

Characteristics of Petroleum and Natural Gas

Third Year



Introduction

- Petroleum is a fossilised mass that has accumulated below the earth's surface from time immemorial.
- Raw petroleum is known as **crude (petroleum) oil** or mineral oil.
 - It is a mixture of various organic substances and is the source of hydrocarbons, such as methane, ethane, propane, butane, pentane, and various other paraffinic, naphthenic, and aromatic hydrocarbons, **the building blocks of today's organic industry**



Crude Petroleum Oil

COMPOSITION OF CRUDE OIL

PHYSICAL PROPERTIES OF CRUDE OIL

ORIGIN OF HYDROCARBONS

EXPLORATION TECHNIQUES

ORIGIN OF HYDROCARBONS

EXPLORATION TECHNIQUES

RESOURCE ESTIMATION

OIL FIELD DEVELOPMENT

WELL LOGGING

TRANSPORTATION AND METERING OF CRUDE OIL

COAL BED METHANE



Composition of Crude oil

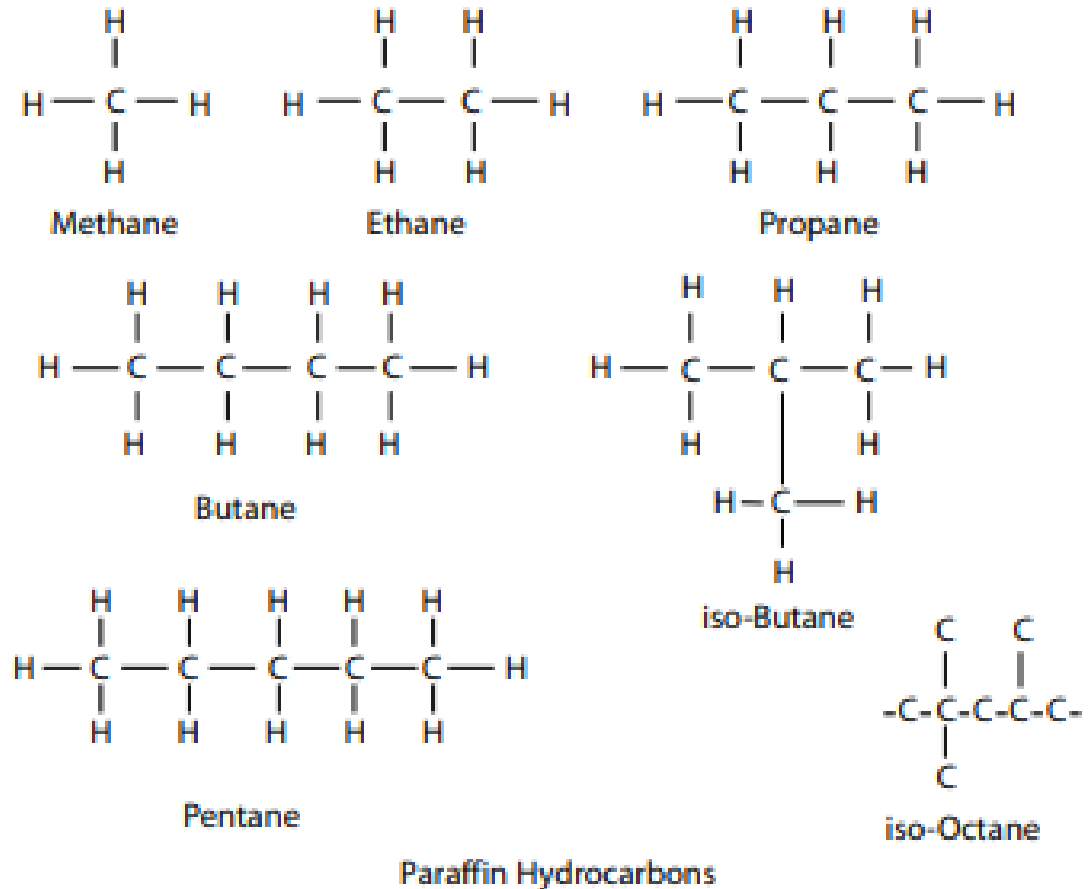
- The compounds in crude petroleum oil are:
 - hydrocarbons or substituted hydrocarbons in which the major elements are
 - carbon at 85%–90%
 - hydrogen at 10%–14%,
 - the rest with non-hydrocarbon elements:
 - sulfur (0.2%–3%),
 - nitrogen (< 0.1–2%),
 - oxygen (1%–1.5%), and organo-metallic compounds of nickel, vanadium, arsenic, lead, and other metals in traces (in parts per million or parts per billion concentration).
 - Inorganic salts of magnesium chloride, sodium chlorides, and other mineral salts are also accompanied with crude oil from the well either because of water from formation or water and chemicals injected during drilling and production.

