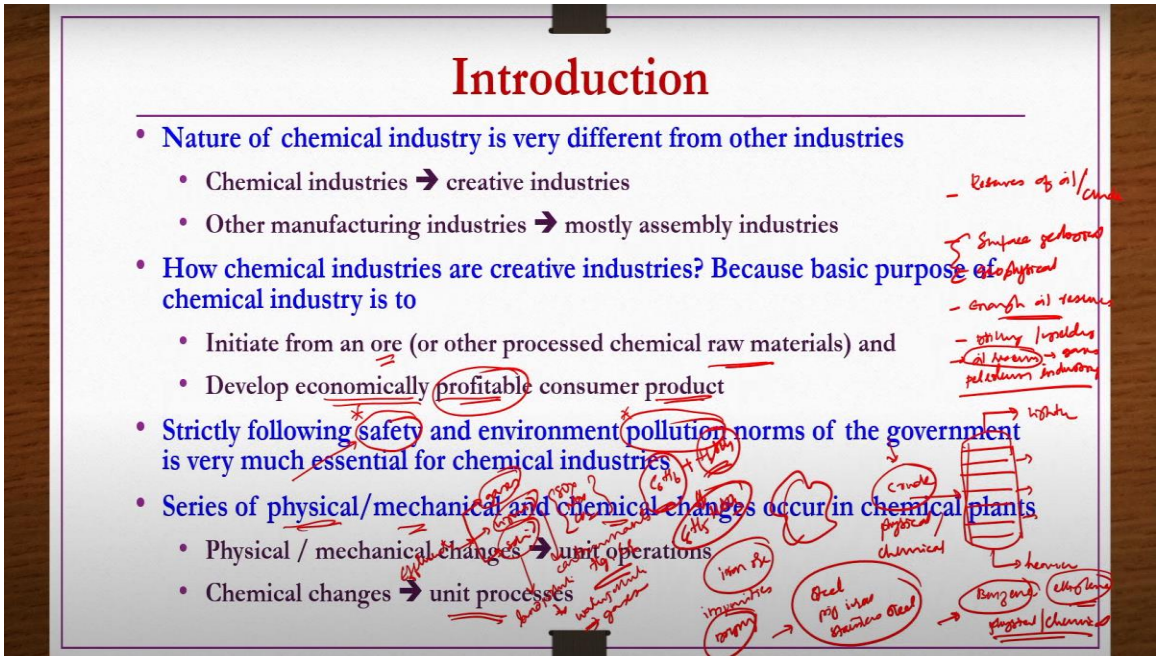
Organic Chemical Technology
Prof. Nanda Kishore
Department of Chemical Engineering
Indian Institute of Technology, Guwahati

Lecture – 01
Introduction to Organic Chemical Technology

Welcome to the MOOCs course Organic Chemical Technology. The title of today's lecture is Introduction to Organic Chemical Technology It is the first class of the course, since the course is on Organic Chemical Technology, primarily we'll be associated with the production of different types of organic chemicals how these are going to be produced in chemical factories, chemical industries that is what we are going to see Since most of the things are happening in chemical industries, whatever the things that we are going to discuss, it is necessary to have a brief introduction about the importance of the chemical industries in general.

(Refer Slide Time: 01:10)



So, let us start with the Introduction. Nature of chemical industry is very different from other industries. How it is different? Chemical industries may be considered as creative

industries. How it is creative industry that also we need to understand. Let us say you have a petroleum industry which is also one of the chemical industry actually. So, in the petroleum refinery what you do you find out the reserves of oil, crude, etc. Then you try to find out the way how to estimate how much it is available and then is it profitable when you do the drilling and excavation to get all these oil reserves from the underground of the earth that is what you have to see. For that purpose, you may be surface geological service may be required or geophysical methods also suitable, right? Then you find that enough reserves are there.

What do you mean by enough reserves? You have certain amount of or some quantum of oil reserves present, but the amount of effort and then money that you are putting into drill it and then get it on the surface and then do the post processing so that you can get different types of chemicals. All that you see the economics of the process. If you find it is sufficiently profitable, then only you can say that the enough oil reserves are there that you can do the excavation, right? Then what you do if you find it is profitable for going for these reserves, so then what you can do you can do the drilling and then yielding kind of technologies are there etc. are available. When you do this drilling not only oil reserves, but also some kind of gases like natural gases etc. would be available.

So, these oil reserves are natural thing, right? Now, these oil reserves are the basic raw material for n number of organic chemicals, those things we are going to see in the petrochemicals chapters when we discuss in the course. So, what happens here this oil reserves that in general what it is done in the petroleum refineries, they will be taken to a fluid catalytic converter, right? So, when you take it and then you do certain kind of fractionation, then what you do you get different types of products, lighter ones, heavier ones and then intermediate ones are these kind of different fractions you can get. So, let us say one of the products here you get the benzene, right? Or ethylene, right? Now naturally this crude is having certain physical and then chemical properties, right? And then these products like benzene or ethylene whatever you are having, they are having different physical and then chemical properties, right? What does it mean by like you know, you take a raw material which is crude or processed And then these products like benzene or ethylene whatever you are having, they are having different physical and then chemical

properties, right? What does it mean by like you know, you take a raw material which is crude or processed raw material whatever in general in chemical industry and then you do certain kind of reactions either catalytic or non-catalytic with different temperature, pressure as per the reaction those conditions changes that is different thing. So, when you take this processed raw material or crude raw material and then do certain kind of reactions you are getting a certain kind of consumer products which are having entirely different properties compared to the raw materials.

So, that means indirectly you are creating some other product from altogether different source. So, because of such kind of reasons one can easily say and then convince that the chemical industries are creative industries. Such kind of creation of different product from a kind of different raw material is possible in only chemical industries, okay? So, that is the reason we can say that chemical industries are creative industries whereas other manufacturing industries are mostly assembly industries. Then how these chemical industries are creative industries because basic purpose of chemical industry is to start with a raw material or ore, ore is also possible in general actually this ores let us say you have to make steel or pig iron or stainless steel etc., right? So, what you do you take the iron ore, this ore is available in a crude form which is having so many impurities etc.

Also, when you do the natural mining of the ores, so then you get these things in big lumps kind of sizes. They are not suitable for the reaction to take place. They have to be size reduced and then impurities has to be removed, right? So, once you do the size reduction and then impurities let us say you have certain kind of material which is also good raw material for some other product but not for the production of whatever you are intended to. You have to separate them. Then after that what you have to do you have to wash it so that to mud, dirt, etc., those kind of impurities can be washed out. Then you have to do the drying of raw materials etc., right? Once it is dried and size reduced, washed, cleaned and then dried it, then it is ready for the proper reaction to undergo in furnaces, etc., to produce the pig iron, etc. That is true for most of the things.

So then you may have an ore or you may have processed chemical raw material. Let us say you may be having benzene C_6H_6 available from some sources in pure form and then you have H_2SO_4. It is also available in pure form from some other sources. So then you react

them and then you try to get C6H5HSO3, right? So then what happens? So now here, so the raw material either it can be processed one, pure one or it can be over one. So these raw materials once it is processed, they will undergo some kind of reaction to develop a consumer product which is economically profitable.

So because of these reasons, we can say that chemical industries are creative industries. Now when these reactions take place in industries, so certain things has to be carefully followed. Indeed, strictly they have to be followed, something like safety and then pollution concerns. Let us say you design a plant for a production of a chemical which is going to be very profitable, but the plant is not safe enough. Then it is going to be dangerous to the personnel working in the plant as well as the neighboring area people also, okay? So that is the reason safety is very much important and then pollution control.

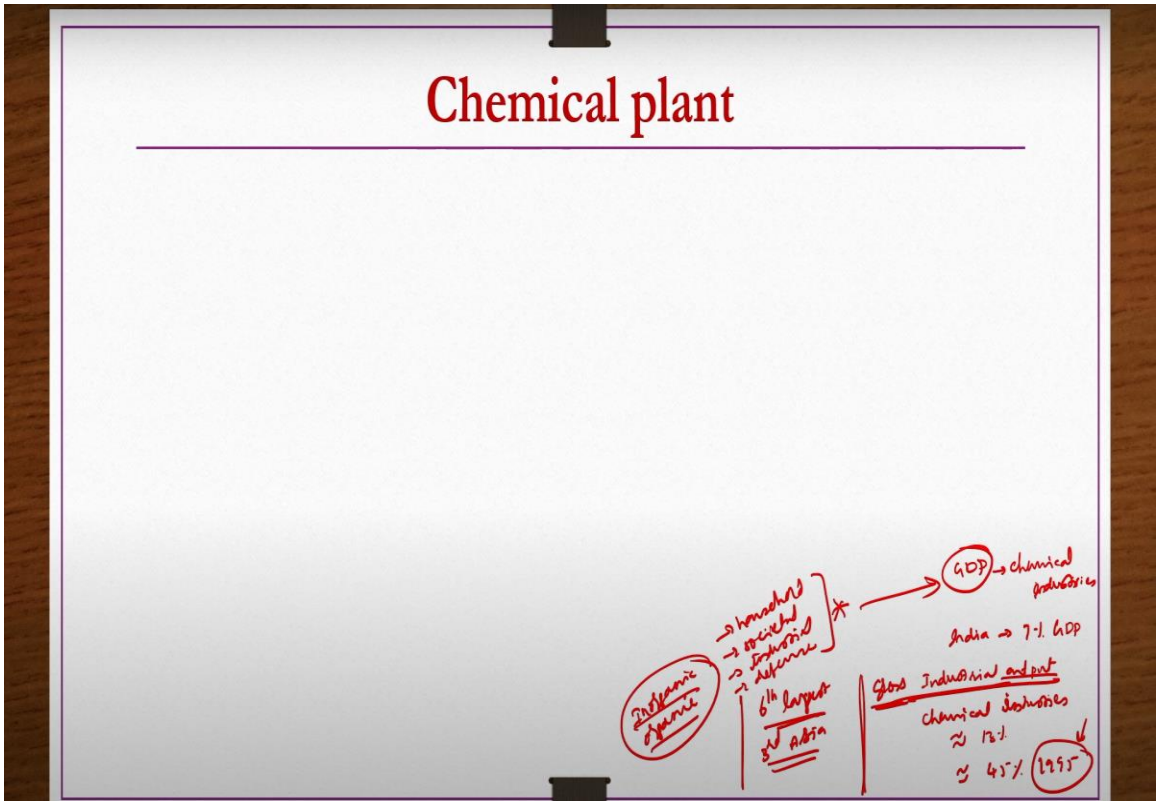
Any chemical plant you take, there would be some kind of effluents, right? So there may be gaseous effluents, there may be liquid effluents and then there may be solid residues or solid wastage. These gases if they are containing like SOX, NOX, etc., or CO2, in PPM more than the admissible one before releasing into the air that you have to check. If it is more than the admissible range of PPM as per the government laws, so you cannot simply release those gases in the environment. What you have to do? You have to do proper processing and then cleaning and then you make sure that the concentration of these dangerous chemicals should be less than the prescribed limit of the government, right? Similarly, liquid also it may be having some kind of contaminants like mercury, chromium, etc.

