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Book of Abstracts
November 2-5, 1998

Kellie Ann Beall, Editor

Building and Fire Research Laboratory
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INTUMESCENCE AND POLYMER BLENDING : AN APPROACH FOR FLAME RETARDANCY ?

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Fire protection of flammable materials by an intumescence process is known for several years. Fire retardant intumescent materials form on heating foamed cellular charred layers on the surface, which protects the underlying material from the action of the heat flux or of a flame. The proposed mechanism is based on the charred layer acting as a physical barrier which slows down heat and mass transfer between gas and condensed phase. Generally, intumescent formulations contain three active ingredients : an acid source, a carbonization compound, and a blowing agent. First, the acid source breaks down to yield a mineral acid then, it takes a part in the dehydration of the carbonific to yield the carbon char and finally, the blowing agent decomposes to yield gaseous products. These latter cause the char to swell and hence provide the insulating material which then decomposes under the action of the outer heat flux.

The carbonization agents (CA) commonly used in intumescent formulations for thermoplastics are polyols such as pentaerythritol, mannitol, sorbitol, ... One of the problem with this kind of compounds is the exudation and the water solubility of the additives. Moreover, there is not a good compatibility between the additives and the polymeric matrix and the mechanical properties of the polymer are then very poor. New carbonization agents have to be found. The Laboratory develops FR intumescent formulations using charring polymers as carbonization agent. The advantage of this concept is to obtain flame-retarded polymers with improved mechanical properties in comparison with polymers loaded with classical FR formulations and to avoid the problems of exudation and solubility of the additives (figure 1).

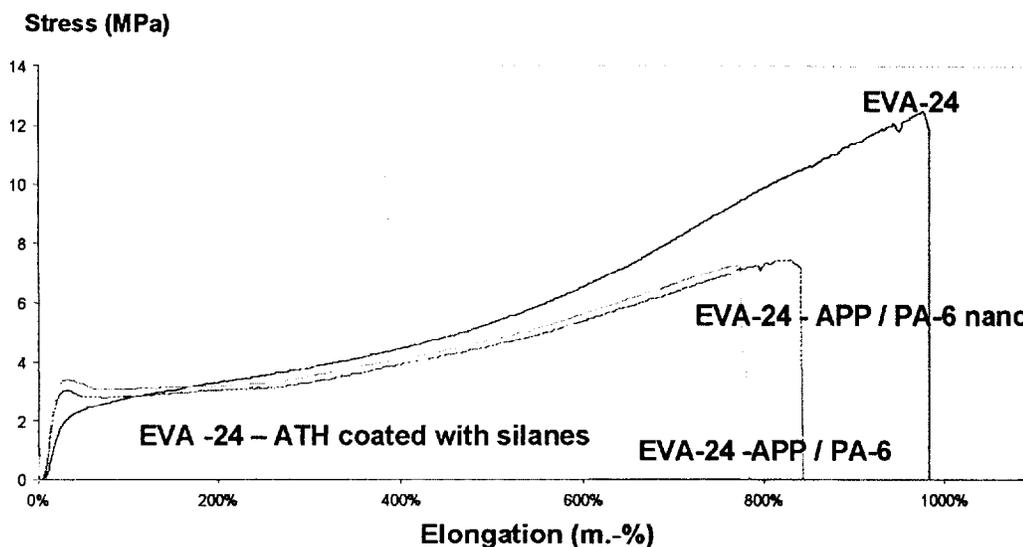


Figure 1 : mechanical properties of the formulations EVA24-ATH, EVA24-APP/PA-6 and EVA24-APP/PA-6nano (PA-6nano=PA-6 clay hybrid from UBE Industries) in comparison with the virgin EVA24

The aim of this work is to show the efficiency of charring polymers as carbonization agent in FR intumescent formulations using fire testing (LOI, UL-94 and cone calorimeter). In this study, we present some examples of formulations using polyurethane (PUR) and polyamide-6 (PA-6) as charring polymers respectively, in polypropylene (PP) and ethylene-vinyl acetate copolymers (EVA).

Figure 2 shows the RHR (Rate of Heat Release) values versus time in the conditions of the cone calorimeter of PP-APP(ammonium polyphosphate)/PUR formulations with different kinds of PUR (see the caption of the figure 2). The RHR values are improved when polyester-based PUR are used in comparison with polyether-based PUR. For the same polyol (S series), RHR values decreases when number of hard segments increases.

