International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

The Study of Pure and Ni Doped Cdo Nanoparticles to Explore their Antimicrobial Activity

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Abstract
This study focuses on the synthesis of Cadmium oxide (CdO) nanoparticles with doped transition metals like Nickel (Ni) of varying concentrations using sol gel citrate synthesis. Chemical and elemental characterization was carried out with X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Ultraviolet-Visible (UV-Vis) spectroscopy, Scanning Electron Microscopy (SEM), Energy-Dispersive X-ray Spectroscopy (EDS). The efficacy of antimicrobial properties of the synthesized nanoparticles against a wide range of Gram-positive and Gram-negative bacterial strains and fungal strains was explored. The results demonstrates that the doping of transition metals enhances the antibacterial and antifungal properties of the CdO nanoparticles and thus it can be used as antimicrobial agent in various industrial and medical fields due to its potential strength.

Keywords: Cadmium Oxide nanoparticles, Nickel, EDS, SEM, , Antibacterial, Antifungal.

1. INTRODUCTION

In past few years we have witnessed enormous growth in research and application in nanoscience and nanotechnology. The vital area of science which deals with the study of small dimensional particles, which brings nanotechnology in focus, can be termed as Nanoscience. Nanotechnology is the field of science which deals which the study of particles in the range of nano scale to bring into existence a variety of products which has its application to our society. Here, Nano means “drawf” in Greek. Nanoscale materials shows how the molecule can be distinguish on the basis of size obtained from the study of nano particles.[1]

The nanoparticles can be synthesized using different techniques which can be beneficial as they serve cluster of atoms helps to determine the size of nanoparticles. The nanoparticles synthesized from sol method are much stable as compared to all other nanoparticles synthesized by chemical process. The rate of synthesis is faster and the shape and size of these nanoparticles are unique in comparison with those produced by other method. In short Nanotechnology is the study of extremely small structures, having size of 0.1 to 100 nm[2]. Nanotechnology is the treatment of individual atom, molecule or any compound to enhance its special properties. Structure also changes with size however it is important that these

materials display different properties such as electrical conductance, reactivity, melting point, surface area, and physical strength[3].

Cadmium oxide (CdO) nanoparticles are categorized as n-type semiconductordue to its large band gap. It has low electrical conductivity and high transmission area. CdO nanoparticles can be used as a precursor and photo catalysts in plastic and rubber industry. High electrical conductivity and optical energy CdO nanoparticles can be used in optoelectronics. It can also be used as catalyst in chemical process and to detect gases like ammonia in gas sensors[4]. Traces of these nanoparticles can be found in cadmium coated bath and paint pigments. Non-linear optical properties can be found in the thin films of the cadmium oxide nanoparticles.Transpearent conducting oxides (TCO) have been used on a larger scale due to its improved physical and chemical properties, CdO is one on the most widely used TCO. The transition metal ions like Ni, Co, Mg, Au shows the various d-d transition and thus when used as dopants in metal oxide nanoparticle synthesis it alters the different properties of nanomaterials[5].

In the present work, pure and Ni doped CdO nanoparticles of varying concentration were prepared by using sol gel citrate method to study the antibacterial, antifungal and antiviral properties along with morphological, elemental and structural analysis.

2. Experimental Details

The nanocrystalline pure and Nickel (0.2, 0.4 and 0.6 %) doped cadmium oxide (CdO) nanoparticles were prepared by using the sol-gel citrate method. A stoichimetric mixture of cadmium nitrate tetrahydrate ($Cd(NO_3)_2 \cdot 4H_2O$) in addition with citric acid and ethylene glycol was properly mixed. The mixture was then stirred on a magnetic stirrer continuously for 3 hours at 80°C to obtain a homogenous and transparent solution. The solution was further heated in a pressure vessel at 130^0 C for about 12 hours to form gel like solution. Then the gel is subjected to heat treatment at 350^0C in a muffle furnace to get the dried fine powder of pure CdO nanoparticles. For, Ni (0.2, 0.4 and 0.6 %) doped CdO nanoparticles the above process was repeated by using nickel nitrate hexahydrate ($Ni(NO_3)_2.6H_2O$.) to obtained $Ni_xCd_{1-x}O$ nanoparticles.

