Textile Finishing
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Lecture No. – 11
Soft Finishing Contd.

Welcome back to the class on textile finishing. Let us see what have we done till now.

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We tried to understand what is the need for softening treatment. We are talking about textile softeners and soft finish. The mechanism, what is the way in which we do? Generally, we understood that you have to reduce the friction between the fibre, between the yarns, and that would result in softening.

We tried to generally broadly classify softeners and the surface active agents and the emulsion formation, the need for emulsion formation also we tried to understand and we did give some examples of anionic softeners which obviously have the hydrophile as an anion, and the rest of course is hydrophobe which is supposed to give us the lubrication or reduction in the surface friction, that is right.

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So, we continue with soft finishing in this part of the lecture and today we will try to talk about three types cationic, amphoteric, and non-ionic softeners. All these softeners are in some way have an embedded hydrophile along with a hydrophobe.

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So, let us say, first we spend some time on cationic softeners. So, if somebody asks what is the essential part, obviously, it looks cation.

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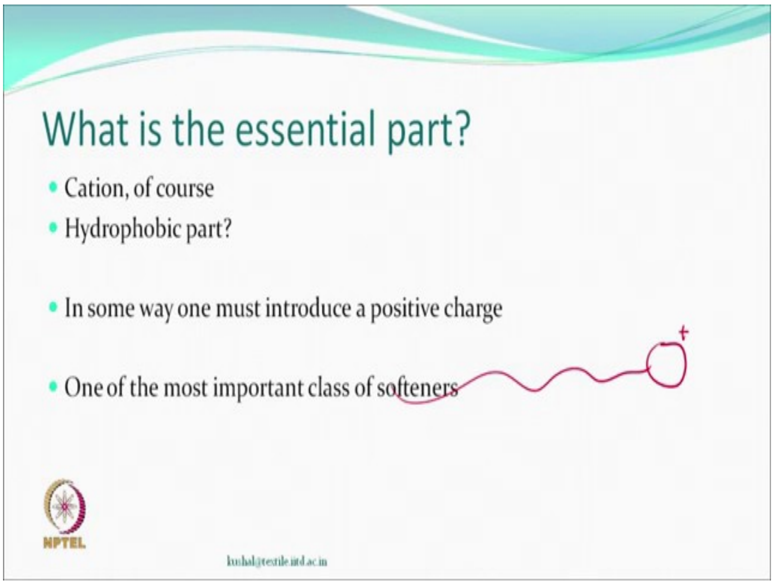

If it has got the cation, then it is a cationic softener. But obviously we should not forget that there has to be a hydrophobe. It is the hydrophobe which is the softener part. The nature of the hydrophile is cation, and therefore, it is a cationic softener. Ok. That is very simple. In some way we have to introduce a positive charge in the molecule. If that can be done, then it will be considered as a cationic softener.

So, two parts, one is the hydrophobe which is a long chain fatty compound connected with a hydrophile which must be a cation, right? Okay. It so happens that this is one of the most important class of softeners. A lot of textile people would like to have it.

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Why why would you like to have this? So, this catatonic we are talking about softeners, right? Substantive; it is believed that these cationic softeners are substantive. They like the textile and therefore the chances are that the wash fastness of such type of compounds on a textile is going to be better. That is one part. And so, people like it. And why they are supposed to be substantive. Let us have a look at the process.

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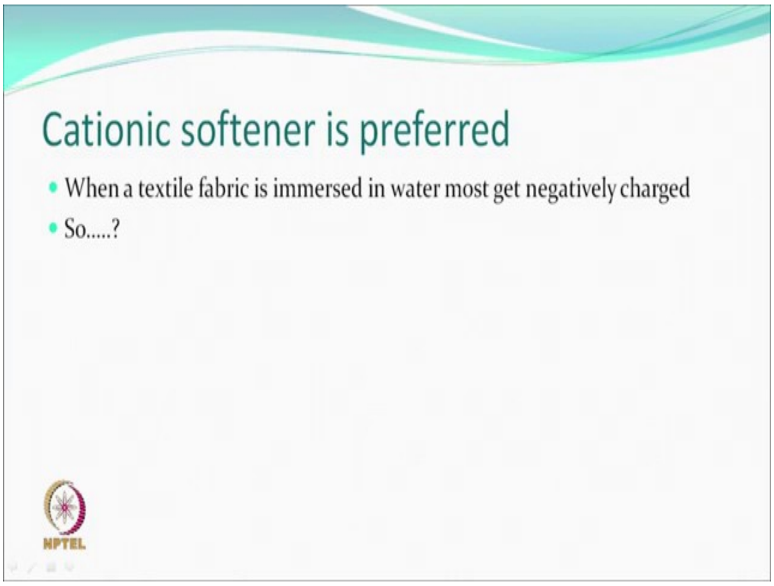

During dyeing or other processes that you may have done on the wet chemical processing, that whenever you immerse a textile fabric in water, it has been probably told to you that it assumes certain amount of negative charge. So, this is true. If this is true, then if the fabric surface has a slight negative charge, then the positive cation or cationic compound like a cationic softener would obviously be attracted towards the surface.

That is an interesting part. So, it becomes substantive, and because of that also the fastness properties are pretty good. Now, let us see what are we talking about.

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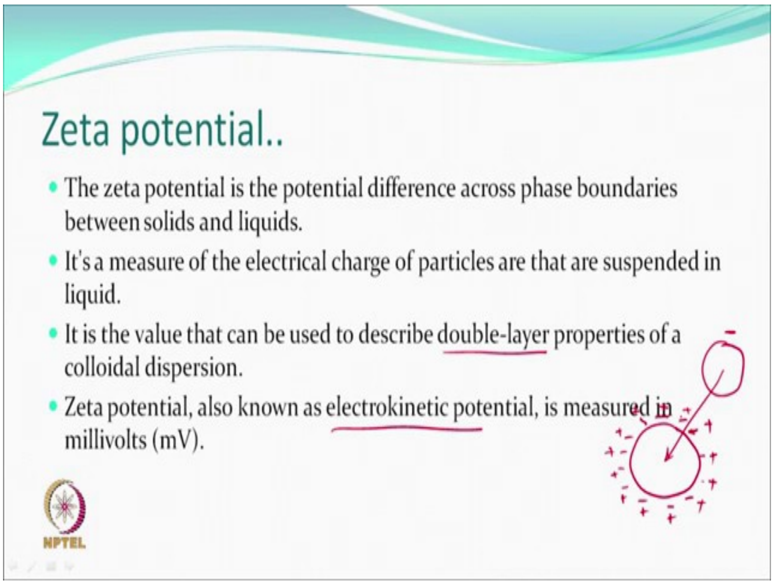

There is a term which you may have heard called the Zeta potential Zeta potential. Now, this is an interesting potential which, in some way, either helps or restricts the diffusion of chemicals in solutions, in the fibres, if they are being transmitted, diffused, solubilised in an aqueous solution. You understand a large number of chemical processing systems are based on aqueous solutions, whether it is dyeing or it is applying any other chemical like a softener.

