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STUDY OF THE MECHANICAL PROPERTIES OF EPOXY NANOCOMPOSITE MATERIALS WITH UCNPS AND GRAPHENE AND THEIR COMPARISON WITH A COMPUTATIONAL RVE/FEM MODEL.

Abstract

In the continuous search for advanced materials for coating applications, this study focuses on the mechanical properties exhibited by epoxy nanocomposites incorporating Upconversion Nanoparticles (UCNPs) and graphene nanoplatelets, intended for use in the aerospace industry. Mechanical tension and flexural tests are rigorously conducted following ISO standards to ensure quality and reproducibility. The Young's modulus is translated into an analytical model and compared with a computational model using Representative Volume Element (RVE) and Finite Element Method (FEM) to understand the mechanism of enhancement by the nano-reinforcements. In this process, epoxy matrix nanocomposites were synthesized with two types of UCNPs nano-reinforcements: ZrO2:6%Yb,1.5%Er and NaYF4:18%Yb,2%Er. Firstly, epoxy nanocomposites were studied using 0, 0.5, 1.0, 1.5, and 2.0 %wt of UCNPs individually, and the photoluminescent response was measured to select the concentration that exhibits the highest efficiency. In both cases, it was determined that the best concentration is 1.0 %wt of UCNPs within the epoxy matrix. To study the photoluminescent quenching effect and major mechanical properties, two lines of nanocomposites were prepared, one with ZrO2 and the other with NaYF4, both with a concentration of 1.0 %wt, and graphene was added to both lines using concentrations of 0.1, 0.4, 0.7, and 1.0 %wt within the epoxy matrix. The mechanical, thermal, and optical properties of the nanocomposites are characterized through a series of tests, including tensile tests, hardness tests, adhesion tests, thermogravimetric analysis, and optical spectroscopy. The results indicate an increase in the Young's modulus between 15% and 45% due to the nano-reinforcements, and the use of graphene can mitigate photoluminescence without compromising properties. This study provides a solid foundation for the future implementation of these epoxy nanocomposites as primer coatings on Al7075 aluminum alloys, which could have a significant impact on improving the strength and durability of such alloys in various industrial and aerospace applications. Furthermore, the experimental Young's modulus and the computational model were used to explain the role of materials as nano reinforcements.