Chemicals from petroleum
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Oil and gas refinery engineering
First course
Chapter one: Introduction / raw material, characterization

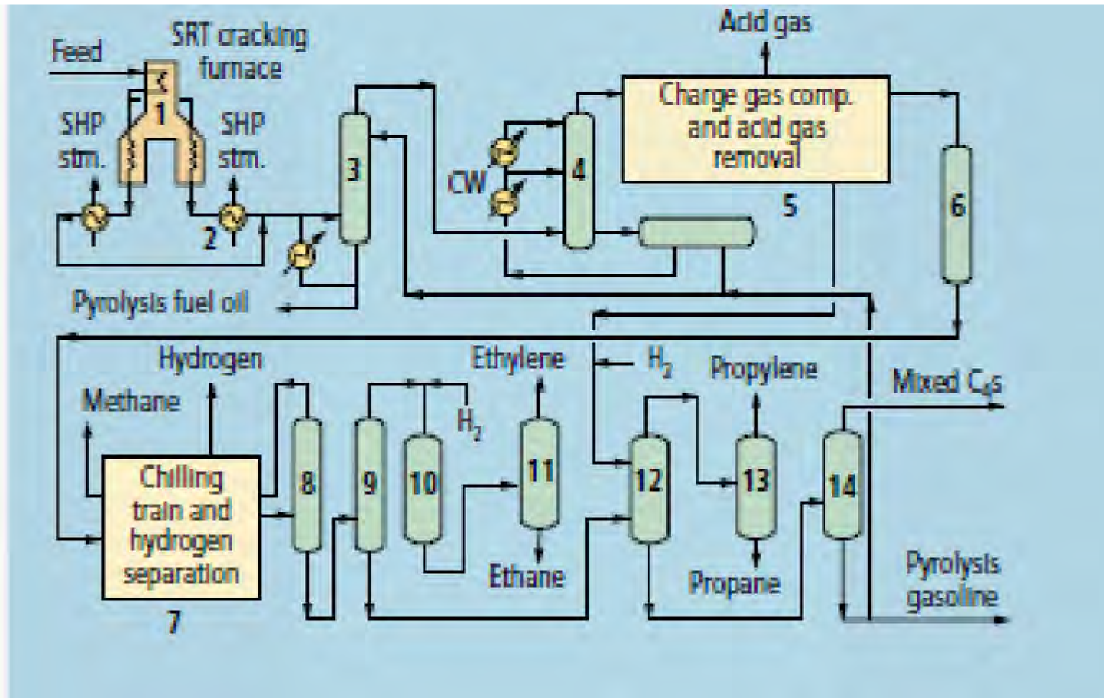
Introduction
Industrial Countries
The world petrochemical industry has changed drastically in the last twenty to thirty years. The United States, Western Europe and Japan previously dominated production of primary petrochemicals, not only to supply their own domestic demand but also to export to other world markets. These areas accounted for over 80% of world primary petrochemical production prior to 1980. However, worldscale construction of petrochemical facilities in other parts of the world has been on the rise. Countries with vast reserves of crude oil and natural gas (e.g., Saudi Arabia and Canada) have constructed plants to add value to their resources. Since these countries generally have smaller domestic demand, a significant share of petrochemical production is earmarked for the export market.
Petrochemicals
Petrochemicals in general are compounds and polymers derived directly or indirectly from petroleum and used
The primary raw materials
In general, primary raw materials are naturally occurring substances that have not been subjected to chemical
Secondary raw materials, or intermediates, are obtained from natural gas and crude oils through different processing schemes.
Two petrochemical classes are olefins including ethylene and propylene, and aromatics including benzene,

Factors affecting development and growth of petrochemical industries:

Characterization petrochemical industries

Generation of petrochemical industry:

Another feed stocks for PCs industries:
1-Nuclear energy. 2-Radinet energy.
4-Thermal-underground
Ethylene
Application: To produce polymer are propylene (chemical or polymer aromatics-rich pyrolysis



Description: Hydrocarbon feedstock is preheated and cracked in the presence of steam in tubular SRT **First: Steam cracking process:**

Treatment of HCS with steam at high temp and low contact time and pressure.:

Mechanism:

1- Dehydrogenation of ethane:

CH3-CH3→CH2=CH2 Ethane Ethylene

CH3CH2CH3 → CH2=CH2+ CH4 Propane Ethylene

2-Dehydrogenation of propane:

CH3CH2CH3 → CH2=CHCH3+ H2

Furnace design:

Operating conditions (OC):

Effect of Operating conditions (OC): on steam cracking process:

Ratio of steam: HCS:

Advantage of use of steam

1-Reduce

2-Reduce

C + H2O →CO +H2

Disadvantages:

1-Reduce the unit capacity. 2-Recovery limited amount of steam.

3- The need of high energy to cool the product

Second: Cooling:

Effluent

Cooling stages:

Cooling is carried out in 2-3 stages according to feed as follows:

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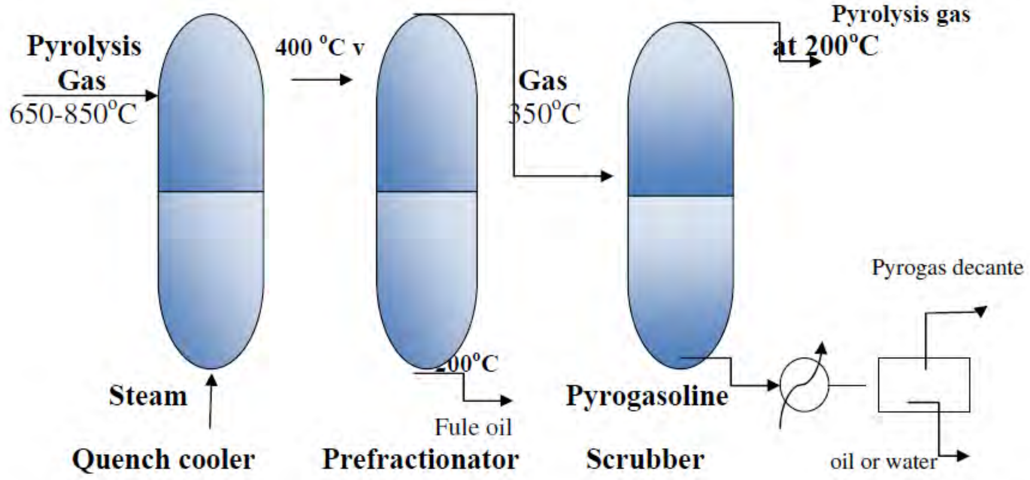


Quenching:

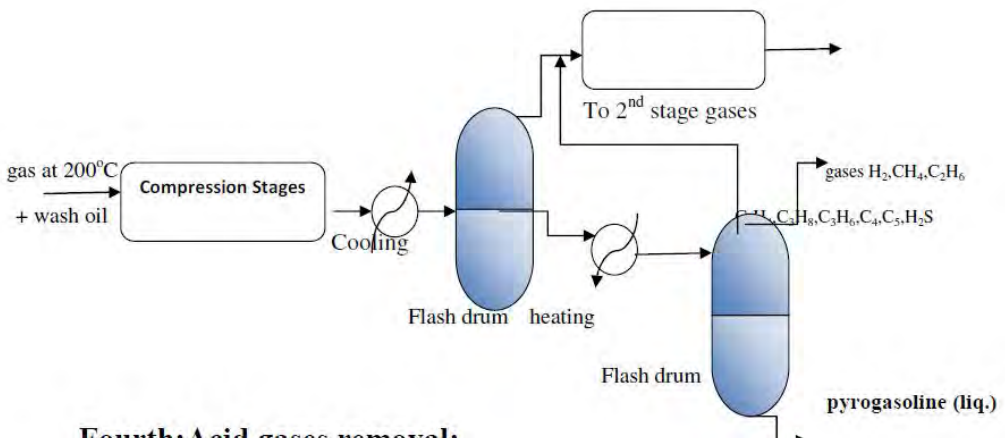
Is carried out first in TLE (Transfer line exchanger) To atemp. Of (375-500OC) by using hot

Final cooling:

Cooling is carried out to about 400C as follows:

Third: Compression:

Pyro.gas contains some impurities with different concentrations differs according to feed type and operating conditions. Impurities are acids gases (H2S, CO2), acetylene and water.



Fourth: Acid gases removal:

Purity requirement in low olefins need to reduce the contain of H2S(1-2)ppm and CO2(10-15)ppm.

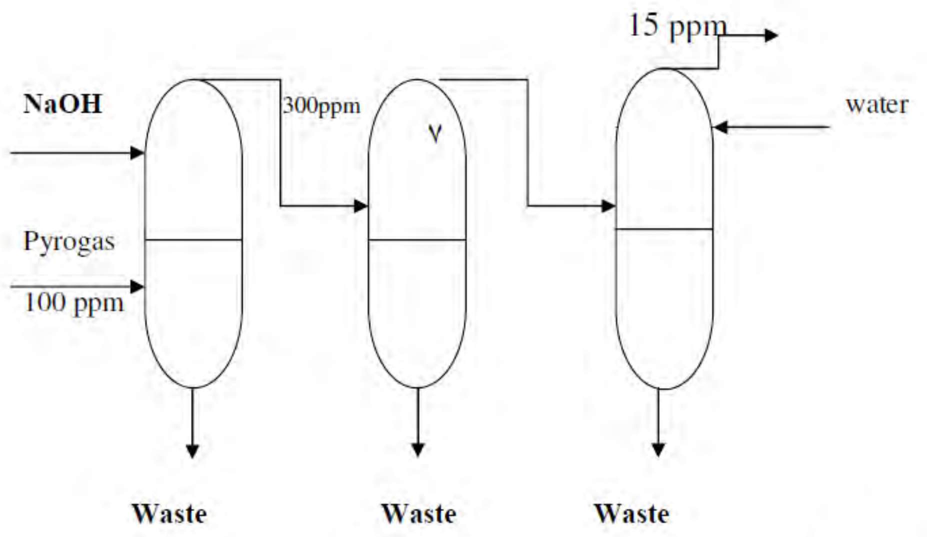
Resonces for acid gas removal:

1-To avoid corrosion problems, and limit solid CO_2 precipitation at low temp.

2- Prevent catalyst (pd) poisoning which is used in acetylene hydrogenation.

Removal process;

Removal



Counter current scrubbing (washing)with dil.NaOH

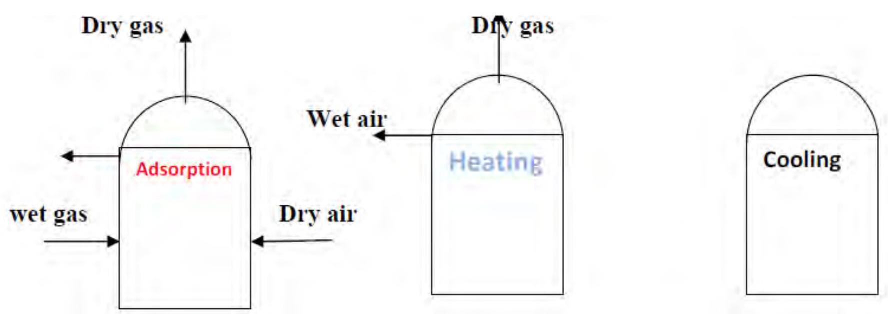
Washing process:

Treated gas from the second stage is washed with water in a separated region in a tower contain

Five: Drying:

Pyro gas

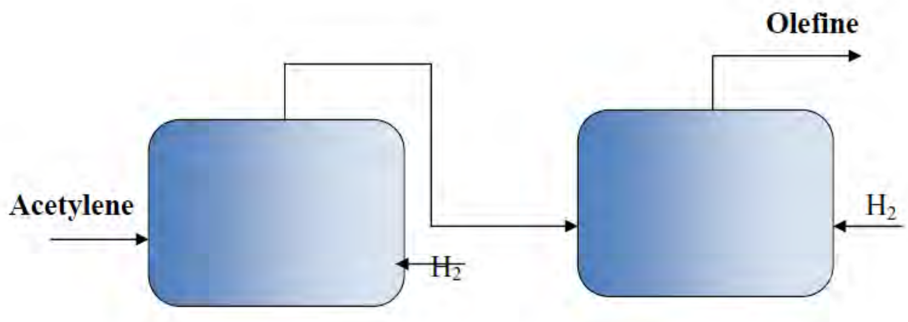
Drying process:



Sixth: Acetylene removal:

Pyro. Gas contains acetylene which its compound separated with olefins with equivalent

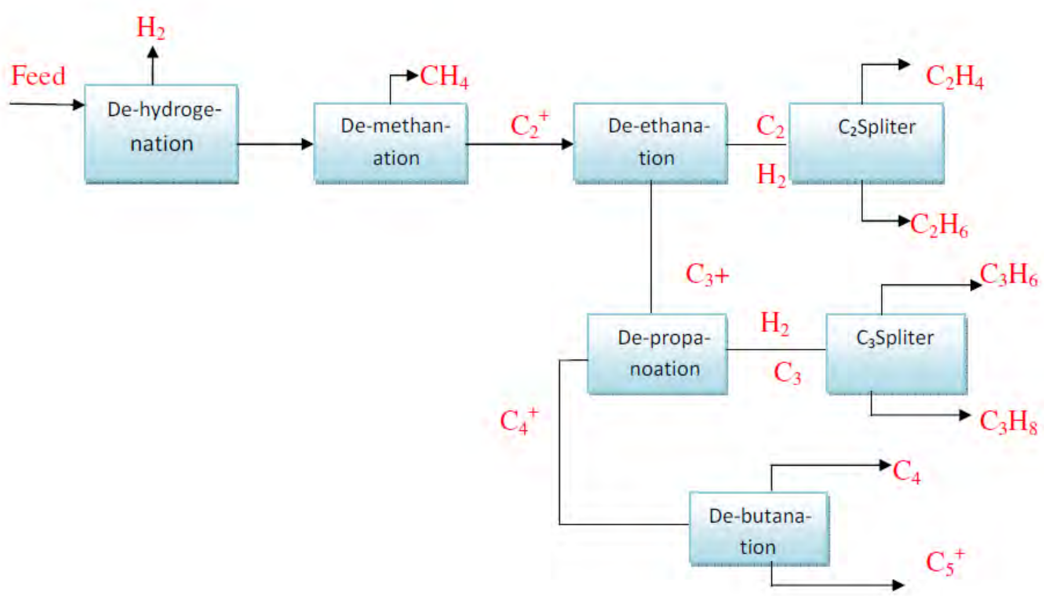
Selective hydrogenation:
Used in almost all low olefins production units.

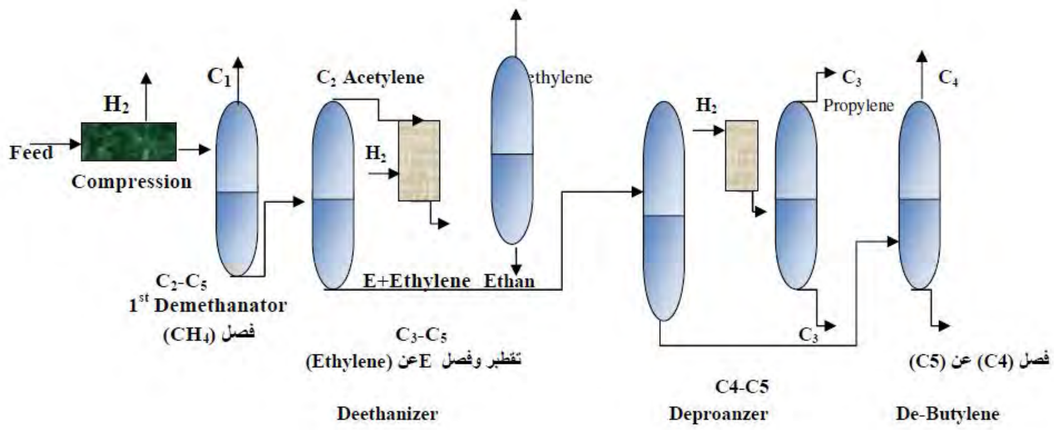


Removal process;
Acetylene removal is carried out either:

Seventh: Product separation:

Separation process:





Energy requirements:

Energy consumption:

Energy recovery:

Buytlenes and Butadienes:

Hydrocarbons with carbon no.4: C4 .Its includes the followings:

Compound	Formula	Mwt.	Density
1- n-butane	$CH_3CH_2CH_2CH_3$	58.12	0.600
2- Isobutane	$CH_3CH_2CH_3$ | CH_3	58.12	0.603
3- Butylene-1	$CH_3CH_2CH_2=CH_2$	56.1	0.668
4- Butylene-2 cis	CH_3 CH_3 CH = CH	56.1	0.635
5- Butylene-2 Trans	CH_3 CH = CH CH3	56.1	0.635
6- Isobutylen	$CH_2=CHCH_3$ CH_3	56.1	0.611
7- 1,3-Butadiene	$CH_2=CH.CH=CH_2$	54.1	------

These chemical available as a mixture with carbon no.-4.Also C4 fraction contains some

Sources of butylene production:

.

Butylene consumption:

Conversion processes-Dehydrogenation

Reactions:

C4H10→CH3CH2CH=CH2 +H2

n-butane 1-butene

C4H10→CH3CH=CH2CH3 +H2

n-butane 2-butene:cis

C4H10→CH3CH=CH2CH3 +H2

n-butane 2-butene:trans

C4H10→CH2=CH-CH= CH2 +H2

Reaction characterization:

1-Reversible 2-Endothermic 3-Occur in gas phase: each vol. gives two vols.:i.e. increase in vol.

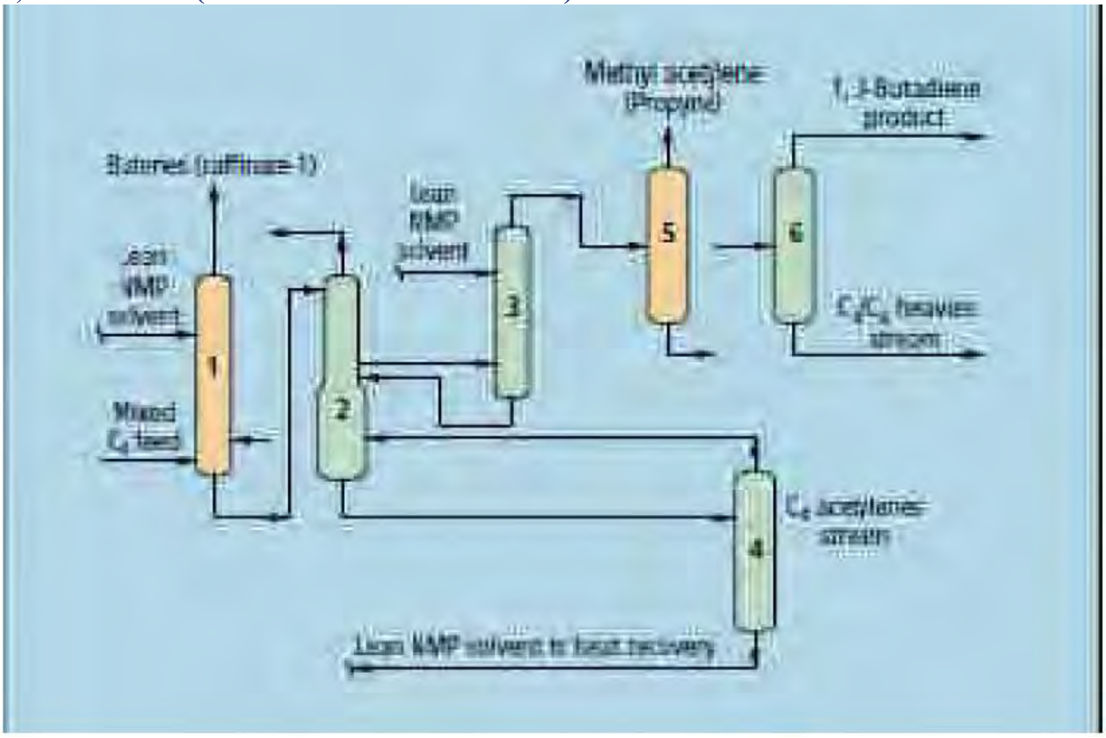
4-Takesplace in selective manner in presence of cata. And T=600-8000C.

