Multifunctional Layers for Safer Aircraft Composites Structures

M. Txapartegi, A. Iriarte, N. Markaide and **C. Elizetxea**

TECNALIA, Plastics and Organic Composites
Mikeletegi Pasealekua 2, E-20009 Donostia-San Sebastian, Spain

The use of composite materials in aeronautics industry has increased constantly over the last 35 years, due mainly to their high specific strength and stiffness combined with the possibility of designing complex geometry components that are more aerodynamically efficient than metals. But due to organic nature of polymeric matrix component, composite materials are electrically and thermally bad conductors and they tend to burn easily, emitting toxic gases and smoke. For that, they require affordable, effective and certifiable protection systems against atmospheric hazards such as icing and erosion, as well as fire and burning not only for accidents prevention, but also for survivability in case of them. Moreover, improved in field inspection techniques for continuous assessment of their structural health are required with the increased use of composite materials.

The limitations of composite structures for thermal, electrical and fire performance have been a drawback to extend it in many applications. Current technologies address those issues separately; ice protection is usually performed by mean of a metal mesh or foil incorporated into the outer ply of fabric on the skin of the structure, fire protection is performed with thermal barrier coatings on the structures and life monitoring, is performed with embedded sensors. All of them add high weight penalty and complexity during the component manufacturing and posterior maintenance even may go against the structural integrity of the component in some cases.

Final objective of the work to be performed consists of developing a multifunctional layer with thermal and electrical conductivity, improved fire performances and sensing capabilities to be incorporated in aircraft composite structures for ice and fire protection, as well as health monitoring. This can be achieved with the developing of a nanocomposite layer consisting of a polymeric matrix doped with fibrous nanomaterials like CNTs (Carbon Nanotubes) or CNFs (Carbon Nanofibres) that afterward will be incorporated in the manufacturing process of composite parts. Low volume additions of those materials (1-5%) provide property enhancements with respect to the neat resin that are comparable to that achieved by conventional loadings of traditional fillers (15-40%), even unique value-added properties not normally possible with traditional fillers are also observed, such as reduced permeability, tailored biodegradability, optical clarity, self-passivation and flammability, oxidation and ablation resistance. In addition, the lower filler percentage facilitates processing and reduces component weight increase.

In the present work, polymer nanocomposite layers have been prepared incorporating different concentrations of MWCNTs into epoxy and benzoxazine resins. Electrical and electro-thermal characterizations have been also performed, and the preliminary electro-thermal tests confirm the heating capacity of the CNT network. The nanocomposites present good heating performance and low electrical resistivity.

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