Chemical Technology
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Module - 8
Polymer
Lecture - 5
Polymides or Nylons (PA)

We are discussing the module eight of organic chemical technology. And already we have discussed about the polymer and the elastomers. Today we will be discussing one of the very important sector of chemical industry, which is playing very important role in meeting the one of the major demand of the mankind, that is the clothing. So, today we will start with nylon 6 and nylon 7, which is the one of the very important synthetic fiber. So, the coverage of the lecture that will be on the introduction capacity and the production of nylon 6 in India because we are not making nylon 6 digit mostly it is in nylon 6 that is available.

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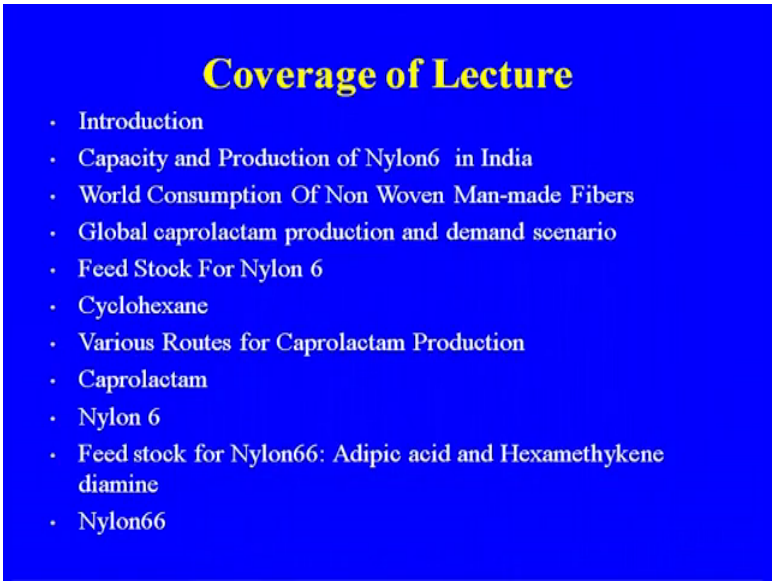

World consumption of non woven man-made fibers, and the what is the percentage of the nylon 6 and nylons in the because we are having the different type of the nylon 6, nylon 66, nylon 10, nylon 13 like that. So, global caprolactam production and the demand scenario, feed stock for nylon 66 and cyclohexane because cyclohexane that is the starting material which is coming from the benzene. And so they will be written in

the process flow diagram for the cyclohexane manufacture in various routes of the caprolactam. Because a number of the routes are available for the making of the caprolactam, but the cyclohexane remains the one of the important feed stock other routes are from lethargic to benzoic acid, and other routes.

But the major route is the from the cyclohexane and through the same final beckmann arrangement of the reaction, that is the then we will be discussing about the caprolactam the what are the processes for the caprolactam. And in detail about the one of the process which are using in India and nylon 6, the manufacture of the nylon 6 because the after making the caprolactam that will go for the polymerization. And then the feed stock will be again we will be discussing about the nylon 66. Introduction of the nylon 66 and feed stock for the nylon 66, which adipic acid and hexamethylene diamine and then the process of the manufacture of the nylon 66.

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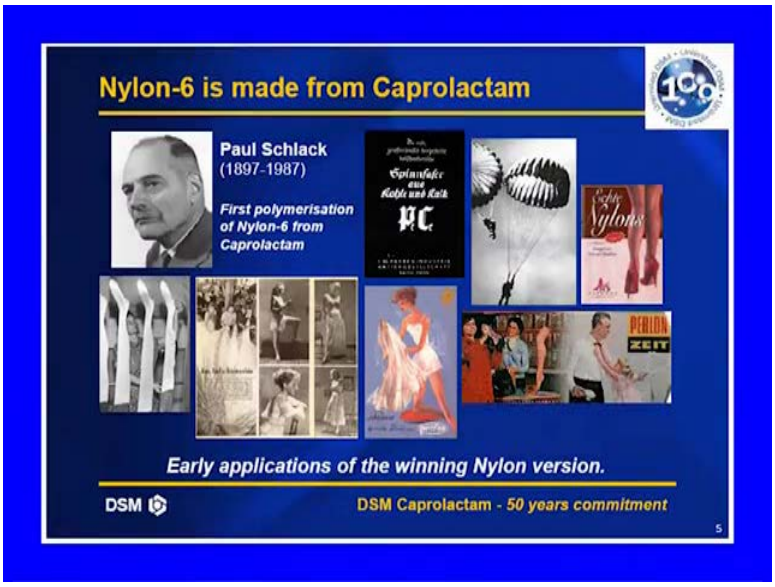

This is the importance of the caprolactam and you can see the a large application and that was the first Paul Schlack that was the who was the first polymerization nylon 66, nylon 6 from the caprolactam he was the man who was the about the invention of the nylon 6. And so these are the various application of the nylon 66 and now the it is not only in the synthetic fiber means, the open industry a huge amount of the nylon 6 that is going to the non woven industry even the electrical appliances also we are using nylon 66, nylon 6.

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And these are the some of the threads parachute and the other application of the nylon 6. And especially as I told you the electrical application means the features and c p n i there we are using the now the nylon 6, which was earlier the bakelite switch is that we are using, but now we are using the nylon 6 or the poly carbonate there.

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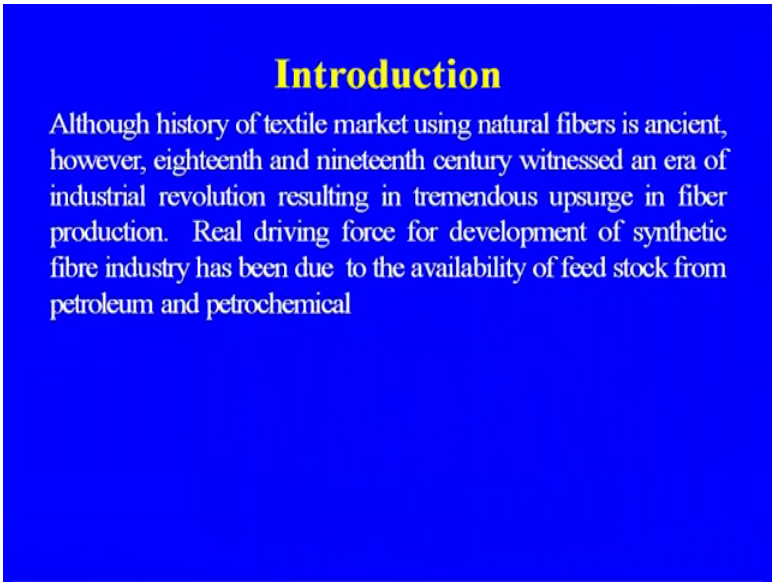

Let us go to the history of the nylon 6ty 6 although history of the textile market using natural fiber is from the ancient time. However eighteenth and nineteenth century witness an era of the industrial revolution, resulting in the tremendous upsurge in the

fiber production, real driving force for the development of synthetic fiber industry has been due to the availability of feed stock from the petroleum and petrochemical.

But during the nineteen till nineteen and up to thirty the other routes were also available for making of these four synthetic fiber, whether it is in your nylon 6 or the polyester or the acrylonitrile alternative routes was there. But it was the real back through or the main driving force has been for the development of the synthetic fiber industry, is the availability of the feed stock from the petrochemical among them because nylon 6 nylon 66 is coming in the category of nylon polymides. Polymides they were first discovered and evaluated in 1929.

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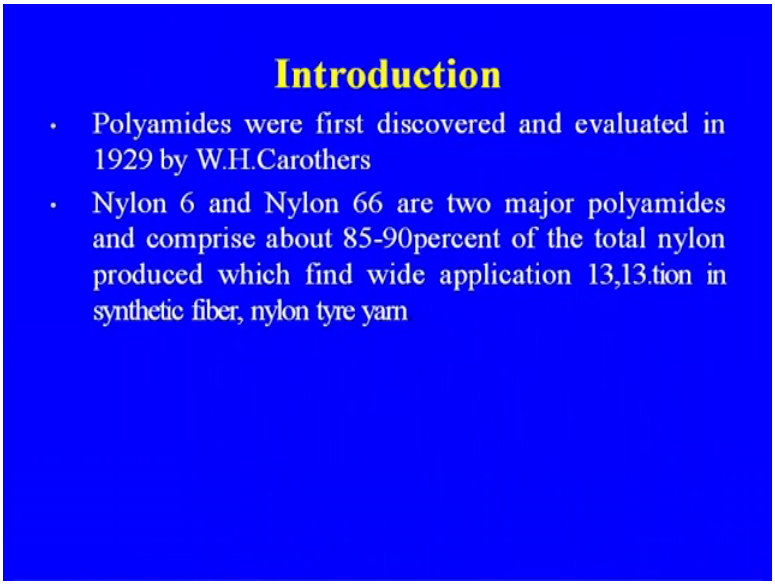

Nylon 6 and nylon 66 are the two major polyamides and compromise about 85 to 90 percent of the total nylon produced, which find wide application in synthetic fiber, nylon tyre yarn and other application. Because of the high melting point although the nylon 66 because it is having higher melting point than the nylon 6. So, the but still the nylon 6 because of its feed stock from the benzene we are making, so the it is more preferred or the because the availability of the nylon 6 is more than nylon 66.

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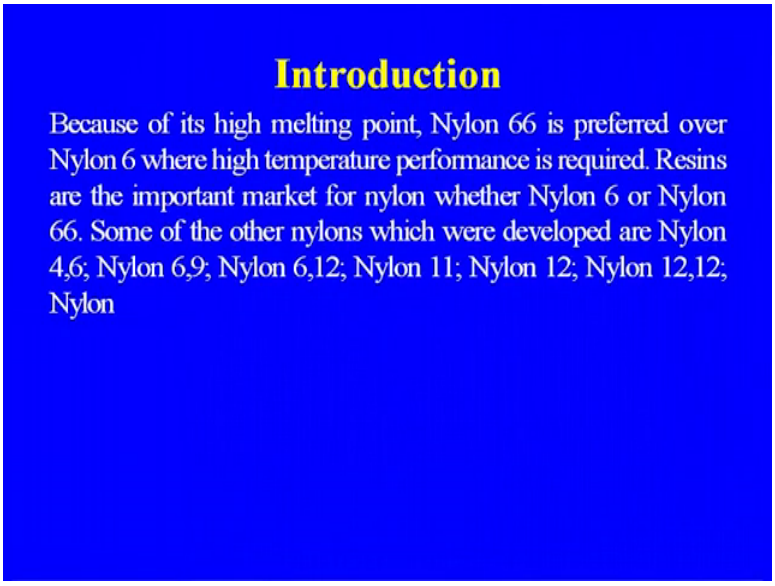

Resins are the important market of the nylon whether nylon 6 or nylon 66. Some of the other nylons which we are developed are nylon 46, nylon 69, nylon 612 and nylon 11 nylon 12, nylon 12, 12 like that a number of the variation in the nylon is there.

