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

PRODUCT APPLICATION NOTES

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Halogen Free Flame Retardant (HFFR), Zero Halogen Flame Retardant (ZHFR), Low Smoke Zero Halogen (LSOH), Low Smoke and Fume (LSF) are all names associated with compounds that are used extensively in Aluminum Composite Panels (ACP), Wire & Cables, Flooring and Foam insulation.

These compounds are generally based on polyethylene or copolymers of polyethylene with the addition of mineral fillers to impart flame retardant properties. They are finding increasing use as replacements for PVC and other halogenated polymers for applications where lower smoke and lower acid gas evolution are required during a fire situation.

HFFR coupling in aluminum composite panel core compounds as well as wire and cable jacketing, can be reliably achieved using OPTIM® functionalized polyolefins from PLUSS®. OPTIM® coupling agents are especially helpful in highly mineral-filled compounds such as polyolefin matrices needing high concentrations of common flame retardants, ATH or $Mg(OH)_2$. ATH has lower degradation temperature (~ 200^0C) and is used with EVA/LLDPE based formulations while $Mg(OH)_2$ (Magnesium Hydroxide) has a higher degradation temperature (~ 340^0C) and is used when Polypropylene is the base polymer.

ATH flame retardancy mechanism

ATH is the most popular and widely used flame retardant filler in ACP compounds. It works by a different flame retarding mechanism than other halogenated flame retardants. ATH performs two additional functions, as filler and as a smoke suppressant. It is considerably cheaper than halogenated flame retardants. This means that it can be used as a cost reducing filler. However, due to its low structure it does not have the reinforcing characteristics of a carbon black. The other important function of ATH is as a smoke suppressant. Recently, the smoke generated by burning materials has become increasingly important. 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. ATH works by a different mechanism that does not produce smoke. When used alone in very large amounts ATH can produce a compound with very little smoke. When used in conjunction with halogenated compounds the smoke level can be reduced. It must be stressed however that ATH requires very high loading levels, 60- 65%. This deleteriously affects physical properties. The mechanism of Non Halogen flame retardants is shown in the reactions given below. 100 grams of ATH releases about 34.6 grams of water while 100 grams of Magnesium Hydroxide releases about 31 grams of water which takes up a substantial energy during fire.

$$2Al(OH)3 \xrightarrow{>200^oC} Al2O3 + 3H2O$$

$$Mg(OH)2 \xrightarrow{>340^oC} MgO + H2O$$

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 of original mechanical performances. In order to keep excellent mechanical performance at a very high mineral loading, it is necessary to increase polymer matrix acceptability of ATH via the use of a highly efficient coupling agent. To optimize mechanical performance, a good adhesion between the filler and the polymer matrix is also needed. Silanes are traditionally used as coupling agents but being in liquid form they impose handling problems. Maleic Anhydride

Functionalized polyolefins on the other hand are excellent candidates as coupling agent.
PLUSS® Maleic Anhydride Functionalized polyolefins- OPTIM® can be used as coupling agents between polymers -- mainly polyolefins such as polyethylene and polypropylene -- and fillers, in order to increase the filler acceptability of polymers. By combining superior compounding performance and consistent quality, OPTIM® can often be used in lower concentrations to achieve required properties in a cost-effective filled compound. Typical addition levels of OPTIM® are in the range of 2-5 weight % based on the entire compound. Flame retardants that show affinity to OPTIM® include fillers such as alumina trihydrate (ATH) and magnesium hydroxide. Improved properties also can be seen when OPTIM® is used with common fillers such as calcium carbonate, Talc etc.

When compared with silane coupling agents or other grafted polyolefins, OPTIM® provides:

- Superior tensile strength and elongation at break of finished compounds
- Lower gel content for higher compound performance consistency
- Very low water absorption of finished compounds.

Other Benefits that OPTIM® Coupling Agents impart in HFFR compounds are as follows:

- Improved adhesion between filler & polymer
- Higher Extrusion Speeds with Improved surface
- Stable Melt Flow Index
- Less stress whitening
- Higher filler acceptability
- Better mixing than liquid coupling agents
- No Limitation in coloring
- Compatible with a very broad choice of polymer systems: LLDPE, HDPE, EVA, mLLDPE, mPE etc.
- The pellet form of OPTIM® coupling agent prevents feeding or dosing problems (down-time, bridging) compared to the dosing of liquid coupling agents such as Silanes.
- Environmentally safe, Non Hazardous

Pluss have evaluated various coupling agents available from other manufacturers and compared them with OPTIM®. The following formulation was used for evaluation of the coupling agents.

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

The processing conditions will be around 160-170^{0}C.

It was found out that the mechanical properties especially Tensile Strength and Elongation at Break obtained when using OPTIM® as coupling agent were greater than those obtained when other grafted products were used. The elongation increased by about 3-4 times (as compared to without any coupling agents). In addition to this the extrusion speed and surface quality was much superior with OPTIM