INFLUENCE OF NANO-FIBER MEMBRANES ON THE SILVER IONS RELEASED FROM HOLLOW FIBERS CONTAINING SILVER PARTICLES

by

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Polyether sulfone was dissolved into dimethylacetamide with the concentration of 20% to prepare a uniform solution for fabrication of nanofiber membranes by bubble electrospinning technique. Morphologies of the nanofiber film were carried out with a scanning electron microscope. The influence on the silver ions escaped from hollow fiber loaded with silver particles was exerted by using different release liquid. The water molecular clusters obtained from the nanofiber membranes filter can slow down the release of silver ions. However, the effect of slowing was weakened with the time increasing. In the end, the trend of change is gradually consistent with the trend of release of silver ions in the deionized water.

Key words: *biomaterials, fiber technology, nanofiber membrane, hollow fiber, silver ions, release property*

Introduction

Sliver has good function of antisepsis and anti-inflammation, and silver is widely used to accelerate wound healing, prevent infection [1, 2], purify water, save drinks and so on with the result of the highest biological activity of all the metal [3, 4]. Recently, silver antibacterial material not only has been widely attention and good prospects for development but also has been used for preparation of antibacterial dressing because of their lasting effective antimicrobial properties. The methods for preparation of silver antibacterial fiber include of silver plating, chemical grafting, finishing, and blend spinning [5]. Numerous studies have shown that fiber antibacterial performance mainly due to silver ions released from the surface or internal of the fiber [6, 7]. The silver hollow fiber is prepared from the force under silver mirror reaction and pressure difference [8]. The silver ion is transferred to the inner surface of the fiber. When using the fiber silver ions released from the head and tail ends of it. The lower content of silver ion can affect the antibacterial properties. However, the higher content increases the toxicity of materials [9] and the silver could release in a twinkling. It is necessary to study the performance of silver ion released from the hollow fiber. And the transfer of silver ions is related to many factors. The influence of the dissolution liquid cannot be ignored. The nanofiber mem-

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brane is prepared through the bubble electrospinning [10, 11]. The paper study that the influence on the transfer of the silver ion was taken by the different dissolution liquid named micro molecular water which is filtered through the nanofiber membranes.

Material and methods

Polyether sulfone (PES) and dimethylacetamide (DMAC), were obtained from Solvay companies in the United States. The hollow silver fiber was purchased from the Yangqian Material Application Technology Co. Ltd., in Shenzhen city, China.

The DF – 101-s thermal constant temperature heating magnetic stirrer was obtained from Instrument Co. Ltd., in China. Hitachi S – 4800 scanning electron microscope (SEM) was purchased in the Japanese Hitachi Ltd. The PE Optima 2100 DV inductively coupled plasma emission spectrometer (ICP – engage) was from Perkin Elmer companies in the United States. Direct current high voltage generator generated from Dalian Beisiman Science and Technology Co. Ltd. Bubble electrostatic spinning device was design by BubbFil Nano Science and Technology Co. Ltd.

Preparation of the PES/DMAC solution

The PES particles are set in the drying box at 60 °C for four hours, 20 gram of PES particles are dissolved into 80 grams of DMAC liquid in the baker. The mixture is stirred for two hours at the speed of 25 rpm with the control of the temperature spreading 35-40 °C in the constant temperature heating magnetic stirrer. The solution appears to be pale yellow, when the particles are completely dissolved.

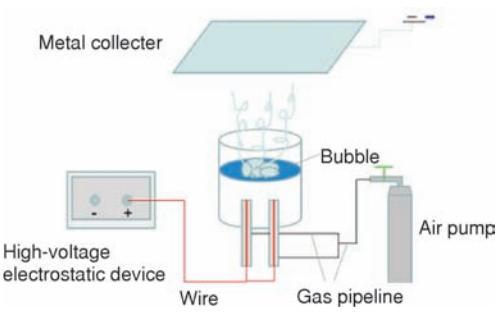

Figure 1. The device schematic diagram of bubble electrospinning

Preparation of the nanofiber membranes

Nanofiber membranes are prepared with the previous solution by the status named bubble electrospinning, fig. 1. The film was spun on the base non-woven fabric at Square meter weight of 20 g/m^2. In the bubble electrospinning, the voltage applied is maintained at 30 kV and the distance between the surface and the collector is 25 cm, the diameter of bubble is 3 mm at the room temperature.

Release of the silver from the hollow silver fiber

Demonized water and tap water are flitted though the nanomembranes. So they become two especially water noted micro molecules of water one and micro molecules of water two, respectively. The hollow silver fiber is immersed in the liquid above at the dipping bath ratio of 1:200 at room temperature. The other end of the fiber is immersed, respectively, into the different liquid for 0.5 hour, 2 hours, 4 hours, and 24 hours. After the scheduled time, 5 mL dipping liquid is absorbed by using pipetting gun, and a small amount of nitric acid is added into the liquid to prepare the sample. The content of the silver in the impregnation liquid is measured by using the ICP-OES. Silver ion release rate in a relatively short time is calculated according to the following equation:

$$V \quad \frac{0.2c}{5} \quad 0.04c$$

where V is the silver ion release rate, and c – the silver ion concentration.