If these are present in high concentration and then that liquid effluent if you are releasing in lakes or rivers that is going to be very dangerous for the water pollution, etc. That is going to be very dangerous and may lead to water pollution, okay? So likewise solids also if you do not do proper processing and then simply dump it here and there then that may lead to land pollution and then simultaneously it may because of the leaching it may cause the water pollution as well and then because of leaving openly it may lead to air pollution also it may take place because of gases being released into the atmosphere. So these kind of things are very important to be considered, right? So not only the profit that one has to see, but also most importantly the safety and then pollution concerns. Each chemical

engineering working in any of the chemical plant must be aware of these kind of minimum safety and pollution concerns of the government, right? In the chemical industries usually physical, mechanical and chemical changes occur in general, right? So let us say whatever the iron ore example I mentioned, so crushing and grinding, size reduction of them and then washing them and then drying them, etc. All those things are a kind of physical operations, there are no chemical changes are occurring.

Such kind of physical operations are known as unit operations, whereas there are some chemical reactions may also take place. Those chemical changes are known as unit processes, okay? So now we can see how creative is a chemical industry that is what we have seen, right? What if it is creative, right? It is good that it is creative, but what is the advantage that a society or nation is having?

(Refer Slide Time: 11:39)

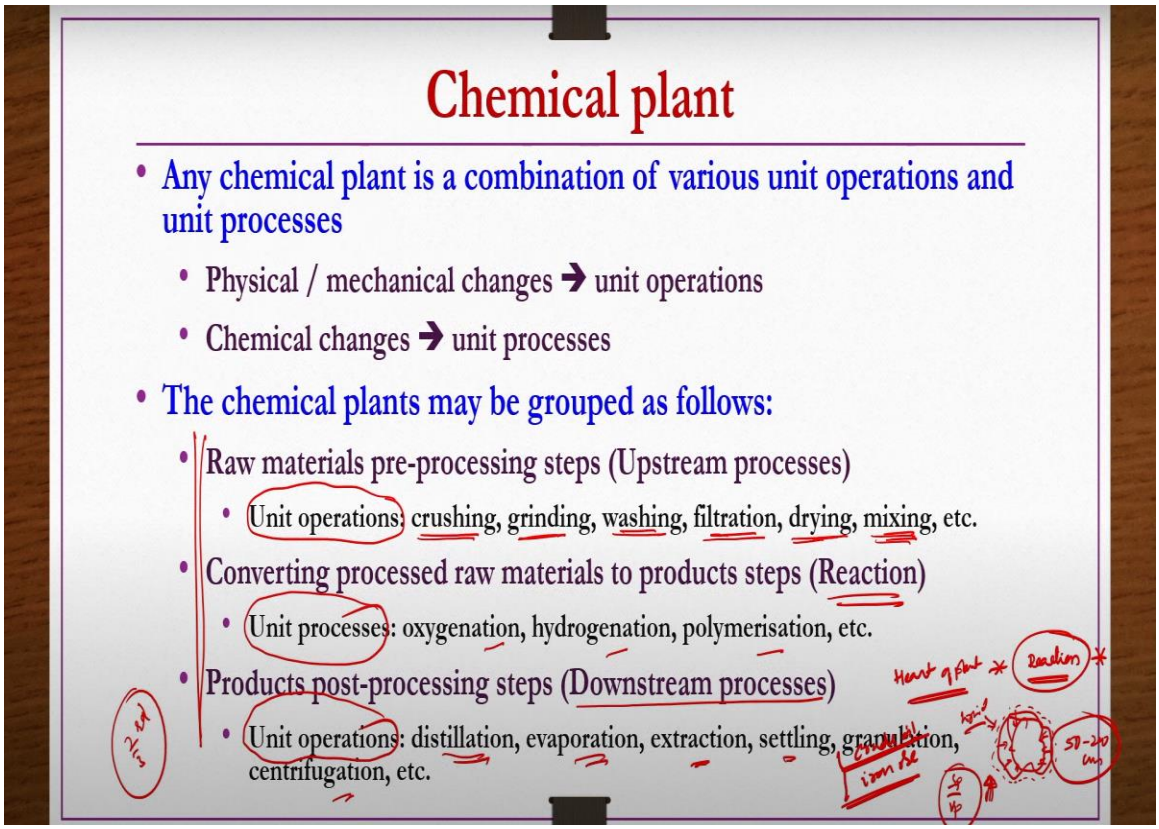


So from that point of view if you see for the growth of any nation GDP is a very important factor and then many factors influence this GDP, right? So one of the factor is chemical

industries also. Let us say for India, Indian chemical industries contribute 7% to its GDP, that is a huge number, right? Now there is something like industrial output, gross industrial output that is like every industry like not only chemical industry, different types of metallurgical industries also, software industries also, hardware industries also, every industry having some gross output. So in this gross industrial output if you see the share of chemical plants or chemical industries, then it was approximately 13% in 1970s and then it is approximately 45% or more in 1995 by which India has already become self-sustained from chemical industry point of view, right? Further Indian chemical industry, you know sixth largest across the globe and then third in Asia. So now what if this is sixth largest or third largest? What if sixth largest company in the globe and then what if it is third largest in Asia? So that actually depends from the market as well as the production as well as the market.

So the Indian chemical industries whatever the products whether they are inorganic or organic, right? These chemicals are having huge market in India, not only for the household purpose, societal purpose, industrial purpose, defence purpose, like this different purposes you know you have market. The market for the inorganic and organic chemicals in India is huge. That is the reason they are able to contribute large to the GDP of the nation. That is the reason its share in the overall gross industrial output of India is very high compared to the other ones, okay? So now we understand from this point how much essentially is chemical industry from the GDP as well as the growth of any nation point of view especially for India statistics also we have seen, right?

(Refer Slide Time: 14:42)



So now it is essential to understand more about a chemical plant because we established that chemical industries or the growth of chemical industry is very important from the point of the nation's growth, right? So, we need to understand as a chemical engineering graduates, we need to understand many more factors you know, aspects related to the chemical plant, okay? Any chemical plant is a combination of various unit operations and unit processes as I mentioned. Just now unit operations are nothing but physical or mechanical changes whereas the unit processes are nothing but the chemical changes that are occurring in the plant, okay? So these chemical plants may be grouped as follows.

Actually, grouping is done by taking the reaction. For any chemical plant, reaction is very much essential, very important. It may be regarded as heart of the plant, right? So just now we have seen as an example of crude oil as well as the iron ore. Whatever the naturally

available resources are there, they are not suitable for the processing directly in the chemical reactors. So what we do? We do some kind of processing of the reactants.

Since they are occurring before the reaction, those things are known as the upstream processes or raw materials pre-processing steps where like you know you may be doing something like crushing of the ore, grinding of the ore, washing of impurities from the ore, filtration, separation if some kind of separation, etc. are required. So then filtration may be required, then drying is required. Sometimes raw materials may be needed mixed with some other things, mixing, etc. are required. So what you can see all these crushing, grinding, washing, filtration, drying, mixing, etc., all of them are you know physical or mechanical changes only. So all these types of upstream processes are almost like unit operations, okay? There may be sequence of reactions occurring or sequence of reactors may be there. So you cannot say that before the third reactor in the second and first reactor some reactions are occurring. So why cannot we say them as a unit operations? It is not about the first or second reaction.

Anything other than the reaction or chemical changes are there. So all those things are regarded as unit operations or whatever the physical, mechanical changes occurring in the plant, all of them are unit operations. So once you do these steps, what you can see the raw material is processed and then suitable for the reaction to occur. What do you mean by processed raw material? Let us say you have the lumps of ore, you know few meters or 50 centimeters or 80 centimeters average diameter, something like that. So if you put it in the reactor, first of all you cannot put it in the reactor especially when the reactors are continuous reactor, right? So then even let us say you assume you put it and then there is a liquid reaction taking place, solid liquid reaction is taking place.

So you interact this ore with the liquid. That liquid would be you know interacting with the outer surface only or maybe it may be going into some interior depth of the raw material or ore, bigger ore, whatever is there. But the core of the raw material which is at the center of these rocks may not be, in fact will not be reacting because of a low surface to volume ratio for this bigger size of rocks. That is the reason we do crushing, grinding, washing, filtration, drying, mixing, etc. So after these steps, especially after crushing and grinding,

the size of the ore decreases such a way that you know Sp by Vp, surface area per volume, whatever is there that increases and then because of that one interaction with the you know liquid or gases stream with which it is going to interact, react is going to increase.

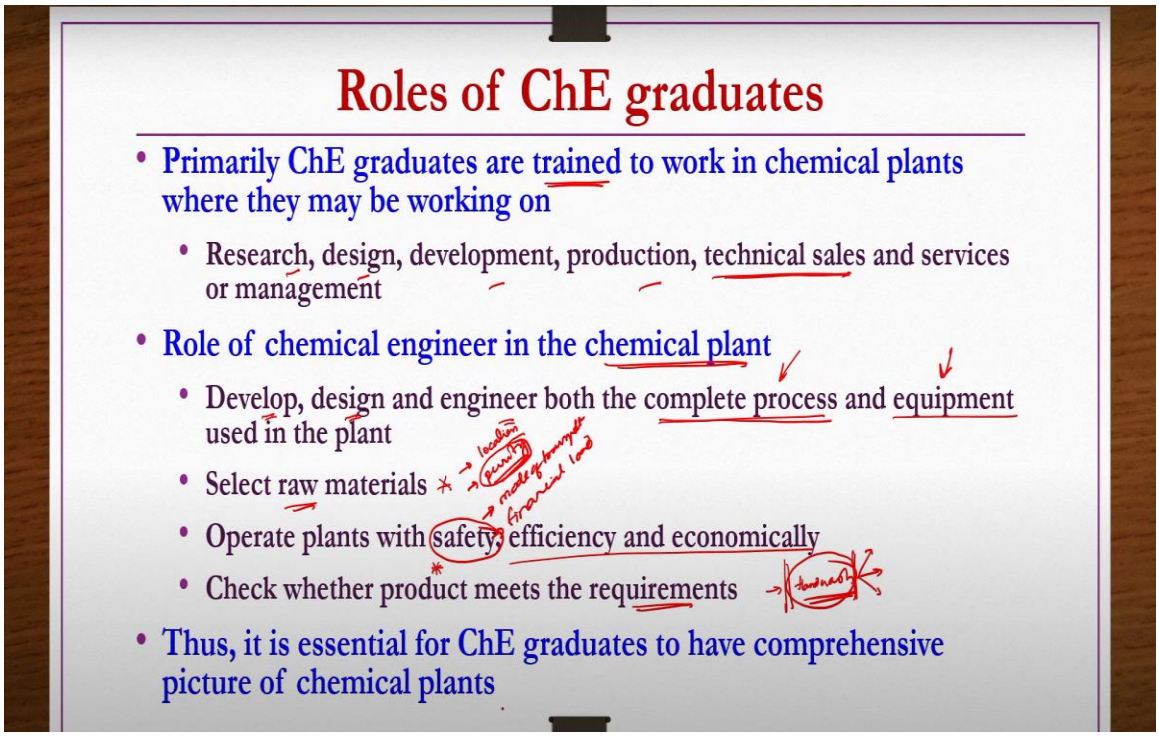
So that is the point, okay? So once you have this processed raw material, then you can do the reaction, right? So converting processed to raw materials to products is the second step in the plant in which chemical reactions like oxygenation, hydrogenation, polymerization, sulfonation, oligomerization, polymerization, hydro processing, hydro treatment, etc., so many different reactions may be undergoing. So all these reactions, chemical changes are there. So then these are known as the unit processes, right? Now whatever the purity of the raw material you have, whatever the temperature, pressure and then catalyst selection, selective catalyst you take, it is not possible to have 100% conversion in general. So then there would be some kind of a unreacted reactants or byproducts, impurities may also be there along with the desired product.

