Notes

32

PETROCHEMICALS

In the first five modules of this course in chemistry you have learnt about the conceptual framework of this vast subject. In the first two modules you studied the chemistry of the elements of s,p,d and f blocks and of organic compounds respectively. In this optional module you would learn about some important industrial chemicals.

The first lesson of this module deals with petrochemicals, the chemicals derived from petroleum. Petrochemicals include a very vast range of chemicals. You would learn about their meaning, classification, production and application. This lesson also deals with soaps and detergents and rocket fuels. Many of them are the important byproducts obtained from petrochemicals. In the next lesson you would learn about polymers another vast class of molecules which are integral part of our day to day life.

Objectives

After reading this lesson you will be able to :

- define petrochemicals;
- explain different generations of petrochemicals with flow sheet diagram;
- cite various examples of petrochemicals;
- list uses of various petrochemicals;
- write about the status of petrochemicals in India;
- distinguish between soaps and detergents;
- explain types of detergents;
- list advantages and disadvantages of detergents over soaps;
- explain cleaning action of soaps and detergents;
- classify rocket propellants;
- give examples of chemicals used in various classes of rocket propellants and
- write about the status of propellants with reference to Indian Space programs.

32.1 What are Petrochemicals?

You are aware, petroleum is a complex mixture of hydrocarbons formed by the decomposition of fossil remains. It exists as a liquid (crude oil), gas (natural gas) or as solids (oil shales) and is found deep underground or below seabed.

You have also studied that petroleum is refined to several useful fractions, which are used as fuel (LPG, petrol, diesel, etc.) or lubricants. About 10% of the petroleum is used to prepare a range of chemicals called petrochemicals, we may define, petrochemicals as a group of chemicals produced directly or indirectly from the hydrocarbons of petroleum or natural gas.

Some gaseous hydrocarbons are also obtained as a by product during petroleum refining. These hydrocarbons may contain one to five carbon atoms, for example, methane, ethane, propane, butane, iso-butane, pentane, etc. Methane (CH_4) is also a major hydrocarbon component of natural gas, which occurs in association with petroleum.

At one time these gaseous hydrocarbons were of almost no use and the only way to dispose them was to burn them. With passage of time these gaseous hydrocarbons have found important use as starting material to produce a large variety of petrochemicals. Today, the demand of petrochemicals and the materials derived from petrochemicals is so great that we need to deliberately convert higher hydrocarbons to smaller gaseous hydrocarbons by the process of cracking.

The list of petrochemicals is endless. Some important petrochemicals are methyl alcohol, ethyl alcohol, acetaldehyde, acetic acid, acetic anhydride, acetone, benzene, toluene, xylenes, phenol, vinyl chloride, etc. some of these can be used directly or as raw materials for the manufacture of other useful products. These are used to manufacture a vast variety of useful materials like solvents, adhesives, antifreezes, synthetic rubbers, synthetic fibers, nylon, polyester, plastics, synthetic detergents, rocket fuels, etc.

Since every area of human activity makes use of petrochemicals or the materials made from petrochemicals, our life without petrochemicals would be very different and less comfortable.

32.2 Classification of Petrochemicals

The nature of petrochemical industry is very complex. The journey from petroleum to useful end products is long and there are many steps in the process. Let us try to understand feed-stock, primary and intermediate petrochemicals and the end products in the context of petrochemicals.

Feed Stock

The starting material used for the production of petrochemicals is called feed stock. There are two common feed stocks for the manufacture of petrochemicals; these are :

1. Natural gas

2. Naphtha and reformed naphtha

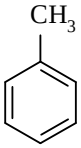
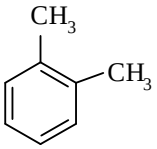
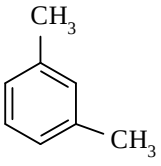
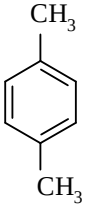
You would recall that natural gas occurs in nature in association with petroleum. The major hydrocarbon component of natural gas is methane. Naphtha is a fraction obtained during refining of petroleum.

