CHEMICALS FROM C_3 COMPOUNDS

Propylene

- Processes within refinery which gives propylene are:
  - Steam cracking of hydrocarbons
  - Direct pyrolysis of propane
  - Refinery off-gases
- Consumption pattern for Propylene
  - Isopropanol → Solvent / Acetone
  - Cumene (Isopropyle benzene) → Phenol/Acetone
  - Acrylonitrile → Fibers/ Intermediate
  - Propylene oxide → Polyethers → Polyurethanes (Foams)
  - Isoprene → Polyisoprene (Synthetic rubber products)
  - Polymer – Polypropylene

Isopropanol

- Properties
  - A colorless liquid .
  - Miscible with water.
  - It melts at -89°C and boils at 82.3°C.
  - Oxidation of isopropanol is now the major source of acetone.
- Methods of production:
  - Direct catalytic hydration of propylene (Using solid acid catalyst, Pure propylene is required))
  - Hydration of propylene via sulfation and hydrolysis (Indirect process)
- Uses:
  - As a coolant. As a coupling agent.
  - Production of polyvinyl fluoride.
  - IPA is used also in the production of acetone .
  - Production of other chemicals (such as isopropyl acetate and Isopropylamine.

Isopropanol manufacture

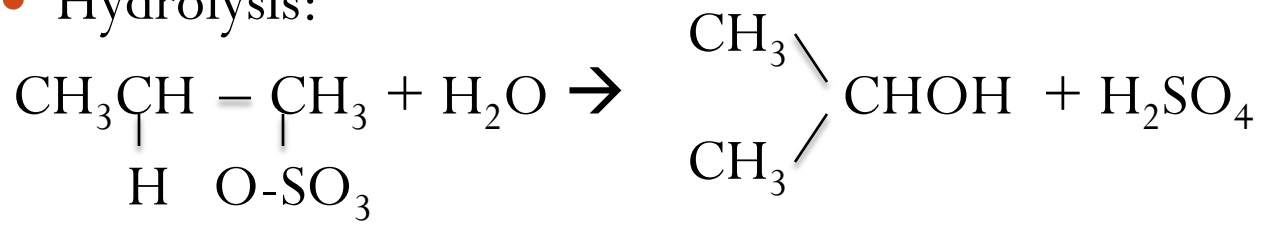
Hydration of propylene via sulfation and hydrolysis

Reaction

- Sulfation:

