INVESTIGATION OF PHASE CHANGING PROPERTY OF OCTADECANE FOR THERMAL ENERGY STORAGE SYSTEMS BY TERAHERTZ SPECTROSCOPY

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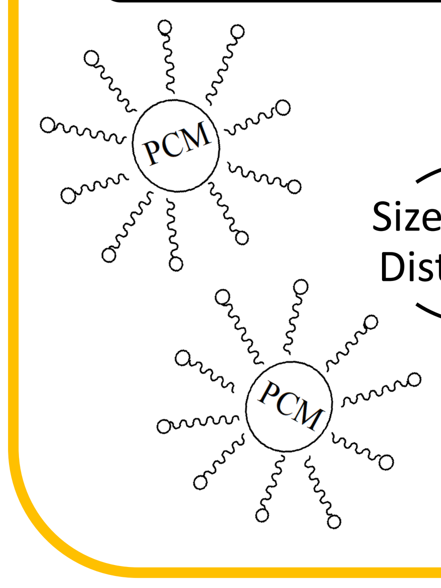
Abstract

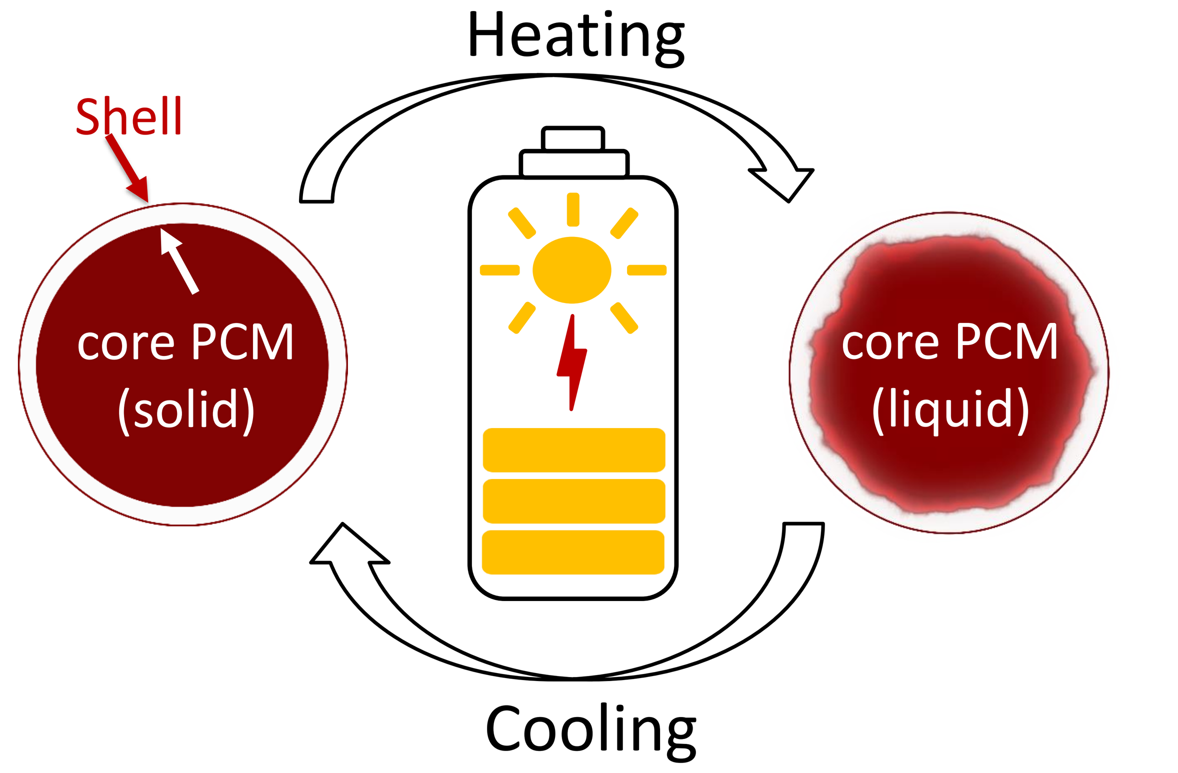
Phase changing material (PCM) based thermal energy storage have drawn significant attention in recent years due to increasing energy demand. PCMs are capable of storing and releasing great amount of energy in the form of latent heat (ΔH) just by a simple phase change. Therefore, they are considered as highly promising candidates for environmentally friendly thermal energy storage systems. In this study, an organic PCM octadecane with a large heat of fusion is investigated. Its energy storage ability and thermal stability are studied both for its bulk form and for its encapsulated form to ensure that it would be efficient to use the encapsulated form in TES systems. Besides, Terahertz-Time Domain Spectroscopy (THz-TDS) is used to provide fast, reliable and nondestructive in-situ investigation of phase change process of octadecane.

