PREPARATION ANTIBACTERIAL PVA/CS ELECTROSPUN NANOFIBER MEMBRANE FOR FACE MASK

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Abstract

Amid mounting concerns regarding fine and ultrafine particulate matter, disposable surgical masks have become widely adopted as a key protective measure. This surge in usage is particularly driven by the onset of the SARS-CoV-2 pandemic and the escalating levels of urban air pollution. Nevertheless, the non-biodegradable composition of these masks poses significant environmental risks, as discarded masks contribute to pollution. To address this pressing issue, this study focuses on creating biodegradable nanofibers through the electrospinning process, utilizing polyvinyl alcohol (PVA) and chitosan (CS) as alternatives to conventional polymers found in commercial surgical masks (CSM). The resulting PVA/CS nanofiber mats displayed impressive characteristics, including an average fiber diameter of 0.14 ± 0.05 µm and a pore diameter of 0.20 ± 0.08 µm. These mats, with a thickness of 20 µm, exhibited exceptional filtration efficiency, effectively removing $PM_{2.5}$ fine dust by 99.6667% with a pressure drop of 186 Pa. Additionally, they demonstrated water resistance and antibacterial properties against both gram-negative and gram-positive bacteria. The successful production of PVA/CS electrospun membranes highlights their potential as sustainable alternatives to non-biodegradable polymers in surgical masks. This research underscores the critical importance of environmentally friendly solutions in combating pollution while ensuring public health safety.

Introduction

Since the start of the COVID-19 pandemic, the production and use of disposable protective masks have surged, leading to significant pollution due to mask disposal. In this study, we used chitosan (CS), polyvinyl alcohol (PVA), and water to create nanofiber mats via electrostatic spinning. These PVA/CS nanofiber mats were crosslinked using glutaraldehyde hydrochloric acid vapor. We evaluated their fiber structure, resistance to hydrolysis, antibacterial properties, and filtration performance. Results showed that the crosslinked composite nanofibers had an antibacterial and filtration effectiveness over 99%. The hybridized fiber mats exhibited strong filtration performance, exceptional antibacterial properties, and resistance to hydrolysis, expanding the potential applications of PVA fiber membranes. This advancement has the potential to replace.

Methods

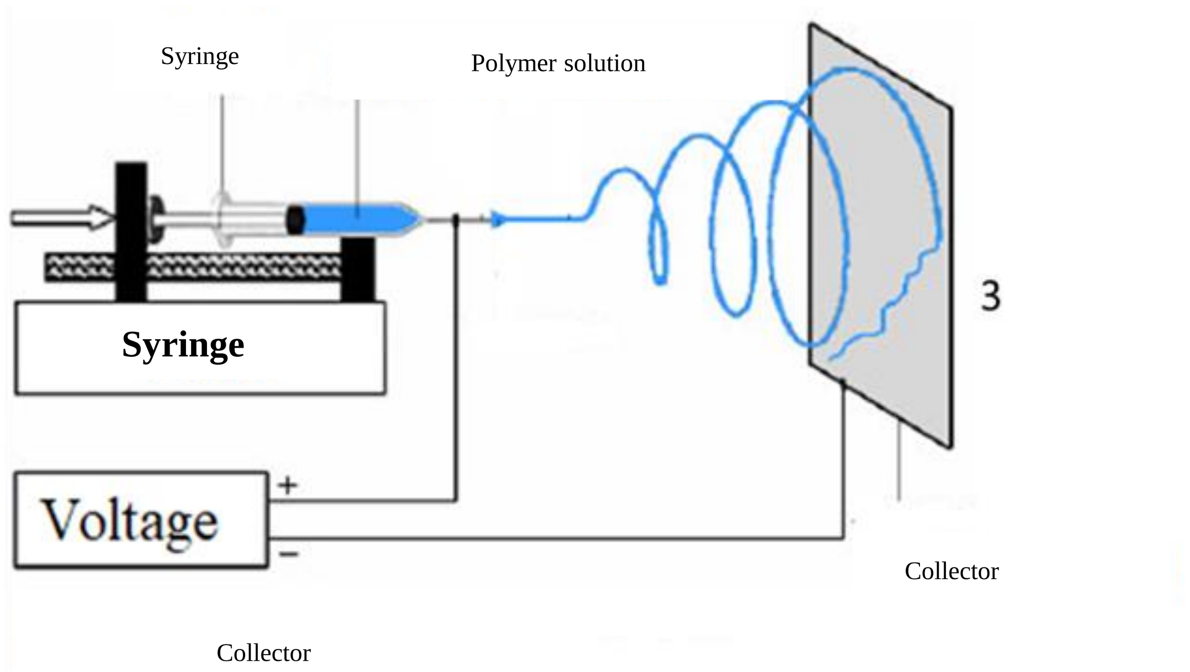

FIGURE 1: The process of preparation electrospun nanofiber mats.

