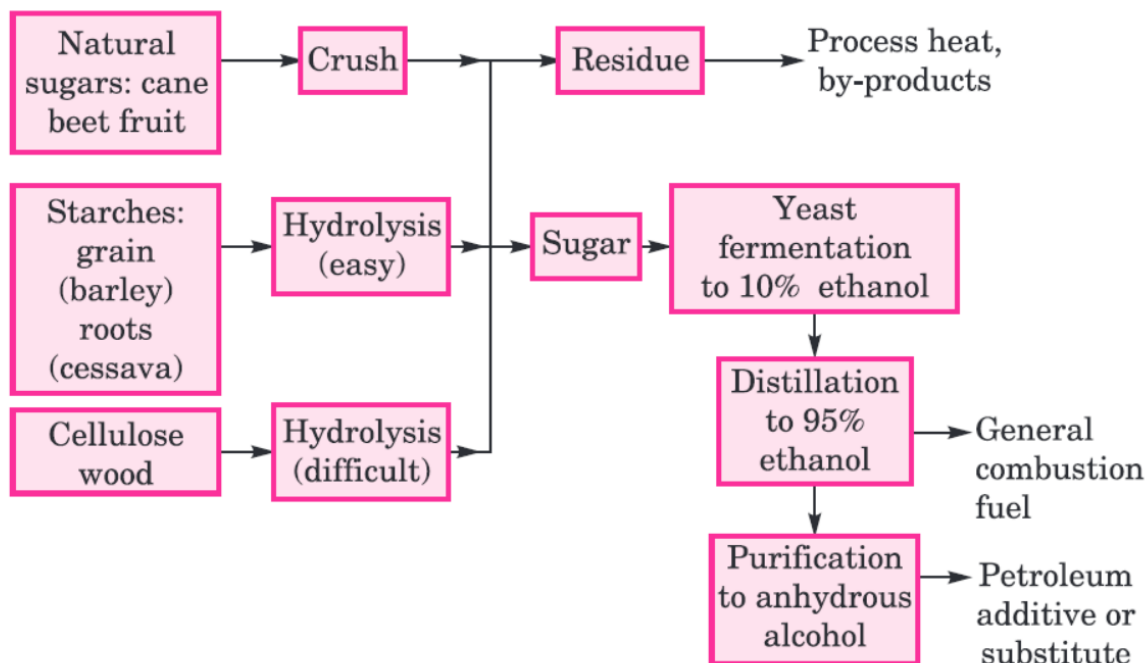


UNIT IV

Ethanol production

Ethanol can be produced from wood through a process known as **cellulosic ethanol production**, which involves converting the cellulose in wood (and other plant biomass) into fermentable sugars, which are then fermented into ethanol. This process is more complex than producing ethanol from simple sugars (as in fermentation of corn or sugarcane) because cellulose is more resistant to breakdown. However, it is considered an important method for producing ethanol from renewable, non-food biomass.



Ethanol production.

Ethanol, C_2H_5OH , is produced naturally by certain micro-organisms from sugars under acidic conditions, pH 4 to 5. This alcoholic fermentation process is used world wide to produce alcoholic drinks. The most common micro organism, the yeast *Saccharomyces cerevisiae*, is poisoned by C_2H_5OH concentration greater than 10%, and so higher concentrations upto 95% are produced by distilling and fractionating. When distilled, the remaining constant boiling point mixture is 95% ethanol, 5% water. Anhydrous ethanol is produced commercially with azeotropic removal of water by codistillation with solvents such as benzene. Only about 0.5% of the energy potential of the sugars is lost during fermentation, but significant amounts of process heat are required for the concentration and separation processes. This process heat may be provided by the combustion or gasification of otherwise, waste biomass.

