Science and Technology of Polymers
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Lecture - 28
Polymeric Nanomaterials And Devices (Contd.)

Good morning, today we continue the nano materials and devices. Previously, I told you the examples of polymers, which are normally used for making those devices nanomaterial and devices.

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Now, probably you are in little confusion, all these polymer molecules, long chain macromolecules could be found in nano devices. Just you go back to emulsion, polymer emulsion. How a polymer emulsion is found? Now, if polymer is hydro phobic in nature, oily in nature, that can be dispersed, in a dispersion medium, such such dispersion the of the size of the dispersion is less than 10 to the power of minus 4 nanometer or centimeter.

Those emulsified particles, droplets and emulsified droplets or particles whatever you can say, they may assume either a spherical or rods sets of configurations, which are, which remain stabilized by emulsified molecules that means myosin is found from soap molecules or emulsified molecules and within the myosin there is a core. Now, the core may be hydrophobic or hydrophilic depending on how those soap molecules are organized to form myosin, depending on the hydrophilicity or hydrophobicity of the dispersion medium.

If it is water, and if you take soap molecules, which contains hydrophilic head and hydrophobic tail, so in that situation, such myosin are formed by spherical or rod like aggregation of soap molecules, so that the core becomes hydrophobic and cell becomes hydrophilic. Now, within the core some organic materials say oils or something like that, hydrophobic materials are dispersed. So, those hydrophobic molecules or materials will decide within the hydrophobic core stabilized by outside cell, hydrophilic cell, alright? Now, since the dimension is very small, so we can consider such type for dimension as nano dimension, nano dispersion.

Now, such device can be considered as nano device. Now, within such emulsified droplets, fine droplets of nano dimension, some drug molecules something like that can be (( )). If such thing is incorportated in the body, so that will be that can be circulated through blood, provided that emulsion is not broken during such circulation. Only when it the reaches the target size for effected site that will be deposited, you understand? Very simple thing. So, you make a nano emulsion, nano dispersion containing the drug, inject in the body that will flow to the blood, circulated through the blood. Blood will be the career there provided emulsion is stable.

That means in the blood environment, in the blood plasma, there chemical nature all these things in presence of the blood contains of all those things. So, in that situation, emulsions should break and it will be circulated from the injected point to the affected site. During that moment emulsion should not break, otherwise that if the emulsion breaks, so that will be coming out and that will be deposited anywhere in the body, so that is not what actually wanted. So, you have to see, how you, you will be preparing emulsion with what of what stabilizer emulsion stabilizer and all those things, then it should be meant stable.

That is our duty, our job. Knowing all those things, you can make it. So, that now today, let us concentrated for the timing, this soft contact lens and artificial lens. Contact lens you know say our lens native lens is, that is made of tissue, sub tissue that is transparent, it acts like lens. Now, if that does not function properly, so you have some problem in visibility and sight and all those things. Then what you do? We use either spectacle glass, spec glass or we use contact lens so that, that lens actually adjusts the focal length in such a way, so that some invisible things can be visible. Sometimes there are something on surface it is invisible.

You take a lens that will magnify, so the role of this lens is to magnify the object. So, for that we need some external lens, that may be in the form of this spectacles or may be in the form of contact lens. If it is contact lens, it is, it is put in the eye ball, it remains there. So, while it remains, so if I have some trouble I can open it, I can remove it and keep aside. When, whenever I need, I can wear it that is external thing. If you use contact lens, it should be put over there for long time or if there is problem then we cannot take it out frequently or we can again rewear frequently. So, invert to overcome those problems, so the contact lens should be soft.

It should match with the softness, hardness and hydrophilicity, hydrophobicity and vary of properties say your (( )) of oxygen, water molecules, salts all those things. So, exactly it should match, it should mimic the native tissue for there. It should be soft enough, it should be hydrophilic enough, it should be stable enough, it should not degrade, it should not cause any irritation to the eye, for that we need soft contact lens. Whereas, this glass is hard sometimes at the beginning of this contact lens history, polymethyl, methyl it was really hard.

So that was today, that is today rejected because of sudden problems. Now, todays sub contact lens is very soft, thin, transparent, stable and it can permit the passage of oxygen, water molecules, all those things. So, polymer molecules have been taken and tailored to compose, its composes a polymers, the composition of the polymers are tailored in a such a way, so that all this your favorable properties, characteristics, performance could be introduce in this contact lens material, so is the case with artificial pancreas.

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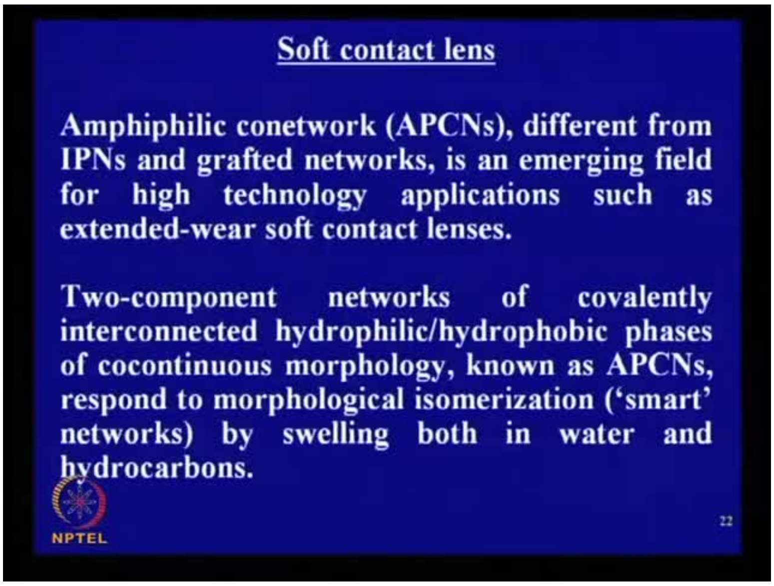

Now, here is a term amphiphilic conetwork. First of all you know, the meaning of this amphiphilic.

