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Module - 8
Lecture - 18
Soil Release Finishing

Hello and welcome back to our class on textile finishing. So, what are we going to do today? Let us see what we have done till now. What we have learnt about is, the how soil repellency is achieved. Okay.

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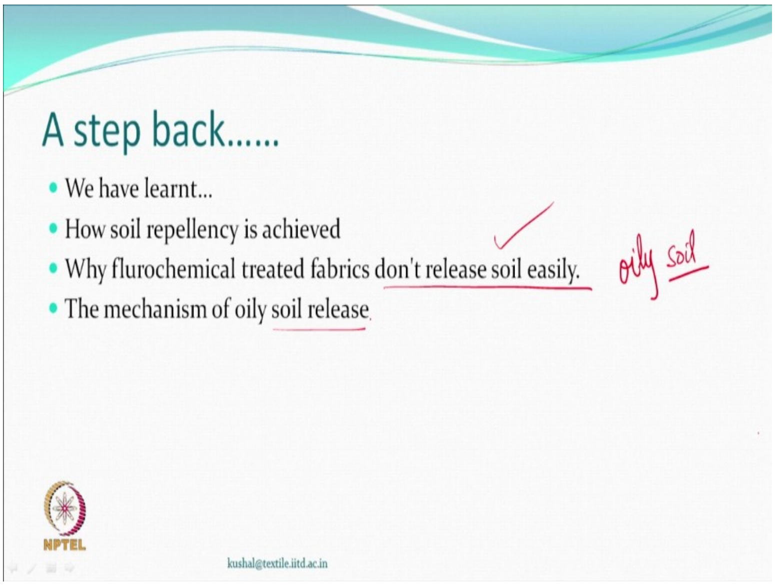

So, by treating with perfluorochemicals, finishing agents, one can achieve soil repellency, which actually means oily soil repellency. If it was only water based, silicon finishes were good enough. Right. But, when we want oil repellency, then we had to go in for the fluorochemical based finishing agents. But, one interesting thing which was noticed in the last time that we were discussing, that these fabrics do not release soil very easily.

And again, when I talk about soil, we are more concerned about the oily soil, more hydrophobic, more hydro, lyophilic. Okay. So, we have to make the surfaces as lyophobic as possible. But after doing that, it was found that they do not release the soil easily. If the fabrics get dirty, then it is not easy to clean them. Okay. Why? Because the mechanism of oily soil release dependent is dependent on the aqueous detergent solution penetrating between the oily layer and the solid surface, so that interface has to be penetrated.

But because the fluorochemical fabrics do not like water at all, they repel even oil as we said. Then they, penetration does not take place very easily. And so, oily soil removal is an issue. So, we will continue this discussion further as to what we can do, so that the release could take place in a better way.

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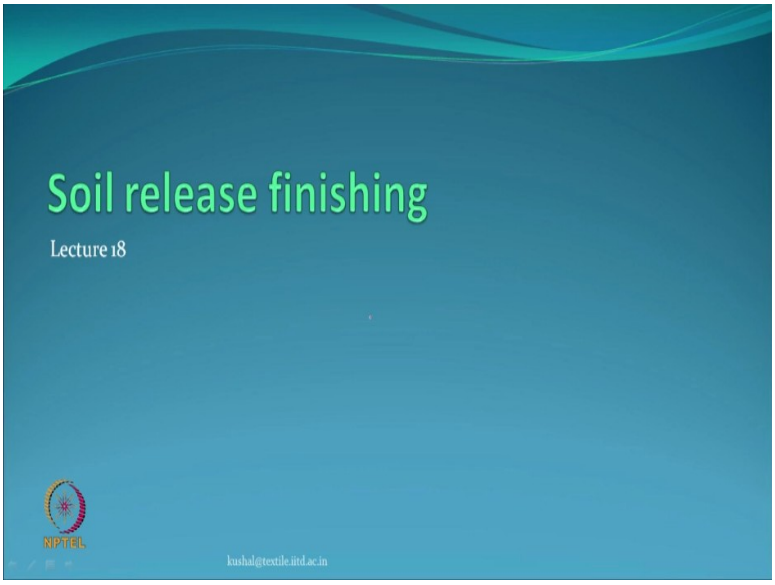

So, today we will talk little more on soil release finishing.

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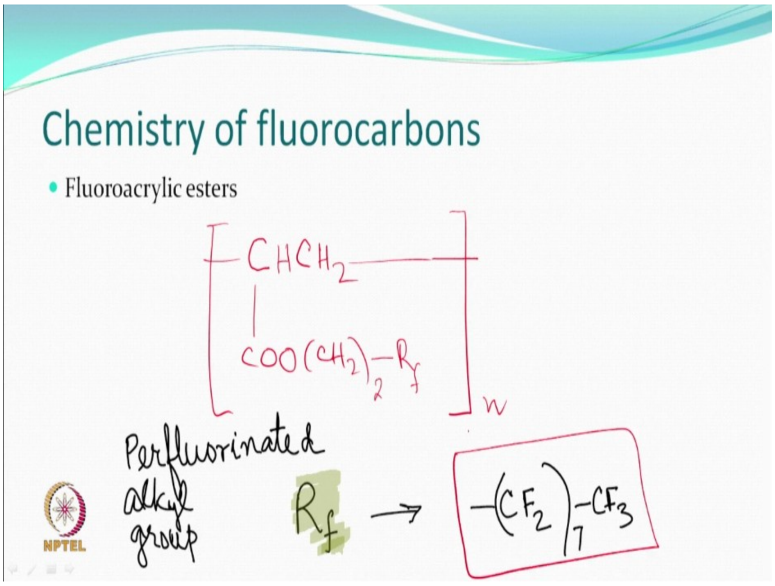

So, just to recall that we had the fluorochemicals which looked like this, where this moiety was an important moiety, which was responsible for the oil repellency.

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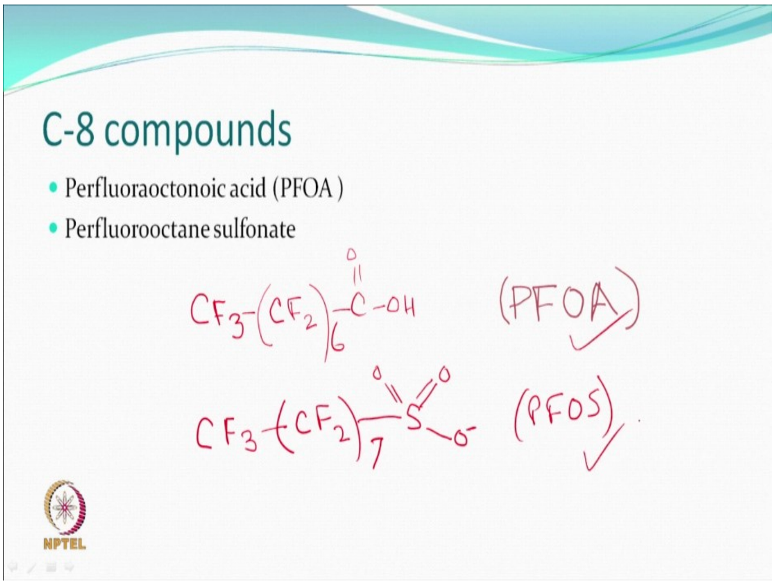

Some compounds like this, we had used as part of the branch, fluorochemical branch, which is the PFOA or a PFOS.

