Oxygen and moisture barrier and heat shielding from polyelectrolyte-clay nanocomposites

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Keywords : layer-by-layer assembly, polyelectrolyte complexes, barrier, flame retardancy

Abstract

Polyethylene terephthalate (PET) and oriented polypropylene (OPP) are widely used in various packaging applications. Vapor deposited SiOx and AlxOy and polymer-clay nanocomposites coatings have been used to improve the gas barrier of these films, but these approaches often reduce flexibility and transparency. Layer-by-layer (LbL) assembly provides a cost-effective alternative. OPP film was coated with a polymer-clay LbL gas barrier nanocoating that improved oxygen and water vapor transmission rate (WVTR). A 30 bilayer polyethylenimine (PEI)/vermiculite (VMT) coating improved the oxygen transmission rate by more than 160X, rivaling most inorganic coatings. WVTR was simultaneously reduced by 42.5% relative to uncoated OPP. This water-based technology is both effective and scalable. Hydrogen-bonded multilayer thin films are very stretchable, but their gas barrier properties are modest compared to more traditional ionically-bonded assemblies like PEI/VMT. In an effort to improve the gas barrier of poly(ethylene oxide) (PEO) – poly(acrylic acid) (PAA) multilayer films, without sacrificing stretchability, montmorillonite (MMT) clay platelets were combined with PAA and alternately deposited with PEO. A ten bilayer PEO/PAA+MMT film (432 nm thick), deposited on a 1 mm polyurethane substrate, resulted in a 54X reduction in oxygen transmission rate and was note damaged after being strained 20%. This nanocoating system is currently the best combination of stretchability and gas barrier ever reported. It is also possible to deposit a high oxygen barrier coating in a single step using a polyelectrolyte complex of polyethylenimine and poly(acrylic acid). A 2 μm thick coating reduces the OTR of 175 micron PET by two orders of magnitude. These types of multilayer coatings are an effective and environmentally benign option for high barrier food, pharmaceutical and electronics packaging. Similar coatings can also be used to reduce the flammability of polyurethane foams used in upholstered furniture and increase the usage temperature of metal sheets used in various forms of transportation.

References

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