NSIEX+RS 2025
NEGERI SEMBILAN INTERNATIONAL EXPOSITION

HARMONY IN PROGRESS:

INTEGRATING SCIENCE, TECHNOLOGY, AND SOCIAL INNOVATION FOR SUSTAINABLE DEVELOPMENT GOALS

e-Book of Extended Abstract
Negeri Sembilan International (NSIEx) & Research Symposium
2025

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YST002 - CHITOTHYM PULP SHIELD: PROTECT, HEAL, REGENERATE

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ABSTRACT

The primary goal of pulp capping material is to protect and maintain a viable pulp. Maintenance of vital pulp encourage its ability to lay down reparative dentin as a protective barrier to the pulp. One of the important elements in regeneration of pulp-dentin structure is pulp capping material. Calcium hydroxide has been widely used as a pulp capping material. However, it is poorly adhered to tooth structure, soluble to oral fluids and brittle. This may cause microleakage which later might lead to secondary caries and pulpal inflammation. Therefore, this project aims to fabricate a chitosan-thyme oil electrospun nanofibers as a potential element for pulp capping material. Studies found that chitosan exhibit a great potential as a pulp capping material due to its ability to stimulate reparative dentin, maintain pulpal vitality, good antimicrobial activity, adherence properties to restorative material and dentin, and can resist forces during placement of restoration. It can also mimic the mineralization process of natural tooth structure. While, thyme oil has been known as a powerful remedy for antibacterial activity and tissue healing. Nanotechnology in tissue engineering such as electrospinning may further enhance the fabrication and application of chitosan in biomedical field. Hence, incorporation of chitosan and thyme oil create a potent natural-based therapy for pulpal protection and healing.

Keywords – Regenerative dentistry, electrospinning nanofiber, pulp capping, chitosan, thyme oil

INTRODUCTION

Calcium hydroxide is widely used as pulp capping and therapy due to its ease of use, antibacterial properties, and biocompatibility. However, it has several drawbacks, including poor adhesion to tooth structure, high solubility in oral fluids, and brittleness. These weaknesses can cause marginal leakage, allowing bacteria to enter and leading to pulpal infection or secondary caries. Because of these limitations, there is a need for better dental materials with improved physical strength, long-term stability, and antimicrobial effectiveness. One promising alternative is chitosan–thyme oil electrospun nanofiber. Chitosan is a natural biopolymer with good biocompatibility and antibacterial activity, while thyme oil is a well-known natural antimicrobial agent. When combined and processed through electrospinning, they form nanofibers that closely mimic natural tissue structures, provide a large surface area, and offer strong antibacterial action. This new material has the potential to overcome the shortcomings of calcium hydroxide and offer a more effective solution for dental pulp protection and healing.

OBJECTIVE

The objective of this project is to fabricate and study the potential of thyme-oil chitosan nanofibers as a potential element for pulp capping material.

DESCRIPTION OF THE PROJECT

The chitosan–thyme oil electrospun nanofiber is an innovative pulp capping material designed to preserve dental pulp vitality while promoting tissue healing and regeneration. Developed through electrospinning technology, it integrates chitosan and thyme oil, both natural, bioactive components, into a single therapeutic platform. Chitosan offers excellent biocompatibility, strong adhesion to dentin, and the ability to stimulate reparative dentin, while thyme oil provides potent antimicrobial and anti-inflammatory properties that help prevent bacterial infiltration and support healing.

The nanofiber's structure mimics the extracellular matrix, creating a high surface area scaffold that promotes cell attachment and tissue regeneration. Its fibrous architecture ensures flexibility, mechanical strength, and controlled biodegradation, allowing it to remain effective throughout the healing process without needing removal. This structure also contributes to superior sealing ability, minimizing microleakage and reducing the risk of secondary caries or pulpal inflammation.

Compared to conventional pulp capping materials like calcium hydroxide, this nanofiber may offer improved antibacterial performance, better physical stability, and enhanced biological response. It is compatible with standard dental procedures and requires minimal changes to existing clinical protocols. Biodegradable and eco-friendly, the chitosan–thyme oil nanofiber presents a practical and sustainable solution for modern, minimally invasive dental care.

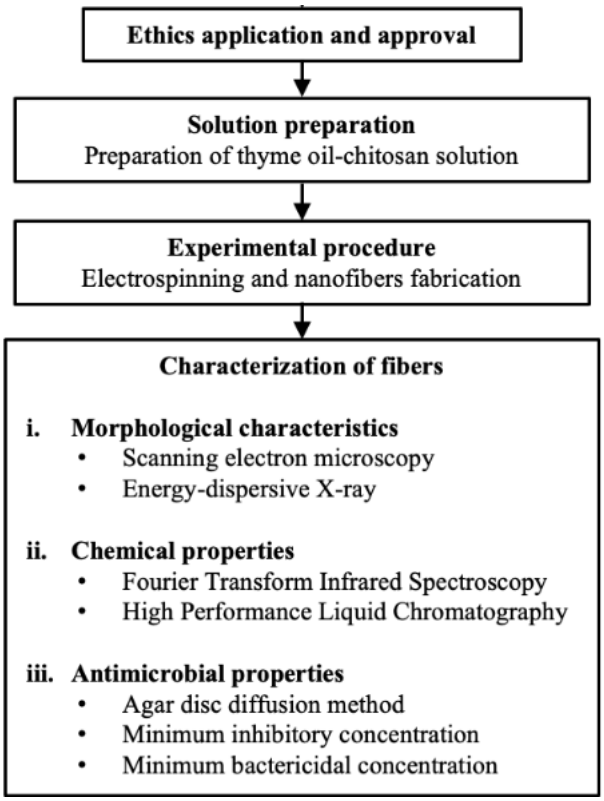

Figure 1. Process flow diagram for the fabrication of chitosan-thyme oil nanofiber.