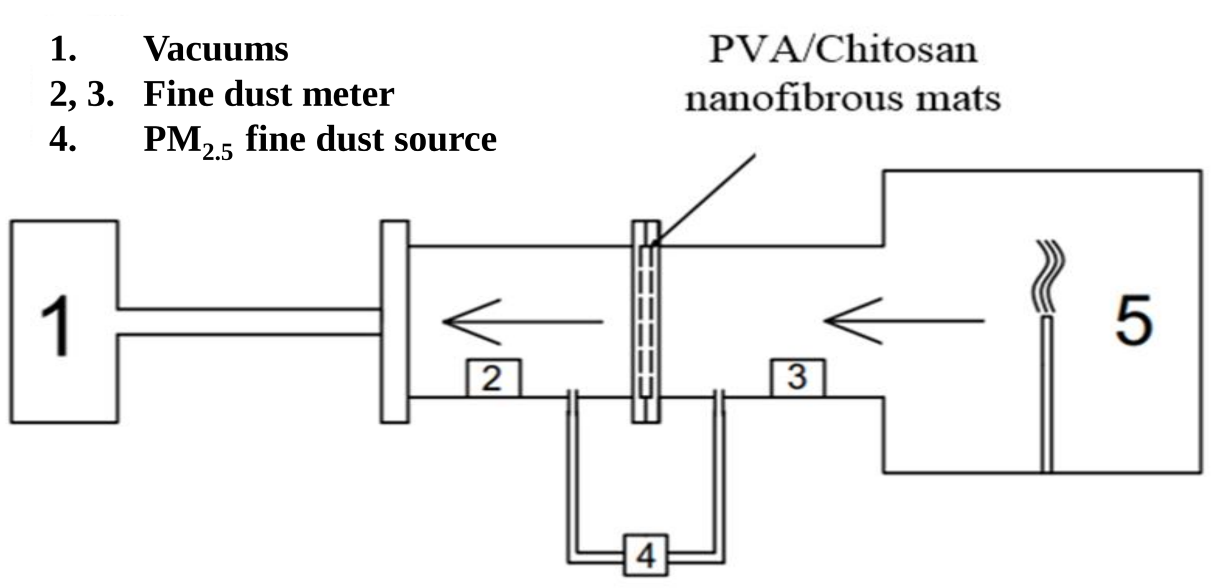

FIGURE 2: $PM_{2.5}$ dust filtration testing process of nanofiber membranes.

Results

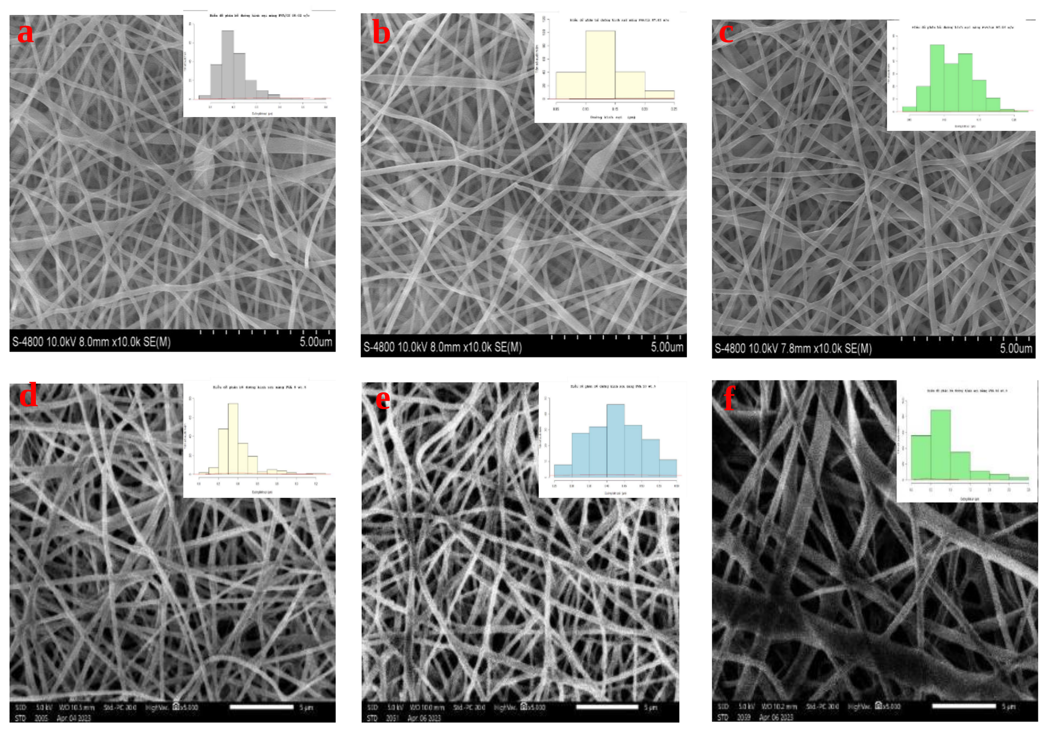

FIGURE 3: SEM micrograph of nanofiber mats. Figures 3a, 3b and 3c illustrate SEM micrographs of nanofiber mats with PVA concentrations of 8 wt. %, 10 wt. % and 12 wt. %. Figures 3d, 3e and 3f show SEM micrographs of nanofiber mats with PVA/CS ratio of 98:02, 97:03, 96:04.

