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Impact of Electrospinning Technical Parameters Coating Morphology and Surface Density on Chitosan Nanofibers

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Abstract
The objective of this study is electrospinning from polymer solutions as a means of generating nanofiber from a nanotechnology viewpoint. Chitosan is used as a nanofiber-forming polymer with a wound-healing effect; it is also non-toxic, biocompatible, and biodegradable. Nanofiber exposes a super developed surface and voids ranking on its basis. Chitosan is very successful in creating ambrosial, long non-healing wounds and trophic ulcers, taking into account curative property relations.Nanospider technology generates electrospunfibers about 50-400nm in diameter from the free liquid surface. Potential differences between electrodes of up to 60 kV were developed during the nanofiber electrospinning stage. The effect of the technical electrospinning parameters on the morphology and surface density of the chitosan nanofiber coating is defined. Many of the preferred process parameters for electrospinning are picked. Nanofiber layer architecture is tested and analyzed by using the scan microscopy method on JSM-5610 LV JEOL. Nanofiber SEM pictures are shown. The impact of practice should be used on the growth of medical devices.
Keyword: electrospinning, chitosan nanofiber, Nanospider technology ElectrospinningElectrosprayingNanofibers Filtration

Introduction
One of the methods for obtaining chemical fibres is the formation of fibres from polymer solutions under the action of an electrostatic field - electroforming (EF) of fibres. Despite the complexity of understanding and studying the physical processes of electrospinning, this method is distinguished by its instrumental simplicity, high energy efficiency in the production of nanofiber, broad versatility for moulded materials and flexibility in process control. All this makes the ESP process attractive for the industrial production of nanofiber.[1]

The Nanospider technology - capillary-free electrospinning of nanofiber from polymer solutions - is a promising field of nanotechnology. Received according to this technology, the nanofiber is characterized by an overdeveloped structure that defines its high efficiency in biomedical filtration processes; having antimicrobial and antiviral barrier properties; controlling water permeability and vapour permeability; Production of dressings for the treatment of big, multi-origin burn surfaces; non-healing wood. "Wound dressings" made of chitosan are highly promising, obtained through the electrospinning process.[2]

The derivative of deacetylated chitin is chitosan. In comparison to practical chitin which insoluble, Chitosan can soluble in solutions which its pH acidic of each mineral acids and the

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organic acids. A decrease in molecular weight allows neutral pH values to dissolve chitosan[3]. A white to white powder with a yellowish sheen, or transparent white granules, is material dependent on chitosan. Hemostatic, bacteriostatic, fungistatic properties are shown by chitosan. Immunomodulatory and antitumor effects, lack of immunoreactivity, ability to biodegrade, complete removal from the body and biostimulation of regeneration processes have been demonstrated[4]. Chitosan in the body is decomposed by a specific group of enzymes and is quickly excreted.[3]

2-aminoglucan, a common portion of polysaccharides in the body that is part of the hyaluronic acid and heparin molecules, is the result of the decomposition of chitosan[5]. It is fully non-toxic and penetrates biological media such as blood, lymph, tissue and articular fluid well.[6]

In the development of 'therapeutic nanotechnology'[7], chitosan nanofiber chemistry plays a special role. It is capable of adsorption of small polar molecules, peptides and protein drugs. Chitosan has high sorption properties. Chitosan, which incorporates chemical and radiation resistance[8], is consistent with antiseptic agents, antibiotics, sulfonamides, local anesthetics, etc.[9]. Chitosan-based herbal preparations are increasingly used for the care of burn wounds of multiple etiologies. The treatment of burns and open exudative wounds is performed using chitosan membranes and films. The results of the use of these films showed microfilm growth .[10]

Material and method

Using various acid-based solvents, chitosan has already been electrospun. the acetic acid utilized at a concentration of 90 percent to 1 percent (or 0.17 M) produces strong fabrics, for example. Also reported was It is important to note that 90 percent and 70 percent of pure fibres of chitosan possess hardly been obtained when using acetic acid [10], but mostly with an acid called trifluoroacetic acid or with mixture that consist of trifluoroacetic acid and dichloromethane. Ionic liquid utilized with 1,1,1,3,3,3-hexafluoro-2 propanol. More commonly, fine nanofibers have been shown to be obtainable in blends of chitosan with poly (vinyl alcohol) PVA, gelatin or collagen, the silk fibroin and the polycaprolactone [11], but mostly with polyethyleneoxide (PEO). Usually, spinning solutions are obtained by combining the two polymer solutions formulated individually in the similar solvent to produce composite fibers. The mono or coextrusion production of chitosan blends occurs [12], Structured PEO-chitosan nanofibers and core-shell are also collected, leading to a hollow nanofiber by eliminating PEO after water washing. Shape-memory activity with relatively high PEO content has been documented to be fascinating. In addition to its low toxicity, strong spinnability of PEO is identified, and contact with processing of chitosan favors[13]

