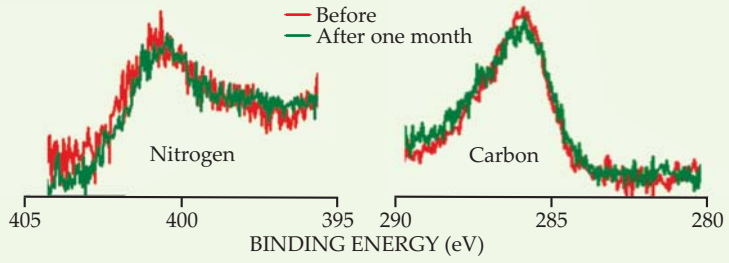
Figure 2. X-ray photoelectron spectroscopy data demonstrate the stability of a self-assembled monolayer of the molecule shown in black in figure 1a. Red and green spectra were taken before and after the monolayer was stored in water at room temperature for one month. If the monolayer had been partially lost from the surface, the heights of the peaks would have decreased. (Adapted from ref. 3.)



which yields distinct peaks for the NHC's carbon and nitrogen atoms. A decrease in the peak heights over time signals a loss of the monolayer from the surface; change in the peak shapes or positions could indicate a chemical reaction.

Overall, the NHC in figure 1a proved to be the more stable, perhaps because its lack of bulky side groups allows it to form sturdier and better ordered monolayers. Figure 2 shows the monolayer's XPS spectra before and after being stored in water at room temperature for one month. It also survived boiling water, the organic solvent tetrahydrofuran, pH 2, and pH 12—each for 24 hours—with no measureable loss of the monolayer. But it wasn't invincible: A 24-hour exposure to a hydrogen peroxide solution degraded the monolayer by about 20%.

Because one appealing application of SAMs is in electrochemistry, the Queen's University researchers sought to test the film's stability to electrochemical cycling. First they synthesized the functionalized NHC shown in black and gray in figure 1a and attached it to a gold surface. Then they modified the functional group to include a metal-based complex that changes its charge state in response to a change in voltage. Although the SAM was lost under negative voltage, it held up well under cycling at positive voltage, outperforming similarly functionalized thiol SAMs in that regime.

In a final series of tests, exposing an NHC monolayer to thiols had no effect: No NHCs were lost, and no sulfur-containing molecules were bound to the surface. But in the reverse situation, NHCs could completely displace a thiol monolayer. That observation may be the key to making better quality monolayers. Because NHCs are so reactive, some researchers have found that they bind not only to bare metal atoms but also to surface contaminants, locking them in place. Thiols, on the other hand, bind more selectively and are often thought to sweep away the contaminants as they do, so a contaminant-free NHC monolayer might be made simply by making a thiol-based SAM first (although Crudden and Horton have also made NHC monolayers on bare gold surfaces and see no obvious difference). "This is truly elegant," says Siemeling. "We possibly have a new gold standard here."

Johanna Miller

References

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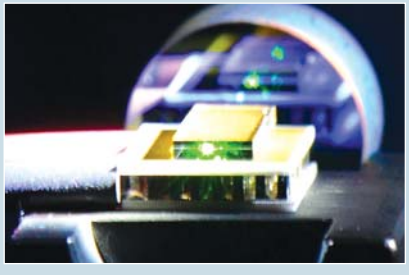
physics update

These items, with supplementary material, first appeared at http://www.physicstoday.org.

A diamond brightness converter. Light at wavelengths within the so-called "eye-safe" region of 1.4–1.8 microns is strongly absorbed in the eye before it reaches the retina. That spectral range is thus particularly desirable for laser applications such as range finding, remote sensing, and lidar. But current laser designs for those wavelengths suffer various performance and practicality limitations, including low pulse-repetition rates, low power levels, and poor beam quality. One promising alternative exploits stimulated Raman emission: Photons from an external pump source are inelastically scattered to a lower frequency, with some energy being lost to heat; above a sufficient pump energy threshold, the scattered photons will lase. Richard Mildren and colleagues at Macquarie University in Sydney, Australia, have now shown that diamond is particularly attractive for such Raman lasers. With its high thermal conductivity, diamond readily dissipates the waste heat. Moreover, the Raman process inherently concentrates the diamond's laser light into a tightly collimated beam. When the researchers placed a 1-mm-thick synthetic diamond crystal (seen here in the foreground) in a resonator and pumped it with 1.064-μm light from a simple, multimode neodymium pulsed laser, they obtained an eye-safe output beam of up to 16 W at 1.485 μm and 35 kHz. Although the conversion efficiency was only 40%, the diamond nevertheless functioned as a brightness converter: The brightness or radiance of the output beam, defined as the beam's power divided by its area and divergence, was 1.7 times the input beam's brightness. (A. McKay, O. Kitzler, R. P. Mildren, *Laser Photonics Rev.* **8**, L37, 2014.) —RJF



Precision trapping on a microfluidic chip. For the past couple of decades, biophysicists have used optical traps to investigate the behavior of cellular structures at the single-molecule level with nanometer precision. But conventional optical-trapping instruments can manipulate only one biomolecule at a time. And methods for generating multiple traps require a laser beam whose power scales up with the number of traps. Cornell University researchers led by Michelle Wang have now developed an optoelectrical fluidic platform that overcomes both drawbacks. Their device, illustrated here, requires little power and can trap and manipulate potentially hundreds of molecules at a time. At its heart are two subcircuits (within the dashed lines), each of which