JURNAL KIMIA VALENSI
p-ISSN: 2460-6065; e-ISSN: 2548-3013
Journal homepage: https://journal.uinjkt.ac.id/index.php/valensi
Research Article

Preparation of Pectin Membranes with Polyvinyl Alcohol (PVA) Blended Method as Dialysis Membrane for Urea Transport

Budi Hastuti[1*], Garnish Teantine Aurura[1], Saptono Hadi[2]

[1]*Department of Chemistry Education, Faculty of Teacher Training and Educational Sciences, Sebelas Maret University, Surakarta, Central Java, 57126, Indonesia*
[2]*Department of Pharmacy, Faculty of Matematics and Natural Sciences, Sebelas Maret University, Surakarta, Central Java, 57126, Indonesia*

[*]*Email: budihastuti@staff.uns.ac.id*

Article Info
Received: July 5, 2024
Revised: April 4, 2025
Accepted: May 13, 2025
Online: May 31, 2025

Citation:
Hastuti, B., Aurura, G. T., & Hadi, S. (2025). Preparation of Pectin Membranes with Polyvinyl Alcohol (PVA) Blended Method as Dialysis Membrane for Urea Transport. *Jurnal Kimia Valensi*, 11(1), 30-40.

Doi: 10.15408/jkv.v11i1.40016

Abstract

Pectin has shown the potential to act as membranes in a variety of applications, such as in biomedical applications such as that carried out in this study. This study aims to modify pectin with polyvinyl alcohol (PVA) for hemodialysis membrane applications. Pectin-PVA membranes were made by immersing the membrane with 4% PVA and tested for the membrane's filtration capacity for transport. Pectin-PVA membranes were tested using Tensile Test, Fourier Transform Infrared (FTIR), X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and Thermal Test. The results showed that the pectin blended polyvinyl alcohol (PVA) membrane was successfully synthesized, confirmed by the spectra on FTIR there were OH vibrations, $–CH_2$, –CH, -CO (ester) and CO (ether) bonds, PVA will increase the stress and strain value, XRD data shows that the membrane has a crystalline structure, SEM data shows that the membrane including in the microspheres, and the membrane undergoes carbonization at a temperature of around 400 °C there is an increase in the absorbance value, and the urea transport process increases the absorption of urea every hour.

Keywords: Blend, pectin, PVA, transport, urea

1. INTRODUCTION

Indonesia is a tropical country, a region characterized by high and humid air temperatures. Many fruits can grow well in Indonesia. Examples of fruits that can grow in Indonesia include oranges, bananas, mangoes, papayas, guavas, and so on. Oranges (Citrus sinensis) are one of the fruit commodities that have a very important role in the market both domestically and internationally, in fresh or processed form. In Indonesia, orange production has occupied the second highest position after bananas. Orange plants are native to Indonesia and almost all areas of Indonesia can be planted with oranges. The components of orange plants that are ready to be harvested consist of 65% edible fruit, 30% peel; 5% seeds [1]. In addition to the fruit, orange peel contains various nutrients, such as vitamin A, vitamin B, vitamin C, calcium, magnesium, and potassium. Orange peel also contains essential oils, flavonoids, phenolics, and pectin. Oranges have a fairly high pectin content, which is around 30%. All orange peels are included in the high methoxyl pectin group [2]. In general, commercial pectin comes from orange peel, because it has a relatively higher pectin content [3].

Development in the field of health is greatly needed because it will undoubtedly bring numerous benefits to life, especially with the increasing prevalence of various diseases in humans today. Diseases can arise due to bad habits, such as kidney failure caused by insufficient intake of water. Kidney failure is a condition where the kidneys cannot function normally due to damage to the kidney's filtration and secretion processes [4]. According to the According to the World Health Organization (WHO), people with kidney failure, both acute and chronic, reach 50%, while those who suffer from kidney failure only 25% are known and receive medical treatment and 12.5% can be treated well [5]. Medical interventions such as kidney replacement therapy can include hemodialysis, peritoneal dialysis, and kidney

transplantation [6]. Dialysis methods involve the transfer of dissolved molecules from a solution through a semi-permeable membrane due to diffusion. Smaller molecules pass through the membrane pores, while larger molecules are retained within it. Dialysis methods used for kidney failure patients include hemodialysis (HD) and peritoneal dialysis (DP), both utilizing semi-permeable membranes. During the dialysis process, there is a transport process where molecules capable of passing through the membrane move in and out [7].

Membrane transport is divided into two types: active transport and passive transport. Passive transport, a process across membranes, involves the movement of molecules that can pass through the membrane [8]. The transport system studied in this research focuses on urea transport. Urea is a molecule derived from ammonia formed during the deamination of amino acids in the liver [9]. Elevated levels of urea in the body can become toxic (uremia), impairing the kidney's ability to filter and eliminate metabolic waste products. In chemistry, a membrane is a thin barrier that selectively restricts passage (semipermeable) between two phases, impermeable to certain particles or chemicals [10]. Some components are permitted to enter the permeate stream (mixture passing through the membrane), while others are retained by the membrane and accumulate in the retentate stream (mixture not passing through the membrane) [11]. Innovations in membrane fabrication are crucial in the field of health, particularly utilizing compounds found in plants. Plant compounds are chosen because their metabolic reactions are compatible with human metabolism, facilitating easy acceptance of their molecular structures by the body [12]. There are several compounds from plants that can be used for membrane production such as alginate, cellulose, and pectin. The functional properties of natural alginate often have weaknesses such as low solubility, unstable solution stability, undesirable gel formation in viscous products, low viscosity and other shortcomings that cause limitations in its use [13]. While in cellulose acetate, it is very sensitive to pH between 2 and 8, biodegradable, which is very susceptible to microbes in nature [14]. So in this study Pectin was chosen because of its biodegradable ability (materials that can be naturally decomposed by nature) and biocompatible (the ability to work with the appropriate host response in certain applications), and has chemical and physical properties such as gelation, permeability, selectivity and others, pectin is a polymer matrix that can be applied in the membrane field [15].

Pectin is a complex polysaccharide composed of esterified D-galacturonic acid residues **(Figure 1)**. Esterification of galacturonic acid residues with methanol or acetic acid is a distinctive functional group characteristic of pectin [16]. Commercial pectin is commonly derived from citrus peels, which have a relatively higher pectin content compared to other fruit peels [17]. Pectin exists as coarse or fine powder, ranging from white to yellowish in color, and nearly odorless. It contains carboxyl (O-H), C-H, carbonyl (C=O), C-O, and CH_3 groups [18]. Pectin is susceptible to physical, chemical, and enzymatic changes. One significant characteristic of pectin is its ability to form membranes [19]. To optimize the characteristics of pectin as a membrane, it is necessary to modify the membrane surface.

