Flame-made high-value nanoparticles for biomedicine

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Flame aerosol technology has emerged as a highly scalable and reproducible manufacturing route for engineering high-value nanomaterials. This talk highlights our recent advances in developing flame-made nanoparticles tailored for cutting-edge biomedical applications, focusing on diagnostics, antimicrobial strategies, and smart therapeutic platforms.

First, we explore the precise structural engineering of plasmonic nanoaggregates. By fine-tuning interparticle distances during aerosol self-assembly [1], we achieve highly uniform surface-enhanced Raman scattering (SERS) substrates for rapid diagnostics [2,3], alongside robust silver nanoparticle-based colorimetric sensors for bedside hyperammonemia detection [4].

Second, we present multifaceted approaches to combatting bacterial biofilms and medical device infections. These include *in situ* deposited nanostructured implant coatings utilizing Ag-bioglass [5] and pH-triggered Ag/Au nanoalloys [6], durable visible-light photocatalytic titanium suboxide nanocomposites [7], and superhydrophobic polymeric coatings to prevent biofouling [8].

Finally, we demonstrate the integration of flame-made nanomaterials into advanced delivery systems. Key examples include hybrid near-infrared photothermal microneedles utilizing plasmonic nanoaggregates for the synergistic eradication of methicillin-resistant *S. aureus* (MRSA) [9], and the one-step synthesis of amorphous CaP-SiO_2 nanoparticles with tunable immunogenicity [10]. Ultimately, this presentation illustrates how the precision and scalability of flame synthesis can accelerate the clinical translation of next-generation nanomedicines.

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