Polymer-Based Nanocoatings for Flame Retardancy, Gas Barrier and Thermoelectric Energy Generation

Layer-by-layer (LbL) assembly is a conformal coating "platform" technology capable of imparting a multiplicity of functionalities on nearly any type of surface in a relatively environmentally friendly way. At its core, LbL is a solution deposition technique in which layers of cationic and anionic materials (e.g. nanoparticles, polymers and even biological molecules) are built up via electrostatic attractions in an alternating fashion, while controlling process variables such as pH, coating time, and concentration. Here we are producing nanocomposite multilayers (50 – 1000 nm thick), having 10 – 96 wt% clay, that are completely transparent and exhibit oxygen transmission rates below 0.005 cm^3/m^2•day. Phosphorus and nitrogen-rich molecules can also be used to impart intumescent behavior. These multilayer assemblies are very conformal and able to impart flame resistance to highly flammable woven and nonwoven fabric substrates without altering other beneficial properties intrinsic to the fibers themselves (strength, breathability, etc.). Nylon-cotton and polyester-cotton blends have passed standard vertical flame tests (ASTM D6413) with 12 – 18 wt% coating deposited. Similar nanocoatings produced with graphene and carbon nanotubes have a surprisingly high Seebeck coefficient (> 100 μV/K) and exhibit very high thermoelectric power factor (up to 3000 $\mu W/m \bullet K^2$). We hope to eventually produce fabric that can generate voltage from body heat. Our work in these areas has been highlighted in *C&EN*, *ScienceNews*, *Nature*, *Smithsonian Magazine*, *Chemistry World* and various scientific news outlets worldwide. For more information, please visit my website: http://nanocomposites.tamu.edu

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Dr. Jaime Grunlan is the Linda & Ralph Schmidt '68 Professor of Mechanical Engineering at Texas A&M University. 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 filed several patents. He has graduated 21 PhD students and mentored more than 50

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