Novel Separation Processes

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Lecture No. # 02
Identification of novel separation processes

Very good morning, to everyone now, we are basically in the last class what we did? We talked about the various types of separation processes, classification of the separation processes they will be broadly categorized into two categories, one is equilibrium based separation processes another is, the rate governed separation processes and we have seen what are the various you know gametes of these separation processes and what are the driving forces? In the you know various other principles roughly involved in these two separation processes broadly.

We have also, discussed the you know some of the unit operations in a equilibrium governed separation processes for example, distillation, absorption, adsorption, drawing, so on so forth and also, some rate governed separation processes; like membrane base processes, like reverse osmosis, dialysis, ultra filtration, so on so forth. So, therefore, in a in these particular course will be taking, those processes which are not conventional and which are not traditional.

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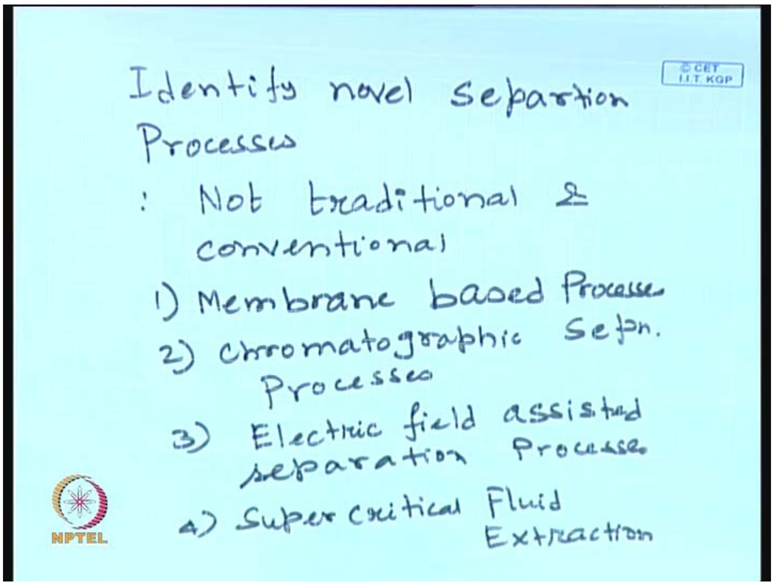

For example, we will be talking about; let us, identify the novel separation processes which are not traditional and conventional. So, these are basically number 1 is membrane based processes, number 2 chromatographic separation processes, number 3 electric field assisted separation processes, number 4 super critical fluid extraction so on so fourth. Therefore, this electric field assisted separation processes is, quite important, because know they have, you know you can use the for separation solute which are charged.

For example, it has trevendum application in the protein separation and fractionation of the protein mixer. Therefore, there are some more topics (()) in the novel separation processes will be basically looking into the, in detail for in the now, onwards and award course is generally oriented about; the description as well as the design of, such processes. So, after doing this course, you should be able to design a separated which is suitable for a particular process; so, now on will be next, will be doing the membrane based separation processes in detail study of various processes and know and other things that in world in such processes.

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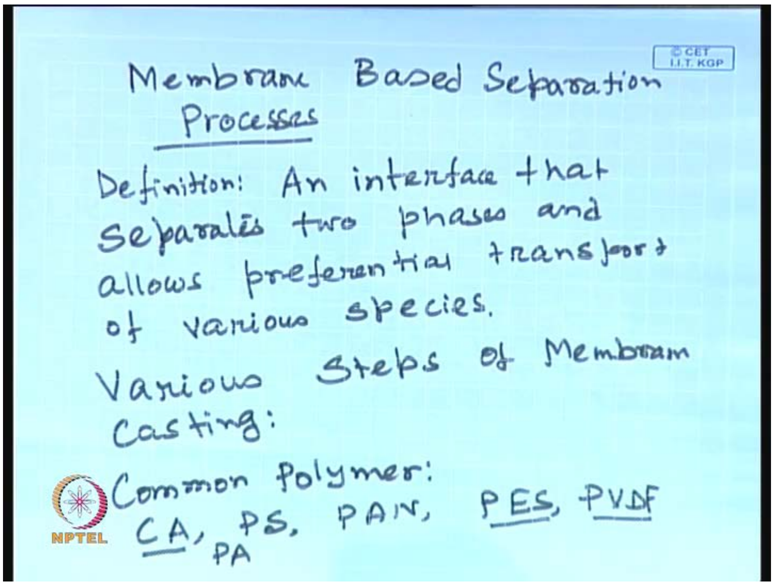

So, we start it, membrane based separation processes; now, let us first look into the definition of a membrane, in membrane is basically if an interface. It is the interface that separates two phases and allows preferential transport of various species, so, it is basically either a polymeric phase; are in a organic phase, that separate two phases and it at preferential transport particular species through it. Therefore, one that cause is separation, if you want species is preferential is more transport; if the rate of transport is more compare to the other species, through the membrane. Then, the downstream it will be least, in the in that particular species that cause is the separation.

We are talking about; the there are no let us, look into the various steps of membrane castings is, how to prepare them? And we are basically talking about; the polymeric membrane now, that common polymer that is used for casting, the membrane is cellulose acetate, poly sulfone, polyacrylonitrile, poly ether, sulfone PVDF, poly vinyl di fluoride; this cellulose acetate is used for casting. The reverse osmosis membrane for example, cellulose acetate, poly amide, PA poly amide is also used for casting; the reverse osmosis membrane, poly sulfone membranes and polyacrylonitrile, polymers are used for casting the ultra filtration membrane.

Now, all these membranes hydrophilic and poly ether sulfone is another, you know polymer which is quite hydrophilic and that will be in though these are generally used for casting reverse osmosis ultra filtration, nano filtration, micro filtration membrane. We generally, look for property which is you know typical for the membrane, which will be very useful for separation of solutes, what is that property? The properties hydrophilic, the membrane are suppose to be very hydrophilic then it will be more selective for the particular species for example, most of the polluters of the hydrophobic in nature for example, organic polluters and distaffs other polluters generally hydrophilic, hydrophobic in nature.