So then those impurities or undesired products, unreacted reactants, etc., has to be separated out from the product because consumer's requirement is a specific product only, not byproducts or unreacted reactants, etc., right? So for that you need to do some post processing of the products. Since these are occurring after the reaction level, so these steps are known as the downstream processes. Now what are these processes? They are something like distillation, evaporation, extraction, settling, granulation, centrifugation, all of them also here again they are physical or mechanical changes depicting.

Only physical or chemical changes occur in these processes also. So these processes are also known as the unit operations. So you can see in a plant majority of the capital cost is occupied by the unit operations and then connections. Almost two-third of the capital cost

of any plant is devoted to unit operations and connecting pipes, etc., in general, okay? So this is about the chemical plant, fine.

(Refer Slide Time: 20:35)



So what are the roles of chemical engineering graduates in the chemical plants that is what we need to understand. Let us say a UG chemical engineering graduate has been hired by a chemical industry. So they will be giving training to those graduates to work in chemical plants and they will be working in different aspects of the plant. They may include research, design, development, production, technical sales. Technical sales is different from the marketing sales.

So this also be trained. Services or management, etc., those kind of aspects would be trained in those kind of aspects so that graduate engineer would be comfortable enough to work in any of the associated segments of the chemical plant, okay? So let us say if you are hired and then given task to look in the chemical plant part only. So what are the basic things that would be expected from you as a undergraduate chemical engineering student? You are expected to develop, design and then engineer not only the complete process but also

individual equipment used in the plant, okay? That means you should have a complete knowledge about the design, operating process and then limitations merits, demerits of each and every equipment and then design and then installation and then commissioning of a complete process you are expected to do, okay? Further, selection of raw materials is also very much essential, okay? Let us say raw material when you select what are the things that you may consider, there may be many things that you need to consider. Let us say location from where are you getting this raw material and then purity.

Purity is very much important. Let us say coal example if you take, the coal that you get in Assam, the coal that you get in Chhattisgarh and the coal that you get in Telangana, its composition is going to be different especially in terms of the ash percentage, etc. And then in which location your plant is there, how far it is from your plant, the source of raw material, how pure it is, those things you have to consider and then also mode of transport. What are the possible modes of transport that are available for you to get those raw materials and then most importantly financial load, how much money are you going to spend in this one? Let us say sometimes what happen even if you have a slightly less grade or less pure raw material, but if it is nearby your location and then it is going to be profitable or does not make much difference in the final yield and purity of the product that you are going to get from that raw material, so it is better to get it from the closer location. So, using all these factors you should able to select the raw materials appropriately, not only raw material from the source of raw material. Sometimes what happens, the raw material is directly available.

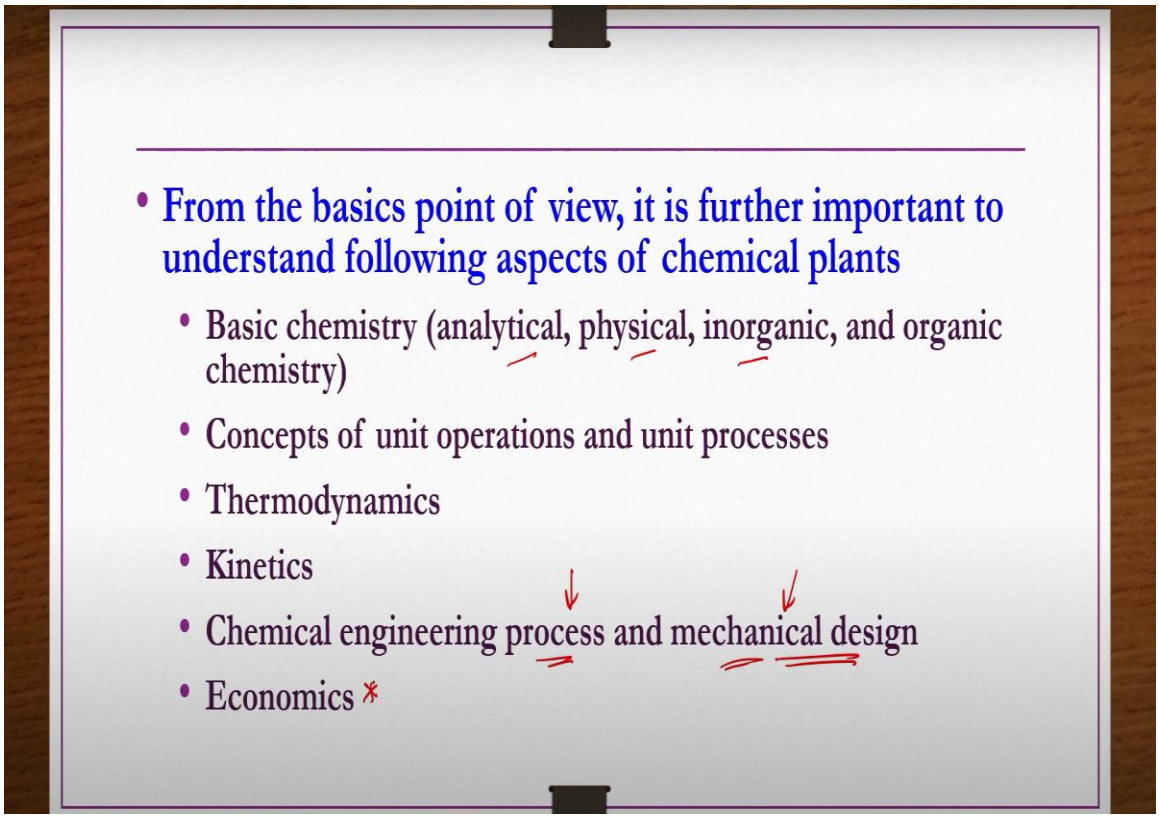
Let us say benzene reacting with the sulfuric acid. Benzene and sulfuric acid individually you may be getting from different plants in pure conditions. So, you do not need to worry too much about all these kind of things because across the country the prices of given a chemical may be remaining almost same, there may not be much difference. If at all there is a difference that is may be coming because of the transportation cost as well as the tax variation from state to the state. Let us say petrol and diesel their prices are slightly different from one state to the other state because of the differences in the taxes.

So, these factors one should consider and then select the raw materials appropriately. Then operate plants with safety, it is very much essential and then efficiency and economically

as I already mentioned. Safety is very much essential. Most important factor in chemical plant is the safety because anything happens it is not only going to be harmful to the personal working in the plant, but also to the neighboring people also it may be affecting. So, safety is very much essential. Then check whether product meets the requirements. It is very much essential.

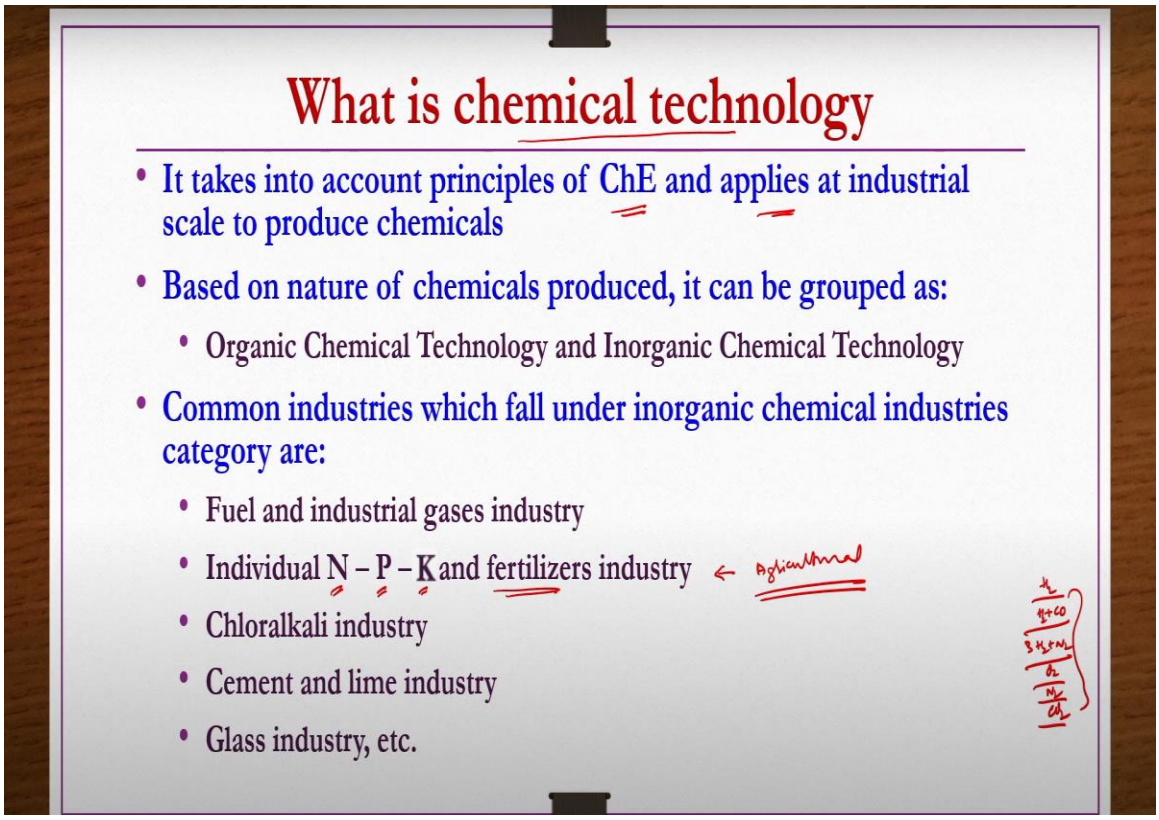
Sometimes in the market you see buy one get one free kind of options would be there let us say hand wash. So why because this hand wash etc., they are kind of colloidal suspensions. If there is some kind of mistakes or some kind of low grade product is there, so then those suspensions may be settling quickly within 6 months or within 1 month rather staying for 2 years or something like that. Settling of suspension that means what actually this hand wash etc., so many ingredients would be there if they are separating. So liquid phase may be at the top and then whatever the suspend particles etc., there may be at the bottom after 6 months or so. So then they have those such kind of material has to be utilized before that period. So in order to sell out such kind of products the marketing strategy is that you know you give such kind of offers. So you have to be very careful to see the requirements, product requirements. If any mistakes if you do then the product quality is going to be decreased and then you know you have to compromise on the marketing, final market value of the product, okay? Thus it is essential for chemical engineering graduates to have comprehensive picture of chemical plants, okay? So are these the only thing? Unlike the other industries, chemical industries is the one where the knowledge of so many variety of different subjects expected to be gained by the train engineers or the engineer working in the plant.