Catalyst used:

BD Separation:

Classical method:

1,3 Butadiene (Extraction from mixed C4)

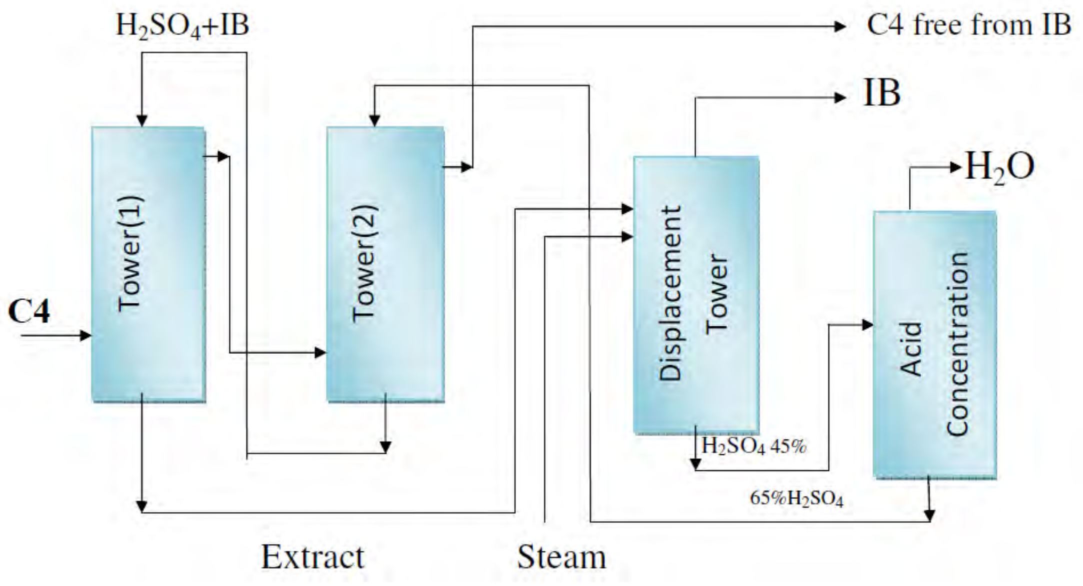


Application: To produce

Description: The mixed C4 feed stream is fed into the first extractive distillation

Isobutylene Separation:

Extraction of Isobutylene from C4 with H2SO4:



Other methods:

Higher olefins:

Products. HO Is classified in to:

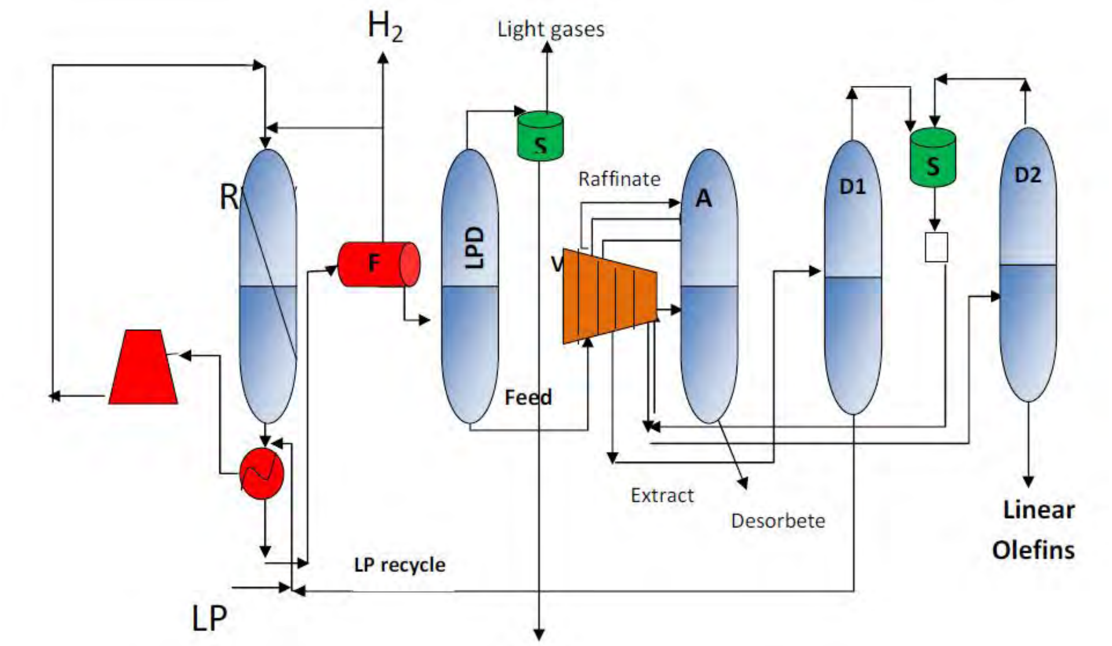
Sources:

Production of HO

Dehydrogenation of n-paraffin U.O.P:

LP: Linear paraffin –H2 → Linear olefin: LO

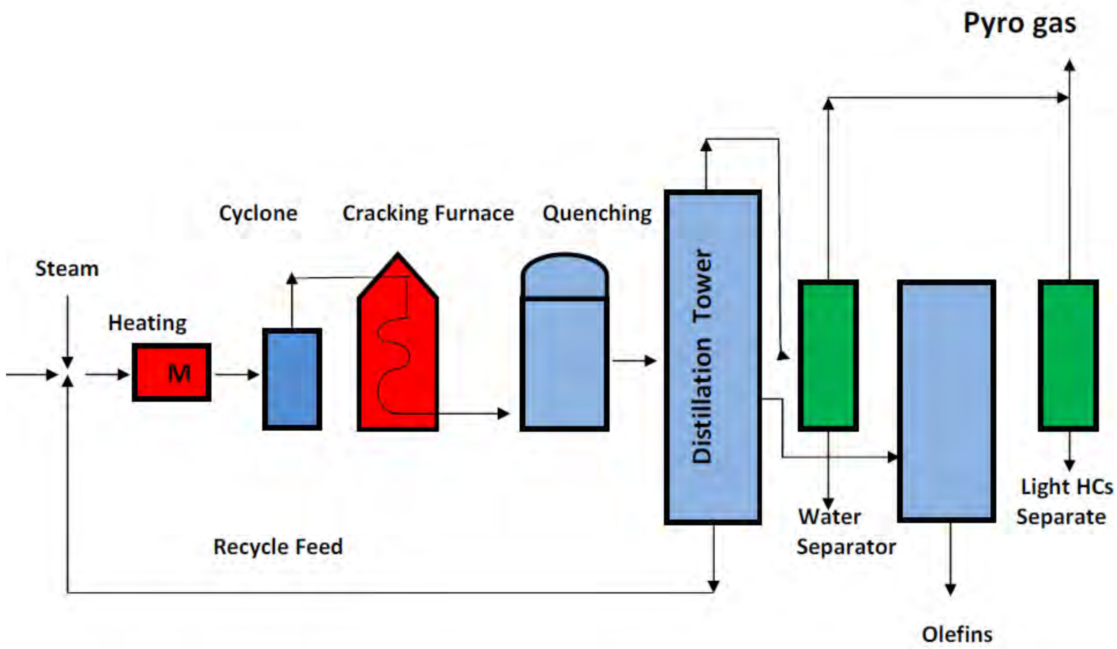
R-CH2CH2-R"↔R- CH=CH-R"



LDP: To separate of light HCS product: by Extraction of LO in special adsorption

Steam cracking of petroleum wax:

Steam cracking conditions:



T=550-650°C RT=10 Sec. Conv.=25-35%

Distillation Tower

This process is considered to be economic if LO-HO is utilized

Linear Alkyl Benzene Complex LAB

LAB: Chemical compounds contains two active parts. **Part(1)**concerning with cleaning process.

Part(2)concerning with dissolving dirt's in water.

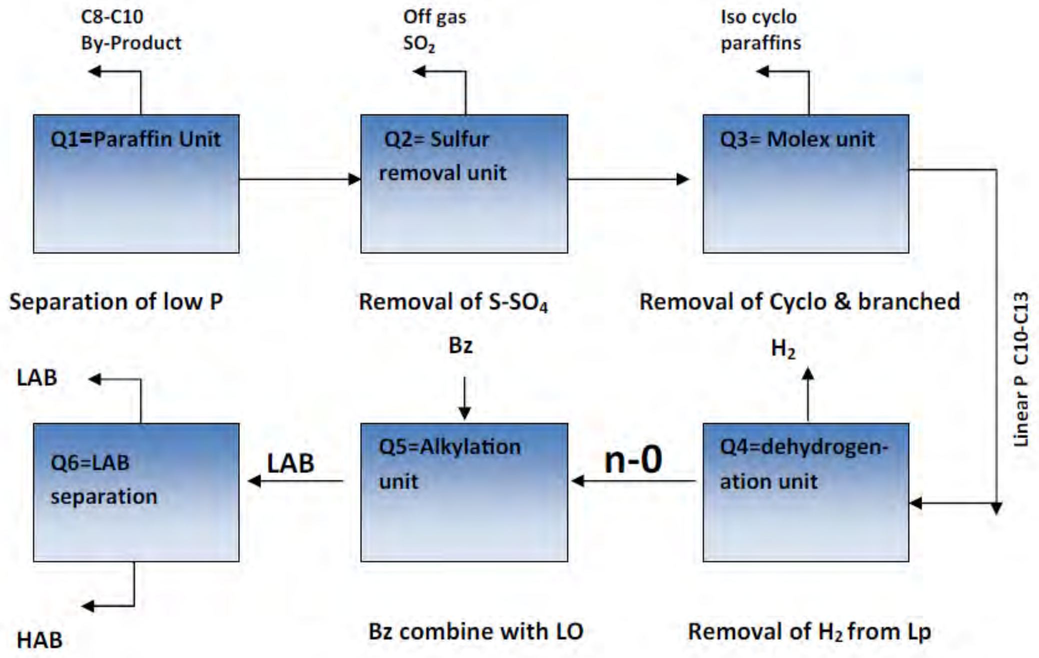
Cleaning process as follows: **1st part** surrounds dirt by inactive layer. The **2nd part** pull the dirt and dissolve them in water and prevent its deposition on the surface.

Example of LAB: Sodium salt of sulfonic acid.

Chemical equation of preparation:

Reaction of

Chemical equation of preparation:



Main units in LAB complex:

1-Paraffin unit 2-Alkyla5on unit 3-Aromatics unit

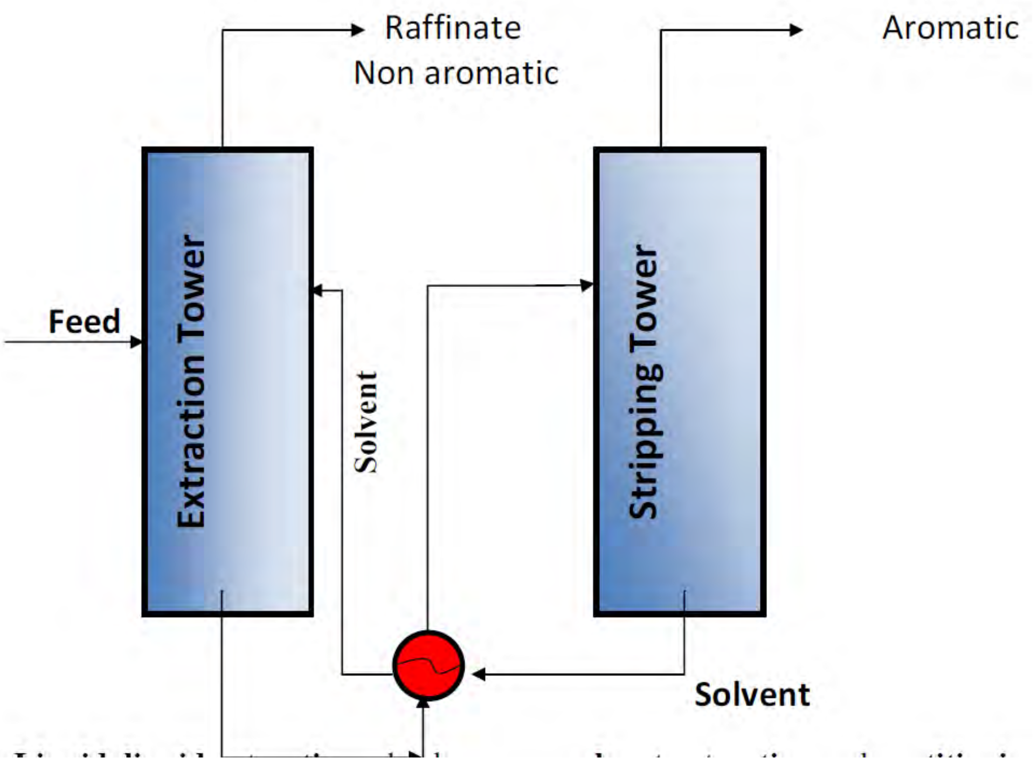
Paraffin unit:

Q1: Paraffin unit **Q2:**Sulfur removal **Q3:**Molex unit.

Alkylation unit:
Q4: Dehydrogenation unit **Q5:**Alkylation **Q6**:LAB separation.
Aromatics:
Compounds with C6-C8 like benzene, toluene ,and xylene(O.M.&P)Known as BTX.

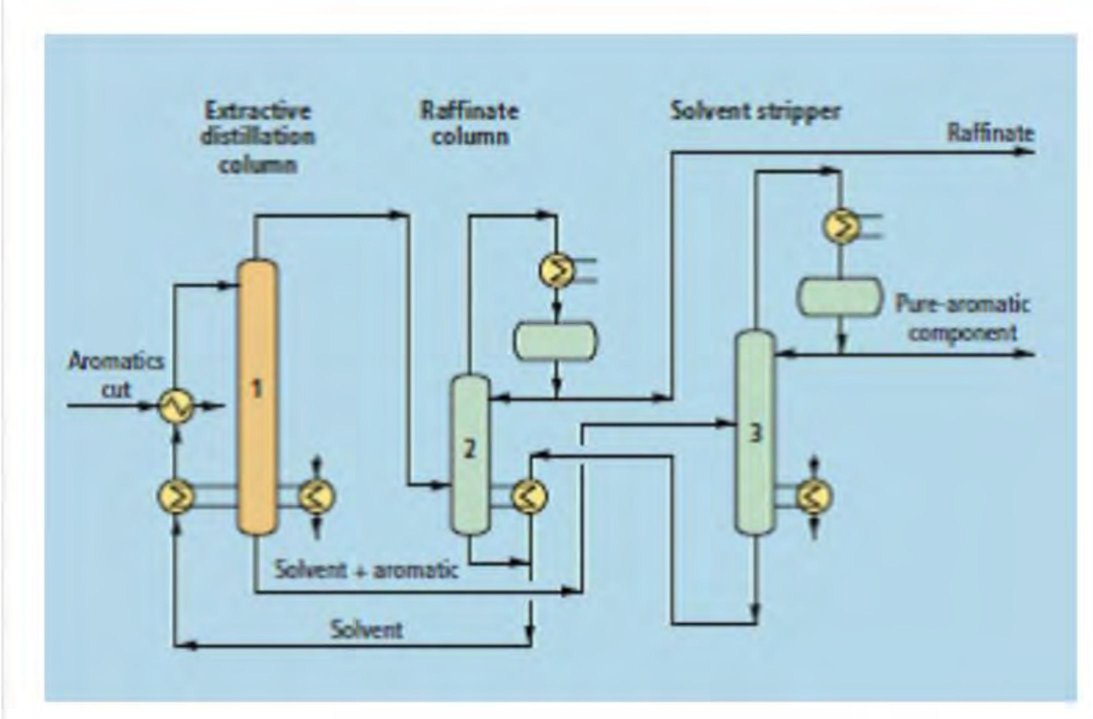
Raw material for basic for PCs.
Uses: Plastic, rubber, fiber, resin adhesive, ,coating, detergents and plasticizer
World production of BTX:
Production of BTX Hydrocarbons

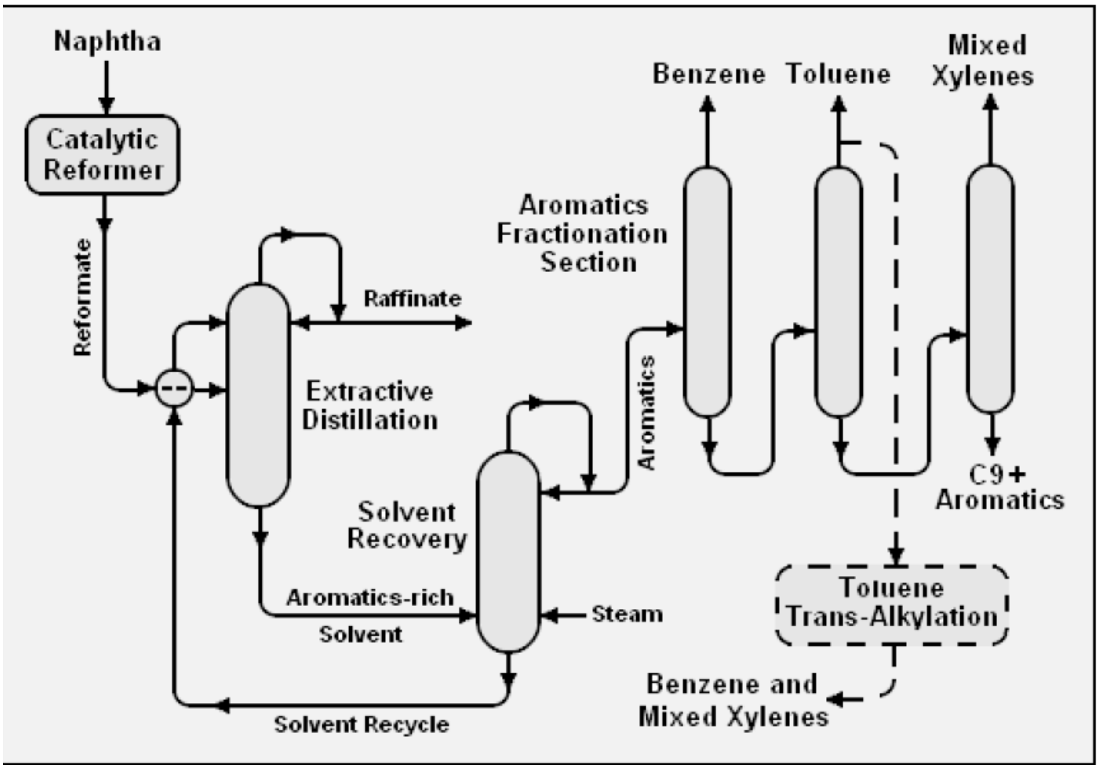
Aromatics separation
1-Solvent extraction:
The BTX aromatics can be extracted from catalytic reformate or from pyrolysis gasoline



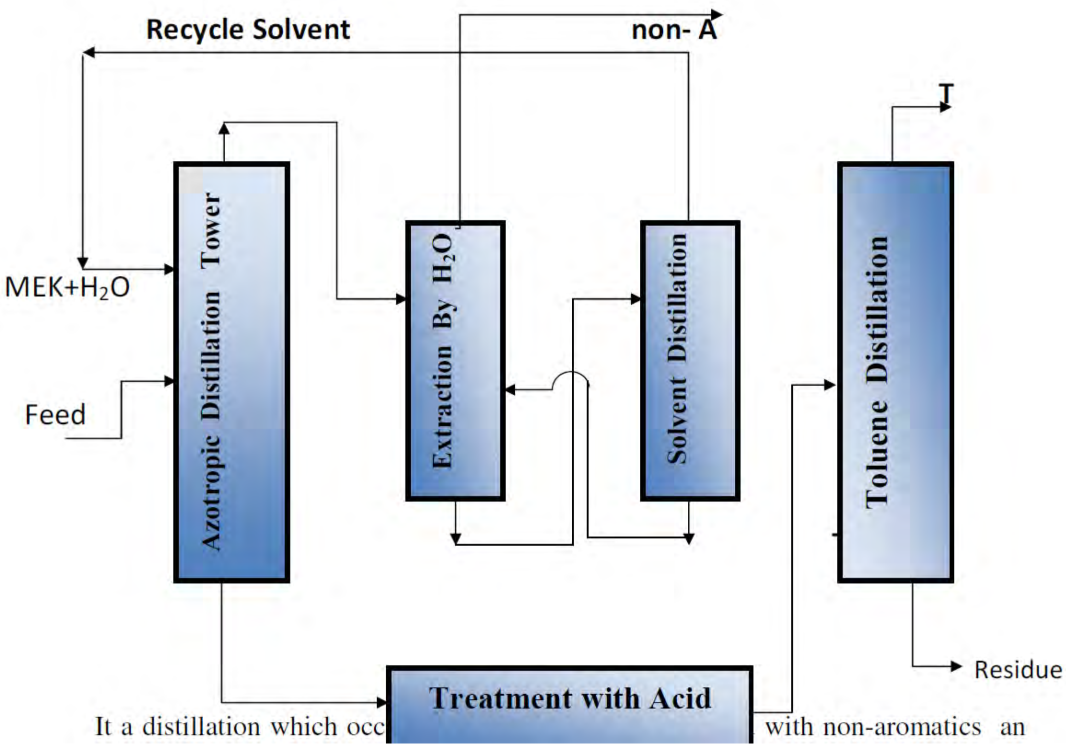
Liquid–liquid extraction, also known as **solvent extraction** and **partitioning**, is a method used to extract
Extraction Tower
Stripping Tower
Solvent
Solvent extraction can also refer to the separation of a substance from a mixture by preferentially

Properties of solvent:





Schematic flow diagram for the extraction of BTX aromatics from a catalytic reformate.

