Title:
The Application of Dynamar Polymer Processing Additives for Gel Suppression

Intro:
Dynamar PPAs (Polymer Processing Additives) are used extensively to enhance the extrusion of various polymers. Dyneon products such as Dynamar™ FX 5920A, FX 9613 and FX 5911X have long found practical utility for the elimination of melt fracture and die build up reduction. More recently studies have shown Dynamar PPAs can also significantly reduce the number of gels formed during blown film extrusion.

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Dynamar™

Polymer Processing Additives

The Application of Dynamar Polymer Processing Additives for Gel Suppression

Introduction

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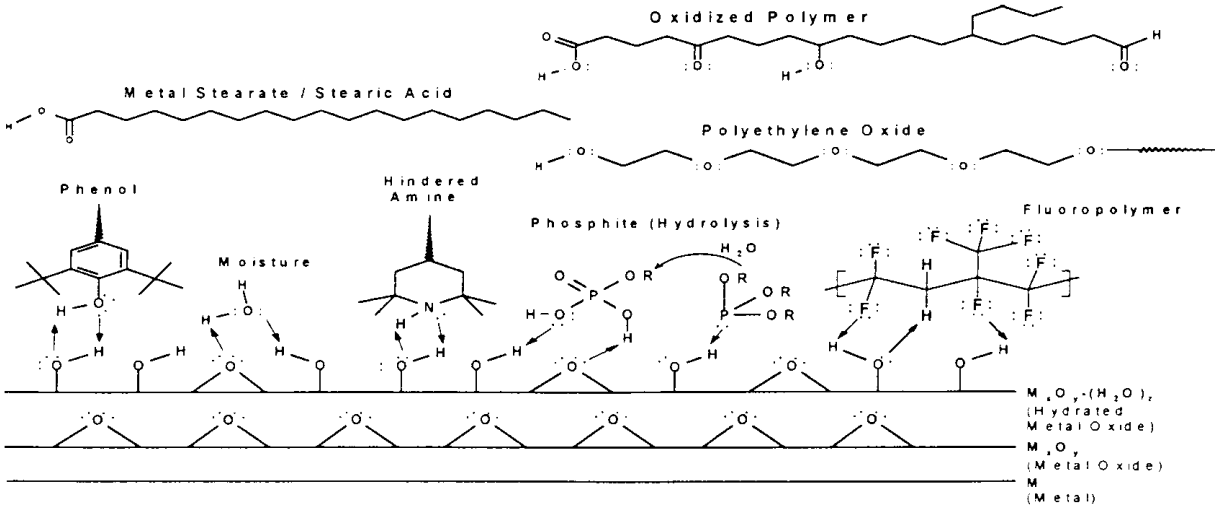
How Dynamar PPAs Work

Dynamar PPAs function by coating metal surfaces, effectively changing the interface between molten polymer and metal, to that of polyolefin to fluoropolymer to metal.

Dyneon postulates that the low energy surface provided by the fluoropolymer coating prevents the accumulation of low molecular weight and oxidized polyethylene and may also (in grooved feed extruders) help prevent gels caused by premature melting of lower density polymers like polyolefin plastomers.

One of the primary mechanisms for bonding to the metal surface is thought to be (multiple) hydrogen bonding sites between the Dynamar PPA and the hydrated oxidized metal surface. The premise of the hydrogen bonding interaction is based on the assertion that the metal surface of the processing equipment is actually a partially oxidized metal surface. On top of the partially oxidized metal surface, there is a thin layer of hydration. One can see in the figure below that this creates a series of –OH bonds and bridging O groups that are capable of hydrogen bonding to Dynamar PPAs, oxidized polymer and other species in the polymer matrix. The oxidation of the polymer is a stepwise process that proceeds from alkane to alcohol to aldehyde or ketone to carboxylic acid. Each of these functional groups is capable of hydrogen bonding and consequently the oxidized polymer has a greater affinity for the metal surface than a non-oxidized polymer chain. Prolonged contact of the oxidized polymer with the metal surface will only lead to further oxidation and crosslinking of the polymer. At some point, if the partially crosslinked or oxidized polymer sloughs off the metal surface and exits the extruder, it exits as a gel. We believe Dynamar PPAs prevent prolonged contact of the oxidized polymer with the heated metal surface and thus helps inhibit the formulation of cross linked gels.

Potential Interactions (via Hydrogen Bonding Mechanism)

