Petrochemicals

By

Assist. Prof. Dr. Kadhum Muttar Shabeeb

Introduction to Petrochemicals

Definition of Petrochemicals

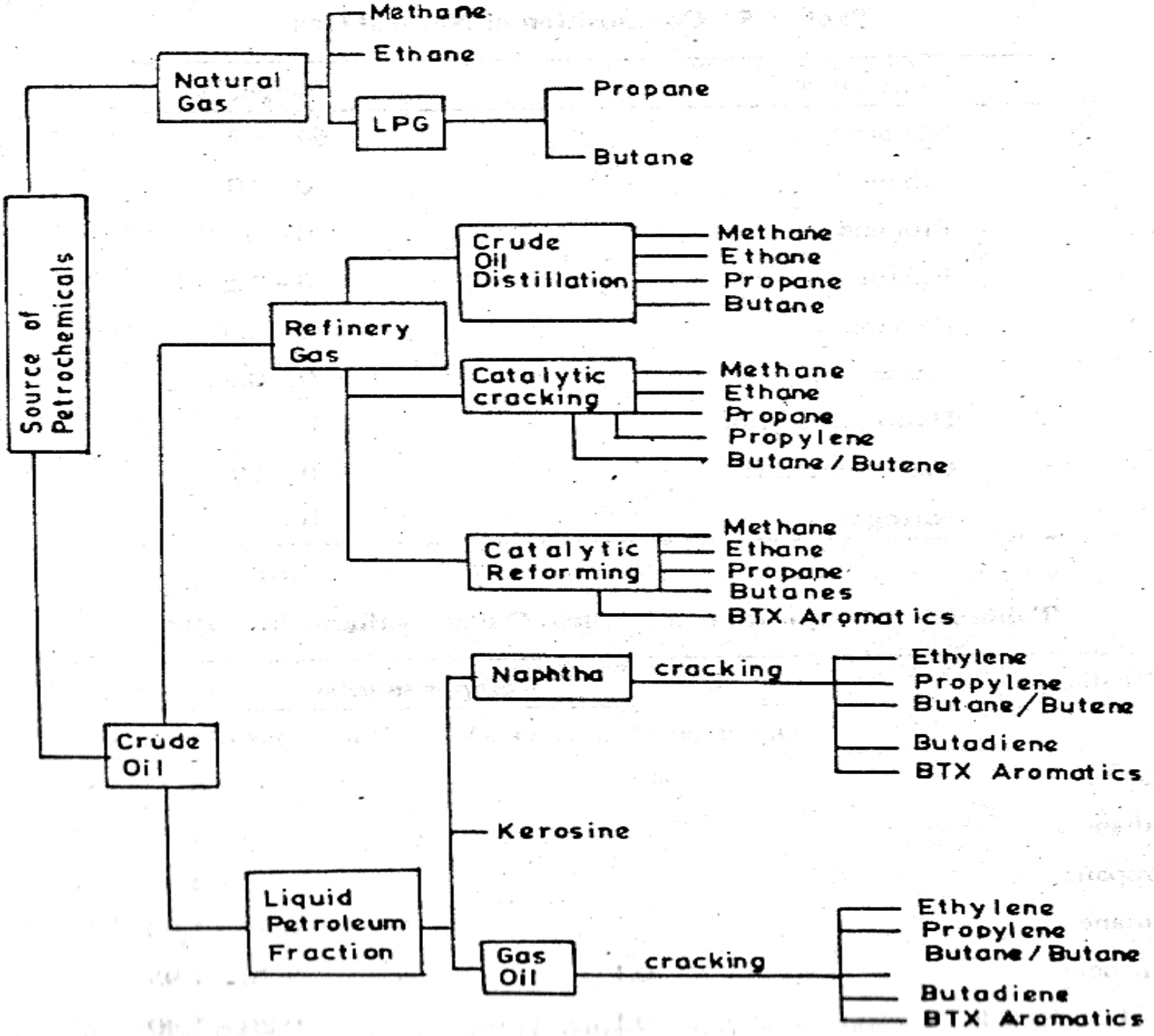
- Petrochemicals are chemicals derived from petroleum products.
- Examples of petrochemicals are plastics, rubbers, fibres, paints, solvents, and detergents.

Source of Petrochemicals

Petrochemicals are available mainly from two sources; **crude oil** and **natural gas**.

Crude oil contains also some amount of dissolved gases, during atmospheric distillation; these dissolved gases are obtained as overhead products (called Refinery gases).

Therefore the petrochemical Feedstocks from crude oil may be grouped under two heads; r**efinery gases** and **liquid petroleum fractions**.


