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Synthesis and Characterization of New Adsorbent Materials Obtained from Modified Thyme for Diclofenac Removal in Advanced Pharmaceutical Effluent Treatment

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ABSTRACT

The purpose of this study was to evaluate the efficiency of new adsorbent material derived from thyme activated with sodium hydroxide and encapsulated with alginate at an optimal ratio. Characterization of these materials involved Fourier transform infrared spectroscopy (FTIR) and isoelectric point determination (pHpzc). Their adsorptive properties were then evaluated in batch mode for the removal of the emerging pollutant diclofenac (DC) from pharmaceutical effluent. Various parameters, including the initial pollutant concentration, solution pH, biomass quantity, and contact time, were systematically examined to gauge their impact on effectiveness. Characterization revealed the significant presence of hydroxyl (OH) and carboxylic group peaks, both integral to the adsorption process. The determined pHpzc was 8.2. Results demonstrated that the adsorption kinetics of DC onto the new adsorbent was most accurately described by the pseudo-second-order model. Under optimized conditions (pH 6, stirring rate of 150 rpm, adsorbent mass of 100 mg, and equilibrium time of 5 h), the maximum adsorption capacity reached 280 mg/g, with an efficiency of 82%. These findings underscore the practical and economic potential of utilizing thyme for the decontamination of water polluted with diclofenac.

Keywords: Adsorption; Biomasse; pharmaceutical effluent; Diclofenac.

1 Introduction

Pharmaceuticals are known to increase life expectancy, and as a result, their consumption has increased. They are often detected in surface, waste, and groundwater, and are referred to as emerging contaminants. The rise in diclofenac (DF) consumption, improper disposal of this pharmaceutical, and its low removal efficiency in wastewater treatment plants have led to the detection of this emerging contaminant in various environmental compartments, particularly in water resources. DF can be toxic to several organisms depending on its concentration. Efficient adsorbents such as clay materials, activated carbon, biochar, and polymer-functionalized nanocomposites are commonly used for pollutant removal. Biosorbents are a more cost-effective option for removing emerging pollutants due to their abundance, low cost, and high biosorption capacity compared to other typical adsorbents. Agricultural biomass is often used to produce adsorbents or biosorbents as it requires no additional nutrients to grow and poses no toxicity risks. The thymus can be easily prepared. In this study, we characterized the modified thymus and used it for the adsorptive removal of DF.

2 Experimental

The adsorbent used in this study is thyme chemically activated by a 0.1 M sodium hydroxide solution. It was then used in the study of the elimination of diclofenac DF, an emerging pollutant of pharmaceutical origin present in pharmaceutical effluents, by adsorption.

The adsorption study was carried out in batch mode by studying the adsorption kinetics and isotherms by

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studying the parameters of equilibrium time, adsorbent mass and pollutant concentration in order to determine the optimum conditions for maximum reduction of DF.

3 Results and Discussion

The results of the batch adsorption study of DF elimination on chemically active thyme showed an equilibrium time of 5 h at room temperature, a DF concentration of 20 mg/L and an adsorbent mass of 100 mg. The adsorption isotherms showed an elimination rate of 90% under these conditions. Modelling of the results gave the best correlation with the first-order model for the kinetics and the Langmuir model for the isotherms.

4 Conclusions

The aim of this work was to study the elimination by adsorption of diclofenac, an emerging pollutant of a pharmaceutical nature, on an adsorbent that is abundant in our country, thyme, chemically activated by sodium hydroxide. These results confirm the practical and economic benefits of using thyme to clean up water contaminated by pharmaceutical pollutants.

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