Chemical Technology
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Module - 7
Petrochemical
Lecture - 1
Profile of Petrochemical Industry and its Structure

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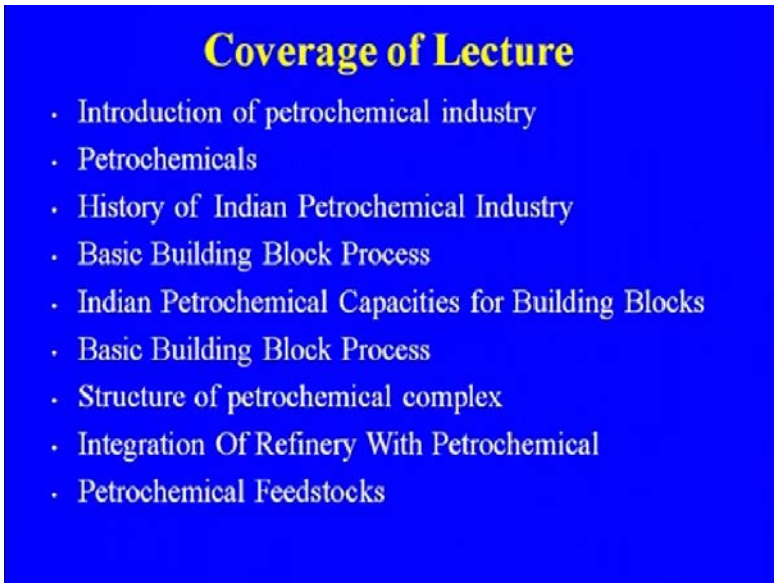

Now, we will be discussing module 7 of the organic chemical technology course, which is dealing with the petrochemical production and the, that will be 8 lecture of the various actually, the aspect of the, of the petrochemical production. So, first lecture, that will be on the introduction of the petrochemical industry. This is the coverage of the lecture introduction of the petrochemical industry, petrochemicals, history of the Indian Petrochemical Industry, what are the development that has taken place. Because you see the Indian Petrochemical Industry that is not it was only after the 60s that the, we started the cracker plants; we started the manufacture of the ethylene for the cracker or the olefin from the cracker.

Earlier, when the evolution of the chemical industry, which I discussed in the module 1 while discussing about the chemical industry. Because most of the products which are getting now the, from the petrochemical or (( )) that was produce either from the, that

was from the non petroleum route that was the either it was the styrene route, or it was from the methanol ethanol from the molasses and from the ethanol to ethylene.

Here actually the that was the, the even as I told you the; as I told you the 17 and after 17 there has been lot of development in the Indian Petrochemical Industry starting from the naphtha to the gas cracker low capacity cracker to the high capacity cracker plant. Hazira; one of the large integrated petrochemical complex or, being Indian Oil and the how the things are changing that will be also in the while discussing the integration of the refine of the petrochemical. Basic building blocks, Indian petrochemical capacity for building block basic, what are the various actually the major petrochemical which we are producing basic building block process structure of petrochemical complex, integration of the refinery with the petrochemical, petrochemical feedstock.

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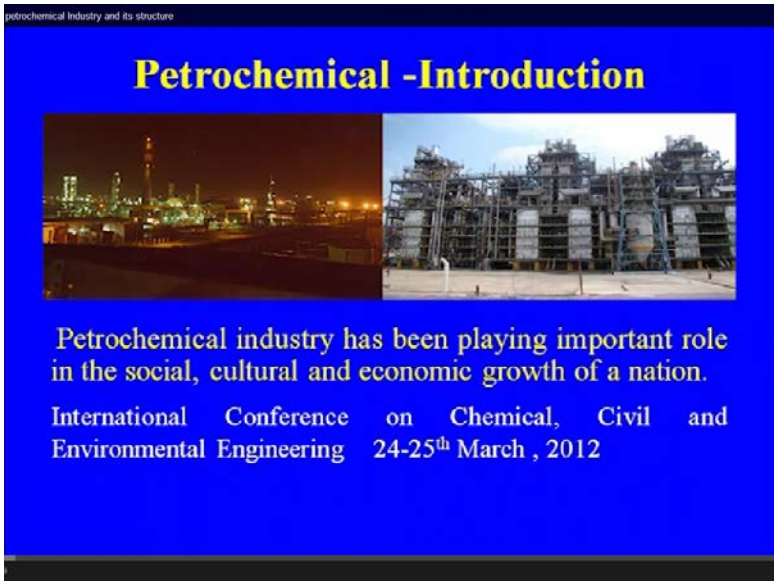

This is about the, a petrochemical you see this is a mother plant of the, a cracker that is the cracker plant of a petrochemical complex. So petrochemical industry has been playing an important role in the social cultural and the economic growth of a nation. Because, whatever the products you are in our daily life, it is in some or other way it is related to petrochemical industry. This is the same as the chemical, because the role of the inorganic chemical industry is there, but organic chemical industry, because the most of the product we are getting in a, this is from the organic chemical industry. So, the

organic, even the development of the organic chemical industry that has been only because, of the coming of the feed stock from the petrochemical industry.

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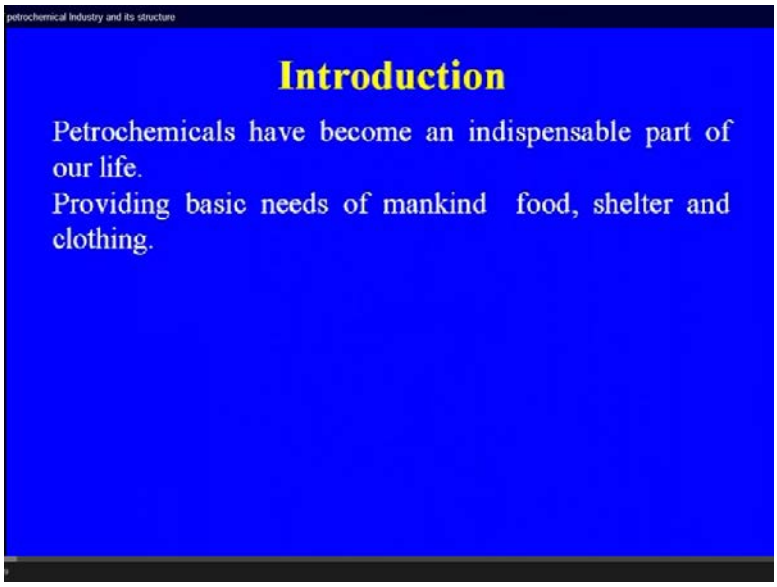

So, petrochemical have become an indispensable part of our life providing basic needs of the mankind food shelter and clothing (( )). So, this is the how the petrochemical that has played a very important role in our daily life. There they have revolutionized the whole economic growth of the country and at the same time providing the basic needs.

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This is the how the you see the I told you this is the petrochemical industry, they are providing the basic needs clothing shelter food you will say the food, food means the various product starting of the fertilizer. The pesticides all we are making through the petrochemical feed stock, which you are getting, clothing; there has been revolution from the cotton to polyester. And then polyester to acrylic fiber are the tax cotton to nylon, even in case of the transportation sector also, the synthetic fiber that has played important. Shelter we are using the various product especially polymer in case of the, even the pipe lines. Now, you will see the all the pipeline fitting there made of the polymer in the electrical fitting they are the polymer. So, that is the how the, your petrochemical industry they are playing important role.

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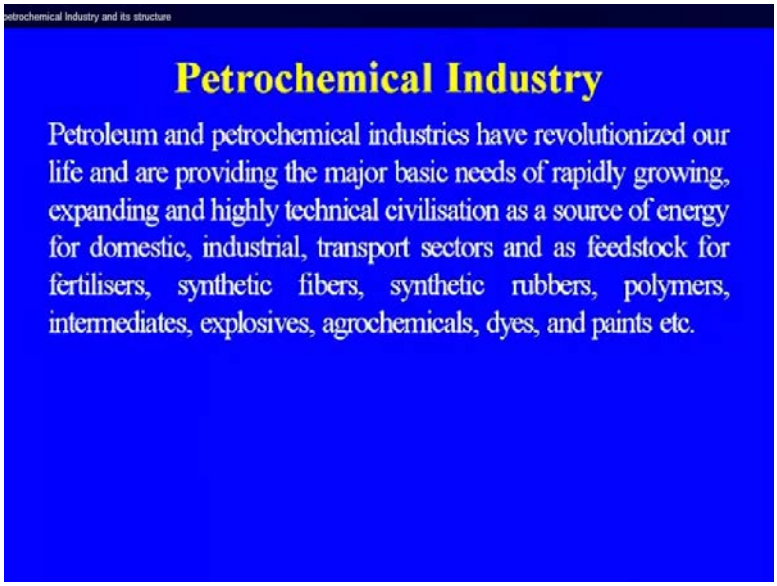

Petro chemical and the petroleum and petrochemical industry have revolutionized our life and are providing the major basic needs of a rapidly growing expanding and highly technical civilization as a source of energy for domestic, industrial, transport sector and as a feed stock for fertilizer, synthetic fiber, synthetic rubber, polymers, intermediates, explosives, agro chemicals, dyes, and paints. So, these are the actually the various product which we are using in our daily life. And this is the rule, because the, we cannot imagine a petrochemical industry without petroleum refinery. Because, the basic feedstock you are getting from the petroleum industry. So, that is why the petroleum, petrochemical are sometimes. So, the new concept is the petrochemical refinery.

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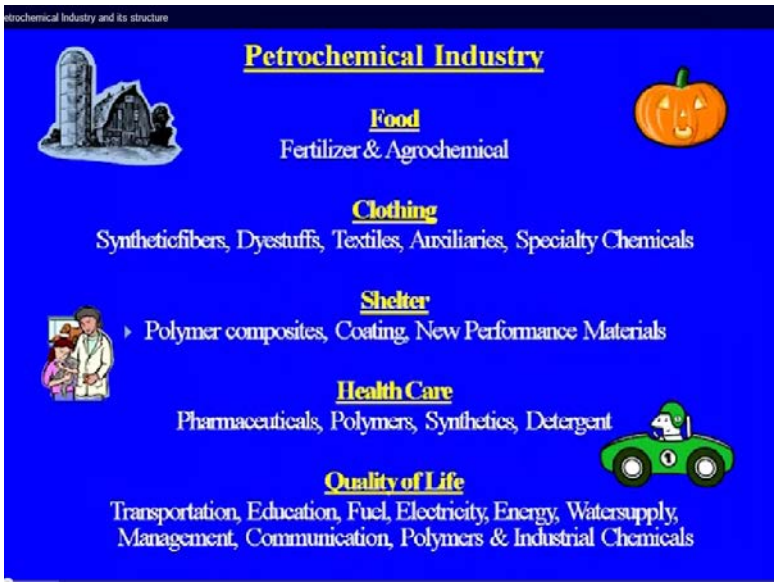

This is the role of the petrochemical in industry, I discussed some of the things in case of the organic chemical. So, food we are making the fertilizer and agrochemical fertilizer, we need the naphtha, you are producing the synthesis gas in case of the making of the ammonia and that synthesis gas that is also the important source of the petrochemical and ammonia. That is also coming in the because now, the raw material of the coal now the raw material is the naphtha or natural gas where we are doing the stimulating forming of the purchase oxidation in case of the heavy residue and agro chemical pesticide.

