in an overall membrane thickness of about 50 μm. This creates a mesh structure with an average pore size of about 10 nm and an impressive internal surface area of 44 $m^2 g^{-1}$ (although this is still a factor of ten lower than the internal surface area of active carbon). The important properties of the membrane are its porosity, which causes liquid to be sucked into the membrane by capillary action, and its wettability, which dictates how the surface interacts with liquids.

The wetting of solids is, in the words of the Nobel prize-winning physicist Pierre-Gilles de Gennes, a complex interplay of physical chemistry, statistical physics and fluid dynamics[5]. Without going into detail, there are two types of wetting[6]. In homogeneous wetting, the introduction of surface roughness increases the available surface area and enhances the intrinsic wetting properties of a material: this means that materials with contact angles (Fig. 1) smaller than 90° become more hydrophilic, whereas those with contact angles above 90° become more hydrophobic. In heterogeneous or composite wetting, on the other hand, small pockets of air are trapped between the liquid and the surface. Air is a very hydrophobic medium and increases the overall hydrophobicity of the surface.

In recent years, many researchers have taken advantage of the controlled manipulation of surface topology to create rough, superhydrophobic surfaces[7,8] that cause water droplets to freely roll off them — like the self-cleaning properties of the lotus leaf. This is exactly what happens with the membrane designed by Stellacci and co-workers.

The surface of the nanowires is modified with a hydrophobic coating and, when combined with high surface roughness, this results in a superhydrophobic material with heterogeneous wetting. However, if a liquid that is less polar than water, such as oil, comes into contact with the surface, it will be drawn into the interstitial space, where it rapidly replaces the air. We now have a case of homogeneous wetting, and the initial oleophilic ('oil-loving') character of the material is further enhanced by the surface roughness. This material may be best described as superhydrophobic and oleophilic. In other words, a surface has been created that repels water while allowing oil to selectively spread.

This combination of wettability properties with strong capillary effects, which are due to the high internal surface area and architecture of the membrane, results in extraordinary selectivity and capacity for the separation of oil from water — the reported uptake capacities are as high as 20 times the initial weight of the nanomaterial. Not only can the membrane selectively collect oil over water — even from surfactant-stabilized emulsions — it can also separate similar organic solvents, such as the highly toxic benzene and its less-toxic close relative, toluene. The membrane boasts added advantages over other materials such as cotton or conventional paper, including its stability at high temperatures and the ease with which it can be recycled and reused.

Stellacci and co-workers have provided an example of a nanomaterial that has been rationally designed to address a major environmental challenge. Owing to potential economic and toxicological arguments about the use of manganese oxide, it is difficult to predict whether this specific membrane will find commercial use, but it clearly provides a blueprint that can guide the design of future nanomaterials for environmental applications. Many other examples are expected to follow and will confirm the potential of nanomaterials for protecting the environment.

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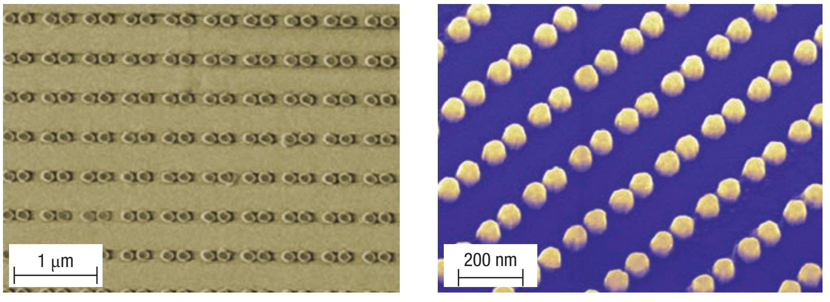
OPTICAL TWEEZERS

Gold standard

Laser-based optical tweezers are routinely used to trap and move nanoscale objects. An important goal in this field is to constrain the random Brownian motion of the trapped objects, which can be done by increasing the power of the laser beam, but this approach can damage biological samples. Researchers at Manchester University have now shown that it is possible to improve the performance of optical tweezers without increasing the laser power (*Nature Photonics* doi: 10.1038/nphoton.2008.78; 2008).



Sasha Grigorenko and co-workers used electron-beam lithography to arrange gold nanoparticles in pairs on a glass substrate, as can be seen in these two electron micrographs (the righthand micrograph is shown in false colour). When a laser is directed onto the surface it excites electronic resonances in the pairs, which leads to the production of strong electromagnetic fields. Grigorenko and co-workers used these fields to trap tiny polystyrene beads, which showed almost ten times less Brownian motion than similar beads in a conventional optical-tweezers set-up.

When the laser was moved sideways, the beads jumped to another discrete trapping site above a different pair of nanoparticles. The trapping properties can be tuned by varying the separation of the nanoparticles.

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