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Study of Eco-accommodating and Reliable method to Synthesis ZnO NPs by Hibiscus sabdariffa plant and their Bio-applications

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ABSTRACT

In this study, ZnO produced using a green synthesis approach and deposited on glass substrate using a drop casting method. The structural and optical properties have been studied. X-ray diffraction (XRD) shows that the ZnO film is crystalline, with an average size of 21 nm. ZnO NPs have an energy gap of 4.7 eV. The sample's behavior, as shown in the figures, indicates that ZnO has good qualities and can be used in many Bioapplications.

Keywords: Green Synthesis Approach, Organic polymers, Semiconductors, X-ray diffraction.

1. INTRODUCTION

The advancement of nanotechnology has opened up new vistas in nanoscience, particularly in gene delivery, drug delivery, biosensing, nanomedicine, and other fields. Metallic nanoparticles (MO) have significant band gaps and a high surface-to-volume ratio. They exhibit considerable photocatalytic and biocidal activity due to the providing of the high surface-to-volume ratio. [1-5]

ZnO is UV-absorbing wide band gap semiconductors with a energy gap of 3-3.3 eV. To expand their light absorption to the visible area, ZnO can be combined with materials with narrower band gaps, such as dye sensitizers, organic polymers, and smaller band gap semiconductors. ZnO NPs have been manufactured using a number of chemical and physical processes, which necessitate the employment of costly, environmentally harmful substances, as well as the expenditure of energy and time. To avoid the usage of environmentally damaging compounds, a green synthesis involving biological systems such as microorganisms, fungus, and plants has been adopted. This less-polluting synthesis method has gained traction in nanobiotechnology [6]. Plant extracts from various components, such as leaf, petals, fruit, seed, stem, roots, peel, rind, and so on, used in green synthesis as shown in Fig.1 [7]. Furthermore, due to the fast synthesis of extract, it preferable to use plant extracts in many experimentation,because of their unique phytochemical make-up, phytoconstituents are employed as a substitute for chemical reducing and cum stabilizing agents [8]. Biogenic synthesis can be easily optimized in terms of reaction conditions such as reaction temperature, solution pH, aging time, precursor concentration, modifier amount, modifier type, and solvent used all have a role in the nucleation and development of ZnO nanoparticles [9-10]. The unusual UV filtering, semiconducting, and catalytic activity of zinc oxide nanoparticles has piqued the interest of scientists all over the world [10-11]. Furthermore, these nanoparticles have been found to be non-toxic, biocompatible, and biologically safe. Zinc oxide nanoparticles are also used in cosmetics and sunscreen creams because they may absorb harmful UV-A and UV-B rays [12]. Zinc oxide is safe (21 CFR 182.8991) and can be used as medicine, according to the US Food and Drug Administration. Zinc oxide nanoparticles can also be employed as an antibacterial agent to kill pathogenic germs [13]. The aim of this work, producing ZnO NPs by green synthesis method from the Hibiscus sabdariffa plant and their Bioapplications.

