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Synthesis and Characterization of Pure and Nickel Doped Zinc Oxide Nanoparticles by Chemical Precipitation Method

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Abstract

The method used for synthesizing Zinc oxide nanoparticles is chemical precipitation method. The crystalline nature of the prepared sample is found by X-ray Diffraction (XRD). The Presence of chemical elements Zn, O, Ni is investigated by Energy Dispersive X-ray Spectroscopy (EDAX). The formation of flower and cluster shaped structure were identified by Scanning Electron Microscopy (SEM). The functional groups present in the nanoparticles were observed by Fourier Transform Infrared spectroscopy (FTIR). The band gap energy was calculated by Ultraviolet studies (UV) in the range as 3.53 and 3.66 eV. The magnetic nature present in Nickel doped zinc oxide nanoparticles were mainly used for Spintronics applications.

Keywords: ZnO, Ni, XRD

1. Introduction

The chemical compound ZnO, because of its unique physical and chemical properties is incorporated in many fields.

ZnO is an n-type semiconductor. Those properties are used in emerging applications for transparent electrodes in heat protecting windows, thin film transistors[1], gas Sensors[2], light emitting diodes and Piezo electric application[3]. These metal Oxides nanoparticles were extensively investigated due to their extended applications in the Spintronics, photo electronic, sensor, lasing devices. All these predominant properties make ZnO a great potential in the field of nanotechnology.

Experiment Details

Materials used for synthesis of ZnO by chemical precipitation method are Zinc nitrate ($Zn(NO_3)_2$), Starch ($(C_6H_{10}O_5)_n$) and Sodium hydroxide (NaOH). Deionised water was used through all the steps. Zinc nitrate and Starch was used as a solvent. The above solvent is mixed with 100ml deionised water and allowed to stirrer for half an hour till it reaches 60°C. Then the Sodium hydroxide solution was slowly added drop by drop to above preparation. Then it is vigorously mixed for 2 hrs and kept for ageing for 24 hrs at room temperature. It was then washed repeatedly using deionised water. The precipitate obtained after ageing was dried at 100°C in a hot air oven. This precipitate is grinded into powder using motor and pestle. Thus, finely white colour ZnO powder was obtained. In second step Nickel nitrate and starch are taken as a solvent. It is dissolved in 100 ml deionised water. Now it is added to prepared concentration. The solution was vigorously stirred for 2 hrs and kept for ageing for 24 hrs at room temperature. It was then washed repeatedly using deionised water. The precipitate obtained after ageing was dried at 100°C in a hot air oven. This precipitate is grinded into powder using motor and

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pestle. Thus finely green colour Ni doped ZnO powder was obtained.

3. Results and Discussion

3.1 XRD Analysis

The prepared Zinc and Nickel doped Zinc oxide samples exposed at 100°C. The Crystalline structure was then analyzed. The XRD peaks of the prepared particles were recorded in 2θ range of 10°-90° using CuKα radiation (1.5406 Å). The samples present wide optical phenomenon, which can be related to Wurtzite structure of Zinc oxide. Using Scherer's formula the average crystalline sizes, Micro Strain and Dislocation density of processed nanocrystal was found.

The peaks which indicate sharp and intense are highly crystalline. The average crystalline sizes of the Zinc oxide and Nickel doped Zinc oxide nanoparticles were found as 25.4253 nm and 20.9713 nm. As compared to Pure ZnO the average crystalline size was slightly decreased for doped ZnO. It is concluded that the Wurtzite structure of ZnO is not altered by the Ni addition and also Ni^{2+} involves the Zn^{2+} site into the crystal lattice. The crystallinity peaks were shown in Figure 1a, b.

