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Lipid membrane nanosensors for environmental monitoring

Research on environmental and food biosensing remains blooming for two decades now, attracting scientists from diverse fields. From an analytical viewpoint, biosensors offer a number of benefits when compared to the conventional techniques (e.g., chromatography or immunoassays), including minimal sample preparation, real time detection, rapid response times, portability, etc. Biosensor technology is very versatile and readily amenable to intended use customizations.

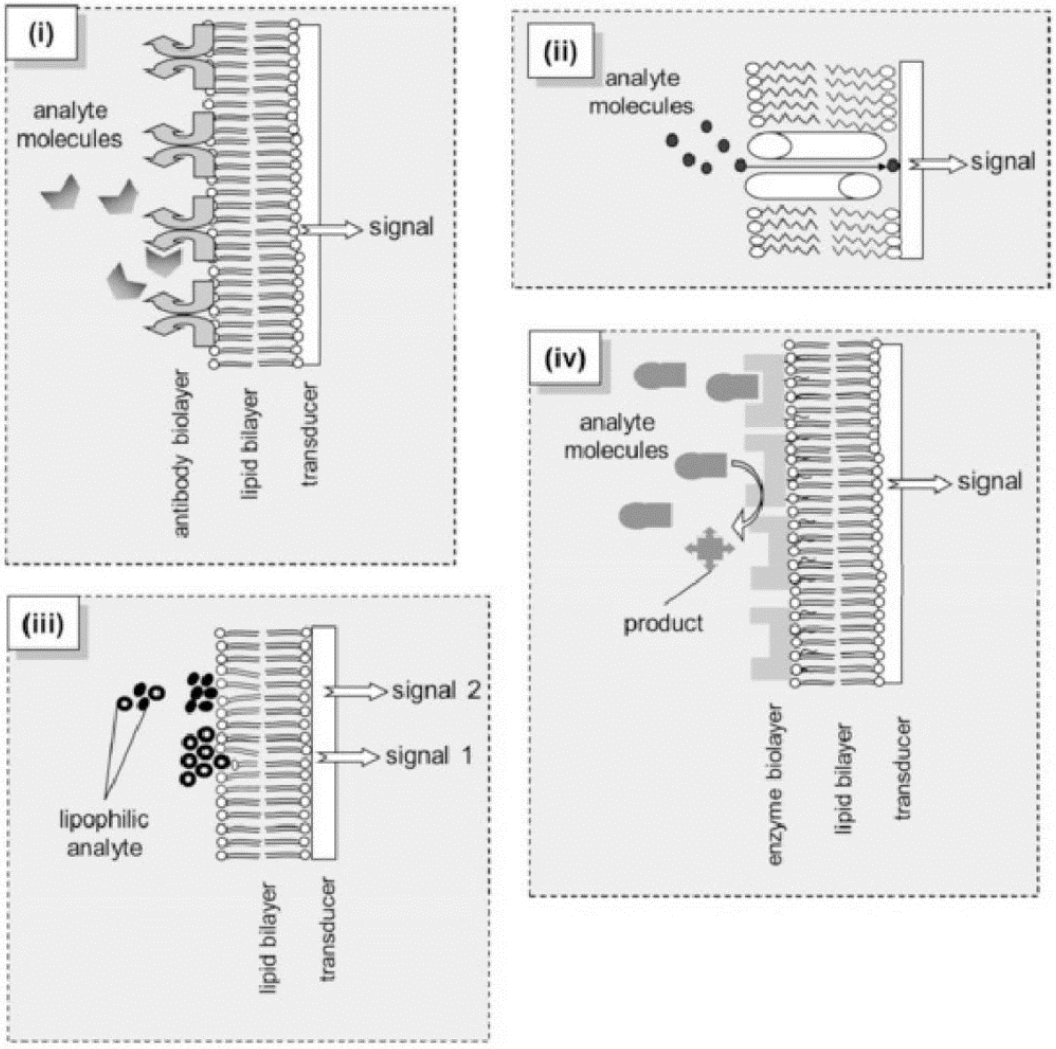

Fig. 1. Different principles of biosensing via structured lipid bilayer interfaces: (i) Immunosensing; (ii) Channel-based sensing; (iii) Lipid adsorption-based sensing; (iv) Enzyme-based sensing.

Nanotechnology is playing an increasingly important role for the development of nanobiosensors. The use of nanomaterials has allowed the introduction of many new signal transduction technologies in biosensors and,

also, improved their sensitivity and performance. Due to their submicron size, nanosensors and nanoprobes are revolutionizing the field of chemical analysis and enable rapid analysis of multiple substances for in the field detection of food toxicants and environmental pollutants. Recent progress in nanotechnology has provided the opportunity to mass produce affordable devices and to integrate them into marketed systems for environmental monitoring or the detection of food toxicants. These devices can detect a broad range of chemical and micro-biological toxicants, such as toxins, insecticides, pesticides, herbicides, microorganisms, bacteria, viruses, and other microorganisms, polycyclic aromatic hydrocarbons (PAHs), hydrazines, phenolic compounds, allergens, genetically-modified foods, hormones, dioxins, etc

The initial drive for the implementation of lipid bilayers in biosensors has been undoubtedly the reconstitution of natural membranes in vitro. The most obvious benefit derives from the nature-like environment that the membranes provide for the immobilization of proteins]. Further, the dynamics of the bilayer in physical terms and the way that the interaction between the biological moiety and the analyte impacts this meta-stable system establish a generic signal amplification mechanism.

However, the initial reconstituted free standing BLMs were fragile and, thus, unsuitable for long-term use. Their low mechanical and electrical stability was the main obstacle to their practical applications. Recent advances in the stabilization of lipid bilayers have resulted in preparing lipid film based biosensors for the detection of a large variety of compounds in real samples using a variety of detection strategies (Fig. 1). Lipid membranes biosensors offer a large number of advantages such as rapid response times (on the order of a few seconds) and high sensitivity (i.e., nanomolar detection limits) that may eventually be used for environmental monitoring applications. Most of these biosensors are cost efficient, easy-to-use, fast-responding, and portable. They could be appropriate alternatives to the expensive, bulky, time-consuming standard analytical methods (e.g., chromatographic techniques).

The bilayer lipid membrane has been mostly coupled to electrochemical transducers and engaged a variety of sensing strategies, including ion sensing, material transport, electric excitability, gated channels, antigen-antibody binding, phase shifting and conformational re-arrangements (Fig. 1). The lipid-based platforms have been proven very versatile and prone to site-specific, analyte-specific or sample-specific customizations.

This work reviews various nanostructure lipid film based nanobiosensors. The chapter provides the state of art of design and microfabrication of prototype lipid membrane nanosensing devices. The engineering principles for achieving rapid in the field detection are also presented, whereas the challenges that lie ahead are thoroughly discussed.

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