Defects in Food Packaging

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Why be Concerned with Packaging Defects?

- The FDA Food Safety Modernization Act (FSMA), the most sweeping reform of our food safety laws in more than 70 years, was signed into law by President Obama on January 4, 2011. It aims to ensure the U.S. food supply is safe by shifting the focus from responding to contamination to preventing it.

Why be Concerned with Packaging Defects?

- Millions of aluminum and tinplated steel cans, glass and plastic bottles, multi-layer plastic pouches enter the marketplace every day.
- The packaging manufacturing plants and their material suppliers are responsible for product integrity prior to distribution of the packaging to food and beverage manufacturing operations throughout the world.
- At the packaging manufacturing facilities, incoming quality control and internal quality control are quite extensive.
- Many of the packaging defects that would result in potential consumer issues are quickly eliminated from the consumer pipeline.

Why be Concerned with Packaging Defects?

- Inevitably, defective packaging will appear in the marketplace, resulting in consumer complaints that must be addressed by the manufacturers.

- The cause and extent of the defects must be determined quickly (especially if a major recall is looming), even if it means shutting down production lines while waiting for answers and corrective actions.

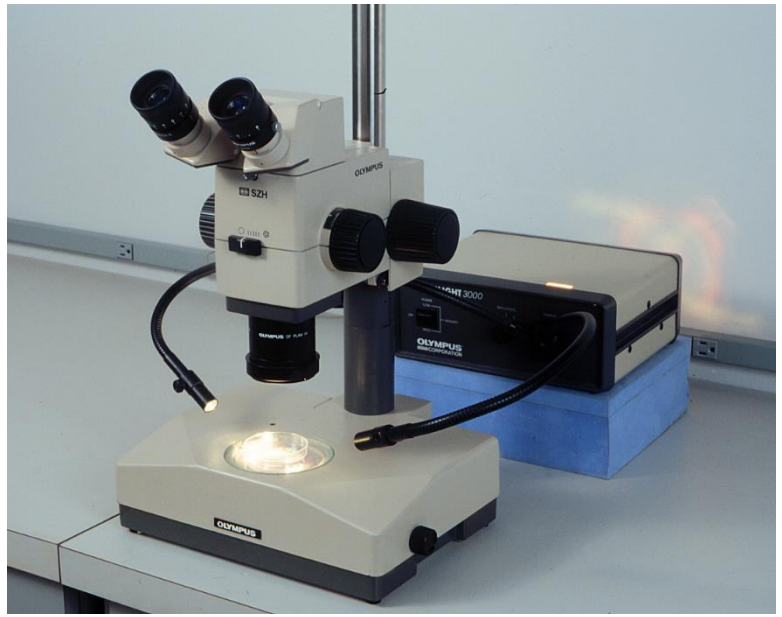
Why be Concerned with Packaging Defects?

- Major packaging manufacturers have extensive analytical laboratories with a vast array of instrumentation and technical expertise for troubleshooting the defects.

- Smaller manufacturers, with limited internal laboratories, usually have to rely on outsourcing to a network of independent laboratories to assist with their troubleshooting analyses.

Common Instrumentation for Packaging Defect Analysis

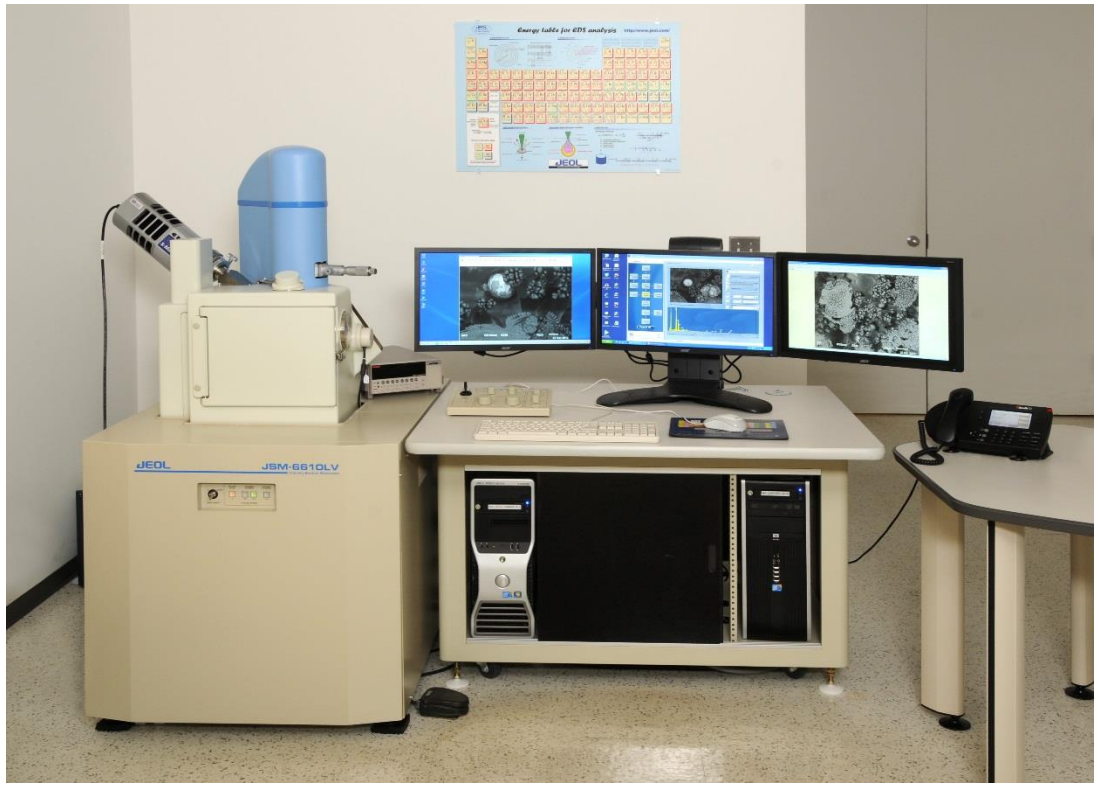
Visual inspection



Stereo microscope

Polarized light microscope

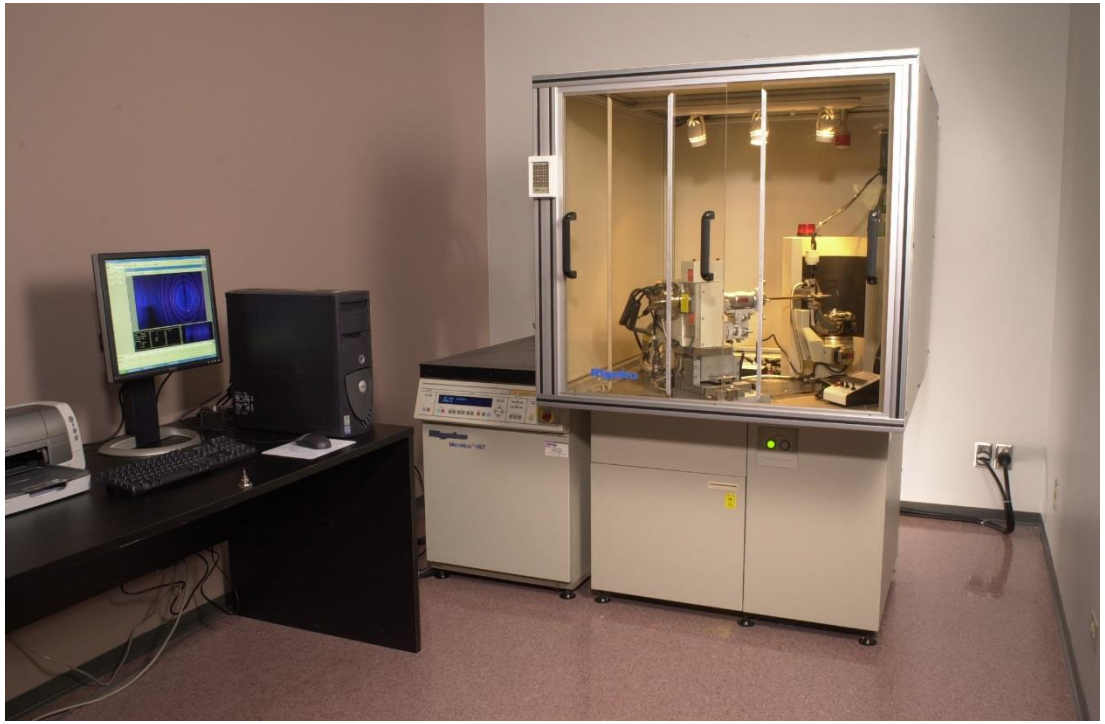
Common Instrumentation for Packaging Defect Analysis



Scanning Electron Microscope (SEM)
with
Energy Dispersive X-Ray Spectrometry (EDXS or EDS)

Fourier Transform Infrared Spectroscopy (FTIR)

Other Instrumentation for Packaging Defect Analysis



X-Ray Diffraction (XRD)

Raman Spectroscopy

Other Instrumentation for Packaging Defect Analysis

Secondary Ion Mass Spectrometry (SIMS)

X-Ray Photoelectron Spectroscopy (XPS)
[also known as Electron Spectroscopy for Chemical Analysis (ESCA)]

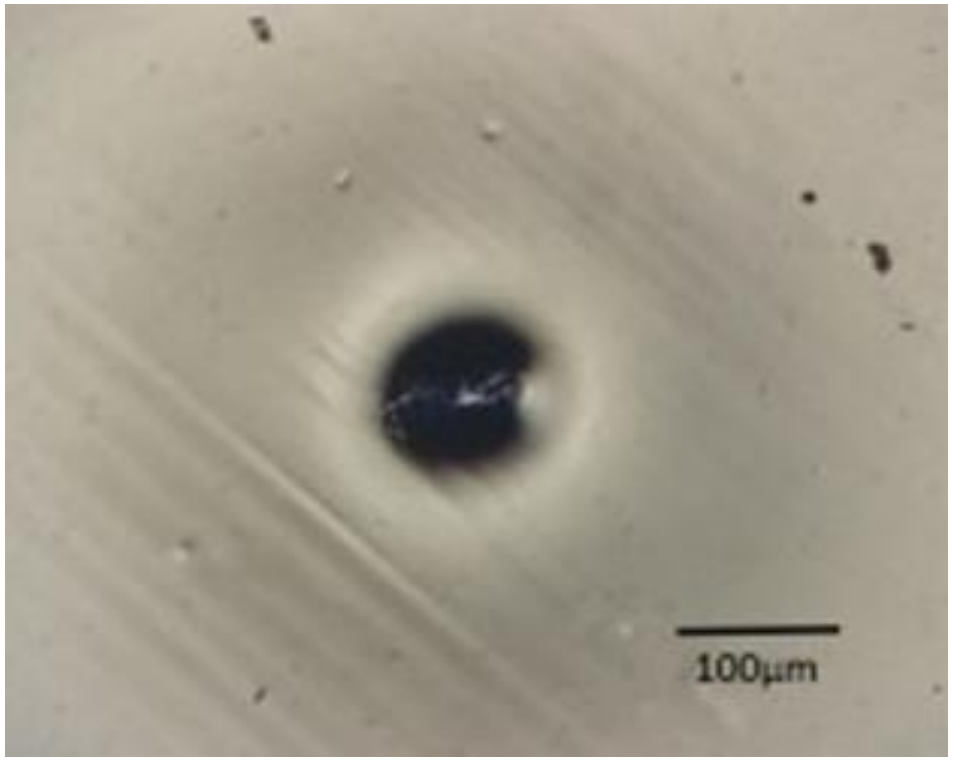
Sample Preparation – The Particle Approach

