Coal Fly Ash Characterization for Rare Earth Elements Recovery

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9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

Rare earth elements (REEs) are critical to several US sectors including technology, electric vehicles, energy, and national security. Although REEs are found commonly in the Earth's crust, REE-rich ore deposits suitable for commercial mining are rare. Identifying alternative sources of REEs, therefore, is essential to ensure the sustainability of the U.S. economy. Coal fly ash, a coal combustion byproduct, serves as a potential economically-viable domestic source of REEs. Significantly, coal fly ash contains up to 2000 ppm of critical minerals and REEs. The REE-bearing minerals contained in fly ash, however, are encapsulated in glass spherules as a result of the combustion process. Thus, the identification of REEs concentrations and their spatial distribution in fly ash is necessary to design and optimize effective recovery techniques. This study focuses on the characterization and recovery of REEs from coal fly ash samples from the Illinois, Powder River, and Green River basins. Elemental composition and spatial distribution measurements are conducted using quadrupole inductively coupled plasma mass spectrometry (ICP-MS) and scanning electron microscopy equipped with energy dispersive X-ray spectroscopy (SEM-EDS). We first determine the REEs yield capacity of current surface-leaching techniques by comparing bulk REEs concentration measured in fly ash using ICP-MS, and REEs concentration measured on glass spherules surfaces using SEM-EDS. Current REEs recovery processes are estimated to extract only ~ 15% of total REEs present in the fly ash samples. As a result, we develop a new method based on total material dissolution to recover up to 99% of the available REEs. We use a novel microfluidic device, to delineate the mass transport and reaction mechanisms by which REEs are extracted. The impact of this work is three-fold: (i) to establish the total feedstock REE concentration as the baseline for future REE

recovery efficiency measurements; (ii) to enable the design of improved REEs recovery from fly ash using bulk dissolution; and (iii) to delineate the mechanisms controlling the dissolution of REEs and fly ash.

AAPG Datapages/Search and Discovery Article # 91200 © 2020 AAPG Annual Convention & Exhibition Online, Sept. 29- Oct. 1.