Modern Food Packaging Technologies: Regulatory Aspects and Global Trends

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Welcome to the NPTEL online certification course on Modern Food Packaging Technologies Regulatory Aspects and Global Trends. Dear friends in the we were discussing testing and regulatory aspects of food packaging materials. In the last class we have dealt with the measuring of textile tensile strength, tear resistance, resistance to abrasion and drop test. In the present lecture we will be covering stack load test, vibration test, water vapour transmission rate, oxygen transmission rate, optical test. Under the optical test we shall be measuring glass, opacity, optical density, haze, light transmission and machinability test, elongation impact test and bursting strength test.

The stock load test, the compression or stacking test, this test is performed to assess the ability of a transport package to withstand compressive force and to protect its content during compression. The test may also be used as a stacking test to investigate the performance of the bottom package in a stack during storage in a warehouse. The test is carried out by stacking the package material above one another or by placing a fixed weight above the unit pack for a certain time. It can also be done by compressing a pack from two opposite sides and measuring the pressure applied to break or deform the container.

This test is generally applicable in case of wooden box, paper box, paper boards, cans and other secondary packaging materials. This property is also important for finding the stacking height in a warehouse. This the vibration test, various forms of transportation vibrations can be simulated in a laboratory through a vibration test. The test bench can be made to swing and vibrate in almost any direction with a number of frequencies and amplitudes to emulate the transportation being used. Vibration refers to mechanical oscillations about an equilibrium point.

The oscillations may be periodic such as the motion of a pendulum or random such as the movement of a tire on a gravel road. Vibration testing is accomplished by introducing a forcing function into a structure usually with some type of shaker. Alternatively a dute that is device under test is attached to the table of a shaker. For relatively low frequency forcing, servo hydraulic or electro hydraulic shakers are used. For higher frequency electro dynamic shakers are used.

Generally one or more input or control points on the device under test are kept at a specified vibration level. Other response points experience maximum vibration, maximum vibration level that is resonance or minimum vibration level that is anti resonance. Two typical types of vibration tests performed are random and sign test. Sign that is one frequency at a time test are performed to survey the structural response of the device under test. A random or all frequencies at once test is generally considered to more closely replicate a real world environment such as road inputs to a moving automobile.

Most vibration testing is conducted in a single DUT axis at a time. Even though most real world vibration occurs in various axis simultaneously. Now the migration test for water vapor termination rate that is WVTR is the steady state rate at which water vapor permeates through a film at a specified conditions of temperature and relative humidity. Values are expressed in gram per meter square per 24 hour in metric or SI units. A critical function of flexible packaging is to keep dry products dry like potato chips, pet jazz, fortune cookies etcetera and the moist product moist for example, cheese, muffins, living gums etc.

Without protective packaging products will quickly gain or lose moisture until they are at equilibrium with the environmental relative humidity. At this point crispy products are soggy and chewy products are hard and dry. WVTR is the standard measurement by which films are compared for their ability to resist moisture transmission. Lower values indicate better moisture protection. Only values reported at the same temperature and humidity can be compared because transmission rates are affected by both of these parameters.

The order of water vapor resistivity in films of 1 millimeter is as follows. That is the BOPP has greatest water resistivity, then HDPE, then cost polypropylene, then BPET, then LDPE, then ethyl vinyl alcohol at 100 degree Fahrenheit or 38 degree Celsius at 90 percent relativity or 1 mil that is 1000s of an inch film. Now what affects the water vapor transmission rate of oriented polypropylene films? The most obvious factor that impacts WVTR is thickness. If an OPP of the same product designs is twice as thick as another its WVTR will be half the value. This is so because WVTR is an inherent bulk film property of OPP.

