**Thermal Processing of Foods**
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**Lecture No. 27**
**Packaging Considerations: Barrier and Mechanical Properties different food Packaging Materials**

Good morning all. So today we are going to discuss about the food packaging considerations. So this week I got two lectures, one is on barrier and mechanical properties of different food packaging materials and the next lecture is all about the bio nano composite food packaging materials. So composite films I have already discussed in one of the lecture how we form composite materials, what was the aim for making such a composites?

So it in today's lecture we are going to discuss about the packaging consideration. So what should be the basic characteristics of the packaging materials and what are all the food packaging materials available and what about their barrier which is nothing but a transport of any gases or water vapor through the packaging material and mechanical properties, which is nothing but a its strength and elongation.

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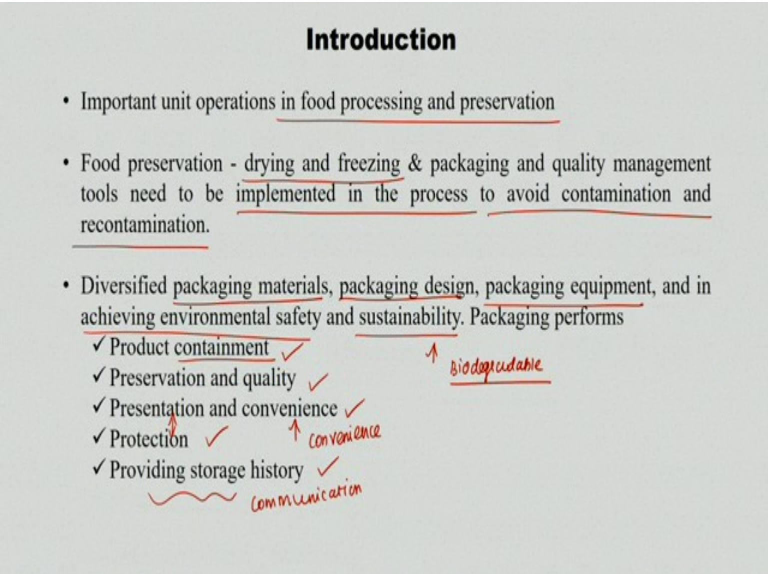


So we will with that small introduction we will go to the lecture. So the food processing and preservation it is important unit operations in food processing and preservation. So the food packaging is nothing but a important unit operation in food processing and preservation. So it is not only the packaging is called food preservation. So earlier we have discussed about drying and freezing also food preservation because drying we reduce the moisture content. In that way we also have minimum water activity for the contamination to occur. That also freezing that we do normally at day-to-day life. If we want to keep any seasonal vegetables or foods, we will freeze them for about maybe 1 to 2 months. So those are also food preservation techniques, drying and freezing.

But in packaging what it offers is the packaging and quality management tools needs to be implemented in the process to avoid contamination and recontamination. Because it has to be store and it has to be distributed. So in that case, the packaging and quality management is a important tool. So if we want to store we can use either drying or freezing, but especially when it has to be transported from place to place and it has to be stored and sometimes in the sterilisation we have also seen with the packaging it is undergoing a thermal treatment. So in such cases the packaging and quality management is very much important.

In recent days packaging materials, diversified packaging materials, we got and various packaging designs and packaging equipments, and in achieving and environmental, safety and sustainability. So we have got many options on packaging materials, packaging design and packaging equipment, with the aim of achieving an environmental safety, as well as sustainability. So here we can say something like biodegradable.

So in one of the lecture what I have discussed this one when I throw it in an environment it should not create any environmental pollution. So, our aim, or our research moves towards that kind of an environmental safety and sustainability. So packaging performs many functions. So one is product containment, and preservation and quality, and presentation, and convenience, protection, providing storage history and it got many more functions. So we put them together in mainly 4 category and we will discuss about that. One is on containment, another one is on protection and preservation. The storage history is nothing but a communication. So how much product is communicated to the customer. Then another thing is the convenience factor. How best it is to handle, so in that 4 functions, we will discuss about the way, food packaging materials.

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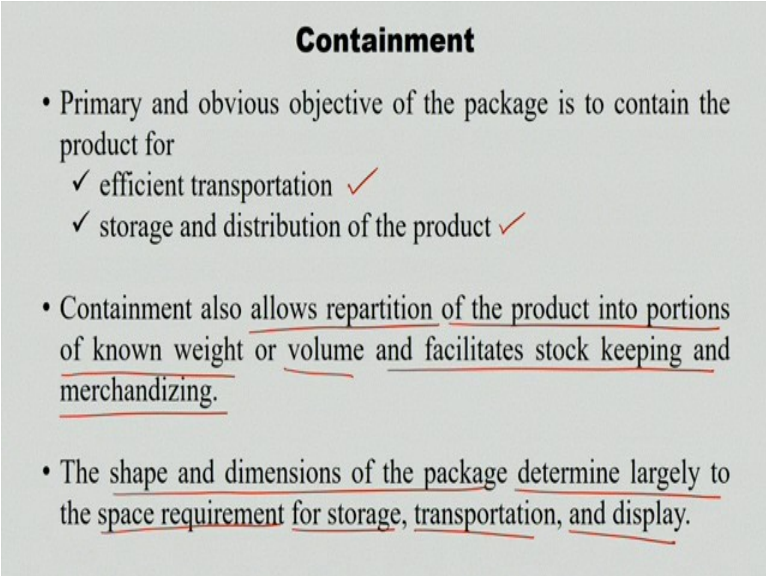


The first one is containment. So this is the primary and obvious objective of the packaging is to contain the product for an efficient transportation and storage and distribution of the product. As I said earlier, so how you are packaging food preservation technique is different from normal drying or freezing food preservation operations. So this is efficient, the containment that is nothing but the package is to contain the product for efficient transportation as well as storage and distribution of the product. The containment also allows repartition of the product into portions of known weight or volume and facilitates stock keeping and merchandizing. So instead of 1 kg, so it may be to 500 kg product.

So that is also containment. So it allows the repartition of the total product into portions of known weight or volume and it will be very easy for stock keeping as well as merchandizing. The shape and dimensions of the package determine largely to the space requirement of the storage, transportation, and display. So this is based on I mean various factors. So it also depends upon sometimes serving quality. So here it is basically given based on the distributors choice. So the space requirement for the storages. So instead of storing big, big boxes or big, big product packages. So if we make it smaller ones of known weight and volume. So then it will be very easy for storage, transportation as well as display. Because we need not deal with the bulk amount of the product.

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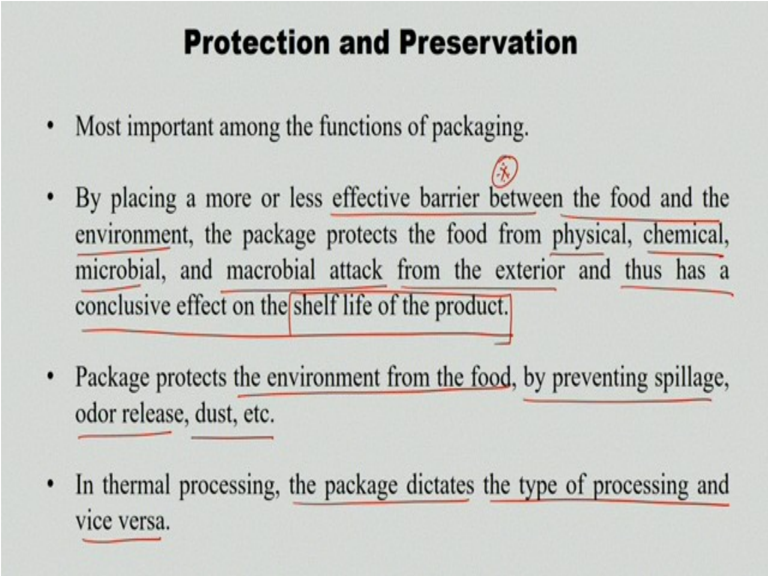


The second important functions packaging is nothing but a protection, preservation. So by placing a more or less effective barrier between the food and the environment. So this is a main and important function of the packaging material. So it places a more or less effective barrier between the food and the environment. The package protects the food from physical, chemical, microbial, and microbial attack from the exterior and thus has a conclusive effect on the shelf life of the product.

So this is very much important, it act as a barrier and also it protects the food from outside like physical, chemical, microbial, and microbial attack from the exterior and thus has a conclusive effect on the shelf life of the product. It also contributes to increase the shelf life of the product. The packaging protects the environment from the food as well, it is not always true, that it acts as an effective barrier between the food and the exterior environment. And it also protects the exterior environment from the food. How, by preventing the spillage, odour release, dust, etcetera.

In thermal processing, the package details the type of processing and vice versa. So this we have seen, in some of the thermal processing itself. So high-pressure processing should use, which kind of packaging material and during sterilisation which kind of packaging material we need to use and during pasteurization which kind of packaging material we need to use. Aseptic processing, which kind of packaging material we need to use. So it also depends upon the thermal processing which thermal processing, we choose. So based on that packaging material has to be decided.

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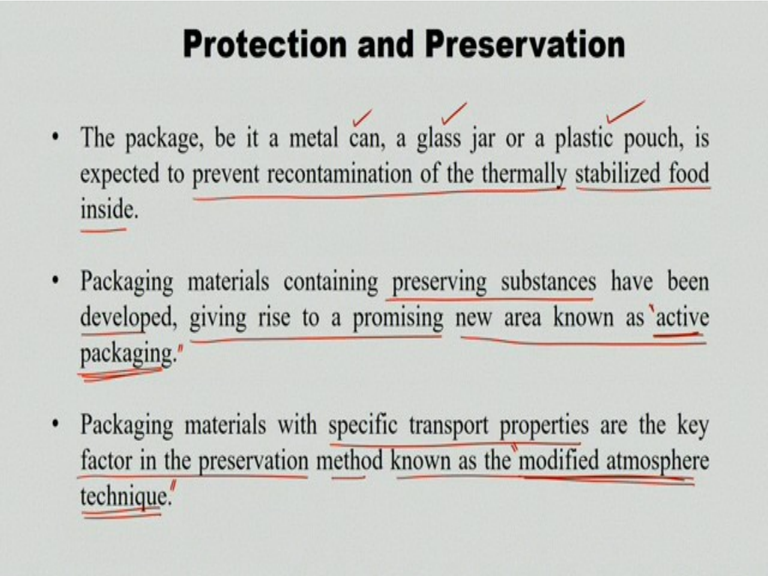


And it is also true that based on the packaging material we can go for a thermal processing as well. So then the packaging be it a metal can, or glass jar or plastic pouches, is expected to prevent contamination of the thermally stabilised to food inside. So normally there are two ways. One is we first pack the food and go for a thermal processing and other times we also do the thermal processing, first then fill the can write. So, whatever it may be your packaging material, whether it is a metal can, or glass jar or plastic pouches. So if the packaging material is of, is expected to prevent recontamination. Once the product is thermally stabilised.

So then the packaging materials containing preserving substances have been developed, giving rise to a promising new area known as active packaging. So the recent research or recent developments in the packaging material is nothing but a active packaging as well as the modified atmospheric technique. So first we will see what is active packaging. For example, we told that instead of thermal processing, sometimes to increase the shelf life of the food there are preservatives used. So during that time, so instead of using the large amount of, or the required amount of preservative agents directly inside the food.

