

IMAGE COURTESY OF MARCUS WECK

This figure shows a comparison of the strategies to obtain copolymers: (A) traditional "living" polymerization strategy and (B) the self-assembly strategy. Conventional strategy (A) relies on the living polymerization of monomers, while the self-assembly method is based on a universal backbone and the controlled self-assembly of side-chains onto the backbone.

Imitating Nature

Future designer polymers may be assembled like children's Lego toys using modular polymer scaffolds programmed to attract building blocks of small molecules. Weak and easily reversed chemical interactions would self-assemble those molecules to form complex structures with predictable physical and chemical properties.

Self-assembly technique may build designer polymers from modular scaffolds and building blocks.

In the natural world, self-assembly techniques produce thousands of varied life forms – from bacteria to human beings — based on a relatively small set of amino acids and nucleosides combined in different ways. By emulating this natural system, polymer chemists at the Georgia Institute of Technology hope to simplify the synthesis of new materials for light-emitting diodes, optical storage materials, biosensors, drug-delivery materials and other applications.

Already, the researchers have built copolymers that use independent chemical bonding mechanisms — also copied from the biological world — to simultaneously self-assemble two building-block functional groups through a simple "one-beaker" process.

"The goal is to simplify the synthesis of designer polymers via self-assembly using combinatorial chemistry," says Marcus Weck, an assistant professor in the Georgia Institute of Technology's School of Chemistry and Biochemistry. "Our group is taking design lessons from nature by incorporating into one system several of these weak interactions to get a degree of complexity that is difficult to achieve otherwise. We believe we now have the basic proof of principle to show that we will be able to address this problem."

He explained the concept and described research progress at the 224th national meeting of the American Chemical Society in Boston in August 2002.

"We are developing a system based on a polymer that contains two or three different basic units,

each having a different recognition motive for weak interactions," Weck explains. "We would ultimately want to have a shelf with 30 or 40 polymer backbones. When someone needed a new LED, for instance, we would just take our polymer backbones, synthesize small molecules, then self-assemble them onto the polymer backbones. In one simple step in a beaker on the lab bench, we could assemble the polymer instead of taking two or three months to synthesize it with traditional methods."

—John Toon

■ For the text of the complete news release, see www.gtresearchnews.gatech.edu/newsrelease/MODULAR.htm. For more information, you may contact Marcus Weck, School of Chemistry and Biochemistry, Georgia Tech, Atlanta, GA 30332-0400. (Telephone: 404-385-1796) (E-mail: marcus.weck@chemistry.gatech.edu).

Turn on the "Nanolight"

Using photon emissions from individual molecules of silver, researchers at the Georgia Institute of Technology have created what may be the world's smallest electroluminescent light source.

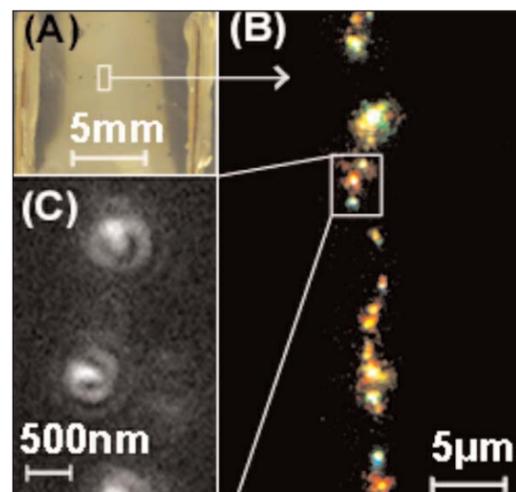
Believed to be the first demonstration of electroluminescence from individual molecules, the work could lead to new types of nanometer-scale optical interconnects, high-resolution optical microscopy, nanometer-scale lithography and other applications that require very small light sources. And because single molecules are known to emit one photon at a time, the technique ultimately could be the basis for high-efficiency, quantum information processing and cryptography.