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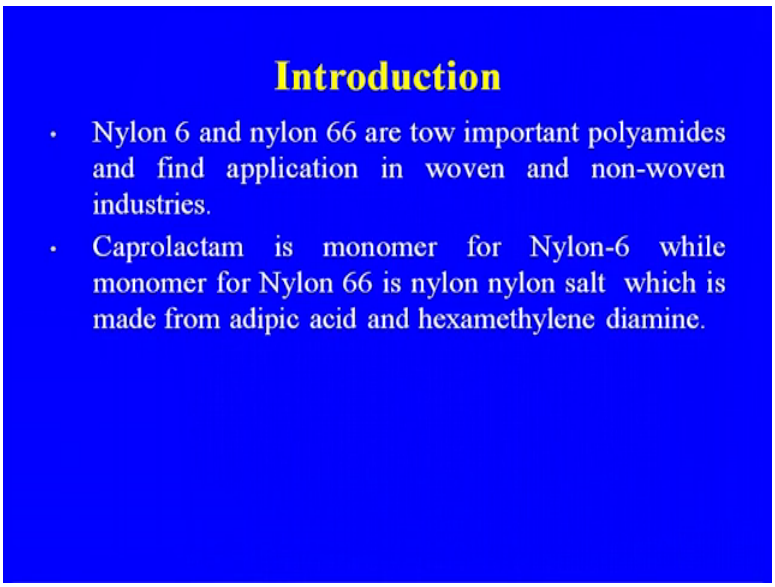

But nylon and nylon 66 are the important polyamides, nylon 6 and nylon 66 are two important polyamides. Two important nylon 6 and nylon 66 are the two important polyamides and find application in woven and non woven because you see the we are having the application of the synthetic fiber both in the woven and non woven industry

means the tire cord another applications are also there in this which. As I told you the electrical appliances we are using the nylon 6 with the woven and non woven both are the major consumer of the nylon.

Caprolactum is the monomer for nylon 66, nylon 6 while monomer for nylon 66 is the nylon salt which is made from the adipic acid, and hexamethylene diamine. These are the two raw material for the nylon 66 which is reacted and then we are getting nylon 6 and nylon 6 nylon salt and nylon salt that is polymerized to nylon 66.

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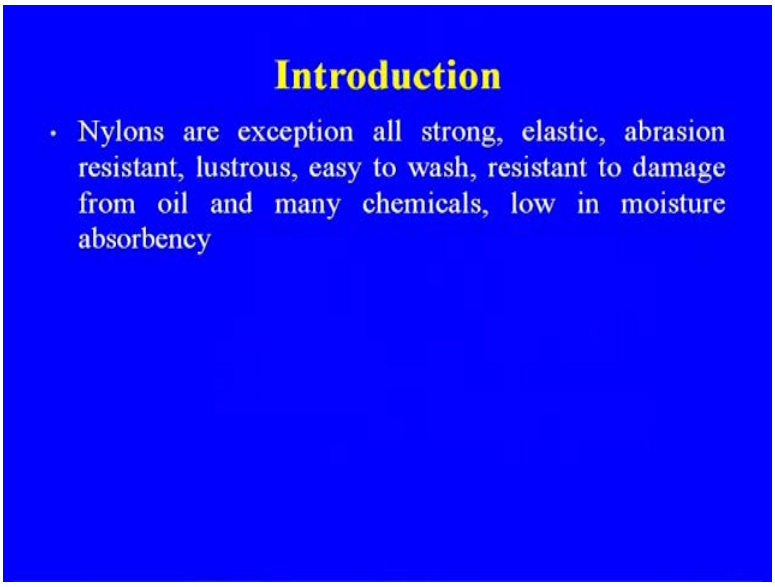

Nylons are exception all strong elastic abrasion resistant lustrous easy to wash resistant to damage from oil and many chemicals, low in moisture this is some one problem in case of the because during the early stage, when the nylon came into the market. So, nylon that was used in the textile also, but as the nylon low moisture absorbency it was not very comfortable, in case of the for the textile purposes. And so its application of the nylon 6 was limited to the hosiery and non woven industry.

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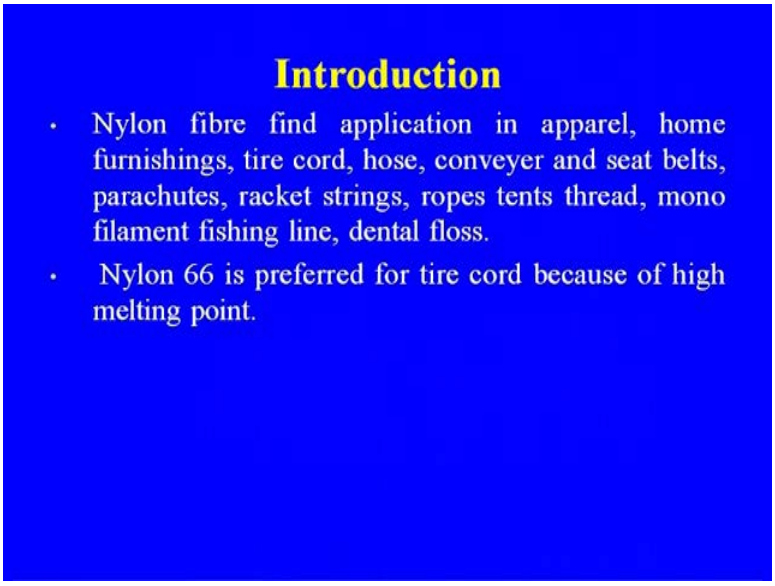

So, nylon fiber find application in apparel home furnishing, tire cord, hose, conveyer, seat belts, parachutes, racket strings, ropes tents thread, monofilament fishing line then the dental floss. So, these are the some nylon 66 is preferred for tire cord because of the high melting points here slightly difference in the about ten degree centigrade difference is there in the melting point of the nylon 66 is higher than the nylon 6. That is why the nylon 66 is preferred although it is preferred, but availability is a major issue in case of the nylon 66.

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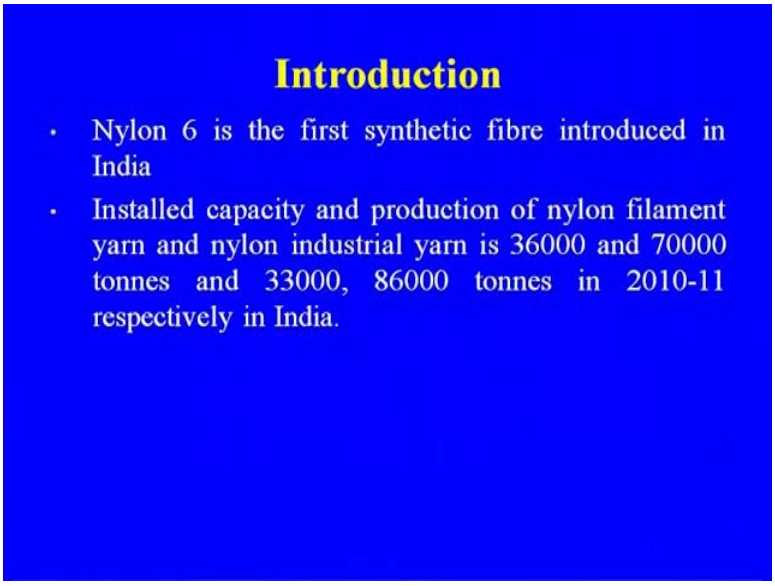

Nylon 6 is the first synthetic fiber introduced in India and I remember getting the 1960, it was the nylon 6 came to the market installed capacity production of the nylon filament yarn and nylon industrial yarn is 36000 and the 7 lakhs tones 36000, 76000 tones and 33000 and 86000 tones in 2010- 2011 respectively in India. This was the figure of the production that was the 36 that was the earlier.

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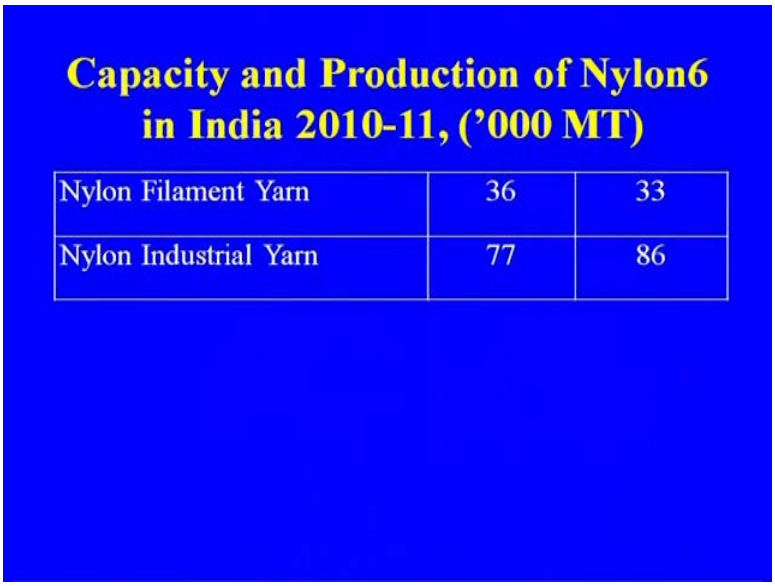

So, far the nylons captrolactam is concerned this is the capacity and production of the nylon 6, nylon filament yarn nylon industrial yarn. So, this is the 36000, 33000 77000 and 86000 this is the status of the world consumption of the non woven man-made fiber which we discussed, while discussing the polymer, elastomer and synthetic fiber.

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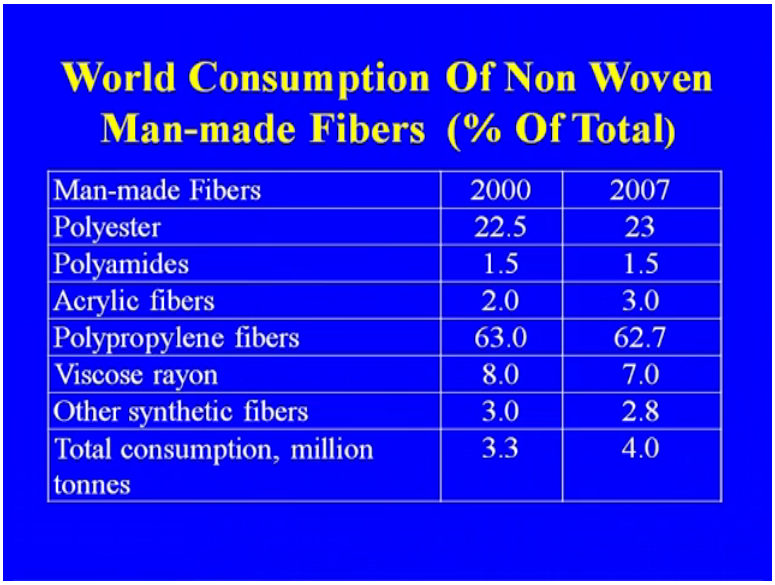

Here you see the although the polyamides are a small portion of the total man-made fiber because the major is the your this polyester. And but the viscose rayon is also the that is playing important role in the synthetic fiber industry, let us discuss about the feed stock for nylon 6. As I told you the major raw material for the or the monomer for the nylon 6 is the caprolactam, and caprolactam they are various routes for getting the caprolactam…

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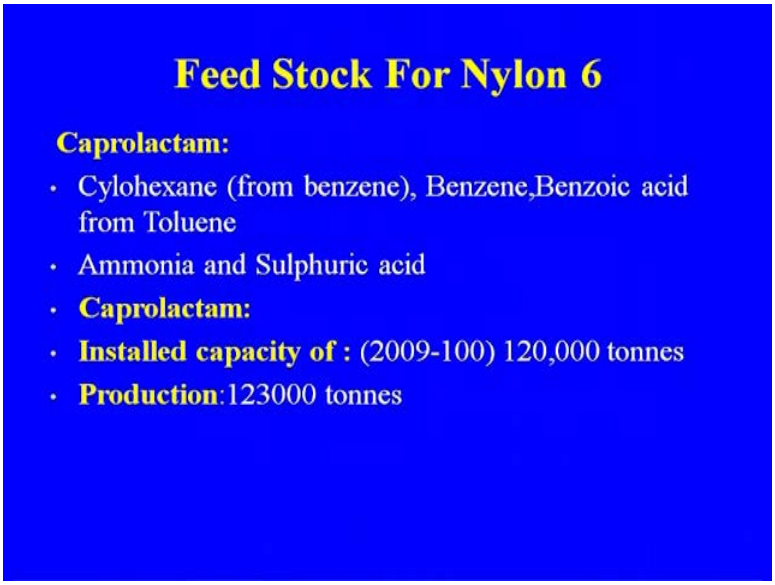

One is the cyclohexane, which we are getting from benzene benzoic acid from toluene that may be another route ammonia and sulphuric acid that we need here one of the

drawback of the earlier caprolactam technology, were that the production of the ammonium sulphate. It is around three times the amount of the caprolactam that we are producing in the form of the ammonium sulphate, that was the and that lead to the development of the some of the greener technology in the manufacture of the caprolactam, were no ammonium sulphate is produced.

