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Influence of different concentrations of Cetyltrimethylammonium bromide on morphological, structural and optical properties of Zinc Oxide nanorods

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Abstract

The Zinc Oxide (ZnO) Nanorods were synthesized by hydrothermal method using Zinc Acetate, Hexamethylenetetramin (HMTA) and Cetyltrimethylammonium bromide (CTAB). The pH of the solution was maintained at 11-12 by adding NaOH. The effect of various concentration of CTAB (0.01mM, 0.03mM and 0.05mM) on morphological, structural and optical were investigated using field emission scanning electron microscopy (FESEM), X-ray diffraction (XRD), UV-Vis spectrophotometer. The functional group analysis of ZnO was carried out using FTIR spectroscopy. It was found that as the concentration of CTAB increases the diameter of the nanorods decreases from 180nm to 80nm. The peak found at 472 cm^{-1} is the characteristic absorption of the Zn–O bond.

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*Keywords:*Hydrothermal method; CTAB; Field emission scanning electron microscopy; FTIR spectroscopy.

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1. Introduction

Zinc oxide (ZnO), a versatile semiconducting material, has attracted intensive research for its applications in sensor [1,2], antireflection coatings [3,4], transparent electrodes in solar cells [5], antibacterial agent [6,7] and photocatalysis [8] due to its wide band gap (3.37 eV) and high excition binding energy of 60 meV at room temperature. It possesses wide interest in the scientific arena due to its unique optical, acoustical and electronic properties [9-11]. Many methods have been developed to synthesize 1-D ZnO nanostructures such as dry methods which includes chemical vapor deposition [12], thermal evaporation [13], molecular beam epitaxy [14] and template based methods [15] and wet solution-phase methods which includes micro emulsion technique [16], surfactant assisted growth [17], sol-gel technique [18] and hydrothermal technique [19]. Among all the techniques, hydrothermal method is the most attractive candidate for synthesis of ZnO nanorods because of its simplicity, eco-friendly and low cost [20]. A number of capping agents have been used for synthesizing nanostructures, for example, triethanolamine (TEA) [21], polyvinylpyrrolidone (PVP) [22], monoethanolamine (MEA) [23], cetyltrimethylammonium bromide (CTAB) [24] and polyethylene glycol (PEG) [25].

In this report, we synthesize the ZnO nanorods using low cost hydrothermal method using CTAB as capping agent. The effect of different concentration of CTAB on morphological, structural, functional groups and optical properties were investigated.

2. Materials and methods

2.1. Materials

Zinc Acetate (ZA), (Zn $(CH3COO)_2.H_20$, Merck 99.9%), Hexamethylenetetramine (HMTA), ($C_6H_{12}N_4$, Sigma-Aldrich),Cetyltrimethylammonium bromide (CTAB), ($C_{19}H_{42}BrN$, Sigma-Aldrich) and Sodium hydroxide (NaOH). All the reagents used are of analytical grade purity and used without further purification.

2.2. Preparation of ZnO nanorods

A solution containing equimolar concentration of ZA and HMTA was made in 50ml distilled water. NaOH was added drop wise to maintain the pH at 11-12. The above solution was stirred for 30 minutes. Then 0.01mM, 0.03mM and 0.07mM of CTAB was added and stirred for 30 minutes. The whole mixture was transferred to Teflon-lined autoclave and maintained at 105^{o}C for 10hrs. The finale product was then washed with DI water followed by ethanol and dried in oven at 50^{o}C for 30 minutes.

2.3. Characterization

The surface morphology and elemental analysis of ZnO nanorods were examined using Field emission scanning electron microscopy (FESEM) and energy-dispersive X-ray spectroscopy (EDX) using FEI Quanta FEG 200. XRD pattern of all the synthesized samples were obtained by PANalytical's X'Pert Pro with CuKα radiation (λ=1.542Å). Functional group analysis was obtained by ALPHA-T FTIR Spectrometer. Optical absorption measurements were carried out using SHIMADZU UV-Vis–Spectrophotometer.

3. Results and discussion

3.1. Morphological Analysis

Fig 1. (a-c)Show the FESEM images of ZnO nanorods grown by hydrothermal method using CTAB as capping agent. The FESEM images reveal that the ZnO nanorods exhibit hexagonal structure. As the concentration of CTAB increases from 0.01mM to 0.05mM the diameter of the nanorods decreases from ~ 96nm to ~50nm. Fig 1. (d) Reveals the EDX analysis indicates the elemental composition of ZnO nanorods as the purity of the sample.