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Equilibrium and kinetic approach of bioadsorbed metanil yellow from aqueous solution onto cross-linked magnetic chitosan nanoparticles

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Abstract— Glutaraldehyde cross-linked magnetic chitosan nanoparticles (GMCNs) were prepared through crosslinking modification of magnetic chitosan nanoparticles (MCNs) using glutaraldehyde as crosslinker that exhibited excellent Metanil Yellow (MY) adsorption performance. The characterization of synthesized GMCNs was performed by Fourier transform infrared spectroscopy (FTIR), transmission electronmicroscopy (TEM), scanning electron microscopy (SEM), dynamic light scattering (DLS), and vibrating sample magnetometry (VSM) analyses. Adsorption characteristics of MY aqueous solutions on to GMCNs have been studied and results indicated that the adsorption capacities were affected by initial pH values, initial dye concentrations and contact time. MY adsorption followed with the pseudo-second-order reaction, and equilibrium experiments were well fitted the Langmuir isotherm model. Maximum adsorption capacities of MY displayed at pH 4.0 and at 30 °C, being up to 625mg per g GMCNs. Furthermore, it was found that the GMCNs can be regenerated and reused through dye desorption in alkaline solution.

Keywords: **Biosorption, Crosslinked-Magnetic Chitosan, Metanil Yellow, Regeneration**

I. Introduction

Metanil yellow is highly water-soluble azo dye which is widely used in dyestuff, textiles, leather, paper, polishes, food, cosmetic and wax industries (1). But it is often released in effluents during processing and transforming and causing a lot of healthy and environmental problems (2,3).Hence, it is a major pullutant and various workers have made attempts to remove Metanil Yellow from wastewater (4).

Chitosan is acknowledged as an easily-available and inexpensive sorbent. Owing to the fact that it possesses amine and hydroxyl functional groups, it is characterized by a high adsorption effectiveness of metal ions (5) and dyes from aqueous solutions (6). A drawback of chitosan is its solubility in acidic solutions. At pH <5.5, it is being dissolved and loses its capacity for sorbates binding. A solution to this problem may be its cross-linking. The cross-linked chitosan maintains constant reactivity in a wide pH range and is characterized by high mechanical resistance (7). The cross-linking may also affect the improvement of its regeneration properties (8).

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In the this study, glutaraldehyde cross-linked magnetic chitosan nanoparticles (GMCNs) were prepared through crosslinking modification of magnetic chitosan nanoparticles (MCNs) using glutaraldehyde as crosslinker that exhibited excellent Metanil Yellow adsorption performance. In addition, the adsorption characteristics of Metanil Yellow from aqueous solutions on GMCNs were investigated. Furthermore, the influence factors such as pH, contact time, adsorbent dose and dye concentrations to adsorption were studied; the equilibrium isotherms parameters and regeneration were determined and discussed.

The MY adsorption capacity of the GMCNs was depend on pH and the initial dye concentration. High adsorption capacities were obtained in the pH range of 3.0-4.0 to remove the anionic dye. The adsorption capacity increased with increase in initial dye concentration and with decrease in pH.

The maximum monolayer adsorption capacity is 625 mg g^{-1} for dye MY at pH 4 and at 30 °C. The Langmuir isotherm model agrees with experimental data better than the Freundlich. In addition, GMCNs can be desorbed efficiently using alkaline solution because adsorption process was spontaneous and exothermic. Desorption studies as a function of pH were conducted to analyze the possibility of

reusing the adsorbent for further adsorption and to make the process more economical. Thus, the adsorbent was used for three adsorption cycles for dye removal. After adsorption experiments the dye loaded GMCNs were washed with distilled water to remove any non-adsorbed dye and then were incubated with NH_4OH/NH_4Cl buffer. The technique used in this study offered a convenient and efficient method for the preparation of the GMCNs, which facilitated a more efficient and economic adsorption of dye from aqueous solution (adsorbed 65% of MY after three repeats) and avoided secondary pollution of adsorbents to water environment.

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