Modern Food Packaging Technologies: Regulatory Aspects and Global Trends

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Welcome to NPTEL online certification course on Modular Food Packaging Technologies regulatory aspects and global trends. In the previous lecture we were discussing about the different plastic materials and in continuation to that the next plastic material is polyethylene terephthalate that is popularly known as PET or P E T E. The polyesters are condensation polymers found from ester monomers resulting from the reaction of a carboxylic acid with an alcohol. There are many different types of polyester depending on the monomers used. When terephthalic acid reacts with the ethylene glycol and polymerizes the result is PET. PET can be made into film by blow or casting.

It can be blow molded, injection molded, foamed, extrusion coated on paper board and extruded as sheet for thermo forming. PET can be made into a biaxially oriented range of clear polyester films produced on essentially the same type of extrusion and stenter orienting equipment as O P P. Film thickness range from thinner than 12 mm for most polyester films to around 200 mm for laminated composites. No processing additives are used in the manufacture of PET films.

Polyesters have a much higher heat resistance than many plastics and when oriented have very high mechanical strength. The ester has more radicals which may link with other chemicals consequently making the surface more reactive to inks and not as resistant to chemicals as compared with polyolefins such as polyethylene and polypropylene. PET melts at a much higher temperature than polypropylene typically 260 degree Celsius and due to the manufacturing conditions does not shrink below 180 degree Celsius. This means that PET is ideal for high temperature applications using steam sterilization. Boil in the bag and for cooking or reheating in microwave or conventional radiant heat ovens.

The film is also flexible in extremes of cold down to minus 100 degree Celsius. Heat sealable versions are available and it can also be laminated to polyethylene to give good heat sealing properties. PET is a medium oxygen barrier on its own, but becomes a high barrier to oxygen and water vapor when metallized with aluminum. This is used for vacuumized coffee and bag in box liquids where it is laminated with EVA on both sides to produce highly effective seals. It is also used in snack food flexible packaging for

products with a high fat content requiring barriers to oxygen and ultraviolet light.

Metalized PET either as a strip or as a flexible laminate is used as a susceptor in microwaveable packaging. PET film is also used as the outer reverse printed ply in retard pouches providing strength and puncture resistance where it is laminated with aluminum foil and other PP and HDPE. PET can be oxide coated with silica oxide to improve the barrier wise remaining transparent, distortable and microwaveable. Paper board is extrusion coated with PET for use as a ready meal trays which can be reheated in microwave or conventional radiant heat ovens that is dual ovenable. The PET coated sides of the paper board is on the inside of the tray which is erected by corner heat sealing.

PET is the fastest growing plastic for food packaging applications as a result of its use in all sizes of carbonated soft drinks and mineral water bottles which are produced by injection stretch blow molding. PET bottles are also used for edible oils as an alternative to PVC. A foamed colored PET sheet has been developed under the trade name of Esco form which can be laminated and used as the bottom web in thermo formable FFS machine package with a printed P label seal top web for example, with modified atmospheric packaging for fresh meat and fish. A high barrier laminate requiring the use of an extruded tie polymer acting as an adhesion promoter would comprise PE EVOS PE PET form that is the 4 ply form. The next of this important plastics is polyethylene naphthalene dicarboxylate.

The pen is a condensation polymer of dimethyl naphthalene dicarboxylate and ethylene glycol. This polyester polymer has created interest in the last few years due to its improved gas and water vapor barrier and strength properties compared to PET. It is UV resistant and has higher temperature resistance compared to PET. It can be made into film and blow molded for bottles. Pen is a modified polyester resin from BP that is the boron phosphide chemicals.

It is available as either a mono polymer pen a copolymer with PET or a PEN PET PEN blend. The selection of a specific naphthalene containing resin is dependent on the performance and cost requirements of the particular application. Suggested applications include one trip beer or soft drink bottles, returnable or refillable beer or mineral water bottles, sterilizable baby feeding bottles, hot fill applications, sports drinks, juices and dehydrated food products in flexible packaging. PEN is a more expensive than PET and this has a limited its food packaging applications. Because of its relatively high cost it is likely that pen containers will only be suitable for use in closed loop returnable packaging systems.

