A new glassy cage for nuclear waste

Mixing unlikely combinations of ingredients sometimes leads to the discovery of useful new materials. In the case of lead-iron phosphate glass, the ingredients were lead phosphate and radioactive waste from the reprocessing of used uranium fuel from military nuclear reactors. This waste happened to contain a high proportion of iron oxide, which turned out to be just the right additive for converting lead phosphate into a very durable glass.

The accidental discovery of this new material more than a year ago at Oak Ridge (Tenn.) National Laboratory led to a systematic study of its properties. Now, Lynn A. Boatner and Brian C. Sales report in the Oct. 5 SCIENCE that lead-iron phosphate glass itself (made by combining oxides of lead and iron with phosphorus pentoxide) may be a suitable material for immobilizing many types of liquid nuclear waste. The process involves melting the glass together with the nuclear waste, then cooling the mixture to form a structure in which the radioactive nuclei are chemically trapped (SN: 12/19/81, p. 396).

"Iron is the critical ingredient," says Boatner. Lead phosphate ordinarily contains long, polymerlike chains of phosphate groups. The addition of iron effectively shortens the chains by creating links between the chains. The result is a glass that is very resistant to chemical dissolution or "corrosion." The word "corrosion" is used, says Boatner, because glasses surrounded by water don't simply dissolve. Instead, certain glass constituents are selectively removed, forming a complex surface layer different in composition from the bulk glass.

Although borosilicate glass (with compositions similar to Pyrex) is the leading and most intensively studied candidate waste form for immobilizing nuclear waste that emits high levels of radiation, lead-iron phosphate glass has several advantages, says Boatner. Its aqueous corrosion rate is about one-thousandth that of borosilicate glass. In addition, all components of the simulated nuclear waste used in tests readily dissolve in molten lead-iron phosphate glass at 1,000°C, lowering the necessary processing temperature by as much as 250°C. The new glass also pours easily at 800°C, and, when solid, doesn't crystallize readily.

"These results indicate that lead-iron phosphate nuclear waste glasses represent a new, very stable and easily prepared medium for the disposal of some important classes of nuclear waste," say the researchers, who already are further testing the suitability of these phosphate glasses.

Whether lead-iron phosphate glass will be developed as a nuclear-waste-holding material isn't clear. The Department of Energy (DOE), according to its "Mission Plan for the Civilian Radioactive Waste Management Program," has already selected borosilicate glass as the waste form for military high-level waste and for commercial high-level waste from the West Valley (N.Y.) Demonstration Project (SN: 1/7/84, p. 5). However, DOE is funding a small development effort devoted to alternative waste forms that have a high potential for reducing treatment requirements or cutting disposal costs, or that can withstand higher internal temperatures.

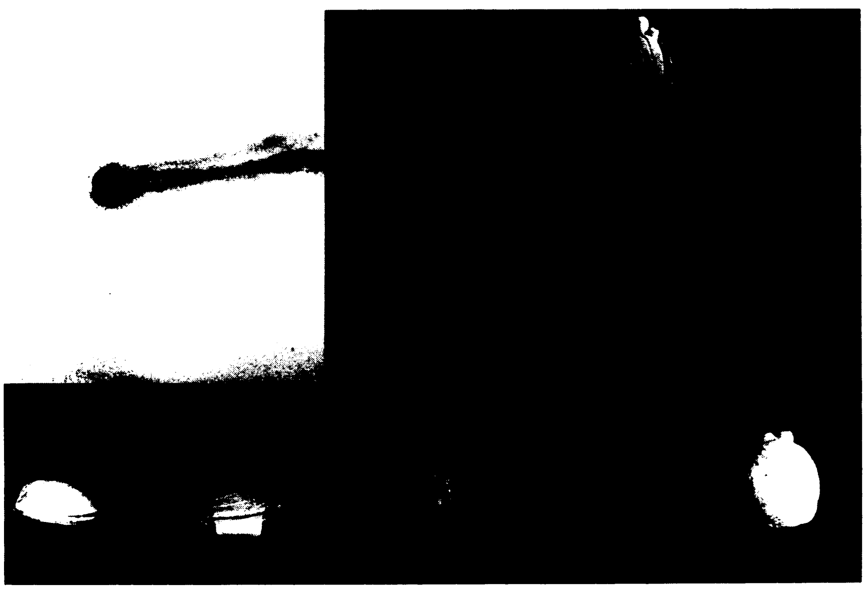
Boatner says it would be relatively easy to substitute iron-phosphate glass for borosilicate glass because the processing steps needed to manufacture a nuclear waste glass in both cases are so similar. "As far as the overall technology is concerned," he says, "there shouldn't be that much difference."

Other applications for this phosphate glass are also possible. A different form of the glass, containing additives other than iron, may produce a very durable optical glass for windows or lenses, says Boatner. Although the nuclear waste glass is black, both colorless and brightly colored forms can be produced. "We're also looking at the glass as a glass-to-metal seal for different types of metals," he says.

Researchers at Sandia National Laboratories in Albuquerque, N.M., have also been studying phosphate glasses, but with sodium oxide, barium oxide and aluminum oxide instead of lead oxide and iron oxide as the glasses' main ingredients. Their research indicates that these glasses provide excellent seals between aluminum, steel or copper and glass.

—*I. Peterson*

Invader clams that catch a current



Prezant and Chalermwat

Asiatic clam (represented with models) positions itself for liftoff, then secretes a mucous thread through its extended siphon and is pulled up with the current. Inset: Stained thread trails a dime-size specimen.

It sounds like a B movie plot: An exotic clam species is let loose on the West Coast and eventually invades every freshwater system south of Lake Erie. But the Asiatic clam *Corbicula fluminea* is a real-life problem for industrial plants that take in the quick-breeding clam with cooling water. One dime-size clam can produce 400 larvae a day, eventually clogging pipes with wall-to-wall clams.

The prolific clam also may be nudging out some native species, which have declined since *C. fluminea* was carried into the United States as a food item 50 years ago. Yet biologists aren't sure how the clam has spread so rapidly.

Robert S. Prezant of the University of Southern Mississippi in Hattiesburg has been investigating how the bottom-dwelling clams might float as a means of getting downstream and across floodplains. Floating clams are usually taken for dead clams, buoyed by decomposition gases, but Prezant thinks flotation may be a part of the healthy *C. fluminea*'s strategy for getting around. Prezant and graduate student Kashane Chalermwat discovered that they secrete a mucous thread from cells within the gills to catch the current. The thread works like a dragline, letting the clams float up much the way spiders "fly" on silk threads.

"They let the thread out the way you let out a kite string, until there is enough so they can take off," says Prezant.

He reports in the Sept. 28 SCIENCE that *C. fluminea* is the first clam found to have such a booster thread. Next, Prezant plans to track just how far downstream the floating clams can travel. — *C. Mlot*