3. Result and Discussion

3.1.X-ray Diffraction

CdO and Ni doped nanomaterials of different concentration obtained from the sol gel synthesis were characterized through X-ray diffraction to get information about crystal structure, crystalline size and purity of sample. XRD pattern of synthesized cadmium oxide and doped cadmium oxide were obtained at room temperature. The scanning angle 2θ was varied from 20-80 degree. X-ray diffraction data were recorded by using Cu Kα radiation (1.5406 A^0) .The crystallite size of prepared pure CdO and transition metal doped CdO nanostructured was estimated using the full width at half maximum (FWHM) of the peaks by means of the Scherrer formula,

$$d = \frac{k\lambda}{\beta \cos\theta}$$

Where,

d is the average crystallite grain size

β is the full width half maximum(FWHM) in radian

θ is the Bragg angle

λ is the wavelength of X-rays which is 0.15406 nm for Cu target Kα radiation

k is shape factor[6]

Figure 1 illustrates a typical XRD spectrum of pure CdO and Ni and Co doped (0.2, 0.4 and 0.6 %) nanoparticles calcinated at 650^0 C. The synthesized material of single phase CdO nanoparticles shows rock salt like cubic crystal structure with unit cell parameters, a= b=c= 4.6990 Å and α=β=γ= 90°. The diffraction peaks occurred at the 2 θ angles at 32.99, 38.28, 55.25, 65.87 and 69.20 and its corresponding reflection peaks of (hkl) were seen at (111), (200), (220) ,(311) and (222) which are consistent with the reference pattern of CdO nanoparticles of JCPDS File No. 1011003. The crystalline nature of the nanoparticle was confirmed because there was a sharpness in the XRD peaks at (111) crystallographic plane of CdO nanoparticles. The crystallinity of the doped nanoparticles decreases with increase in the doping percentage which is tabulated in table No.1