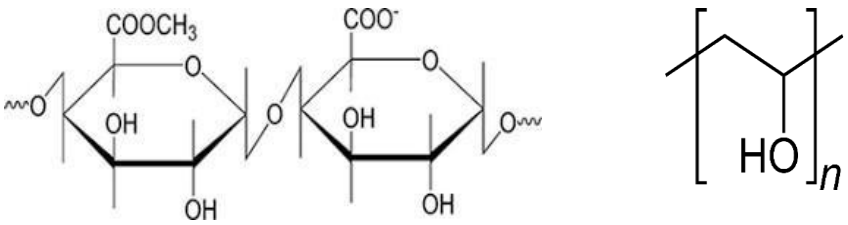
The goals of membrane surface modification are: (1) reduction of undesirable human serum protein-membrane interactions, which cause blood activation, in addition to protein adsorption (membrane fouling) which reduces efficiency, and (2) improvement of selectivity or even creation of completely new separation capabilities [20,21]. In the membrane modification process, various variables must be critically controlled, including stability, homogeneity, roughness, process control, and acceptable cost, as well as refinement of functional groups, which is an important issue [22].

To modify the membrane there are three types of methods, namely grafting, crosslinking, and blending [23]. By using one of the techniques mentioned above, namely blending, hollow fiber membranes can be modified, unlike most grafting methods, which modify the surface of flat sheet membranes. The most widely used blending components to improve the hydrophilic properties of HD membranes are biocompatible hydrophilic polymers such as polyethylene glycol (PEG), oligo(ethylene glycol) (OEG), polyvinylpyrrolidone (PVP), polyvinyl alcohol (PVA), and zwitterionic polymers (ZW) [24,25]

The blending agent used is PVA, which is a non-toxic and water-soluble synthetic polymer, widely used in polymer blends due to its good physical and chemical properties as well as excellent film-forming and emulsifying properties. Its use is important in various applications such as controlled drug delivery systems, membrane preparation, polymer recycling and packaging, etc. Its bioinertness makes it useful in medical applications such as artificial pancreas, hemodialysis, nanofiltration, and implantable medical devices [26].

PVA appears to be an attractive material for constructing asymmetric porous membranes with good selectivity and permeability. In addition to its high fouling resistance, PVA is highly hydrophilic, has good pH stability, is mechanically very durable, and exhibits excellent biocompatibility [27]. PVA can be used as an additional polymer or low molecular weight additive to modify the membrane structure [28].

In this study, pectin is synthesized into a dialysis membrane with the addition of polyvinyl alcohol to enhance its tear resistance, resulting in improved chemical stability, effective transport of toxic compounds (urea), high mechanical strength, and better compatibility. The interaction between the polymer membrane and the transferred compounds through this mass transfer channel can occur via hydrogen bonding.



(a) (b)

Figure 1. Structure: (a) pectin, (b) PVA

2. RESEARCH METHODS

Materials and Instruments

Pectin (orange peel), 4% poly(vinyl alcohol) (PVA), 1000 ppm urea, 5 ppm vitamin B_{12}, sodium hydroxide (NaOH), potassium dihyrogen phosphate (KH_2PO_4), 4-dimethylaminobenzaldehyde ($C_9H_{11}NO$), ethanol (C_2H_5OH), hydrochloric acid (HCl), and aquabidest.

Measuring cup, beakers glasses, watch glasses, dropper, spatula, stirrer, measuring flask, funnel, vials, filter paper, thermometer, stirrer (Mtops MS300 Hs), magnetic stirrer, digital analytical balance, pH meter (Lutron pH-201), plastic mold container (PVC), oven (Memmert), hotplate magnetic stirrer (Thunder), a series of transport device, Tensile Test On Plastic ISO 527 (Zwick Roell UTM Z020), FTIR (Shimadzu FT-IR 8201PCi), XRD (Bruker D2 Phaset 2nd Gen), SEM (Zeiss DSM 960), and spektrofotometer UV-Vis (UV-1601PC Spektrofotometer UV-Visible).

Pectin Membrane Synthesis

Make a pectin membrane by dissolving 0.5gram of pectin into 50 mL of distilled water and 0.5gram of pectin into 100 mL of distilled water and stir until homogeneous. Then pour into PVC molds and oven at 50 °C for 24 hours to dry. After drying, the membrane was removed from the PVC and characterized.

In this study the pectin studied was only 1% and 0.5% (A and B), because the higher the concentration the thicker the resulting membrane will be. membrane thickness is a significant characteristic that has a negative effect on the flux value, which means that the flux value will decrease as a function of membrane thickness [29].

PVA Blend Pectin Membrane

The pectin membrane was immersed in a 4% PVA solution and allowed to stand for 6 hours in a closed state. After 6 hours, the membrane was washed with distilled water to remove unblended hydroxyl groups on the membrane surface. After that, it was baked at a temperature of 50 °C to dry and characterization was carried out.

In this study, a PVA concentration of 4% was used because the higher the PVA concentration, the thicker the membrane will be, so that the distance that the sample must travel to pass through the membrane becomes longer, the permeation takes longer, so that the flux value becomes lower [30].

Urea Transport with Pectin-PVA Membrane

Transport is done by placing the Pectin-PVA membrane in the chamber. The solution in the source phase contains 1000 ppm urea, 5 ppm vitamin B_{12}, while the receiving phase contains Phosphate-buffered Saline (PBS) solution with a pH of 7.4 [31]. Transport was carried out for 2 hours, every hour 2 mL of sample solution was taken from the receiving phase, and urea levels were measured using UV-Vis.

The function of vitamin B_{12} in this study is as another substance assumed to be in the blood such as urea in patients with kidney failure. Vitamin B_{12} in kidney metabolism, shows its role in vitamin homeostasis (vitamin balance in the body). So when applied, it is expected that vitamin B_{12} cannot pass through the membrane because it is still beneficial for the body and only urea will pass through the membrane so that it can be disposed of.

