Researchers: Molecular forklifts overcome obstacle to 'smart dust'

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Algae is a livid green giveaway of nutrient pollution in a lake. Scientists would love to reproduce that action in tiny particles that would turn different colors if exposed to biological weapons, food spoilage or signs of poor health in the blood.

Now, University of Florida engineering researchers have tapped the working parts of cells to clear a major hurdle to creating such "smart dust."

The feat, which signifies a new approach to technology known as the "lab on a chip," is to be reported Sunday in the journal *Nature Nanotechnology*.

"Instead of just changing one part of an existing system, we have a new and different way of doing things," said Henry Hess, a UF assistant professor of materials science and engineering and the senior author of the paper. "And we can do it this way because of building blocks from bionanotechnology, and that's what makes it very exciting."

Chip-based labs have been developed in recent years as portable tools to gauge the presence of bioweapons, pollution, or to conduct on-the-spot blood tests. They are essentially assays, or ways to test for different pathogens, chemicals or compounds.

Scientists have suggested that the ever-shrinking labs could be reduced to the size of tiny particles of "smart" dust. But although today's versions may be small, they require equipment that is hand-held at its smallest, and often large enough to require a lab bench.

"It's like a computer," Hess said. "The central processing unit is the really interesting thing, but you need all this other stuff to make it work."

The extra equipment is needed because the assay, which uses pairs of antibodies to latch onto target contaminants and the markers that give away their presence, requires repeated flushing with water. That requires pumps, which need power. To miniaturize the system, it's necessary to build miniature pumps and batteries. But that's a challenge, especially for miniaturization to the level required for individual pieces of smart dust, Hess said.

His research strips out all peripheral equipment by using an altogether unique and different approach: biologically powered molecular forklifts.

The forklifts are assembled from natural motor proteins that are active in cell division. Hess and his team's main innovation is manipulating these tiny proteins to perform heavy lifting and transport tasks -- tasks that lead to a successful assay.

For a system rooted in biology, the process is uncannily mechanical.

Using standard laboratory methods, the researchers squirt the forklifts into the central zone of three-zone circular surface no larger than the period at the end of this sentence. They then attach the same antibodies used in traditional chip-based labs.

When the surface is exposed to a contaminant, the antibodies latch onto it, just as happens with traditional assays. But then, activated by a flash of light, molecular shuttles start pushing the forklifts into a second zone, where they load aboard fluorescent particles, or tags. They move their cargo to the third zone, at the edge of the circle. There, over several hours, they crowd against each other, accumulating to the point where their combined loads form a line visible under magnification - and providing the telltale indicator of the contaminant.

The process requires no rinsing. And instead of electricity, the naturally derived forklifts are powered by adenosine triphosphate, or ATP, the molecule that carries energy for cells.

"You have replaced all this washing with this active transport by molecular shuttles, so you don't need a pump or battery," Hess said.

Michael Sailor, a professor of chemistry and biochemistry at the University of California San Diego and prominent smart-dust researcher, called the research "quite promising."

"The key advance is that the authors incorporate a transport mechanism derived from a natural system into an artificial microsensor," he wrote in an e-mail. "The authors show how adding the ability to move around in an autonomous fashion can dramatically improve the performance of the microsensor."

Hess emphasized that the research results represent only the initial of many steps toward smart dust. Among other challenges, the molecular forklifts need to be sped up, producing results in seconds or minutes rather than hours. But, he said, the process suggests that there are promising, alternative to traditional lab-on-a-chip assays.

"Right now, this is light years away from competing with any assay," he said. "But, it is a completely different way of doing it."

Source: University of Florida