A Bio-Inspired Adsorbent for the Recovery of Rare Earth Elements from Wastewater

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The separation and recovery of Rare Earth Elements (REEs) from industrial process residues and wastewater streams has attracted growing interest due to the ever-increasing REEs demand and the limited supply of REEs. A Grand Challenge in REEs recovery from industrial wastewater is to develop efficient, recyclable, and sustainable adsorbents especially with tunable selectivity of REEs from other metals. In our efforts to develop high capacity chelating adsorbents for REE recovery from industrial wastewater, we report a one-pot cross-linked method for the preparation of a series of chitosan and dopamine hybrid (mass ratio 1:0.5, 1:1, 1:2) bio-inspired materials. Inspired by mussel-adhesion behaviour in nature, dopamine, a biomolecule which contains adequate catechol and amine groups and shows similar characteristics to the adhesive foot proteins secreted in the byssus of mussels, was immobilized on chitosan via one-pot synthesis by using EDTA as cross-linker. In this setting, each component of the chitosan-EDTA-dopamine has a crucial role in its functioning: Chitosan is considered as the backbone of this novel biopolymer; the dopamine groups are in charge of binding REEs; the EDTA moieties are responsible not only for cross-linking but also for the supplementation of REEs adsorption. These novel adsorbents were characterized by FT-IR, Elemental Analysis, SEM, zeta-potential, TGA, and conductometric-potentiometric titration. The REEs adsorption kinetics and isotherms were investigated by varying experimental conditions, revealing a fast and effective adsorption for La(III), Ce(III), Eu(III), and Er(III). The FT-IR, XPS and SEM mapping results revealed the importance of the catechol functional groups as the primary REE binding sites. Furthermore, the regeneration and reuse of the bio-inspired adsorbent using 0.1 M H_3PO4 were demonstrated 5 times by without a significant loss in activity. More significantly, as an example of the practical applications of REE separation, Eu(III) was successfully separated from other transition metals such as Pb(II) in a synthetic solution of wastewater produced from mining the rare earth minerals by a batch-type method using the bio-inspired adsorbent.