So, this was the this is the one of the development that has taking place in the caprolactam technology because we need the ammonia and sulfuric acid the production of the caprolactam that is confined to fertilizer complexes, where they are making both ammonia and the sulfuric acid. This is the status of the caprolactam manufacture in India and the we are having the two major in the future.

So, one is the Gujarat state fertilizer and the at Vadodara a large integrated complex and second is the fertilizer and chemicals and co. So, these are the two units which are producing caprolactam another unit was to come in, but at that was due to some other reason that project did not come. Another actually the for the nylon 66 as I told you the nylon 66 we need the two raw material major raw material.

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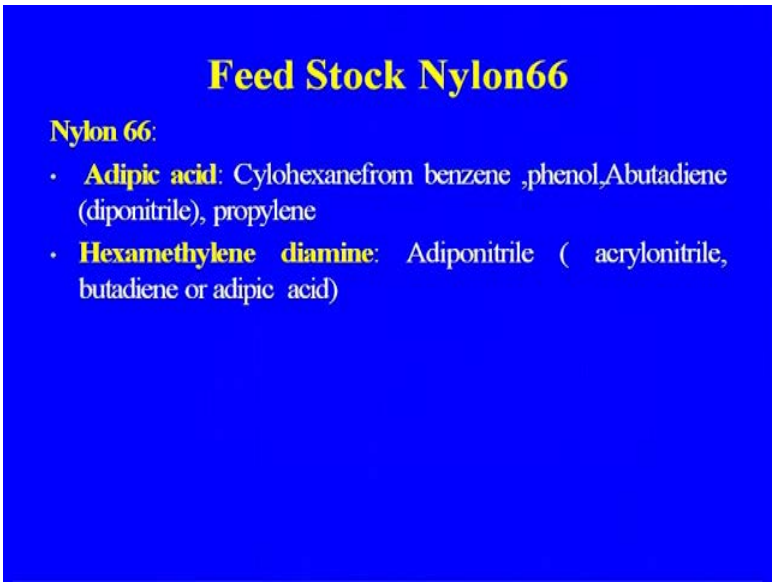

That is the adipic acid hexamethylene diamine, so the for the adipic acid also the various routes are there which we can get the adipic acid, but cyclohexane which is from benzene that is one of the major route. Another route is the phenol, butadiene, adiponitirle from the adiponitrile the butadiene from the butadiene we are getting

adiponitrile, which is used for the adipic acid. Propylene that is another route for making of the because that is being used for the any manufacture of the other intermediates which is finally, converted to the adipic acid.

Another important that is hexamethylene diamine that is the adiponitrile from the acrylonitrile where we need the propylene butadiene or the adipic acid. These are the some of the other routes for the making of the hexamethylene diamine. Let us now discuss the cyclohexane, which is the major feed stock for the and the most of the process they are using the cyclohexane for manufacture of the caprolactam.

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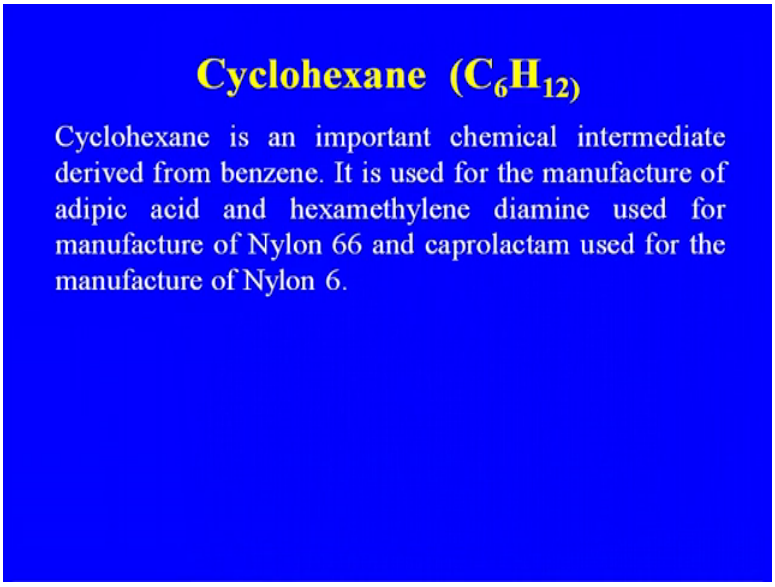

Cyclohexane is an important chemical intermediate derived from benzene. It is used for the manufacture of adipic acid and hexamethylene diamine also. And which is used for the manufacture of nylons 66, and caprolactam used for the manufacture of nylon 6.

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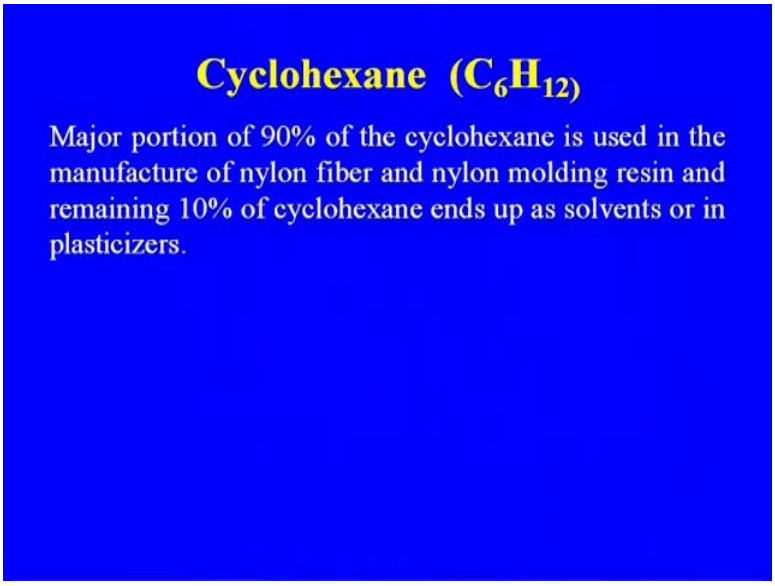

Major portion about 90 percent of the cyclohexane is used in the manufacture of nylon fiber, and nylon molding resin. And remaining ten percent of the cyclohexane ends up as solvent in plasticizers.

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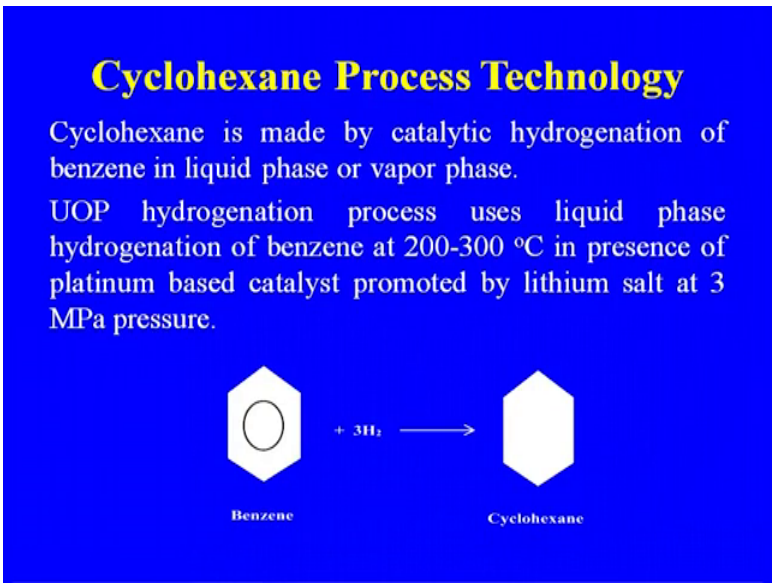

This is the process, how we are making the cyclohexane. Cyclohexane is made by catalytic hydrogenation of benzene in liquid phase or the vapor phase. UOP hydrogenation process use a liquid phase hydrogenation of benzene at 200 to 300 degree centigrade in presence of platinum based catalyst promoted by lithium salt at 3

megapascal pressure. This is the reaction, that is taking place after the hydrogenation of benzene we are getting the cyclohexane.

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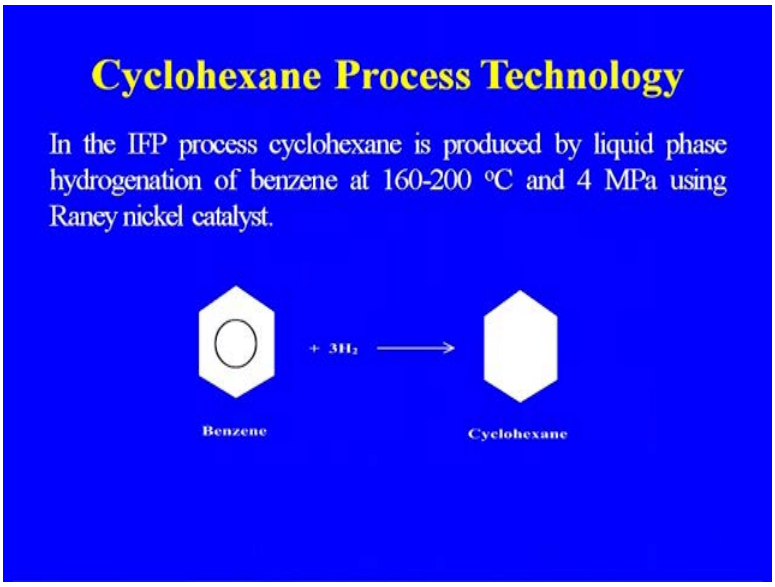

In the IFP process again, the cylcohexane is produced by liquid phase hydrogenation. Only the difference is the in the catalyst and the temperature, slower lower temperature required and this is the reaction that is taking place.

