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Multilayer-Graphene Fillers for Improved Gas Barrier Properties in Polymer Composites

Graphene as a 2D carbon structure has emerged as the strongest lightweight material with excellent charge mobility for many electronic, optoelectronic and energy storage applications [1]. Unlike its other carbon family members such as carbon nanotubes and fullerenes, impermeable platelet structure of graphene can effectively separate gas molecules or completely halt its transportation through polymer matrix when mixed with it. Therefore, an increasing trend of use of layered-graphene structures into polymer composites has been noticed for several applications [2]. In this abstract, a comparison of gas permeability of thermoplastic polyurethane filled with few-layer and multi-layer graphene nanofillers has been presented. Graphene with the different number of stacked layers were mixed with TPU solutions with the help of ultrasonication. Chloroform was used as a common solvent during all preparations. The as-prepared TPU/graphene composites demonstrated a trend of enhanced O_2 gas barrier properties with the increasing number of graphene layers. As such, graphene with 1.3 nm thickness corresponding to ≈ 3 or few-layer graphene displayed 42% reduction in O_2 gas permeability at 5 wt.% concentration. On the other hand, graphene or graphene nanoplatelets with 5.3 nm thickness (≈ 16 layers) produced 54% reduction in O_2 gas permeability at a similar concentration, given that lateral sizes were close to 450 nm in both cases. As shown in Figure 1, graphene with the least number of layers is rolled-up into tube-like structures when mixed with TPU solution. In contrast, graphene with ≥ 10 layers remained equally dispersed throughout the TPU matrix and preserved its platelet geometry as shown in Figure 1. Another multilayered graphene with 13 nm thickness and 740 nm lateral size was also incorporated into TPU/graphene composites for comparison and could not produce any substantial increase in barrier properties. As a result, one can conclude that graphene with more number of layers is highly favorable for gas barrier properties in polymer composites, provided that lateral size is kept constant [3]. In addition to gas barrier properties, the as-prepared TPU composites with 5.3 nm thick graphene fillers demonstrated improvement in mechanical properties. For instance, Young's modulus of TPU film was increased from 6 MPa (for neat) to 15 MPa after 5wt.% graphene loading. However, at more than 5 wt.% graphene concentration the elongation at break was reduced from 600% to 300% [4]. The prepared TPU/graphene composites with enhanced gas barrier and mechanical properties can be used in packaging, pneumatic tubes in industrial process or vehicles and gas container applications.

References

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Figure

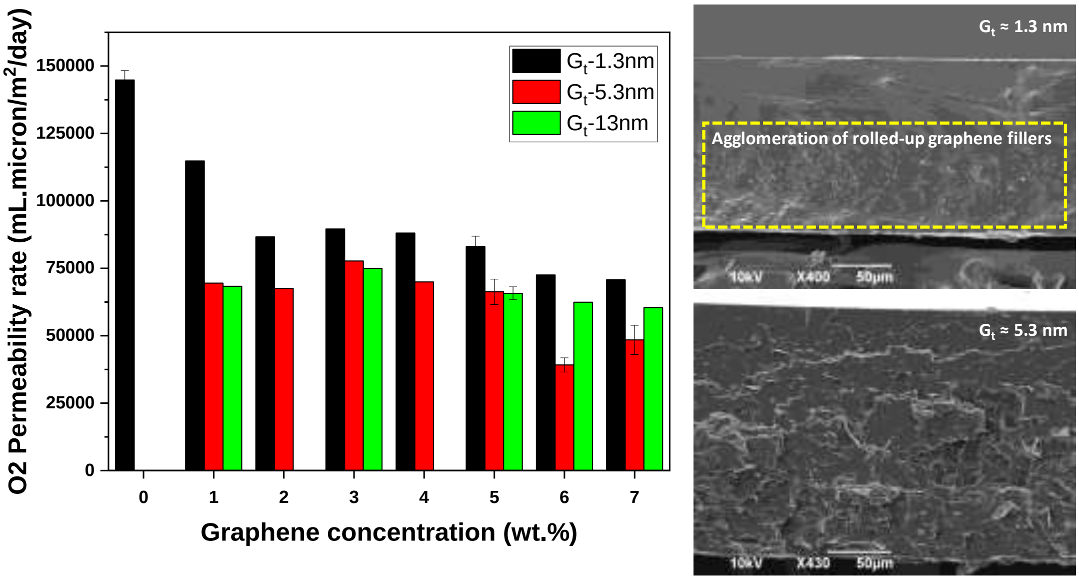

Figure 1: O_2 Gas barrier properties of the TPU/graphene composites loaded with graphene of different thickness or number of layers and their corresponding cross-sectional SEM images. (G_t indicate graphene thickness in nm).

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