Pectin Membrane Characterization

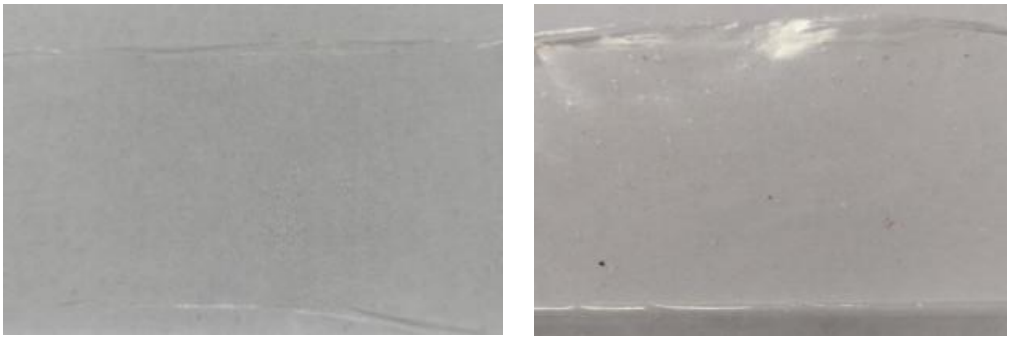
Characterization of PVA blended pectin membrane using tensile strength test, FTIR, XRD, SEM, Thermal Test, and measurement of urea content using UV-Vis Spectrophotometer of Adsorption Capacity.

3. RESULTS AND DISCUSSION

Pectin Membrane Synthesis

The results of the synthesis of Pectin A membrane (1%) by dissolving 0.5 g of pectin in 50 mL of distilled water, are shown in **Figure 2 (a)**, while the Pectin B membrane (0.5%) by dissolving 0.5 g of pectin in 100 mL distilled water, shown in **Figure 2**

(b), the two membranes produced were clear and thin like plastic but easily torn. So, the pectin membrane needs to be blended so that the pectin membrane is not easily torn so that it can be applied.



(a) (b)

Figure 2. Pectin membrane synthesis results (a) Pectin A (b) Pectin B

In the pectin A membrane, it is completely dry when heated in oven at 50°C for 24 hours, but in the pectin B the middle part is not completely dry. The two membranes formed have differences in the level of thickness and the time required to form the membrane, Pectin A membranes are thinner and faster to form than Pectin B membranes, because more water is used in Pectin B membranes.

PVA Blend Pectin Membrane

The results of transplanting pectin membranes using 4% PVA as much as 30 mL for 6 hours in closed conditions. At first the pectin membrane was clear and thin and easily torn, after the addition of PVA on the Pectin A membrane (1%) shown in **Figure 3 (a)** and Pectin B membrane (0.5%) shown in **Figure 3 (b)**, the two membranes were Resulting colour is clear, cloudy, thicker, and stronger.

However, what distinguishes the two membranes formed is the thickness of the membrane and the time it takes for the membrane to dry after blending. The addition of PVA affects the thickness, strength (not easily torn), and elasticity of the membrane, because PVA is a plasticizer that functions to repair the functional groups of pectin membranes.

The functional groups found in the PVA structure are the -OH group, the -CH_2 group, the -C=O group, the C-H group, the C-O group, and the C-C group. The functional groups that increase due to the addition of PVA are the C-O group, C=O group, C-H group, and -OH group (**Figure 4**).

(a) (b)

Figure 3. Results of Blended Membrane (a) Pectin-PVA A (b) Pectin-PVA B

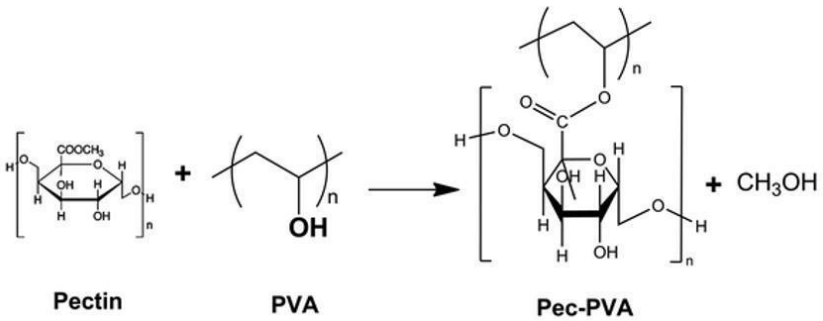


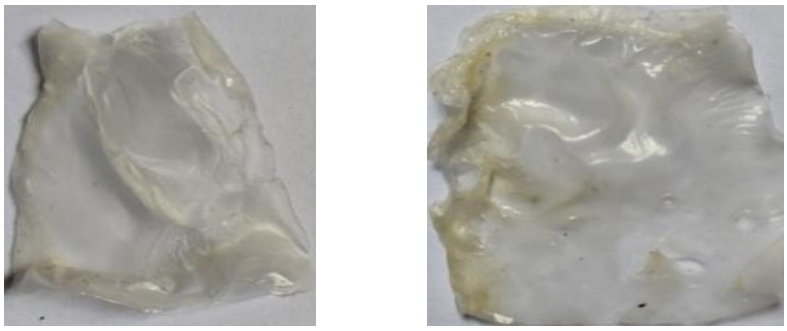
Figure 4. Reaction of Pectin Membrane with PVA

Urea Transport with Pectin-PVA Membrane

The results of the Pectin-PVA membrane used for transport for 2 hours after drying at room temperature changed. The Pectin-PVA A membrane (1%) is shown in **Figure 5 (a)**, while the Pectin-PVA B membrane (0.5%) is shown in **Figure 5 (b)**, both of which are seen to have a clear, cloudy, slightly yellowish color. In this study, the urea transport process was carried out to absorb urea in the source phase, so that the urea in the source phase could enter the receiving phase.

In **Figure 6,** dialysis A uses Pectin-PVA A membrane and dialysis B uses Pectin-PVA B membrane. The graph shows an increase, this increase in value is an absorbance value which indicates that the membrane can be used for the dialysis (transport) process (**Table 1**).

The results of the application of Pectin-PVA dialysis membranes in urea transport using 2 mL of sample solution from the receiving phase taken every hour, the sample solution obtained is clear as **Figure 7 (a)**, after that the solution is complexed with a ratio of 1:1 so that the solution becomes clear yellow as **Figure 7 (b)**. After complexing, followed by testing with a UV-Vis Spectrophotometer to determine the urea content contained in the sample solution.