Result and discussion

An analysis of laboratory data on the impact of various chitosan forms (such as solution form, gel form and film) on process of healing for cutaneous wounds in rats and rabbits has shown that utilized of gel form provides a substantial increasing of the recovery process for the skin and the various mucous membranes [14]. Chitosan is used to render suture materials which are biodegradable. These sutures linger for a long time in the tissue before they recover, but only disappear steadily, so they do not need to be extracted. These do not induce allergic reactions,

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unlike many other biodegradable suture products, and do not weaken their strength [15]. Chitosan, thus, has distinctive properties and biological function, which makes it commonly used in medicine and pharmacy.[1]

Electrospinning technology consists of drawing the polymer solution (melt) from units to one hundred kilovolts into thin jets under the action of an electrical voltage. In the polymer solution, the high voltage creates the same electrical charges, resulting in Taylor cones being formed and the polymer solution being more electrostatically extended. During the drawing process, the polymer jet will undergo a chain of successive separations into thinner jets. The resultant jets solidify, turn into fibers and drift to the substrate with the opposite electrical potential by evaporation of the liquid or as a result of freezing, under electrostatic powers activity.[5]

The properties of the spinning solution and the parameters of the electroforming process exert the principal effect on the electroforming process. In each particular case, the optimum collection of both the properties of the molding solution discussed above and the technical parameters of the electrospinning process is a research task. [3]. Primary segment. Scientific parameters such as voltage, interelectrode distance, fiberization electrode rotation rate are directly influenced by the properties of the resulting nanofiber coating. The purpose of this work is to analyze the effect of these parameters on the average nanofiber diameter and the deposition density of the chitosan nanofiber coatings. To prepare the molding solution, chitosan developed by KitoZyme with a molecular weight of 30–50 kDa was used. The concentration of chitosan in the molding solution was 7% by weight. As a solvent, the acetic acid (70%) was utilized. Polyethylene oxide with a 0.3 percent molecular weight of 400 kDa by weight. It has been used as an additive to technology. On the day that the solution was prepared, shaping was finished. Nonwovens from Spunlace and Spunbel were used as support materials. On an NS LAB 500S computer, the molding was carried out. A JEOL JSM-5610 LV scanning electron microscope was used to analyze the collected material. Using the Image software, the average nanofiber coating diameter was determined from the surface images collected. On 10 ?? 10 cm samples, the density of the nanofiber coating was calculated using the gravimetric method [13]. The table shows the dependency of mushroom chitosan's average nanofiber diameter on voltage, interelectrode size, and fiber-forming electrode rotation velocity when using spunbel as a substrate.[8]

The study of the measured data revealed that there is no substantial variation in the average diameter of nanofibers when electroforming the nanofiber coating from molding solutions based on mushroom chitosan at various voltage values. The maximum value of the average nanofiber diameter is 280 nm (at 65 kV interelectrode voltage) and as the voltage rises to 70 kV, the average nanofiber diameter changes slightly - 270 nm.[16] Around the same time, a further increase in voltage (75, 80 kV) leads to a decrease in the average nanofiber diameter value to 220 nm nanofibers That would possibly be caused by a greater drawing of the molding fluid jet due to an increase in the strength of the electric field and, thus, an increase in the strength of the Coulomb .[17]

Experimental results suggest an enhancement with increased voltage in nanofiber coating deposition density when Spunlace and Spunbel are used as backing materials. At a voltage of 60 kV, the deposition density was respectively 0.15 for spunbel and spaniels. And 0,18 g / m2, and