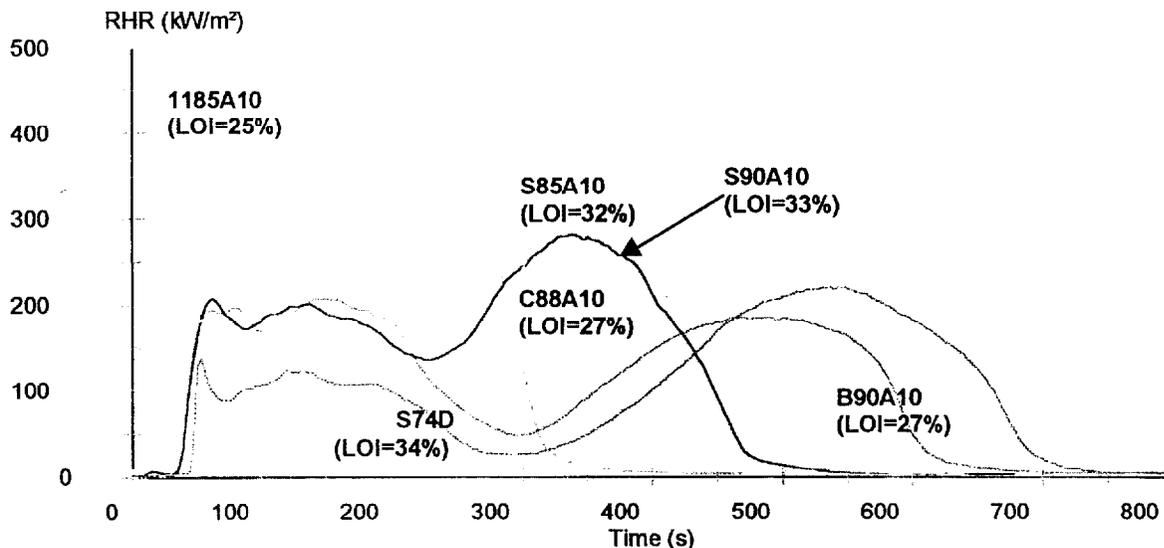


Figure 2 : RHR values versus time of PP-APP/PUR formulations in the conditions of the cone calorimeter under an external heat flux equaling 50 kW/m² (PUR from Elastogran of the series Elastollan : 1185A10 polyether-based PUR and series S, C and B polyester-based PUR. In the series B, C and S the nature of polyol is changed. From S85 to S74 the number of hard segments is increased).

RHR values of the flame retarded EVA24 are strongly reduced in comparison with the virgin one (figure 3). As in the case of PP, it is demonstrated the efficiency of using charring polymers in FR intumescent formulations. It is also shown that the use of PA-6nano improves the FR performance of the system : RHR peak = 320 kW/m² without nanocomposite and RHR peak = 240 kW/m² with nanocomposite. Moreover, figure 4 shows an interesting result. The residual mass of EVA24-APP/PA-6nano is strongly increased in comparison with EVA24-APP/PA-6. This means that there are lower evolved gases during combustion which could feed the flame.

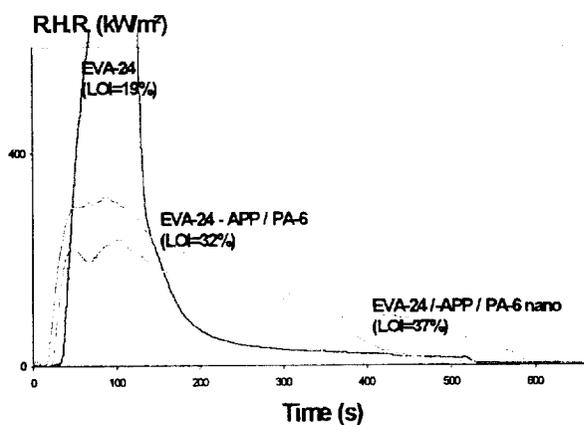


Figure 3 : RHR values versus time in the conditions of the cone calorimeter under an external heat flux equaling 50 kW/m² of the formulations EVA24-APP/PA-6 and EVA24-APP/PA-6nano in comparison with EVA24

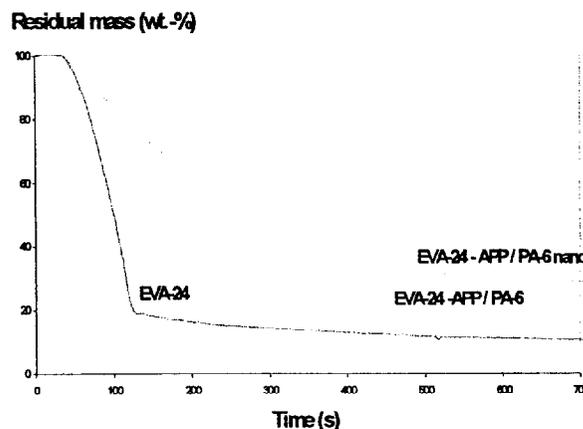


Figure 4 : Residual mass versus time in the conditions of the cone calorimeter under an external heat flux equaling 50 kW/m² of the formulations EVA24-APP/PA-6 and EVA24-APP/PA-6nano in comparison with EVA24