



## Heat-Storage Modules Containing $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$ and Graphite Foam

Heat capacity per unit volume has been increased.

NASA's Jet Propulsion Laboratory, Pasadena, California

A heat-storage module based on a commercial open-cell graphite foam (Poco-Foam or equivalent) imbued with lithium nitrate trihydrate ( $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$ ) has been developed as a prototype of other such modules for use as short-term heat sources or heat sinks in the temperature range of approximately 28 to 30 °C. In this module, the  $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$  serves as a phase-change heat-storage material and the graphite foam as thermally conductive filler for transferring heat to or from the phase-change material. In comparison with typical prior heat-storage modules in which paraffins are the phase-change materials and aluminum fins are the thermally conductive fillers, this module has more than twice the heat-storage capacity per unit volume.

The use of  $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$  as a phase-change heat-storage material is not new in itself, but heretofore, it has been used with aluminum fins. Open-cell graphite foam has been used as the thermally conductive filler material in conjunction with paraffin phase-change materials in some prior heat-storage modules but, heretofore, it has not been used with  $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$  because graphite foam is hydrophobic and, therefore not readily wet by  $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$ . The novelty of the present development lies in the choice of materials to make it possible to use graphite foam as the filler with



The **Components Shown Separately** here were assembled to make a heat-storage module. Prior to sealing the module, the open-cell graphite foam was filled with molten  $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$  containing small proportions of a surfactant and a freezing catalyst.

$\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$  in order to exploit the greater (relative to aluminum) specific thermal conductivity of graphite to reduce the mass of filler needed to obtain a given level of thermal performance.

The prototype heat-storage module consists of an  $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$ -imbued open-cell graphite foam core of 76-percent porosity in an aluminum housing that has a ribbed top that provides a rigid mounting surface for electronics. During fabrication, grooves to receive the ribs were cut into the open-cell graphite foam core (see figure). To overcome the hydrophobicity of the graphite foam to enable the core to absorb the  $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$ , an organosilicon surfactant was added to the molten

$\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$  in the proportion of 0.3 mass percent.

Also added to the  $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$  was 1 mass percent of zinc nitrate, which serves as a freezing catalyst to reduce, to an interval of 2 °C, what would otherwise be the susceptibility of  $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$  to freezing supercooling by as much as 35 °C. With this catalyst, the  $\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$  freezes at 28 °C when cooled from a higher temperature and melts at 30 °C when warmed from a lower temperature.

*This work was done by Michael Pauken and Nickolas Emis of Caltech and John Boote of XC Associates for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov). NPO-44169*

## Precipitation-Strengthened, High-Temperature, High-Force Shape Memory Alloys

Shape memory alloys capable of performing up to 400 °C have been developed for use in solid-state actuator systems.

John H. Glenn Research Center, Cleveland, Ohio

Shape memory alloys (SMAs) are an enabling component in the development of compact, lightweight, durable, high-force actuation systems particularly

for use where hydraulics or electrical motors are not practical. However, commercial shape memory alloys based on NiTi are only suitable for applications

near room temperature, due to their relatively low transformation temperatures, while many potential applications require higher temperature capability.