MANCHESTER 1824
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Face Mask with Nanofibre Coating

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Technology
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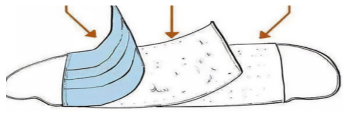
What is electrospining?

Electrospinning is a versatile and practical way to make ultrafine fibres from polymer solutions or melts. Electrospun fibres of sizes ranging from a few micrometres to a few nanometers, and most commonly hundreds of nanometers, have been observed. An electrospinning setup typically includes a high-voltage power source ranging from 5-30 kV, a syringe pump, a spinneret, and a conductive collector. During the electrospinning process, the liquid is initially extruded from the spinneret to form a pendant droplet. A Taylor cone is created by distorting the charged droplet.(Subbiah et al., 2022)

Problems about today's facemask

A typical surgical mask is composed of at least three layers of nonwovens made by PP fibers: the cover layer, filter layer and shell layer (Brown, 2022)..Generally , the filter efficiency of such filters will be greatly reduced after long wear or after other post-processing. If you want to improve the filtration efficiency, you usually need to enhance the thickness of the filter layer, which will lead to an increase in air resistance and reduce the comfort. On the other hand, masks produce mist when used, which for some special workers (medical personnel, etc.) may be used in hot and humid environments and further exacerbate moisture buildup(Lepelletier et al., 2022), which can lead to bacterial growth and increase the risk to users. The short life span of masks also leads to environmental unfriendliness and waste.



Objectives of the project

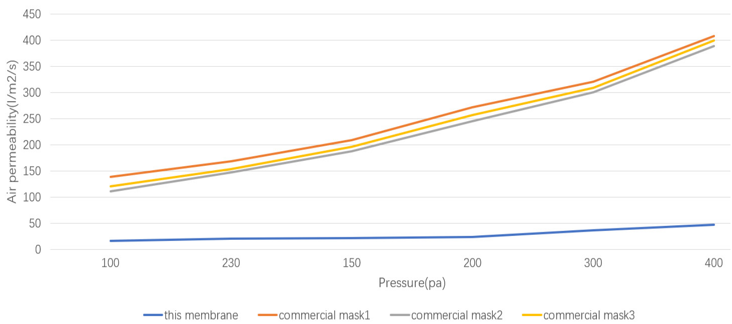
In recent years the topic of how Electrospinning can be applied to masks has become more popular due to the increasing number of pandemics. Cellulose acetate(CA) as a derivative material of cellulose, is low cost with good weaving properties. When applied to electrostatic spinning, cellulose acetate reduces energy waste and its impact on the environment and people while maintaining excellent breathability compared to other polymers.(Waimin et al., 2022)In this project, a cellulose acetate based filtration membrane, which was biodegradable and reusable, was prepared with electrospinning technology. The durability and filtration performance of the membrane compared to traditional non-woven fabric are examined

Preparation of CA membrane

Predetermined amount of cllulose acetate powder was placed in an acetone mixture and stirred under room temperature on a magnetic agitator for 6 h until the CA powder was completely dissolved and finally obtain a homogeneous spinning solution.The electrospun membrane was collected on the grounded roller at a rotating speed of 200 r/min with baking paper. When all the parameters were set, the pump was started to allow the forming of a small droplet at the tip of the needle. The applied voltage was adjusted between 15 and 25 kV. The electrospinning was carried out in an enclosed Plexiglas chamber and performed under a temperature of 25 $\pm$ 2 ° C and a humidity of 60%-70%. For post-treatment ,the fabricated membranes was collected for drying 24 h at room temperature to remove the residual solvents. All these experiments were carried out at ambient atmospheric conditions.

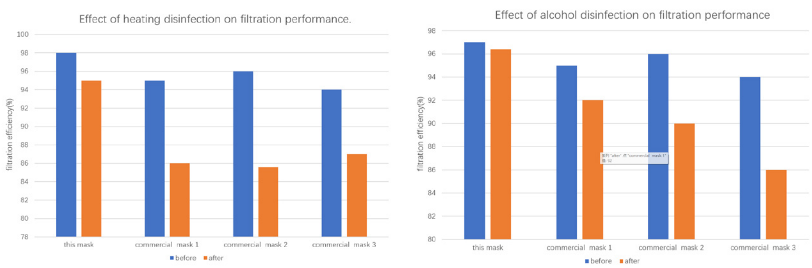
Airpermeability test

The air permeability of the membranes was tested by an air permeability tester with a testing area of 20 cm2 .Air permeability is an important parameter to evaluate the comfort of the mask, and this experiment compared the gas flow rate of the membrane and the nonwoven fabric of different masks at different pressures. From the results, there is a big difference in the gas flow rate of the membrane compared to the nonwoven at different air pressures, which is because the nanofibers are thicker and denser, and the pores between the fibers are smaller, so less air can pass through. Nevertheless the membrane still complies with the GB19038-2010 standard.