Though the effect was first reported in silver clusters composed of two to eight atoms, the researchers also demonstrated electroluminescence in similarly prepared copper clusters, suggesting

Nanometer-scale light source is first to show single-molecule electroluminescence.

“This is the first time anyone has seen electroluminescence from individual molecules.”

—Robert Dickson



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Shown here is a (A) discolored silver oxide region between copper electrodes on a glass substrate in a vacuum, DC potentials of 9 volts were applied across the film; (B) multi-colored electroluminescence from single silver molecules occurs within the electrically discolored region. (C) These features exhibit dipole emission patterns and blinking dynamics (not shown) characteristics of single-molecule behavior.

the effect may broadly apply to other metals. Details of the research were reported in the Aug. 6, 2002 issue of the *Proceedings of the National Academy of Sciences*.

"This is the first time that anyone has seen electroluminescence from individual molecules," says Robert Dickson, an assistant professor in Georgia Tech's School of Chemistry and Biochemistry. "What we have observed involves sub-nanometer-scale sources to which an electric field is applied. These molecules emit very strongly, and are very robust."

Dickson and collaborators Tae-Hee Lee and Jose Gonzalez began with thin films of silver oxide that are not electroluminescent. By exposing the film to electrical current of about one amp, they "activated" some of the silver oxide molecules, which then appeared within "discolored" regions in the film. When electrodes were attached to the film and an alternating current applied, a thin line of silver clusters began to emit light in colors that varied depending on the size of the clusters. The system operated at room temperature.

"When you zoom in more closely, you can see the emissions coming from single molecules," Dickson says. "They blink and have dipole emission patterns. You see an incredibly thin line of emissive species close to the middle of the sample."

Electroluminescence occurs when an electron recombines with a positively charged molecule from which a single electron has been removed to create an electron-hole pair. First, an electron is removed from a molecule, creating a positive charge. Then, an electron is quickly injected into a different state of the same molecule. Because of the charge differences, the electron is attracted to the hole, and when they recombine, a photon is released.

—John Toon

■ For the complete news release, visit www.gtresearchnews.gatech.edu/newsrelease/NANOLIGHT.htm. For more information, you may contact Robert Dickson, School of Chemistry and Biochemistry, Georgia Tech, Atlanta, GA 30332-0400. (Telephone: 404-894-4007) (E-mail: robert.dickson@chemistry.gatech.edu).

Dirty Air, Warmer Climate

A new study on the role that atmospheric soot particles may play in global warming suggests a new near-term control strategy, introduces a new element of uncertainty in climate models and shifts more responsibility for curbing pollution to developing nations such as China and India.

Published in the Sept. 27, 2002 issue of the journal *Science*, the report — by researchers from NASA's Goddard Institute for Space Studies — suggests that by absorbing sunlight and altering weather patterns, light absorbing carbon-based particles could have nearly as much impact on global warming as carbon dioxide: a greenhouse gas that has long been considered the primary culprit in global warming. The soot particles are produced by diesel engines, cooking fires and other sources.

In a perspectives article published with the NASA Goddard paper, atmospheric researchers at the Georgia Institute of Technology describe some of the policy implications of the new findings. Among them:

- Because black carbon particles have relatively short atmospheric lifetimes, successful control efforts could curb their effects in a matter of months or years. Carbon dioxide remains in the atmosphere for hundreds of years, meaning control efforts couldn't impact global warming for generations.

Report assessing impact of soot on global warming could shift burden to developing nations and create new uncertainty in climate model predictions.



A typical hazy day near Lin An, China. Black carbon emanates from a small brick factory.

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• Soot emissions come primarily from developing nations such as India and China. If these emissions do in fact play a large role in global warming, that could shift pressure for environmental control to those nations. Industrialized nations in North America and Europe are responsible for the bulk of carbon dioxide emissions.

• Efforts to control soot may also bring immediate improvements in human health since the small particles thought to be most active in affecting climate are the same PM 2.5 particles that cause respiratory distress when trapped deep in the lungs.