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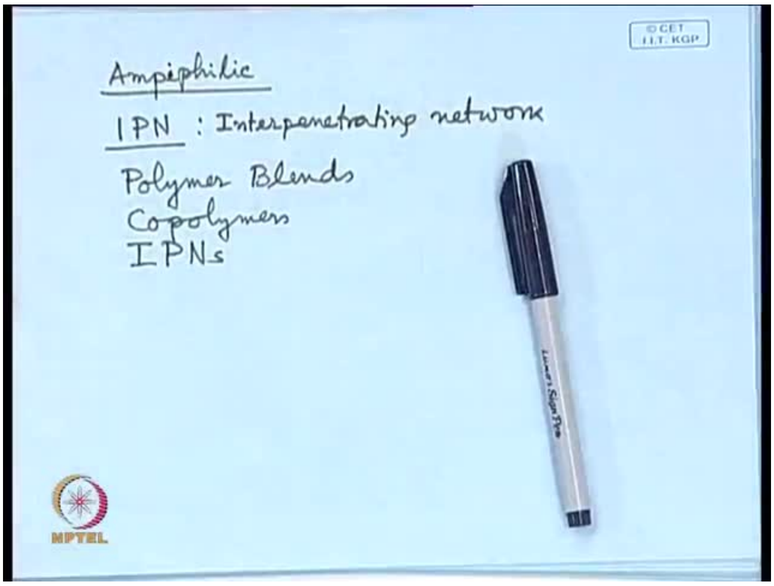

Amphiphilic means, it has both hydrophilic and hydrophobic characteristic. There is one more terminology IPN, this is interpenetrating network-interpenetrating network. In this connection, you will get some concept of polymer blends, copolymers and IPNs, IPNs. Why this will develop before this polymer blends? We knew only huge polymers, very simple. Polyethalin, polypropaline, polyhanel chloride, polymehyl methyl chloride polyhydroxy methyl methyl chloride so and so and polyesters, polycarbonates, (( )) polymers, polyethers, polyimides, polyamides.

So, this way we can site large examples. Now, each of this polymers have a domain properties, each one has a property domain is not it? Polyester has one properties in some domain, polyether has some properties in another domain, that means each and every of polymer has got some characteristic properties. Now, during this use, during making devices or applications you will find that the existing polymers are not able to provide the properties and performances what we required for some particular equations. It is not that to, it is not true that whatever available polymers are there, this polymer can fulfill our necessity.

That means each must we are expecting some new properties for some other characteristics for which I can use it. Now, there are certain container suppose, in which we can store water, but in that container we cannot store petroleum hydrocarbons fluids. Again in the same container we cannot store food radicals is it not? Like those things, so for some specific applications we need some specific range of properties, specific list of the properties for that. So, we will keep you found that the existing polymers cannot provide such broad spectrum of properties. In order to develop such broad spectrum in newer properties we provide the (( )) for this polymer blends.

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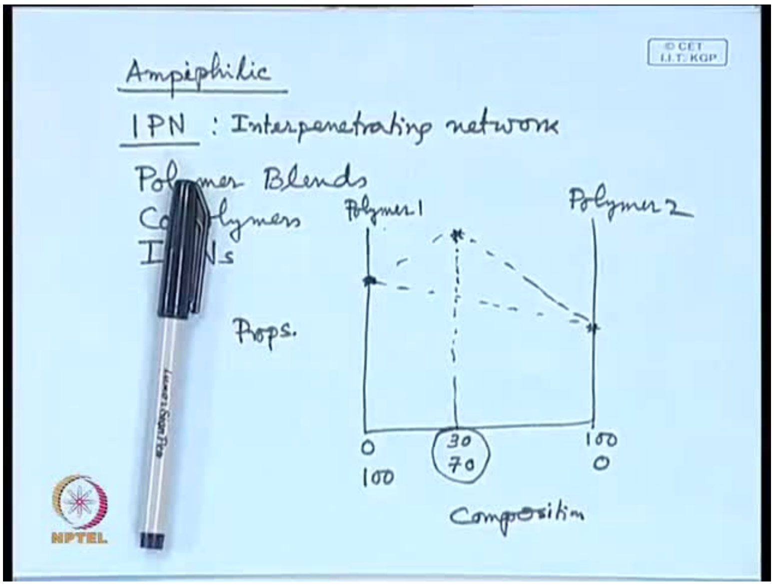

One polymer, suppose say this is axis for polymer 1, this is axis for polymer 2, here it is 0 and here it is 100 and here it is polymer 100 and here it is 0. So, this is composition axis and these are properties, properties. Now, the polymer 1 polymer 1 when it is 0 when it is 100, this property suppose lie over here. Polymer two when it is 100 and that is pure polymer or pure polymer sorry, I am sorry, polymer, this will be polymer 1. So, polymer 1 0 here, 0 here 100. So, polymer 2 when it is 100 its property is here and polymer 1 when it is pure, so property is here.

Now some sometimes you may need a property to this extent. But if we, I use either polymer 1 or polymer 2, it is not possible because polymer 1 has a limitation of up to this level, polymer 2 has a limitation up to this level. So, what do have to do, take, do, see here it is polymer 2 is suppose 30 and polymer 1 is 70. So, if you take a mixture of blend of polymer 1, 30 polymer 1 and 70 parts polymer 2. We will get a new composition, which can give you better property than the individual polymers, so this is the concept. So, we make a mix, mix of blend a blend two polymers.