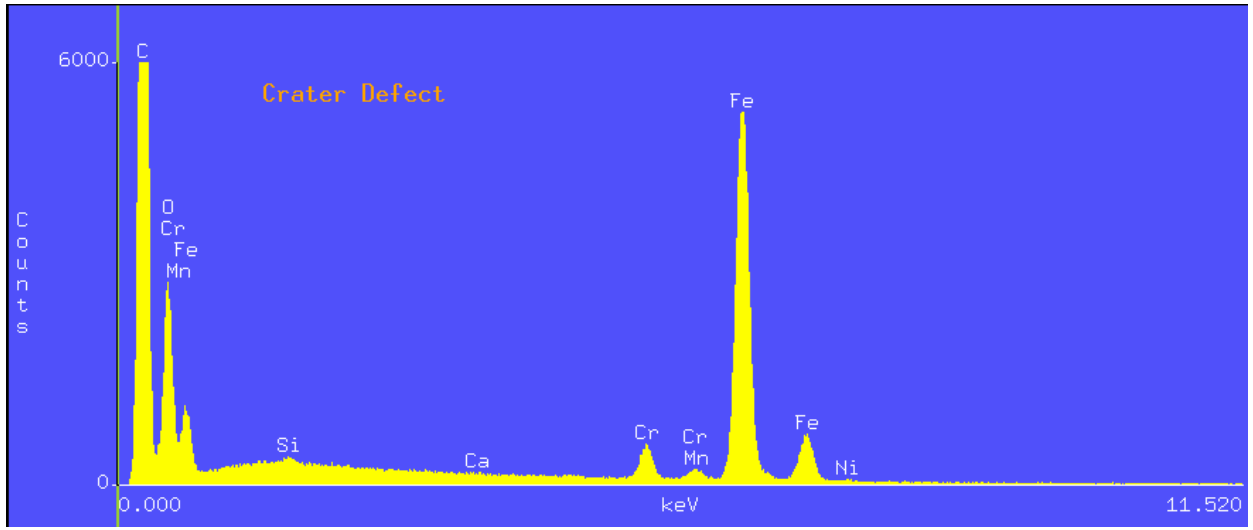
It takes a team of well trained and highly skilled microscopists to isolate, manipulate, and mount microscopic quantities of materials (often found in packaging defects) for the analytical microscopy methods used to characterize and identify the materials.

Case Studies – Packaging Defect Investigative Analysis

- Crater defect in a tinplate steel can interior coating
- Aluminum can interior coating blisters
- Corrosion attack on aluminum baked product pan
- Sulfide staining on tinplate steel tuna can end
- Loose end seams on aluminum beer cans
- A contaminant in plastic food pouch sheet
- Multi-layer plastic pouch heat seal failure
- “Brown” stains under a food can internal coating
- Severe pitting corrosion in aluminum cans prior to applying the coating

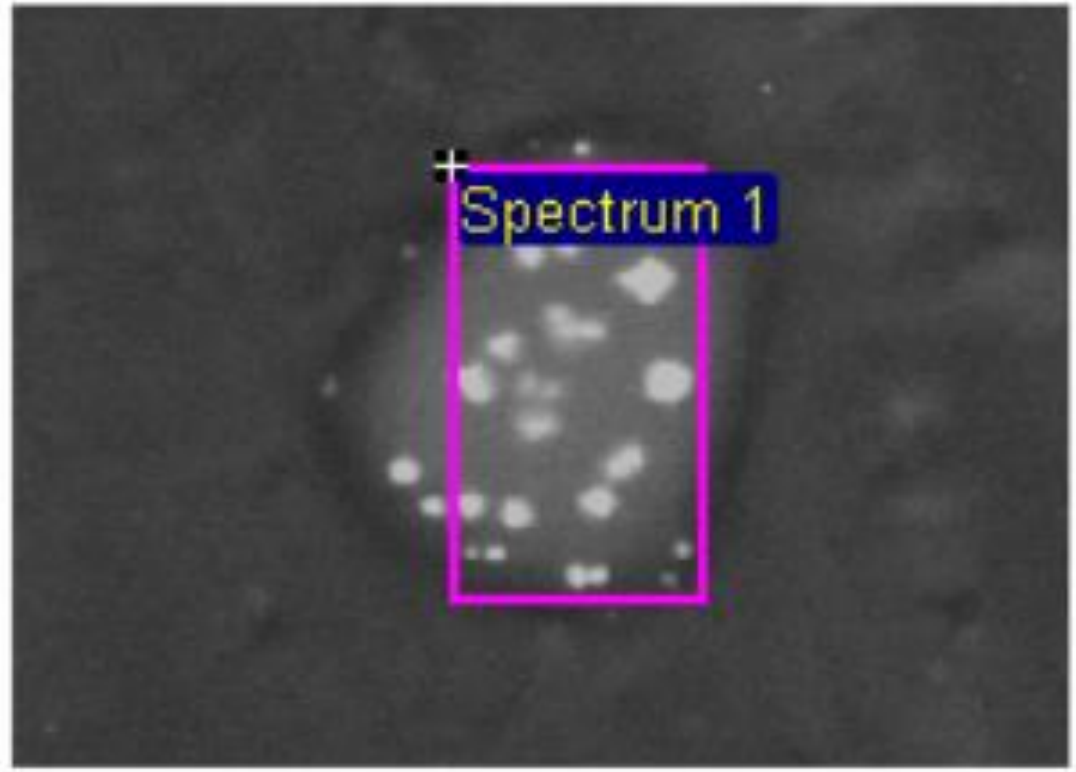
Crater Defect in Tinplate Steel Can Interior Coating



