

## ABSTRACT

Water pollution caused by textile industry dye waste, particularly methylene blue (MB), is a serious environmental problem that requires an effective and eco-friendly solution. Conventional methods still have limitations including high operating costs and the generation of secondary pollutants, making nanomaterial-based photocatalysis a more promising alternative capable of degrading dyes into  $\text{CO}_2$  and  $\text{H}_2\text{O}$  without producing secondary pollutants. This study aimed to synthesize and characterize an  $\text{Fe}_3\text{O}_4/\text{C-dots}$  nanocomposite derived from pineapple peel waste (*Ananas comosus*) via green synthesis and to evaluate its photocatalytic activity in degrading methylene blue under UV irradiation. The research was conducted through several stages: pineapple peel extraction, synthesis of carbon dots (C-dots) by hydrothermal method at  $180^\circ\text{C}$  for 12 hours, synthesis of  $\text{Fe}_3\text{O}_4$  nanoparticles by coprecipitation, and fabrication of  $\text{Fe}_3\text{O}_4/\text{C-dots}$  nanocomposites at mass ratios of 0.5:10 w/v and 1:10 w/v, followed by characterization using X-Ray Diffraction (XRD) and UV-Vis spectrophotometry, and photocatalytic activity testing. XRD characterization confirmed the formation of the magnetite phase with an inverse cubic spinel structure, space group  $\text{Fd}\bar{3}m$ , with average crystallite sizes of 11.48 nm for pure  $\text{Fe}_3\text{O}_4$  and 7.23 nm for the nanocomposite, indicating that C-dots inhibit crystal growth. UV-Vis analysis revealed band gap energies of 3.84 eV for C-dots, 2.57 eV for  $\text{Fe}_3\text{O}_4$ , 2.87 eV for the 0.5:10 w/v nanocomposite, and 2.77 eV for the 1:10 w/v nanocomposite, suggesting the formation of a type-II heterojunction between the two components. Photocatalytic tests showed that C-dots addition consistently enhanced photocatalytic activity, with MB degradation efficiencies after 120 minutes of UV irradiation of 42.05% for pure  $\text{Fe}_3\text{O}_4$ , 50.65% for the 0.5:10 w/v nanocomposite, and 52.48% for the 1:10 w/v nanocomposite. This study demonstrates that pineapple peel waste has the potential to be simultaneously utilized in the synthesis of eco-friendly nanocomposites for the treatment of textile industry dye wastewater.

**Keywords:** carbon dots,  $\text{Fe}_3\text{O}_4$ , green synthesis, methylene blue degradation, nanocomposite, photocatalysis, pineapple peel