Textile Finishing
Prof. Kushal Sen
Department of Textile Technology
Indian Institute of Technology-Delhi

Lecture-22
Antimicrobial finishing

Welcome back to this class on textile finishing, we have covered a lot of ground let us see in the last lecture what did we cover. In the last lecture we were talking about flame retardants. We learnt about the general mechanism.

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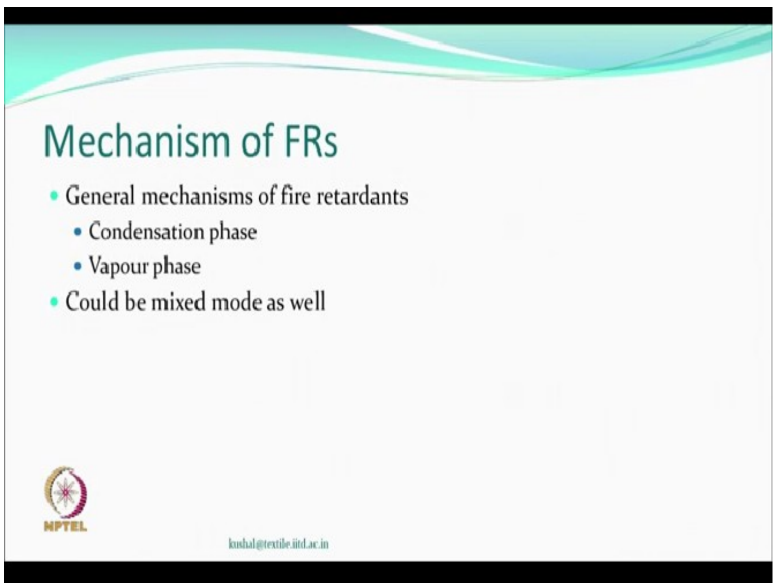

That is condensation phase mechanism which meant the flame retardant would participate in altering the path of decomposition or in the other case all the activity that happens for retardants happens in the flame, in the gas phase, so that called the vapor phase mechanism, some agents can work in both ways, in both by both mechanisms. So they could be called the mixed mode or a dual mode type of FRs as well.

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So we also learned about the chemistry of some of the efforts, we also understood what is specialty with of flame retardants which are used for synthetic fibers, also considered the ecological issues particularly with the halogen based compounds. The for special requirements there are special fibers which are inherently flame retardant, some of the examples we talked about was Kevlar, Nomex etc. or also we did spend some time talking about how to evaluate frame retardant finish.

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So now we move on to a different topic we will call this the NP microbial finish, so we will be talking today on antimicrobial finishing of textiles, but before we do that we must know what is a microbe all right. So what is a microbe, so they are microorganisms, small enough to penetrate many porous systems and participate in their growth process and because of that there can be some damage.

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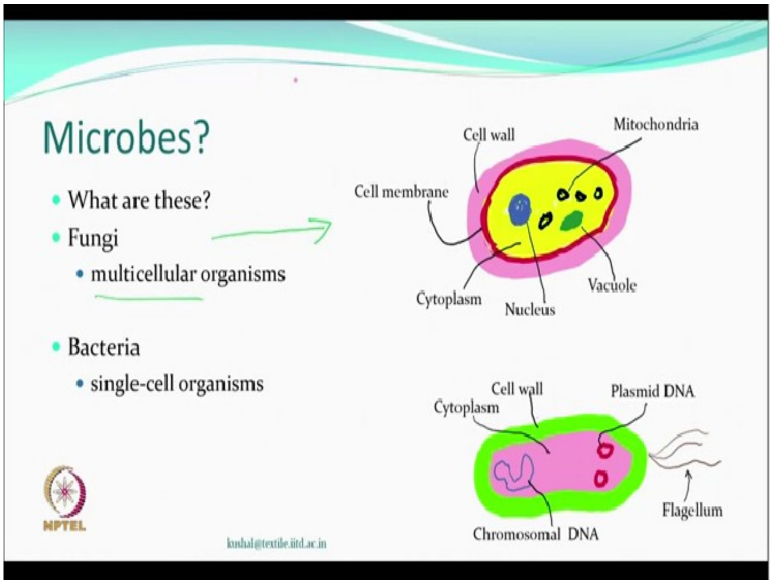

Very complex type of these microorganisms are like any biological system, so they would have their cellular compounds, so they would have nucleus in a cell, they can have various kinds of important things like in the case of fungi. So this particular representation is of a fungi cell which is supposed to be multicellular. So you have many things in between and otherwise also there is a nucleus there.

The genetic material may be lying there, you have mitochondria which is basically energy giving substances, there could be in 1000s and of course there is cell membrane and there is a cell wall and there is a liquid which we call a cytoplasm where which contains all these things in a way. So as long as these things are available the fungus cell is live would do things for it to grow into many more.

Similar to fungus you have other microorganisms which are known as bacteria, it so happens that the bacteria is a single-cell microorganism and is simpler from that point of view it can divide itself into 2 and then multiply keep on multiplying. So it also has a cell wall, it also a cytoplasm, some plasmids are there which also contain a DNA of a type and chromosomal DNA which is in the cytoplasm.

Some of them may have this flagellum but not necessarily all of them, but you can appreciate that these are smaller like micro structures which are in some sense we can call them live because they will grow. If they grow on their own and do not bother us it is fine, but in case they create some trouble for us then we have to work around them. So in these 2 types of microorganisms about which we will be concerned.

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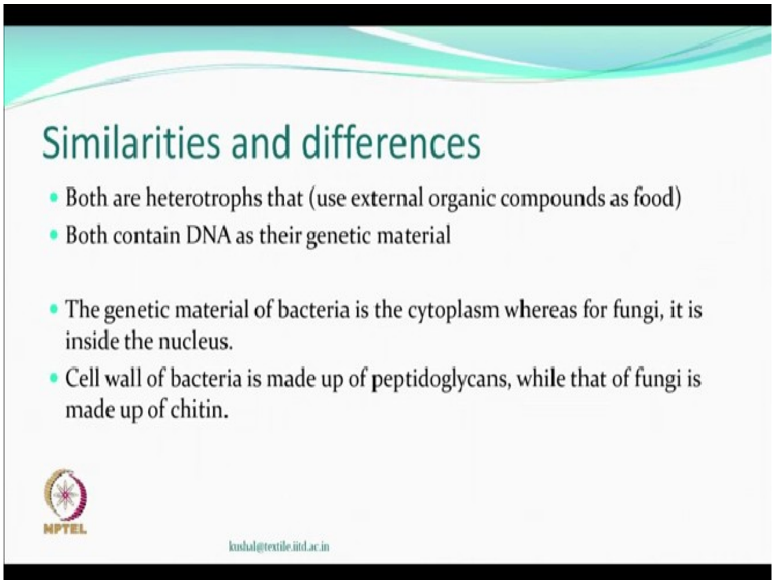

There are some similarities, both are heterotrophs means they use they need external organic compounds for food. So that is one both of them need, both contain DNA as their genetic materials, so in one way or the other they appear to be similar. The difference in the genetic material of bacteria is in the cytoplasm whereas for the fungi it is in the nucleus. So there is a nucleus in the cell of fungi.

But in bacteria they are in the cytoplasm itself that is one difference, the cell wall of a bacteria is made up of peptidoglycans while that of fungus is made up of chitin, you must have heard this term chitin in textile a lot of people use Chitosan which is a derivative of this chitin, we will learn about that also. So that is some difference we can think of.

