incineration and industrial bleaching, suppress the immune system. For example, they've been blamed for spurring a 1988 virus outbreak that killed 20,000 European harbor seals feeding on PCB-tainted fish. And in Taiwan, a group of infants born to mothers who had accidentally consumed high doses of PCBs in 1979 had an elevated rate of infections.

To find whether health effects might also arise from the lower exposures more typically seen in developed countries, in 1990 Weisglas-Kuperus and colleagues began a long-term study of 207 mothers and infants living outside Rotterdam. Roughly half the mothers nursed their babies and the others fed them formula, which was not contaminated with PCBs.

When the infants were 18 months old, the researchers detected slight changes in the immune cells of some of them, particularly those who had been breast-fed, suggesting that their immune systems had been influenced by PCB exposure and might be less able to fight infections. These changes correlated with PCB and dioxin levels in blood from the babies' umbilical cords and in the mothers' blood and breast milk. At that time, however, those with greater immune changes didn't get sick more often than the other babies.

That changed when the researchers reexamined the children at age 3 1/2, when a typical child has had many infections. As before, they found that the toddlers whose mothers had more PCBs in their blood had higher levels of certain T cells. The researchers then looked at the current level of PCBs in the children's blood and their history of infections. After adjusting for confounding factors such as parental smoking, which tends to increase infection rates in children, and breast feeding, which, while exposing the babies to PCBs, is also well known to boost immunity, they found that children with high PCB exposures at age 3 1/2 were eight times more likely to have had chickenpox, and three times more likely to have had at least six ear infections than those with lower exposure.

The Weisglas-Kuperus team continues to monitor the children for neurological and other effects. But she says the immune suppression alone underscores the importance of strict regulations on the release of PCBs and dioxins. **–JOCELYN KAISER**

MEETING **AMERICAN CHEMICAL SOCIETY**

Chemists Unveil Molecular Wizardry in San Francisco

SAN FRANCISCO, CALIFORNIA—Baseball fans looking to check out the new stadium of the hometown Giants aren't the only ones flocking to the City by the Bay this spring. The 219th meeting of the American Chemical Society (ACS) drew nearly 20,000 chemists, physicists, biologists, and engineers from around the globe from 26 to 30 March. Among the meeting's home runs were reports of novel organic molecules that give old plastics new life and a new alternative to DNA chips.

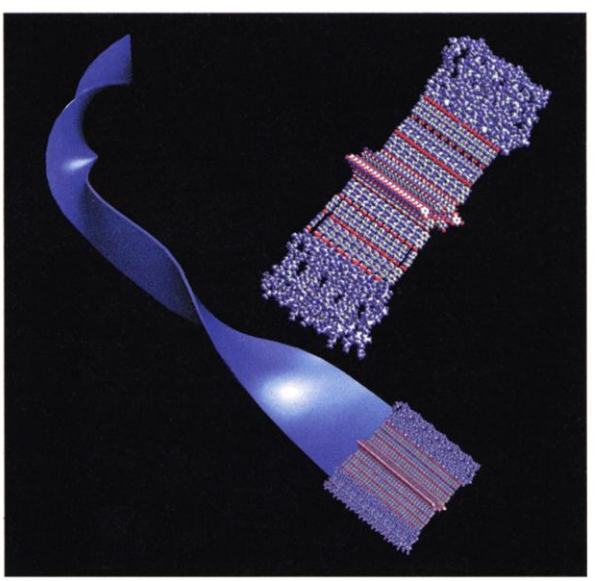
Ribbons Make Tough Stuff

In fairy tales, a sprinkling of magic dust can make your dreams come true. In the world of plastics chemistry, that makes Samuel Stupp a wizard. At the ACS meeting, Stupp, a chemist at Northwestern University in Evanston, Illinois, reported developing new three-part molecules, a pinch of which can drastically change the strength and optical properties of commodity polymers such as those used to make coffee mugs and Plexiglas. Down the road, the new molecular seasoning could be used to lend everyday plastics like polystyrene the strength and toughness of a bulletproof vest at a fraction of the cost.

"It's really a unique approach" to polymer chemistry, says Timothy Long, a polymer chemist at Virginia Polytechnic Institute and State University in Blacksburg. "It's really remarkable how the properties [of the plastics] changed by adding so little of the new material."

