Recent Advances in Enzyme Based Glucose Biosensors for Biomedical Applications

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Mini Review

Busy lifestyle has significant influence on health. Unhealthy living style not only leads to unbalanced nutrition but also increases occurrence of metabolic diseases, particularly diabetes. Therefore, there is a constant need of monitoring blood glycemic level using biosensor [1]. In recent decades, biosensing has proven to be an innovative technique in several fields, such as environment and biomedical applications [2].

A litmus-paper-like test that utilized glucose oxidase (GOx), peroxidase (POx), and a chromogen to quantify glucose in urine was developed by the Miles-Ames Laboratories in 1957 [3]. Since urine glucose level is fluid intake dependent and suffers from accuracy and reliability problems, more accurate blood glucose test-strip was developed and accepted by consumer market. Because of advances in technology, test-strip was then replaced by glucometer for personal use. First revolutionary glucose electrode was proposed by Clark & Lyons [4]. And then immobilized GOx based sensor was commenced by Updike & Hicks [5]. Since then amperometric, potentiometric, and impedimetric or conductometric glucose biosensors based on the GOx were developed and employed for biomedical applications.

Enzymatic detection methods always rely on biological activity of free or native enzyme. Most of the enzymes can only keep their activity under some limited condition and the enzyme instability often limits their use in sensor device. Various immobilization strategies can be employed to improve the storage and thermal stability as well as the specificity of enzymes. Improved sensitivity, selectivity and specificity with reusability of the enzymes can be achieved by immobilization methods such as entrapment, cross-linking, physical adsorption, covalent or ionic bonding, and encapsulation. Owing to the mesoporous network based matrix, biopolymers, synthetic polymers and one, two and three dimensional nanostructures are useful platform to immobilize glucose oxidase and other enzymes for glucose biosensing [7,8].

Biosensors can be classified into three generations according to the method of attachment of the biorecognition molecule/bioreceptor to the transducer [9]. The first generation biosensors were mostly oxygen sensors where bioreceptor is physically entrapped in the vicinity of the sensor separated by a barrier such as dialysis membrane. In the second generation biosensor architecture, the individual components remain essentially distinct and use mediators for communication. In the third generation biosensors the bioreceptor becomes an integral part of the base sensing element by coupling technique. Different enzymes such as GOx, POx, hexokinase, glucokinase and glucose dehydrogenases (GDHs) have been used for fabricating glucose sensors [3]. GOx is a dimeric enzyme which catalyzes the conversion of β-d-glucose to d-glucono-1, 5-lactone, it is the first enzyme used in bi/tri-enzyme glucose sensing systems which depend upon two or three step detection. GOx, catalase, invertase, beta-glucanase and peroxidase are used in conjunction with active fluorescent, visible light chromophore, nanodot or nanostructure for optical sensors. GOx with flavin adenosine dinucleotide (FAD) cofactor is electrochemically active, thus the mediated and other enzymes can be eliminated to construct the third generation sensors. This not only reduces the cost of the probe system but also allows direct electron transfer between...
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Nanomaterials and nanofabrication techniques for improvement of sensor architecture is still needed. There are limitations on clinical use of nanosensors for continuous glucose monitoring as these devices suffer from fouling, decreased sensor life due to immune response and management cost. Despite extensive research on enzyme-free glucose sensors, there is still no commercial product. Biosensors for continuous glucose monitoring will undoubtedly focus on accuracy, reliability, cost and durability.

References