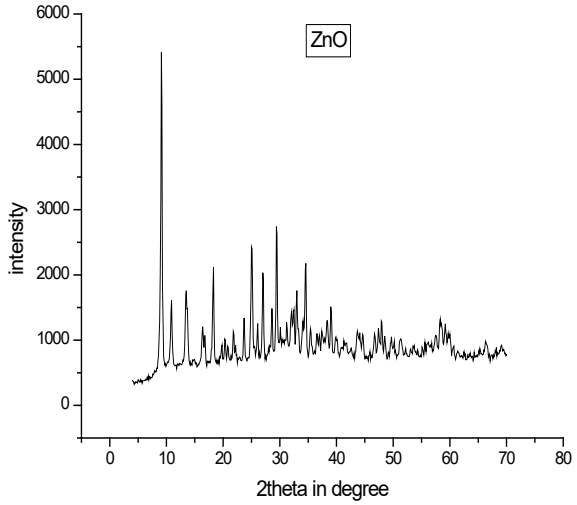

Figure 1a. XRD analysis of ZnO nanoparticle.

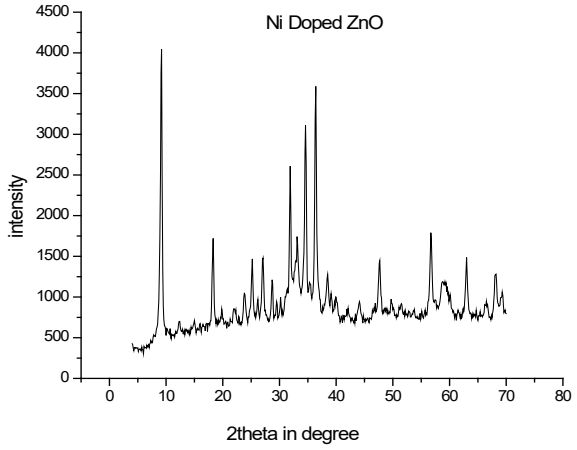

Figure 1b. XRD analysis of Ni-ZnO nanoparticle.

3.2 FTIR Analysis

FTIR study is used to determine the functional groups of the manufactured compound. The characteristic vibrational frequencies are assigned and compared with ZnO and Ni doped ZnO. The Fourier transform infrared spectrum of prepared nano powders were recorded in 400-4000 cm^{-1}. The wavelength 517.41 cm^{-1} correlates to ZnO nanoparticle. The fundamental mode of vibration, 3577.50 cm^{-1} correlates to the O-H stretching vibration, 2926.04 cm^{-1} correlates to the C-H stretching vibration and 1374.29 cm^{-1} correlates to the C-O symmetric

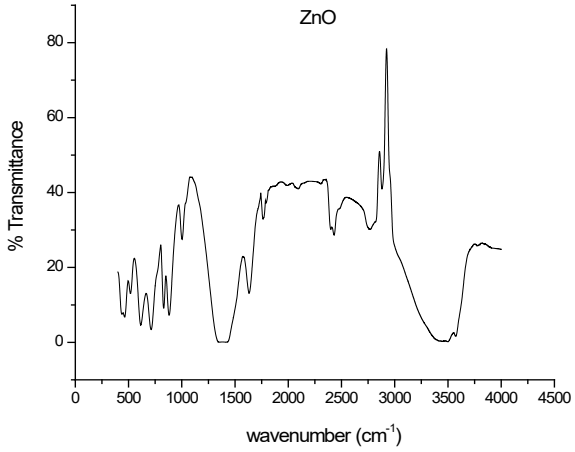

Figure 2a. FTIR analysis of pure ZnO nanoparticle.

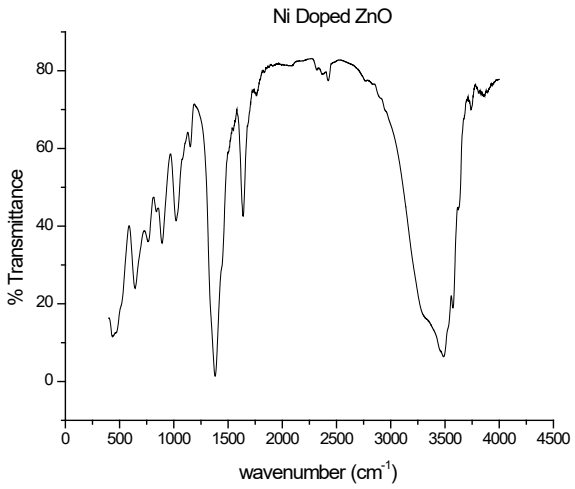

Figure 2b. FTIR analysis of Ni-ZnO nanoparticle.

