Nanostructured coatings with flame retardant properties for EBA-based materials

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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, while the second involved the utilization of a pre-prepared EBA/nanoclay film that was applied, as a surface coating, onto unfilled EBA specimens. Furthermore, since the morphology of the coating film, in terms of dispersion, distribution or orientation of the embedded nanofillers, can affect its performances 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.
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 appeared homogeneously dispersed and distributed within the host EBA matrix, and no agglomerates or clusters were observed. As expected, a preferential orientation of the nanoclays along the extrusion direction was clearly noticeable in the cast extruded film.

The combustion behavior of all formulated EBA-based systems was evaluated through cone calorimeter tests. From an overall point of view, regardless the exploited strategy (namely, bulk or surface approach), the incorporation of the nanoclays lowered the pHRR of the unfilled EBA. More specifically the bulk system exhibited the lowest pHRR value, indicating the most significant flame-retardant effect, although this is likely due to the higher concentration of nanoclays in this sample compared to the surface-coated ones. Furthermore, when comparing bulk incorporation and surface coating, important differences emerged: in the first case the nanofillers anticipated both time to ignition and time to peak as compared to unfilled EBA, while an opposite behavior was observed for the surface-coated samples. 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 correlated 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.

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