Main types of non-renewable sources of energy

1. Coal

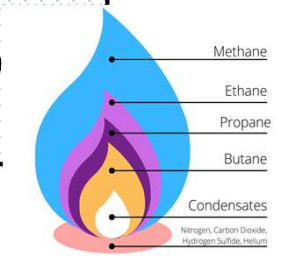
- Comes from the remains of biomass that died hundreds of millions of years ago
- Has the highest level of carbon of all fossil fuels

2. Oil

- Obtained from the biomass remains being decomposed for several millions years
- Extracted in crude form, refined to obtain gasoline, diesel, jet fuel, chemicals, etc.

3. Natural Gas

- Formed from the remains of sea plants and animals that died millions of years ago
- Mainly composed of methane



Kudankulam Nuclear Power Plant

4. Nuclear Energy

- Energy released when atoms' nuclei are fused together (fusion) or split apart (fission)
- Nuclear power plants produce electricity through nuclear fission

1. COAL

- Coal is a primary form of solid fuel along with wood and peat and is available in three forms lignite, bituminous and anthracite.
- Coal is thought to have been formed from the decomposition of plants/biomass over several millions of years.
- Coal is a combustible black or brownish-black sedimentary rock and has been used for a very long time as a fuel.
- Also storing and transportation of coal is very easy.

Continued…..

Coal is mostly comprised of carbon (75% including moisture) & it also has small amounts of other elements; chiefly hydrogen (4.5%), sulfur (2.5%), oxygen (6.9%), nitrogen(1.25%) and remaining chlorine and ash (carbon, metals and minerals - ~10%).

Among all the fossil fuels, it has the highest amount of carbon content.

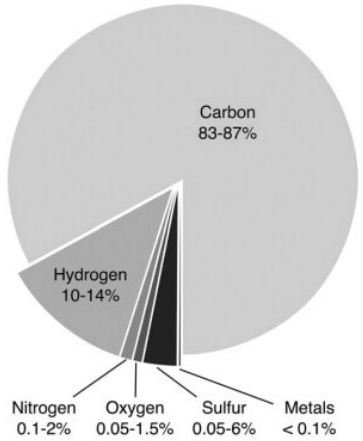
It is a nonrenewable fossil fuel that is combusted and used to generate electricity.

The major disadvantage of coal combustion is its damaging impact on the environment.

Burning coal is a major source of pollution and greenhouse gas emissions.

