At Long Last, Will Electrorheological Fluids Compute?

Researchers touting electrorheological fluids for commercial applications find themselves in the same fix as the boy who cried "Wolf." In the late 1940s, after the first publication describing ER fluids, several companies tried to make use of their unique property of hardening when exposed to an electric field to make vibrators and dampers, but gave up because the fluids were then too abrasive and damaged the equipment. Interest revived in the late 1960s, and for the past 20 years a succession of firms has dabbled in the field, but many have become discouraged by the difficulties in making ER devices and quit. There is still no successful ER product on the market.

So why should the 1990s be different? James Stangroom of ER Fluid Developments Ltd. in England has a compelling answer. "The need for ER fluids has only developed over the past 10 years as we have developed the ability to calculate," he says. Today's computers can manipulate tremendous amounts of information at fantastic speeds, but for most applications there is no good way to transform those calculations into action. Industrial robots, for instance, rely on such things as stepper motors and feedback loops which cannot take full advantage of speedy computer decision-making. "We need [mechanical] systems that are computer-compatible," Stangroom says. ER fluids, which can respond to electric signals faster and more precisely than existing technologies, offer that capability.

Theodore Duclos at Lord Corporation in Cary, North Carolina, describes several prototype ER devices that could be controlled by computer. The simplest is a valve with no moving parts. In it, fluid passes between two electrodes; applying a voltage across the electrodes solidifies the fluid and reduces or stops the flow within a millisecond or so. An experimental ER clutch has been constructed out of two plates separated by a thin layer of ER fluid, one plate connected to a rotating drive shaft and the other to an output shaft; varying the intensity of an electric field between the plates controls the viscosity of the fluid, so that the rotation of the output shaft can be adjusted with exquisite accuracy. And ER vibration-control devices could be valuable in engine mounts, Duclos says. Industry rumor has it that a Japanese car maker will have an ER engine mount on a 1991 model, he says, but he suspects that is unlikely. Still, he adds, it would not be too surprising to see such an automotive application by 1995.

Stangroom compares the state of ER fluids now to that of transistors in the 1950s, when they were used mainly by the military and kept in temperature-controlled cabinets. And like transistors, ER fluids offer a unique capability likely to be applied in ways that cannot even be imagined now. The analogy with electronics seems particularly fitting since the future of ER fluids may rest on their ability to ride the coattails of the computer revolution and provide a simple, efficient way for computers to do more than just compute. ■ **R.P.**

turned off, the water molecules retreat into the particles and the bridges disappear.

These same water bridges are what cause a flour-water mixture to be solid, Stangroom notes. Indeed, he says, if water is added to a slurry of flour and oil, the mixture will solidify even without an electric field.

Stangroom's argument that water is all important is flawed, says Harry Block, a chemist at Cranfield Institute of Technology in England, because some ER fluids function quite well without any water at all. Although Stangroom replies that it is impossible to get all of the water out, Block contends that, "The amount of water [in the nonwater mixtures] is not enough to produce the ER effect."

Block gets backing from Zukoski at Illinois, who has recently completed a careful series of experiments on anhydrous ER fluids. By using particles made out of a polymer that can be doped to give a variety of dielectric constants, Zukoski was able to test how the ER effect changed as the polarizability of the particles was varied and everything else kept constant. The experiments matched up quite well with predictions made from a model based only on electrical effects, he says. In this particular case, Zukoski says, the presence of water was not an important factor.

That still begs the question of exactly what role water does play, since many ER fluids will not function when completely dry and most work much better after water is added. The proponents of the particle polarization model suggest that water increases the polarizability of the particles in the fluid. For instance, water molecules adhering to the surface of particles could greatly increase their dielectric constant since water is easily polarized. And, Zukoski says, it is not impossible that chemical effects such as water bridges might play a role in some ER fluids.

The question of how essential water is for the ER effect is vitally important for commercial applications. Engineers would like to find ER fluids that can endure a wide range of temperatures, and fluids dependent on water do not last long at temperatures much over 100°C.

But the temperature range is just one of the important factors for industrial use, says Theodore Duclos, a researcher at the Lord Corporation in Cary, North Carolina. An ideal ER fluid would have low viscosity in the absence of an electric field but solidify with as low an electric field as possible; the particles should remain in suspension for a long time without settling to the bottom; the fluid should not damage equipment; and it should be nontoxic and nonpolluting.

Right now, the engineers are not waiting for the scientists to explain what is going on. They are proceeding to look for that ideal ER fluid by themselves. ■ **ROBERT POOL**

Gene Therapy Proposed

NIH scientists R. Michael Blaese and W. French Anderson have submitted the first protocol to test real human gene therapy. The two are asking for permission to insert a working gene in children having a genetic defect that causes a life-threatening immune deficiency.

In another ongoing experiment at NIH, Blaese, Anderson, and cancer surgeon Steven A. Rosenberg are already infusing melanoma patients with potentially therapeutic cells labeled with a foreign gene, but the study is not, strictly speaking, a case of gene *therapy* because the foreign gene is being used only as a marker, not as a drug.

Now, Blaese and Anderson propose administering the gene for adenosine deaminase to children who do not have this enzyme, which is vital to immune functioning. Their protocol will be reviewed on 30 March when the NIH's Recombinant DNA Advisory Committee meets in concert with the human gene therapy subcommittee.

■ **BARBARA J. CULLITON**