Water treatment to reduce the porosity of nanowebs

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Research Article

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Abstract

Here a way used to reduce the porosity of the electrospun web which removed PVA nanofibers from PVA/PA6 hybrid nanoweb by water treatment. Measuring the porosity of the electrospun web before and after treatment by BET method and image processing, proved this. The specific surface area of the web 70 % reduced after water treatment.

Introduction

Increasing porosity by solving PVA or PEO [1, 2] nanofibers is used to reduce the porosity of the hybrid web of PVA/non-hydrophobic nanofibers but here reducing the porosity for a hybrid web of PVA/ hydrophilic nanofibers happened. This fact happened due to the different hydrophilicity of the second part of the hybrid web. This product can use for applications in which we need lower porosity than usual [3]. The porosity measuring was done by BET (measuring surface area), image analysis (for surface porosity) and porosity formula (for total porosity).

Materials

PVA pellets with molecular weight of 78000g/mol prepared from Tavana company (Iran) with analytical grade, PA6 pellets with melt flow index of 26.3 g/10min with textile grade prepared from Parsilon Khorramabad company (Iran). Formic acid and n-butanol with analytical grade prepared from Merck company.

Instruments And Sample Preparation

2 nozzles horizontal electrospinning (digital pump from DAWHA company with MS-2211 model, drum collector, voltage supply with voltage range of 1-20kV) used to prepare PVA/PA6 hybrid web. The electrospinning condition was 10wt%, 15cm, 0.2ml/h and 20kV for PVA nanofibers and 15wt%, 10cm, 0.5ml/h and 20kV for PA6 nanofibers. Electrospinning continued for 4h. Circles with 2cm diameter cut from resultant web and then for solving PVA nanofibers, samples floated in 60°C distilled water for 2h.

Samples Characterizing

SEM images of the nanofibers prepared from Seron Technology (South Korea, AIS2100 model) microscope. Nanofiber's diameter measured by Image J software. The average of 100 nanofiber diameters used. Thickness and weight of the web measured by Insize digital microscope micrometer and digital balance with 0.0001 g accuracy. All the histograms drawn with Minitab 19 software.

Morphology Of The Nanofibers

By 2 nozzles electrospinning the web average diameter was lower compare to 1 nozzle electrospinning of each nanofiber (according to table 1).

Porosity And Pore Size Measurement

Pore size distribution of samples are presented in table 2. Porosity of the web measured by BET [4, 5] and image processing [6, 7] method and results showed that the porosity decreased by solving one part (according to table 3). Image processing shows surface porosity and BET shows total porosity. Also, the pore size received by image processing and equations 1 and 2 where D, d and ε are pore size, nanofiber diameter and porosity, respectively [8]. BET adsorption and deadsorption curves showed that the pores of the nanowebs are slit-like (table 4). BET showed that the nanoweb is not porous so, this method is not suitable for measuring the porosity of the nanoweb.

In source number 11 the porosity and pore size received by thresholding the SEM image which was only considered the surface nanofibers but here all the nanofibers which saw was considered without removing any of the nanofibers so, it is considerable that the porosity and the pore size of the new method is smaller than the old one. The result showed that by formula [8], by this kind of image processing this do not give right answers so this formula is for pore size and porosity measuring for all of the web or only considering the surface nanofibers as in source number 11 this method could be correct. From the results, equation 1 could compare samples much better. So, with thresholding (table 4) the porosity and pore size measured (table 5) and with results the porosity of the layer calculated with equation 1 which could give the real porosity of the layer that shows that this technique was measured the pore size correctly that could give the real porosity of the web but from the results concluded that this equation is not correct for water treated layer. Gravity method which is the simplest way but due to error in measuring the dimensions, so the best way from above results which had same results as this method, is calculating the surface porosity and put the results of pore size and diameter in equation 1. As a better way 3D city scan images can measure all the pore volumes which give the sample's porosity and pore size with high accuracy. Attention that thresholding is a method to remove back fibers and different persons can do it different from others and it depends on the judgeship of person. Every person should find the best for her/his work. Other methods to measuring the porosity for nanowebs are not appropriate due to error in measuring the dimensions (to overcome can measure with SEM but again you should weight the sample too) or needing liquids which are not safe and make a lot of troubles and BET as above results could not measure the porosity of the nanowebs (is a good way for meso pores of the sample which are not a lot in nanowebs). So, city scan images or above method are the best ways to measure the porosity of the nanowebs but above method is the cheapest way which can measure surface porosity, total porosity and pore size.

Results

From the results this kind of electrospinning resulted in lower dimeter and pore size and reduction of the porosity by solving PVA in water occurred. This is proved before by density method [9, 10] too but the solving of PVA nanofibers was different [11] but there is a question that why the results of this article are completely different from another article with almost the same manner and materials [1]. The application of this nano web is in applications which they need lower porosity than usual like in avoiding from fluid

transport. This method reduced porosity and pore size without changing the average nanofiber diameter [3] and solving PVA nanofibers in hot water resulted in better removal compare to solving them in water in the ambient temperature for 24 hours [11].

Declarations

Competing interests:

The author declares no competing interests.

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Sources

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Tables

Tables 1-5 are available as a download in the Supplementary Files section.

Supplementary Files

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