A1 CABLES ET ACCESSOIRES BT ET MT FOSE ET INSTALLATION RETOUR D’EXPLOITATION (1)

A.1.4 Development of functionalized polyolefin based thermo-plastic elastomers (TPEs) and composites as insulating material for medium voltage cables. Preparation, characterization and life time prediction by thermoanalytical techniques.

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ABSTRACT

Attempts made to develop a novel series of insulating material based on thermoplastic elastomers (TPEs) and blend composites for low to medium voltage applications. These have been prepared from the blends of PE-EPR and PE-EPR using the ratio of 30:70. In the cases of TPEs rubber phase have been vulcanized dynamically at a temperature of 160°C. Either or both of the phases have been modified by peroxide initiated grafting of dibutyl maleate and vinyl silane in the Brahame modality at the temperature range from 140°C to 200°C. Optimized peroxide (0.2 - 0.5%) and monomer (1 - 2%) have been used for grafting. Peroxide, peroxide sulfur and accelerated sulfur have been applied for dynamic curing. Filled and unfilled composites have been made by simultaneous blending of PE and ERG and grafting of vinyl silane on to it followed by crosslinking at ambient temperature. Silane modified compounds (TPEs) have been characterized for their mechanical properties, oxidative degradation and ageing resistance properties. Life time of TPEs at service temperature (70°C) and at short time temperature (200°C) has been calculated as 10 -12 years and 35 - 45 minutes respectively. Through mechanical properties crosslinking of vinyl silane and polyfiller interactions have also been provided.

INTRODUCTION

Thermoplastic elastomers (TPEs) based on polyethylene or polypropylene -polyolefin rubber blends have received considerable technological importance in recent years because of their ease of processing, possibility of reprocessing, low cost and favourable physical properties. Large number of efforts have been expended to make it viable for product applications (1,2,3,4). These attempts are made in the present investigation to exploit these for application in low and medium voltage insulations as well as in the field of cable insulation. It is expected that ageing of cable insulation, especially during continuous operation at high temperatures, affects the technical performance, which is in turn important for an understanding of thermal and thermo-oxidative degradation of this compound.

In the present investigation attempt is made to develop a novel series of insulating material based on TPEs and blend composites using PE, EPDM and functionalized polyolefins. Techniques of functionalization, preparation of TPEs and comparative properties have been reported. Efforts have also been made to calculate the service life of the insulating materials through the high temperature ageing and degradation studies.

EXPERIMENTAL

MATERIALS

Low density polyethylene (LDPE) (Hosta Polyethylene EPDM-4445 of density 0.915 g cm⁻³ and EPDM 2.0 g (10 min)⁻¹ (ASTM D-1238), ethylene propylene diene monomer (EPM) (KELFON 520 of DDH, Netherlands), Ethylene propylene rubber (EPR) (Vistanex EG20 of Exxon Chemical Inc, Belgium), dibutyl maleate (DBM), Vinyl Silane (VS), Trimethyl pentenyl (TMTD), mercaptobenzthiazyl disulfide (MTS) and other ingredients were used as received.

GRAFT MODIFICATION, MIXING AND PREPARATION OF TPEs

Grafting of DBM and VS onto PE, EPDM and EPDM as the case might be were carried out in a Brabender Plasticorder (PL 10) using a car type mixing head (50+50%). Different blend composition were made in the same mixture.

Infrared Spectroscopy: Infrared Spectroscopy was carried out by EMINAR IR-620 using thin film of polymer. Free DBM and VS were removed by acetone extraction of the film.

Mechanical Properties

Tensile properties were studied by Elvick UPN (Model 1145) using dumbbell specimen (ASTM D 412-80).

Thermogravimetry: A METTLER TG 50 of a TA 3000 System with 10 mA microprocessor was used throughout the study. The heating rate was 20°C per minute.

Volume Resistivity: Volume Resistivity was measured by Salvietti Packard 4329A High resistance meter, according to the specification ASTM D 257-88.

Hot Elongation and Set Properties: Hot elongation and Set properties were determined at 250°C under a load of 20N as per the specification EN60811:1994.

Air Oven Ageing: Air ageing was carried out at different temperatures for different extent of time in Ceast Modular System Oven.

RESULTS AND DISCUSSION

Functionalisation of polyolefin and its characterisation

PE, EPDM and free DBM were functionalised by grafting dibutyl maleate (DBM) and Vinyl Silane using DCP as Initiator at the temperature ranging from 140°C to 260°C. The optimum concentration of monomer (2 - 10%) was used for graft modification of the polymers and this was dependent on the type of monomer and according to the requirement. Due to corrosive nature and toxicity of the maleic anhydride it was not used for functionalization and further studies. Similarly 0.3 to 6.5% of UCP as Initiator was used depending on the nature of monomers. IR Spectra of Polyethylene-DBM, Polyethylene-DBM and Polyethylene-Silane are shown in Fig.1. DBM functionalised polymers show a strong absorption peak at 1738 cm⁻¹ associated with stretching absorption of C=O in the water groups; of the maleic anhydride. Absorption bands are present at 2970 cm⁻¹ of the silane group on polymers. The detailed methods of grafting has been described elsewhere (5). The mechanism of DBM and silane grafting onto PE is shown in Fig.2.