Journal of **A**pplied **B**iotechnology **R**eports

Original Article

Synthesis of Zinc oxide and Chromium (III) oxide nanoparticles with diverse physiological properties

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Abstract

The use of an inorganic phase in water-in-oil (w/o) microemulsion has recently received considerable attention for preparing metal oxide nanoparticles. This is a technique, which allows preparation of ultrafine metal oxide nanoparticles within the size range 40 to 80 nm. Preparation of nano ZnO and Cr_2O_3 studied, investigated in the inverse microemulsion system. Therefore the nucleation of metal particles proceeds in the water capsules of the microemulsion. Zinc oxide and Chromium (III) oxide nanoparticles powder has traditionally been used as a pigment and diverse physiological properties. Physiologically important nanoparticles are currently under investigation for their bio-medical applications as well as for therapeutics.

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Keywords: Inverse microemulsion, Water capsule, Sol–gel processing, Nano chromium (III) oxide, Zinc (II) oxide

Submission Date: 4/2/2014
Accepted Date: 4/29/2014

Introduction

Among inorganic nanoparticles, Zinc (II) oxide (ZnO) and chromium (III) oxide (Cr_2O_3) nanoparticles have received great attention due to its numerous application domains, including green pigments [1], heterogeneous catalysts [2-4], coating materials for thermal protection [5-6], hydrogen storage [7-9] antimicrobial and antibacterial activity [10] as air or liquid vibration sensors [11-12] antioxidant action by occupying iron or copper binding sites in lipids, proteins, and DNA [13-15]. Physiologically important nanoparticles are currently under investigation for their biomedical applications as well as for therapeutics [16]. Various techniques have been developed to synthesize ZnO and Cr_2O_3 nanoparticles such as hydrothermal [17], solid thermal decomposition [18], combustion [19], sol-gel [20], precipitation-gelation [21], oxidation of zinc or chromium in oxygen [22], laser induced deposition [23], mechanochemical reaction and subsequent heat treatment [24] and sonochemical methods [25].The basic and traditional process used by the manufacturers consists of reducing an alkali dichromate by sulphur, carbon, wood or ammonium chloride [24]. But since either these processes are complex or their reaction apparatus are expensive, most of them have difficulties in being industrialized. Some new methods of preparation should be explored.

In the present study, a simple and original method for the synthesis of nanosized ZnO and Cr_2O_3 by sol-gel technique in nano and micro micelles is described. The surface properties, size, morphology and crystallographic structure of ZnO and Cr_2O_3 particles are characterized by means of X-ray diffraction (XRD), transmission electron microscope (TEM) and scanning electron microscope (SEM) which will give much valuable information about these materials.

Materials and methods

Preparation of nanoparticles

Experimental procedure for the Zinc (II) oxide (ZnO) and chromium (III) oxide (Cr_2O_3) nanoparticles are briefly summarized in Fig. 1. $Zn(NO_3)_2$ and $CrCl_3$, NaOH, purified soybean oil, Tween 80 and distilled water were used in the experiments.

Nanoparticles were synthesized by the following steps: 0.30 g of $Zn(NO_3)_2$ (or $CrCl_3$) in 1 ml of water and 4% Tween 80 were added into 30 ml of purified soybean oil under mechanical stirrer with 2000 rpm until obtaining a nearly clear emulsion. This solution was referred to as solution A. 0.16 g of NaOH was dissolved into 1.5 ml of water was added into solution A under mechanical stirrer with 2000 rpm for 2 h at room temperature and then the reaction mixture was filtrated. The precipitate was washed with absolute water (300 ml) for 3 times. This material was calculated in electronic oven at 200 °C for 1 h. The resulting powder X-ray diffraction was conducted on a Philips Analytical XPERT diffractometer using a Cu Kα radiation (λ = 1.54056 A°) with a MINIPROP detector and operating at 40 kV and 40 mA. X-ray diffraction patterns were recorded between $2\theta = 5^\circ$ and 79° with a step of 0.04° and a time of 0.8 s by step. The crystallographic data of the resulting Cr_2O_3 powders were collected by using the PC-APD, Diffraction software. Surface morphologies of the specimens were observed with a scanning electron microscope (SEM, Philips XL-30). The ordered nano

structures of C_r2O_3 can be further confirmed by transmission electron microscope (TEM, Philips KV-120).

