One is the comparatively large surface area and more active sites which is related to the smaller crystal of the photocatalyst sample (Table 1). Therefore, much more space is available for the absorption of methyl orange, and the improvement of photocatalytic degradation percentage is inevitable; the other is the increased band gap and increasing absorption the ultraviolet light irradiation of high pressure mercury lamp. We can conclude that annealing temperature has high effect on the photocatalytic activity of Mn-doped ZnO. The development of such photocatalysts for remediation of water polluted investigates of effect of annealing temperature, as a synthesis parameter could be useful.

4. Conclusions

Zinc oxide nanoparticles doped with manganese were synthesized by a hydrothermal method and were used as a catalyst in the process of photodegradation of methyl orange as a dye model. Doping of ZnO with manganese results in an enhanced photodegradation efficiency. Based on the experimental results obtained in this study, the photodegradation efficiency was influenced by different reaction parameters such as the existence of dopant and annealing temperature. The absorption edge shifts to longer wavelengths with the increase of annealing temperature. The maximum photodegradation efficiency for methyl orange was obtained with a catalyst Mn-ZnO with annealing temperature at 300°C. The enhanced

photocatalytic activity of Mn-doped ZnO might be ascribed to the increase of surface-to-volume ratio, mean grain size, oxygen defects density and increase band gap relative to undoped ZnO.

Acknowledgments

This work was supported by Payam Noor University and University of Qom.

References

[1] A. Umar, Y.B. Hahn, Metal oxide nanostructures and their applications, American Scientific Publication, 2010.
[2] O.I. Lupan, S.T. Shishiyanu, T.S. Shishiyanu, Superlattices Microstruct. 42 (2007) 375-378.
[3] J. Guo, J. Zhang, M. Zhu, D. Ju, H. Xu, B. Cao, Sens. Actuators B: Chem. 199 (2014) 339-345.
[4] R. Khan, M.S. Hassan, L.W. Jang, J.H. Yun, H.K. Ahn, M.S. Khil, I.H. Lee, Ceram. Int. 40 (2014) 14827-14831.
[5] Y. Chen, D. Bagnall, T. Yao, Mater. Sci. Eng. B 75 (2000) 190-198.
[6] E.R. Carraway, A.J. Hoffman, M.R. Hoffmann, Environ. Sci. Technol. 28 (1994) 786-793.
[7] I. Poulios, D. Makri, X. Prohaska, Global Nest: Int. J. 1 (1999) 55-62.
[8] B. Pal, M. Sharon, Mater. Chem. Phys. 76 (2002) 82-87.
[9] R.Y. Hong, S.Z. Zhang, G.Q. Di, H.Z. Li, Y. Zheng, J. Ding, D.G. Wei, Mater. Res. Bull. 43 (2008) 2457-2468.
[10] C. Xu, L. Cao, G. Su, W. Liu, X. Qu, Y. Yu, J. Alloys Compd. 497 (2010) 373-376.
[11] C. Wu, L. Shen, H. Yu, Q. Huang, Y.C. Zhang, Mater. Res. Bull. 46 (2011) 1107-1112.
[12] S. Yılmaz, E. McGlynn, E. Bacaksız, J. Cullen, R.K. Chellappan, Chem. Phys. Lett. 525–526 (2012) 72-76.
[13] R. Ullah, J. Dutta, J. Hazard. Mater. 156 (2008) 194-200.
[14] M.A. Mahmood, S. Baruah, J. Dutta, Mater. Chem. Phys. 130 (2011) 531-535.
[15] X. Zhang, J. Qin, Y. Xue, P. Yu, B. Zhang, L. Wang, R. Liu, Sci. Rep. 4 (2014).
[16] Y.L. Chen, C.E. Zhang, C. Deng, P. Fei, M. Zhong, B.T. Su, Chin. Chem. Lett. 24 (2013) 518-520.
[17] L. Shi, L. Liang, J. Ma, J. Sun, Superlattices Microstruct. 62 (2013) 128-139.
[18] J.B. Zhong, J.Z. Li, X.Y. He, J. Zeng, Y. Lu, W. Hu, K. Lin, Curr. Appl. Phys. 12 (2012) 998-1001.
[19] M. Ahmad, E. Ahmed, Z.L. Hong, X.L. Jiao, T. Abbas, N.R. Khalid, Appl. Surf. Sci. B. 285 (2013) 702-712.
[20] J.C. Sin, S.-M. Lam, I. Satoshi, K.T. Lee, A.R. Mohamed, Appl. Catal. B: Environ. 148–149 (2014) 258-268.
[21] H. Wang, C. Xie, J. Phys. Chem. Solids 69 (2008) 2440–2444.
[22] K. Omri, J. El Ghoul, O.M. Lemine, M. Bououdina, B. Zhang, L. El Mir, Superlattices Microstruct. 60 (2013) 139-147.
[23] A. Patterson, Phys. Rev. 56 (1939) 978.
[24] R. Saravanan, V.K. Gupta, V. Narayanan, A. Stephen, J. Mol. Liq. 181 (2013) 133-141.
[25] K. Kaviyarasu, P.A. Devarajan, Adv.Mat. Lett. 4 (2013) 582-585.
[26] S. Senthilkumaar, K. Rajendran, S. Banerjee, T.K. Chini, V. Sengodan, Mater. Sci. Semicond. Process 11 (2008) 6-12.
[27] L. Brus, J. Phys. Chem. 90 (1986) 2555-2560.
[28] Y.S. Wang, P.J. Thomas, P. O'Brien, J. Phys. Chem. B. 110 (2006) 21412-21415.
[29] Z. Banu Bahşi, A.Y. Oral, Opt. Mater. 29 (2007) 672-678.
[30] N.S. Sabri, A.K. Yahya, M.K. Talari, J. Lumin. 132 (2012) 1735-1739.
[31] M. Wen, M. Cheng, S. Zhou, Q. Wu, N. Wang, L. Zhou, J. Phys. Chem. C. 116 (2012) 11702-11708.
[32] S. Yamamoto, H. Watarai, J. Phys. Chem. C. 112 (2008) 12417-12424.