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Thermophysical Properties of Sodium Acetate Trihydrate Composites as Heat Storage Material

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Introduction: Sodium acetate trihydrate (SAT) can be used as a phase change material (PCM) in heat storage applications. The melting point at 58 °C and favorable thermophysical properties makes it a suitable storage material in solar heating systems applications for space heating and domestic hot water preparation. Additives are used to stabilize the PCM, optimize or enhance the material properties and ensure cycling stability.

SAT can be used for long term heat storage by utilizing its ability to supercool stable ambient temperature or for short term heat storage where the supercooling is avoided. Material investigations were carried out considering the behavior of SAT with and without supercooling.

Density - porosity: The density and thermal expansion of SAT in liquid and solid state was measured. The characteristics of the cavities formed inside of solidified SAT were found by x-ray scanning. The measured density of SAT solidified from a supercooled state was less than the typical literature value. The X-ray scanning confirmed that 15% of the volume of a sample which had solidified from supercooled state was cavities.

Thermo-mechanical analyzer (TMA)

Heat capacity: The specific heat capacities and latent heat of fusions of SAT composites were measured by differential scanning calorimetry (DSC) and the Th-history method. The measurements showed that the additives had little effect on the specific heat capacities of the SAT composites. SAT composites with CMC or Xanthan rubber was investigated.

Sample

<table>
<thead>
<tr>
<th>Sample</th>
<th>Latent heat of fusion (kJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAT</td>
<td>265</td>
</tr>
<tr>
<td>SAT – CMC</td>
<td>218</td>
</tr>
<tr>
<td>SAT – Xanthan</td>
<td>225</td>
</tr>
</tbody>
</table>

Literature values for specific heat of solid and liquid SAT

Specific enthalpy for SAT without additives measured with DSC.

Specific enthalpy for SAT with CMC measured with DSC.

Significant difference in measured solid is for 1st and 2nd heating period.

Slices and corresponding segmentation and 3D illustration of SAT solidified from supercooled state.

Slices and corresponding segmentation and 3D illustration of SAT solidified from supercooled state.

Temperature [°C]

Specific enthalpy for SAT without additives measured with DSC.

Specific enthalpy for SAT with 1% CMC measured with DSC.

Characteristic drop in measured liquid 5°C and around 43°C.

LATENT HEAT FUSION MEASUREMENTS

Specific enthalpy for SAT with 0.5% Xanthan rubber measured with DSC.

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Experimental investigations on density were carried out in the laboratory of the GITSE research group, University of Jönköping. X-ray scanning was carried out at Department of Physics, Technical University of Denmark. The authors thank the Spanish Ministry of Economy and Competitiveness for the funding of this work within the framework of projects ENE2011-28269-C03-01 and ENE2014-57252-R and the Danish Energy Agency supporting the joint IEA SHC Task 40/IES Annex 29 program on Compact Thermal Energy Storage. Grant no. 046120230.

References: