NATURAL ANTIOXIDANTS – STUDY OF THE PROCESSING STABILIZING EFFICIENCY AND MECHANISM OF CURCUMIN IN POLYETHYLENE

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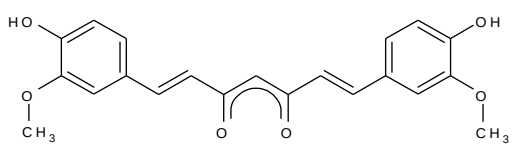
Lately our interest turned towards natural antioxidants because of some health issues related to the reaction products of commercial phenolic stabilisers used in polyolefins. Curcumin is obtained from curcuma longa rhizomes. The powdered root is used as a spice, food colorant, and food perservative[1]. The medical activity of curcumin has been known since ancient times. It is an efficient free radical scavenger and inhibits lipid peroxidation[2]. The question is how it behaves under the conditions of polyethylene processing and whether it can protect the polymer from degradation.



Stabilization experiments were run with the Phillips type ethylene-1-hexene copolymer, Tipelin FS 471 (*TVK*). The polymer was stabilized with curcumin (*Sigma-Aldrich*) in concentrations changing between 0 and 1000 ppm. Stabilization efficiency was determined with and without Sandostab PEPQ phosphonite secondary antioxidant (PEPQ, 1000 and 2000 ppm; *Clariant*). Irganox 1010 (I1010; *BASF Switzerland*) was used as a reference phenolic antioxidant. The polymer was homogenized with the additives then extruded six times consecutively at 260 °C. FT-IR spectroscopy, optical microscopy rheology (MFI), residual thermo-oxidative stability (OIT), and color were used for the characterization of the samples after each extrusion step.

The results reveal that curcumin protects polyethylene from thermal- and thermo-oxidative degradation during processing more efficiently than the same amount of I1010. Its efficiency is increased by the addition of the phosphonite secondary antioxidant. Although the processing stability of PE is controlled by the phosphorous compound[3], curcumin enhances its efficiency already in a very small concentration, at 5 ppm. The decrease in MFI and the consumption of the phosphorous stabilizer are reduced in the multiple extrusion process compared to the effect of the phosphonite alone. Contrary to the behaviour of polyethylene processed with I1010 or its combination with PEPQ, melt flow index increases and yellowness index decreases with increasing number of extrusions when 1000 ppm curcumin or its mixture with PEPQ are used for stabilization. It is remarkable that the decrease in the concentration of vinyl groups with increasing number of extrusions is influenced more by the amount of the phosphonite than by the type of the phenolic antioxidant.

The analysis of polymer characteristics supported by model reactions of curcumin indicate that the stabilizing efficiency of this natural antioxidant is influenced by several factors at high temperatures, by its reactions with hydroperoxides, alkyl, hydroperoxy and oxy radicals, as well as by its self association and specific interaction with the phosphonite secondary stabilizer. The reaction mechanism is controlled by the ability of the phenolic group to donate hydrogen, but the heptadienone linkage between the two methoxyphenol rings also participates in the stabilization of PE.

Although curcumin discolours the polymer, its medical activity and food preservative properties can be especially advantageous in food packaging films and bottles.

References

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