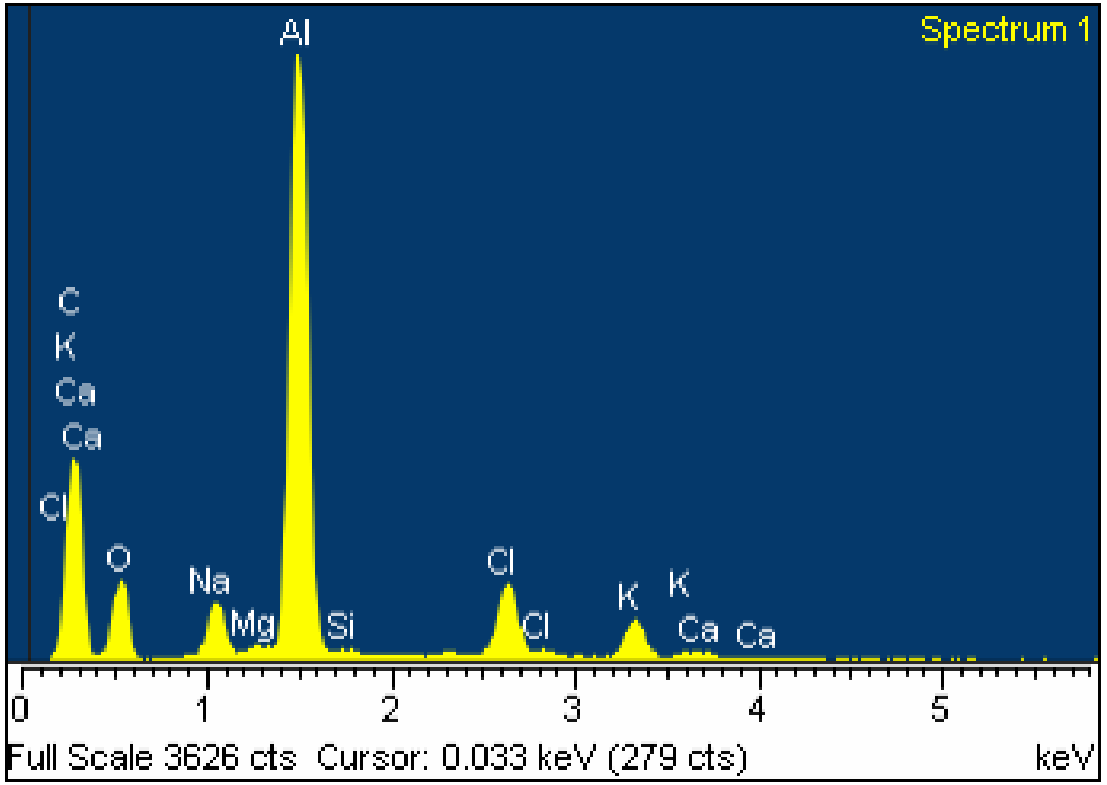


EDS element X-Ray spectrum

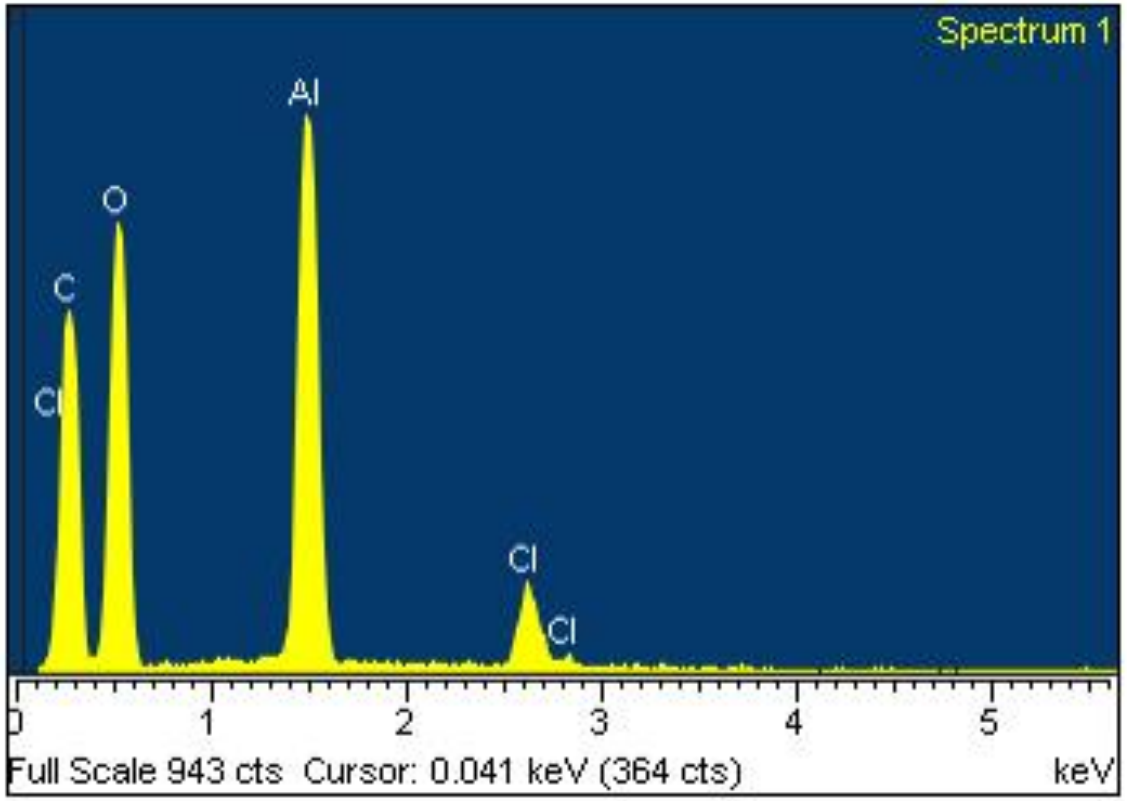
Aluminum Can Interior Coating Blisters

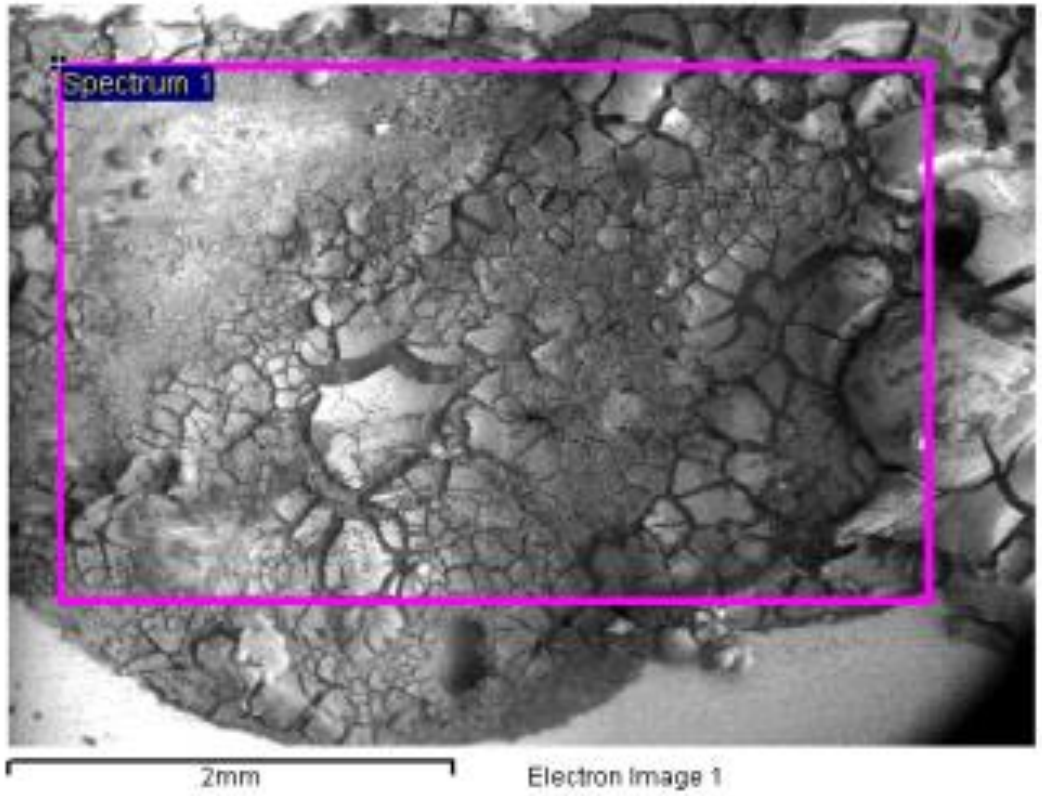


40µm Electron Image 1

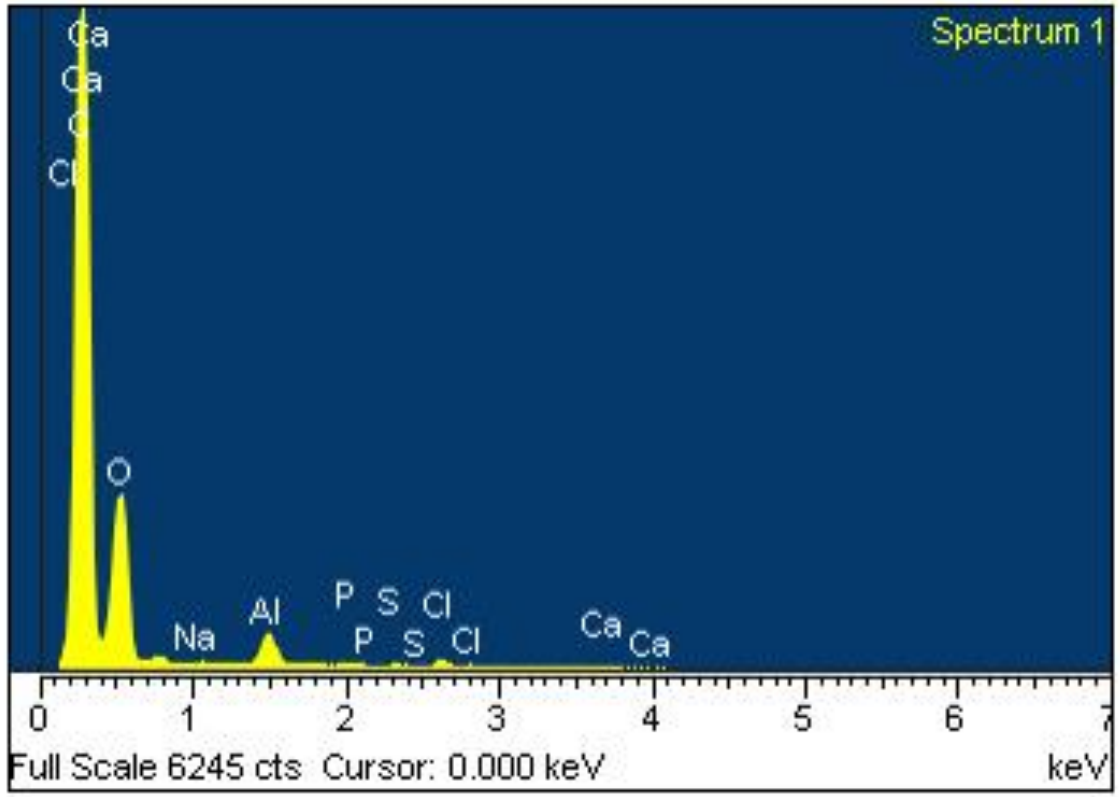


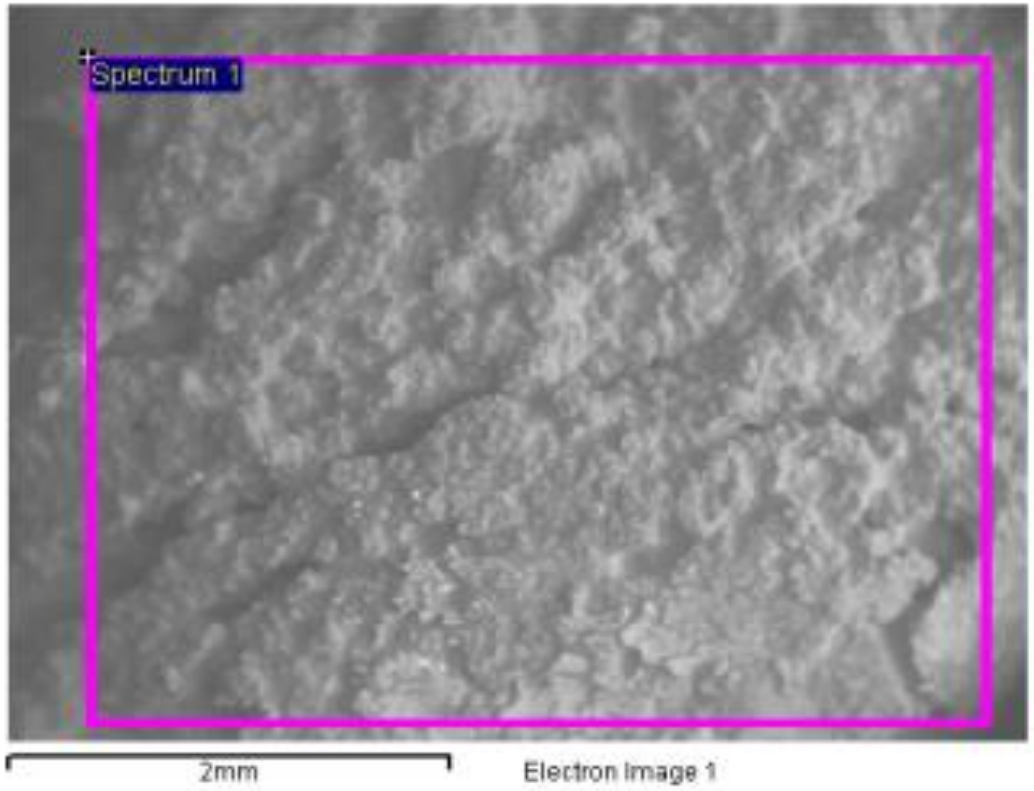
Corrosion Attack on Aluminum Baked Product Pan





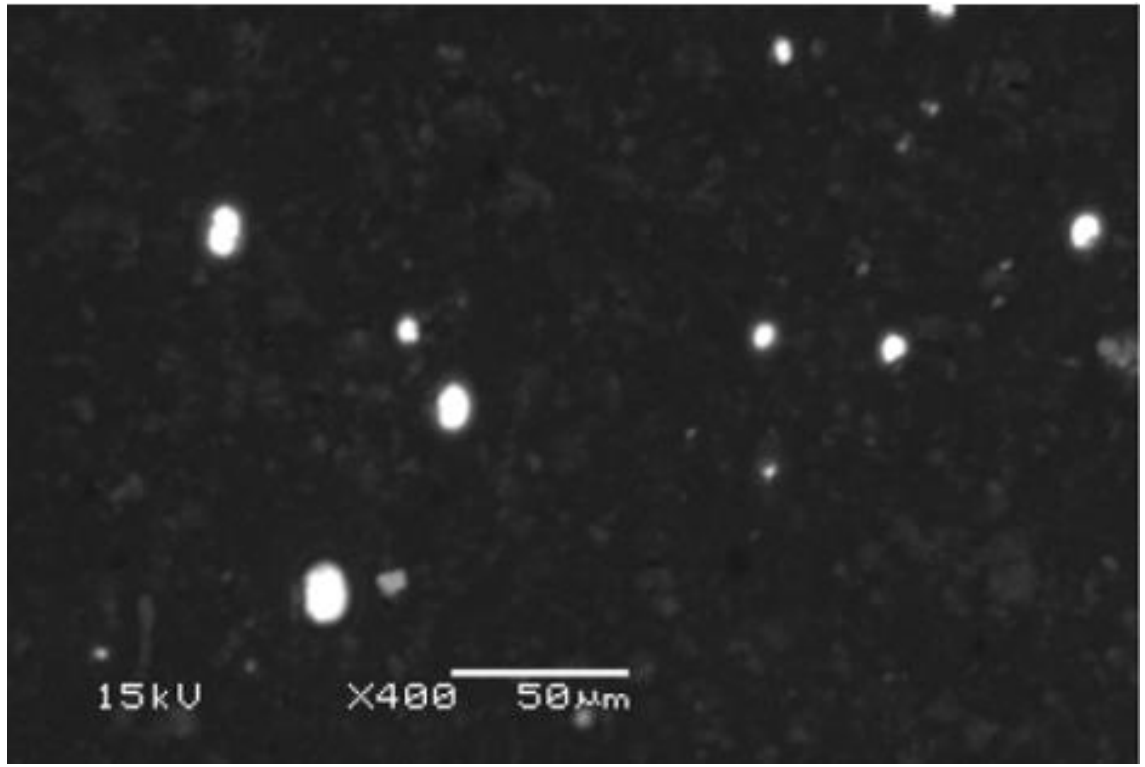
Corrosion Attack on Aluminum Baked Product Pan



