Lysozyme controls the character of biomimetic silica composites

DANIELA B. MEIER*[1], TOMASZ M. STAWSKI[1], CAROLINE L. PEACOCK[1] AND LIANE G. BENNING[12]

[1]School of Earth & Environment, University of Leeds, Leeds, LS2 9JT, UK (*correspondence: eedbm@leeds.ac.uk, t.m.stawski@leeds.ac.uk, c.l.peacock@leeds.ac.uk, l.g.benning@leeds.ac.uk)

[2]German Research Center for Geosciences, GFZ, 14473, Potsdam, Germany (benning@gfz-potsdam.de)

Silica-lysozyme composites are good analogues for biosilicification because both lysozyme and the proteins (silaffins) controlling for example silica precipitation in diatoms exhibit a high content of basic amino acids, e.g. lysine and arginine [1]. Such amino acids can induce silica polymerisation by interactions between their ammonium groups with the silanol groups resulting in the protein incorporation into the silica precipitate [3]. However, the role of the proteins on silica aggregation or their effect on the silica precipitates is still unknown. Here we describe data on the characteristics of silica-lysozyme composites as derived from electron microscopy combined with electron loss spectroscopy (EELS), infrared spectroscopy, surface charge and surface area measurements. Our results reveal that lysozyme was not incorporated into primary silica nanoparticles but that, due to electrostatic interactions between positively charged lysozyme and negatively charged silica particles, lysozyme acted as a flocculating agent. This induced faster aggregation of the silica particles but also lead to smaller silica nanoparticle diameters than in the pure silica system. During flocculation, lysozyme became incorporated into the bulk precipitate (up to 15 wt.%) but EELS data revealed that it was not distributed homogeneously throughout the composite but was present as larger clusters within the silica colloid matrix. The presence of lysozyme also strongly affected the surface properties of the composites as the surface areas were reduced by up to 90% compared to the pure silica system. Finally, the isoelectric point of the silica-lysozyme composites was also significantly higher ($pH_{IEP,silica} < 2$, $pH_{IEP,lysozyme} = 11$, $pH_{IEP,composites} = 5 - 8$). Our results improve the understanding of the aggregation behaviour of silica colloids in the presence of lysozyme, with implications on how silicifying organisms such as diatoms control the characteristics and morphology of silica precipitated inside their cells through interactions with specific organic molecules.

[1] Kröger et al. (1999), *Science* **286**, 1129-1132. [2] Coradin et al. (2003), *Coll & Surf B: Biointerfaces* **29**, 189-196.