Journal of Metallurgical and Materials Engineering, Vol.31, No.2, 2021.

Fabrication of Polysulfone/Chitosan/Polyvinyl alcohol composite by electrospinning method and investigation of its morphology

Sanaz Rezaei Soulegani[1] Maryam Rasouli[2]

Zahra Sherafat[3]

1-Introduction

Electrospinning is a versatile route for preparation of high porous polymeric membranes. Polysulfone (PSU) is a thermoplastic polymer with unique properties which is mostly used in filtration applications. However, the intrinsic hydrophobicity of this polymer makes polysulfone membranes more susceptible to be fouled. One approach to alter wettability of PSU membrane is fabrication of an electrospun fibrous composite mat made of polysulfone fibers and a distinct fibrous polymer with inherent hydrophilicity such as chitosan (CS). Since chitosan is not easily electrospinnanble, it was blended with polyvinyl alcohol (PVA) to enhance its electrospinnability. The aim of the current research is to fabricate a fibrous composite mat consisting of polysulfone-chitosan/polyvinyl alcohol fibers with uniform morphology.

2-Experimental procedure

For preparation of a fibrous composite mat, PSU solution and CS/PVA blend solution were fed into two distinct syringes and were electrospun simultaneously under co-electrospinning condition. In the first stage, in order to obtain a beadles polysulfone mat with minimum fiber diameter, PSU in dimethyl formamide solutions with three different concentrations (i.e., 15, 20, 25 wt.%) were electrospun at fixed voltage, feed rate, and distance of 15 kV, 1.5 ml/h and 15 cm respectively. In the second stage, PVA and CS solutions were mixed in different proportions. The resultant blend solutions were electropun under fixed voltage of 15 kV and feeding rate of 0.5 ml/h to determine optimum concentration for fabrication of CS/PVA fibers. The optimum CS/PVA concentration was further used to prepare PSU-CS/PVA fibrous composite mat via co-electrospinning. Morphology of the resultant composite mat made of CS/PVA with six mass ratios (0:100, 20:80, 30:70, 40:60, 50:50 and 60:40 wt%) was examined by SEM. Finally, according to the optimum concentration for electrospinning of CS/PVA solution, fibrocomposite membrane made of PSU-CS/PVA was fabricated with three mass ratios (i.e., 90:10, 80:20 and 70:30) under co-electrospinning process.

3-Results and discussion

SEM observations revealed that PSU electrospun from solution with 15wt% concentration, had bead-on-string structure, while PSU mat electrospun from 20wt% concentration possess beadless thin fibers with average fiber diameter of 0.954 µm. As the concentration increased to 25 wt.%, uniform thicker fibers with average fiber diameter of 1.592 µm formed (Figure1). Since thinner fibers are more favorable for membrane applications, PSU with 20 wt.% concentration was selected for preparation of fibro composite mats. From the SEM images, higher chitosan concentrations did not lead to a proper fiber formation. The composite sample made of chitosan/polyvinyl alcohol blend fibers with 30:70 mass ratio, showed uniform beadless morphology with maximum chitosan content and minimum fiber diameter (Figure2). Therefore, CS/PVA sample with 30:70 mass ratio was considered as optimum sample for further examinations. CS/PVA solution with optimum concentration were electrospun at three levels of feed rate (0.5, 0.9 and 1.5 ml/h). It was observed that as the feed rate exceeds 0.9 ml/h, bead like defects arise. Therefore, 0.9 ml/h was considered as maximum possible feeding rate for electrospinning of CS/PVA blend fibers.

According to the optimum concentration for electrospinning of CS/PVA fiber which was 30:70 mass ratio, fibrocomposite membrane made of PSU-CS/PVA was fabricated with three mass ratios (i.e., 90:10, 80:20 and 70:30) under co-electrospinning process. For this purpose, PSU solution (20 wt% concentration) and CS/PVA solution (30:70 mass ratio) were fed into two syringes separately and then placed in two adverse sides of the collector. Next, CS/PVA blend solution was electrospun with appropriate feed rate discussed above (0.9 ml/h), while feeding rate of PSU solution varied from 0.8 to 3.2 ml/h to fabricate various fibrocomposite PSU-CS/PVA mats with three different mass ratios. According to the SEM observations for three fibrocomposite samples, thicker fibers represent PSU fibers while, thinner fibers in the composite are CS/PVA blend fibers.

