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Nanostructured photoelectrochemical biosensing platform for cancer biomarker detection

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Abstract

The innovative photoelectrochemical properties of multifunctional nanomaterials are here investigated for the development of biosensing platforms for rapid and sensitive detection of a class of cancer biomarker candidates, known as microRNAs. Many different transducers have been proposed, so far, for microRNA detection. Recently, with the emergence of novel photoelectrochemically active species and new detection schemes, photoelectrochemistry has received increasing attention. Gold nanostructures have been, here, used to modify TiO_2 electrodes. The surface of the nanostructured platform has been modified by nucleic acid capture probes (CPs). Biotinylated target miRNAs have been recognized by the specific CPs. The biosensing platform has been incubated with streptavidin alkaline phosphatase and exposed to a proper substrate. The product of the enzymatic reaction has been photoelectrochemically monitored. A compact and hand-held analytical device has been developed in order to have a final prototype in line with the concept of point of care testing.

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Keywords: TiO_2 nanocrystals; Au nanorods; genosensor

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1. Introduction

Nowadays, there is a great interest for the photocatalytic and photoelectrochemical properties of nanomaterials, such as semiconductor nanocrystals, nanoparticles of noble metals, carbon nanotubes or graphene heterostructures, and their applications in biosensing. Colloidal gold nanomaterials show chemical-physical size- and shape-dependent properties, high surface-volume ratio, high density of active sites for the immobilization of molecules, which make them promising for advanced applications. In the present report, the use of titania electrodes, modified with colloidal gold nanorods (AuNRs) has been proposed for the photoelectrochemical detection of miRNA. miRNAs are endogenous, evolutionarily conserved, non-coding RNA molecules of about 20 nucleotides in length, functioning as posttranscriptional gene regulators. Individual miRNAs have been found to regulate cell apoptosis and proliferation and modulate chemotherapy response. So, their detection has potential in diagnosis and therapy of cancer [1]. Many different transducers have been proposed, so far, for microRNA detection [2]. Indeed, recently, with the emergence of novel photoelectrochemically active species and new detection schemes, photoelectrochemistry has received increasing attention.

2. Development of a nanostructured photoelectrochemical genosensor based on TiO_2 electrodes and AuNRs

In Figure 1 the scheme of the assay is reported. The capture probe was immobilized on the AuNRs with the well-known chemistry of thiols. The capture-probe-modified electrode was then allowed to react with the analyte (the synthetic, biotinylated, target miRNA). Then, the biotinylated hybrid was exposed to the alkaline-phosphatase-streptavidin conjugate and the product of the enzymatic reaction was electrochemically monitored using chronoamperometry. Phosphorylated ascorbic acid was used as substrate of the biocatalytic reaction in order to recognize the hybridization event on the gold modified electrode surface. The measurements were performed at a wavelength of 470 nm.

3. Conclusions

Applying this photoelectrochemical assay, a detection limit of 20 fmole of the target miRNA (RSD of 5%) was obtained.

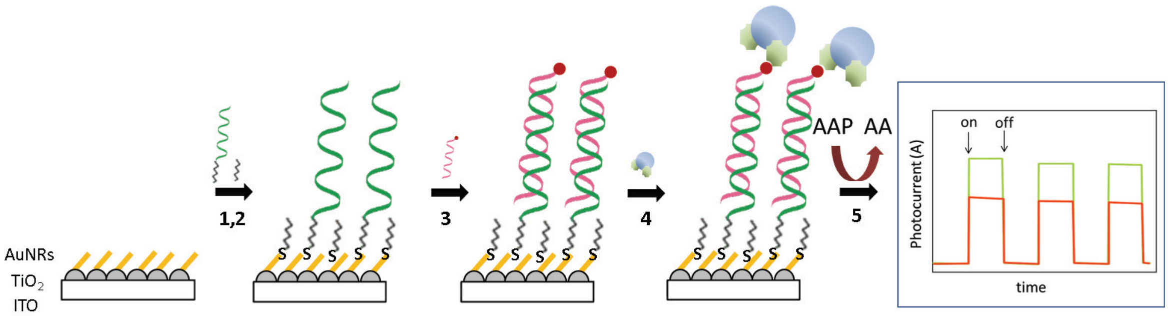

Figure 1: Scheme of the assay

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