Supercritical Fluid Extraction of Rare Earth Elements from Coal Fly Ash

SAND2021-10618C

Authors: Kenny Walker (BS Candidate in Chemical Engineering), Catherine Brewer, Ph.D. New Mexico State University, Dept. of Chemical and Materials Engineering, Guangping Xu (Sandia, 8915)

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Introduction and Motivation

Supercritical Fluid Extraction uses a solvent under temperature and pressure conditions that bring the fluid beyond its critical point.

Properties of a supercritical fluid:

- Viscosity is similar to a gas
- Density resembles that of a liquid
- Diffusivity is in between that of a liquid and gas

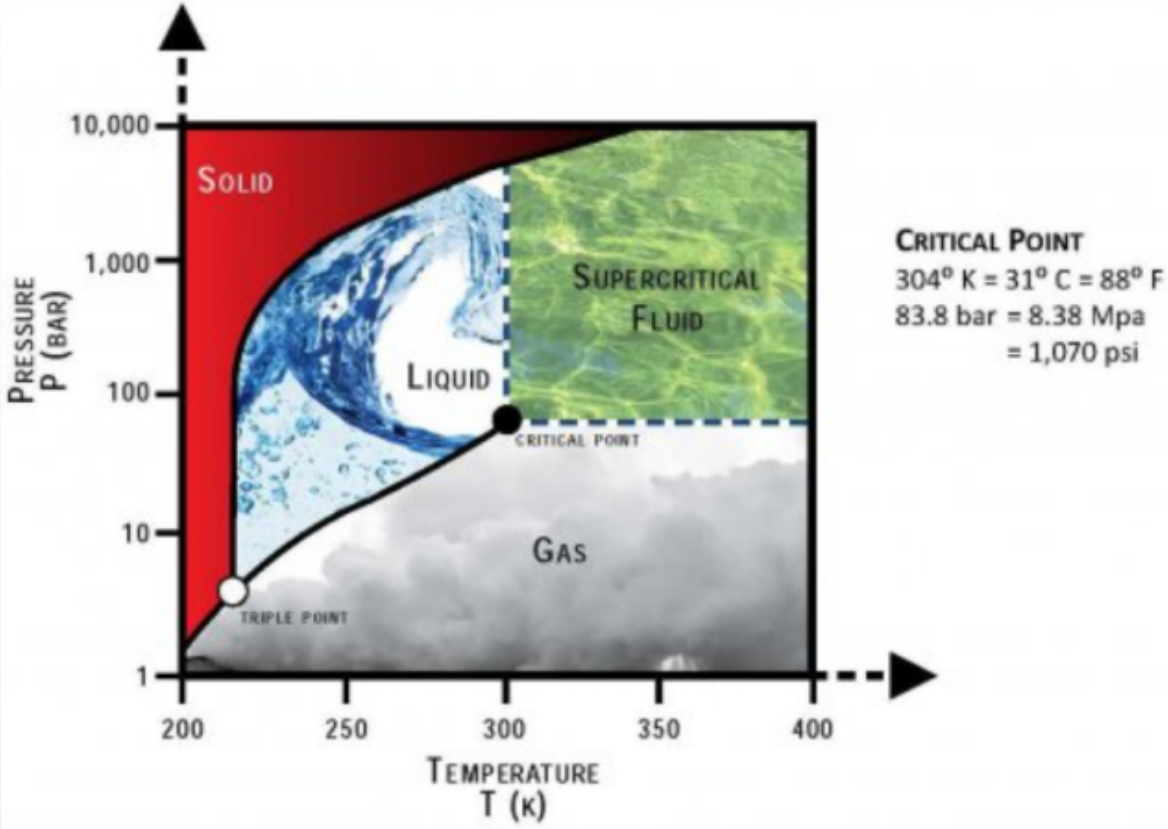

Image retrieved: https://www.energy.gov/supercritical-co2-tech-team

This work was supported by the Laboratory Directed Research and Development program at Sandia National Laboratories, a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

