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A Molecular Beacons-Based SERS Assay for Rapid and Duplex Detection of MRSA

Ramya Krishna*

Department of Pharmacy, Osmania University, Hyderabad, Telangana, India

Abstract

Methicillin-Resistant *S. aureus* (MRSA) is a serious public health threat due to its resistance to multiple antibiotics. The detection of MRSA is crucial for proper treatment and prevention of further spread of the bacteria. One potential method for detecting MRSA is through the use of surface-enhanced Raman scattering (SERS) based molecular biosensors. SERS is a powerful analytical technique that has been widely used for the detection of biological molecules.

Keywords: MRSA • Antibiotics • SERS

Introduction

In recent years, SERS-based biosensors have shown great potential for the detection of bacteria, including MRSA. The technique relies on the enhancement of Raman scattering signals of analytes by plasmonic nanoparticles. The use of plasmonic nanoparticles as the substrate for SERS not only enhances the sensitivity of the detection but also enables multiplexed detection [1].

One of the key components of MRSA that can be targeted for detection is penicillin-binding protein (PBP). PBP is a bacterial protein that plays a crucial role in cell wall synthesis and is the target of several antibiotics, including beta-lactams. MRSA strains have evolved to have altered PBPs, which are resistant to the antibiotics, leading to the development of MRSA strains. The SERS-based biosensors for the detection of MRSA typically utilize molecular beacons as the recognition element. Molecular beacons are single-stranded oligonucleotides that form a stem-loop structure and are labeled with Raman-active molecules. In the absence of the target, the molecular beacon is in a closed conformation and the Raman signal is quenched. In the presence of the target, the molecular beacon hybridizes with the target, leading to the opening of the stem-loop structure and the release of the Raman-active molecules, which can be detected by SERS [2].

Description

The plasmonic nanoparticles used in SERS-based biosensors can be functionalized with specific antibodies or peptides that can selectively bind to the target bacteria. The binding of the bacteria to the functionalized nanoparticles leads to the amplification of the SERS signal, enabling the detection of low concentrations of the bacteria. SERS-based molecular biosensors have great potential for the rapid and sensitive detection of MRSA. The use of molecular beacons as the recognition element, combined with plasmonic nanoparticles as the substrate for SERS, enables the selective detection of MRSA strains. The incorporation of specific antibodies or peptides further enhances the sensitivity and selectivity of the biosensors. These biosensors have the potential to be developed into portable, point-of-care devices for the rapid detection of MRSA in clinical settings [3].

Methicillin-resistant *S. aureus* (MRSA) is a serious bacterial infection that is resistant to many antibiotics. MRSA infections can be life-threatening and early detection is critical for successful treatment. Conventional methods for detecting MRSA can be time-consuming, requiring bacterial culture and identification, which can delay treatment and increase the risk of spread of the infection. In recent years, the development of molecular beacons-based surface-enhanced Raman scattering (SERS) assays has provided a rapid and sensitive method for the detection of MRSA. Molecular beacons are single-stranded oligonucleotides that form a stem-loop structure and are labeled with Raman-active molecules [4,5].

In the presence of the target, the molecular beacon hybridizes with the target, leading to the opening of the stem-loop structure and the release of the Raman-active molecules, which can be detected by SERS. This detection method offers high sensitivity and specificity for MRSA detection due to the molecular recognition ability of the molecular beacon. SERS is a powerful analytical technique that has been widely used for the detection of biological molecules. It relies on the enhancement of Raman scattering signals of analytes by plasmonic nanoparticles. The use of plasmonic nanoparticles as the substrate for SERS not only enhances the sensitivity of the detection but also enables multiplexed detection.

In a recent study, a molecular beacons-based SERS assay was developed for the rapid and duplex detection of MRSA. The assay utilized two molecular beacons, each targeting a different gene of MRSA, mecA and nuc. The assay was carried out using gold nanoparticles as the SERS substrate and a portable Raman spectrometer for detection. The results of the study showed that the assay was able to detect as low as 100 CFU/mL of MRSA in a clinical sample within 30 minutes. The duplex assay was also able to differentiate between MRSA-positive and MRSA-negative samples with high specificity and sensitivity [6].

Conclusion

The use of a molecular beacons-based SERS assay for the detection of MRSA offers several advantages over conventional detection methods. The assay is rapid, sensitive and specific, allowing for the early detection of MRSA infections. The duplex assay also offers the potential for the detection of multiple targets simultaneously, making it a valuable tool in clinical settings. The molecular beacons-based SERS assay provides a promising method for the rapid and duplex detection of MRSA. The use of this assay has the potential to significantly improve patient outcomes by allowing for the early detection of MRSA infections and the timely administration of appropriate

***Address for Correspondence:** Ramya Krishna, Department of Pharmacy, Osmania University, Hyderabad, Telangana, India, E-mail: ramya_k@gmail.com*

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treatment. The development of portable devices for the detection of MRSA using this assay may also enable its use in resource-limited settings. Further research and development are needed to optimize the assay for clinical use and to evaluate its performance in larger patient populations.

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Conflict of Interest

None.

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