Recently, however, R. Chakrabarty at the Desert Research Institute in Reno and the University of Nevada, M.A. Garro of the Desert Research Institute in Reno and Harvard University, J.G. Slowik of the University of Toronto, E.S. Cross of Boston College, T.B. Onasch of Aerodyne Research, Inc. in Billerica, Mass., and their colleagues have observed ensembles of cluster-dilute soot FAs with much lower D_f values, in the range of 1.2–1.5.

As reported in the June 12 issue of *Physical Review Letters* (DOI: 10.1103/PhysRevLett.102.235504; #235504), Chakrabarty and co-researchers used a pre-mixed ethene-oxygen flame set-up that allowed them to vary the fuel-to-air equivalence ratio, ϕ, from 2.3 to 5.0. After removing soot particles larger than 5 μm from the sample with an impactor, the particles were bipolarly charged with a neutralizer, and then directed to two in-series electrostatic classifiers (ECs), which are widely used for particle sizing and operate with a combination of viscous and electrostatic force to select particles with a combination of charge and electrical mobility diameter, D_m. The researchers said that this morphology segregation technique is based on the higher likelihood for more elongated particles becoming doubly charged than compact particles because less energy is required to add a second charge at a larger distance than at a short one. Constituting about 3% of the total submicron particle sample and following a Gaussian distribution with a peak D_m of about 460 nm, elongated FAs were impacted onto clear polycarbonate filters for scanning electron microscopy (SEM) analysis.

Samples were coated with 1 nm Pt to prevent aerosol charging during SEM. The researchers imaged about 150 doubly-charged FAs for each ϕ and corrected for the screening effect of 3D particles projected onto two dimensions. Image analysis showed a monotonic decrease in D_f from 1.51 to 1.20 as ϕ increases from 2.3 to 3.5, which the researchers explained by suggesting that the electric field inside the flame causes a partial alignment of aggregates with a dipole moment and non-Brownian diffusion of charged monomers during the aggregation process. D_f should approach unity in the limit of vanishing Brownian motion.

The researchers said, "If the electrostatic force hypothesis can be verified, it may be possible to control the fractal dimension and associated properties of soot through application of a static electric field."

STEVEN TROHALAKI

Surface-Modified Mesoporous Silica Nanoparticles Serve as Drug Carrier System

The future of cancer therapies will draw from nanotechnology, cell biology, and organic chemistry. Drug delivery will play a vital role in realizing the potential success of newly discovered therapeutic agents, at least 40% of which are poorly soluble in water. Drug delivery matrices, targeting systems, and drug discovery can combine to create the ideal cancer therapy. By utilizing an interdisciplinary approach to address these requirements, J.M. Rosenholm of Åbo Akademi University, Finland, E. Peuhu of the University of Turku and Åbo Akademi University, Finland, and their colleagues have recently described their study using poly(ethylene imine) (PEI)-functionalized mesoporous silica nanoparticles as a cancer therapy delivery system.

As reported on July 2 in the online issue of *Nano Letters* (DOI: 10.1021/nl901589y), the research team created mesoporous silica nanoparticles with hyperbranched PEI conjugated to the surface. In order to design a cancer-targeting system, folic acid moieties, a ligand for a cell surface receptor that is over-expressed in cancer cells, were covalently attached to the PEI layer. By incubating nanoparticles with fluorescent dyes, delivery to cells could easily be monitored by confocal microscopy. Two different fluorescent dyes were used as models of poorly water-soluble compounds. Both molecules could be delivered into HeLa cells, a commonly studied cervical cancer cell line, without any leakage prior to endocytotic uptake. Furthermore, both fluorescent dyes could be co-delivered, suggesting the ability to administer multiple therapeutic agents simultaneously. As a final control, nanoparticles were incubated with both HeLa cells and a noncancerous cell line, epithelial HEK 293 (human embryonic kidney) cells. Minimal fluorescence was observed in HEK 293 cells, while HeLa cells were easily detected by fluorescence microscopy, demonstrating specificity of delivery between healthy and cancerous cell populations.

By combining aspects of materials chemistry, polymer chemistry, cell biology, and biotechnology, a very complex and innovative delivery matrix was designed. The researchers said that future research will be aimed at evaluating targetability, pharmacokinetics, toxicity, and particle degradation in animal tumor models *in vivo*.

DEVIN G. BARRETT

Optical Transistor Developed with Single Molecule

In order to reduce heat and increase the rate of data transfer in computers, scientists are searching for ways to produce integrated circuits that operate on the basis of photons instead of electrons. While optical transistor-like action has been previously reported in molecular systems involving many molecules as well as in single emitter configurations such as high-finesse micro-cavities or waveguides, these approaches are not generally suitable for photonic integrated circuits. Now V. Sandoghdar and colleagues at the Swiss Federal Institute of Technology have created an optical transistor using a single emitter configuration consisting of single molecules of dibenzanthanthrene doped in an *n*-tetradecane matrix.

As reported in the July 2 issue of *Nature* (DOI: 10.1038/nature08134; p. 76), the researchers discuss using one laser beam to prepare the quantum state of a single molecule of dibenzanthanthrene in a controlled fashion, such that they could significantly attenuate or amplify a second laser beam incident upon the molecule. This mode of operation is similar to that of a conventional transistor, in which electrical potential can be used to modulate a second signal. In order to enable this mode of operation, the researchers found that it was necessary to focus both laser beams to spot sizes approximately equal to the interaction cross-section of the single molecule. However, laser beams cannot generally be focused to spot sizes below the optical diffraction limit. On the other hand, at low temperatures, the cross-section for interaction of light with the dibenzanthanthrene molecule increases. The researchers found that by cooling the molecule down to –272°C, they could achieve a regime in which the enlarged interaction cross-section of the molecule corresponded approximately to the diameters of the tightly focused laser

beams. They also found that control of the intensity of the optical beams was critical to observing transistor-like action in the single molecule.

