Use of poly (methyl methacrylate) for the graphene and polymer composites production

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Abstract

Graphene plays a crucial role in the field of polymer composites, enhancing the mechanical, electrical, gas-barrier and thermal properties compared to the pristine polymers. [1] However, in order to develop high-performance graphene-based composites, it is essential to solve two main issues, *i.e.,* the scalability of the graphene production [2] and their optimal dispersion in the polymer matrix. [1]

Liquid phase exfoliation (LPE), due to its up-scalability, is one of the most used techniques for the production of graphene.[3] This technique is based on use of ultra-sonication to exfoliate graphite in a suitable solvent.[2] The main requirement for a solvent is its surface tension.[4] Indeed, the surface tension of the solvent has to match with the graphene surface energy to minimize the interfacial tension of the graphene flakes[4]. Appropriate solvents mostly possess high boiling point, with the addition of toxicity issues[5] (*e.g.*, N-Methyl-2-pyrrolidone). On the other hand, the use of water with the aid of a surfactant [6] for the LPE process leads to subsequent issue, such as removal of the surfactant itself.

In this study, we investigated the use of poly (methyl methacrylate) (PMMA), which doesn't need to be removed, unlike surfactants. Indeed, it can be used as a multifunctional component both for the production of graphene flakes in acetone and to enhance the compatibility in a polymer composite. In the LPE process, using different concentrations of PMMA, the thinnest flakes (3-4 layers) were produced with 1 wt.% of PMMA. Indeed, the PMMA polymer can act both as a stabilizer, avoiding the flakes restacking due to its steric effect, and as a compatibilizer, enhancing the interaction between the flakes surface and the polymer matrix. In fact, the presence of the PMMA polymer improves the graphene production, i.e., increasing the few layer graphene (FLG) concentration (from 0.08 mg mL^{-1} in the acetone dispersion to 0.22 mg mL^{-1}).

Acrylonitrile butadiene styrene (ABS) is chosen as polymer matrix, due to its wide use and versatility in the industrial field (*e.g.,* automotive and electronics[7]).

The demonstration of graphene compatibility enhancement with ABS in presence of PMMA is shown by the improvement in the polymer composites properties compared to the pristine ABS. In fact, we achieved improvements in the mechanical properties with the FLG-based ABS composites (*e.g.*, +20%, and +22% for Young's modulus, and tensile strength, respectively, at 0.001 wt. % of FLG flakes loading).

References

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