesis of organic compounds under solvent-free conditions,[26] herein, we wish to report a simple, environmentally friendly and proficient method for the preparation of *β*-aminoalcohol in the presence of a catalytic amount of MCM-41 as a green reusable and efficient catalyst (Scheme 1).

Scheme 1



In order to obtain the standard conditions, 2,3-epoxypropyl phenyl ether (1 mmol) was treated with aniline (1 mmol) under solvent-free conditions in the presence of MCM-41 at various temperatures and their effect on the yield and rate of the reaction was investigated (Table 1). The desired product was attained at 120 ℃ and 0.03 g of catalyst in 75% yield. Increasing temperature did not result in higher yield and shorter reaction time. Various aromatic and aliphatic amines were treated with cyclohexene epoxide or 2,3-epoxypropyl phenyl ether and their corresponding results are summarized in Table 2. To examine the recyclability of the

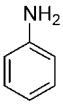
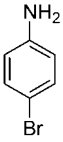
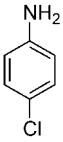
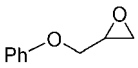
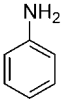
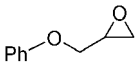
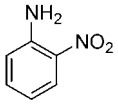
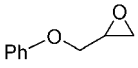
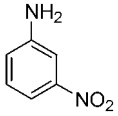
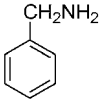
Table 1 Effect of catalyst and temperature on the reaction of 2,3-epoxypropyl phenyl ether with aniline

Entry	Temperature/℃	Time/h	Yield[a]/%
1	Room temperature	12	40
2	50	12	40
3	110	1	65
4	120	0.55	75
5	130	1	65

[a] Yields refer to isolated products.

* E-mail: mmh1331@yahoo.com; khb1352@yahoo.com; Tel.: 0098-21-88044051; Fax: 0098-21-88041344
Received August 9, 2009; revised September 24, 2009; accepted October 19, 2009.

Table 2 MCM-41 catalyzed synthesis of *β*-aminoalcohols through regioselective opening of epoxide by aromatic and aliphatic amines

Entry	Epoxide	Amine	Product	Time/min	Yield[a]/%
1			**1a**	60	85
2			**1b**	50	80
3			**1c**	45	82
4			**1d**	55	75
5			**1e**	45	66
6			**1f**	45	68
7			**1g**	100	70
8			**1h**	90	75
9		$CH_3CH_2CH_2CH_2NH_2$	**1i**	75	75

[a] Yields refer to isolated products.

catalyst, after completion of the reaction, hot ethanol was added to the mixture and the catalyst was filtered, washed with diethyl ether, dried at 120 ℃ for 1 h and reused in subsequent two reactions. The results are summarized in Table 3. It is worthwhile to mention that desired regioselective transformation of epoxides to corresponding *β*-aminoalcohols in high yields was achieved by MCM-41 and product **2** was not observed (Scheme 1).

Working on the model reaction, 2,3-epoxypropyl phenyl ether (1 mmol) and aniline (1 mmol) in the absence of catalyst gave poor yield (30%) and side reactions.

Table 3 Reusability of catalyst in reaction of aniline and 2,3-epoxypropyl phenyl ether

Entry	Number of recycle	Time/min	Yield[a]/%
1	Fresh	55	75
2	1	55	75
3	2	55	70
4	3	55	70

[a] Yields refer to isolated products.

Experimental

Melting points were measured by using a capillary tube method with a Bamstead Electrothermal 9200 apparatus and are uncorrected. ^{1}H NMR spectra were recorded on a Bruker AQS-AVANCE spectrometer at 500 MHz, using TMS as an internal standard ($CDCl_3$ solution). FTIR spectra were recorded from KBr disks on FT-IR Bruker Tensor 27 instrument. GC/Mass analysis was performed using an Agilent 6890 GC system of Hp-5 capillary 30 m×530 μm×1.5 μm. The reactions

were monitored by TLC. All solvents and reagents were purchased from Aldrich and Merck with high-grade quality, and used without any purification. Known products were characterized by their spectral and physical data.

General procedure

MCM-41 was prepared according to the procedure reported in literature.[27]

To a mixture of epoxide (1 mmol) and amine (1 mmol), MCM-41 (0.03 g) was added and the reaction mixture proceeded at 120 ℃ for corresponding time in Table 2. After completion of reaction as indicated by TLC, hot ethanol was added to the mixture, the catalyst was filtered and solvent was evaporated under reduced pressure. The crude products were purified by recrystallization from ethanol.

All products were characterized by ^{1}H NMR, ^{13}C NMR, FTIR and GC-mass spectrometry.

