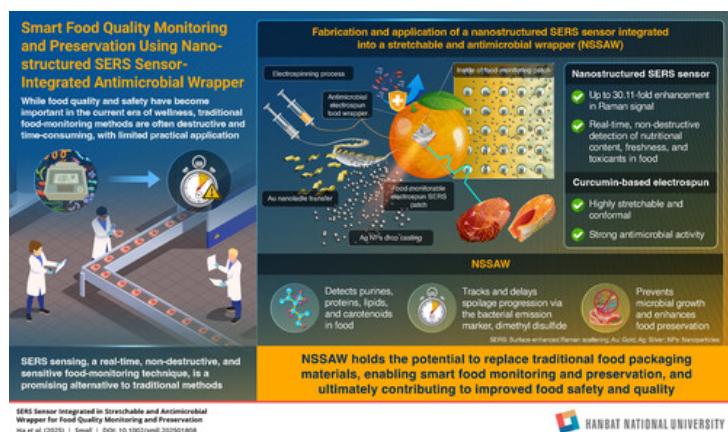


Korean researchers unveil 2-in-1 SERS wrapper with antimicrobial food protection

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Food quality and safety are crucial. However, conventional food-monitoring methods, including ribotyping and polymerase chain reaction, tend to be destructive and lengthy. These shortcomings limit their potential for broad applications. In this regard, surface-enhanced Raman scattering (SERS) sensing, with real-time, non-destructive, and high sensitivity capabilities, is a highly promising alternative.



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In a new breakthrough, a team of researchers, led by Associate Professor Ji-Hwan Ha from the Department of Mechanical Engineering, Hanbat National University, Republic of Korea, has developed a two-in-one nanostructured SERS sensor integrated into a stretchable and antimicrobial wrapper (NSSAW) that not only monitors food directly on the surface but also actively preserves it.

The proposed wrapper incorporates a nanostructured SERS sensor—Au nano-arrays loaded with Ag nanoparticles—that delivers up to 30.11-fold Raman enhancement, enabling real-time, non-destructive detection of nutritional components, including purines, proteins, lipids, and carotenoids, and even the pesticide thiram on meats, fish, and fruit. At the same time, the curcumin-thermoplastic polyurethane (TPU) electrospun wrapper shows strong antimicrobial efficacy of 99.99% against *S. aureus* and 99.9% against *E. coli*, helping extend shelf life.

Notably, NSSAW is highly stretchable and conformal, withstanding elongation of 716% and maximum stress of 52.3 MPa. The SERS layer is spontaneously integrated into it during fabrication via nanoimprint lithography, e-beam slanted deposition, and electrospinning with nanotransfer printing, indicating a practical route to scalable packaging.

"In cold-chain logistics and storage, the wrapper can help distributors decide when to ship and sell food by continuously tracking freshness and spoilage chemistry. In retail smart packaging, its stretchable, conformal, and biocompatible nature enables non-destructive, on-package checks of quality and nutrition markers—without any damage to food—supporting point-of-

sale quality automation and transparent date labeling. Thus, the real-world uses of our technology span the entire farm-to-fork chain," says Prof. Ha.

Furthermore, NSSAW tracks spoilage progression over time by following the bacterial emission marker dimethyl disulfide, linking chemistry to freshness in a way that consumers and industry can interpret. This research is thus expected to open new horizons in monitoring the freshness and composition of human food.

"NSSAW can act as an on-food freshness indicator during consumer storage for home use and meal-kit delivery, linking chemical changes to easy-to-interpret signals over time. In addition, for high-value seafood and meats, quantitative tracking of purines such as hypoxanthine supports premium-grade verification and shelf-life decisions. Moreover, as active packaging, the curcumin-TPU, with its antimicrobial properties, complements sensing with preservation to extend shelf life in distribution and retail," says Prof. Ha.