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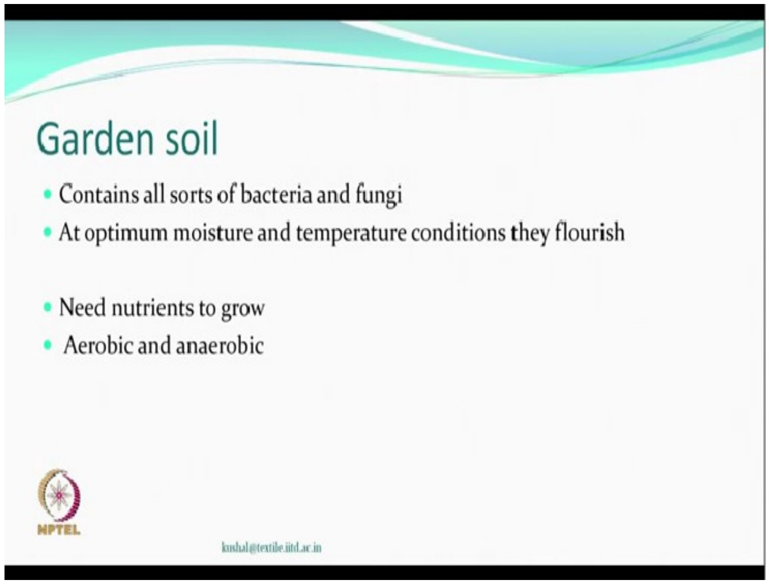

Where are they found, they found everywhere but there is something called a garden soil contains all sorts of bacteria and fungus, if you get optimum moisture and temperature they grow they flourish in leaps and bounds but of course they need some nutrient which obviously is available in the soil and some of them required for their growth and survival oxygen they are called the aerobic microorganisms or bacteria while some can survive grow without oxygen they are the anaerobic types.

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What can happen if these microorganisms are there around us now we are looking at textile as a fabric, as a substrate which is being used everywhere, it could be your garments, it could be your curtains, the bed sheets, the upholstery, what have you think about the carpets, the wall coverings and so you use textiles and we should be concerned if there is microorganism somewhere there what do they do.

Can they degrade fibres, well they can degrade some fibers, for example the fiber that are going to be susceptible to degradation which we can also term as a biodegradation are like cellulose that is the cotton, the viscose, the jute you can even consider other natural fibers. So all of them can be degraded by some of these organisms which fibers will not be susceptible**.** So all synthetic fibers like polyester, nylon, acrylics polypropylene, polyethylene.

They are non biodegradable, we are all talking every day the non biodegradability of these material. So from this point of view these fibers by themselves are not susceptible to any microbial degradation. So what are we worried about, we are worried about some fibers which get degraded or we worried about the fibers which are not going to get degraded. So what is our worry, well obviously we are worried about those fibers which will degrade that is one part of it.

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So the mildew is one term which you may have heard many times, this is a form of a fungi which can do damage to fibers which fiber we just talked about right, the naturally occurring fibers, if they are in contact let us say with the soil like for example you have a tent made of cellulose you make the structure the tent is for example here, this part of the tent is in contact with the soil. So it is susceptible to various types of degrading microbes.

They may have enzymes called cellulases and then you just keep eating it up that will become a nutrient and they grow, but all such things like the tents, tarpaulins, ropes, awnings, home furnishings etc. can be degraded by mildew, you would see some white, green things deposited over surfaces, you natural woody material, leather you can see some white things getting deposited sometime greenish.

They are all mildew and form of fungus and they would grow and by doing this they would decompose, degrade the area around that thing and so that will be there, of course when they start working discoloration can occur on the surface which will be visible even after you wash it if it is there is no hole, if there is a hole it will be visible anyway, but if you have been able to arrest before the growth then there will be discoloration odor yes they do not smell very nicely, it can be there they could be allergic.

And so you may not feel very good about it, so health related issues can be of concern other than the degradation of the textile.

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So what about synthetic fibers, we said they are non biodegradable, so they generally hydrophobic yes and so shall we say there is no problem with these fibers, so are what are we looking at are we looking at the degradation of the fiber and you want to protect the fiber or we looking at protecting the human beings and surroundings, what are we actually concerned, because if synthetic fibers are the one which obviously have nothing to do with the bacterial degradation most of them are called non biodegradable.

So is there a problem or there is no problem because they do not degrade, so we are safe, we can keep them whichever way you want we do not have to worry about them, have you ever felt bad odor coming from textile could be synthetics or otherwise when they are stored for a long period or let us say you have a textile which has just been used you had gone as a for a jog it is call sweaty leave it for some time, did you ever feel that there was some smell coming out of that what was that.

The smell was it perspiration or you keep it for some more time the smell will only increase. So what is it, so the important thing what you like is.

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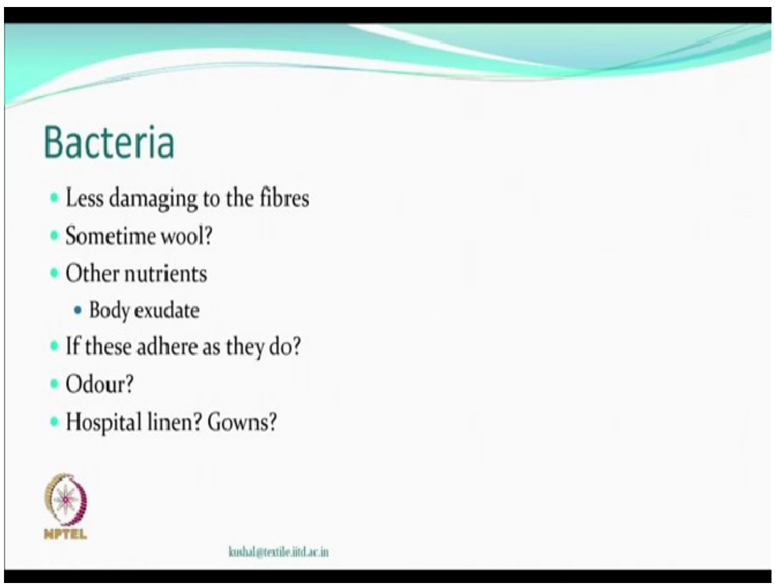

They may bacteria otherwise also do less damage to the fibers, but can do some damage to some protein fibers, but they are looking at nutrients from anything that gets attached to the surface of the fabric, like sweat body exudates which come get stuck something falls on the thing, a stain and oily or other kind of stain, or blood spill, all of them if they get stuck. These are the things which can become nutrients for the bacteria to grow.

And if it is a bad bacteria then you had it, although your synthetic fiber may be safe but what has been stuck due to whatever reason if this is a nutrient for the bacteria, bacteria will grow and obviously if it is infectious the infection will grow if it is otherwise harmful it will harm you and so they would give bad order that is a sign that something has gone wrong and then hospitality linen hospital-based linens, gowns, all of them can have various kinds of exudates liquid, soiling which may be a very convenient nutrient or a food for the bacteria.

And the bacteria would start growing there, your synthetic fiber fabric may not get damaged but you can be sick sweats while that is why we would like to give antimicrobial finishing treatments to the textiles, somewhere our aim may also be saving protecting the fiber like the biodegradable fibers but mostly it will be protecting us from any damage that could be caused because of fungus or bacteria that we grow.

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So this good bad stuff good fungus, good bacteria, bad bacteria bad fungus, so everything that is available the nature's cannot be bad, but some of things could be so we have to isolate we have to understand what are we looking at, so this is very clear that all bacteria or fungus are not bad ok, but there are some bad ones also this you must have heard these term like E.coli ok Staphylococcus you must have heard these terms.

They are obviously not very friendly to us, they can really make you sick if they grow because there is some nutrient available then it is going to be a problem. So we must worry about them.

Similarly not all fungal species are bad, you know you have heard about mushroom, so there are edible mushroom and there are non edible mushrooms. So these are actually fungus, the edible people are eating anyway.

Some of things obviously are required but some obviously are not so good, they can cause diseases, they are called the pathogenic types ok and they will call allergy, so some people get allergic suddenly in some place and that is because the pollen or any such thing is there in the air or on substances where it may have been stuck because of but they can fall off, they can grow we can fall off, they can go in the environment.

So they are going to be not so good, some of these examples like Aspergillus and Fusarium are some of the genera that falls in the category of pathogenic fungal group and so we have got to be careful for them, but what we have learned is they all are cellular structure. So what we have to do you know we have to if we can break their cellular structure, if it can do something so that the nutrients are not there or we can do something that the nutrients along with that have got some other chemical which they do not like that means they cannot grow.

So any of those things can be done if we selectively choose some chemicals which we can apply as finish onto the textiles, then hopefully we will be able to handle the bad bacteria right. These are the bad bacteria and the bad fungi.

