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Original article

Modelling and simulation of photosynthetic microorganism growth: random walk vs. finite difference method

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Abstract

The paper deals with photosynthetic microorganism growth modelling and simulation in a distributed parameter system. Main result concerns the development and comparison of two modeling frameworks for photo-bioreactor modelling. The first “classical” approach is based on PDE (reaction–turbulent diffusion system) and finite difference method. The alternative approach is based on random walk model of transport by turbulent diffusion. The complications residing in modelling of multi-scale transport and reaction phenomena in microalgae are clarified and the solution is chosen. It consists on phenomenological state description of microbial culture by the lumped parameter model of photosynthetic factory (PSF model) in the re-parametrized form, published recently in this journal by Papáček, et al. (2010). Obviously both approaches lead to the same simulation results, nevertheless they provide different advantages.

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Keywords: Multi-scale modelling; Distributed parameter system; Boundary value problem; Random walk; Photosynthetic factory

1. Introduction

The photosynthetic microorganism growth description is usually based on the microbial kinetics (so-called *P–I* curve), i.e. on the static lumped parameter models (LPM) describing the photosynthetic response in small cultivation systems with a homogeneous light distribution [5,21]. However, there is an important phenomenon, which occurs under fluctuating light condition, the so-called flashing light enhancement, demanding some other model than it residing in the artificial connection between the steady state kinetic model and the empiric one describing the photosynthetic productivity under fluctuating light condition, see e.g. [22]. Nevertheless, even having an adequate dynamical LPM of microorganism growth, e.g. phenomenological model of so-called photosynthetic factory [6,7,9,25], another serious difficulty resides in the description of the microalgal growth in a photo-bioreactor, i.e. in a distributed parameter system with strongly non-homogeneous light distribution, e.g. accordingly to the exponential attenuation, see Section 4.

In our previous papers [15,19,17,16,4] we studied the PSF model behavior and the techniques for parameter estimation as well. In this paper we aim to develop the distributed parameter model (DPM) of a photosynthetic microorganism

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