HYDROCARBON GROUPS



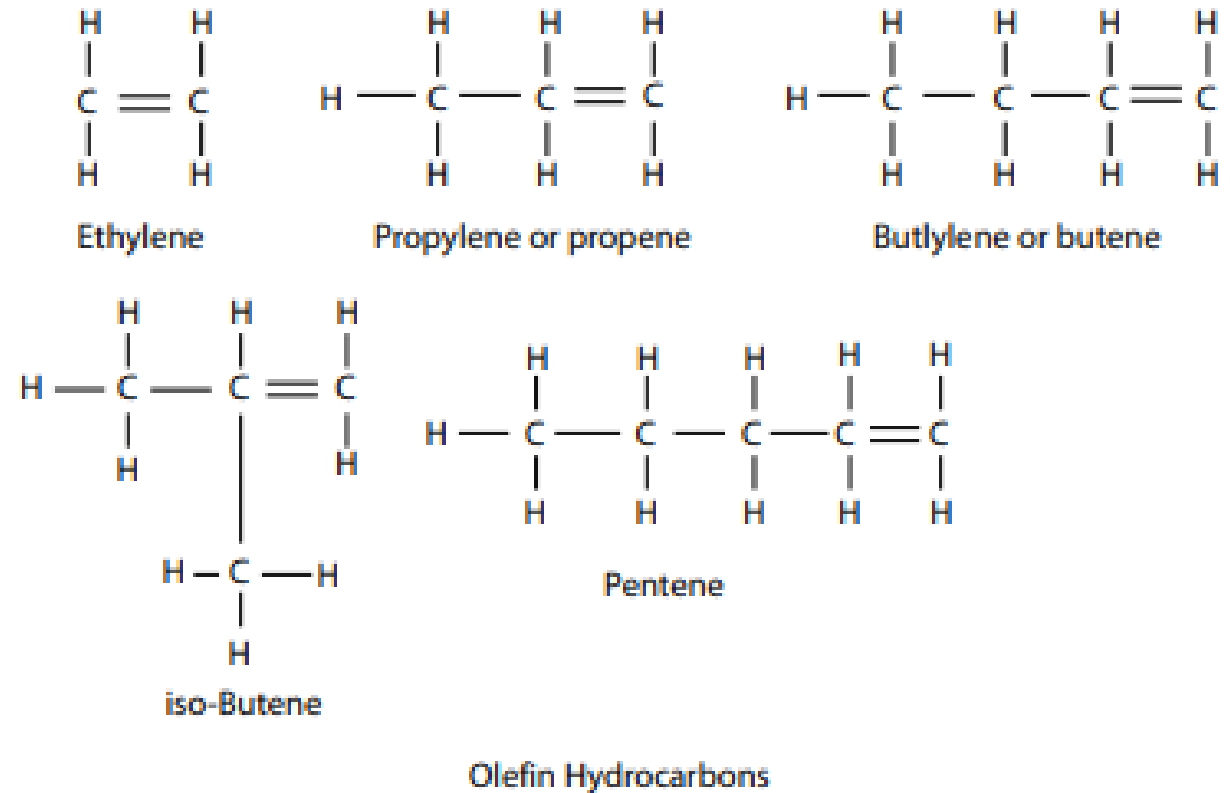
Paraffins

- Paraffins are saturated hydrocarbons. A saturated hydrocarbon is a compound where all four bonds of a carbon atom are linked to four separate atoms. Examples are methane, ethane, propane, butane, pentane, hexane, with the generic molecular formula of C_nH_{2n+2} , where n is the number of carbon atoms in that compound. The homologous series of these hydrocarbons are called alkanes.



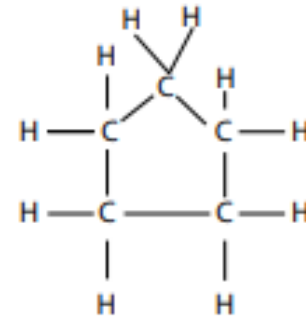
Olefins

- Olefins are unsaturated hydrocarbons, i.e., the double bond is present between the two carbon atoms in the formula. The generic formula is C_nH_{2n} , and the lowest member of this homologous series is ethylene, C_2H_4 . This series is known as alkenes. These are highly reactive and can react to themselves to mono olefins (Figure 1.2).