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So now this question if somebody asked, what is this biodegradability, but if you add any antimicrobial finish, then the bacteria would get damaged and so the biodegradability will be lost. So what is our aim, our aim should be to protect ourselves first in case we feel endangered because of the growth of bacteria or fungus. But a biodegradable textile product may have an extended life but it is not going to become non biodegradable.

But otherwise we have just talked about the non biodegradable compounds also would require antimicrobial finish, because the nutrients can come from any source. And adhere to the surface.

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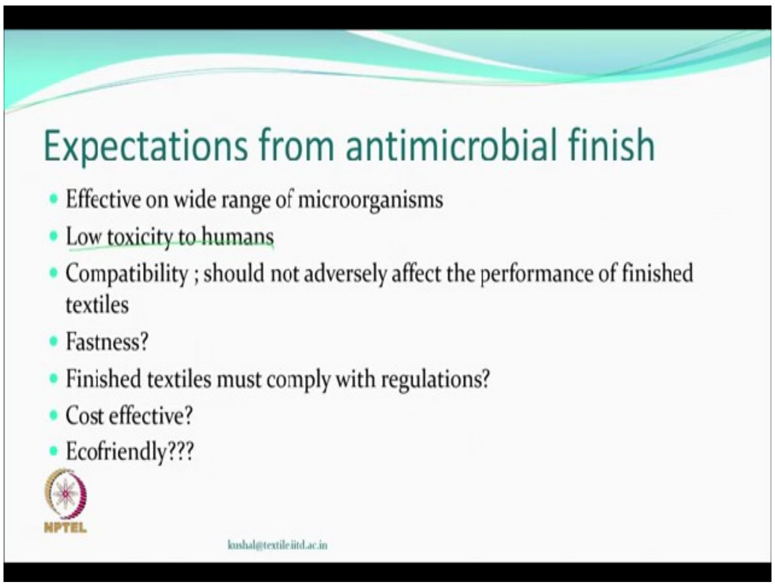

So what are our expectations from the so called antimicrobial agents, so we want to finish we are going to be spending money, so what do you expect, so one thing which you may like to expect because we do not know which type of organism is going to be available we will try to attack which kind of fungus or bacteria would attack, would get adhered, would grow, so if you have an agent which can work on a wide range of microorganism this will be good for us.

But because all of us know that there are good bacteria also which we need, now we have an antibacterial agent which is going to kill, if suppose this starts killing the good bacteria also, then it will also be harmful that means these agents now we are not talking about the toxins generated from fungus, we are not talking about the toxicity of the antimicrobial agent itself because it is attacking the natural microorganisms.

So by whichever mechanism so it can also attack the good microorganisms as well, so at least they should have low toxicity for the human and why not animals of course and why not plant for that matter, so whenever you use any such agent called the antimicrobial agent it would have the plus side which we are hoping for our benefit but it may have a negative side also and that one has to worry about whenever you choose.

If there are some considerations when somebody says there are ecological consideration that means those type of agents are not good even if they are good antimicrobial agents but they are actually not good for you us for our ecology for human for other species that we have. So actually it is a very contradictory requirements. So compatibility we expect that you would be applying various other things on the textile like dyed or printed textiles are there, there are otherwise you are putting various kinds of finishing agents.

It should not have you know bad effects on them and if that happens then obviously it's a different kind of a compromise you may like you may not like. Of course once you given treatment one would expect that this treatment last for a longer period, if it does then really happy so fastness of the finishing treatment is something which you will expect and normally what would they either they react or make a polymeric network or they get I dared by one mechanism or the other.

Finished textiles must also comply with the regulations, what it means is that these agents if they leach out from your textiles after finishing and go to waterways and otherwise and soil one must check what the regulation says that would anyway say that do not use such and such compound, if the regulations say do not use a certain type compound, so let us not use that that's the only solution that we have because some people have done little hard work.

And found out what damages can be caused by such agents, of course anybody would love them to be as cheap as possible, but then the cost will be based on the fact whether it is a special chemical, whether they have taken care of all ecological considerations. So it may or may not be very cheap, eco-friendly, so what is eco-friendly, it is going to be acting against some of the bacteria which were naturally there.

They were harming us so far from that ecology point of view they already gone so what kind of a contradictions and then we talk but what it means is that we should still have a choice to select such type of an agent which at least would not harm the good fungus or good bacteria alright, hard choices it is not going to be easy for anyone, you find a good antibacterial agent it may not be ecologically very nice. But that is it well we keep working and researching on them. So how does an antimicrobial agent work.

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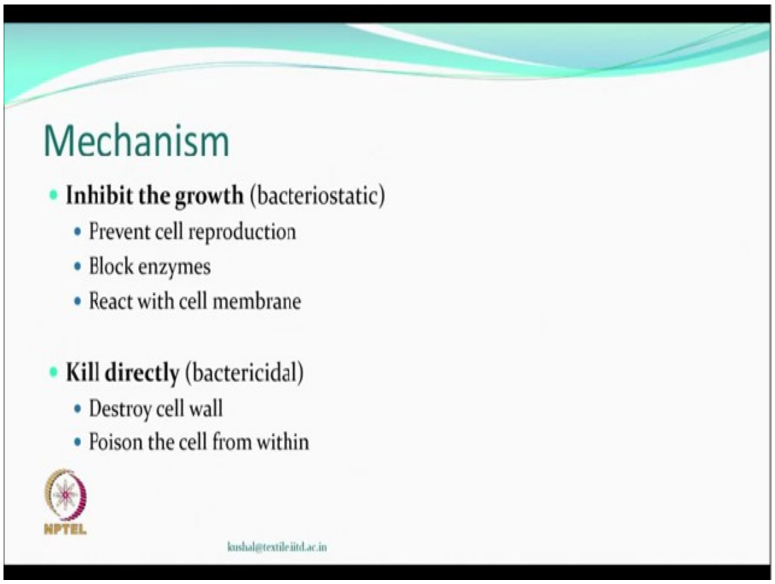

So it can work either by inhibiting the growth the area would like to grow multiply, so they would hinder that process that can be done, so which would mean cell reproduction can be affected they can block the enzymes which actually work and get them the nutrient ok enzyme is very specific it has to go to a certain site, break the thing, bring it out use it as a nutrient if suppose that does not work it is blocked enzyme becomes ineffective or react with the cell membrane make it different if possible let it be it could be cross-linked.

And then that is function the way it was supposed to function because these are complex systems which still work in various kinds of balancing acts and if you change any of those things their growth gets affected. These type of things which we taught in the first word called bacteriostatic agent, so they are working in a static way, the others are which actually kill the bacteria they are called bactericidal bounds.

So they would destroy the cell wall, there is a lot of genetic material in the cytoplasm there are other kind of things in thing it just leaks out the wall breaks gets disorganized completely then obviously there is nothing the bacteria is that dead or it gets inside and poisons the bacteria itself and so the kill directly so that is the kind of thing they can do so these are the 2 basic mechanisms with which would be there, the question is how do we apply, what happens how do they kill, whether the bacteria goes when they own to the textile.

Then it gets killed or the system's cannot least out in around the thing surrounding things and work that has to be seen. Let us look at some of the examples where people look quite successful have been successful as far as antimicrobial activity is concerned.