Source of Petrochemicals
Natural Gas
Methane
Ethane
LPG
Propane
Butane
Crude Oil
Refinery Gas
Crude Oil Distillation
Methane
Ethane
Propane
Butane
Catalytic cracking
Methane
Ethane
Propane
Propylene
Butane / Butene
Catalytic Reforming
Methane
Ethane
Propane
Butanes
BTX Aromatics
Liquid Petroleum Fraction
Naphtha
cracking
Ethylene
Propylene
Butane/Butene
Butadiene
BTX Aromatics
Kerosine
Gas Oil
cracking
Ethylene
Propylene
Butane / Butane
Butadiene
BTX Aromatics

So there are three sources for petrochemicals (**see Fig. 1.1**):

1. **Natural gas**
2. **Liquid petroleum fractions**
3. **Refinery gases**

Natural Gas

- Natural gas essentially consists of **methane** (about 95%). Other constituents of natural gas include ethane, propane, butane, and hexane, and non-hydrocarbon gases such as H_2S, CO_2, and N_2.
- The composition of natural gas varies from source to source. Certain natural gases are almost pure methane (>99%), and some contain as low as 64% methane (see Table 1.1).

Table 1.1: Composition of Natural Gas

Constituent	Range (%)
Methane	64 – 99
Ethane	0 – 10
Propane	0 – 5
Butane	0 – 1.5
Pentane	0 – 0.5
Hexane	0 – 0.3
H_2S	0 – 15
CO_2	0 – 10
N_2	0 – 14

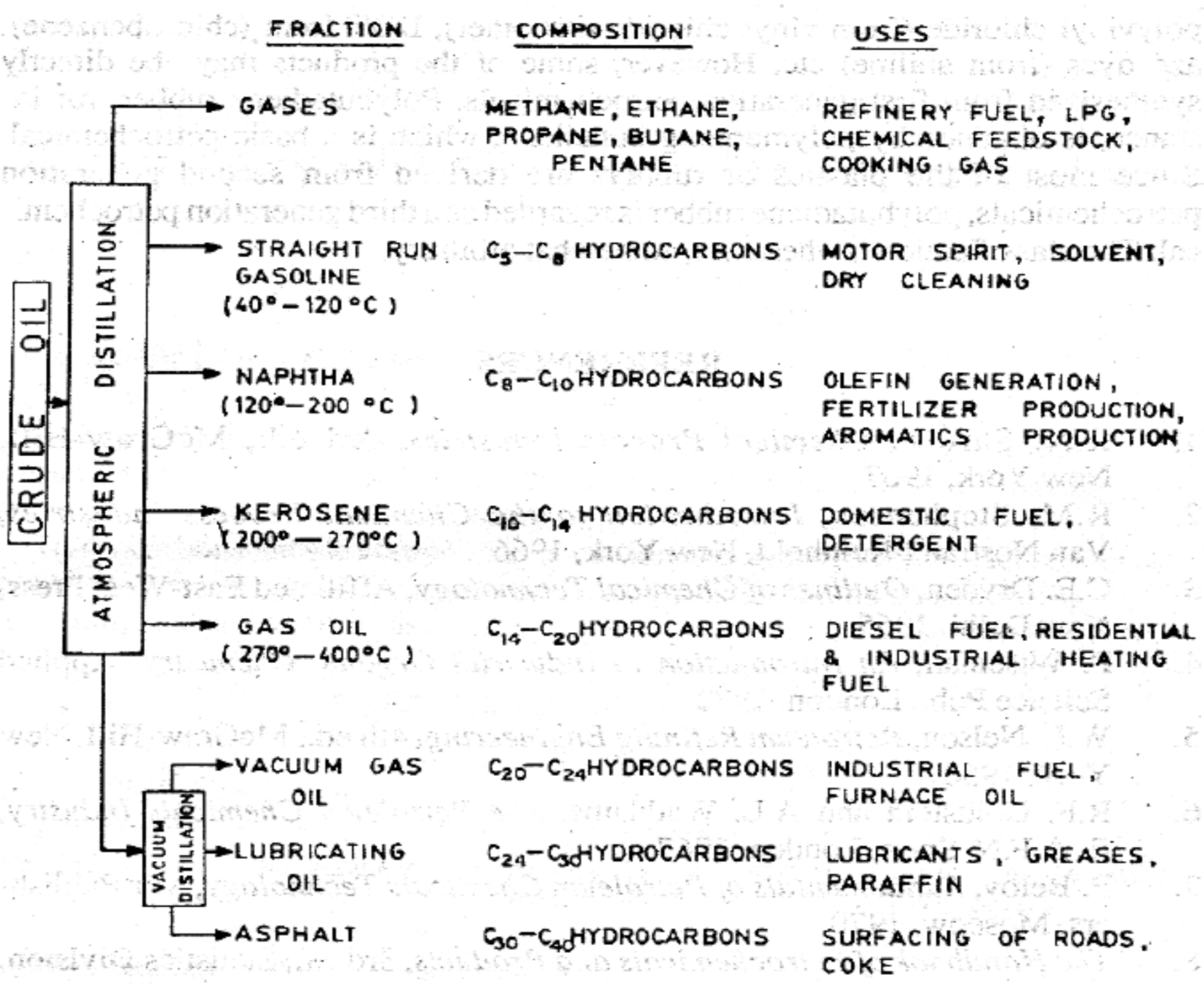
- The natural gas may be **wet** or **dry**. When relatively greater proportion of higher hydrocarbons which are condensable such as propane, butane and pentane, it is regarded as wet.
- These gases when condensed and separated from methane and ethane it is called liquefied natural gas (**LNG**).
- This natural gas liquid is called liquefied petroleum gas (**LPG**) when it consists of almost 95% propane, 5% butane and a little amount of pentane and hexane.
- **LPG** may be used as a chemical feedstock for generating ethylene, propylene and other olefins via **steam cracking process.**