(Refer Slide Time: 26:32)



Something like you know basic chemistry, you are expected to have some knowledge of analytical, physical, inorganic and organic chemistry also. Not only that one, concepts of unit operations and unit processes also required, thermodynamics also required, kinetics, then chemical engineering process design and mechanical design. Chemical process design is different from the mechanical process design. Chemical process design let us say distillation column is there, how many columns should be there, what should be the height of the column and then to which stage the feed has to enter and all those things are you know chemical engineering process design calculations. Whereas the mechanical design, the construction of the material, which material should be used for constructing that distillation column, right? What should be the thickness of the column, by which material trace should be prepared, all those things are you know mechanical design aspects, okay? But still you are expected to have such knowledge also, if not completely minimum knowledge you are expected to have, then most important economics, okay?

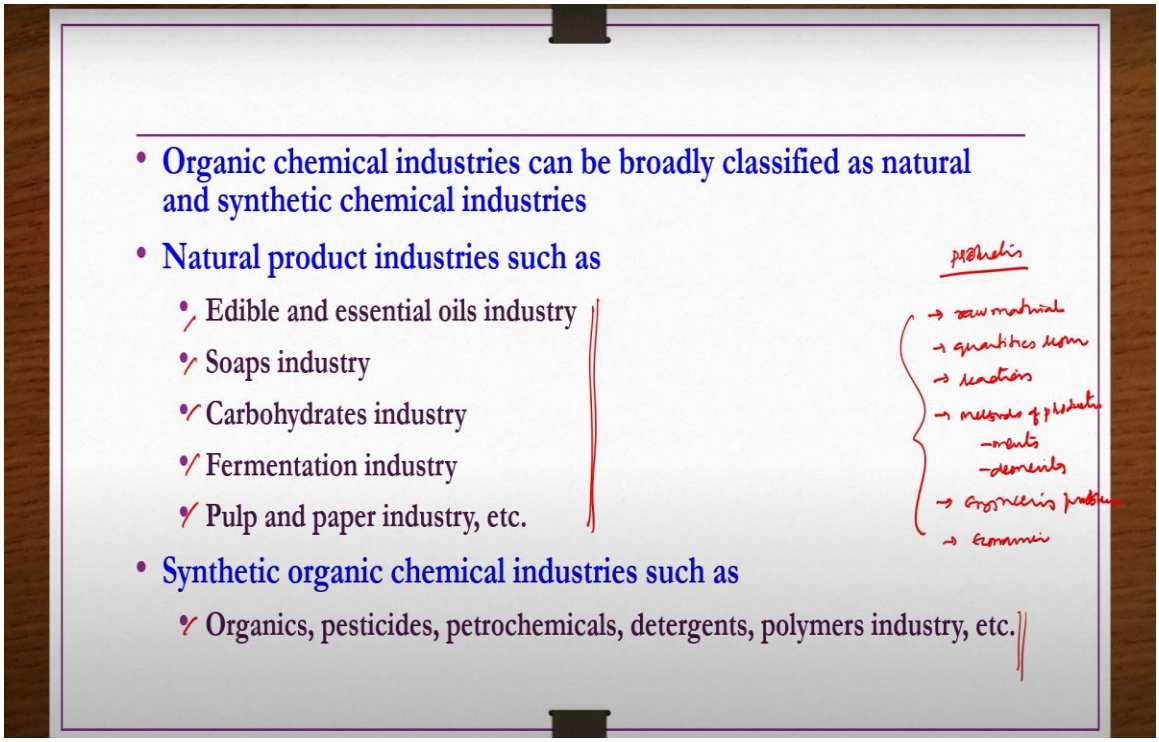
(Refer Slide Time: 27:39)



So next is to understand what is chemical technology. Since we are talking about the organic chemical technology, first of all whether it is organic chemical technology or inorganic chemical technology, you should understand what is chemical technology. Chemical technology in the sense you are using chemical engineering principles to produce certain kind of chemicals under profitable manner, right? So chemical technology takes into account principles of chemical engineering and applies at industrial scale to produce chemicals, right? And then by the nature of the chemicals whether the produced chemical is inorganic or organic, the chemical technology may be grouped as organic chemical technology and inorganic chemical technology, right? So common industries which fall under inorganic chemical industries categories if you see, let us say fuel gases you have like H2, H2 plus CO synthesis gas and then ammonia synthesis gas and then industrial gas like O2, N2, CO2, etc. All of them are inorganic in nature. So most of the fuel and industrial gases industries are inorganic chemical industries. Likewise individual fertilizers as well as the mixed chemical fertilizers what we can understand from here, agricultural industry

for which fertilizers are very essential cannot sustain without the role of chemical engineers that you can understand. Some other inorganic chemical industries are like chloralkali industry, cement and lime industry, glass industry like that and number of inorganic chemical industries are also existing.

(Refer Slide Time: 29:25)



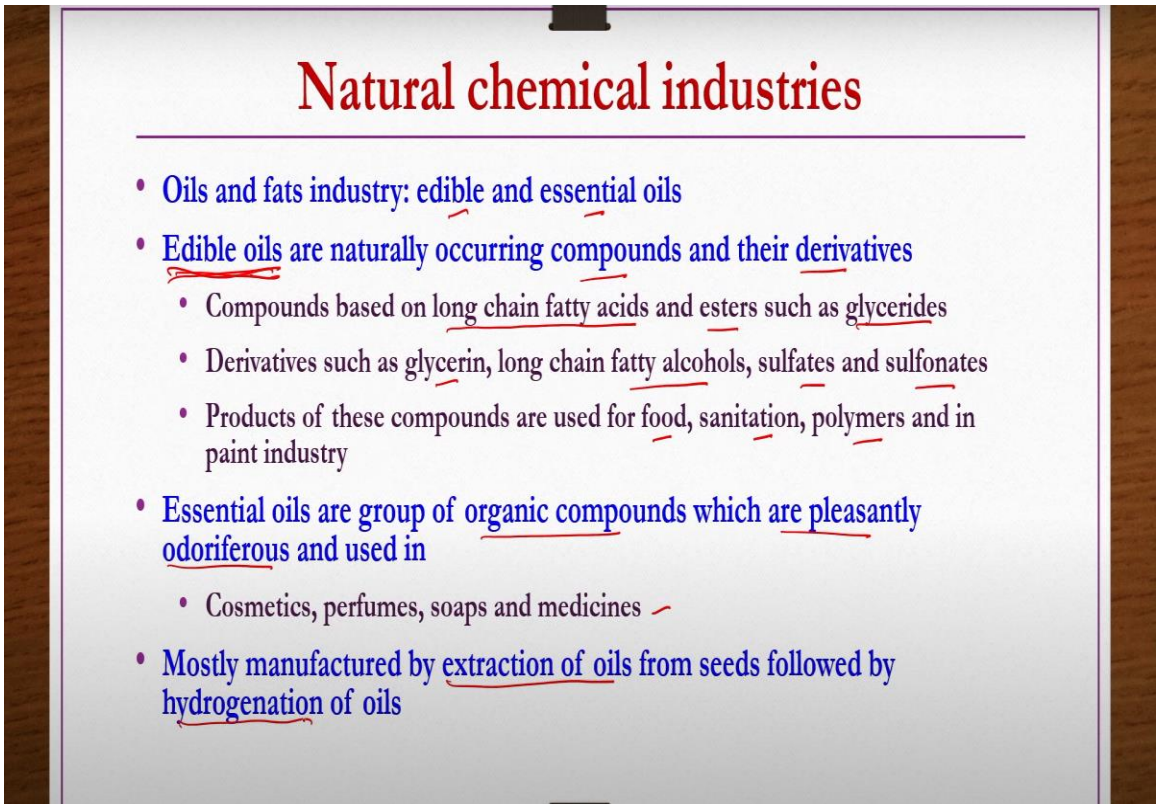
Now based on the source as well as the method of production, organic chemical industry can be natural or synthetic chemical industry. What do you mean by natural product industries? That means the product that whatever you are getting the source is very natural source. Let us say oils, vegetable oils are there. How are you getting vegetable oils? You get from the seeds, different types of vegetable seeds you use and then you try to get the oil where you do some kind of extraction followed by hydrogenation. So since they are naturally available, so that is the reason such products are natural products and then corresponding industries are natural product industries.

So some of the natural product industries are edible and essential oils industries, soaps industries, carbohydrate industries where sugars, starch, cellulose, etc. comes into the picture, then fermentation industries where you can produce ethanol, butanol, etc. Then

pulp and paper industry, etc. So if you list out a few synthetic organic chemical industries, then you can have organics, different types of organics, pesticides, petrochemicals, detergents, polymer industries, etc. all of them comes under synthetic organic chemical industries, okay? Now what we do? We see a few details of these industries.

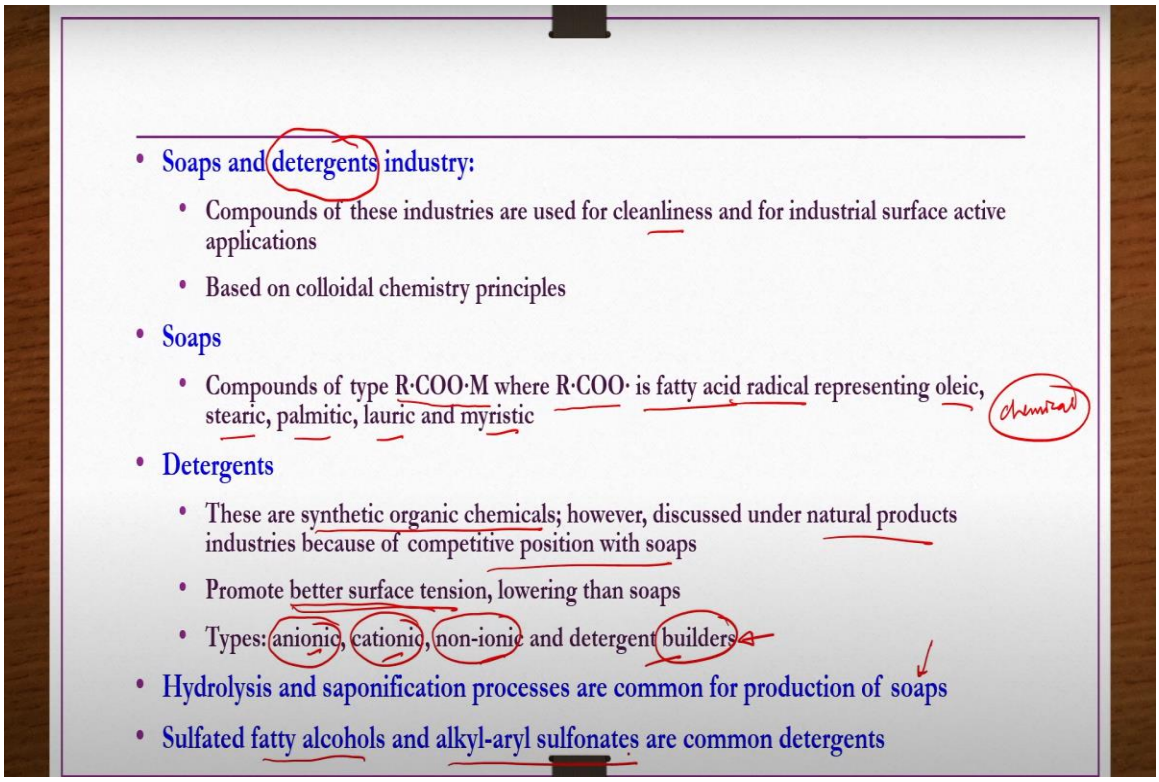
Actually these 2 industries, natural product industries and synthetic organic chemical industries, whatever their products are there, how are they being produced at the plant level? Production, production of these natural as well as synthetic organic chemicals in the chemical plants, how it is being done? Before that raw materials, their quantitative requirements, what are the reactions, what are the methods of productions, right? What are the merits, demerits of each method that is available for the production of a given chemical? Sometimes to obtain one particular chemical, you may be having more than one process, then selection of process is also very important, okay? So those things then what are the engineering problems, major engineering problems of the plant, etc. that you can look upon and then try to improve and then what are the economics, applications, etc. All these things we are going to see for each of these industries and then their major products also. So for the major products of all these industries, we are going to see all these steps in detail in the due course of you know this particular organic chemical technology course, right? However, in this lecture, we are going to see a few minimum basic details so that it will be giving a picture what are we going to study in the remaining of the weeks of the course that we can understand, those things we are going to see now, okay?