It is common to find variation in the reported WVTR values for same gauge OPP films produced are measured by different manufacturers. The primary factors causing these differences are the first is raw material, the homopolymer polypropylene resin differences in average molecular chain length, range of chain lengths and degree of crystallinity can account for up to a 10 percent difference in water vapor transmission rate. Additives and copolymer resin layers can account for differences of up to 30 percent. The next is process. The normal differences in process conditions between one orienter and another account for about 5 percent variation in WVTR values.

WVTR is reduced through orientation because the crystalline regions of the polymer matrix are aligned. In other words orientation efficiently packs polymer chains so that larger spaces are minimized. Process conditions affect this packing and therefore, WVTR values. The test principle dry nitrogen gas is swept through a chamber where the test film acts as a membrane separating this dry gas stream from a wet nitrogen stream on the other side. The partial pressure difference creates a driving force for the water vapor to permeate through film to the low pressure side.

The barrier of the film determines how much water vapor can transfer and this is continuously measured by an infrared detector in the outgoing stream of the dry side. The test is complete when equilibrium or steady state is achieved which is when the infrared sensor detects water molecules leaving the dry chamber at a constant rate. The amount of water vapor permeating through the sample per unit time period is not changing. This rate is sample WVTR and is recorded in units of grams of water per 100 inch square per 24 hour at 37.8 degree Celsius and 90 percent relative humidity.

The testing of water vapor transmission rate is depicted in this picture. This is the test specimen and this is the dry nitrogen which is for going through this way and coming through this way and here is the water vapors which are here the pressure is less and here pressure is more. So, water vapor will cross this thing and it will saturate the nitrogen going out. The water content by infrared sensors measured in the outgoing nitrogen and when the equilibrium established that is the that is taken as the water vapor transmission rate. Now the migration test for oxygen transmission rate that is OTR is the steady state rate at which oxygen gas permeates through a film at specified conditions of temperature and relative humidity.

The value is expressed in cc cubic centimeter per meter square per 24 hour in metric or SI units. Total test conditions are 23 degree Celsius at 0 percent relative humidity. What affects the OTR of films? Good oxygen barrier is achieved by combining functional layers to create a film with the required barrier as well as those other properties necessary to produce a serviceable package. For example, ethylene vinyl alcohol has exceptional OTR properties, but needs moisture barrier and mechanical properties provided by layers that are co extruded or laminated around it. The dry nitrogen gas is swept through a chamber where the test film acts as the membrane separating this stream from an oxygen stream on the other side.

The partial pressure difference creates a driving force for oxygen molecules to diffuse through the film to the low pressure side. The film barrier determines the rate of oxygen permeation and this is continuously measured by a colometric sensor in the outgoing stream of the nitrogen side. This standard test conditions are 23 degree Celsius and 0 percent relative humidity. The test is complete when equilibrium is or steady state is achieved that is it is complete when the sensor detects a constant amount of oxygen in the nitrogen carrier stream. Now the now the optical test, in the optical test these 5 types of tests are performed that is the glass, opacity, optical density, haze and light transmission.

Now the gloss, gloss is a measurement of the relative luster or shininess of the film surface. The incident light beam strikes the film surface at a 45 degree angle from the perpendicular. A sensor measures the amount of light reflected by the film at a mirror image angle. The gloss value is the ratio of this reflected light to incident light and is reported in glass units. Theoretically the range of the gloss scale is 0 to 100.

Shine, shininess, brilliance and sparkle are properties related to a films gloss value. Precise comparisons of gloss values can only be made when the measurements are performed on samples of the same general type of material using the same procedure and test angle. In particular it is not valid to compare the gloss values of transparent films and opaque films. In the picture the incident light is falling at a 45 degree angle, this degree this angle is 45 degree and the reflected light is measured. The ratio of reflected light and the incident light is presented as a gloss value.

