Textile Finishing
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Lecture No. – 10
Soft Finishing

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

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We learned about the mechanism of imparting stiffness to the textile fabrics or any of textile for that matter, the chemistry of some of the stiffeners which can be used, some for a temporary finish, others relatively more permanent finish. And the application processes also we looked other than padding. We could see the coating and lamination can also be used as one of the application processes.

And where do we use stiffened fabrics also we discussed a bit on this. Today, we will try to highlight some of the requirements of soft finishing. That means instead of stiff we are now talking about soft. So, first, we should understand why somebody would need a soft finish, what exactly is the soft finish, and may be some of the chemistry which is required. We shall try to discuss this in today's lecture.

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So, the important thing you may notice is that most people prefer softer touch. You see very few people, particularly in terms of garments, would like to have stiffer garment. It is very rare that people ask for stiffer garment. And this soft touch is related to what we call as a tactile comfort. So, it is more comfortable to wear softer material apparel to begin with compared to stiffer, and so it appears there is a need. Clothing for babies need special care.

They obviously have a tender skin and so much more softer material is what somebody would like to use next to their skin. Towels, bed linen, and other type of linens where drape becomes an important characteristic the softness is something what people would prefer. That makes a case in a way why should somebody go for a soft finish.

In fact, you may have practically noticed that harsh feel is not a preferred choice of people whether it is household textiles or it is apparel textiles. People would prefer softer feel. So, that in some way is the need of a user.

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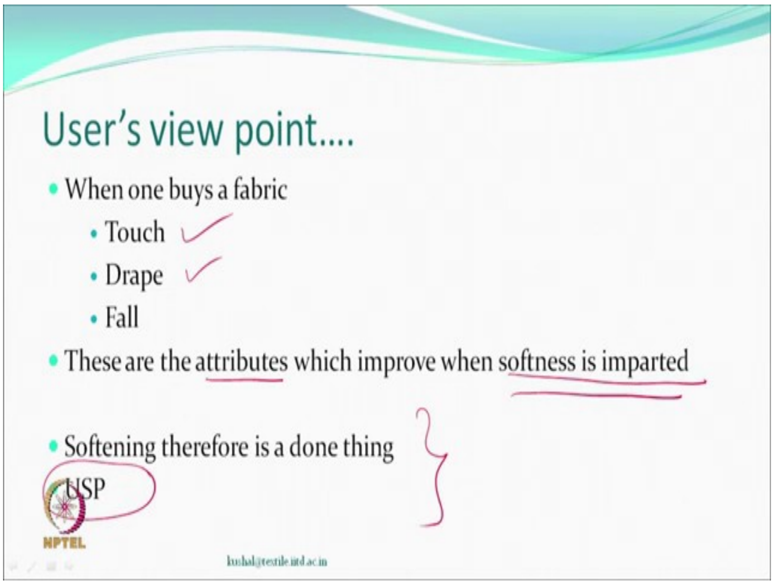

So, from a user point of view, the touch becomes an important thing. So, every time you want to go and buy a fabric the first thing that you do is touch and you feel with your hand is it softer or stiffer. The hand is a beautiful equipment shall we say or a sensor which can very easily distinguish between very small differences of forces and the resistances.

So, some of the other terms which people may like to understand, if you want a good drape, stiffer material will not be able to give you the kind of drape that you want or sometimes this is known as the fall. So, drapes and fall for curtains and other kind of upholstery may be important. For wear aesthetics also drape becomes an important attribute. So, these are the attributes which improve whenever softness is imparted.

So, you will have a better touch, nice feel, you would have better drape and fall of the fabrics. And so, it appears that we may like to actually impart soft finish. So, if somebody says that this actually is the unique selling point for softening, people like it, and it must be done. So, very few people actually would want a stiffer finish. And therefore, in various types of unit operations and finishing softening becomes an important finishing operation.

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So, if we say the same thing again, an important area of textile finishing. We would like to add, if possible, some of the chemicals which are called softeners into the pad bath of the regular finish that you are doing. For example, if you are doing crease-resistant finishing, then we may like to add a softener if possible in the pad bath of the cross linking agent itself. But in case it is not possible, that you cannot add for various reasons, compatibility reasons or any other thing, then in that case, it by itself will become a separate process.

So, you will have to do it again and apply the softeners.

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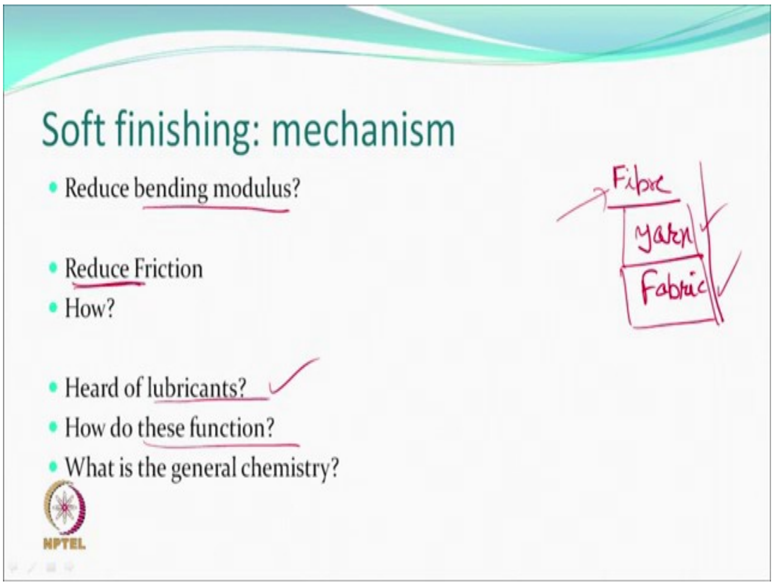

So, what would be the mechanism for making it soft? Well, something to do with the bending modulus. Are we talking about again the bending modulus of fibre, or a yarn, or fabric, what? Say, somebody says let us reduce the bending modulus of the fibre, that would mean that you are internally at intermolecular level wanting to change the morphology. For example, if people use plasticizers with polymer or fibre, it becomes softer.

But that normally, as far as textile finishing is concerned, we may not like to do so. So, what we may like to do is reduce the bending modulus of a yarn without actually modifying the fibre or a fabric again without modifying the bending modulus of any fibre. So, we are not really going to change the fibre properties, but we are interested in changing the fabric properties, that is the most important, and in case required, yarn properties.

So, how do we do this? It is the opposite of what we were doing for stiffening purposes. So, here we will reduce the friction. We mentioned earlier also, there we were increasing the friction, friction between fibres, friction between yarns, and that will lead to softening. Now, how do we reduce friction? Have you heard of lubricants? What do they do, lubricants? You add in any kind of gearing system, system which are moving, you add lubricants.

What are they? They are basically oil, fats, and waxes. They reduce, they function. How do they function? They make a film all around a moving part and it is the film which gets the shear force and the metal or a plastic or other parts do not touch each other. So, it makes a film and keep them separated. So, this layer is the one which is responsible for reducing the material to material friction, let us say ball bearings and gears and other moving parts.

Now, similar thing we like to do on the textile. So, what is the general chemistry they say, they could be basically oils, waxes, and combination of various such chemicals which can make a very thin liquid film around the surfaces.