(Refer Slide Time: 32:36)



So let us start with natural chemical industries. First one is oils and fats industry that is what we are going to discuss in which edible and then essential oils we are going to discuss. Soil oils are naturally occurring compounds and then derivatives, what are these naturally occurring components or what is the chemical nature of these naturally occurring compounds if you see, mostly they are long chain fatty acids and then esters such as the glycerides and then what are the derivatives of these long chain fatty acids and then glycerides, etc. If you see, they are nothing but glycerin, long chain fatty alcohols, some sulfates and sulfonates, right? Then where are they used? These edible oils, where are they used in general for the food that we clearly understand by the name that is edible oils, then they are also used for the sanitation, polymers and then paint industries as well. Then coming to the essential oils, these are group of organic components which are pleasantly odoriferous and used in cosmetics, perfumes, soaps, medicines, etc. Now most of the oils in general, they are obtained by the extraction followed by the hydrogenation. We see the details of those processes anyway.

(Refer Slide Time: 34:10)

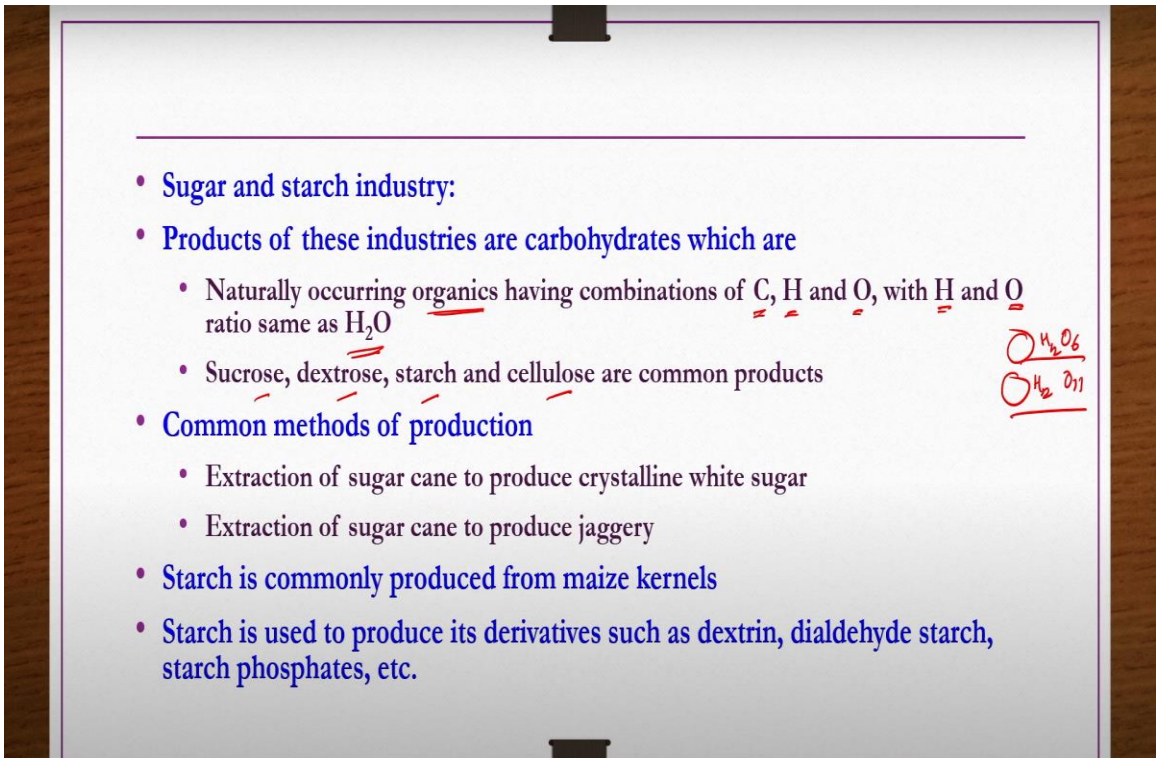


Next is soaps and detergents industry. Actually detergents is not a natural product actually, it does not come under natural product industry. However, it is having competitive role compared to the soaps, that is the reason detergents are also discussed along with the soaps industries, okay? So compounds of these industries are used in general for cleanliness and for industrial surface active applications. The basic chemistry involved in such kind of industries is nothing but the colloidal chemistry. Soaps they contain compounds of type R-COO-M, where R-COO is fatty acid radical representing oleic, steric, palmitic, lauric, myristic, etc.

Their chemical structure, properties, etc., all those things we are going to see when in detail about soap industries. Then detergents, they have a lower surface tension compared to the soaps in general. So they promote or they have the better performance compared to the soaps. Though they are synthetic organic chemicals, they are discussed under the natural product industries because of their competitive position with the soaps. There are 4 different types of detergents in general existing anionic, cationic, nonionic and then

detergent builders. Under each category what are the anionic detergents, what are the cationic detergents, what are the nonionic detergents, what are the builders, etc., all those things we are going to discuss when we discuss individually on these industries. Hydrolysis and saponification processes are commonly used for the production of soaps. Common detergents are sulfated fatty alcohols and alkyl aryl sulfonates.

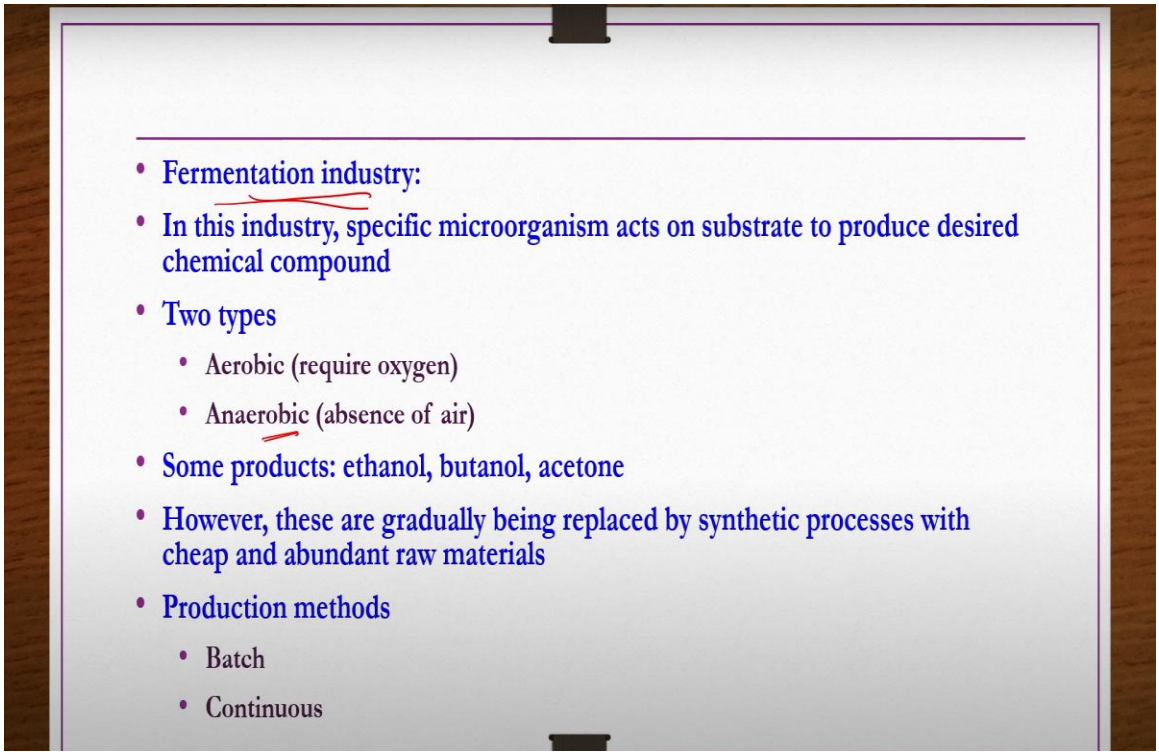
(Refer Slide Time: 36:07)



Next is sugar and starch industry which come under carbohydrates industry. So products of these industries are carbohydrates which are having naturally occurring organics having combinations of C-H-O such a way that H and O are having the ratio same as H2O. Let us say O6 is there, H12 would be there and then C maybe some other different number. If O is 11, H is going to be 22, C maybe some other number. These kind of chemical structure they will be having these carbohydrates. Some common products of these industries are sucrose, dextrose, starch, cellulose. Common methods of production actually extraction from the sugarcane is the common method. However, it is extracted and post-processed in the form of sugars, then extraction of sugarcane to produce crystalline white sugar is one

category. If the extraction is done and then to produce jaggery, then extraction of sugarcane to produce jaggery is the other method. Ok. Starch is commonly produced from maize kernels. It is used to produce its derivative such as dextrin, dialdehyde, starch, phosphate, etc.

