Antimicrobial Electrospun Nanofibers

Dr. Cagri Tekmen / Application Engineering Manager
Elmarco Ltd., 3-4-1 Sekido, Tama, Sekido Bld 4F, Tokyo 206-0011, Japan
E-mail: cagri.tekmen@elmarco.com

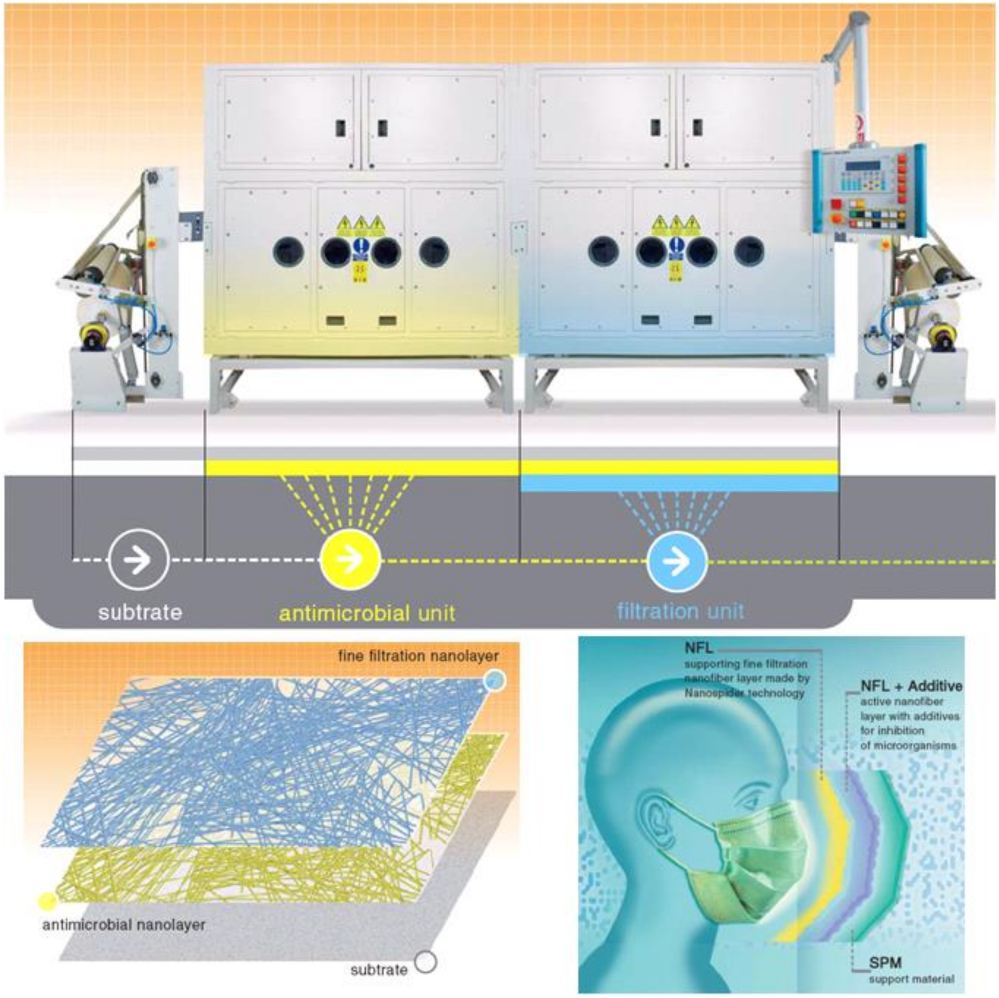
1. Introduction

With the growing public health awareness of the pathogenic effects, malodors and stain formations caused by microorganisms, there is an increasing need for antimicrobial materials in many application areas, especially as protective clothing for medical and chemical workers, first responders, sportswear, underwear and other health related products, which will act against a wide range of gram-positive and gram-negative bacteria by inhibiting their growth. Many antimicrobial agents, such as antibiotics, silver ions, quaternary ammonium, N-halamines, and other biocidal agents, have been applied to textiles and membrane materials by various chemical and physicochemical finishing techniques to protect the substrates from chemical and biological activities [1].