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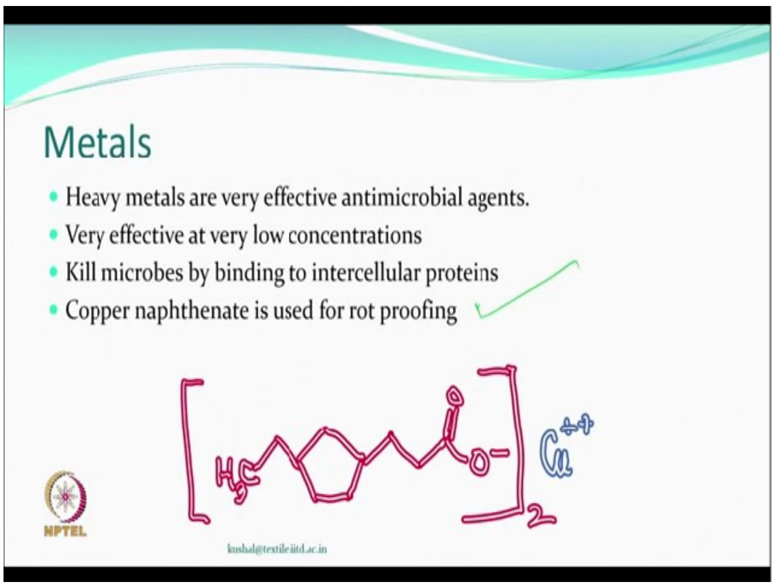

In these some of the early things started with the metals metal ions. The metal ions can penetrate and do a lot of damage **to** to the cell structure, heavy metal like chromium, copper, cobalt, they are effective in killing the bacteria, but and at very very low concentrations they can work, if they are on the textiles and they actually kill so whatever the intercellular matter is their material which is so important to them they hacked there.

Because they are let us say bivalent, trivalent bound they will make coordinate bonds at different places and disturb the balance and so things can get ruptured. So they kill and then what happens well when the bacteria or the fungus is not really growing the cells are killed and there nothing grows, one of the successful examples earlier people used was called the copper naphthenate, it was for let us say cotton, tent ages awnings etc. was being used.

Because they would come in contact with the soil, this there was a term called rot start with mildew and rot, the rotting means is degrading, decomposing. So if you use let us say copper nephthanate then you will stop the rot or rotting, so sometimes we call to rot proofing ok. Simple structure which is an naphthenic naphthoic acid and the copper salt of that would be larger molecule, but yes it gives some color if you greenish yellow color maybe there.

Because the copper and therefore some people may not like but if it is a tent which anyway normally is green, so it is ok, so a very effective rot proofing agent it was.

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There is another interesting finishing treatment called the willesden finish, have you used or heard about cuprammonium solutions for what it is used cuprammonium, have heard of copper ammonium fibers cuprammonium solution at a particular concentrations of copper and ammonia can actually dissolve cellulose. So cuprammonium rayon was one of the fibers which is the re fiber generated from the wood pulp and after purification and dissolving and then doing wet spinning one can make fibers.

These days you use to test what we call as cuprammonium fluidity what is it, so if there is any damage done to let us say the fiber because of any treatment like bleaching or it is covering so molecular weight goes down, so people test cuprammonium fluidity that way it can dissolve but only if the composition is same. Otherwise it can make a gel kind of a thing softer material. So if you apply cuprammonium solution of some kind it does not dissolve completely or you do not permit to be dissolved you apply part of the cellulose surface may dissolve.

If you compress it calendar it you may find the interstices can be closed and this material becomes part of the gel or the viscous system which was on the surface gets deposited it is cell yourself and the copper basically get bound in some sense, so because there copper so medline will kill the bacteria. There is one the only thing which happened with the time is people found the chrome copper are not so good for the environment point of view.

This is what we are talking about ecology, so they are good antimicrobial but they are bad for the other good bacteria also and therefore they can be a problem and people may not like them so much, but they were very effective.

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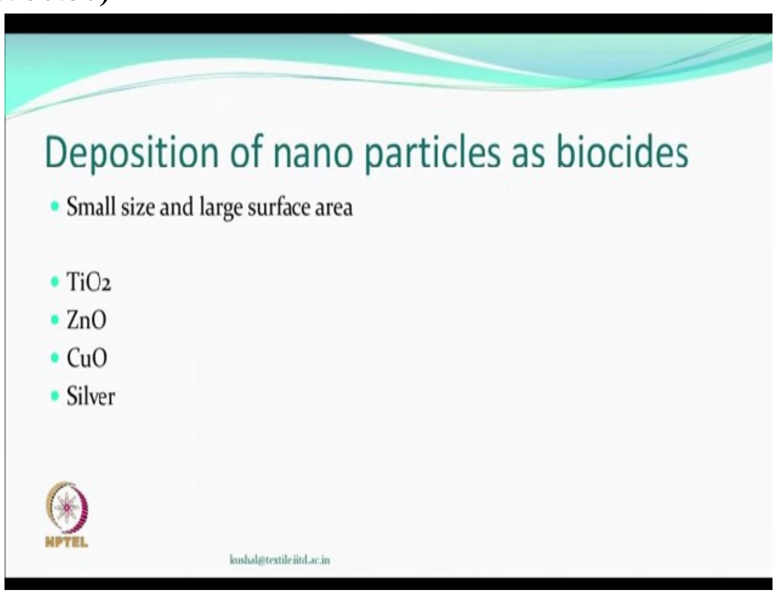

So other type of particles which are not bad so much like TiO_2 particle in nano scale or zinc oxide copper of course as we mentioned we have seen the copper works with copper is not so ecologically favorable compound and then silver. The silver people you know they eat silver and on the various kinds of sweet people put a thin film of the silver they eat so this is not a problem as far as the ecology is concerned.

Of course in a certain amount but that is ok the silver is something which can be used as an antimicrobial agent. So of late silver has become a more popular choice for generating developing antimicrobial finish.

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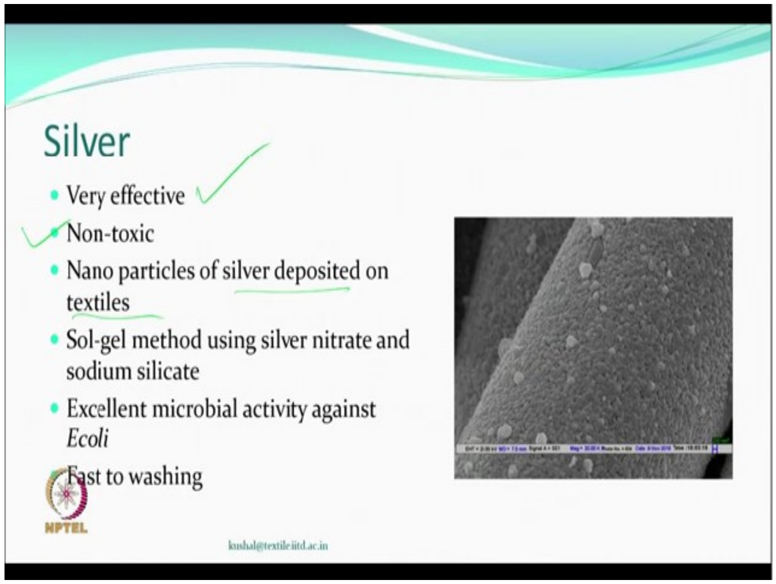

So the silver is very effective particularly if you apply at a nano level, you see this picture of fiber it is quite magnified some of the particles are around 50 to 100 nanometer size deposited on the surface if you generally look at you would not even see them obviously they are very small then nano but they get adhered at the nano level the different kind of forces work and so addition could be better based on what you have done to define.

What is the size the particle, how they applied, so people obviously are quite happy as long as this is properly attached the generally non-toxic, the nano silver particles can be deposited by many methods, many methods can be used to deposit these particles, sometime they are deposited as void something called electroless plating, then there are method like sol-gel method using silver nitrate and sodium silicate combinations which can create some particles of this kind.

And once they get attached they are alright and they are pretty good against some bacteria’s tested, in fact various kinds of bacteria they are pretty good, if done very nicely they would be first to washing alright, if the particle size is very small. So the metals as we've seen can work ok.

