

Graphene-based coatings on polymeric films for gas barrier application and separation purposes

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The peculiar properties of graphene are very attractive for several applications, such as the very low gas permeability of the graphene sheet and their characteristic 2-D structure, suitable for the fabrication of barrier materials or gas separation membranes [1]. However, the production of a large and defect-free graphene surface is not practically feasible, and consequently the assembling technique and the method used to couple graphene with e.g. polymeric materials are crucial. Sheets organization can also be exploited for gas separation purposes, selectively blocking only some penetrants, as in molecular sieves.

In this work, use is made of the layer-by-layer (LBL) technique to produce ultra-thin multilayer coatings on polymeric substrates [2]. Commercial polymeric films (PET, PLA or polyimide) are alternatively dipped into polyelectrolyte (polyethyleneimine - PEI) and graphene oxide (C/O \approx 1) water solution, exploiting electrostatic forces to obtain a molecular-thin layer with a high order degree.

The SEM images revealed a quite flat top surface of the coating, in which the GO sheets can be clearly identified, while the analysis of the sample cross section suggested the existence of an alternated structure.

The highly ordered GO structures produced by this method provided a remarkable barrier effect, leading even to a 96% reduction of the O₂ transfer rate on PET, by a 25 bilayer translucent coating (overall thickness about 200 nm). The calculated O₂ permeability of the coating only resulted remarkably low, comparable to the best already-available gas barrier solutions.

The sieving ability of the GO-based coatings on top of Matrimid films (a polyimide characterized by moderate H₂/CO₂ separation performances) was also investigated by direct permeability test of CO₂ and H₂. The peculiar assembly produced by the LbL technique, indeed, conferred to the coating a sieving ability based on penetrant molecular size, suitable to H₂/CO₂ separation, relevant in pre-combustion carbon capture applications. The evaluation of the coating selectivity returned an astonishing value of 70, proving the validity of such approach.

Therefore, this technique allows to conveniently tailor the gas transport properties of ultra-thin coating layers characterized by large sieving selectivity values, and moderate resistance towards the diffusion of small probes such as H₂.

References

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