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Photoelectrochemical degradation of methylene blue dye under visible light irradiation using EG/Ag-ZrO_2 nanocomposite electrodes

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The present study reports the application of three electrodes, consisting of exfoliated graphite (EG), EG and zirconium oxide (EG-ZrO_2), and EG and silver-doped zirconium oxide (EG/Ag-ZrO_2) in a comparative photoelectrochemical degradation of methylene blue (MB) dye in water under visible light irradiation. The Ag-ZrO_2 is prepared using a sol-gel method and used in the fabrication of EG/Ag-ZrO_2 electrodes via a wet solution method. The morphologies, crystalline structures, and surface/physicochemical properties of the nanocomposites are characterized by SEM, TEM, XRD, and UV-Vis, FTIR, and Raman spectroscopies. The SEM results show that ZrO_2 and Ag-ZrO_2 are evenly dispersed on the surfaces of EG. The XRD and Raman analyses reveal that ZrO_2 exists in the tetragonal phase. The modification of ZrO_2 with EG and Ag results in electrodes with strong absorption in the visible light region. All fabricated electrodes display the capacity to degrade MB, with EG/Ag-ZrO_2 exhibiting the highest degradation efficiency and EG the lowest. The electrode with the highest efficiency (EG/Ag-ZrO_2) is used in optimization studies, which identify the optimum conditions required for maximizing the efficiency of the degradation process. In addition, the EG/Ag-ZrO_2 is used in the degradation of MB via photolysis, as well as electrochemical and photoelectrochemical methods. The photoelectrochemical method exhibits superior performance when compared to photolysis and photocatalytic methods in the degradation of MB. The synergistic effects of Ag and ZrO_2 enhance the efficiency of EG/Ag-ZrO_2 toward the degradation of MB.

Keywords: Exfoliated graphite, Ag, ZrO_2, electrode, photoelectrochemical degradation, dye

FULL TEXT