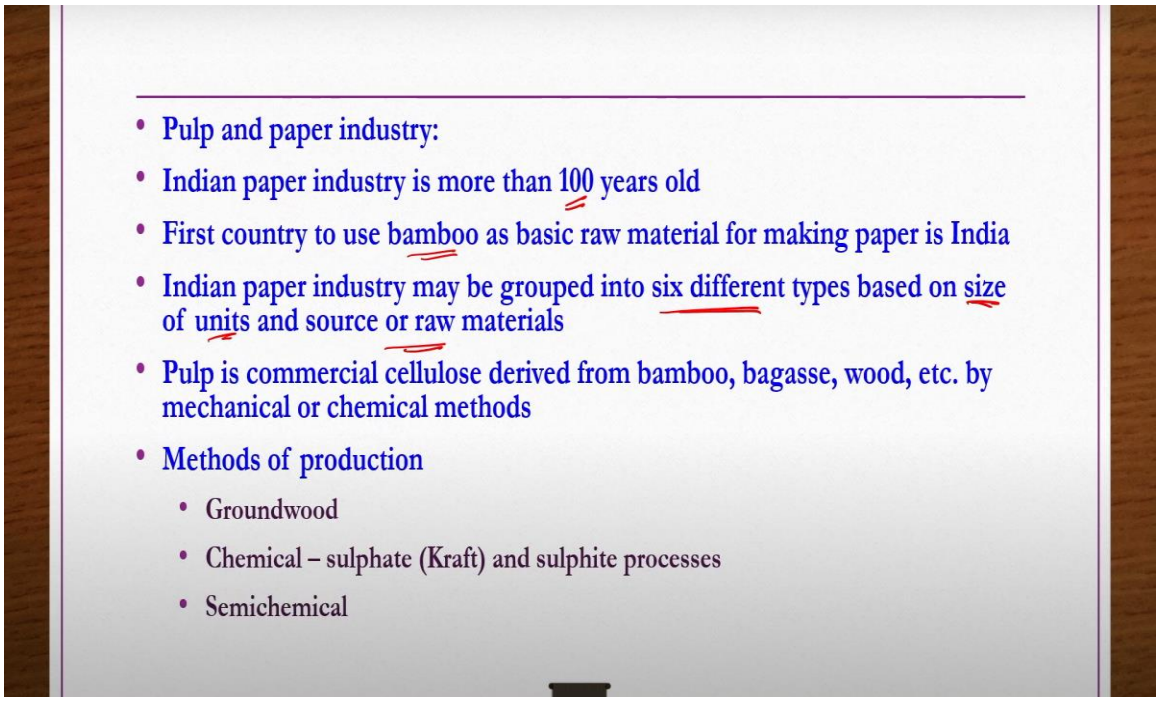
(Refer Slide Time: 37:28)



Fermentation industries, in fermentation industry what happens specific microorganisms acts on a substrate such a way that desired product is obtained, that is what happens. But given a microorganism may be good for producing one kind of product, may not be good enough for the other kind of product. So, including the selection of microorganism is also very essential in fermentation industry. So, in this industry specific microorganism acts on substrate to produce desired chemical compound. Two types are there in the fermentation industry, in the presence of air and in the absence of air. So, if it is in the presence of air or oxygen, these fermentation processes are known as aerobic. If it is occurring in the absence of air or oxygen, then we call it anaerobic fermentation process. Some products are ethanol, butanol, acetone, but however, nowadays, these products are also produced by the synthetic

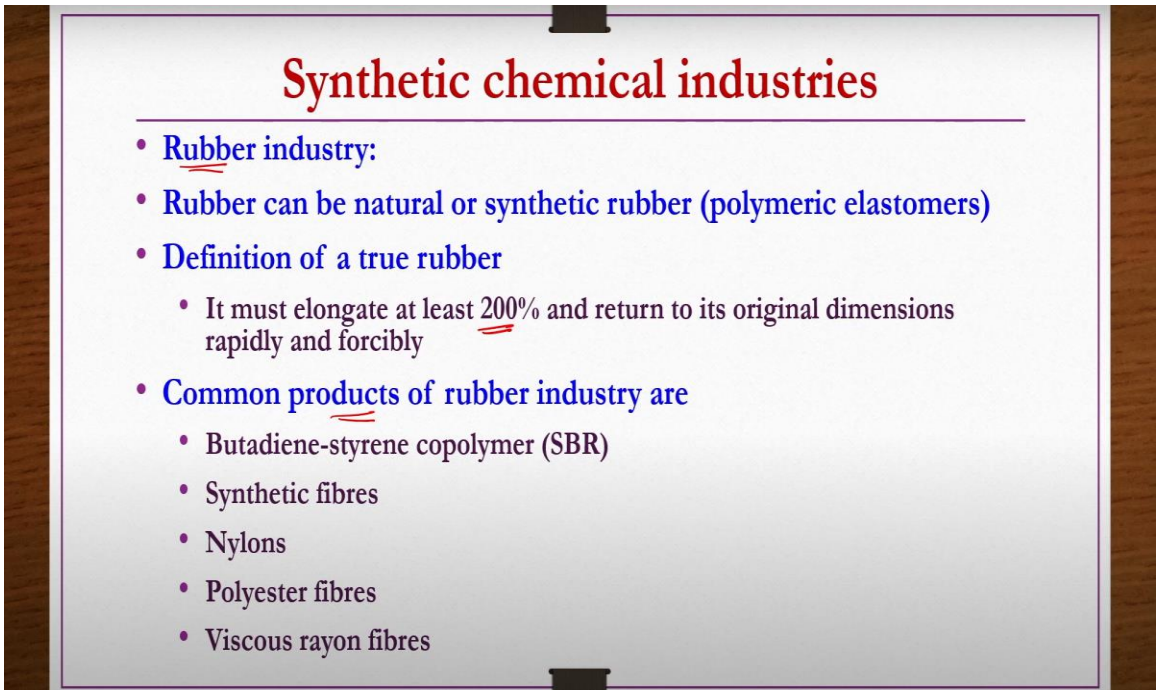
methods because of the cheap and abundant raw materials available to produce this ethanol, butanol, etc. Production methods, it can be batch or continuous.

(Refer Slide Time: 38:41)



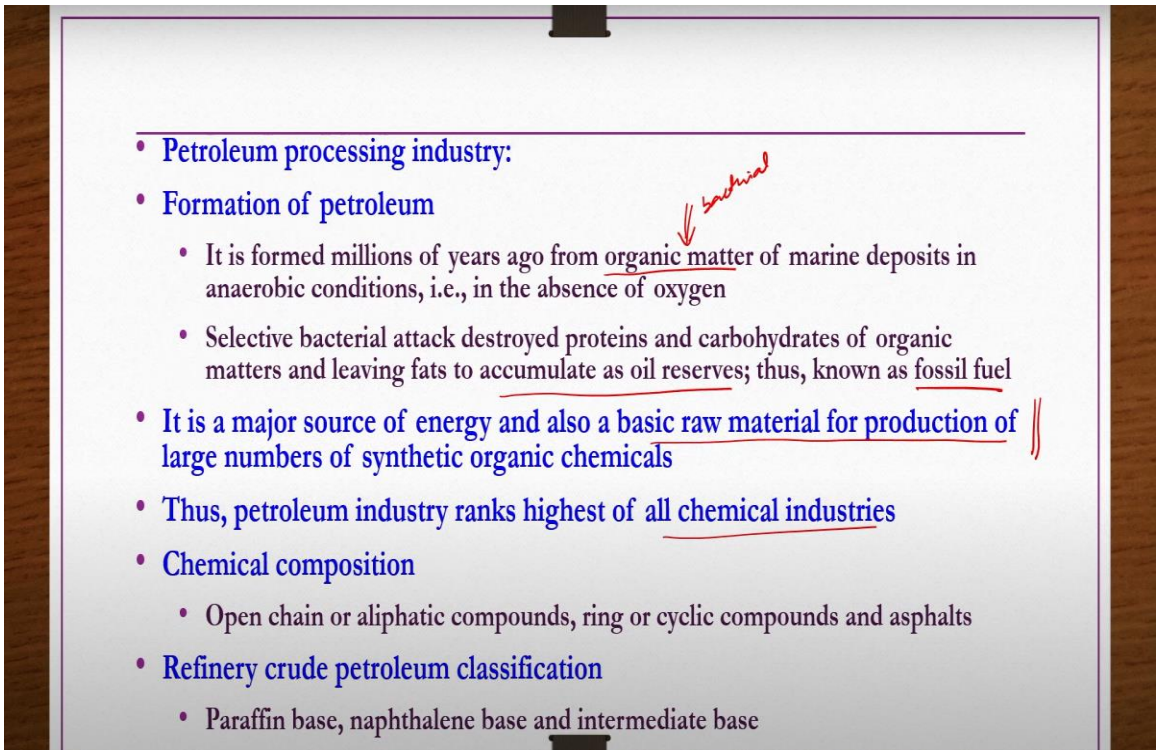
Next is pulp and paper industry. Indian paper industry is more than 100 years old and Indian paper industry is the first one which has used bamboo as basic raw material for making paper in the world. Indian paper industry depending on the size of units and then sources or raw materials, Indian paper industry may be grouped into 6 different types. Those things we discussed when we talk about pulp and paper industries in detail. So, pulp is commercial cellulose derived from bamboo, bagasse, wood, etc. by mechanical or chemical methods. So, methods of production, if it is mechanical, ground wood, if it is chemical, then sulphate and sulphide processes and then some semi-chemical processes are also available.

(Refer Slide Time: 39:27)



Now, synthetic chemical industries, let us start with the rubber industry. So, this rubber is not only synthetic, but also natural product industry. It is naturally also produced, but you know synthetic rubber is having so many different types of varieties that synthetic rubber industry has dominating over natural rubber industry. So, that is the reason rubber industry is discussed under synthetic chemical industry section. Rubber can be natural or synthetic rubber. Definition of a true rubber if you see, it must elongate at least 200% and return to its original dimensions rapidly and forcibly. If you see common products of rubber industry, styrene, butadiene, copolymer, SBR, synthetic fibers, nylons, polyester fibers, viscous rayon fibers, etc., so many are there. These are also used for different types of textile manufacturing also.

(Refer Slide Time: 40:28)

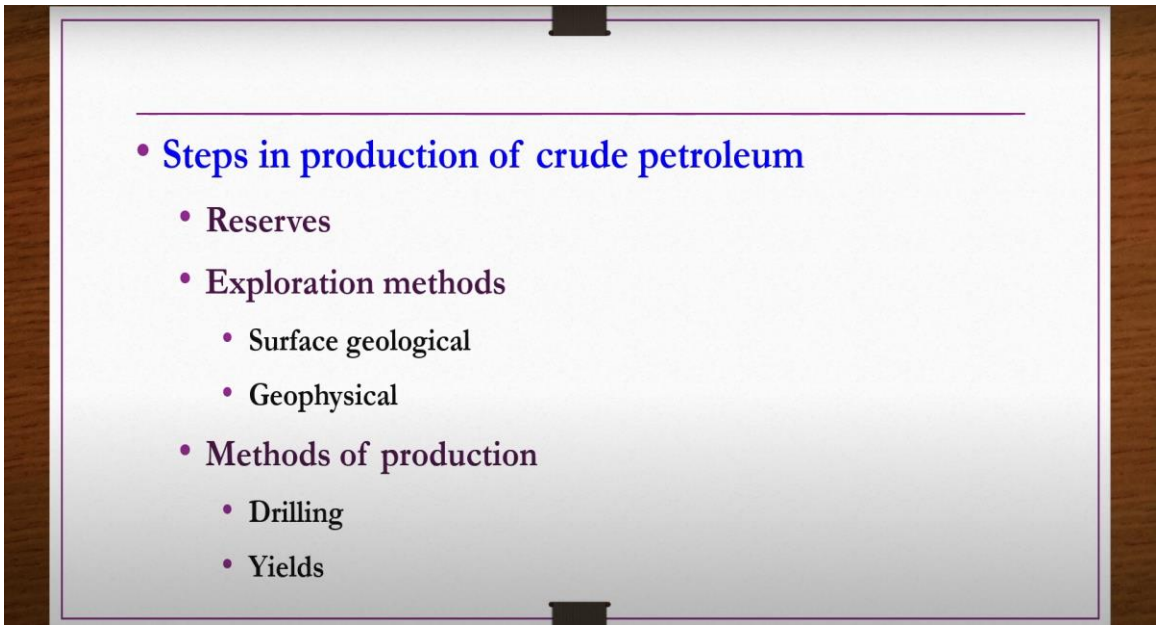


Next is the petroleum processing industry. Actually petroleum refinery and petrochemicals, nowadays there is a separate discipline in some of the university, but you know these petroleum refinery and petrochemical industries are completely based on the chemical engineering principles. That is the reason they should be considered as subset of chemical industries only and then chemical engineers are the base for the petroleum refinery and petrochemicals industry as well. So, that is the reason for chemical engineering students also it is essential to have a basic knowledge about petroleum processing and then petrochemicals industries as well.