Some countries or industries prefer to use natural gas while some other use naphtha as a starting material (feed stock) for the production of petrochemicals. The choice for the use of natural gas or naphtha as feed stock by a particular country or industry depends upon the availability of a particular feed stock or the availability of technology for the manufacture of petrochemicals.

32.2.1 Primary Petrochemicals

Primary petrochemicals are the molecules obtained from the feed stock and are used to manufacture petrochemical intermediates. Since the feedstock consists of natural gas, naphtha and reformed naphtha, these give different primary petrochemicals. The primary petrochemical obtained from these are compiled in Table 32.1.

Table 32.1 : Important Primary Petrochemicals from different feed stocks

S.No.	Feed Stock	Primary petrochemicals	Formulae
1.	Natural gas	Ethene	$CH_2 = CH_2$
		Propene	$CH_3 - CH = CH_2$
		Ethyne	$CH \equiv CH$
2.	Naphtha	Ethene	$CH_2 = CH_2$
		Propene	$CH_3 - CH = CH_2$
		Butadiene	$CH_2 = CH - CH = CH_2$
3.	Reformed Naphtha	Benzene	
		Toluene	
		o – xylene	
		m-xylene	
		p-xylene	

32.2.2 Intermediate Petrochemicals and Derivatives

The petrochemicals obtained from primary petrochemicals by chemical reaction are called (secondary) intermediate petrochemicals. Petrochemicals are also refered to as first generation petrochemicals and second generation petrochemicals, First generation petrochemicals are converted to second generation petrochemicals. These intermediate petrochemicals may be put to some use or these may be further processed to get derivatives of petrochemicals by a chemical reaction or a series of reactions to get products for other end uses.

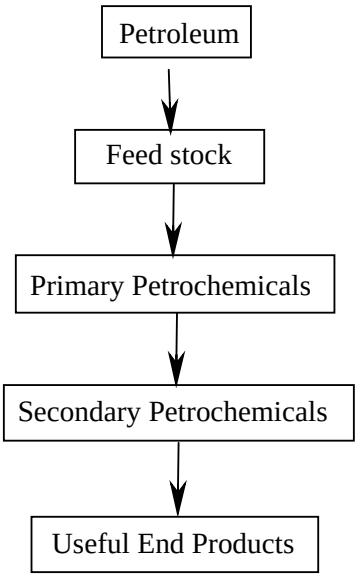


Fig. 32.1 : *Relationship between petroleum, feedstock, primary petrochemicals, secondary (intermediate) petrochemicals and useful end products.*

32.2.3 Down Stream Petrochemicals

The petrochemicals obtained from a given feedstock by a series of reactions are called down stream petrochemicals. Down stream means that a particular petrochemical comes at a later stage in the sequence of chemicals produced. For example in the following reaction.

$$CH_4 \rightarrow CH_3Cl \rightarrow CH_3OH$$

Methyl alcohol is referred to as a down stream petrochemical.

It is not possible to list here all the petrochemicals and the chemical processes used for their manufacture. Uses of the petrochemicals are very diverse and it is impossible to give a complete list. Therefore, we are giving methods of manufacture of some of the petrochemicals and their derivatives along with their uses. We will discuss in detail the petrochemicals obtained from methane and ethene as two typical examples. While for some other starting materials we will give, only the names of the petrochemicals which can be obtained from them You can learn more details in higher classes or in more advanced books. Here you will have some idea about the vastness and importance of the petrochemicals.

Intext Questions 32.1

1. Define petrochemicals

   .....

2. What do you understand by the term feed stock with reference to petrochemicals?

   .....

3. Write names of two feed stocks used in petrochemicals industry.

   .....

4. What do you understand by the term down stream petrochemical? Explain with an example.

   .....

5. Methane is converted into methyl chloride then methyl chloride is converted to methyl alcohol. In this case identify the first generation and second generation petrochemical.

   .....

32.2.4 Petrochemicals from Methane

Methane is the major hydrocarbon component of natural gas. CNG is the compressed natural gas and LNG is the liquified natural gas. Moreover, methane is also obtained in large quantities as a by product of petroleum refining.