New products characterization data

2-(2-Nitro anilino)-3-phenoxy-1-propanol (1e) m.p. 104—106 ℃; ^{1}H NMR ($CDCl_3$, 500 MHz) δ: 2.51 (d, J=5.25 Hz, 1H, OH), 3.52—3.56 (m, 1H, CH-1), 3.63—3.64 (m, 1H, CH-1), 4.07—4.14 (m, 2H, CH_2-3), 4.33—4.36 (m, 1H, CH), 6.66—6.70 (m, 1H, ArH), 6.93—6.95 (m, 3H, ArH), 7.01 (t, J=7.3 Hz, 1H, ArH), 7.31 (dd, J=8.48, 7.5 Hz, 2H, ArH), 7.43—7.45 (m, 1H, ArH), 8.19 (dd, J=8.56, 1.3 Hz, 1H, ArH), 8.33 (s, 1H, NH); ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 158.21, 139.3, 133.6, 129.1, 121.5, 120.4, 118.1, 114.4, 63.5, 63.1, 54.1; IR (KBr) v: 3310, 1600, 1585, 1490, 1445, 1355, 1295, 1240, 1170, 1110, 1085, 1035, 1020 cm^{-1}; MS m/z: 288 (M^+), 207, 151, 119, 94, 77. Anal. calcd for $C_{15}H_{16}N_2O_4$: C 62.50, H 5.55, N 9.72; found C 62.55, H 5.87, N 9.63.

2-(3-Nitro anilino)-3-phenoxy-1-propanol (1f) m.p. 101—103 ℃; ^{1}H NMR ($CDCl_3$, 500 MHz): δ_H: 2.5 (d, J=4.75 Hz, 1H, OH), 3.34—3.51 (m, 2H, CH_2-1), 4.0—4.13 (m, 2H, CH_2-3), 4.35 (s, 1H, CH), 4.49 (s, 1H, NH), 6.93 (d, J=7.93 Hz, 3H, ArH), 7.01 (t, J=7.3 Hz, 1H, ArH), 7.27—7.33 (m, 3H, ArH), 7.46 (s, 1H, ArH), 7.55 (d, J=8.0 Hz, 1H, ArH); ^{13}C NMR ($CDCl_3$, 125 MHz) δ: 158.5, 149.9, 148.5, 139.1, 133.1, 130.5, 129.4, 121.9, 120.4, 119.5, 118.1, 113.9, 110.05, 107.4, 63.6, 63.1, 54.1; IR (KBr) v: 3320, 1600, 1590, 1490, 1455, 1355, 1295, 1240, 1165, 1110, 1075, 1040, 1020 cm^{-1}; MS m/z: 288 (M^+), 151, 105, 77, 51. Anal. calcd for $C_{15}H_{16}N_2O_4$: C 62.50, H 5.55, N 9.72; found C 62.73, H 5.65, N 9.42.

Conclusion

In conclusion, MCM-41 is a highly efficient and reusable catalyst for the opening of epoxides with aromatic and aliphatic amines leading to the synthesis of β-aminoalcohols. The procedure of these reactions is very simple and presents some specific advantages such as low toxicity and low cost, mild reaction conditions, short time and excellent regioselectivity.

Acknowledgment

We gratefully acknowledged for partial financial support from the Azzahra University.

References

1 Rogers, G. A.; Parsons, S. M.; Anderson, D. C.; Nilsson, L. M.; Bahr, B. A.; Kornreich, W. D.; Kaufman, R.; Jacobs, R. S.; Kirtman, B. *J. Med. Chem.* **1989**, *32*, 1217.

2 Scarpi, D.; Galbo, F. L.; Occhiato, E. G.; Guarna, A. *Tetrahedron*: *Asymmetry* **2004**, *15*, 1319.

3 Deyrup, J. A.; Moyer, C. L. *J. Org. Chem.* **1969**, *34*, 175.

4 Harris, C. E.; Fisher, G. B.; Beardsley, D.; Lee, L.; Goralsky, C. T.; Nicholson, L. W.; Singaram, B. *J. Org. Chem.* **1994**, *59*, 7746.

