Chitosan-Functionalized Lignin Nanoparticles as a Bioactive Microneedle Platform

Mengxue Lu[1]*, Kirsi S. Mikkonen[1,2], Leena Peltonen[3], Patrícia Figueiredo[1]

[1] Department of Food and Nutrition, P.O. Box 66, FI-00014, University of Helsinki, Finland.

[2] Helsinki Institute of Sustainability Science (HELSUS), FI-00014, University of Helsinki, Finland.

[3] Division of Pharmaceutical Chemistry and Technology, P.O. Box 56, FI-00014, University of Helsinki, Finland.

*Email: mengxue.lu@helsinki.fi

Key findings

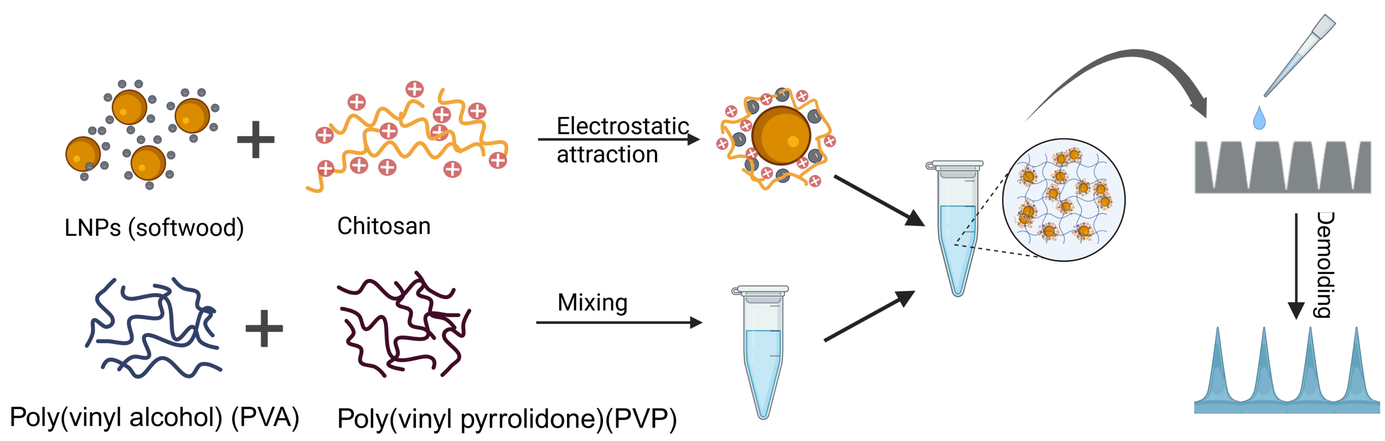
- Chitosan-functionalized lignin nanoparticles (Cs-LNPs) possess spherical morphology and high colloidal stability with positively charged surface.
- Compared to bare particles, Cs-LNPs show ~3-fold higher inhibition rate against *Escherichia coli* and *Staphylococcus aureus*, attributed to the presence of chitosan.
- Cs-LNPs loaded microneedles exhibit well-defined morphology and structural integrity with sufficient mechanical strength for skin penetration.

1. INTRODUCTION

While nanoparticles (NPs) in microneedle (MN) systems are primarily used as delivery vehicles, here we develop a bioactive chitosan-coated lignin nanoparticles (Cs-LNPs) platform to combine the antibacterial properties of chitosan with the antioxidant capacity of lignin, providing multifunctionality beyond payload delivery.[1,2]

Cs-LNPs were incorporated into poly(vinyl alcohol)–poly(vinyl pyrrolidone) (PVA–PVP) hydrogels to fabricate MNs with well-defined morphology and sufficient mechanical strength for transdermal delivery application.

2. METHODS



3. RESULTS

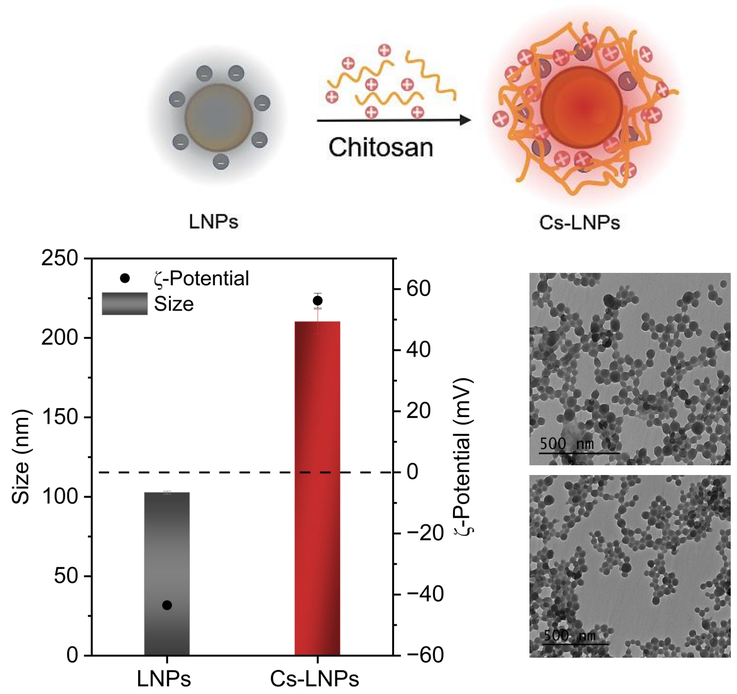


Figure 1: Left: Size and surface charge of pristine LNPs and Cs-LNPs; right: TEM images of LNPs (up), and Cs-LNPs (bottom).

