On the Electrospinning of Poly(vinyl alcohol) Nanofiber Mats: A Revisit

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Received 18 October 2006; accepted 16 October 2007
DOI 10.1002/app.27664
Published online 18 January 2008 in Wiley InterScience (www.interscience.wiley.com).

ABSTRACT: Electrospinning was used to fabricate mats of poly(vinyl alcohol) (PVA; $\bar{M}_w$ = 72,000 Da, degree of hydrolysis ≈ 97.5–99.5) nanofibers from PVA solutions in reverse osmotic water. The effects of solution concentration, applied electrical potential, sonication, and collection distance on morphological appearance and diameters of the as-spun fiber mats as well as those of the individual fibers were carefully investigated mainly by scanning electron microscopy. The effect of the distance from the center of the as-spun fiber mat on morphological appearance and diameters of the as-spun fibers was also investigated. The mechanical integrity of some as-spun PVA fiber mats was also investigated. At all concentrations and applied electrical potentials investigated, the average diameters of the as-spun PVA fibers ranged between 85 and 647 nm. The use of sonication to prepare a PVA solution caused the viscosity of the solution to decrease; hence, the observed decrease in the average diameters of the as-spun fibers and the average diameters of the as-spun fibers were practically the same throughout the as-spun fiber mat. © 2008 Wiley Periodicals, Inc. J Appl Polym Sci 108: 969–978, 2008

Key words: electrospinning; nanofibers; poly(vinyl alcohol)

INTRODUCTION

Poly(vinyl alcohol) (PVA) is a hydrophilic, semicrystalline polymer that has received much attention because of its good chemical resistance, good thermal stability, good physical properties, excellent biocompatibility, and inexpensiveness.[1,2] Moreover, PVA is a hydrogel polymer—a hydrophilic polymer that forms a three-dimensional network structure—that is capable of absorbing a large quantity of water.[3]

When diameters of polymeric fibers decrease from micrometer down to nanometer range, there appear several interesting characteristics, such as high surface area to volume or mass ratio, vast possibilities for surface functionalization, and improved mechanical performance due to an improvement in the structural organization. These interesting properties make ultra-fine electrospun polymeric fibers excellent candidates for many important applications, some of which are filtration, reinforcing materials, wound dressing, tissue scaffolding, releasing vehicles of drugs, and so on.[4,5] The electrospinning process seems to be a simple method that can be further developed for mass production of continuous, ultra-fine fibers from materials of diverse origins, e.g., polymers, ceramics, etc. Some advantages of the process are simple tooling, cost-effectiveness, and ability for producing nonwoven mats of fibers with certain degrees of control over the alignment of and pore sizes between the depositing fibers.[4,5]

Over the past few years, many researchers have investigated various parameters affecting the morphology and the diameters of the electrospun PVA fibers, e.g., solution concentration, solution flow rate, degree of hydrolysis, applied electrical potential, collection distance, ionic salt addition,[6] molecular weight of PVA,[2,7,8] pH,[9] surfactant addition,[10] and type of collector,[11] but, often times, conflicting results were observed. Emphatically, none of these existing reports was focused on the effect of various parameters on the deposition area of the as-spun PVA fiber mat, nor the effect of sonication applied during the preparation of the spinning PVA solutions on the morphology and the diameters of the resulting fibers. Potential uses for the as-spun PVA fiber mats are, for examples, immobilization membranes for cellulase,[12] delivery membranes for bovine serum albumin (BSA),[13] and sodium salicylate, diclofenac sodium, naproxen, and indomethacin,[14] and antimicrobial membranes from the as-spun PVA fiber mats that contained silver nanoparticles.[15]

In the present contribution, nonwoven mats of PVA nanofibers were prepared by electrospinning. An attempt was made to understand the effects of

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Contract grant sponsor: National Research Council of Thailand (NRCT), Petroleum and Petrochemical Technology Consortium, Petroleum and Petrochemical College (PPC), Chulalongkorn University.

some solution properties (e.g., concentration and viscosity) and some process conditions (e.g., applied electrical potential, sonication, and collection distance) on morphological appearance and diameters of the as-spun fiber mats as well as those of the individual fibers. Mechanical property in terms of the Young's modulus some of the as-spun fiber mats were also investigated.

EXPERIMENTAL DETAILS

Materials and preparation of spinning solutions

PVA powder [M_w = 72,000 Da; degree of hydrolysis (DH) ≈ 97.5–99.5 mol %; specific gravity = 1.25 g cm^{-3}] was purchased from Fluka (Switzerland). The solvent used was reverse osmotic (RO) water which was filtered by an Elix Millipore Z1XS5005Y RO water filter.

The PVA solutions were prepared by dissolving a weighed amount of PVA powder in RO water at 85°C under constant stirring for 4 h to attain the solutions with concentrations ranging between 6 and 14% w/v (2% w/v increment). To investigate the effect of sonication, the as-prepared 10% w/v PVA solution was sonicated at 50°C for 10 min prior to being cooled down to room temperature. Prior to electrospinning, each of the as-prepared PVA solutions was measured for their viscosity and conductivity at room temperature (~ 26 ± 1°C) using a Brookfield DV-III programmable viscometer and a Suntex SC 170 conductivity meter, respectively.

