The influence of the solvent on the growth of zinc oxide

Ankica Šarić[1 a], Goran Štefanić[2 a]
[a] *Ruđer Bošković Institute, Zagreb, 10000, Croatia*
e-mail: Ankica.Saric@irb.hr

Zinc oxide (ZnO) is one of the most important and widely used metal oxides with applications ranging from catalysis, electronics and energy harvesting to cosmetics and biomedicine. ZnO has attracted worldwide research interest due to its low toxicity, biocompatibility and diverse morphology [1,2]. Morphologically different ZnO nanostructures enable a wide range of applications, as the behavior of ZnO depends on its size and morphology. ZnO also serves as a biocompatible, antibacterial and antiviral agent, which enables its use in biomedical applications [3]. Among the various synthesis methods, the solvothermal method is attractive due to its simplicity and excellent control over particle size, shape and dispersibility [4]. The development of a surfactant-free solvothermal synthesis route, characterized by the presence of a small number of reactants, provides a deeper insight into the formation mechanism of ZnO nanoparticles and the control of reaction pathways. The kinetics of nucleation and growth of ZnO nanoparticles strongly depend on the properties of the solvent. The alcoholic solvent and the intermediate species formed during ZnO synthesis can selectively bind to different crystal facets of polar ZnO or suppress its crystal growth, leading to preferential crystal growth. In the present work, zinc oxide particles were prepared by solvothermal synthesis with different alcoholic reagents and in aqueous media. The nucleation and growth process of ZnO nanoparticles were investigated by X-ray diffraction (XRD) and field emission scanning electron microscopy (FE-SEM). The results of the X-ray diffraction analysis show that the use of 1-butanol alone as a solvent leads to a rather isotropic crystallite shape, while the ZnO nanoparticles grow predominantly in the *c*-direction in the presence of all other alcohols used as well as in aqueous media. The alcohols of different size and polarity act both as solvents and reactants and as controlling agents for crystal growth by providing different bonding interactions that are involved in both the nucleation processes and the preferential growth of the ZnO nanoparticles. On the other hand, the differences in the nucleation processes in aqueous solution determine the two subsequent growth processes, primary ZnO nanosubstructures and potential hierarchical microstructures. A synergistic effect between the I_{002}/I_{100} values and the crystallite size on the photocatalytic activity was found.

References
[1] H. Lim, M. Yusuf, S. Song, S. Park, K.H. Park, RSC Adv., 11 (2021) 8709–8717.
[2] N. Wiesmann, W. Tremel, J. Brieger, J. Mater. Chem. B, 8 (2020) 4973–4989.
[3] Y. Liu, L. He, A. Mustapha, H. Li, Z.Q. Hu, M. Lin, J. Appl. Microbiol., 107 (2009) 1193–1201.
[4] A. Šarić, I. Despotović, G. Štefanić, J. Phys. Chem. C, 123 (2019) 29394–29407.