# Electrospun Materials from Poly (Vinyl Alcohol) Nano-Microfibers with Undoped and Boron Doped Hydroxyapatite Particles

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**Introduction.** Electrospinning (electrostatic fiber spinning) is a modern and efficient method which uses electric field to produce fine fibers whose diameters can be reduced to nano-micrometer level by adjusting the electrospinning parameters [1]. During electrospinning process high voltage is applied to polymer solution and grounded collector. In increasing electrical field a polymer jet is formed from polymer droplet. On the way to collector, the jet split to nano-microfibers and fibers solidifies due solvent evaporation.

Nano-microfibers which used in tissue engineering scaffolds should have the following characteristics: degradation capability so that they get completely reabsorbed after implantation, porosity for cell migration and nontoxic by products balance between surface hydrophilicity and hydrophobicity for cell attachment [2,3]. Electrospinning has recently gained popularity with the tissue engineering and there are many reports in the literature addressing the preparation of electrospun synthetic and natural polymers [4].

Hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$, (HAp) is a biomimetic material (a member of the apatite family of calcium phosphates) has been widely used in biomedical applications in combination with different materials since it is an inorganic component of bones and teeth [5]. Due to its poor mechanical properties, it cannot be used alone as bone implant material but can constitute as the beneficial reinforcement materials which trigger the tissue growth [6]. In addition, the advantages of Hap can be improved by doping with foreign elements.

Boron (B) is one of the promising elements which is used for addition to the structure of HAp [7-10]. Compelling evidence was provided by the studies of Jain et al. [11], Hakki et al. [12] and Gorustovich et al. [13], in which not only the positive effect of B on bone formation but also the beneficial effect of B on bone cell differentiation when added to bioglass bone-replacement scaffolds were reported.

The aim of this study is to investigate the influence of different types of HAp particles on structure of electrospun poly (vinyl alcohol) nano-microfibers mats.

**Materials and Methods.** Electrospinning solution of 12% concentration were prepared dissolving PVA $M_w$ = 72000 g/mol (ROTH, Germany) polymer in distilled water and stirred for 4 hours at 80°C temperature by magnetic stirring equipment (Yellow Line MSH basic, Germany). 5 wt% of undoped HA or B doped HA (BHA) powders were added to the PVA polymer solution and obtained suspensions were dispersed ultrasonically for 5 min. The powders used in the current study were synthesized by acid-base method [8], and two different treatments were applied to these powders. Obtained four different kinds of powders used in the electrospinning solution were coded as presented in Table 1.

**Table 1.** Types of the HAp powders used in the electrospinning solution

| Code sample | Method of synthetize | Treatments |
|---|---|---|
| **A** | HA powders were synthesized by acid-base method. | Obtained powders were dried in an oven at 110 °C for 48 hours. |
| **B** | BHA powders were synthesized by acid-base method: 2.0 wt. % B were used in the synthesis stage of the HA. | Obtained powders were dried in an oven at 110 °C for 48 hours. |
| **C** | HA powders were synthesized by acid-base method. | Obtained powders were dried in an oven at 110 °C for 48 hours and sintered at 1000°C for 2 hours. |
| **D** | BHA powders were synthesized by acid-base method: 2.0 wt. % B were used in the synthesis stage of the HA. | Obtained powders were dried in an oven at 110 °C for 48 hours, and sintered at 1000°C for 2 hours. |

The mat from nano-microfibers was formed using "Nanospider ™" (Elmarco, Chech Respublic)**,** at applied voltage 70 kV, distance between bottom rotating electrode and support material 13 cm, the temperature of electrospinning environment was t = 25±2°C.

The structure of PVA nanofibers mats was determined using field emission scanning electron microscope (FESEM) (Zeiss, Supra 55, Germany). The diameter of PVA nanofibers was measured using image analysis system NIS-Elements D 4.50.00.

**Results.** In this study to 12 % of concentration PVA polymer solution also was added 5 wt % HA powders. The structure of electrospun with different types of HAp particles are presented in Figure 1.

