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Biosensors for Indirect Monitoring of Foodborne Bacteria

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Abstract

Microbiological safety assessment in food samples is often a cumbersome and time consuming task that has to be done in a regular basis in most food manufacturing facilities. Standard microbiological techniques for evaluating critical levels of bacteria take several days to yield results, thus the food products have to be withheld in the processing IDFWRULHV XQWLO WKH VDIHW\ LQVSHFWLRQ LV FRQFOXGHG 7KH IRRG LQGXVWU\ PLFURELRORJLFDO WHVWLQJ WKDW FDQ UHGXFH WKH VDIHW\ LQVSHFWLRQ ODJ VL associated with bacterial activity are amongst the most promising technologies for addressing this need. State-of-WKH DUW ELRVHQVRUV DOORZ IRU LQVWDQWDQHRXV TXDQWL¿FDWLRQ RI PROHFX the operation mechanism and technological challenges and opportunities for developing high performance biosensors capable of real-time monitoring of biomarkers from foodborne bacteria.

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Villalonga et al. demonstrated a biosensor enhanced with single walled carbon nanotubes (SWNT) and gold nanoparticles (pAuNP) for the direct determination of xanthine, which is a commonly found marker of bacterial spoilage in meat. e operating mechanism of this electrochemical device is based on an enzymatic reaction catalyzed by xanthine oxidase (XO), immobilized on the surface of a pAuNP/SWNT glassy carbon electrode (GCE) [9]. Ko et al. presented a biosensor consisting of a chip functionalized with gold nano-islands (CGi), single-walled carbon nanotubes (SWNT) and a 25 mer p-DNA for selective detection of t-DNA. e sensing principle is based on changes in the overall conductance occurring a er hybridization of t-DNA with p-DNA on the chip surface [10]. Lata et al. developed a D-amino acid biosensor based on covalent immobilization of D-amino acid oxidase (DAAO) onto a gold electrode (Au) modi ed with multi-walled carbon nanotubes (c-MWCNT), copper nanoparticles (CuNPs) and polyalinine (PANI). In this study, the authors only aimed to quantify the level of amino acids in fruit juices as a measure of their nutritional value; nonetheless, the device could also be used to estimate presence and maybe even viability of bacteria based on the relative amounts of D and L amino acids and the rate of racemization [11]. Wang et al. created a biomimetic sensor based on graphene, gold nanoparticles (Gr-AuNPs) and molecularly imprinted polymers (MIP) onto a glassy carbon electrode (GCE) for detecting glycoproteins. In this case, a BSA template was used as model protein for technology demonstration. is amperometric device could be applied for detecting cell membrane glycoproteins which are known to be important virulence factors in pathogenic microorganisms such as E. coli and Streptococcus spp. [12]. Cao et al. built an electrochemical biosensor functionalized with graphene, platinum, palladium, chitosan (GS-CS-PtPd) and cholesterol oxidase (ChOx). e probe was designed for cholesterol sensing in food samples, and has a potential use for monitoring the transformation of sterols by speci c spoilage microorganisms [13].

Challenges and opportunities

Enzymatic biosensors for monitoring biomarkers are highly accurate, but adoption of these technologies has been slow. In large part, this is due to a lack of demonstration under eld conditions, or poor shelf life (primarily due to enzyme denaturation). Maintaining enzyme activity in thin lms is a major challenge in the eld, particularly when sensors are used in complex solutions during eld applications. Problems inherent to enzyme immobilization include loss of purity, stability, activity, and/or speci city [14]. Bio-based nanomaterials provide durability and stability in the thin protein lm formed on the electrode surface [15].

New biomaterials and nanomaterials that can enhance the performance of biosensors in terms of sensitivity, response time, shelf life, and biocompatibility are continuously under development. ese improvements provide new opportunitd/orD0.5(adoptis of p/orD0ability

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agents, hydrogels based on weakly ionizable polysaccharides show pH-responsive phase transition [23]. is stimulus-response behavior can be exploited in biosensors for controlled release of small molecules and sca olding of enzymes.

Conclusions

e long time required for testing the microbiological safety and quality of food products using standard microbiological methods is a concerning problem for the food industry and public health. Biosensor technologies that target bacterial biomarkers are promising alternatives for rapid screening of harmful bacteria in food samples. Incorporation of nanomaterials with unique electrical and photonic properties, as well as biomaterials with high biocompatibility are the most e ective strategies for developing biosensors with ultrafast response time and high stability.

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