Electrospinning

Electrospinning of the as-prepared PVA solutions was carried out by first loading each of the as-prepared solutions in a 50-mL plastic syringe. A blunt stainless-steel gauge-20 hypodermic needle (OD = 0.91 mm) was used as the nozzle. Both the syringe and the needle were tilted ~ 45° from a vertical baseline to ascertain a constant presence of a solution droplet at the tip of the nozzle. A sheet of aluminum foil on a plastic backing (stationary collector) or a rotating cylinder (rotating collector) was used as the collection device. A Gamma High Voltage Research DES30PN/M692 power supply was used to charge the solution across the needle (connected to the positive emitting electrode) and the collector (connected to the grounding electrode). The feed rate of the solution was controlled by means of a Kd Scientific syringe pump at 1 mL h^{-1}. The as-spun products were dried in an oven at 95°C for 24 h prior to further characterization.

To study the effects of the PVA solution concentration and the applied electrical potential on morphological appearance and average diameter of the as-spun fiber mats and those of the individual fibers within the obtained fiber mats, PVA solutions of varying concentration ranging between 6 and 14% w/v (prepared without sonication) were electrospun under an applied electrical potential of 12.5 to 25 kV (2.5 kV increment) over a fixed collection distance of 15 cm. To study the effect of the collection distance on morphological appearance and average diameter of the as-spun fiber mats and those of the individual fibers, a sonicated 10% w/v PVA solution was electrospun under a fixed applied electrical potential of 15 kV over a collection distance of 5–20 cm (2.5 cm increment). To study the effect of the distance from the center of the as-spun fiber mat on morphological appearance and average diameter of the individual fibers, the sonicated 10% w/v PVA solution was electrospun under a fixed applied electrical potential of 15 kV over a fixed collection distance of 15 cm. All of these experiments were carried out on a stationary collector and a fixed collection time of ~ 1 min.

To fabricate the electrospun fiber mats for mechanical testing, the sonicated 8–12% w/v PVA solution was electrospun under a fixed applied electrical potential of 15 kV onto a rotating collector (outer diameter = 15 cm and rotational speed = 50–65 rpm) which was set 15 cm apart from the tip of the needle. In this case, the collection time was fixed at ~ 24 h.

Characterization

The morphological appearance of the as-spun PVA fiber mats and that of the individual fibers was investigated by a JEOL JSM-5200 scanning electron microscope (SEM), operating at an acceleration voltage of 10 kV. For each sample, the average diameter of the individual fibers was measured from multiple SEM images at the magnification of ×7500 by Semafore 4.0 software. The result for each sample was reported as an average value from at least 50 measurements. A Lloyd LRX universal tester was used to determine the mechanical integrity of some of the as-spun PVA fiber mats. The dimension of the fiber mat specimens was 6 mm × 70 mm, with the thickness ranging between 20 and 30 μm. The gauge length and the crosshead speed were 50 mm and 20 mm min^{-1}, respectively.

RESULTS AND DISCUSSION

Electrospinning of PVA fibers

To arrive at the suitable electrospinning condition that resulted in the production of thin and uniform PVA nanofibers, the effects of solution concentration, applied electrical potential, sonication, and collection distance on morphological appearance and average

TABLE I
Some Properties of the As-Prepared PVA Solutions

Sample	PVA solution concentration (% w/v)	Sonication	Viscosity (mPa s)	Conductivity (mS cm^{-1})
(a)	6	No	62	0.727
(b)	8	No	181	0.865
(c)	10	No	810	1.011
(d)	12	No	1932	1.215
(e)	14	No	2430	1.267
(f)	10	Yes	604	1.011

diameter of the as-spun fiber mats and those of the individual fibers were investigated. The results were divided into three subsections to illustrate each effect. To draw a complete understanding of the results, one needs to be familiar with the six types of forces involving in the electrospinning process[16]: they are (1) body or gravitational force, (2) electrostatic force (viz., force exerting on charges carried within a jet segment when the jet is in an electrostatic field) which carries the charged jet from the needle to the collector, (3) Coulombic stretching force (viz., repulsion force between charges of mutual polarities) which tries to push apart adjacent charged species carried within the jet segment and is responsible for the thinning or the stretching of the charged jet during its flight to the target, (4) viscoelastic force which tries to prevent the charged jet from being stretched, (5) surface tension also acts against the stretching of the surface of the charged jet, and (6) drag force from the friction between the charged jet and the surrounding air.

