Catalyst alternatives to replace DBTDL and crosslink speed improvement of a low voltage cable insulation

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ABSTRACT

In order to increase speed of silane crosslinking polyethylene, a catalyst is needed. The most common one is DBTDL (DiButyl Tin DiLaurate) which is classified as reprotoxic 1B, mutagenic 2 and toxic for specific target organs. For many years alternatives to DBTDL were investigated and studied in cable and other applications. A brief state of the art indicates that some catalysts were explored. Some catalysts as well as additional factors were studied to increase crosslinking speed. In the present paper the authors describe the development of low voltage (LV) insulation without CMR product where the speed of the crosslinking process has been improved.

KEYWORDS

CROSSLINKING – LOW VOLTAGE – INSULATION – CATALYST

I. INTRODUCTION

Crosslinked polyethylene is commonly used as insulation as it allows insulation to withstand 90°C in normal service conditions and 250°C in case of short-circuit. Among the three crosslinking methods (e-beam, peroxide and silane), silane crosslinking is the most used in low voltage cables as it associates a low cost, a good processability and a good efficiency. However, silane crosslinking polyethylene is very slow and needs a catalyst to increase crosslinking speed. The most common catalyst is DBTDL (DiButyl Tin DiLaurate) as it allows a good and quick crosslinking of polyethylene without damaging the other insulation properties.

However, in addition to be corrosive and very toxic to environment, DBTDL is classified as:

- Reprotoxic 1B (H360FD), that is to say, it may damage fertility and may damage the unborn child.

- Mutagenic 2 (H341), that is to say, it is suspected of causing genetic defects.

- Toxic for specific target organs (H370 & H372) after short and long term (or repeatable exposure).

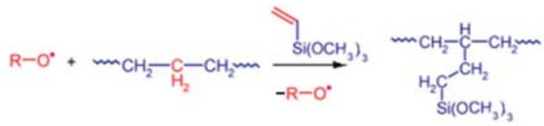
One other demand of industry is to be able to crosslink insulation at ambient conditions without using a process to accelerate again the reaction (water bath or sauna). This study deals with the development of a formula without CMR catalyst, able to crosslink at ambient conditions. This solution was specially developed to comply with the French specification NF C 33-209 (overhead LV cables) as the test method used to evaluate crosslinking is one of the most severe.

II. SILANE CROSSLINKING POLYETHYLENE

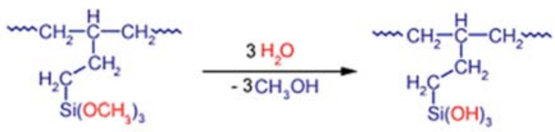
Silane crosslinking polyethylene is based on 3 reaction steps:

1) Vinylsilane grafting onto the polyethylene chains

This reaction is initiated by the decomposition of peroxide, creating radicals. Then, radicals react with polyethylene molecules, allowing silane to graft onto polyethylene.



2) Hydrolysis of silane functions to silanol



3) Condensation of silanol groups to create siloxane bonds (three dimensional network)