• Little is known about the worldwide impact of soot emissions or even how to properly measure them. Significant new research will be needed before the role of black carbon emissions can be reliably assessed.

"The study reported in *Science* really raises some important policy issues regarding soot," says Michael Bergin, an assistant professor in Georgia Tech's School of Earth and Atmospheric Sciences and co-author of the perspectives article. "In the past, researchers have felt that soot didn't really have a significant warming effect. But as we've learned more about the amount of black carbon emitted by countries like China and India, it appears now that soot could have important climatic effects, and that these effects may be almost as much as those of carbon dioxide."

In their perspectives article, Bergin and Professor William Chameides, also in Georgia Tech's School of Earth and Atmospheric Sciences, point out the differences between black carbon soot and greenhouse gases such as carbon dioxide

and methane. For instance, soot particles are removed from the atmosphere on time scales of weeks to months, while carbon dioxide lingers for hundreds of years. That could point toward a better near-term control strategy.

"This could be 'low-hanging fruit' in trying to deal with the anthropogenic (human-caused) effects on the climate," Bergin notes. "From a policy standpoint, the payoff for controlling soot could be on the scale of years rather than centuries."

—John Toon

■ For the complete news release, see www.gtresearchnews.gatech.edu/newsrelease/SOOT.htm. For more information, you may contact Michael Bergin, School of Earth and Atmospheric Sciences, Georgia Tech, Atlanta, GA 30332-0355. (Telephone: 404-894-9723) (E-mail: mike.bergin@ce.gatech.edu)

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Measuring Atmospheric Pollutants

Scientists studying a class of atmospheric pollutants known as aerosols now have a new tool at their disposal — an instrument that automates the collection of air samples for analysis with sensitive ion chromatography equipment. Fine-particulate aerosol pollutants have attracted considerable attention because of recent studies linking them to human health effects such as heart attacks and respiratory problems.

By automating the collection of data, the Particle-Into-Liquid-Sampler (PILS) developed at the Georgia Institute of Technology can measure particulate pollutants several times an hour, giving atmospheric scientists detailed time-dependent information not previously available. In a recent study, this ability to make frequent measurements revealed previously unknown morning and afternoon peaks in the levels of two key pollutants.

"Chemists have made significant advances in measuring trace species," says Rodney Weber, an assistant professor in Georgia Tech's School of Earth and Atmospheric Sciences. "We are applying those technologies to measure the composition of atmospheric particles. In combination with the ion chromatograph, this instrument provides some unique insights that could not be obtained before."

Weber presented information about the instrument's capabilities at the 224th national meeting of the American Chemical Society in August 2002 in Boston. The instrument is already in use around

Instrument automates sampling of aerosols, provides more detailed data

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These are aerosol particles collected near Lin An, China on a 47-mm Teflon filter. The blackness of the filter indicates the presence of black carbon.

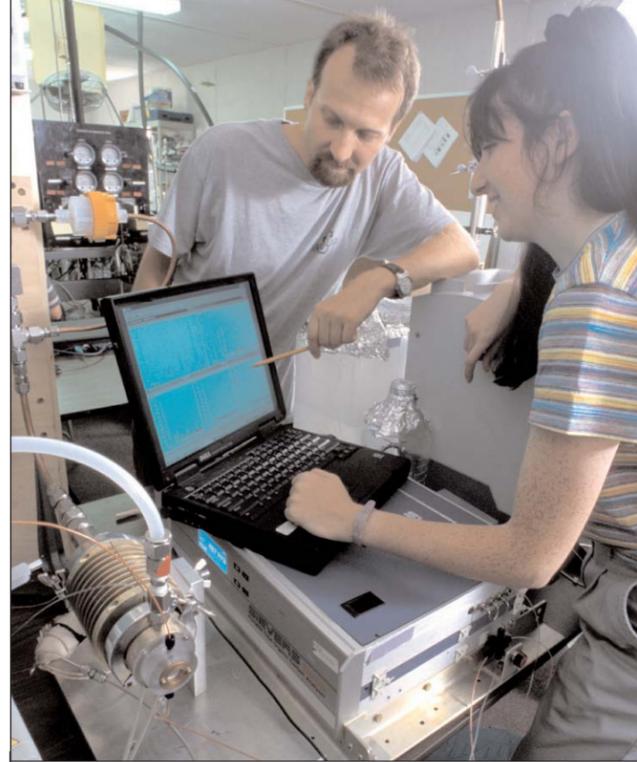
Rodney Weber and Amy Sullivan check measurements being made by a Particle-in-Liquid-Sampler (lower left) connected to an ion chromatograph.

