Scientists develop 'lab on a chip' that costs one cent to make

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Researchers at the Stanford University School of Medicine have developed a way to produce a cheap and reusable diagnostic "lab on a chip" with the help of an ordinary inkjet printer.

At a production cost of as little as 1 cent per chip, the new technology could usher in a medical diagnostics revolution like the kind brought on by low-cost genome sequencing, said Ron Davis, PhD, professor of biochemistry and of genetics and director of the Stanford Genome Technology Center.

A study describing the technology will be published online Feb. 6 in the *Proceedings of the National Academy of Sciences*. Davis is the senior author. The lead author is Rahim Esfandyarpour, PhD, an engineering research associate at the genome center.

The inexpensive lab-on-a-chip technology has the potential to enhance diagnostic capabilities around the world, especially in developing countries. Due to inferior access to early diagnostics, the survival rate of breast cancer patients is only 40 percent in low-income nations—half the rate of such patients in developed nations. Other lethal diseases, such as malaria, tuberculosis and HIV, also have high incidence and bad patient outcomes in developing countries. Better access to cheap diagnostics could help turn this around, especially as most such equipment costs thousands of dollars.

"Enabling early detection of diseases is one of the greatest opportunities we have for developing effective treatments," Esfandyarpour said. "Maybe $1 in the U.S. doesn't count that much, but somewhere in the developing world, it's a lot of money."

A two-part system

A combination of microfluidics, electronics and inkjet printing

technology, the lab on a chip is a two-part system. The first is a clear silicone microfluidic chamber for housing cells and a reusable electronic strip. The second part is a regular inkjet printer that can be used to print the electronic strip onto a flexible sheet of polyester using commercially available conductive nanoparticle ink.

"We designed it to eliminate the need for clean-room facilities and trained personnel to fabricate such a device," said Esfandyarpour, an electrical engineer by training. One chip can be produced in about 20 minutes, he said.

Designed as a multifunctional platform, one of its applications is that it allows users to analyze different cell types without using fluorescent or magnetic labels that are typically required to track cells. Instead, the chip separates cells based on their intrinsic electrical properties: When an electric potential is applied across the inkjet-printed strip, cells loaded into the microfluidic chamber get pulled in different directions depending on their "polarizability" in a process called dielectrophoresis. This label-free method to analyze cells greatly improves precision and cuts lengthy labeling processes.

The tool is designed to handle small-volume samples for a variety of assays. The researchers showed the device can help capture single cells from a mix, isolate rare cells and count cells based on cell types. The cost of these multifunctional biochips is orders of magnitude lower than that of the individual technologies that perform each of those functions. A standalone flow cytometer machine, for example, which is used to sort and count cells, costs $100,000, without taking any operational costs into account.

Potential to democratize diagnostics

"The motivation was really how to export technology and how to

decrease the cost of things," Davis said.

The low cost of the chips could democratize diagnostics similar to how low-cost sequencing created a revolution in health care and personalized medicine, Davis said. Inexpensive sequencing technology allows clinicians to sequence tumor DNA to identify specific mutations and recommend personalized treatment plans. In the same way, the lab on a chip has the potential to diagnose cancer early by detecting tumor cells that circulate in the bloodstream. "The genome project has changed the way an awful lot of medicine is done, and we want to continue that with all sorts of other technology that are just really inexpensive and accessible," Davis said.

The technology has the potential to not only advance health care, but also to accelerate basic and applied research. It would allow scientists and clinicians to potentially analyze more cells in shorter time periods, manipulate stem cells to achieve efficient gene transfer and develop cost-effective ways to diagnose diseases, Esfandyarpour said. The team hopes the chip will create a transformation in how people use instruments in the lab. "I'm pretty sure it will open a window for researchers because it makes life much easier for them—just print it and use it," he said.

The work is an example of Stanford Medicine's focus on precision health, the goal of which is to anticipate and prevent disease in the healthy and precisely diagnose and treat disease in the ill.

More information: Multifunctional, inexpensive, and reusable nanoparticle-printed biochip for cell manipulation and diagnosis, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1621318114

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