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Nano biosensors and its applications in agriculture

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Abstract

Nanotechnology has emerged as a miraculous blessing in the field of various researches in general and in the field of agriculture in particular. Nano biosensors are highly advanced and augmented with improved techniques which make it highly efficient in detecting pesticide and herbicide residues and controlling fertilizer application, pesticide and herbicide application, nutrient deficiency, soil quality and good soil health optimization etc. The use of the nano materials with biosensors are now enabling to provide optimum and productive yield with lower inputs in case of agriculture thus leading to sustainability in the field of agriculture.

Keywords Nanobiosensors, Nanotechnology, Sustainable agriculture, Applications

Introduction

Nanobiosensors are modified compact analytical devices consisting of a biological derived sensitized element linked to another property-based transducer like physico-chemical transducer. The nano biosensor technology can be integrated with other lab-chip to analyse the samples on molecular levels thus broadening the applications such as detection of different analytes (Urea, glucose, pesticides etc.) detection of microbes/pathogens in agricultural fields etc.

Characteristics of Nanobiosensors

Stability Sensors are stabilized at normal storage room temperature.

Accuracy Sensors should give accurate, precise data free from different noises and disturbances.

Specificity The biosensors should be specific to analytes and can discard other non-analytes.

Response Timing Sensors should give quick response.

Interaction Type Sensors should be independent. While interacting with analytes and free from other factors such as temperature, pH etc.

Aspect and Flexibility Sensors should be non-toxic, eco-friendly, tiny, compatible with biomaterials, flexible in nature.

Parts of a Nanobiosensor

Probe

It is a bio sensitized element including the receptors, antibodies, enzymes, nucleic acid, tissues, microorganisms, those are either bio-components or biologically derived materials that receives the signals emitting from analytes and transmit it to transducer.

Transducer

It serves as an interface between probe and detector. It transforms the any changes like physical changes that happen due to interaction of probe and detector into electrical energy.

Detector

the microprocessor present in detector receives the energy signal from transducer then amplifies it and give the processed output. (Hassani 2016)

Types of Nano biosensors

Mechanical Nanobiosensors

Nanoscale mechanical forces helps in detection of response from analytes and give readings. Cantilever beams are used to identify biomolecules by measuring the deflection upon interaction with specific biomolecules. Loading of materials, changes in temperature etc controls the detection of responses from analytes.

Optical Nanobiosensors

This biosenors can detect the analytes by using the potential light source, optical transducer system, detector and sensing element. Optical transducer emits the light and also helps in detection of interaction; thus, the interaction creates some physico-chemical changes and detector measures the output as transduced light.

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Viral Nanobiosensors

These are bio nanoparticles use the Herpes Simplex Virus (HSV) and adenovirus to set off the aggregation of magnetic nanobeads as sensor for those particular viruses. (Perez *et al.,* 2003).

PEBBLE Nanobiosensors

This PEBBLE stands for Probes Encapsulated by Biologically Localized Embedding nanobiosensors contains sensing molecules fitted inside inert matrix by the process of emulsion polymerization producing sensors in size range of 20-200nm. The sensing molecules influence the optical change, changes in pH and other ions such as Calcium or detect the fluorescence (J.P Sumner *et al.,* 2006). The nanosensors present can monitor real-time cellular images like inter and intra molecular structures as well as showing reversibility and stability to leaching along with photobleaching.