So these active packaging technique is introduced to have these preservatives in the package and film itself, and it slowly releases to the product, whenever required or what rate it is required for the food to acquire the preservatives. So what is active packaging? Active packaging, the packaging material itself has the preservatives substances. So it releases the preservative substances to the food product at a given rate and given time. So these are called active packages. So the packaging material contains preservative substances have been developed giving rise to a promising new area known as active packaging.

And packaging materials with a specific transport properties are the key factor in the preservation method known as the modified atmosphere technique. The active packaging what we told? The preservatives substances kept in the packaging material and it slowly releases the rate at which the food needs those preservative substances to increase its shelf life. The same way the transport properties, for example at what rate water vapor should go inside the food material or at what rate oxygen needs to get inside the food material. So that also can be designed. So these two are hot areas, one is active packaging another one is modified atmosphere techniques. So these are the new areas, which is developed in the food packaging industry.

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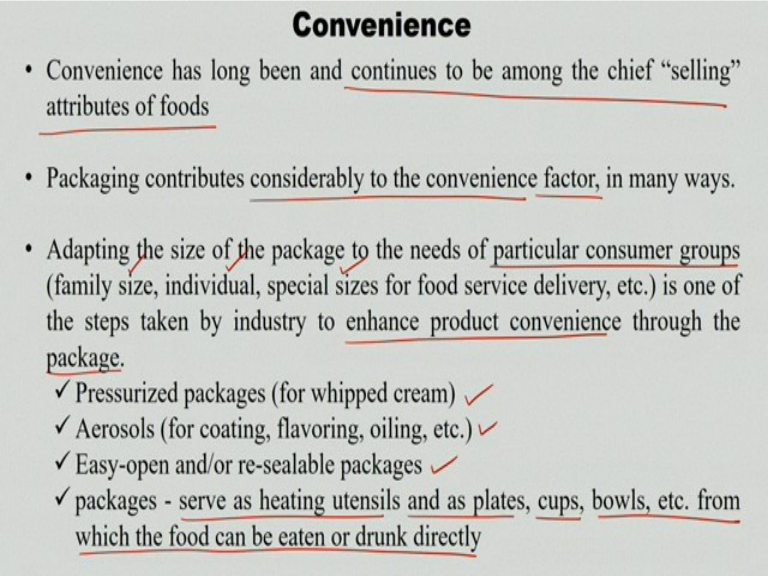


The next one is convenience. So convenience has long been and continues to be among the chief selling attributes of the foods. So this is very much important as I said. So the packaging contributes considerably to the convenience factor, in many ways. One is the adapting the size of the package to the needs of the particular consumer groups, whether it is a family size, or individual size, or special sizes for food service delivery. So this we have seen also. For example, in sauces, ketchups are available in the small, small packs for a particular serving.

So those are examples, is one of the steps taken by the industry to enhance the product convenience through the packaging and also we might have seen not only in the food even in the cosmetic industries. So to travel, to take those products during the travel, there were small sizes, small size cosmetic items. And certain products might have got very small shelf life, maybe 1 month only the product can be used. In that case, instead of 5 kg if I buy 1 kg, that would be of more convenient for the consumer. So in such cases this convenience factor come into play.

So one example is based on the serving need of the consumer, it can be design. And pressurized packaging, so in case of for whipped cream and aerosols for coating, flavouring, oiling, etcetera. And easy open or re-sealable packages, these are all convenience factor. And packages which is served as a heating utensils, and as a plates, cups, bowels, etcetera from which the food can be eaten or drunk directly. So you might have seen this noodles, cup noodles, we just have to pour the hot water and we can directly eat from the cups itself. So these kind of packages will come under the category of the convenience factor. So how convenient the consumer feels when they get these products under those packaging materials.

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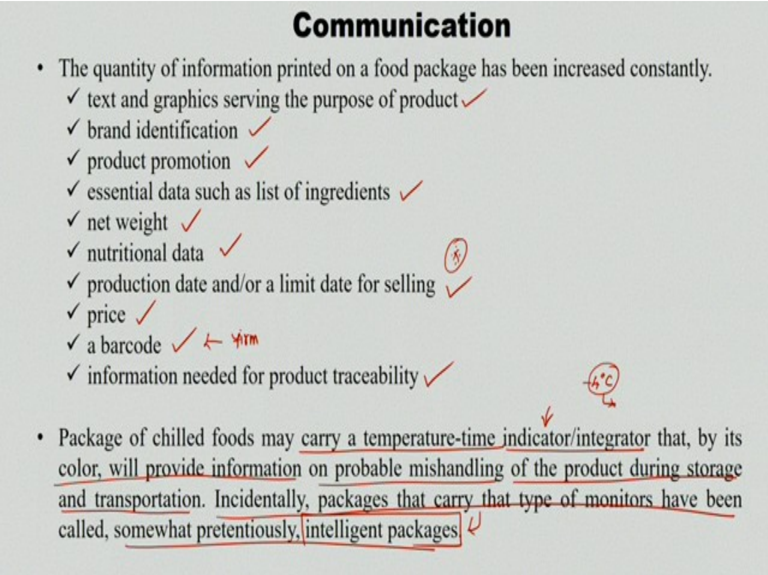


So then communications. So communication is also another important parameter to be considered while designing a food packaging material. So this gives the following information, one is the text and graphics serving the purpose of the food. So it should be visible and it should be clearly and legibly written. And brand identification, sometimes we go by brand. And product promotion, so that also appealing to the consumer. And essential data such as list of ingredients should be printed. And net weight. And nutritional data, so this we have seen in one of the aseptic processing lecture. I have got the packaging. I think Amul milk the packaging information I have shown you. The nutritional data, how much vitamin, how much protein and are all there. And the production date or a limited for selling. So this comes under shelf life and it is very much important information. So use by date and best before date.

And price and a barcode. Barcode will help the firm to have an idea about. So which one is the hot selling product and which one is low selling product and how to arrange and which needs to be shuffled quite often. Which product to be shuffled quite often, all this information is you can get from the barcode and it helps mostly the departmental stores to have such information. And also information needed for product traceability. So, which, warehouse it was stored and all such information also, one can get from the packaging material. These are all the information we can get from the data printed on the food packaging materials and also our food packaging material should be flexible enough to have all this information on it.

And package of chilled foods may carry a time-temperature indicator or integrator that, by its color, will provide information on probable mishandling of the products during storage and transportation. So in shelf life studies we have seen these also. So one particular product has to be stored under freezing conditions whatever mentioned. So if it is not stored for two days, for example, it has to be stored for minus 4 degree centigrade. During storage and transportation this particular temperature may not be able to maintain, for 1 or 2 days. So if this particular product has the time-temperature indicator or integrator.

So that we show by colour, even for the one-day if it is not stored at particular freezing temperature. It will show it is by colour. So in that way, we can identify whether the particular product is mishandled or not. So these kind of packaging materials we call it as a intelligent packaging. So in the packaging material itself, we will insert the time temperature indicator. So if the particular time temperature combination is not maintained for that particular product. So it will show by its change in colour. So in that way we can easily understand. So that particular product is not stored at particular temperature. So this packaging comes under the category of intelligent packaging. So these are all the recent research developments, active packaging, modified atmosphere technique and intelligent packaging and everything.

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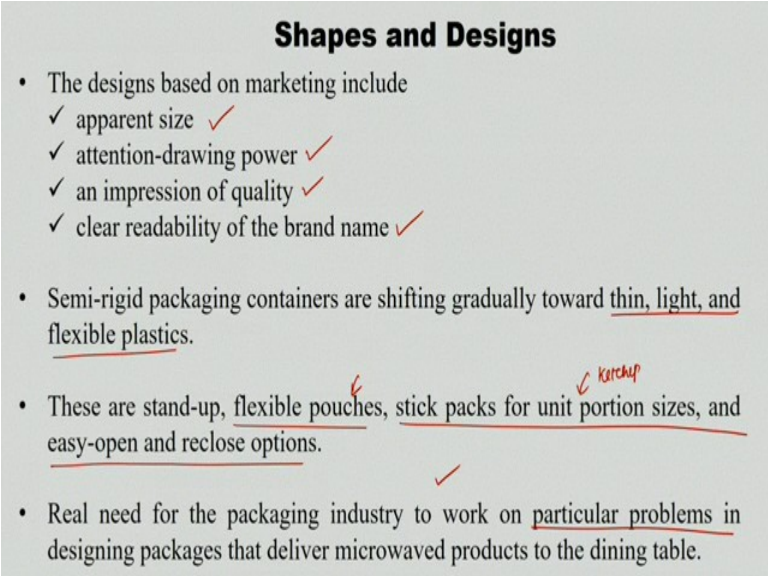


Then the main consideration of the packaging material is shapes and designs. So the designs based on the marketing include apparent size, attention drawing power, an impression of the quality, and clear readability of the brand-name. And semi-grid packaging containers are shifting gradually towards thin, light, as well as flexible plastics. So earlier days, I think in canning operations we have also discussed, so how the packaging is changed from the glass material, then thin material, then we have got aluminium. So everything is based on semi-rigid into thin, light, and flexible plastics.

So these are stand-up, flexible pouches, stick packs for unit portion sizes, and easy open and reclose options. So these thin, light and flexible plastics got a advantage of stick packs for unit portion sizes. So this I told even ketchup and easy open and reclose options. So that we have got such kind of seals. And real need for the packaging industry to work on the particular problems in designing packages that deliver microwaved products for a, to the dining table.

Most of us use microwave to reheat the food. More than cooking the food itself. So in such case, now, now another search trend in the packaging industry is nothing but to work on the problems and to design the packaging for the microwave products. So it can be easily put into the microwave and take it outside and directly put in the dining table, without transferring any containers, microwaveable containers and to the plate nothing. So like how we use the noodles with the just pour the hot water and so from the packaging material itself. So the same way how we can use the food packaging material for microwave products. So that is a another research development in the packaging.

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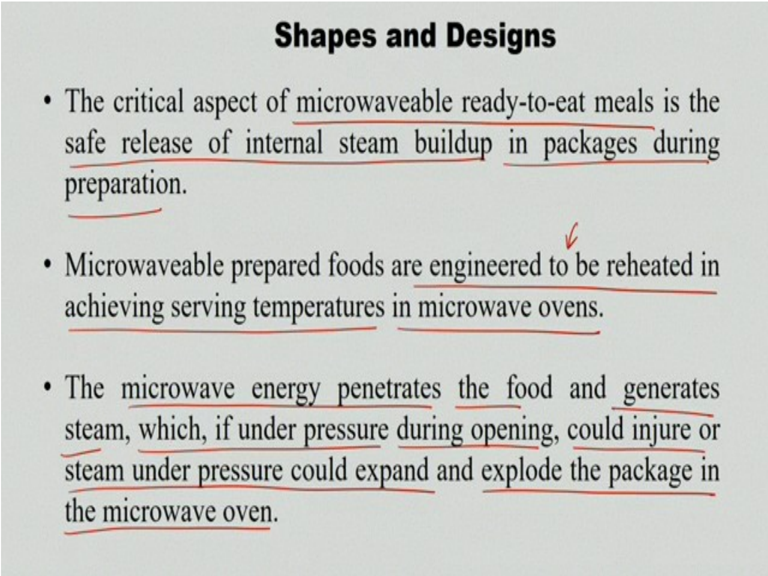


So the critical aspect of microwaveable ready to eat meals is the safe release of internal steam buildup in packages during preparation. So we also know that most of the products contains the water. Most of the food materials and also for the microwave to pass, it has to be a polar molecule. So, in such case, mostly the microwave product should be having the water quantity. So when you will microwave it, so these water gets changes into steam. So then there is a steam buildup inside the packaging material. So microwaveable prepare foods are engineered to be reheated in achieving serving temperatures in microwave ovens. So these microwaveable prepared foods are engineered to be reheated in achieving serving temperature in the microwave ovens. So these we already know, instead of cooking most of the time we use it for reheating.