So, we would like to have a membrane, which will be hydrophilic so, it does not in look in does not like the environment of hydrophobic. So, it does not one to have the polutance but since, but it will be having a great liking for the water. Therefore, water will be preferential, it transported through it and you can expect a pure water solution in the downstream, in the permeate stream of the membrane. Therefore, hydrophilic is very important property polymer PES is generally used for having for you know importing more hydrophilic characteristics, in the membrane matrix PVDF is polymer; which is hydrophobic in nature.

So, using PVDF polymer, one can have hydrophobic membrane and hydrophobic membranes having various applications. In case of membrane distillation and osmotic distillation and things like that; those application we may be looking in detail later on this class. Therefore, various polymers of different kinds and utilized for casting, the membrane and selection of these polymers and generally done for importing, important and desirable properties to the membrane.

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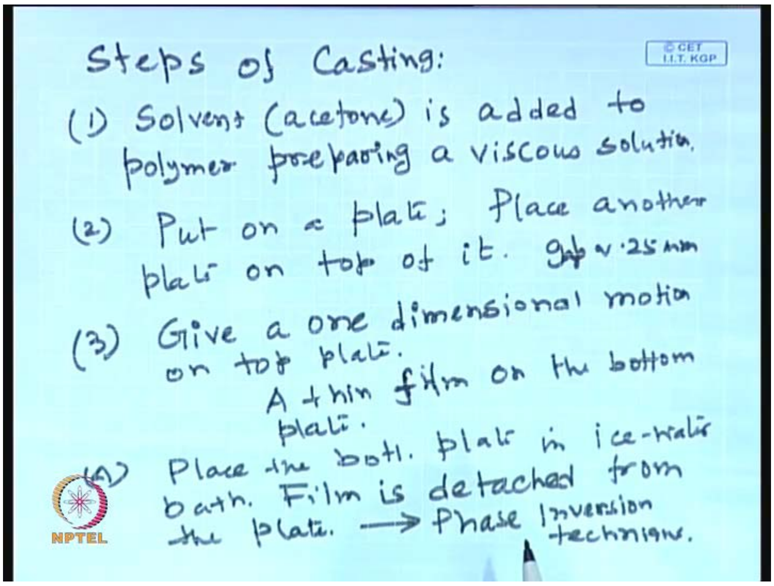

Now, let us, look into the know various steps in (()) the casting process solvent, a typical solvent is acetone, is added to the polymer. Polymer preparing in viscous solution, then it is put on a plate solution, viscous solution is put on a plate glass. Plate and place another plate on top of it, the gap may be around you know is very small around point 25 millimeter then third step is, give a one dimensional motion on top plate. What is results it? Results a thin film on the bottom plate, then you take out the bottom plate and place the bottom plate in ice water bath.

What it does the polymer? Film becomes solidified, this is known as it takes detached from the plate film, is detached from the plate. So, that basically the membrane and these technique known as phase inversion technique. Why is called phase inversion technique? Because the phase is just inverse, initially we started the liquid viscous phase and then we when you place it in the water? It becomes solidified and the phase becomes come liquid to solid. So, it become say different phase and the film gets separated from the plate and that film basically a membrane film

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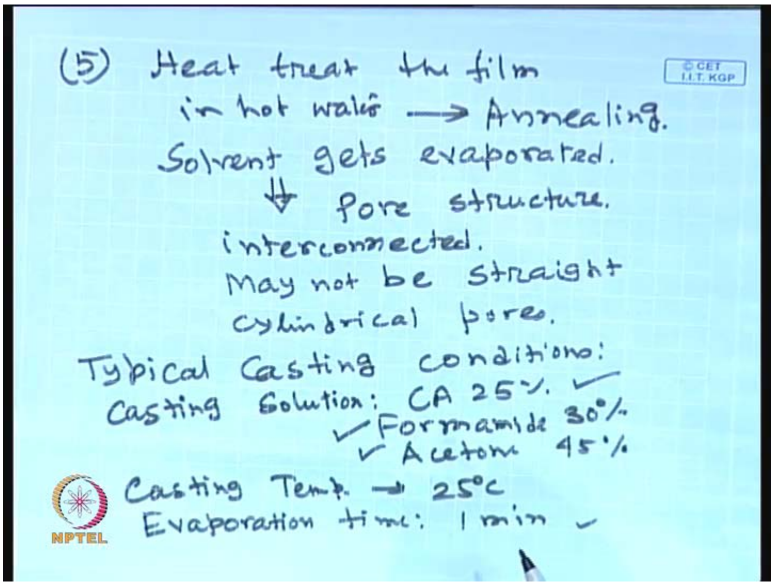

Now, there are some more steps are there, we heat treat is heat treat the film either in hot water and this process is known as annealing. Now, during this process the solvent gets evaporated from the polymeric metrics; during evaporation, it creates the pores. Now, these pores are these results, in pores, pore structure or pore network; these pores can be straight (()) they are basically, you know interconnected may not be straight pores, straight cylindrical pores they may be interconnected they may be (()) there will be some kind of torch city.

In the membrane matrix and these pores are formed now, they are typical I will just write down, the typical casting condition for casting reverse osmosis, membrane casting solution, cellulose acetate, let us, a 25 percent form amide, 30 percent acetone, 45 percent this is the polymer, this is the solvent acetone, is another solvent and casting temperature is 25 degree centigrade and evaporation time 1 minute. What is evaporation time? Evaporation time is the, time duration for evaporating, the solvent. So, that means when you put in the ice water solution, we just put in the ice water bath for 1 minute, so during that evaporation, will take place and you know pores network will be produced. Now, there is a so, this is the typical, you know procedure and typical casting condition for, casting membrane film, but there is a problem in it; the membrane film that is that your producing out of these method very fledge.

