Validation of power cable material technology with reduced degassing burden

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ABSTRACT

New technology has been developed with the objective to reduce crosslinking byproducts and thereby reduce the required degassing time of high voltage power cables. A diffusion model estimated a 50% reduction in degassing time with the new compositions. The new composition was utilized for cable extrusion and the byproducts were measured and compared to that of a standard crosslinked polyethylene cable. The results are consistent with the model expectations for reduced degassing, while also delivering an acceptable degree of crosslinking. High voltage cables manufactured with the new technology have successfully completed a 110kV Type Test.

KEYWORDS

Degassing, polyethylene, XLPE, byproducts

INTRODUCTION

Extruded cables with polymeric insulation are commonly crosslinked through the use of radical chemistry initiated by the thermal decomposition of organic peroxides. The byproducts of the crosslinking reaction based upon the use of dicumyl peroxide include cumyl alcohol (CA), acetophenone (AP) and methane[1-3]. Any voids which might be formed within the insulation during the cable manufacturing process remain pressurized by the residual volatile byproducts for a period of time after cable extrusion. Pressurized voids will have a reduced likelihood of being detected with a partial discharge test. Therefore, it is important that the byproducts be removed from the cable prior to quality testing [4]. The "degassing processes" for removal of byproducts in high voltage cable often involves the facilitation of the diffusion of byproducts out of the cable through the use of increased temperatures within degassing chambers, while distribution class cables are often allowed to degas under ambient conditions. A reduction in the amount of time necessary to achieve a sufficient level of degassing is viewed as a benefit in the cable manufacturing process.

The potential benefits of compositions with reduced crosslinking byproducts not only include a reduction degassing time, but also a reduction in the potential number and size of voids which may form in the cable manufacturing process. While crosslinking typically occurs within a pressurized continuous vulcanization tube, the volatile byproducts may yield small voids with the potential to grow after exit from the pressurized region and before the cable has completely cooled. The reduced level of byproducts may also increase the likelihood of detection of detrimental voids using the factory electrical tests such as partial discharge [4]. Published work [4] has also described that the degassing process does improve the resistivity of the insulation material through the reduction in the number of charge carriers.

SIMPLIFIED MODEL OF DIFFUSION

Diffusion in a Material Slab

In the consideration of diffusion of a component from a large cable construction, the domain of interest is an annular region. Reasonable boundary conditions would include a no-flux condition at the inner radius and a zero concentration condition at the outer radius. The initial concentration gradient for the component can be considered spatially uniform. While these boundary conditions may not represent the actual situation for degassing of a manufactured cable, they represent the most general baseline from which useful engineering estimates may be studied.

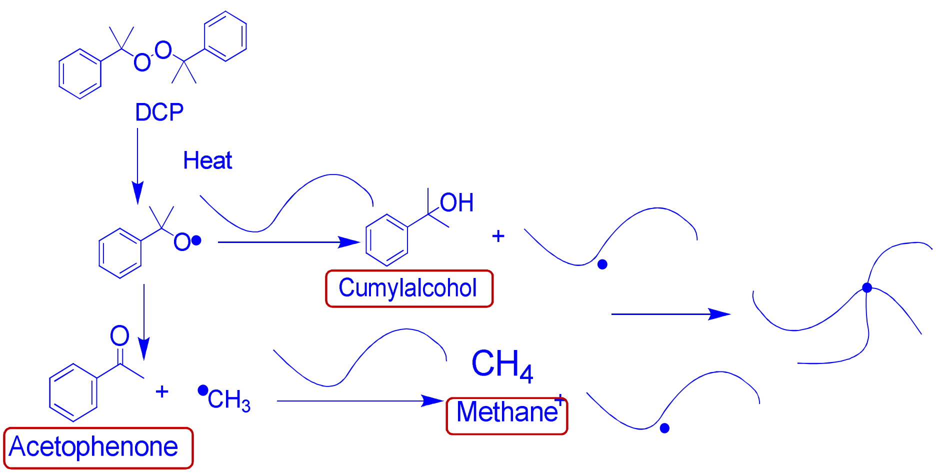

Figure 1: Scheme of byproducts generation from DCP decomposition during crosslinking.