JASMAC Conference of the Japan Society of Microgravity Application

OS5-2

閉鎖生態系生命維持システムにおける利用を目的としたバイオフィルムフォトバイオリアクタ

Novel biofilm photobioreactor for closed ecological life support system

○稲田敬[1], 青木慎一[1], 森山枝里子[2], 布施哲人[3], 星野孝仁[1]

○**Takashi INADA[1], Shinichi AOKI[1], Eriko MORIYAMA[2], and Tetsuhito FUSE[3], Takanori HOSHINO[1]**

1 株式会社ちとせ研究所，Chitose Laboratory Corp.

2 宇宙システム開発株式会社，Space Systems Development Corp.

3 国立研究開発法人宇宙航空研究開発機構，Japan Aerospace Exploration Agency

1. Introduction

As a tool to promote material cycles, and thus, to enhance the capability of life supporting mechanisms in space, applications of photosynthesis have been long investigated. Microalga is one of the most intensively studied organism among various photosynthetic organisms for such applications [1, 2].

Under the conventional laboratory environment, microalgae are grown in a medium solution under the light with the supplementation of CO_2 by simple bubbling. However, the same culturing technique is not able to be applied under the micro-gravity environment due to the following reasons;

- Bubbling does not cause effective mixing of solution, and
- Gaseous bubbles introduced into or generated within the solution do not uncouple efficiently from the solution.

Therefore, when the conventional culturing techniques are used under the micro-gravity environment, CO_2 needs to be provided through the gas-liquid interface by diffusion or through a CO_2 permeable membrane in the solution. O_2 generated by photosynthesis is in the same manner. Such methods, however, require additional complexities to the system, e.g., the use of high concentration CO_2, the establishment of a large gas diffusing surface area, and the application of a solution mixing system.

To avoid the technical difficulties previously mentioned and to achieve efficient growth of microalgae, a new culturing technique has been recently developed and studied [3, 4, 5]. This newly developed technique allows microalgal cells to attach and grow on a wet surface of a certain substance. Due to a higher ratio of the gas-liquid interface area to the liquid volume in this technique compared to the conventional ones, the supplementation of gas mixture containing a low concentration CO_2 by diffusion, in theory, is supposed to be sufficient to maintain efficient growth of microalgae. Further, this technique minimizes the use of water.

2. Objectives

The purposes of the current study are

(1) to develop a microalgal biofilm photobioreactor apparatus, with which (i) the used of water is minimized, (ii) the air regeneration is performed by using gas containing relatively low concentration of CO_2 (< 3000 ppm), and (iii) the effective research/experiment can be conducted under micro-gravity environment, for an intention of applying this technology to the closed ecological life support system in space station.

(2) to develop a non-destructive measurement technique for the growth of microalgae attached on the surface of a certain substance.

3. Preliminary Results

3.1 Development of Preliminary Biofilm Photobioreactor System

A preliminary biofilm photobioreactor system was developed as shown in **Fig. 1**. *Arthrospira platensis* (thereafter, Spirulina) cells were attached and grown on the surface of substances placed vertically next to the light sources. The cultivation apparatus shown in **Fig. 1** including light sources, solution circulation/supply system, and substances with Spirulina cells, was located in a transparent polymethyl methacrylate (thereafter, PMMA) container. The SOT medium [6] was continuously supplied from the top of each cultivation apparatus through the diffuser by peristaltic pump at a flow rate of 10 mL min^{-1}. The Spirulina cells grown on the surface of the substances were illuminated at 10,000 lx by white LEDs.

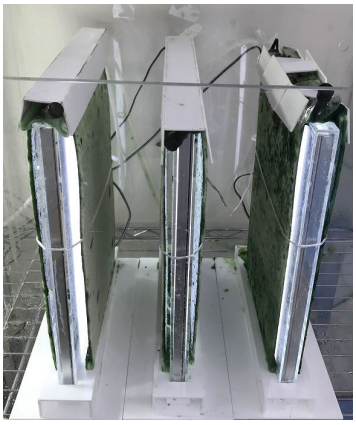

Fig. 1 Biofilm photobioreactor in this study.

3.2 Evaluation of cell growth on different substances

The growth of Spirulina grown on different materials were evaluated. The results showed the correlation between the growth and the water-holding capacity of the materials, i.e., the growth was greater on filter papers with higher water-holding capacity (**Fig. 2**). Based on the result, cellulose filter (1034-3A, ADVANTEC) which showed the highest water holding capacity, and thus, the highest growth of Spirulina, was used in the preliminary studies.

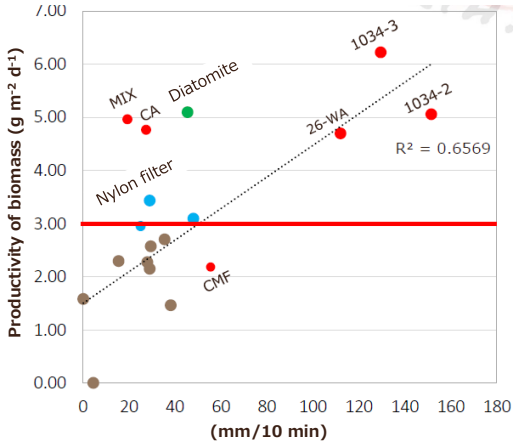

Fig. 2 Correlation between the growth of Spirulina and water-holding capacity of the materials.

3.3 Development of a non-destructive measurement of Spirulina growth in the Biofilm Photobioreactor System

Spirulina cells attached on 1034-3A were measured optically to correlate with the dry cell weight. **Fig. 3** shows the obtained relationship between the biomass and light absorbance.

This study was accomplished by a joint study with the JAXA Space Exploration Innovation Hub and was adopted as a feasibility study of the Japanese Experiment Module Kibo usage.

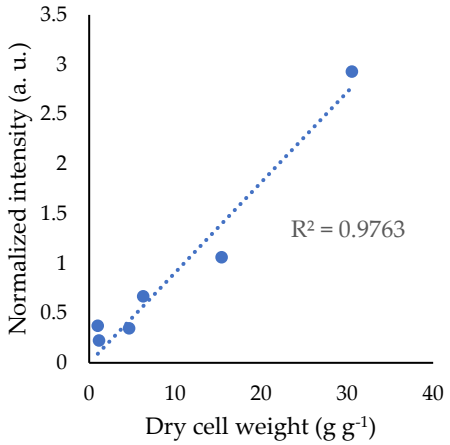

Fig. 3 Correlation between dry cell weight and optical measurement.

References

1) G. Detrell: 50th International Conference on Environmental Systems, July. 2021, 185.
2) E. D. Revellame, R. Aguda, A. Chistoserdov, D. L. Fortela, R. A. Hernandez and M. E. Zappi: Algal Res., **55**, 2021, 102258.
3) J. Wang, J. Liu and T. Liu: Biotechnol. Biofuels, **8**, 2015, 49.
4) L. K. P. Schultze, M-V. Simon, T. Li, D. Langenbach, B. Podola and M. Melkonian: Algal Res., **8**, 2015, 37.
5) X-Q, Xu, J-H, Wang, T-Y, Zhang, G-H, Dao, Guang-Xue Wu, H-Y, Hu: Algal Res., **27**, 2017, 198.
6) S. Aikawa, A. Joseph, R. Yamada, Y Izumi, T. Yamagishi, F. Matsuda, H. Kawai, J-S Chang, T. Hasunuma and A. Kondo: Energy Environ. Sci., **6**, 2013, 1844.