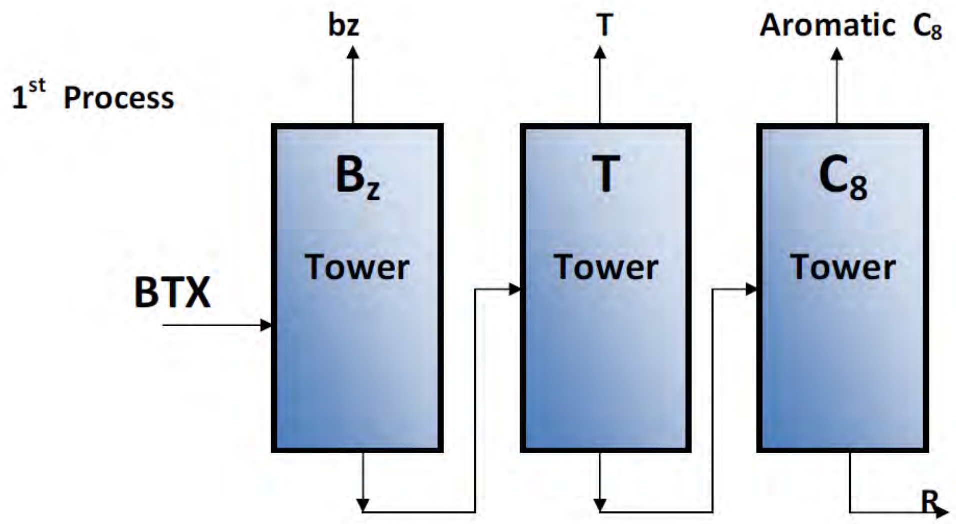


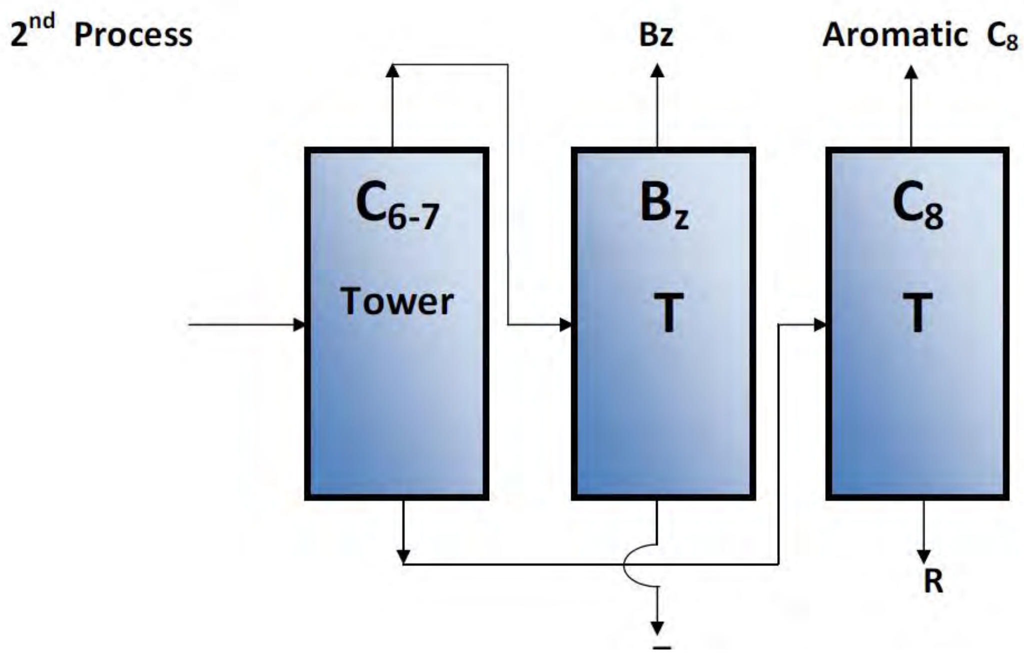
Azotropic Distillation Tower Toluene Distillation Extraction By H2O Solvent Distillation Treatment with Acid

Extractive	Azotropic
System:Solvent+Aromatics:bottom of distillation tower(DT)	Solvent+non-aromatics:top (DT)
Feed:low aromatics content:less than 40%	Aromatics :higher than 40%
Slvent:phenol+H2O,N-methyl pyrolidine,Formal morpholine	Acetone+H_2O for Bz Methanol+H_2O for T MEK+H_2O fot T
Fraction: need fraction with narrow range of b.pt	Fraction: need fraction with narrow range of b.pt

BTX Separation:

Super Fractionation



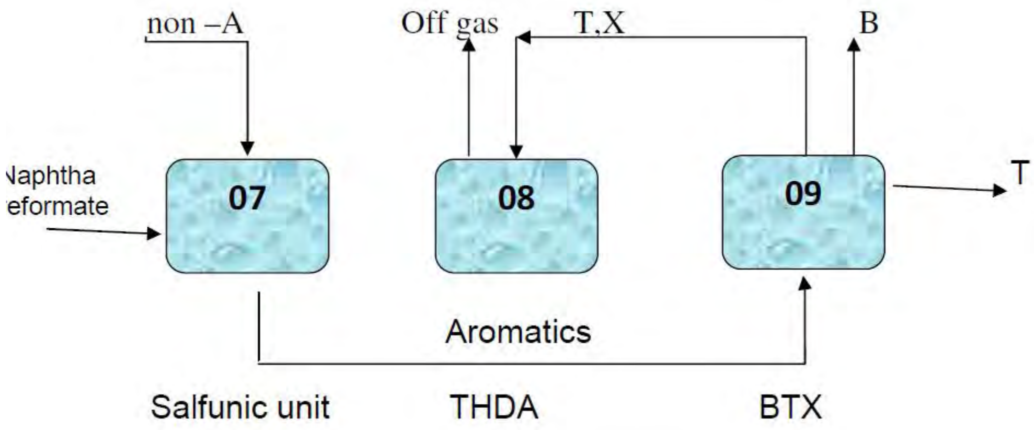


Isomerization of C8:

Isomerization:

Catalyst used in Isomerization:

Aromatics unit in LAB Complex:



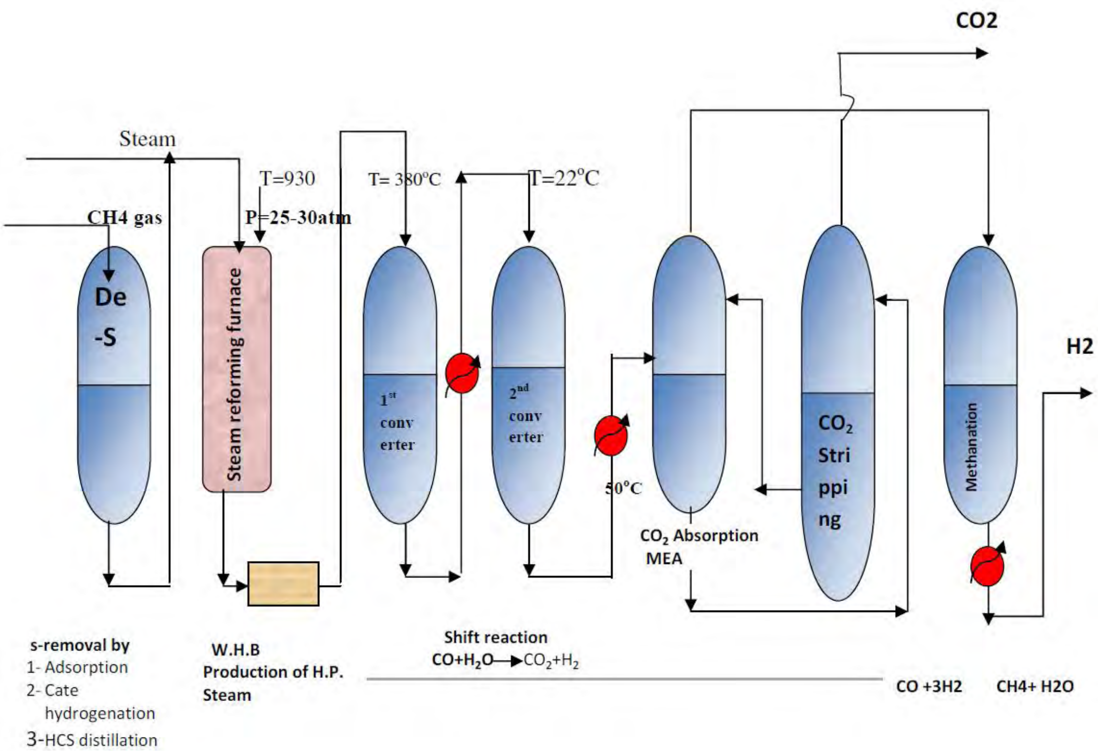
Synthetic gas(syn gas): H2+CO

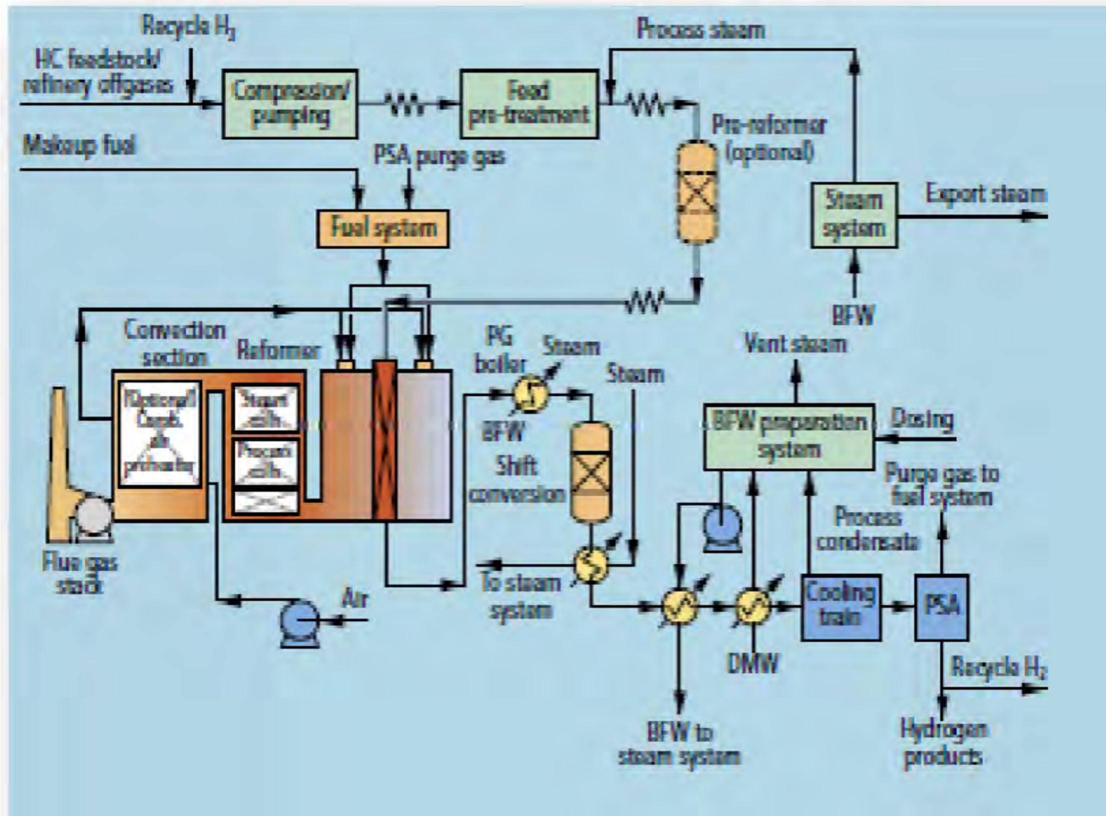
Importance:

Syn gas production:

Hydrogen production from HCs feed

Hydrogen by steam reforming





Application: Production of hydrogen (H steam reforming.

Feed stocks: Ranging from natural gas to heavy naphtha as well as potential refinery off gases. Many

Description: The generic flow sheet

Reactions:

1-CH4+H2O→CO+3H2

2-CO+H2O→CO2+H2 Shift reaction.

3-CO+3H2→CH4+H2O Methanation.

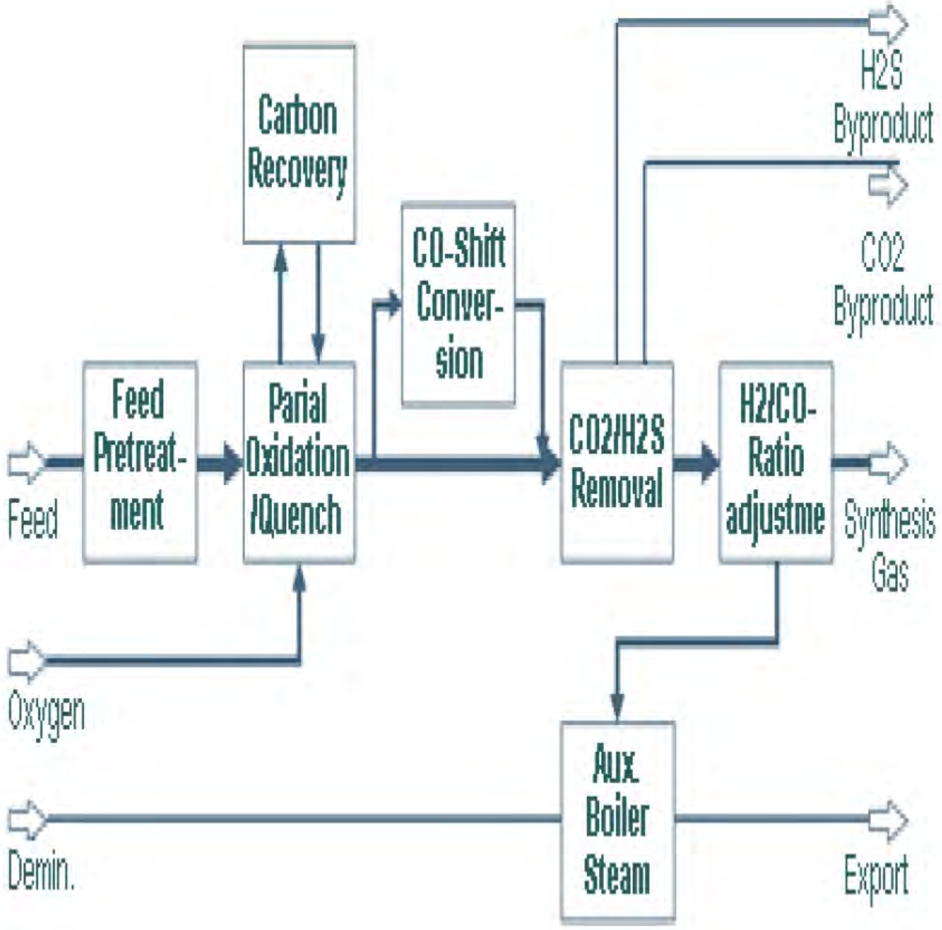
Operating conditions:

T=800-900OC P=25-30 atm. Cata.=Ni(SRF)

H2O/C high ratio

Partial oxidation

Partial oxidation (**POX**) is



PO:Advantages:

Reactions:

$CH_4+O_2 \rightarrow CO_2+H_2O$

$CH_4+CO_2 \rightarrow 2CO+2H_2$

$CH_4+H_2O \rightarrow CO+3H_2$

Basic steps:

1-Gasification:

2-Cooling: Two types according to companies:

a-Quench system:Texco process .

b- W.H.B.:Shell process.

3- **Removal of soot**. 4-**Conversion of CO to CO2** 5-**Removal of CO2,H2S.**

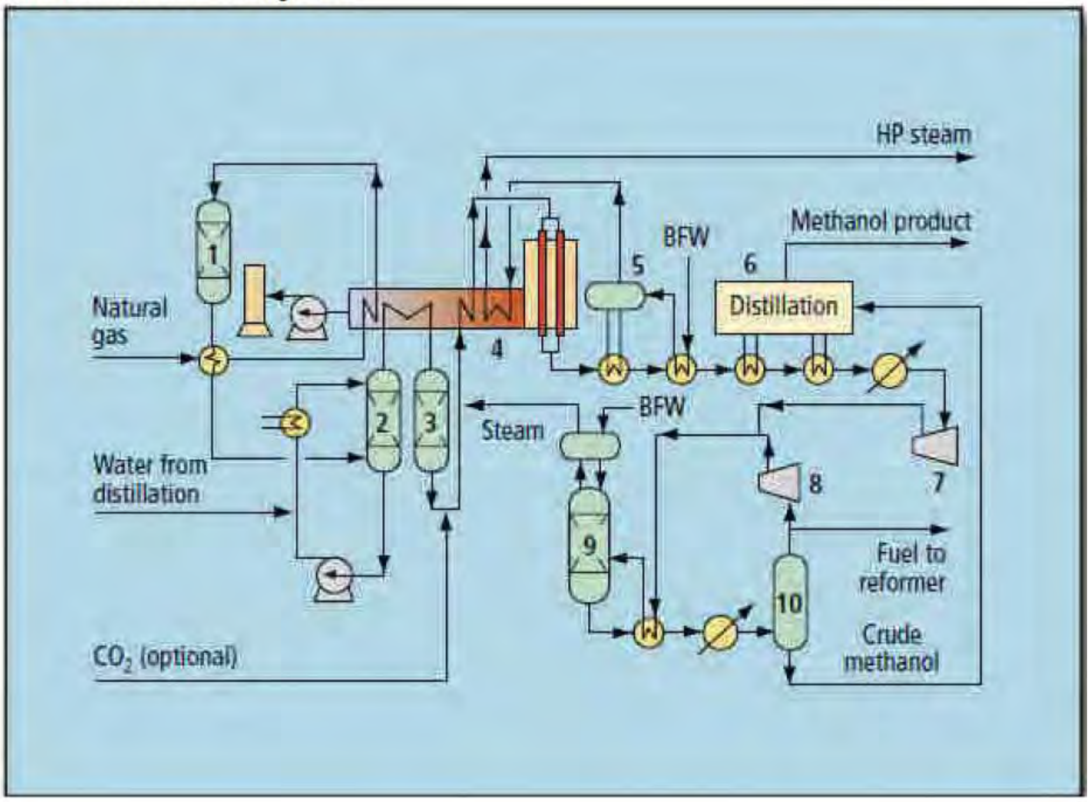
6-**Removal of inert gases like Ar,CO**.

7-**Compression of resultant gases(H2) or mixture(CO,H2)**

Comprism between Steam reforming(SR)and Parital oxidation(PO)

Properties	SR	PO
Feed	More important when CH_4 or NG as feed	Used for heavy pet. Fraction and residue
Cata.	Need Cata.	Does not need Cata
Economic	More economic due to low investment cost, also no need to oxygen unit	Less economic due to high investment cost, and the demand of oxygen unit.

1-Methanol CH_3OH



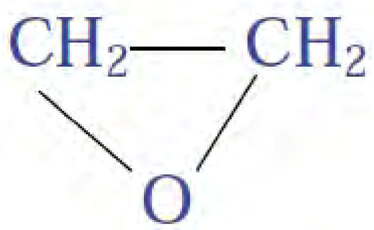
$$CO + 2H_2 \leftrightarrow CH_3OH$$

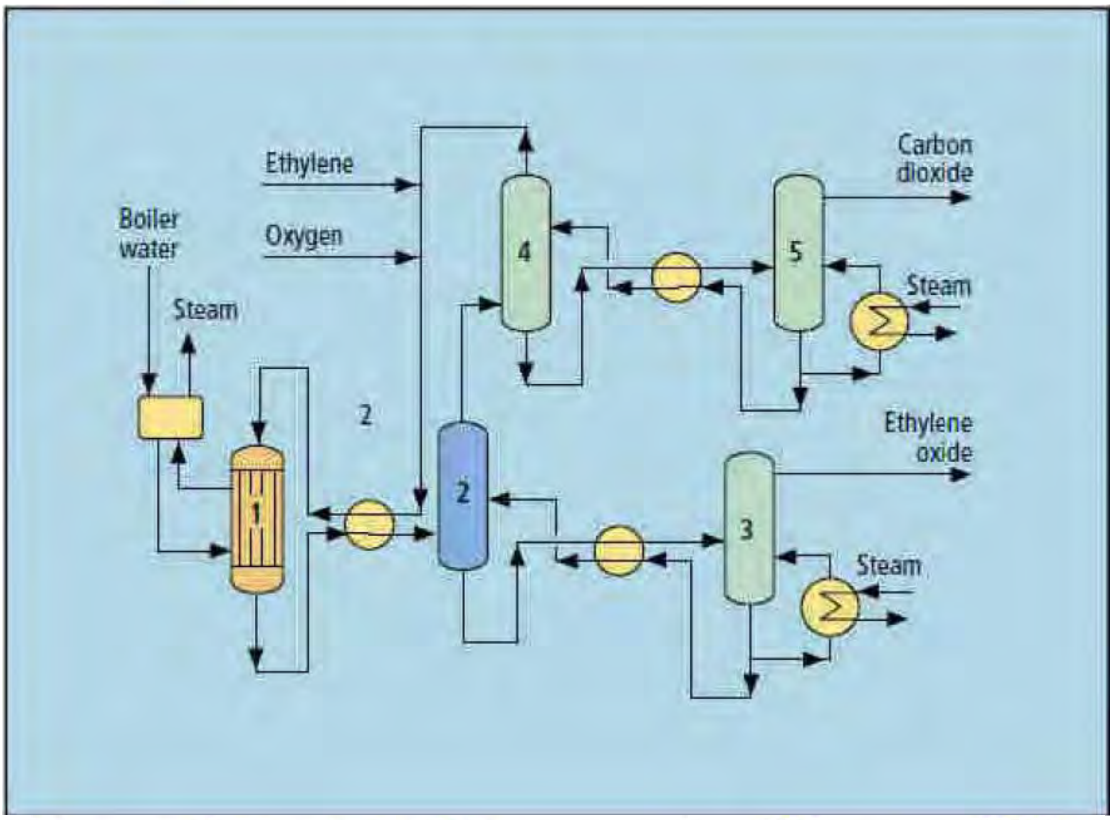
Application: The One Synergy process is improved low-pressure methanol process to produce methanol

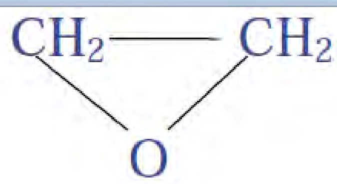
Description: Gas feedstock is

Economics: Recent trends have been to build methanol plants in regions offering low-cost gas (

2-Ethylene oxide





$CH_2 = CH_2 + 0.5O_2 \longrightarrow$ 

Application: To produce ethylene oxide (EO) from the direct oxidation of ethylene using the Dow Meteor process.

