

Development of New Device for Measuring the Thermal Conductivity of Polymeric nanocomposite Materials

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This work presents a miniaturized version of a previously designed device^{[1][2]} capable of measuring the thermal conductivity of polymeric nanocomposite materials. The new device (Figure 1) is based on two cylindrical tanks containing cold and hot liquid, respectively, each of them wetting one side of a disc-shaped polymeric sample. The new device uses much smaller size samples (diameter $d=2.7\text{cm}$, thickness $\delta=3\text{mm}$) in comparison with the previous design sample size ($d=15\text{cm}$, $\delta=3\text{mm}$), which ensures sample integrity/rigidity and saves material which in the case of nanoadditives may be expensive or scarce. In addition, the device is affordable and portable without compromising the operation convenience and precision/accuracy. The device is based on the hot/cold tank principle, which is simple and easy to operate, is non-destructive to the sample, is safe to use and thermal conductivity is estimated through a simple mathematical model. The technique relies on recording the temperature evolution of a fluid in two separate tanks exchanging heat to each other. One tank contains a hot fluid ($45\text{-}55^\circ\text{C}$), and the other a cold fluid (room temperature), while heat is being transferred through a sample placed in between the tanks.

Teflon samples are used first for the validation of the device's capacity, with the acquired results of thermal conductivity being in good agreement with literature values and also with measurements of the previous version of the device. Next, samples of polymeric nanocomposites of different nano additives concentrations are measured. Results demonstrate that the thermal conductivity of two types of epoxy resins (EPON828,827) increases with the addition of different concentrations of nano additives such as; Alumina (Al_2O_3), Boron nitride (BN), Silicone Carbide (SiC), Organoclay nanomere (I.30E), carbon nanotubes (CNT's) and different Silicone dioxide (SiO_2) additives. It is found that some additives such as Alumina yield observable impact on the thermal conductivity of the epoxy resin whereas others such as multi-walled carbon nanotubes (MWCNT's) give a noticeable effect only at the higher examined concentrations. In the absence of additives, no impact on the epoxy resin thermal conductivity is observed when cured by different curing agents such as D2000, D230 and IPD. On the contrary, in the presence of additives, a clear effect of the curing agents D2000, D230 on the thermal conductivity of epoxy resin is observed. The significance of the nanocomposites curing process and the impact of achieving good degree of dispersion of the nanoadditives in the polymeric matrix is discussed.



Figure 1. Schematic of the new miniaturized device

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References

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