Plasmon-Enhanced Fluorescence: Amplification Strategy in Fluorescence Biosensors

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Plasmonics represents a branch of photonics research that offers an attractive means for signal amplification in various optical spectroscopies employed for diagnostic and analytical purposes. In particular, these include surface-enhanced Raman spectroscopy (SERS), surface-enhanced infrared spectroscopy (SEIRA), and surface plasmon-enhanced fluorescence spectroscopy (PEF) that is also referred as to metal-enhanced fluorescence (MEF). Fluorescence is (arguably) mostly used optical method for detection of chemical and biological species in important fields of medical diagnostics, food safety and security. The amplification of fluorescence signal through the coupling of fluorophore labels with metallic (nano)structures exhibiting surface plasmon resonance (SPR) offers an attractive way to push forward the sensitivity of fluorescence assays. This can be achieved through the combination of a) increasing excitation rate at the fluorophore absorption wavelength ($\lambda_{\text{abs}}$), b) improving the efficiency of collecting the fluorescence light at the emission wavelength ($\lambda_{\text{em}}$) by directional emission, and by the increasing of quantum yield.

![Fig. a) Schematic of surface plasmon interaction with fluorophore labels, b) compact biochip with implemented PEF that utilizes propagating surface plasmons, c) structure for collective localized surface plasmons for PEF.](image)

This paper reports several PEF approaches pursued in our laboratory for enhancing signal in fluorescence assays by a factor by up to $10^3$. In particular, the employing of collective (lattice) localized surface plasmons (cLSPs) on arrays of diffraction-coupled metallic nanoparticles will be discussed (see Fig c) [1] and our efforts on the implementation of PEF either to existing SPR instruments or to new compact portable devices by using diffractive elements [2] (see Fig. b) will be presented. The performance of PEF will be illustrated by several assays for detection of molecular analytes at low-femtomolar concentrations [3] and harmful bacterial pathogens at concentrations as low as 10 colony forming units [4].