Already, will be discussing one lecture on the pesticide also, you see the, we are producing a large variety of the pesticide in the various form insecticide herbicide roadicide. So, all those your pesticide or insecticide they need the petrochemical feedstock. Clothing - synthetic fibers, dyestuffs, textiles, auxiliaries, specialty chemicals. Shelter; polymer composite, coating, new performance materials, that is health care; pharmaceuticals, polymers, synthetic fiber and detergent.

This is we required in case of the, then the quality of life, you see the quality of life, how the improvement in the quality that has been. Because of the petrochemical the transportation sector, you say the transportation section if you go to the any, you see any new car and the old car. You will find the there is lot of variation because, the material which are using in the car. Now, in the any automobile sector the, there has been vast

change from the metallic to polymer composite, polymer metal composite, lighter weight of the vehicle and then at the same time the tire.

Now, we are talking about the tubeless tire, we are talking about the longer life of the tire. And so, the when in case of the tire making these, your petrochemical industry that is playing very important role the education, fuel education. Now, you are seeing the revolution in case of the electronic industry or the computers industry. So, what are the, the, whatever the product we are using in the electronics industry are making of the computers, now we are talking about the CD.

So, from where it is coming? All the components of the, your computer, from where it is coming. We are using the various type of the polymers, which are available fuel electricity, energy, water supply management communication, polymers and industrial chemicals. So, these are the some of the actually, the other products which are available, which are helping in the improvement of our daily life and this is the role of the petrochemical industry. This is the product how they have; they have played very important role in the industrial economical development, culture development of a country. How the petrochemicals they have, they have playing already, we have discussed packaging to agriculture.

Packaging industry; all the carry bags we used to have the paper carry bags. Now, that has been replaced with the, your poly ethylene bags, because of the longer durability lower cast, although there is some problem in case of the poly ethylene. Similarly, other packaging material there has been lot of, you see the revolution in case of the mineral water bottle, or the various packaging bottles which you are being used already to metallic glass.

But now what we doing, we are using all the PET resin that we are using agriculture, you will find that in the agriculture, how it is playing important role, because through the pesticide that is one part. But you see the, now the pipeline for the irrigation purpose pipes, PVC pipes, now normally it is being used in the various pipe. So, this is also the how the petrochemicals they are part from the pesticide and fertilizer, because fertilizer is always part of the petrochemical.

Now, and this is the reason why many of the fertilizer like the refinery integration of the refinery the petrochemical. There is also the integrated fertilizer plant where we are not

only making the fertilizer, we are also making many of the petrochemicals and one of the large integrated fertilizer come the petrochemical complex is the Gujarat State Fertilizer Complex At Badhodra, where they are making the all the fertilizers phosphateic. And then, the nitrogen fertilizer at the same time they are making the caprolactam, caprolactam. They are making the melamine, they are making the some of the other, another development was the RCF they are also making large. So, these are how the development that is taking place.

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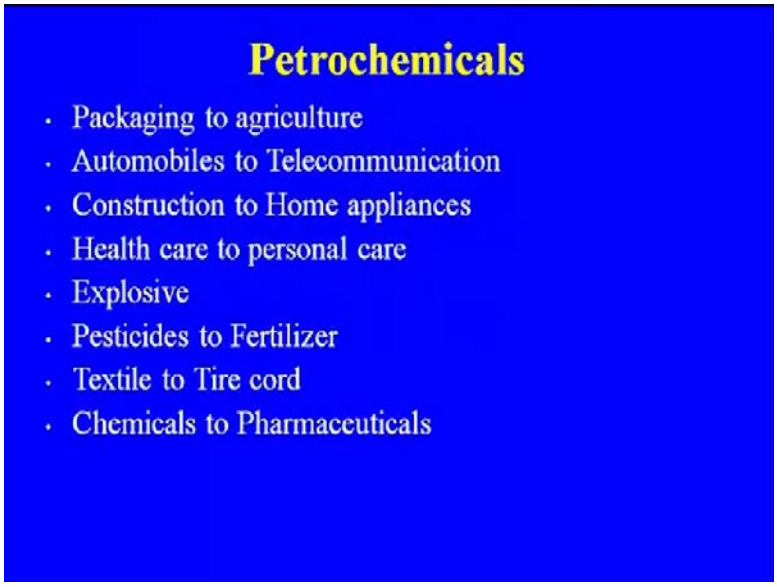

So, automobile so telecommunication construction to home appliances, heat, health care to personal care. You see the, what is happening detergent industry take the case of the soap, there has been lot of the changes in the quality. At the same time even the cost of the detergent. So, that is playing or even the non, which are making that is possible we are making now explosive where earlier that was the TNT tinitrothylene that was the nitrocile, TNT; that was the one of the major explosive. Everywhere we are using some other form the petrochemical feedstock, pesticide soap fertilizer already, I discuss in the agriculture, how they are playing very important textile to tire cart. Because the tire cart in the lining, and this was the, actually the development of the synthetic fiber during the World War 1 and World War 2. Because there was need of the more and more tire for the automobile sector. At that time and so the various synthetic fiber, either it was the earlier viscous Ryan polyester or the nylon 6 or the nylon 60 sis.

They have played very important role in making of the tire and the textile of course, already I discuss you the how they have playing important role. And because, the cost of the polyester that is much lower than where you are having for the cotton. So, this is the how the in the textile industry you are seeing the revolution that is only, because of the synthetic fiber, which you are producing in the petrochemical industry chemicals to already. A large number of the intermediate we are manufacturing in the petrochemical complexes that is finding application as intermediates.

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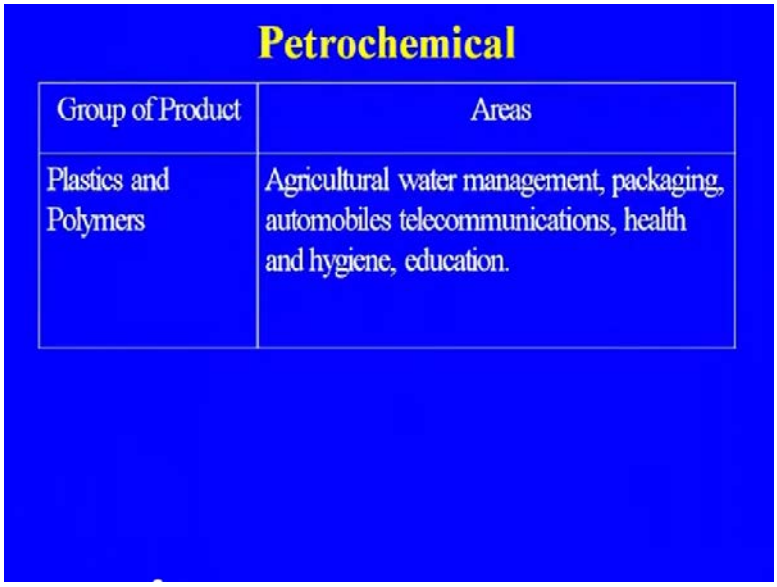

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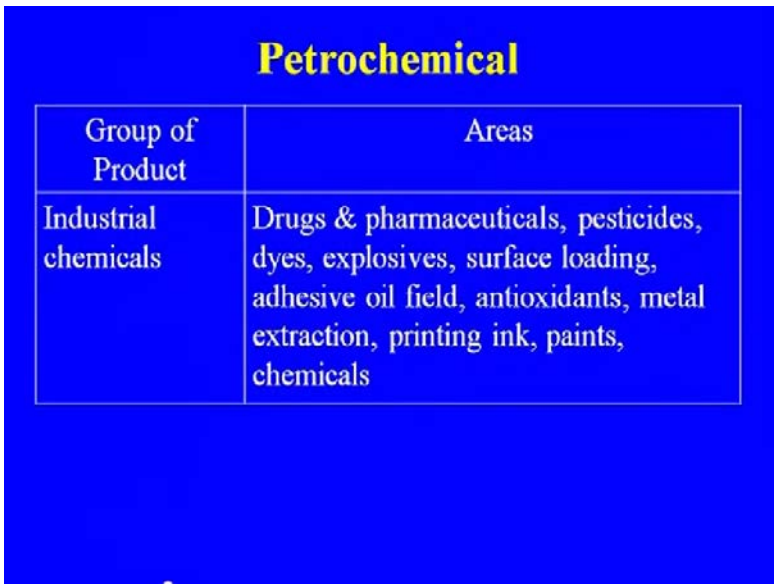

These are the some of the products already, I have discuss these products, but plastic and polymers, agriculture, water management packaging, automobile, telecommunication, health, hygiene, and the education. Synthetic rubber in the transportation industry, synthetic detergent; health and hygiene industrial chemicals, synthetic, synthetic rubber usually. Now, you are having the some of the clause, also where you need the elasticity. So, industrial chemicals another very important product of the petrochemical industry, which is drugs pharmaceutical, pesticides, dyes, explosives, surface loading, adhesive oil field, antioxidants, meta extraction, printing ink, paints and chemicals.

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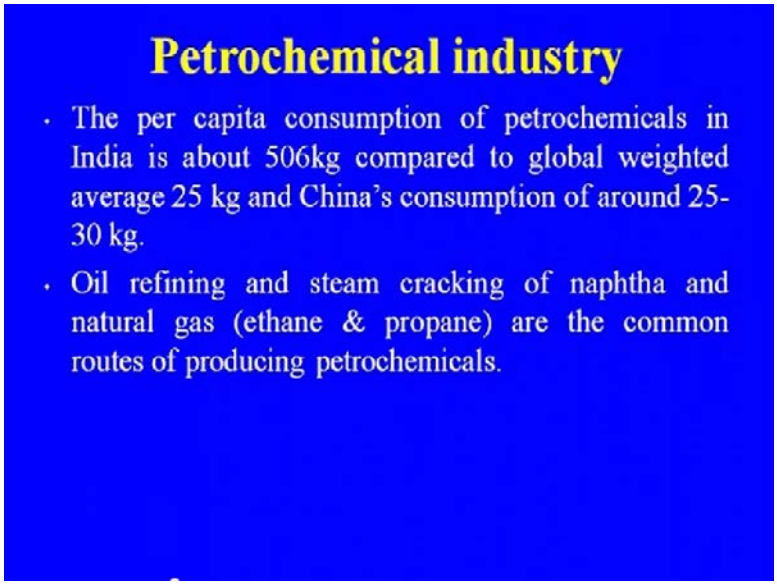

The per capita consumption of the petrochemical in India is about 5 kg, compared to the global weighted average of 25 kg and China's consumption of around 25 to 30 kg. Oil refining and the steam cracking of the naphtha and natural gas are the common route for producing the petrochemical. So, various plastic, you see the in case of the polyethylene, various quality of the polyethylene we are using that is the low density, high density, linear low density, polyethylene, poly propylene PVC, poly sterile and some of the other special polymers also we are producing that is the combination just like alcobutadine styrene.

So, ABS plastic and although the, so the poly propylene that has come in big way, because the poly propylene huge amount of the poly propylene that we are using in the automobile sector. And at the same time, poly propylene fibers also, poly propylene in

the all the because of the good. Your this in the hospital various actually, the earlier we used to have the glass bottles and other thing for the glucose bottles. But now in syringes glass, syringes now it is all has been replaced with the poly propylene.