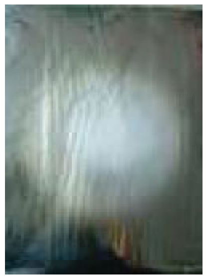
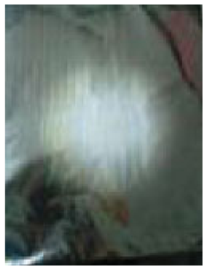
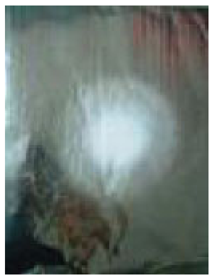
Effects of solution concentration and applied electrical potential

Table I(a–e) summarizes both the viscosity and the conductivity of the as-prepared PVA solutions at various concentrations investigated. Apparently, both property values increased monotonously with increasing the solution concentration. It is now a common knowledge in electrospinning that, in order to obtain uniform ejection of the charged jet, the spinning solution with a proper concentration or viscosity is required. If the concentration of the solution is too low, a continuous stream of the charged liquid (i.e., the charged jet) cannot be formed, as the charged jet undergoes a flow instability leading to the formation of droplets (i.e., electrospraying).[17] In other words, a critical solution concentration needs to be exceeded as extensive molecular entanglements are prerequisite for the formation of a stable, continuous charged jet. However, if the solution concentration is too great, continuous flow of the polymer liquid from the nozzle tip becomes prohibitive. As a result, there is a processing window in terms of the concentration or the viscosity range within which the polymer solutions are electrospinnable and beyond which discrete droplets are likely to occur.[18]

Table II shows selected optical images illustrating the deposition area of the as-spun fiber mats from unsonicated 6–14% w/v PVA solutions under various applied electrical potentials in the range of 12.5–25 kV, while quantitative results in terms of the diameters of the as-spun fiber mats for all of the conditions investigated are summarized in Table III. For a given applied electrical potential, the diameters of the as-spun fiber mats decreased monotonically with increasing the solution concentration. Similarly, for a given solution concentration, the diameters of the as-spun fiber mats decreased monotonically with increasing the applied electrical potential. For a given applied electrical potential, increased solution concentration caused the viscoelastic force to increase. The increased viscoelastic force caused the thinning of the charged jet less likely to occur, resulting in the onset for the bending instability to occur closer to the collector.[19,20] On the other hand, for a given solution concentration, increased applied electrical potential caused both the electrostatic and the Coulombic repulsion forces to increase. The increased electrostatic force caused both the speed and the mass flow rate of the charged jet to increase, which could, in turn, cause the onset for the bending instability to occur closer to the collector.[19,20]

Figure 1 shows selected SEM images illustrating the morphological appearance of the as-spun fibers from the unsonicated 6–14% w/v PVA solutions under various applied electrical potentials in the range of 12.5–25 kV. Regardless of the applied electrical potential, electrospinning of the 6% w/v PVA solution only resulted in the formation of beaded fibers. This is due to the low viscosity of the solution; hence, the low viscoelastic force that was not enough to prevent the partial breakup of the charged jet caused by the Coulombic repulsion. Further increase in the solution concentration only resulted in the formation of uniform fibers. This is due to the increased viscosity, hence the increased viscoelastic force that was sufficient to totally prevent the partial breakup of the charged jet and allowed the Coulombic stress to elongate the charged jet much more evenly. For a given solution concentration, increasing the applied electrical potential caused the number of the as-spun fibers (or beaded fibers) per unit area to increase, which is in line with the observed decrease in the diameters of the as-spun fiber mats with increasing the applied electrical potential (see above). Interestingly, increasing the applied electrical potential also caused the size of the beads to decrease and their shape to be more elongated (i.e., spindle-like),[19,20] an indication of the increased stretching force exerting on a jet segment.

TABLE II
Selected Optical Images Illustrating the Deposition Area of the As-Spun Fiber Mats from 6–14% w/v PVA Solutions

Applied electrical potential (kV)	Solution concentration (% w/v)				
	6	8	10	12	14
15.0					
20.0					
25.0					

The varying electrical potential in the range of 12.5–25.0 kV was applied over a fixed collection distance of 15 cm and the feed flow rate was 1 mL h^{-1}. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

Figure 2 shows the diameters of the as-spun PVA fibers obtained at all conditions investigated. For beaded fibers, only the diameters of the fiber sections between beads were measured and reported. For a given applied electrical potential, increasing the solution concentration caused the fiber diameters to increase monotonically. This is in general accordance with those reported in the literature.[2,6–8,21] At the lowest concentration investigated (6% w/v), the average diameter of the as-spun fibers ranged between 85 and 105 nm, whereas, at the highest concentration investigated (14% w/v), it ranged between 486 and 647 nm, regardless of the applied electrical potential investigated. Specifically, at 10% w/v, the average fiber diameter ranged between 261 and 301 nm. Among those previously reported,[2,6–8,21] Koski et al.[2] reported that the average diameters of the as-spun PVA (M_w = 9000–50,000 Da; DH = 98–99%) fibers ranged between ~ 250 nm and ~ 2 μm [for the PVA concentration of 25% w/v and the applied electrostatic field strength (EFS) of 30 kV/10.2 cm]. Zhang et al.[6] reported that the average diameters of the as-spun PVA (M_w = 78,000–81,000 Da; DH = 98%) fibers ranged between ~ 90 and

TABLE III
Average Diameters (cm) of the As-Spun Fiber Mats from 6–14% w/v PVA solutions

Applied electrical potential (kV)	Solution concentration (% w/v)				
	6	8	10	12	14
12.5	22.0	19.5	18.0	12.0	10.0
15.0	20.0	19.0	15.0	7.5	6.5
17.5	19.0	17.5	13.5	7.0	5.0
20.0	17.0	15.0	12.5	6.0	3.2
22.5	15.5	13.5	12.0	4.5	4.5
25.0	13.0	12.5	11.5	4.0	4.5

The varying electrical potential in the range of 12.5–25.0 kV was applied over a fixed collection distance of 15 cm and the feed flow rate was 1 mL h^{-1}.

