Determination of the Activation Energy of the Reaction of Photosynthesis in Chlorophyll Synthesizing Microalgae

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Abstract – The dynamics of absorption of carbon dioxide at corresponding temperature by microalgae Chlorella was studied. The results of experimental research will allow to calculate the energy of activating photochemical reaction and other values of kinetics of increase of microalgae within the limits of the investigating temperatures. The analytical dependence of coefficient of growth biomass on temperature within the limits of the investigating temperature was established. The stages of transport of carbon dioxide from air to internal volume of microalgae cell was determined through literature. The optimal terms of their cultivation was selected and analyzed. The results showed that it is possible to forecast the technological scheme of cleaning of gas emissions from carbon dioxide by biological method.

Key words – photosynthesis, microalgae, kinetics, biomass, chlorella, increment rate, carbon dioxide.

I. Introduction

About 150 world leaders met in the suburb of Paris, in a township Lai Burzhe, where a world climatic summit began on November, 30, 2015 concerning incessant growth of content of carbon dioxide in an atmosphere. Main task – to agree about measures which would allow to retain growth of temperature in our planet within the limits of 2 degrees Celcius. Scientists have already alarmed and warned – if this question is not decided in an urgent order, the middle temperature of Earth will rise up 5 degrees Celcius till the end of the century and it will threaten global sea level rise and catastrophic consequences for all mankind. One solution to this problem is to use photosynthesis in industrial environment. The ability to absorb carbon dioxide from the atmosphere by plants and algae and its "storage" in the form of biomass is an objective condition for the implementation of these processes to the treatment of industrial gas emissions of carbon dioxide.

II. Description of the problem

Photosynthesis - the process of converting sunlight into energy of chemical bonds and synthesis of organic compounds (carbohydrates) from inorganic (CO_2 ↑ and H_2O). This is the only process in the biosphere, which leads to an increase of free energy from domestic sources. The energy is stored in the products of photosynthesis - the main source of energy for mankind. Therefore, targeted products of photosynthesis can be used for the purpose of energy recovery, including anaerobic biodegradable to produce methane. The ability of photosynthesis are not only with plants, but also microalgae. In 1890, Danish scientist M. W. Beijerinck discovered a new species of microscopic algae - chlorella. The name Chlorella was given through the Greek root "chloros", which means yellow-green, and the Latin ending - ella - literally means "little". Chlorella vulgaris cells are spherical, 5-10 microns in diameter and have a cup-shaped chloroplast. This single-core algae, kernel size are about 1 micron.

Habitat - it's mostly freshwater. This microscopic alga, which has a large supply of chlorophyll and rare complex nutrients, takes part in the process of photosynthesis, absorbing carbon dioxide and saturating the air with oxygen. Microscopic algae chlorella is considered survivor of our planet. Its existence is measured by more than two billion years. Chlorella cultivation can be done in varied temperature (22-45°C). No seasonality in its reproduction. Chlorella is not demanding to the culture medium. Heavy-duty walls of Chlorella cells contain three levels, protecting thus the cell nucleus from external adverse factors.[1]

Moreover, the advantage of chlorophyll synthesising microalgae is that they grow quickly and absorb much more carbon dioxide than the plants, and able to adapt to the land of adverse conditions.[2] So, finding ways of photosynthesis in an industrial environment is an urgent task.

Biological objects are usually very complex, and the processes occurring in them, are influenced by many factors, which are often dependent on each other. The most important for photosynthesis by microalgae is the degree of aeration with carbon dioxide, temperature, light, alkaline-acid balance, and so on. That is to say that absorption of carbon dioxide and air by microalgae has diffusion, chemical and biological processes.

Due to the correlation of physicochemical quantities with biological we can get a more deeper understanding of processes by analyzing the biological object.

In the basis of the mass transfer processes of cells of microalgae with the environment is a complex of series organized in a certain way in time and space by biochemical reactions. As a result of these processes, the concentrations of the absorbing material, the number of single cell microalgae, biomass of microorganisms are changes which in turn changes other values. Thus, the absorption of carbon dioxide by microalgae - is a complex heterophase process in which the mass transfer of carbon dioxide from the gas phase to "relatively solid" phase occurs. For this processes, the typical simultaneous dependence of the rate from diffusion and kinetic factors. The system "gas-liquid-cell" is a three-phase, which inevitably creates additional difficulties for describing and more even in comparison with complex gas-liquid two-phase systems. The carbon dioxide is penetrated into the aqueous phase, and then transfered by diffusion to the wall of cell with subsequent transport through the membrane into the cell.