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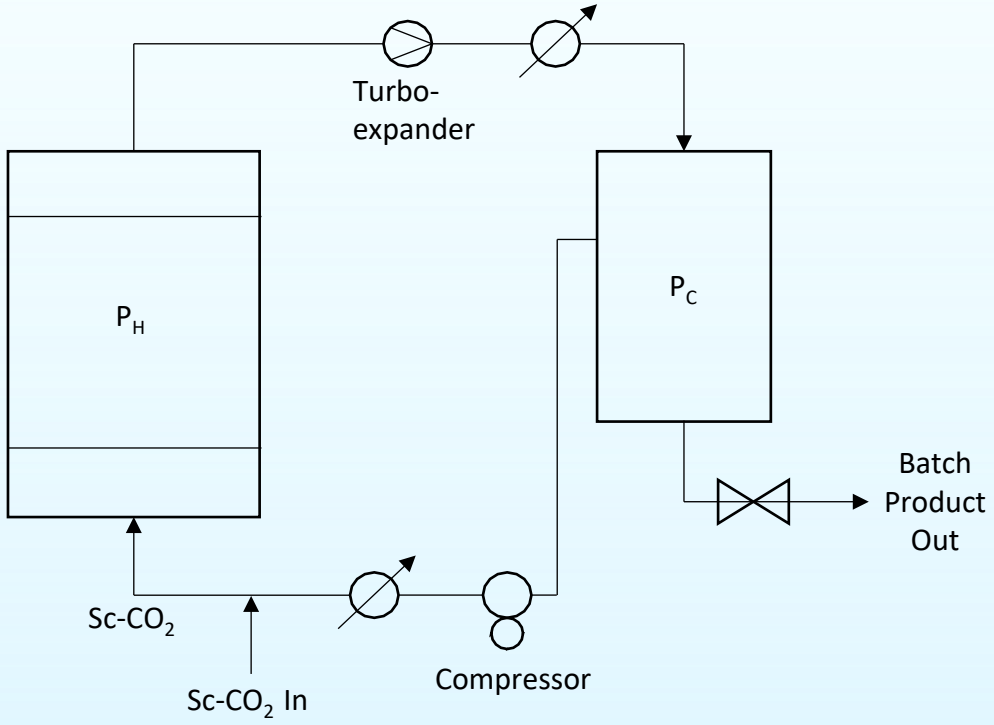
Approach

Perform the extraction of Rare Earth Elements from coal fly ash with supercritical fluid:

- Supercritical carbon dioxide (Sc-CO_2) as a solvent
- Solution includes a chelator
- Water functions as the entrainer



Batch Supercritical Fluid Extraction

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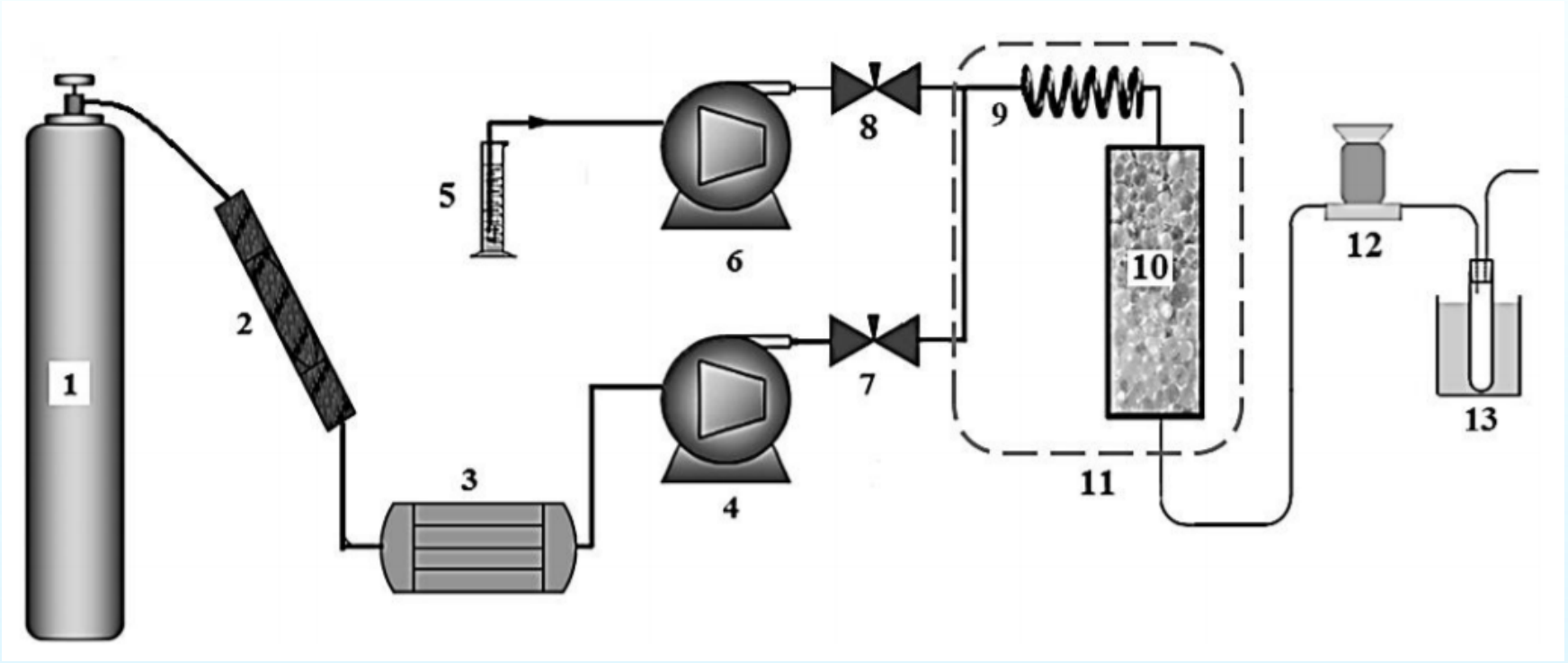
Current Status and Results (if any)

