Experiment –8

OBJECTIVE:

Estimation of volumetric oxygen transfer coefficient (K_La) in a fermentor by dynamic gassing out technique.

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_La in order to determine oxygen transfer capabilities of the fermentor under permissible aeration and agitation conditions.

MATERIALS

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

THEORY

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

Accumulation = Oxygen supply - Demand

i.e., $$dC_L/dt = K_La\,(C^* - C_L) - rX \qquad \text{……………….} (1)$$

where:
K_La = volumetric oxygen transfer coefficient (h^{-1})
C_L = dissolved oxygen concentration at any time t, (mg O_2/l)
C^* = saturation level of dissolved oxygen in culture medium in the fermentor, (mg O_2/l)
r = specific oxygen uptake rate (mg O_2/g/h)
X = cell mass concentration (g/l)

In this method, air is turned off in an actively growing cell culture and as a result the respiring cells cause the DO value to drop. Before this value falls to critical level, the air supply is resumed. When air is turned off, the oxygen supply rate becomes zero and we get from equation (1):

$$dC_L/dt = -\,rX \qquad \text{………………}(2)$$

The equation indicates following air cut off, the DO value falls linearly with time. The slope of C_L vs t (time) equals oxygen uptake rate (rX). Upon resumption of air, the accumulation rate of DO in the broth follows equation (1). Therefore rearranging equation (1) we get,

$$C_L = (-1/K_La)\,(dC_L/dt + rX) + C^* \qquad \text{………………}(3)$$

From the plot of C_L vs. ($dC_L/dt + rX$), K_La can be evaluated from the slope of the line.