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Synthesis and characterization of Cadmium Oxide nanoparticles for antimicrobial activity

ABSTRACT

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Cadmium Oxide (CdO) nanoparticles were prepared by precipitation method using Cadmium acetate and ammonia solution. Presence of chemical species, were verified by Fourier Transform Infra Red (FTIR) Spectrum. From X-Ray Diffraction (XRD) spectrum the particle size, d-spacing value and structure of the nanoparticle were analysed. Size of the nanoparticles and the elemental composition were detected by using Scanning Electron Microscope (SEM) with Energy Dispersive X-Ray Analysis (EDAX). The optical band gap of CdO nanoparticles has been determined by using UltraViolet-Visible (UV-Vis) absorption spectroscopy. The antimicrobial activities of different concentration of the CdO nanoparticles were tested by treating *E.coli* cultures with CdO nanoparticles. Cadmium Oxide nanoparticles show effective antimicrobial activity. Different organisms were used to observe the zone of inhibition of CdO nanoparticles.

Keywords: Nanoparticle; Cadmium Oxide; Antimicrobial activity; *Escherichia coli*; Scanning Electron Microscope (SEM).

INTRODUCTION

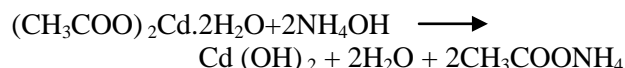
Nanotechnology is providing the means to create such “Nano Particles”, which are essentially shrunken down versions of modern day particles and are made of various metals. Currently, nanoparticles are in the research and development phase; however, Progress is showing a bright future for the particles especially for computing devices and sensor applications. Cadmium Oxide (CdO) is a II-VI n-type semiconductor has interesting properties like large band gap, low electrical resistivity and high transmission in the visible region. The brown CdO is, generally formed by burning of Cd in air. The CdO is insoluble in water and absorbs CO₂ from air and can be reduced to the conducting oxides. CdO has 2.5 eV direct band gap and 1.98 eV indirect band gap [1].

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CdO has not only the unique optical and optoelectrical characteristics but also has the selective catalytic properties that can be used to photo degrade some of the organic compounds, dyes, pigments and many of environmental pollutants [2-4]. CdO is used in cadmium plating baths, electrodes for storage batteries, cadmium salts, catalyst ceramic glazes, phosphors and nematode. Major uses for cadmium oxide are as an ingredient for electroplating baths and pigments [5-7]. Metal nanoparticles, which have a high specific surface area and a high fraction of surface atoms have been studied extensively due to their unique physicochemical characteristics such as catalytic activity, optical properties, electronic properties, antimicrobial activity and magnetic properties. The effect of nanoparticles on bacteria is very important since they constitute the lowest level and hence enter the food chain of the ecosystems [8, 9]. Recent studies have demonstrated that specifically formulated nanoparticles demonstrate good antibacterial activity and constitute the antimicrobial formulations [10-12]. Nano CdO has been reported for antibacterial properties. Cadmium oxide is non-toxic and chemically stable under exposure to both temperatures and capable of photo catalytic oxidation [13, 14]. In the present paper, synthesis and characterization of cadmium oxide nanoparticles and its antimicrobial activity has been studied.

EXPERIMENTAL

0.5M of cadmium acetate was dissolved in 100ml distilled water. The ammonia solution was added to above solution dropwise until pH value of about 8 was reached with constant stirring. The white precipitate was formed and it was allowed to settle for overnight. Then filtered and washed 3-4 times with distilled water. It was dried at 100°C for 6 hours and then grinded using mortar and pestle. The resulting powder was calcined at 400°C for 2 hours.



During calcinations as prepared powder loses H₂O which is as follows:



Effect of CdO on the growth of micro organism

The nutrient broth was loaded with 0.01%, 0.5%, and 1% of CdO in three different flasks respectively. The three flasks were inoculated with 2ml E.Coli culture and it was kept for overnight incubation along with 0.12% glucose. The nutrient broth without culture was kept in an uninoculated control.

