

**SUMMER EXAMINATIONS 2019**

**EXAMINATION:**

**UNIT 3 Packaging Materials and Containers 2**

**COURSE:**

**CPD Diploma in Packaging Technology**

**DATE:**

**9th May 2019**

**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.

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**Question 1 (25 marks)**

1. Discuss the following types of polymer outlining their structure, properties and providing an example of each.
   * Thermoplastic (4 marks)
   * Thermoset (4 marks)

**(8 marks)**

1. Briefly describe 2 polymerization processes. Provide an example of a material produced from each.

**(8 marks)**

1. Explain three of the following terms as applied to polymer characteristics.
   * Polymer chain branching
   * Crystallinity
   * Orientation
   * Copolymer

**(3 x 3 marks)**

**Question 2 (25 marks)**

1. Discuss the properties of the following materials for the packaging on the given products.
   * An amorphous polyethylene terephthalate injection stretch moulded bottle for a carbonated soft drink.
   * A micro‐perforated biaxial orientated polypropylene bag of salad leaves.
   * A high density polyethylene extrusion blow moulded bottle.
   * A polypropylene flip to closure for a shampoo bottle.

**(4 x 5 marks)**

1. Identify and briefly justify an appropriate material or material combinations for these applications
   * A dissolvable film for detergent tablets.
   * A high performance heat seal which can seal through powder contamination.
   * A ready meal tray for reheating in either oven or microwave.
   * A vacuum bag for whole shell on shell fish
   * A robust transparent plastic for use in water cooler containers which can be sterilised.

**(5 marks).**

Unit 3 Page 2 of 3

**Question 3 (25 marks)**

1. Identify the layers present in a laminate structure suitable for a carton of juice such as the product ***Ribena***. Review the rational for each of the layers you have chosen for this structure.

**(12 marks)**

b) What are the advantages and disadvantages of wet and dry bond lamination?

**(6 marks)**

1. A typical laminate structure for a bag of crisps is MOPP / PE. What are the functions of these two layers

**(5 marks)**

d) How is the OPP in the above structure metalized to form MOPP

**(2 marks)**

**Question 4 (25 marks)**

1. Describe the production of a 500 ml polyethylene terephthalate injection stretch blow moulded bottle for a carbonated drink.

**(15 marks)**

1. Justify the materials and process for this application.

**(5 Marks)**

1. Discuss how an additional barrier layer could be formed into this container for use with wine or beer.

**(5 marks)**

**Question 5 (25 marks)**

1. Describe how a bag of crisps is formed and sealed from the reel of raw material to finished product.

**(10 marks)**

b) Review the 3 key parameters to control in this form fill seal process

**(6 marks)**

1. Review 3 other key parameters to control

**(6 marks)**

1. List three methods of testing for the effectiveness of the sealed bag

**(3 marks)**

Unit 3 Page 3 of 3

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   * **Crystallinity**
   * **Orientation**
   * **Copolymer**

**(3 x 3 marks**

### Answer:

\*\*Types of Polymers:\*\*

1. \*\*Thermoplastic\*\*:

- \*\*Structure\*\*: Linear or branched chains that can be repeatedly softened and hardened by heating and cooling.

- \*\*Properties\*\*: Can be melted and reshaped multiple times, good impact resistance, and recyclable.

- \*\*Example\*\*: Polyethylene (PE) used in plastic bags and bottles.

2. \*\*Thermoset\*\*:

- \*\*Structure\*\*: Cross-linked chains that undergo irreversible hardening when cured by heat or chemical reaction.

- \*\*Properties\*\*: Excellent dimensional stability, high heat resistance, and superior strength.

- \*\*Example\*\*: Epoxy resin used in adhesives and coatings.

\*\*Polymerization Processes:\*\*

1. \*\*Polymerization Process 1: Addition Polymerization\*\*:

- \*\*Description\*\*: Monomers react to form a polymer without the elimination of byproducts.

- \*\*Example\*\*: Polyethylene terephthalate (PET) produced from the reaction of ethylene glycol and terephthalic acid, used in beverage bottles.

2. \*\*Polymerization Process 2: Condensation Polymerization\*\*:

- \*\*Description\*\*: Monomers react with the elimination of small molecules like water or alcohol.

