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Pengaruh Waktu Perendaman pada Pembuatan Membran CA/NMP untuk Pemisahan Mikroplastik dalam Air

Effect of ImmersionTime on CA/NMP Membrane Preparation for Microplastic Separation in Water

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ABSTRAK: Setiap tahun Indonesia menghasilkan lebih dari 4,8 juta ton sampah plastik yang tidak dapat dikelola dengan baik sehingga akan berakhir di perairan Indonesia. Sampah plastik ini kemudian terdekomposisi menjadi mikroplastik (MPs) yang berukuran <5 mm. Keberadaan MPs di perairan Indonesia dapat berdampak negatif bagi makhluk hidup, sehingga perlu dipisahkan dari perairan. Salah satu metode yang dapat digunakan untuk memisahkan MPs dalam air adalah mikrofiltrasi menggunakan Teknologi Membran. Penelitian ini bertujuan untuk mengetahui pengaruh waktu perendaman pada pembuatan membran terhadap karakteristik dan kinerja membran mikrofiltrasi. Pembuatan membran dengan metode inversi fasa, Selulosa Asetat (CA)/N-Metil-2Pirolidon (NMP) sebagai polimer/pelarut dan aquadest sebagai non pelarut. Analisis karakteristik untuk mengetahui hidrofilisitas membran antara sudut kontak, kadar air, porositas dan ukuran pori pada membran. Scanning Electrone Microscope (SEM) untuk menentukan morfologi permukaan dan struktur membran, serta analisa rejeksi mikroplastik dalam air. Hasil analisis karakteristik menunjukkan bahwa, membran bersifat hidrofilik dengan hasil sudut kontak dalam range 61-53°, porositas sebesar 80-83%, kadar air sebesar 79-82% dan memiliki ukuran pori berkisar 8,4-5,8 µm yang sesuai dengan membran mikrofiltrasi, serta kemampuan rejeksi membran mampu mencapai 99%. Sehingga teknologi membran perlu dikembangkan lagi untuk memisahkan MPs dalam air.
Kata Kunci: mikroplastik; membran mikrofiltrasi; inversi fasa; selulosa asetat; rejeksi

ABSTRACT: Every year Indonesia produces more than 4.8 million tons of plastic waste that cannot be managed properly so that it will end up in Indonesian waters. This plastic waste is then decomposed into microplastics (MPs) which are <5 mm in size. The presence of MPs in Indonesian waters can have a negative impact on living things, so it needs to be separated from the waters. One method that can be used to separate MPs in water is microfiltration using Membrane Technology. This study aims to determine the effect of immersion time on the characteristics and performance of microfiltration membranes. Membrane manufacture by phase inversion method, Cellulose Acetate (CA)/N-Methyl-2Pyrolidone (NMP) as polymer/solvent and distilled water as non-solvent. Characteristic analysis to determine the hydrophilicity of the membrane between the contact angle, water content, porosity and pore size of the membrane. Scanning Electrone Microscope (SEM) to determine the surface morphology and membrane structure, and analysis of microplastic rejection in water. The results of the characteristic analysis show that the membrane is hydrophilic with the results of the contact angle in the range of 61-53 °, porosity of 80-83%, moisture content of 79-82% and has a pore size ranging from 8.4-5.8 µm which is in accordance with the microfiltration membrane, and the membrane rejection ability can reach 99%. So that membrane technology needs to be developed again to separate MPs in water.
Keywords: microplastics; microfiltration membrane; phase inversion; cellulose acetate; rejection.

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1. Introduction

In 2020, Indonesia has a population of 270.20 million people. This figure causes Indonesia to produce 33,133,277.69 tons of waste, of which 5,655,851 tons or 17.07% is plastic waste. From the amount of waste produced, 4.8 million tons of plastic waste in Indonesia is not managed properly and will end up in Indonesian waters every year (Maskun et al., 2022). Over time, plastic waste will break down into microplastics (MPs). MPs are characterized by small size with diameter <5 mm, large specific surface area, and good chemical stability (Kurniawan, *et al*., 2020).