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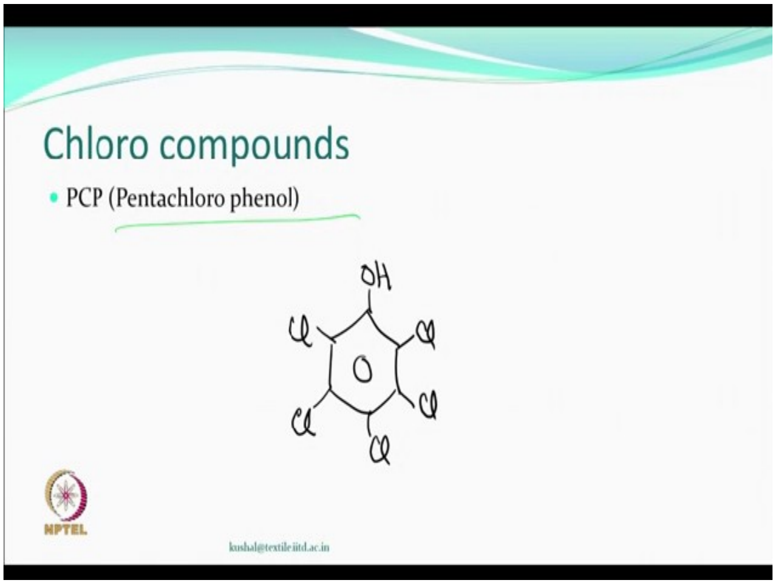

The other compounds which were obviously initially tried as a finish were chloro compounds and there are many chloro compounds but which are antibacterial and so they were tried on textiles also. One of them which is very very popular at some stage was PCP pentachlorophenol. So I see so many chlorine so it is an organic chlorine compound it is very effective because of the chlorine itself and this would destroy the growth, inhibit the growth of the material.

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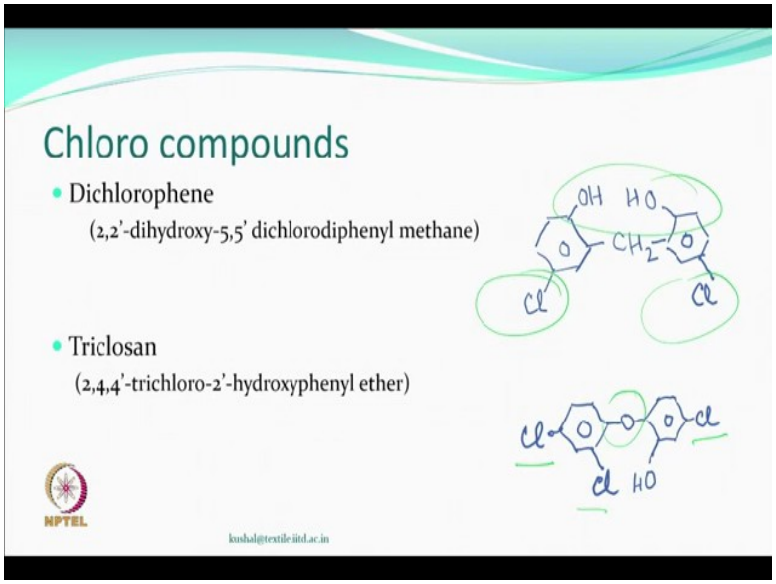

Other chloro compounds are also there some very specific like dichlorophene is very specific compound and looks like this, so I have 2 chlorine groups here 2 phenyl groups and hydroxyl groups. So that way you can have some affinity for the textile substrates and can stay for a little longer period, these are effective compounds and that very interesting compound which people have been using quite a lot is triclosan.

The triclosan has got its an ether we have got 3 chlorine and 1 hydroxyl group so these type of compounds have been found to be very effective on the bacteria and so good antibacterial agents just that the ecology and these compounds have some dust. So organochlorine compounds somehow are obviously not finding too much favor from the environment point of view.

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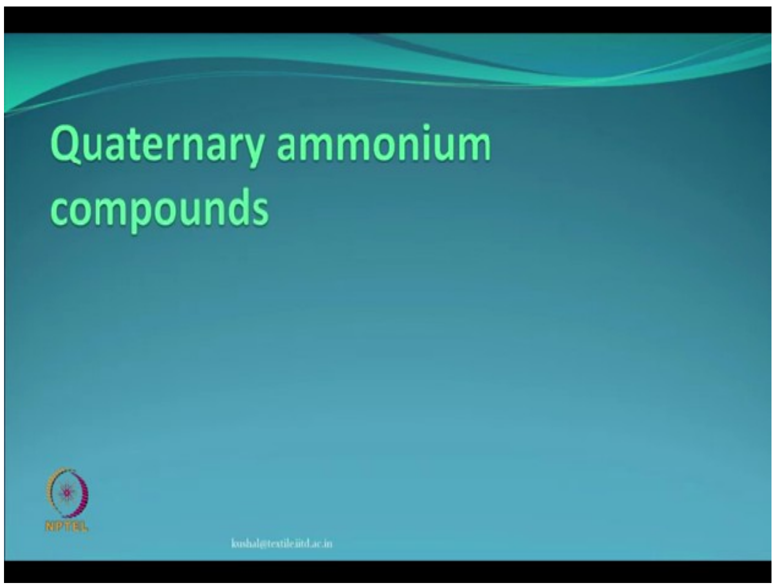

Other interesting compounds are quaternary ammonium compounds, the quaternary ammonium compounds as the name suggests would have a positive charge, because of the quaternary nature of these compounds they are normally called QA C's.

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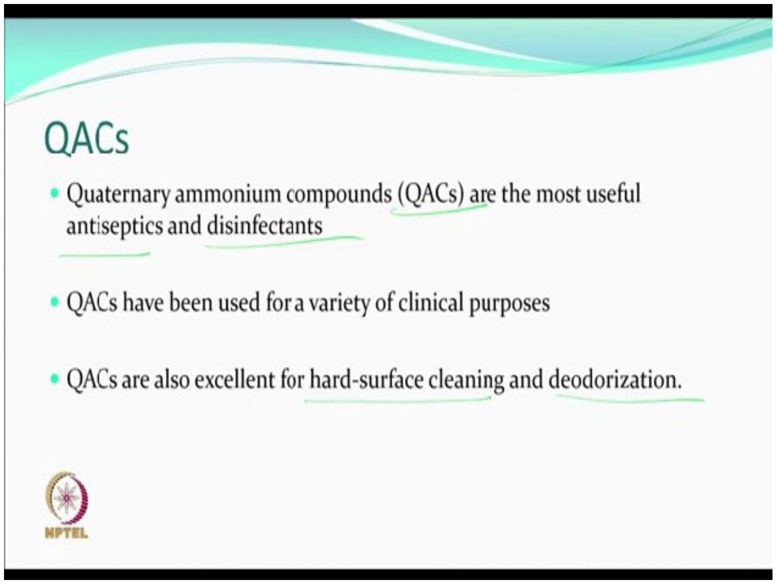

And they are being used quite a lot in the clinical environment also that means they are accepted more accepted as antiseptics, so that would mean that doctors may like to use it, so obviously you can use on textile so people will not have too much of an objection as disinfectants so you just apply here there push them around very effective compounds. Because they are as I said being used for clinical purposes.

So from ecological point of view they will be considered more safe only question is how to apply it on textiles what kind of compound will look like textiles can you make them reactive or otherwise, they are also hard surface cleaning surfaces you want to clean surfaces table tops, benches, kitchen, tabletops, people use them and for deodorization or deodorizing purposes, so they can be used so what are we coming to they are effective.

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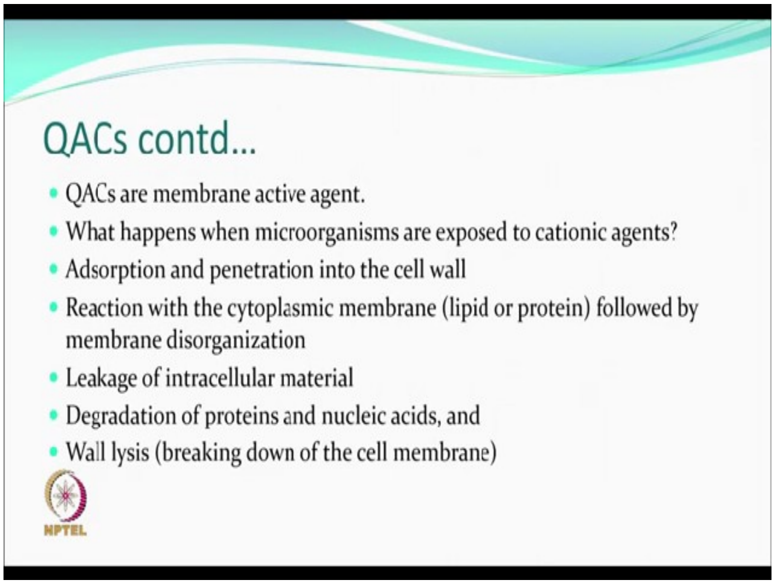

And can be effective antibacterial antimicrobial agents they also are membrane active agents and they would like to again destroy positive one, so one thing remember just like if there is a cation somewhere most the bacteria and then the cell growth systems do not like them too much if they are they right kind of quantities. So its quantity becomes an important, so what do, they do they would do absorption, penetration into the wall cell wall, so that is one.