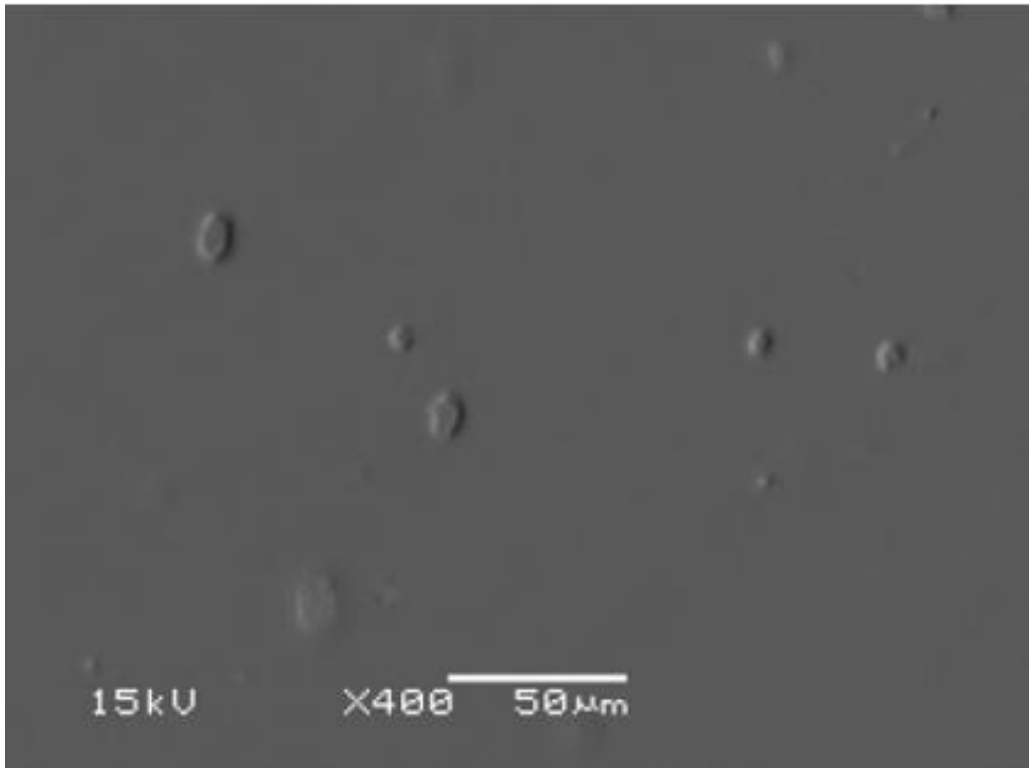


Corrosion residue elements found on the bottom of the baked product

Sulfide Staining on Tinplate Steel Tuna Can End

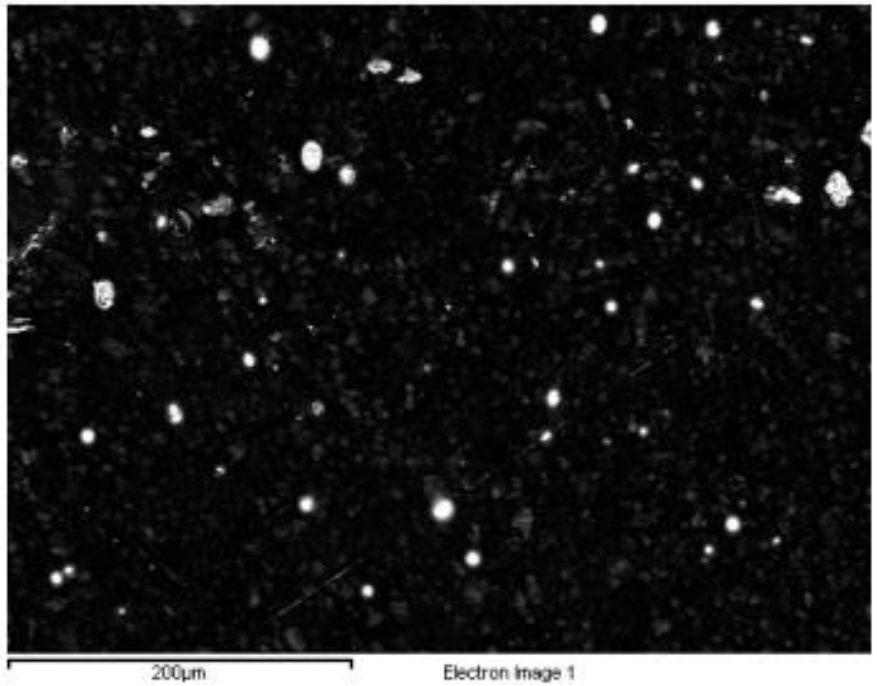


SEM backscattered electron image of the internal coating

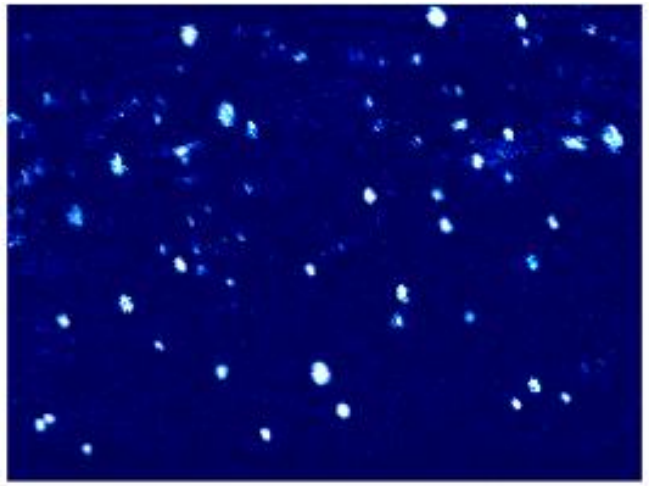


SEM Topographic Image

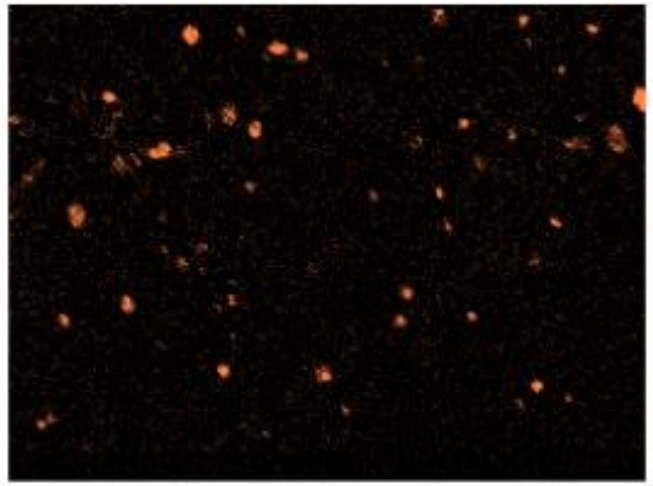
Sulfide Staining on Tinplate Steel Tuna Can End