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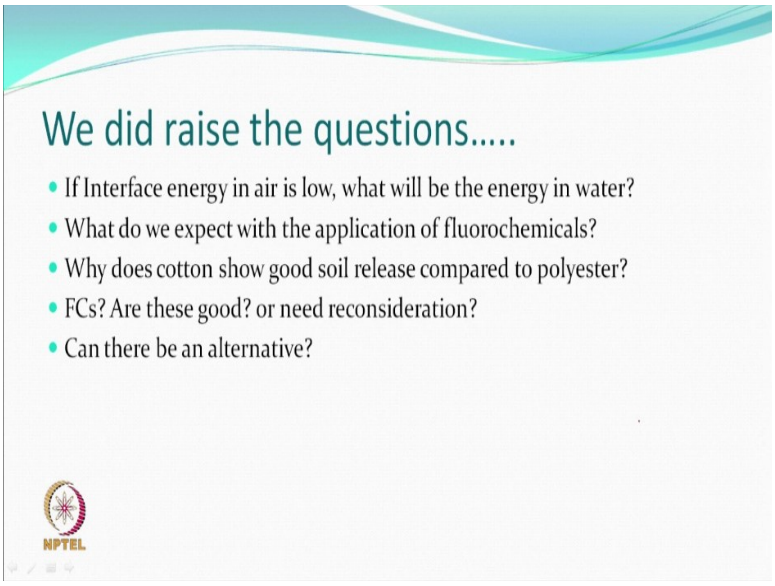

And we did raise some questions. And the questions were: If the interface energy of a surface in air is low, then what would be the energy or interface energy in water of the same surface? So, we said, it is going to be high. We just talked. What do we expect when we apply the fluorochemical the way just now we saw? They will repel oil. They will reduce the surface energy in air.

But in water, the surface energy will be high. And therefore, release of soil may not be as easy. Now, this question also was raised. Why does hydrophilic fabrics like cotton would release soil much easily, more easily compared to let us say polyester, which becomes soiled as we keep on washing? And somewhere we were partly convinced that, because the mechanism of removal involves penetration of an aqueous detergent layer; therefore, hydrophilic fiber fabrics in this respect behave better, compared to let us say polyester which is hydrophobic.

Son, we left at this point in the last discussion. Whether the fluorochemicals are good or we need to look at them from different angle. And yes, what is the angle? Angle is, can there be an alternate chemical compound, which could be considered the better soil release agent.

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So, if somebody asked this question: What is more important, a soil release or soil repellency? We would love repellency. No doubt about it. But, as we mentioned that in case the soil actually gets embedded by some mechanical force or action. Like we talked about the mechanics clothing; soil with grease, grease which contains particles also. What do we do then? We will be obviously very happy if the soil is released from the garment after washing.

That will be important to us. You get the point. Suppose, we create a molecular architecture which helps in soil repellency and also in soil release. Well, that is the ideal thing that can happen. If someone just starts thinking about it, then what do I do? If I take silicon based, they make the thing hydrophobic. If you go to fluorochemical base, they make it more repellent, oil repellent also, the fabric becomes. Then, what do we do? How do we do a release part of it? Can we make such a molecule? Well, that is what the research always brings out.

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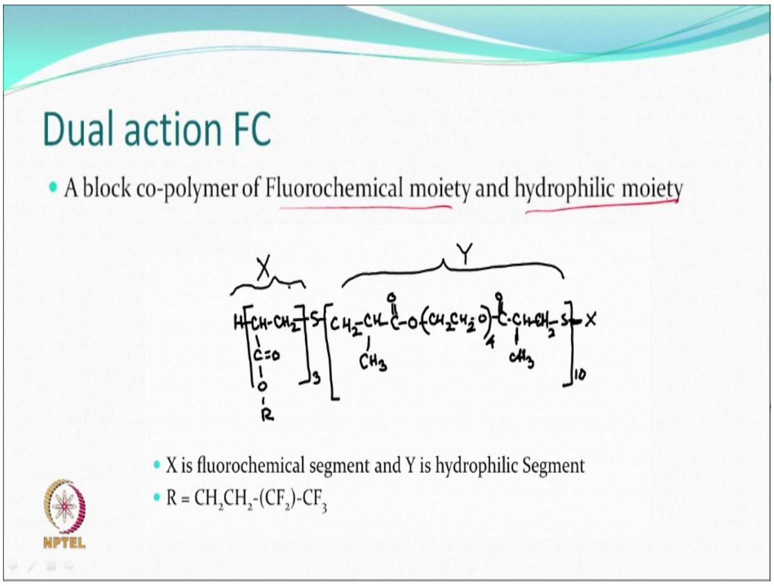

The interesting, beautiful, innovative effort was development of copolymers of 2 types of segments. One was a hydrophilic moiety, along with a fluorochemical moiety. If they become the part of the same polymer, same compound, maybe something like this can happen. Now, what are we talking about? So, we would have a block copolymer of 2 types of compounds; a fluorochemical and a hydrophilic.

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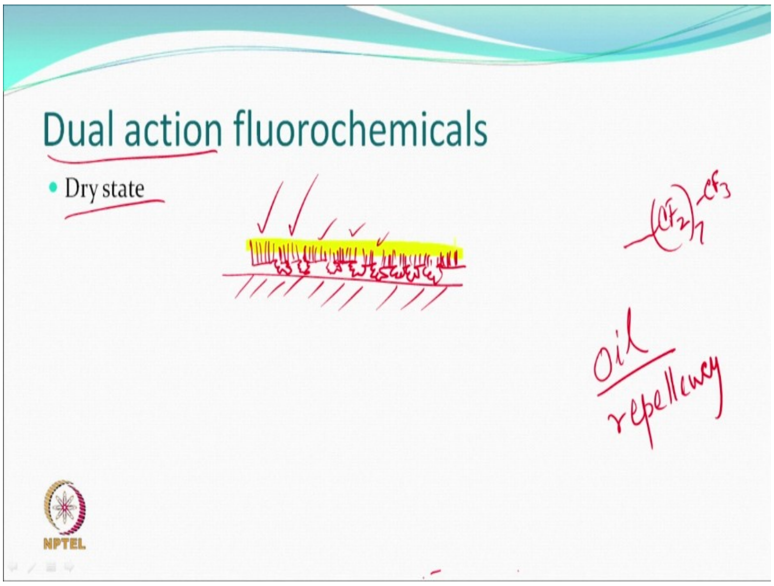

What do we expect? We expect that this compound, let us say in a dry state, we have a textile surface. And we have our compounds which has got a fluorochemical moiety. And it also has a hydrophilic moiety which is generally dormant in a dry state. If suppose this kind of a environment we can create, that the fluorochemical moiety which you really thought, that something like $(CF_2)_7$ -CH_3 -CF_3 type of a thing are projecting, projecting out like this.

They will repel soil. So, they were called dual action. The other action would start happening only when you have immersed, submerged the fiber or a fabric in water, let us say the aqueous solution. Okay. Now, what do we do then? If you go from here; in a dry state, we will always find, these are the moieties which are prominent. And therefore, they participate in a repellency, oil repellency. So, we are okay, like the way the original fluorocarbons were working, they will be working. What happens when we do a wet state?

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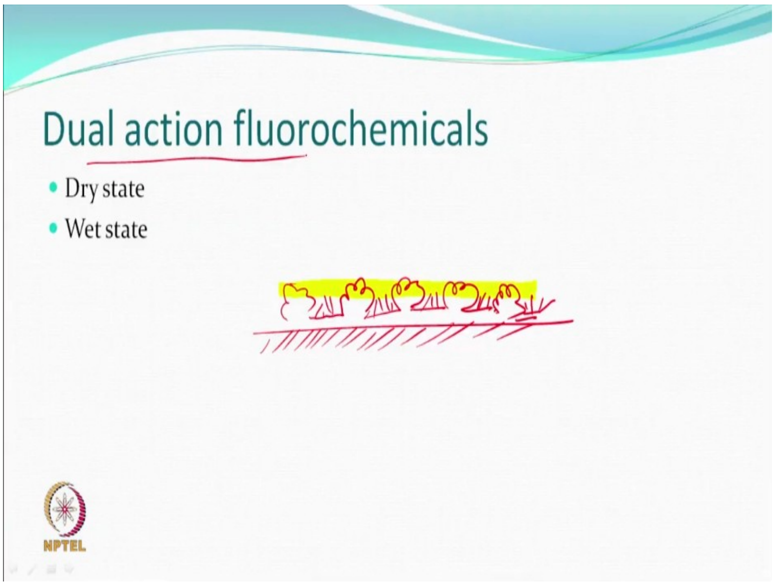

Because we said, other part is a compound which has hydrophilic segment. The other segment is hydrophilic segment. So, whenever there is a opportunity from anywhere, it will attract water. If it attracts water, it will start swelling. So, let us say, now, in a wet state, the hydrophilic part swells. Because it is hydrophilic, it absorbs moisture. But, during this so called swelling part, the fluorochemical projections are nondominant now.

