Stitching together a thin polymer sheet

It's not exactly quilt making, but materials scientists have now chemically stitched molecules together into polymer sheets. The resulting polymers are considerably tougher than microscopically thin films produced by other means, yet just as flexible.

Samuel I. Stupp and his co-workers at the University of Illinois at Urbana-Champaign describe their technique for fabricating these molecular sheets in the Jan. 1 SCIENCE.

Over the last six decades, polymer scientists have found many ways to link large numbers of small molecular units into lengthy chains, branched structures, and three-dimensional networks. They have succeeded in constructing large molecules in the shape of rings, stars, combs, and ladders – but not sheets.

"Until now, experimental polymer science has virtually ignored two-dimensional polymers," notes materials scientist Edwin L. Thomas of the Massachusetts Institute of Technology.

In fact, most efforts to synthesize sheetlike objects have involved simply laying down thin films on surfaces or letting certain types of molecules known as amphiphiles assemble themselves into layers. But because their molecular components interact only weakly, these structures have generally proved unstable and fragile.

To synthesize a polymer sheet in which adjacent molecular units are linked by strong chemical bonds, Stupp and his group start with long, relatively stiff molecules specially designed with a group of reactive atoms at one end of each molecule and a different group of reactive atoms in the center. In solution, these molecular units pair up – reactive end to reactive end – into double-length strands.

The strands, in turn, spontaneously organize into a layer, orienting themselves like the evenly spaced bristles of a brush. This puts the set of paired reactive sites in the middle of the layer and the two other reactive sites aligned in planes one-quarter of the distance from the top and bottom of the layer.

The researchers then initiate two independent chemical reactions to create chemical bonds tying the molecular strands together at three different levels. Although neither reaction succeeds in converting all the reactive sites into chemical bonds, there is sufficient redundancy in the chemical stitching to create a robust molecular sheet.

"Stupp's polymers . . . are simply connected sheets with boundaries and thus have two distinct surfaces as well as edges," Thomas says.

The resulting sheet – in effect, a single huge, flat molecule – is about 10 nanometers thick and covers an area as large as several square microns. Electron diffraction studies confirm the orderliness of molecular units within individual sheets. Moreover, at room temperature these sheets stack neatly to form crystals.

"This remarkable registry among the flat molecular objects suggests that their top and bottom surfaces have the same chemical structure," Stupp and his colleagues report.

The researchers have also discovered that a solid, transparent film made up of two-dimensional polymer patches can double the frequency of laser light passing through it. In other words, the film generates green light from an infrared laser beam. This new material lasts much longer than other types of polymers now used for the same purpose. *– I. Peterson*

Clinton's man of science

OTA

On Christmas Eve, President-elect Bill Clinton nominated John H. Gibbons as his science adviser. Like the four preceding White House science advisers, Gibbons is a physicist. More notable is the timing of this nomination – early enough to influence the coming year's federal budget priorities. Jimmy Carter, Ronald Reagan, and George Bush all waited until well after issuing their first budget blueprint to name a science czar.

Director of the Office of Technology Assessment (OTA) since 1979, Gibbons is a Washington insider. His role at OTA – overseeing Congress' "technology think tank" – gave him broad experience in helping to define and marry research and policy issues. But he cut his teeth coordinating science and policy in the decade prior to joining OTA, during which he directed the University of Tennessee's energy, environment, and resources center, the Oak Ridge (Tenn.) National Laboratory's environment program, and the former Federal Energy Administration's energy-conservation efforts.

Following Senate confirmation, Gibbons will head the White House Office of Science and Technology Policy. □

Diabetes: Clarifying the role of obesity

Roughly 90 percent of diabetics suffer from a form of the disease described as Type II, or non-insulin-dependent. Though obesity constitutes one of the most common predisposing factors for this type of diabetes, clinicians have never known why. Now a trio of Boston-based researchers has uncovered surprising clues – opening up the prospect of managing this often lethal disease more effectively with drugs.

In the Jan. 1 SCIENCE, Bruce M. Spiegelman and his colleagues at the Dana-Farber Cancer Institute report on animal studies showing that obesity somehow stimulates fat cells to overproduce a hormone-like substance known as tumor necrosis factor-alpha (TNF-alpha).

Compared to lean rodents, obese animals of the same strain showed a sharp elevation in the activity of genes responsible for producing TNF-alpha. Not only did obese animals have more fatty tissue to make the compound, but each of their fat cells secreted about twice as much of the hormone-like substance as did those of lean cohorts. This trend held up in at least four animal models of obesity: All four generally express insulin resistance and other symptoms of developing or mature diabetes.

High levels of TNF-alpha have been shown capable of causing both septic shock and a wasting syndrome common in cancer victims. But Spiegelman's team now reports finding that a much smaller excess of TNF-alpha depresses the expression of the genes responsible for producing the proteins adipsin and glut4.

Though adipsin's function remains unknown, Spiegelman notes that glut4 enables glucose to pass through cell membranes under the regulation of insulin. Indeed, work by him and others has shown that the activity of the genes coding for these proteins is typically low in animals suffering from obesity-linked insulin-resistant syndromes.

The Dana-Farber scientists also showed that when TNF-alpha's effects are blocked with a drug that binds to and disarms the molecule, obese animals immediately experience a remarkable increase in their responsiveness to insulin. A primary feature of obesity-linked diabetes is the patient's resistance to insulin, the chief hormone responsible for lowering concentrations of sugar in the blood.

Spiegelman says that, taken together, these new data suggest that if obese diabetics similarly overproduce TNF-alpha, clinicians may eventually be able to control a patient's blood sugar concentrations with drugs that block TNF-alpha. Several such drugs are currently under development for treating septic shock. *– J. Raloff*