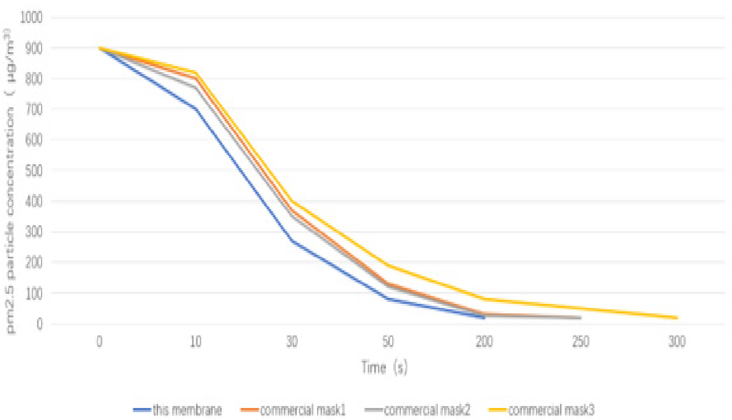
Reusability test

The stability of the material and the effect of disinfection treatment on filtration performance were investigated by performing alcohol and heat disinfection tests on the fiber membranes. The study was designed to test the membrane's stability, reusability and performance under "extreme" conditions. The filtration efficiency of the membranes remained unchanged after the alcohol immersion treatment, while the filtration efficiency of the commercial masks decreased significantly to different levels. This could be due to the attenuation of the electret electric field of polypropylene melt blown nonwovens in commercial masks due to solvent immersion, which reduced filtration efficiencies. The filtration efficiency of this membrane and all commercial masks was significantly reduced after the heat treatment . However, the reduction of the membrane was much smaller than that of the commercial masks and still maintained a good filtration effect. In conclusion, the membrane is much more stable than the commercial masks after disinfection.



Air Filtration Performance Evaluation

PM2.5 aerosols were produced by burning amoxa stick.The membrane and the meltblown layer for commercial masks was fixed separately on a holder with a ducted fan driven by a brushless motor in a storage box as the confined room .The ducted fan's high-speed air flow continuously pushes the air through the filter membrane,



causing aerosol particles in the confined space to accumulate on the membrane during the filtration test process.The downtrend of PM2.5 concentration was recorded by an air quality monitoring system.

From the results, both surgical masks performed essentially the same and better than the dental mask, while the membrane and all commercial masks reduced pm2.5 concentrations to low levels within 200 seconds. However, the membrane was significantly more efficient in comparison. In the first 30 seconds of the experiment, the film absorbed pm2.5 significantly more efficiently than the other three masks. It reduced the concentration of pm2.5 to less than 100 μ g/m3 in 50 seconds. In conclusion, the membrane has a significant improvement in PM2.5 aerosol filtration compared to the conventional masks.

PM2.5 is a major air pollution problem for today's society,As a typical aerosol pollutant, pm2.5 is also very harmful to humans (Feng et al., 2022). On the other hand, today people wear masks for protection against coronaviruses, and aerosols have been recognized as the main transmission route for the spread of 2019 coronavirus disease during the pandemic from 2020 to the present . Therefore, the use of this film in masks can effectively improve the filtering effect of masks against pm2.5 and the defense against viruses.

referencelist:
1.Feng, S., Gao, D., Liao, F., Zhou, F. and Wang, X., 2022. The health effects of ambient PM2.5 and potential mechanisms.
2.Waimin, J., Jiang, H., Detwiler, D., Jimenez-Castaneda, M., Mutlu, Z., Cakmak, M., Filley, T. and Rahimi, R., 2022. Noninvasive assessment of microbial activity by realtime monitoring degradation of cellulose acetate via electrochemical impedance measurement.
3.Brown, C., 2022. Respiratory Protection Against Emerging Infectious Diseases: Face Masks, Respirators, and Tools for Choosing Between Them.