



Innovative and sustainable materials for high temperature Thermal Energy Storage (TES) systems

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Abstract

Renewable energy, such as solar, wind, ocean and geothermal energy, plays a crucial role in mitigating climate change and the global warming effect. It is clean and available almost everywhere to meet the growing energy demand in a sustainable way, eliminating the greenhouse gas emissions caused by the exploitation of fossil fuel reserves. Among the different renewable energy sources, the sun is the most abundant. However, the intermittency and weather-dependency of solar energy make challenging its industrial application.

Thermal Energy Storage (TES) technologies tackle this challenge, acting as a link between solar power generation and optimal load distribution. TES systems can be classified as sensible, latent, and thermochemical heat storage systems, with the sensible TES systems being the only ones that have currently commercial industrial applications. However, the commercial sensible heat storage systems struggle to supply high heat temperatures, due to limitations of the used materials' thermal and mechanical stability. For example, the Ordinary Portland Cement-based materials and especially concrete, which are widely used in sensible solid-state TES systems, undergo thermal degradation at temperatures higher than 450°C. However, the decarbonization of certain manufacturing processes in energy intensive industries, such as glass, metal, and cement, make essential the development of novel, for low-cost materials that can withstand higher temperatures, offering higher storage capacity to sensible TES systems.

This work aims to investigate the use of geopolymers based on Construction and Demolition Waste (CDW) as an alternative to the Ordinary Portland Cement-based materials for TES systems that will operate at temperatures higher than 700 °C. Geopolymers are sustainable materials with very good mechanical and thermal properties and an inherent fire resistance. The development of CDW-based geopolymers was theoretically investigated in both alkaline systems, of sodium and potassium and their applicability in TES systems was experimentally evaluated. Specifically, their thermal stability at temperatures up to 800 °C was studied and basic thermal and mechanical properties, such as specific heat, thermal diffusivity and compressive strength at these temperatures, were evaluated. The experimental results of this research revealed that the developed CDW-based geopolymers are very promising materials to be applied in sensible TES systems working at high temperatures.

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