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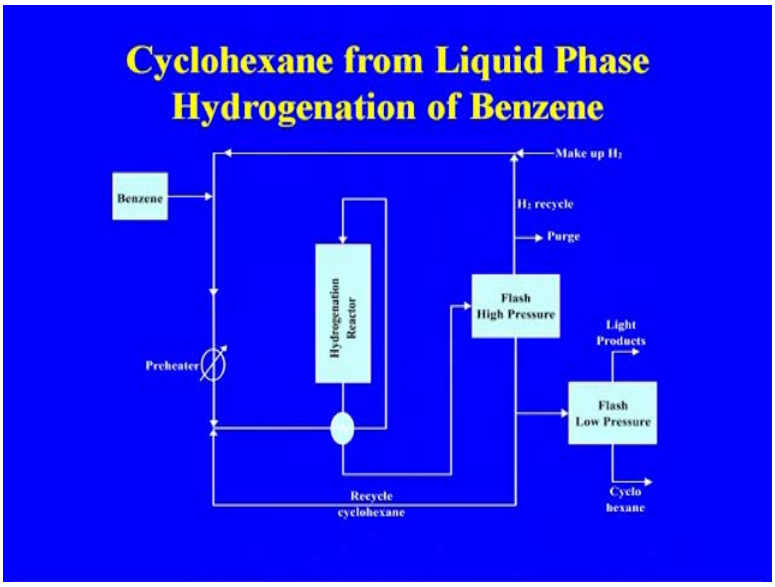

This is the process flow diagram for the manufacture of cyclohexane, by the benzene. Benzene that is going to the hydrogenation tower and the from the hydrogenation tower

the product that is going to the high press. And from the high press the hydrogen that is this it is recycled to the system and make up hydrogen, that is adjust there and so the offshore separation, it is going to the plus low pressure. And from the low pressure again, the light products that we are getting and then this finally, we are getting the cyclohexane from the bottom of this flash low. Now let us come to the caprolactam.

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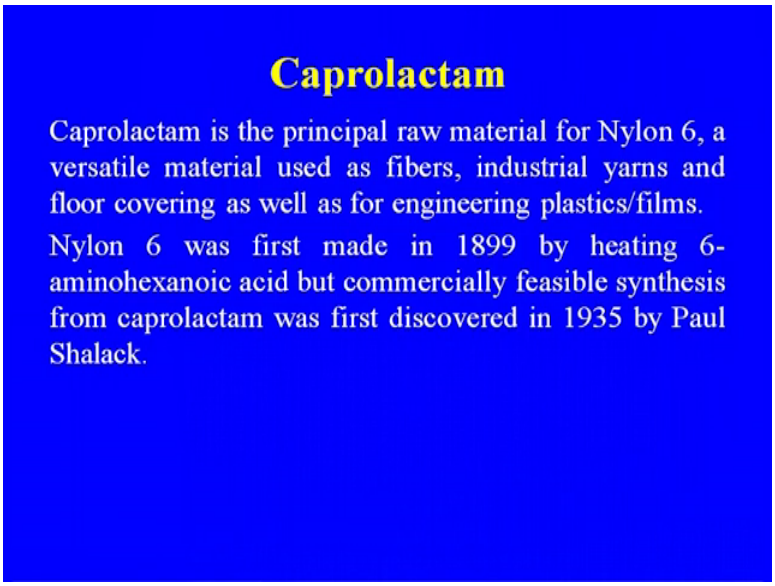

Caprolactam is the principle raw material for nylon 6, which I told you a versatile material used as fiber industrial yarns, and flooring covering as for engineering plastic, because the phenol flooring that the flooring that also we are using this nylon. Nylon 6 was first made in 1899 by heating 6 amino hexanoic acid, but commercially feasible synthesis for caprolactam was first discovered in 1935 by Paul Shalack.

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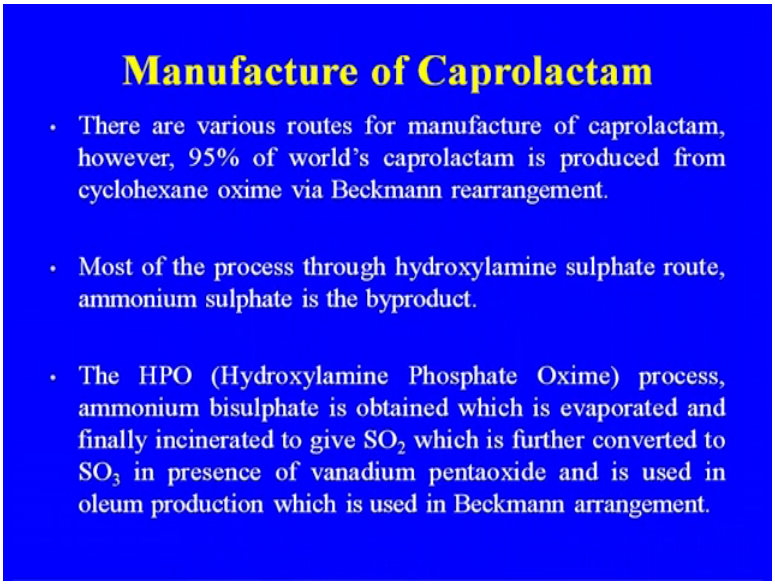

There are various routes for manufacture of caprolactam, however 90 of the worlds caprolactam is produced from cyclohexane oxime via beckmann rearrangement. This is the major reaction, that is taking place most of the process through hydroxylamine sulphate, through ammonium sulphate is bi-product. As I told you about three times at the various stages the ammonium sulphate, we are getting in the process. So, it is almost three times of the amount of the caprolactam, which we are producing.

So, hydroxym, hydroxyl amine phosphate oxime process ammonium bisulphate is obtained, which is evaporated and finally, incinerated to give SO2, which is further converted to SO3 in presence of the vanadium pentoxide and used in the oleum production, which is used. So, this is the in the process, that we are using the sulphuric acid also, the global caprolactam production and demands…

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Global caprolactam production and demand scenario

Year	Caprolactam Production ('000 Tonnes)		Caprolactam Demand ('000 Tonnes)	
	Fibers	Resins	Fibers	Resins
1990	2,463	499	-	-
2010	2,559	1,845	2,463(56%)	1,941(44%)

Source: Carmichael, 2005

We know, this is the about the caprolactam and the, so for the this is the global, but in case of the India, there has been not much increase in the production of the caprolactam because, these are the only two units, which I told you Gujarat state fertilizer complex GCFC at vadodara, and the fact they are the two major producer. And some of the units they are importing their a caprolactam, because in DSM this is also one of the company, which is multinational company, which is making the nylon 6.

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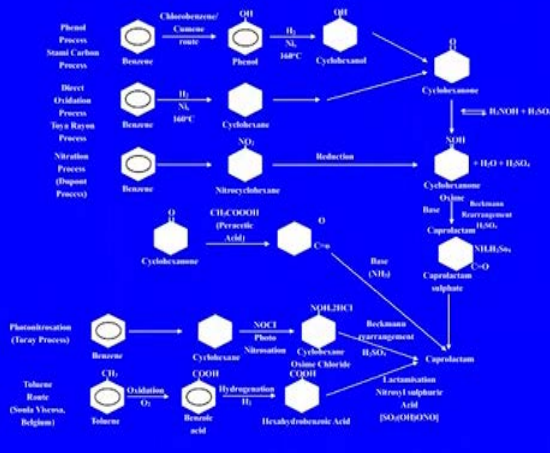
Various Routes for Caprolactam Production



So, as I told you there are various routes that is from where we are getting the, but finally, the caprolacatam in most this is the Beckmann rearrangement. And that may be the from the benzene to phenol or the benzene to cyclohexane, or benzene to nitro cyclohexane or this may be benzene to cyclohexane then the toluene to benzoic acid.

So, these are the some of the routes and similarly, in case of the Indian carbide, again the cyclohexane because during the process cyclohexane is converted to cyclohexanone, which is actually going for the further reaction. And cyclohexonol is also produced, which is the cycling the system.

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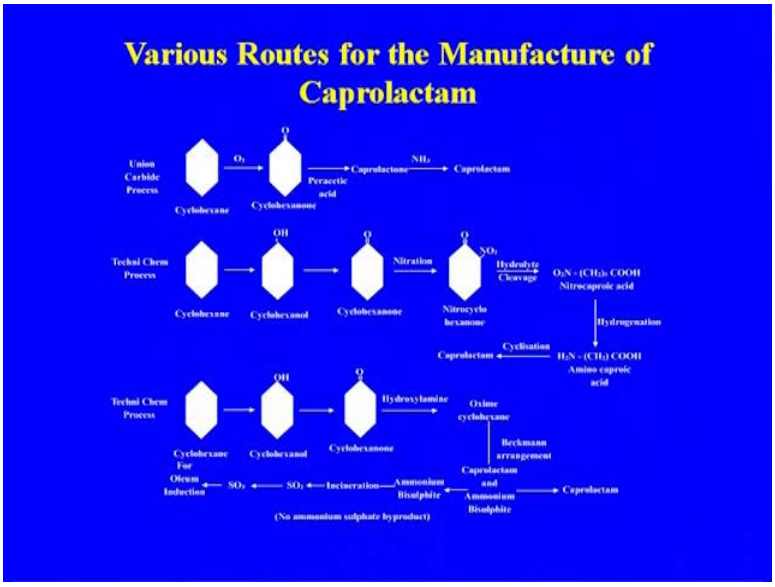

This is the cyclohexane process, where we are getting the cyclohexanol is converted to cyclohexanone. And then the techni chem process, that is the again, the cyclohexane process that we are using. Finally, the during the oxine cyclohexane Beckmann rearrangement, we are getting the your caprolactam, and during the process we are generating also, as I told you the ammonium sulphate.

So, these are the two major producer of the caprolactam, which I told you Gujarat chemicals and fertilizer at Vadodara, and this was start, this is the one of the largest integrated fertilizer complex, which is not making only fertilizer, but also some of the important like. It is not on the capital income, they are making the nylon, they are making the that melamine also, which is produced from the urea, fertilizer and chemicals.

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Travancore that is also another unit, which is making the caprolactam. So, the process step for manufacture of caprolactam from cyclohexane. Three steps are there.

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One is the manufacture of cyclohexanone, the manufacture of hydroxylamine sulphate and manufacture of the final caprolactam. So, these are the three major sections in case of the production of the caprolectam, from the cyclohexane. So, first step that is the manufacture of the hydroxylamine sulphate.

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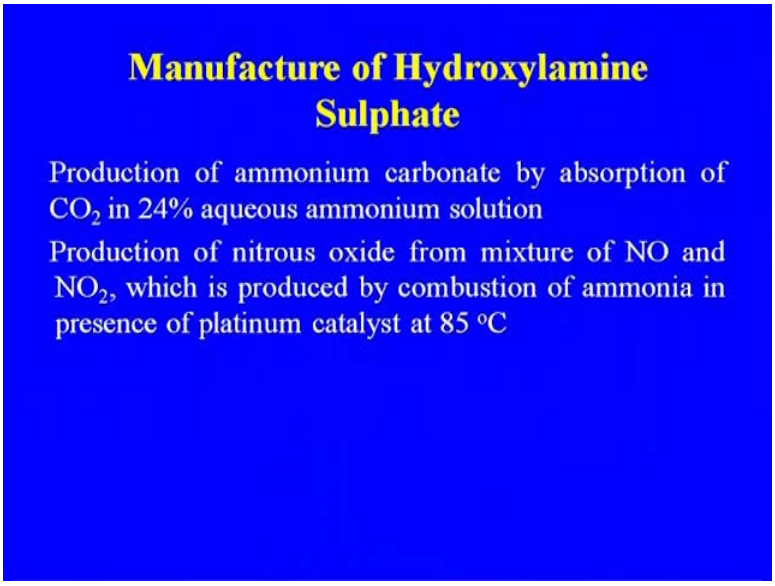

Production of the ammonium carbonate. So, first step is the production of the ammonium carbonate by absorption of CO2 in 24 percent of the ammonium solution. Production of the nitrous oxide from mixture of NO and NO2, which is produced by combustion of ammonia in presence of the platinum catalyst at 85 degree centigrade. So, this is the process from where we are getting these two nitrous oxide mixture, which is used in the process.

