Electrochemical Mass Immunosensor for Insulin Detection in Human Serum

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Insulin is a protein hormone that plays a vital role in glucose metabolism. The normal concentration of insulin in blood under a fasting condition is in the range 50-80 pM and lower levels indicate insulin deficiency that lead to a poor glucose metabolism. This condition is called type 1 diabetes. While elevated insulin levels denote the condition of type 2 diabetes, in which the available excess insulin in pancreas is not recognized by the cell receptors. The presence of blood glucose levels either below (hypoglycemia) or above (hyperglycemia) the normal level can cause serious health problems. Hence the continuous maintenance of normal insulin level is utmost important to regulate the glucose metabolism in our body.

Due to the presence of ultra-low levels of insulin in blood even under normal healthy conditions, we require highly sensitive analytical methods to detect insulin and diagnose diabetes. Simple and reliable bioanalytical methods for insulin detection have gained enormous importance at present. The challenging aspect of any biosensor for protein detection is its usability at the point-of-care sites with minimal or no laboratory support. Electroanalytical techniques possess the required advantages of simplicity, user-friendly, cost-effectiveness, high sensitivity, and non-tedious procedure for detecting biological molecules in serum.

We present herein a highly sensitive electrochemical mass sensor for the detection of insulin in human serum by a dual detection mode (frequency change and charge-transfer resistance) using an electrochemical quartz crystal microbalance (eQCM). The high sensitivity of this insulin sensor is achieved by conjugating insulin to magnetic nanoparticles. And the high specificity of the sensor is accomplished by a direct immunoassay utilizing an antibody immobilized sensor surface to capture the insulin-magnetic nanoparticle conjugate in solution. The unique features of the sensor are the dual independent detection of clinically relevant picomolar concentrations of insulin and high sensitivity. The detection limit of the sensor is 5 pM insulin in serum. The sensitivity of the sensor in the frequency detection mode is 3 Hz pM^{-1} and in the impedance mode 13 Ohm pM^{-1}. This electrochemical mass sensor is a valuable method for performing diabetes test in blood serum at the clinical sites.

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