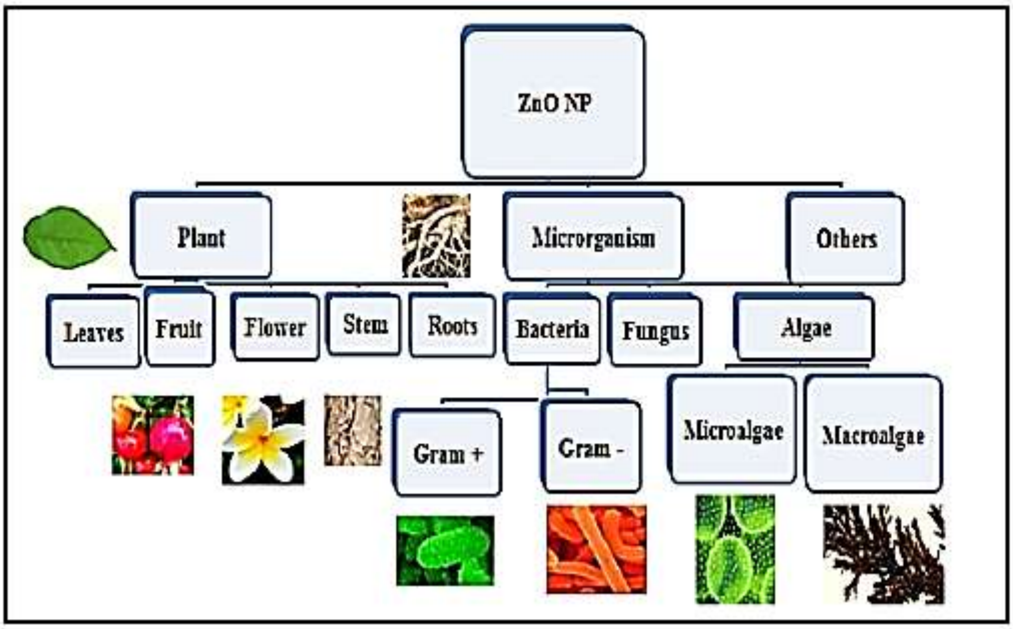

Fig. 1. Zinc oxide nanoparticle synthesis by using different sources.

2. EXPERIMENTAL PART

100 ml Distilled water used to dissolved 1.8 g of zinc nitrate. The solution added in a round flask with flipping.. About 15 mL of extract of Hibiscus sabdariffa plant add to the mixture. The suspension s maintained at 70 ° C for one hour to the nano suspension formed. By X-ray measuring device (XRD-6000, Shimadzu, wavelength = 0.154056 nm) ZnO nanostructure examined. The optical absorption spectra of colloidal NPs ZnO measured using the optical spectrometer.

3. RESULT AND DISCUSSION

ZnO produced using a green synthesis approach and deposited on glass substrate using a drop casting method as shown in Fig.2 six peaks observed with Miller indices value of (100), (002), (101), (102), (110) and (112) respectively, this corresponding [14-17]. X-ray diffraction (XRD) show that the ZnO film is crystalline. The preferential growth along (002) plane of ZnO crystallites, with average size about 21 nm.

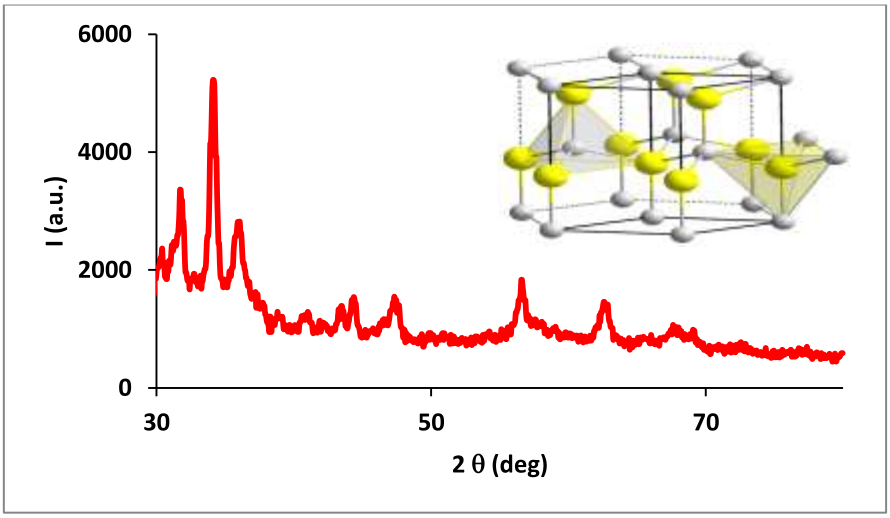

Figure 2. XRD pattern of Zinc oxide nanostructure

The UV-Vis spectra of ZnO NPS solution prepared using the green synthesis approach shown in Fig. 3. The spectrum shows a plasmon resonance peak due to the quantum size effect in the UV range (277-316) nm [18]. The absorption curve divided into two regions. In the region No. 2 from 340 nm to 500 nm the absorption curve drops quickly. In the region No.3 at wavelength >500 nm starts to saturate. As a result, the ZnO NPS has a high transmittance and can be employed in solar cells and smart windows.

