

Recovery of Rare Earth Elements from Coal Combustion Residuals by Leaching and Membrane-Based Separations

ROSS K. TAGGART¹, RYAN C. SMITH¹, JAMES C.
HOWER², HEILEEN HSU-KIM¹

¹Duke University, Department of Civil & Environmental
Engineering, Durham, NC USA ross.taggart@duke.edu,
ryan.smith3@duke.edu, hsukim@duke.edu

²University of Kentucky, Center for Applied Energy
Research, Lexington, KY USA james.hower@uky.edu

Coal combustion residuals are the solid wastes generated at coal-fired power plants and include fly ash, bottom ash, and sludge from flue gas desulfurization scrubbers. Collectively coal ash represents one of the largest industrial waste streams in the United States, with more than 100 million tons generated annually. Recent failures of coal ash impoundments in the U.S. has encouraged environmental policy makers to reconsider guidelines for coal ash disposal and to explore opportunities for beneficial reuse purposes.

Here, we investigated the potential to use of coal ash as an alternative resource for rare earth elements (REEs). Our previous survey of U.S. coal ashes demonstrated that the total REE content as well as the contents of high value REEs (Nd, Eu, Tb, Dy, Y and Er) varied considerably and depended on the origin basin of the feed coal. This presentation will focus on strategies to leach and concentrate REEs from coal ash. The leaching of REEs was tested with heated acid digestion methods (with HNO₃ or HCl) and with alkaline sintering prior to leaching. Parameters relevant to the scalability of the extraction methods were varied, including the alkaline additive, additive:ash ratio, and leach acid concentration. For ashes of Powder River Basin coals in the western U.S., acid digestion was the most effective method for extracting REEs, with recoveries consistently above 80 percent. In contrast, ashes originating from Appalachian coals in the eastern U.S. benefited significantly from alkali sintering with sodium peroxide or sodium hydroxide. After sinter pretreatment, REE recoveries by acid leaching improved from 30-40% to 70-100%, depending on the sample and the sintering parameters. These findings suggest that REE recovery processes can be tailored to fly ashes based on general characteristics inherited from the feed coal. Ongoing work includes the development of REE separation methods from coal ash leachates using liquid membrane-based separation processes.