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FUEL CELLS FOR OXYGEN CONTROL INSIDE AN ALGAL PHOTOBIOREACTOR SYSTEM FOR FUTURE HYBRID LIFE SUPPORT SYSTEMS

Abstract

Future human space exploration missions require reliable and self-sustaining space systems. Advanced life support systems (LSS) will be key elements of those systems. Since physico-chemical LSS cannot produce food, biological processes are needed. A logical intermediate step is the development of hybrid LSS, combining both physico-chemical and biological processes. The cultivation of edible microalgae in a photobioreactor (PBR) is a feasible approach. At the Institute of Space Systems of the University of Stuttgart a PBR system for in-situ oxygen (O_2) and biomass production in space is currently being developed. Its key features are a lighted cultivation chamber, automated sensor measurements as well as periodic nutrient supply and biomass harvesting. O_2 is both a useful by-product (from a LSS perspective) and a putative toxic substance to the algae, if not extracted from their closed habitat. Consequently, a PBR requires the separation of O_2 from the water-based medium wherein the microalgae are cultivated. Phase separation can be achieved by a μg capable vortex separator, which was already tested during parabolic flights. A PBR gas phase preferably comprises high carbon dioxide (CO_2) and low O_2 concentration, which makes it incompatible with the cabin atmosphere. The challenge is therefore to realize either a concentrated O_2 extraction from the PBR system or an O_2 reduction inherent to the system. A reasonable O_2 reduction should be based on oxidation reactions (e.g. a fuel cell reaction), which release useful products like CO_2 or H_2O.

This paper highlights the development and testing of a breadboard including an algae driven PBR with a closed gas phase, which is looped trough a polymer-electrolyte fuel cell (PEFC). The fuel cell operation conditions have to comply with PBR system conditions, being ambient temperature and pressure as well as low O_2 concentrations. The primary objective is therefore to investigate the PEFC performance under these suboptimal conditions. Of course, also the algae are examined and their performance is compared to the experiments without a PEFC in the loop. After a brief description of the breadboard setup, this paper focuses on the presentation of experimental data. The results are evaluated from a PBR system perspective. Finally, a system development strategy is derived including upscaling of the system.