SANS maps protein distribution in silica matrix for novel biotech applications

Researchers at ORNL, in collaboration with the Air Force Research Laboratory, have investigated the properties of a novel composite material with antimicrobial properties that is formed by lysozyme-templated precipitation of silica synthesized by sol-gel chemistry.

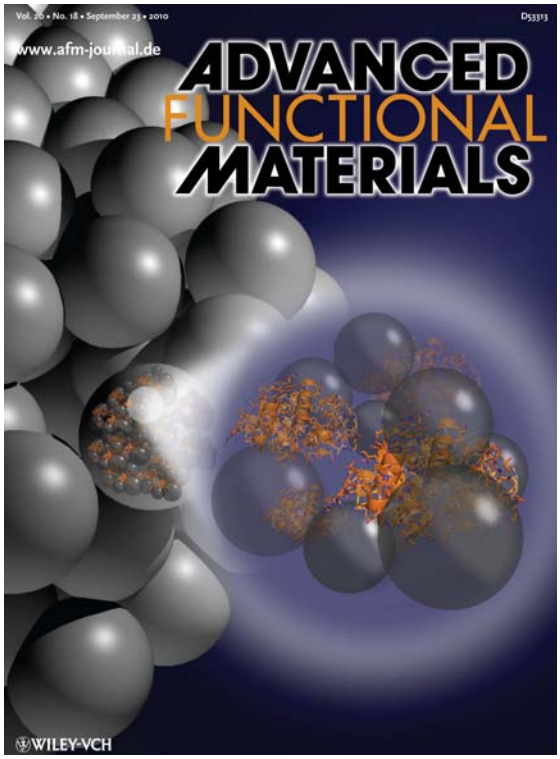
Biomineralization reactions, common in nature, have become a versatile tool for nanobiotechnology. Understanding how proteins interact with the silica matrix is key to optimizing this process for practical applications.

Small-angle neutron scattering (SANS) experiments, carried out at the High Flux Isotope Reactor in ORNL, were combined with electron microscopy analysis to understand the assembly and organization of the lysozyme–silica composite material formed via an in vitro biomineralization reaction.

Using SANS with contrast variation, the scattering signatures of the lysozyme and silica within the composite were separated. It was determined that the lysozyme molecules are spatially correlated in the material and form clusters with colloidal silica particles. The size of the clusters determined by SANS agrees well with the structural architecture observed by transmission electron microscopy. Furthermore, scanning electron microscopy showed that the clusters coalesce to form larger quasi-spherical structures (~450 nm), which aggregate to form the macroscopic composite material. A hierarchical structure for the composite is proposed, providing important insight into the structural organization of the biomimetic composite material synthesized through a sol-gel method.

In addition to demonstrating a well-organized sol-gel synthesis that generates a functional material with antimicrobial applications, the analysis and modeling approaches described herein can be used for characterizing a wide range of mesoporous and ultra-structural materials.

The paper was featured on the cover of the September 23 issue of *Advanced Functional Materials*.



The figure depicts nanoscale clusters of lysozyme and silica colloids that in turn agglomerate to form microparticles. The biosilica exhibits antimicrobial activity and can accommodate other proteins or nanomaterials to broaden its functionality.

"Protein localization in silica nanospheres derived via biomimetic mineralization," M. B. Cardoso, H. R. Luckarift, V. S. Urban, H. O'Neill, G. R. Johnson, *Advanced Functional Materials* **18**(20), 3031–3038, September 23, 2010. http://onlinelibrary.wiley.com/doi/10.1002/adfm.201000144/pdf

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