INGENIA

Ingenia Flexible Packaging Brief

What Are Film 'Gels'?

The term 'gels' is used to describe all manner of localized film defects, ranging from oxidized resin, to foreign fibres, to inorganic agglomerates. Gels can range in size from microscopic pinpricks a few microns across, to several millimeters in diameter or more. In addition to being visually unappealing, gels can cause issues for printing and weaken the physical properties of the film. Issues with film gels will occur for a wide range of reasons, so identifying the root cause of the defects is critical to quickly correcting issues, thereby minimizing wasted time and resources.

Identifying Gels

When troubleshooting film defects, the context of a defect is often as important as the actual form of the defect in identifying root cause. For instance, if we examine a single gel and identify it as oxidized resin, this could be attributed to a wide range of causes: resin stabilization package, extruder temperature, worn screw elements… the list is near endless! But if we examine the film and find all our gels fall in a single line parallel to the direction of extrusion (machine direction), then the broad 'oxidized gel' become a 'die line,' a much more precise problem with a narrower set of causes and solutions.

Figure 1 - When the defect is on the surface of the film rather than encapsulated, it must come from a source at or beyond the die. This picture comes from a particularly bad case of die lip buildup that has sloughed off onto the film surface.

Figure 2 - When gels form lines in the machine direction, the gels must be forming in the die, as they would otherwise be distributed across the width of the web.

Useful information in identifying gels includes:

• Gel location in the film. Are the gels distributed across the entire web, or restricted to sections?

• Occurrence pattern. Do gels appear on start-up or after some amount of run time? Are they constant, or do they appear intermittently? Does their appearance correspond to other process changes?

• Gel appearance. How large are the gels? What colour are they? Are they on the surface of the film or encapsulated? Are they spherical, elongated, or irregular in shape?

Analysis methods such as microscopy and microscope-assisted spectrometry can further assist with gel composition determination, when and where the appropriate equipment is available.

If you are able to identify the type of gel from the above or other information you will have fewer possible causes to address, allowing you to solve the issue more quickly.

Common Types of Film Gels and Their Causes

Crosslinked Polymers

Also called ‘burns’, these gels are made of resin that has undergone thermo-oxidative degradation, forming crosslinked high molecular-weight domains that are unable to disperse. When degradation is particularly advanced, these gels can be yellow or brown in colour; they will otherwise have the same colour (or clarity) of the underlying material.

