Tapping Industrial Waste Streams to Promote a Circular Economy for Rare Earth Elements

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REEgen is building a clean, climate-smart system for bio-manufacturing rare earth elements (REE) and other critical metals using engineered, nature-based processes. We are focusing on recovering REE from secondary sources, such as recycled electronics and other post-consumer goods, to help fill the gap between supply and demand and to promote a circular economy.

REE are important components for many modern technologies including electric cars, wind turbines, nickel-metal hydride batteries, and many types of fluorescent lighting (1). Despite their criticality, less than 1% of REE are recycled world-wide (2). Many efforts are underway to develop processes for recycling REE; however, logistical challenges, such as electronics disassembly, have made this effort slow-going.

Instead, REEgen has been exploring recovery of REE from the by-products of existing metal recycling processes, including precious metal and steel recycling. In both industries, the reclaimed metal is smelted in furnaces for purification, and undesirable components go to the slag portion. Previous work identified steel slag as a potential end point for magnet-relevant REE in e-waste (3). At REEgen, we have also found that slag from recycling platinum group metals from catalytic converters (autocat) is even higher in REE – up to 3%, which is higher than some REE mines.

At REEgen, we can recover the REE from these slags with high efficiency using REEgen's proprietary bioleaching system (**See Figure**). For REE bioleaching, microbes convert sugars into a solution of organic acids, called a biolixiviant, that leaches metals from a solid matrix (4,5). This process is based on natural mechanisms that have been optimized through genetic engineering (6,7). In contrast to harsh, concentrated acids currently used in this process such as sulfuric acid and nitric acid, REEgen's biolixiviant is non-hazardous and biodegradable. For many REE feedstocks, including metallurgical slags, bioleaching is competitive with leaching using concentrated nitric acid, and the lack of hazardous wastewater production is attractive to our feedstock suppliers.

With clean technologies for REE recovery, REEgen can more easily mine from these industrial waste streams at the source of production without generating hazardous waste or incurring unnecessary shipping costs. In doing so, REEgen can manufacture recycled, US-sourced rare earth materials at a competitive price, helping to close the gap between supply and demand and support the creation of a circular economy for these critical metals.

References:

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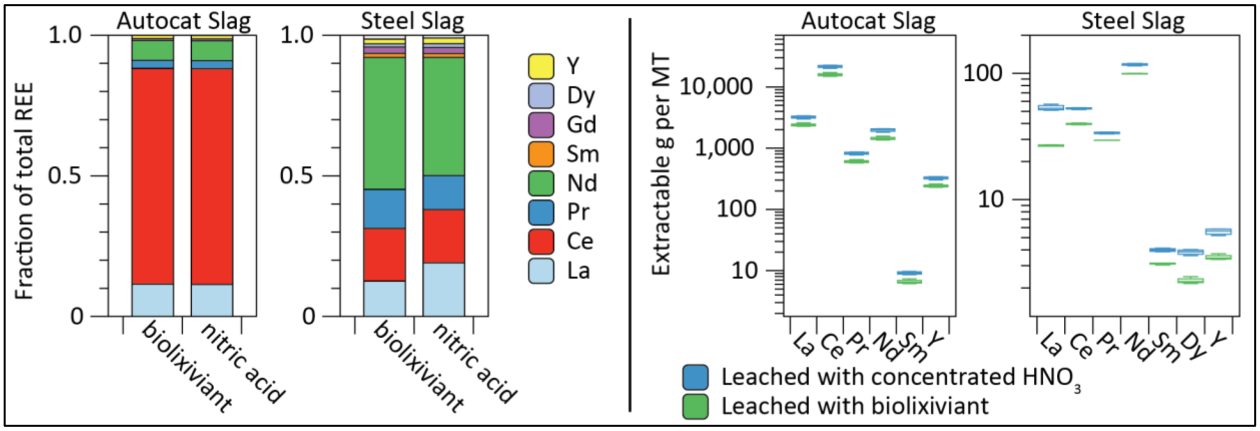

Left: *Breakdown of the different types of REE in the two types of metallurgical slags. Autocat slag has a larger fraction of cerium compared to the other REE due to the use of ceria as a ceramic in the catalytic converter honeycomb. Steel slag has a larger fraction of neodymium relative to any other REE due to the presence of REE magnets that accompany the steel components of e-waste during magnetic separation.* ***Right:*** *Extraction of the REE from the slags with REEgen's nonhazardous biolixiviant is competitive with concentrated nitric acid leaching. Also demonstrated is the very high level of REE in the autocat slag.*