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Title: OPTICOLI: SELF-ASSEMBLED BACTERIAL MICROLENSES FOR OPTICAL APPLICATIONS

Abstract

Microlenses are a cutting-edge technology for imaging, detecting, and coupling light, but current fabrication methods require labor- and energy-intensive steps. The use of bacteria for the assembly of microlenses can combine high refractive indices, short focal lengths, and the aberration free nature of silica bioglass, while also being more tunable, patternable, and 10-100X smaller than conventional microlenses. Sea sponges create their internal silicate skeletons through expressing the enzyme silicatein, which can catalyze the polymerization of monomeric silica into polysilicate layers at physiological pH and temperature. We have engineered Escherichia coli to express silicatein fused to outer membrane protein OmpA at the surface of the bacteria, so that the silicatein enzyme can polymerize a layer of polysilicate surrounding the cell. Fluorescence confocal microscopy was used to image silicatein-expressing bacterial cells stained with Rhodamine123, which binds polysilicate. This imaging revealed a highly stained cell boundary with little internal staining, indicating that the E. coli are encapsulated with polysilicate. To measure the light-focusing behavior of the polysilicate-coated bacterial cells, we illuminated them with total internal fluorescence microscopy and detected the pattern of light that was scattered into a fluorescent agarose pad. The polysilicate-coated bacterial scattered light off their surface that illuminated a larger area with a brighter intensity compared to bacteria not expressing silicatein, indicating that the engineered bacteria can capture and focus light. Through the overexpression of BolA and SulA, E. coli are significantly rounder (aspect ratio shifting from 2 to 1) and longer respectively (over 40 μm). Applying this size and shape manipulation to the polysilicate-coated cells will enable the creation of novel-sized microlenses with tunable optical properties. Our bacterial microlenses have vast applications in the optical and biomedical industries, such as compact image sensors, 3D displays, concentrators for photovoltaics, solar cell technologies, and more.