THERMOPHYSICAL AND FLOW PROPERTIES OF COCONUT OIL WITH SILICA FUMED NANOPARTICLES

J. J. Jiménez-Galea[1] J.L. Arjona-Escudero[2], I.M. Santos Ráez[2]

V. Tamames-Rodero[3], A.I. Gómez-Merino[3] , FJ Rubio-Hernández[3], J. Rubio-Merino[4]

[1]Departamento de Ingeniería Civil, de Materiales y Fabricación, Universidad de Málaga (Spain)

[2]Departamento de Ingeniería Mecánica, Térmica y de Fluidos, Universidad de Málaga (Spain).

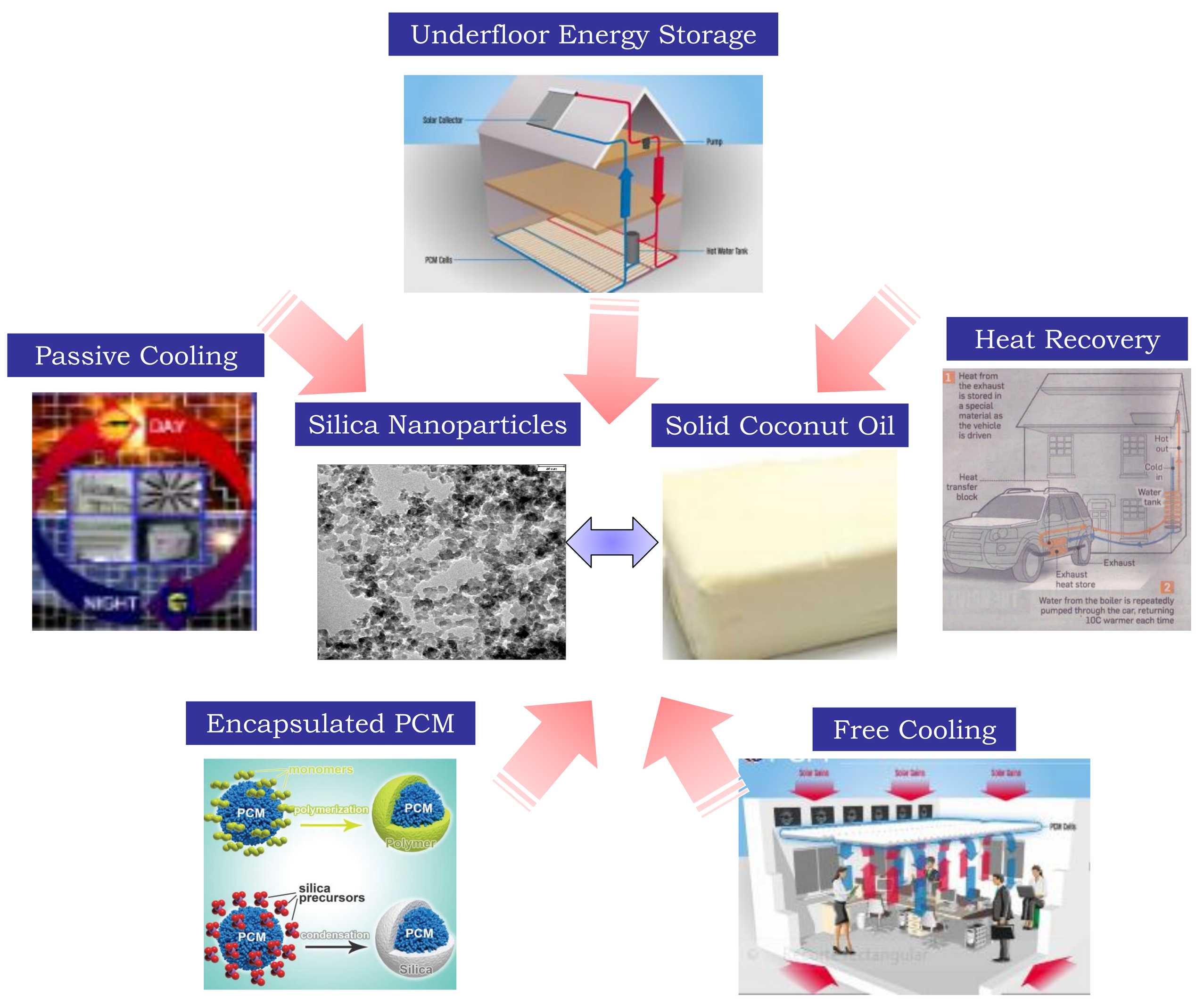
[3]Departamento de Física Aplicada II, Universidad de Málaga (Spain).

[4]Hospital Clínico Universitario Virgen de la Victoria, Málaga (Spain).

e-mail of the presenter: imsantos@uma.es

Why Phase Change Materials are of interest

Latent heat thermal energy storage (LHTES) through the use of phase change materials (PCMs) to store and release thermal energy is one of the most efficient and reliable ways to reduce energy consumption. PCMs have a high heat storage capacity and nearly isothermal phase change behaviour but they usually have low thermal conductivity. However, small amount of nanoparticles, when dispersed uniformly, can provide tremendous improvements in the thermal properties of the carrier fluid.