- \*\*Example\*\*: Nylon-6,6 produced from the reaction of adipic acid and hexamethylenediamine, used in textiles and automotive parts.

\*\*Polymer Characteristics:\*\*

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

- \*\*Definition\*\*: Polymer chains with side chains or branches extending from the main backbone.

- \*\*Importance\*\*: Branching affects polymer properties like flexibility, crystallinity, and melt viscosity.

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

- \*\*Definition\*\*: The degree of molecular order in a polymer, where chains align to form crystalline regions.

- \*\*Importance\*\*: Crystallinity influences properties like strength, stiffness, and transparency in polymers.

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

- \*\*Definition\*\*: Alignment of polymer chains in a specific direction, often induced during processing.

- \*\*Importance\*\*: Orientation affects mechanical properties like strength, stiffness, and barrier properties in polymers.

4. \*\*Copolymer\*\*:

- \*\*Definition\*\*: A polymer formed from two or more different monomers.

- \*\*Importance\*\*: Copolymers combine the properties of different monomers, offering a balance of characteristics not found in homopolymers.

**Question 2 (25 marks)**

1. **Discuss the properties of the following materials for the packaging on the given products.**
   * **An amorphous polyethylene terephthalate injection stretch moulded bottle for a carbonated soft drink.**
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   * **A high density polyethylene extrusion blow moulded bottle.**
   * **A polypropylene flip to closure for a shampoo bottle.**

**(4 x 5 marks)**

1. **Identify and briefly justify an appropriate material or material combinations for these applications**
   * **A dissolvable film for detergent tablets.**
   * **A high performance heat seal which can seal through powder contamination.**
   * **A ready meal tray for reheating in either oven or microwave.**
   * **A vacuum bag for whole shell on shell fish**
   * **A robust transparent plastic for use in water cooler containers which can be sterilised.**

**(5 marks).**

### Answer:

\*\*Properties of Materials for Packaging:\*\*

1. \*\*Amorphous Polyethylene Terephthalate (PET) Injection Stretch Moulded Bottle for a Carbonated Soft Drink\*\*:

- \*\*Properties\*\*: Transparent, lightweight, good barrier to gas and moisture, impact-resistant.

2. \*\*Micro-Perforated Biaxial Oriented Polypropylene Bag of Salad Leaves\*\*:

- \*\*Properties\*\*: Breathable, lightweight, transparent, good moisture resistance, suitable for fresh produce.

3. \*\*High Density Polyethylene (HDPE) Extrusion Blow Moulded Bottle\*\*:

- \*\*Properties\*\*: Sturdy, impact-resistant, chemical-resistant, suitable for liquids like detergents or cleaning agents.

4. \*\*Polypropylene Flip-Top Closure for a Shampoo Bottle\*\*:

- \*\*Properties\*\*: Durable, chemical-resistant, easy to open and close, suitable for personal care products.

\*\*Appropriate Material Selection:\*\*

1. \*\*Dissolvable Film for Detergent Tablets\*\*:

- \*\*Material\*\*: Polyvinyl Alcohol (PVA)

- \*\*Justification\*\*: PVA dissolves in water, making it ideal for dissolvable packaging for detergent tablets, ensuring convenience and reducing waste.

2. \*\*High Performance Heat Seal for Sealing through Powder Contamination\*\*:

- \*\*Material\*\*: Aluminum Foil

- \*\*Justification\*\*: Aluminum foil provides excellent heat sealing properties and can seal through powder contamination, ensuring product integrity.

3. \*\*Ready Meal Tray for Reheating in Oven or Microwave\*\*:

- \*\*Material\*\*: Polypropylene (PP)

- \*\*Justification\*\*: PP is microwave-safe, heat-resistant, and suitable for oven reheating, making it ideal for ready meal trays.

4. \*\*Vacuum Bag for Whole Shell-on Shellfish\*\*:

- \*\*Material\*\*: Nylon/Polyethylene (PE) Combination

- \*\*Justification\*\*: Nylon provides strength and barrier properties, while PE offers flexibility, ensuring freshness and protection for shellfish.

