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Polyethylene Gels: A Primer

Presented by:

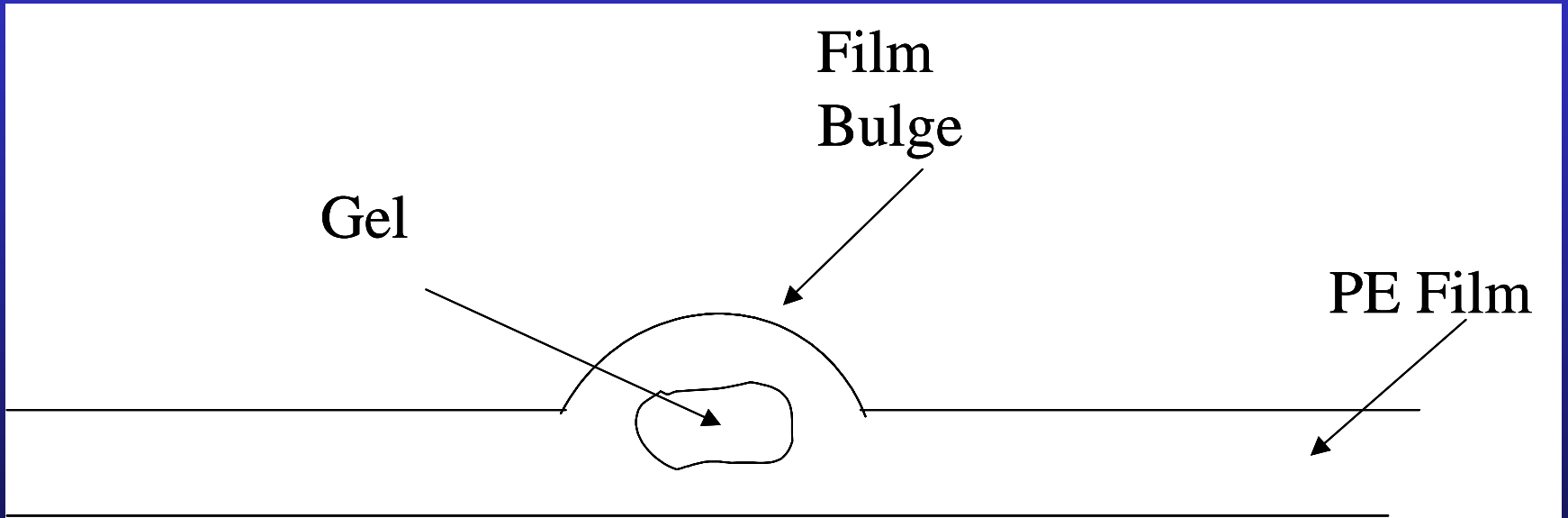
Norman Aubee

 **NOVA** Chemicals®

Outline

- Why do gels cause problems
- Types of gels
- Process for trouble Shooting Gel Issues
- Collection and Analysis
- Troubleshooting/Corrective Actions
- Acknowledgements

Why Do Gels Cause Problems?



Types of Gels

- **Polyethylene**
 - (cross-linked, high density, high molecular weight)
- **Oxidized polyethylene**
- **Other polymers**
 - (e.g. EVA, ionomers, cyclic olefins, etc.)
- **Fibers**
 - (e.g. cellulose)
- **Additives**
- **Miscellaneous**
 - (metal shards, dust particles, etc.)

Trouble Shooting Gel Issues

- **Collection of Information is Key**
- **Collection and Analysis of gels**
 - **Appropriate sample, number of gels needed**
- **Corrective Action**
 - **Knowing the type of gel present narrows the troubleshooting or corrective action process**

Collection of Information

- Is the gel issue specific to one extrusion line or multiple extrusion lines?
- What do the gels look like?
 - (Size, shape, color, any defining characteristics?)

Collection of Information

- Where are the gels located on the web or bubble?
 - Location
 - Across web or bubble?
 - Specific Lanes or areas?
 - Uniform in the machine direction?
 - Bursts?

Collection of Information

- Problem on monolayer or coextrusion lines?
- When was the problem first noticed?
- What materials are being used
- Did the problem occur during transition to new resins or formulation?

Collection of Information

- What was run last on the film line? Did the last formulation exhibit gels?
- Has any other materials been run on the processing line since the gel issue was observed?
- What actions have been taken to reduce the gels?