Description: The Meteor Process, a technology first commercialized in1994, is a simpler,

Economics: The process requires a lower capital investment and has lower fixed costs due to process

Commercial plants

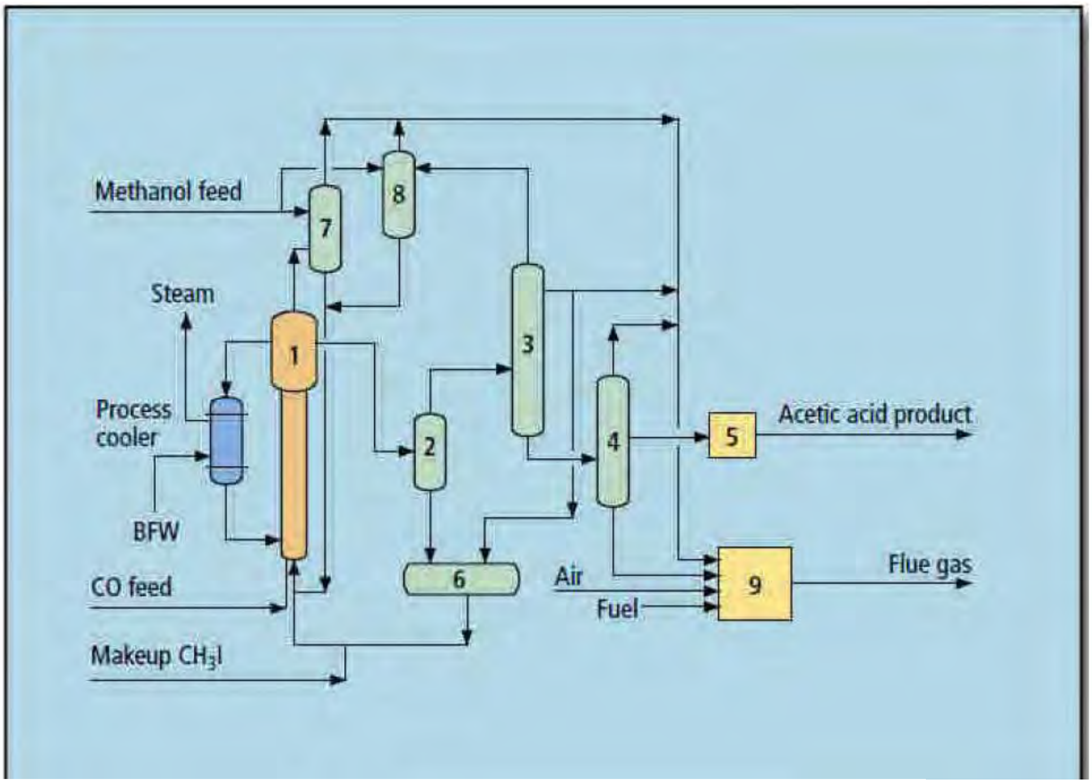
Advantages:

Plant with one reactor work with high selectivity with low conversion for each cycle. Reactants used with high concentration which reduced the capital cost.

Disadvantages:

EO Uses:

3-Acetic acid CH3COOH



$$CH_3OH + CO \rightarrow CH_3COOH$$

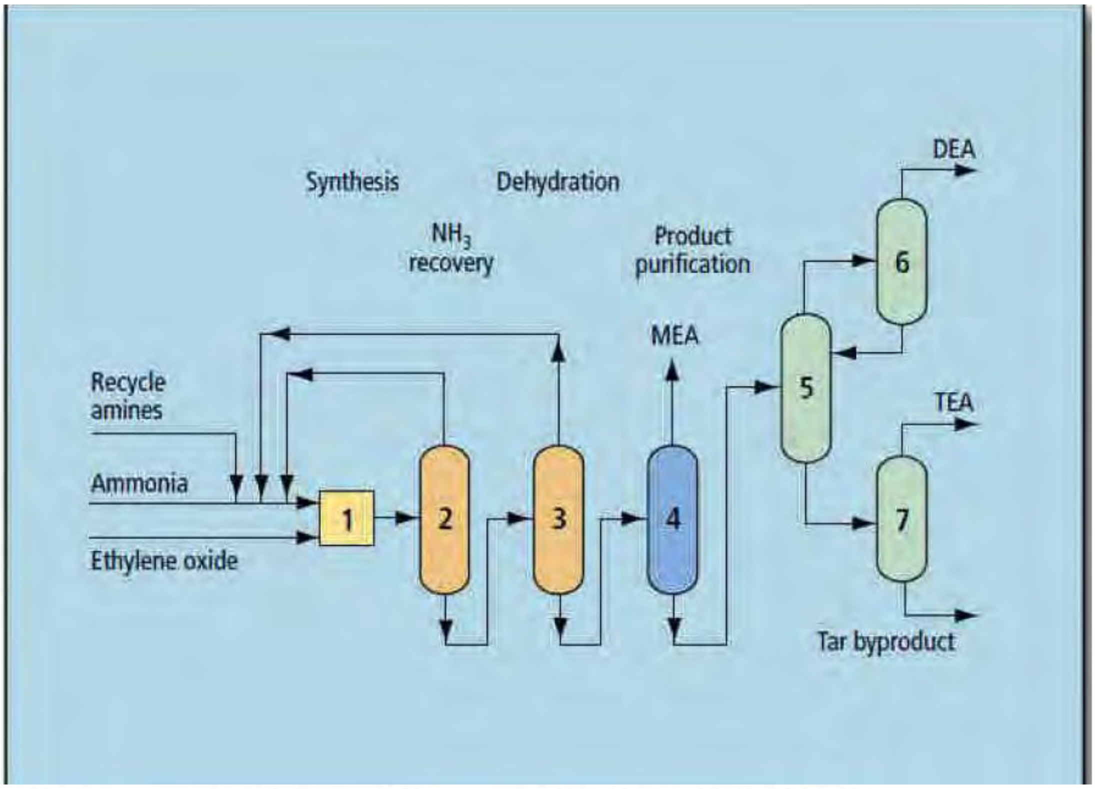
Application: To produce acetic acid using the process, ACETICA. Methanol and carbon monoxide (CO) are reacted with the carbonylation reaction using a heterogeneous Rh catalyst.

Description:

Feed and utility consumption:

Commercial plant: One unit is under construction for a Chinese client.

4-Ethanolamines,MEA,DEA &TEA



$$\underset{\text{O}}{CH_2 - CH_2} + NH_3 \rightarrow HOCH_2CH_2NH_2$$

MEA (75%)

$$MEA + EO \rightarrow (HOCH_2CH_2)_2NH$$

DEA (21%)

$$DEA + EO \rightarrow (HOCH_2CH_2)_3N$$

TEA(4%)

Application: To produce mono-(MEA), di-(DEA) and triethanolamines (TEA) from ethylene oxide and ammonia.

Description:

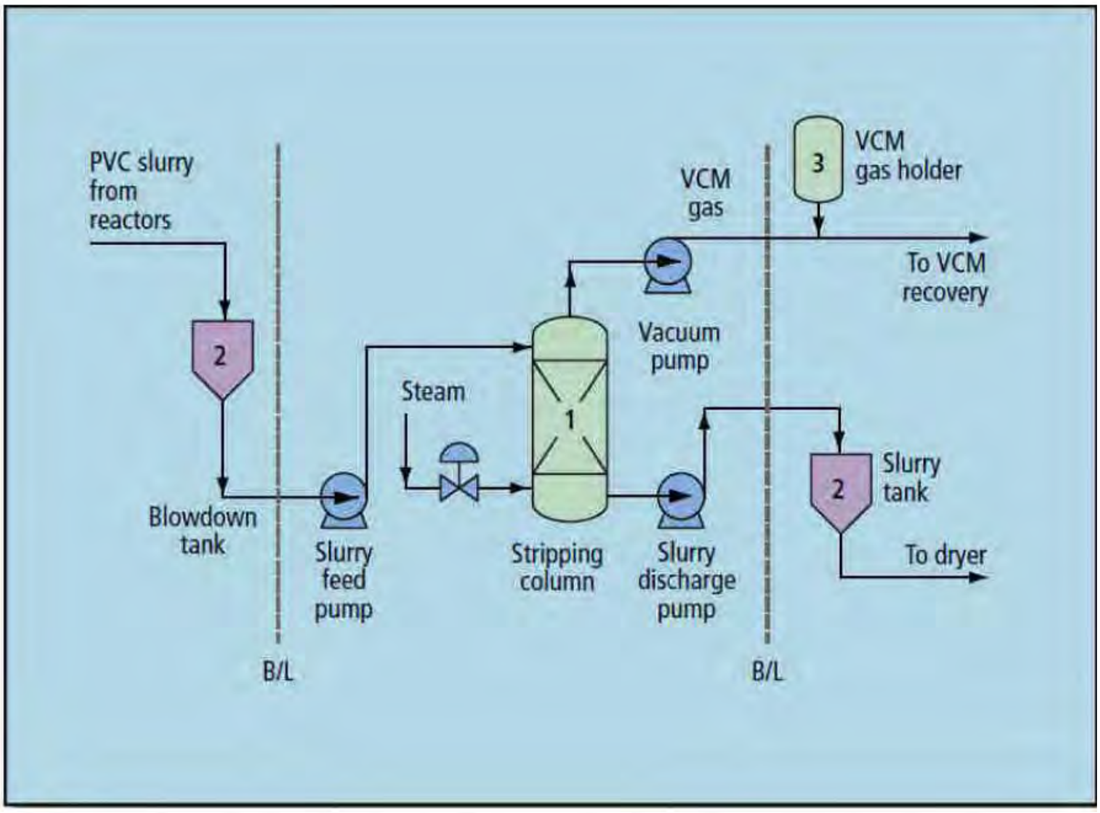
Yields: Greater than 98% on raw materials.

Economics: Typical performance data

Commercial plants: One 20,000-mtpy original capacity facility.

Uses:

5-Vinylchloride monomer VCM CH(Cl)=CH2



$$C_2H_4 + Cl_2 \rightarrow ClCH_2CH_2Cl \quad \text{catalyst } FeCl_3 \text{ and } C_2H_5Br$$

$$C_2H_4 + 2HCl + \frac{1}{2}O_2 \rightarrow ClCH_2 - CH_2Cl + H_2O \quad \text{catalyst } Cu_2Cl_2$$

Application: Adding a stripping column to existing polyvinyl chloride (PVC) plants to remove vinyl chloride monomer (VCM) from PVC slurry. The recovered VCM can be reused in the PVC process, without any deterioration of PVC polymer quality.

Description: PVC

The process design is compact with a small area requirement and low investment cost. The size of the column is 2.5 t / h to 30 t / h.

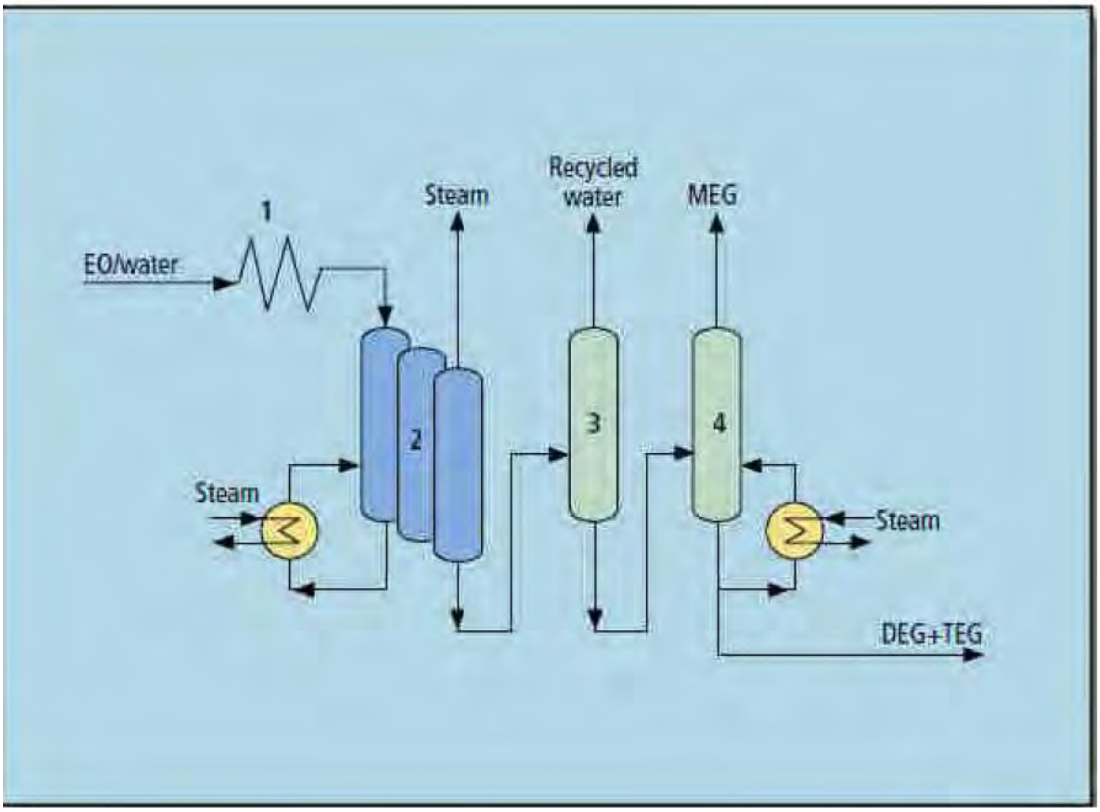
Economics:

Steam 130 kg/t of PVC

Commercial plants: Chisso has licensed the technology to many PVC producers worldwide. More than 100 columns of the Chisso process are under operation or construction, and total capacity exceeds 5 million tpy of PVC.

6-Ethylene glycol

$$HOCH_2CH_2OH$$



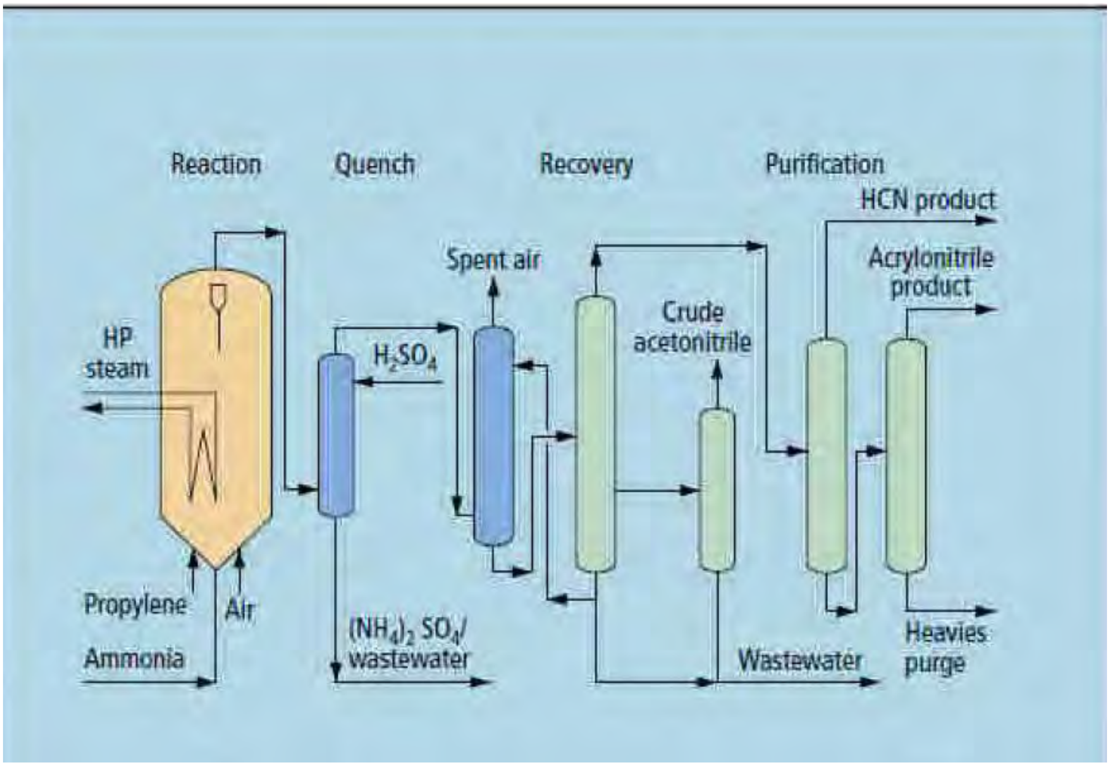
$$CH_2 - CH_2 \;(\text{O bridge}) + H_2O \rightarrow HOCH_2CH_2OH$$

MEG

Application: To produce ethylene glycols (MEG, DEG, TEG) from ethylene oxide (EO) using Dow's Meteor process.
Description: In the
Economics: The conversion of EO to glycols is essentially complete. The reaction not only generates the desired MEG, but also produces DEG and TEG that can be recovered as coproducts.
Commercial plants: Since 1954, 18 UCC-designed glycol plants have been started up or are under construction.
Uses:

7-Acrylonitrile

$$CH_2 = CHCN$$



$$CH_{2=}CH - CH_3 + NH_3 + 4O_2(air) \rightarrow CH_2 = CHCN + 4H_2O$$

Application: A process to produce high-purity acrylonitrile and highpurity hydrogen cyanide from propylene, ammonia and air. Recovery of byproduct acetonitrile is optional.

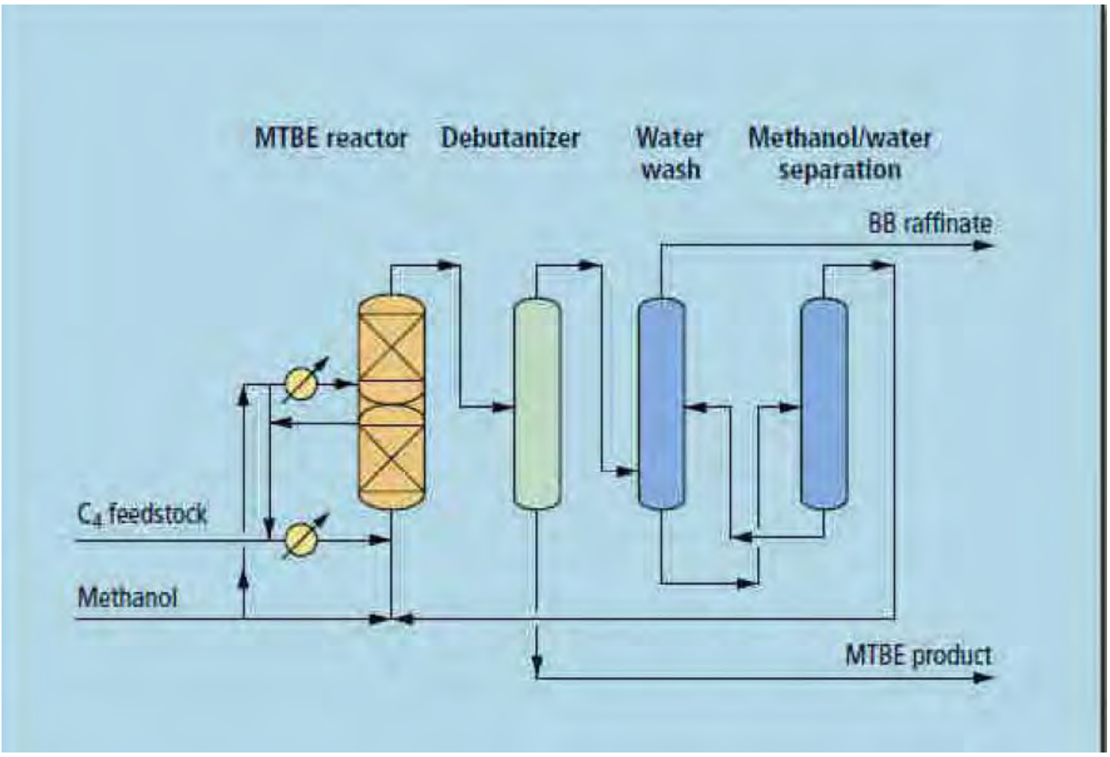
Description: Propylene, ammonia, and air are fed to a fluidized bed reactor to produce acrylonitrile

Commercial plants: DuPont Chemical Solution Enterprise,
Beaumont, Texas (200,000 mtpy).

