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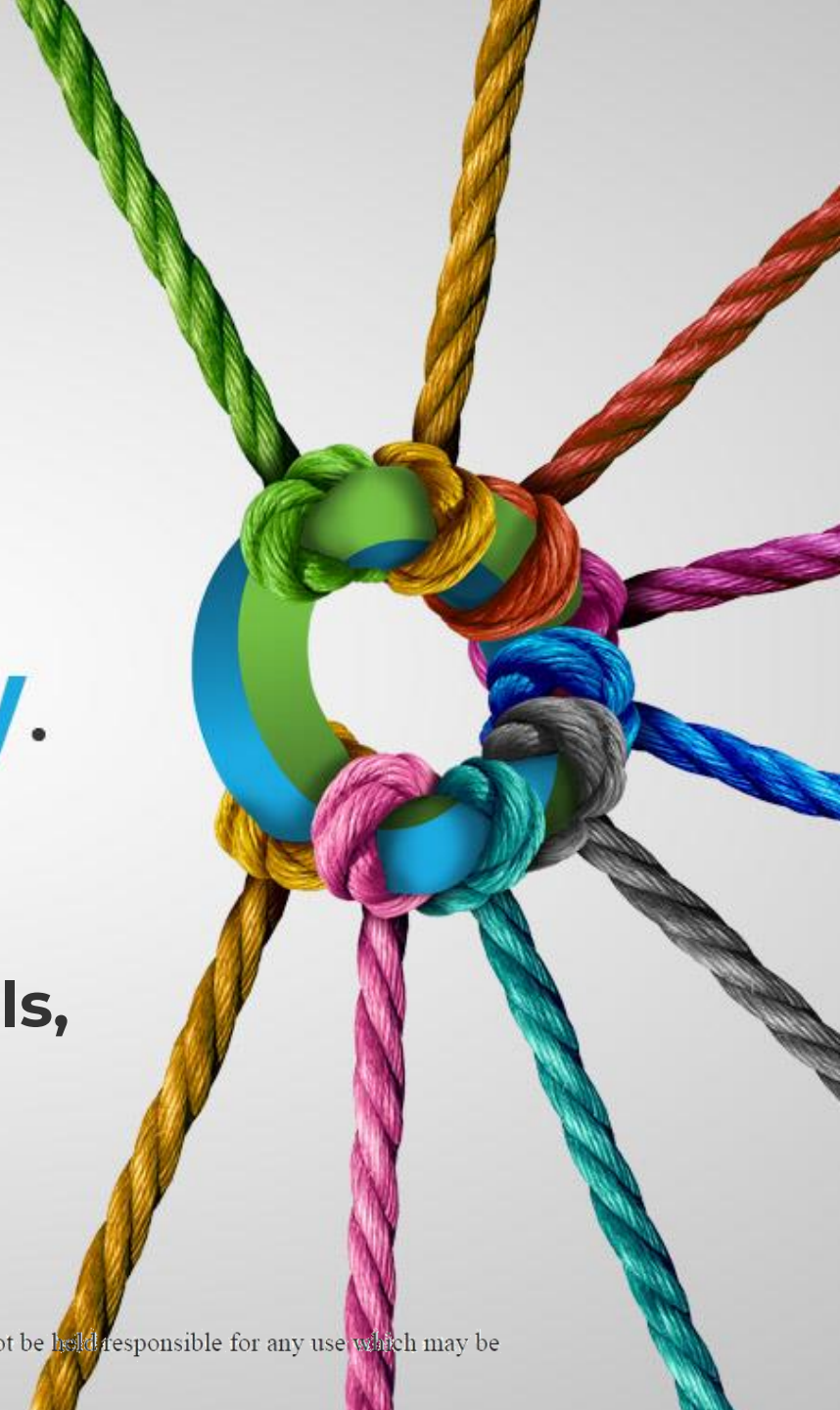
European alliance for innovation training
& collaboration towards future packaging

Linking Academy to Industry.

