

Electrospun of Epoxidized Natural Rubber with Polyvinylpyrrolidone (PVP) Composites Membrane for PEMFC Application

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Abstract

The aim of this study is to electrospun epoxidized natural rubber/ Polyvinylpyrrolidone (ENR/PVP) blend composite membranes were prepared by electrospinning technique for PEMFC application. Various concentrations of epoxidized natural rubber (ENR) solution in N,N-dimethylformamide (DMF) and tetrahydrofuran (THF) were directly added to PVP solution for plasticization of the electrospun nanofibrous. Then study the properties of the membrane, Chemical properties, Fourier transform infrared spectroscopy (FTIR) Morphology, From the scanning electron microscope (SEM) were used to characterize the pristine and plasticized nanofibrous. SEM images showed the reduction in fiber size with the ENR content of up to 1% in the mixture ENR/PVP. FTIR analysis revealed a possible interaction between carboxylic groups of the PVP group of ENR. The reported properties indicate the possibility to use such fiber mats as potential materials in composite membrane for PEMFC application.

Keywords: Electrospinning: PVP: ENR: Membrane: PEMFC: Natural Rubber

Introduction

Natural rubber (NR) has outstanding properties in many respects, such as natural rubber or glass transition temperature T_g below room temperature is about $-73\text{ }^\circ\text{C}$, making it highly flexible. Tensile good and crystals when the flexible Are resistance to tearing and has bounced higher, the rubber can be used to produce a variety of products. However, natural rubber has some disadvantages, such as not resistance to hydrocarbon oil. Because the molecules of natural rubber is not a terminal. It is soluble in non-polar solvent. And there is deteriorating due to the heat. Ozone and sunlight need to adjust the polarity of the molecule by modifying a natural rubber latex Electric Pocket website. By filling among my pocket onto the double bond at the molecular chain of rubber tires are

resistant to hydrocarbon oil higher. With the passage of gas and low water. And mixed with a polymer whose terminals can be improved.

Epoxidized natural rubber (ENR) has good properties with low glass transition temperature, T_g , soft elastomer characteristics at room temperature and good elasticity. Blending ENR with another polymer, such as Polyvinyl pyrrolidone (PVP) which is an important commercial polymer, to improve some properties of blends as well as good thermal stability is currently one of the important topics. PVP is hard, stiff material, although, mechanical properties, notably the flexibility, can be extensively modified with plasticization. [1] It also gives excellent contact between an electrolyte layer and an electrode in batteries [2]. This research aims to use natural energy. Which will

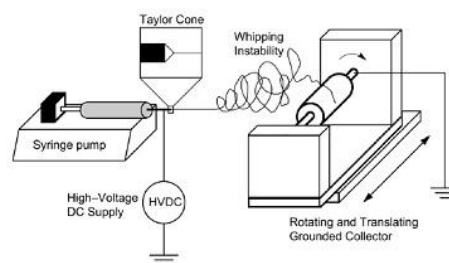
explore the possibility of importing natural rubber is applied to a material called. Polymer electrolyte membrane or membrane lead cation. This will be used as a component of a fuel cell. For fuel cell such as proton exchange membrane fuel cell have advantages as a viable option due to their high energy efficiency and environmental friendly [3]. Polymer electrolyte membrane is interesting of researchers because it is a new source of electrical power generation and energy storage systems, such as displays, sensors, electric windows, super capacitors and rechargeable batteries. Unlike conventional fiber spinning techniques (wet spinning, dry spinning, melt spinning, the gel is spinning), which are capable of producing polymer fiber with diameters down to the micrometer range, electrostatic spinning, or electrospinning is a process capable of producing polymer fiber in the nanometer diameter range. [4] Electrospinning is the process in which a polymer solution is ejected from a syringe that has a directly attached to a high power supply. This power source generates a high voltage difference, usually selected between 5–30 KV, which support the ejection of a liquid jet followed by solvent evaporation and the formation of a dry polymer fiber, which deposits on a grounded cathode-connected metallic collector. Under the appropriate conditions, a single jet may undergo solution instability and splay or split, resulting in smaller diameter fiber. Therefore, by controlling the electrospinning parameters, optimal nanofiber can be prepared [5].