Testing the antimicrobial activity of CdO

The test organism was swabbed in Muller Hinton Agar and it was loaded with CdO in a well. It was kept for incubation for zone of inhibition.

RESULTS AND DISCUSSION

Fourier Transform Infra Red (FTIR) Study

The [Figure 1](#) shows the Fourier Transform Infra Red (FTIR) Spectrum gives a broad band at 3400-3560 cm⁻¹, corresponds to the vibration mode of OH group indicating the presence of small amount of water adsorbed on the surface. The bands at 1022.27, 1047.35, 2852.72 cm⁻¹ and 2922.16 cm⁻¹ are the stretching mode of C-H group. The peak at 1660.71 and 675.09 cm⁻¹ belongs to the Cd-O. The band at 1124.50 cm⁻¹ belongs to the -OCH₃. The band at 650.01 cm⁻¹ is correlated to Cd-O.

X-Ray Diffraction (XRD) Study

X-Ray Diffraction (XRD) pattern of CdO nanoparticles calcined at 400°C is shown in [Figure 2](#). It confirms a face centered cubic (fcc) structure. Diffraction peaks observed are well in correlation with standard JCPDS data (75-0594) and lattice parameters were calculated using the (h k l) values. It is clear from the [Figure 2](#), that all peaks corresponds to fcc structure of CdO and no any other impurity peaks are found. The average crystalline size of CdO nanoparticles is found to be 39.73 nm.

