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Development of Polyimide Membrane for Solvent Resistant Filtration

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Abstract.

In this study, we mainly investigated the membrane permeability and ability for applications in harsh solvent environments, an excellent stable polyimide membrane was successfully developed by Taiwan Textile Research Institute (TTRI). The novel technologies combined molecular design, cross-linked and membrane processing, and these membranes can be safely used in various polar organic solvents such as NMP, DMAc, IPA, alcohol, etc. Therefore, the objective in urgent need for development in the field is to prepare a separation membrane with good solvent resistance and make it processed that can be used in ultrafiltration (UF), pervaporation (PV) or assisted pre-esterification in a biodiesel process. In our research, we focus on the development of PV of dehydration process. In PV testing, the feed of isopropanol (IPA) solution or ethanol (EtOH) solution concentration can increase from 70 to 99 wt% or from 70 to 90 wt%, and the permeation concentration of water is all higher than 95%. Based on the above, it has the superiority of polyimides over other polymers in separation property as distinguished materials for pervaporation.

Keywords: polyimide, solvent-resistant membrane, pervaporation

THE DEVELOPMENT OF SOLVENT RESISTANT POLYIMIDE MEMBRANE

Membrane separation processes are a technology that becomes increasingly important in the field of separation science, and find wide use in the separation of gas or liquid components, for example gas separation, pervaporation (PV), vapour permeate (VP) or liquid filtration. In general, most polymer membrane can't survive in the harsh solvent environment, especially under the condition of the organic solvent, e.g. IPA and DMAc. Polyimide is a high performance material with excellent chemical and heat resistance, it is classified as high-performance plastic for industry or semi-conductor use. In our research, we designed a special polyimide structure which having reactive functional group to react with crosslinker for solvent resistant membrane separations. The solvent resistant PI membrane can be accomplished and survived in the high polar organic solvent like NMP, DMAc, it can be wildly used in the pharmaceutical and high-tech industrial.

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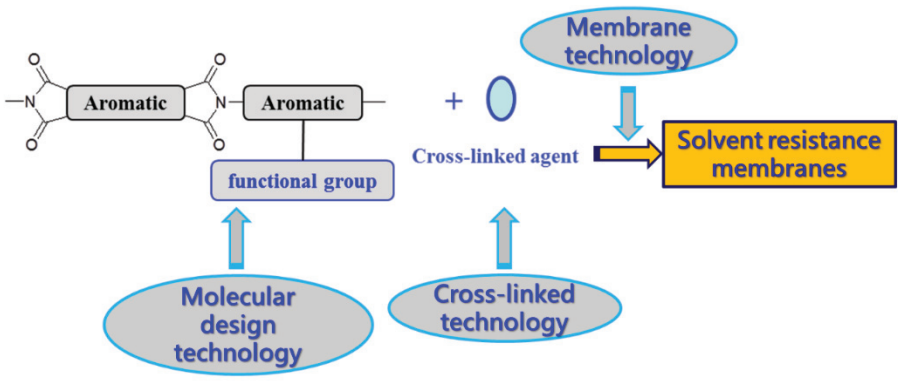

Figure 1-1.The schmetic diagram of PI solvent resistant membranes

Solvent resistant polyimide membrane on pervaporation application

The solvent resistant membrane can be widely used in industries and it is also used on the waste solution treatment and separation. The figure 2-1 shown the high value of filtration line from the waste solution to high purity solvent recycling, it combined solid-liquid separation (MF, UF, NF, etc.) and liquid-liquid separation(PV, VP, column, etc.) processes. In this research, we focus on our designed PI membrane for the azeotropic solvent separation by pervaporation process.

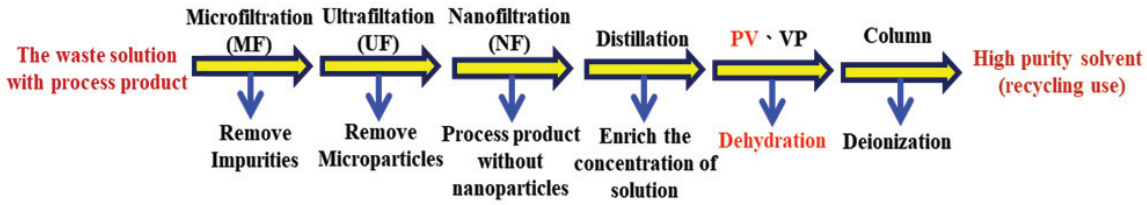

Figure 2-1.The shematic diagram of filtration line

The process of pervaporation is shown on figure 2-2. For example, the isopropanol/water mixture as feed was put on the left side of solvent resistant PI membrane and the other side of membrane is on the vacuum condition. We can enrich the concentration of IPA solution from 70 to 99 wt% and the permeation concentration of water is all higher than 95%. In so doing, we can get the high purity and concentration solvent by dehydration to achieve recycling. It is important for the environment which is getting worse today.

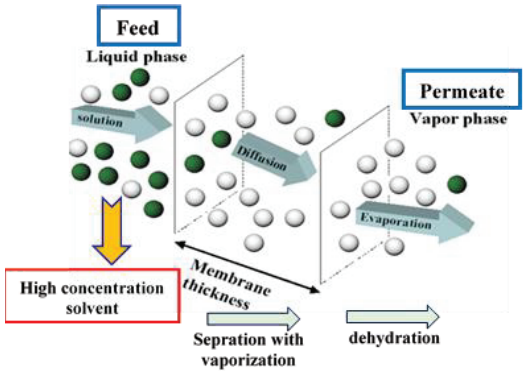

Figure 2-2.The shematic diagrame of pervaporation (PV) process process

The feed solutions are a 70 wt% isopropanol (IPA) solution, a 90 wt% IPA solution, a 70 wt% ethanol (EtOH) solution and a 90 wt% EtOH solution, and the permeation flux and the water concentration are shown in Table 1. As the result, our PI membrane shows excellent performance in PV test, all the selectivity approaching 100%.