5 Sabitha, G.; Reddy, B. V. S.; Abraham, S.; Yadav, J. S. *Green Chem.* **1999**, *1*, 251.

6 Abaee, M. S.; Hamidi, V.; Mojtahedi, M. M. *Ultrason. Sonochem.* **2008**, *15*, 823.

7 Kamal, A.; Prasad, B. R.; Reddy, A. M.; Khan, M. N. A. *Catal. Commun.* **2007**, *8*, 1876.

8 Vijender, M.; Kishore, P.; Narender, P.; Satyanarayana, B. *J. Mol. Catal. A*: *Chem.* **2007**, *266*, 290.

9 Ollevier, T.; Lavie-Campin, G. *Tetrahedron Lett.* **2004**, *45*, 49.

10 Sagawa, S.; Abe, H.; Hase, Y.; Inaba, T. *J. Org. Chem.* **1999**, *64*, 4962.

11 Narsaiah, A. V.; Sreenu, D.; Nagaiah, K. *Synth. Commun.* **2006**, *36*, 3183.

12 De, S. K.; Gibbs, R. A. *Synth. Commun.* **2005**, *35*, 2675.

13 Chini, M.; Crotti, P.; Macchia, F. *Tetrahedron Lett.* **1990**, *31*, 4661.

14 Carree, F.; Gil, R.; Collin, J. *Org. Lett.* **2005**, *7*, 1023.

15 Azizi, N.; Saidi, M. R. *Tetrahedron* **2007**, *63*, 888.

16 Sreedhar, B.; Radhika, P.; Neelima, B.; Hebalkar, N. *J. Mol. Catal. A*: *Chem.* **2007**, *272*, 159.

17 Kureshy, R. I.; Singh, S.; Khan, N. H.; Abdi, S. H. R.; Suresh, E.; Jasra, R. V. *J. Mol. Catal. A*: *Chem.* **2007**, *264*, 162.

18 Chakraborti, A. K.; Kondaskar, A.; Rudrawar, S. *Tetrahedron* **2004**, *60*, 9085.

19 Yadav, J. S.; Reddy, B. V. S.; Basak, A. K.; Narasaiah, A. V. *Tetrahedron Lett.* **2003**, *44*, 1047.

20 Negrón-Silva, G.; Hernández-Reyes, C. X.; Angeles-Beltrán, D.; Lomas-Romero, L.; González-Zamora, E.; Méndez-Vivar, J. *Molecules* **2007**, *12*, 2515.

21 Procopio, A.; Gaspari, M.; Nardi, M.; Oliverio, M.; Rosati, O. *Tetrahedron Lett.* **2008**, *49*, 2289.

22 Bhanushali, M. J.; Nandurkar, N. S.; Bhor, M. D.; Bhanage, B. M. *Tetrahedron Lett.* **2008**, *49*, 3672.

23 Hosseini-Sarvari, M. *Acta Chim. Slov.* **2008**, *55*, 440.

24 (a) Kresge, C. T.; Leonowicz, M. E.; Roth, W. J.; Vartuli, J. C.; Beck, J. S. *Nature* **1992**, *359*, 710.
(b) Beck, J. S.; Vartuli, J. C.; Roth, W. J.; Leonowicz, M. E.; Kresge, C. T.; Schmitt, K. D.; Chu, C. T. W.; Olson, D. H.; Sheppard, E. *J. Am. Chem. Soc.* **1992**, *114*, 10834.

25 (a) Tanchoux, N.; Pariente, S.; Trens, P.; Fajula, F. *J*. *Mol*. *Catal*. *A*: *Chem*. **2009**, *305*, 8.
(b) Kugita, T.; Jana, S. K.; Owada, T.; Hashimoto, N.; Onaka, M.; Namba, S. *Appl*. *Catal*. *A* **2003**, *245*, 353.
(c) Nagarapu, L.; Kumari, M. D.; Kumari, N. V.; Kantevari, S. *Catal*. *Commun*. **2007**, *8*, 1871.
(d) Juarez, R.; Padilla, A.; Corma, A.; Garcia, H. *Catal*. *Commun*. **2009**, *10*, 472.
26 (a) Heravi, M. M.; Behbahani, F. K.; Daraie, M.; Oskooie, H. A. *Mol*. *Divers* **2009**, *13*, 375.
(b) Heravi, M. M.; Behbahani, F. K.; Oskooie, H. A.; Bamoharram, F. F. *Chin*. *J*. *Chem*. **2008**, *26*, 2150.
(c) Heravi, M. M.; Ranjbar, L.; Derikvand, F.; Alimadadi, B. *Mol*. *Divers*. **2008**, *12*, 191.
(d) Heravi, M. M.; Bakhtiari, K.; Taheri, S.; Oskooie, H. A. *Green Chem*. **2005**, *7*, 867.
(e) Heravi, M. M.; Beheshtiha, Y. S.; Ghasemzadeh, M.; Hekmatshoar, R.; Sarmad, N. *Monatsh*. *Chem*. **2000**, *131*, 187.
(f) Heravi, M. M.; Aghapoor, K.; Nooshabadi, M. A.; Mojtahedi, M. M. *Monatsh*. *Chem*. **1997**, *128*, 1143.
27 Xia, Q. H.; Hidajat, K.; Kawi, S. *Mater*. *Lett*. **2000**, *42*, 102.

(E0908098 Sun, H.; Dong, H.)

