Concentrating Rare Earth Elements in Acid Mine Drainage Using Coal Combustion By-products through Abandoned Mine Land Reclamation

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Two-Step Process
- Recover rare earth elements in acid mine drainage (AMD) using stabilized flue gas desulfurization material (sFGD)
- Concentrating recovered REEs using a selective extraction process to produce feedstock with >2wt.% T-REEe

AMD from Unreclaimed AMLs
- Historical environmental problem
  - Over 6,000 recorded abandoned underground mines and 119,000 acres of unclaimed surface mined lands in Ohio
  - Approximately 1,200 miles of streams are adversely impacted by acid mine drainage (AMD) from abandoned mine lands (AMLs)
  - About 4,000 miles of streams in the Appalachian Region
  - Between 5,000 to 10,000 miles of streams in the western US regions
- Reclaiming AMLs faces significant financial challenge

Using CCRs in AML Reclamation
- Ohio Coal Development Office, Ohio Dept. Natural Resources, and American Electric Power
- Full-scale demonstration project
  - Over 1.8 million tons of FGD gypsum, fGD, and fly ash
  - Environmental monitoring has been carried out for over seven years and is on going
  - Cheng et al. (2016)

Using sFGD in Reclamation of AMD-producing AML
- Potential of using sFGD material to reclaim AMD producing AMLs
  - High Alkalinity
  - Low permeability
  - Combining source control and passive treatment approaches

Laboratory Testing
- Conducting column tests to maximize the retention of rare earths in sFGD
- Analyze the mineral and elemental compositions of the spent sFGD
- Apply sequential extraction to concentrate REE in spent sFGD

Current Progress
- Collaborate with ODNR and select over 20 AMD discharges
  - Most from underground mines
  - Coal Seams #4a & #9

Tasks
- Carry out analytical and laboratory-scale studies to validate the proposed process
- Conducting column tests to maximize the retention of rare earths in sFGD
- Analyze the mineral and elemental compositions of the spent sFGD
- Apply sequential extraction to concentrate REE in spent sFGDs
- Integrate basic technological components for next phase pilot-scale study
- Field Investigation
  - Techno-economic analysis and life-cycle assessment for full-scale applications
  - Propose potential site for pilot-scale study

SFGD Material
- Hanabachite (Ca$_{x}$Si$_{y}$O$_{z}$H$_{2}$O$^{2-}$)
- Portlandite (CaOH$_{2}$)
- Hematite (Fe$_{2}$O$_{3}$)
- Quartz (SiO$_{2}$)
- Mullite (3Al$_{2}$O$_{3}$·2SiO$_{2}$)
- and Maghemite (Fe$_{3}$O$_{4}$)

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Objectives
- Validate the effectiveness and feasibility of the integrated rare earth recovery/concentrating process
- Determine mechanisms controlling the rare earth recovery
- Quantify the associated economic and environmental benefits
- Evaluate the full-scale application

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