Small angle neutron scattering (SANS) and TEM studies of the internal porosity of three cultured diatom frustules.

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Background/Aim: Diatoms are microscopic algae that produce intricate silica cell walls, called frustules. These structures have well-defined pore classes that characterise the species of diatom. In this way a particular species is able to produce porous silica containing several highly monodisperse pore sizes. The ability to culture relatively large amounts of diatom frustules supports the investigation of pore size distribution in bulk samples with a small angle scattering technique. In this work, we compare SANS scattering curves for three species of diatoms with internal porosity visualised from frustule sections examined under TEM. We comment on the relative merits of each approach for determining the internal porosity of diatom frustules.

Methods: SANS were collected from three samples of known packing density using two instruments at the Hahn Meitner Institute (Berlin). The V12a instrument[1] is a bent crystal diffractometer which collects the slit smeared scattered intensity using cold neutrons (□=4.76Å). The V4 instrument[2] is a conventional pin-hole SANS instrument. The path length of sample was chosen to minimise the effects of multiple scattering. Using the two instruments, and numerically slit smearing the data from V4, data was collected over a wide q-range. TEM was performed on embedded and sectioned diatom frustules to the reveal the internal structure.

Results: Slit-smeared neutron scattering curves from frustules could be obtained over the q-range $10^{-4} < q < 10^{-1}$ Å^{-1}, where $q = 4\pi \sin 2\theta/\lambda$ (2 is the scattering angle and λ the neutron wavelength). When scaled for the packing density of frustules the scattering curves are similar. The curves diverge at a length scale equivalent to the pore visualised with EM techniques. The limiting high q behaviour of the scattering curves is equivalent to the Porod law for a smooth interface.

Summary: The small angle scattering of neutrons provides an insight into the average structure of diatom frustules over a range of range of length-scales. The smallest of these length scales is not accessible by TEM, and points to a basic unit of construction of the frustule. This is consistent with current knowledge on the biosynthesis of frustules[3]. This knowledge is placed in the context of synthesis of technological porous silica.

References:
[1] http://www.hmi.de/bensc/instrumentation/instrumente/v12/v12.html.
[2] http://www.hmi.de/bensc/instrumentation/instrumente/v4/v4.html
[3] Sumper, M., Science, 295, 2430-2433 (2002).