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80 kV at -0,38 and 0,45 g / m2. To achieve the highest density of the chitosan nanofiber coating, it is important to use the full voltage. However, due to the fact that an increase in voltage contributes to a decrease in the formation time, Prior to lying on the substrate and the emergence of defects, the fibers may not dry out [16]. For a high voltage source, The use of voltage values close to the limit is also not recommended [17]. In most situations, an increase in voltage leads to a larger drawing out of the molding solution's jet due to an increase in the Coulomb forces and the power of the electric field. A decrease in the average fiber diameter is observed in this case. [19], It also accelerates the evaporation of the liquid from the jet[20]. Growing the voltage, however, Reduces travel time for jets. For a longer flying time, the plane has more time for drawing and orientation, which may lead to the development of thinner fibers[21]. At high voltages, defects can form. The shape of the defects will vary between spindle shaped and spherical [17]. In certain cases , with increasing voltage, a decrease in the number of defects is found due to a greater stretching of the jet of the molding solution. Higher stress values favor the division of the jet into smaller ones by using low-viscosity spinning solutions, leading to a drop in the average diameter of the resulting fabric.[18]

The most suitable voltage value for obtaining a nanofiber coating is 70 kV based on the data provided, because under these conditions a reasonably high output of the equipment is observed in normal mode and a high density nanofiber coating is obtained. Generally, the evidence collected were consistent with the literature. An significant technical parameter is the interelectrode distance, as it directly affects the flight time of the jet and the power of the electric field. Based on the measurements of the nanofiber diameters collected, it was discovered that the value of average nanofiber diameter during electrospinning at an interelectrode distance of 100 mm was estimated to be the mean nanofiber diameter value.[19]

Dependence of the average diameter of nanofiber, the density of nanofiber coating deposition on voltage, interelectrode distance, and rotation speed of the fiber-forming electrode for spunbel and Spunlace nonwovens

Indicators	Spunbel					Spunlace				
At voltage, kV	60	65	70	75	80	60	65	70	75	80
mean diameter, nm	250	250	210	210	180	310	320	280	250	220
coating density (ρ), g / m2	0,20	0,25	0,29	0,32	0,36	0,17	0,20	0,32	0,38	0,41
With interelectrode distance, mm	100	125	150	165	185	100	125	150	165	185
mean diameter, nm	390	260	240	230	200	410	280	250	190	280
coating density (ρ), g / m2	1,14	0,28	0,20	0,16	0,12	1,28	0,35	0,28	0,16	0,12
At the speed of rotation of the fiber-forming electrode, rpm	5	8	10	15	18	6	9	10	15	18
mean diameter, nm	270	250	240	260	290	260	240	270	240	270
coating density (ρ), g / m2	0,20	0,26	0,31	0,23	0,24	0,27	0,32	0,37	0,31	0,34

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The most notable reduction in fiber diameter found is an increase in the inter-electrode difference from (100 mm to 125 mm) and from (390 mm to 260 nm) for the spunbel lining material and from 410 to 280 for Spunlace. It was known from the findings provided that the density of the nanofiber coating decreases with an increase in the distance between the interelectrode, which does not allow the articles to be obtained with a satisfactory collection of properties. An increase in the distance between the interelectrode can cause the average diameter of the resulting fibers to decrease. [20]. This is due to the fact that the jet has more time to draw with a large inter-electrode gap. However, with an increase in the inter-electrode gap due to a reduction in the electric field strength[15], an increase in the average fiber diameter is also likely [15]. The data collected is consistent with the literature. The flight time of the jet must be adequate for much of the solvent to evaporate from the jet for the creation of single fibers. The jet would need to fly a shorter distance to reach the substrate with a reduction in the inter-electrode distance. However, the electrical field force acting on the plane also increases as the interelectrode gap reduces, which contributes to an increase in By the acceleration. As a outcome, jet form will not have enough time to evaporate the solvent until it is mounted on the substrate [18]. If the distance between the interelectrode is inadequate, the fibers can stay together because of the high solvent content. Low interelectrode distance values will contribute to the development of bead-shaped defects[19]. This arises since a reduction in the difference between the electrodes has a reciprocal interaction with a rise in voltage between the electrodes, enhancing the electric field power, while jet instability increases. This encourages the development of defects in beads. The data obtained on the change in the density of the deposition of the nanofiber coating on the rotation speed of the fiber-forming electrode shows an increase in the density with an increase in the number of fiber-forming electrode revolutions to a certain value, and a decrease in the density is observed. [12] . The highest density of the fiber-forming electrode is observed at a rotation speed of 10 rpm, which is possibly attributed to the existence of the most suitable conditions for the formulation of a nanofiber coating, because there is a lack of the forming solution on its surface at low values of the rotation speed of the fiber-forming electrode, which limits the process efficiency even at higher speeds. Therefore, new Taylor cones are unnecessarily initiated when molding from the current cones is already possible. [17]. This effects results adversely. For Spunlace and Spunbel lining fabrics, the average diameter varies insignificantly and stays in the region of 240-270 nm. Therefore, spinning should be carried out at a rotation speed of the fiber-forming electrode of 10 rpm in order to achieve the maximum value of the deposition density of the nanofiber coating of chitosan on the Spunlace and Spunbel nonwoven lining materials. The surface images of the nanofiber coating made of chitosan on Spunlace and Spunbel are shown in Figures 1 and 2 in the most appropriate mode: 70 kV voltage, 145 mm interelectrode width, 10 rpm rotation speed of the fiber-forming electrode .[22]