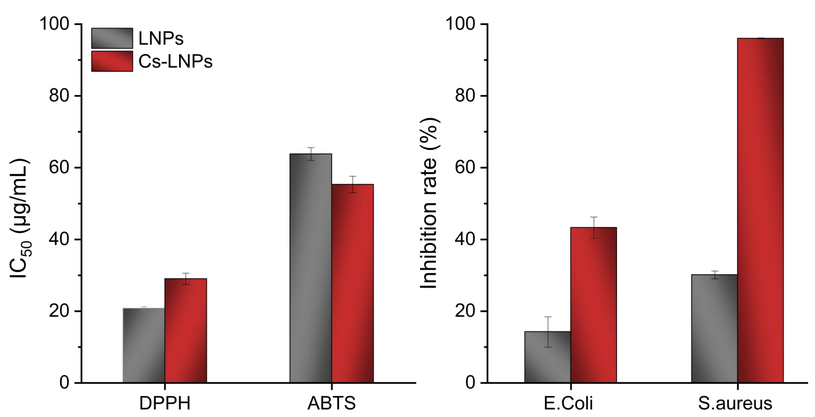


Figure 2: The effect of chitosan on (left) antioxidant capacity of LNPs, (right) antibacterial activity.

➢ Chitosan **preserves** the instinct **antioxidant capacity**, while **enhancing** significantly the **antibacterial properties** of LNPs .

Cs-LNPs was incorporated into a PVA-PVP hybrid hydrogel to fabricate microneedles using a centrifugal method.

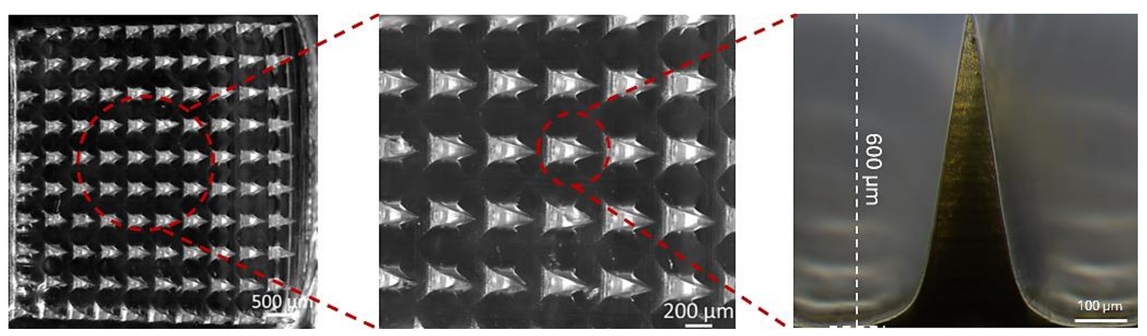


Figure 3: Fabricated microneedles under stereoscopic optical microscope.

➢ The fabricated microneedles show **well-defined morphology** and **structural intergrity**.

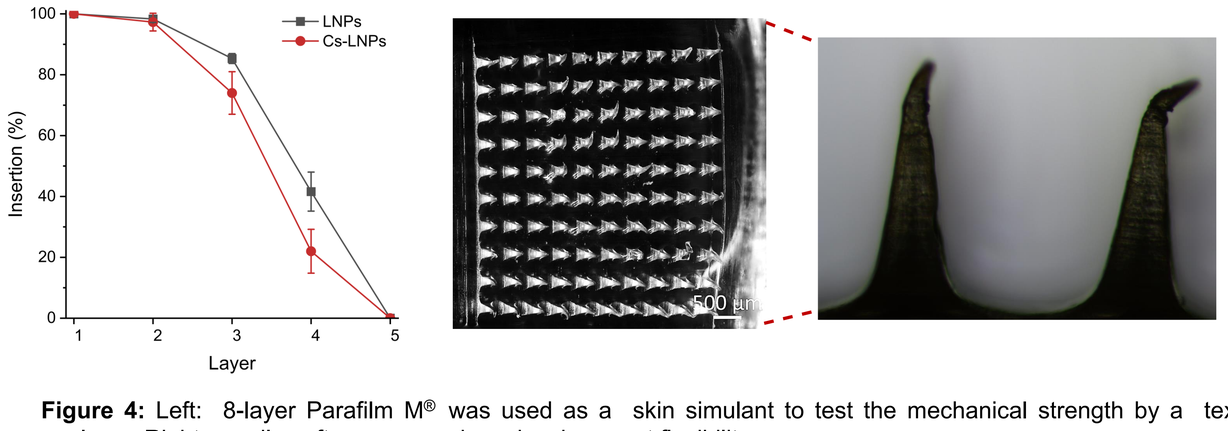


Figure 4: Left: 8-layer Parafilm M® was used as a skin simulant to test the mechanical strength by a texture analyzer. Right: needles after compression, showing great flexibility.

➢ With (Cs)-LNPs, full penetration up to 2 layers (**≈ 250 μm**), with 80% insertion on 3rd layer (**≈ 380 μm**), sufficient for dermal penetration.

ACKNOWLEDGMENTS

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HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI
MAATALOUS-METSÄTIETEELLINEN TIEDEKUNTA
AGRIKULTUR-FORSTVETENSKAPLIGA FAKULTETEN
FACULTY OF AGRICULTURE AND FORESTRY