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Adsorption of uranium(VI) onto *Ulva sp.*-sepiolite composite

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摘要

Abstract *Ulva sp.* and sepiolite were used to prepare composite adsorbent. The adsorption of uranium(VI) from aqueous solutions onto *Ulva sp.*-sepiolite has been studied by using a batch adsorber. The parameters that affect the uranium(VI) adsorption, such as solution pH, initial uranium(VI) concentration, and temperature, have been investigated and the optimum conditions determined. The adsorption patterns of uranium on the composite adsorbent followed the Freundlich and Dubinin-Radushkevich (D-R) isotherms. The Freundlich, Langmuir, and Dubinin-Radushkevich (D-R) models have been applied and the data correlate well with Freundlich model. The sorption is physical in nature (sorption energy, E = 4.01 kJ/mol). The thermodynamic parameters such as variation of enthalpy ΔH, variation of entropy ΔS and variation of Gibbs free energy ΔG were calculated from the slope and intercept of $\ln K_d$ vs. $1/T$ plots. Thermodynamic parameters (ΔH_{ads} = −22.17 kJ/mol, ΔS_{ads} = −17.47 J/mol • K, ΔG^{o}_{ads} (298.15 K) = −16.96 kJ/mol) show the exothermic heat of adsorption and the feasibility of the process. The results suggested that the *Ulva sp*-sepiolite composite adsorbent is suitable as a sorbent material for recovery and biosorption/adsorption of uranium ions from aqueous solutions.

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Introduction

Uranium, a toxic and weak radioactive heavy metal, is relatively widespread in the environment, and as a naturally occurring element it is found at low levels in all rocks, soils and waters.[1] Uranium usually occurs in the hexavalent form as a mobile, hydrated uranyl ion. In developing adsorption techniques for uranium(VI), preconcentration are important, because uranium(VI) plays a role in many nuclear industrial application procedures for waste disposal.[2] Uranium adsorption on various solids is impotant from the purification, environmental and radioactive waste disposal viewpoints.[3] Although a large number of studies on uranium adsorption on various adsorbents have been reported[4–9] only a few of them addressed adsorption kinetics.[2]

Sepiolite ($Mg_4Si_6O_{15}(OH)_2 \cdot 6H_2O$) is a natural clay mineral with formula of magnesium hydro-silicate. Most of the world sepiolite reserves are in Turkey. The special type of sepiolite which is called 'Lületaşı' is used for hand-crafted souvenirs, such as tobacco pipes, chessman and necklaces because of its softness and whiteness. Sepiolite is a natural hydrated magnesium silicate with a wide range of industrial applications derived mainly from its sorptive properties.[10] Sepiolite is known to contain a continuous two dimensional tetrahedral sheet but differs from other tetrahedral-octahedral-tetrahedral (T-O-T) layer silicates in lacking continuous octahedral sheets. The tetrahedral basal oxygen atoms invert apical direction at regular intervals coordinating talc-like ribbons. Each talc-like ribbon alternates with channels along the fiber axis. Magnesium fills 90–100% of the octahedral positions.[11]

The unique fibrous structure allows the penetration of organic and inorganic ions into the structure of sepiolite. Naturally occurring low cost sepiolite as an ion-exchanger, it offers great potential for removing lead from industrial wastewater. Several works related to wastewater treatment using sepiolite have been performed.[12] The interaction between some heavy metals including lead and sepiolite has been studied in order to verify the heavy-metal cation sorption-desorption rates.[13] The sorption capacity of sepiolite is restricted to the external surface, which can be enhanced, by chemical[14] and heat treatment.[15] The enhanced surface area of sepiolite is given in the range of 263–350 m^2/g in the literature.[13,16,17]

Biosorption, the process of passive cation binding by dead or living biomass, represents a potentially cost-effective way of removing toxic metals from industrial wastewaters.[18] Biosorbent may be used as an ion-exchange material.[19] Researchers typically utilize dead organisms so that the metal uptake is only due to adsorption onto the algae through interactions with the chemical functional groups found on the cell wall. The biosorption of uranium and other radionuclides by algae has received attention. It seems that physicochemical interactions comprise the majority of total uptake. Adsorption occurs through interaction of the metal ions with functional groups that are found in the cell wall biopolymers of either living or dead organisms.[20] The cell wall of algal cells is surrounded by a porous three-dimensional macromolecular network. Important cell wall components are: peptydoglycan, teichuronic acid, teichoic acid, polysaccharides and proteins,[21] which display mainly carboxylic, hydroxyl and phosphate groups.[22] Most of these molecules are polyelectrolytes that carry charged groups, such as carboxyl, phosphate,

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