Now, what happens again, when we going to make such polymer blends, what you have to do, you take polymer 1 and polymer 2 into your form, you have to mix it there of their high molecular weight, there are high viscous. So, you have only two routes of two paths have a level. One is, you take a common solvent for the both polymers, if dissolve, you put two polymers in the common solvent, both of them will dissolve, then you can mix. Otherwise in the solid phase, you cannot mix them, is it not? You take granules of polymer 1 and polymer 2, that will be heterogeneous mixer from that we can make a product. In order to make a product in this composition - 30 70 composition, so what you have to do?

You have to mix them blend them either in solution phase, single phase, homogenous phase or you take 30 parts of one polymer, 70 parts of another polymer and heed them and mix. So, either by mell belling or by solution blending you can make a polymer blend. Then it is solution, blending it remove the solvent, remove the solvent and make the device. So, in the final form, in the blend form it can give you this property. Now, this property may be the size or strength. Hardness or any sort of chemical properties or any optical properties or any electrical properties, so I am taking in terms of general aspects.

So, if you meet develop a new property or a property beyond the properties of an individual polymer, then you have to make a blend. So, this a procedure of how to make a blend. Then you can make the device, your purpose is served. But the problem is, by virtue of the high molecular weight, macro molecular characteristics, by solution or by melting forcefully by force you have blended them. So, if you take say 50 goats and 50 cows, try to make in one room, what will happen? By virtue of their individual characteristics, they will be separated. All the cows will be one side and all the goats will be another side, all right?

But if you take a stick and beat them again they will be scattered. So, this hitting and solvent is a case of beating. See, the molecules are mixed and you are getting a blend, alright? Otherwise, they separated to two phases; that is a problem, beating blends. A phenomenon, phenomenon phase separation is a problem. They will separate into phase slowly, slowly. In ambient condition, you have to prepare the, you are using at ambient condition and what will happen? That will remain and they will separate the phases. That is one problem, still then people going for blend.

There is a successful blend, I tell you, a blend between please note down, A blend between nitrile rubber and nitrle rubber and Polystylene and polybutylene these are, these are stable, commercial blend, commercially available and products are made out of that. Now, you see this cable seizing, high voltage cables are seized, after this solution. Say high voltage cables is figured, thicker cables, large diameter cables, those are covered by this blend of nitrile rubber and (( )). This is a successful blend, is a successful blend. Successful blends if you see phase separation and other properties detoriation during service are not that way pronounced there. That is why that blend, we are successfully in making blend.

Student: There is a physically interaction between two group polymers

Yes, Yes. There is a there is a physically interaction between two group polymers.

Student: (( ))

Detoriation means decreasing in decrease

Student: (( ))

Properties due to separation to phases, you see, if these two, here you see both phases are present. Now, you see separation into phases, two phases so in some portion of the product you will find, this strength and some other portion of the product you will this strength. Overall the properties are the not uniform, property of uniformity will be lost. That has that I am telling in detoriation. Property uniformity is lost due to phase separation; that is a problem. Now, you have to overcome those problems, although you want such combinations of the properties of individual polymers, without such long term properties decrease.

People who go for co polymerization, co polymerization chemical binding between the units; chemical binding between the units, say ethylene can, from ethylene you can get polyethylene, from prophilene you can get polyprophiline, two polymers. When ethylene and prophilene monomers are taken together in the reactor in the container and polymerize, so ethylene will link of prophilene and prophilene will link of ethylene. This way styrene will link of buthylene and buthylene will link of styrene. This way you can get co polymer of styrene buthyrene, ethylene prophilene this way and isobuthylene isoprene this way you get co polymer.

There the separation into phases is restricted, restricted, because those units monomeric units are linked with correlated bands, very simple, you understand? When ethylene property units are covalent linked link, so it is is no longer a blend, but it is a new co polymer where such monomer units are link with covalent band. But in case of blends such covalent linkage is not there, there is only physical mixing, physical blending. Now, peoples also tried to get stability in properties of blends, stability in properties of blends for that for they did, they use some compatibilizer, compatibilizer or coupling agent or mediator.

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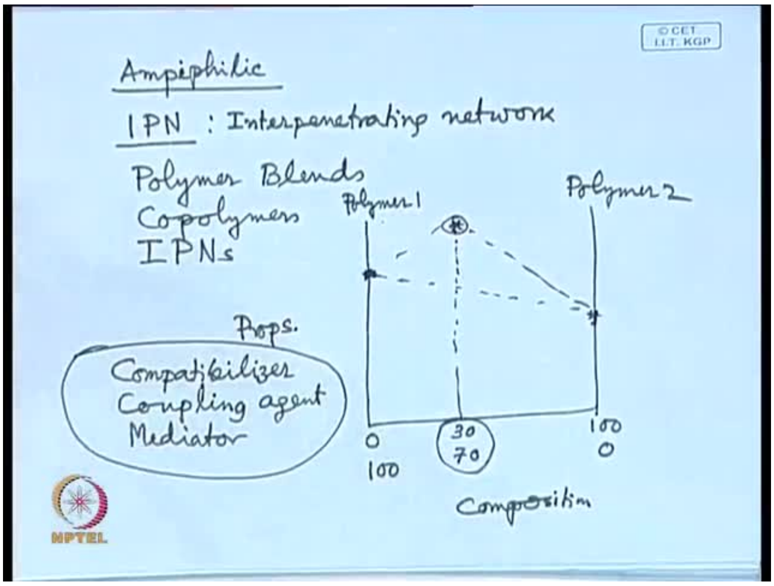

That will remain in between the phases. So, polystyne and polybuthylene after blending you will get a blend of polybuthylene and polysthyrene. You can get properties of say styrene buthyrene copolymer rubber. For that rubbery properties, in case of polystyrene and polybuthyrene blend is not stable, because of the problem of this phase separation. But if there is a mediator or a coupling agent or a compatibilizer, then that will hold one polymer on the one end and the other polymer on the another end. So, compatible make compatible. Again you think of those cows and goats, you take tiger as compatibiliser. You will get such a (( )) in his blend that he will never separated into phase, you understand? That is compatibilizer.

