

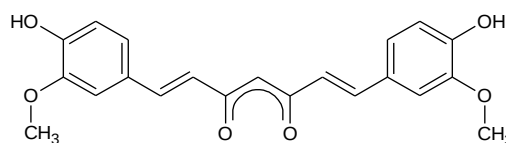
NATURAL ANTIOXIDANTS – STUDY OF THE PROCESSING STABILIZING EFFICIENCY AND MECHANISM OF CURCUMIN IN POLYETHYLENE

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Lately our interest was turned to the natural antioxidants because of some health issues about the possible danger of the reaction products of commercial phenolic stabilisers used in polyolefins. Curcumin is obtainable from *Curcuma longa* rhizomes. The powdered root is used as a spice, food colouring, and food preservative¹. The medical activity of curcumin has been known since ancient times. It is an effective scavenger of free radicals and inhibits lipid peroxidation². The question is how it behaves under the conditions of polyethylene processing and whether it can protect the polymer from degradation.

The experiments were run with Phillips type ethylene-1-hexene copolymer, Tipelin FS 471 (TVK). The polymer was stabilized with curcumin (*Sigma-Aldrich*) without and in the presence of Sandostab P-EPQ of 1000 and 2000 ppm (P-EPQ; *Clariant*) changing the concentration between 0 and 1000 ppm. Irganox 1010 (I1010; *BASF Schweiz*) was used as a reference phenolic antioxidant. The polymer was mixed with the additives and six consecutive degradative extrusions were carried out at 260 °C. FT-IR spectroscopy, rheological (MFI), residual thermo-oxidative stability (OIT), and colour measurements, as well as optical microscopy were used for characterization after each extrusion step.



The results reveal that curcumin protects more effectively polyethylene from thermal- and thermo-oxidative degradation during processing than the same amount of I1010. Its efficiency is increased by addition of phosphonite secondary antioxidant. Although the processing stability of polyethylene is controlled by the phosphorous compound³, curcumin enhances its efficiency already in a very small concentration, as 5 ppm. The decrease in MFI and the consumption of the phosphorous stabilizer is reduced in the multiple extrusion processes compared to the effect of single phosphonite. Contrary to the behaviour of polyethylene processed with I1010 or its combination with P-EPQ, the melt flow index increases and the yellowness index decreases with increasing number of extrusions when 1000 ppm curcumin or its mixture with P-EPQ are used for stabilization. It is remarkable that the decrease in the concentration of vinyl groups with increasing number of extrusions is more influenced by the amount of the phosphonite than the type of the phenolic antioxidant.

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

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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