UCLL HOGESCHOOL

Faculty of Technology, campus Gasthuisberg, Herestraat 49, 3000 Leuven, Belgium

Bioplastics with antimicrobial properties

Ruben Claeys, Giel Lambrechts, Noa Vanpeteghem, Mauro Clé, Joren Serneels, Olivier Van De Mierop

MEMBER OF ASSOCIATIE KU LEUVEN

Promotor research: L. De Smet

Introduction

Conventional plastics cause significant environmental pollution and are difficult to recycle. Bioplastics are a more sustainable alternative. These are bio-based, biodegradable, and biocompatible plastics, making them suitable for wound care. Alginate offers high absorption and biocompatibility, while chitosan has an antimicrobial effect. Additives such as glycerol and zinc oxide influence the mechanical and functional properties, such as flexibility, UV resistance, and antimicrobial activity. Optimizing the correct ratios of polymers and additives remains a challenge because the results in literature still vary greatly. This study investigated different bioplastic formulations, which were compared using tests such as tensile strength, antimicrobial effect, water permeability, and UV resistance to determine which composition is most suitable for use in wound care.

Materials and methods

Alginate–chitosan bioplastics were prepared by combining 1% (w/v) alginate and chitosan solutions in different mass ratios of 50:50 and 40:60 (chitosan:alginate). Glycerol was added as a plasticizer to improve flexibility, while zinc oxide was incorporated to enhance antimicrobial activity and UV resistance. The homogeneous mixtures were degassed with an ultrasonic bath, cast into Petri dishes, and dried at 65 °C to obtain bioplastic films. The antimicrobial activity of the films was evaluated using a zone of inhibition assay against *Escherichia coli*, *Staphylococcus aureus*, and *Enterococcus faecalis*. Mechanical properties were assessed by tensile testing using a universal testing machine made by Gunther Fleerackers. Water vapor permeability, water absorption, and UV stability were determined to evaluate the suitability of the bioplastics for wound care applications.

Enterococcus faecalis — ***Staphylococcus aureus*** — ***Escherichia coli***

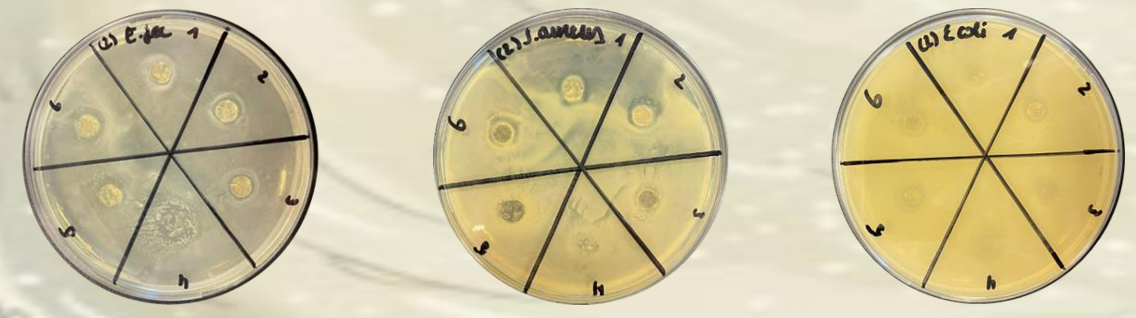

Figure 1: zones inhibition setup for six bioplastic formulations tested against Enterococcus faecalis, Staphylococcus aureus, and Escherichia coli

Figure 2: setups for water permeability testing of falcon tubes with bioplastic around the opening in a glass desiccator

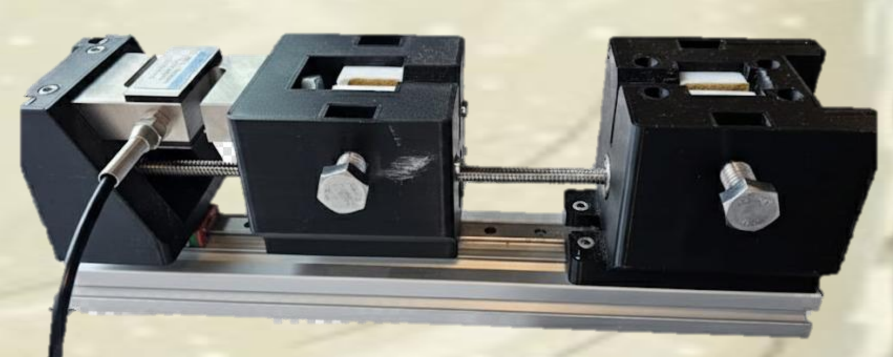

Figure 3: Figure 2: Universal Tensile Testing Machine Designed by Mr. Gunther Fleerackers