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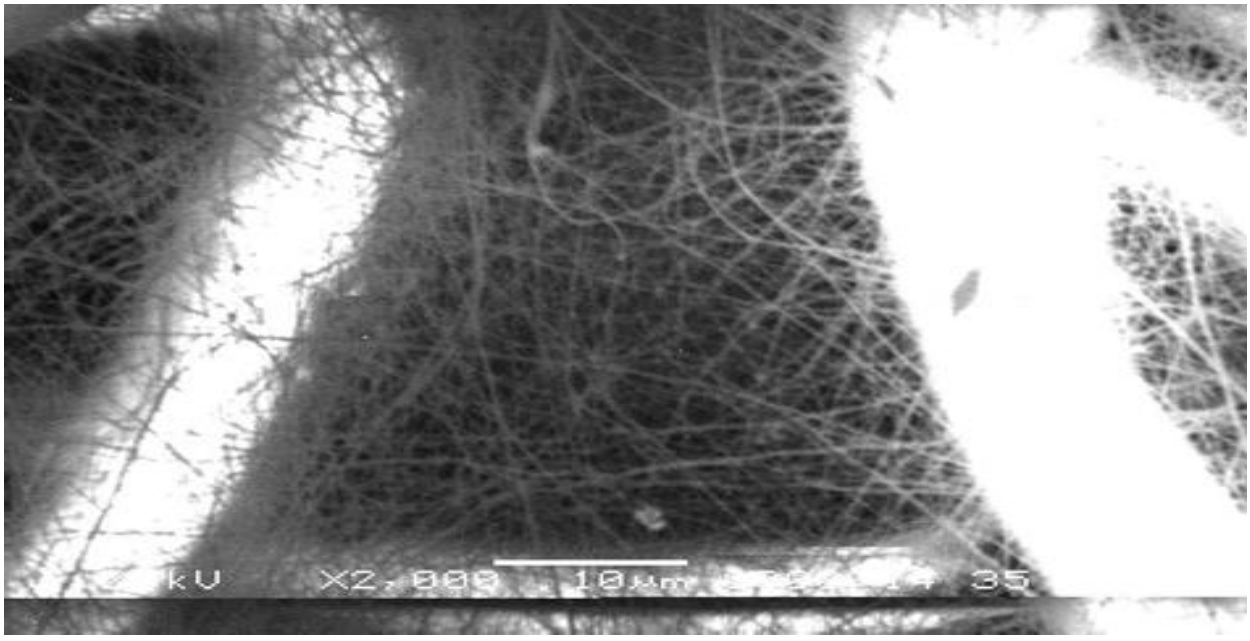

figure: 1. Electronic snapshot of the surface Chitosan nanofiber coating on Spunlace nonwoven fabric