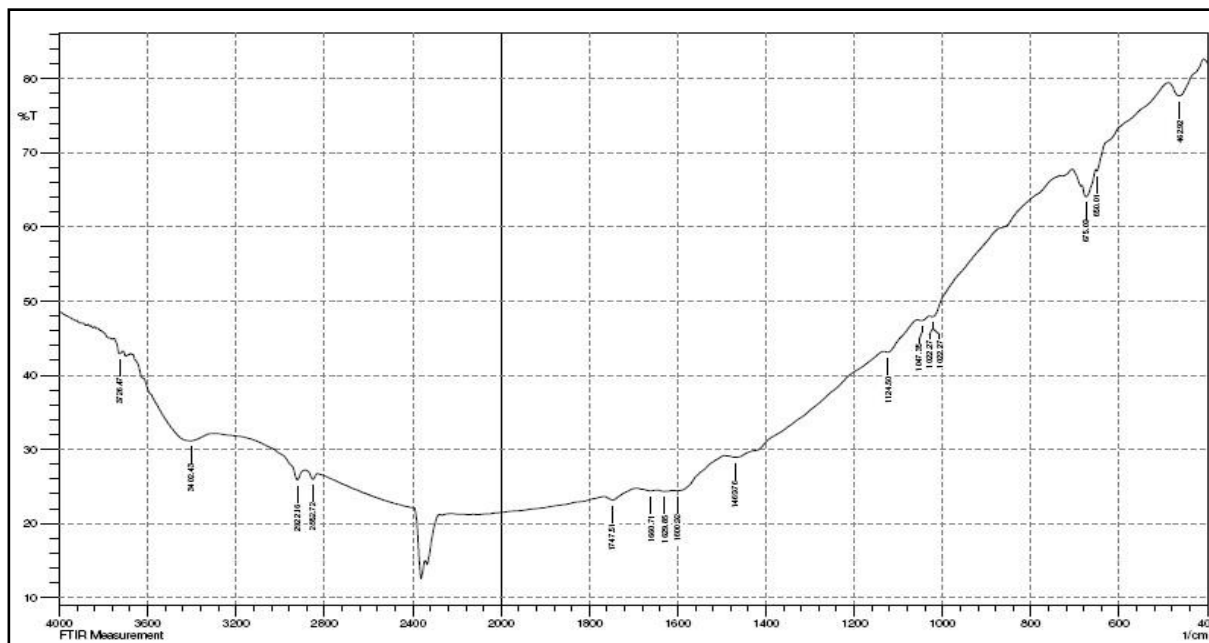


Fig. 1. FTIR Spectrum of CdO nanoparticle prepared in 0.5 M

Table 1. XRD data of CdO nanoparticle at 0.5 M

d-spacing (Å) Observed	JCPDS Value	Intensity (cps)	JCPDS Card no	FWHM β(deg)	h k l	System	Grain size (nm)
2.70712	2.7088	100.00	65-2908	0.21	1 1 1	Cubic	41.2358
2.34451	2.3480	79.32	75-0594	0.23	2 0 0	Cubic	38.215
1.65894	1.6598	42.54	75-0592	0.26	2 2 0	Cubic	36.0512
1.41490	1.4158	24.87	75-0594	0.24	3 1 1	Cubic	41.236
1.35521	1.3552	10.69	75-0591	0.22	2 1 1	Cubic	45.8643
1.21621	1.2180	0.72	39-1221	0.3	3 3 1	Cubic	35.7592

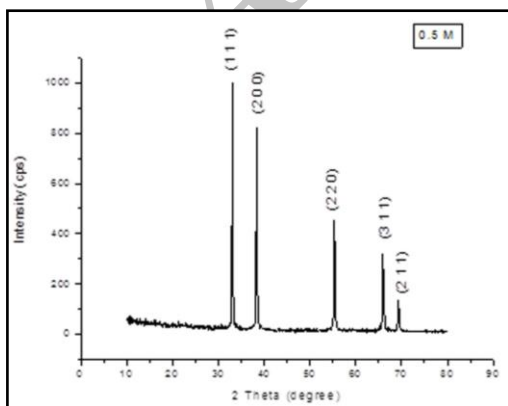


Fig. 2. Shows the XRD Spectra of CdO nanoparticles prepared at 0.5 M of Cadmium acetate at 400°C

Scanning Electron Microscope (SEM) Study

The Scanning Electron Microscope (SEM) micrographs of the sample are shown in Figure 3 calcinations at 400°C. The shape of grain particle is spherical. The presence of elements in the sample was identified with the help of Energy Dispersive X-ray Analysis (EDAX) spectrum given in Figure 4.

Table 2 indicates the amount of Cadmium and Oxide present in the CdO Nanoparticle is 84.02% & 15.98% and no characteristic peaks of impurities or other precursor compounds are observed.