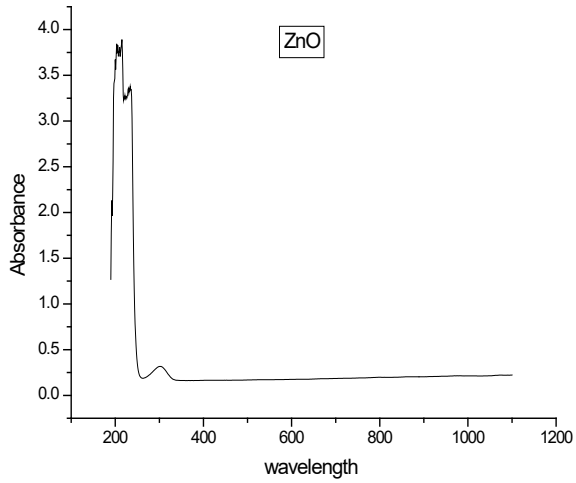

Figure 3a. UV analysis of pure ZnO nanoparticle.

stretching vibration. The bands occurring near 700-860 cm^{-1} are attributed to the vibration of Zn-O-Ni bonds. The addition of Ni in the ZnO leads to small shifts of some peaks of ZnO. Fourier Transform Infrared Spectrograph confirms the presence of functional groups and also the interaction between ZnO and Ni doped ZnO nanoparticles. The Presence of Functional groups are shown in Figure 2a, 2b.

3.3 UV Optical Spectroscopy Analysis

The optical absorption spectra have been observed by using UV-visible and results are as shown in the Figure. The characteristic absorption peak due to ZnO appears in wavelength range 190-1100 nm. The band gap energy of the ZnO nanoparticles sample was calculated by using formula as, $E = h \times c/\lambda$. The conversion factors for 1 eV are equal to (1.6×10^{-19} joule). The band gap energy of the fabricated nanoparticles was calculated as 3.53 and 3.66 eV. This shows that value of ZnO increase on doping. The Absorption peaks of ZnO and Ni-ZnO were represented in Figure 3a, 3b.

3.4 SEM Analysis

The texture of samples was inspected using Scanning Electron Microscope (SEM). The image of ZnO shows

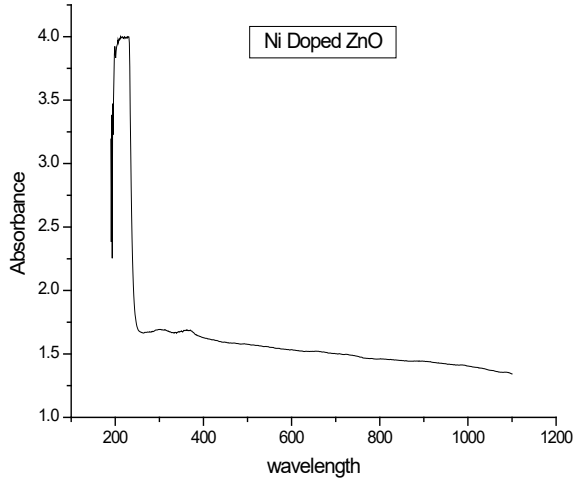

Figure 3b. UV analysis of Ni- ZnO nanoparticle.

flower in shape. The Ni-ZnO nanoparticles form clusters like spherical shaped morphology due to Vander Walls force of attraction between them. The structure of the particle has been changed with addition of Ni in doped nanoparticle as compared to pure ZnO nanoparticle. Morphology of both the samples are given in Figure 4a, b and 4c, d.