Due to its small size and ability to float on the surface of the seas and oceans, MPs is distributed in all marine ecosystems. Differences between locations are observed in MPs concentration and/or abundance. The Pacific Ocean is the most sampled area. Comparatively, measured concentrations in this ocean varied from nearly 27,000 to 448,000 particles per km^2 and from 0.004 to 9,200 particles per m^3. Comparatively, there were nearly 0.3 to 2175 particles per kg of microplastics in river sediments (Phuong et al., 2016). MPs in these aquatic environments pose a risk of harming the environment due to increased toxicity through contamination of microplastic compounds, this can pose many threats to humans and other living organisms (J. Yang et al., 2023).

Polyethylene terephthalate (PET) is a type of plastic that is widely used as a polymer material to produce packaging for food and beverage products due to its strong mechanical properties, high transparency, and good gas barrier durability. However, as a consequence, millions of PET bottles are discarded as waste every day, causing serious environmental problems as they are not biodegradable. Many studies report that only a fraction of used plastic bottles are recycled, which means that used plastic bottles are mostly disposed of as waste without further treatment or simply incinerated, causing serious environmental problems (Kusumocahyo et al., 2020). So, removing MPs in waters is one way to reduce pollution. One method of removing MPs that is considered not costly is microfiltration using membrane technology.

Membrane technology is considered cost-effective and effective due to its low energy consumption, good stability, and operational flexibility. In addition, it has the advantage of being able to process large quantities of water samples (Mahreni, 2022). One method that can be done in making MPs removal membranes is the phase inversion method. Phase inversion is a process where the polymer is converted from liquid phase to solid phase through a certain control mechanism. By controlling the initial stage of phase change, it can later affect the formation of the resulting membrane morphology (Nyamiati, Nurkhamidah, Rahmawati, et al., 2023).

One of the membrane building blocks is polymers, polymers are widely used due to their properties such as excellent film-forming properties, good mechanical strength, physical and chemical thermal stability, and stability at various pH levels (Nyamiati, Nurkhamidah, Nanda, et al., 2023). Some materials often used for microfiltration membranes are usually polymers, such as cellulose acetate (CA), polyvinylidene fluoride (PVDF), polysulfone (PS), polytetrafluoroethylene (PTFE), and polycarbonate (PC) (Imtiaz et al., 2022).

Cellulose acetate has a high commercial value because it has good physical and optical characteristics and is biodegradable (Nyamiati, Nurkhamidah, Rahmawati, et al., 2023). Cellulose acetate has advantages as a basic material for making membranes because it has an asymmetrical structure with a very thin active layer, can hold dissolved materials in a rough buffer layer, is resistant to precipitation, produces a balance of hydrophilic and hydrophobic properties (Vatanpour et al., 2022).

CA polymer will be dissolved using NMP solution. NMP is classified as a biodegradable solvent, resistant to chemicals and heat, low toxicity, low viscosity and has strong polarity. In addition, NMP is also volatile and is not expected to bioconcentrate or leach into soil, sediment or suspended organic matter as it is fully soluble in water

This research will study the effect of immersion time variation on the characteristics and performance of the membrane in separating MPs in water. The membrane will be made using Cellulose Acetate (CA) and N-methyl Pyrrolidone (NMP) as solvent. This membrane is printed using the casting method, where this method uses the principle of phase inversion. The membrane will be tested for selectivity using microplastic solution made from Polyethylene Tereftalate (PET).

2. Materials and Method

2.1. Materials

In the process of making membranes for microplastics, a chemically pure Cellulose Acetate (CA) polymer base material with a degree of purity of 39.2% was purchased from Sigma-Aldrich. The solvent used N-methyl-2-pyrrolidone (NMP) 99% with a molecular weight of 99.13 g/mol purchased from Merck KgaA (Darmstadt, Germany). And distilled water as non-solvent. Also, the MPs particles used were of PET (Polyethylene Terephthalate) type derived from used beverage packaging bottles of the same brand.

