

“A CIRCULAR ECONOMY STARTS HERE: RECYCLING CRITICAL MINERALS FROM WASTES”

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ABSTRACT

Excessive carbon emissions from fossil fuels combustion have substantially driven global warming since the pre-industrial era, causing severe climate changes. To achieve a circular economy, critical minerals such as rare earth elements (REE) are the “essential vitamins” in a wide range of clean energy technologies, including electric vehicles and wind turbines. However, REE production predominantly relies on mining, which depletes natural resources and causes severe environmental pollution. Compared to mining, recycling REE from waste streams (e.g., spent electronics, incineration byproducts) represents a promising strategy to address the growing demand while offering both economic and environmental benefits. My primary research goal is to advance the application of critical mineral recycling in practice and build a sustainable and resilient supply chain.

My research established a “knowledge-to-technology” framework that translates fundamental knowledge of critical minerals in waste streams into the development of feasible recycling technologies. The major REE-bearing mineral phases in waste streams were identified using synchrotron X-ray absorption spectroscopy (XAS) and microscopy, and their dissolution behaviors in the presence of non-hazardous organic acids (e.g., citric acid) were examined. Based on these insights, I designed a green, closed-loop treatment system that not only effectively recovers REE but also upcycles the waste byproducts to eliminate secondary pollution. This system was further modified to selectively recover multiple valuable metals, including Al, Fe, Cu, Zn, along with REE, through physical crystallization and chemical precipitation. This framework integrates advanced analytical techniques and modeling tools with experimental results. It is versatile and broadly applicable to critical minerals in diverse resources and can inform future development of mature recycling technologies.

BIOGRAPHY

Dr. Yinghao Wen is a postdoctoral researcher in the School of Earth and Atmospheric Sciences at Georgia Institute of Technology. He has a Bachelor’s degree in Chemistry from University of Wisconsin-Madison, a Master’s degree in Civil and Environmental Engineering from Northwestern University, and a Ph.D. degree in Civil and Environmental Engineering from Texas A&M University. His interdisciplinary background and skillset enable him to translate scientific discoveries into practical solutions for real-world challenges. His doctoral research focused on photocatalytic degradation of legacy and emerging pollutants in water. After completing his Ph.D., Dr. Wen expanded his research focus to the growing fields of resource and energy sustainability. To reduce the supply risks and environmental impacts associated with the development of clean energy technologies, his current research primarily centers on the recycling of critical minerals from waste streams. He is also interested in understanding the evolution of geological hydrogen in natural rock-water systems and exploring its potential to transform the existing energy infrastructure. Together, Dr. Wen’s works will support the energy transition and promote a decarbonized economy.