Genetics Day Poster Submission

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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-based bioglass, while also being more tunable and patternable. The sea sponge enzyme silicatein 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 bacterial cell. Fluorescence confocal microscopy of silicatein-expressing bacterial cells stained with Rhodamine123, which binds polysilicate, revealed a highly stained cell boundary with little internal staining. This result indicates that the E. coli are encapsulated with polysilicate. Additionally, an anti-silicatein antibody confirms silicatein's localization to the cell membrane. 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 bioglass-coated bacteria scattered light off their surface that illuminated a larger area with a brighter intensity compared to wildtype bacteria, with a focus area 2-4 microns away from the encapsulated cells. This indicates that the engineered bacteria can capture and focus light. Additionally, Mie scattering modeling of multi-layered rods illustrates that a polysilicate layer enhances the focusing behaviors of the rod-shaped bacterial cells. Using CFU and alamarBlue assays, we have also shown that our encapsulated cells have 100,000X reduction in the number of dividing cells and that their metabolism is not compromised by the coating. Our self-assembled bacterial microlenses are 10-100X smaller than conventional microlenses, are produced without the need for expensive machinery or clean room techniques, do not require harsh or toxic chemicals for silica deposition, and are more environmentally friendly and sustainable. These 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.