Thermal Conductivity Determination of Organic Nanofluids by MDSC

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Rationale

- Conventional refrigeration is difficult to implement in remote areas of developing countries.
- Vegetable oil phase change materials (PCMs) are a promising solution, requiring no external energy source.[1] Jojoba oil (melting point of 11°C) is a candidate PCM.
- Carbon nanoparticles can be added to increase thermal conductivity and the cooling rate of the PCM.
- Modulated differential scanning calorimetry (MDSC) can be used to determine thermal conductivity of low temperature solid oils, unlike many conventional methods.[2]
- This work explores jojoba oil with the inclusion of three different nanoparticles, using MDSC analysis.

Methodology

- Nanoparticles: multi-walled carbon nanotubes (MWCNTs), graphene, coconut shell activated carbon (AC)
- DSC equipment: Thermal Analysis Q2000 Series
- MDSC run at 0°C for 30 minutes, with ± 1.0°C amplitude temperature and oscillating period of 90 seconds

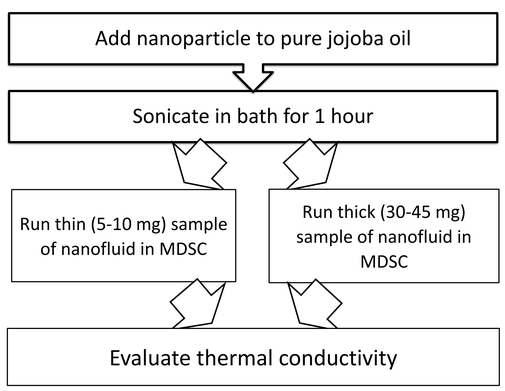

Figure 1: Summary of experimental approach

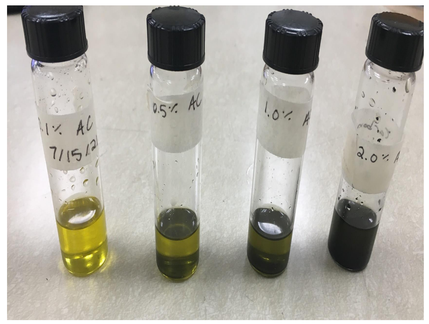

Figure 2: Activated carbon samples after 1 hour of sonication

Results

Table 1: Characteristics of pure jojoba oil and highest concentration of each nanofluid

Species	Latent Heat (J/g)	Onset Temp. (°C)	Peak Temp. (°C)	End Temp. (°C)	Heat Capacity (J/g·°C)
Jojoba Oil	105.5	4.36	11.72	13.30	3.00
2.0% MWCNT	100.4	5.49	12.30	13.59	2.82
0.2% Graphene	108.0	4.51	11.77	13.44	2.58
2.0% AC	108.7	4.34	11.31	12.70	3.05

Melting Point

Thermal Conductivity

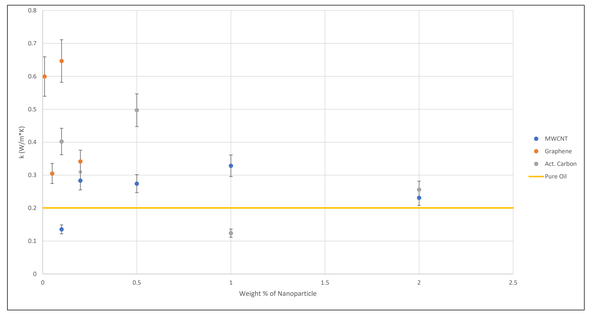

Figure 3: Thermal conductivity enhancement for all solid phase nanofluids

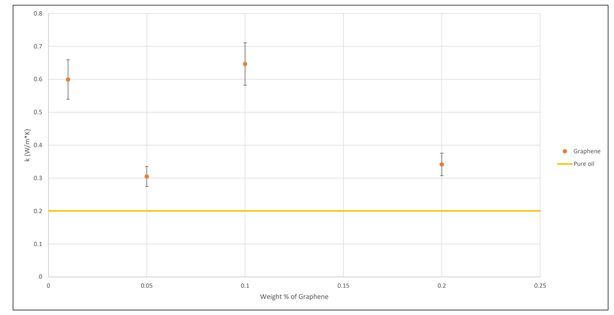

Figure 4: Thermal conductivity enhancement for solid phase graphene nanofluid

Adding nanoparticles to the base oil significantly increases thermal conductivity in the solid phase, but not as consistently as expected.

Conclusions

- Thermal conductivity of nanofluids was higher than the base oil, and there is potential for jojoba oil as a practical PCM for refrigeration.
- Inconsistent results likely the effect of too much uncertainty in MDSC analysis and a poor stability of nanoparticles in the base fluid.
- Future work should utilize other methods of thermal conductivity measurement and shape stabilized PCMs rather than nanofluids.

Acknowledgements and References

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1. Amaral, et al. *Renewable and Sustainable Energy Reviews*, **2017**, *79*, 1212-28.
2. Marcus, et al. *Thermochemica Acta*, **1994**, *243*, 231-9.