Abstract and Introduction

We designed an artificial photosynthesis device and fabricated the construction part of this device. This device can absorb light energy and produce organic compounds. In order to constrain reaction solution in a solid state structure and increase the reaction efficiency, we designed a novel artificial photosynthesis device with porous chitosan scaffold with interconnected micro-channels. We built 3D interconnected chitosan channels by a heterogeneous 3D rapid prototyping machine, and then, we used lyophilization method to generate pores inside the chitosan scaffold.

We found a proper material recipe to construct 3D scaffold by our own rapid prototyping machine. Optional support material sodium bicarbonate is used in printing 3D scaffold for holding the printed structure permanently, and the result shows that this method can make the scaffold stronger and harmless to further processes such as adding light reaction units and dark reaction solution into the device.

Design and Fabrication Method

Our own rapid prototyping machine can perform heterogeneous 3D building with extreme high viscous fluid materials. The chitosan structure with channels was printed by pre-loaded G-code. After building the whole micro channels structure, we generated micro-size porous structure for dark reaction by lyophilization.

In this system, it contains a 3D moving table with accurately controlled motors in X, Y, and Z directions. The printing head is pneumatic valve (Nordson EFD) with optional heating elements. The valve controller send signals to direct the pneumatic movement in the valve, and the air pressure supply for the valve is controlled by solenoid kit that translate the electric signals from controller and the computer into air pump for the valve.

Using the hydrophobic and hydrophilic properties of PETOz-PDMS-PETOz triblock polymer, we can put the triblock polymer in ethanol together with ATP synthase and light reaction pigment, which can be chlorophyll but not limited to chlorophyll.

Materials and Results

Attempts were made to identify the chlorophyll-L and chlorophyll-P by an electrophoretic method. Three bands were identified at 435 nm, 665 nm, and 680 nm. The chlorophyll-L and chlorophyll-P bands were identified by absorption at 665 nm and 680 nm, respectively.

In order to constrain reaction solution in a solid state structure and increase the reaction efficiency, we designed a novel artificial photosynthesis device with porous chitosan scaffold with interconnected micro-channels. We built 3D interconnected chitosan channels by a heterogeneous 3D rapid prototyping machine, and then, we used lyophilization method to generate pores inside the chitosan scaffold.

We found a better way to form a solid 3D structure for chitosan scaffold by using sodium bicarbonate NaHCO₃ to react with acetic acid. Also the extra NaHCO₃ will function as support material to support the upper layers without falling nor collapsing during the printing progress. The code used in this printing method is layer-by-layer printing code, which means the waiting time between layers is about 3min which is long enough to deposit NaHCO₃ powder.

Chitosan printing results of 7% (wt%) medium molecular weight chitosan; line space is 2mm; layer thickness is 0.3mm; and the needle tip inner diameter is 300 micron. (a) 5 layers chitosan scaffold without support material; (b) four layers of chitosan scaffold with support material.

Summary

The novel artificial photosynthesis device has constructing scaffold made by chitosan. The 3D printing method of rapid prototyping followed by lyophilization can generate porous chitosan scaffold with inter connected micro channels. With supporting material sodium bicarbonate, the whole structure can last for much longer time before lyophilization process. The introduced support material sodium bicarbonate is harmless to the fabrication of chitosan scaffold and harmless to the further processes of adding light reaction and dark reaction materials.

Acknowledgement

The authors want to thank Dr. Wayne Yuan, Dr. Ying Sun, and Brandon Lee for their help in this research. This work was supported by National Science Foundation CMMI-1141815.