The distribution of diameters of the electrospun PVA nano-microfibers with different types of HAp powders are presented in Figure 2. From the data presented in Figure 2, it can be noticed that from PVA polymer solution with BHA powders (code B) and HAp powders sintered at 1000°C for 2 hours (code C and D) were formed more thicker nano-microfibers. 60% of nanofibers with diameter to 100 nm were formed from PVA polymer solution with HAp powders which were synthesized by acid-base method (code A), and only 15% of nanofibers with diameter to 100 nm were formed from solution with BHA

powders (code B). Addition of B in HAp powders does not have apparent influence on diameter of electrospun nano-microfibers, if prepared powders are sintered at 1000°C for 2 hours (comparing C and D).

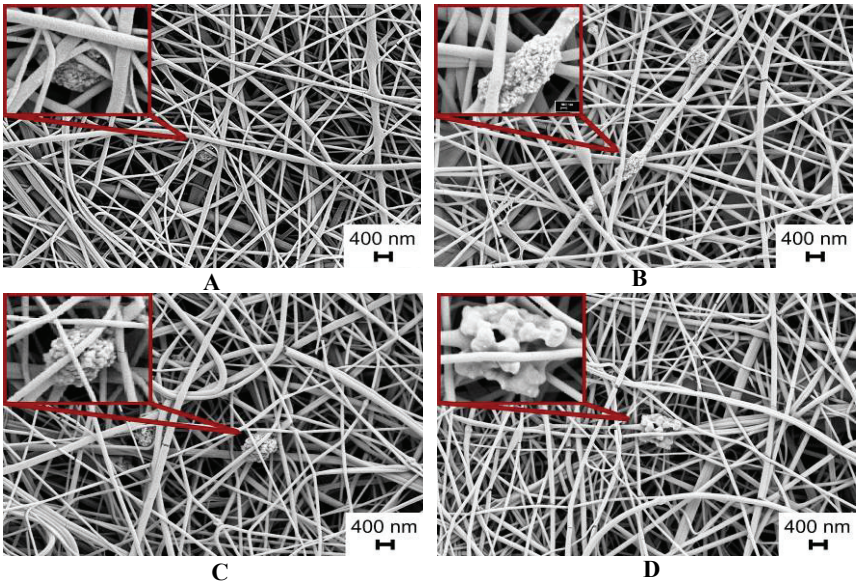


**Fig. 1.** SEM images of electrospun mats from PVA nano-microfibers with HA (the amount of HAp powder in electrospun solution is 5 wt%): A - HAp powders, B - BHA powders, C - HAp powders sintered at 1000°C, D – BHA powders sintered at 1000°C.

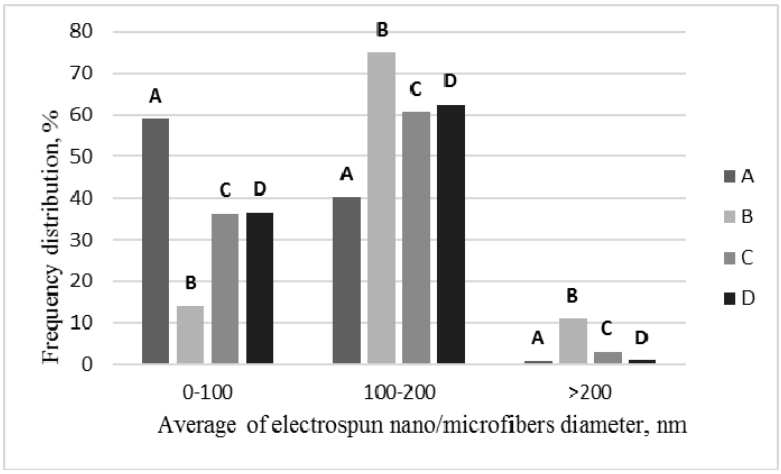


**Fig. 2.** The distribution of electrospun PVA nano-microfibers diameter with HAp powders (A - HAp powders, B - BHA powders, C - HAp powders sintered at 1000 °C, D – BHA powders sintered at 1000 °C)

**Conclusions.** It is possible to form nano-microfibers with boron doped and undoped hydroxyapatite particles by using electrospinning method. The type of HA powders has influence on diameter of electrospun nano-microfibers.

In the future work amount of HA and BHA particles will be increased in electrospun mat, increasing time of ultrasound mixing of polymer solution.

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