Bacterial cellulose: Application as drug delivery system

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ABSTRACT

Bacterial cellulose (BC) is a very interesting biopolymer to the biomedical application, including drug delivery system, due to unique characteristics as high degree purity and porosity, high permeability to liquid and gases, high holding water capacity, tensile strength, and randomly oriented three-dimensional fiber network. Several authors described the use of BC membranes or copolymers to use as drug delivery system. The aim of the present mini-review was to show the wide and vantages application of the BC and its copolymers for use as controlled drug delivery system.

Introduction

Polymeric drug delivery systems may be designed in many forms, including matrices, composites, pure membranes and copolymers in which the bioactive compound must be dispersed or dissolved (1,2). The route of administration, carrier formulation, release mechanism and physicochemical properties of the drug molecule may influence the rate of release and, therefore, should be considered when selecting a suitable polymer for this purpose (2,3). In addition, the polymers used for the development of drug delivery systems must be chemically inert and present appropriate physical and chemical characteristics (2). In the last years, BC (Figure 1), a very interesting biopolymer, has been widely applied in transdermal drug delivery as membranes, being commonly used in the fabrication of matrix-type patches due to its high water capacity, tensile strength and randomly oriented three-dimension fibers network, viscoelasticity and poroelasticity (5,6). BC can be produced by several organisms species, such as Gluconacetobacter and Komagataeibacter, recently named Komagataeibacter (Figure 2), especially the species K. xylinus and K. hansenii (6,9,10), using a variety of natural and synthetic culture media with several carbon sources of different origins (11,12). Nevertheless, BC membranes maintain a physical barrier that reduces pain, bacterial infection and allows drug transfer into the wounded region (13–15). These BC membranes characteristics constitute an important aim to development of studies for application this biopolymer as drug delivery system (16–18).

The aim of the present mini-review was to show the wide and vantages application of the BC and its copolymers for use as controlled drug delivery system.

Application of bacterial cellulose as a drug delivery system

In recent years, several drug delivery systems based in BC membranes for various pharmaceutical applications have been proposed including antimicrobial, and anticancer agents, small molecules, inorganic nanoparticles and a metal complex (19).

Studies developed by Stoica-Guzun et al. (20) demonstrated the delivery of the antibiotic tetracycline encapsulated on BC matrix comparing irradiated (doses of 5 or 15 kGy) to non-irradiated BC membranes an in vitro study demonstrating that electron beam radiated over BC-tetracycline system promoted faster drug release rate.

Antimicrobial bacterial cellulose-silver nanoparticles composite membranes obtained by in situ preparation of silver nanoparticles from hydrolytic decomposition of silver nitrate solution using triethanolamine as reducing complexing agent exhibited strong antimicrobial activity against Gram-positive S. aureus and Gram-negative E. coli and P. aeruginosa bacteria Gram-positive S. aureus (21).

In another work, Kaplan et al. (22) performed a comparative study to evaluate the in vitro release behavior of gentamicin (GM) and ampicillin (AMP) by BC membranes. These authors demonstrated that membranes exhibited sustained release capacity of AMP and GM in 7 days and the amounts of antibiotic released by BC reached the proportion of dose required to inhibit the growth of E. coli, E. feacalis, S. aureus and P. aeruginosa.

In study using the Box-Behnken statistical design to study the release of amoxicillin (AMX) from the BC, BC / glycerol and BC / hexadecyltrimethylammonium bromide enhancer showed that amoxicillin concentration had a greater influence on drug release and a significant contribution was also observed for the linear and quadratic terms of the glycerol concentration, the linear concentration of potentiator, and the interaction between the concentration of glycerol and concentration of the enhancer. These results show that independent variables affect the release of AMX from BC membranes (23).

In vitro antibacterial assay using BC composite membranes prepared with tetracycline hydrochloride (BC-TCH) demonstrates that this composites displayed excellent antibacterial activity solely associated with the loaded TCH drug (24).

A study using immobilized lysozyme onto BC nanofibers (BCNF) produced by physical absorption method was performed to evaluate the antimicrobial activity and other properties of immobilized lysozyme and also morphological characteristics of BCNF. This result demonstrates that the antimicrobial activity of lysozyme against S. aureus, E. coli, L. monocytogenes, Y. enterocolitica, Aspergillus niger, and Saccharomyces cerevisiae were increased after immobilization evidencing the potential for the use of BCNF as lysozyme delivery system (25).

Transparent antimicrobial silver nanoparticles/bacterial cellulose (AgNPs/BC) membranes produced by reducing silver nitrate as a precursor in the presence of sodium tripolyphosphate and in situ impregnation into the BC membranes. The AgNPs/BC membranes were nontoxic and showed good biocompatibility on peripheral blood mononuclear cells due to the controlled silver ion release. According to the results, it is suggested that the AgNPs/BC membranes can be applied for many antimicrobial purposes such as antibacterial wound dressing (26).

In a study, using bilayer BC membrane produced by G. hansenii ATCC 23769, from sugar-cane molasses carbon sources, impregnated with ceftriaxone (CRO), was demonstrated a higher capacity for retention and release of CRO when compared to the commercial BC membranes (18).

In a recent study, Volova et al. (27) demonstrated...
pronounced antibacterial activity against E. coli, P. aeruginosa, K. pneumoniae, and S. aureus, and the BC/antibiotics amikacin and cefazoxime composites were more active than BC/AcGNp. S. aureus was the most susceptible to the effect of BC composites.

Lazarini et al. (18) obtained a dissimilar BC membrane with high drug delivery capacity by G. hanseni variety after application of different culture temperatures. The BC membrane produced by variety acquired from the culture at 35°C produced membranes with dissimilar interweaving of fibers and thick layers and high dry mass yield. This BC obtained was impregnated with CRO and maintained release capacity for 72 hours.

A new hybrid material based on bacterial cellulose containing silver phosphate microparticles on one side of the matrix and high ciprofloxacin loading has been developed by Bayón R et al. (21) and high potential pharmaceutical use with advantage application for the controlled drug delivery system justifying the increase of the interest of the researchers in the development of products based in BC to this application.

References


