ABSTRACT

Textile industry wastewater contains synthetic dyes that are difficult to degrade, one of which is malachite green, a toxic and carcinogenic dye that poses a potential threat to the environment. One of the most widely used methods to overcome this problem is photocatalysis, which utilizes semiconductor materials. Zinc oxide (ZnO) is a semiconductor material with good photocatalytic activity; however, its performance is limited by the rapid recombination of electron-hole pairs. Therefore, iron (Fe) doping was employed to enhance the photocatalytic activity of ZnO. This study aimed to synthesize ZnO and Fe-doped ZnO (Fe-ZnO) semiconductor materials using the sol-gel method and to investigate the effect of Fe doping on the photocatalytic activity of ZnO in degrading malachite green solution. Fe-ZnO was synthesized with Fe doping concentrations of 2, 4, 6, and 8%. The synthesized materials were characterized using X-Ray Diffraction (XRD) to determine their crystal structure and UV-Vis Diffuse Reflectance Spectroscopy (UV-Vis DRS) to determine the band gap energy. The photocatalytic activity was evaluated through the degradation of malachite green under irradiation for 15, 30, 45, 60, and 75 minutes, while the residual concentration of the dye solution was analyzed using UV-Vis spectrophotometry. The results showed that ZnO and Fe-ZnO were successfully synthesized with a hexagonal wurtzite crystal structure. UV-Vis DRS characterization indicated that Fe doping reduced the band gap energy from 3.28 eV for ZnO to 3.22, 3.17, 3.13, and 2.95 eV for 2, 4, 6, and 8% Fe-ZnO, respectively. The 4% Fe-ZnO photocatalyst exhibited the highest photocatalytic performance, achieving a degradation efficiency of 92.24%, which was higher than that of ZnO (48.90%), 2% Fe-ZnO (75.40%), 6% Fe-ZnO (83.60%), and 8% Fe-ZnO (78.77%).

Keywords: *Photocatalysis, ZnO, Fe-ZnO, Iron Doping, Malachite Green, Sol-Gel.*