Extraction of rare earths from coal ash by organic acids

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Coal combustion residues represent a potential source of rare earth elements (REE) as well as other valuable metals (e.g., gallium, indium and vanadium). These metals are critical for many modern electronics and clean energy technologies, but concerns exist over whether supplies are adequate to meet anticipated growing global demand. Recovery from coal ashes could ameliorate supply risks for these valuable elements as well as result in a beneficial use for the large volumes of coal wastes generated in the U.S. and abroad. We have been evaluating the use of organic acids as lixiviants to leach REE from coal fly ash. An advantage of organic acids is that they can be produced by heterotrophic microorganisms from wastes generated by industries such as agriculture or food processing. Finding beneficial uses for both types of waste products (coal ash and organic wastes) could result in economic and more environmentally friendly production of REE, compared to conventional methods of extraction from ores.

We have obtained fly ashes derived from combustion of an Appalachian Basin coal (560 ppm total REE) and a Wyoming Powder River Basin coal (370 ppm total REE). Thus far we have tested leaching by acetic and gluconic acid at various concentrations, at pulp densities of 10%. Preliminary data indicate that for both fly ashes gluconic acid is more effective at extracting REE than acetic acid, as would be expected from the stronger acidity of gluconic acid. Thermodynamic modeling is being used to interpret the solubilization results and also to inform lixiviant selection. In addition to assessing leaching efficiency, we have been testing whether binding by a ligand that can enhance lanthanide luminescence can be used as an effective screening tool for leaching. A positive fluorescence signal would indicate the presence of solubilized REE. We are currently evaluating the conditions under which the luminescence screening can be applied, and the extent to which it might be considered quantitative.