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Investigating the Photocatalytic Dye Degradation and Antibacterial Abilities of *Manihot esculenta* Peel-based Mn_3O_4 Nanoparticles

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With increasing population in the modern world, removing domestic and industrial waste has become a global challenge. Therefore, studies have been focused on adding values to these waste materials by utilizing them for various applications. The green synthesis of nanoparticles (NPs) through waste products recently emerged as an eco-friendly and low-cost method for waste management and recycling waste products. This specific study focused on synthesizing Mn_3O_4 NPs using cassava (*Manihot esculenta*) peel, which is a common household waste in Sri Lanka. Further, this study focused on studying the ability of that NPs on photocatalytic dye degradation of Methylene Blue (MB), a common textile dye, and the antibacterial activity against Gram-positive *Staphylococcus aureus* and Gram-negative *Escherichia coli* bacteria. Mn_3O_4 NPs were successfully synthesized under optimized reactions conditions of plant-to-metal ratio (1:8), metal salt concentration (0.1 $moldm^{-3}$) and pH (10) with an incubation time of 48 hours. Then the formed NPs were characterized by using UV-Visible spectroscopy, Fourier Transfer Infrared spectroscopy (FTIR) and X- ray diffraction (XRD) analysis. The UV- Vis spectra of Mn_3O_4 NPs characteristic peak at ~ 267 nm clearly indicating the formation of NPs. The FTIR spectrum showed a sharp peak at 587.86 cm^{-1} indicating a Mn—O stretching vibration. This suggested that the formed product is the desired NPs. The crystallinity of Mn_3O_4 NPs was identified using XRD analysis and they are found to be in body-centered cubic crystal structure. According to the Debey-Scherrer equation the average crystallite size of these NPs was found to be 36.69 nm. The presence of both Mn^{2+} and Mn^{3+} in the final product suggested an air oxidation process of Mn^{2+} ions under applied conditions. The NPs were further investigated for their ability on photocatalytic dye degradation of MB under optimized parameters of catalytic load (10 mg), dye concentration (5 ppm), and pH (10). The percentage degradation was calculated by taking absorbance (λ_{max} = 663 nm) of the reaction mixture for 240 minutes at 30-minute intervals. Under optimized conditions, these Mn_3O_4 NPs showed 78.8% photodegradation indicating their suitability as photocatalysts under ambient conditions. The antibacterial activity of the synthesized NPs was tested against *Staphylococcus aureus* and *Escherichia coli* by well diffusion method using Muller-Hinton medium. The experiments were carried out by using different NP concentrations (50 ppm to 150000 ppm), plant extract, positive control (Gentamicin) and negative control (deionized water). During the investigation, inhibition zones were not observed even with high NPs concentrations. Overall, these cassava-peel based Mn_3O_4 NPs were found to be potential photocatalysts for the removal of certain textile dyes from wastewater, but they are not effective against *S. aureus* and *E. coli*. Therefore, these NPs have the ability to be used as tools to remediate certain environmental impacts caused by certain organic pollutants under ambient conditions.

Keywords: Characterization, Green synthesis, Manganese oxide, Methylene blue, Nanoparticles