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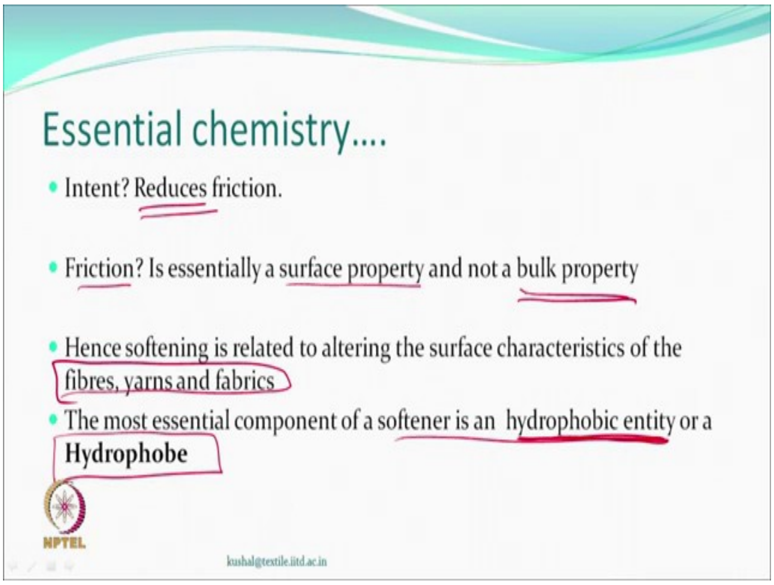

So, if you look at textiles we obviously may not be interested in exactly what we are doing, let us say, in a machinery part which are moving, but intent definitely is to reduce the friction. You must remember now friction is a surface property. It is not a bulk property. It is the surfaces which have frictions. Whatever happens inside the fibre or the material is a very different story.

And therefore, we must remember this is also, in finishing treatment, which is going to alter the surface characteristics of the fibres or the yarns. So, this is where our goal will be. And if you look at general requirement in any case, which is with otherwise also, we need an interesting part of any chemical that is going to act like a softener,that will be the hydrophobic entity. Hydrophobic in some sense you can also say oleophilic.

But in our terms we would like to use another term which you would like to remember, that is the hydrophobe. So, whatever this chemical is, this chemical certainly should have some hydrophobe, that is something which does not generally like water. So, does not like water kind of stuff. So, how do we get them?

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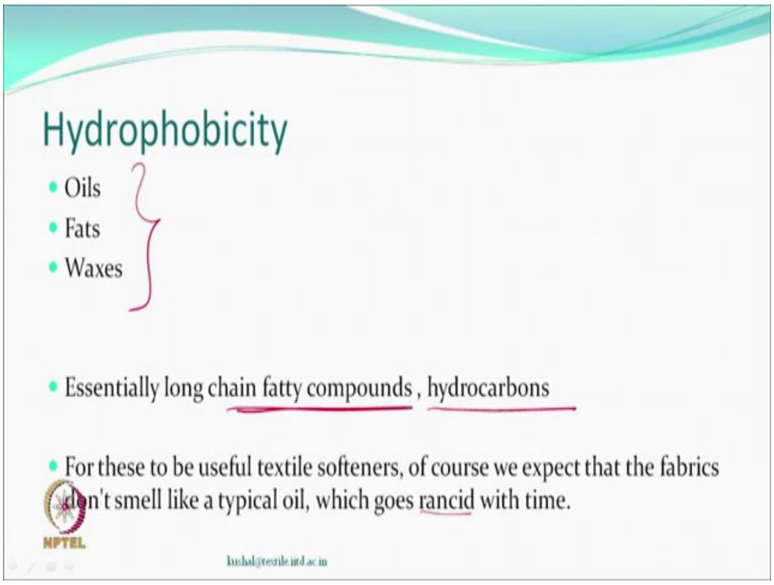

Some of these compounds which are being used otherwise can also be used to impart softness in the fabric. And how do we do that? By reducing surface to surface friction. Essentially all these are long chain fatty compounds or hydrocarbons, C_{16}, C_{15}, C_{17} types of hydrocarbons are going to be used for such purposes. But then, when we look at fabrics we may like to have different requirements.

A normal oil which is lying here and there you can feel the smell, it depends on which oil we are talking about and how much has been used, the smell, I do not think people would like to have any kind of odour coming out of their textile just because they have used some softener which is also a hydrocarbon or a fatty compound. And so, this may be an interesting part which we would like to say we would not like. Normal oils may get rancid and start smelling, that is why the normal process of degradation.

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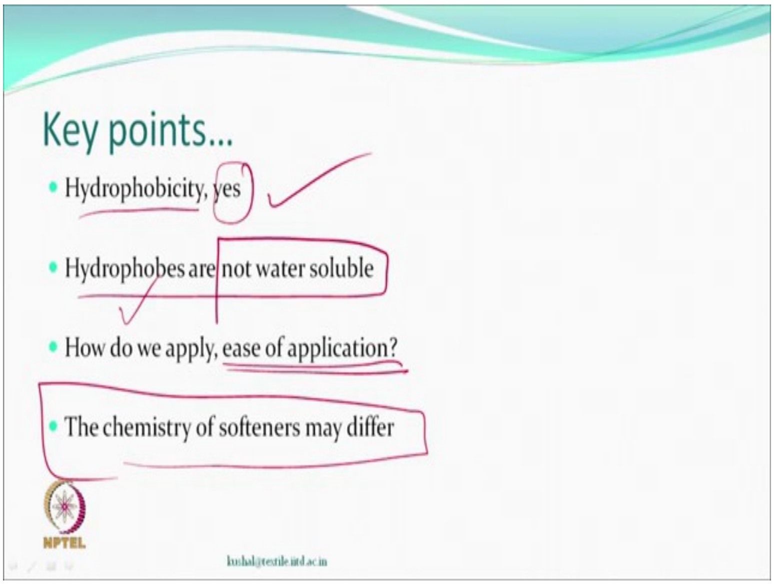

So, the key point for this is hydrophobicity. Yes, this is important, hydrophobicity will be an important component of this whole softening business. All the molecules that we will talk about will have hydrophobicity, yes. But it is important to note that hydrophobes are not water soluble. So, if something is not water soluble, how would you like to use it? You can say, well, we can use solvents.

But solvent processing is not a very preferred method. People would like to prefer Aqua systems, water based recipes and formulations that is what people would like. And therefore, when you say these hydrophobes are not water soluble because they are called hydrophobes, so how do we use them? We would obviously be interested in ease of application.

So, if they are not water soluble, then the ease of application may not be there. So, when you do a solvent-based processing then you will have to recover the solvent, the cost of recovering the solvent and any other dangers that are also involved will also have to be taken care of. And therefore, the chemistry of the softener may differ from a normal lubricant. For a normal lubricant which is used in machine parts as we said are basically hydrophobic compounds, oleophilic compounds, but for textiles will have to change the chemistry a bit.

So, before we look at some of the examples of softeners that have been suggested for textiles, let us say, as a user, what will be the requirements or demands of a user?