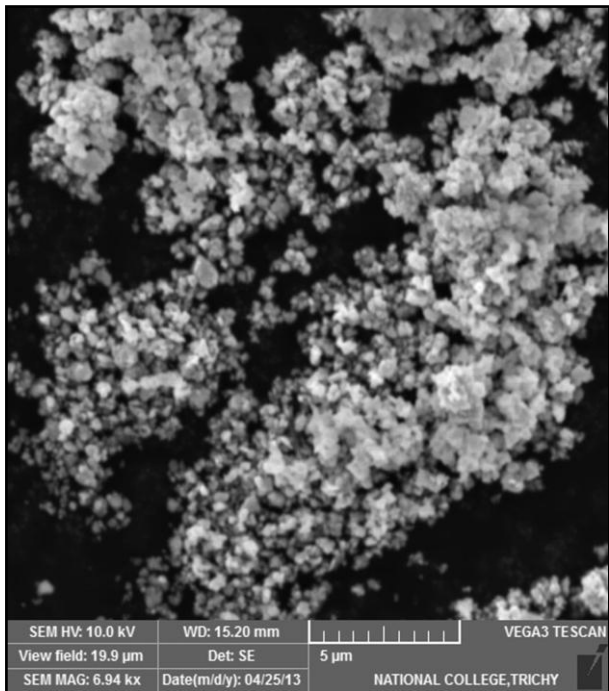


Fig. 3. shows the SEM image of CdO Nanoparticles prepared in 0.5M

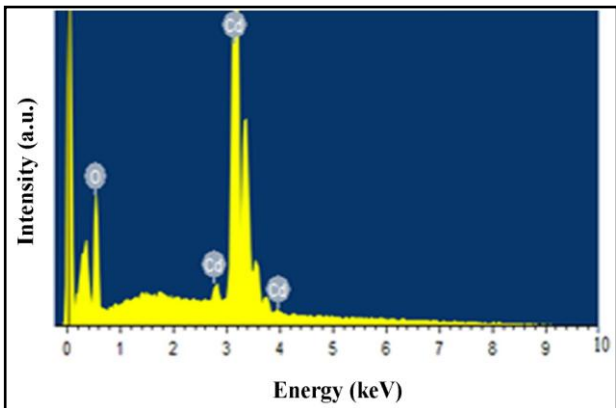


Fig. 4. shows the EDAX Pattern of CdO Nanoparticles prepared in 0.5M

Table 2. Chemical composition of CdO nanoparticles

Element	Weight %	Atomic %
O	15.98	57.20
Cd	84.02	42.80
Totals	100.00	100.00

UltraViolet-Visible (UV-Vis) Study

The energy band gap is measured with the help of absorption spectra and a graph of $(\alpha h\nu)^2$ versus energy is plotted (Figure 5). The energy band gap of Cadmium Oxide nanoparticle is 2.15 eV. Using Figure 6 the optical absorption peak is calculated as 73.33%.

Antimicrobial Activity

- **Effect of nano CdO on the growth of *E.coli* in liquid medium**

The effect of different concentrations of nanoparticles in liquid culture of *E.coli* was investigated in the first study. The optical density of the medium was investigated after the bacteria’s contact with the nanoparticles. Figure 7 and 8(a-e) show the effect of different concentrations of nano CdO in the growth of *E. coli*.