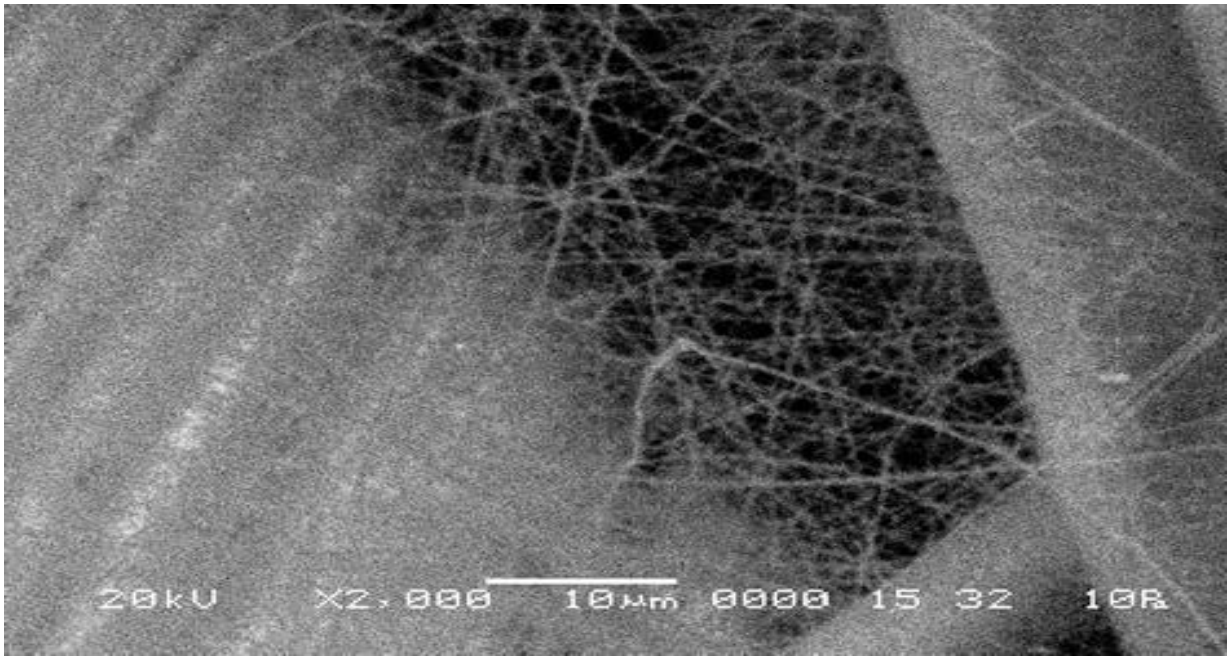

figure: 2. Electronic snapshot of the surface Chitosan nanofiber coating on spunbel nonwoven fabric

Conclusion

Research on the impact of technology logical parameters for the process of electrical moldings showed that the highest density coverage with chitosan nanofiber achieved with a minimum interelectrode distance of 100 mm. However, The study of the nanofiber coating structure showed that the average fiber diameter increased dramatically to 390-410 nm.. Most the acceptable interelectrode distance is within 125–150 mm, at which the average fiber diameter is 240-280 nm and the density of the nanofiber coating 0.2– 0.4 g / m2. With increasing stress

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occurs reducing the average diameter of nanofibers and an increase in the density of nanofiber covering. Since exploitation the source of your voltage on maximum power is not recommended, then the most acceptable voltage is 70 kV, at which the nanofiber diameter is 240–280 nm, and the density of the nanofiber coating is 0.31–0.37 g / m2. The rotation speed of the fiber-forming electrode has no significant effect on the diameter of the resulting nanofiber coating. The maximum coating density is observed at a speed of 10 rpm.The data obtained can be used vans at JSC "Plant of Mining Wax" when organizing the production of medical devices with chitosan nanofiber. Preclinical research tests on laboratory animals have shown their greater efficiency compared to traditional means. The preliminary cost estimate showed that the product cast, obtained by the method of electrospinning, will be 2–3 times cheaper than foreign analogues.

References

1 .Prokopchuk N. R., Prishchepenko D. V., ShashokZh. S. Electrospinning of nanofibers from solutions of chitosan. Polymer materials and technologies, 2015, vol. 1, no. 2, pp. 36–56

2.Vihoreva G. A., Rogovina S. Z., Pchelko O. M. Phase state and rheological properties of chitosan – acetic acid – water system. VMS [Polymer science], 2001, vol. 43, no. 6, pp. 1079–1084

3.Bobrova L. V., Bol'shakov I. N., Mikhal'kov R. V. Enterosorption by chitosan in children with inflammatory diseases of the nervous system (encephalomyelopolyradiculoneuritis). 2001. No. 1. P. 21–25.