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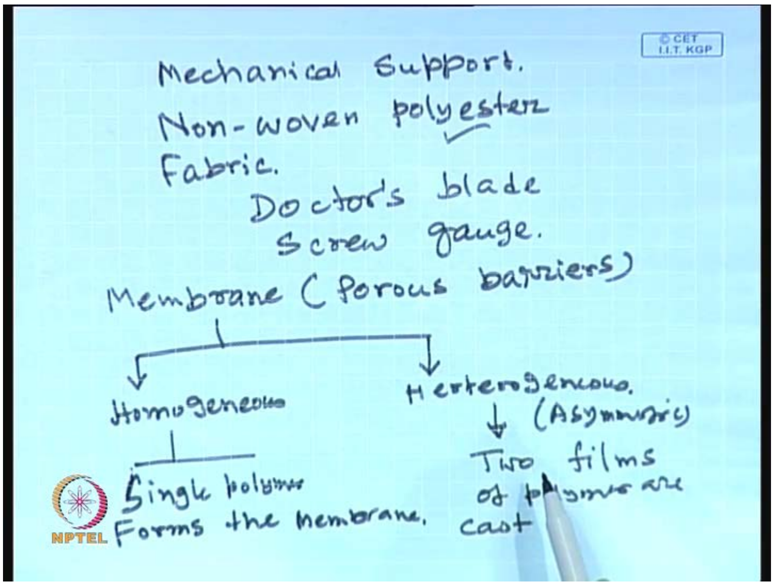

So, there should be some mechanical support given to this film; so, what is generally done? These film is cast (()) non woven fabric, non woven polyester fabric, woven non fabric, polyester fabric, woven non woven polyester fabric, these film is cast and it is the thickness of the film is generally maintained by something called doctors blade or screw gauge, that mend is the thickness of the film and the thickness will be in the order of let say few microns 40, 50 micron like that. Now, this polyester fabric gives the, mechanical strength or mechanical support polymer film, because most of the operations are high pressure operation.

For example, reverse osmosis is a very high pressure operation, that typical operating condition reverse osmosis is more than 25 atmospheres for nano filtration; it will be more than 15 atmosphere roughly around 10 to 15 atmosphere for ultra filtration. The pressure is operating pressure is among about; 4 to 6 atmosphere for micro filtration, it will be less so, will be talking about all these typical condition excreta and categorization of various membrane base processes is later on. So, should be that, should be kept in mind now, these types of various, the membrane base processes is later on.

So, should be that, should be kept in mind now, these types of barriers the membranes are also, known as the porous barrier these type of barrier, these type of barrier can be two types homogeneous and heterogeneous. Homogeneous is basically the membrane, is of a particular polymer, single polymer forms the membrane, in the case of heterogeneous I, this also known as asymmetric. There are two films of polymer are cast one above another, why it is cast one above another? Now, the basically the membrane base processes, there are two outputs you looking for, what is the first output you are looking at the productivity of the process? How first the process is one is the volumetric fluoride or filtrate rate you are going to get?

If you get something very low, let say 1 litter per meter square that means, if you provide 1 meter square, here you are getting 1 litter in 1 hour, that is very low and it is not specific for a practical operation for, if it is 200 litters per meter square. It is quite specific that is called the productivity of the process and these litters per meter square areas known as the volumetric permeates flux of the filtrate rate. Volumetric filtrate rate so, that is the productivity of the process second asymmetric, you are looking for is the quality, so that is the quantity; so, second aspect what is the quality of the permeate? what is the concentration of the solute? That you are going to expect in a particular spices.

If it is a case of solution control, you must be looking for a particular; you know threshold value of the particular of particular spices. Let say should be concentration, should be less than 1 p p m, something like that if it is a recovery problem, then you must be looking for a in the concentration of a particular solute in the permeate stream must be abort from concentration depending on the situation. Here now, the permeate flux of the productivity of the process is very important, as for as the fusibility practical fusibility of the process, is concerned. Now, these permeate flux is inversely proportional to the thickness more be the thickness, more mechanical resistance, it will be offering against the fluoride.

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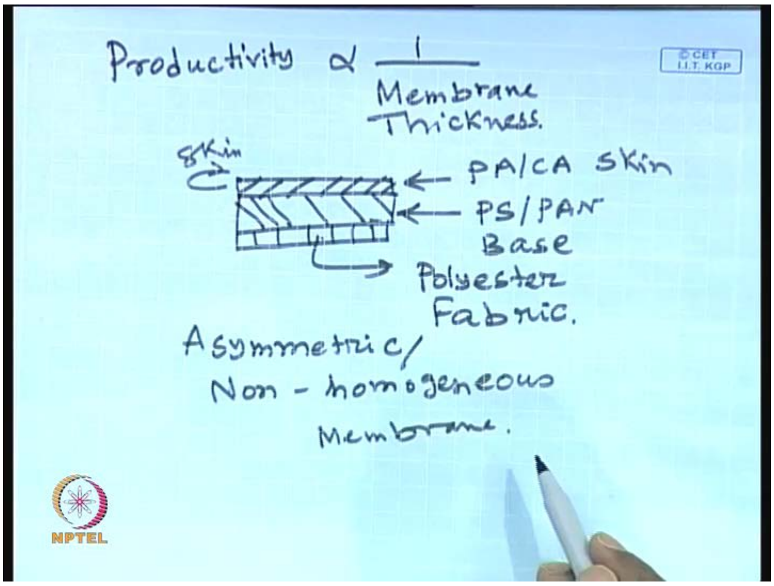

So, productivity of the processes or permeate flux is inversely proportional to the thickness of the membrane. If you note down thickness of the membrane, if the productivity becomes very high; so, you can you can go for higher productivity of the process. How it is done first on the non woven polyester fabric? If put a coating of let say PAN or PS something like that, so those these polymers will be cast on as a film on the polyester fabric, we select the pore size then you cast another film of let say CA or poly amide over it, so basically that will that will create a skin over the over the higher pore site polymer support so there will be a skin at the lower end then will be another polymer let say this is poly amide or CA skin and this is let say PS or PAN base and below.

Here you are having the polyester fabric, now, actual membrane is basically these skin; this is the actual membrane since, these thickness is much lower compare to the thickness of the supports that will be then you can expect higher productivity of the process, this is known as asymmetric or non homogeneous membrane. Therefore, in order to increase the productivity of the process asymmetric membrane are quite important and these asymmetric membranes are invented in the during 1970s and during the invention of the asymmetric membranes. The membrane base process is becoming more feasible as for as, the industrial or practical using concerned.

