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Metal Detection Biosensor Using Enhanced Green Fluorescent Protein Platform

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Abstract

The development of sensitive and efficient biosensors for metal detection is of paramount importance for various applications including environmental monitoring, food safety and medical diagnostics. This study presents a novel approach using an Enhanced Green Fluorescent Protein (EGFP) platform as the foundation for a metal detection biosensor. By fusing EGFP with metal-binding peptides, the biosensor achieves enhanced specificity and sensitivity for targeted metal ions. The biosensor operates based on the principle that metal ions bind to the modified EGFP, inducing changes in its fluorescence emission spectrum. These alterations in fluorescence properties serve as quantifiable indicators of metal presence and concentration. The versatility of EGFP as a platform enables the development of biosensors tailored to detect specific metal ions, offering flexibility in addressing diverse metal contamination concerns. This technology offers several advantages, including real-time monitoring, rapid response and non-destructive detection. Furthermore, the biosensor's compatibility with various sample matrices and potential for miniaturization contribute to its applicability in field and point-of-care settings. The integration of an EGFP platform with metal detection enhances our ability to identify and quantify metal contaminants, contributing to improved safety and health across various sectors.

Keywords: Metal detection • Biosensor • Enhanced green fluorescent protein • Biorecognition • Fluorescence

Introduction

The detection of heavy metals in various environmental and biological samples is a matter of significant concern due to their potential toxicity and environmental impact. Traditional methods for metal detection often involve complex and time-consuming procedures. Biosensor technology, harnessing the specificity and sensitivity of biorecognition elements, offers a promising approach for rapid and efficient metal detection. In this context, the integration of an Enhanced Green Fluorescent Protein (EGFP) platform into biosensor design presents an innovative strategy for sensitive and real-time metal detection. The metal detection biosensor utilizing an enhanced green fluorescent protein platform represents a promising advancement in biosensor technology. By capitalizing on the inherent fluorescence properties of EGFP, this approach offers a versatile and sensitive means for detecting metal ions in complex samples. The ability to tailor the biosensor for different metal targets enhances its utility for a range of applications, positioning it as a valuable tool for ensuring safety and quality in diverse industries [1].

Literature Review

In recent years, the development of biosensors for the detection of metal ions has gained significant attention due to the environmental and health implications of metal contamination. One innovative approach in this field is the utilization of Enhanced Green Fluorescent Protein (EGFP) as a platform for metal detection biosensors. EGFP, a naturally occurring protein, emits green fluorescence when exposed to ultraviolet or blue light. This intrinsic property has been harnessed to create biosensors capable of selectively detecting and quantifying various metal ions in a sensitive and non-invasive manner. Several studies have explored the use of EGFP-based biosensors for metal detection. These biosensors typically involve genetic engineering techniques to modify the EGFP structure in a way that enables it to bind specifically to a target metal ion. Upon binding, the fluorescence of the EGFP is altered, providing a quantifiable signal that corresponds to the concentration of the metal ion in the sample [2,3].

EGFP-based biosensor is designed for mercury detection; in which EGFP contain specific binding motifs that bind to mercury ions with high affinity. When mercury ions are present, the binding induces a conformational change in the EGFP, resulting in a change in fluorescence intensity. This change was directly proportional to the concentration of mercury ions, enabling quantitative detection. An EGFP-based biosensor was developed for the detection of zinc ions. The researchers inserted zinc-responsive DNA sequences into the EGFP gene, creating a biosensor that exhibited changes in fluorescence intensity upon zinc ion binding. The biosensor showed high selectivity for zinc ions over other metal ions, highlighting its potential for accurate detection in complex samples. One of the main advantages of EGFP-based biosensors is their non-destructive and real-time nature. The fluorescence emission is reversible, allowing for continuous monitoring of metal ion levels without the need for additional reagents. Moreover, these biosensors can be tailored for different metal ions by engineering the EGFP structure to accommodate specific binding motifs, providing versatility in detection capabilities [4].

Discussion

The enhanced green fluorescent protein, a modified variant of the Green Fluorescent Protein (GFP) from *A. victoria*, has gained popularity in biotechnology and bioimaging due to its remarkable fluorescence properties. Exploiting these properties, researchers have leveraged EGFP's ability to undergo conformational changes in response to external stimuli, including the presence of specific metal ions. By engineering EGFP to act as a sensing element, a fluorescence-based biosensor can be developed for metal detection. The principle of the EGFP-based biosensor involves attaching EGFP to a metal-binding domain or peptide. When exposed to a target metal, such as mercury or lead, the metal binds to the peptide and induces a conformational change in EGFP [5]. This change is reflected in alterations in fluorescence intensity, providing a quantifiable readout for metal concentration. The real-time and reversible nature of the fluorescence change enables dynamic monitoring of metal interactions, facilitating both qualitative and quantitative metal detection. The EGFP platform offers several advantages, including high sensitivity, selectivity and non-destructive detection. Additionally, its compatibility with genetic engineering allows for the customization

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of metal-binding peptides to enhance specificity for target metals. The EGFP-based biosensor has demonstrated its potential in various applications, such as environmental monitoring, food safety and medical diagnostics [6].

Conclusion

The integration of the enhanced green fluorescent protein platform into biosensor technology represents a promising avenue for metal detection. By harnessing EGFP's inherent fluorescence response to metal interactions, a sensitive and real-time biosensor can be engineered. This innovation has the potential to revolutionize metal detection practices, offering rapid and reliable analytical tools for a wide range of applications. As research continues to refine EGFP-based biosensors and expand their capabilities, their adoption could lead to improved environmental management, enhanced consumer safety and more effective monitoring of metal contamination in diverse settings.

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Conflict of Interest

There are no conflicts of interest by author.

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