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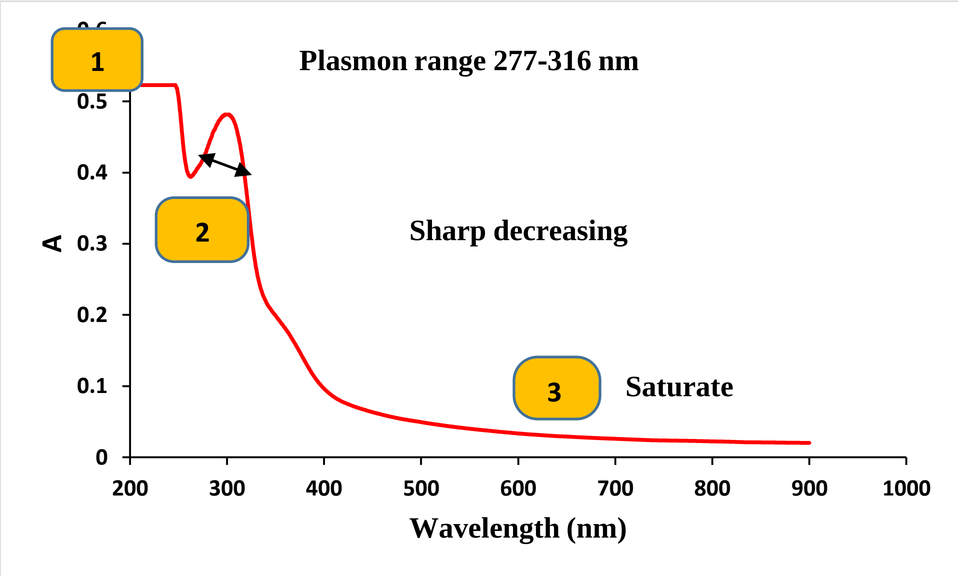

Fig.3 Shows the connection between absorbance and wavelength

Plotting graph between $(\alpha h\nu)^2$ vs hν the band gap of ZnO NPs determined by. The linear section of the curve extrapolated toward the photon energy axis. E_g of prepared sample was 3.7 eV and 4.7 eV, and that the band gap values rose. This behavior points to the nano situation [19]. Two energy gaps may exist because of Fermi fission and an increase in the permitted states due to the increase in the concentrations of charge carriers [20]. The fluctuation of the absorption edge produced by the energy band structure and variation in density of state with energy level, lead to the occurrence of a two-energy gap.

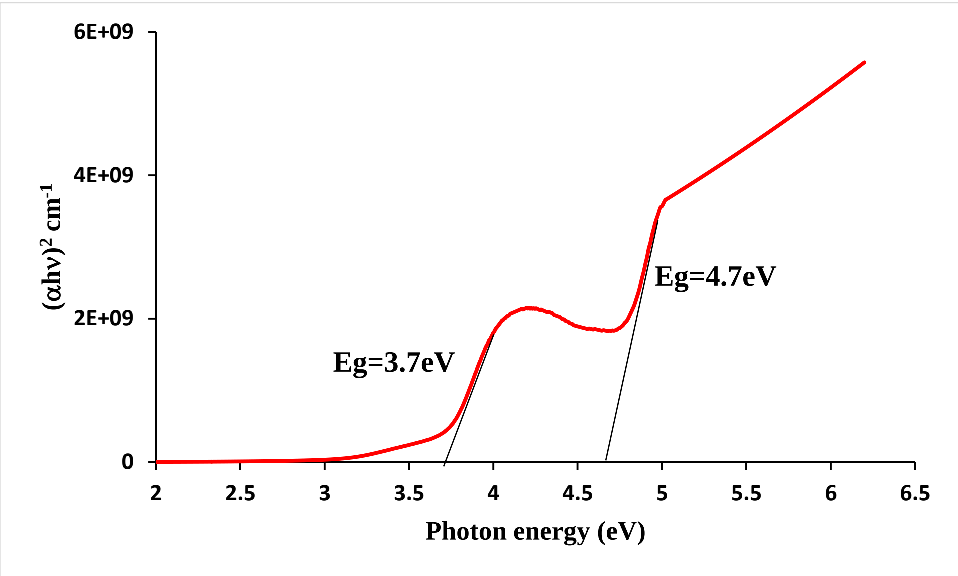

Fig.4 $(\alpha h\nu)^2$ and (hν) for ZnO NPs

Figure 5 shows the ZnO reflection spectrum. Because ZnO has a high transmittance and low absorbance at wavelength (400-900) nm, the reflection values for > 405 nm are low. The maximum reflectance value of 0.44 at 331 nm wavelength, this agree with [21].

