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Influence of low pressure on electrets behaviour at various air gaps

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ABSTRACT

Polypropylene samples, 20 μm thick, charged in a negative corona were studied. Each sample was placed on a metal pad. The samples were charged to different initial surface potentials, by means of a conventional corona triode system. The negative corona voltage was 5 kV and the grid voltages of the same polarity were 350 V, 500 V, 650 V, 800 V and 950 V. After measuring the surface potential, the samples, together with their metal pads, were placed for 30 min between two short circuited plate electrodes in a vacuum chamber under various low pressures from 10 Pa to 1×10^5 Pa. The air gap thicknesses between the charged surface of electrets and the upper electrode were 0.28 mm, 0.84 mm, 1.69 mm and 3.00 mm, respectively. The results obtained show that there is a pressure range within which the surface potential sharply decays. The sharp surface potential decay depends on the pressure-to-initial surface potential ratio and it is different for different air gap thicknesses and for different initial surface potentials. A spark breakdown in the air gap according to the Paschen's law and processes of desorption from the electret surface are assumed to occur.

1. Introduction

Electrets have been investigated for many years and the dependences of charge decay on various factors have been studied [1,2]. However, there are only a few publications [3–6] dealing with the influence of low pressure on charge decay. In the papers [3–5] a dissectible capacitor was used to measure the surface charge density and the electrets were placed between two plate electrodes. The charge decay was assumed to be the result of a sparking breakdown in air [3,5] or desorption of ions from the electret surface [4,6].

Recently, we have studied the influence of pressure on charge decay for polypropylene (PP) and polytetrafluoroethylene (PTFE) film electrets [7]. Non-metalized round samples were placed onto metal pads with the same diameter. Having been charged, the electrets, together with their metal pads, were placed into a vacuum chamber. No second electrode was used. The results obtained showed that there is a relatively narrow range of pressure within which a sharp decay of surface potential occurs and the sharp surface potential decay depends on the ratio p/V_0, where p is the pressure under which the electrets had been stored, and V_0 is the initial surface potential. The behaviour of electrets was presented by only one generalized curve well described by an equation which was analogous to the equation describing linear desorption accompanied with surface diffusion.

The present paper is dedicated to the investigation carried out of the impact of low pressure on corona charged PP electret behaviour. In contrast with the previous investigation [7], the electrets were placed into the vacuum chamber between two short circuited plate electrodes. Air gaps of different thicknesses were formed between the charged surface of electrets and the upper electrode.

2. Experiment

2.1. Sample preparation

Electret samples, prepared from a 20 μm isotactic polypropylene film, manufactured by Assenova Krepost Ltd., Bulgaria, were studied. Initially PP films had been cleaned with alcohol in an ultrasonic bath for 4 min, rinsed in distilled water and dried under room conditions. The samples, each of them 30 mm in diameter, were cut from the clean films. All samples were put on metal pads with the same diameter.

2.2. Corona charging

The sample charging was carried out in a corona discharge by means of a corona triode system consisting of a corona electrode (needle), a grounded plate electrode and a grid placed between them. The distance between the corona electrode and the grid was 10 mm and the distance between the grid and the grounded plate electrode was 3 mm.

These samples were charged for 1 min under room conditions. The negative corona voltage was 5 kV and the grid voltages of

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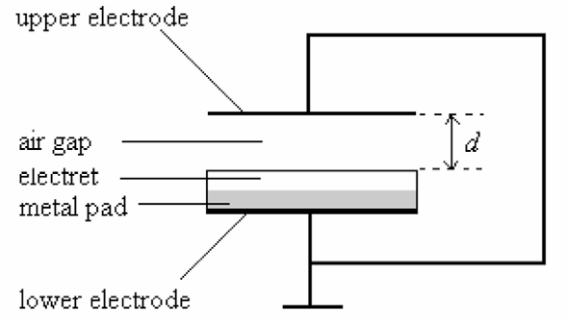

Fig. 1. Schematic diagram of the electret storage in the vacuum chamber (d is the air gap thickness).

the same polarity were 350 V, 500 V, 650 V, 800 V and 950 V, respectively. It should be notice that when the grid potential was 350 V the initial surface potential was a little more than 400 V.

After charging, the electret surface potential was measured using the method of the vibrating electrode compensation, by which the error did not exceed 5%.

2.3. Low pressure treatment

After measuring the initial surface potential V_0, the samples, together with their metal pads, were placed for 30 min between two short circuited plate electrodes (Fig. 1) in a vacuum chamber under various low pressures.

The pressures in the vacuum chamber were 10 Pa, 10^2 Pa, 10^3 Pa, 2×10^3 Pa, 6.6×10^3 Pa, 1.32×10^4 Pa or 10^5 Pa. After removing the electrets from the vacuum chamber, their surface potentials V were measured again and the normalized surface potentials V/V_0 were calculated.