So the microwave energy penetrates the food and generate the steam, which, if under pressure during opening, could injure or steam under pressure could expand and explode the package in the microwave oven itself. So as we said, so most of the time we use it for reheating. So the water inside the food material gets change into steam upon microwave heating. And the steam buildup happens inside the packaging. So if you open the package with steam buildup, because that is a serving temperature. So that is the main aim, I am heating the food material in the microwave. So when such steam buildup happens inside the packaging material, when we reopen so it can injure us or sometimes if the pressure is so high inside the pouches. Then it may explode or expand as well. So this particular problem to be handle in the food packaging industry during design of microwaveable food packaging materials.

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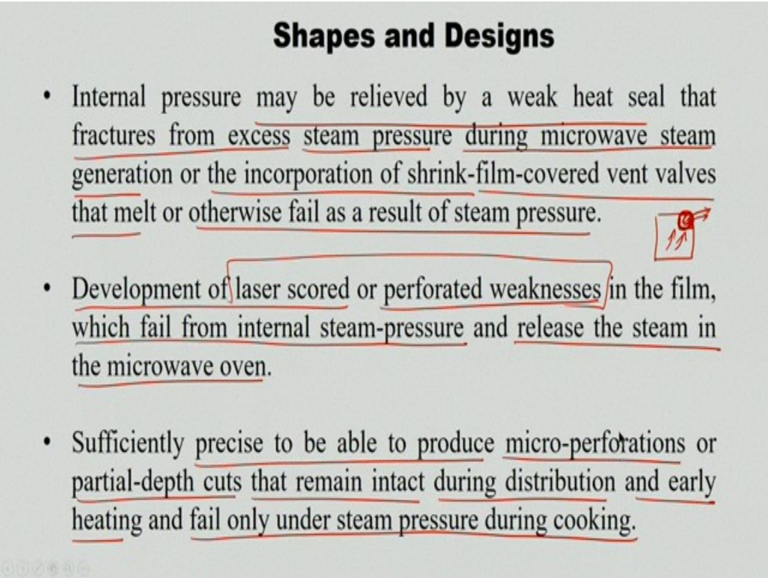


The internal pressure may be relieved by a weak heat seal that fractures from excess teams pressure during microwave steam, steam generation or the incorporation of shrink film covered vent valves that melt or otherwise fail as a result of steam pressure. So in the microwaveable package they will put a one particular vent valve. So, which has the shrinkable, shrinkable package. So when the steam buildup happens inside, so this shrinkable package, this shrinkable film will shrink and it will open and it releases the steam. So that kind of design also tried for the microwaveable food packaging material.

Development of laser scored or perforated weakness in the film, which fail from internal steam pressure and release the steam in the microwave oven. So one problem in this kind of shrink film covered, vent valve or weak heat seals is. So when the steam buildup is happening it releases. So it fails to withstand the steam buildup and it rapture and that is way your steam is escaping. So this is almost equivalent to the blow up of your food packaging material.

But it happens in certain places where we design. But still instead of this kind of either weak heat seal mechanism or shrink film covered vent valves. So there is a latest trend where we create our laser scored or perforated weakness in the film. So through which the steam releases. So, in such case, so there will not be any further re-contamination as well. Because these laser holds will not be that micro level. So that the re-contamination occurs further.

Sufficiently precise to be able to produce micro perforations or partial depth cuts that remain intact during distribution and early heating and fail only under steam pressure during cooking. So it happens only the steam pressure during cooking. But these micro perforations or partial depth cuts that remain intact during distribution. For example, whatever we have designed as a weak heat seal mechanism or shrink film covered vent valves. So during distribution also, there may be our chances, if there is a force applied on that particular places. There may be rapture can occur, so at that particular place. But this kind of laser perforations that problem is not that. And also compared to this weak heat seal or shrink film covered vent valves. So your laser perforation will have less possible reconsideration.

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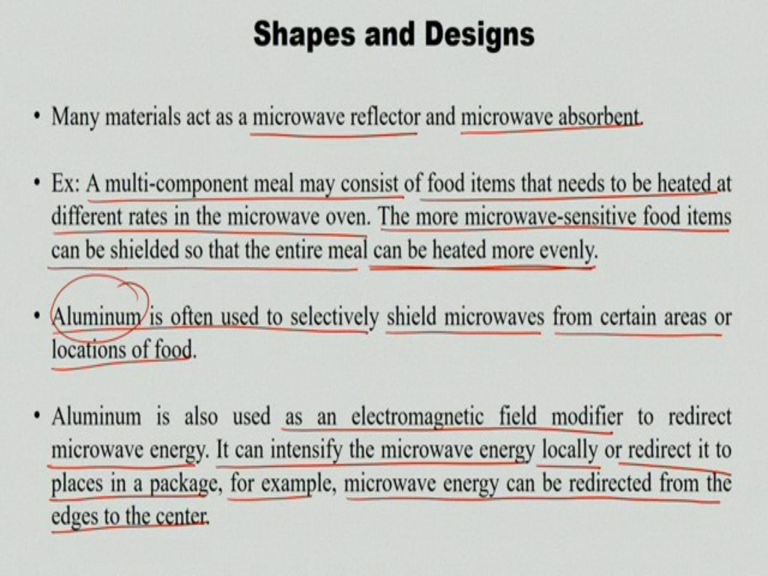


And many materials act as a microwave reflector and microwave absorbent. So a multicomponent meal may consist of food items that needs to be heated at different rates in the microwave. So sometimes the food material contains multicomponent, so each has to be heated at different rates. For example if you have a vitamins or sometimes you can have a material with nuts. So solid as well as liquid material, solid has to be heated at different rate than the liquid. So in such cases we need to take care of these micro sensitive food items. So they can be shielded using a particular shielding material. So that is what it is given.

A multicomponent mail may consist of food items that needs to be heated at different rates in the microwave. The more microwave sensitive food items can be shielded, so that the entire meal can be heated more evenly. So one has to heated for almost 5 minutes and another has to be heated for 1 minute in the multicomponent meal. So after 1 minute, so these food items can be shielded in the mean. So that every component gets heated at the proper rate. So aluminium is often use as a selectively shield microwaves from certain areas or locations of the food. So this also we have discuss about, the metals mostly act as a waveguide. So they can, they have this property of selectively shield microwaves from certain areas or locations of the food.

Aluminium is also used as an electromagnetic field modifier. This is where we told as a waveguide and to redirect the microwave energy. It can intensify the microwave energy locally or redirect it to the places in package, for example, microwave energy can be directed from the edges to the centre. So instead of having it in the edges, so it can redirect the microwave energy into the centre. So this we have discussed in the microwave heating itself, many metals can be used as a waveguide, for the microwave heating.

So here in this particular slide, what we are discussing is some microwave reflector as well as absorbent. So reflector is nothing but a it reflects the microwave into certain parts of the food material. So if my food material has multicomponent meal and each one of them has to be heated at different rates. Then I can use the selective shielding packaging material to make sure that certain areas or locations of the food is not heated at the same rate, where other locations of the food materials are heated. So once such shielding material is aluminium.

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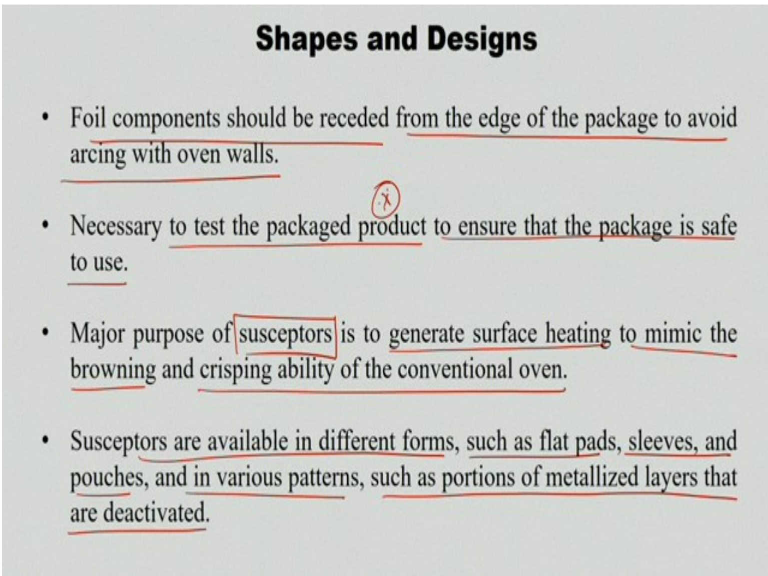


And foil components should be receded from the edge of the packaging to avoid arcing with the oven walls, so microwave oven walls. So this arcing is nothing but due to electromagnetic waves there may be a shock. So the electric arc can be produce. So this foil components, should be receded from the edge of the packaging to avoid arcing with the oven walls. Necessary to test the packaged product to ensure that the package is safe to use. So those is common for all the packaging. And the major purpose of the susceptors, there is something called susceptors. So they are used to generate surface heating to mimic the browning or crisping ability of the conventional oven.

So the susceptors are the microwave observants, like microwave reflector or the metals. So one such example, we have seen is aluminium. So these susceptor materials are to generate surface heating to mimic the browning or crisping ability, what we get in conventional oven. So they are available in the different forms, so such as flat pads, sleeves, and pouches in various patterns, such as portions of the metallized layers that are deactivated. So what we can do here is so based on the where you wanted to create such a kind of surface heating. So there we can use really as a susceptors and in other portions or other locations of the food material, it can be deactivated. So that, that particular portion or the location of the food is not heated further.

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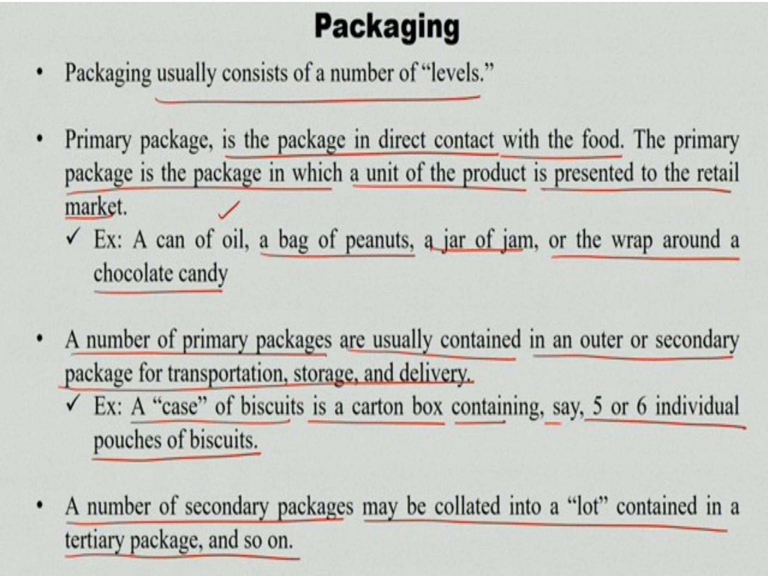


Then sometimes the packaging can be of many levels. So one is primary packaging, is the package in direct contact with the food material. The primary package is the package in which a unit of the product is presented to the retail market. So a can of oil, so your food is directly in contact with the can, and a bag of peanuts, so peanuts bags and a jar of jam, and wrap around a chocolate candy. So where in all the examples, so your food product is directly in contact with the packaging material.

