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Net-zero Carbon Emissions Technology for Producing Rare Earth Elements (REE) from Waste Magnets

A catalytic hydrothermal process that recovers high-purity rare earths from used magnets with hydrogen byproduct and minimal waste.

Permanent magnets, a critical component within a wide range of consumer and commercial products like electric vehicles, wind turbines, magnetic resonance imaging (MRI), and hard disk drives, are predominately composed of four rare earth elements (REEs) -- Nd, Pr, Dy, and Tb. These elements collectively account for over 80% of the total market value of REEs. The current methods for producing magnet REEs involve an energy intensive mining and purification process that separates magnet REEs from their initial ore and clay forms. This process yields 2% magnet REEs from the precursor material, which then need to undergo further purification to provide high-purity (>99.5%) material for use. Furthermore, recycling of these permanent magnets at their end-of-life is challenging due to massive amounts of toxic and non-recyclable waste that is generated. This prevents these magnets from undergoing the recycling process in the United States and results in the used magnets ending up in landfills.

To address these challenges, Purdue researchers have developed a scalable catalytic hydrothermal recycling process to produce high-purity magnet REEs from waste magnets. This process has been scaled up to pilot scale and demonstrates the production of highly pure elements from end-of-life magnets. Many of the chemicals associated with the recycling process are environmentally benign and the process is likely to be more energy efficient than traditional methods in the market as it is done at relatively modest temperatures (above 200 C). Additionally, the byproduct of this recycling process is hydrogen gas, which can be then used as clean fuel to provide energy for the hydrothermal conversion. This new technology shows potential to be a solution to the environmental issues posed by current magnet REE recycling methods.

Technology Validation:

Technology ID
2024-WANG-70345

Category
Chemicals & Advanced Materials/Specialty & Performance Chemicals
Chemicals & Advanced Materials/Green & Bio-Based Chemistry
Chemicals & Advanced Materials/Materials Processing & Manufacturing Technologies

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Parr batch reactor was used to perform small batch reactions. Waste magnets from hard disk drives were successfully recycled through the use of a potassium catalyst

Advantages:

- More energy efficient over traditional methods

- Little to no generation of waste

- High purity output of magnets

- Production of H2 for use as fuel

- Does not require grinding.

Applications:

- Clean energy

- Magnet recycling

TRL: 3

Intellectual Property:

Provisional-Patent, 2023-09-08, United States

PCT-Patent, 2024-09-06, WO

Keywords: bulk polymerization, Chemical Engineering, Materials and Manufacturing, muconate esters, photo-polymerization, polydienes, polymerization