

**SUMMER EXAMINATIONS 2020**

**EXAMINATION:**

**UNIT 3 Packaging Materials and Containers 2**

**COURSE:**

**CPD Diploma in Packaging Technology**

**DATE:**

**14h May 2020**

**10am to 12pm**

**EXAMINERS: Tony Duffy, Ron Gardiner**

**TIME ALLOWED: 2 hours**

**INSTRUCTIONS: Please answer four questions. All questions carry equal marks**

**PLEASE DO NOT TURN OVER THIS PAGE UNTIL YOU ARE INSTRUCTED TO DO SO**

The use of programmable or text storing calculators, smart phones etc are expressly forbidden. Please note that where a candidate answers more than the required number of questions, the examiner will mark all questions attempted and then select the highest scoring ones.

Unit 3 Page 1 of 3

**Question 1 (25 marks)**

a) Describe the polymerisation of low-density polyethylene (LDPE).

**(9 marks)**

1. Discuss how the production of high density polyethylene (HDPE) and linear low density polyethylene (LLDPE) is different from that of LDPE and what impact this has on the materials’ properties?

**(2 x 3 Marks)**

1. Briefly explain the meaning of the following polymer characteristics and describe how they can influence their properties.
   * Chain Branching
   * Crystallisation
   * Orientation
   * Glass transition
   * Melt flow index

**(5 x 2 marks)**

**Question 2 (25 marks)**

1. Describe the following three types of adhesion: Chemical, Mechanical and Diffusion Adhesion.

**(10 marks)**

1. Adhesives set after application. Describe three processes by which adhesives set and provide an example of use for each.

**(10 marks)**

1. Corrugated cases are often constructed using a different adhesive for construction of the corrugated board, the creation of the manufacturers joint and closing the flaps once the case is filled. Justify the use of an adhesive for each of these applications

**(5 marks)**

**Question 3 (25 marks)**

1. Describe the production of bi-axial orientated case polypropylene film from granules of material to rolls of film ready for dispatch.

**(20 marks)**

1. Briefly describe how the production of blown film production for Polyethylene film is different from that of bi-axial orientated case polypropylene film.

**(5 marks)**

Unit 3 Page 2 of 3

**Question 4 (25 marks)**

1. Briefly describe what a laminate structure is and why materials are laminated together. Then describe two methods of laminating plastics to board.

**(5 marks)**

1. A typical carton for a juice product such as Ribena, is laminated from PE/Aluminium Foil/PE/Board/Lacquer. What are the functions of each of these laminate layers?

**(10 marks)**

c) Briefly note & justify how each layer is bonded to the next.

**(5 marks)**

1. As a packaging technologist describe how you could make this juice laminate pack more ‘environmentally friendly’

**(5 marks)**

**Question 5 (25 marks)**

A bottle of beer is labelled with a glue applied metallised label, which has been printed and embossed.

a) Describe an appropriate glue and label for this application

**(6 marks).**

1. Discuss the material properties to be considered when specifying, manufacturing and applying this label

**(4 marks)**.

c) Why has the spirits industry seen the move from paper to plastic labels?

**(9 marks)**

1. Discuss the benefits of using in-mould labelled containers for butter and yellow fat products

**(6 marks)**

Unit 3 Page 3 of 3

**Question 1 (25 marks)**

**a) Describe the polymerisation of low-density polyethylene (LDPE).**

**(9 marks)**

1. **Discuss how the production of high density polyethylene (HDPE) and linear low density polyethylene (LLDPE) is different from that of LDPE and what impact this has on the materials’ properties?**

**(2 x 3 Marks)**

1. **Briefly explain the meaning of the following polymer characteristics and describe how they can influence their properties.**
   * **Chain Branching**
   * **Crystallisation**
   * **Orientation**
   * **Glass transition**
   * **Melt flow index**

**(5 x 2 marks)**

\*\*Polymerization of Low-Density Polyethylene (LDPE):\*\*

Low-density polyethylene (LDPE) is typically produced via a process called "free radical polymerization" or "high-pressure polymerization." Here's how it works:

1. \*\*Initiation:\*\* The process begins with the initiation of the polymerization reaction. This can be achieved by using initiators such as organic peroxides or oxygen. These initiators break down into free radicals when exposed to heat or pressure.