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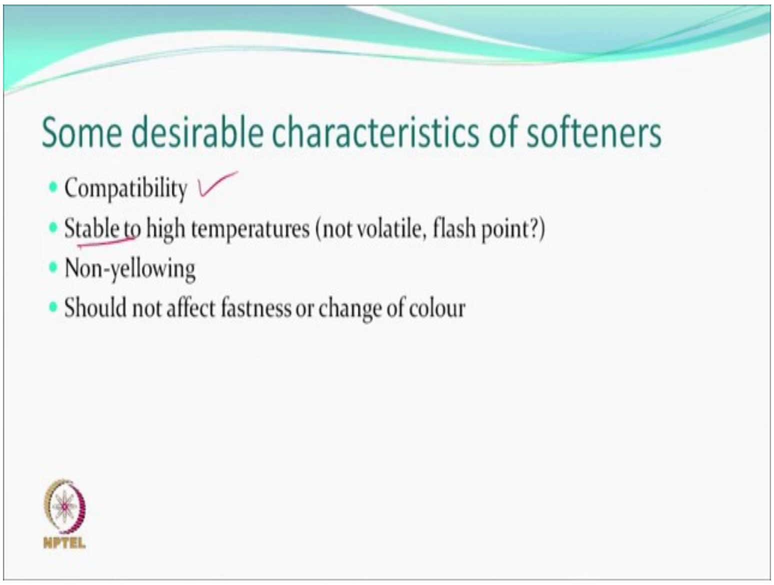

Now this user I am not talking about the user who is wearing the fabrics or the garments but the person who is going to apply also is a user in some sense. So, you may look into what they called as compatibility. Compatibility means when you add, as I said, it is quite possible that a large number of softeners you may like to use them along with the main finishing operation, you can, as I said, do a separate finishing treatment itself, but you may like to use them along with whatever going on.

In that sense, the compatibility with whatever other chemicals are there will have to be checked, and which will be not same, because you are using different types of chemicals. So, compatibility will have to be obviously checked. In case we are combining, or otherwise also, we may like to look at their stability at higher temperatures. Let us say you are doing a pad-dry cure operation along with a softener which by itself may not be reacting but it has to withstand that temperature.

If that is true, then we will have to look at the temperature stability as well. It has been seen that some of the chemicals by themselves, the stability related issue, thermal stability, they do have a tendency with time also to get a bit yellow. So, yellowing could be tolerated if you are looking at a dark shade fabric garment, but if you are processing white or pale shade, very very pale shade, then yellowing may not be a preferred, definitely not for the whites. This is also a part of, in a way, long-term compatibility issue.

It should not change the shade or the fastness, whether it is the light fastness or the other fastness properties. It should not affect the fastness of the dyed material. If that happens, then obviously it is not a good idea to have such type of chemical.

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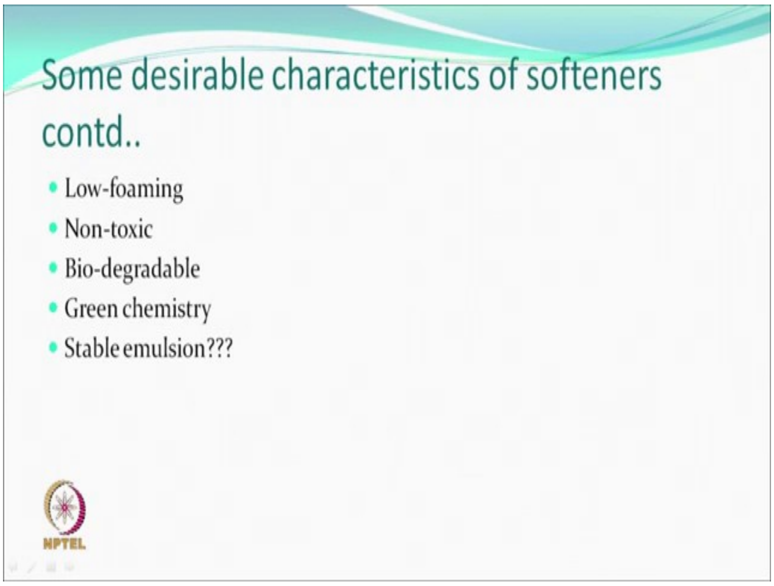

Some more properties, it is interesting that most of these materials may have a tendency to foam, so one will have to see they should not foam too much because if they do foaming and unless it is a foam finishing where of course we want to form, all other things are non-foam, low viscosity application systems. And there we would not like things to just keep foaming. Yes, this of course anybody can say that it should not be a chemical which is toxic in any manner, and that somebody has to certify.

Today, everything that we use we would like to question is it biodegradable or not? Because at the end of a life cycle the products will have to be disposed in one way or the other and so people would like to know whether this compound is biodegradable or how much. Well, this is again related to environment, the green chemistry. Green chemistry means not just the application but even manufacture and later disposal, all of them would come into the part. The biodegradability is important.

The green chemistry, how much energy you spent and how much pollution you have created while you were synthesizing this compound also may have to be checked. Emulsion, so as I said they are hydrophobic compounds, all right, and therefore it is possible that you may have to make an emulsion out of them to apply. So, compounds which are not water soluble but they are useful otherwise as a softener we may have to go for emulsions.

When you make emulsion, then you have to talk about stability of emulsion. It should not happen that you make an emulsion today and after two days you find that the emulsion is broken down which will not be a good idea at all.

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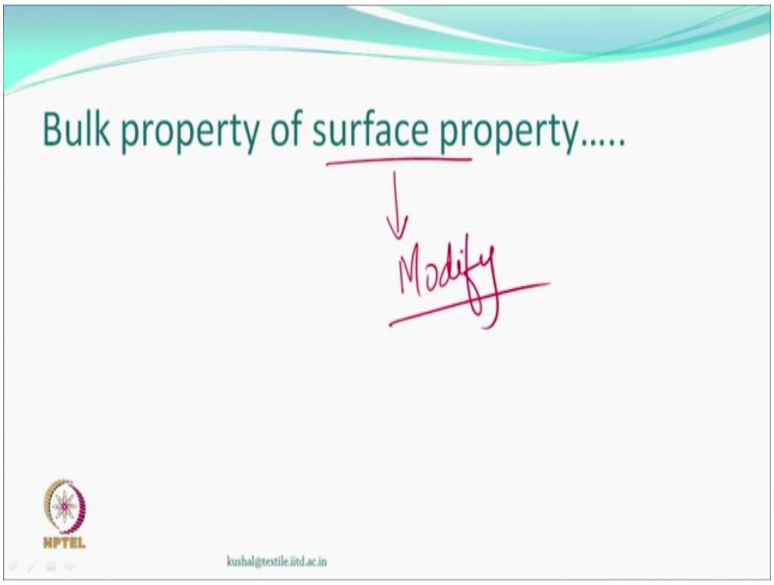

So, we want to know something which is interesting for us. Softening treatment of the textile, is this a bulk property change or a surface property. So, we must remember we are not intending to change any bulk property of the fibre. We are only interested in surface. So, we modify only surface.

So, just a point to note forever, that softening is a surface treatment although for durability purposes you may like it to react, you may like it to diffuse, but you obviously are not measuring or not in any way concerned about what happens to the bulk. As long as it does not get degraded you are all right. Surface is what must be changed.

