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Application of Contact Lens Biosensors for determining Diabetes

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ABSTRACT

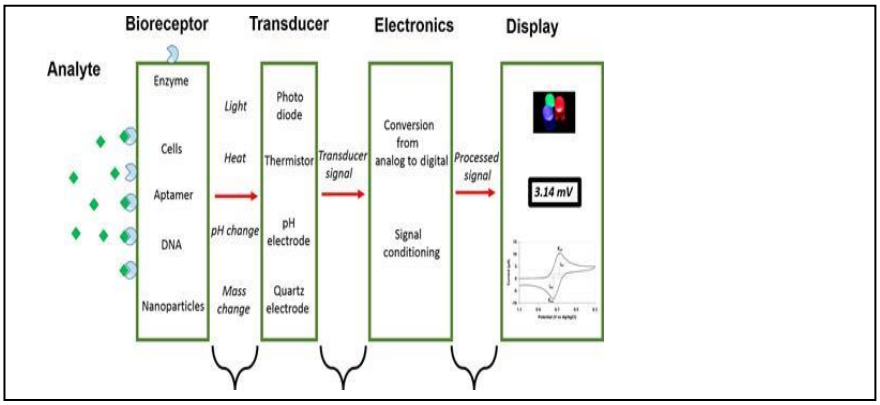
Diabetes is a hormonal disorder that impairs the body's ability to process blood glucose, due to which insulin blood glucose level is disturbed in the body, resulting in upliftment or limiting the glucose concentration. The system of biosensors can help in glucose monitoring and control the problem of diabetes, for this purpose contact lens biosensors can be used. As diabetes has become a significant global challenge affecting 382 million people in the world therefore this system is an unmet medical need. Biosensors are analytical systems that transform a biological response into an electrical signal. Biosensors are highly specific and are combination of detecting elements like transducer and sensor system. Various types of biosensors are being used as DNA Biosensors, Immuno biosensors, Piezoelectric biosensors, Optical biosensors, Wearable biosensors and more. In this paper, contact lens biosensors and their usage in glucose monitoring is discussed. Other advantages and future scope of the biosensors have also been highlighted, therefore contact lens biosensors can play a major role in controlling the diabetes in patients and regular monitoring of glucose ca n be done at regular interval which can be visualized on smart phones.

Keywords*: *Biosensors, Contact lens biosensors, Diabetes, Blood glucose level, Smart phones.

I. INTRODUCTION

Diabetes is a hormonal disorder that impairs the body's ability to process blood glucose, due to which insulin blood glucose level is distributed in the body, resulting in the upliftment or limits the glucose concentration. The system of biosensors can help in glucose monitoring and control the problem of diabetes.

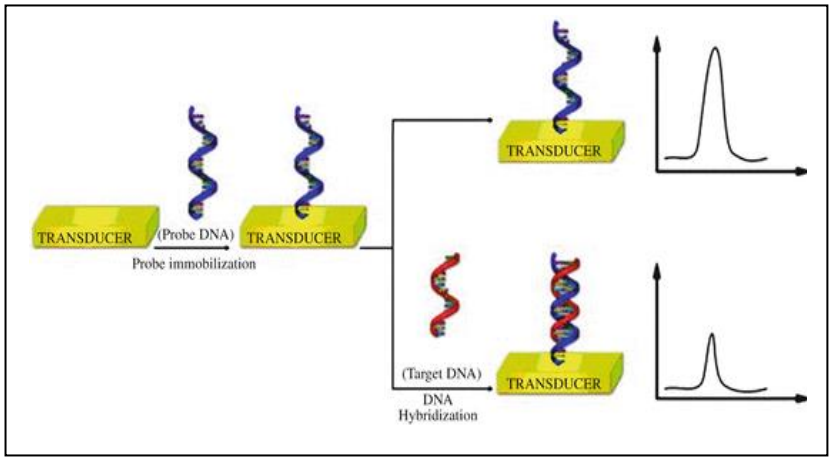
Biosensors are analytical systems that transform a biological response into an electrical signal. The first biosensor was invented by LL Clark an American Biochemist. Biosensors are highly specific and combination detecting element like transducer and sensor system [1-2.] Various types of biosensors are being used as DNA biosensors, Immuno biosensors, Piezoelectric Biosensors, Optical Biosensor and Wearable Biosensor and more. A biosensor usually comprises of three parts namely, sensor, transducer and associated electrons represented in figure 1.