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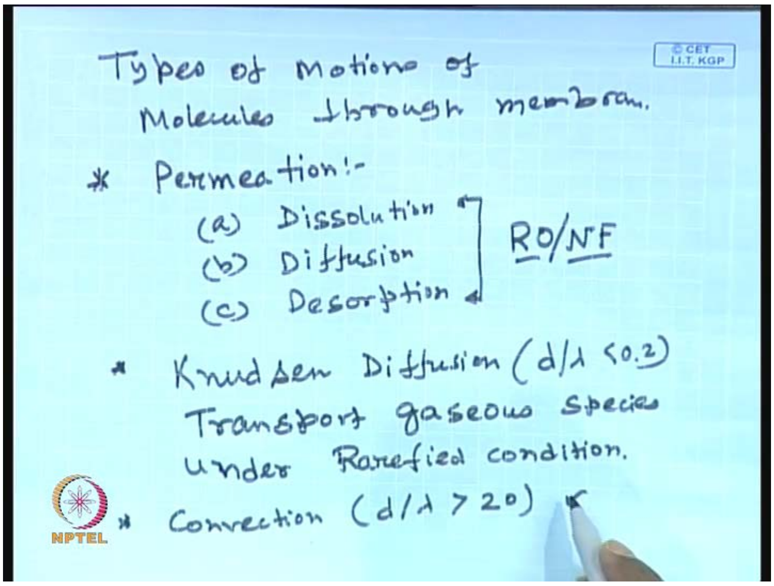

Now, let us, look into the types of motions, we will be motions of molecules through membranes, one can encounter in the membrane first process is called permeation. What is permeation? Permeation has three distinct steps, one is dissolution another is, diffusion third one is desorption, here we are talking about almost non porous membrane or pores are very small in case of reverse osmosis and nano filtration. The solute are getting dissolved in the dissolution steps solute have getting dissolved in the membrane phase, because of the concentration gradient and because of the concentration gradient.

Only it will diffuse from the upstream to the permeate side feed to the permeate side through the membrane matrix then again, because of the concentration gradient in the permeate side the concentration is this nothing almost and it get dissolved in the permeate side these three steps including a in total they are called permeation mechanism second one is, Knudsen diffusing d by lambda is less than 0.2 d is the core diameter and lambda is the mean free path of the molecule if it is less than 0.2 these mechanism called, Knudsen diffusion and these are basically you know transport of gaseous species under rarefied condition third one is convection if d by lambda is greater than 20 then pure convection will be taking place under the pressure gradient.

So, these are three typical various, you know different mechanisms that will be coming across, the various membrane processes, the permeation will be typical operation or typical mechanism transfer mechanism for reverse osmosis and nano filtration convection and you know ultra filtration, both diffusion and convection will be more or less predominant as you go towards the more pore size of the membrane, next relax pore size of the membrane. The mechanism is transfer from diffusion to the convection right for lower molecular, cut off ultra filtration membrane diffusion may be predominant for let us, say around 40,000 or 50,000 cut off ultra filtration membrane both are equally you know good and for higher cut off membrane lets a 1 lakh or 2 lakhs cut of ultra filtration membrane convection, is only mechanism for micro filtration membrane, convection is the only mechanism.

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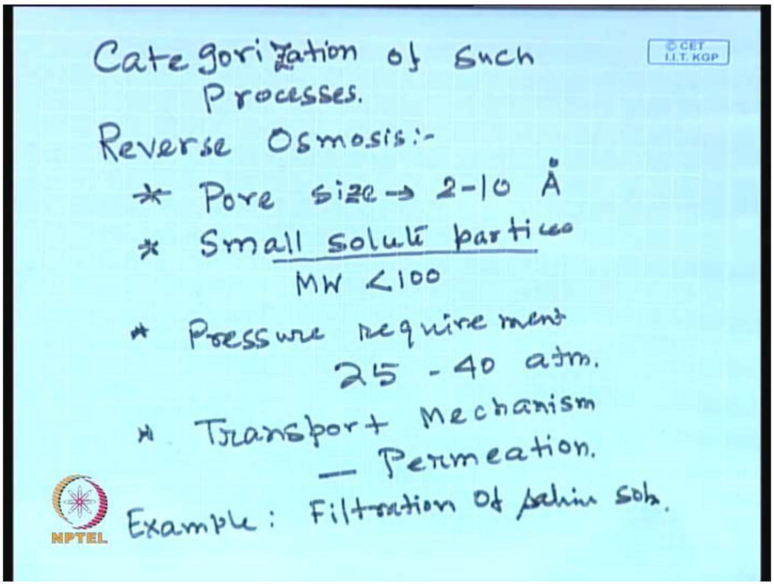

Now, probably we are in a position for categorization of various membrane base processes, the first process will be talking about is reverse osmosis. So, in the last class you get some I get some idea about; reverse osmosis now, let us, look into the various characteristics of reverse osmosis process as first one first of all it has the smaller pore size the pore size is very small and it will be in the range of 2 to 2 10 Armstrong, second is since the pore size is 2-10 Armstrong, it will be used for separation of very low molecular size material, that means you are going to separate small solute particles which will be having a molecular weight typically less than 100 that means various types of salts.

If the sodium chloride will be having a molecular weight 58.5, now, since operation since, the pore size very small the osmotic pressure will be will become predominant in such cases and if you that will talk about it later on the osmotic pressure has two thing, two characteristics. It is directly proportional to the concentration that is why it is known as the calefactive property? this inversely proportional to the molecular weight therefore, if you encounter solute which will be having very small, very low molecular weight is osmotic pressure become very high for higher molecular solute.

The osmotic pressure becomes low, it is not very important. So here, because of that particular property since, you are talking about the small size solute particles, the osmotic pressure becomes very high. Now, in case of reverse osmosis as, we talked about in the in the last class, we have to apply pressure in the feed side to overcome the osmotic pressure right, then only the first step of permeate coming in the other in the downstream side. So, pressure requirement is in reverse osmosis becomes highest, because of the, because to overcome the very high osmotic pressure so, pressure requirement is in the order of 25-40 atmosphere and main transport mechanism is permeation that will just discussed is permeation and typical example or application is filtration of saline solution, that means salt solution it is tremendously useful in case of desalination purposes so, that goes for the reverse osmosis.