So, they are generally in the aqueous medium including what we did before was the anti-crease or crease-resistant finishing treatment. So, what happens then? In case we are dependent on this exhaustion, diffusion through the surface, then this potential becomes an important component in determining the process conditions. So, as defined in general this potential is the potential difference across boundaries, let us say solids and liquids.

Now we are talking about solids and liquids, it could be a particle which is suspended in, let us say, an aqueous or in our case it could be a textile which is a solid which is now in an aqueous system. So, obviously there is a phase different, there are boundaries, so you have a solid and liquid, so you have a liquid-solid interface type situation. So, that is one interesting thing.

It is also defined as a measure of electric charge on the particles that are suspended in a liquid. Now, in our case, we are talking about water and textile as a solid, but theoretically this is defined for any solid and any liquid based on their nature. So, it is also a value that can be used to describe a double-layer property of a colloidal dispersion. So, something is there, let us say you get a negative charge on the surface and something positive will collect around the particle.

For example, if you have a particle which, let us say, develops some type of a negative charge on the surface, remember now we are talking about surface, so if there are positive particles around, let us say, a cation is available, then obviously it will get attracted to this positive charge and you get what we call as an electrical double-layer.

Now, this sometimes can be important if you remember. We add, let us say, in a direct dyeing through an exhaust process we add electrolytes like Glauber's salt to create such an electrical double layer so that a good molecule which we are interested in may like to diffuse inside, if particularly like a direct dye which also has a negative charge. Otherwise, it would have been repelled, all right?

So, this is an interesting proposition. So, like anything else, it can be measured in millivolts and also known as electrokinetic potential. That means you need some motion also. Whenever there is a motion there is a kinetic involved. And so, you will get this change in the surface, let us say, charge, very mild, but it does work.

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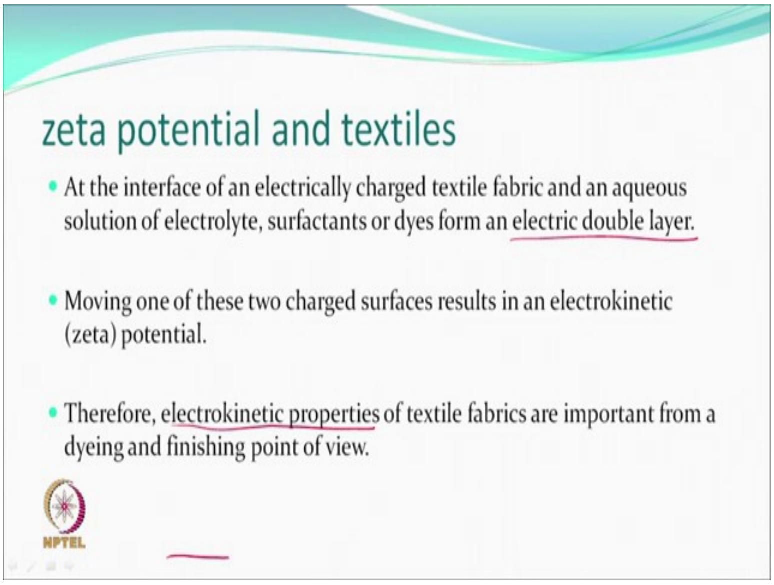

Now, as far as textiles are concerned, let us see. So, one important thing is at the interface of electrically charged textile fabric and aqueous solution of electrolyte, surfactants, dyes can form an electrical double layer, all right, can form like we just saw in any particle. So, moving one of these two charges are charged surfaces would result in result in some kind of a potential difference.

And this potential difference obviously will be seen in a double layer. So, if a dye has to diffuse, if some compound has to come to the surface, if some compound is resisted from a surface, you may be interested in that also, then there is definitely an importance in the wet processing of textiles of this so called electrokinetic properties, okay? That is an important part.

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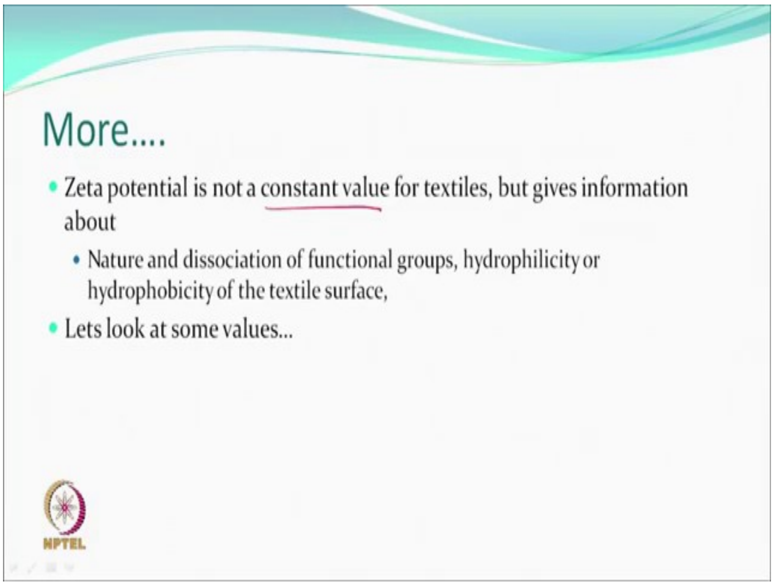

More? What more? That this is not a constant value. It is not like thermal conductivity of a material or density of a fibre. So, this is not a constant value, but it does talk about, in a given situation, how the functional groups, the hydrophobicity or the hydrophilicity of the textile, will result in some type of electrical surface charge, right? This is a dynamic system. So, let us say, just for getting some ideas to what exactly are the values and what we mean by that.

