

A new phase change material for thermal energy storage

The technologies currently used to generate energy through renewable sources such as solar, wind and biomass are still characterized by high costs and insufficient continuity of generation. Such sources will therefore continue to have a secondary role in meeting world primary energy demand while carbon dioxide emissions from the energy sector will grow by 61% over 2011 levels by 2050. To limit these emissions, it is necessary to make better use of the produced thermal energy by increasing the energy efficiency of industrial processes and by making the renewable sources more competitive respect to fossil fuels.

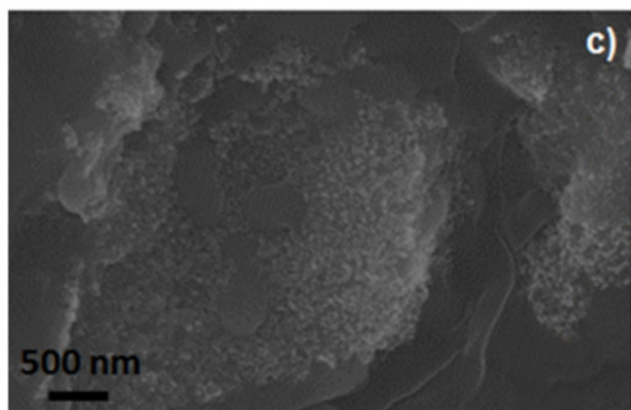
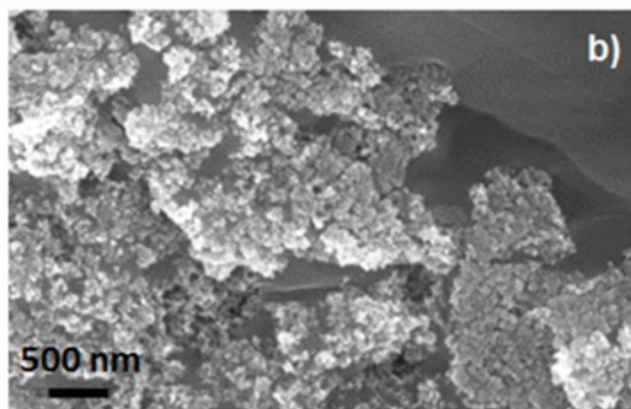
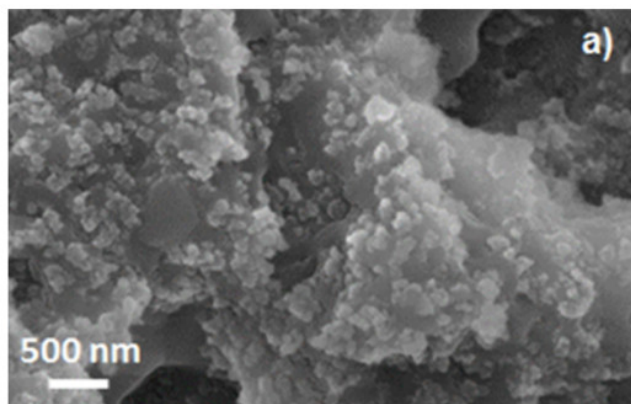


Fig. 1. SEM images at 50.000x magnification of the nanofluids based on KNO₃ with 1.0 wt.% of: (a) silica; (b) alumina; (c) silica-alumina nanoparticles.

The main disadvantage of solar energy is its intermittency linked to the presence of the sunshine and to the variability of the day/night cycle. So, research on thermal energy storage technologies is essential in concentrated solar plants to improve efficiency by reducing the costs of solar energy.

Among the various methods of energy storage, Latent Heat Thermal Energy Storage (LHTES) Systems have been gaining great importance since the storage material used can store both the sensible and the latent heat involved in a solid-liquid transformation (Phase Change Materials, PCMs). In particular solar energy can be stored in the form of heat by using high temperature molten salts as PCMs.

However, some thermal properties of molten salts need to be further improved (latent heat, thermal conductivity and specific heat that is the amount of heat per unit mass required to raise the temperature by 1°C). For this reason research is lately focused on the addition of different nanoparticles to the base salt thus producing the so called nanofluid (a concept introduced by Choi in 1995) with enhanced properties.

We developed a new nanofluid with a melting temperature in the range 300-350°C, by mixing potassium nitrate (KNO₃) as PCM (which is low cost salt with a melting temperature of 336°C, powder like at room temperature and usually used as fertilizer) with 1.0 wt.% of different nanoparticles: silica (SiO₂), alumina (Al₂O₃) and a mix of silica-alumina (SiO₂-Al₂O₃). Each nanofluid was prepared in water solution, sonicated and evaporated. The microstructures of the nanofluids showed the presence of aggregates: with silica nanoparticles they were homogeneously present while with alumina and silica/alumina also zones with pure salt could be detected (Fig. 1).

