ATMOSPHERIC DBD DISCHARGE MODIFICATION OF POLYESTER FABRIC

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This paper is focused on a study of treatment of polyester fabric by an atmospheric dielectric barrier discharge (DBD). The experiment has been done in air pumping regime. Modification efficiency was analyzed by a drop test measurement. A time dependent modification was observed. The positive effect of the plasma treatment is more prominent in the case of 360 s modification time. Stability of modification effect in time is also discussed. PACS: 52.77.-j

1. INTRODUCTION

Polyester fabric has become one of the most popular available fabrics nowadays since it meets high comfort and aesthetic standards of modern consumer. However, these synthetic fibers have essential lacks: low wettability and low adhesion. These shortcomings could be overcome by plasma treatment that has already given positive results in finishing of synthetic fibers, wool, linen, cotton and hemp fabric [1-5].

Costs of the textile improvement by means of the low pressure plasma are governed by purchase of necessary equipment, technical gases etc. Operation at atmospheric pressure with implementation of DBD is more profitable in comparison with the low-pressure treatment, especially due to its simplicity and low operation costs.

Atmospheric pressure DBD has been used to control surface wettability and dyeability, and to improve capillarity of synthetic fabrics. Polyester fabric is a system with micro and macro-pores. Plasma consists of various active particles (e.g. electrons, radicals, ions, photons etc.). These species can attach or react with polyester (PES) surfaces, changing the nature of the functional groups present, capillary-porous structure and, as a result, the properties of the surfaces [6].

The aim of this research is the study of the usability of the atmospheric DBD for PES fabric modification. In particular, the effect of the treatment time on surface wettability was investigated. We considered the modification effect reduction after some days as unimportant in practice. The longer modification time resulted in improved time stability of the treated samples.

2. EXPERIMENTAL

For all the experiments the polyester fabric (TIS/05/F04/hot 9858) was used as the test specimen. Prior to DBD treatment the samples were cleaned as follows:

-double washing in water solution of a proper washing agent

-rinsing under running tap water

-double washing in distilled water

-chemical cleaning

The PES samples were placed into the DBD reactor thereafter. The DBD was generated between two plane iron electrodes, both with diameter 45 mm and 10 mm thick. The glass barrier was created with an (83x83) mm, 2 mm thick glass table stuck to one of the electrodes.

The DBD assembly was connected to an HV transformer supplied with 220 V/50 Hz. The DBD input voltage varied between 18.0 and 18.5×10^3 V and discharge current ranged from 1.1 to 1.9×10^{-3} A.

The series of the experiments were performed in air under atmospheric pressure (745…753) torr and room temperature (25…27)°C. The samples were treated for 240 and 360 seconds. The air was pumped through the reactor at the flow rate of 0.075 m^3/s during the experiments. The permanent pumping provided stable air composition during the treatment. The results are compared here with the previous experiments [7].

The wettability was evaluated by means of the drop test [8]. Water solution of potassium dichromate (5×10^{3} g/μl) was used as a test liquid for better visualization. The 20 μl of the solution was dropped on the textile sample and the feathering spot size was recorded with a camera. Monitoring was performed in 5 seconds intervals within the first 30 seconds after drop incidence on the fabrics and in 10 seconds intervals afterwards. The total observation time was 200 seconds. The area of the spot in the 60th second after the drop release was used as the standard for the evaluation.

3. RESULTS AND DISCUSSION

The samples of polyester fabric were investigated in unmodified state and with 240s and 360s modification time with pumping.

The improved wettability was observed for the fabric treated at longer time. At longer modification time the frequent undesirable sparks appeared between two electrodes, presumably because of the high concentration of active plasma particles generated in the plasma volume. Air pumping out from the reactor was applied to avoid an ignition of samples from micro discharges.

Plasma radicals penetrated through the fabric fibrous micro- structure between two discharge electrodes and modified the surface of the material. Processing by plasma active particles influenced the capillary-porous structure of the fabric altering its macro- and micro pores. Activated in plasma oxygen and nitrogen species reacts with organic constituents of polyester chains to form polar groups on the surface and hence the fabric wettability increases.

Fig.1 represents the time dependence of the feathering area with modification time of 240 seconds. The wettability improvement is most remarkable immediately after the treatment. On the 3rd day after the treatment the area of feathering decreases but still it exceeds by 50 % that of the unmodified sample. On the 13th day only an insignificant effect can be discerned. And on the 20th day there is no difference between modified and unmodified sample.

Fig.2 shows the time dependence of the fabric feathering area for the longer modification time – 360 seconds. More stable preservation of the modification effect is evident in this case. In 17 days the speed of drop spreading was reduced only to 600 mm^2. In the 20th day the state of the samples with 360-seconds modification time approached the unmodified state.