(a) (b)

Figure 5. Membrane Results After Transport (a) Pectin-PVA A (b) Pectin-PVA B

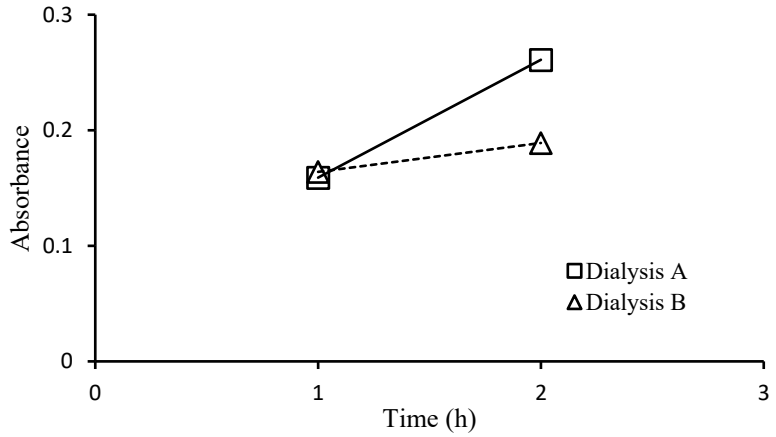
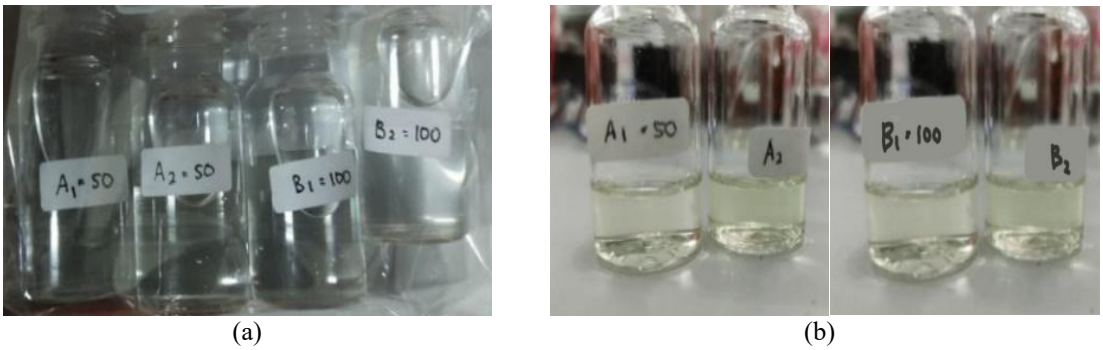


Figure 6. Graph of UV-Vis results mambrane pectin A-PVA and pectin B-PVA

Table 1. UV-Vis Result Data

Sample	1st Hour Absorbance	2nd Hour Absorbance
Dialysis A	0.159	0.261
Dialysis B	0.164	0.189



(a) (b)

Figure 7. Sample solution (a) transport results (b) after complexing the sample solution

In the urea diffusion mechanism through the pore mechanism, the chemical structure of the membrane does not play much role, because the membrane pore size is the main factor in the selectivity of the membrane. Urea can pass through a membrane that has a pore size larger than its molecular size, in contrast to the diffusion mechanism through interaction with the membrane. The diffusion of urea through the mechanism of interaction with the membrane occurs because of the interaction between urea and the membrane which will then be transferred to the dialysate. The interaction between the membrane polymer and the compound transferred through this mass transfer channel can be through hydrogen bonds.

The interaction between the membrane polymer and the compound transferred through the mass transfer channel can occur through hydrogen bonds (**Figure 8**). Hydrogen bonds occur due to the attraction of hydrogen atoms from a molecule that is partially positive by lone electron pairs from atoms of another molecule that are electronegative such as nitrogen (N) and oxygen (O). Hydrogen bonds are not all the same strength. An O···H–O hydrogen bond is stronger than an N···H–N hydrogen bond, because oxygen is more electronegative than nitrogen, so the O–H group is more polar and has a more positive H. Pectin membranes have functional groups –OH, C-O (ether), and C=O (ester) which can act as formers of hydrogen bonds with urea. The following is a description of the interaction reaction between membrane polymers and urea.

Through this hydrogen bonding, a conceptual approach to the transfer of urea across the pectin membrane can be explained. The H atom in the $–NH_2$ group of urea compounds can interact with the O atom in the –OH, CO, or C=O groups of pectin. It is also possible that hydrogen bonding occurs due to the interaction of the O atom of C=O urea with the H atom of the –OH group of pectin. The possibility of interaction of urea with pectin membranes, the hydrogen bonds formed are relatively weak intermolecular hydrogen bonds, so that these hydrogen bonds will be released when they reach the surface of the membrane with the dialysate.

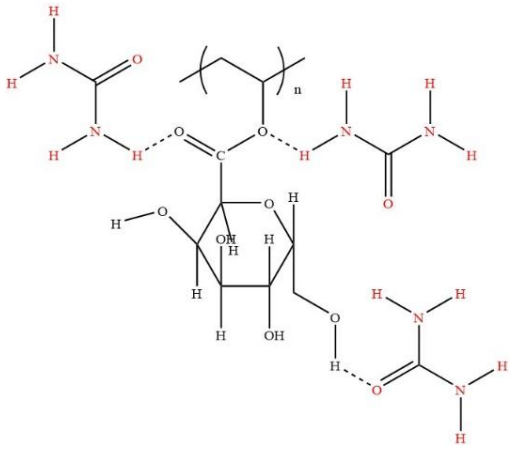


Figure 8. Interaction Reaction Pectin-PVA Membrane with Urea

Pectin Membrane Characterization

Tensile strength testing aims to analyze the resilience of a membrane when subjected to force. A higher tensile strength indicates better resistance to damage or tearing [32]. From the graph shows that the tensile strength of the Pectin A membrane the tensile stress value of the specimen is 6.8593 MPa and the strain is 2.20197 mm/mm, while on the Pectin-PVA A membrane the tensile stress value of the specimen is 8.74964 MPa and the strain is 6.01897 mm/mm (**Figure 9**). In Pectin B the tensile stress value of the specimen is 8.15798 MPa and the strain is 2.26271 mm/mm, while in Pectin-PVA B the tensile stress is 18.9574 MPa and the strain is 10.4751 mm/mm.

