Fabrication and Characterization of Antimicrobial PAN Nanofibers web with Nano Porous Carbon

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1. INTRODUCTION

Electrospinning is a process, which produces ultrafine polymer fibers. Electrospun polymer nanofibers exhibiting high surface area-to-volume and length-to-diameter ratios can be prepared via electrospinning. These Characteristics are essential for various advanced applications. Ultrafine polymer nanofibers are of interest in many applications such as filter-media, wound dressing materials, artificial blood vessels, sensors, composite reinforcements, so on [1-5].

Recently, several researchers have been reported to employ the electrospinning technique to prepare PAN (Polyacrylonitrile) nanofibers web. PAN is an important engineering polymer that has been widely used to produce a variety of synthetic fibers. Lee et al. prepared ultrafine polyacrylonitrile fibers web containing silver nanoparticles via electrospinning using added $AgNO_3$ powder PAN/DMF solution [6].

NC (Nano Porous Carbon) have been of significant research interest because of their potential applications, e.g., in gas separation, as molecular sieves, photonic band gap crystals, catalyst supports and electrode materials for lithium ion batteries. NC serve as supporting substrates owing to their high surface-to-volume ratio and high structural stability, etc [7]. One of the aims of this study is to find process parameters to fabricate PAN nanofibers web containing NC. The Changes in the fiber formation efficiency and the fiber diameter and morphology by changing concentration of solution and adding NC were investigated in terms of solution viscosity, conductivity. Also its antimicrobial property was investigated

2. EXPERIMENTAL

PAN (M_w = 40,000~50,000) was purchased from TaeGwang Co. and use as receives. NC was kindly supplied with korea company that keep company name under wraps. DMF (N, N- dimethylformamide) was purchased from Yukari Pure Chemicals, Japan.

The electrospinning setup utilized in this study consisted of a stainless steel syringe and needle (I.D=0.495 mm), a ground electrode (a rotational stainless steel drum), and a high voltage supplier. PAN solutions in DMF were prepared in the concentration range of 13~20 wt% and delivered by a micro step pump with the mass flow rate 1.2~2 mL/h. The needle tip to distance was in a range of 10~20. The voltage applied to polymer solutions were in a range of 15~25 kV.

The viscosity of PAN solution in the range of 10~20 wt% was determined by using a digital viscometer (DV II+, Brookfield, USA) at room temperature. Conductivity of polymer solution were examined five times and averaged by using a conductivity meter (HI 8033, HANNA instruments, USA) at room temperature. Morphology of Samples were observed by a scanning electron microscope (SEM, JSM-5510, JEOL, JAPAN), field emission scanning electron microscope (FE-SEM, Sirion, FEI company, USA), and transmission electron microscope (TEM, Tecnai G2 Spirit, FEI company, USA).

The antimicrobial activity of the PAN nanofibers web with NC was tested against Gram-positive *Staphylococcus aureus* (*S. aureus*, ATCC 6538) and Gram-negative *Escherichia coli (E. coli*, ATCC 8739) by test method for antibacterial of textiles (KS K 0693 or AATCC 100, KATRI (Korea Apparel Testing & Researching Institute)). The agar plates containing the test samples and control (blank) were incubated at 37 ℃ for 18 h. The reduction in the number of bacteria was calculated using the following equation,

(1) Reduction (%) = $(B\text{-}A)/B \times 100$,

where A and B are the numbers of surviving cells (colony forming unit/ml) for the plates containing the samples and the control, respectively, after 1 h of contact time.

3. RESULTS AND DISCUSSION.

Various solution properties are given in Fig 1. The PAN solutions had 10 to 20 wt% polymer and their viscosities and conductivities differed.

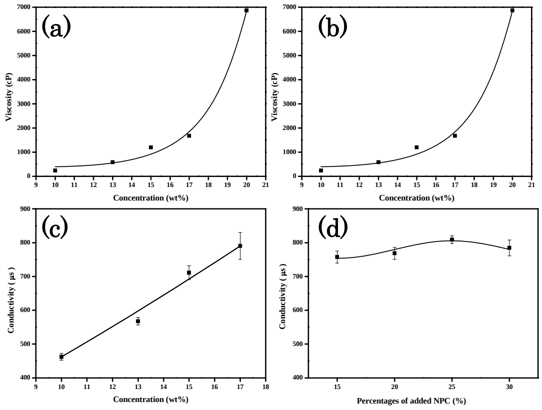

Fig. 1 Graphs of PAN solutions: (a) viscosities of PAN solutions, (b) viscosities of PAN with NC, (c) conductivities of PAN solutions, and (d) conductivities of PAN with NC solutions

In this study, a PAN solution containing nano porous carbon particles in DMF was prepared by using ultrasonication equipment to dispers NC in a PAN solution, and this solution was electrospun to make ultrafine PAN nanofibers.

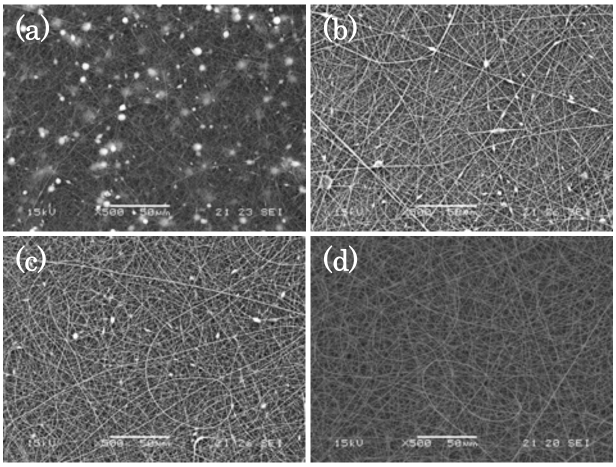

Fig. 2 SEM Images of PAN nanofibers web using solutions of (a) 10 wt%, (b) 15 wt%, (c) 17 wt%, and (d) 20 wt%. All scale bars are 50 ㎛.

Fig. 2 shows SEM images of PAN nanofibers electrospun from different concentration. At the concentrations below 17 wt%, beaded-nanofibers were generated and then were changed to continuous nanofibrous at the concentration of 20 wt%.

Antimicrobial activity of the PAN nanofibers containing NC particle was tested against Gram-positive *Staphylococcus aureus* (*S. aureus*, ATCC 6538) and Gram-negative *Escherichia coli. (E. coli*, ATCC 8739) The numbers of bacteria was reduced by 99.9% after 18 h incubation, indicating that the NC additive successfully inhibited the growth of these bacteria (Table 1).

Table 1. Antimicrobial test results on PAN nanofiber with NC

Test Specimen	PAN+NC nanofiber
Staphylococcus aureus	99.9
Escherichia coli	99.9

4. Conclusions

PAN and PAN with NC nanofibers web were successfully electrospun by using a dispersed NC in a PAN solutions.

The PAN nanofibers web with NC particle had an excellent antimicrobial activity. Non- woven membranes of PAN nanofiber will be further studied for various applications.

5. Acknowledgment

This study was conducted by the research fund of PAKA RGB Co.Ltd.

6. References

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