화학과 세미나

박성호 교수
연세대학교 화학과

Hot nanoparticles for near-field focusing: Synthesis and their biosensor applications to answer, “how can we detect early Covid or Alzheimer's diseases?"

Surface plasmonics of nanomaterials has been one of the major research themes in nanoscience. The control of size and shape of corresponding nanoparticles is necessary to fully utilize their optical behavior for further applications, such as biosensing, catalysis, and energy conversion. Here we successfully synthesized a new class of nanomaterials: two-dimensional and/or three-dimensional nanoframes with high uniformity through wet-chemistry. As a representative example, we will discuss the synthesis of a novel class of nanoparticles denoted as annular Au nanotrenches (AANTs). AANTs are engineered to possess embedded, narrow circular nanogaps with dimensions of approximately 1 nm, facilitating near-field focusing for detection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) via a surface-enhanced Raman scattering (SERS)-based immunoassay. Notably, AANTs exhibited an exceedingly low limit of detection (LOD) of 1 fg/mL for SARS-CoV-2 spike glycoproteins, surpassing the commercially available enzyme-linked immunosorbent assay (ELISA) by 6 orders of magnitude (1 ng/mL from ELISA). To assess the real-world applicability, a study was conducted on 50 clinical samples using a SERS-based immunoassay with AANTs. The results revealed a sensitivity of 96% and a selectivity of 100%, demonstrating the significantly enhanced sensing capabilities of the proposed approach in comparison to ELISA and commercial lateral flow assay kits. Additionally, we will present how a similar tactic can be applied to the early detection of Alzheimer’s disease, a significant modern brain illness.

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