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# Lost-cost Nonreversible Far-field Wireless pH Sensor for Intelligent Packaging and Spoilage Detection in Packaged Meat Products

**Battery-free PET-based tags that detect microbial pH shifts in packaged meats.**

Foodborne diseases and illnesses commonly occur when meat products are spoiled, which can be due to contamination or poor refrigeration of the product. Moreover, spoilage can also occur during the refrigeration of the meat products as certain microbes can proliferate at low temperatures. For meat products, the USA recommends that these products are cooked and maintained at 60 Â°C or above before serving or stored below 4.4 Â°C within two hours of preparation. For grocery stores, products must be maintained under 4.4 Â°C for 5 â€“ 10 days. Refrigeration is a useful strategy at curbing some food spoilage, it is inadequate at stopping the growth of bacteria that can grow at lower temperatures than the advised 4.4 Â°C. An early sign of meat spoilage is a change in the surface pH from the normal range of 5.8 to 6.2 to higher pH values caused by bacterial decomposition, indicating spoilage. Traditional spoilage detection methods such as handheld probes and pH test strips are currently used for detecting this change in pH. However, these methods are limited to individual testing, often being labor-intensive and invasive, limiting their applicability for continuous, large-scale monitoring of meat freshness in packaged foods.

Purdue Researchers have developed a battery-free, chipless and flexible pH sensor tag using laser etching technique on metalized PET films. The sensor tag demonstrates enhanced wettability and adhesion with a single-step metal nanoparticle functionalization. The sensor tag is comprised of paired UHF resonators with a pH-sensitive bilayer coating, which is sensitive to changes in the pH. The S100 layer dissolves at pH levels above 6.8â€”indicative of spoilageâ€”exposing the PVA layer and shifts the resonant frequency. The shift in frequency allows for the detection of spoilage, which is measured wirelessly by the resonator. The researchers were able to use the sensor tags to detecting spoilage in packaged chicken samples, showing

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experimental efficacy of the sensor tag.

**Technology Validation:**

-Sensing tags showed a frequency shift from 0.874 GHz to 0.778 GHz within 24 hours in pH>7 buffers.

-20% frequency shift was established as the threshold for indicating spoilage

-Sensor tag placed in a commercially packaged chicken under refrigeration detected a shift exceeding the 20% threshold

**Advantages**:

-Battery and chip free

-Flexible

-Scalable

**Applications**:

-Meat product monitoring

**TRL:** 4

**Intellectual Property:**

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

PCT-Patent, 2024-03-11, WO

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

**Keywords:** Chemical Engineering, Food and Nutrition, meat products, Sensors, Wireless