Training program: New materials and biomaterials

Characteristics of new materials and biomaterials, and their types and uses (part 2)



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Module: New materials and biomaterials

Topic: Characteristics of new materials and biomaterials, and their types and uses (part 2)

TABLE OF CONTENTS

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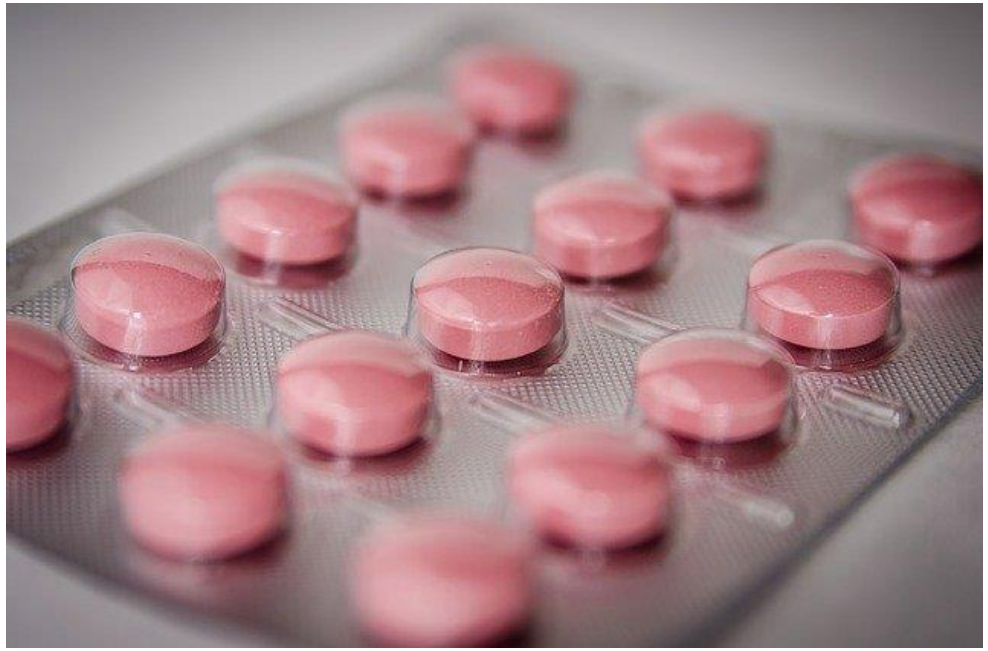
1. Introduction

Knowledge of the properties of polymer packaging materials is necessary for their proper use. Due to the large variety of packaging materials available on the market, in addition to testing the basic parameters characterizing their properties, sometimes also specific tests are performed, which are related to the detailed determination of the functional properties of the material intended for a specific purpose.

The scope of possible tests is extremely wide, but the knowledge of the basic properties allows for the appropriate selection of material for the packed goods.



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Packaging materials property groups'

- Chemical properties
- Physical properties
- Mechanical properties
- Optical properties
- Electrical properties

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Molecular weight

An important feature describing macromolecules is their molecular weight being the sum of atomic masses included in a given macromolecule expressed in units of atomic mass u or molar mass expressed in g / moll.

The molecular mass (m) is the mass of a given molecule: it is measured in daltons (Da or u).

1 dalton is $1.66053906660(50)\times10^{-27}$ kg

The mass of a sample of that compound divided by the amount of substance in that sample, measured in moles. It is the mass of 1 mole of the substance or 6.022×1023 particles, expressed in grams. The molar mass is a bulk, not molecular, property of a substance.

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Chemical properties

Average molar masses dependent on the size of macromolecules have a great influence on many physical and mechanical properties of polymers, e.g .:

- Solubility,
- Viscosity in the molten state and in solution,
- Processability,
- Brittle temperature, glass transition temperature, melting point,
- Ability to crystallize,
- The ability to form membranes and fibers,
- Plasticity,
- Tensile strength,
- Resistance to multiple deformation,
- Modulus of elasticity,
- Chemical resistance,
- Thermal resistance.