The process of transport of carbon dioxide in the cell of microalgae conditionally consists of four phases:

1. Mass transfer of carbon dioxide from air to water solution of microalgae culture;
2. Transfer carbon dioxide to the surface of the biomass of algae colonies;
3. The diffusion of carbon dioxide in the intercellular space to the surface microalgae;
4. Diffusion through a porous membrane of cells of algae colonies.
5. Photosynthesis.[4]

To study the effect of temperature on the absorption of carbon dioxide by microalgae, experimental reaearch was conducted in three photobioreactors. The equipment provided sufficient amount of carbon dioxide for the whole volume of photobioreactor. The mixing and lighting contributed to the process of absorption of carbon dioxide, which was accompanied by the increasing number of algae cells (biomass). The temperature of the culture medium in photobioreactor was 20 ± 1 °C, 28±1°C, 35 ± 1 °C, respectively. pH of culture medium was 6.5. Selection of algae biomass was carried out with established intervals of days. Determination of concentration of biomass of algae conducted by photocolorimetric method. Dynamics of increase of biomass of microalgae in the respective temperatures is shown in Fig.

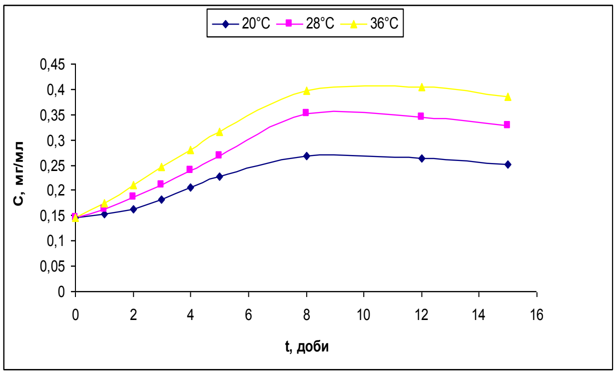

Fig. 1. Dependence of change of concentration of cells of microalgae over time in the respective temperatures

Kinetics photosynthesis described by the equation:

$$\frac{dC}{dt} = kC_{CO_2}C_{H_2O}; \qquad (1)$$

where k - constant of speed of biochemical reactions of photosynthesis.

The dependence on constant of the rate of biochemical reaction - k from the temperature - T has the form:

$$k = k_o e^{-\frac{E}{RT}}; \qquad (2)$$

After the logarithm of equation (2) and improving the value - lgk through - B , and $\frac{E}{4{,}575}$ through - A we obtain an expression known as the Arrhenius equation:

$$\lg k = B - \frac{A}{T}; \qquad (3)$$

The values A and B are constants of reactions. If built the graphic of dependence with the experimental datas, $\lg k = f(\frac{1}{T})$, this dependence will describe by straight line and a slope of a curve allow to determine the quantity $-A$.[1] The activation energy was determined from the curve.

Small activation energy indicates that this biological process, and it should be used, because it is not energy-consuming but effective.

Conclusion

The effect of temperature on the process of absorption of carbon dioxide by chlorophyll synthesizing microalgae was studied. The value of activation energy of biochemical reaction of photosynthesis in the experiment and the growth factor of biomass was determined. The feasibility to combine the processes of cultivation of microalgae with cleaning the gas emissions from the main greenhouse gas - carbon dioxide was established.

References

[1] V. V. Dyachok “Extraction process of intracellular substance. Chemistry & chemical technology”, Vol. 4. - №2. P. 163-167, 2010

[2] Encyclopedia "Plants of the World", 2009-2014. Access to the encyclopedia: http://roslunu.com.ua/v/45/

[3] S. D. Varfolomyeyev, S. V. Kalyuzhny “Biotech-nology. Kinetic foundations microbiological processes”, Moscow: High School, 1999, p. 102

[4] A.N. Polovyy “Modelyuvannya diffusion resistance towards CO2 molecules in green leaf”, Odessa: Herald, 2009, p. 300.