Photonic Sensors for Biomedical Applications

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Editors

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CHAPTER 7

Surface Plasmon Resonance (SPR)-Based Biosensor for Sugar Monitoring via Urine Samples

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ABSTRACT

The surface plasmon resonance (SPR) phenomenon has become an acclaimed technique for the real-time and label-free investigation of diverse biological interactions. This chapter encompasses the design and operational principles of SPR device, along with the pivotal role of material selection in achieving enhanced sensitivity and specificity for sugar detection. The SPR device's core working principle involves the interaction of light with surface plasmons, resulting in a drip in the intensity of reflected light recorded at a particular angle. This angle is extremely sensitive to changes in refractive index (RI) close to sensor's surface, allowing for detection of molecular binding events. In the context of sugar monitoring, the binding interactions between sugar molecules and specific receptors immobilized on the sensor surface induce RI changes that can be quantified in real time. Material selection plays a critical role in optimizing

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the device's performance for sugar detection. The choice of materials for the sensor surface and immobilized receptors determines the device's sensitivity, selectivity, and stability. Various materials, such as gold and silver, are commonly employed due to their strong plasmonic properties. Additionally, advanced surface functionalization techniques ensure the stable attachment of receptors, enabling specific sugar recognition.

7.1 INTRODUCTION

Diabetes is a medical condition characterized by dysregulated insulin levels inside the body, which can arise from either insufficient insulin creation by the pancreas or inadequate utilization of insulin by body's cells [1]. Insulin, a hormone, plays a decisive role in the regulation of glucose levels throughout the body. It facilitates the absorption of glucose by cells from the circulation, enabling them to acquire energy or store it for subsequent use. Nevertheless, prolonged periods of excessively low or high blood glucose levels can give rise to hypoglycemia or hyperglycemia, respectively. These conditions can result in severe medical complications such as heart diseases, stroke, blindness, tissue damage, and kidney failure among other ailments. If left untreated, these complications can ultimately lead to fatality [2]. Insufficient synthesis of insulin inside the pancreatic gland results in the onset of type 1 diabetes, which is distinguished by an abrupt decline in glucose concentrations. Conversely, inadequate intake of insulin outcomes to the beginning of type 2 diabetes which is a condition characterized by elevated glucose levels. Neither of these disorders can be cured, hence, necessitating lifelong glucose monitoring in those with diabetes [3].

Unpleasantly, the act of routinely monitoring blood glucose levels is a considerable challenge for majority of individuals with diabetes. Traditional methods of glucose monitoring utilize the electrochemical approach [4], necessitating the extraction of a tiny blood sample from the individual by either finger puncture or the subcutaneous implantation of a thin lancet. Figure 7.1 shows the illustration of various approaches for the glucose monitoring. The primary distinction is in the fact that the first method alone offers a singular measurement of glucose concentration at a single moment, without necessitating the involvement of a healthcare expert. Therefore, it is commonly known as a self-monitoring blood glucose device. Furthermore, the second device is equipped with continuous monitoring capabilities,