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Ultrasonic Synthesis of ZnO Nanorods for Coating and Pigment Applications

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Abstract
Zinc oxide is a multifunctional material due to its unique physical and chemical properties. The most important methods of preparation of ZnO is sonochemical method in which ZnO can occur in one- (1D), two- (2D), and three-dimensional (3D) structures on usage of different ways. In this article irradiation of ultrasonic homogenizer are used during synthesis of ZnO with one-dimensional structures, including nanorods. Scanning Electron Microscopy (SEM) images shows the ZnO nanorods that have been exposed under ultrasonic irradiation are quite uniform and homogeneous in structure. The X-ray diffraction pattern (XRD) admits that ZnO synthesized under ultrasonic irradiation results ZnO with highly uniform and preferred orientation along [101]. Uniformity of nanorods can make more effective use of nanocomposites in corrosion control and protection surface.

Keywords**: Ultrasonic homogenizer -ZnO nanorods – sonochemistry - nanocomposite**

1-Introduction
Zinc oxide can be used as pigment to create the desired white and bright color of the paint medium. [1]. Zinc oxide molecules protect the base material against corrosion with large applications in various branches of industries [2, 3]. Alkyd coatings embedded with nano-TiO_2 and nano-ZnO pigments have shown excellent protection characteristics[4]. Produced connected rods of ZnO using a sonochemical process (exposure to ultrasound in ambient conditions) and by microwave heating is reported[5].

2-Experimental
The ZnO nanoparticles have been synthesized by ultrasonic irradiation of an aqueous-alcoholic/aqueous solutions of zinc nitrate (6ml,1M) and sodium hydroxide(6ml,10M) with 15ml ethanol. It is found that the ultrasonic irradiation time and the solvents both influence the growth mechanism and optical properties of ZnO nanoparticles. Fatty acid was applied as capping agent during precipitation.The used ultrasonic homogenizer with titanium probe is made in Iran by FAPAN Co. Ltd, model 400UT. Maximum power of 400 watts with tunable power and pulse duration. Probe diameter is 14mm (Fig.1). The resulting ZnO was analyzed using SEM and XRD technique.

3-Results and Discussion
The ZnO nanoparticles precipitation occurs as Eq.1. It has been shown that concentration of reaction components could effectively change particle size.

$$\begin{aligned} Zn(NO_3)_2 &\rightarrow Zn^{2+} + 2NO_3^- \\ Zn^{2+} + 2OH^- &\rightarrow Zn(OH)_2 \\ Zn(OH)_2 &\rightarrow ZnO\downarrow + H_2O \end{aligned} \qquad (1)$$

SEM image of the synthesized ZnO nanorods under ultrasonic irradiation with quite large area to provide for the formation of nanocomposites are shows Fig.2. For preparation of highly uniform and homogenous shape of ZnO nanorods during synthesize fatty acid has been employed as a capping agent plus irradiation of ultrasonic wave. These nanorods are shown in Fig.3. SEM image of Fig.3a, confirms that ZnO synthesized nanorods are uniform and homogenous. Accordingly Fig.3b shows the zinc oxide nanorods with 70 nm diameter and 1 µm lengths. Study of XRD patterns shows that synthesizing of ZnO nanorods under ultrasonic irradiation results ZnO nanorods with highly uniform and preferred orientation along [101] with the JCPDS number of 00-001-1136. This is shown in Fig4. Capping agent causes decrease in nanorods

diameter, which is visible in Fig4b on more narrow peaks. Ultrasonic Irradiation method is a technique of making nanoparticles with fully reproducible.

4-Conclusion

Irradiation of ultrasonic waves was used during synthesis of ZnO. The ZnO with one-dimensional structures, including nanorods were produced in a precipitation process under ultrasonic irradiation. SEM image shows nanorods are made of zinc oxide with quite large area to provide for the formation of nanocomposites. SEM image confirms that ZnO nanorods were synthesized with dimension of about 70 nm diameter and 1µm lengths. Study of XRD patterns shows that synthesizing of ZnO nanorods under ultrasonic irradiation results ZnO nanorods with highly uniform and preferred orientation along [101] plane.

Fig. 1 Ultrasonic homogenizer (Sonicator) made in Iran by FAPAN Co. Ltd. with titanium probe and sound absorbing box.

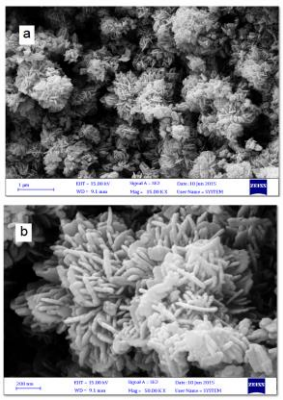

Fig.2 SEM images of ZnO nanorods synthesized under ultrasonic irradiation: with 1 micrometer scale, (b) with 200 nanometer scale.

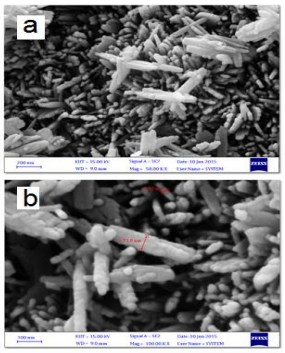

Fig.3 SEM images of ZnO nanorods synthesized under ultrasonic irradiation and usage capping agent: (a) with 200 nanometer scale, (b) with 100 nanometer scale.

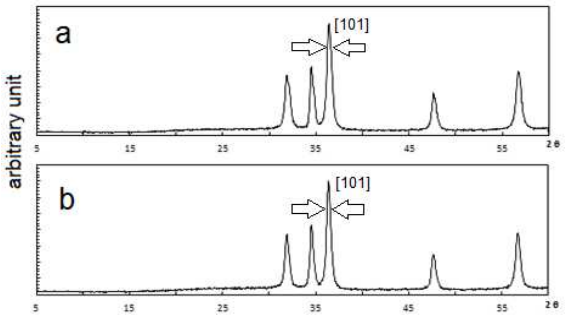

Fig.4 XRD of ZnO nanorods synthesized under ultrasonic probe irradiation: (a) without capping agent, (b) with capping agent.

Reference

1. Almeida, E., T.C. Diamantino, and O. de Sousa, *Marine paints: the particular case of antifouling paints.* Progress in Organic Coatings, 2007. **59**(1): p. 2-20.
2. Lai, J., K. Lo, and K.W. Wong, *Failure of centrifugal chillers: Coating and anode location problems.* Journal of failure analysis and prevention, 2012. **12**(3): p. 281-285.
3. Feng, Z.C., *Handbook of Zinc Oxide and Related Materials: Volume Two, Devices and Nano-Engineering*. Vol. 2. 2012: CRC Press.
4. Shi, H., et al., *Effects of nano pigments on the corrosion resistance of alkyd coating.* J. Mater. Sci. Technol, 2007. **23**(4).
5. Kołodziejczak-Radzimska, A. and T. Jesionowski, *Zinc oxide—from synthesis to application: a review.* Materials, 2014. **7**(4): p. 2833-2881.
6. Yadav, R.S., P. Mishra, and A.C. Pandey, *Growth mechanism and optical property of ZnO nanoparticles synthesized by sonochemical method.* Ultrasonics sonochemistry, 2008. **15**(5): p. 863-868.