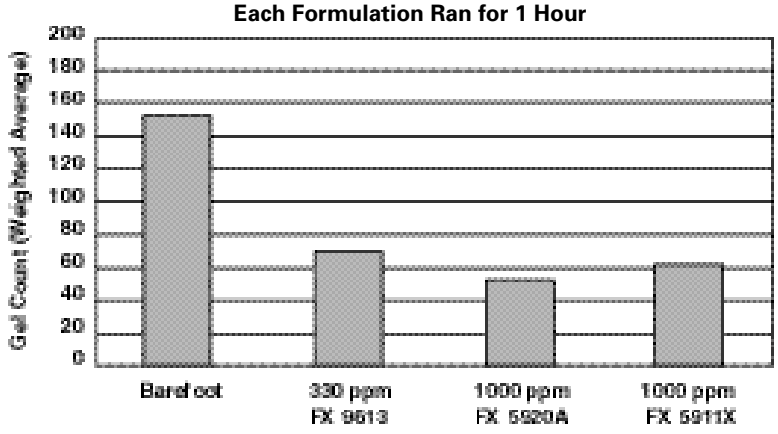


S. Woods, R. King, J. Kunde; Proceedings from Polyolefin XI Conference, Houston 1999 p. 591-610

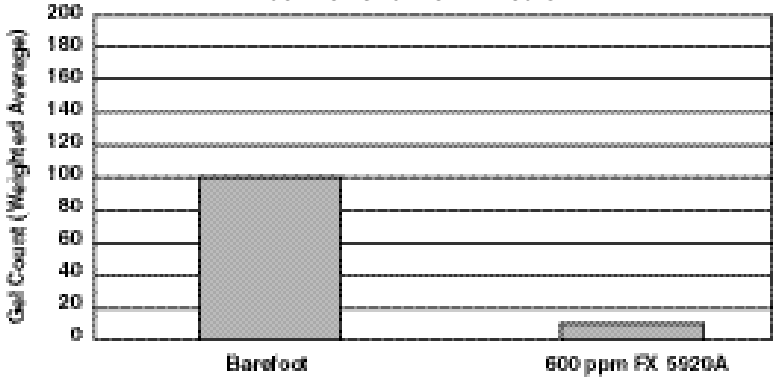
Gel Study Results

The results plotted below were generated on a Kiefel blown film line, 40 mm grooved feed extruder, 24/1 L/D, 18/35/60 mesh screen pack, 40 mm die, 2 mm die gap, single lip air ring. Temperature profile was 49°C (120°F) feed, 88°C (190°F) flat through the rest of the extruder, output was 8-9 kg/hr.

Study 1 - 0.9 MI, 0.910 Density Resin (with low stabilization)
Each Formulation Ran for 1 Hour



Study 2 - 1.0 MI, 0.910 Density Resin (well stabilized)
Each Point Ran for 12 Hours



Dynamar™ PPAs Reduce Certain Types of Gels

While the Dynamar PPAs studied in these evaluations resulted in a significant gel reduction none totally eliminated gels. We believe this is because Dynamar PPAs are effective at reducing gels formed in the extruder, such as crosslinked gels and unmelted/unmixed gels. However, there are other types of gels such as contamination gels (fiber and angel hair/dust contamination) formed during the polymerization process that Dynamar PPAs could not help reduce.

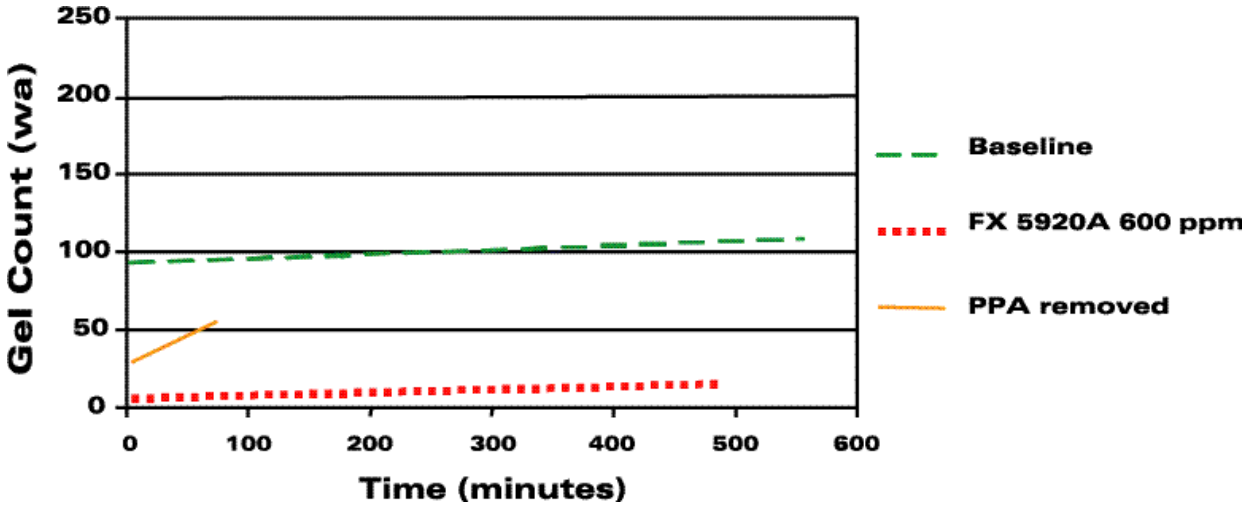
Recommended Levels

Our lab tests have shown levels as low as 330 ppm of Dynamar PPAs reduce gels. We believe that levels as low as those typically used for die build-up (50-500 ppm) may help reduce gel formation.

The Importance of Purging

It is important to start with a clean extruder when using Dynamar PPAs. If your extruder is "dirty" when you add the Dynamar PPA, it will displace any material hung up in the extruder, perhaps resulting in the appearance of black specs or gels initially until the Dynamar PPA is coated down.

Study 2 - 1.0 MI, 0.870 Density Resin (well stabilized)
Gel Count Trend Line Plot



This plot shows how FX 5920A reduced the gel count level.
Removing the FX 5920A allowed the gel count to creep back up again.

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Technical Information and Test Data:

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