They can react with these cytoplasmic membrane and whether their lipids or proteins and would lead to disorganization of the membrane and so it can rupture, once it ruptures the leak there is a leakage of the real good entire cellular material which ever was there like a cytoplasm can come out and so the cell would stop functioning, they can participate in if the quantities are more than a certain amount in degradation of proteins or nucleic acids also which is only if the concentrations are higher.

So one has to worry about that but definitely they are better than any organochlorine compounds and finally they would remove the cell membrane completely, that is called the process of lysis right that is the process.

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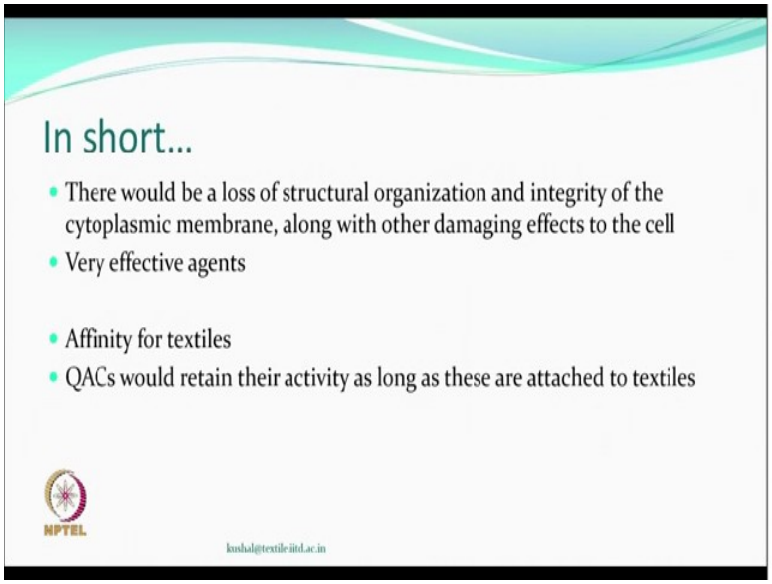

So in short what we are looking at that these quartery ammonium compounds would act in a way that there will be loss of structural organization and the integrity of the membrane along with other things that can also damage the cell very effective agents and also they have affinity for textiles remember whenever we treat textiles in liquids and other solutions they do develop a negative charge polarity.

So the positively charged systems get attracted to them textile surface, so that is a good so they have affinity for textiles and if they can be retained by fixing them by a covalent bond or something, then they will last till the textile is there right, so that is what one can think in short as for the QAC are concerned very important class of compounds.

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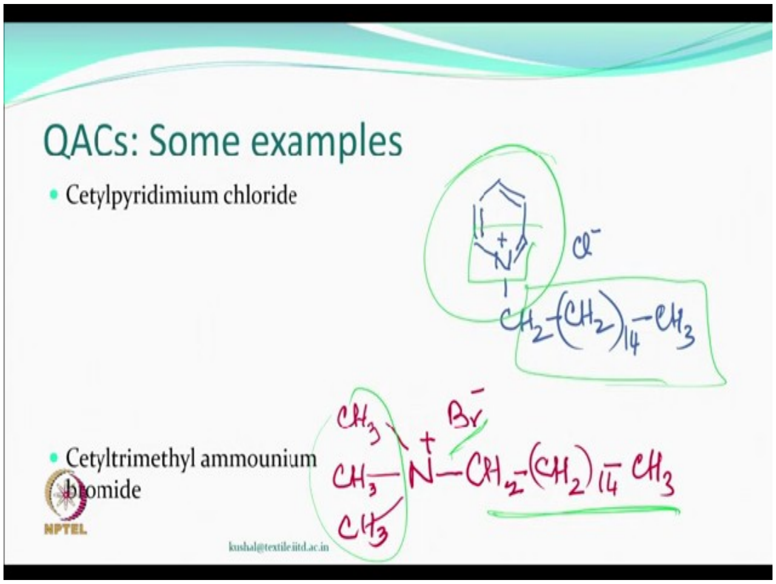

So one of the example is cetylpyridinium chloride. And this has got this group, we know this group can react ok, also if it otherwise it has the positive charge and interestingly it also has a little long chain, some of these compounds can work as cationic agents and may act as water repellent also. Again you can have another ammonium compound. For example which is so many methyl groups here.

And you have this compound and this is against cetyl so a long-chain fatty compound. So these can act and if they remain, so remember all those get ionic softeners that we are talking about cationic for example water repellents, they will work as softeners water repellents, and also antibacterial agents so multifunctional.

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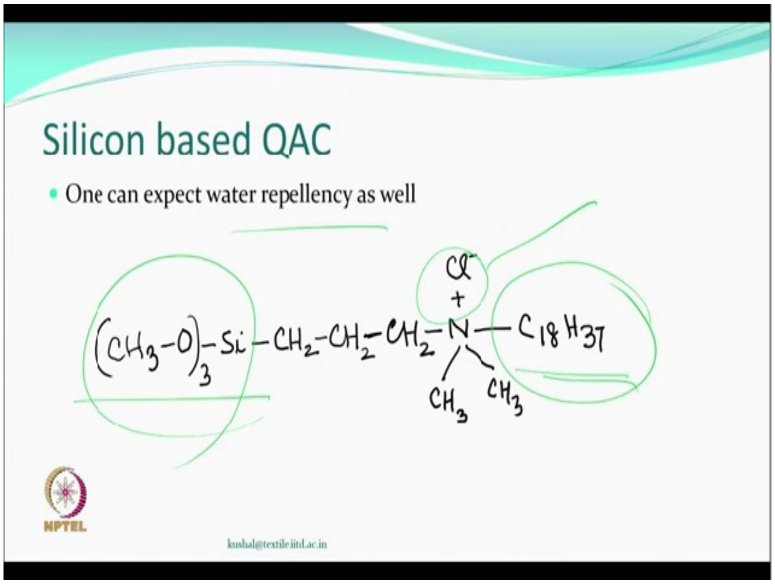

Some special type of chemicals which are the acryloyloxy based compounds and there is this group it can participate in addition reactions also and then it can become a part and when they would always have possibility of this ammonium group is a bromide here the bromine can go somewhere anything else other thing can come but because all these things are already attached so the plus charges always they are going to be n on the nitrogen and that is why they are quaternary ammonium compounds.

And based on the n here the hydrophobicity can also be increased, so you can have multi-purpose cationic agent, other special agents also have been designed based on silicon compounds we can expect other than the cation which obviously is going to do the antimicrobial activity with so much of hydrophobe some silicon based systems also one can expect water repellency as well.

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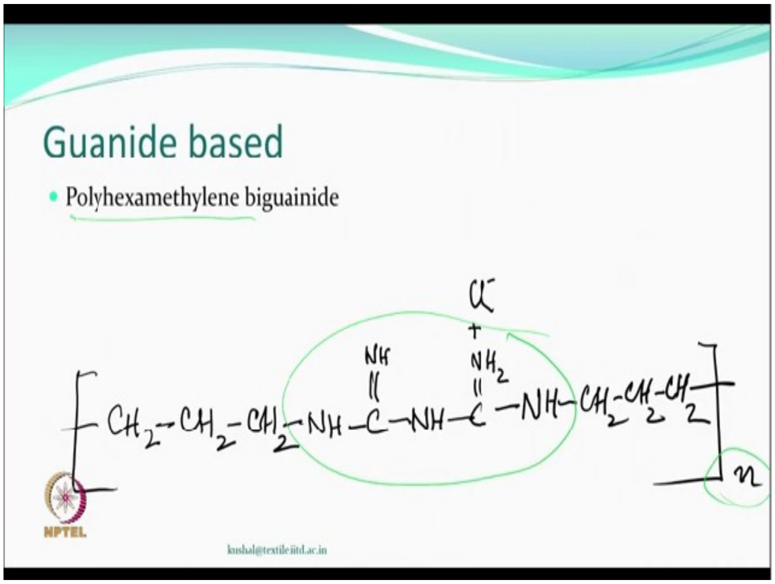

Now that guanide based compounds also have been suggested for antimicrobial activity for example a compound called the polyhexamethylene biguainide because of this here this is the biguainide structure and rest of course based on this plus charge, you would have either chlorine or bromine iron will be there. So it can be polymeric so even if it does not react it will still have a large molecular weight and so fastness cetera could be better.

