Bioresorbable Starch Aerogel for Implantable Wireless Amylase Sensors

Yoon Kyeung Lee*, Jae Do Yang, Mi Rin Lee, Jin Tae Park, Soon Joo Yoon

Jeonbuk National University, Korea
*yoonklee@jbnu.ac.kr

생체 삽입용 아밀라아제 센서를 위한 생분해성 녹말 에어로겔

이윤경*, 양재도, 이미린, 박진태, 윤순주
전북대학교

Abstract

Real-time monitoring of pancreatic fluid leakage is crucial for preventing complications after pancreatic surgery. We present a bioresorbable starch-based aerogel film integrated with an implantable wireless amylase sensor designed for continuous, non-invasive monitoring. The sensor utilizes a starch-polymer aerogel prepared by freeze-dry process whose state can be monitored wirelessly by the RF receiver coil. Amylase-triggered hydrolysis of the starch alters the physical and chemical state of the polymer film, enabling wireless detection of the presence of amylase. Experimental validation confirms the effectiveness of this wireless system, demonstrating its potential for real-time post-surgical monitoring applications.

Ⅰ. Introduction

Real-time monitoring through implantable biosensors represents a significant advancement in medical diagnostics, allowing for continuous assessment within the body and eliminating the need for specialized clinical equipment. This capability is especially vital during postoperative period, where complications must be detected swiftly to prevent poor outcomes. In pancreatic cancer surgery, one major concern is pancreatic fluid leakage, which can activate amylase enzymes, leading to organ damage around pancreas if not identified early. Despite recent progress in indirect detection methods, achieving real-time, in situ monitoring remains a challenge. To address this, we introduce a bioresorbable starch-polymer-based aerogel integrated with an RF receiver coil specifically designed for the wireless detection of pancreatic fluid leaks.

Ⅱ. Method

Drop-casting of aqueous starch solutions with various percent of solid contents form thin films. These films were subject to freeze dry to form aerogel. The porous structures and their structural stability under soaking were evaluated. Mechanical and physicochemical stability in dried and wet conditions of the samples prepared through different curing methods were compared. Leakage simulation was performed by introducing amylase enzyme solutions to the starch-based aerogel, triggering hydrolysis and altering the resonance modulation properties. Additionally, biodegradation properties were monitored under physiological conditions to assess long-term stability and bioresorbability.

Ⅲ. Conclusion

The enzymatic hydrolysis of starch can change the characteristics of passive RLC circuit on the starch-polymer-based aerogel. The system provides a robust platform for continuous, non-invasive monitoring. Experimental results validate the system's effectiveness for real-time amylase sensing, emphasizing its promise for implantable post-surgical applications.

ACKNOWLEDGMENT

본 연구는 전북대학교병원『혁신형 미래 의료 기반 마이랩 구축 지원사업』의 지원을 받아 수행됨.

REFERENCES

[1] Li, Shuo, et al., "Bioresorbable, wireless, passive sensors for continuous pH measurements and early detection of gastric leakage", Science advances, 10, eadj0268 (2024)

[2] Juanita NC et al. HPB (Oxford) 2023 Sep;25(9):1011-1021