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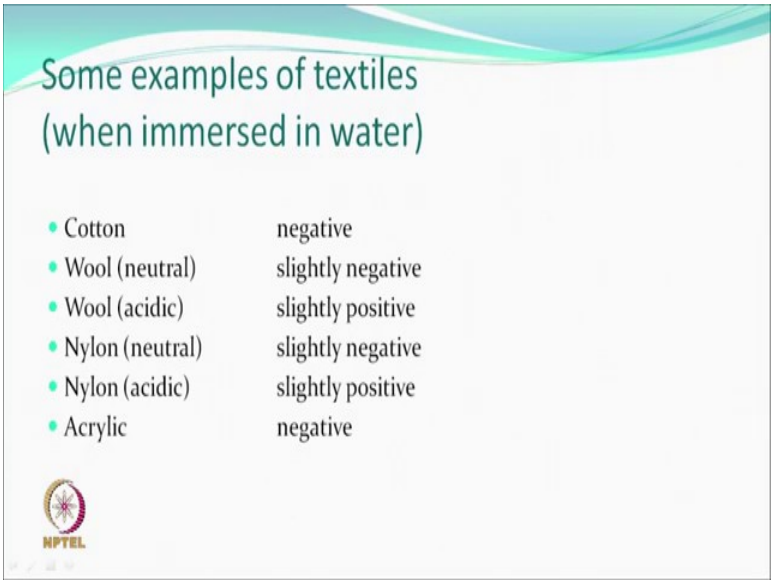

So, let us say we talk about cotton fabric. In general, when you immerse in water it generates some kind of a negative charge, that is a general, but if you look at wool, this does not immediately behave in the way that cotton has behaved, no. It depends on the pH. If the wool fabric or a fibre or a yarn is submersed immersed in water, if the pH is neutral, then it gets a negative charge. But if it is acidic pH, then we know it gets a positive charge.

That is why acid dyes can go in, right, do we do acid dyeing in acidic pH, right? True, is it not? So, when we said the last statement that this is not a constant value, the nature of the charge itself says how can the value be constant, right. So, it will depend on the process conditions. That is one important thing you may like to note.

Similarly, nylon which is a polyamide, wool is a polypeptide, but generally in acidic medium nylon also gets a positive charge, and therefore it is dyed by an acid in acidic medium. But in neutral you have a negative charge. Acrylic in general may be found to have negative charge. That means that every textile in every condition may not get a negative charge. So, one should be aware of this, right?

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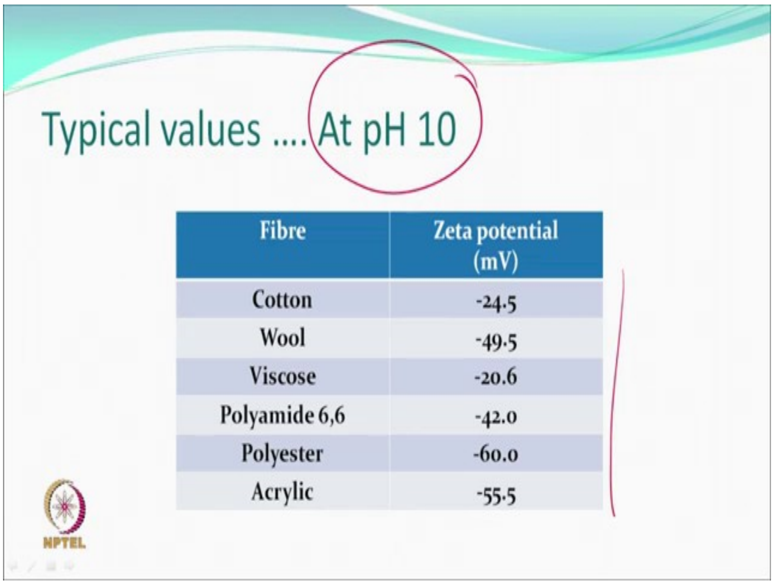

However, it is interesting to note at a pH which is 10 most of them have negative Zeta potential. That is interesting. So, if you have to do anything around this pH, then you will find, well, most of them are negative, so you must add or subtract from the bath type of ions which you do not require, you can remove them. If you require them you have to and they are similar charge, then you will have to do something, make an electrical double layer for something else, okay, like when you want to do.

As I said, a negatively charged direct dye would find it difficult to penetrate the cotton because it also develops negative charge, but if we put electrolyte, then double layer is created. The charge in some sense is neutralised and the dye can then relatively easily diffuse into the fibre. So, what we are saying is that these values, or shall we say the Zeta potential or electrokinetic potential does play a role.

So, in case we find that our substance is generally going to get a negatively charged surface, then obviously cationic softeners will be attracted. Is that right? So, if it does not, then you have to know what is to be done.

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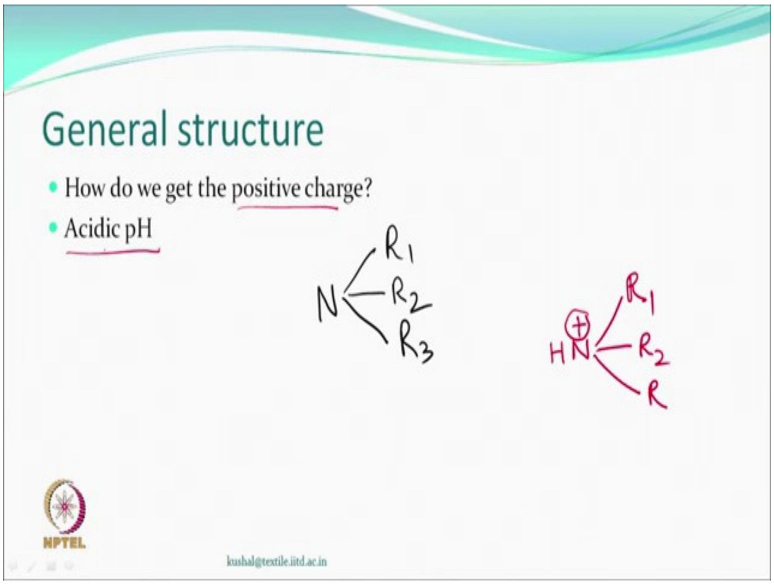

So, if you look at the importance of cationic softener is that because most of them around neutral or around little alkaline pH would be negatively charged, so they would have a tendency to go and adhere, and then after that either they diffuse or deposit onto the surface, right? So, let us say a compound like this which is amine-based compound, it has got very satisfied arrangement, how do you get a positive charge?

It can get a positive charge in acidic pH and then what will you get? You will get, because of the acidic nature, you will get a proton and then you will get this positive charge. And so, if you are in some conditions of this kind, then you will be able to easily use these compounds, so you will get some positive charge.

