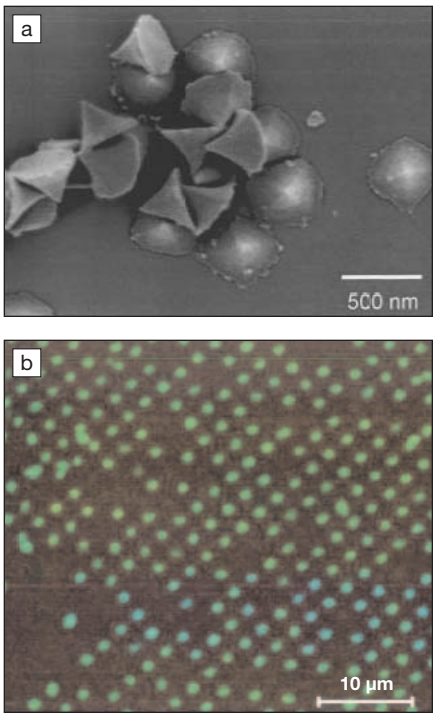


*Figure 1: Conical-shaped particles made using the PRINT (particle replication in nonwetting templates) process: (a) scanning electron micrograph of conical triacrylate particles, <50 nm at the tip, mechanically harvested from an array by using a doctor blade; (b) fluorescent confocal micrograph of 500 nm conical-shaped poly(ethylene glycol) acrylate particles containing avidin, tagged with fluorescent dye.*

that was pooled onto one of the masters. The researchers demonstrated the fabrication of monodisperse particles of technologically relevant materials such as poly(ethylene glycol acrylate), or PEG-acrylate; bioabsorbable poly(lactide); and triacrylate resin. PRINT allows a variety of particles to be created, ranging from triacrylate nanoparticles (~200 nm in size) to complex micrometer-scale objects such as fluorescently labeled avidin (a protein) encapsulated in conical PEG-acrylate particles, shown in Figure 1. Vacancies are sometimes observed in regular arrays because material that was meant to be deposited remains trapped in the walls of the mold, but the researchers are working on methods to ensure release of the material to make error-free arrays. The researchers said that the PFPE-elastomeric molds are robust, having been used for multiple experiments with no deterioration. The ability to encapsulate delicate cargos, such as DNA, proteins (e.g., avidin), and chemotherapeutics (e.g., doxorubicin) within particles will make PRINT an important technique for next-generation particulate drug-delivery agents, the researchers said.

ADITI RISBUD

## UV Irradiation Combined with $TiO_2$ Photocatalyst Kills Bacteria in Flowing Air Streams

Recent outbreaks of diseases such as SARS and pneumonia, caused by airborne pathogens, has led to great interest in methods for decontaminating bacteria-containing air, especially in closed environments such as hospitals, factories, public buildings, and aircraft. $TiO_2$ shows strong oxidizing ability under UV irradiation and is commonly used to decompose organic pollutants in air and water. However, only recently has the pathogen-killing power of UV-irradiated $TiO_2$ been explored, with bactericidal effects demonstrated in aqueous suspensions of $TiO_2$ or in cell suspensions deposited on substrates coated with $TiO_2$ thin films. In the June 13 issue of *Chemical Communications* (p. 2918; DOI: 10.1039/b503638k), V. Keller and colleagues from Louis Pasteur University (Strasbourg, France) report a method to harness this photocatalytic ability of $TiO_2$ to decontaminate a bacteria-containing air stream.

The researchers used a specially designed air-decontamination device, consisting of an aerosol generator and a bacteria cultivation medium, to provide a steady stream of bacteria-containing air, and a high-surface area UV photoreactor with a specific geometry. A 5 µm uniform coating of the titania photocatalyst (80:20 mixture of anatase and rutile phases) was prepared on the inner surface of a Pyrex tube, which had a geometry designed to maximize contact (surface area, ~50 $m^2/g$) between the pathogen-containing air stream and the photocatalyst. Keller and co-workers used *Escherichia coli* as the model bacteria, because of their similar size and morphology to *Legionella pneumophila*, and both are Gram-negative bacteria. The researchers carried out photocatalysis using 380 nm light from black-light tubes surrounding the reactor. The number of live bacteria was determined by collecting samples before and after the photocatalytic reactor. The stain 5-cyano-2,3-ditolyl tetrazolium chloride was used as a fluorescent indicator to identify breathing and dead bacteria through fluorescence microscopy. Furthermore, the researchers said that both UV irradiation and $TiO_2$ were essential for the removal of the bacteria; the process did not work with only UV irradiation or only $TiO_2$.

The photocatalytic reactor showed a 99.1–99.8% efficiency in removing bacteria from flowing air streams, even at high flow rates (1.5–6 L $min^{-1}$) with up to 26,000 colony-forming units (CFUs) of bacteria per cubic meter, demonstrating that this device could potentially be used for on-line applications in contaminated areas. The researchers said that this technique represents a rapid, easy, and practical route toward addressing risks to public health from microbial pathogens.

