

RESEARCH/RESEARCHERS

Hollow-Shell Silicalite Nanostructures Formed on Sacrificial Latex Beads

The zeolite silicalite has general applications in catalysis and separation processes. Recently, Sean Davis and co-workers at the School of Chemistry at the University of Bristol, U.K., and the Max-Planck-Institute for Colloid and Surface Science in Golm, Germany, reported the assembly of silicalite nanoparticles into macroporous bulk materials. The assembly consisted of (1) the electrostatic deposition of multiple layers of nanoparticles onto polystyrene beads, and (2) the centrifugation of these heterostructures to obtain the bulk product. Calcination produced a silica material containing a hierarchical pore structure. Davis said, "[C]urrently at Bristol we are developing a number of strategies for the assembly (e.g. self-, directed-, templated) of nanoparticles into higher-order architectures. This particular assembly protocol has the advantage that it can be altered to control the pore diameter and wall thickness of the product."

As reported in the October 16 issue of *Chemistry of Materials*, silicalite nanoparticles were prepared by an established method using tetrapropylammonium hydroxide as the structure-directing agent. The nanoparticles had a mean diameter of 47 ± 10 nm, as measured by transmission electron microscopy.

The electrostatic deposition of the nanoparticles was accomplished by first coating the 640-nm polystyrene beads with a layer of poly(diallyldimethylammonium chloride) (PDADMAC) to give the surface of the bead a positive charge. The modified beads were then exposed to the negatively charged nanoparticles. Subsequent nanoparticle layers were deposited by coating the last adsorbed layer with PDADMAC and again exposing the heterostructure to the nanoparticles. Up to five layers of nanoparticles were deposited on the beads. The average thickness of each layer was found to be 39 nm.

The heterostructures were assembled into macroporous solids by centrifugation at 2000 rpm. This was followed by calcination above 800°C to remove the organic components and fuse the nanoparticles by silanol condensation. The product, characterized by transmission and scanning electron microscopies, was a macroporous solid having, on average, 500-nm-diameter pores, separated by 200-nm-thick microporous walls for five nanoparticle-layer heterostructures, that is, a hollow-shell, multilayer nanostructure. Electron-diffraction measurements showed that the

walls separating the pores consisted of crystalline silicalite nanoparticles.

This approach to the production of bulk solids from nano-sized components differs from the usual method of introducing nanomaterials into an ordered superstructure lattice. The new method allows precise control over both pore size and wall thickness by controlling bead diameter and the number of capping layers, respectively. This method also allows for systematic modification of the wall composition by using heterostructures prepared with layers of several types of nanocrystals.

GREG KHITROV

C₆₀-Doped Zirconia Produces Homogeneous Dispersion of Carbon

A multidisciplinary team of researchers in Japan is developing a procedure to obtain zirconia ceramics doped with C₆₀.

Its main interest is to take advantage of the tribological properties of C₆₀ while decreasing its high manufacturing costs. This combination is expected to result in a ceramic with outstanding mechanical properties and reduced friction resistance.

The scientists, from the University of Tokyo, the Electrotechnical Laboratory, and the National Institute for Research in Inorganic Materials, have obtained a uniform distribution of C₆₀ in the zirconia matrix, as they report in the September issue of the *Journal of the American Ceramics Society*. This homogeneous distribution was achieved after mixing a combination of zirconium oxynitrate dihydrate (ZOD) and hexadecyltrimethylammonium chloride (C₁₆ TMA) in aqueous solution. C₆₀ powders were added to obtain a final composition of ZrO₂-3mass%C₆₀. The powders were then dried and sintered in an ultrahigh-pressure machine at 5.5 GPa and 600°C for 2 h. The resulting density of

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this material was 92% of the theoretical density, and x-ray images show a uniform carbon distribution. High-resolution transmission electron microscopy observations showed several crystalline C₆₀ particles as intergranular precipitates, but most of the carbon present formed a thin film covering the zirconia grains. The carbon present in these films was either graphitic or amorphous carbon, with a film thickness between 3 nm and 10 nm. The Vickers hardness of the composite specimen was a factor of 6 smaller than that of stabilized zirconia ceramics. The researchers suggest that the graphitic/amorphous carbon film

is responsible for a reduction in the mechanical properties of this material, particularly in the hardness. However, they also said that, with further research, this material may have applicability as electric-conductive and wear-resistant fine solid lubricants in the future.

SIARI S. SOSA

Antimatter Generated Using Table-Top Laser System

Recent progress has been rapid in the field of table-top laser technology. Focused intensities approaching 10²⁰ W/cm² are becoming common, and the

generation of γ -rays, x-ray/ultraviolet (XUV) radiation, and fusion neutrons has been reported. Now, antimatter in the form of positrons has been observed by researchers from the Max-Planck-Institute for Quantum Optics in Garching, Germany, and the Lund Institute of Technology in Sweden. In the October 23 issue of *Applied Physics Letters*, they report the production of 10⁶ positrons (e⁺) per laser pulse, with a mean energy of approximately 2 MeV. The maximum intensity of this new source is estimated to be equivalent to 2 × 10⁸ Bq. Although positron generation has been reported in experiments at Lawrence Livermore National Laboratory using the petawatt laser source, this is the first report of such phenomena produced with a tabletop system.

By focusing 790-nm wavelength laser pulses of 130-fs duration and 220 mJ pulse energy from the ATLAS laser facility at the Max-Planck-Institute onto a helium gas jet, a beam of fast, multi-MeV electrons was generated. Electron-positron pairs were produced by directing this beam onto a 2-mm-thick slab of Pb, which served as a high-Z converter. Known mechanisms for such conversions include Bremsstrahlung photon processes and electron-nucleus collisions. Preliminary calculations carried out by the investigators indicated that the indirect Bremsstrahlung process should dominate, and that given a 2-mm-thick Pb converter and 3-MeV electrons, a fraction of 10⁻³ should be converted into positrons.

The primary electrons emerging from the gas jet were collimated by passing through a 1-cm-diameter hole in a plastic block. The Pb converter disk was placed inside this hole, at a distance of 16 cm from the helium-gas jet. Upon exiting the converter, the electron-positron pairs were separated by a 150-mT magnetic field; the positrons were detected by a light-tight, 1.5-cm-thick plastic scintillator coupled to a photomultiplier tube.

Two types of measurements were taken: one with the path of the positrons to the scintillator blocked (to measure only the background signal), and one with the path open (measuring both background plus positron signal). The difference between these measurements accounts for the positron contribution only. In the 2 ± 0.08 MeV channel, 30 ± 14 positrons on average were detected per laser pulse, comparing favorably with the calculated average of approximately 25 positrons per pulse. After scaling this over the full energy range and the entire solid angle, the researchers infer a value of 10⁶ positrons per pulse. Further scaling this result to the full uncollimated elec-

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