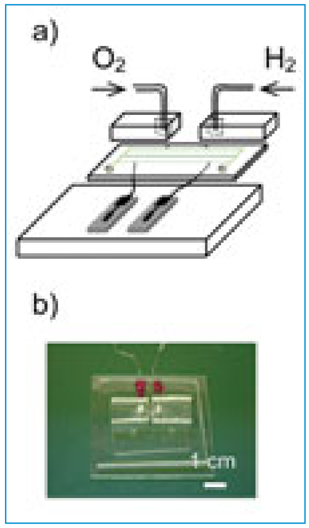
Microfluidic Fuel Cells

One key goal of practical microfluidic technology is to provide an efficient and reliable power source that can be integrated with other microfluidic components. Researchers at the University of Illinois at Urbana-Champaign have recently reported on the fabrication and performance of a microfluidic H_2-O_2 fuel cell composed of electrodes that are immersed in a liquid electrolyte fueled through a gas-permeable membrane (*Langmuir* **2004**, *20* (17), 6974–6976). Because of this construction, the cell relies on passive fuel uptake and requires no pumps to supply fuel or circulate the electrolyte. This cell consists of two 1.23-mm^2 platinum electrodes separated from each other by 1 cm, each embedded in gas-exchange-membrane-sealed, poly(dimethylsiloxane) (PDMS) microfluidic channels. The electrode array consists of 0.1-µm thin platinum films deposited on quartz, and the rest of the components are constructed of PDMS. The microfluidic channels physically confine the liquid electrolyte while simultaneously serving as a thin, gas-permeable membrane that allows reactants to reach the electrodes for efficient operation of the fuel cell.

KEY TERMS: biotech, environmental, materials/nanotech, pharmaceutical, sample prep, separation science, spectroscopy, synthesis



Schematic and photo of a microfluidic fuel cell. (Adapted with permission from *Langmuir* 2004, *20* (17), 6974–6976.)

Oxygen is reduced at the platinum cathode and hydrogen at the anode. Current is sustained by reactant gas permeation through the PDMS membrane. Selective feed of gases toward the appropriate electrode permits current densities of around 1 mA/cm^2. Inefficiencies were due to the loss of ~30% of each gas over the course of 5–10 min to the inappropriate electrode because of the freely permeable nature of the device. Lowering the gas partial pressure decreased this loss, but it also resulted in less power output because of less gas reaching its appropriate electrode as well. With the lack of an integrated anode–cathode separator, the device is designed to eventually depolarize because of crossover. When operated continuously at maximum power for 3 h, the cell lost almost 75% of its output within the first 1.5 h; then the observed current stabilized. The authors plan to investigate the effects of a number of modifications, including electrode separation, to improve this first-generation device.

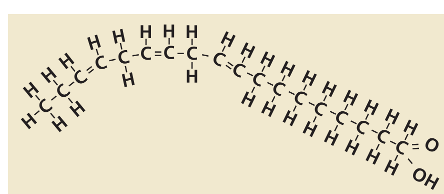
Mark S. Lesney

Oxidation and Omega-3

Scientists learned some time ago that there are significant health benefits from consuming omega-3 fatty acids, which are found mostly in fish oils, algal oils, and linseed oil. These fatty acids improve many systems, from the cardiovascular system to the brain. The problem with the fatty acids found in these oils is their uninviting flavor. All are highly susceptible to oxidation, which tends to deteriorate flavor. Adding the oils to food would be beneficial to health, but not if the flavor suffers and consumers choose unfortified foods.

At the Institute of Food Technologists Annual Meeting and Food Expo held this year in Las Vegas, scientists suggested that the problem in omega-3 fortification is that compounds already in the food that serve as efficient antioxidants can actually increase oxidation of omega-3 oils in complex food systems. Researchers at the Danish Institute for Fisheries Research found, in a case study of omega-3 fatty acids in mayonnaise, that the dressing's low pH and high iron content are main factors that cause lipid oxidation, which negatively affects flavor. The researchers suggested that flavor would change less with lower iron levels, which may decrease lipid oxidation.

According to Brian Langdon of Omega Protein, preserving the flavor and shelf life of omega-3-fortified foods can be a matter of careful handling of products and thoughtful placement of oils in the ingredient stream. Langdon says that adding omega-3's as close to the end of the ingredient stream as possible is helpful, with the best time being before the final mixing of the product.



α-Linolenic acid is one of several important omega-3 fatty acids.

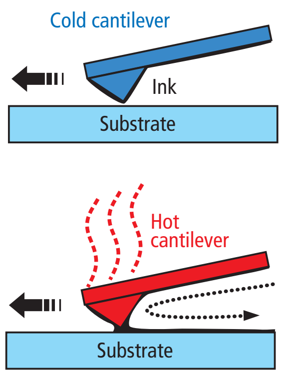
According to the panelists at the Annual Meeting and Food Expo, products emerging as the best candidates for omega-3 fortification include frozen food entrées, soups, refrigerated foods, salad dressings, yogurts, spreads, juices, egg products, and cheeses, which are especially helpful in providing omega-3's because these products are used by a wide variety of people, from children to older people.