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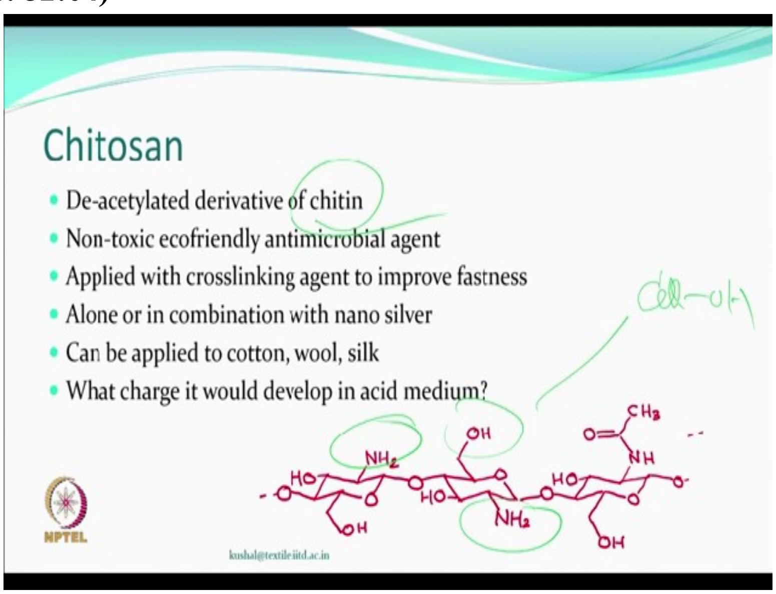

Now another interesting compound which we just talked in the beginning you know the chitin which was the outer thing which made the cell wall some of these things are very interesting from the chitin, from the chitin you get Chitosan, the Chitosan as a textile finishing material has got many roles to play. In this case we are expecting that at a certain pH levels they will also become cationic, they will also have affinity for the textiles.

And because of that cationic nature they may inhibit the growth of the bacteria, so they are derived from chitin right, so deacetylated derivative, so you have these groups now there is so many of them, they can assume positive charge whenever environment is acidic, they are also generally non-toxic eco friendly. So that is a good idea, their fastness can be improved if you have some more cross linking agents that BTCA you remember that can combine with hydroxyl groups of this.

And maybe hydroxyl groups of cellulose under certain circumstances and you can get a permanent things and this will be available can be used along with silver nano silver that would increase the effectiveness and it can also do certain other things if required, can be applied to almost any hydrophilic fiber because they are hydrophilic themselves they will have an attraction, what charge they will develop any acidic medium.

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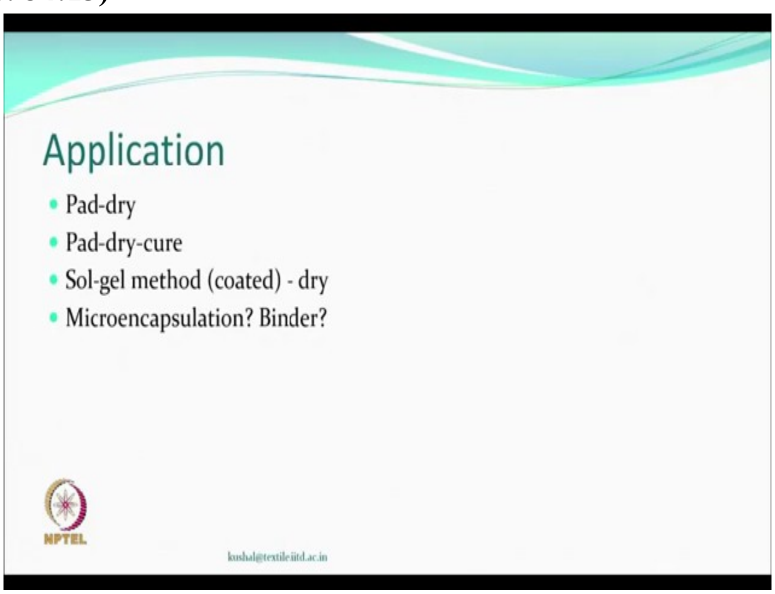

Cationic charge as far as application is concerned the similar thing like if it is not reacting pad dry can work if it can react then pad dry cure can work sol-gel method we talked about generation of particles we can also have something called a micro encapsulation, because if you find that you do not want it to be active generally. So you can and capsule this material in micro sized capsules which can be then adhered to the textile surface by maybe use of a binder.

Then they will become active only when these micro capsules are ruptured if the micro and capsule accelerated person things are ruptured then they will come out, it could happen because let us say some exudate with a nutrient otherwise falls and then the rupture, so bacteria wants to go there and get killed otherwise they are not harming. If then maybe you can use little stronger compounds also.

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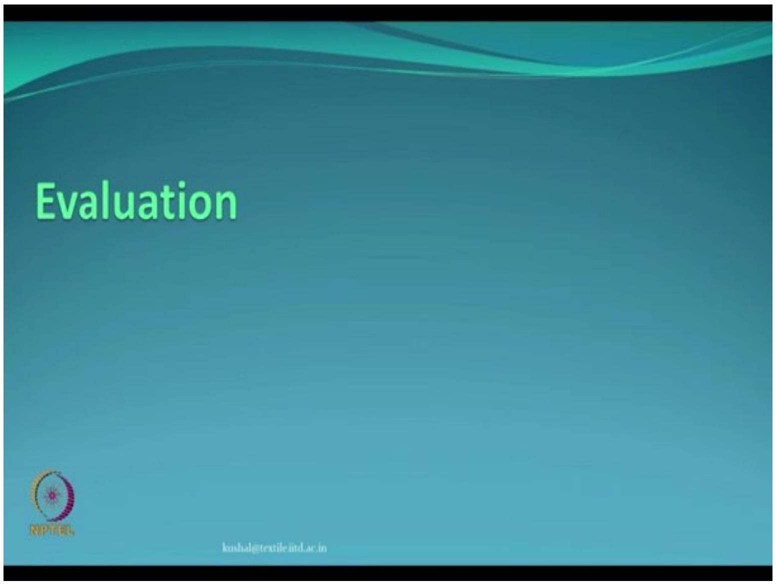

Finally we may like to have some comments on how do we evaluate, from the point of view of rot proofing one can put the fabrics like the fabric.

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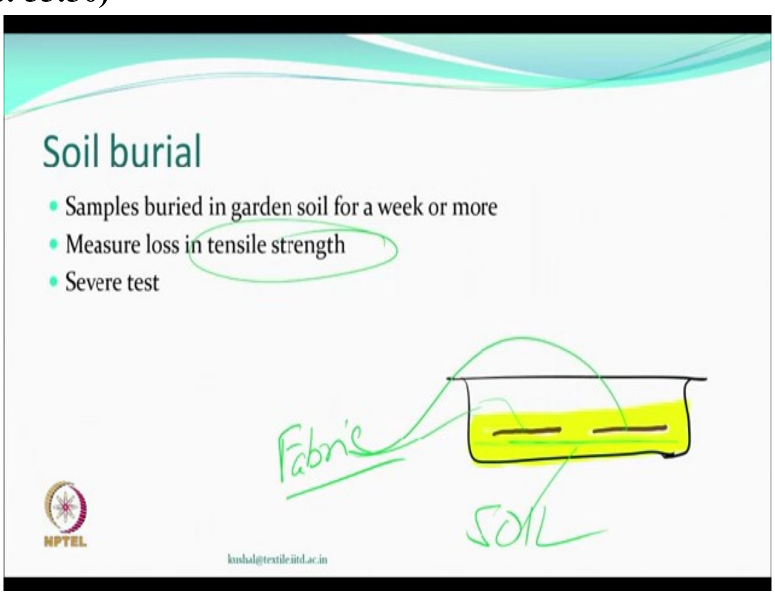

This is let us say the fabric, in soil actual soil the garden soil so you have a layer of soil in a container maybe a garden soil and if you right temperature right moisture and humidity then these bacteria which are always there in the garden soil the fungal they will start acting and start eating up **any** any material which they can eat of course they would not eat polyester, but it is meant for such fibers which are otherwise biodegradable.

