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Laboratory for strategic materials: Extraction, processing and utilization of strategic materials

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Rare earth elements (REEs) are classified under strategic materials, i.e., those with high demand and subject to supply risk. These elements offer unique physicochemical properties, thus they are the key component of many critical and emerging green technologies, including magnets for wind turbines and batteries for electric vehicles. Since these technologies are dominating the world to meet the GHG emission target, the demand for REEs is increasing fast, causing sustainability challenges. The current raw materials for REEs are enough to accommodate several decades of increased demand; however, bringing these sources into the supply chain is challenging. Opening a new mine and building a refinery is challenging and may take 10-15 years. Thus, it is imperative to find new secondary sources for these elements through technospheric and urban mining. Here we present efficient extraction processes based on hydrometallurgy and supercritical fluid extraction to recover REEs from industrial process residues: phosphogypsum and red mud, as well as nickel metal hydride (NiMH) batteries and neodymium iron boron (NdFeB) magnets. Our hydrometallurgical process employs a modified version of sulfuric acid leaching and subsequent impurity removal by selective precipitation. Our supercritical fluid extraction process is robust, as it relies on an inert, safe, and abundant solvent (CO_2), runs at low temperature and generates minimum waste. In all cases, we obtained more than 90% extraction efficiency for REEs. Another challenge with REEs is supply imbalance, i.e., the more critical ones are less abundant and because they occur together, there is a surplus of less critical ones, such as cerium. In a recent discovery, we showed that robust REE oxide ceramics are hydrophobic, thus they can enhance the efficiency of various industries. Research in our group is twofold: Extraction and processing of REEs from secondary sources and their utilization to fabricate super non-wetting materials with far-reaching technological impact.

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