I give you some real examples, say today polyethylene is non degradable from low density polyethylene we make polyethylene fill for making packaging for application in packaging, carry bags all these things, it is non degradable and it is creating environment nuisance. There is a huge concern about is environmental problems. So, what people are doing? Try try sorry, starch is a natural polymer, it is a biodegradable polymer. Microbes, if the microbes get this starch, they will be very happy, because this is starch, it is a food. Very good food, nutritious food for microbes, they will eat. In order to make polyethylene biodegradable, what people did?

They took some quality of starch and blended with poly ethylene. Then they blend fill, starch polyethylene blend fill. Now, again that is a problem, forcefully you can blend it, by melting, you can do. But this starch is polar polymer, highly polar polymer whereas, polyethylene highly non polar polymer. So, these two polymer remain at two extremes and your forcing them to decompatible. So, when this starch is melted I mean blended in presence of polyethylene. So, polyethylene is encapsulate this starch. So, dispersion will not be good, film quality will be good and this is not a successful blend and suitable truth full product could not be made. Now, what people did after that, they took maleic anhydride droplet polyprophilene or polyethylene, maleic anhydride. You know what is maleic anhydride?

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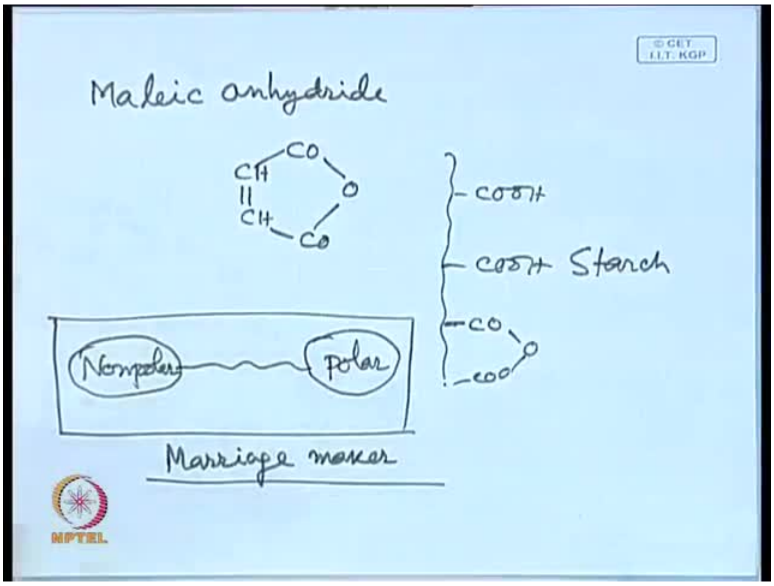

This is maleic anhydride, if it is hydrolyze it will form maleic acid, you tearing the double band. If this thing is grafted on to polyethylene or polyprophilene, what will be there? So, this is polyethylene and polyprophilene onto which you will get like this or sometimes if an hydride kept in dry condition, one can get like this. Some part of the polyethene molecule are made are polar. That means polarity of the system is increased. Then if you put starch on this side, which is polar, this side is polar, so this polyethylene if it is modified like this, so starch can be accommodated.

So, starch you know, that is anhydro glucose unit is there, hydroxyl groups are there, so that can be (( )). So, we will took such maliec anhydryde grafted, polyethylene, polypropylene or there are other competibalizer, which is having this polar and this non polar. Now, this is actually a marriage maker. You have seen the marriage maker, the role of marriage maker, but yet to experience. You have, you know what is the role of marriage maker, but yet to experience. is it not? Am I right? So, this role of marriage maker is to tell sometimes, if he wants to make the marriage sometimes he will tell all the good things on both sides.

And if he does not want to make the marriage he will tell all the evil things or bad things on both sides. Now, imagine whether marriage will be held or not? So, that marriage maker having two characters, two characters. Those two characters help matching between the two parties, here also the same thing. So, if you take a compitabilizer like marriage maker you can get a successful blend. So, I hope you have little basic concept on what is homo polymer, what is polymer blend, all right? Next comes this IPN. It has been found in some applications that neither the homo polymer nor the polymer blends nor the co polymers are suitable in some applications. This homo polymers, co polymers or polymer blends may not be found suitable, may not be found adequate, may not have or may not provide adequate performances.

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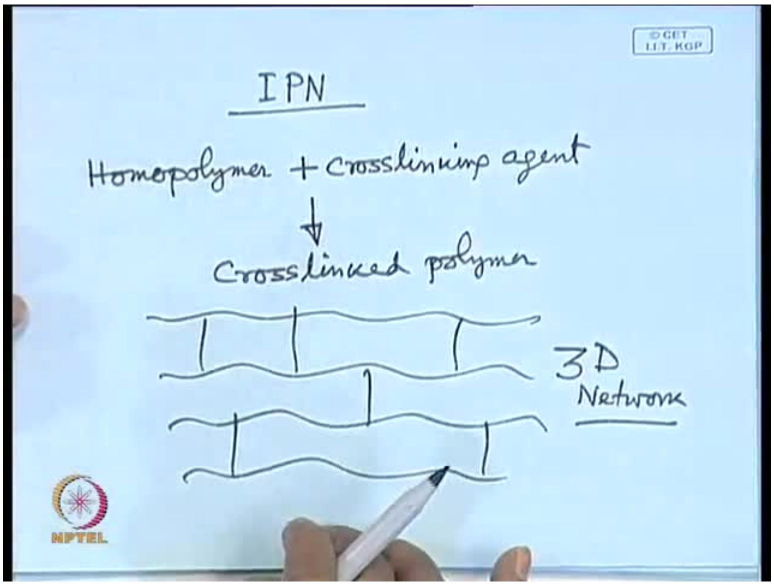

Then people went for inter penetrating networks IPN. What is IPN? You take a homo polymer, put some cross linker, you take homo polymer, put some cross linker, you will get cross linked polymer. That means you will have this kind of inter three Dimensional 3 D network. 3 D network we will get 3 D network. It will be like a gel, cross linked gel all right? This is insoluble and infusive. The properties of 3 D, physical properties, they are insoluble and infusible and they have a list of properties, domain of properties, which is not sufficient enough for my use.

