**Structure based photocatalytic efficiency and optical properties of ZnO nanoparticles modified by annealing including Williamson-Hall microstructural investigation**

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**Abstract**

Structural deficiency in annealed ZnO nanoparticles would be a critical concern for the optical properties and photocatalysis efficiency of ZnO. Therefore, the structure and microstructure of synthesized ZnO nanoparticles annealed at 500 ◦C, 700 ◦C, and 900 ◦C for 4 h have been analyzed by X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), and UV–visible Diffuse Reflectance Spectroscopic (UV–Vis DRS) techniques. Williamson-Hall and modified Williamson-Hall models have explored microstructural properties. The bandgap in ZnO decreases from 3.18 eV to 3.11 eV for annealing, which coincides with the assessed optical band edge approximately and the accumulation of particles observed from SEM images. Moreover, the redox potential has been calculated for annealed samples to perform the photocatalytic experiment. Additionally, the photocatalytic performance has been estimated from the degradation of UV irradiation through the studied samples. Finally, the sample ZnO annealed at 500 ◦C confirms maximum RhB degradation rate of 60.9% due to its lower particle size with a higher surface area. The ZnO-500 may be a potential photocatalyst material, including semiconducting properties.

**Keywords:** Annealing, Optical bandgap, Redox potential, Kinetic rate, Williamson-hall model, Photocatalytic activity