The Compound and Cure

Our 3-part technical series on compounding EPDM at our website began with Part 1-Polymer EPDM then on to Part 2-Peroxides. We will now discuss compounding and the cure associated with peroxides for EPDM/EPR namely, but with peroxide cured polymers in general.

Part 3 –The Compound and Cure

In general, most polymers, both elastomers and thermoplastics, are able to be cross-linked using peroxides. They include: Natural Rubber (NR), Styrene Butadiene Rubber (SBR), Polybutadiene (PBD), Acrylonitrile Butadiene (NBR), Hydrogenated Acrylonitrile Butadiene (HNBR), Ethylene Propylene Diene Monomer (EPDM), Ethylene Propylene Rubber (EPR), Silicone (MQ), Polyurethane (PU), Chlorinated Polyethylene (CPE), Chlorosulfonated Polyethylene (CSPE), Fluroelastomer (FKM), Ethylene Vinyl Acetate (EVA), Acrylonitrile Butadiene Styrene (ABS), Acrylic, and Polyethylene (PE).

The few Polymers that *CANNOT* be cross-linked using peroxides include: Butyl (IIR), Polyisobutylene (PIB), Polyvinyl chloride (PVC), Polystyrene (PS), and Polypropylene (PP).

EPDM and EPR are cross-linked with peroxides in high performance applications where sulfur cure systems fall short.

EPDM and EPR' s are compounded using many ingredients to optimize physical properties and processing. Certain ingredients can interfere with the peroxides and reduce the state of cure. Key properties like compression set and heat resistance are compromised when raw materials are not carefully selected to minimize this interference.

Compound additives can cause problems by consuming free radicals. Polymer crosslinking is initiated by the free radicals created by the decomposition of the peroxide (see Part 2 of this series for more information on peroxide decomposition rates). The additives that can consume the free radicals include fillers, process oils and antioxidants.

EPDM and EPR's require highly reinforcing fillers, often at very high loading levels, to create compounds with acceptable physical properties. They are capable of accepting high loading levels due to their high molecular weight and the low levels of crystallinity in the polymer structure.

Fillers with high surface area can reduce peroxide efficiency due to absorption of free radicals. The acidity of fillers can also cause cure retardation. Black and non-black fillers that are neutral to basic are best choices. These non-acids fillers (listed with their pH levels) include: Carbon black-8, Austin Black-7, Silica-7, and Calcium Carbonate-9.

Fillers that are slightly acidic include products such as kaolin clays (hard clay, water washed clay, or calcined clay all have a pH in the 4-5 range). If you must use clay, adding a slightly basic material, like Carbowax Polyethylene Glycol PEG-3350 or Triethanolamine (TEA) will be preferentially absorbed to the filler surface. These materials are also used when compounding with silicas to help minimize the surface absorption issues. It is typically suggested to add the basic ingredient early in the mix cycle prior to the peroxide. Another approach is the use of a silane treated filler or to add a vinyl silane, such as Silquest® RC-4, and treat the filler “in-situ” (during the mixing process). This new product from Momentive Performance Materials, formerly known as GE Silicones, is similar to vinyl-tris-(2-methoxyethoxy) silane, only more environmentally friendly. These silanes then react on the surface of the mineral allowing the peroxide to react.

In addition to the high levels of fillers, high levels of process oils and plasticizers are used to aid in processing, extending, and to some extent reinforcing.

Paraffinic oils, products such as HSDC Stan-Lube 10, 60 and 80 are the best choice since they have a low aromatic content. Napthenic oils such as HSDC Stan Plas 100, 1200 and 2000 that are hydrotreated would be a second choice since they also contain low aromatic content, although they affect the peroxide cure more than a paraffinic oil. Aromatic process oils that contain high levels of aromatic content and are well known to inhibit a peroxide cure and are not recomended. The aromatic oils are not suggested and not compatible with linear EPDM, EPR polymers. It is also possible to use plasticizers these include synthetic esters of phthalic, adipic, sebacic and trimellitic acids like Polycizer® DOP, DOA , DOS and TOTM. These are generally more costly than oils and have limited compatibility, but are even better in not inhibiting the peroxide cure. They can also be very efficient and can contribute to improved low temperature properties.

EPDM and EPR typically do not need extra protection from oxygen, ozone or heat since they contain low levels of unsaturation that is pendant; i.e. not on the polymer backbone.

If it is necessary to add an antioxidant to a black compound, it is suggested to use a polymeric type product such as Flectol® TMQ. The high molecular weight of this type of antioxidant protects well and tends not to scavenge radicals to any great extent. These materials do have a tendency to stain. In non-black compounds, it has been found that Stangard® ODP (octylated diphenyl amine) along with a imadazole can be used. Alternatively, Wingstay® S, a styrenated phenol and imadazole synergist, can also be used. Many of the remaining antioxidants will scavenge peroxide radicals and it will typically be necessary to add additional peroxide to make up for those lost radicals.

The traditional zinc oxide and stearic acid activator system used with sulfur cure systems is not needed with peroxide cure. However, a small amount of stearic acid can help as a processing aid and the typical level of zinc oxide can also add to the high temperature stability of the compound by increasing the thermal conductivity.