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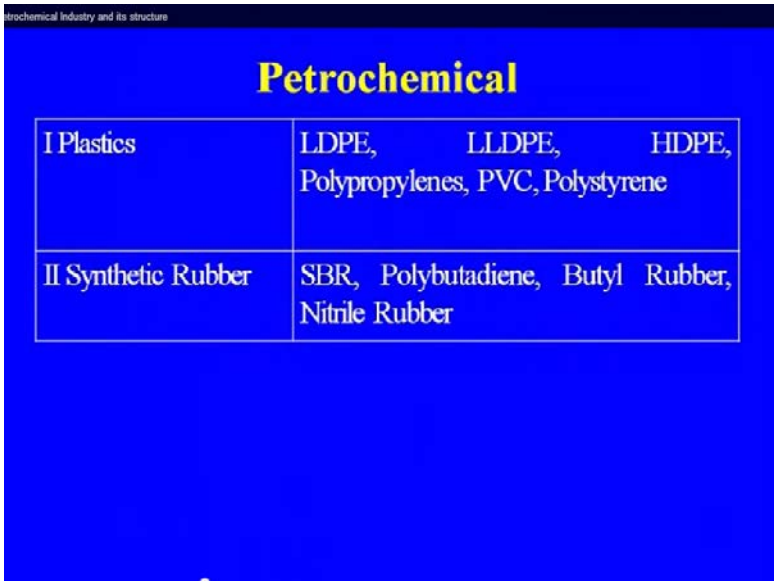

So, synthetic rubber, first it was the styrene butadiene rubber, poly butadiene .Many of the petrochemical, they are making, because the butadiene that is produces from the naphtha cracker, butadiene rubber, nitrile rubber. Again you see the one of the requirement in case of the yours resistance source oil, so nitrile rubber very important, synthetic fiber; various types of the synthetic fiber. Now, we are having nylon 6, nylon 66, polyester acrylic fiber, poly propylene fiber. And in case of the synthetic fiber although viscous is not, now we having the various blend of the viscous with the linen polyester or the acrylic.

Intermediates; these are the various intermediates, which are finding application in the various chemical industry. ethylene and ethylene propylene, DMT, PTA caprolactam, aniline, ethanol, methanol formaldehyde, aniline, phthalic anhydride, maleic anhydride and so a long list is there. This is the only summary of this some of the intermediates, which are making, which is fine application in the petrochemical industry.

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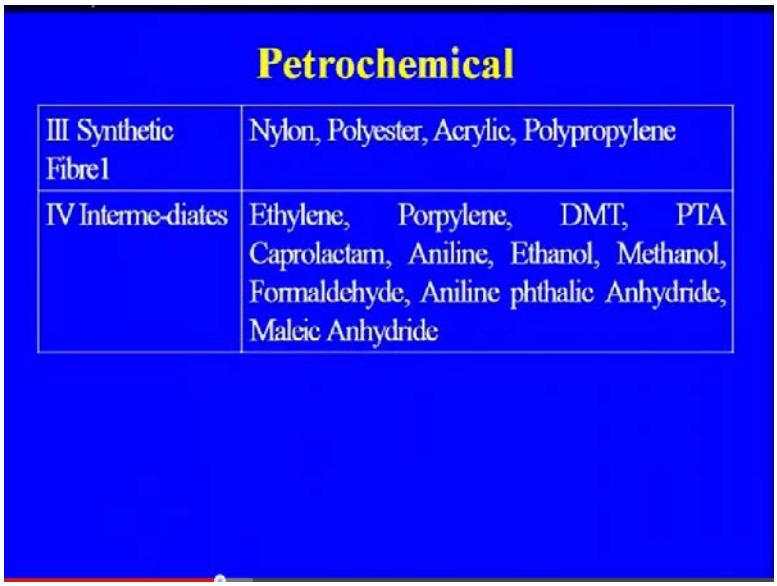

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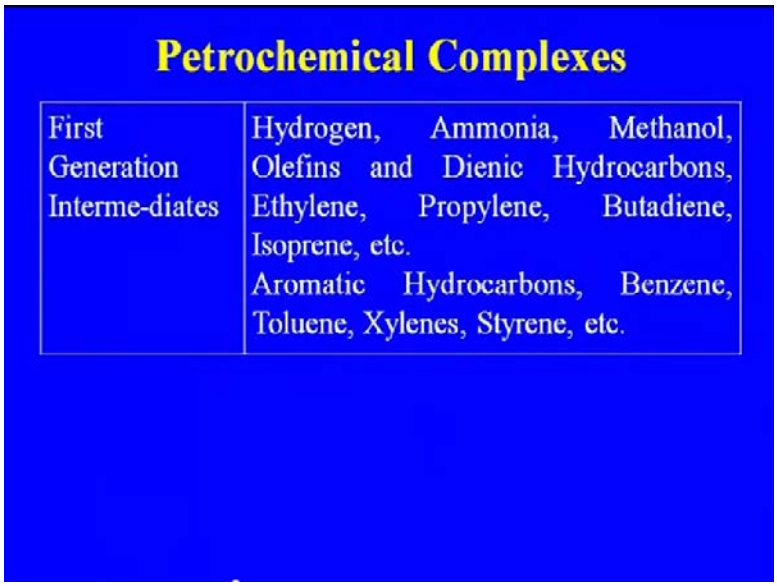

Petrochemical complexes; first generation that is the what we are the, we started with the first generation chemicals that the hydrogen, methanol, olefins, hydrocarbons, propylene, isoprene, aromatic benzene is there. Even ammonia, ethylene, butadiene these are all the first generation intermediate of the chemical. Second generation intermediate introduction, some of the various hetro atoms into final molecule including oxygen, nitrogen, chlorine and sulfur by various unit processes that was the intermediate, these intermediates were made.

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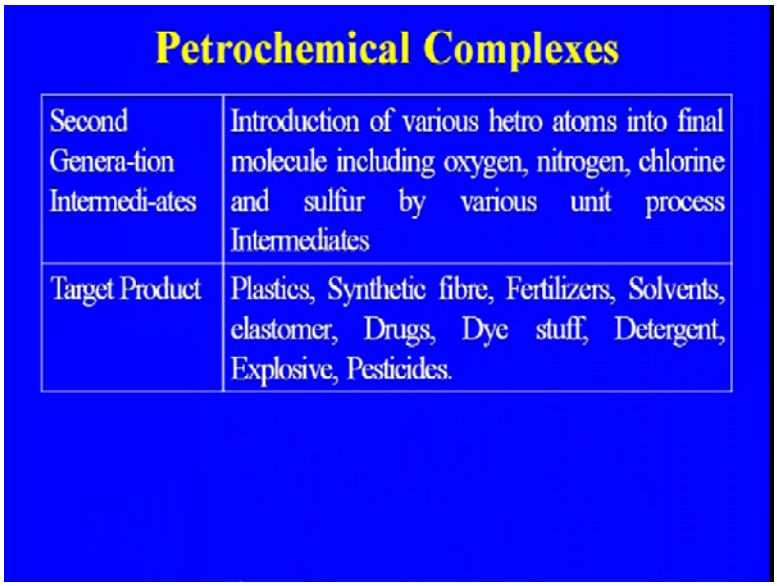

Target products; plastics, synthetic fiber, fertilizers, solvents, elastomor, drugs, dye stuff, detergent, explosive, pesticides. So, this was the final third generation you can say the after the getting the various raw material from the, you take the case of the another petrochemical industry. Because the layer, it was the phthalic anhydride, that was available from the naphthalene route, which was available from the coke oven plant. Now, all the phthalic anhydride, they are being made from the ortho xylene which are available from the anhydride phthalic anhydride, we are using the paint industry.

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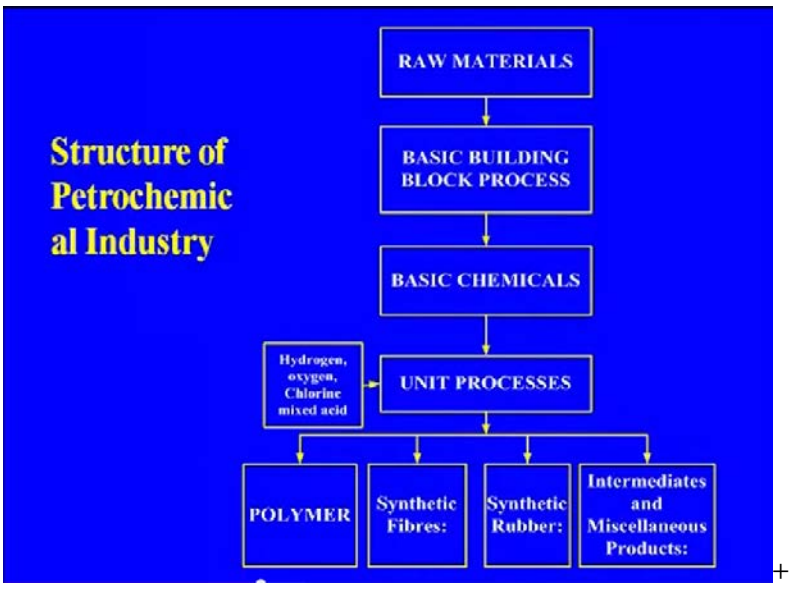

This is the basic structure of a any petrochemical complex that is the raw material, that is going to basic building, block processes and then the basic chemicals we are getting may I say the basic building process. Already we have discussed in case of the organic chemical industry, various process cracking reforming all those process are there. And then, we are getting the basic chemicals and then some of the further processes are there like the chlorinisation, sulfurisation, sulphonation or it may be the oxidation hydro formation. So, number of the action that is taking place they have chlorination is also there. So, the hydrogen oxygen chlorine and mixes it that you are adding and then you are getting the target product, the polymer, synthetic fiber, synthetic rubber.

Because the any combination that may be in any petrochemical complex, it may be only the polymer, it may be only synthetic fiber, synthetic rubber or even some of the intermediates which are needed just like you take it. All the petrochemical they are having the ethylene oxide and ethylene, MEG, because the MEG plant MEG that is required in case of the polyester manufacture.

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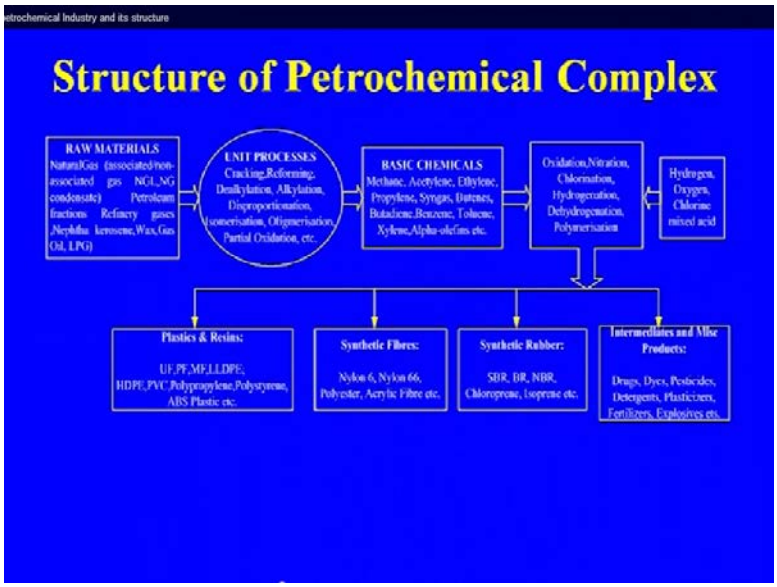

This is more details about the various raw materials, which we are getting the natural gas means the, it may be the natural condense sheet also and now, in case of the natural gas, shell gas, coal bel, methane are even your this gas hydride. They are going to play very important role in case of the petrochemical. Already we have discuss in detail about the raw material for the organic chemical industry, in that we discuss about the importance

of the industry. Various unit processes that is involve already the cracking reforming dealkylation, alkylation, disproportionation, isomerisation, algoisomerisation, partial action. These are the various unit process that is involve, we are manufacturing the basic chemicals, the methane, because the various chloro methane, chlorinated methane compounds are available just like carbon tetrachloride then the chloroform.

