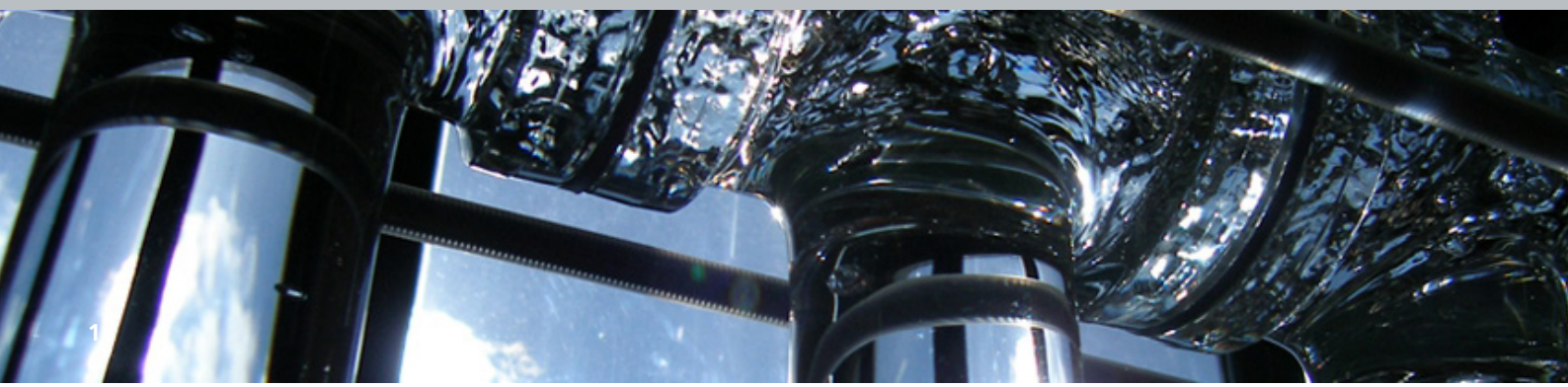
Fraunhofer
IZI

FRAUNHOFER INSTITUTE FOR CELL THERAPY AND IMMUNOLOGY IZI



1 *multiLoop photobioreactor filled with medium for thermal sterilization.*

PHOTOBIOREACTORS FOR HIGH QUALITY PRODUCTS FROM MICROALGAE

Fraunhofer Institute for Cell Therapy and Immunology IZI, Bioanalytics and Bioprocesses Branch of Institute

Am Mühlenberg 13
14476 Potsdam-Golm
Germany

Contact

Dipl.-Ing. (FH) Felix Jorde
Phone +49 331 58187-323
felix.jorde@izi-bb.fraunhofer.de

Dr. Thomas Leya
Phone +49 331 58187-304
thomas.leya@izi-bb.fraunhofer.de

www.izi.fraunhofer.de
cccryo.fraunhofer.de

multiLoop photobioreactors

Motivation

Phototrophic organisms like microalgae or cyanobacteria are a resource for novel bioactive metabolites of cosmetical, or pharmaceutical interest. To yield high quality products adjustable photobioreactor systems are needed to cultivate those microorganisms under sterile and controlled conditions. Currently available systems mostly are not sterilizeable or not suitable for sensitive algal strains.

Solution

The multiLoop system developed at the Fraunhofer IZI-BB prevents typical problems of algal cultivation like fouling and cell sedimentation with an optimized design and an effective airlift system that prevents cell damaging shear stress. Mechanical pump or stirrer devices are unnecessary. Sterilization is performed in situ by heat or chemicals. Due to the design, the illumination intensity and source, LED or fluorescence tubes, can be adapted to organism and growth phase.

Technical data

The system consists of borosilicate glass components, manufactured in Mainz (Germany) by DeDietrich Process Systems in accordance with GMP guidelines and the directive 97/23/EG. Every photobioreactor holds a CE-certification for pressure vessels.

Advantages

The multiLoop photobioreactor system makes the biotechnological utilization of a broad range of phototrophic microorganisms possible.

