THE DYNAMIC METHOD FOR MEASURING OF AERATION CAPACITY IN GLUCOSE–GLUCOSE OXIDASE SYSTEM

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The method of measuring the aeration capacity $k_L a$ (volumetric mass transfer coefficient) by rapidly responding oxygen probe in the case of absorption accompanied by first order reaction in the liquid phase was shown. The advantage of this method is that it does not need any knowledge of the oxygen solubility data in absorption liquid. The absorption of oxygen into the aqueous solution of glucose in the presence of enzyme glucose oxidase conforms to this model.

The absorption of oxygen into the aqueous solution of glucose in the presence of enzyme glucose oxidase (GGO system) is used for measurement of aeration capacity $k_L a$ of fermenters. The value of $k_L a$ in mechanically agitated dispersion of gas in the liquid (MAD) can be obtained by using balance method[1]. But the value of oxygen solubility in the liquid has to be known. We present a method by which the value of $k_L a$ can be obtained by dynamic measurement technique. One of the advantages of this method is that the knowledge of oxygen solubility is not necessary. This technique was worked out for the case, when in the liquid the zero order reaction with respect to oxygen (respiration of microorganisms) occurs[2-4]. We are going to derive a way of applying the dynamic method for the case of absorption accompanied by first order reaction in the liquid phase. The oxygen absorption into GGO system conforms to this model[5,6].

The rate equation for the oxygen absorption into GGO system is the following

$$dc/dt = k_L a(c_2^+ - c) - k_1 c\,, \qquad (1)$$

when assuming both phases perfectly mixed. Integrating the equation (*1*) with the initial condition

$$c = 0 \quad \text{for} \quad t = 0 \qquad (2)$$

we obtain this relation

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$$c = \frac{c_2^+}{1 + k_1/k_L a} [1 - \exp(-Kt)] , \quad (3)$$

where

$$K = k_L a(1 + k_1/k_L a) . \quad (4)$$

The principle of the dynamic method of measuring $k_L a$ is based on the tracing the changes of oxygen concentration by oxygen probe in the MAD caused by sudden interruption and subsequent resumption of liquid aeration. After the aeration is stopped (the gas supply and rotation of the agitator is stopped) the oxygen concentration in GGO system decreases to zero value (the condition (*2*)) as a result of the reaction taking place between dissolved oxygen and glucose. The course of oxygen concentration in GGO system when the aeration is resumed is given by Eq. (*3*). For the normalized response Γ of oxygen probe after the resumed aeration is valid a relation derived elsewhere[2,4]

$$\Gamma = 1 - \frac{\pi B^{1/2}}{\sin(\pi B^{1/2})} \exp(-Bkt) - 2\sum_{n=1}^{\infty}(-1)^n \frac{\exp(-n^2 kt)}{n^2/B - 1} , \quad (5)$$

where

$$B = K/k . \quad (6)$$

The relation (*5*) was derived assuming that the main resistance against the oxygen diffusion to the cathode is concentrated in the membrane. The methods of calculating the values of B from the pairs of Γ and t values, taken from the recorder chart of oxygen probe response, were described elsewhere[4,5] together with the process of determinating the values of membrane constant k.

For the oxygen concentration c_0 in GGO system under steady state aeration follows from Eq. (*1*) the following relation

$$c_0 = c_2^+/(k_1 + k_L a) . \quad (7)$$

Thus the ratio z of the reading of oxygen probe placed in the gas leaving the fermenter and the reading of the probe placed in GGO system under steady state conditions of aeration is

$$z = c_2^+/c_0 = 1 + k_1/k_L a . \quad (8)$$

Combining the Eqs (*6*)–(*8*) we obtain a relations for the aeration capacity $k_L a$

$$k_L a = Bk/z . \quad (9)$$

For illustration the actual oxygen concentration in GGO system and oxygen probe reading are plotted in Fig. 1.

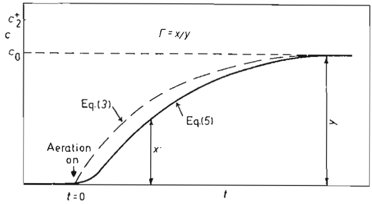

FIG. 1

Oxygen Concentration in Liquid (GGO) after Resumed Aeration

— — — — Actual oxygen concentration given by Eq. (*3*); ——— oxygen probe reading given by Eq. (*5*).

We conclude, that there was shown the method of measuring the aeration capacity for the GGO system in MAD. The advantage of this method is that it does not need any knowledge of the oxygen solubility data in absorption liquid.

LIST OF SYMBOLS

a area of interface per unit volume of liquid
$B = K/k$
c oxygen concentration
c_2^+ equilibrium oxygen concentration with respect to gas leaving dispersion
c_0 steady state oxygen concentration
k membrane constant
k_L liquid phase mass transfer coefficient
t time
x abscissa defined in Fig. 1
y abscissa defined in Fig. 1
$z = c_2^+/c_0$
GGO aqueous solution of glucose with glucose oxidase
MAD mechanically agitated gas–liquid dispersion
Γ normalized response of oxygen probe defined in Fig. 1

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