Table 3. Different runs for choosing the optimum duration.[a]

Entry	Time[b] (min)	Yield[b] (%)	Time[c] (h)	Yield[c] (%)
1	3	64	6	80
2	5	89	12	83
3	10	90	18	86
4	15	91	24	87
5	30	91	48	92

[a]Reaction conditions: benzylamine (0.0085 mol, 0.937 mL), glyoxal (0.0037 mol, 0.427 mL), acetonitrile (7.75 mL), H_2O (0.775 mL), and citric acid (5% mol with respect toglyoxal).
[b]Ultrasound irradiation (150W).
[c]Stirring at room temperature.

3.4. Influence of ultrasound power on the product yield

In order to verify the effect of irradiation power, the reaction was also performed at 50, 100, 150, and 200 W. By increasing the irradiation power from 50 to 150W, the yield increased from 58 to 89% (Table 4). The best yield for HBIW was obtained by ultrasonic irradiation for 5 min at room temperature and 150W.

4. Conclusions

In this study, we have reported citric acid as a green catalyst for the preparation of hexabenzylhexaazaiso-wurtzitane (HBIW) under both conventional stirring and ultrasonic irradiation conditions. In general, improvements in rates and yield of the reactions were observed by carrying out the reactions under ultrasound irradiations.

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References

[1] G. Centi, S. Perathoner, Catal. Today. 77 (2003) 287–297.
[2] I. Lavilla, V. Romero, I. Costas, C. Bendicho, TrAC-Trend. Anal. Chem. 61 (2014) 1–10.
[3] A. Richard, B. Poliakoff, M. Poliakoff, Mendeleev Commun. 21 (2011) 235–238.
[4] G.J. Hutchings, Catal. Today. 122 (2007) 196–200.
[5] C. Wen, A. Yin, W.L. Dai, Appl. Catal. B: Environ. 160 (2014) 730-741.
[6] S. Sami, M. Norollahi, S. Miri, Iran. J. Catal. 4 (2014) 55-61.
[7] S. Khodabakhshi, M. Baghernejad, Iran. J. Catal. 3 (2013) 67-71.
[8] R. Mahesh, A.K. Dhar, T.S. TVNV, S. Thirunavukkarasu, T. Devadoss, Chin. Chem. Lett. 22 (2011), 389-392.
[9] H. Zhang, D. Zhao, D. Tang, T. Zhang, Z. Shao, Int. J. Hydrogen Energy 39 (2014) 9467-9472.
[10] C. Wehmer, Chem. Zentr. 2 (1893) 457–462.
[11] H.A. Krebs, W.A. Johnson, Enzymologia 4 (1937) 148–156.
[12] H.S. Grewal, K.L. Kalra, Biotechnol. Adv. 13 (1995) 209-234.
[13] B.M. Yapo, Bioresource Technol. 100 (2009) 3147–3151.
[14] M. Berovic, M. Legisa, Biotechnol. Annu. Rev. 13 (2007) 303-343.
[15] K. Kirimura, Y. Honda, T. Hattori, Comprehensive Biotechnology. Second Edition, Elsevier, 2011, pp. 135-142.
[16] M. Moresi, E. Parente, Encyclopedia of Food Microbiology. Second Edition, Elsevier, 2014, pp. 804-815.
[17] J. Xu, Y.Q. Chen, H.J. Zhang, J.W. Bao, L. Tang, K. Wang, J.H. Zhang, X.S. Chen, Z.G. Mao, Bioresource Technol. 176 (2015) 121–128.
[18] A.K. Sider, B.R. Nirmala Sikder, J.P. Gandhe, S. Agrawal, S. Haridwar, Def. Sci. J. 52 (2002) 135-146.
[19] Y. Bayat, H. Ebrahimi, F. Fotouhi-Far, Org. Process Res. Dev. 16 (2012) 1733−1738.
[20] A.T. Nielsen, R.A. Nissan, D.J. Vanderah, C.L. Coon, R.D. Gilardi, C.F. George, J. Flippen-Anderson, J. Org. Chem. 55 (1990) 1459-1466.
[21] W. Qiu, Sh. Chen, Y. Yu, J. Chem. Crystallogr. 28 (1998) 593–596.
[22] M.R. Crampton, J. Hamid, R. Millar, G. Ferguson, J. Chem. Soc. Perkin Trans. 2 (1993) 923–929.
[23] M.A. Quraishi, F.A. Ansari, J. Appl. Electrochem. 33 (2003) 233–238.
[24] S.K. Singh, A.K. Mukherjee, M.M. Singh, Indian J. Chem. Technol. 18 (2011) 291-300.
[25] R. Arabian, A. Ramazani, B. Mohtat, V. Azizkhani, S.W. Joo, M. Rouhani, J. Energ. Mater. 32 (2014) 300-305.
[26] J. Safari, Z. Zarnegar, S. Naseh, Z. Akbari, Iran. J. Catal. 4 (2014) 125-132.
[27] M.R. Nabid, S.J. Tabatabaei Rezaei, R. Ghahremanzadeh, A. Bazgir, Ultrason. Sonochem. 17 (2010) 159-161.
[28] S.J. Tabatabaei Rezaei, M.R. Nabid, A. Yari, S.W. Ng, Ultrason. Sonochem. 18 (2011) 49-53.
[29] S.J. Tabatabaei Rezaei, Y. Bide, M.R. Nabid, Tetrahedron Lett. 53 (2012) 5123–5126.
[30] M. Rouhani, A. Ramazani, S.W. Joo, Ultrason. Sonochem. 22 (2015) 391-396.
[31] M. Rouhani, A. Ramazani, S.W. Joo, Ultrason. Sonochem. 21 (2014) 262–267.