Chemical Technology
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Module - 8
Polymer
Lecture - 7
Acrylic Fibre, Modified Acrylic Fibre,
Acrylonitrile, Acrolein Propylene Fibre, Polyurethane

Today will be discussing about the module 8 of the organic chemical technology. In the module 8 we earlier discussed about the polymer elastomers. And today we will be discussing about the synthetic fiber, and already on nylon and polyester we have covered in the previous lecture. Today it will be on the acrylonitrile, acrylic fiber, polyurethane and the next lecture that will be on the viscose rayon. So, the in case of today's lecture that will be acrylic fiber, modified by acrylic fiber, acrylonitrile and acrolein, because the acrolein that is the byproduct we are getting during the manufacture of acryonitrite. But some of the process are there in case of acrynitrite will be known acrolein, propylene fiber and the polyurethane. Because the propylene we have already discussed so the other process is same making, so we are not going in detail about the propylene fiber, but polyurethane that definitely will be discussing, because the polyurethane that is also one of the very important class of the plastic which we could not discuss while discussing the polymer.

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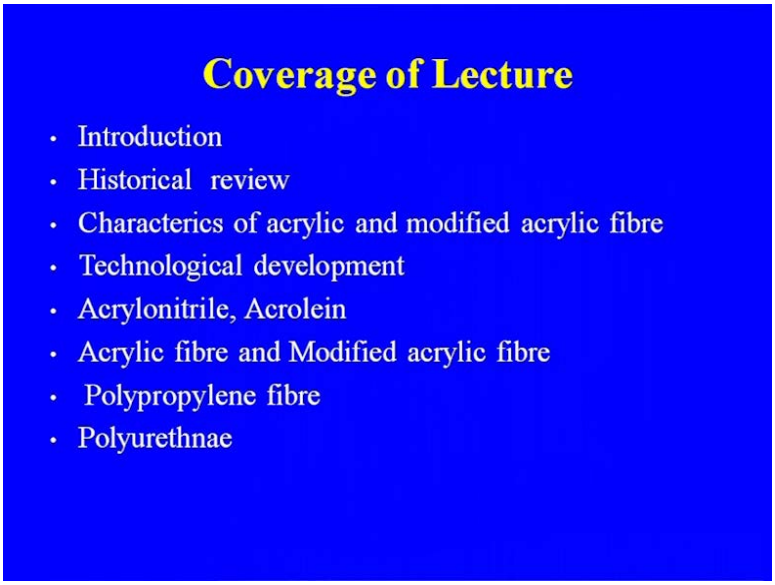

So, this will be the coverage of the lecture introduction, historical review, characteristics of the acrylic and modified acrylic fiber, technological development, acrylonitrile, acrolein manufacture, acrylic fiber and modified acrylic fiber. And then the first we will be discussing the polyurethane and then the polypropylene fiber.

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This you can see the by appearance and seeing the importance's of the acrylic fiber because this is just like a wool like material and what about the revolution you are seeing in case of the acrylic fiber that is because of the in the synthetic fiber that is because of the coming of the acrylic fiber in the market and now the it is capture whole wool market and has replaced the conventional wool material that was being used for the woolen fabrics.

And this is the some of the product of the acrylic fiber and even in case of the now if you see the carpet and in case of curtain also we are using acrylic fiber. This is a towel; this is the sweater and other. Because woolen a material this is the thrived of the acrylic fiber. So, this is how the importance of the acrylic fiber is there. And are real revolution came in the case of the acrylic fiber, that was the availability of the raw material propylene from the naphtha cracker and then the propylene to amnoxidation process of the acryonitrite.

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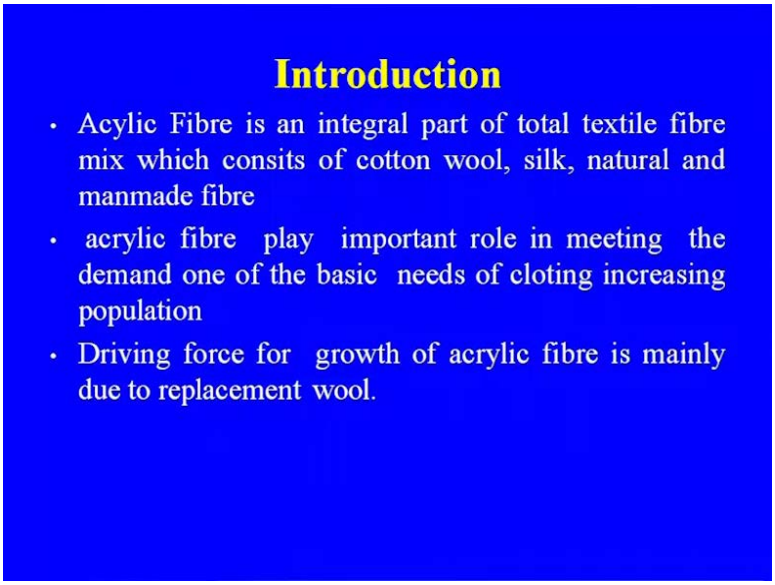

So, let us discuss about the first thing the introduction of about the acrylic fiber. Acrylic fiber is an integral part of total textile fiber mix which consists of the cotton, wool, silk natural and manmade fiber. Acrylic fiber plays an important role in meeting the demand of one of the basic needs of the clothing and to meet the demand of the increasing population. Driving force for growth of the acrylic fiber is mainly due to replacement of the wool and at the same time availability of the raw material propylene. Because you see the here also will be discussing what are the various routes of the acrylonitrile which is main polymer.

Here are the sometimes it is co-polymers also added there to when we are manufacturing the modified acrylic fiber to enhance some of the property which is not inherent in case of the acrylic fiber. So, in all the whether it is acrylic fiber modified. This is because it has replaced the wool material even in the blanket, in the market you are seeing this is all made of the acrylic fiber. And so the earlier processes which will be discussing about the acrylonitrite. That was the acetylene route or the ethylene route or the ethanol route for or acetaldehyde. Because, the starting for all these the your ethylene so that was the route for making of the and again the major development as I have been disusing earlier also that is the major development in case of the various the petrochemical products intermediates.

And the final that was during the 1910 to 1930 that was the time of the World War 1, World War 2 lot of the requirement of the polymer elastomer or the synthetic fiber was there acrylic fibers. Why the importance of the acrylic fiber? Because it is having the specific property appearances like wool which I have shown in the picture that the how it looks like this is just like a woolen material.

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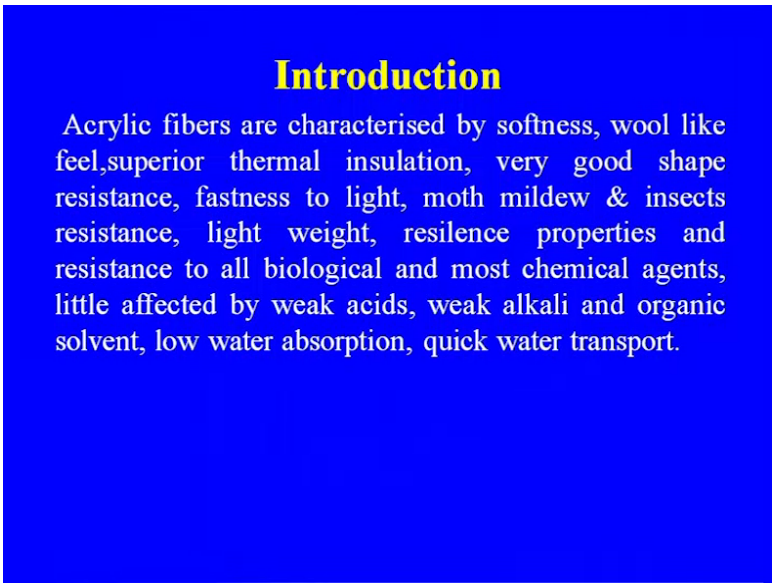

Acrylic fiber are characterized by softness that is the basic requirement in case of the wool like feel superior thermal insulation, very good shape, resistance, fastness to light, moth, mildew and the insects resistance. Because these are the some of the property which is the requirement for the carpet which was earlier we normally it was the woolen material that was being used. And another property with the light weight resilience property resistances to all biological and most chemical agent little affected by weak acids, weak alkali and organic solvent. Low water absorption, quick water transport means the drying so that is much faster in case of the acrylic fiber. And this is the reason why the material made from the acrylic fiber the washing is also easier. And the because the water drainage is (( )).

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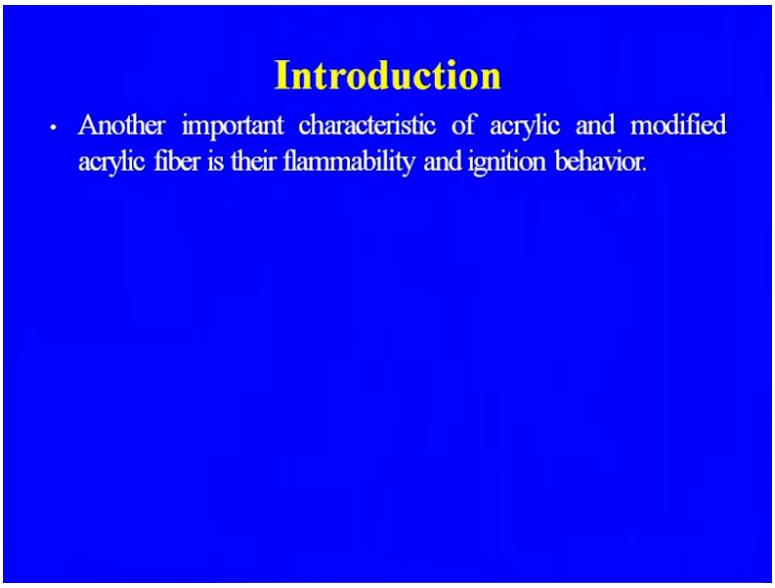

~~Another important characteristic of the acrylic and modified acrylic fiber is their flammability and the ignition behavior. Because these are the two another important in case of the modified acrylic fiber that is, the flammability and the ignition behavior. And because the vinyl chloride that has been incorporated as monomer while making the modified acrylic fiber acrylic.~~

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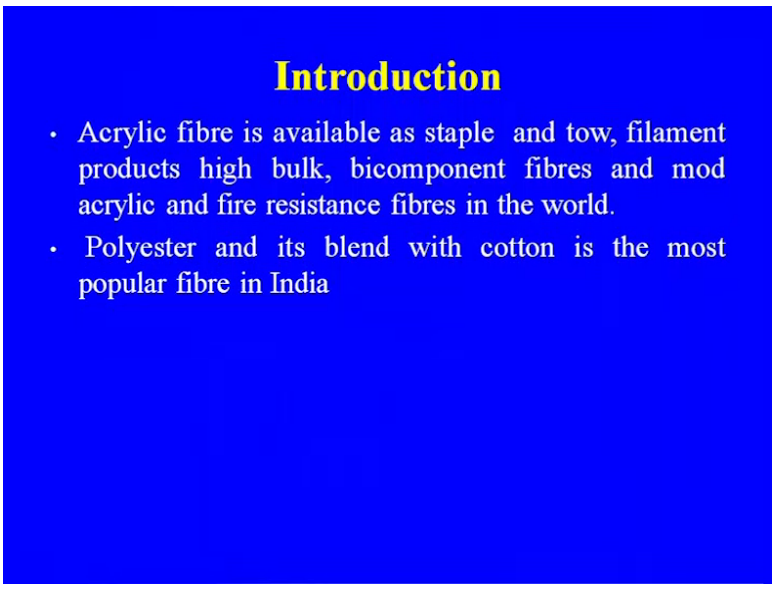

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Fiber is available as stable and tow filament products high bulk bi-component fibers and modified acrylic and the fire resistances fiber. In the world polyester and its blend with the cotton is the most popular fiber in the India. It has been blended as I told you now whatever the synthetic fiber various blend of the cotton or the viscose or it may be the acrylic are there just to improve some of the property or some of the deficiency of the polyester which is improved with the help of the when you are having the acrylic fiber or the viscose.

