Water Holding Capacity and Water Release Rate of Bacterial Cellulose-Silver Nanoparticles

R. Abu[1,*], S. Mohamad[1], J. Zakaria[1], S. H. Mortan[2] and N. A. Yah[1]

[1]Faculty of Chemical & Process Engineering Technology, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia
[2]College of Engineering, Universiti Malaysia Pahang, 26300 Gambang, Kuantan, Pahang, Malaysia

*Corresponding author's email: rohanaa@ump.edu.my

ABSTRACT: Silver nanoparticles (AgNPs) has been introduced into bacterial cellulose (BC) as an antibacterial agent. However, the AgNPs affects its excellent water holding and release properties of BC. In this study, the water holding capacity (WHC) and water release rate (WRR) of bacterial cellulose-silver nanoparticles (BC-AgNPs) were investigated. BC was produced using oil palm frond juice as a fermentation medium by *Acetobacter xylinum*. BC-AgNPs was thermally synthesized at different concentrations of silver nitrate solution (0.001 – 1.0 M). The films were characterized for its surface morphology by a field emission-scanning electron microscope (FE-SEM) and its WHC and WRR. The results show that the WHC and WRR of BC-AgNPs films decreased as the AgNPs increased. From the FE-SEM images, the films have a randomly arranged of fibrils with the increasing compactness as AgNPs increased as compared to pure BC. BC impregnated AgNPs with 0.001 – 0.1 M $AgNO_3$ have a high potential as a dressing material as they still can maintain suitable moisture requirement as respect to its WHC and WRR.

Keywords: *Bacterial Cellulose; Silver nanoparticles; water holding capacity; water release rate*

1. INTRODUCTION

Bacterial cellulose (BC) has shown as an ideal dressing material due to its high water holding capacity and its slow water release rate. The BC provides a suitable moisture environment due to its ability to hold water and prevent it from dehydration and from sticking to the wound, thus providing faster healing. Although BC have such excellent properties, the fact that it has no antibacterial activity that limits its wound dressing application. In order to maintain it effectiveness for wound treatment, antibacterial property can be added by impregnation of an antibacterial agent such as, silver nanoparticles (AgNPs) into BC matrix. AgNPs is known to have a high potent antibacterial effect that are widely used against bacteria, viruses, and fungi [1]. However, the addition of such component will affect the water holding and release properties in BC [2].

Recently, the development of low-cost fermentation media for BC production using natural carbon sources from biomass is intensively reviewed [3]. Oil palm frond (OPF) is a biomass source that can be mechanically pressed to obtain juice and use it as a fermentation medium due its glucose content and other essential nutrients [4]. To date no study has been done to determine the WHC and the WRR in the BC produced from OPF juice. Therefore, the objectives of the present work were to produce BC from OPF juice as a fermentation medium and incorporate AgNPs into the produced BC films by hydrothermal synthesis at different concentration of silver nitrate solution (0.001 – 1.0 M). The WHC and WRR of the BC-AgNPs were determined and compared with the pure BC (without AgNPs).

2. METHODOLOGY

2.1 BC Production by OPF juice

OPF was collected from LCSB oil palm plantation, Lepar Pahang. The petioles were squeezed by a hydraulic press to obtain fresh juice. The juice was filtered and stored before use at –20 °C. In this work, 80 % v/v OPF medium was prepared and the medium was adjusted at pH 4 with 50 %v/v acetic acid before sterilizing at 121 °C for 10 min. 10 % v/v *A.xylinum* inoculum was cultured in 24-well plates for 7 days under static conditions at 30 °C (Shel Lab, USA). BC films were collected and purified by boiling in 0.5 M NaOH for 20 min. The films were further immersed in distilled water for several times to until neutral pH was achieved.

2.2 BC-AgNPs Hydrothermal Synthesis

BC films were put in glass vials containing 25 ml of silver nitrate solution (0.001 M, 0.01 M, 0.1 M and 1.0 M) covered by aluminium foil. The glass vials were autoclaved at 0.103 MPa and 121 °C for 10 min for hydrothermal treatment [5]. BC-AgNPs and BC without AgNPs (as a control sample) were cooled down at room temperature and stored in distilled water at 4 °C. Samples were further freeze-dried at -70 °C at 0.011 Mbar for 24 h for analysis.

2.3 BC-AgNPs characterization

Surface morphology of BC and BC-AgNPs was determined by FE-SEM (JEOL JSM-7800F) operated at 5 kV acceleration voltage. Samples were sputter-coated with platinum before observation.