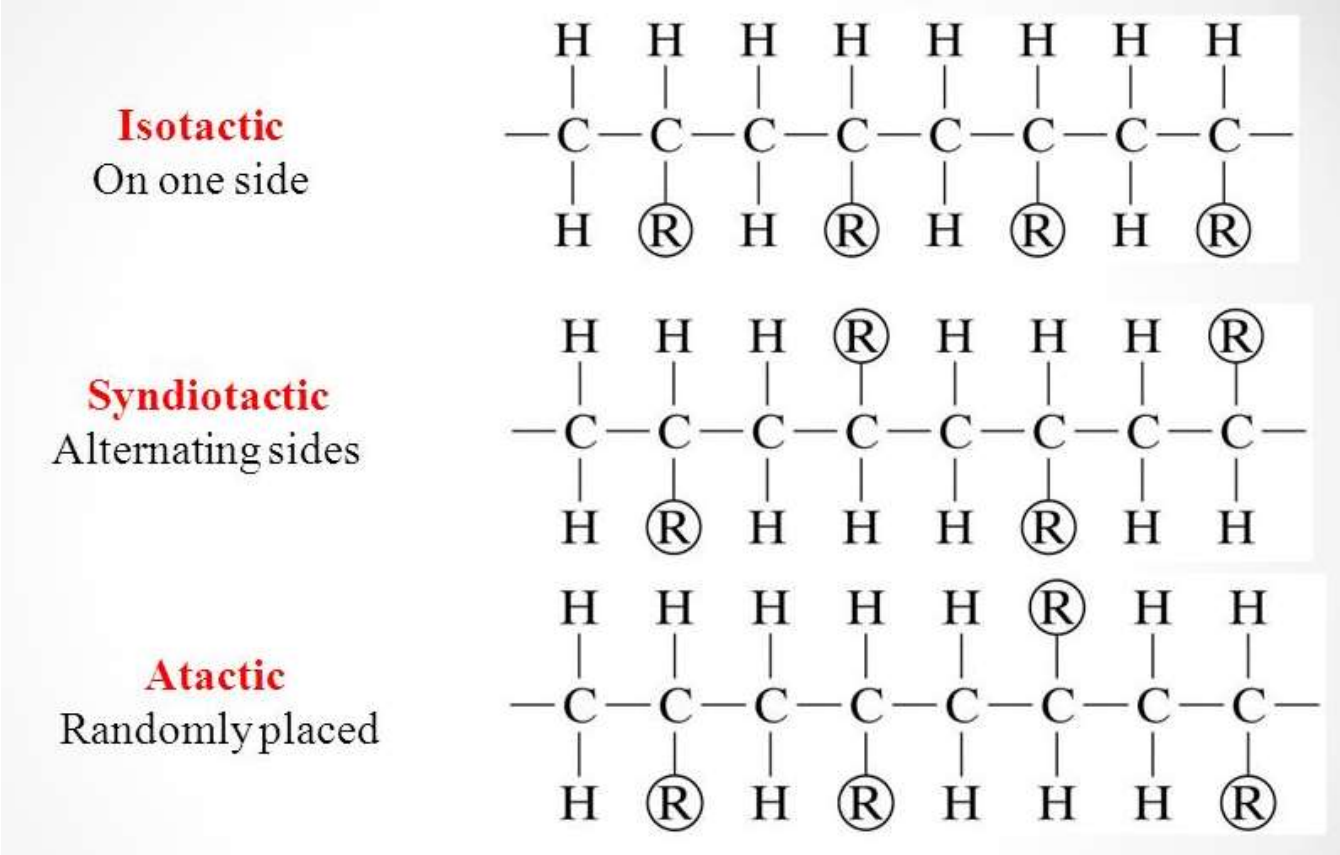
Several unwanted gases such as carbon monoxide and sulfur dioxide including few heavy metals like mercury are released that are also responsible for acid rains.

