Crosslink cables manufactured using UV radiation Technology: An experimental investigation.

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ABSTRACT

UV technology used for the crosslinking of LDPE compounds to produce cables has been extensively studied (1, 2, 3, 4, 5) and had been mainly confined to the use of Low-Density Polyethylene (LDPE) as the primary source for the insulation of the cable. This presentation is an experimental treatment of cables made using other compounds that can offer additional useful attributes to the cable. The versatility of this physical process allows many compounds to be manufactured, employing production equipment from a simple twin screw to a more sophisticated kneading extruder using Polyethylene of different physical properties, as the base material, together with other easily accessible supplementary chemicals such as photo initiators, sensitizers, synergists, antioxidants, and coupling agents. Of particular interest, is a still to be named product, simply called "PVC Sub" because it is meant to be a replacement for PVC cables that are extensively in use today. This product not only replaces more than 50% of the plastic used in the insulation of cables with mined minerals, thereby reducing its overall carbon footprint, but because it is crosslinked, exhibits superior mechanical and thermal properties. All the compounds used in the cable extrusion were made using actual production equipment, with some of the products already being used in the commercial production of cables.

This paper will discuss the different types of products that can be made and the advantages of using such a system to manufacture them.

KEYWORDS

crosslink of polyethylene, crosslinking reaction, photon initiator, Inter System Crossing, Phosphorescence, treeing

AUTHOR NAMES & AFFILIATIONS

Maurice ALPHONSO is the founder of Plexchem Technologies with over 30 years of experience in the cable compounding industry. Under his stewardship, Plexchem and its affiliates have expanded its reach with marketing and compounding facilities, working on a variety of products from proprietary specialty compounds, innovative systems and processes, creative compounding machinery and pioneering testing equipment. Maurice graduated with degrees in Chemical Engineering, MSC (chemistry) and an MBA. He had worked for Shell, Exxon and Chevron before staring Plexchem Technologies in 1987.

Fauziee ZAIN is a polymer specialist with over 10 years of compounding experience. He is responsible for the formulation and compounding of the products .

Mohammd Mohseni has a degree in electrical engineering and is a contribution partner in Plexchem Technologies. He has compiled a comprehensive book on cables and has been a consultant to many countries around the world. He s an expert on cable technology.

Photochemistry : is the branch of chemistry that studies the chemical processes and reactions that are triggered or influenced by light. The Photophysical processes involve the interaction of light with molecules, including absorption, fluorescence, and phosphorescence. Some of these physical actions may result in chemical reactions that occur when a molecule absorbs light energy, gets energized and can undergo various types of reactions.

The ultraviolet (UV) crosslinking technique is a non-heat-sensitive process for producing XLPE cables with the advantages of a high production rate, short- or long-term continuous production, utilizing low-cost raw materials, energy, and equipment investment, while having the ability to produce many different types of crosslink cables. (6, 7, 8)

The source of light is derived from the radiation spectrum which refers to the distribution of electromagnetic radiation across different wavelengths or frequencies. Electromagnetic radiation includes a wide range of wavelengths, from extremely short gamma rays to long radio waves, and everything in between, such as X-rays, ultraviolet (UV) rays, visible light, infrared (IR) radiation, and microwaves. The radiation spectrum is typically divided into different regions based on the wavelength or frequency of the radiation. The discussions are mainly focused on UV radiation with wavelengths ranging from about 200 nanometers to 400 nanometers. UV radiation itself can be classified into UV A, B and C with UV C being the most concerning as it can have various effects on a biological system. On the other hand, UV A which is close to visible light is considered the safest.

1. Electronic transitions

Electronic transitions within a molecule refer to the movement of electrons from one energy level to another. These transitions can occur due to the absorption or emission of electromagnetic radiation, such as ultraviolet (UV) or visible light. Quantum chemistry plays a crucial role in the theoretical understanding of photochemistry. Of particular interest are the rules that govern the various electronic orbitals where an electron can occupy based on a set of rules developed by Aufbau, Hund's and Pauli, with the most important from the chemical standpoint is the Pauli's Exclusion Principal. This principal states that no two electrons in an atom or molecule can have the same set of quantum numbers, which leads to the requirement that electrons in the same orbital must have opposite spins (i.e., paired spins). This rule is important as it is the basics of the excited electron having extended residence time instead of immediately returning to the ground state, thus allowing enough time for chemical reactions to occur. (9, 10, 11, 12).

As mentioned, when a molecule absorbs energy, typically in the form of heat, light, or an electric field, its electrons can be promoted to higher energy levels. The critical