the fuel rods and into the distant environment over millennia. The panel agrees that DOE has done a good job assessing such possible disruptions as earthquakes, volcanic eruptions, and nuclear reactions suddenly taking off, but notes that other assumptions "may be unduly optimistic." For example, the cladding that encases the enriched uranium rods and provides the first line of defense may not hold up as well as assumed. More lab work on the cladding's behavior under repository conditions is needed, says the report.

The behavior of the radioactive material once it leaks out, as it eventually must, is also unclear, says the report. More exploratory holes should be drilled into aquifers far from Yucca Mountain, where the radioactivity will ultimately spread, it suggests. The panel is especially concerned about the assumptions behind the repository's "hot" design, in which heat from the waste is supposed to keep temperatures well above boiling and thus initially keep out moisture that could corrode the rods. "We don't think anybody can model that convincingly," says Whipple. Such stubborn problems might be handled by making some conservative, simplifying assumptions, says Whipple, an approach DOE has yet to accept.

Van Luik says he's "a tad surprised at the amount of material they think we need to do." Some of the suggested work is already under way, he notes, and project staff are still debating the merits of a hot design. "This is not our final design, nor our final understanding of the site," he explains. But he's concerned by the fact that "the panel recommends that we do additional work that would extend us beyond our current schedule."

Kevin Crowley, staff director of the National Research Council's Board of Radioactive Waste Management in Washington, D.C., says DOE would be wise to take the panel's advice because its current schedule is unrealistic. The panel's emphasis on gathering more data and dealing with the intractable complexities, he adds, could be key to resolving the technical issues. "The DOE has some real challenges ahead," he warns.

–RICHARD A. KERR

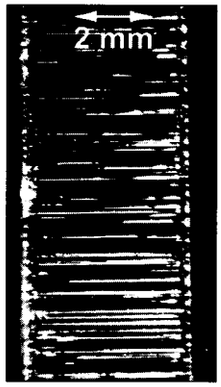
MATERIALS

Stress Profiling Gets The Best Out of Glass

Try to bend a piece of window glass, and you'll get a vivid demonstration of glass's brittle behavior. When stressed, it shatters without warning into thousands of shards. Now an international team of researchers has developed a clever way to make glass a little more pliant and predictable. On page 1295, materials scientist David Green of Pennsylvania State University in University Park and his team describe a chemical toughening process that resulted in glass that both resists fracture better and delivers a warning before it finally fails, in the form of small cracks on its surface.

"Usually, when a piece of glass starts to break, that's the end of the story. In this glass you can arrest the cracks and you get some warning before the final failure," says Green. "The fact that multiple cracking can be observed in glass is indeed remarkable," agrees William Tredway, advanced ceramics group manager at United Technologies Research Center in East Hartford, Connecticut.

The traditional method for making glass more resistant to fracture is called tempering. Manufacturers use either heat or chemicals to increase the "residual stress"—the compressive forces between atoms—at its surface. Before an external stress forms a crack, it must overcome not only the normal strength of the material, but also this extra residual stress. Tempered glass is more resistant to fracture, but when a crack does form at the surface it quickly moves deeper where the stress is lower, and the material fails catastrophically.



Flexiglass. Cracks form on a piece of treated glass as it is flexed, but it does not break.

In 1991, Green and Rajan Tandon, now at Caterpillar Inc. Technical Center, a construction machinery manufacturer in Peoria, Illinois, did theoretical studies that pointed to a better way to strengthen glass. The studies showed that a compressive stress "profile," with relatively weak stress at the surface increasing to a maximum at a depth of 20 to 30 micrometers, would stop cracks because they would face increasing compressive stress as they moved deeper into the material. "The idea went against the current dogma of what you are supposed to do," says Green. "Usually people try to get the maximum compression at the surface."

To create the required stress profile, the researchers developed a two-stage chemical tempering process. The main skeleton structure of glass is composed of silicon and oxygen atoms, interspersed with sodium atoms. The researchers immersed a glass sample in a bath of molten potassium nitrate at high temperature, allowing some of the potassium ions in the bath to swap places with sodium ions in the glass—a process called "ion exchange." Potassium atoms have a radius that is 25% larger than sodium, says team member Vincenzo Sglavo of the Uni-

CREDITS: (TOP) GREEN *ET AL.*; (BOTTOM) IOWA STATE UNIVERSITY

ScienceScope

Food Fight Fed up with the ongoing media feeding frenzy surrounding genetically modified (GM) food, 19 of Britain's most eminent scientists, all Fellows of the Royal Society, have called for the use of peer review rather than public opinion to judge scientific results. Writing in the 23 February issue of London's *Daily Telegraph* and *Guardian* newspapers, they say that "it is a dangerous mistake ... to assume that all statements claiming to be scientific can be taken at face value."

The letter follows a public statement from 21 scientists in defense of protein chemist Arpad Pusztai (*Science*, 19 February, p. 1094). Last summer, Pusztai was suspended from his post at the Rowett Research Institute near Aberdeen after declaring in a TV documentary that his unpublished research indicated that potatoes genetically altered to resist pests stunted growth and suppressed immunity in rats.

One signatory of the new letter, botanist Ghillean Prance, director of the Royal Botanical Gardens at Kew, says that the Fellows are concerned about several recent incidents in which unpublished results have been promoted in the media. "So much bad science is going into the press," he says. The society is convening an expert panel to review Pusztai's results and broader issues related to GM foods.

Meltdown Nuclear research reactors continue to disappear from U.S. university campuses as the field loses ground to other disciplines. Last month, Iowa State University in Ames finalized plans to dismantle by next year its 10-kilowatt minireactor, whose $200,000-a-year budget became an unjustifiable expense after the school closed its nuclear engineering program a few years ago.

The 40-year-old reactor (above) becomes the 43rd campus-based atomic plant to close since 1975, leaving about 30 operating academic reactors. Up to a third of the remaining plants could close within the next decade, experts say, due to operating cost concerns and relicensing expenses. Several advisory panels have called on the Department of Energy to stem the decline, which they say threatens a wide range of engineering, materials, and physics research.

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