A.V.V.M. Sri Pushpam College (Autonomous)

Poondi– 613 503, Thanjavur-Dt, Tamilnadu

(Affiliated to Bharathidasan University, Tiruchirappalli – 620 024)

3.7.1 Number of Collaborative activities per year for research/ faculty exchange/ student exchange/ internship/ on –the-job training/ project work

Collaborating Agency:

Dr. A. T. Ravichandran National College(Autonomous), Tiruchirapalli.

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Date: 18.06.2015

LINKAGE

For the year 2015-2016

Between

1. Dr. K. Ravichandran,
Associate Professor
PG & Research Department of Physics
A.V.V.M Sri Pushpam College
(Autonomous), Poondi – 613 503.

&

2. Dr. A. T. Ravichandran
Associate Professor
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National College (Autonomous)
Tiruchirapalli – 620 001.

Considering the significance of the noble cause for the student community, we have come forward to collaborate with each other to exchange research knowledge, expertise, laboratory and library facilities to the process of scientific research and education in the field of materials science. The parties (mentioned above as 1. & 2.) have had preliminary discussion in this matter and have ascertained areas of broad consensus. The parties now therefore agreed to enter in writing these avenues of consensus, under a flexible linkage, and this project aims to fill the gap between knowledge demand and subject expertise related to the mentioned field.

Joint Responsibilities

- Sharing of laboratory facilities, library resources, database etc.,
- Joint Publication of research articles, books, magazines, bulletins etc.,
- Jointly organizing conferences, seminars, symposia and workshops.
- Submitting joint proposals for research funding from agencies like UGC, CSIR, DST and TNSCST.

K. Ravi

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Zr + F codoping-induced variations in antibacterial and magnetic behaviours of ZnO nanopowders

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Zr- and (Zr + F)-doped ZnO nanopowders were synthesized using a simple soft chemical route having Zr and F doping concentrations as 3 and 10 at.%, respectively. The structural, morphological, optical, magnetic and antibacterial properties of these samples are studied and compared with those of undoped ZnO. The X-ray diffractometer studies reveal that the synthesized nanopowders exhibit hexagonal wurtzite structure of ZnO, and the crystallite size increases after doping. The field effect scanning electron microscope and transition electron microscopy images show that the synthesized ZnO nanopowders have reduced grain size after doping. The dopant-induced room temperature ferromagnetism is observed from vibrating sample magnetometer studies. Enhancement in the antibacterial efficiency due to doping against three different bacterial strains, *viz. Bacillus subtilis*, *Staphylococus aureus* and *Pseudomonas aeruginosa* are studied and reported.

Keywords: ZnO, (Zr+F) nanopowders, TEM, Ferromagnetic property, Antibacterial activity

1. Introduction

Among the transition metal oxides, zinc oxide (ZnO) is one of the promising multifunctional materials for the biomedical applications.[1-4]

ZnO is a low cost and environmentally friendly n-type semiconductor with wide band gap of 3.3 eV. It is chemically and thermally stable.[5-7] The properties of nanostructured ZnO can be tailored by doping selective elements such as Al, Mg, Mn, F, Zr, Ag and N.[6-8] Simultaneous addition of cationic and anionic dopants into ZnO is attracting considerable interest since it could result in the modification of electronic structure and some other properties of the intrinsic ZnO efficiently.[10-12]

A semiconductor which is ferromagnetic at room temperature and having antibacterial property is desirable for applications in the field of biomedicine, targeted drug delivery and biosensors.[13,14] Expecting an increase in the carrier concentration and modification in the magnetic behaviour of ZnO, in this study, zirconium (Zr) has been doped.[15,16] As fluorine (F) has the efficiency to enhance the antibacterial activity of the ZnO nanopowders,[17] F is added as a second dopant. To the best of our knowledge, this is the first report on the study of effect of simultaneous doping of Zr and F on the magnetic and antibacterial properties of ZnO nanopowders.

ZnO nanostructures have been synthesized using different methods.[12,13] Among these, the soft chemical route has attracted much attention because it is a facile, inexpensive and low-temperature process.[14] In this work, ZnO:Zr:F nanopowders have been synthesized using this soft chemical method.

2. Materials and methods

2.1. Synthesis process

Zinc acetate dihydrate ($Zn(CH_3COO)_2 \cdot 2H_2O$) (0.2 M) was used a host precursor. Zirconyl nitrate ($ZrO(NO_3)_2 \cdot H_2O$) and ammonium fluoride (NH_4F) were used as dopant precursors for Zr (3 at.%) and F (10 at.%), respectively. The precursors were dissolved in 200 mL of distilled water, and the pH value was maintained at 7 by adding NaOH solution drop by drop with the starting solution. The prepared solution was stirred using magnetic stirrer for 2 h at a temperature of 85 °C and then allowed to cool to room temperature and kept undisturbed for 1 h to get the required precipitate. The precipitate was filtered and rinsed separately with water and ethanol (3:1) several times and then dried in air at room temperature. Finally, it was calcined at 550 °C for 3 h to obtain the final product.

