Simulation study of plasmonic nanostructure to tune optical property in the visible spectra

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**Abstract**

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Plasmonic nanostructures have gained profound scientific interest for their distinctive electronic arrangements to confine the local electric field in the nanogaps known as “hotspots” produced by characteristic Localized surface plasmon resonance (LSPR) property of the noble metal nanoparticles, e.g., gold, silver, and platinum. It is the collective oscillation of the conduction band electrons in response to the irradiated electromagnetic wave on the surface of the metal nanostructures. The plasmonic properties of the nanostructures can be easily tuned by altering the size, shape, material or the local refractive index of the nanostructures of interest. Therefore, the resonant wavelength of the nanostructures can be shifted to the region of interest by the synthesis of different shaped nanostructures or by composites of nanostructures having different shapes, sizes or materials. As of now such composites of nanostructures could be prepared by using high end instruments like Electron Beam Lithography, Optical Lithography, or various patterning techniques. However, one of the facile syntheses methods of such nanostructures could be to use synthesized nanoparticles to assemble into new structures by varying the assembly parameters or permutations of the composite materials to build nanostructures to refine the resonance frequency. In this perspective, we have conducted a simulation study of optical properties and plasmonic enhancement of hierarchical nanostructure of nanoparticles using COMSOL Multiphysics software. The plasmonic materials considered in this study are silver, gold and platinum. Initially, the nano-assembly considered are synthesized using spherical nanoparticles of different size of each material. Significant surface plasmon enhancement (up to ~10 fold) can be achieved if we only consider dimer of these nanoparticle compared with single nanoparticle of same size (20 nm). This enhancement can be further improved for hierarchical nano-assembly of same metal nanoparticle. Further, some sets of simulation are performed for hierarchical nano-assembly (up to three layer) using different combination of size and materials.

**Keywords:** Plasmonic nanostructure, COMSOL Multiphysics, surface plasmon resonance