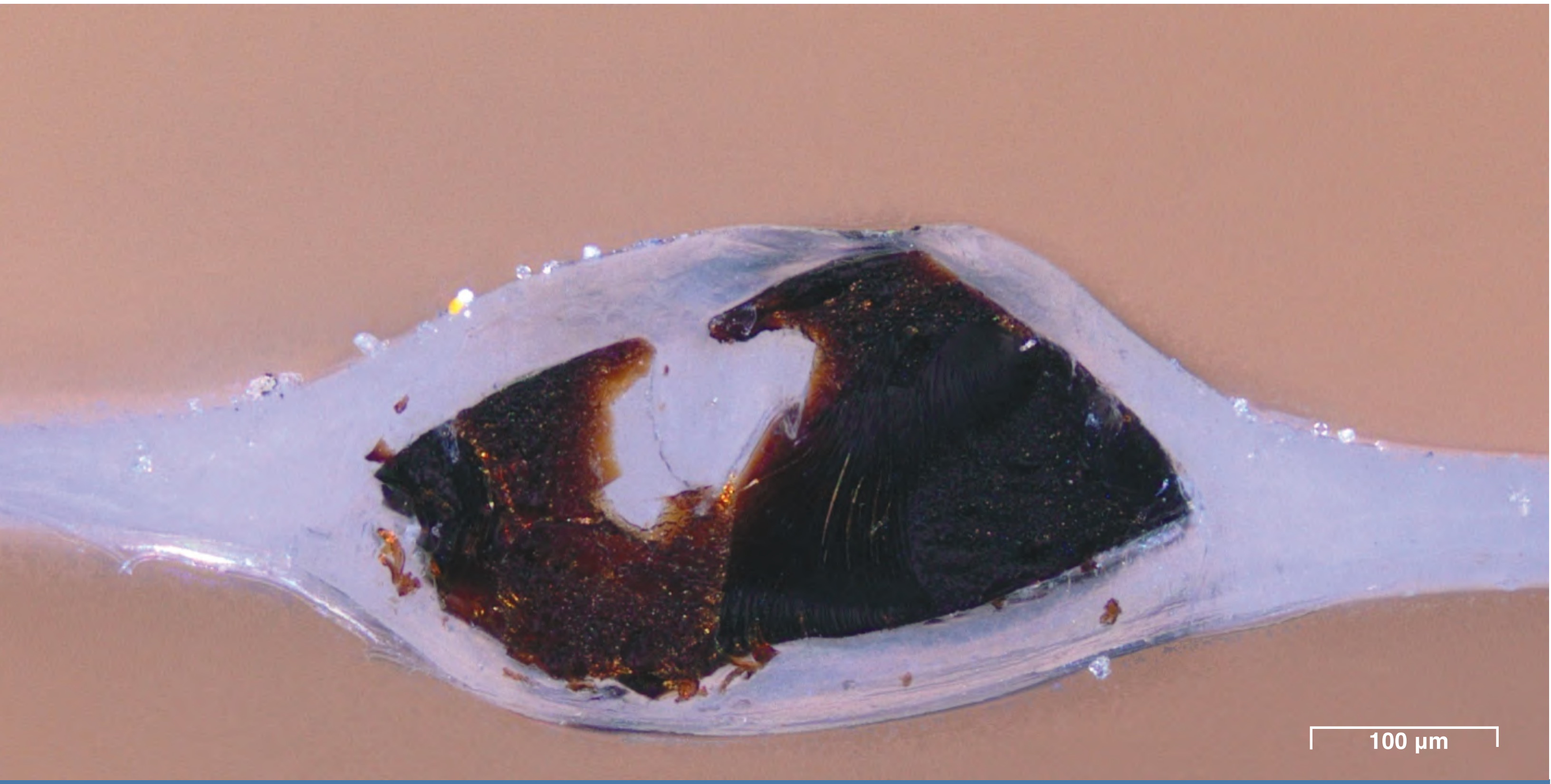

Figure 3 - A particularly blackened crosslink gel. This was found when the customer's letdown resin was run alone, identifying it as the source of the defects.

These gels are caused by resin degradation, too much time with too much heat, with ‘too much’ depending on the stabilization package of the resin. They can be caused by weak stabilization packages, high extruder temperature, and material hang-up in the extruder, among other things.

Lightly crosslinked gels will often be difficult to distinguish from resin unmelts. See below for discussion of how to differentiate these two gel types.

Inorganic Agglomerates

Colloquially known as ‘grits’, inorganic agglomerates result from poor dispersion of mineral additives such as antiblocks and inorganic pigments like titanium dioxide. Qualitatively, these grits will feel ‘sharper’ to the touch than crosslinked polymeric gels.

If you are using well-dispersed additive masterbatches, grits should be minimized due to the dispersion performed by the masterbatch producer. Additives with high moisture levels or that have clumped together can be more difficult to disperse in the masterbatch compounding line.