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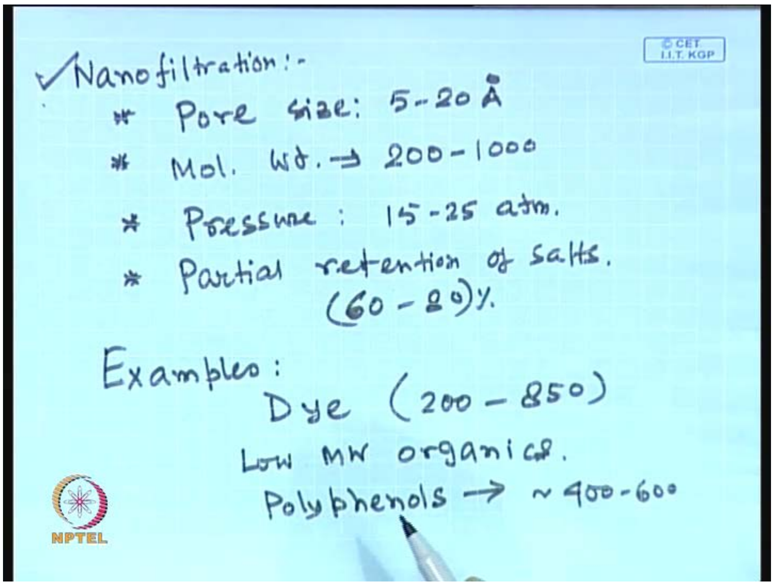

The next filtration processes, next category of such process is, nano filtration here the pore size are straightly higher, then reverse osmosis, the average pore size will be in the range of 5 to 20 Armstrong and the particle therefore, you can since, the pore size is straightly higher one can expect a high pore you know to separate the particles of higher molecular weight. So, molecular weight of the particles to be separated, will be in the range of 200-1000 the since, the pore size higher and the molecular weight of the particle to be separated is higher is osmotic pressure will be lower. Therefore, pressure requirements will be slightly lower in these case now, it good and it causes a partial retention of salts a good reverse osmosis membrane is (()) to the very good reverse osmosis membrane.

If it can reject a sodium chloride solution to the tune of 95 to 98 percent, if sodium chloride is separated to the extent of 95 to 98 percent, that particular reverse osmosis membrane is suppose to be good reverse osmosis membrane and the other hand in case of nano filtration membrane the moravalance salt for example, the sodium chloride should be separated in the tune of 65-80 percent so, it is called partial sep separation or partial retention of the salts, that that difference between nano filtration and reverse osmosis is very thin is, very know, very film. The only difference is the salts monovalance salts or partially rejected by the nano filtration membrane, if the you know 60 to 80 percent and the other hand, in case reverse osmosis the morvalance salts are highly rejected by the membrane to the tune of 95 to 98 percent this is the main difference between the nano filtration and reverse osmosis.

The applications and examples nano filtration are dyes separation of dye molecules, dye molecules will be having generally they have the molecular weight in the range of 200 to 850 and 900, these are various dye solution are the dyes are there, which will be having molecular weight in these range. The small low molecular weight organics and given example like, poly phenols they will be having a typical molecular weight between four 100 to 600 they can be separated by the nano filtration completely so, you can select appropriate cut of or characterized nano filtration membrane and can separate the poly phenols dye and it is nano filtration has tremendous application in the in treatment of the textile effluent. So, it can separated out the dyes, but the same time you know any textile effluent, they will be in a apart from dye first of all the color and dye and dye if the color becomes very you know a (()) lower concentration.

So, if you know the concentration around 50 ppm something like that dye becomes colored so for removal of the dye, the color will be basically one thing another is the pollute polluting capability so, typically the dye textile effluent should be containing dye concentration less than 1 ppm there is a typical known also the textile effluent contents. Very high amount of sodium chloride salt why, because this is this is require this is the requirement to fix the color on the fabric, so, any textile effluent will be having a page very high sodium hydroxide sodium chloride sodium sulfide these are salts and the alkaline, they there in the alkaline conditions so, that typical page in the order of 11 to 13 in textile effluent. Therefore, one has to so one has to separate out the dyes as well as , one has to recover the sodium chloride in a white so, that you can recycle them and can reduce the operating cost of the plant.

Therefore, nano filtration is as now, becoming routine unit of version is textile effluent plant at the same time, their separating out the dyes and the permeation permeate retain content most of the dyes and the permeate condense sodium chloride and the other salts and alkaline and that is simply recycled back. Therefore, by using, nano filtration membrane one can have a 0 research plant, even in the textile effluent process textile industry, you can separated out the dye can reuse it or in the same time in the returned stream are in the permeate stream, you will be having a solution which will be (()) in salt and alkaline recycle in the upstream of the dye path. Otherwise dye nano filtration is a typical process in the form of nutricals and other application daily industries.

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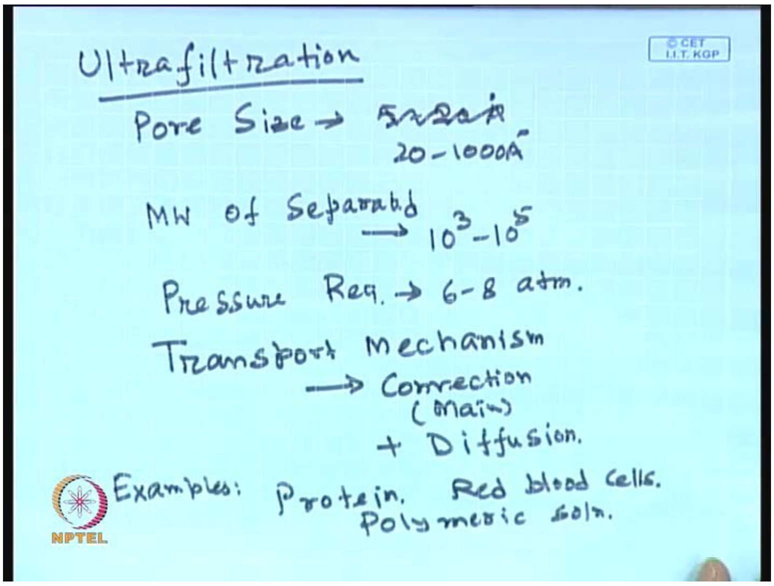

The most important and most utilized process is ultra filtration here the pore size is are larger than nano filtration membrane is 5-20 Armstrong no 5-20 Armstrong was nano filtration it will be 20-100 Armstrong. The molecular weight of solutes that is separated will be in the range of 1000-10 to the 5 1 lakh and the pore size is 20-1000 Armstrong and pressure requirements since, we are talking about the higher pore sized and higher molecular separation of higher molecular solute, the pressure requirements will be less and it will be 6-8 atmosphere and the transport mechanism is, a mixer of convection as diffusion, this is main plus diffusion so, and it has a wide variety of application and you know examples for example, one can have the separation of high molecular weight protein.

