

Antioxidant properties of lignin in polypropylene

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Abstract

This work deals with lignin antioxidant properties in polypropylene. We extracted and characterised 15 lignin samples from various botanical origins (wheat straw and wheat bran) using different processes of extraction and using industrial Kraft lignin fractions (Westaco). These lignins were incorporated in polypropylene (1% weight). We underline the effect of lignin solubility in PP on stabilisation behaviour. The solubility in polypropylene is very low; as a consequence, classically important factors such as phenol content and intrinsic reactivity of the molecule are less important than factors making easier solubility. Solubility in PP could not be measured directly; a morphological criterion (average dimension of lignin aggregates in the blend) has been correlated to antioxidant activity and is thought indirectly to reflect solubility behaviour. The following factors tend to improve the compatibility (blend morphology) and consequently the antioxidant activity:

- low molecular weight
- low total OH content (aliphatic + phenolic)

The non-linear relation between Kraft lignin activity and its concentration in the blend has been explained by molecular weight polydispersity, and correlated to activities of Kraft fractions.

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1. Introduction

Lignins are complex phenolic polymers (see Fig. 2) occurring in higher plant tissues and are the second most abundant terrestrial polymer after cellulose. Due to their very complex structure, lignins are amorphous polymers with rather limited industrial use. They are usually seen as waste products of pulp and paper industry and often used as fuel for the energy balance of the pulping process. In 1998, only 1% of the lignin produced was used in valuable industrial processes [1]. Hence, the great challenge is to find new applications for lignins. For the last decades, a great deal of research was devoted to the development of lignin-containing polymeric materials. Two strategies were mostly used. The first consisted in blending large amounts of underivatized [2] or derivatized lignins [3,4] (with or without copolymerisation [5]) with synthetic polymer. Usually, this approach tends to

decrease the mechanical properties of the resulting materials. The other way of lignin use consists in the incorporation of lower amounts of lignin in order to take advantage of lignin structure and to stabilise the material against photo and thermooxidation [6–9]. Indeed, lignins are hindered phenolic polymers which can exert antioxidant properties. However, lignins are polar polymer (on average 1–2 hydroxyl groups per monomer [10,11]) and thus exhibit a very poor solubility in apolar media—such as polyolefins. This may limit their reactivity with the radicals responsible for the oxidation and subsequently limit their protecting effect compared to that of synthetic antioxidants. Some factors have importance on stabilisation properties of classical antioxidants: good solubility, mobility and low volatility [12]. However, the structure of lignins depends on a number of factors and accordingly can be modulated by several means including the botanical origin, the environmental conditions of growth and also the conditions of extraction from the in situ lignin network. Indeed, all the delignification techniques consist in the cleavage of covalent linkages of the

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