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CHLAMYDOMONAS-COMMUNITY BIOREACTOR

Abstract

Within the scope of ModuLES (Modular Life Support and Energy Systems), initiated and funded by the German Space Agency, DLR, a photobioreactor (PBR) with the unicellular microalgae Chlamydomonas reinhardtii was selected as the starting point of this research. The PBR and its subsystems were designed to understand the behavior and physiology of Chlamydomonas in a closed system - in regards to the production of oxygen under a given supply of carbon dioxide, nutrients and light energy.

On ground, Chlamydomonas is the most researched unicellular algae around the globe, but when considering cultivation in an exploration environment over a long duration of time, several areas show up, which have never been researched. In general, research on ground is conducted in an open system, but for spaceflight application, a closed system is a basic requirement. Thus, the importance to understand the general behavior and physiology is a prerequisite for successful operation of a PBR in space.

Additionally, it is important to allow a community of algae, bacteria and fungi to develop and coexist within the closed system of the PBR, because in future steps of ModuLES, the PBR will be connected to other modules to slowly build up a life support system. Latest when connecting the PBR to a second module it will not be operating under sterile. Thus, the ModuLES-PBR will be filled with a sterile algae solution, but under non-sterile conditions, allowing contamination to occur, already during the last steps before closure of the reactor.

The design is based on a constant algae concentration, allowing the investigation of environmental impacts on the microalgae-community, with a set of sensory devices and a sampling unit supporting the physiological research. With these results the next step to a turbidostatic performance can be completed.

As an interface to other subsystems an oxygen removal and carbon dioxide supply over a liquid to gas exchange system is implemented. To achieve the recycling of media, a filtration, analysis, and resupply unit is designed to minimize the needed resupply mass for spaceflight applications.

To understand the required flexibility of an MRU to sustain a community-PBR, upper and lower limits of specific media components were tested and the recovery of the community documented in tests. Based on this data and the design adjustments to the media recycling system, the obtained performance data can be used to design the next ModuLES module which will couple to the PBR.