Uses: For production of Acrylic fibers ,flexible plastic ,Rubber And resins.

8-Methyl-Tetra-Butyl-Ether (MTBE)

$$(CH_3)_3COCH_3$$



$$CH_3C(CH_3) = CH_2 + CH_3OH \rightarrow (CH_3)_3COCH_3$$

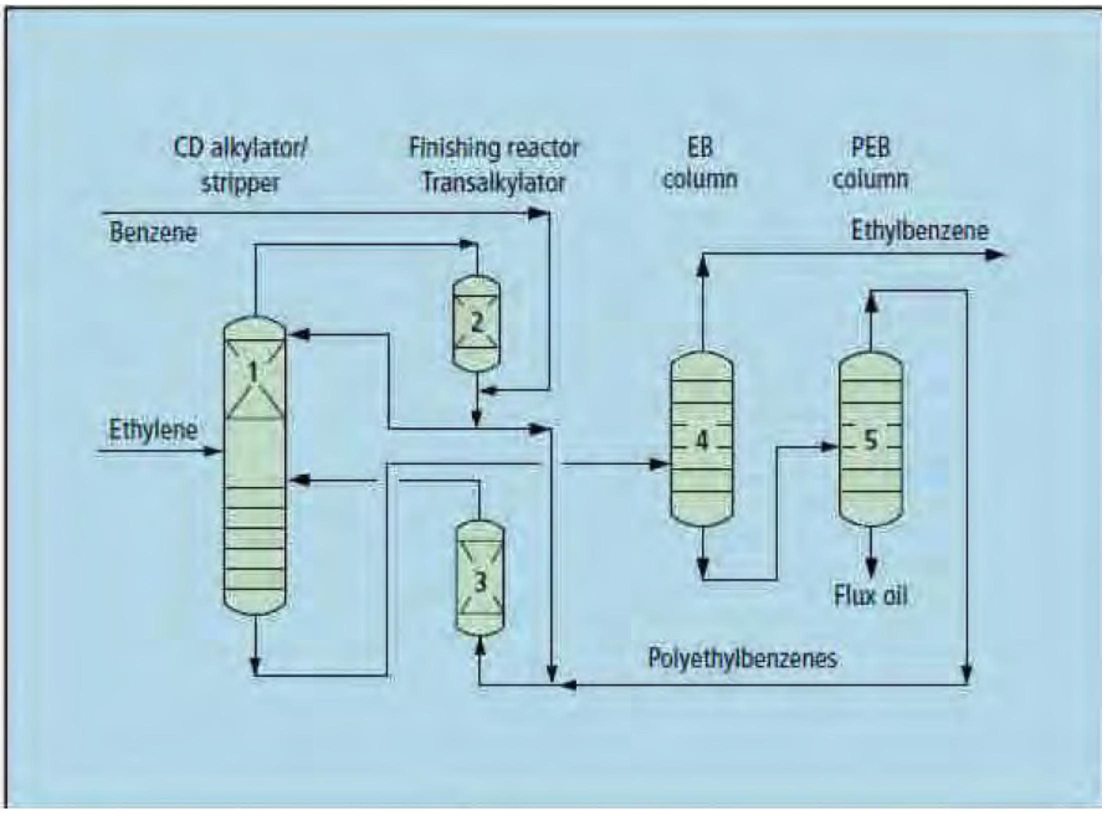
Application: The Uhde

Products: MTBE and
Description: The technology
Utility requirements, (C4 feed containing 21% isobutene; per metric ton of MTBE):

Commercial plants: The Uhde (Edeleanu)

Uses: Octane booster.

9-Ethylbenzene $C_6H_5CH_2CH_3$



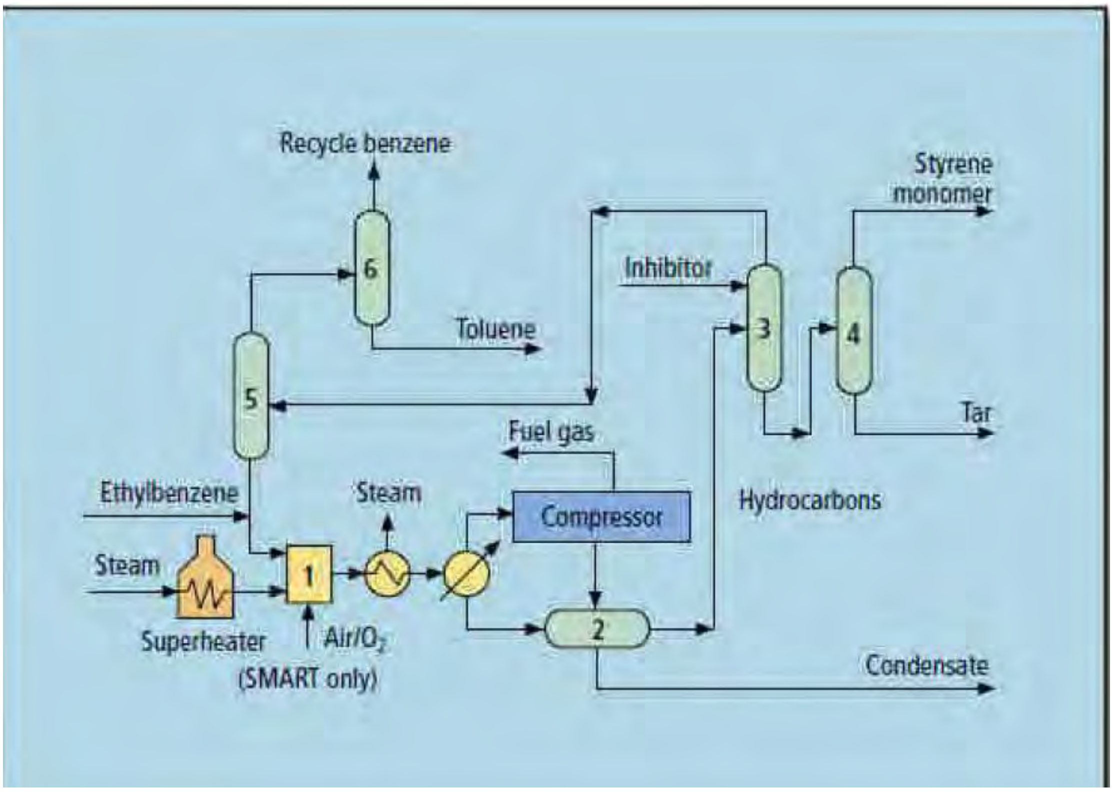
$$CH_2{=}CH_2 + C_6H_6 \xrightarrow[BF3]{ALCL3} C_6H_5CH_2CH_3$$

Application: Advanced technology to produce high-purity ethylbenzene (EB) alkylating.
Description: The CD alkylator stripper (1) operates as a distillation column. Alkylation and
Yields and product quality: Both

Economics: The EB
Investment (500,000 tpy, ISBL Gulf Coast), US$: 17 million
Raw materials and utilities, based on one metric ton of EB:

Commercial plants: Three commercial.
Uses:
0.5 consumption of B:in EB production: which is used in production of styrene.

10-Styrene $C_6H_5CH = CH_2$



$$C_6H_5CH_2CH_3 \leftrightarrow C_6H_5CH = CH_2 + H_2$$

EB S

Application: To

Description: In the Classic SM process, EB is catalytically dehydrogenated to styrene in the presence

Economics: (Classic) 500,000 mtpy, ISBL, US Gulf Coast:

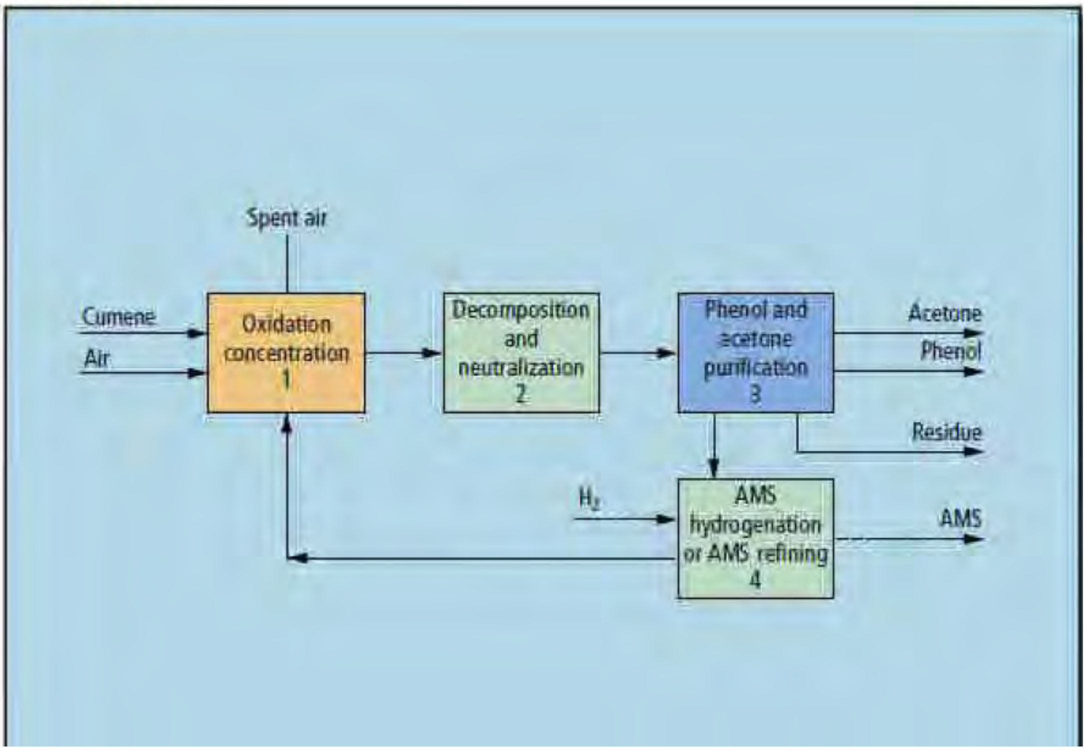
Investment, US$ million 78

Ethylbenzene, ton/ton SM 1.055

Utilities, US$/mton SM 29

Commercial plants: Currently,

11-Phenol



$$C_6H_5CH(CH_3)_2 + O_2 \rightarrow C_6H_5C(CH_3)_2OOH$$

$$C_6H_5C(CH_3)_2OOH \rightarrow C_6H_5OH + (CH_3)_2CO$$

Phenol **acetone**

Application: The Sunoco/UOP phenol process produces high-quality phenol and acetone by liquid-phase peroxidation of cumene.

Description: Key process steps:

Oxidation and concentration (1): Cumene is oxidized to cumene hydroperoxide (CHP). A small.

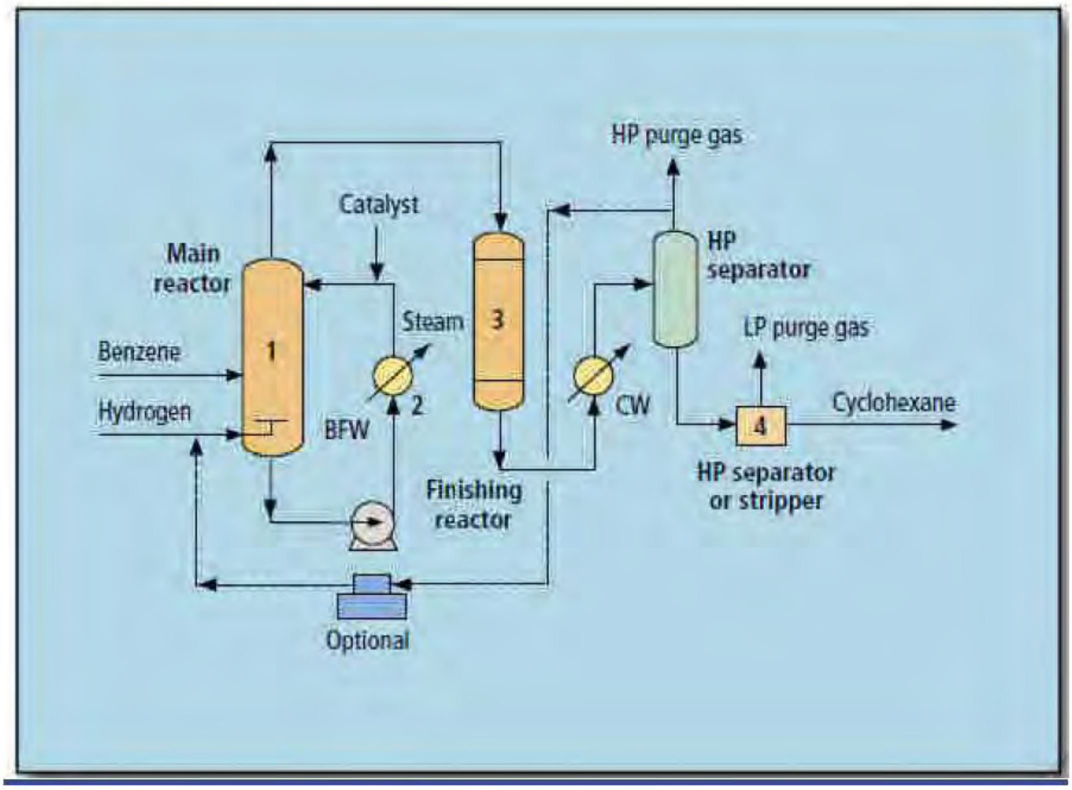
Decomposition and neutralization (2): CHP is decomposed to phenol and acetone, accompanied by **Phenol and acetone purification (3):** Phenol and acetone are separated and purified. A small amount of byproduct is rejected as heavy residue.

AMS hydrogenation or AMS refining (4): AMS is hydrogenated back to cumene and recycled to oxidation, or AMS is refined for sale.

Commercial plants:

Uses: Raw materials or intermediate for production of:

12-Cyclohexane



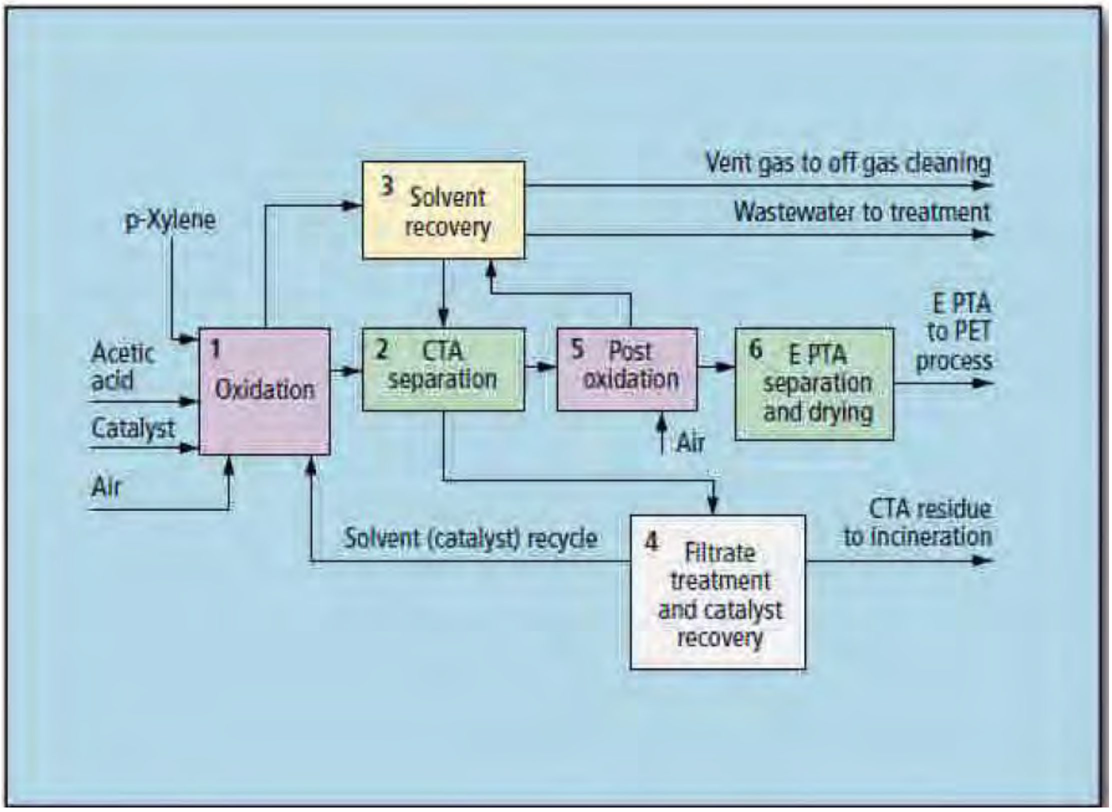
$$C_6H_6 + 3H_2 \leftrightarrow C_6H_{12}$$

Application: Produce high-purity cyclohexane by liquid-phase catalytic hydrogenation of benzene.
Description: The main reactor (1)
Yield: 1.075 kg of cyclohexane is produced from 1 kg of benzene.

Economics: Basis: 200,000-tpy cyclohexane complex, ISBL 2005 Gulf Coast location with PSA hydrogen is US$8 million. Catalyst cost is US$ 1.2/metric ton of product.
Commercial plants: Thirty-three cyclohexane units have been licensed.

13-Terephthalic acid (EPTA) COOH(C6H5)COOH

CH3(C6H5)CH3 [5]→**COOH(C6H5)COOH**
P-xylene **TPA**

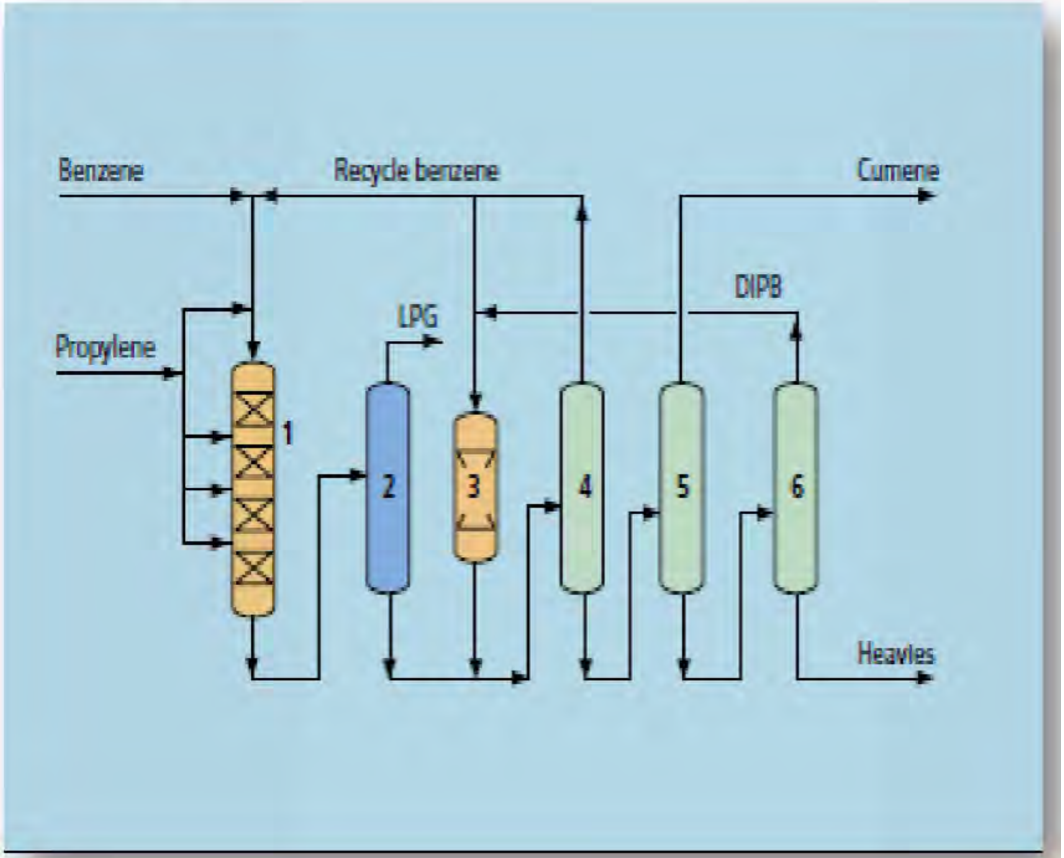


Application: E PTA
Description: The general

Crude terephthalic acid (1,2,3): CTA is produced by the catalytic oxidation of p-xylene with air in the liquid phase using acetic acid as a solvent (1). The feed mix—p-xylene, solvent and catalyst—

Polymer-grade terephthalic acid (5,6): The crude acid is purified to obtain EPTA in a post-oxidation step, at elevated temperature conditions.
Catalyst recovery (4):
Economics: The advanced
Commercial plants: Commercial plants are operating in the US, Europe and Asia Pacific.