A number of primary packages are usually contained in an outer or secondary package for transportation, storage, and delivery. So we might have seen some biscuit packet. So in case of a biscuits in a cotton box containing say, 5 or 6 individual pouches of biscuits. So one secondary packaging will be the, so inside we have 5, 6 small packages. So those were primary packages, they are directly in contact to the food. So these 5 or 6 small, small pouches can be put together in the carton box. So this carton box is called secondary packages. A number of secondary packages may be collated into lot contained in a tertiary package, so this goes on. So based on that, but primary is nothing but with the one which is in direct contact the food.

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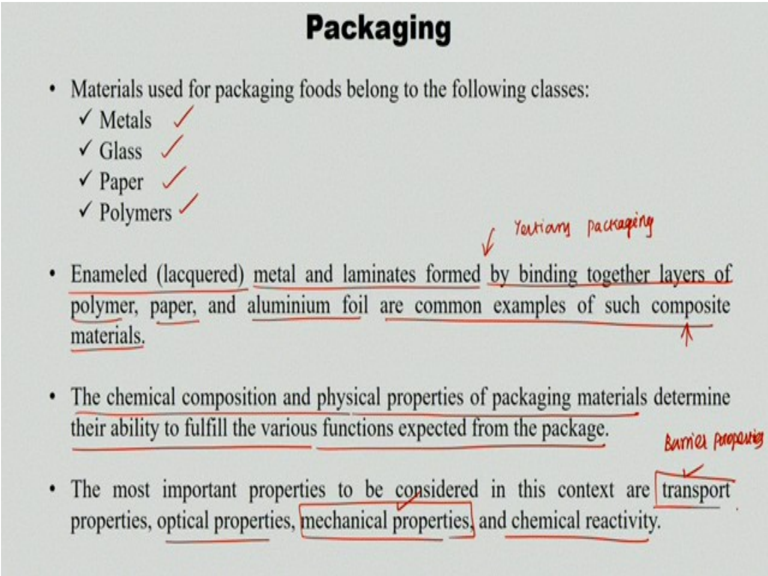


So materials used for packaging foods belong to the any one of the category, that may be a metals, glass, paper, and polymers. And sometimes what happens this is where that composite film came into existence. So sometimes to modify certain properties of the packaging material, these can be combined as well. So the enameled or lacquered metal or laminates formed by binding together layers of polymer, paper, aluminium foil. So this we have seen as a tertiary packaging, tertiary packaging. So sometimes the enameled metal and the laminates formed by the binding together layers of polymer, paper, and aluminium foil are common examples of such composite materials. So this is where the composite materials came into existence.

So the chemical composition and physical properties of the packaging materials determine their ability to fulfil the various functions expected from the packaging. So whether it is our mechanical property or optical property or their chemical inertness, or the barrier properties. So everything decided by the chemical composition and physical properties of the packaging material. The most important properties to be considered in this context is transport properties, we call it as a, barrier properties, barrier properties. So other than that optical is there, mechanical is there, chemical reactivity is there. So what we are going to see todays in the case of mechanical and transport properties only.

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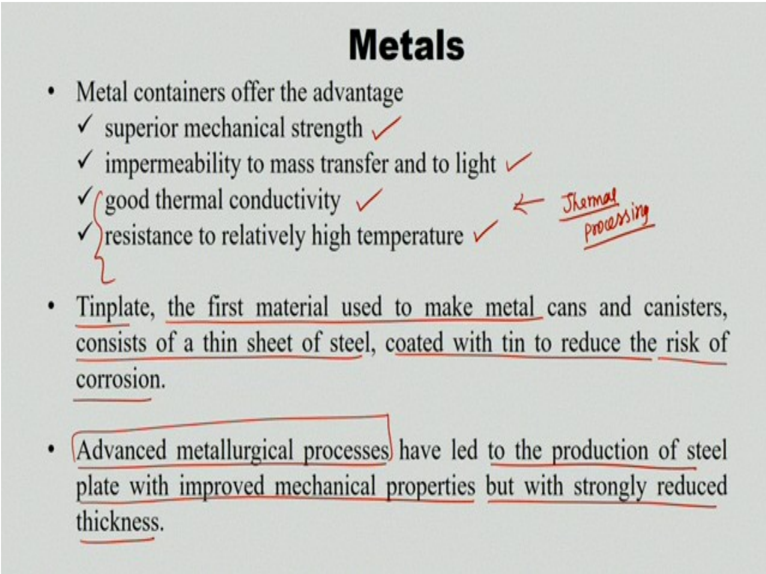


And first one is the metals. So they got certain advantages, so they are having superior mechanical strength, impermeability to mass transfer as well as light, optical properties, as well as the barrier property and good thermal conductivity and resistance to relatively high temperature. So this takes care of whatever we the aim of the course, so thermal processing. So that is where the metals are a best food packaging materials for thermal processing or food. So they have got good thermal conductivity and resistance to relatively high temperature.

The tinplate, it was the 1st material used to make a metal cans, this I have discussed in the canning operations itself. And consist of a thin sheet of steel, coated with tin to reduce the risk of corrosion. So they are a thin sheet of steel, so about which the tin is coated and to avoid the corrosion process. Advanced metallurgical processes have led to the production of steel plate with improved mechanical properties, but with strongly reduced thickness. So now we are able to use very thin sheets . Because the amount of coating, the thickness of the coating what we do it on the steel as well as the thickness of the sheet also got its own effects in the food packaging material. So with the advanced metallurgical process, we are able to produce the steel plate with improved mechanical properties with it strongly reduced thicknesses.

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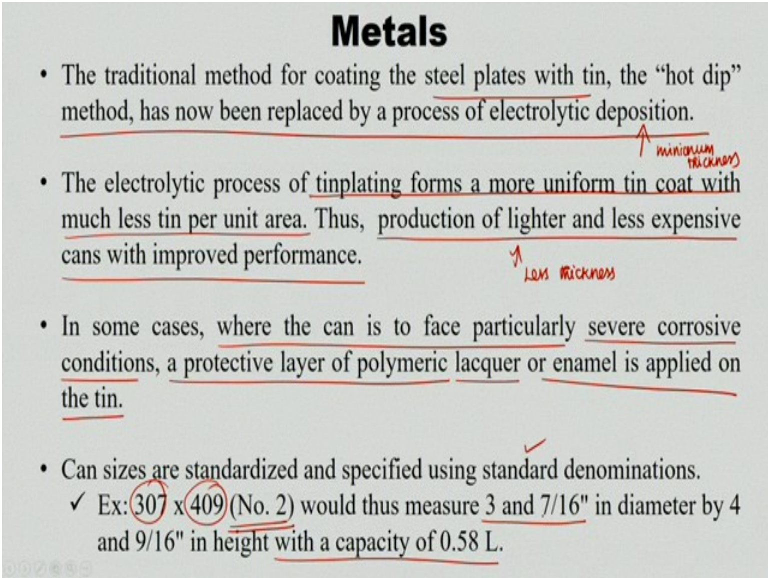


The traditional methods for quoting the steel plates with tin is a hot dip method. So now has been replaced by the process of electrolytic deposition. So with this electrolytic deposition we can go up to minimum thickness. Which we could not achieve using a hot dip method. So the electrolytic process of tinplating forms a more uniform tin coat with much less tin per unit area. So that is what we could achieve minimum thickness whatever we aimed for, production of lighter as well as less expensive cans with improved performance. So lighter can, so due to less thickness and because we are using less tin material per unit area, the cost also reduced.

In some cases, where the can is to face the particularly severe corrosive conditions. So even though we coated with tin but still the corrosive property or the corrosion conditions are not achieved to the minimum level, whatever we wanted. A protective layer of polymeric lacquer or enamel is applied on the tin. So more than above the tin, there is a protective layer of polymeric enamel as well, is applied, so to reduce the corrosion further more. So can sizes are standardized and specified using standard dimensions. So this also we have discussed in the canning operations. So 3 naught 7 into 4 naught 9 can, so we call it as a number 2 can, would thus measure 3 and 7 upon 16 inch in diameter by 4 and 9 upon 16 inch in height with the capacity of 0.58 L. So if we say number 2 can this is the standard dimension.

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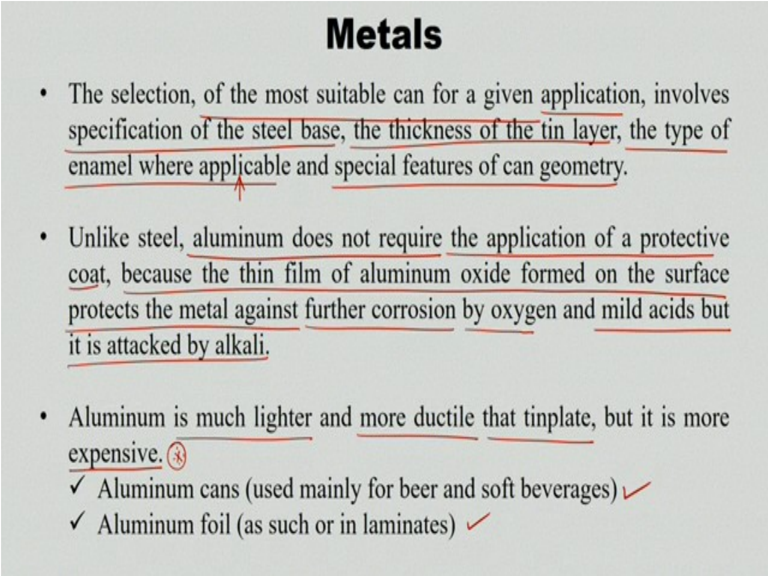


The selection, of the most suitable can for a given application, involves specification of the steel base, the thickness of the tin layer, and the type of enamel where applicable. So if you need better corrosion properties, so this enamel is also applied and special features of the can geometry. So the selection of any suitable metal cans, so based on these properties, one is specification of the steel base and the thickness of the tin layer. So if enamel has to be applied for more or better corrosion properties. So that type of enamel as well as the special features of the can geometry. So then after that initially the steel with tin coated or enamel coated were used as a metal food packaging material. Then after that aluminium got into the metal food packaging industry.

The aluminium does not require the application of the protective coat, because thin film of aluminium oxide formed on the surface protects the metal against further corrosion by oxygen. So that means, so when the aluminium is interacting with the oxygen it forms the aluminium oxide film. So that acts as a protective layer against the further corrosion. But these aluminium is and mild acids, but it is attacked by the alkali. So these aluminium oxide protective layer can protect the aluminium metal food packaging material by oxygen and mild acids, but alkali seems to be attacking this aluminium food packaging material. So this is much lighter element and more ductile than that of tinplate, but it is more expensive. So that is another disadvantage of using aluminium. So aluminium cans are used mainly for beer and soft beverages. Aluminium foils are used as a laminates.

