The Characteristics of Recyclable Thermo-plastic Materials Based on Polyethylene Blends for Extruded Cables

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ABSTRACT

Due to the poor recyclability and high energy consumption of XLPE, it is very acute to develop new environmental-friendly insulation materials. In this investigation, the properties of binary polyethylene blend systems with HDPE and LLDPE have been discussed. A blend system which has the most excellent comprehensive performance has been chosen: 70LLDPE-30HDPE (31MPa in tensile strength, 829% in breaking elongation, $3.2\times10^{15}\Omega$•m in volume resistivity and 94 kV•mm^{-1} in breakdown strength of 63.2% cumulative probability), in which the eutectic structure have been formed by the analysis of DSC and microscopic observation. Furthermore, water-treeing test of the chosen blend shows that the chosen material can suppress water-treeing.

KEYWORDS

recyclable; HDPE; LLDPE; XLPE

INTRODUCTION

Chemically crosslinked polyethylene (XLPE) has been used as the power cable insulation material since 1960s, because of its favorable performances of electrical and mechanical properties. However, as the electrical engineering community has become increasingly aware of the life cycle environmental impacts in recent green globe background, XLPE shows weak point for its lack of recyclability and the high process energy burden involved in its manufacture. Although technologies are being developed to facilitate the reuse of XLPE at the end of its initial service life, such an approach is inferior to fully recyclable and low process energy alternative [1].

Recent years, engineers have started to find new materials which can exhibit suitable recyclability and comparable dielectric and mechanical properties as XLPE to solve the mentioned problems. The thermo-plastic polyolefin blends catch the focus for it can supply desirable combination properties, be easy to process and have well recyclability. Recent researches have shown when blending in specific proportion, blends possess good mechanical and electrical properties and even better than XLPE. The relationship between mechanical, electrical characteristics and morphology, structure is also studied [2-5]. Furthermore, the thermo-plastic polyethylene blends are environment-friendly because green warming potential (GWP) of new blends in whole life cycle is about 36% lower than XLPE, and the cost is lower than XLPE too [6].

In this investigation, a group of blends which contains linear low-density polyethylene (LLDPE) and high-density polyethylene (HDPE) in different proportions have been prepared. The electrical, mechanical behavior of blends have been tested and discussed. Differential scanning calorimetry (DSC) also was done with different proportion blends. From the results of basic properties above we choose a specific proportion blend which exhibits better an overall performance to carry out water-treeing tests and scanning electron microscopy tests. Pure HDPE, LLDPE and XLPE are also prepared for comparison.

EXPERIMENTAL AND CHARACTERIZATION

Sample preparation

HDPE used in this study was from Dow Chemical Company and LLDPE was from Borealis. XLPE used for comparison was used in 110kV cable system. HDPE and LLDPE were mixed by using a rheometer. Different proportions of blends are given in Tab.1.

Tab.1: Composition of samples

Sample	Proportion (wt%)	
	LLDPE	HDPE
HDPE	-	100
10LLDPE-90HDPE	10	90
20LLDPE-80HDPE	20	80
30LLDPE-70HDPE	30	70
40LLDPE-60HDPE	40	60
50LLDPE-50HDPE	50	50
60LLDPE-40HDPE	60	40
70LLDPE-30HDPE	70	30
80LLDPE-20HDPE	80	20
90LLDPE-10HDPE	90	10
LLDPE	100	-

Differential scanning calorimetry (DSC)

The sample for DSC is about 5-10 mg in weight. Test starts at 20℃ with a rising rate of 10℃/min to 200℃ and hold on for 5 min, then cooled down with a rate of 10℃ /min to 20℃ to complete a whole circle.

Tensile tests

The dumbbell type samples for tensile test were prepared by vulcanizing machine at 175℃ and 10 atm for 5 min, the thickness of samples was about 1mm.Tensile tests were carried out via a tensile testing machine at room temperature. The rate of extension was 50 mm/min. A 24 hrs annealing treatment at 70 ℃ was performed on samples to relax the internal stress before tests.

Electrical tests

The film samples for DC resistivity, permittivity and loss tangent tests were prepared by vulcanizing machine at 175℃