Polysaccharide-based materials with antibacterial properties

ANNA KUTOVÁ*, KLAUDIA HURTUKOVÁ, ONDŘEJ KVÍTEK, VÁCLAV ŠVORČÍK

*anna.kutova@vscht.cz

DEPARTMENT OF SOLID STATE ENGINEERING, UNIVERSITY OF CHEMISTRY AND TECHNOLOGY, PRAGUE
Anna Kutová *1993

- Master degree at UCT Prague – Drug production, 2019
- Summer 2019 – internship at Manipal Institute of Technology (MIT) in India
- Ph.D. at UCT Prague – Drugs and Biomaterials

Publications
Bacterial nanocellulose (BNC)\textsuperscript{1}

Produced by some particular bacterial strains
Its fibre diameter does not exceed 100 nm
Hydrophilic, biocompatible
Excellent mechanical properties, high porosity, high crystalinity

Chitosan (Chit)\textsuperscript{2}

Deacetylation of chitin from crustaceans shells
Non-toxic, biocompatible, promotes wound healing
Antibacterial properties

!!! The chitosan content could negatively affect some properties (e.g. mechanical\textsuperscript{3} or biological\textsuperscript{4}) !!!

---


Graphical abstract

Modified Hestrin-Schramm culture medium inoculated with *Komagataeibacter sacrofermentans* bacterial strain → BNC growth → Harvesting, washing → Immersing into chitosan solution for 24 hours → Lyophilization → Composite material BNC-Chit

1 g of BNC immersed into 72 ml of Chit solution (5 g · l⁻¹)
Chitosan degree of deacetylation 76 %
Composite preparation

Chitosan content: approx 17% (w/w)

FTIR\(^1\,^2\)
- 3346 – OH stretching
- 3290 – NH stretching
- 2900 – CH stretching
- 1649 – amide I
- 1537 – amide II
- 1300-1500 – C-C-H, C-O-H bending vibrations
- 1100-1300 – glycosidic bond
- 950-1100 – C-OH
- 600-900 – glucose cycle

Fig 2: FTIR spectrum of Chit (red), prepared composite BNC-Chit (blue) and BNC (black)


Surface morphology

Fig 3: SEM image of pure BNC showing the nanostructure of the material with present pores.

Fig 4: SEM image of BNC-Chit composites showing the preserved nanostructure of BNC. However its pores are clogged with Chit.

Fig 4 shows the penetration of chitosan into the nanostructure of cellulose fibres in the BNC-Chit composite leading to a less porous surface and less pronounced fibrous character compared to pure BNC at Fig 3.
# Mechanical and swelling properties

<table>
<thead>
<tr>
<th></th>
<th>BNC</th>
<th>BNC-Chit</th>
<th>BNC lit.(^1)</th>
<th>BNC-Chit lit.(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chitosan solution ((c \approx 0.5 \text{ g} \cdot \text{L}^{-1}))</td>
<td>-</td>
<td>5 mL</td>
<td>-</td>
<td>100 mL</td>
</tr>
<tr>
<td>Loading velocity</td>
<td>10 mm(\cdot)min(^{-1})</td>
<td>1 mm(\cdot)min(^{-1})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young´s modul [MPa]</td>
<td>39 ± 7</td>
<td>29 ± 12</td>
<td>83 ± 7</td>
<td>341 ± 37</td>
</tr>
<tr>
<td>Elongation [%]</td>
<td>9.1 ± 1.2</td>
<td>7.7 ± 2.4</td>
<td>4.7 ± 0.7</td>
<td>1.3 ± 0.3</td>
</tr>
<tr>
<td>Tensile strenght [MPa]</td>
<td>3.6 ± 0.8</td>
<td>2.1 ± 0.9</td>
<td>4.5 ± 1.0</td>
<td>3.8 ± 0.5</td>
</tr>
<tr>
<td>Swelling ratio [%]</td>
<td>7790 ± 730</td>
<td>2600 ± 690</td>
<td>8414</td>
<td>1714</td>
</tr>
</tbody>
</table>

Antibacterial properties against *Staphylococcus aureus* (SA)

These graphs show the antibacterial activity of BNC-Chit composite towards the SA bacterial strain. However, the bacteria profit from the BNC itself leading to an increase of CFUs compared to CTRL.

**Fig 5:** A) BNC and BNC-Chit antibacterial activity after 2 hours against *S. aureus* B) drop-plate method for BNC C) drop-plate method for BNC-Chit

**Fig 6:** A) BNC and BNC-Chit antibacterial activity after 24 hours against *S. aureus* B) drop-plate method for BNC C) drop-plate method for BNC-Chit

CFU: Colony forming unit
CTRL: Control
BNC: Bacterial nanocellulose
BNC-Chit: BNC-chitosan composite
Antibacterial properties against *Escherichia Coli* (EC)

Fig 7: A) BNC and BNC-Chit antibacterial activity after 2 hours against *E. coli* B) drop-plate method for BNC C) drop-plate method for BNC-Chit

Fig 8: A) drop-plate method for BNC B) drop-plate method for BNC-Chit

The number of CFUs after 24 hours was not countable. However, the decrease in the number of CFU for the composite is visible.

CFU: Colony forming unit
CTRL: Control
BNC: Bacterial nanocellulose
BNC-Chit: BNC-chitosan composite
Main results

The composite material BNC-Chit was prepared with preserved nanostructure with Chit in its pores.

The addition of Chit led to a slight decrease in mechanical properties but significant embrittlement did not occur.

The clogged pores of chitosan caused a significant decrease in the swelling ratio.

The BNC-Chit showed high antibacterial activity towards gram-positive bacteria.

**Future:** → Higher concentration of chitosan to provide better antibacterial properties against gram-negative bacteria but with preserved mechanical properties.
   → Cell adhesion studies.

Material suitable for biomedical applications or as packaging in the food industry.

Thank you for your attention