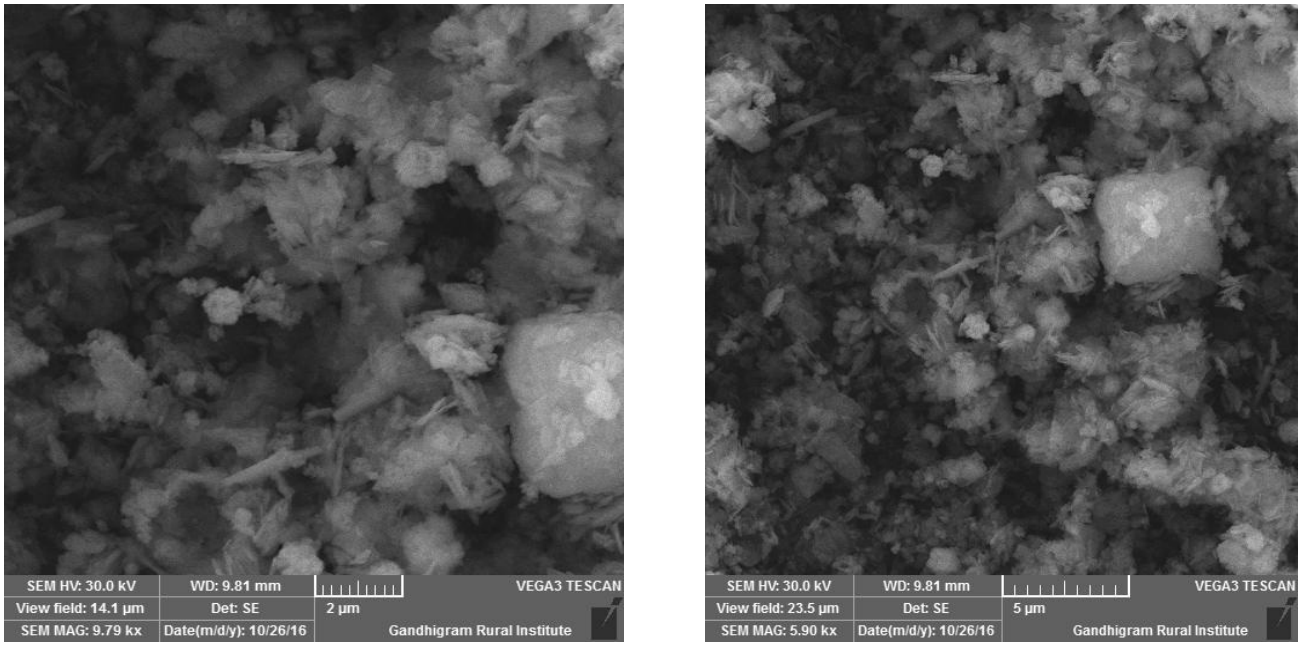

Figure 4a, b. SEM image of pure ZnO.

