permit a quick resolution of the contentious question of the correct cosmic distance scale? Sadly, the answer is no. A major part of the difference between the so-called 'long' and 'short' distance scales (de Vaucouleurs, G. *Observatory* **102**, 178; 1982) stems from disagreements in the calibration of the intrinsic period-luminosity relationship for cepheids. The calibration depends on those few cepheids of known distance in our own Galaxy and is sensitive to the assumed membership of variables in loose star clusters and to the effects of interstellar and circumstellar obscuration. Madore and Freedman's techniques will shed no light on these fundamental questions of calibration. Yet they will extend our ability to derive precise relative distances for external galaxies in reasonable time periods and must be welcomed as a major contribution to the effective use of a new instrument. □

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Materials science

A spongy way to new ceramics

from Paul Calvert

INDUSTRIAL ceramics such as alumina, zirconia or titania are normally prepared from a 'green body' of compacted powder that is sintered at 1,500°C or more, slowly converting by solid-state diffusion to a dense solid. But the increasing use of ceramics in microelectronics and their potential as engine parts have imposed requirements of uniformity and strength that are difficult to meet with this process while using crude powders as starting materials, and companies are thinking seriously about making powders by processes similar to those sponges and diatoms use to produce skeletal silica.

IMAGE UNAVAILABLE FOR COPYRIGHT REASONS

Top surface of 0·5 μ spheres of compacted titania (E.A. Barringer, Massachusetts Institute of Technology).

For maximum strength the sintered body should have a very fine grain size and either no pores or, at least, no large pores. During sintering a 'rich get richer' law operates: the big pores in the compacted powder initially grow at the expense of the small ones, before shrinking slowly by vacancy diffusion; meanwhile the small grains are swallowed up by the large ones. Thus the final structure is normally 95–99 per cent material with a few large pores and a large average grain size (10 – 100 μm) — the opposite of what is wanted.

A philosophy argued strongly by H.K. Bowen of the Massachusetts Institute of Technology is that these problems could be avoided by starting from an 'ideal' green state. The aim is to produce submicron spherical particles of uniform size and then pack them into a regular lattice or into dense random packing so that all the grains and pores are the same size before sintering. This egalitarian state should sinter rapidly to a dense, fine-grained, strong ceramic. The success of this approach has recently been demonstrated for silica by Sacks and Tseng[1]. As an amorphous material silica is not such an interesting ceramic as alumina or zirconia, but the work goes a long way to vindicating the concept. This approach depends on the ability to produce uniform submicron spheres, which was described for silica by Stober and colleagues[2] and involves the slow hydrolysis of silicon tetraethoxide in alcoholic solution. Subsequently, this has been extended to hydrolysis of other metal alkoxides, including zirconium and titanium, but it has so far proved very difficult to produce single-size particles in the 0.1–1 μm range in quantities to make the process commercially attractive.

One joke in the ceramics field is that the only reason for working with spheres is that we are not clever enough to make cubes. It would appear that we might take some lessons from the sponges. Their skeletons are a particularly impressive example of the use of silica, which forms spicules of about one micron diameter in a huge variety of shapes including umbrellas, commas and double-ended anchors. They are formed intracellularly within a vesicle surrounded by a membrane, the silicalemma[3], and the shape is determined by deposition from dilute silicic acid on a protein filament of 0.2 μm diameter. Li and Volcani[4] have recently reviewed the deposition of silica in diatoms, which appear to employ a similar mechanism: deposition takes place within the silicalemma, and polymeric (possibly polysaccharide) filaments act as templates for the formation of columns that fuse to form solid plates; four forms of silica can be distinguished.

Although the ceramics industry has no immediate requirement for umbrella-shaped particles, they might well find a use for them if they were available. The possibility of forming particles using a membrane to control the reaction and polymeric templates are ideas worthy of consideration. First the companies must convince themselves that the perfection and control available through such techniques will compensate for the much greater cost of powders.

An intriguing marriage of the natural and synthetic approaches currently being developed commercially is the production of silicon carbide fibres from rice hulls that contain up to 30 per cent by weight of silica. Pyrolysis in the absence of air results in the conversion of the silica to SiC fibres of about 0.3 μm diameter and 50 μm length that seem to have great potential as a reinforcement for ceramics and metals[5]. □

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Scanning electron micrographs of fossil diatoms from upper Cretaceous deposits in western Siberia. The silicaceous exoskeletons of these unicellular algae consist of two valves and a variable number of girdle bands. The species illustrated are joined together in chains; *a* shows two valves, one from each of two adjacent cells. In *b* the interlocking spines and the fine perforations through the silica wall are seen in more detail. *c* is a detail of a closely related genus with partial occlusions of the pores. From Ross, R. and Sims, P.A. *Bull Br. Mus. nat. Hist. (Bot)* 13, 277 (1985) by courtesy of the Trustees of the British Museum (Natural History).