Tensile Test (Tensile Test)

These data indicate that Pectin B membranes and Pectin-PVA B membranes dissolved with distilled water had higher tensile stress and strain values, because the membranes formed were thicker and the addition of PVA was successfully used to reduce brittleness, increase strength, and elasticity. So that the pectin membrane becomes stronger or not easily torn and has good chemical stability.

So far, there has been no reference that can be used as a standard for the mechanical strength of hemodialysis membranes. As an illustration, the mechanical strength of the membrane is at least 1.9-14.4 MPa, comparable to the tensile strength of cartilage [33].

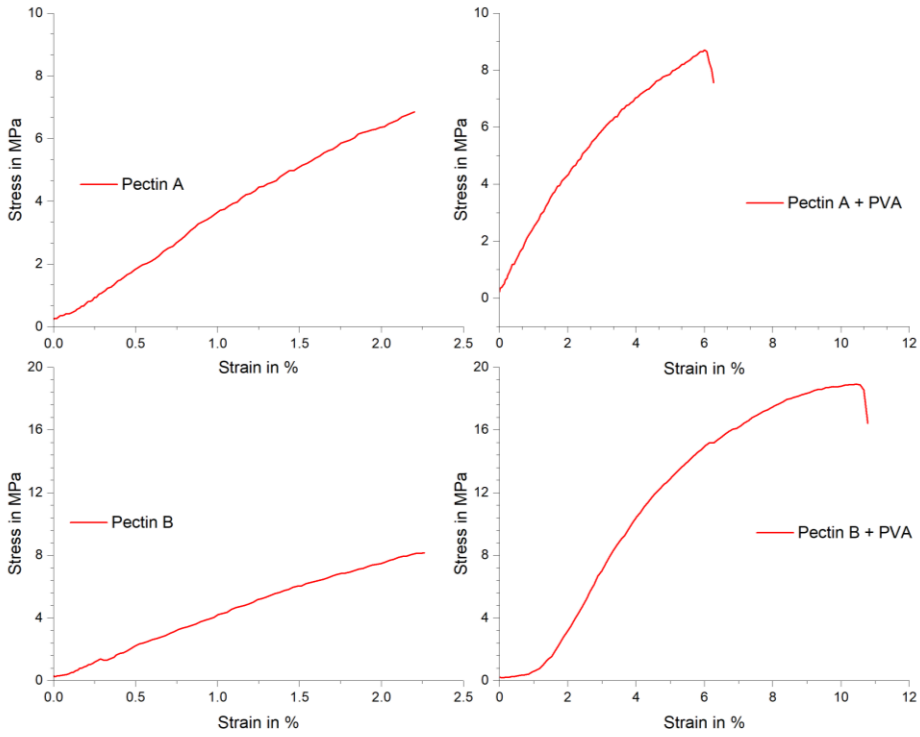


Figure 9. Tensile strength test results for membrane pectin A, pektin A+PVA, pectin B, and pectin B+PVA

Fourier Transform Infrared (FTIR)

In the membrane characterization results, the wave number peaks are obtained as shown in **Table 2**. There was a shift in the wave number of the Pectin membrane with the Pectin-PVA membrane in CO (ether), C=O (ester), CH because the bonding was getting stronger marked by an increase in the wave number (**Figure 10**). Then, the OH on the Pectin membrane with the Pectin-PVA membrane there was a decreasing wave number shift because the bond weakened with the addition of PVA.

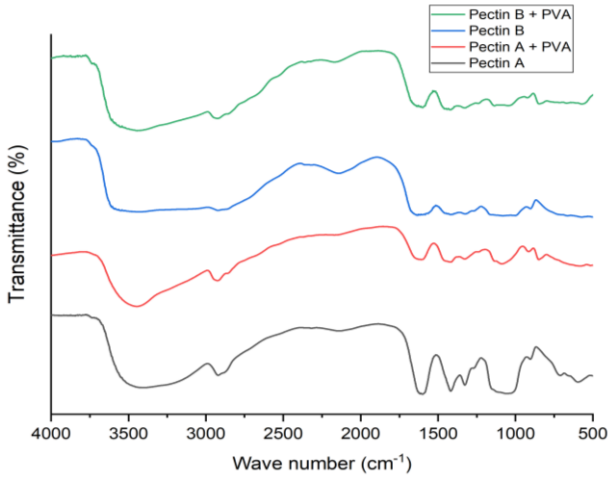


Figure 10. FTIR characterization results for membrane pectin A, pectin A+PVA, pectin B, and pectin B+PVA

Table 2. Results of membrane FTIR spectrum

Wave number	Pectin A	Pectin-PVA A	Pectin B	Pectin-PVA B
CO (ether)	1059 cm^{-1}	1073 cm^{-1}	1081 cm^{-1}	1094 cm^{-1}
$-CH_3$	1418 cm^{-1}	-	1422 cm^{-1}	-
$-CH_2$	-	1424 cm^{-1}	-	1437 cm^{-1}
-C=O (ester)	1735 cm^{-1}	1737 cm^{-1}	1740 cm^{-1}	1742 cm^{-1}
CH	2920 cm^{-1}	2925 cm^{-1}	2921 cm^{-1}	2924 cm^{-1}
OH	3481 cm^{-1}	3461 cm^{-1}	3482 cm^{-1}	3460 cm^{-1}

X-Ray Diffraction (XRD)

The results of the XRD membrane characterization obtained data as shown in **Table 3**. In the diffractogram, Pectin A and Pectin B have low diffraction intensity which indicates the presence of an amorphous structure (**Figure 11)**. Meanwhile, Pectin-PVA A and Pectin-PVA B have a high and sharp diffraction intensity which indicates the presence of a crystalline structure. In pharmaceutical preparations, the crystalline solid form is preferred because it is easier to purify, stable, and reproducible [34].

When viewed based on these results, there is an effect of adding PVA to pectin A membrane and pectin B membrane, which shows that the longer the crystallization time (drying of pectin-PVA membrane) in the manufacture of dialysis membranes can increase the crystal size and also the degree of crystallinity. Factors that affect crystallization are crystallization temperature, cooling rate, agitation, solvent: oil ratio, crystallization time, and type of solvent [35].