They are disoriented. And therefore, now you create a different situation altogether. So, that means, in a wet state, you will always be able to find surfaces like this, which are going to be dominant. So now, the dominating portion is this. In the dry state, the dominating portions were fluorochemical moieties projecting outwards. In the wet state, the hydrophilic moieties predominate.

And therefore, the textile surface, let us say we are talking about the textile which has been treated with this type of a dual action fluorochemical agent, will be more hydrophilic now. And that would mean that, in case we have this possibility that the detergent solution, that is the aqueous detergent solution must penetrate between the layer of the oil and the surface, oil and the textile surface, which is finished textile surface.

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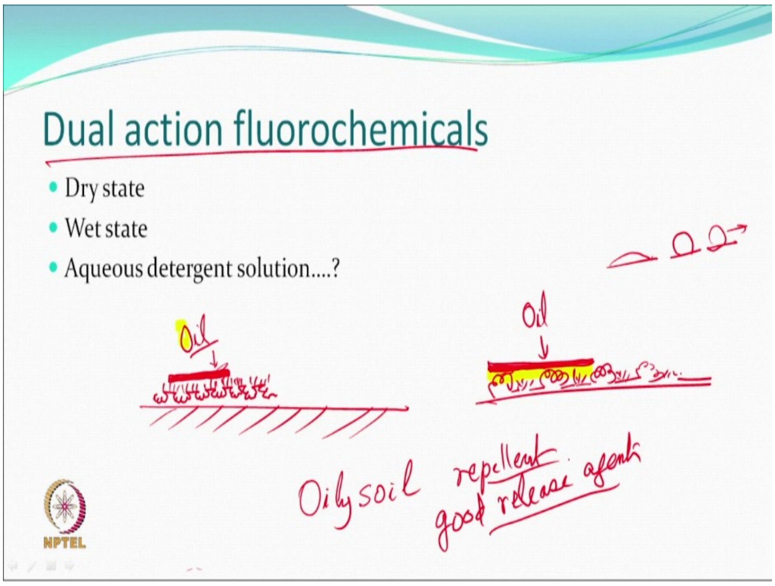

So, let us say, in the case when we have a detergent solution now, what are we expecting is, that before the penetration. And you had lot of oriented fluorochemical moieties pointing outwards. And let us say an oil based soil was deposited on this surface by some force. Okay. Like mechanics clothing, we talked about. By force, the grease has been put inside. But now, when you put the same thing now in water, what we will see is the hydrophilic part becomes predominant.

The fluorochemical part becomes less predominant; becomes not so much oriented; becomes let us say in a way disoriented. Now, this layer is actually going to be almost lifted. Because, the hydrophilic portions have swollen. So, what has happened? Now, this is a hydrophilic portion. The hydrophilic portion and the oil layer are now in touch. So, interface has changed. The interface has changed.

Originally interface was with the hydrophobic type of material, oleophobic type of material. And the oil layer was there. So, this is the oil layer. And now, this oil layer has been pushed up by what? Because of swelling of the hydrophobic. Sorry. Swelling of the hydrophilic segments. And what is in contact? Hydrophilic and oil. If this is what happens everywhere, then the oil does not like the hydrophilic substrates.

And so, it will start rolling up now. The contact angle will slowly increase till the point it just rolls off the surface. So, the dual action fluorochemicals; if the material or the product, the molecule is designed in a manner that you have a hydrophobic oleophilic material, followed by a hydrophilic material; then, this situation can be created. Where in the wet state, you will be able to get hydrophilic surface outwards.

And the oil will be repelled. Interesting, beautiful molecule. So, this way, these type of chemicals can be soil; we are talking about oily soil repellent, as well as good release agents. Very smartly, you have been able to solve the problems. So, you have a good repellency as well as good release, smart materials.

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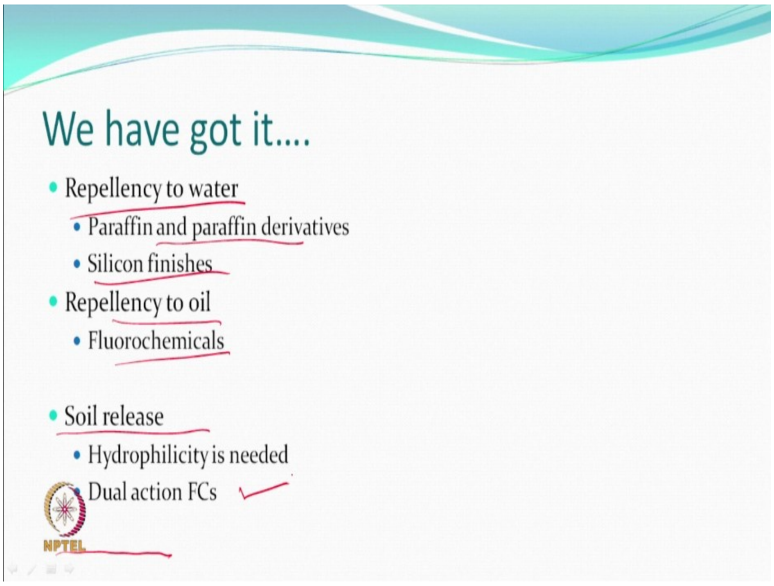

Now, the important part is: What have we got? We have, repellency can be achieved by paraffin derivatives in silicon finishes. Repellency to the oil can be done by the fluorochemical. But soil release, in some sense therefore requires: What does it require? It requires hydrophilicity on the surface. It is a very important thing to learn. Like we said, the cotton fiber fabrics are hydrophilic.

Therefore, soil release is easy. So, that is what we have learned for release. Hydrophilicity is a good idea, because generally, we are washing and; in a hydrophilic environment, which is the aqueous detergent solution. In this respect, the dual action fluorochemicals can work much, much better. Is it right?

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So, while we are very happy about everything that we have seen, what is happening? A new problem has come. This is being discussed. So, we have solved one problem. That from silicon to fluorochemical to dual action fluorochemical; we have solved problems of soil attraction, so that we repel it. And soil release became better. But now, the question people started asking is: Are these fluorochemicals ecologically friendly?

That became a big question. You may have heard about somewhere ozone depletion in the environment became an important issue. And therefore, some of the refrigerants which were fluorochemical based refrigerants are not used these days. But we are talking about polymers which are not free chemical which can just go somewhere else. They are reacted. But they say that anything that is reacted can be hydrolyzed, can break down into different compounds.

And you will get something else then. Then, what do we do, if beautiful compound which are doing exactly our function, also get into this situation? The reason is very clear, that anything which the nature did not have, was not synthesizing, cannot be very easily biodegraded. And so, there can be problems. What kind of problems?

