T183: Synthesis and characterization of nanostructured materials

Design and development of self-healing polymeric materials functionalized with carbon nanotubes for cutting-edge applications

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Strategies to obtain self-healing polymers have rapidly increased and diversified in the last decades, in response to the need to improve the properties of components, extending their service life and reducing the amount of waste [1]. In this context, interest in "vitrimers", a type of self-healing thermosetting polymers, has grown exponentially since their initial publication by Leibler et al [2]. These materials take advantage of exchange reactions between their dynamic bonds to achieve reparation. The exchange reactions modify the topology of the polymeric network, although they maintain the same crosslink density throughout the process, at least theoretically. In the case of epoxy vitrimers, the reaction of epoxy groups with a carboxylic acid yields β-hydroxyesters. These groups can be mutually exchanged through thermally activated transesterification reactions (between an ester of one chain and the -OH of another chain) in the presence of a suitable catalyst [2-4]. Epoxy vitrimers share some characteristics with conventional epoxy networks, such as good mechanical properties and solvent resistance, but with the advantage of being self-healing, reprocessable and recyclable. In this work, we synthesized epoxy vitrimers with graphene oxide (GO), with the aim of endowing the material with the possibility of remotely activating the healing mechanism through irradiation with visible or infrared light, thanks to the photothermal effect of the GO. This methodology allows to achieve the reparation by locally heating only the damaged part of the material, saving energy and preventing an eventual material degradation.
A vitrimeric matrix was synthesized from a commercial epoxy resin based on diglycidyl ether of bisphenol A (DGEBA), glutaric acid (GA) was used as crosslinking agent in stoichiometric ratio and 1-methylimidazole (1MI) at 5% in equivalents with epoxy was used as catalyst. The curing process consisted of 1 hour at 100°C, followed by 2 hours at 160°C. A modified vitrimer was developed by incorporating GO from the initial formulation (0.1% w/w) and sonicated for 20 min. The Tg of the crosslinked virgin matrix, determined by DSC, was close to 53°C (onset). The use of transmission optical microscopy allowed confirming the absence of macroscopic aggregates of graphene oxide in the vitrimeric matrix. Self-healing testing of the modified system was made by a simple way cut on the surface of the sample. At the same time, it was demonstrated that it is possible to join (weld) two specimens of the material together, by direct contact between them under thermocompression. Mechanical tests, characterization by scanning and transmission electron microscopy, stress relaxation and self-healing by photothermia are in progress. As a future synthesis, the impregnation of GO on a fine powder

of the vitrimer is proposed with the idea of achieving adhesion between powder particles from the heating induced by the photothermal effect generated by NIR irradiation.

Acknowledgments

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References

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