Silk-based Microneedle Technology for the Colorimetric Detection of Bacteria for Improved Food Quality Monitoring System

Doyoon Kim
Postdoctoral Research Associate, Massachusetts Institute of Technology

Abstract:
Food safety is a major threat to public health and well-being of society. Improved food quality monitoring throughout the food supply chain can ensure global food safety and minimize food loss. In particular, the detection of bacterial pathogens and spoilage is a major challenge for this global mission. Incorporation of sensors into packaging is a promising approach, but it is difficult to achieve the required detection volume while using food-safe sensor materials. In this study, we developed a platform for detection of pathogenic bacteria in food using a porous microneedle array by utilizing non-toxic and edible properties of silk fibroin extracted from Bombyx mori silkworm. The microneedle array was able to sample fluid from the interior of the food and deliver the fluid to a colorimetric sensor located on the surface of the array. Through the development of color patterns of the polydiacetylene-based sensor printed onto the backside of the microneedle array, we identified the presence of E. coli in fish fillets within a day of injection. This bacterial detection was distinguished from spoilage measured via increase in the sample pH. The microneedle-based device can penetrate commercially used polymer film packaging and function in the same manner, indicating the feasibility of successful adaptation of the technology downstream in current food supply chains. This study highlights that regenerated structural biopolymers can serve as a platform with robust mechanical properties, and tailored chemistry, to design materials for food contact and sensing.

Bio:
Dr. Doyoon Kim joined the Marelli research group in 2019 as postdoctoral research associate. At MIT CEE, he has been working on nanofabrication techniques to confront food security. His research interests include exploring nanoscale reactions at organic/inorganic interfaces for engineering applications. He obtained B.S in Civil and Environmental Engineering in 2009 and M.S. in Environmental engineering in 2012 from the Hanyang University, Seoul, South Korea. He received his Ph.D. degree in Energy, Environmental, & Chemical Engineering from the Washington University in St. Louis 2018. He is the recipient of the Doh Won Suk Memorial Award in 2018.