14- CUMENE



$$C_6H_6 + CH_3CH{=}CH_2 \rightarrow C_6H_5CH(CH_3)_2$$

Benzene propylene cumene

Application: To produce high (isopropylbenzene) by alkylating benzene with propylene (typically refinery or chemical grade) using liquid process based on zeolitic

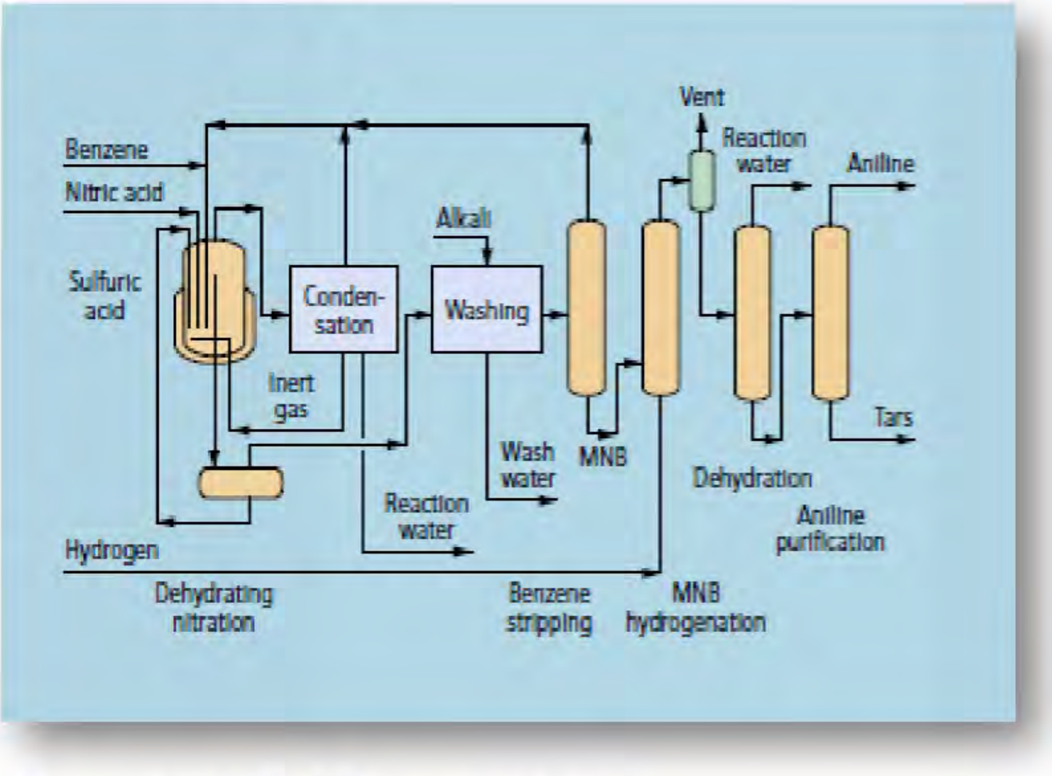
Description:

Economics: Basis: ISBL US Gulf Coast

Investment, US$/tpy 40 – 90

Raw materials & utilities, per metric ton of cumene

15-_Aniline $C_6H_5NH_2$



$$C_6H_5 \ + HNO3 \xrightarrow{H_2SO_4} \rightarrow C_6H_5NH_2$$

Application: A process for the production of high benzene and nitric acid.
Description:
Commercial plants: DuPont

Raw materials: Toluene ,oxygen

$$C_6H_5CH_3 \xrightarrow{[O]} \rightarrow C_6H_5COOH.$$

Toluene Benzoic acid

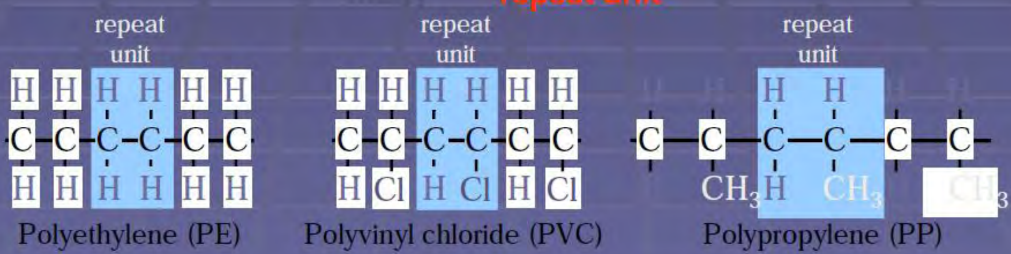
Polymers

What is a polymer?

Very Large molecules structures chain-like in nature.

mer

repeat unit

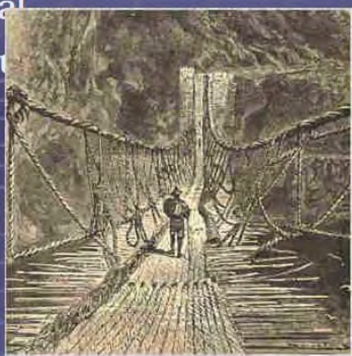


Adapted from Fig. 14.2, *CALLISTER 7E.*

4.1 Ancient Polymers

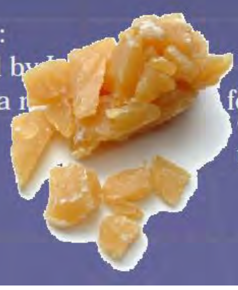
Originally natural polymers were u

- Wood
- Rubber
- Cotton
- Wool
- Leather
- Silk



Oldest known use:
Rubber balls used by I
Noah used pitch (a r
for the ark

Noah's pitch
Genesis 6:14 "...and cover it inside and outside with pitch."

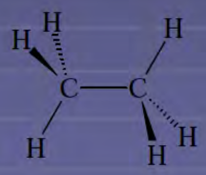


gum based resins extracted from pine trees

Polymer Composition

Most polymers are hydrocarbons
– i.e. made up of H and C

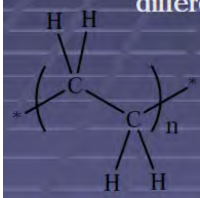
- Saturated hydrocarbons
  - Each carbon bonded to four other atoms



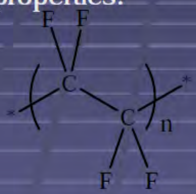
C_nH_{2n+2}

Polymer chemistry

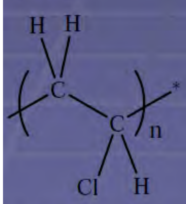
- In polyethylene (PE) synthesis, the monomer is ethylene
- Turns out one can use many different monomers
  - Different functional groups/chemical composition – polymers have very different properties!



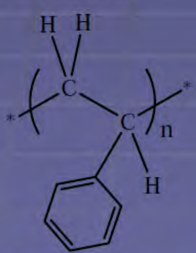
poly(ethylene)
(PE)



poly(tetrafluoroethylene)
(PTFE, teflon)

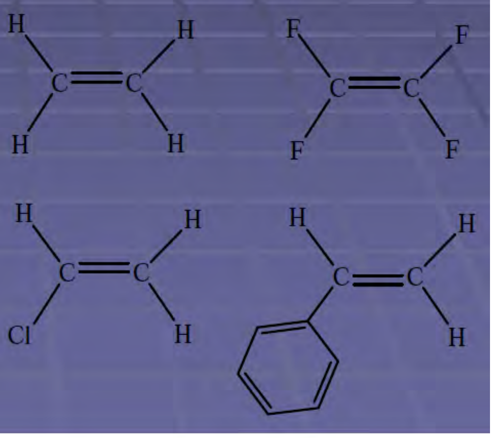


poly(vinylchloride)
(PVC)



poly(styrene)
(PS)

Monomers

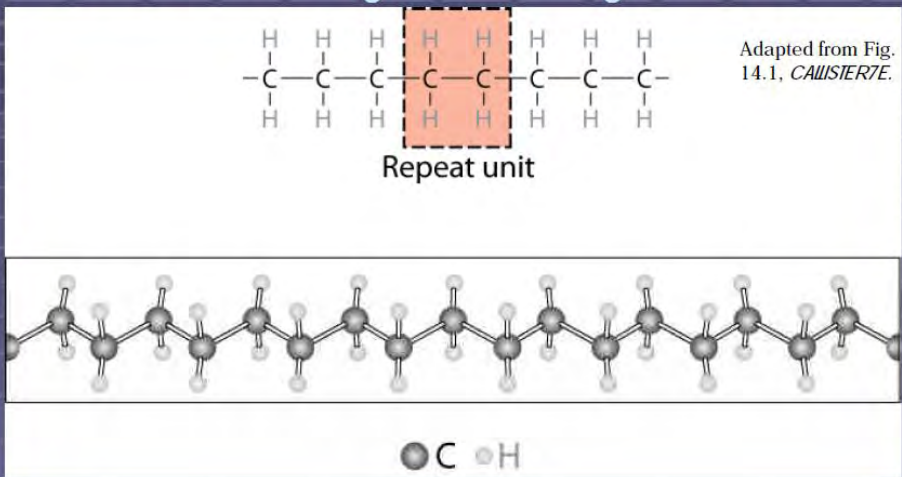


Chemistry of Polymers

- Free radical polymerization

- Initiator: example - benzoyl peroxide

Chemistry of Polymers

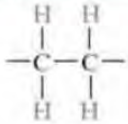
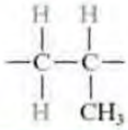


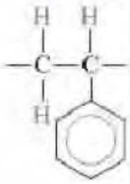
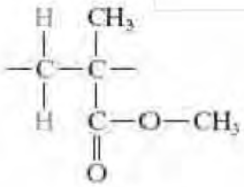
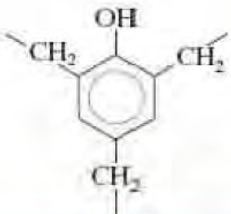
Adapted from Fig. 14.1, *CALLISTER7E.*

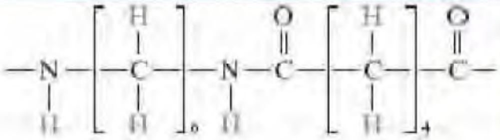
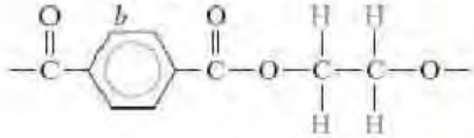
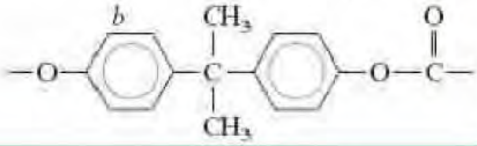
Note: polyethylene is just a long HC
- paraffin is short polyethylene

Bulk or Commodity Polymers

Table 14.3 A Listing of Repeat Units for Polymeric Materials

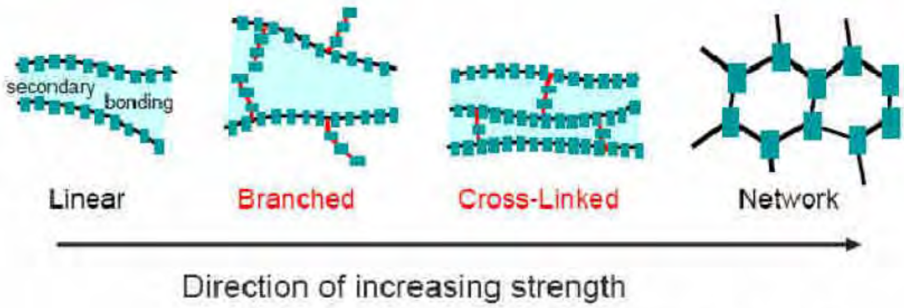
Polymer	*Repeat Unit*
Polyethylene (PE)	
Poly(vinyl chloride) (PVC)	
Polytetrafluoroethylene (PTFE)	
Polypropylene (PP)	

Polymer	*Repeat Unit*
Polystyrene (PS)	
Poly(methyl methacrylate) (PMMA)	
Phenol-formaldehyde (Bakelite)	

Polymer	*Repeat Unit*
Poly(hexamethylene adipamide) (nylon 6,6)	
Poly(ethylene terephthalate) (PET, a polyester)	
Polycarbonate (PC)	

Molecular Structures

- Covalent chain configurations and strength:



Adapted from Fig. 14.7, *Callister 7e.*

Not all chains in a polymer are of the same length i.e., there is a distribution of molecular weights

Molecular weight of polymers

1-No. average Mwt Mn

$$Mn = \frac{\sum MiNi}{\sum Ni}$$

2-Weight average Mwt Mw

$$Mw = \frac{\sum Mi^2Ni}{\sum MiNi}$$

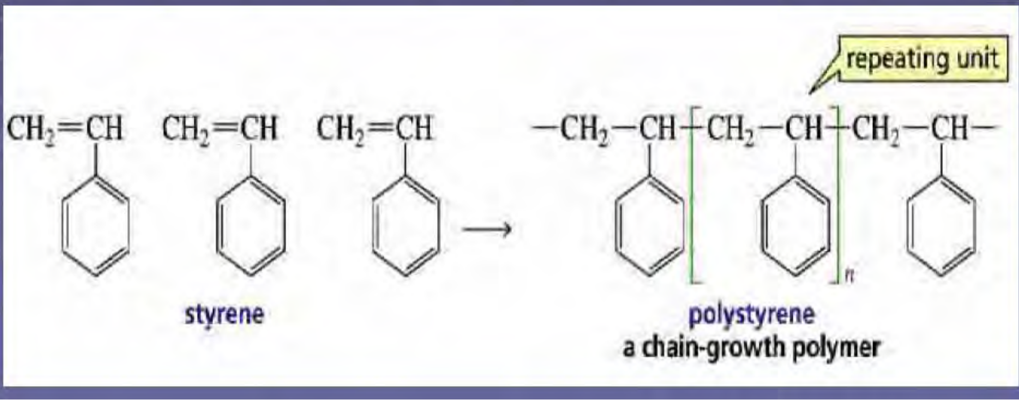
Synthesis of Polymers

Synthesis of Polymers

- There are a number different methods of preparing polymers from suitable monomers, these are
  - step-growth (or condensation) polymerisation
  - addition polymerisation
  - insertion polymerisation.

Types of Polymerization

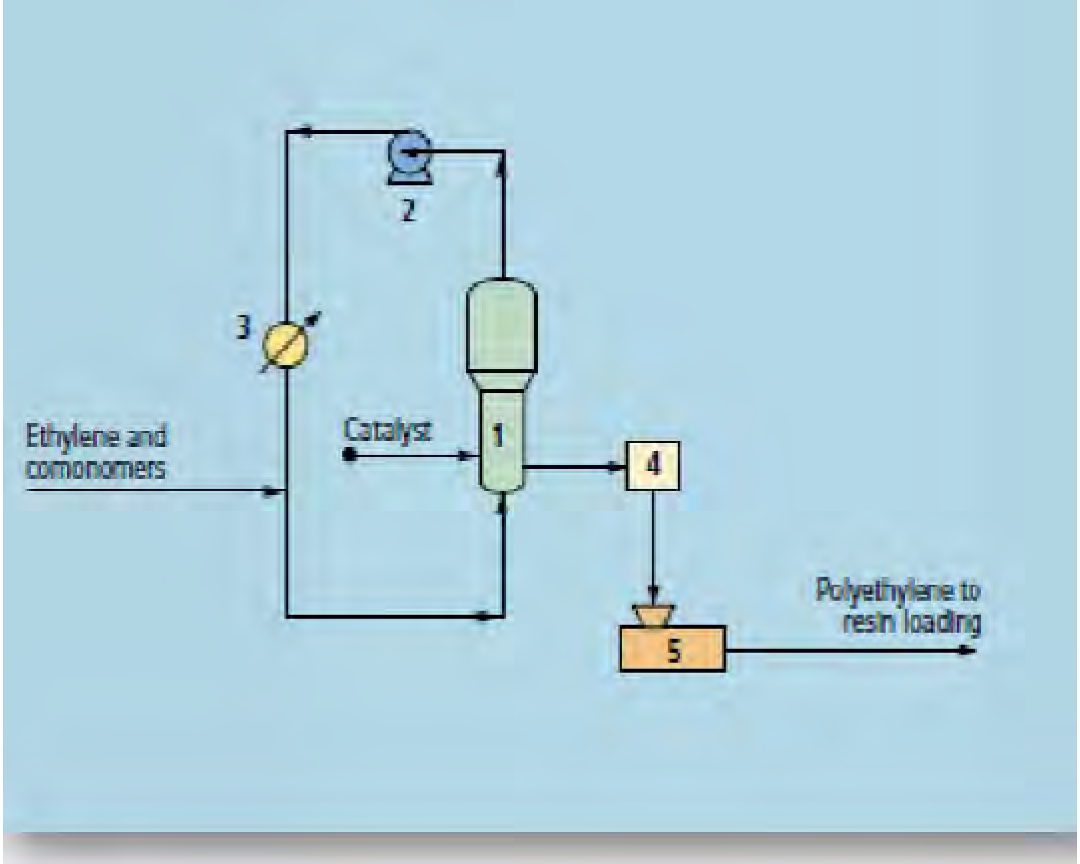
- Chain-growth polymers, also known as addition polymers, are made by chain reactions



Thermodynamics

- For polymerization to occur (i.e., to be thermodynamically feasible), the Gibbs free energy of polymerization $\Delta G_p < 0$.

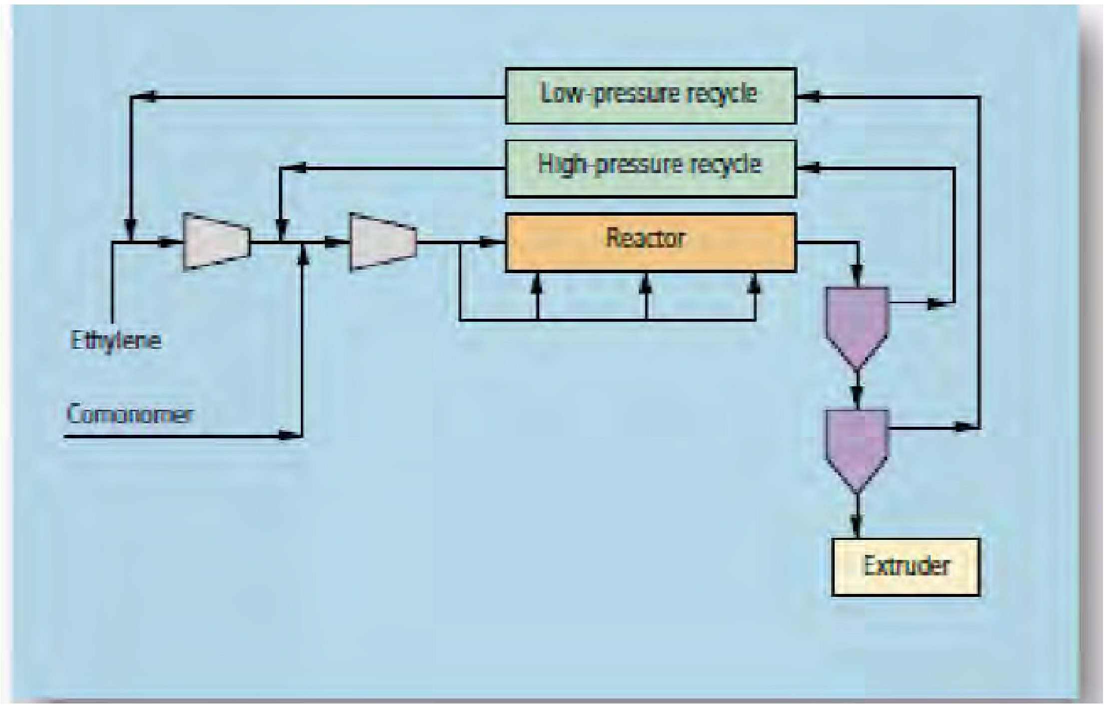
- If $\Delta G_p > 0$, then depolymerization will be favored.