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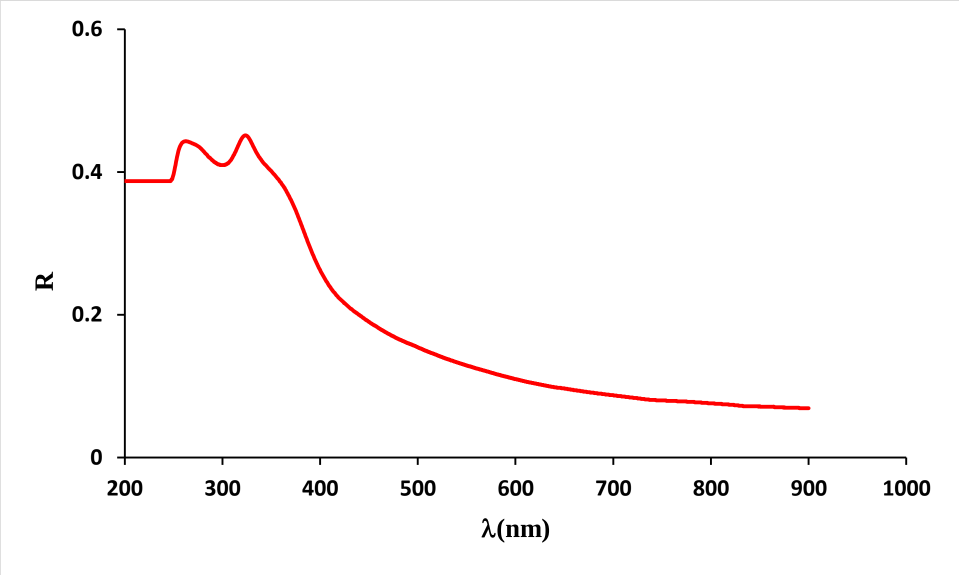

Fig. 5 Reflection spectrum of ZnO NPs.

Figure 6 shows how the refractive index (n) was determined from the reflectance (R) findings using the following equation. [9].

$$R+T+A=1$$

$$n=(1+\sqrt{R})/(1-\sqrt{R})$$

Refractive index reaches its maximum value of 4.4 at 800 nm, as shown in Figure 7.

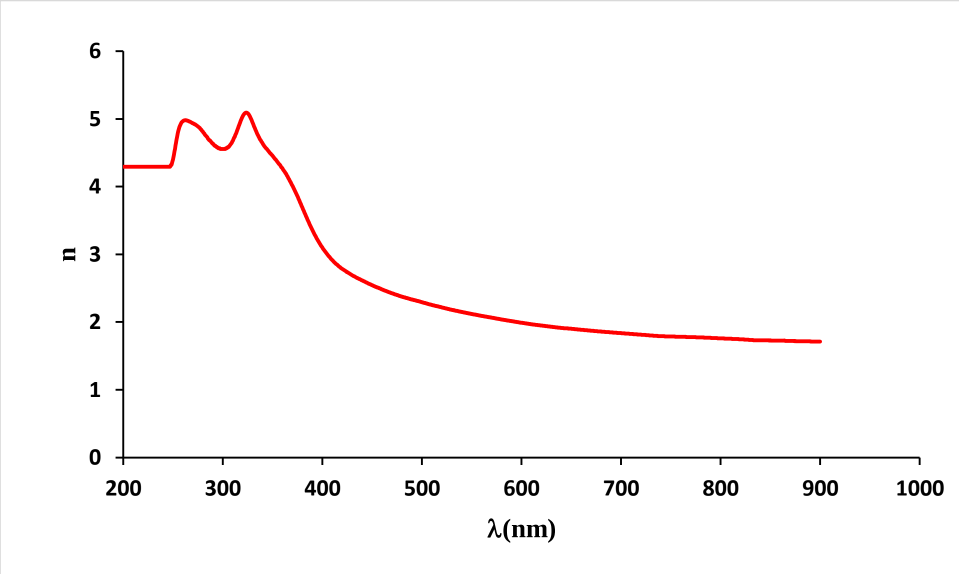

Fig. 7 Refractive index versus wavelength of ZnO NPs.

