Upscaling an Antimicrobial Biopolymer via a Novel Co-Culture Process

Matthew Arango*, Joshua Day*, Ghada Eldib*, Hang Le*, Graeme Low
Department of Chemical and Petroleum Engineering, University of Calgary
*Department of Biomedical Engineering, University of Calgary

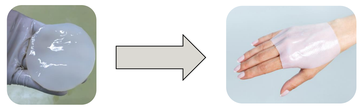
BacteriTech

SCHULICH School of Engineering — University of Calgary

Introduction

What is Bacterial Cellulose (BC)?

BC is a versatile biomaterial. It has unique properties, such as high water retention and biocompatibility, making it useful in applications like wound dressings.



Project Scope

The goal of this project is to design a biochemical plant capable of producing **100 metric tonnes** of antimicrobial bacterial cellulose annually with a competitive unit selling price of **$151.88/kg** USD.

Market Focus

3 key markets were explored for 10% of their market:
1. Wound Care and Healing
2. Tissue Engineering and Regenerative Medicine
3. Pharma Delivery Systems

Product

Value Proposition

Originally designed for packaging solutions by iGEM 2022, our team has redefined the application of this antimicrobial biopolymer to deliver a **safe and sustainable** material for medical products at large scales.

Cellulose Matrix

Nisin Protein

Material Properties

Strong and Flexible

Medically Safe

Fights Pathogens

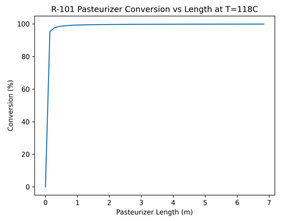
Biodegradable

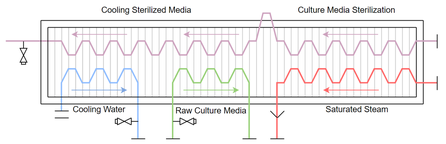
Process

1 Culture Media Preparation

This section prepares our **Culture Media** – the nutrient-rich liquid in which our product grows. It has three main steps:

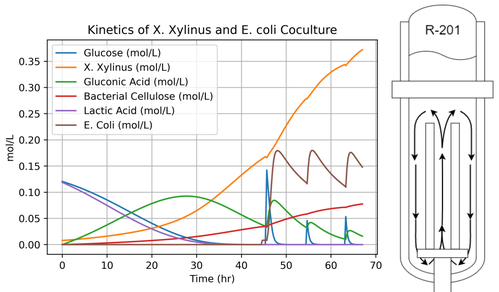
1. **Mix** water and nutrients.
2. **Sterilize** the culture media to 99.9% at 118ºC.
3. **Store** the media in tanks prior to fermentation.



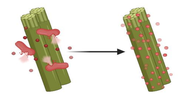


2 Fermentation to Produce Bacterial Cellulose and Nisin

The sterilized media is fed into an internal airlift reactor where it is cultured with *K. xylinus* and *E. coli* in a fed batch process to produce bacterial cellulose pellets and nisin proteins.



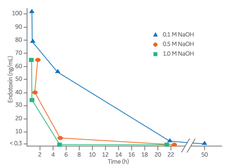
3 Lysis and Purification



E.coli lysis releases Nisin onto cellulose

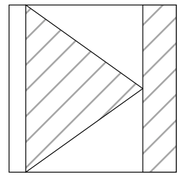
The fermented culture is **lysed and sterilized** to deactivate microbes in the culture broth. Sterilization takes place at 76 ºC and held for 140 seconds.

An alkaline wash of 0.5M NaOH is mixed with the cellulose polymer and held for 3 hours to achieve **medical grade quality**.



4 Dewatering, Packaging and Vacuum Sealing

1. **Refine** the BC pellets and water into a uniform slurry
2. **Remove** 10% of absorbed water content.
3. **Seal** BC at 23°C to extend the shelf life of the BC to ~6.5 months.



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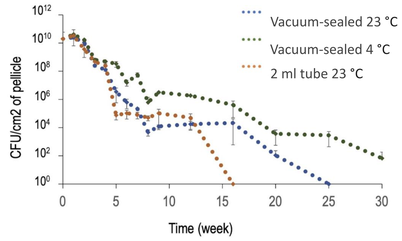


Economics

Investment & Upkeep

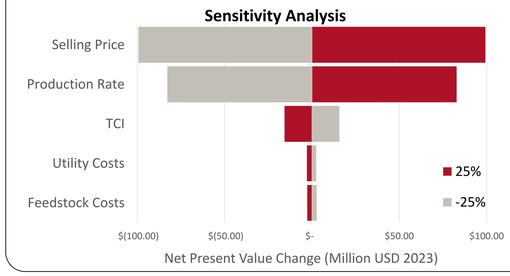
Capital Investment:	**$67M**
Operating Cost:	**$10M/y**

Market

Dry Product Price:	**$592/kg**
Production Rate:	**100 tonnes/y**

Profitability

Net Present Value:	**$280M**
Internal Rate of Return:	**84%**
Payback Period:	**1.4 Years**



Safety, Environment, & Social

Safety

- A **HAZOP** study was conducted to identify, evaluate, and control hazards.
- **ERPG** was used to determine the hazardous distance from a possible chemical release.

Environment

- **Scope 1 and 2 emissions** were used to evaluate the direct and indirect emissions.
- Implementation of **recycling processes** reduced wastewater production throughout the plant.

Social

- **SIA** addressed the effects of the plant on the community.
- **Hazardous distances** from the elected plant location were established to minimize public impact.

Acknowledgements

We would like to formally thank the ***2022 University of Calgary iGEM team*** for producing the novel biomaterial that inspired this project and for assisting us in understanding and upscaling their process. We would also like to thank our capstone supervisor ***Dr. Jinguang Hu*** and course coordinator ***Dr. Hector de la Hoz Siegler*** for their extraordinary support throughout the duration of this project.