EXPERIMENTAL



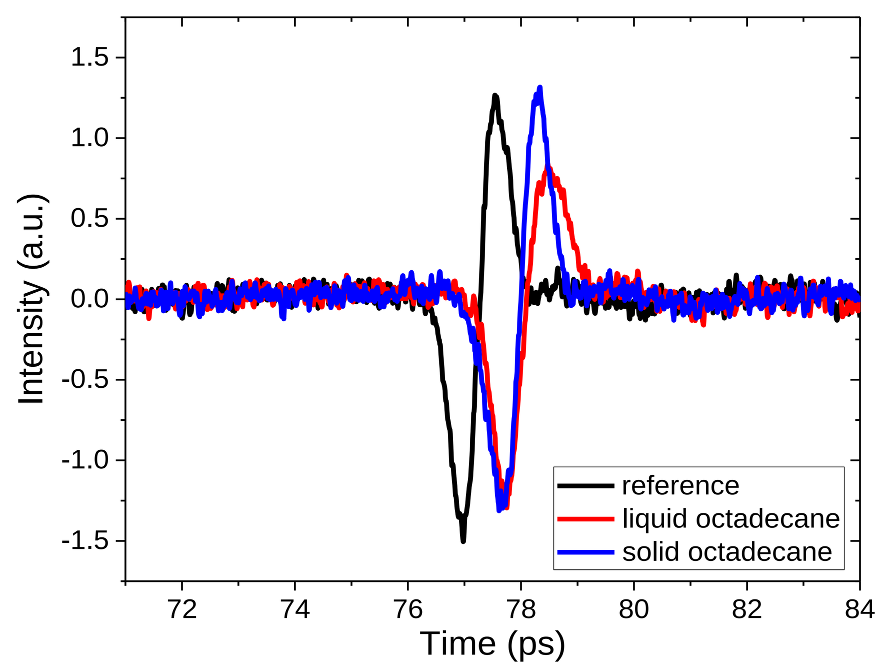
Bulk and encapsulated octadecane

- Size and Size Distribution → DLS
- Chemical Identification → FTIR-ATR
- Melting Point and Latent Heat of Fusion → DSC
- Thermal Stability → TGA
- Phase Change Process → THz-TDS



