Mechanical reinforcement and multifunctionality in graphene/polymer nanocomposites

Cristina Vallés
Ian Kinloch, Robert J. Young

Department of Materials and National Graphene Institute, University of Manchester, Oxford Road, Manchester M13 9PL, UK

cristina.valles@manchester.ac.uk

Graphene-related materials (GRMs) are of particular interest to the field of polymer composites due to GRMs' exceptional mechanical, electrical and thermal properties.
In order to achieve their potential as mechanical reinforcement, good dispersions of the flakes in the polymer matrix and strong interfaces between both components are required. Gong et al. [1] used Raman spectroscopy to monitor the stress transfer efficiency of the graphene/polymer interface, finding that this interface is weak, and the stress transfer between polymer and graphene depends on both the aspect ratio of the graphene flake and the interfacial stress transfer efficiency (i.e. the degree of interaction between graphene and polymer matrix). Relatively large graphene flakes (>20 μm) will be thus needed before efficient reinforcement can take place in an unfunctionalized graphene/polymer composite [2, 3]. Alternatively, chemical modification of the graphene flakes may significantly strengthen the interface between graphene and polymer, reducing the critical length and increasing the interfacial stress transfer efficiency [4, 5]. This paper will show how GRMs of different nature (which includes unfunctionalized graphene, graphene oxide and polymer grafted graphene) lead to different levels of dispersion and different filler/polymer interfaces, which will determine the final mechanical and thermal properties of the composites.
In addition to mechanical and thermal reinforcement, GRMs are recently raising an enormous interest to provide a polymer with additional functionality, such as electrical conductivity or electromagnetic interference (EMI) shielding properties, leading to multifunctional polymer nanocomposites with great potential for a wider range of technological applications.
For example, we have recently demonstrated that above the critical loading the electrically conducting networks of GNPs formed in an epoxy matrix shows the ability to act as integrated nanoheaters when an electric current is passed through them, successfully curing the composites by a simple Joule heating. This emerges as a promising route for Out-of-Autoclave in-situ thermoset curing method with promise to replace the conventional processing methods [6].
Furthermore, electrically conductive GRMs can also provide a composite structure with outstanding EMI shielding performances. We have recently found that the EMI shielding performance of graphene-based composite structures can be easily tuned by varying the nature and electrical properties of the graphene employed [7], opening the door to applications of composite materials in the communications, medical, aerospace and electronics sectors, where it is vital to isolate the electromagnetic radiation emitted from electronic equipment.

References

[1] L. Gong *et al.* Adv Mater, 22(2010), 2694
[2] C. Vallés *et al.* Faraday Discussions, 173 (2014) 379
[3] C. Vallés *et al.* Compos Sci Technol, 111 (2015) 17
[4] C. Vallés *et al.* Compos Sci Technol, 88 (2013) 158
[5] C. Vallés *et al.* Carbon, 157 (2020) 750
[6] T. Xia *et al.* Compos Sci Technol, 164 (2018) 304
[7] C. Vallés *et al.* ACS Appl. Nano Mater. 2 (2019) 5272