In this research, the effects of electrospinning condition, including electric voltage, tip-to-collector distance and polymer solution concentration was studied on the morphological and physical properties of ENR/PVP nanofibrous.

Materials and Methods

Epoxidized natural rubber (ENR) was kindly Supplied by San-Thap International Co.,Ltd. The solvent N,N-dimethylformamide (DMF) and tetrahydrofuran (THF) were used as received. ENR was

dissolved in a mixed solvent of DMF/THF (at weight ratio 20:20). PVP was dissolved in a mixed solvent of Ethanol (at weight ratio 3:27) the ENR/PVP concentration of 0.0:10.0, 0.2:9.8, 0.4:9.6, 0.8:9.2, 1.0:9.0, 10.0:0.0 by room temperature. The nanofibrous membranes were prepared by eS-robot electrospinning capable of the nanofibrous membranes were performed at a flow rate 0.5 ml/h with applied voltage between 12 and 18 kV. The distance between the syringe tip and collector plate was varied from 12 to 23 cm as shown in Figure 1.



a)



b)

Figure 1 The working principle of electrospinning is imaged a) and electrospinning machine is image b) (N. Charensriwilaiwat, 2012)

Characterizations

Morphology of the PVP and ENR/PVP electrospun mats was obtained by scanning electron microscopy (SEM) in a microscope at an acceleration voltage of 18 KV. Samples were previously sputter-coated with gold.

Fibers diameters were analyzed from the images with the help of Image J® software.

Fourier transform infrared (FTIR) spectra of the PVP and the blends were obtained using VARIAN spectrometer over the wave number range of 4000 - 500 cm^{-1} , at an accumulation of 32 scans with a resolution of 4 cm^{-1} .

Results and Discussion

Scanning Electron Microscopy (SEM)

The morphological structure of the ENR/PVP nanofibrous was changed by changing the ENR concentration. ENR blending with PVP blends with ENR/PVP ratios of (0.0:10.0), (0.2:9.8), (0.4:9.6), (0.8:9.2), (1.0:9.0) and (10.0:0.0) it clearly shows the beads on the fiber be disappear, which ENR composition can be attributed to higher viscosity and surface tension with increasing ENR composition.

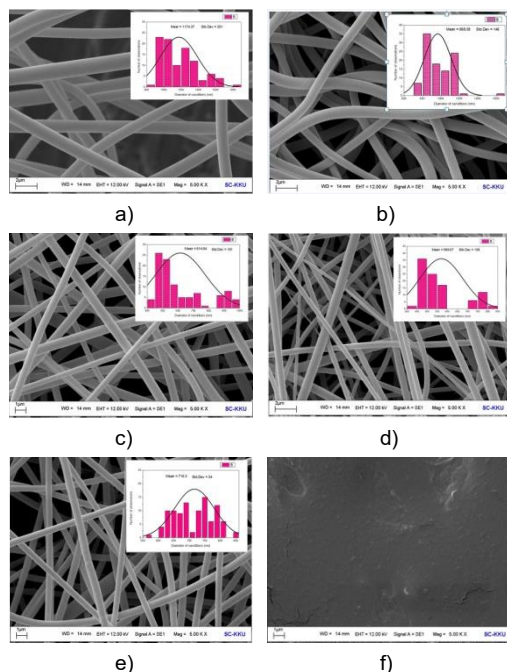


Figure 2 SEM images of electrospun nanofiber from ENR blending with PVP of a) 0:10, b) 0.2:9.8, c) 0.4:9.6, d) 0.8:9.2, e) 1:9 and f) 10:0 electrospun blends with magnification of 5000x.

Viscosity and surface tension play an important role in determining the fiber formability and diameter. The morphological structure of ENR/PVP nanofibrous as shown in Figure 2(a)-(f), the diameters of electrospun fibers were 1174 (± 216), 968 (± 146), 615 (± 161), 569 (± 106), 716 (± 63) nm, respectively.