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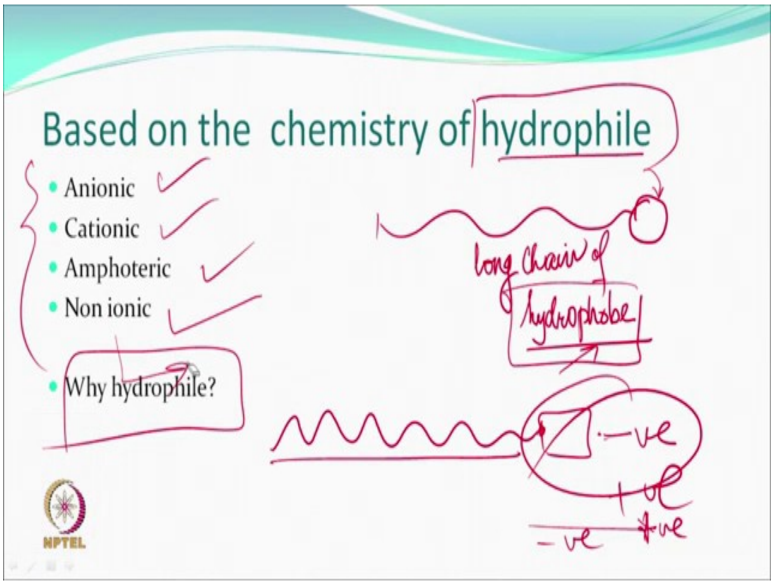

So, based on the chemistry of the hydrophile, now what is this hydrophile coming from, so if we represent a hydrophile as a long chain of hydrophobe, so we said hydrophobe is an important component element of a softener and we also said that this is not water soluble by name itself and the character also. So, what do we do. We add a hydrophile. Hydrophile is the component which likes water.

So, imagine now, although our purpose is going to be served of reducing the friction by the hydrophobe but to make it let us say applicable through Aqua system these compounds are attached with a water loving group and that way you can make them water soluble. Therefore, you can apply through aqueous medium. So, hydrophile is important. Is that right?

So, based on the nature of the hydrophile the softeners can be considered as anionic softeners, cationic softeners, amphoteric softeners, or non-ionic softeners. So, this is an important thing. So, you have a long chain connected with some hydrophile. Do you remember something what kind of compound these could be? So, you have an anion attached, then it will be anionic. If it is a cation attached, it will be cationic.

Amphoteric obviously means that the same molecule has the possibility of having a positive and a negative ion. So, these are ionic compound and therefore their water solubility is high. Of course the solubility will depend upon the length of this chain as well. But if you do not have this, then they are not water soluble. So, that is the chemistry.

Of course in some cases we may prefer to have only non ionics, but still we would like to have a hydrophile which is water loving but is not ionic, right? So, this is how we look into it. So now we understand why hydrophile, otherwise they will not be water soluble, okay? To make them water soluble you will attach a hydrophile to a hydrophobe.

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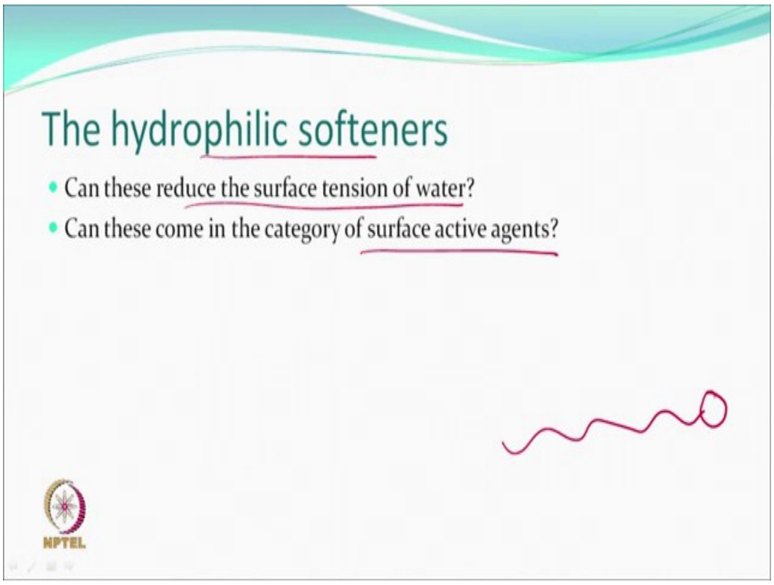

So, these are therefore hydrophilic softeners in some sense. They like water but we know what it is, a long fatty chain attached with a hydrophile, okay? So, the question that was there which can be asked now, whether they will reduce the surface tension of water, whether these type of agents which we call as hydrophilic softeners which have a hydrophobe and a hydrophile, will these reduce the surface tension of water?

Yes, they will. They are almost like anything which we call as surface active agents. They do come in some sense in the category of surface active agents because they also have a hydrophobe and a hydrophile.

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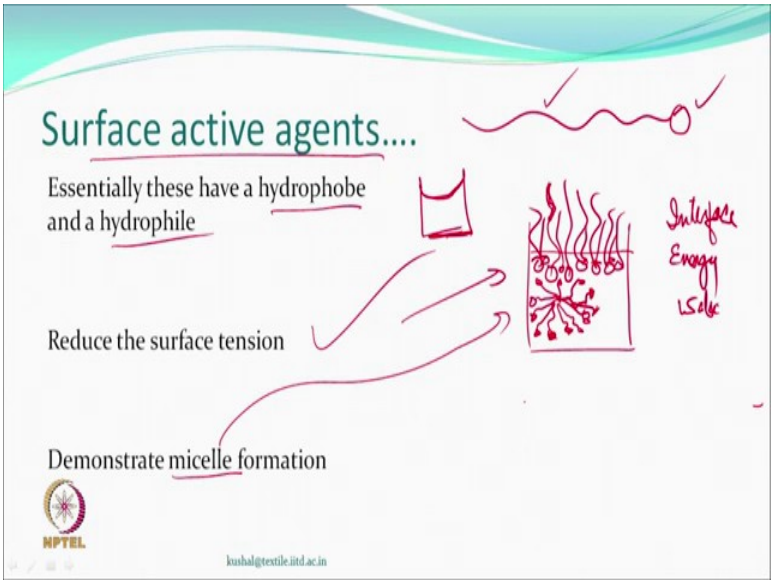

So, this is again a recall, may be you have learnt somewhere sometime. So, these are surface active agents and active agents also have a hydrophobe and a hydrophile. They reduce the surface tension. How do they reduce the surface tension, a surface active agent, how do they reduce the surface tension? So, let us say, this is our molecule which has got the hydrophilic part here and hydrophobic part here.

So, if you put it in water, the moment you put this in water the hydrophobic part would like to come to the surface because this part does not like the water. So, it wants to get out of water, right? So, they are therefore surface active. If there are so many of them, all of them would like to come to the surface, and in some sense they have changed the interface energy or tension of the water. And this is how they can reduce the surface tension.

Normally because of the surface tension the water would have the meniscus of this type, okay? But in a way these molecules are going to push this film or the interface towards the outside. So, that is how they reduce the surface tension and these softener also will do the same thing, okay? Will they demonstrate micelle formation? What is micelle formation? Micelle formation is when there is no space left for them to rush out.

Then, what will they do? Then, they will have to, if you keep on increasing the concentration, then this molecule does not know what to do. So, if that condition comes, this part loves water, this part and this part love water, but this part does not. So, in some sense there will be a hydrophobic interaction and the hydrophobic part may like to come near each other and help in the formation of what is known as micelle.

Because you have increased the concentration there is no surface available through which they could satisfy their energy levels, and therefore they will make micelle. Now, these micelles could be spherical, lamellar, all those things are there, but they would definitely, and this obviously is why it is thermodynamically most satisfying. Therefore, you will form a micelle. So, in our case, which is a softener something like this you can expect whenever the concentration is going to increase in the solution.