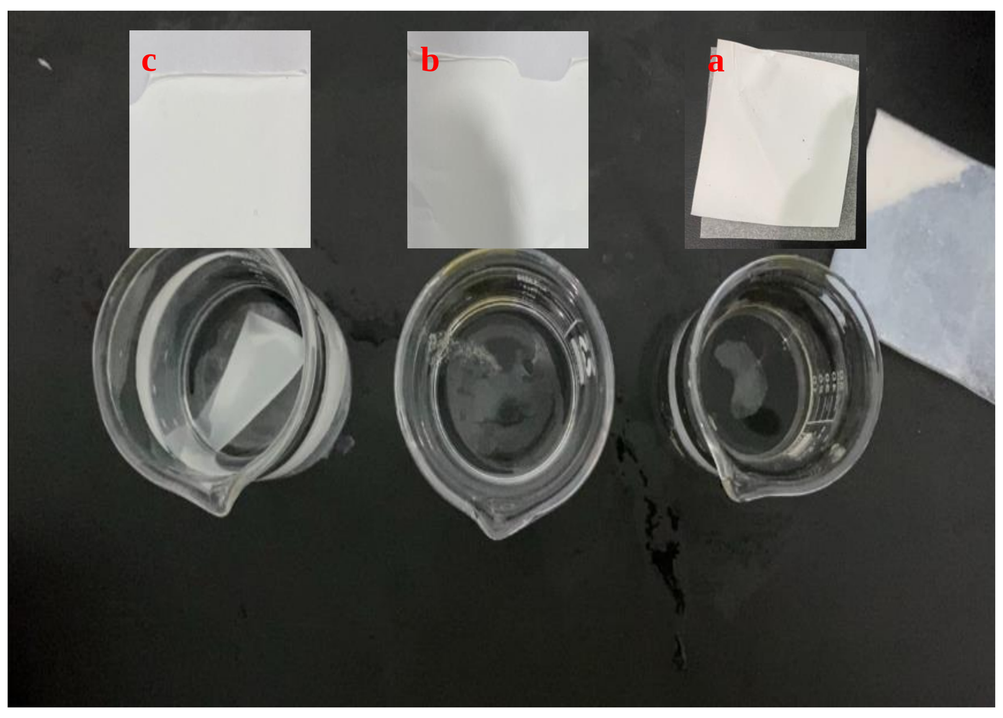

FIGURE 4: Investigation the water resistance of nanofiber membrane.. Figures 3a illustrate PVA nanofiber mats before and after exposure to water. Figures 3b show PVA/CS nanofiber mats before and after exposure to water. Figure 3c shows PVA/CS nanofiber mats cross-linked with GA before and after exposure to water.

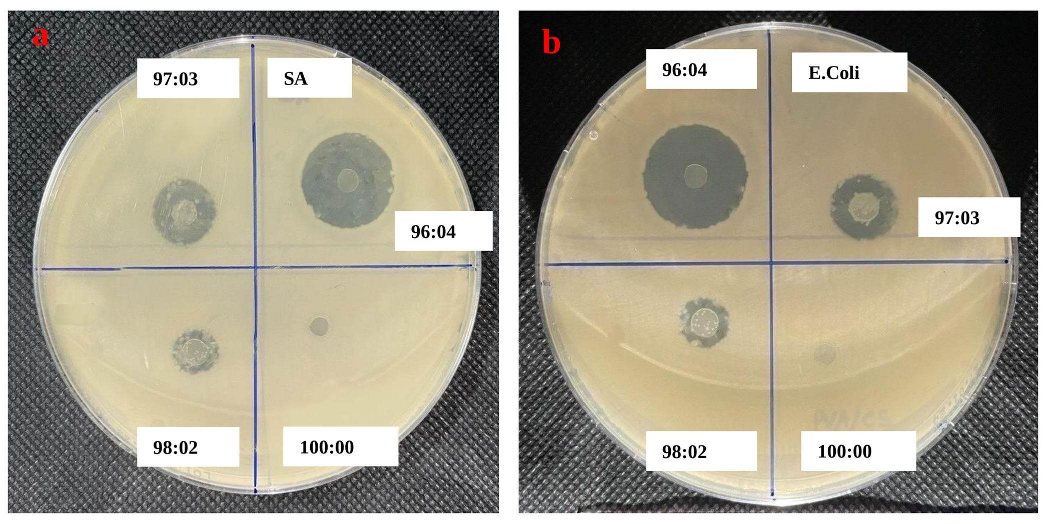

FIGURE 5: Disk diffusion tests showed the zone of inhibition exhibited by the nanofiber membrane against a) Staphylococcus aureus b) Escherichia coli.