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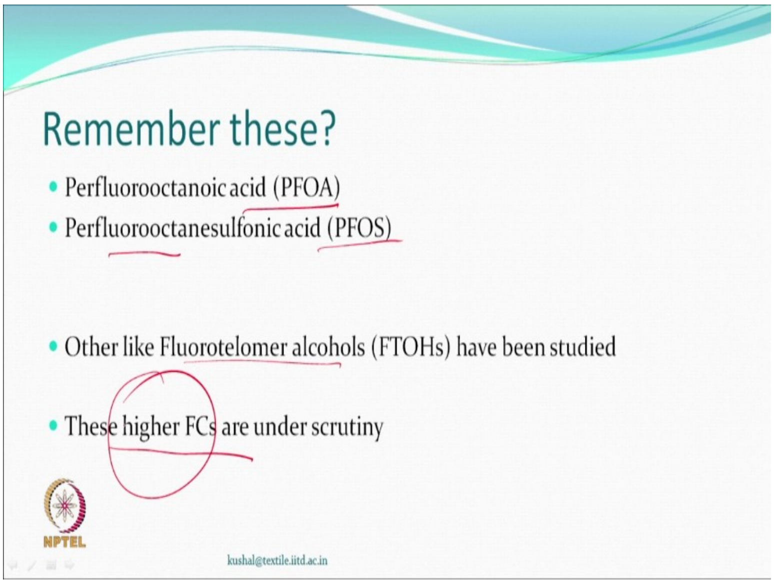

You remember this, PFOA perfluorooctanoic acid. These were the branches which were, let us say reacted to, on the main branch of acrylic polymer or polyurethane base polymers. Or chemicals of these type, PFOS. And there are other chemicals also, branches which are used, which are called though telomere, fluorotelomer alcohols, sometimes represent FTOH. They are the kind of branches which may be available on these large fluorochemical segments that we have.

Even in duel, we will have these only. The segment in a dual action fluorochemical also will be similar, along with something which is hydrophilic. But, if there is a, you discard the material, either the chemical or the polymer or the textile, whenever you do; something can get released to the environment, in the waterways, in any other way. And therefore, these higher FCs; now, this higher FC means what?

When we are talking about only hydrocarbons, we are looking at C_{16}, C_{17}, C_{18} type of thing. When we are looking at the fluorochemicals, the C_8, like octanoic acid was able to do your job. So, C_8 type of things. So, they were able to get much better repellency with these compound which were theoretically shorter carbon chains. But from the environment point of view, even these C_8 type of compounds are also called higher FCs.

That means, you are still looking at these molecules. If they get separated out and they get into waterways, there can be problems. That is why they are called higher. Because, they may get their; if they are not water soluble, they dissociate, but they are not water soluble. If they are not water soluble, then they can go into the intestines and everywhere, from the animals or humans, if they get consumed. So, they do not get washed out. They get stuck. And so our systems can have problems. So, the impact was:

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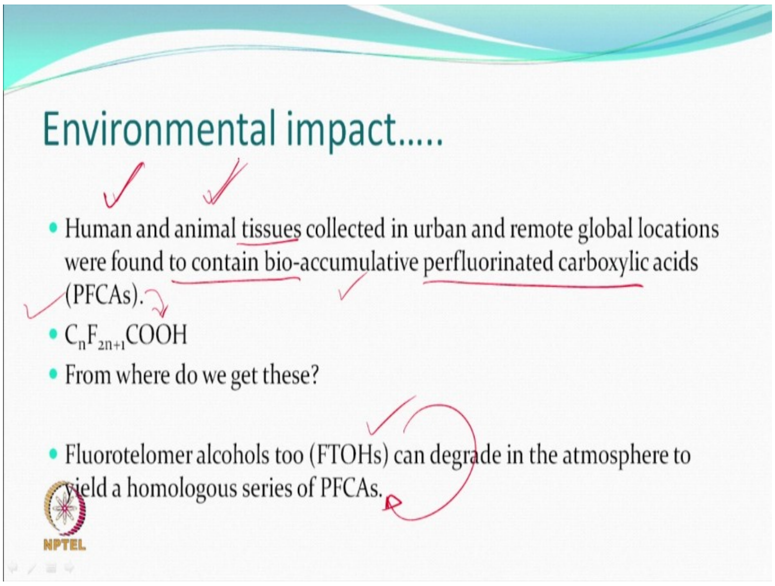

Some of the studies obviously showed that tissues from animals or humans contained perfluorinated carboxylic acids, which are considered as PFCAs. So, they were accumulating, bioaccumulative. These compounds are called the bioaccumulative compounds. So, that means, with time, instead of normally when someone ingest something, it gets excreted out from the body, after whatever actions, physiological other changes that we have.

It will comes out. Instead of if coming out, if they remain within the body, then obviously body cannot tolerate this for a long time. So, you will get problems. That is what people found, that actually these were accumulating in the body tissues. So, that was a cause of concern. And the PFACs can be represented like this. So, they basically, all fluorine perfluoro compounds with N-carboxylic end group.

How do you get these end groups? Well, you may have used them. As we said, we had used them in the thing. Or you may have used the other compounds like FTOH, that is the telo fluorotelomers, alcohols. They can also degrade and get into PFCAs. Okay. So now, you have these fluorochemicals actually in the environment, could be in waterways; after some dissociation from the main chain; and they get stuck.

Why do they get stuck? Well, they do get stuck. They are found, because they may not be water soluble. If they are not water soluble, then they get stuck in the tissues. And obviously, this cannot be very nice to anyone.

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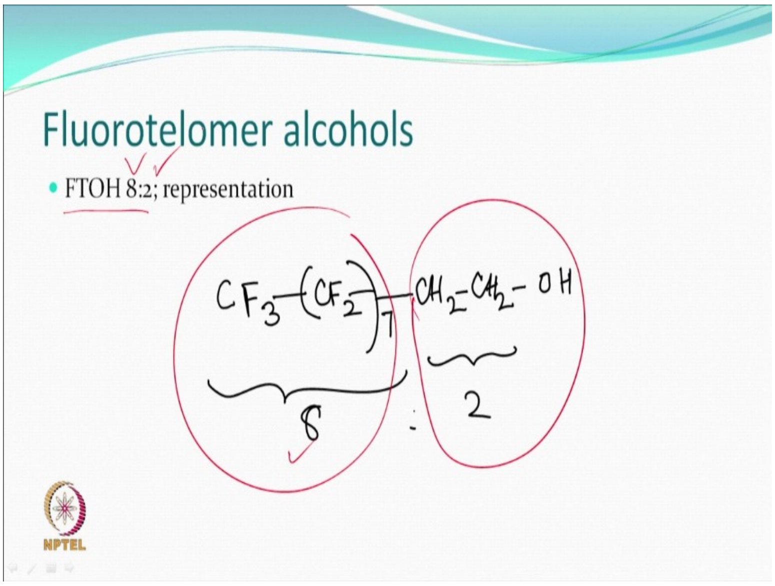

So, the fluorotelomer alcohols, the one which people may be using or they may be getting out are called normally FTOH 8 is to 2. That is the representation for, of moiety of this kind which is the perfluoromer, which has got 8 carbon. And the other is an alcohol kind of environment which is 2 carbon So, it is called 8 is to 2. This is the normal way of course. These can get converted to acids, as per the oxidation and so on so forth. So, they will get into the perfluoro carboxylic acids, which were found in the tissues.

