World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:17, No:06, 2023

The Impact of β Nucleating Agents and Carbon-Based Nanomaterials on Water Vapor Permeability of Polypropylene Composite Films

Authors : Glykeria A. Visvini, George N. Mathioudakis, Amaia Soto Beobide, George A. Voyiatzis

Abstract : Polymer nanocomposites are materials in which a polymer matrix is reinforced with nanoscale inclusions, such as nanoparticles, nanoplates, or nanofibers. These nanoscale inclusions can significantly enhance the mechanical, thermal, electrical, and other properties of the polymer matrix, making them attractive for a wide range of industrial applications. These properties can be tailored by adjusting the type and the concentration of the nanoinclusions, which provides a high degree of flexibility in their design and development. An important property that polymeric membranes can exhibit is water vapor permeability (WVP). This can be accomplished by various methods, including the incorporation of micro/nano-fillers into the polymer matrix. In this way, a micro/nano-pore network can be formed, allowing water vapor to permeate through the membrane. At the same time, the membrane can be stretched uni- or bi-axially, creating aligned or cross-linked micropores in the composite, respectively, which can also increase the WVP. Nowadays, in industry, stretched films reinforced with CaCO3 develop micro-porosity sufficient to give them breathability characteristics. Carbon-based nanomaterials, such as graphene oxide (GO), are tentatively expected to be able to effectively improve the WVP of corresponding composite polymer films. The presence in the GO structure of various functional oxidizing groups enhances its ability to attract and channel water molecules, exploiting the unique large surface area of graphene that allows the rapid transport of water molecules. Polypropylene (PP) is widely used in various industrial applications due to its desirable properties, including good chemical resistance, excellent thermal stability, low cost, and easy processability. The specific properties of PP are highly influenced by its crystalline behavior, which is determined by its processing conditions. The development of the β-crystalline phase in PP, in combination with stretching, is anticipating improving the microporosity of the polymer matrix, thereby enhancing its WVP. The aim of present study is to create breathable PP composite membranes using carbon-based nanomaterials, such as graphene oxide (GO), reduced graphene oxide (rGO), and graphene nanoplatelets (GNPs). Unlike traditional methods that rely on the drawing process to enhance the WVP of PP, this study intents to develop a low-cost approach using melt mixing with β-nucleating agents and carbon fillers to create highly breathable PP composite membranes. The study aims to investigate how the concentration of these additives affects the water vapor transport properties of the resulting PP films/membranes. The presence of β-nucleating agents and carbon fillers is expected to enhance β-phase growth in PP, while an alternation between β- and α-phase is expected to lead to improved microporosity and WVP. Our ambition is to develop highly breathable PP composite films with superior performance and at a lower cost compared to the benchmark. Acknowledgment: This research has been co-financed by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call «Special Actions "AQUACULTURE"-"INDUSTRIAL MATERIALS"-"OPEN INNOVATION IN CULTURE"» (project code: T6YBP-00337)

Keywords : carbon based nanomaterials, nanocomposites, nucleating agent, polypropylene, water vapor permeability
Conference Title : ICCMCN 2023 : International Conference on Composite Materials and Carbon Nanostructures
Conference Location : Copenhagen, Denmark
Conference Dates : June 15-16, 2023