Nanoparticle Design for Photothermal Applications and the Path to Commercialization

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Plasmonic metal nanoparticles – including gold, silver, and platinum – are highly efficient at absorbing and scattering light. Despite their subwavelength size, the particles behave as tiny antennas that strongly couple to incident light and enable applications ranging from diagnostics to sophisticated hyperthermia and photothermal treatments.

The ability to control nanoparticle size, shape, and composition allows the resulting optical extinction to be tuned to overlap with a chosen wavelength of incident light. While tuning the total extinction provides a useful starting point for designing and selecting the optical response of a nanomaterial, understanding and control over the scattering and absorption cross-sections at different wavelengths is required for optimizing optical properties for use in specific instances.

Here, we describe the fabrication of colloidal plasmonic nanoparticles with different morphology and composition – including gold nanorods, silica-core gold nanoshells, hollow-core bimetallic nanoshells, and silver nanoplates – that can be tuned during fabrication to produce materials with overlapping peak optical extinction in the near-infrared. Selection of particular materials is driven by data collected from a number of sources, including reflectance spectroscopy and other methods to measure the scattering and absorption components of the total extinction, functional testing including photothermal measurements on dispersions under continuous laser irradiation, and modeling of the optical properties. Further design criteria related to composition and surface chemistry are driven by the application method of the material, for example whether a nanoparticle formulation is to be used in a topical or injectable formulation.

Examples of the design and use of plasmonic materials in applications ranging from dermatology to the thawing of cryogenically-preserved zebrafish embryos are described along with the pathway to regulated commercial manufacturing.