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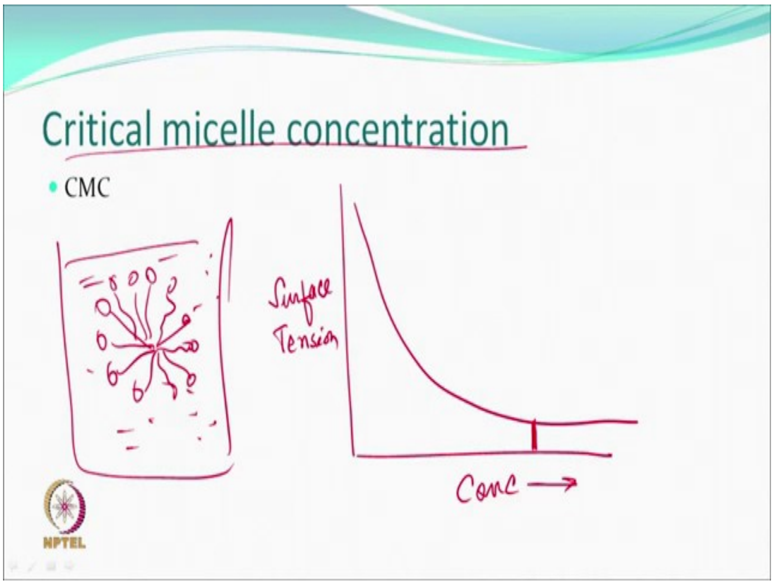

So, they also have what we define as a critical micelle concentration. If you plot concentration of a surfactant, or in our case it could be our own softener, and measure the surface tension, so as we said surface tension will reduce but after some time it cannot reduce further. That is the concentration where the micelles will start forming. Therefore, it is called the critical micelle concentration.

They are not bad, micelle formation by any means is not bad. It is okay as long as we know how to handle because this bonding is not a very strong bond, it is just an arrangement because there was too much water all around and only some part of the molecule likes the water and so you have this micelle formation, right? So, in a way we are revising that something like this can happen.

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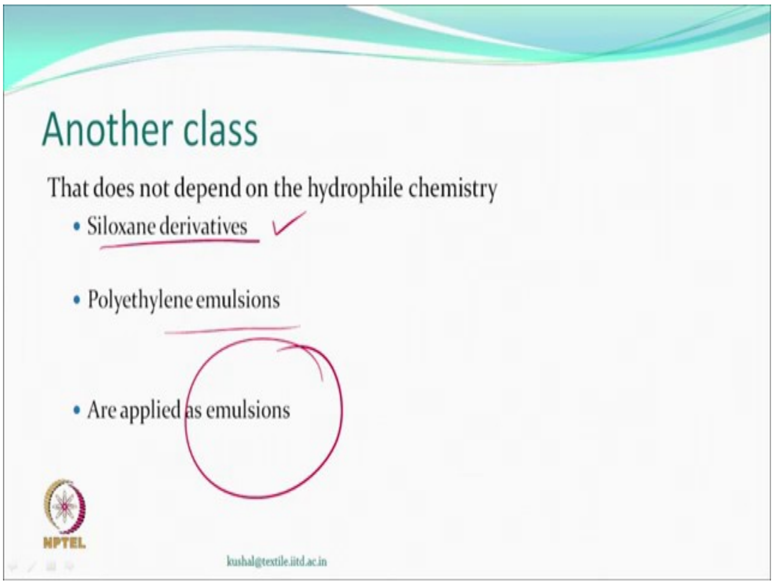

So, there is another class of softeners which does not depend on the hydrophile chemistry. The four which we looked into just before are dependent on the hydrophile chemistry and therefore they were classified accordingly. Now, they do not believe that they should be soluble in water. If they are not soluble in water, then what happens? So, some of the compounds that we looked at are siloxane, silicone based compounds, or polyethylene.

Polyethylene is also hydrocarbon, a long chain hydrocarbon. If you do not attach any hydrophile, it is not water soluble. So, what do we do? We apply them as emulsions. So, an emulsion is prepared in an Aqua system and that emulsion is applied to whichever process, pad-dry cure or any other process, that could be exhaust process, they are applied. Once they go on to the textile then obviously the emulsion breaks, the water evaporates, and the compound stays on to the textile.

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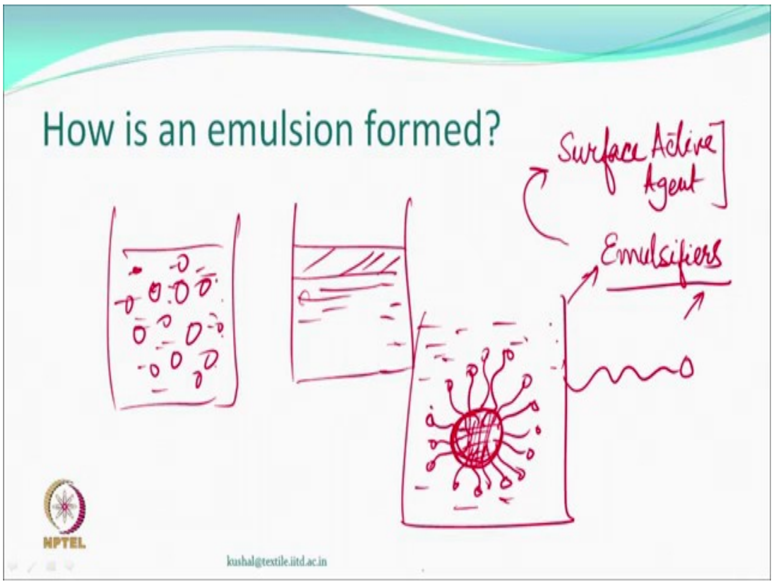

How is emulsion formed? The emulsion is formed by another surface active agent. They are also known as emulsifiers, and what are they, they are also compounds which have got a hydrophobe and a hydrophile. Now, how this is helping? This will help. If you have water and you put oil droplets and mix them, you may get some oil droplets floating, if you mix at high speed for example.

So, they will get mixed in some sense. There will be all over small small oil particles. Keep it for some time and you will find that the oil is on the top and water is at the bottom. It separates. And so, what are we talking about then? We said the second class of softeners which do not rely on the hydrophile and its chemistry they are not water soluble. So, they are oil soluble or their oils by themselves, okay?

In such a case an emulsion has to be made and what does the emulsion do? Let us say this is an oil droplet created like this. So, the hydrophobe will love the oil droplet. They will go towards the oil droplet and the outside will be hydrophiles of this emulsifier. Is that right? This is hydrophilic which is outside. So, an oil droplet now is entrapped within the group of molecules.

Now, this is in some sense a micelle which has the oil droplet. Now, this whole thing is as much stable in the whole water condition. So, we will have so many oil droplets which will be kept separated and thermodynamically satisfied by the use of emulsifiers which are surface active agents and so emulsion forms. So, once you form the emulsion, whether it is silicon based system or it is polyethylene based emulsions, these can then be mixed into Aqua systems and can be applied.

So, we have now two types; one type of softeners which are the hydrophile is chemically attached to them, other is no hydrophile, does not have any hydrophile, but they can be emulsified and then applied.

