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Modified Nanocellulose-Based Adsorbent from Sago Waste for Diclofenac Removal

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Abstract: A nanocellulose-based adsorbent was successfully synthesized via a hydrothermal process. It was characterized by X-ray diffraction, Fourier Transform Infrared Spectroscopy, Field Emission Electron Microscopy and Brunauer–Emmett–Teller surface area analysis. Photocatalysis has the best potential to replace the conventional wastewater treatment technology through the photodegradation of organic contaminants. This study focuses on the preparation of a photocatalytic adsorbent of nanocellulose prepared from sago waste for the removal of diclofenac from industrial wastewater. Its photocatalytic activity was evaluated through the degradation of diclofenac (100 mg/L) under ultraviolet (UV) light. The effect of different loadings of TiO_2 and kinetics on the photocatalytic activity was investigated. To study its removal, the experiments were carried out under UV light with different contact times ranging from 30 to 120 min at room temperature. The maximum removal percentage was found to be 57.5% for 200 µL of TiO_2, and this increased up to 82.4% for 800 µL of TiO_2. The maximum removal capacity was found to be 13.3 mg/g. The kinetics was well fitted with "pseudo-first order model" (PSO). Kinetic analysis using the PSO model at 100 ppm of diclofenac sodium gave a value of equilibrium adsorption capacity, qe of 13.52 mg/g. The adsorption kinetics gave a value of calculated equilibrium adsorption capacity, qe of 13.52 mg/g using different non-linear regression plots. It obeyed a pseudo-first-order reaction with the lowest AICc, RSME values of 0.56 and 0.53 and the highest correlation coefficient, R^2, of 0.99. Three kinetics models were fitted for the current adsorption kinetics data, and their suitability was inferred as the following: pseudo-first-order > pseudo-second-order > Langmuir–Hinshelwood.

Keywords: nanocellulose; magnetite; titanium dioxide; photocatalyst; kinetic study; diclofenac

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1. Introduction

Diclofenac (DCF) is widely used to treat fever, pain, rheumatoid arthritis, etc. [1–3]. The molecule is readily absorbed from the gastrointestinal tract. However, is water insoluble. DCF has been detected in µg/L in in drinking water, ground water and surface water all around the world. It can cause harmful effects on both human health and aquatic ecosystems, such as cytopathological symptoms in the gills, kidneys and liver of rainbow trout. DCF cannot be removed effectively by conventional wastewater treatment due to its stable chemical structure. Therefore, it is essential to develop more effective and sustainable treatment technologies for the removal of DCF and to treat and reuse wastewater.

Over the years, there has been increasing research into the application of nanocellulose (NC) as a smart material for water purification. Several studies have proven that NC provide greater surface areas, functional groups, water insolubility and high holding ability