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Multifunctional β-Cyclodextrin-EDTA-Chitosan Polymer Adsorbent Synthesis for Simultaneous Removal of Heavy Metals and Organic Dyes from Wastewater

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Abstract : Heavy metals and organic dyes are the major sources of water pollution. Herein, a trifunctional β−cyclodextrin−ethylenediaminetetraacetic acid−chitosan (β−CD−EDTA−CS) polymer was synthesized using an easy and simple chemical route by the reaction of activated β−CD with CS through EDTA as a cross-linker (amidation reaction) for the removal of inorganic and organic pollutants from aqueous solution under different parameters such as pH, time effect, initial concentration, reusability, etc. The synthesized adsorbent was characterized using powder X-ray diffraction, Fourier transform infrared spectroscopy, field scanning electron microscopy, energy dispersive spectroscopy, Brunauer-Emmett-Teller (BET), thermogravimetric analyzer techniques to investigate their structural, functional, morphological, elemental compositions, surface area, and thermal properties, respectively. Two types of heavy metals, i.e., mercury (Hg^{2+}) and cadmium (Cd^{2+}), and three organic dyes, i.e., methylene blue (MB), crystal violet (CV), and safranin O (SO), were chosen as inorganic and organic pollutants, respectively, to study the adsorption capacity of β-CD-EDTA-CS in aqueous solution. The β-CD-EDTA-CS shows a monolayer adsorption capacity of 346.30 ± 14.0 and 202.90 ± 13.90 mg g^{-1} for Hg^{2+} and Cd^{2+}, respectively, and a heterogeneous adsorption capacity of 107.20 ± 5.70, 77.40 ± 5.30 and 55.30 ± 3.60 mg g^{-1} for MB, CV and SO, respectively. Kinetics results followed pseudo-second order (PSO) kinetics behavior for both metal ions and dyes, and higher rate constants values (0.00161–0.00368 g mg^{-1} min^{-1}) for dyes confirmed the cavitation of organic dyes (physisorption). In addition, we have also demonstrated the performance of β-CD-EDTA-CS for the four heavy metals, Hg^{2+}, Cd^{2+}, Ni^{2+}, and Cu^{2+}, and three dyes MB, CV, and SO in secondary treated wastewater. The findings of this study indicate that β-CD-EDTA-CS is simple and easy to synthesize and can be used in wastewater treatment.

Keywords : adsorption isotherms, adsorption mechanism, amino-β-cyclodextrin, heavy metal ions, organic dyes
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