Photothermal characterization of polyester composites loaded with parallelly arranged graphite rods

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Background – One of the most important techniques to measure thermal diffusivity is front flash developed by Parker et al. [1]. But in order to perform a complete thermal caracterization of a material it is necessary to find two important thermal properties, thermal diffusivity (D) and thermal effusivity (e). It is possible to find the thermal conductivity of the material using a simple relation $e = K/\sqrt{D}$ [2]. Composite materials are always of great interest as they provide improvements in the thermal and mechanical properties of simple materials. Composites with fillers in a resin matrix have been studied by several authors, showing how oriented fillers can improve thermal diffusivity of the composite [3,4].

In this work we present results of how graphite rods can help to improve the thermal properties of a polymeric resin and whether the the arrangement of the rods within the resin has any influence.

Methods – The polyester matrix used was an unsaturated polyester resin elaborated by Plastic Polyforms S.A. The graphite rods were loaded in the matrix resin orientated in the thickness direction with concentrations of 4.31% (m30), 5.75% (m40), 7.81% (m50) and 8.62% (m60) v/v. Additionally, the rods inside the matrix were placed in three different configurations for each graphite concentration, polygonal, rectangular, radial (figure 1). Those composites were compared with a composite with the same v/v concentration, but the graphite inside the resin was powdered and randomly arranged.

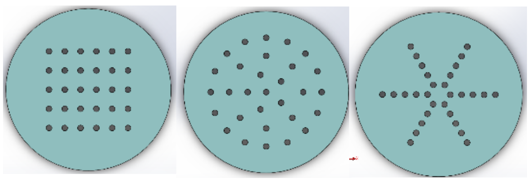

Fig. 1. Composites schematic for 4.31% v/v (m30) with the graphite rods in three different configurations. Rectangular (left), radial (center) and polygonal (right).

A two-layer system was used to create a thermal contrast to find thermal effusivity and thermal diffusivity of the samples. Composites of 1 mm thickness were used as a first layer and water as a semi-infinite fluid backing. Using the approach of Pech et al [5] in Laplace space, the thermal properties were determined using the front flash thermography.

$$T(0)=\frac{P_0\chi}{e_1\sqrt{s}}\frac{\cosh(x\sqrt{s})+b_{21}\sinh(x\sqrt{s})}{\left(b_{21}+\frac{hp}{\sqrt{s}}\right)\cosh(x\sqrt{s})+\left(1+\frac{hpb_{21}}{\sqrt{s}}\right)\sinh(x\sqrt{s})};\qquad b_{21}=\frac{e_2}{e_1};\quad x=\frac{L}{\alpha}\qquad \text{Eqn. 1}$$

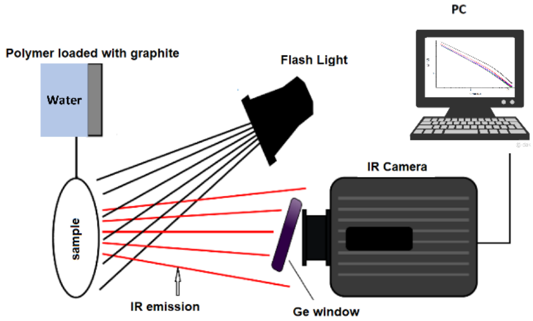

Fig. 2. Experimental setup

Results and Conclusions – Our results indicate that samples loaded with the same graphite concentration as we can see in figure 3 (left) present different thermal decays for samples with graphite with powder in random arrangement compared with composites with graphite rods, which present similar behaviour and the configuration has significative effects in thermal decays. On the other hand, figure 3 (right) present thermal decays for several graphite concentrations for polygonal configuration where it is possible to notice that there is a region where the increase of thermal properties stops due to a possible graphite saturation.

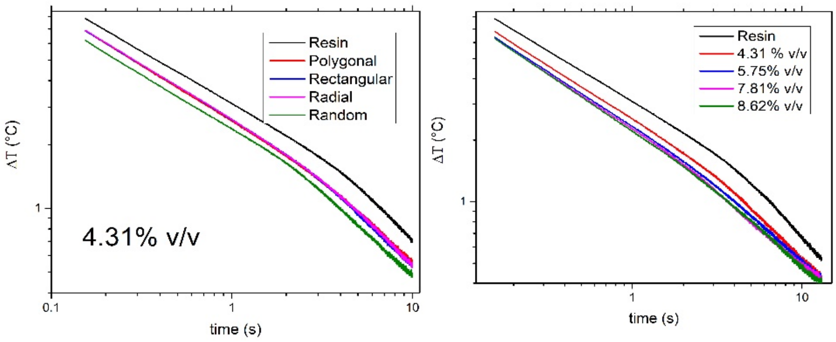

Fig. 3. Thermal decay for composites with 4.31 % v/v graphite concentration with different configurations (left) and composites with polygonal configuration changing the graphite concentration from 4.31 to 8.62 % v/v (right).

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