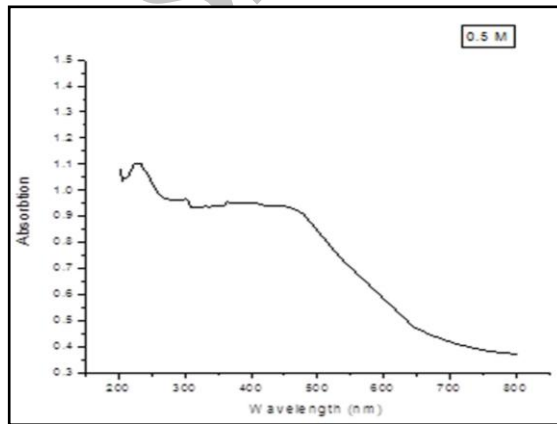


Fig. 5. Shows the Wavelength vs Absorption for 0.5 M of CdO nanoparticle

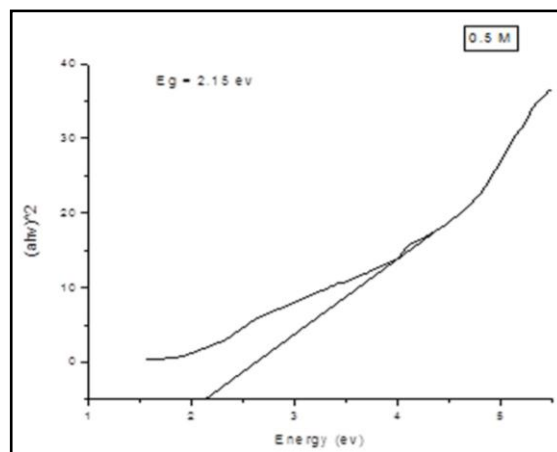


Fig. 6. Shows the Energy vs $(\alpha h\nu)^2$ for the 0.5 M of CdO nanoparticle

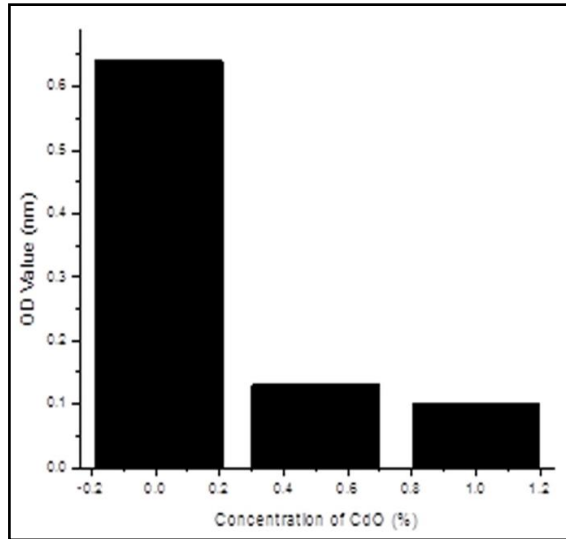


Fig. 7. Shows the comparison of Concentration of CdO and OD Value

Table 3. Comparison of CdO concentration and OD value

Sample (CdO concentration)	OD Value
0.01 %	0.64
0.5 %	0.13
1 %	0.10
Control	-

From the studies made with CdO at different concentrations, it was observed that with the increase in concentration of CdO, the Optical Density (OD) value decreases. From this it can be clearly inferred that with the increase in concentration of CdO the microbial growth gets inhibited (Table 3).

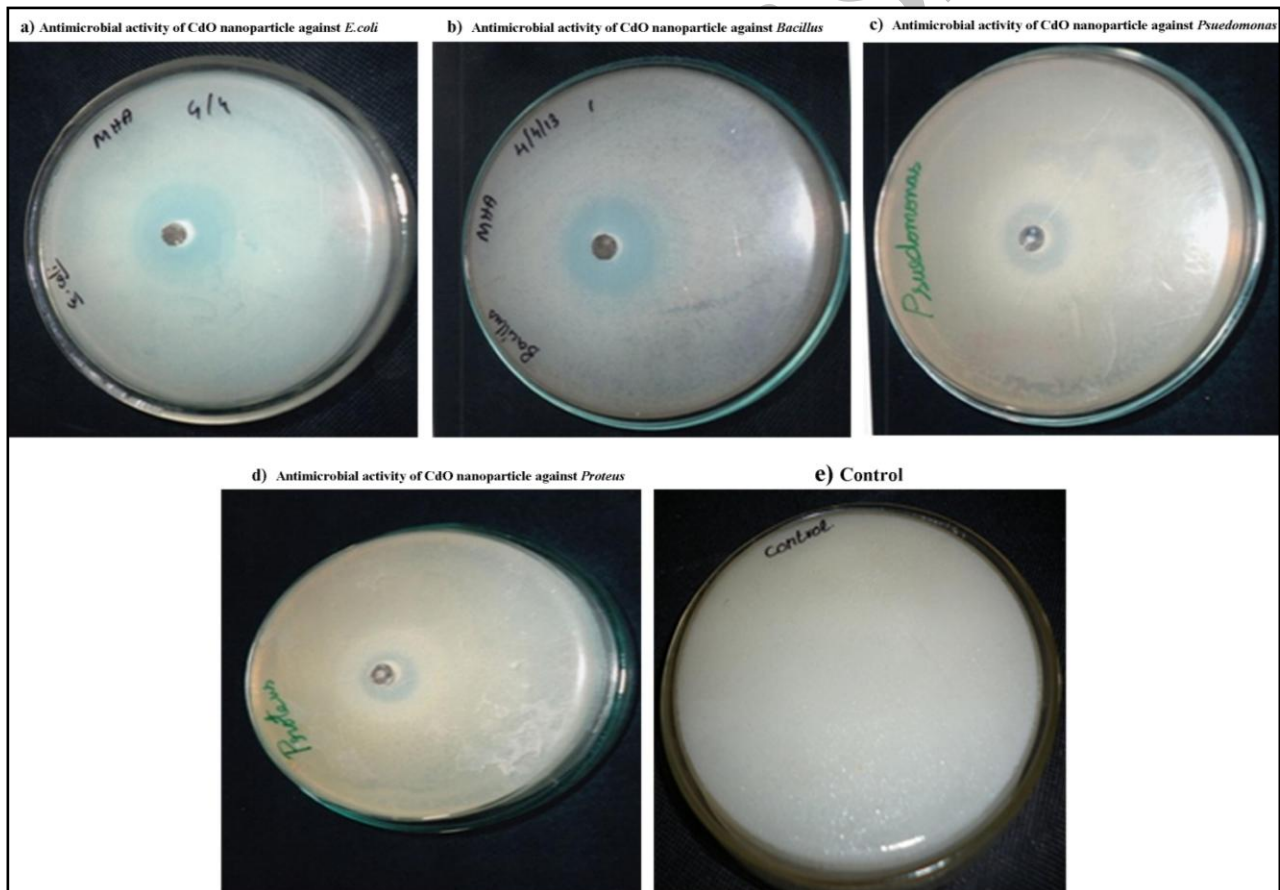


Fig. 8. Growth inhibition of a) *E. coli*, b) *Bacillus*, c) *Pseudomonas*, d) *Proteus* and e) Control for the CdO Nanoparticles.

