

Tuning the Properties of Polymeric Materials by Controlling Molecular Level Interactions

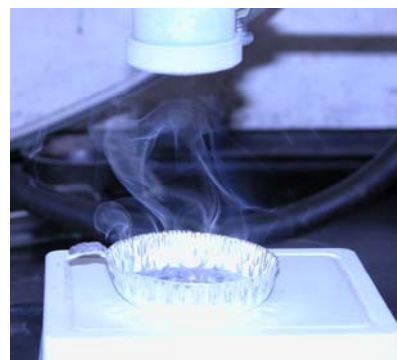
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Synopsis

The dispersion of nanoscale particles or domains in a polymer matrix can provide non-linear enhancement of the material properties and produce novel nanostructured materials with unique and controllable properties. Our group is currently examining systems that will provide an understanding of how manipulation and control of the structure of polymeric components can be utilized to efficiently and reproducibly produce nanoscale dispersions in a host polymer matrix. We are also examining the chemistry of the superglue fuming process, a mechanism used by forensic scientists to develop latent fingerprints. The goal of this study is to understand the molecular level actors that are important in this process, so that new methods can be cultivated to improve the reproducibility and quality of prints that are developed with this method.

Understanding the Chemistry of Superglue Fuming of Latent Fingerprints

A common forensic technique to develop (i.e. make visible) fingerprints is called “superglue fuming”, where the superglue used is the common adhesive; chemically, superglue is a cyanoacrylate. In this technique, the object with the fingerprint is placed above a heated pan that contains the cyanoacrylate, during which the cyanoacrylate monomers vaporize and travel to the fingerprints, as shown in the adjacent figure. Then, by a mechanism that is not well understood, the cyanoacrylate molecules polymerize only off of the fingerprint ridges to form poly(cyanoacrylate). The formation of the



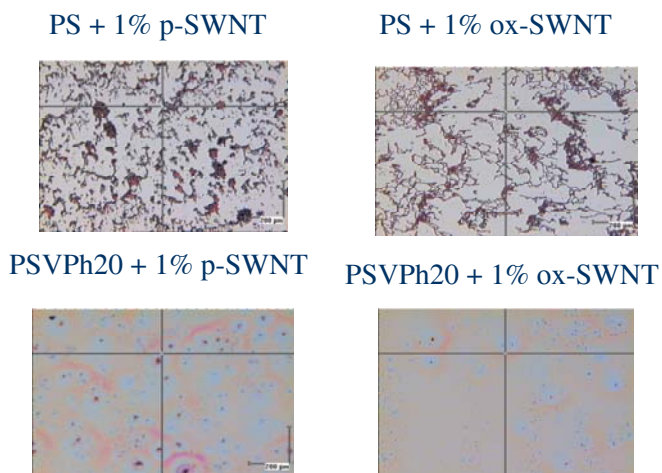
polymer on the fingerprint ridges turns them white and makes them visible. This technique has been utilized by forensic scientists for the past 20 years and has been incrementally improved, but there is still a lack of fundamental understanding of the chemistry of this process. Recent work in our lab has identified the carboxylate functional group as the initiator of the polymer growth, contrary to conventional wisdom that identified the water in the print as the initiator. This has dramatic repercussions, as fingerprints that have been exposed to the atmosphere are not readily developed by this method, and a fundamental understanding of the chemistry of this process can provide insight that can improve the quality of these prints.

Our group is continuing to examine this problem, attempting to understand the role of humidity on the development of the latent print, to create new methods to improve the quality of aged prints that are developed by superglue fuming, and to document the mechanism of degradation in aged prints that is responsible for the decreased quality of fumed aged prints.

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Improved Dispersion and Properties of Polymer Nanocomposites

The dispersion of the minor phase in a multi-component polymer system can readily lead to nonlinear enhancement of material properties. In any multicomponent polymer system, including polymer nanocomposites, understanding and control of interfacial adhesion between the components and the dispersion of the nanofiller in the polymer matrix is critical to rationally design and create a *useful* new material. Work in our group is ongoing to optimize the non-covalent interactions (i.e. hydrogen bonding) between components of multicomponent systems, including polymer blends and nanocomposites with the goal of improving the miscibility and properties of these mixtures. In particular, this protocol has been successful at improving the miscibility of polymer blends containing liquid crystalline polymers as well as improving the dispersion and properties of polymer nanocomposites where the nanofillers are silicate sheets, carbon nanofibers, and single-walled carbon nanotubes, as shown in the neighboring figure.



For example, the addition of a small amount of carbon nanotubes to a polymer matrix can create new materials with extra-ordinary properties, if the extent of dispersion and interfacial interactions can be *reproducibly* controlled. Unfortunately, there exists very little work that attempts to tune the interfacial interactions and dispersion in polymer nanocomposites, however, work in our lab has shown that optimized non-covalent interactions between a copolymer and an anisotropic filler enhances miscibility of the mixture. Controlling the extent of hydrogen bonding between a copolymer and carbon nanotube gives a well-dispersed nanocomposite for both single and multi-wall carbon nanotubes as indicated by Raman spectroscopy, dynamic mechanical analysis, electrical conductivity, optical microscopy and SEM. This work is ongoing in our lab, incorporating electron-donor acceptor interaction between the polymer and carbon nanotubes, where determination of electrical and thermal properties of the nanocomposites, as well as spectroscopy and microscopy, document the amount of electron donor-acceptor interactions between components of the nanocomposite, correlates this to the dispersion and properties of the nanocomposites, and thus provides a method to reproducibly tune the dispersion, properties, and interfacial interaction in polymer nanocomposites.

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