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DETERMINATION OF RATIONAL MODES OF OBTAINING NANOFIBROUS MATERIALS BY ELECTROSPINNING ON THE FLUIDNATEK LE-50

ОПРЕДЕЛЕНИЕ РАЦИОНАЛЬНЫХ РЕЖИМОВ ПОЛУЧЕНИЯ НАНОВОЛОКНИСТЫХ МАТЕРИАЛОВ МЕТОДОМ ЭЛЕКТРОФОРМОВАНИЯ НА УСТАНОВКЕ FLUIDNATEK LE-50

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ABSTRACT

ELECTROSPINNING, NANOFIBERS, POLYMERS, POLYVINYL ALCOHOL

The work is devoted to the determination of rational modes of obtaining nanofibrous materials on the Fluidnatek LE-50 installation, in which the electrospinning process proceeds stably and with the highest efficiency. The criterion for the effectiveness of the electrospinning process was established. The features of the electrospinning process are investigated at different values of voltage, the distance between forming electrodes, and consumption of fiber-forming solution.

АННОТАЦИЯ

ЭЛЕКТРОФОРМОВАНИЕ, НАНОВОЛОКНА, ПОЛИМЕРЫ, ПОЛИВИНИЛОВЫЙ СПИРТ

Работа посвящена определению рациональных режимов получения нановолокнистых материалов на установке FluidnatekLE-50, при котором процесс электроформования протекает стабильно и с наибольшей эффективностью. Был установлен критерий эффективности процесса электроформования. Исследованы особенности процесса электроформования при различных значениях напряжения, расстоянии между формующими электродами и расходе волокнообразующего раствора.

Electrospinning is one of the most promising methods for the production of new types of textiles allowing to develop fibrous webs from submicron diameters to nanometer diameters using a high-potential electric field [1–3]. Electrospinning from polymer solutions and melts is of interest because of wide range of applications. The nanofibers obtained by electrospinning method are successfully used to solve different problems: for filtering highly dispersed aerosols in systems of purifying gas-air emissions, creating filters in respiratory protective equipment, providing antimicrobial and antiviral properties, regulating water and vapor permeability, creating dressings in the treatment of extensive burn surfaces, long-term non-healing wounds and trophic ulcers. These materials are also used in tissue engineering, for systems of controlled drug delivery, for the regeneration of cartilaginous, bone, nerve tissues, skin, and walls of blood vessels [2, 3]. Electrospinning is distinguished by a combination of high efficiency, instrumental simplicity and high flexibility that makes it possible to obtain fibrous materials with a wide range of properties and sizes of a single fiber from 50 to 500 nm [4].

The object of the study was a machine Fluidnatek LE-50 for electrospinning nanofibrous materials in the Vitebsk State Technological University in the laboratory of the DepartmentTextile Technology. The electrospinning machine Fluidnatek LE-50 is equipped with a syringe that fits into the pump. The solution flows through the capillary from the syringe to the electrospinning head, to which a positive voltage is applied. The flow rate of the solution can be adjusted by the speed of the piston lowering by the pump. The nanofibers are deposited on a non-woven material attached to a drum (collecting electrode), to which a negative voltage source is applied.

The aim of this work was to determine the rational modes of obtaining nanofibrous materials from aqueous solutions containing 15 % and 20 % polyvinyl alcohol (PVA) grade Sevol 205 by Sekisui Specialty Chemicals Europe S.L. (USA) in which the electrospinning process is stable at different distances between electrodes of the Fluidnatek LE-50. The variation intervals for the experimental factors are presented in Table 1.

Table 1 – Ranges and intervals of variation of experimental factors

Factor	Range of variation		Variatio-ninterval
	Min. level	Max. level	
Solution consumption Q, µl/h	150	850	50
Emitter voltage (P+), kV	13	29	1
Collector voltage (P-), kV	-5	-9	1
Distance between spinning electrodes, cm	8	12	2

We decided to consider the process electrospinning as stable in which the drop at the tip of the needle of the spinning head does not change over time and the processes of forming and pulling the jet occur continuously.

The productivity of the machine depends on the consumption of the polymer solution. In this regard, the maximum solution consumption was taken as a criterion for the efficiency of the electrospinning process.

Analysis of the experimental results showed that stable electrospinning of nanofiber materials from a solution containing 15 % polyvinyl alcohol occurs at a minimum voltage of 14 kV, while the solution consumption is 150 μL/h. On average, with an increase in voltage by 1 kV the rise of the solution flow rate of by 25 μL/h is observed.

The maximum consumption of the polymer solution during a stable electrospinning process was 850 μL/h. It was achieved at a distance between the spinning electrodes of 8 cm and a voltage of 25 kV.

A solution containing 20 % polyvinyl alcohol has the same tendency. The maximum consumption of the solution with a stable electroforming process was 400 μL/h with a distance between the forming electrodes of 12 cm and a voltage of 26 kV.

Based on the analysis of experimental data taking into account the criterion of the efficiency of the process it was found that it is rational to use the solution with 15 % polyvinyl alcohol for the electrospun material manufacturing. Its dry matter mass consumption with the maximum flow rate of 850 μL/h was by 1.6 times higher than for a 20 % polyvinyl alcohol solution the maximum flow rate of which was 400 μL/h.

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