CHEMISTRY

Julie Ann Miller reports from the meeting in Houston of the American Chemical Society

Medical implants: What can go wrong

Over the past twenty years, more and more implants made of polymers have been placed in patients to solve medical problems. A variety of techniques have been used to judge how suitable those materials are. The implants include artificial joints, heart valves and pacemakers, orthopedic pins, vascular grafts, IUD's and catheters. James M. Anderson of Case Western Reserve University described perhaps the ultimate "biocompatibility" evaluation. He and colleagues in the Implant Retrieval and Evaluation Program are collecting implants and the surrounding tissue from autopsies. Every year they recover 40 to 70 implants from about 500 autopsies. They have found three major problems associated with the implants: fibrous capsule formation, wear and infection.

Encapsulation of the implant by fibrous tissue is a normal healing response, Anderson explains. But in some cases the capsule becomes so large it distorts other organs. Fibrous tissue around bone cement can compress the ureter or press against a vein. Sometimes a layer of fibrous tissue between the bone and the bone cement holding an artificial joint allows the implant to move slightly, impairing its function and causing inflammation and more fibrous tissue formation.

Wear is a problem difficult to evaluate in short-term testing. Anderson finds evidence that fibers from implants, such as heart valves, can migrate in the blood to the brain, spleen, liver and other parts of the body where they can block small blood vessels. Wear can also decrease the fit of a valve and allow blood to flow backwards in the heart. In one case a silicon rubber ball became so worn that it escaped from the valve and lodged in the aorta.

Infections are a "major, major problem," with implants, Anderson finds. He says that clinicians often don't recognize the problem until it is out of hand. In one case he found a large ball of fungus formed around the lead to an implanted pacemaker. Anderson says that less than 5 percent of patients receiving artificial heart valves develop an infection, but 80 percent of those that become infected die. Scientists do not know why infections seem to seek out the plastic implants, but current research is aimed at counteracting that predisposition. Experimental heart valves have been designed to release an antibiotic gradually during the months after implantation. In dogs, the antibiotic more than doubled survival after valve implantation. Anderson says that he remains optimistic about implant use, although as a pathologist he concentrates on the most disastrous cases. He concludes that the disasters best point out the problems for polymer chemists to address as they work to develop materials better suited for the human body.

Polymer salve for burn wounds

Evaporation of body fluids and bacterial infection are the major dangers following serious burns. Therefore, covering the wound is crucial to successful healing. Now Paul Y. Wang and Nimet Samji of the University of Toronto suggest a synthetic polymer "hydrogel" that would permit gas exchange, fluid regulation and antibiotic diffusion, while preventing bacterial access. The scientists made a gel of water and a polymer of dextran, a sugar already used clinically to dilute blood. Dextran does not trigger an immune response in the body. Samji says that dressings of any size and shape can be made by reinforcing a hydrogel 3 millimeters thick with a matrix of fine cotton gauze. The dressing clings to the moist tissue surface, ensuring a good seal, and may be coated with petroleum jelly to limit fluid evaporation. The hydrogels have been tested on laboratory rats, where they functioned well. After two weeks the dressings could be replaced successfully with skin grafts.

Measuring with laser fluorescence

Radioimmunoassay opened up wide areas of biomedical investigation by allowing scientists to detect and measure tiny amounts of crucial chemicals in the body. Now a second generation of sensitive techniques uses lasers and fluorescence in an attempt to avoid the problems associated with storage and handling of radioactive materials.

Steven Lidofsky of Stanford University has worked out two fluorescence techniques and has applied them to measure insulin. In the first method a fluorescent label, bound to insulin, is excited with a laser beam."Because the laser is such an intense light source, we can detect very low levels of the label," Lidofsky says. In a laboratory solution, the laser method is as sensitive as radioimmunoassay, detecting 0.4 nanograms of insulin per milliliter of solution. But attempts to measure insulin in blood were hampered by naturally fluorescent components of serum.

A second method now being developed uses an enzyme to convert a label, which does not itself fluoresce, into a fluorescent cleavage product. The enzyme Lidofsky uses is beta-galactosidase, and a single enzyme molecule can liberate many fluorescent fragments. This method can detect 2.5 nanograms of insulin per milliliter of solution in less time than radioimmunoassay can. Currently Lidofsky and colleagues are using the enzyme-linked method to measure insulin levels in human blood serum and are correlating their results with radioimmunoassay measurements.

Conductivity going organic

Many laboratories are working to find materials that combine the electronic properties of metals and semiconductors with the mechanical properties, processibility, low weight and low cost of organic polymers. Now a new family of organic materials that can conduct electrical current has been announced by polymer chemists. Researchers both at Allied Chemical in Morristown, N.J., and at IBM Research in San Jose, Calif., almost simultaneously have reported the first commercially available polymer that can be made conductive. The scientists "dope" the polymer, which is called poly(*para*-phenylene sulfide) or PPS, with low concentrations of arsenic pentafluoride, an electron acceptor, to boost conductivity. PPS is a string of phenyl groups (6-carbon rings) joined by sulfide conductors. Successive phenyl groups are approximately at right angles to each other. This arrangement presents a theoretical puzzle, because in all other conducting polymers, such as polyacetylene (SN: 9/10/77, p. 171), the units are in the same plane and their electron orbitals overlap.

From a practical standpoint, PPS is promising because it can be processed using both melt and solution techniques, says Ray H. Baughman of Allied. Last year the researchers found a similar compound, poly(*meta*-phenylene), which also can become highly conductive. Lawrence Shacklette at Allied has constructed various types of semiconductor junction devices using the two polymers. The high ionization potential of the polymers makes them especially attractive.

A method for directly transforming monomeric chemical units to highly conducting polymers was also described by Baughman. The chemists treat short chains, having two to four phenyl groups, with arsenic pentafluoride and then polymerize them into a highly conducting form. This route allows the chemists to prepare conducting films by vapor or solution deposition of simple molecules and to obtain conducting polymers in which the chains are strictly oriented. The major problem that remains is instability of the material. Baughman says that although there are possible applications even with this instability, full realization of the "enormous applications potential" must await solution of that problem.