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Polydispersity

Molar mass distribution, **polydispersity**, is related to the fact that macro polymer molecules have different chain lengths.

The magnitude of this distribution is an index of polydispersity, which determines the heterogeneity of the molar mass of the polymer.

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Solubility

Solubility is the property of a solid, liquid or gaseous chemical substance called solute to dissolve in a solid, liquid or gaseous solvent.

The solubility of a substance fundamentally depends on the physical and chemical properties of the solute and solvent as well as on temperature, pressure and presence of other chemicals (including changes to the pH) of the solution.

The extent of the solubility of a substance in a specific solvent is measured as the saturation concentration, where adding more solute does not increase the concentration of the solution and begins to precipitate the excess amount of solute.

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Melting point

The melting point of a substance is the temperature at which it changes state from solid to liquid.

At the melting point the solid and liquid phase exist in equilibrium. The melting point of a substance depends on pressure and is usually specified at a standard pressure such as 1 atmosphere or 100 kPa.

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Viscosity

One of the most characteristic properties of macromolecular compounds, especially those made of chain molecules, is the high viscosity of their solutions, as well as the viscosity of the polymers themselves when they are in liquid form. This property results from the structure of macromolecules and their concentration, it is relatively easy to determine, so it can be a very simple parameter for characterizing liquid polymers and their solutions, and it can also be used to determine the molecular weight.

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Physical properties

The thickness is the distance between the two outer surfaces of a sheet of packaging material, expressed in mm.

The grammage is the mass of one square meter of a sheet of packaging material, determined in standardized conditions, expressed in g/m^2.

The apparent density is the mass of 1 cm^3 of packaging material, expressed in g/cm^3.

The specific volume is the volume of 1 g of the packaging material, expressed in cm^3/g.

Packaging efficiency is the area of the packaging material in m^2 per 1 kg of the product, expressed in m^2/kg.

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Barrier properties

Barrier properties include permeability of gases (such as O_2, CO_2, and N_2), water vapour, aroma compounds and light.

These are vital factors for maintaining the quality of packaged foods. The permeability is the rate at which the gas permeates through the membrane after the gas has come to equilibrium in the polymer.

The time lag is the time it takes the gas to permeate from the feed side of the membrane to the permeate side and can be used to calculate the diffusivity.

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Mechanical properties (1)

Strength stress at the first local maximum observed during a tensile test. It is expressed in megapascals (MPa).

Calculate all stress values, using the following equation:

$$\sigma = F/A$$

where:

- σ is the stress value in question, expressed in megapascals (MPa);
- F is the measured force concerned, expressed in newtons (N);
- A is the initial cross-sectional area of the specimen, expressed in square millimetres (mm^2).

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Mechanical properties (2)

Strain ε increase in length per unit original length of the gauge. It is expressed as a dimensionless ratio, or as a percentage (%).

$$\varepsilon = \Delta L_0 / L_0$$

where:

- ε is the strain value in question, expressed as a dimensionless ratio, or as a percentage;
- L_0 is the gauge length of the test specimen, expressed in millimetres (mm);
- ΔL_0 is the increase of the specimen length between the gauge marks, expressed in millimetres (mm).

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Summary

Plastic materials change their properties over time, which in turn leads to a decrease in their usable properties. Changes in individual parameters are caused by the entirety of physical and chemical changes taking place in the structure of plastic materials are referred to as the aging process.

All unfavorable changes occurring in products during their storage are related primarily to climatic exposures, those exposures resulting from the destructive influence of many climatic factors, such as: temperature, solar radiation, oxygen, moisture, pollution or internal stresses.

The effect of the influence of the above factors depends mainly on the time of their operation (exposure time) and the type of tested polymer (including molecular structure). Changes in the properties of plastics under the influence of the above-mentioned factors are associated with the formation of changes in the polymer as a result of chemical reactions such as: cross-linking, oxidation, degradation and destruction. These transformations are very complex, most often they occur simultaneously and are often linked to biological processes.

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