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Short communication

# Enhancement of antibacterial and anticancer properties lanthanum insight into zinc oxide nanoparticles prepared via coprecipitation process

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ABSTRACT

The development of La-doped ZnO NPs exhibits potential to improve the biocidal properties of nanomaterials for medical applications to treat MDR bacteria and breast cancer activity. A co-precipitation process was used to make zinc oxide (ZnO) nanoparticles (NPs) and lanthanum doped ZnO (ZnLaO) NPs. XRD patterns revealed the hexagonal wurtzite structure of the ZnO and ZnLaO NPs. ZnO stretching frequencies, ZnO, and ZnLaO were found in the FTIR spectra at 486 and 556 cm-1, respectively. SEM and EDAX spectra validated the shape and chemical composition of ZnO and ZnLaO NPs. Based on UV–Vis spectroscopic measurements, the excitonic peaks for the two samples were found to be about 367 nm and 364 nm, respectively. The PL experiments were conducted at room temperature, and green emission peaks were observed in the visible range for ZnO and ZnLaO NPs at 522 and 523 nm, respectively. ZnO and ZnLaO NPs were examined for antibacterial activity against gram-positive bacteria (S. aureus and B. subtilis) and gram-negative bacteria (E. coli and K. pneumoniae) bacterial strains. The ZnLaO NPs potential antibacterial activity was higher than that of ZnO NPs alone, and increasing the concentration of ZnLaO NPs also increased the antibacterial activity. Furthermore, the ZnO and ZnLaO NPs were treated with human breast cancer (MCF-7) cell lines. The ZnLaO NPs exhibit more anticancer activity at a minimum concentration. As a result of these investigations, the ZnLaO NPs can make antibacterial and anticancer agents and these employed in biomedical applications.

## 1. Introduction

The nanostructured metal oxides show essential physical and chemical properties like semiconducting, insulating behavior, etc., over their same bulk materials [27,20,12]. In recent years, zinc oxide (ZnO) nanomaterials have been attracted the attention of many scientific researchers owing to their low cost, easy fabrication, photocatalytic activity, wide band-gap semiconductor, unique optical, magnetic, electronic properties, photocatalysts and biomedical, etc. [24,47,22,30,17,24,15,29,26,32,41,2,6].

ZnO materials are piezoelectric and electro-conductive materials that are translucent [23]. Furthermore, ZnO materials are effective UV absorbers and antimicrobial agents. At room temperature (RT), ZnO materials have bandgap energy of 3.37 eV and a high excitation binding energy of 60 meV, allowing for more efficient excitonic emission even at high temperatures [34]. Chemical precipitation [21], sol-gel [11], microwave radiation [40], hydrothermal processes [31], and other methods (Saleh et al., 2007) have all been used to make ZnO materials. Co-precipitation is more critical since it produces higher-quality material. Aside from that, it has a low processing cost, requires a low temperature, and makes a higher yield (Lokhande et al., 2020).

Doping ZnO materials with various metallic ions improves their optical, magnetic, conducting, and biological properties [25,28]; Hemam et al. 2015[29]. Improved ZnO materials potentially enhance magnetic semiconductors, solar cells, field-effect transistors, gas sensors, light-emitting materials, photo-catalysts, and biological systems [13,8]. Doping ZnO materials with rare earth elements (e.g., La, Tb, Er, Eu, Dy, and Sm) leads to various unique behaviors, including effective

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# Biocidal Properties of Vanadium, ZnO Nanoparticles Prepared Via Green Process

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**Abstract**
This research focused on developing eco-friendly biocidal substances with low cost and high efficiency. The researchers prepared Vanadium doped Zinc oxide nanoparticles (VZnO) NPs using a green process and studied their structural, optical, antibacterial, and anticancer properties. The XRD pattern showed that the VZnO NPs had a hexagonal wurtzite structure, with an average crystalline size of 33 nm. The morphology of the VZnO NPs had a cyclooctane structure, and the average particle size was 36 nm. The chemical composition was identified using EDAX analysis, and the XPS spectra revealed the oxidation state of C (1 s), O (1 s), V (2p), and Zn (2p) for VZnO NPs. The FTIR spectrum showed Zn-O stretching bands at 497 cm-1 for the VZnO NPs. The photoluminescence spectrum of VZnO NPs emitted green emissions (oxygen vacancies) at 530 nm, which play an important role in the generation of reactive oxygen species (ROS) responsible for biocidal activities. The VZnO NPs exhibited both antibacterial activity against gram-negative bacteria and anticancer activity against breast cancer cells (MDA-MB-231), as tested using an MTT assay that showed increased concentration of VZnO NPs decreasing cell viability.

