**Determination of maximum specific growth rate of photosynthetic organisms based on steady-state measures in CSTR**

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**Highlights**

* Diazotrophic cyanobacterium *Anabaena* PCC7122 was cultivated in continuous photobioreactors
* Respirometric tests used to measure kinetic parameters of N, temperature and light
* Maximum specific growth rate was determined from continuous experiments
* Kinetic model was developed and implemented in Aspen Plus process simulator

**1. Introduction**

Modeling the growth of photosynthetic organisms is challenging, mostly due to the complex role of light, which can be limiting because of self-shading, or photoinhibiting in the case of high intensities. The determination of the maximum specific growth rate is often affected by many variables that, in batch growth systems, may change significantly. On the other hand, in a continuous system, once steady-state is reached, all the process variables remain constant, including the biomass concentration and the specific light supply rate. This allows a quantitative assessment of the effect of this operating variable on the culture performances.

A case of particular interest is represented by nitrogen-fixing cyanobacteria (Anabaena PCC 7122), whose growth is controlled not only by the light intensity, but also by the availability of atmospheric nitrogen, which is related to its liquid solubility. In this work, a new approach, that combines the use of the cultivation in continuous systems and respirometric tests was presented.

**2. Methods**

Continuous experiments were carried out in vertical flat-panel PBRs with working volume ($V\_{R}$) of 350 mL and 4 cm thickness, at a temperature T = 24°C. CO2-enriched air (5% v/v) was sparged from the bottom. Mixing was checked by means of tracer experiments, that allowed to consider the reactor as a completely stirred tank one (CSTR) [1]. Fresh inlet BG11 or BG110 (with no nitrogen) was continuously fed by means of a tunable peristaltic pump. Continuous artificial white light was provided by a LED lamp.

The equation describing the autotrophic growth rate can be written as a function of biomass concentration ($c\_{x}$), the maximum specific growth rate ($μ\_{max}$), temperature ($f\left(T\right)$), specific light $(f\left(I\_{sp}\right))$ and the most limiting nutrient, i.e. nitrogen $(f\left(N\right))$. Moreover, the kinetic model takes into account the specific maintenance rate ($μ\_{e}$) that is a negative term, thus reducing the biomass growth rate ($r\_{x}$).

$r\_{x}=c\_{x} ∙μ\_{max} ∙f\left(T\right)∙ f\left(N\right)∙f\left(I\_{sp}\right)-μ\_{e}∙c\_{x}$ (Eq. 1)

The kinetic parameters for temperature, nitrogen and light were measured by respirometric tests [2]. The specific maintenance rate ($μ\_{e}$) was evaluated by elaborating experimental data of continuous cultivation according to the model proposed by Gons and Mur [3]. Finally, the maximum specific growth rate $μ\_{max}$ could hence be determined by applying the kinetic model in the material balances of the continuous PBR.

**3. Results and discussion**

The cyanobacterium was cultivated in continuous photobioreactors with and without supply of nitrates, showing that no nitrogen limitation occurred, and similar productivities were obtained in the two cases. This suggests that the half-saturation constant of the nitrogen is lower than its solubility in water. This was confirmed by the respirometric tests, that resulted in a half-saturation of about 3 mg L-1. In addition, the kinetic parameters for temperature and light were measured by respirometric tests. Afterwards, the experimental results obtained under different incident light intensities were used to evaluate the specific maintenance rate, which was found dependent from the light intensity, ranging between 0.5 and 0.8 d-1. The experimental data were finally elaborated to derive the value of *μmax* (8.22 $\pm $0.69d-1).

**4. Conclusions**

In this work, the diazotrophic cyanobacterium *Anabaena* PCC7122 was cultivated in continuous photobioreactors with and without supply of nitrates, to investigate the role of nitrogen, light and residence time on growth kinetics. Based on the results of continuous experiments, the specific maintenance and maximum growth rates were evaluated.

**References**

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