The major petrochemicals produced from methane are:

1. Chlorinated products
2. Unsaturated hydrocarbons
3. Carbon black
4. Hydrogen
5. Methyl alcohol

1. Chlorinated products of methane

Methane is chlorinated to get methyl chloride (CH_3CI), methylene chloride (CH_2CI_2), chloroform ($CHCI_3$) and carbon tetrachloride (CCI_4). Most of the chlorinated products of methane are used as a solvent.

$$CH_4 + CI_2 \rightarrow CH_3CI + CH_2CI_2 + CHCI_3 + CCI_4$$

2. Unsaturated hydrocarbons

Methane is cracked (by pyrolysis) with the help of suitable catalysts to get ethylene, propylene and acetylene. These are used to get other products, which will be discussed later.

3. Carbon black

Methane is converted into carbon black (a form of carbon) by pyrolysis (cracking) and

hydrogen is obtained as a by product. Carbon black is used as a black pigment in manufacture of black printing ink and in rubber tyre industry.

$$<CH_4 \xrightarrow{\Delta} C + 2H_2>$$

4. Hydrogen

Hydrogen obtained by pyrolysis of methane is used for the manufacture of ammonia gas. Ammonia is used as a raw material for manufacture of urea (a fertilizer), ammonium nitrate and several other products.

5. Methyl alcohol

Methane is converted into methanol (methyl alcohol, CH_3OH) by catalytic oxidation.

$$<CH_4 + O_2 \xrightarrow{\text{Catelyst}} \underset{\textbf{(methanol)}}{CH_3OH}>$$

Methyl alcohol (methanol is further oxidized to get formaldehyde. Formaldehyde is an important raw material for number of useful products, for example phenol-formaldehyde resins (bakelite). Methyl alcohol is an important industrial solvent.

$$<CH_3OH \longrightarrow \underset{\textbf{(formaldehyde)}}{HCHO}>$$

32.2.5 Petrochemicals from Ethylene

Ethylene is obtained by pyrolysis of natural gas or from naphtha by cracking. Ethylene is an unsaturated hydrocarbon and has a carbon-carbon double bond. Therefore, ethylene is very reactive and can be converted to a variety of petrochemicals and useful end products.

The major petrochemicals produced from ethylene are :

1. Ethyl alcohol
2. Ethylene oxide
3. Ethylene glycol
4. Dichloroethane
5. Vinyl chloride
6. Polyethylene
7. Ethyl benzene

1. Ethyl Alcohol

Ethyl alcohol (ethanol) is made by hydration of ethylene. Ethyl alcohol is used as a solvent and a raw material for the manufacture of acetic acid, ethyl acetate and a large number of other useful products.

$$<H_2C = CH_2 \xrightarrow{H_2O/H_2SO_4} \underset{\textbf{(ethanol)}}{CH_3CH_2OH}>$$

2. Ethylene Oxide

Ethylene is oxidized to ethylene oxide with air or oxygen in the presence of a catalyst. It is a raw material for the manufacture of ethylene glycol, which is a starting material for the manufacture of polyester.

$$H_2C = CH_2 \xrightarrow[O_2]{\text{Catalyst}} H_2C\!-\!CH_2 \quad (\text{O bridge})$$

(ethylene oxide)

3. Ethylene Glycol

Ethylene glycol (1,2-dihydroxyethane) is manufactured by starting with ethylene. There are several methods by which ethylene is converted to ethylene glycol.

Glycol is used as an anti freeze in automobiles. Ethylene glycol is an important starting material for the manufacture of polyester.

$$H_2C = CH_2 \longrightarrow HO - CH_2 - CH_2 - OH$$

(ethylene glycol)

4. Dichloroethane

Dichloroethane (1,2-dichloroethane) is made from ethylene by the reaction of chlorine. It is used as a starting material for several other raw materials like ethylene glycol, vinyl chloride, etc.

$$H_2C = CH_2 + Cl_2 \longrightarrow Cl - CH_2 - CH_2 - Cl$$

(1, 2-dichloroethane)

5. Vinyl Chloride

Vinyl chloride is made directly from ethylene or is made from ethylene dichloride.

$$H_2C = CH_2 + Cl_2 \longrightarrow CH_2 = CH - Cl + HCl$$

(vinyl chloride)

$$Cl - CH_2 - CH_2 - Cl \longrightarrow CH_2 = CH - Cl + HCl$$

(vinyl chloride)

6. Polyethylene

On polymerization ethylene gives polyethylene (polyethene), which is an important plastic material.

