

## ABSTRACT

Water pollution caused by synthetic dyes such as methylene blue (MB) has become a serious environmental concern due to their toxicity and persistence in aquatic environments. One promising approach to overcome this issue is the adsorption–photocatalysis method. In this study, chitosan/PVA membranes were synthesized and modified with aluminum-doped ZnO (ZnO:Al) nanocomposites as photocatalysts. The objectives of this research were to synthesize chitosan/PVA/ZnO:Al composite membranes, characterize their physical and chemical properties, and evaluate their performance in the adsorption–photocatalytic degradation of MB. ZnO:Al nanocomposites were prepared using the sol–gel method and incorporated into a chitosan–PVA solution to form composite membranes via the phase inversion method. Characterization of the nanocomposites was conducted using UV–Vis DRS, XRD, and FTIR, while the membranes were characterized by SEM–EDX, FTIR, and tested for weight, thickness, swelling ratio, water uptake, porosity, and hydrophilicity. The UV–Vis DRS results revealed a band gap of 2.93 eV for the ZnO:Al nanocomposite. XRD peaks showed slight shifts due to Al substitution in the ZnO lattice at  $2\theta = 31.722^\circ$ ,  $34.425^\circ$ , and  $36.233^\circ$ , with an estimated crystallite size of 14.8 nm. FTIR spectra of chitosan/PVA membranes exhibited changes in intensity and peak shifts, such as the transition from  $2876\text{ cm}^{-1}$  to  $2866\text{ cm}^{-1}$  after PVA addition, and the presence of a characteristic band at  $463\text{ cm}^{-1}$  indicated Zn–O vibrations. SEM analysis revealed that the membrane surface changed from smooth and dense to rougher, while EDX confirmed the presence of Zn, O, and Al elements. Adsorption–photocatalytic activity tests showed that the chitosan/PVA/ZnO:Al (1%) membrane achieved the highest MB degradation efficiency of 93.07%.

**Keywords:** *membrane, chitosan, adsorption, photocatalysis, nanocomposite, methylene blue*

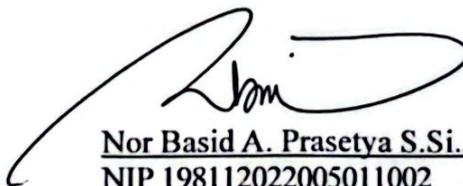
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