



Functionalized magnetic mesoporous palm shell activated carbon for enhanced removal of azo dyes



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ABSTRACT

A novel adsorbent magnesium and silica coated magnetized palm shell activated carbon (MMPAC) was synthesized via hydrothermal process. MMPAC exhibited high adsorption capacity of 369.54 mg L⁻¹ for methylene blue, 528.98 mg L⁻¹ for methyl orange and 257.25 mg L⁻¹ for congo red. MMPAC removed single, double and multiple dyes effectively and the experimental results matched Langmuir isotherm and pseudo second order kinetic models. MMPAC was regenerated and recycled four times using simple technique with no significant drop observed in the adsorption capacity. Thermodynamic parameters revealed that the adsorption is endothermic and spontaneous at room temperature. Pseudo second order kinetic model parameters and intraparticles diffusion of dyes implied that the dominating adsorption mechanism was physical in nature.

1. Introduction

Pollution caused by textile waste water has received major attention worldwide in the last decade [1]. Dyes discharged from textiles and other industries are main contributors of organic pollutants in the water [2]. Dyes are easily visible and undesirable [2]. Most organic dyes are toxic in nature, non-biodegradable, carcinogenic, mutagenic, endocrine disruptor, and cause serious health hazards to humans, animals and aquatic microorganisms ([2,3]; N [4]). It is therefore significant to remove these dyes from waste water to reduce their negative impact on the ecology and environment [5].

Textile waste water contains high amount of azo dyes [2] such as methylene blue (MB), methyl orange (MO) and congo red (CR). Azo dyes are synthetic dyes that are resistant to chemical and biological degradation [6]. Most of the azo dyes contain only one azo group but some may contain two (diaz), three (triaz) or more [7]. Azo dyes exist in the form of hydrazine and contain double bond hybridized nitrogen atoms (-N = N-), which bonds two sp² orbitals [6].

Conventional water treatment processes such as precipitation (coagulation and flocculation), ion exchange, membrane filtration, oxidation, bio-removal and adsorption were applied to remove dyes from water [2,8]. Adsorption is the most desirable method for dyes removal due to its high yield, easy handling and cost efficiency [9]. Furthermore, adsorption material such as palm shell activated carbon (PAC) is readily available, widely used and inexpensive [2,3,10].

Although there have been numerous studies on adsorption using PAC, some investigations have highlighted its shortcomings such as low efficiency and poor separation caused by micro pores and small particle size of adsorbent ([8,11]; Y [12]). Conversely, the magnetized adsorbent MMPAC has its advantage, where it can be separated easily from the solution using a magnet.

Silica is abundant, biocompatible, and chemically inert. Moreover, its core surface does not get oxidized or reduced during adsorption (Yuet al., 2015). Where else, magnesium will ionize the surface of PAC to produce high density cationic and anionic molecules (Mg²⁺ - OH⁻) that can enhance the adsorption of hydrophilic dyes. The presence of high density silanol (Si-OH) and magnesium hydroxide (Mg-OH) allows the bond creation with many organic pollutants [8,13].

The aim of this study was to synthesize a novel adsorbent, magnetized activated carbon coated with Si and Mg (MMPAC) for removal of multiple dyes. The objectives were to functionalize PAC; characterize the material using physical and chemical analysis; determine the removal capacity of the MMPAC with different types of dyes and to elucidate the removal mechanism via kinetic and thermodynamics analysis. Methylene blue, MO and CR were selected as model pollutants for this investigation.

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