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Study of electrets stored at pressures lower than atmospheric

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Abstract

20 μm thick polypropylene electrets obtained in a corona discharge were studied. Before charging, the samples were cleaned in an ultrasonic bath with alcohol for 4 min, rinsed with distilled water and dried under room conditions. After charging, the electret surface potential was measured by the vibrating electrode method with compensation. The measurement system was located in a vacuum chamber, with a gauge to measure the pressure. The surface potential vs storage time relationships for electrets stored at various pressure (20, 50, 100, 150, 200 and 300 Torr) were measured. The dependence of the electret surface potential on the time of storage at room conditions, after the samples had been taken out of the vacuum chamber, and the second evacuated effect on the electret surface potential were also studied. A desorption from the electrets is suggested to explain the results obtained. The dependence of the surface potential on time is satisfactorily described by an equation that is analogous to the equation of desorption. The results also show that if the electrets are initially held at a pressure much lower than 200 Torr for a time, their subsequent time stability under room conditions increases.

Keywords: Electret; Polypropylene; Corona discharge; Desorption; Low pressure

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1. Introduction

Many applications in the field of transducers are based on the possibility of charge storage in polymer electrets. The corona charging method is one of the widespread methods for obtaining polymer electrets [1–3]. If a voltage U_c is applied to a thin metal tip (needle), a corona discharge occurs in the air around the needle. The resulting ions are driven towards the surface of the electret sample placed on the grounded plate electrode. The electret surface potential V_e can be regulated by a metal grid positioned between the sample surface and the needle and kept at a constant voltage U_g. The surface charge decay is thought to be due to emission processes in the bulk or injection mechanisms at the surface and subsequent transport of the injected charge through the sample. But it has been shown that if the corona discharge is produced in different gases [4,5] or if the electrets are stored at different relative humidities [6], the surface charge decay is different for electrets of the same material.

In [7] the effect of pressure upon electret charge has been investigated. The electrets were made of carnauba wax, and the method of dissectible capacitor [1] was used to measure the equivalent surface charge of the electrets. It has been shown that surface charge decay is different when the electrets are subjected to different pressures lower than atmospheric [7].

The present work is intended to study the behaviour of polymer electrets obtained by corona discharge and placed under conditions of various pressures lower than atmospheric.

2. Experimental details

Nonmetalized samples of PP664 polypropylene, manufactured in Bulgaria, have been studied. The sample thickness was 20 μm, and all samples had a diameter 30 mm. Before charging, the samples were cleaned in an ultrasonic bath with alcohol for 4 min, rinsed with distilled water and dried at room conditions.

Charging of the electrets in a corona discharge was carried out by means of a conventional three-electrode system—grounded plate electrode, corona electrode (needle) and a grid placed between them, called the control electrode. The voltage of the corona electrode was $U_c = -5$ kV, and the charging time was 1 min. The electret surface potential (V_{eo}) was limited by the grid potential which was set to -650 V.

The electret surface potential was measured by the vibrating electrode method with compensation [8], by which the estimated error was better than 5%. The measurement system was located in a chamber connected to a vacuum pump and a vacuum gauge to measure the pressure in the chamber.

After charging, the samples were placed in the measurement system and the initial electret surface potential (V_{eo}) was measured. Then the pump produced low pressure, and the electret surface potential was measured for 1 h. After that the electrets were removed from the vacuum chamber and kept at room conditions, and the surface potential was periodically measured. Each result presented here summarizes four samples.