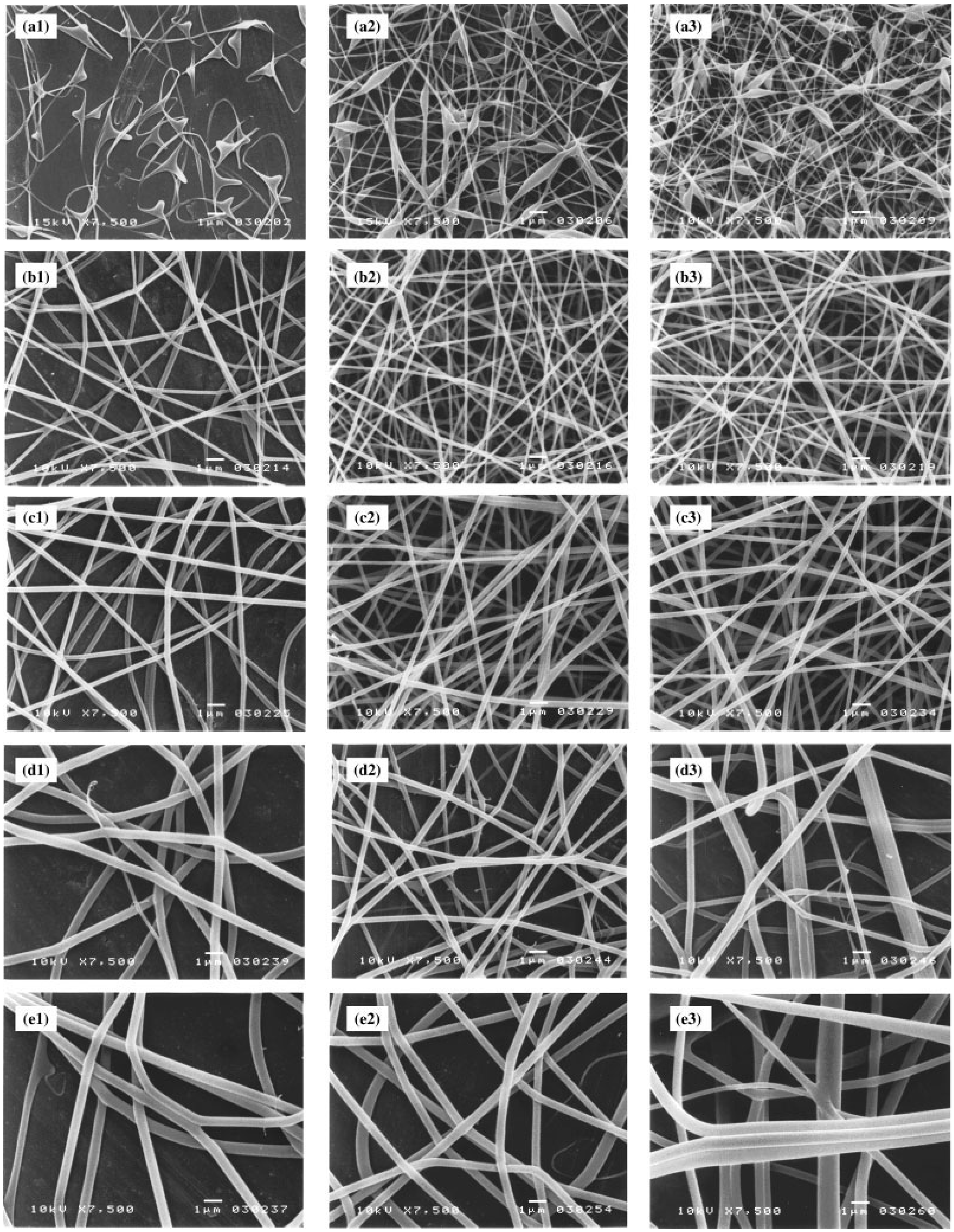


Figure 1 Selected SEM images (magnification = ×7500 and scale bar = 1 μm) of the as-spun fibers from (a) 6, (b) 8, (c) 10, (d) 12, and (e) 14% (w/v) PVA solutions. ''1,'' ''2,'' and ''3'' represent the electrical potentials of 12.5, 17.5, and 22.5 kV, respectively, which were applied over a collection distance of 15 cm. The feed flow rate was 1 mL h^{-1}.

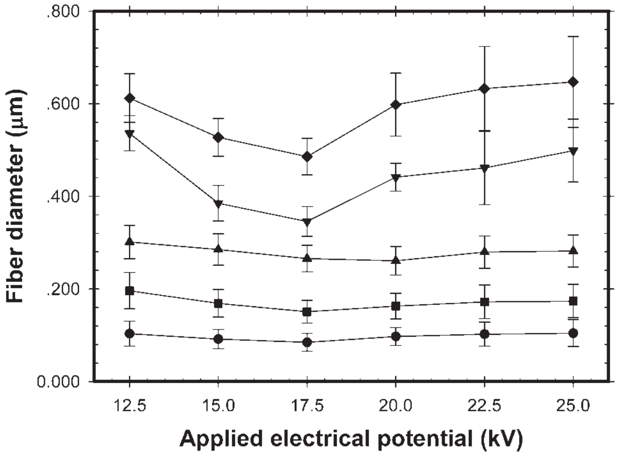


Figure 2 Average diameters of the as-spun fibers from (●) 6, (■) 8, (▲) 10, (▼) 12, and (◆) 14% w/v PVA solutions. The varying electrical potential in the range of 12.5–25.0 kV was applied over a fixed collection distance of 15 cm and the feed flow rate was 1 mL h^{-1}.