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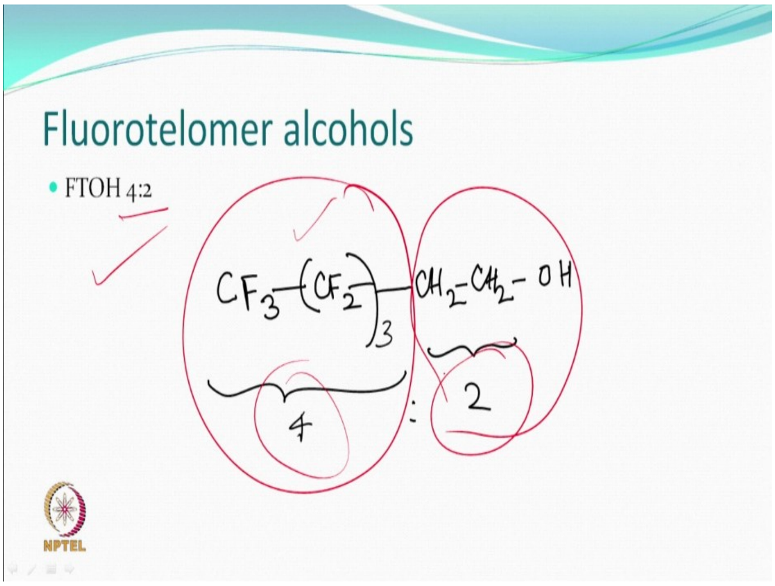

If suppose, instead of this, we have another telomere which is 4 is to 2. That means, this part is 4 carbon, which is the fluoro part. And the other of course remain the same alcohol, which we can see. So, this is this. Now, what are we trying to get at? We are trying to get at, that if the fluorochemical moieties, number of carbon in this moiety are reduced, maybe it will help. How does it help?

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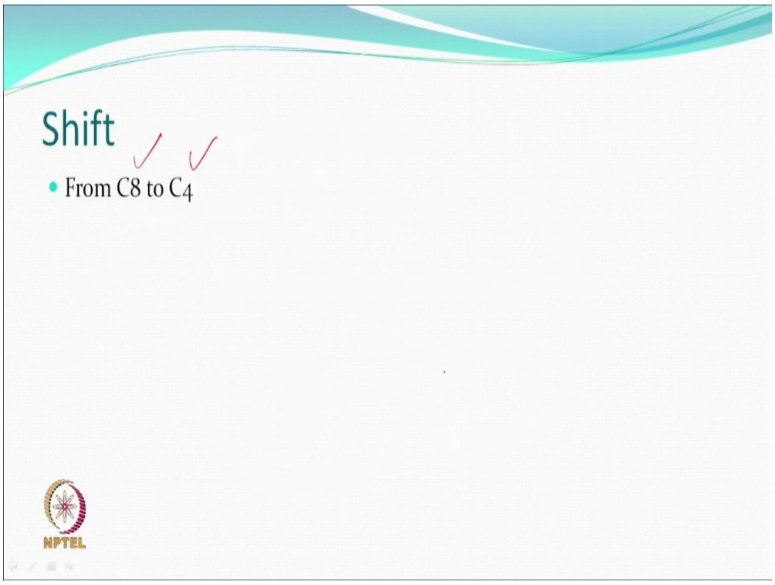

There has been a deliberate shift in the fluorochemical being used for purposes that we are talking about. Instead of using a C_8, we use, let us say C_4 carbon. Right. This kind of a compound; 4 and 2. If you use this kinds of compounds, then; and if they get, let us say dissociated and they get into waterways, then what happens? So, there is a shift. Why there is shift?

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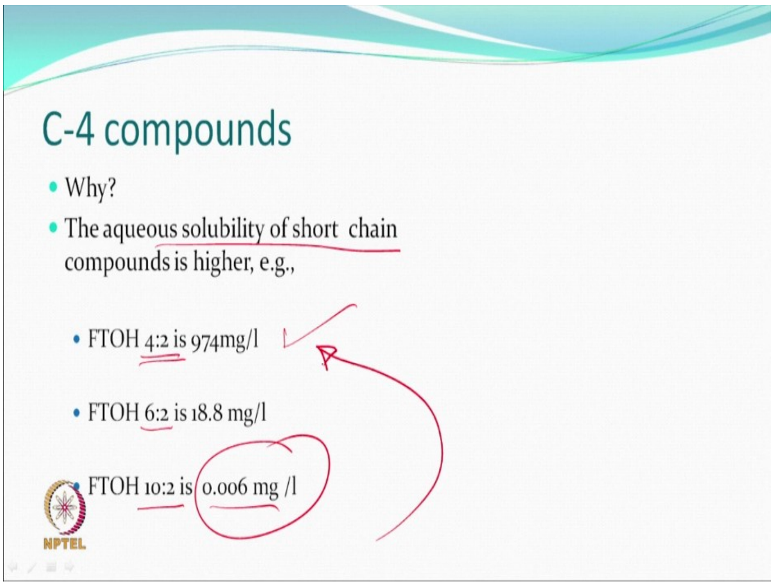

The C_4 compounds are more water soluble. Let us say how. The aqueous solubility of short chains. So, we were talking about the higher FC. That means C_8. Now, short chain would mean, let us say C_4. If it is a 4is to 2 kind of a situation, the solubility has been found to be approximately 974 milligram per litre. If you make it 6 is to 2, it is 18, around 18 milligrams per litre.

If you make it 10 is to 2, this is 0.006. So, anything which is not water soluble, cannot be good. Nature is not able to degrade very easily, because these things never existed in nature. We keep talking about polyethylene and other non-biodegradable polymers causing environmental issues. Because they did not exist in nature before, so nature had not handled them. Maybe after about 50 years or 100 years, nature would know enough, different kinds of enzymes which would degrade them also very easily.

The way they do, let us say a cellulose. So, if solubility is very low, then it will get stuck. But if you say, well, we are now going into this type of a material, then so much of this is soluble. So, if, the possibility therefore of this compound getting out of the body will be much larger, even if they have not degraded. So, they are not going to be absorbed in the tissues.

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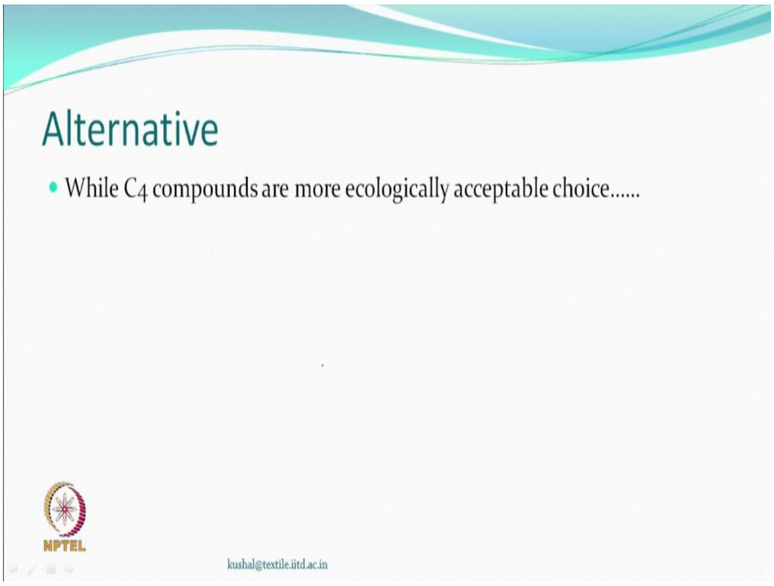

So, we have an alternative, that you have a fluorochemical moieties that you can use, which will be C_4 and not C_8. Life can be relatively easy. But, in case people say, well, we are not very, very happy with any fluorochemicals, which should not be as such. Then you may have to look for some other alternatives, which are non-fluoro compounds. Some compound; and, but also studied; an aim. What was the aim and objective?

