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Ceramic-salt composite materials, based on solid waste, for thermal energy storage applications.

Abstract. A high penetration of renewable energy technologies can mitigate the global dependency on non-sustainable pathways to generate energy. However, a transition to a renewable-based economy leads to a higher number of energy conversion steps throughout the energy supply chain, which necessities a coordinated optimization of energy production. The majority of energy losses throughout these conversion steps are in the form of heat. One of the most promising cost-effective technologies that can provide leverage to this problem is thermal energy storage (TES). Latent heat TES (LHTES) are a promising form of TES that have been extensively investigated in recent years and large-scale industrial deployments have been reported for peak-shaving of electricity grids, solar energy utilization and waste heat recovery. The core principle of LHTES systems is centered on thermal energy absorption/release of a material, commonly referred to as the phase change material (PCM), during its isothermal phase transition. PCMs have many advantages, but still suffer from design bottlenecks that affect their performance at both the device and system levels. This can be largely resolved by encompassing them in a porous matrix. The resulting materials are called composite phase change materials (CPCMs). The carrier materials for PCMs in CPCMs typically consist of metal, carbon, or ceramic materials. In this context, several solid wastes of industrial origin can be utilized as carrier materials for CPCMs. One of these is red mud (RM). RM is a waste of the aluminum industry with a present amount of 4 billion tones, typically compacted in dams or dykes (stockpiles). This practice is highly problematic due to its alkaline profile ($pH>10$) and traces of heavy metals. Despite efforts its present global utilization rate is only 15%. We recently combined RM with molten nitrate salts to fabricate novel CPCMs aiming at medium-high temperature thermal energy storage/management and waste heat recovery applications. The resulting combination considerably improves the thermal properties of the PCM, with only a minor reduction in energy storage density. This novel energy commodity provides a cost-effective, compact solution for high-temperature heat storage/heat recovery systems for providing industrial symbiosis solutions with a simultaneous leverage to both waste valorization and green energy transition problems.