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STRUCTURAL AND ANTIBACTERIAL PROPERTIES OF SOL-GEL DRIVED ZnO:Mg NANOPARTICLES

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ABSTRACT
sol-gel method is used successfully for synthesis of ZnO nanoparticles doped with different concentrations of Mg . Synthesized ZnO samples showed hexagonal wurtzite structure with size of 30 nm. The phase segregation takes place for 15% amount of doping. The effect of Mg dopant on the structure of sample was studied. ZnO nanofluid shows good antibacterial activity which increases with increase of its concentration, and slightly decreases with the amount of doped Mg .

1. INTRODUCTION

Zinc oxide (ZnO) has been the topic of high-standard contemporary research because of its wide energy band gap (3.37 eV) , large exciton-binding energy (60 meV) , biocompatibility , relatively easy manufacturing technology etc. This II–VI semiconductor, due to its interesting electrical , optical and magnetic properties, has found great application in various fields such as electronics , spintronics , optoelectronics [1].ZnO is also an environmentally friendly material and has little toxicity, which is why it is widely used in personal care products. Moreover it has been shown that ZnO, like some other metal oxide nano particles (TiO_2[2], MgO [3]), has distinctive antibacterial properties[4-7]. In the fields in close contact with human body , ZnO has several advantages: showing a marked antibacterial activity in neutral region (pH 7) even in darkness , and being a mineral element essential to human being , which makes it superior to conventional organic antimicrobial agents such as quaternary ammonium salt and chlorine disinfectant[5].

Although exact mechanism of its antibacterial action is not clearly known , several mechanisms have been proposed: photocatalyst activities ,electrostatic interactions[8] , metal ion release , ROS (Reactive Oxygen Species) generation [4], membrane damage[1],cellular internalization of the nanoparticles has also been reported[9]. Results of the antibacterial activity of ZnO nanostructures show that antibacterial activity increases with decreasing the particles size [4], the crystallographic orientation has no effect [5], while increase in the lattice constant leads to increase of its antibacterial activity [6]. Yamamoto et.al investigated the effect of CaO doping on antibacterial properties of ZnO [7]. But till now there has not been any reports on studing the effect of MgO doping. In this work nanoparticles of ZnO with different amount of Mg were successfully synthesized via sol-gel method , and its antibacterial activity ,in addition to structural properties were studied.

2.EXPERIMENTAL DETAILS:

ZnO:Mg nanoparticles were synthesized by refluxing solution of $Zn(NO_3)_2.6H_2O$ and $MgCl_2.6H_2O$,ethanol and double distilled water (1:1) were used as solvent and ethylene glycol and acetic acid were used as polymerization and complexing agents, respectively. The homogeneous mixture was maintained under reflux at 100-110 °C for 6 hours. After vaporizing the excess solvents, the wite powder was obtained. Before characterization, the powder was calcinated at 600 ° C and then milled.

To make nanofluid for antibacterial tests, certain amount of NPs was mixed with distilled water ,at the concentration of 1g/Lit, and stirred vigorosly. To have homogenous nanofluid , a ball-mill mixer (Retsch MM400 ,28 Hz, 5 min) was used. Nanofluids prepared were autoclaved at 121 ° c .

Characterization:

The typical XRD spectra of the powder was characterized with using X ray diffractometer (Cu K_{α}line λ=0.15406 nm) . The intensity was determined in the range 20 ° <2θ <80 ° and 0.04 degree step size.

Antibacterial test was done by measuring growth curve of **E.coli HB 101** incubated in the LB broth medium in presence of nanofluids [4]. The growth curve was obtained by measuring time evaluation of optical density (OD) of the sample. The measurements were done at 600 nm wavelength using UV/VIS spectrophotometer (WPA LightWave S2000) at the frequency of once an hour.

3.Result and discussion:

3.1.Structural properties:

Figure .1 shows the XRD pattern of the samples. As can be clearly seen ZnO particles possessed polycrystalline hexagonal wurtzite structure. No peaks originating from MgO rock-salt structure was detected below Mg concentration of 15%. This result indicates that Mg^{2+} can be incorporated into the ZnO lattice with no phase segregation taking place, which was not unexpected because Mg atom has a similar ionic radii with that of Zn atom (0.57 A° for Mg and 0.60 A°for Zn) [11]. The presence of (002)- wurtzite peak along with(200)-cubic peak at dopant percentage of 15% indicates the coexistence of two phases. The size of nanoparticles, calculated with sherrer equation, is 30 nm. To gain further insight , the lattice parameter c of samples with varying Mg content was calculated. The increase of Mg content results in decrease of lattice constant, which could be due to structural adjustment as the variation of lattice constant is related to the bond flex of anion and cation , radius difference of substitutional ion , and change of crystal structure.

To see the effect of Mg doping on Zn–O bond length, bond length has also been calculated. The results are shown in table (1).

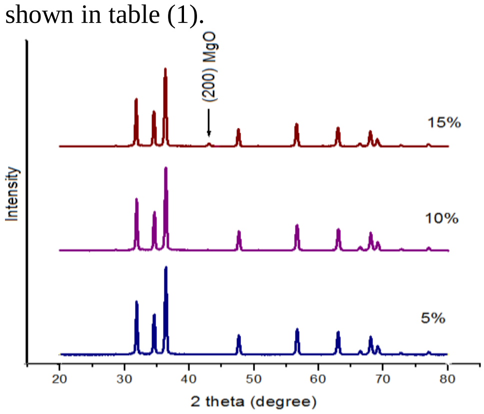


Figure.1 XRD pattern of ZnO:Mg

Table .1 structural change with dopant concentration

Dopant (%)	a (A°)	c (A°)	Change(%) in lattice parameter	Bond length (nm)
0	3.2400	5.2070	0	0.1968
5%	3.2449	5.2057	-0.024	0.1971
10%	3.2467	5.1734	-0.62	0.1972
15%	3.2516	5.1434	-1.22	0.1975

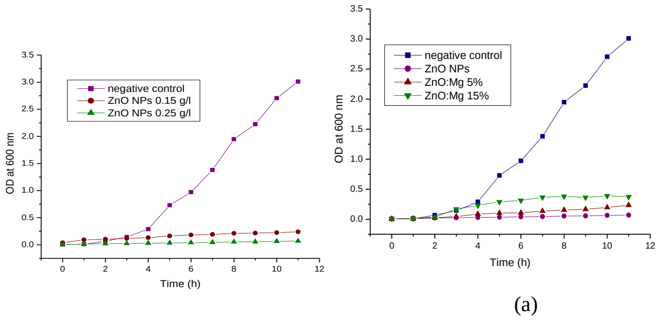
3.2. Antibacterial test results:

3.2.1 .Effect of nanoparticles concentration:

Figure.2a shows the growth curves of the nanofluids together with the negative control. As the value of the optical density (OD) at 600 nm represents the absorbance of the bacteria, an increase in the number of bacteria implies more light being absorbed by the bacteria.

3.2.2. Effect of dopant incorporation:

Figure.2b shows the effect of doping on antibacterial activity of nanoparticles. As it can be clearly seen by increase in doping level , the antibacterial activity slightly decrease . This is in agreement with the results of Yamamoto et al [6] that with decrease of lattice constant , antibacterial activity decrease. However doped nanoparticles still shows significant antibacterial effect.



(b) (a)

Figure .2 growth curve of **E.coli** in LB medium (a) in the presence of two different concentration of NPs (b) in the presence of NPs with different dopant concentrations

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