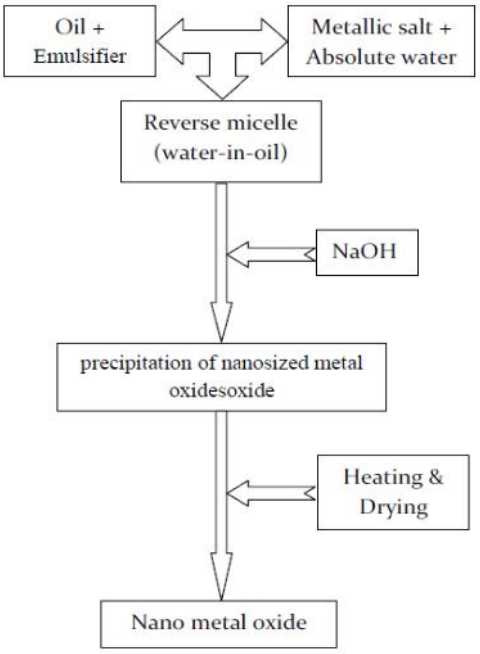

Figure 1. Experimental procedure for the formation of nano metal oxide by the emulsion approach.

Results

The synthesis of nano Zinc (II) oxide (ZnO) and Chromium (III) oxide (Cr_2O_3) were carried out with the concurrent addition of sodium hydroxide and increasing the stirring time, to prevent excessive grain growth and aggregation of nanoparticles. The overall reaction scheme is shown below:

$$Zn(NO_3)_2 + 2NaOH \rightarrow Zn(OH)_2 + 2NaCl$$

$$Zn(OH)_2 \rightarrow ZnO + H_2O$$

This is a multi step process that involves the transformation of the salt of metal to an metal hydroxide $M(OH)_n$ followed by the dehydration to form an oxo-hydroxide intermediate, that will constitute the precursor in the sol-gel process. In this study, when the mixture of ML_x ($Zn(NO_3)_2$ & $CrCl_3$), soybean oil (containing Tween 80) and water were mixed with mechanical stirrer, water solution was dispersed in the oil phase and Tween 80 assembled at the water/oil interface, acting as the emulsifier for the formation and stabilization of emulsion. The water solution was in the droplets and the oil solution became the continuous phase, hydroxyl groups in the droplets of water emulsion diffused to the water/oil interface, a part of which reacted with ML_x to form Metal oxides. In order to characterize the nature of the Metal oxides nanoparticles, SEM (Fig. 2 & Fig. 3), TEM (Fig. 4) and XRD (Fig. 5 & Fig. 6) measurements were carried out.

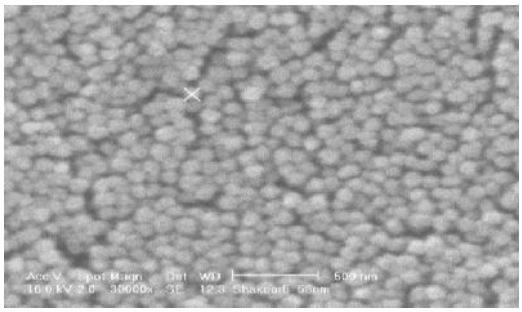

Figure 2. SEM image of the ZnO nanoparticles.

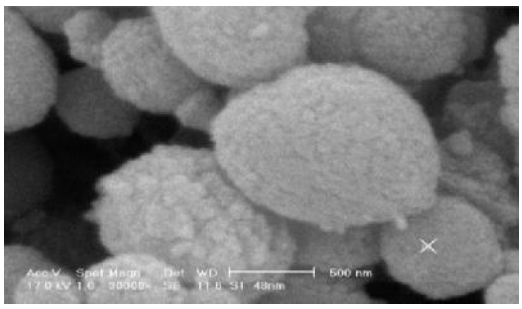

Figure 3. SEM image of the Cr_2O_3 nanoparticles.