What I will do? I have to incorporate another few more properties, add few more properties for that I found, that yes there is another polymer available. If you can incorporate this polymer probably you, it will do. So, what is done? We can take a gel of this polymer, then if we put this gel in the monomer liquid monomer of another, another liquid monomer, then it will swell over there. Then it is polymerized. That means within one network if we polymerize another poly, monomer we will get interpenetration of one polymer system into another, clear?

You grow a second polymer within this network, inside these few volume interpenetrating, you understand? You are having a 3 D network, within the 3 D network we are growing another polymer system. So, that polymer will just will be grown inside this network. That is a you can call a interpenetrating network. Now, if there is a problem of again solubility of the second homopolymer grown inside the 3 D network, if you want make it insoluble and infusive, then you also add cross linker for the second polymer, so that will form again another network, that will form another network inside this.

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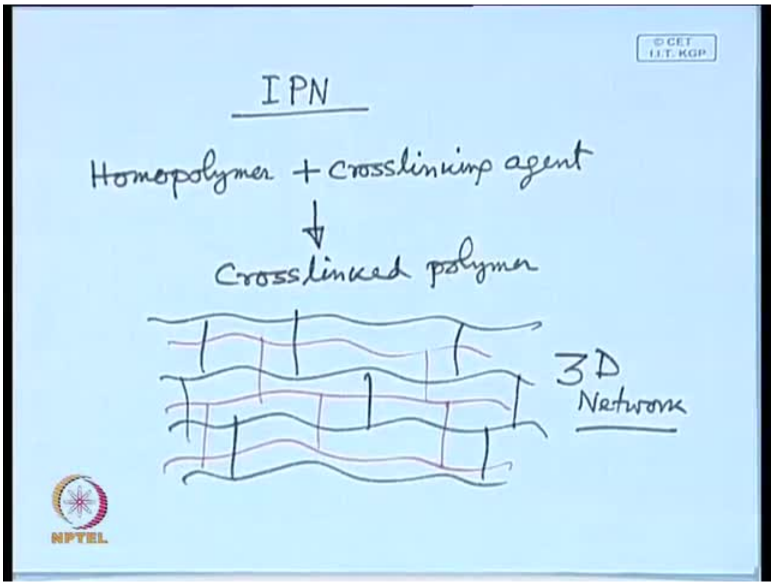

You can see some configurations and drawings given in books. So, it is a, you can say it is a blend of its not a true blend, but it is a blend kind of mixer kind of thing of two interpenetrating polymer networks, both are insoluble and infusive. So, the question of the problem of separation into phases solubility infusibility, all those things will be overcome. So, that is a IPN, yes.

Student: (( ))

Not blend, not blend you see, you think of one polymer network, say vulcanized natural simple, polymer. Suppose you consider this room if there are wires and ropes or strings or filaments, just suspended from the top to ceiling to bottom floor and again those filaments extended from one wall to other wall, this way, this way this way so you will get. What will happen? If there are knots, if there are knots in this crossover points, then that is a network, 3 Dimensional network, 3 D network of one thread. Now, you can develop another network of different thread, different colour, different properties.

The same network both are separately, but both are interconnected, both are interconnected of one kind. So, you will have threads of one kind, which are interconnected and you have interpreted it another thread, another filament through this network and those are again interconnected between themselves. That is called inter penetrating network that network inter penetrating network much more, will be much more stable than either homopolymer or co polymer. This thing not only that, you will get combination of properties both the polymers have hiding the problems of insolubility infusability problem of a phase separation all those things. So, the properties will be further improved that is the IPN system.

For example, I will tell you if you take a network of hydrophilic polymer, if you take a network of hydrophilic polymer, what will happen? If you put some water it will swell, crosslink hydrophilic gel, hydrogel. Hydrogels are always cross linked, which are hydrophilic. Now, if you regulate the swelling extent means swelling in volume, what you can do? You can regulate the amount of intermolecular bonds. More number of intermolecular bonds, more will be the cross link density, less will be the swelling, is it not? Very simple thing. Hydrogel, if the crosslink density is more, swelling will be less.

And if the crosslink density is less swelling will be more. So, that way you can regulate the volume swelling of that network can be regulated controlled by the amount of crosslink bonds present over there or cross link density. That can be, that is possible by adjusting the amount of cross linking agents we have taken for cross linking of those polymers. That means the length of the segment between two cross links, length of the segments between two. Say this is the length of the segment of this polymer molecule between these two cross links, this is the length, now if there is one more bond introduced, then length of the segment is decreased.

That means crosslink density is increased. So, this way we can regulate the swelling properties or the network characteristics of that polymer, depending on the crosslink density, alright? Else, we can control the hydrophilicity or hydrophobicity of that network by putting or linking some hydrophobic agents. For example, this black one is hydrophilic in order to regulate its hydrophilicity, if you introduce this red network, which is hydrophobic in nature, is the IPN of hydrophilic and hydrophobic. IPN of IPN system of hydrophilic polymer and hydrophobic polymer.