And then after a certain period of time you measure their tensile strength let us say you bury them for about week and then test the strength before burial and after burial and if you see there is a change in you acceptable, non acceptable. So theoretically if you have untreated let us say cotton fabric in a nice garden soil after 1 week they will be so weak, that you cannot actually test them they just break down.

But hopefully if you have antimicrobial treated sample it may last longer, it is a severe test tough test you're putting the whole thing inside the soil where there are so many bacteria or fungal activity is taking place.

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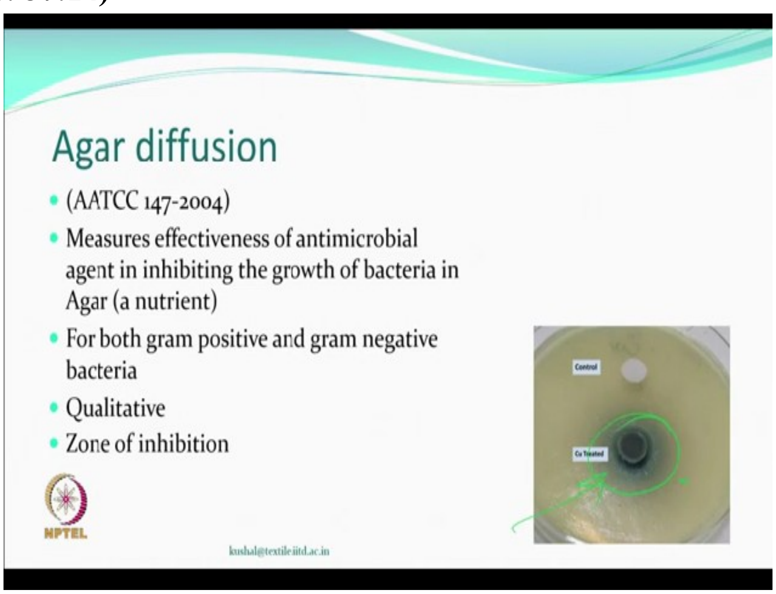

Other test which is people do use is called the agar diffusion test and here you have a treated fabric and untreated fabric put it in a guard which is like a nutrient and you have bacterial bacteria wants to grow on the nutrient and if any agent is leased out, let us say in this case there is one treated material which from which something is getting leached out in the environment inside there a zone of inhibition can be created around this while an untreated control sample everything can grow wherever it goes very near to the fiber itself.

And so it is not inhibiting so standard tests have been designed let us say this test for example by the AATCC standard so measures the effectiveness of antimicrobial agent in inhibiting the growth of bacteria in let us say a nutrient called the agar alright and what do you measure so this test is for gram positive, gram negative 2 types of bacteria that people want to test and will measure qualitatively the effectiveness of the compound by observing the zone of inhibition.

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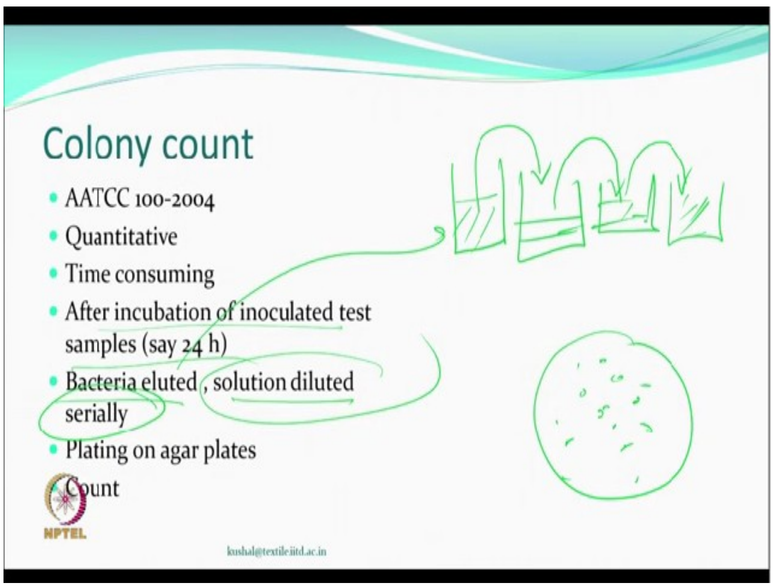

Then another quantitative test is there where you have to do actually count the bacteria and their growth you remember the growth is very very rapid and so theoretically you cannot count unless you control so there is also standard test methods available whenever you get a times you do read about them this is quantitative because you will be counting. So when you count as a quantitative the previous one was qualitative.

But time consuming very very requires lot of attention, a lot of hard work to complete this test. So you prepare a bacterial solution of a standard concentrations of a standard bacterium, then you let it grow and then you add a certain liquid certain amount of solution of this on to the textile completely absorbed then incubate the samples. So that the bacteria on the textile whatever textile material grows and after it grows then you eluted into a different solution.

And the solution is diluted serially that you have to keep on diluting then you have a solution which has been for example first a little take a little bit of this put it another one and value it again then from here little bit and then put again and dilute and then put take a little bit from here and then dilute, so keep on diluting a serial dilution methodology is adopted and after that then that it is possible you for you to be able to count.

Then you do what they call as plating on the agar plates and then you count actually under the microscope you count that in a certain area how many bacteria are there. So this is more of a quantitative type of a test.

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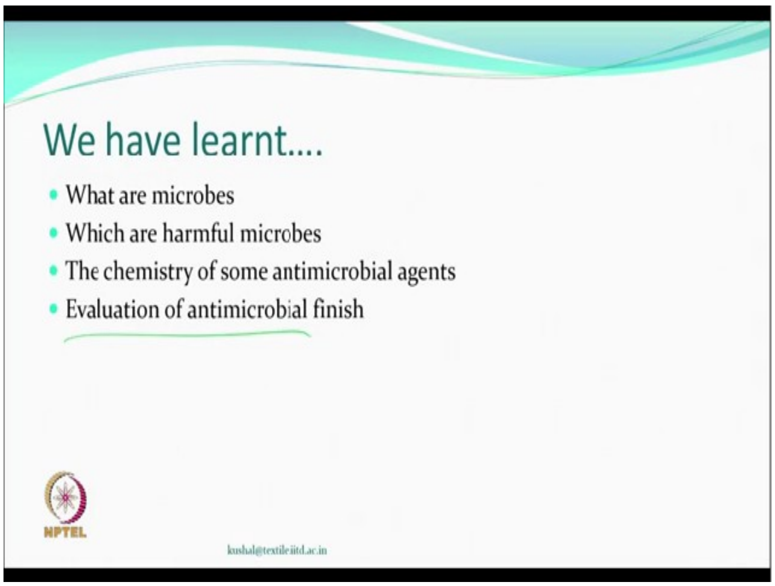

So what have you learned we have learnt that what a microbe, there of the bacteria could be fungus some of them are not so bad but some of them are very bad, we have to worry about the bad guys right and the harmful effects of microbes also we can appreciate chemistry of some of the antimicrobial agents we have learnt one of them was the QAc right quaternary ammonium compound the very effective nano silver very effective and how we can evaluate the antimicrobial finish, I think will finish today here till we meet next time have fun see you in the next class thank you.