MATERIALS SCIENCE

Colloids get complex

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Self-organization of soft-matter components can create complex and beautiful structures. But the intricate structures created by adding a second stage of organization could reveal more than just a pretty face.

The term 'soft matter' denotes materials that are easily deformed by external stresses, and encompasses liquid crystals, polymers, surfactants and colloids (particles dispersed within another medium). Their basic constituents have characteristic sizes of between several nanometres and several micrometres, and, crucially, have the potential to self-organize, forming beautiful, regular three-dimensional structures. A triplet of recent papers[1–3] presents the latest such structures: complex colloids formed through self-organization on scales up to a micrometre.

Alternative terms that have been used to describe these colloid structures — 'colloidal molecules', or 'patchy particles' — hardly do justice to their intricacy. What is considered a complex colloid is, admittedly, somewhat arbitrary: the colloidal 'ice-cream cones' (Fig. 1a) produced some years ago[4], which resulted from repeated polymerization and the subsequent phase separation of the polymers formed, would certainly have merited the term complex colloid. The innovation of recent efforts, however, is that structures are being designed with a second stage of self-organization in mind. Such an approach, in which colloidal particles are first formed at soft-matter scales, and then built up to far more intricate structures, should allow unprecedented control over the three-dimensional organization of materials, as well as the combination of different materials over several length scales.

The results of Cho *et al.*[1], published in the *Journal of the American Chemical Society*, exemplify the fruits of this technique. The authors created complex colloidal structures (Fig. 1b, c) by drying emulsion droplets containing 'bidisperse' charged colloids, consisting of components of two quite different sizes — one on the nanometre and one on the micrometre scale. Using the same or opposite charges on the two components, an amazing richness of structural motifs could be obtained. Equally impressive results have been published by Lin *et al.*[2] (Fig. 1d) in *Chemistry of Materials* and by Zoldesi and Imhof[3] (Fig. 1e) in *Advanced Materials*. Their structures were fabricated by depositing silica on liquid crystals formed by surfactants[2], and through the regular deformation by osmotic stresses of thin siloxane shells grown around emulsion droplets that are monodisperse (all the same shape and size)[3].

It is important to mention at this point that

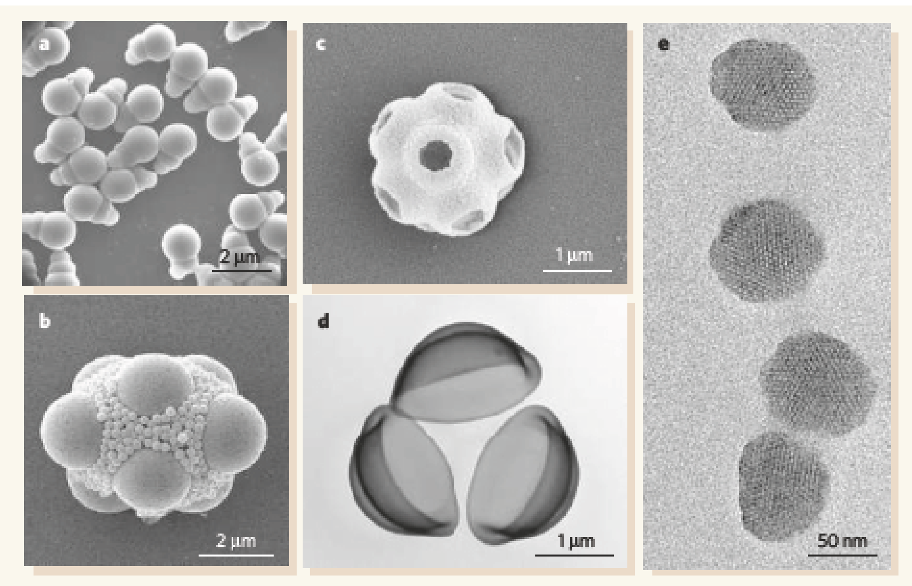
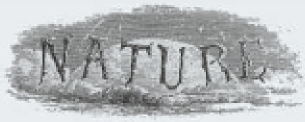


Figure 1 | A selection of complex colloids achieved by various means of self-organization. **a**, 'Ice-cream cones' resulting from repeated polymerization and phase separation between polymers of different composition[4]. **b, c**, Through controlled drying of a binary dispersion in water-in-oil emulsion droplets[1]; **b**, both colloids same charge; **c**, colloids with opposite charge. **d**, Through silica deposition on liquid crystal phases formed by surfactants[2]. **e**, Through osmotic stress deformation of thin hybrid siloxane shells after growing them on monodisperse oil droplets[3]. (Courtesy of: **a**, John Wiley, Inc.; **b, c**, American Chemical Society; **d**, C. M. van Kats, D. C. 't Hart and J. D. Meeldijk; **e**, C. I. Zoldesi and A. Imhof. All scale bars are approximate.)



50 & 100 YEARS AGO

50 YEARS AGO

"The training of university teachers" — The question of the advisability and possibility of providing new recruits to university teaching with some initial guidance in the technique of their calling has been examined by S. Radcliffe, lecturer in German at the University of Bristol… In general, lecturers are conscientious about the matter of their lectures, but give little thought to their form or their delivery… [Radcliffe] suggests that an artist requires some basic instruction, at least in the rudiments of his craft. The following are a few of the purely mechanical skills which might be considered desirable in a good teacher or lecturer. First, the adoption of a fitting speed and clarity of diction. Secondly, the clear formulation and appropriate stressing of the main points of the subject under review. Thirdly, the ability to use a blackboard successfully. Fourthly, the 'staging' of material to make it come 'alive'… Learning the students' names is an essential requirement in establishing closer contact with them…The prompt return of written work not only helps to keep up students' interest in their subject, but also gives the right to demand written work from the students within the time-limit specified.

From *Nature* 4 February 1956.

100 YEARS AGO

"The Revolution of the Corpuscle"

A corpuscle once did oscillate so
 quickly to and fro,
He always raised disturbances
 wherever he did go.
He struggled hard for freedom
 against a powerful foe —
An atom — who would not let
 him go.
The aether trembled at his
 agitations
In a manner so familiar that I only
 need to say,
In accordance with Clerk
 Maxwell's six equations
It tickled people's optics far away.
 You can feel the way it's done,
 You may trace them as they run
— dy by dy less $d\beta$ by dz is equal
$K.dX/dt$

From *Nature* 1 February 1906.