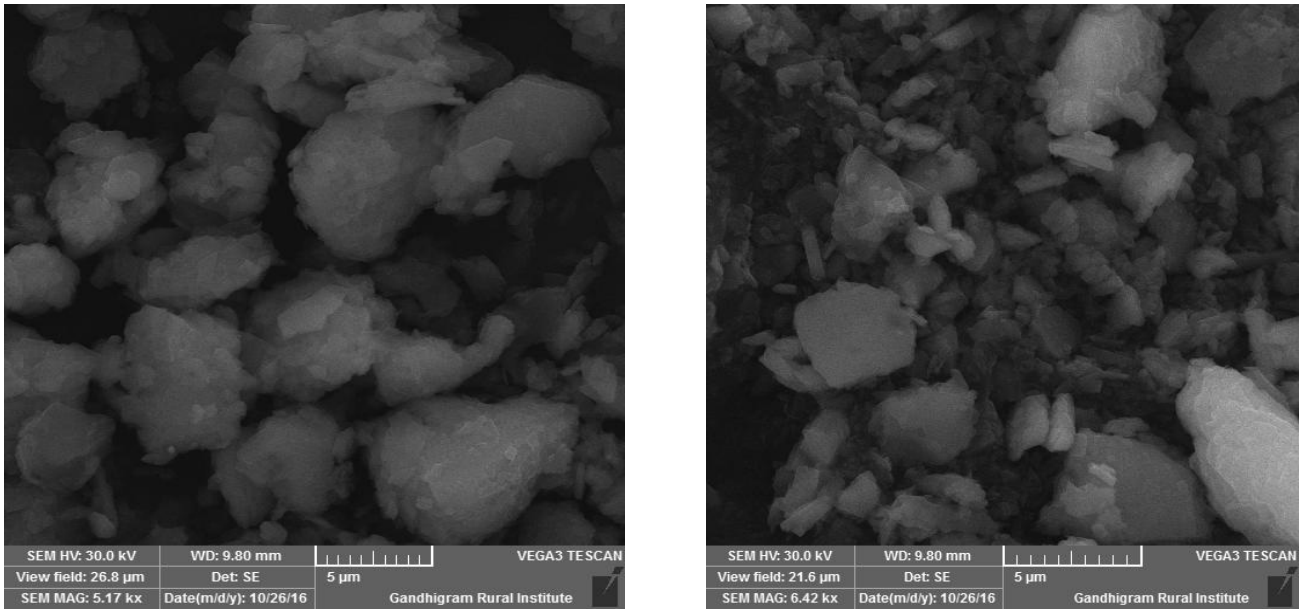

Figure 4c, d. SEM image of Ni- ZnO.

3.5 EDAX Analysis

The chemical elements present in ZnO and Ni-ZnO nanoparticles can be identified using EDAX analysis. The characteristic peaks of chemical elements are represented in Figure 5 (a and b). The presence of Zn and O in Figure 5(a) confirms the presence of pure ZnO nanoparticles. The presence of Ni, Zn, and O is confirmed by its peaks in Figure 5(b) for the Ni-ZnO nanoparticles.

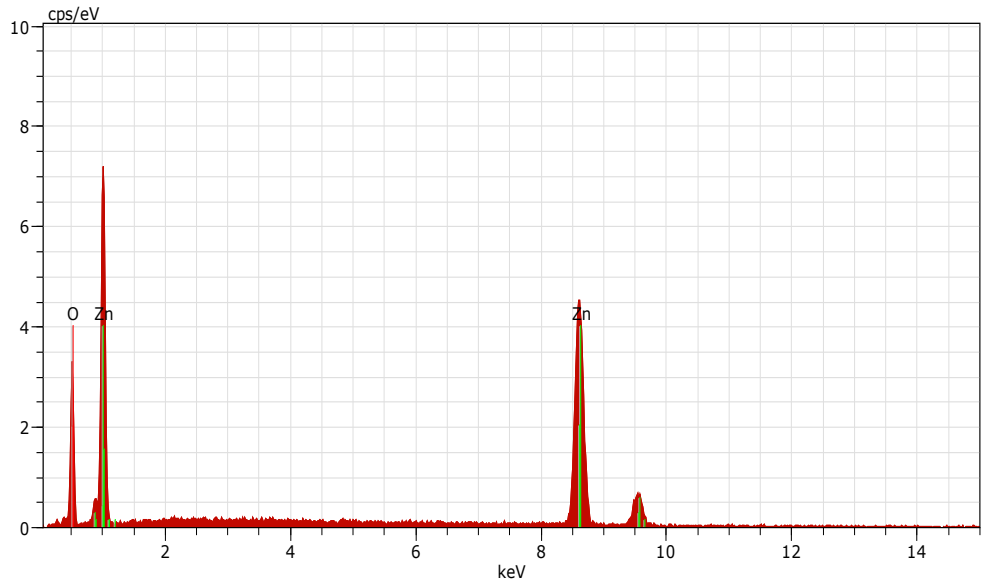

Figure 5a. EDAX analysis of pure ZnO.

