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ABSTRACT

Advanced Epoxy-Based Composites with Improved Environmental Sustainability

A. Jiménez-Suárez[1,2], Z. Esmaeili[1,2], A. Cortés[1], I. Isarn[1], S.G. Prolongo[1,2]

[1]Smart and Sustainable Polymers and Composites Group, ESCET, Universidad Rey Juan Carlos, Spain.
[2] Instituto de Investigación de Tecnologías Para La Sostenibilidad, Universidad Rey Juan Carlos, Madrid, Spain

The use of composites has been increasing over the past decades, mainly those of high performance based on continuous fibers and thermoset resins. Their main use is related to the transportation industry (aircraft and trains but there is also an expected growth in the automotive industry), the energy industry (mainly wind blades production), the sports industry, and defense, among others. This extensive use has raised a huge concern about the origin of the raw materials required and other life cycle stages such as maintenance, repairing, or disposal.
The work is focused on reducing the use of petrol-based raw materials (polymer and carbon fibers) by two different approaches: development of bio-based monomers and the use of high performance alternative continuous fibers. An epoxy monomer based on resveratrol was synthesized and used to impregnate different types of continuous fibers (carbon, glass, and basalt fibers). The use of this epoxy resin avoids the use of DGEBA, a common monomer for epoxy resins, which is a derivative of petroleum and is associated with some toxic concerns. The results obtained were extremely good in terms of mechanical properties and, particularly, thermal properties including flame behavior.
To improve the maintenance and repairability of this material and approach, self-healing and self-sensing were developed. Regarding self-healing, the formation of covalent adaptable network was explored, but the high thermal stability of the thermoset hindered the mobility of the network until temperatures near the degradation of the polymer. In this way, an alternative way to promote self-healing was studied by adding a thermoplastic phase to create a thermoset/thermoplastic blend.
On the other hand, by the addition of carbon-based discontinuous reinforcement the self-sensing capabilities were explored. Strain and failure were monitored by continuously measuring the electrical resistance of the materials, which changes under these two phenomena.

In conclusion, advanced matrices and composites were manufactured and tested to produce multifunctional composites with improved life cycle analysis to reduce their environmental impact and a reduction of petrol-based raw materials.