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Monitoring Food Spoilage Using Biopolymer-coated UHF RFID Sensing Transponder

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In 2015, the United Nations adopted SDG (Sustainable Development Goals) that states to reduce FWI (Food Waste Index). To comply with this, food market must use strong logistic management and extend products shelf-life. World Health Organization (WHO) estimated that more than 600 million foodborne disease have been declared in 2010 and these diseases led to numerous fatalities including death and disabilities [1]. In United States of America, many years of improvements in food safety regulations have not dramatically reduced the risks [2]. Between 1993 and 1997, 37 % of foodborne disease are due to improper storage temperature. This led to success of Time-Temperature Indicator (TTI). But, among the remaining cases, only 11 % foodborne disease are due to improper cooking. Spoiled food must be discarded before cooking, and monitoring must target other variables including food package gas concentration. Using bio-sourced biopolymer sensors are suggested for this need. Their dielectric properties have proven to be sensitive to environmental gas changes that are related to food spoilage [3].

To address logistics needs (i.e., non-line of sight and long-range reading) and SDG waste reduction, battery-less UHF RFID (RAIN compliant) transponder layout is chosen. The developed transponder antenna is a curved-dipole T-match. A biopolymer layer is used to tune the antenna and to make it sensitive to gas concentration. And, to better sense biopolymer permittivity, interdigitated electrodes take place between its T-match stubs, as described in Figure 1. In this paper, experiments in real food packaging conditions are presented to prove that developed solution can successfully track food packages through their shelf-life. To emulate real conditions, beef meat is stored in Modified Atmosphere Packages (MAP) consisting of 30 % CO_2 and 70 % O_2. Food spoilage is monitored using humidity logger, microbiological tests, colorimetry, and subjective visual aspect. Over RFID communication measurements, forward transponder turn-on power is preferred. So, surrounding perturbation is limited to one-way signal trip. As of now, RFID measurements must stay with same distance between reader and transponder, and with same environment. According to previous experiments with humidity or gaseous changes [4], 3 steps differentiate in Figure 2. Between start to second day, it is ambient atmosphere to MAP stabilization. Then, signals are steady for 5 days. Finally, they rise again with exponentially growing microbiological activity and with related gaseous changes inside the food packaging. Resulting RAIN transponder can sense food spoilage in MAP.

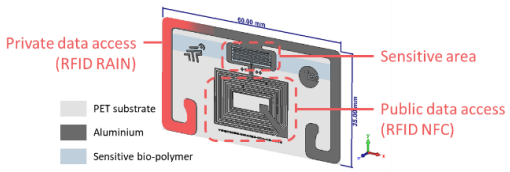

Figure 1. Food spoilage sensitive RAIN transponder schematic

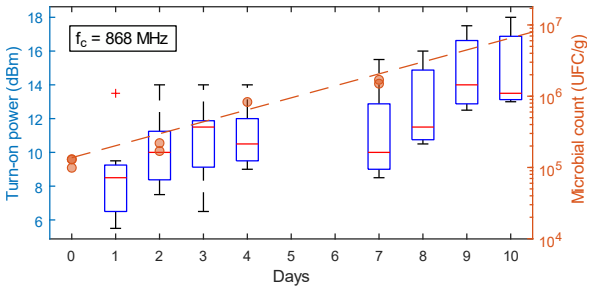

Figure 2. Transponders turn-on power signals in MAP with beef meat at 5 °C for change in packaged quality

References

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