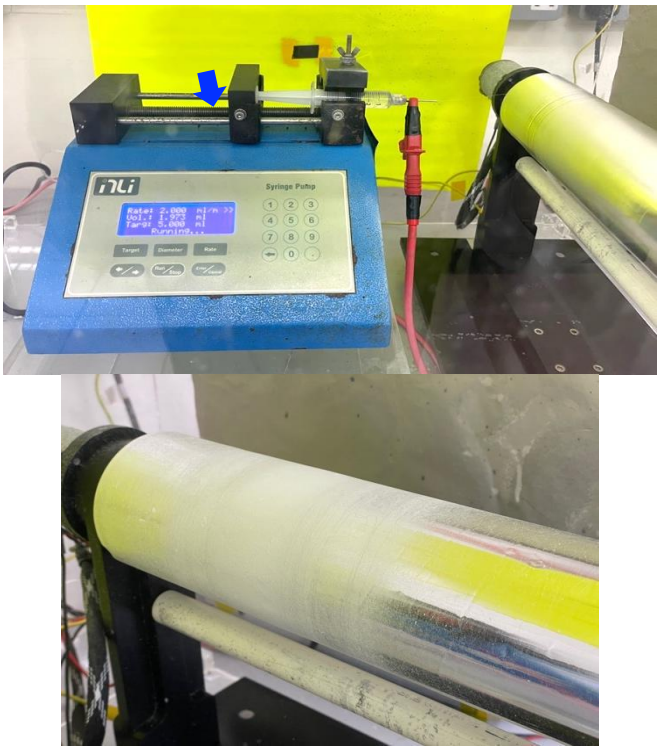

Figure 2. Electrospinning of chitosan-thyme oil. The arrow shows nanofiber formation from the solution.

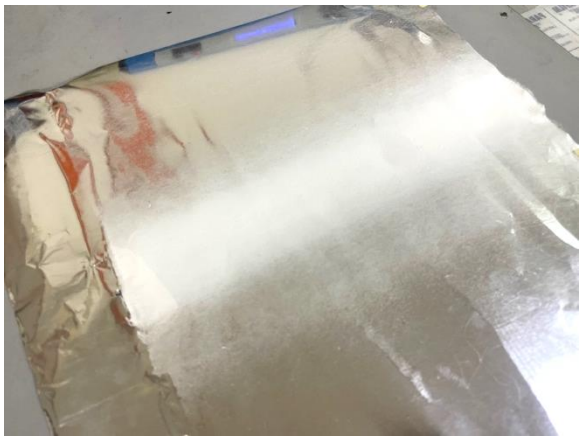

Figure 3. Sample of electrospun chitosan-thyme oil nanofiber.

NOVELTY

The chitosan-thyme oil electrospun nanofibers provide the following novelty aspects as part of their potential for pulp capping material:

Natural-Based Composition:
Combines two natural, biocompatible agents, which are chitosan and thyme oil. This offers a safer, more sustainable alternative to synthetic or chemical-based materials.

Electrospun Nanofiber Technology:
Utilizes electrospinning to create a high-surface-area, fibrous scaffold that mimics the extracellular matrix and enhances tissue regeneration.

Dual Functionality for Regenerative & Antibacterial:
Provides both reparative dentin induction (via chitosan) and potent antibacterial action (via thyme oil), addressing both healing and infection control in a single material.

Biodegradable and Biocompatible Scaffold:
Offers gradual, non-toxic degradation, minimizing the need for removal while supporting long-term tissue healing and mineralization.

CONCLUSION

In conclusion, the chitosan–thyme oil electrospun nanofiber represents a smart and sustainable advancement in the potential material for vital pulp therapy, offering a natural-based solution that may preserve pulp vitality while promoting tissue regeneration. Its combination of chitosan and thyme oil provides excellent biocompatibility, antibacterial protection, and biodegradability, making it both clinically effective and environmentally friendly. By utilizing renewable, non-toxic materials derived from crustacean shells and plants, this innovation supports eco-conscious dental practices. Beyond its therapeutic benefits, this nanofiber also presents a strong opportunity for commercialization within the dental and biomedical sectors, especially as the demand for bio-based and minimally invasive materials continues to rise. With dental caries affecting approximately 85% of Malaysians, there is a clear and urgent need for advanced materials that support effective caries management and pulp preservation. The product's unique advantages over traditional materials like calcium hydroxide and MTA, combined with its appeal in both private and public healthcare settings, position it well for widespread adoption. Through strategic partnerships, regulatory approval, and clinical validation, this innovation has the potential to become a leading solution in modern restorative dentistry both in Malaysia and globally, while supporting the future of sustainable oral healthcare.

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