Binary mixtures of Fatty Acids with Sodium Acetate Trihydrate as PCMs

Muhsin MAZMAN, Yeliz KONUKLU
Hunay EVLİYA, Halime Ö. PAKSOY

Çukurova University, Adana, -TURKIYE
Contents

1. Introduction
2. Previous work
3. Purpose
4. PCMs used and their thermophysical properties
5. Mixtures prepared
6. Results
7. Conclusions
Phase Change Materials (PCMs)

During their phase transition

- can absorb or release large quantities of latent heat
- at fairly constant temperatures
Challenges in PCM utilization

Finding the optimum combination of
- appropriate phase transition temperature
- favorable thermal properties
- encapsulation technique
- cost of PCM
Solid-Liquid phase change

- Organics
  - Paraffins
  - Fatty Acids
  - Mixtures
- Inorganics
  - Hydrated salts
  - Mixtures
Advantages - Disadvantages

- Inorganic materials:
  - Subcooling,
  - Corrosion,
  - Phase separation
  - Lack of thermal stability.

- Organic materials:
  - Lower phase change enthalpy and thermal conductivity,
  - Flammability
Designing PCM mixtures

- Additives
  - overcome problems like supercooling, phase separation
  - increase thermal conductivity
- Multi-component PCM mixtures
  - to adjust the melting range for a given application
  - to enhance storage capacity
Previous work on mixtures

- Several studies on paraffin-paraffin, fatty acid-fatty acid and inorganic-inorganic mixtures
- Fatty Acids-Paraffins
  - Buddhi et al. (1988): Fatty acids, naphthalene and paraffin wax in a solar cooker
  - Dimaano and Watanabe (2002) capric-lauric acid and pentadecane
- Fatty Acids-Hydrated salts
  - No present work
Purpose

- prepare hydrated salt (sodium acetate trihydrate) - fatty acid (capric and lauric acid) mixtures
- determine stability of mixtures to melting/freezing cycles,
- determine melting range and latent heat
PCMs used

- Fatty acids
  - capric acid
  - lauric acid

- Hydrated salt
  - Sodium acetate trihydrate (CH$_3$COONa·3H$_2$O)
    - Na$_2$HPO$_4$·12H$_2$O as nucleator
Thermophysical properties of the PCMs

<table>
<thead>
<tr>
<th>PCMs</th>
<th>Lauric Acid</th>
<th>Capric Acid</th>
<th>Sodium acetate trihydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Formula</td>
<td>C_{12}H_{24}O_{2}</td>
<td>C_{10}H_{20}O_{2}</td>
<td>CH_{3}COONa·3H_{2}O</td>
</tr>
<tr>
<td>Molecular Weight (g/mol)</td>
<td>200</td>
<td>172</td>
<td>136</td>
</tr>
<tr>
<td>Melting Point (°C)</td>
<td>43-45</td>
<td>29-32</td>
<td>58</td>
</tr>
<tr>
<td>Latent Heat (kJ/kg)</td>
<td>178</td>
<td>153</td>
<td>264</td>
</tr>
<tr>
<td>Thermal Conductivity (W/m·K)</td>
<td>0.147(50 °C)</td>
<td>0.153 (38 °C)</td>
<td>-</td>
</tr>
<tr>
<td>Density (kg/m³) Liquid</td>
<td>862 (60°C)</td>
<td>886 (84°C)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solid</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1007 (24°C)</td>
<td>1004 (24°C)</td>
<td>1450</td>
</tr>
</tbody>
</table>
Mixtures

- Capric acid - $\text{CH}_3\text{COONa}.3\text{H}_2\text{O}$
  - 10:90*
  - 20:80
  - 30:70

- Lauric acid- $\text{CH}_3\text{COONa}.3\text{H}_2\text{O}$
  - 10:90*
  - 20:80
  - 30:70

*% weight ratio of fatty acid to salt hydrate
Results
Lauric Acid - $\text{CH}_3\text{COONa} \cdot 3\text{H}_2\text{O}$

- Subcooling effect (3-4°C)

![Graph showing temperature over time for different ratios of Lauric Acid and NaAc](image-url)
Results

- (20:80, 30:70) mixed homogeneously when the lauric acid ratios were increased (40:60), in a few melting/freezing cycles observed phase separation.
Lauric acid - \( \text{CH}_3\text{COONa.3H}_2\text{O} \) (30:70) at 10 °C/min scan rate with DSC

- Onset = 40.50 °C
- Area = -400.794 mJ
- \( \Delta H \) = -77.0758 J/g
- Peak = 47.93 °C
Lauric acid - CH₃COONa.3H₂O (20:80) at 5 °C/min scan rate with DSC

Onset = 50.58 °C
Area = -190.467 mJ
Delta H = -119.0418 J/g
Peak = 52.09 °C
Results

Capric Acid - CH$_3$COONa·3H$_2$O

- (20:80, 30:70) mixed homogeneously
- When capric acid ratios were increased (like, 40:60) the mixtures showed phase separation
Capric acid - $\text{CH}_3\text{COONa.3H}_2\text{O}$ (30:70) at 10 °C/min scan rate with DSC

Onset = 10.27 °C

Area = -1129.861 mJ
Delta H = -112.9861 J/g

Peak = 24.32 °C
Capric acid - CH$_3$COONa.3H$_2$O (20:80) at 5 °C/min scan rate with DSC

Onset = 32.56 °C
Area = -1164.607 mJ
Delta H = -121.3132 J/g
Peak = 30.10 °C