SEM Backscattered Electron Image

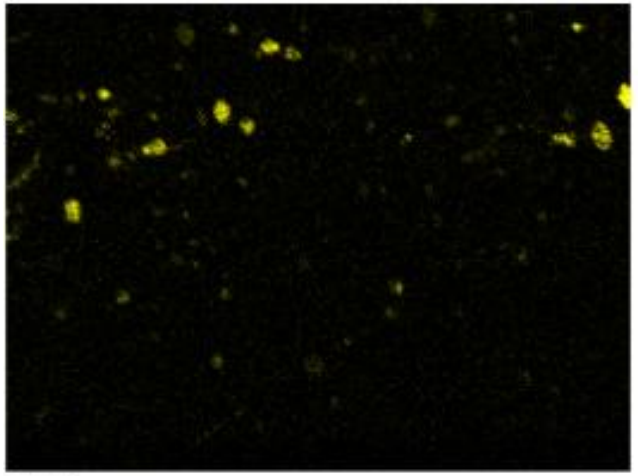


Sn La1



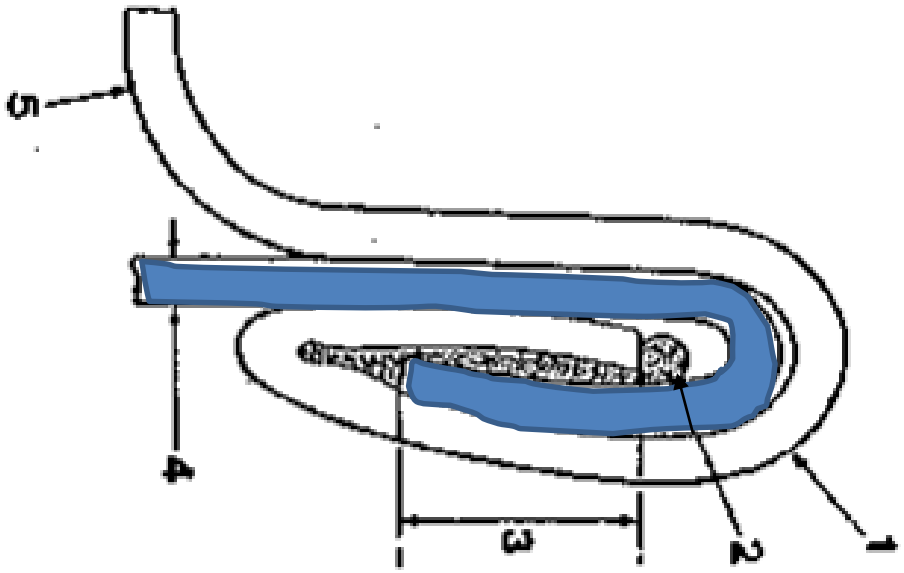
Fe Ka1

EDS X-Ray Elemental Maps



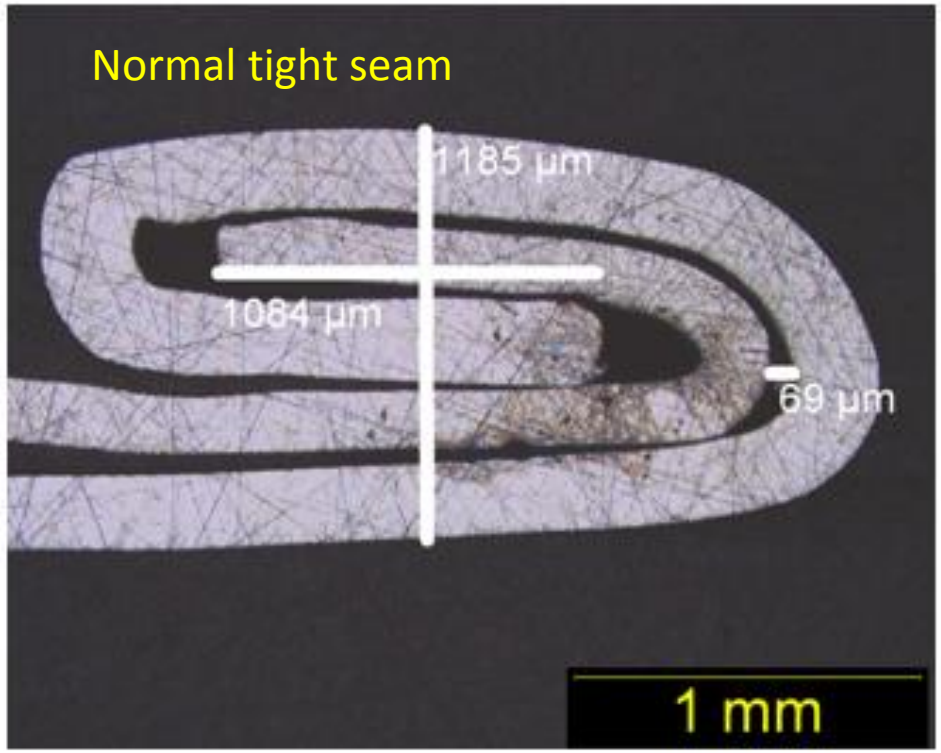
S Ka1

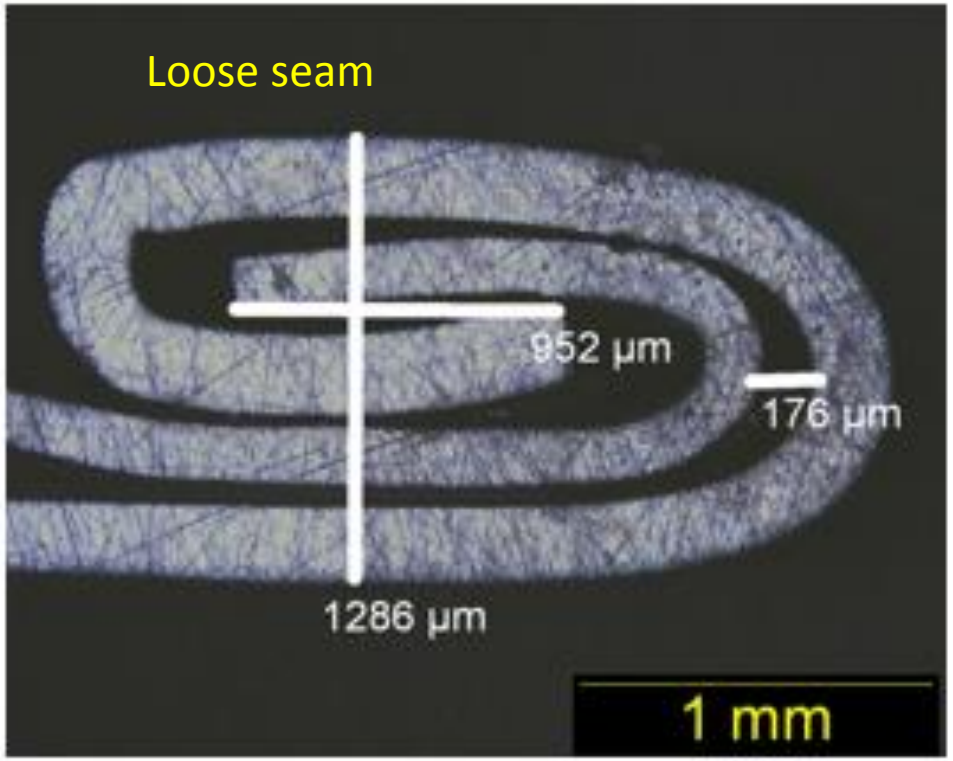
Loose End Seams on Aluminum Beer Cans



1. Can end curl folded around can body hook (flange area)
2. Sealing compound
3. Seam overlap
4. Can body
5. Can end

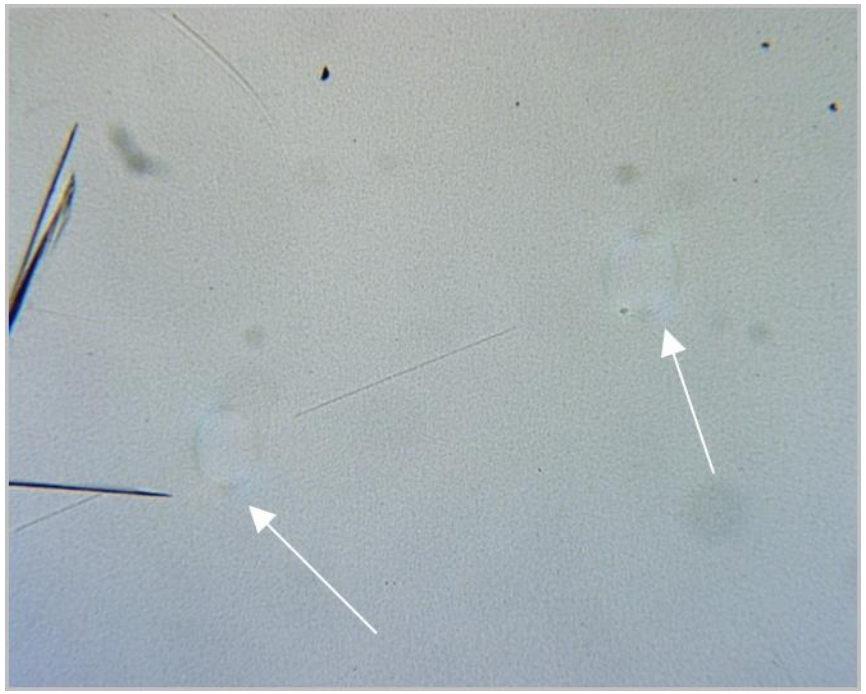
Loose End Seams on Aluminum Beer Cans



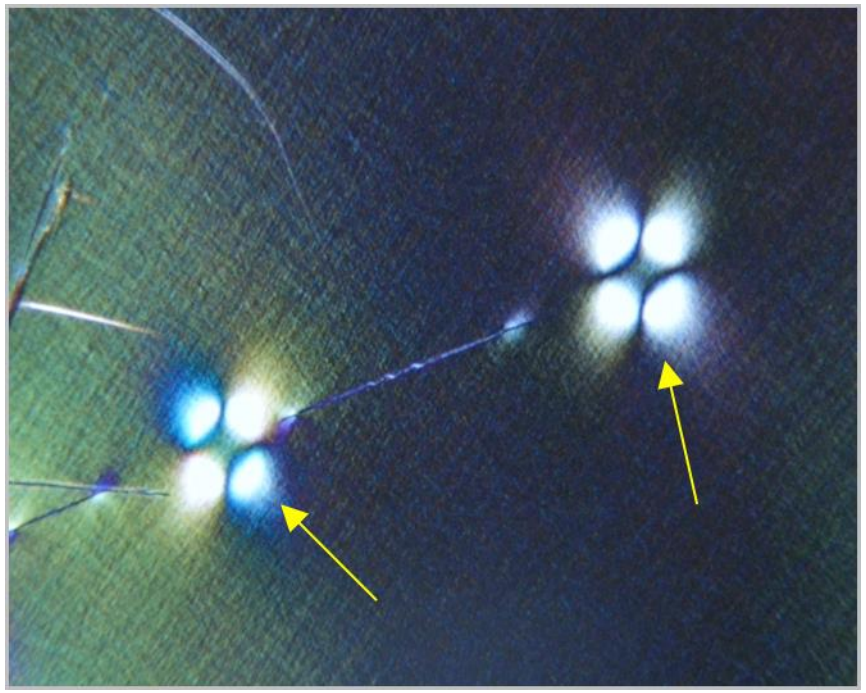


Metallographic semi-polished cross sections embedded in epoxy mount

A Contaminant in Plastic Food Pouch Sheet

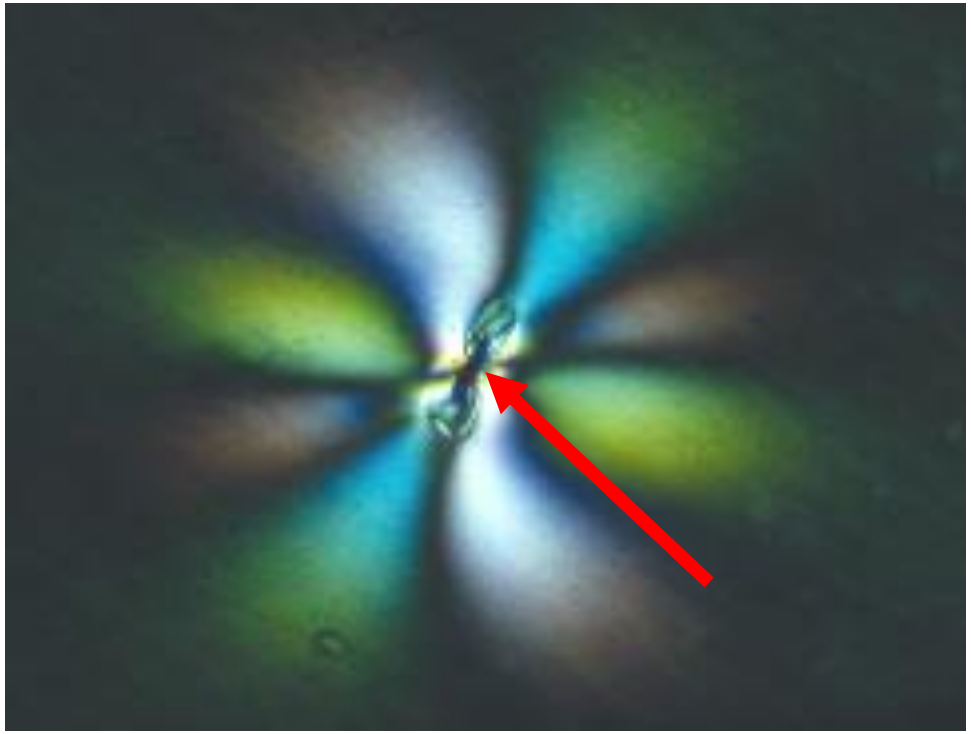


Polarized Light Microscope (PLM) image viewed with transmitted brightfield lighting

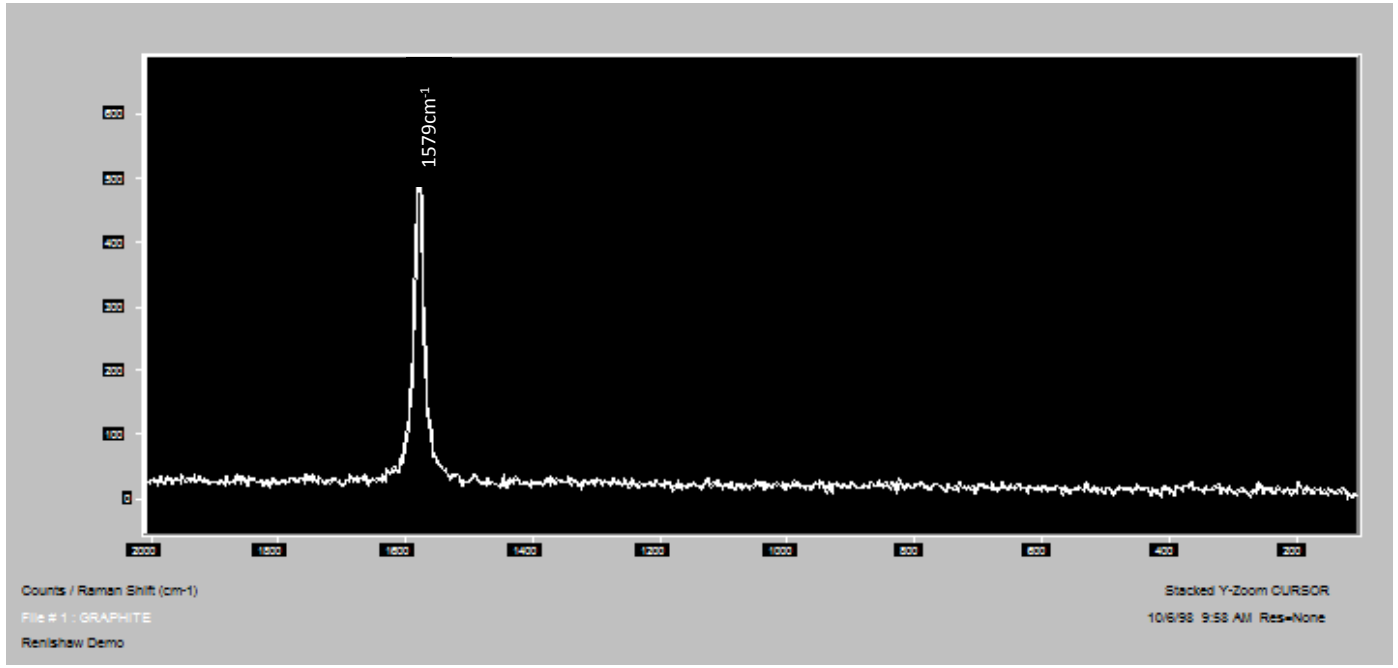


Polarized Light Microscope (PLM) image viewed with transmitted lighting and crossed polarizing filters

