# Researchers demonstrate single molecule absorption spectroscopy

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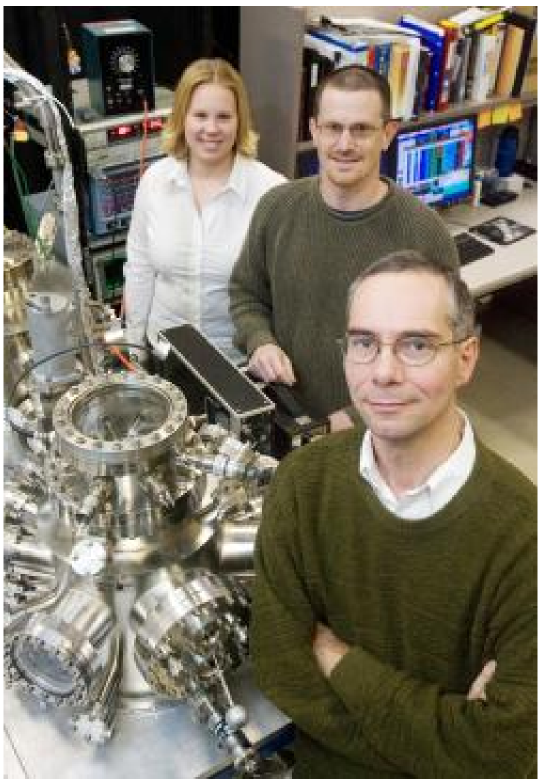

A powerful new tool for probing molecular structure on surfaces has been developed by researchers at the University of Illinois at Urbana-Champaign. Single molecule absorption spectroscopy can enhance molecular analysis, surface manipulation and studies of molecular energy and reactivity at the atomic level.

*Photo: Martin Gruebele, front, a professor of chemistry, physics and biophysics, stands next to the device he and Joshua Ballard, postdoctoral research associate, and graduate student Erin Carmichael use for laser-assisted scanning tunneling microscopy. Photo by L. Brian Stauffer*

"This new measurement method combines the chemical selectivity of optical absorption spectroscopy with the atomic-scale resolution of scanning tunneling microscopy," said Martin Gruebele, a professor of chemistry, physics and biophysics and corresponding author of a paper accepted for publication in the journal Nano Letters, and posted on its Web site. "The method literally feels how a molecule changes shape when it absorbs energy."

Unlike single molecule fluorescence spectroscopy, which is now a commonly used measurement technique, single molecule absorption spectroscopy has been an elusive goal.

"Single molecules don't absorb much light, making detection difficult to begin with," said Gruebele, who also is a researcher at the university's Beckman Institute for Advanced Science and Technology. "An even bigger problem, however, is that light-induced heating in the sample and in the microscope tip can produce so much noise that the signal is lost."

To reduce the noise, the researchers combined several special techniques -- each insufficient by itself -- into a method that allows them to detect single molecule absorption under laser illumination by scanning tunneling microscopy.

"First, the sample molecule is placed on a transparent silicon substrate," said Joseph Lyding, a professor of electrical and computer engineering and a researcher at the Beckman Institute. "Laser light will either be absorbed by the sample or will pass through the substrate with little or no heating effect. Second, the tip-sample junction is illuminated through the rear face of the substrate, significantly reducing tip heating."

Modulating the laser light with a mechanical chopper further reduces heating, Lyding said. A lock-in amplifier, which switches on and off at the same rate as the laser, filters out mechanical and electronic noise. As a result, the absorbed energy causes a change of shape in the electron density of the sample molecule, and the scanning tunneling microscope then measures that change of shape.

"Single molecule absorption spectroscopy is an extremely sensitive technique for analytical chemistry, for measuring electrical properties of molecules, and for studying energy transfer on surfaces," Gruebele said. "While most molecules don't fluoresce -- limiting the usefulness of single molecule fluorescence spectroscopy -- all molecules absorb, making single molecule absorption spectroscopy a much more general approach."

Source: University of Illinois at Urbana-Champaign