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Exploring Plasmonic Nanoparticles inside Cells: A Comprehensive Methodology Integrating Spontaneous and Stimulated SERS, FACS, SEM and ICP-AES

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Extended Abstract

In the fields of modern diagnostics, therapy, and biotechnology, noble metal nanoparticles show great promise due to their unique physico-chemical characteristics. This includes high stability, extensive surface area for modification, and the crucial plasmonic resonance effect, enabling the tuning and enhancement of optical signals and inducing localized light-induced heating [1]. Numerous papers describe the perspectives of different types of theranostic agents for cancer diagnostics and treatment based on various effects, such as surface-enhanced Raman spectroscopy, fluorescence, photothermal, and photodynamic effects [2], [3].

Despite the promising nature of these systems, proper evaluation of their affinities to specific cell lines is sometimes lacking. This is crucial for proving the targeting nature of therapeutic effects and the selectivity of nanoparticles [4]. The origin of the interaction, whether binding to membrane receptors or lysosomal transport inside cells, may impact the expected mode of action [5]. Agglomeration of nanoparticles before or after internalization can affect affinity, and cell viability, and lead to optical effects such as quenching of fluorescence or the "hot spots" effect. A thorough evaluation of these properties is essential before considering nanotags for further biological studies.

This report discusses, evaluates, and compares the methodology of different modern instrumental methods used in in vitro studies. Plasmonic nanoagents, obtained by layer-by-layer polymer coating of gold nanobones synthesized using a modified seed-mediated method, serve as the model object. These multilayered core-shell anisotropic gold nanoparticles were studied in cells using techniques such as SERS and fluorescent mapping. The affinity of nanoparticles, conjugated with the folic acid or anti-FOLR1 as the delivery vectors, was examined in a comparative affinity study using FACS and ICP-AES. Fluorescent dye incorporated into the multilayered structure provides both SERS and fluorescence, offering valuable insights into nanoparticle behavior inside cells. FACS quantitatively reveals the affinity of nanoparticles to specific cell lines, while ICP-AES measures the amount of nanoparticles absorbed by cells based on gold quantification after dissolution in aqua regia.

In summary, this research underscores the promising applications of gold nanoparticles in biomedicine. The thorough methodology, encompassing techniques like SERS, fluorescent mapping, FACS, and ICP-AES, provides a comprehensive understanding of nanoparticle-cell interactions. This approach, focusing on factors like affinity and intracellular behavior, offers a reliable foundation for advancing from lab studies to clinical applications, boosting the potential for innovative diagnostic and therapeutic methods.

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