

Self-Assembled Interfaces Using Biomolecular Receptors for Detection and Visualization of Low-Molecular-Weight Substances

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Low-molecular-weight substances are difficult to detect by surface plasmon resonance (SPR) immunosensors because they induce only small changes in the refractive index at the sensor surface. In our previous studies, ultra-sensitive SPR sensors using antibodies as biomolecular receptors were developed for the detection of low-molecular-weight compounds, including odor-related substances and explosives. By introducing self-assembled monolayers (SAMs) onto sensor surfaces, functional molecular recognition interfaces were constructed while nonspecific adsorption was effectively suppressed, enabling highly sensitive detection of trace amounts of target analytes. For indirect competitive assays, sensor surfaces based on mixed SAMs containing ethylene glycol (EG) chains, dendron-immobilized SAMs, and polymer brush layers prepared by surface-initiated atom transfer radical polymerization (SI-ATRP) were developed. These surface designs enabled ultra-sensitive detection of low-molecular-weight substances, including trinitrotoluene (TNT) and aroma compounds such as benzaldehyde and furfural found in fruit juices [1],[2].

Based on the surface preparation techniques established for SPR biosensors, we further developed a method for two-dimensional imaging and visualization of low-molecular-weight substances secreted from plant roots. In this approach, bovine serum albumin (BSA) was employed as a biomolecular receptor and chemically immobilized onto glass microfiber filters. The filters were modified with 3-aminopropyltriethoxysilane (APTES) and subsequently functionalized with covalently immobilized BSA. Since BSA exhibits fluorescence around 340 nm when excited at 285 nm, BSA-immobilized filters were imaged before and after contact with plant roots using a UV-sensitive electron-multiplying charge-coupled device (EM-CCD) camera. Significant fluorescence quenching was observed near the root tips and lateral roots of soybean, enabling two-dimensional visualization of daidzein, the major isoflavone secreted from soybean roots [3]. Similar visualization of phenolic compounds in pea root exudates was achieved, and the fluorescence quenching intensity correlated with the amount of kaempferol glycosides. These results demonstrated that the fluorescence quenching of BSA induced by interactions with phenolic compounds secreted from leguminous plants can be utilized to visualize the spatial distribution of root exudates [4].

In this presentation, self-assembled interfaces incorporating biomolecular receptors, including antibodies and BSA, will be highlighted as a common platform for both ultra-sensitive detection and two-dimensional imaging of low-molecular-weight substances. The versatility and future prospects of sensing technologies based on self-assembled interfaces and biomolecular receptors will be discussed.

Keywords: Self-assembled monolayers; Surface plasmon resonance; Biomolecular receptors; Bovine serum albumin; Root exudates

References

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