TECHNOLOGY OFFER **PORTAL**

NOVEL PHOTOBIOREACTOR FOR MASS CULTIVATION OF MICROALGAE

PATENTED TECHNOLOGY

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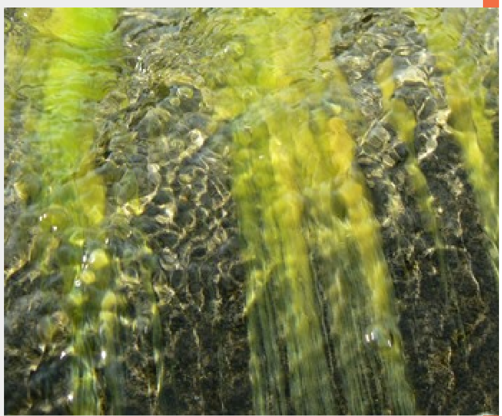
ABSTRACT

The research group Polymer processing and pyrolysis of the University of Alicante has developed a novel photobioreactor in order to grow massively different species of microalgae, even on industrial scale and with automation.

The main advantages of this technology are: high productivity, better CO_2 consumption, better light transfer to the culture, more effective shaking and less cleaning and maintenance time. It can be used in the following industrial sectors: biofuels, aquaculture, food, pharmaceutical, cosmetics, etc.

The research group is looking for companies acquiring this technology for licensing agreement and technical cooperation.



TECHNICAL DESCRIPTION

For mass cultivation of microalgae can be used different types of photobioreactors. Vertical ones are compact and simple to use. Currently, there are several vertical reactor configurations:

-Bubble column;
-Air-lift type with suction tube;
-Air-lift type with internal recirculation concentric tubes (the main drawback is that the swirl formed by the bubbles is smaller than the diameter of the photobioreactor, so that the walls thereof are coated with adhered microalgae, preventing thus an optimal light transfer).
-Submersible reactor, enabling economic control of the culture temperature (the main problem is the structure cost and complexity of use. In addition, it must be controlled gases as oxygen, which is accumulated because the container is leakproof).
-The present invention has been developed to overcome the limitations previously described them and to provide a better performing photobioreactor.

Technology Description

This novel photobioreactor combines the mechanism of a bubble column with the air-lift type for higher biomass production than that obtained for both systems separately.

In this sense, it has been developed a vertical cylindrical photobioreactor (rigid or flexible), with a flat or a conical bottom, made of transparent material for the optimum light transmission. The photobioreactor can be closed by a transparent lid to prevent foreign substances (dust, insects, etc...) to introduce into it, although the lid does not seal the container, so gases can leave. It also has, at least, one internal recirculation pipe located at the bottom that allows combining the air-lift and bubble column effects.

For the optimal microalgae growth, it is necessary to provide light, air and CO2 to control the culture pH and not to reach values that threaten the microalgae survival.

The injection of air and CO2 is carried out at the bottom of the photobioreactor. The amount of CO2 injected is controlled by a pH probe with internal temperature compensation.

The photobioreactor also has a heat exchanger to maintain the optimum temperature for the microalgae growth.
Possible system configurations

The first possible configuration is a modification of the conventional air-lift wherein the cultivation and gas mixture, instead of being introduced by the top, it is introduced through a drilling recirculation pipe located at the bottom. Thus, two aspects are improved:

• The use of CO2 supplied: the gas rises to the top of the photobioreactor and have more time to be dissolved in the culture.
• The culture mixing: gradients (temperature, pH and concentration of nutrients) are lower and the light transfer to the culture is better.

An alternative configuration is to place several drilling recirculation pipes (see Figure 1), thereby achieving greater and more uniform mixing, thus solving the problems of the air-lift type (for example, getting dirty the walls of the photobioreactor).
Another possible configuration is to drill the recirculation pipe (see Figure 2 (a)), thus introducing bubbles rising forming a swirl. The drillings should be sized so that the entrance of bubbles in the medium is homogeneous through the pipe and avoid cell death of the culture incorporated back into the photobioreactor due to stress caused by an incorrect hydrodynamic diameter of the drilling. The number of perforations must be enough so the output of the gas flowing therethrough is uniform. In this way, it achieves a more uniform mixing and the bubbles are distributed throughout the diameter of the photobioreactor. Therefore, this technology improves:

• The microalgae exchange between areas of light and dark;
• The light transfer to the culture;
• The control of temperature, pH and nutrients concentration gradients;
• The use of CO2 (increases the residence time of CO2 in the culture medium);
• Keep clear microalgae on the walls of the photobioreactor when the culture reaches high concentrations.

Another alternative configuration is to place several recirculation pipes with multiple drillings (see Figure 2 (b)), thereby achieving the effect of the stirring produced is more uniform along the photobioreactor.