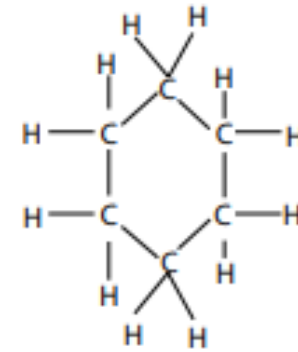


Naphthene

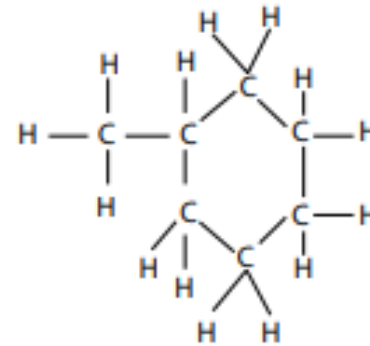
- Naphthene are cyclic saturated hydrocarbons with the general formula, like olefins, of C_nH_{2n} , also known as cyclo-alkanes. Since they are saturated, they are relatively inactive, like paraffins. Naphthenes are desirable compounds to produce aromatics and good quality lube oil base stocks. Some of these are shown in (Figure 1.3)



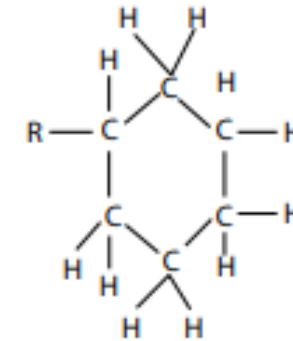
Cyclo-pentane



Cyclo-hexane



Methyl-cyclo-hexane

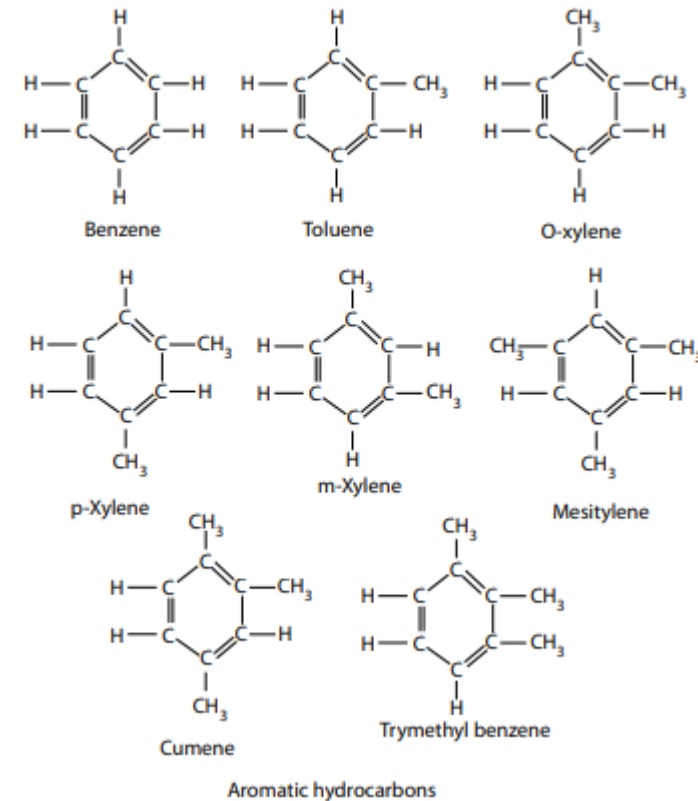


Alkyl substituted cyclohexane
R is the alkyl radical methyl, ethyl, etc

Naphthene hydrocarbons

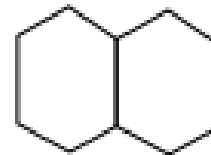
Aromatics

- Aromatics, often called benzenes, are chemically very active as compared to other groups of hydrocarbons. Their general formula is C_nH_{2n-6} . These hydrocarbons in particular are attacked by oxygen to form organic acids.
- **Naphthenes** can be dehydrogenated to aromatics in the presence of a platinum catalyst.
- Lower aromatics, such as benzene, toluene, and xylenes, are good solvents and precursors for many petrochemicals.
- Aromatics from petroleum products can be separated by extraction with solvents such as phenol, furfural, and diethylene glycol. Some of these are presented in (Figure 1.4).

