Dynamic modelling and optimization of biohydrogen production

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Cultivation of microorganisms for biofuel production is being widely researched at present. Amongst different biofuels, biohydrogen generated by cyanobacteria and purple non-sulphur bacteria (PNS) has drawn great attention. Despite the extensive study of biomass cultivation and biohydrogen production, scaling up these processes from laboratory setup to industrial production is still an open issue. For scaling up processes good understanding of the underlying mechanisms is necessary in order to produce accurate models and more particularly capturing also process dynamics. The dynamic simulation of biohydrogen generation process faces mainly two challenges. First, few kinetic models are capable of simulating all the different phases of photo-fermentation from cell growth to hydrogen production. Second, it is difficult to estimate model parameters accurately due to both the non linearity and dynamic nature of associated process models. To overcome these difficulties, the current study investigates a series of models derived from the Droop model. The aim is the dynamic simulation of biohydrogen production by different species including cyanobacteria and PNS bacteria. All the models are found to represent the underlying dynamic process very reliably and accurately. Using these models, the effects of incident light intensity, light attenuation, temperature and limiting-nutrient concentration on gas production is extensively explored in the current work. Because biomass growth and biohydrogen production maximizations are conflicting objectives, the current models have been used to determine the optimal operating conditions of different short-term (30-day) industrially relevant processes aiming to maximize biohydrogen production. Both traditional off-line optimization and novel on-line optimizing control techniques (model predictive control, MPC) are investigated. A significant increase of 116% on gas production is predicted computationally through the optimization of operating conditions of the process. The constructed dynamic models are also employed in the design of photo bioreactors and the economic analysis of a pilot scale cyanobacterial hydrogen production process. Following the very encouraging results obtained in the work presented here, ongoing efforts are focused on high-density biomass cultivation optimization utilizing the principles established for biohydrogen productivity maximization.

Biography

Dongda Zhang holds a master degree in advance chemical engineering (distinction) from Imperial College London. Currently, he’s a second year PhD student in the Department of Chemical Engineering and Biotechnology, University of Cambridge. His PhD project is dynamic simulation and optimization of bioprocesses for biofuels and high-value bio-products production. At the time of PhD research, he have been collaborating with different groups in Imperial College, University of Technology Sydney, Chinese Academic of Science and Xiamen University for the modelling of bio-hydrogen, bio-hydrocarbon, astaxanthin, phycocyanin and high density green algae cultivation, and published 5 journal papers with 2 additional manuscripts under review.

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