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Harnessing G-quadruplex Structures: A Perspective on Biosensors for SARS-CoV-2 Detection

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Introduction

The COVID-19 pandemic has underscored the critical need for rapid, accurate, and accessible diagnostic tools to detect SARS-CoV-2, the virus responsible for the disease. Traditional methods such as PCR testing, while effective, often require specialized equipment and trained personnel, leading to delays in diagnosis and treatment. In recent years, there has been growing interest in the development of biosensors based on G-quadruplex structures for various applications, including disease detection. In this perspective article, we highlight the potential of G-quadruplex-based biosensors in the fight against COVID-19.

G-quadruplex structures are non-canonical nucleic acid secondary structures formed by the stacking of G-quartets, which are planar arrangements of four guanine bases held together by Hoogsteen hydrogen bonding. These structures can form in guanine-rich regions of DNA or RNA sequences, leading to unique structural properties with potential biological significance. Recent research has elucidated the role of G-quadruplex structures in gene regulation, telomere maintenance, and genome stability.

One of the most promising applications of G-quadruplex structures lies in biosensor technology. Biosensors are analytical devices that detect biological molecules and convert this information into measurable signals. G-quadruplex-based biosensors leverage the unique structural properties of G-quadruplexes to achieve highly sensitive and selective detection of target analytes.

Description

Electrochemical biosensors represent one of the most widely studied platforms for G-quadruplex-based detection. These biosensors rely on the electrochemical properties of G-quadruplex structures to transduce the binding events into measurable electrical signals. By functionalizing electrode surfaces with G-quadruplex-forming oligonucleotides, researchers have developed biosensors capable of detecting various biomolecules, including nucleic acids, proteins, and small molecules, with high sensitivity and specificity.

In addition to electrochemical biosensors, optical biosensors offer another promising approach for G-quadruplex-based detection. These biosensors exploit the optical properties of G-quadruplex structures, such as fluorescence or surface plasmon resonance, to achieve label-free and real-time detection of target analytes. By integrating G-quadruplex probes into optical sensor platforms, researchers have demonstrated the detection of diverse analytes with high sensitivity and rapid response times.

The emergence of SARS-CoV-2 has prompted urgent efforts to develop diagnostic tools capable of rapid and accurate detection of the virus. G-quadruplex-based biosensors hold significant promise for SARS-CoV-2 detection due to their inherent sensitivity, selectivity, and versatility. One potential strategy involves designing G-quadruplex probes that specifically bind to conserved regions of the viral genome, allowing for the sensitive detection of viral RNA.

Furthermore, the development of G-quadruplex-based biosensors for SARS-CoV-2 detection could offer several advantages over existing diagnostic methods. These biosensors have the potential to provide rapid results, enabling timely clinical decision-making and outbreak control. Moreover, G-quadruplex-based biosensors could be adapted for point-of-care testing, facilitating decentralized testing and expanding access to diagnostic services.

Conclusion

In conclusion, G-quadruplex-based biosensors represent a promising avenue for the development of sensitive, selective, and rapid diagnostic tools for SARS-CoV-2 detection. By harnessing the unique structural properties of G-quadruplex structures, researchers can design biosensors capable of detecting viral RNA with high sensitivity and specificity. Moving forward, continued research and innovation in this field will be essential to realize the full potential of G-quadruplex-based biosensors for combating COVID-19 and other infectious diseases.

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