Oxygen and moisture barrier from polyelectrolyte-clay nanocoatings

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Polyethylene terephthalate (PET) and oriented polypropylene (OPP) are widely used in various packaging applications. Vapor deposited SiO_x and Al_xO_y 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 two micron 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.

Grunlan Bio: Dr. Jaime Grunlan is the Linda & Ralph Schmidt ’68 Professor of Mechanical Engineering. He obtained a B.S. in Chemistry from North Dakota State University in 1997 before getting his Ph.D. in Materials Science and Engineering from the University of Minnesota. His research focuses on thermal and transport properties of nanocomposite materials, especially in the areas of thermoelectric energy generation, gas barrier and fire prevention. He won the NSF CAREER and 3M Untenured Faculty awards in 2007, the Dow 2009 Young Faculty Award, the 2010 Carl A. Dahlquist Award, the 2013 E. D. Brockett Professorship, the 2014 Texas A&M Engineering Experiment Station (TEES) Fellowship, 2015 Dean of Engineering Excellence Award and 2016 TEES Senior Research Fellow for his work in these areas. He has published over 140 journal papers and been granted several patents in these topics. He has graduated 19 PhD students and mentored more than 50 undergraduate students in his laboratory. Dr. Grunlan also holds joint appointments in Chemistry and Materials Science and Engineering. He is an Editor for *Journal of Materials Science*, Associate Editor for *Green Materials* and serves on the International Advisory Board for *Macromolecular Rapid Communications* and *Macromolecular Materials and Engineering*.