CHAPTER V
CONCLUSIONS

To summarize, we succeeded in the production of bacterial cellulose from *Acetobacter xylinum* strain TISTR 975. The characterization showed that the bacterial cellulose has the same chemical structure as the cellulose produced from plant, β -1, 4-glucan chain. However, its macromolecular structure and properties were different, namely; the surface morphology of bacterial cellulose membrane showed the three dimensional non-woven network of nanofibrils. In addition, the multilayer of bacterial cellulose membranes linked together with the nanofibrils was observed in the cross-section morphology of bacterial cellulose. These unique structures were not found in the plant cellulose, which resulted in a large surface area that could hold a large amount of water resulting in the high absorbency in hydrated state and exhibited the great elasticity and high wet strength. These properties are necessary for wound dressing material.

Then we succeeded in the chemical reduction of silver nanoparticles in the three dimensional non-woven networks of bacterial cellulose nanofibrils. The size and size distribution are controllable by adjusting the molar ratio of $NaBH_4$: $AgNO_3$. Under optimized conditions, well dispersed and regular spherical silver nanoparticles were obtained. The unique structure and the high oxygen (ether and hydroxyl) density of bacterial cellulose fibers constitute an effective nanoreactor for in situ synthesis of silver nanoparticles. These properties are essential for introduction of silver ion and reduction into bacterial cellulose fibers and removal of the excess chemical from bacterial cellulose fibers. The ether oxygen and the hydroxyl group not only anchor silver ions tightly onto bacterial cellulose fibers via ion-dipole interactions, but also stabilize silver nanoparticles by strong interaction with their surface metal atoms. This work easily extends to other wound dressing materials that has nucleophile functional group that used to anchor the cat-ion of silver ions and has suitable structure that can stabilize silver nanoparticles. Moreover, the preparative procedure is surprisingly simple. It can provide a facile approach toward manufacturing of metallic nanocomposites, antimicrobial materials, low-temperature catalysts, and other useful materials.

The silver nanoparticle-impregnated bacterial cellulose exhibited a strong antimicrobial activity against both *Staphylococcus aureus* (gram-positive bacteria) and *Escherichia coli* (gram-negative bacteria), which are general bacteria that found on the contaminated wound. This result show that silver nanoparticle-impregnated bacterial cellulose can be used as the antimicrobial wound dressing that prevent the infection of wound. A recent study showed that impregnation, instead of coating the wound dressing with silver nanoparticle or nanocrystal such as Acticoat^{TM} consists of the absorbent rayon-polyester core sandwiched between two layers of silver nanocrystalline-coated high density polyethylene, improved the antimicrobial activity of the wound dressing and lowered possibility of the normal human tissue damage. This is probably due to the slow and continual release of silver nanoparticles and then was slowly changed to silver ions under our physiological system and interact with bacterial cells, thus silver ions will not be so high enough to cause the normal human cells damage and can prolonged the antimicrobial effect (Furno *et al.,* 2004). On contrary, silver nanocrystalline-coated wound dressing, silver nanocrystalline that coated on the surface of high density polyethylene were rapidly released and changed to silver ions, thus silver ions may be high enough to cause normal human tissue damage. However, the use of the silver-based antimicrobial wound dressing can delay wound healing or inhibition of wound re-epithelialization in wound healing process (Burd *et al.,* 2007). They suggested that silver-based wound dressings should be used with caution in situations where rapidly proliferating cells may be harmed as in donor sites, superficial burns, and application of cultured cells. It must be observed that some studies demonstrate the silver enhances acute wound healing were performed on the incision wounds where keratinocyte proliferation is not a major feature (Parsons *et al.,* 2005).

Despite the findings of this study, there are several aspects that require further investigation. Firstly, clinical evidence is required to demonstrate the impact of this wound dressing in the reduction of wound infections. Secondly, as other micro-organisms are involved in the wound infections, it is necessary to test the silver nanoparticle-impregnated bacterial cellulose against more microbial species, such as *Pseudomonas*, *Enterococci* and *Candida* species. Lastly, the vivo study is required to investigate the toxicity of silver nanoparticles in the human skin cell.