PRODUCT APPLICATION NOTE

Coupling agent for Halogen Free Flame Retardant (HFFR) wire & cable compounds

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Coupling Agent for Halogen Free Flame Retardant (HFFR) Wire & Cable Compounds

Introduction

Halogen Free Flame Retardant (HFFR), Zero Halogen Flame Retardant (ZHFR), Low Smoke Zero Halogen (LSZH), are all names used interchangeably for Wire & Cable compounds as well as for optical fiber cable compounds companies.

Applications

These compounds are generally based on polyethylene or copolymers of polyethylene, with the addition of special mineral fillers to impart flame retardant properties. They are finding increasing use as replacements for popular halogenated polymers like PVC for applications where low smoke and no acid gas evolution are required during a fire situation.

Coupling of HFFR fillers in wire and cable jacketing, can be reliably achieved using OPTIM® functionalized polyolefin from PLUSS®. OPTIM® coupling agents are especially helpful in highly mineral-filled compounds such as polyolefin matrices with high concentrations of common flame retardants, ATH, or $Mg(OH)_2$. ATH has a lower degradation temperature (~ 200°C) and is used with EVA/LLDPE based formulations while $Mg(OH)_2$ (Magnesium Hydroxide) has a higher degradation temperature (~ 340°C) and is used when polypropylene is the base polymer. The mixture of ATH and magnesium hydroxide is also used in some formulations, to achieve specific properties.

OPTIM® coupling agent is also used with low smoke zero halogen (LSZH) compounds for the application in sheathing for fiber optic cables.

ATH flame retardancy mechanism

ATH and Magnesium Hydroxide are the most widely used non-halogenated flame-retardant fillers used in wire & cable industry. They work by a different flame retarding mechanism than common halogenated flame retardants. The mechanism of non-halogen flame retardants is shown below.

$$2Al(OH)_3 \xrightarrow{>340^{o}C} Al_2O_3 + 3H_2O$$
$$Mg(OH)_2 \xrightarrow{>200^{o}C} MgO + H_2O$$

100 grams of ATH releases about 34.6 grams of water while 100 grams of magnesium hydroxide releases about 31 grams of water. This removes a substantial amount of heat energy in converting it to steam during incident of fire.

ATH performs two additional functions - as filler and as a smoke suppressant. Smoke generated by burning materials has increasingly become a concern in recent times. This is especially true in mass transit networks. Halogenated flame retardants produce smoke as part of their functioning; it is this smoke that aids in putting out the fire. But this smoke is also responsible for more fatalities due to choking and poor visibility. As shown above, ATH works by a different mechanism that does not produce smoke. When used alone in sufficiently large amounts ATH can produce a compound with very little smoke. When used in conjunction with halogenated compounds the smoke level can be considerably reduced. It must be stressed however that ATH.

requires very high loading levels of 60- 65% to be effective. This has a deleterious effect on the physical properties of the cable compound.

OPTIM® coupling efficiency

For efficient flame retardancy, 60-65% of the filler needs to be added to the polymer matrix which results in the reduction in tensile strength of the polymer matrix.

To keep excellent mechanical performance at a very high mineral loading, it is necessary to increase polymer matrix acceptability of ATH. This task is performed by using a highly efficient coupling agent between the polymer base and the mineral flame retardant. A good adhesion between the filler and the polymer matrix optimizes mechanical performance.

OPTIM® brand of maleic anhydride functionalized polyolefins, manufactured and marketed by PLUSS® can be effectively used as coupling agents between polyolefin polymers and fillers, as required in the present application. Typical addition levels of OPTIM® coupling agents are in the range of 2-5 weight % based on the total compound weight. Apart from flame retardants like aluminum trihydrate (ATH) and magnesium hydroxide, common fillers such as calcium carbonate, talc etc. also show good affinity to OPTIM® coupling agent grades.

Silanes were traditionally used as coupling agents in mineral filled polymer compounds. From cost, performance, and handling viewpoints, however, OPTIM® maleic anhydride functionalized polyolefin coupling agents have become the preferred material now, because of:

• Granular shape and size being like the base polymer. This prevents feeding or dosing problems (down-time, bridging) compared to the dosing of liquid coupling agents such as silanes.
• Silanes are liquids that have limited shelf life due to reactivity with atmospheric moisture and self- polymerization tendency. OPTIM® maleic anhydride functionalized polyolefin coupling agents do not suffer from this limitation.
• Similar polymer nature as the base polymer in the compound formulation. It also contributes to the mechanical properties in the resultant compound.
• Better distribution of the coupling agent in the compound formulation. This provides consistent compound properties.
• Very low water absorption in finished compounds.

Compatibility with a very broad choice of polymer systems such as LLDPE, HDPE, EVA, mLLDPE, mPE etc.

Benefits that a consistent quality of HFFR wire & cable compounds made with OPTIM® coupling agents provide are:

- Stable melt flow characteristics.
- Higher extrusion Speeds with Improved surface appearance.
- Less stress whitening in cable insulation layer
- Higher filler acceptability
- No limitation in coloring

Product Validation

As a case study, Pluss have used the following formulation to show the effect of one of its grades of coupling agents:

LLDPE (MFI 4.5)	(14-25) %
EVA (1802)	(10-20) %
ATH (Apyral 60D)	60%
Antioxidant (Kinox 10)	0.15%
Paraffin Oil (Aromatic)	0.1%
OPTIM® E-119	(5-6) %

The compound was made in an internal mixer and extruded into pellets at overall processing conditions around 160 -170°C.

Comprehensive test data for the compound thus made is tabulated below.

Property	Typical Value*	Unit	Test Method
Specific Gravity at 23°C	1.49	g/cm^3	ASTM D792
Shore D Hardness	48	-	ASTM D2240
Melt Flow Index 160°C/21.6 kg	12	g/10 min	ASTM D1238
Tensile Strength	12-14	N/mm^2	ASTM D638
Elongation at Break	220-250	%	ASTM D638
Mechanical Properties after Ageing			
[7days at 100°C]			
Variation on Tensile Strength	±12	%	ASTM D638
Variation on Elongation at Break	±20	%	ASTM D638
Limiting Oxygen Index	31	% O_2	ASTM D2863
Temperature Index	275	°C	ASTM D2863
Volume Resistivity	$1x10^{14}$	Ohm-cm	ASTM D257
Smoke Density	< 20		ASTM2843
Halogen Acid Gas Emission	< 0.5	%	IEC 754 PT(I)
Toxicity Index	< 5	-	NES 713

Typical values based on tests conducted on 2 mm thick sheets and should not be taken as specifications.

This is only an indicative study. Properties required in a specific cable compound are dictated by the application and can be achieved by suitable changes in the formulation.

Apart from relative quality and quantity of materials in the composition, processing machine and conditions used also play a major role in properties of the HFFR cable compounds made. Since flame retardance of ATH and magnesium hydroxide takes place by release of water when heated, care is to be taken to maintain temperatures below 170°C, at compounding and cable making stages.