Can you not regulate the hydrophilicity and hydrophobicity that way? Are you listening? You are not responding to me? Can you not regulate this hydrophilicity and hydrophobicity? If you put some red network within the black network, black network is hydrophilic, red network is hydrophobic. So, you can regulate the hydrophilicity and hydrophobicity by such by such inter penetrating network. Yes.

Student: (( ))

Then you have not understood the interpenetrating IPN system of formation. Say initially you take hydrophilic polymer crosslink it. That that will form a hydrophilic a network of hydrophilic polymer, you swell it. In another monomer polymerize the second monomer, within that gel spaces, there are lot of space available inside. You have incorporate the monomer. So, you have allowed the polymer to grow inside this gel second polymer is grown over there. Then you have added a cross linking agent, which will specificallt cross link the second polymer. So, you will get two interpenetrating 3 D networks.

Student: (( ))

That you have to adjust by adjusting the solvent. You see hydrophilic and hydrophobic there is you see it everything is not hydrophilic 100 percent cent percent hydrophilic or hydrophobic. So, you take some solvent, such a solvent that it has got some hydrophilicity 50 percent hydrophilicity and 50 percent hydrophobicity or 60 percent hydrophilicity and 40 percent hydrophobicity, you understand? There you add the monomer. Now, I tell you methyl methacrylate. Methyl methacrylate is hydrophobic in nature. Although it is hydrophobic, but some methyl methacrylate monomers will be soluble in water, you understand? That means depending on its solubility, although it is hydrophobic, but it is little bit soluble. So, 1 percent or 2 percent is soluble in water. So, that soluble will form a monomer, will form a polymer network. Like network that way you have to make, you understand?

Student: (( ))

It may be or anything this solubility, you have to regulate the solubility. You take a different you take different composition of solvent. It is not that always you have to take only one solvent, you take two solvent. You see water is a, water is highly polar, with water you take tea or take some alcohol isopropanol something like that, so polarity will change. Solubility of some polymer in that solvent will get changed. That way you have to regulate you have to adjust. But what I am trying to get you, the concept, concept of in IPN system, you understand? Two networks are interpenetrated, now one network may be hydrophilic and another network will be hydrophobic, that is possible. People have done already, it is not…

You can also do, you can also prepare in the laboratory. So, that thing I want to tell you over here for that I have to take, I took so much of time to explain the concepts of contact lens, amphiphilic cool network. Amphiphilic cool network see, you think that this black net network 3 D network is suppose hydrophilic and red network is suppose hydrophobic. Now, such a network is called amphiphilic network. Why it is necessary? Because oxygen is hydrophobic, so the permeability of oxygen in all this thing, you see this science has come out through research. It is difficult to ask, how this oxygen is hydrophilic? Because oxygen is soluble in water, to what extent? There some limit in solubility of oxygen up to certain concentration. It is not that is soluble in high concentration.

Like that of ammonia, ammonia is highly soluble in water, but like that of ammonia, oxygen is not that highly soluble in water. So, this contact lens that needs penetration of oxygen. So, it needs certain hydrophobicity for transmission of tears. Tear needs hydrophilicity. So, that balance hydrophilic and hydrophobic balance can be made, people have seen that if we take such a IPN, amphiphilic IPN that can make this balance of hydrophilicity and hyfrophobicity and that can lead to a successful contact lens as well as it is soft. So, it is not only softness any other properties its stability, inertness, all these things should be developed.

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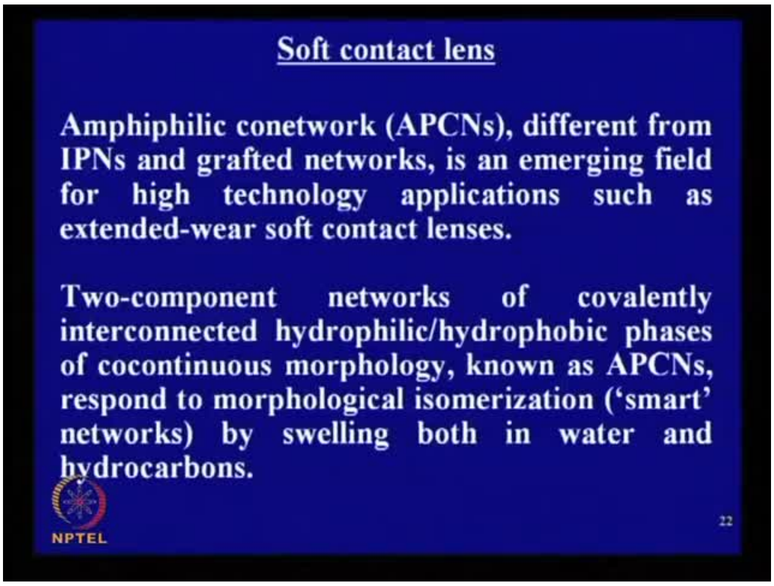

So, IPNs and grafted networks is an emerging field for high technology applications such as extended wear soft contact lenses. It is not always you have to take this IPN, this ampiphilic IPN. You can graft a soft sin of hydrophobic polymer, into the network of hydrophilic polymer. It is a simple common sense will tell, hydrophilic when to make little, little bit hydrophobic in nature character, so you graph little bit hydrophobic polymers at certain locations.

So, you can get amphiphilic characteristics; two component networks of covalently interconnected hydrophilic, hydrophobic phases of co continuous morphology. Co continuous morphology means morphology should be identical. So con co continuos permiability and other properties are maintained over there known as APCN's respond to morphological isomerization, sometimes called smart networks by swelling both in water and hydrocarbons. You see it will swell in water as well as hydrocarbons is little contradictory things no, because you have added two things, both the things.

So, it will show a limit of swelling. If it is purely hydrophilic, it will swell to very high extent. If it is purely hydrophobic, it will not swell at all. But if if if remains in between it will swell both in water, as well as in hydrocarbon. That characteristic has been developed in such network.

