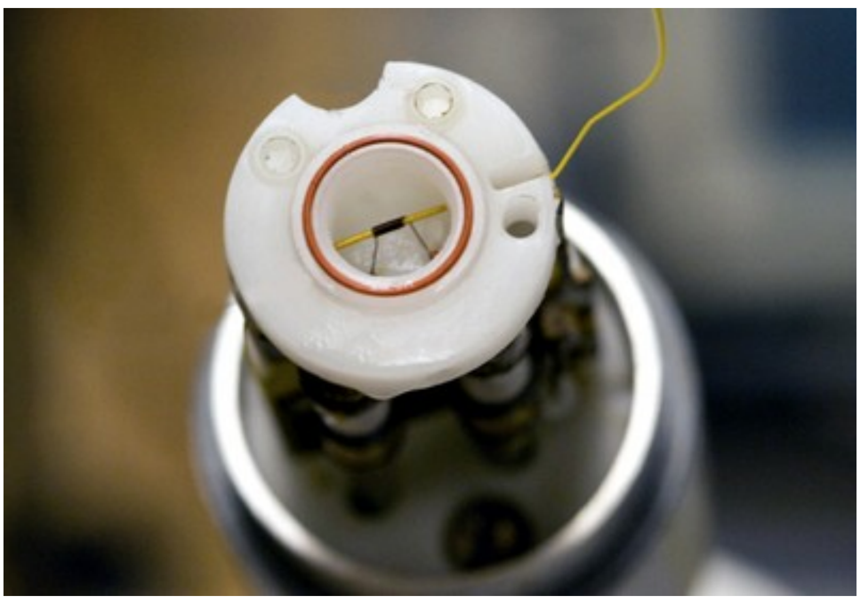
Microfluidic MRI may someday analyze blood in doctor’s offices

An application of MRI recently reported by QB3-Berkeley researchers Vikram Bajaj and Alex Pines might one day enable compact devices to analyze drug levels in a patients’ blood in the clinic. The technology could also find use in a wide spectrum of industries.

October 19, 2010
By Kaspar Mossman, QB3

An application of magnetic resonance imaging (MRI) recently reported in *Science* by QB3-Berkeley researchers Vikram Bajaj, Ph.D., and Alex Pines, Ph.D., might one day enable compact devices to analyze drug levels in a patients’ blood in the clinic. The technology could also find use in a wide spectrum of industries.



The microfluidic MRI probe developed by Vik Bajaj and Alex Pines. The wire detection coil is wrapped around the narrow-gauge tube in the center. Photo: Vik Bajaj

MRI provides images of the inside of your body, whether your knee, stomach, chest, or head, without invasive surgery or dangerous radiation. A routine MRI shows the density of water in tissue, obtained from a quantum-mechanical magnetic property called “spin” that the protons in water possess.

Taking images of tiny samples is a challenge, though, if you don’t have a tiny scanner. MRI sensitivity is highest when a sample completely fills the detection coil, because any unnecessary material in the coil adds electronic noise without contributing to the signal. It is difficult to image small blood samples inside an analytical device, for example, because the device itself takes up space and generates noise.

Why would a scientist want to use MRI to look at small samples of blood—or any other liquid? In medicine, or in drug discovery or other fields, often scientists have only a small quantity of a biopsy or a valuable reagent to analyze. And often they wish to know the chemical composition of a mixture, or whether a drug molecule has bound to a target protein. NMR, the parent technology on which MRI is based, provides detailed chemical information about a sample, without scientists needing to modify the sample with intrusive markers. MRI is basically a 3D picture of chemistry that can be much more complicated than the density of water.

Pines, who is the Glenn T. Seaborg Professor of Chemistry at UC Berkeley, and Bajaj, a postdoctoral fellow in Pines' laboratory, hope to perform MRI of microfluidic assays, an emerging lab technology. In microfluidics, a complicated experiment can be performed in a maze of tiny tubes and reaction chambers, and liquid outputs are channeled through a narrow-bore exit.

Bajaj and Pines solved the small-sample MRI challenge by using a technique Pines had pioneered a decade ago: "remote" MRI, in which properties (such as velocity) of the sample are converted, through the technical wizardry of MRI pulse sequences, into bulk magnetization that lasts for a few seconds. This encoding is done while the sample is inside the powerful main magnet coil that most MRI requires. The image information is temporarily frozen into the fluid sample, and is recovered later when it flows through a detection coil that can be much smaller than the main coil.

Bajaj and Pines developed a detector coil 0.25 x 0.5 mm in cross-section, which they wrapped around the output of a zigzag microfluidic channel. By extracting information from packets of liquid that passed through the output, they were able to reconstruct an image of the entire apparatus at an earlier time.

"The first commercial device that we see emerging from this work will be a kind of NMR chemical microarray in which we place dense arrays of sensitive sensors on a microfluidic device and use remote detection to record an 'NMR picture' to read out the assays," Bajaj says. He sees a host of industries that could use such a device, including point-of-care clinical analysis and security and contraband detection.

Bajaj and Pines are seeking funding that will allow them to develop a proof-of-concept prototype. They are no strangers to technology commercialization: along with Rick Glogau of UCSF Dermatology and Bernhard Bluemich of RWTH Aachen, they founded startup company SkinScan. Skinscan produces a portable MRI scanner for dermatologists.