**Keywords** Vanadium · Antibacterial · Anticancer · Reactive oxygen species · Nanoparticles

## 1 Introduction

In recent decades, the better biocidal activity of nanostructured materials against cancer and microorganisms has drawn the attention of many young researchers. Multidrug-resistant bacteria (MDR) have nevertheless become one of the major clinical issues in healthcare settings wherever MDR pathogenic bacteria activity has emerged. The bacteria have resisted the antibiotics in conventional antibiotics treatment with a bacterial infection. In addition, the excessive use of traditional antibiotics has created various side effects and imposed several issues on the human health system because of their toxic effects [1]. Our team has developed new biocidal materials that effectively combat cytotoxicity while offering several advantages. For example, these materials are cost-effective, smaller in size, produce higher yields, have tunable properties, are biocompatible, and have non-toxicity levels [2]. Biocidal nanoparticles are synthesized using inorganic materials and can be activated by light irradiation [3]. Because of their small size, increased surface area, and better biocidal activity, the photocatalytic effects of metal oxide NPs can stop the viability of bacteria and cancer cells from growing [3].

ZnO NPs are II–VI semiconductor group compounds that crystallize with a wurtzite structure and hexagonal unit cell. ZnO has outstanding properties, such as a broad and direct bandgap (~3.36 eV), intense absorption in the ultraviolet region, and a high room-temperature exciton binding energy (~60 meV). The unique characteristics of ZnO NPs, such as catalysis, photochemical capability, medicinal effects, antimicrobial and anticancer properties, and UV filtration, have made them a multi-functional agent and more promising for wastewater remediation. However, antibacterial and anticancer activities are strongly related to the generation of reactive oxygen species (ROS) in nanomaterials due to their large surface areas, increased oxygen vacancies, reactant

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International Journal of Thin Films Science and Technology

# Influence of Effective Surface Area on Gas Sensing Properties and Surface Morphology of Ag Doped $Cu_2O$ Thin Films by Cost Effective Method of M-SILAR Technique

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**Abstract:** Undoped and silver (Ag) doped $Cu_2O$ ($Cu_{2-x}Ag_xO$, x= 2.5, 5.0, 7.5 and 10.0 mol. %) thin films were deposited onto glass substrate using modified successive ionic layer adsorption and reaction (M-SILAR) technique. The Ag doping level causes significant influence on the properties of the system prepared. The results indicated that 10.0 mol.% Ag doping causes major property improvements. The deposited films were characterized by their structural, morphological, surface smoothness, optical and gas sensitivity. The X-ray diffraction analysis shows the polycrystalline growth of $Cu_{2-x}Ag_xO$ films. The substitution by $Ag^+$ ions result in cubic structure (111) preferential orientation. The transmittance and optical band-gap values are minimum (2.12 to 1.73eV) for the Ag doping level of 10.0 mol.%. The Fourier transform infrared (FTIR) results confirmed the stretching vibrations of $Cu_2O$ and $Ag_2O$. The Gas sensitivity revealed, Ag doped $Cu_2O$ serve as sensor material for the detection of $NH_3$ molecules at room temperature compared to undoped film. The gas sensing test was performed by the resistance measurement of the system using a Keithley System.

**Keywords:** Silver (Ag) doped $Cu_2O$ thin films, 3D Flower-like structure, Structural and Gas Sensitivity

## 1. Introduction

In the search of a suitable p-type semiconductor, cuprous oxide ($Cu_2O$) appears to be one of the promising semiconductors for solar cells. $Cu_2O$ based materials are especially useful for light emitting diodes [1]. Cuprous oxide is the parent compound of many p-type transparent conducting metallic oxides (TCO) such as $Cu_2O$:delafossites (X= Ag, Zn, Fe, Co, Al, [illegible], etc.) [2]. The property of the $Cu_2O$ material can be enhanced with doping of Ag without affecting the crystal structure. Generally, metal doping materials are making radical changes in electrical, optical, morphological, magnetic properties, gas sensitivity and antibacterial activities of copper oxide thin films [3]. It is used in many applications which include photo catalyst [4-10], lithium-ion batteries [11], solar energy [12,13], magnetic semiconducting material [14], transparent conductors [15], water splitting [16-24] and gas sensors [25]. For the preparation of this material in thin film form, several deposition techniques are available such as chemical vapour deposition [26,27], thermal oxidation [28], hydrothermal deposition [29], electro thermal deposition [30], magnetic reactive sputtering [31], one step hydro thermal [32], chemical bath deposition(CBD) [33], epitaxial growth [34], Pulsed laser deposition [35-37], spray pyrolysis [38] and successive ionic layer adsorption and reaction method (SILAR) [39]. Among the various methods, the SILAR technique is a simple one, non-toxic with low processing temperature and also can lead to large area deposition. However, there are only a few reports available on the deposition of metal doped $Cu_2O$ thin films by SILAR technique. Here, we have reported the deposition of Ag-doped $Cu_2O$ films using SILAR method.

## 2. Experimental Procedure

Undoped and Ag doped $Cu_2O$ (2.5, 5.0, 7.5 and 10.0 mol. %) films were deposited onto glass substrates using SILAR technique. High pure copper sulphate pentahydrate, sodium thiosulfate, silver nitrate and sodium hydroxide were used for preparing precursor solution. Then 2.5, 5.0, 7.5 and 10

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