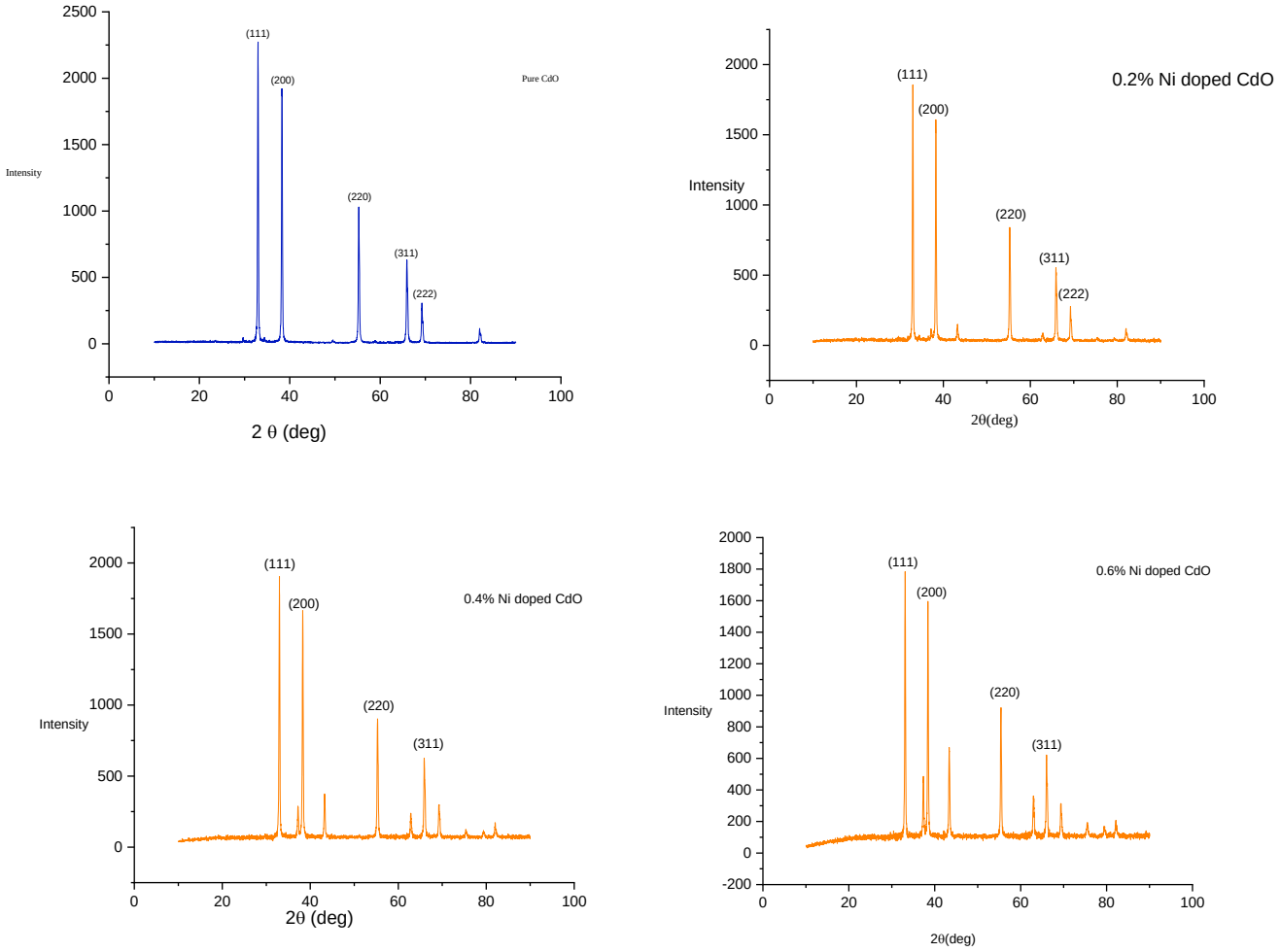


Figure 1 XRD Spectra of undoped and Ni-Doped Nanosystems

Table 1 Sizes of particles in CdO and Ni-doped CdO

Samples	Particle Size (nm)	Lattice Parameter (Å)
CdO Nanoparticles	37.70	4.6990
CdO: Ni (0.2%)	41	4.1786
CdO: Ni (0.4%)	36.10	4.1771
CdO: Ni (0.6%)	30.38	4.6944

3.2.Fourier transmission infrared spectroscopy (FTIR) spectroscopy

Figure 2 demonstrates the pure and 0.6% Ni doped CdO nanoparticles spectrum recorded in the range of 500 to 4000 cm^{-1}. It was observed that due to moisture from the atmosphere the O-H stretching vibrations occurred at 3741.90 cm^{-1}. The Cd-O stretching was confirmed by the absorption peak at 2407.16 cm^{-1} and 23.55.08 cm^{-1} were assigned to asymmetric and symmetric CH_2 stretching respectively. FTIR also confirms the presence of O-H and Cd-O vibrations[7].

