

Overview of Fluorescence Glucose Sensing: A Technology with a Bright Future

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Abstract

Fluorescence represents a promising alternative technology to electrochemistry and spectroscopy for accurate analysis of glucose in diabetes; however, no implanted fluorescence glucose assay is currently commercially available. The method depends on the principle of fluorescence, which is the emission of light by a substance after absorbing light. A fluorophore is a molecule that will absorb energy of a specific wavelength and reemit energy at a different wavelength. A fluorescence glucose-sensing molecule can be constructed to increase or decrease in fluorescence from baseline according to the ambient concentration of glucose. A quantum dot is a semiconductor crystal that can serve as a sensor by fluorescing at a desired wavelength or color, depending on the crystal size and materials used. If receptor molecules for glucose can be adsorbed to single-wall carbon nanotubes, then the resulting binding of glucose to these receptors will alter the nanotubes' fluorescence. Fluorescence glucose sensors can provide a continuous glucose reading by being embedded into removable wire-shaped subcutaneous or intravenous catheters as well as other types of implanted structures, such as capsules, microcapsules, microbeads, nano-optodes, or capillary tubes.

Fluorescence glucose-sensing methods, which are under development, offer four potential advantages over commercially used continuous glucose monitoring technologies: (1) greater sensitivity to low concentrations of glucose, (2) the possibility of constructing sensors that operate most accurately in the hypoglycemic range by using binding proteins with disassociation constants in this range, (3) less need to recalibrate in response to local tissue reactions around the sensor, and (4) no need to implant either a transmitter or a power source for wireless communication of glucose data.

Fluorescence glucose sensors also have four significant disadvantages compared with commercially used continuous glucose monitoring technologies: (1) a damaging foreign body response; (2) a sensitivity to local pH and/or oxygen, which can affect the dye response; (3) potential toxicity of implanted dyes, especially if the implanted fluorophore cannot be fully removed; and (4) the necessity of always carrying a dedicated light source to interrogate the implanted sensor. Fluorescence sensing is a promising method for measuring glucose continuously, especially in the hypoglycemic range. If currently vexing technical and engineering and biocompatibility problems can be overcome, then this approach could lead to a new family of continuous glucose monitors.

J Diabetes Sci Technol 2012;6(6):1242-1250

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Abbreviations: (ConA) concanavalin A, (FL) fluorescent lifetime, (FRET) Förster resonance energy transfer, (GBP) glucose-binding protein, (QD) quantum dot, (SWCNT) single-walled carbon nanotube, (UV) ultraviolet

Keywords: fluorescence, glucose, nanotube, quantum dot, sensor, tattoo

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