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Electrochemical Biosensors: Advanced Methodology for the Diagnosis of Plant Diseases

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The most popular and conventional techniques for identifying and detecting fungal pathogens responsible for plant diseases primarily rely on morphological, microbiological, and biochemical identifications, these techniques are insufficiently sensitive, and thus novel technologies for identifying plant pathogens have been developed in the past ten years. In recent years, 13 biosensors have attracted significant attention for their promising findings in plant disease identification, classification, detection, and quantification (Ray et al., 2017). Biosensors allow speedy and accurate plant disease diagnosis, minimize disease prevalence, and efficiently facilitate disease control.

A sensor is a device that transforms chemical information, which might include the concentration of a specific sample, into an analytical signal. The electrochemical approach employs specific features of an electrochemical biosensor. Additionally to the electrochemical technique, the sensor signal readout format addresses various aspects of pathogen detection using biosensors. A "biosensor" is thus a device designed to measure the availability and amount of a specific biological substance through the combination of a mechanism that converts the physicochemical changes that occur in response to the analytes present in the sample with a receptor capable of expressing this as a recognizable signal (Bhalla et al., 2016).

Owing to its ability to detect the investigated elements selectively and quickly. Biosensors are widely employed in a variety of industries, including medical diagnosis, new medication development, plant pathology, food safety testing, and environmental monitoring. Furthermore, the development of important supporting elements such as diverse interfaces and nanotechnology has expanded the range of biosensor applications to include point-of-care diagnostics and the Internet of Things (IoT). An electrochemical cell with a functioning electrode as its primary component serves as the transduction element in electrochemical biosensors. While the two electrode format (working and auxiliary) is frequently used for conductometry and electrochemical impedance spectroscopy and the three-electrode system (working, auxiliary, and reference electrodes) is typically employed in potentio-static systems.

An electrode is a type of electrical conductor where electrons and/or holes move to carry a charge. Thus, conductors and semiconductors, including metals like gold and non-metals like carbon, can be used to create electrodes. The structure and characteristics of the electrode, which in turn determines the biosensor's performance, are influenced by the materials, fabrication techniques, and designs employed during the electrode creation process. The sensitivity, selectivity, limit of detection (LOD), and dynamic range of biosensors are their most crucial functional characteristics. The cost of manufacturing, disposability, measuring capability, and manufacture of the biosensor are all impacted by these requirements. Numerous studies on the creation of biosensors for the detection of plant diseases have been published in recent years (Khater et al., 2017).

In 2013, Umasankar and Ramasamy presented an electrochemical sensor based on nanomaterials for the identification of plant diseases. The electrochemical detection of methyl salicylate, a significant volatile organic molecule emitted by plants during infection, was carried out using a cathode enhanced with gold nanoparticles (GNP). Volta-metric techniques have been employed in DNA-based electrochemical methodologies to identify all DNA bases simultaneously without the requirement for a hydrolysis phase and to discriminatively investigate nucleic acid structure and its alteration.

A more practical approach to overcome ambiguous plant infection diagnosis is to use more recent disease detection technologies, such as fiber-optic biosensors (FOBS) and electrochemical biological sensors. Given the significance of plant health monitoring and the state of nano-biosensors, along with the general shortcomings of current methods, developments in nanomaterials and new biomarkers will give researchers a motivation to shift their attention to plant health and growth monitoring using such technologies (Miguel-Rojas and Perez-de-Luque 2023).

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