Announcing a short course on

Plastics Packaging and Shelf Life

Presented by
Gordon L. Robertson PhD
University of Queensland &
Food●Packaging●Environment
Australia

© Food●Packaging●Environment
Why a short course on this topic?

- Packages made from glass and metal are essentially impermeable to gases and vapors

- Determining the shelf life of foods packaged in metal and glass containers is relatively straightforward
Why a short course on this topic?

- But packages made from thermoplastic polymers are permeable to small molecules such as gases, water vapor, organic vapors, etc.

- Need to know how permeable so can choose the right polymer(s) to provide the required shelf life.
There’s an old saying:

Any fool can do for $10 what a good engineer can do for $1
Why a short course on this topic?

- The same applies to packaging technologists!
- Anyone can over-package a product – requires expert knowledge to provide just the right amount of protection to give the desired shelf life

- With the current interest in sustainability, many companies are critically examining their packaging to ensure that they are not over-packaging (or offering unnecessary shelf life)
Packaging to Optimize Shelf Life
Short Course Agenda

Day 1:
- Functions and environments of packaging; packaging innovation; finding packaging information
- Structure and related properties of plastic polymers
- Processing of thermoplastic polymers
- Permeability of thermoplastic polymers
Short Course Agenda

Day 2:

- Deteriorative reactions in foods
- Shelf life determination
- Factors controlling shelf life
- Shelf life examples and discussion
Short Course Agenda

Functions and Environments of Packaging

Chapter 1
Functions/Environments Grid

- **Functions**
  - Containment
  - Protection
  - Convenience
  - Communication

- **Environments**
  - Physical
  - Ambient
  - Human

Our focus
Chemical Structure of Polymers

- Properties and structure of all the major polymers used in food packaging will be discussed
- Polyethylenes; polypropylene; ethylene-vinyl acetate copolymer; ethylene-vinyl alcohol copolymer; ethylene-acrylic acid copolymer; polystyrene; polyvinyl chloride; polyvinylidene chloride; polyethylene terephthalate; polyamides; acrylonitriles
Biobased Packaging Materials
Chapter 3
Short Course Agenda

Processing and Converting of Thermoplastic Polymers

Chapter 5
Extrusion

Feed hopper
Plastic pellets

Turning screw
Barrel
Molten plastic
Extrudate

Heaters
Shaping die

Tubing and pipes
Sheet and film
Structural parts

© FoodPackagingEnvironment
Vapour Deposition Processes

- Used to improve the barrier properties of plastics
- Physical vapour deposition (PVD)
- Chemical vapour deposition (CVD)
- Plasma-enhanced CVD (PECVD)
Nanocomposites

Automotive
Sport
Packaging

© Food•Packaging•Environment
Types of Composites

- Layered silicate
- Polymer

(a) microcomposite
(b) intercalated
(c) exfoliated
Extrusion Blow Moulding (EBM)

1. Parison ready
2. Mold closes over parison
4. Bottle removed and trimmed.

© Food•Packaging•Environment
Short Course Agenda

Permeability of Thermoplastic Polymers

Chapter 4
Possible Interactions

<table>
<thead>
<tr>
<th>Environment</th>
<th>Polymer film</th>
<th>Foodstuff</th>
<th>Migrating substances</th>
<th>Adverse consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td></td>
<td>PERMEATION</td>
<td>Oxygen, Water vapor, Carbon dioxide, Other gases</td>
<td>(1) Oxidation, Microbial growth, Mold growth, Off-flavor</td>
</tr>
<tr>
<td>(2)</td>
<td></td>
<td>MIGRATION</td>
<td>Monomers, Additives</td>
<td>(2) Dehydration, Decarbonation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ABSORPTION (SCALPING)</td>
<td>Aroma compounds, Fats, Organic acids, Pigments</td>
<td>Off-flavor, Safety problems, Loss of aroma intensity, Development of unbalanced flavor profile, Damage to the package</td>
</tr>
</tbody>
</table>
Permeability Model

Sorption (Henry’s Law)  Diffusion (Fick’s Law)  Desorption (Henry’s Law)

Polygon thickness X

P₁  c₁  P₂  c₂
Permeability Relationships

Thickness normalized flux, $N$
\[ \text{(quantity)(thickness)} \]
\[ \text{(area)(time)} \]

Transmission rate, WVTR, GTR
\[ \text{(quantity)} \]
\[ \text{(area)(time)} \]

Permeability coefficient, $P$
\[ \text{(quantity)(thickness)} \]
\[ \text{(area)(time)(\Delta p)} \]

Permeance, $R$
\[ \text{(quantity)} \]
\[ \text{(area)(time)(\Delta p)} \]
Measurement of Permeability

Aqua-Tran for WVTR measurements down to $5 \times 10^{-4} \text{ g m}^{-2} \text{ day}^{-1}$

See www.mocon.com

© Food●Packaging●Environment
Oxygen Measurement
OxySense

www.oxysense.com

© Food●Packaging●Environment
Short Course Agenda

Deteriorative Reactions in Foods

Chapter 11
Deteriorative Reactions in Foods

- Knowledge of the kinds of deteriorative reactions that influence food quality is the first step in developing food packaging that will minimize undesirable changes in quality and maximize development and maintenance of desirable properties.
- Once the nature of these reactions is understood, need to know the factors that control their rates.
Deteriorative Reactions in Foods