A Contaminant in Plastic Food Pouch Sheet

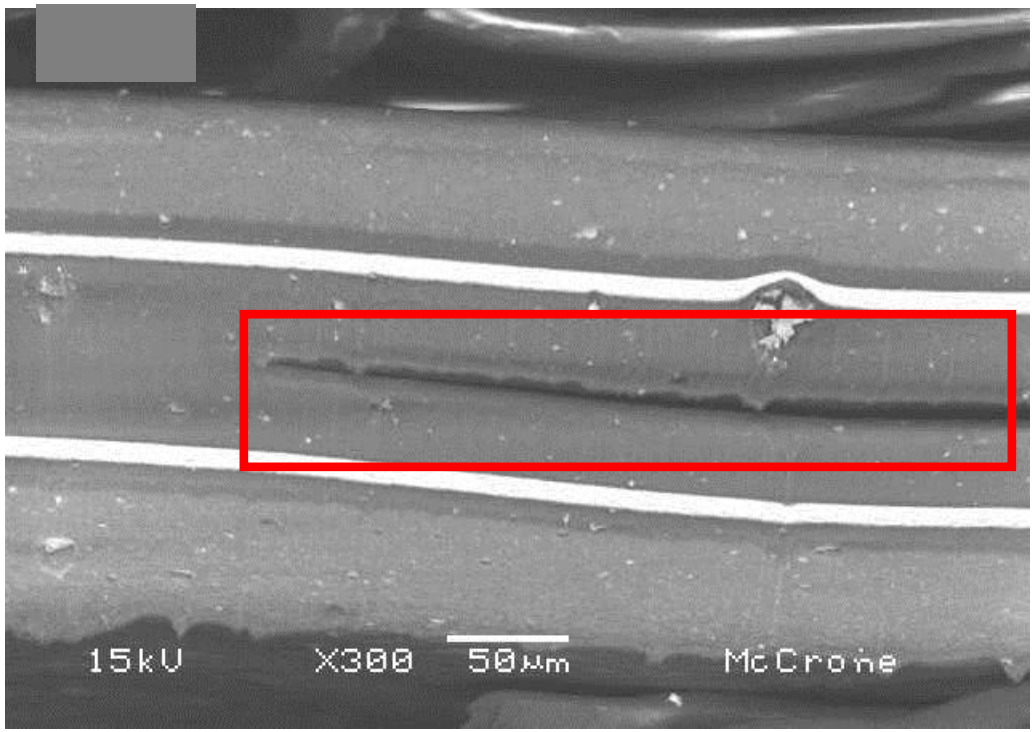


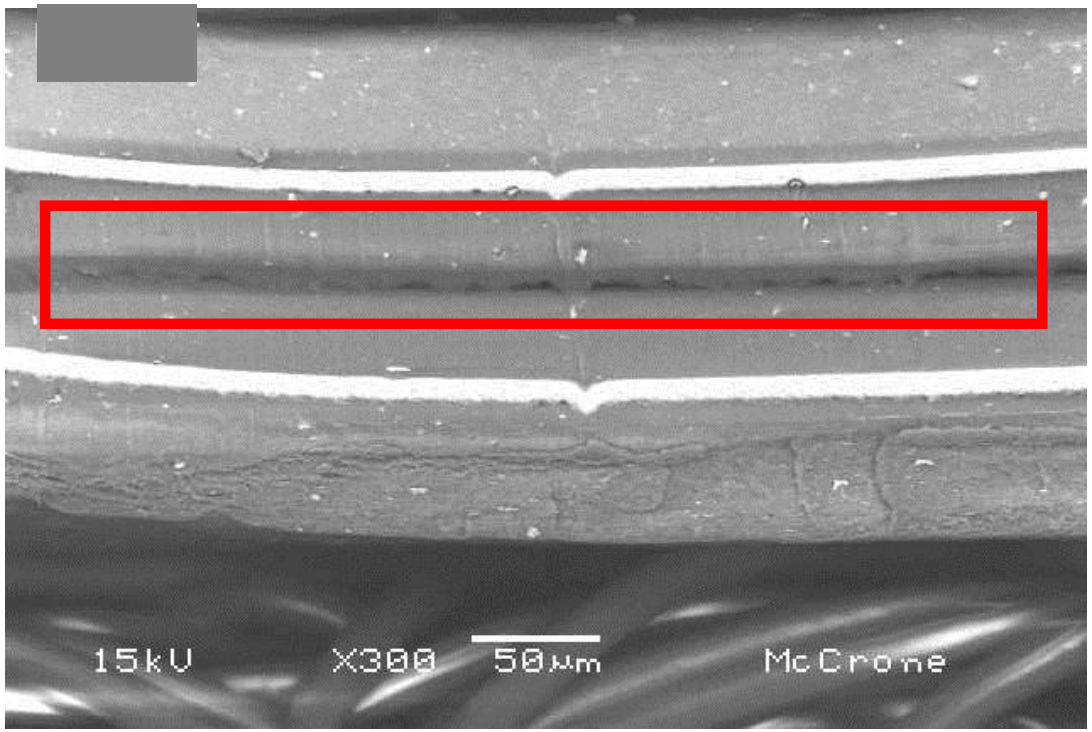
Polarized Light Microscope (PLM) image viewed with transmitted lighting and crossed polarizing filters



Raman spectrum of graphite – 1579cm^{-1}

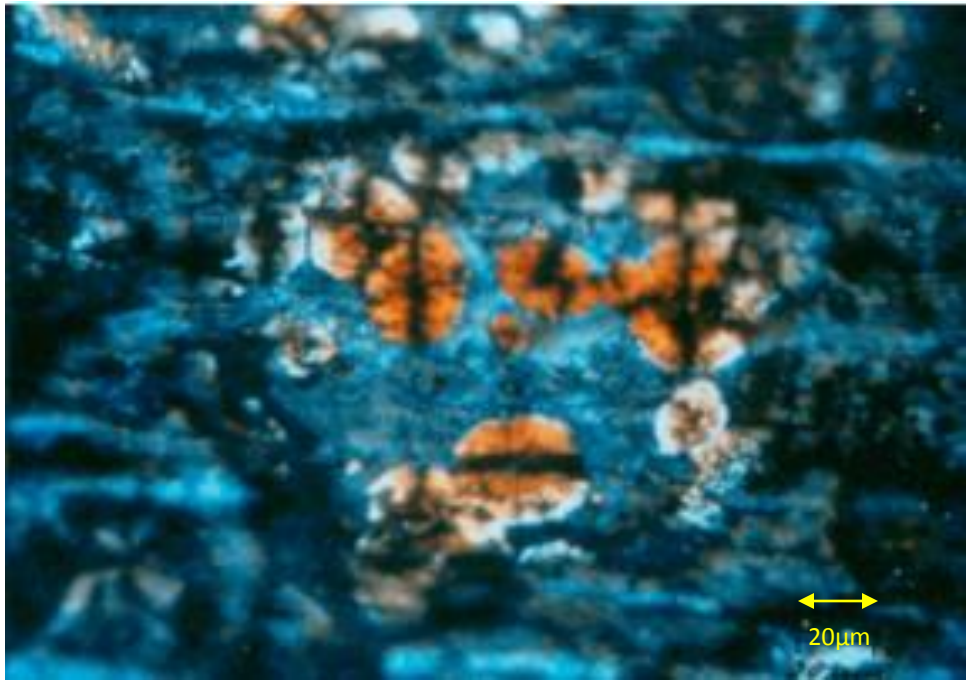
Multi-layer Plastic Pouch Heat Seal Failure



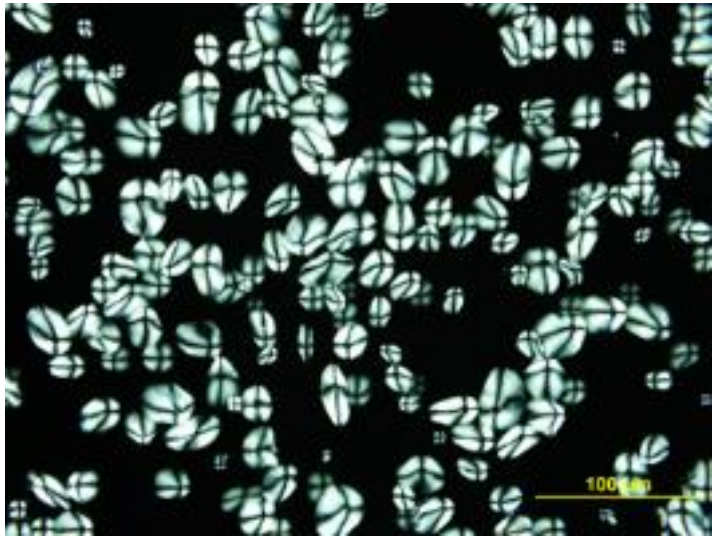


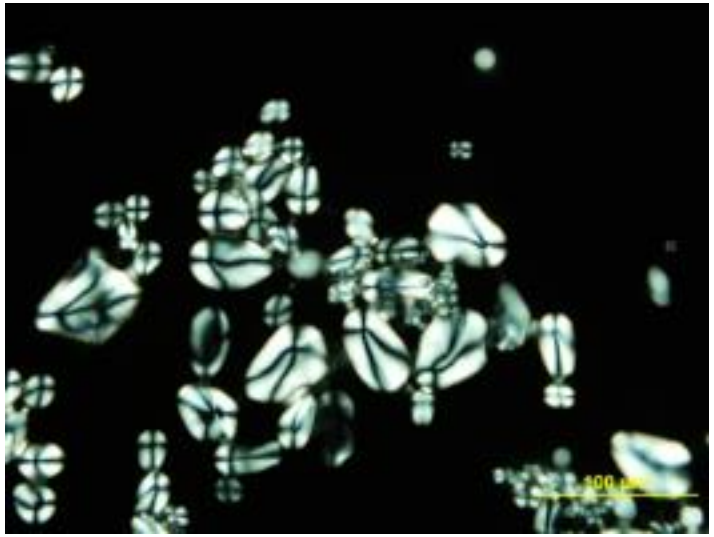
SEM Backscattered Electron images of pouch cross sections

“Brown” Stains Under a Food Can Internal Coating



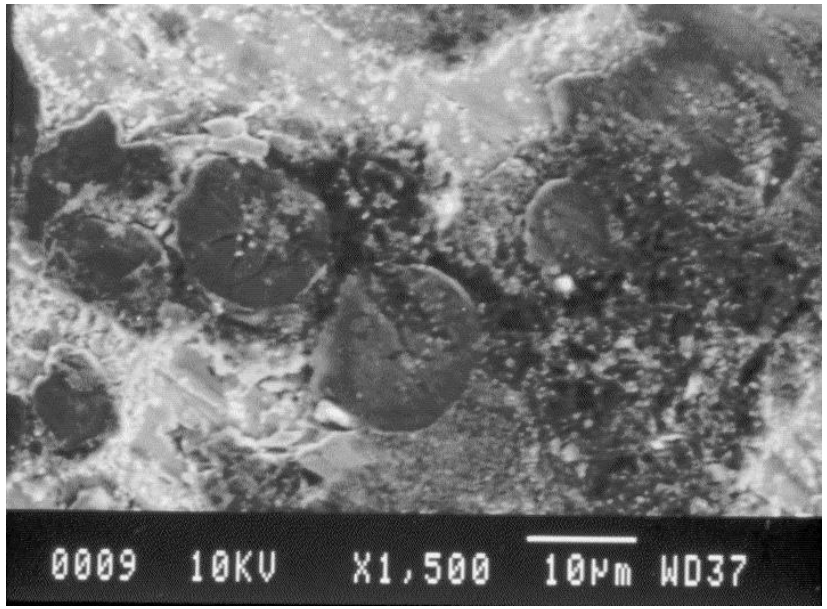
PLM of “brown stains” - reflected lighting with crossed polarizing filters



