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Polarity reversal charging of polypropylene films under DC corona discharge

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Abstract

In this paper, a needle–plane electrode system and polypropylene (PP) films were used to study the DC corona charging of polymers. It was found that the charges injected into the PP films sometimes show different polarity to the applied DC voltage, called polarity reversal charging, which may results in invalidation charging. The pulsed electro-acoustic (PEA) space charge measurement showed that charges of different polarities have been injected into the PP films' bulk, simultaneously. From these results, a mechanism of two charging processes of high-field injection and return-stroke injection has been introduced here. We presumed that the return-stroke injection can be boosted with the increase of corona voltages and thus reduces the net charge as well as even change the polarity of charges injected.

Keywords: Polypropylene; Corona charging; Polarity reversal; Space charge

1. Introduction

Typical processes of corona charging of polymers have been described by Giacometti et al. [1] and Leal Ferreira et al. [2]. After giving a series of calculation,

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Jones provided the drift model of gaseous ions in air [3]. Efforts have been made to improve charge accumulation in polymers [4,5]. However, few attentions have been paid on the discharge characteristics in gases. It has been lately reported that there was a special reversal charging phenomenon which may result in invalidation charging of polymers when applied with nanosecond pulses [6].

In this paper, a needle–plane electrode system and polypropylene (PP) films were used to study the DC corona charging of polymers. The net charge of PP films and the charge distribution in the bulk of the films have been measured. The uncertainty of the charge polarity in PP films applied with DC corona discharge was found. The influences of voltage polarity and magnitude on the rate of polarity reversal phenomena have been investigated. A mechanism of two charging processes of high-field injection and return-stroke injection has been introduced to fit the polarity reversal charging phenomena.

2. Experimental

A needle–plane electrode system was used in our experiments to charge polymers, as shown in Fig. 1. The PP films with 85 μm thickness and 32 mm diameter were charged for 3 min under room conditions. The net charge of the PP films was measured by an EST111 electrostatic charge meter whose accuracy was 0.5% ranging from ± 10 pC to ± 20 μC. A pulsed electro-acoustic (PEA) space charge measuring device with the spatial resolution 1 μm was introduced to display the distribution of the charge injected into the bulks of the PP films. In the process of measuring, an externally applied pulsed electrical field is applied to the sample and induces a perturbation electrical force on space charge in sample. This force causes the space charge to move slightly in its position. And this movement launches an acoustic pressure wave. The wave is collected and analysed to get the space charge profile in the sample. All of the films after charging were short-circuited for 1 min

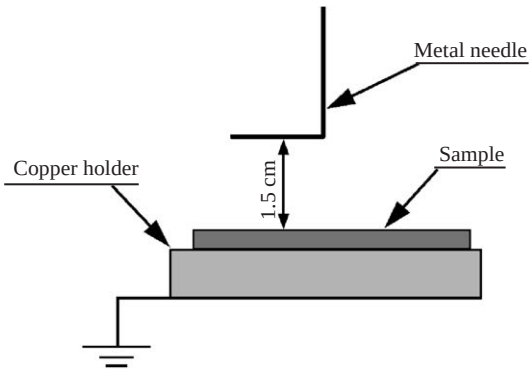

Fig. 1. Schematic diagram of needle–plane electrode system for charging of polymers.