These are all the methyl chloride, all these are of the chlorinated ethylene are also there. So, these are the basic chemical we are making the methane acetylene is also produce during the crack from the cracker plant, ethylene propylene, syn gas, butane, butadiene, benzene, toluene. These are the basic chemicals which are needed by organic chemical. So, this is the major integrated part and then we can start any organic chemical with using this raw material. And these are the further unit processes and after that you are getting the basic chemicals plastic resins, synthetic fiber which already I discuss. Let us discuss about the history of the petroleum industry in India.

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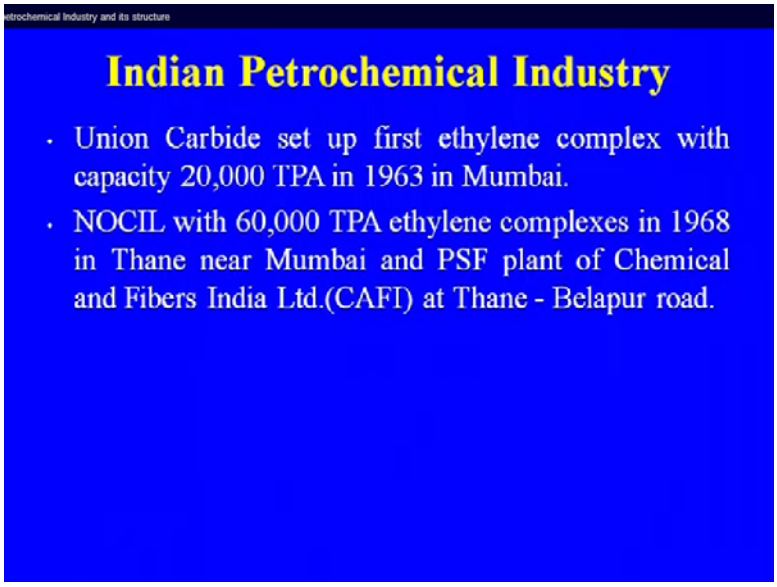

Union carbide set up the first ethylene complex with a capacity of 20,000 only. Now, we compare with the more than 8,00,000 ton capacity that is 8,00,000 ton capacity of the Reliance and the same capacity of the IOC Paniput Refinery. So, you can imagine the capacity wise, how the changes that has taken place, that will be discussing while discussing the naphtha cracker.

So, this was the first starting of the petrochemical real, otherwise before that the ethylene that was being manufacture from the, your alcohol route, bis molasses to alcohol and alcohol to so NOCIL with 60,000 TPA ethylene complex in 1968 in Thane. Now, it is closed because, that has taken over by the Reliance and they have stop this plant, because of the lower capacity. Another plant, that was set up there in the Thane, that was the fiber India chemical and fiber India CAFI at the thane, Belapur road. That was again taken over by Reliance in the name of trany fiber and that has been closed now. And the all the your corporate office of the Reliance Industry where the Mukesh Ambhani, Anil Ambhani that is there and the this is the how the development in case of the petrochemical industry.

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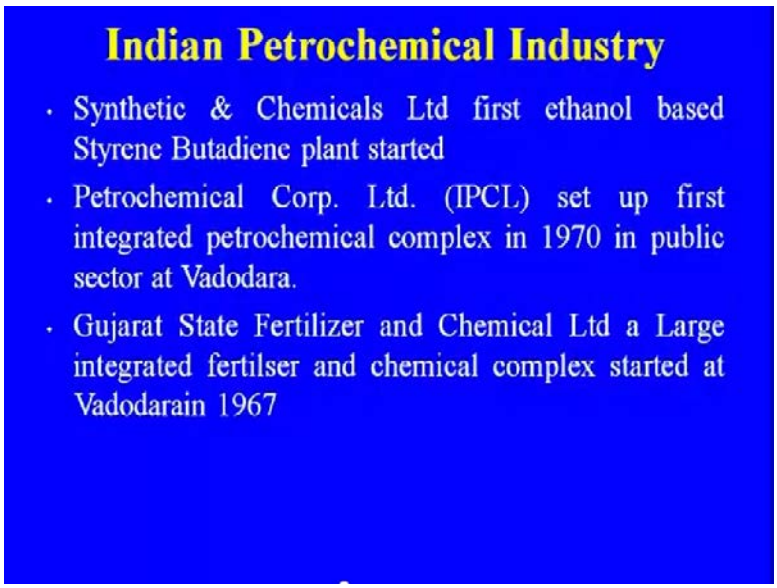

So, synthetic and chemicals, Bareli that was the first actually the plant with non petroleum route, ethanol bases styrene butadiene rubber. Petrochemical complex was setup that was the first integrated complex in 1977 in the public sector. Now, it actually IPCL is now the Reliance Industry they have taken all the 4 units of the IPCL. And that was large about 17 plants are there here Gujarat State Fertilizer and it is just near the, because the IPCL and the GCFC they were side by side of the Indian Oil Corporation and the basic raw material they are getting from these from the refinery. So, that is the integrated fertilizer in chemical complex.

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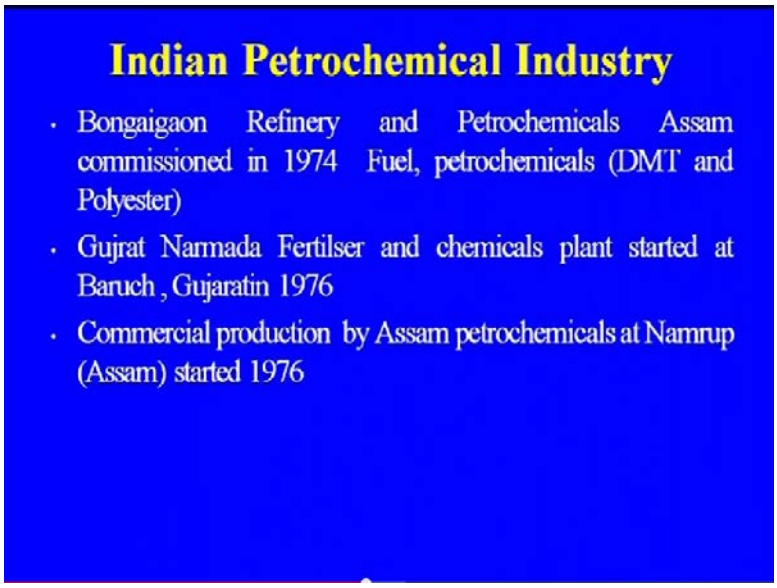

Bongaigaon refinery and the petrochemical where they are making the DMT, DMT to polyester that was Bongaigaon refinery and petrochemical in Assam that was commissioned in1974. Gujarat Narmada Fertilizer and chemicals plant started at Baruch that was the in Gujarat in 1976. Commercial production of the Assam Petrochemical at Namrup, because Namrup, there was the first fertilizer plant and the petrochemical plant there where they are making the methanol and methanol of the formaldehyde.

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So, that was the first plant start in Assam using the natural which available from that oil fields. So, the another development, major development that was coming of the Reliance and the your Nirma in the synthetic detergent industry.

So, Nirma limited enter in business of to carry on the business of the manufacturing and selling synthetic detergent soap, chemicals and allied products in 1984. Tamilnadu Petro Products that was the one of the major unit and still they are making huge amount of the LAB. Reliance Industry. Patalganga, which they started with LAB and the polyester making in 1987. Reliance Industry, Hazira, that is the one of the largest integrated petrochemical complex and the in 3 phases that was the, that came into existence and the further addition of the one more PET resin plant that was there earlier. They were having the one another, it totally depend in upon the import for the import, export of the PET resin that was started IPC L.

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Now, Reliance Industry, Nagothane, that was the first cracker plant commissioned in 1992. Manglore Refinery and Petrochemicals, again it has been taken by ONGC that was 1996. Nirma LAB plant came into 90, because the Nirma they started with the small scale formation and the real plant of the Nirma LAB plant that came only in 1997.

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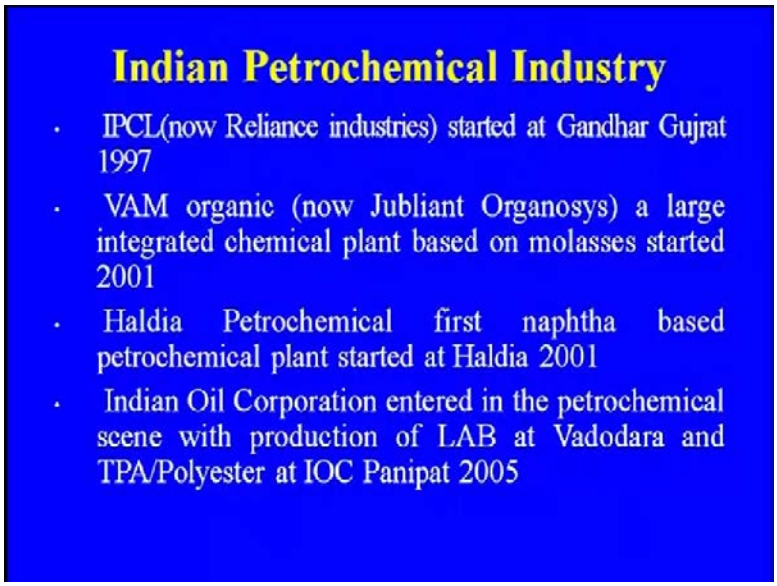

IPCL; the Gandhar unit, where they are having the gas cracker VAM organic one of the largest integrated chemical plant based on the molasses started 2001. Here also the a large number of the plants are there already, we discussed while the discussing the alcohol Haldia petrochemical first naphtha based petrochemical started at Haldia in west Bengal 2001. Indian Oil Corporation entered in the petrochemical scene with LAB at Vadodara in 2005.

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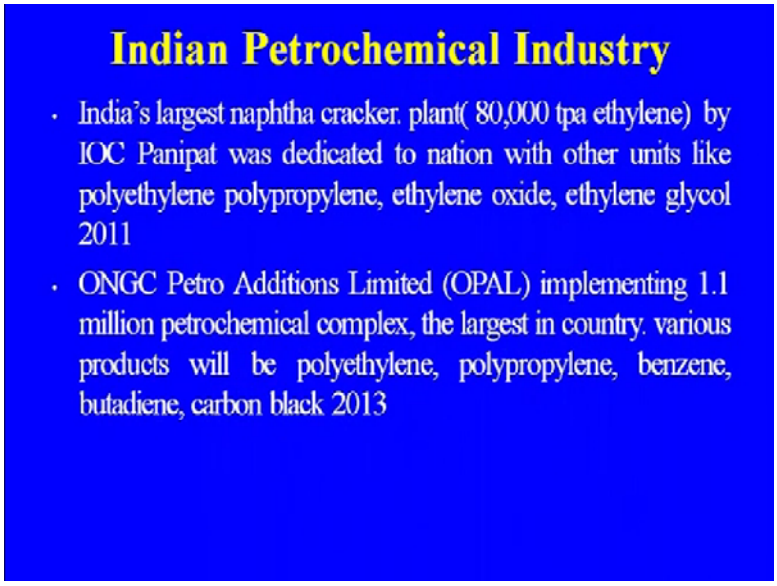

India's first largest cracker plant, the same capacity there, Reliance Hazira cracker by IOC Paniput was dedicated to nation in 2011. ONGC petro addition limited implementing 1.1 million ton petrochemical complex, the largest in the country various product will be poly ethylene, poly propylene, benzene it is near Gandhar, same place where the Reliance there having butadiene, carbon black. These are the some of the product they are expecting and oil added the progress of the project is there 2013 that was started.