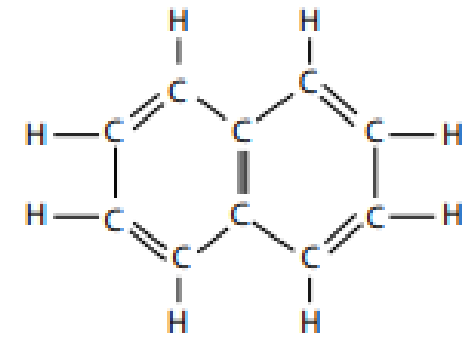


Complex Hydrocarbons

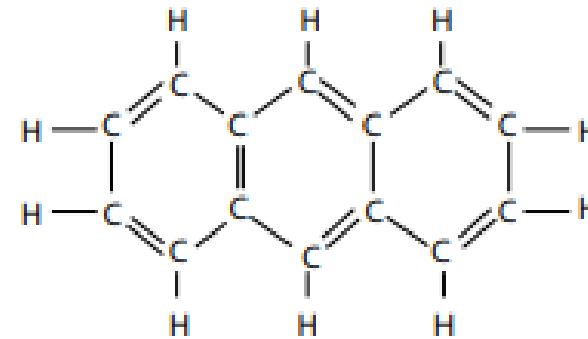
- Crude oil also contains a large number of hydrocarbons that do not fall into the category of paraffins, olefins, naphthenes, or aromatics, but may be the combined group of any two or more groups of paraffins, naphthenes, or aromatic hydrocarbons.
- By joining two or more naphthene rings or combining naphthene and aromatic rings, paraffin chains with aromatic rings (alkyl-aromatics), etc., a vast array of complex hydrocarbons may be formed.
 - Examples of these compounds are **decalin**, **naphthalene**, and **diphenyl**. Heavier fractions of crude oil contain these types of hydrocarbons.
 - Multinuclear (multi ring) aromatics or polynuclear aromatics (PNA) are well known in crude oil and its residual products.
 - PNA's are the precursors of coke, which forms due to thermal effect. These cannot be decomposed easily even by severe hydro-cracking (Figure 1.5)



Decalin



Naphthalene



Anthracene

Polynuclear hydrocarbons

Sulfur Content

- Sulfur compounds are present in crude oil as mercaptans, mono- and disulfides with the general formula $R-SH$, $R-S-R_1$, $R-S-S-R_1$, where R and R_1 are the alkyl radicals.
- Mercaptans are very corrosive whereas mono- and disulfides are not. Examples of cyclic sulfur compounds are thiophenes and benzothiophene.
- Hydrogen sulfide (H_2S) gas is associated with crude oil in dissolved form and is released when heated. H_2S is corrosive at high temperatures and in the presence of moisture.
- Crude oil that contains large amounts of H_2S is called sour crude.
- Sulfur present in petroleum fuel products also forms various oxides of sulfur (SO_x) during combustion, which are strong environmental pollutants.
- H_2S can be removed from gases by absorption in an amine solution.

What is the effect of heavier fractions of sulfur in the crude oil?

- In the light distillates, sulfur may be present as H_2S , mercaptans, and thiophenes, but in the heavier fractions of crude oil, 80%–90% of the sulfur is usually present in the complex ring structure of hydrocarbons.
- In this combination, the sulfur atom is very stable and non-reactive. As a result, sulfur from heavier petroleum cannot be removed without a destructive reaction, such as severe thermal or catalytic reactions. Nowadays, sulfur is recovered during refining and sold as a product. Sulfur also has a poisoning effect on various catalysts.

Nitrogen compounds

- Nitrogen compounds in hydrocarbons are usually found in the heavier parts of the crude oil. These are responsible for colour and colour instability and poisoning of certain catalysts.
- Nitrogen in petroleum fuels causes the generation of oxides of nitrogen (NO_x), which are also strong pollutants of the atmosphere. Nitrogen can be eliminated from petroleum products by catalytic hydrogenation. Like sulfur, nitrogen in the heavier parts of petroleum cannot be removed without severe cracking or hydrogenation reactions.

Oxygen compounds

- Crude oil may contain oxygen containing compounds, such as naphthenic acids, phenols, and cresols, which are responsible for corrosive activities.
- Oxygen also acts as a poison for many catalysts. This can be removed by catalytic hydrogenation. Excess oxygen compounds may even lead to explosion.

Metallic compounds

- Metallic compounds of vanadium, nickel, lead, arsenic, etc., are also found in crude oil.
 - Vanadium and nickel are found in the form of organo-metallic compounds mostly in the heavier fractions of crude oil where the metal atoms are distributed within the compound in a complex form called porphyrins. Petroleum fuels containing these metallic compounds may damage the burners, lines, and walls of the combustion chambers.