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Abstract: The article reports that it might be possible to train gelatin-like substances to remove toxic wastes, treat diabetes or dehumidify a car. Since chemicals can trigger a response, gels could be used to sense or control elements in continuous processes, such as oil refining. A gel sensitive to blood sugar could release appropriate amounts of insulin into the blood-stream, acting as an artificial pancreas for diabetics. A gel can be designed, for example, to absorb only those chemicals in soymeal slurry whose size falls below a specified cutoff point. Another selective absorption gel would suck water from the air, allowing for dehumidification that wastes no energy on cooling. All gels consist of a pinch of polymer, called a matrix, mixed into about 30 times as much fluid, called a solute.

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It might be possible to train gelatin-like substances to remove toxic wastes, treat diabetes or dehumidify a car.

SMART JELL-O

THINK OF how abruptly water increases its volume 1,700-fold as it crosses the boiling point and turns into steam. Back in 1978 Toyoichi Tanaka, a researcher at MIT, made a gel -- a semisolid blend of a fluid and a polymer -- that could produce comparable hair-trigger transitions between two molecular structures, one compact, the other loose. Tanaka's transformation, moreover, was reversible, just as the vaporization of water is reversible.

Although most of his peers scoffed at the time, Tanaka was on to something important. Since chemicals can trigger a response, gels could be used to sense or control elements in continuous processes, such as oil refining. Electricity can be the trigger, so gels might become part of the artificial muscles in an artificial limb. Globs of gel ``antibodies'' might selectively bind to toxic wastes, immobilizing them for easy disposal. A temperature-sensitive gel implanted in the body might act as an automatic dispenser of aspirin. A gel sensitive to blood sugar could release appropriate amounts of insulin into the bloodstream, acting as an artificial pancreas for diabetics.

Rising to become a professor of physics at MIT, Tanaka doggedly pursued the commercial potential in his academic research. He hooked up with George McKinney III in founding Gel Sciences, Inc. two years ago in Waltham, Mass. Armed with eight patents and imaginative descriptions of the endless possibilities, they rounded up approximately $1 million in venture capital.

Tanaka, 48, spends his time with beakers and lasers, free-associating ideas about how gels might support alternative forms of life. Chief Executive McKinney, 50, a veteran of American Superconductor and Corning, is more down-to-earth. He prefers not to talk about the more fantastic applications of gels: ``We're taking the easier technologies and moving them to commercialization first.''

A gel can be designed, for example, to absorb only those chemicals in soymeal slurry whose size falls below a specified cutoff point. That would be extremely useful in the production of baby food and tofu, for which the food processor wants to sop up worthless whey (smaller molecules) and leave behind the valuable curds (large protein molecules). The swollen gel can then be stimulated to discharge its load of whey, thus returning to its absorptive state.

Another selective absorption gel would suck water from the air, allowing for dehumidification that wastes no energy on cooling. The dehumidifying gel can even be regenerated to its thirsty state with sunlight. Solar dehumidifiers would come in handy in an electric car -- if a practical one ever reaches the market -- the feeble batteries of which couldn't run the wheels and an air conditioner as well.

Next on the agenda for Gel Sciences are applications of a gel's ability to release its contents in response to precise triggers. Allan Hoffman of the University of Washington, an adviser to Gel Sciences, is working on gels for drug delivery. These gels would ferry proteins and other acid-sensitive drugs past the stomach and into the more neutral environment of the small intestine, where the capsules would give up their cargo for easy absorption.

All gels consist of a pinch of polymer, called a matrix, mixed into about 30 times as much fluid, called a solute. The tendrils of the polymer interact with the solute to produce something midway between a solid and a liquid. Jell-O, the standard example, has a matrix of gelatin and a solute of sugar water. Tanaka's original gel had a polyacrylamide matrix and a solute of acetone and water. Many, many other combinations are possible.

Tanaka set up a series of beakers in which the concentration of acetone varied from nothing to 100% and put polyacrylamide in each one. ``The next day I found that half of the gels had collapsed and the other half were swollen,'' he says. In each case the reaction was all one way or the other.

Tanaka's gels showed immense changes in volume in response to tiny changes in the concentration of acetone. That is, these gels weren't just ``responsive''; they were abruptly responsive. Soon Tanaka found he could design gels to swell in response to different acetone concentrations; later he found ways to tune them for other chemicals and even temperatures. Hence their potential adaptability to so many difficult jobs.

Tanaka's company may fall back on toys as a revenue source while the bigger projects are jelling. Japanese scientists have already demonstrated gel ``inchworms'' that crawl in time with the alternation of an electric field. Soft machines can be creepy in more ways than one -- just the thing for the tots next Christmas.

PHOTO: McKinney and Tanaka observe gel filtration. From left: A gel absorbs light molecules from a slurry, leaving heavy ones behind. (Seth Resnick)

ILLUSTRATIONS: A slight rise in temperature can spark big changes in gel structure. Here the polymer matrix clumps up, creating pores that let large molecules in -- or out. (Andy Christie/Forbes)

PHOTOS: A gel inchworm ratchets its way through liquid with each change in an applied electric field. The field attracts molecules to the gel's top, which shrinks, giving the worm a U shape. Reversing the field releases the molecules, swelling the top of the gel. The U relaxes, and the worm lurches forward. (Yoshihito Osada, Hokkaido University)

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By Philip E. Ross

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