

# The Effect of Curcumin on the Processing Stability of Polyethylene

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## Introduction

Polyethylene (PE) is one of the most widely used polymers applied in many areas. The material is exposed to heat, shear, and a small amount of oxygen during processing. Without adequate stabilization this leads to degradation reactions: chain scission and/or chain extension, which ultimately results in the formation of a network, and the deterioration of mechanical properties. In practice, synthetic antioxidants are used to hinder these reactions, but several questions were raised earlier regarding the effect of the reaction products of phenolic antioxidants on human health, which have not been answered yet [1]. Therefore the interest is focused more and more on the potential use of natural antioxidants [2,3]. The aim of our work is to select some natural antioxidants, which can efficiently hinder the degradation of polyethylene during processing without any danger of possible health damage when dissolving from the polymer during application, and eventually may even have some positive physiological effects. In this study the effect of curcumin was investigated and compared to that of the most commonly used phenolic antioxidant, Irganox 1010.

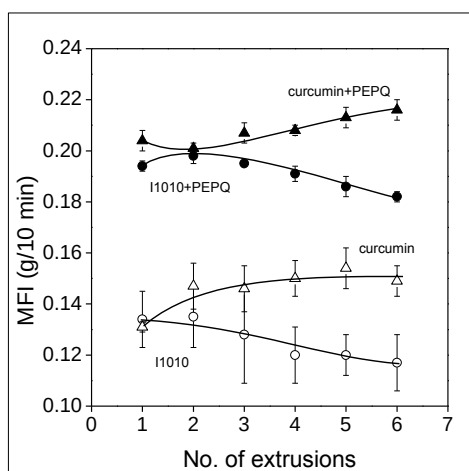
## Experimental

Tipelin FS 471 grade Phillips type additive-free polyethylene powder was provided by TVK, Hungary. The polymer was stabilized with 1000 ppm curcumin, and with a mixture of 1000 ppm curcumin + 2000 ppm Sandostab P-EPQ. The neat polymer and samples processed with synthetic antioxidants (Irganox 1010 and Sandostab P-EPQ) used in industry were studied for references. The polymer and the additives were homogenized in a high speed mixer then extruded at 260 °C and 50 min<sup>-1</sup> for six times using a single screw extruder. Samples were taken after each extrusion step. The polymer was characterized with different methods: infrared spectroscopy, the measurement of color, rheological properties (melt flow index, dynamic viscosity, creep compliance), and residual thermo-oxidative stability (OIT), mechanical tests, as well as optical microscopy.

## Results and discussion

The results reveal that curcumin is a more efficient processing stabilizer of polyethylene either alone or in combination with a secondary antioxidant than the synthetic hindered phenol used for reference. Fig. 1 shows that the melt flow index of samples containing curcumin increases with the number of extrusions, while it decreases in the presence of the synthetic phenolic antioxidants (in accordance with earlier observations). The decrease in melt flow index is a result of chain extension reactions, while the increase reflects the dominance of chain breaking reactions during the processing of polyethylene. The results presented in

Fig. 1 indicate that the stabilization mechanism of curcumin and the synthetic hindered phenol differs.



**Fig. 1.** Melt Flow Index of polyethylene stabilized with different antioxidants as a function of the number of extrusions

Curcumin is efficient not only in oxygen-poor environment (under processing conditions) but also in the presence of oxygen (OIT measurement). The residual thermo-oxidative stability of samples containing curcumin is significantly larger than that of those processed with the synthetic hindered phenol. Curcumin has an orange color due to the long sequence of conjugated double bonds in its structure resulting in strong discoloration of the polymer. The dissimilarities of the stabilizing mechanism of curcumin and the reference phenol are reflected also in the color changes of the polymer during multiple extrusions. Different derivatives with quinoidal structures are formed from I1010 resulting in a continuous increase in the yellowness index of polyethylene. On the contrary, the yellowness index of samples containing curcumin decreases with increasing number of extrusions. The morphology and the tensile properties of polyethylene do not depend on the chemical structure of the phenolic antioxidants used.

## Conclusions

Curcumin proved to be an efficient melt stabilizer of polyethylene. Its efficiency is further improved by the addition of a phosphorous secondary antioxidant. The changes in the chemical structure, the rheological characteristics and the color of the polymer as a function of the number of extrusions indicate that not only the phenolic OH groups but also the double bonds located in the linear chain of curcumin participate in the stabilization reactions. However, the coloring effect of curcumin can be disadvantageous in certain applications.

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## References

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