~ 250 nm (over the PVA concentration range of 6–8% w/v and the applied EFS of 8 kV/15 cm). Jun et al.[7] reported that the average diameters of the as-spun PVA (M_w = 100,000–195,000 Da) fibers ranged between ~ 50 and ~ 700 nm (for the PVA concentration of either 6 or 8% w/v and the applied EFS of 10 kV/10 cm). Obviously, our results were in line with these selected previous reports.

According to Figure 2, for any given solution concentration, the average diameters of the as-spun PVA fibers as well as their variation were generally found to decrease with the initial increase in the applied electrical potential, reach a minimum value at an intermediate value, and increase with further increase in the applied electrical potential, despite the fact that such an observation for the as-spun PVA fibers from 6–10% w/v PVA solutions was not statistically significant. The increase in the applied electrical potential should cause the number of charges carried within a jet segment to increase, hence an increase in both the electrostatic and the Coulombic repulsion forces. The increased Coulombic repulsion force should cause the diameters of the as-spun fibers to decrease (due to increased stretching force exerting on the jet segment), while the increased electrostatic force should cause the diameters of the as-spun fibers to increase (due to both the increase in the speed of the jet segment and the increase in the mass flow rate, the phenomena that cause the onset for the bending instability to occur closer to the screen collector[19,20]). It is quickly recognized, based on such a postulation, that the observed decrease in the fiber diameters with the initial increase in the applied electrical potential could be due to the contribution from the increase in the Coulombic repulsion force, while the observed increase

TABLE IV
Selected Optical Images and Diameters of the As-Spun Fiber Mats from Sonicated 10% (w/v) PVA Solution

Collection distance (cm)	5.0	7.5	10.0	12.5	15.0	17.5	20.0
							
	D = 3 cm	D = 4.5 cm	D = 6.5 cm	D = 9 cm	D = 12 cm	D = 13.5 cm	D = 17 cm

The electrical potential of 15 kV was applied over varying collection distance in the range of 5–20 cm and the feed flow rate was 1 mL h^{-1}. [Color figure can be viewed in the online issue, which is available at www.interscience. wiley.com.]