2.2. Membrane Preparation Method

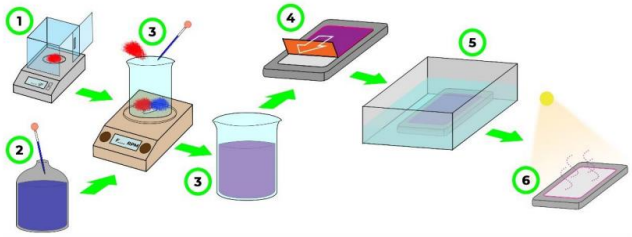

Figure 1. Membrane Preparation by Casting Method

Preparing the Polymer Solution. This method begins with the preparation of the polymer solution. The process of preparing the polymer solution is described in Figure 1 at

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numbers 1-3. (1) Weighing the CA polymer to be used according to the calculation variables. (2) Then the polymer is put into a bottle which is then added to the NMP solvent according to the specified variables. The ratio of polymer and solvent used is Polymer:Solvent (15:85). (3a) CA polymer and NMP solution were homogenized using a hotplate stirrer at 80°C with a rotating speed of 500 rpm. (3b) After homogenization, the solution was allowed to stand for 24 hours to remove bubbles in the anesthetic solution.

Preparation of microplastic membrane. The next stage is the manufacture of flat sheet membrane by casting method. The process of making flatsheet membranes is described in Figure 1 numbers 4-6. This stage begins with preparing a membrane mold that will be used to print the membrane. (4) The polymer solution that has been homogeneous is poured and molded using a mold/molding, before being immersed in a non-solvent solution, the polymer solution in the molding is allowed to stand for 1 minute at room temperature (30°C). (5) Then the membrane mold is inserted into the non-solvent solution, namely distilled water and (6) immersion according to the variable immersion time, namely 10; 17.5; 25 minutes at room temperature (30 ° C).

MPs solution for membrane performance test. In conducting performance tests on the durability and effectiveness of the membrane in removing microplastics, it is necessary to have a test solution that will be filtered. In the production of the test solution, it is done by smoothing plastic bottles that have PET content in them. Plastic bottles are cut into small pieces and baked at 100°C for 24 hours to remove the water content in the bottle. Next, the plastic bottle pieces were pulverized using a miller. The crushed plastic bottle powder was filtered using a 400 mesh sieve to obtain MPs particles <37 μm. Then the MPs particles <37 μm were rinsed using 70% alcohol to clean them from contaminants, then the MPs were dried and degassed by aeration for 60 min. 500 mg of MPs powder <37 μm was dissolved in 1L of distilled water, and mixed using a magnetic stirrer hot plate at 30°C with 120 rpm for 1 hour (Dey et al., 2023).

Membrane Characterization. The expected membrane is microfiltration and hydrophilic, so testing is needed including contact angle, porosity, and water content to determine the nature and tendency of the membrane to absorb water and also to determine the hydrophilicity of the membrane, as well as bubble point test and Scanning Electron Microscope (SEM) to determine membrane surface morphology and membrane pore diameter size.

The contact angle (θ) was carried out by dripping distilled water on the membrane surface. The distilled water was dripped using a drop pipette with a volume of 10 μm. Next, observe the changes in the droplets of distilled water on the membrane surface for 10 seconds, and measure any changes in the angle of the distilled water droplets on the membrane surface. Distilled water was dripped at 5 different points on the surface of the membrane to further accentuate the hydrophilicity of the membrane.

Analysis of porosity (ε) and moisture content (X%) in the membrane can be done by immersion the membrane in distilled water for 24 hours. After immersion, the membrane is dried by aerating. Next, measure the wet weight of the membrane with an analytical balance, then the membrane is dried using an oven at a temperature of 70 ° C for 2 hours to remove the content of distilled water in the membrane. After the membrane is dry, the dry weight is measured. Porosity was calculated with the equation:

$$\varepsilon = \frac{(\frac{W_w - W_d}{\rho_w})}{(\frac{W_w - W_d}{\rho_w}) + (\frac{W_d}{\rho p})} \times 100\% \quad \text{..... (1)}$$

Description :
Ww = wet membrane weight
Wd = dry membrane weight
ρw = density of water
ρp = polymer density

and membrane moisture content can be calculated using the following equation:

$$X\% = \frac{W_s - W_d}{W_s} \text{ x } 100\% \quad (2)$$

Description:
X% = Water content (%)
Ws = Wet membrane
Wd = Dry membrane

The bubble point (Dp) method is carried out to determine the largest pore size in the membrane. This method begins with wetting the surface of the membrane and filled with liquid in the form of distilled water, then the liquid in the pore will be pushed with N_2 gas from the bottom of the membrane. The membrane pore size can be calculated using the equation:

$$D_p = \frac{4\gamma \times \cos\theta}{\Delta P_b} \text{..... (3)}$$

Description:
Dp = Diameter of the largest pore
γ = Surface tension of liquid-gas interface (water-N2)
θ = Membrane contact angle
Pb = Membrane bubble point pressure