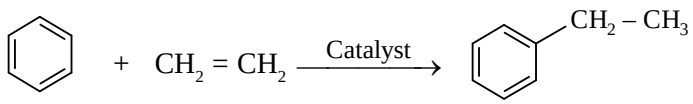
$$n\ \ H_2C = CH_2 \longrightarrow -CH_2 - CH_2\left[-CH_2 - CH_2-\right]_n CH_2 - CH_2 -$$

(ethylene) **(polyethylene)**

7. Ethyl Benzene

Ethylene reacts with benzene in the presence of a suitable catalyst to give ethyl benzene. Ethyl benzene is converted to styrene. Styrene is a raw material for the manufacture of

an important plastic material polystyrene.



Ethylbenzene

32.2.6 Petrochemicals from Propylene

Propylene is obtained by pyrolysis of natural gas or by cracking of naphtha. Propylene is an unsaturated hydrocarbon.

The main petrochemicals produced from propylene are:

1. Iso-propyl alcohol
2. Polypropylene
3. Cumene (isopropyl benzene)
4. Glycerol

32.2.7 Petrochemicals from Acetylene

Acetylene (ethyne) is obtained by pyrolysis of natural gas. It is an unsaturated hydrocarbon. It has a carbon-carbon triple bond. It is highly reactive in nature.

The major petrochemicals produced from acetylene are:

1. Vinyl chloride, vinyl acetate and acrylonitrile
2. Acetaldehyde

32.2.8 Petrochemicals from Butadiene

1, 3-Butadiene is obtained from naphtha by cracking. It is a diene, that is, it has two carbon-carbon double bonds.

It is a monomer for polybutadine which is used as a substitute for natural rubber. Butadiene and styrene on polymerization give a copolymer called BUNA-S.

32.2.9 Petrochemicals from Benzene

Benzene is obtained from reformed naphtha. Naphtha is subjected to catalytic reforming (also called aromatization). In the process aliphatic hydrocarbons present in naphtha are converted to aromatic hydrocarbons.

Important petrochemicals obtained from benzene are:

1. Ethyl benzene and cumene
2. Chlorobenzene
3. Nitrobenzene
4. Cyclohexane
5. Linear alkyl benzenes (LAB)
6. Branched alkyl benzenes (BAB)

Intext Questions 32.2

1. Define primary petrochemicals.

   .....

2. Mention three petrochemicals obtained from natural gas.

   .....

3. What are the important petrochemicals obtained from propene?

   .....

4. What are the important petrochemicals obtained from ethyne (acetylene)?

   .....

5. What are the petrochemicals obtained form benzene?

   .....

32.3 Status of Indian Petrochemical Industry

The Indian petrochemical industry is very small by international standards. For example, India accounts for less than three percent of the world's ethylene capacity. Ethylene capacity of India is 24 lakh tones per annum, while that of USA is 288 lakh tones per annum (2002 figures)

The common polymers manufactured in India are Low Density Poly Ethylene (LDPE), High Density Poly Ethylene (HDPE), Poly Propylene (PP), Poly Vinyl Chloride (PVC) and Poly Styrene (PS).

The main producers of polyethylene and polypropylene in India are the Reliance Industries Limited (RIL), Indian Petrochemicals Corporation Limited (IPCL), Haldia Petrochemicals Limited (HPL) and the Gas Authority of India Limited (GAIL). These industries have an advantage of having integrated petrochemical complexes. The integrated complexes have a petroleum refinery and plants producing petrochemicals at the same location. It saves on the cost of production and transportation etc. The Indian share in the production of petrochemicals has increased significantly since the commissioning of refinery based polypropylene facilities at Jamnagar by the RIL.