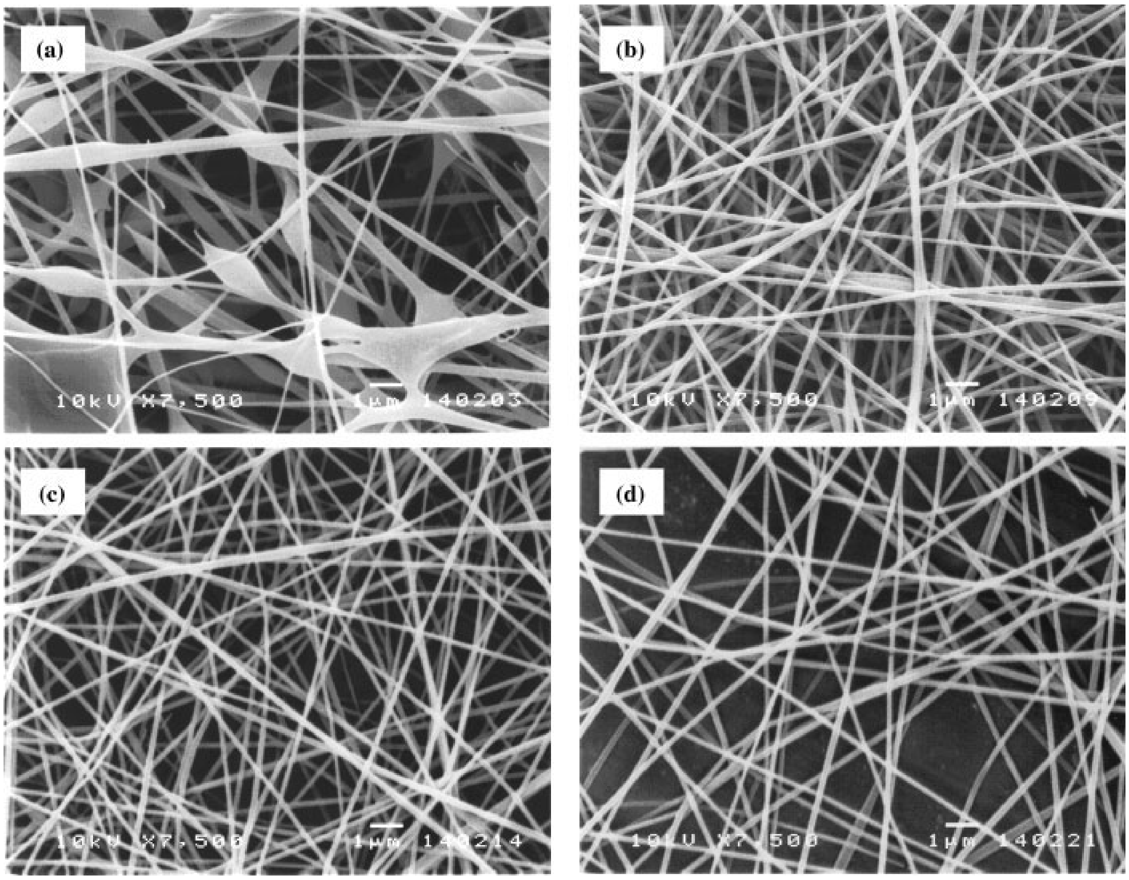


Figure 3 Selected SEM images (magnification = ×7500 and scale bar = 1 μm) of the as-spun fibers from sonicated 10% w/v PVA solution. The electrical potential of 15 kV was applied over varying collection distance of (a) 5, (b) 10, (c) 15, or (d) 20 cm and the feed flow rate was 1 mL h^{-1}.

in the fiber diameters with further increase in the applied electrical potential could be due to the contribution from the increase in the electrostatic force. These competing effects should be the reason for the conflicting results reported in the literature.[6,8,21]

Effect of sonication during preparation of spinning solutions

Table I(c,f) summarizes the effect of sonication on the viscosity and the conductivity of the 10% w/v PVA solution. Evidently, the viscosity of the PVA solution decreased from 810 mPa s to ∼ 600 mPa s upon sonication, while the conductivity was not affected. The reduction in the molar mass of PVA should be responsible for the observed decrease in the viscosity of the solution. Though not shown, electrospinning (applied electrical potential = 15 kV and collection distance = 15 cm) of the sonicated 10% w/v PVA solution produced smooth fibers with diameters (169 ± 15 nm) being much smaller than those obtained from the unsonicated solution (285 ± 34 nm), most likely a direct result of the observed decrease in the molar mass, hence the viscosity, of the solution upon sonication. Since the critical chain overlap concentration, one of the contributing factors controlling the electrospinnability of a polymer, varies inversely with the intrinsic viscosity of the polymer

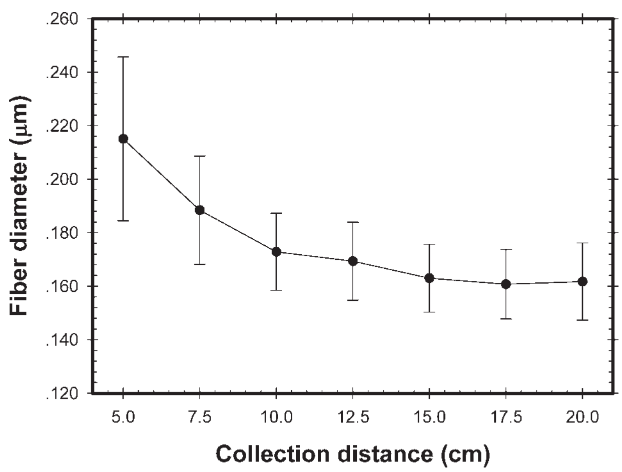


Figure 4 Average diameters of the as-spun fibers from sonicated 10% w/v PVA solution. The electrical potential of 15 kV was applied over varying collection distance in the range of 5–20 cm and the feed flow rate was 1 mL h^{-1}.

