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OXYGEN HARVESTING FROM EUKARYOTIC GREEN ALGAE CULTIVATION ON MOON'S SURFACE

Abstract

Oxygen availability represents a key resource for humans survival on other planets. Nowadays vital resources on board the ISS, the only manned outpost in space, are constantly resupplied from Earth in open-loop. Whenever deep-space manned exploration is considered, a different strategy mostly relying on a closed-loop resources management scheme must be adopted to ensure the mission independence from Earth. Leveraging on the knowledge acquired by the MELiSSA ESA Project, the paper proposes to support incoming manned missions on the Moon's surface by recycling part of the emitted carbon dioxide and urine nitrites through a dedicated photobioreactor for closed-loop oxygen production.
Oxygen availability indeed opens to a variety of new scenarios for planetary colonization and exploration, being exploitable as propellant as well.
Mass-production of chlorophytes for biotechnological purposes is an established activity, and as in MELiSSA, selected chlorophytes species (e.g. *Dunaliella* and *Chlorella* genus) are here proposed to produce oxygen through photosynthesis and to recycle urine. A green algae photobioreactor has been already tested on the ISS.
If a daily requirement of 0.84 kg oxygen (26.251 moles of O_2) is assumed per person, the photobioreactor is requested ingesting 26.251 moles of CO_2. An 80L photobioreactor is estimated to satisfy the single person daily need.
The photobioreactor is self-standing as consumables to properly work can be almost recovered from the plant manipulation and the in-situ crew resources. More specifically, by drying the biomass, the Water depleted during the photosynthesis ($6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$), can be reintroduced in the photobioreactor with a 95% estimated efficiency, leading to an almost closed-loop plant; the nitrogen to fix to make the cultivation growing, can be supplied by introducing urea into the photobioreactor in a controlled fed-batch process that might be exploited to tune the cultivation growing rate and thus the rate of oxygen production.

The paper discusses the sizing of a scaled bioreactor proposed to fly on-board the incoming landing missions to the Moon as technological demonstrator in relevant environment to step further in assessing its potentials for oxygen production and nitrites removal.
The flexibility of the proposed solution is also presented with potential applications in the Martian environment as well, leveraging the presence of carbon-dioxide-rich atmosphere, leading to strong technological simplifications of the plants, and an increased capability in the recycling of vital molecules constituents.
Importantly, the proposed photobioreactor module could be coupled to a microinvertebrate-based bioreactor engineered to produce animal proteins to be used as food.