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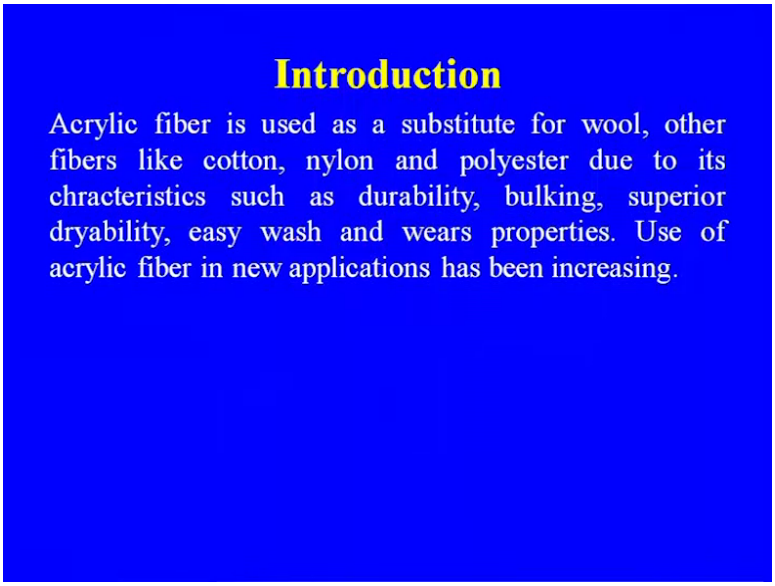

Acrylic fiber used as a substitute for wool. As I told you other fibers like cotton, nylon and polyester due to its characteristics such as the durability, bulking and superior dry ability. The water density property is good easy wash and wears properties easy wash and because that is also one of the basic requirement in case of the textile, or the when you are using the various. Even in case of the hosiery material in case of the carpet you are able to wash it in case of the acrylic fiber. Use of acrylic fiber new application has been increasing and these are the some of the driving force for the more and more consumption of the acrylic fiber.

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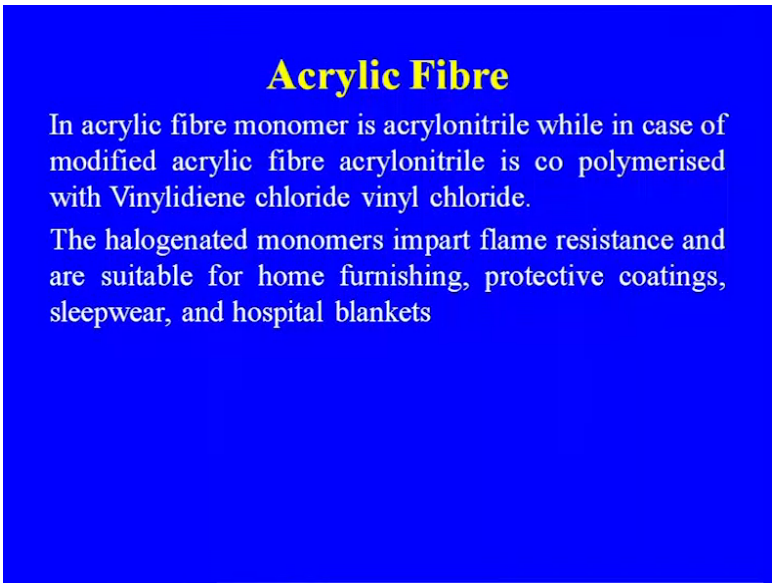

~~In acrylic fiber monomer is the acryolnitrite. While in case of the modified acrylic fiber, acrylonitrite is co polymerized with vinylidiene chloride or vinyl chloride. These are the two material coordinate compound which are being co polymerized along with the acryl nitrite the halogenated monomers impart flame resistance and are suitable for home furnishing protective coating, sleepwear and hospital blankets so these are the some of the advantage why we are going for the modified acrylic fiber.~~

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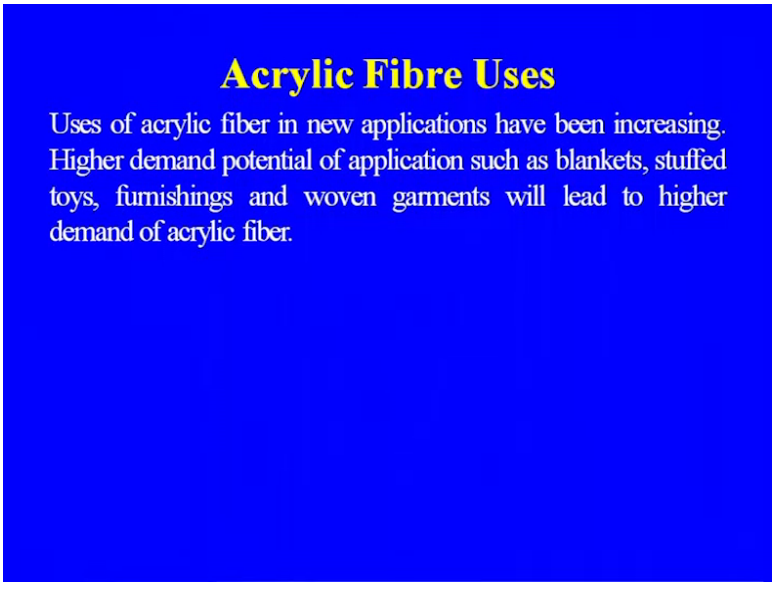

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Usage of the acrylic fiber in new application has been increasing higher demand potential of the application such as blanket stuffed toys. We are using lot of the acrylic fiber although the amount that is less if you compare to other user but, the in this stuffed toys we are using lot of the acrylic fiber material furnishing and woven garments will lead to higher demand of the acrylic fiber.

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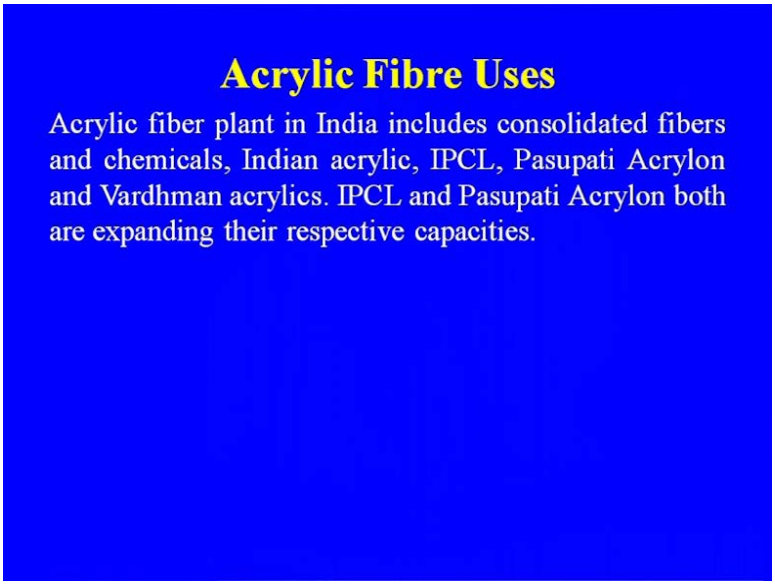

Acrylic fiber plant in India includes consolidated fibers and chemicals, Indian acrylic, IPCL. IPCL in India petro petrochemical complex that is now reliance industry at Vadodara that was the one of the unit large integrated unit that was started during the 70's which we discussed while discussing the petrochemicals. And so that is also having the acrylonitrite plant. Pasupati acrylon that is one of the major producers of the acrylic fiber, where they are making the acrylic fiber and modified acrylic fiber.

Another important Vardhaman acrylics because vardhaman wool and another thing they are very important. They have also grown in the case of the making of the acrylic

because you see the now the cost of the wool material the natural wool that is very high in compression to the acrylic fiber. And that is the reason why it has been almost completely replaced the conventional wool material which in the hosiery and other application so IPCL and Pasupati acrylon both are expanding their respective capacities.

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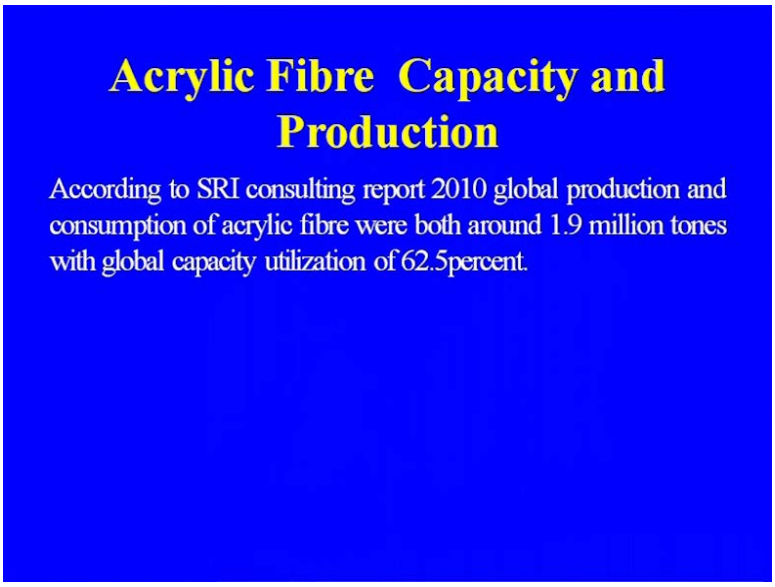

According to SRI consulting report two 2010 the consumption of acrylic fiber were both around production consumption both were around 1 point 9 million tones with the global capacity utilization of 62 point 5 percent.

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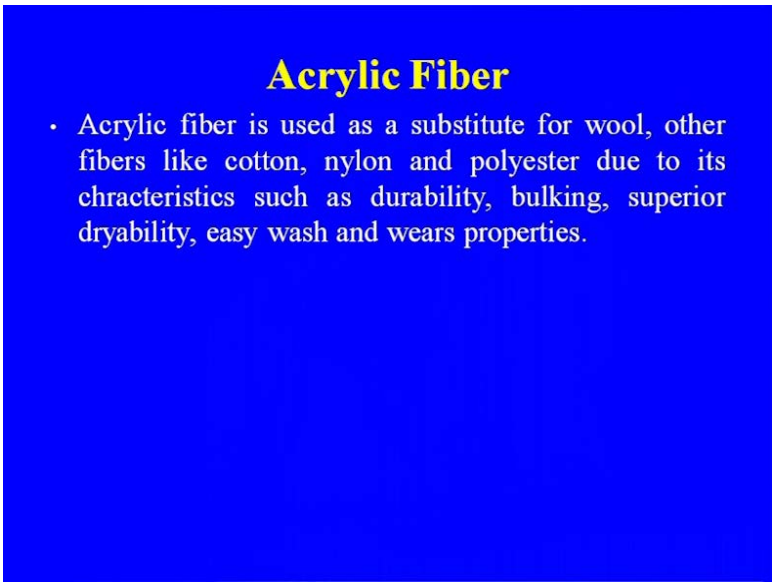

So, the acrylic fiber used as I told you the substitute for cotton, nylon, polyester due to its characteristics, durability, bulking, superior dry ability. easy wash and wear property acrylic fiber already here actually the how the we differentiate between the acrylic fiber and the modified acrylic fiber.

