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BEL-850 (Advance Biochemical Engineering Laboratory)

Experiment 5

OBJECTIVE:

The goal is to estimate the overall oxygen transfer coefficient $K_L a$ in a fermenter by the cell-free dynamic method.

INTRODUCTION

In aerobic fermentation processes, oxygen is transferred into the reactor by blowing air through a sparger. The air exits the sparger in the form of relatively air bubbles, which are broken into smaller air bubbles by the action of the rotating impellers, thus increasing a, the interfacial area per unit volume.

In many aerobic fermentation processes, productivity is limited by the availability of dissolved oxygen. It is therefore important to estimate the mass transfer coefficient $K_L a$ in order to calculate the rate at which oxygen is delivered from the air bubbles to the cells (which live in the liquid phase).

MATERIALS

a) Bioreactor with agitation and aeration system
b) Dissolved oxygen probe
c) Nitrogen cylinder and air supply
d) Stop Watch

THEORY

In this method, there are no cells in the fermenter. To begin with, the air supply is cut off, and the dissolved oxygen (DO) in medium is displaced by sparging nitrogen in the medium until the DO reaches zero. At the time point, which we designate $t = 0$, the nitrogen supply is cut off, and the air supply is started. Consequently, oxygen transfer from air bubbles to liquid bulk starts and the DO begins to rise. We measure the variation of DO with time, and calculate the value of by fitting the data to the model described below.

In the absence of cells, the mass balance for dissolved oxygen is given by the equation

$$\frac{dc_o}{dt} = K_L a\,(c_o^* - c_o), \qquad (1)$$

where c_o is the DO concentration at any time t (in mg O_2/L), c_o^* is the saturation level of DO in the culture medium (in mg O_2 /L), and $K_L a$ is the oxygen transfer coefficient (in h^{-1}). To capture the experiment described above, eq. (1) should be solved subject to the initial condition

$$c_o(0) = 0. \qquad (2)$$

The solution of the initial value problem (1)-(2) is

$$\frac{c_o^* - c_o(t)}{c_o^*} = e^{-K_L a t},$$

which describes the temporal evolution of the DO concentration $c_o(t)$ from its initial value 0 to its final value c_o^*. It follows that

$$\ln\left(\frac{c_o^* - c_o}{c_o^*}\right) = -(K_L a)t,$$

and $K_L a$ can be estimated from the slope of the line obtained by plotting $\ln(c_o^* - c_o)/c_o^*$ versus t.

OBSERVATION

Table – 1: DO vs. time data after air supply is resumed
Aeration rate: 0.5 VVM
Agitation : 500 RPM

Time (sec)								
DO (%)								

Table -2:
Aeration rate: 0.5 VVM
Agitation : 800 RPM

Time (sec)								
DO (%)								

Table -3:
Aeration rate: 0.1 VVM
Agitation : 500 RPM

Time (sec)								
DO (%)								

Table -4:
Aeration rate: 0.1 VVM
Agitation : 800 RPM

Time (sec)								
DO (%)								

RESULTS
Attach graphs and report the values of K_La in h^{-1} for each set

DISCUSSION Write a discussion on your results.

REFERENCES

1. Heineken, F. G. (1970), On the use of fast-response dissolved oxygen probes for oxygen transfer studies. Biotechnol. Bioeng., 12: 145–154. doi:10.1002/bit.260120113

2. Heineken, F. G. (1971), Oxygen mass transfer and oxygen respiration rate measurements utilizing fast response oxygen electrodes. Biotechnol. Bioeng., 13: 599–618. doi:10.1002/bit.260130502

3. Linek, V. "Determination of aeration capacity of mechanically. Agitated vessels by fast response oxygen probe." *Biotechnology and Bioengineering* 14.2 (1972): 285-289.

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