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The effect of surfactants on the properties of poly(vinyl alcohol) (PVA) nanoweb by electrospinning

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Abstract : Poly(vinyl alcohol) nanowebs were prepared by electrospoinning technique. The electrospinning technique produced nanometer scale of polymer fibres. This technique used the electrostatic force draw the polymer solution from the needle tip and deposited on substrate to from nanowebs. The PVA nanowebs were prepared with various surfactant types (anionic, cationic and nonionic surfactant). The cetyltrimethylammonium bromide, polyethylene glycol sorbitanmonolaurate, polyoxyethylenesorbitanmonolaurate, sodium lauryl sulfate were employed as surfactants. The morphology of PVA nanowebs were investigated using scanning electron microscope (SEM). The SEM micrograph shows that PVA nanowebs with all surfactants were successfully prepared with no beat. Thermal properties were measured by using differential scanning calorimetry (DSC). The results show that the %crystalline of PVA with SLS surfactant was slightly decreased. The mechanical property of nanowebs were measured using universal testing machine. The structure of nanowebs were analyzed by x-ray diffraction technique.
Keywords: Poly(vinyl alcohol), nanowebs, electrospoinning technique;

1. Introduction

Electrospinning has been considered as a simple and a unique technique for the fabrication of nanowebs or nanofibres. The widely applications are in the areas of textile applications and medical applications such as wound dressings, drug delivery systems and tissue engineering.[1,2] The electrospinning process is that a polymer solution or melt (polymer or polymer blended) is loaded into a syringe. An electrostatic force is applied by the high voltage and then the polymer is pushed from the nozzle by the pump. The Taylor cone shape was observed at the tip of the nozzle. The continuous electrostatic fields are maintaining the polymer jetanda find fibresdeposited on a collector.The shape of the base depends on the surface tension of polymer solution.[1]

The nanowebsprepared by the electrospinning process have been shownstraightforward properties such as high surface area compared to the film, small pore sizes and high porosity. Therefore, numerous studies have highlighted the various types of polymer as the carrier in wound dressings and drug delivery application.[2,3]

Poly(vinyl alcohol) (PVA) are one of the most widely used polymers in biomedical, because of their unique properties such asbiocompatibility, good chemical resistance, high hydrophilicityand nontoxic. These properties have led to its broad industrial used. Many researchers have been reviewed on various parameters of the PVA nanofibressuch as degree of hydrolysis, polymer solution concentration, polymer solution flow rate, applied voltage, tip-target distance and pH of the polymer solution.[2-5] Therefore, it has become more interesting to explore the effect of surfactants on the properties of poly(vinyl alcohol) (PVA) nanowebs such as morphology and thermal properties.

2. Experimental

2.1. Materials

Poly vinyl alcohol (PVA) was supplied from Vam&Poval,Japan. Sodium lauryl sulfate (SLS), polyethylene glycol sorbitanmonolaurate (TW20), polyoxyethylenesorbitanmonolaurate(TW80)and cetrimonium bromide (CTAB) were purchased from Sigma-Aldrich at the highness purity.All samples were used as received. All other chemicals were used as supplied by the companies.

2.2. Preparation of poly(vinyl alcohol) solution

Poly(vinyl alcohol) solution 10wt% was prepared by adding PVA into hot water. The solution was stirred for 2 hours. The 0.25wt% of surfactants,sodium lauryl sulfate, polysorbate 20 and polysorbate 80 and cetrimonium bromide weremixed with the PVA solution. It was continuous stirred for 1 hr. PVA with surfactants were obtained.

2.3. Preparation of PVA nanowebs by electrospinning

PVA solution was placed in a syringe pump. The pump was set 0.3mL/hr. Power supply was set 15kV-20kV. The high voltage was supplied by Glassman high voltage Inc., USA. The distance between needle and substrate was 12 cm. The needle number was 18. The nanowebs were obtained after 4 hr.