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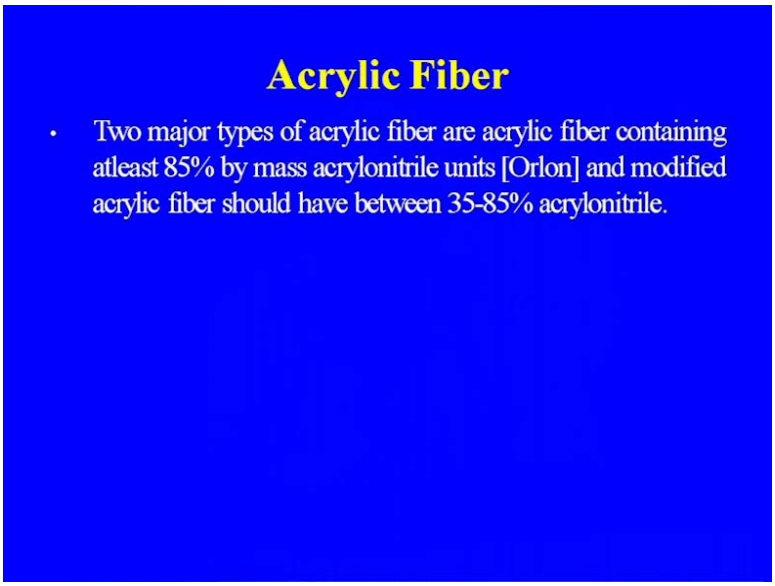

Two major types of acrylic fiber are acrylic fiber containing at least 85 percent by mass acrylonitrile units Orlon. Orlon was the trade name that was given to the acrylic fiber like tyrene or the decron in case of the polyester. So, orlon that was the name given due point because deposit that has been the pioneer in case of the synthetic fiber, whether it was the nylon or it was the acrylic fiber so modified acrylic fiber should have between 35 to 85 percent of the acrylonitrile. And in case of the acrylic fiber it is the 85 percent the acryonitrile unit here.

~~It is around the 35 to 85 percent rest is the other co monomer. So, this is the basic difference and normally as I told you we are using the vinyl chloride and so these are the two actually the chlorinated compound which imparting the water fire resistant property to the acrylic fiber.~~

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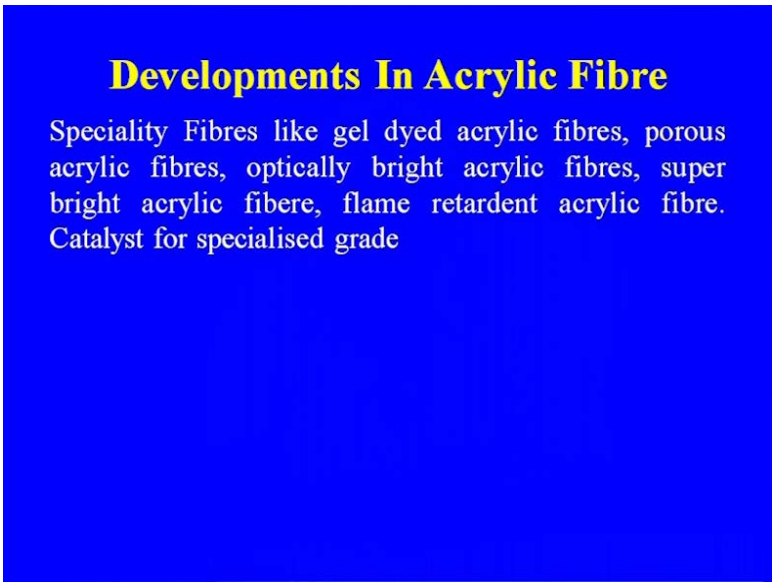

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These are the major technology supplier licenses the DuPont, Ashai Japan, Exlan Anta Vicosa, Monte fiber, American cyanide and American cyanide and Countauids. Development in the acrylic fiber: specialty the fibers like gel, these are another special

quality of the acrylic fiber. So, the specialty fiber like gel dyed acrylic fiber, porous acrylic fiber, optically bright acrylic fiber, super bright acrylic fiber and flame retardant acrylic fiber are the some of the catalyst. For that we will be discussing separately the retardant acrylic fiber.

The global acrylic fiber consumption expected to the average growth of 4 point 6 percent per year from 2009 to 2014 and around 1 point 1 percent from 214 to 19. Apparel uses accounted for over half of the total global acrylic fiber consumption in 2009. Other applications include industrial uses and the home furnishing.

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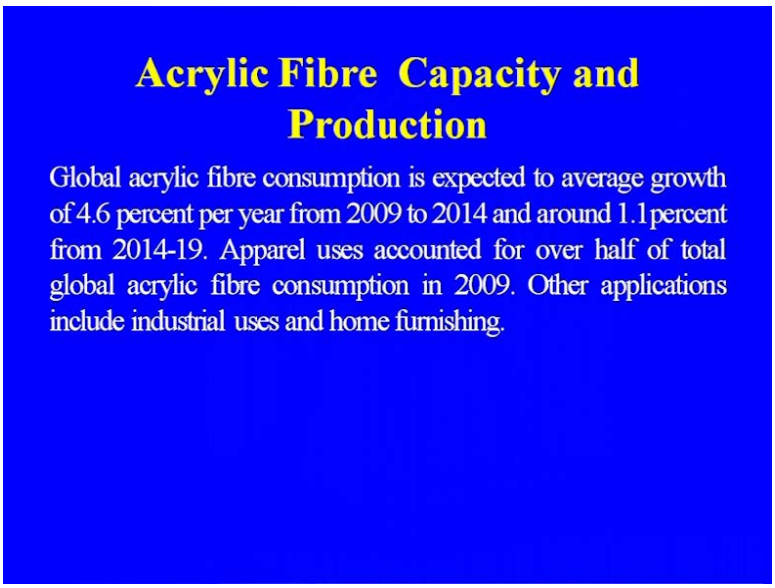

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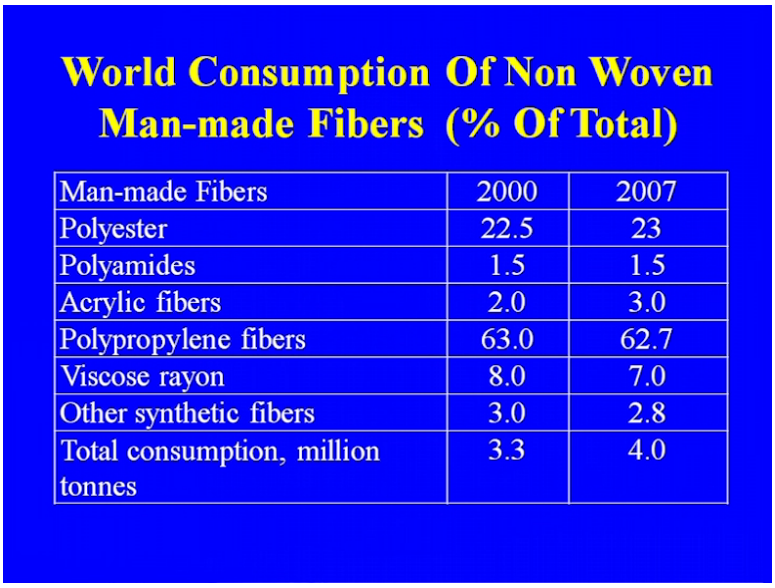

This is already discussed this part of the work non woven manmade fibers. Here you can see the acrylic fiber around 2 to 3 percent that we are using in case of the non woven manmade fibers.

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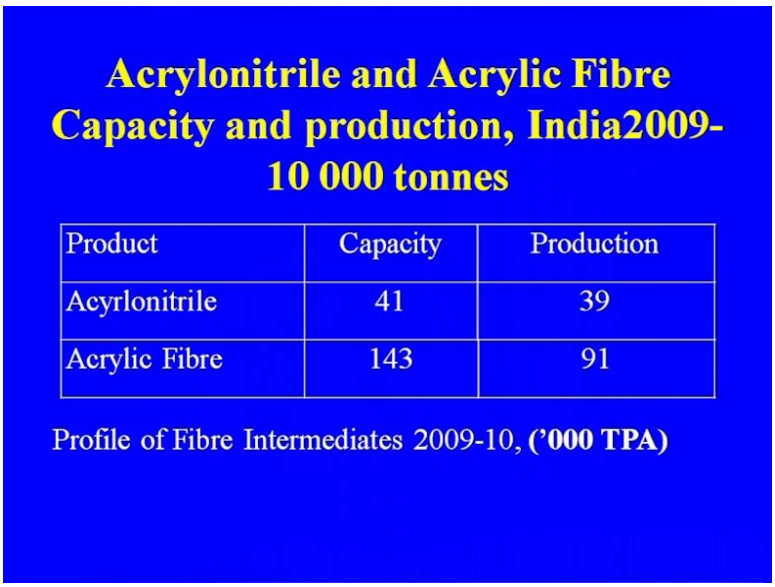

This is the status of the acrylic fiber production capacity and the production in India that is the acrylonitrile and acrylic fiber this is forty 41,000 and that is the and 39,000. Here acrylic fiber 143 and 91,000 and this is the about the capacity and production of the acrylic fiber.

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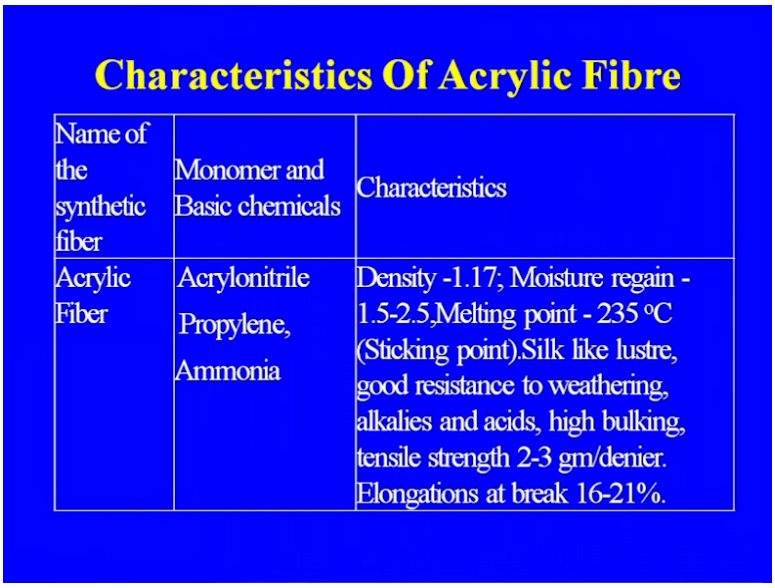

These are some of the characteristics which I discus about the acrylic fiber. That is the acrylic fiber here the monomer and basic chemicals acrylonitritile propylene and ammonia and ammonia oxidation of the propylene that we are using here. The technology, the characteristic is density 1 point 17, moisture again 1 point 52 to 2 point 5, melting point around two 235 degree centigrade, silk like luster, good resistances to weathering alkalis and acids high bulking high bulking and that is the property in case of the woolen material.

Also the tensile strength 2 to 3 gram per denier elongations at breaks 16 to 21 percent. And at the same time its wool like appearance that is what it is giving its use in the woolen industry where we are making a lot of the woolen material. It may be the hosiery or it may be blanket, or even in case of the carpet other areas where we are using.

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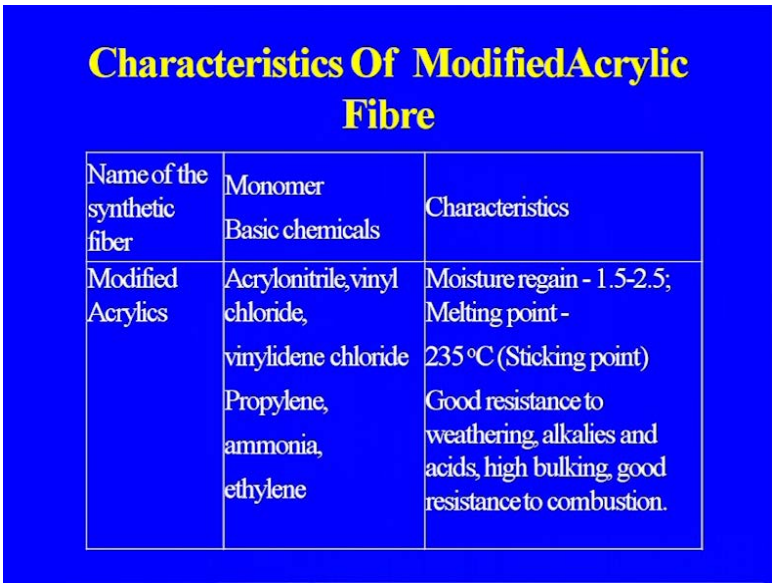

Modified acrylic fibers that is the acrylonitrite, vinyl chloride and vinylidene chloride, here propylene and ammonia and ethylene that may be depending up on the route but, the propylene ammonia that is the now the most of the process they are using the propylene and the ammonia. So, moisture regain, melting point 235, good resistances to weathering, alkalis and acids high bulking good resistances to combustion.

