Optical Limiting Displayed by Polymer Films with Ag Nanoparticles Grown *In Situ*

Assemblies of metal nanoparticles within polymer or sol-gel films have nonlinear optical applications such as optical limiting. Typically, such films are cast from a mixture containing preformed nanoparticles, but with current concerns about the health hazards of inhalable nanoparticles, the growth of nanoparticles in thin films *in situ* is preferable. T.P. Radhakrishnan of the University of Hyderabad, S. Singh of the Centre for Cellular and Molecular Biology in India, and their colleagues have developed such a method that uses chemical reduction to form metal nanoparticles within a polymer matrix.

As reported in the January 11 issue of *Chemistry of Materials* (p. 1; doi: 10.1021/cm0485963), the researchers fabricated a poly(vinyl alcohol) (PVA) film with silver nanoparticles grown *in situ*. The simple fabrication process, which uses environmentally friendly materials, has three steps. First, an aqueous mixture of silver nitrate and PVA is spin-coated to a thickness of 400–500 nm onto quartz substrates or glass slides previously coated with polystyrene (PS). In the second step, silver nanoparticles are generated by heating the silver nitrate/PVA films in ambient atmosphere at temperatures ranging from 50°C to 110°C for 5–60 min. PVA acts as both the reducing agent for the silver nitrate and the matrix for homogeneous distribution and immobilization of the silver nanoparticles. In the third step, freestanding films are peeled off the PS substrate. The films are transparent and colorless, but increasing amounts of silver nanoparticles result in a yellow color.

Radhakrishnan and co-researchers performed optical absorption studies (on films formed on glass substrates) to show that nanoparticle production increases with heating times up to a saturation point of ~1 h. The researchers said that a decrease in particle size is shown by a steady but slow blueshift in the absorption maxima with increasing heating time. In addition, the decrease in linewidth observed with heating time demonstrates that particle size becomes more monodisperse with heating. Transmission electron micrographs (with electron diffraction) revealed that films heated for 60 min at 90°C have small particles (with a mean diameter of 2.6 nm) and a tight distribution (estimated standard deviation of 0.2 nm). The researchers said that the particle size can be fine-tuned with temperature and that the average diameter and size distribution of the particles both increase as the silver nitrate concentration increases.

Z-scan measurements at 532 nm demonstrated that the films show strong reverse-saturable absorption at high laser intensities. The researchers also observed appreciable optical limiting with a threshold (defined as the input fluence at which the transmittance reduces to half of the linear transmittance) of 0.83 J cm^{-2} and output clamped at 0.35 J cm^{-2}. The researchers said their method can be easily extended to other metal–polymer and semiconductor–polymer systems that will facilitate device development for optical limiting and other nonlinear optical and sensor applications.

STEVEN TROHALAKI

Nanotubes Fluoresce within Biological Cells

In work documenting the uptake of carbon nanotubes by living cells, a team of chemists and life scientists from Rice University and the University of Texas Health Science Center at Houston, and the Texas Heart Institute have selectively detected low concentrations of nanotubes in laboratory cell cultures. The research suggests that white blood cells incubated in dilute solutions of nanotubes treat the nanotubes as they would other extracellular particles—actively ingesting them and sealing them off inside chambers known as phagosomes.

"Our goal in doing the experiment was both to learn how the biological function of the cells was affected by the nanotubes and to see if the fluorescent properties of the nanotubes would change inside a living cell," said lead researcher B. Weisman, professor of chemistry at Rice. "On the first point, we found no adverse effects on the cells, and on the second, we found that the nanotubes retained their unique