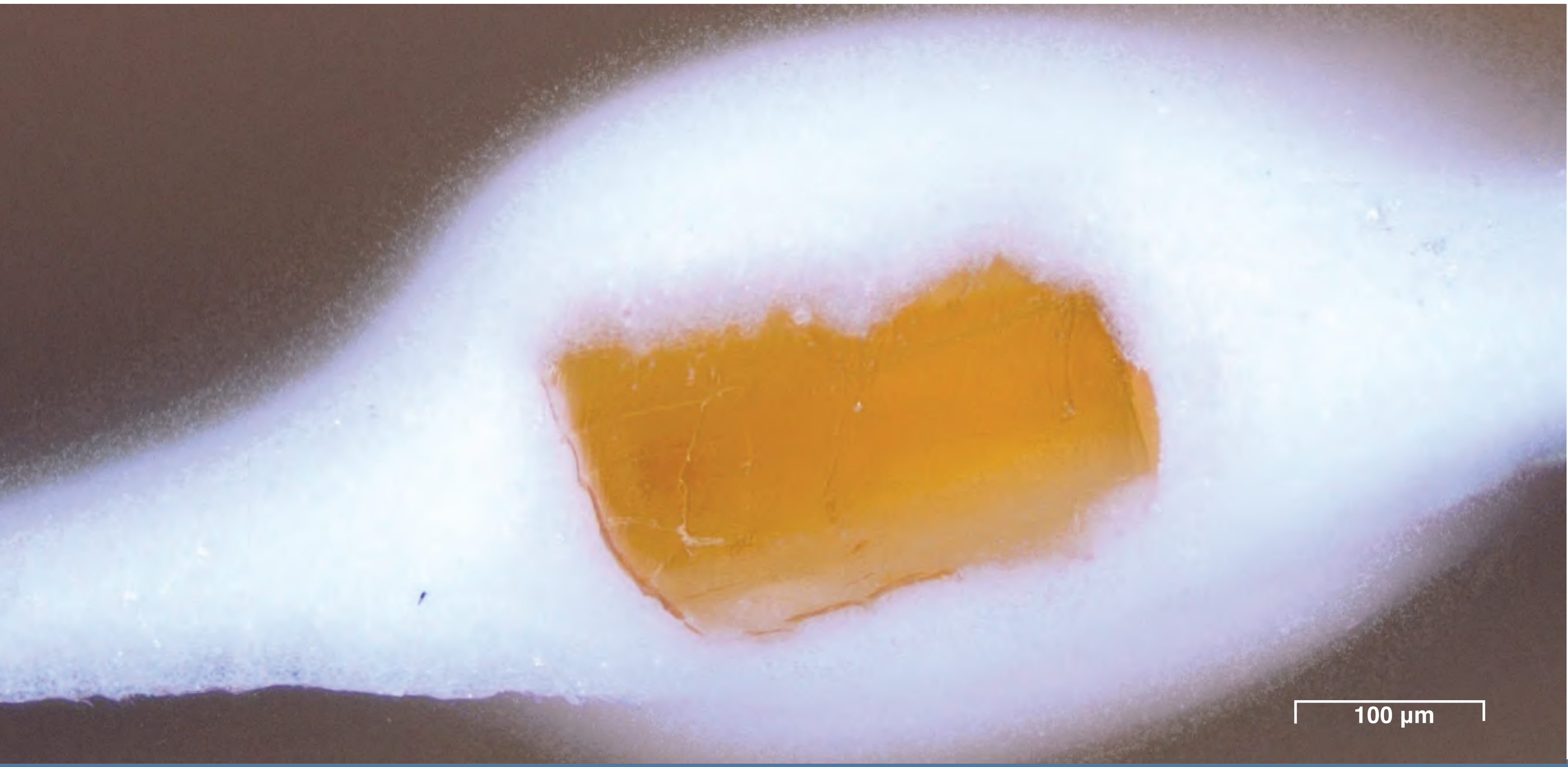

Figure 4 - In this cross-section of a white film sample, we see the gel is not pigmented by the white masterbatch. This indicates the gel pre-existed mixing with the masterbatch.