- **2. Crude Oil**



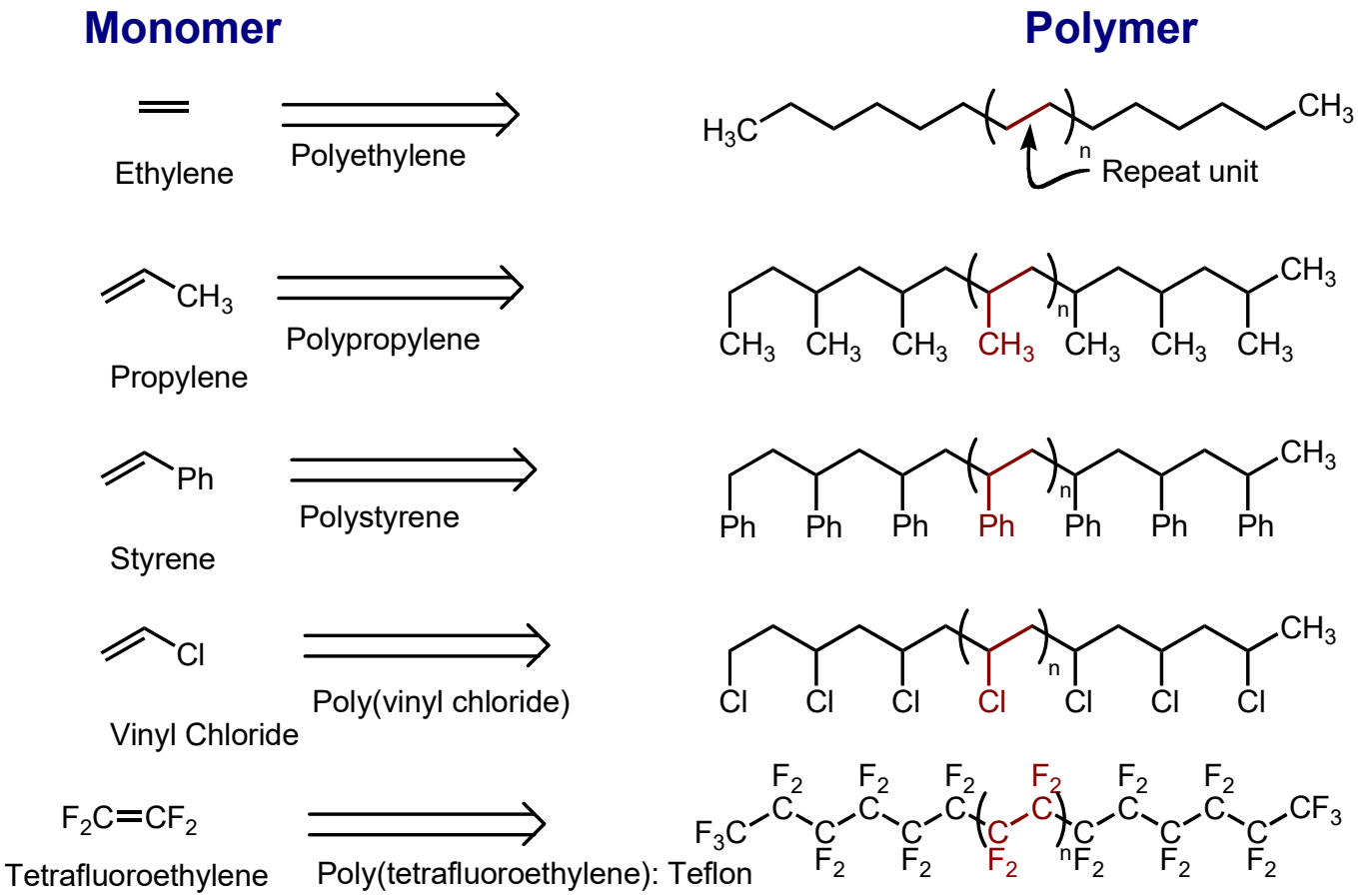
- The second point is about the main topic of this course, i.e. Oil or Crude oil or Petroleum.
- It is generally a mixture of carbon containing alkane derivatives (C1 to C40 chains), that maybe linear and branched chains, naphthalenes, aromatic hydrocarbons that occur naturally in oil fields.
- Low boiling fractions are composed of alkanes in almost all petroleum / crude oil.

Polypropylene Tacticity

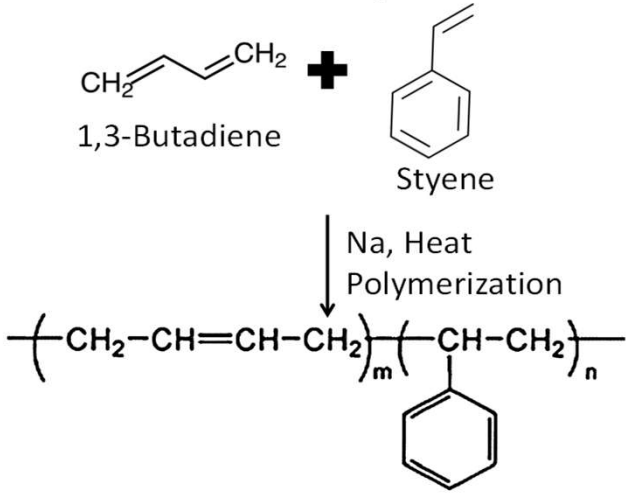


Isotactic and Syndiotactic polypropylene are semi- crystalline and crystalline whereas Atactic polypropylene is amorphous.