Polycarbonate polycarbonate is a polyester containing carbonate group in its structure. It is formed by polymerization of the sodium salt of biphenolic with phosgene. It is glass clear, heat resistant and very tough and durable. Polycarbonate is mainly used as a glass replacement in processing equipment and for glazing applications.

Its use in packaging is mainly for large returnable refillable 3 to 6 liter water bottles. It is used for sterilizable baby feeding bottles and as a replacement in food service. This polycarbonate is not to be confused with the thermosetting polycarbonate used in contact lens manufacture. This has been used for returnable milk bottles, ovenable trays for frozen food and if coextruded with nylon could be used for carbonated drinks. The next important plastic material is inomers.

Inomers are polymers formed from metallic salts of acid copolymers and possess interchange ionic cross links which provide the characteristic properties of the family of plastics. The best known in food packaging applications is surlyn which is a trademark from DuPont where the metallic ions are zinc or sodium and the copolymer is based on ethylene and methacrylic acid. Surlyn is related to polyethylene. It is clear tougher than polyethylene having high puncture resistance and has excellent oil and fat resistance. It is therefore, used where products contain essential oils as the aseptic liquid packaging of fruit juices in curtains and fat containing products such as snack foods in sachets.

It has excellent hot tack and heat sealing properties leading to increased packaging line speeds and outputs. Even sealing when the seal area is contaminated with product. It is used in the packaging of meat poultry and cheese. It is particularly useful in packaging product with sharp protrudence. Surlyn's grades are available for use in conventional extrusion and co extrusion blown and cast film and extrusion coating on equipment designed to process PE. It is also used as a tie or graft layer to promote adhesion between other materials such as PE onto aluminum foil or PET to nylon.

And, inomer heat seal can be peelable if PE is used adjacent to one of the inomer layers and buried in the laminate for example, PET PE and inomer. In food packaging, inomer films including extruded films are used in laminations and extrusion coatings in all the main types of flexible packaging. These include vertical and horizontal FFS machines, vacuum and MAP packing, four side shield pouches and twin web pouches with one web thermo formed. Inner ply of paper board composite cans for example, aluminum foil inomer. Diaphragm are membrane seals.

Inomers are used in laminated and coated form with PET, PA, PPE, PE, aluminum foil, paper and paper board. The another important material is ethylene vinyl acetate. EVA is a copolymer of ethylene with vinyl acetate. It is similar to PE in many respects and it is

used blended with polyethylene in several ways. The properties of the blend depend on the proportion of the vinyl acetate component.

Generally, as the vinyl acetate component increases, sealing temperature decreases and impact strength, low temperature flexibility, stress resistance and clarity increases. At a 4 percent level, it improves heat sealability. At 8 percent, it increases toughness and elasticity along with improved heat sealability and at higher levels, the resultant film has good stress wrapping properties. EVA is a tough high barrier film which is used in vacuum packaging, large meat cuts and with metalized PET for bag in box liners for wine. Modified EVAs are available for use as peelable coatings on leading materials such as aluminum foil, OPP, oriented PET and paper.

They enable heat sealing resulting in controllable heat sealed strength for easy clean peeling. These coatings will seal to both flexible and rigid PE, PP, PET, PS and PVC containers. An alternative approach to achieving a peelable heat seal is to blend non-compatible material with a resin which is known to give strong heat seal bonds so that the bond is weakened. Modified EVAs are also available for use in this way. Modified EVAs are also used to create a strong interlayer tie bonding between dissimilar materials for example, PET and paper, LDPE and EVOH.

EVA is also a major component of hot melt adhesives frequently used in packing machinery to react and close packs for example, folding curtains and corrugated packing. The next important material is polyamide. Polyamides are commonly known as nylon. However, nylon is not a generic name, it is a brand name for a range of nylon products made by DuPont. The nylon name has come as the production of this polyamide was simultaneously started in two cities that is New York and London and from there that nylon word has been derived.

They were initially used in textiles, but subsequently other important applications were developed including uses in packaging and engineering. Polyamide plastics are formed by a condensation reaction between a diamine and a diacid or a compound containing each functional group that is amine. The different types of polyamide plastics are characterized by a number which relates to the number of carbon atoms in the originating monomer. Nylon 6 and a related polymer nylon 6. 6 have packaging applications. It has mechanical and thermal properties similar to that of pet and therefore, similar applications. Polyamide resins can be used to make blown films and they can be co-extruded as well. Polyamide can be blended with polyethylene, polyethylene terephthalate, ethylene vinyl acetate and ethylene vinyl alcohol. It can be blow molded to make bottles and jars which are glass clear, low in weight and have a good resistance to impact. Biaxially oriented PA film has high heat resistance and excellent resistance to

stress cracking and puncture.

