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SYNTHESIS AND ENCAPSULATION OF BIOMATERIALS FOR THEIR USE AS SORBENTS

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ABSTRACT

The aim of this study is to prepare bio-adsorbent beads from pomegranate peel, calcium alginate for the removal of two cationic dyes and a heavy metal in batch system. In order to increase the adsorption properties of Alg-PP beads, porous beads Alg-CaCO₃-PP were prepared with calcium carbonate as the pore forming agent. Adsorbent identification was carried out using a variety of analyses, including elemental analysis, infrared spectroscopy (FTIR), X-ray diffraction (XRD), specific surface area (BET), scanning electron microscopy coupled with (EDS-SEM) and physicochemical analysis. The experimental results indicated that the removal efficiency of RB improved from 23% to 95% when utilizing Alg-PP and Alg-CaCO₃-PP beads, respectively. The influence of contact time, initial concentration, initial pH, adsorbent dosage, and temperature was examined via batch experiments. For the adsorption onto PP, the equilibrium time was fast which. The data demonstrated that the adsorption kinetics of SO attained equilibrium within 30 minutes and extended to 180 minutes, while the adsorption of CrVI take a long time to reach equilibrium within 24 hours and extended to 30 hours on Alg-PP beads. The equilibrium time for RB adsorption on Alg-CaCO₃-PP was attained at 2 hours. The adsorption is dependent on concentration, with a slight influence of pH for the beads, while the adsorption on the PP is pH dependent. The adsorption data of PP and the synthesized beads adhered to the pseudo second-order model, whereas, for adsorption of RB and CrVI onto Alg-CaCO₃-PP and Alg-PP beads respectively adhered to the pseudo-first order. Adsorption isotherm studies aligned for the Temkin, Langmuir, Freundlich, and D-R adsorption isotherms indicating that multilayer physisorption on top of the previously chemisorbed layer played a significant role in the multi-mechanistic SO dye adsorption by PP with $q_m = 152.67$ mg/g. The experimental data aligned closely with the Langmuir model, indicating the favorable nature of SO adsorption onto Alg and Alg-PP with 33.25 and 30.769 mg/g respectively. Physical and chemical adsorption was attained for CrVI onto PP, while its adsorption on Alg-PP followed by D-R and Temkin isotherms suggesting that the adsorption is chemical with q_m calculated from D-R of 11.67 mg/g. The adsorption of RB on PP and the porous Alg-caCO₃-PP were described well by the Freundlich model indicating that the adsorption is homogenous monolayer process. Central Composite Design (CCD) was employed to optimize process variables, including initial CrVI concentration, solution pH, and adsorbent dosage, regarding the efficacy of percentage removal. The calculation of Gibbs free energy and enthalpy demonstrated that the adsorption of SO and CrVI onto the adsorbents is spontaneous and endothermic, except for RB adsorption which is non-spontaneous and endothermic. The removal efficiency was determined to be 88% during the initial cycle and declined to 71% by the conclusion of the seventh cycle, the regeneration of Alg-PP loaded CrVI and Alg-CaCO₃-PP loaded RB showed a slight decrease for ten consecutive cycles. This indicates the high performance and reusability of these beads in the removal of organic and inorganic pollutants from water. The findings indicated that the prepare beads serve as an innovative natural adsorbent for the extraction of concentrated solutions of dyes and metal ions from liquid effluents, and may potentially be employed to eliminate various pollutants from wastewater in the future.

Keywords: Alginate, Pomegranate, Adsorption, Dye, Beads, Porous, Hexavalent chromium.

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