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Chitosan@Succinic Acid: A green adsorbent for Diclofenac removal from wastewaters

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INTRODUCTION

In last decades, the interest of scientist focused on chitosan modification. Chitosan is a natural cationic polymer which is a low-cost material, non-toxic, biodegradable and offers antimicrobial and adsorbent prosperities. Moreover, chitosan provides two different functional groups, -NH_2 and -COOH that create new chemical bonds with other smaller chemical compounds to improve mechanical properties and adsorption capacity. Many researchers studied the chitosan modification with dicarboxylic acid such as itaconic acid, citric acid, malonic acid. In this study, the modification of chitosan with a tricarboxylic acid, i.e. succinic acid, was tested. In literature there are numerous research articles that refer the chitosan modification with succinic anhydrate. However, succinic acid is less toxic (succinic acid is a GRAS-approved food additive by the FDA) than succinic anhydrate and make the new adsorbent Chitosan@Succinic acid (CS@SA) more environmentally friendly. In this work, CS@SA was synthesized and characterized via FTIR technique. Thereafter, CS@SA was investigated for diclofenac removal. Batch experiments evaluated the effect of pH, kinetic and isotherm studies.

Chemical structure

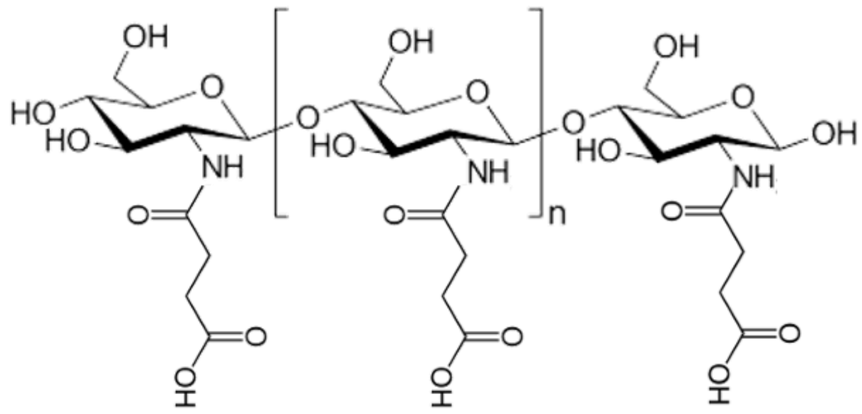

Figure 1. Chemical structure of CS@SA

RESULTS & DISCUSSION

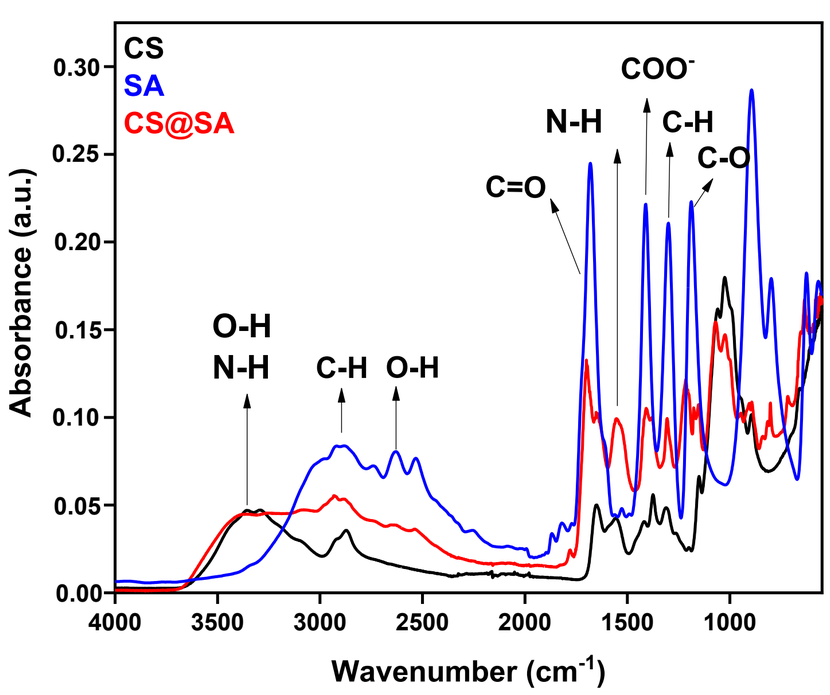

Figure 2. FTIR spectrum of CS, SA and CS@CS

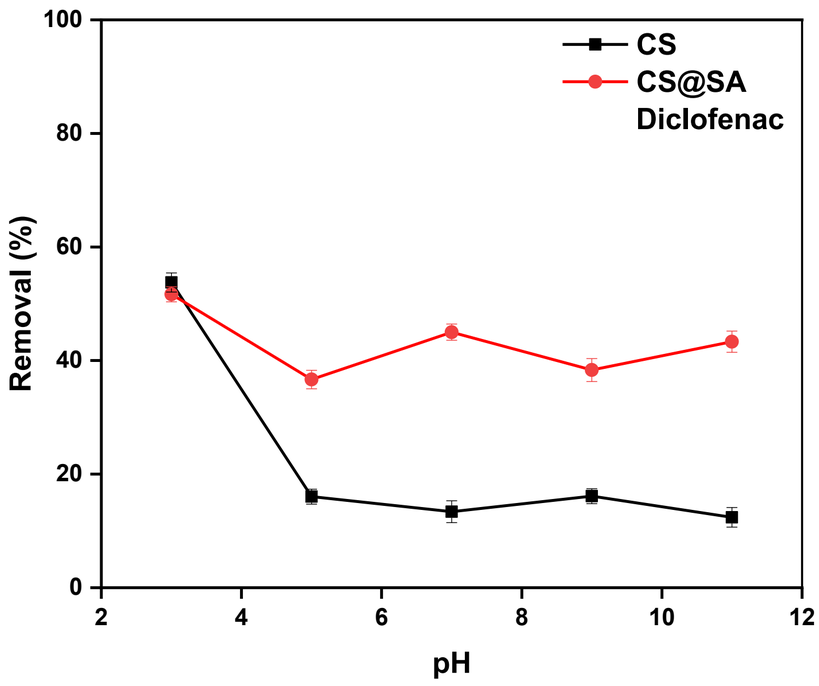

Figure 3. Effect of pH of removal diclofenac from CS and CS@SA (C_0= 50 mg/L, t = 24h, T=30°C)

