VALORIZATION OF POLYETHYLENE COMPOUNDS: INCORPORATION OF HALOGEN-FREE FLAME RETARDANTS AND HEAT STABILIZERS

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ABSTRACT

Polyethylenes (PEs) are the most widely used commodity polymers with a high potential of value-adding via proper compounding. An increasing fraction of PEs is nowadays used in inhouse and outdoor piping and the relevant applications need to be flame retarded in order to comply with stringent fire safety standards [[1]]. In addition, resistance to heat is very important especially when it comes to outdoor applications, such as pipes, gardening hoses etc and in countries where average temperature is very high (e.g. Middle East).

In order to improve the flame resistance, halogen-containing flame retardants (HFRs), such as brominated FRs, e.g. decabromodiphenyl ether, are mainly used in combination with antimony oxide, due to their efficiency at low loadings (ca. 1-2 % wt) and their low cost[[2]]. Nevertheless, HFRs present significant disadvantages, namely corrosion of the equipment during processing, and production of highly toxic gases (e.g. brominated and chlorinated furans and dioxins) during combustion. The need to substitute HFRs by halogen-free alternatives is therefore rising due to environmental legislations and EU directives, but also due to industrial initiatives and public consciousness[[3],[4]]. Therefore, inorganic flame retardants, e.g. $Al(OH)_3$ or $Mg(OH)_2$, need to be added in high loadings (>50 % wt.) in order to be effective. Consequently, the end products show poor mechanical, physical and rheological properties meanwhile showing difficulties in compounding[[2]]. Alternatively, phosphorus- and nitrogen-based compounds, including intumescent flame retardant systems (IFRs), present a viable alternative. IFRs play an effective role mainly by the condensed-phase mechanism forming a carbonaceous foam residue (swollen char) on the surface of the polymer that acts as a heat insulator and a physical barrier to the transport of oxygen and pyrolysis products[[5]].

On the other hand, regarding heat stabilization, additives like hindered amines and/or triazine derivatives which are known for UV stabilization, can offer also protection against heat. These additives can be effective in very low loadings (e.g. 0.1-0.5wt%) without affecting the end properties of the polymer, nevertheless their high cost should be taken into account.

In this work the effect of six halogen-free flame retardant (FR) formulations was investigated on the thermal stability of two low-density polyethylenes (LDPE) and one linear low-density polyethylene (LLDPE), by means of thermogravimetric analysis (TGA) under nitrogen and air atmosphere and flammability properties (UL94V). Furthermore, four different UV/heat additives were incorporated to the raw PE materials and the resulting twelve formulations were subjected in accelerated thermal ageing experiments in an air circulating oven at 100°C. The samples were removed once a month and the mechanical properties were measured (tensile strength) and were compared to the respective values of the neat polymers. The results showed high FR efficiency when a combination of a triazine compound and ammonium polyphosphate was used and also good stabilization against heat for almost four months of exposure.

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