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Alanine and serine functionalized magnetic nano-based particles for sorption of Nd(III) and Yb(III)

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Abstract. Magnetic nano-based sorbents have been synthesized for the recovery of two rare earth elements (REE: Nd(III) and Yb(III)). The magnetic nano-based particles are synthesized by a one-pot hydrothermal procedure involving co-precipitation under thermal conditions of Fe(III) and Fe(II) salts in the presence of chitosan. The composite magnetic/chitosan material is crosslinked with epichlorohydrin and modified by grafting alanine and serine amine-acids. These materials are tested for the binding of Nd(III) (light REE) and Yb(III) (heavy REE) through the study of pH effect, sorption isotherms, uptake kinetics, metal desorption and sorbent recycling. Sorption isotherms are well fitted by the Langmuir equation: the maximum sorption capacities range between 9 and 18 mg REE g^{-1} (at pH 5). The sorption mechanism is endothermic (positive value of $\Delta H°$) and contributes to increase the randomness of the system (positive value of $\Delta S°$). The fast uptake kinetics can be described by the pseudo-second order rate equation: the equilibrium is reached within 4 hours of contact. The sub-micron size of sorbent particles strongly reduces the contribution of resistance to intraparticle diffusion in the control of uptake kinetics. Metal desorption using acidified thiourea solutions allows maintaining sorption efficiency for at least four successive cycles with limited loss in sorption capacity.

Keywords: rare-earth element; magnetic sorbent; nano-based particles; neodymium; ytterbium; amino-acid functionalized chitosan; sorption isotherms; uptake kinetics; thermodynamics; metal desorption; sorbent recycling

1. Introduction

The use of rare earth elements (REEs) is widespread in industry due to the increasing demand for developing photo-electronic products, but also for nuclear sector (radiation detector, plutonium "diluent", structural materials and flux controller). On the other hand, the resource for the production of these metals is distributed in a limited number of countries and China has a quasi-monopole in the commercial production of this important resource necessary to the manufacturing

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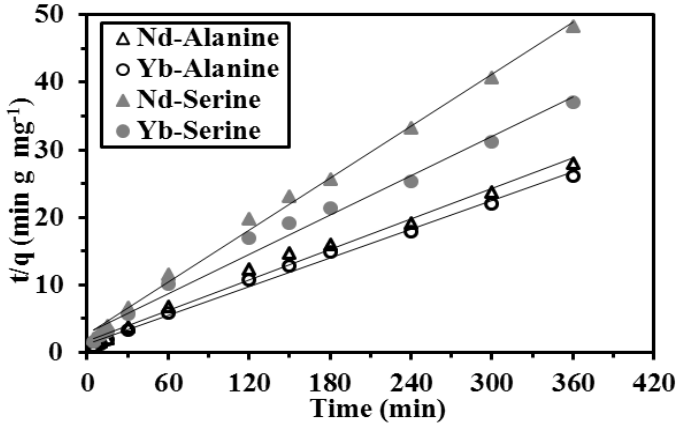

Fig. AM3 Fitting of uptake kinetics with the PSORE for Nd(III) and Yb(III) recovery using alanine and serine functionalized chitosan magnetic nano-based particles (data from Fig. 3)

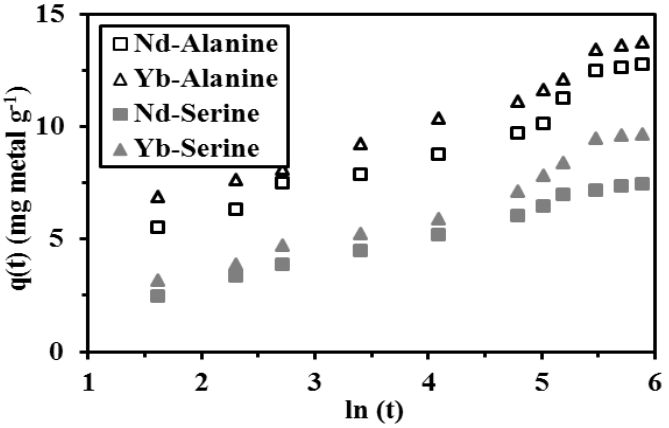

Fig. AM4 Fitting of uptake kinetics with the Elovich equation for Nd(III) and Yb(III) recovery using alanine and serine functionalized chitosan magnetic nano-based particles (data from Fig. 3)

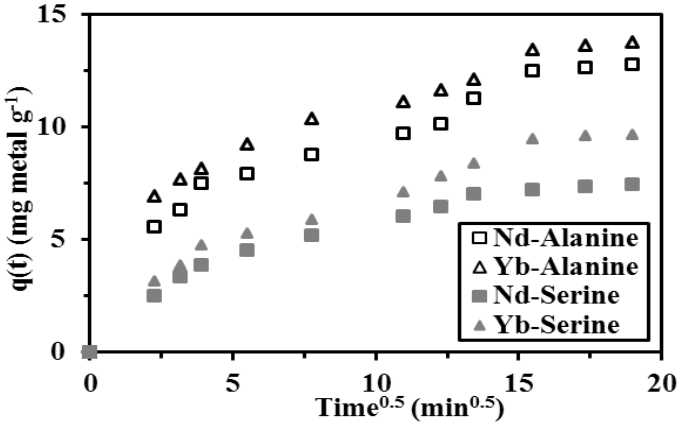

Fig. AM5 Fitting of uptake kinetics with the sRIDE equation for Nd(III) and Yb(III) recovery using alanine and serine functionalized chitosan magnetic nano-based particles (data from Fig. 3)