Membrane Performance Test. In this experiment, the flat sheet membrane will be tested for performance using the permeation method. In the performance test, the flow rate of the test solution will be set as a fixed variable and the operating pressure will be a changing variable. During the performance test, the permeate solution will be taken after 5 minutes under pressure. The sample obtained will be calculated %MRE (Mass Removal Efficiency) MPs. The filtration result (filtrate) is collected in a container to

measure its volume. The concentration of the microplastic solution was measured before and after filtration using the dry weight method.

The microplastic separation efficiency (MRE%) was calculated as follows:

$$\text{MRE\%} = (1 - \frac{\text{Im}}{\text{Fm}}) \times 100$$

Description:
Im = Initial mass of microplastics before microfiltration
Fm = Final mass of microplastics after microfiltration

3. Results and Discussion

3.1 Analysis of Membrane Characteristics

The CA/NMP (15:85) membrane produced by the phase inversion method was flatsheet-shaped and white in color. The membrane flatsheet was printed using molding, so that each membrane has almost the same thickness size, which is about 125 ± 2 μm. After measuring the thickness, the membrane will be tested for its characteristics and performance in separating microplastics in water.

Based on the results of the analysis of the characteristics that have been carried out, the results are obtained as in Table 1, below:

Table 1. Results of Characteristic Analysis of CA/NMP Membrane (15:85)

Immersion Time (min)	θ (°)	ε	X%	Dp (μm)
10	53.4	83.08%	82.21%	8.4
17.5	55.2	82.33%	81.44%	6.3
25	60.5	80.29%	79.32%	5.8

Based on **Table 1**, it is known that variations in immersion time affect the hydrophilicity of a membrane. Surface hydrophilicity is one of the important properties in microfiltration membranes for MPs separation. Superior membrane hydrophilicity properties are able to attract more water molecules and reduce contaminant deposition on the membrane, resulting in higher permeability with enhanced anti-fouling capabilities. Fouling is the accumulation of unwanted substances on the membrane surface or within its pores, leading to a decrease in filtration performance over time (Nyamiati, Yulianto, et al., 2023).

In this study, it is expected to obtain a hydrophilic membrane because its properties are needed for the microfiltration process of MPs from water. Hydrophobic membranes will cause the membrane to be difficult to separate MPs in water which will cause a decrease in membrane performance because the fouling formed due to MPs will cover the membrane pores and cause the solution to not be able to enter through the membrane. (Gnanasekaran et al., 2021).

3.1.1 Membrane Contact Angle

Based on **Table 1**, it is known that the longer the immersion time in the membrane formation process, the contact angle value increases. At the immersion time of 10 minutes, the contact angle formed is 53,4° and increases as the immersion time increases, so that at the immersion time of 17.5 minutes the contact angle formed is 55.2° and at the immersion time of 25 minutes the contact angle formed is 60,5°.

This increase in contact angle is in line with the research conducted by Fonouni *et al.*, (2017) and Nawi *et al.*, (2020), they reported that the increase in immersion time caused an increase in the contact angle which indicates that the membrane is increasingly hydrophobic. This increase in contact angle can occur because with respect to longer immersion times it can be attributed to a higher amount of polymer residue being within the membrane matrix. Although a small portion of the polymer dissolves during the phase inversion process, some remains in the membrane matrix, leading to the formation of a denser pore structure on the upper surface of the membrane during the immersion time (Nawi et al., 2020).

The contact angle formed is still in the range of 50°-60°, indicating that the membrane formed is hydrophilic. This is in accordance with the results of research conducted by Ali et al who reported that contact angle values above 90◦ indicate that the membrane is hydrophobic, while below 90◦ is hydrophilic (Ali et al., 2023). In addition, the nature of the polymer used in the manufacture of this membrane also affects the hydrophilicity of the membrane itself. This membrane is made with the main polymer material is cellulose acetate, which cellulose acetate is a polymer that is hydrophilic (Pizzichetti et al., 2021). Hydrophilic membranes have advantages such as absorbing more water molecules so that the resulting membrane permeability value is higher than hydrophobic membranes (Gnanasekaran et al., 2021).

