Graphene and reduced graphene oxide based coatings to improve moisture barrier performance of PET bottles.

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Abstract

Polyethylene Terephthalate (PET) is one of the most used polymers in packaging, because of its properties and versatility. It is becoming the packaging material of choice for many food products, especially beverages (carbonated drinks) and mineral waters. However, a limiting of polymeric materials in packaging is their inherent non negligible permeability to gases and vapors, including oxygen, carbon dioxide and water.[1]

The project intends to address the important issue of improving the barrier properties of PET containers. Aim of this is to explore among possible alternatives, those potentially providing an efficient and cost effective procedure to develop a container with significantly improved moisture barrier.

Possible technological solutions should be easy to implement at lowest cost, sustainable with no impact on recycling and with no impact on bottle appearance. The attention is focused on the technological routes that are considered more amenable to an industrial implementation and a cost effective. The most considered and feasible approach to improve PET barrier properties is the use of a barrier coating.

The concept is the realization of a coating made of a PET compatible polymer additivated with water impermeable fillers, such as graphene and reduced graphene oxide. Coatings are deposed by rod coating and spray coating onto PET substrates and tested to determine WVTR and OTR. The PET compatible polymer is a prevalently amorphous vinyl alcohol polymer with high gas barrier properties. Furthermore, it is transparent and biodegradable.

Graphene and graphene oxide are used in literature as fillers in polymers to improve gas barrier properties of polymer matrix. The permeability coefficient P is dependent upon solubility S and diffusion D coefficients of a gas in a polymer film and can be expressed as $P = S \times D$. The addition of sheets to a pristine polymer would reduce gas solubility, due to insolubility of gas in the nanosheets, and, more importantly, diffusivity, as the gas molecules must move around the introduced impermeable two-dimensional nanofiller to diffuse through the polymer. While a change in gas solubility is normally dependent upon the concentration of the nanofiller, diffusivity is also affected by the aspect ratio of the two-dimensional barriers.[2] Graphene oxide is significantly affected by relative humidity because of its hydrophilic nature. Oxygen-containing functional groups of graphene oxide can be reduced in order to prevent the water vapour transmission.[3] The reduction of graphene oxide can be achieved using ascorbic acid as chemical reducing agent. Ascorbic acid is a non-toxic natural product and it is ideal in the large-scale production of solution-processable graphene.[4]

References

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