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Now discuss the, let us discuss the raw material for the acrylic and modified acrylic fiber, acrylonitrile, acetylene because that was the earlier route acetylene, acetaldehyde,

ethylene oxide then the propylene and ammonia. This is the now the route which we are using the raw material ammonia and propylene for ammon oxidation of the propylene and for making acrylonitrile vinyl chloride and vinylidene chloride that is needed in case of the modified acrylic fiber and the demethyl formamide. That is the solvent which we are using because earlier in case of the acrylic fiber wet spinning was there and now we are using the dry spinning in case of the acrylic fiber.

This was only possible with the availability of the demethyl fromamide and that is the product from the synthesis gas. And some of the fertilizer company integrated fertilizer complexes they are making dimethyl fromamide. Although the dimethyl fromamide it has been used as the solvent that has been reported for other purposes also but, the change over from the wet spinning to the dry spinning in case of the acrylic fiber that was only possible because of the dimethyl formamide solvent.

So, this is the one of the important solvent because you see I have already discuss about the spinning. We are having the 3 type of the spinning1 is the melt spinning where the polymer is melted and then it is passed to the spinneret or in case of the dyes that is solution from then it is pass to the spinneret.

Then the dying is taking place and removal stripping of the solvent. And then we are having the oronal steples from that and but, in case of the wet spinning which was earlier done by for acrylic fiber, that was wet spinning process means the wet bath spinning bath was there through which the your material that is the polymers that was passed and there is the fiber that we are getting from that. Acrylonitrile: now, let us discuss about the acrylonitrile which is the raw material for the acrylic fiber and the importance of acrylonitrile that is not only because of the acrylic fiber but, there are very various combination of acrylonitrile butadiene an styrene, for making of the synthetic rubber also which are having the better silent properties towards oiling.

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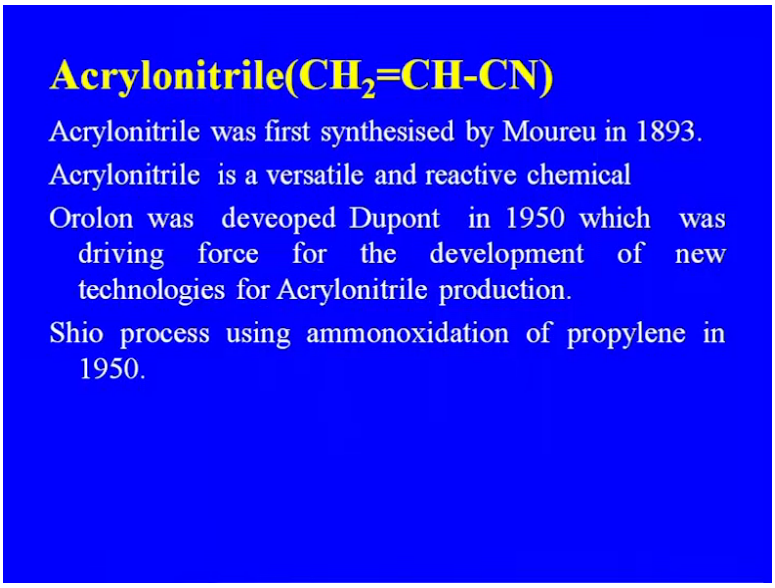

So, acrylonitrite was first synthesized by Moureu in 1893. Acrylonitrile is a versatile and the reactive chemical orolon was developed in 1950 which as the driving force for the development of new technology for acrylonitrile. Because as I told there has been continuous development in the process technology from the manufacture of the acrylonitrile and the starting that was the acetylene. As in case of the other petro chemicals, we are making through the petroleum route.

Shio process using ammonooxidation that came in to 1950 and after that number of the process licenses of the technology based on the ammono oxide oxidation that has been used even in case of the technological development. In the reactor fixed bed to the fluidized bed reactor. We are using in case of the now the mostly it is fluidized bed reactor in case of the acrylonitrile manufacture.

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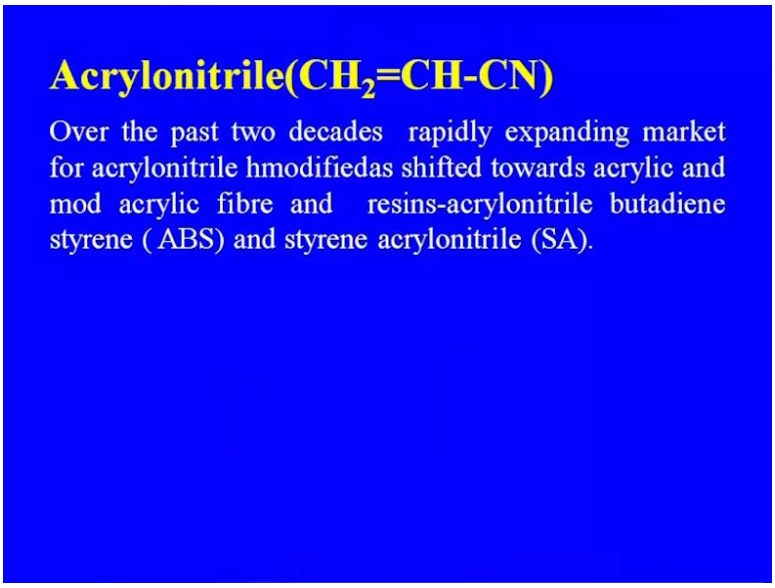

So, over the past decades as I told the rapidly expanding market for acrylonitrile and the modified shifted towards the acrylic. And the modified acrylic fiber and resins acrylonitrile, butadiene, styrene and styrene acrylonitrile. So, these are the various combination of the rubber also which has lead to the development of acrylonitrile in industry.

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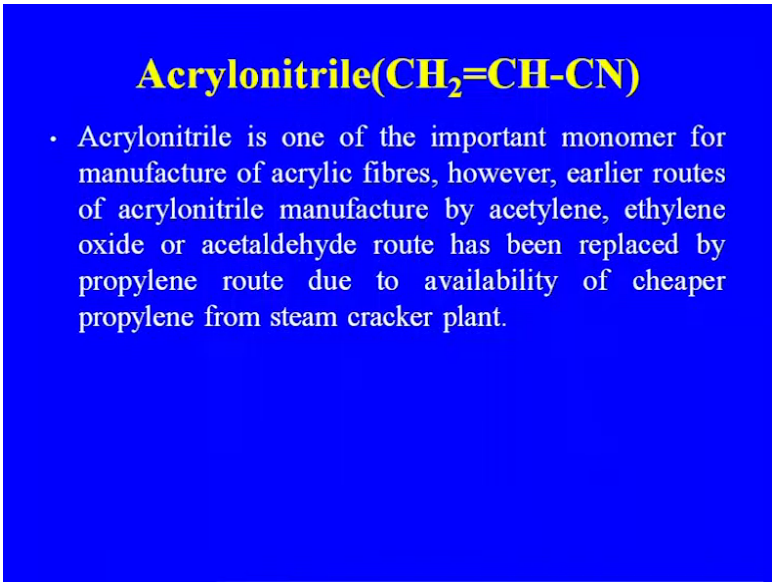

Acrylonitrile is one of the important monomer for the acrylic fiber. Earlier, routes of the acrylic, acrylonitrile manufacture were the acetylene route, ethylene oxide route or the

acetaldehyde. Because from ethylene you can get the ethylene oxide, ethylene oxide to acetyldehyde for the ethylene more specific routes was there earlier and still we are manufacturing lot of the ethylene through the molasses route. So, this is the conventional methyl earlier before coming of the propylene route where we are doing the ammoniation of the ammono oxidation of the propylene. So, this is the process and the process became cheaper because of the availability of the propylene from the steam cracker plant.

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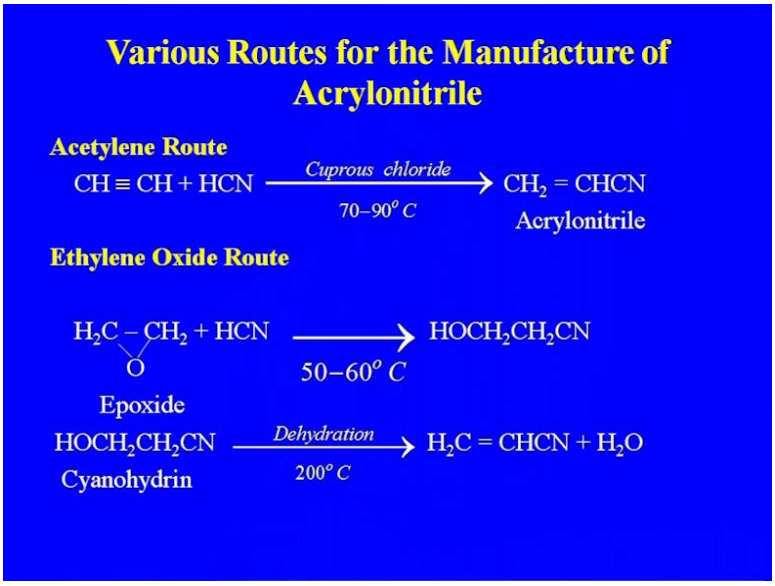

If you can see the how we are getting from the acetylene route hydro cyanide reacting with acetylene that we are getting the acrylonitrile. Earlier, this was the ethylene oxide route. And ethylene oxide has cyanohydrins. Cyanohydrins to acrylonitrile so by dehydration these were the other technology that was earlier used before coming of the pure propylene the ammono oxidation of the propylene.

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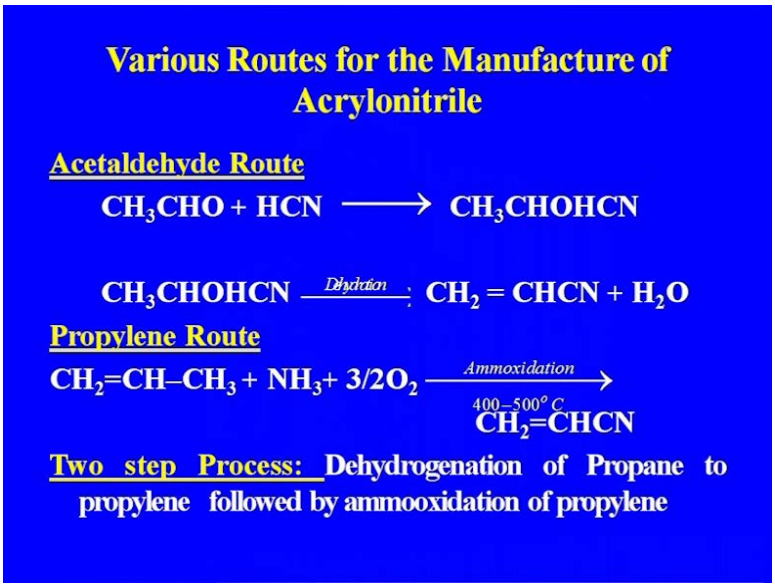

Another process that is the acetaldehyde, again the acetaldehyde as you know that we are making to the ethylene route so that is also available and then we can make the acetylene. But, if you see the propylene route now it is more common and most of the even due point in the earlier stages they used. Some other technology not the ammonia but, that was the oxides of the nitrogen for the propylene route but, here again direct that is also we are getting from the process during the process of NH3 and the oxygen is there and.

So, this is the process ammono oxidation of your acrylonitrile this propylene to acrylonitrile. That is the process we are using another two step process that we are having because you see the propylene how to get the propylene, because the it is not only the cracker but, also we can get the propylene from the dehydrogenation of the propane. That is one purpose of propylene. And so the propylene to propane to propylene and followed by ammono oxidation of the propylene.

