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Kinetic and thermodynamic studies on biosorption of Ni (II) and Cd (II) by chemically modified lemon peel

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Extended Abstract

The valorization of agricultural wastes as biosorbent represents a promising circular economy strategy: a waste is applied for the treatment of wastewater containing contaminants. The removal of heavy metals from water receives an increasing attention due to their risks for the human health and the environment [1]. This work is focused on the removal of Ni and Cd encountered in aquatic systems, such as industrial effluents from battery manufacturing, electroplating and mine drainage. Even though former studies have assessed the metal biosorption using several agricultural wastes [2]–[4], there is limited results about the simultaneous biosorption mechanism of Ni and Cd. From the evaluation of the production rates of agricultural wastes reported by Food and Agriculture Organization of the United Nations (FAO) [5], lemon peel was selected due to its large production.

The characterization of the biosorbent was carried out by Attenuated Total Reflection Fourier-transform infrared spectroscopy (FTIR-ATR) and scanning electron microscopy (SEM). With the aim of improving the adsorption capacity, several chemical modifiers were proposed. Concentration of metals in samples was determined by AAS Varian SpectrAA-110. The maximum adsorption capacity was obtained treating the biosorbent surface with NaOH. Hence, the surface was treated with this reagent before performing kinetic and isotherm studies. The most influential parameters in the biosorption behaviour, such as: contact time, pH, particle size and adsorbent dosage were optimized through batch experiments. Experimental data was evaluated applying several adsorption isotherm models for single and binary metal system, such as Freundlich, Langmuir, Dubinin- Radushkevich, competitive and uncompetitive Langmuir and extended Freundlich. The kinetic essays for single and binary metal systems were carried out varying concentration at optimum conditions of pH, solid to liquid ratio and size particle. The reusability of the biosorbent was evaluated performing five consecutive adsorption-desorption cycles using HNO_3 and H_2SO_4 as desorbing reagents.

From kinetic studies, it was concluded that the uptake of Ni (II) and Cd (II) on modified lemon peel was better described by pseudo first-order model. During the first 10 minutes, it was obtained more than 90% of the maximum sorption of Ni and Cd for single metal systems (0.626 and 0.726 mmol g^{-1}, respectively, according to Langmuir isotherm) at optimum conditions (pH = 5, S/L = 5 g L^{-1}, 25 ºC). Regarding binary metal system, the reduction of adsorption capacity was more relevant for Ni (II) in presence of Cd (II) which was associated with the higher affinity of biosorbent peel for Cd (II) ions. These promising results suggested the alkali-modified lemon peel could be proposed as an inexpensive material for the remediation of wastewater polluted with several metals.

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