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ORIGINAL PAPER

An organic bioactive pro-oxidant behavior in thermal degradation kinetics of polypropylene films

Lara B. Tavares[1] · **Rafaela G. Rocha**[1] · **Derval S. Rosa**[1]

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Abstract Due to its versatility and low cost, polypropylene (PP) is one of the most widely used polymers in the world. However, since it does not easily degrade in natural environment, various methods have been studied to reduce its lifetime. The pro-degrading additives promote the polymer degradation process by accelerating the polymer degradation under heat and/or UV. Eco-one is an organic bioactive pro-oxidant additive that induces biodegradation when it is incorporated into a polymeric matrix by attracting microorganisms in the biotic phase. The aim of this work was to investigate the abiotic degradability of this organic bioactive pro-oxidant additive in PP films. Thermal oxidation studies of the specimens were carried out to investigate the abiotic degradability. We analyzed compositions of PP films containing 1, 3, and 5% Eco-one by mass. These films were characterized by thermogravimetric analysis to calculate the activation energy (E_α) and to estimate their lifetime. Differential scanning calorimetry was conducted to provide oxidative induction time. The samples were then aged at 80 °C and characterized by Fourier transform infrared spectroscopy to obtain the carbonyl index (CI). Compositions containing 1% Eco-one additive showed the optimal composition with lower activation energy, and shorter predicted lifetime, suggesting easier thermal degradation. Furthermore, high CI was also observed in samples containing 1% additive, indicating thermodegradation for this composition.

✉ Lara B. Tavares
lara.tavares@ufabc.edu.br

[1] Centro de Engenharia, Modelagem e Ciências Sociais Aplicadas, UFABC, Santo André, São Paulo 09210-580, Brazil

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Introduction

Polyolefins, as highly stable polymers, when disposed improperly in the environment, take many decades to degrade. These polymers do not easily degrade, so study on degradation of polyolefins has become a major research topic [1–3]. Degradable polyolefins are obtained with special additives, called pro-oxidants or pro-degradants, which accelerate the abiotic oxidation rate by catalyzing chain scission with light or heat; this creates decomposition into oxidized fragments, improving the degradability of the polymers [4, 5]. The most commonly used additives are compounds of transition metals [6], but there are also organic additives that induce chain scission of polymers. Montagna et al. [7] evaluated the effect of benzoin as an organic pro-degradant additive on the degradation rate of polypropylene (PP) in natural weathering and simulated soil. In this method the polymer degradation was accelerated, but the evaluation procedure was lengthy. Carvalho and Rosa [8] studied the thermal degradation of PP with two pro-oxidant additives: polyoxymethylene (POM), an organic additive, and d2w® (a metal-based additive). The activation energy was estimated from thermogravimetric analysis and the measured oxidation induction time.

The lifetime of organic materials at selected temperatures can be estimated by Arrhenius activation energy (E_α) and calculated from thermogravimetric analysis [9]. This has been widely used to investigate the kinetics of thermal decomposition of polymers and to determine their thermal stability instantaneously [10, 11]. Huang et al. [12] compared