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Plasmonic Biosensor for Early Detection of Environmental DNA (eDNA) Combined with Enzyme Amplification

Authors : Monisha Elumalai, Joana Guerreiro, Joana Carvalho, Marta Prado

Abstract : DNA biosensors popularity has been increasing over the past few years. Traditional analytical techniques tend to require complex steps and expensive equipment however DNA biosensors have the advantage of getting simple, fast and economic. Additionally, the combination of DNA biosensors with nanomaterials offers the opportunity to improve the selectivity, sensitivity and the overall performance of the devices. DNA biosensors are based on oligonucleotides as sensing elements. These oligonucleotides are highly specific to complementary DNA sequences resulting in the hybridization of the strands. DNA biosensors are not only an advantage in the clinical field but also applicable in numerous research areas such as food analysis or environmental control. Zebra Mussels (ZM), Dreissena polymorpha are invasive species responsible for enormous negative impacts on the environment and ecosystems. Generally, the detection of ZM is made when the observation of adult or macroscopic larvae's is made however at this stage is too late to avoid the harmful effects. Therefore, there is a need to develop an analytical tool for the early detection of ZM. Here, we present a portable plasmonic biosensor for the detection of environmental DNA (eDNA) released to the environment from this invasive species. The plasmonic DNA biosensor combines gold nanoparticles, as transducer elements, due to their great optical properties and high sensitivity. The detection strategy is based on the immobilization of a short base pair DNA sequence on the nanoparticles surface followed by specific hybridization in the presence of a complementary target DNA. The hybridization events are tracked by the optical response provided by the nanospheres and their surrounding environment. The identification of the DNA sequences (synthetic target and probes) to detect Zebra mussel were designed by using Geneious software in order to maximize the specificity. Moreover, to increase the optical response enzyme amplification of DNA might be used. The gold nanospheres were synthesized and characterized by UV-visible spectrophotometry and transmission electron microscopy (TEM). The obtained nanospheres present the maximum localized surface plasmon resonance (LSPR) peak position are found to be around 519 nm and a diameter of 17nm. The DNA probes modified with a sulfur group at one end of the sequence were then loaded on the gold nanospheres at different ionic strengths and DNA probe concentrations. The optimal DNA probe loading will be selected based on the stability of the optical signal followed by the hybridization study. Hybridization process leads to either nanoparticle dispersion or aggregation based on the presence or absence of the target DNA. Finally, this detection system will be integrated into an optical sensing platform. Considering that the developed device will be used in the field, it should fulfill the inexpensive and portability requirements. The sensing devices based on specific DNA detection holds great potential and can be exploited for sensing applications in-loco.

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