Emulsion with a round-trip ticket

June 14 2007

Oil and water are not miscible. However, it is possible to combine both into an emulsion in which they act as a unit—for example, in creams, body lotion, milk, or mayonnaise. In these substances, one of the two liquids is dispersed as tiny droplets in the other, which requires an emulsifier and vigorous shaking or stirring.

Whether the oil droplets are suspended in water (oil-in-water emulsion O/W) or the water droplets are suspended in oil (water-in-oil emulsion W/O) depends on various factors. In the journal *Angewandte Chemie*, a British team from the University of Hull now reports a double inversion of a nanoparticle-containing emulsion: By the successive addition of a surfactant, they were able to convert an O/W emulsion into a W/O emulsion and then back again.

The emulsifier's job is to make droplet formation easier and to counteract separation. In addition to surfactants (substances contained in detergents and the like), fine solid particles also have a stabilizing effect. Mustard powder has thus long been used to stabilize mayonnaise. Both surfactants and particles aggregate at the phase boundary of the two liquids and keep the droplets from flowing together. Many commercial formulations contain surfactants as well as solid particles.

If the conditions are changed, a phase inversion can occur, converting an O/W into a W/O emulsion, for example, if more and more surfactant is added. This is no great feat. However, Bernard P. Binks and Johnny A. Rodrigues have now achieved something astonishing: a double inversion. Their system initially contains silica nanoparticles and a small quantity of a surfactant with a water-loving (hydrophilic), positively charged head and two nonpolar, water-repellent (hydrophobic) tails. The tiny silica spheres are negatively charged, hydrophilic, and easily wettable by water. In this state, they stabilize oil drops in water (O/W).

If more surfactant is added, a layer of surfactant molecules surrounds each sphere, all with their hydrophobic tails sticking out. The spheres are now covered with a hydrophobic layer and are no longer wettable. They stop repelling each other and begin to aggregate. This causes the emulsion to undergo its first inversion into W/O. If further surfactant is then added, these additional molecules lodge tail-to-tail with those already surrounding the spheres. This forms a double layer around the spheres, with the positively charged heads of the second surfactant layer now sticking out. The spheres thus once again have a charged, hydrophilic surface and again stabilize oil droplets in water. The emulsion undergoes its second inversion back into O/W.

Source: John Wiley & Sons