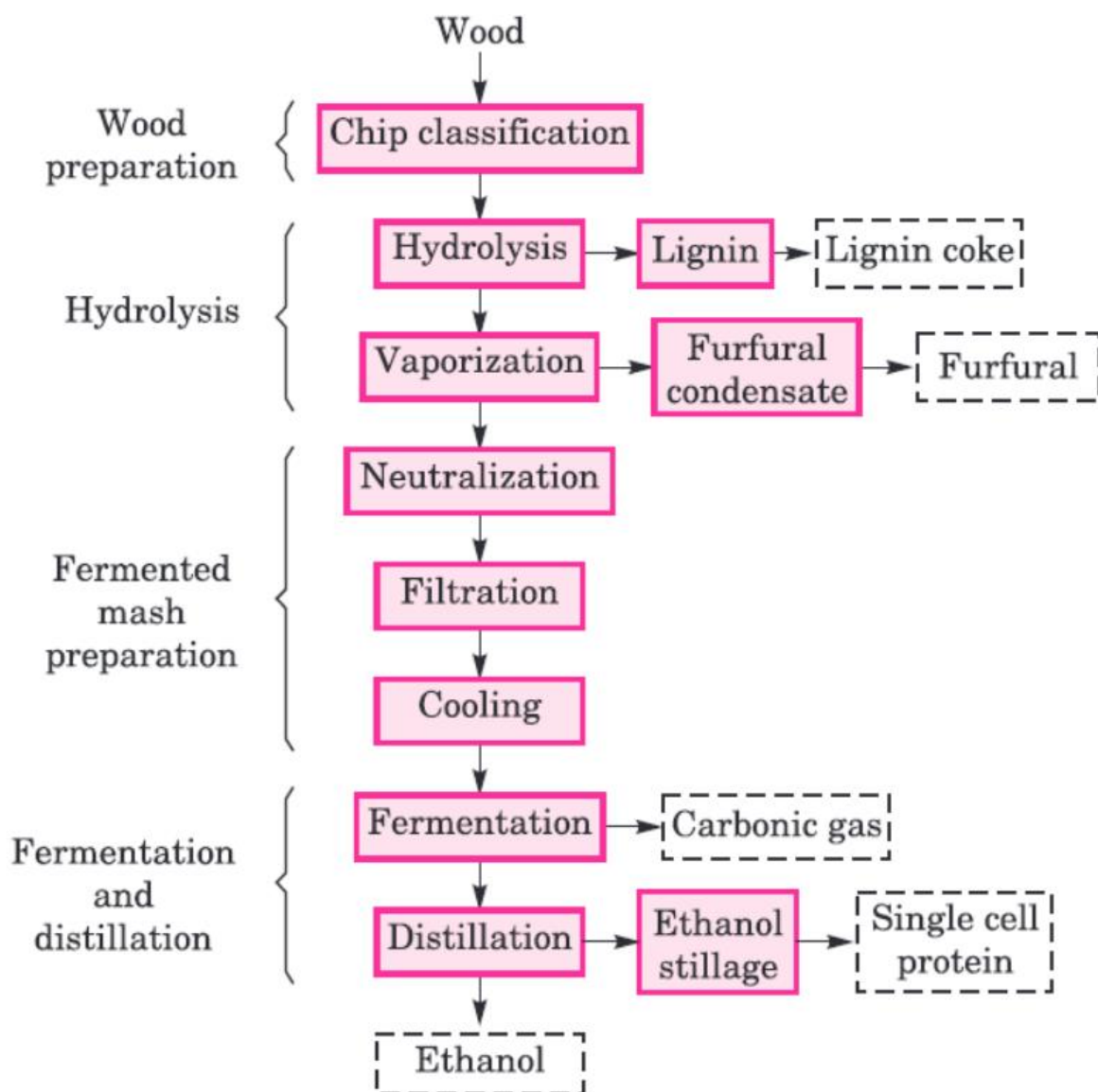
Starch or carbohydrate is an attractive feedstock for many fermentation processes. High yields and starch content (50–60%) give corn an advantage. Spoiled and low quality starches, not suitable for food or animal feed, can be effectively used for production of alcohol.