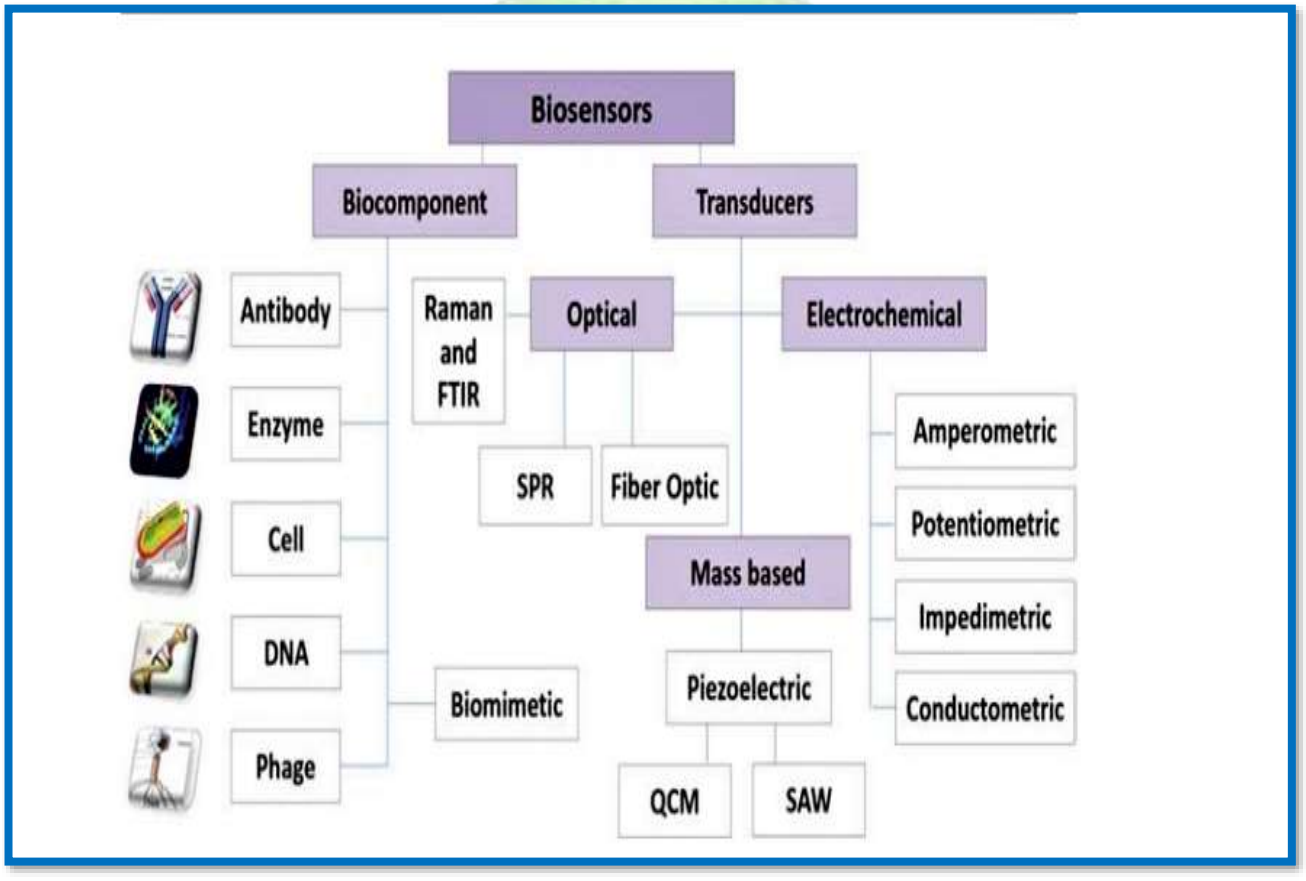

Fig.1- Parts of Nanobiosensors (Hassani 2016)

Nanowire Biosensors

It is a hybrid of two molecules those are sensitive to outside signals such as Single Stranded DNA and Carbon nanotubes among which DNA act as detector and nanotubes as transmitter. The surface properties can be modified to observe the changes in any physico-chemical changes made by interaction with analytes.

Use of Nanobiosensors in Agriculture

As Diagnostic Tool for Soil Quality ad Disease Assessment

Assessment of various diseases caused by soil microbes such as bacteria, viruses, soil micro-organisms, fungi etc by measuring the oxygen consumption differential in the respiration process. The assessment of soil diseases and soil condition is based on semi-quantitative approach, as sensors (For good bacteria and bad bacteria) are immersed in buffer solution to give accurate oxygen consumption.

Tool for effective detection of DNA and Protein

SS-DNA and CNT (carbon Nanotubes) sensors can detect the DNA oligonucleotides. Nanowire Field Biosensors avoid PCR multiplication, bisulphite treatment, achieves simple DNA methylation (Maki *et al.,*2008). The Protein-biosensors can detect the special proteins thus can control plant pathogens, abnormalities in plants due to nutrient deficiencies etc.

Nanobiosensors for Urea Detection

The sensors are made to detect the activities of Urease enzyme and Glutamate Dehydrogenase enzyme as they convert the amide form of urea to NH_4 (ammonical form), thus the losses can be minimized by tracking the various losses paths. The nanocomposite materials during interaction develops signals which are detected by detectors thus producing output.

Heavy metals and other contaminants Detection

As biosensor methods are rapid, accurate thus integrating some techniques like spectroscopy, Polarography and Voltametry heavy metals can be detected. In waste water a urease-based conductometric biosensors are able to detect the heavy metals and other contaminants detection. (Zhylyak *et.al.,* 1995). Organophosphorus pesticides could be monitored by liposome-based biosensors even at low concentrations.

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Food products analysis

Biosensors with advanced augmented materials or substances are used in checking and maintaining quality standards of food materials. Antibiotics detections in honey and other materials, vitamins analysis, food spoilage detection by using amperometric biosensors and microbial contaminations detections are possible.

Sustainable Agriculture

Applications of nanofertilizers in crop fields are having various advantages like checking the nutrients losses due to leaching, volatilization etc. The encapsulated fertilizer nutrients can provide nutrients to the crop plants for longer duration thus ensuring sustainable agriculture. Introduction of Zeolites (naturally occurring crystalline alumino silicate) thus proven to be beneficial by enabling optimum plant growth, fertilizer use efficiency enhancement, improving soil health and quality, nutrient usage. Zeolites augmented with biosensors help in detection of nutrient deficiencies, pesticide and herbicide residue detection, soil environment analysis etc.

