**ОДЕСЬКА НАЦІОНАЛЬНА АКАДЕМІЯ
ХАРЧОВИХ ТЕХНОЛОГІЙ**

ЗБІРНИК
НАУКОВИХ ПРАЦЬ
МОЛОДИХ УЧЕНИХ, АСПІРАНТІВ ТА СТУДЕНТІВ

**ОДЕСА
2016**

НТБ ОНАХТ

ББК 36.81 + 36.82
УДК 663 / 664

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НТБ ОНАХТ

Одеська національна академія харчових технологій
Збірник наукових праць молодих учених, аспірантів та студентів
Міністерство освіти і науки України. – Одеса: 2016. – 408 с.

Збірник опубліковано за рішенням вченої ради від 01.07.2016 р., протокол № 12
За достовірність інформації відповідає автор публікації

ISBN 966-571-063-х
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РОЗДІЛ 2

ХІМІЧНІ, ФІЗИЧНІ ТА МАТЕМАТИЧНІ МЕТОДИ ДОСЛІДЖЕННЯ ПРОЦЕСІВ ТА АПАРАТІВ

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CORONA – DISCHARGE TRIODE WITH A VIBRATING CONTROL GRID FOR CHARGING OF DIELECTRICS AND ELECTRETS

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Southgate [1] was the first who showed that the strong residual polarization in polyvinylidene fluoride (PVDF) can be formed at room temperature, if the electrification was carried out in the corona and in a strong field. This results in conversion of a non-polar α phase in a ferroelectric β phase. Using of the corona discharge has several advantages over the thermoelectret poling both in terms of its practical application, and in providing more information in research, as follows:

— due to absence of the second electrode, the breakdown phenomenon is less likely allowing one to use and explore high fields reaching 200 MV/m;

— in the event of breakdown, its consequences are less disastrous than in the case of the thermoelectret electrification, since the value of the effective capacitance being discharged through the breakdown place is small, and the corona discharge impedance is high enough;

— the possibility of continuous measurement of the electret potential magnitude, kinetics of which contains important information about process of polarization formation and the the space charge dynamics;

— by using the corona discharge the homocharge of the predetermined polarity can be inject into the sample.

Corona discharge occurs in a strongly inhomogeneous field near the electrode with high curvature and it is an effective emitter of ions. Under normal atmospheric conditions hydrated protons ($H^+(H_2O)$) are formed in the positive corona discharge. The main negative corona ions are CO_3^-, but there are also $CO_3^-(H_2O)$, O_3^-, O_2^-, O^- and free electrons [2]. The penetration depth of the ions from the corona into the polymer dielectric is less than 1 nm. It is believed that the charge exchange processes between ions and surface states occur on the surface [3]. The formed neutral molecules are desorbed, while the charge remains on the surface, or in traps, or it is injected into the volume.

In early works, the two-electrode "needle-to-plane" circuit type of discharge has been used. Its main disadvantages are the heterogeneity of distribution of ions on the surface, the uncontrolled mode, and impossibility of the direct measurement of the surface potential. In the three-electrode scheme proposed by Moreno and Gross [4] many of these disadvantages are eliminated through the use of the control grid.

For experimental studies, we designed a specialized installation. Metallized on one side in a vacuum samples with the working surface area of 4 cm^2 were fixed on a massive metal table, in which an electric heater was mounted with a possibility of regulating and measuring temperature by chromel-copel thermocouple. The heater power was automatically adjusted by an electronic circuit, so that a constant temperature was ensured, or a linear heating or cooling with a prescribed rate in the range of 0.5-5 K/min. It was also possible to quickly cool the sample at the rate of 35-40 K/min. The temperature was continuously recorded by a chart tape recording potentiometer.

Corona discharge of positive or negative polarity was excited by a sharpened tungsten electrode, to which voltage was applied by the automatically controlled rectifier, in a feedback loop of which there was a signal proportional to the DC component of the charging current. Thus, it implemented, if necessary, the stabilization of the charging current, the value of which was introduced in the feedback control circuit. It was also possible to manually set the DC voltage on the discharge electrode in the range from zero to 25 kV.

Between the free surface of the sample and the pointed electrode there was a metal control grid having a constant potential up to 4000 V supplied by the B5-24 stabilized power supply. The principal difference from the applied methodology described above was using a vibrating grid, that allowed to continuously measure and record the charging current and the efficient electret potential, because the current through vibration grid and the sample contained the constant and variable components. A signal proportional to the main charging current was supplied directly to the U5-6 electrometer amplifier and the recording KSP-4 potentiometer.

The variable component proportional to the difference between the voltage at the grid and the electret potential was applied to the narrow-band F-550 amplifier tuned to the grid frequency fluctuations. The converted signal through the detector and amplifier was fed to another recording potentiometer.

Calibration was performed at the beginning of each experiment by applying a DC grid stabilizing potential when the power was off the discharge electrode and the installation with the help of the F-550 amplifier initial deviation carriage automatic recorder. Linearity was provided between the readings of the measuring KSP-4 instrument and the value of the electret potential for both polarities in the whole range of 0-4000 V. The measurement error of the electret potential was 5-7 %.

A significant advantage of the applied scheme with a ground sample in comparison to the previously described circuits with grounded stationary grid is no need to create a high-voltage insulation of the measuring devices, as well as a significant simplification of the mechanical part of the installation. To eliminate the influence of external factors and improve the safety of the discharge area, it was placed into a cylindrical metal cup. The unit was provided with the ability to accurately install distance between the discharge electrode and the grid pattern by using micrometer screws.

In the described installation, experiments were performed on isothermal and thermally stimulating electrization of polymer ferroelectrics like polyvinylidene fluoride (PVDF) and copolymers of polyvinylidene with tetrafluoroethylene P(VDF-TFE). Kinetics of the electret potential decay has been studied, as well as the current-voltage characteristics were measured. The dielectric hysteresis phenomenon has been also studied both in homopolymers and copolymers.

Application of the corona discharge has allowed finding and describing interrelation between the strong polarization and the space charge in the ferroelectric polymers and composites.

Scientific Supervisor – D.Sc. (Physics & Mathematics), Professor S.N.Fedosov

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РОЗДІЛ 3 – ХОЛОДИЛЬНА ТЕХНІКА ТА ТЕХНОЛОГІЯ. ПРОЦЕСИ ТА АПАРАТИ ХАРЧОВИХ ТЕХНОЛОГІЙ

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Наукове видання

Збірник наукових праць молодих учених, аспірантів та студентів

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НТБ ОНАХТ

Підписано до друку 2016 р. Формат 60×84/8. Папір офсетний.
Ум. друк. арк. 47,4. Тираж 30 прим. Замовлення