5. \*\*Robust Transparent Plastic for Water Cooler Containers\*\*:

- \*\*Material\*\*: Polycarbonate (PC)

- \*\*Justification\*\*: PC is durable, transparent, and can withstand sterilization processes, making it suitable for water cooler containers in demanding environments.

**Question 3 (25 marks)**

1. **Identify the layers present in a laminate structure suitable for a carton of juice such as the product *Ribena*. Review the rational for each of the layers you have chosen for this structure.**

**(12 marks)**

**b) What are the advantages and disadvantages of wet and dry bond lamination?**

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1. **A typical laminate structure for a bag of crisps is MOPP / PE. What are the functions of these two layers**

**(5 marks)**

**d) How is the OPP in the above structure metalized to form MOPP**

**(2 marks)**

Answer:

a) Laminate Structure for a Carton of Juice (e.g. Ribena):

Layer 1: Paperboard (e.g. Solid Bleached Board - SBB)

- Provides stiffness and structure to the carton

- Offers a smooth surface for printing and graphics

- Allows for easy folding and creasing during carton formation

Layer 2: Polyethylene (PE) Extrusion Coating

- Acts as a heat-sealable layer for sealing the carton

- Provides a barrier against moisture and grease

- Improves the carton's resistance to leakage

Layer 3: Aluminum Foil

- Offers an excellent barrier against light, oxygen, and odors

- Helps maintain the flavor and quality of the juice

- Contributes to the carton's tamper-evident properties

Layer 4: Polyethylene (PE) Extrusion Coating

- Provides a second heat-sealable layer for improved sealing strength

- Acts as a protective layer for the aluminum foil

- Enhances the carton's resistance to punctures and abrasion

Layer 5: Polyethylene Terephthalate (PET) or Oriented Polypropylene (OPP) Print Layer

- Allows for high-quality printing of graphics and branding

- Provides a protective layer for the printed surface

- Enhances the carton's appearance and shelf appeal

b) Advantages and Disadvantages of Wet and Dry Bond Lamination:

Wet Bond Lamination:

Advantages:

- Allows for the use of a wider range of adhesives

- Suitable for laminating materials with different surface energies

- Can be used to laminate materials with irregular surfaces

Disadvantages:

- Slower production speeds compared to dry bond lamination

- Requires longer drying times for the adhesive

- Potential for adhesive migration into the food product

Dry Bond Lamination:

Advantages:

- Higher production speeds

- Shorter drying times for the adhesive

- Lower risk of adhesive migration into the food product

Disadvantages:

- Limited to the use of solvent-based or hot-melt adhesives

- Requires materials with similar surface energies

- Potential for delamination if the adhesive bond is not strong enough

c) Functions of MOPP and PE in a Typical Crisp Bag Laminate Structure:

MOPP (Metalized Oriented Polypropylene):

- Provides a barrier against light, oxygen, and odors

- Contributes to the bag's overall strength and puncture resistance

- Enhances the bag's appearance with its metallic finish

PE (Polyethylene):

- Acts as a heat-sealable layer for sealing the bag

- Provides a barrier against moisture and grease

- Improves the bag's resistance to leakage

d) Metallization of OPP to form MOPP:

Metallization is the process of depositing a thin layer of metal, typically aluminum, onto the surface of OPP (Oriented Polypropylene) film. This is usually done using a vacuum deposition process, where the OPP film is passed through a vacuum chamber and exposed to vaporized aluminum. The aluminum atoms condense on the film's surface, forming a thin, uniform metallic layer.

**Question 4 (25 marks)**

1. **Describe the production of a 500 ml polyethylene terephthalate injection stretch blow moulded bottle for a carbonated drink.**

**(15 marks)**

1. **Justify the materials and process for this application.**

**(5 Marks)**

1. **Discuss how an additional barrier layer could be formed into this container for use with wine or beer.**

**(5 marks)**

### Answer:

\*\*Production of a 500 ml Polyethylene Terephthalate (PET) Injection Stretch Blow Moulded Bottle for a Carbonated Drink:\*\*

1. \*\*Preform Injection Moulding\*\*:

- PET resin is melted and injected into a preform mould to create a tube-shaped preform with a screw thread at the top.

2. \*\*Preform Conditioning\*\*:

- The preform is heated to the optimal temperature for stretching and blowing.

