Water-Based Multifunctional Nanocoatings from Polyelectrolyte Complexation: Opportunities & Challenges

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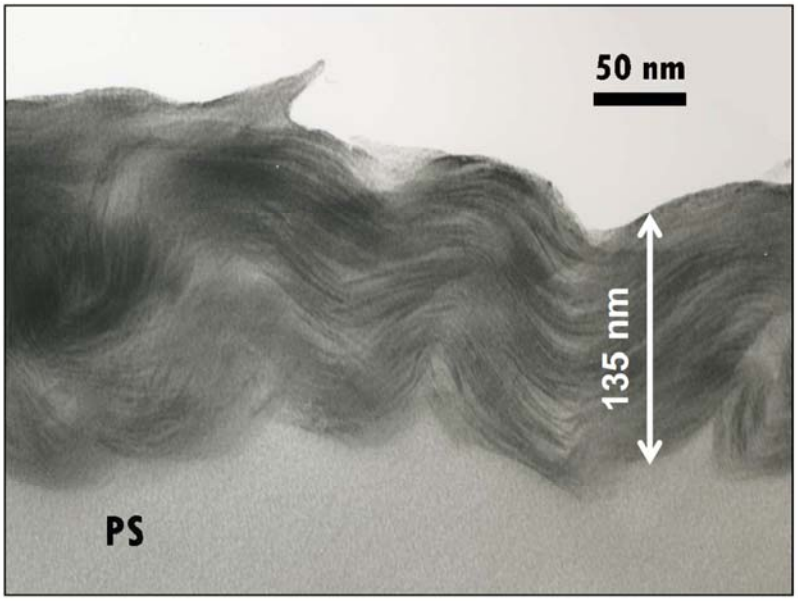
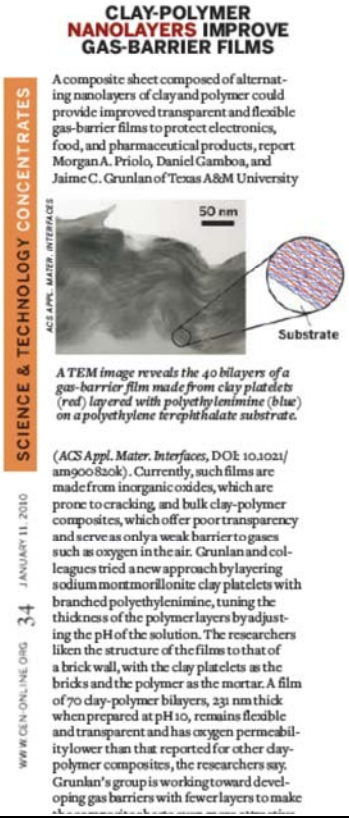
Extended Abstract:

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 can be completely transparent, stop gas permeation, and impart extreme heat shielding to polymeric substrates. In an effort to impart flame retardant behavior to fabric using fewer processing steps, a water-soluble polyelectrolyte complex (PEC) was developed. This nanocoating is comprised of polyethylenimine and poly(sodium phosphate) and imparts self-extinguishing behavior to cotton fabric in just a single coating step. Adding a melamine solution to the coating procedure as a second step renders nylon-cotton blends self-extinguishing. More recently, a PEC coating was developed for polyester-cotton. It passes vertical flame testing after five standard washes or 8 hours in boiling water. Either of these two coating techniques can be deposited using flexographic printing or spray-coating tools. Opportunities and challenges will be discussed. 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



40 BL film of pH 10 PEI-MMT grown on polystyrene and cured in epoxy prior to sectioning.

Grunlan. et al., *ACS Applied Materials & Interfaces* **2010**, *2*, 312.



CLAY-POLYMER NANOLAYERS IMPROVE GAS-BARRIER FILMS

SCIENCE & TECHNOLOGY CONCENTRATES

A composite sheet composed of alternating nanolayers of clay and polymer could provide improved transparent and flexible gas-barrier films to protect electronics, food, and pharmaceutical products, report Morgan A. Priolo, Daniel Gamboa, and Jaime C. Grunlan of Texas A&M University

50 nm

ACS APPL. MATER. INTERFACES

Substrate

A TEM image reveals the 40 bilayers of a gas-barrier film made from clay platelets (red) layered with polyethylenimine (blue) on a polyethylene terephthalate substrate.

(*ACS Appl. Mater. Interfaces*, DOI: 10.1021/am900820k). Currently, such films are made from inorganic oxides, which are prone to cracking, and bulk clay-polymer composites, which offer poor transparency and serve as only a weak barrier to gases such as oxygen in the air. Grunlan and colleagues tried a new approach by layering sodium montmorillonite clay platelets with branched polyethylenimine, tuning the thickness of the polymer layers by adjusting the pH of the solution. The researchers liken the structure of the films to that of a brick wall, with the clay platelets as the bricks and the polymer as the mortar. A film of 70 clay-polymer bilayers, 231 nm thick when prepared at pH 10, remains flexible and transparent and has oxygen permeability lower than that reported for other clay-polymer composites, the researchers say. Grunlan's group is working toward developing gas barriers with fewer layers to make