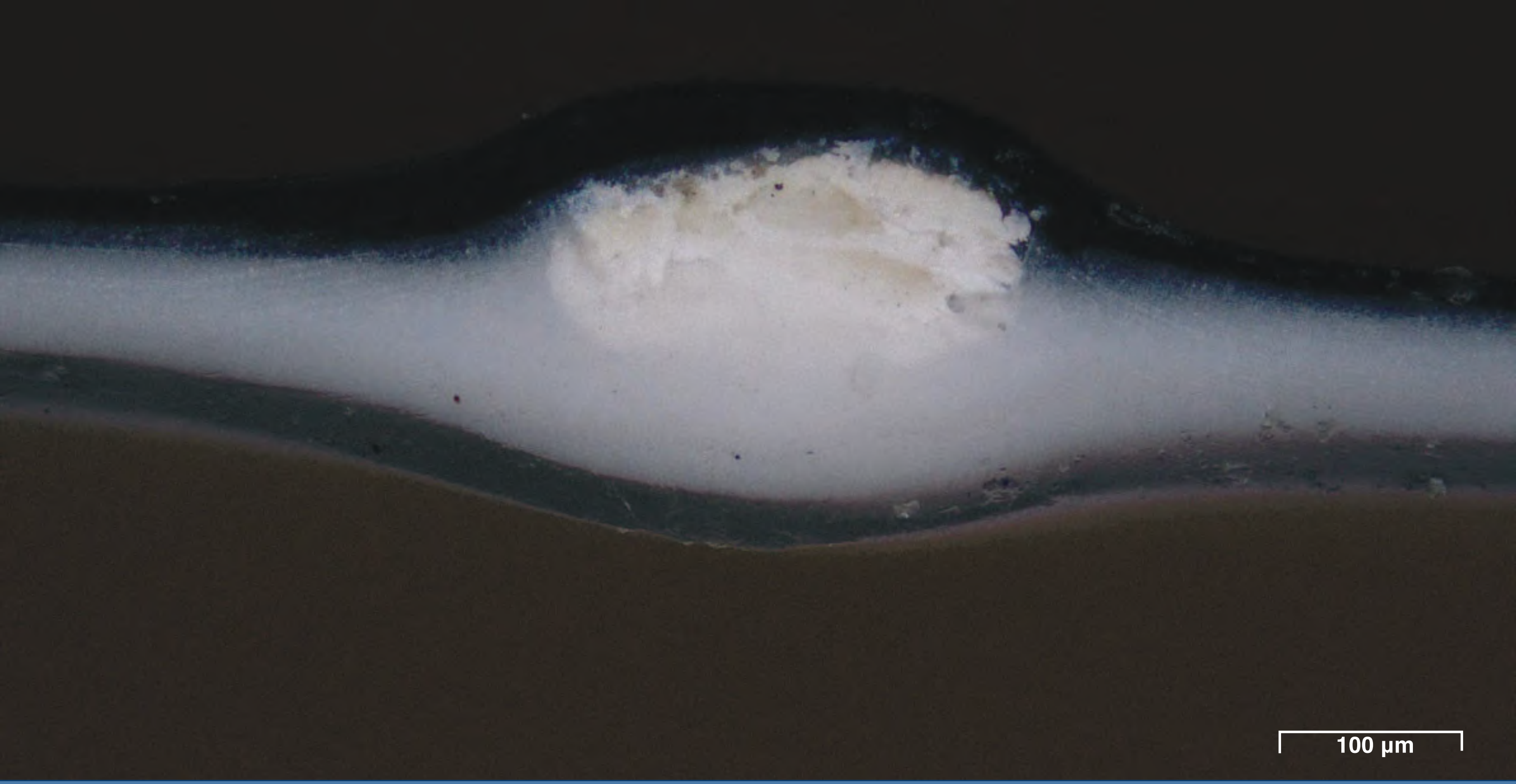

Figure 5 - Cross-sectional analysis can help identify which part of the film is responsible for defects. Here, we see a TiO_2 agglomerate present in the middle white layer of the film.

Undispersed Colourant

Similar to inorganic additives added in masterbatch form, this gel type should be infrequent when a well-dispersed masterbatch is used. These gels will typically be the colour of the colourant, though the true colour of the defect may not be visible if it is embedded in a pigmented film structure. In this case, a cross-section of the gel can reveal the true colour of the defect.

Unmelts

Unmelts occur when the resin is not fully melted in the extruder. If unmelted portions do not mix in, they will form clear gels in the final part. Unmelts are very similar in appearance to crosslinked gels but can be distinguished by very simple tests. When heated on a hot plate (or under a hot stage microscope) a gel will not melt if it is crosslinked but will if it was simply an “unmelt”.

