Process Development for the Production of Microalgae Biomass Using a Novel Photobioreactor with Integrated Temperature Control and Biomimetic Design

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Algae Biomass Summit
September 29 – October 2, 2014
San Diego Marriott Marquis & Marina
- Introduction
- Christmas tree photobioreactor
- Microalgae platform
- Stable long-term cultivation
- Summary
Introduction

Challenges of photobioreactor systems for commercial use (outdoor)

Stable, resource-conserving production of microalgae biomass

- Effective incidence of light
- Temperature control
- Nutrient supply
- Control and regulation
- High operation times
- Scalability
Christmas tree photobioreactor (WO2011048108 A2)

- Characteristics

- Biomimetic design ("Christmas tree") → effective incidence of light
- Flexible, tubular double-wall hose system
  → Separation of algae suspension and temperature control medium
- Integrated temperature control in a closed cycle
- Pulsation
- Reaction medium = transport medium

Adaptable to different geographic areas
- high & low light intensities
- different temperature ranges

Photo: M. Salisch
Christmas tree photobioreactor (WO2011048108 A2)
- Biomimetic design

Effective incidence of light as result of “christmas tree” geometry
Christmas tree photobioreactor (WO2011048108 A2) - Further development geometries double-wall hose system

Design parameters
- Variation of diameters
  - Suspension segment
  - Temperature control segment
- Variation of wall thickness
- Effective heat removal
- Minimizing of dark phase in photoactive volume segment
- Compressive strength
Microalgae platform
- Characteristics

- 4 photobioreactor units each 300 L photoactive volume (total of 1,200 L)
- Different operating modes (single, in series, parallel)
- Semi-continuous harvest (disc separator, dissolved air flotation)
- More than 70 sensors to cover biological and engineering data
- Process control system (Software-SPS control)
- Temperature control unit in closed cycles
Microalgae platform – Process monitoring and control

- Temperature control (22 June used as example)

Maintaining of suspension temperature at 25 – 26 °C

(Flow temperature of cooling water: 18 – 20 °C)
Microalgae platform – Process monitoring and control

- Oxygen removal by means of pulsation

The photosynthetic formed oxygen is continuously removed from the suspension by using defined pulsation.
Microalgae platform

- Stable long-term cultivation (51° 45’ 1” N, 11° 58’ 49” E)

**Mixed culture**

- 04/16/2014 – proceeding (145 days)

**Vol. biomass productivity**

<table>
<thead>
<tr>
<th>Ø</th>
<th>0.27 g/L/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>0.74 g/L/d</td>
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</table>

**Cultivation parameters**

- $T_{\text{max}}$: 26 – 28 °C (8 am – 10 pm)
- 15 – 18 °C (10 pm – 8 am)
- pH: 7.5 – 8
- PPFD: Ø 498 µmol/m²/s
Microalgae platform
- Stable long-term cultivation

Nutrient supply
- Metering of macro- and micronutrients separately and semi-continuous in defined concentration limits
- Supply in relation to consumption

<table>
<thead>
<tr>
<th>Nutrient consumption (Ø)</th>
<th>Biomass composition (Ø)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C:N:P:S 29 : 4.2 : 1 : 0.2</td>
<td>C:N:P:S 28 : 4.5 : 1 : 0.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proteins</th>
<th>Lipids</th>
<th>Carotenoids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø 42 %</td>
<td>Ø 38 %</td>
<td>Ø 11 mg/g BTM</td>
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</tbody>
</table>
Summary

A stable long-term production of microalgae at optimal growth conditions has been successfully performed with this Christmas tree photobioreactor concept at cubic meter scale.

- Effective incidence of light
- High operation times
- Temperature control
- Nutrient supply
- Control and regulation
- Scalability

Stable, resource-conserving production of microalgae biomass

→ Ready for commercial scale applications
Array of services GICON®

- Building of micro plants based on customers wishes
  - Service: Entire range from inoculum until packing through all fields
- Sale of reactors
  - One or more reactor units for customers purposes

Array of services Anhalt University of Applied Sciences

- Algae screening laboratories and product-based analytic facilities
- Targeted process and product development
  - E.g. Lipids, nutraceuticals, pharmaceuticals, pigments

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Culture collection and lab-scale screening experiments

Selected analytical equipment

- GC-MS
- Stirred bead mill
- High pressure homogenizer
- LC-MS
Microalgae platform
I want to thank all collaborators...

Prof. Dr. Carola Grieihl
Dr. Martin Ecke
Stephanie Krause-Hielscher
Christian Kleinert
Christian Täger
Sandra Ludewig
and the entire research group
algae biotechnology!

This project is funded by the European Commission and
the state of Saxony-Anhalt. Thank you very much!
Thank you very much for your attention!

Meet us at our stand (403) and get in touch!