Case Study

Reducing NIAS* in polyolefin food packaging by using higher performant antioxidants

Introduction

Antioxidants are used in polyolefins to stabilize polymer against the processing and thermal stress. It is known that the use of primary and secondary antioxidants, such as hindered phenol and phosphite, together has a synergistic effect and allows for a better process stabilization with lesser total amount of additives required.

The demand of the polyolefin industry however is to achieve good and even better results with using lesser additives. Some reasons behind this are objective, such as additives compatibility and stricter regulatory requirements.

With this study BASF demonstrates some of the solutions to stabilize polyolefins with using lesser additives, as well as resulting additives migration.

Two antioxidant packages for LLDPE stabilization are compared (Table 1).

Formulation 1	Formulation 2	Comment
1000ppm Irgafos® 168	500ppm Irgafos® 168 100ppm Irganox® E 201	Phosphite, secondary AO Vitamine E, C-radical scavenger
500ppm Irganox® 1076	500ppm Irganox® 1076	Hindered phenol, primary AO
500ppm Zn-Stearate	500ppm Zn-Stearate	Antacid

Table 1: Two formulations used in the stabilization of LLDPE compounding and cast film production.

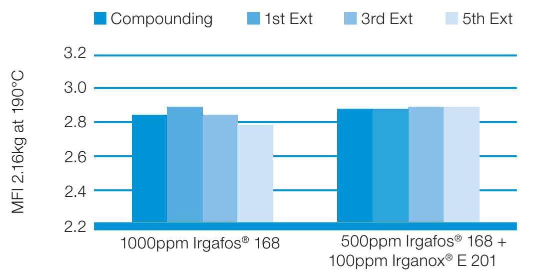
The use of highly efficient additives reduces of roughly 25% of the antioxidant concentration in the polymer with formulation 2.

NIAS*: non-intentionally added substances

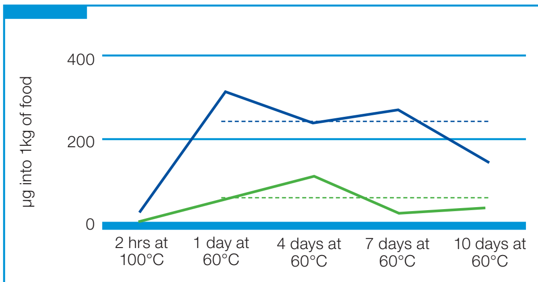
Processing stability

To compare the stabilization performance of both formulations, multiple-pass extrusion experiments were performed. Both formulations provided very good melt stability after five extrusion passes (figure 1a). Additional investigation of the rheology indicated that not only melt-flow index but also near to zero-shear viscosity (~ molecular weight) remained stable for both formulations. Molecular weight and molecular weight distribution were very well protected with both formulations especially considering that only half amount of phosphite is used in formulation 2.

A slight increase in yellowness index (YI) upon multiple extrusion was observed (figure 1b). The YI increase of the second formulation containing Irganox® E 201 was higher compared to the first formulation but remained low in terms of absolute values. This slightly higher yellowness is a known attribute of Irganox® E 201 oxidation products.



1a: Change in melt flow after multiple extrusion at 230°C

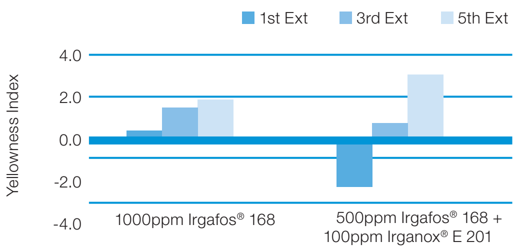


Migration of phosphite hydrolysis product in ethanol

Migration study

In a polyethylene packaging film in prolonged contact with water, the phosphite processing stabilizer can be hydrolyzed. The migration rates of Irgafos® 168 and its degradation product (2,4-di-tert-butylphenol) were studied in 95% ethanol as the fatty food simulant with a two hours of pre-exposure to 100°C and followed by 10 days kept at 60°C. From the measured amounts of products, the migration into food was derived as µg/kg into food (figure 2).

The amount of hydrolysis products from the formulation 2 with 500ppm of phosphite and 100ppm of vitamin E was much lower and achieved the saturation at about 60µg/kg of food (240µg/kg of food for formulation 1). Using lower amount of phosphite in the formulation 2 helped to significantly reduce the migration into food simulants. For the monolayer mimicking 70µm thick L-LDPE packaging and the two tested formulations, the phenol migration was well below regulatory limits.



1b: Change in color (YI) after multiple extrusion at 230°C

Conclusion

The melt flow and the molecular-weight retention during multiple extrusions with Irganox® E 201 is as good or slightly better than the standard phosphite/phenol formulation. The use of Irganox® E 201 helps to reduce the amount of phosphite by 50% in the stabilization formulation of a polyethylene film.
This results in the significant reduction of phosphite hydrolysis products migration into ethanol as food simulant.