Fraunhofer IZI-BB

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

PHOTOBIOREACTORS FOR HIGH QUALITY PRODUCTS FROM MICROALGAE

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 Photobioreactor (PBR) 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 can be easily 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 PBR photobioreactor system makes the biotechnological utilization of a broad range of phototrophic microorganisms possible.

Technical data of our Photobioreactor

Volume and Surface to Volume ratio (AV^{-1})	25 L PBR with 80 m^{-1} 10 L PBR with 120 m^{-1}
Illumination	Dimmable 100 W LED bars (up to 1,000 $\mu E\, m^{-2} s^{-1}$) or any other light source including natural sunlight
Sterilization	*in situ* with heat (121 °C) or chemicals
Aeration vvm	0.04 – 0.08 $L\,L^{-1}\,min^{-1}$ (air / CO_2 mix)
Culture flow rate	1.0 – 1.6 $km\,h^{-1}$ (airlift system)
Sensors	7 – 9 ports
Material	Borosilicate glass with PTFE gaskets CE-certification for pressure vessels

In some microalgae, the adaptation of metabolism to new nutrient conditions becomes visible through a color change.
(1) Under sufficient provision with nitrate, this microalgal strain appears green like most other microalgae due to a high chlorophyll content.
(2) Under nitrate depletion and light stress the same microalgae changes its appearance from green to red due to accumulated asthaxanthin.
In photobioreactors, the different growth conditions can be simulated to increase the yields of astaxanthin or other metaboliter.

Growth data of microalgal strains in a photobioreactor from Fraunhofer IZI-BB

algal strain	max. productivity* g dry mass L^{-1} day^{-1}	max. concentration g dry mass L^{-1}	Culture temp.
Chroococcus thermalis CCCryo 186b-04	0.13	8.1	40 °C
Chlamydocapsa sp. CCCryo 101-99	0.39	10	12 °C
Chlorella sp. CCCryo 297-06	0.15	5.2	2 °C

* productivities were measured at least during 3 days

Background

Microalgae are an alternative and natural resource for these essential fatty acids. They are the primary producers of EPA, DHA and many other polyunsaturated fatty acids, and they pass these on to crayfish, fish, and finally the human within the natural food web. Thus, they are an ideal alternative source to fish, also because microalgae can be grown on an industrial scale under controlled conditions and free from pollutants. 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.

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.

Production line

A two phase production line can be realized by a system of two PBR 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.

Kontakt

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

Fraunhofer IZI-BB
Am Mühlenberg 13
14476 Potsdam | Germany
www.izi-bb.fraunhofer.de

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

Fraunhofer IZI-BB
Am Mühlenberg 13
14476 Potsdam | Germany
www.cccryo.fraunhofer.de