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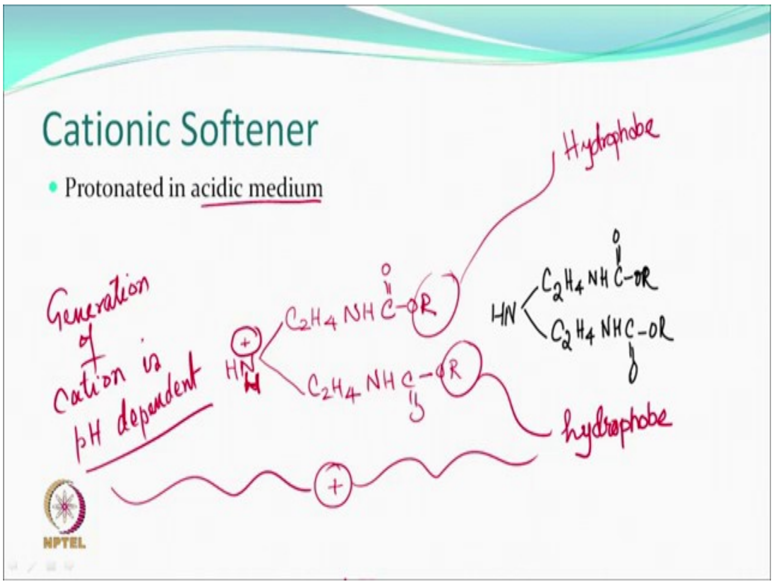

For example, another cationic softener which has a structure like this. So, what will happen here? You have nitrogen and then some R, which is I am just repeating what is written there, and another one also is similar looking, so it already had a hydrogen. When you go to the acidic medium, then the protonation will take place and another hydrogen will come into play, and then you will get.

So, these are the examples of softeners. So, from where the softening effect is coming? It is coming from here. The interesting part also here is that if you consider this as one hydrophobe and if it is the same one, this is also in a hydrophobe, so the cation or a cationic group is embedded, but not at the end. So, it is something like, you have a hydrophobe and a hydrophile which is cationic and another hydrophobe that is in the centre but it still works.

After all, what is your idea? Idea is that it should be water soluble, right? Why are you making the ionic compounds, why? Because we want them to be water soluble. Do you realize something here that this cation is getting generated in an acidic medium. So if it is an alkaline medium or a neutral medium, the same compound may behave differently. There may not be any ion. Now, this type of a compound therefore is, if you call it, pH dependent.

So, the nature of the cation or generation shall we say, generates an cation, is pH dependent. That is something which we have to realize but may not like it, right? So, if you have a process situation where the softener has to be used which is a cationic softener and the process conditions that is an acidic condition and generally the surface, for example, has negative charge and it will get attracted, right?

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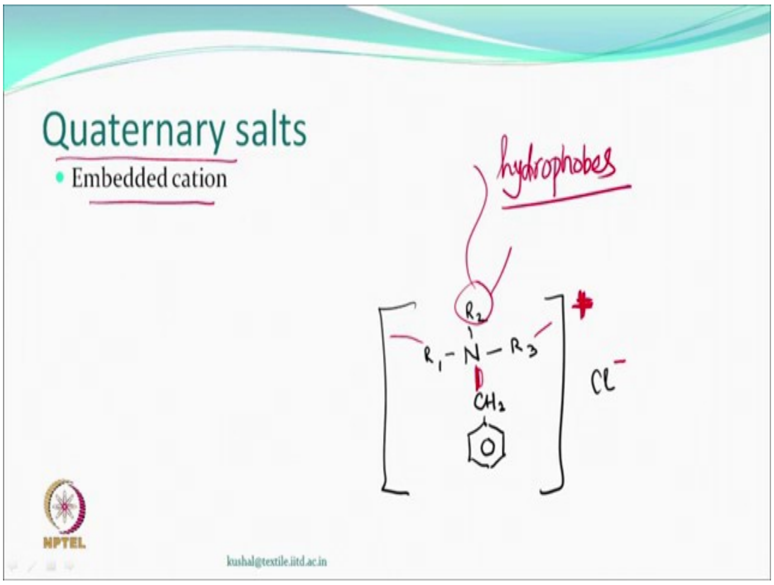

There are other classes of cationic softeners which are dependent on quaternary salts, okay? Now, here it has an embedded cation. Now, this compound has got all the portions connected and because of this structure which is called quaternary this compound always has a positive charge. This is interesting. So, if one of the Rs or most of the Rs are hydrophobes, then you have a softener which would have embedded cation and is not going to be pH dependent.

Does it make sense? This class of compound therefore is advantages. It is a cation, so it has some advantage, some affinity for the substrate and this is going to be available almost at all pH unless and until you destroy the compound which obviously you will not do.

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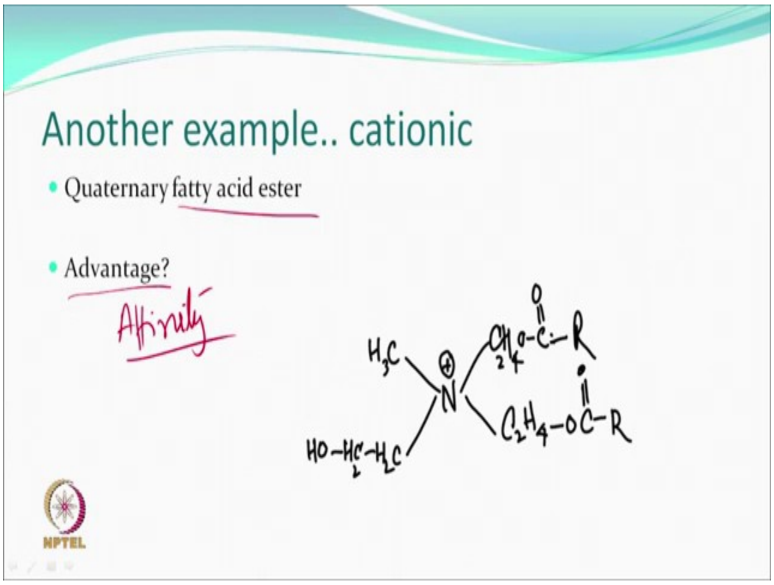

So, another quaternary compound is given here which has a positive charge embedded because of these four groups which have been attached, okay, and so this will be also the advantage we considered this type is pH independent more or less and affinity so good affinity and pH indepedence are the advantages. So, cationic softener therefore are an important class of softeners which are almost used in every process house.

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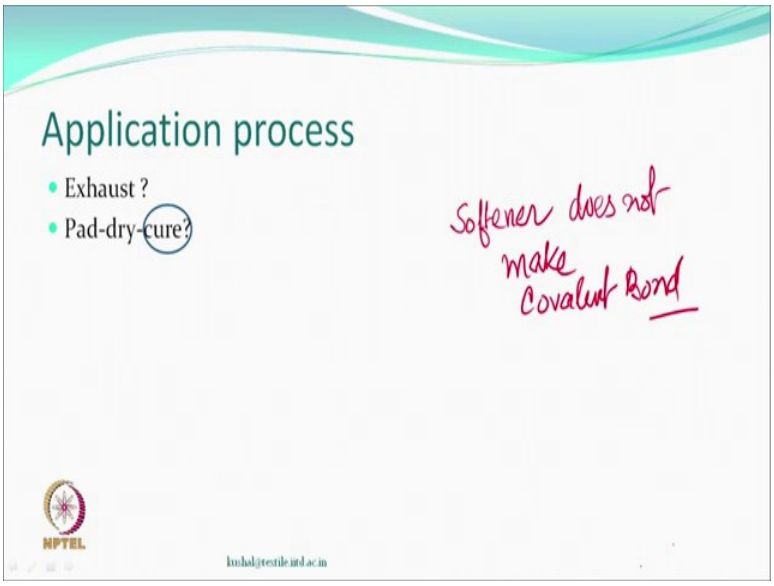

The application; exhaustion? Yes, of course you can. If the bath is such or the process is such which requires an exhaustion to take place and if it can easily be added, then this is a good way to add through an exhaust process. Of course, you can add these compound in a pad-dry cure process also.