Apparent morphology of nanofiber membranes

Figure 2 shows the SEM picture of the nanofiber membranes. As can be seen from fig. 2, the diameter of the nanofibers presents from dozens of nanometers to hundreds of nanometers with large specific surface area and the size effect. The nanofiber membranes prepared by bubble electrospinning not only has the nanometer size effect, but also improve the fiber strength and compressive ability. The nanofiber membranes can effectively filter out the impurities in the water to get strong activity of micro molecules of water.

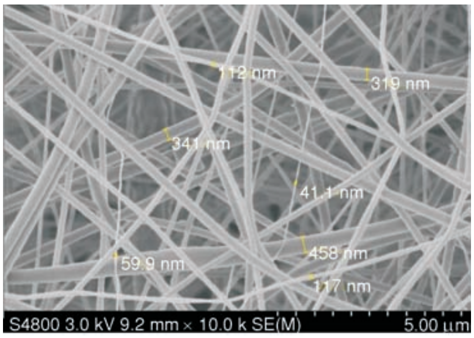

Figure 2. The SEM of nanofiber membranes

The release of the silver ions

Figure 3 shows the link to silver ion content of releasing and the releasing time. It can be seen in fig. 3 there is a linear correlation with significant level between silver ions concentration releasing from the hollow silver fiber and releasing time.

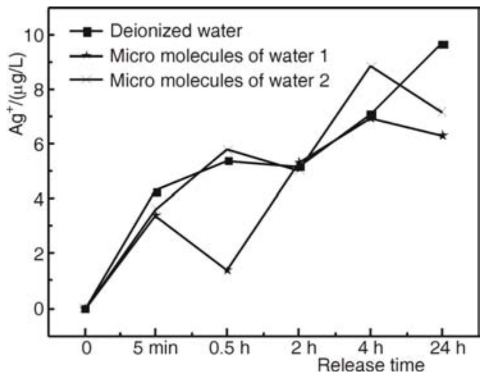

Figure 3. The relationship of the release concentration with the release time of the silver ions

Table 1 shows that the rate of silver ions of releasing from the hollow fiber associated with type of releasing liquid. Three points as K0, K2, and K1 marked in tab. 1 reduce in turn. That is to say, the releasing rate from the hollow silver fiber in the in deionizer water is higher than that in the micro molecules water. In the absence of oxidant and reducing agent, the silver particles attached on the inner wall of the hollow fiber are generated to be silver ions according to chemical equation of the reaction:

$$4Ag_{(s)} \quad 4H_{(aq)} \quad O_{2(aq)} \quad Ag_{(aq)} \quad 2H_2O_{(l)}$$

Table 1. The rate of silver ions from the hollow silver fiber in different liquid

The rate of release of silver ions from the hollow silver fiber in deionized water K0	The rate of release of silver ions from the hollow silver fiber in micromolecule water 1 K1	The rate of release of silver ions from the hollow silver fiber in micromolecule water 2 K2
0.171	0.136	0.144

In the generation of silver ions is accompanied by micro molecules of water. When the soaking liquid is deionized water, the micro molecules of water disperse quickly to promote the formation of silver ions. When the soaking liquid is micro molecules of water, the micro molecules of water can not disperse. It is results with increase the amount of micro molecules of water and slowing the silver ion release rate. To a certain extent, the sudden release of silver ions is inhibited. The silver ions on the hollow silver fiber transfer differently between in the micro molecules of water one and micro molecules of water two. It may because the different ingredient in the micro molecules of water one and the micro molecules of water two.

As the extension of dipping time, the influence of different liquid on the release of silver ions concentration could tend to be more consistent. Silver ions can only spread out from the port of fiber under the effect of aqueous solution, because the silver ions can exist only on the inner wall of the hollow fiber with special structure. With the increase of time, the activity of small molecules of water cut. The inhibitory effect on the chemical equation is reduced with the result that the amount of the silver ions releasing from the fiber ports increases. And the end, the concentration tends to be the same with the concentration in the deionized water.

Conclusions

The diameter of the nanofiber spreads from only a few tens of nanometers to hundreds of nanometers, which can effectively remove the impurities in the water, with the formation of strong activity of micro molecules of water.

In a relatively short period of time, the micro molecules of water can slow down the release of silver ions. However, with the increase of time, slowing effect is reduced. Eventually the concentration of the silver ions tends to be the same with the concentration in the ordinary deionized water.

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