The zone of inhibition was observed and the results were tabulated (Table 4).

Table 4. Comparison of organism and zone of inhibition

Organism	Zone of inhibition
<i>E.coli</i>	Positive
<i>Bacillus</i>	Positive
<i>Psuedomonus</i>	Positive
<i>Proteus</i>	Positive
Control	-

CONCLUSIONS

Cadmium Oxide (CdO) nanoparticles were prepared by using precipitation method. The developed nanoparticles were characterized by FTIR, XRD, SEM with EDAX and UV-Vis measurements which showed good antimicrobial activity by inhibiting their growth.

REFERENCES

- [1] Lide D.R., (1996), *CRC Handbook of Chemistry and Physics*, (77th edition, CRC Press, Boca Raton), 12/97 and 3/278.
- [2] Karunakaran C., Dhanalakshmi R., (2009), Semiconductor-catalyzed degradation of semiconductors. *Cent. Eur. J. Chem.* 7: 134-137.
- [3] Karunakaran C., Dhanalakshmi R., Gomathisankar P., Manikandan G., (2010), Enhanced phenol-photodegradation by particulate semiconductor mixtures: Interparticle electron-jump. *J. Hazard. Mater.* 176: 799-806.
- [4] Nezamzadeh-Ejhih A., Banan Z., (2011), A comparison between the efficiency of CdS: A and CdO/zeolite A as catalysts in photodecolorization of crystal violet. *Desalination.* 279: 146-151.
- [5] Karunakaran C., Dhanalakshmi R., (2009), Selectivity in photo catalysis by particulate Semiconductors. *Cent. Europ. J. Chem.* 7:134-138.
- [6] Lewis R.J., (1997), *Sr. Hawley's condensed chemical dictionary*, 13th edition, 189.
- [7] Clifford A., Hampel and Gessner G.H., (1973), *The encyclopedia of chemistry*. 3rd edition 169.
- [8] Fortner J.D., Lyon D.Y., Sayes C.M., Boyd A.M., Falkner J.C., Hotze E.M., (2005), C-60 in Water: Nanocrystal formation and microbial response. *Environ. Sci. Technol.* 39: 4307- 4316.
- [9] Herrera M., Carrion P., Baca P., Liebana J., Castillo A., (2001), In vitro antibacterial activity of glass-Ionomer cements. *Microbios.* 104: 141-148.
- [10] Matsumura Y., Yoshikata K., Kunisaki S., Tsuchido T., (2003), Mode of bactericidal action of silver Zeolite and its comparison with that of silver nitrate. *Appl. Environ. Microbiol.* 69: 4278- 4281.
- [11] Sondi I., Salopek-Sondi B., (2004), Silver nanoparticles as antimicrobial agent: a case study on *E.coli* as a model for Gram-negative bacteria. *J. Coll.Interf. Sci.* 275:177- 182.
- [12] Lee H.J., Yeo S.Y., Jeong S.H., (2003), Antibacterial effect of nanosized silver colloidal solution on Textile fabrics. *J. Mater. Sci.* 38: 2199-2204.
- [13] Wang R.H., Xin J.H., Tao X.M., Daoud W.A., (2004), ZnO nanorods grown on cotton fabrics at low temperature. *Chem. Phys. Lett.* 398: 250-255.
- [14] Fu G., Vary P.S., Lin C., (2005), Anatase CdO nanocomposites for antimicrobial coatings. *J. Phys. Chem. B.* 109: 8889- 8898.

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