The plote of extinction coefficientvs wavelength is shown in Figure 8. (k). When the wavelength exceeds 440 nm, the extinction coefficient decreases and increase with the the absorption edge from 277 to 377nm

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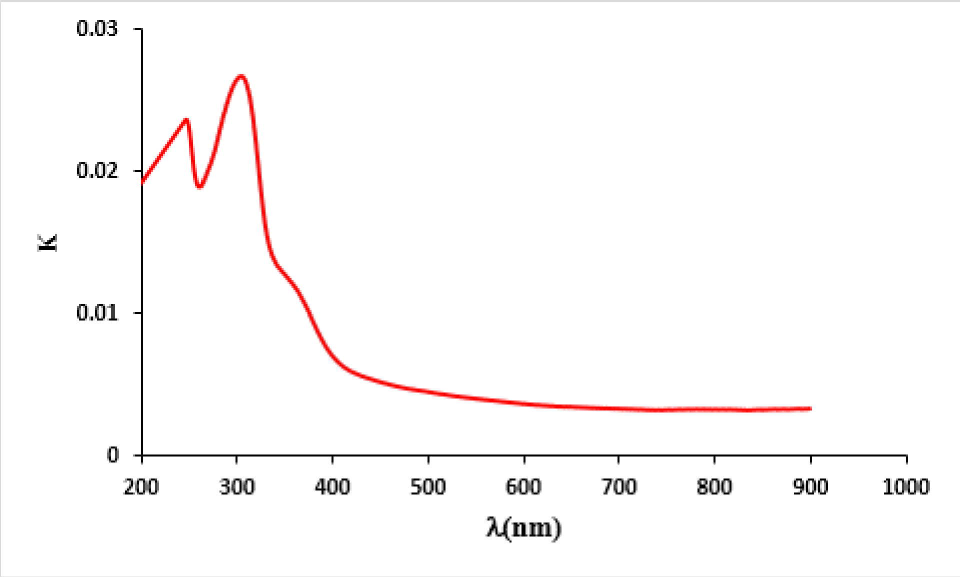

Fig. 8. Extinction coefficient versus wavelength of ZnO NPs.

The dielectric constant real and imaginary part variation (εr and εi) respectively as a function of wavelength was show in fig. 9.It can be observe that the real / imaginary part has a large value in the range of 300-400 nm then start to decrease until zero at the 1100nm.

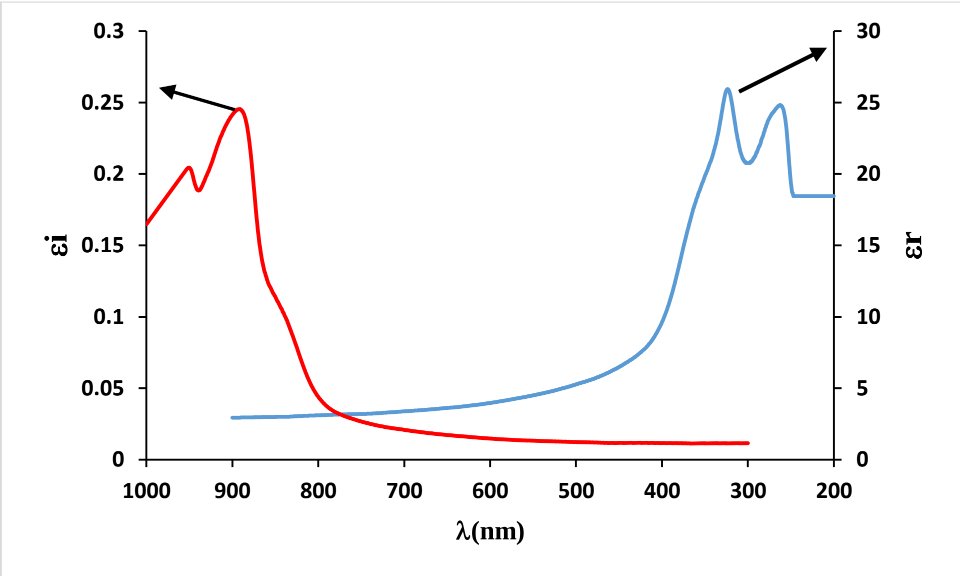

Fig. 9. Plot between wavelength and real part of the dielectric constant and the imaginary part of the dielectric constant.

