

BOEHMITE AS SYNERGIST FOR FLAME RETARDANT POLYOLEFIN COMPOUNDS



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Boehmite is used as flame retardant additive in combination with other FR products (hydroxides, phosphorus additives, etc) due to the high temperature application, the smoke suppressant and char promoting effect. ALUPREM® TB 1/T and TB DRY are two grades of boehmite characterized by 99,4% of AlO(OH) content and with the characteristics reported in the following table.

The performance of the two boehmites have been evaluated in EVA and PE based compounds as partial substitution of magnesium hydroxide (MDH) at increasing levels. All the recipes have been produced at twin-roll mixer at temperature of 140-150°C.

Boehmite TB 1/T is indicated with A and TB DRY with B (formulations containing only magnesium hydroxide are called O).

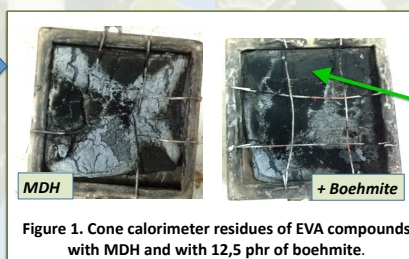
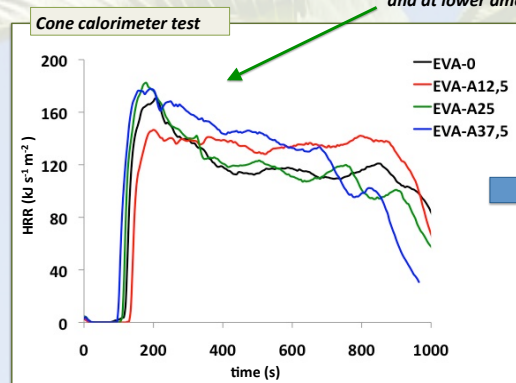
Properties	TB 1/T	TB DRY
Particle Size - d50, (µm)	1,0	2,5
Specific Surface, (m ² /g)	12	4,5

EVA based formulations

Composition: 70 phr EVA28, 20 phr mLLDPE, 10 phr LLDPE-g-MAH, 2 phr silicon lubricant, 1phr stabilizer/antioxidant, 150 phr of total fillers (amounts of added boehmite is indicated in the formulation names and they correspond to 12,5 , 25 and 37,5 phr).

PROPERTIES	EVA-0	EVA-A12,5	EVA-A25	EVA-A37,5	EVA-B12,5	EVA-B25	EVA-B37,5
Density at 23°C	1,462	1,472	1,480	1,491	1,466	1,483	1,490
MFI 190°C/21.6 kg	1,1	2,7	3,6	3,1	1,4	4,4	5,2
Mooney viscosity (1+4 minutes@140°C)	51,3	49,2	46,4	45,4	52,9	47,9	46,2
White Index	80,8	81,7	80,4	80,7	79,9	79,8	78,9
Tensile strength at break (N/m ²)	12,5	12,5	11,6	11,6	11,1	11,3	11,1
Elongation at break (%)	173	182	193	207	184	182	198
Water absorption 336 hours at 70°C	1,98%	2,20%	2,32%	2,51%	2,15%	2,13%	2,13%
LOI (%O ₂)	36	38	38	39	39	39	38

Best performance with the finest boehmite and at lower amounts.



Very positive effect especially on VISCOSITY, ELONGATION and LOI.

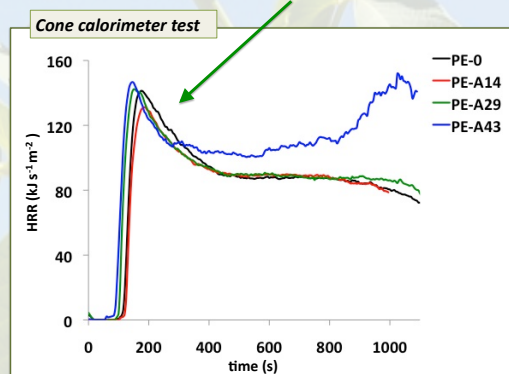
More compact and homogenous residue surface.

PE based formulations

Composition: 66 phr mLLDPE, 23 phr mLLDPE, 11 phr LLDPE-g-MAH, 6 phr silicon lubricant, 3 phr stabilizer/antioxidant, 177 phr of total fillers (amount of added boehmite is indicated in the formulation names and they correspond to 14 , 29 and 43 phr).

PROPERTIES	PE-0	PE-A14	PE-A29	PE-A43	PE-B14	PE-B29	PE-B43
Density at 23°C	1,468	1,473	1,481	1,478	1,477	1,474	1,482
MFI 190°C/21.6 kg	3,6	3	3,5	3,3	3	3	3,3
Mooney viscosity (1+4 minutes@140°C)	69,2	69,4	66,9	64,3	70,5	67,8	68,3
White Index	65,5	62,8	65,1	70,7	66,5	72,6	71,8
Tensile strength at break (N/m ²)	10,6	9,7	10,1	10,3	10,8	10,8	11
Elongation at break (%)	224	211	236	223	218	222	231
Water absorption 336 hours at 70°C	1,19%	1,19%	1,21%	1,28%	1,14%	1,08%	1,14%
LOI (%O ₂)	34	32	33	31	33	32	33

No effect on VISCOSITY and MECHANICAL PROPERTIES. Negative effect on LOI.



Small positive effect at the lowest amount of boehmite.

Vertical burning test (DIN 4102)



Figure 2. Vertical burning test of EVA-compounds with MDH alone (P1) and boehmite (P4).

Class	Compound	Time to grad line (s)	Total combustion time before flame off
EVA	EVA-A12,5	-	135
	EVA-A37,5	-	150
	EVA-A25	-	180
PE	PE-0	120	-
	PE-A14	100	-
	PE-B14	100	-
	PE-A29	90	-
	PE-B29	90	-
EVA	EVA-0	165	-
	EVA-B12,5	150	-
	EVA-B25	135	-
	EVA-B37,5	135	-
	PE-A43	90	-
	PE-B43	80	-

Conclusions

Comparison of two different particle size boehmites in combination with MDH:
-the finest one generally takes to better compound properties.

Characterization of EVA-compounds with combination of boehmites and MDH:

- increased elongation and decreased viscosity;
- synergistic FR effects with lower flammability, higher material stability, reduced dripping, better char formation and barrier effect.

Characterization of PE-based compounds:

- boehmite with MDH causes no particular synergistic effect in this system.

References

- [1] Camino G. et al: Effect of hydroxides and hydroxycarbonate structure on fire retardant effectiveness and mechanical properties in ethylene-vinyl acetate copolymer. *Polymer Degradation and Stability* 2001, **74**, 457-464.
- [2] El Hage R. et al: Flame retardancy of ethylene vinyl acetate (EVA) using new aluminium-based fillers. *Polymer Degradation and Stability*, 2014, **108**, 56-67.

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