Organic Solvent-Free Biodegradable Polymeric Membrane Fabrication: A Potential for Antibacterial and Anti-Adhesion Applications

Ratima Suntornnond*, Jia An, Wai Yee Yeong, and Chee Kai Chua

***Abstract*—**This organic solvent-free biodegradable membrane fabrication can generate antibacterial membrane without any usage of any organic solvent. Membranes can be formed by the principle of surface tension between hydrophobic polymer and water. By blending biodegradable polymer which are polycaprolactone, (PCL) with antibiotic drug (e.g. Novobiocin or Vancomycin), an antibacterial membrane can be form and has a potential to be used for bacterial infection prevention. Moreover, because by nature PCL is hydrophobic so this membrane also has a potential to be used for anti-adhesion applications.

***Keywords*—**Antibacterial, Anti-adhesion, Biodegradable polymer, Bio-medical engineering.

I. Introduction

BIODEGRADABLE polymer membranes have been used for many applications such as tissue engineering and biomedical applications. Because of its biodegradable property *in vivo*, biodegradable is also suitable to use for antibacterial drug release. Over a past decade, there are reports that showed potential of biodegradable membrane for antibacterial applications, for example, poly(lactic acid) siloxane/calcium carbonate composite membrane with mercapto groups [1]. Nowadays, there are many methods to fabrication biodegradable membrane such as solution casting[2] and elctrospinning [3]. However, most of membrane fabrication methods require the use of organic solvent to form a membrane such as tetrahydrofuran [4]. Organic solvent not only can be harmful to cell and human tissue but also may cause some effect to drug properties. Thus, organic solvent-free method was invented to eliminate the use of organic solvent. By disperse powder onto water surface and insert heat into system, membranes can be formed with the principle of surface tension between hydrophobic polymer and water. In this paper, we further investigated this method by combining hydrophobic polymer with antibiotic drug to further study potential of this membrane for antibacterial and anti-adhesion application.

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II. Materials And Methods

Polycarprolactone, PCL powder was from Perstorp which has average particle size of 500 μm (as shown in Fig. 1) and density of 1.1 g/cm^3. First, 0.7 g PCL powders were dispensed on to 30 ml de-ionized water that in a 10 cm-diameter circular glass dish.

After that as illustrated in Fig. 2a, the glass dish was shaken gently to confirm homogeneous spreading of powder on water surface. Next, the glass dish was put onto a laboratory heater (Thermolyne Cimarec® 1, Thermo scientific, USA). After 15 minutes, the heater was turn off and 0.08 g of Novobiocin (Sigma-Aldrich) were mixed on to melted layer of PCL by slowly dispensed to form concentration of 10% w/w with PCL. Then, the glass dish was cooled down at room temperature. After around 5 minutes, a solid white membrane appeared onto water surface. A pure PCL membrane was made by using same method with total weight of 0.8 g to be used for comparison.

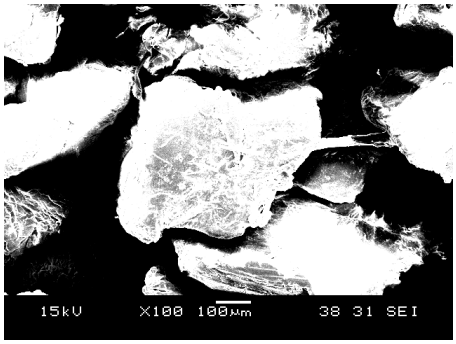

Fig. 1 SEM image of PCL powder at x100 magnification

The morphology of both membranes and Novobiocin powders were further investigated by using light microscopy (Olympus, CKX41) at the magnification of x4. Both membranes were cut into 10 mm x 10 mm square pieces for investigation.

Both membranes were characterized by using Thermo Scientific Nicolet™ 6700 FT-IR spectrometer (Cambridge, UK) in ATR absorbance mode which were demonstrated in the range of 500–4000 cm^{-1} and a resolution of 4 cm^{-1}. The FTIR machine is equipped with OMNIC software for analysis. Samples were cut into a size of 15 mm x 15 mm square shape and mounted on to the orbit sampler.

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III. Results And Discussion

As shown in Fig. 2 (a), this method is fast and simple. Because of surface tension, polymer mixture can be stay on top of water surface in both solid and liquid state. By using this method, the use of organic solvent can eliminated and membrane with antibacterial property can be easily formed within 20 minutes. The microscopic of membranes were shown in Fig. 2 (b-d). The red box in Fig. 2(c) showed that Novobiocin powder was blended and kept inside PCL membrane.

By comparing Fig. 2(a) and 2(b), surface morphology of both membranes were same which proved that Novobiocin powder did not affect overall membranes morphology. Fig. 3 represented the signal curve of pure PCL and blended membranes. The signal follows the same finger print as identified by Elzein, T., et al. (2004) [5]. However, the results of blended membrane (PCL and Novobiocin) showed stronger signal compared to pure PCL membrane.