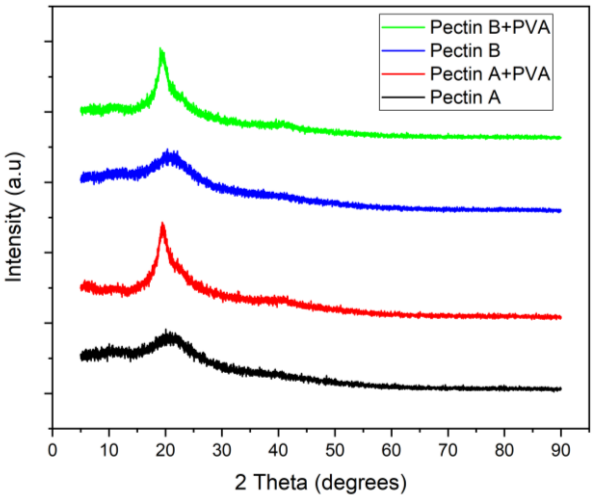


Figure 11. XRD characterization results for membrane pectin A, pectin A+PVA, pectin B, and Pectin B+PVA

Table 3. Diffractogram Analysis

Membrane	Peak Position (2θ)	FWHM	Crystal Size D (nm)	Degree of Crystallinity (%)
Pectin A	20.3715	0.09	82.74906134	0.73
Pectin A + PVA	19.6752	0.09	83.11636163	0.74
Pectin B	20.7437	0.09	82.54770897	0.61
Pectin B + PVA	19,441	0.09	83.23714673	0.85

Scanning Electron Microscopy (SEM)

The results of membrane sample characterization with SEM at a magnification of 10,000× are shown in Figure 12. In **Figure 12 (a) and (c)** are SEM results from Pectin A and Pectin B membranes which show the presence of a rough and wavy membrane surface, while in **Figure 12 (b) and (d)** are SEM results of Pectin-PVA A and Pectin-PVA B membranes showing a more even and unified membrane surface, visible changes in the membrane surface after the addition of PVA. The addition of PVA makes the membrane more even and unified (homogeneous). The less smooth part of the membrane is usually caused by the agglomeration or clumping process on the membrane surface which causes the membrane surface to look different compared to its surroundings.

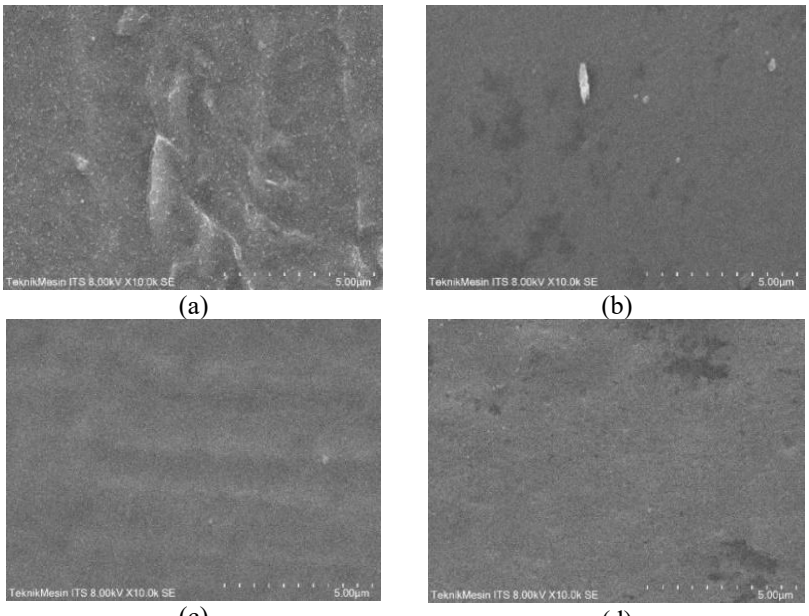


Figure 12. SEM characterization results: (a) pectin A, (b) pectin-PVA A, (c) pectin B, (d) pectin-PVA B

Based on the analysis using ImageJ application, the average particle size of Pectin A membrane was 0.043 µm, Pectin-PVA A was 0.037 µm, Pectin B was 0.063 µm, and Pectin-PVA B was 0.041 µm. The addition of PVA causes the particle size of the membrane to be smaller. Based on this size, the membrane is included in the size of the microsphere. The size of the microspheres should not be greater than 250 µm and ideally less than 125 µm [36].

Thermal Test

Thermal analysis is the analysis the change mass of a sample with a change in the applied temperature. Pure PVA membranes, the first stage ranged from 230 °C with weight loss 11.15%, which was mainly due to evaporation of the adsorbed and bound water. A higher 70% mass loss occurs at 232-481 °C, which is attributed to the thermal decomposition of PVA involving degradation of CH and CH-OH. The third stage with a mass loss of 10% was observed at 481-800 °C, which was associated with complete decomposition. Meanwhile, pure pectin membranes showed three main regions at 30-215 °C weight loss 10-15% of the absorbed free water, 215-400 °C mass loss of about 50% which is attributed to the thermal decomposition of pectin, and 400-600 °C which was associated with complete decomposition [37].

