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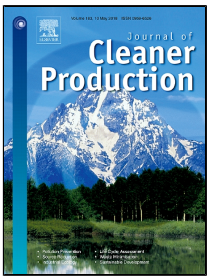

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Saptarshi Das, Gabrielle Gaustad, Ashok Sekar, Eric Williams

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Techno-economic analysis of supercritical extraction of rare earth elements from coal ash

Saptarshi Das[a*], Gabrielle Gaustad[a], Ashok Sekar[b] and Eric Williams[a]

[a]Golisano Institute for Sustainability, Rochester Institute of Technology, 190 Lomb Memorial Drive, Rochester NY 14623

[b]LBJ School of Public Affairs, University of Texas at Austin, 2300 Red River Street, E-2700, Austin TX 78712

*Corresponding author

Abstract

Given increasing demand and importance of rare earth elements (REE), exploration is underway to find alternatives to ore-extracted product. With REE concentrations varying between 270 and 1,480 ppm, coal ash has been deemed as one such potential source. A number of research groups are exploring technologies to separate REEs from coal ash and super critical extraction has emerged as a high yield contender. Estimating the economic viability of this lab-scale process at the industrial scale is both important and challenging. In this study we estimate industrial scale cost and revenues of production of REEs from coal ash by combining prior laboratory results, scaling models, combinatorial scenarios and sensitivity analysis. The processing cost of extracting REEs from one ton of coal ash using super-critical CO_2 and tributylphosphate (TBP) is found to vary between $380 and $1,200 for 550 grams of REE. The value of REE oxides that may be obtained per ton of ash is estimated to vary between $6 and $557, with a median of $250. Scandium is the most expensive REE and can account for up to 90% of the value of the yield. The results suggest that factors critical to the economic viability of the process include scandium content & yield, reagent use, and processing time.

Key Words – Rare earth elements, coal ash, super-critical extraction, techno-economic analysis

1. Background

1.1 Coal ash as a source of rare earths

Rare earth elements (REEs) are a relatively abundant group of 17 elements consisting of scandium, yttrium, and the lanthanides. REEs have received special attention in recent years due to their critical role in electronics and energy technologies and the geographic concentration of production activities. Although REEs are relatively abundant in the Earth's crust, most mining activities occur in China. In 2015, China was responsible for 85% of global production. Some other countries that produce REEs include Australia, Russia, Malaysia and Thailand. In the USA, only one company was active in REE extraction in 2015, mining and processing Bastnäsite, a fluorocarbonate mineral, from a site in Mountain Pass, California. The United States continues to be an importer