"Chemical Tailoring of Biologically-Assembled Nanostructured 3-D Microassemblies: the Potential for Genetically Engineered Materials and Microdevices (GEMs)"

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The scalable syntheses of three-dimensional (3-D) nanostructured assemblies with wide ranges of selectable shapes, patterned nanoscale features, and functional chemistries remains a significant impediment in nanotechnology. However, remarkable examples of 3-D nano-to-microscale self-assembly can be found in nature. Among the most productive, longest surviving, and spectacular biomineral-generating organisms are the diatoms (microscopic unicellular algae). Diatoms generate silica-bearing cell walls (frustules) with complex 3-D shapes and intricate patterns of nanoscale features (e.g., pores, channels, protuberances). Each diatom species generates a frustule with a unique 3-D shape and patterned nanoscale features that are faithfully preserved upon repeated biological reproduction (e.g., 80 diatom reproduction cycles can yield 2^{80} or more than 1 trillion trillion replicas). Furthermore, a large variety of morphologies may be found among the 10^4-10^5 extant diatom species. However, the silica-based chemistry limits the range of applications for such nanostructured micro-assemblies. The patented BaSIC (Bioclastic and Shape-preserving Inorganic Conversion) process* has been developed to convert the silica-based chemistry of diatom frustules into numerous other compositions (e.g., MgO, TiO_2, ZrO_2, SnO_2, Mn-doped Zn_2SiO_4, Si, Ag, Au, Pd, polymer, etc.) while preserving the starting frustule morphology. Such a hybrid protocol (genetically-precise biological assembly + synthetic shape-preserving chemical alteration) provides a robust pathway to the scalable manufacturing of shape-selectable and chemically-tailorable 3-D nanostructures. The BaSIC process, coupled with future work on the genetic tailoring of diatom frustule morphologies, would then enable Genetically Engineered Materials and Microdevices (GEMs). The development of sealed, x-ray transparent chambers and HTXRD for evaluating BaSIC reaction processes will be discussed.

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