So, this is the how the various technological developments that is that has taken place regarding the raw material. But, you see the one of the method which i told you because the most of the development in the earlier stages of the organic chemical industry that was the acetylene route. And for that as u know the calcium carbide to acetylene and that is we need the lime stone and the coal. So, that was process earlier that was used for the

making of it. And then it was of course, the ethylene oxide to and the ethylene oxide again you can get the ethylene form the alcohol.

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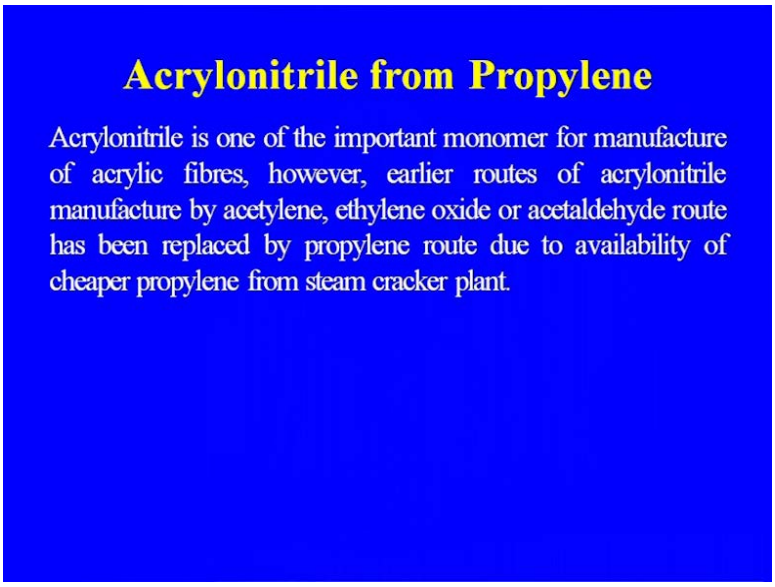

Now, let us discuss about the acrylonitrile from the propylene route. Acrylonitrile is one of the important monomer for manufacture of acrylic fiber. However, earlier routes of the acrylonitrile manufacture of acetylene by acetylene, ethylene oxide or acetaldehyde route has been replaced by propylene route due to the availability of the cheaper propylene from steam cracker.

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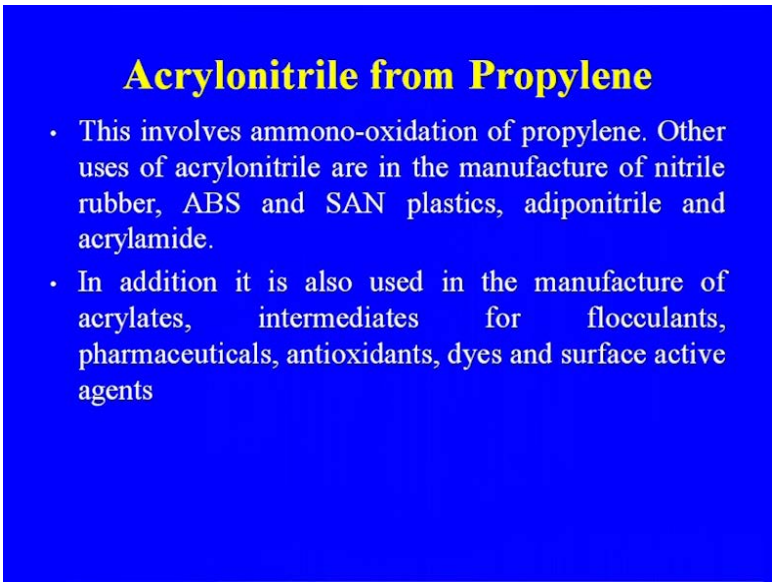

The process involves ammono-oxidation of propylene. Other uses of acrylonitrile are in the manufacture of nitrile rubber. ABS acrylonitrile butadiene styrene or the styrene acrylonitrile plastic, adiponitrile and acryl amide these are the other uses of the acrylonitrile. And this is the one of the major that is the ABS acrylonitrile butadiene or the styrene acrylonitrile plastic. The elastomers also this is one of the important outlet for the acrylonitrile. In addition it is also used in the manufacture of acrylates, intermediates, of flocculants pharmaceuticals, antioxidants dyes and surface active agent.

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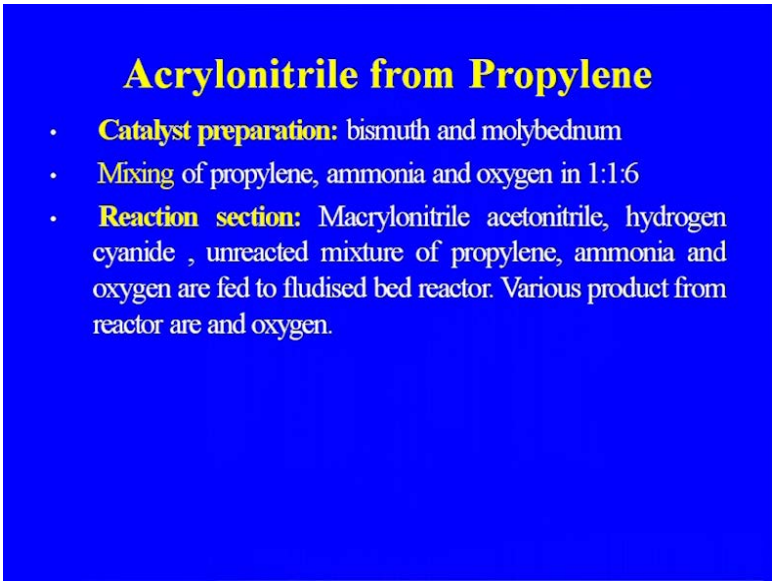

The catalyst: the various stages involves first is the catalyst preparation bismuth and molybdenum mixing of the propylene, ammonia and oxygen in this ratio along with the catalyst. Then the reaction where your acetonitrile, hydrogen cyanide unreacted mixture of the propylene, ammonia and oxygen are fed to the fluidized bed reactor. Various production reaction product from the reactor or the acrylonitrile, acetonitril the hydro cyanide these are the some of the raw byproduct also we are getting along with the reaction is highly this reaction of the because of the as we know we are doing the oxidation this reaction is highly exothermic.

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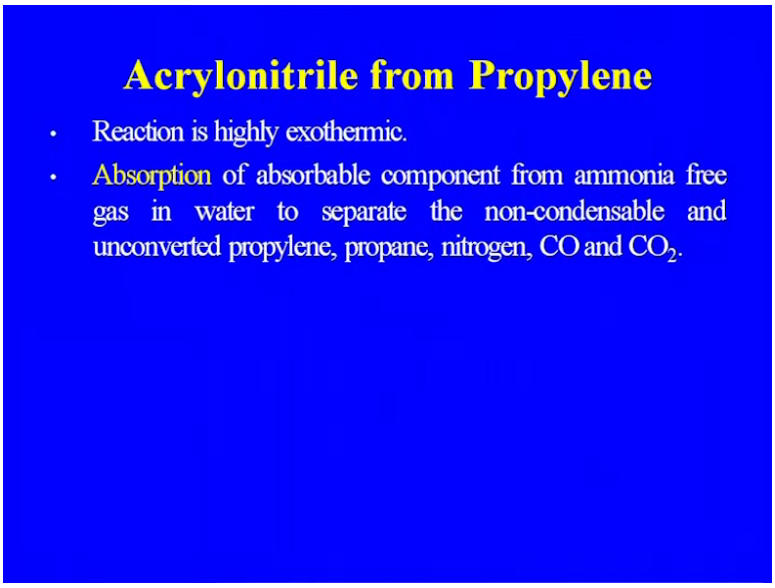

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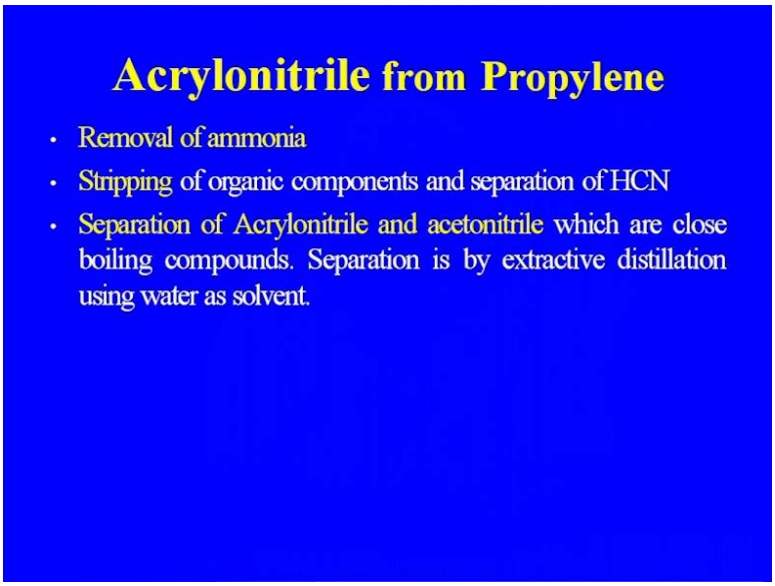

Absorption: the next step the absorption of the component from the ammonia free gas in water to separate the non-condensable unconverted propylene, Propane, nitrogen, c o and co2. Removal of ammonia, stripping of the organic component and separation of the hydrogen cyanide. Separation of the acrylonitrle and acetonitrile which are because the here also because the acrylonitrile and the acetonitrile they are having the close boiling point so that is separated by extracted distillation column using water as a solvent. Because the otherwise it may not be possible, it will not possible for separation of the acrylonitrile and the acetonitrile.

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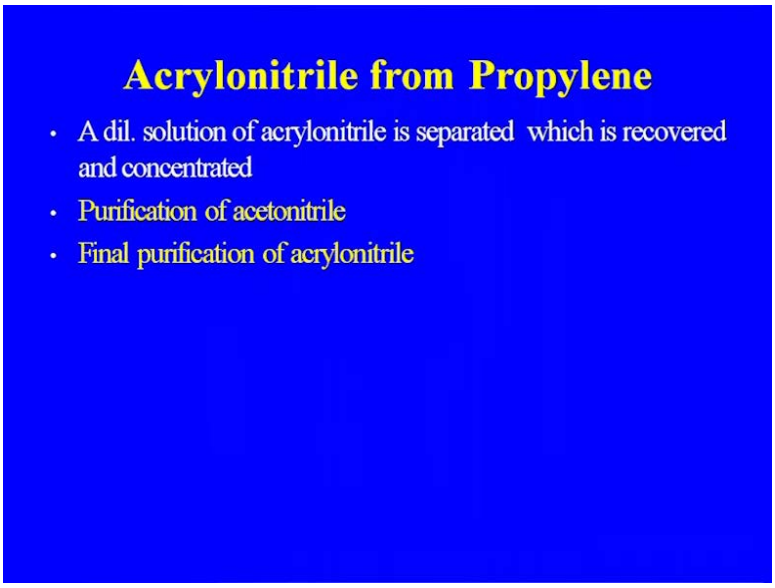

Then the dilute solution of the acrylonitrile is separated, which is recovered and concentrated, Purification of the acetonitrile final purification of the acrylonitrile.

