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JEDANAESTI SIMPOZIJUM O TERMODINAMICI I FAZNIM DIJAGRAMIMA

sa međunarodnim učešćem

ZBORNIK IZVODA RADOVA

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Jedanaesti simpozijum o termodinamici i faznim dijagramima

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SEM-EDS and thermodynamic studies of onion peels used as a biosorbent for the adsorption of Cu^{2+} ions from synthetic solutions

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Abstract

Biosorbents represent a biomass which has the ability to adsorb metal ions from water solutions. Biomass is mostly consisted of celulose, hemicelulose and lignin, as the main components. These components consist of functional groups, which give them the ability to bind metal ions into their structure [1].

In this paper, the results of SEM-EDS and thermodynamic analysis of onion peels before and after the adsorption of Cu^{2+} ions are presented. The morphology of onion peels before and after Cu^{2+} ions adsorption was examinated using a SEM scanning electron microscope (VEGA 3 LMU TESCAN) with integrated energy-dispersive X-ray detector (X-act SDD 10 mm^2, Oxford Instruments). Before the SEM analysis, the samples were steamed with thin layer of carbon to become conductive. These prepared samples were then transferred into the microscope chamber and observed at a voltage of 8 kV.

At micrographs of raw onion peels, pores and cavities can be spotted, which facilitates the penetration of the aqueous phase into the adsorbent structure, where copper ions are adsorbed at the internal active sites [2,3]. The EDS spectrum of the sample before adsorption of copper ions show the presence of O, Mg, K, and Ca.

After the adsorption of Cu^{2+} ions, it can be observed quite different morphology of the surface of onion peels. The absence of cavities and channels is evident, with compact and uniformly ordered structure. The changes in the morphology of onion peels after the adsorption of copper ions is due to the incorporation and binding of copper ions to active sites in the adsorbent structure [4]. The obtained EDS spectrum after the adsorption of copper ions demonstrated the presence of O, Ca, and Cu. The absence of Mg, and K, and detected lower levels of Ca, indicated that any of these ions could be exchanged with copper ions during the adsorption process.

Adsorption of metal ions from aqueous solutions is a reversible process, which is why a change in temperature has an impact on its development. Thermodynamic parameters, such as standard Gibbs energy change (ΔG^0), standard enthalpy change (ΔH^0), and standard entropy change (ΔS^0), are evaluated to better understand the effect of temperature on adsorption.

Thermodynamic parameters were determined by bringing into contact 0.5g of onion peels with 50 ml of a synthetic solution of copper ions with a concentration

of 0.2 g dm^{-3} at three different temperatures, 298, 308, and 318 K. The obtained ΔG^0 values were negative at 298 and 308 K, which indicated that the removal of Cu^{2+} ions from aqueous solutions using onion peels was a spontaneous process at low temperatures. The obtained positive value of enthalpy (ΔH^0 = 3.89 kJ mol^{-1}) indicated the existence of an energy barrier and endothermicity of the process [5]. Obtained negative value of entropy (ΔS^0 = -12.45 J mol^{-1} K^{-1}) indicated a decrease in the "disorder" in the liquid-solid intermediate region during the adsorption process. It is assumed that these results were a direct consequence of: (i) changes in adsorbent structure, (ii) increased mobility and depth of solution penetration within the adsorbent structure and (iii) predominance of activation energy and enhanced intraparticle diffusion [6]. The activation energy was determined to be Ea = 32.37 kJ mol^{-1}, meaning that the adsorption of copper ions onto onion peels occurred by chemisorption [7].

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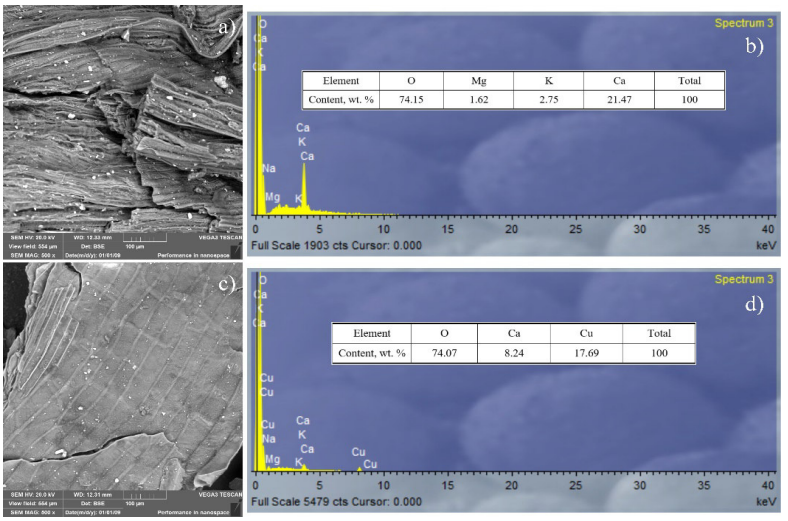
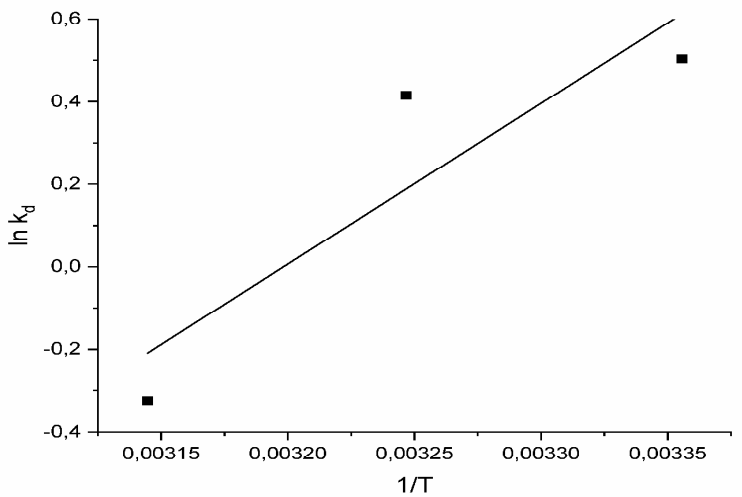
Graphical abstract:



SEM-EDS analysis of onion peels before and after the adsorption of copper ions.



Thermodynamic dependence (ln K_d = f(1/T)) for the adsorption of copper ions onto onion peels.