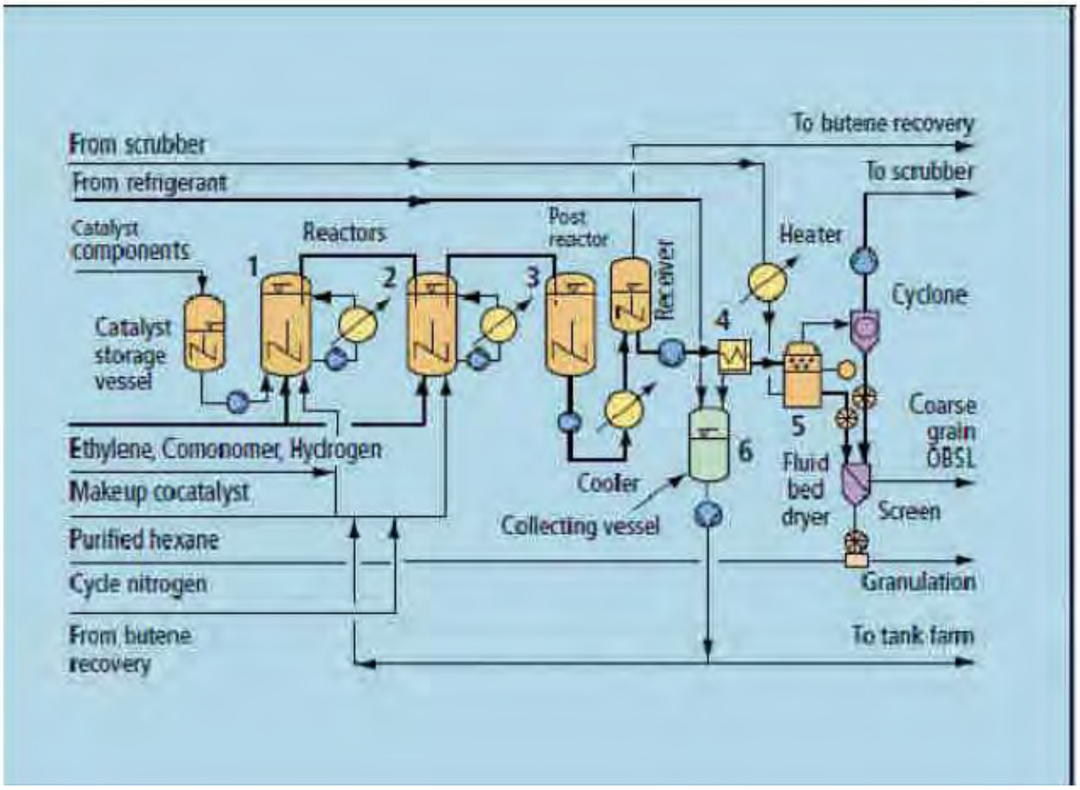
Application: To produce linear low high density polyethylene (HD UNIPOL PE process.
Description:A

Products: Polymer
Commercial plants: Ninety

2-Polyethylene, LDPE

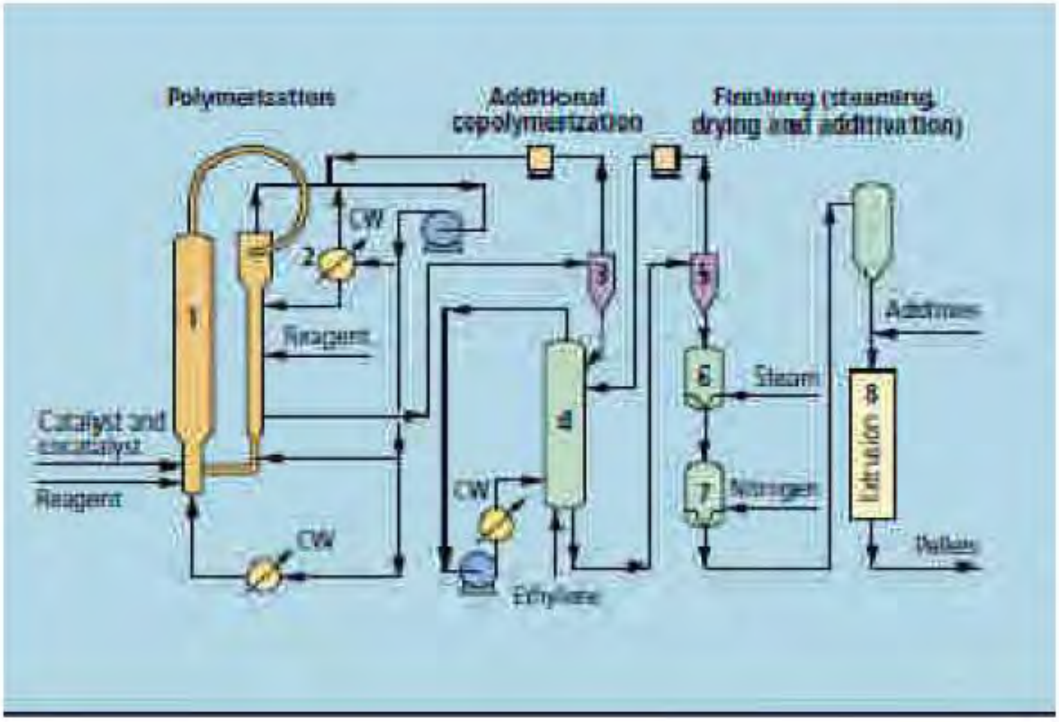


Application: The high process is used to produce low homopolymers and EVA copolymers. Single 400,000 tpy can be provided.
Description: Ethylene,
Economics: Consumption, permetric ton of PE:
Ethylene, t 1.010
Electricity, kWh 700–1,000
Steam, t –1.2 (export credit)
Commercial plants: Many



Application: To produce high-density polyethylene (HDPE) using the stirred-tank, heavy-diluent *Hostalen* process.
Description: The
Products: The cascade **Economics:** Consumption, per metric ton of PE (based on
Commercial plants: There are 33 *Hostalen* plants in operation or under construction.

5-Polypropylene:



Application: *Spheripol* process technology produces propylene-based polymers including homopolymer PP and many families of random and heterophasic impact and specialty impact copolymers.

Description: In **Yields:** Polymer yields of 40,000 – 60,000 kg / kg of supported catalyst are obtained. The polymer has a controlled particle size distribution and an isotactic index of 90 – 99%.

Economics: The

Consumption, per metric ton of PP:

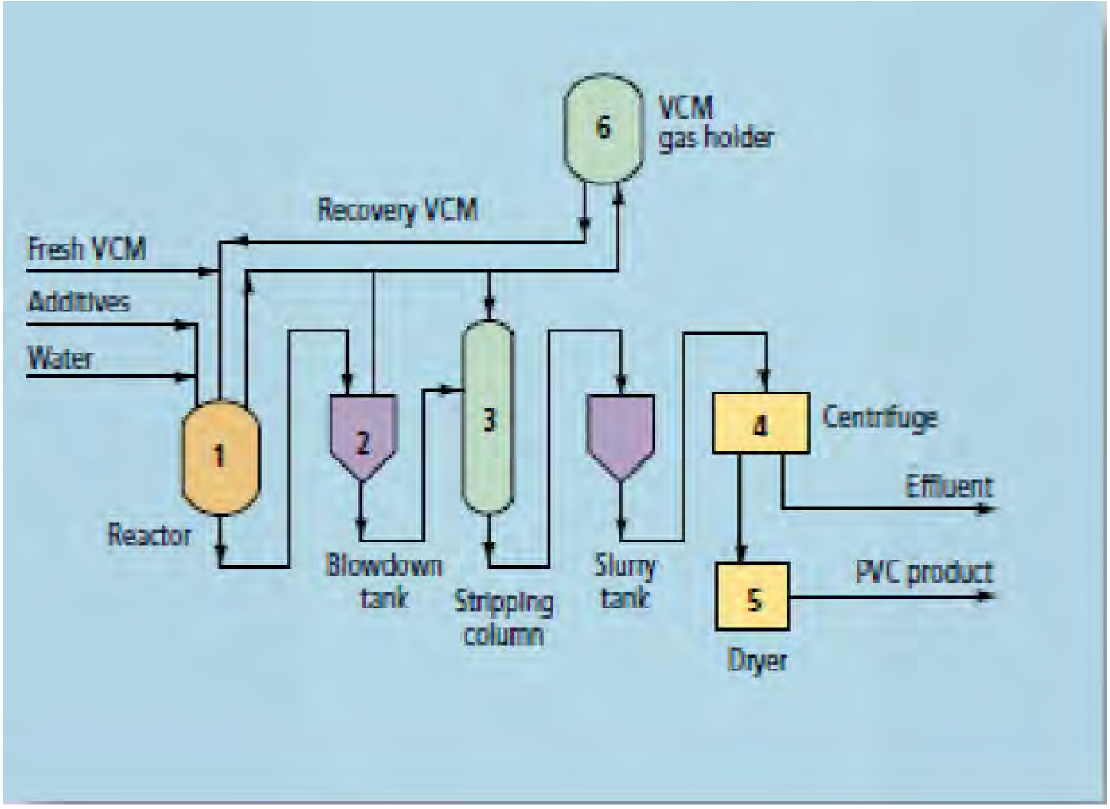
Products: The process

Commercial plants: *Spheripol*

6-PVC (suspension)

Application: A

Description: PVC



Application: A process

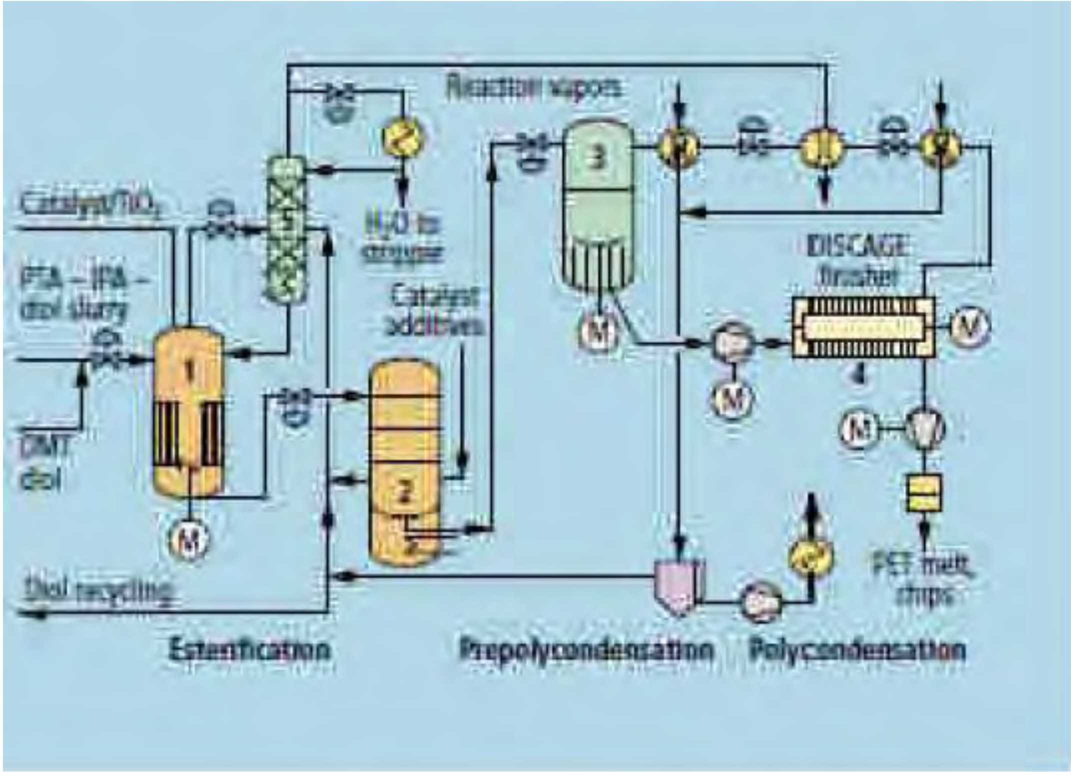
Description: PVC is

Economics:

Commercial plants: The process

Synthetic fibers

1-Polyesters (polyethylene terephthalate)



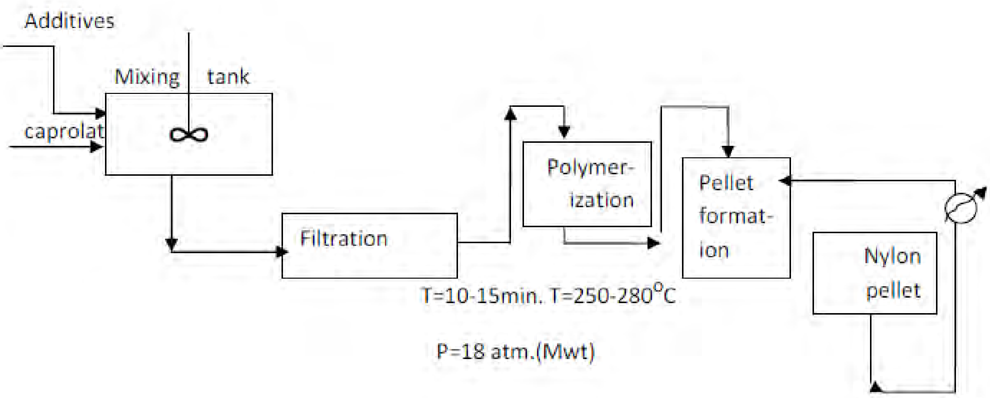
Application: To produce polyesters for resin and textile applications from terephthalic acid (PTA) or dimethyl terephthalate (DMT) and diols [ethylene glycol (EG) or others], using the UIF-proprietary four reactor (4R)- process including DISCAGE-finisher

Description: A slurry

Economics: Typical utility requirements per metric ton of PET are:

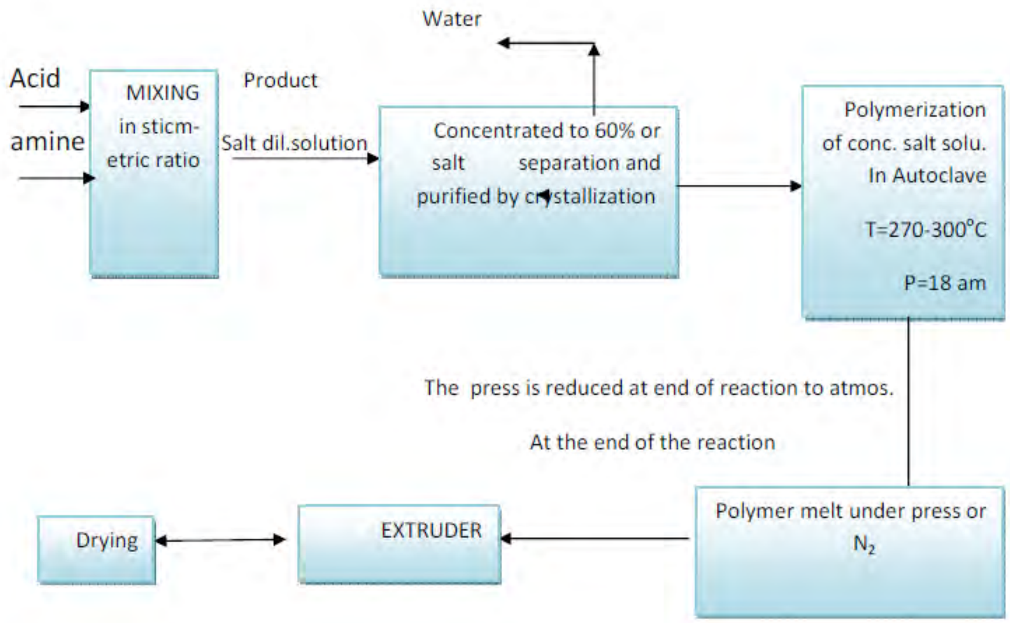
2-Nylon 6

Is a polyamide contain –CONHRaw material:Caprolactum.



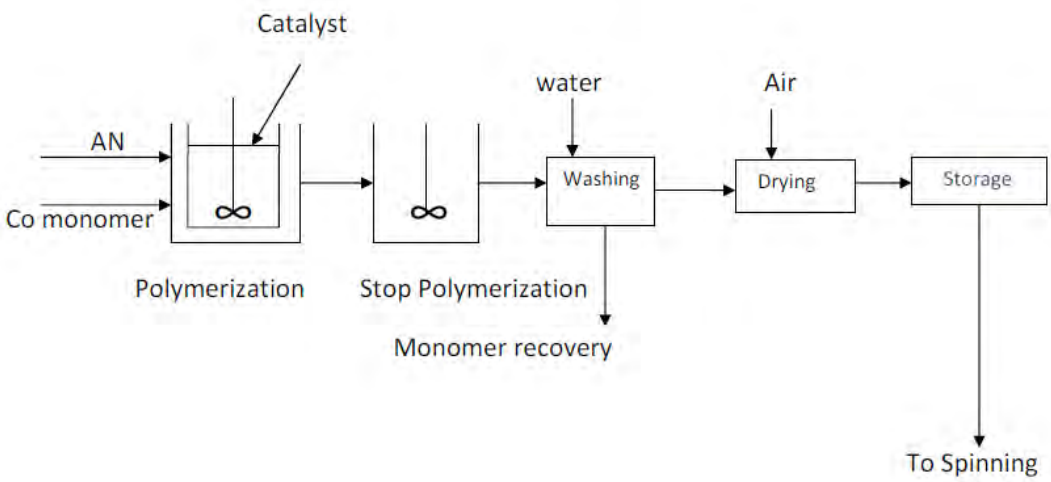
3-Nylon 66:

Polymer is produced from hexamethylene adipamide which produced from condensation polymerization of adipic acid and hexamethylenediamine.



4-Acrylic :

Uses: Wool replacement.



Disadvantage:

The high

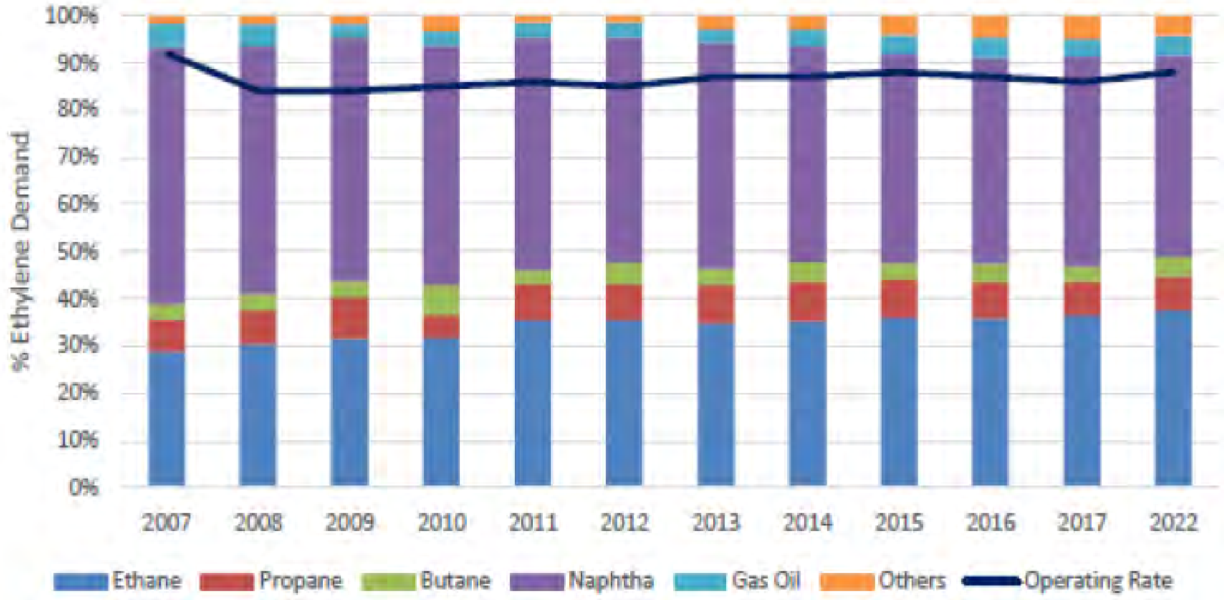
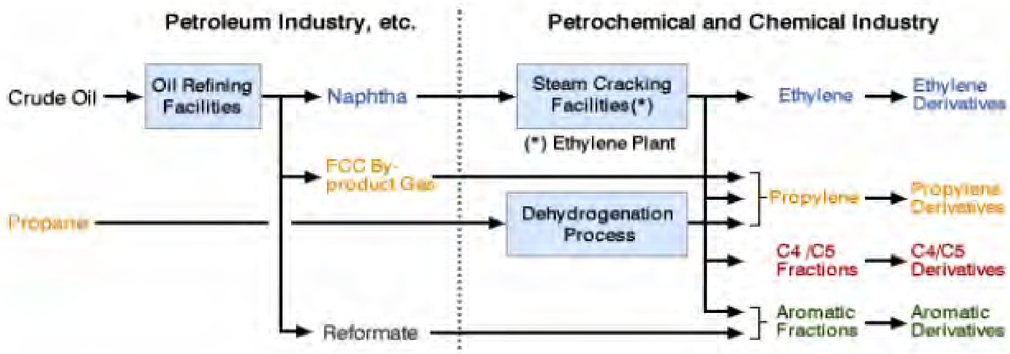
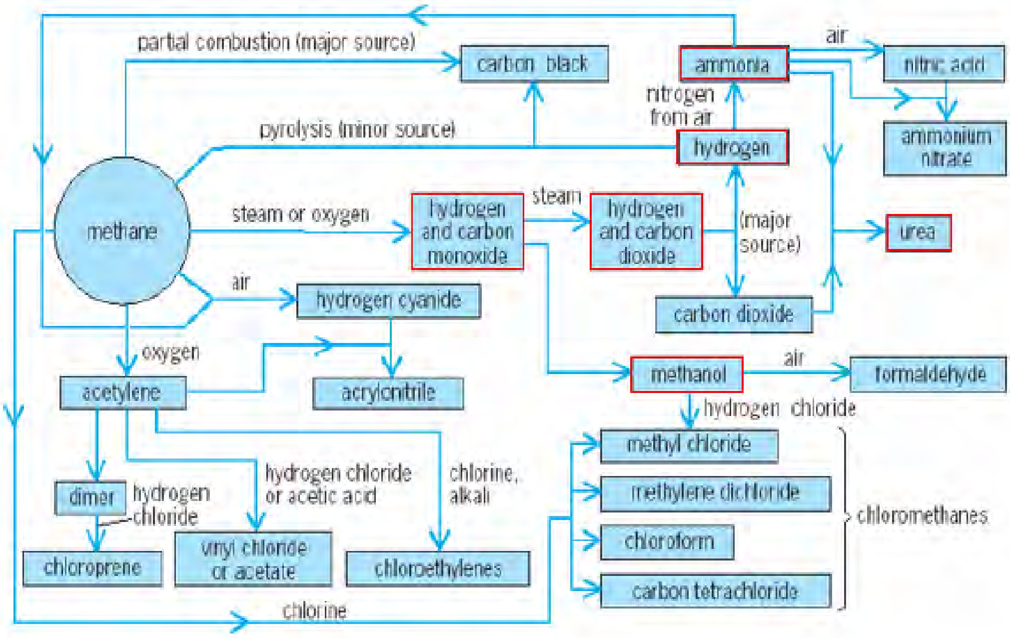


Figure 2.1 - Feedstock comparison for ethylene production.