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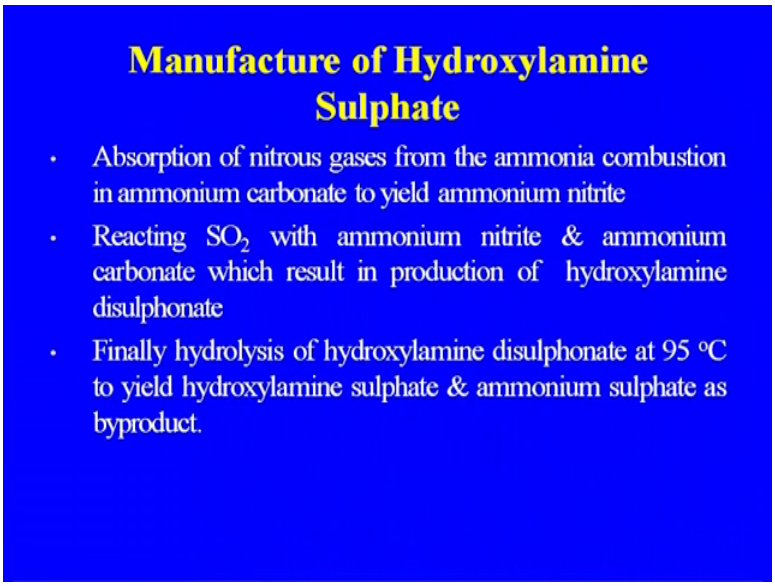

Then the absorption of the nitrous gases, from the ammonia combustion in ammonium carbonate to yield ammonium nitrite. Reacting SO2 with the ammonium nitrite ammonium carbonate, which result in the production of hydroxylamine sulphate. Finally, hydrolysis of hydroxyl amine disulphonate, sorry that was the production of the hydroxyl. I mean disulphonate and after the hydrolysis of this hydroxyl, hydroxyl amine disulphonate, we are getting the finally, the hydroxylamine sulphate and ammonium sulphate as a byproduct.

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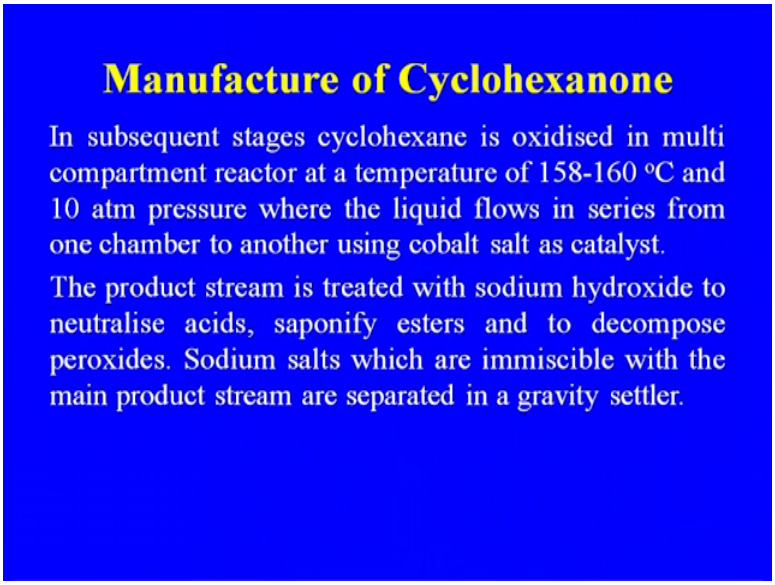

In subsequent stages the cyclohexane is oxidized in multi compartment reactor at the temperature of around 160 degree centigrade and 10 atmosphere pressure at the liquid flows in series, from one chamber to another using cobalt salt as catalyst. The product stream is treated with the sodium hydroxide to neutralize the acid, saponify esters and to decompose the peroxide. Sodium salts, which are immiscible with the main product stream are separated in a gravity settler.

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Organic phase containing hexane cyclohexanol and cyclone because we are getting the mixture of the cyclohexanol and the cyclonhexanone, and the plus among reactor cyclohexane. So, the cyclohexane at the recycle and cyclohexanone are fed to series of three distillation column for the separation. And though finally, we are getting the cyclohexene, which is the again recycle and the product is the cyclohexane finally, which is needed in the process.

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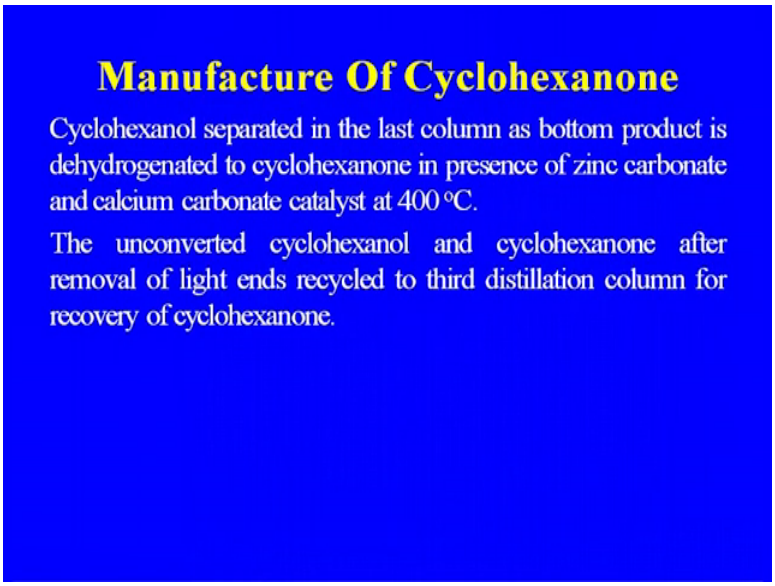

Cyclohexanol separated in the last column as bottom product is dehydrogenated to cyclohexanone, because the cyclohexanone is the in the process, we are getting. So, the cyclohexanone in the presence of zinc carbonate and calcium carbonate catalyst at 400 degree centigrade. The unconverted cyclohexanol and cyclohexanone after removal of light ends recycled to the third distillation column for recovery of the cyclohexanone.

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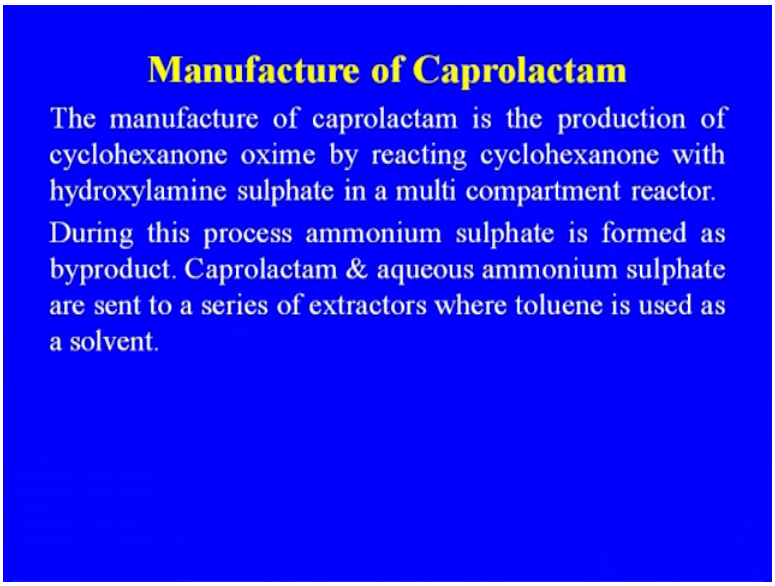

Then the manufacture of the caprolactam, the manufacture of the captrolactam is the production of cyclohexanone oxime by reacting cyclohexanone and hydroxylamine sulphate, because one unit is the production of the cyclohexanone. And another is the hydroxyl amine sulphate, that is the reactor in a multi compound compartment reactor these two. And then during this process ammonium sulphate again, it is formed as a byproduct caprolactam and the aqueous ammonium sulphate are sent to a series of extractor, where toluene is used as a solvent.

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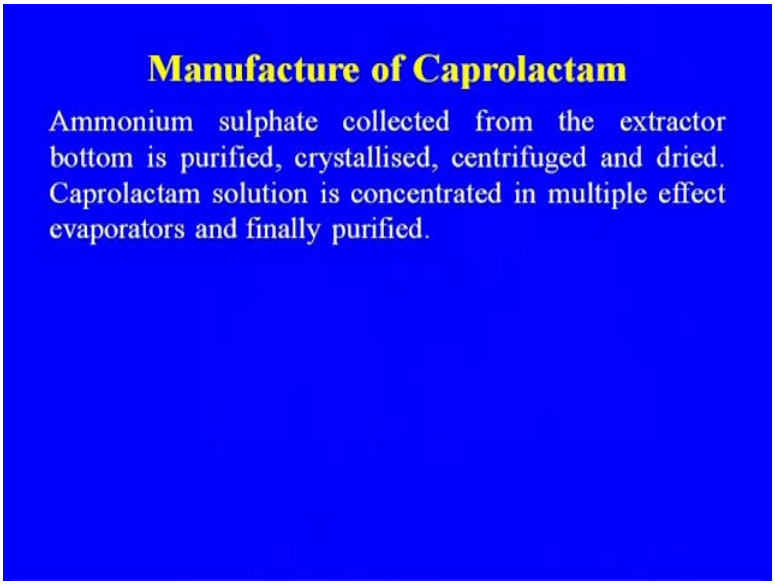

Ammonium sulphate collected from the extractor bottom is purified, crystallized, centrifuged and dried. Caprolactam solution is concentrated in multiple effect evaporators and finally purified.

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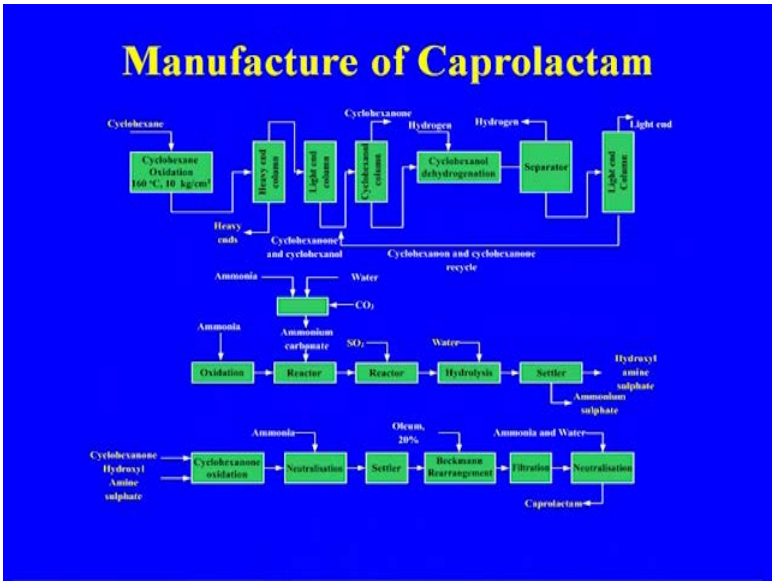

This is the manufacture of the caprolactam three major units, which I told you one is the production of the cyclohexanone, were the after the oxidation we are getting the cyclohexanone, cyclohexanol, which is recycling here. And then the cyclohexane finally, it is going here, and the reactors were the it is reacted with the hydroxylamine sulphate.

