XLPE FOR MEDIUM AND HIGH VOLTAGE CABLES INSULATION: DETERMINATION OF ORGANIC PEROXIDE'S DECOMPOSITION PRODUCTS BY THE MOST SUITABLE ANALYSIS

Alfredo **DEFRANCISCI**, Sandra **GRIMALDI**, Edwin-Joffrey **COURTIAL,**
Arkema Centre de Recherche Rhône-Alpes, Pierre-Bénite, France
alfredo.defrancisci@arkema.com, sandra.grimaldi@arkema.com, edwin-joffrey.courtial@arkema.com

ABSTRACT

Peroxide crosslinked polyethylene is by far the most accepted conductor insulation for medium and high voltage cables.

One of the consequences of peroxide crosslinking is the formation of volatile peroxide decomposition products that can diffuse slowly from the insulation. If the concentration of these species is high they can compromise the ability of the insulation to function properly.

The objective of this study is to propose and compare several laboratory techniques to produce and analyse XLPE samples. We focused on the two main crosslinking peroxides used in LDPE crosslinking: dicumyl peroxide and tert-butyl cumyl peroxide.

KEYWORDS

XLPE, insulator, crosslinking, peroxide, decomposition products, methane, degassing.

INTRODUCTION

In this study we will review some analytical techniques that can be useful to characterize the content of decomposition products generated by the crosslinking system during XLPE curing. Today, two peroxides are mostly used in XLPE production: dicumyl peroxide (Luperox DCP) and tert-butyl cumyl peroxide (Luperox 801). Those peroxides will be used in some examples of testing results. But the objective of the analytical techniques discussed in this paper is to provide some tools for the development of novel crosslinking systems or, more generally, crosslinked materials able to reduce the total amount of volatile organic compounds. Final objective of the VOC reduction is to reduce the today compulsory degassing operation, which can be very long or can require expensive climatic chambers (or heated rooms)

In this document we will discuss the decomposition of organic peroxide in solvent, as the fastest method to identify the typical VOC generated by a crosslinking system. Then we will describe a laboratory technique to crosslink polyethylene in a way that is closer to CV line curing than the common plate press curing. We will complete this presentation comparing two analytical techniques to quantify VOCs. One of these techniques is based on solvent extraction, the other one works on emission characterization.

DECOMPOSITION OF ORGANIC PEROXIDES IN SOLVENT

This analytical technique[1] is suitable to test crosslinking systems, like peroxides, blends of various peroxides, blends of peroxides and other chemicals, etc. The principle is simple: the crosslinking system is opportunely dissolved in tetradecane, a solvent that simulates LDPE. The solution is put into a vial, which is flushed with an inert gas, argon, nitrogen or helium for instance, in order to remove oxygen and then sealed; it is then placed in an oven or other heating equipment set at the chosen crosslinking temperature.

After a defined crosslinking time, the vial is removed from the oven and analyzed by gas chromatography coupled to mass spectroscopy in order to identify the decomposition products generated by the selected crosslinking system; once decomposition products are all identified, head-space gas chromatography can be used for quantitative analysis.

Both liquid and gaseous phases into the vial are analyzed in order to quantify both light and heavy decomposition products. The following table shows the results obtained with this analysis on dicumyl peroxide and tert-butyl-cumyl peroxide decomposition:

Name	dicumyl peroxide	tert-butyl cumyl peroxide
Methane	9,1%	8,5%
Acetone	1,2%	10,9%
Tert-butanol	0,0%	23,6%
Butanone-2	0,9%	0,4%
Acetophenone	51,5%	33,9%
Cumylalcohol	36,3%	21,3%

Fig. 1: HS-GC-FID analysis results of peroxides decomposed in tetradecane at 230℃; quantity of decomposition products is expressed as % over initial peroxide quantity

Comments

The main advantage of this analytical method is that it allows benchmarking very rapidly the chemical interaction between peroxide and other eventual additives added to LDPE, like antioxidants for example. It is easy to set up and precise in the quantification of well-defined decomposition products. One limitation of this method is that the decomposition doesn't happen in real crosslinking conditions, but in a solvent that simulates LDPE.

CROSSLINKING OF XLPE SAMPLES

The main crosslinking technology involved in cable production is the CV (continuous vulcanization) line. A CV lines is a tube made of two main sections, one for curing one for cooling. For the most recent ones, the total