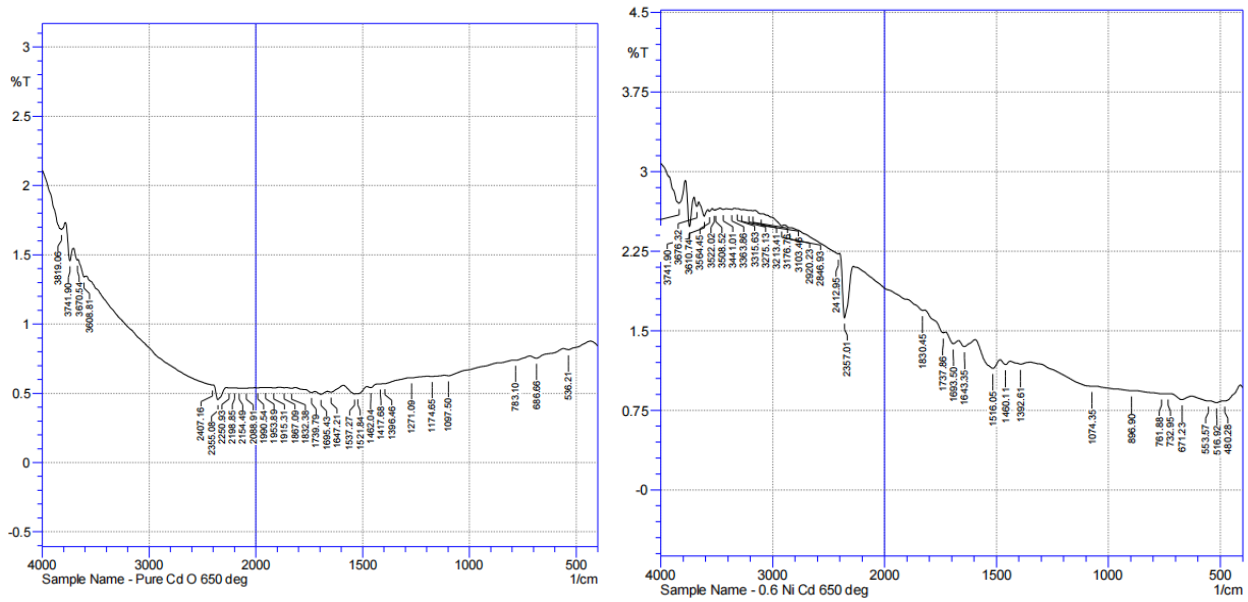


Figure 2 FTIR Spectrum

3.3.UV- visible spectroscopy

Figure 3 shows the absorption spectra of CdO and 0.6% Ni doped CdO nanoparticles, which confirms that CdO nanoparticles absorbs in the length of 200-500nm, which indicates that CdO samples absorbs the light in the visible range. The aborption spectrum at around 279nm which is due to the interband electronic transition indicates that the CdO nanoparticles were prepared successfully. As the transmittance improves the CdO nanoparticles can be used in opto-electrics. The band gap of CdO nanoparticles is 2.7eV[8].

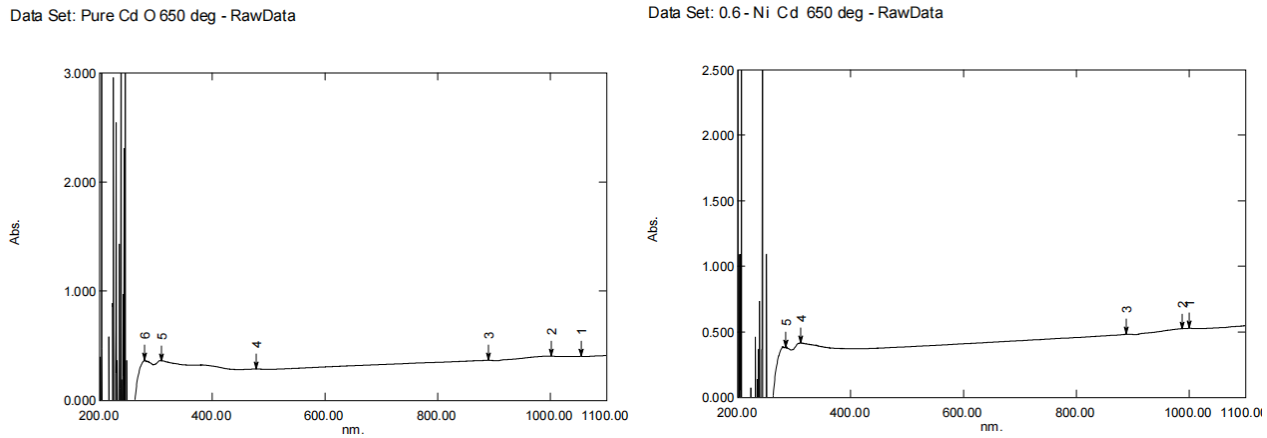
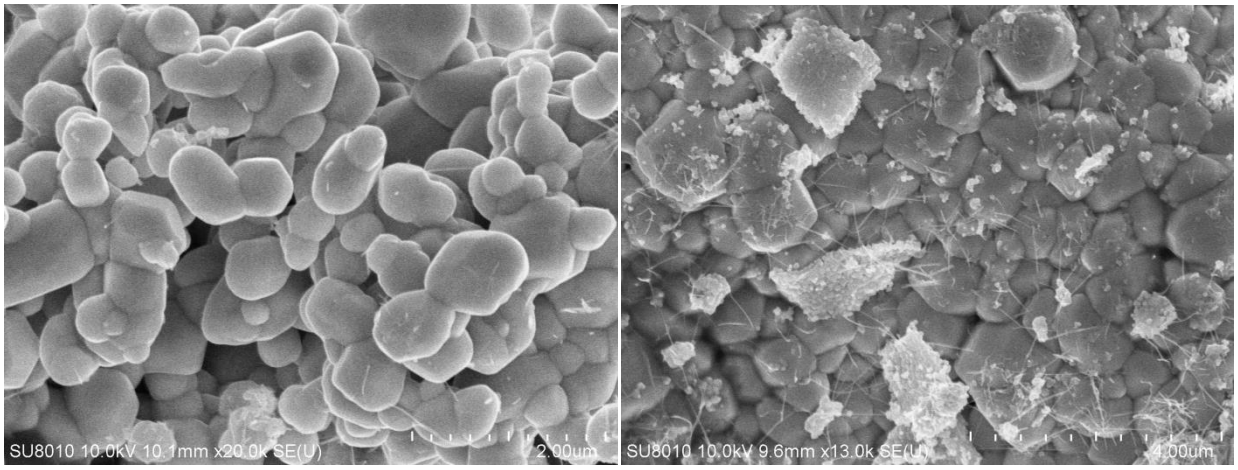


