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Investigation of Polypropylene Composite Films With Carbon Nanotubes and the Role of β Nucleating Agents for the Improvement of Their Water Vapor Permeability

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Abstract : Polymeric nanocomposites have generated considerable interest in both academic research and industry because their properties can be tailored by adjusting the type & concentration of nano-inclusions, resulting in complementary and adaptable characteristics. The exceptional and/or unique properties of the nanocomposites, including the high mechanical strength and stiffness, the ease of processing, and their lightweight nature, are attributed to the high surface area, the electrical and/or thermal conductivity of the nano-fillers, which make them appealing materials for a wide range of engineering applications. Polymeric «breathable» membranes enabling water vapor permeability (WVP) can be designed either by using micro/nano-fillers with the ability to interrupt the continuity of the polymer phase generating micro/nano-porous structures or/and by creating micro/nano-pores into the composite material by uniaxial/biaxial stretching. Among the nanofillers, carbon nanotubes (CNTs) exhibit particular high WVP and for this reason, they have already been proposed for gas separation membranes. In a similar context, they could prove to be promising alternative/complementary filler nano-materials, for the development of "breathable" products. Polypropylene (PP) is a commonly utilized thermoplastic polymer matrix in the development of composite films, due to its easy processability and low price, combined with its good chemical & physical properties. PP is known to present several crystalline phases (α, β and γ), depending on the applied treatment process, which have a significant impact on its final properties, particularly in terms of WVP. Specifically, the development of the β-phase in PP in combination with stretching is anticipated to modify the crystalline behavior and extend the microporosity of the polymer matrix exhibiting enhanced WVP. The primary objective of this study is to develop breathable nano-carbon based (functionalized MWCNTs) PP composite membranes, potentially also avoiding the stretching process. This proposed alternative is expected to have a better performance/cost ratio over current stretched PP/CaCO3 composite benchmark membranes. The focus is to investigate the impact of both β-nucleator(s) and nano-carbon fillers on water vapor transmission rate properties of relevant PP nanocomposites.

Keywords : carbon nanotubes, nanocomposites, nucleating agents, polypropylene, water vapor permeability
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