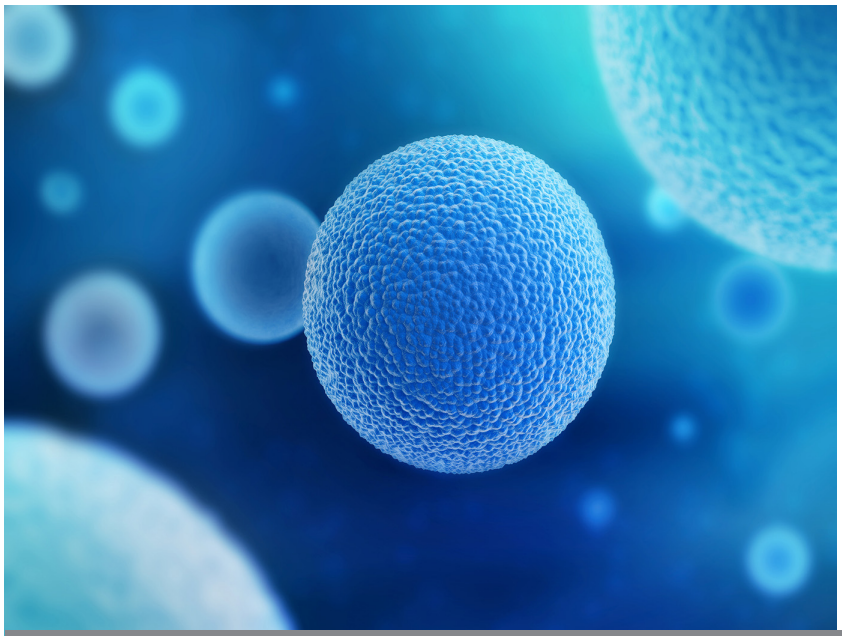


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Health, Medicine and Biotechnology

Surface Attached BioReactor (SABR) for Microbial Cell Cultivation

Capillary driven micro-organism cultivation platform for human life support

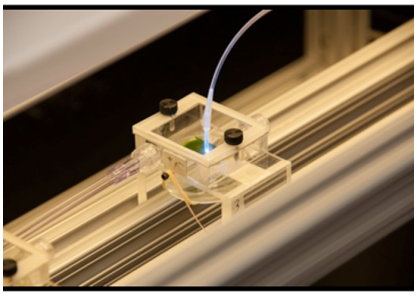
The high water-to-biomass ratio characteristic of conventional algae cultivation systems requires large energy inputs for pumping and mixing the culture during cultivation, as well as for dewatering and harvesting the resultant biomass. In light of this challenge, the Surface-Adhering BioReactor (SABR) cultivates micro-organisms as densely packed biofilms rather than in suspension, leading to an approximately 100-fold reduction in the water-to-biomass ratio of the system. Moreover, the mechanism of nutrient delivery to the cells is completely passive, eliminating the need for a pump. This mechanism is also independent of gravitational and inertial forces, making it an ideal candidate for human life support in space. The SABR is ideally suited for cultivating shear-sensitive cells, which can be product-secreting candidates due to their potential lack of cell walls. It reduces the number of steps in the cascade of cultivation, harvesting, dewatering, and extraction, favorably impacting the energetic and economic sustainability.

BENEFITS

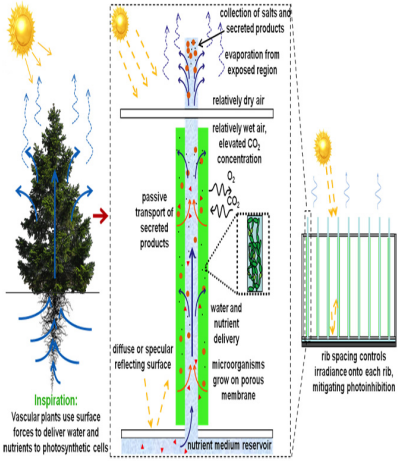
- Reduction in energy input for cultivating microorganisms
- Up to 25 fold reduction in water volume for photosynthetic growth
- Passive means of secreted product harvesting
- Controlled light delivery for optimal per-footprint performance
- Greatly enhances CO2 gas transfer
- Independent of gravitational and inertial forces
- Eliminates dewatering costs

THE TECHNOLOGY

The Surface-Adhering BioReactor (SABR) is a novel microbial cell cultivation platform that mimics the way vascular plants use transpiration to deliver nutrients to their cells. In this biomimetic platform, microbial cells are cultivated as immobilized cells on a porous substrate where transpiration is used to passively deliver water and nutrients as well as harvest and concentrate secreted biomolecules by the microbial cells. The SABR transports nutrients to microorganisms without using a pump. Instead, evaporation and the cohesive property of water are exploited to pull the nutrient medium through the device, with a high degree of control, on an as needed basis. It eliminates the hydrodynamic shear stress on the cells and decreases the working volume of water needed for cultivation by a factor of 25 compared to planktonic bioreactors. Furthermore, the transpiration mechanism allows for the concentration of secreted products in areas of relatively fast evaporation, thus providing a passive means of secreted product harvesting. By matching the time scales of nutrient medium delivery and product harvesting with the time scales of growth and product formation, minimal energy is wasted in bioreactor operation. Transpiration enables a passive cooling system for the cells where either externally imposed or internally generated heat due to cellular activity is mitigated, thus preventing overheating that can lead to decreased productivity or even cell death. This technology enables significant reductions in energy input for cultivating microorganisms.



A single rib SABR prototype being cultivated in a custom test chamber for environmental control and performance monitoring. The photosynthetic yield is being measured with a PAM fluorometer.



Surface-Adhering BioReactor (SABR) principle of operation

APPLICATIONS

The technology has several potential applications:

- Cultivate lipid-producing microorganisms for biofuel feedstock
- Harvest bioactive molecules
- High value food supplements
- Cultivate shear-sensitive cells
- Biological life support for humans in space
- Fermentation
- CO2 scrubbing

PUBLICATIONS

Patent No: 10,072,239

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NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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