Recovery of Rare Earth Elements from Low-Grade Feedstocks using Engineered Bacteria

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The high demand for rare earth elements (REEs) in renewable energy technologies and electronics coupled with the uncertainity in the global supply chain necessitates the development of new approaches for REE extraction and recovery. As a step towards this goal, we developed a bioadsorption-based approach by engineering bacteria for high-density cell surface display of lanthanide binding tags, peptides that exhibit high affinity and selectivity for REEs. Systematic characterization of this bioadsorption technology through batch-scale extraction experiments using geothermal fluids and the leachates of mine tailings, electronic waste, and fly ash, highlighted several important performance features. 1) Native cell surface functional groups, in general, preferentially adsorb REEs over non-REEs and heavy over light REEs. 2) Functionalization with LBT further enhances the cell surface preference for HREEs 3) Little to no adsorption of Ca, Ba, Zn, Mg, Na, Ni, K, Mn, or Sr is observed by LBT-displayed cells, facilitating removal of these common impurities in a single adsorption/desorption cycle 4) LBT-displayed cells perform optimally within a pH range of 5-6 with an appreciable adsorption capacity at pH down to 3. 5) Engineered cells are robust to high total dissolved solid (TDS) concentrations; efficient and selective REE extraction was observed in geofluid that contains Tb at 10 ppb and TDS concentrations up to 165,000 ppm. 6) REE adsorption capacity and selectivity increase as a function of temperature up to 70 °C. Together, these data demonstrate the utility of the bioadsorption approach for REE recovery from low-grade feedstock leachates.