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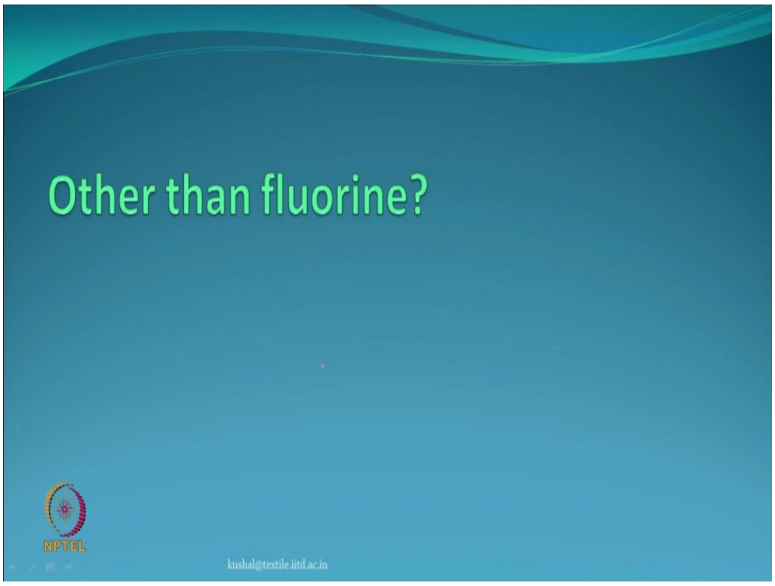

Objective still is that you make more soil release character. Got to have the character of the surfaces soil release. That means more hydrophilic. So, if more hydrophilic is the answer, then people said, why are we looking at fluorochemical which are very, very hydrophobic.

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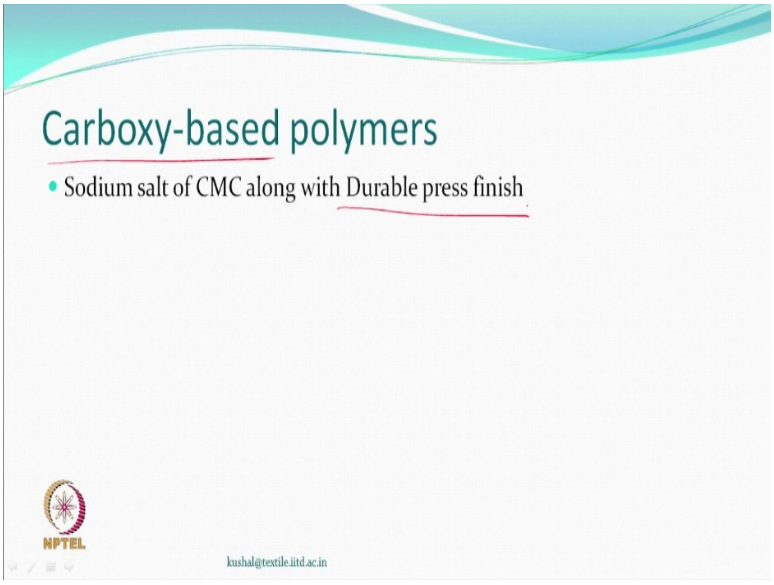

So, some compounds like carboxy based compounds were suggested for use along with the anti-shrink durable press finish. And it so happened that in one, some studies was also seen that normal cotton fabrics would release soil better than crease resistant fabrics. Why? Because, based on what you have done, if you have cross linked more. Then the hydrophilicity reduces hydrophobicity increases, other than whatever happened, all the good ones, good improvement in properties we have seen.

But this thing also happens. And they found, they would have difficulty in release of soil, the finished fabric. So, there were suggestions that you can use some hydrophilic agents along with it. So, one of them was a carboxy based polymer like CMC, carboxymethyl cellulose. What is this compound?

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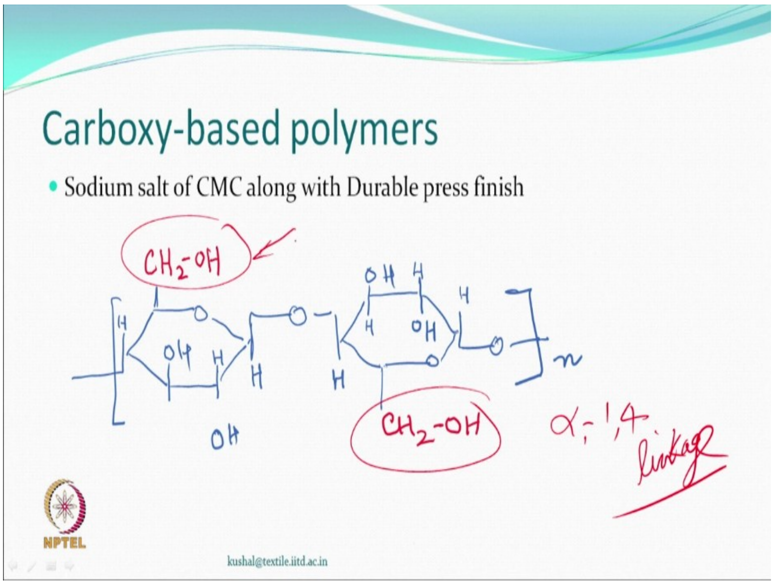

This compound is the cellulose. Alright. You have primary hydroxyl groups which are obviously more reactive, compared to the other secondary hydroxyl groups. So, this is as you remember, has an alpha 1, 4 linkage. Remember? An hydro glucose linkage.

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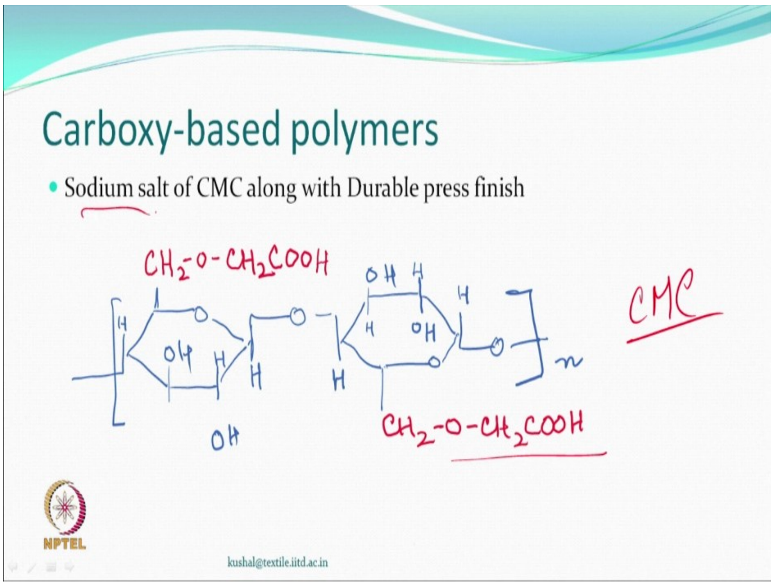

Now, if we change this to compound like this, this becomes the CMC. So, we have changed this primary hydroxyl group to this. Of course, when you want a sodium salt, then obviously, you will have the sodium salt of this, which will be in a way water soluble.

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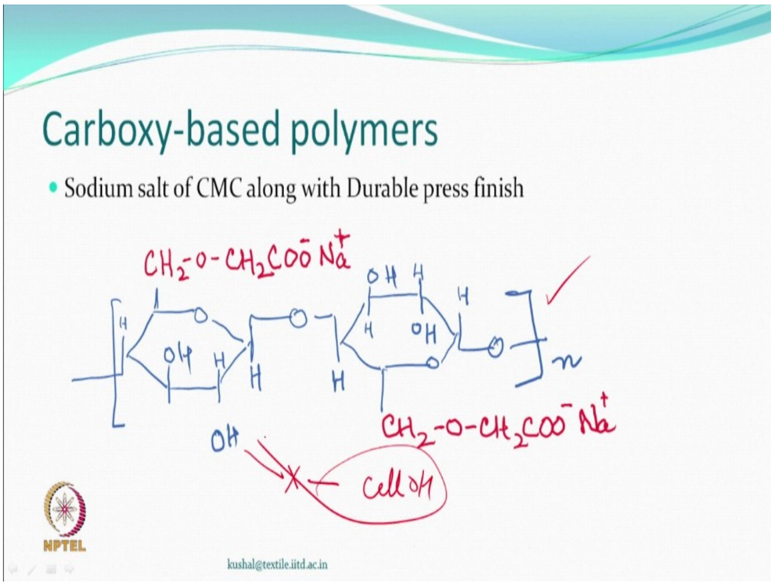

And then, it can also react along with the durable press compound. Part of it may get cross linked. This part, this will be the cross linking agent with another cellulose molecule, which actually is, let us say cotton. And so, you will have a compound like this, covalently bonded. And therefore, this would give enough hydrophilicity which may have been compromised after cross linking. So, you can get that. So, these are the things which people had suggested. For some other fiber, for other fibers, compound like this.

