Bioinspired Nanoarchitecture

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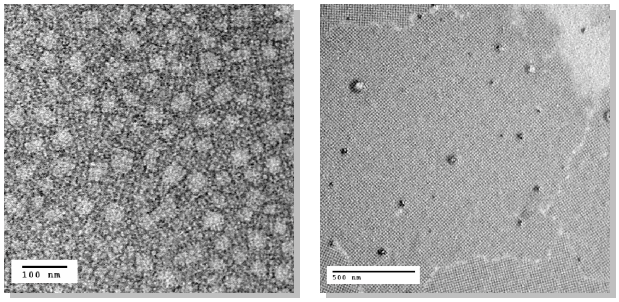

Figure 1. Influence of substrate type on unmodified SbpA S-layer protein reassembly. **(a)** Reassembly on hydrophobic carbon-coated formvar TEM surfaces results in small patches ~100 nm. Scale bar = 100 nm. **(b)** Reassembly on hydrophilic SiO_2-coated TEM surfaces results in micrometer-sized single-crystalline domains.

Self-assembling microbial surface-layer ("S-layer") proteins are being explored as biological materials in nanofabrication and templating.[1] S-layer protein arrays are 2-D biological nanostructures that represent a surface feature common to almost all archaeal microorganisms. The nano-sized features, long-range order, and stable binding of nanoparticle arrays biotemplated on S-layers makes them particularly interesting candidates for optical sensor applications such as Surface Plasmon Resonance (SPR) and Surface Enhanced Raman Spectroscopy (SERS), where ordered metal nanoparticles have been shown to lead to dramatically enhanced sensitivity. [2]. A variety of SbpA S-layer protein variants derived from *Bacillus sphaericus* are being investigated for the surface reassembly and ligand-binding properties of S-layers. whereas longer-range single-crystal lattices can typically be obtained on hydrophilic surfaces, S-layer reassembly on hydrophobic surfaces tends to result in only random-sized polycrystalline domains (**Figure 1**). S-layer protein lattices from *Deinococcus radiodurans* and *Sulfolobus acidocaldarius* were compared for their ability to biotemplate the formation of self-assembled, ordered arrays of inorganic nanoparticles.[4] The nanoparticles employed for these studies included citrate-capped gold nanoparticles and various species of CdSe/ZnS core/shell quantum dots (QDs). Transmission electron microscopy (TEM), Fourier transform analyses, and pair correlation function (PCF) calculations revealed that ordered nanostructured arrays with a range of spacings (~7-22 nm) and different geometrical arrangements could be fabricated through the use of the two types of

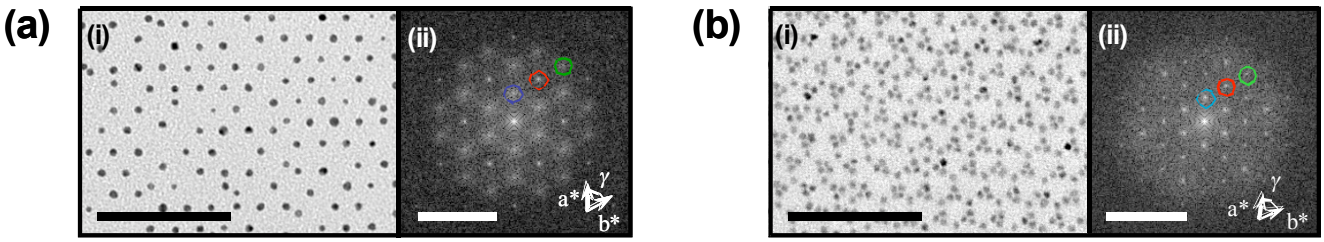

Figure 2. Brightfield TEM images (i) and corresponding 2-D FFT power spectra (ii) of unstained S-layers after incubation in a solution of water-soluble nanoparticles. **(a)** Gold nanoparticles biotemplated on HPI S-layer. **(b)** CdSe/ZnS core-shell quantum dots functionalized with 7-carboxy-1-heptanethiol biotemplated on SAS S-layer. The blue, red, and green circles mark, respectively, representative diffraction spots which can be indexed to the (10), (11), and (12) lattice lines found in a (hypothetical) 2-D hexagonal array structure.

S-layers (**Figure 2**).

As part of the NIRT K-12 education outreach effort, we are currently collaborating with high school teachers in the Ithaca district to develop an activity that enables students to do the same by examining various types of bacterial species having colony morphologies with interesting symmetry properties.

References (10 point font)

[1] For further information about this project please email Carl A. Batt at **<cab10@cornell.edu>**

[2] Sara, M.; Sleytr, U.B., *J. Bacteriol.*, 2000, 182, 859-868.

[3] Ilk, N.; Kosma, P.; Puchberger, M.; Egelseer, E.M.; Mayer, H.F.; Sleytr, U.B.; Sara, M., J. Bacteriol., 1999, 181, 7643-7646.

[4] Mark, S.S.; Bergkvist, M.; Yang, X.; Teixeira, L.M.; Bhatnagar, P.; Angert, E.R.; Batt, C.A. Bionanofabrication of metallic and semiconductor nanoparticle arrays using S-Layer protein lattices with different lateral spacings & geometries. *Submitted to Langmuir*.