But remember the curing is going to be important for the other chemical. Let us say, if it is applied through or along with a crosslinking agent which is going to be cured, so the curing will be there for the crosslinking agent, but the cationic softener does not chemically covalently bonded. Is that right? So, you must remember that.

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Compatibility, well, what are we talking about? Compatibility will depend on, if you are adding in a bath, what is the charge there of the other chemicals. If the charge is negative on the textile, you are very happy about it. If there are many other chemicals which have to be added and they are negatively charged, then what would happen? Yeah, it may not be the best situation. Is that okay?

It will not be the best situation because it can react with that and because it has got a large hydrophobe, it can precipitate and you do not want precipitate systems. That would not be good for any kind of reactions. Do you understand? Otherwise, they are pretty compatible. Of course, when such a situation comes where one of the agent is going to likely to react, so then the other processes, separate processes, you know softening is an important thing.

And if somebody believes that you can get value and lost value to your textile material, then you can also use it as a separate process. In that case, there is no issue of compatibility in a particular bath because that process is over. Now, the textile is already partly finished or one part of the finish over or dyed, and now you are applying a softener. So, its function will be served by applying, by almost like a pad dry process. You will not have to go for cure process that can be done, you do not have to go for an exhaust.

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There is other class, not so important class, but interesting class. They are called amphoteric softeners, amphoteric And what does amphoteric means? This means that you have both anion and cation in the same molecule.

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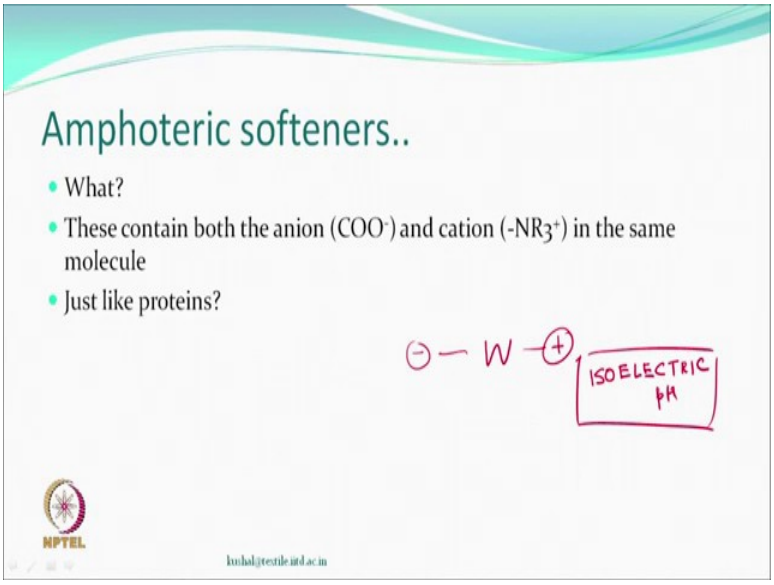

If you have anion and cation in the same molecule, then you will have an amphoteric softener. Do you remember any molecule which we use in textile? Proteins, silk is a protein, right? Wool is a protein. So, in a wool you can think of a cation and an anion on the same molecule. You remember that because of this at one level of pH it would behave in one way, at other pH it behaves in another way. And of course there can be a balance at a particular given pH, there can be balance.

The number of negative ions could be equal to positive ions. That is possible at a particular pH which will be different for different proteins. Silk will have a different pH. The wool will have a different pH. Other proteins will have different pH. Sometimes you may have heard about this term called the isoelectric point or isoelectric pH. So, that is where the negative charge in the molecule is equal to the positive charge in the molecule. So, different pH in different ways. So, these kinds of things also will behave almost like that.

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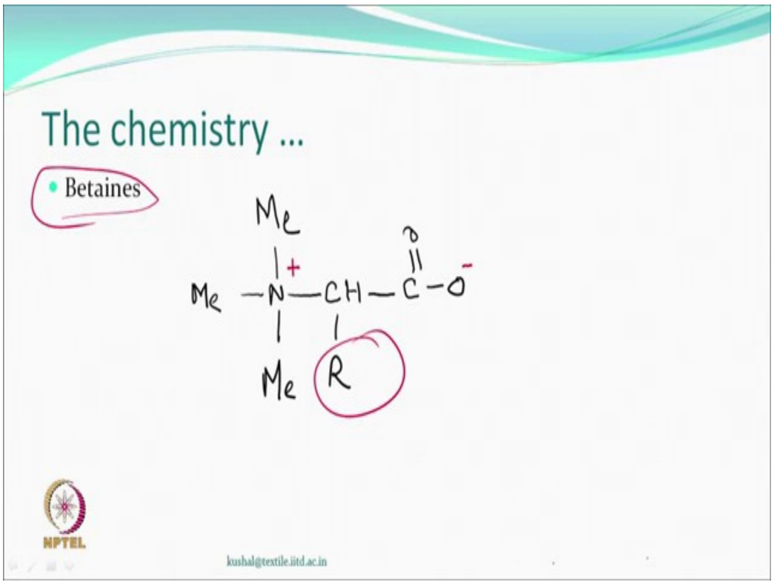

One of the interesting compounds which is used for many purposes, softeners we are talking about here, they could be a surfactant, they could be any surfactant, which also can be used, like betaine, so there are such betaines. They are important compounds from the point of view that they, in our case, are giving softening. In the case of a surfactant it can give the property of a surfactant which could be reducing the surface tension or doing some dispersion or any such things. So, all that is possible. You can see you have a possibility of this and you obviously have this, interesting compounds.