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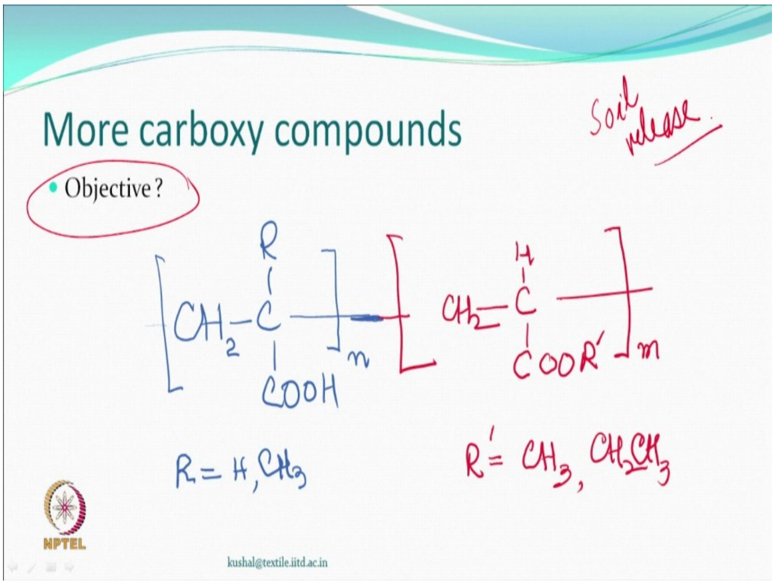

Because objective was, you want the surfaces to be more hydrophilic. So, block copolymers of this type of compound, which are carboxylic acid or esters of carboxylic acid, together would be able to give a polymer which will, let us say, not so much water soluble. But surface is hydrophilic. And so, soil release could be better. So, all this work is being done to improve the soil release.

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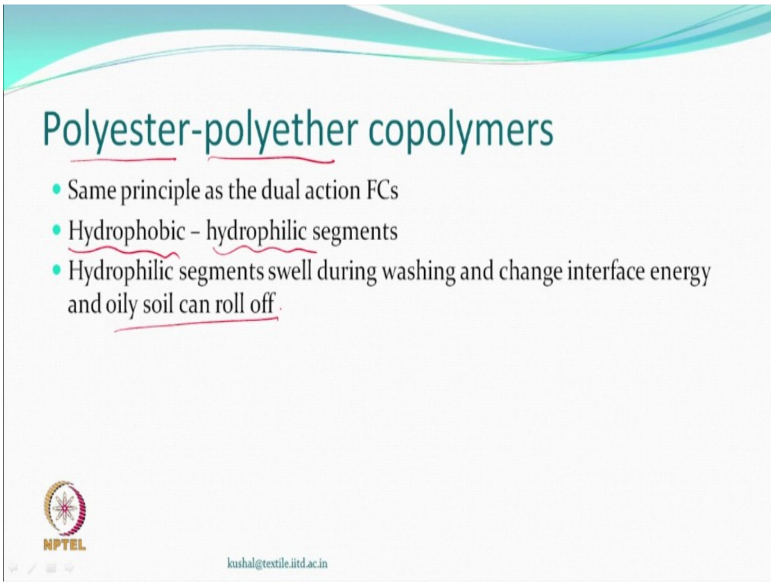

We can look at some other compounds also. Things like smart compounds again formed. Some polyester polyether type of linkages, if you can form; then you will again have hydrophobic segment and hydrophilic segment. And if that happens, the same mechanism which we thought we just learnt as a dual action fluorochemicals can be used. Are you getting the point? They can be used. And so, oily soil therefore can roll off.

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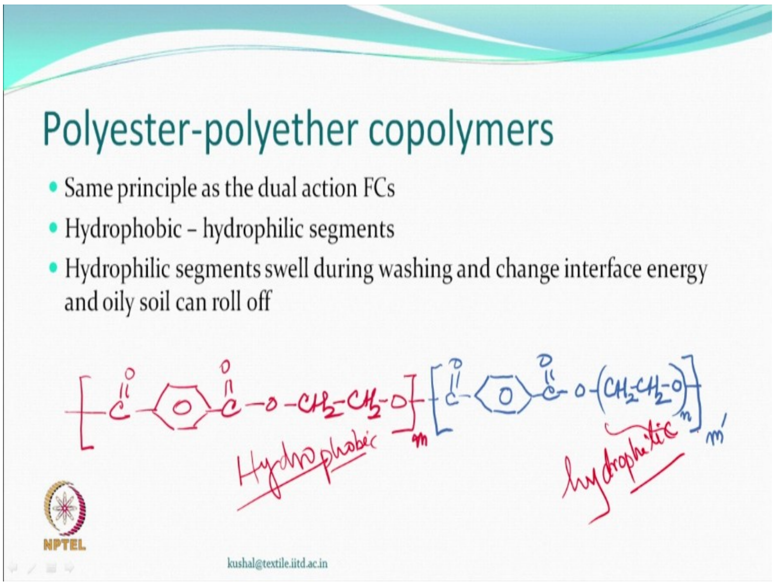

So, this is almost like a normal polyester, you see that. Normal polyester, this particular molecule looks like a normal polyester molecule. If suppose you add another moiety here, which could be a moiety which has got a lot of hydroxyl based hydrophilic groups, which are from, coming from epoxy groups, polymerized. So, you will certainly have a polyester polyether type of a situation, which means more hydrophobic and hydrophilic segments.

So, similar mechanisms can be seen with these type of smart materials again. So, people are looking at possibilities of non fluorine based compound, as well as fluorine based compounds, which are short chain, C_4 type of compounds. All of them can give us relatively more repellency and more release. If somebody asked this question whether fluorochemicals will repel more or these type of polyester polyether compounds will repel more.

Well, the answer is fluorochemicals. No doubt about that, repel. But release? They can do. So, if people are obviously saying, let at the end of day, the fabric must be clean after washing. So, these type of materials can do a job. Other interesting things that one can do, which are simple. I name again, is to make surface more hydrophilic surface, not the whole polymer, not the whole fiber. Let us say polyester, which is hydrophobic; fine. If you do saponification.

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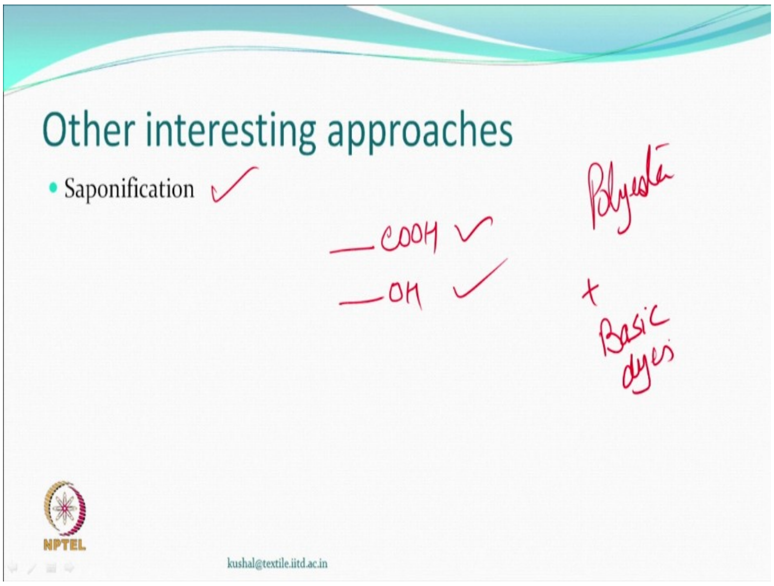

That means, basically, a treatment of polyester fiber fabrics, let us say in alkaline solutions. So, what will happen? On the surface, the polyester molecule may hydrolyze, generating carboxyl groups and hydroxyl groups. True or not? If a polyester, that is the ester molecule is hydrolyzed in an alkaline situation on the surface, limited treatment; you will get good number of carboxyl and hydroxyl groups.

