Journal of Environmental Chemical Engineering 11 (2023) 111295

Contents lists available at ScienceDirect

Journal of Environmental Chemical Engineering

journal homepage: www.elsevier.com/locate/jece

A sustainable solution for diclofenac adsorption: Chitosan-modified fibrous silica KCC-1 adsorbent

L.W. Lai [a], L.P. Teh [a,b,*], S.N. Timmiati [b], N.H.N. Kamarudin [c], H.D. Setiabudi [d,e]

[a] Department of Chemical Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia
[b] Fuel Cell Institute, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia
[c] Department of Chemical and Process Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Malaysia
[d] Faculty of Chemical and Process Engineering Technology, Universiti Malaysia Pahang, Lebuh Persiaran Tun Khalil Yaakob, Gambang, 26300 Kuantan, Pahang, Malaysia
[e] Centre for Research in Advanced Fluid & Processes, Universiti Malaysia Pahang, Lebuh Persiaran Tun Khalil Yaakob, Gambang, 26300 Kuantan, Pahang, Malaysia

ARTICLE INFO

Editor: Xin Yang

Keywords:
Fibrous silica KCC-1
Modification
Chitosan
Adsorption
Diclofenac

ABSTRACT

This work aims to assess the potential of chitosan/fibrous silica KCC-1 composite in diclofenac adsorption. Fibrous silica KCC-1 was synthesized by microemulsion technique and chitosan/fibrous silica KCC-1 composite was prepared by ultrasound assisted impregnation. The physical and chemical properties were characterized by using X-ray diffraction (XRD), field emission scanning electron microscope (FESEM), thermogravimetric analysis (TGA), Fourier transform infrared spectroscopy (FTIR), point zero charge (PZC) and N_2 physisorption. The removal of diclofenac was analysed through ultraviolet-visible spectroscopy (UV-Vis) under different parameters such as contact time, pH value and initial concentration of diclofenac. The characterization results showed that chitosan/fibrous silica KCC-1 composite has an amorphous structure with dendritic morphology, good thermal stability, various functional groups such as amine and hydroxyl that act as the active site for diclofenac adsorption, large surface area of 510 m^2/g and total pore size of 0.4922 cm^3/g, as well as pH_{PZC} at pH 4.6 for efficient removal of diclofenac. The results showed that chitosan/fibrous silica KCC-1 composite can interact and adsorb more diclofenac as compared to pure fibrous silica KCC-1. Chitosan/fibrous silica KCC-1 composite gives an adsorption capacity of 142.01 mg/g whereas fibrous silica KCC-1 gives an adsorption capacity of 65.33 mg/g under the optimum contact time at 40 min, pH value of 4.0 and initial concentration of diclofenac at 160 mg/L. Langmuir adsorption isotherm and Elovich kinetic model resulted to be the best fit for diclofenac adsorption by chitosan/fibrous silica KCC-1 composite with the R^2 value of 0.9721 and 0.9597, respectively.

1. Introduction

Sustainable solutions for pharmaceutical waste removal from water sources has gained significant attention in recent years due to the growing concern about the environmental impact of pharmaceutical pollutants [1]. The rapid development in the field of modern medicine has produced many pharmaceutical wastes especially from the non-steroidal anti-inflammatory drugs (NSAID) due to the improper disposal methods. It is proven that pharmaceutical waste is being found on the surface of water that can threaten the aquatic life even in low amount and some conventional plants for water treatment cannot removes the pharmaceutical residues completely due to high solubility of these pharmaceutical wastes in water [2,3]. One common pharmaceutical pollutant that has drawn particular attention is diclofenac, a NSAID widely used to manage pain and inflammation. Diclofenac has been detected in water bodies around the world, and its persistence in aquatic ecosystems raises concerns about its potential adverse effects on aquatic life and human health [4]. Diclofenac has been detected in water effluent with a high content of 7.1 μg/L which exceeds the value of environmental quality standard (EQS) for diclofenac in water, 0.1 μg/L [5,6]. The concentration of diclofenac was found to be highest in the secondary wastewater then followed by seawater and tap water as compared to other pharmaceutical waste such as ibuprofen, ketoprofen and naproxen [7]. Diclofenac has a low biodegradability and is difficult to filter using the water treatment [3]. Thus, it may accumulate and deposit in the water which can further affect the

* Corresponding author at: Department of Chemical Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia.

E-mail address: lpteh@ukm.edu.my (L.P. Teh).

https://doi.org/10.1016/j.jece.2023.111295
Received 14 June 2023; Received in revised form 24 September 2023; Accepted 20 October 2023
Available online 21 October 2023
2213-3437/