Till recently India could not produce enough purified terphthalic acid (PTA) and dimethyl terephthalate (DMT) to fulfill the demand of the Indian polyester industry. The production capacity was lower than the local demand. Therefore, India had to import PTA and DMT. The increase in the production of polyester in India has led to the building up of world scale plants for the manufacture of key intermediates like PTA and DMT. In India, the production of raw materials for polyester received a big boost with the commissioning of the petrochemical complexes at Patalganga and Hazira by the RIL.

The RIL, along with IPCL has a share of over 60% of the Indian polymer market for LDPE, HDPE, PP and PVC. RIL have large petrochemical complexes. The RIL also has the largest naphtha cracker in Asia. IPCL has three small to medium-sized petrochemical complexes based largely on natural gas (two medium-sized crackers using natural gas and one small-sized cracker using naphtha).

The RIL has a large share of the Indian polyester market. It has a significant position in the global market for PTA and paraxylene (a raw material for PTA). The RIL's facilities are world scale, while the plants of other companies are much smaller.

IPCL produces mono ethylene glycol (MEG) at two locations. One plant is natural gas based and the other is naphtha based. The RIL has a large naphtha based MEG facility at Hazira petrochemical complex.

32.4 Soaps and Detergents

Soaps and detergents are widely used as cleaning agents. Chemically soaps and detergents are quite different from each other. The common feature of soaps and detergents is that when dissolved in water the molecules of soap and detergent tend to concentrate at the surface of the solution or at interface. Therefore, the surface tension of the solution is reduced, it causes foaming of the solution.

Soaps and detergents lower the surface tension of the solution. Such substances are called surface-active agents or surfactants.

To sum up, soaps and detergents:

1. are used as cleansing agents
2. cause foaming of the solution
3. lower surface tension
4. molecules tend to concentrate near the surface of the solution
5. are the surface active agents
6. are the surfactants
7. can emulsify grease
8. can remove dirt, etc.

Hydrophilic and Lipophilic Parts

Both soap and detergent molecules have two parts. One part of the molecule is polar (ionic) in nature. Polar nature is due to the presence of groups like carboxylate ($-COO^-$) or sulphonate ($-SO_3^-$). The polar group is a hydrophilic group. The hydrophilic group makes soaps and detergents soluble in water. The other part of the soap or detergent molecule is non polar (nonionic) that is lipophilic. The lipophilic part (a long chain alkyl or a long chain substituted aryl group) makes the molecule oil soluble.

Depending on the nature of the hydrophilic (polar) part in the soap or detergent molecule these are classified as anionic, cationic or non-ionic type. For example, soap has a carboxylate anion therefore soap is anionic type (table 8.5.1). Synthetic detergents have sulphonate anion thus they are also classified as anionic type. Anionic types are the most common. However, cationic and non-ionic detergents are also known.

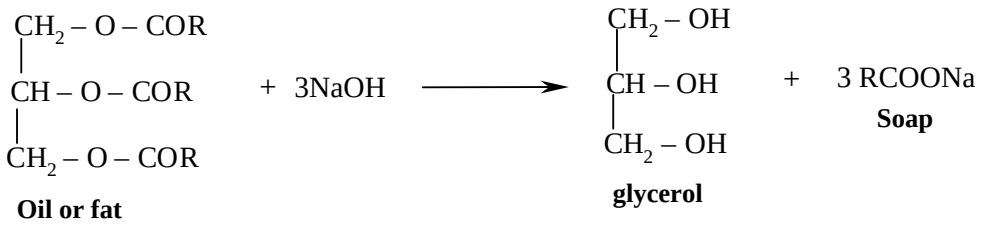
Soaps

Soaps are the sodium or potassium salts of long chain fatty acids. These fatty acids are present in oils and fats in the form of glycerides. The glycerides present in oils and fats are

the esters of glycerol and long chain carboxylic acids for example palmitic acid and stearic acid.