The membrane can be utilized for separation or purification or fractionation all the purpose is can be solved, one can separated out particular solute, one can purified a particular solute by separating. How to water from the solution? One can fractionated suppose, you are you are having a 2 solutes, which will be having molecular weight let say 60,000 another solute, which will be having molecular weight 7000 then we can select a particular membrane. Let say, 40,000 or 30,000 cut off that will retain in the higher molecular solute, in the upstream side and it will allow lower molecular solute in the downstream side, so, it can be utilized for the case of fractionation.

So, protein separation purification or fractionation blood red, blood cells, polymeric solution separation on purification of polymeric solution, it can be done under ultra filtration process now, out of these, all these processes ultra filtration and micro filtration on widely used now, we going to the next processes, there is the micro filtration process.

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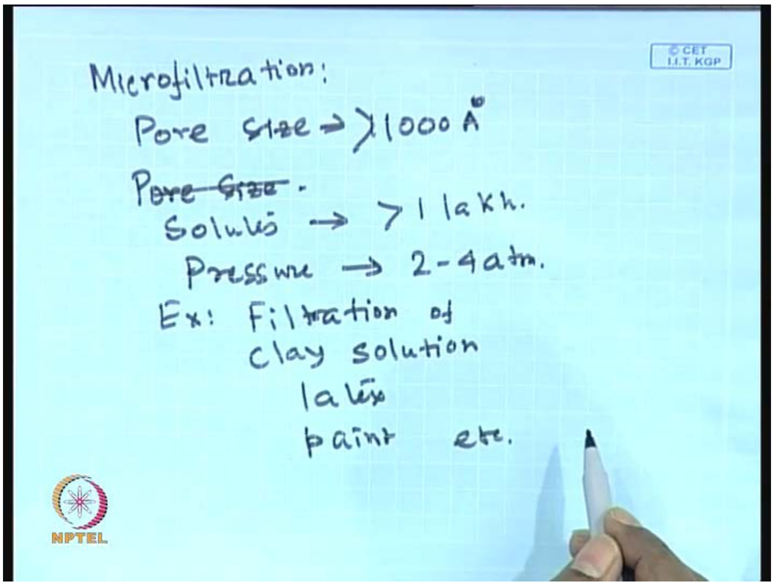

The first characteristics of micro filtration is, pore size is very high and it will be in the order of more than 1000 Armstrong, 0.1 micron, 0.2 micron, 1 micron, 2 micron like that and the pore size more than 1000 and the solute molecular weight of solutes to be separated is greater than 1 lakh 10 to the power of 5 and pressure requirement is lower, it is 2 to 4 atmosphere and example, is the filtration of clay solution latex paint excreta. So, if you just observed the if the when the pore size of the membrane becomes higher the pressure requirement is going to be lower and lower you do not require very high pressure for effect.

The separation this simply, because if we talking about the low pore size membrane, then the osmotic pressure becomes pretty important and becomes very high, we have to overcome that pressure requirement, becomes very high. In those cases now, once you categorized various membrane processes will go for certain definition and which has pretty important in whenever; will be doing the design and other will be discussing various processes in the retired of the course.

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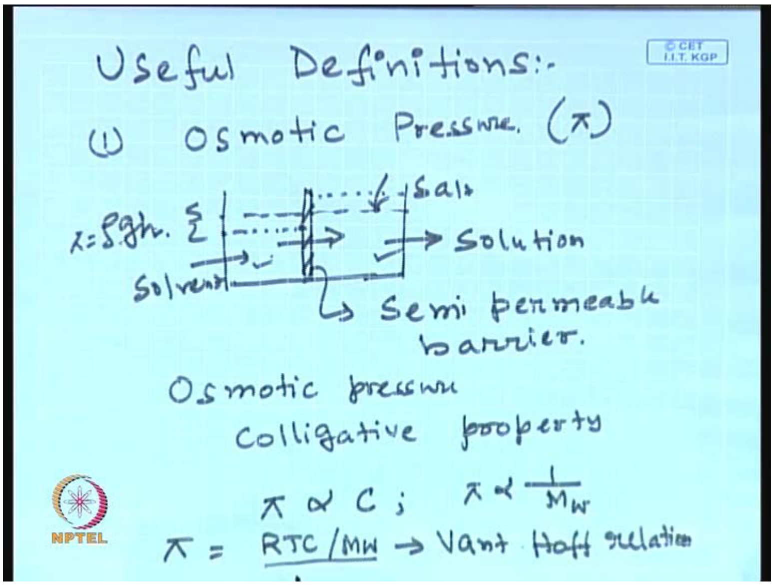

So, let us, look into the some of the useful definitions, the first definition is osmotic pressure. Osmotic pressure is denoted by the symbol pi and I think we have discussed in (()) some extent, in the last class I will discussed it again in more detail suppose, we are having a chamber separate by a semi permeable barrier, semi permeable means, it is between the2 solute, 2 species it will selective to a particular species that means, it will allows water, but it will not allows salt and will be having let say some volume of water both the chambers, then there is this is the solution side, we are some salt here and this is the solvent is pure water then the solvent water activity less in the solution chamber and more in the solvent side.

So, water will be transported from the solvent to the solution side, because under the I know, driving force of chemical potential gradient so, and after some time, the equilibrium will be taking, will be in effort and it may be after 24 hours may be occur 36 hour in the finally, the level of water under solvent side will go down and level of water in the solution side, will go up that will calls a hydrostatic development of a hydrostatic head roe g h and this is nothing but the osmotic pressure. Now, since we have discussed in the last class that osmotic pressure is colligative property.

Colligative property means, any property means, any property that will be depending on the amount of solute present in the system. So, that means if you increase the concentration of the salt in the solution side the concentration difference will be higher, so of the water activity difference for water activity difference of activity higher so more water will be permeating from the solvent side to the solution side. In that case, the hydrostatic pressure roe edges delta edge between the final equilibrium position of the in the solution side and solvent side will be more so osmotic pressure develop will be more.

