Preparation of a Hydrophilic Nitrocellulose Membrane

Yuting Tang1, *, Li Xing2, Ping Wang2
1 Zhejiang University Kunshan Innovation Institute, Kunshan, China
2 Suzhou Optfull Environmental Science and Technology Co., Ltd, Kunshan, China

*Corresponding author e-mail: 3414699595@qq.com

Abstract. This paper analysed the present situation of hydrophilic nitrocellulose membrane at home and abroad. Then we propose the preparation method of commercialized hydrophilic nitrocellulose membrane. The hydrophilic nitrocellulose membrane is suitable for rapid diagnostic products after steam-inducing phase separation. The membrane has uniform surface and internal structure and good protein adsorption capacity. It is applied to the test of fast diagnostic products, and the test results are good.

1. Current situation analysis at home and abroad
Nitrocellulose, a product of esterification of cellulose with nitric acid, has good film-forming property. And nitrocellulose is one of the earliest macromolecule polymers used to prepare thin films in the world. Bechhold prepared the first artificial membrane by dipping the filter paper with nitrocellulose into glacial acetic acid in 1908. The permeability of the membrane can be adjusted by changing the ratio of the nitrocellulose and the glacial acetic acid. In 1918, Zsigmondy [1] used nitrocellulose membranes to separate large molecules and small particles from aqueous solutions [2].

In recent years, the application of nitrocellulose has gradually shifted from filtration and separation to biological analysis with higher added value because of it’s macromolecule characteristics. This is mainly due to the non-specific adsorption capacity of nitrocellulose to proteins and other substances. On the other hand, hydrophilic membranes are needed in the application of fast diagnostic products. The post-treatment of the membrane is required because of the hydrophobicity of nitrocellulose. At present, this kind of membrane in China basically depends on imports [3].

2. Characteristics of commercialized nitrocellulose membrane on the domestic market

2.1. It is basically monopolized by foreign products
At present, almost all of the bio-environmental testing membrane market is monopolized by European and American enterprises (such as Sartorius and Milpore). At present, there is basically no mature commercial membrane in China.

2.2. There are few customized products
Because the market is monopolized by foreign products, membrane production bases are not in China. And the customization of new membrane products requires long-term communication between
customers and manufacturers. Therefore, foreign manufacturers only produce general membrane, almost no customized membrane.

3. Preparation plan

3.1. Preparation of membrane preparation liquid
Dissolving the nitrocellulose polymer materials in Solvents. Then we add the cosolvent, water and surfactant. Membrane-making liquid was obtained after stirring, defoaming and filtering at 15-50°C.

3.2. Coating the liquid
Coating the membrane-making liquid on continuously running stainless steel strips or plastic support substrates. The wet membrane thickness is 100-800um [4].

3.3. Drying
The coated stainless steel strip or plastic support substrate is immediately dried in a drying channel with temperature and humidity control and air flow control.

3.4. Post processing
When the solvent content in the solution decreases to 5-20% of the initial content, putting the solution into water for cleaning and dust removal. Subsequently, soaking it continuously in the post-treatment solution. The cleaning and dust removal time is 0.5-20 minutes and the soaking time is 0.5-20 minutes.

Finally, hydrophilic nitrocellulose membranes are obtained by drying at 20-75°C after post-treatment.

3.5. Main technical indicators
The main technical indicators are shown in Table 1.

| Table 1. Main technical indicators. |
|-------------------------------------|
| aperture size                      | 6-15 um                  |
| thickness                          | 130±15 um                |
| content components                 | >99% nitrocellulose      |
| porosity                           | >80%                     |
| lateral chromatographic flow velocity of pure water(4cm) | 120±15s                 |
| membrane structure                 | bilateral symmetrical cortex-free network structure |
| interlaminar bonding strength       | >1.0                     |

In addition, there are no black spots, speckles and other abnormal spots on the hydrophilic nitrocellulose membrane surface, showing a uniform white surface without dust. And the combination of protein and membrane produces has clear lines with no surface diffusion.

4. Experimental results and comparison.
We did a series of experiments and comparative experiments to record the data.

Experiment 1.
Nitrocellulose solution was prepared with the following components: 9.2% nitrocellulose, 25.9% acetone, 8.5% distilled water, 0.08% sodium tetradecyl sulfate, 11.2% ethanol, and 45.12% isopropanol. The defoamed and filtered polymer solution was coated on the 150um PET support layer. In the drying channel at 15-30°C, the concentration of solvent vapor and relative humidity were controlled by adjusting the exhaust air volume to 0.7% and 70% - 75% respectively. After solidification, we cleaned the dust with distilled water. Then getting nitrocellulose solution passing through the solution pool of sodium dodecyl sulfate with 1% concentration, and finally drying and rolling up at 40-50°C.

After completing the above steps, the nitrocellulose membrane with backing with pore size of 8um can be obtained, and its positive surface structure is shown in Figure 1.
Comparative experiment 1.

Repeat the procedure 1. The only difference was that there was no surfactant in the preparation solution. The positive surface structure of the membrane is shown in Figure 2.

**Figure 1.** Positive surface structure.

**Figure 2.** Positive surface structure of Comparative membrane.

The results of membrane testing are shown in Table 2.
Table 2. Testing results.

| Performance parameter          | Product 1 | Comparative Product 1 |
|-------------------------------|-----------|-----------------------|
| Chromatography 4 cm height time(s) | 133       | 116                   |
| Formation Curing Time(min)     | 25        | 25                    |
| Average pore size              | 8         | 10                    |

The experimental results show that the existence and amount of surfactants have a great influence on the pore size of the final membrane.

![Detection lines of two products.](image)

Figure 3. Detection lines of two products.

From figure 3, it can be found that the quality of detection lines in product 1 and comparative product 1 varies greatly. Although there are obviously larger apertures and faster chromatography rates for the comparative membrane, there are ripples in the lines. This phenomenon may be attributed to the fact that in the rapid post-treatment of continuous production of non-surfactant membrane, the treatment solution cannot be uniformly distributed on the surface in a short time.

5. Conclusion

At present, almost all of the domestic hydrophilic nitrocellulose membrane market is occupied by European and American film manufacturers, and there is no commercialized membrane in China. Through the method proposed in this paper, we can independently develop and prepare the hydrophilic nitrocellulose membrane without cortical network structure. At the same time, we use the specific technology to realize the membrane surface without dust and has sufficient interlayer bonding strength and tensile strength. After the treatment of surfactants, we can get the commercialized membrane with homogeneous structure. This hydrophilic nitrocellulose membrane can replace or surpass similar products abroad when used in bio-environmental testing products.

References

[1] Antoine Venault,Yung Chang. A Review on Polymeric Membranes and Hydrogels Prepared by Vapor-Induced Phase Separation Process.(2013)568-626.
[2] R. L. Fleischer et al., Ann. Rev. Nucl.,15, 1(1965).
[3] Information on http://baike.baidu.com/item/ hydrophilic nitrocellulose membrane /5636678
[4] Jian Cui. Polyurethane and cellulose emulsion leather finishing agent[J]. Leather chemical industry; 1983, 04.