Biosensors for the Detection of Food Allergens

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The emerging health issues related to food-induced allergic reactions present an important challenge to the food industry. The National Institute of Health estimates that six to seven million people in the United States suffer from food allergies. Some of these people may develop serious or life threatening allergic reactions when exposed to the causative protein(s). The major food allergens that account for more than 90% of all food allergies are found in peanuts, soybeans, milk, eggs, fish, shellfish, tree nuts and wheat.

The presence of unlabeled allergens in food products can lead to serious health, legal and financial ramifications for the industry. Undeclared allergenic foods are a major source of product recalls that have taken place in past years. A small number of fatalities have also been reported as a consequence of accidental allergens. The allergens may be present because of inclusions in the food products or potentially after detergents and other sanitizing agents were ineffective in removing allergens from food contact surfaces.

A convenient, quick and cost-effective method for detecting the presence of allergenic components is one of the greatest challenges confronting the food processing industry today. Although several enzyme-linked immunosorbent assay (ELISA) test kits are commercially available, they are costly and time-consuming and, thus, a need exists for an alternative detection method.

A biosensor using surface plasmon resonance (SPR) is an alternate technology for rapid, cost-effective, yet sensitive, on-site detection of allergens in food. The assay is based on the measurement of the total sample binding to allergen specific antibodies on the sensor surface.

The SPR biosensor works by the detection of a bimolecular (antigen-antibody)
interaction. The most common method for setting up a surface plasmon at a metal ambient interface is referred to as the Kretschmann Configuration (Figure 2) and is based on the total internal reflection of light.

For theta > theta C1, (theta C1, the critical angle), reflected light intensity approaches unity, and no propagating light beam is refracted into the ambient medium. However, a part of of the light called the "evanescent field" penetrates outside the glass, which is coated into the thin layer of the sensor. The sensor's surface consists typically of a thin layer of gold onto which the ligand (antigen) is immobilized. The antibody acts as the bio-receptor. The gold surface acts as a transducer. If the metal deposit on the prism is sufficiently thin, d ~ 50nm, then the evanescent field can penetrate through the metal and set up a surface plasmon (charge density waves) at the metal-ambient interface. SPR occurs when the light wave vector component matches the wave vector of the surface plasmon. An analyte pulse containing an antigen directed against the immobilized antibody is then injected over the sensor surface and an antigen-antibody complex is formed. Thus, a small shift in the resonance angle theta sp (the resonance or SPR signal), which occurs for a given experimental setup is proportional to the change in the refractive index delta na (np - n1), caused by the biomolecular interaction on the surface of the metal of the dielectric constant sigma m. The immunosensor output is expressed in resonance units (RU), where 1000 RU = 0.1° shift in the resonance angle.

SPR can be achieved by varying the frequency of the light or the angle of incidence. SPR's position is extremely sensitive to the refractive index of the sample. Hence, SPR is often touted as being an excellent technique for accurately measuring refractive indices. Factors influencing the performance of SPR are the level of immobilization, temperature, air bubbles, flow rate and sensitivity. The detection limit of the SPR biosensing system is approximately 1 RU, which corresponds to 1 pg/mm2 of a biomolecule.

SPR has shown to have potential in a wide range of applications, such as food safety, national defense, water quality, beverages, medical diagnostic tools and basic research.

References:

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