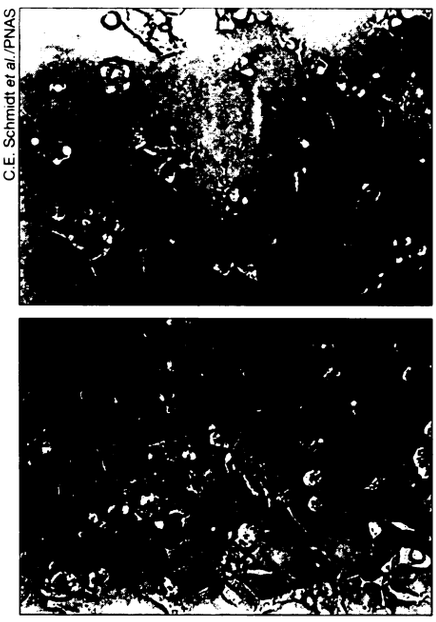
Polymer, buckyballs combat nerve damage

By marrying materials science and medicine, researchers have found two possible ways of combating nerve damage caused by injury, stroke, and neurodegenerative diseases. Two new reports suggest that a polymer that conducts electricity could help damaged nerves grow back and that chemically modified buckyballs—60-carbon spherical molecules—could prevent the nerves from degenerating.

Scientists at the Massachusetts Institute of Technology and at Harvard University's Children's Hospital in Boston have demonstrated that nerve cells will grow on oxidized polypyrrole films made to carry a negative charge. Neurons adhere well to this polymer, says study coauthor Venkatram R. Shastri of MIT, perhaps in part because the negative surface charge attracts positively charged proteins on the nerve cells.

The researchers spread rat neurons onto polymer films and bathed the samples in nerve growth factor, a protein that helps maintain the cells. "When we apply an electrical stimulus, we can double the length of the [nerve fibers] and increase their number," Shastri says.

Scientists don't know why electricity helps neurons to elongate, says Robert F. Valentini of Brown University in Providence, R.I., although it appears to play a role in the growth of many tissues, including bone and muscle. The conductive polymer provides an opportunity to test "a whole variety of charge patterns." Growth may differ with higher and lower currents and different stimulation frequencies, he notes.



C.E. Schmidt *et al.*/PNAS

Neurons grow on a polypyrrole film (top). With an applied current (bottom), the cells extend longer nerve fibers and spread farther over the film.

The researchers envision using the polypyrrole to form an "interactive conduit" that would both stimulate regeneration of a cut nerve and guide its growth, thus reestablishing a connection, Shastri says (SN: 7/27/96, p. 52).

Meanwhile, a group of researchers from Washington University in St. Louis and National Taiwan University in Taipei has focused on preventing injured nerves from degenerating. Their study shows that modified buckyballs can protect nerves from damaging molecules called free radicals. Both studies appear in the Aug. 19 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

After trauma or stroke, free radicals seem to attack nerves and trigger their death, says study coauthor Laura L. Dugan of Washington University. Previous work has shown that a single buckyball can mop up more than 30 free radicals, whereas one molecule of a typical antioxidant such as vitamin C neutralizes just one free radical.

To make buckyballs soluble in water, and thus suitable for biological uses, the researchers added carboxylic acid groups to the outside of the molecules. In the test tube, Dugan says, these compounds seem to protect cells from various types of induced damage.

In mice that carry a gene for human amyotrophic lateral sclerosis, the neurodegenerative condition commonly known as Lou Gehrig's disease, the modified buckyballs delayed the onset of paralysis for 10 days—a 15 percent increase in symptomfree life. The buckyballs also extended the life of the mice by about 8 days, a better outcome than another research team obtained with the antioxidant vitamin E in a similar study last year, Dugan says.

One form of the compound, with the acid groups concentrated on one hemisphere of the buckyball, worked better than a version with the groups attached along the equator. The improvement may arise from an enhancement of the buckyballs' ability to slip through cell membranes, the researchers suspect.

Both groups are continuing their tests in hopes of turning these preliminary successes into real-life treatments. —*C. Wu*

Cool cars: Running clean on liquid nitrogen

With the approach of deadlines in California and several other states for the production of vehicles that emit no pollutants, nearly everyone's attention has focused largely on electric cars. Now, developments suggest that vehicles fueled by liquid nitrogen may offer an attractive alternative to battery power.

Working independently, two groups of researchers have updated the steam engine, using liquid nitrogen instead of water. Ambient air warms and vaporizes liquid nitrogen, generating compressed gas that drives a motor. Carlos A. Ordonez and his colleagues at the University of North Texas in Denton demonstrated the concept in a prototype vehicle they named CooLN2Car. Abraham Hertzberg, Carl Knowlen, and their coworkers at the University of Washington in Seattle converted an old mail truck into a prototype dubbed LN2000.

The idea of using liquid nitrogen to power a vehicle has been around for several decades, but until recently there was little incentive to develop the concept and build a prototype.

Now, liquid nitrogen can be produced with much greater efficiency than before, Ordonez says. "It helps make the cost per mile of the fuel economically competitive with gasoline."

The Washington group also developed an innovative heat exchanger and vaporizer that circulates air and engine exhaust over an array of pipes to warm the nitrogen and prevent the buildup of frost.

At present, CooLN2Car can travel 15 miles at 20 miles per hour on 48 gallons of liquid nitrogen. "That doesn't show the concept is practical yet, but it does show that it's possible," Ordonez says.

Univ. of North Texas

Engineer Mitty C. Plummer of the University of North Texas sits in a prototype vehicle powered by liquid nitrogen, contained in the insulated tank in the rear. The chassis and transmission come from a 1973 Volkswagen.

Both groups are working to improve their vehicles. One focus is the air-driven motor, which is "horribly inefficient," Knowlen says. "It's a type of motor that hasn't had much of an application before, and no one has tried to develop it to run efficiently at a low temperature."

The use of liquid nitrogen even offers the possibility of partially reversing the impact of pollution-emitting cars and power plants. The procedure used to liquefy nitrogen, which makes up 78 percent of the atmosphere, also removes airborne particles and other gases, such as carbon dioxide, from the mix. "You clean the air in the process," Ordonez says. —*I. Peterson*