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Effect of Packaging Material and Water-Based Solutions on Performance of Radio Frequency Identification for Food Packaging Applications

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Abstract : The growth of large food supply chains demanded improved end-to-end traceability of food products, which has led to companies being increasingly interested in using smart technologies such as Radio Frequency Identification (RFID)-enabled packaging to track items. As technology is being widely used, there are several technological or economic issues that should be overcome to facilitate the adoption of this track-and-trace technology. One of the technological challenges of RFID technology is its sensitivity to different environmental form factors, including packaging materials and the content of the packaging. Although researchers have assessed the performance loss due to the proximity of water and aqueous solutions, there is still the need to further investigate the impacts of food products on the reading range of RFID tags. However, to the best of our knowledge, there are not enough studies to determine the correlation between RFID tag performance and food beverages properties. The goal of this project was to investigate the effect of the solution properties (pH and conductivity) and different packaging materials filled with food-like water-based solutions on the performance of an RFID tag. Three commercially available ultra high-frequency RFID tags were placed on three different bottles and filled with different concentrations of water-based solutions, including sodium chloride, citric acid, sucrose, and ethanol. Transparent glass, Polyethylneterephtalate (PET), and Tetrapak® were used as the packaging materials commonly used in the beverage industries. Tag readability (Theoretical Read Range, TRR) and sensitivity (Power on Tag Forward, PoF) were determined using an anechoic chamber. First, the best place to attach the tag for each packaging material was investigated using empty and water-filled bottles. Then, the bottles were filled with the food-like solutions and tested with the three different tags and the PoF and TRR at the fixed frequency of 915MHz. In parallel, the pH and conductivity of solutions were measured. The best-performing tag was then selected to test the bottles filled with wine, orange, and apple juice. Despite various solutions altering the performance of each tag, the change in tag performance had no correlation with the pH or conductivity of the solution. Additionally, packaging material played a significant role in tag performance. Each tag tested performed optimally under different conditions. This study is the first part of comprehensive research to determine the regression model for the prediction of tag performance behavior based on the packaging material and the content. More investigations, including more tags and food products, are needed to be able to develop a robust regression model. The results of this study can be used by RFID tag manufacturers to design suitable tags for specific products with similar properties.

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