Stevens Institute of Technology
Nanotechnology Graduate Program

Thick and Thin Film Polymer – CNT Nanocomposites for Thermoelectric Energy Conversion and Transparent Electrodes

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This presentation will cover two examples of work we do in the Polymer NanoComposites (PNC) Laboratory (http://nanocomposites.tamu.edu/). The first uses segregated network (latex-based) composites containing carbon nanotubes to produce electricity from a thermal gradient. Thermoelectric materials harvest electricity from waste heat or any temperature gradient in the environment. Polymers are intrinsically poor thermal conductors (desired behavior for thermoelectrics), but low electrical conductivity and thermopower have prevented them from serious evaluation as thermoelectric materials in the past. However, by combining single-walled carbon nanotubes, stabilized with poly(3,4-ethylenedioxythiophene): poly(styrene sulfonate) [PEDOT:PSS] in water, an electrical conductivity (s) near 1300 S/cm is achieved in a poly(vinyl acetate) [PVAc] latex-based matrix. When combined with a thermal conductivity (k) near 0.33 W/m•K and thermopower (S) above 30 mV/K, a thermoelectric figure of merit ($ZT = S^2sT/k$) of approximately 0.11 is achieved at room temperature. The second example demonstrates the ability to make highly transparent and electrically conductive thin films as a potential indium tin oxide (ITO) replacement using layer-by-layer (LbL) assembly of SWCNTs, stabilized with negatively-charged deoxycholate (DOC) and positively-charged poly(diallyldimethylammonium chloride) [PDDA]. The PDDA/(SWNT+DOC) system produced transparent (> 82% visible light transmittance) and electrically conductive (~ 160 S cm^{-1}) 20-bilayer films with a 38.4 nm thickness. Moreover, a series of post treatments, involving heating and nitric acid doping, were used to increase conductivity to 1430 S cm^{-1} (R_s ~ 300 Ω/sq), with no change in transparency, owing to the removal of PDDA and the charge transfer doping. This study demonstrates high visible light transmittance and electrical conductivity of SWNT-based thin films, which are potentially useful as flexible transparent electrodes for a variety of optoelectronic applications.

Professor Jaime Grunlan joined Texas A&M University as an Assistant Professor of Mechanical Engineering in July 2004, after spending three years at the Avery Research Center in Pasadena, CA as a Senior Research Engineer. He obtained a B.S. in Chemistry, with a Polymers & Coatings emphasis, from North Dakota State University and a Ph.D. from the University of Minnesota in Materials Science and Engineering. Prof. Grunlan was promoted to Associate Professor in September 2010. He won the NSF CAREER and 3M Untenured Faculty awards in 2007, and the Dow 2009 Young Faculty Award, for his work in these areas. Dr. Grunlan also holds a joint appointment in Chemical Engineering and serves on the Executive Committee for Texas A&M's Materials Science and Engineering Program.

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