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Special Article - Biosensor Elements

Prospect of Gas Biosensor

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Abstract

This review article introduces the prospect of biosensor used in gas phase. Agriculture and livestock go toward to automated farming based on IoT technology. This technology essentially requests sensor. However, farmers use only physical sensors for monitoring of temperature, pressure, moisture, illuminance, etc. Even though gas sensors are widely used in automobile industries and homeland securities, very few applications had been reported in biochemical sensing.

As you know well, biosensors are extensively investigated for the evaluation of metabolism, diagnosis of illness, etc. We can create tremendous progress in the automated farming, if biosensor would be used in gas phase.

It is summarized here the trends of gas biosensor, the challenges, and the prospect in this article.

Keywords: Gas biosensor; VHH

Introduction

Trend of gas biosensor

It is very difficult to apply the biorecognition element in gas phase. Biomaterials such as antibody, enzyme are easily decomposed due to loosing the hydrophobic interaction used for formation of the sterical structure. Therefore, the maintenance of moisture condition is definitely necessary for biomaterials.

Avnir et al. [1] summarized the trapping method of biomaterials in the Sol-Gel membrane. They found that SiO_2 gel marvelously maintained 50% of activity of creatine kinase at 47°C for 125 hours [2]. In other words, Sol-Gel could hold the sterical structure of enzyme under the extreme condition. They also reported the trap of antibodies, DNA, phospholipids, and poly-saccharides in Sol-Gel membrane.

A use of membrane is useful way as the trap of biomaterials. Copolymer is one of the trends. Mistubayashi et al. [3] reported copolymer consisted of 2-methacryloyloxyehyl phosphoryl choline and 2-ethylhexyl methacrylate to entrap the Nicotinamide Adenine Dinucleotide (NADH)-dependent Secondary Alcohol Dehydrogenase (S-ADH) on the fiber optical sensor. This sensor successfully monitored the volatile organic compounds in exhaled breath gas.

In the basic concept, membrane works as the separator between donor phase (gas phase) and acceptor phase (moisture layer). Recently, Zhang et al. summarized the concept of membrane diffusion [4]. The diffusion needs to be considered with the permeated flux density and selectivity for species. The membrane often has selectivity due to the physical properties (molecular size, pore size, mobility, viscosity, etc.) and the chemical affinities (hydrophilic, hydrophobic, etc.). Therefore, the resistance in chemical reaction becomes a high. In other words, the reactivity could be decreased due to the resistance.

Here, very unique concept is introduced. Wagner et al. proposed a use of cell as the bio recognition element for gas biosensor [5]. They directly immobilized the living cell (A549 cell) onto the sensor chip of MIR-spectroscopy. As the living cell swallowed water insoluble gas (CO) and/or water-soluble gas (NH_3), the MIR sensor responded with the gas concentrations. Because living cell is tough in aero condition, this concept was succeeded.

The simple concept is just a trap into water by gas bubbling [6] or mist shower [7]. Biochemical reaction itself was carried out in liquid vessel. They are also effective methods. However, the concentration of analyte would be diluted by solvent. Therefore, the highly sensitive biosensor might be requested in those methods.

Challenge and prospect of gas biosensor

Activity of biorecognition element falls down when it touched the air. It is very difficult to solve this challenge. A use of living cell provides a potential solution for this challenge.

In recent, variable domain of heavy chain of heavy chain antibody (VHH antibody) has been developed and commercialized. Only the fragment of recognition part of antibody was independent from unnecessary parts of antibody. This is totally different from single chain antibody or single chain Variable Fragment (sc FV). Mass production using Bacillus bacteria is already established. The emphasized feature of VHH antibody is robust under the extreme ambient conditions such as low or high temperature, acid or base. It should be appreciated that VHH antibody maintains the activity of recognition in gas phase.

It is expected that gas biosensor using VHH antibody will be started and be applied to various fields.

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