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So, today we will just spend some more time to look at some of the examples of anionic softeners.

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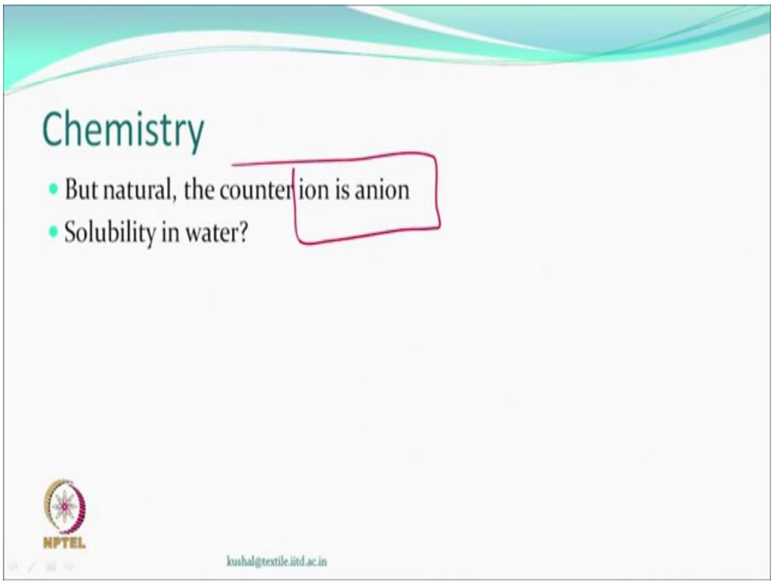

So, as far as the chemistry is concerned, the counter ion is an anion, okay? What about solubility? Yes, they are water soluble. Because they are water soluble so you have no problem. Of course in every system, as we have said, if they are water soluble, it is because of the ionic nature, but if you keep on increasing the concentration, there will be a time when they will form micelle.

And if you go further and further they can just get out of the system, phase separate out. So, obviously you have to but generally it is a good solubility. That is why we added an anion. So, remember one thing, ionic compounds are water soluble. Anytime when you find a dye or thing you add solubilizing group groups and they are ionic.

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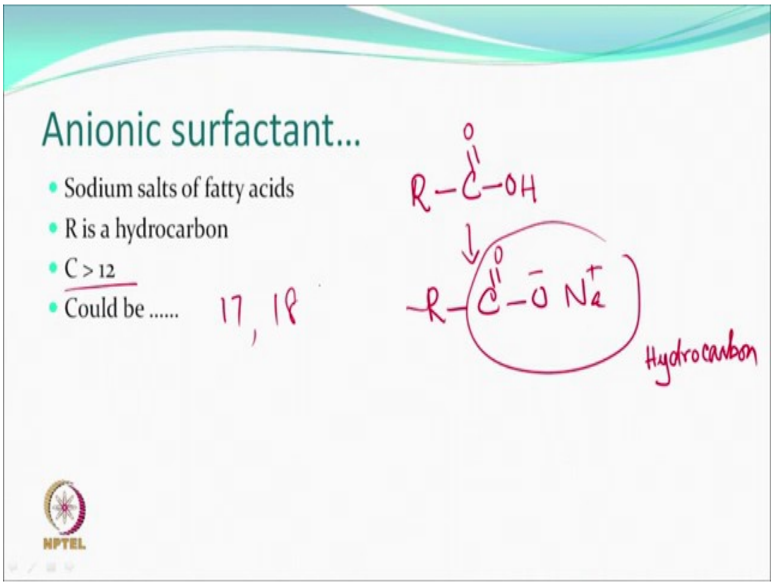

So, one of the simplest examples could be, if it is -OH which is a fatty acid, it is not going to be very much soluble, but the moment you convert this to a sodium salt this will be water soluble, all right? So, solubility is here because of this hydrophile and the softening abilities which come from this are, which is obviously a hydrocarbon, this R could be more than 12 but can go up to 17 carbon or 18 carbon units, and therefore, enough hydrophobicity will be there.

So, the more is the length of the carbon chain the more hydrophobic it will become, right? So, generally 15, 16, 17 carbon units are good enough to be useful for softening.

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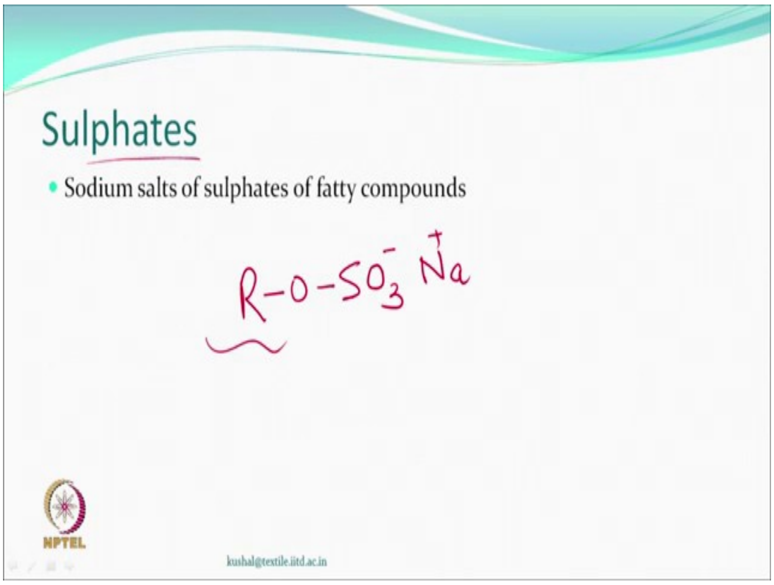

You remember the compound that we just described is almost like a normal soap, a fatty sodium salt of an acid, fatty acid. What was the problem with them? The problem was hard water. Instead of sodium if it becomes a calcium salt or a magnesium salt, it would precipitate and so you require softening treatment for the water, not just the textile. So, if you get soft water this works.

Therefore, some of the chemistry was changed of the hydrophile instead of just having sodium salt of an acid. You said if we make sulphates, then a good amount of this hardness related problems can be tackled and sodium salts of fatty compounds, sulphates would be something like this. So again, ionic and cationic, and therefore R could be similarly our normal hydrophobe. Whatever length one chooses, accordingly its effects will be seen.

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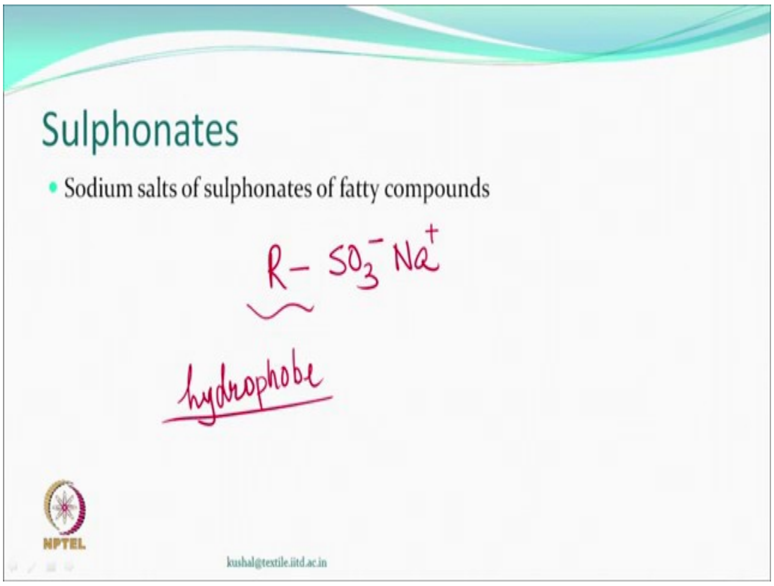

Similarly, we can have compounds on sulphonates which also you are familiar. So, again, there is an anion here and R is a flexible hydrophobe. So simple. So, any type of R if it is combined with one or the other hydrophile it will become water soluble. This water solubility will ensure that it can be easily applied and R part which is the hydrophobe will do your work buffer, doing reducing the friction.

