

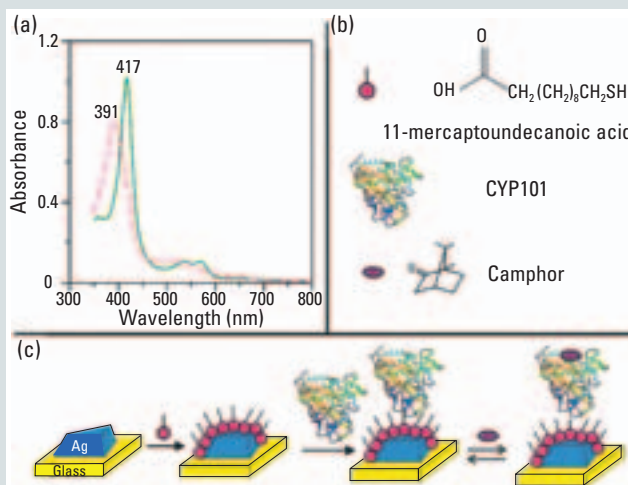
ANALYTICAL CURRENTS

Enhanced LSPR detects binding of small molecules

Richard Van Duyne and colleagues at Northwestern University and the University of Illinois at Urbana–Champaign have shown that resonant chromophores in proteins can drastically enhance the localized surface plasmon resonance (LSPR) response of nanoparticles. The investigators exploited the response as a sensitive detector of the binding between small molecules and proteins and suggested that this approach could further extend the utility of LSPR spectroscopy in drug-discovery research.

The LSPR extinction maximum, λ_{max} , typically undergoes a shift upon the binding of an analyte. But when the nanoparticles' LSPR occurs at a wavelength that is close to and slightly longer than the substrate's absorption maximum, the red shift is enhanced 3-fold.

To study the binding of small molecules to a nanoparticle-bound protein, the investi-



Camphor binding to CYP101 was sensitively detected using a resonance-enhanced LSPR signal from protein-bound nanoparticles.

gators examined the well-characterized pair of camphor and cytochrome P450cam protein (CYP101). They compared two sensors that were made by depositing Ag nanoparticles on a glass surface and modifying them with a self-assembled monolayer to promote the binding of protein. One sensor had a λ_{max} that was far from the molecular reso-

nance of CYP101 (417 nm), and one had a λ_{max} near this value. After each sensor was incubated with a solution that contained CYP101, the λ_{max} values were measured again. For the sensor that had a λ_{max} near the molecular resonance of CYP101, the change in LSPR resonance was significant—a red shift of 66.2 nm (from 421.4 to 487.6 nm). For the other sensor, the shift was 13.2 nm (636.1 to 649.3 nm).

When camphor was added, the investigators observed a blue shift that persisted across nanoparticle surfaces with different λ_{max} values. If the binding event had been nonreactive, it should have led to an additional red shift. Instead, these results indicate that camphor binding led to a change in the electronic state of the protein. (*J. Am. Chem. Soc.* **2006**, *128*, 11,004–11,005)

Nanoliter containers for controlled chemical reactions

David Gracias and colleagues at Johns Hopkins University have fabricated miniature, metallic containers that can release reagents through pores on their surfaces. The chambers provide a way to spatially control chemical reactions with pico- to nanoliter volumes of reagents.

The investigators made the containers by creating a 2D metallic template with solder hinges by photolithography. The template self-assembled into a 3D hollow structure when it was heated above the melting point of the solder—the driving force for self-assembly came from the surface tension of the molten solder. Gracias and colleagues demonstrated that the fabrication process was highly parallel

by making containers of various shapes and volumes, ranging from 230 pL to 8 nL, in a single run. Yields were 60–90% for a 3-in. wafer, depending on the size and shape of the container. The sizes of the pores on the faces of the container could also be controlled.

The investigators filled the containers with a polymer gel loaded with a chemical of interest. When the containers were immersed in a solution that either softened or dissolved the gel, the chemical was released. Because a wide range of polymers exist with different softening or dissolving properties, the rates of chemical release could be manipulated. By varying the relative porosity of differ-

ent faces of a container, the researchers could select for anisotropic or isotropic release of a chemical.

Gracias and colleagues showed that multiple containers could be controlled to create spatially localized chemical reactions. In one example, a container was filled with copper sulfate and another with potassium hydroxide. When the containers were brought close together, copper hydroxide formed along the central line between the two reagents. When the rate of release of one reactant was slowed down, the reaction occurred closer to the container with the slower release rate. (*J. Am. Chem. Soc.* **2006**, *128*, 11,336–11,337)