Figure 3 UV visible Spectrum

3.4 SEM with EDS Ananlysis

The surface morphology of the samples was studied using Scanning Electron Microscopy. The morphology of undoped CdO samples along with 0.6% Ni doped CdO is shown in Figure 4 which gives an idea that there is an agglomeration of grains with spherical structure while 0.6% Ni doped CdO nanoparticles due to slight agglomeration of nanoparticles corn like nanorods morphology[9].



FESEM image of Pure CdO nanoparticles **FESEM image of 0.6% Ni doped CdO nanoparticles**

The EDS of Undoped CdO nanoparticles shows the presence of Cd and O element whereas 0.6% Ni doped EDS shows the presence of Ni and no other impurities.

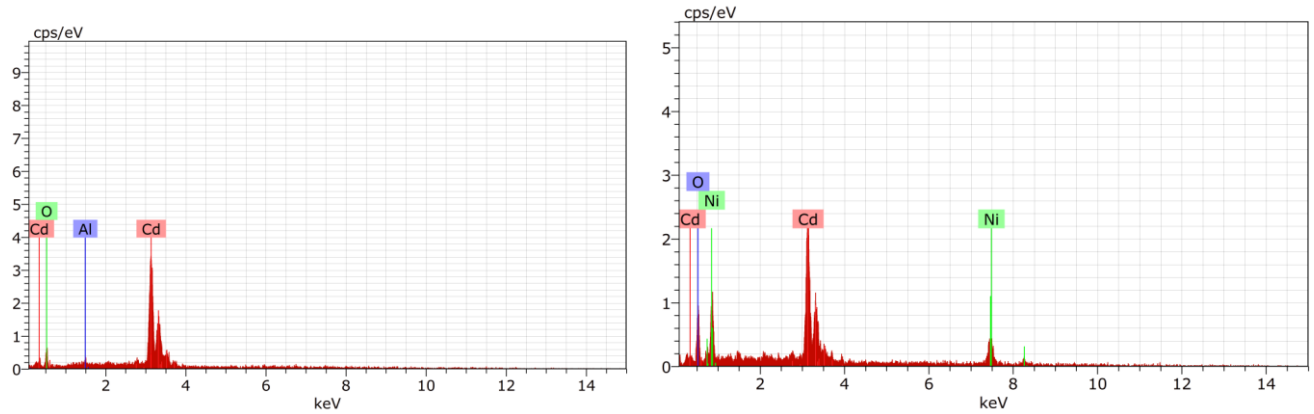


Figure EDS spectrum of Pure and 0.6% Ni doped CdO nanoparticles

4. Antimicrobial Application

Nanoparticles due to their potential applications in various fields, including medicine and antimicrobial chemotherapy are extensively studied. Some of the bacteria have the ability to survive and adapt themselves to the surface of materials. And due to this ability of microorganisms, they can be used in the production of consumer products like curd, bread, and alcohol, but many are responsible for spoiling the food materials and are harmful for cellular life as they can transmit the disease.