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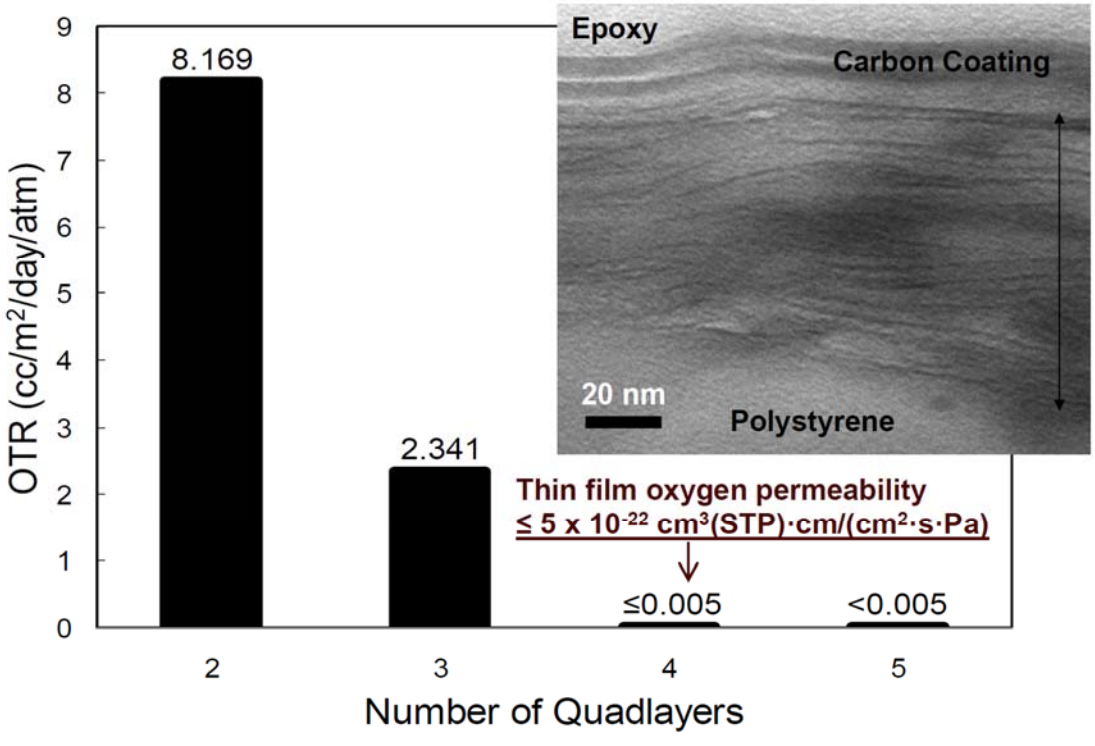
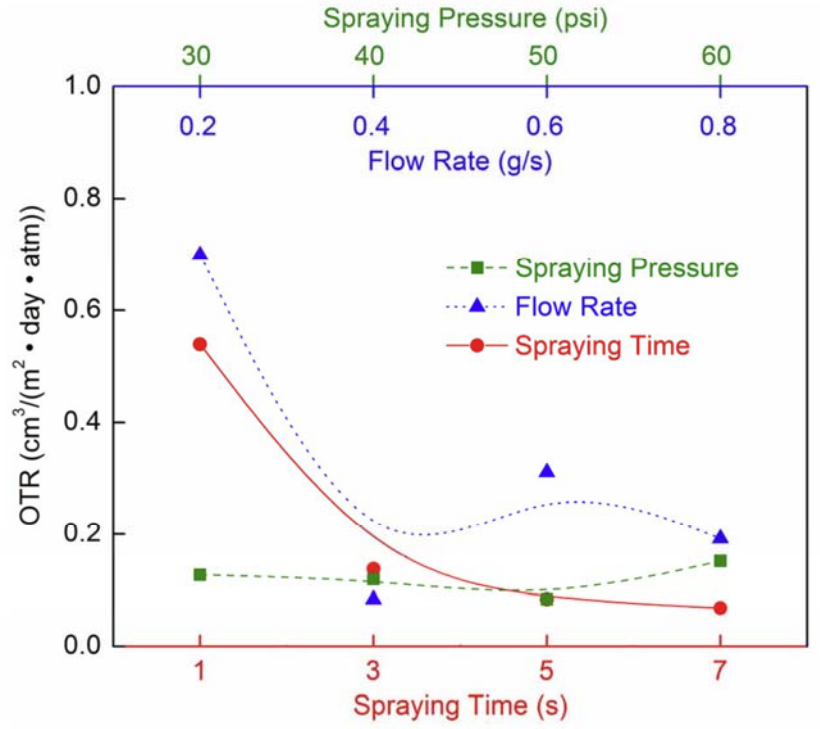
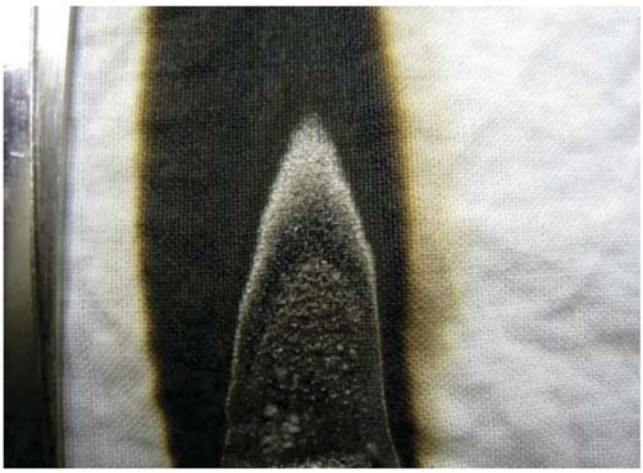


Priolo, M. A.; Gamboa, D.; Holder, K., Grunlan, J. C. *Nano Letters* **2010**, *10*, 4970.



7 BL PEI/PAA nanocoatings on a PET substrate can be quickly sprayed to achieve high oxygen barrier.

Xiang, F.; Grunlan J.C. et al. *Ind. Eng. Chem. Res.* **2015**, *54*, 5254.



An intumescent assembly applied to virgin cotton fabric extinguishes a direct flame from a bunsen burner.

Li, Y. -C., Grunlan, J. C. *Advanced Materials* **2011**, *23*, 3926.