Chitosan-bentonite biocomposite as an environmentally-benign adsorbent for Ciprofloxacin removal from aqueous solutions

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KEYWORDS

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SHORT SUMMARY

A chitosan – Calcium bentonite biocomposite was formed and thermally acid activated to optimize its surface adsorption characteristics. The prepared biocomposite benefits from both the biodegradability and functionality of chitosan on one hand and the abundance and surface characteristics of the clay on the other hand.

EXTENDED ABSTRACT

Background

Recently, there has been a crucial need to find eco-friendly materials to remove pollutants released into the aquatic environment. The clay minerals are natural inorganic materials with layered structures used for wastewater treatment [1, 2]. Of such materials, calcium bentonite is the most abundant clay in Egypt [3]. In this study, the bentonite clay (bent) was thermally acid-activated and the activation conditions were optimized to enhance the surface adsorption characteristics of the clay, and allow for the intercalation of the chitosan (CS) biopolymer into the gallery of bentonite to form CS-bent biocomposite.

Methodology

The composite was characterized by Fourier Transform Infrared (FTIR) spectroscopy, Scanning Electron Microscopy combined with Energy-Dispersive X-ray spectroscopy (SEM-EDX), Dynamic Light Scattering (DLS) and Thermogravimetric Analysis (TGA).

Results

DLS measurements showed that the CS-bent composite possesses a zeta potential ranging from 15.5 to -34.4mV at a pH range of 2.22-10. FTIR spectra exhibited peaks at 3621, 3400, and 1121 cm^{-1} assigned to Al-OH octahedral sheet, water molecules interlayer spaces, and Si-O tetrahedral sheet, respectively. Another peak appeared at 2900 cm^{-1} and was assigned to the CH aliphatic stretching in chitosan. TGA revealed the thermal stability of the composite within the temperature range of 25-800 °C. SEM-EDX analysis confirmed that the layer structure of clay consisted mainly of silica and aluminum sheets at 2:1 ratio, with trace cations such as iron, magnesium and water molecules entrapped between the interlayer spaces of clay. Adsorption studies were performed to remove the antibiotic ciprofloxacin HCl (CPX) from aqueous solutions using CS-bent at pH 5.5 to promote possible electrostatic interaction between the oppositely-charged

CPX and CS-bent. The adsorption capacity (q_e) for CS-Bent reached about 42 mg/g while the percent removal was about 91% at an initial concentration of 50 pp and an adsorbent dose of 1.067 g/L. Effects of initial concentration and adsorbent dose were performed at ranges of 10-50 ppm and 0.267-4.267 g/L, respectively. They revealed that the percent removal increased up to 98.3% and 99.2% upon decreasing the initial concentration to 20 ppm and increasing the adsorbent dose to 4.267 g/L. However, q_e was observed to decrease; in response to these changes to about 18.4 and 11.6 mg/g, respectively. Adsorption isotherm showed a linear fitting to Langmuir model with a maximum adsorption capacity of about 50 mg/g at pH 5.5 and temperature of 25 °C indicating a monolayer and homogenous adsorption.

Conclusion

The prepared biocomposite benefits from both the biodegradability and functionality of chitosan on one hand and the abundance and surface characteristics of the clay on the other hand.

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