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Green Synthesis of Zinc Oxide Nanoparticles Using *Hibiscus moscheutos* Extract and Evaluation of its Antioxidant Activity

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Abstract – Zinc oxide nanoparticles (ZnO-NPs) have garnered considerable attention due to their favourable properties and widespread applications in biomedical, industrial, cell imaging, and biosensor fields. This study presents the green synthesis of stable ZnO-NPs using a 0.1M concentration of zinc nitrate solution and *Hibiscus moscheutos* leaves extract as an efficient stabilizing agent. The antioxidant activity of the synthesized ZnO-NPs was evaluated using the 2,2-diphenyl-1-picryl hydroxyl (DPPH) free radical scavenging assay. The characterization of the ZnO-NPs involved various spectroscopic and microscopic techniques. The UV–vis spectroscopy results revealed an absorption peak around 369 nm. The involvement of bioactive compounds from *Hibiscus moscheutos* in stabilizing the ZnO-NPs was confirmed through X-ray diffraction, and Fourier transforms infrared analysis. Scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX) analysis confirmed the spherical morphology and the presence of primarily Zn, C, and O. The biosynthesized ZnO-NPs exhibited robust antioxidant activity with an IC_{50} of 32.2 µg/mL. This eco-friendly and simple green route, utilizing *Hibiscus moscheutos* extract, proved effective in synthesizing ZnO-NPs with potent antioxidant potential.

Keywords – Characterization, Morphology, Eco-friendly, Stabilizing Agent, Microscopic Technique

I. INTRODUCTION

Nanotechnology is an advanced area of study that's is growing rapidly, and it utilizes technologies that are environmentally friendly for the purpose of synthesizing biosynthetic nanoparticles (ZnO, Ag, Au, Na, nanoparticles), which are chemically stable, nontoxic, biocompatible, and can be used as anticancer agents (Hassan *et al.*, 2017), anti-microbials (Nirmala and Anukalini, 2011), antidiabetics (El-Gharbawy *et al.*, 2016), drug carriers(Albert *et al.*, 2006), cell imaging (Xu *et al.*, 2017), biosensors (Thapa *et al.*, 2017), and cosmetics (Rosi and Mirkin, 2005), due to their unique physiochemical characteristics. Before the advance of green synthesis, metal oxide nano-particles (MO NPs) are synthesized using chemical and physical methods which involve the use of antagonistic chemicals, which make it tedious, expensive and toxic (Li and Carter, 2009).

Zinc oxide (ZnO) is an inorganic compound commonly used in everyday life. In recent years, the rapid development of nanotechnology has led to the creation of zinc oxide nanomaterials with unique properties (Espitia et al., 2012). Zinc oxide nanoparticles (ZnO-NPs) exhibit enhanced catalytic properties when their diameters are below 100 nm due to the higher surface area to volume ratio of the nanoparticle (Zhou et al., 2010; Khan et al., 2019). There are many methods of synthesis that can alter the physicochemical properties of a material, including laser ablation, microwave-assisted combustion method, hydrothermal methods, sol-gel method, ultrasound, anodization, coprecipitation, electrochemical depositions, and electrophoretic deposition. (Kumar et al., 2013; Bharat et al., 2019). ZnO possesses photocatalytic properties, yet its stability is somewhat limited. In contrast, ZnO nanoparticles (ZnO-NPs) offer enhanced stability, improved crystallinity, and reduced defects. These characteristics make them highly effective in the degradation process of various substances, including organic impurities (Hariharan, 2006; Xiao and Ouyang, 2009).

Hardy hibiscus (*Hibiscus moscheutos*) is becoming increasingly popular as a landscaping plant, with a notable rise in the volume of planted material. The genus Hibiscus, a polymorphic member of the Malvaceae family, encompasses approximately 300 species of trees, shrubs, and herbs that thrive in tropical, subtropical, and temperate regions globally (Mohammad et al., 2020). These hibiscus varieties are classified based on the number and arrangement of petals, falling into categories of single, semi-double, or double flowers. *H. sinosyriacus*, a deciduous and winter-hardy shrub, closely resembles *H. syriacus*. The cultivar 'Malmauve' of *H. sinosyriacus*, initially cultivated in France in 2001, made its way to Korea in 2003 and was named 'Seobong' (Jo et al., 2019).

This study synthesized ZnO-NPs using *Hibiscus moscheutos* leaves extract as a stabilizing agent. Various spectroscopic and microscopic methods were employed to characterize the synthesized *Hibiscus moscheutos*-mediated ZnO-NPS and their antioxidant potential was analysed employing standard methods.

II. Materials and Method

Describe in detail the materials and methods used when conducting the study. The citations you make from different sources must be given and referenced in references.

A. *Sample collection and preparation*

Hibiscus-moscheutos was collected from Lefkosia during spring, and its botanical features were identified as a Herbarium specimen; it was given a voucher specimen number CIU/Phar/malv/001; it was then deposited at the Faculty of Pharmacy Laboratory of CIU for future references.

B. *Synthesis of ZnO-NPs*

The synthesis of ZnO-NPs was successfully carried out using the aqueous extract of Hibiscus moscheutos, following the method described by Umar et al. with slight modifications. In this process, a solution of 0.1M Zn(NO3)2·6H2O in 80 mL distilled water was used. Subsequently, 20 mL of the prepared extract was added dropwise into the zinc nitrate solution with constant stirring at 80°C for 3 hours to facilitate complex formation. The resulting mixture (zinc nitrate + extract) was then subjected to calcination at 450°C±10°C for 1 hour in a muffle furnace to obtain ZnO NPs.

C. *Characterization*

The synthesized ZnO-NPs were characterized using various spectroscopic and microscopic techniques. UV–visible spectrum was evaluated using a UV–Visible spectrophotometer (Shimadzu UV-2450), and the spectrum was recorded between 300 and 800 nm. Fourier transform infrared (FTIR) analysis of the NPs was carried out with a Fourier transform spectrometer (Shimadzu FT-IR Prestige-21 Model) at a frequency range of 4,000–500 cm^{-1}. The crystalline structure was analyzed using an X-ray diffractometer (Rigaku ZSX Primus II). Morphological analysis of the synthesized ZnO NPs coated with platinum was carried out using a scanning electron microscope (SEM) (JOEL JSM 6335-F) equipped with 150 kV acceleration voltage and energy-dispersive X-ray spectroscopy (EDS) (Oxford Instruments AZTEC EDS) attached to the same instrument was used to ascertain the elemental composition and purity of the synthesized ZnO-NPs.

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