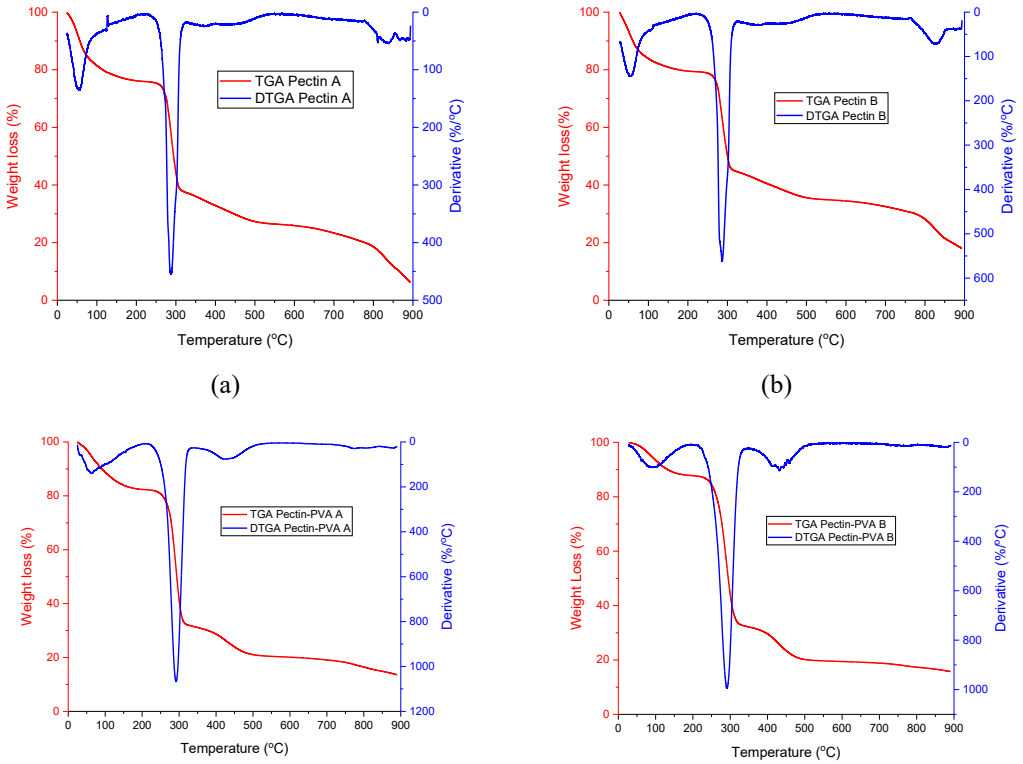


Figure 13. TGA and DTGA: (a) pectin A, (b) pectin B, (c) pectin-PVA A, (d) pectin-PVA B

Analysis of **Figure 13 (a)** show that the Pectin A membrane loses a little about 10-20% in weight due to evaporation of water starting at a temperature of about 25-100°C, at a temperature of 288ºC shows a mass loss of about 75% due to the decomposition of pectin, and at temperatures above 450 °C loses a small amount of mass due to the carbonization of pectin.

Analysis of **Figure 13 (b)** show that the Pectin B membrane loses a little about 10-20% in weight due to evaporation of water starting at a temperature of about 28-100 °C, at a temperature of 288 ºC shows a mass loss of about 75% due to the decomposition of pectin, and at temperatures above 450 °C loses a small amount of mass due to the carbonization of pectin.

Analysis of **Figure 13 c** show that the Pectin-PVA A membrane slightly loses about 10% in weight due to evaporation of water starting at a temperature of about 25-100 °C, at 293 ºC shows a mass loss of about 70% caused by decomposition of pectin, at a temperature of 431 °C. loses a little mass due to pectin carbonization, and at temperatures above 500 °C it loses a little mass due to PVA carbonization.

The analysis of **Figure 13 (d)** show that the Pectin-PVA B membrane slightly loses about 10% in weight due to evaporation of water starting at a temperature of about 28-100 °C, at a temperature of 290 ºC shows a mass loss of about 70% caused by the decomposition of pectin, at a temperature of 425 °C. loses a little mass due to pectin carbonization, and at temperatures above 500 °C it loses a little mass due to PVA carbonization.

4. CONCLUSIONS

Based on the results of the research that has been done and the results of the discussion, the following conclusions can be drawn that : Blending pectin membrane Polyvinyl alcohol (PVA) was successfully synthesized based on the results of the characterization of the Tensile Strength Test, FTIR, XRD, SEM, Thermal Test, and UV-Vis Spectrophotometer; Based on the results of the tensile strength test characterization the addition of PVA will increase the value of the tensile stress and strain of the membrane so that it is not easily torn. The characterization of FTIR contained OH vibrations, –CH_2 bonds, –CH bonds, -C=O (esters), and CO (ethers). XRD characterization showed that the Pectin-PVA membrane had a crystalline structure. The Pectin-PVA membrane formed is included in the microspheres. Thermal test, the membrane was carbonized at a temperature of about 400 °C; In the membrane dialysis process for urea transport, the absorbance value increased on the UV-Vis spectrophotometer and this indicates that the absorbed urea level is also getting higher, because the absorbance value is directly proportional to the concentration.

ACKNOWLEDGMENTS

The authors gratefully acknowledge to the LPPM UNS for funding this research under Grant Fundamental Reasearch SKIM (PF-UNS).

REFERENCES

1. Solika N, Napitupulu M, Gonggo ST. Bioadsorpsi Pb(II*eeeeeee*) Menggunakan Kulit Jeruk Siam (Citrus Reticulata). *Jurnal Akademika Kimia*. Published online January 2018.
2. Perina I, Satiruiani, Soetaredjo FE, Hindarso H. Ekstraksi Pektin dari berbagai Macam Kulit Jeruk. *Widya Teknik*. 2007;6. doi:10.33508/wt.v6i1.1227
3. Kanmani P, Dhivya E, Aravind J, Kumaresan K. Extraction and analysis of pectin from citrus peels: augmenting the yield from citrus limon using statistical experimental design. *Journal of Energy and Environment*. Published online 2014. Accessed November 28, 2022. https://reader.elsevier.com/reader/sd/pii/S0360319911018386?token=574C95A73BD776006D22F2AD15B0F1D1599264889B31D4E4145382129BEFE71FD7F16F6A0262F5A7261C77404BD5E0A1&originRegion=eu-west-1&originCreation=20221128054357
4. Shaleha RR, Yuliana A, Amin S, et al. Penyuluhan Penyakit Gagal Ginjal Kronik Di Puskesmas Rancah Kabupaten Ciamis. *To Maega : Jurnal Pengabdian Masyarakat*. Published online 2023.
5. Indrasari DN, Anita DC. Perbedaan Kadar Ureum dan Kreatinin pada Pasien Gagal Ginjal Kronik Berdasarkan Lama Menjalani Terapi Hemodialisa di RS PKU Muhammadiyah Yogyakarta. In: ; 2015.
6. Nusantara DTH, Irawiraman H, Devianto N. Perbandingan Kualitas Hidup Antara Pasien Penyakit Ginjal Kronik yang Menjalani Terapi CAPD dengan Hemodialisis di RSUD Abdul Wahab Sjahranie Samarinda. *Jurnal Sains dan Kesehatan*. Published online 2021.
7. Wulandari MP, Purwanti OS. Literatur Review Intervensi Peritoneal Dialisis pada Kehamilan. *Seminar Nasional Keperawatan Universitas Muhammadiyah Surakarta*. Published online 2020:110-119.
8. Ayuni NPS, Siswanta D, Suratman A. Kajian Transport Kreatin Menggunakan Membran Kompleks Polielektrolit (PEC) Kitosan-Pektin. *Jurnal Wahana Matematika dan Sains*. 2014;8(2):77.
9. The JY, Paruntu ME, Assa YA. Gambaran kadar urea nitrogen darah pada vegetarian lacto-ovo. *Jurnal e-Biomedik*. 2016;4(1):4-7. doi:10.35790/ebm.4.1.2016.12203
10. Remucal CK, Cory RM, Sander M, McNeill K. Low molecular weight components in an aquatic humic substance as characterized by membrane dialysis and orbitrap mass spectrometry. *Environ Sci Technol*. 2012;46 17:9350-9359.
11. Singh R. Chapter 1 - Introduction to Membrane Technology. In: Singh R, ed. *Membrane Technology and Engineering for Water Purification (Second Edition)*. Second Edition. Butterworth-Heinemann; 2015:1-80. doi:https://doi.org/10.1016/B978-0-444-63362-0.00001-X
12. Naeem A, Hu P, Yang M, et al. Natural Products as Anticancer Agents: Current Status and Future Perspectives. *Molecules*. 2022;27(23). doi:10.3390/molecules27238367
13. Subaryono. Modifikasi Alginat dan Pemanfaatan Produknya. *Squalen*. 2010;5(1).
14. Bhongsuwan D, Bhongsuwan T. Preparation of Cellulose Acetate Membranes for Ultra-Nano Filtrations. *Kasetsart J (Nat Sci)*. 2008;(42):311-317.
15. Nurjanah S. *Modifikasi Pektin Untuk Aplikasi Membran Dengan Asam Dikarboksilat Sebagai Agen Penaut Silang*. Institut Pertanian Bogor; 2008.
16. Assifaoui A, Lerbret A, Uyen HTD, et al. Structural behaviour differences in low methoxy pectin solutions in the presence of