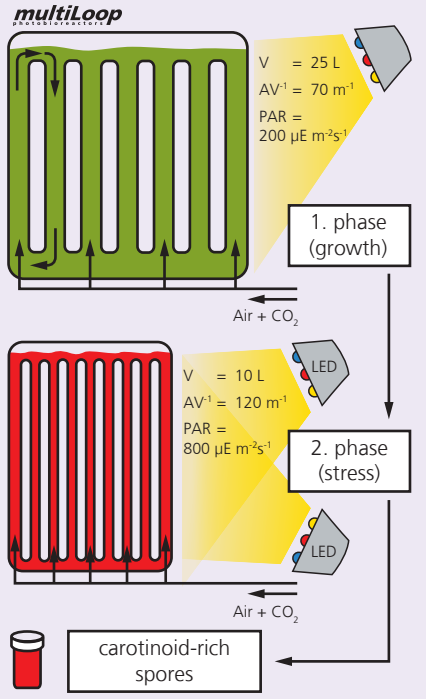
1

2

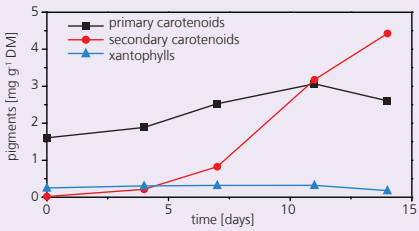
Background

Snow algae are cryophilic microalgae growing on snow fields and glaciers. Adaptation strategies of snow algae to temporarily extreme environmental conditions often include the formation of cysts that do not show any growth but are extremely resistant due to a changed cell structure and special metabolites. Predominant stress factors on glaciers are frost, desiccation, absence of nutrients and permanent UV-irradiation from the sun. Cysts face those conditions by adapting their metabolism and increase the production of secondary carotenoids (e. g. astaxanthin), which are not involved in photosynthesis but protect the cells from free oxygen radicals due to their antioxidant effects. This becomes evident by a color change from green to red. Furthermore, they produce vitamins (e. g. vitamin E) or ice structuring proteins (ISP). Improved growth conditions induce the return to vegetative cells.

Diagramm of cyst production in two phases (A = surface, V = volume, PAR = photosynthetically active radiation)



Progress of the secondary carotenoid accumulation in cysts



Application

Due to the high diversity and partly exceptionally high concentrations of novel ingredients the production of such cysts is of commercial interest. For mass production a two phase photobioreactor system favors growth and formation of cysts separately. Green cells grow in the first phase under optimal nutrient conditions until the absence of nitrate induces formation of cysts. For the second phase the culture can be transferred into the second phase reactor where in addition to the absence of nitrate the cells are exposed to high light conditions. They respond with the formation of cysts.

Growth data of microalgal strains in a 25 L multiLoop photobioreactor with LED illumination

algal strain	strain-number	max. productivity *2 g dry mass L^{-1} day^{-1}	max. concentration g dry mass L^{-1}
Acutodesmus obliquus *1	CCCryo 001b-99	0,28	2,8
Chlamydo-capsa sp.	CCCryo 101-99	0,39	4,6
Chlorella vulgaris	CCCryo 347-10	0,33	1,9

*1 synonym: *Scenedesmus obliquus* (Turpin) Kützing 1833
*2 productivities were measured during at least 3 days

Production line

A two phase production line can be realized by a system of two multiLoop reactors of differing design. The working volumes of the reactors used at the Fraunhofer IZI-BB are 25 L for the 1. phase and 10 L for the 2. phase. The size can be adapted by addition or removal of single vertical columns without changing the general growth conditions inside the reactor. To increase illumination columns of smaller diameter can be used. Transfer of cultures, re-filling of medium, just as well harvesting can be performed pneumatically. External temperature control as well as incorporation of sensors (e. g. for pH, O_2) is possible.

1 *multiLoop photobioreactor with a green vegetative microalgal culture.*
2 *multiLoop photobioreactor for production of carotenoid containing cysts of snow algae.*