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# PROTECTIVE NANOSTRUCTURED FLAME RETARDANT COATINGS FOR CABLE INDUSTRY APPLICATIONS

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## INTRODUCTION

This work deals with the formulation of nanocomposites based on ethylene butyl acrylate (EBA) copolymer and nanoclays potentially suitable as halogen-free flame retardant materials for applications in wire and cable industry. In particular, two different strategies were exploited: the first dealt with the incorporation of the nanofillers into the bulk copolymer; the second involved the utilization of a pre-prepared EBA/nanoclay film that was applied, as a surface coating, onto unfilled EBA specimens. This latter approach has been already proposed and discussed in the literature, showing its suitability in providing protection to an underlying polymer matrix [1].

Furthermore, since the morphology of the coating film, in terms of dispersion, distribution or orientation of the embedded nanofillers, can affect its effectiveness as protective layer, the surface films were prepared through cast extrusion or compression molding, aiming at gaining important insights into the processing/microstructure relationships of nanostructured materials endowed with flame retardant properties.

## EXPERIMENTAL

*Materials*

EBA Lucofin® 1400MN (content of butyl acrylate 17%, MFI 7.0 (190 °C, 2.16 kg)) was used as matrix while the nanoclays were introduced at 4 wt% (referred to the inorganic content) starting from a commercially available masterbatch Lucofin 7500.

*Preparation*

EBA/nanoclay nanocomposite was prepared through a melt compounding step in a twin-screw extruder and further processed through: *(i)* cast extrusion or compression molding for obtaining films having a thickness of about 300 μm; *(ii)* injection molding for obtaining EBA/nanoclay_bulk specimens. The films were then applied on unfilled EBA specimens, pre-prepared through an injection molding step.

*Characterizations*

Cone calorimetry tests were carried out with a Noselab Ats (Nova Milanese, Italy) instrument, following the ISO 5660 standard. Each sample (size: 50 × 50 × 3 $mm^3$) was tested under a 35 $kW/m^2$ irradiative heat flux. The morphology of the different samples and of the residues at the end of the cone calorimeter tests was assessed through SEM (EVO15, Zeiss) observations.

## RESULTS AND DISCUSSION

The preliminary evaluation of the morphology of the cast extruded and compression molded films demonstrated the achievement of a uniform microstructure in both materials; in fact, the embedded nanofillers appear homogeneously dispersed and distributed within the host EBA matrix, and no agglomerates or clusters are observable. As expected, a preferential orientation of the nanoclays along the extrusion direction is clearly noticeable in the EBA/nanoclay_CE film.

The combustion behavior of all formulated EBA-based systems was evaluated through cone calorimeter tests (Figure 1). From an overall point of view, it is worthy to note that, regardless the exploited strategy (namely, bulk or surface approach), the incorporation of the nanoclays lowers the pHRR of the unfilled EBA, likely due to the well documented action of nanoclays [2]. In brief, the acidic sites on the silicate layers resulting from the thermal degradation of the organomodifier are able to catalyze the formation of a coat-like char on the specimen surface (that serves as a potential barrier to both mass and energy transport) and the oxidative dehydrogenation of the polymer chains, leading to the formation of double bonds and consequent aromatization and charring. Lastly, a minor contribution could be also provided by the barrier created through the ablative reassembly of the silicate layers on the polymer surface. Obviously, the more pronounced effect in the EBA/nanoclay_bulk system can be ascribed to the higher amount of nanoclays contained in this sample as compared to the surface-coated ones.

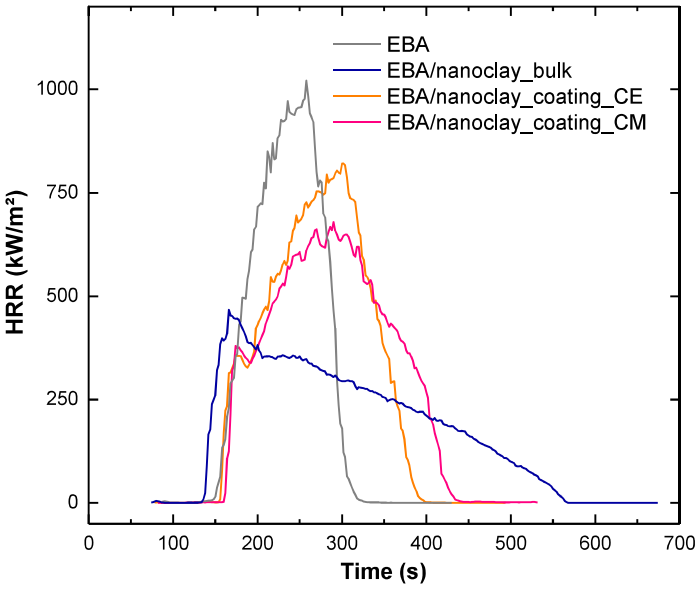


Fig. 1 HRR curves for pristine EBA and all investigated nanoclay-containing systems

Furthermore, looking at the HRR curves of the samples prepared following the two approaches, important differences emerge when comparing bulk incorporation and surface coating. In particular, in the first case the nanofillers anticipate both time to ignition and time to peak as compared to unfilled EBA, while an opposite behavior is observed for the surface-coated samples. In particular, the delayed time to peak of both systems obtained through the surface approach is a clear indication of the thermal shielding effect provided by the presence of the nanofillers on the surface of the sample exposed to the irradiative heat flux. Concerning the effect of the processing adopted for the formulation of the protective layer, the differences observed between the HRR curves of the two specimens can be ascribed to the different microstructure of the residues at the end of the cone calorimeter test, resulting from the different state of dispersion and orientation of the nanoclays in the original cast-extruded or compression molded films.

In all, the obtained results demonstrated the effectiveness of the proposed surface approach, capable to concentrate the flame retardant action on the surface of a polymer system, where the combustion specifically takes place, thereby preserving the required features of the polymer bulk and minimizing the amount of flame retardant.

**References**

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