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Editorial

Multifunctional Polymers and Composites

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The use of polymer and polymer-based composites has increased over the last decades. This has mainly been due to their low density, which in turn sometimes translates into quite good specific mechanical properties. Nevertheless, these materials present drawbacks in terms of absolute mechanical properties, and the electrical and thermal conductivity of insulators is neither the desired behavior nor durable. Traditional composites reinforced with long fibers, such as carbon or glass fibers, significantly enhance their mechanical behavior, but they show other functional limitations. To solve some of these drawbacks, the modification of polymers and the addition of reinforcements at the micro- and nanoscale has resulted in the development of a wide research field to overcome some of these limitations and offer new functionalities, with several applications in areas such as the aerospace, electronics, biomedical industry, or treatment of wastewater, among others [1,2].

The articles published in this Special Issue offer an important overview of the opportunities for the addition of inorganic reinforcements to meet some of the requirements that are different from the properties of every type of polymer. Examples include materials such as thermosets, thermoplastic, or elastomers, and there are examples found of all of them in this Special Issue. Moreover, this issue deals with some of the major concerns over the use of polymers, highlighting the environmental aspects of their production, use, and disposal [3].

The addition of fillers has been proven to be an effective approach to modify the polymer matrix properties by conferring thermal and electrical conductivity, to increase the thermal resistance in terms of glass transition and degradation temperatures or even enhance their mechanical properties [4]. Thermal conductivity has proven to be a particularly important drawback for the use of polymer materials in electronics or informatics, where their low density is particularly interesting. However, heat dissipation in small volumes requires improvements in terms of thermal conductivity [5]. Sangermano et al. [6] proposed the addition of inorganic fillers to reach this purpose in PDMS, which are widely used as thermal interface materials (TIMs). The addition of different types of fillers: metallic, ceramic, and carbon-based ones, with different morphologies, allowed researchers to obtain a 300% of increment of base thermal conductivity when using dendritic Cu, being the material with the highest volume concentration and the best results. Moreover, the study concluded that larger Ni particles allowed researchers to reach better thermal conductivity results.

While thermal conductivity has been enhanced by the use of metallic-based fillers, the increase in thermal conductivity while maintaining or improving the electrical insulator behavior has recently received particular attention. The potential application of these materials for power engineering, as stated Wang et al. [7], has led usually to the addition of inorganic fillers. However, it must avoid many of the carbon nanostructures as they would promote electrical conductivity through the material. The use of boron nitride (BN) has proven to be a good option to reach these properties. Nevertheless, as the research concludes, the use of a proper coupling agent has been found necessary to obtain the best results in epoxy resins and, additionally, the combination of nano- and micro-scale BN particles allows for particularly good results.

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The addition of the particles to reach different functionalities might affect some other intrinsic properties of the polymer matrices, as was mentioned by Sangermano et al. when adding the reinforcements to the silicone-based polymer and observing a modification of the rigidity of the matrices [6]. Ambriško et al. [8] proposed in this Special Issue an experimental approach to prove the effect of experimental setup in the measurement of impact properties and establish a relationship between the impact force and the tensile force, which followed a steeper relation when the support system set-up was used. This study confirmed the importance of the set-up when evaluating impact properties in rubbers.

The Special Issue also addresses another important industry for polymers, the coatings industry, and another important problem and challenge for these materials related to environmental aspects [9]. In this regard, Shen et al. propose in this issue a solution of biobased cationic waterborne polyurethanes, which means a reduction of volatile organic compounds (VOCs) during their production [10]. The use of a suitable castor oil content allowed them to obtain stable aqueous dispersions, strongly homogeneous particle distribution, better film-forming capabilities, and finally, enhanced in-service properties such as the T-peel strength of the coating.

Finally, the Special Issue is completed by research works that deal with the development of hydrogels [11] and the use of conductive polymers in electronics, particularly the use of polymer tantalum capacitors, which were introduced in the 1990s and present some advantages that can be found at [12].

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