"The ideal bioplastic integrates antimicrobial functionality with mechanical flexibility while remaining environmentally sustainable"

Results

Alginate–chitosan bioplastics were successfully obtained with different physical and mechanical properties depending on composition and additives. Films containing glycerol showed increased flexibility and elongation, whereas zinc oxide significantly improved tensile strength. Bioplastics with a 40:60 chitosan–alginate ratio generally showed higher tensile strength compared to 50:50 formulations. Antimicrobial testing revealed clear inhibition zones against the Gram-positive bacteria *Staphylococcus aureus* and *Enterococcus faecalis*, while limited activity was observed against the Gram-negative bacterium *Escherichia coli*. The largest inhibition zones were observed for zinc oxide-containing bioplastics. Water vapor permeability and water absorption results indicated that the films were capable of maintaining a moist environment, which is essential for wound healing. UV exposure did not result in significant mass loss or structural degradation, particularly for bioplastics containing zinc oxide.

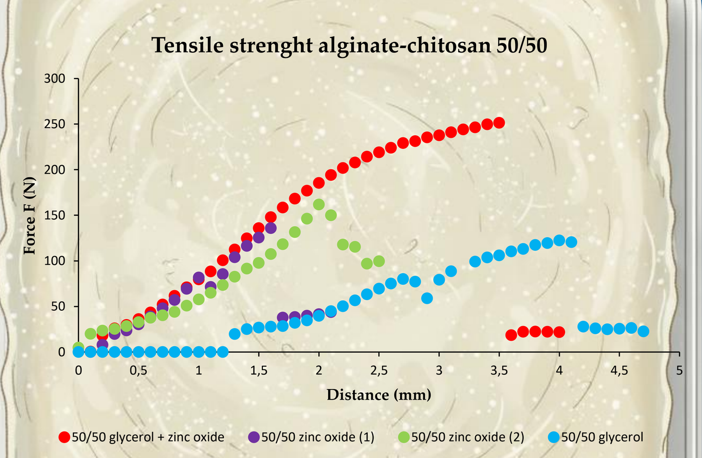

Figure 4: Relation between force and distance for 50:50 chitosan-alginate bioplastics containing different components

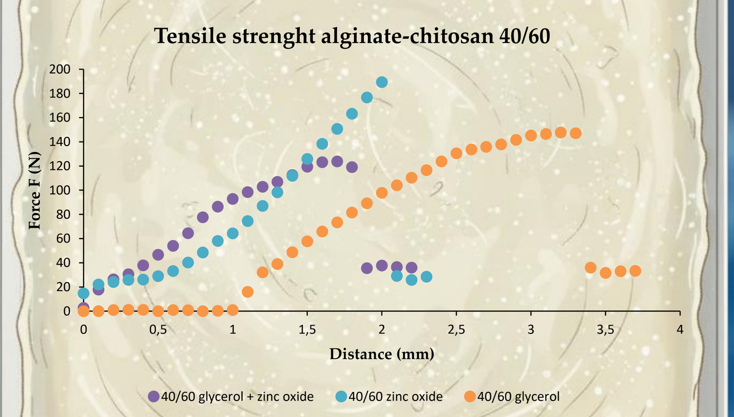

Figure 5: Relation between force and distance for 40:60 chitosan-alginate bioplastics containing different components

Conclusion

This study demonstrates that alginate–chitosan bioplastics can successfully combine antimicrobial activity, mechanical flexibility, and sustainability. Zinc oxide enhances antimicrobial performance, mechanical strength, and UV stability, while glycerol improves flexibility and elasticity. The balance between these components is crucial to obtain bioplastics with suitable properties for wound dressing applications. Overall, alginate–chitosan bioplastics show strong potential as sustainable, bioactive materials for medical use, particularly in the prevention of wound infections.