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Smart Packaging for Wireless Monitoring of Fish Freshness

Chipless wireless sensors that track seafood spoilage via hypoxanthine chemistry.

Food waste is a critical sustainability concern, especially notable for seafood where it is estimated that 30-35% of harvested seafood goes to waste. Fish are particularly problematic due to ideal conditions for microorganism growth which leads to spoilage,. The biggest reason for seafood waste is a misconception about the expiration date of fish, which is only an estimate provided to the consumer. Fish spoilage can occur from temperature variations within storage and freezer facilities, which range from place to place. Determining the freshness of the fish is critical, for both consumers and market providers.

Purdue Researchers have developed a new technology that assesses fish freshness in a more accessible and precise manner than traditional monitoring devices. This technology is based on a chipless wireless sensor that utilizes a passive sensing platform combined with a responsive polymer bilayer that is activated when the fish begins to spoil. This sensor technology allows for remote assessment of fish spoilage without the need for invasive monitoring, a massive improvement over traditional technology that necessitates the package opening. The developed technology also uses significantly less power than other methods, which allows for the technology to be used commercially. The wireless tag-based sensor system integrates with seafood packaging and uses a self-calibrating mechanism incorporating Hypoxanthine (HX) as a specific marker of fish freshness. The HX indicates the state of the fish, with the wireless technology then allowing for remote monitoring of this indicator, thus ensuring real-time feedback on fish quality.

Technology Validation:

- A wireless sensor tag demonstrating both working coil and reference coil was developed

Technology ID
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Category
Agriculture, Nutrition, & AgTech/Food Safety & Traceability
GreenTech/Sustainable Packaging Materials

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- Testing of sensor tag using the HX bilayer polymer coating correctly identified fresh and spoiled fish

- Scanning electron microscopy and X-ray spectroscopy was used to characterize surface topography and wettability of the biosensor

Advantages:

- Higher precision over traditional methods for fish spoilage

- Non-invasive monitoring eliminates the need for open packaged assessment

- Better energy efficiency over traditional methods, which allows for more sustainability

Applications:

- Food freshness applications

- Supply chain monitoring

- Smart refrigeration

TRL: 4

Intellectual Property:

Provisional-Patent, 2023-03-10, United States

PCT-Patent, 2024-03-11, WO

NATL-Patent, 2025-09-09, United States

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