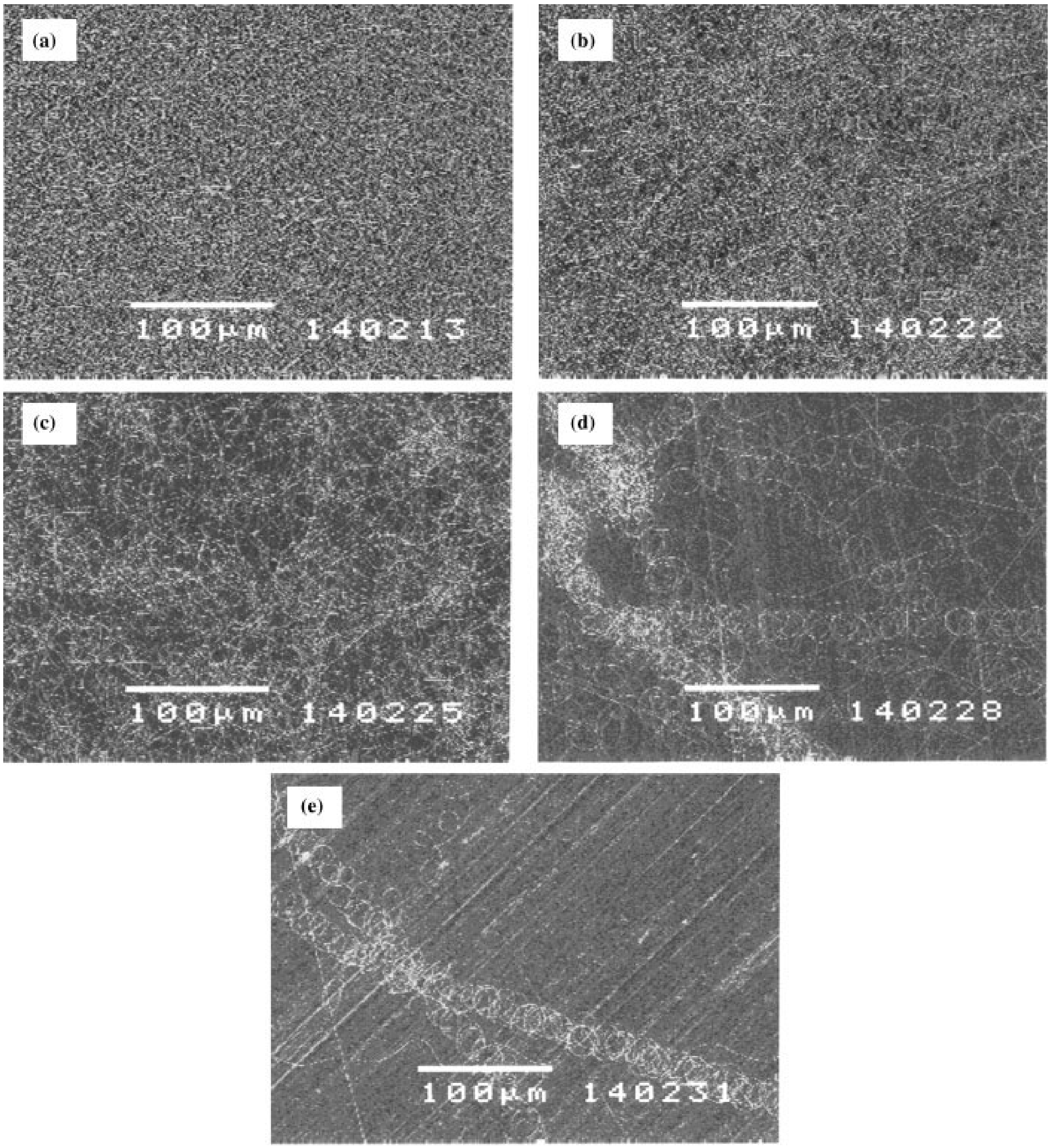


Figure 5 Selected SEM images (magnification = ×200 and scale bar = 100 μm) of the as-spun fibers from sonicated 10% (w/v) PVA solution which was observed at the distances of (a) 0, (b) 3, (c) 6, (d) 9, and (e) 12 cm from the center of the as-spun fiber mat. The electrical potential of 15 kV was applied over a fixed collection distance of 15 cm and the feed flow rate was 1 mL h^{-1}.

solution, which, in turn, relates to the molar mass of the polymer, the reduction in the molar mass of PVA as a result of the sonication should cause the critical chain overlap concentration to increase, which, in turn, should cause the diameters of the as-spun fibers to decrease.[22]

Effect of collection distance

To study the effect of the collection distance, the sonicated 10% w/v PVA solution was electrospun under a fixed applied electrical potential of 15 kV over various collection distances in the range of 5–20 cm. As shown in Table IV, the diameters of the as-spun fiber mats were found to increase monotonically with increasing the collection distance. Specifically, they increased from about 3 cm at the collection distance of 5 cm to about 17 cm at the collection distance of 20 cm. Increased collection distance caused the EFS to decrease. The decreased EFS caused both the electrostatic and the Coulombic repulsion forces to decrease. The decreased electrostatic force caused the onset for the bending instability to occur closer to the nozzle tip, resulting in an increase in the total path trajectory of a jet segment, thus the observed increase in the diameters of the as-spun fiber mats.

Figure 3 shows selected SEM images illustrating the morphological appearance of the as-spun fibers from the sonicated 10% w/v PVA solution collected at various collection distances in the range of 5–20 cm. Evidently, at the collection distance of 5 cm, a combination of smooth and beaded fibers was obtained and some of the adjacent fibers appeared to fuse to one another at touching points, an indication of the incomplete drying of the jet prior to the deposition on the collector. The presence of beads at the collection distance of 5 cm was surprising. Since at such a short distance, the EFS was high. High EFS favors the formation of smooth fibers. However, at such a short distance, the path trajectory of the jet was also short, which could lead to uneven stretching of the jet. Further increase in the collection distance resulted in the formation of smooth fibers without the presence of beads, indicating that the jet was stretched enough prior to the deposition on the collector. Furthermore, it is evident from Figure 3 that the number of fibers per unit area decreased with increasing the collection distance, which supported the observed increase in the diameters of the as-spun fiber mats with increasing the collection distance.

With regards to the diameters of the as-spun fibers, conflicting results with those reported in the literature[6,8,21] were evident. It is obvious from Figure 4 that the average diameters of the as-spun PVA fibers decreased very rapidly from ~ 215 nm at the collection distance of 5 cm (for this particular condition, the diameters of the fiber sections between beads were measured and reported) to ~ 173 nm at the collection distance of 10 cm and reached a plateau value of ~ 161–163 nm when the collection distance was greater than or equal to 15 cm. Despite the mandatory decrease in the EFS with increasing the collection distance, the observed decrease in the fiber diameters with increasing the collection distance should be a result of the increase in the total path trajectory of the jet that allowed uniform stretching of the jet during its flight to the collector. In addition, the constancy in the average diameters of the fibers obtained at the collection distance greater than ~ 15 cm suggested that when the collection distance was greater than or equal to 15 cm, the jet was so dry that it became too strong to be stretched further.