4.Varlamov V. P. Some aspects of chemical and enzymatic modification of chitosan. Scientific basis for the production of veterinary biological products: thesis. report. scientific-practical conf. M., 2000.S. 377.

5.Riccardo A. A. Chitin and chitosan's for the repair of wounded skin, nerve, cartilage and bone. Carbohydrate Polymers, 2009, vol. 76, pp. 167–182.

6.Kryzhanovskaya E. V. Preparation of the low molecular weight chitosan and the study of its antimicrobial properties. [Advances in science and technology AIC], 2008, no. 11, pp. 45–46.

7.Agawal S., Wendorff H., Greiner A. Use of electrospinning technique for biomedical applications. Polymer, 2008, vol. 49, pp. 5603–5621.

8.Kumar G., Smith P. J., Payne G. F. Enzymatic grafting of a natural product onto chitosan to confer water solubility under basic conditions. BiotechnolBioeng, 1999, no. 2, pp. 154–165.

9.Safronova T. M. Evaluation of the antibacterial action of intermolecular chitosan disk method. materials of the 4th Congress of the Society of Biotechnologists of Russia. M., 2006.S. 228.

10 . .Haider, S.; Park, S.Y. Preparation of the electrospun chitosan nanofibers and their applications to the adsorption of Cu(II) and Pb(II) ions from an aqueous solution. J. Membr. Sci. 2009, 328, 90–96.

11 .Homayoni, H.; Ravandi, S.A.H.; Valizadeh, M. Electrospinning of chitosan nanofibers: Processing optimization. Carbohydr. Polym. 2009, 77, 656–661.

12 .Sencadas, V.; Correia, D.M.; Areias, A.; Botelho, G.; Fonseca, A.M.; Neves, I.C.; Gómez-Ribelles, J.L.; Mendez, S.L. Determination of the parameters affecting electrospun chitosan fiber size distribution and morphology. Carbohydr. Polym. 2012, 87, 1295–1301

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 2319 - 2326
Received 16 February 2021; Accepted 08 March 2021.

13 .Ojha, S.S.; Stevens, D.R.; Hoffman, T.J.; Stano, K.; Klossner, R.; Scott, M.C.; Gorga, R.E. Fabrication and characterization of electrospun chitosan nanofibers formed via templating with polyethylene oxide. Biomacromolecules 2008, 9, 2523–2529.

14.Hunafin S. N., Bajkov D. A., Munirov R. R. Experience of using filmy wound coverings based on PVA and chitozin in the treatment of patients with burn injury. Materials of the republic scientific and practical conference “New medical technologies in surgical and therapeutic practice in the Republic of Bashkortostan. , 2000,51 p .

15 .Chen C. S., Liau W. Y., Tsai G. J. Antibacterial effects of N-sulfonated and N-sulfobenzoylchito- san and application to Oyster preservation. J. Food Protection., 1998, vol. 61, no. 9, pp. 1124–1128.

16.Rogovina S. Z. Properties of films derived from mixtures of chitosan and cellulose. VMS [Polymer science], 1999, vol. 41, no. 11, pp. 1839–1842

17.Elinson V. M. Investigation of the natural polymer chitosan-based resistance to biodegradation. Materials of the International scientific conference “High technologies in industry (materials and devices of functional electronics and microphotonics., 2012, p. 10

18.Wang H. Preparation of electrospinning nanofibers composite chitosan, polylactic acid and the study of their properties// Polymer Mater. Sci. Technol. Eng. 2013. No. 1. P. 162–165..

19.Lee J. S., Choi K. H., Ghim H. D., Kim S. S., Chun D. H., Kim H. Y., Lyoo W. S. Role of molecular weight of atactic poly(vinyl alcohol) (PVA) in the structure and properties of PVA nanofabric prepared by electrospinning. J. Appl. Polym. Sci., 2004, vol. 93, pp. 1638–1646.

20.Pawlowski K. J., Belvin H. L., Raney D. L., Su J., Harrison J. S., Siochi E. J. Electrospinning of a micro-air vehicle wing skin. Polymer, 2003, vol. 44, pp. 1309–1314.

21.De Vrieze, S.; Westbroek, P.; van Camp, T.; van Langenhove, L. Electrospinning of chitosan nanofibrousstructureseasibility study. J. Mater. Sci. 2007, 42, 8029–8034.