the world in studies conducted from aircraft, ships and ground stations.

Developed by Weber and colleague Douglas Orsini with help from Brookhaven National Laboratory, the PILS system uses small quantities of steam to form water droplets on individual aerosol particles. The water droplets containing the dissolved aerosols can then be captured and analyzed by ion chromatography techniques to detect as many as 15 different chemical species. The instrument can operate unattended for extended periods of time on the ground or in research aircraft, and can take samples as often as every four minutes

Scientists analyzing airborne particulates had previously relied on filters that collected the aerosol particles over a long period of time, usually 24 hours. The particles were then removed from the filters and dissolved in water for ion chromatograph analysis. It is these types of long time-integrated measurements that have provided the air quality data to study the effects of aerosols on human health and that are the basis for current EPA particulate matter standards. This, however, is likely to change since the EPA is now moving toward more real-time measurements for assessing air quality.

— John Toon

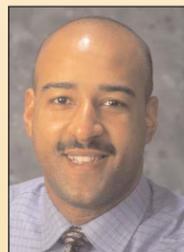


■ For the full-text news release version of this article, see www.gtresearchnews.gatech.edu/newsrelease/PILS.htm. For more information, contact Rodney Weber, School of Earth and Atmospheric Sciences, Georgia Tech, Atlanta, GA 30332-0340. (Telephone: 404-894-1750) (E-mail: rodney.weber@eas.gatech.edu)

Faculty Awards and Honors

The American Association of Engineering Societies honored Georgia Tech President **Wayne Clough** with the National Engineering Award, the organization's highest honor. Clough was recognized for his outstanding contributions as an educator, university administrator and statesman for the engineering profession.

Assistant Professor **Reginald DesRoches** of the School of Civil and Environmental Engineering



and Associate Professor **Z. John Zhang** of the School of Chemistry and Biochemistry were among 60 researchers who received the 2002 Presidential Early Career Awards for Scientists and Engineers from President George Bush in July. The awards are the nation's highest honor for professionals working at the outset of their independent research careers.

The Human Factors and Ergonomics Society has awarded School of Psychology Professors **Wendy Rogers** and **Dan Fisk** the 2002 Best Ergonomics in Design Article

award. Graduate students **Amy Mykityshyn** and **Regan Campbell** were also cited in the award. The team published research that shows that problems exist with the design of and instructions for various home medical devices.

C.P. Wong, a professor in the School of Materials Science and Engineering, received the 2002 Exceptional Technical Achievement Award from the Components, Packaging and Manufacturing Technology Society. He was cited for his pioneering work in polymeric materials for electronics packaging applications.

Georgia Tech faculty and staff receive recognition

Faculty Research in the News

Georgia Tech researchers' work covered in the news media.

Popular Mechanics covered the unusual structures formed by the growth of silica nanowires using a new type of gallium catalyst. The researcher is **Z.L. Wang**. (See the *Research News* story at gtresearchnews.gatech.edu/newsrelease/SIWIREs.htm.)

In an article about medical innovators, *Forbes* magazine mentioned research by **Phil Kennedy**, a former Georgia Tech faculty member and founder of Neural Signals, an Advanced Technology Development Center company. Kennedy's technology helps disabled persons control the operation of computers and other devices. (See the *Research Horizons* article at gtresearchnews.gatech.edu/reshor/rh-win02/rlinkW02.html#rlink3.)

