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Highly Sensitive DNA-biomacromolecule Sensor for Detecting Clinical Cancer Samples

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Abstract

Ultrasensitive DNA-biomacromolecule refers to a system or technology that can detect and analyze DNA molecules with extremely high sensitivity. DNA, as the genetic material of living organisms, plays a vital role in various biological processes and is often used for diagnostic and research purposes. Ultrasensitive DNA-biomacromolecule technologies are designed to detect and measure minute quantities of DNA molecules present in a sample. These technologies employ various detection methods, such as fluorescence, electrochemical sensing, nanopore sequencing, or amplification techniques like polymerase chain reaction. By leveraging these techniques, scientists can achieve highly sensitive and accurate detection of DNA molecules, even at very low concentrations.

Keywords: DNA-biomacromolecule • DNA molecules • Ultrasensitive DNA

Introduction

Ultrasensitive DNA detection is crucial in molecular diagnostics for detecting diseases, genetic disorders, and infectious agents. It enables the identification of specific DNA sequences associated with particular conditions, helping in early disease detection and personalized medicine. DNA analysis is extensively used in forensic investigations for identifying suspects or establishing genetic relationships. Ultrasensitive DNA technologies can extract and analyze DNA from trace amounts of biological samples, enhancing the accuracy and reliability of forensic analysis. DNA-based monitoring methods are employed to assess the presence and abundance of various organisms in environmental samples. Ultrasensitive DNA-biomacromolecule technologies enable the detection of rare or low-abundance species, aiding in biodiversity studies and ecological research [1].

Literature Review

Detection and analysis of cancer-related DNA mutations or aberrations are critical for understanding the molecular basis of cancer and developing targeted therapies. Ultrasensitive DNA technologies facilitate the identification of rare mutations or circulating tumor DNA, enabling early cancer diagnosis and monitoring treatment response. DNA analysis is an essential part of drug development and clinical trials. Ultrasensitive DNA-bio macromolecule technologies can be used to quantify drug target genes, assess the efficacy of treatments, and monitor the presence of drug-resistant mutations. For early detection of disease and cancer, diagnostic testing of biological macromolecules is crucial. However, the interface-based sensing method's sensitive detection of macromolecules remains challenging due to its limited surface area and significant steric hindrance. Introduced here is a "biphasic replacement" electrochemical aptamer-based (BRE-AB) sensing technique that replaces the biomacromolecule's capture reaction with a small diameter of single-stranded DNA to attach to the interface. The ultrasensitive detection of luteinizing hormone (LH) with a detection limit of 10 1012 m is demonstrated by means of the BRE-AB sensor [2].

Discussion

The aptamer-target LH binding mechanism is investigated using Molecular Dynamics simulations. In addition, it has been established that the BRE-AB sensor exhibits superior sensing capabilities in both undiluted plasma and whole blood. The BRE-AB sensor successfully quantifies the LH concentrations in 40 clinical samples, revealing that breast cancer patients have higher LH expression. Additionally, the sensor's simplicity, low cost, and ease of regeneration and reuse point to its potential use in biological macromolecule diagnostics at the point of care. Depicts the BRE-AB system's signaling mechanism. There is a solution reaction and an interface reaction in the BRE-AB system. Prehybridized aptamer/signal duplexes were in the solution phase without a target, and only a few free signal probes with the redox indicator methylene blue were able to enter the interface. The steady state of the anchored helper probes on the interface continued in the meantime. It formed more stable aptamer/target complexes by binding specifically to the aptamer and releasing signal probes from aptamer/signal duplexes following the addition of target biomacromolecules. The helper probes, which were anchored to the surface of the gold electrode using Au–S chemistry, enter the interface and then hybridize with the released signal probes. As a result, the MB indicators are able to get within easy reach of the gold surface, accelerating electron transfer significantly [3,4].

Conclusion

A Biphasic Replacement E-AB (BRE-AB) sensing platform for the highly sensitive detection of bio macromolecules at the picomolar level has been demonstrated in this work. The advantages of this sensor include ultrahigh sensitivity, excellent regenerability, and reusability. It was made in a simple and inexpensive manner. In addition, the BRE-AB sensor has a detection limit even in whole blood. The MD simulation results showed that electrostatic interaction, hydrogen bonding, and the -alkyl hydrophobic effect were the primary forces that caused LH to bind to the aptamer. We hypothesize that the BRE-AB sensor can be used to analyze and detect a target of interest. This is based on reasonable probe sequence design, guided by theoretical simulation and free energy prediction. This study demonstrates that the BRE-AB sensor has great potential for early cancer diagnosis and is an ideal candidate for macromolecular detection [5,6].

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Conflict of Interest

No potential conflict of interest was reported by the authors.

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