Light can be used to control the properties of surfactants

>> JULIAN EASTOE

Photo-tuneable films

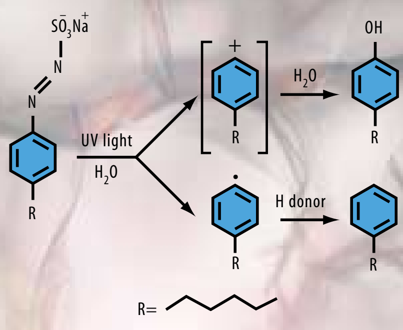

Figure 1
The structure of a surfactant which is broken up into its water and oil-loving segments by light

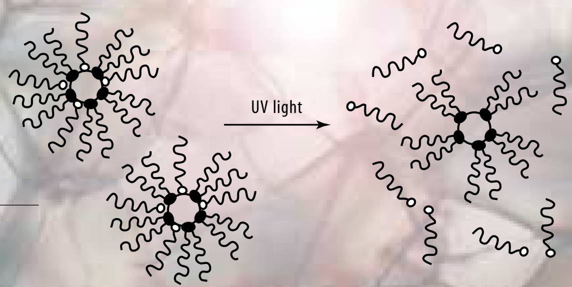

Figure 2
The concept behind photo-tuneable surfaces comprising a photo-destructible surfactant

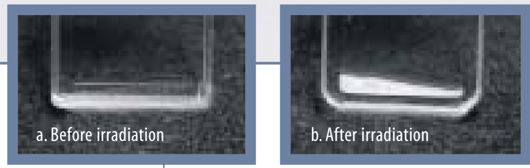

Figure 3
The effect of irradiation with UV light: initially the stable microemulsion sample is transparent (a) since dilute nanometre-sized aqueous droplets are present. After a burst of UV light (b), a milky emulsion containing micrometre-sized droplets begins to form, which eventually resolves into a clear upper microemulsion phase and a denser, opaque water-surfactant mixture seen at the bottom of the sample

Surfactants are molecules that adsorb at interfaces between two liquids which don't normally mix, or between a liquid and vapour. They usually consist of two parts – a water-loving ionic component and an oil-loving carbon chain – and so can modify the structure and behaviour of the interface, perhaps creating tiny surfactant-coated droplets of one liquid dispersed in another (emulsion) or gas bubbles in a liquid (foam). It is this property that is responsible for the cleaning power of detergents, and the ability of living cells to take in materials, or lungs to absorb gases. Synthetic surfactant systems are being considered as a means of delivering drugs or even genes into cells.

In domestic cleaning products, the surfactant performance is controlled by adding an electrolyte like salt, or by changing the pH or increasing the temperature. We have been looking at another approach – using light to modify the behaviour of photo-sensitive surfactants. For example, UV light breaks up the molecule above (figure 1) into its separate water and oil-loving segments, thus 'switching off' the surfactant properties.

If mixed with an inert co-surfactant to give a water-in-oil nanodroplet dispersion, or microemulsion, we can then alter the behaviour of the system using UV light, which selectively destroys the photosurfactant. This results in a dramatic drop in the stability of the microemulsion and also the size of the nanodroplets (figure 2), and some of the water separates out from the oily medium.

Julian Eastoe's team

Shrinking water droplets

We were able to follow the shrinkage of the water nanodroplets using SANS (p.5), which can pick out the detailed structure of the droplets using the well-established contrast technique (p.5). First, deuterated water was used so that the SANS experiments revealed the dimensions of the water cores. Then both water and oil were deuterated to pick out the hollow surfactant shell. Detailed analysis reveals a shrinkage of the water cores from 6.3 to 4 nanometres after UV irradiation, corresponding to a decrease in nanodroplet volume of about 75 per cent. Therefore, using light to destroy the photo-surfactant is equivalent to reducing the effective surfactant concentration, thereby controlling the stability and size of the dispersed water droplets.

Chemicals like the molecule in figure 1 represent a new generation of surfactants with additional chemical properties that can be tuned so as to control properties like surface tension, formation of droplets, stability of emulsions, and viscosity and gelation (p.13). These kinds of photosensitive systems could be used to transfer materials such as drugs, and pigments used in printing and paints. ■

 Research team J. Eastoe, M. Sanchez Dominguez and P. Wyatt *(University of Bristol, UK)*, and R. K. Heenan *(ISIS-CLRC, Rutherford Appleton Laboratory, UK)*