Label-free plasmonic biosensors for environmental and medical applications

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Nanostructured materials exhibit unique size/shape-dependent features. The extraordinary evolution of synthesis routes and characterization techniques provides unprecedented opportunities to design, synthesize and organize nanomaterials. Accordingly, nanomaterials can be exploited as building blocks to fabricate structures with compelling complexity. Nanostructures based on noble metal nanoparticles (M-NPs) provide relevant examples in this framework. The main property of M-NPs is the phenomenon of Localized Surface Plasmon Resonance (LSPR). It arises from the collective oscillation of electrons polarized at the M-NPs surface, in resonance with the impinging wavelength. Any change of the dielectric constant of the medium surrounding the M-NPs surface alters the ability of the surface to accommodate the electron charge density, resulting in a variation of the plasmon resonance wavelength. Such a phenomenon underlies LSPR-based biosensing. The present contribution will show the fabrication, characterization, and sensing investigation of nanostructures resulting from the random assembly of M-NPs. The proposed nanostructures are designed to enable the detection of microorganisms and compounds relevant to environmental and medical applications. The selectivity is achieved by a suitable nanostructure biofunctionalization that, exploiting the charge density alteration, allows detecting biorecognition events by absorption spectroscopy. Remarkably, the proposed nanostructures beyond accomplishing sensitive and selective LSPR biosensing are reusable as they enable the on-demand photo-thermal disinfection and the analyte removal. The reusability is accomplished by exploiting the metal nanoparticle arrays' highly efficient light-to-heat conversion ability.