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Graphene Oxide Coated Sand Composites as Molecular Sieves to Mitigate Water Contaminants

Perera, W.P.R.T.[1,3]*, Ruwanthi, N.M.N.[1], Perera, P.L.R.A.[2,3], Vitharama, A.V.A.P.[1], Liyanage, J.A.[2,3], Kumarasinghe, A.R.[4]

[1]Department of Indigenous Medical Resources, Gampaha Wickramarachchi University of Indigenous Medicine, Yakkala, Sri Lanka
[2]Department of Chemistry, University of Kelaniya, Kelaniya, Sri Lanka
[3]CKDu Information and Research Centre and Department of Chemistry, University of Kelaniya, Kelaniya, Sri Lanka
[4]Department of Physics, University of Sri Jayewardenepura, Nugegoda, Sri Lanka
*wprtp@gwu.ac.lk

Abstract

This research focuses on the synthesis of a novel adsorbent, a sand/graphene oxide composite with five layers of graphene oxide coating, referred to as S-GO5. The primary aim of this study is to assess the potential suitability of S-GO5 as a molecular sieving material via the adsorption of Methylene blue (MB) dye and 2-methyl-4-chlorophenoxyacetic acid (MCPA) pesticide molecules. The composite is created through a stepwise deposition of graphene oxide onto river sand using a thermal annealing process. Characterization studies conducted with scanning electron microscopy (SEM) and Fourier-transform infrared spectroscopy (FT-IR) reveal a non-uniform graphene oxide coating on the sand's surface and the incorporation of oxygenated functional groups within the composite structure. The study compares the adsorption capacity of S-GO5 with other sorbent materials like activated carbon, graphene oxide, and sand, for the removal of MB dye and MCPA. For the analysis of MB dye and MCPA adsorption, UV visible spectroscopy (665 nm) and high-performance liquid chromatography (HPLC) methods were employed respectively. The optimization studies for MB adsorption on S-GO5 revealed that the ideal conditions are a concentration of 5 mg/L, a dosage of 0.09 g, a contact time of 20 minutes, at pH 9. Focusing on the adsorption of MCPA onto the S-GO5, the optimum concentration, dosage, and contact time were 75 mg/L, 0.05 g, and 105 minutes respectively, at neutral pH values. The investigation of adsorption equilibrium isotherms indicated that the Freundlich model best describes the adsorption process, with high correlation coefficients for both MB and MCPA. Additionally, adsorption kinetics analysis suggests a pseudo-second-order model best fits the data, indicating a chemical sorption mechanism governing the adsorption process. It is evident that MB (98.6%) has a significantly higher adsorption capacity on S-GO5 compared to MCPA (53.3%). The adsorption capacity values of MB, and MCPA were 52. 861 mg/g and 4.7316 mg/g respectively. Despite MB having a cationic charge and MCPA being either neutral or negatively charged in solution, the S-GO5 composite demonstrates a remarkable adsorption capacity for both compounds. This suggests that the synthesized composite could be a promising solution for molecular sieving material, owing to the removing positively charged molecules (MB) as well as negatively charged (MCPA) pesticide contaminants from water.

Keywords: Adsorption, Graphene, Sand, Dye, Pesticide

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