Additives Primer
Blown Films, Cast Films & Extrusion Coating

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“Common” Additives for PE & PP Films

- Slips
- Antiblocks
- Antistats
- Antifogs
- Antioxidants
- UV absorbers
- UV inhibitors
- Fillers
“Exotic” Additives

- Nucleating/Clarifying agents
- Flame Retardants
- Antimicrobials
- Oxygen scavengers
- Odor absorbers
- Desiccants
Processing Temperatures for PE films

• Blown Film - Typically < 400F
• Cast Film - Range from 450 to 550F
• Extrusion Coating – Generally > 600F
• Challenges for high temp. processes (Cast film & extrusion coating)
  – Thermal Stability of additives
  – Moisture adsorption by additives
Slips: Mechanism

Layers Of Slip molecules

Slip Migration

Plastic Film
Slips

- Erucamide & Oleamide - most commonly used
- Challenges:
  - COF Control - Correct Loading
  - Thermal Stability (CF, EC)
  - Heat sealing
  - Printing
  - Maintenance of corona treatment
  - Adhesive laminations
  - Transfer on a roll
Antiblocks - Mechanism

Antiblock Particles

PE film layers

Film with Antiblock

Film without Antiblock
Antiblocks

• Diatomaceous earth (DE) and Talc - the most commonly used

• Challenges:
  – Quality of dispersion
  – Particle size & film layer ratios
  – Abrasiveness
  – Haze/Clarity
  – Correct loading (Related to polymer type)
  – Synergy with slips
Antistats - Mechanism

Layer of Antistat molecules

Charge Dissipation

Plastic Film

Antistat Migration
Antistats

- Various Chemistries- Amines, Amides & Esters most common
- Challenges:
  - Knowledge of specifications
  - Humidity Dependent
  - Migration slow- properties are time dependent
  - Polymer selection (Diff. AS chemistry)
  - Correct Loading (Multilayer films)
Antistats

• Challenges:
  – Thermal stability (CF, EC)
  – Heat Sealing
  – Printing (Ink Adhesion)
  – Maintenance of corona treatment
  – Adhesive Laminations
  – Other additives
Antifogs- Mechanism

Flat film of water

Layer of Antifog molecules

Antifog Migration

Plastic Film
Antifogs

- Chemistries must be FDA approved
  - Limited Chemistries
- Challenges:
  - Migration slow- properties are time dependent
  - Polymer selection (Diff. AF chemistry)
  - Correct Loading (Multilayer films)
  - Performance dependent on film structure, type of test, test equipment etc.
Antifogs

• Challenges:
  – Thermal stability (CF, EC)
  – Heat Sealing
  – Printing (Ink Adhesion)
  – Maintenance of corona treatment
  – Adhesive Laminations
  – Other additives
**Electromagnetic Spectrum**

- **Infrared (IR)**: 750 - 35000 nm
- **Visible light**: 400 - 750 nm
  - Red: 647-750 nm
  - Orange: 585-647 nm
  - Yellow: 575-585 nm
  - Green: 490-575 nm
  - Blue: 424-490 nm
  - Violet: 400-424 nm
- **Ultra Violet (UV)**: 200 - 400 nm
- **X Rays**: 0.01 - 10 nm

Intensity of the total sun irradiation is expressed in Kilolangleys (Kly):

1 Kly = 4.184 KJ/cm²
UV Absorbers vs. UV Inhibitors

- UV light (high energy) - can degrade the polymer as well as degrade the contents of a plastic package
- UV inhibitors - added to prevent polymer degradation and protect the film or the plastic package itself
- UV absorbers - added to absorb UV light & protect contents of a package
  - Organic UV absorbers
  - Inorganic UV absorbers
Organic UV Absorbers

- Efficiency
  - Lambert-beer’s law
    \[ \text{Abs} = k \cdot t \cdot c \]
    - Abs = Absorbency
    - k = extinction coefficient
    - t = thickness
    - c = concentration
  - UV absorbency is proportional to additive concentration and film thickness
  - Only for “thick” film (above 100µm)
  - Compatibility limit: 5000-6000ppm
UV Screening of 100µm films containing 2000ppm Organic UV Absorber 1 (2% 10057) and 2000ppm Organic UV Absorber 2 (100645)
UV Absorbers

- **Challenges:**
  - Blocking UV light completely in a thin, transparent film (< 100 µ)
  - Organic UVAs
    - Additive migration
    - Yellowish color
  - Inorganic UVAs
    - Quality of dispersion
    - Haze/poor clarity
UV Inhibitors

- Protect the polymer from degradation caused by exposure to UV light
- Scavenge free radicals
- Hindered Amine Light Stabilizers (HALS) are the most common ones
Auto Oxidation Cycle

1. UV light/Heat causes HALS to initiate the cycle.
2. HALS reacts with ROO. forming ROOH.
3. ROOH decomposes to form RO. + HO.
4. RO. reacts with oxygen to form ROO. + RH.
5. ROO. reacts with polymer to form ROO.+ polymer.
6. RH reacts with HALS to resume the cycle.
UV Inhibitors

• Challenges:
  – Correct loading
  – Proper selection of HALS
  – Interaction with other additives
  – Interaction with acidic chemicals such as pesticides & herbicides
Antioxidants

- Protect the polymer from thermal degradation
  - Processing
  - Long term storage under hot conditions
- Hindered phenols (primary AO) and phosphites (secondary AO) are the most common
Auto Oxidation Cycle

ROO. + RH → ROOH
ROOH → ROO. + RH
ROO. + HO → RO. + HO
RO. + R → polymer

Phenols
Phosphites
Oxygen
UV light/Heat
Antioxidants

• Challenges:
  – Discoloration such as pinking or yellowing caused by phenolic AOs (biggest challenge)
  – Hydrolysis of phosphites
  – Correct loading
SUMMARY

• Additive Challenges:
  – Proper chemistry selection & correct loading
  – Migration (slips, antistats, antifogs)
  – Thermal Stability/Smoking (cast film & extrusion coating)
  – Heat sealing, Printing & Adhesive Lamination
Thank You

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Please remember to turn in your evaluation sheet...