Designing Tailored Silver Nanoparticles for SERS-Based Analysis of Organic Dye Properties

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In recent decades, Surface-Enhanced Raman Spectroscopy (SERS) has become a leading analytical technique for identifying organic colorants in the field of cultural heritage. Various strategies exist for producing SERS-active substrates, with wet chemical reduction of silver or gold salts remaining the most widely adopted approach. Among the available metal colloids, silver nanoparticles are particularly favoured for solution-based SERS measurements, owing to their broad plasmonic response spanning the visible to near-infrared range, their notable stability, the strong signal enhancement they provide, and the relative simplicity of their synthesis.

Despite this widespread use, the relationships linking the physicochemical characteristics of chemically synthesized nanoparticles to their effectiveness as SERS substrates remain poorly understood. Considering how commonly aggregated silver colloids are employed in SERS applications, there is a clear need for a systematic investigation connecting enhancement performance to analyte structural features, as well as to the morphological and electrodynamic characteristics of the metal nanostructures, including particle size and shape.

This work explores how to optimize the properties of chemically synthesized silver nanoparticles for SERS detection, testing three excitation wavelengths (532, 633, and 785 nm) and analytes that engage with the metallic surface via distinct binding mechanisms. Specifically, the investigation centres on acid and basic solvent dyes relevant to modern and contemporary art materials.

Nanoparticles of both isotropic and anisotropic morphology were synthesized, with their size distribution, polydispersity, and surface charge characterized through UV-visible spectrophotometry, scanning electron microscopy (SEM), and dynamic light scattering (DLS).