This is the production of the hydroxylamine sulphate, were the ammonia oxidation it is going to reactor, where ammonium carbonate that is free to this reactor has been near from the nitrous oxide that is given to reactor.

And the, SO2 and then the hydrolysis and finally, the hydroxylamine sulphate, which we are getting, but again here also, you see this at this stage also we are getting the ammonium sulphate. And this is the finally, what is happening here? The cyclohexanone hexanone and the hydroxylamine sulphate that is reacted here, and then after the Beckmann rearrangement, that we are getting. This is the beckmenn rearrangement reactor, where we are getting the caprolactam and then the finally, the caprolactam is separated.

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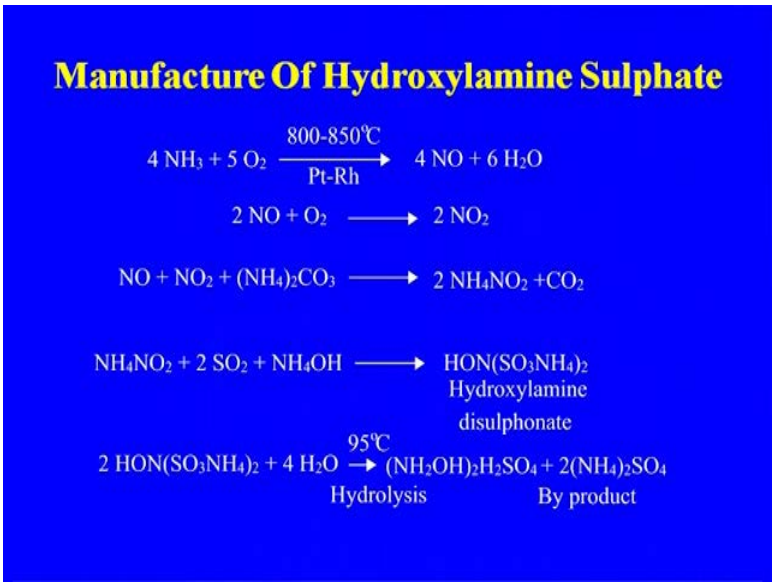

This is the reaction that is the taking place in the hydroxylamine sulphate, where the NH 3 the mixture of this NO NO 2 we are getting. And then again, this is reacted with the ammonium carbonate and this ammonium nitrate that, we are getting NH 4 NO 2 and this NH4 N2 again, with the, so two that is going to the hydroxylamine disulphonate, which I told you. And this hydroxyl, di hydroxyl amine disulphonate again, after hydrolysis that give the your hydroxylamine sulphate, and the byproduct ammonium sulphate that we are getting. Now, the after getting the caprolactam the next section, in case of the nylon 6 preparation is the nylon polymerization of the caprolactam.

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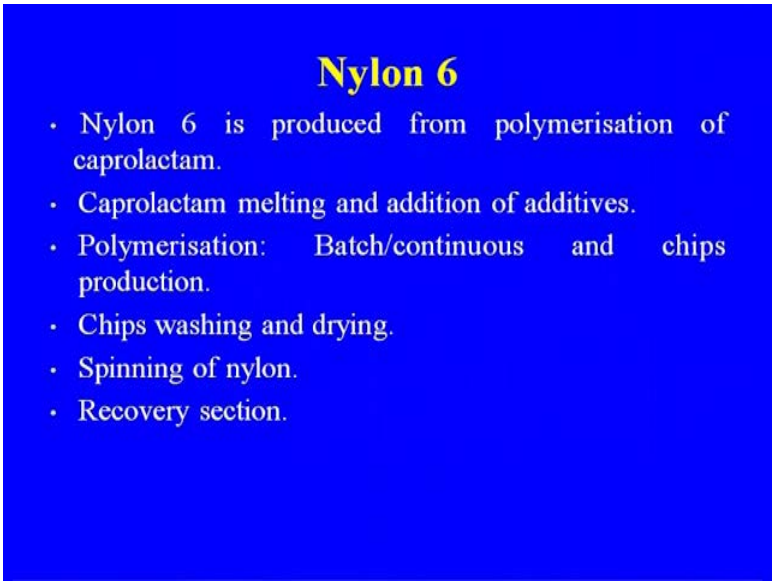

So, nylon 6 is produced from polymerization of the caprolactam, so the process consists of the caprolactam melting and addition of additive polymerization batch or continuous. And finally, chips production because during the after the polymerization, we are getting the nylon chips and that chips again depending up on that, that can be used for this paining viewing. In case of the nylon 6 spheres are using the melt spinning. So, chips washing and drying spinning of the nylon and the recovery section. These are the various units or these are the in case of the nylon 6 manufacturing.

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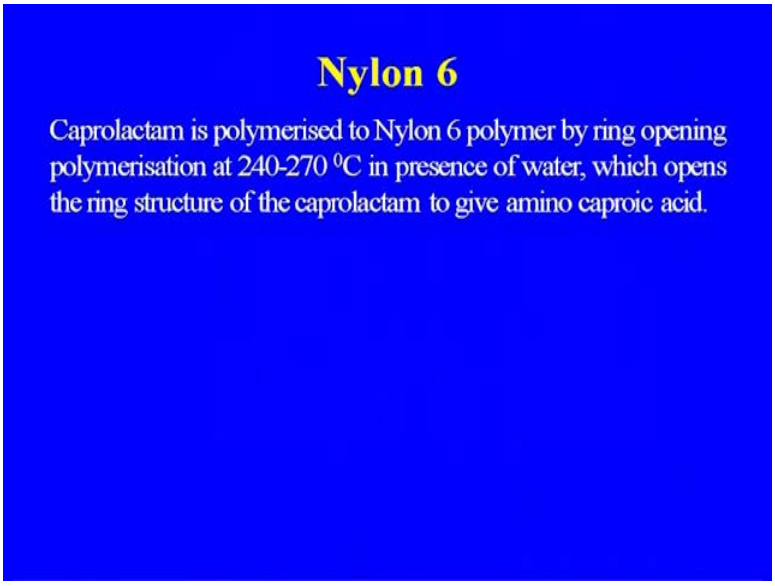

So this is the actually the caprolactam is polymerized to nylon 6 polymer by ring opening polymerization at 240 to 270 degree centigrade in presence of water, which opens the ring structure of the caprolactam to give the amino caproic acid.

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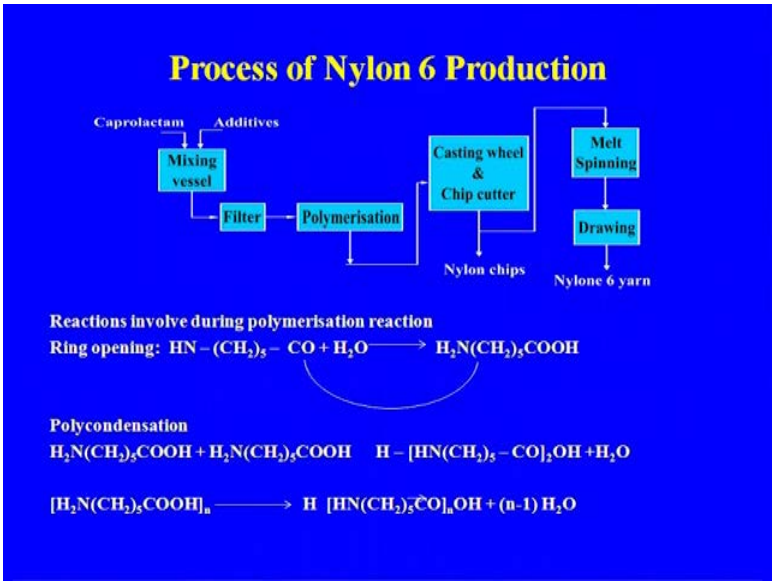

This is the manufacture of the nylon 6, that is the captrolactam additive filter and then the polymerization reactor. And after the polymerization reactor we are getting the nylon chips either, it may be the in the form of the nylon chips or the nylon chips that may go to the spinning section, were the melt spinning process. And in case of the melt spinning, what we are doing, we are having the number of ways spin rate through which, the melted nylon 6, that will be passed and while coming from that, that will be dry up.

And then you will be getting, and then it will be the various stages are involved testing of the yarn, which you are getting or if you want to make this staple, then you will have to cut at the staple or it may be in the form of the yarn. So, this may be nylon 6 yarn or the staple and these are the reaction that that is taking place, which I told you the ring opening, and then the poly-condensation reaction that is taking place in the making of the nylon 6.

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This is the caprolactam plant of the Gujarat state fertilizer and chemicals complex at Vadodara unit.

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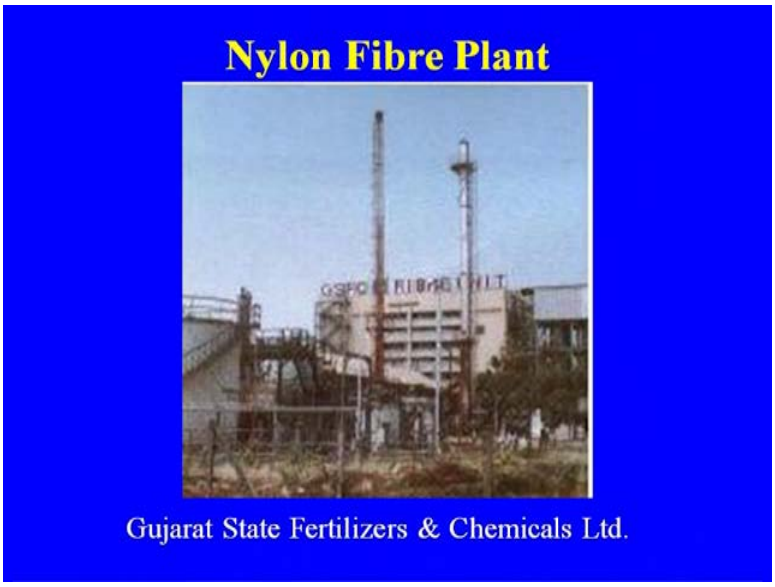

And this is the nylon fiber unit of the your Gujarat state.

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And these are the some of the actually the product and nylon 6 filament yarn and the application and of the nylon 6. And that is there and this is the actually, the required denier, that I discussed while discussing the introduction of the polymer, that this is the one of the very important denier tenacity, these are the important measurement of the your this yard.

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These are the another actually application, because one of the major user is the tire cord industry, and these are the other products that you are getting. Now, let us discuss the

nylon 66. Already I have told you, the why we are going for why we are testing nylon 66, because nylon 6, 66 is having the higher melting point than nylon 6. But here, we need the two important feed stock, that the adipic acid and hexamethylene diamine. And one of the technology for the adipic, acid that has been developed by the IIP Dehradun in India. And that has been commercialized also.

