Development and characterization of biosorbent film from eggshell/orange waste enriched with banana starch

ABSTRACT

The conversion of waste into a valuable product is regarded as a promising alternative to relieving the burden of solid waste management and could be beneficial to the environment and humans. This study is focused on utilizing eggshell and orange peel enriched with banana starch to fabricate biofilm via the casting technique. The developed film is further characterized by field emission scanning electron microscope (FESEM), energy dispersive X-ray spectroscopy (EDX), atomic force microscopy (AFM), X-ray diffraction (XRD), and Fourier transform infrared spectroscopy (FTIR). The physical properties of films, including thickness, density, color, porosity, moisture content, water solubility, water absorption, and water vapor permeability, were also characterized. The removal efficiency of the metal ions onto film at different contact times, pH, biosorbent dosages, and initial concentration of Cd (II) were analyzed using atomic absorption spectroscopy (AAS). The film's surface was found to have a porous and rough structure with no cracks, which can enhance the target analytes interactions. EDX and XRD analyses confirmed that eggshell particles were made of calcium carbonate ($CaCO_3$), and the appearance of the main peak at $2\theta = 29.65^\circ$ and $2\theta = 29.49^\circ$ proves the presence of calcite in eggshells. The FTIR indicated that the films contain various functional groups, such as alkane (C-H), hydroxyl (-OH), carbonyl (C=O), carbonate (CO_3^{2-}), and carboxylic acid (-COOH) that can act as biosorption materials. According to the findings, the developed film exhibits a notable enhancement in its water barrier properties, thereby leading to improved adsorption capacity. The batch experiments showed that the film obtained the maximum removal percentage at pH = 8 and 6 g of biosorbent dose. Notably, the developed film could reach sorption equilibrium within 120 min at the initial concentration of 80 mg/L and remove 99.95% of Cd (II) in the aqueous solutions. This outcome presents potential opportunities for the application of these films in the food industry as both biosorbents and packaging materials. Such utilization can significantly enhance the overall quality of food products.