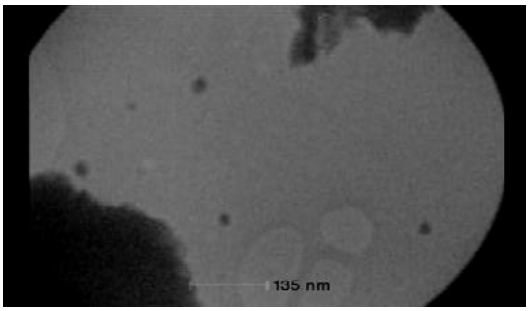

Figure 4. TEM image of the Cr_2O_3 nanoparticles.

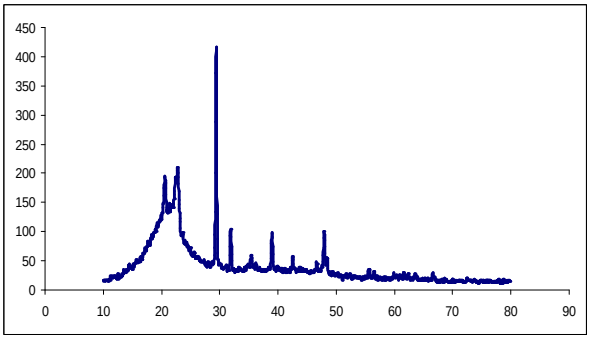

Figure 5. XRD pattern of the ZnO nanoparticles.

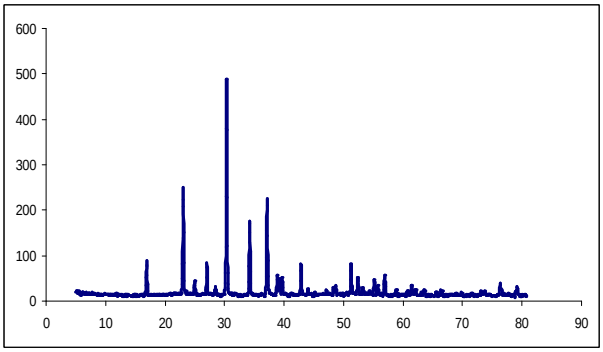

Figure 6. XRD pattern of the Cr_2O_3 nanoparticles.

Discussion

Fig. 1 and 2 show SEM images of the ZnO and Cr_2O_3 powder. This metal oxides show agglomeration of particles, with diameters ranging from 40 to 80 nm.

The morphology of the prepared ZnO and Cr_2O_3 nanoparticles calculated at 200°C was characterized by SEM and TEM images as shown in Fig. 2, 3 & 4. From images results, we can observe a large quantity of uniform nanoparticles (NPs) with average particle size of 40-80 nm, indicates that our synthesis process is an easy method for the preparation of this nanoparticles.

The corresponding diffraction patterns are shown in the insets. Fig. 5 and 6 shows the XRD patterns of ZnO and Cr_2O_3 powders after calcinations at 200 °C. The nano-sized particles are in amorphous structure. Its average particle size was 58 and 50.78 nm. That calculated through the Scherrer's formula $D=0.89\lambda/B\cos\theta$. D, λ, B and θ were the average particle size, the X-ray wavelength, the angular line width of half maximum intensity and the Bragg's angle respectively.

Conclusion

We have described the use of an inorganic phase in water-in-oil (w/o) microemulsion has received considerable attention for preparing metal oxide nanoparticles. In addition, the easily controllable conditions with using low cost zinc and chromium source are merit to be considered for scaling up by industrial researchers.

Acknowledgement

We are grateful to department of chemistry Zanjan University and Baqiyatallah University of Medical Sciences for financial support of this work.

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