Therefore, osmotic pressure is directly proportional to the concentration of the solute and osmotic pressure is inversely proportional to the molecular weight of the solute. Therefore, if you are talking about; it solute which will be having a lower molecular weight the osmotic pressure is, very high and therefore, for dilute solution pi is given as RTC by M molecular weight; this is known as Vant Hoff relation. Now, for the it has been observed that for the salt solution, this is for the monovalent salt for the divalent salt, I let you know, what the relation for the divalent salt is.

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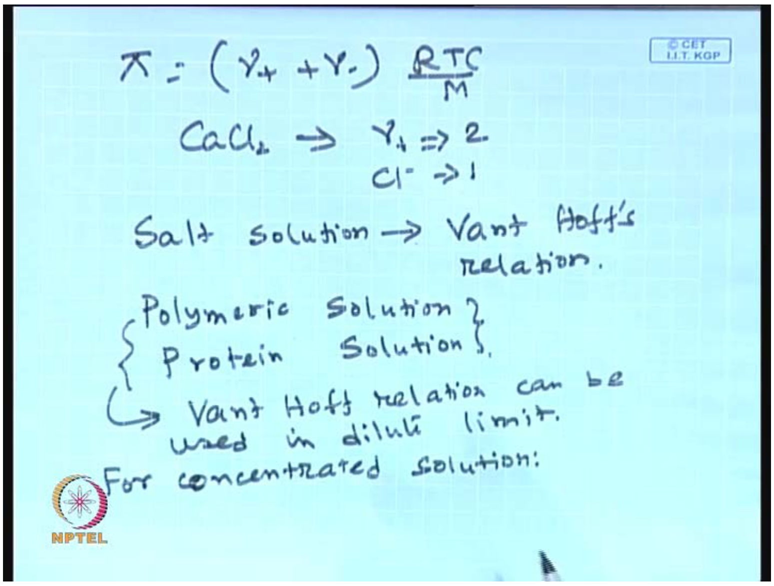

Is basically pi is equal to nu plus, nu minus RTC by M that means, for C a C l 2 these basically (()) nu plus is 2 and chlorine minus is1. So, will be getting the you can the osmotic pressure, will be slightly higher; therefore, for the salt solution Vant Hoff relation is good enough for the so, for the salt solution you can use Vant Hoff relation either monovalent or divalent or multivalent for the higher. So, know you know for other solute like polymeric solution, protein solution, the Vant Hoff relation can be (()) used and Vant Hoff relation can be used only under dilute condition for these cases Vant Hoff relation can be used, in dilute limit for concentrated solution for Vant Hoff relation is not, cannot be used one can go to the thermodynamics and can get the derivation, that in the in such cases for that concentration solution, the osmotic pressure will be in the form of (()) coefficient.

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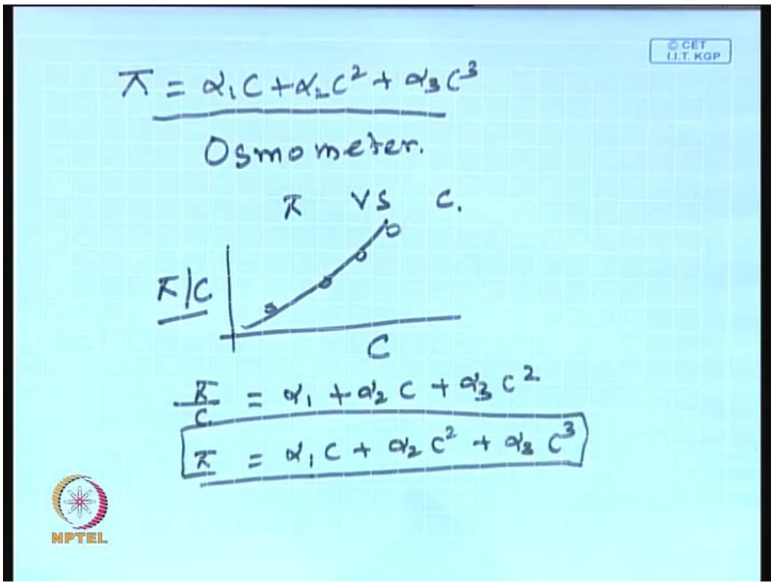

So, in that case osmotic pressure can be expressed in the term of you know, the polynomial of concentration like alpha 1 C plus alpha 2 C square plus alpha 3 C cube like that. So, in most of the cases, these relation are available in literature people do people is osmo meter; the osmotic pressure measurement machine instrument is called osmo meter, they conduct experiments under various concentration and measure the osmotic pressure pi versus C, these measurements are their then it is plot and the trick is you not you should not plot pi verse C, you should plot pi by C verses C then feed a polynomial and express pi by C verses C is something like; alpha 1 plus alpha 2 C plus alpha three C square so, after multiplying C in both side will be get will be getting pi is equal to alpha 1 plus alpha 2 C square plus alpha 3 C cube.

Therefore, why it is cast in these form is simply, because if you put in the expression C is equal to 0 pi become 0. What does physically? That means physically significant signifies that, if you have a pure water, pure solvent. The osmotic pressure is 0 so, if you plot pi versus C from the experimental measurement, then you will be having d if will be having some residual osmotic pressure for if you put C is equal to 0; which is which goes against the physical principle so, in order to forever physical principle the experimental result are pi by C versus C in order to have 0 osmotic pressure for pure solvent.

Now, for membrane base processes, the osmotic pressure becomes very important why any actually? any solution will be having its own osmotic pressure for example, if you have a saline a glass of saline solution, it will be are let us, a sugar solution or let us, a (()) solution, it will be having its own osmotic pressure, that means when you having glass of saline water? It will be having its own osmotic pressure, but you cannot realize the osmotic pressure. Why you cannot realize? Because osmotic pressure can be realized if one only if, that is very important if one only is semi permeable barrier is present, in the solution.

