

Flexible XLPE cables for renewable energy sources

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ABSTRACT

Flexible cables with very high bending radii are gaining more and more importance, especially for renewable energy applications. Renewable energy sources such as electrical vehicles and windmills will need flexible cables. These cables consist historically of EPR/EPDM. The use of XLPE instead can be advantageous for several reasons, such as the lower density of LDPE and the better dielectric properties but also due to a safer and a more environmental friendly handling of XLPE. For that purpose, a flexible insulation material based on a polar silane LDPE has been developed and is a good alternative to EPR.

KEYWORDS

Flexibility, XLPE, EPR replacement, ethylene-vinyl silane copolymer, silane curing

INTRODUCTION

Low voltage cables (up to 6 kV) are the cornerstone of the electrical network. Their application spectra spreads from energy cables (typically at 1 kV) and building wires to specific cables such as signal and instrumentation cables, digital technology, robotics and security. Flexible low voltage cables are gaining more and more focus, opening an interesting market segment especially for sustainable energy sources. Flexible cables with very high bending radius are needed in for example, electrical vehicle charging cables as well as in windmills.

Flexible, soft cables are historically made of soft PVC (Polyvinylchloride) or EPR (Ethylene Propylene Rubber-copolymer), EPM (Ethylene Propylene Copolymer) or EPDM (Ethylene Propylene Diene Terpolymers). PVC and EPR use are associated with the formation or the use of hazardous substances such as chlorine release during heating of PVC or the use of additives and fillers in EPR/EPM. The aim should be to produce cables in a sustainable and environmental friendly way.

The most flexible cables on the market are currently EPR/EPM based, but they can be made of a flexible crosslinked polyethylene (XLPE) as well.

Crosslinked polyethylene (PE) was historically prepared via electron irradiation (1930s). General Electrics introduced 1955 peroxide crosslinked XLPE [1], followed by the invention of silane-based crosslinking by Dow Corning, called Sioplas™ [2], and Monosil™ by BICC/Maillefer [3]. In both technologies silanes are introduced to the polyethylene backbone by the use of a small amount of peroxides. The silane moiety undergoes hydrolysis and a condensation reaction forming a silane crosslinked network of the low density polyethylene (LDPE).

As these silanes are introduced via reactive extrusion with

peroxides after the polymerization, peroxide residues from the grafting can be found in the final silane polymer, causing a quicker degradation. The silane groups are randomly dispersed along the polymer backbone (see Fig. 1).

Mitsubishi introduced in 1978 ethylene vinyl silane copolymers, EVS [4], produced in a high pressure reactor. These silane copolymers do not require any grafting with peroxides during the extrusion as the ethylene and silane are polymerized at the same time in the reactor. The silane groups are evenly dispersed along the polymer backbone in the EVS and can be moisture cured in the presence of a catalyst very similar to Sioplas™ and Monosil™ processes [5-7].

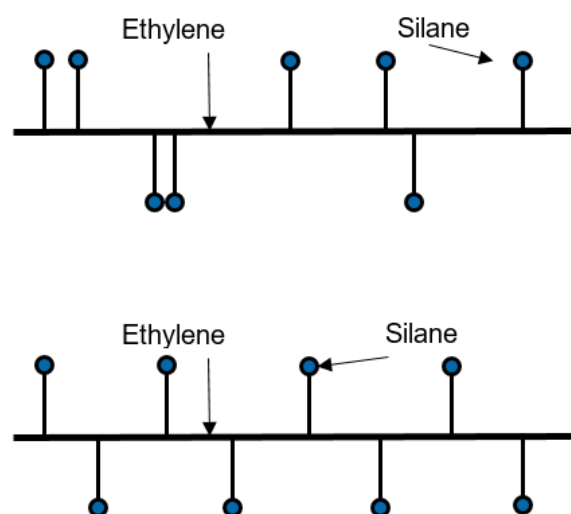


Fig. 1: Chemical structure of grafted silane polymer (above) compared to vinyl silane copolymer (below).

Flexible EVS

A major percentage of low voltage XLPE cables produced in Europe are made of EVS, ethylene-vinyl silane-copolymer. EVS crosslinks with moisture and this mechanism is accelerated by using a catalyst system, such as Lewis acids or Brønsted Acids [7].

In order to create an alternative to the filled EPR compounds, the EVS concept was further developed by introducing polar EVS terpolymers, creating significant flexibility.

Polar groups, such as acrylates, are introduced during the high pressure polymerisation, resulting in ethylene-vinyl silane acrylate terpolymer (see Fig. 2).