- Aim is to provide an overview of the major biochemical, chemical, physical and biological changes that occur in foods during processing and especially storage.
- These changes combine to affect food quality.
- Knowledge of such changes is essential before a sensible choice of packaging materials can be made since the rate and/or magnitude of the changes can often be minimized by selection of optimal packaging materials.
Deteriorative Reactions in Foods

- Deterioration of packaged foods depends largely on transfers between the internal environment inside the package and the external environment exposed to the hazards of storage and distribution.
- Example: transfer of moisture from humid atmosphere into a dried product.
- Packaging is directly related to food safety:
  - As a barrier to gases and water vapor to prevent microbial growth, and
  - Migration of food contact substances from the packaging material into the food.
Rates of Deteriorative Reactions

- Rates of deteriorative reactions depend on both intrinsic (compositional) and extrinsic (environmental) factors.
- It is important to have an understanding of the rates so that they can be controlled.
- Control requires a quantitative analysis based on knowledge of the kinetics of food deterioration.
- Fortunately, simple chemical kinetics can be applied to such reactions.
- Requires a measurable index of deterioration (IoD); that is, a chemical, physical, or sensory measurement that correlates with changes in food quality.
Intrinsic Factors Controlling Rates of Deteriorative Reactions

The two most important intrinsic factors are:

- Water Activity $a_w$
- Oxidation-Reduction Potential
Extrinsic Factors Controlling Rates of Deteriorative Reactions

- Temperature
- Gas Atmosphere
- Light
Transmission Curves of Milk Packaging Materials

- Clear glass
- Clear PET
- Pigmented PET
- Pigmented HDPE
- Paperboard carton
- 3-layer pigmented HDPE
Short Course Agenda

Shelf Life of Foods

Chapter 12
Shelf Life

- Quality of most foods and beverages decreases with storage or holding time (some exceptions)
- It follows that there will be a finite length of time before the product becomes unacceptable
- Time from production to unacceptability is referred to as shelf life
- Inadequate shelf life leads to consumer dissatisfaction and complaints
Shelf Life Determination

At least three situations when shelf life determination might be required:

- To determine the shelf life of existing products
- To study the effects of specific factors or combination of factors such as storage temperature, packaging materials, processing parameters or food additives on product shelf life
- To determine the shelf life of prototype or newly developed products
Critical Descriptors and Indices of Failure (IoFs)

- When a food is stored, changes occur that can be defined by one or more descriptors
- The critical descriptor is the one that limits shelf life
- In designing suitable packaging for foods, it is important first to define the critical descriptor(s) or indices of failure (IoFs) of the food, that is, the quality attributes that will indicate that the food is no longer acceptable to the consumer
- In shelf life testing, there can be one or more critical descriptors that constitute sample failure
Cutoff Point (COP)

- Next step is to specify the cutoff point (COP) or the endpoint of the particular degradation
- The COP indicates the limit beyond which (normally) acceptance by the consumer is significantly decreased
Influence of Packaging

- The final step is to ascertain which (if any) of the critical descriptors or IoFs might be influenced by the packaging, as packaging cannot prevent all deteriorative reactions or undesirable changes in foods.
- Different plastic films, for example, have different WVTRs and, thus, the shelf life obtained varies depending on the particular plastic polymer(s) selected for a given pack size.
Factors Controlling Shelf Life

- **Product characteristics** including formulation and processing parameters (*intrinsic* factors such as pH, $a_w$, enzymes, microorganisms and concentration of reactive compounds)
- **Properties of the package**
- **Environment** to which the product will be exposed during distribution and storage (*extrinsic* factors such as temperature, RH, light, total pressure and partial pressure of different gases, and mechanical stresses)

Thus the shelf life of food can be altered by changing its composition and formulation, processing parameters, packaging system or environment to which it is exposed.
Factors Controlling Shelf Life

Package Properties

- Water vapor transfer
- Gas and odor transfer
- Light transmission
- Package dimensions
- Package/product interaction
Shelf Life Determination

Accelerated Shelf Life Testing (ASLT)

- Chemical kinetics can be applied to quantify the effects of extrinsic factors on the rate of deteriorative reactions.
- By subjecting the food to controlled environments in which one or more extrinsic factors is maintained at a higher than normal level, rates of deterioration will accelerate.
- Result will be a shorter time to failure or end of shelf life.
- Magnitude of the acceleration can be calculated and the ‘true’ shelf life under normal conditions calculated.
- Thus shelf life testing can be completed in a much shorter time.
Short Course Agenda

- The short course concludes with an opportunity for you to discuss your own shelf life challenges

www.gordonlrobertson.com
Intensive but Enjoyable
Day 1:
- Functions and environments of packaging; packaging innovation; finding packaging information
- Structure and related properties of plastic polymers
- Processing of thermoplastic polymers
- Permeability of thermoplastic polymers

Day 2:
- Deteriorative reactions in foods
- Shelf life determination
- Factors controlling shelf life
- Shelf life examples and discussion
Why not register today?

Plastics Packaging and Shelf Life

March 31-April 1, 2016
Hyatt Regency New Brunswick
2 Albany St, New Brunswick, NJ 08901


© FoodPackagingEnvironment