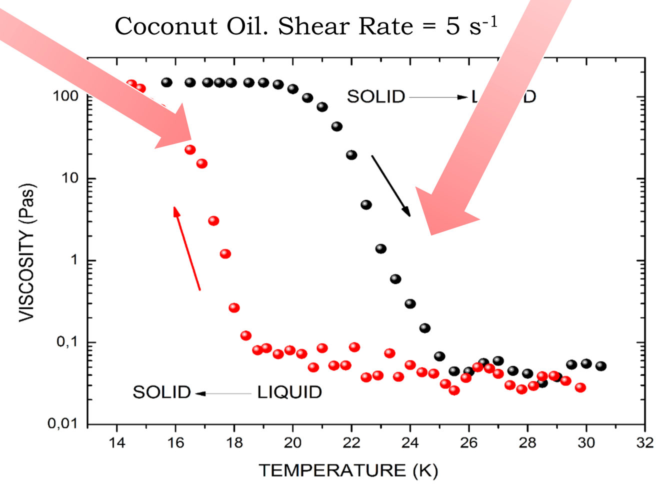
Objetives

This work is concerned with the rheological and thermal study of silica fumed dispersed in coconut oil. The dispersed phase behave as a non newtonian fluid during the phase change. The addition of nanoparticles complicates considerably the flow behaviour of the system. Therefore, a very thoughtful study of the flow and thermal properties with temperature when silica particles are added must be carried out.

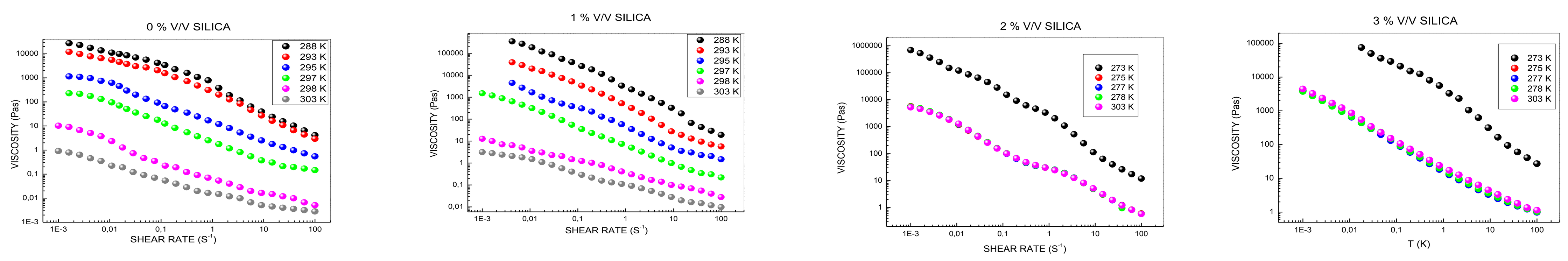
Evolution of temperature during the cooling process

Evolution of temperature during the heating process

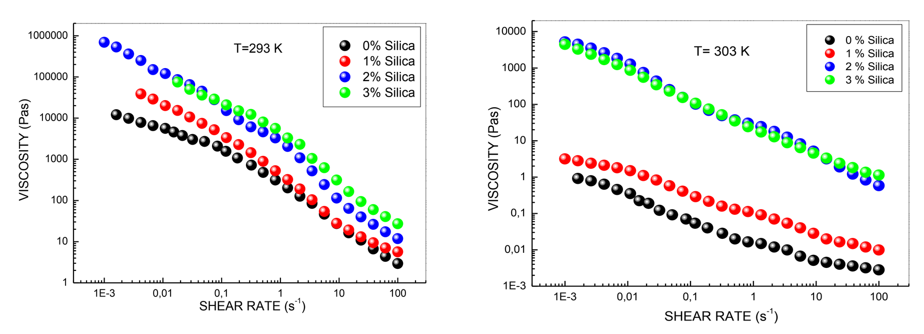
Phase Change Transition of coconut oil. The mechanical energy provided by the shear stress produces an hysteresis loop. During the heating process the mechanical energy also contributes to the microstructure rupture and the melting temperature reduces compared to the rest value. In the cooling process, the mechanical energy destroy microstructure and the solidification temperature start al lower temperatures.