It is possible to produce functional nanofibers having optical, electrical, or catalytic properties by incorporating metal nanoparticles into them and subsequently extend their field of application. Silver has been known to have effective bactericidal properties for centuries. Nowadays, silver-based topical dressings have been widely used as a treatment for infections in burns, open wounds, and chronic ulcers. Ag^{+}-loaded zirconium phosphate nanoparticle is a novel nanosized and highly crystalline antibacterial agent which carries Ag^{+} ions by ion-exchanging. It can also protect the host material from oxidation and discoloration and have been often used as additive for wound dressing []. It has been demonstrated that Ag^{+}-loaded nanoparticle loaded PVA nanofibers, prepared by electrospinning technique, were bactericidal to the testing microorganisms due to the strong antibacterial ability of silver ions, and have great potential in the applications of wound dressings [2]. Not only PVA but cellulose acetate nanofibers containing Ag nanoparticles are also very effective for antimicrobial separation filters for submicron particles [3]. In another study, a significant improvement in photocatalytic activity and photoelectrochemical response has been observed through the attachment of Au or other metal nanoparticles onto titania nanofibers [4]. Researchers also demonstrated that superparamagnetic polymer nanofibers, produced by electrospinning magnetic nanoparticle suspensions in poly(ethylene oxide) and poly(vinyl alcohol) solutions, exhibited superparamagnetic behavior at room temperature [5].

Among the polymers, chitin and chitosan are polysaccharides having excellent biocompatibility and admirable biodegradability with versatile biological activities such as antimicrobial activity, low immunogenicity and low toxicity. Coupled with the possibility of preparing a variety of chemically or enzymatically modified products and processes, these biopolymers having the rare amino functionality and two hydroxyl groups for chemical modifications are potential materials in a variety of applications in biomedical, biotechnological and pharmaceutical areas [6]. Recently, electrospinning has found much interest as an attractive technique for producing polymer fibers with diameter in the range from several micrometers down to tens of nanometers. Because of the unique properties of the electrospun fibers, such as high specific surface area and high aspect ratio, they have potential to find a wide variety of applications. Nanofibers are usually obtained in nonwoven form, which is very suitable for applications such as wound dressings. The nonwoven mats usually have pores which are small enough to prevent bacterial penetration. The high surface area is of importance for fluid absorption and dermal drug delivery.

Elmarco is producer of industrial line designed for the production of the new unique material Nanospider AntimicrobeWeb™. AntimicrobeWeb™ is a new material for the elimination of mechanical or biological impurities of inhaled or exhaled air. The material consists of an inner and outer side of nonwoven textile with a double nanofiber layer between them. One of the nanofiber layers contains at least one antimicrobial additive and therefore is effective in the inhibition of biological impurities. The second nanofiber layer with smaller pores is designed as a supporting fine filtration layer. The utilization of this unique material is in face masks and filter media for capture of mechanical or biological impurities. Face masks made by Nanospider technology were tested at different accredited laboratories and results confirmed > 99.9 % capture of bacteria, viruses, fungi and yeasts [7].



Nanospider AntimicrobeWeb™ production line

References

[1] Kuitian Tan, S. Kay Obendorf. Journal of Membrane Science 305 (2007) 287–298.

[2] JIA Jun, DUAN Yuan-yuan, WANG Shao-hai, ZHANG Shao-feng, WANG Zhong-yi. Journal of US-China Medical Science. (2007). Volume 4, No.2, 52-54.

[3] Won Keun Son, Ji Ho Youk, Won Ho Park. Carbohydrate Polymers 65 (2006) 430–434.

[4] Li, D., McCann, J. T., Gratt, M., & Xia, Y. (2004). Chemical Physical Letters, 394, 387–391.

[5] Wang, M., Singh, H., Hatton, T. A., & Rutledge, G. C. (2004). Polymer, 45, 5505–5514.

[6] C. K. S. Pillai and Chandra P. Sharma. Trends Biomater. Artif. Organs, Vol 22(3), pp 179-201 (2009).

[7] Elmarco – http://www.elmarco.com