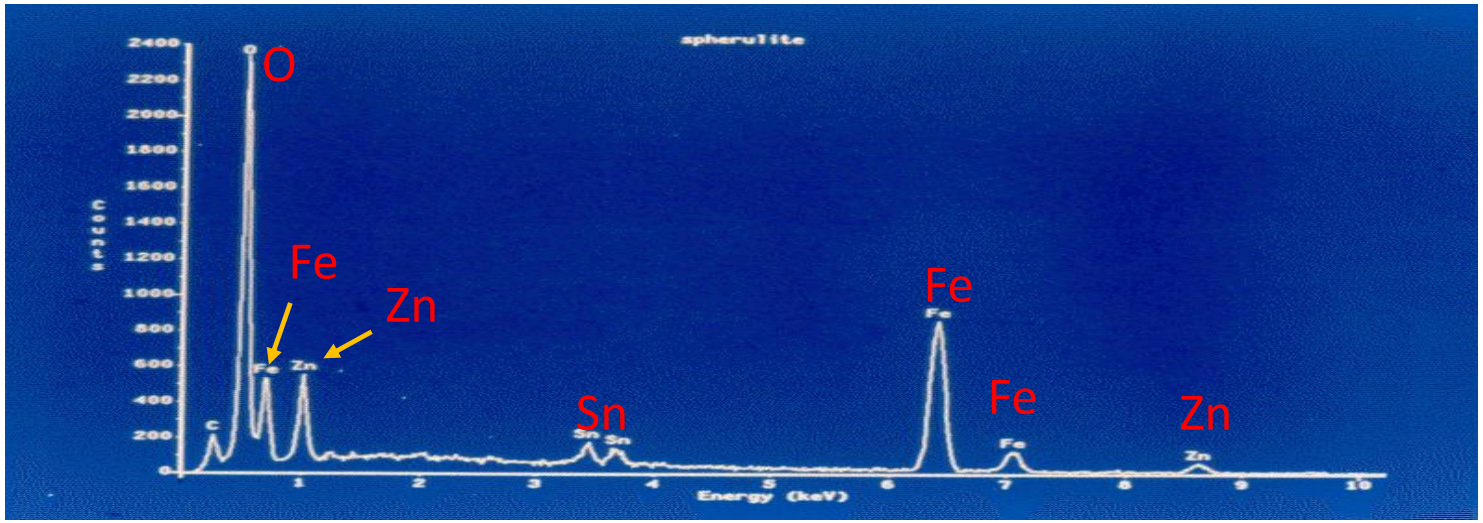


PLM of starch grains - transmitted lighting with crossed polarizing filters. Left is tapioca starch and right is potato starch.

“Brown” Stains Under a Food Can Internal Coating

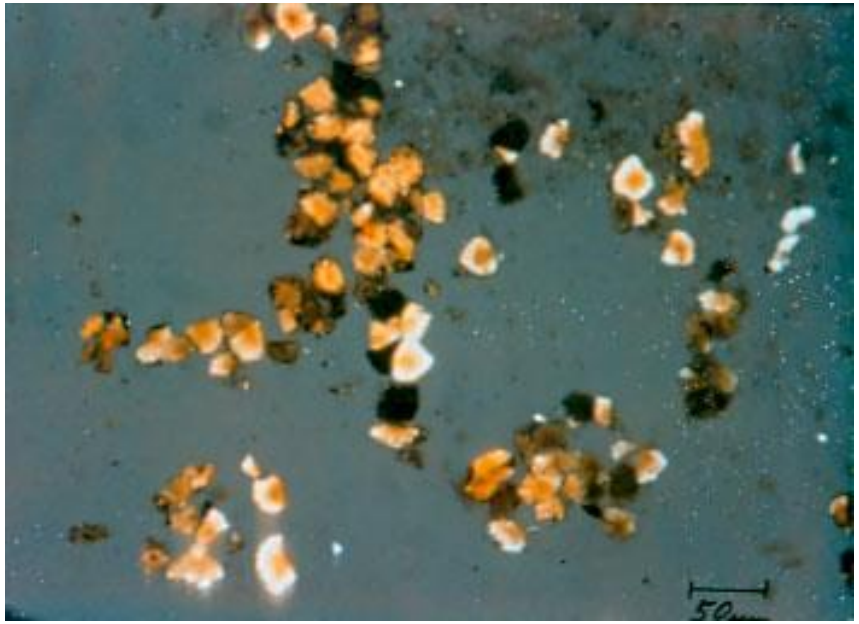


SEM image of “brown stains”



EDS spectrum of the “brown” stains
(Zn is from zinc oxide in the internal coating)

“Brown” Stains Under a Food Can Internal Coating



PLM of isolated “brown” stain particulates- transmitted lighting with partially crossed polarizing filters

SAMPLE Birefringent Spherulites	
d-spacing	I/I_o
3.60	60
2.80	100
2.49	<10
2.36	30
2.15	50
1.965	30
1.810	20
1.74	50
1.515	20
1.480	<10
1.425	10
1.382	<10
1.362	20
1.200	<10

X-Ray diffraction (XRD) data of the particulates and identified as iron carbonate.

“Brown” Stains Under a Food Can Internal Coating

The “brown” stains were caused by migration of the water-based product through an under cured coating, resulting in corrosion attack on the base tinplate steel.

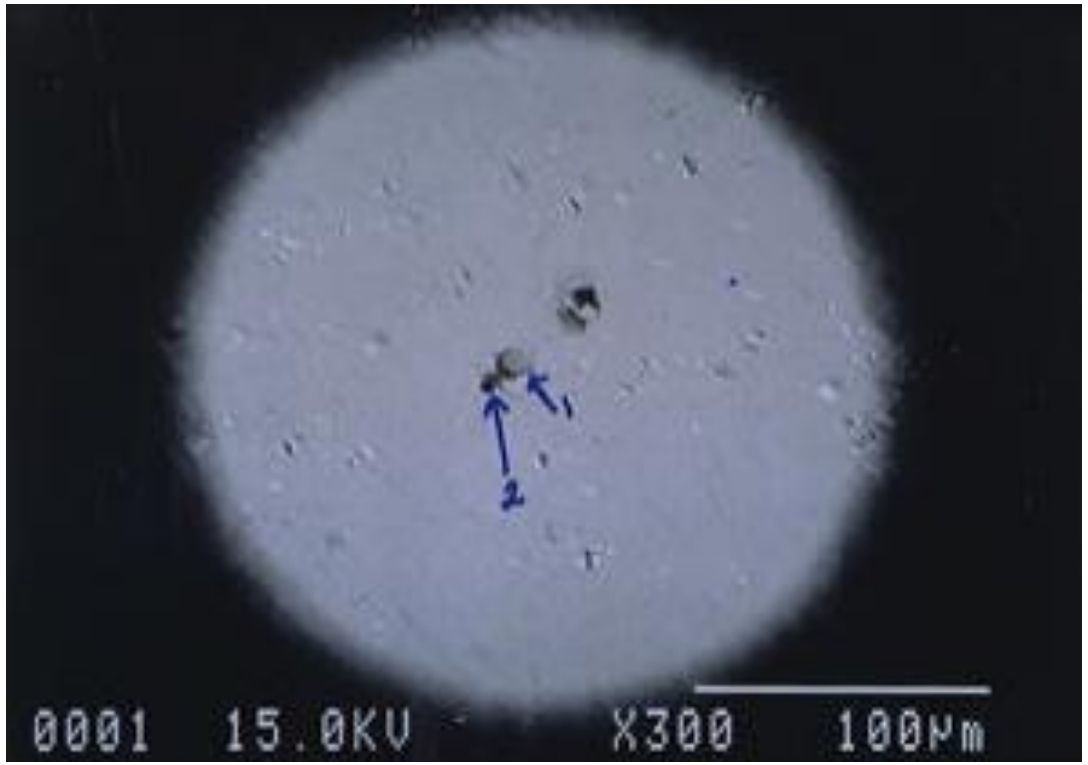
Severe Pitting Corrosion in Aluminum Cans Prior to Applying the Coating

"Microanalysis of Craters in Organic Coating of Aluminum Cans"

Frank McDonough, Quaker Chemical
Wayne D. Niemeyer, McCrone Associates, Inc.
Mike Shuster, Ball Packaging International

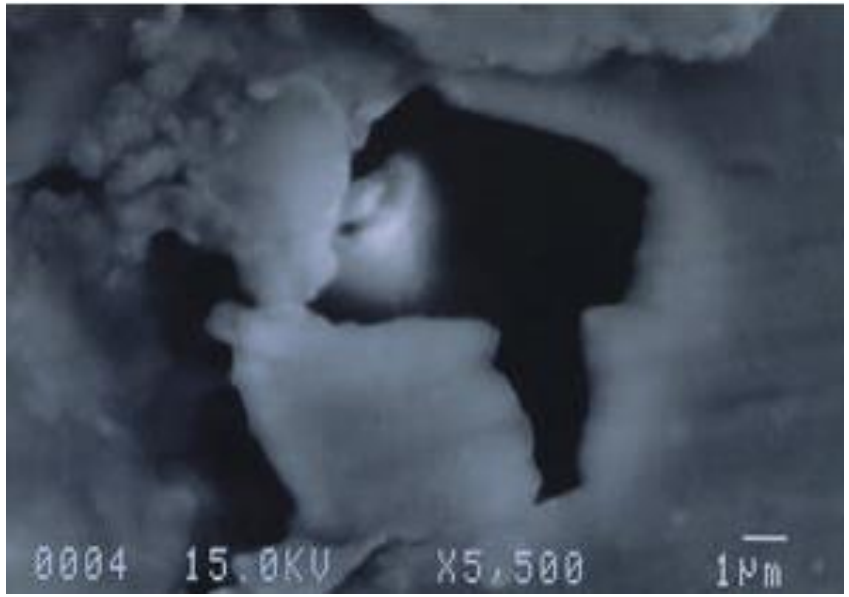
Download the entire article from:
http://www.modernmicroscopy.com

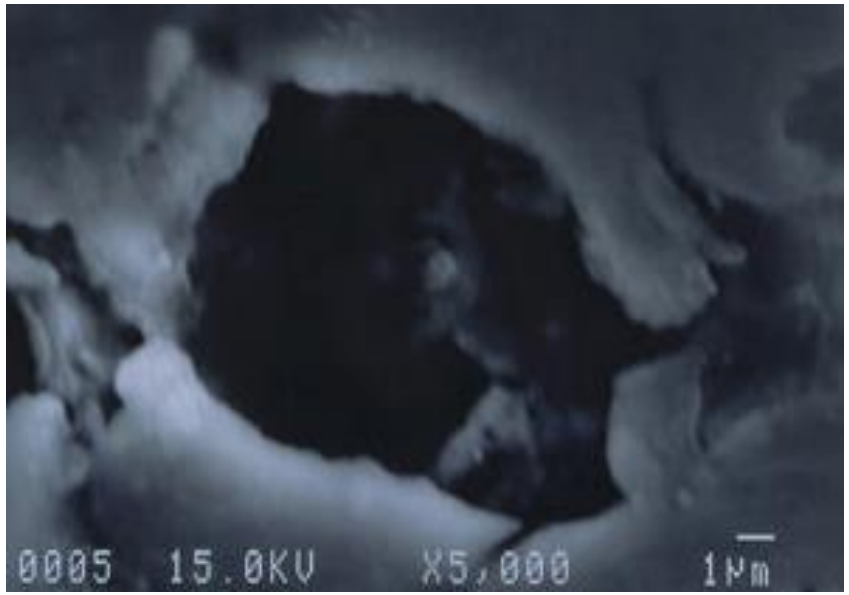
Severe Pitting Corrosion in Aluminum Cans Prior to Applying the Coating



SEM image of corrosion pits in the aluminum which caused cratering in the coating.
(The exposed metal and premature pitting attack would result in rapid perforation of the cans, loss of product, and contamination of surrounding cans.)