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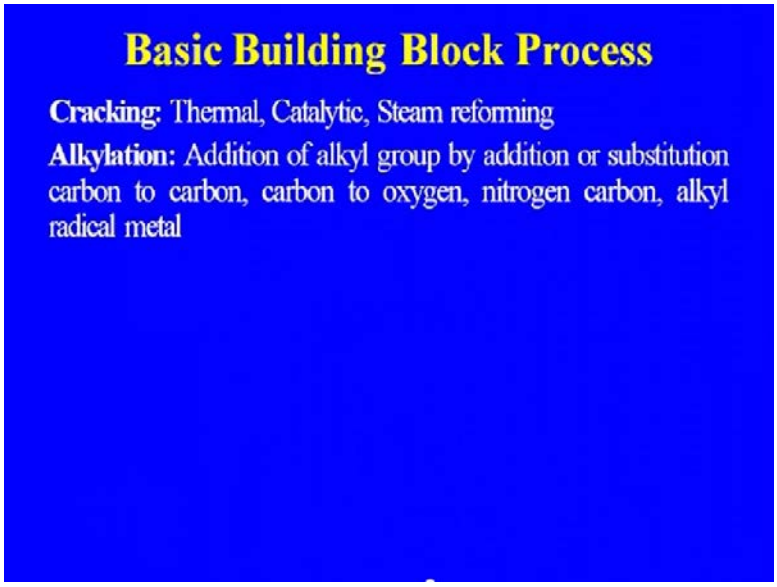

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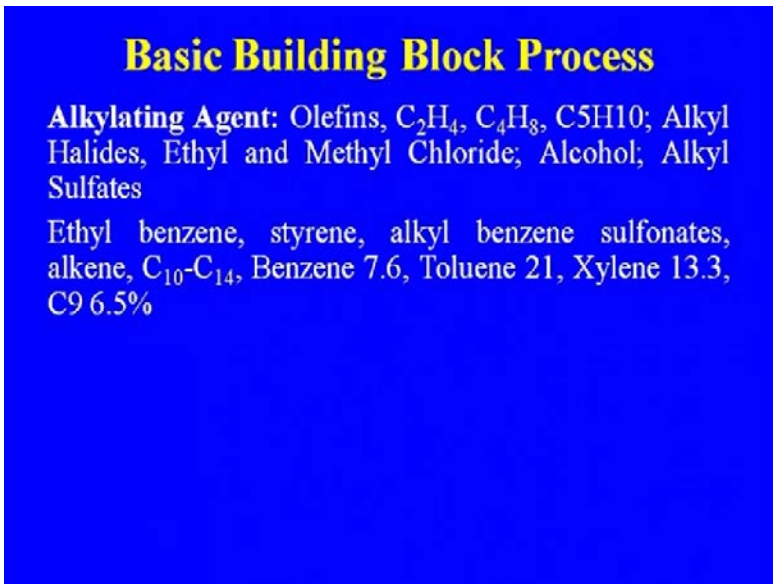

So, these are the various basic building blocks, the cracking thermal catalytic steam reforming, alkylation addition of the alkyl group. These are the some of the alkylating, alkylating agent already we discuss about the catalyst part and these are the some of the other basic raw material which are using for the alkylation Petro, petrochemical building block, because you see the any, already we discuss about the structure of the what we are doing, we are doing the cracking. So, naphtha is going to cracker and we are producing the ethylene propylene and C 4 C 5, because earlier C 4 C 5 fraction, that was neglected part. But now, because of the more and more utilization of the C 4 steam, because you are getting the many large number of the value added product. So, the importance of the recovery of the gases C 4 especially, for the isobutylene that has been a very important. Similarly, the C 5 steam there is containing the isoprene although in case of the naphtha. we are recovering the butadiene in the all the petrochemical complexes, if you are having the naphtha cracker.

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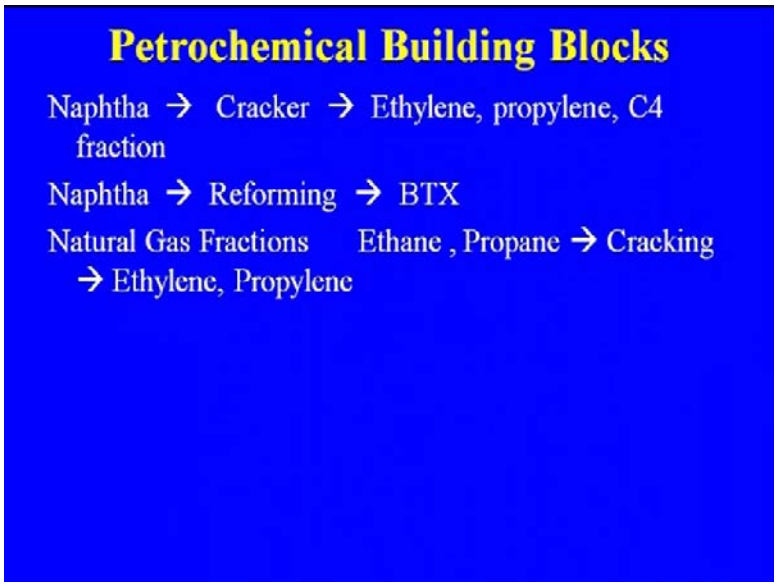

Naphtha to the reforming and then reforming to aromatics, benzene, toluene, xylene, natural gas fraction, ethane propane, again it will go to the cracking ethylene and propylene you will get. So, these are the some of the building blocks what we call the kerosonic extraction, LAB, LPG from the refinery again, you can go for the cracking propylene and butylene gas oil, cracker, ethylene, ethane, propane, butane. It can go for the manufacture of ole alpha olefins, which is finding use in case of the some of the

polymers. These are the some of the install capacity of the major feedstock, major product which you are getting from the finding.

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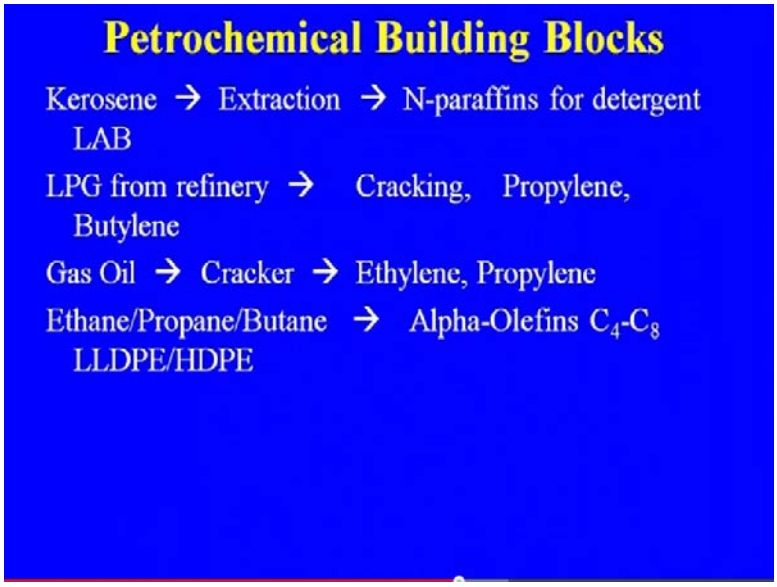

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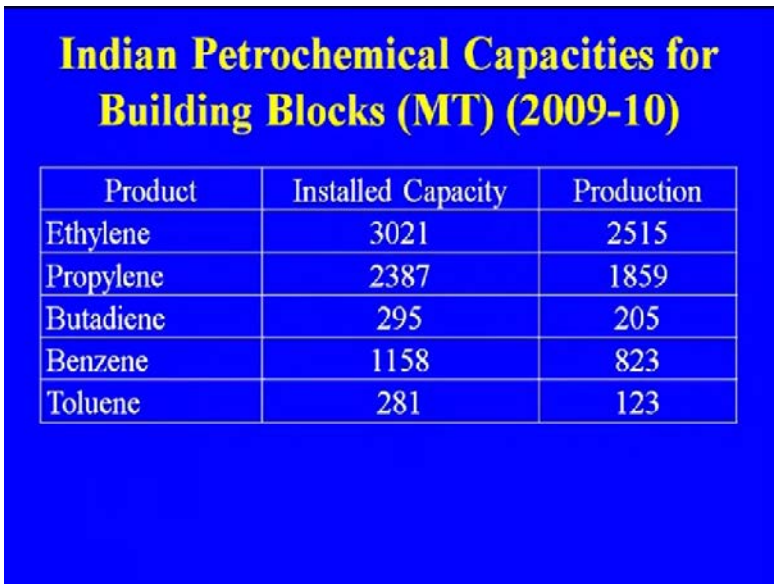

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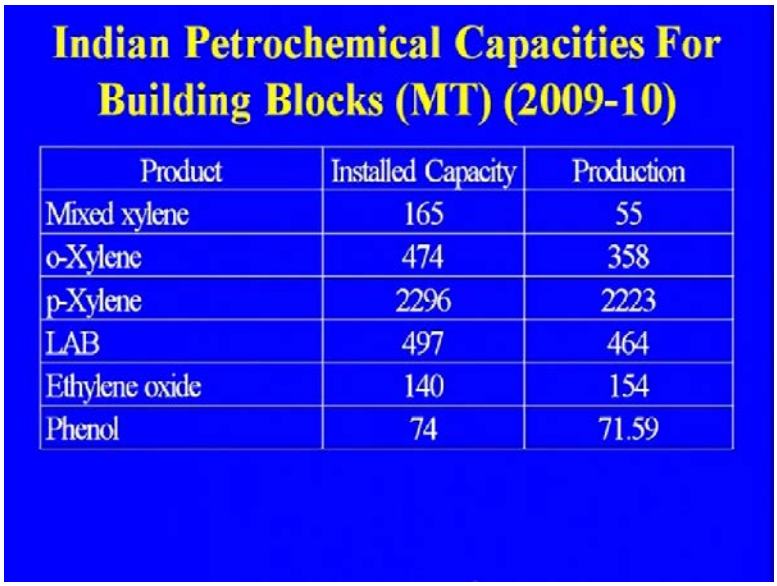

Ethylene, propylene, butadiene, benzene, toluene, because in case of the cracker plant, we are getting a complimentary steam that is the pyrolysis gasoline. So, this is the production and installed capacity in million tons of the in case of the refine. Mixed xylene, because ortho xylene as to the ortho xylene that is ;that is being a very important feedstock, phthalic anhydride which is being used in the paint industry plaster. Para xylene, that is for the your polyester manufacture that is one of the major raw material for the TP or DMD LAB linear alkyl benzene, ethylene oxide and phenol.