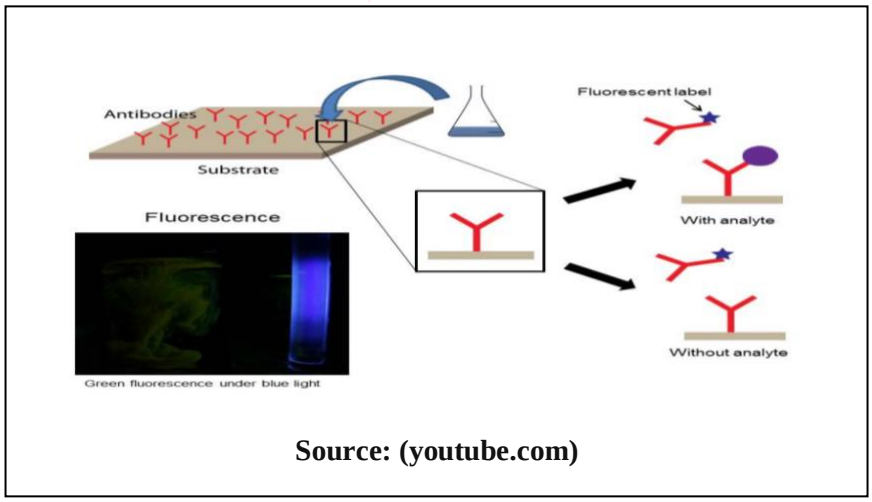
A. Types of Biosensors:

There are different types of biosensors which work on different principle. Some of them are mentioned below;[1]

- **DNA Biosensor**: The DNA biosensors works on the principle that a single stranded nucleic acid molecule recognizes and binds to its complimentary strands in a sample. This binding is possible with the help of hydrogen bonding that provides stability to the strands. DNA biosensors are shown in figure 2.



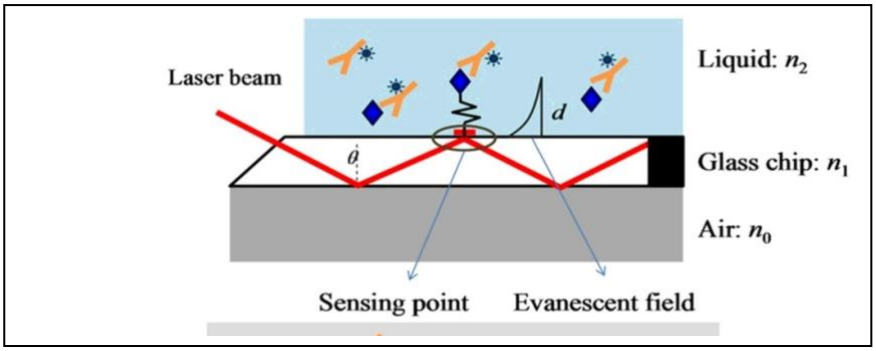
- **Immuno Biosensor:** These sensors were developed on the fact that antibodies have higher affinity for their respective antigens, that is the antibodies specifically bind to the pathogen or toxins present in the host immune system shown in figure 3.



Source: (youtube.com)

- **Piezoelectric Biosensors:** These are mainly of two types, The Quartz crystal microbalance and The Surface acoustic wave device. They are based on the measurement of changes in resonance frequency of a piezoelectric crystal due to mass changes on the crystal.

- **Optical Biosensors:** Optical biosensors (figure 4) comprises of a light source, along with various optical components to produce a beam of light with particular characteristic and to beeline this light to a
modulating agent, a modified sensing head along with a photo detector. The optical biosensors are classified into two types namely, Direct optical detection biosensor and Labelled optical biosensor.

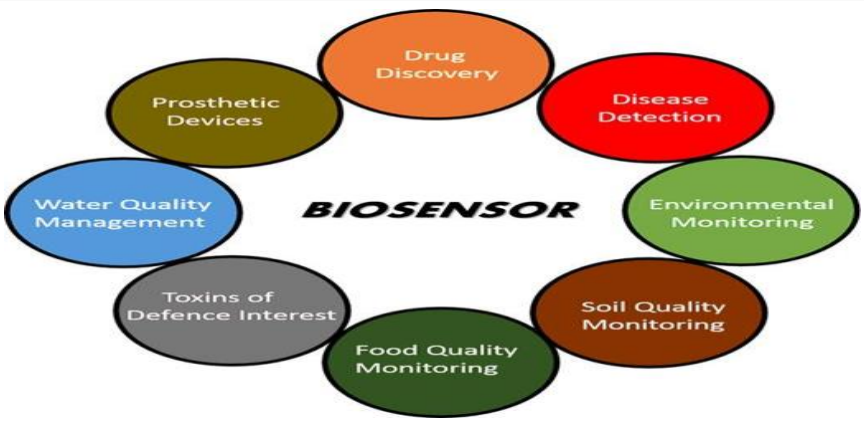


- **Wearable Biosensors:** These biosensors are digital devices used to wear on human body in different wearable system like smart watches, smart shirts, tattoos which allows the levels of blood glucose level, blood pressure, the rate of heartbeat, etc. For the human beings, these sensors may assist in premature recognition of health action and prevention of hospitalization depicted in figure 5.

Fig. 5: Wearable Biosensors

B. Application of Biosensors:

These biosensors are applicable in various fields represented in figure 6.[2]



Source: (Ref [2]) Fig. 6:Applications of Biosensors

Diabetes has become a significant global challenge affecting 382 million people in the world therefore, this system of biosensors is an unmet need, for this purpose Contact Lens Biosensors are used.

II. Contact Lens Biosensors

Contact lens biosensors are the combination of two types of biosensors which include optic biosensors and wearable biosensors. These are cost effective, reusable and continuous glucose monitoring device that can be a boon to the society [3] (figure no. 8). A research propose that metabolic control can be tracked in the diabetic patients known- invasively through measurement of tear glucose. This is possible making the use of Contact lens produced from hydrogel polymers (containing over 90% of water) inserted with glucose sensing agents or nano scale digital electronic technology [4]. The contact lens is illustrated in figure 7.