RESULTS and DISCUSSION

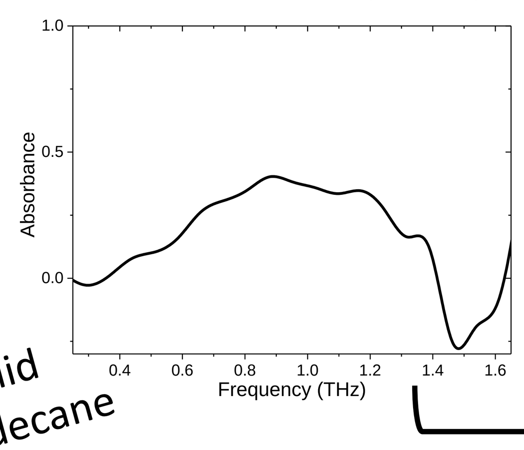
Time Domain Profiles



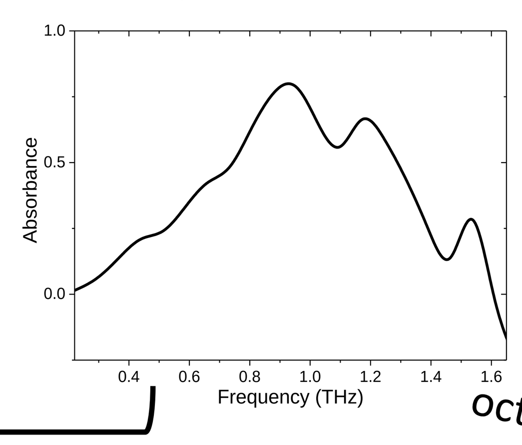
Liquid octadecane shows

- Larger shift in time domain → Larger refractive index
- Significant decrease in intensity → Larger absorption