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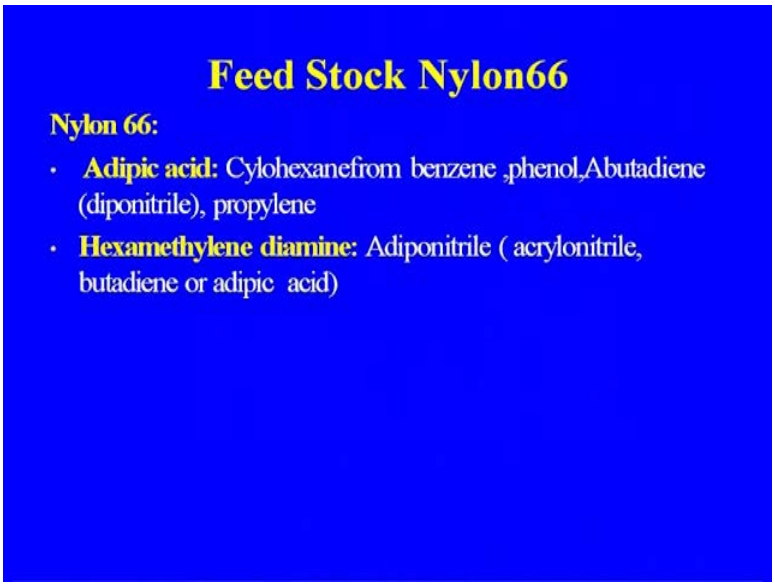

So, the adipic acid, what we need, we need the cyclohexane from benzene or the it may be the phenol butadiene propylene, and hexamethylene diamine, adiponitrile that we need from, which may come from the acrylobitrile butadiene or the adipic acid.

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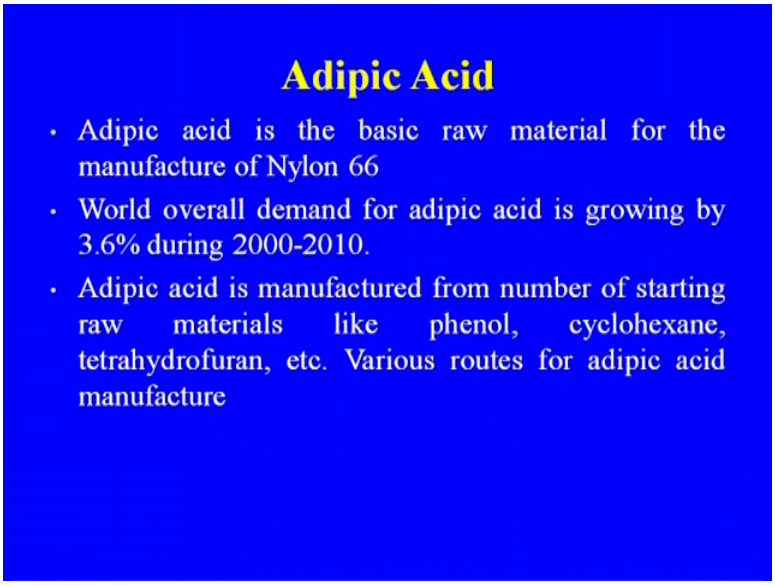

Let us, now discuss the adipic acid, adipic acid is the basic raw material for the manufacture the nylon 66. World over demand for the adipic acid is growing by 3.6 percent during 2000 to 2010. Adipic acid is manufactured from number of starting raw materials like phenol, cyclohexane, and tetrahydrofuran etcetera various routes for the adipic acid.

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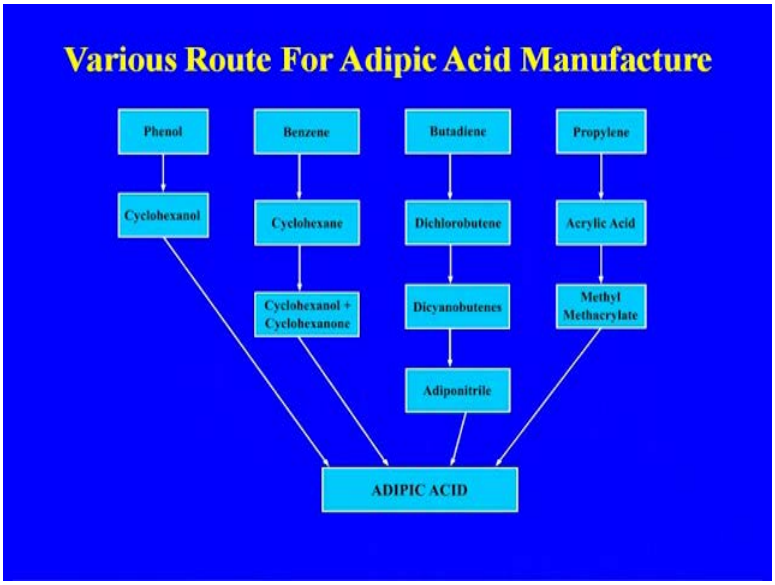

These are the as I told you, the large amount of the raw material that we are using here, it may be the phenol, it may be benzene or butadiene of the propylene route. But, the major

production of the adipic acid is the through the cyclohexane route, and there cyclohexanol and cyclonehexanone that we are getting. And then phenol also cyclohexanol here, at the dichlorobutane and then the adiponitrile and adiponitrile route, which I told you, so these are the some of the routes that we are getting.

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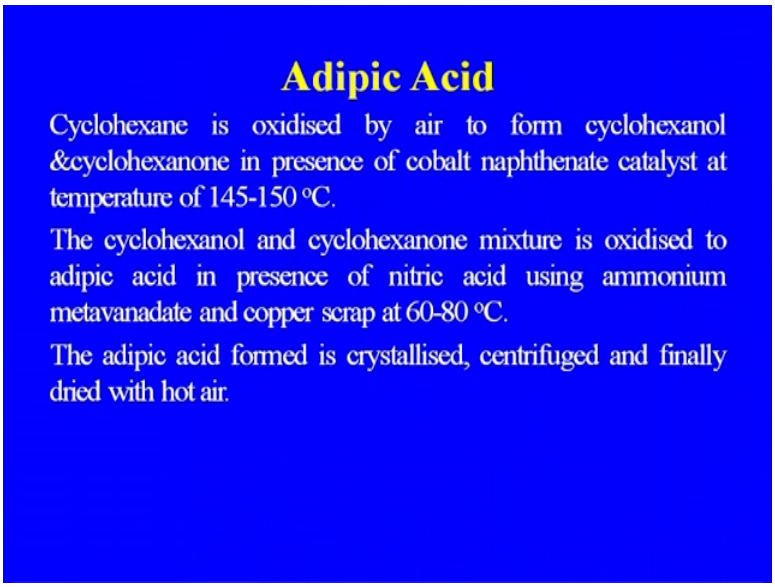

So, in the process cyclohexane is oxidized by the air to form when the cyclohexane is the raw material. Then the cyclohexane is oxidized by air to form cyclohexanol, and cyclohexanone in presence of the cobalt catalyst at temperature of 145 to 150 degree centigrade. The cyclohexanol and cyclohexanone mixture is oxidized to adipic acid in presence of nitric acid using ammonium metavanadate, and the copper scrap at 60 to 80 degree centigrade. Adipic acid form is crystallized, centrifuged and finally, dried with air.

So, this is the method for making of the and various routes, already I discussed we are having, but phenol route or the butadiene route or the propylene route. But, benzene route is the more prefer, because the benzene that is available from the aromatic plant or the catalytic reforming plant and, so that benzene and this is the reason why even for the making of the caprolactam, we are using the benzene route now. The next product the feed stock, which we need for the nylon 66, is the hexamethylene diamine.

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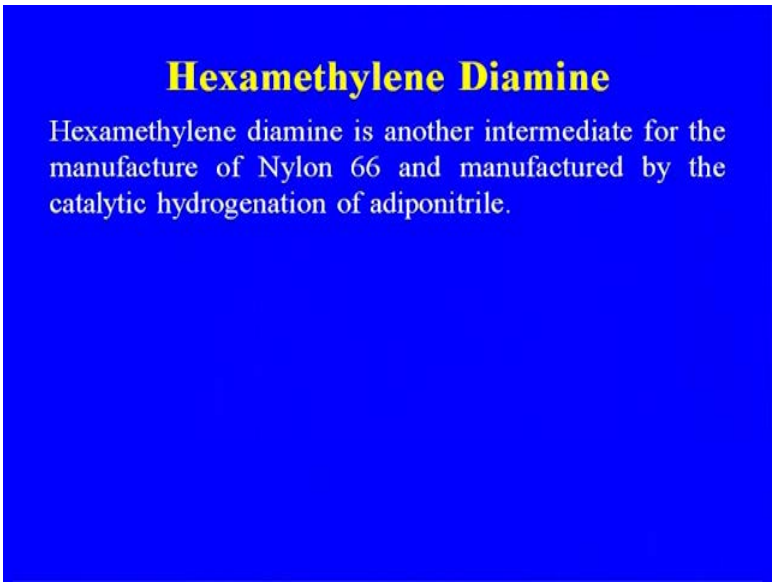

Hexamethylene diamine is the intermediate for the manufacture of nylon 66 and manufacture by the catalytic hydrogenation of adiponitrile.

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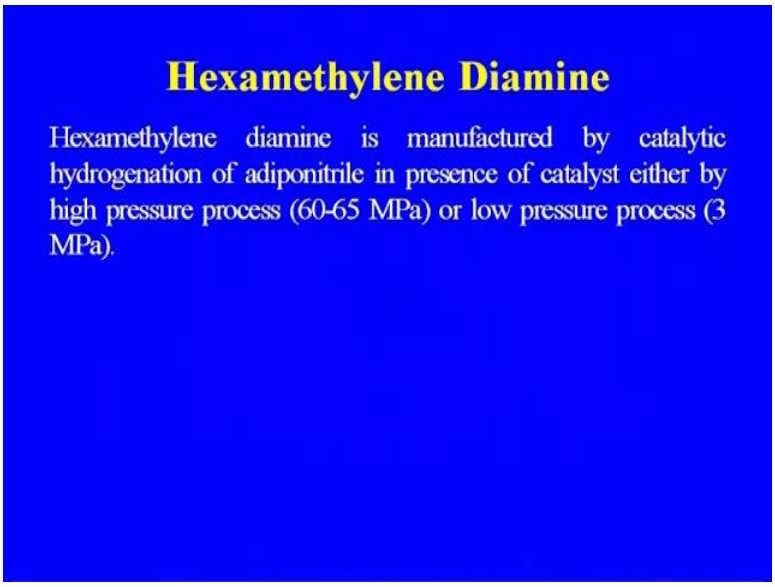

These are the process that we are using high pressure technology or the low pressure technology, were the catalytic hydrogen is by to adiponitrile in presence of catalyst is taking place.