Felicia M. Willis

Better Nano Pens

Dip-pen nanolithography (DPN) is a technique that has been developed to directly write nanometer-scale patterns on surfaces. DPN is based on atomic force microscopy (AFM), as AFM probes are coated with a liquid and then dipped onto a surface.

However, there are problems with using liquid ink. It is difficult to turn the ink flow on and off, and existing AFM "pen" probes apply ink as long as they remain in contact with the surface. Therefore, the same AFM probe with liquid ink cannot be used to sense or image the surface, because every time it would touch the surface, it would deposit ink. In addition, liquid inks can't be used in a vacuum because they would quickly evaporate.



Heated cantilever melts ink. Source: U.S. Naval Research Laboratory

Researchers at Georgia Tech and the Naval Research Laboratory have developed a DPN technique that is not dependent on liquid inks. The method, called thermal DPN, uses a solid ink that is easily melted, along with an AFM probe with a built-in heater. The first ink used was octadecylphosphonic acid, which melts at 100 °C. The ink can then be heated so that it flows onto the surface to "write" nanoscale patterns, but when the heat is turned off the ink returns to a solid and is no longer deposited, even when the tip touches the surface.

Using thermal DPN, researchers can now examine more about nanoscale phenomena and applications of DPN. Heating the solid ink is interesting in itself, as conventional heat transport does not transfer well from the macroscopic world to the nanoworld. The technology may cast new light on heat transfer at the nanoscale.

Because DPN can create extremely narrow lines, it may be useful as a next-generation technology for making computer microprocessors. The current thermal DPN process has produced lines about 95 nm wide. Although current computer processors are being made with structures as small as 65 nm using photolithography, the researchers believe that the DPN can draw lines as small as 10 nm wide. In addition, solid inks can be applied under vacuum. The researchers also suggest that combining thermal DPN pens into arrays could enable the fabrication of computer chips.

Michael J. Felton ◆

Science Bits

New DNA Walker. No, DNA has not gotten old and in need of help. Researchers at the California Institute of Technology have demonstrated a bipedal DNA nanowalker. Walkers have been developed before, but they shuffled along, keeping their feet in the same place with respect to one another. The new DNA motor attaches its front leg to the DNA strand, and then the back leg moves in beyond the front leg, much as if you were walking down a balance beam. The researchers suggest the walker could be used to carry molecules from one place to another. (*J. Am. Chem. Soc.* **2004**, *126,* 10834–10835)

Methane-Splitting Ocean Bugs. Researchers at the Monterey Bay Aquarium Research Institute and the Joint Genome Institute have discovered mud-dwelling microorganisms that live on methane that seeps from the ocean floor off the coast of California. Methane-splitting microorganisms have been found before, but they also contain most of the cellular processes that make methane as well. However, by sequencing the DNA found in the mud, the scientists found that these organisms appear to lack the genes for producing methane, relying instead on external sources of methane to live. (*Science* **2004**, *305,* 1457)

Molecular Transport and Raman. Molecules are transported in and out of cells through channels, and researchers at Cardiff University and the Université de Bordeaux are studying transport in a crystalline nanochannel to learn more. Previous studies showed that having guest molecules waiting, in essence pushed the guest molecule in the channel through. However, the spatial distribution could not be seen. The scientists used confocal Raman microspectrometry, and they found that crystals at the ends of the tunnels had a significant impact on the occurrence and rate of transport. (*J. Am. Chem. Soc.* **2004**, 10.1021/ja040117d)

Nanotube Spinsters. The fantastic physical properties of nanotubes are legendary. But if only nanotubes could be easier to work with. For instance, spinning many nanotubes into rope has been extremely difficult because the tubes tend to aggregate randomly. Researchers at Rice University, the University of Pennsylvania, and Carbon Consultations have formed well-ordered nanoropes by dissolving nanotubes in sulfuric acid. The superacid is stronger than pure sulfuric acid, and at certain concentrations it contains individual tubes and a "spaghetti phase," in which positively charged nanotubes with interspersed sulfuric acid anions form an aligned group of tubes. (*Science* **2004**, *305,* 1447)

Quantum Dot Laser. Researchers at Los Alamos National Laboratory have made the first colloidal quantum dots with particle-size tunable, mid-IR emission. These dots, made of PbSe, are much more efficient at producing mid-IR light than organic dyes and doped crystals that are currently used. And because the PbSe quantum dots are particle-size tunable, quantum dots can be designed to produce wavelengths by controlling the particle size. To demonstrate this, the researchers synthesized a range of particle sizes from 8 to 16 nm. The size range also shows an interesting twist—the larger particles are cubelike because of the influence of the crystal structure, while the smaller particles are spherical because the shape minimizes surface energy. This shows the changing dominance of the forces involved at this small scale. (*J. Am. Chem. Soc.* **2004**, 10.1021/ja047659f)