Frequency Dependent Absorption

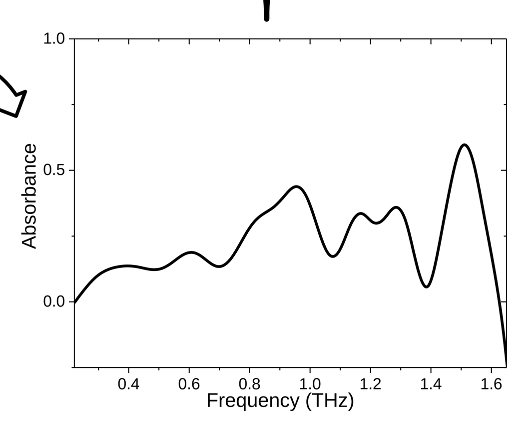


solid octadecane



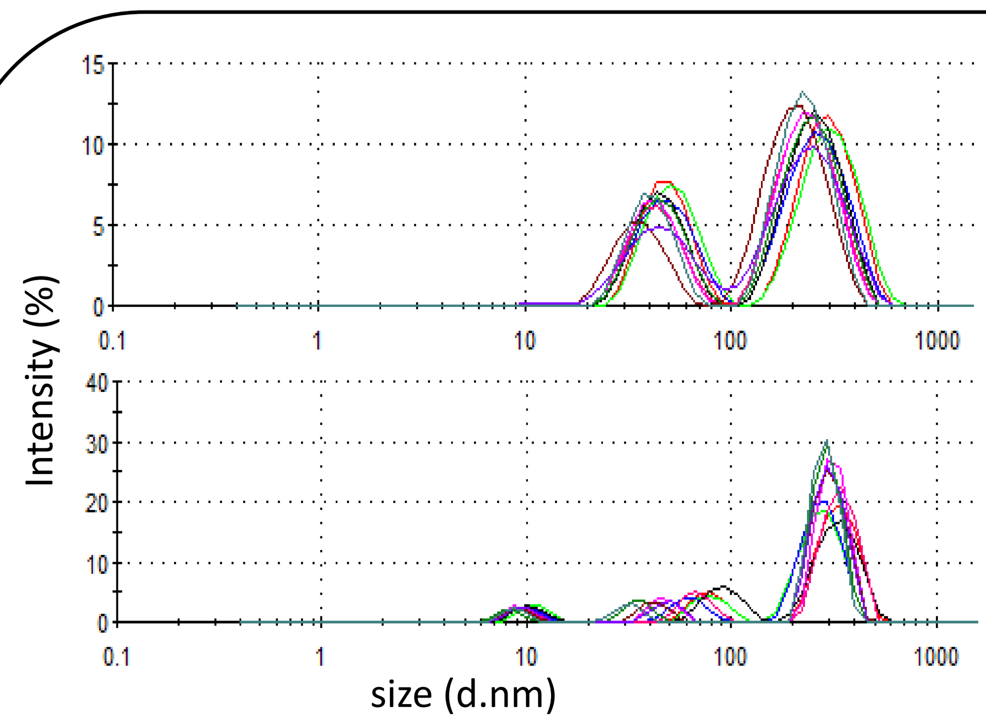
liquid octadecane

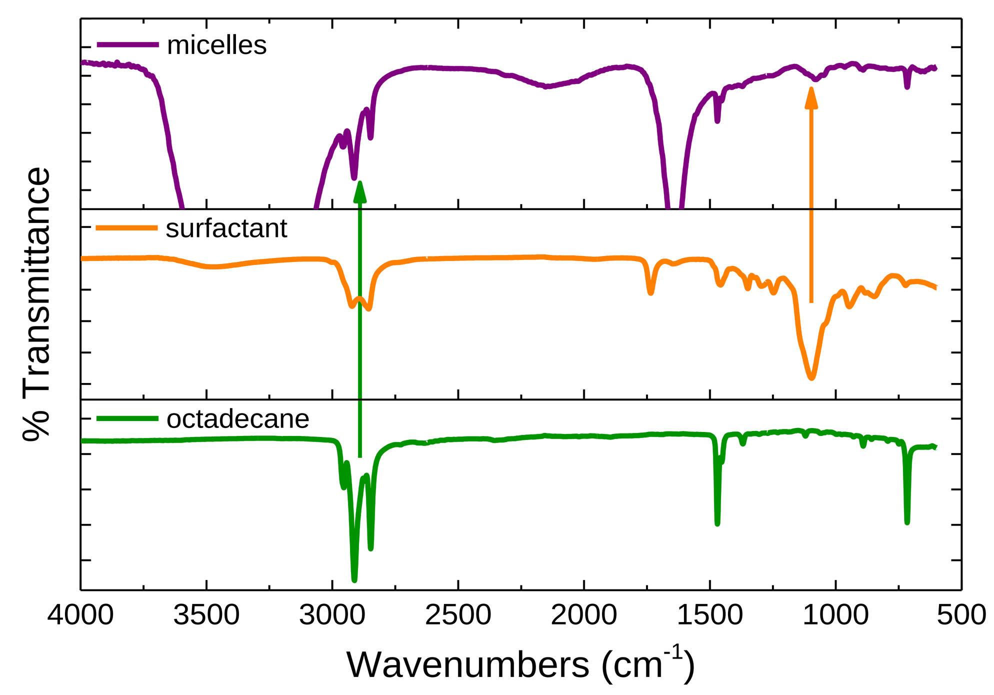
Direct change in the absorbance of liquid octadecane taking solid octadecane as reference



Significant increase in absorption when octadecane changes phase from solid to liquid

- Liquid phase of octadecane has a larger refractive index and a larger absorption.
- THz-TDS can be used successfully to monitor the phase changes in a nondestructive manner.