One can do this treatment and try to dye this polyester, in basic dyes. You will see that the cationic dyes can get attracted in a suitable pH. Obviously, an acidic pH will be 2 polyester surfaces. That is an indication that the surface has changed. And if what is surface change? As we said, ester breaking up and giving you carboxyl and hydroxyl groups jetting out on the surface.

That means hydrophilic. If hydrophilic is the surface, then the chances are, that your detergent solution, aqueous detergent solutions will work. And the soil, the oily soil also will roll off.

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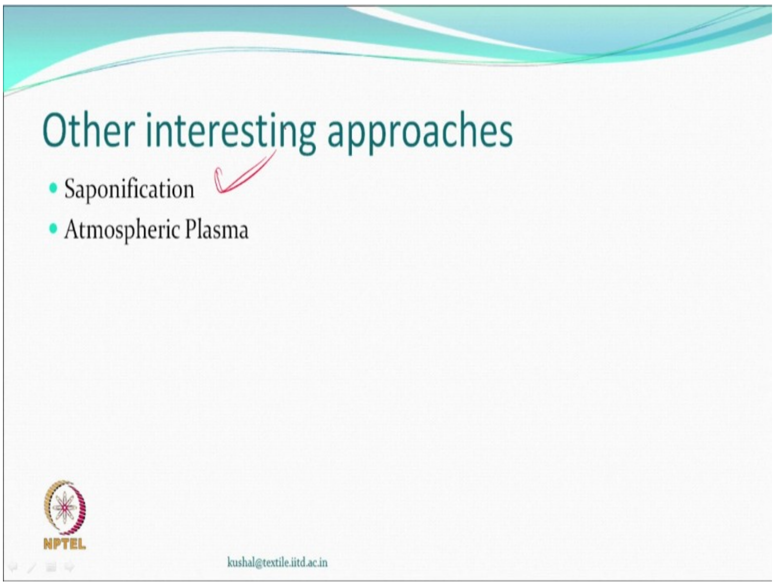

Well, something similar, people have done using atmospheric plasma, using gases like argon, helium and so on so forth. So, one can ensure that the surface becomes more wettable of the polyester synthetic. We are not talking about cottons and silks and wool. They are anyway hydrophilic. So, we have already agreed more or less, that if the surface is a hydrophilic, the chances are, soil release is going to be good.

And that is what is approached. Now, look at this. Saponification is a very simple treatment. And this change will be permanent. When these 2 groups, like cannot react by themselves again. And will remain hydrophilic more or less surface. So, soil repellency, oil repellency, water repellency; they are all surface finishes. So, from the point of view of economy and ecology, maybe simple treatments like saponification of polyesters can do a wonders.

Something similar can be done to the others. Of course, finishes, as we said, can also be applied. Plasma can also create hydrophilic surfaces. You put a drop of water on a plasma treated surface, it will immediately spread. But the rest of the material is still hydrophobic. Surface is hydrophilic, that is what is required. So, evaluation.

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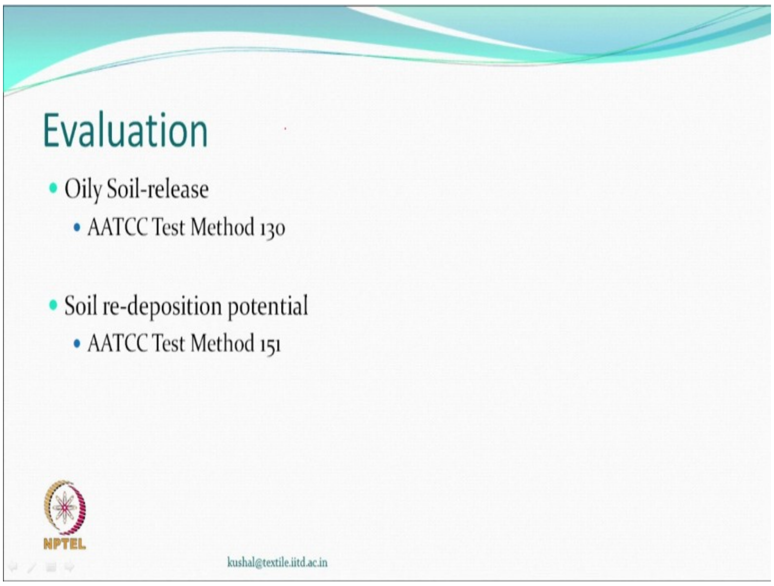

Well, evaluation can be done of the soil release properties. So, you do a standard soil, it could be an oil, a vegetable oil. Certain amount of drop; a certain amount of absorption time; a certain amount of heat treatment; and then certain way you wash them. And then see how much soil has been removed. You know, this is, can be done by standards, with normal optics or spectrophotometrically.

You can see the differences and find out whether soil release properties are good or not so good. Other thing; so, this test is there. You can go and read this test yourself. Other thing is, if the soil has been released once. And it is in the detergent solution has come out. Whether it can go back and deposit. What is the possibility of the soil getting deposited back. So, there are tests which have been, standard tests which have been decided for this type of an activity as well.

So, one can check both these things. The soil release property, as well as soil redeposition potential of that, whatever finish that you have done. So, we have learnt quite a lot. Right. What have we learnt?

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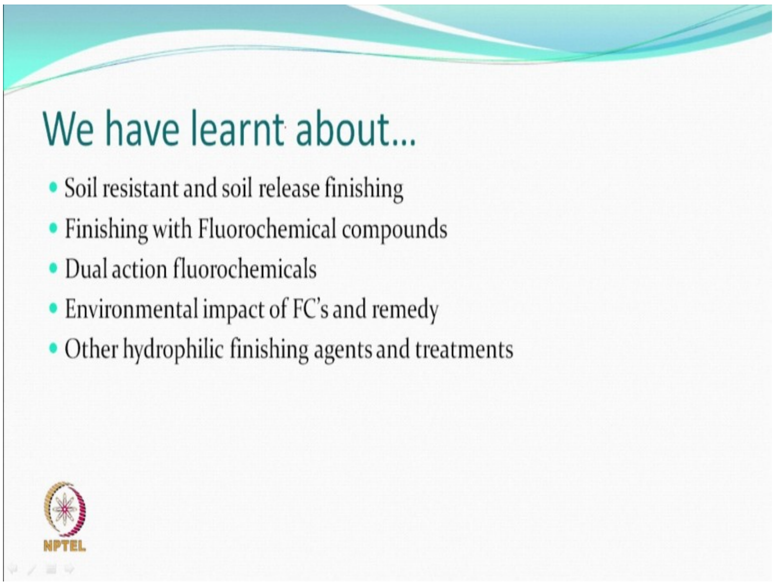

So, what is a soil resistant and soil release finishes. We have talked about the fluoro compound, fluorochemical compounds and their limitations, we have talked about. We have talked about dual action fluorochemicals; C_8 based fluorochemicals versus C_4 base fluorochemicals; the advantages thereof. And other possible hydrophilic surfaces that can be achieved by either a polymer, which is hydrophilic hydrophobic combinations; or just changing the surface and making it more hydrophilc.

This all can lead to more and more soil release. And when we talk about soil release, we are obviously talking about oily soil release, which is the most difficult soil to be removed. Alright. Next class, we will talk about a different subject, which is flame retardant finishes. Till then, have fun, enjoy learning. Thank you.