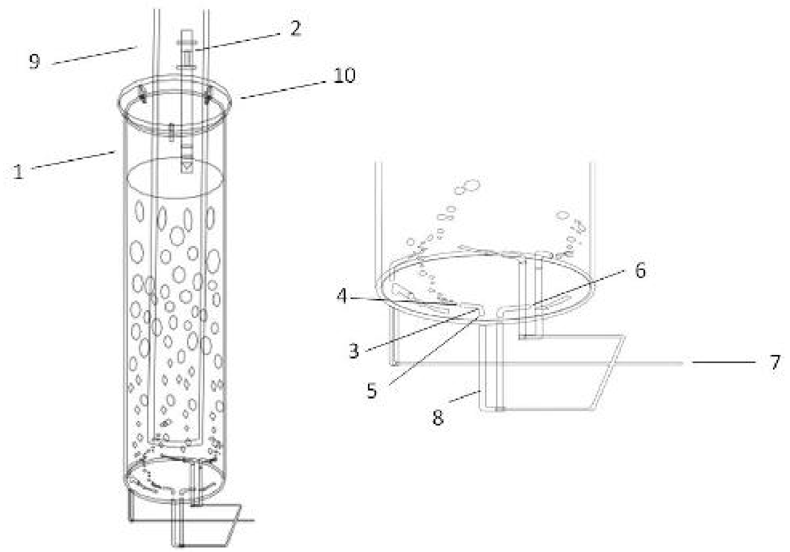


Figure 1: Photobioreactor with three drillings recirculation pipes located at the bottom (including the detail at the bottom).

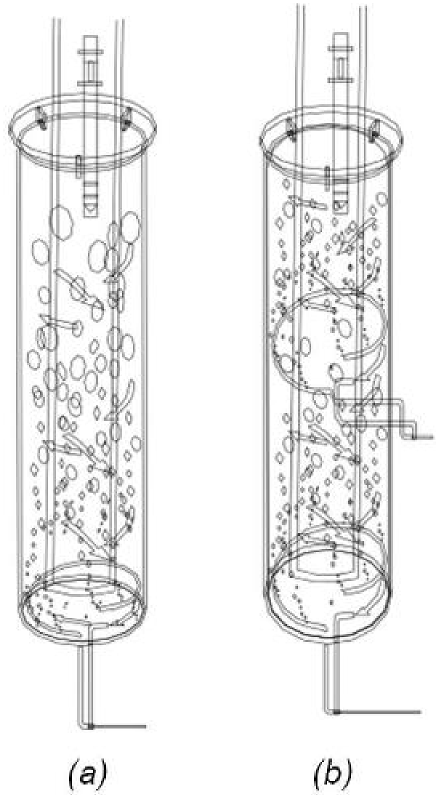


Figure 2:
(a) Photobioreactor which comprises a recirculation pipe with multiple drillings equally spaced.
(b) Photobioreactor with two recirculation pipes with multiple drillings distributed along the photobioreactor.

TECHNOLOGY ADVANTAGES AND INNOVATIVE ASPECTS

The main innovation of this invention is that this novel photobioreactor combines the mechanism of a bubble column with the air-lift type for higher biomass production than that obtained for both systems separately.

Moreover, the main advantages of this technology are:

• High productivity.

• The stirring is more effective because the effects of both types of reactor (bubble column and air-lift type) are added, which allows a faster microalgae exchange between areas of light and dark.

• Better light transfer to the culture because the bubbles generated directly mix the culture resulting in an expansion thereof.

• Maintenance of the uniformity in the distribution of gas in the system.

• Improves nutrient solution: the way in which is injected CO2 to maintain the pH of the culture allows that the residence time of CO2 in the medium increases, thus making better use of it (the whole culture must be crossed to reach the surface).

• Better control of the culture conditions (pH, temperature, etc.).

• There is a lower adhesion of microalgae on the photobioreactor walls, which achieves a greater use of light when the culture reaches high concentrations, and it barely requires cleaning and maintenance.

• CO2 consumption to reach a suitable microalgae growth is significantly reduced compared with other systems. The best use of this nutrient compared to the conventional air-lift reactor is due to the higher residence time of CO2 it is in the culture: there is a higher concentration dissolved and therefore higher availability for microalgae. Figure 3 shows how the number of CO2 injections performed in a culture of Nannochloropsis oculata in a given time interval is reduced with respect to a reactor of conventional air-lift type:

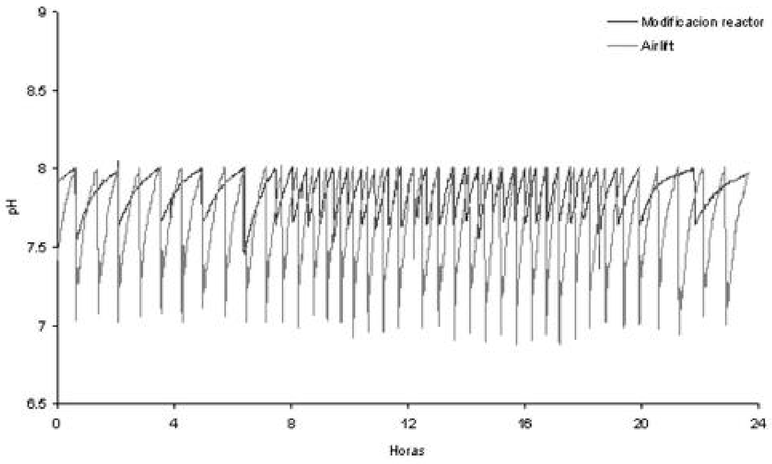


Figure 3: Comparison of the pH profiles using the photobioreactor described in this invention and a conventional air-lift reactor

• Due to its configuration, it allows easy scaling on industrial level.

• It is robust and easy to install and operate (technical experience is not required for its management).

• The better use of sunlight minimizes energy consumption and cost.

• It is able to be automated (it has aeration, circulation, feeding and harvesting circuits).

• It is thermostated for optimum growth of microalgae.

• It has an automatic pH probe for CO2 injection.

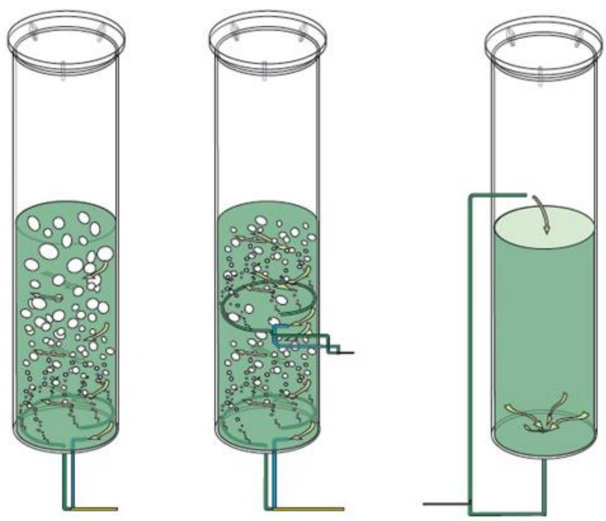
• It allows to cultivate some microalgae species, such as: Chlorella, Nannochloropsis oculata, Nannochloropsis gaditana, Isochrysis aff. Galbana, Spirulina platensis, Dunaliella salina, Odontella aurita, Phaedactylum tricornutum, Porphyridium cruentum, etc.
• The culture conditions have been optimized for Nannochloropsis oculata, a kind of microalgae particularly resistant to pollution (fungi, yeasts, bacteria, viruses, etc.).

CURRENT STATE OF DEVELOPMENT

Currently, there is nothing similar in the market, so it is a novel technology with great possibilities of internationally marketing.

The research group has developed a prototype that is available for experimental demonstration. The photobioreactor has a work volume of 30 litres and its average productivity is 6 g/day.

Furthermore, the research group has a pilot plant for carrying out the pre-industrial scaling with reactors of 500 litres (with a production capacity of 100 g/day). There are also available sea water tanks, decantation tanks, filtration, lyophilization and molecular characterization equipment, and culture conditions can be optimized for some microalgae species.



Schematic drawing of the prototypes

MARKET APPLICATIONS

The present invention consists in a photobioreactor combining a bubble column with the air-lift type mechanisms to achieve higher biomass production than both systems separately.

Microalgae have high photosynthetic efficiency, so their growth is faster than plants. In this sense, microalgae are a very interesting material for the generation of biofuels.

Addition of biomass to produce biofuels, microalgae can be used to obtain other valuable substances on different industry sectors: food, pharmaceuticals, cosmetics, nutraceuticals, etc.

Depending on the species cultured, it can be obtained:

Antibiotics

Enzymes

Proteins

Peptides

Pigments

Vitamins

Biopolymers

Polysaccharides

Polyunsaturated fatty acids

Triglycerides

Essential lipids

Oxylipins

Antioxidants
Etc.

COLLABORATION SOUGHT

The research group is looking for companies interested in acquiring this technology for commercial exploitation by:

• Licensing agreement.

• Technical cooperation to test new applications (biofuels, cosmetics, pharmaceuticals, nutraceuticals, food, etc.) and to adapt it to microalgae species, such as: Chlorella, Nannochloropsis oculata, Nannochloropsis gaditana, Isochrysis aff. Galbana, Spirulina platensis, Dunaliella salina, Odontella aurita, Phaedactylum tricornutum, Porphyridium cruentum, etc.

INTELLECTUAL PROPERTY RIGHTS

This technology is protected by patent application:

• Application number: P201200903.

• Application date: 19th September 2012.

MARKET APPLICATION (7)

Agri-food and Fisheries
Biology
Molecular Biology and Biotechnology
Pharmacology, Cosmetics and Ophthalmology

Engineering, Robotics and Automation
Chemical Technology
Transport and Automotive