Saponification

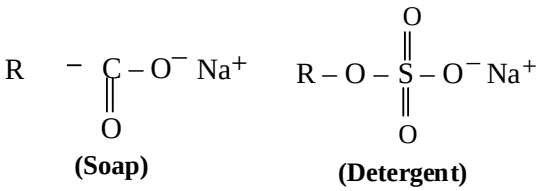
Saponification is the process of making soap. Saponification is done by hydrolysis of oils or fats (of vegetable or animal origin) with the help of alkali like sodium hydroxide (NaOH) or potassium hydroxide (KOH)



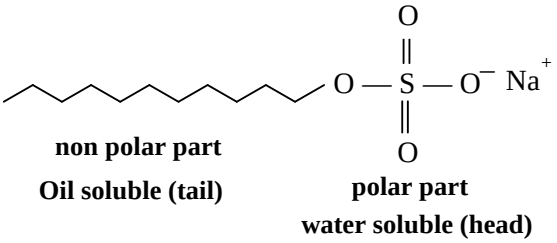
(where R= long chain alkyl group containing 11 to 17 carbon atoms)

Synthetic Detergents

Synthetic detergents are used as cleaning agents much like soaps. Chemically, detergents are sodium salts of long-chain alkyl hydrogen sulphate or sodium salts of long-chain alkyl benzene sulphonic acids. (Remember that soap is a sodium or potassium salt of long-chain fatty acid.)



Detergent molecules are similar to that of soap molecules, that is they have an oil-soluble (lipophilic) long chain of carbon atoms and a polar (hydrophilic) water-soluble part. For example, sodium lauryl sulphate ($C_{12}H_{25}$–O – SO_3Na) has a 12 carbon atom hydrocarbon like alkyl chain. The long carbon chain is oil-soluble (lipohilic) part and the sulphate is polar (hydrophilic) part that makes the molecule water-soluble. The water-soluble part is referred to as water-soluble head and the long chain of carbon atoms is referred to as oil-soluble tail.



Advantages and Disadvantages of Synthetic Detergents

The synthetic detergents are better than soaps in certain respects. Synthetic detergents can be used for washing of clothes even if the water is hard. Calcium and magnesium ions

present in hard water make corresponding salts with detergent molecules. The calcium and magnesium salts of detergent molecules are soluble in water (unlike that formed by soap molecules).

However, detergent containing branched alkyl benzene sulphonate is not completely biodegradable (Table 32.2). Soap is completely biodegradable. Therefore, excessive use of synthetic detergents is a cause of worry. The problem has been partly solved by using linear alkyl benzene sulphonate, which has better bio-degradability then the branched alkyl benzene sulphonate (Table 32.2)

Table 32.2 : Bio-degradability and class of soaps and some synthetic detergents

Detergent	Class	Polar Group	Bio-degradable
Soaps	anionic	Carboxylate	100%
Branched alkyl benzene sulphonate	anionic	Sulphonate	50-60%
Linear alkyl benzene sulphonate	anionic	sulphonate	90%
Lauryl alcohol	anionic	Sulphate	100%

Intext Questions 32.3

1. What is the active component in soaps ?

   .....

2. What are the raw materials used for the manufacture of soaps ?

   .....

3. What is the polar part in a soap molecule ?

   .....

4. What is the polar part (hydrophilic) in a synthetic detergent molecule ?

   .....

5. What is the oil-soluble (lipophilic) part in the soap molecule ?

   .....

6. Branched alkyl benzene sulphonate is more bio-degradable than linear alkyl benzene sulphonate. Is it true or false ?

   .....

32.5 Rocket Propellants

Development in rocket technology and use of better rocket propellants has enabled American astronauts to land on moon and successful spacewalk by the Russian astronauts. Launching of satellites and development of missiles has also been possible due to the advances in the rocket propellants.

India also has made considerable advances in the use and development of space technology. Indian Space Research Organization (ISRO) is the main organization for the development of space technology in India.

India has developed missiles, which can be used for the defense of our country. Moreover, India is one of those few countries that are capable of launching satellites.

Rocket Fuels

Space rockets are used for launching satellites and for propelling missiles. These rockets work on the same principle as that of fire-work rocket the Newton's third law of motion. However, their design and fuels are more complicated.

Rocket Fuels Are different

Fuels used in the rockets are very different form the fuels used in cars, trucks or airplanes. Following are the main differences between the rocket fuels and other conventional fuels.