3.1.2 Porosity and Water Content of Membrane

Based on the research data in Table 1, as the membrane immersion time increases, the porosity value and membrane water content decrease. In the variable immersion time of 10 minutes, the porosity value of the membrane is 83.08% and the water content value is 82.21%. Then in the variable immersion time of 17.5 minutes, the porosity value decreased to 82.33% and the water content value was 81.44%. And continued to decline so that in the 25-minute immersion time variable, the porosity value became 80.29% and the water content value was 79.32%. The decrease in porosity value and water content indicates a lower water permeability value (Yang et al., 2022).

Increasing membrane immersion time causes porosity and membrane moisture content to decrease. This is in line with research conducted by Silva, *et al*., (2021) and Wang *et al.*, (2022), which states a decrease in porosity due to the increase in membrane immersion time. This can occur because the increase in immersion time makes the solvent and non-solvent membrane have more time to diffuse so that

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water has enough time to absorb and replace the solvent in the polymer matrix thoroughly, which can increase the porosity of the membrane. The pores formed are more evenly distributed because the water spreads well and replaces the solvent thoroughly throughout the membrane (Wang et al., 2022).

The decrease in water permeability value is also related to the results of the contact angle analysis of the membrane. Based on the results of the contact angle in Table 1, it is known that the contact angle value of the membrane increases as the membrane immersion time increases, this indicates that the membrane is increasingly hydrophobic. Therefore, the more hydrophobic the membrane will cause the porosity value and moisture content of the membrane to decrease, and its water permeability ability also decreases. (Silva *et al.*, 2021).

In addition, it can also be seen if the porosity value and moisture content are directly proportional. When the porosity value of a membrane increases, the moisture content value of the membrane also increases. This can happen because the high porosity value can make the membrane permeability high, where the high permeability value can be characterized by the high value of water content in the membrane. This is in accordance with the wrong statement that the factor that affects permeability is porosity. Permeability is strongly influenced by pore characteristics, especially pore stability. The more pores in the membrane, the more pore space that can transmit water so that the permeability becomes large, and the water content in the membrane becomes high (Silva *et al.*, 2021).

3.1.3 Membrane Morphology Structure

Morphological analysis of the membrane is carried out to determine the morphological structure of the membrane, both on the surface and cross of the membrane. The morphological analysis carried out is by Bubble Point Test and SEM.

Membranes used for microfiltration have pore sizes on the scale of 10 - 0.1 μm (Oprea & Voicu, 2023). The largest pore size can be calculated based on the pressure generated when the first bubble appears from the membrane sample, this pressure is called "bubble point pressure". The "bubble point pressure" is defined as the gas pressure when the last bubble of the sample disappears, and this pressure corresponds to the largest pore mouth size (Yu *et al.*, 2010)

In the bubble point test results that have been carried out in Table 1, it is known that the largest pore diameter size in the CA / NMP membrane (15: 85). At the immersion time of 10 minutes, the largest pore size of the membrane formed was 8.4 μm and decreased as the immersion time increased, so that at the immersion time of 17.5 minutes the largest pore size formed was 6.3 μm and at the immersion time of 25 minutes the largest pore size formed was 5.8 μm. From these results, it is known that the largest pore size on the membrane has met the pore size of the microfiltration membrane.

The pore size decreases as the membrane immersion time increases, this can occur due to the diffusion process between solvents and non-solvents. During the immersion process, the NMP in the polymer solution will diffuse out into the non-solvent solution (distilled water) in the coagulant bath, while the non-solvent will diffuse into the polymer solution. This movement causes the polymer in the solution to precipitate and form a pore structure. The longer the immersion time, the more solvent diffuses out and the more distilled water diffuses in, resulting in an increase in the density of the polymer structure and a reduction in the pore size (Wang et al., 2022).

The bubble point test results were validated by performing SEM analysis to ensure that the pore size measured mechanically matched that seen visually.

