Impedance Biosensors: Remaining Technical Challenges

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Adam Heller is a pioneer in continuous glucose monitoring, co-founding the company Therasense, which went public in 2001, and was acquired by Abbott Laboratories in 2004. Continuous glucose monitoring can be considered a tremendous success in the application of DC electroanalytical methods to the monitoring and treatment of diabetes.

Impedance biosensors can be viewed as an AC electroanalytical method for the detection of species of interest in the fields of biomedicine, environmental monitoring, and food and agriculture, amongst other fields. The most common format for AC impedance biosensors involves surface immobilization of an antibody, receptor protein, DNA strand, or other species capable of bio-recognition, and AC impedance detection of the binding event.

Technological application of AC impedance biosensors has been hindered by several obstacles, including the more complex circuitry required for AC relative to DC electrochemistry, chemical and physical interference arising from non-specific adsorption, and the stability and reproducibility of protein immobilization.

Research in my laboratory has focused on methods to reduce or compensate for non-specific adsorption, including sample dilution, site blocking with BSA, and the use of control electrodes onto which reference antibodies are immobilized. Examples that will be presented include impedance detection of food allergens, such as peanut protein Ara h 1, and food pathogens, such as Listeria monocytogenes.

Additional research has focused on alternative substrates and linker chemistries for protein immobilization, including the use of degenerate (highly doped) Si. Advantages of degenerate Si include a simpler equivalent circuit, simple and reproducible surface preparation, easy incorporation into ULSI devices, and the greater strength of Si-C bonds (~520 kJ/mole) relative to Au-S bonds (125-150 kJ/mole). Additional alternative substrates and linker chemistries will also be discussed.

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