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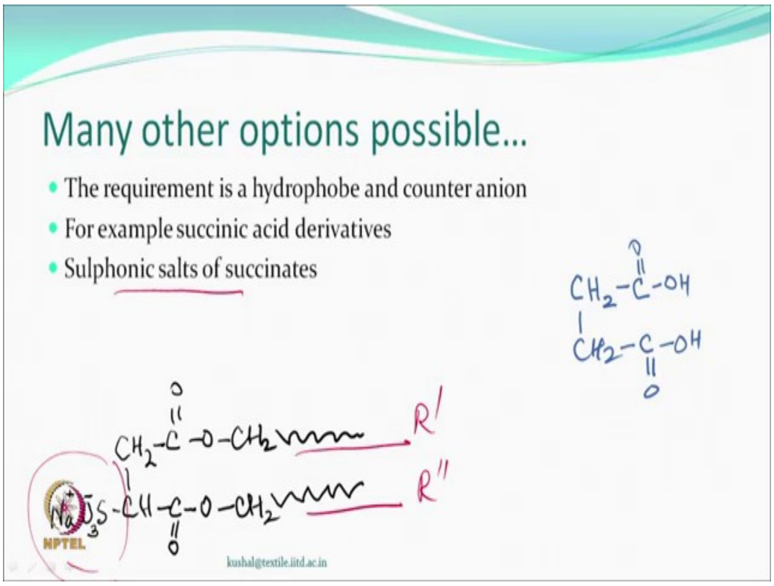

So, theoretically, in this category also many options are available. It is not just these three types. The R changes and the various kinds of chemicals and the acids can change. And one of the other interesting options people have been using is with the help of let us say a succinic acid. Succinic acid is simple. So, you got two carboxylic groups attached to a simple compound like CH_2-CH_2.

Sodium salts of succinates, sulphonic group is here, and there is a hydrophobe here, hydrophobe, and a hydrophobe here which you can term as R_1 or R prime and R double prime, and this succinic acid has reacted with this hydrophobe in this manner. It is also an interesting compound because this compound had the hydrophile in between two hydrophobes. So, it is very different.

So, some attachments and attraction, etc., are in the middle of the compound. So, that is also interesting compound. So, people obviously have been looking at the possibilities of introducing many more types of compounds, but we are just looking at some of the examples of the anionic type softening agents. Remember we are not talking about water softening here. We are talking about the fabric softeners, textiles softeners.

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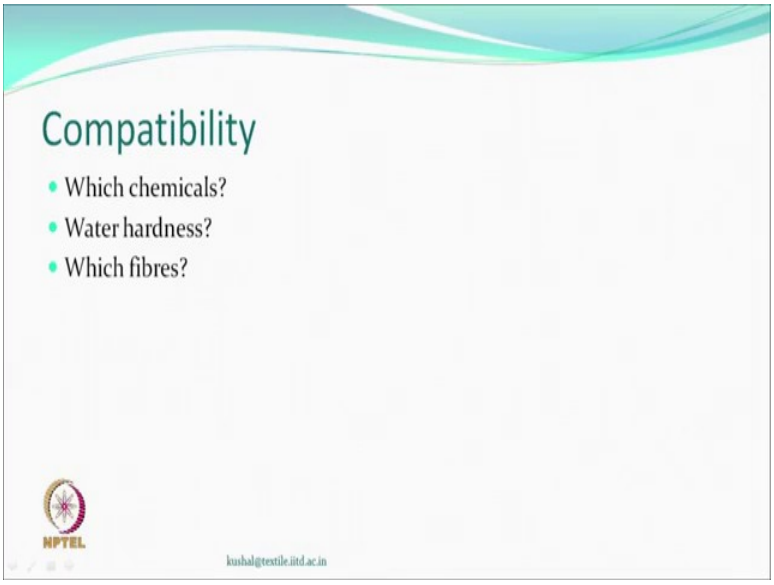

Last few comments for today. When you talk about compatibility, what type of chemicals are we looking at? This anionic compound, you can be very sure, if in the solution, anything that you use which is cationic, then anionic softeners are out. You cannot use them, right? Sulphonates can tackle the hardness but one would prefer, when you are doing the thing, if the water is as less hard as possible, that would be a good idea, although the fatty acid salts will have problem more than sulphonates.

This is how the thing goes. Which fibres, theoretically, as long as the chemical is able to go, say an anionic dye, this is also anionic, compatibility issues are not there, and adding anything anionic it will follow the same path as the dye, for example, will follow, okay? So, you can add this in the same bath the dying is happening. Along with this this also will get attached.

However, if, for example, you have a situation where the fibres have a positive charge, like in acidic medium any protein fibre would have a positive charge, so they will have more affinity to go towards them. So, this will be some binding taking place, all right? So, if anionic dye or system is going in whichever way it is going, this can be added to the same bath. The exhaustion can also take place. Otherwise, pad-dry cure process should not be a problem.

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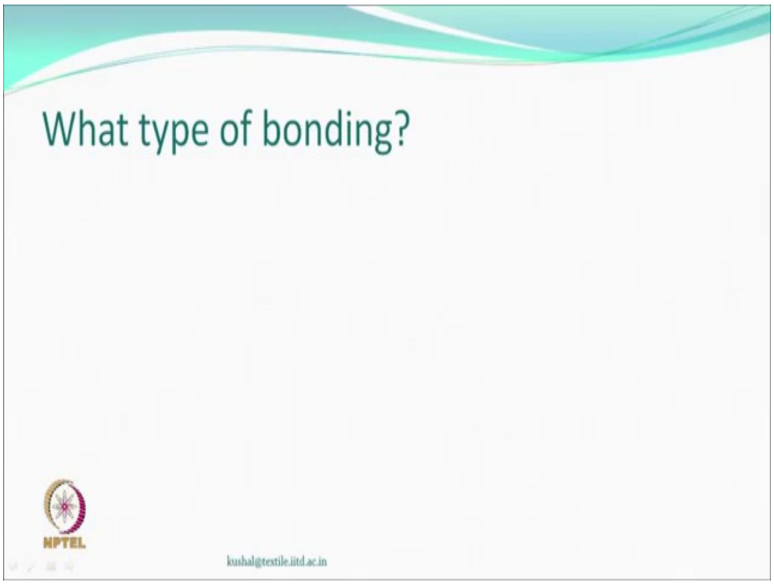

So, a few more sentences on this bonding. So, we can expect if it is cationic site on the fibre, it will be electrovalent bonding, salt linkage. But if it is like a direct dye going to cotton and you also have a softener going to cotton and get exhausted, once it gets exhausted, after that, the bonding will be based on, let us say, Van der Waals forces. The whole hydrophobe in a way, the molecule will be attached.