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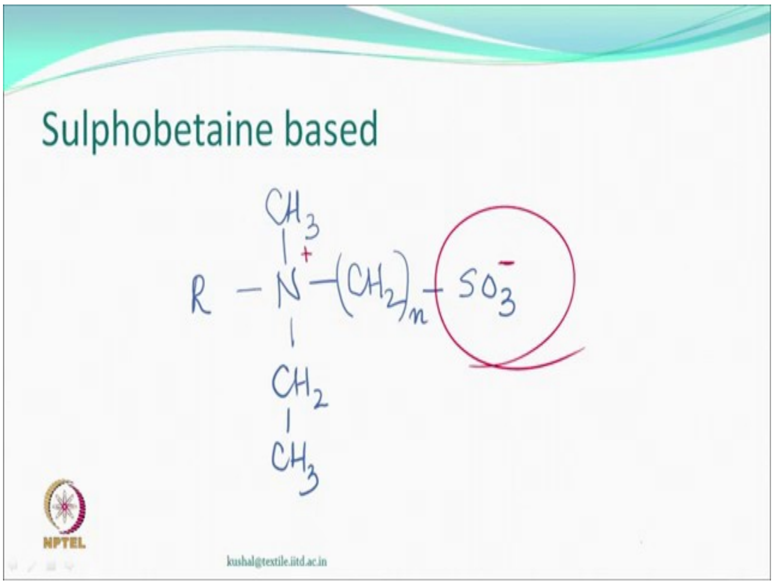

Another compound which is similar is sulphobetaine based compound, okay. So, because of the sulphonic group instead of a carboxyl group you have sulphonic group.

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And so, we have another class of compound which is not ionic. So, you have the amphoteric, you have the cationic, and you have the anionic hydrophile, but a hydrophile which is non-ionic, but it is a hydrophile.

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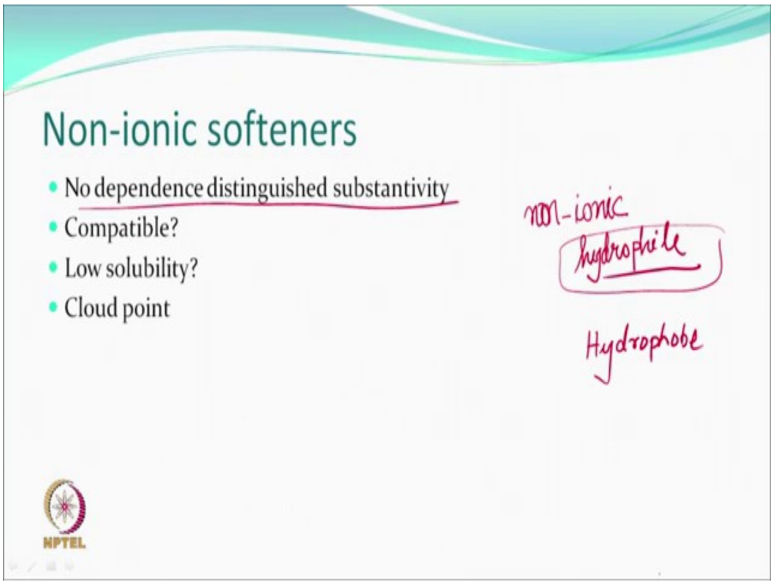

So, what we are looking at, non-ionic hydrophile. Of course, it will also have a hydrophobe which is the part which gives us which gives us which gives us the softening effect. So, important part is it does not depend on substantivity in general. It is So, wherever there are issues of compatibility, then you can add this type of softener. There are positive charges, so cationic can be added, but anionic cannot be added. If there are anionic things, cationic cannot be added. But here we are getting a distinct advantage of compatibility.

That is why someone will go for a non-ionic softener. But this is an important part which must be remembered, that they would have low solubility. For example, if you have simple compounds which is, let us say, stearic acid, that one by itself is not or alcohol of a fatty acid although the OH group or COOH group are hydrophilic, but that is not enough for solubilising unless you make it ionic, and we do not want to make it ionic.

If you do not want to make it ionic, then this hydrophile has to be worked around. So in general, their solubility compared to an ionic compound is going to be less, is that right? We do not want them to ionise because if they ionise, then they are either anionic or cationic which we already talked about. So, low solubility is there. So, if it is a disadvantage, then it is a disadvantage.

There is another term which we use whenever we talk about non-ionics, either surfactants or softeners. In some way, we have accepted a softener is also like a surfactant doing a different job, right? So, there is something called a cloud point. What is a cloud point? Let us see.

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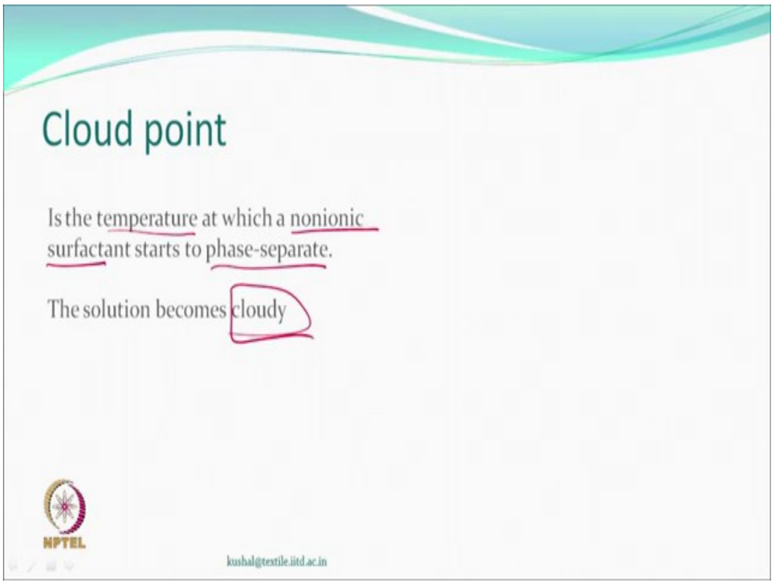

Cloud point is a temperature, a particular temperature, at which a non-ionic compound like a surfactant will phase separate, phase separate means come out. So, when it is in a solution, it looks like a single phase, two compounds, one is water let us say, other is a non-ionic softener and you mix them up properly. It is a nice beautiful solution. Whatever we have done to the molecule of the hydrophile we have done whatever we have done, so there is solubility.

So, softener is soluble, but then at a temperature its phase separates. That means the surfactant will come out of the solution, and as it comes out the of solution the solution becomes cloudy, milky. That is what it is called the cloud point. So, at a temperature where the solution from a transparent appearance goes into a cloudy appearance that temperature is called the cloud point.

And this remember, the cloud point is talked about only with respect to the non-ionic surfactants are now softeners. Right. With anionic system this cloud point is not an issue, there is nothing called a cloud point there. So, it is a new phenomena which also gets associated. Two things which are important from the point of view of a non-ionic; one is that its solubility is reduced, is lower compared to an ionic compound.

