Graphene composites: enabling innovative applications in the aerospace and automotive industries

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Abstract
The design of lightweight vehicles is crucial for enhancing fuel efficiency and achieving improved performance while minimizing negative environmental impacts. In order to lower fuel consumption and meet the CO_2 emission targets set by EU regulations, the automotive and aerospace sectors have been increasingly interested in the production of lightweight components and the replacement of metal parts with composite structures. In this context, graphene emerges as the next-gen solution to improve vehicle functionality, reduce production costs for manufacturers and decrease fuel consumption for end users.
In this talk, two case studies of innovative applications of graphene-based composites in the automotive and aerospace sectors are discussed: i) the graphene-enhanced Dallara Stradale car and ii) graphene-based ice protection systems.
Graphene-related materials (GRMs) have been introduced into CFRP panels in the Dallara Stradale car with the aim to enhance fracture toughness, damping, impact, strength and stiffness of specific exterior and interior components. Specifically selected GRM grades were mixed with resin in view of the production of modified CFRP prepregs. The initial selection of materials was followed by the production of prepregs and the fabrication of model panels, which were also subjected to a predefined testing campaign, prior to the fabrication of the final parts to be mounted on the modified Dallara Stradale test car. The efforts were integrated by the assembly of the protype vehicle, followed by a set of large-scale testing and evaluation of the new materials, mounted on the car. The Dallara Stradale prototype exhibited a paramount fire resistivity behaviour, an increase of 23% in the thermal conduction properties, an impressive enhancement in the attenuation of vibrations by 55%, combined with an improvement of 15% in stiffness and bending resistance.
Accumulation of ice on the external surfaces of the aircraft (e.g. wings and propellers) can be extremely dangerous, and graphene-based de-icing systems can offer a low-weight, highly efficient and flexible solution. Graphene-polymer nanolaminates have been recently demonstrated to be highly efficient and responsive heaters [1]. These composites consisting of continuous layers of graphene alternated to thin films of high-performance polymers, present not only a significant enhancement of mechanical and electrical properties but, very interestingly, show impressive Joule heating efficiency. In fact, upon the application of an electrical potential, they can reach temperatures higher than 250 °C, with heating rates up to 325 °C/s. The produced heaters show a very uniform distribution of the temperature even when bend and are characterized by low power consumptions and high areal power densities, and can be introduced as de-icing elements in aircrafts.

References

[1] C Pavlou et al, Chemical Engineering Journal, 497 (2024) 154744.