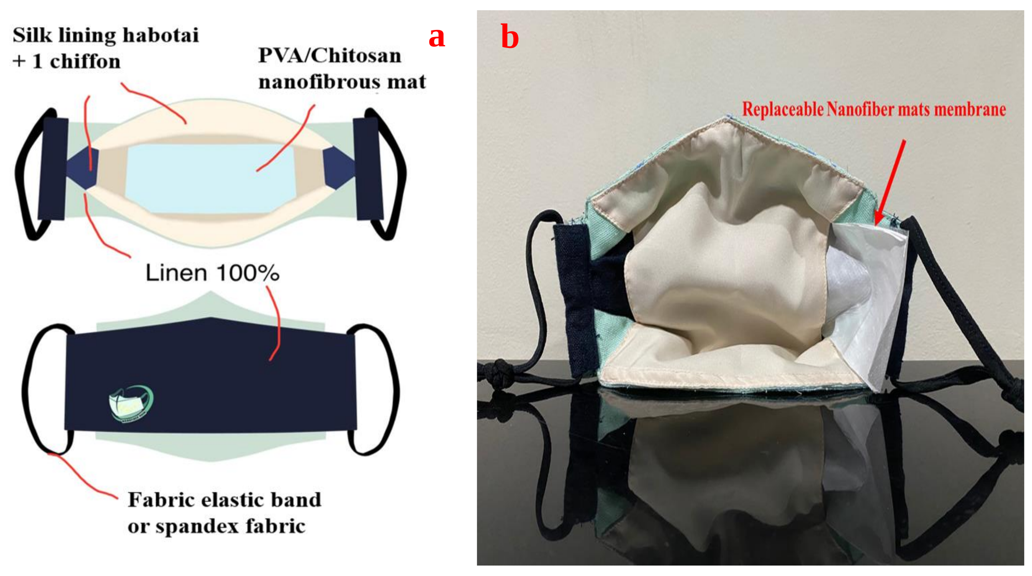

FIGURE 6: a) Mask models and b) actual products.

TABLE 1: The influence of nanofiber mat thickness on $PM_{2.5}$ dust filtration parameters

Thick (µm)	10	20	40
Δp (Pa)	56	**168**	536
η (%)	92.0000	**99.6667**	>99.6667
QF (Pa^{-1})	0.4510	**0.0309**	-

TABLE 2: The influence of nanofiber mat thickness on WVTR and porosity

Thick (µm)	WVTR ($\frac{g}{m^2.day}$)	Porosity (%)
10	640.69 ± 1.20	96.17 ± 0.36
20	**612.16 ± 1.06**	**87.68 ± 0.34**
40	597.95 ± 1.05	71.66 ± 0.39

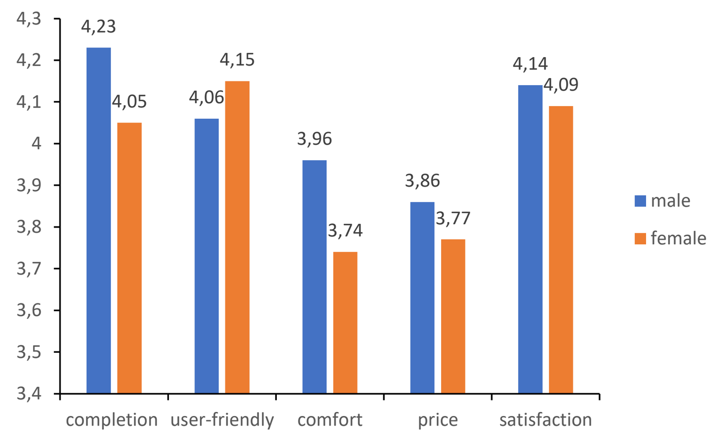

FIGURE 7: Bar chart illustrating actual mask experience survey data.

Conclusion

The research team has successfully manufactured a $PM_{2.5}$ fine dust filter for use in making masks. The PVA/CS nanofiber membrane crosslinked with GA has much better parameters than the N95 mask because the pressure difference of the N95 is 350 Pa while the membrane has a much lower pressure difference, but the ability to block fine dust is much higher. However, the group's masks still have aesthetic limitations that need to be overcome, even though the design is very creative. In conclusion, nano/micro PVA/CS membranes are highly applicable and much more optimal than N95 masks.

References

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