Otherwise, you cannot (()) presence of you, gonna realized the realize, the presence, the osmotic pressure, that is why? Whenever; we are talking about membrane base separation process. Since, a semi permeable barrier is present in the solution itself. The osmotic pressure becomes very important, when you are drinking a glass of saline water are having a the osmotic pressure? Your drinking it before that you are not filling it, but when it is going inside? The body in the know vessels excreta are in the basically semi permeable barrier; so, it creates an increasing blood pressure therefore, the know doctor also, advise do not take, if you have a heart problem, do not take water do not take salt you should decrease is the intake of salt, because that will increase osmotic pressure in the (()) are it may robcher.

Osmotic pressure can be realized, only in presence of semi permeable barriers and that is why? it is become very important, in case of membrane base separation process later on will see whenever; will be modeling such know systems the most important model is osmotic pressure model.

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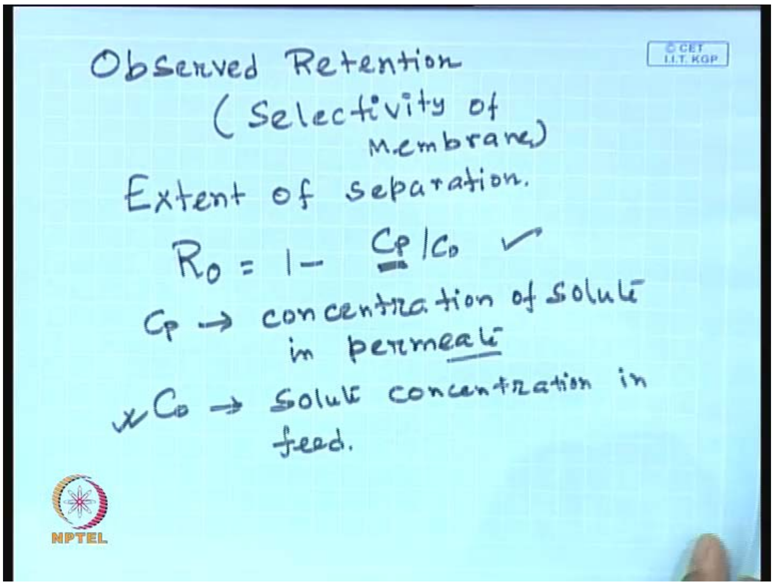

The next important definition will be observed retention; it indicates selectivity of the membrane is how? Selective my membrane is that means how selective my membrane is means, how much? Solute it can retain. It indicate physically, it indicate extent of separation, this is defined as R subscript O and it is 1 minus C p by C 0 C p is the concentration in the permeate concentration of the solute. In the permeate C not is solute concentration in the feed so, these gives directly the extent of separation, that means you can, you know what is the concentration of the feed solution? you can experimentally measure, it you can run the experiment and get permeate and are the filtrate and measure the concentration of it you know and will getting the C p.

By using this definition, one can get the you know, extend of separation this is known as the observed retention. Why it is known as the observed retention? Observed retention it is because the permeates concentration or the permeate stream quality of the permeate stream is, compare with the feed stream that is why its called observed retention? Therefore, there their exist another counter part of observed retention, that is known as the real retention.

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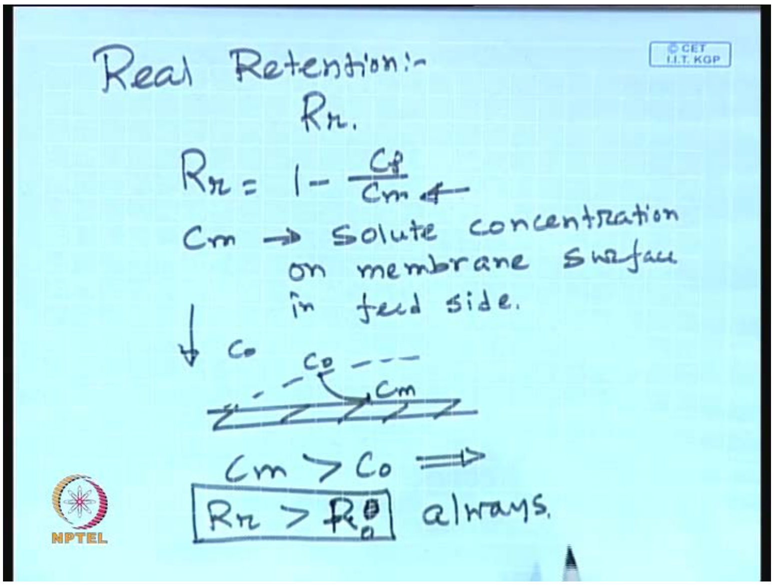

And what is the difference between the observed retention and real retention? the definition of real retention is 1 minus C p by C m C m is the solute concentration on membrane surface in feed side. So, what did give basically the difference between real retention? When it will be used? When observed retention will be used observed retention? Will give a direct measurement because you do not know, how to measure the membrane, the surface concentration over the membrane surface, because it is liquid phase.

Now, suppose you take out the membrane and dry it and measure the concentration and dissolved re dissolved weight that will not give, you the real picture, because when you are taking it out? When you when release the pressure? Then if you want take the membrane out of the system, you have release the pressure, when you release the pressure some of the solutes that will be deposits towards, the membrane surface will be again re dissolved that will not give a you give you a direct measurement of so direct measurement of C m is really very difficult.

What you can do? There are theory is present so, that you can have an estimate or you can theoretically calculate, what is the membrane surface concentration? In fact membrane surface concentration will be always higher than the feed concentration. Why because it is pressure different process suppose, this is the membrane and this is the feed concentration, you are pressurizing the system under pressure solutes will be convective towards. The membrane surface and they will be return by the membrane. So, that will be is sort of concentrate solution of the solute present near the membrane or are you can otherwise, you can more technical term you can say that is the development of concentration boundary layer or mass transfer boundary layer towards membrane surface something like this.

So, the there so they exist say, concentration gradient starting from C0 up to C m near the membrane surface and C m is always greater than C0. Therefore, real retention is always you can now, you can use this relationship and the definition of the real retention observed; retention you can identify that real retention is greater than observed retention always.

Now, why then these two definition solutes, because when one definition it is directly measurable real observed retention, is directly measurable and you can say that, my membrane is let say is rejecting 40 percent of the solute or 90 percent of the solutes then, what is the use of real retention? The use of real retention is, not in the direct observation it is used in the, in design of such processes. Why it will be use in design of the processes? Significance of the real retention will just discuss after in the next class.