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THIS WEEK

RESEARCH NOTES

ARTICLES

COVER: The large apatite (calcium phosphate) crystals and small, white specks of zeolite clay that form on the surface of the recently prepared SPLEGs (Stable Product Low Leach Glasses) may prevent encapsulated nuclear waste ions from escaping when water contacts this nuclear waste form. See p. 339. (Photo: Bancroft et al.)

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SCIENCE NEWS OF THE WEEK

A Nuclear Waste Band Jam

The "No Nukes Anywhere" graffiti that dot the walls of the Boston subway did not appear to faze the researchers who gathered in that city last week for the Materials Research Society International Symposium on the Scientific Basis for Nuclear Waste Management. As one symposium participant explained, "A lot of these people probably don't see themselves as either pro- or anti-nuclear power; they just consider themselves to be scientists working on a solution to a problem."

And while that problem — what to do with the high-level (spent fuel and fuel reprocessing waste), transuranic (man-made elements heavier than uranium) and low-level (industrial materials somewhat contaminated with radioactivity) nuclear wastes — has been clearly defined since the 1943 dawn of the U.S. nuclear age, a solution that meets with widespread scientific and social acceptance has yet to be outlined. In fact, even the waste products from the earliest atomic experiments remain in temporary near-surface storage tanks or bins.

The search for safe disposal of such wastes has included discussion of more exotic methods, such as deep-space and deep-sea dumping and Antarctic burial. But at least for now, the research focus seems to have narrowed to underground burial of the wastes in salt, basalt, tuff, granite or shale host rock surrounded by a suitable geologic barrier (backfill), following solidification of the liquid nuclear waste into a glass, cement or ceramic waste form. The various waste forms, host rocks and backfills, in addition to the potential problems associated with each (see page 345), were discussed at the Boston symposium.

Combining liquid waste with borosilicate glass formers reigns supreme among the nuclear waste form options. But borosilicate glass is far from the perfect nuclear trash can, and researchers continue attempts to improve on the vitreous idea. At the present time, a glass suitable for containment of nuclear wastes must meet three major criteria: Its melting temperature should be as low as possible to minimize vaporization of the volatile nuclear fission products to be added; it should be compatible with engineering components of the system; and when it contacts water, the glass should resist dissolution to ensure long-term isolation of the encapsulated nuclear wastes. At the nuclear waste symposium, G. Michael Bancroft and colleagues of the University of Western Ontario in London, Ont., proposed a fourth criterion for nuclear waste glass: If dissolved, its components should readily precipitate in the form of stable minerals that will accept fission product ions in their structure.

Working under the assumption that nuclear waste glass will be subjected to underground water and that it will undergo some dissolution, Bancroft and colleagues set out to design a "fail-safe" SPLEG (Stable Product Low Leach Glass)—one that after surface dissolution would precipitate stable minerals to trap the encapsulated nuclear waste ions that would otherwise escape when glass is leached. Bancroft reports preliminary laboratory work suggesting that dissolution precipitates of glasses based on a combination of tourmaline (an alumina-silicate mineral), bentonite clay and calcium phosphate may trap waste ions in their structures when the glass is leached (see cover photo). "The ability to tailor glass to give particular mineral products raises the possibility of producing a glass which is in near equilibrium with the backfill materials and/or host rock of a waste repository," Bancroft reports. "This should then reduce leach rates — a factor which would greatly enhance the security of a waste repository."

Bancroft says you can't judge a potential waste form merely by its leaching performance in distilled water (the usual measure of a waste form's worth); instead, "It is necessary to consider the nuclear waste host, backfill and repository rocks as one chemical system," he explains, and to find a "whole system" that is unreactive, or stable.

To illustrate this approach, Bancroft discussed using sphene ($CaTiSiO_5$) as the nuclear waste form, granite as the host rock and clay bentonite with additives as the backfill. He says, "Sphene can be thermodynamically stable in this system and should suffer no net leaching." Moreover, Bancroft reports, sphene is potentially more stable in most environments than another titanium mineral — perovskite ($CaTiO_3$). Bancroft's attack on perovskite kicked off one of the more firey sessions of the nuclear waste symposium. Following his presentation, another meeting participant, A.E. Ringwood of the Australian National University in Canberra, used a two-minute rebuttal period to blame Bancroft's reported high leach rates for perovskite on contaminated samples. Ringwood is the principal developer of SYNROC — a ceramic nuclear waste form that includes the mineral perovskite (SN: 5/17/80, p. 310).

Later, in that same session, Ringwood presented a SYNROC status report, citing leach rates that he said demonstrated that SYNROC's ability to immobilize high-level wastes is "far superior" to that of borosilicate glass waste forms. "A modest extrapolation of existing data suggests that SYN-

Spitsyn

Black-and-white (left) and X-ray (center) photos compared with a beta-radiograph.

ROC would be less leachable than glass by a factor exceeding 1,000 after 55 days," he said.

Meanwhile, Bancroft observed from the audience that while he had presented his perovskite leach rates in kilogram per square centimeter per second units, Ringwood was reporting his leach rates in grams per square meter per day. After some impromptu unit conversion calculations, Bancroft noticed that at least for one set of perovskite leach rates, he and Ringwood were presenting the same results. "Those are exactly the numbers I reported," Bancroft informed the SYNROC promoter. "I think we won't resolve this," answered Ringwood, moving on to another question from the audience.