Severe Pitting Corrosion in Aluminum Cans Prior to Applying the Coating



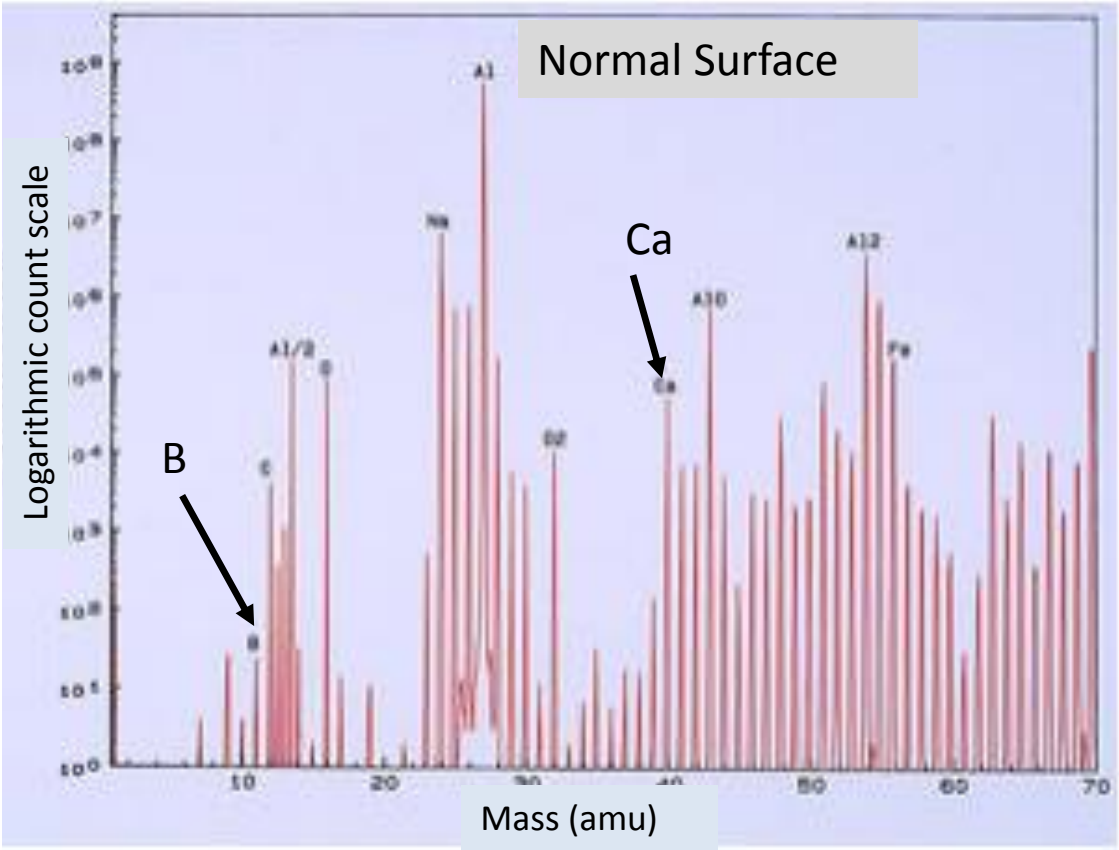


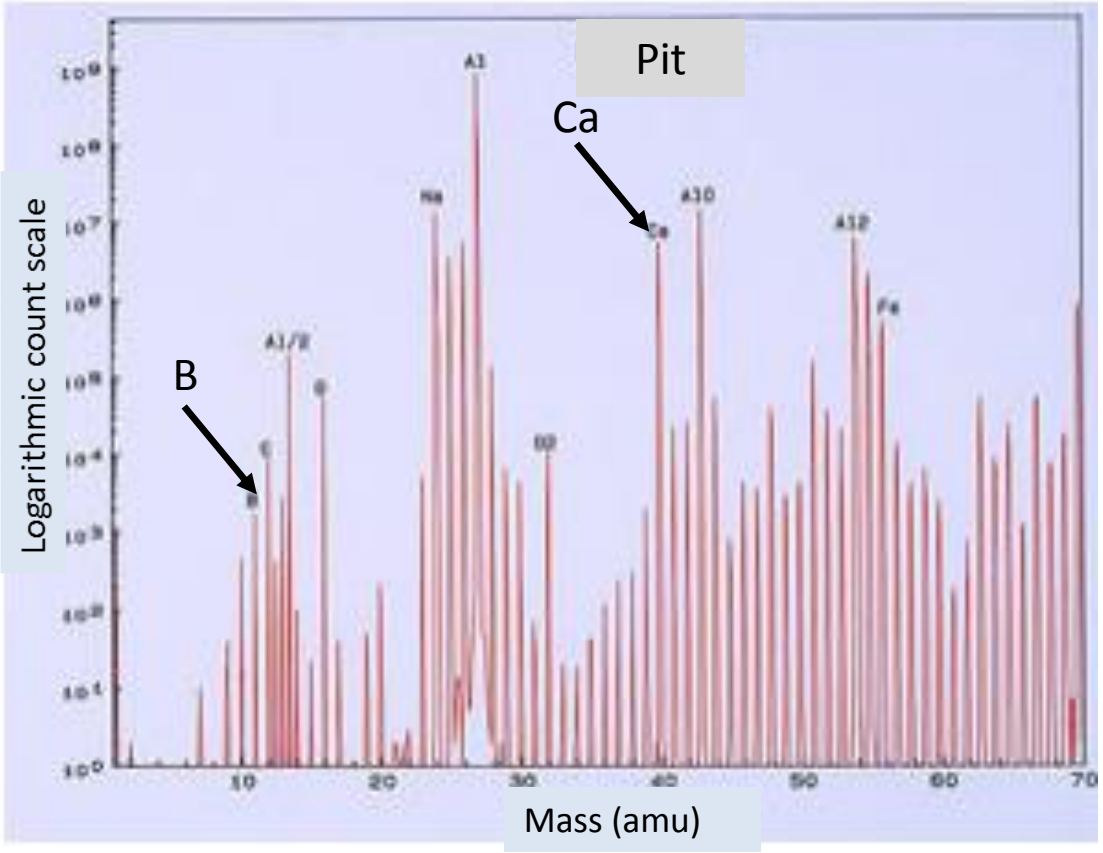
SEM images of corrosion pits in the aluminum.

Severe Pitting Corrosion in Aluminum Cans Prior to Applying the Coating

- EDS analysis revealed no evidence of inorganic contamination or a corrosive agent
- FTIR revealed no evidence of organic contamination
- Solvent micro-extractions from the pits revealed no foreign contamination

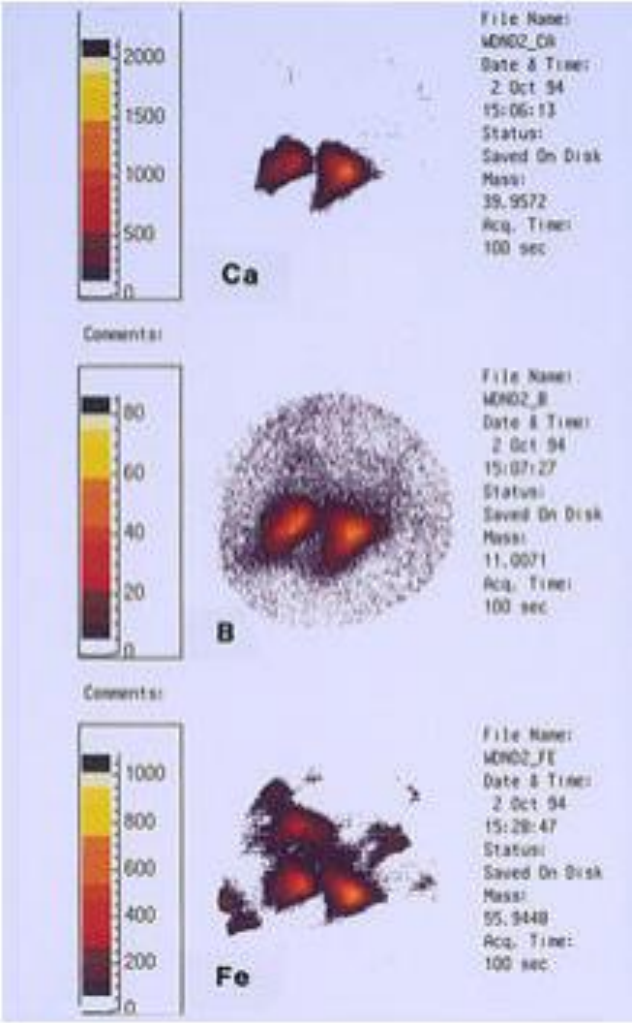
Severe Pitting Corrosion in Aluminum Cans Prior to Applying the Coating



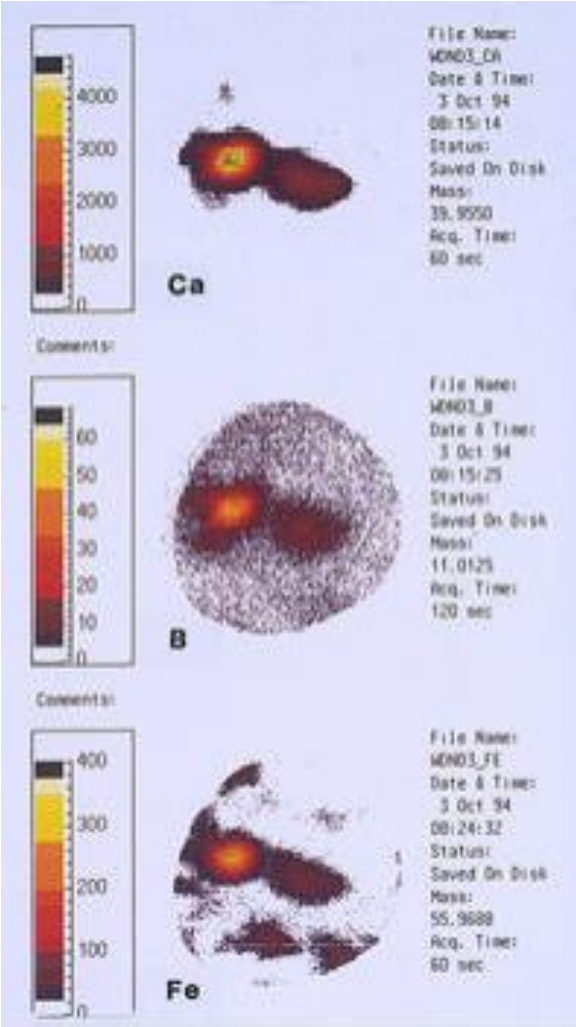


SIMS analysis revealed elevated boron (B) and calcium (Ca) in the pits

Severe Pitting Corrosion in Aluminum Cans Prior to Applying the Coating



SIMS maps for Ca, B, Fe in the pits



Severe Pitting Corrosion in Aluminum Cans Prior to Applying the Coating

The discovery of B, Ca, Fe in the pits pointed to cooling tower water used in heat exchanger tubing within the 7000 gallon lubricant/coolant system for the can manufacturing process.

It was speculated that a borate corrosion inhibitor (for steel corrosion resistance) was used in the cooling tower water. High levels of Ca and Fe were also found in the water. Additional factors made the cooling tower water very corrosive to aluminum.

When the lubricant/coolant system was dumped; subsequent inspection of the heat exchanger tubing revealed several cracks as the source of major cooling tower water leakage into the lubricant/coolant system.

The Typical Packaging Defect Dilemma

"Whatever it is, it's very, very tiny"

Our Solution

Analytical microscopy can help identify:
"Whatever it is,…"

Thank you for joining us.

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