Graphene composites; current status and new perspectives towards commercial applications

Prof. C. Galiotis
FORTH/ ICE-HT & Chemical Engineering Dept., University of Patras,
Stadiou Str, Platani, P.O Box 1414, Patras, Greece
c.galiotis@iceht.forth.gr or galiotis@chemeng.upatras.gr

Over the last decade, Graphene and Related 2D materials (GRMs) have emerged as ideal inclusions for the development of a whole range of advanced composite materials with enhanced multifunctionality. This is due to the exceptional mechanical, electrical, thermal and impermeable properties of GRMs. In fact, these remarkable properties of GRMs can be imparted to composite material systems in various forms such as fillers, coatings or continuous sheets depending on desired function and cost considerations. Furthermore, GRMs can be integrated in all type of matrices such as metals, ceramics and polymers giving rise to diverse industrial applications in the fields of aerospace, automotive, electronics, renewable energy, biomedical and consumer goods. More specifically, to support wide spread diffusion of GRMs in the plastics industry, low cost, quality controlled and tailor made GRM masterbatches (MBs), *i.e.* polymeric pellets containing high concentrations of GRMs, have been developed at an industrial scale [1]. Integration of GRMs in FRPs (fibre-reinforced plastics), has enabled the development of mechanically enhanced and/or multi-functional integrated system components in industries such as the aerospace and automotive. Low content GRM fibre reinforced plastics (FRPs) have demonstrated notable enhancements [2] in properties such as damping, fracture toughness, impact damage resistance, etc. Likewise, in elastomeric materials, GRMs can bestow a number of physical enhancements [3] (e.g. chemical resistance, thermal stability etc) that has given rise to a multitude of new applications (e.g. smart seals, wear-resisting tires, thermal interface materials, fire retardant elastomers, etc.). Regarding continuous CVD graphene sheets embedded in polymers, recent work [4] has shown the resulting nanolaminates can outperform conventional laminates in certain aspects of mechanical behaviour and most importantly in EMI shielding effectiveness per unit weight. Furthermore, GRM composites containing inorganic components (*e.g.* metallic powders, nanoparticles or nanofibers) have a significant impact in the thermal and electrical efficiency of conductors, tribological characteristics (e.g. switches) and environmental protection of coatings, thus, enabling enhancements in the thermo-electrical properties and life-cycle of the components and reductions in assembly time and cost. As manufacturing goes digital and the industry is striving for more sustainable solutions, GRM composites can significantly contribute towards this goal. For example, GRM composites can substitute poor performing materials presently utilized in additive manufacturing processes (e.g. 3D printing), and thus, enable to produce functional products rather than simple replicas. . They can also readily attain sustainability key drivers, such as reductions in weight, energy savings, system integration, longer service life, lower maintenance, assembly costs and others. The future of graphene composites still faces important challenges. Widespread adoption by the industry would inevitably require further developments in the scaling-up of graphene production, especially if graphene were to be used for example as reinforcement – even at low loadings - in construction applications. Finally, standardization of graphene composites is an issue that is not only limited to maintaining the quality of graphene in large quantities, but also improving product identification amongst different suppliers regarding number of layers, oxygen content, densities, lateral sizes, aspect ratios, etc.

REFERENCES

[1] J. Gomez et. al., Results in Materials, Vol. 7, 2020
[2] F. Valarosi et al., Composite Science and Technology, 2020, pp. 995 -1013
[3] D. G. Papageogiou et al., Carbon, Vol. 95, 2015, pp. 460-484
[4] C. Pavlou et al., Nature Communications, 2021, Submitted