While processing conditions (temperature profile, processing speed, etc.) can cause unmelts, they are most commonly caused by issues with the raw material or regrind. Small particles (‘fines’) are not subjected to as much shear energy in extrusion and may not properly melt. These small particles are common in regrind, and in more friable pellet formulations. Contamination by higher melting-point resins will also cause unmelts: melting point can be determined by a variety of analytical methods.

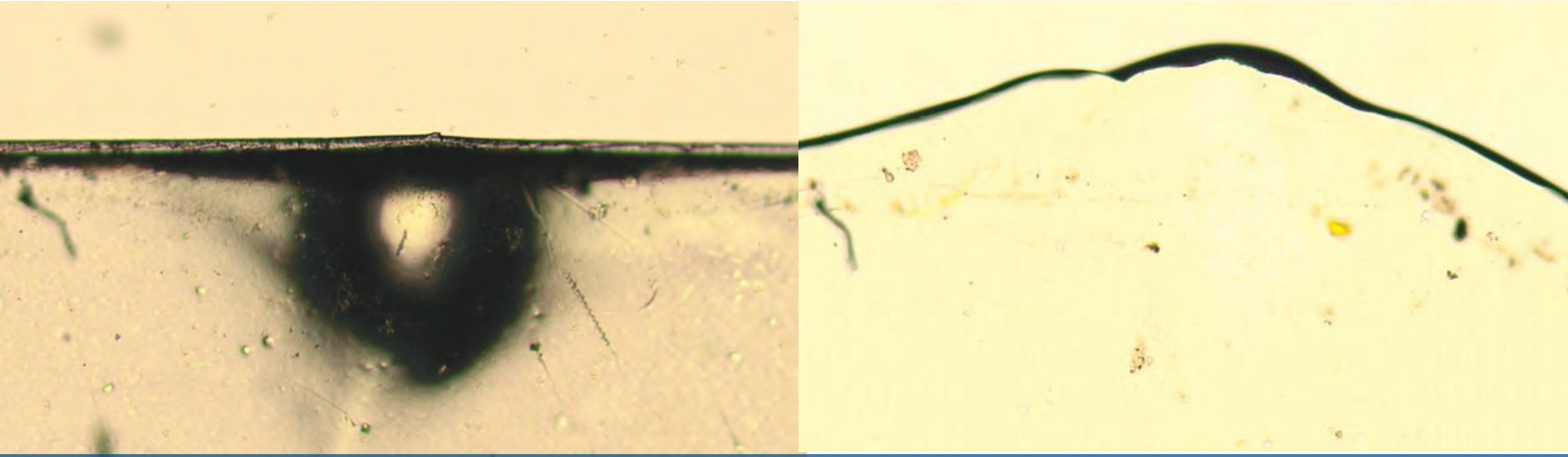

Figure 6 - When heated, unmelt gels can combine with the surrounding film, disappearing. Picture on left shows large unmelt distortion. In picture on right, unmelt has melted and is no longer visible.