$CH_3CH{=}CH_2 + H_2SO_4 \rightarrow (CH_3)_2CH(OSO_3H)$ Isopropyl acid sulphate

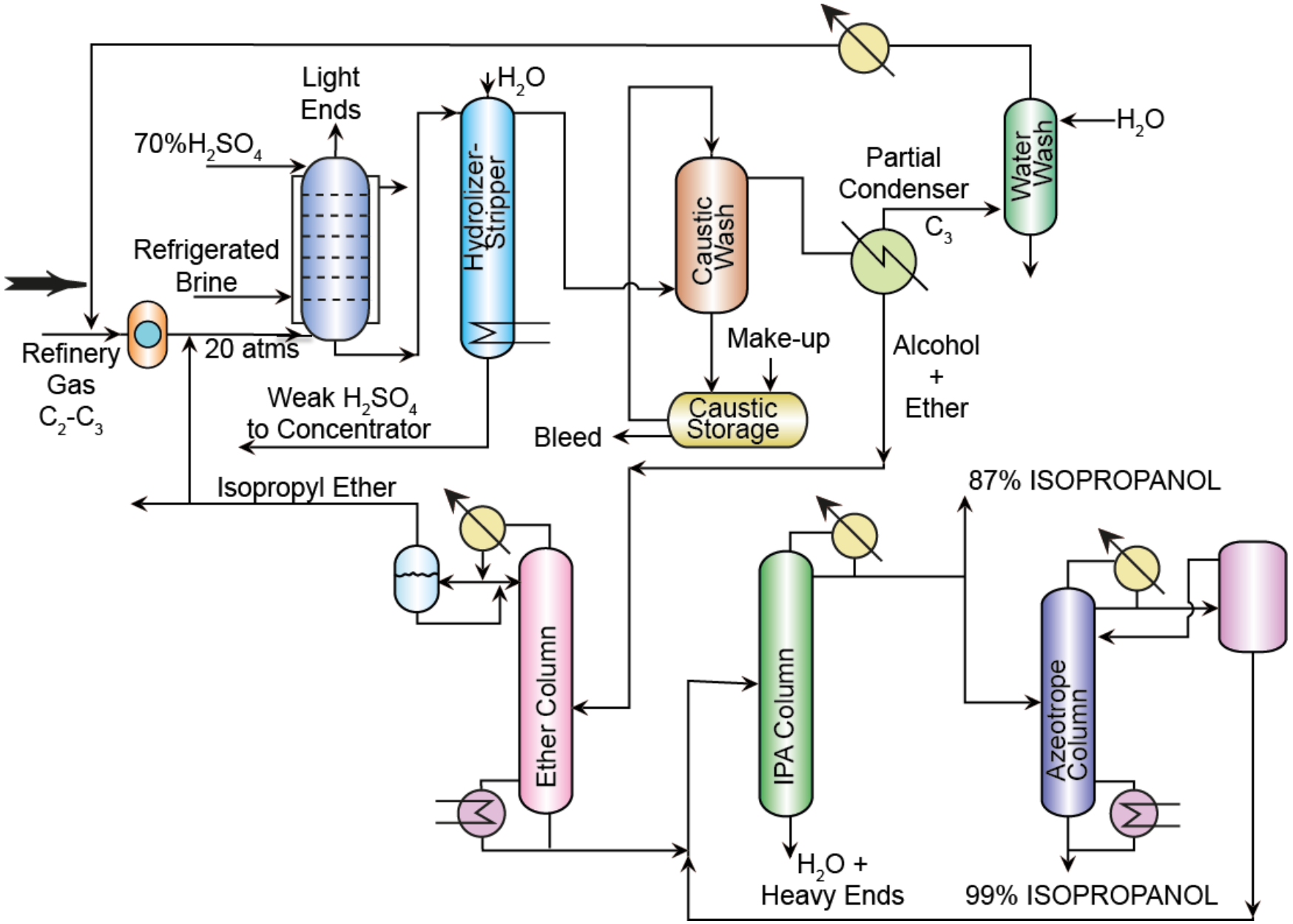
- Hydrolysis:



- Thus sulfuric acid is regenerated in the process
- Side reaction: Di-isopropyl ether forms
- The primary reaction is a gas liquid reaction in which propylene is absorbed into a tray tower fed with sulfuric acid.

- Operating conditions: Room temperature but 20 – 25 atms pressure
- Reaction is highly exothermic

Process Flow sheet



Process Description

- Either pure propylene or a mixture of Propylene and other C_2, C_3 components can be fed to a reactor.
- The hydrocarbon feed is compressed and fed to the reactor at about 20 – 25 atms pressure.
- Sulfuric acid of about 70% acid strength is fed in a countercurrent mode to the tray column where reactive absorption takes place. Here, sulfonation reaction takes place.
- The reaction is highly exothermic and therefore, refrigerated brine is used to control the temperature in the absorber. Jacketed arrangement will be preferred for the tray absorption column to circulate the refrigerated brine in the cooling jacket.
- After reaction, the unreacted light ends such as saturated components will leave the unit as the gas stream.
- The sulfonated product rich stream is then sent to a hydrolyzer cum stripper where isopropanol is produced and is vaporized due to existing stripper temperatures.
- The hydrolyzer is fed with water to facilitate the conversion of the sulfonate product.

