



Research article

Water purification through removal of toxic dyes using novel GO-grafted magnetic polyvinyl acetate: Kinetics, isotherms and thermodynamic studies

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ABSTRACT

Wastewater pollution has been a significant environmental concern in recent decades, largely due to the substantial increase in the use of chemicals and dyes across various industrial sectors. The present study reports a facile co-precipitation method for synthesizing magnetized polyvinyl acetate (MPVA) and magnetized polyvinyl acetate blended with graphene oxide (MPVA-GO). A comparative assessment of their efficiency in removing methylene blue dye from wastewater has been performed. Numerous analytical characterisation techniques, such as FT-IR, XRD, FE-SEM, HRTEM, EDX, and AFM have been adopted to examine the morphological features and to determine the structural properties of these nanocomposites. Results of batch adsorption studies demonstrated a superior uptake potential of MPVA-GO. Interestingly, the pseudo-second-order model was found to most accurately describe the adsorption kinetic behaviour of both materials. Among the evaluated isotherm models—Langmuir, Freundlich, and Temkin—the adsorption behaviour of MPVA was best described by the Langmuir model, while the Temkin isotherm provided the most accurate representation of the adsorption equilibrium for the MPVA-GO adsorbent. Furthermore, thermodynamics studies indicate a greater ΔG° , ΔS° , and ΔH° values for MPVA-GO which draws conclusion to the results that MPVA-GO is a more efficient adsorbent toward cationic dyes with a more thermodynamically favoured adsorption process.

1. Introduction

Dyes are employed as colouring agents in several industries, including textile, rubber, leather, printing, paper, food and beverage industries [1]. The past few decades have witnessed a growing demand and widespread use of dyes in industries leading to significant environmental concerns as a result of the discharge of dye effluents into wastewater from these sectors. Cheruiyot et al. [2]. Dyes, known for their high toxicity, can inflict damage on the human nervous system, leading to symptoms such as vomiting, diarrhoea, shortness of breath, kidney failure, lung cancer, and skin irritation characterized by redness and pain upon contact with the dye [3]. Methylene blue is a water-soluble synthetic basic dye that finds extensive use in the

treatment of methemoglobinemia and urinary tract infections, as well as serving as a staining agent. However, it poses significant risks to human health and the environment, leading to issues such as nausea, dizziness, upset stomach, mild bladder irritation, and, in cases of large dye doses, symptoms like chest pain and mental confusion [4,5]. In addition to health concerns, the build-up of these substances in water can impede sunlight penetration, hindering the process of photosynthesis [6]. Consequently, the treatment of dye effluent has become increasingly crucial. Hence, removal of these dyes or reducing their content to a minimum permissible dosage is of utmost importance. Various conventional methods are currently employed to eliminate organic dyes from water systems [7,8]. Among the different techniques for wastewater treatment, adsorption stands out as a particularly advantageous

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