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Development of nanoreinforced resins with self-heating capabilities for 3D printing technologies

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The use of 3D printing technologies has attracted the interest of the industrial and scientific community during last decades. The possibility of quick and non-costly redesign can be used also for repairing and easy replacement structures after in service wear. Present work used Direct Write technology to print nanoreinforced resin circuits on continuous fiber reinforced polymers (CFRPs). The use of a carbon nanostructure resin would allow electrical conductivity through the resin circuit which could be used for structural health monitoring (SHM) and/or self-heating by Joule effect. This last effect could be used to create the first layer of a multilayer coating with anti-icing purposes taking advantage of the self-heating capability of this coatings by Joule effect. Previous research has allow the selection of graphene nanoparticles (GNP) and carbon nanotubes (CNT) as nanoreinforcements to modify the epoxy resin and allow Joule effect heating. Nevertheless, the characteristics of Direct Write 3D printing technology as well as morphology of the printed lines, do not allow the direct extrapolation of results obtained in bulk nanocomposites to the printed circuits. Thus, it requires an optimization of the carbon nanostructures contents to allow resin flow through the injector as well as the formation of conductive nanoparticle networks. The morphology of the printed circuit, the voltage applied and the type and content of carbon nanoparticles need to be tuned in order to improve the anti-icing purpose. The study has determined that the greatest influence is the carbon nanotube content followed by the voltage and circuit morphology. The selected conditions allowed to melt the frozen distilled water built-up on a fiber reinforced polymer composite similar to those that could be find in wind turbine blades.

Fig. 1. Image of the 3D printed circuits based on nanoreinforced epoxy resin with carbon nanostructures

Recent Publications

1. Moriche R, Jiménez-Suárez A, Sánchez M, Prolongo S.G, Ureña A. (2018) Sensitivity, influence of the strain rate and reversibility of GNPs based multiscale composite materials for high sensitive strain sensors. Compos Sci Tech 155:100-107.
2. Fernandez Sanchez-Romate X.X, Molinero J, Jiménez-Suárez A, et al. (2017) Carbon nanotube-doped adhesive films for detecting crack propagation on bonded joints: A deeper understanding of anomalous behaviors. ACS Applied Materals and Interfaces 9:43267-43274.
3. Moriche R, Jiménez-Suárez A, Sánchez M, Prolongo S.G, Ureña A. (2017) Graphene Nanoplatelets coated lass fibre fabrics as strain sensors. Compos Sci Tech 146:59-64.
4. Prolongo S.G, Moriche R, Del Rosario G, Jiménez-Suárez A et al. (2016). Joule effect self-heating of epoxy composites reinforced with graphitic nanofillers. Journal of Polymer Research 23:189.
5. Jiménez-Suárez A, Campo M, Prolongo. S.G et al. (2016). Effect of filtration in functionalized and non-functionalized CNTs and surface modification of fibers as an effective alternative approach. Composites Part B: Engineering 94:286:291.

Biography

A. Jiménez-Suárez has his expertise in the optimization of manufacturing processes of nanoreinforced matrices and multiscale reinforced composites with multifunctional capabilities. His research started with optimization of mechanical routes of dispersion for carbon nanofibers and carbon nanotubes with improved electrical and mechanical conductivities as well as better barrier properties. Afterwards this research is translated into graphene nanoparticles based nanocomposites and the use of these nanoreinforced matrices to manufacture multiscale reinforced composites. These multifunctional composites showed improved interlaminar shear strength and self-sensing capabilities for structural health monitoring (SHM). Finally, recent publications are related to parametric modeling of properties as a function of morphological aspects of nanoreinforcements and manufacturing processing parameters and the introduction of carbon nanostructures in polymer matrices to be used in 3D printing technologies to obtain multifunctional materials with SHM, anti-icing, de-icing capabilities among others.

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