Sandoghdar said, "Many more years of research will still be needed before photons replace electrons in transistors. In the meantime, scientists will learn to manipulate and control quantum systems in a targeted way, moving them closer to the dream of a quantum computer." Thus component parts such as the new single molecule optical transistor may also pave the way for a quantum computer.

Mechanical Stress Leads to Self-Sensing in Solid Polymers

Parachute cords, climbing ropes, and smart coatings for bridges that change color when overstressed are several possible uses for force-sensitive polymers being developed by N. Sottos, D. Davis, and colleagues at the University of Illinois—Urbana-Champaign (UIUC). The polymers contain mechanically active molecules called mechanophores. When pushed or pulled with a certain force, specific chemical reactions are triggered in the mechanophores.

"This offers a new way to build function directly into synthetic materials," said Sottos, a Willett Professor of materials science and engineering at UIUC. "And it opens the door to creating mechanophores that can perform different responsive functions, including self-sensing and self-reinforcing, when stressed."

In previous work, Sottos and collaborators showed they could use mechanical force to induce a reaction in mechanophore-linked polymers that were in solution. Now, as reported in the May 7 issue of *Nature* (DOI: 10.1038/nature07970; p. 68), the researchers show they can perform a similar feat in a solid polymer.

The researchers used molecules called spiropyrans, a class of molecular probes that serve as color-generating mechanophores, capable of vivid color changes when they undergo mechanochemical change. Normally colorless, the spiropyran used in the experiments turns red or purple when exposed to certain levels of mechanical stress.

"Mechanical stress induces a ring-opening reaction of the spiropyran that changes the color of the material," said D. Davis, a graduate research assistant and the article's lead author. "The reaction is reversible, so we can repeat the opening and closing of the mechanophore."

To demonstrate the mechanochemical response, the researchers prepared two different mechanophore-linked polymers and subjected them to different levels of mechanical stress. In one polymer, an elastomeric mechanophore-linked poly(methyl acrylate) (PMA), the material was stretched until it broke in two. A vivid color change in the polymer occurred just before it snapped. The second polymer, a glassy mechanophore cross-linked poly(methyl methacrylate) (PMMA), was formed into rigid beads 100–500 μm in diameter. When the beads were squeezed, they changed from colorless to purple. The color change that took place within both polymers could serve as a good indicator of how much stress a mechanical part or structural component made of the material had undergone.

"We've moved very seamlessly from chemistry to materials, and from materials we are now moving into engineering applications," Sottos said. "With a deeper understanding of mechanophore design rules and efficient chemical response pathways, we envision new classes of dynamically responsive polymers that locally remodel, reorganize or even regenerate via mechanical regulation."

Working Model of a Two-Qubit Electronic Quantum Processor Developed

L. DiCarlo, J.M. Chow, L.S. Bishop, B.R. Johnson, D.I. Schuster, L. Frunzio, S.M. Girvin, and R.J. Schoelkopf of Yale University, J.M. Gambetta of the University of Waterloo, J. Majer of Vienna University of Technology, and A. Blais of the Université de Sherbrooke have implemented simple algorithms using a quantum processor based on microwave solid-state technology—similar to that found in computers and cell phones. The new processor is far from conventional, however, in that it uses the potent power of quantum mechanics to bring the dream of quantum computing a small but significant step closer to reality.

"Our experiment can only perform a few very simple quantum tasks, which have been demonstrated before using other systems such as photons, trapped ions, and nuclear magnetic resonance," said Robert Schoelkopf, a principal investigator and professor of applied physics and physics at Yale. "But this is the first time it has been done in an all-electronic device, which looks and feels much more like a regular microprocessor."

As reported in the June 28 online issue of *Nature* (DOI: 10.1038/nature08121), the research team used artificial atoms as quantum bits, or qubits. Although made from over a billion aluminum atoms in a superconducting electronic circuit, these qubits behave as single atoms. The difference is that the manufactured atoms are much larger and therefore easier to control than single atoms or other types of qubits.

The devices were fabricated on an *R*-plane α Al_2O_3 wafer with 180-nm thick Nb coplanar waveguides. The artificial atoms (qubit structures), based upon interdigitated capacitors and split-junction structures, were fabricated using double-angle evaporation of Al (20/90 nm) with intermediate oxidation.

Just like a single atom, an artificial atom can be stimulated into different energy states, akin to the "on" and "off" states of the bits in conventional computers. But following the counterintuitive laws of quantum mechanics, the scientists can also place these artificial atoms in "superpositions" of quantum states—both "off" and "on" at the same time. This wider variety of possible states allows for greater information storage and processing power.

"The success of the experiment relied on integrating three previously demonstrated capabilities," said Leonardo DiCarlo, lead author of the article. According to DiCarlo, the key building blocks included local tuning of qubits on nanosecond timescales, which enabled the researchers to switch the interaction between the qubits "on" and "off" abruptly; a joint readout scheme that efficiently reveals two-qubit correlations; and state-of-the-art coherence times of about 1 μs for both qubits.

"There have been several earlier instances of two-qubit logic gates, but to do a quantum computation, you need to be able to control single qubits, and you

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