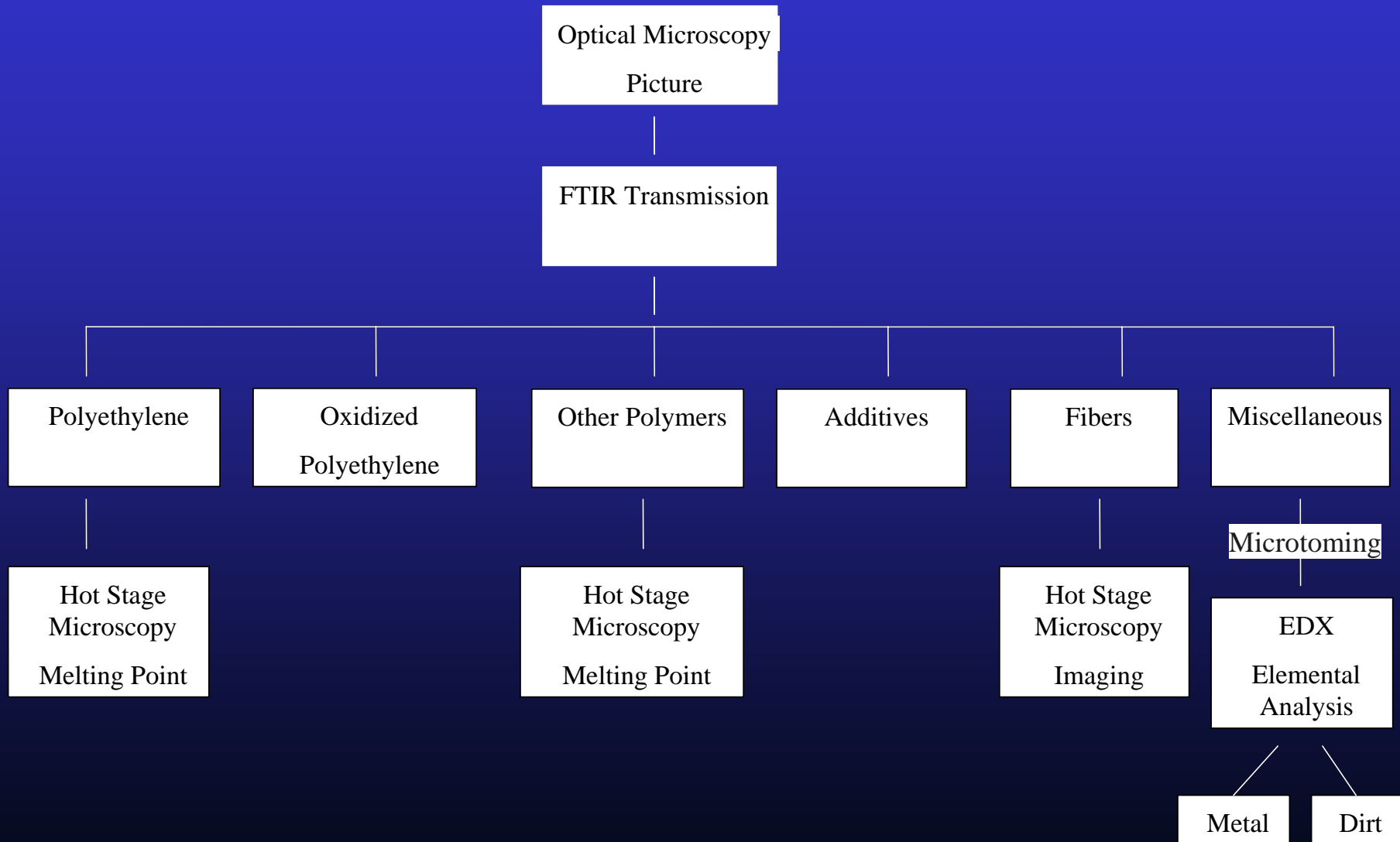
Collection of Gels

- Representative sample
- Check for distinguishing features
- How many gels are enough?

Analysis of Gels

- **Optical microscope with hot stage attachment**
- **Fourier Transform Infrared Spectrometer (FTIR) fitted with microscope**
- **Energy Dispersive X-ray spectroscopy (EDX)**

Gel Analysis



Corrective Action

- **Knowing the type of gel will determine the corrective actions**
- **If gel type is unknown, information collected will help narrow the possible causes/gel types**

Corrective Action

- **Always keep samples when making adjustments**
- **Record any changes and note what effect those changes had on the process as well as the product**
- **Collect resin and film sample for potential third party analysis**

Acknowledgements

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Thank You

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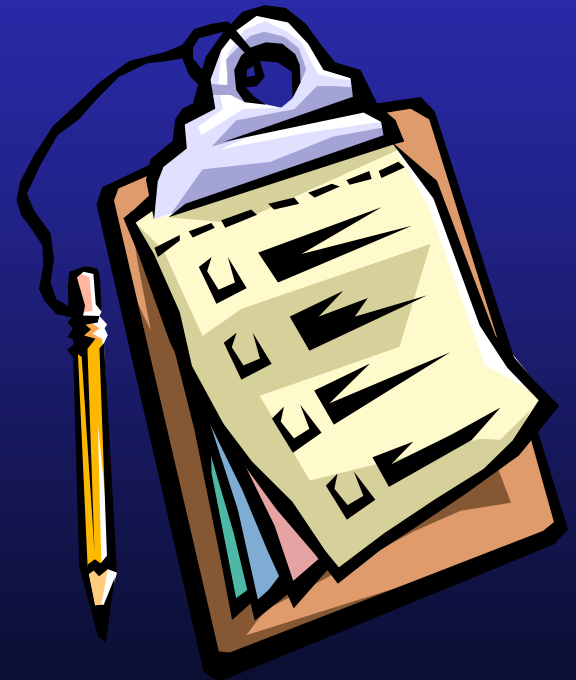
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*Please remember to
turn in your evaluation
sheet...*

