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Failure Analysis of Polymers

For more than 50 years, scientists and engineers at Eurofins EAG have investigated and resolved product failures for clients. Our team of experts identify key failure indicators and follow them to the root cause.

Polymeric Materials Evaluated at EAG

Failure analysis of plastics, thermosets, and rubber materials is commonly performed on finished products and typically involve comparative analysis between failed and non-failed samples. Once the potential root cause is identified, experiments can be designed and conducted to test the hypothesis and recreate the failure in the laboratory. Eurofins EAG can evaluate a variety of polymer types, including:

- Raw materials in polymer formulations
- Adhesives (heat/moisture/UV-cured, silicones, epoxies, acrylates)
- Coatings (functional or decorative)
- Thermoplastics, thermosets, thermoplastic elastomers, composites
- Molded, extruded, cast components

Case Study: Incompatible Contaminant

A device manufacturer observed defects in a specific lot of thermoplastic tubing. The tubing exhibited signs of dimpling and axial deformation, suggesting chemical attack or exposure of the tubing to localized heating.

TGA was performed to compare weight loss profiles as a function of temperature. The defect tubing had a significantly lower decomposition onset temperature compared to the control tubing. Additionally, the deformed tubing exhibited multiple weight loss steps compared to a single major weight loss step for the control. DSC profiles in the 1st heat scan (as-received thermal history), cooling scan, and 2nd heat scan (inherent properties) were also different.

Results indicated a compositional difference between the defect and control tubing materials, consistent with exposure of the defect tubing to an incompatible chemical.

Case Study: Delamination in Food Packaging

A client wanted to investigate the failure of a multilayer laminate used for food packaging. Lots of roll stock did not meet the seal strength specification; bad lots exhibited seal strengths that were an order of magnitude lower than the known good lots.

Cross-sections of samples from the seal strength test were prepared using a cryo-microtome. The failure location for samples analyzed from good and bad lots were different; laminates that failed the test exhibited a mixed mode failure of the adhesive between polyolefin and polyester layers, whereas laminate that passed the test delaminated between the foil and polyester layers. Based on pyrolysis GC-MS of the adhesive, polyurethane species were detected in the desorption step for the bad lots and only in the pyrolysis step for the good lots. In addition, the adhesive from the bad lots had lower average molecular weight values and a higher polydispersity index.

Results indicate that the reduced seal strength was due to degraded adhesive in the bad laminate lots.

Case Study of Environmental Stress Cracking of a Polycarbonate Part

A company was investigating a rise in cracking of polycarbonate (PC) components used in a conveyor device that was frequently sanitized with disinfectants. The components were reportedly exposed to a disinfectant product containing quaternary ammonium compounds, which have been known to cause environmental stress cracking (ESC) of polycarbonate materials under certain conditions.

Fractography was performed on the failed components to assess the failure mode based on the crack morphology and fracture surface features. The components were severely embrittled and the fracture surface features were consistent with ESC. Additionally, the components were extracted with a solvent and screened by LC-MS for non-volatile organic compounds.

Based on the mass spectral signal, ions consistent with a benzyl quaternary ammonium compound were detected, confirming PC components were in contact with a known stress cracking agent.

Additional Case Studies

Additional polymer failure analysis case studies can be viewed at eag.com:

- Cracking of Molded Components (link)
- Molded in Stresses (link)
- Weathering Polymeric Films (link)
- Off-Odor Memory Foam (link)
- Blistering Paint (link)
- Curing issues with Silicone Adhesive (link)

Analytical Techniques for Polymers

Eurofins EAG Laboratories offers a full suite of analytical techniques to evaluate the identity, composition, morphology, topography, and rheology of polymeric materials and components.

Service	Techniques
Chromatography	GC, GC-MS, HPLC, IC, LC-MS, Pyrolysis GC-MS, HS/TD/SPME GC-MS
Inorganic Identification and Quantification	ICP-MS, ICP-OES, SEM-EDS, XRD, XRF
Physical Testing	Contact Angle, Mechanical Testing, Rheometry, Viscometry
Spectroscopy	Ellipsometry, FTIR, NIR, NMR, Raman, UV-Vis
Surface Analysis	Auger, SEM, TOF-SIMS, XPS
Surface Metrology	AFM, Nanoindentation, Profilometry
Thermal Analysis	DMA, DSC, RGA, TGA, TGA-IR, TGA-MS, TMA