So, we need to define petroleum. It is formed millions of years ago from organic matter of marine deposits in anaerobic condition that is in the absence of oxygen and these organic matters are allowed to attacked by selective bacterias, so that destruction of carbohydrates and proteins may take place and leaving only fatty components. So those fats accumulate as oil reserves that is the reason these are also known as the fossil fuels. It is major source of energy and also basic raw material for production of large numbers of synthetic organic chemicals. Actually 4 weeks of the course is dedicated to the petroleum related subject in

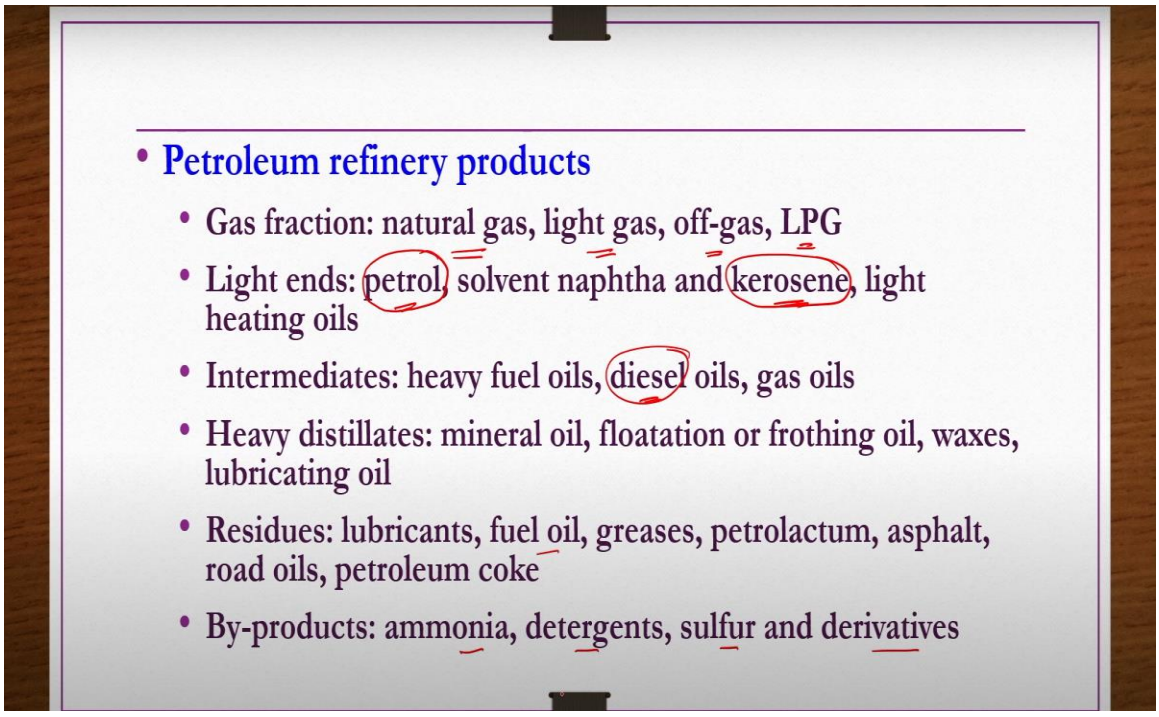
this course because the crude that whatever crude oil that you get from the petroleum refining, you know that is source for huge number of chemicals, hundreds of chemicals, organic chemicals are being produced from there, right? So, it is very much essential to understand a few basics about these industries. Thus petroleum industry ranks highest of all chemical industries. Chemical composition of petroleum crude if you see, mostly they contain open chain or aliphatic compounds, ring or cyclic compounds and asphalt. Then refinery crude petroleum classification if you see, there are 3 categories paraffin base, naphthalene base and intermediate base, right?

(Refer Slide Time: 42:43)



Steps in production of crude petroleum, there are several steps are there. First you have to find out the reserves, then exploration methods you have to see whether surface geological methods are sufficient or should you also go to the geophysical methods you have to check and then methods of production drilling and then yields are 2 methods.

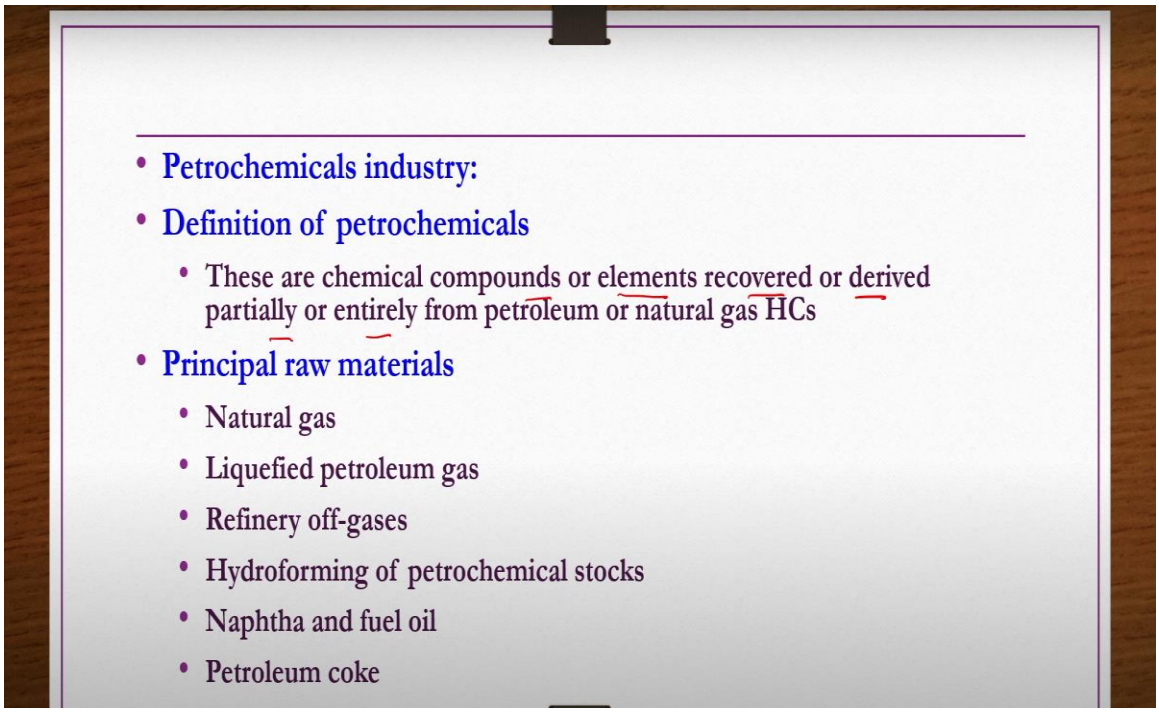
(Refer Slide Time: 43:02)



Petroleum refinery products if you see as I already mentioned n number of products are there but you know depending on their volatility and nature, they can be classified as follows. When you do the drilling of these oil reserves, there would be several gases products would also be there such as natural gas, etc.

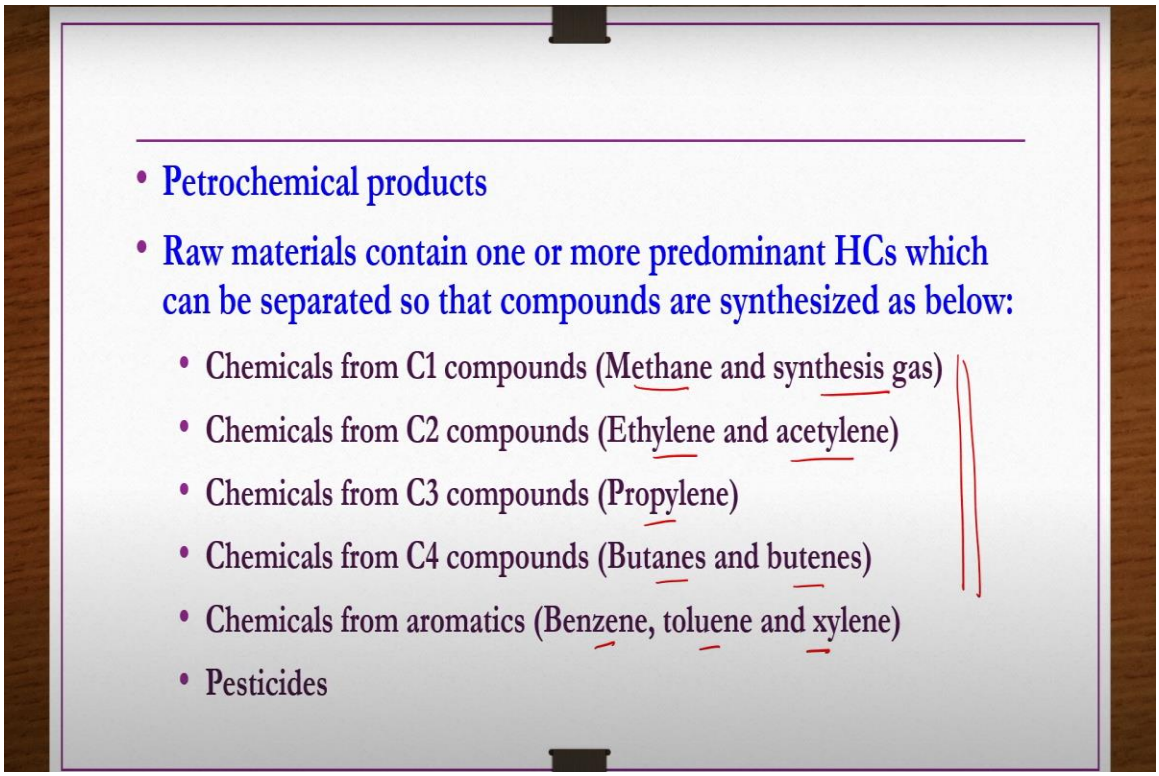
So gas fraction is also taken as one of the petroleum refinery product, right? So and this gas fraction include natural gas, light gas, off gas, LPG. Then light ends like petrol, solvent, naphtha and then kerosene, light heating oils, intermediates like heavy fuels, diesel oils, gas oils. We mostly come across in general in regular life this petrol, kerosene and then diesel, right? Diesel is intermediate whereas the petrol and kerosene are light ends. Heavy distillates like mineral oil, flotation or frothing oil, waxes, lubricating oils, etc. Residues like lubricants, fuel oil, greases, petrolactam, asphalt, road oils, petroleum coke, etc. Some byproducts like ammonia, detergents, sulfur and their derivatives would also be there, okay?