From the relationship, optical conductance was calculated: [22]

$$\sigma = \frac{\alpha n c}{4\pi}$$

Where (σ) is the optical conductance, c is radiation velocity in the space, (n, α):are the refractive index and absorption coefficient respectively. Figure 10 illustrates the relation between the optical conductivity and energy of photon for ZnO. Figure 10 shows the optical conductance increases from 3.9to 4.5eV and 5 eV then it is constant over that.

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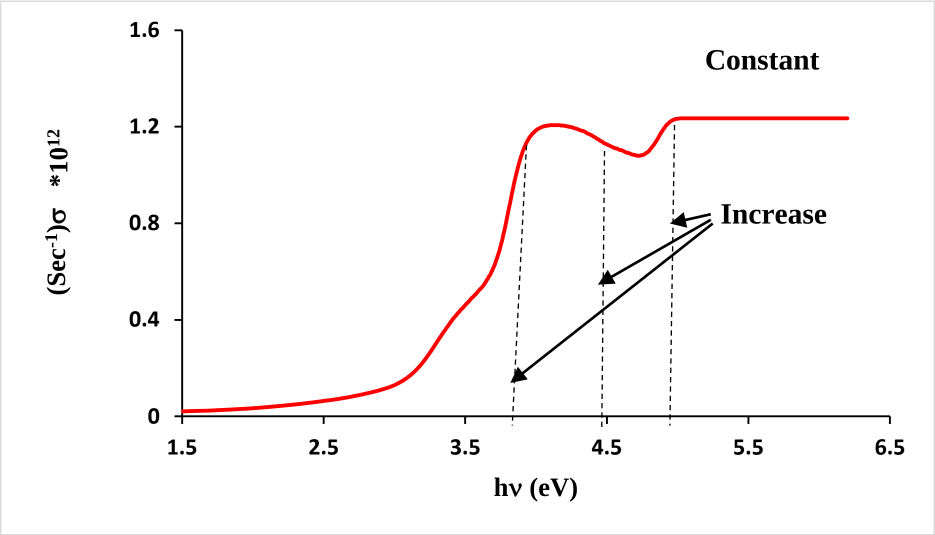

Fig.10: Optical conductivity of ZnO as a function of photon energy.

ZnONPs have antibacterial properties. By using the agar well diffusion method, the synthesized ZnO NPs tested for antibacterial and antifungal activity against clinical pathogens (Gram+ve and Gram-ve bacteria) at a concentration of 100 L/mL, where a clear inhibition Diameter observed at range 27 and 31mm, as shown in Fig. 11. (Klebsiella Sp., Escherichia coli, Staphylococcus epidermidis,Staphylococcus aureus, and Candida). ZnO NPs causses cell damage by disrupting the cell wall due to the ionic interaction between the negatively charged ZnO NPs and the gram positive or gram negative cells [23, 24]. This could be because direct nanoparticle communication on the cell membrane surface disrupts the cell membrane and inhibits cell development by preventing cell wall synthesis or inactivating other cellular processes [22-25]. The sample's behavior, as shown in the figures, indicates that ZnO has good qualities and can beused in many Bioapplications.