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If you divide all the organic chemical or the petrochemical C 1 group; methane, synthetsis gas derivatives. C 2 group; ethane, ethylene, ethylene derivatives, acetylene. C 3 group; propane, propylene and propylene derivatives. C 4, C 5; butadiene, benzene derivatives. So, these are the some of the basic hydrocarbon group and will be discussing in the next few lecture. The various product in each case in 4 5 lectures about the, what are the C, C 1 organic, C 2 hydrocarbon, C 3 hydrocarbon and C 4 hydrocarbon.

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Major end products already, we have discussed; polymers, synthetic fiber, synthetic rubber, synthetic detergent, chemical intermediate dyes, intermediate, chemical intermediate and pesticides. These are the basic building processes already, we have discuss cracking steam reforming and the partial, these are for the synthesis gas. Making of the synthesis gas and from the synthesis gas means synthesis gas hydrogen and nitrogen.

That is synthesis gas for the ammonia C O and H 2, which you are manufacturing that will go for methanol; that will go for the methanol to your olefins or now the newer technology or what we are called the methanol to olefin, methanol to plastic like that. So, in all the steam reforming that is going to a very important role at the same time a steam reforming that is being all the refinery they are having the steam refinery, because the, we need the hydrogen in various process, catalytic reforming for the aromatic production.

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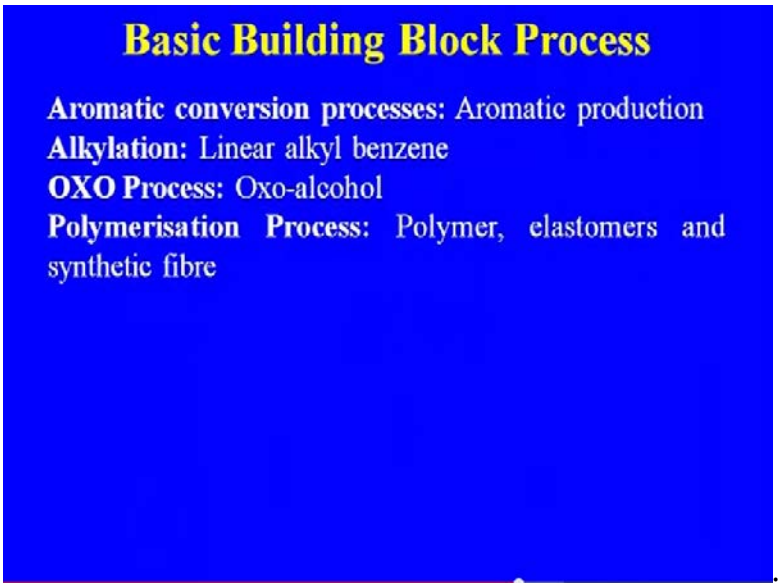

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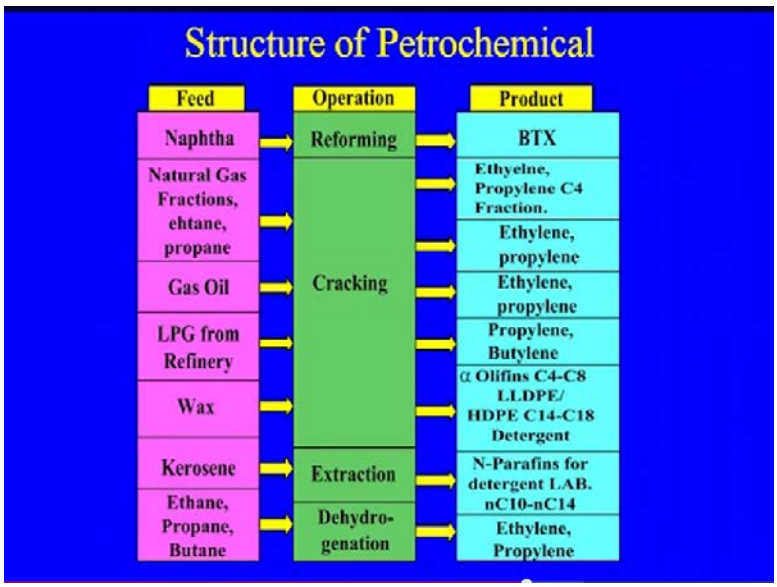

Some of the aromatic conversion process also they are alkylation, oxo processes, polymerization processes from where we are getting the various product. This is the basic structure of a already, we discuss earlier the what are the basic structure the feedstock operation. These are the major operation naphtha natural gas, gas oil LPG, wax, kerosene and the operation reforming cracking extraction dehydrogenation.

Just like we can all 9 production of the propylene from the ethane, propane that has become also one of the major process to meet the requirement at the site. And so, these

are the product which we are getting from the reforming from the cracking. A long list of the product are there, extraction in from the kerosene already, we have discuss while discussing the linear alkyl benzene, dehydrogenation. So, these are the major petrochemical feedstock, which are using in the petrochemical complex natural gas condensate. That is also because, huge amount of the condensate which is using their aromatic and now in future we are going to ehtylise these natural gas condensate also.

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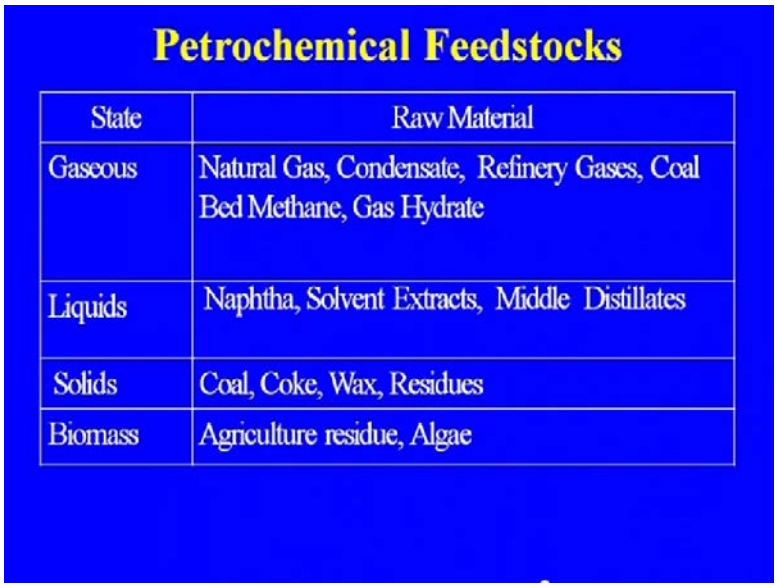

So, the gaseous natural gas, condensate refinery gases, coal bed, methane solid coal, coke, wax, residue, bio mass agriculture. Because why I have added this last 2 part that is the coal, coke, or wax agriculture, because now we are refinery we are going for the petro coke classification. So, the petro coke are the coal, coal to synthesis gas, and then the synthesis gas that can be use for making of the various products, which we are getting from the petrochemical. Similarly, the, your biomass means ethanol, ethanol to various petrochemical.

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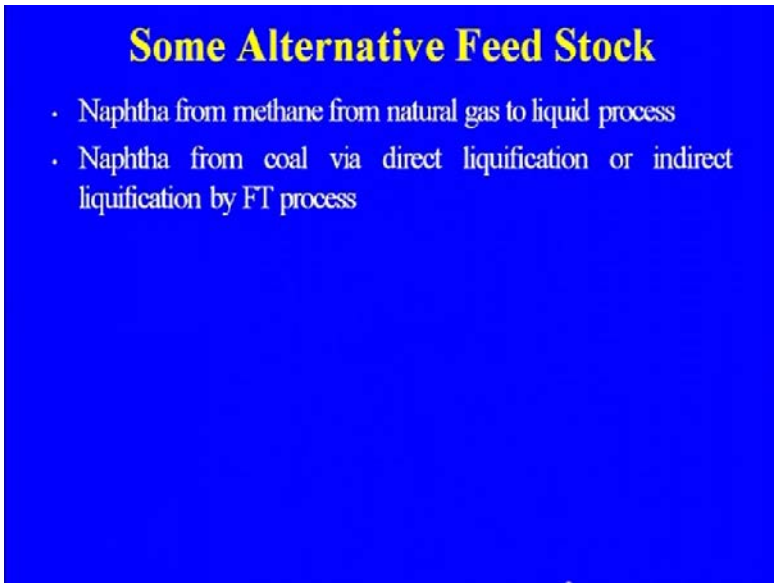

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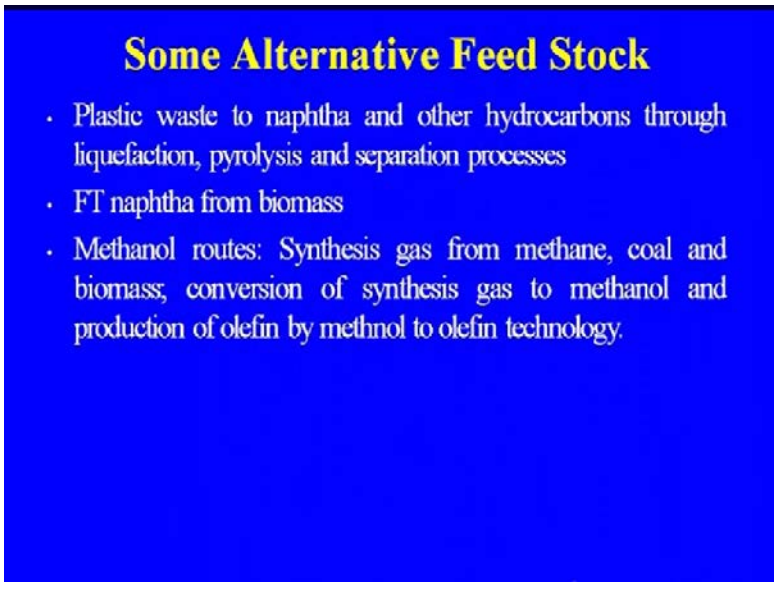

Some alternative feedstock, naphtha from the methane, from natural gas to liquid processes naphtha from because, you see in case of the GTL technology, which was in that is because, now GTL technology that has become a very important process for making of the utilization. Better utilization of the natural gas to natural gas to liquid technology, natural gas to chemical, naphtha from the coal via directly liquification or indirect liquification by fisher trop synthesis.

Plastic waste to naphtha and other hydrocarbon through liquification pyrolysis and separation process because, these are also because we are producing huge amount of the plastic waste and so the how to utilize this plastic. So, that there in lot of the work that has been done and some of the smaller plant they are already in operation for the destruction distillation of the plastic waste to get the monomer back. F T naphtha from the biomass again from the biomass gas, you see the, as I discuss, while discussing the in the introduction of raw material biomass that is coming in a big way for the providing the, for making the synthesis gas through the gasification route, or from the fermentation route the ethanol.

Methanol routes again, we are talking about the various technology synthesis gas from methane, coal and biomass conversion of synthesis gas to methanol and production of olefin by methanol to olefin technology. So, this is the from the methanol route. Now, we are talking about the gas to liquid technology that is the gas to methanol and methanol to again you can go for making of the large number of the product, product either it may be the formaldehyde from methanol. Or these products that is the again methanol to olefin technology that methanol to propylene technology that has become very important role.