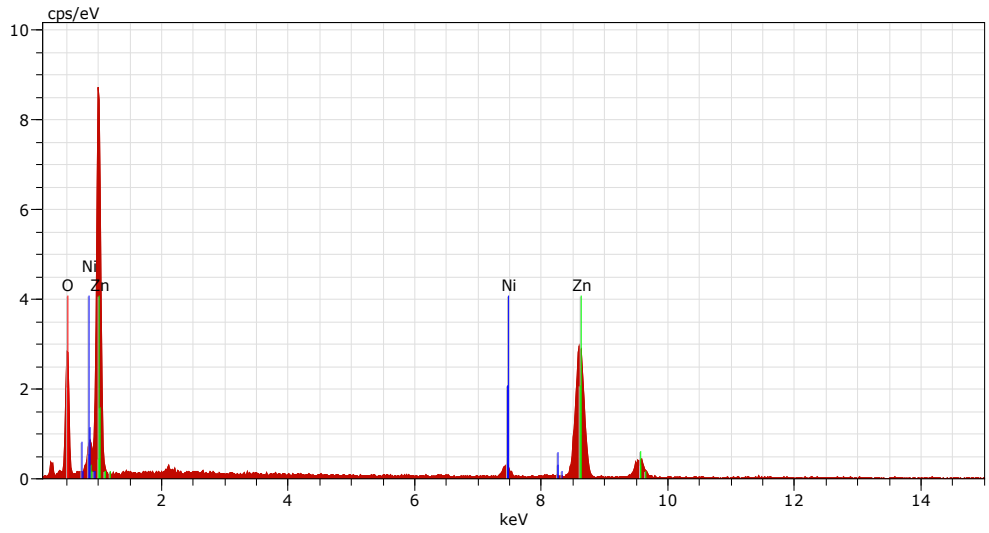

Figure 5b. EDAX analysis of Ni- ZnO.

3.6 ANTI–bacterial Activity

The antibacterial activities of the synthesized materials ZnO, Ni–ZnO were investigated in- vitro against Staphylococcus aureus (Gram +Ve) and Escheria coli (Gram -Ve) strains using Agar well diffusion method. Antibacterial activities of the synthesized samples are studied by measuring the Zone of inhibition of the respective samples. For antibacterial study the Zinc oxide and prepared nanopowder was made into solution in Petri dish. The powder was dissolved in 5 ml of hydrochloric acid. The Zone of inhibition observed for synthesized materials ZnO, Ni–ZnO was tabulated. The image 6 (a and b) shows the antibacterial studies of synthesized materials against Staphylococcus aureus and Escheria coli.

