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ORIGINAL PAPER

Effects of zinc borate loading on thermal stability, flammability, crystallization properties of magnesium oxide/(90/10) mLLDPE/(NR/ENR-50) blends

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Abstract Effects of different zinc borate (ZB) loadings on thermal, flammability and crystallinity properties of blends of 10 % rubber (9/1) natural rubber (NR)/epoxidised natural rubber (ENR)/metallocene linear low density polyethylene/*N*,*N*-*m*-phenylenebismaleimide/MgO were investigated. Fourier transform infrared spectroscopy revealed that –C=O and –OH groups appeared while C–O–C and C=C groups disappeared in all blend samples. ZB increased the activation of HVA-2 by changing the reaction mechanism and increasing the concentration of the –C=O groups in the blends due to the peak at 1,714–1,718 cm^{-1}. The crystallinity of all blends was increased by ZB loading increase; therefore, it played the heterogeneous nucleation center and maximum crystallinity was observed at 6 phr ZB blend. The thermal stability of NR improved with increase of zinc borate loading and the highest thermal stability was determined for 8 phr ZB blend. Good compatibilization between the two rubbers (NR/ENR-50) was achieved in the presence of ZB, which was revealed by the presence of only one peak for their decomposition. The limiting oxygen index value of mLLDPE was decreased by two rubbers loading increase, while it was increased by ZB loading increase to provide fire barriers to protect flammable materials from thermal damage. It was concluded that ZB has a synergistic effect on the LOI values of flame retardant mLLDPE/rubber containing MgO.

Keywords mLLDPE · Natural rubber · Epoxidised natural rubber · Thermal properties · Flammability · Crystallization

Introduction

Thermal stability, flammability and processability are important properties of wire and cable insulation materials. Linear low density polyethylene (LLDPE) offers excellent dielectric properties, mechanical toughness for wire and cable applications, good resistance to chemicals and ease of processing, and thus has been used as an insulation material in several applications [1, 2]. However, its applicability is restricted as it is flammable with poor thermal properties. Flame inhibition can be performed with the addition of inert fillers (e.g., $MgOH_2$ and MgO) as heat sinks or for releasing of inert gases (e.g., H_2O, CO_2 and NH_3) [3, 4]. Thermal analysis (TA) techniques (TGA, DSC, DTA, etc.) are of critical importance in the characterization of flame-retardant features, thermal stability of polymers and in the study of the retardation of combustion mechanism [5].

Zinc borates have been also used as flame retardant, smoke suppressant, afterglow suppressant, and anti-tracking agent in both halogen-containing and halogen-free polymers [6, 7]. Zinc borate with compositions of $3ZnO.2B_2O_3.3.5H_2O$, $2ZnO.3B_2O_3.3H_2O$ and anhydrous $2ZnO.3B_2O_3$ is most widely used [6, 7]. Zinc borate has been shown to reduce smoke in specific formulations [8] and its action was, at first, cooling through water release and then forming borate glass to protect the substrate [8]. These approaches are usually not sufficient to meet the most stringent smoke release standards [8]. The addition of aluminum trihydrate to the zinc borate forms a synergistic

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