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EDITORIAL

Biosensor: An Emerging Technological Tool for Microorganisms and Its Disease Diagnosis

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Over the past three decades, there has been a notable shift in the approach to detecting microorganisms and their associated diseases. We have seen a move away from reliance on laboratory infrastructure towards the use of point-of-care devices. Conventional, methods such as Multiplex PCR, Real-time PCR, NABSA, LAMP, PSR and DNA microarray have been used for detecting microorganisms [1]. However, these approaches come with pitfalls such as prolonged delay in results, for sample collection and processing highly skilled workers are required, an elevated risk of transmission of communicable diseases while collection, processing, and disposal, as well as high expenses [2, 3]. To overcome these drawbacks, researchers have been working on developing biosensors that offer advantages such as cheap, quick processing, and limited possibility of disease transmission [4]. To approach such advantages, efforts have been made to develop biosensors for direct and indirect (Biomarker based) diagnosis of microorganisms as well as their associated diseases [5]. As we are aware several biosensor-based medical devices are in the market such as glucometers, bilirubin diagnosis devices, breath analysers, pregnancy kits, and COVID-19 diagnosis kits, and may more be in the startup phase [6]. This field is continuously growing day by day and efforts are made in top priority to detect various food, air, and waterborne microorganism diagnoses. Recently, efforts have been made towards the diagnosis of neonatal sepsis by using biosensors through an indirect approach [6]. Here a novel 20-mer oligonucleotide has been designed for the diagnosis of the *fimA* gene of *E. coli* that is responsible for neonatal sepsis. This indirect approach will not only help in the diagnosis of neonatal sepsis but also helps the doctor in the selection of selective drug against microorganism for the curing of this disease [7]. Along with this, it has been reported by WHO (World Health Organization) and UNICEF (United Nations Children's Fund) that drinking water should be free from *E.coli*, because it may cause to development of a lot of mammalian gastrointestinal diseases [8]. Keeping this in view, efforts have been made to develop biosensors for the detection of *E. coli.* In 2020 Nugen et al. developed a syringe-based biosensor for rapid diagnosis of *E. coli*. In this approach, genetically engineered bacteriophage has been used and the developed biosensor can detect less than 20 colony-forming units present in 100 mL of water within 5 h. This approach will help in the time-to-time monitoring of *E. coli*-free drinking water [9]. While this biosensor boasts numerous advantages, addressing the time it takes for detection remains a prominent challenge. Researchers are now investigating the practical use of electrochemical techniques and the creation of several biosensors to overcome this constraint [10–13].

After the COVID-19 pandemic, there is a growing concern among people regarding other diseases caused by microorganisms such as the H1N1 Virus, Nipah Virus, *salmonella typhi*, *Neisseria gonorrhoeae*, and the diseases associated with them, such as swine flu, typhoid, and sexually transmitted diseases [14, 15]. To address this issue, scientists have begun working on the diagnosis of these specific microorganisms and their associated diseases.

Recently, Kumar et al. have made significant progress in this area by developing a series of electrochemical

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biosensors for the indirect diagnosis of airborne viruses, specifically H1N1 and its associated disease, swine flu. This approach utilizes a swine flu protein biomarker called Serum amyloid A (SAA) for the detection of swine flu. The latest electrochemical biosensor developed by Kumar et al. can detect swine flu within 8 min, exhibiting a high level of sensitivity [16–19]. Continuing with the ongoing efforts to detect viruses within the body, it has been reported that certain electrochemical diagnostic devices have been created with the capability to collect airborne viruses from the surrounding environment and detect them using a biosensor. In this regard, a laminar flow water condensation-based growth tube collector (GTC) has recently been developed to collect MS2 viruses from the environment. Additionally, a carbon nanotube-coated porous paper working electrode has been created, which has immobilized antibodies for airborne coronaviruses [20]. This working electrode has the advantage of a three-dimensional structure, resulting in a higher surface-to-volume ratio and faster electron transfer rate compared to conventional electrode surfaces. With this technique the detection of coronaviruses up to a concentration of 65.7 plaque-forming units (PFU)/mL can provide results within 2 min without sampling and with sampling results obtained within 10 min. The main benefit of this biosensor is that, during detection, virus lysis and elution are not necessary. Like airborne viruses, efforts are also being made towards the production of foodborne viruses/bacteria like Norovirus (NoV), *Staphylococcus aureus* (*S. aureus*), *Vibrio parahaemolyticus*, *Listeria monocytogenes* etc. To identify NoV a peptide-target-aptamer sandwich electrochemical biosensor has been made by using Au@BP@Ti3C2-MXene and Au@ZnFe2O4@COF nanocomposites. As per the obtained result, it has been noticed that the fabricated biosensing platform can able to detect NoV in the concentration range of 0.01–105 copies mL^{-1} with a detection limit (LOD) of 0.003 copies mL^{-1} (S/N = 3) [21]. This developed biosensor has been successfully tested in the stool sample without any complex pretreatment and also has the potential to diagnose NoV in the various food, clinical as well and environmental samples. Further, for the detection of foodborne bacteria, *S. aureus*. This platform utilizes a combination of saltatory rolling circle amplification (SRCA) and the CRISPR/Cas12a system. The results obtained from this innovative approach demonstrated a sensitivity of 100%, specificity of 97.8%, and accuracy of 98% [22].

From the previous discussion, it has been noted that research towards the detection of microorganisms through rapid diagnostic approaches, specifically Biosensors, has increased significantly after the COVID-19 pandemic. Among the various biosensor approaches, electrochemical biosensing stands out as a reliable, highly specific, reproducible, and easily manageable approach that is also cost-effective. This method is capable of detecting targeted microorganisms either through direct or indirect means. However, it is important to acknowledge that the applications of biosensors in diagnosing microorganisms are still in the early stages and require the attention of the scientific community to further develop these biosensors into point-of-care devices. We anticipate that the upcoming decade will be characterized by the widespread use of rapid and cost-effective microbial diagnosis through biosensing approaches.

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