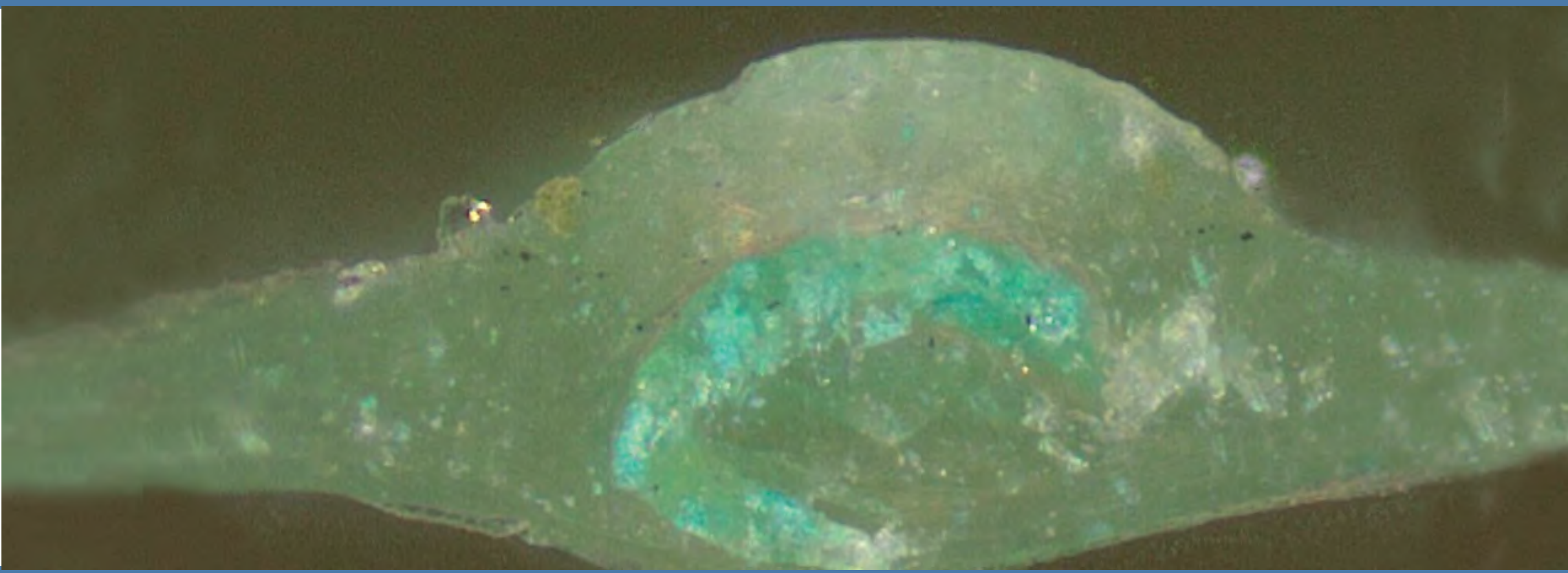

Figure 7 - A gel caused by unmelted regrind fines. Note that while the contaminant is curved, the surrounding material will give it a round appearance if you fail to examine the cross-section.

Fisheyes

Also known as ‘lensing’, fisheyes are elongated, hollow gels caused by moisture or other volatiles in the film, which produce gas pocket in the film during processing. Moisture testing of raw materials is the simplest way to identify the cause of fisheyes.

Fibres

Fibrous gels are irregular in shape, being long, narrow, and either straight or curved. Both polymeric and non-polymeric fibres can cause gels.

Polymeric Fibres

Wispy strands of resin ('Angle hair') can be formed by vacuum conveying systems, and cause elongated, fibre-like gels similar to nonmelting fines. However, polymeric fibres can also be introduced by contamination from bulk bags or other woven & nonwoven polymer articles in the production facility. As these articles are typically polypropylene, polyesters, or polyamides (all of which have higher melting points than polyethylene), they will not melt and will produce fibre-like defects in the film.

Non-Polymeric Fibres

Cardboard (cellulose) and other fabric fibres can also cause gels when they contaminate the material stream. Unlike polymeric fibres, non-polymeric fibres will not melt when heated, regardless of the processing temperature.

Solving Gel Issues

When the type of gel has been identified, root cause identification is a matter of systematically working through possible causes until you find a positive indicator for a single cause (e.g. high moisture in the resin causing fisheyes) or have eliminated all possible causes but one. Learning to identify the common types of gels as described above will reduce the number of factors you need to examine, saving time & resources.

Additionally, remember that with the exception of unmelts of your intended material, additional processing will not eliminate gels. Using regrind from defective film will simply feed those same gels back into your film line's new production and should be avoided.

Ingenia has the experience and know how to assist in determining the root cause of gels in film. As well, providing recommendations to correct may involve changes in raw material QA, extrusion conditions or adding additional stabilization to the resin system. With a wide range of analytical equipment and experienced, market focused technical support, the solution is available at Ingenia.