Fourier Transform Infrared Spectroscopy (FTIR)

Exhibits the FTIR spectra in the region 4000-500 cm^{-1} of ENR, PVP and ENR/PVP blends with ENR/PVP ratios of (0.0:10.0), (0.2:9.8), (0.4:9.6), (0.8:9.2), (1.0:9.0) and (10.0:0.0). From the FTIR spectra of ENR, the peaks at 1045, and 950 cm^{-1} are attributed to C-H stretching from $=\text{CH}_2$ group as shown in Figure 4(f). In the case of PVP, the absorptions at 3399, are 953 cm^{-1} attributed to O-H stretching from C-H group from 1287 and 1226. Are attributed to O-H stretching from C-H group. The bands at 646 and 734 cm^{-1} are originated from Ar-H bending vibrations as shown in Figure 4(a). and PVP/ENR ratios of (0.2:9.8) the peaks at 3412, 2551 and 2923 cm^{-1} are attributed to O-H group from 1653 and 1286 cm^{-1} are attributed to C=C stretching from O-H group as shown in Figure 4(b). (0.4:9.6) the peaks at 3387 and 2955 cm^{-1} are attributed to N-H group from 1640 cm^{-1} are attributed to stretching from C=O group as shown in Figure 4(c). (0.8:9.4) the peaks at 3412, 2551 and 2923 cm^{-1} are attributed to O-H group from 1653 and 1286 cm^{-1} are attributed to C=C stretching from O-H group as shown in Figure 4(d). (1.0:9.0) the peaks at 3412, 2551 and 2923 cm^{-1} are attributed to O-H group from 1653 and 1286 cm^{-1} are attributed to C=C stretching from O-H group. From 1287, 1317 and 1227 cm^{-1} are attributed to O-H stretching from C-H group as shown in Figure 4(e). This picture of FT-IR also shows that the peaks of the blends consists of PVP and ENR characteristic peaks. The peak position at 1287 cm^{-1} of PVP shifted to higher wave numbers in the blends as the ENR content increased, which suggests some interaction between the carboxylic group end group of PVP chains and oxirane group of ENR.

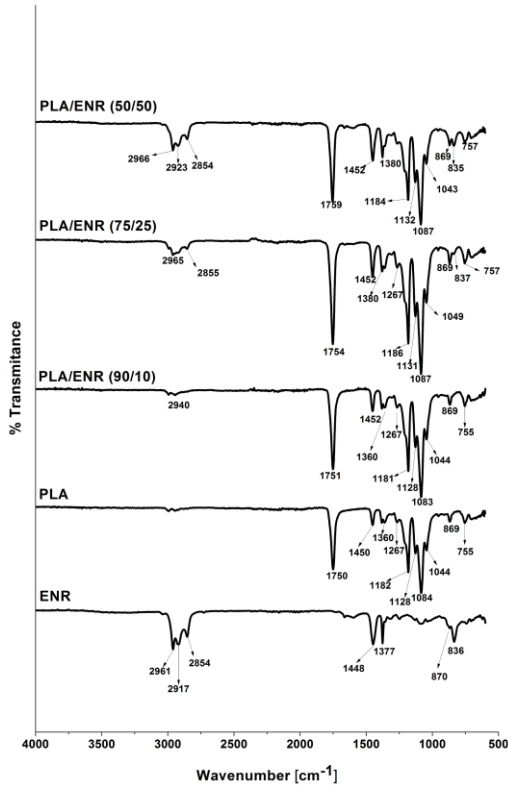
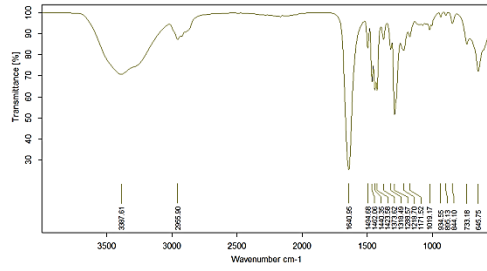
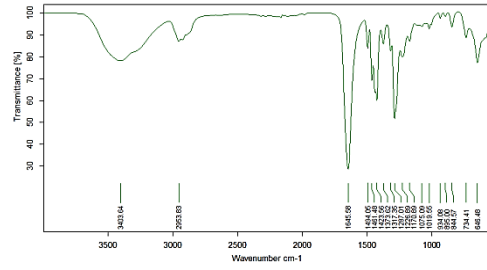


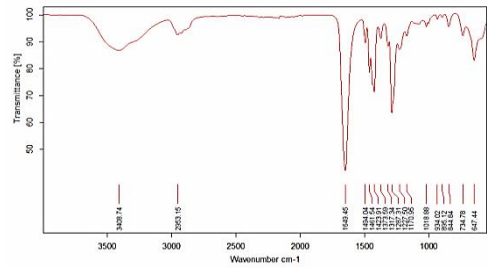
Figure 3 FTIR spectra of PLA, ENR and PLA/ENR electrospun blends [7].