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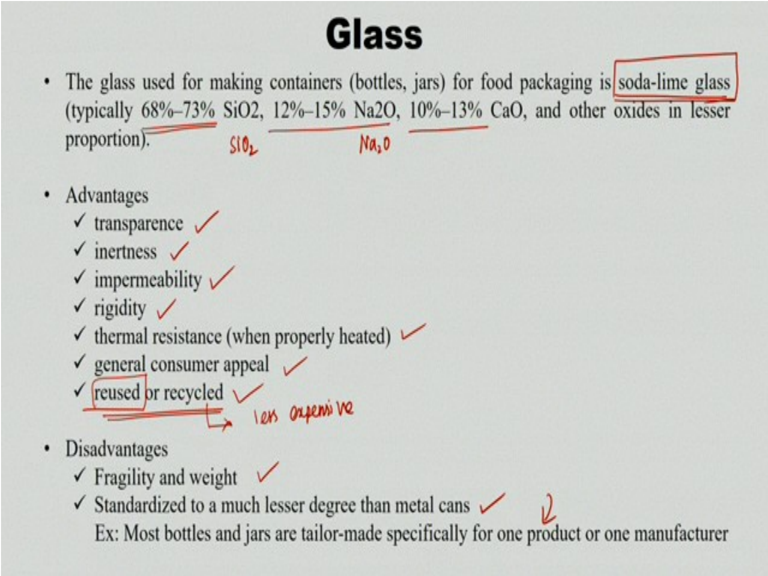


The next one is glass, so in the food packaging industrial mostly used are soda lime glass. So, which typically got 68 to 73 percent a silicon oxide and 12 to 15 percentage Na2O sodium oxide, so this is silicon dioxide and 10 to 13 percentage of CaO calcium oxide and other oxides in lesser proportion. So the glass is used are soda lime glass. Advantages, transparency, inertness, impermeability, rigidity, thermal resistance when properly heated, and general consumer appeal, and reused or recycled. So here bit need to be careful because the reusing may recontaminate. But recycling seems to be a less expensive process, because it will be melted again moulded into particular shape. And disadvantage is fragility and weight because it is not a lightweight material. And standardized to a much lesser degree than metal cans. So most bottles and jars are tailor made specifically for one product or one manufacturer. So it is not like generalised dimensions. So based on product or the manufacturer, so it is a tailor made.

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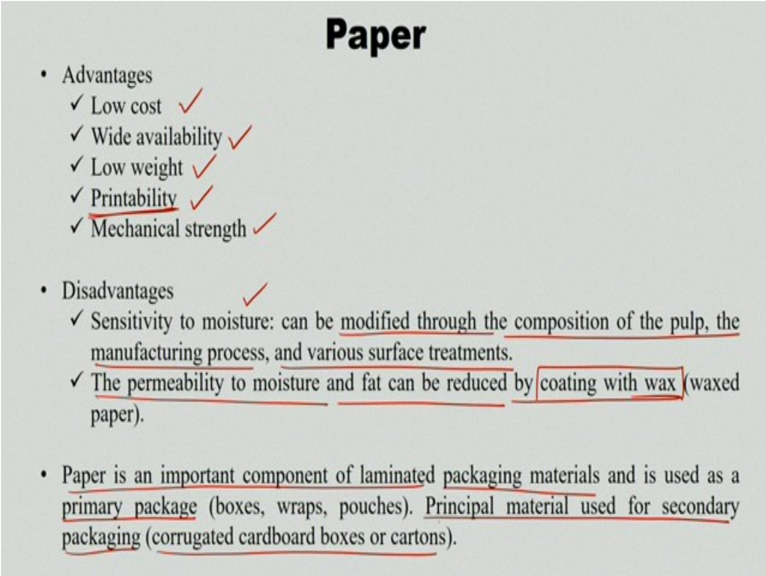


The next one is paper, advantages are low-cost, wide availability, low weight, printability, mechanical strength, etcetera. So this also I told, so one of the major functions to be considered when we use the food packaging material. And disadvantages wise sensitivity to moisture; can be modified. But this also cannot be considered as a directly disadvantages, because this disadvantages can be modified through the composition of the pulp, and the manufacturing process, and various surface treatments.

So these are maybe instead of high moisture sensitivity. If we take care of the composition of the pulp as well as the manufacturing processes and various surface treatments, so it will be possible to have less moisture sensitive paper packaging material. The permeability to moisture and fat can be reduced by coating with wax. So these are all called waxed paper food packaging materials. So there is a coating with the wax, so it takes care of the permeability of moisture or fat into the packaging material. Paper is an important components of the laminated packaging materials and is used as a primary package boxes, wraps, and pouches. Principal material used for secondary packaging corrugated cardboard boxes and cartons. So it can be used for direct food contact as well and also it can be a primary material in secondary packaging as well.

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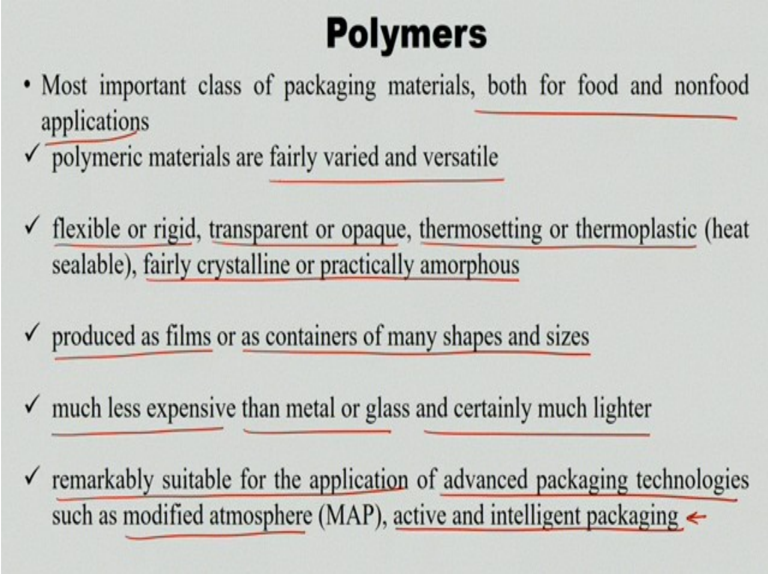


So the most important and the growing food packaging industry uses the polymer as a food packaging material. Most important class of packaging materials, both for food as well as non-food applications. So polymeric materials are fairly varied and versatile. And they can be made flexible or rigid, transparent or opaque, and thermosetting or thermoplastic and fairly crystalline or practically amorphous. So we can have variety is as well as these are versatile packaging material.

And produced as films or as containers of many shapes and sizes, so there also we have got variety. And much less expensive than the metal or glass and certainly much lighter than other packaging material. Remarkably suitable for the application of advanced packaging technologies, one is modified atmosphere, active and intelligent packing. So this I told recent developments. So this is the APT material for it to be used as a advanced packaging technologies, whether it is a MAP or modified atmosphere packaging or active packaging or intelligent packaging.

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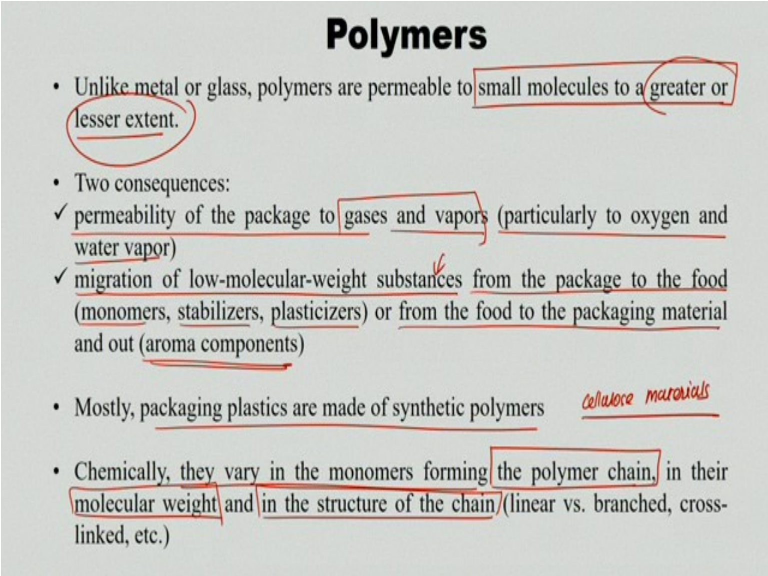


So unlike metal or glass, polymer permeable to small molecules to greater or lesser extent. So this also can be varied because the intelligent packaging or active packaging has that only. Intelligent packaging have the sensor property in it, but active as well as modified packaging, the aim is to control the rate of any material diffusion or the permeability, so for that, this is the APT packaging material. The two consequences are permeability of the package to gases and vapors, particularly to oxygen and water vapor. The another thing is migration of low molecular weight substances from the package to the food or from the food to the packaging material. So the two consequences, because we told that metal or glass are impermeable. But polymers has got a permeability property. Unlike metal or glass polymers are permeable to small molecules to a greater or lesser extent.

So that means the rate can be varied in the polymeric materials. So, which rate? The small molecules penetration rate or permeability rate can be varied in the polymer material. So the consequences is, the permit ability of the packaged to gases or vapors. So the gases and vapors, mostly water vapor and oxygen. And migration of low molecular weight substances from the packaging to the food. So this is also important because the polymers what we use as a package material, if it gets direct contact with the food material. So sometimes there may be a possibility for migration of low molecular weight substances from the packaging to the food. So examples are monomers or stabilizers or plasticizers, plasticisers we use it to have the flexible, flexibility for elongation purpose. So there may be a chance for this substances to permeate from the packaging material to the food. And the vice a versa also happens, sometimes from the food to the packaging material. So those were aroma components.

And mostly, packaging plastics are made of synthetic polymers and there are natural polymers is also. So those were cellulosic, cellulose material based, so those were natural polymers. But most of the packaging plastics are made from synthetic polymers. Chemically, they vary in monomers forming the polymer chain, in their molecular weight and in the structure of the chain. Whether it is linear or branched, or cross-linked, etcetera. So they mainly classified based on the polymeric chain and also the molecular weight of the material and structure of the chain, whether it is a linear or branched or cross-linked.

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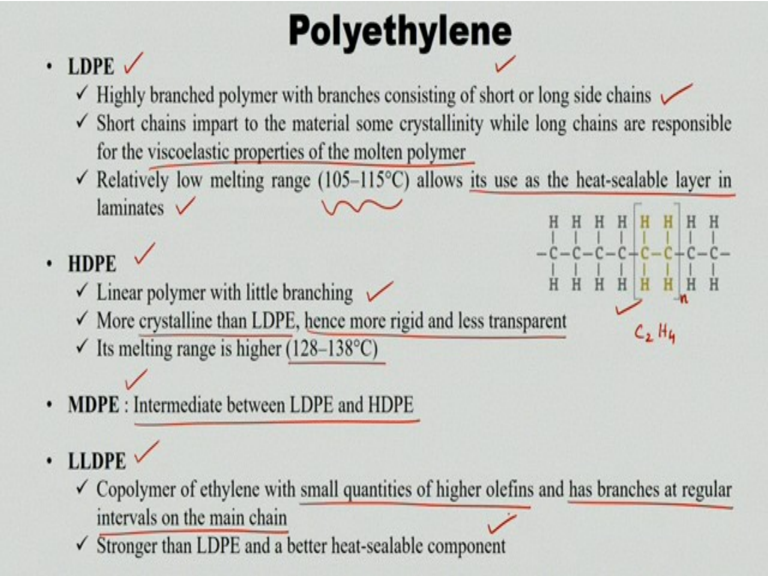


So the most important polymer which are used as a packaging material is polyethylene. So this you already aware of LDPE, HDPE, MDPE and LLDPE. So this is nothing but low-density polyethylene. So the polyethylene has got this particular molecular structure, so it is nothing but C2H4. So this is arranged in that N number of units. So they are highly branched polymers with the branches consisting of short or long side chains. And short chains impart to the material, some crystallinity while long chains are responsible for the viscoelastic properties of the molten polymer. And they have got really low melting range 105 to 115 degree centigrade, which allows it is used as the heat sealable layer in the laminates. So this we have discussed few slides earlier, so the heat sealable layer.

