



**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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> been explored, with bactericidal effects demonstrated in aqueous suspensions of TiO<sub>2</sub> or in cell suspensions deposited on substrates coated with TiO<sub>2</sub> 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<sub>2</sub> 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<sup>2</sup>/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<sub>2</sub> were essential for the removal of the bacteria; the process did not work with only UV irradiation or only TiO<sub>2</sub>.

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<sup>-1</sup>) 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 K<sub>2</sub>Gd(WO<sub>4</sub>)<sub>2</sub>, 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 selectively 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