2.4. Characterization

The morphology of the nanowebs was observed on scanning electron microscope(SEM) JSM-7600F from Jeol, Japan.All of the samples were coated with palladium prior used .Thermal propertieswere measured using differential scanning calorimetry (DSC)model 200 F3 from Netzsch, Germany. The scan was performed from 30°C to 300°C under nitrogen atmosphere .The heating rate and cooling rate were set at 10°C/min .The tensile tests were recorded on Instron 5569 universal testing machine. The cross head speed was10 mm/min.

3. Results and discussion

3.1. Morphology of the nanowebs

The morphology of the nanowebs of pristine PVA with various apply voltage were examined using scanning electron microscope (SEM), as seen in Fig. 1a-1c. It was found that the diameter of PVA nanowebsdecreased from 0.33μm to 0.194μm with increasing apply voltage form 15kV to 17kV, respectively. However, the diameter was raised to 0.32μm when applied high voltage at 20kV. Therefore, it was hard to control nanowebs diameter at high voltagewhile the diameter of nanowebswas irregular at low voltage. The medium voltage was selected due to the well-defined structure as showed in Fig 1b.

In order to understand the effect of surfactant to the morphology of the nanowebs, the various of surfactants were investigated. As presented the Fig. 1d-1f. the SEM image of SLS/PVA nanoweboffered the smallest diameter 0.015μm whereas diameter of TW20/PVA nanowebsand TW80/PVA nanowebswere 0.137μmand 0.128μm, respectively.

3.2. Thermal properties of the nanowebs

The thermal properties of the PVA nanowebswith various surfactants were performed ondifferential scanning calorimetry(DSC). The melting temperature, glass temperature, crystalline temperature and %crystalline were summarized in Table. 1. The results from Table 1 are demonstrated in Fig. 2. It was found that the glass temperature, crystalline temperature and melting temperature of PVA nanowebswith all surfactants were increased higher than pristine PVAnanowebs. Except, crystalline temperature of CTAB/PVA nanowebswas similar to pristine PVAnanowebsand melting temperature of TW80/PVA nanowebswas slightly lower than pristine PVAnanowebs. Therefore, the %crystalline of CTAB/PVAnanowebswas highest at 49.88% while both of SLS/PVA nanowebsand TW20/PVA nanowebswere lowest at 37.89 and at 37.93, respectively.

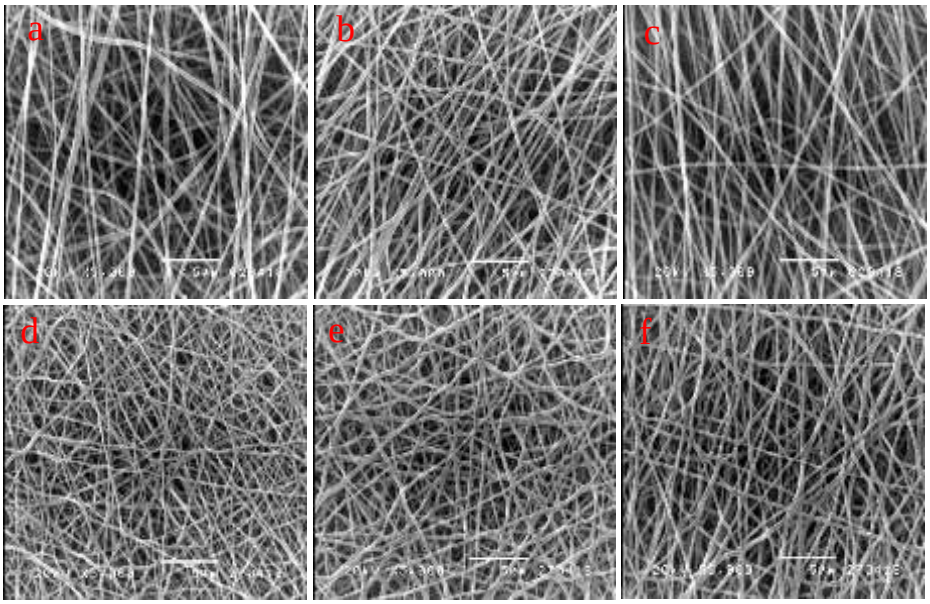

Fig. 1. The SEM images of (a) Pristine PVAnanowebs15kv; (b)Pristine PVAnanowebs17kv (c)Pristine PVA nanowebs20kv (d)SLS/PVAnanowebs17kv (e)TW20/PVAnanowebs17kv (f) TW80/PVAnanowebs17kv

Table 1. The thermal properties of melting temperature, glass temperature, crystalline temperature and %crystalline of PVA nanowebswith various surfactants.