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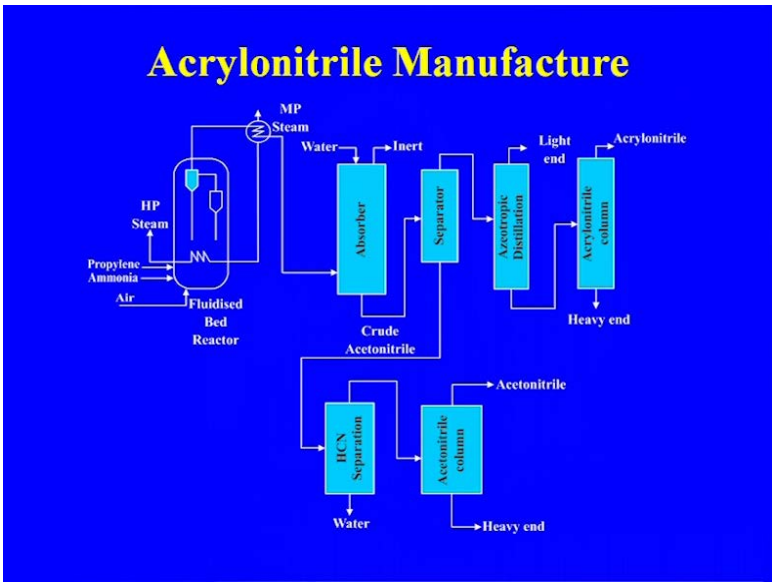

This is the process which we are using in case of the acrylonitrile manufacture I told you that normally now the most of the technology, they are based on the fluidized bed reactor. But, in the earlier stages it was the fixed bed reactor that was being used for the manufacture of the acrylonitrile. So, the propylene and ammonia in the air that is going to fluidized bed reactor cyclones are there for separation of the catalyst. And then it is

going to the absorber separator then the azeotropic distillation for the separation of the acrylonitrile. And here actually the acetonitrile that is going to the again separator and then the finally, acrylonitrile that we are getting as a byproduct.

So, this is the process that we are using in manufacturing of the acrylonitrile. So, this was the major because in the process acetonitrile that will be also form. So, that will be important by product of the acrylonitrile or now the technology are also there that may be acetonitrile that may be optional as in case of the dew point process.

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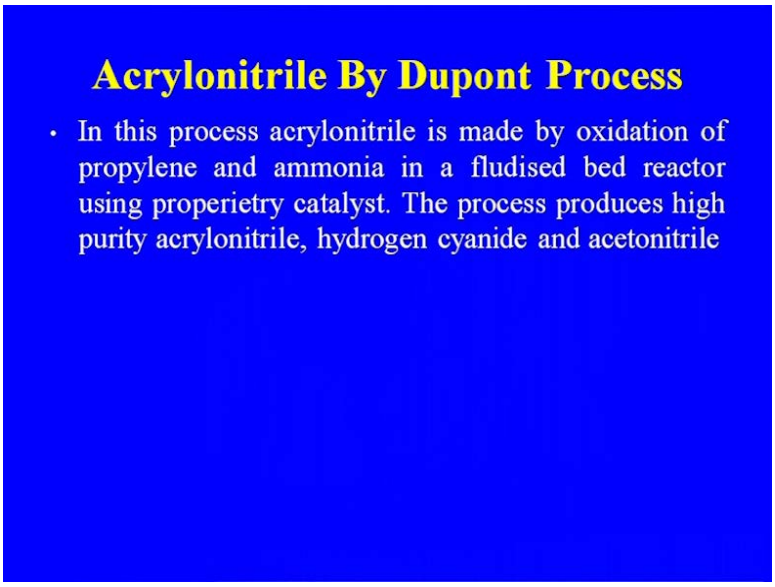

~~In this process, the dew point process acrylonitrile is made by oxidation of propylene and ammonia in a fluidized bed reactor using propriety catalyst. The process produces high purity acrylonitrile, hydrogen cyanide and acetonitrile. So, here as I told you, the acetonitrile that may be optional. The other process that has been that is the Montedison UOP process here also we are using the same fluidized bed reactor.~~

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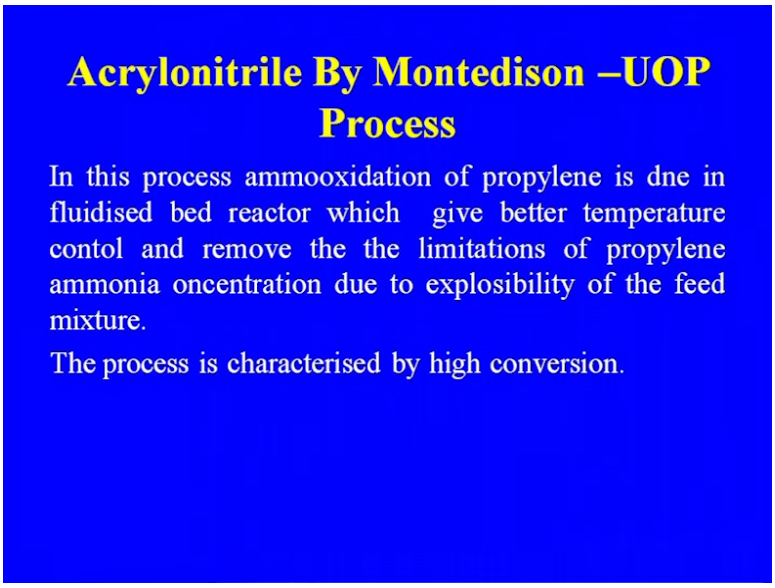

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In this process ammono oxidation of the propylene is done in fluidized bed reactor which give better temperature control and remove the limitation of propylene ammonia concentration. Because here the explosive mixture that is there in case of the propylene and ammonia so this process remove the limitation of propylene ammonia concentration. Due to explicability of the feed mixture the process is capitalized by high conversion rate and which is the basic requirement in case of the any process.

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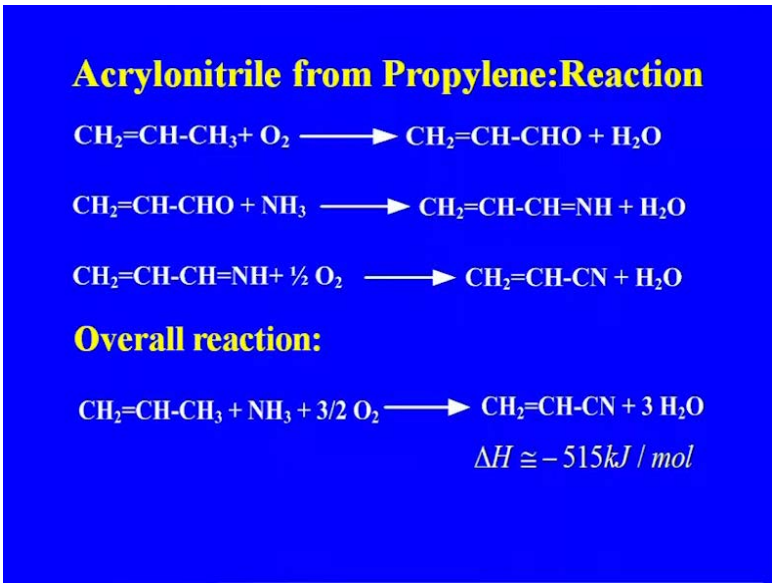

This is the reaction in case of the acrylonitrile manufacture. We are in the process we are also getting the acetonitrile. This is the oxygen propylene oxide from the propylene oxide and the ammonia that you are using for the acrylonitrile this is the overall reaction that is taking place.

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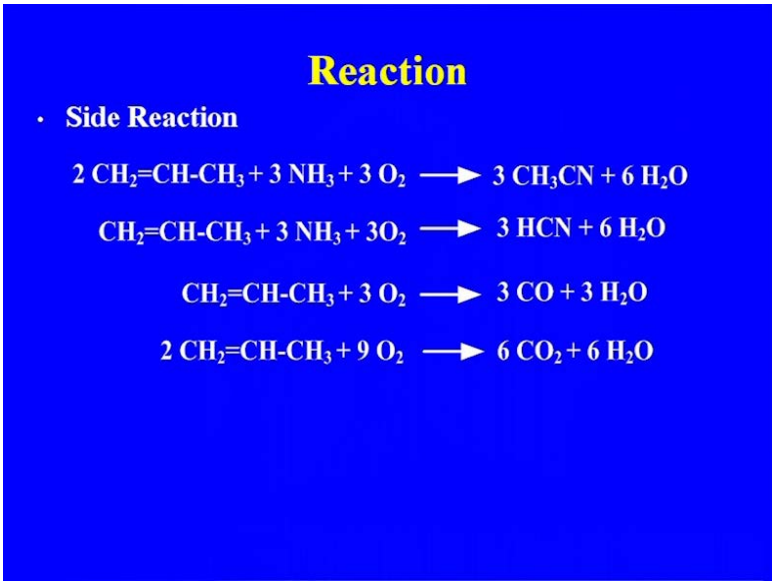

These are the side reaction that is taking place in case of the acrylonitrile where the HCN or the CH3 cyclone nitrile is there. So, that is the how the separation that can be there for the separation of HCN and the acetonitrile. Now, let us come to the fiber part. From the

acrylonitrile to acrylic fiber the process technology the two major steps are there. In the polymerization and spinning and after spinning definitely the fiber which is coming will be of going for the dying and the cutting bailing. That is the different that will be always there in all the process that is there.

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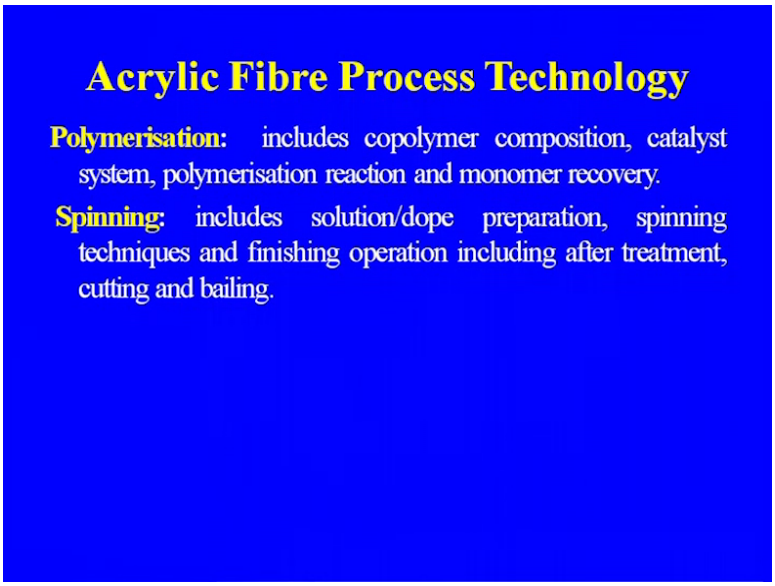

So, polymerization includes the co-polymer composition, catalyst system polymerization, reaction and monomer recovery. So, co-polymer means the when you are going to the modified acrylic fiber spinning process. This includes solution or the dope preparation or it may be the dye spinning techniques and finishing operation including after treatment cutting and bailing.

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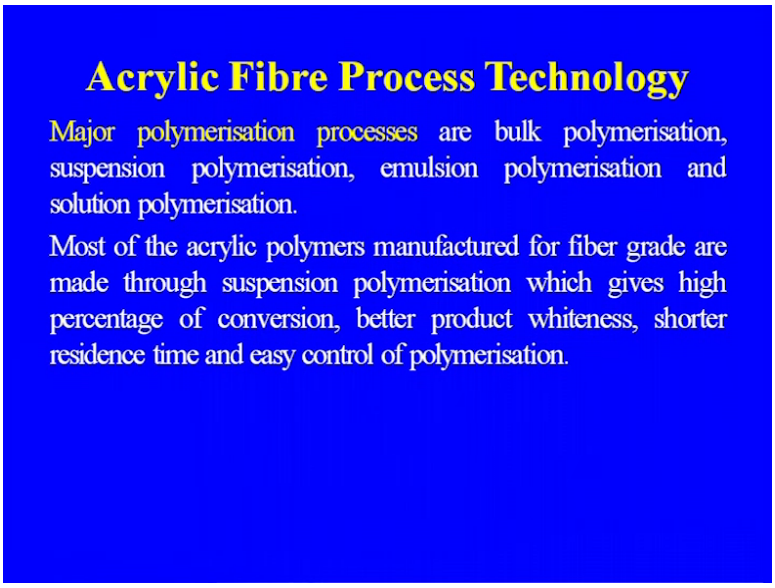

~~Then the major polymerization processes are bulk permission, suspension polymerization, emulsion polymerization and the solution polymerization. All the four process that can be but, common process which we are using for the acrylic fiber manufacture specially for the fiber grade that is, the suspension polymerization which gives the high percentage of conversion, better product, whiteness, shorter residences time and easy control of the polymerization.~~

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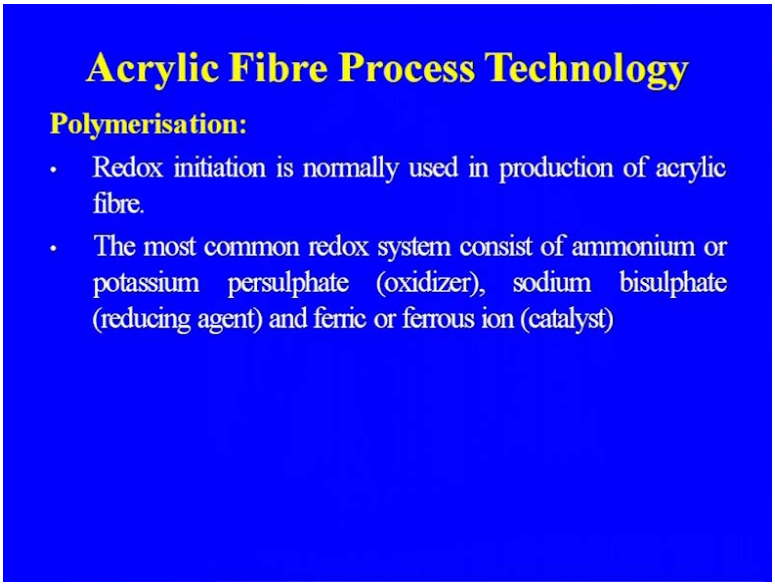

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Redox initiation is normally used in production of the acrylic fiber. The most common redox system consists of the ammonium or the potassium persulphate,, sodium bisulphate and the ferric or the ferrous ion. Now, as I told you the after the polymer is made the next step in any synthetic fiber is the spinning process. Depending up on the type of the material which you are having type of polymer which we are having the different type of the spinning process that is available. As I told you that dry spinning wet spinning or it may be melt spinning.

