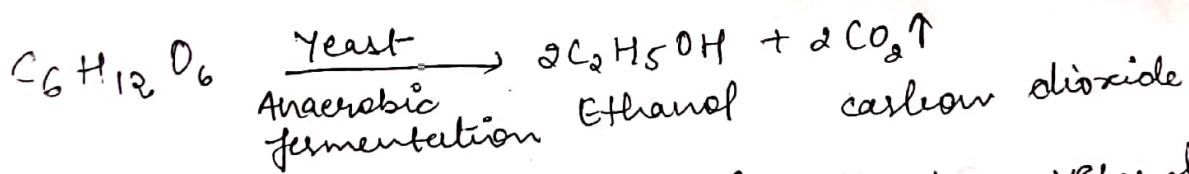


Ethanol or ethyl alcohol (C_2H_5OH) is produced for human consumption for thousand of years and it is used for industrial, laboratory, and fuel (ethanol fuel) purposes, it is referred to as industrial alcohol. Commercial production of ethanol utilizes microorganism belonging to yeast (such as *Saccharomyces cerevisiae* and *Kluyveromyces fragilis*) and the bacteria such as *Zymomonas mobilis*).

The principle substrates for the commercial production of industrial alcohol include molasses or corn, sulphite waste liquor, whey, potatoes and wood wastes.

The process of ethanol production starts by milling a feedstock (such as sugar cane, maize and cheap cereal grains) followed by the addition of dilute sulphuric acid or fungal amylase enzymes from *Aspergillus* or *Rhizopus*, to break down the starches into fermentable sugars. Yeasts are then added to convert the sugars to ethanol which is then distilled off to obtain ethanol up to 96% in concentration.



Fermentation of ethanol is carried out in a very large fermentor, and the inoculum for these fermentor in the range of 3-10 percent and maintained at the optimum growth conditions such as temperature ($21-27^\circ C$), pH, oxygen and concentration of carbohydrates. The fermentation lasts approximately 2-3 days. Fermentation of 100g carbohydrate by selected strains of *S. cerevisiae* yields 45-49% ethanol concentration using both batch and continuous processes.

Butanol

Louis Pasteur, first observed the production of butanol by bacteria in the 19th century. *Clostridium acetobutylicum* is used for the production of acetone, butanol and ethanol. At the present time, butanol is being extensively used in brake fluids, antibiotic recovery procedures, Urea-formaldehyde resins, amines for gasoline additives, and as esters in the protective coating industry.

Butanol is industrially synthesized by using ethylene as a substrate. Butyric acid, butanol, acetone and isopropanol are obtained through clostridial fermentation of starch, molasses, sucrose, wood hydrolysates and pentoses. The fermentation by the clostridia yields a number of products of which acetone, butanol and ethanol are the major products. During fermentation, the starch is digested to yield glucose which is then metabolized to yield butanol and acetone. The culture stocks are usually maintained on dried soil, and continuous culture are not used.

Corn meal for the corn fermentation is prepared by grinding deembryonated corn to fine powder, 8-10% of this corn is heated to gelatinize the starch. The molasses production medium contains 6% sucrose to which are added ammonium sulphate, calcium carbonate, superphosphate and cornsteep liquor.

The fermentation passes through three phases: In the first phase, there is rapid growth and production of acetic and butyric acids and carbon dioxide and hydrogen are evolved in large amounts. With

In the second phase, there is a sharp decrease in the acidity, referred to as 'acid break', in the third stage, there is a decrease in gas evolution and acetone and butanol production. The final product contains 3% acetone, ethanol and butanol. Corn meal medium yields butanol, acetone and ethanol in the ratio 6:3:1, while for molasses, the ratio becomes 6:5:3:5 respectively. The products are removed by distillation which operates in a continuous mode. Individual solvents are separated by fractional distillation.

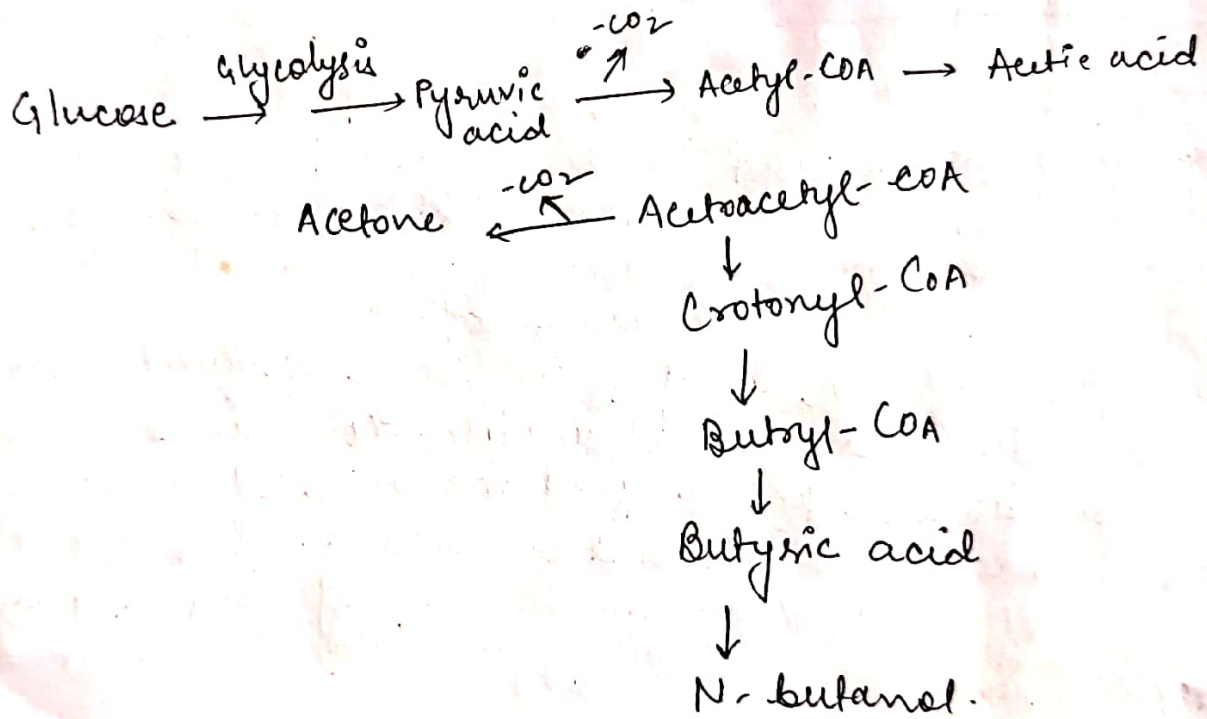


Fig:- Schematic diagram for the production of n-butanol, acetone and isopropanol during acetone-butanol fermentation.

Application of Ethanol:

- Ethanol is used extensively as a solvent in the manufacture of varnishes and perfumes.
- as a preservative for biological specimens
- In the preparation of essences and flavorings.
- In many medicines and drugs.
- As a disinfectant.
- Used as a fuel and gasoline additive.

Application of Butanol:

- Butanol is considered as a potential biofuel.
- Used as a solvent for a wide variety of chemical and textile processes, in organic synthesis, and as a chemical intermediate.
- Used as a component of hydraulic and brake fluids.
- It is used as a base for perfumes.
- It is used as a paint thinner.