The preparation and characterization of cellulose derivative membrane as matrix for sustained release formulation

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Abstract: A synthesis of cellulose derivative membrane has been performed as good candidate for sustained release matrix. Alginate is a polysaccharide that water-soluble, consisting of β-D-mannuronic and α-L-guluronic, and contains of carboxylic (–COOH) and hydroxyl (–OH) groups which allow to form hydrogen bonds with drug compounds. The purpose of this study is to determine the physicochemical properties of alginate membranes. The membranes were prepared by the solution casting method on polypropylene container. Structural characterization of the membrane was done by fourier transform infrared spectra (FTIR) and the mechanical properties of the membrane was analyzed with tensile strength test and elongation test based on variation of alginate concentration. Scanning Electron Microscopy (SEM) was done to determine the surface morphology of the membrane. The FTIR spectra showed the presence of carbonyl group (C=O) at 1597 cm⁻¹ and hydroxyl group (–OH) at 3426 cm⁻¹. The tensile strength of membrane for alginate with different concentration at 3.3, 5, and 10% w/v were 8.84, 17.07, and 7.36 MPa, respectively. This indicates that the higher concentration of alginate membrane will increase the strength of the membrane, but at higher alginate concentration the membrane strength tend to decrease.

Keywords: Alginate, membrane, sustained release formulation

1. Introduction

The use of thin films from natural polymers tend to increase and expand in various fields such as the pharmaceutical, medical, biotechnology, environmental, and agricultural industries [1-3]. Non-porous polymer films are also widely applied as membranes in the pervaporation process. This is due to the superiority of non-porous film layers that offer high permeability, mechanical strength, and selectivity, and their ability to separate azeotropic solutions [4].

Film material is one of the variables that greatly determine the film performance. Natural polymers are currently receiving attention from researchers in film synthesis as they are low-cost materials and also their nontoxic, biodegradable, and biocompatible properties [5]. Alginate (Figure 1) is a linear polysaccharide consisting of β-D-mannuronic acid monomers and α-L-glucoronic which are connected through a 1.4 bond. Alginate is very important because of its extensive use in various industrial fields [6]. Alginates which are polyanionic when dissolved in the right conditions can interact with each other through carboxyl groups of alginate [7,8]. Alginate is also a linear polysaccharide extracted from brown algae, it dissolves in aqueous solutions. It contains a variety of 1-4 linked α-L-glucoronic and β-D-mannuronic acid residues [9,10].
In this study, preparation and characterization of membranes formed by alginate at various concentrations was performed. Membrane will be applied as a slow-release matrix of drugs. Slow release is a form of method that is designed to slowly release the drug into the body or gradually to release it longer, prolong the action of the drug, maintain continuous levels of drug therapeutic range and improve patient compliance. Structural characterization of the membrane was done by FTIR and the mechanical properties of the membrane was analyzed with tensile strength test and elongation test based on variation of alginate concentration. SEM test was done to determine the surface morphology of the membrane.

2. Methodology

2.1 Material
Alginat (food grade) was obtained from CV Nura Jaya Surabaya, aquadest

2.2 Membrane preparation.
Alginate was dissolved in water with variation concentration of 3.3%, 5%, and 10% w/v and were stirred until homogeneous and then printed in a polypropylene container. The solution was left for about 5 minutes and then dried at 60 ℃ for 24 hours to form a thin layer of membrane.

2.3 Membrane characterization.
Structural characterization of the membrane was done by Fourier transform infrared spectra (FTIR) and the mechanical properties of the membrane was analyzed with tensile strength, and SEM test to determine the surface morphology of the membrane.

3. Results and discussion

3.1 FTIR spectra
FTIR test is an observation of functional groups contained in the membrane. From Figure 2, it can be seen that the C–O vibration peak which is characteristic of the saccharide structure is located at a wavelength of about 1004-1300 cm⁻¹. The membrane has a new vibration peak of carboxyl salts at a wavelength of 1597 and 1419 cm⁻¹ which shows the C=O group. The peak at a wavelength of 3410 cm⁻¹ indicates the –OH group.

Figure 1. Chemical structure of alginate
Figure 2. FTIR spectra of alginate membrane under study

3.2 XRD spectra

Analysis with XRD spectrometry was intended to determine the crystallinity of alginate. The diffractogram is shown in Figure 3.

Figure 3. XRD chromatogram of alginate membrane under study
The diffractogram of alginate showed slightly sharp peak at $2\theta = 25^\circ$, indicating semi-crystalline characteristic of alginate. The crystal structure of the alginate is strongly influenced by the hydrogen bonds that occur at one chain (intra) or between (inter) alginate chains.

3.3 SEM test
Figure 4 presents the results of visualization of the surface of the alginate membrane. The SEM image confirmed a microporous texture of the alginate surface membrane. This porous characteristics shows that the membrane is suitable for sustained release matrix formulation.

![SEM images](image1.png)

Figure 4. SEM test results: (A) Surface cross-section image with 500x magnification; (B) Surface cross-section image with 3000x magnification.

3.4 Mechanical properties test
From Table 1, the membrane with alginate concentration of 5% (w/v) has the largest modulus young than other concentration. The mechanical properties of membranes are getting better with increasing alginate concentrations. However, at the concentration higher than 5%, the modulus young is decreasing. This is because of its close structure causing the distance between the molecules in the membrane to be denser. At excessive alginate concentrations it may cause mechanical properties of the membranes to become fragile. The greater the value of Young’s modulus, the better ability to prevent the damage caused by external forces, resulting in a stronger alginate membrane.

| Composition    | % elongation | Young’s Modulus (N/mm$^2$) |
|----------------|--------------|----------------------------|
| Alginate 3.3% (w/v) | 9.03         | 8.84                       |
| Alginate 5% (w/v)    | 17.08        | 17.07                      |
| Alginate 10% (w/v)   | 6.69         | 7.36                       |

4. Conclusion
The alginate membrane can be applied as matrix of sustained release drug formulation. The FTIR data showed that the alginate membrane has carbonyl group (C=O) and hydroxyl group (–OH). The SEM test results showed that the alginate membrane has a microporous surface. The results of mechanical tests showed the young modulus obtained in the membrane for variation of the concentration of alginate in water were 3.3% w/v, 5% w/v, and 10% w/v and the tensile strength of membranes indicated 8.84 MPa, 17.07 MPa, and 7.36 MPa respectively. The mechanical properties of membranes are better with increasing alginate concentration, but at larger concentration of alginate, the Young’s modulus tend to decrease.

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