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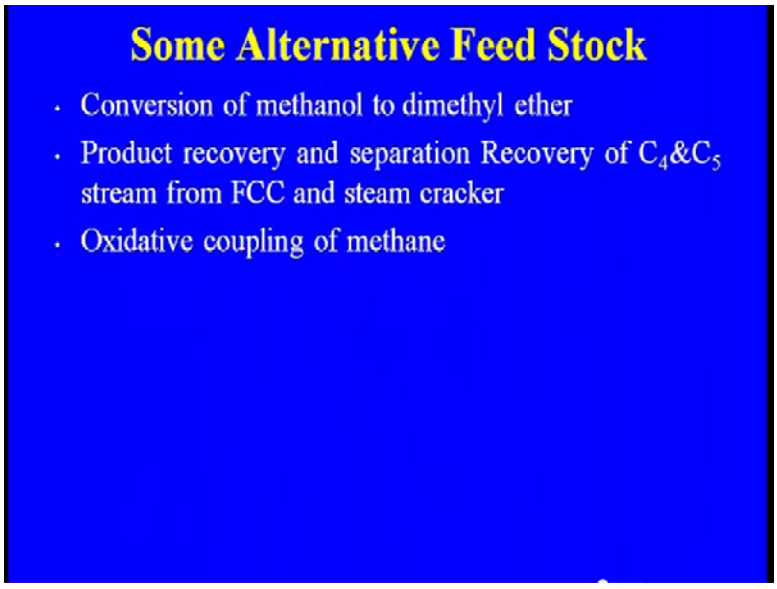

Then the conversion of methanol to dimethyl ether, this also one of the very important process that is going to the future refinery. Because dimethyl ether that is a very good compound high octane component.

Product recovery and separation of the recovery of the C 4, C 5 steam from FCC and steam cracker. Again, as I told you the earlier we are not only it was the up to the propylene part because, the birth of the petrochemical, if you see that that was with the recovery of the propylene from the FCC during the 1920. Even the first refinery 20 or 30 I think. So, the propylene that was recovered, but C 4 C 5 steam that was not except when the MTB was there. So, I saw butylene fraction that was use for the your MTB, but other fraction butane, isobutene, butene 1, butene 2, these are all present in case of the C 4 C 5.

Another very important product that the isoprene so, recovery of the C 4 and C 5 steam from the FCC steam cracker that is that will pay high revenue to the petrochemical complexes. And so the, this is the reason why in future may be I think of the recovery of the more chemical from the C 4 and C 5 steam of the cracker plant are the FCC Oxidative coupling of methane to olefin, this is also one of the emerging technology that we are going to have so that the methane, because you see the natural gas we are having the plenty of the methane.

So, why not utilize this methane from making of their. So, this is one of the technologies, that is another technology, that is for the natural gas to aromatic by using the cyclar process. In case of the that cyclar process ethane, propane from the natural gas that can be used for making of the aromatics from the propane and butane. And that process already, one plant that is working on the based on the cyclar process. Although it was developed long back, but still not many, but in the GTL technology now there units are there.

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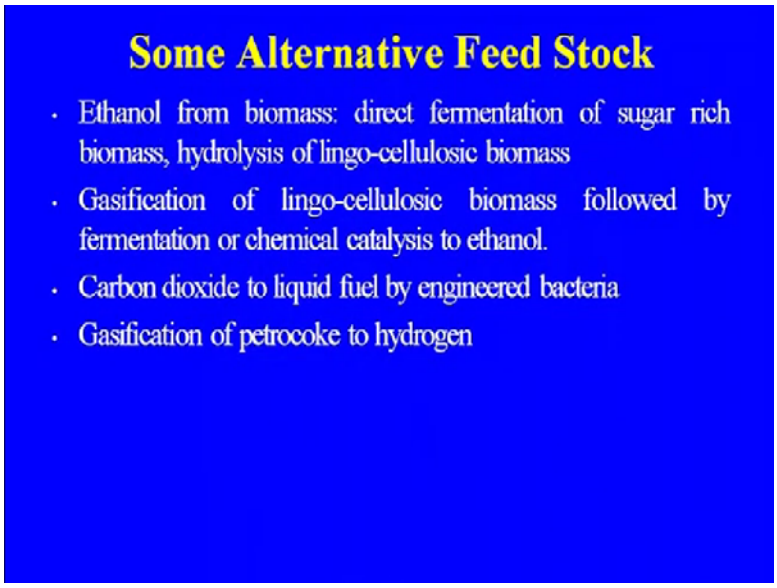

Ethanol from biomass already, I have discuss about the importance, gasification of the biomass and the, from then the fermentation to alcohol carbon dioxide to liquid fuel. Because, the in the refinery we are producing huge amount of the carbon dioxide. Now, that can be available in the future, it may be the carbon dioxide it may be utilize for making a large number of the chemicals.

Gasification of the petro coke to hydrogen as (()) the hydrogen production that is integral for of the refinery as well as the petrochemical. Because you are having the large number of the your hydro process treatment of the feed before it is going to the main process even in case of the fertilizer manufacture in making of the other petrochemicals reforming. You take the reforming it has to be PT at the your naphtha before it is going to the reforming for production of the aromatics. So, this is the hydrogen production that is going to be the we are still now, what we are doing most of the petro coke that was being used by the fuel by other agencies like cement, plant and.

Integration; the, the next part that is the changes in the up petroleum and petrochemical industry, because you see the petroleum industry that is we highly costly (()) and so what is happening in case of the petroleum refinery. The products which are being made that is under control and the you cannot increase the and so the refinery. Now, they are going for the integration of the refinery with the petrochemical to produce more and more value added product because, the various steam which you are getting from the refinery

that can use. And, that was the one of the, I will be discussing about the, how the integration of the refinery with the petrochemical that has been done in the in case of the Reliance and at the same time. Now, the Indian Oil Corporation, Paniput Refinery.

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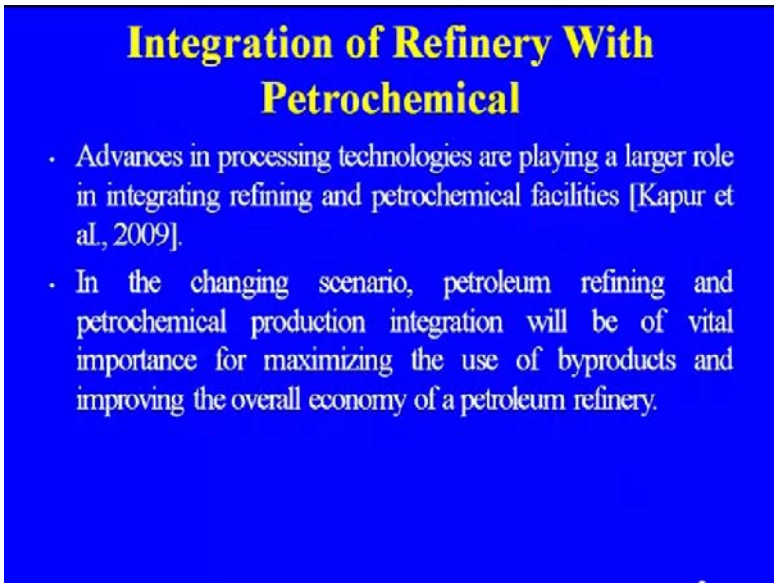

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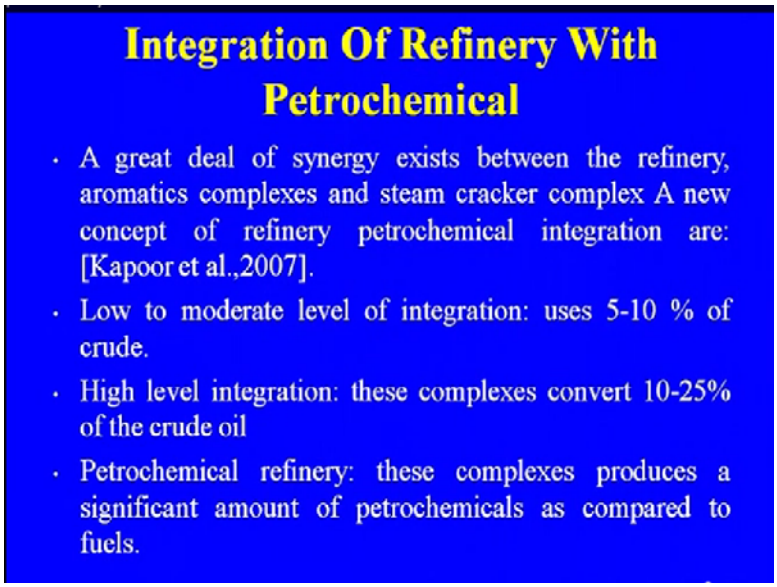

Advances in processing technologies are playing a larger in integrating defining in the petrochemical facility. In the changing scenario petroleum refinery and the petrochemical production integration will be of vital importance for maximizing the use of byproduct and improving the overall economy of the petroleum refinery. Integration of the refinery

with the petrochemical a great deal of the synergy exists between the refinery aromatics complexes and steam cracker plant. A new concept for the refinery petrochemical integration, or low to moderate level of integration uses 5 to 10 percent of the crude high level of the integration petrochemical refinery. These complexes produces significant amount of petrochemicals compared to the fuel.

So, this is the, in the future refinery as I told you, gasoline why you are saying the gasoline free refinery, because some of the operation definitely that will be there which is there in the refinery. But the major product emphasis will be on the petrochemicals not the gasoline, or so this is the how the petrochemical industry are going to be are the concept for the petrochemical refinery is there.

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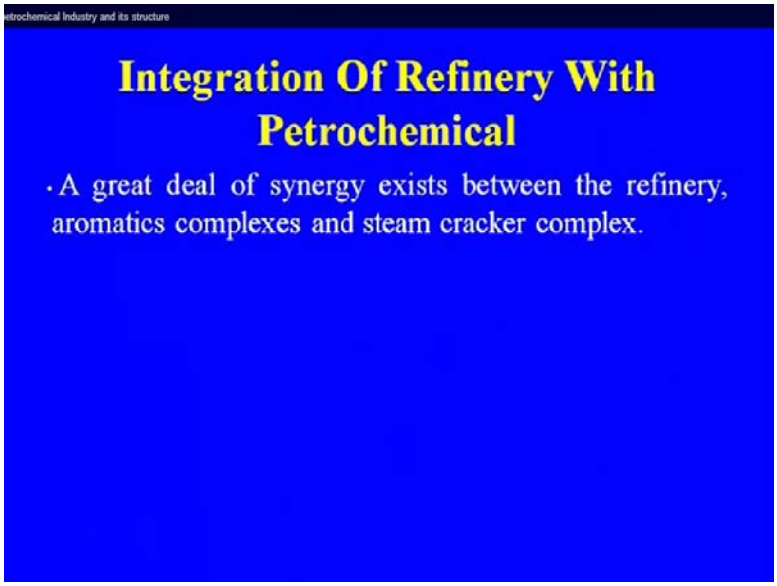

A great deal of the synergy exists between the refinery aromatic complex and steam cracker complex for, for the integration of the refinery the petrochemicals in. So, petrochemical process within the refinery which will help in the integration of refinery and petrochemicals are propylene, propylene recovery from FCC gas already, we are doing. Ethylene from the FCC gases because, the FCC gases they are containing although concentration is low that is why, but in the future definitely we will have to recover because, the large capacity FCC are there. The 7 to 8 percent of the ethylene that can be recover from there C 4 and C 5 recovery from the FCC already, we have discussed.