3. Results

All electret samples were divided into four groups according to the air gap thickness values (0.28 mm, 0.84 mm, 1.69 mm and 3.00 mm). Each group was divided into five sets according to the grid potential values (350 V, 500 V, 650 V, 800 V or 950 V).

The dependences of the normalized surface potential V/V_0 on the normalized pressure p/p_0 for different groups of PP electrets are illustrated in Figs. 2–5. The symbol V_0 indicates the initial value

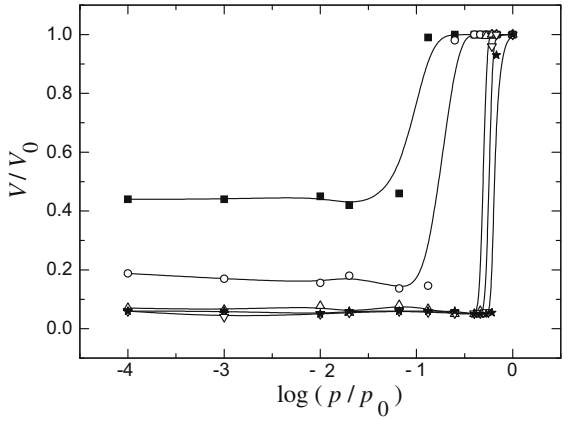

Fig. 2. Dependence of the surface potential on pressure for PP films charged by different grid potential V_g: (■) 350 V; (○) 500 V; (△) 650 V; (▽) 800 V; (★) 950 V. The air gap is 0.28 mm. The lines are drawn as guides for the eyes.

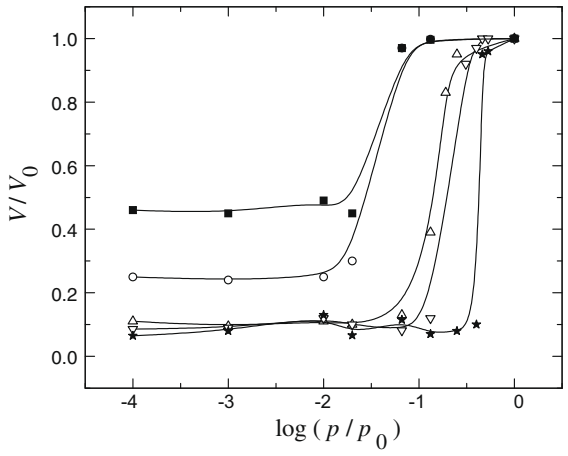

Fig. 3. Dependence of the surface potential on pressure for PP films charged by different grid potential V_g: (■), 350 V; (○), 500 V; (△), 650 V; (▽) 800 V; (★) 950 V. The air gap is 0.84 mm. The lines are drawn as guides for the eyes.

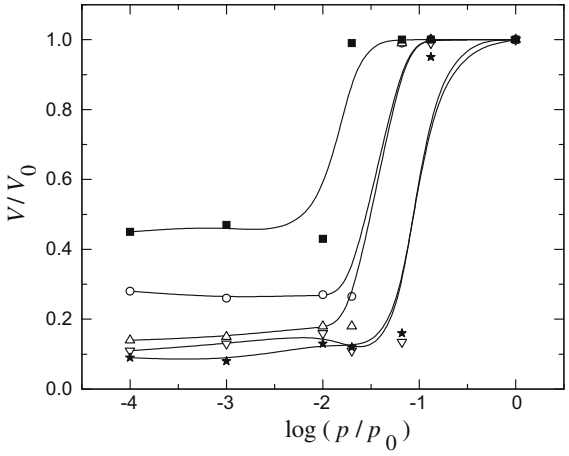

Fig. 4. Dependence of the surface potential on pressure for PP films charged by different grid potential V_g: (■), 350 V; (○), 500 V; (△), 650 V; (▽) 800 V; (★) 950 V. The air gap is 1.69 mm. The lines are drawn as guides for the eyes.

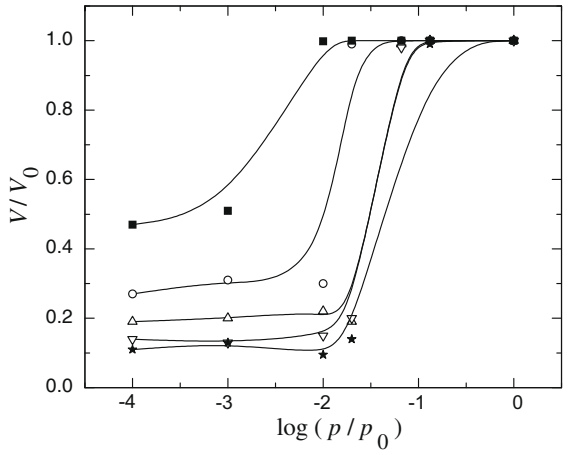

Fig. 5. Dependence of the surface potential on pressure for PP films charged by different grid potential V_g: (■), 350 V; (○), 500 V; (△), 650 V; (▽) 800 V; (★) 950 V. The air gap is 3.00 mm. The lines are drawn as guides for the eyes.