The main objective of this research is to fabricate an artificial photosynthesis device that is capable of converting sunlight, CO2, and water into sugars for the production of biofuels. Solid freeform fabrication (SFF) enhanced by high-resolution heterogeneous printing technology was investigated to design and build this innovative device. This device contains multi-layer interconnected channels and micro-porous structures. This research enables manufacturing and deployment of large-scale solar conversion systems which not only mimic the nature process of photosynthesis for the production of biofuels, but also make these reactions independent of the life of nature plants.

By mimicking natural leaves, we will design and fabricate an innovative architecture with multi-layer interconnected channels and micro-porous structures to support artificial photosynthesis for sugar production. This device will be heterogeneously printed using a specifically designed SFF machine with multi-function nozzle array.

**Bacteriorhodopsin (BR) proton pumping measurement**

BR is a light-driven proton pump that creates a pH gradient across the cell membrane via a light-induced BR photocycle. This electrochemical proton gradient is used to drive the synthesis of ATP from ADP and Pi. The method mainly consists of incorporating BR into triblock polymers and taking a luminescence measurement. Photo-induced changes in intravesicular pH were measured using pyranine as a fluorescent pH probe. Photo-induced activity was measured after illumination using a 5.0 W light source (green LED). An excitation scan from 350 to 475 nm at an emission wavelength of 511 nm was performed using a Microplate Reader.

**Heterogeneous materials printing**

The technical processes of the 3Multi-AM are briefly described as follows. Before the printing we will design the 3D multi-layer leaf in CAD software. Then we’ll use our new developed heterogeneous materials printing algorithm to generate sliced G-code files to control and move the nozzle array.

**Materials study**

Chitosan hydrogel was produced by dissolving 1.5 wt% of chitosan with and without 5 wt% gelatin scaffold. This solution was mixed with ADP, P1, and deionized water. A 5.0 W green LED was used to illustrate the expected light reaction from vesicles. Photo-induced changes in intravesicular pH were measured using pyranine as a fluorescent pH probe. Photo-induced activity was measured after illumination using a 5.0 W light source (green LED). An excitation scan from 350 to 475 nm at an emission wavelength of 511 nm was performed using a Microplate Reader.

**Conclusions**

The light reaction layer will create a pH gradient which drives F2F2 ATP synthase to convert ADP to ATP. The Heterogeneous materials printing machine can fabricate porous interconnected structures via printing with or without light conversion vesicles. According to materials study, chitosan is appropriate for forming porous structure. The large scale leaf structure proves that the chitosan hydrogel can achieve 3D fabrication of porous structure with interconnected channels.

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