The Syncure System

Crosslinked Polyethylene

Frequently Asked Questions.

Introduction

The Syncure™ System is a silane-grafted, moisture-crosslinkable polyethylene produced and marketed by The Geon Company. The Syncure System can be used in several applications including low-voltage Wire & Cable, molded products, or films—it can even be foamed. A VW-1 rating has been achieved for use in XHHW-2 products.

It is made following the Sioplas E™*, two-step technology, offering the processor significant advantages and economics over organic peroxide, radiation, or reactor copolymer-crosslinking processes.

Many polymers, including polyethylene, can be crosslinked using any of the three major techniques. The crosslinking process essentially forms chemical bonds between the polymer chains, resulting in a dense network characterized by high molecular weight. This polymer now becomes less mobile when subjected to heat or loads, and properties such as heat distortion, environmental stress crack resistance (ESCR), creep, and abrasion resistance are enhanced. These changes allow the polymer to be used at higher service temperatures than the starting thermoplastic would be capable of enduring. Regardless of the crosslinking method employed, the final products are comparable, creating a stable, irreversible structure. As with all thermosets, the crosslinked polyethylene structure can only be decomposed and destroyed at high temperatures. Under no circumstances can it be returned to its original thermoplastic form.

Where should you use Syncure?

Syncure Systems are available for low-voltage Wire & Cable and other specialty applications. The Syncure System should be considered wherever enhanced temperature, creep, and stress crack resistance are desired. Because of the processing versatility of the Syncure system, it can be used to produce solid, coextruded, or foam profiles, films, or injection-molded parts. Many downstream operations are also possible.

What is crosslinking and what method does Syncure use?

There are three common methods of crosslinking polyethylene: **(1) peroxide**, **(2) irradiation**, and **(3) moisture**.

(1) Peroxide-Initiated Crosslinking
This method has been practiced extensively by the Wire & Cable industry for many years. It requires special compounds containing an initiator, usually an organic peroxide in its original unprocessed chemical structure, and special downstream crosslinking equipment. The compound must be both prepared and extruded at low temperatures, below the peroxide's decomposition temperature, then crosslinked in the downstream equipment at significantly higher temperatures and pressures. The higher temperatures decompose the peroxide and liberate free radicals that remove a hydrogen atom from the polymer chain. This abstraction site then becomes a reactive radical forming a crosslink bond with another PE radical. This reaction occurs repetitively until all peroxide is consumed or the temperatures fall below the decomposition point.

This method has the advantage of potentially producing items that have higher cure levels than the other two crosslinking processes. Gel levels of 90% are achievable by using a peroxide cure, but care must be taken because that can be too high for some applications. One major disadvantage with this method is the limitation on the number of additives (such as antioxidants) employed in the compound, as they can interfere with the reaction. In addition, stabilization systems can become more complex. Some other disadvantages of this method can include high capital investment for the equipment, the energy-intensive nature of the process, high scrap rates, low outputs, and limitations on part thickness.

(2) Irradiation Crosslinking
This method involves bombarding the polyethylene with high-energy electrons, which liberate the free radicals and thereby promote subsequent crosslinking. This is done by passing the finished product through an irradiation unit one or more times to achieve the desired level of cure. Polyethylene can be crosslinked this way without any chemical additions, but accelerators are typically incorporated to speed up the reaction times.

Elevated costs of installation and operation, plus somewhat elaborate precautions needed to protect personnel from radiation together with government permits required, detract from the popularity of irradiation. Irradiation in-line can be done for thin walls, up to 10-mil coatings, with low-energy irradiation units. Thicker coatings can be irradiated employing more expensive high-energy beams or multiple passes in a post-extrusion operation that adds to the overall cost. Another disadvantage of this method lies in potential nonuniformity in the crosslink density as compared to the other two crosslinking methods.

Some advantages of this method are high extrusion speeds (because curing is done off-line), potentially lower raw material costs, and simplicity due to using one raw material, not a system. However, the last item would depend on whether any accelerators were added, and its importance depends upon the application.

(3) Moisture Crosslinking
There are two basic methods for crosslinking polyethylene by moisture, both involving the use of a vinyl silane-ethylene copolymer. These copolymers can be produced in a reactor either by polymerizing ethylene with vinyl silane or by extruder grafting of polyethylene with the vinyl silane. There are some very important differences between the two methods, but both are becoming increasingly popular as replacements in certain applications for the "old technologies", due to lower capital investment and increased productivity.