And it will have a temperature which is going to be limiting temperature, say cloud point. After all we dissolved something, so that remains in solution. So, if your process required higher temperature, a temperature higher than the cloud point of that non-ionic compound, then you will not be able to use this. Otherwise, it has the advantage of compatibility.

Without, irrespective of which are the type of ions present in the bath you will be able to add it. So, everything comes with some baggage, right?

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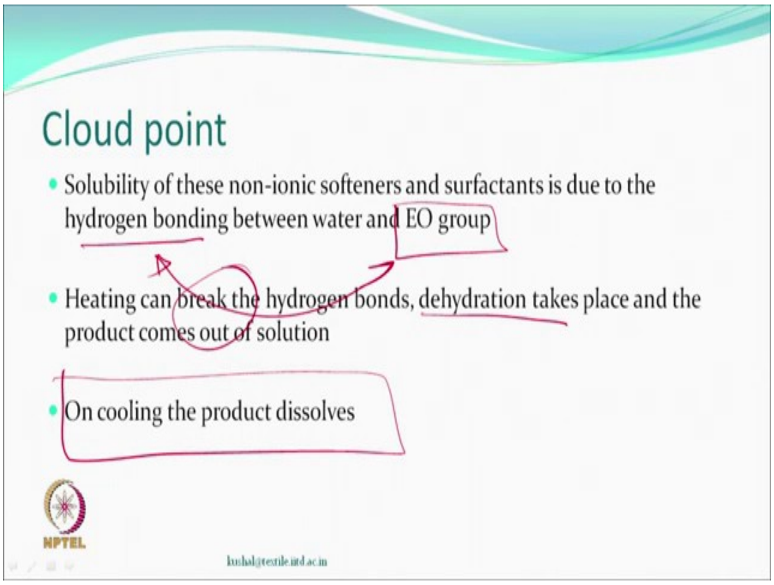

So, what happens? This solvency or dissolution of a non-ionic compound happens because some of these groups which are the hydrophile or related to the hydrophile can make hydrogen bonds with water. Right. So, in water either you make an ion so it becomes soluble or you make hydrogen bonds like, for example, if you add methyl alcohol or ethyl alcohol in water, they just become soluble, right. And why it becomes valuable?

These compounds are able to make hydrogen bonds with water. Without these water molecules are making hydrogen bonds with each other. Now, if you add something like what we talked about and some alcohols of methyl and ethyl type, they will also dissolve. But when the methyl becomes ethyl and keeps on increasing the carbon chain and goes up to, let us say C17, C18, C16, it is not water soluble.

That is one part, but you have made it water soluble by using some of the groups called ethylene oxide groups. We will just see some of the examples. So, these groups can make hydrogen bonds with water. So, they remain soluble. When you heat, increase the temperature, the first casualty is this weak hydrogen bond which has been formed with water through an ethylene oxide group, it would break, you can call it dehydration.

Breaking of the hydrogen bond and the product will phase separate out into solution and would look like cloudy, right? And so, But this is an interesting part. This is not a one-way phase change. If you cool that, it will go back again. So, what is heating? Heating is kinetic energy, molecules start vibrating, and so the water molecules start vibrating, the softener molecule will start vibrating, the hydrogen bond is the casualty.

If you reduce the temperature the kinetic energy goes down and then again it can dissolve. So, the compound is not broken down, nothing has happened to the compound, right? So, what does it say? It only says that these type of compounds are going to show some amount of phase separation after a certain temperature. So, your process condition or process temperature should be less than that. If that is there, no problem.

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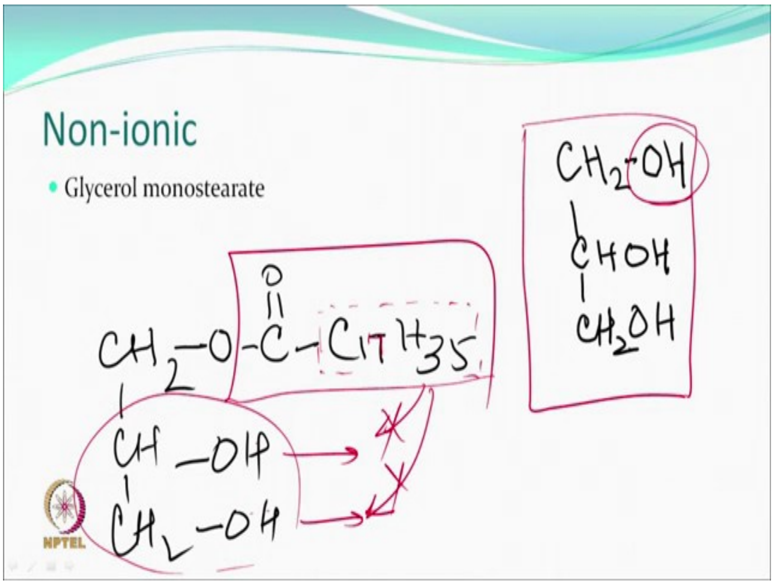

So, you have seen this compound which is glycerol. If you replace one of these groups by stearic acid group, then it becomes a softener, okay? And these groups are left free. So, it is one type of a non-ionic softener. If suppose, I replace this one also and this one also with this type of a group, then what will happen? It will not be water soluble. So, even at room temperature it will not be soluble. So, it becomes a compound which is not going to be a useful softener, and therefore we are not going to be doing this kind of job.

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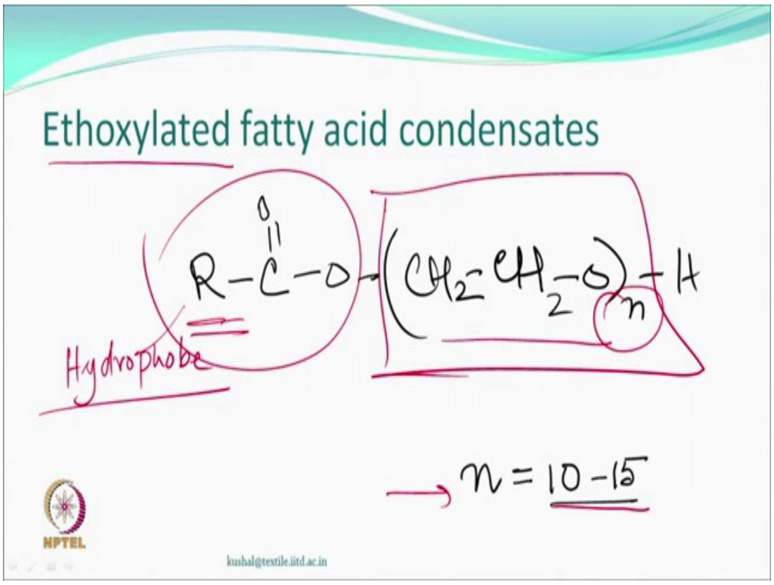

But remember what we had. We had one hydrophobe as stearic acid or a stearate of glycerol, this was the hydrophobe, this actually is the hydrophobe. But the hydrophile is this area which has some affinity for the water, and therefore, some dissolution can take place. But the solubility of this product is also not very high. So, what do you do? Will you say we do ethoxylation of fatty acid.