Now the opacity, opacity, so opacity represents a substrates light blocking ability. It is primarily used as a property of paper and predicts the relative visibility on one side of the paper of the image that exist on the other side. Opacity that is 89 percent reflectance backing is equal to c 0.89 that is opacity is equal to 100 into r 0 plus r at 0.89, where r 0 is the reflectance of the substrate when it is backed by a black body of 0.5 percent reflectance or less. Any light that passes through a partial opaque sheet will reflect back negligibly. r 0.89 is the reflectance of the substrate when it is backed by a white body having a reflectance of 89 percent. This value will be higher than r 0 or equal to it if the sample is perfectly opaque because any light that passes through the substrate will largely be reflected and a portion of that will transmit through the film a second time. Now the optical density, optical density is a representation of a materials light blocking ability.

Optical density scale is unit less and logarithmic and it is enhances the data resolution for materials that transmit only a small fraction of incident light. A unidirectional perpendicular light beam is directed onto the film sample. Light that is transmitted through the film is collected, measured and logarithmically amplified. The densityometer calculates and displays the optical density value. The optical density values represents the following calculation and relationship to percent light transmission.

The optical density is equal to log of ratio of incident light and transmitted light that is log of 100 divided by light transmitted in percentage. optical density values are reported to two decimal places. Now the HAGE, HAGE is the scattering of light by a film that results in a cloudy appearance or poorer clarity of objects when viewed through the film. More technically HAGE is the percentage of light transmitted through a film that is deflected more than 2.5 degree from the direction of the incoming beam.

This property is used to describe transparent and translucent films not opaque films. As represented in figure a unidirectional light beam is directed onto the film specimen. After it enters an integrating sphere a photo detector measures the total light transmitted by the film and the amount of transmitted light that is scattered more than 2.5 degree. HAGE is the percentage of total transmitted light that is scattered by more than 2.

5 degree. This is the measurement of the HAGE, this is the film of which the HAGE is to be measured, this is the transmitted light and after it is passing through the test specimen some part of the light will be passed through and some light will be scattered that is the scattered TD is the scattered light and TO is the outgoing light and TI is the incident light and there is a photo sensor that detects the photo detector. So when the gate is closed the photo detector measures the total transmitted light that is TT. When gate is open it measures the transmitted light. This is the gate when it is open then it measures the transmitted light and it measures the transmitted light that deviates more than 2.

5 degree. The HAGE is calculated as TD by TT that is the transmitted ratio of transmitted deviated light and the total transmitted light into 100. Now the light transmission, light transmission is the percentage of incident light that passes through a film. A unidirectional perpendicular light beam is directed on to the film specimen and a photo detector measures the total light transmitted by the specimen after it enters an integrating sphere. Commercial HAGE meters are typically used for this testing. The light transmission is equal to ratio of total light transmitted by specimen divided by incident light into 100.

Now the machinability test. Machinability refers to the ease of which packaging material may be used in manufacturing and packaging operations. Material with a lower machinability causes less tool wear, require less cutting force and power, provide a better surface finish and better chip disposal. It is also includes the following handling properties, slip properties or frictional properties, printability, efficiency, convenience function, crimp test and sealability etc. Now the elongation impact test. The pendulum impact tester can be used to measure impact strength of papers, boards and films.

An impacting head on the end of a pendulum is swung through an arc into and through sample. Tester means of measuring difference between potential energy of pendulum at maximum height has a in free swing and potential energy of the pendulum after rupture the sample. This difference in energy is defined as impact strength and is reported in units of kilogram centimeters. Now the bursting strength test. This is the ability of a material to resist rupture by pressure.

This test is also known as Muller test. The bursting strength test gives an indication of tensile strength and stretch of paper. The instrument may use hydraulic or pneumatic pressure. This test is used as a control test in the paper mill. The bursting strength is largely accepted as a specification for boards used in container construction and also for all types of papers. The specimen is fixed in the testing equipment and the pressure in the form of pneumatic or hydraulic is applied.

The pressure in form of PSI or kg per centimeter square at which the specimen ruptures is noted that is the bursting strength. That is all for today. Thank you very much. .