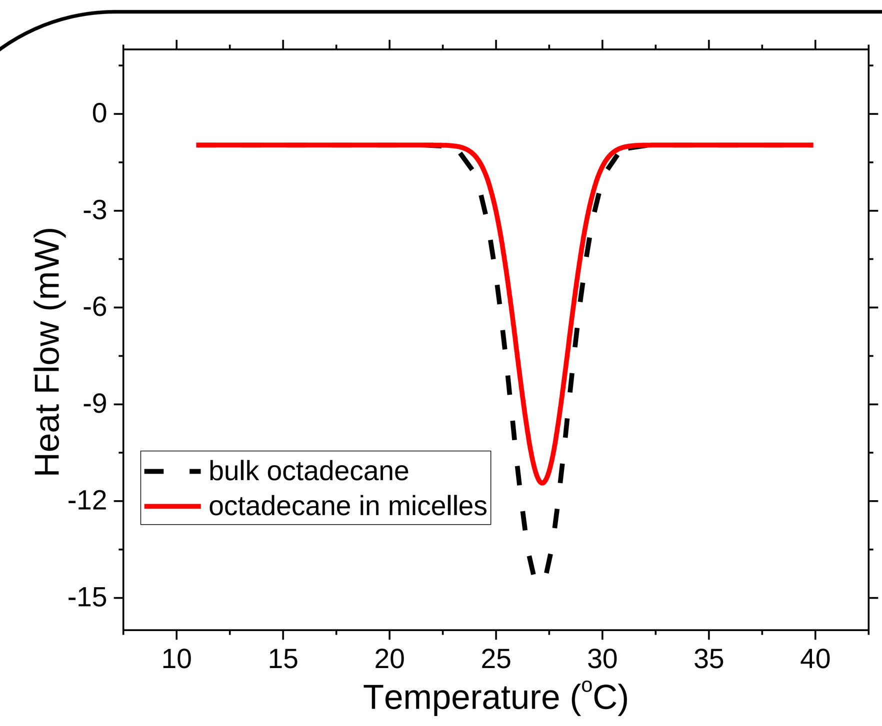
Octadecane containing solution shows

- Decrease in 10-100nm region
- Increase in 100-1000nm region

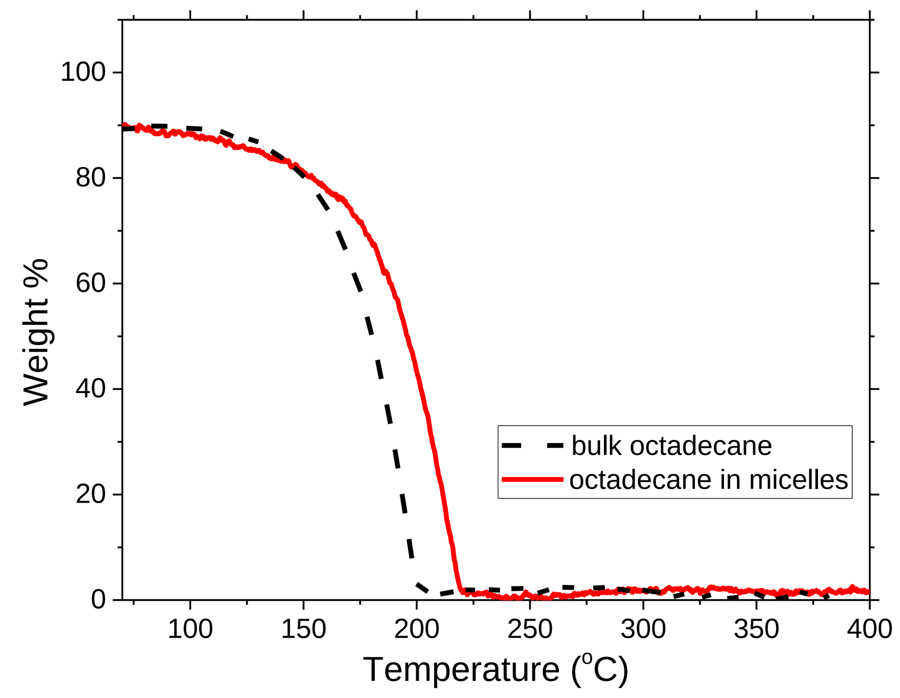
The spectrum of micelles shows

- Indication of octadecane at 3200 cm^{-1}
- Indication of surfactant at 1090 cm^{-1}

Octadecane is successfully placed in the micelles.



- Latent heat of fusion is the amount of thermal energy stored.
- Bulk octadecane → 230 J/g
- Encapsulated octadecane → 202 J/g
- Almost 90% of latent heat of fusion is preserved after the encapsulation.



- Both are thermally stable in the working range.
- Bulk octadecane decomposes earlier.
- Surfactants positively contribute to the thermal stability.

CONCLUSION

Octadecane is a highly promising candidate for thermal energy storage systems. It is successfully stabilized in water and encapsulated with surfactants to increase its thermal conductivity and heat transfer efficiency. Large amount of latent heat of fusion is preserved and thermal stability is increased. THz-TDS results showed the differences in absorptions and refractive indexes both in time domain and frequency dependent absorption plots therefore THz-TDS can be used to monitor the phase changes in a nondestructive manner. Further work will include taking THz-TDS measurements with 1 °C increments to monitor the phase change more clearly. Another goal is coating the micelles with a thermoelectric polymer and testing if the stored heat released from the PCM can be used to generate electricity via thermoelectric effect.