(Refer Slide Time: 44:21)



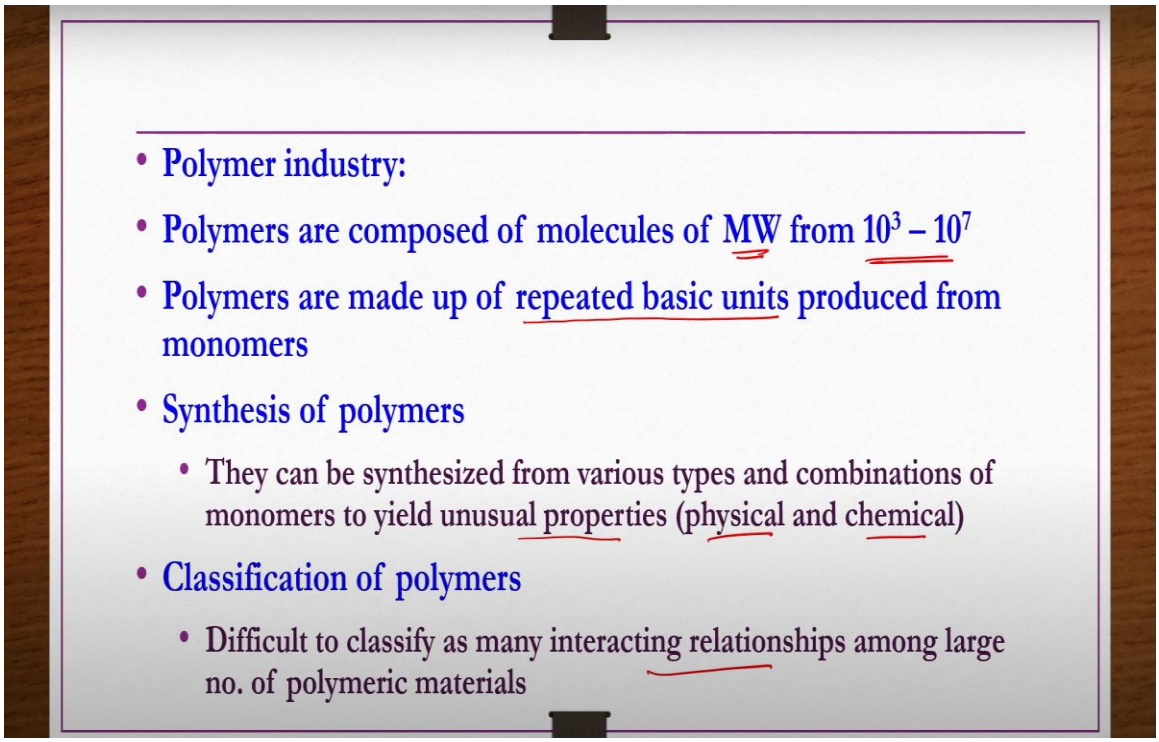
Next one is the petrochemicals industry. Petrochemical by definition if you see these are chemical compounds or elements recovered or derived either partially or entirely from petroleum or natural gas hydrocarbons, okay? Raw materials if you see obviously natural gas, liquefied petroleum gas, refinery of gases, hydroforming of petrochemical stocks, naphtha and fuel oil, petroleum coke, whatever we get in the petroleum refinery all of them may be used as a raw material to get different types of petrochemicals, right?

(Refer Slide Time: 45:04)



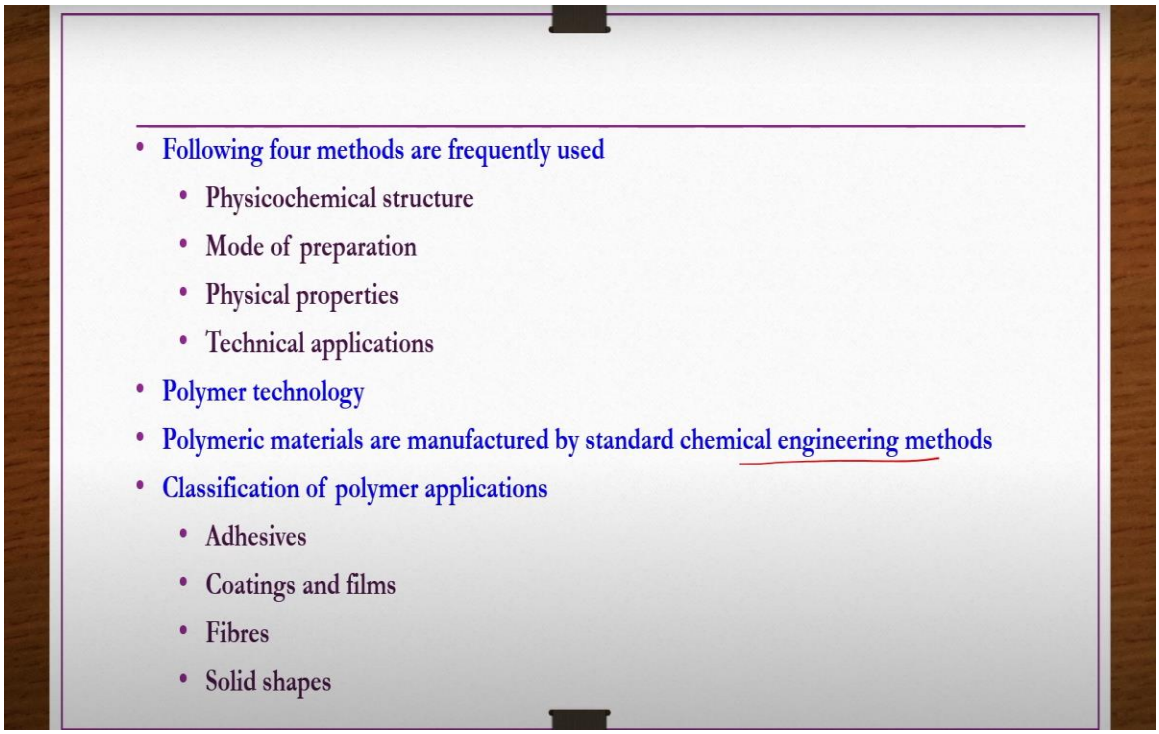
Raw materials contain one or more predominant hydrocarbons which can be separated so that compounds are synthesized as below based on the carbon number let us say chemicals from C1 compounds, chemicals from C2 compounds, chemicals from C3 compounds, chemicals from C4 compounds like from C1 compounds like maybe methane and synthesis gas, from C2 compounds that means ethylene and acetylene, C3 components that mean propylene and then C4 components are nothing but butanes and butanes. We are going to discuss all of them in detail when we discuss about petrochemical industries anyway. Then chemicals from aromatics something like benzene, toluene, xylene, etc., also some pesticides.

(Refer Slide Time: 45:52)



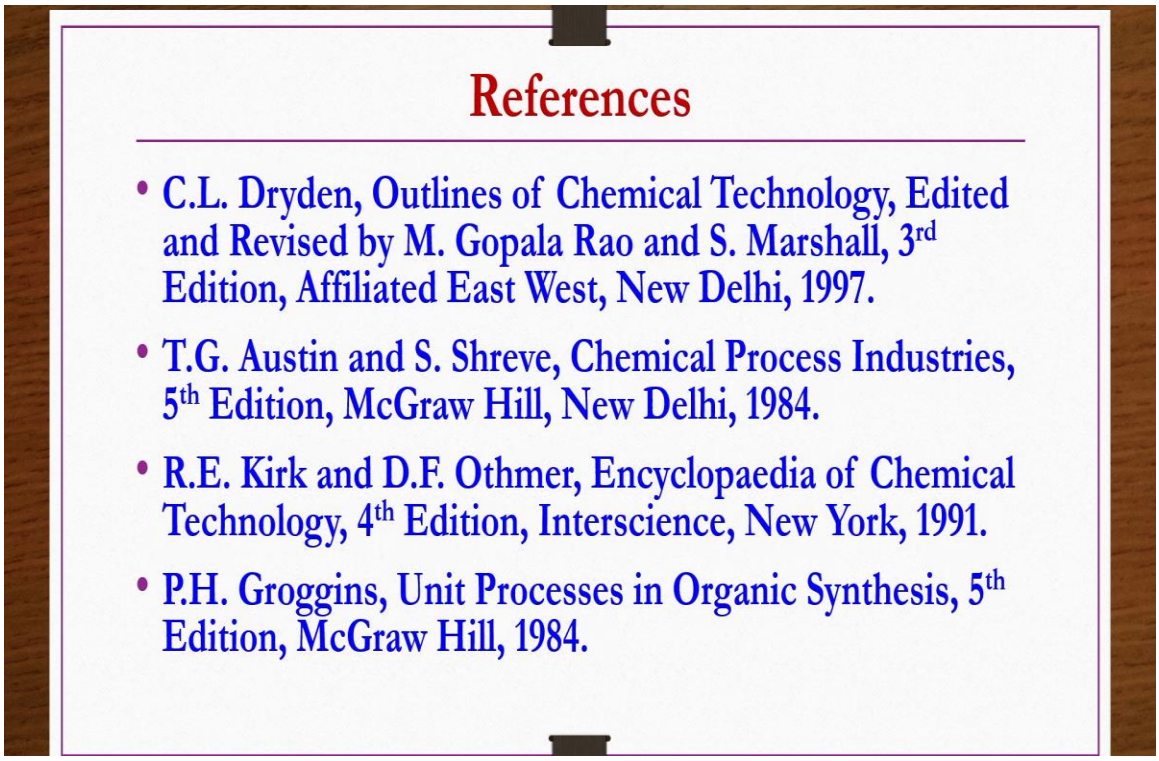
In the last chapter of the course, we will be discussing about the polymer industry. So, polymers are in general composed of molecules of molecular weight in the order of 10 power 3 to 10 power 7. These are made up of repeated basic units produced from monomers and then synthesis of polymers, they can be synthesized from various types and combinations of monomers to yield unusual properties, both physical and chemical properties. So, classification of polymers is very difficult because of the interacting relationships among large number of polymeric materials, but however, 4 classification or 4 different types are considered as common ones.

(Refer Slide Time: 46:33)



They are nothing but based on the physicochemical structure, one classification, based on the mode of preparation, another classification and then based on the physical properties is another classification and fourth one is based on the technical applications is one another classification. So, polymer technology. Polymeric materials are manufactured by standard chemical engineering methods. So, need not to say that polymer industry is also subset of chemical industry or also one of the important component of chemical industry. Classification of polymer applications if you see, they may be used as adhesives, coatings and films, fibers, solid shapes, etc. Many more applications are possible.

(Refer Slide Time: 47:29)



Now the references for today's lecture are provided here. Outlines of chemical technology by Dryden edited and revised by Gopala Rao and Marshall 3rd edition. Chemical process industries by Austin and Shreve 5th edition and then encyclopedia of chemical technology Kirk and Othmer 4th edition. Unit processes in organic synthesis by Groggin's 5th edition. Thank you.