Sieve shake method was used to measure WHC of BC films [2]. The films were immersed in distilled water for 24 h to completely absorb the distilled water and then dried for 24 h. WHC was calculated by the mass of water removed during drying divided by the dried mass of BC sample [2]. For WRR, the absorbed water in films were dried at room temperature by continuously weighing the films every hour until a constant dried weight were achieved [2].

3. RESULTS AND DISSCUSSION

In this work, BC films was produced from OPF juice by *A.xylinum* at 30°C, pH 4 for 7 days under static condition. The hydrothermal synthesis was further performed on the films with various concentration of $AgNO_3$ solution (0.001 – 1.0 M) by autoclaving at 0.103 MPa and 121 °C for 10 min. The method was used to reduce the Ag^+ ions from the solution by cellulose end aldehyde and alcohol groups [1, 5].

The structural variations due to impregnation of secondary components into BC films affect WHC and WRR. The WHC of pure BC was 171.54 times its dry weight, which is higher than all the AgNPs impregnated into BC. The WHC of BC-AgNPs impregnated with 0.001 M, 0.01 M, 0.1 M and 1 M of $AgNO_3$ concentration were 167.95, 160.97, 150.88 and 44.88 times its dry weight, respectively. The WHC decreased due to the increasing compactness arrangement of fibrils in BC-AgNPs (Fig. 1b-d) as compared to pure BC (Fig. 1a). The smaller pore size available for the water to penetrate between the fibrils.

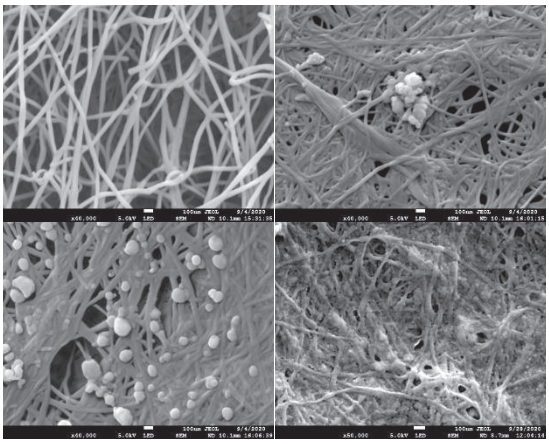

Fig. 1 FE-SEM images. (a) BC, (b) BC-AgNPs (0.01 M), (c) BC-AgNPs (0.1 M) and (d) BC-AgNPs (1.0 M).

The WRR is the rate of water molecules releases from the absorbed water in dried BC. WRR was measured at different time intervals within 24 h period. In Fig. 2, it shows that initially the evaporation rates of water molecules from all BC films were similar because the water on the surface of the films escapes at similar rates. BC-AgNPs prepared with 0.001 – 0.1 M $AgNO_3$ solution have a higher WRR due to its high water absorption which is comparable to pure BC. This is because the water molecules needed a longer time to slowly release from the fibril network at room temperature. However, the WRR of BC-AgNPs prepared with 1 M of $AgNO_3$ has the lowest WRR due to its low WHC content as obtained in the WHC analysis.

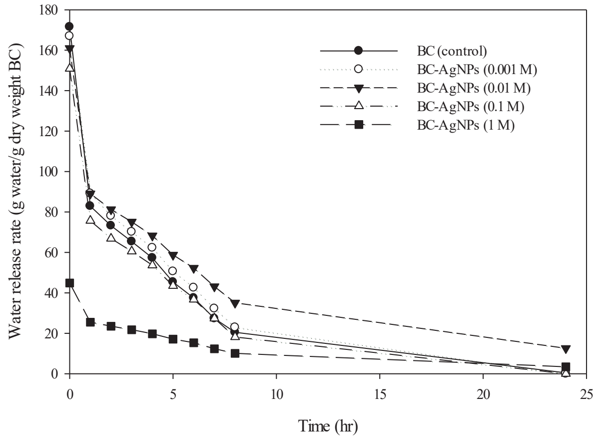

Fig. 2 Water release rate of BC-AgNPs.

4. CONCLUSION

In this study, KC were produced from oil palm frond juice by *Acetobacter xylinum*. BC-AgNPs films prepared with 0.001 – 0.1 M $AgNO_3$ provide a suitable moisture environment as respect to its WHC and WRR when compared to pure BC. It is suggested that OPF juice can be used as a suitable growth media for bacteria in BC production and can be further utilized as a potential dressing material with AgNPs as a microbial agent.

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