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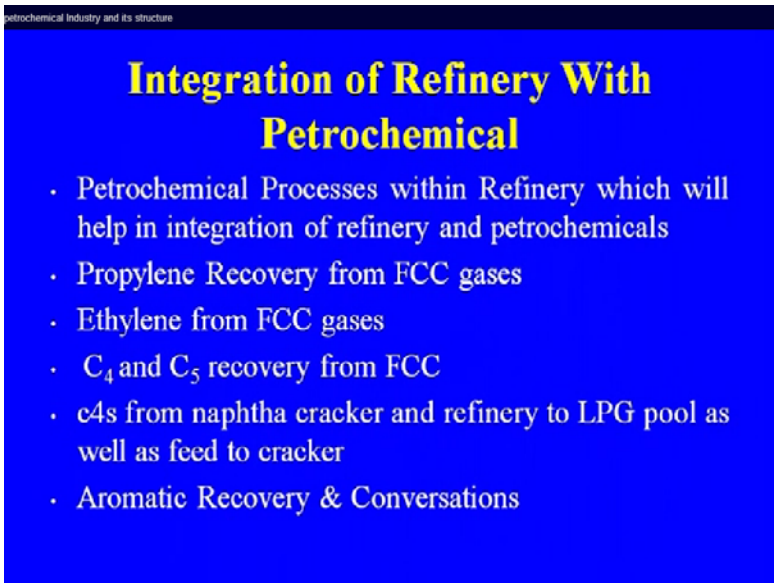

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C 4 from the naphtha cracker and refinery to LPG pool, as well as feed to the cracker aromatic recovery and the conversion processes. Light ends and light naphtha conversion residue and the coke gasification hydrogen production, butane to maleic anhydride and derivative benzene, cumene, phenol acetone, because the arrangement lot of the change you are finding.

Because the benzene that is coming from the aromatic plant, propylene that is coming from the, where the cumene process where you are using the benzene and cumene phenol

and acetone. Phenol is the main product acetone is a byproduct benzene, cyclohexane, caprolactam, n paraffins extraction from kerosene for LAB velorisation of the refinery stream light cycle, oil light cycle, gas oil and the heavy cycle gas oil. So, these are the other that can be use in the in the various form in the petrochemical complexes.

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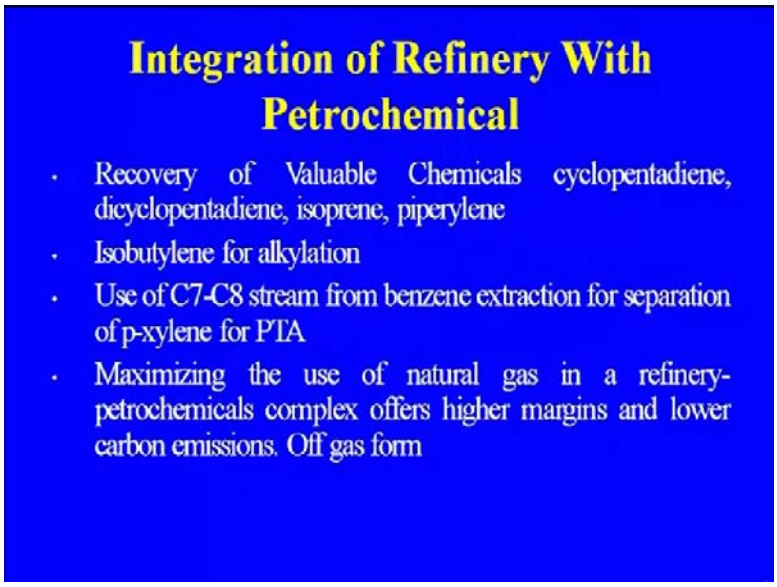

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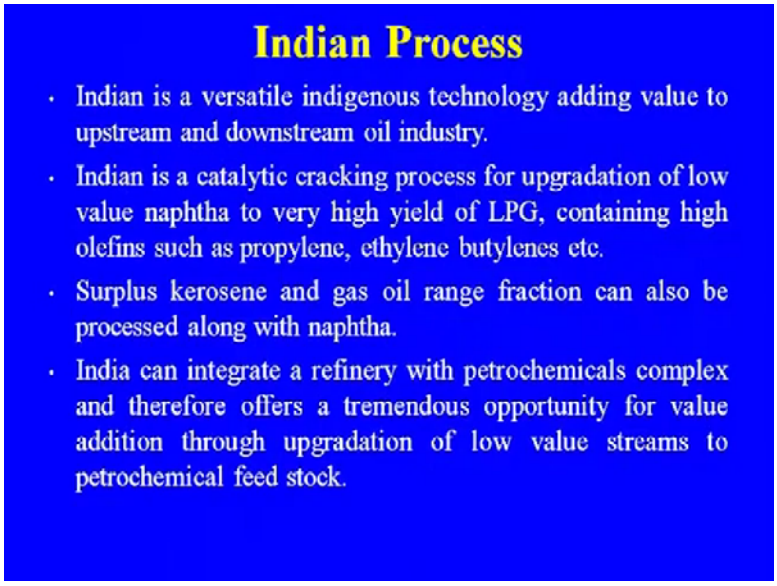

Recovery of the valuable chemicals, cyclopentadiene, dicyclopentadiene isoprene, piperylene, because cylopentadiene again, because we are using in case of the paraxylene that is the, for the dissolvent. So, that is lot of the scope of the especially the isoprene and

cylopentadiene is there. Isobutylene which I told you from the C 4 fraction for alkylation in use of C 7 C 8 steam from the benzene extraction, maximizing the use of natural gas in, in a refinery petrochemical complex offer higher margins and lower carbon emission. This is one of the process that has been developed by Indian Oil Corporation.

Indian is a versatile indigenous technology, adding value to upstream and downstream of the oil industry. Indian is a catalytic cracking process for upgradation of low value naphtha to very high yield of the LPG, containing high olefin, such as propylene, ethylene and butylenes. So, this is the, because we are interested in the more and more ethylene and propylene. Surplus kerosene and the gas oil range fraction can also be process along with the naphtha.

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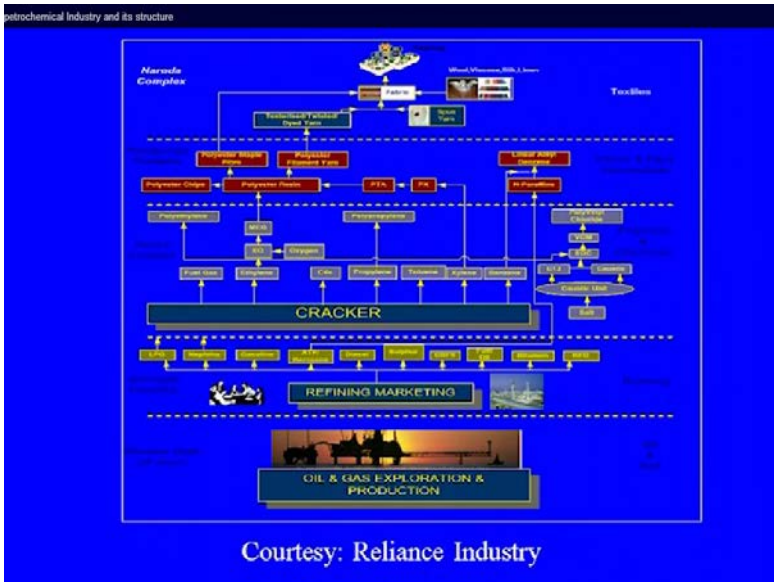

This is a typical integration of a refinery with the petrochemical and sometimes the back. We call with the backward integration sometime it is called the vertical integration, because the Reliance Industry they started with the retailing of the fabrics. And then they started making the polyester and the your, this lab and then the they went for a large petrochemical complex. Hazira from the cracker the various products which you are getting already, we will be discussing.

While discussing of the next few lecture about the product, which you are getting from the cracker, it may be the ethylene, propylene. These are the some of the major products butadiene. So, ethylene that is going for the manufacture of large number of the chemical

already, what are the various products, we have discuss from the ethylene route from the alcohol to ethylene route, from the alcohol to ethylene, from ethylene to various product. And, all those product that can be made even alcohol can be made from the ethylene.

But we are not because, most of the alcohol, ethylene which have producing alcohol which have, we have being producing from the molasses route. So, this is the vertical, this now they in the large they enter in the gas oil and gas (()) and then the biggest one of the largest refinery 60 million tons of refinery and Jam Nagar refinery. That was the actually the real revolution in the petroleum in the petrochemical industry in India and the Reliance they have been or you can say the Dhirubhai Ambani. He was the person it was the, his vision that now India is on the map, world map of the petroleum and petrochemical industry. And the large amount of the, your petrochemical or the refinery product, we are export, importing not importing exporting.

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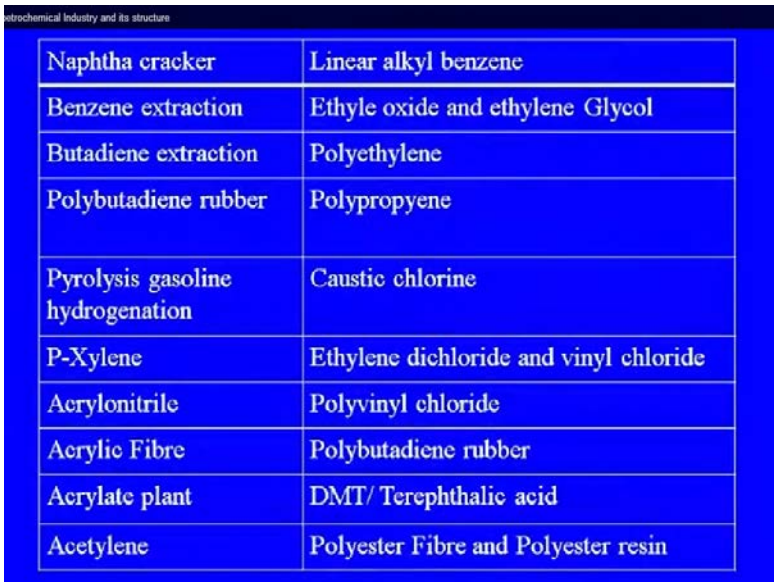

So, these are the, one of the, I was telling the, how the integration that has been and it was in 1970; these are the some of the product which has being made in case of the IPC L. Some of the units because of the low capacity they have been close just like DMT that plant has been closed. But still many of the plant we are running and this was the concept of the large integrated when the IPCL unit was there. And the same concept now, they are having, because you see the IPCL Gandhar unit, Reliance Gandhar unit. They are going to have; they are going to add few product there where they are making the, your

polymers PVC or the poly ethylene, ethylene glycol, ethylene oxide. Now, they are going to have the polyester plant also there.

So, this is the how the integration of the, so this was about the, the next few lecture will be discussing about the cracker and the various product, which you are getting and the making of the various intermediate and the final product. That will be the module 8 also will be discussing about the, how these product from the petrochemical industry. We are making the finish product, starts in from the polymers, synthetic fiber or synthetic rubber, all those thing that will be discuss in detail.

So, this is all about the Indian about the petrochemical industry and in particular about the Indian Petrochemical Industry. How the development that has taken place and, how the importance of the petrochemical in our daily is there, because now you cannot imagine life without petrochemical or their product. So, this is the, so the, next lecture will be on the naphtha cracker and the gas cracker from where you are producing the olefins.