Effect of distance from the center of as-spun PVA fiber mat

Another important aspect of the electrospun fibers which is usually overlooked is the characterization of the as-spun fibers at different distances from the center of an as-spun fiber mat. Usually, characterizations of the morphology and the size of the as-spun fiber mat are carried out on randomly-selected parts of the mat. Here, we systematically investigated the effect of the distance from the center of the as-spun PVA fiber mat on morphology and diameters of the as-spun fibers. In this experiment, the sonicated 10% w/v PVA solution was electrospun under a fixed applied EFS of 15 kV/15 cm. Small pieces of the aluminum foil covered with as-spun fibers were cut at different positions (i.e., 0, 3, 6, 9, and 12 cm) from the center of the as-spun fiber mat. It is obvious that the number of fibers per unit area consistently decreased with increasing the distance from the center of the as-spun fiber mat (see Fig. 5). Fibers were uniformly deposited over the viewing area when the collection distance was equal to or less than about 6 cm, beyond which fibers that underwent secondary bending instability formed tight loops with the diameters of the loops being ~ 15–20 μm. Careful examination of the fiber diameters was carried out as a function of the distance from the center of the mat, as shown in Figure 6. While the average fiber diameters were practically unchanged with the variation in the distance from the center of the mat (~ 169 nm), the variation in the fiber diameters was found to decrease monotonously with increasing the distance from the center of the mat (i.e., from ±19 nm at the center to ±7 nm at 12 cm from the center of the mat).

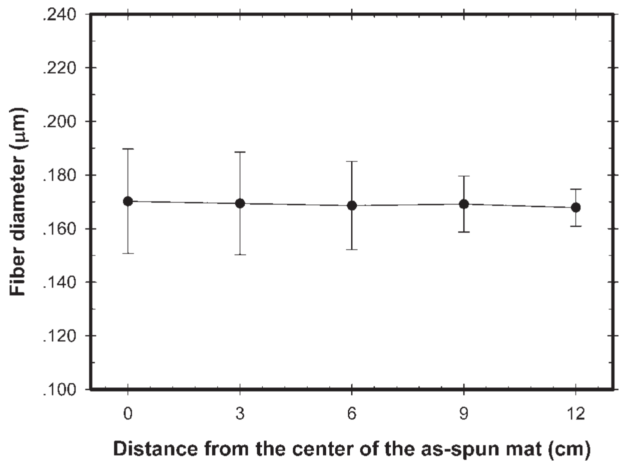


Figure 6 Average diameters of the as-spun fibers from sonicated 10% (w/v) PVA solution which was observed at various distances from the center of as-spun fiber mat. The electrical potential of 15 kV was applied over a fixed collection distance of 15 cm and the feed flow rate was 1 mL h^{-1}.

Mechanical properties of PVA fiber mats

The mechanical integrity in terms of the Young's modulus of the as-spun PVA fiber mats was tested on the mats that were prepared from the sonicated

8–12% w/v PVA solutions that were electrospun continuously for ~ 24 h under a fixed EFS of 15 kV/15 cm. The thickness of the mats ranged between ~ 20 and ~ 30 μm. It was found that the Young's modulus of the as-spun fiber mats increased rather monotonically with increasing the concentration of the PVA solutions. Specifically, the property value increased from ~ 17 ± 10 MPa for the fiber mats obtained from the sonicated 8% w/v PVA solution, to ~ 30 ± 27 MPa for the fiber mats obtained from the sonicated 10% w/v PVA solution, and finally to ~ 42 ± 34 MPa for the fiber mats obtained from the sonicated 12% w/v PVA solution.

CONCLUSIONS

Electrospinning was used to fabricate mats of PVA nanofibers from PVA solutions in reverse osmotic water. The average diameters of the as-spun PVA fiber mats decreased with increasing the solution concentration (6–14% w/v) and the applied electrical potential (12.5–25 kV), while they increased with increasing the collection distance (5–20 cm at a fixed applied electrical potential of 15 kV). At the lowest concentration of the PVA solutions studied (6% w/v), beaded fibers were observed, regardless of the applied electrical potential used. Further increase in the concentration of the solutions resulted in the formation of smooth fibers. The average diameters of the as-spun PVA fibers increased with increasing the solution concentration, but they decreased with increasing the collection distance. Furthermore, they increased with the initial increase in the applied electrical potential, reached a minimum value at an intermediate value, and increased with further increase in the applied electrical potential. The use of sonication to prepare a PVA solution caused the viscosity of the solution to decrease; hence, the observed decrease in the average diameters of the as-spun fibers. Additionally, the average diameters of the as-spun fibers at different positions from the center of the as-spun fiber mat were practically the same. Lastly, mechanical properties of the as-spun PVA fiber mats with the thickness of the mats being ~ 20–30 μm were characterized and the results showed that the Young's modulus ranged between 17 ± 10 and 42 ± 34 MPa, respectively.

Jirawut Junkasem is acknowledged for his assistance with the additional mechanical testing.

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