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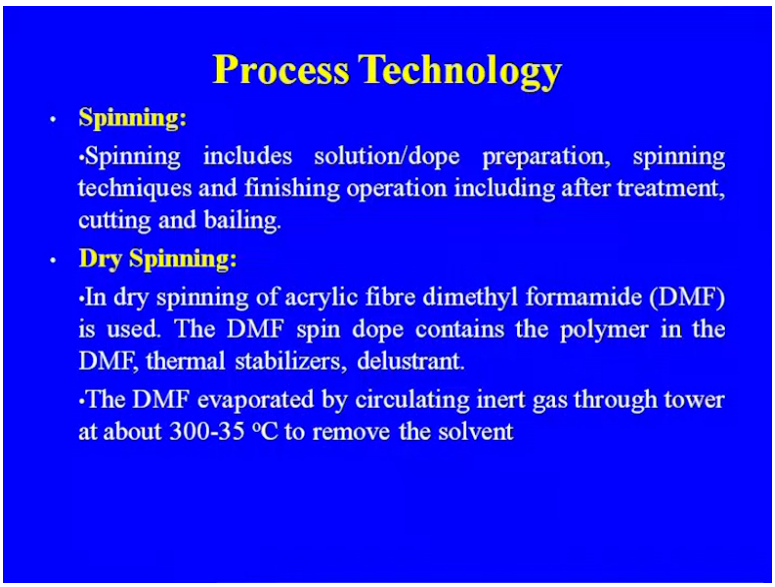

So, spinning include the solution or dope preparation spinning techniques and finishing operation including after treatment, cutting and baling. Dry spinning: in dry spinning of the acrylic fiber dimethyl form amide is used. As I told you earlier also the DMF spin dope contains the polymer in the DMF thermal stabilizer, delustrant the DMF evaporated by circulating the inert gas through the tower at about 30 to 35 degree centigrade.

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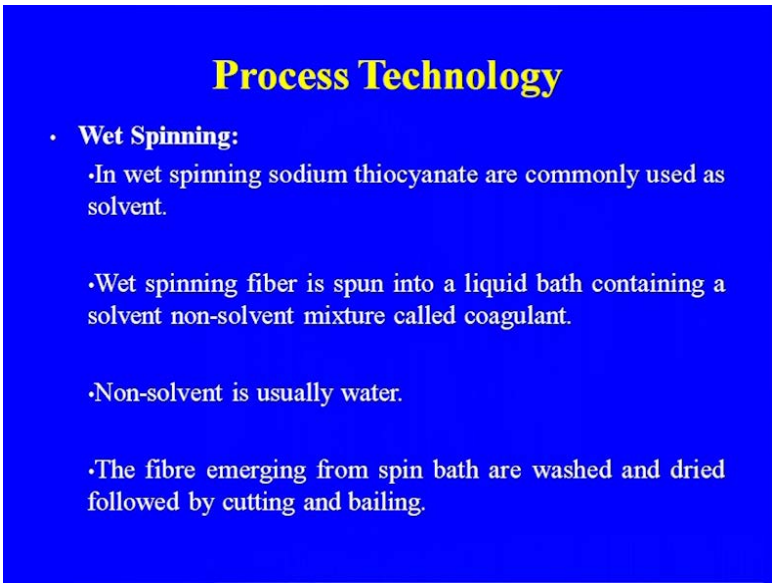

And in the wet spinning sodium thiocyanate are commonly used as the solvent. Wet spinning fiber is spun into a liquid bath containing a solvent non-solvent mixture called the coagulant. Non solvent is usually water. The fiber emerging from the spin bath are washed and dried fallowed by cutting and bailing.

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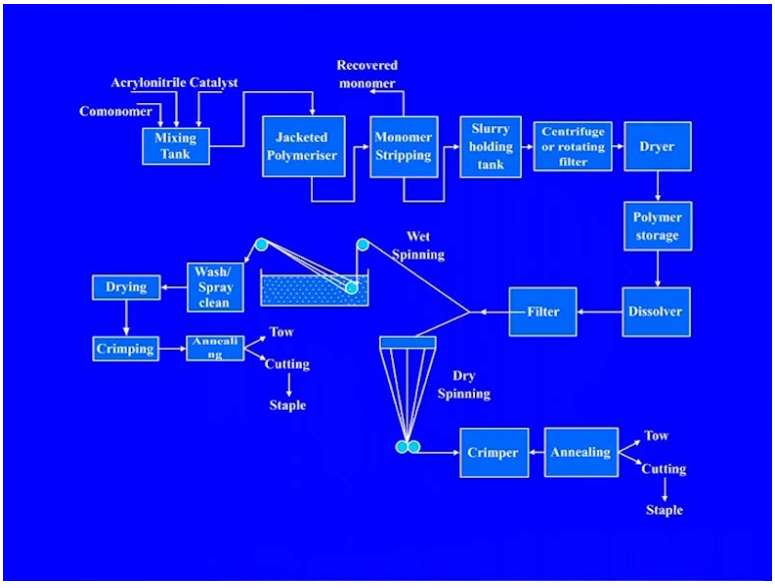

This is the process which we are having in case of the preparation of the acrylonitrile tow or the cutting to staple fiber is there for the acrylonitrile. So, mixing time where you are using the where adding the acrylonitrile catalyst or if you are using the co-monomer

then, the co-monomer will be also there. Jacketed polymerization, the monomer stripping which is recycled back and then the slurry handling, centrifuging, polymer storage then dissolver. Here we are having the dissolver but, here you see what is happening, here it is being passed through the spinning bath and after whatever are there that is going for the drying, crimping annealing tow cutting.

If you are having in the staple fiber then it is cut and so the same case. If you are interested in the fiber staple yarns then it will go through the spinneret. Here actually if you see in case of the wet spinning with the spinning bath it is going from a large number of the spray continuous moving and then rotating. And so whatever the fibers that is drawn that is going to the crimper then the annealing and finally, we are getting the acrylic fiber as staples.

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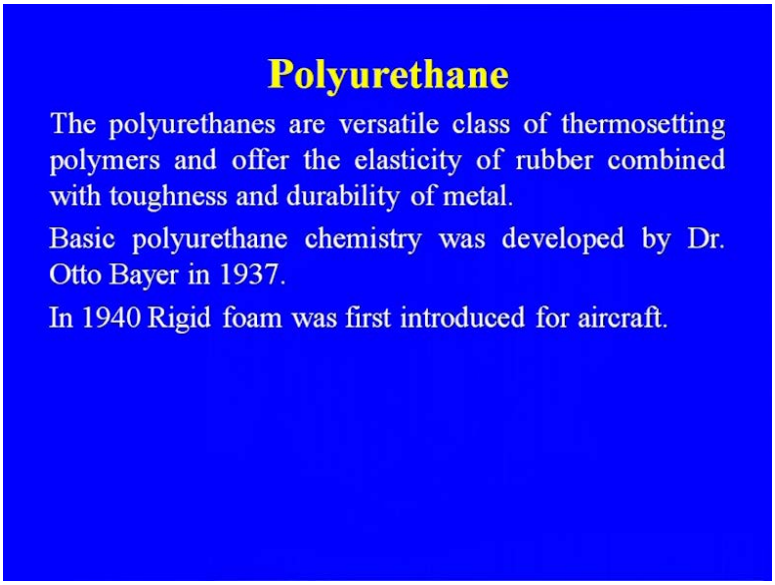

Now, let us discuss about the polyurethane that is also one of the important polymer. The polyurethanes are versatile class of the thermoset polymers and are offer the elasticity of the rubber combined with the toughness and durability of metal. So, basic polyurethane chemistry was developed in 1937 by Dr Otto Bayer. In 1940 rigid foam was first introduced for aircraft.

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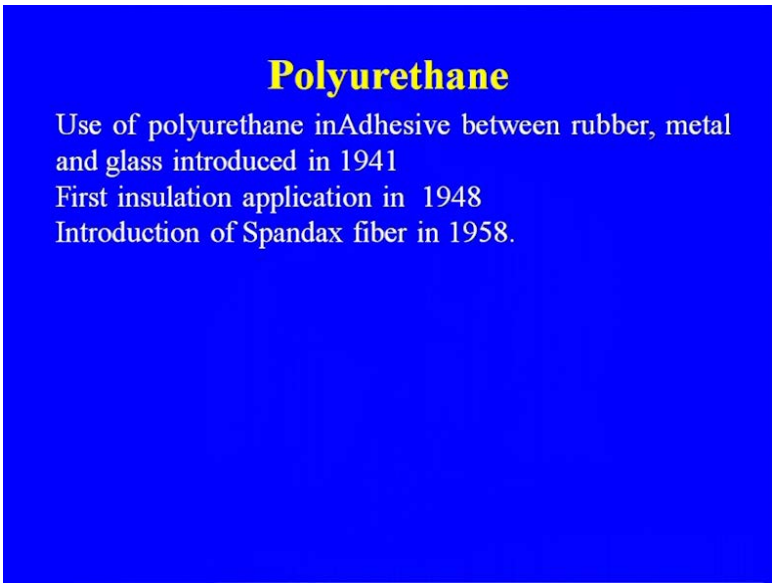

Use of polyurethane in adhesive between rubber, metal and the glass introduces in 1941. First insulation application in 1942-48. Introduction of the spandex fiber was in 1958. As the synthetic fiber industry for the textile started some of the polyurethane are also there that is being used especially the spandex fiber.

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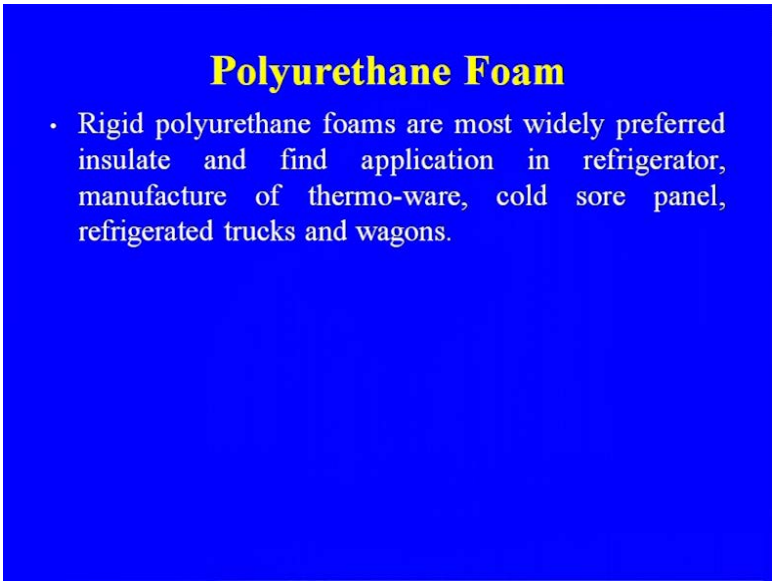

The rigid polyurethane foams are most widely preferred to insulate and find application in refrigerator manufacture of thermo ware, cold sore panel, refrigerated trucks and wagons.