The syndicated television program *Discoveries* and *Breakthroughs Inside Science* aired a story on the Mars Entomopter under development in GTRI for NASA. **Rob Michelson** heads the project for GTRI. *CNN.com* also published an article about the Entomopter. Additional coverage included an Associated Press article that appeared in the *Baltimore Sun*, *Orlando Sentinel*, *Rocky Mountain News* and *Sacramento Bee*, among other newspapers. (See the *Research Horizons* article at gtresearchnews.gatech.edu/reshor/rh-f01/mars.html.)

American Scientist published an article about a Georgia Tech study of the classic 17th century Huygens clock experiment – the first recorded instance of synchronized oscillators. **Michael Schatz** and **Kurt Wiesenfeld** of the School of Physics conducted the study. (See the *Research Horizons* article at gtresearchnews.gatech.edu/reshor/rh-f00/time.html.)

Professors Kurt Wiesenfeld and Michael Schatz are reflected in the pendulum bob of one clock they used to recreate the 1665 experiment of Dutch physicist Christiaan Huygens.

Industry Week and *Laser Focus World* reported on the porous silicon gas sensor being developed in the School of Materials Science & Engineering and the School of Physics. **Peter Hesketh** and **Jim Gole** are the researchers involved. (See the *Research Horizons* article at gtresearchnews.gatech.edu/reshor/rh-ss02/sensor.html.)

Design News and *Emergency Medical Services* magazine published articles on technologies being developed at the Center for Emergency Response Technology, Instruction and Policy. *National Defense* did an article on the Center's biosensor technology. (See the *Research Horizons* article at gtresearchnews.gatech.edu/reshor/rh-win02/r-first.html.)

Popular Mechanics, *Designfax*, *Machine Design* and *Medical Equipment Designer* reported on DentAART technology that will provide a "virtual mouth" to help dentists plan reconstructive surgeries and other procedures. **Jeff Sitterle** is heading the research effort for GTRI. (See the *Research Horizons* article at gtresearchnews.gatech.edu/reshor/rh-win02/rnoteW02.html#rnote1.)

Discover magazine included the RADAR Flashlight developed at GTRI in an article on technology and privacy. The lead researcher is **Gene Greneker**. (See the *Research Horizons* article at gtresearchnews.gatech.edu/reshor/rh-ss01/rnoteS01.html#rnote4.)



Aviation Week & Space Technology reported on Georgia Tech research designed to improve the performance of unmanned aerial vehicles. The researchers leading the project are **Daniel Schrage** in the School of Aerospace Engineering and **George Vachtsevanos** in the School of Electrical and Computer Engineering. (See the *Research News* article at gtresearchnews.gatech.edu/newsrelease/SMARTUAV.htm.)

Southwest Airlines Spirit magazine mentioned the "Digital Family Portrait" developed by **Beth Mynatt** in the College of Computing. The portrait is part of the Aging in Place initiative designed to help older adults remain independent longer. This technology and others under development for the Aware Home Research Initiative was also the cover story of a Sunday "Technology" section in the *Atlanta Journal-Constitution*. Among the other researchers involved with the project are **Gregory Abowd**, **Aaron Bobick**, **Irfan Essa**, **Wendy Rogers** and **Thad Starner**. (See the *Research Horizons* article at gtresearchnews.gatech.edu/reshor/rh-ss02/age-side.html.)

Photonics Spectra magazine covered research by **Thomas Orlando** in the School of Chemistry and Biochemistry. Orlando simulates conditions on the moons of Jupiter, studying energetic reactions that take place in frozen brine there. (See the *Research Horizons* article at gtresearchnews.gatech.edu/reshor/rh-f01/weird.html.)

Motion System Design magazine published an article on a machine vision system for automated poultry inspection. The system was designed by GTRI engineers in the Food Processing Technology Division headed by **Craig Wyvill**. (See the *Research Horizons* article at gtresearchnews.gatech.edu/reshor/rh-f01/poultry.html.)