Ethanol preparation from wood

The basic dilute acid hydrolysis process consists of upto six steps : feed stock preparation, prehydrolysis, hydrolysis of cellulose, neutralization and clean up of the hydrostate, fermentation of hexose sugars to ethanol and distillation.

Pretreatment of the feedstock is not as critical for acid hydrolysis as it is for other conversion methods. With wood, size reduction to chips is generally sufficient. Further size reduction may be required for plug flow reactors.

After hydrolysis, lignin is removed by filtration or centrifugation and sent to the boiler.



Ethanol from wood by acid hydrolysis.

Here's an overview of the process for producing ethanol from wood:

1. Pre-treatment of Wood

The first step is to break down the complex structure of wood, which is primarily made up of cellulose, hemicellulose, and lignin. The goal is to make the cellulose more accessible for enzymatic hydrolysis.

Common pre-treatment methods include:

Steam explosion: The wood is subjected to high-pressure steam followed by rapid decompression, which causes the wood to "explode," breaking open the cell walls and making the cellulose more accessible.

Acid Hydrolysis: Wood is treated with dilute acid (e.g., sulfuric acid) to break down the hemicellulose and cellulose into simpler sugars.

Alkaline Hydrolysis: Wood is treated with an alkaline solution (e.g., sodium hydroxide) to break down lignin and hemicellulose, making the cellulose more accessible.

Enzymatic Hydrolysis: Enzymes are added to break down cellulose and hemicellulose into fermentable sugars (glucose and xylose).

Pretreatment of the feedstock is not as critical for acid hydrolysis as it is for other conversion methods. With wood, size reduction to chips is generally sufficient.

2. Enzyme Hydrolysis

After pre-treatment, enzymes such as cellulase (which breaks down cellulose into glucose) and xylanase (which breaks down hemicellulose into xylose) are used to hydrolyze the polysaccharides (cellulose and hemicellulose) into their constituent sugars. This step is crucial for converting the complex sugars into simple sugars that yeast or other microorganisms can ferment.

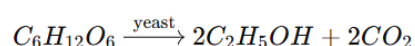
3. Fermentation

The sugar-rich solution obtained from the hydrolysis step is then fermented by microorganisms, usually *Saccharomyces cerevisiae* (a type of yeast), which converts the simple sugars (mainly glucose and xylose) into ethanol and carbon dioxide. However, since *S. cerevisiae* primarily ferments glucose, specialized yeasts or other microorganisms are sometimes used to also ferment xylose, which is abundant in hemicellulose.

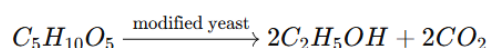
The fermentation process typically occurs in a fermentation tank or bioreactor under controlled temperature and pH conditions. The typical yield is about 1 gram of ethanol for every gram of fermentable sugar present.

Fermentation Reaction:

Fermentation Reaction:



For xylose:



During fermentation, glucose (and potentially xylose) is converted to ethanol and carbon dioxide. The concentration of ethanol in the fermenting mash typically reaches 10–15%, at which point the mixture is distilled to separate the ethanol.

4. Distillation

After fermentation, the mixture contains ethanol along with water and other byproducts. The next step is distillation to separate ethanol from the rest of the liquid. Since ethanol and water have different boiling points, distillation allows ethanol to be concentrated.

Distillation usually results in a concentration of ethanol (usually around 95-96% ethanol by volume), which can then be dehydrated to produce anhydrous ethanol (nearly 100% pure ethanol) if required.

5. Byproduct Treatment

During the production of ethanol from wood, there are various byproducts, including leftover lignin and spent solids from the hydrolysis process. These can be used as:

- **Biofuels:** Lignin can be burned to produce heat or electricity, making the process more energy-efficient.
- **Animal feed:** The remaining solids, known as "stillage," can be processed into animal feed.

Alcohol ethanol production from sugarcane

