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Remote Detection Like Taking a Photograph

New Technique Can Be Applied to Forensic Detective Work

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UC Berkeley chemistry professor Alexander Pines and his team of scientists have recently developed a new technique of nuclear magnetic resonance (NMR) called remote detection that greatly improves the performance of a microfluidics chip and allows for the analysis of very small materials.

NMR is a process that measures the responses of atoms with nuclear spin that are exposed to an external magnetic field.

Their version of NMR separates the two basic steps of NMR and increases the sensitivity of the analytical tool.

"The significance of developing remote detection NMR is that it allows for molecular structures, chemical reactions and flow processes that are of great interest in biochemistry applications to be studied by NMR and MRI on a microfluidic chip," Pines said. "It has all the advantages of NMR and MRI and then brings all those powerful tools on a normal macroscale down to microfluidic scale."

NMR can determine structural, physical, chemical, and electronic properties of a molecule, and is considered one of the most powerful spectrometry tools currently available.

"It's a great technique because it's completely non-invasive and non-destructive. It uses a process that is going on in your body all the time anyway but obtains information by manipulating it," said Erin McDonnell, a UC Berkeley chemistry graduate student in Pines' lab.

Remote detection NMR is a breakthrough in microfluidics because it allows for minute samples to be examined, a task that essentially defines the field of microfluidics.

Microfluidics is the study of designing devices and processes that work with liquids in volumes of nanoliters. The NMR developed in Pines's lab can detect extremely small amounts of liquids.

"Microfluidic devices are important because they allow a person to work with a very small amount of fluid," said Christian Hilty, a post-doctoral fellow and lead author of the research. "For example, even if you have small droplet of fluid, that can be much easier to work with whether you're performing a medical application in which you need a small droplet of blood or environmental analyses where you just need a small drop of water," he said.

Hilty added that microfluidics also has great application in biochemistry. In some cases, a scientist may want to study a protein that is not available in large amounts. Microfluidics allows the person to use just a few micrograms of the sample for analysis. In addition, if one wanted to screen for certain properties of a large variety of compounds, performing such a task on a small scale equates to less reagents needed and thus more environmentally friendly and less costly.

Another possible use can be applied to forensic detective work in identifying certain compounds since it has the ability work with such a tiny amount.

"These detection techniques are crucial in applying to microfluidic devices, partly because microfluidics is a relatively new field, and because it is difficult to detect things on a small scale," Hilty said. "There are not that many sensitive techniques that give a lot of information. Of all the detection techniques you can envisage, NMR is one of the most information rich because NMR can directly probe molecular structure, as well as get images."

However, determining the structure or image of such molecules has not been so effective because of two handicaps: NMR's low sensitivity and its incapacity for encoding and detection to be carried out independently.

NMR is broken down into two main components, encoding and detection, which typically occur on the same device. The encoding phase is when the atomic nuclei in the sample are subjected and respond to a series of radiofrequency pulses. Detection incorporates determining the frequencies of the encoded signals in order to obtain a NMR spectrum, which ultimately leads to the identification of the chemical structure.

However, separating these two

elements not only makes it more efficient but more effective, as it now allows scientists to use more sophisticated analysis to analyze what was encoded.

Pines explained that remote detection NMR is analogous to taking a photograph. An individual that is interested in something in a dark region that cannot clearly see the object may snap a photograph in the dark. Later, the photograph can be developed and the image amplified in the light to be viewed better and more carefully-like how the information encoded in the first phase of NMR can be detected with better tools.

"It's a big deal because when you have small stuff in big concentrations, your sensitivity is very low," Pines said. "If you don't have enough molecules, the signal is very feeble...in remote detection of microfluidics, you don't look at the signal, but you let it happen, encode the information...and then you collect it outside where you can use very sensitive methods like optics."

Because of the great potential of remote detection NMR, and its wide range of applicability, the team has been receiving responses for more information. The Pines Lab is working with other campus faculty to apply their work to the field of biochemistry in analyzing cancer cell cultures.

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