Taking high performing peroxide crosslinked polyethylene technology towards a further improvement in performance and sustainability

Annika **SMEDBERG**, Daniel **NILSSON**, Peter **WALTER**, Anders **GUSTAFSSON**, Ramona **HUUVA**; Borealis AB, (Sweden), annika.smedberg@borealisgroup.com, daniel.nilsson@borealisgroup.com, peter.walter@borealisgroup.com, anders.gustafsson@borealisgroup.com, ramona.huuva@borealisgroup.com

Marc **BAILLEUL**; Borealis N.V., (Belgium), marc.bailleul@borealisgroup.com

Davide **VIELMI**; Borealis AG, (Austria), davide.vielmi@borealisgroup.com

ABSTRACT

During dicumylperoxide initiated crosslinking of polyethylene, methane is formed as one of the peroxide decomposition products. This paper discusses composition design routes that lead to a reduction of the overall methane formed during crosslinking. Examples are given where the methane content formed is reduced while the degree of crosslinking is maintained. In addition to these features, the scorch resistance can be improved. How these cable manufacturing productivity aspects could influence the overall greenhouse gas emissions are reviewed. When these tools are applied in a base resin produced using second generation renewable feedstock further greenhouse gas emissions reductions can be reached.

KEYWORDS

Methane, crosslinking, degassing, cable manufacturing, scorch resistance

INTRODUCTION

Background

Peroxide initiated crosslinked polyethylene (XLPE) is the major insulation material used today for HVAC as well as for HVDC cables. The reasons are that it is highly performing, it allows proven and flexible utilisation, it is fit with a vast range of applications, and is largely available and cost effective. The main benefit of using a crosslinked polyethylene is that it is a thermo-set material and several properties are improved such as tensile strength, creep properties as well as the deformation resistance at the elevated temperatures that could be experienced under overload and short circuit conditions [1].

Dicumylperoxide (DCP) is the most frequently used peroxide for XLPE cable insulation applications. There are several reasons for this and two of them are highlighted here. First, its decomposition temperature enables a relatively safe processing with a minimum of precuring (also known as scorch) at temperatures used for the melting and homogenisation during the extrusion step in the cable manufacturing process. Secondly, when the extruded cable core exits the triple head and enters the vulcanising tube the associated moderate temperature increase leads to comparably fast curing times. Apart from initiating the crosslinking reaction, DCP also results in low-molecular weight molecules, so-called peroxide decomposition products (PDP). The main PDPs from DCP are methane, cumylalcohol (CA), and acetophenone (AP) where CA and AP are referred to as polar decomposition products. The DCP initiated crosslinking [2] of polyethylene is described in Figure 1.

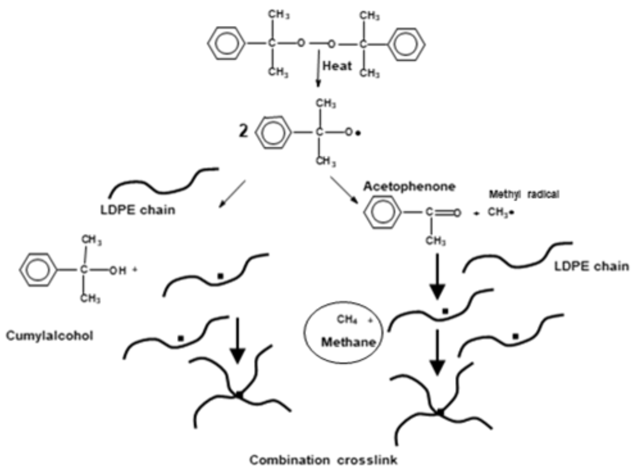

Figure 1. DCP initiated crosslinking of polyethylene and schematic illustration of the main PDPs formed

As can be seen methane is released during the crosslinking reaction and the precursor for methane, the methyl radical, is expelled when the cumyloxyradical is transformed into acetophenone. When the methyl radical abstracts a hydrogen atom from the surrounding polyethylene chains methane is formed. There is a need to reduce the methane content in the produced cable core in a degassing step, a process step taking place after the cable core manufacturing. Degassing is a widely established practice in the industry today but is a time and energy consuming process step. Thus there is a desire for a peroxide crosslinkable material where the degassing burden is reduced.

Possible tools to reduce methane contents

Design of base resin

The well-established Low Density Polyethylene (LDPE) base resin, produced in the high pressure (HP) polymerisation process, is the basis for crosslinkable insulation compounds such as classic XLPE. The HP process is also an ideal platform for the development of designed polymers suitable to meet specific demands. The polymer is the main constituent in a peroxide crosslinkable formulation and its properties are of key importance for the resulting polymer composition.

Vinyl groups have been shown to have a beneficial effect on the peroxide initiated crosslinking reaction of