Appendix

Methods to Minimize Oxidized, Cross-linked Gels

- **Suspected Cause: Using Materials which have multiple heat histories (e.g. reprocessed resin)**
 - Remove scrap or trim from formulation
 - Additional stabilizer either to formulation or to reprocessed resin
- **Suspected Cause: Degraded material being sloughed from extrusion line**
 - Perform a purge procedure
 - Shut down line a clean equipment

Methods to Minimize Oxidized, Cross-linked Gels

- **Suspected Cause: Excessive shear heating during extrusion process**
 - Reduce melt temperature of polymer
 - Reduce adaptor and die temperatures
 - Utilize a screen pack with coarser mesh
 - Consider adding polymer process aid to reduce frictional heating
 - Consider modifications to processing equipment (new screw design to reduce frictional heating)
 - Ensure melt temperature reading are correct

Methods to Minimize Oxidized, Cross-linked Gels

- **Suspected Cause: Processing Line**
 - Check wear of feedscrew and barrel, check die and adaptor for pitting or wear of metal coating
 - Check for dead zones
- **Suspected Cause: Raw Material**
 - Collect resin and finished product samples and contact material supplier

Methods to Minimize Polyethylene Gels

Prior to attempting these corrective actions, ensure there is no cross contamination

- **Suspected Cause: Poor Mixing**
 - Adjust temperature profile to increase mixing. Typically this can be accomplished by increasing barrel temperature set point of the last 3 zones
 - If blending two materials, eliminate blend or minor component.
 - If applicable, increasing heat pressure

Methods to Minimize Polyethylene Gels

- **Suspected Cause: Mismatch Particle Size**
 - Reduce feed zone temperature to prevent pre-melting of finer or smaller particles
 - Reduce or eliminate amount of finer particle size material
 - Utilize feedthroat cooling or increase coolant flow rate
- **Suspect Cause: Raw Material**
 - Collect resin and finished product samples and contact material supplier

Methods to Minimize other Polymer Gels

- **Suspected Cause: Melt Viscosity Mismatch**
 - Select blend component with more similar melt viscosities
 - Attempt to improve mixing (see section on poor mixing under polyethylene gels)
- **Suspect Cause: Contamination**
 - Ensure there is no contamination of pellets up stream of extruder feedthroat. Check main hopper on extruder for different pellet shapes or types. Check material handling system upstream of processing line for contamination. Work back to silo(s) for each of the formulation components
 - Clean all blending equipment and material hoppers on processing line
 - Process formulation on another line. If no gels are observed then purge or clean the line

Methods to Minimize Fier/Metal/Dirt gels

- **Suspected Cause: Fibers**
 - Determine fiber type
 - Do not store material in unlined boxes, fiber drums, paper bags (cellulose fibers)
 - If using paper or cardboard packaging, ensure a sharp knife is used to make a clean cut when opening
 - Ensure air used in resin conveying equipment is filtered to eliminate dust, dirt, fibers
 - Change filtering media on resin conveying equipment at recommended intervals
 - Check resin in feedhopper and resin silo for contaminate
 - Ensure conveying equipment hoses are capped when not in use, and are stored in a clean location

Methods to Minimize Fiber/Metal/Dirt gels

- **Suspect Cause: Metal**
 - Determine type of metal
 - If metal is ferromagnetic, a magnet installed in the feedthroat will help minimize reoccurrence and protect extrusion equipment
 - Ensure extrusion line has not been damaged. Check screen packs for build up
 - Inspect resin conveying system for wear, especially elbows and bends
 - Inspect raw material
- **Suspect Cause: Metal**
 - Ensure conveying equipment hoses are capped when not in use, and are stored in a clean location
 - Use gaylord covers when using materials in boxes

Is problem specific to one extrusion line or multiple lines?

Problem related to a single line

Problem related to multiple lines

Has resin formulation been run before?

Has resin formulation been run before?

Yes

No

No

Yes

Determine nature of gel

Remove blend components to determine source of gels

Collect 25- 50 kg. of each raw material as well as the blend.
Contact raw material supplier(s)

Poor mixing a potential issue
Contamination a potential issue



Gel Frequency

Gels present in bursts

Gel level constant

Are gels visible around bubble or specific lanes?

Are gels visible around bubble or specific lanes?

Visible around bubble

Gels in specific lanes

Visible around bubble

- * Possible contamination
- * Variation in blend ratio
- * Possible raw material issue

Review section on Dirty Processing Line

Remove blend components to determine if gel level improves

Gel level improves

Gel level remains the same

Possible blend issue or raw material issue

Possible raw material issue or dirty processing line