[1] M.Sc. Department of Materials Science and Engineering, School of Engineering, Shiraz University, Shiraz, Iran.
[2] M.Sc. Department of Materials Science and Engineering, School of Engineering, Shiraz University, Shiraz, Iran.
[3] Corresponding Author: Assistant professor, Department of Materials Science and Engineering, School of Engineering, Shiraz University, Shiraz, Iran. Email: zsherafat@shirazu.ac.ir

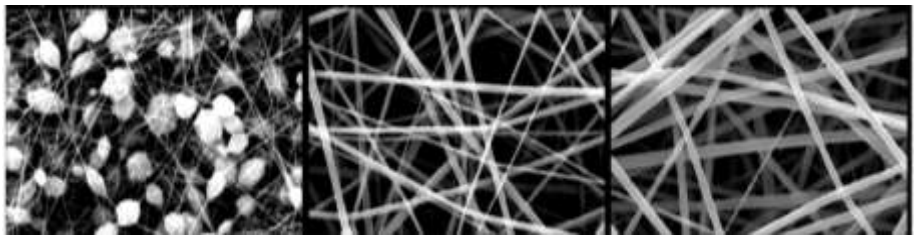

Figure 1. SEM images of PSU mats electrospun from three different concentrations.

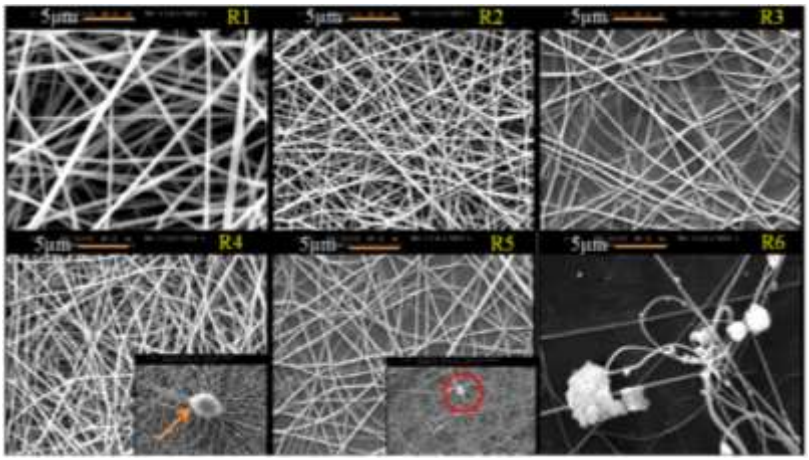

Figure 2. SEM images of CS/PVA blend fibers with different mass ratios.

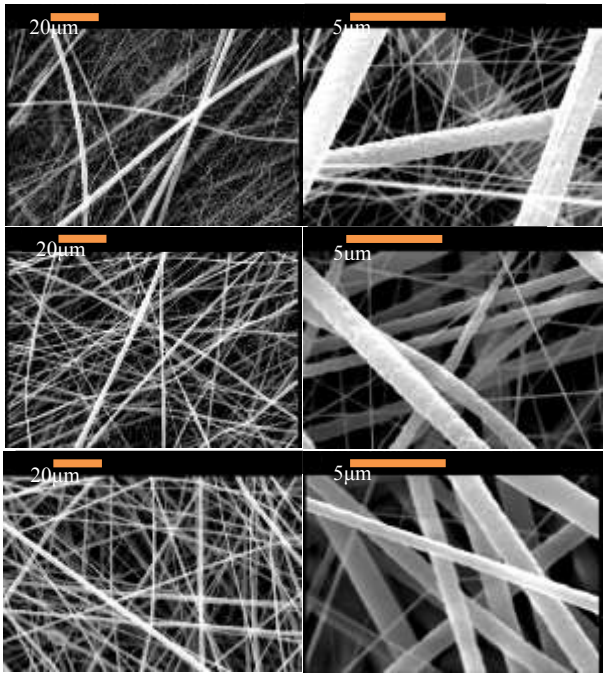

Figure 3. SEM images of PSU-CS/PVA composite samples with different weight ratios.

4-Conclusions

A direct relationship between chitosan content and uniformity of blend PVA/CS fibers was observed in this study. CS/PVA sample with 30:70 mass ratio showed a uniform morphology with maximum chitosan content. This composition was utilized for fabrication of a fibrocomposite membrane made of PSU-PVA/CS Fiber.