Heavy metals have previously been extracted from coal fly ash using supercritical carbon dioxide:

Zn, Pb, Cu, V, Mn, Cd, Sb, Ni, Mo, Cr, and Co



Schematic diagram of experimental setup for the supercritical extraction system.
Image retrieved: The Journal of Supercritical Fluids http://dx.doi.org/10.1016/j.supflu.2016.06.012

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Impact of Work

Concerns with solvent extraction of rare earth elements include:

- Highly concentrated acids
- Unrecyclable solvent waste
- Extractant contamination

Supercritical Fluid Extraction with CO_2

- Nontoxic solvent that is recyclable and can be collected
- Solvent contamination does not impact the final product's quality

Image retrieved: https://learn.kegerator.com/co2-questions/

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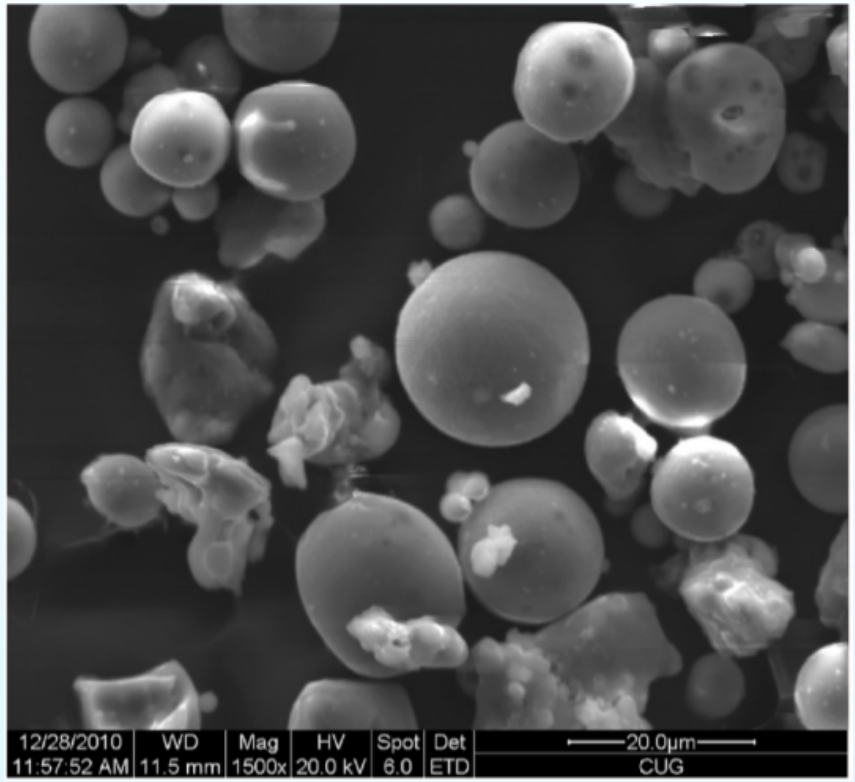
Challenges and Risks / Next Steps and Future Work

Challenges and Risks:

- Safety concerns related to high pressure
  - Strict pressure vessel specifications
  - Additional shielding and PPE
  - Ambient gas monitoring
- Supercritical CO_2 functions as a nonpolar solvent—extraction is heavily dependent on presence of polar chelator

Future Work:

- Measure wettability of coal fly ash
- Quantify extraction efficiency
- Bring supercritical CO_2 extractor online



SEM image of coal fly ash particles
Image retrieved: dx.doi.org/10.1021/ie2001378 | Ind. Eng. Chem. Res. 2011, 50, 7763–7771

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