SARBAJIT BANERJEE

## All-Solid-State Laser Shines in the Orange, Yellow, and Green

Although diode lasers offer some important capabilities, there is still no widely available, all-solid-state laser system that can be easily tuned over a large range of visible wavelengths. However, thanks to a team of researchers from Macquarie University in Australia, that may soon change. The researchers, R.P. Mildren, H.M. Pask, H. Ogilvy, and J.A. Piper, have demonstrated an all-solid-state laser that can be easily tuned to discrete orange, yellow, and green wavelengths while achieving powers of more than a watt.

As reported in the June 15 issue of *Optics Letters* (p. 1500), the researchers based their laser system on existing techniques for yellow–orange lasers currently used in medical and defense applications. They began by pumping a neodymium-doped yttrium aluminum garnet (Nd:YAG) crystal with 808 nm light, generating near-infrared light at 1064 nm. The crystal was placed in an optical cavity with a slab of $KGd(WO_4)_2$, which Raman-shifted some of the Nd:YAG light to 1159 nm and 1272 nm. The novel aspect of the system is the presence of two nonlinear lithium triborate (LBO) crystals in the cavity, to perform frequency mixing of the fundamental and Raman-shifted wavelengths. Frequency mixing, which is used to combine low-energy, long-wavelength light fields to produce higher-energy, shorter-wavelength light, is usually performed with a single crystal, and strongly depends on the crystal's temperature and angular placement, making it difficult to tune. With the innovative use of two independently temperature-controlled LBO crystals placed in the cavity at different angles, the research team was able to use frequency mixing to selectably convert the near-infrared light to 532 nm (green), 555 nm (greenish-yellow), 579 nm (yellow), and 606 nm (orange) with high efficiency. The scheme required that the crystal temperatures be tuned over a relatively small range (19°–95°C), and generated 0.25–1.5 W of optical power. This laser system is very promising for potential commercial applications because of the



https://doi.org/10.1557/mrs2005.176 Published online by Cambridge University Press

speed of tuning (about 1 minute) and the fact that no mechanical motion, such as rotating the crystals, is required.

The team concluded by noting that a $KGd(WO_4)_2$ crystal can be rotated by 90 degrees to produce a different set of Raman-shifted wavelengths from the 1064 nm fundamental. They speculated that with only minor adjustments the same double-LBO-crystal scheme combined with this alternative orientation could produce a different set of frequency-mixed laser wavelengths, which could be useful for certain wavelength-specific applications.

COLIN MCCORMICK

## Cross-Linked Nanostructures Synthesized From Block Copolymers

Nanoparticles formed by selectively cross-linking block copolymers have attracted interest for possible use as nanoreactors and as agents for encapsulation, transduction, and drug delivery. The production of these nanoparticles is complex, requiring multiple controlled synthesis steps. Recently, however, S. Harrisson and K.L. Wooley of the Center for Materials Innovation and the Department of Chemistry at Washington University in St. Louis have developed a simplified "one-pot" technique for the synthesis of cross-linked nanostructures.

In issue 26 of *Chemical Communications* (p. 3259; DOI: 10.1039/b504313a), Harrisson and Wooley described the synthesis procedure and presented transmission electron microscopy (TEM) images of the resulting nanostructures. The synthesis begins with commodity monomers of styrene (STY) and maleic anhydride (MA). Diblock and triblock copolymers were produced by radical addition fragmentation chain transfer (RAFT) polymerization. The ratio of MA/STY/RAFT agent during this polymerization step determined the length of the copolymers.

Water was then added to the copolymer solution to form micellar aggregates. These particle assemblies were analyzed by TEM, and most showed a definite structural ordering, with micelles arranged in a rosette pattern. The observed uniform structures are intriguing for aggregates having lengths of tens of nanometers.

In the final synthesis step, cross-linked nanoparticles are formed by carbodiimide-mediated amidation. The cross-linking was confirmed by infrared spectral analysis of the cross-linked structures and their subsequent dissociation. TEM images recorded from these nanoparticles showed a further increase in microstructural complexity. Measurements of nanoparticles in solution using dynamic light scattering agreed well with TEM measurements of nanoparticles prepared on substrates.

This work demonstrates a new method for the synthesis of cross-linked nanoparticles having well-defined structural characteristics and morphologies using a "one-pot" route. According to the research team, this advance should lead to an improved understanding of the internal structures of these assemblies and increased control over their characteristics.

ANDY FRANCIS

## Single-Molecule Spectroscopy of Organic Dye Nanoparticles Explains Bulk Fluorescence

A.J. Gesquiere of the University of Texas at Austin, T. Uwanda of Osaka University, and their colleagues reported in the May 23 issue of *NanoLetters* (p. DOI: 10.1021/nl050567j) the application of single-molecule spectroscopy (SMS) to





https://doi.org/10.1557/mrs2005.176 Published online by Cambridge University Press