2. \*\*Propagation:\*\* The free radicals react with ethylene monomer molecules, initiating a chain reaction. Each monomer molecule adds to the growing polymer chain, forming a long-chain polymer.

3. \*\*Termination:\*\* The polymerization reaction continues until all available monomer molecules are consumed or until terminated by the combination of two free radicals. This termination step halts the growth of the polymer chains.

4. \*\*Result:\*\* The result of the polymerization process is a polymer consisting of long, branched chains of ethylene monomer units. LDPE typically has a high degree of branching, which gives it a low density and flexible, amorphous structure.

\*\*Production and Properties of HDPE and LLDPE:\*\*

1. \*\*High-Density Polyethylene (HDPE):\*\*

- Production: HDPE is produced through a process called "slurry" or "gas-phase polymerization" using Ziegler-Natta catalysts or metallocene catalysts. This process typically operates at lower pressures and temperatures compared to LDPE production.

- Impact on Properties: HDPE has a more linear structure with minimal branching compared to LDPE. This results in higher density, greater stiffness, and improved mechanical properties such as tensile strength and abrasion resistance.

2. \*\*Linear Low-Density Polyethylene (LLDPE):\*\*

- Production: LLDPE is produced using similar catalysts and polymerization techniques as HDPE but with the addition of co-monomers like octene or hexene. This process allows for the incorporation of short chain branches along the polymer backbone.

- Impact on Properties: LLDPE has a higher degree of short-chain branching compared to LDPE, giving it improved toughness, puncture resistance, and tear strength. It also maintains flexibility similar to LDPE while offering higher tensile strength and environmental stress crack resistance.

\*\*Explanation of Polymer Characteristics and Their Influence on Properties:\*\*

1. \*\*Chain Branching:\*\*

- \*Meaning:\* Chain branching refers to the presence of side chains or branches along the polymer backbone.

- \*Influence on Properties:\* Increased branching, as seen in LDPE, results in a more amorphous structure with lower density and flexibility. In contrast, lower branching in HDPE and LLDPE leads to higher density and stiffness.

2. \*\*Crystallinity:\*\*

- \*Meaning:\* Crystallinity refers to the degree of molecular ordering within a polymer, resulting in the formation of crystalline regions.

- \*Influence on Properties:\* Polymers with higher crystallinity, such as HDPE, exhibit greater stiffness, strength, and resistance to environmental factors. In contrast, polymers with lower crystallinity, like LDPE and LLDPE, tend to be more flexible and have lower mechanical properties.

3. \*\*Orientation:\*\*

- \*Meaning:\* Orientation refers to the alignment of polymer chains in a specific direction, induced through processing techniques such as stretching or extrusion.

- \*Influence on Properties:\* Oriented polymers exhibit anisotropic properties, meaning their properties vary depending on the direction of orientation. Orientation can improve mechanical properties such as strength and stiffness while also affecting optical properties like transparency and clarity.

4. \*\*Glass Transition:\*\*

- \*Meaning:\* The glass transition temperature (Tg) is the temperature range at which an amorphous polymer transitions from a glassy, rigid state to a rubbery, flexible state.

- \*Influence on Properties:\* The glass transition temperature influences the polymer's stiffness, impact resistance, and processing behavior. Polymers with higher Tg values tend to be more rigid and have better dimensional stability, while those with lower Tg values are more flexible and can undergo deformation at lower temperatures.

5. \*\*Melt Flow Index (MFI):\*\*

- \*Meaning:\* Melt flow index measures the flowability of a polymer melt under specific conditions of temperature and pressure.

- \*Influence on Properties:\* MFI provides an indication of a polymer's processability and can impact its ease of extrusion, molding, or processing. Higher MFI values indicate greater flowability, making the polymer suitable for processes requiring high melt flow rates, while lower MFI values are suitable for applications requiring slower processing speeds and greater control over flow characteristics.