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Uranium and lead adsorption onto bentonite and zeolite modified with polyacrylamidoxime

期刊 [Journal of Radioanalytical and Nuclear Chemistry](#)
出版社 Akadémiai Kiadó, co-published with Springer
Science+Business Media B.V., Formerly Kluwer
Academic Publishers B.V.

ISSN 0236-5731 (Print)
1588-2780 (Online)

学科 [Physics and Astronomy](#), [Chemistry and Materials Science](#), [Chemistry](#), [Nuclear Chemistry](#), [Physical Chemistry](#), [Nuclear Physics](#), [Heavy Ions](#), [Hadrons](#), [Diagnostic Radiology](#), [Inorganic Chemistry](#)

页 1-11

DOI 10.1007/s10967-011-1415-1

Subject Group [化学和材料科学](#)

在线日期 2011年9月7日

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作者

 Selçuk Şimşek¹, Ulvi Ulusoy¹
¹Department of Chemistry, Cumhuriyet University, Sivas, 58140 Turkey

摘要

Abstract

Polyacrylonitrile (PAN) and bentonite (B)/zeolite (Z)-PAN composites were prepared by direct polymerization of acrylonitrile (AN) and AN adsorbed onto B and Z. PAN and the composites were subjected to amidoximation procedure to obtain polyacrylamidoxime (PAO), B-PAO and Z-PAO compositions. The structural features were evaluated by FT-IR, XRD and SEM analysis. The adsorption dependency of the materials on ion concentration, temperature and time were investigated for Pb²⁺ and UO₂²⁺. The adsorption capacities of B/Z-PAO composites were higher than those of pure PAO. The values of enthalpy and entropy changes were positive. The kinetics of the adsorption was well defined by the pseudo second order rate model. For the use of 1 M HCl as a regenerative effluent, the composites were reusable for five sequential treatments without any change in their structures whereas PAO completely gelled in the first use.

Keywords

Adsorption, Polyacrylonitrile, Composite, Aluminosilicate, Uranium, Lead

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Uranium and lead adsorption onto bentonite and zeolite modified with polyacrylamidoxime

Şekiz Şimşek · U. Ulsoy

Received: 20 July 2011
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Abstract Polyacrylonitrile (PAN) and bentonite (B) zeolite (Z)-PAN composites were prepared by direct polymerization of acrylonitrile (AN) and AN adsorbed onto B and Z. PAN and the composites were subjected to amidoximation procedure to obtain polyacrylamidoxime (PAO), B-PAO and Z-PAO compositions. The structural features were evaluated by FT-IR, XRD and SEM analysis. The adsorption dependency of the materials on ion concentration, temperature and time were investigated for Pb^{2+} and UO_2^{2+} . The adsorption capacities of B/Z-PAO composites were higher than those of pure PAO. The values of enthalpy and entropy changes were positive. The kinetics of the adsorption was well defined by the pseudo second order rate model. For the use of 1 M HCl as a regenerative effluent, the composites were reusable for five sequential treatments without any change in their structures whereas PAO completely gelled in the first use.

Keywords Adsorption · Polyacrylonitrile · Composite · Aluminosilicate · Uranium · Lead

Introduction

The adsorption processes are generally known to be one of the most effective techniques for removal and recovery of heavy metal ions because of the economic and environmental concerns. Adsorbents with strong affinity and high loading capacity for targeted metal ions have been developed by modifications of the surface of various substrates,

such as polymers and clays with metal complexing groups [1–3]. Whilst synthetic ion-exchange resins are expensive to use on a large scale, natural materials such as clay and zeolite are classified amongst the low-cost adsorbents [2, 4, 5].

Bentonite (B) is the clay mainly composed of montmorillonite, which is a 2:1 type of aluminosilicate. Its crystalline structure presents an alumina octahedral layer between two tetrahedral layers of silica. Compensation of the negative charges of their laminar edges by isomorphous substitutions requires cations, denominated exchange cations (Na, Ca, Mg etc.). The specific affinity of some metal cations such as uranyl to bentonite is of interest for adsorption applications [6]. Unlike bentonite, zeolites are crystalline porous solids, with pores and channel systems in the molecular size range of 300–3,000 pm. They are also tectosilicates that consist of corner sharing AlO_4 and SiO_4 tetrahedra. These physicochemical features are considered to be the basis for their immense importance in catalysis, separation, and ion exchange. Natural zeolites have ion-exchange capability to preferentially remove unwanted heavy metals. This unique property makes zeolites favourable for wastewater treatment [7].

The aggregation and coagulation of zeolite and clay particles under varying conditions of temperature and electrolytes lead variations in flow properties of these minerals. This is an undesired feature for their practical use of these minerals as adsorbents, e.g. in its column applications [8–10]. Having a composite of a mineral and a polymer might be helpful to overcome this limitation, the mineral dispersed in the polymer network may enable the use of mineral or polymer itself as an adsorbent confined in an isolated and practically usable medium in aquatic solutions. Beside this, the particles embedded in a network strengthen the structure and prevent its collapse in bad solvents. The enhancement in adsorptive features can also

S. Şimşek · U. Ulsoy (✉)
Department of Chemistry, Cumhuriyet University, Sivas 58140,
Turkey
e-mail: ulsoy@cumhuriyet.edu.tr



AKADÉMIAI KIADÓ

Akadémiai Kiadó

H-1519 Budapest, Pf. 245

Telephone: +36-1-464-8222

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