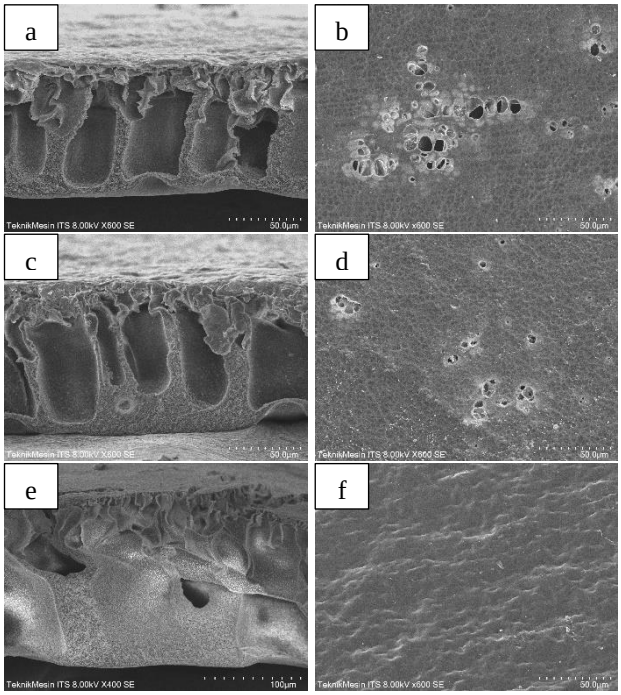

Figure 2. SEM analysis results of CA/NMP (15:85) membrane with cross section of the membrane for immersion time (a) 10 minutes, (c) 17.5 minutes, (e) 25 minutes. And the cross section of the membrane surface with immersion time (b) 10 minutes, (d) 17.5 minutes, (f) 25 minutes.

Asymmetric membranes consist of a thin top layer supported by a porous sublayer that often contains large void spaces, or macro cavities. These macrovoids can exhibit different morphologies (i.e., finger-like or sponge-like), the presence of macrovoids in the membrane has advantages and disadvantages. Macrovoids can result in compaction or collapse of the membrane and hence limit applications in high-pressure processes (Anuar *et al*., 2019).

The results of SEM analysis that have been carried out on the CA/NMP (15:85) membrane on the cross-sectional structure of the membrane show that the three membranes

are asymmetrical membranes consisting of two layers where the top layer is thin and tight while the bottom layer is porous which functions as a buffer and can provide resistance to the membrane. From Figure 2, it is known that the increase in immersion time causes a more membrane pore structure. In Figure 2(a) shows the cross section of the membrane, it can be seen that the membrane has a hollow cross-sectional structure that resembles a finger. Then in Figure 2(c) the pore cavity structure formed is not as clear as Figure 2(a), the finger cavity structure begins to fade but the finger shape is still visible. Furthermore, in Figure 2(e) it can be seen if the finger-shaped structure on the membrane is increasingly invisible. The shape of the membrane pore structure increasingly resembles a sponge and becomes denser.

In addition, based on the bubble point test results, it shows that the increase in immersion time causes a decrease in the pore size on the membrane surface. This can be strengthened by the results of SEM analysis that has been carried out. Figure 2(b) shows the top surface of the membrane with an immersion time of 10 minutes, which shows there are pores on the membrane. Based on the results of SEM analysis with a magnification of 50 μm, the largest pore size in the membrane is 10.58 μm. Furthermore, Figure 2(d) shows the surface of the membrane with an immersion time of 17.5 minutes, where the pores formed are fewer and have the largest pore size of 6.6 μm, which indicates a decrease in the pore size of the membrane. Figure 2(f) shows the surface of the membrane soaked for 25 minutes. The membrane pores are not visible at 50 μm magnification, this can occur because the membrane pores formed are so small that they are not visible on the membrane surface.

Changes in the pore structure of the membrane can change due to the influence of the membrane immersion time, it results in the appearance of a denser pore structure without large macrovoids. With the increase of immersion time, the diffusion of NMP out of the membrane and distilled water into the membrane becomes more controllable. This allows CA to precipitate more The membrane structure becomes denser and more organized. At the beginning of immersion, macrovoid structures (large pores) were formed in the membrane due to the high diffusion speed of NMP. However, over time, the diffusion becomes slower and more stable, reducing the formation of macrovoids resulting in a smaller and more uniform pore structure (Saffar et al., 2014). This is in line with research conducted by Wang *et al.*, (2022) who examined the effects of various immersion times on Cellulose Acetate (CA) membranes. They reported that the increase of immersion time, the open porosity of the membrane surface decreases. The porous structure of the membrane surface gradually converges into a macroporous structure with low porosity, which causes the permeability of the membrane to decrease. The longer the immersion time, the more solvent is evaporated. Therefore, it is easy to form a denser porous structure in cross section.

