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Microfluidic Plasmonic Bio-Sensing of Exosomes by Using a Gold Nano-Island Platform

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Abstract : A bio-sensing method, based on the plasmonic property of gold nano-islands, has been developed for detection of exosomes in a clinical setting. The position of the gold plasmon band in the UV-Visible spectrum depends on the size and shape of gold nanoparticles as well as on the surrounding environment. By adsorbing various chemical entities, or binding them, the gold plasmon band will shift toward longer wavelengths and the shift is proportional to the concentration. Exosomes transport cargoes of molecules and genetic materials to proximal and distal cells. Presently, the standard method for their isolation and quantification from body fluids is by ultracentrifugation, not a practical method to be implemented in a clinical setting. Thus, a versatile and cutting-edge platform is required to selectively detect and isolate exosomes for further analysis at clinical level. The new sensing protocol, instead of antibodies, makes use of a specially synthesized polypeptide (Vn96), to capture and quantify the exosomes from different media, by binding the heat shock proteins from exosomes. The protocol has been established and optimized by using a glass substrate, in order to facilitate the next stage, namely the transfer of the protocol to a microfluidic environment. After each step of the protocol, the UV-Vis spectrum was recorded and the position of gold Localized Surface Plasmon Resonance (LSPR) band was measured. The sensing process was modelled, taking into account the characteristics of the nano-island structure, prepared by thermal convection and annealing. The optimal molar ratios of the most important chemical entities, involved in the detection of exosomes were calculated as well. Indeed, it was found that the results of the sensing process depend on the two major steps: the molar ratios of streptavidin to biotin-PEG-Vn96 and, the final step, the capture of exosomes by the biotin-PEG-Vn96 complex. The microfluidic device designed for sensing of exosomes consists of a glass substrate, sealed by a PDMS layer that contains the channel and a collecting chamber. In the device, the solutions of linker, cross-linker, etc., are pumped over the gold nano-islands and an Ocean Optics spectrometer is used to measure the position of the Au plasmon band at each step of the sensing. The experiments have shown that the shift of the Au LSPR band is proportional to the concentration of exosomes and, thereby, exosomes can be accurately quantified. An important advantage of the method is the ability to discriminate between exosomes having different origins.

Keywords : exosomes, gold nano-islands, microfluidics, plasmonic biosensing
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