

# Mastering the fermentation process

## Oxygen and carbon dioxide measurements for fermentation

A specific group of proteins, largely unknown to the general public but used in various industrial processes, are manufactured by a Finnish company. Roal Corporation produces these enzyme proteins for the needs of food, paper, baking, and textile industries. The biological process utilized to produce the enzymes is called fermentation.

Roal produces enzymes in submerged fermentation units. The company is jointly owned by ABF Ingredients, a division of Associated British Foods, and Altia Corporation, a publicly held beverage company that focuses on wines and spirits and operates in the Nordic and Baltic countries. The plant is located in Rajamäki, Finland and it produces enzyme products mainly for use in the textile industry, for example in cloth desizing, denim finishing or biofinishing. In the adjacent pilot plant, new research projects for novel enzyme processes are carried out. The person in charge of Roal's pilot plant is R&D Manager Dan Haglund.

### Fermentation basics

The souring of milk to yogurt, the rising of bread dough with yeast, or the conversion of sugar to alcohol in wine making or beer brewing are common everyday examples of fermentation.

Fermentation is a chemical change brought about by the action of micro-organisms. In industrial fermentation, the term is used broadly to refer to the growth of micro-organisms on a growth

medium. The fermentation process itself typically takes place in a tank called a bioreactor or fermentor, but the whole production process can be composed of multiple process steps that refine the raw materials to the end product. These process steps include raw material treatments such as blending and sterilization as well as end product processing such as filtration, concentration, drying, and finally packaging.

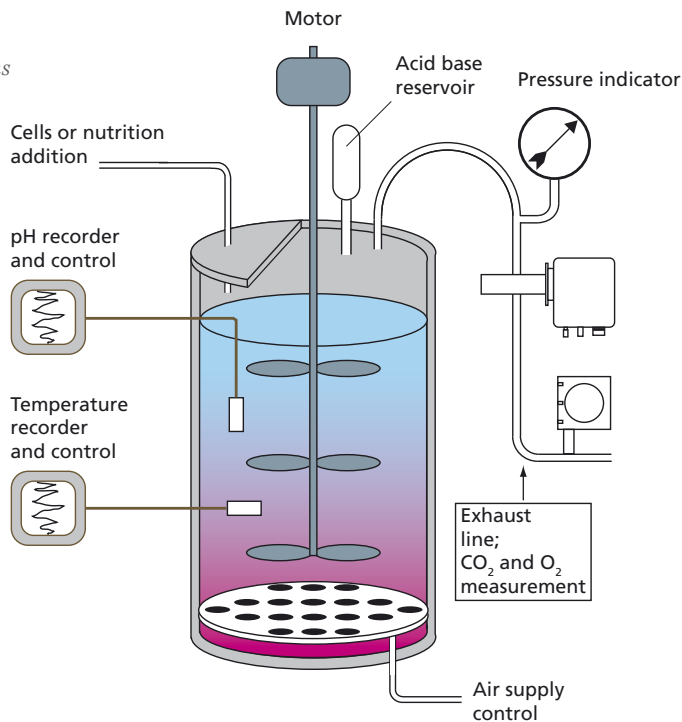
In the heart of the fermentation process - the bioreactor - the control of acidity and temperature of the growth medium is important. The constant supply of nutrients as well as gases such as CO<sub>2</sub> and O<sub>2</sub> is also monitored. Oxygen is the most important gaseous substrate in aerobic fermentation, while carbon dioxide is the most important gaseous by-product of the process.

### Enzyme manufacturing

The production of yeast and alcohols is a large part of the fermentation industry. Besides this, it also produces antibiotics, enzymes, and amino acids.

A growing field of fermentation is enzyme manufacturing. Most of the enzymes produced globally are used in detergents. In the future, more enzymes will be needed for example in the baking industry, which uses enzymes in bread manufacturing. Enzymes are also produced for food and animal feed as well as the pulp and paper industry. Enzyme manufacturers have to maintain constant research activities, so that new

A schematic of a fermentor tank:  $CO_2$  and  $O_2$  concentrations are measured from the exhaust line of the fermentor.



applications for enzyme use are developed and the production of older enzyme generations is enhanced.

