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Nano-Prospecting

Energy companies pour millions into nanotechnology for oil and gas recovery.

By Duncan Graham-Rowe

Could nanotechnology help squeeze more oil and gas out of the ground? That's the hope of a consortium of energy companies that is putting millions of dollars into the development of new micro- and nanosensor technologies.

The seven companies that make up the Advanced Energy Consortium (AEC), which includes Halliburton Energy Services, BP America, and ConocoPhilips, will put up $21 million in total to fund the research. The aim is to develop subsurface sensors that can be used to improve both the discovery and the recovery of hydrocarbons.

"It's been a long time coming," says Wade Adams, director of the Richard E. Smalley Institute for Nanoscale Science and Technology at Rice University, in Houston, a technical partner to the consortium. "It's the first time the energy companies have got together to fund this kind of research, so it really is a big deal," he says.

Currently, even with the most advanced recovery techniques, only about 40 percent of the oil and gas in reservoirs can be recovered. The hope is that by injecting novel sensors into these reservoirs, it will be possible to more accurately map them in 3-D, increase the amount of fuel extracted, and minimize the environmental impact.

The financial investment--equivalent to $1 million per year from each company for three years--is "a very good sign," says Kris Pister, a professor of electrical engineering and computer science at the University of California, Berkeley, who has spent several years developing distributed sensors known as smart dust. It means that the energy companies now understand the potential of small-scale distributed-sensors technologies, he says.

"There is good reason to suspect that this technology could help," says Pister. Distributed wireless sensor technologies are becoming increasingly sophisticated, and now even have their own wireless standard: the highway addressable remote transducer, or HART.

Right now, the only way to find these reservoirs and gauge their precise size and capacity is through seismic means, or by simply drilling down. "But you don't get much information," says Adams. Surface and down-hole seismic techniques have limited resolution, while drilling can only take readings for the two-foot region surrounding the drill bore, he says.

Moreover, oil and gas reservoirs tend not to be formed in huge underground chasms, or wells, as many people think. Instead, the reservoirs are formed in porous rock formations, which act like high-pressure geological sponges, says Scott Tinker, director of the AEC, state geologist of Texas and a professor at the University of Texas, in Austin. "The pores are very small," he says. They can be anywhere from 10 microns to one micron in diameter. Because of their size, once the initial high pressure of the reservoir has been reduced by releasing some of the oil, this porosity can impede the flow of oil or gas through the rock formation. "It can take a lot of work to get the oil out of the rock," says Tinker.

What is needed is a means of mapping the pore structure and the voids between formations, he says, and to do this, researchers need sensors that are smaller than the pores. So the aim is to create micro- or nanosensors that can not only pass through the pores, but also form mesh networks to create detailed, 3-D maps of the structure of rock formations.

Another possibility with smaller-sized pores is to use magnetic nanoparticles to enhance aboveground sensing techniques, says Adams. By pumping the sensors into a rock formation, it could be possible to map the formation by detecting slight changes that the nanoparticles create in the earth's magnetic field.

The researchers believe that, in addition to locating and mapping oil and gas, nanoparticles might also be able to help recover the fuels. "The trouble is that the oil in the pores sticks to the walls," says Adams, even when high-pressure steam is blasted into the rock. The hope is that with the right nanoparticles, the researchers might be able to free the hydrocarbons from the rock.

Despite this potential, the energy industry hasn't shown much interest in nanoparticles until now. It was the high price of oil that caused its change of heart, Adams says. "All the big formations have been tapped, and most fields are in depletion. So cheap and easy oil is getting scarcer," he says.

Pister agrees. "A huge amount of money has been put into traditional extraction techniques," he says. But these have reached their limits in existing reservoirs. "They are about as tapped out as they can get."

However, there are lots of challenges ahead. Little is known about how nanoparticles will flow through porous rock. "And we have not generally designed nanoparticles for use at high temperatures and high pressures, nor for extreme chemical environments," says Adams. If these problems can be overcome, the payoff is likely to be great.