An optical biosensor is created for continuous quantification of glucose at physiological conditions in real time, simplifying the fabrication process. It gives result on smartphones making it more convenient [3]. Stretchable and skin-like electronics, combined with wireless communications along with the stability of soft contact lens have been studied widely and remarkable advances have been made to limit irritation in the eyes to widen the comfort for the users.[5]

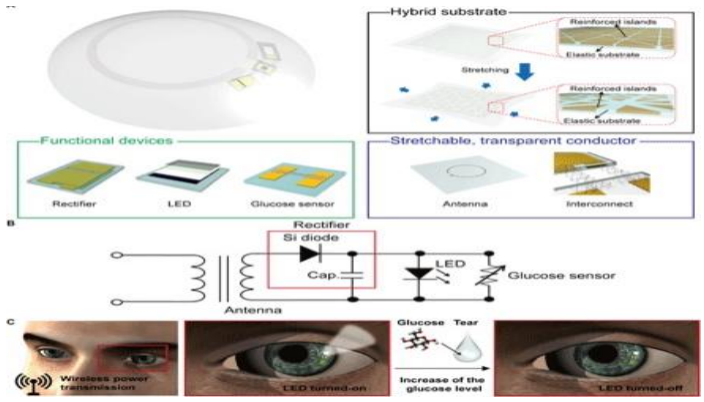


Fig . 7: Contact Lens

Figure no. 7 Illustration

- **A.** Composed of hybrid substrate, functional devices (rectifier, LED, and glucose sensor), and a transparent, stretchable conductor (for antenna and interconnects).
- **B.** Circuit diagram of the smart contact lens system.
- **C.** Operation of this soft, smart contact lens.

Electric power is wirelessly transmitted to the lens through the antenna. This power activates the LED pixel and the glucose sensor. After detecting the glucose level in the tear fluid above the threshold, this pixel turns off [5].

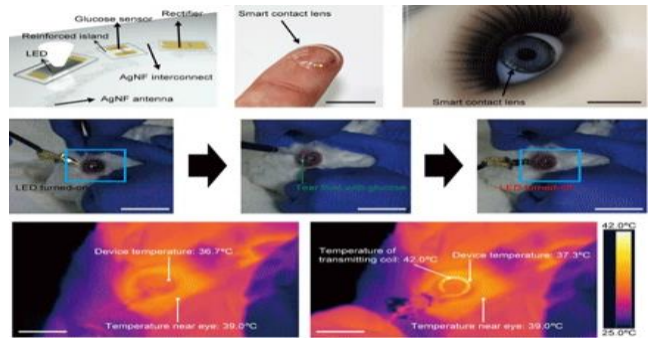


Fig no. 8: Contact Lens Biosensor for detecting glucose

Figure no. 8 Illustration

- **A.** Schematic image of the Contact Lens. The rectifier, the LED, and the glucose sensor are located on the reinforced regions. The transparent, stretchable Ag NF-based antenna and interconnects are located on an elastic region.
- **B.** Image of fabricated Contact Lens. Scale bar, 1cm.
- **C.** Image of the Contact Lens on an eye of Mannequin. Scale bar, 1cm.
- **D.** Image of the in-vivo test on a live rabbit using the Contact Lens.

LEFT; turn on state of the LED in the Contact Lens mounted on the rabbit's eye.
MIDDLE; injection of the tear fluids with the glucose concentration of 0.9mM.
RIGHT; turn off state of the LED after detecting the increased glucose concentration. Scale bar,1cm.

- **E.** Heat tests while a live rabbit is wearing the operation Contact lens. Scale bar, 1cm [5].

Advantages

- Contact lens could be a suitable way for the rectification of the vision for patients suffering from diabetes [4].

- Studies have reported that Contact lens have certain therapeutic applications as it can be helpful in calculating the concentration of tear glucose and can b ed used to record diabetic metabolic control non-invasively in diabetic patients. This can be done using Contact lens constructed through polymers with nano-scaled digital electronic technology or glucose sensing agents inserted within it.[4]
- These are the devices that can detect glucose lev el in real time and these levels could be monitored on the smart phones that has become an integral part of individual's life.
- Cost-effective, reusable and can be used by any human being irrespective of their age.

III. FUTURE SCOPE

Contact lens biosensors can benefit the researcher to sense the hormonal level, drugs or toxins, continuously and non-invasively using bio-photonics or other physical principles. Further, there could be a vast research done on the contact lens biosensors to make human life easier and reliable.[1]

IV. CONCLUSION

Contact lens biosensors are a boon for the society. These biosensors are cost-effective, reusable and continuous glucose monitoring device. Other advantages and future scope of biosensors have also been highlighted in this paper. Therefore, Contact Lens Biosensors can play a major role in controlling the diabetes in patients and regular monitoring of glucose can be done at regular intervals that can be visualized on smart phone.

V. ACKNOWLEDGEMENT

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