Initially, Stupp and his colleagues weren't looking for a way to spice up tired plastics. Stupp's team had previously made two-part molecules called rodcoils, so named because half of each molecule was rigid, the other half flexible. And this unique structure, they found, caused the molecules to assemble into mushroom-shaped clumps that stacked themselves into sheets (*Science*, 18 April 1997, p. 354).

For their current project, they wanted to see if they could tweak the chemistry of the rodcoils to coax them to form one-dimensional chains. They started by grafting a third section onto the rigid end of the molecules. This new portion, called a dendron, begins as a "Y" shaped group with two arms jutting from the end of the molecule. Each arm is capped by hydroxyl groups that can readily form weak hydrogen bonds with their neighbors. That gave them three-part molecules, which they dubbed "dendron-rodcoils," or DRCs. When the researchers dissolved a dash of DRCs in an organic solvent, they were surprised to find that the liquid solvent instantly turned into a gel. Evidently the DRCs were sticking together. Closer inspection showed that the DRCs had indeed lined themselves up, not into chains, but into ribbons.



Cordon bleu. A dash of DRC molecules is enough to festoon a solvent with chemical ribbons that create a tough blue gel.

CREDIT: E. R. ZUBAREV *ET AL*./BECKMAN INSTITUTE FOR ADVANCED SCIENCE AND TECHNOLOGY, UNIVERSITY OF ILLINOIS, URBANA-CHAMPAIGN

When DRCs are added to a solvent, Stupp explains, the hydroxyl-tipped arms of one dendron meet up and form hydrogen bonds with hydroxyls on a second dendron, linking two DRCs together like pencils fused at their erasers. Afterward, the DRCs can still form additional hydrogen bonds, so as other molecular pairs drift by they line up alongside the first one. The result is a zipperlike structure only 10 nanometers wide but up to 500 nanometers long, with the hydroxyl "teeth" locked in the middle and the long bodies of the molecules trailing behind them. Still more hydrogen bonds in other parts of the molecules then link the ribbons into a web.

But the DRCs don't just force one another into line, Stupp says. The rib-

bons in the newly formed web also attract solvent molecules to nuzzle alongside, as doing so allows the ribbons to lower a property known as their surface energy. As this association occurs, the liquid solvent stops flowing and becomes a blue gel. (The color, Stupp adds, likely results from the fact that the ribbons are about the same size as the wavelength of blue light and therefore scatter it more effectively than other colors.) And this entire transformation occurs with a mix of just 0.3% nanoribbons to 97.7% solvent.

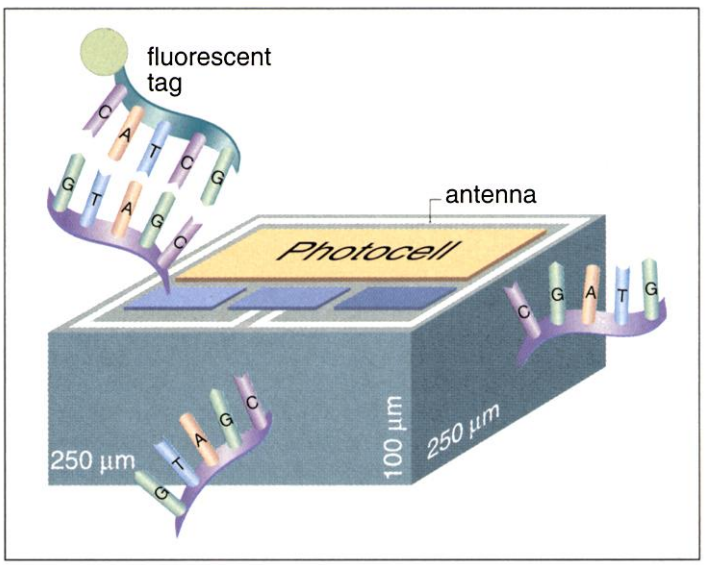
And that isn't all the magic the nanoribbons have in store. Stupp and his collaborators—postdoc Eugene Zubarev and graduate student Martin Pralle of the University of Illinois, Urbana-Champaign, along with graduate student Eli Stone of Northwestern—decided to see what would happen if they replaced their original solvent with styrene, the liquid precursor to the common plastic polystyrene. To their surprise, they found that the solution again formed the blue gel. And the ordering remained even after they linked the styrene into polymer chains. What's more, when they then melted the nanoribbon-spiked plastic and pulled the plastic melt into a fiber, they found that all of the nanoribbons and associated polymer chains lined up in the same direction, making the fibers far stronger than those in which the polystyrene molecules are randomly oriented.