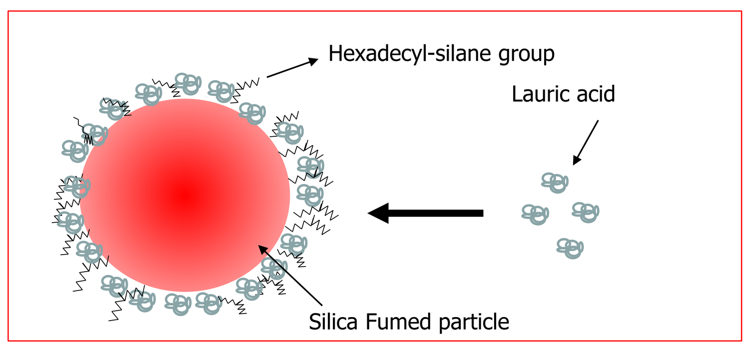


Rheology

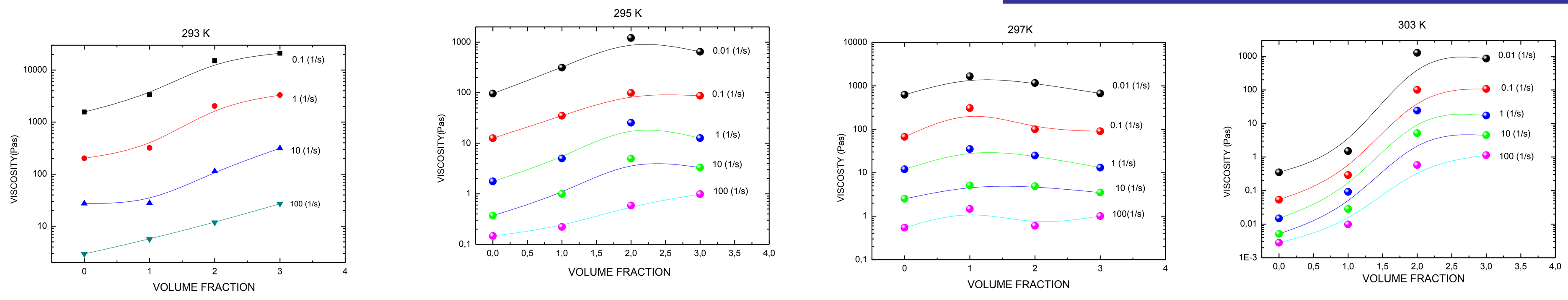


Viscosity curves of silica fumed, temperatura effect. The addition of silica nanoparticles increases the viscosity. However, fractions higher than 1% of silica fumed provokes a gel formation. 2 and 3% of silica show very similar curves of viscosity. As It is can be seen below.



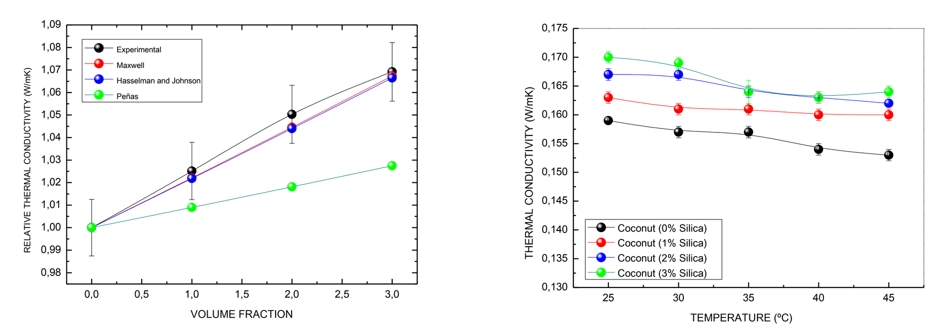


Graph of the gel-like structure of silica fumed dispersed in coconut oil



The formation of a gel-like structure can be seen in the rheological behaviour. The more solid particles the stronger gel-like structure. Notice that the 2 and 3 % of silica fumed suffer smaller changes in viscosity with temperatura.

THERMAL CONDUCTIVITY



$$K_{nf} = \frac{K_{np} \cdot K_{bf}}{K_{np} - (K_{np} - K_{bf}) \cdot \emptyset}$$

Peñas et al. model

$$K_{nf} = K_{bf} \frac{K_{np} + 2 \cdot K_{bf} + 2 \cdot (K_{np} - K_{bf}) \cdot \emptyset}{K_{np} + 2 \cdot K_{bf} - (K_{np} - K_{bf}) \cdot \emptyset}$$

Maxwell model

$$K_{nf} = K_{bf} \frac{(1+2\alpha)K_{np} + 2 \cdot K_{bf} + 2 \cdot \left(K_{np} \cdot (1-\alpha) - K_{bf}\right) \cdot \emptyset}{(1+2\alpha)K_{np} + 2 \cdot K_{bf} - \left(K_{np} \cdot (1-\alpha) - K_{bf}\right) \cdot \emptyset}$$

Hasselman and Johnson model

Mathematical models of Thermal Conductivity as a funtion of solid volumen fraction. The agreement of Maxwell and Hasselman models are fairly good. This result is similar to others found in ceramic colloid suspensions.

Evolution of Thermal Conductivity with temperature. The liquid phase, coconut oil decreases its Thermal Conductivity with temperature. This result is common in non thermal conductive materials. The addition of termal conductive particles reduces this tendency and increases the Thermal Conductivity.

Concluding Rermarks

The coconut oil filled with silica fumed shows a strong shear thinning behaviour at temperatures around 273 K. The addition of a filler produces an increment of viscosity.
The formation of a gel structure varies the flow properties of the suspensions. The melting point changes, which permits different applications. conductivity with solid particle concentration and a decrease with temperature was found.
Thermal conductivity increases with particle concentration and decreases with temperature. The decreasing with temperature is an unexpected result. A better understanding of the microstructure by means of rheological measurements could throw some light about this concern.

References

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