- The isopropanol rich vapors then enter a caustic wash unit to remove the acidic impurities.
- The isopropanol rich vapors then enter a partial condenser which separates the unreacted propylene from the alcohol + ether mixture. Here, propylene is separated as the vapor and alcohol + ether is separated as the liquid stream.
- The separated propylene gas is once again subjected to water wash to remove soluble impurities (such as ethers and alcohols). Subsequently, pure propylene is sent to mix with the fresh feed stream. Before sending to the unit, the propylene is cooled to room temperature so as to have identification conditions as the fresh feed stock.
- The alcohol and ether enter an ether column that separates isopropyl ether which is returned to the reactor.
- The bottom product consisting of isopropyl alcohol and water is sent to a isopropyl alcohol column that produces water + heavy ends as the bottom product and 87 % isoprpanol-water azeotrope mixture as the top product.
- The azeotrope is sent to an azeotropic distillation column that uses isopropyl ether as a azeotropic agent to obtain 99 % isopropanol as the bottom product. The top product is a mixture of isopropyl ether and water. The top product is a low boiling azeotrope. This stream upon gravity settling will produce the isopropyl ether as the top product which is sent as a reflux stream to the azeotropic column. The bottom product is a mixture of isopropanol and water is recycled back to the isopropyl alcohol column along with the bottom product generated from the ether separating column.

ACETONE

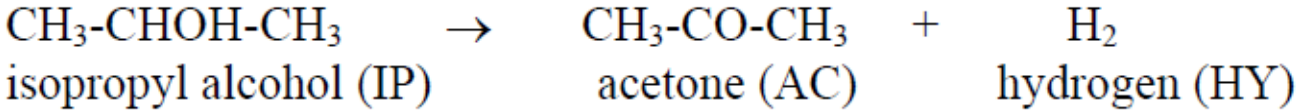
- B.P. = 56.5 ˚C
- Acetone is one of the most widely used industrial solvents and is increasingly used as a chemical intermediate.
- Acetone is extremely flammable with a high vapor pressure; use only with good ventilation and avoid all ignition sources.
- It readily mixes with most organic solvents and mixes completely with water.

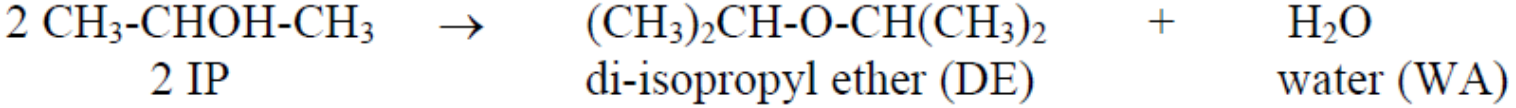
Methods of production:

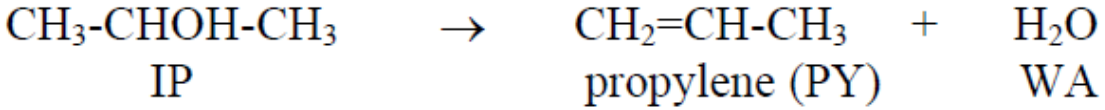
- Acetone is typically produced in commercial quantities as a by-product during the formation of phenol. However, acetone manufactured thus generally contains small amounts of the reactant benzene and the desired product phenol.
- Catalytic dehydrogenation of isopropanol : alternative processes (which do not involve benzene) more attractive.