2.2. Characterization of ZnO:Zr:F nanopowders

The structure studies were carried out using X-ray diffractometer (XRD) (PANalytical-PW 340/60 X' pert PRO). The surface morphology was studied using field effect scanning electron microscope (FESEM, Hitachi SU8000) and transition electron microscopy (TEM, Hitachi H-7100). The elemental analyses were made using energy dispersive X-ray analysis (EDAX) (Model: JEOL-JSM 6390 with attachment INCA-Penta FETX3 OXFORD). Photoluminescence (PL) spectra were observed using spectrofluorometer (Jobin Y

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Sm doping effect on structural, morphological, luminescence and antibacterial activity of CdO nanoparticles

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Abstract Undoped cadmium oxide along with samarium doped CdO are synthesized by simple soft precipitation method. Resulting precursor was calcined at 400 °C for 2 h. As a result of heating, a pure material was produced. The obtained compound possesses a cubic crystalline structure at nanoscale. Also, FESEM image showed that the resulting material is composed of nanoparticles and its size decreases with increase of Sm doping relative with the particle size calculated from XRD. The photoluminescence shows the emission of violet and blue colour peaks and the peak at 468 nm which is responsible for a better antibacterial activity. The synthesized nanopowders are subjected to two different gram positive (*Staphylococcus aureus* and *Enterococcus faecalis*) and two different gram negative (*Escherichia coli* and *Klebsiella pneumoniae*) bacterial strains respectively. It is noted that there are high activity of the Sm doped CdO towards gram negative bacteria.

1 Introduction

Cadmium oxide (CdO) is an N-type II–VI semiconductor material, also noted as Transparent conducting oxides (TCO), which is found to be a promising candidate for optoelectronic applications such as solar cells, photo transistors, photo diodes, transparent electrodes, gas sensors etc. [1]. Thus, this TCO material plays an important role in integrating various components, because of their unique combination of optical transmittance and electrical conductivity through UV and NIR regions of solar spectrum [2]. Numerous methods have been reported for the preparation of pure and doped CdO nanoparticles such as sol–gel [3], solvothermal [4], co-precipitation [5], and microemulsion [6]. Synthesising techniques with different interesting morphologies including nanowires [7], nanofibres [8], nanoparticles [9], nanoclusters [10], nanorods [11], nanobelts [12], nanocubes [13] are also reported as obtained. Certain techniques require sophisticated equipments, time consumptions and energy dissipation. Among all the techniques co-precipitation is a low process cost, low temperature of heat treatment, high yield, controllability, reproducibility, vacuum-free usage, and wide possibility to varying properties by changing the composition of the solution, etc. The physical and other properties of these TCO's are controlled by doping metals such as aluminium [14], indium [15], fluorine [16], zinc [17], nickel [18], magnesium [19] and also with certain rare earth elements. CdO is not as popular as that of its counterpart ZnO, thou it has interesting properties and potentialities. The main reason can be assumed because of its low optical band gap (2.2 eV) [20].

From literature two works have been noted in accordance with the dopants with different ionic concentrations. When the ionic radius is higher than that of Cd^{2+}, it results in the creation of significant lattice defects because of the charge compensation and the ionic radii mismatch between cation and Cd^{2+}. Whereas, Velusamy et al. [21], reported if the ionic radius on the size of the dopant ion is less than that of the Cd^{2+} there arises a change in unit cell and

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Effect of size reduction on the magnetic and antibacterial properties of ZnO:Zr:Mn nanoparticles synthesized by a cost-effective chemical method

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Abstract Zr and Zr + Mn doped ZnO nanopowders were synthesized using a simple soft chemical route keeping the Zr concentration in the precursor solution constant (3 at.%) and varying the Mn concentration (0, 1.5 and 9 at.%). From the X-ray diffraction studies, the crystallite size of ZnO:Zr nanopowder is found as 57 nm. The crystallite size decreases with the increase in the Mn doping level and attains a minimum of 23 nm at the maximum doping level examined in the present work (9 at.%). The Zr doped ZnO nanopowders found to have ferromagnetic property. The saturation magnetization increases with the increase in the Mn doping level and attains a maximum value at 7 at.% of Mn doping. The material shows superparamagnetic behavior at the doping level of 9 at.%. The antibacterial efficiency is found to be maximum at 9 at.% of Mn doping and at this doping level the grain size is minimum (20 nm) as evidenced from the SEM and TEM results.

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1 Introduction

In recent years, there is a hectic search for materials with superparamagnetic as well as antibacterial properties, as these properties are prerequisites for magnetically targeted drug delivery systems. In targeted drug delivery systems, high gradient external magnetic fields exert a force on the drugs with magnetic properties and thus they can be manipulated or transported to specific pathological sites by applying an external magnetic field [1–6].

Among different types of semiconducting nanomaterials, zinc oxide (ZnO) is one of the significant multifunctional materials that finds application in the field of light emitting diodes, spintronics, solar cells, bioimaging and biomedical applications [7–12]. It is a low cost and environmental friendly n-type semiconductor with wide band gap of 3.3 eV and high exciton binding energy of 60 meV [13–15]. It is chemically and thermally stable and non-toxic towards human cells. Moreover it is biocompatible, biosafe and also an antibacterial agent and hence it is considered as one of the most suitable materials for use in biomedical applications [5].

However, the undoped ZnO nanopowders have only diamagnetic nature. By suitably adding transition metals with the ZnO nanopowder, one can tailor its physical, chemical and magnetic properties [16–18]. The enhanced carrier concentration caused by the doping can improve the efficiency of the antibacterial activity and change the magnetic behavior. In order to increase the carrier concentration, in this work, zirconium (Zr) has been doped with ZnO [19]. As manganese (Mn) has the efficiency to enhance the antibacterial activity of the ZnO nanopowders [20], Mn has been doped simultaneously as a second dopand.

Various methods such as combustion [21], sol–gel [22], sonochemical [23], coprecipitation [24], solvothermal [25],