3. \*\*Stretch Blow Moulding\*\*:

- The preform is transferred to the blow moulding machine where it is stretched and blown into the shape of the bottle using high-pressure air.

4. \*\*Cooling and Ejection\*\*:

- The bottle is cooled to set its shape and then ejected from the mould.

5. \*\*Trimming and Quality Control\*\*:

- Excess material is trimmed off, and the bottle undergoes quality checks for defects.

\*\*Justification for Materials and Process:\*\*

- \*\*PET Material\*\*: PET is chosen for its transparency, lightweight, durability, and barrier properties against gas and moisture, ideal for carbonated drinks.

- \*\*Injection Stretch Blow Moulding\*\*: This process allows for precise control over bottle thickness, uniform wall distribution, and high production efficiency, ensuring consistent quality.

\*\*Additional Barrier Layer for Wine or Beer Container:\*\*

- \*\*Material\*\*: EVOH (Ethylene Vinyl Alcohol) Barrier Layer

- \*\*Process\*\*: Co-extrusion during the blow moulding process

- \*\*Justification\*\*: EVOH provides excellent oxygen barrier properties, crucial for preserving the freshness and quality of wine or beer by preventing oxidation. Incorporating this layer during blow moulding enhances the bottle's barrier performance without compromising its structural integrity.

**Question 5 (25 marks)**

1. **Describe how a bag of crisps is formed and sealed from the reel of raw material to finished product.**

**(10 marks)**

**b) Review the 3 key parameters to control in this form fill seal process**

**(6 marks)**

1. **Review 3 other key parameters to control**

**(6 marks)**

1. **List three methods of testing for the effectiveness of the sealed bag**

**(3 marks)**

Here is a concise answer to your question about the production of crisp bags:

\*\*Formation and Sealing of Crisp Bags from Raw Material to Finished Product:\*\*

1. \*\*Film Unwinding\*\*: The crisp bag film, typically a laminate of MOPP (metalized oriented polypropylene) and PE (polyethylene), is unwound from a reel[1].

2. \*\*Printing\*\*: The film may be printed with graphics and branding using flexographic or rotogravure printing[1].

3. \*\*Forming\*\*: The printed film is formed into a tube shape by passing it through a forming collar[1].

4. \*\*Longitudinal Sealing\*\*: The edges of the film are sealed together using heat to form a longitudinal seam, creating a tube[1].

5. \*\*Transverse Sealing and Cutting\*\*: The tube is intermittently sealed across its width using heated jaws, forming individual bags. The bags are then cut apart[1].

6. \*\*Filling\*\*: The bags are filled with potato crisps through a hopper[1].

7. \*\*Final Sealing\*\*: The top of the filled bag is sealed using heated jaws, completing the package[1].

8. \*\*Inspection and Packaging\*\*: The sealed bags are inspected for defects and packed into larger bags or cartons for distribution[1].

\*\*Key Parameters to Control in the Form-Fill-Seal Process:\*\*

1. \*\*Film Tension\*\*: Maintaining proper film tension is crucial for consistent sealing and bag formation[1].

2. \*\*Sealing Temperature\*\*: The temperature of the sealing jaws must be precisely controlled to ensure effective sealing without damaging the film[1].

3. \*\*Dwell Time\*\*: The duration for which the sealing jaws apply pressure and heat to the film is critical for creating a strong seal[1].

\*\*Other Key Parameters to Control:\*\*

1. \*\*Film Registration\*\*: Accurate registration of the printed film is necessary for proper alignment of graphics and seals[1].

2. \*\*Filling Accuracy\*\*: Consistent filling of crisps into each bag ensures uniform weight and appearance[1].

3. \*\*Bag Dimensions\*\*: Maintaining the desired bag size and shape is important for product presentation and packaging efficiency[1].

\*\*Methods of Testing Sealed Bag Effectiveness:\*\*

1. \*\*Visual Inspection\*\*: Bags are visually inspected for proper sealing, alignment, and absence of defects[1].

2. \*\*Seal Strength Testing\*\*: Samples are tested for seal strength using destructive testing equipment to ensure adequate bond strength[1].

3. \*\*Leak Detection\*\*: Bags may be tested for leaks using methods like bubble testing or gas flushing to verify seal integrity[1].