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Electrochemical biosensors with Aptamer recognition layer for the diagnosis of pathogenic bacteria: Barriers to commercialization and remediation

Mohammad Al Mamun [a, b, *], Yasmin Abdul Wahab [a, **], M.A. Motalib Hossain [a], Abu Hashem [a, c], Mohd Rafie Johan [a]

[a] *Nanotechnology and Catalysis Research Centre, Institute for Advanced Studies, University of Malaya, 50603 Kuala Lumpur, Malaysia*
[b] *Department of Chemistry, Jagannath University, Dhaka, 1100, Bangladesh*
[c] *Microbial Biotechnology Division, National Institute of Biotechnology, Ganakbari, Ashulia, Savar, Dhaka-1349, Bangladesh*

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A B S T R A C T

One of the serious public health threats is pathogenic bacteria due to the lack of affordable and early-stage diagnosis and treatment. The existing diagnostic methods are tedious, time-consuming, expensive, and labor-intensive. Therefore, there is an urgent need for achieving simple, low-cost, precise, and rapid detection methods. Besides a plethora of efforts to meet those promises, electrochemical biosensors technologies with aptamers (synthetic ssDNA or ssRNA) recognition moieties have emerged as a promising sensing platform for bacterial diagnosis. In this review, we have comprehensively discussed the recent advances of different potentiometric and non-potentiometric electrochemical aptasensors emphasizing their surface designs, functionalization, and significant performance for the detection of pathogenic bacteria. At the end of this review, various quality advancements of aptasensors technologies, prospects, challenges, and boundaries of commercialization with research directions have been focused on and summarized.

1. Introduction

Pathogens cause foodborne or waterborne illnesses, resulting in loss of working hours and (and in extreme cases) human life, which in turn costs billions to the public health systems and social security systems [1]. The common bacterial-derived diseases are urinary tract infections [2,3], sexually transmitted infections [4,5], and healthcare-associated infections [6]. According to the CDC (Centers for Disease Control and Prevention) data, about 50 million people suffer from foodborne illnesses caused by pathogenic bacteria, more than a million are hospitalized and thousands of people die each year around the world [7]. Developing countries will be hardest hit by this scenario. In these circumstances, the primary aim with a major challenge is the development of selective, sensitive, rapid, cheap, robust, and in-field early screening devices maintaining minimum sample amount, operational simplicity and reproducibility for the diagnosis of pathogenic bacteria [8]. For the past few decades, biosensors have meticulously exhibited their promise as diagnostic devices associated with sensitive detection, fast response, predicted selectivity to the analyte of interest, lower sample analysis cost and ease of transportability compared with conventional methods.

According to the IUPAC definition, biosensor is a self-contained integrated device which is able to provide specific quantitative or semi-quantitative analytical information using a biological recognition element (such as antibodies, enzymes, aptamers, natural receptors, cells and others), which is retained in direct 3-D contact with a transduction component [9,10]. Biosensors offer enormous potential in different fields of applications including clinical diagnosis [1], medicine [11], environmental monitoring [12], soil and food-quality monitoring [13,14], forensics [15], industrial processing [16], drug abuse [17] and others. Considering minute sampling, reagent-free analysis, real-time and fast detection of targeted

* Corresponding author. Nanotechnology and Catalysis Research Centre, Institute for Advanced Studies, University of Malaya, 50603 Kuala Lumpur, Malaysia. Fax: +603 7967 6956.
** Corresponding author. Fax: +603 7967 6956.
E-mail addresses: zithrox@gmail.com (M. Al Mamun), yasminaw@um.edu.my (Y.A. Wahab).

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