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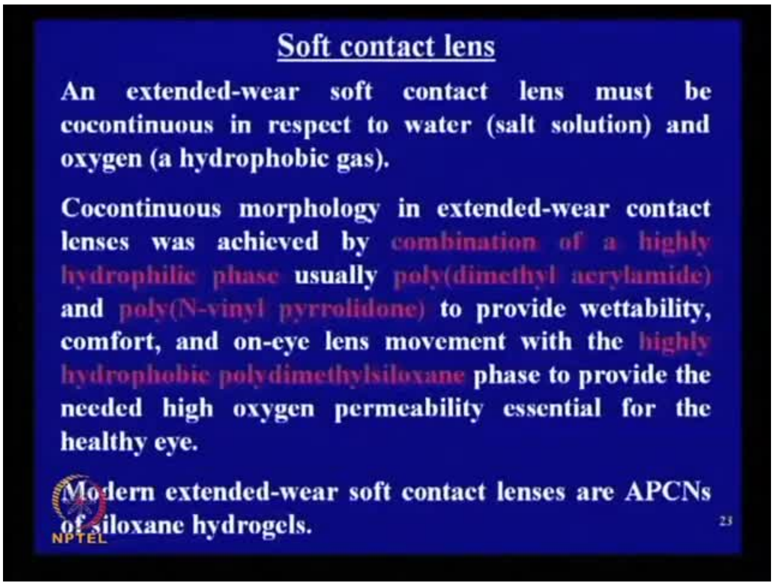

Soft contact lens an extended wear, extended wear means, without any problem without any problem, we can get extended wear, without any, any irritation or other things. Soft contact lens must be co continuous in respect to water, salt solution, tear and oxygen, a hydrophobic gas. So, co continuous morphology in extended wear contact lens by achieved by combination of a highly hydrophilic phase, say for example, poly dimethyl acrylamide, poly dimethyl acrylamide. Acrylamide you know, poly acrylamide you know, dimethyl acrylamide. Dimethyl acrylamide means groups are there on the nitrogen atom. On the nitrogen atom you think of PIPAM.

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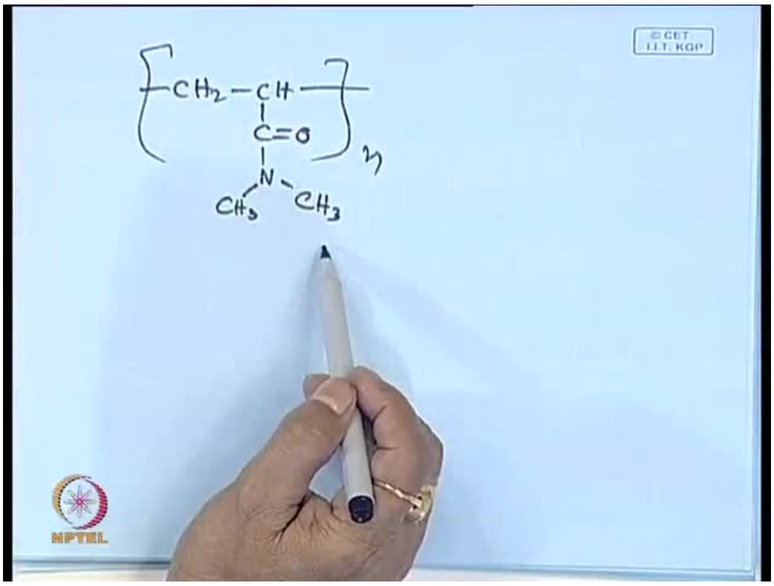

N H 2, this poly dimethyl acrylamide and as well as poly n vily vinyl pyrolenole to provide wettability, it must wettive otherwise it cannot use for extend wear. It will give comfort by virtue of the flexibility of this chain. It will show the hydrophilic characteristics by virtue of this C O O N polar nature, on eye lens movement, within the with the highly hydrophobic poly dimethyl siloxane. Now, if it is highly hydrophilic and there will be again some interaction between the native tissue and the lens.

But if it is little bit hydrophobic also, then movement lens movement can be made easier. So, lens movement with the highly hydrohobic poly dimethyl siloxane. So, a network of this polymer with network of silicon polymer, silicon polymer poly dimethyl siloxane, poly dimethyl siloxane here, poly dimethyl siloxane phases to provide the needed high oxygen permeability essential for the healthy eye. Modern extended wear soft contact lenses are APCN’s of siloxane hydrogels.

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Now, there are few systems of amphiphilic amphiphilic cool network. Amphiphilic cool network means hydrophilic as well as hydrophobic networks. Poly N-N dimethylacrylamide L polyisobutylene, Polyisobutylene co 2 methylamino ethyl methacrylate, Poly N-N dimethylamino ethylmethacrylate L polyisobutylene, Poly 2 hydroxyrthyl methacrylate L polyisobutylene, these hold promise as controlled and delayed implantable delivery devices of various drugs also. So, not only that, if there are certain problems in the eye, you see what we do?

We take eye drops, some antibiotics and other things in the form of some eye drops, some liquid we put a drop to the eye. But you can have some encapsulated drug inside, we developed in our laboratory some membrane, some polymer film, that may be loaded with drugs. So, if that film small some portion can be put inside eye. We actually contacted with a doctor, eye surgeon here, he was very much enthusiastic and excited looking at the development.

That some drug could be antibiotic could be put inside the polymer membrane and put it inside, the eye and that will slowly release of the drug because majority of the time you forget to put the eye drop, take the eye drop and it actually does not help our quick curing, quick healing of the problem in the eye. But if there is some if you go to a doctor, he will place within your eye and it will remain over there. So, you do not have to bother whether you are taking regularly frequently that eye drop, so these can help solutions of such problems.