It has good clarity and easily thermo formed giving a relatively deep draw. It provides a good flavor and odor barrier and is resistant to oil and fat. It has a high permeability to moisture and is difficult to heat seal. These features can be overcome by PBDC coating. They can also be overcome by lamination or co extrusion with polyethylene and this structure is used as the bottom thermo formable web.

For example, deep drawn for packing bacon and cheese in vacuum packs or in gas flush packs that is modified atmosphere packaging. The film can be metallized. Polyamide film is used in retardable packaging in structures such as polyamide, aluminum foil and PP. The film is non whitening in retard processing. Polyamide is relatively expensive compared with for example, PE, but as it has superior properties it is effective in low thicknesses.

Next important material is polyvinyl chloride. If one of the hydrogen atoms in ethylene is replaced with a chlorine atom. The resultant molecule is called vinyl chloride monomer. Addition polymerization of vinyl chloride produces PVC. Unplasticized PVC has useful properties, but it is hard brittle material and modification is necessary for it to be used successfully.

Flexibility can be achieved by the inclusion of plasticizers, reduced surface friction with slip agents, various colors by the addition of pigments and improved thermal processing by the addition of stabilizing agents. Care must be exercised in the choice of additives used in film which will be direct contact with food. Particularly with respect to the migration of packaging components into food stuffs. A rigid unplasticized PVC is used for transparent or colored compartmented trays for chocolate assortments and biscuits.

It is used with MAP for thermoform trays to pack salads, sandwiches and cooked meats. Most PVC films are produced by extrusion using the bubble process. It can be oriented to produce film with a high degree of shrinkability. Up to 50 percent shrinkage is possible at quite low temperature. The film releases the lowest energy of the commonly used plastic films when it is heat shrunk around products.

It is plasticized and the high stretch and cling make it suitable for over wrapping fresh produce for example, apples and meat in rigid trays using semi automatic and manual methods. PVC has excellent resistance to fat and oils. It is used in the form of blow molded bottles for vegetable oils and fruit drinks. It has good clarity as a film it is tough with high elongation though with relatively low tensile and tear strength. The moisture vapor transmission risk is relatively high though adequate for the packaging of mineral

water, fruit juice and fruit drinks in bottles.

Unplasticized PVC is good gas and water vapor barrier, but these properties decrease with increasing plasticizers content. There are grades which are used to wrap fresh meat and fresh produce where a good barrier to moisture vapor retards weight loss, but the permeability to oxygen allows to product to breathe. This allows fresh meat to retain its red color and product such as fruits vegetables and salads to stay fresh longer by reducing the rate of respiration especially when packed in a modified atmosphere packaging. Next important material is polyvinylidene chloride. Polyvinylidene chloride is a copolymer of vinyl chloride and vinylidene chloride.

The latter forms when two hydrogen atoms in ethylene are replaced by chlorine atoms. PVDC is heat sealable and is an excellent barrier to water vapor and gases and to fatty and oily products. As a result of the high gas and odor barrier it is used to protect flavor and aroma sensitive foods from both loss of flavoring and ingress of volatile contaminants. It is used in flexible packaging in several ways. Monolayer film this includes poultry packaging where hot water shrinkable bags are used to achieve a tight wrap around the product.

The film can be used in the form of sachets, but is less likely to be cost effective compared with other plastic films. Some of which may incorporate PVDC as a coating and interesting use is as sauces and chubb casing. Coextrusion PVDC is often used in coextrusion where today extruders incorporate 3, 5 and even 7 extrusion layers to meet product protection and packaging machinery needs cost effective. Coatings these may be applied using solutions in either organic solvents or aqueous dispersions to plastic films such as BOPP and PET or RCF and to paper and paper board. Hence PVDC is a widely used component in the packaging of cured meats, cheese, snack foods, tea, coffee and confectionery.

It is used in hot filling, retorting, low temperature storage and MAP as well as ambient filling and distribution in a wide range of pack shapes. Thank you very much.