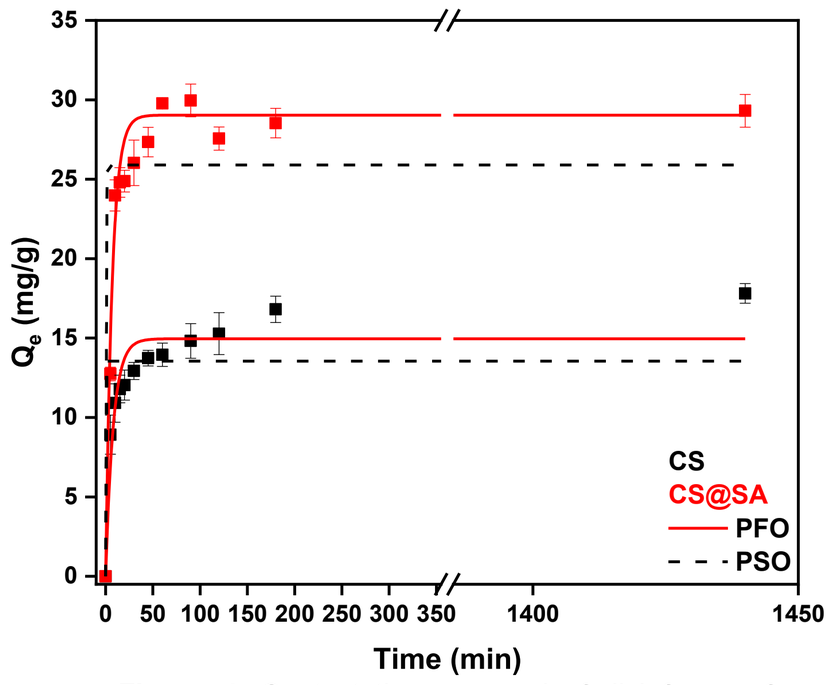

Figure 4. Contact time removal of diclofenac of CS and CS@SA adsorbents (C_0= 50 mg/L, pH 7, T = 30°C)

The FTIR analysis (Figure 2) demonstrates that the N–H bond vibration, which is absent in the SA spectrum and appears weakly in the CS spectrum, is prominently observed in the CS@SA spectrum. This vibration, recorded at 1546 cm^{-1}, confirms the formation of a chemical bond between CS and SA.
Figures 3, 4, and 5 present the results of diclofenac removal using the adsorbent materials CS and CS@SA. The maximum pollutant removal was achieved at neutral pH (Figure 4), with removal efficiencies of 13% and 45% for the respective adsorbent materials. The kinetic study (Figure 5) showed that the PFO model provided the best fit (R^2 = 0.954) for the CS@SA material, indicating that the process follows a physisorption mechanism. Finally, the isotherm study (Figure 6) demonstrated that the Langmuir model fits the experimental data best, confirming that the adsorption occurs as a monolayer process.

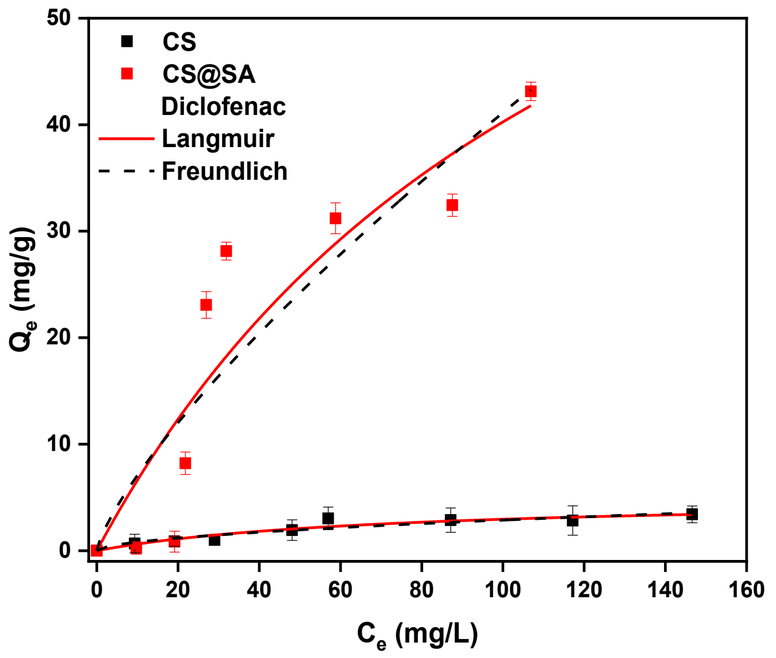

Figure 5. Isotherm study of diclofenac from CS and CS@SA (C_0=50 mg/L pH 7, t 120 min, T=30°C)

CONCLUSION

In this study, chitosan was chemically modified with succinic acid for the removal of diclofenac. FTIR spectroscopy confirmed that succinic acid was successfully grafted onto the polymeric chain of chitosan. The optimal experimental conditions were found to be pH 7 and a contact time of 120 min, following the physisorption model. The adsorption process was determined to be monolayer, with adsorption capacities of 0.78 mg/g for CS and 97 mg/g for CS@SA, respectively.

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