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Signal-on Photoelectrochemical bioassay for DNA based on CdTe quantum dots by endonuclease-aided cycling amplification strategy

Yang Zhao,[a] Zhi Li,[b] Qian Kuang,[a] Guifen Jie*[a]

a *Key Laboratory of Sensor Analysis of Tumor Marker, Ministry of Education, Qingdao University of Science and Technology, 266042, P. R. China;*

b *School of Polymer Science and Engineering, Qingdao University of Science and Technology, 266042, P. R. China;*

Abstract

In the present work, a novel signal-on photoelectrochemical (PEC) sensing scaffold was developed for sensitive detection of target DNA by cycling amplification strategy, in which the CdS quantum dots (QDs) labeled DNA was served as a highly efficient photoactive species. The Au nanoparticles (NPs) with excellent electroconductibility were introduced to the sensing platform to improve the photocurrent, and the endonuclease-aided cycling amplification strategy was further applied to amplify the detection signal. Under the optimized conditions, this "signal-on" PEC bioassay showed a linear relationship between photocurrent and the target concentration in the range of 0.001−100 nM. The developed PEC bioassay with high sensitivity and good specificity has a great potential for detecting biomolecules with trace amounts in bioanalysis and clinical biomedicine.

***Keywords*:** photoelectrochemical; cycling amplification; CdS quantum dots

1. Introduction

DNA sensors are of vital importance to the determination of many biological markers of disease and have been extensively applied in many areas, such as clinical diagnosis, pathogen detection, and gene therapy.[1−3] Various analytical techniques have been used for DNA detection, including fluorescence,[4] colorimetry,[5] electrochemistry,[6] photoelectrochemistry (PEC),[7] and electrochemiluminescence.[8]

Photoelectrochemical bioanalysis is newly emerging and sensitive method for biomolecular detection, which combine the advantages of optical methods and electrochemical sensing.[9, 10] It is important to develop sensitive and accurate method for biomolecular detection. Because of total separation between detection signal and excitation source, PEC detection has a high sensitivity and low background signal compared with traditional optical and electrochemical assays,[11, 12] so a series of PEC platforms have been designed for the detection of small molecules,[13, 14] thrombin,[15] DNA damage,[16] antigens,[17, 18] and cells.[19] Moreover, it has been generally recognized that, in the early stage of diseases, the concentrations of relevant biomarkers are usually on a relatively low level. Thus, various efforts have been devoted to the design of signal amplification strategies for sensitively detecting target analytes to meet the requirements of clinical diagnosis and medical treatment of diseases.[20-22]

Recently, a new class of nuclease-based signal amplification strategies have been reported and demonstrated to be useful in detecting trace levels of DNA targets.[23, 24] Among them, DNA nicking endonuclease has been used in more and more biological detection, because of its strong recognition of DNA sequences, the target can be reused by repeated cycles of hybridization, cleavage, and separation, resulting in exponential amplification.[25, 26] The reactions can be performed in an isothermal condition without specialized instrumentation, which holds great potential for routine analysis.[27]

In this work, a novel signal-on photoelectrochemical sensing platform based on CdS QDs by cycling amplification strategy was developed for target DNA detection (Scheme 1). First, the presence of target DNA initiate the cycles of nicking-digestion-hybridization, releasing abundant CdS QDs-labeled DNA sequences which further hybridized with the capture DNA for enhanced PEC signal. Moreover, the Au NPs with excellent electroconductibility were modified on electrode to further improve the photocurrent signal. The proposed PEC bioassay performed simple experimental procedure and exhibited high sensitivity and selectivity for target DNA detection, which can be widely applied to detect various DNA sequences and show a great potential for early diagnosis in gene-related diseases.