Photosynthesis of cyanobacteria in an optofluidic platform

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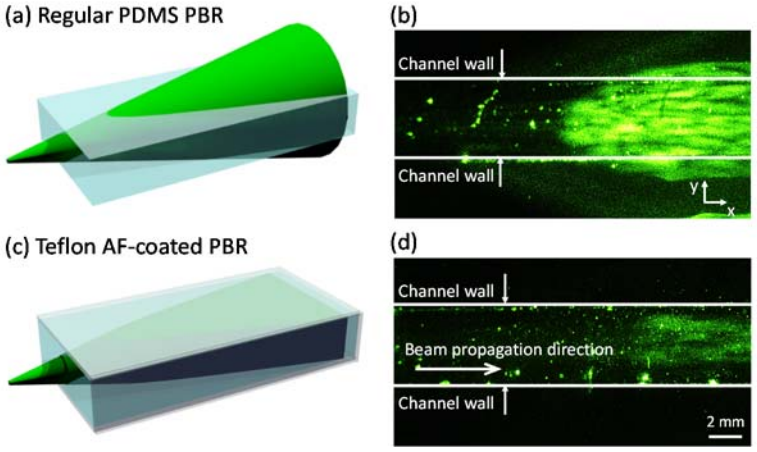
Abstract

We investigated the effect of increasing the optical penetration length, inside polydimethylsiloxane (PDMS)-based photobioreactors (PBRs), upon the photosynthetic cell growth of cyanobacteria. A thin layer of Teflon amorphous fluoropolymers (Teflon AF) was applied inside the PDMS-based PBRs to prevent the light loss at the solid-liquid interface. The Teflon AF layer, with a refractive index (n_{Teflon} = 1.31) lower than the PDMS (n_{PDMS} = 1.442) and higher than the culture medium (n_{medium} = 1.332), constructed the light waveguide in the PBRs via the total internal reflection. Such a combination of refractive indices led to the prevention of light loss at the interface. Schematic descriptions (a, c) and CCD images (b, d) of the light propagation in the regular PDMS-based PBR and Teflon AF-coated PBR are shown below.



In the regular PDMS-based PBR, the light propagated freely along the beam propagation direction, leading to the undesirable loss at the solid-liquid interface. However, in the Teflon AF-coated PBR, the light confined in the PBR chamber due to the waveguide. Synechococcus elongatus PCC 7942 (ATCC, USA) in BG-11 growth medium was used for all experiments. The cell growth rate and the optical cell density were measured periodically for 5 days under different light power and Teflon AF-coating conditions. The local or global auto-fluorescence signal and the optical density at 450 nm wavelength (OD450) were measured in parallel by a fluorescence microscope and a micro plate reader, respectively. The Teflon AF-based PBR improved the photosynthetic cell growth up to ~9% compared to the regular PDMS-based PBR.

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