And HDPE is nothing but high-density polyethylene materials, so they are linear polymer with little branching and more crystalline than LDPE, low-density because the high-density is due to the crystalline nature of the polymer. And hence more rigid and less transparent. HDPE you cannot see, so they got a property of less transparent. And it is melting ranges nothing but 128 to 138 degree. So by increasing its linear chain, then the branching, so we can make low-density to high-density polyethylene. So medium density polyethylene, are in between the LDPE and HDPE. And LLDPE is nothing but a linear LDPE. So that means the co-polymer of ethylene with a small quantities of higher olefins and has a branches at regular intervals in the main chain. It is not like total branches, so it has a branches at regular intervals in the main chain. So these are stronger than LDPE and are better heat sealable component.

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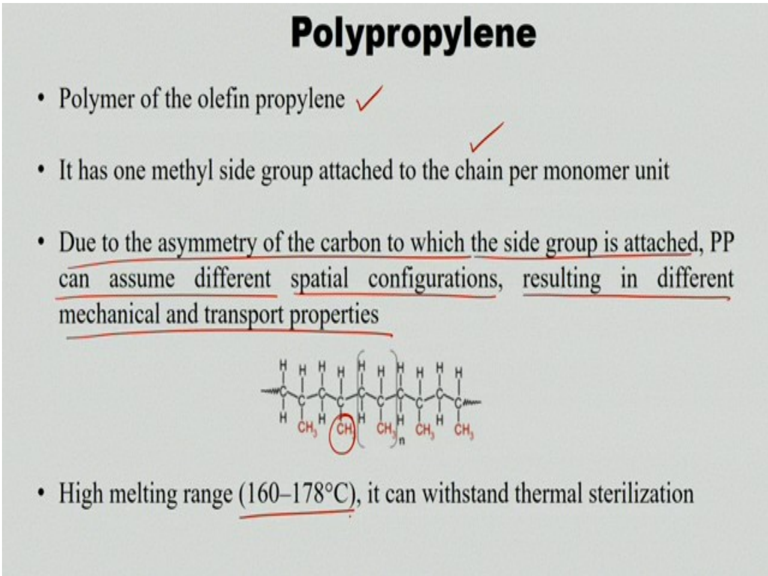


The next one is polypropylene, so they have got methyl group in their branch chain. Polymer of the olefin propylene and it has got one methyl side chain group attached to the chain per monomer unit. Due to the asymmetry of the carbon to which the side group is attached. The polypropylene can assume difference spatial conflagrations, resulting in different mechanical and transport properties. So because of this methyl group, so it gives the asymmetric nature to the carbon. So because of which we can get different spatial configurations. And due to which we can also get different mechanical and transport properties. So they got high melting range 160 to 178 degree centigrade, it can also withstand thermal sterilization.

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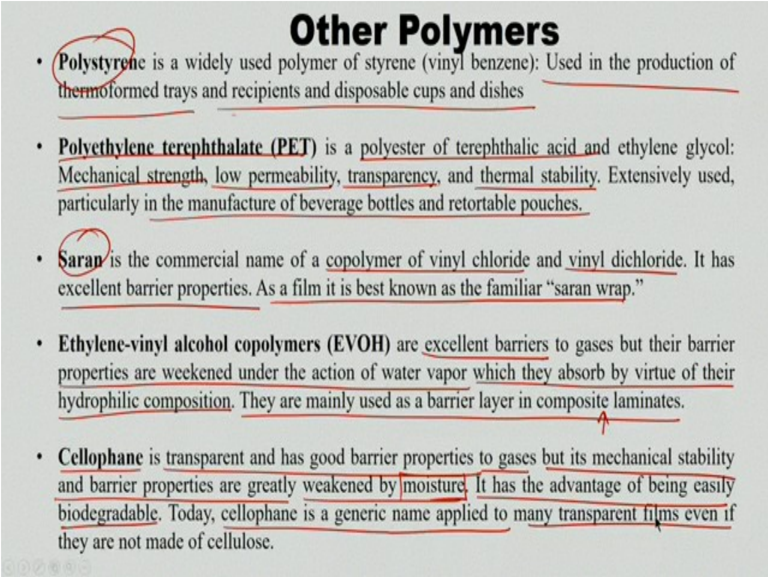


So other polymers are polystyrene. So they can be used in the production of thermoformed trays and recipients and disposable cups and dishes. And PET jars so this we are very much known polyester of terephthalic acid and ethylene glycol; so they have got mechanical strength, low probability, transparency, and thermal stability. And extensively used, or particularly in the manufacture of beverage bottles and retortable pouches. And saran, so this is the commercial name of copolymer of vinyl chloride and vinyl dichloride. So it has got excellent barrier properties. So as a film it is known as the familiar saran wrap. And ethylene vinyl alcohol copolymers, so we call it as EVOH, so they also got excellent barriers to gases, but their barrier properties are weakened under the action of water vapor is the absorbed by virtue of their hydrophilic composition.

So this EVOH are excellent barriers to gases, but they have got this hydrophilic composition because of which they have got excellent permeability to water vapor. They are mainly used as a barrier layer in composite laminates, composite laminates. So they can be used for excellent barriers for gases and their affinity towards a water vapor can be reduced by designing proper composite laminates along with EVOH. And cellophane as I told earlier, so they are made from the cellulosic materials. So they are transparent and has got good barrier properties to gases, but it is mechanical stability and barrier properties are greatly weakened by the moisture. So that we know, cellulose did not get good barrier against the moisture. It has the advantage of being easily biodegradable. So this is another advantage. And cellophane is generic name apply to many transparent films, even if they are not made up of cellulose.

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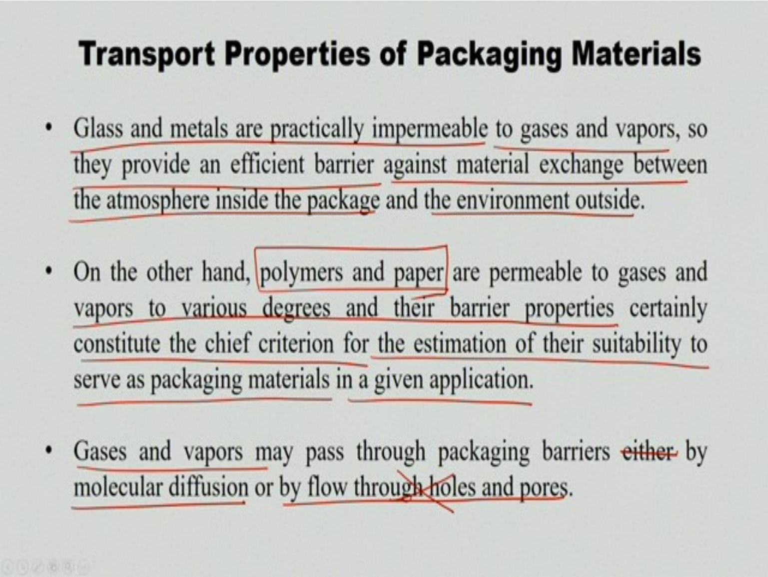


So the transport properties wise glass and metals are particularly impermeable to gases and vapors, so they can provide an efficient barrier against the material exchange between atmosphere inside the package and the environment. So we have already told the classes and metals are impermeable to gases and vapors. And so they can provide efficient barrier against the material exchange between the food inside the package and as well as the outside environment.

But polymers and paper are permeable to gases and vapors to various degrees and their barrier properties certainly constitute a chief criterion from the estimation of their suitability to serve as packaging materials in the given application. So based on the food material which is packed inside the packaging material. So the rate of the permeation of gases as well as the water vapor can be varied for these packaging material, which are nothing but a polymers and papers.

So gases and vapors may pass through packaging barriers either by molecular diffusion or by flow through holes and pores. But this we are not going to discuss because that is not of our interest because if we have holes and pores, so that may act as a re-contamination. So what we are discussing about here as a transport properties are gases and vapors may pass to the packaging barriers by molecular diffusions. So we are not going to discuss anything about the flow-through holes or pores.

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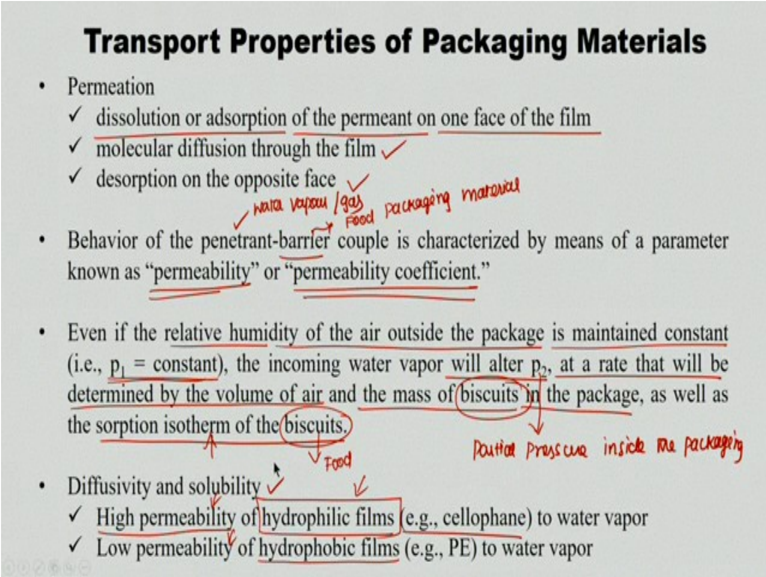


So the permeation has got three levels, one is the dissolution or adsorption of the permeant on one face of the film. So it has got the three components the dissolution or adsorption of the permeant on one face of the film. Then molecule diffusion through the film and desorption on the opposite face. So the behavior of the many penetrant-barrier couple is characterized by means of a parameter called permeability or we call it as a permeability coefficient. So penetrant is nothing but a water vapor or gas. So the barrier is nothing but your food packaging material, food packaging material. So the behavior of the penetrant barrier couple is characterized by means of a parameter known as permeability or permeability coefficient.

And one thing we should remember here is the relative humidity of the air outside the package is maintained at constant pressure. So even then the incoming water vapor will alter the P2, P2 is nothing but a pressure inside the packaging that is partial pressure inside the packaging, partial pressure inside the packaging. So what it is told, even if the relative humidity of the air outside the package is maintained constant. So that means the partial pressure outside the packaging is maintained constant. The incoming water vapor will alter P2, which is nothing but a partial pressure inside the packaging.

At a rate that will be determined by the volume of the air, which is coming inside and the mass of biscuits in the package. So this is nothing but a food product, the mass of the biscuit is in the package, as well as the sorption isotherm of the biscuits. So that is nothing but a food material. So this is told as an example. So whatever we are going to derive font a permeability or permeability coefficient is under steady-state. But in normal practical situation. So, even though we maintain the constant relative humidity outside of the packaging by maintaining the partial pressure as constant. The incoming water vapor will alter the partial pressure inside the packaging as well as the rate at which volume of the air is coming inside as well as the mass of the foods in the packaging, as well as the sorption isotherms, sorption isotherm in the sense the rate at which it acquires the moisture. So that also important.

The diffusivity and solubility are the 2 main properties which has to be considered, while considering the transport properties. We always talked about the permeability, permeability, but it has got 2 components, one is diffusivity and solubility. So this is got two consequences of high permeability of hydrophilic films, so the example is nothing but a cellophane. So high permeability, so they have got high permeability to gases of hydrophilic films. So that means they have also got high moisture content because hydrophilic. So example is cellophane to water vapor. And low permeability of hydrophobic films to water vapor, low permeability in the sense, so they have got low permeability, but they are the hydrophobic films. So example is polyethylene. So these 2 categories are determined by the properties of diffusivity as well as solubility.