The new nanofluids obtained showed an enhanced specific heat up to 9.5% in solid phase (260-330°C) and 6% in liquid phase (350-390°C) in particular with the addition of silica nanoparticles.

Another important result was the decrease of the temperature at which the nanofluid starts to melt of about 3°C. This means that the storage material starts to adsorb energy early than the base salt giving an important advantage in energy storage. Moreover, our results show that KNO₃ with nanoparticles at 390°C can store up to 16% more energy than the salt without nanoparticles (Fig. 2).

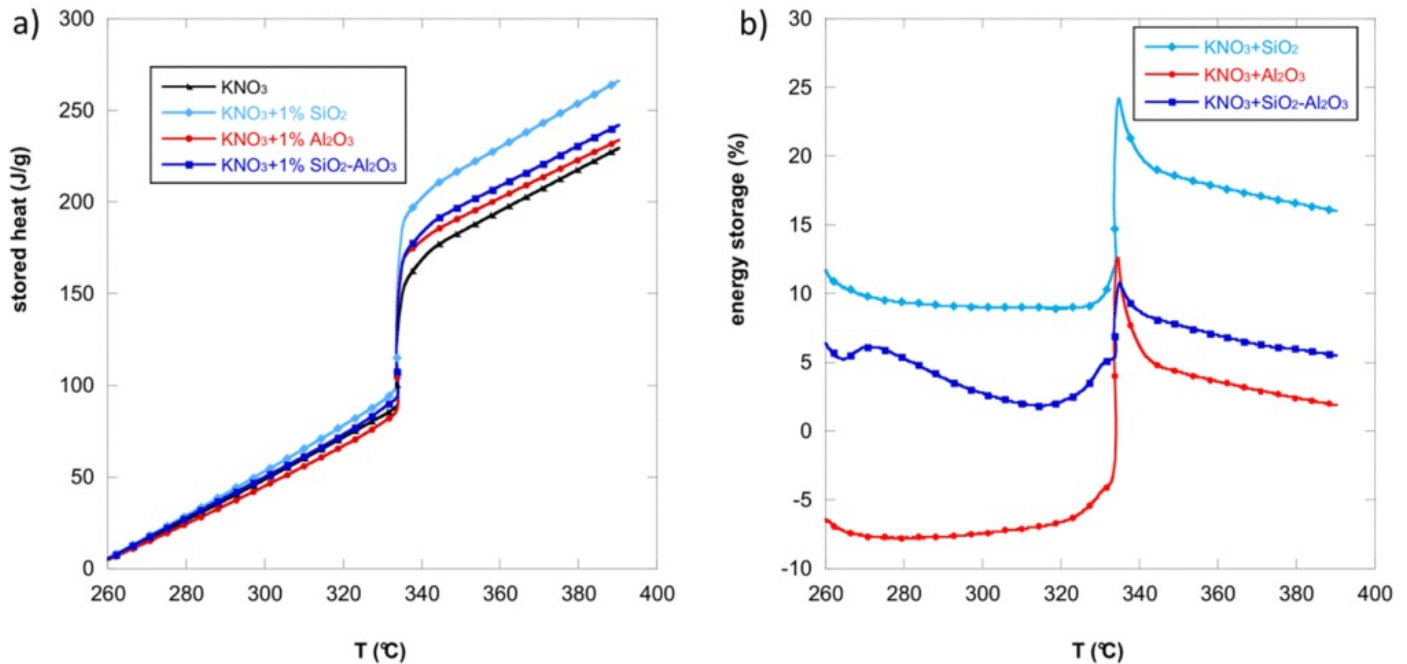


Fig. 2. Stored heat of KNO₃ and the nanofluids with 1.0 wt.% of oxide nanoparticles calculated from the integration of the heat flow curve in the range of temperatures between 260°C and 390°C (a); ratio of energy storage versus temperature calculated respect to KNO₃ (b).

The increase of these thermal properties of a storage media may allow several advantages since a high quantity of heat can be stored in a small volume of material. The increased energy density non only implies a reduction of the required amount of the storage medium but also a decrease of the size of thermal energy storage systems together with a reduction of the number of weldings, insulating material, material to contain the salt, that are needed to build up the overall storage structure. In this way the thermal storage systems become more convenient with a consequent reduction of the cost of electricity.

We believe that nanofluids can be the future in thermal energy storage systems and our research is going on in this field.

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Publication

[A New Phase Change Material Based on Potassium Nitrate with Silica and Alumina Nanoparticles](#)

[for Thermal Energy Storage.](#)

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