Recent Advances and Applications of Biosensors in Novel Technology

Rajpoot K

amplification labels in electrochemical immunosensor for detection of alpha-fetoprotein [50]. In milk, magneto immunosensor was also employed as electrochemical immunosensor for the detection of fluoroquinolone antibiotics [51]. Akter et al. reported enhancement in sensitivity of an electrochemical immunosensor *via* the electrocatalysis method in magnetic bead-supported non-enzymatic labels [52]. In another investigation, a simultaneous triple signal amplification effect was studied using bi-enzyme, gold NPs, and platinum NPs functionalized graphene as enhancers for multiple electrochemical immunoassays [53]. Recently, Reverte et al. reviewed the application of electrochemical biosensors in the detection of toxins using magnetic beads, microfluidics technique for the investigation of nucleic acid interactions. Surface

Biosensor type	**Nanomaterial**	**Applications**	**References**

measurement system highly amplif es the signal. Hence, f uorescence is used as a light in these biosensors. A wide range of ligand-binding and immune assays are performed for detection and investigation of small molecules. Water-soluble vitamins and drug residues *viz*., β-agonists and sulfonamides have been prepared to utilize SPR based sensor systems, of en revised from current ELISA or from another immunological assay. T e biosensor is an ef cient, attractive, and alternative method to various other techniques. Since it is reliable and responds quickly. It showed high potential in the food industry for monitoring quality and safety of food as well as in bioprocessing industries [145].

Ozone biosensors are important since ozone f lters harmful ultraviolet radiation. T e f nding of the hole in the ozone layer has become a matter of worry. How much ultraviolet (UV) light reaches the surface of the earth and how deeply it reaches into sea water. Ultraviolet radiation can penetrate sea and can produce harmful ef ects on marine organisms, especially f oating microorganisms (plankton). Plankton is the basis of marine food chains and is supposed to af ect earth's weather and temperature *via* maintaining a balance between oxygen and CO_2 by photosynthesis. Karentz et al. have developed a simple technique for measuring intensity and UV penetration. A thin plastic bags was submerged to several depths holding particular strains of *E. coli*. T e study revealed that *E. coli* were impotent to repair damage caused *via* ultraviolet radiation to their DNA. T e bacterial "biosensors" showed persistent signif cant damage owing to UV light at depths of 10 m and regularly at 20 m and 30 m [146].

T e f rst biosensor was introduced in the 1960s and described the application of enzyme based bioelectrodes and their biocatalytic action. Af erward, several types of biosensors are being designed and utilized that include; cell or tissue-based, enzyme based, immunosensors, thermal and piezoelectric biosensors, and nucleic acid biosensors.

Enzyme based biosensors are being developed using immobilization techniques, i.e., covalent or ionic bonding and adsorption of enzymes *via* van der Waals forces by utilizing enzymes such as polyphenol oxidases, oxidoreductases, amino-oxidases, and peroxidases. Whereas, the tissues-based sensors were designed from animal and plant sources. In addition, the organelle-based sensors were developed by exploiting chloroplasts, membranes, microsomes, and mitochondria. Organelle-based biosensor reveals high stability but shows longer time for detection with decreased specif city. Antibodies based biosensors have more af nity towards particular antigens, *viz*., the antibodies bind specif cally to the toxins or pathogens, or interact with

8. Xia Y, Si J, Li Z (2016) Fabrication techniques for microfuidic paper-based analytical devices and their applications for biological testing: A review. Biosens Bioelectron 77: 774-789.
9. Arduini F, Micheli L, Moscone D, Palleschi G, Piermarini S, et al. (2016) Electrochemical biosensors based on nanomodifed screen-printed electrodes: Recent applications in clinical analysis. TrAC, Trends Anal Chem. 79: 114-126.
10. Samiei E, Tabrizian M, Hoorfar M (2016) A review of digital microfuidics as portable platforms for lab-on a-chip applications. Lab on a Chip 16: 2376-2396.
11. Updike SJ, Hicks GP (1967) T e enzyme electrode. Nature 214: 986-988.
12. Marazuela D, Moreno-Bondi MC (2002) Fiber-optic biosensors-an overview. Anal Bioanal Chem 372: 664-682.
13. Wen W, Yan X, Zhu C, Du D, Lin Y (2017) Recent advances in electrochemical immunosensors. Anal Chem 89: 138-156.
14. Dutta G, Park S, Singh A, Seo J, Kim S, et al (2015) Low-interference washing-free electrochemical immunosensor using glycerol-3-phosphate dehydrogenase as an enzyme label. Anal Chem 87: 3574-3578.
15. Xu W, Wu Y, Yi H, Bai L, Chai Y, et al (2014) Porous platinum nanotubes modifed with dendrimers as nanocarriers and electrocatalysts for sensitive electrochemical aptasensors based on enzymatic signal amplifcation. Chem Commun (Camb) 50: 1451-1453.
16. Jost C, Pluckthun A (2014) Engineered proteins with desired specifcity:

51. Pinacho DG, Sanchez-Baeza F, Pividori MI, Marco MP (2014)

90.

134. Zhang S, Zhang L, Zhang X, Yang P, Cai J (2014) An efficient nanomaterial-based electrochemical biosensor for sensitive recognition of drug-resistant leukemia cells. Analyst 139: 3629-3635.

135. Feng R, Zhang Y, Ma H, Wu D, Fan H, et al. (2013) Ultrasensitive non-enzymatic and non-mediator electrochemical biosensor using nitrogen-doped graphene sheets for signal amplification and nanoporous alloy as carrier. Electrochim Acta 97: 105-111.

136. Li G, Li T, Deng Y, Cheng Y, Shi F, et al. (2013) Electrodeposited nanogold decorated graphene modified carbon ionic liquid electrode for the electrochemical myoglobin biosensor. J Solid State Electrochem 17: 2333-2340.

137. Atay S, Piskin K, Yılmaz F, Cakır C, Yavuz H, et al. (2016) Quartz crystal microbalance based biosensors for detecting highly metastatic breast cancer cells via their transferrin receptors. Analytical Metal m s