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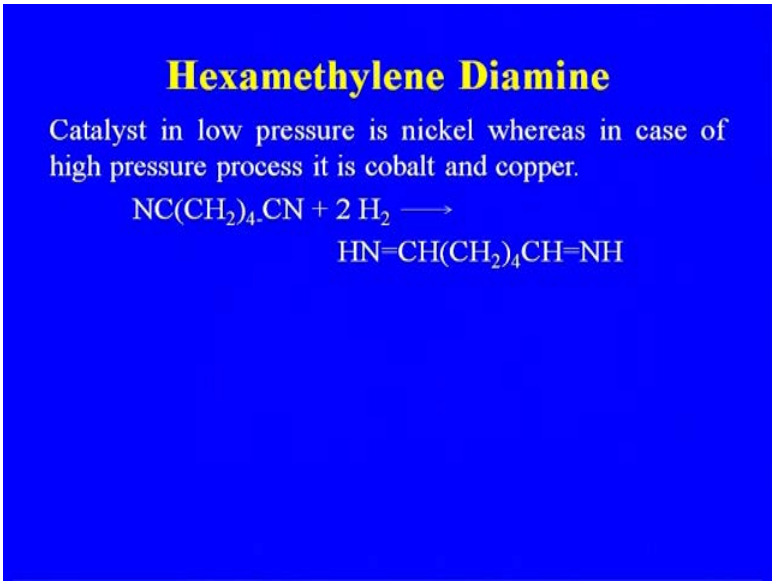

This is the catalyst low pressure is nickel whereas, the in case of the high pressure, it is cobalt and copper. So, this is the reaction, that is taking place in case of the hexamethylene diamine.

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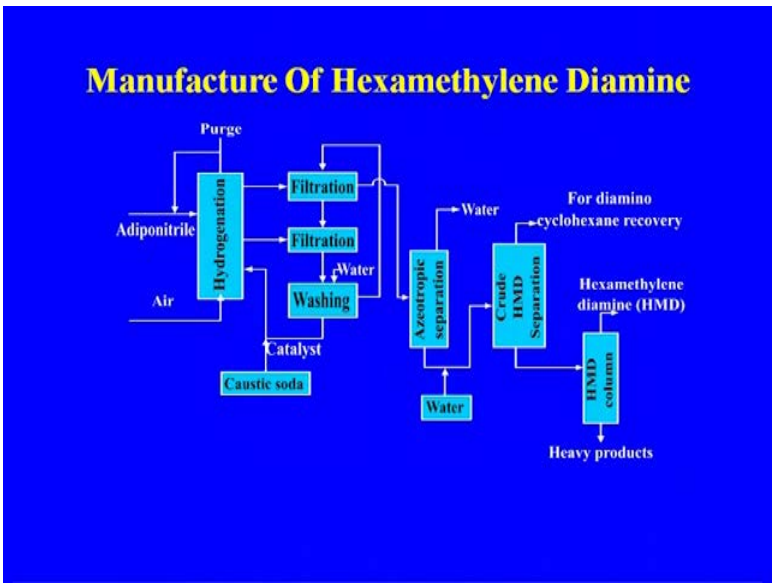

This is the process, that we are using in making of the hexamethylene diamine adiponitrile and or here, that is going to the hydrogenation. Then it is going to the your finally, we are getting here in the process filtration and washing. Then it is going to

azeotropic distillation and the crude hexamethylene diamine here, we are getting that is in to diamino cyclohexane recovery.

And finally it is a separation, where heavy end sphere separately and hexamethylene diamine that you are getting the final product, which is going for the manufacture of the adipic acid and for the nylon 66. And so the two major raw material, which is required for nylon 6, 66 is the adipic acid using hexamethylene diamine.

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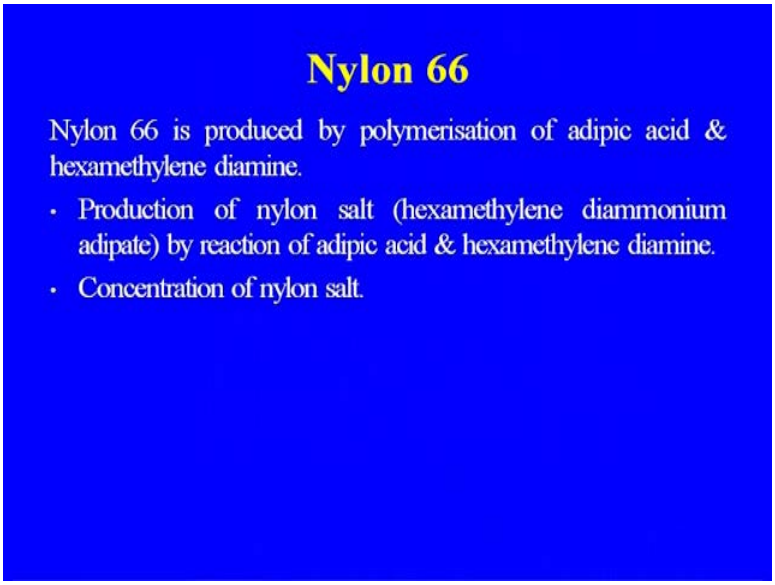

So, nylon 66 is produced by polymerization of adipic acid and hexamethylene diamine, what is happening during the reaction is the nylon salt is made by the reaction of the adipic acid and hexamethylene diamine and the, which is further polymerize.

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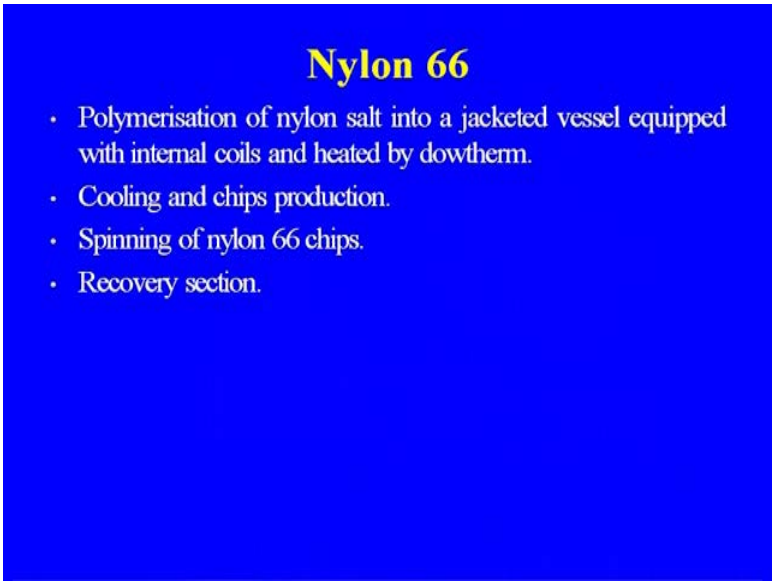

Polymerization of the nylon salt into a jacketed vessel equipped with the internal coil, and heated by dowtherm cooling, and chips production spinning of the nylon 66 here, also we are having the melt spinning and the recovery section.

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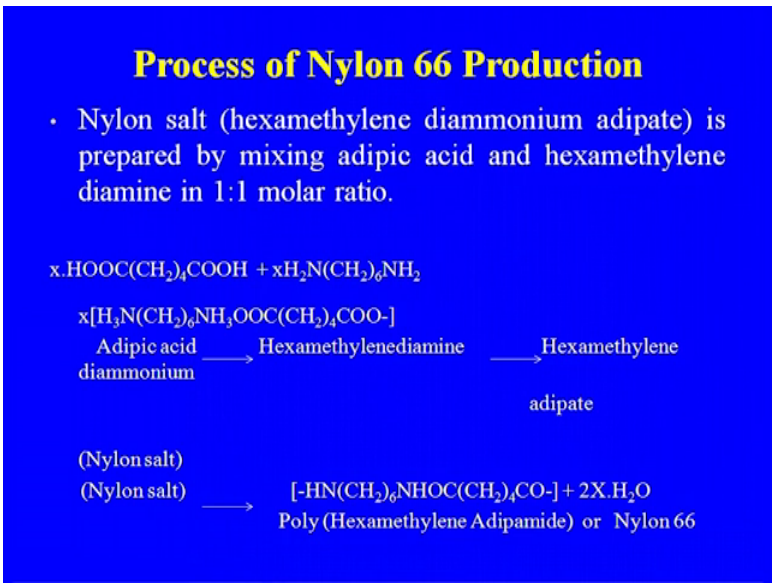

This is the reaction that is taking place, when we are having the adipic acid and hexamethylene diamine, and by the reaction we are getting the nylon salt, and this nylon salt after the polymerization we are getting the nylon 66. So, this is the reaction that is taking place in, in production of nylon 6 from hexamethene diamine and the adipic acid.

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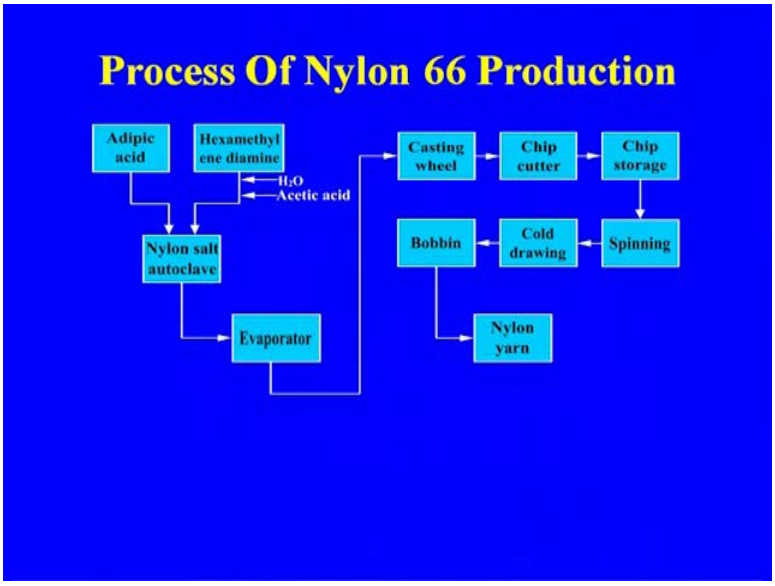

This is the process, that we are using again here also, the nylon salt and then the nylon salt auto clave, where the polymerization is taking place. Then the final here, also the same age in case of the nylon 6, either you can have the chip, chip form. And then the chip can be used for the because the, because the N downstream process of the nylon 6 or nylon 66 units are there directly they are taking the nylon 6 or nylon 66 chip, which is further process. Means, the spinning is done and, so the spinning part that is the as I told you it is the melt spinning both in case of the nylon 6 and nylon 66.

So, the again here, in the spinning process melted nylon 6 is passed through the spin rate a large sum of the spin rates are there. And that through the spin rate that is pass in the continuous thread is coming, and then we are getting the nylon yard, which may be also cut the staple form. So, the continuous spinning, then the twisting, then the, the throw of the your nylon 66 that we are getting.

So this is the in brief about the nylon 66 process that we are using. So, this was about the two major product nylon 6 and nylon 66, but as I told you the only nylon 6 we are making in India, and to measure is nylon, manufacturing the caprolactam for the nylon 6 that is you are the CFC and the fact. And the raw material and what about the development that you are seeing, in case of the caprolactam technology, that is the people what. Now, going for more and more greener technology because that is one of

the major problem that is three times of the three to four times of the your caprolactam with the ammonium sulphate and huge amount of the ammonia that is required.

So, but at the same time you see the nylon 6 or the nylon 66, they are playing very important role in meeting some of the demands of the synthetic fiber industry. In the next lecture, we will be discussing about another important sector of the synthetic fiber industry, that is the polyester. And the polyester again, there has been continuous development in the technology, in the raw material setting from the DMT to terra ethylic acid and or the purified terra ethylic acid.

This was the major change over in the process technology of the polyester. And polyester, that is the one of the major synthetic fiber, which we are using both in the woven and non woven industry. Major application in the non woven, and the again the real back through in all the cases of the synthetic fiber, that has been because of the coming up the petrochemical complexes and the aromatic production.