(a) Reactor Copolymers

Made directly in the polyethylene reactor, silane copolymers were introduced in the late eighties. This copolymer is supplied to the processor as the base component of a multipart system which also includes a catalyst and other additives as desired. Mixed with the catalyst before or during processing, the active copolymer begins crosslinking in the presence of moisture. Additives such as antioxidants and flame retardants are not a problem as they can be added as one of the components of the masterbatches.

The biggest advantage of the reactor copolymers over the extruder grafted products is the shelf life. The reactor copolymers are inherently more stable than the graft products. Reactor copolymers can be stored for longer periods; however, they will take longer to cure under identical conditions.

A major disadvantage of the reactor process is the limitation of the type of product that can be made. The polymerization is done in a high-pressure reactor which results in a highly branched, low-density product. Higher-density polymers, or terpolymers, are not possible with the current technology, so this method cannot be used to manufacture HDPE-, EVA-, LLDPE-, or EPR-type products.

(b) Silane-Grafted Polyethylenes

As in the silane copolymer method, silane-grafting technology uses a polyfunctional organosilane compound as the crosslinking agent. However, rather than copolymerizing the organosilane in a polyethylene reactor, the silane is grafted on the polyethylene during a compounding step. Silane may be grafted to any ethylene-containing polymer, so crosslinkable HDPEs, LLDPEs, EVAs, and EPRs are possible.

The silane compound contains unsaturated vinyl groups that allow grafting to the polyethylene backbone. The silane-grafted polyethylene also contains hydrolyzable alkoxy groups which, in the presence of moisture, react to join adjacent grafted polyethylene molecules into stable, three-dimensional, crosslinked networks of siloxane linkages.

Crosslinking is usually accelerated with a catalyst masterbatch blended at the point of processing and is ideally done in a “hot room” or water bath at elevated temperatures. However, unlike reactor silane copolymers, silane-grafted compounds offer the processor faster and better moisture crosslinking such that, in favorable geographical or environmental conditions, the customer may forego the need for steam chambers, water baths, or water circulation systems and rely simply on ambient moisture to effect the crosslinking process.

After crosslinking, the silane-grafted compound is a silyated ethylene copolymer, having the same characteristics usually associated with crosslinked polyethylene produced by peroxide vulcanization or irradiation.

The One-Step (Monosil) Process

In this process, as the name infers, the grafting takes place during the fabrication of the product, whether it be wire, pipe, or other profile. The silane, initiator, polyethylene, catalyst, and antioxidants are all introduced in the same operation, and the extruded product begins to crosslink immediately. While this process seems simple and appears to have economic advantages, the need for special processing equipment, specialized training and equipment for handling and storage of the chemicals, and the high degree of specialization needed to manage the generation of scrap offsets this apparent advantage.

Furthermore, this method can place limits on the inclusion of specialty additives required for particular applications because they can inhibit the grafting process. Thus, formulation is critical and requires specialized and experienced personnel.

The Two-Step (Sioplas) Grafting Process

This process is used to produce the Syncure System of moisture-crosslinkable polyethylenes. The process is referred to as “two-step” because two distinct steps are used to obtain the final crosslinked product. In the first step, the material compounder grafts silane to the polyethylene. In the second step, the processor mixes the grafted compound with a catalyst and processes it into a finished product. The process is straightforward and allows for high output rates with low scrap using conventional equipment. The compounder can tailor formulations to fill the processorís specific requirements.

What are the UL/CSA ratings?

Syncure moisture-crosslinkable polyethylene has achieved a VW-1 rating from UL. Any current or potential customers that have an approved moisture-curable product are entitled to use the S110FV system and print “VW-1”, as well as “Oil-Resistant I and II” and “Gas-Resistant”, without submitting the cable for approvals.

Syncure is your best choice for the following applications:

UL	CSA
XHHW-2	NMD-90
RHH	RW-90
RHW-2	RWU-90
USE-2	Teck-90
SIS	

*Sioplas E is a registered trademark of Dow-Corning.

THE GEON COMPANY

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