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Phase Change Materials for Temperature Control in Biologic Shipping Containers

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Introduction

Phase change materials (PCMs) are used to help maintain a constant temperature within a container. PCMs that melt near room temperature are needed for preservation of certain payloads in biologic shipping containers. For these PCMs to be viable in commercial application, the following constraints need to be met:

- Freeze close to melt temperature
- Large melting enthalpy
- Non-toxic and environmentally friendly
- Inexpensive

A range of PCM candidates were screened using Cryo-Differential Scanning Calorimetry (cryo-DSC) in an attempt to discover more effective PCMs that melt at or near 22 °C and 5 °C. Some good candidates were identified, although their performance did not exceed that of commercial formulations.

Figure 1. Biologic shipping container
https://www.savsu.com/

Methods

Materials classes

- Aqueous inorganic salt solutions
- Organic liquids
- Surfactants
- Polymer solutions
- Natural oils
- Commercially available PCMs

Differential Scanning Calorimetry (DSC)

- Instrument: Netzsch DSC 214 Polyma
- Measures heat flow to and from the sample and reference
- Specimen subjected to freeze-melt cycles
- Aluminum cold-welded sample pans
- Sample and reference subjected to same controlled temperature program and specified atmosphere

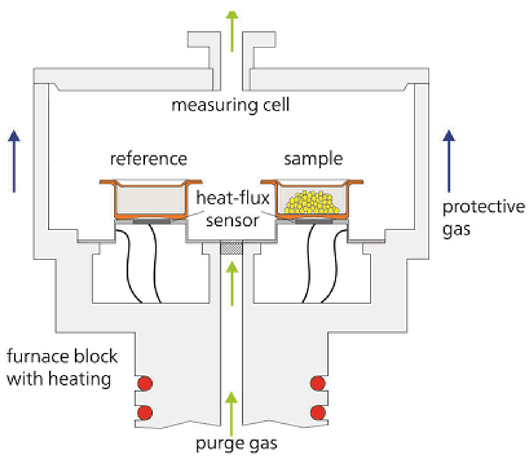

Figure 2. The heat-flux cell of DSC 214 *Polyma*
https://www.netzsch-thermal-analysis.com/en/products-solutions/differential-scanning-calorimetry/dsc-214-polyma/

Data Analysis

- Onset melting point used to determine when sample began melting
- Melting enthalpy is area under the melting curve
- Freezing peak (exothermic) points down
- Melting peak (endothermic) points up

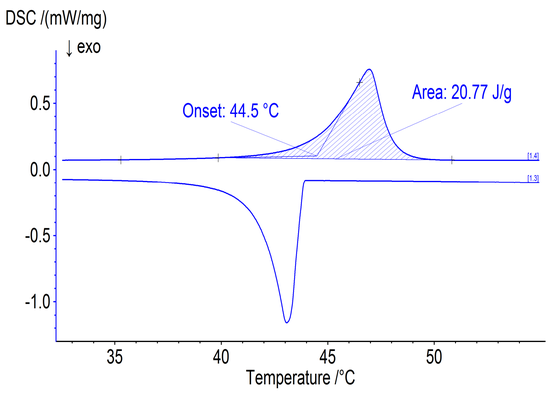

Figure 3. Display of onset temperature and melting enthalpy

RESULTS

Organic Compounds

- A displays bimodal properties, but small temperature difference between freezing and melting
- B shows slight bimodal melting
- C has melting point close to 25 °C, but large difference between freezing and melting temperatures

Melting Enthalpy (J/g)

A	B	C
210.3	195.5	170.7

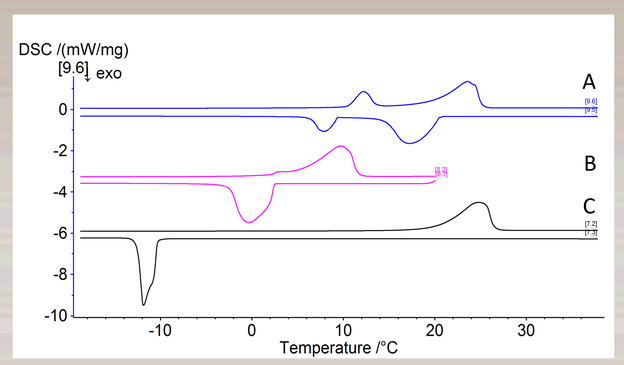

Figure 5. DSC traces for organic compounds

Polymers

- Broad melting peaks
- Difference between melting and freezing is small
- Environmentally benign

Melting Enthalpy (J/g)

D	E
116.3	140.7

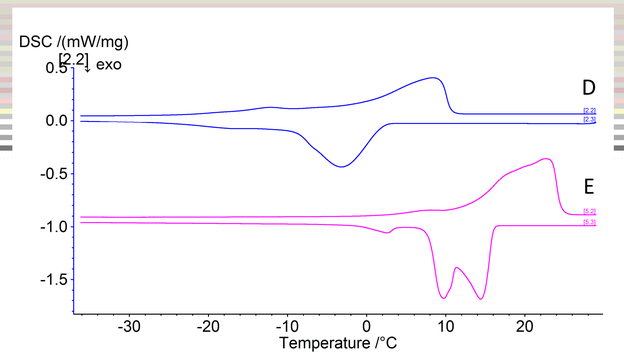

Figure 6. DSC traces for polymers

Commercially available PCMs

- Higher melting enthalpies, ranging from 180-228 J/g
- Temp difference between melting and freezing point is only 10-12 °C

Melting Enthalpy (J/g)

F	G	H	I
182.7	205.2	222.8	227.8

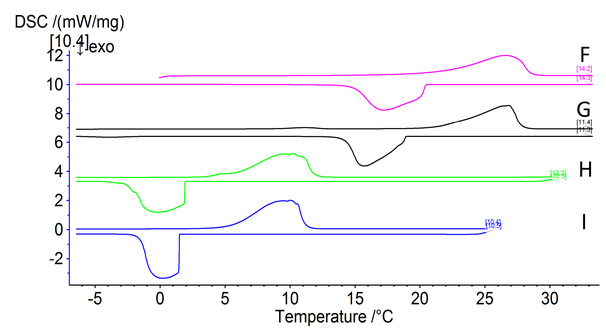

Figure 4. DSC traces for Commercial PCMs

SUMMARY

The commercially available PCMs display the highest melting enthalpies, however organic compounds A and B came close to matching the energetics of the commercial materials. The commercial PCMs also displayed a relatively small temperature difference between freezing and melting. The polymer solutions D and E had suitable melting points but rather low melting enthalpies. The best non-commercial 5° C PCM candidate is organic compound B. The best non-commercial 22° C PCM candidate is organic compound A. Polymer solutions D and E are also attractive and may be considered more environmentally benign than compounds A and B.

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