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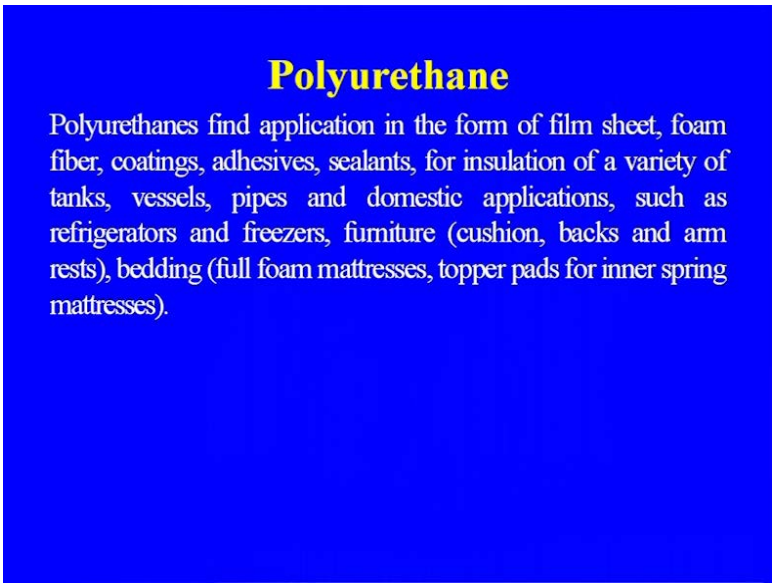

Polyurethanes find application in the form of film sheet, foam fiber, coatings, adhesives, and sealants. Some of the resins they are also going to the coating and adhesives purposes for insulation of variety of tanks where it has broad application for insulation purpose. Which we use to have the glass whole, vessels pipes, domestic application such as refrigerators, freezers, furniture, cushion backs and arm rests. Then the bedding full foam, mattresses topper pads for inner spring mattresses. So, these are the some of the broad application of the polyurethane.

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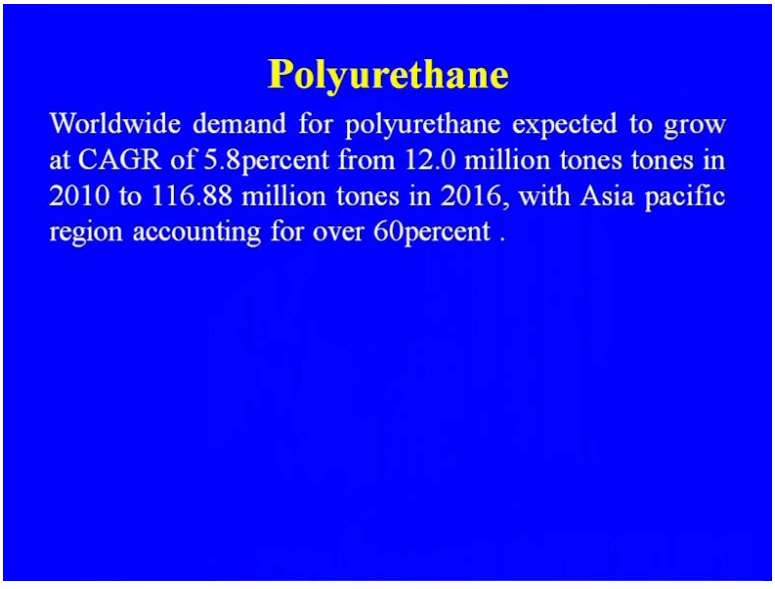

Worldwide demand for polyurethane expected to grow at CAGR of 5 point 8 percent from 12 point 0 million tons in 2010 to 116 point 8 million tons in 2016 with Asia pacific region accounting for over 60 percent.

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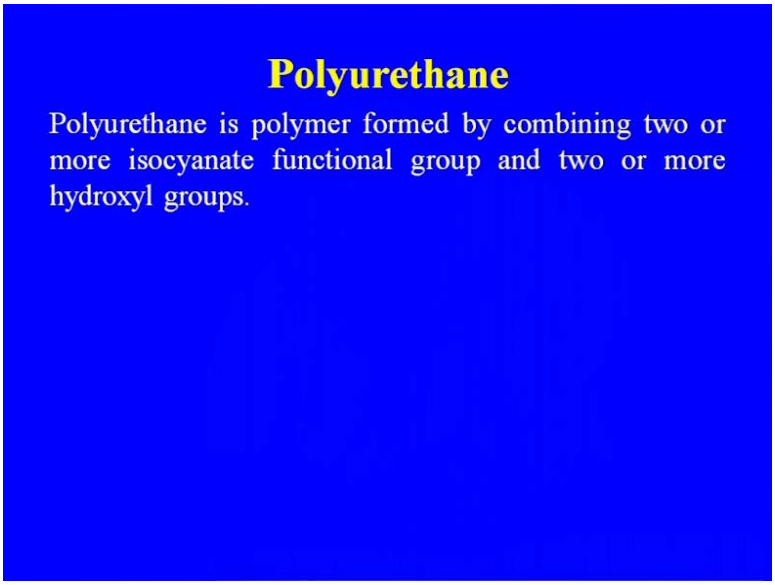

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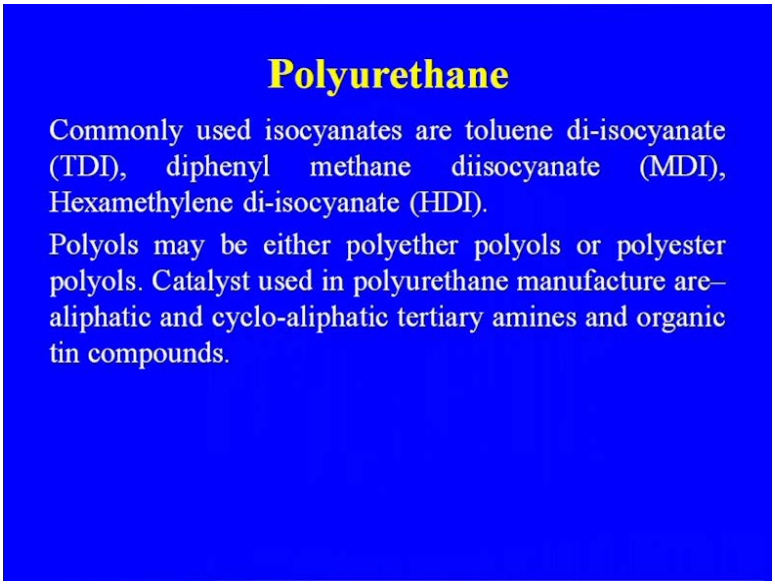

Polyurethane is polymer formed by combining 2 or more isocyanade functional group and 2 or more hydroxyl group. Commonly used isocyanades are toluene diisocyanade this is the one of the major consumer of the toluene. As I told you earlier while discussing the aromatic diphenyl methane, diisocyanade, hexamethylene diisocynanade

HDI. Polyols may be either polyether polyols or polyester polyols. The catalysts used in the polyurethane manufacture are aliphatic and cyclo-aliphatic tertiary amines and the organic tin compound organic tin compounds.

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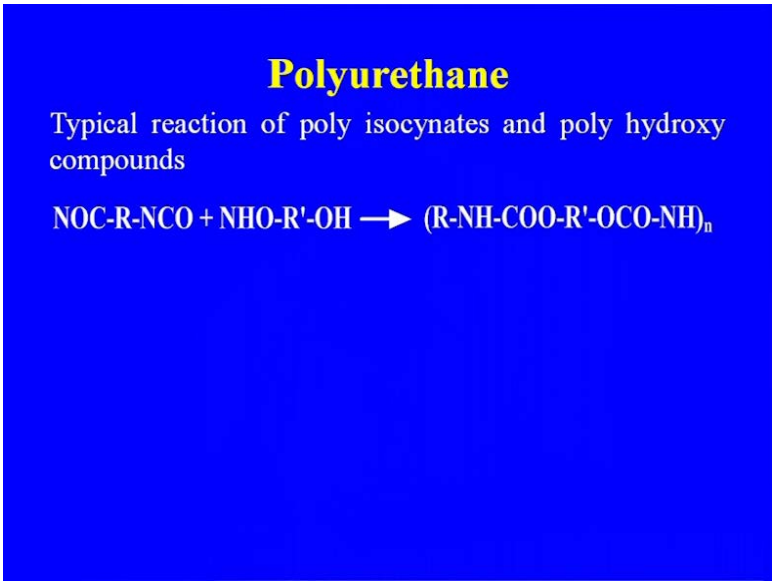

This is the reaction typical reaction that is taking place in case of the isocynates and the poly hydroxyl compounds which is we are using for the making of the polyurethane. Another type that is now it has become important in uses at the polyurethane foam.

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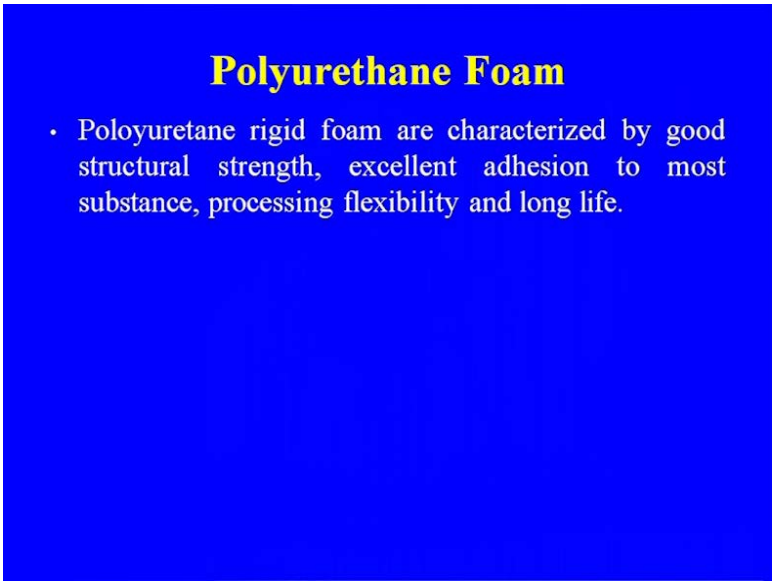

So, polyurethane rigid foam is characterized by good structure strength, excellent adhesion to most substance, processing flexibility and longer life. So, these are the some of the advantages of the in case of the polyurethane foam. So, this was about the acrylic fiber, modified acrylic fiber and then the about the importance of the acrylonitrile and the polyurethane fiber. Acrylic fiber as I told you that has replaced because of its low cost.

The conventional wool martial which is now just like in the cotton that is that has been replaced by the blend of the polyester and the your viscose rayon. So, the in case of the synthetic fiber industry the cellulosic raw material base fibers are also playing very important role and they are also very important sector.

Although it is not considered a part of the chemical organic chemical industry or the petrochemical that is more concerned connected with the pulp manufacturing or the pulp and paper industry. Because some of the paper industry they are making the your rayon grade pulp and that is one of the century rayon which is having one unit and harrier ploy the Birla's they are the pioneer in case of the making of the rayon in the it may be viscose rayon by the harrier poly fiber by Grasim industry that is the they are having a at Nagaba.

So these this is the importance in case of the viscose rayon and then we are having the acetate rayon which is having the silk like appearances so that will be discuses in the next lecture in the lecture number 8 of the this module .