1. A rocket fuel must occupy small space in the rocket.

If the fuel occupy a large space then the rocket will become very big and heavy. It may not be able to attain high velocity to go out high in the space.

2. A rocket must carry enough supply of oxygen (or oxidizing agents) to burn the fuel.

A space rocket has to pass through areas in space where there is little or no oxygen (air become rarer as we go out in space - away from earth).

Classification of Rocket Propellants

Rocket propellants are classified on the basis of their physical state. The major classes of rocket propellants are:

1. Solid propellants

2. Liquid propellants

3. Hybrid propellants

1. Solid Propellants

Solid propellants are the most commonly used rocket propellants. These are also known as solid composite propellants. It is a mixture of a solid fuel and a solid oxidizer.

Polymeric solid substances like polyurethane or polybutadiene are used as fuel. Solid ammonium per chlorate is used as an oxidizer. Finely divided aluminum or magnesium is also added to improve the performance of the propellant.

Double Base Propellants

Another type of solid propellant is a double base propellant. It consists of nitroglycerine and nitrocellulose. Nitrocellulose gels in nitroglycerine to set as a solid mass. Both nitrocellulose and nitroglycerine have enough oxygen in their nitro groups to support the combustion of fuel. This do not need any separate oxidizer.

Solid propellants on ignition can be made to burn at a predetermined rate. The problem with solid propellants is that once ignited they will continue to burn and it is not possible to stop ignition or to change the rate of ignition.

2. Liquid Propellants

Liquid propellants use a combination of a liquid fuel and a liquid oxidizer.

Liquid propellants, in general, give a higher thrust than solid propellants. Switching on and off the flow of the propellant can control the thrust. Controlling the rate of flow of the fuel can also control the thrust.

Liquid propellants are of two types. These are:

(a) Bi-liquid propellants

(b) Mono-propellants

(a) Bi-Liquid Propellants

Bi-liquid propellants contain a liquid fuel and a liquid oxidizer. The liquid fuel and liquid oxidizer are kept in separate tanks. These are taken to the ignition chamber through separate pipelines.

If liquid oxygen is used as an oxidizer and liquid hydrogen is used as a fuel then the very low temperatures are to be maintained. Therefore, special engines are used to pump them through the pipes. The engines, which can work at extremely low temperatures, are known as **cryogenic engines.** Very few countries have the capability to manufacture cryogenic engines.

The most commonly used liquid fuels are kerosene, alcohol, hydrazines, liquid hydrogen, etc. The commonly used oxidizers are liquid oxygen, nitric acid, nitrogen tetraoxide (N_2O_4).

(b) Mono-Propellants

Mono-propellants contain a single chemical compound. On decomposition or ignition these produce a large volume of gases.

Hydrazine (N_2H_4) can be used as a mono-propellant. Hydrazine on catalytic decomposition produces nitrogen and hydrogen gas. Some other examples of monopropellants are nitro methane, methylene nitrate, hydrogen peroxide, etc.

3. Hybrid Propellants

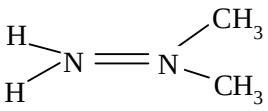
Hybrid propellants are those, which have a solid fuel and a liquid oxidizer. For example, a mixture of acrylic rubber is used as a fuel and liquid nitrogen tetraoxide (N_2O_4) as an oxidizer.

Propellants used in Various Rockets

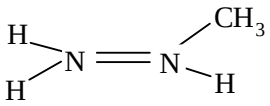
Different fuels have been used in different space programs. Some rockets may use different fuels in the different stages of ignition.

In India SLV-3 (Space Launch Vehicle) and ASLV (Augmented Space Launch Vehicle) rockets have used composite solid propellants.

The PSVL (Polar Satellite Launch Vehicle) used solid propellants in the first and the third stages. In the second stage liquid propellant nitrogen tetraoxide (N_2O_4) as oxidizer and unsymmetrical dimethyl hydrazine (UDMH) as a fuel is used. In the fourth stage N_2O_4 and monomethyl hydrazine (MMH) is used as a fuel. India is one of the six nations, which have PSLV capability. The other five nations are the US, Russia, China, France and Japan.



