Physics

A tight squeeze for mobile water

Water molecules trapped in a porous material partially filled with water seem more mobile than water molecules in, say, a cup of water. "To our knowledge, this peculiar result has never been observed before," William P. Halperin of Northwestern University in Evanston, Ill., and his co-workers report in the July 3 PHYSICAL REVIEW LETTERS. The finding provides a striking example of how a material's pore structure can alter a liquid's bulk properties.

The researchers performed their experiments on porous silica glass filled so that water takes up different fractions of the space available. Relying on nuclear magnetic resonance measurements, they found that water molecules move around inside the pores more rapidly than would be expected—so long as the glass sample isn't saturated with water.

The effect seems to stem from the fact that water "wets" the glass, forming a layer on the pores' inner surfaces. The remainder of the pore volume is filled with air saturated with water vapor. The resulting sponge-like system consists of two interpenetrating pore structures—that of the liquid and that of the vapor—each with a different geometry. In such an arrangement, water molecules, instead of following paths through the liquid layer, apparently take shortcuts by going into the vapor phase before reentering the liquid phase. This increases the overall mobility of any water molecules present.

The efficiency of the exchange of water molecules between the liquid and vapor phases depends on how large and how full the pores are. Such a rapid exchange between liquid and vapor doesn't occur when water sits in a cup exposed to air or when the material's pores are very small. The process also seems to reflect details of the porous material's microstructure. "The importance of these effects varies from one kind of material to another," Halperin says.

The findings may have implications for how rapidly liquids diffuse through porous materials, affecting processes such as the hardening of cement and the spread of contaminants in groundwater and materials such as sandstone. "In these cases, transport by diffusion can be much faster than would otherwise have been thought," Halperin says. However, none of these possibilities has been investigated yet.

Splat prints of floppy molecules

A molecule's geometric shape is one of its most fundamental properties, but many molecules are difficult to characterize geometrically, especially those held together loosely or having absorbed enough energy to be in a highly excited state. Researchers from the Weizmann Institute of Science in Rehovot, Israel, and the Argonne (Ill.) National Laboratory have developed a technique that yields geometrical images of individual molecules – no matter how floppy or excited.

The method, called Coulomb explosion imaging, takes advantage of the large electrical repulsion between the nuclei within molecules rapidly stripped of all or most of their electrons. To get an image, the researchers first accelerate a beam of molecules to a velocity about 2 percent that of the speed of light, then smash them into a foil of solid material only 30 angstroms thick. The foil strips electrons from the molecules but allows the nuclei to pass through unscathed. Like an exploding shell, the stripped molecule flies apart as a detector records the speed and direction of each fragment. From that information, the researchers can calculate the original arrangement of the nuclei in the molecule.

The group has already used the technique to reveal the structure of positively charged methane ions and other carbon-based ions. It also works with neutral molecules if an extra electron is added to each molecule to make it easier to accelerate and then removed later.

Science & Society

Have your rain forest and eat it, too

Is a live rain forest worth more money than a dead one? A new study suggests that efforts to harvest the products of tropical forests may generate substantial monetary profits while at the same time preserving the ecological wealth stored there.

Most financial analyses of a rain forest's worth have focused only on the value of felled timber. As a result, these calculations indicate the forest is worth more as farmland or pastureland than as a source of timber. Such work has provided support for forest clearing—a process that eliminates uncounted species of plants and animals while exacerbating the greenhouse effect.

Research by a group of U.S. scientists now shows that an intact rain forest can provide more revenue than a cleared one. The investigators, who describe their findings in the June 29 NATURE, estimated the value of a hectare of Amazonian forest near Iquitos, Peru, by examining the annual production of fruits, oils, rubber and medicines there. "These data indicate that tropical forests are worth considerably more than has been previously assumed and that the actual market benefits of timber are very small relative to those of nonwood resources," say Charles Peters of the New York Botanical Garden in the Bronx, Alwyn Gentry of the Missouri Botanical Garden in St. Louis and Robert Mendelsohn of Yale University.

The analysis shows that 1 hectare of forest produces $400 in fruit and $22 in rubber annually. Since such products grow every year, the forest's real value far exceeds one year's profit from these crops. To estimate the total worth of resources, the researchers used a model to calculate a figure called the net present value. For fruit and rubber, the net present value is $6,330 per hectare. This amount would be higher if it included revenues from medicinal plants and other products.

In contrast to harvesting fruits, cutting a hectare of rain forest timber earns a net revenue of $1,000, but this is a one-time payout. Periodic cutting of selected trees yields a net present value of only $490. A tree plantation located on a hectare of cleared forest has a net present value of $3,184. For pastureland, the figure is less than $2,960.

Nuclear waste still homeless

The Energy Department has once again decided to postpone opening the first U.S. underground repository for nuclear waste. While allowing more time to address safety concerns and to meet regulatory requirements, the delay also causes problems for the department, which is quickly running out of storage space for its radioactive waste.

The facility in question is the $700 million Waste Isolation Pilot Plant (WIPP), a series of rooms and shafts carved out of a salt formation 2,000 feet below the desert surface near Carlsbad, N.M. Although WIPP was originally scheduled to open last October, the Energy Department pushed the date back a year when it became clear the plant would not be ready. More recently, Congress and other groups have criticized the Energy Department for again proceeding too quickly (SN: 6/24/89, p.389). At the end of June, Energy Secretary James D. Watkins announced that WIPP will not open this year and that panels of experts will review the department's plans for the facility.

WIPP will store plutonium-contaminated waste generated at the nation's nuclear weapons plants, beginning with some from the Rocky Flats facility near Denver (SN: 6/24/89, p.391). The Energy Department is temporarily storing Rocky Flats waste in Idaho, but Idaho Governor Cecil D. Andrus says he will not permit any more shipments to enter his state after Sept. 1 of this year. That leaves the department scrambling to find a new facility because Colorado Governor Roy Romer says he must shut down Rocky Flats when it runs out of storage space, which may happen by next February.