Organic Superconductor, Made Without Metals

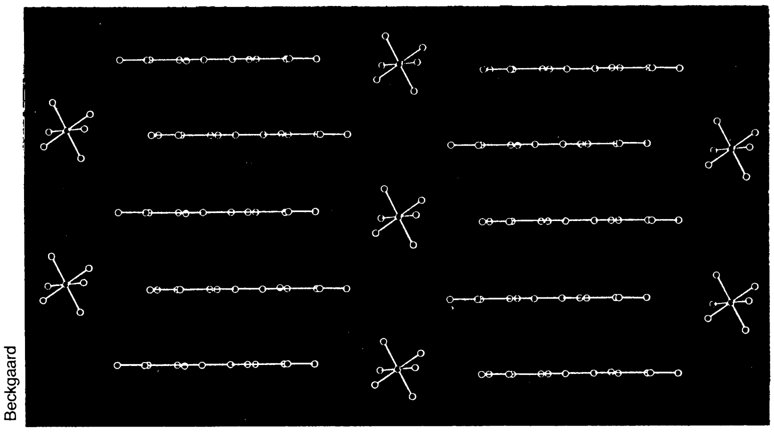
Heike Kammerlingh Onnes discovered superconductivity in 1911. Since then there has been a continuing search for new superconducting materials. Until now all that had been found were metals or metal compounds. Now there is a superconducting organic compound, one that has no metals in its composition. The demonstration of its superconductivity was reported at last week's meeting of the American Physical Society in New York by Denis Jerome of the University of Paris South in Orsay, France.

The search for new superconducting materials is motivated in part by technological desires, in part by the wish to demonstrate new physics. Superconductivity is the property of conducting an electrical current without resistance. Superconducting circuit elements do not dissipate energy in resistance heating. The saving is potentially tremendous.

The hitch is that any superconductor becomes superconducting only below a certain critical temperature, T_c. For all known superconductors T_c is within a few degrees of absolute zero. The only refrigerant that will cool things to those levels — below 20°K — is liquid helium, which is rare and difficult to work with.

There are always dreams of room-temperature superconductivity, but most physicists would be happy just to get above the helium range. "What everyone wanted was to increase T_c to work with cryogenic fluid other than helium," says Jerome. "If you could work with hydrogen, it would be less expensive." It seemed that substances known as molecular conductors might have enhanced T_c. By an amendment to the usual theory of superconductivity, it seemed that the electrons responsible for superconductivity might interact with the whole molecule in molecular conductors instead of with the crystal lattice as they do in superconducting metals, and this could raise T_c.

For superconductivity to exist, the conduction electrons of the substance, which are normally single, must form pairs with oppositely directed spins. In pairs they can sail through the material unhindered by the attraction of the ions. Because negatively charged electrons repel each other, pairs can form only under the influence of an intermediary that converts the repulsion to a net attraction. In superconducting metals the intermediary is an interaction between the electrons and the vibrations of the crystal lattice (called phonons). In a molecular conductor vibrations of the whole molecule might theoretically be the intermediary. This would change the energy in such a way that higher critical temperatures than those customary for metals might result.



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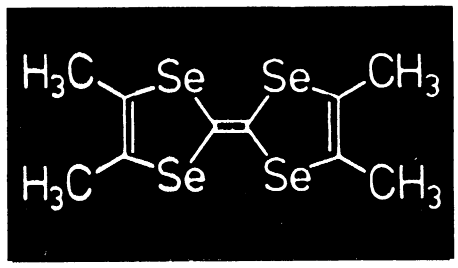

In the organic superconductor TMTSF *molecules (below) form planar stacks held together by phosphorous hexafluoride molecules (section at left).*

"If you believe in theory," says Jerome, "and we don't believe too much — but a little bit."

"You need a molecule which can be polarized and has internal modes of vibration," says Jerome. Molecular conductors entered physics in 1972 with the famous organic compound TTF-TCNQ. This had a promising relation between temperature and conductivity. "An understanding of electronic principles allowed synthesis of a new compound, TMTSF-DMTCNQ," says Jerome. It had better properties. Finally came $(TMTSF)_2PF_6$, the idea for which came from Klaus Beckgaard of the H.C. Oersted Institute in Copenhagen. It becomes superconducting below 0.9°K and under a pressure of 12 kilobar. It doesn't seem immediately practical, but it shows that "superconductivity in organic matter ... exists ...," as Jerome says. He believes $(TMTSF)_2PF_6$ is the precursor of a family of superconducting organics, some of which will not need the pressure, and some of which will show critical temperatures perhaps up to 40°K. □

Sweet medicine: Tiny pumps and packets

The hypodermic needle, the capsule and the spoonful of medicine are on their way out, according to polymer chemists. Drugs of the near future will be supplied in more convenient vehicles that will provide a constant level of therapeutic agent over long periods of time. A few such medicinals are already on the market (SN: 2/17/79, p. 102). A variety of new strategies were described last week at the meeting of the American Chemical Society in Houston. Some are in clinical trials, while others are barely off the drawing board.

One device, already tested on patients, is a portable system to deliver drugs intravenously to ambulatory patients. It has allowed persons receiving cancer chemotherapy to leave the hospital and participate in work and sports, while receiving continuous drug treatment. The system, which was developed by the Alza Corp. of Palo Alto, Calif., consists of a thin catheter that remains inserted into a vein and a drug-containing cartridge that can be changed daily. The drug is introduced into the vein under constant pressure from the cartridge's elastomeric reservoir. Alejandro Zaffaroni, president of Alza, says the device has been licensed for use beginning next year.

To deliver drugs orally, Alza scientists have developed an elementary osmotic pump that the patient swallows. Essentially it is a shell made of cellulose esters and filled with crystalline material. Water gradually passes through the polymer shell and dissolves the contents, which are pumped by osmotic pressure out through a tiny hole made by a laser in the shell. Zaffaroni says the shell remains intact in the stomach and intestines until it is eliminated from the body. It can pump its contents continuously for many days, although it would remain in the digestive tract only for about 24 hours. Working with pharmaceutical companies, Alza is attempting to put a variety of drugs into such pumps. Theophylline and an anti-inflammatory drug are already under development. The system allows drugs to be taken only once or twice a day instead of more frequently and provides much smaller fluctuations of drug level in the blood, Zaffaroni says.