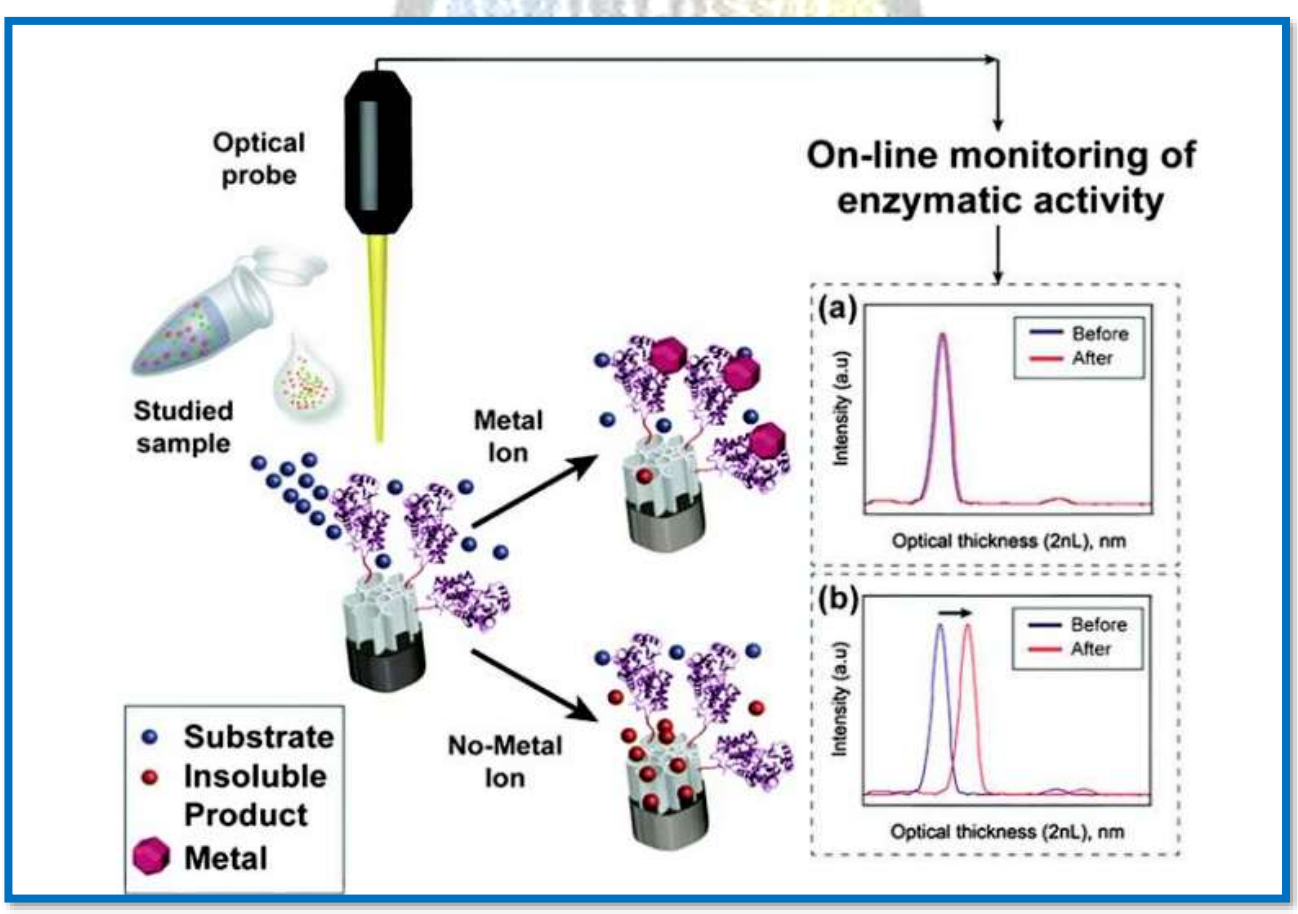

Fig-2: Detection of Heavy metals by Nanobiosensors –Zhylyak *et al.,* 1995

Advantages of Nanobiosensors over other sensors

Nano biosensors work at the level of atomic orientation so high efficiency is seen.

Biosensors can detect the various microbes as well as virus particles and also some low concentration harmful chemicals.

Conclusion

The Nanobiosensors are advanced sensing systems influencing all important functions occurring in soil and environment. Nanobiosensors are minute, rapid responsive, highly efficient in nature thus revolutionizing field of nanotechnology. Optimum resource utilization and sustainable production is ensured by using nanobiosensors in agriculture. Enhanced detection system provides multilevel applications.

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