### What are enzymes?

Enzymes are proteins composed of amino acids. They are produced by all living organisms - in the fermentation industry by moulds or bacteria, but they are not living organisms. The enzyme production process requires a strictly controlled environment within the bioreactor. In the fermentation process the enzymes are produced in the microbial cells and then secreted into the fermentation broth. Prior to the production fermentor, the biomass serving as the growth medium is built up in several inoculum fermentors.

### What are enzymes used for?

Enzymes work in various industrial production processes breaking more complex compounds into simpler ones. In baking, enzymes are used for example to increase baking volume, act as stabilizers, and extend the shelf-life of the product. Enzymes are used in the extraction of fruit juices in the beverage industry and in wine making. In the animal feed industry, enzymes are used for improved animal feed conversion. In the textile industry, enzymes are used for biofinishing, cloth desizing, and denim finishing. The pulp and paper industry uses enzymes for bleaching, deinking, and improved paper production.

The use of enzymes in industries results in reduced chemical costs, increased

production capacity, and better quality of the end product. Using enzymes generally requires minor investments.

### The pilot plant at Roal

At the pilot plant at Roal, careful monitoring of the fermentation process is essential. The pH-value, temperature, dissolved oxygen, and carbon dioxide are usually measured from the fermentor broth. The oxygen and carbon dioxide levels are measured from the exhaust gas. The gas temperature is typically 25°-30°C and the relative humidity is around 100%. The exhaust gas may also contain ammonia, since the substance is used to control the pH levels of the fermentor broth. Also the humidity of the fresh air blown into the fermentor is measured. The demanding surroundings require reliable measurement instruments.

The  $CO_2$  concentration of the enzyme production process is monitored in order to get a picture of the state of the process. The level of  $CO_2$  is an indication of the metabolic activity of the mould or bacteria, and the information is used to control the feed of new nutrient pulses to the process. "The correct level depends on the microbial strain and the fermentation process itself, and it is a matter of experience to know when a new nutrient pulse should be fed into the process", says Dan Haglund, the R&D Manager of the pilot plant at Roal. It is essential to ensure that fresh air supply to the bioreactor is sufficient to keep the fermentation process on-going.

Exhaust gas measurements are generally taken from a secondary line, which



R&D Manager Dan Haglund from ROAL states that Vaisala carbon dioxide transmitters require minimal maintenance, and minimize the downtime of the fermentation process.

enables removing undesired elements such as foam or excess humidity from the exhaust gas. The carbon dioxide concentration of the enzyme production process is typically from 0 to 5% of  $CO_2$ , in exceptional cases concentrations as high as 10% of  $CO_2$  have been measured. In a fermentation process where mould is elevated, the carbon dioxide concentration is typically around 1 or 2% of  $CO_2$ . The oxygen concentration of the exhaust gas also depends on the metabolism. Often the metabolism consumes  $O_2$  as much as it produces  $CO_2$ . The relation of the volume of  $CO_2$  released to the volume of  $O_2$  consumed is called the respiratory quotient (RQ).

At the Roal plant, the humidity of the fresh air blown into the bioreactor is measured with Vaisala humidity instruments. Carbon dioxide and oxygen are monitored with the Vaisala CARBOCAP® Carbon Dioxide Transmitter GMT221 and the Vaisala SPECTRACAP® Oxygen Transmitter OMT355, respectively.

The Vaisala carbon dioxide transmitter has been installed in the pilot plant to measure the exhaust gas line with the aid of a field-check adapter from a secondary line. A water trap and a foam removing trap are used since the exhaust gas is very humid and occasionally foam rises into the exhaust tube. The extremely robust Vaisala oxygen transmitter is installed directly into the exhaust tube. "The Vaisala instruments have proved to be very reliable in the pilot plant. They require minimal maintenance and minimize the downtime of the fermentation process", says Dan Haglund.