R is important to us as a hydrophobe, Correct, but here we are now getting into another oligomeric system which is derived synthesised from ethoxy groups and so you have ethoxylation. This number n could be if 10 to 15, you can keep on increasing, no problem, it would determine the solubility. If this number or this number is large, solubility will be higher. If this number is less or smaller, solubility will be less, is that clear?

That means you can play around with the solubility of the molecule and theoretically therefore with the cloud point also, okay, because if there are more possibilities of getting hydrogen bonds, then the chances are it will be more soluble. So, you have this hydrophile now is a long thing remember. We had a hydrophile like an anion suddenly it is water soluble, a cation suddenly it is water soluble.

But in this case, it is a non-ionic thing, you need a little longer chain. So hydrophilic and lyophilic balance, these comes into play. Hydrophilic-lyophilic balance, you change this it will be more soluble or less soluble depending on what you actually are looking forward to. That is interesting, is not it? So, you have some control.

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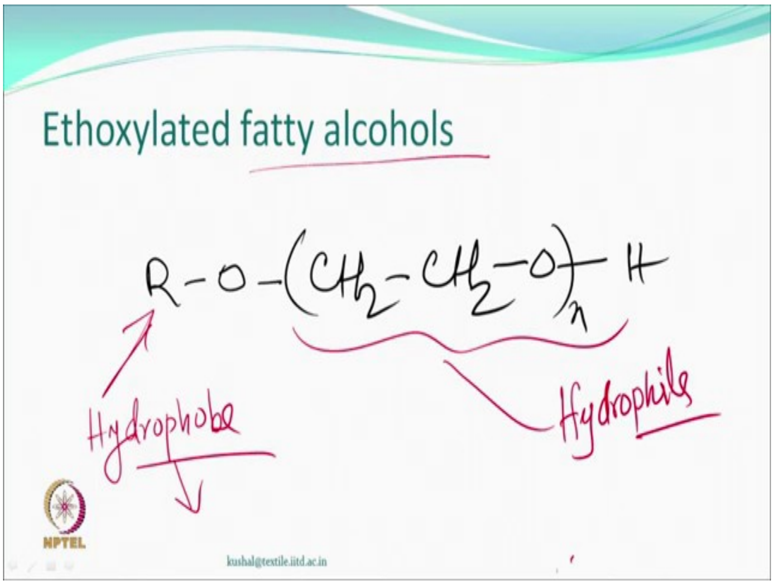

You can do this from alcohols as well, but then R is the hydrophobe and this is our hydrophile. So, we have a possibility of having a non-ionic softener and its solubility can be controlled by a hydrophilic-lyophilic balance. Lyophilic is the one which likes the oil which is this part. So, length of the chain if you change, then we will get a different molecule, and so you can play around with any limitation that you can think of.

Otherwise, the advantage is compatibility, add to anything and use it. So, we are coming to the end of this part. What have we learnt?

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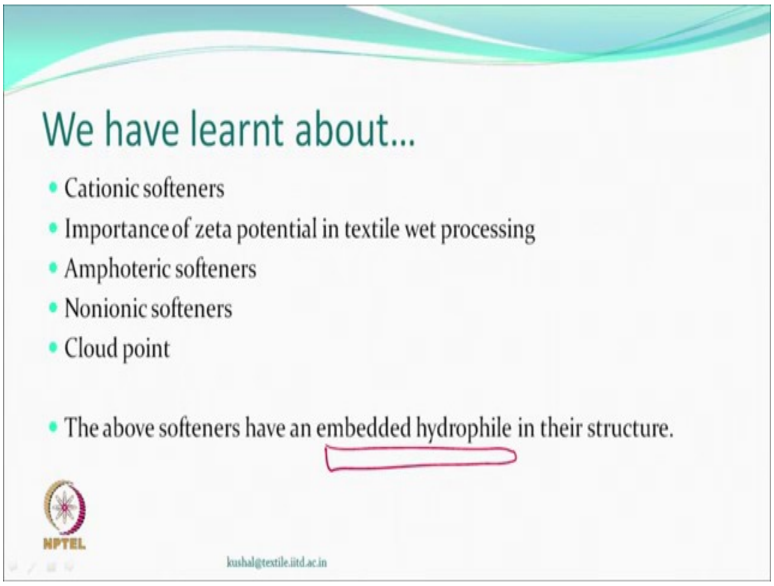

So, we have learnt about cationic softeners, we have learnt about Zeta potential and its importance in textile wet processing; amphoteric which has got a cation and an anion embedded in the same molecule; also we have learnt about the non-ionic softeners and the importance of the cloud point. Remember all these including the one which was anionic have an embedded hydrophile in this structure, okay?

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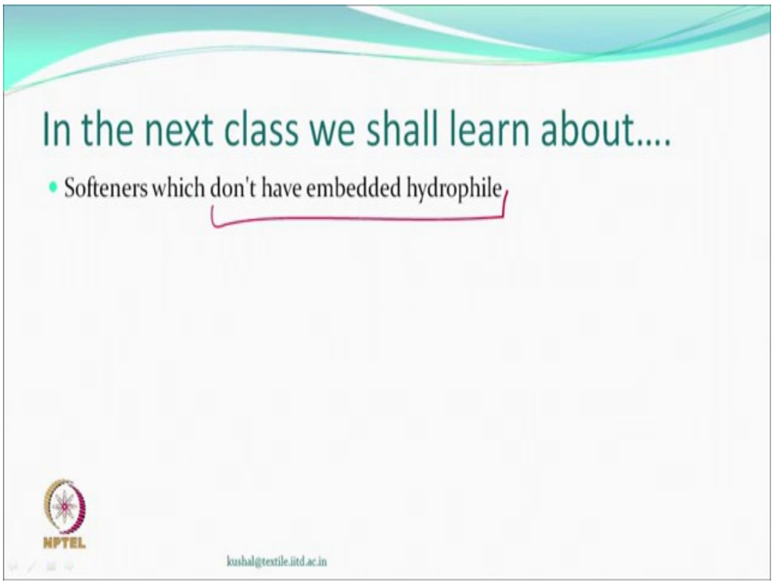

In the next class, when we meet, we shall talk about some other softeners which may not have any embedded hydrophile. They are only hydrophobes and you have to apply those hydrophobes to textile surfaces. Is that right? So, next time when we meet this is what we are going to talk about. Till then, have fun. Thank you.