4.1.Antibacterial Activity

Nanocrystalline undoped CdO and doped $Ni_xCd_{1-x}O$, (where x= 0.2%, 0.4 % and 0.6%) synthesized by sol gel method calcinated at 650^0C were subjected to antibacterial analysis by using Agar well disc diffusion method against different gram positive and gram negative bacterial strains. In the disc

diffusion test sterile disc (Himedia – SD067 different samples were impregnated at 20µl/ml for 24 hours at 37^0C.

Test organisms used:

1. *E. coli* (MTCC 118)
2. *K. pneumoniae* (MTCC 109)
3. *S. aureus* (MTCC 1430)
4. *E. faecalis* (MTCC 2729)

Sensitivity Results

S.N.	Samples	Zone of Inhibition (mm)			
		E. coli **(MTCC 118)**	***K. pneumoniae*** **(MTCC 109)**	***S. aureus*** **(MTCC 1430)**	***E. faecalis*** **(MTCC 2729)**
1	**Sample A**	14	14	15	14
2	**Sample B**	13	13	15	13
3	**Sample C**	13	15	16	14
4	**Sample D**	13	14	16	15

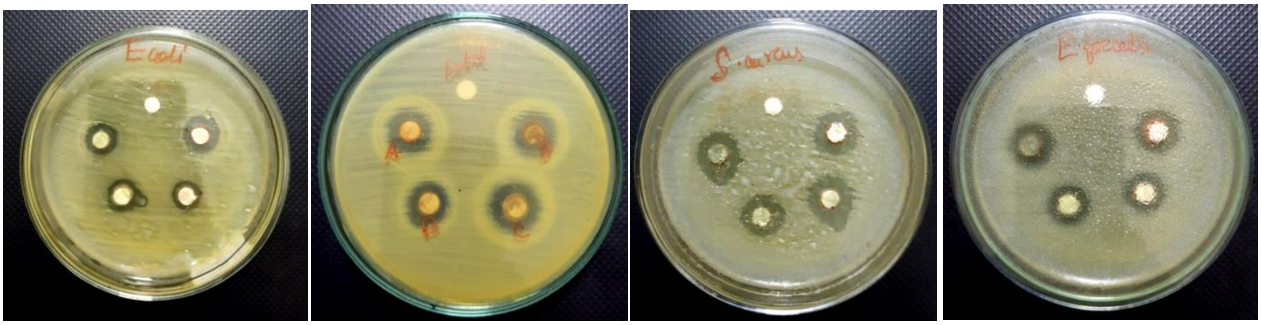


Figure 4 Zone Of inhibition for E.coli , *K. pneumonia, S. aureus, E. faecalis*

4.2.Antifungal Activity

Antifungal antibiotic control with DMSO was used during analysis. The compound was dissolved in DMSO

Test organisms (fungus) used:

1. *Candida albicans*
2. *Trichophyton rubrum*

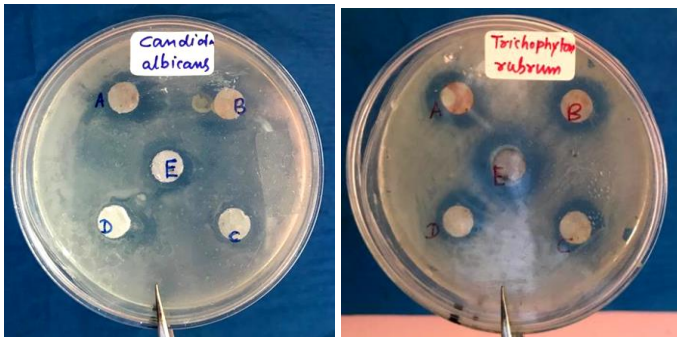


Figure 4.2 Zone of inhibition for Candida albicans and Trichophyton rubrum

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