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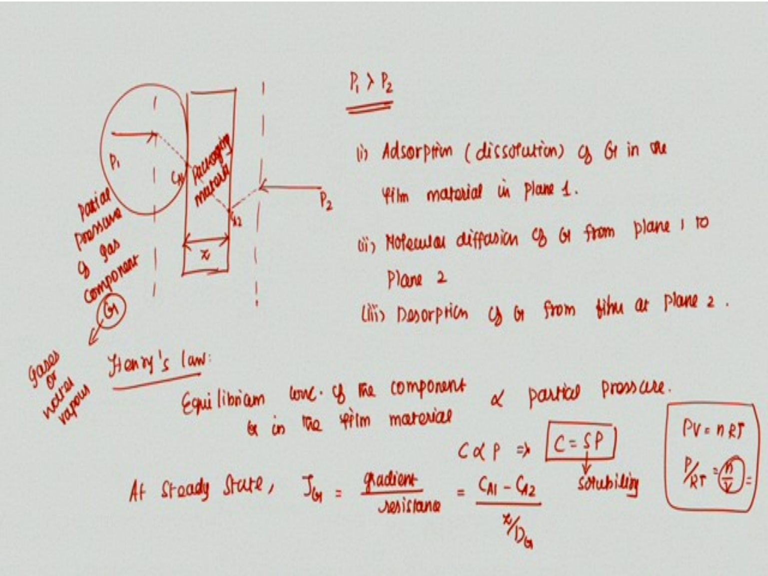

So if we see the model, so this is my packaging material. So this is the film near the packaging material. So here we have got P1 which is nothing but a partial pressure of, partial pressure of gas component G. So from here, this is a bulk. So it has got into the CA1, so then it further reduce to CA2, so this is nothing but P2. So this is other side of the film. So this is packaging film, so this is partial pressure of the gas component G. So here it is a concentration CA1 and this is CA2, so this is a packaging material. So we consider the case of P1 is greater than P2. So this has got 3 components we said, one is adsorption or dissolution of G in the film material in plane 1. So this particular portion. Then the second one is diffusion and molecular diffusion of G from plane 1 to plane 2. So then the third component is desorption, so that is where the concentration here is increased. So the desorption of G from film at plane 2.

So we might of studied Henry’s law. So what Henry’s law says? Equilibrium concentration of the component G in the film material is proportional to its partial pressure. So the G here represents the gases as well as water vapor, gases or. So this is a concentration is proportional to the partial pressure. So the proportionality constant we can say it as a solubility. So S here is nothing but a solubility. So you can make the concentration by using a ideal gas law. So this I can take it as one example. So, P is equal, P by RT is nothing but N by V. So this is number of moles upon volume, so this has got the molar density unit.

So, which is nothing but a concentration. So from using the EOS, equation of state, you can calculate the concentration from the pressure given. So the C equal to S into P, so S into P. Where S is a solubility, P is a partial pressure, C is a concentration. So from Henry’s law, so in earlier classes, we have told at steady-state. So any flux, so I can any flux, so here I will put JG, so the component flux. So that can be written as the gradient upon resistance. So what is a gradient here? So this is CA1 minus CA2 so that is nothing but my gradient. So resistance is nothing but Z upon diffusivity of the G. So Z is nothing but a thickness of this packaging material in the direction of transfer.

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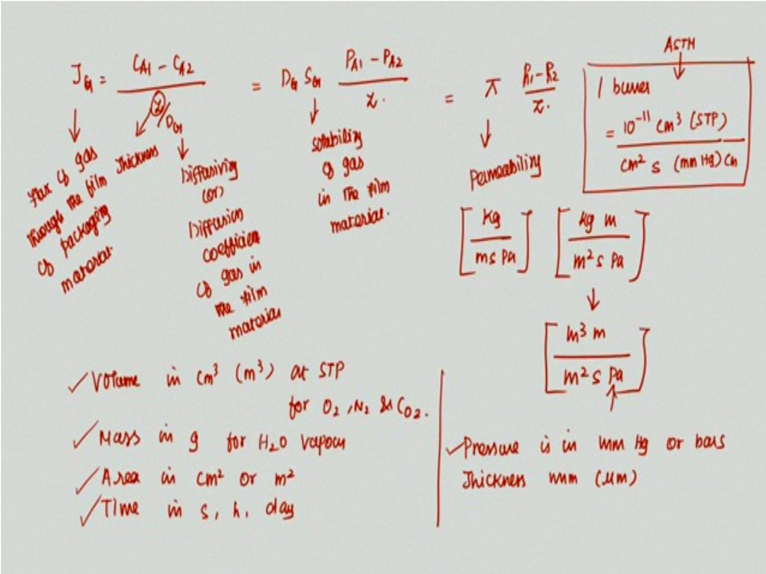


So what we got, so JG is nothing but CA1 minus CA2 upon Z upon DG. So what Z? Z is nothing but a thickness and DG is nothing but diffusivity, or we can call it as a diffusion coefficient. So now I am going to write C in terms of solubility as well as, so this can be taken above. So the C I can write it in terms of solubility into partial pressure. So PA1 minus PA2 upon Z. So this we call it as a solubility, solubility of gas in the film material, diffusion coefficient of gas in the film material. What is JG? So this is nothing but flux of gas through the film of packaging material. So if we want to combine so we can combine as pi into P1 minus P2 upon Z. So this we call it as a pi, which is nothing but a permeability.

So this has got a unit of Kg per metre second Pascal. So not only this unit, it has also if you want to define in terms of mass then it has got Kg metre square second Pascal. So if we defines in terms of volume, so this is got a unit of metre cube per metre, so metre square second Pascal. So based on which unit we takes, so it also varies. So, for example here the pressure unit is taken as a Pascal and for example volume, if you take so that is in centimeters cube or metre cube at STP, standard temperature and pressure conditions.

So for O2, N2 and CO2. So if we are considering water vapor, so we consider mass and in grams for water vapor, for water vapor. So area is considered in centimeters square or metre square, time is considered in seconds or hours or day. So pressure is considered in mm HG or bars and thickness, mostly we will not get, thickness will be of an millimeter or micrometer, there will not be any metre this thing. And as per the ASTM standard so the permeability is defined as a 1 bearer. So 1 bearer has got 10 to the power of minus 11 centimeter cube STP upon CM square second MMHG into CM.

So this is the ASTM standard of a 1 bearer. So this permeability based on which unit you take for volume, mass, area, time, so it depends. So here we calculated the flux which is nothing but JG is equivalent to pi into PA1, which is nothing but partial pressure of the gas at plane 1 and PA2, which is nothing but a partial pressure of the gas in the plane 2 and divided by Z. Z is nothing but a thickness and pi got permeability. So that is based on many units. So this is all about the how we calculate the transport properties. So here we use the Henry's law for a simple model that is all. But here, this is what I told, we calculate the flux at steady-state. So most of the time in the practical situation. So it depends upon the rate at which the volume of the air is getting inside and mass of the food material in the package and the sorption isotherm of the food materials okay.

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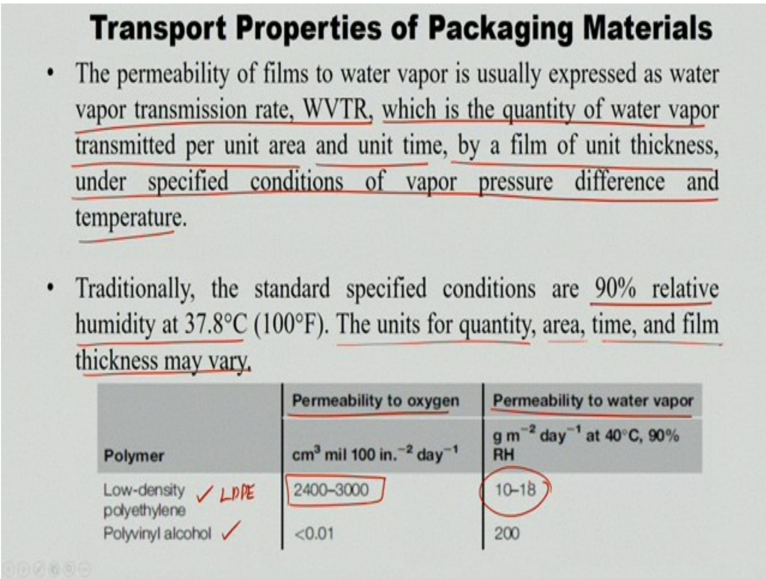


So normally the permeability of films to water vapor is usually expressed as water vapor transmission rate, which is nothing but WVTR, which is the quantity of water vapor transmitted per unit area and unit time, by a film of unit thickness, under specified conditions of vapor pressure difference and temperature. So under specified conditions of vapor pressure difference and temperature. So how much quantity of water vapor transmitted per unit area, per unit time is nothing but a water vapor transmission rate by which the permeability of films against the water vapor is defined.

So traditionally, the standard specific conditions are taken as a 90 percentage relative humidity, 90 or H at 37.8 degree centigrade. The units of quantity, area, time, and the film thickness may vary. So as we told earlier, so volume can be represented in centimeter cube, metre cube and your time will be expressed in seconds, hour, etcetera. So here for the reference there are two, permeability to oxygen and permeability to water vapor is given for low-density polyethylene LDPE as well as PVA polyvinyl alcohol.

So permeability to oxygen that LDPE got permeability to oxygen of around 2400 to 3000 centimeter cube MIL 100 per inch square day power minus 1. But at the same time, it has got permeability to water vapor as a 10 to 18 gram per metre square per day at 40 degree centigrade and 90 percentage relative humidity. So that means it has got good permeability to water vapor, but not against the oxygen.

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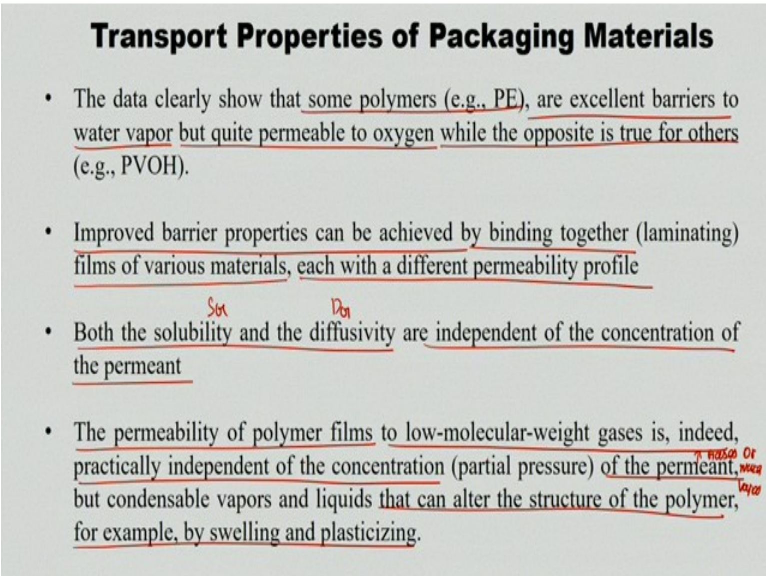


So the data clearly shows that some polymers example polyethylene, are excellent barriers to water vapor, but quite permeable to oxygen while opposite is true for others. So other one is what we have seen here is PVOH. So that is nothing but an exactly opposite, so it has got less permeability towards oxygen. But it is permeable to water vapor. So in that case, these 2 properties can be combined together, one has got excellent permeability properties against oxygen, other has got excellent permeability properties against the water vapor. So this can be combined and formed as a composite material. So that is what is all about our next lecture.