divalent cations (Ca2+ and Zn2+): a process driven by the binding mechanism of the cation with the galacturonate unit. *Soft Matter*. 2015;11(3):551-560. doi:10.1039/C4SM01839G

17. Kanmani P, Dhivya E, Aravind J, Kumaresan K. Extraction and analysis of pectin from citrus peels: augmenting the yield from citrus limon using statistical experimental design. *Journal of Energy and Environment*. Published online 2014.
18. Roikah S, Rengga WDP, Latifah L, Kusumastuti E. Ekstraksi Dan Karakterisasi Pektin Dari Belimbing Wuluh (Averrhoa bilimbi,L). *Jurnal Bahan Alam Terbarukan*. 2016;5(1):29-36. doi:10.15294/jbat.v5i1.5432
19. Maria C, Freitas P, Jane S, Gomes V, Souza L, Rita C. Structure and Applications of Pectin in Food, Biomedical, and Pharmaceutical Industry: A Review. *Coatings*. 2021;11(922):1-22.
20. Upadhyaya L, Qian X, Wickramasinghe SR. Chemical modification of membrane surface — overview. *Curr Opin Chem Eng*. Published online 2018.
21. Kochkodan V, Johnson DJ, Hilal N. Polymeric membranes: Surface modification for minimizing (bio)colloidal fouling. *Adv Colloid Interface Sci*. 2014;206:116-140.
22. Gopal R, Zuwei M, Kaur S, Ramakrishna S. Surface Modification and Application of Functionalized Polymer Nanofibers. *Springer*. Published online 2007.
23. Lusiana RA. *Sintesis Senyawa Turunan Kitosan Melalui Reaksi Cangkok Dan Taut Silang Dan Aplikasinya Sebagai Membran Biokompatibel Hemodialisis*. Universitas Gajah Mada; 2014.
24. Wenten IG, Aryanti PTP, Khoiruddin K, Hakim AN, Himma NF. Advances in polysulfone-based membranes for hemodialysis. *Journal of Membrane Science Research*. Published online 2016:78-89.
25. Lu S, Zhuang L, Lu J. Homogeneous blend membrane made from poly(ether sulphone) and poly(vinylpyrrolidone) and its application to water electrolysis. *J Memb Sci*. 2007;300(1-2):205-210.
26. Park SY, Jung ST, Marsh KS. *Characteristics (Mechanical Properties) of PVA and Chitosan Blending Films.* Clemson University; 2000.
27. Marin E, J R, Y C. A review of PVA derivatives : Promising Materials of Pharmaceutical and Biomedical Applications. *African Journal Pharmacy and Pharmacology*. 2014;8(24).
28. Yin J, Fan H, Zhou J. Cellulose acetate/poly(vinyl alcohol) and cellulose acetate/crosslinked poly(vinyl alcohol) blend membranes: preparation, characterization, and antifouling properties. *Desalination Water Treat*. 2016;57(23):10572-10584.
29. Alkhudhiri A, Darwish N, Hilal N. Membrane distillation: A comprehensive review. *Desalination*. Published online 2012.
30. Andayani U, Jumina, Siswanta D, Mardiana D. Peningkatan Efisiensi Permeasi Etanol Menggunakan Membran Poli(Vinil Alkohol Termodifikasi. *JKPK (Jurnal Kimia dan Pendidikan Kimia)*. 2017;2(3):133-138. doi:10.20961/jkpk.v2i3.11874
31. Ayuni NPS, Siswanta D, Suratman A. Kajian Transpor Kreatin Menggunakan Membarn Kompleks Polielektrolit (PEC) Kitosan-Pektin. *Jurnal Wahana Matematika dan Sains*. 2014;8(2):77.
32. Alvianto D, Nurhadi FAA, Putranto AW, Argo BD, Hermanto MB, Wibisono Y. Sintesis dan Karakterisasi Membran Selulosa Asetat dengan Penambahan Antibiofouling Alami Ekstrak Bawang Putih. *ALCHEMY Jurnal Penelitian Kimia*. 2022;18(2):193. doi:10.20961/alchemy.18.2.57199.193-204
33. Bundela H, Bajpai AK. Designing of hydroxyapatite-gelatin based porous matrix as bone substitute: Correlation with biocompatibility aspects. *Express Polym Lett*. 2008;2:201-213.
34. Shan N, M. J. Zaworotko. The role of co-crystals in pharmaceutical science. *Drug Discov Today*. Published online 2008.
35. Hartel RW. *Crystallization in Foods*. Aspen Publishers Inc.; 2001.
36. Jain RA. The manufacturing techniques of various drug loaded biodegradable poly(lactide-co-glycolide) (PLGA) devicesl. *Biomaterial*. Published online 2000.
37. Regina S, Poerio T, Mazzei R, Sabia C, Iseppi R, Giorno L. Pectin as a non-toxic crosslinker for durable and water-resistant biopolymer-based membranes with improved mechanical and functional properties. *Eur Polym J*. 2022;172. doi:10.1016/J.EURPOLYMJ.2022.111193