

Microwave Digestion for Rare Earth Elements (REE) Quantification in Coal and Coal Ash

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As the world continues to progress towards renewable energies, demand for Rare Earth Elements (REE) will increase as they are essential to clean energy technologies. One potential source for REE is coal and coal byproducts generated from coal combustion at power plants. Digestion of coal and coal ash for REE quantification involves combinations of nitric, hydrochloric and hydrofluoric acids. Traditionally the samples were first digested by a mixture of nitric and hydrochloric acids (i.e., aqua regia or inverse aqua regia) on a hotplate and then the mixture was dried up before digestion again with hydrofluoric acid to attract the silicates. The digestion process can take several days and often has incomplete digestion. Microwave digestion (MWD) is a potential candidate to replace traditional digestion methods as it can be completed in minutes to 1-2 hours rather than several days. In addition, under MWD samples can be digested at temperatures much higher than the boiling points of acids and with pressure. Further, the conditions of MWD can be optimized to increase recovery efficiencies.

In this study, we investigated REE concentrations in coal and coal ash that have been dissolved using MWD and traditional hotplate. MWD digestion uses an acid mixture of 6 mL HNO₃ + 2 mL HCl + 2 mL HF and heating to 200 °C in 15 minutes and kept for 15 minutes. The process was repeated two more times to ensure the complete digestion. The mixture can be either diluted for ICP-MS analysis if the equipment is HF resistant or dried-and-then-digested with 2% HNO₃ for analysis. The traditional hotplate digestion method involves two separate steps of digestion-and-drying processes with 6 mL HNO₃ + 2 mL HCl and 2 mL HF, respectively, both at 95 °C. The REE yields are similar for both digestion methods. Ongoing efforts are testing if pre-ashing of coal or coal ash will further improve the REE recovery.

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