In some sense, it is a long molecule, diffusion may be not so easy because of the long molecule, but part of it will be obviously adhering to the surfaces. And the water solubility is there, but if that becomes an issue, durability can also be low. So, from bonding point of view you are looking at basically, generally, for the main hydrophobe as Van der Waals forces which can get attached.

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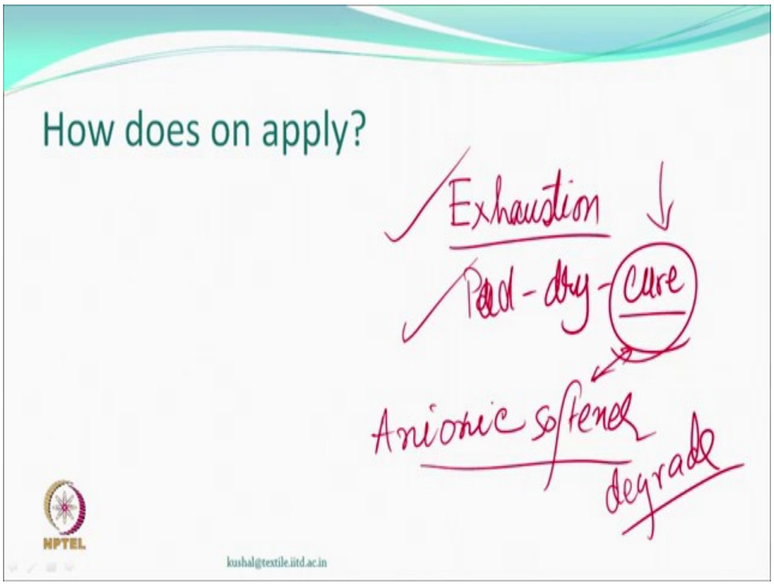

How to apply? Well, exhaustion is definitely a possibility. Pad-dry cure would never be an issue. If somebody asks do we require curing to fix an anionic softener, do we require curing, normally the kind of example that we have seen you can understand. There is no covalent bonding happening with the softener here. But if your other process requires curing, let us say you have added the softener in cross linking agent recipe, then the cross linking agent requires curing, we only hope that this softener will not degrade during this process.

That is all. But no other reaction will be possible. So, you can apply through any of these methods.

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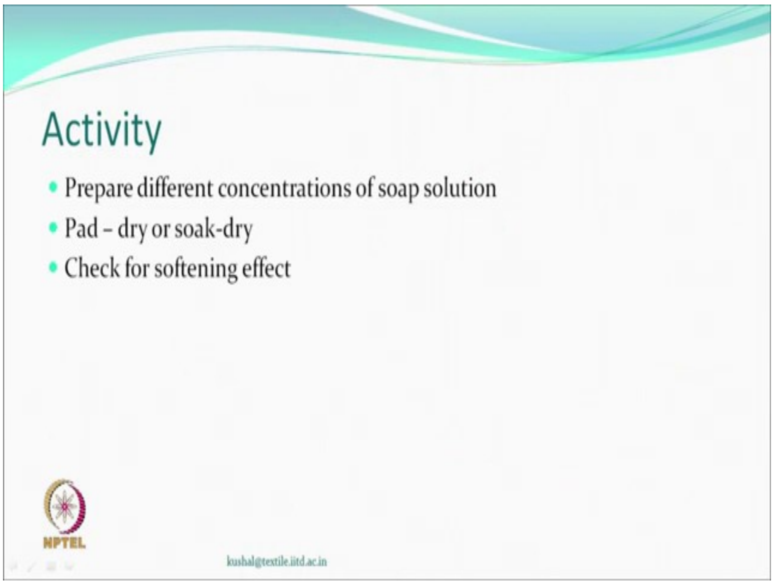

Whenever you have time you may be using soaps every day. So, you can see if different concentrations actually, when you do a pad dry or a soak dry, immerse, wring, and dry versus no softener, that is even soap that is what I am saying could be a softener, so check whether you get any softening effect by doing this simple exercise.

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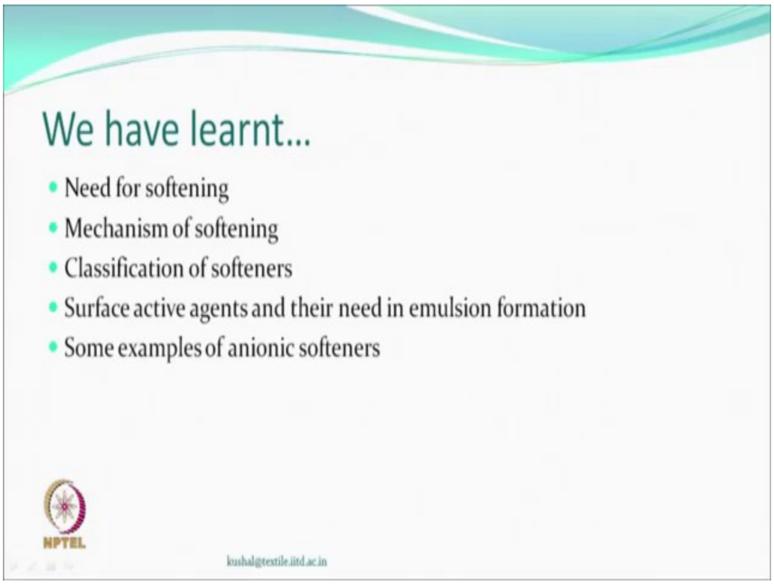

So, what have we learned today? We have learned what is the need for softening. I think we are quite convinced hopefully. The mechanism, which basically means reducing surface friction, right? Classification based on the hydrophile or non hydrophilic material also. We just discussed a bit on the emulsion formation and how surface active agents reduce surface tension and what is critical micelle concentration and we have seen some of the examples of anionic softeners. I think this is for today.

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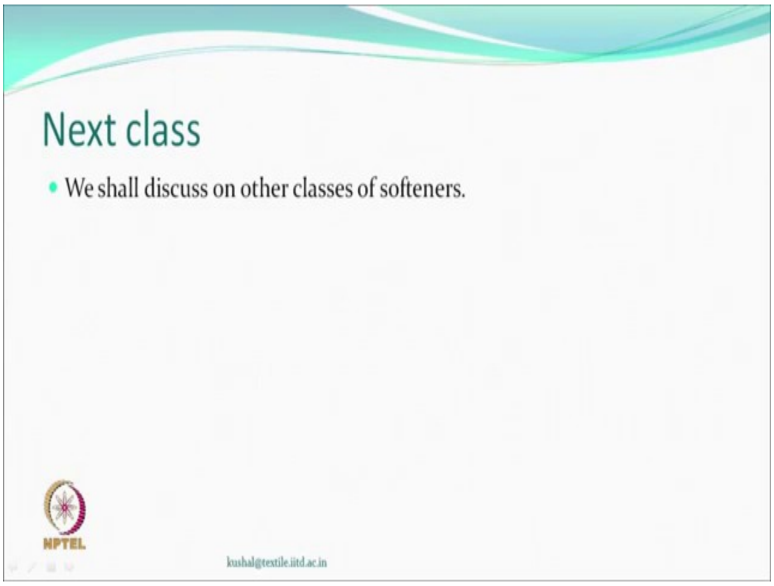

Next time when we meet we will talk about the other types of softeners. Till then, thank you very much.