November 12-13 2024
RamanFest
Paris | FRANCE

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Rapid detection of Pesticide Residues Based on Surface-Enhanced Raman Scattering through Core-Shell nanoparticles

In the context of the rapid development of the food industry and agriculture science and technology, it is very important to detect the target molecules within the complex biological or chemical environment, such as pesticide residues in various foods, pollutant detection in the marine environment, virus detection in vivo, etc. To detect the target molecules with higher sensitivity and linearity, specificity, speed, and reproducibility in a complex environment has always been our pursuit, and quantitative measurement with high accuracy would be another challenge for rapid and accurate trace detection. Recently novel method like surface-enhanced Raman scattering (SERS) has emerged as a promising label-free detection method for multifarious applications due to its advantages of high sensitivity, time-saving experiment process special molecular fingerprint, along with non-destructive nature. Core-shell nanoparticles have been commonly used as surface-enhanced Raman scattering (SERS) substrates for sensing and detection due to their prominent optical properties such as localized surface plasmon resonance (LSPR) and tunability. In this study, AuNRs@Ag core-shell nanoparticles with different thicknesses of silver shells were synthesized. A Raman reporter 1, 4-benzenedithiol (1,4-BDT) was then sandwiched in between the Au-Ag nanogap to obtain a strong Raman signal as a reference signal for the quantitative measurement of the concentration of pesticide residue. The longitudinal resonance peak of AuNRs@Ag core-shell nanoparticles can be tuned from 760 nm to 610 nm by controlling the thickness of the silver shell. Also, we evaluated the SERS-enhancing properties of the AuNRs@1,4-BDT@Ag nanoparticles by measuring the Raman signal of the mixture of these nanoparticles with pesticide residue solutions. The highest detection sensitivity and reproducibility of quantitative measurements were achieved, corresponding to an optimized longitudinal resonance peak and probes. We also combined it with machine learning algorithms to accurately identify and quantify the SERS spectra of the pesticide residue in the system. To evaluate the performance of machine learning algorithms different metrics were applied that demonstrated accuracy in pesticide residue status prediction. This developed approach helps as a simple and expeditious tool for the analysis of food and exhibits potential for broader applications in various domains in the future.

Figures

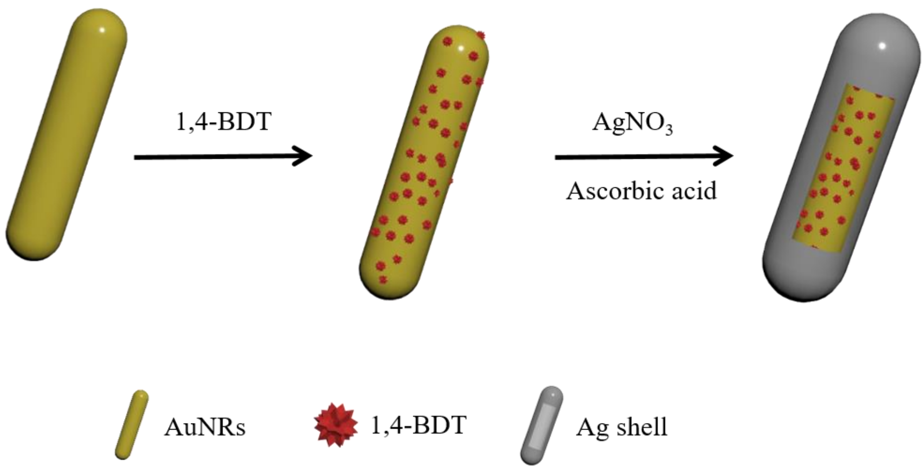

Figure1. Schematic fabrication procedure for the core-shell GNRs@1,4-BDT@Ag NPs.