Table 1 PV test

	70 wt% IPA	90 wt% IPA	70 wt% EtOH	90 wt% EtOH	70 wt% NMP	90 wt% NMP
Permeation flux (g/m^2h)	2061	1185	2024	1034	1218	870
Water conc. in permeate (wt%)	99.4	99.9	99.8	99.8	99.9	99.9

The comparison on performance of the pervaporation membrane with international company(sulzer) under the pervaporation process

The well-known company for making pervaporation membrane is sulzer internationally. The appearance of sulzer pervaporation module is shown on figure 3-1 and it is assembled by multi-plate membrane. The comparison on performance of pervaporation between sulzer and us is shown on figure 3-2. It is apparently that the selectivity of water on permeate is about 95% higher than the sulzer as the feed of 70, 80, 90 wt% IPA solution. However, we still have to consider the flux and the lifetime of membrane. Our selectivity is higher than the sulzer, we expect to improve the performance of membrane in the future. In terms of application, it is expected to extend from plate to tubular membrane and scale up to the market in final goal.

Figure 3-1.The sulzer pervaporation module

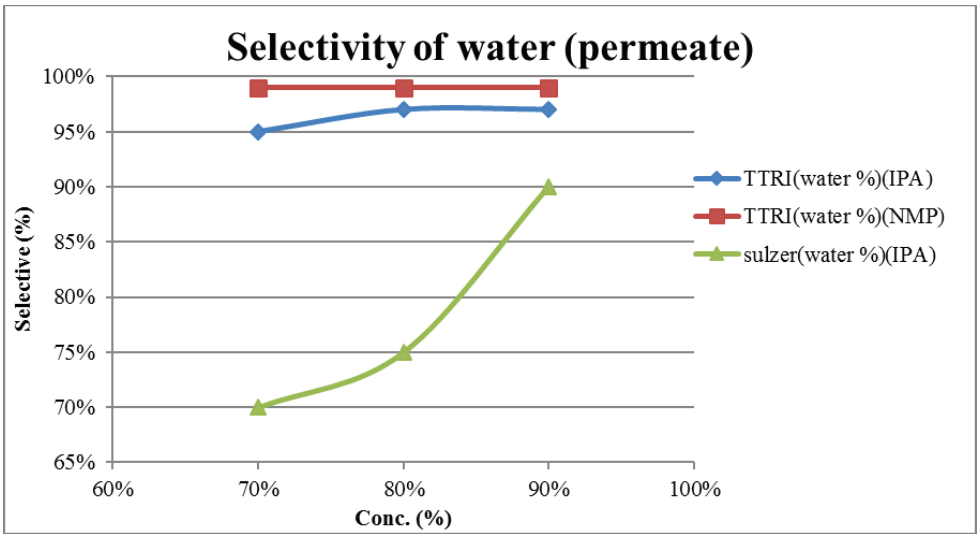

Figure 3-2.The selectivity of water on permeate(compare with sulzer)

In addition, we also try to test our membrane durability under pervaporation to make sure it can maintain the performance under the long time test. The result indicate that the selectivity of water on permeate maintain at 95% within 20 days and declined to 90% after 20 days as shown on figure 2-3. As you can see, it is still keep on the 90 % with little vibration from 20 to more than 90 days. The experiment will continue to make sure the real lifetime of PI membrane. We will keep testing to know the lifetime, it is the key point of the process for scale up in the future.

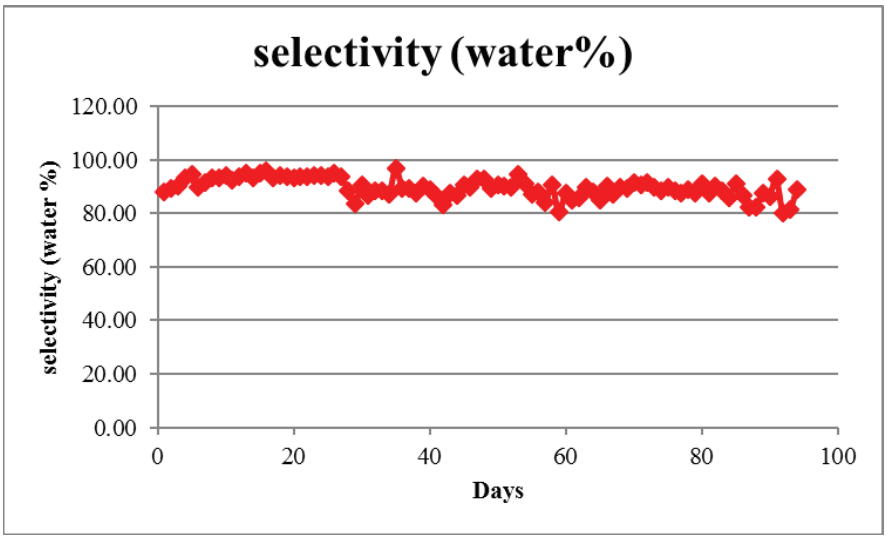

Figure 3-3.The durability of PI membrane under pervaporation

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