Leach rates again were the center of controversy after J.M. Pope of Westinghouse Research and Development Center in Pittsburgh, Penn., reported an "advanced method" for making glass waste forms. The conventional route to glass waste forms involves dissolving nuclear waste oxides in molten glass at temperatures above 1,000°C. In order to minimize foaming, slagging, dusting, the time required to achieve homogenization of this melt and vaporization of the volatile fission products added, researchers have favored borosilicate glass compositions over those that are more durable (and therefore more resistant to leaching) but that require higher-forming temperatures.

In the Westinghouse procedure, glass formers and waste sludge chemically combine before they melt into a homogeneous mixture at temperatures below 600°C. This separation of the mixing and melting operations eliminates several of the usual glass-forming problems without sacrificing use of the higher-melting, more durable glass compositions — silica and alumina, for example.

At least for one of the glass compositions formed by this novel procedure, Pope reports that his colleagues have measured leach rates lower than those of conventional glasses by a factor of 10,000. Following Pope's presentation, however, a representative from the Savannah River Laboratory in Aiken, S.C., challenged that leach rate. Apparently the Savannah laboratories had tested a Westinghouse glass and had come up with a leach rate improved by a factor of two, not 10,000.

According to Pope, the Savannah laboratories had tested a glass with a lower alumina content — and therefore higher leach rate — than the glass he had referred to in his presentation. Comparing the leach rates of the higher and lower alumina glasses is like "comparing French pastry to a damn cupcake," Pope says. But even if the Savannah and Westinghouse laboratories have tested the same glass, there is still no basis for comparison of leach rates. The labs used two different types of tests to measure the leach rates.

The confusion following the presentations of Ringwood and Pope (and evident in other areas of the nuclear-waste disposal field) emphasized the need for the Nuclear Waste Materials Characterization Center (MCC) at the Pacific Northwest Laboratories of Battelle in Richland, Wash. Established by the U.S. Department of Energy in October 1979, "The center has the charter to develop standard tests for the characterization of the components of the waste package — which include spent fuel, waste forms, overpacks, canisters and barriers — and to publish a Nuclear Materials Handbook," Dennis M. Strachan explained at the nuclear waste symposium. Five separate leach tests, for example, have been proposed by the center to study time-dependent leaching of waste forms under various circumstances. While all researchers now use roughly the same method to measure leach rates, "Everyone seems to modify it to suit his or her needs," Strachan says. "You have to standarize these things, and that's what MCC is all about." The test farthest along in the review process, MCC 1, now is undergoing a "round robin" analysis in which 22 laboratories are comparing the leach rates they obtain for three samples using the specifications outlined for MCC 1.

The progress report on the MCC program shined a hopeful light on the nuclear waste symposium; another beam of optimism came from the Soviet Union. Taking a different approach to the problem of nuclear waste, Victor I. Spitsyn of the Institute of Physical Chemistry in Moscow described a method of extracting from radioactive wastes kilogram quantities of the metal technetium — number 43 on the periodic table. The fission of uranium 235 yields about 6 percent of the 212,000-year half-life species of technetium. In addition to inhibiting corrosion, this metal has high catalytic activity in certain organic systems. Moreover, the metal is an excellent source of low-energy beta particles: One square centimeter of metallic technetium emits nearly 2.5 million beta particles per second. As a result, technetium can be used to study the structure and thickness of the thin-layer targets of beta-radiography. In his presentation, Spitsyn demonstrated that while a "soft" X-ray photograph of a 19th century Swedish postage stamp reveals little more than its black-and-white counterpart, the technetium beta-radiograph of the same stamp shows the water mark of the paper.

Extracting technetium from nuclear wastes, of course, is still a rather expensive endeavor; but, says symposium chairman John G. Moore of Oak Ridge National Laboratory in Tennessee, "The fact that the Soviet Union is obtaining large amounts of the material and may find a use for what we thought was a waste — that's significant." □

Harvard bows out of gene-splice plan

Harvard University's brief flirtation with the business end of genetic engineering ended, at least for now, with a decision not to participate in the creation of a new company. The plan under consideration had been for the university to establish a corporation to develop, manufacture and market medical uses of gene manipulations developed in Harvard laboratories. The university would hold shares in the corporation, at most 10 to 15 percent, in return for giving over some of its faculty's research and potential patents for development. The corporation would have had separate facilities and would not have used Harvard's name.

Many faculty members expressed strong opposition to the corporation proposal, which was expected to bring to the university some of the financial fruits of genetic engineering research. The opposition centered on the need for secrecy in commercial ventures, which runs counter to academic ideals of free information exchange. Opponents also envisioned difficulties for the university in fairly handling such matters as faculty salary, tenure and promotion if some faculty members were also the university's business partners. The university would be pressured to make decisions according to commercial, rather than academic, interests.

"The preservation of academic values is a matter of paramount importance to the university, and owning shares in such a company would create a number of potential conflicts with these values," said Harvard president Derek C. Bok in explanation of the university's decision.

Although Harvard will not start a new