Catalytic dehydrogenation of Isopropanol

Main Reaction

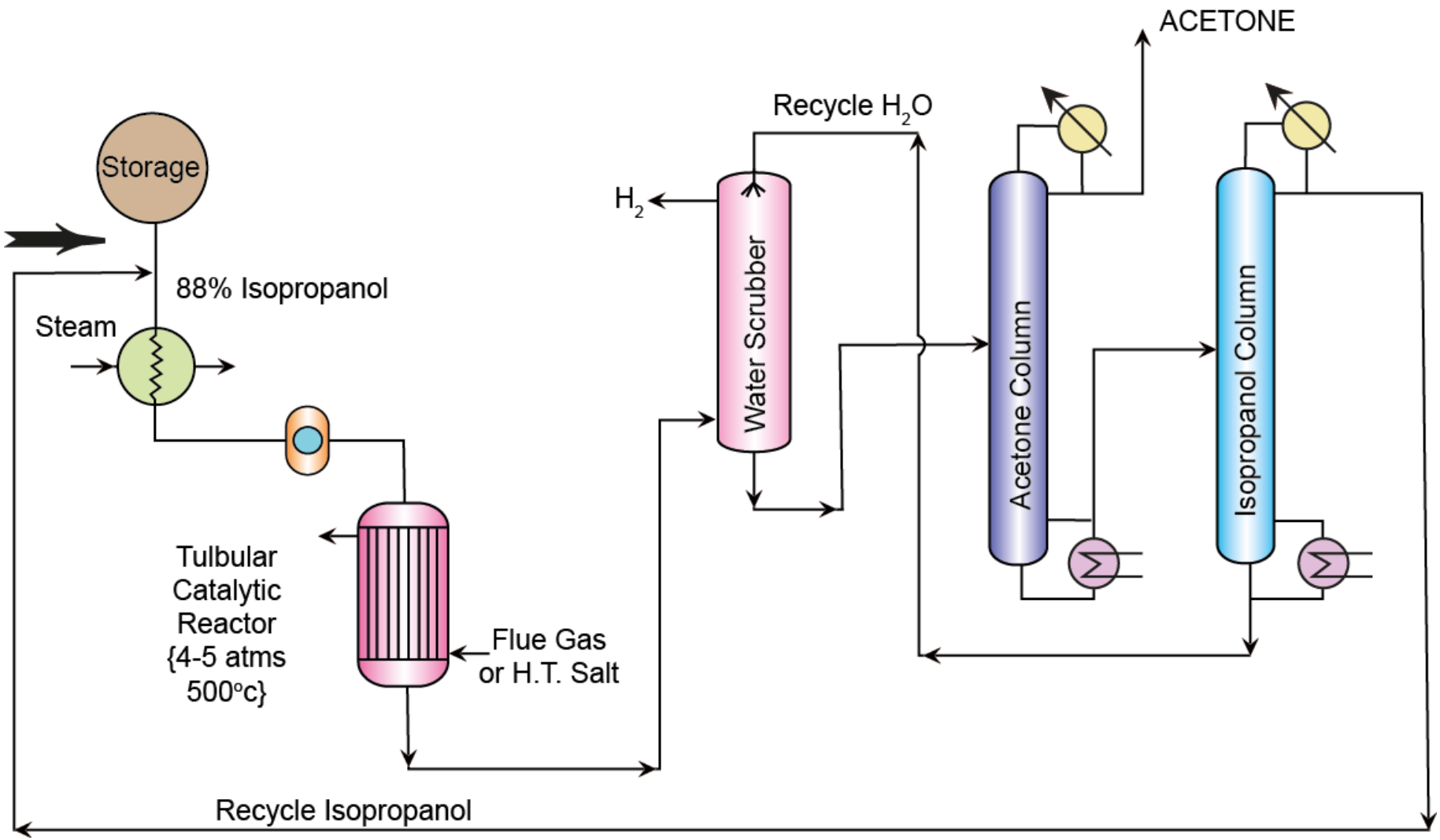






- Reaction pressure: 3 – 4 atms
- Reaction temperature: 400 – 500 °C
- Copper catalyst on porous carrier is used
- Vapor phase reaction

Process Flow sheet



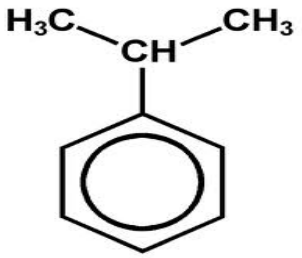
Cumene (Isopropyl Benzene)

- Cumene is produced in large scale plants as intermediate for the phenol manufacturing; it is used as raw material for obtaining phenol and acetone. Cumene is produced by reacting benzene and propylene.
- The reactions for cumene production from benzene and propylene are as follows:

Main Reaction

- $C_3H_6 + C_6H_6 \rightarrow C_6H_5\text{-}C_3H_7$

Propylene Benzene Cumene



Side Reaction

- $C_3H_6 + C_6H_5\text{-}C_3H_7 \rightarrow C_3H_7\text{-}C_6H_4\text{-}C_3H_7$

Propylene Cumene Diisopropylbenzene (DIPB)

Phenol

- Phenol is one of the most important petrochemicals. Ranging from solvents to polymers, phenol is required for several petrochemical processes as an important raw material.

- Phenol can be produced from many sources such as
  - Peroxidation of Cumene followed by hydrolysis of the peroxide (Most common route, Produces 'Acetone' as by product)
  - Two stage oxidation of Toluene
  - Chlorination of Benzene and hydrolysis of chloro-benzene
  - Direct oxidation of Benzene