Common Polyolefins



BUNA-S Rubber (elastomer)



Styrene-Butadiene Copolymer – SBR or BUNA-S

- **Styrene-butadiene** or **styrene-butadiene rubber** (SBR) describes families of synthetic rubbers derived from styrene and butadiene.
- In Buna-S, **Bu** stands for butadiene, **Na** for sodium and **S** for styrene.
- Random co-polymer formed by the emulsion polymerization of a mixture of 1,3-butadiene and styrene in the presence of peroxide catalyst.
- These materials have good abrasion resistance and good aging stability when protected by additives.

Continued…..

- Composition varies based on the geographical location and the source & there may be presence of higher boiling fractions.
- Crude oil obtained from certain places also consists of nitrogen, oxygen, sulfur and also metallic constituents in addition to the hydrocarbons.
- Crude oil has numerous unwanted impurities like heavy metals, waxes, salts, etc. Crude oil with a high sulfur content is considered “sour” and low-sulfur oil is “sweet”.
- Cyclic alkanes are also present in the crude oil.
- These chemical fuels constitute >90% of world energy requirements.

3. Natural gas

- It mainly consists of methane gas.
- It also has first six alkanes in approximately 97% but chiefly contains methane, followed by ethane, propane and then higher alkanes.
- Other gases such as water vapour, hydrogen, nitrogen, carbon dioxide and hydrogen peroxide are also present in varying quantities in natural gas.
- Since the natural gas generally flows easily up through wells to the surface it is not very difficult to get it.

Continued…..

- With newer technologies, natural gas is also produced from shale and other types of sedimentary rock formations
- This can be done by forcing water, chemicals, and sand down a well under high pressure.
- This has been practiced and is hugely successful in USA and it is now a oil exporting nation.
- Natural gas is an important source of fuel since it releases low levels of emissions thereby reducing acid rain and greenhouse gases emissions.

4. Nuclear energy

- Nuclear energy, is generated from fusion or fission reaction process.
- India also has been setting up nuclear power plants and the recent is of the Kudankulam nuclear power plant in Tamilnadu.
- In a nuclear reactor the nuclear chain reactions occur that produces large amount of heat through a physical process called fission.
- Splitting U235/Pu239 by neutron bombardment give fission products (an unstable U236/Pu240) atom that releases heat energy (200 million eV) (Kr92, Ba141, U236, Pu240, Xe134, Zr103). 1g U235 produces 200 million joules of energy = 4.5 tonnes coal.

Continued…..

- The large heat energy is used to make steam that spins a turbine to create or produce carbon-free electricity.
- The three most widely used fissile isotopes are uranium-233, **uranium-235 and plutonium-239**.
- There are several disadvantages of this method such as an explosion at a nuclear fission power plant can spread radioactive fuel into the environment.
- Also the radioactive wastes generated in the plants cannot be decomposed easily and can be hazard to life for thousands of years.

The balanced nuclear equation for the fission of uranium-235 (U-235) can be represented as follows:
$U_{235} + n_1 \rightarrow Ba_{141} + Kr_{92} + 3n_1$

This equation represents the fission of a U-235 nucleus after absorbing a neutron (n_1), resulting in the formation of a barium-141 (Ba_{141}) nucleus, a krypton-92 (Kr_{92}) nucleus, and the release of three additional neutrons.

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow P1 + P2 + P0$$

$$^{239}_{94}Pu + {}^{1}_{0}n \longrightarrow P3 + P4 + P0$$

Answer :

$$^{92}_{36}Kr + {}^{141}_{56}Ba + 3\,{}^{1}_{0}n$$

$$^{134}_{54}Xe + {}^{103}_{40}Zr + 3\,{}^{1}_{0}n$$

What is the balanced equation for the fission of U-235 and Pu-239?