Unsymmetrical dimethyl hydrazine
UDMH



mono methyl hydrazine
MMH

You often read in newspapers or watch news on TV about the development of missiles by India. India has developed various missiles and you are familiar with their names. Some of them are Bhramos, Dhanush, Prithvi-I, Prithivi-II, Prithivi-III, Agni-I, Agni-II, Akash, Trishul, Nag, Astra, etc. All these missiles need a rocket to fire them

The titan ballistic missiles use hydrazine as a fuel and nitrogen tetraoxide as an oxidizer. The space-shuttle uses liquid hydrogen and liquid oxygen combination along with solid boosters in the lower stages of the rockets. The Saturn booster rocket (used in American Space Program) derives its thrust from a bi-liquid propellant. It uses a combination of kerosene as a fuel and liquid oxygen as an oxidizer for the initial stages. Liquid oxygen and liquid hydrogen is used for the higher stages of the rocket. Russian rockets such as Proton use a bi-liquid propellant, which is a combination of kerosene and liquid oxygen. Continuous efforts are being made to find better and better rocket propellants.

Intext Questions 32.4

1. Which of the Newton's laws of motion governs the motion of rockets?

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2. Why are rocket fuels different from the fuels used in automobiles?

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3. What are the main classes of rocket propellants?

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4. Name one oxidiser used in ballistic missiles.

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What You Have Learnt

- Definition of petrochemicals
- Different generations of petrochemicals with flow sheet diagram
- Different examples of petrochemicals
- Learnt the uses of various petrochemicals
- Known the status of petrochemicals in India
- Difference between soaps and detergents

- Lipophilic and hydrophilic parts of soap and detergent molecules
- Advantages and disadvantages of detergents over soaps
- Classification of rocket propellants
- Chemical composition of various classes of rocket propellants
- Different propellants used in Indian Space programs

Terminal Exercises

1. What is the major hydrocarbon component present in the natural gas?
2. What are the common feed stocks used in the manufacture of various petrochemicals?
3. "Alkenes (olefins), benzene, toluene and xylenes are the primary petrochemicals." Is this statement true or false?
4. What are the major uses of the carbon black?
5. What are the major chemicals manufactured from methyl alcohol?
6. How is ethyl alcohol manufactured from ethylene?
7. How is vinyl chloride manufactured from ethylene?
8. What is the name of the polymer obtained from polymerization of styrene?
9. Write the name of the dicarboxylic acid obtained by oxidation of para-xylene?
10. Name a primary petrochemical obtained from reformed naphtha, which is used for the manufacture of synthetic detergents?
11. Why are the fuels used in rockets different from the fuels used in homes?
12. What is a double-base rocket propellent?
13. What are cryogenic engines?

Answers to Intext Questions

32.1

1. Petrochemicals are the chemicals obtained directly or indirectly from petroleum or its fraction.
2. Starting material used for the production of petrochemicals is called feedstock.
3. Natural gas and naphtha
4. Down stream petrochemical means a petrochemical which is formed at a later stage in the sequence (order) of the chemicals produced.
5. Methyl chloride is the first generation petrochemical and methyl alcohol in the second generation petrochemical.

32.2

1. Primary petrochemicals are the petrochemicals which are directly obtained from the feedstock.

2. Methyl alcohol, methyl chloride, carbon black.
3. Isopropyl alcohol, polypropylene, cumene and glycerol
4. Vinyl chloride, vinyl acetate, acrylonitrile and acetaldehyde.
5. Ethyl benzene, chlorobenzene, nitrobenzene, cyclohexane, linear alkyl benzene (LAB) and branched alkyl benzene (BAB)

32.3

1. Sodium or potassium salt of higher fatty acid.
2. Sodium or potassium hydroxide and oils and fats.
3. Carboxylate anion
4. Sulphonate anion.
5. Long normal alkyl chain.
6. False

32.4

1. The third law of motion.
2. Rockets need to carry their own supply of oxygen and should be light and occupy less volume.
3. Solid, liquid and hybrid propellent.
4. Nitrogen tetraoxide.