Sample	T_g(◦C) °	T_c (◦C)	T_m (◦C)	ΔH_f (J/g)	%Crystallinity (%)
PVA	63.6	108.2	181.1	55.42	39.99
SLS/PVA	71.1	115.6	193.6	51.2	37.89
TW20/PVA	67	109.8	197	51.27	37.93
TW80/PVA	66.4	110.7	173.1	58.51	43.30
CTAB/PVA	66.7	108	192.5	67.41	49.88

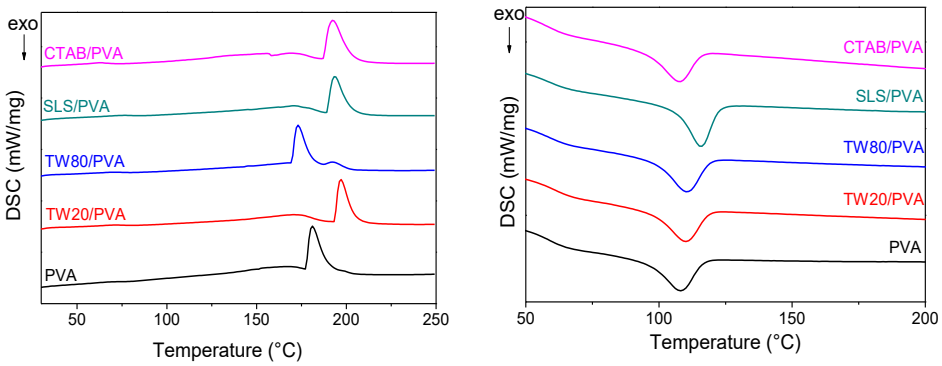

Fig. 2.Thermogram of (a) Glass temperature and Melting temperature ;(b) Crystalline temperature.

3.3. Mechanical properties

The mechanical properties of the various surfactants/PVA nanowebs were inspected by using tensile testing method. The results show that SLS/PVA nanowebs offered the best tensile strength at 39.06N/mm^2 as presented in Fig. 3. Moreover, the tensile strength of TW20/PVA nanowebswas 23.60 N/mm^2 which higher than pristine PVAnanowebs. On the other hand, the tensile strength of TW80/PVA nanowebs was lowest at 6.27 N/mm^2.

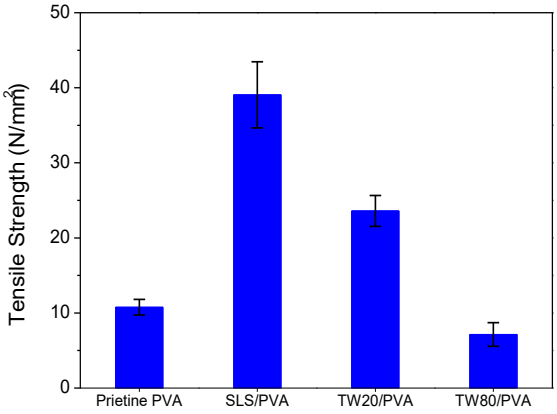

Fig. 3. Tensile strength of pristine PVAnanowebs, SLS/PVAnanowebs, TW20/PVAnanowebsand TW80/PVAnanowebs

4. Conclusion

The PVA nanowebs was successfully blended with various surfactants. The morphology of the PVA nanowebs were investigated by using SEM. The SEM images presented no beat with all PVA nanowebs. Most of thermal properties were higher than pristine PVA nanowebs. However, melting temperature of TW80/PVA nanowebswas slightly lower than pristine PVA nanowebs. Moreover, the SLS/PVA nanowebswas highest tensile strength.

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