Photobioreactor Designs for Hydrogen Production by Microalgae

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Abstract
Some of the green algae have shown the ability to produce hydrogen from water and sunlight. The main cost of biohydrogen production is design and construction of photobioreactor system. One of the great challenges that we confront is light penetration in large scale cultivation. Other dependable factors include area/volume (A/V) ratio, mode of agitation, temperature and gas exchange. This review article focuses on different photobioreactor designs for hydrogen production.

Keywords: Biohydrogen; Photobioreactor; Tubular; Flat panel

Introduction

Many different photobioreactor designs have been used for microalgae cultivation and some of them have been used for hydrogen production [1-4]. Light conversion efficiency and hydrogen production efficiencies for phototrophic organis, and their relations to bioreactor design have been reviewed in this paper.

Photobioreactor designs

Shaking flasks

The simplest setup for microalgae cultivation, having also been used for hydrogen production, is Erlenmeyer flasks with shaking of agitation method. Such design has been applied for studies of cell age optimization for hydrogen production [5], and for he effect of light intensity on hydrogen production from *Chlamydomonas* microalgae [6].

Stirred tank (STR)

Different variations of stirred tank reactors represent a common category of photobioreactor used for hydrogen production at lab scale. The simplest systems consist of bottles with magnet stir bars, without inserted sensors, where extraction of samples from the bottles is needed to follow other parameters than hydrogen production through the experiment. The advantage of such simple systems is their very cheap and easy to handle, allowing a large number of parallel cultures to be studied. Equivalent bottles with sensors usually inserted from the top or from the side, allowing logging of several parameters inside the reactor, are also in common use [7].

Tubular reactors

The tubular reactors are of different configurations falling under the following major categories [8]: i) simple airlift and bubble column (vertical type) agitated by bubbling CO_2, ii) horizontal tubular reactor in which the light harvesting and gas exchange units are separated, iii) helical tubular reactor in which the material of construction is transparent and flexible and is coiled in a desired fashion.

Flat panel

Flat panel photobioreactors have many advantages and are commonly used for lab-scale studies of algae cultivation; up-scaled versions have also been used outdoors. The advantages of this type of photobioreactors are a high surface to volume ratio and the fact that the light path can be very short and evenly distributed across the reactor. This bioreactor type can also have flexibility as regards

light capture angle, and depending on which agitation method is used, a high mixing rate can be achieved in addition to low shear stress.

Flat plate bioreactors have been used for hydrogen production with agitation by sparging with recirculated gas, avoiding hydrogen inhibition by using a sophisticated system for separating the hydrogen from the rest of the gas phase by Tamburic et al. [9].

Conclusion

The design of photobioreactors in commercial scale has made good progress in the last decade. The basic principles have been extensively developed into designs with relatively high efficiencies. Suitable process engineering calculation methods have been published to give a quantitative understanding of mass and light transfer. But none of the existing pilot plants have proven economical on a large scale.

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