In addition to working with polystyrene, Stupp's team showed that by adjusting the chemistry they could prompt other types of plastic and rubber building blocks to assemble around the nanoribbon webs. Using the ribbons as templates, they also deposited semiconductors to create nanosized wires, which could be used to wire up future miniaturized computer chips. Not quite on a par with Harry Potter's sorcerer's stone, perhaps, but blue-ribbon magic all the same.

Tracking DNA When The Chips Are Down

Tracking which genes are turned on or off in different tissues, or during the course of a disease, is becoming de rigueur in biology labs these days. Eventually, if the enthusiasts are right, physicians will routinely check your patterns of gene expression to determine which medicines will work best for you. The key to this new world of gene tracking is the DNA chip—a small slice of silicon dotted with thousands of snippets of DNA corresponding to genes of interest. But the technique has one big downside: A single chip can cost thousands of dollars, and it's used just once and thrown away. However, help may be on the way. At an ACS symposium that explored the latest research in DNA diagnostic technologies, Wlodek Mandecki of the New Jersey–based start-up company Pharmaseq reported a potentially cheap way to track active genes with tiny radio transmitter tags.

DNA chips have surged in popularity in recent years in part because they are so simple to use. To track active genes, researchers first synthesize short snippets of single-stranded DNA, link them to a glass or silicon chip in a checkerboard array, and use a computer to keep track of the DNA sequence of each spot on the array. DNA bases bind only with complementary pairs—A's with T's, G's with C's. So short DNA segments on a chip can be used to bind genes with a complementary sequence. To find out if an organism is expressing one of those genes, researchers convert its cellular messenger RNA (mRNA)—which is made by active genes—into a single-stranded version of DNA and tag it with a fluorescent compound. They then wash the tagged DNA over the chip, see which spots on the array light up, and check those positions in the computer to find which genes are active.



Radio star. Tiny light-activated transponders identify fluorescent DNA.

To find a cheaper alternative, Mandecki needed a new way to tell DNA snippets apart. The solution he hit upon was what he calls microtransponders, essentially tiny silicon chip–based devices each just a few hundred micrometers on a side, about the width of a few hairs. Each transponder stores an ID number in memory and when prompted emits an identifying radio signal that can be picked up by a nearby receiver. Much larger transponders—about the size of aspirin tablets—are already used as ID tags for everything from luggage to cars. But because they are powered by incoming radio-frequency energy, they require comparatively bulky imbedded devices to convert that energy to electricity and back into a radio signal.

To make a transponder small enough to track molecules, Mandecki teamed up with researchers at the Sarnoff Corp. in Princeton, New Jersey, who designed a version that incorporates a tiny photocell to absorb laser light and then uses the energy to broadcast a unique ID number programmed into the device.

The transponders are relatively straightforward to use as DNA tags, Mandecki says. First Mandecki and his Pharmaseq colleagues synthesize short DNA fragments called oligonucleotides, tailored to bind to complementary sequences in known genes. They attach these probes to their silicon ID tags, using a standard chemical process. As the oligo is attached, a computer records its sequence along with the number of the transponder to which it is paired. Next, the Pharmaseq team follows the same strategy as with DNA chips to convert a cell's mRNA to single-stranded DNA with fluorescent tags, which they then mix into a solution containing the radio-tagged oligos.

The researchers then simply flow their solution through a device akin to a flow cytometer, a common lab instrument for counting cells one at a time. As the transponders and their genetic cargo stream through a narrow channel, the researchers shine a laser light on them. When the light hits a transponder, the device emits a radio signal revealing its identity and, by association, that of its attached oligo. The laser light also triggers the fluorescent tags on the DNA to emit light. So if a flash of light accompanies the radio signal, Mandecki and his colleagues know that the oligonucleotide has a stretch of DNA in tow—and therefore that the gene is actively expressed. If no light flash occurs, DNA didn't bind to the oligo, and thus the corresponding gene is inactive.

"It looks like an impressive technology," says Wai Tak Law, an analytical chemist at PortaScience Inc. in Moorestown, New Jersey. Law says that the new technology has a way to go to catch up with DNA arrays. But he adds that it could also push into new areas, such as tracking proteins and small molecules used in pharmaceutical research.

–ROBERT F. SERVICE

SOURCE: PHARMASEQ; ILLUSTRATION BY C. CAIN