The **petrochemical industry** produces various kinds of chemical products such as polymers, fibers or rubber, from such raw materials as petroleum, LPG, natural gas and other hydrocarbons through many different production processes.
Hydrocarbons, the source material, are used to produce a variety of components including ethylene, propylene, butadiene and pyrolysis gasoline through non-catalytic thermal decomposition reaction with steam (steam cracking).
The feedstock to ethylene process varies depending on the availability of resources in each country. For example, in Japan, naphtha (crude gasoline) produced by refining crude oil is often used. In recent years, many ethylene plants that use light gas as a feedstock which comes from refinery and natural gas plant are being built in Middle East. When light gas is used as a feedstock, products other than ethylene are produced in smaller quantities, which leads to plants that produce propylene by dehydrating propane also being constructed.
The petrochemical industry is wide-ranging, creating a variety of chemical products.

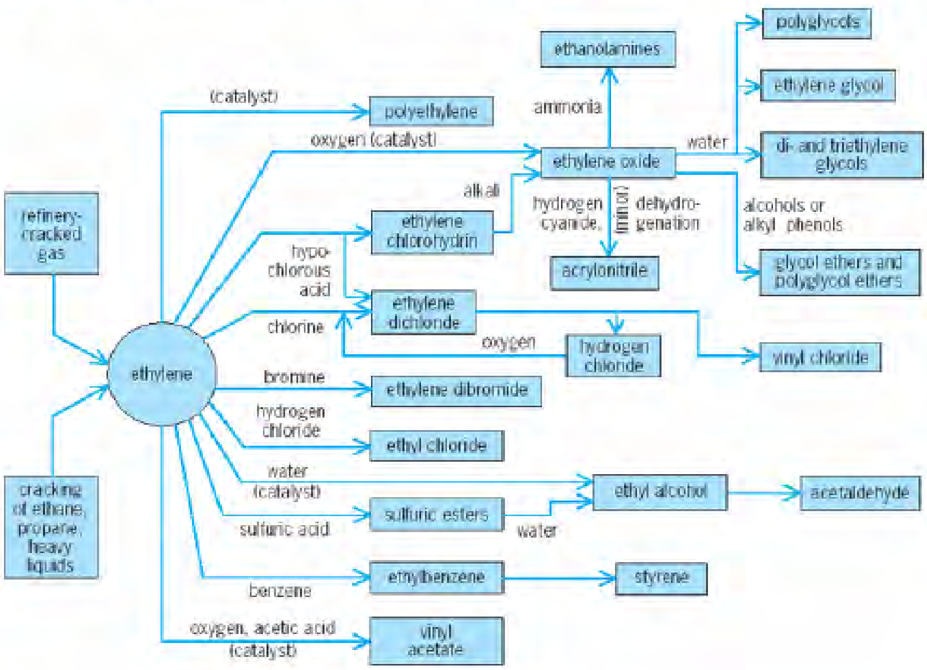


Chemicals from methane

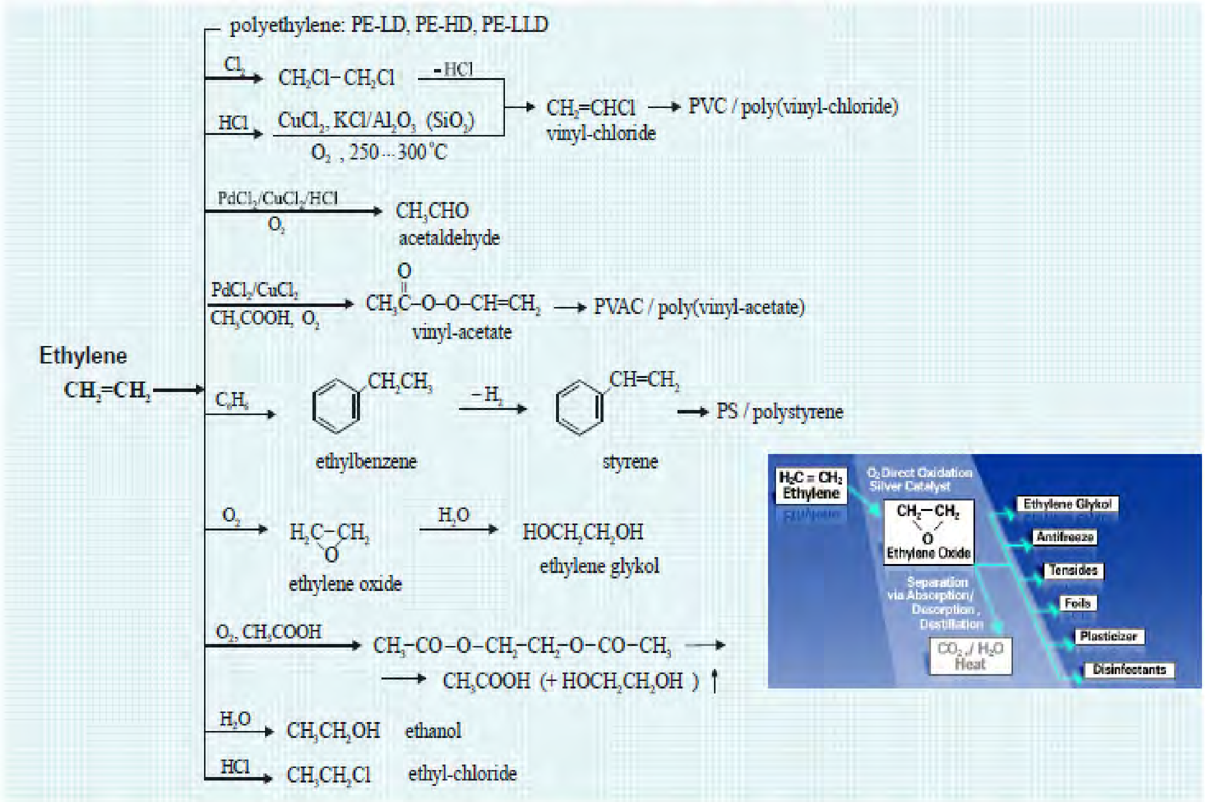


Chemicals from ethylene

The most important chemicals based on ethylene



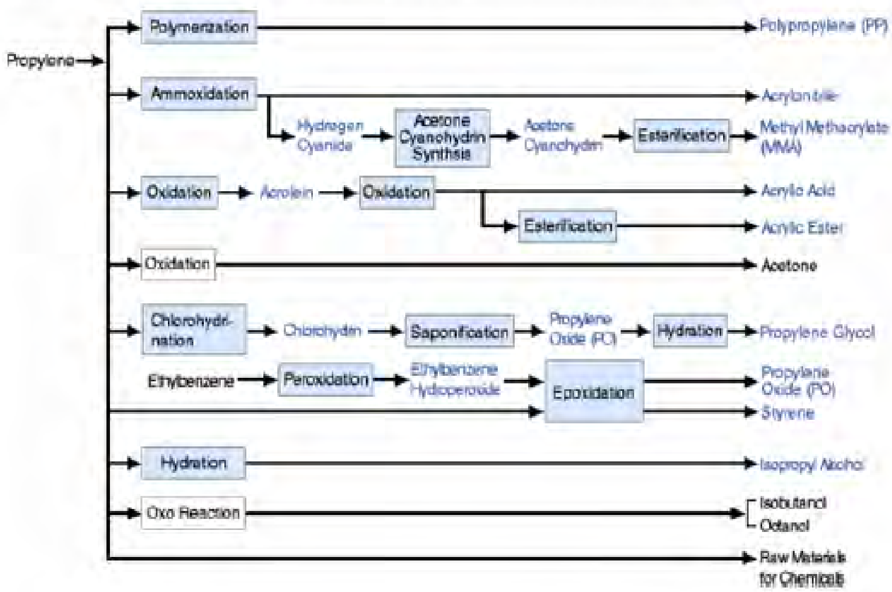
Ethylene – most important products: chemicals and polymers



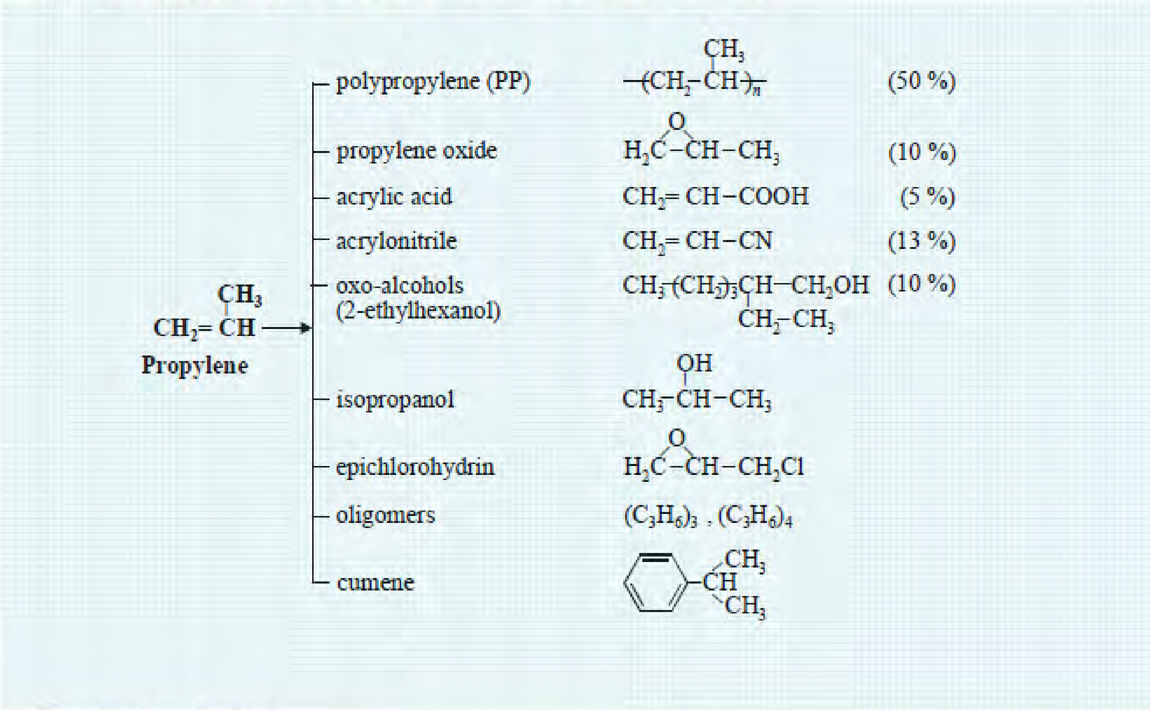
Propylene and Its Derivatives

Propylene is used to produce polypropylene resin, acrylonitrile, acrylic acid, propylene oxide, isopropyl alcohol, and acetone through polymerization, oxidation, alkylation, hydration and the addition of halogen.

Propylene is as important a basic chemical in the petrochemical industry as ethylene.



Most important propylene derivatives / products

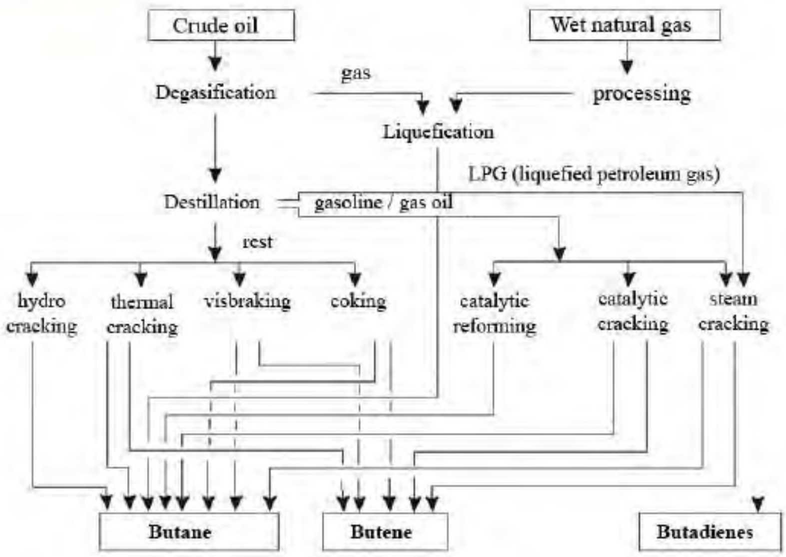


Propylene production:

- by steam cracking / pyrolysis 65 %
- from refinery gases (FCC) 30 %
- propane dehydrogenation 5 %

Hydrocarbons with four C-atoms, primarily butane, butene and butadiene, are derived from three main sources:

- from natural gas and oil
- steam cracking of higher hydrocarbons
- from refinery gases

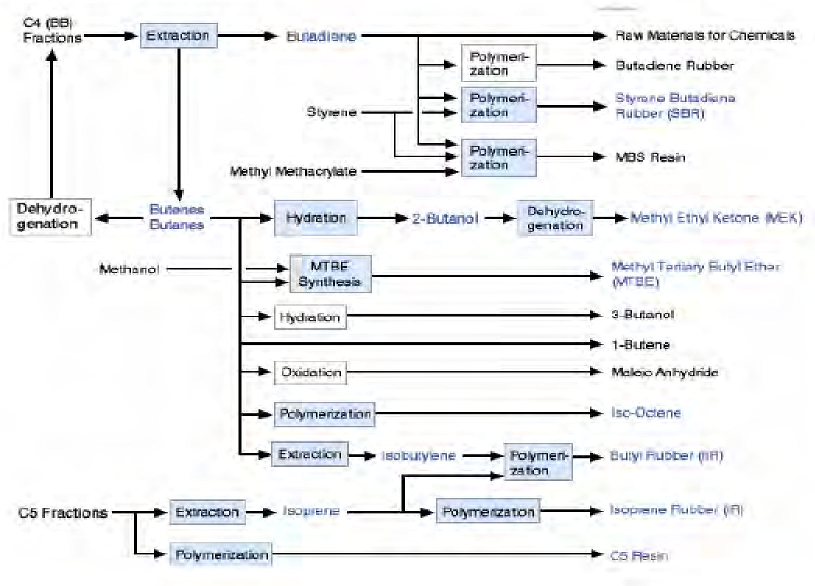


Schematic representation of production of C4-hydrocarbons

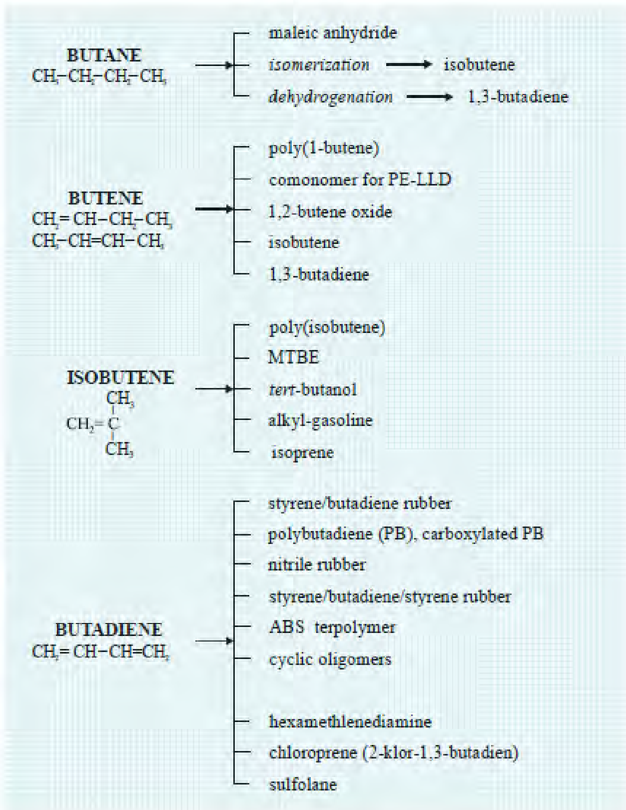
C4/C5 fractions and its derivatives

Using naphtha as a raw material, an ethylene plant produces highly reactive materials in C4 (BB) fractions or C5 fractions as by-products.

Butadiene in the C4 fractions and isoprene in the C5 fractions in particular, are useful chemicals as they are used to produce synthetic rubber such as tires for cars.



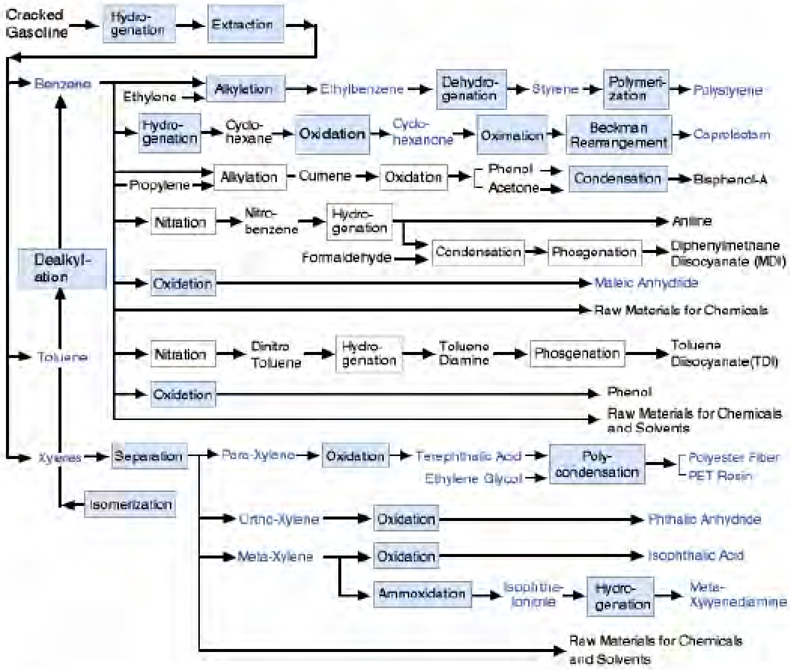
The most important products based on C_4-hydrocarbons



Butadiene is mostly converted into **Styrene Butadiene** or **Styrene Butadiene Rubber (SBR)** more well known as synthetic **Rubber**. **Polybutadiene** is also used in tyres and can be used as an intermediate in the production of **acrylonitrile-butadiene-styrene (ABS)**. **ABS** is widely used in items such as telephones, computer casings and other appliances.

Aromatics and Its Derivatives

Using naphtha as a raw material, an ethylene plant produces aromatic derivatives (BTX fractions) such as benzene (B), toluene (T), and xylenes (X) as cracked gasolines.



Of the BTX fractions, benzene and xylenes are particularly used in large quantities in general-purpose resins and fibers after being processed with polystyrene, caprolactam, and terephthalic acid.

Since cracked gasolines produced from ethylene plants only are not enough to meet the demand for these products, supply from reformulated gasolines in the oil refining industry is increasing.

Chemicals from cycloaliphatic compounds and from aromatic compounds