Life support Challenges for Human Space Exploration (10)
Life Support Technologies and Systems (1)

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LIFE SUPPORT SYSTEMS UTILIZING PHOTOBIOREACTORS AND FUEL CELLS TO ENHANCE MASS AND POWER EFFICIENCY FOR LONG DURATION EXPLORATION MISSIONS

Abstract

Human deep space exploration demands advanced life support systems. A key issue is the regeneration of essential resources as oxygen, water and food in order to minimize resupplies and overall system mass. In-situ food production involving biological technologies poses a special challenge. A feasible way to produce food geo-space exploration vehicles is the cultivation of microalgae in photobioreactors (PBR). Microalgae grow about ten times faster than higher plants and require significantly less volume. They perform photosynthesis and thereby use carbon dioxide to generate oxygen as well as edible biomass. Besides crew, other components process oxygen as well, e.g fuel cells, if part of the electrical power supply system. Therefore, advanced life support systems benefit from a synergistically joint infrastructure by enhancing reliability and reducing system mass. The pursued approach of an integrated hybrid life support system utilizes proton exchange membrane fuel cells (PEMFC) and microgravity suitable PBR. Hereby, the PEMFC is operated with exhausted cabin air. Conducted experimental research concerns crucial issues of individual components and joint infrastructure. Of special interest are contaminants found in component output streams. Organic and inorganic compounds are present in PBR emitted gas. Their influence on PEMFC degradation is discussed and efficient measures to prevent their distribution throughout the joint infrastructure are described. Another important issue is the two-phase fluid flow in the PBR. Based on experiments conducted during parabolic flights, a hydrodynamic-driven PBR suitable for microgravity environment is presented. The design allows for optimum supply of light, nutrients as well as carbon dioxide and ensures removal of oxygen. Resulting from experimental research, a synergetic hybrid system concept meeting the demands of space exploration evolved. The introduced concept demonstrates the assets of PBR and PEMFC to a life support system. Its potential to partially reinstate carbon into food and to relieve the power supply system is specified. Terms of technical realization of the system concept are pointed out. The inclusion of photobioreactors into a physicochemical life support system is very promising, provided the interaction with fuel cells is fully understood and can be controlled over long time.