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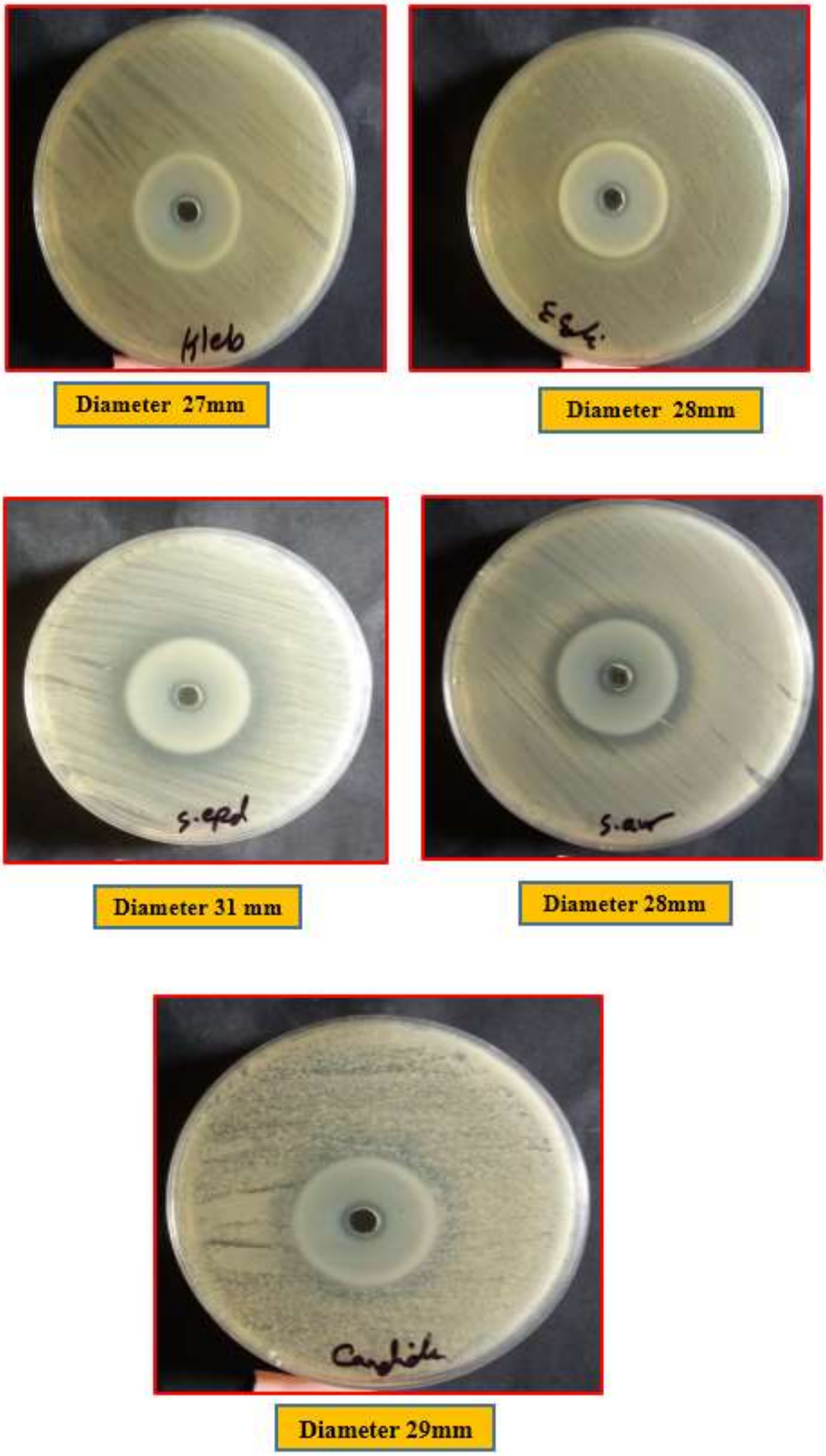

Fig.11: Antibacterial and antifungal activity of ZnO NPs

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4. CONCLUSION

This paper has demonstrated how ZnO can be produced using a green synthesis process (simple, low cost, and quick method for the synthesis of ZnO Nanoparticals). The sample's behavior, as shown in the figure, indicates that ZnO has good qualities and can be used in many applications such as solar cells, detectors, antibacterial/antifungal, and anticancer applications. From the results of XRD and SEM, average size of ZnONPs was 21nm; this small size has more antibacterial action Because of their surface area. Where size and shape have an important role in process. The spherically or semi spherical shaped NP, For example, can easily release Zn^{2+} ions, and tiny-sized particles are more permeable to bacteria membranes.

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