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BEL-850 (Advanced Biochemical Engineering Laboratory)

Experiment 6

OBJECTIVE:

The goal is to estimate the volumetric oxygen transfer coefficient, $K_L a$ in a fermenter by the dynamic gassing out technique in a culture containing cells.

INTRODUCTION:

In aerobic fermentation processes, the oxygen demand is met by sparging air, which comes out from sparger as air bubbles in the liquid bulk. The bubbles are then broken down to tiny air bubbles by the action of rotating impellers. This results in increased interfacial area per unit volume for oxygen transfer from the air bubbles to the liquid bulk. In many aerobic fermentation processes, productivity is limited by availability of dissolved oxygen. Therefore, it becomes important to estimate $K_L a$ in order to determine oxygen transfer capabilities of the fermentor under permissible aeration and agitation conditions.

MATERIALS:

- Bioreactor with agitation and aeration system
- Dissolved oxygen probe
- Nitrogen cylinder and air supply
- Stop watch

THEORY

For an actively growing batch culture in a bioreactor, the mass balance for dissolved oxygen can be written as :

$$\frac{dc_o}{dt} = K_L a(c_o^* - c_o) - r_o x \tag{1}$$

where

$K_L a$ = volumetric oxygen transfer coefficient (h^{-1})

c_o = dissolved oxygen concentration at any time t, (mg O_2/L)

c_o^* = saturation level of dissolved oxygen in culture medium in the fermentor, (mg O_2/L)

r_o = specific oxygen uptake rate (mg O_2 gdw^{-1} h^{-1})

x = cell mass concentration (g L^{-1})

In this method, the air is first turned off in an actively growing cell culture, which causes the DO to drop. This decline occurs in accordance with the equation

$$\frac{dc_o}{dt} = -r_o x \tag{2}$$

obtained from (1) by letting the oxygen transfer rate be zero. Since the air supply is resumed before the DO falls to sub-critical levels, both r_o and x remain approximately constant, and c_o declines linearly.

It follows that the slope of the c_o vs. t curve yields $r_o x$, the volumetric oxygen uptake rate. Upon resumption of air, the accumulation rate of DO in the broth follows equation (1). Therefore, rearranging equation (1) we get,

$$c_o = (\frac{1}{K_L a})(\frac{dc_o}{dt} + r_o x) + c_o^* \tag{3}$$

which implies that $K_l\, a$ can be evaluated from the slope of the c_o vs. $dc_o / dt + r_o x$ plot.

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