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CHARACTERIZATION OF ENHANCED BIOBASED PHASE CHANGE MATERIAL WITH GRAPHENE NANOPLATELETS – EARLY RESULTS

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INTRODUCTION

Energy consumption is expected to continue rising, and in conjunction with greater environmental concern, it has boosted the development of renewable and sustainable energy sources, including storage media materials for latent heat thermal energy storage. Biobased Phase Change Materials (PCMs) are materials derived from renewable and environmentally friendly resources and are a great solution as they have similar properties to paraffin-based PCMs. In view of designing a nano-enhanced PCMs (NEPCMs) based on a commercial plant-based PCM, CrodaTherm60, was selected due to its high latent heat capacity as well as its medium melting point, 60°C, making it suitable for solar domestic hot water systems.

OBJECTIVES

- In the current study, NEPCMs based on the commercially available bio-organic PCM, CrodaThem60 (derived from plant-based feedstock), were incorporated with 2, 4 and 6 wt.% of graphene nanoplatelets (GNPs) through the magnetic stirring and ultrasonication synthesis process.
- The effects of the different mass fractions of GNPs on the main thermophysical properties of the CrodaTherm60 were studies experimentally.

METHODOLOGY

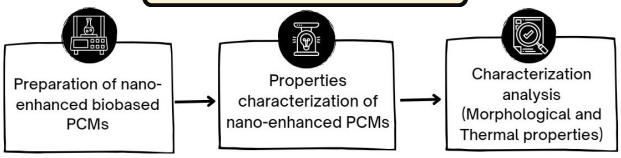

Fig. 1: Methodology

RESULTS

Morphology and microstructure of the NEPCMs

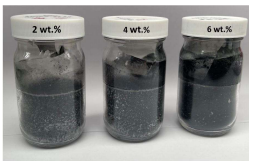

Fig. 2: NEPCMs with mass fraction of 2, 4 and 6 wt.% GNPs

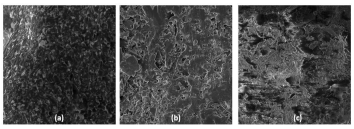

Fig. 3: SEM images of NEPCMs with (a) 2 wt.%, (b) 4wt.% and (c) 6 wt.% with a view field of 100 µm at a 5.0 kV

Thermal properties of the CrodaTherm60 and NEPCMs

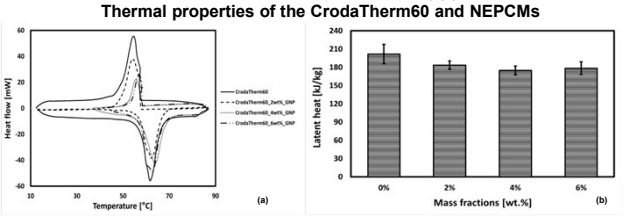

Fig. 4: (a) DSC curves of CrodaTherm60 and NEPCMs and (b) difference in Latent heat capacity

Effects on the density of NEPCM

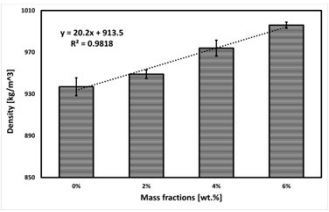

Fig. 5: Effects on the density with the increase of mass fractions of GNPs

Effects of the mass fraction on the thermal conductivity of NEPCM

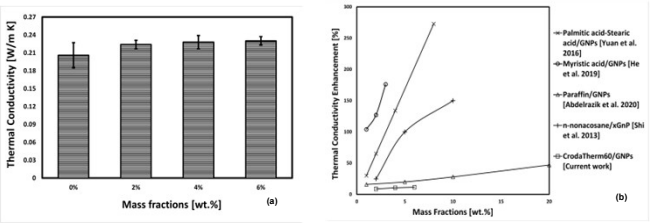

Fig. 6: (a) Measured thermal conductivity of the solid NEPCMs as a function of the loading of graphene nanoplatelets and (b) Comparison of thermal conductivity enhancements of NEPCMs vs additive mass fractions (wt.%) using carbon based nanomaterials

DISCUSSIONS

- The measured melting temperature of 57.2°C and high latent heat capacity of 201.7 kJ/kg make this material suitable for space and domestic water heating applications.
- Latent heat capacity of NEPCMs decreased with the addition of GNPs into the CrodaTherm60 (fig. 4b).
- The NEPCMs density increase was directly proportional to the mass fraction of the GNPs (fig. 5).
- GNPs were ineffective in boosting the thermal conductivity of CrodaTherm60 despite its high thermal conductivity (fig. 6a).
- There are significant discrepancies in the results reported in this study compared with previously published studies (fig. 6b).

CONCLUSIONS

The thermal conductivity enhancement of the NEPCMs was lower than expected, despite the excellent thermal conductivity of GNPs; this can be associated to the high specific surface area of the GNPs, 750 m^2/g, which can be prone for agglomeration and sedimentation issues. Therefore, further efforts will be required to address and investigate any possible agglomeration issues, including the improvement of the preparation process. Besides that, due to weight loss reported during the DSC characterization, different crucibles will be used to reduce the error associated with the latent heat and phase change temperatures measurements.

REFERENCES

ABDELRAZIK, A., AL-SULAIMAN, F. & SAIDUR, R. 2020. Numerical investigation of the effects of the nano-enhanced phase change materials on the thermal and electrical performance of hybrid PV/thermal systems. *Energy Conversion and Management*, 205, 112449
HE, M., YANG, L., LIN, W., CHEN, J., MAO, X. & MA, Z. 2019. Preparation, thermal characterization and examination of phase change materials (PCMs) enhanced by carbon-based nanoparticles for solar thermal energy storage. *Journal of Energy Storage*, 25, 100874
SHI, J.-N., GER, M.-D., LIU, Y.-M., FAN, Y.-C., WEN, N.-T., LIN, C.-K. & PU, N.-W. 2013. Improving the thermal conductivity and shape-stabilization of phase change materials using nanographite additives. *Carbon*, 51, 365-372
YUAN, Y., ZHANG, N., LI, T., CAO, X. & LONG, W. 2016b. Thermal performance enhancement of palmitic-stearic acid by adding graphene nanoplatelets and expanded graphite for thermal energy storage: A comparative study. *Energy*, 97, 488-497

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