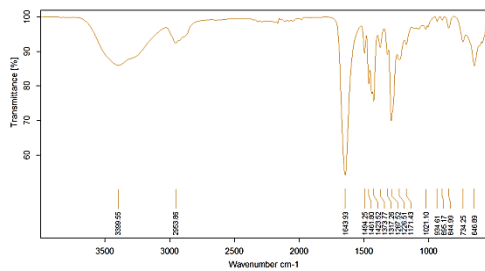
c)



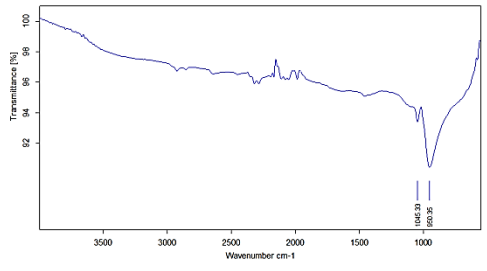
d)



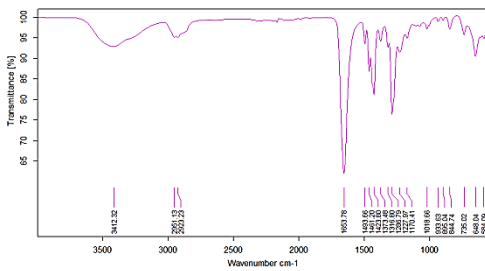
e)



a)



b)



b)

Figure 4 FTIR spectra of PVP, ENR and ENR/PVP of a) 0:10, b) 0.2:9.8, c) 0.4:9.6, d) 0.8:9.2, e) 1:9 and f) 10:0 electrospun blends.

Conclusions

The ENR/PVP nanofibrous membrane can be prepared by electrospinning method. The electrospinning condition with applied voltage 18 KV and distance between the syringe tip and collector plate is

23 cm gave smooth surface ENR/PVP nanofibrous and desired properties. ENR blending with PVP, it clearly shows the beads on the fiber be disappear, which ENR composition can be attributed to higher viscosity and surface tension with increasing ENR composition. Viscosity and surface tension play an important role in determining the fiber formability and ENR content reduced the fiber diameters and the. FTIR studies showed some level of interaction between a carboxylic end group of PVP chains and an epoxy group of ENR of the ENR/PVP nanofibrous results indicates that the ENR/PVP membrane.

Acknowledgments

This work was supported by Department of Physics, Faculty of Science and Technology Rajabhat Mahasarakham University and the authors thank the Department of Physics, Department of Chemistry Faculty of Science Khon Kaen University for their support.

References

- [1] Lee, K.H., et al. (2003). *J. Polym. Sci. B: Polym. Phys.*, 41, 1256-1262.
- [2] Zhong, Z., et al. (2012). *Mat. Sci. Eng. B*, 177, 86-91.
- [3] Pedicini, A.; Farris J.R.(2003), *J. Polym.*; 44: 6857–6862.
- [4] Frenot, A. and Chronakis I.S. (2003). *Current Opinion in Colloid and Interface Science*, 8, 64–75.
- [5] Phatcharasit K., et al. (2014). Electrospun epoxidized natural rubber with poly(vinyl chloride)(ENR-PVC) nanofibrous for PEMFC applications. 660-701
- [6] Li N., et al. (2008). The Effects of Spinning Conditions on the Morphology of Electrospun Jet and Nonwoven Membrane. *Polymer Engineering & Science*, 48, 2362-2366.
- [7] Jaqueline G.L. et al. (2016). 7, 210-219.
- [8] Kancheva M., et al. (2015). Enhancing the mechanical properties of electrospun polyester mats by heat treatment. *Express Polymer Letters*, 9, 49-65.
- [9] Wang X.Y., et al. (2002). Electrospun nanofibrous membranes for highly sensitive optical sensors. *Nano Letters*, 2, 1273-1275.