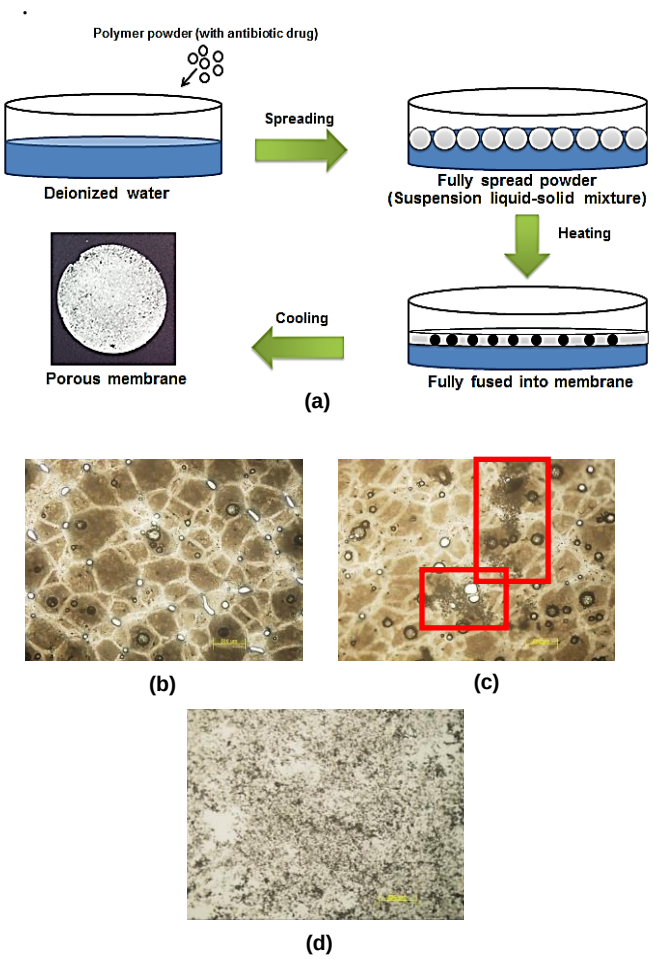

Fig. 2 (a) Schematic of organic solvent-free membrane fabrication (b) Microscopic of pure PCL membrane from light microscope with the magnification at x4 (c) Microscopic of blended membrane (PCL with novobiocin) from light microscope with the magnification at x4 (d) Microscopic of novobiocin powder light microscope with the magnification at x4 where scale bar equal to 500 micron.

By blending Novobiocin powder with hydrophobic biocompatible polymer powder a potential antibiotic drug delivery membrane can be created to prevent bacterial infection to patients. Furthermore, as this membrane made from PCL which is hydrophobic polymer so it is a good alternative to use this membrane for post-surgery anti-adhesion application. However, there are some criteria for this method. First, in order to obtain homogeneous membrane; powders have to be equally fully spread. Moreover, polymer that used in this method has to be hydrophobic. Lastly, because this method require the use of heat, antibiotic drugs that used for this fabrication method should have good heat stability properties such as Novobiocin and Vancomycin [6].

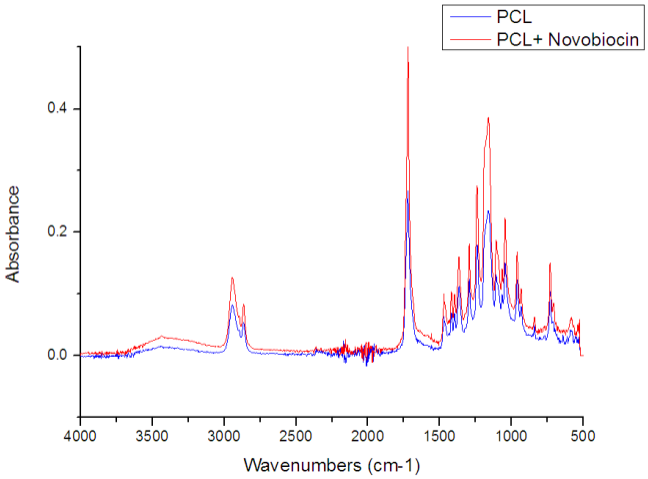

Fig. 3 ATR-FTIR curve of pure PCL membrane (blue line) and blended membrane (red line) in absorbance mode

IV. Conclusions

In this paper, we showed that membrane with antibacterial properties can be formed without involving with any organic solvent via solvent-free method. The method is simple, it requires general laboratory equipment and membrane can be formed within a short period of time. Future work is to optimize drug concentration and investigate efficiency of this membrane by testing its antibacterial properties with *staphylococcus epidermis* which is a bacteria that can caused infection resulted from biofilms on medical plastic devices in human body such as catheters. Moreover, this membrane can further investigate its anti-adhesion application by *in vivo* testing in animal.

Acknowledgment

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