MATERIAL AND ENERGY BALANCES AND TRANSFER RATES IN AEROBIC FERMENTATIONS

by

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B.S., Universidad de Guayaquil, 1966

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

FOOD SCIENCE

Department of Chemical Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1977

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CHAPTER I

INTRODUCTION

Aerobic fermentations depend on a continuous supply of oxygen to the liquid phase for microorganisms to grow and function properly. Aeration also provides mixing which frequently prevents the settling of solids.

Oxygen and heat removal requirements are affected by the choice of carbon substrate. Yeast produced on a normal alkane will require roughly three times as much oxygen as yeast grown on carbohydrate. Hydrocarbon fermentations produce more than twice as much heat per gram of cells produced compared to carbohydrate fermentations. From an engineering point of view, there is a need to design fermenters with improved oxygen and heat transfer systems so that higher production rates can be achieved.

One purpose of this report is to review the available literature on oxygen requirements and heat evolution in aerobic fermentations. The methods for determining oxygen transfer rate and oxygen transfer coefficients are also reviewed. Relationships between oxygen transfer requirements and oxygen transfer rates are presented and used to estimate the mass transfer coefficient.

CHAPTER II

LITERATURE SURVEY ON OXYGEN MATERIAL BALANCES AND REQUIREMENTS IN AEROBIC FERMENTATIONS

A major factor in aerobic fermentations is oxygen transfer from the gas phase to the aqueous medium. In microbial propagation oxygen transfer frequently limits the production rate. Therefore, the real capacity of the fermenter is often determined by the quantity of oxygen the fermenter is able to transfer to the microorganisms. Material balances are needed to relate the oxygen transfer rate to the rate of cell production. Literature is reviewed on the stoichiometric relationships between oxygen consumption and cell production in aerobic fermentations.

Darlington (1) assessed for the first time the merits of biosynthesis from hydrocarbon and carbohydrate starting materials by using a material balance. He made the following assumptions in his calculations:

a) The composition of the product from the carbohydrate and hydrocarbon fermentations is identical.

b) A typical microbial composition is 47% carbon, C; 6.5% hydrogen, H; 7.5% nitrogen, N; 8% ash; and 31% oxygen, O.

c) The dry weight yield of yeast from carbohydrate is 50%.

d) The dry weight yield of yeast from hydrocarbon is 100%.

With these assumptions the empirical C, H, O formula for 100 g. yeast of this composition would be:

$$C_{3.92}\,H_{6.5}\,O_{1.94} \qquad (1)$$

and the amount of carbohydrate (CH_2O) required, based on a 50% yield, would be 200 g. or 6.67 moles CH_2O. Writing the equation:

$$6.67\ CH_2O \rightarrow C_{3.92}\,H_{6.5}\,O_{1.94} \qquad (2)$$