Crude oil

- Crude oil is a complex mixture of hydrocarbons with minor amounts of oxygen-, nitrogen-, and sulfur-containing components.
- The hydrocarbons present in crude oil containing carbon atom C_1 to C_{40} belong to paraffins, cycloparaffins (naphthenes), and aromatics.
- Olefins, acetylenes, dienes, and other unsaturated hydrocarbons are generally absent in crude oil.

Liquid petroleum fractions

- Distillation of crude oil is carried out in two stages. First is the atmospheric distillation and the second is the vacuum distillation, composition and uses of various petroleum fractions obtained are shown in fig. 1.2.
- Distillation of crude oil at atmospheric pressure separate crude oil into the following main products: (a) Gases, (b) Gasoline, (c) Naphtha, (d) Kerosene, (e) Gas-oil, and (f) Heavy residue.
- Heavy residue is sent to vacuum distillation unit where it is further fractionated into: (a) Vacuum gas-oil, (b) Lubricating oil, and (c) Asphalt.


FRACTION
COMPOSITION
USES
CRUDE OIL
ATMOSPHERIC DISTILLATION
VACUUM DISTILLATION
GASES
METHANE, ETHANE, PROPANE, BUTANE, PENTANE
REFINERY FUEL, LPG, CHEMICAL FEEDSTOCK, COOKING GAS
STRAIGHT RUN GASOLINE (40°–120 °C)
C_5–C_8 HYDROCARBONS
MOTOR SPIRIT, SOLVENT, DRY CLEANING
NAPHTHA (120°–200 °C)
C_8–C_{10} HYDROCARBONS
OLEFIN GENERATION, FERTILIZER PRODUCTION, AROMATICS PRODUCTION
KEROSENE (200°–270°C)
C_{10}–C_{14} HYDROCARBONS
DOMESTIC FUEL, DETERGENT
GAS OIL (270°–400°C)
C_{14}–C_{20} HYDROCARBONS
DIESEL FUEL, RESIDENTIAL & INDUSTRIAL HEATING FUEL
VACUUM GAS OIL
C_{20}–C_{24} HYDROCARBONS
INDUSTRIAL FUEL, FURNACE OIL
LUBRICATING OIL
C_{24}–C_{30} HYDROCARBONS
LUBRICANTS, GREASES, PARAFFIN
ASPHALT
C_{30}–C_{40} HYDROCARBONS
SURFACING OF ROADS, COKE

Classification of Petrochemicals

Petrochemicals may be classified as:-

1) Feedstocks (first-generation petrochemicals)
2) Intermediates (second-generation petrochemicals)
3) Finished products (third-generation petrochemicals)

First generation petrochemicals

These are chemicals directly available from crude oil or natural gas either by fractionation or steam cracking processes. These generally represent the **basic petrochemicals** which are used to derive various chemicals.

Examples of this class of petrochemicals are methane, ethane, propane, ethylene, propylene, butylenes, acetylene, butadiene and related dienes, aromatics such as benzene, toluene, and xylenes (BTX) etc.

Second generation petrochemicals

These chemicals are not present as such in petroleum fractions, but they obtained from basic petrochemicals by simple operations such as reforming, alkylation, hydrogenation, cracking, or hydrocracking.

Examples of such products are styrene (derived from benzene and ethylene), acrylonitrile (derived from propylene), ethylene glycol (derived from ethylene), vinyl chloride (derived from acetylene or ethylene) …etc.

Third generation petrochemicals

These petrochemicals are derived generally from second generation petrochemicals. They represent the most important commercial products such as plastics, rubbers, fibers, detergents etc.