BIO-MIMIC DESIGN OF PM2.5 ANTI-SMOG MASKS

by

Jing SHEN [a,b], ***Rou-Xi CHEN*** [a,b], **and *Ji-Huan HE*** [a,b*]

[a] Nantong Textile Institute, Soochow University, Nantong, China
[b] National Engineering Laboratory for Modern Silk, College of Textile and Clothing Engineering, Soochow University, Suzhou, China

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The basic property of anti-smog masks is to block PM2.5 with excellent air permeability. A multi-layer nanofiber woven fabric with hierarchical structure is the best candidate for this purpose.

Key words: *bubble electrospinning, bio-mimic, PM2.5, nanofiber membrane*

Introduction

Non-woven fabric covered with nanofiber membrane has a higher filtration performance than melt-blown and micrometer fabrics, and a thicker nanofiber membrane always results in a higher filtration efficiency [1]. Nanofiber membrane is a must to fabricate PM0.1, PM1.0, and MP2.5 masks, and the bubble electrospinning [2] is the best choice for fabrication of nanomembranes with different thickness. An anti PM2.5 mask should have not only an efficient blocking ability, but also have good air permeability, which has not been considered seriously in the present market. This paper is to solve the problem using cocoon's tree-like structure.

Having a hierarchical structure, a cocoon has almost no resistance to oxygen and water vapor [3], similarly a wool with a multilayer structure has excellent heat transfer properties [4]. These nature phenomena hint possibly an optimal structure for anti-smog masks, which admit excellent permeability of air.

Experiment

In this paper, polyethersulfone (PES) solution with different concentrations of 27% and 29% is used in the bubble electrospinning [2]. The fiber size depends mainly on the applied voltage, while the thickness of the nanomembrane depends upon spinning period, the pore size is controllable by voltage and spinning period, as shown in tab. 1.

Table 1. The parameters of nanofiber non-woven fabrics

Sample	Concentration [wt.%]	Voltage [kV]	Spinning period [min]	Permeability [mms^{-1}]	Filtration efficiency [%]	Pore size hole [μm]
1	27	25	5	1930	38.3	29.6
2	29	20	5	1050	41.9	10.3
3	29	25	5	806	56.9	9.8
4	27	30	20	368	85.4	7.4
5	29	30	20	106	96.6	4.6

Figure 1 shows that filtration efficiency increases with the spinning period (thickness of the nanomembrane) and applied voltage (smallness of fiber diameter), this can be explained easily by a simple mathematical analysis.

* Corresponding author; e-mail: hejihuan@suda.edu.cn

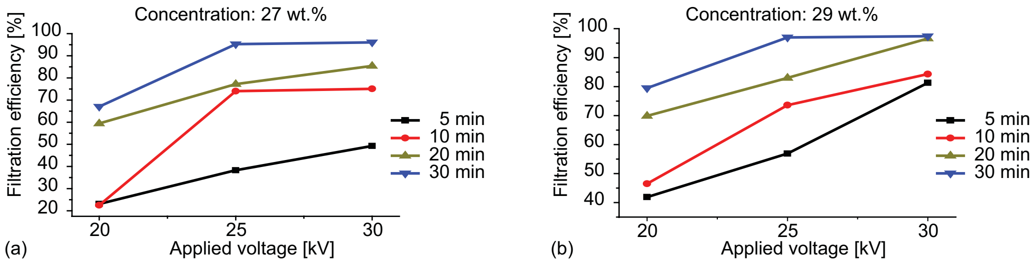

Figure 1. Filtration efficiency of different spinning parameters

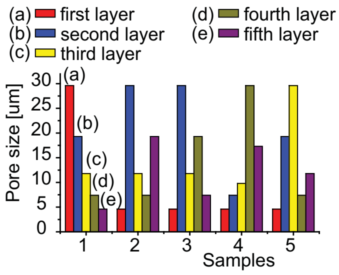

Figure 2. Samples with different orders

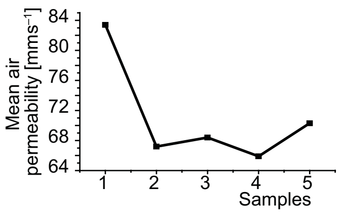

Figure 3. The permeability of these five samples

We use five samples of 5 layers with different orders. The first sample is such arranged as that of a cocoon, that is the pore sizes reduce gradually from the outer layer to the inner layer, the left samples are arranged in a chaotic way as given in fig. 2. The filtration efficiency of 5 samples is given in fig. 3, showing that the first sample with hierarchical structure reaches maximum.

Conclusion

Nanofiber membranes with hierarchical structure have both high filtration efficiency and excellent air permeability. The paper gives a preliminary theoretical analysis and experimental support for the bio-mimic design of anti-smog masks.

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