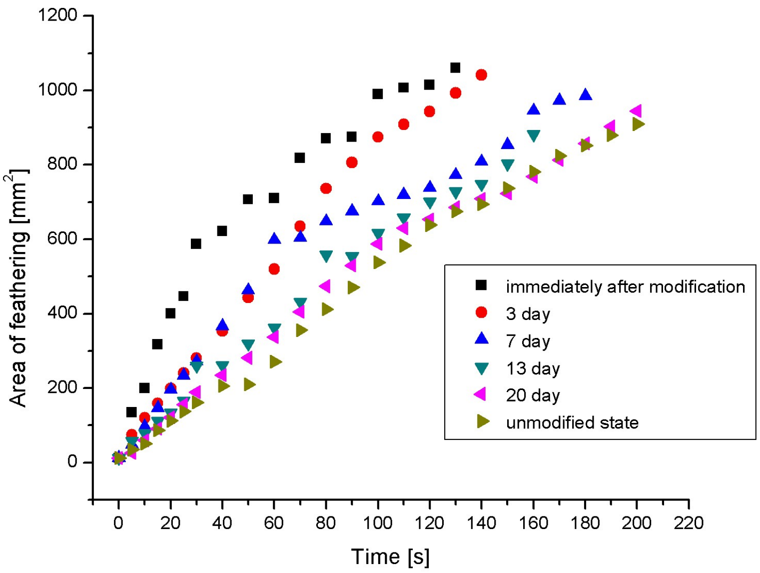

Fig.1. Time dependence of the fabric feathering area (240-seconds modification time)

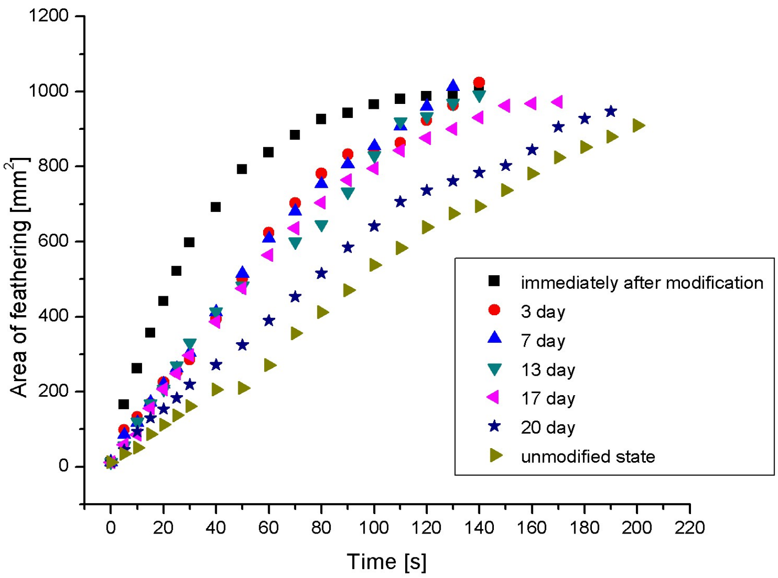

Fig.2. Time dependence of the fabric feathering area (360-seconds modification time)

CONCLUSIONS

Atmospheric DBD was employed for the treatment of the PES textile samples. The modification periods were for 240 and 360 seconds. The air in the reactor was pumped during all experiments.

The most stable modification was achieved with the modification time of 360s. The stable of modification effect was observed in 17 days after the treatment.

ACKNOWLEDGEMENTS

This research has been supported by the GACR grant № 202-03-H162 "Advanced study in Physics and Chemistry of the Plasma".

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МОДИФИКАЦИЯ АТМОСФЕРНЫМ ДИЭЛЕКТРИЧЕСКИМ БАРЬЕРНЫМ РАЗРЯДОМ ПОЛИЭСТЕРНОЙ ТКАНИ

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Внимание сосредоточено на изучении обработки полиэстерной ткани атмосферным диэлектрическим барьерным разрядом. Эксперимент был проведен в режиме с воздушной откачкой. Эффективность модификации была проанализирована капельным тестом. Предметом наблюдения являлась зависимость модификации от времени. Положительный эффект плазменной обработки наиболее заметен в случае времени модификации 360 с. Также обсуждается стабильность эффекта модификации.

МОДИФІКАЦІЯ АТМОСФЕРНИМ ДІЕЛЕКТРИЧНИМ БАР'ЄРНИМ РОЗРЯДОМ ПОЛІЕСТЕРНОЇ ТКАНИНИ

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Увага зосереджена на дослідженні обробки поліестерної тканини атмосферним діелектричним бар'єрним розрядом. Експеримент був проведений у режимі з повітряною відкачкою. Эфективність модифікації була проаналізована краплинним тестом. Предметом спостережень була залежність модифікації від часу. Позитивний ефект плазмової обробки найбільш помітний у випадку з часом модифікації 360 с. Також обговорюється стабільність ефекту модифікації.