So the improved barrier properties can be achieved by binding together or laminating together films of various materials, each with a different probability profile. So both the solubility and diffusivity are independent of the concentration of the permeant, most of the time because this is SG and this is DG. So this together, we call it as a permeability.

The permeability of polymer films to low molecular weight gases is, indeed, a particularly independent of the concentration. So, which is nothing but a partial pressure of the permeant, permeant is nothing but gases or water vapor. But condensable vapors and liquids that can alter the structure of the polymer, for example, by swelling and plasticizing. So what we told the both celebrity as well as the diffusivity are independent of the concentration of the permeant. So concentration of the gases or water vapor, but sometimes what happens in case of condensable vapors and liquids they can alter the structure of the polymer, for example, by swelling it or by plasticizing it.

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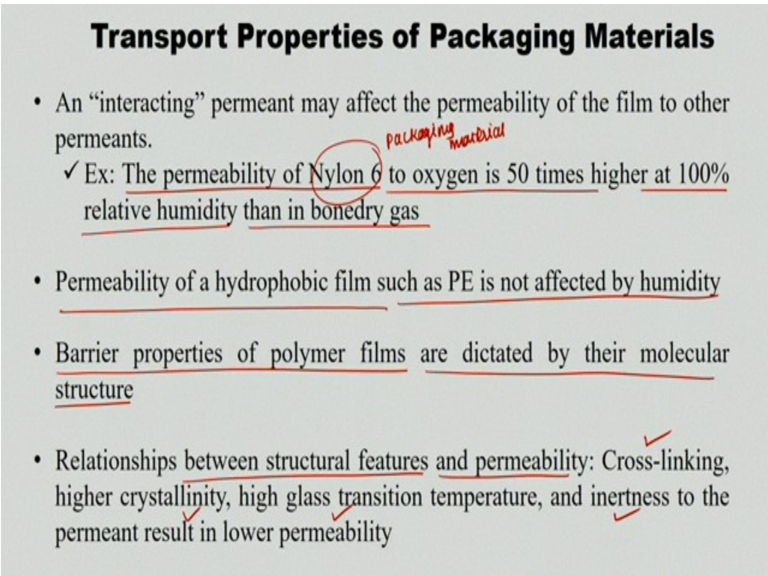


So interactive permeant may affect the probability of the film to other permeants. For example, the permeability of nylon 6 to oxygen is 50 times higher at 100 percentage relative humidity than in the bonedry gas. So if nylon 6 to oxygen, nylon 6 here is nothing but a packaging material, packaging material. So this packaging material to oxygen is 50 times higher at 100 percentage relative humidity than in bonedry gas. So that means if oxygen is bonedry gas, so it has got very less permeable. But if it is 100 percentage relative humidity the permeability of nylon 6 to oxygen is nothing but 50 times higher than that. So that means, so the interactive permeant may affect the permeability of the film to the other permeants.

So the permeability of a hydrophobic films such as polyethylene is not affected by humidity at all. And barrier properties of polymer films are dictated by their molecular structure as well. And relationships between structural features and permeability. So also affects the permeability of the material which is nothing but cross-linking, higher crystallinity of the packaging material, high glass transition temperature, and inertness to the permeant result in lower permeability. So inertness to the permeant result in lower permeability.

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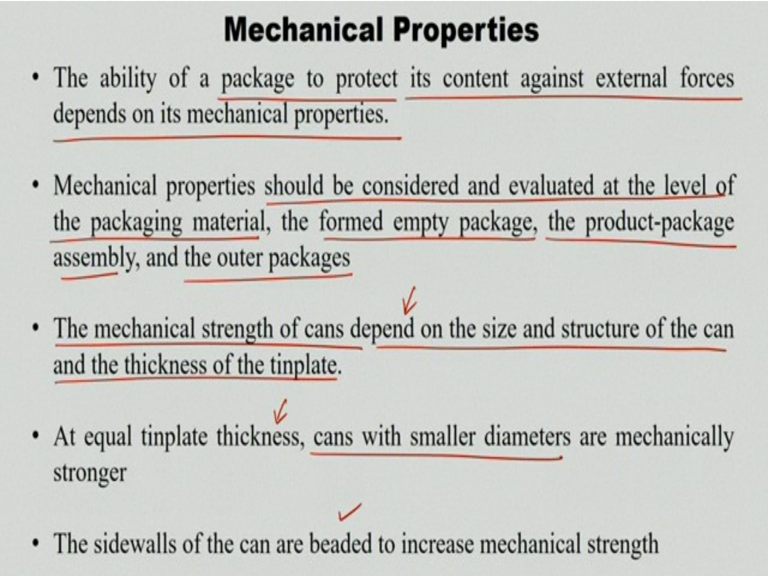


The next one is mechanical properties. So these mechanical properties, also very much important. So this gives the packaging to protect its content against the external force depends on its mechanical properties. So they should be considered and evaluated at the level of packaging material, as well as, actually there are different levels, so it has to be tested under empty condition, and product package assembly, and also outer packages. This has to be tested at various levels.

The mechanical strength of cans depends on the size and structure of the can and thickness of the tinplate. So the mechanical properties depends upon for metal packaging material, it depends upon its size, structure, as well as thickness. And equal tinplate thickness, the cans with smaller diameters are mechanically stronger. The side walls of the cans are beaded to increase the mechanical strength. So this we have discussed in the canning operations itself. So drawing process. So that brings the mechanical strength to the cans or metal packaging films.

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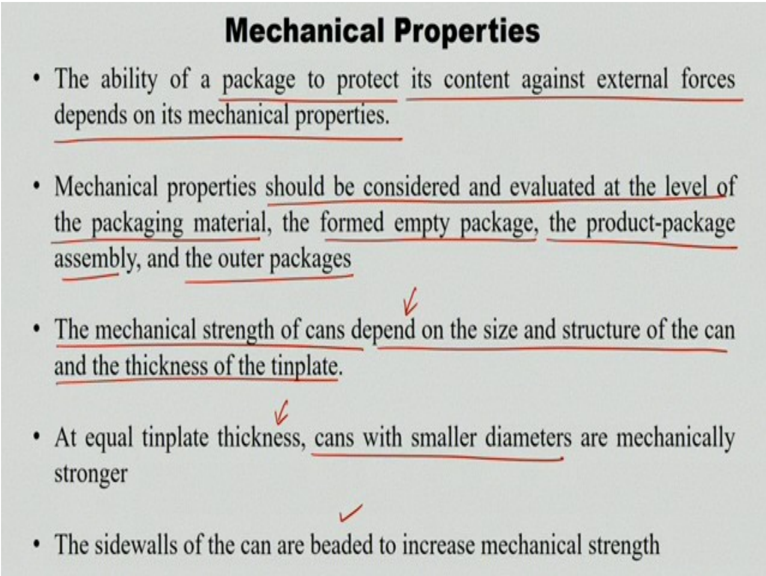


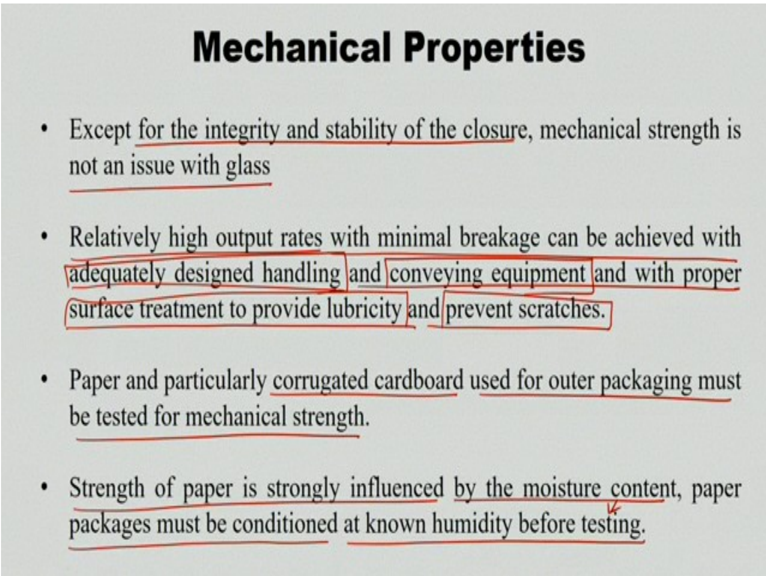


Except for the integrity and stability of the closure, the mechanical strength of the glass is not an issue. And relatively high output rates with minimal breakage can be achieved with adequately designed handling and conveying equipment with proper surface treatment to provide lubricity and prevents scratches. So how we can improve mechanical properties in the glasses, so by using adequately designed handling. Because it is breakable, fragile and conveying equipment and also with proper surface treatment to provide lubricity and to prevent the scratches.

And paper or particularly corrugated cardboard used for outer packaging must be tested for its mechanical strength. And strength of the paper is strongly influenced by the moisture content, and paper packages must be conditioned at known humidity before testing. So the testing is important. So normally for mechanical properties, they do testing at empty level, empty packaging level and product packaging assembly, as well as the outer packaging.

But in the mechanical or metal cans, so we do not have much problem. So the main factors to be considered are the size and structure of the metals, metals, food packaging materials and its thickness. And when we considered the glass, then we need to be care about or considered about the handling and the conveying equipment and also any surface treatment which provided for lubricity and scratches.

And paper or the outer packaging material, they also must be tested for the mechanical strength. And the strength of the paper is strongly influenced by the moisture content. So it has to be tested at known humidity level for enhancement or for checking the mechanical properties So with this I will end this lecture. So if some material has got good barrier property against oxygen and less barrier property against other water vapor. So how do we combine such material to achieve the aim of the less or high, so it based on the food material. So how do we combine such materials and to form a particular goal or particular aim of the packaging material. So that is what we are going to discuss is a bio nano composite films.

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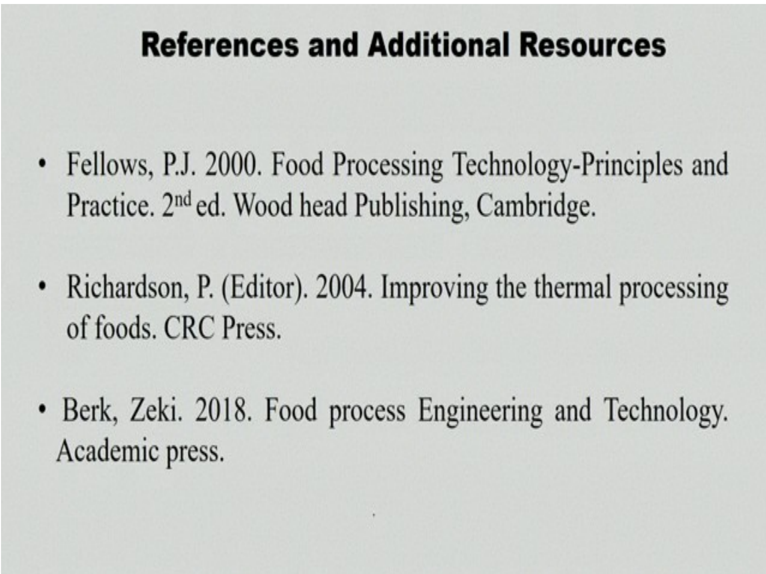


So these are references I have used in this particular lecture. So we will see in next class. Thank you.