3.2. Membrane Performance

Macrovoids in the membrane greatly affect the performance of the membrane. The macrovoids structure of the membrane can increase the overall permeability of the membrane, however, this often compromises the selectivity of the membrane, as it allows unwanted components to pass through. Macrovoids become pathways through which particles or solutes can pass without being filtered, leading to reduced separation efficiency (Anuar *et al*., 2019).

The variation of immersion time causes changes in the macrovoid structure of the membrane to become denser, so to determine the efficiency of these structural changes, it is necessary to test the performance of the membrane. Therefore, we report the separation efficiency (%MRE) of microplastics in water to help provide comparable results with other studies.

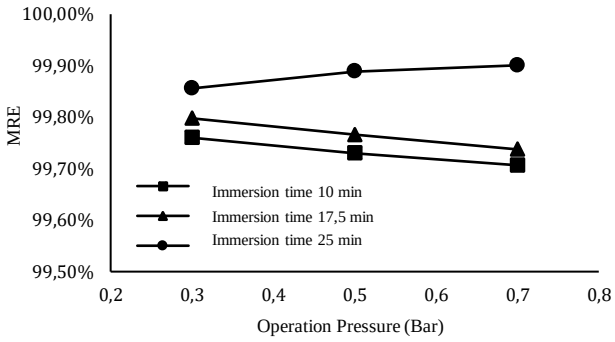

Figure 3. CA/NMP (15:85) Membrane Performance Test Results

Based on the test results in Figure 3 above, it can be seen the results of microplastic rejection on membranes with CA / NMP composition (15: 85) with an immersion temperature of 30 ° C with immersion times variation of 10; 17.5; 25 minutes. Based on the graph above, MP membrane %rejection with variable 10 and 17.5 minutes decreased with increasing pressure, so that at a pressure of 0.7 bar %rejection reached 99.74% and 99.71%. However, the CA/NMP (15:85) membrane with a variable of 25 minutes increased with increasing pressure, so that at a pressure of 0.7 bar % rejection reached 99.9%.

It can be seen that the immersion time of 10 and 17.5 minutes decreases as the operating pressure increases. This decrease in %rejection can occur because MPs particles passing through the membrane have different sizes, so that large particles will be pushed through the membrane pores and will tear the inside of the membrane. In addition, in the variable immersion time of 10 and 17.5 minutes there are still many macrovoid structures formed in the membrane pores, this causes the selectivity of the membrane to be low and makes it easier for microplastic particles to penetrate the membrane, so that the greater the driving force, the MPs particles that will pass through the membrane will increase (Dey et al., 2023). However, in the CA / NMP membrane (15: 85) with a variable immersion time of 25 minutes, the %rejection increased. At this immersion time, the membrane pore structure formed becomes denser with reduced macrovoids in the membrane, this makes microplastic particles not easily penetrate the membrane and are retained in the membrane pores which results in closed membrane

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pores so that microplastic particles cannot pass through the membrane and increase membrane %rejection (Gnanasekaran et al., 2021).

4. Conclusion

The formed CA/NMP (15:85) membrane has good hydrophilicity. Membrane immersion time has an influence on the characteristics and performance test of CA/NMP (15:85) flatsheet membrane. As the immersion time increases during the phase inversion process, the hydrophilicity of the membrane increases. The results of the analysis of the characteristics obtained, the membrane has a contact angle in the range of 53° - 61°, porosity of 83-80% and moisture content of 82-79% and has a pore size ranging from 8.4-5.8 μm which is in accordance with the microfiltration membrane, and the membrane's rejection ability can reach 99%. From these results, it can be seen that microfiltration with membrane technology can be used to separate microplastics in water. Based on the experiments that have been carried out, the best membrane is obtained as the immersion time increases. CA/NMP membrane (15:85) with 25 minutes immersion time is the best membrane in this experiment, the membrane is the most effective in reducing microplastics in water.

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