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Reactive dye adsorption onto a novel mesoporous carbon

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HIGHLIGHTS

- A mesoporous carbon was synthesized for its application as reactive dyes adsorbent.
- The adsorption onto the mesoporous carbon synthesized was fast and non-affected by pH.
- The carbon synthesized have high removal capacity for all the reactive dyes (q_e > 200 mg/g).
- The carbon synthesized was efficient for reactive dye removal in fixed bed.

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ABSTRACT

A new mesoporous carbon (MCSG60) was developed using an inexpensive commercial mesoporous silica gel as a template and sucrose as the carbon source. The surface area, porosity and density of the carbon were determined. The material possesses a high specific surface area and pore volume accessible for most typical aqueous pollutants. The adsorbent material was tested in a batch dye adsorption system. The behaviour of three reactive dyes adsorbed onto MCSG60 was evaluated (Naphthol Blue Black, NBB; Reactive Black 5, RB5; and Remazol Brilliant Blue R, RBBR). The maximum adsorption capacities obtained for the dyes were: 270 mg/g for NBB; 270 mg/g for RB5; and 280 mg/g for RBBR. Kinetic studies indicated that the adsorption process onto the mesoporous carbon was rapid and that equilibrium was reached in less than 1 h for all the dye systems investigated. Further batch experiments showed MCSG60 successfully adsorbed the dyes over a wide pH range and at low adsorbate concentration. The adsorption potential of MCSG60 for dye removal was further evaluated using a fixed-bed adsorption column.

1. Introduction

Industrial users are responsible of more than a half of global water consumption and water pollution [1]. Industrial effluents typically contain substances that cannot be removed by conventional treatment processes, moreover some of the effluents are subjected to special regulations because of their high toxicity [2], this is the case with dyes [3]. Azo dyes are synthetic organic compounds widely used in textile and paper industries [4], the most common of which are reactive dyes [5]. The worldwide annual production of dyes is more than 7×10^5 tonnes [6] and the loss of some reactive dyes in the dying process can be as high as 50% [7].

Dyes are among the pollutants that have severe restrictions on disposal [8]. In order to meet the current regulations, industries have to employ technologies to reduce pollution prior to discharge. They are typically classified as physical, chemical and biological treatment [9]. The treatment method selected will depend primarily on the pollutant concentration, the effluent flow and the discharge body.

Reactive dyes present high solubility and low biodegradability. For these reasons, conventional physiochemical techniques are not capable for reactive dye removal. Therefore adsorption may be employed for the treatment of reactive dye waste [10,11]. Adsorption has significant advantages: low operating cost, high flexibility, simple design and operation, easy automation, lack of sensitivity to toxic pollutants and the capability to operate at very low concentrations [12]. However, it also has some disadvantages: it is a non-destructive technique and it has a high initial cost [9].

Therefore, adsorption technology should be applied to processes that have low concentrations of pollutants or when the adsorbent has a low cost or can be easily regenerated. Different adsorbents have shown potential for pollutant removal in wastewater treatment but activated carbon is by far the most widely used. This is due to activated carbon's high internal surface area and porosity, and its surface chemical properties that provide a high adsorption capacity [13]. However, uses are limited because

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