



## Optimization of Fe<sub>2</sub>O<sub>3</sub>@BC-KC composite preparation for adsorption of Alizarin red S dye: Characterization, kinetics, equilibrium, and thermodynamic studies

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### ABSTRACT

Optimization of the preparation conditions of Fe<sub>2</sub>O<sub>3</sub>@BC-KC composite was investigated. The adsorbent preparation involved chemical impregnation with FeCl<sub>3</sub> and subsequent thermal activation. Calcination temperature, calcination time, mixing ratio, and heating rate were the independent variables. The adsorption efficacy of Fe<sub>2</sub>O<sub>3</sub>@BC-KC was assessed with Alizarin red S (ARS) dye uptake and the best result was obtained at calcination temperature of 611 °C, calcination time of 102 min, mixing ratio of 3.0:1 w/w of BC/KC, and heating rate of 10.85 °C/min. The adsorbent was characterized by X-ray diffraction (XRD), Fourier transform infrared (FT-IR) spectroscopy, and scanning electron microscopy (SEM). Furthermore, the highest grade Fe<sub>2</sub>O<sub>3</sub>@BC-KC was used to carryout batch adsorption studies for ARS at different levels of time, solution pH, adsorbent dosage, and adsorption temperature. An optimum adsorption capacity of 174.9 mg/g was recorded at 0.25 g/L Fe<sub>2</sub>O<sub>3</sub>@BC-KC dosage, pH of 2, and Temp. of 45 °C, and 90 min adsorption time. Similarly, optimum removal rate of 98.7% was obtained at 1.75 g/L Fe<sub>2</sub>O<sub>3</sub>@BC-KC dosage, pH of 2, and adsorption time of 90 min. The kinetic data was well fitted into the pseudo second order model, while the equilibrium data was most suitably described by Redlich-Peterson three parameter isotherm model. Consequently, the process was adjudged to be monolayer with uniformly distributed affinity for ARS molecules. Mechanistic studies revealed that although intraparticle diffusion took part in ARS adsorption, external mass transfer majorly controlled the process. Thermodynamic parameters ( $\Delta G^\circ$ ,  $\Delta H^\circ$  and  $\Delta S^\circ$ ) revealed that the adsorption of ARS on the Fe<sub>2</sub>O<sub>3</sub>@BC-KC composite was a favorable, spontaneous, and endothermic chemisorption process.

### 1. Introduction

Rapid industrialization and growing population have resulted in

some significant deterioration of the general security of our aquatic ecosystems (Ohale et al., 2020). Textile industries are among the highest consumers of water, and as such, produce an almost equivalent amount

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