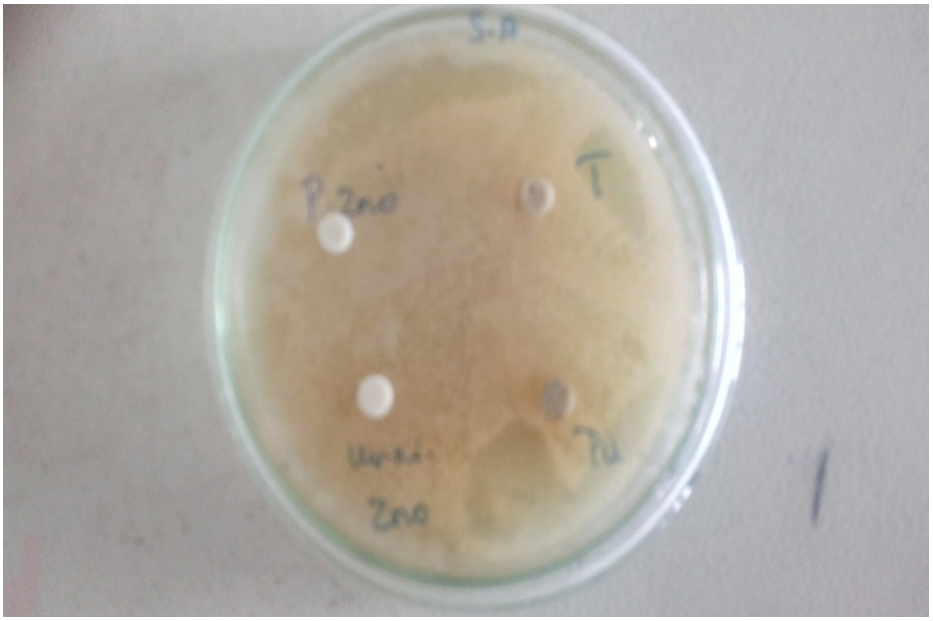

Figure 6a. Antibacterial activity of ZnO and Ni-ZnO against S. aureus.

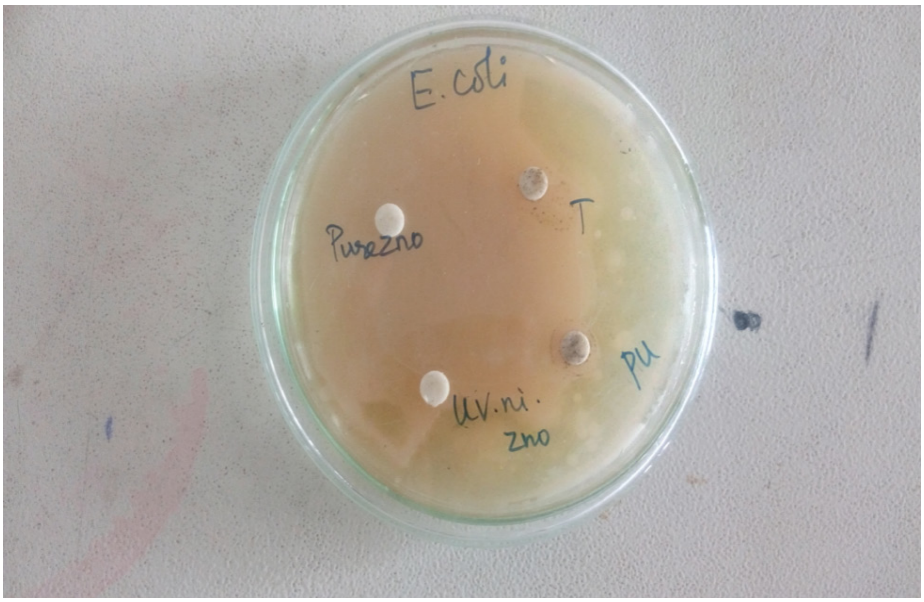

Figure 6b. Antibacterial activity of ZnO and Ni-ZnO against E. Coli.

4. Conclusion

- Due to its miscellaneous properties, ZnO is efficaciously used in multipurpose areas. Thus it is substantially used in medical skin creams, concrete, cigarette filters etc.,
- Similarly, Nickel doped zinc oxide is also used for dormant applications in Spintronics and as Diluted Magnetic Semiconductor (DMS) material.

5. References

1. Nomura K, Ohta H, Ueda K, Kamiya T, Hirano M, Hosono H. Thin film transistor fabricated in single crystalline transparent oxide semiconductor. Science. 2003; 300(5623): 1269–7. PMid: 12764192. https://doi.org/10.1126/science.1083212
2. Roy S, Basu S. Improved zinc oxide film for gas sensor application. Bull Mater Sci. 2002; 25(6):513–5. https://doi.org/10.1007/BF02710540
3. Zhao MH, Wang ZL, Mao SX. Piezoelectric characterization of individual zinc oxide nanobelt probed by piezoresponse force microscope. Nano Lett. 2004; 4(4):587–90. https://doi.org/10.1021/nl035198a