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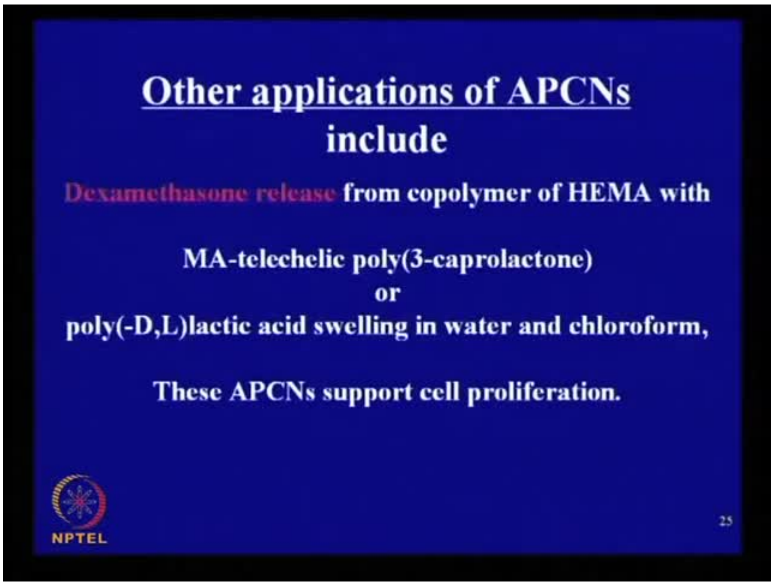

The other applications include dexamathasone; that is a drug released from copolymer of HEMA malic acid telechelic poly 3 caprolactone, Poly d l lactic acid swelling in water and chloroform, these ampiphilic conetworks support cell proliferation.

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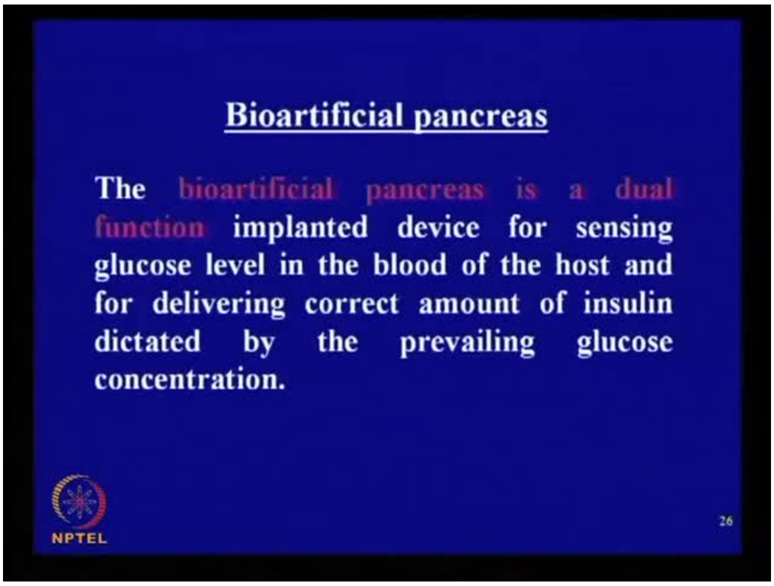

I will give you this thing you read it later. This bioartificial pancreas, in the last day I told you what is artificial pancreas. You can show the ability of sensing the insulin concentration or glucose concentration as well as which can release insulin trapped inside encapsulated inside. So, this bioartificial pancreas is a dual function device for sensing glucose level in the blood of the host and for delivering correct amount of insulin dictated by the prevailing glucose concentration

So, you have got the concept, now you are polymer scientist, you have knowledge in polymer. You can help some other researcher. That look, here is a polymer you can try with this thing. It is not that always you have to know everything, but if you know little bit if you have some exposure you can help. Then you go for study find out the literature, search the literature, details of the literature and you can develop the product.

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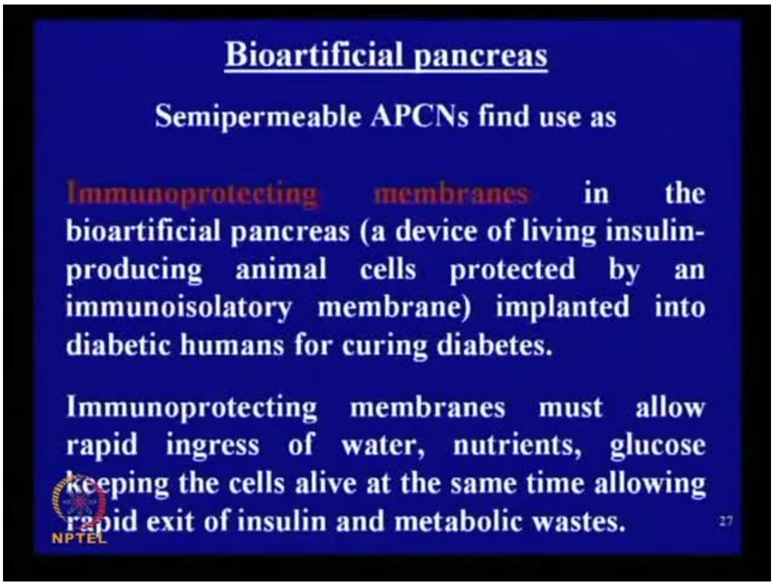

So, these are by immunoprotecting membranes in the bioartificial pancreas a device of living insulin producing animal cells, protected by an immunoisolatory membrane. These are some specific technological development made on this line, implanted into diabetic human for curing diabetes. So, this bioartificial pancreas can be made with such type of polymer networks. These are mostly hydrogens and their hydrophilicity and hydrophobicity are regulated by regulating their combinations.

Thank you.

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